T5 Conditions Report

Shots 2526–2823

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Abstract

This report contains information on 254 experiments performed in the Caltech T5 Hypervelocity Reflected Shock Tunnel on a 5 degree half angle cone between December 12, 2008 (shot 2526) and July 31, 2013 (shot 2823). This is the time period covered by the work described in Jewell (2014), and the reader is referred to that thesis (especially Chapters 2–4) for the relevant details of facility operation, computational modeling, and data reduction.

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1 Shot 2526

Experiment 2526 was performed in T5 on 12 December 2008. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

1.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3090	m/s
Shock Tube Fill Pressure	P_1	90.50	kPa
Reservoir Pressure	P_{res}	50.4	MPa

Table 1: Measured quantities, Shot 2526

1.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5818	K
Reservoir Density	ρ_{res}	27.47	kg/m^3
Reservoir Enthalpy	h_{res}	9.16	MJ/kg

Table 2: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2526

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.95×10^{-2}	0	1.36×10^{-1}	0	3.37×10^{-3}	1.01×10^{-1}

Table 3: Computed reservoir species mass fractions, Shot 2526

1.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3900	1353.0	1353.0	5.40	23.2	0.059	4.54×10^6
72 cm	3872	1380.1	1388.9	5.16	27.1	0.067	5.12×10^6

Table 4: Computed freestream conditions, Shot 2526

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.57×10^{-9}	1.67×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.31×10^{-2}	0	3.81×10^{-9}	9.67×10^{-3}

Table 5: Computed freestream species mass fractions, Shot 2526

1.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3862	1475.6	1475.6	5.12	33.2	0.077	5.56×10^6
72 cm	3807	1561.9	1559.6	4.77	38.6	0.085	5.83×10^6

Table 6: Computed boundary layer edge conditions, Shot 2526

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.57×10^{-9}	1.67×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	1.68×10^{-8}	9.38×10^{-3}

Table 7: Computed boundary layer edge species mass fractions, Shot 2526

	T^* K	Unit Re^* 1/m
1D 100 cm	1788	4.02×10^6
72 cm	1760	5.17×10^6

Table 8: Dorrance reference conditions, Shot 2526

1.5 Stability Computations

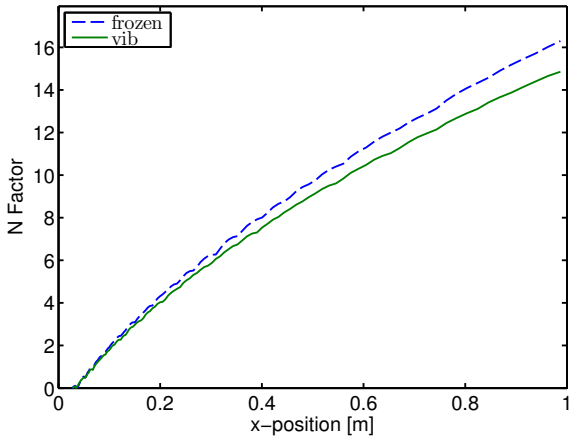


Figure 1: Locus of maximum N factor with and without vibrational energy transfer, Shot 2526

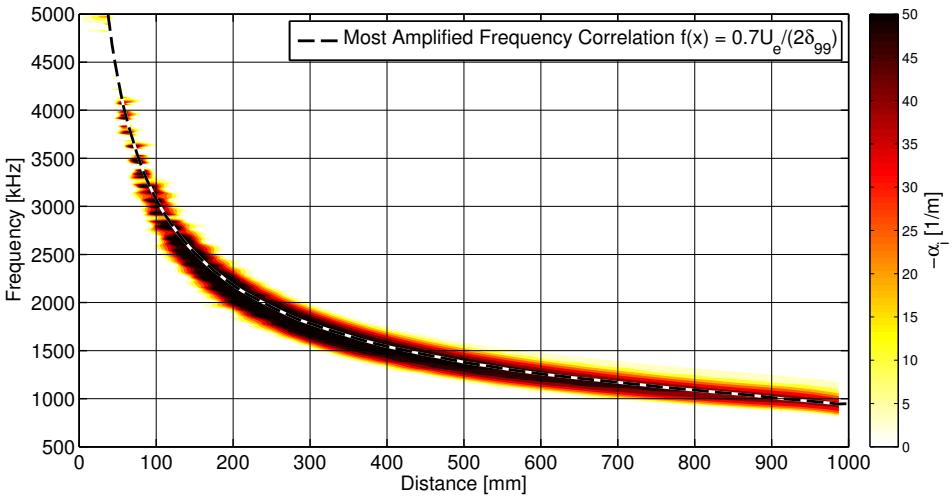


Figure 2: Stability diagram with vibrational energy transfer, Shot 2526. Dashed line indicates $0.7U_e/(2\delta_{99})$.

1.6 Heat Transfer Results

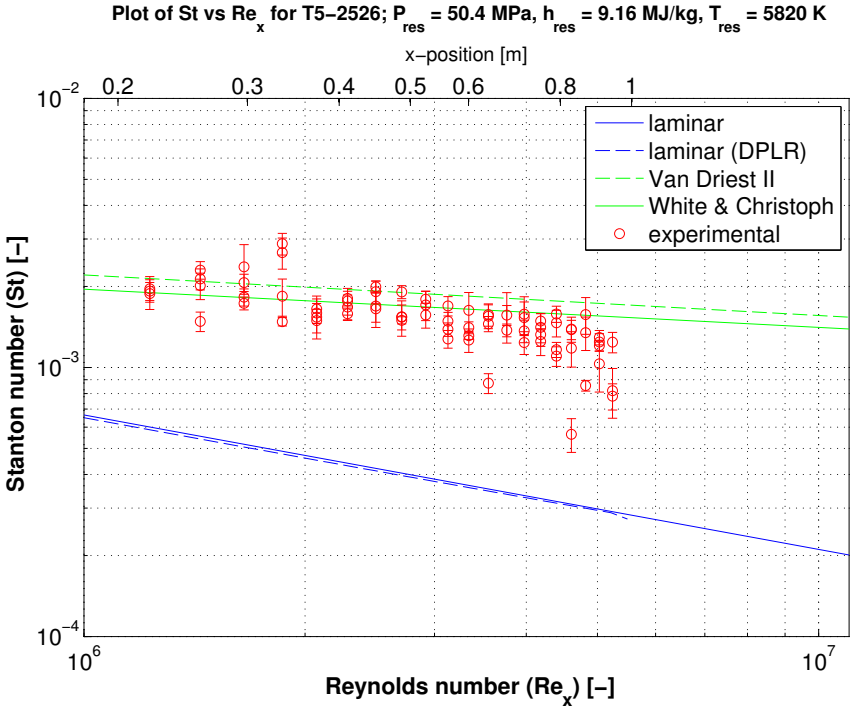


Figure 3: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

2 Shot 2527

Experiment 2527 was performed in T5 on 22 December 2008. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

2.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	86.00	kPa
Reservoir Pressure	P_{res}	48.5	MPa

Table 9: Measured quantities, Shot 2527

2.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6042	K
Reservoir Density	ρ_{res}	25.14	kg/m^3
Reservoir Enthalpy	h_{res}	9.73	MJ/kg

Table 10: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2527

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	4.87×10^{-2}	0	1.32×10^{-1}	0	5.05×10^{-3}	1.14×10^{-1}

Table 11: Computed reservoir species mass fractions, Shot 2527

2.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3998	1438.0	1438.0	5.36	22.7	0.054	4.10×10^6
72 cm	3969	1477.5	1487.4	5.10	26.7	0.062	4.60×10^6

Table 12: Computed freestream conditions, Shot 2527

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.99×10^{-2}	0	5.18×10^{-9}	2.18×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	1.23×10^{-8}	1.34×10^{-2}

Table 13: Computed freestream species mass fractions, Shot 2527

2.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3959	1566.5	1566.5	5.08	32.4	0.070	5.00×10^6
72 cm	3902	1668.5	1666.1	4.72	37.9	0.078	5.23×10^6

Table 14: Computed boundary layer edge conditions, Shot 2527

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.99×10^{-2}	0	5.18×10^{-9}	2.18×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	4.61×10^{-8}	1.29×10^{-2}

Table 15: Computed boundary layer edge species mass fractions, Shot 2527

	T^* K	Unit Re^* 1/m
1D 100 cm	1872	3.70×10^6
72 cm	1847	4.73×10^6

Table 16: Dorrance reference conditions, Shot 2527

2.5 Stability Computations

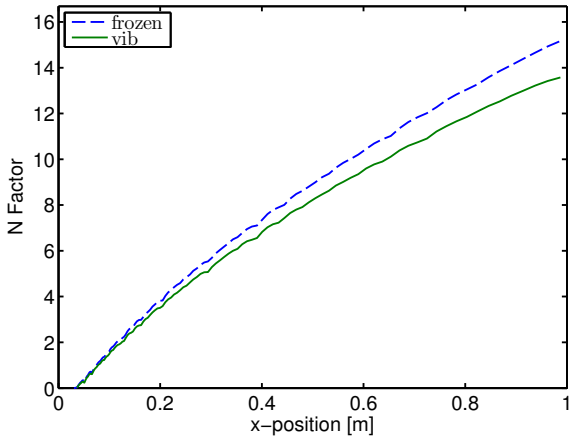


Figure 4: Locus of maximum N factor with and without vibrational energy transfer, Shot 2527

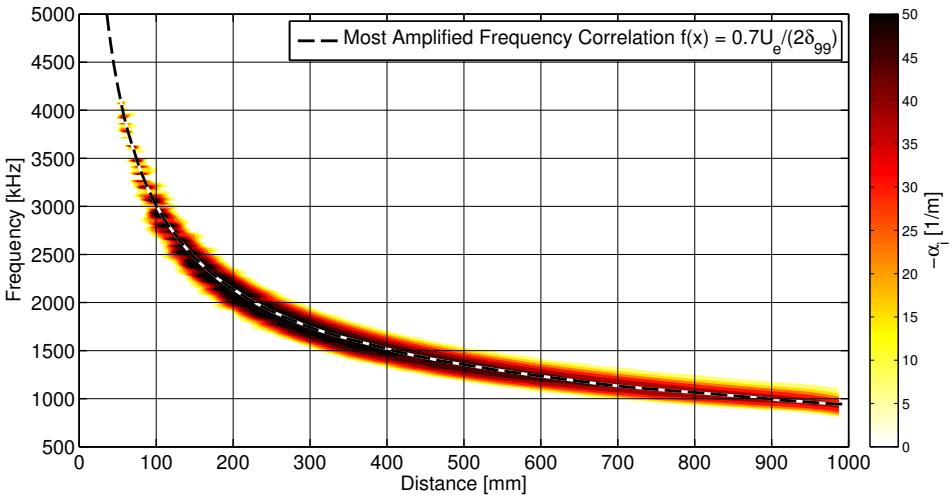


Figure 5: Stability diagram with vibrational energy transfer, Shot 2527. Dashed line indicates $0.7U_e/(2\delta_{99})$.

2.6 Heat Transfer Results

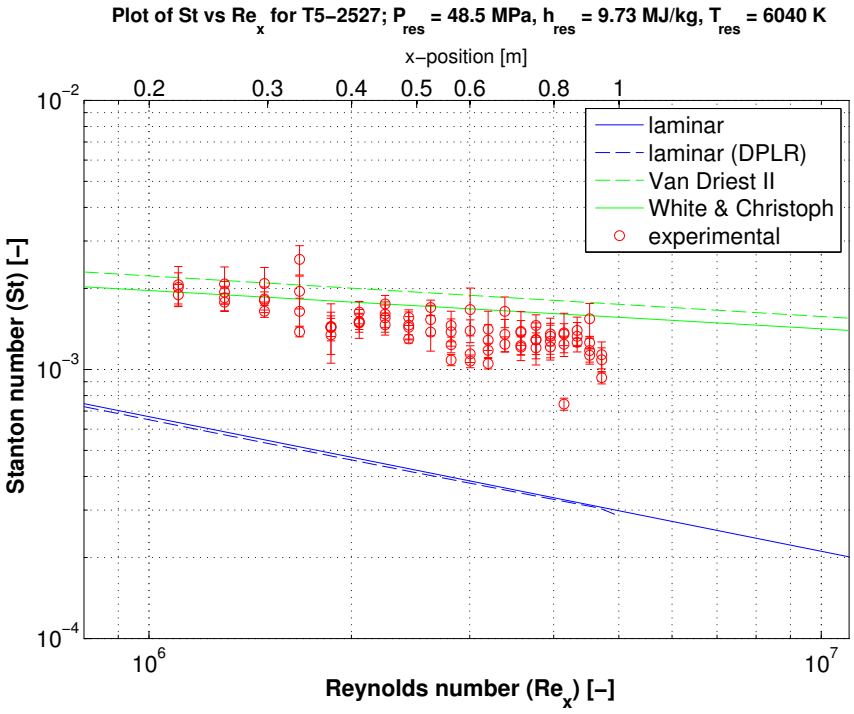


Figure 6: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

3 Shot 2528

Experiment 2528 was performed in T5 on 15 January 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

3.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	48.7	MPa

Table 17: Measured quantities, Shot 2528

3.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6089	K
Reservoir Density	ρ_{res}	24.99	kg/m^3
Reservoir Enthalpy	h_{res}	9.84	MJ/kg

Table 18: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2528

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	4.69×10^{-2}	0	1.31×10^{-1}	0	5.44×10^{-3}	1.16×10^{-1}

Table 19: Computed reservoir species mass fractions, Shot 2528

3.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4011	1449.0	1449.0	5.35	22.5	0.053	4.02×10^6
72 cm	3987	1496.7	1506.6	5.09	27.0	0.062	4.57×10^6

Table 20: Computed freestream conditions, Shot 2528

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.97×10^{-2}	0	5.76×10^{-9}	2.27×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.29×10^{-2}	0	1.50×10^{-8}	1.40×10^{-2}

Table 21: Computed freestream species mass fractions, Shot 2528

3.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3972	1577.9	1577.9	5.08	32.0	0.069	4.90×10^6
72 cm	3920	1689.2	1686.9	4.71	38.2	0.078	5.19×10^6

Table 22: Computed boundary layer edge conditions, Shot 2528

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.97×10^{-2}	0	5.76×10^{-9}	2.27×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	5.47×10^{-8}	1.36×10^{-2}

Table 23: Computed boundary layer edge species mass fractions, Shot 2528

	T^* K	Unit Re^* 1/m
1D 100 cm	1883	3.63×10^6
72 cm	1865	4.70×10^6

Table 24: Dorrance reference conditions, Shot 2528

3.5 Stability Computations

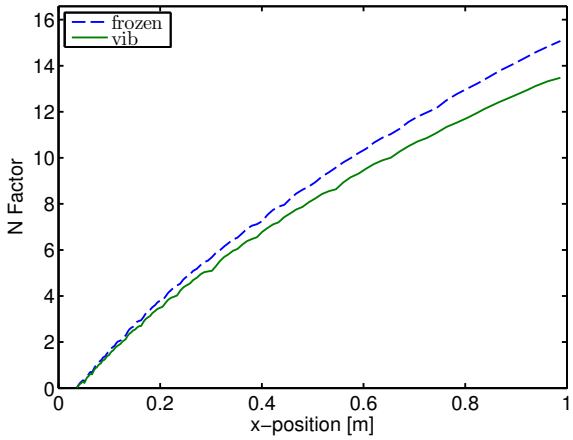


Figure 7: Locus of maximum N factor with and without vibrational energy transfer, Shot 2528

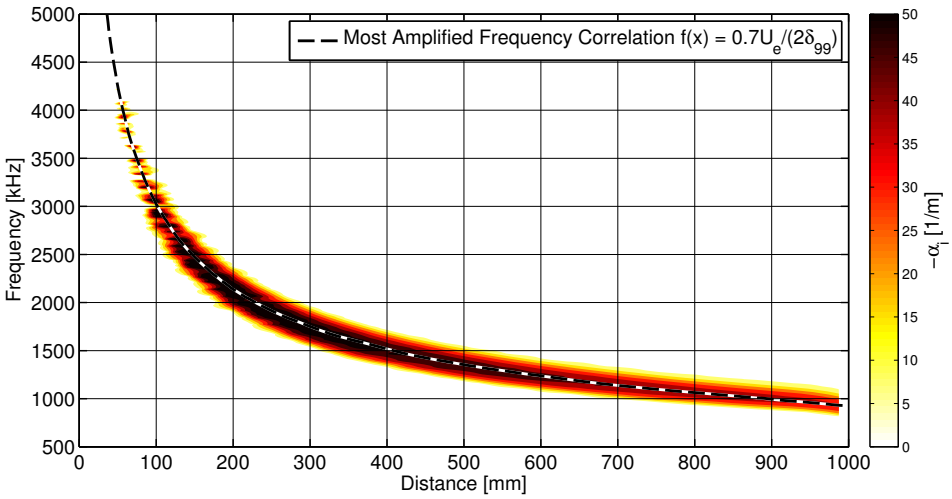


Figure 8: Stability diagram with vibrational energy transfer, Shot 2528. Dashed line indicates $0.7U_e/(2\delta_{99})$.

3.6 Heat Transfer Results

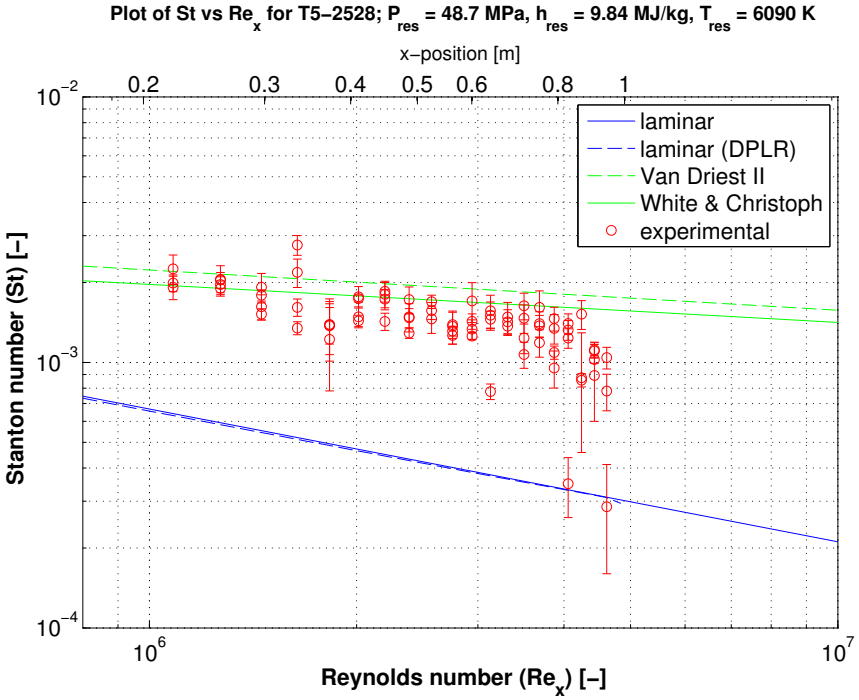


Figure 9: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

4 Shot 2529

Experiment 2529 was performed in T5 on 22 January 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

4.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3240	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	48.9	MPa

Table 25: Measured quantities, Shot 2529

4.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6126	K
Reservoir Density	ρ_{res}	24.90	kg/m^3
Reservoir Enthalpy	h_{res}	9.93	MJ/kg

Table 26: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2529

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	4.55×10^{-2}	0	1.30×10^{-1}	0	5.76×10^{-3}	1.18×10^{-1}

Table 27: Computed reservoir species mass fractions, Shot 2529

4.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4027	1463.0	1463.0	5.35	22.7	0.053	4.00×10^6
72 cm	4002	1512.0	1522.0	5.08	27.2	0.062	4.54×10^6

Table 28: Computed freestream conditions, Shot 2529

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.96×10^{-2}	0	6.81×10^{-9}	2.33×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.29×10^{-2}	0	1.76×10^{-8}	1.45×10^{-2}

Table 29: Computed freestream species mass fractions, Shot 2529

4.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3987	1593.3	1593.3	5.07	32.3	0.069	4.87×10^6
72 cm	3935	1705.9	1703.6	4.71	38.5	0.077	5.16×10^6

Table 30: Computed boundary layer edge conditions, Shot 2529

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.96×10^{-2}	0	6.81×10^{-9}	2.33×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.29×10^{-2}	0	6.24×10^{-8}	1.40×10^{-2}

Table 31: Computed boundary layer edge species mass fractions, Shot 2529

	T^* K	Unit Re^* 1/m
1D 100 cm	1897	3.62×10^6
72 cm	1879	4.68×10^6

Table 32: Dorrance reference conditions, Shot 2529

4.5 Stability Computations

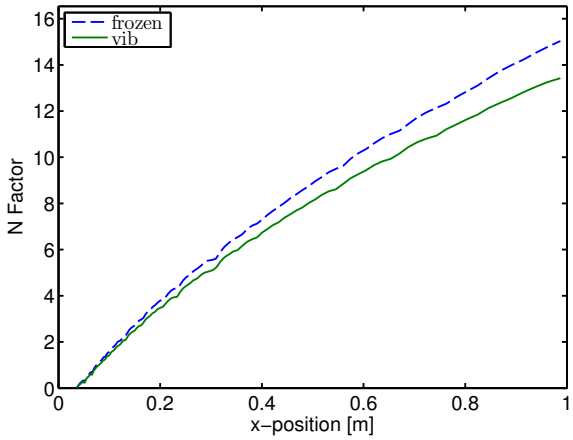


Figure 10: Locus of maximum N factor with and without vibrational energy transfer, Shot 2529

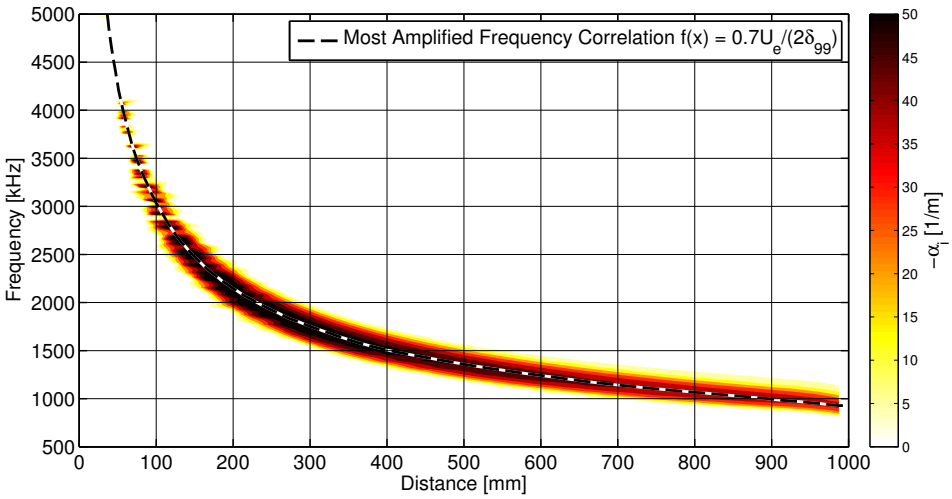


Figure 11: Stability diagram with vibrational energy transfer, Shot 2529. Dashed line indicates $0.7U_e/(2\delta_{99})$.

4.6 Heat Transfer Results

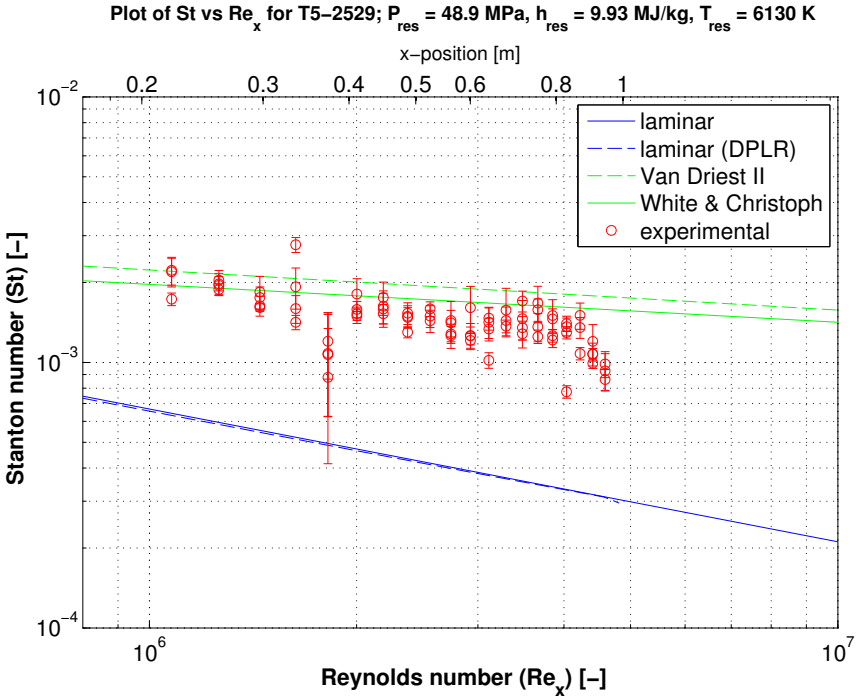


Figure 12: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

5 Shot 2535

Experiment 2535 was performed in T5 on 1 May 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

5.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3120	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	51.5	MPa

Table 33: Measured quantities, Shot 2535

5.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5931	K
Reservoir Density	ρ_{res}	27.39	kg/m^3
Reservoir Enthalpy	h_{res}	9.42	MJ/kg

Table 34: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2535

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.47×10^{-2}	0	1.35×10^{-1}	0	4.06×10^{-3}	1.06×10^{-1}

Table 35: Computed reservoir species mass fractions, Shot 2535

5.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3940	1389.0	1389.0	5.38	23.4	0.058	4.43×10^6
72 cm	3919	1427.6	1436.7	5.13	28.0	0.067	5.07×10^6

Table 36: Computed freestream conditions, Shot 2535

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.04×10^{-2}	0	2.26×10^{-9}	1.83×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	6.52×10^{-9}	1.08×10^{-2}

Table 37: Computed freestream species mass fractions, Shot 2535

5.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3901	1513.7	1513.7	5.10	33.4	0.075	5.42×10^6
72 cm	3853	1613.5	1611.2	4.75	39.9	0.085	5.77×10^6

Table 38: Computed boundary layer edge conditions, Shot 2535

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.04×10^{-2}	0	2.26×10^{-9}	1.83×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	2.63×10^{-8}	1.05×10^{-2}

Table 39: Computed boundary layer edge species mass fractions, Shot 2535

	T^* K	Unit Re^* 1/m
1D 100 cm	1823	3.95×10^6
72 cm	1803	5.16×10^6

Table 40: Dorrance reference conditions, Shot 2535

5.5 Stability Computations

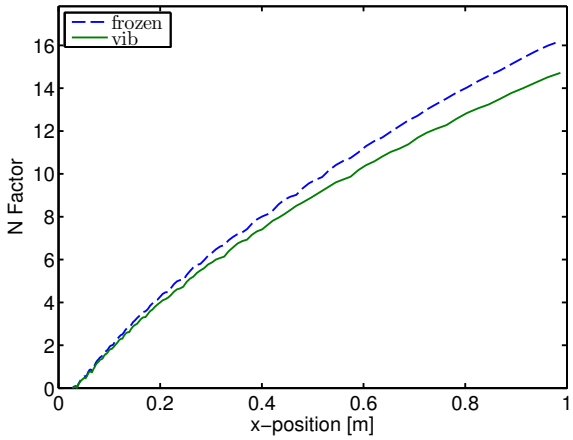


Figure 13: Locus of maximum N factor with and without vibrational energy transfer, Shot 2535

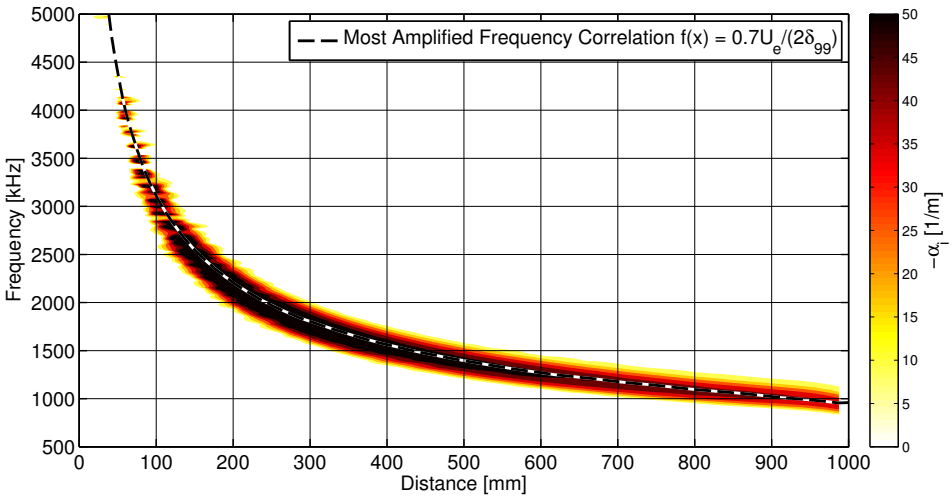


Figure 14: Stability diagram with vibrational energy transfer, Shot 2535. Dashed line indicates $0.7U_e/(2\delta_{99})$.

5.6 Heat Transfer Results

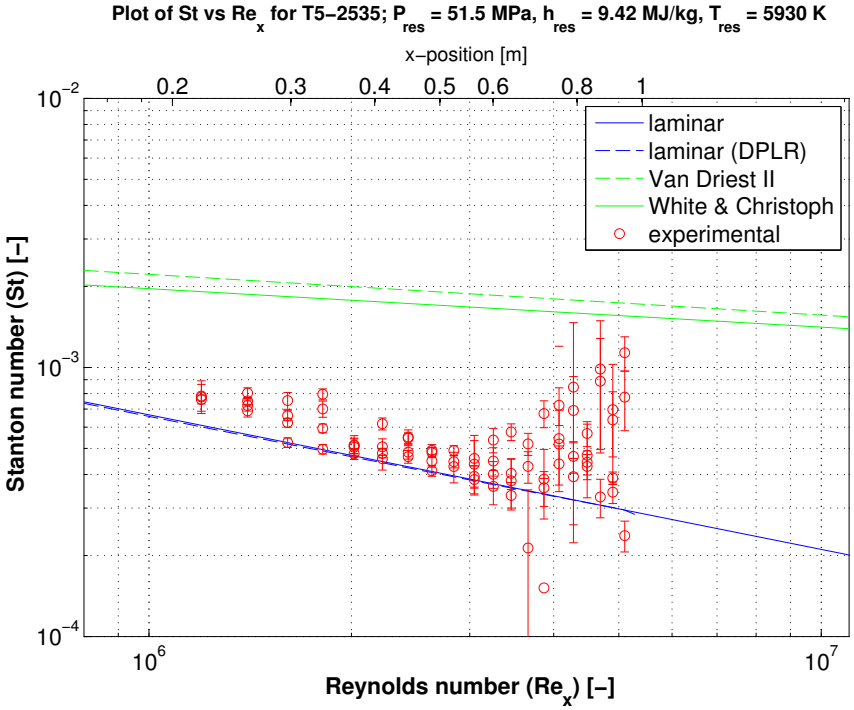


Figure 15: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

6 Shot 2536

Experiment 2536 was performed in T5 on 18 May 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and one-row injector section. The initial shock tube composition was 100% air by mass.

6.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	51.2	MPa

Table 41: Measured quantities, Shot 2536

6.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6008	K
Reservoir Density	ρ_{res}	26.77	kg/m^3
Reservoir Enthalpy	h_{res}	9.61	MJ/kg

Table 42: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2536

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.12×10^{-2}	0	1.34×10^{-1}	0	4.64×10^{-3}	1.10×10^{-1}

Table 43: Computed reservoir species mass fractions, Shot 2536

6.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3977	1422.0	1422.0	5.36	23.7	0.057	4.34×10^6
72 cm	3952	1460.8	1470.2	5.11	28.1	0.066	4.92×10^6

Table 44: Computed freestream conditions, Shot 2536

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	3.92×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	9.56×10^{-9}	1.20×10^{-2}

Table 45: Computed freestream species mass fractions, Shot 2536

6.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3938	1549.2	1549.2	5.09	33.8	0.074	5.30×10^6
72 cm	3885	1649.5	1647.3	4.73	39.9	0.083	5.60×10^6

Table 46: Computed boundary layer edge conditions, Shot 2536

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	3.92×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	3.65×10^{-8}	1.16×10^{-2}

Table 47: Computed boundary layer edge species mass fractions, Shot 2536

	T^* K	Unit Re^* 1/m
1D 100 cm	1855	3.90×10^6
72 cm	1832	5.05×10^6

Table 48: Dorrance reference conditions, Shot 2536

6.5 Stability Computations

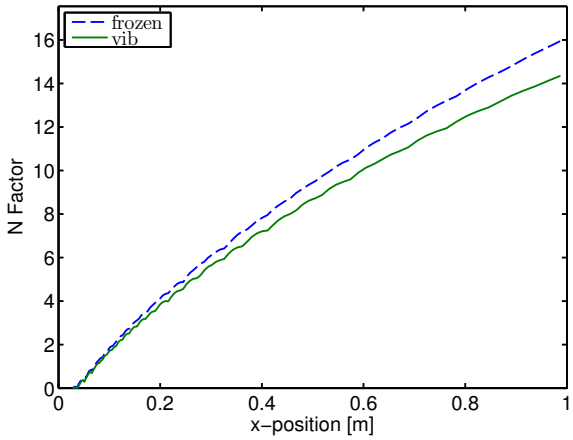


Figure 16: Locus of maximum N factor with and without vibrational energy transfer, Shot 2536

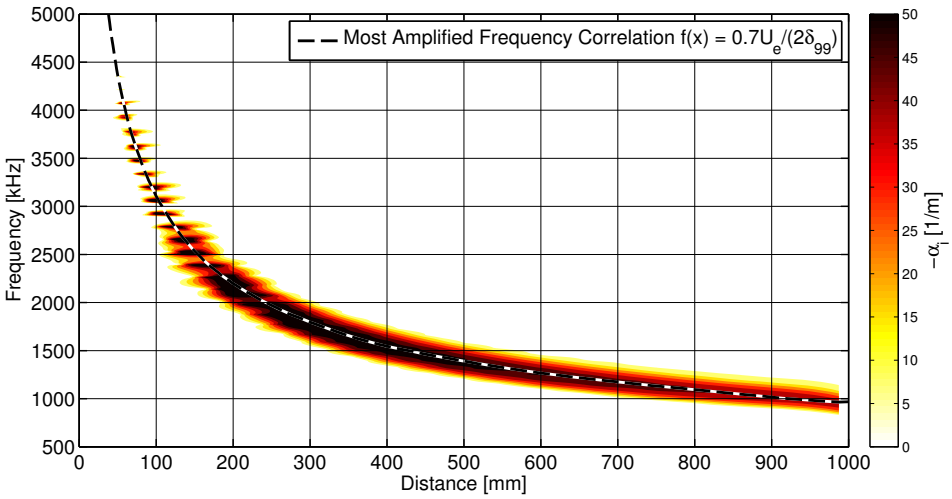


Figure 17: Stability diagram with vibrational energy transfer, Shot 2536. Dashed line indicates $0.7U_e/(2\delta_{99})$.

6.6 Heat Transfer Results

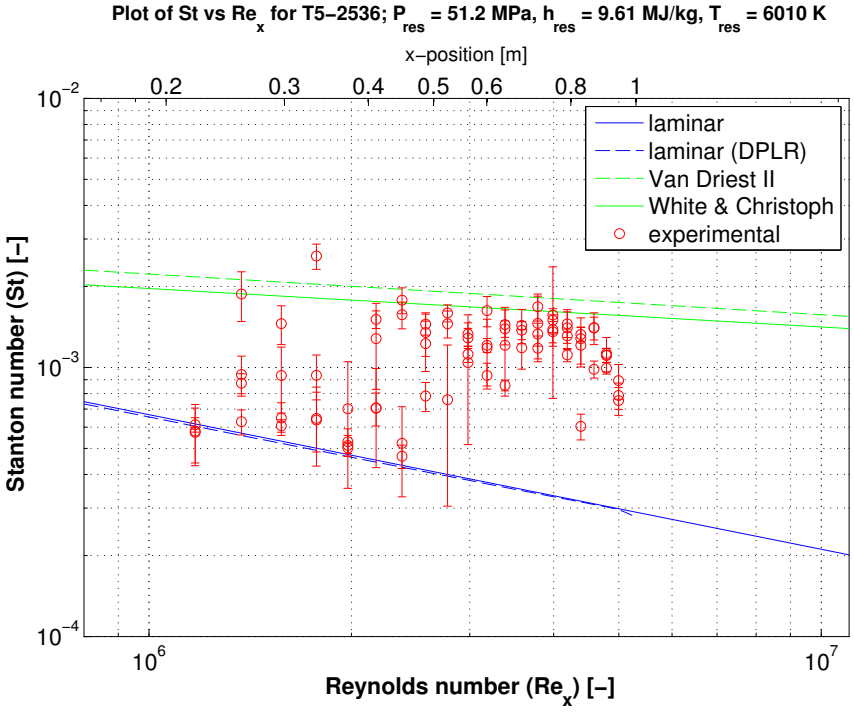


Figure 18: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

7 Shot 2537

Experiment 2537 was performed in T5 on 17 July 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

7.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2700	m/s
Shock Tube Fill Pressure	P_1	150.00	kPa
Reservoir Pressure	P_{res}	44.7	MPa

Table 49: Measured quantities, Shot 2537

7.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4688	K
Reservoir Density	ρ_{res}	31.89	kg/m^3
Reservoir Enthalpy	h_{res}	6.55	MJ/kg

Table 50: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2537

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.07×10^{-1}	1.23×10^{-1}	0	1.27×10^{-1}	0	3.05×10^{-4}	4.16×10^{-2}

Table 51: Computed reservoir species mass fractions, Shot 2537

7.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3367	902.0	902.0	5.69	17.6	0.067	5.70×10^6
72 cm	3348	893.4	887.8	5.58	19.6	0.076	6.39×10^6

Table 52: Computed freestream conditions, Shot 2537

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.95×10^{-1}	0	6.33×10^{-2}	0	0	4.13×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.76×10^{-2}	0	0	1.67×10^{-3}

Table 53: Computed freestream species mass fractions, Shot 2537

7.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3334	997.0	997.0	5.36	26.0	0.090	7.14×10^6
72 cm	3291	1036.9	1033.2	5.08	29.0	0.097	7.39×10^6

Table 54: Computed boundary layer edge conditions, Shot 2537

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.95×10^{-1}	0	6.33×10^{-2}	0	0	4.13×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.76×10^{-2}	0	0	1.66×10^{-3}

Table 55: Computed boundary layer edge species mass fractions, Shot 2537

	T^* K	Unit Re^* 1/m
1D 100 cm	1360	4.35×10^6
72 cm	1335	5.74×10^6

Table 56: Dorrance reference conditions, Shot 2537

7.5 Stability Computations

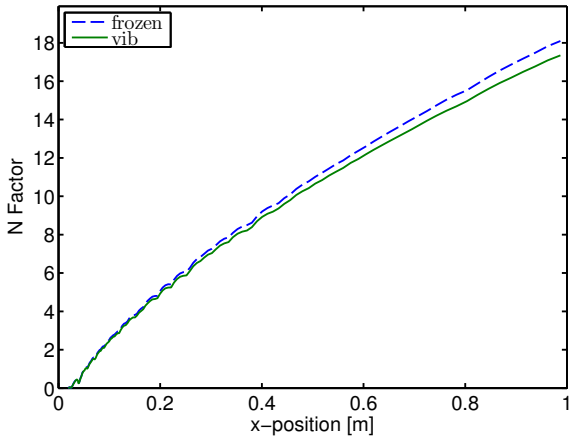


Figure 19: Locus of maximum N factor with and without vibrational energy transfer, Shot 2537

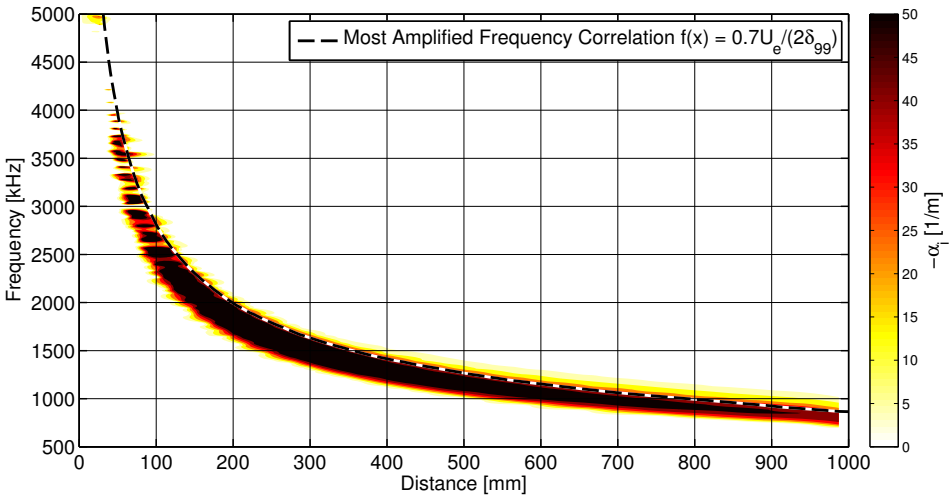


Figure 20: Stability diagram with vibrational energy transfer, Shot 2537. Dashed line indicates $0.7U_e/(2\delta_{99})$.

7.6 Heat Transfer Results

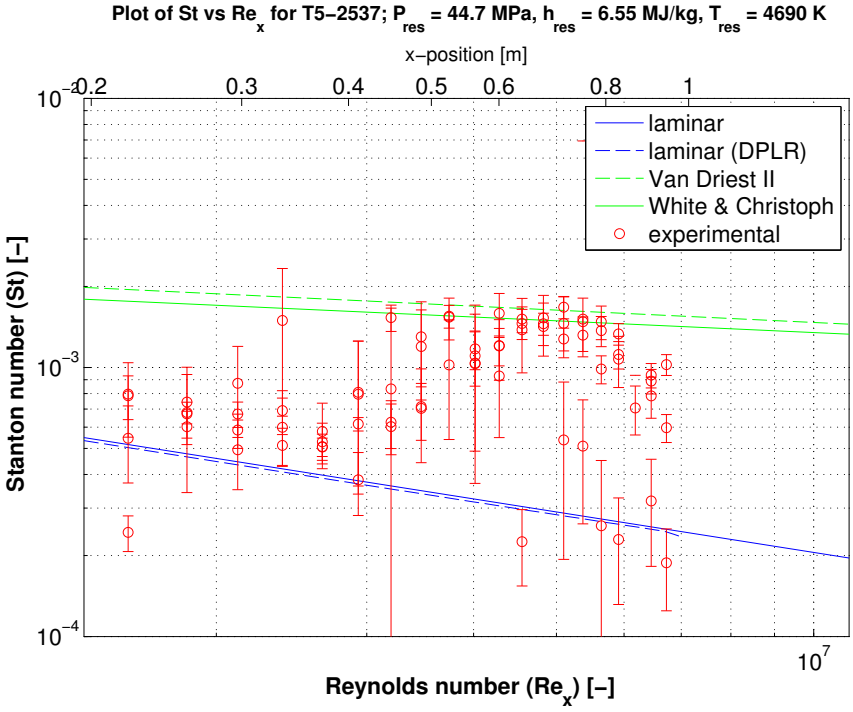


Figure 21: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

8 Shot 2538

Experiment 2538 was performed in T5 on 7 August 2009. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

8.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2540	m/s
Shock Tube Fill Pressure	P_1	151.70	kPa
Reservoir Pressure	P_{res}	42.6	MPa

Table 57: Measured quantities, Shot 2538

8.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4378	K
Reservoir Density	ρ_{res}	32.88	kg/m^3
Reservoir Enthalpy	h_{res}	5.89	MJ/kg

Table 58: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2538

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.12×10^{-1}	1.42×10^{-1}	0	1.17×10^{-1}	0	1.29×10^{-4}	2.85×10^{-2}

Table 59: Computed reservoir species mass fractions, Shot 2538

8.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3214	790.0	790.0	5.78	16.1	0.070	6.14×10^6
72 cm	3197	764.3	758.7	5.76	16.5	0.075	6.59×10^6

Table 60: Computed freestream conditions, Shot 2538

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.36×10^{-2}	0	0	2.55×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.54×10^{-2}	0	0	1.04×10^{-3}

Table 61: Computed freestream species mass fractions, Shot 2538

8.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3183	877.8	877.8	5.43	24.0	0.095	7.71×10^6
72 cm	3142	900.6	895.3	5.21	24.9	0.096	7.55×10^6

Table 62: Computed boundary layer edge conditions, Shot 2538

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.36×10^{-2}	0	0	2.55×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.54×10^{-2}	0	0	1.03×10^{-3}

Table 63: Computed boundary layer edge species mass fractions, Shot 2538

	T^* K	Unit Re^* 1/m
1D 100 cm	1251	4.42×10^6
72 cm	1224	5.55×10^6

Table 64: Dorrance reference conditions, Shot 2538

8.5 Stability Computations

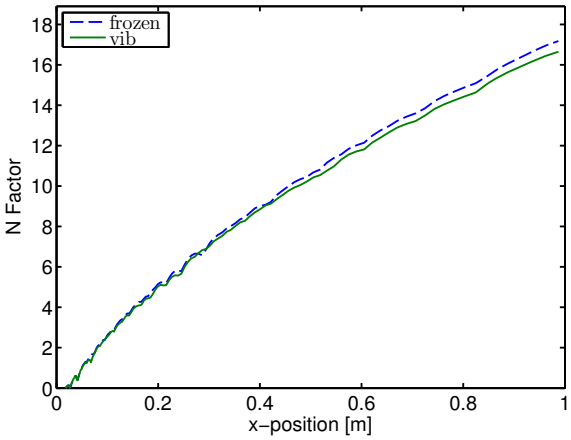


Figure 22: Locus of maximum N factor with and without vibrational energy transfer, Shot 2538

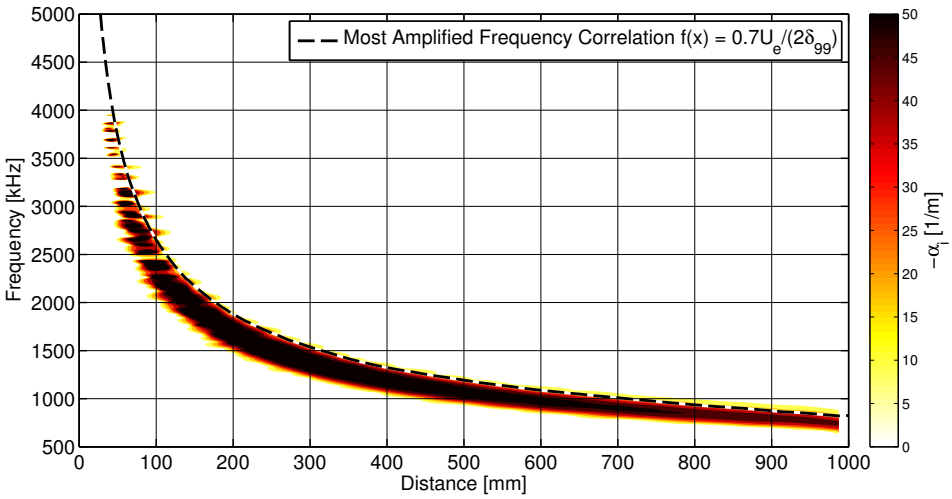


Figure 23: Stability diagram with vibrational energy transfer, Shot 2538. Dashed line indicates $0.7U_e/(2\delta_{99})$.

8.6 Heat Transfer Results

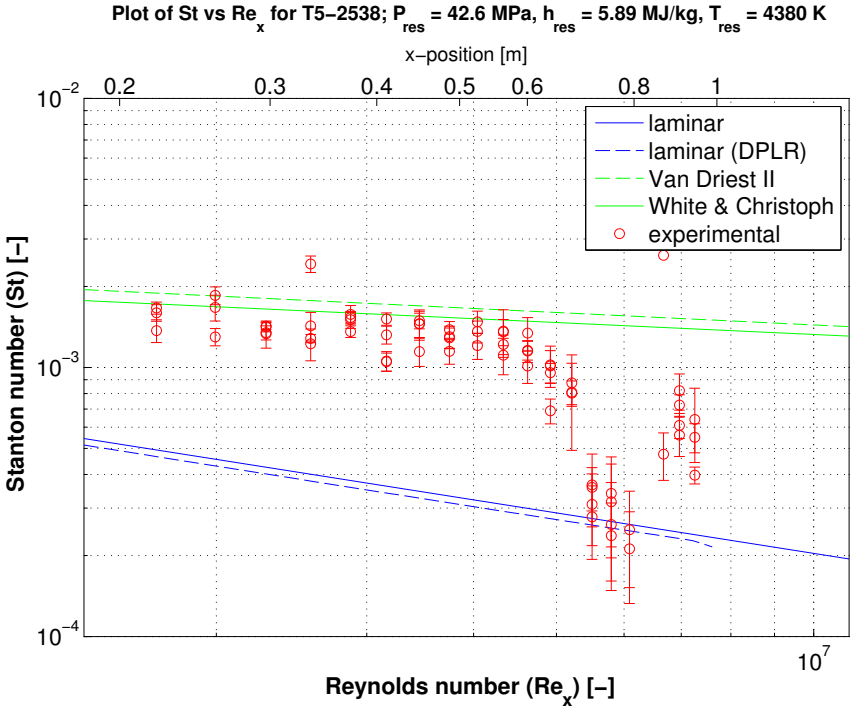


Figure 24: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

9 Shot 2539

Experiment 2539 was performed in T5 on 9 September 2009. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

9.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.40	kPa
Reservoir Pressure	P_{res}	48.8	MPa

Table 65: Measured quantities, Shot 2539

9.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6087	K
Reservoir Density	ρ_{res}	25.07	kg/m^3
Reservoir Enthalpy	h_{res}	9.83	MJ/kg

Table 66: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2539

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	4.70×10^{-2}	0	1.31×10^{-1}	0	5.42×10^{-3}	1.16×10^{-1}

Table 67: Computed reservoir species mass fractions, Shot 2539

9.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4010	1448.0	1448.0	5.35	22.5	0.053	4.02×10^6
72 cm	3987	1496.0	1505.9	5.09	27.0	0.062	4.58×10^6

Table 68: Computed freestream conditions, Shot 2539

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.97×10^{-2}	0	5.68×10^{-9}	2.26×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.29×10^{-2}	0	1.49×10^{-8}	1.40×10^{-2}

Table 69: Computed freestream species mass fractions, Shot 2539

9.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3970	1576.8	1576.8	5.08	32.0	0.069	4.91×10^6
72 cm	3920	1688.3	1686.0	4.71	38.3	0.078	5.21×10^6

Table 70: Computed boundary layer edge conditions, Shot 2539

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.97×10^{-2}	0	5.68×10^{-9}	2.26×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	5.41×10^{-8}	1.35×10^{-2}

Table 71: Computed boundary layer edge species mass fractions, Shot 2539

	T^* K	Unit Re^* 1/m
1D 100 cm	1882	3.64×10^6
72 cm	1864	4.71×10^6

Table 72: Dorrance reference conditions, Shot 2539

9.5 Stability Computations

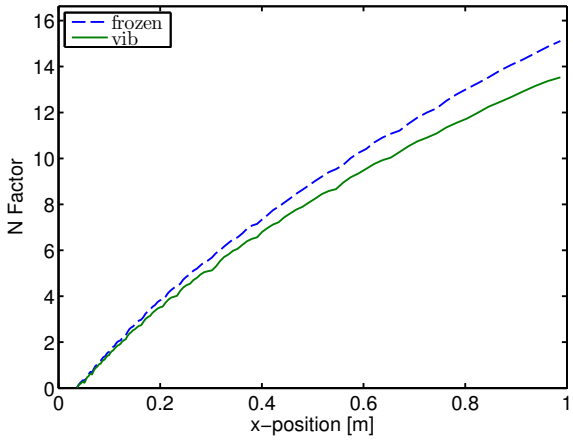


Figure 25: Locus of maximum N factor with and without vibrational energy transfer, Shot 2539

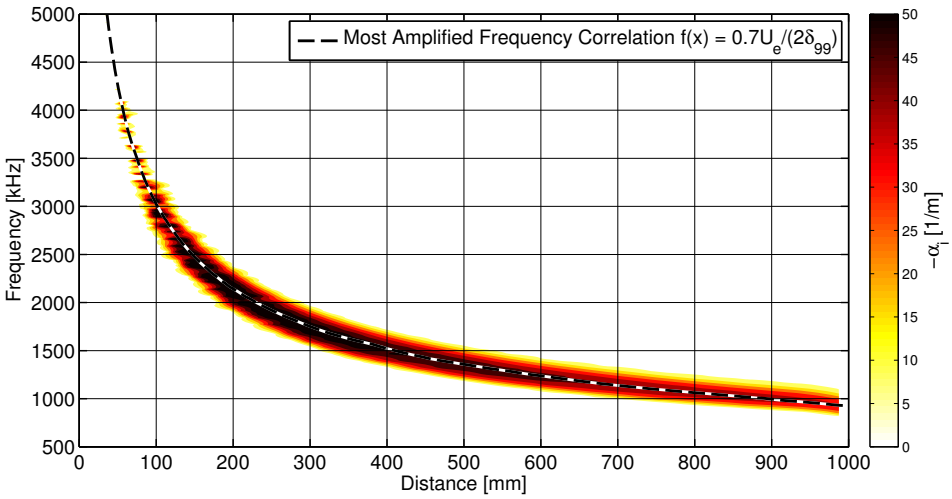


Figure 26: Stability diagram with vibrational energy transfer, Shot 2539. Dashed line indicates $0.7U_e/(2\delta_{99})$.

9.6 Heat Transfer Results

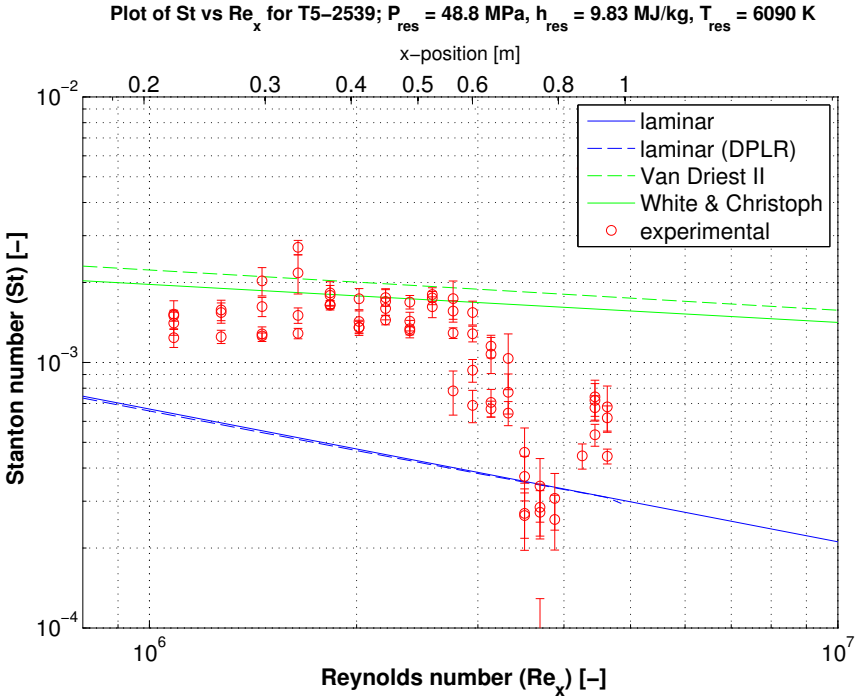


Figure 27: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

10 Shot 2540

Experiment 2540 was performed in T5 on 11 September 2009. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

10.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3060	m/s
Shock Tube Fill Pressure	P_1	85.25	kPa
Reservoir Pressure	P_{res}	51.6	MPa

Table 73: Measured quantities, Shot 2540

10.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5828	K
Reservoir Density	ρ_{res}	28.08	kg/m^3
Reservoir Enthalpy	h_{res}	9.17	MJ/kg

Table 74: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2540

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.95×10^{-2}	0	1.36×10^{-1}	0	3.39×10^{-3}	1.01×10^{-1}

Table 75: Computed reservoir species mass fractions, Shot 2540

10.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3899	1353.0	1353.0	5.40	23.5	0.059	4.61×10^{6}
72 cm	3875	1382.9	1391.5	5.16	27.7	0.069	5.23×10^{6}

Table 76: Computed freestream conditions, Shot 2540

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.59×10^{-9}	1.64×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	3.82×10^{-9}	9.47×10^{-3}

Table 77: Computed freestream species mass fractions, Shot 2540

10.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3861	1475.2	1475.2	5.12	33.6	0.078	5.64×10^{6}
72 cm	3810	1564.7	1562.4	4.77	39.5	0.087	5.96×10^{6}

Table 78: Computed boundary layer edge conditions, Shot 2540

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.59×10^{-9}	1.64×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	1.67×10^{-8}	9.18×10^{-3}

Table 79: Computed boundary layer edge species mass fractions, Shot 2540

	T^* K	Unit Re^* 1/m
1D 100 cm	1788	4.07×10^{6}
72 cm	1762	5.29×10^{6}

Table 80: Dorrance reference conditions, Shot 2540

10.5 Stability Computations

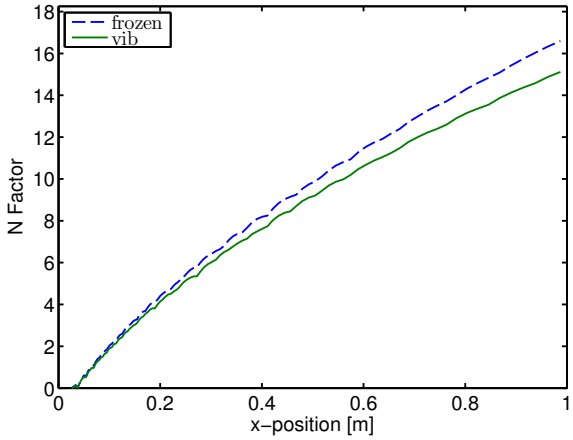


Figure 28: Locus of maximum N factor with and without vibrational energy transfer, Shot 2540

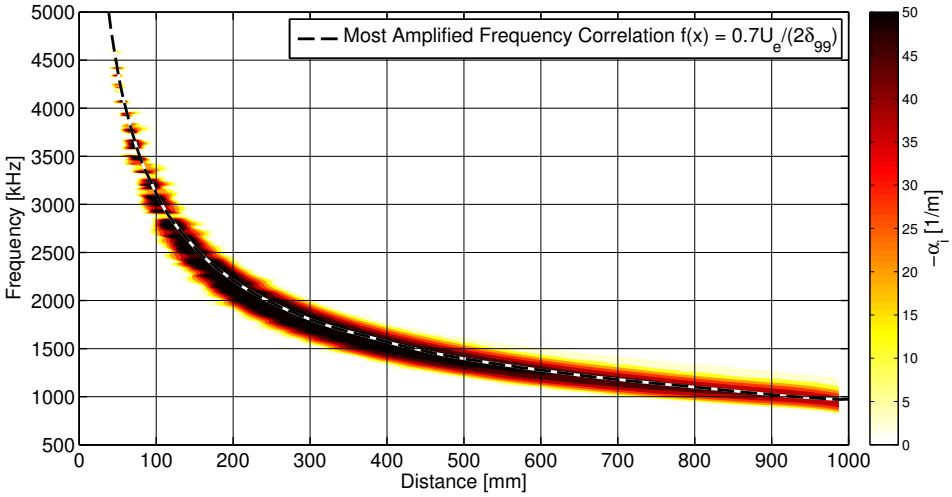


Figure 29: Stability diagram with vibrational energy transfer, Shot 2540. Dashed line indicates $0.7U_e/(2\delta_{99})$.

10.6 Heat Transfer Results

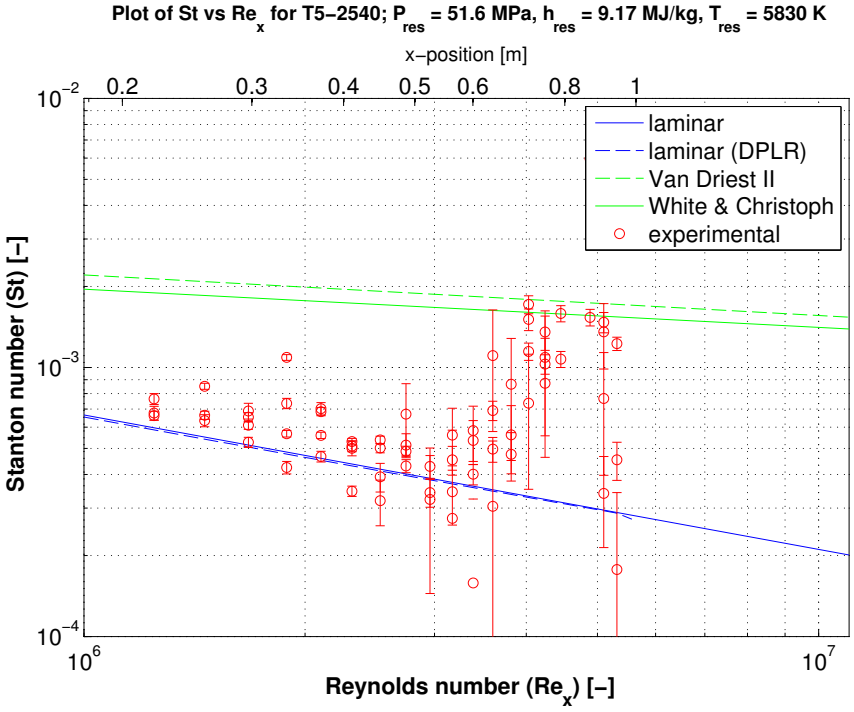


Figure 30: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

11 Shot 2541

Experiment 2541 was performed in T5 on 14 September 2009. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

11.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	85.15	kPa
Reservoir Pressure	P_{res}	50.9	MPa

Table 81: Measured quantities, Shot 2541

11.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5938	K
Reservoir Density	ρ_{res}	27.04	kg/m^3
Reservoir Enthalpy	h_{res}	9.45	MJ/kg

Table 82: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2541

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.42×10^{-2}	0	1.35×10^{-1}	0	4.13×10^{-3}	1.07×10^{-1}

Table 83: Computed reservoir species mass fractions, Shot 2541

11.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3946	1394.0	1394.0	5.38	23.3	0.057	4.39×10^6
72 cm	3922	1431.0	1440.2	5.13	27.7	0.067	5.00×10^6

Table 84: Computed freestream conditions, Shot 2541

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.03×10^{-2}	0	2.80×10^{-9}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	6.88×10^{-9}	1.11×10^{-2}

Table 85: Computed freestream species mass fractions, Shot 2541

11.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3907	1518.9	1518.9	5.10	33.3	0.075	5.37×10^6
72 cm	3856	1617.1	1614.8	4.75	39.4	0.084	5.69×10^6

Table 86: Computed boundary layer edge conditions, Shot 2541

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.03×10^{-2}	0	2.80×10^{-9}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	2.76×10^{-8}	1.07×10^{-2}

Table 87: Computed boundary layer edge species mass fractions, Shot 2541

	T^* K	Unit Re^* 1/m
1D 100 cm	1828	3.92×10^6
72 cm	1805	5.09×10^6

Table 88: Dorrance reference conditions, Shot 2541

11.5 Stability Computations

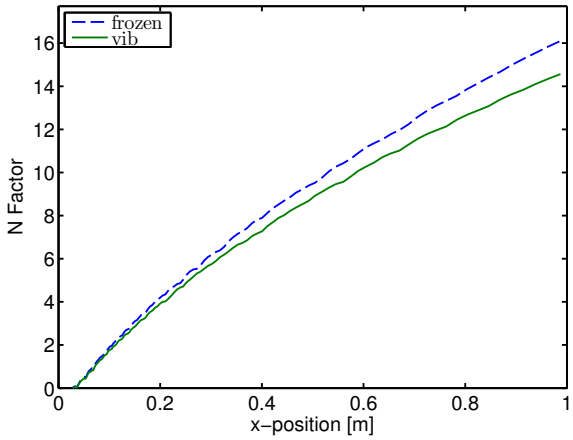


Figure 31: Locus of maximum N factor with and without vibrational energy transfer, Shot 2541

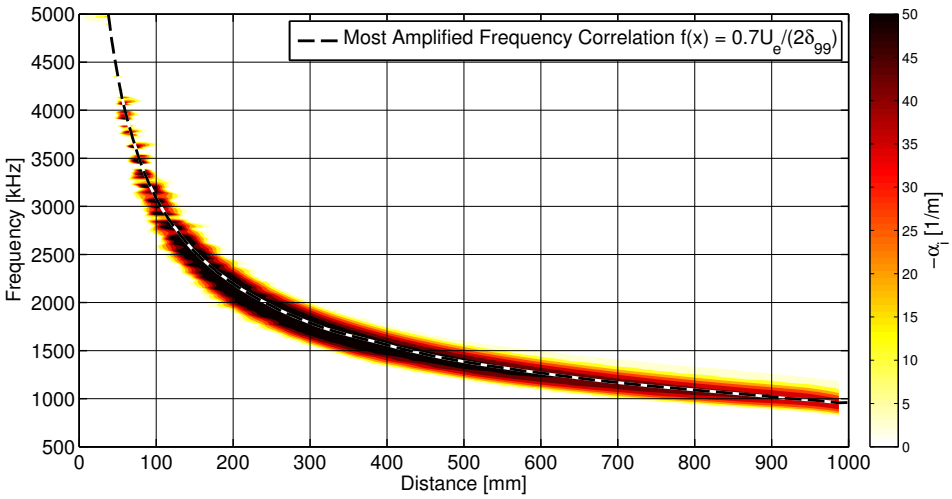


Figure 32: Stability diagram with vibrational energy transfer, Shot 2541. Dashed line indicates $0.7U_e/(2\delta_{99})$.

11.6 Heat Transfer Results

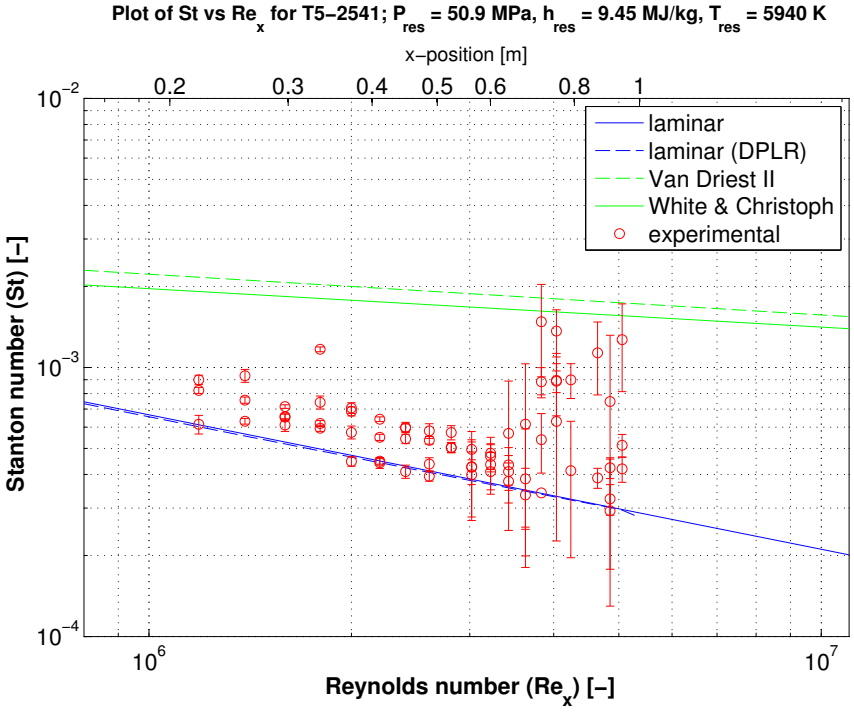


Figure 33: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

12 Shot 2568

Experiment 2568 was performed in T5 on 4 February 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

12.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	55.1	MPa

Table 89: Measured quantities, Shot 2568

12.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6052	K
Reservoir Density	ρ_{res}	28.62	kg/m^3
Reservoir Enthalpy	h_{res}	9.68	MJ/kg

Table 90: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2568

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.09×10^{-2}	0	1.35×10^{-1}	0	4.80×10^{-3}	1.10×10^{-1}

Table 91: Computed reservoir species mass fractions, Shot 2568

12.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3987	1434.0	1434.0	5.36	25.3	0.060	4.59×10^{6}
72 cm	3966	1475.5	1484.3	5.11	30.4	0.071	5.26×10^{6}

Table 92: Computed freestream conditions, Shot 2568

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.27×10^{-9}	1.91×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	1.02×10^{-8}	1.14×10^{-2}

Table 93: Computed freestream species mass fractions, Shot 2568

12.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3948	1562.1	1562.1	5.08	36.1	0.079	5.60×10^{6}
72 cm	3899	1665.4	1663.4	4.73	43.2	0.089	5.99×10^{6}

Table 94: Computed boundary layer edge conditions, Shot 2568

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.27×10^{-9}	1.91×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.78×10^{-8}	1.10×10^{-2}

Table 95: Computed boundary layer edge species mass fractions, Shot 2568

	T^* K	Unit Re^* 1/m
1D 100 cm	1865	4.14×10^{6}
72 cm	1844	5.40×10^{6}

Table 96: Dorrance reference conditions, Shot 2568

12.5 Stability Computations

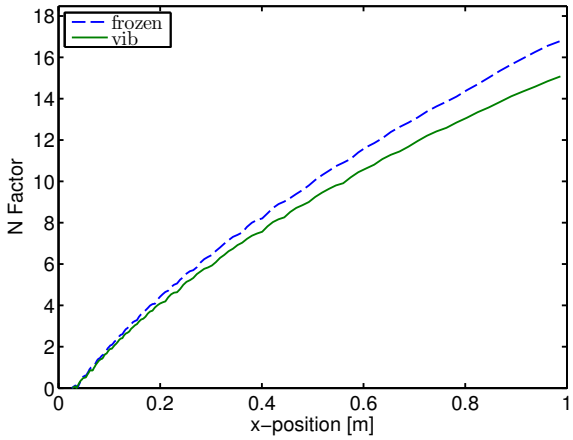


Figure 34: Locus of maximum N factor with and without vibrational energy transfer, Shot 2568

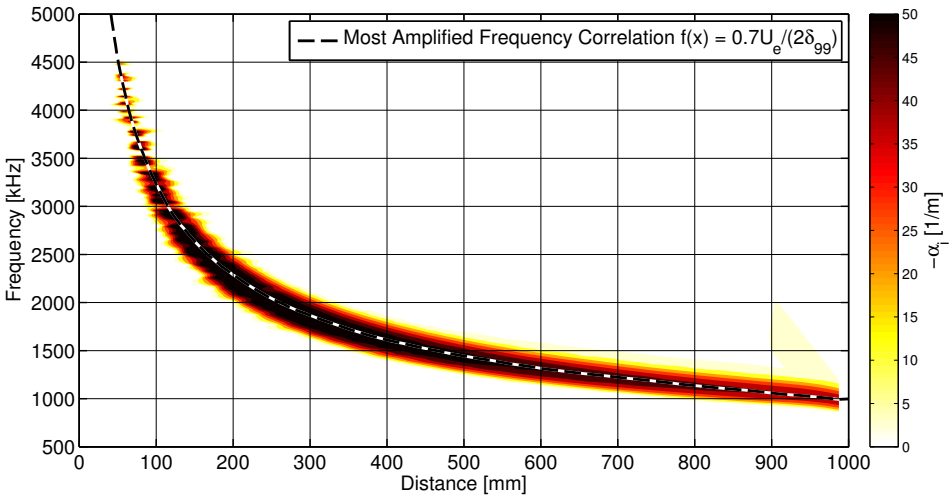


Figure 35: Stability diagram with vibrational energy transfer, Shot 2568. Dashed line indicates $0.7U_e/(2\delta_{99})$.

12.6 Heat Transfer Results

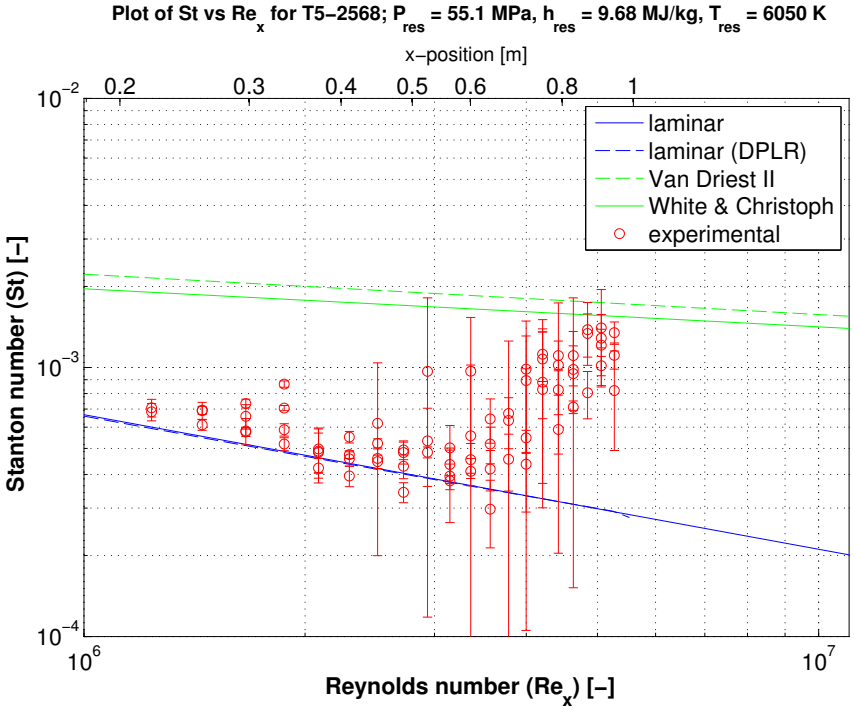


Figure 36: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

13 Shot 2569

Experiment 2569 was performed in T5 on 11 February 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

13.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	54.0	MPa

Table 97: Measured quantities, Shot 2569

13.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6064	K
Reservoir Density	ρ_{res}	27.97	kg/m^3
Reservoir Enthalpy	h_{res}	9.72	MJ/kg

Table 98: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2569

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.00×10^{-2}	0	1.34×10^{-1}	0	4.94×10^{-3}	1.11×10^{-1}

Table 99: Computed reservoir species mass fractions, Shot 2569

13.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3997	1443.0	1443.0	5.35	25.1	0.059	4.51×10^{6}
72 cm	3972	1481.6	1490.6	5.10	29.9	0.069	5.13×10^{6}

Table 100: Computed freestream conditions, Shot 2569

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.71×10^{-9}	1.98×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.12×10^{-8}	1.19×10^{-2}

Table 101: Computed freestream species mass fractions, Shot 2569

13.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3958	1571.5	1571.5	5.08	35.8	0.078	5.51×10^{6}
72 cm	3905	1671.9	1669.9	4.72	42.4	0.087	5.84×10^{6}

Table 102: Computed boundary layer edge conditions, Shot 2569

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.71×10^{-9}	1.98×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	4.11×10^{-8}	1.14×10^{-2}

Table 103: Computed boundary layer edge species mass fractions, Shot 2569

	T^* K	Unit Re^* 1/m
1D 100 cm	1874	4.08×10^{6}
72 cm	1850	5.28×10^{6}

Table 104: Dorrance reference conditions, Shot 2569

13.5 Stability Computations

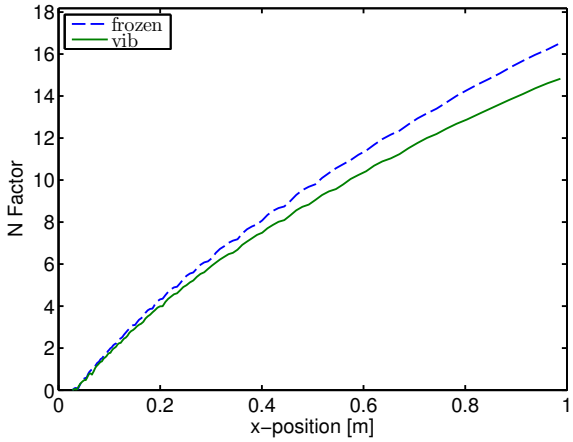


Figure 37: Locus of maximum N factor with and without vibrational energy transfer, Shot 2569

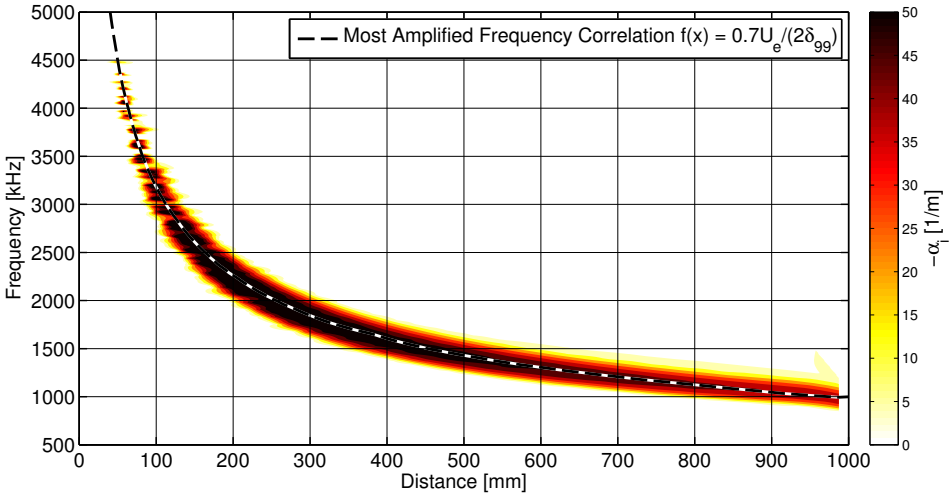


Figure 38: Stability diagram with vibrational energy transfer, Shot 2569. Dashed line indicates $0.7U_e/(2\delta_{99})$.

13.6 Heat Transfer Results

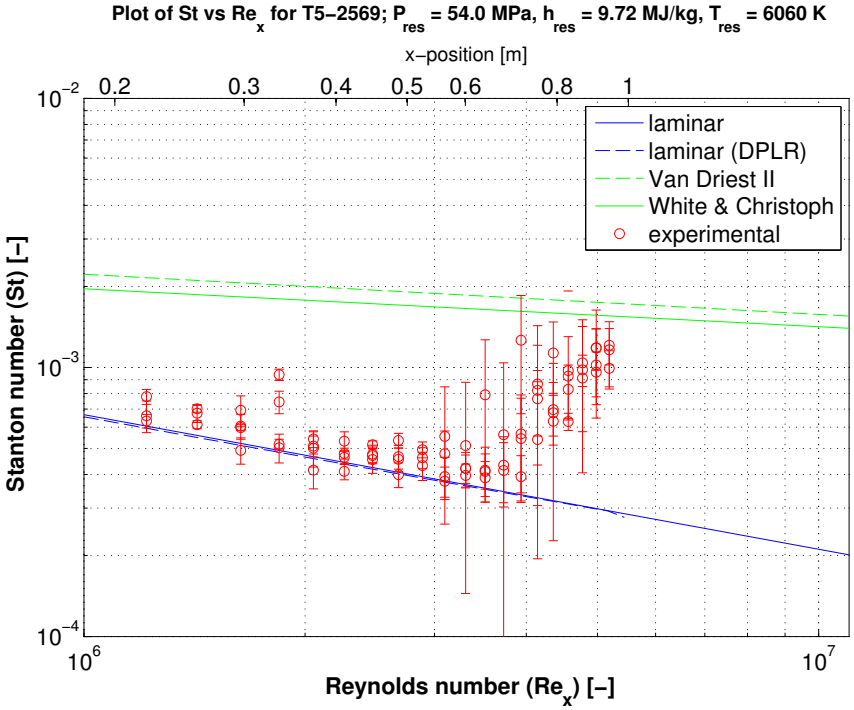


Figure 39: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

14 Shot 2570

Experiment 2570 was performed in T5 on 12 February 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and four-row injector section. The initial shock tube composition was 100% air by mass.

14.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3300	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	53.0	MPa

Table 105: Measured quantities, Shot 2570

14.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6316	K
Reservoir Density	ρ_{res}	26.00	kg/m^3
Reservoir Enthalpy	h_{res}	10.3	MJ/kg

Table 106: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2570

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.01×10^{-2}	0	1.28×10^{-1}	0	7.44×10^{-3}	1.24×10^{-1}

Table 107: Computed reservoir species mass fractions, Shot 2570

14.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4101	1534.0	1534.0	5.32	24.9	0.055	4.11×10^6
72 cm	4075	1588.2	1597.9	5.05	30.1	0.065	4.69×10^6

Table 108: Computed freestream conditions, Shot 2570

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.76×10^{-1}	0	5.90×10^{-2}	0	1.40×10^{-8}	2.54×10^{-2}
72 cm	7.33×10^{-1}	1.78×10^{-1}	0	7.29×10^{-2}	0	3.36×10^{-8}	1.61×10^{-2}

Table 109: Computed freestream species mass fractions, Shot 2570

14.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4060	1668.9	1668.9	5.05	35.3	0.072	5.01×10^6
72 cm	4007	1789.1	1787.0	4.68	42.4	0.081	5.33×10^6

Table 110: Computed boundary layer edge conditions, Shot 2570

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.76×10^{-1}	0	5.90×10^{-2}	0	1.40×10^{-8}	2.54×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.29×10^{-2}	0	1.08×10^{-7}	1.54×10^{-2}

Table 111: Computed boundary layer edge species mass fractions, Shot 2570

	T^* K	Unit Re^* 1/m
1D 100 cm	1964	3.79×10^6
72 cm	1946	4.90×10^6

Table 112: Dorrance reference conditions, Shot 2570

14.5 Stability Computations

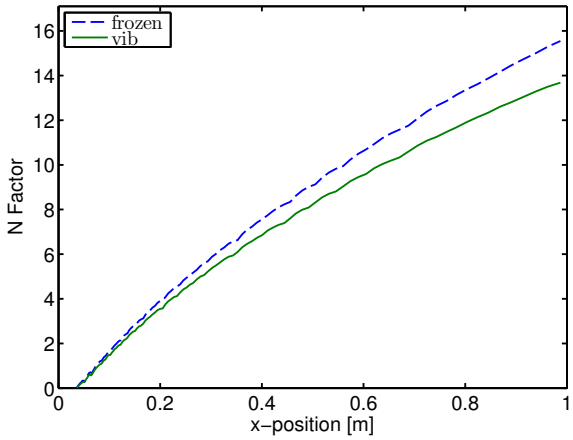


Figure 40: Locus of maximum N factor with and without vibrational energy transfer, Shot 2570

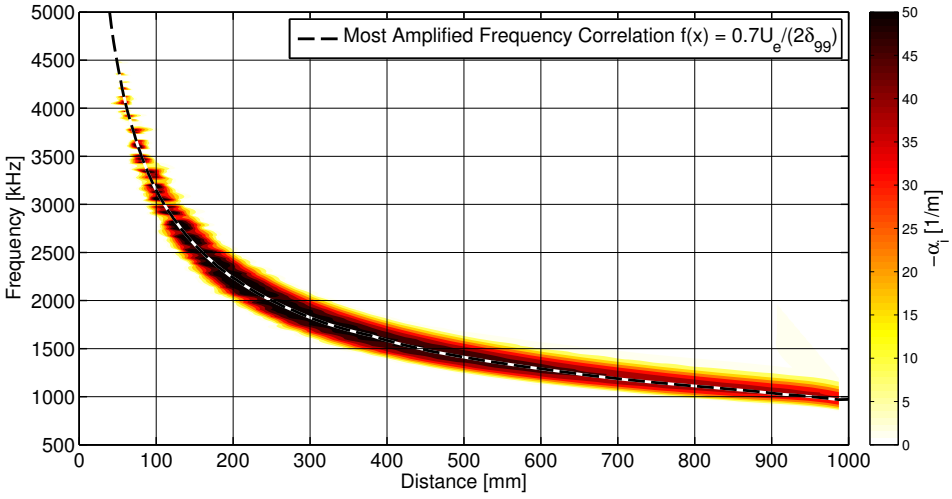


Figure 41: Stability diagram with vibrational energy transfer, Shot 2570. Dashed line indicates $0.7U_e/(2\delta_{99})$.

14.6 Heat Transfer Results

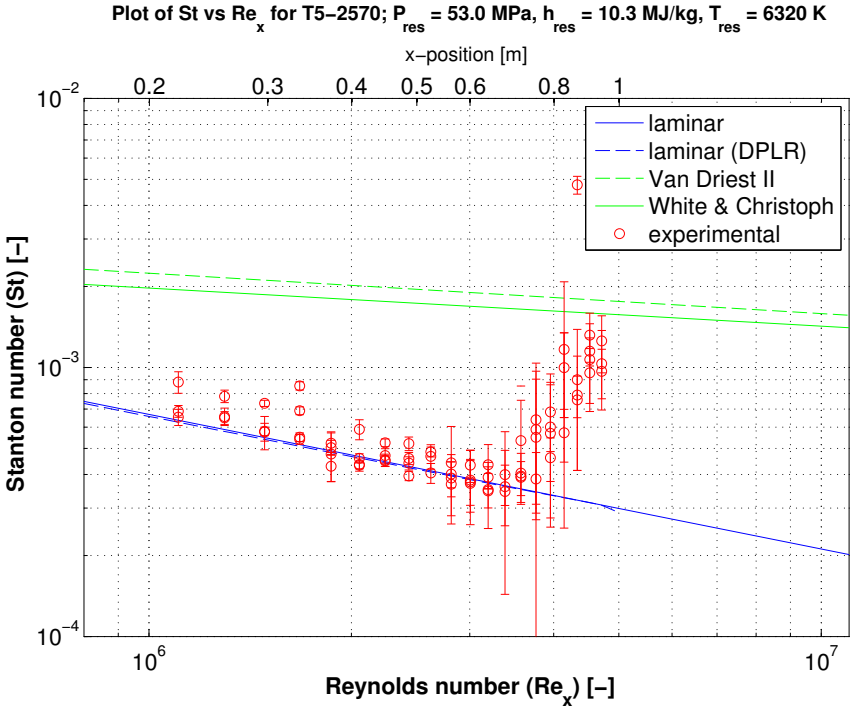


Figure 42: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

15 Shot 2571

Experiment 2571 was performed in T5 on 1 March 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

15.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	85.30	kPa
Reservoir Pressure	P_{res}	53.8	MPa

Table 113: Measured quantities, Shot 2571

15.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6155	K
Reservoir Density	ρ_{res}	27.29	kg/m^3
Reservoir Enthalpy	h_{res}	9.94	MJ/kg

Table 114: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2571

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.63×10^{-2}	0	1.32×10^{-1}	0	5.75×10^{-3}	1.16×10^{-1}

Table 115: Computed reservoir species mass fractions, Shot 2571

15.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4032	1474.0	1474.0	5.34	24.9	0.058	4.35×10^6
72 cm	4009	1520.5	1529.8	5.08	30.0	0.068	4.98×10^6

Table 116: Computed freestream conditions, Shot 2571

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.96×10^{-2}	0	7.04×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	1.69×10^{-8}	1.33×10^{-2}

Table 117: Computed freestream species mass fractions, Shot 2571

15.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3992	1604.2	1604.2	5.07	35.4	0.075	5.30×10^6
72 cm	3942	1714.7	1712.6	4.71	42.5	0.085	5.66×10^6

Table 118: Computed boundary layer edge conditions, Shot 2571

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.96×10^{-2}	0	7.04×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	5.91×10^{-8}	1.28×10^{-2}

Table 119: Computed boundary layer edge species mass fractions, Shot 2571

	T^* K	Unit Re^* 1/m
1D 100 cm	1904	3.96×10^6
72 cm	1885	5.15×10^6

Table 120: Dorrance reference conditions, Shot 2571

15.5 Stability Computations

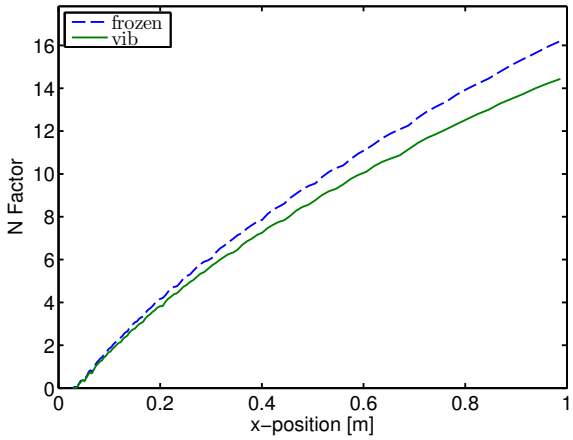


Figure 43: Locus of maximum N factor with and without vibrational energy transfer, Shot 2571

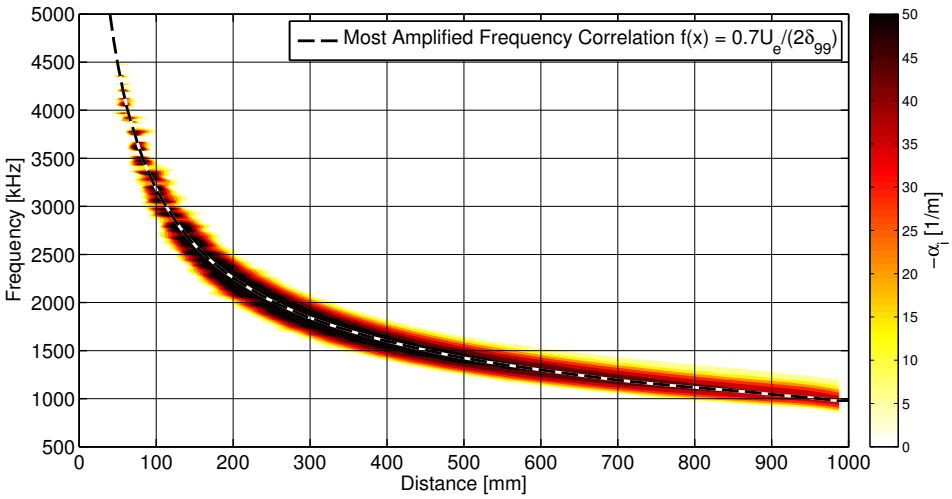


Figure 44: Stability diagram with vibrational energy transfer, Shot 2571. Dashed line indicates $0.7U_e/(2\delta_{99})$.

15.6 Heat Transfer Results

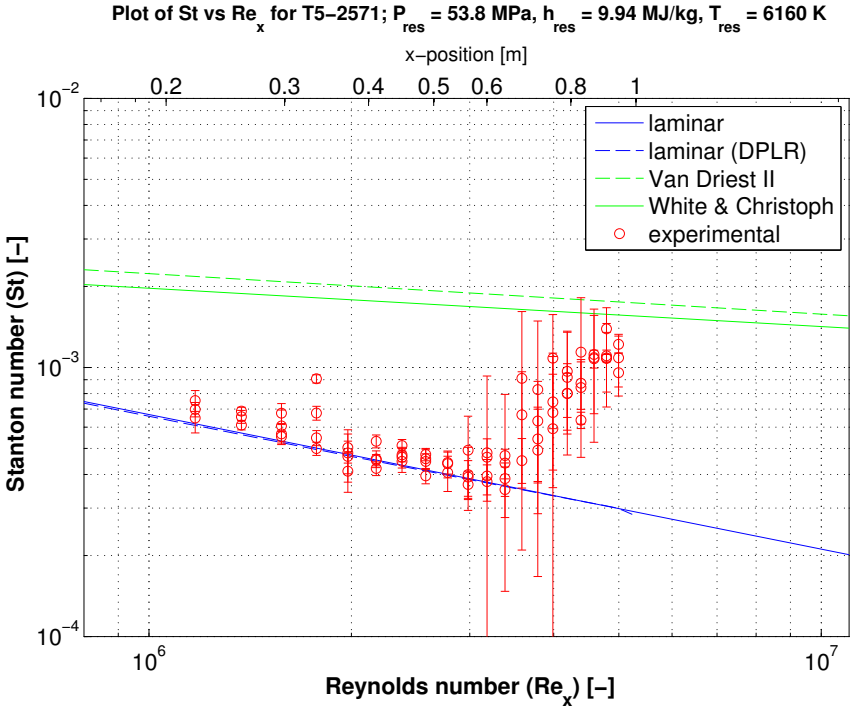


Figure 45: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

16 Shot 2572

Experiment 2572 was performed in T5 on 16 March 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

16.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 121: Measured quantities, Shot 2572

16.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6101	K
Reservoir Density	ρ_{res}	27.87	kg/m^3
Reservoir Enthalpy	h_{res}	9.81	MJ/kg

Table 122: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2572

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.86×10^{-2}	0	1.33×10^{-1}	0	5.24×10^{-3}	1.13×10^{-1}

Table 123: Computed reservoir species mass fractions, Shot 2572

16.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4013	1458.0	1458.0	5.35	25.3	0.059	4.49×10^{6}
72 cm	3987	1497.1	1506.2	5.10	30.1	0.069	5.10×10^{6}

Table 124: Computed freestream conditions, Shot 2572

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.98×10^{-2}	0	5.70×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.31×10^{-8}	1.23×10^{-2}

Table 125: Computed freestream species mass fractions, Shot 2572

16.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3973	1587.2	1587.2	5.07	36.1	0.077	5.48×10^{6}
72 cm	3920	1688.5	1686.5	4.72	42.7	0.087	5.81×10^{6}

Table 126: Computed boundary layer edge conditions, Shot 2572

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.98×10^{-2}	0	5.70×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	4.71×10^{-8}	1.19×10^{-2}

Table 127: Computed boundary layer edge species mass fractions, Shot 2572

	T^* K	Unit Re^* 1/m
1D 100 cm	1888	4.08×10^{6}
72 cm	1863	5.26×10^{6}

Table 128: Dorrance reference conditions, Shot 2572

16.5 Stability Computations

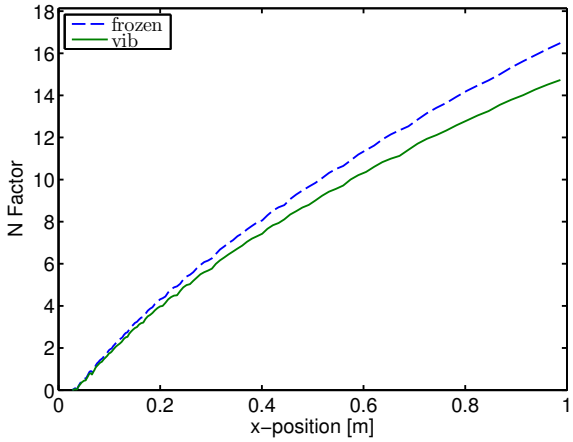


Figure 46: Locus of maximum N factor with and without vibrational energy transfer, Shot 2572

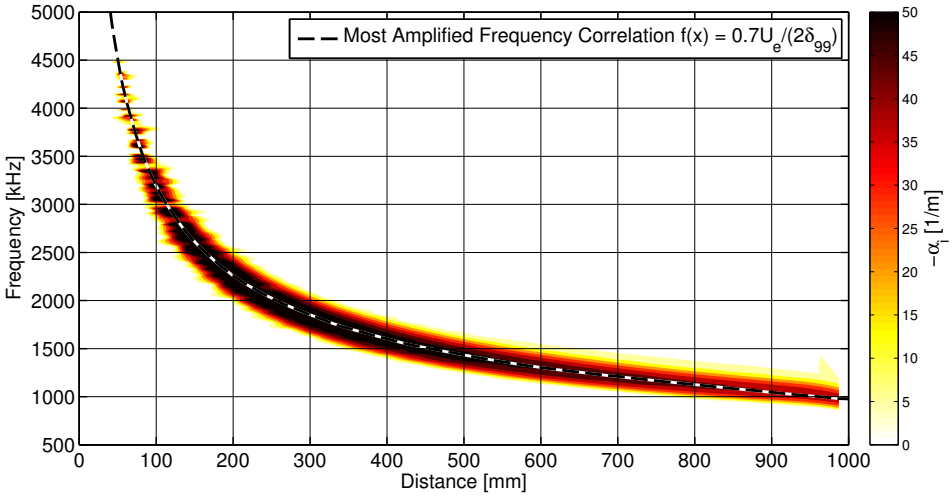


Figure 47: Stability diagram with vibrational energy transfer, Shot 2572. Dashed line indicates $0.7U_e/(2\delta_{99})$.

16.6 Heat Transfer Results

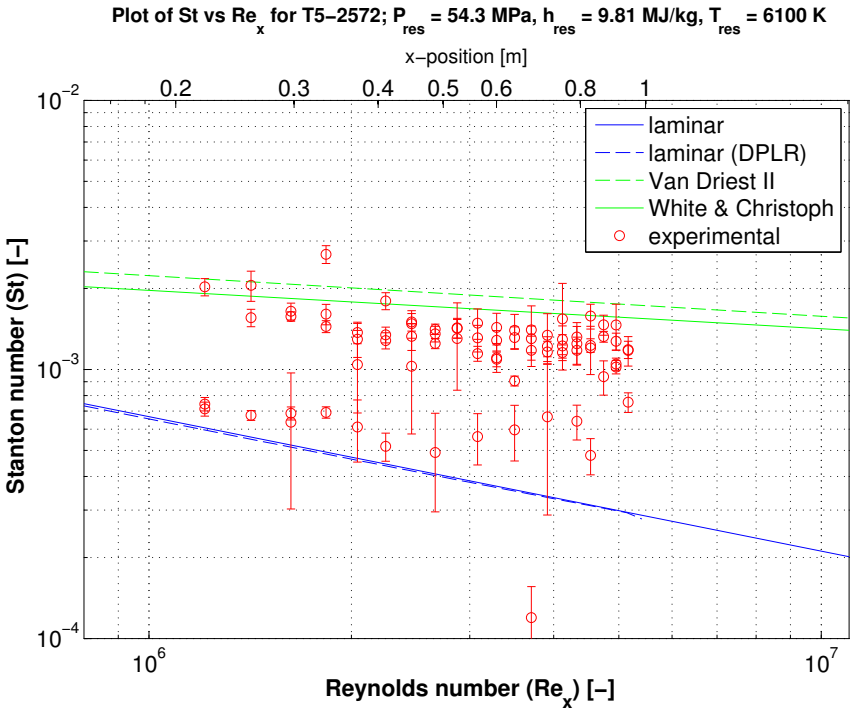


Figure 48: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

17 Shot 2573

Experiment 2573 was performed in T5 on 24 March 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

17.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3190	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	53.0	MPa

Table 129: Measured quantities, Shot 2573

17.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6108	K
Reservoir Density	ρ_{res}	27.14	kg/m^3
Reservoir Enthalpy	h_{res}	9.84	MJ/kg

Table 130: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2573

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.78×10^{-2}	0	1.33×10^{-1}	0	5.37×10^{-3}	1.14×10^{-1}

Table 131: Computed reservoir species mass fractions, Shot 2573

17.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4015	1457.0	1457.0	5.35	24.5	0.057	4.35×10^6
72 cm	3991	1501.2	1510.5	5.09	29.4	0.067	4.96×10^6

Table 132: Computed freestream conditions, Shot 2573

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.98×10^{-2}	0	5.83×10^{-9}	2.11×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	1.41×10^{-8}	1.28×10^{-2}

Table 133: Computed freestream species mass fractions, Shot 2573

17.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3975	1586.3	1586.3	5.07	34.9	0.075	5.30×10^6
72 cm	3923	1693.7	1691.5	4.71	41.7	0.084	5.64×10^6

Table 134: Computed boundary layer edge conditions, Shot 2573

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.98×10^{-2}	0	5.83×10^{-9}	2.11×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	5.07×10^{-8}	1.24×10^{-2}

Table 135: Computed boundary layer edge species mass fractions, Shot 2573

	T^* K	Unit Re^* 1/m
1D 100 cm	1888	3.95×10^6
72 cm	1868	5.12×10^6

Table 136: Dorrance reference conditions, Shot 2573

17.5 Stability Computations

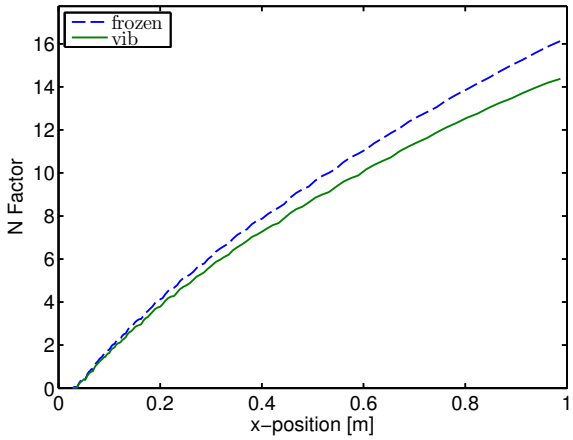


Figure 49: Locus of maximum N factor with and without vibrational energy transfer, Shot 2573

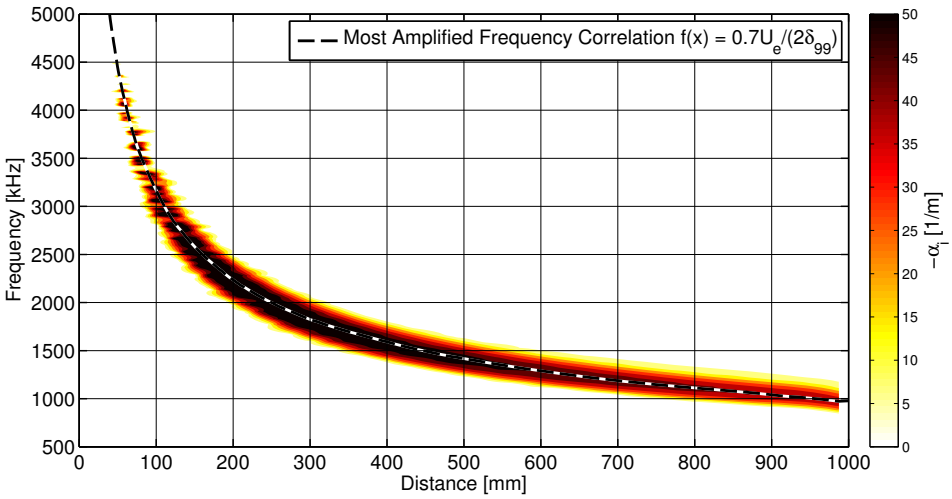


Figure 50: Stability diagram with vibrational energy transfer, Shot 2573. Dashed line indicates $0.7U_e/(2\delta_{99})$.

17.6 Heat Transfer Results

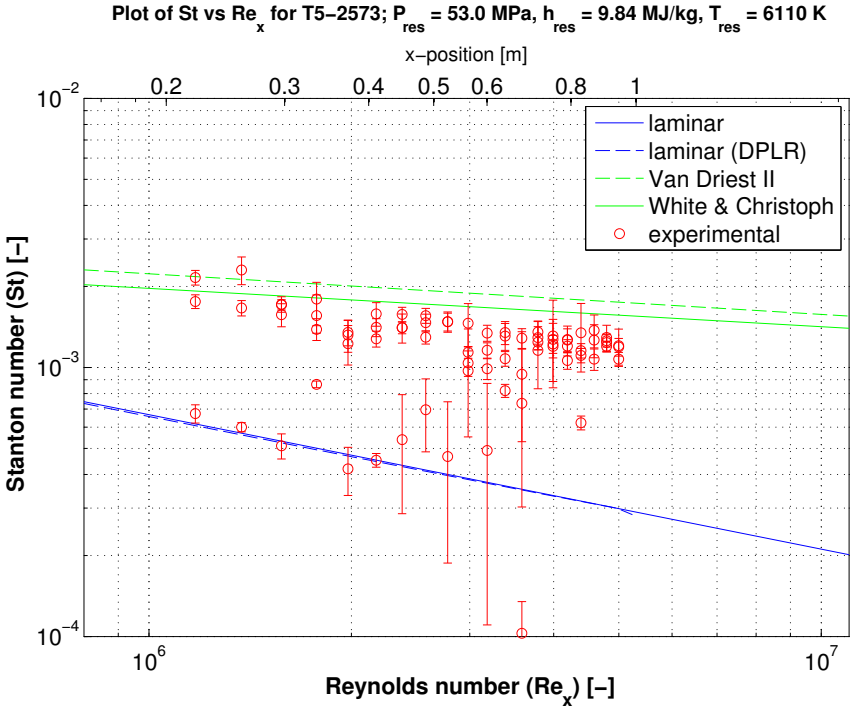


Figure 51: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

18 Shot 2574

Experiment 2574 was performed in T5 on 1 April 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

18.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	53.5	MPa

Table 137: Measured quantities, Shot 2574

18.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6087	K
Reservoir Density	ρ_{res}	27.57	kg/m^3
Reservoir Enthalpy	h_{res}	9.78	MJ/kg

Table 138: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2574

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.89×10^{-2}	0	1.33×10^{-1}	0	5.16×10^{-3}	1.13×10^{-1}

Table 139: Computed reservoir species mass fractions, Shot 2574

18.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4010	1455.0	1455.0	5.35	25.1	0.059	4.46×10^{6}
72 cm	3982	1491.9	1501.1	5.10	29.7	0.068	5.05×10^{6}

Table 140: Computed freestream conditions, Shot 2574

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	5.88×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.26×10^{-8}	1.23×10^{-2}

Table 141: Computed freestream species mass fractions, Shot 2574

18.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3970	1583.7	1583.7	5.07	35.7	0.077	5.45×10^{6}
72 cm	3915	1683.3	1681.2	4.72	42.1	0.086	5.74×10^{6}

Table 142: Computed boundary layer edge conditions, Shot 2574

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	5.88×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	4.58×10^{-8}	1.19×10^{-2}

Table 143: Computed boundary layer edge species mass fractions, Shot 2574

	T^* K	Unit Re^* 1/m
1D 100 cm	1885	4.05×10^{6}
72 cm	1859	5.20×10^{6}

Table 144: Dorrance reference conditions, Shot 2574

18.5 Stability Computations

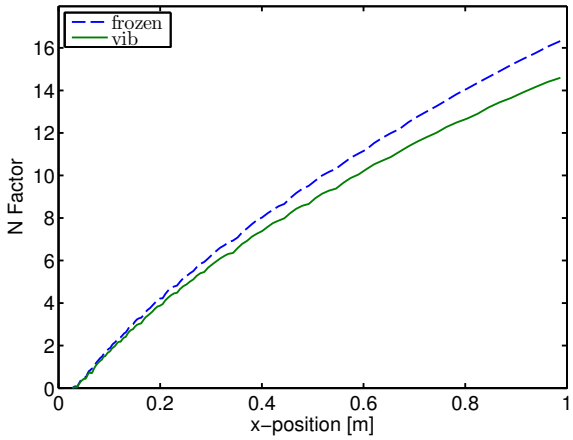


Figure 52: Locus of maximum N factor with and without vibrational energy transfer, Shot 2574

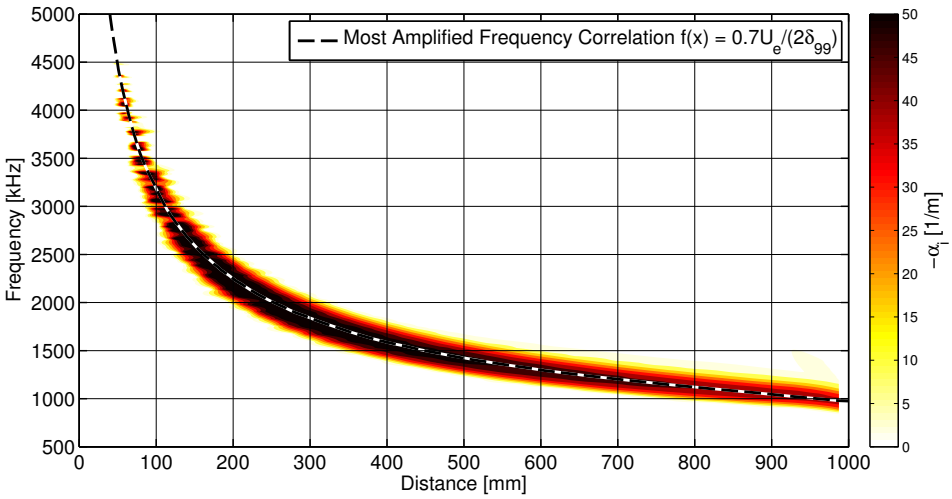


Figure 53: Stability diagram with vibrational energy transfer, Shot 2574. Dashed line indicates $0.7U_e/(2\delta_{99})$.

18.6 Heat Transfer Results

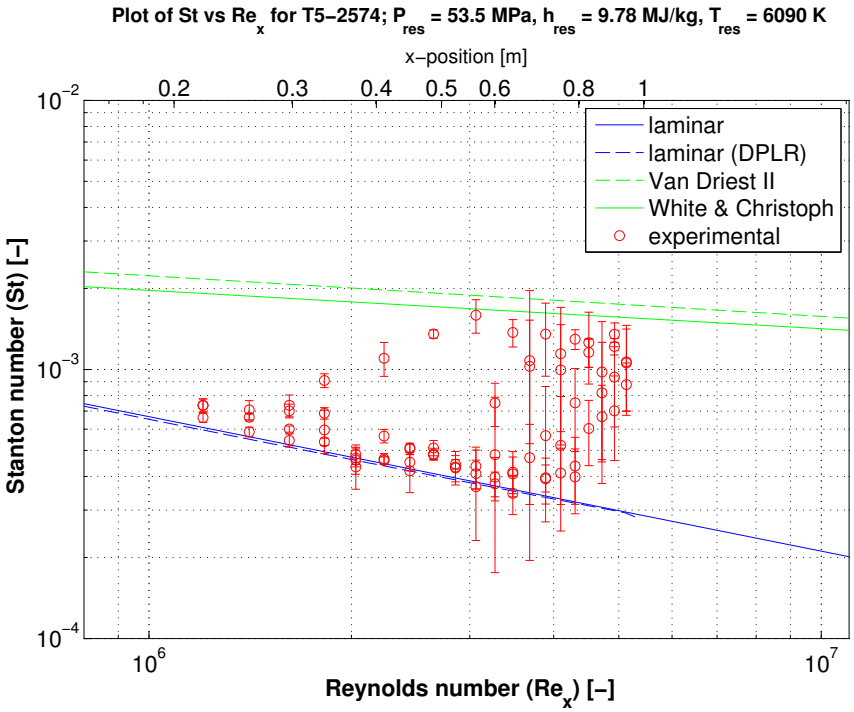


Figure 54: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

19 Shot 2575

Experiment 2575 was performed in T5 on 10 May 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG20: 20 micron) injector section. The initial shock tube composition was 100% air by mass.

19.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3020	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	53.7	MPa

Table 145: Measured quantities, Shot 2575

19.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5799	K
Reservoir Density	ρ_{res}	29.45	kg/m^3
Reservoir Enthalpy	h_{res}	9.08	MJ/kg

Table 146: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2575

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.18×10^{-2}	0	1.38×10^{-1}	0	3.15×10^{-3}	9.77×10^{-2}

Table 147: Computed reservoir species mass fractions, Shot 2575

19.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3884	1341.0	1341.0	5.40	24.4	0.062	4.84×10^{6}
72 cm	3861	1368.0	1376.1	5.17	28.8	0.072	5.51×10^{6}

Table 148: Computed freestream conditions, Shot 2575

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.09×10^{-2}	0	1.27×10^{-9}	1.52×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	3.01×10^{-9}	8.61×10^{-3}

Table 149: Computed freestream species mass fractions, Shot 2575

19.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3846	1462.5	1462.5	5.12	34.9	0.082	5.93×10^{6}
72 cm	3796	1548.4	1546.2	4.78	41.1	0.091	6.28×10^{6}

Table 150: Computed boundary layer edge conditions, Shot 2575

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.09×10^{-2}	0	1.27×10^{-9}	1.52×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.31×10^{-2}	0	1.35×10^{-8}	8.34×10^{-3}

Table 151: Computed boundary layer edge species mass fractions, Shot 2575

	T^* K	Unit Re^* 1/m
1D 100 cm	1776	4.27×10^{6}
72 cm	1749	5.56×10^{6}

Table 152: Dorrance reference conditions, Shot 2575

19.5 Stability Computations

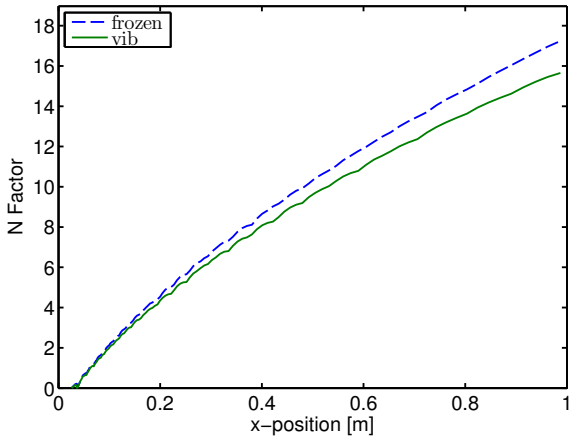


Figure 55: Locus of maximum N factor with and without vibrational energy transfer, Shot 2575

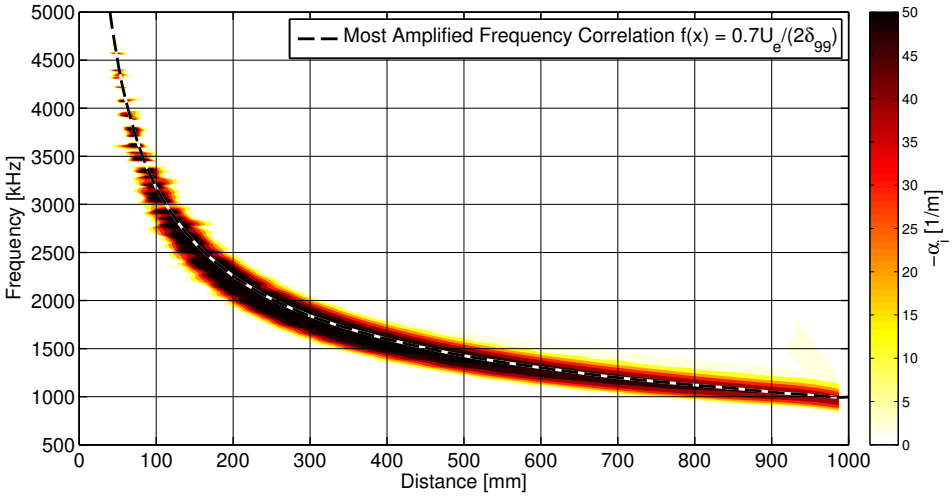


Figure 56: Stability diagram with vibrational energy transfer, Shot 2575. Dashed line indicates $0.7U_e/(2\delta_{99})$.

19.6 Heat Transfer Results

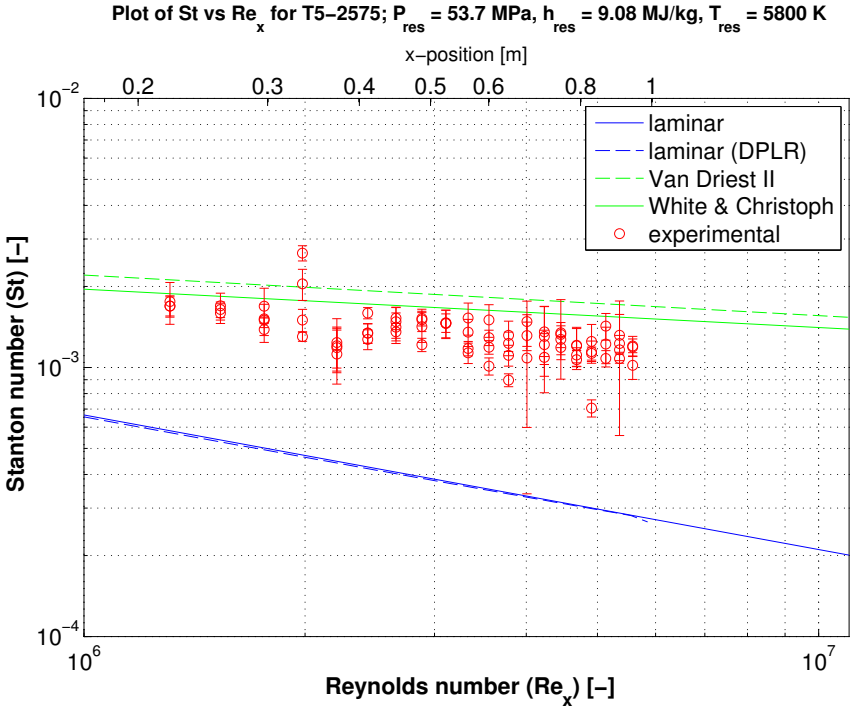


Figure 57: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

20 Shot 2576

Experiment 2576 was performed in T5 on 13 May 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG20: 20 micron) injector section. The initial shock tube composition was 100% air by mass.

20.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3120	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	53.2	MPa

Table 153: Measured quantities, Shot 2576

20.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5979	K
Reservoir Density	ρ_{res}	28.02	kg/m^3
Reservoir Enthalpy	h_{res}	9.52	MJ/kg

Table 154: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2576

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.33×10^{-2}	0	1.35×10^{-1}	0	4.33×10^{-3}	1.08×10^{-1}

Table 155: Computed reservoir species mass fractions, Shot 2576

20.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3962	1411.0	1411.0	5.37	24.6	0.059	4.55×10^6
72 cm	3937	1446.4	1455.3	5.12	29.1	0.069	5.17×10^6

Table 156: Computed freestream conditions, Shot 2576

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.02×10^{-2}	0	3.29×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	7.74×10^{-9}	1.10×10^{-2}

Table 157: Computed freestream species mass fractions, Shot 2576

20.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3923	1537.0	1537.0	5.09	35.0	0.078	5.56×10^6
72 cm	3871	1633.5	1631.4	4.74	41.4	0.087	5.89×10^6

Table 158: Computed boundary layer edge conditions, Shot 2576

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.02×10^{-2}	0	3.29×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.01×10^{-8}	1.06×10^{-2}

Table 159: Computed boundary layer edge species mass fractions, Shot 2576

	T^* K	Unit Re^* 1/m
1D 100 cm	1843	4.08×10^6
72 cm	1818	5.29×10^6

Table 160: Dorrance reference conditions, Shot 2576

20.5 Stability Computations

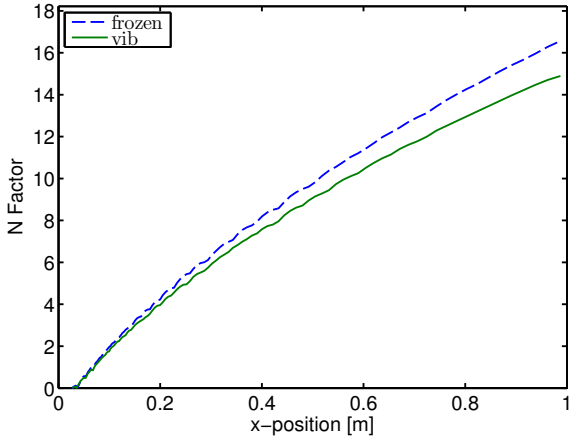


Figure 58: Locus of maximum N factor with and without vibrational energy transfer, Shot 2576

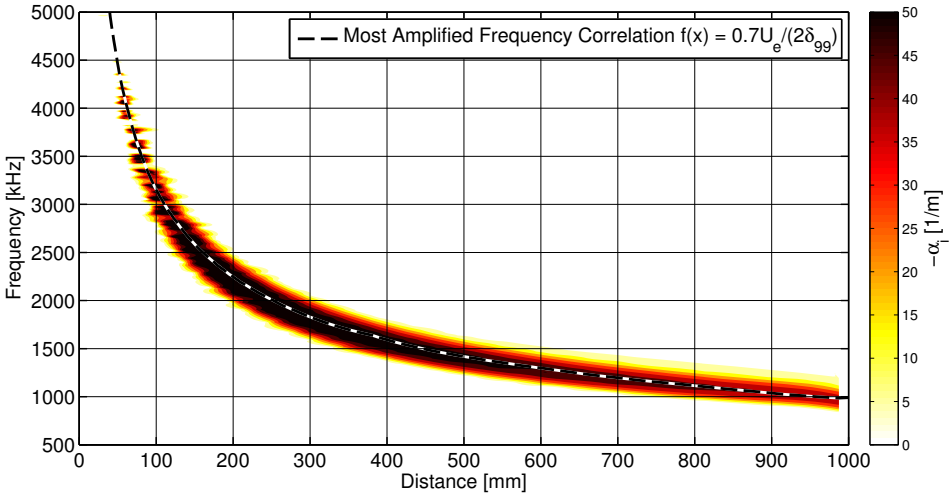


Figure 59: Stability diagram with vibrational energy transfer, Shot 2576. Dashed line indicates $0.7U_e/(2\delta_{99})$.

20.6 Heat Transfer Results

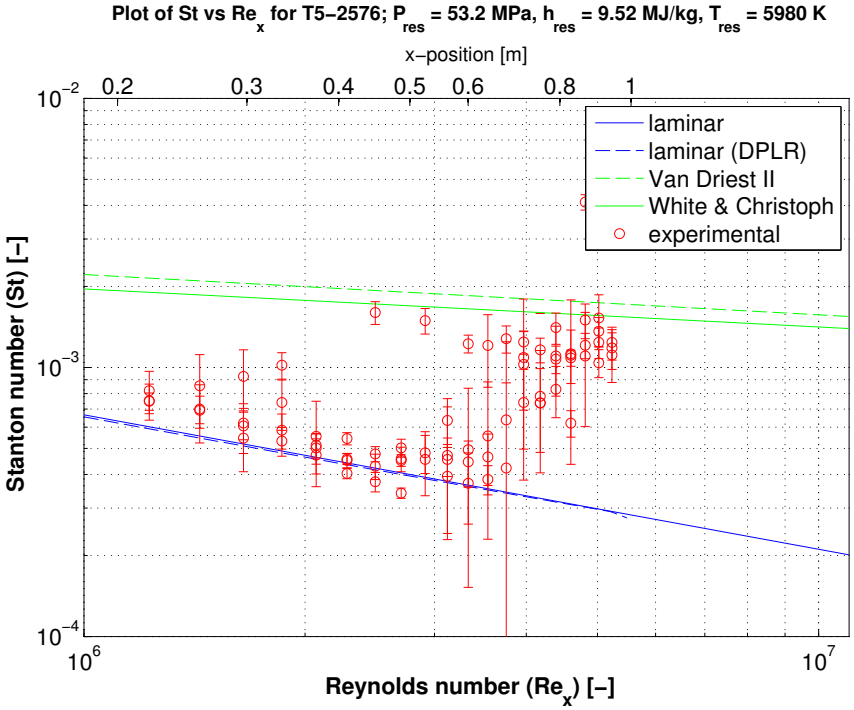


Figure 60: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

21 Shot 2577

Experiment 2577 was performed in T5 on 18 May 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG20: 20 micron) injector section. The initial shock tube composition was 100% air by mass.

21.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	51.7	MPa

Table 161: Measured quantities, Shot 2577

21.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5803	K
Reservoir Density	ρ_{res}	28.32	kg/m^3
Reservoir Enthalpy	h_{res}	9.11	MJ/kg

Table 162: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2577

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.08×10^{-2}	0	1.37×10^{-1}	0	3.24×10^{-3}	9.92×10^{-2}

Table 163: Computed reservoir species mass fractions, Shot 2577

21.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3887	1341.0	1341.0	5.40	23.4	0.060	4.64×10^{6}
72 cm	3864	1372.0	1380.4	5.17	27.7	0.070	5.29×10^{6}

Table 164: Computed freestream conditions, Shot 2577

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.08×10^{-2}	0	1.11×10^{-9}	1.59×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	3.32×10^{-9}	9.13×10^{-3}

Table 165: Computed freestream species mass fractions, Shot 2577

21.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3848	1463.4	1463.4	5.12	33.5	0.078	5.69×10^{6}
72 cm	3799	1553.1	1550.8	4.78	39.6	0.088	6.02×10^{6}

Table 166: Computed boundary layer edge conditions, Shot 2577

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.08×10^{-2}	0	1.11×10^{-9}	1.59×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	1.49×10^{-8}	8.85×10^{-3}

Table 167: Computed boundary layer edge species mass fractions, Shot 2577

	T^* K	Unit Re^* 1/m
1D 100 cm	1777	4.09×10^{6}
72 cm	1753	5.34×10^{6}

Table 168: Dorrance reference conditions, Shot 2577

21.5 Stability Computations

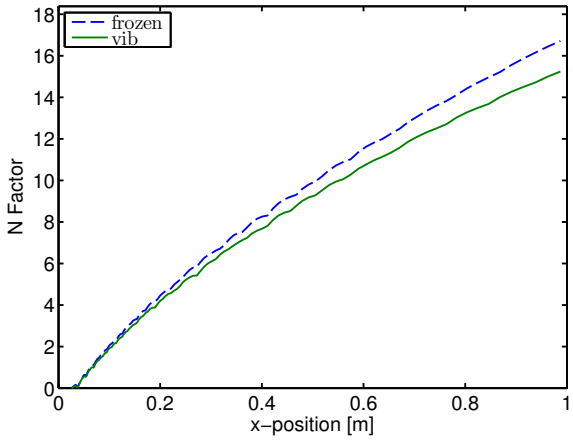


Figure 61: Locus of maximum N factor with and without vibrational energy transfer, Shot 2577

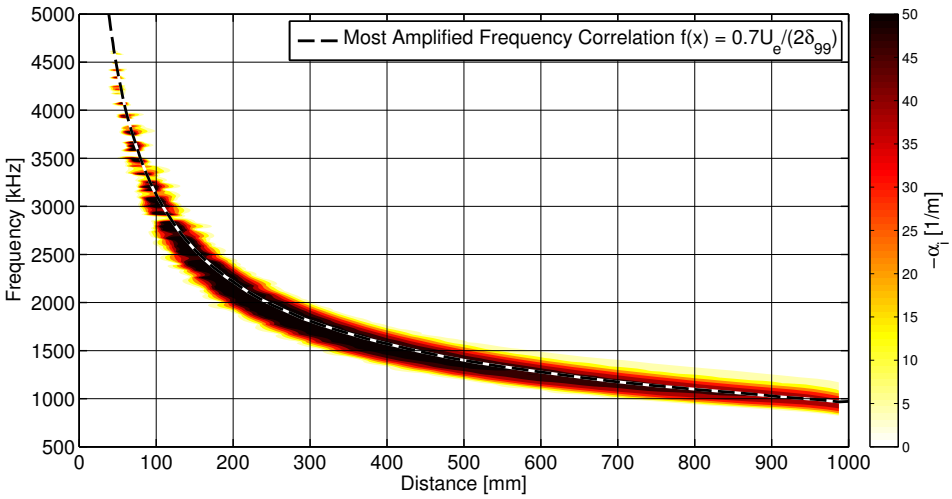


Figure 62: Stability diagram with vibrational energy transfer, Shot 2577. Dashed line indicates $0.7U_e/(2\delta_{99})$.

21.6 Heat Transfer Results

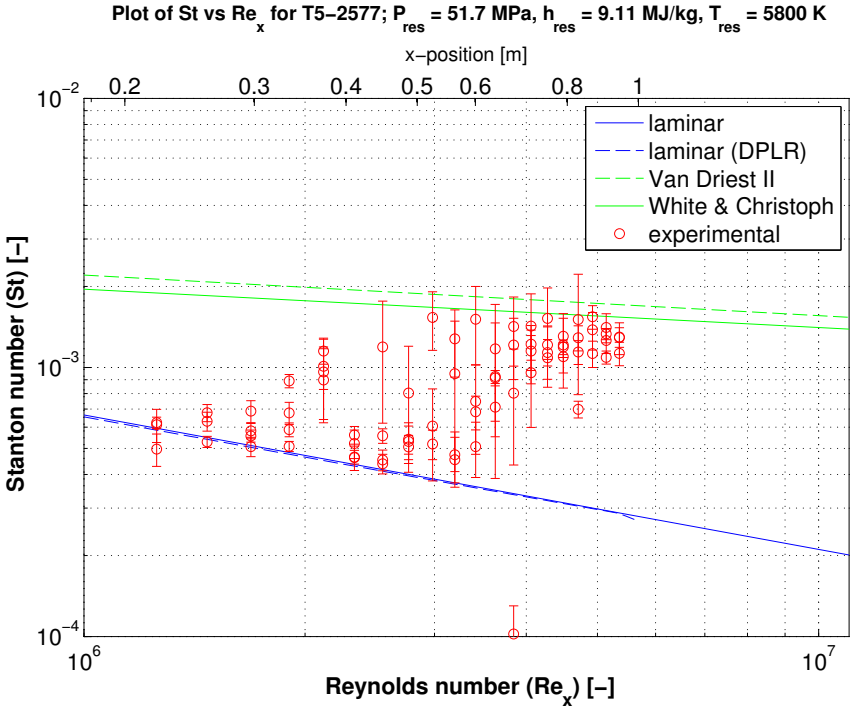


Figure 63: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

22 Shot 2578

Experiment 2578 was performed in T5 on 28 May 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and one-row injector section. The initial shock tube composition was 100% air by mass.

22.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	85.50	kPa
Reservoir Pressure	P_{res}	52.3	MPa

Table 169: Measured quantities, Shot 2578

22.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6058	K
Reservoir Density	ρ_{res}	27.09	kg/m^3
Reservoir Enthalpy	h_{res}	9.72	MJ/kg

Table 170: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2578

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.96×10^{-2}	0	1.33×10^{-1}	0	4.98×10^{-3}	1.12×10^{-1}

Table 171: Computed reservoir species mass fractions, Shot 2578

22.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3995	1439.0	1439.0	5.36	24.2	0.057	4.36×10^6
72 cm	3971	1481.0	1490.3	5.10	28.9	0.067	4.97×10^6

Table 172: Computed freestream conditions, Shot 2578

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.71×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.16×10^{-8}	1.23×10^{-2}

Table 173: Computed freestream species mass fractions, Shot 2578

22.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3955	1567.0	1567.0	5.08	34.4	0.075	5.32×10^6
72 cm	3904	1671.6	1669.4	4.72	41.0	0.084	5.65×10^6

Table 174: Computed boundary layer edge conditions, Shot 2578

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.71×10^{-9}	2.04×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	4.28×10^{-8}	1.19×10^{-2}

Table 175: Computed boundary layer edge species mass fractions, Shot 2578

	T^* K	Unit Re^* 1/m
1D 100 cm	1871	3.94×10^6
72 cm	1850	5.11×10^6

Table 176: Dorrance reference conditions, Shot 2578

22.5 Stability Computations

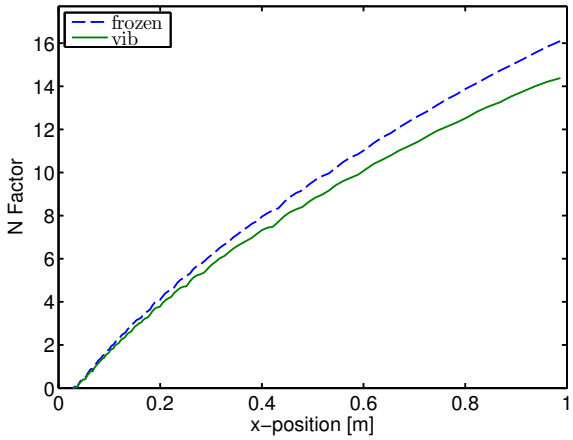


Figure 64: Locus of maximum N factor with and without vibrational energy transfer, Shot 2578

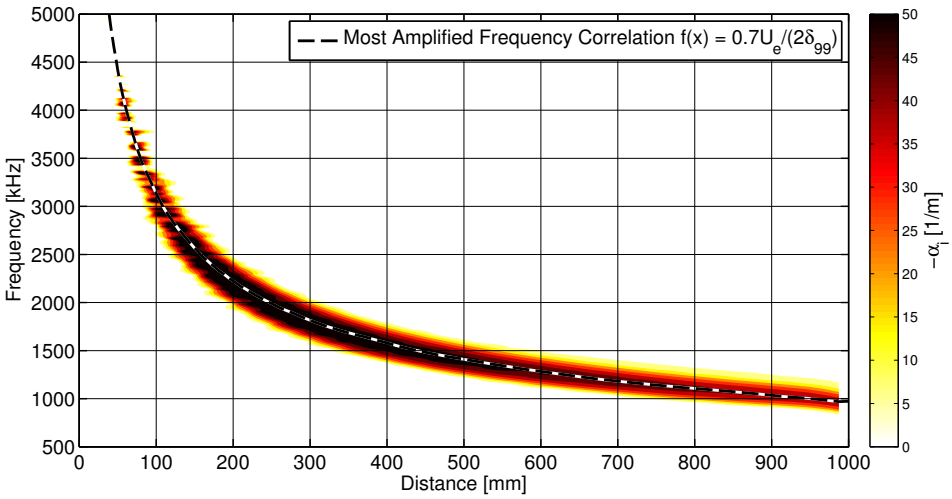


Figure 65: Stability diagram with vibrational energy transfer, Shot 2578. Dashed line indicates $0.7U_e/(2\delta_{99})$.

22.6 Heat Transfer Results

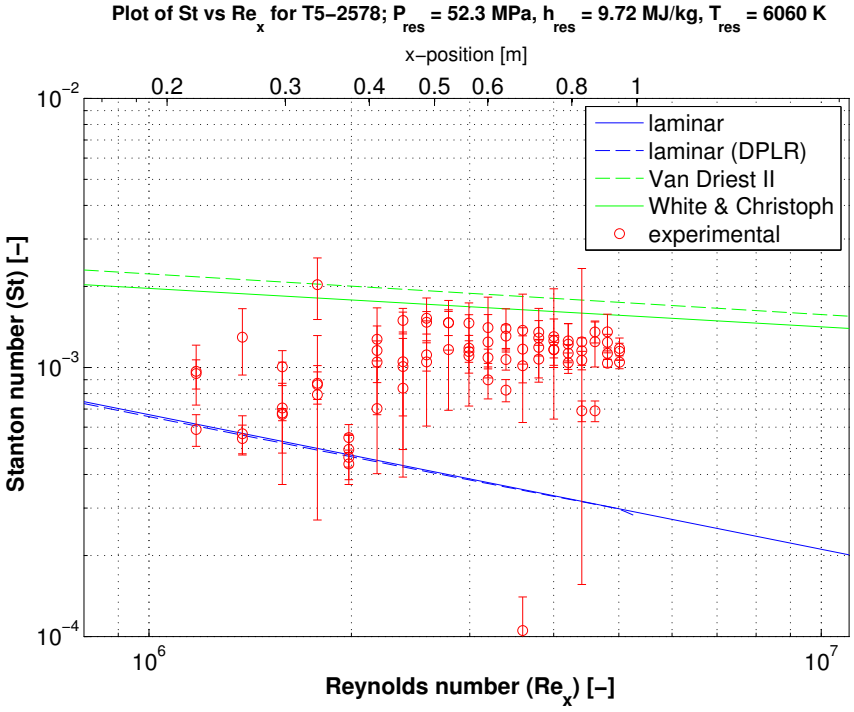


Figure 66: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

23 Shot 2579

Experiment 2579 was performed in T5 on 4 June 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

23.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2760	m/s
Shock Tube Fill Pressure	P_1	150.00	kPa
Reservoir Pressure	P_{res}	46.4	MPa

Table 177: Measured quantities, Shot 2579

23.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4821	K
Reservoir Density	ρ_{res}	32.02	kg/m^3
Reservoir Enthalpy	h_{res}	6.84	MJ/kg

Table 178: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2579

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.06×10^{-1}	1.16×10^{-1}	0	1.31×10^{-1}	0	4.23×10^{-4}	4.75×10^{-2}

Table 179: Computed reservoir species mass fractions, Shot 2579

23.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3439	958.0	958.0	5.64	19.0	0.069	5.75×10^6
72 cm	3412	947.2	944.4	5.52	21.0	0.077	6.38×10^6

Table 180: Computed freestream conditions, Shot 2579

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.30×10^{-2}	0	0	4.88×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.80×10^{-2}	0	0	2.00×10^{-3}

Table 181: Computed freestream species mass fractions, Shot 2579

23.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3406	1056.4	1056.4	5.32	28.0	0.092	7.18×10^6
72 cm	3354	1095.0	1091.7	5.04	30.9	0.098	7.38×10^6

Table 182: Computed boundary layer edge conditions, Shot 2579

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.30×10^{-2}	0	0	4.88×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.80×10^{-2}	0	0	1.98×10^{-3}

Table 183: Computed boundary layer edge species mass fractions, Shot 2579

	T^* K	Unit Re^* 1/m
1D 100 cm	1414	4.49×10^6
72 cm	1382	5.85×10^6

Table 184: Dorrance reference conditions, Shot 2579

23.5 Stability Computations

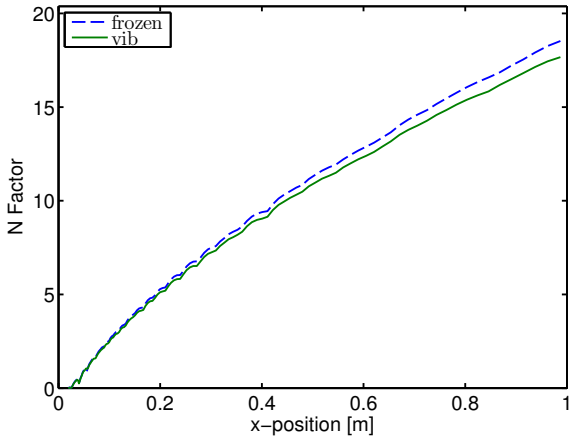


Figure 67: Locus of maximum N factor with and without vibrational energy transfer, Shot 2579

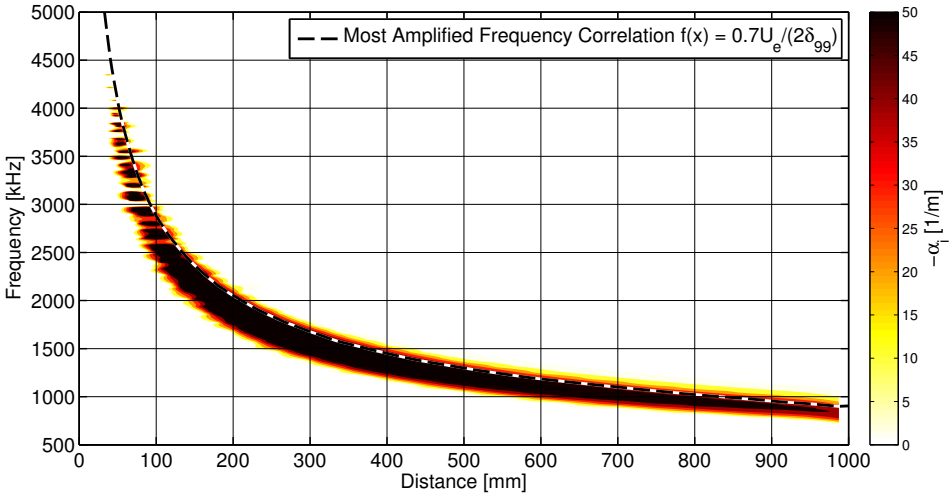


Figure 68: Stability diagram with vibrational energy transfer, Shot 2579. Dashed line indicates $0.7U_e/(2\delta_{99})$.

23.6 Heat Transfer Results

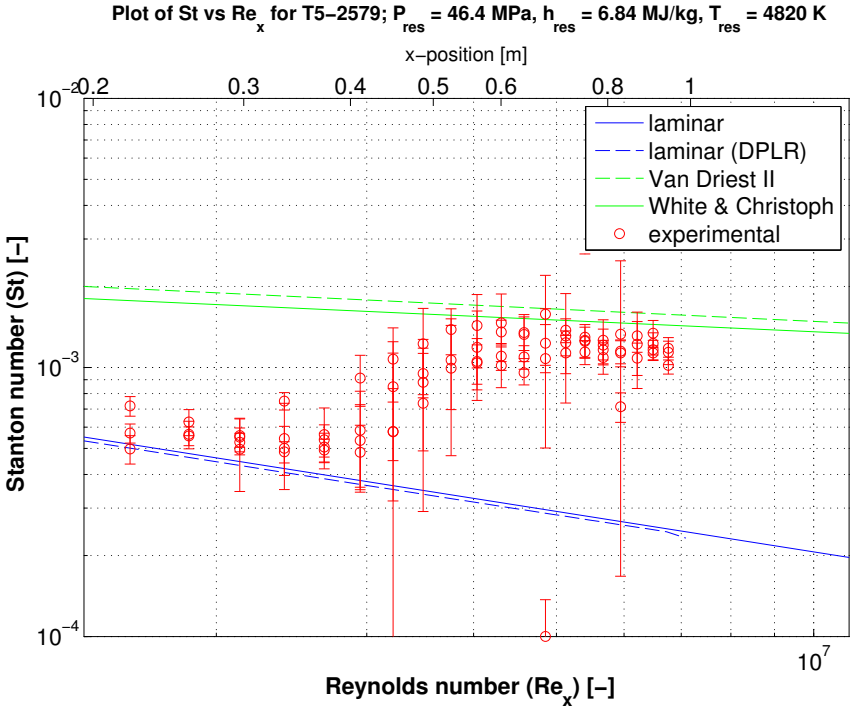


Figure 69: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

24 Shot 2580

Experiment 2580 was performed in T5 on 7 June 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

24.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2390	m/s
Shock Tube Fill Pressure	P_1	252.50	kPa
Reservoir Pressure	P_{res}	50.3	MPa

Table 185: Measured quantities, Shot 2580

24.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3925	K
Reservoir Density	ρ_{res}	43.93	kg/m^3
Reservoir Enthalpy	h_{res}	4.96	MJ/kg

Table 186: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2580

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.22×10^{-1}	1.69×10^{-1}	0	9.65×10^{-2}	0	2.54×10^{-5}	1.25×10^{-2}

Table 187: Computed reservoir species mass fractions, Shot 2580

24.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2980	638.0	638.0	5.94	17.6	0.096	8.88×10^6
72 cm	2982	572.8	603.5	6.21	14.2	0.086	8.51×10^6

Table 188: Computed freestream conditions, Shot 2580

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.99×10^{-1}	0	6.17×10^{-2}	0	2.60×10^{-10}	8.31×10^{-4}
72 cm	7.35×10^{-1}	1.96×10^{-1}	0	6.94×10^{-2}	0	0	3.26×10^{-4}

Table 189: Computed freestream species mass fractions, Shot 2580

24.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2952	714.7	714.7	5.55	26.9	0.130	1.11×10^7
72 cm	2930	700.3	695.3	5.51	22.4	0.111	9.49×10^6

Table 190: Computed boundary layer edge conditions, Shot 2580

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.99×10^{-1}	0	6.17×10^{-2}	0	2.60×10^{-10}	8.31×10^{-4}
72 cm	7.35×10^{-1}	1.96×10^{-1}	0	6.94×10^{-2}	0	0	3.26×10^{-4}

Table 191: Computed boundary layer edge species mass fractions, Shot 2580

	T^* K	Unit Re^* 1/m
1D 100 cm	1094	5.67×10^6
72 cm	1066	6.24×10^6

Table 192: Dorrance reference conditions, Shot 2580

24.5 Stability Computations

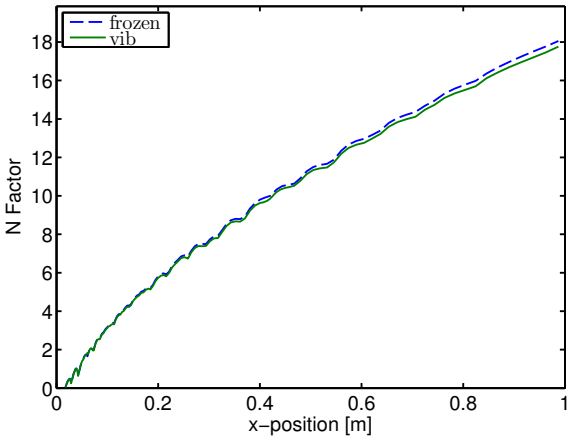


Figure 70: Locus of maximum N factor with and without vibrational energy transfer, Shot 2580

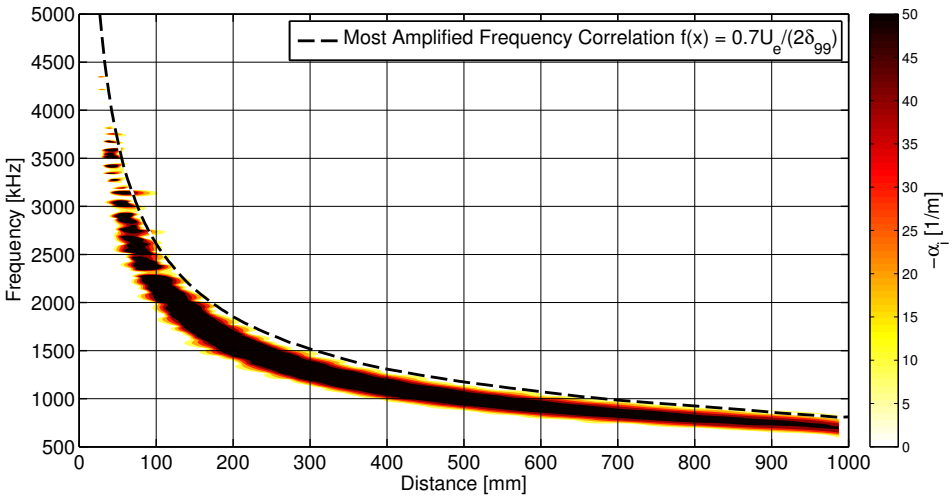


Figure 71: Stability diagram with vibrational energy transfer, Shot 2580. Dashed line indicates $0.7U_e/(2\delta_{99})$.

24.6 Heat Transfer Results

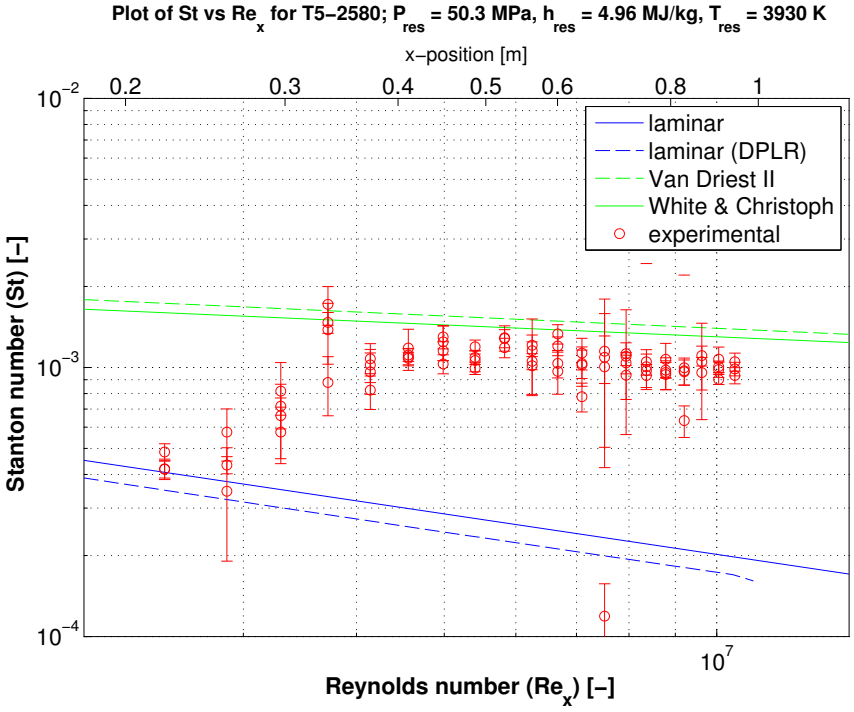


Figure 72: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

25 Shot 2581

Experiment 2581 was performed in T5 on 11 June 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

25.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2540	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_res	29.9	MPa

Table 193: Measured quantities, Shot 2581

25.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	4441	K
Reservoir Density	ρ_res	22.61	kg/m^3
Reservoir Enthalpy	h_res	6.10	MJ/kg

Table 194: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2581

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
7.12×10^{-1}	1.34×10^{-1}	0	1.17×10^{-1}	0	1.86×10^{-4}	3.66×10^{-2}

Table 195: Computed reservoir species mass fractions, Shot 2581

25.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3264	824.0	824.0	5.75	11.6	0.049	4.21×10^6
72 cm	3236	813.2	810.9	5.65	12.5	0.053	4.54×10^6

Table 196: Computed freestream conditions, Shot 2581

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.40×10^{-2}	0	0	4.66×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.68×10^{-2}	0	0	2.12×10^{-3}

Table 197: Computed freestream species mass fractions, Shot 2581

25.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3233	914.6	914.6	5.41	17.3	0.065	5.28×10^6
72 cm	3180	952.0	944.0	5.13	18.6	0.068	5.23×10^6

Table 198: Computed boundary layer edge conditions, Shot 2581

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.40×10^{-2}	0	0	4.66×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.68×10^{-2}	0	0	2.11×10^{-3}

Table 199: Computed boundary layer edge species mass fractions, Shot 2581

	T^* K	Unit Re^* 1/m
1D 100 cm	1285	3.09×10^6
72 cm	1260	3.95×10^6

Table 200: Dorrance reference conditions, Shot 2581

25.5 Stability Computations

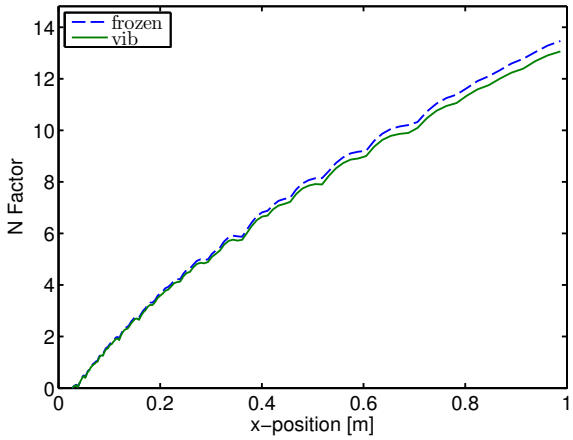


Figure 73: Locus of maximum N factor with and without vibrational energy transfer, Shot 2581

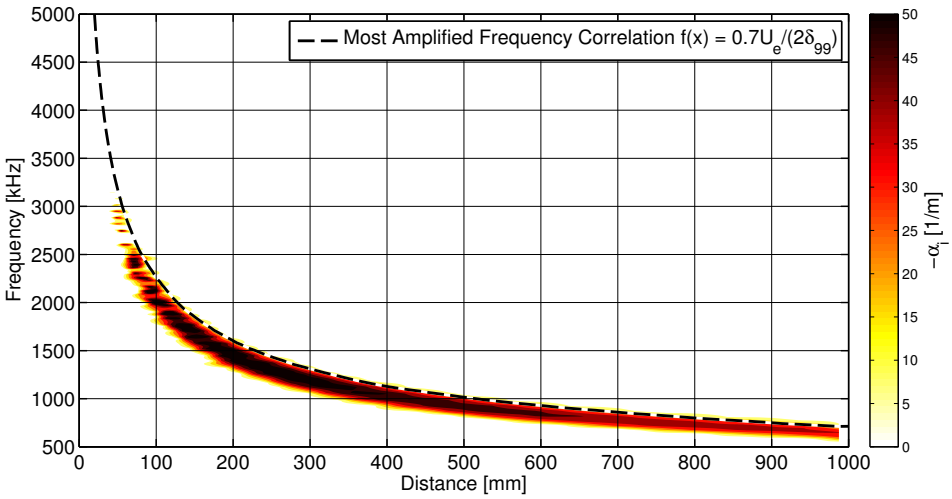


Figure 74: Stability diagram with vibrational energy transfer, Shot 2581. Dashed line indicates $0.7U_e/(2\delta_{99})$.

25.6 Heat Transfer Results

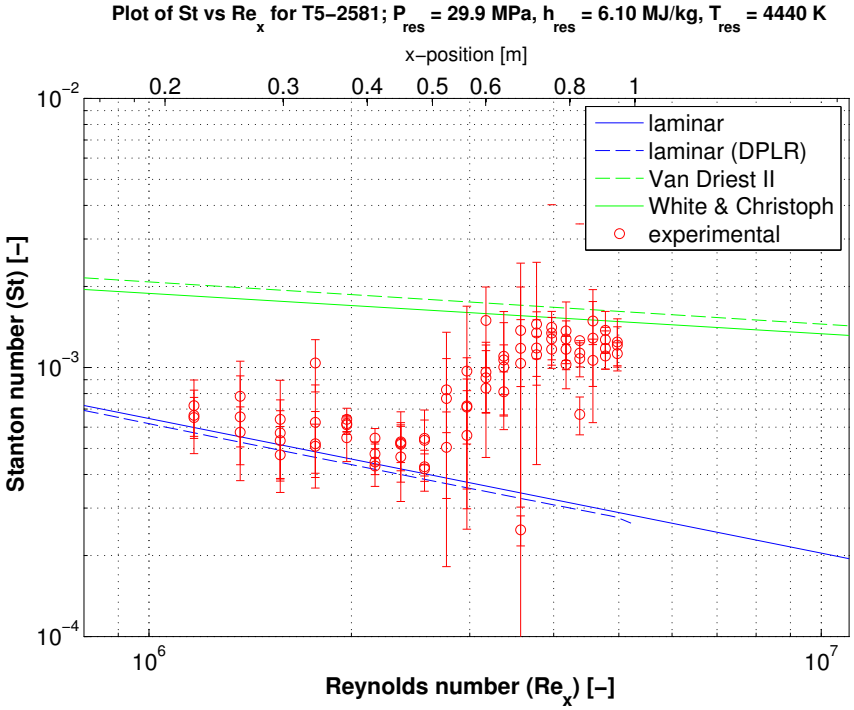


Figure 75: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

26 Shot 2582

Experiment 2582 was performed in T5 on 28 June 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

26.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2340	m/s
Shock Tube Fill Pressure	P_1	90.30	kPa
Reservoir Pressure	P_{res}	29.6	MPa

Table 201: Measured quantities, Shot 2582

26.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4110	K
Reservoir Density	ρ_{res}	24.46	kg/m^3
Reservoir Enthalpy	h_{res}	5.39	MJ/kg

Table 202: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2582

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.18×10^{-1}	1.55×10^{-1}	0	1.04×10^{-1}	0	6.47×10^{-5}	2.24×10^{-2}

Table 203: Computed reservoir species mass fractions, Shot 2582

26.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3089	706.0	706.0	5.86	10.8	0.053	4.78×10^6
72 cm	3070	672.7	692.1	5.89	10.4	0.053	4.91×10^6

Table 204: Computed freestream conditions, Shot 2582

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.40×10^{-2}	0	0	2.56×10^{-3}
72 cm	7.33×10^{-1}	1.92×10^{-1}	0	7.37×10^{-2}	0	0	1.15×10^{-3}

Table 205: Computed freestream species mass fractions, Shot 2582

26.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3060	787.6	787.6	5.50	16.4	0.072	5.98×10^6
72 cm	3017	804.3	794.2	5.29	15.9	0.069	5.53×10^6

Table 206: Computed boundary layer edge conditions, Shot 2582

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.40×10^{-2}	0	0	2.56×10^{-3}
72 cm	7.33×10^{-1}	1.92×10^{-1}	0	7.37×10^{-2}	0	0	1.15×10^{-3}

Table 207: Computed boundary layer edge species mass fractions, Shot 2582

	T^* K	Unit Re^* 1/m
1D 100 cm	1165	3.23×10^6
72 cm	1141	3.90×10^6

Table 208: Dorrance reference conditions, Shot 2582

26.5 Stability Computations

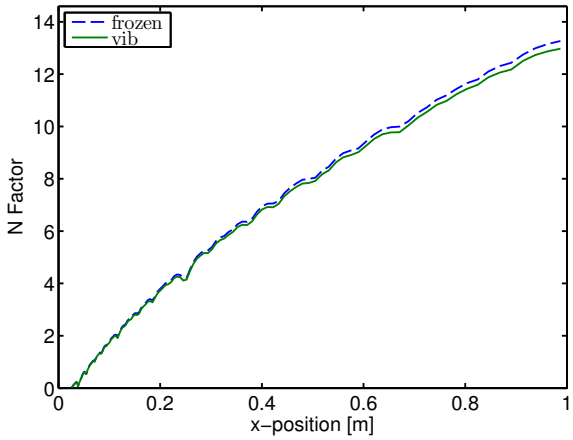


Figure 76: Locus of maximum N factor with and without vibrational energy transfer, Shot 2582

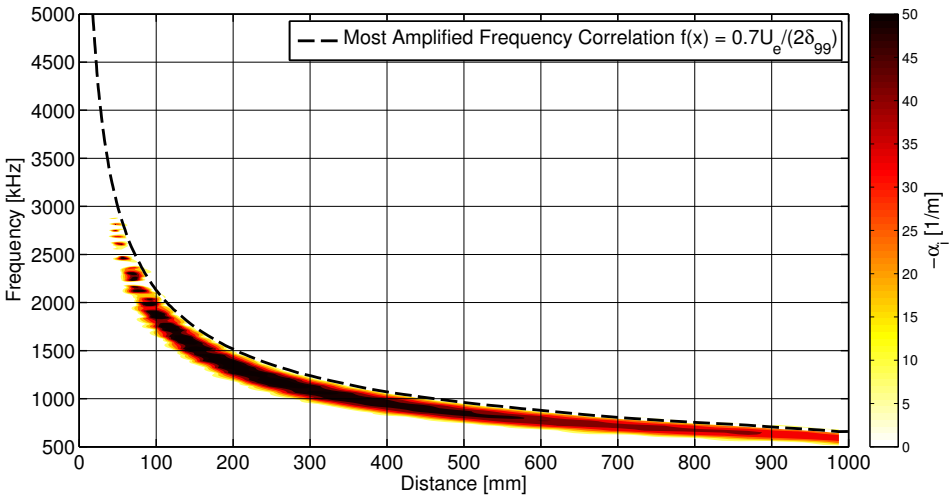


Figure 77: Stability diagram with vibrational energy transfer, Shot 2582. Dashed line indicates $0.7U_e/(2\delta_{99})$.

26.6 Heat Transfer Results

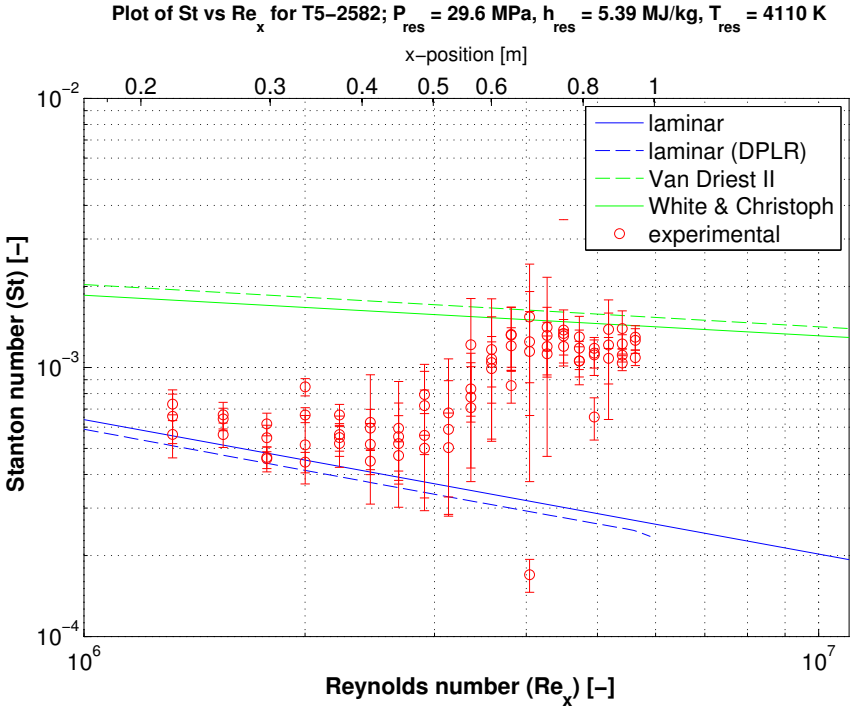


Figure 78: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

27 Shot 2583

Experiment 2583 was performed in T5 on 29 June 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

27.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2240	m/s
Shock Tube Fill Pressure	P_1	91.00	kPa
Reservoir Pressure	P_{res}	31.1	MPa

Table 209: Measured quantities, Shot 2583

27.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3964	K
Reservoir Density	ρ_{res}	26.77	kg/m^3
Reservoir Enthalpy	h_{res}	5.09	MJ/kg

Table 210: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2583

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.21×10^{-1}	1.64×10^{-1}	0	9.76×10^{-2}	0	3.74×10^{-5}	1.70×10^{-2}

Table 211: Computed reservoir species mass fractions, Shot 2583

27.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3010	656.0	656.0	5.91	11.0	0.058	5.36×10^6
72 cm	2999	610.6	648.2	6.04	9.8	0.055	5.31×10^6

Table 212: Computed freestream conditions, Shot 2583

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.97×10^{-1}	0	6.31×10^{-2}	0	4.72×10^{-10}	1.80×10^{-3}
72 cm	7.34×10^{-1}	1.94×10^{-1}	0	7.14×10^{-2}	0	0	7.87×10^{-4}

Table 213: Computed freestream species mass fractions, Shot 2583

27.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2982	734.4	734.4	5.54	16.8	0.079	6.70×10^6
72 cm	2946	739.6	730.1	5.39	15.2	0.071	5.93×10^6

Table 214: Computed boundary layer edge conditions, Shot 2583

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.97×10^{-1}	0	6.31×10^{-2}	0	4.72×10^{-10}	1.80×10^{-3}
72 cm	7.34×10^{-1}	1.94×10^{-1}	0	7.14×10^{-2}	0	0	7.86×10^{-4}

Table 215: Computed boundary layer edge species mass fractions, Shot 2583

	T^* K	Unit Re^* 1/m
1D 100 cm	1113	3.48×10^6
72 cm	1089	4.03×10^6

Table 216: Dorrance reference conditions, Shot 2583

27.5 Stability Computations

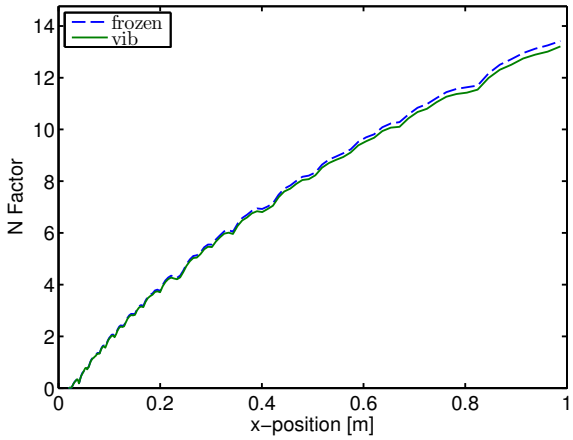


Figure 79: Locus of maximum N factor with and without vibrational energy transfer, Shot 2583

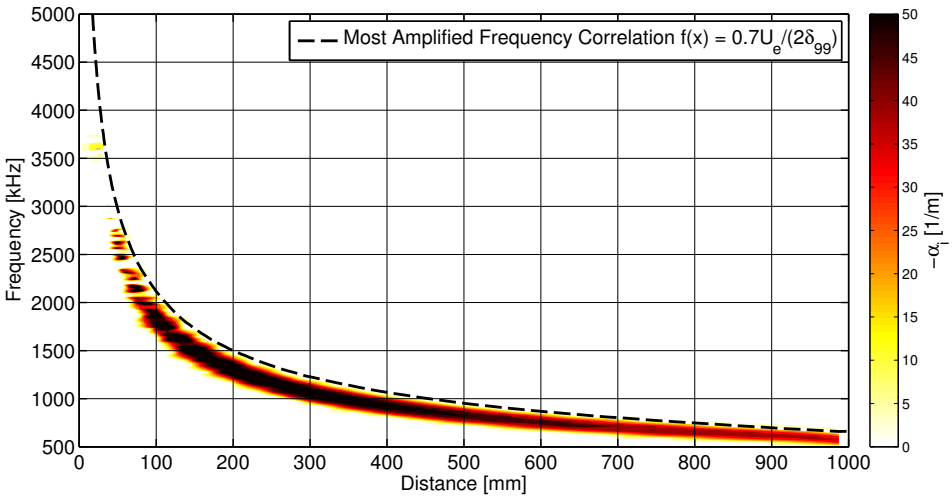


Figure 80: Stability diagram with vibrational energy transfer, Shot 2583. Dashed line indicates $0.7U_e/(2\delta_{99})$.

27.6 Heat Transfer Results

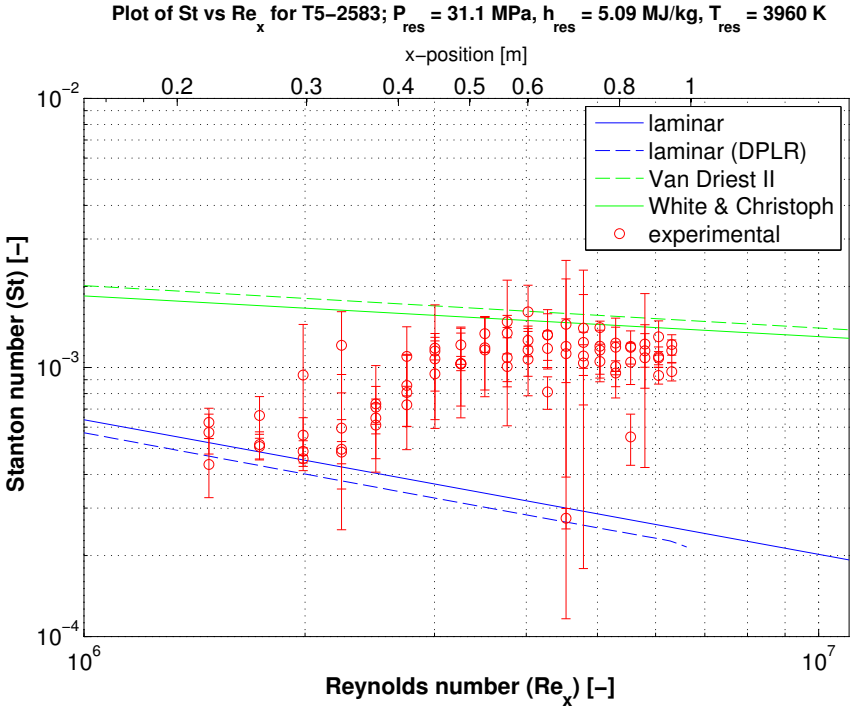


Figure 81: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

28 Shot 2584

Experiment 2584 was performed in T5 on 30 June 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

28.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2340	m/s
Shock Tube Fill Pressure	P_1	90.70	kPa
Reservoir Pressure	P_{res}	29.9	MPa

Table 217: Measured quantities, Shot 2584

28.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4115	K
Reservoir Density	ρ_{res}	24.73	kg/m^3
Reservoir Enthalpy	h_{res}	5.40	MJ/kg

Table 218: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2584

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.18×10^{-1}	1.55×10^{-1}	0	1.05×10^{-1}	0	6.55×10^{-5}	2.25×10^{-2}

Table 219: Computed reservoir species mass fractions, Shot 2584

28.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3090	706.0	706.0	5.86	10.9	0.054	4.82×10^6
72 cm	3073	674.5	692.8	5.89	10.6	0.054	4.96×10^6

Table 220: Computed freestream conditions, Shot 2584

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.40×10^{-2}	0	4.12×10^{-10}	2.55×10^{-3}
72 cm	7.33×10^{-1}	1.92×10^{-1}	0	7.37×10^{-2}	0	0	1.14×10^{-3}

Table 221: Computed freestream species mass fractions, Shot 2584

28.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3061	788.4	788.4	5.49	16.5	0.072	6.02×10^6
72 cm	3019	806.8	796.7	5.29	16.1	0.069	5.59×10^6

Table 222: Computed boundary layer edge conditions, Shot 2584

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.40×10^{-2}	0	4.12×10^{-10}	2.55×10^{-3}
72 cm	7.33×10^{-1}	1.92×10^{-1}	0	7.37×10^{-2}	0	0	1.14×10^{-3}

Table 223: Computed boundary layer edge species mass fractions, Shot 2584

	T^* K	Unit Re^* 1/m
1D 100 cm	1166	3.26×10^6
72 cm	1143	3.94×10^6

Table 224: Dorrance reference conditions, Shot 2584

28.5 Stability Computations

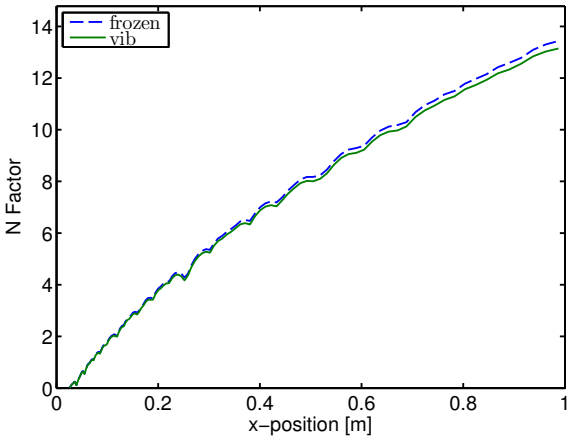


Figure 82: Locus of maximum N factor with and without vibrational energy transfer, Shot 2584

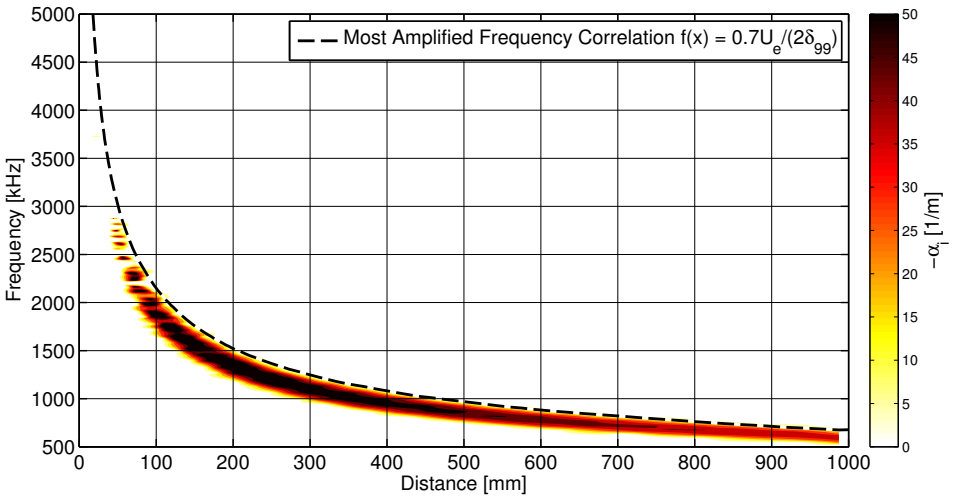


Figure 83: Stability diagram with vibrational energy transfer, Shot 2584. Dashed line indicates $0.7U_e/(2\delta_{99})$.

28.6 Heat Transfer Results

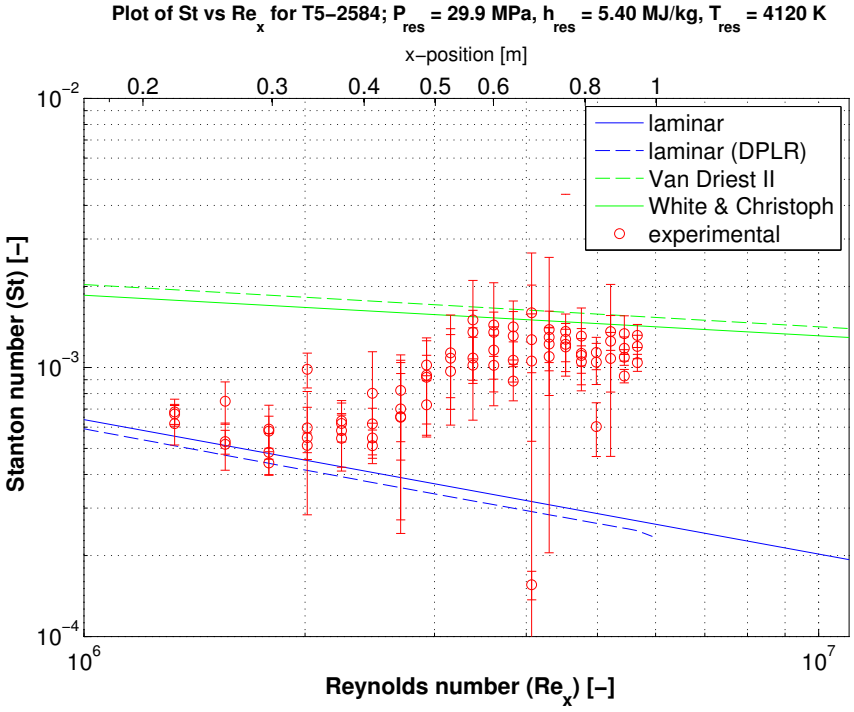


Figure 84: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

29 Shot 2585

Experiment 2585 was performed in T5 on 1 July 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

29.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2400	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_res	30.4	MPa

Table 225: Measured quantities, Shot 2585

29.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	4223	K
Reservoir Density	ρ_res	24.43	kg/m^3
Reservoir Enthalpy	h_res	5.62	MJ/kg

Table 226: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2585

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
7.16×10^{-1}	1.48×10^{-1}	0	1.09×10^{-1}	0	9.33×10^{-5}	2.65×10^{-2}

Table 227: Computed reservoir species mass fractions, Shot 2585

29.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3148	745.0	745.0	5.82	11.4	0.053	4.69×10^6
72 cm	3126	719.3	726.4	5.80	11.4	0.055	4.92×10^6

Table 228: Computed freestream conditions, Shot 2585

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.42×10^{-2}	0	0	3.05×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.49×10^{-2}	0	0	1.37×10^{-3}

Table 229: Computed freestream species mass fractions, Shot 2585

29.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3118	829.3	829.3	5.46	17.1	0.071	5.87×10^6
72 cm	3071	853.1	843.8	5.23	17.3	0.070	5.59×10^6

Table 230: Computed boundary layer edge conditions, Shot 2585

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.42×10^{-2}	0	0	3.05×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.49×10^{-2}	0	0	1.36×10^{-3}

Table 231: Computed boundary layer edge species mass fractions, Shot 2585

	T^* K	Unit Re^* 1/m
1D 100 cm	1205	3.27×10^6
72 cm	1180	4.04×10^6

Table 232: Dorrance reference conditions, Shot 2585

29.5 Stability Computations

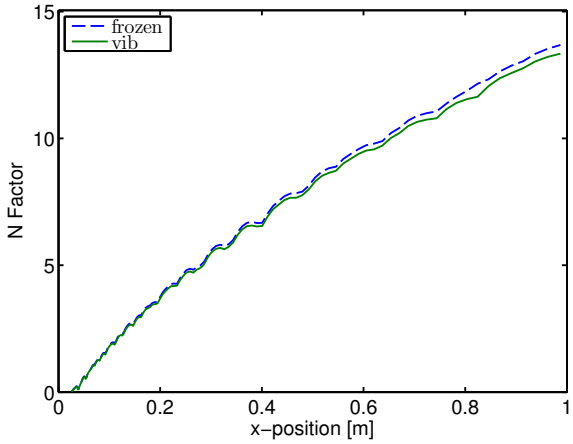


Figure 85: Locus of maximum N factor with and without vibrational energy transfer, Shot 2585

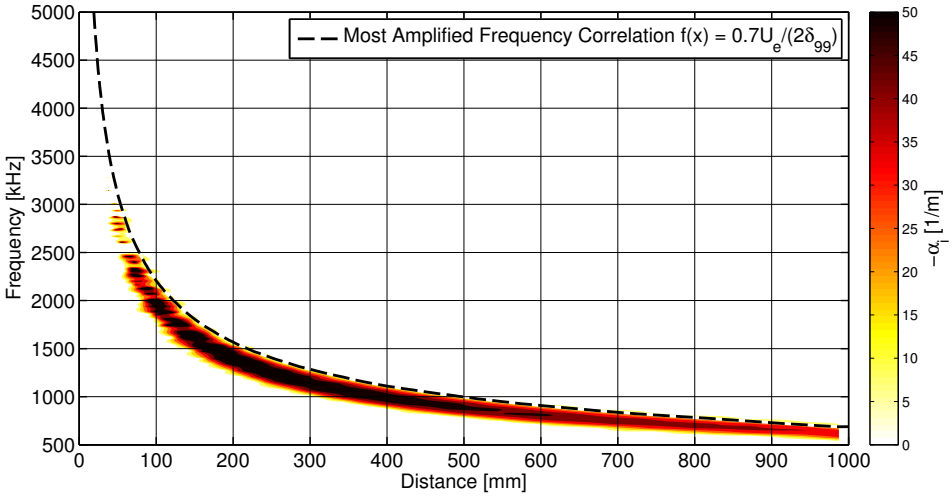


Figure 86: Stability diagram with vibrational energy transfer, Shot 2585. Dashed line indicates $0.7U_e/(2\delta_{99})$.

29.6 Heat Transfer Results

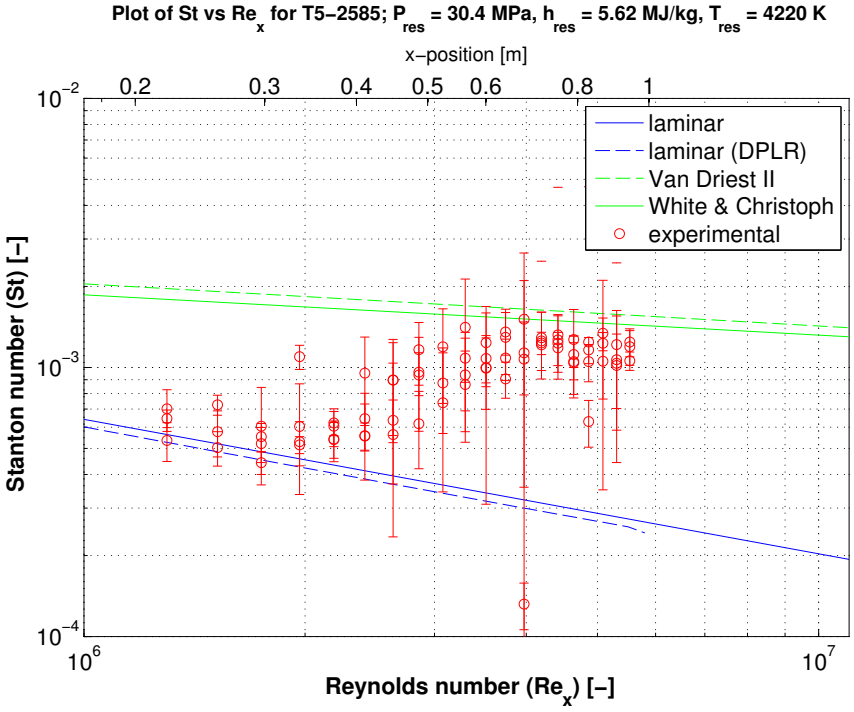


Figure 87: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

30 Shot 2586

Experiment 2586 was performed in T5 on 2 July 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

30.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2320	m/s
Shock Tube Fill Pressure	P_1	90.30	kPa
Reservoir Pressure	P_res	29.6	MPa

Table 233: Measured quantities, Shot 2586

30.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	4067	K
Reservoir Density	ρ_res	24.81	kg/m^3
Reservoir Enthalpy	h_res	5.30	MJ/kg

Table 234: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2586

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_NO	Y_CO	Y_N	Y_O
7.19×10^{-1}	1.57×10^{-1}	0	1.02×10^{-1}	0	5.56×10^{-5}	2.08×10^{-2}

Table 235: Computed reservoir species mass fractions, Shot 2586

30.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3065	690.0	690.0	5.88	10.7	0.054	4.86×10^6
72 cm	3049	654.8	679.3	5.93	10.1	0.053	4.97×10^6

Table 236: Computed freestream conditions, Shot 2586

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.97×10^{-1}	0	6.39×10^{-2}	0	0	2.36×10^{-3}
72 cm	7.33×10^{-1}	1.93×10^{-1}	0	7.31×10^{-2}	0	0	1.05×10^{-3}

Table 237: Computed freestream species mass fractions, Shot 2586

30.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3036	770.7	770.7	5.51	16.2	0.073	6.08×10^6
72 cm	2996	785.6	775.3	5.32	15.6	0.069	5.58×10^6

Table 238: Computed boundary layer edge conditions, Shot 2586

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.97×10^{-1}	0	6.39×10^{-2}	0	0	2.36×10^{-3}
72 cm	7.33×10^{-1}	1.93×10^{-1}	0	7.31×10^{-2}	0	0	1.05×10^{-3}

Table 239: Computed boundary layer edge species mass fractions, Shot 2586

	T^* K	Unit Re^* 1/m
1D 100 cm	1149	3.25×10^6
72 cm	1126	3.90×10^6

Table 240: Dorrance reference conditions, Shot 2586

30.5 Stability Computations

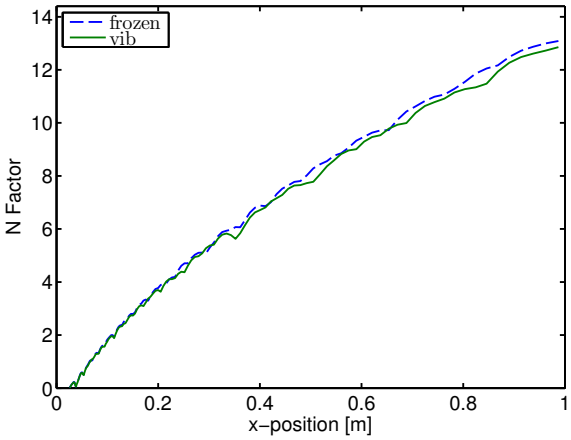


Figure 88: Locus of maximum N factor with and without vibrational energy transfer, Shot 2586

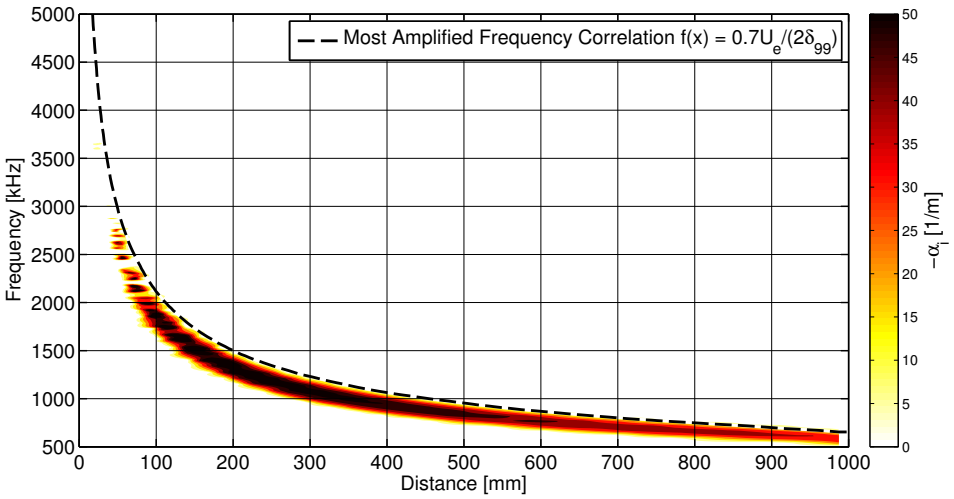


Figure 89: Stability diagram with vibrational energy transfer, Shot 2586. Dashed line indicates $0.7U_e/(2\delta_{99})$.

30.6 Heat Transfer Results

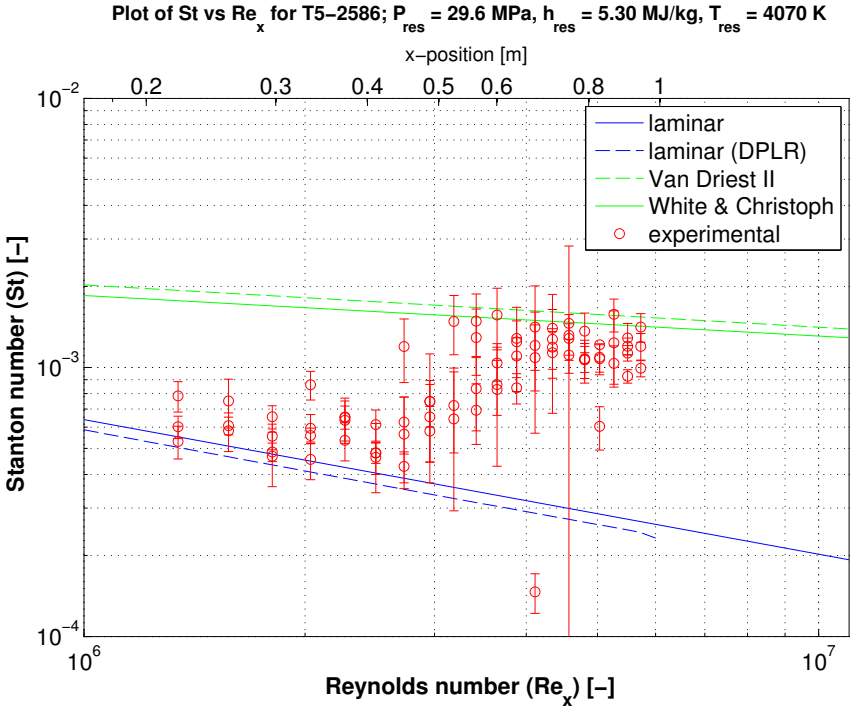


Figure 90: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

31 Shot 2587

Experiment 2587 was performed in T5 on 7 July 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

31.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	51.9	MPa

Table 241: Measured quantities, Shot 2587

31.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6026	K
Reservoir Density	ρ_res	27.04	kg/m^3
Reservoir Enthalpy	h_res	9.65	MJ/kg

Table 242: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2587

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
7.00×10^{-1}	5.08×10^{-2}	0	1.34×10^{-1}	0	4.74×10^{-3}	1.11×10^{-1}

Table 243: Computed reservoir species mass fractions, Shot 2587

31.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3982	1427.0	1427.0	5.36	23.9	0.057	4.36×10^6
72 cm	3958	1467.5	1476.8	5.11	28.6	0.067	4.97×10^6

Table 244: Computed freestream conditions, Shot 2587

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	4.01×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.01×10^{-8}	1.20×10^{-2}

Table 245: Computed freestream species mass fractions, Shot 2587

31.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3943	1554.2	1554.2	5.09	34.1	0.075	5.33×10^6
72 cm	3891	1657.0	1654.8	4.73	40.5	0.084	5.65×10^6

Table 246: Computed boundary layer edge conditions, Shot 2587

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	4.01×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	3.82×10^{-8}	1.16×10^{-2}

Table 247: Computed boundary layer edge species mass fractions, Shot 2587

	T^* K	Unit Re^* 1/m
1D 100 cm	1859	3.93×10^6
72 cm	1838	5.10×10^6

Table 248: Dorrance reference conditions, Shot 2587

31.5 Stability Computations

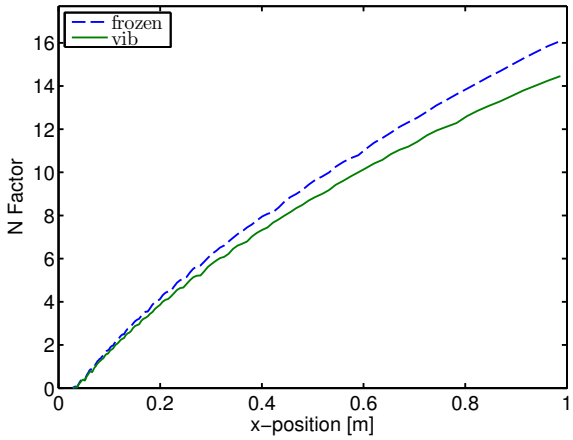


Figure 91: Locus of maximum N factor with and without vibrational energy transfer, Shot 2587

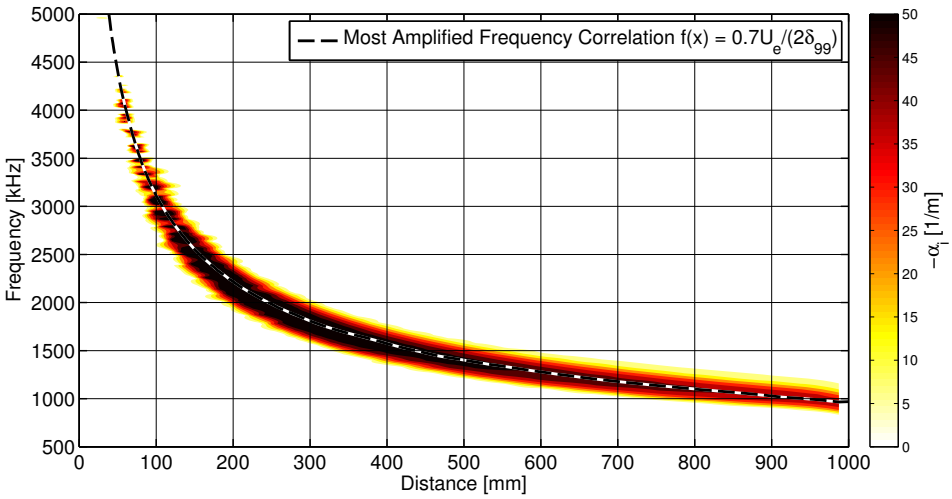


Figure 92: Stability diagram with vibrational energy transfer, Shot 2587. Dashed line indicates $0.7U_e/(2\delta_{99})$.

31.6 Heat Transfer Results

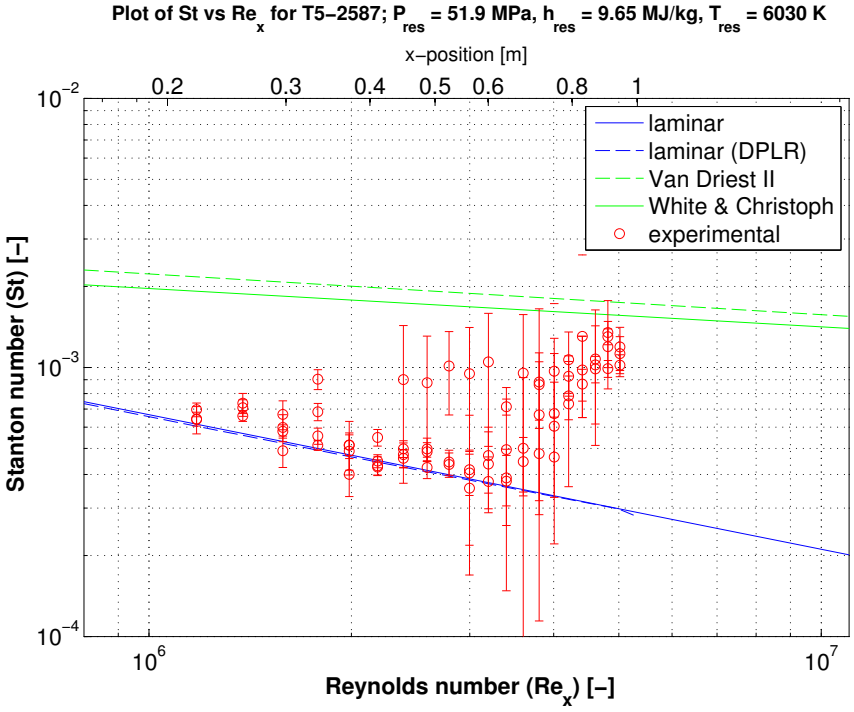


Figure 93: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

32 Shot 2588

Experiment 2588 was performed in T5 on 8 July 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

32.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	84.85	kPa
Reservoir Pressure	P_res	54.8	MPa

Table 249: Measured quantities, Shot 2588

32.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6180	K
Reservoir Density	ρ_res	27.71	kg/m^3
Reservoir Enthalpy	h_res	9.99	MJ/kg

Table 250: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2588

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	4.57×10^{-2}	0	1.32×10^{-1}	0	5.92×10^{-3}	1.17×10^{-1}

Table 251: Computed reservoir species mass fractions, Shot 2588

32.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4047	1489.0	1489.0	5.33	25.8	0.059	4.45×10^6
72 cm	4018	1530.2	1539.4	5.08	30.7	0.069	5.05×10^6

Table 252: Computed freestream conditions, Shot 2588

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.08×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	1.82×10^{-8}	1.33×10^{-2}

Table 253: Computed freestream species mass fractions, Shot 2588

32.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4007	1620.3	1620.3	5.06	36.7	0.077	5.42×10^6
72 cm	3951	1725.2	1723.2	4.70	43.5	0.086	5.74×10^6

Table 254: Computed boundary layer edge conditions, Shot 2588

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.08×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	6.26×10^{-8}	1.28×10^{-2}

Table 255: Computed boundary layer edge species mass fractions, Shot 2588

	T^* K	Unit Re^* 1/m
1D 100 cm	1918	4.07×10^6
72 cm	1893	5.23×10^6

Table 256: Dorrance reference conditions, Shot 2588

32.5 Stability Computations

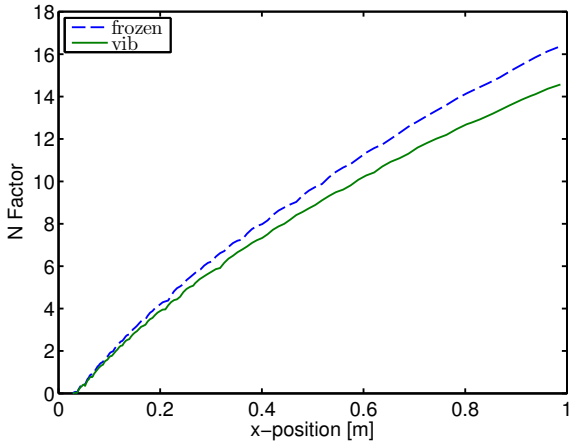


Figure 94: Locus of maximum N factor with and without vibrational energy transfer, Shot 2588

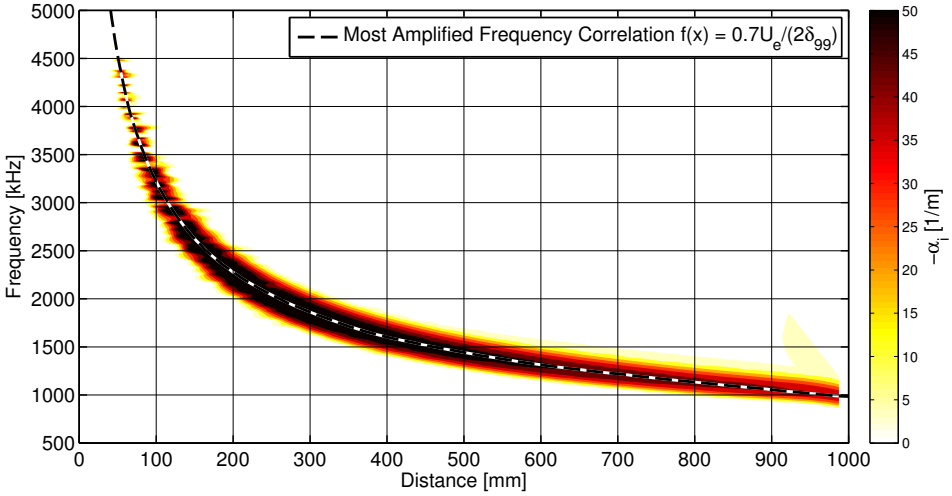


Figure 95: Stability diagram with vibrational energy transfer, Shot 2588. Dashed line indicates $0.7U_e/(2\delta_{99})$.

32.6 Heat Transfer Results

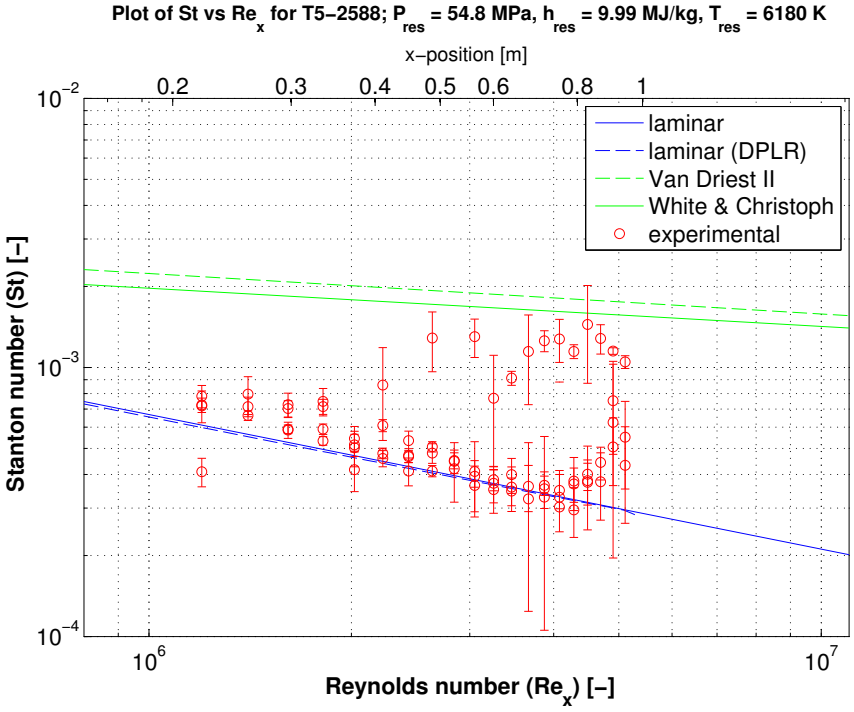


Figure 96: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

33 Shot 2589

Experiment 2589 was performed in T5 on 23 July 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

33.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3220	m/s
Shock Tube Fill Pressure	P_1	85.15	kPa
Reservoir Pressure	P_{res}	56.3	MPa

Table 257: Measured quantities, Shot 2589

33.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6218	K
Reservoir Density	ρ_{res}	28.25	kg/m^3
Reservoir Enthalpy	h_{res}	10.1	MJ/kg

Table 258: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2589

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	4.48×10^{-2}	0	1.32×10^{-1}	0	6.20×10^{-3}	1.18×10^{-1}

Table 259: Computed reservoir species mass fractions, Shot 2589

33.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4058	1500.0	1500.0	5.33	26.3	0.060	4.49×10^{6}
72 cm	4033	1545.1	1554.1	5.07	31.7	0.070	5.14×10^{6}

Table 260: Computed freestream conditions, Shot 2589

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.96×10^{-9}	2.19×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	2.05×10^{-8}	1.34×10^{-2}

Table 261: Computed freestream species mass fractions, Shot 2589

33.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4017	1631.8	1631.8	5.06	37.4	0.078	5.48×10^{6}
72 cm	3965	1741.4	1739.5	4.70	44.8	0.088	5.84×10^{6}

Table 262: Computed boundary layer edge conditions, Shot 2589

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.96×10^{-9}	2.19×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	6.88×10^{-8}	1.29×10^{-2}

Table 263: Computed boundary layer edge species mass fractions, Shot 2589

	T^* K	Unit Re^* 1/m
1D 100 cm	1928	4.12×10^{6}
72 cm	1906	5.34×10^{6}

Table 264: Dorrance reference conditions, Shot 2589

33.5 Stability Computations

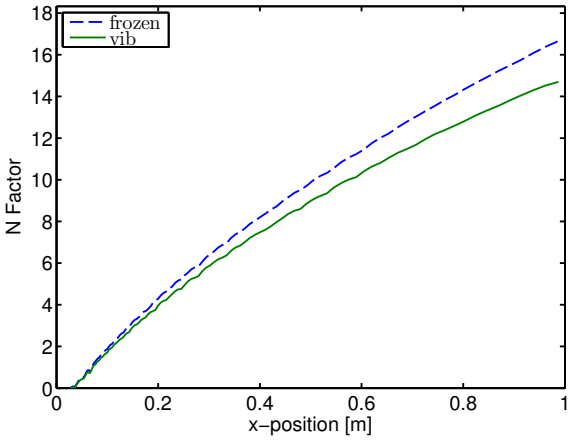


Figure 97: Locus of maximum N factor with and without vibrational energy transfer, Shot 2589

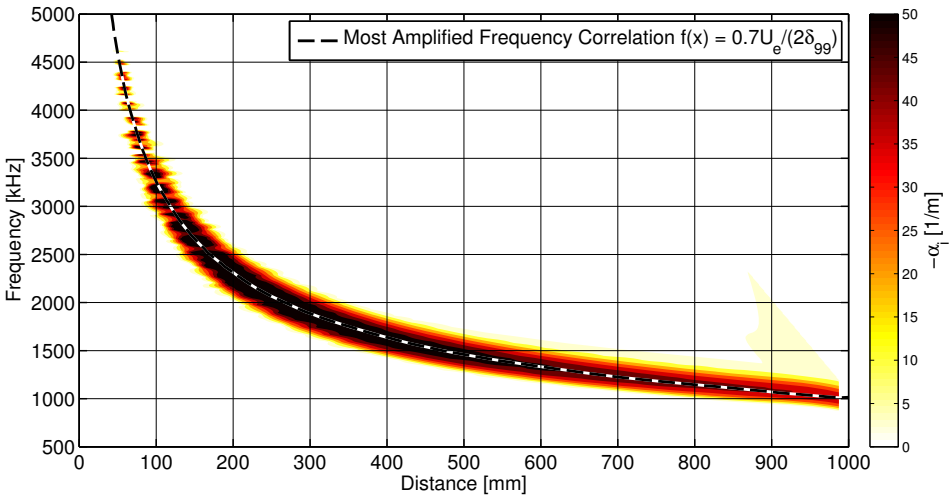


Figure 98: Stability diagram with vibrational energy transfer, Shot 2589. Dashed line indicates $0.7U_e/(2\delta_{99})$.

33.6 Heat Transfer Results

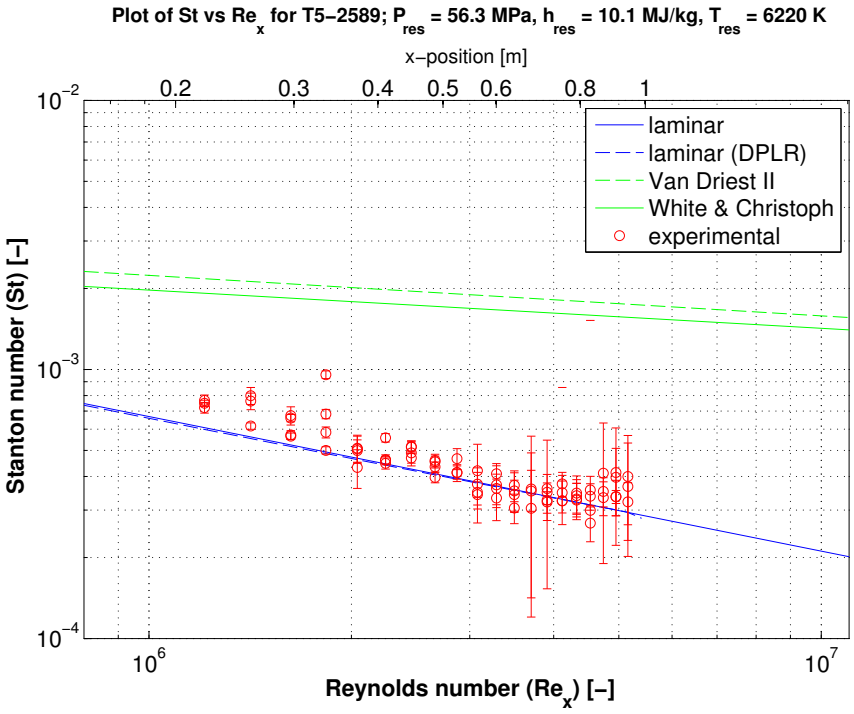


Figure 99: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

34 Shot 2590

Experiment 2590 was performed in T5 on 2 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

34.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	55.9	MPa

Table 265: Measured quantities, Shot 2590

34.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6032	K
Reservoir Density	ρ_{res}	29.14	kg/m^3
Reservoir Enthalpy	h_{res}	9.62	MJ/kg

Table 266: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2590

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.20×10^{-2}	0	1.35×10^{-1}	0	4.61×10^{-3}	1.09×10^{-1}

Table 267: Computed reservoir species mass fractions, Shot 2590

34.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3983	1432.0	1432.0	5.36	26.0	0.062	4.72×10^6
72 cm	3957	1466.5	1475.2	5.11	30.8	0.072	5.37×10^6

Table 268: Computed freestream conditions, Shot 2590

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.07×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	9.07×10^{-9}	1.09×10^{-2}

Table 269: Computed freestream species mass fractions, Shot 2590

34.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3944	1559.8	1559.8	5.08	37.0	0.081	5.76×10^6
72 cm	3890	1655.4	1653.4	4.73	43.7	0.091	6.11×10^6

Table 270: Computed boundary layer edge conditions, Shot 2590

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.07×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.41×10^{-8}	1.05×10^{-2}

Table 271: Computed boundary layer edge species mass fractions, Shot 2590

	T^* K	Unit Re^* 1/m
1D 100 cm	1862	4.26×10^6
72 cm	1836	5.51×10^6

Table 272: Dorrance reference conditions, Shot 2590

34.5 Stability Computations

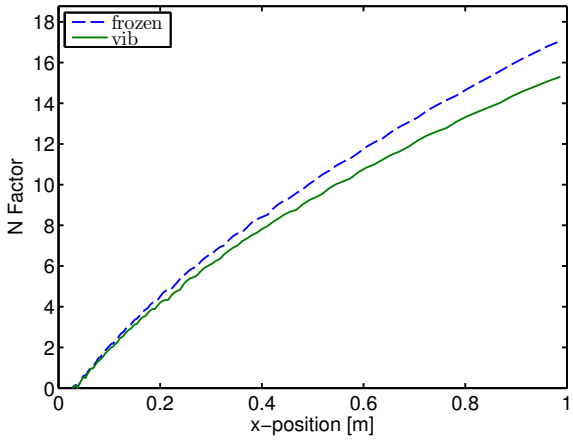


Figure 100: Locus of maximum N factor with and without vibrational energy transfer, Shot 2590

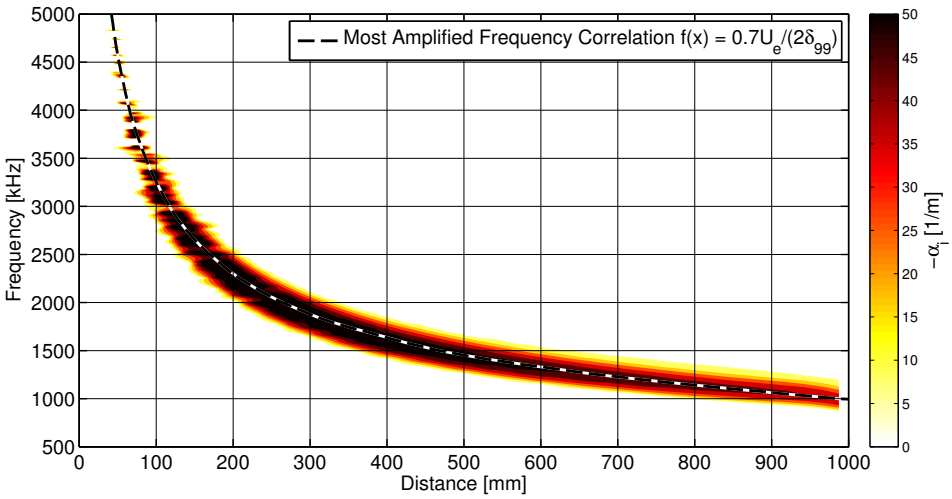


Figure 101: Stability diagram with vibrational energy transfer, Shot 2590. Dashed line indicates $0.7U_e/(2\delta_{99})$.

34.6 Heat Transfer Results

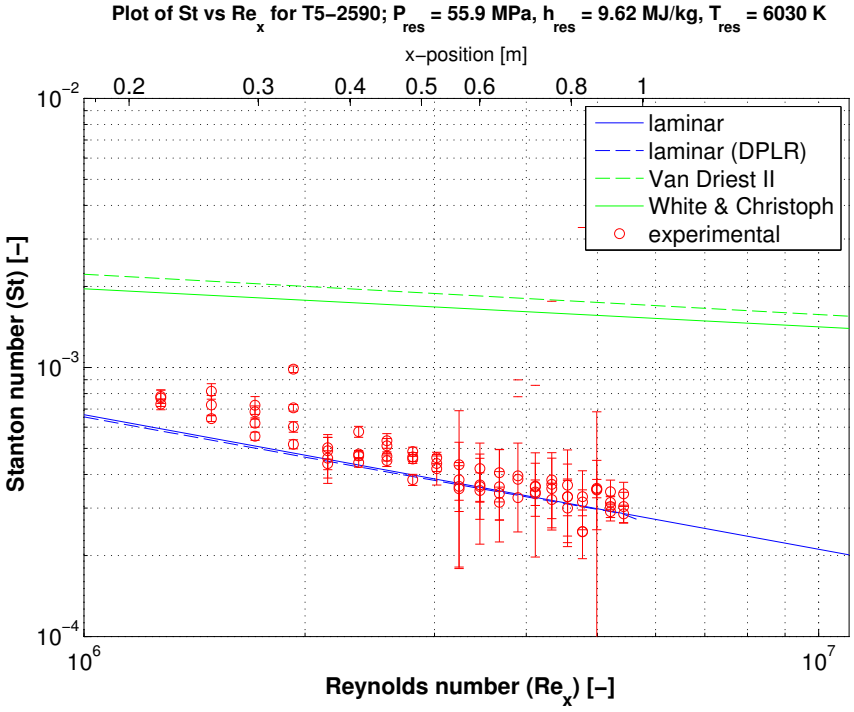


Figure 102: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

35 Shot 2591

Experiment 2591 was performed in T5 on 3 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

35.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	84.90	kPa
Reservoir Pressure	P_{res}	53.2	MPa

Table 273: Measured quantities, Shot 2591

35.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5842	K
Reservoir Density	ρ_{res}	28.86	kg/m^3
Reservoir Enthalpy	h_{res}	9.19	MJ/kg

Table 274: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2591

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.95×10^{-2}	0	1.37×10^{-1}	0	3.42×10^{-3}	1.00×10^{-1}

Table 275: Computed reservoir species mass fractions, Shot 2591

35.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3907	1361.0	1361.0	5.39	24.5	0.062	4.76×10^{6}
72 cm	3879	1387.1	1395.5	5.16	28.6	0.071	5.38×10^{6}

Table 276: Computed freestream conditions, Shot 2591

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.67×10^{-9}	1.61×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	3.86×10^{-9}	9.24×10^{-3}

Table 277: Computed freestream species mass fractions, Shot 2591

35.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3868	1483.9	1483.9	5.11	35.0	0.081	5.83×10^{6}
72 cm	3814	1568.8	1566.6	4.77	40.8	0.090	6.13×10^{6}

Table 278: Computed boundary layer edge conditions, Shot 2591

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.07×10^{-2}	0	1.67×10^{-9}	1.61×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	1.67×10^{-8}	8.95×10^{-3}

Table 279: Computed boundary layer edge species mass fractions, Shot 2591

	T^* K	Unit Re^* 1/m
1D 100 cm	1795	4.22×10^{6}
72 cm	1766	5.45×10^{6}

Table 280: Dorrance reference conditions, Shot 2591

35.5 Stability Computations

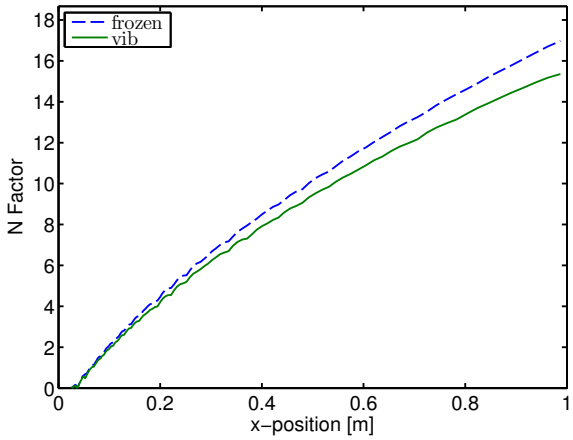


Figure 103: Locus of maximum N factor with and without vibrational energy transfer, Shot 2591

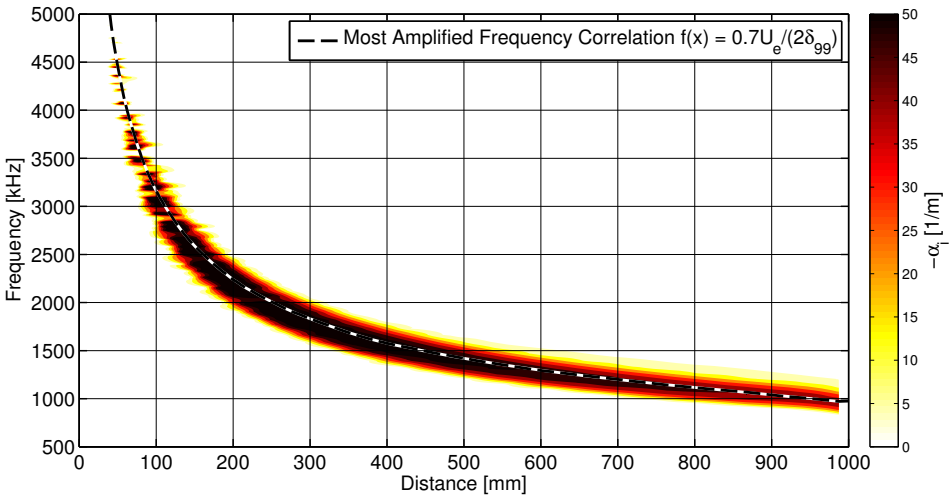


Figure 104: Stability diagram with vibrational energy transfer, Shot 2591. Dashed line indicates $0.7U_e/(2\delta_{99})$.

35.6 Heat Transfer Results

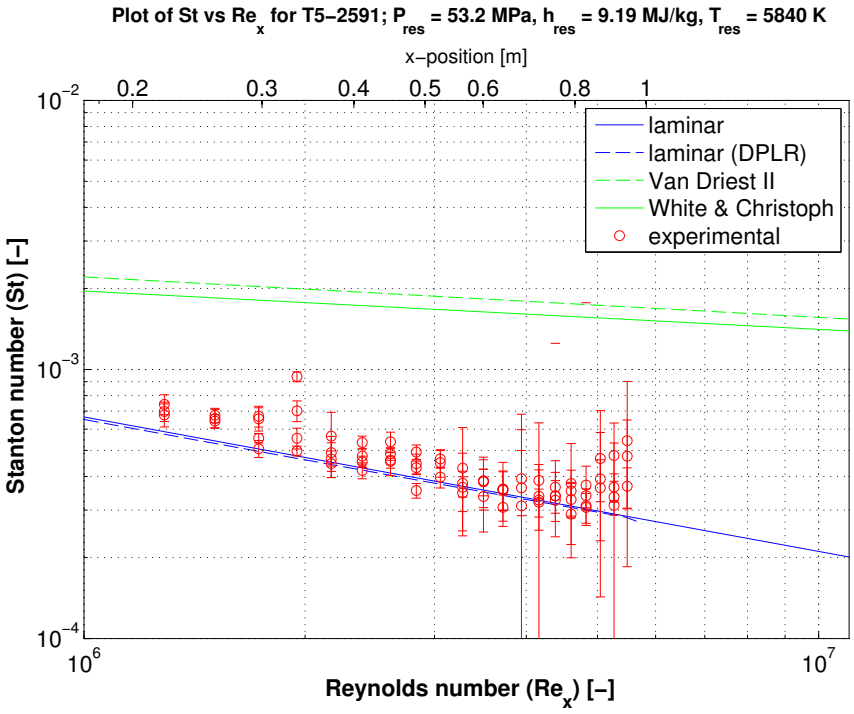


Figure 105: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

36 Shot 2592

Experiment 2592 was performed in T5 on 4 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

36.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	85.05	kPa
Reservoir Pressure	P_{res}	52.5	MPa

Table 281: Measured quantities, Shot 2592

36.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6005	K
Reservoir Density	ρ_{res}	27.49	kg/m^3
Reservoir Enthalpy	h_{res}	9.59	MJ/kg

Table 282: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2592

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.19×10^{-2}	0	1.34×10^{-1}	0	4.55×10^{-3}	1.09×10^{-1}

Table 283: Computed reservoir species mass fractions, Shot 2592

36.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3978	1424.0	1424.0	5.36	24.5	0.059	4.48×10^6
72 cm	3949	1458.2	1467.3	5.12	28.8	0.068	5.06×10^6

Table 284: Computed freestream conditions, Shot 2592

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	3.94×10^{-9}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	8.98×10^{-9}	1.15×10^{-2}

Table 285: Computed freestream species mass fractions, Shot 2592

36.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3938	1551.3	1551.3	5.09	34.9	0.077	5.47×10^6
72 cm	3882	1646.6	1644.5	4.73	40.9	0.085	5.76×10^6

Table 286: Computed boundary layer edge conditions, Shot 2592

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	3.94×10^{-9}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.44×10^{-8}	1.11×10^{-2}

Table 287: Computed boundary layer edge species mass fractions, Shot 2592

	T^* K	Unit Re^* 1/m
1D 100 cm	1856	4.04×10^6
72 cm	1829	5.18×10^6

Table 288: Dorrance reference conditions, Shot 2592

36.5 Stability Computations

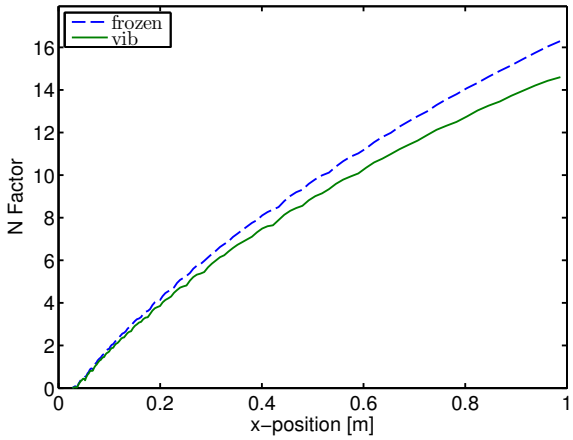


Figure 106: Locus of maximum N factor with and without vibrational energy transfer, Shot 2592

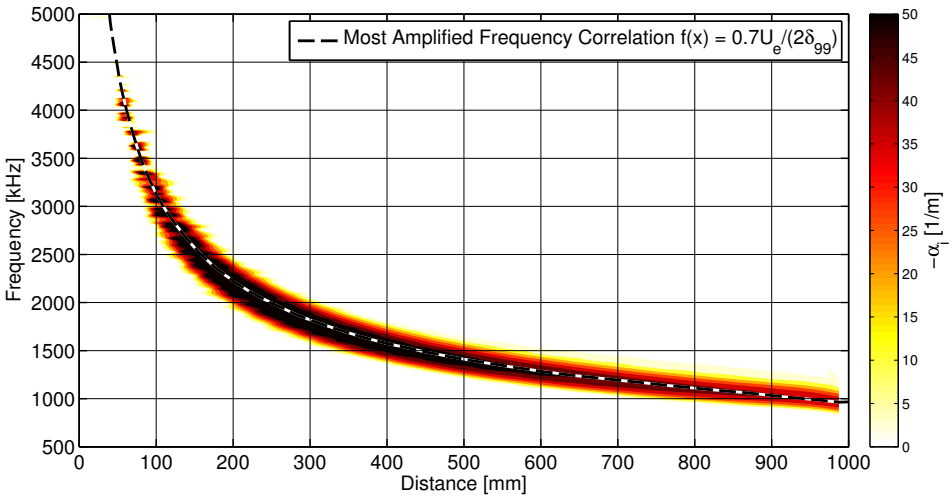


Figure 107: Stability diagram with vibrational energy transfer, Shot 2592. Dashed line indicates $0.7U_e/(2\delta_{99})$.

36.6 Heat Transfer Results

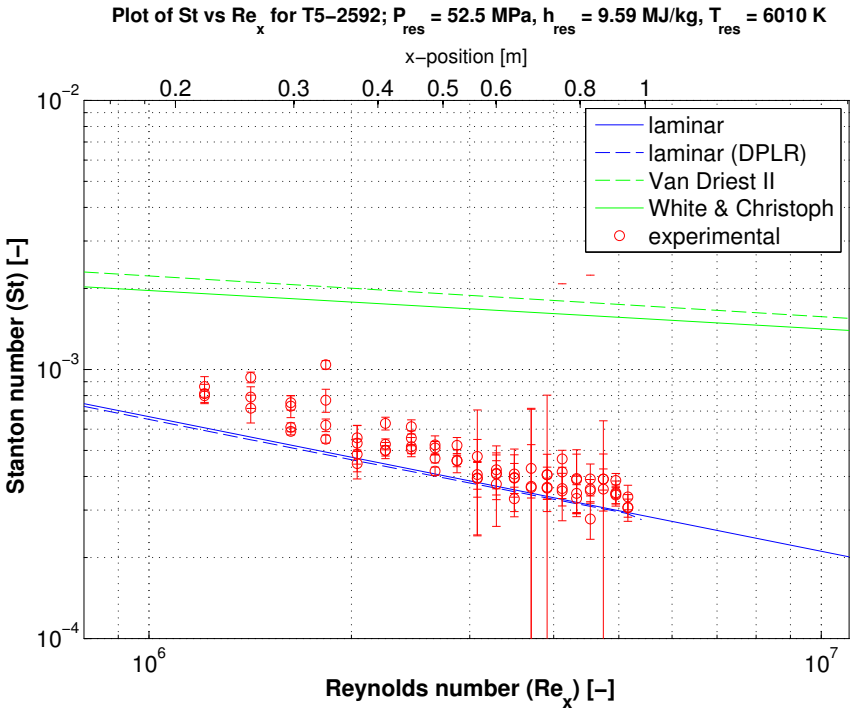


Figure 108: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

37 Shot 2593

Experiment 2593 was performed in T5 on 5 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

37.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	55.2	MPa

Table 289: Measured quantities, Shot 2593

37.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6058	K
Reservoir Density	ρ_{res}	28.64	kg/m^3
Reservoir Enthalpy	h_{res}	9.69	MJ/kg

Table 290: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2593

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.07×10^{-2}	0	1.35×10^{-1}	0	4.84×10^{-3}	1.10×10^{-1}

Table 291: Computed reservoir species mass fractions, Shot 2593

37.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3989	1437.0	1437.0	5.36	25.4	0.060	4.58×10^6
72 cm	3968	1478.0	1486.8	5.11	30.5	0.071	5.26×10^6

Table 292: Computed freestream conditions, Shot 2593

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.00×10^{-2}	0	4.43×10^{-9}	1.92×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	1.04×10^{-8}	1.14×10^{-2}

Table 293: Computed freestream species mass fractions, Shot 2593

37.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3950	1564.4	1564.4	5.08	36.1	0.079	5.60×10^6
72 cm	3901	1668.2	1666.1	4.73	43.3	0.089	5.99×10^6

Table 294: Computed boundary layer edge conditions, Shot 2593

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.00×10^{-2}	0	4.43×10^{-9}	1.92×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.86×10^{-8}	1.10×10^{-2}

Table 295: Computed boundary layer edge species mass fractions, Shot 2593

	T^* K	Unit Re^* 1/m
1D 100 cm	1867	4.14×10^6
72 cm	1847	5.41×10^6

Table 296: Dorrance reference conditions, Shot 2593

37.5 Stability Computations

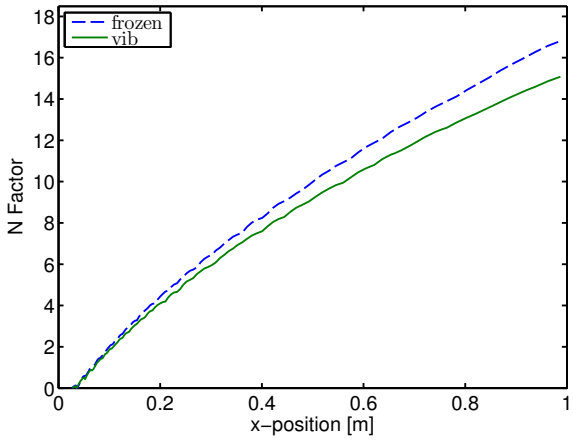


Figure 109: Locus of maximum N factor with and without vibrational energy transfer, Shot 2593

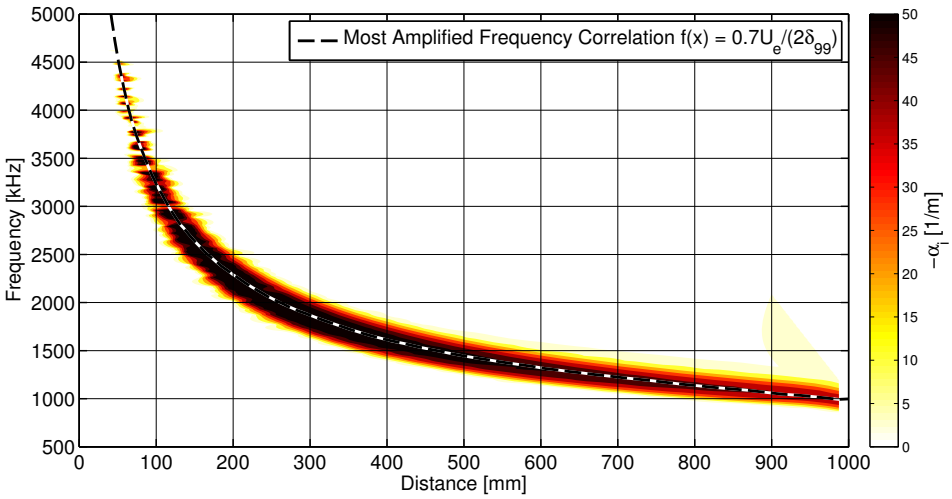


Figure 110: Stability diagram with vibrational energy transfer, Shot 2593. Dashed line indicates $0.7U_e/(2\delta_{99})$.

37.6 Heat Transfer Results

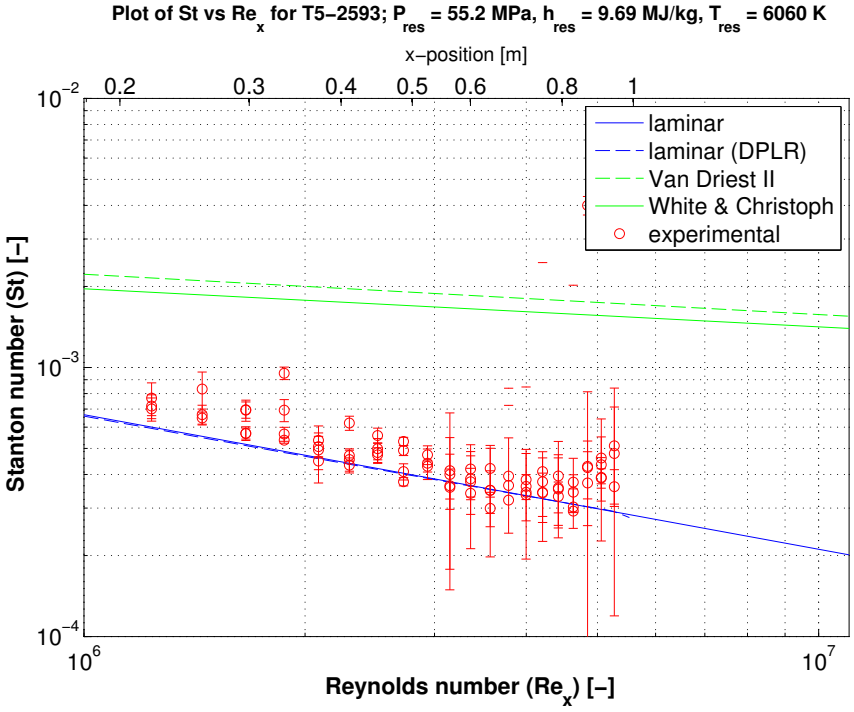


Figure 111: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

38 Shot 2594

Experiment 2594 was performed in T5 on 6 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

38.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3110	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	56.1	MPa

Table 297: Measured quantities, Shot 2594

38.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6002	K
Reservoir Density	ρ_{res}	29.46	kg/m^3
Reservoir Enthalpy	h_{res}	9.55	MJ/kg

Table 298: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2594

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.34×10^{-2}	0	1.36×10^{-1}	0	4.38×10^{-3}	1.07×10^{-1}

Table 299: Computed reservoir species mass fractions, Shot 2594

38.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3968	1419.0	1419.0	5.36	25.9	0.062	4.76×10^6
72 cm	3944	1453.3	1461.8	5.12	30.8	0.073	5.44×10^6

Table 300: Computed freestream conditions, Shot 2594

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.02×10^{-2}	0	3.45×10^{-9}	1.79×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	7.79×10^{-9}	1.05×10^{-2}

Table 301: Computed freestream species mass fractions, Shot 2594

38.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3929	1545.2	1545.2	5.09	36.9	0.082	5.82×10^6
72 cm	3878	1640.8	1638.8	4.74	43.8	0.092	6.19×10^6

Table 302: Computed boundary layer edge conditions, Shot 2594

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.02×10^{-2}	0	3.45×10^{-9}	1.79×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	2.98×10^{-8}	1.01×10^{-2}

Table 303: Computed boundary layer edge species mass fractions, Shot 2594

	T^* K	Unit Re^* 1/m
1D 100 cm	1850	4.29×10^6
72 cm	1824	5.57×10^6

Table 304: Dorrance reference conditions, Shot 2594

38.5 Stability Computations

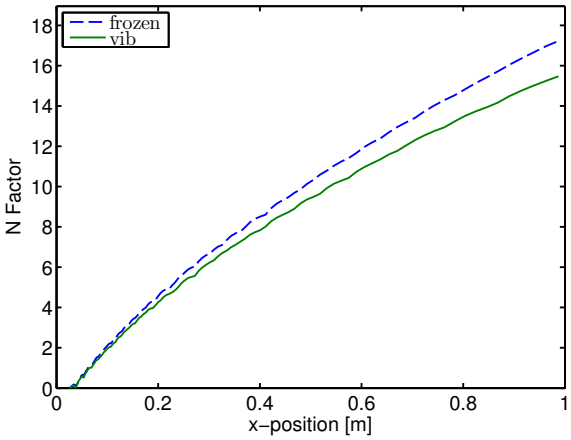


Figure 112: Locus of maximum N factor with and without vibrational energy transfer, Shot 2594

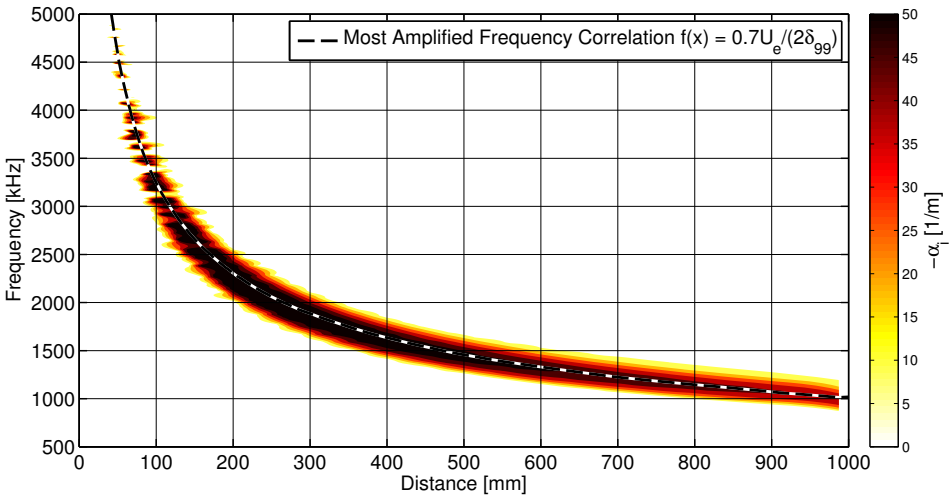


Figure 113: Stability diagram with vibrational energy transfer, Shot 2594. Dashed line indicates $0.7U_e/(2\delta_{99})$.

38.6 Heat Transfer Results

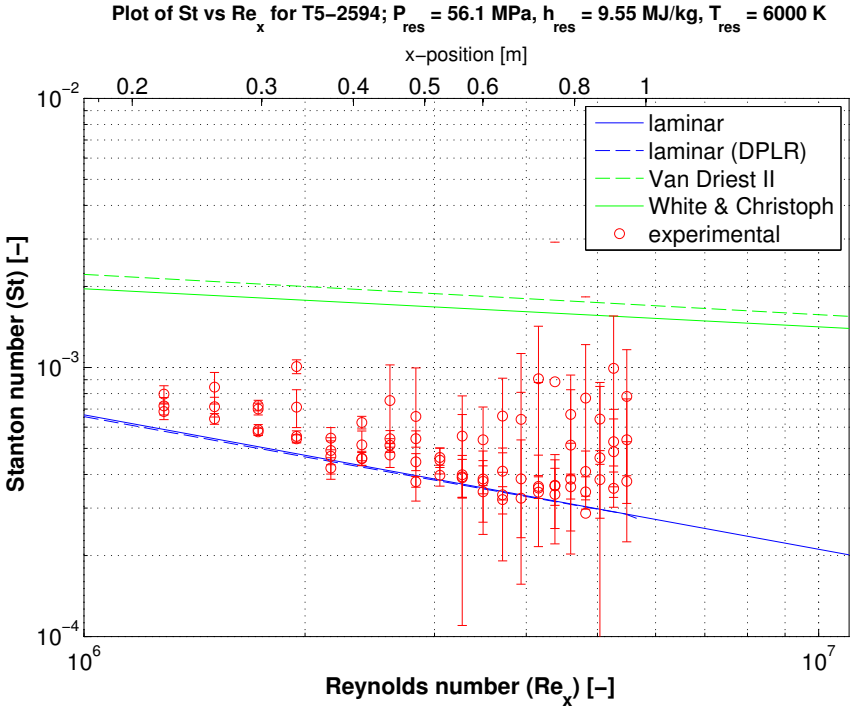


Figure 114: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

39 Shot 2595

Experiment 2595 was performed in T5 on 18 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

39.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3150	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	55.3	MPa

Table 305: Measured quantities, Shot 2595

39.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6074	K
Reservoir Density	ρ_{res}	28.56	kg/m^3
Reservoir Enthalpy	h_{res}	9.73	MJ/kg

Table 306: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2595

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.01×10^{-2}	0	1.34×10^{-1}	0	4.97×10^{-3}	1.11×10^{-1}

Table 307: Computed reservoir species mass fractions, Shot 2595

39.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3997	1443.0	1443.0	5.35	25.4	0.060	4.57×10^6
72 cm	3974	1484.7	1493.6	5.10	30.6	0.071	5.24×10^6

Table 308: Computed freestream conditions, Shot 2595

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.72×10^{-9}	1.95×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.12×10^{-8}	1.17×10^{-2}

Table 309: Computed freestream species mass fractions, Shot 2595

39.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3957	1571.3	1571.3	5.08	36.2	0.079	5.58×10^6
72 cm	3908	1675.3	1673.3	4.72	43.4	0.089	5.96×10^6

Table 310: Computed boundary layer edge conditions, Shot 2595

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.00×10^{-2}	0	4.72×10^{-9}	1.95×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	4.10×10^{-8}	1.12×10^{-2}

Table 311: Computed boundary layer edge species mass fractions, Shot 2595

	T^* K	Unit Re^* 1/m
1D 100 cm	1874	4.14×10^6
72 cm	1853	5.39×10^6

Table 312: Dorrance reference conditions, Shot 2595

39.5 Stability Computations

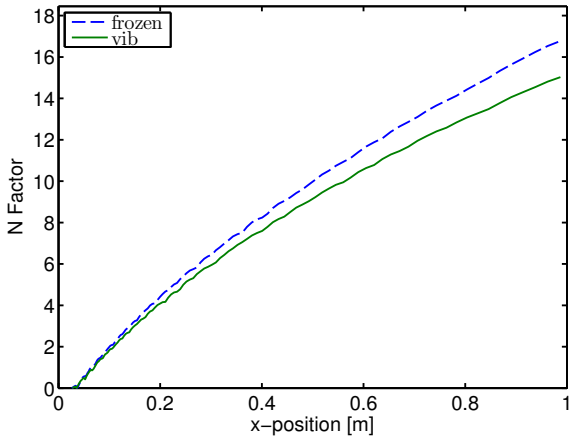


Figure 115: Locus of maximum N factor with and without vibrational energy transfer, Shot 2595

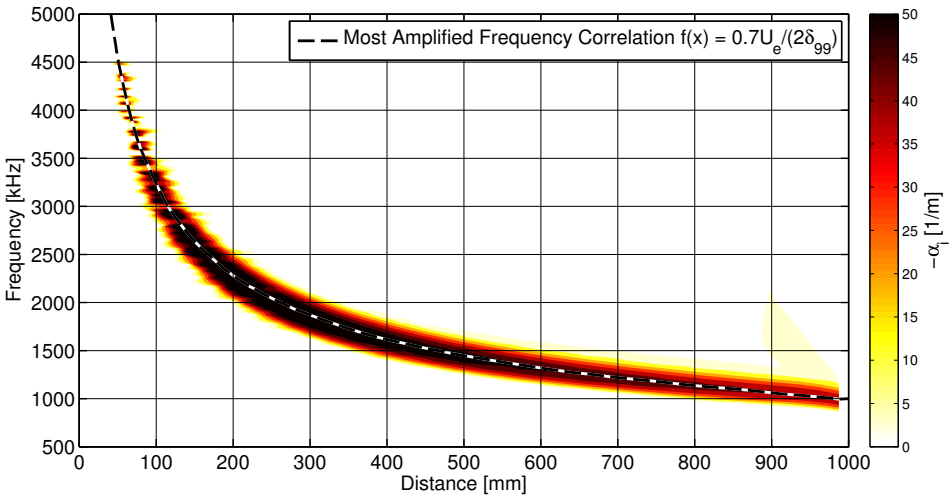


Figure 116: Stability diagram with vibrational energy transfer, Shot 2595. Dashed line indicates $0.7U_e/(2\delta_{99})$.

39.6 Heat Transfer Results

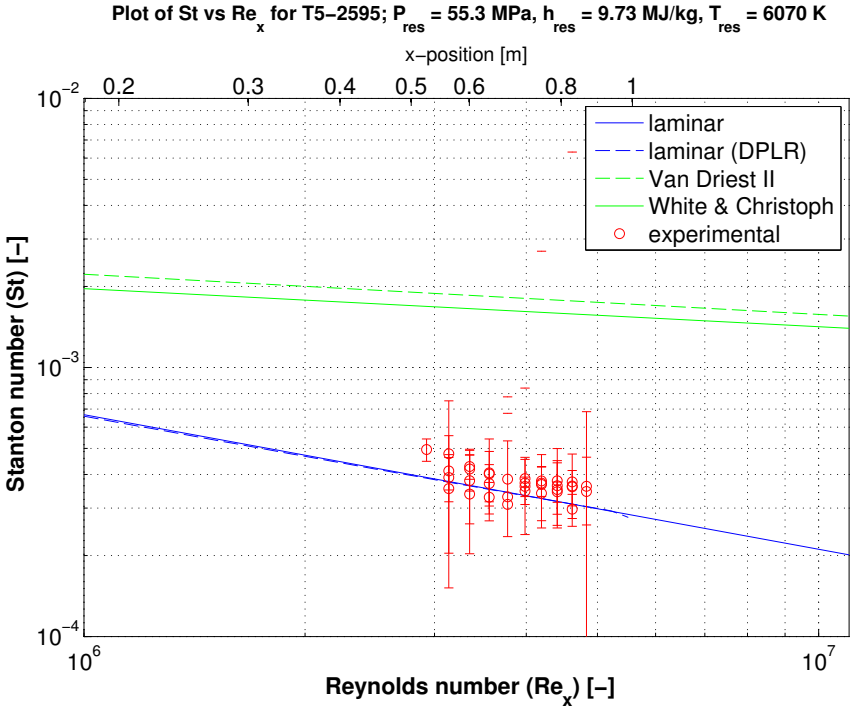


Figure 117: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

40 Shot 2596

Experiment 2596 was performed in T5 on 20 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

40.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	54.1	MPa

Table 313: Measured quantities, Shot 2596

40.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6069	K
Reservoir Density	ρ_{res}	27.98	kg/m^3
Reservoir Enthalpy	h_{res}	9.73	MJ/kg

Table 314: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2596

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.98×10^{-2}	0	1.34×10^{-1}	0	4.99×10^{-3}	1.12×10^{-1}

Table 315: Computed reservoir species mass fractions, Shot 2596

40.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4000	1445.0	1445.0	5.35	25.2	0.059	4.51×10^6
72 cm	3974	1484.0	1493.0	5.10	29.9	0.069	5.14×10^6

Table 316: Computed freestream conditions, Shot 2596

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	4.92×10^{-9}	1.98×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	1.14×10^{-8}	1.19×10^{-2}

Table 317: Computed freestream species mass fractions, Shot 2596

40.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3960	1573.7	1573.7	5.08	35.8	0.078	5.51×10^6
72 cm	3907	1674.6	1672.5	4.72	42.5	0.087	5.84×10^6

Table 318: Computed boundary layer edge conditions, Shot 2596

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	4.92×10^{-9}	1.98×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	4.19×10^{-8}	1.15×10^{-2}

Table 319: Computed boundary layer edge species mass fractions, Shot 2596

	T^* K	Unit Re^* 1/m
1D 100 cm	1876	4.09×10^6
72 cm	1852	5.28×10^6

Table 320: Dorrance reference conditions, Shot 2596

40.5 Stability Computations

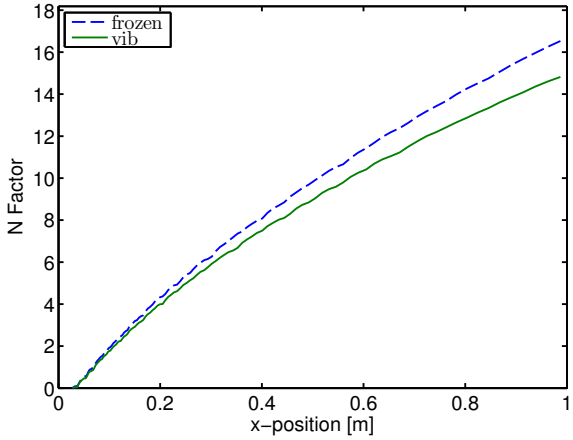


Figure 118: Locus of maximum N factor with and without vibrational energy transfer, Shot 2596

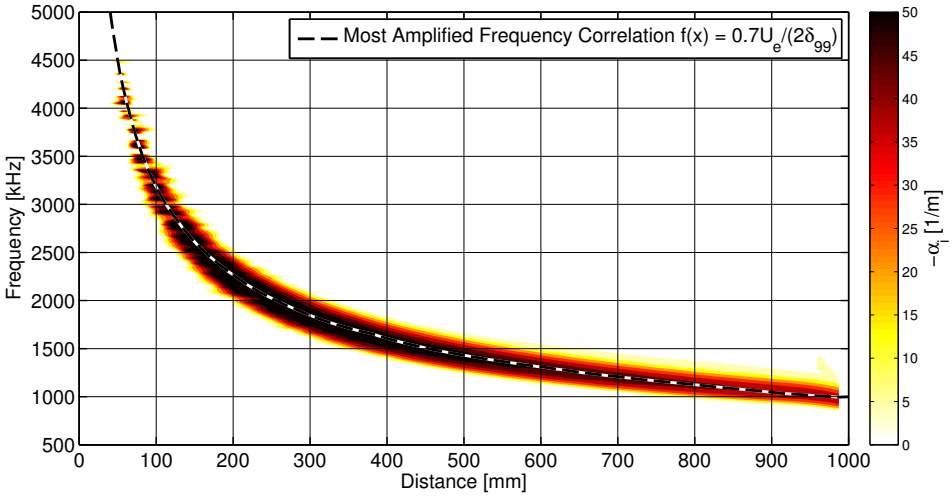


Figure 119: Stability diagram with vibrational energy transfer, Shot 2596. Dashed line indicates $0.7U_e/(2\delta_{99})$.

40.6 Heat Transfer Results

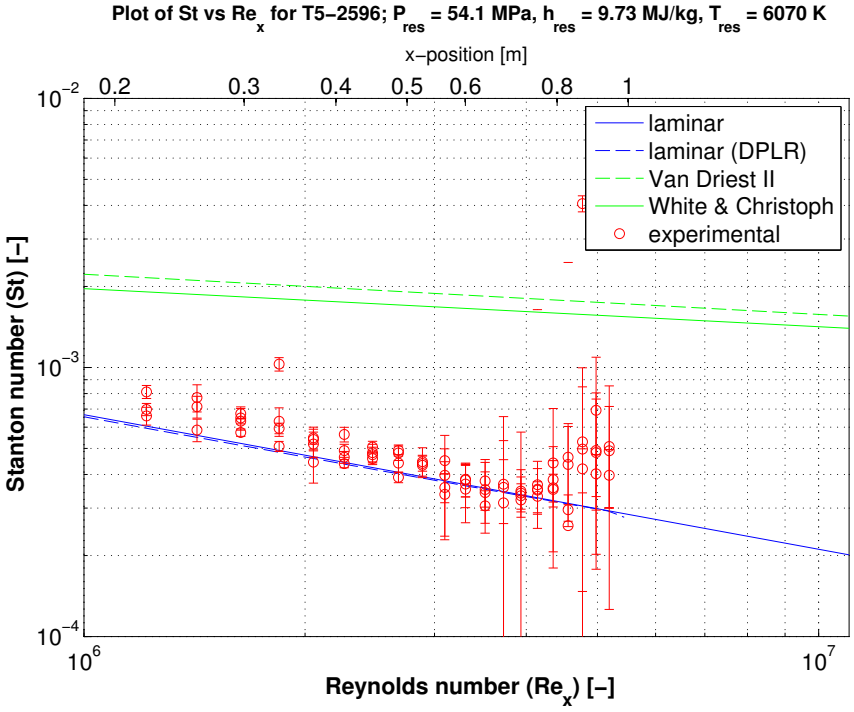


Figure 120: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

41 Shot 2597

Experiment 2597 was performed in T5 on 23 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

41.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	85.20	kPa
Reservoir Pressure	P_{res}	55.6	MPa

Table 321: Measured quantities, Shot 2597

41.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6103	K
Reservoir Density	ρ_{res}	28.55	kg/m^3
Reservoir Enthalpy	h_{res}	9.80	MJ/kg

Table 322: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2597

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	4.90×10^{-2}	0	1.34×10^{-1}	0	5.20×10^{-3}	1.12×10^{-1}

Table 323: Computed reservoir species mass fractions, Shot 2597

41.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4009	1454.0	1454.0	5.35	25.7	0.060	4.56×10^6
72 cm	3986	1497.0	1505.9	5.10	30.9	0.071	5.23×10^6

Table 324: Computed freestream conditions, Shot 2597

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	5.55×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.30×10^{-2}	0	1.27×10^{-8}	1.20×10^{-2}

Table 325: Computed freestream species mass fractions, Shot 2597

41.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3969	1583.4	1583.4	5.07	36.5	0.079	5.56×10^6
72 cm	3919	1688.7	1686.7	4.72	43.7	0.089	5.95×10^6

Table 326: Computed boundary layer edge conditions, Shot 2597

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.99×10^{-2}	0	5.55×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.30×10^{-2}	0	4.56×10^{-8}	1.15×10^{-2}

Table 327: Computed boundary layer edge species mass fractions, Shot 2597

	T^* K	Unit Re^* 1/m
1D 100 cm	1884	4.14×10^6
72 cm	1864	5.39×10^6

Table 328: Dorrance reference conditions, Shot 2597

41.5 Stability Computations

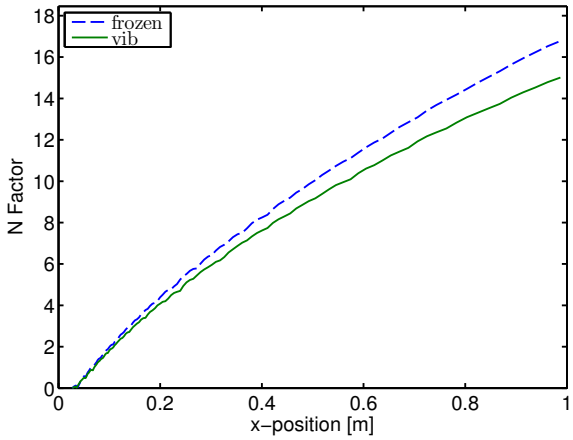


Figure 121: Locus of maximum N factor with and without vibrational energy transfer, Shot 2597

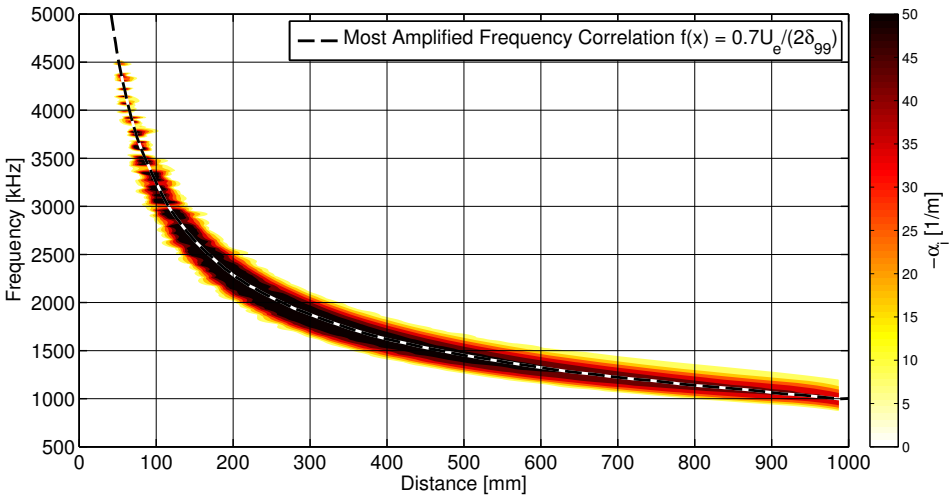


Figure 122: Stability diagram with vibrational energy transfer, Shot 2597. Dashed line indicates $0.7U_e/(2\delta_{99})$.

41.6 Heat Transfer Results

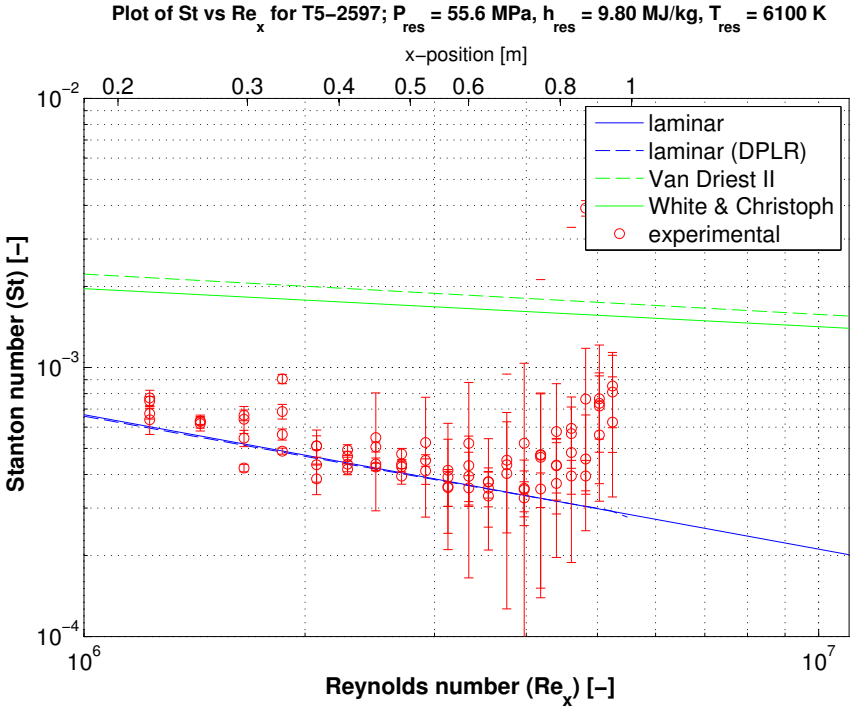


Figure 123: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

42 Shot 2598

Experiment 2598 was performed in T5 on 24 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

42.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3200	m/s
Shock Tube Fill Pressure	P_1	84.90	kPa
Reservoir Pressure	P_{res}	55.3	MPa

Table 329: Measured quantities, Shot 2598

42.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6171	K
Reservoir Density	ρ_{res}	27.99	kg/m^3
Reservoir Enthalpy	h_{res}	9.97	MJ/kg

Table 330: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2598

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	4.62×10^{-2}	0	1.33×10^{-1}	0	5.81×10^{-3}	1.16×10^{-1}

Table 331: Computed reservoir species mass fractions, Shot 2598

42.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4041	1484.0	1484.0	5.33	25.9	0.059	4.48×10^6
72 cm	4014	1526.0	1535.1	5.08	30.9	0.069	5.10×10^6

Table 332: Computed freestream conditions, Shot 2598

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.96×10^{-2}	0	7.09×10^{-9}	2.13×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	1.73×10^{-8}	1.30×10^{-2}

Table 333: Computed freestream species mass fractions, Shot 2598

42.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4001	1614.6	1614.6	5.06	36.8	0.078	5.46×10^6
72 cm	3947	1720.4	1718.4	4.70	43.8	0.087	5.80×10^6

Table 334: Computed boundary layer edge conditions, Shot 2598

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.96×10^{-2}	0	7.09×10^{-9}	2.13×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	5.96×10^{-8}	1.25×10^{-2}

Table 335: Computed boundary layer edge species mass fractions, Shot 2598

	T^* K	Unit Re^* 1/m
1D 100 cm	1913	4.10×10^6
72 cm	1889	5.29×10^6

Table 336: Dorrance reference conditions, Shot 2598

42.5 Stability Computations

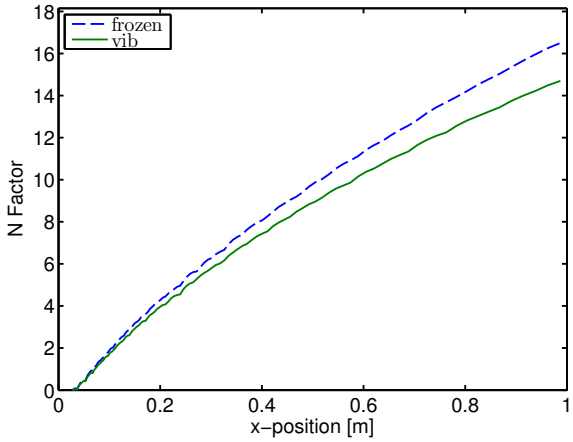


Figure 124: Locus of maximum N factor with and without vibrational energy transfer, Shot 2598

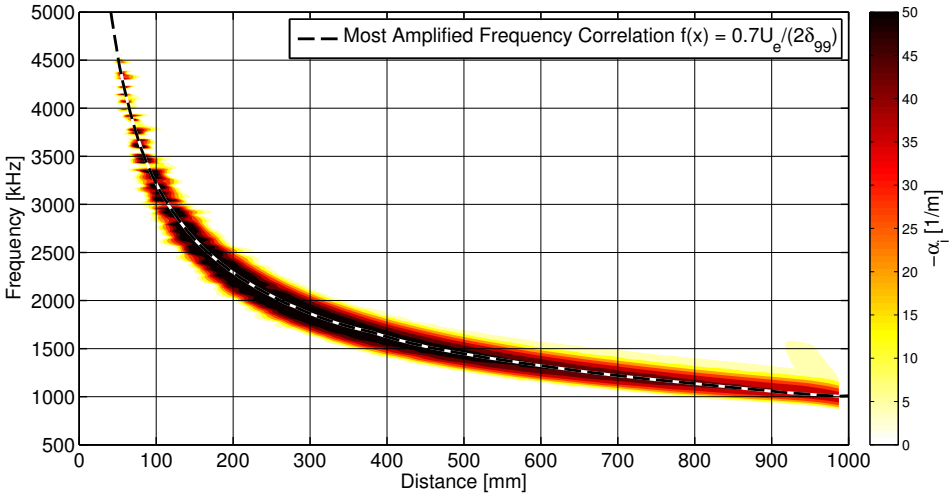


Figure 125: Stability diagram with vibrational energy transfer, Shot 2598. Dashed line indicates $0.7U_e/(2\delta_{99})$.

42.6 Heat Transfer Results

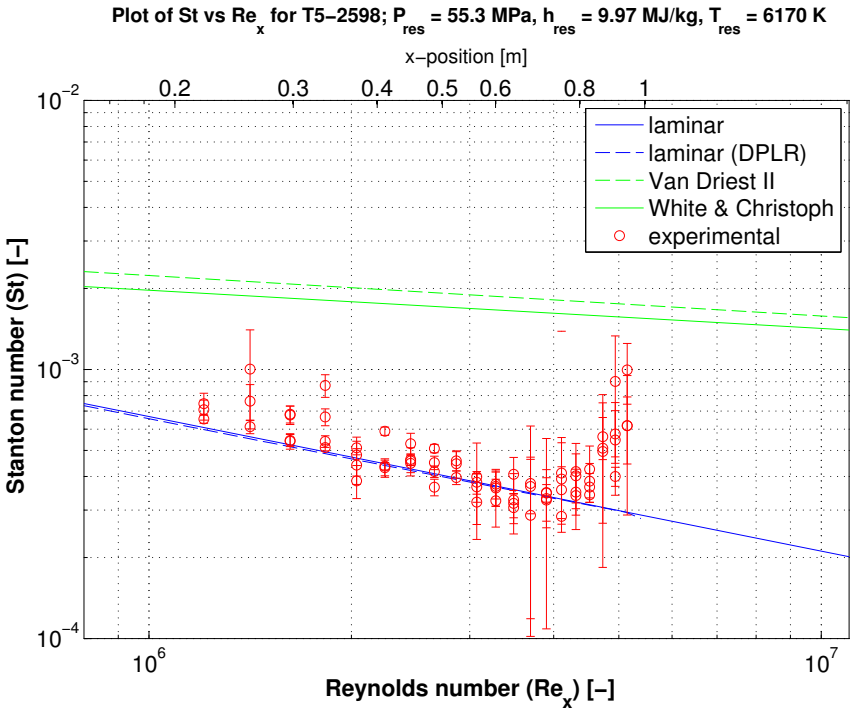


Figure 126: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

43 Shot 2599

Experiment 2599 was performed in T5 on 26 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

43.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	67.35	kPa
Reservoir Pressure	P_{res}	47.7	MPa

Table 337: Measured quantities, Shot 2599

43.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6217	K
Reservoir Density	ρ_{res}	23.79	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 338: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2599

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	4.16×10^{-2}	0	1.28×10^{-1}	0	6.75×10^{-3}	1.23×10^{-1}

Table 339: Computed reservoir species mass fractions, Shot 2599

43.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4068	1497.0	1497.0	5.33	22.3	0.050	3.81×10^6
72 cm	4041	1550.2	1560.6	5.06	26.7	0.059	4.31×10^6

Table 340: Computed freestream conditions, Shot 2599

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.75×10^{-1}	0	5.92×10^{-2}	0	1.05×10^{-8}	2.60×10^{-2}
72 cm	7.33×10^{-1}	1.78×10^{-1}	0	7.28×10^{-2}	0	2.67×10^{-8}	1.66×10^{-2}

Table 341: Computed freestream species mass fractions, Shot 2599

43.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4027	1629.5	1629.5	5.06	31.7	0.066	4.64×10^6
72 cm	3973	1748.2	1745.9	4.69	37.8	0.074	4.89×10^6

Table 342: Computed boundary layer edge conditions, Shot 2599

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.75×10^{-1}	0	5.92×10^{-2}	0	1.05×10^{-8}	2.60×10^{-2}
72 cm	7.33×10^{-1}	1.78×10^{-1}	0	7.28×10^{-2}	0	9.05×10^{-8}	1.60×10^{-2}

Table 343: Computed boundary layer edge species mass fractions, Shot 2599

	T^* K	Unit Re^* 1/m
1D 100 cm	1931	3.48×10^6
72 cm	1914	4.47×10^6

Table 344: Dorrance reference conditions, Shot 2599

43.5 Stability Computations

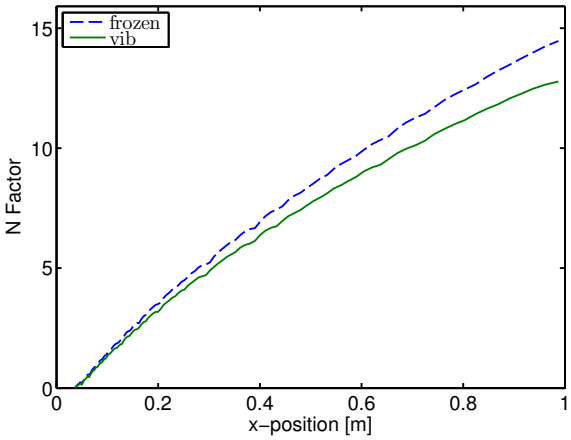


Figure 127: Locus of maximum N factor with and without vibrational energy transfer, Shot 2599

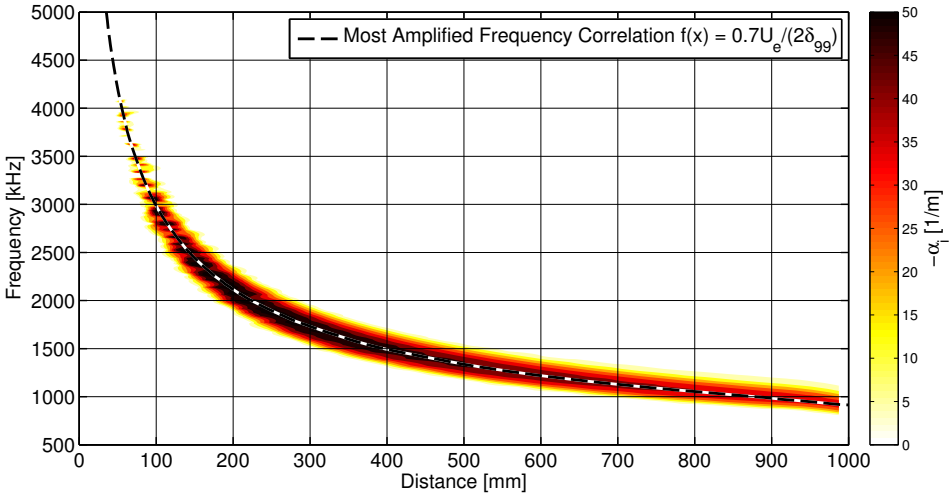


Figure 128: Stability diagram with vibrational energy transfer, Shot 2599. Dashed line indicates $0.7U_e/(2\delta_{99})$.

43.6 Heat Transfer Results

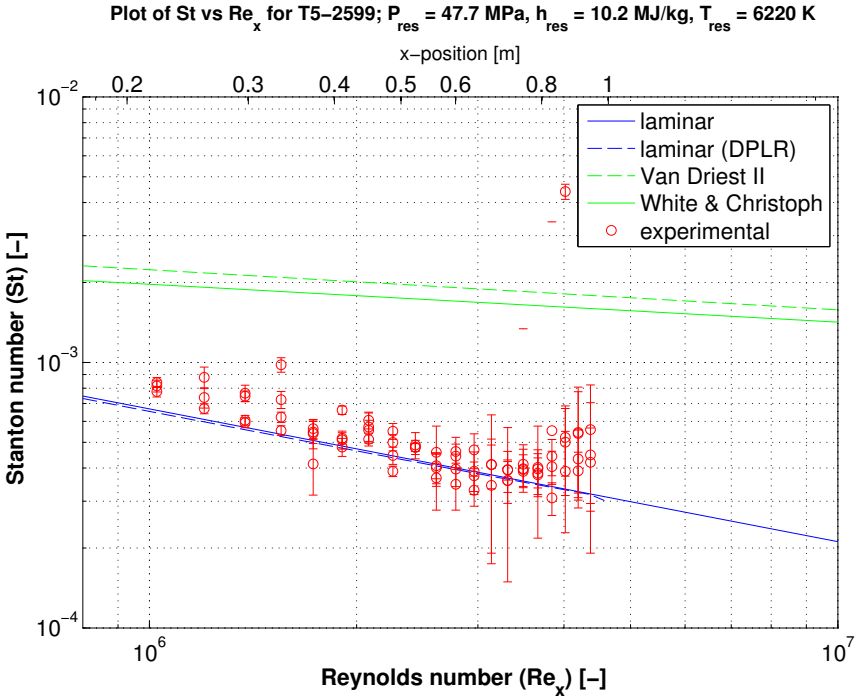


Figure 129: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

44 Shot 2600

Experiment 2600 was performed in T5 on 27 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

44.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	85.05	kPa
Reservoir Pressure	P_{res}	54.7	MPa

Table 345: Measured quantities, Shot 2600

44.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6012	K
Reservoir Density	ρ_{res}	28.66	kg/m^3
Reservoir Enthalpy	h_{res}	9.59	MJ/kg

Table 346: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2600

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.25×10^{-2}	0	1.35×10^{-1}	0	4.51×10^{-3}	1.08×10^{-1}

Table 347: Computed reservoir species mass fractions, Shot 2600

44.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3971	1419.0	1419.0	5.36	25.1	0.060	4.60×10^{6}
72 cm	3950	1458.9	1467.7	5.12	30.1	0.071	5.28×10^{6}

Table 348: Computed freestream conditions, Shot 2600

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.02×10^{-2}	0	3.52×10^{-9}	1.86×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	8.57×10^{-9}	1.10×10^{-2}

Table 349: Computed freestream species mass fractions, Shot 2600

44.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3931	1545.8	1545.8	5.09	35.7	0.079	5.62×10^{6}
72 cm	3883	1647.3	1645.2	4.74	42.7	0.089	6.01×10^{6}

Table 350: Computed boundary layer edge conditions, Shot 2600

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.02×10^{-2}	0	3.52×10^{-9}	1.86×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.26×10^{-8}	1.06×10^{-2}

Table 351: Computed boundary layer edge species mass fractions, Shot 2600

	T^* K	Unit Re^* 1/m
1D 100 cm	1851	4.14×10^{6}
72 cm	1830	5.41×10^{6}

Table 352: Dorrance reference conditions, Shot 2600

44.5 Stability Computations

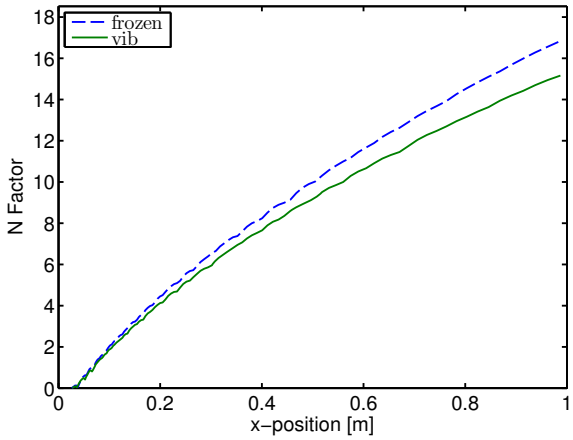


Figure 130: Locus of maximum N factor with and without vibrational energy transfer, Shot 2600

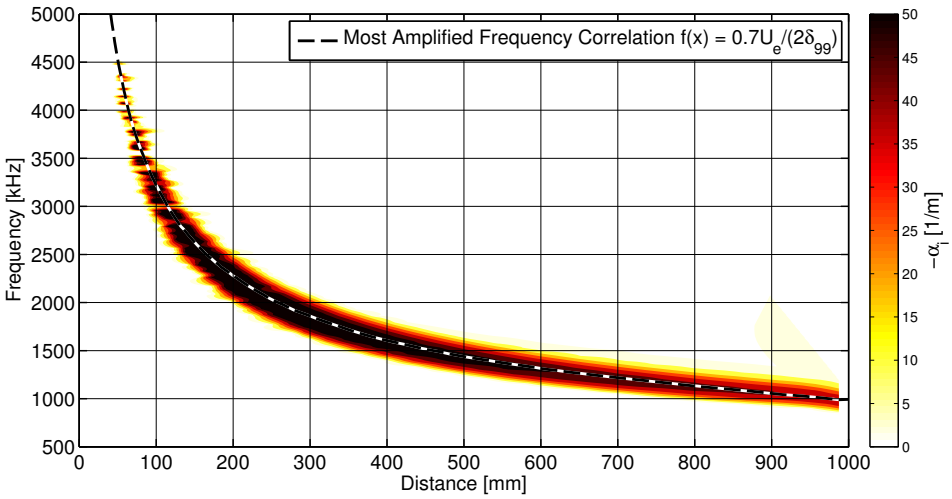


Figure 131: Stability diagram with vibrational energy transfer, Shot 2600. Dashed line indicates $0.7U_e/(2\delta_{99})$.

44.6 Heat Transfer Results

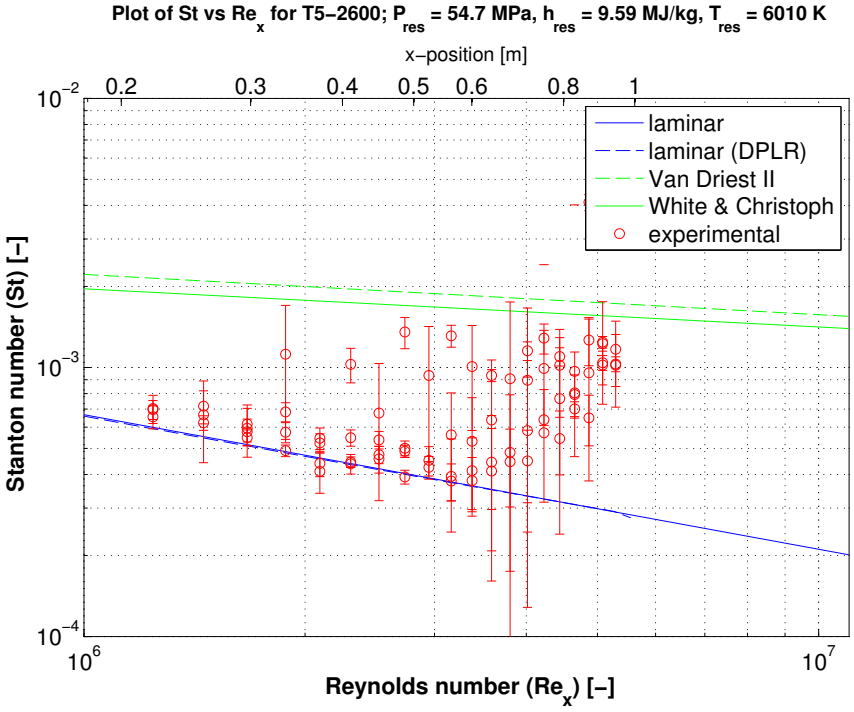


Figure 132: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

45 Shot 2601

Experiment 2601 was performed in T5 on 31 August 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

45.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3190	m/s
Shock Tube Fill Pressure	P_1	102.90	kPa
Reservoir Pressure	P_{res}	74.9	MPa

Table 353: Measured quantities, Shot 2601

45.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6323	K
Reservoir Density	ρ_{res}	37.11	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 354: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2601

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	4.65×10^{-2}	0	1.38×10^{-1}	0	6.27×10^{-3}	1.13×10^{-1}

Table 355: Computed reservoir species mass fractions, Shot 2601

45.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4080	1537.0	1537.0	5.31	35.1	0.078	5.80×10^6
72 cm	4060	1573.5	1580.5	5.07	42.7	0.093	6.79×10^6

Table 356: Computed freestream conditions, Shot 2601

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.95×10^{-2}	0	9.75×10^{-9}	1.75×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.33×10^{-2}	0	1.87×10^{-8}	1.02×10^{-2}

Table 357: Computed freestream species mass fractions, Shot 2601

45.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4039	1670.0	1670.0	5.04	49.7	0.102	7.06×10^6
72 cm	3992	1770.5	1769.1	4.70	60.3	0.117	7.72×10^6

Table 358: Computed boundary layer edge conditions, Shot 2601

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.95×10^{-2}	0	9.75×10^{-9}	1.75×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.33×10^{-2}	0	5.93×10^{-8}	9.67×10^{-3}

Table 359: Computed boundary layer edge species mass fractions, Shot 2601

	T^* K	Unit Re^* 1/m
1D 100 cm	1956	5.40×10^6
72 cm	1930	7.09×10^6

Table 360: Dorrance reference conditions, Shot 2601

45.5 Stability Computations

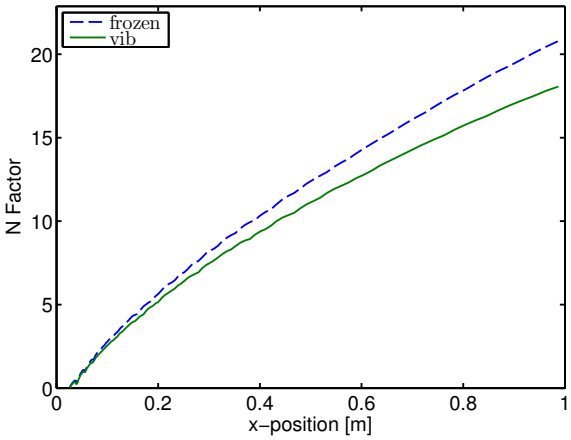


Figure 133: Locus of maximum N factor with and without vibrational energy transfer, Shot 2601

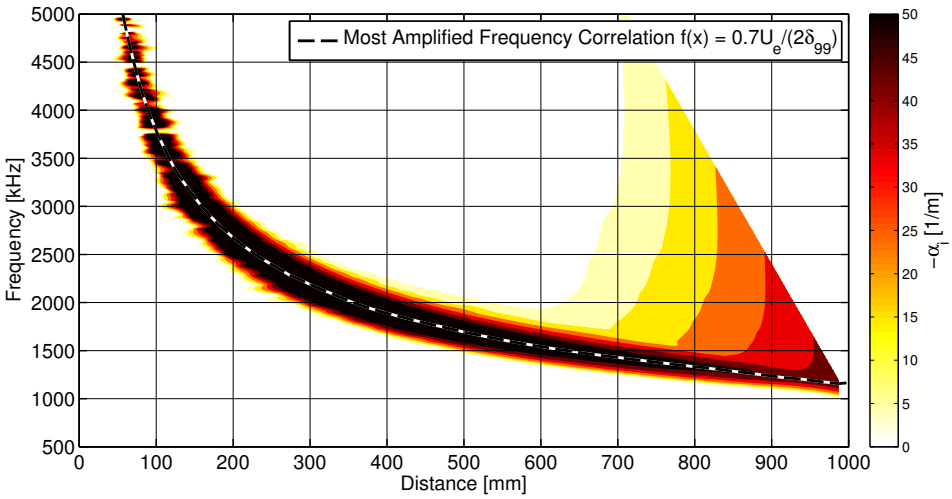


Figure 134: Stability diagram with vibrational energy transfer, Shot 2601. Dashed line indicates $0.7U_e/(2\delta_{99})$.

45.6 Heat Transfer Results

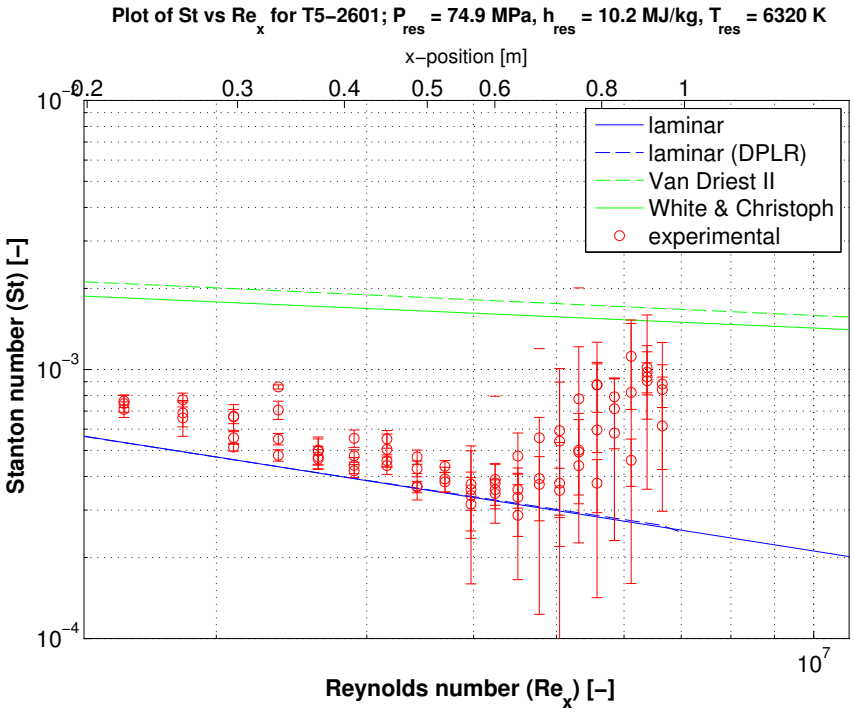


Figure 135: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

46 Shot 2602

Experiment 2602 was performed in T5 on 1 September 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

46.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	103.15	kPa
Reservoir Pressure	P_{res}	72.4	MPa

Table 361: Measured quantities, Shot 2602

46.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6353	K
Reservoir Density	ρ_{res}	35.60	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 362: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2602

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	4.48×10^{-2}	0	1.37×10^{-1}	0	6.69×10^{-3}	1.15×10^{-1}

Table 363: Computed reservoir species mass fractions, Shot 2602

46.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4102	1557.0	1557.0	5.30	34.7	0.076	5.63×10^6
72 cm	4074	1589.1	1596.4	5.06	41.4	0.089	6.49×10^6

Table 364: Computed freestream conditions, Shot 2602

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.93×10^{-2}	0	1.23×10^{-8}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.33×10^{-2}	0	2.27×10^{-8}	1.11×10^{-2}

Table 365: Computed freestream species mass fractions, Shot 2602

46.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4061	1691.9	1691.9	5.03	49.1	0.099	6.86×10^6
72 cm	4006	1787.5	1786.0	4.69	58.4	0.112	7.38×10^6

Table 366: Computed boundary layer edge conditions, Shot 2602

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.93×10^{-2}	0	1.23×10^{-8}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	7.07×10^{-8}	1.05×10^{-2}

Table 367: Computed boundary layer edge species mass fractions, Shot 2602

	T^* K	Unit Re^* 1/m
1D 100 cm	1976	5.26×10^6
72 cm	1943	6.79×10^6

Table 368: Dorrance reference conditions, Shot 2602

46.5 Stability Computations

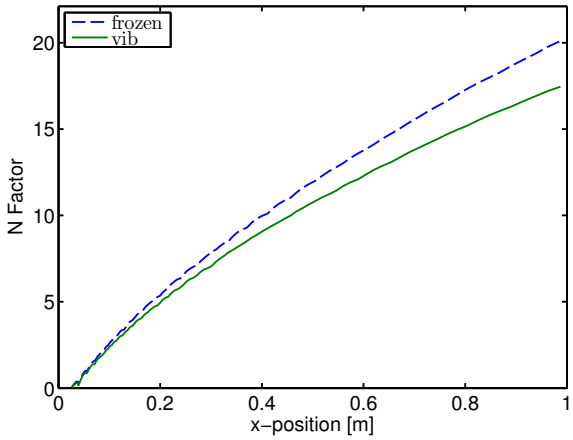


Figure 136: Locus of maximum N factor with and without vibrational energy transfer, Shot 2602

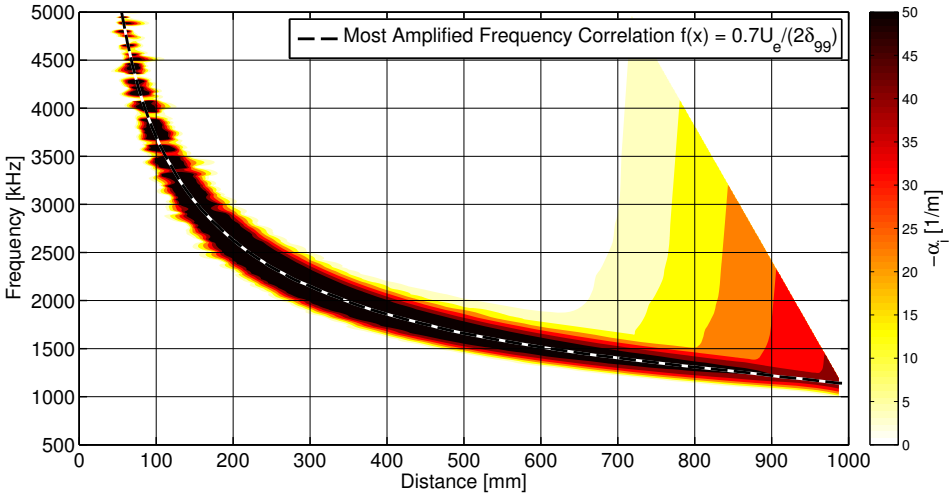


Figure 137: Stability diagram with vibrational energy transfer, Shot 2602. Dashed line indicates $0.7U_e/(2\delta_{99})$.

46.6 Heat Transfer Results

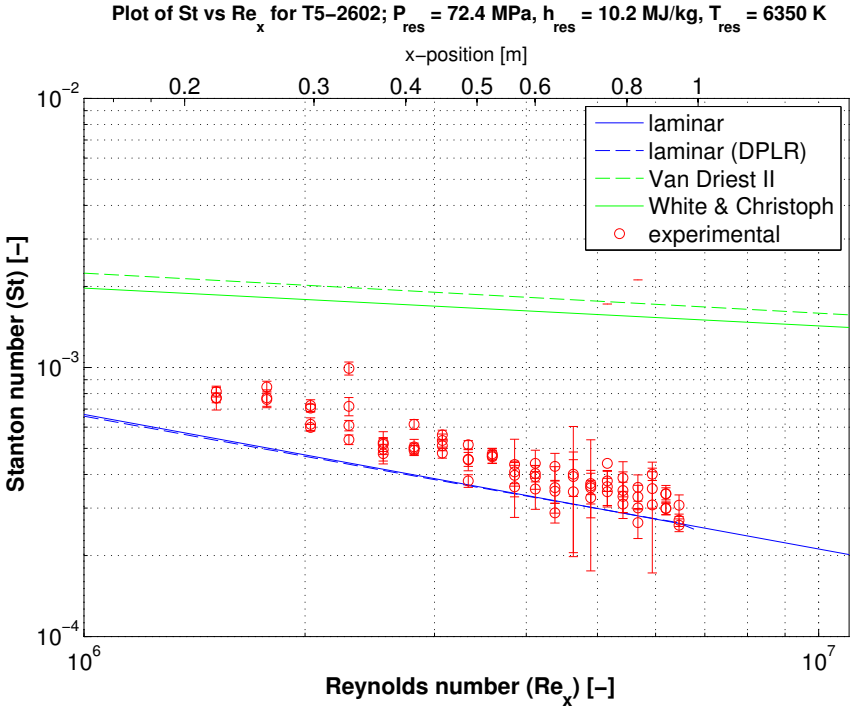


Figure 138: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

47 Shot 2603

Experiment 2603 was performed in T5 on 2 September 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

47.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3090	m/s
Shock Tube Fill Pressure	P_1	103.00	kPa
Reservoir Pressure	P_{res}	78.8	MPa

Table 369: Measured quantities, Shot 2603

47.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6176	K
Reservoir Density	ρ_{res}	40.30	kg/m^3
Reservoir Enthalpy	h_{res}	9.77	MJ/kg

Table 370: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2603

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	5.31×10^{-2}	0	1.42×10^{-1}	0	4.86×10^{-3}	1.04×10^{-1}

Table 371: Computed reservoir species mass fractions, Shot 2603

47.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4023	1485.0	1485.0	5.33	37.3	0.086	6.46×10^6
72 cm	3998	1505.0	1511.4	5.11	44.2	0.101	7.47×10^6

Table 372: Computed freestream conditions, Shot 2603

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.00×10^{-2}	0	5.39×10^{-9}	1.43×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.31×10^{-2}	0	8.73×10^{-9}	7.93×10^{-3}

Table 373: Computed freestream species mass fractions, Shot 2603

47.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3983	1614.9	1614.9	5.06	53.0	0.112	7.87×10^6
72 cm	3931	1695.6	1694.3	4.73	62.7	0.127	8.52×10^6

Table 374: Computed boundary layer edge conditions, Shot 2603

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.00×10^{-2}	0	5.39×10^{-9}	1.43×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.31×10^{-2}	0	3.01×10^{-8}	7.55×10^{-3}

Table 375: Computed boundary layer edge species mass fractions, Shot 2603

	T^* K	Unit Re^* 1/m
1D 100 cm	1906	5.94×10^6
72 cm	1869	7.73×10^6

Table 376: Dorrance reference conditions, Shot 2603

47.5 Stability Computations

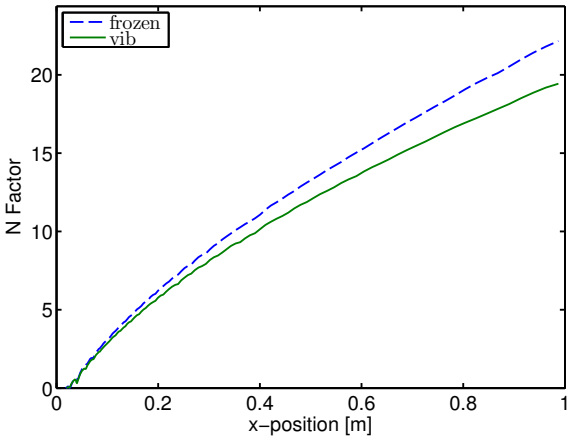


Figure 139: Locus of maximum N factor with and without vibrational energy transfer, Shot 2603

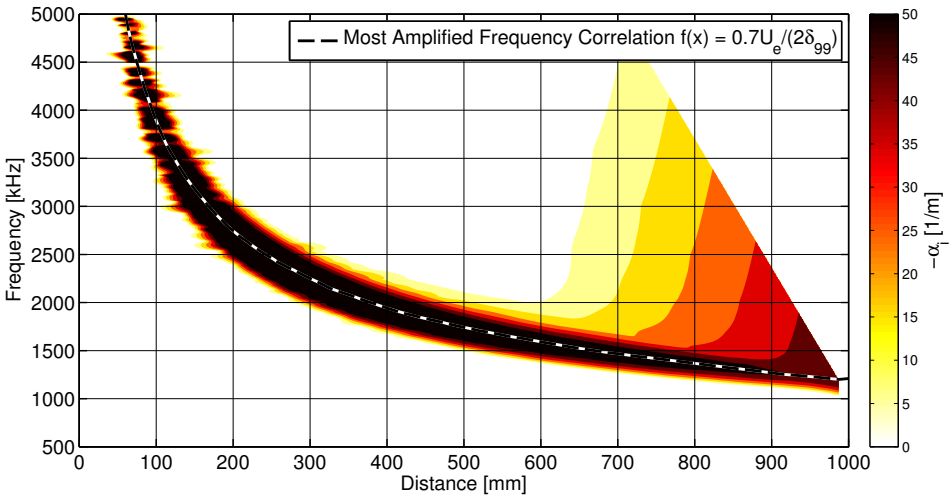


Figure 140: Stability diagram with vibrational energy transfer, Shot 2603. Dashed line indicates $0.7U_e/(2\delta_{99})$.

47.6 Heat Transfer Results

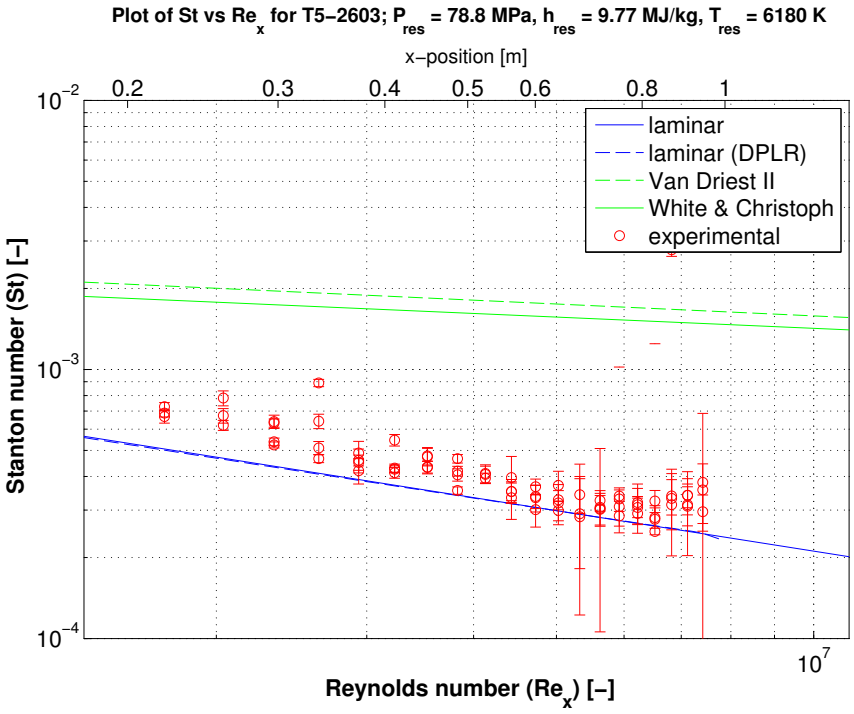


Figure 141: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

48 Shot 2604

Experiment 2604 was performed in T5 on 7 September 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

48.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	103.15	kPa
Reservoir Pressure	P_{res}	78.6	MPa

Table 377: Measured quantities, Shot 2604

48.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6408	K
Reservoir Density	ρ_{res}	38.32	kg/m^3
Reservoir Enthalpy	h_{res}	10.3	MJ/kg

Table 378: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2604

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	4.44×10^{-2}	0	1.38×10^{-1}	0	6.95×10^{-3}	1.15×10^{-1}

Table 379: Computed reservoir species mass fractions, Shot 2604

48.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4117	1575.0	1575.0	5.29	37.6	0.081	6.01×10^{6}
72 cm	4092	1607.4	1614.1	5.05	45.2	0.097	6.98×10^{6}

Table 380: Computed freestream conditions, Shot 2604

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.92×10^{-2}	0	1.40×10^{-8}	1.80×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.33×10^{-2}	0	2.42×10^{-8}	1.05×10^{-2}

Table 381: Computed freestream species mass fractions, Shot 2604

48.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4076	1711.1	1711.1	5.03	53.1	0.106	7.31×10^{6}
72 cm	4023	1807.5	1806.1	4.69	63.8	0.121	7.94×10^{6}

Table 382: Computed boundary layer edge conditions, Shot 2604

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.92×10^{-2}	0	1.40×10^{-8}	1.80×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.33×10^{-2}	0	7.37×10^{-8}	9.92×10^{-3}

Table 383: Computed boundary layer edge species mass fractions, Shot 2604

	T^* K	Unit Re^* 1/m
1D 100 cm	1992	5.64×10^{6}
72 cm	1959	7.33×10^{6}

Table 384: Dorrance reference conditions, Shot 2604

48.5 Stability Computations

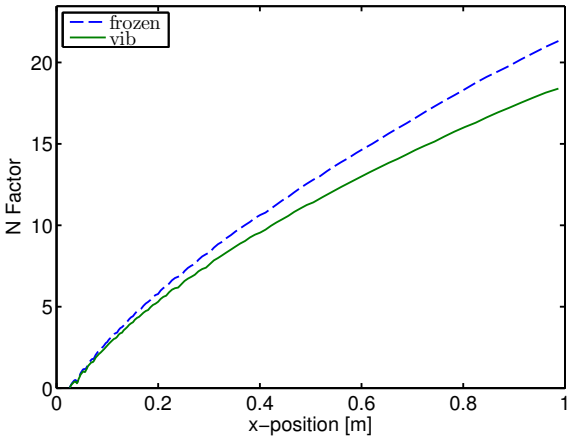


Figure 142: Locus of maximum N factor with and without vibrational energy transfer, Shot 2604

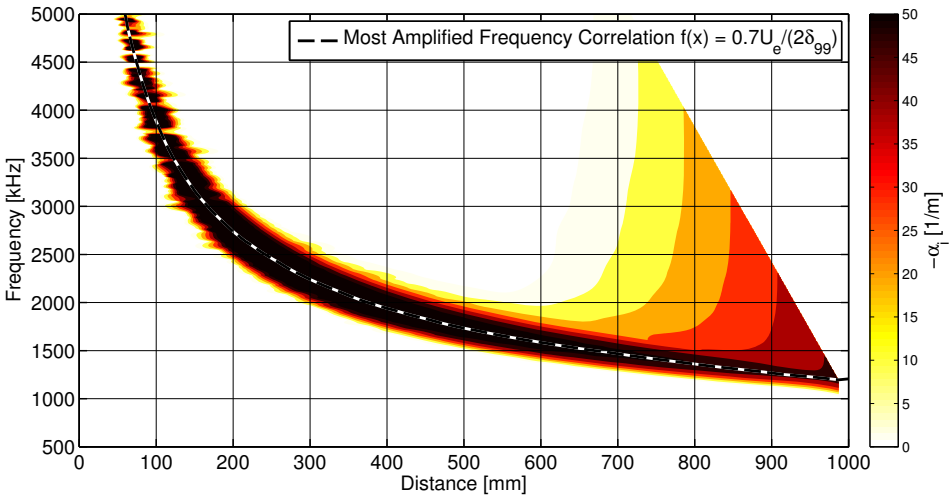


Figure 143: Stability diagram with vibrational energy transfer, Shot 2604. Dashed line indicates $0.7U_e/(2\delta_{99})$.

48.6 Heat Transfer Results

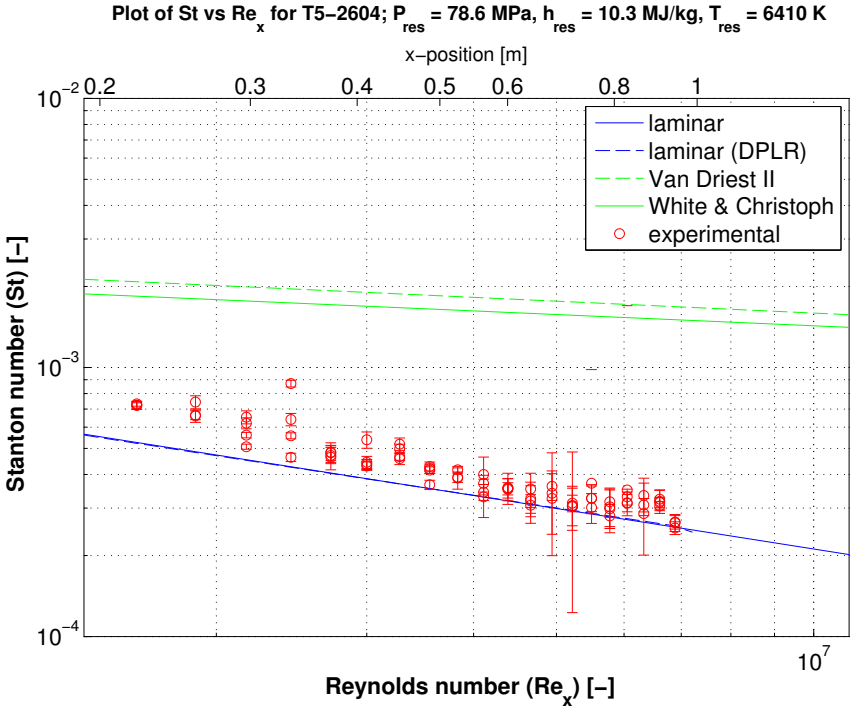


Figure 144: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

49 Shot 2605

Experiment 2605 was performed in T5 on 9 September 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

49.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	103.15	kPa
Reservoir Pressure	P_{res}	80.0	MPa

Table 385: Measured quantities, Shot 2605

49.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6358	K
Reservoir Density	ρ_{res}	39.43	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 386: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2605

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	4.65×10^{-2}	0	1.39×10^{-1}	0	6.39×10^{-3}	1.12×10^{-1}

Table 387: Computed reservoir species mass fractions, Shot 2605

49.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4090	1550.0	1550.0	5.30	37.6	0.083	6.14×10^6
72 cm	4071	1584.1	1590.7	5.07	45.8	0.099	7.22×10^6

Table 388: Computed freestream conditions, Shot 2605

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.94×10^{-2}	0	1.04×10^{-8}	1.68×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.33×10^{-2}	0	1.90×10^{-8}	9.64×10^{-3}

Table 389: Computed freestream species mass fractions, Shot 2605

49.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4049	1683.5	1683.5	5.04	53.2	0.108	7.48×10^6
72 cm	4003	1781.8	1780.5	4.70	64.7	0.125	8.22×10^6

Table 390: Computed boundary layer edge conditions, Shot 2605

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.94×10^{-2}	0	1.04×10^{-8}	1.68×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.33×10^{-2}	0	5.92×10^{-8}	9.14×10^{-3}

Table 391: Computed boundary layer edge species mass fractions, Shot 2605

	T^* K	Unit Re^* 1/m
1D 100 cm	1967	5.74×10^6
72 cm	1939	7.55×10^6

Table 392: Dorrance reference conditions, Shot 2605

49.5 Stability Computations

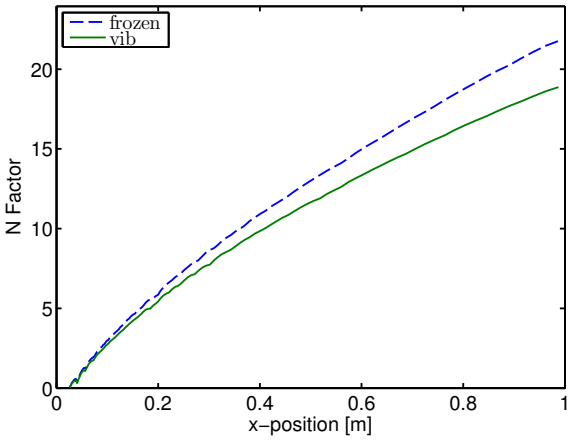


Figure 145: Locus of maximum N factor with and without vibrational energy transfer, Shot 2605

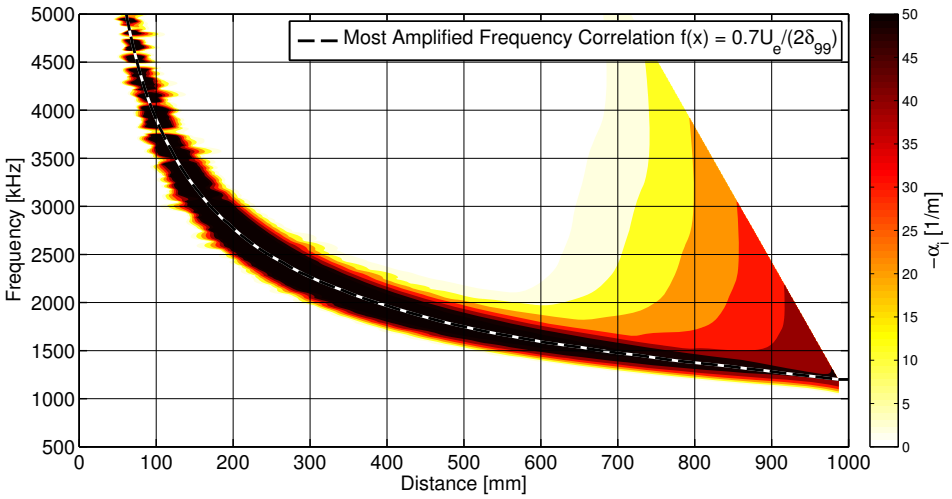


Figure 146: Stability diagram with vibrational energy transfer, Shot 2605. Dashed line indicates $0.7U_e/(2\delta_{99})$.

49.6 Heat Transfer Results

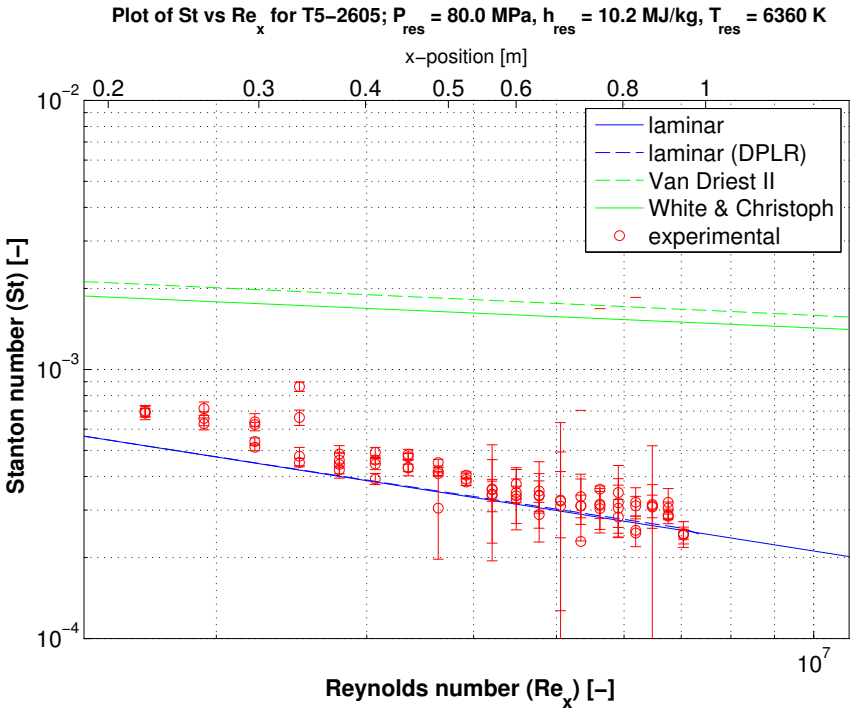


Figure 147: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

50 Shot 2606

Experiment 2606 was performed in T5 on 13 September 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

50.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	130.10	kPa
Reservoir Pressure	P_{res}	80.4	MPa

Table 393: Measured quantities, Shot 2606

50.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6172	K
Reservoir Density	ρ_{res}	41.15	kg/m^3
Reservoir Enthalpy	h_{res}	9.75	MJ/kg

Table 394: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2606

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	5.37×10^{-2}	0	1.43×10^{-1}	0	4.78×10^{-3}	1.03×10^{-1}

Table 395: Computed reservoir species mass fractions, Shot 2606

50.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4017	1479.0	1479.0	5.33	37.6	0.087	6.55×10^{6}
72 cm	3996	1501.7	1507.8	5.11	45.1	0.103	7.64×10^{6}

Table 396: Computed freestream conditions, Shot 2606

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.00×10^{-2}	0	4.61×10^{-9}	1.39×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.31×10^{-2}	0	8.21×10^{-9}	7.66×10^{-3}

Table 397: Computed freestream species mass fractions, Shot 2606

50.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3977	1608.4	1608.4	5.06	53.4	0.114	7.99×10^{6}
72 cm	3929	1692.3	1691.0	4.74	63.9	0.130	8.71×10^{6}

Table 398: Computed boundary layer edge conditions, Shot 2606

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.00×10^{-2}	0	4.61×10^{-9}	1.39×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.31×10^{-2}	0	2.85×10^{-8}	7.29×10^{-3}

Table 399: Computed boundary layer edge species mass fractions, Shot 2606

	T^* K	Unit Re^* 1/m
1D 100 cm	1900	6.02×10^{6}
72 cm	1867	7.90×10^{6}

Table 400: Dorrance reference conditions, Shot 2606

50.5 Stability Computations

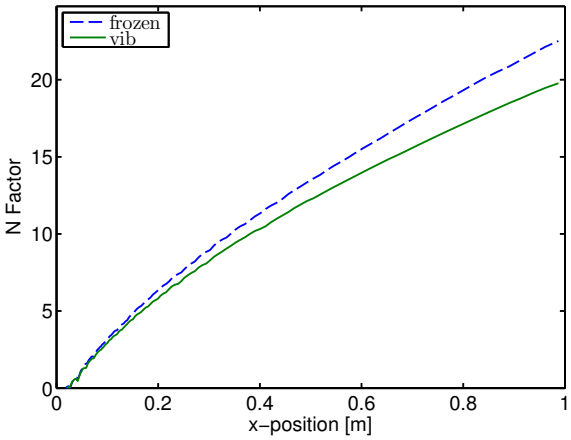


Figure 148: Locus of maximum N factor with and without vibrational energy transfer, Shot 2606

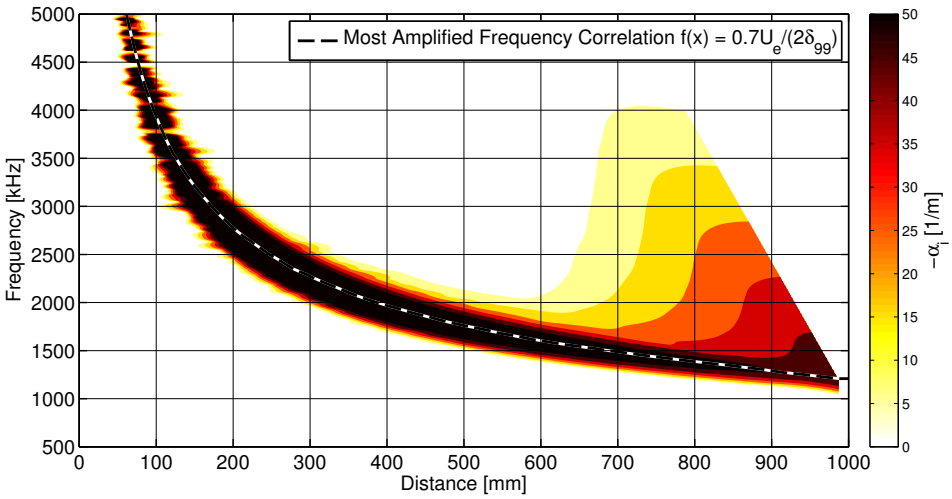


Figure 149: Stability diagram with vibrational energy transfer, Shot 2606. Dashed line indicates $0.7U_e/(2\delta_{99})$.

50.6 Heat Transfer Results

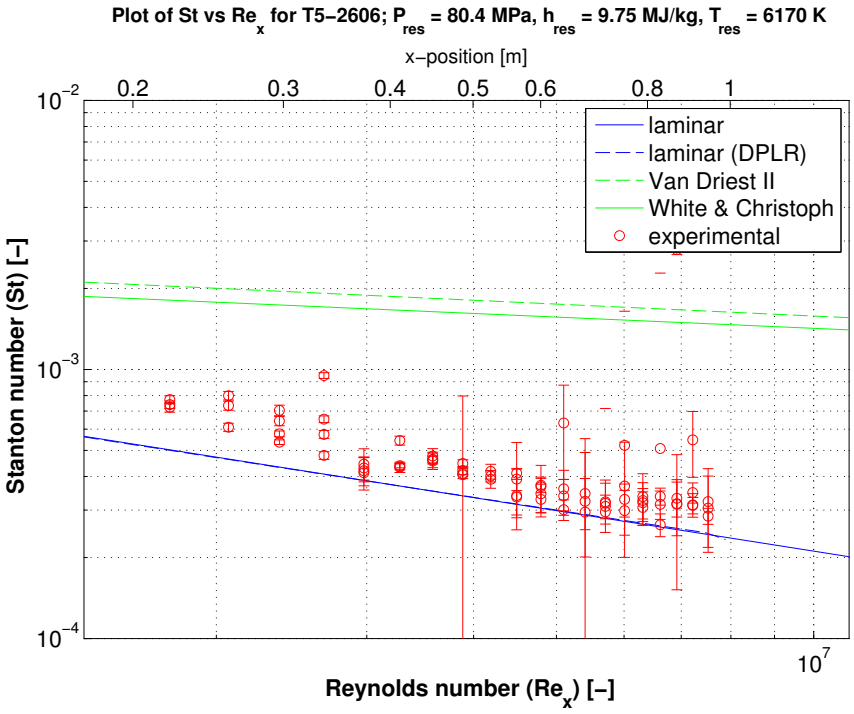


Figure 150: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

51 Shot 2607

Experiment 2607 was performed in T5 on 17 September 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

51.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3110	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	54.5	MPa

Table 401: Measured quantities, Shot 2607

51.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5977	K
Reservoir Density	ρ_res	28.75	kg/m^3
Reservoir Enthalpy	h_res	9.50	MJ/kg

Table 402: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2607

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	5.39×10^{-2}	0	1.36×10^{-1}	0	4.26×10^{-3}	1.07×10^{-1}

Table 403: Computed reservoir species mass fractions, Shot 2607

51.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3963	1413.0	1413.0	5.37	25.4	0.061	4.70×10^6
72 cm	3935	1444.0	1452.7	5.13	29.8	0.071	5.31×10^6

Table 404: Computed freestream conditions, Shot 2607

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.03×10^{-2}	0	3.30×10^{-9}	1.80×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	7.29×10^{-9}	1.06×10^{-2}

Table 405: Computed freestream species mass fractions, Shot 2607

51.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3924	1539.7	1539.7	5.09	36.3	0.080	5.74×10^6
72 cm	3869	1631.0	1629.0	4.74	42.4	0.089	6.05×10^6

Table 406: Computed boundary layer edge conditions, Shot 2607

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.03×10^{-2}	0	3.30×10^{-9}	1.80×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	2.85×10^{-8}	1.02×10^{-2}

Table 407: Computed boundary layer edge species mass fractions, Shot 2607

	T^* K	Unit Re^* 1/m
1D 100 cm	1845	4.22×10^6
72 cm	1816	5.43×10^6

Table 408: Dorrance reference conditions, Shot 2607

51.5 Stability Computations

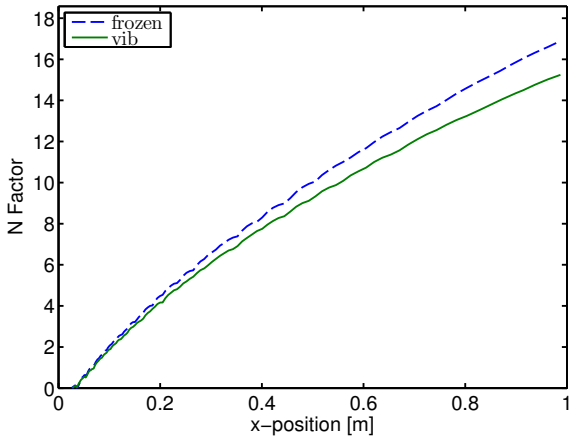


Figure 151: Locus of maximum N factor with and without vibrational energy transfer, Shot 2607

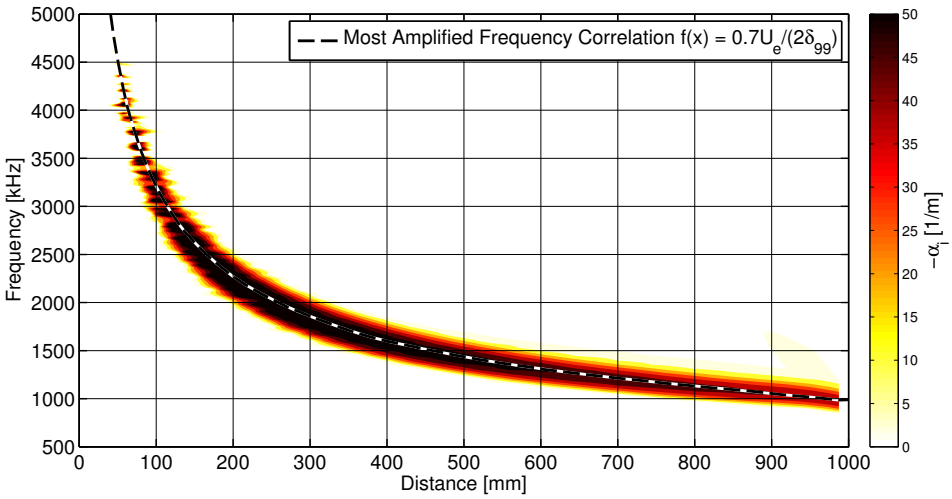


Figure 152: Stability diagram with vibrational energy transfer, Shot 2607. Dashed line indicates $0.7U_e/(2\delta_{99})$.

51.6 Heat Transfer Results

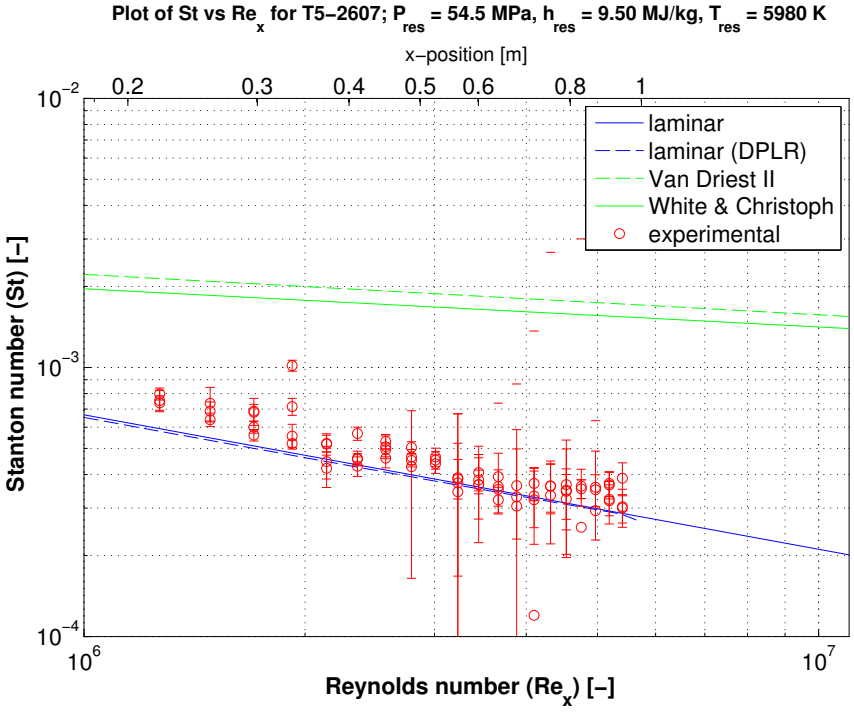


Figure 153: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

52 Shot 2608

Experiment 2608 was performed in T5 on 20 September 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

52.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3090	m/s
Shock Tube Fill Pressure	P_1	84.85	kPa
Reservoir Pressure	P_{res}	55.2	MPa

Table 409: Measured quantities, Shot 2608

52.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5961	K
Reservoir Density	ρ_{res}	29.26	kg/m^3
Reservoir Enthalpy	h_{res}	9.46	MJ/kg

Table 410: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2608

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.49×10^{-2}	0	1.36×10^{-1}	0	4.11×10^{-3}	1.05×10^{-1}

Table 411: Computed reservoir species mass fractions, Shot 2608

52.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3953	1404.0	1404.0	5.37	25.5	0.062	4.76×10^6
72 cm	3928	1436.3	1444.8	5.13	30.2	0.072	5.42×10^6

Table 412: Computed freestream conditions, Shot 2608

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.04×10^{-2}	0	2.89×10^{-9}	1.74×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	6.55×10^{-9}	1.02×10^{-2}

Table 413: Computed freestream species mass fractions, Shot 2608

52.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3914	1529.7	1529.7	5.09	36.4	0.081	5.81×10^6
72 cm	3861	1622.6	1620.5	4.75	42.9	0.091	6.16×10^6

Table 414: Computed boundary layer edge conditions, Shot 2608

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.04×10^{-2}	0	2.89×10^{-9}	1.74×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	2.59×10^{-8}	9.82×10^{-3}

Table 415: Computed boundary layer edge species mass fractions, Shot 2608

	T^* K	Unit Re^* 1/m
1D 100 cm	1836	4.27×10^6
72 cm	1809	5.53×10^6

Table 416: Dorrance reference conditions, Shot 2608

52.5 Stability Computations

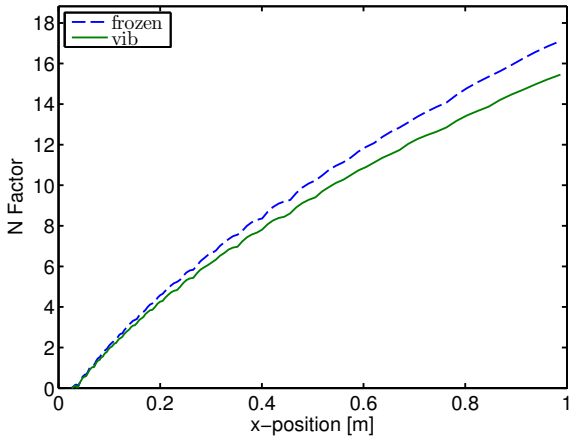


Figure 154: Locus of maximum N factor with and without vibrational energy transfer, Shot 2608

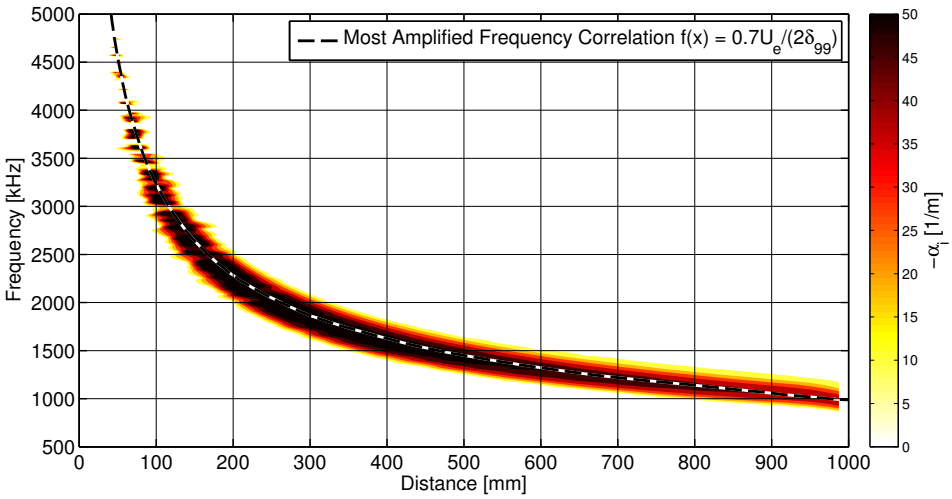


Figure 155: Stability diagram with vibrational energy transfer, Shot 2608. Dashed line indicates $0.7U_e/(2\delta_{99})$.

52.6 Heat Transfer Results

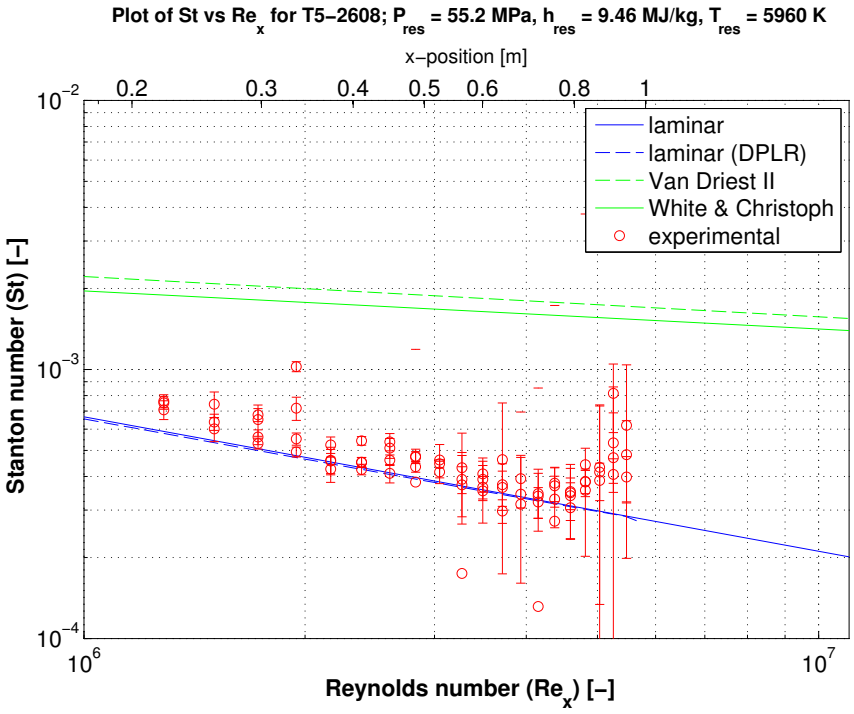


Figure 156: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

53 Shot 2609

Experiment 2609 was performed in T5 on 21 September 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

53.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	55.7	MPa

Table 417: Measured quantities, Shot 2609

53.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6031	K
Reservoir Density	ρ_res	29.08	kg/m^3
Reservoir Enthalpy	h_res	9.62	MJ/kg

Table 418: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2609

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	5.20×10^{-2}	0	1.35×10^{-1}	0	4.61×10^{-3}	1.09×10^{-1}

Table 419: Computed reservoir species mass fractions, Shot 2609

53.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3983	1432.0	1432.0	5.36	26.0	0.062	4.71×10^6
72 cm	3957	1466.2	1474.9	5.11	30.7	0.072	5.36×10^6

Table 420: Computed freestream conditions, Shot 2609

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.19×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	9.06×10^{-9}	1.10×10^{-2}

Table 421: Computed freestream species mass fractions, Shot 2609

53.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3944	1559.7	1559.7	5.08	37.0	0.081	5.75×10^6
72 cm	3890	1655.2	1653.1	4.73	43.6	0.091	6.10×10^6

Table 422: Computed boundary layer edge conditions, Shot 2609

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.82×10^{-1}	0	6.01×10^{-2}	0	4.19×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.41×10^{-8}	1.06×10^{-2}

Table 423: Computed boundary layer edge species mass fractions, Shot 2609

	T^* K	Unit Re^* 1/m
1D 100 cm	1863	4.26×10^6
72 cm	1836	5.50×10^6

Table 424: Dorrance reference conditions, Shot 2609

53.5 Stability Computations

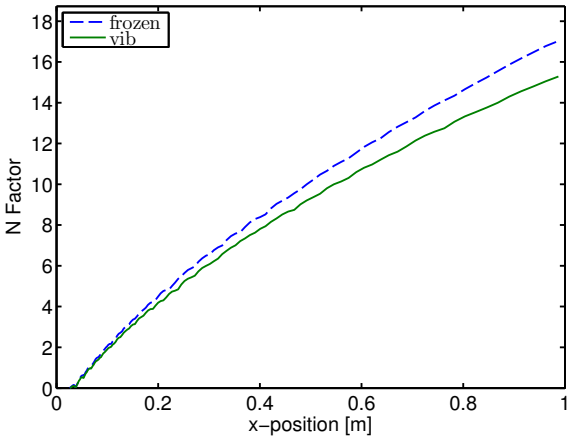


Figure 157: Locus of maximum N factor with and without vibrational energy transfer, Shot 2609

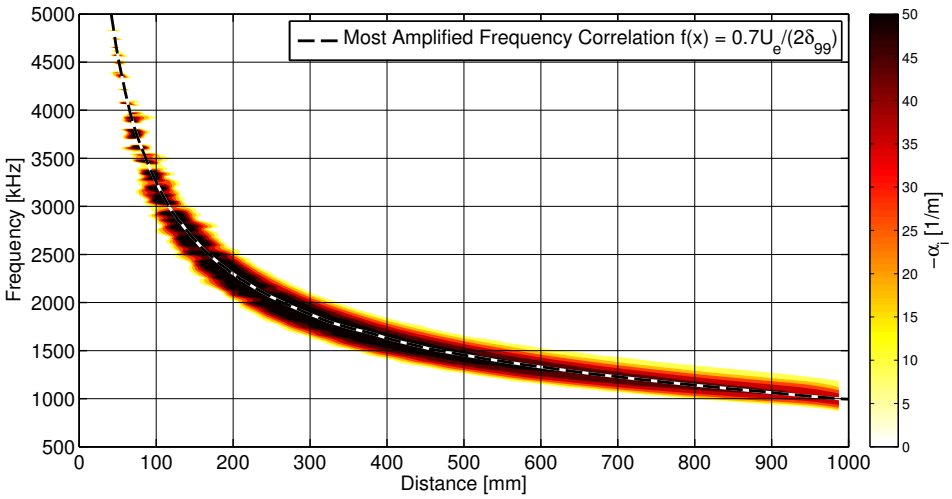


Figure 158: Stability diagram with vibrational energy transfer, Shot 2609. Dashed line indicates $0.7U_e/(2\delta_{99})$.

53.6 Heat Transfer Results

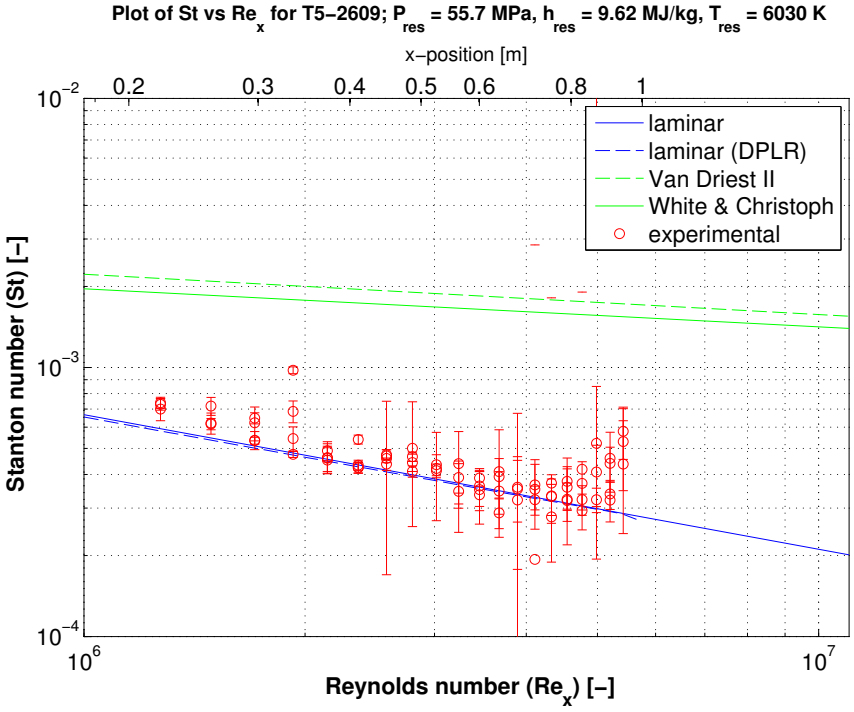


Figure 159: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

54 Shot 2610

Experiment 2610 was performed in T5 on 27 September 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

54.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	54.9	MPa

Table 425: Measured quantities, Shot 2610

54.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6214	K
Reservoir Density	ρ_res	27.54	kg/m^3
Reservoir Enthalpy	h_res	10.1	MJ/kg

Table 426: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2610

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	4.44×10^{-2}	0	1.32×10^{-1}	0	6.24×10^{-3}	1.18×10^{-1}

Table 427: Computed reservoir species mass fractions, Shot 2610

54.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4062	1503.0	1503.0	5.33	26.0	0.059	4.42×10^6
72 cm	4032	1544.4	1553.6	5.07	30.9	0.068	5.01×10^6

Table 428: Computed freestream conditions, Shot 2610

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.94×10^{-2}	0	9.48×10^{-9}	2.23×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	2.10×10^{-8}	1.38×10^{-2}

Table 429: Computed freestream species mass fractions, Shot 2610

54.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4021	1635.0	1635.0	5.06	36.9	0.077	5.39×10^6
72 cm	3964	1740.5	1738.5	4.70	43.6	0.086	5.69×10^6

Table 430: Computed boundary layer edge conditions, Shot 2610

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.94×10^{-2}	0	9.48×10^{-9}	2.23×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	7.07×10^{-8}	1.32×10^{-2}

Table 431: Computed boundary layer edge species mass fractions, Shot 2610

	T^* K	Unit Re^* 1/m
1D 100 cm	1932	4.06×10^6
72 cm	1906	5.20×10^6

Table 432: Dorrance reference conditions, Shot 2610

54.5 Stability Computations

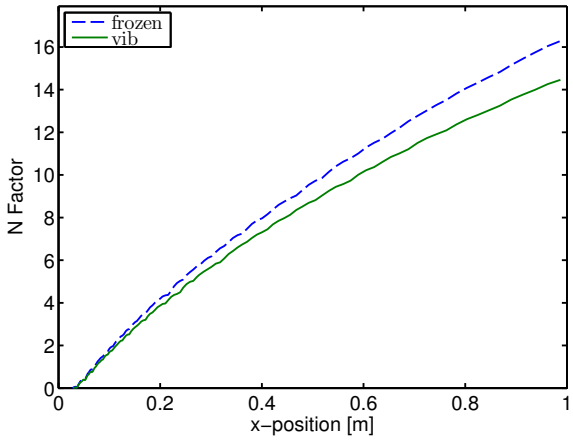


Figure 160: Locus of maximum N factor with and without vibrational energy transfer, Shot 2610

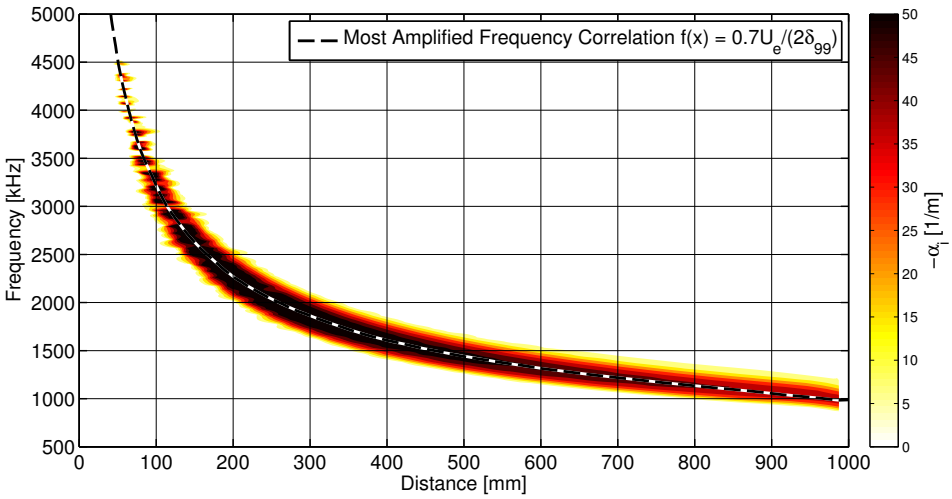


Figure 161: Stability diagram with vibrational energy transfer, Shot 2610. Dashed line indicates $0.7U_e/(2\delta_{99})$.

54.6 Heat Transfer Results

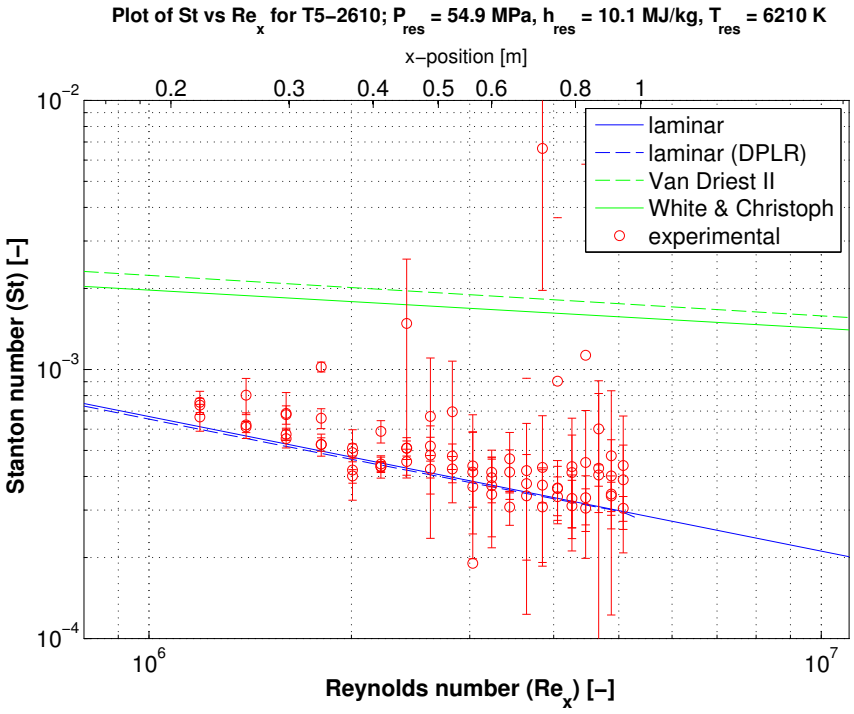


Figure 162: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

55 Shot 2611

Experiment 2611 was performed in T5 on 28 September 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

55.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3240	m/s
Shock Tube Fill Pressure	P_1	84.95	kPa
Reservoir Pressure	P_{res}	54.6	MPa

Table 433: Measured quantities, Shot 2611

55.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6243	K
Reservoir Density	ρ_{res}	27.22	kg/m^3
Reservoir Enthalpy	h_{res}	10.1	MJ/kg

Table 434: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2611

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	4.33×10^{-2}	0	1.31×10^{-1}	0	6.55×10^{-3}	1.20×10^{-1}

Table 435: Computed reservoir species mass fractions, Shot 2611

55.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4069	1507.0	1507.0	5.33	25.5	0.057	4.32×10^6
72 cm	4044	1556.9	1566.2	5.06	30.8	0.068	4.94×10^6

Table 436: Computed freestream conditions, Shot 2611

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.93×10^{-2}	0	1.00×10^{-8}	2.31×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	2.39×10^{-8}	1.43×10^{-2}

Table 437: Computed freestream species mass fractions, Shot 2611

55.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4028	1639.9	1639.9	5.05	36.2	0.075	5.26×10^6
72 cm	3976	1754.3	1752.3	4.69	43.5	0.085	5.61×10^6

Table 438: Computed boundary layer edge conditions, Shot 2611

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.93×10^{-2}	0	1.00×10^{-8}	2.31×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	7.94×10^{-8}	1.38×10^{-2}

Table 439: Computed boundary layer edge species mass fractions, Shot 2611

	T^* K	Unit Re^* 1/m
1D 100 cm	1937	3.96×10^6
72 cm	1918	5.14×10^6

Table 440: Dorrance reference conditions, Shot 2611

55.5 Stability Computations

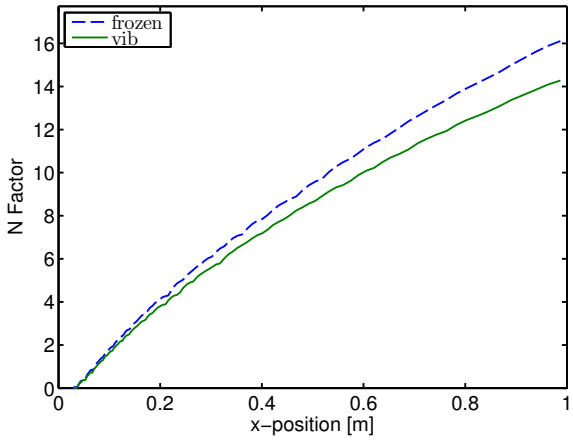


Figure 163: Locus of maximum N factor with and without vibrational energy transfer, Shot 2611

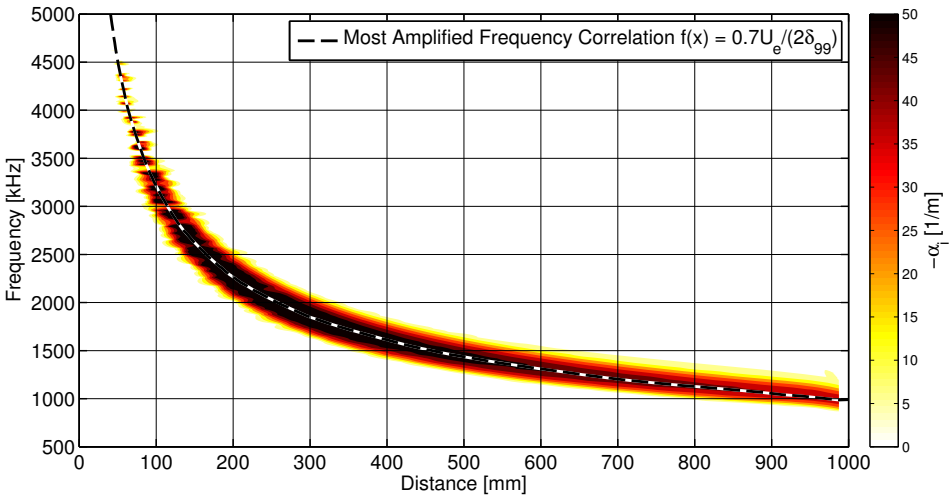


Figure 164: Stability diagram with vibrational energy transfer, Shot 2611. Dashed line indicates $0.7U_e/(2\delta_{99})$.

55.6 Heat Transfer Results

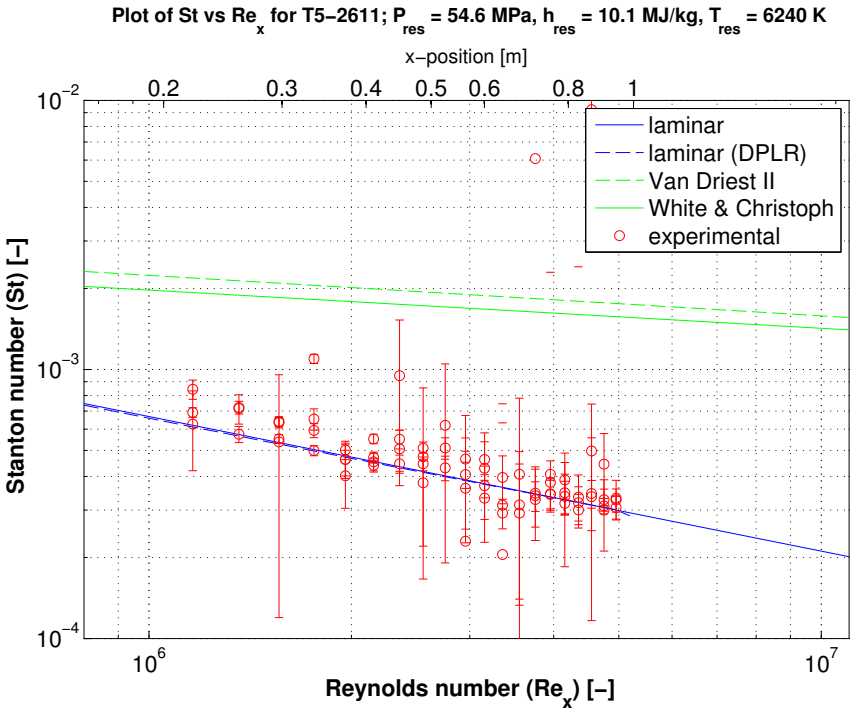


Figure 165: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

56 Shot 2612

Experiment 2612 was performed in T5 on 1 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

56.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3280	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	55.5	MPa

Table 441: Measured quantities, Shot 2612

56.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6329	K
Reservoir Density	ρ_res	27.17	kg/m^3
Reservoir Enthalpy	h_res	10.4	MJ/kg

Table 442: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2612

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	4.05×10^{-2}	0	1.29×10^{-1}	0	7.42×10^{-3}	1.23×10^{-1}

Table 443: Computed reservoir species mass fractions, Shot 2612

56.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4104	1540.0	1540.0	5.31	26.0	0.057	4.28×10^6
72 cm	4078	1592.3	1601.6	5.05	31.5	0.068	4.91×10^6

Table 444: Computed freestream conditions, Shot 2612

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.90×10^{-2}	0	1.42×10^{-8}	2.45×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.30×10^{-2}	0	3.30×10^{-8}	1.54×10^{-2}

Table 445: Computed freestream species mass fractions, Shot 2612

56.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4063	1674.8	1674.8	5.04	36.9	0.075	5.22×10^6
72 cm	4009	1793.4	1791.4	4.68	44.5	0.085	5.57×10^6

Table 446: Computed boundary layer edge conditions, Shot 2612

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.90×10^{-2}	0	1.42×10^{-8}	2.45×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.30×10^{-2}	0	1.05×10^{-7}	1.48×10^{-2}

Table 447: Computed boundary layer edge species mass fractions, Shot 2612

	T^* K	Unit Re^* 1/m
1D 100 cm	1968	3.96×10^6
72 cm	1949	5.13×10^6

Table 448: Dorrance reference conditions, Shot 2612

56.5 Stability Computations

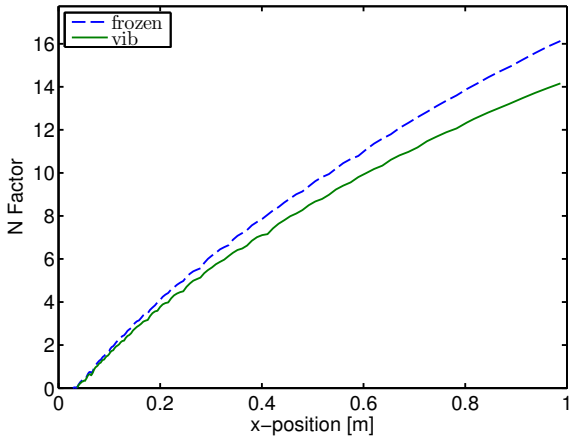


Figure 166: Locus of maximum N factor with and without vibrational energy transfer, Shot 2612

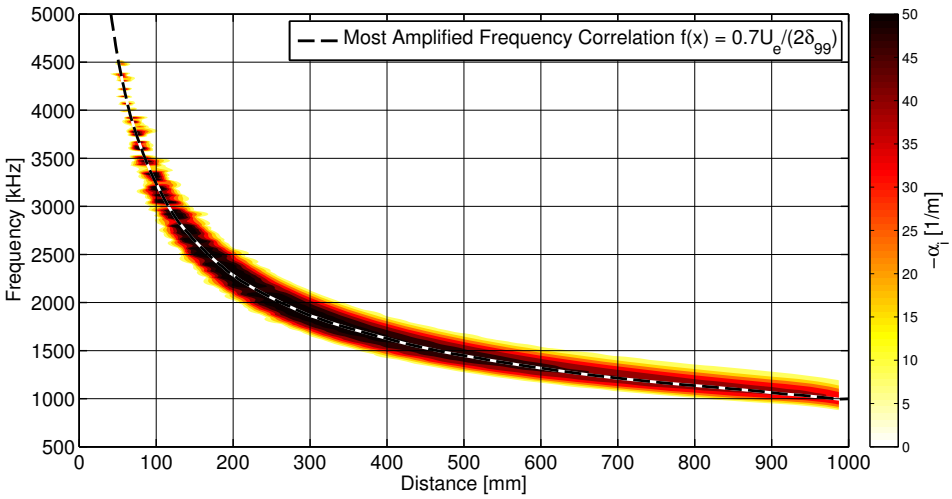


Figure 167: Stability diagram with vibrational energy transfer, Shot 2612. Dashed line indicates $0.7U_e/(2\delta_{99})$.

56.6 Heat Transfer Results

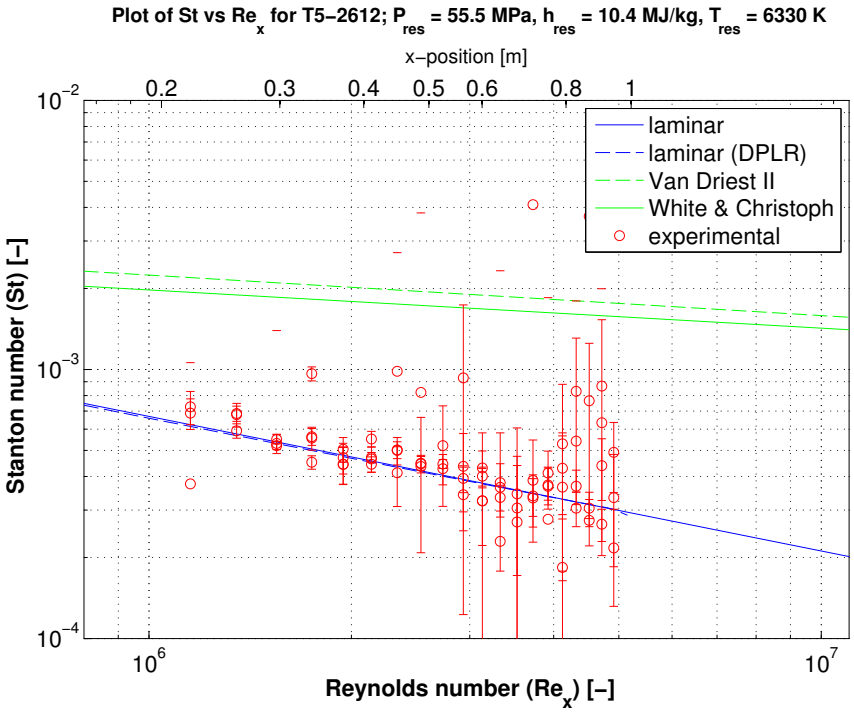


Figure 168: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

57 Shot 2613

Experiment 2613 was performed in T5 on 8 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

57.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	54.6	MPa

Table 449: Measured quantities, Shot 2613

57.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6208	K
Reservoir Density	ρ_res	27.42	kg/m^3
Reservoir Enthalpy	h_res	10.1	MJ/kg

Table 450: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2613

$Y_{\mathrm{N_2}}$	$Y_{\mathrm{O_2}}$	$Y_{\mathrm{CO_2}}$	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
6.99×10^{-1}	4.46×10^{-2}	0	1.32×10^{-1}	0	6.20×10^{-3}	1.18×10^{-1}

Table 451: Computed reservoir species mass fractions, Shot 2613

57.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4061	1501.0	1501.0	5.33	25.9	0.059	4.41×10^6
72 cm	4030	1542.2	1551.4	5.07	30.7	0.068	4.99×10^6

Table 452: Computed freestream conditions, Shot 2613

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.94×10^{-2}	0	9.26×10^{-9}	2.23×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	2.07×10^{-8}	1.38×10^{-2}

Table 453: Computed freestream species mass fractions, Shot 2613

57.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4020	1633.5	1633.5	5.06	36.8	0.077	5.38×10^6
72 cm	3962	1738.1	1736.1	4.70	43.4	0.086	5.67×10^6

Table 454: Computed boundary layer edge conditions, Shot 2613

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.94×10^{-2}	0	9.26×10^{-9}	2.23×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	6.99×10^{-8}	1.33×10^{-2}

Table 455: Computed boundary layer edge species mass fractions, Shot 2613

	T^* K	Unit Re^* 1/m
1D 100 cm	1930	4.05×10^6
72 cm	1903	5.18×10^6

Table 456: Dorrance reference conditions, Shot 2613

57.5 Stability Computations

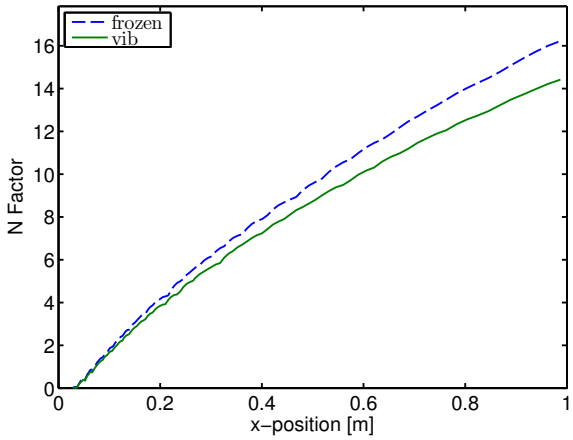


Figure 169: Locus of maximum N factor with and without vibrational energy transfer, Shot 2613

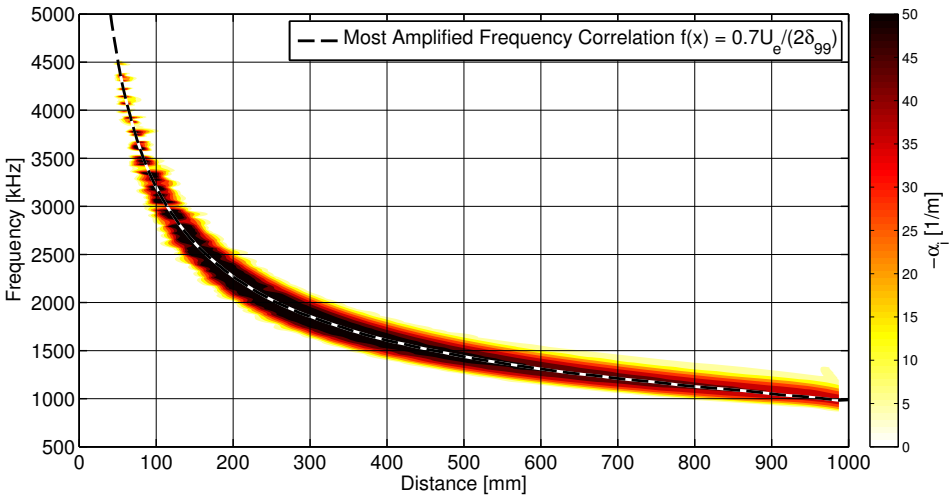


Figure 170: Stability diagram with vibrational energy transfer, Shot 2613. Dashed line indicates $0.7U_e/(2\delta_{99})$.

57.6 Heat Transfer Results

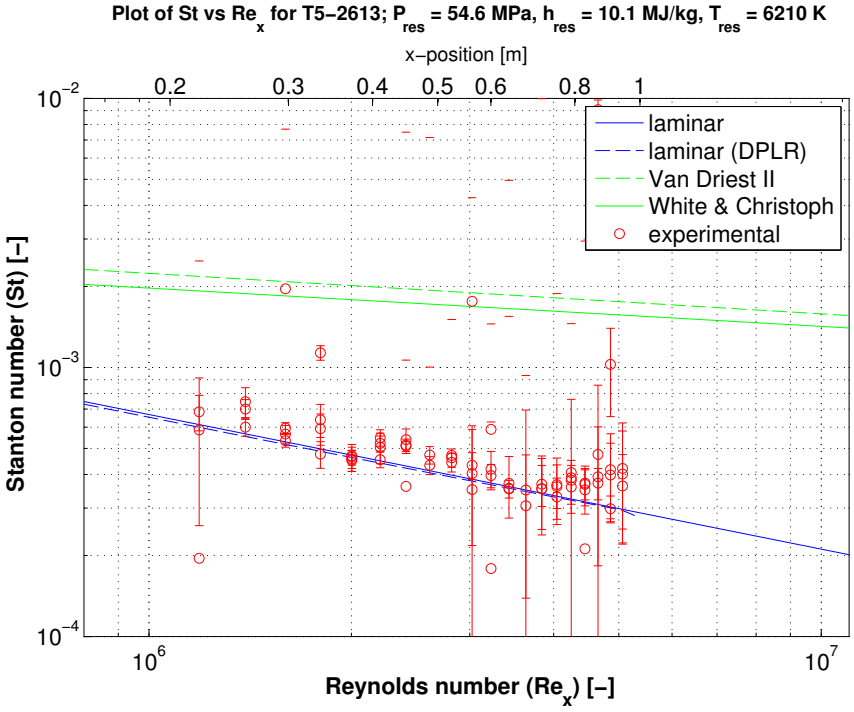


Figure 171: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

58 Shot 2614

Experiment 2614 was performed in T5 on 12 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

58.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3110	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 457: Measured quantities, Shot 2614

58.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5830	K
Reservoir Density	ρ_{res}	29.02	kg/m^3
Reservoir Enthalpy	h_{res}	9.16	MJ/kg

Table 458: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2614

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.01×10^{-2}	0	1.37×10^{-1}	0	3.34×10^{-3}	9.96×10^{-2}

Table 459: Computed reservoir species mass fractions, Shot 2614

58.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3900	1355.0	1355.0	5.39	24.5	0.062	4.78×10^6
72 cm	3874	1381.8	1390.1	5.16	28.7	0.071	5.41×10^6

Table 460: Computed freestream conditions, Shot 2614

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.07×10^{-2}	0	1.68×10^{-9}	1.58×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	3.61×10^{-9}	9.07×10^{-3}

Table 461: Computed freestream species mass fractions, Shot 2614

58.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3862	1478.0	1478.0	5.11	35.0	0.081	5.85×10^6
72 cm	3809	1563.0	1560.9	4.77	40.9	0.090	6.17×10^6

Table 462: Computed boundary layer edge conditions, Shot 2614

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.07×10^{-2}	0	1.68×10^{-9}	1.58×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.30×10^{-2}	0	1.57×10^{-8}	8.78×10^{-3}

Table 463: Computed boundary layer edge species mass fractions, Shot 2614

	T^* K	Unit Re^* 1/m
1D 100 cm	1790	4.23×10^6
72 cm	1761	5.48×10^6

Table 464: Dorrance reference conditions, Shot 2614

58.5 Stability Computations

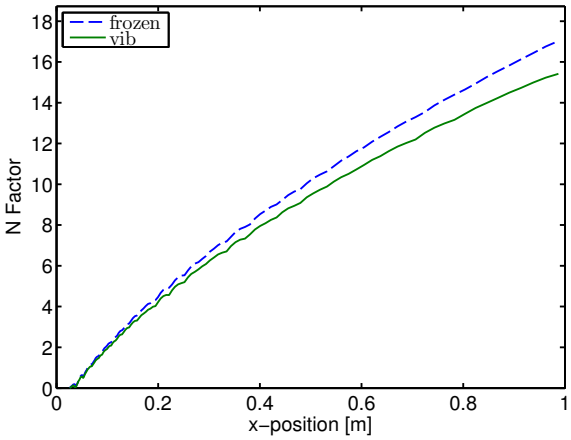


Figure 172: Locus of maximum N factor with and without vibrational energy transfer, Shot 2614

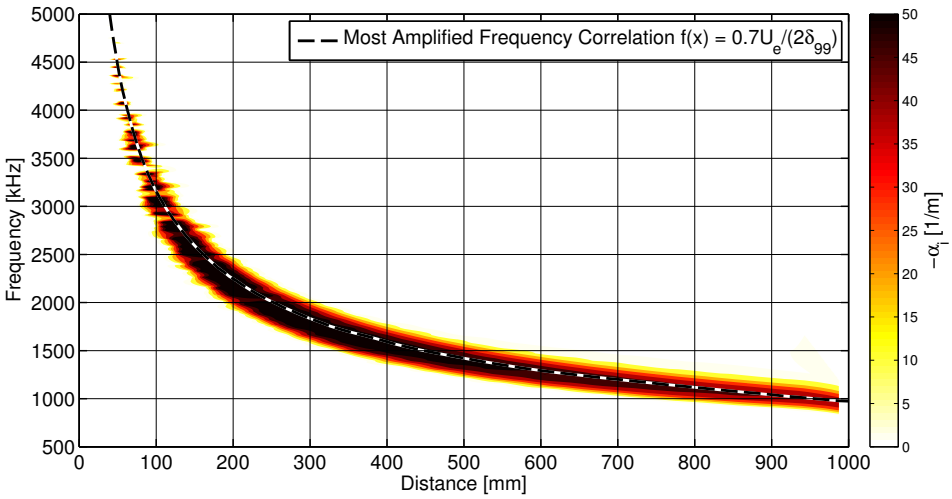


Figure 173: Stability diagram with vibrational energy transfer, Shot 2614. Dashed line indicates $0.7U_e/(2\delta_{99})$.

58.6 Heat Transfer Results

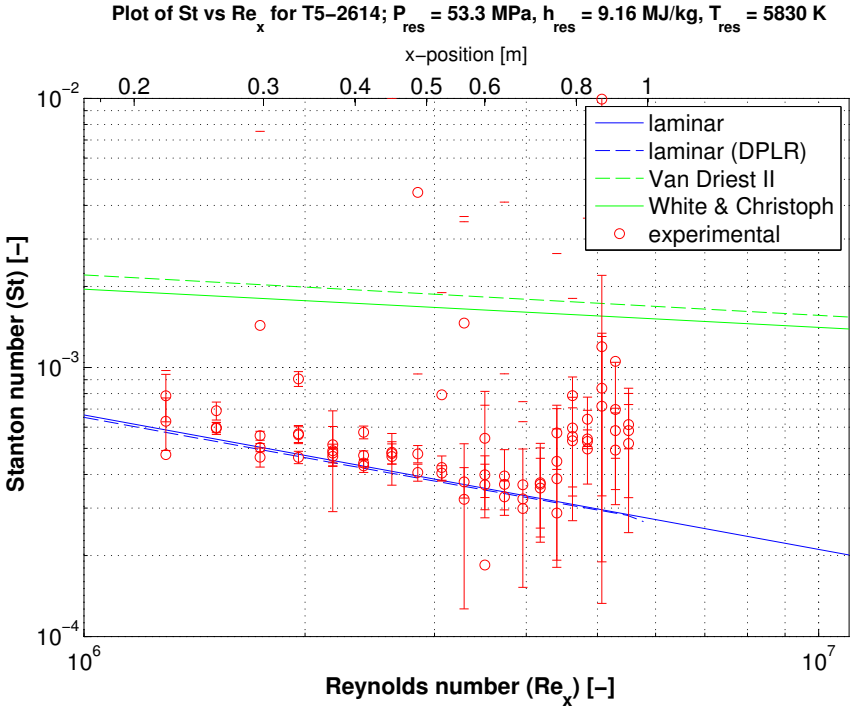


Figure 174: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

59 Shot 2615

Experiment 2615 was performed in T5 on 13 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

59.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3030	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.2	MPa

Table 465: Measured quantities, Shot 2615

59.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5578	K
Reservoir Density	ρ_{res}	30.64	kg/m^3
Reservoir Enthalpy	h_{res}	8.56	MJ/kg

Table 466: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2615

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.28×10^{-2}	0	1.39×10^{-1}	0	2.10×10^{-3}	8.58×10^{-2}

Table 467: Computed reservoir species mass fractions, Shot 2615

59.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3789	1255.0	1255.0	5.45	23.8	0.065	5.13×10^6
72 cm	3765	1270.9	1277.8	5.24	27.6	0.075	5.82×10^6

Table 468: Computed freestream conditions, Shot 2615

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.15×10^{-2}	0	0	1.19×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.42×10^{-2}	0	8.32×10^{-10}	6.38×10^{-3}

Table 469: Computed freestream species mass fractions, Shot 2615

59.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3752	1371.9	1371.9	5.16	34.2	0.086	6.32×10^6
72 cm	3701	1443.2	1440.9	4.83	39.6	0.095	6.67×10^6

Table 470: Computed boundary layer edge conditions, Shot 2615

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.15×10^{-2}	0	0	1.19×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.42×10^{-2}	0	4.72×10^{-9}	6.21×10^{-3}

Table 471: Computed boundary layer edge species mass fractions, Shot 2615

	T^* K	Unit Re^* 1/m
1D 100 cm	1695	4.43×10^6
72 cm	1664	5.79×10^6

Table 472: Dorrance reference conditions, Shot 2615

59.5 Stability Computations

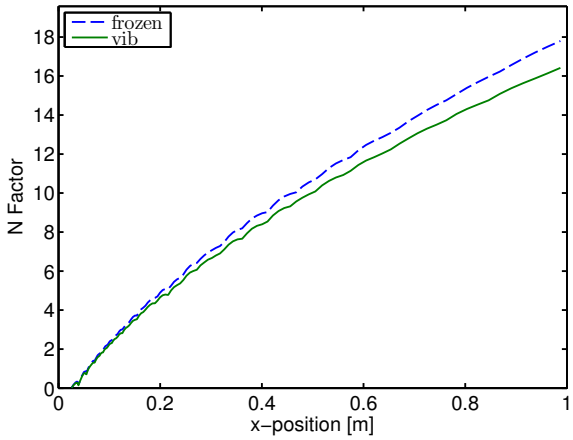


Figure 175: Locus of maximum N factor with and without vibrational energy transfer, Shot 2615

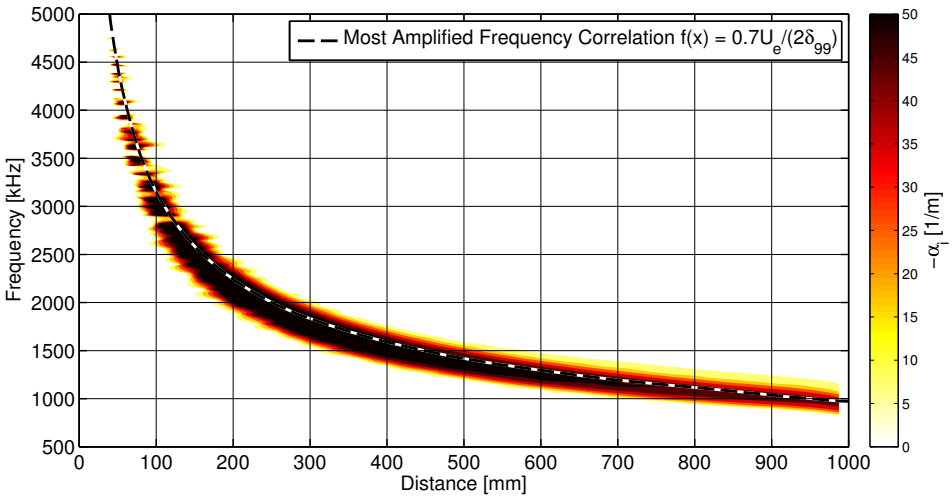


Figure 176: Stability diagram with vibrational energy transfer, Shot 2615. Dashed line indicates $0.7U_e/(2\delta_{99})$.

59.6 Heat Transfer Results

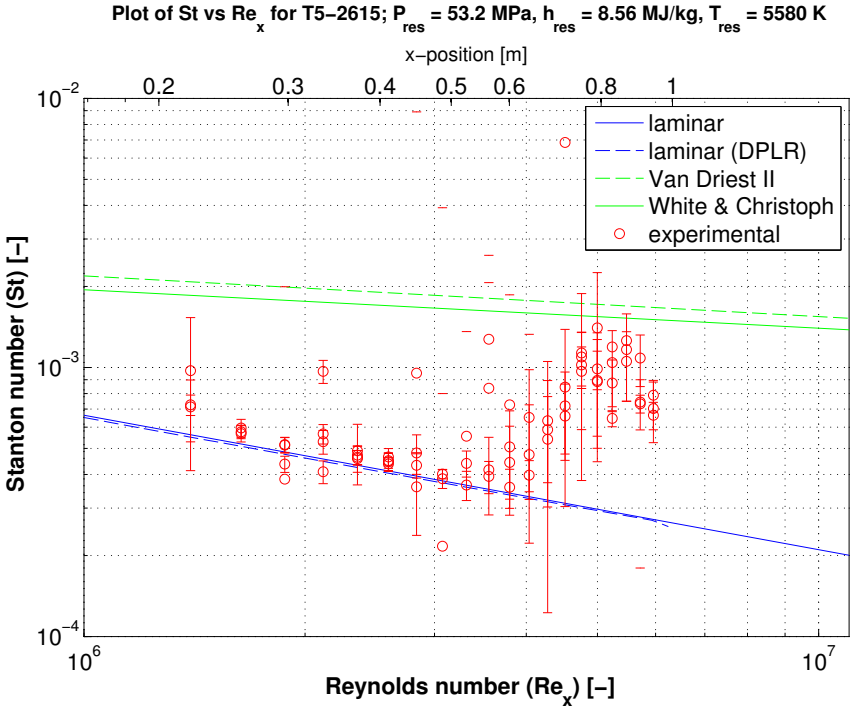


Figure 177: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

60 Shot 2616

Experiment 2616 was performed in T5 on 14 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

60.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2930	m/s
Shock Tube Fill Pressure	P_1	125.00	kPa
Reservoir Pressure	P_res	53.8	MPa

Table 473: Measured quantities, Shot 2616

60.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5343	K
Reservoir Density	ρ_res	32.74	kg/m^3
Reservoir Enthalpy	h_res	7.99	MJ/kg

Table 474: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2616

$Y_{\mathrm{N_2}}$	$Y_{\mathrm{O_2}}$	$Y_{\mathrm{CO_2}}$	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
7.01×10^{-1}	8.62×10^{-2}	0	1.40×10^{-1}	0	1.30×10^{-3}	7.22×10^{-2}

Table 475: Computed reservoir species mass fractions, Shot 2616

60.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3678	1158.0	1158.0	5.51	23.3	0.069	5.56×10^6
72 cm	3656	1164.4	1169.1	5.32	26.9	0.080	6.34×10^6

Table 476: Computed freestream conditions, Shot 2616

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.21×10^{-2}	0	0	8.72×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.63×10^{-2}	0	1.53×10^{-10}	4.26×10^{-3}

Table 477: Computed freestream species mass fractions, Shot 2616

60.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3642	1268.7	1268.7	5.21	33.7	0.091	6.89×10^6
72 cm	3594	1328.7	1326.4	4.90	38.9	0.101	7.30×10^6

Table 478: Computed boundary layer edge conditions, Shot 2616

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.21×10^{-2}	0	0	8.72×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.63×10^{-2}	0	1.27×10^{-9}	4.16×10^{-3}

Table 479: Computed boundary layer edge species mass fractions, Shot 2616

	T^* K	Unit Re^* 1/m
1D 100 cm	1603	4.67×10^6
72 cm	1572	6.17×10^6

Table 480: Dorrance reference conditions, Shot 2616

60.5 Stability Computations

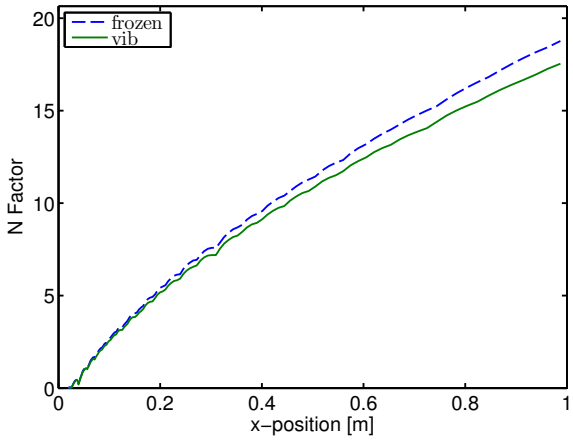


Figure 178: Locus of maximum N factor with and without vibrational energy transfer, Shot 2616

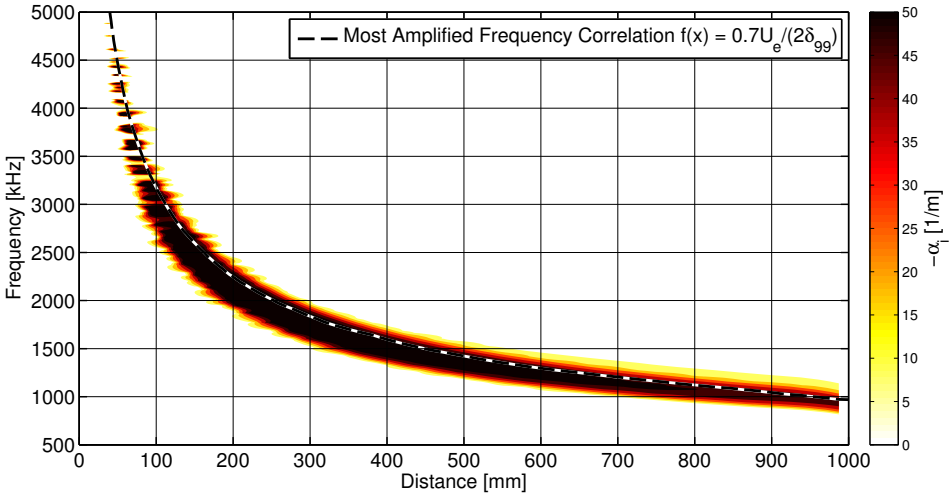


Figure 179: Stability diagram with vibrational energy transfer, Shot 2616. Dashed line indicates $0.7U_e/(2\delta_{99})$.

60.6 Heat Transfer Results

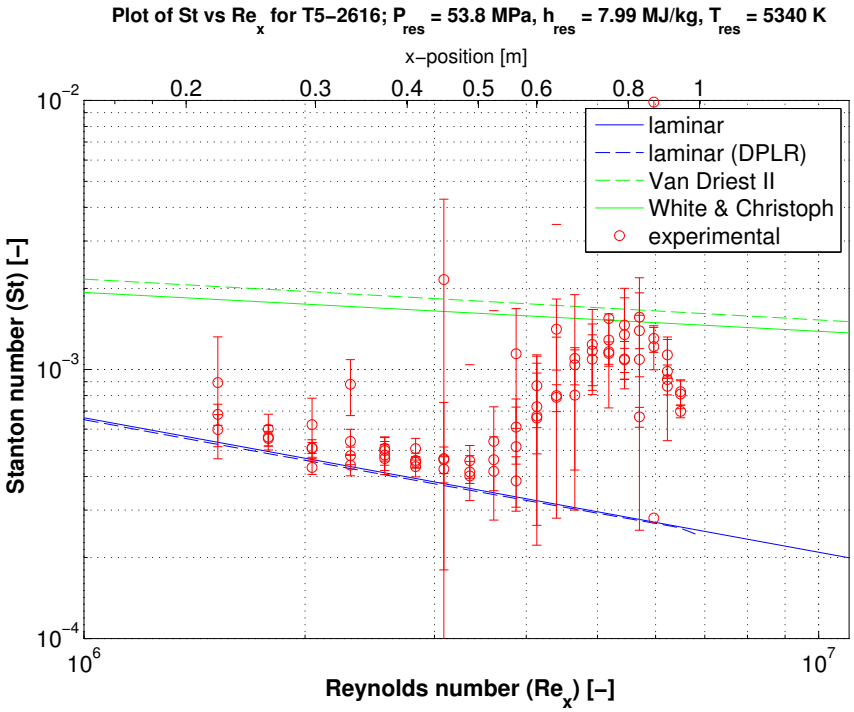


Figure 180: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

61 Shot 2617

Experiment 2617 was performed in T5 on 20 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

61.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_res	52.3	MPa

Table 481: Measured quantities, Shot 2617

61.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5427	K
Reservoir Density	ρ_res	31.18	kg/m^3
Reservoir Enthalpy	h_res	8.21	MJ/kg

Table 482: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2617

$Y_{\mathrm{N_2}}$	$Y_{\mathrm{O_2}}$	$Y_{\mathrm{CO_2}}$	Y_{NO}	Y_{CO}	Y_{N}	Y_{O}
7.00×10^{-1}	8.08×10^{-2}	0	1.39×10^{-1}	0	1.57×10^{-3}	7.78×10^{-2}

Table 483: Computed reservoir species mass fractions, Shot 2617

61.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3719	1193.0	1193.0	5.48	22.8	0.066	5.25×10^6
72 cm	3697	1204.4	1210.2	5.29	26.5	0.076	5.99×10^6

Table 484: Computed freestream conditions, Shot 2617

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	2.89×10^{-10}	1.01×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	3.10×10^{-10}	5.15×10^{-3}

Table 485: Computed freestream species mass fractions, Shot 2617

61.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3682	1305.4	1305.4	5.19	33.0	0.087	6.50×10^6
72 cm	3634	1371.6	1369.2	4.87	38.2	0.096	6.89×10^6

Table 486: Computed boundary layer edge conditions, Shot 2617

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	2.89×10^{-10}	1.01×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	2.19×10^{-9}	5.02×10^{-3}

Table 487: Computed boundary layer edge species mass fractions, Shot 2617

	T^* K	Unit Re^* 1/m
1D 100 cm	1636	4.45×10^6
72 cm	1606	5.88×10^6

Table 488: Dorrance reference conditions, Shot 2617

61.5 Stability Computations

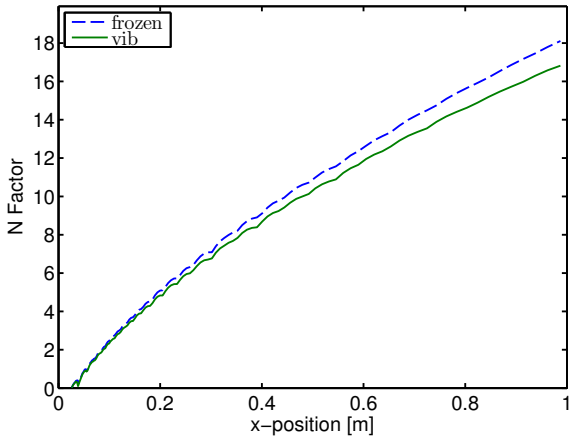


Figure 181: Locus of maximum N factor with and without vibrational energy transfer, Shot 2617

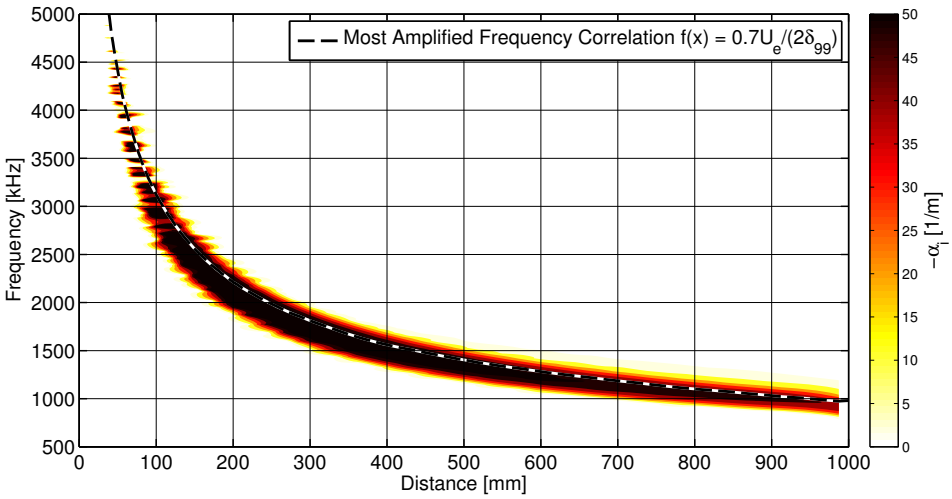


Figure 182: Stability diagram with vibrational energy transfer, Shot 2617. Dashed line indicates $0.7U_e/(2\delta_{99})$.

61.6 Heat Transfer Results

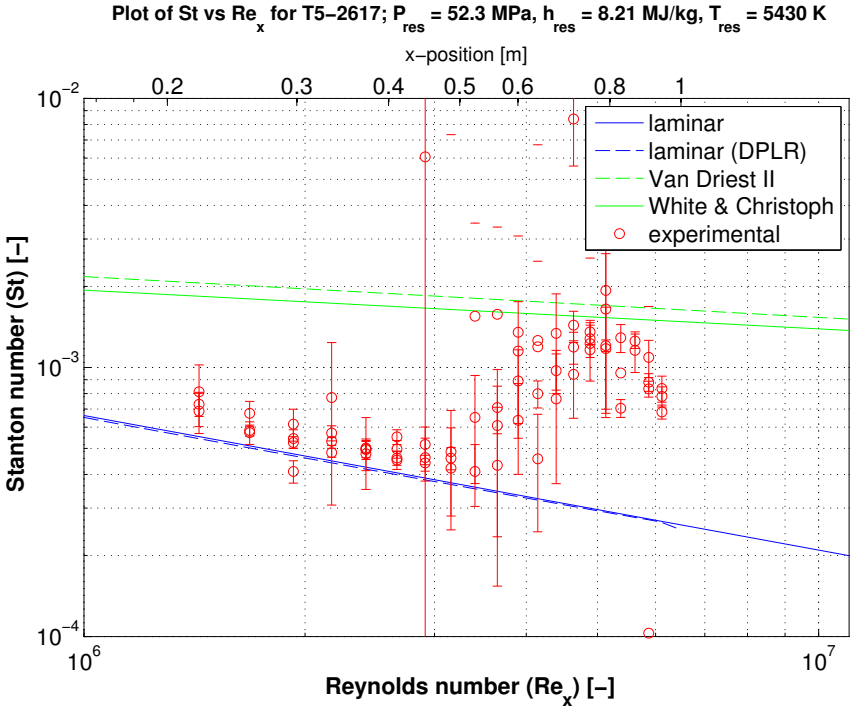


Figure 183: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

62 Shot 2618

Experiment 2618 was performed in T5 on 21 October 2010. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

62.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2970	m/s
Shock Tube Fill Pressure	P_1	114.60	kPa
Reservoir Pressure	P_res	53.2	MPa

Table 489: Measured quantities, Shot 2618

62.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5472	K
Reservoir Density	ρ_res	31.43	kg/m^3
Reservoir Enthalpy	h_res	8.31	MJ/kg

Table 490: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2618

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_NO	Y_CO	Y_N	Y_O
7.00×10^{-1}	7.86×10^{-2}	0	1.40×10^{-1}	0	1.71×10^{-3}	7.98×10^{-2}

Table 491: Computed reservoir species mass fractions, Shot 2618

62.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3737	1209.0	1209.0	5.47	23.3	0.066	5.26×10^6
72 cm	3717	1223.3	1229.4	5.28	27.2	0.077	6.02×10^6

Table 492: Computed freestream conditions, Shot 2618

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.18×10^{-2}	0	0	1.05×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.51×10^{-2}	0	4.09×10^{-10}	5.39×10^{-3}

Table 493: Computed freestream species mass fractions, Shot 2618

62.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3700	1322.7	1322.7	5.18	33.6	0.087	6.50×10^6
72 cm	3654	1392.2	1389.9	4.86	39.2	0.097	6.92×10^6

Table 494: Computed boundary layer edge conditions, Shot 2618

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.18×10^{-2}	0	0	1.05×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.51×10^{-2}	0	2.70×10^{-9}	5.26×10^{-3}

Table 495: Computed boundary layer edge species mass fractions, Shot 2618

	T^* K	Unit Re^* 1/m
1D 100 cm	1651	4.48×10^6
72 cm	1623	5.93×10^6

Table 496: Dorrance reference conditions, Shot 2618

62.5 Stability Computations

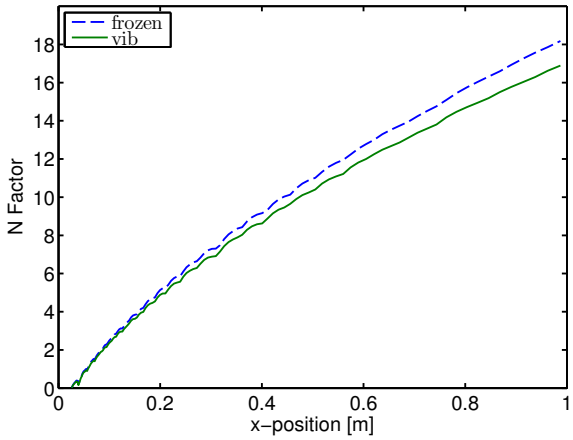


Figure 184: Locus of maximum N factor with and without vibrational energy transfer, Shot 2618

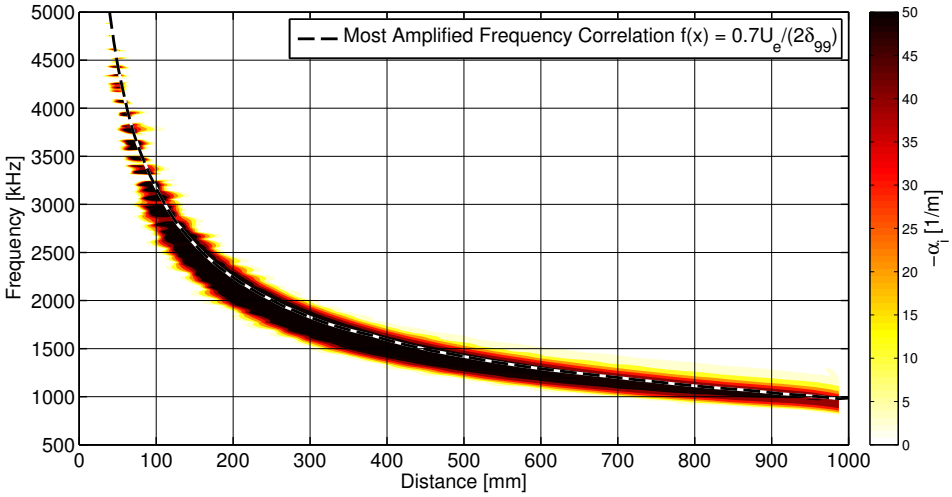


Figure 185: Stability diagram with vibrational energy transfer, Shot 2618. Dashed line indicates $0.7U_e/(2\delta_{99})$.

62.6 Heat Transfer Results

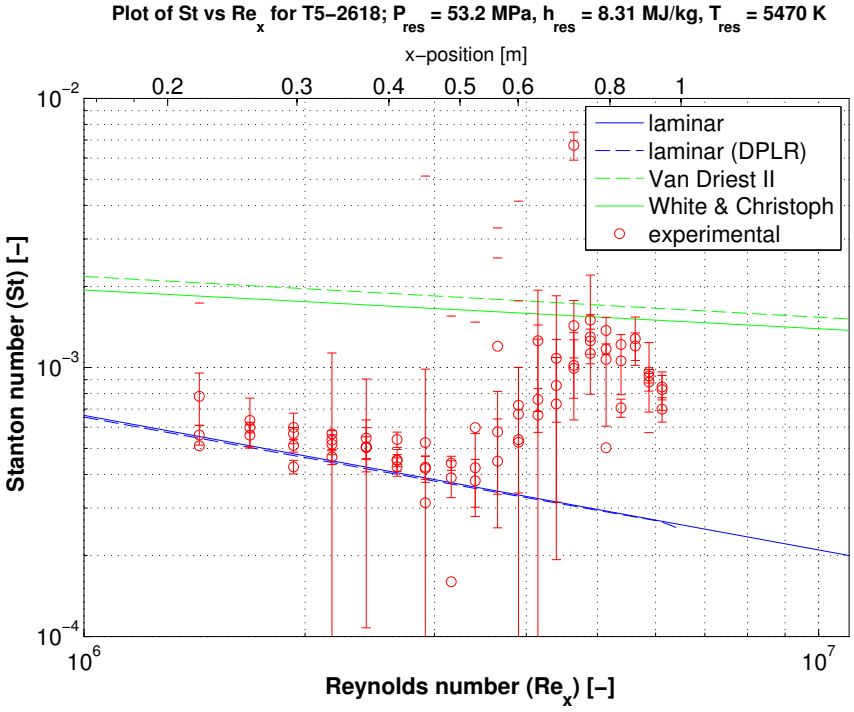


Figure 186: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

63 Shot 2619

Experiment 2619 was performed in T5 on 26 October 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

63.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2880	m/s
Shock Tube Fill Pressure	P_1	115.10	kPa
Reservoir Pressure	P_{res}	53.2	MPa

Table 497: Measured quantities, Shot 2619

63.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5316	K
Reservoir Density	ρ_{res}	32.63	kg/m^3
Reservoir Enthalpy	h_{res}	7.93	MJ/kg

Table 498: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2619

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	8.76×10^{-2}	0	1.39×10^{-1}	0	1.24×10^{-3}	7.10×10^{-2}

Table 499: Computed reservoir species mass fractions, Shot 2619

63.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3667	1148.0	1148.0	5.51	23.0	0.069	5.56×10^{6}
72 cm	3644	1153.0	1157.6	5.33	26.5	0.079	6.33×10^{6}

Table 500: Computed freestream conditions, Shot 2619

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.22×10^{-2}	0	8.25×10^{-10}	8.51×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.65×10^{-2}	0	1.27×10^{-10}	4.12×10^{-3}

Table 501: Computed freestream species mass fractions, Shot 2619

63.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3631	1258.0	1258.0	5.21	33.4	0.091	6.89×10^{6}
72 cm	3583	1316.2	1313.9	4.91	38.4	0.101	7.29×10^{6}

Table 502: Computed boundary layer edge conditions, Shot 2619

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.22×10^{-2}	0	8.25×10^{-10}	8.51×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.65×10^{-2}	0	1.11×10^{-9}	4.03×10^{-3}

Table 503: Computed boundary layer edge species mass fractions, Shot 2619

	T^* K	Unit Re^* 1/m
1D 100 cm	1593	4.65×10^{6}
72 cm	1562	6.14×10^{6}

Table 504: Dorrance reference conditions, Shot 2619

63.5 Stability Computations

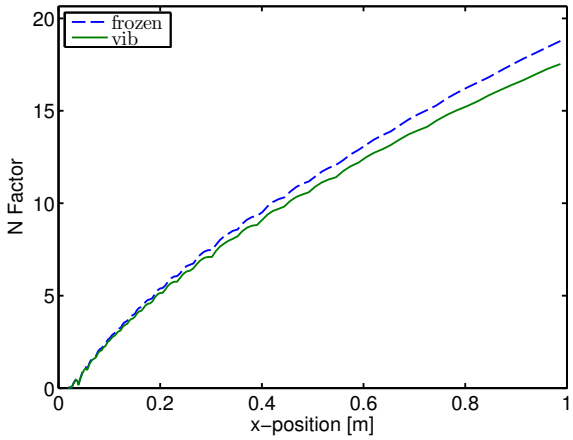


Figure 187: Locus of maximum N factor with and without vibrational energy transfer, Shot 2619

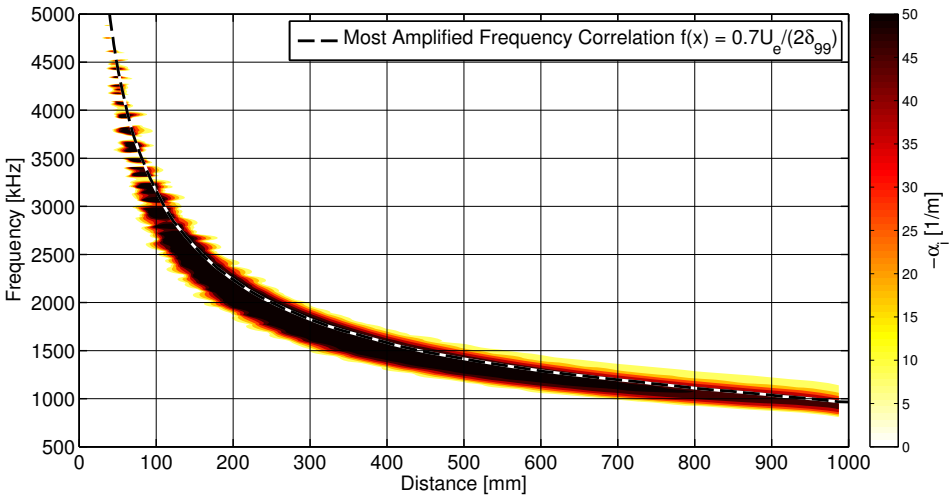


Figure 188: Stability diagram with vibrational energy transfer, Shot 2619. Dashed line indicates $0.7U_e/(2\delta_{99})$.

63.6 Heat Transfer Results

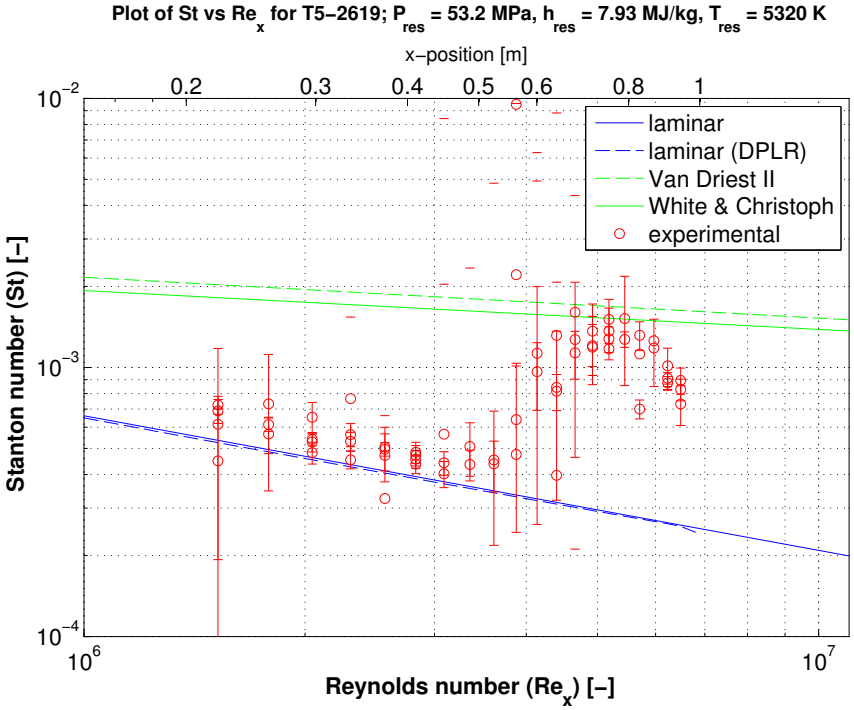


Figure 189: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

64 Shot 2620

Experiment 2620 was performed in T5 on 27 October 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

64.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3000	m/s
Shock Tube Fill Pressure	P_1	116.00	kPa
Reservoir Pressure	P_{res}	51.7	MPa

Table 505: Measured quantities, Shot 2620

64.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5490	K
Reservoir Density	ρ_{res}	30.35	kg/m^3
Reservoir Enthalpy	h_{res}	8.36	MJ/kg

Table 506: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2620

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.70×10^{-2}	0	1.39×10^{-1}	0	1.80×10^{-3}	8.17×10^{-2}

Table 507: Computed reservoir species mass fractions, Shot 2620

64.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3753	1223.0	1223.0	5.47	23.0	0.065	5.14×10^{6}
72 cm	3726	1233.6	1240.1	5.27	26.5	0.074	5.80×10^{6}

Table 508: Computed freestream conditions, Shot 2620

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	1.99×10^{-10}	1.11×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	4.98×10^{-10}	5.81×10^{-3}

Table 509: Computed freestream species mass fractions, Shot 2620

64.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3716	1337.1	1337.1	5.18	33.2	0.085	6.34×10^{6}
72 cm	3663	1403.3	1400.9	4.85	38.1	0.094	6.66×10^{6}

Table 510: Computed boundary layer edge conditions, Shot 2620

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	1.99×10^{-10}	1.11×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	3.20×10^{-9}	5.67×10^{-3}

Table 511: Computed boundary layer edge species mass fractions, Shot 2620

	T^* K	Unit Re^* 1/m
1D 100 cm	1664	4.39×10^{6}
72 cm	1631	5.73×10^{6}

Table 512: Dorrance reference conditions, Shot 2620

64.5 Stability Computations

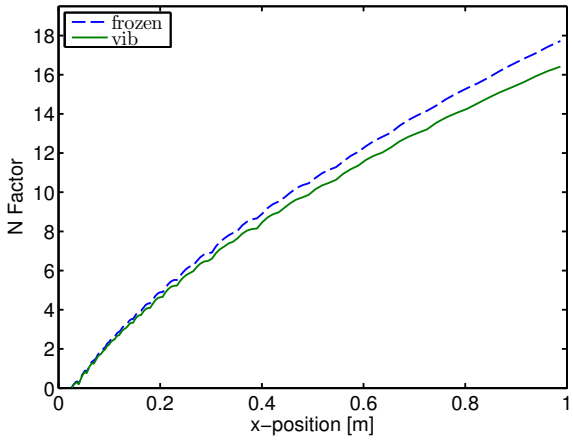


Figure 190: Locus of maximum N factor with and without vibrational energy transfer, Shot 2620

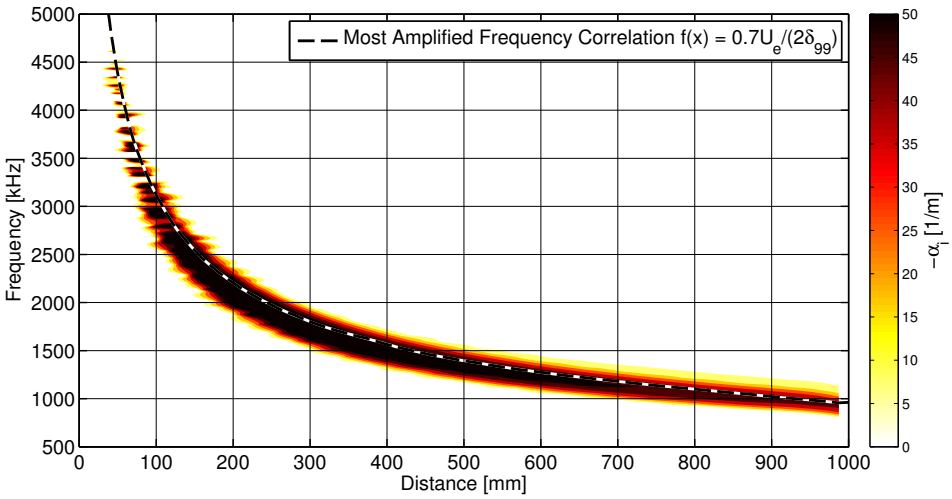


Figure 191: Stability diagram with vibrational energy transfer, Shot 2620. Dashed line indicates $0.7U_e/(2\delta_{99})$.

64.6 Heat Transfer Results

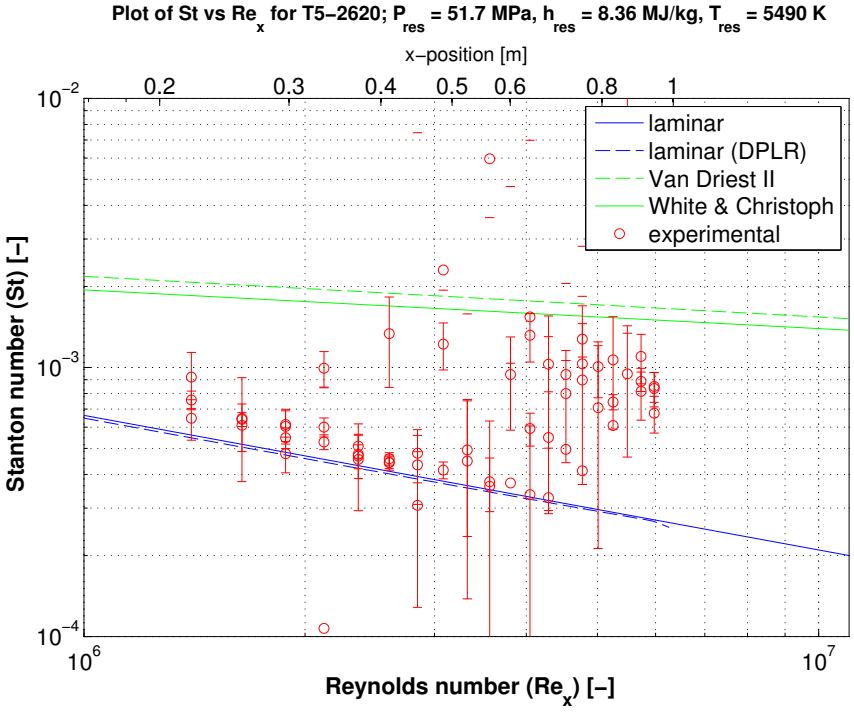


Figure 192: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

65 Shot 2621

Experiment 2621 was performed in T5 on 28 October 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

65.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	115.45	kPa
Reservoir Pressure	P_{res}	52.4	MPa

Table 513: Measured quantities, Shot 2621

65.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5426	K
Reservoir Density	ρ_{res}	31.24	kg/m^3
Reservoir Enthalpy	h_{res}	8.20	MJ/kg

Table 514: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2621

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.09×10^{-2}	0	1.39×10^{-1}	0	1.57×10^{-3}	7.77×10^{-2}

Table 515: Computed reservoir species mass fractions, Shot 2621

65.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3718	1192.0	1192.0	5.48	22.9	0.066	5.26×10^{6}
72 cm	3696	1203.8	1209.6	5.29	26.6	0.076	6.00×10^{6}

Table 516: Computed freestream conditions, Shot 2621

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	0	1.01×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	3.07×10^{-10}	5.12×10^{-3}

Table 517: Computed freestream species mass fractions, Shot 2621

65.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3681	1304.6	1304.6	5.19	33.0	0.087	6.51×10^{6}
72 cm	3634	1370.8	1368.5	4.87	38.3	0.097	6.90×10^{6}

Table 518: Computed boundary layer edge conditions, Shot 2621

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	0	1.01×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	2.17×10^{-9}	5.00×10^{-3}

Table 519: Computed boundary layer edge species mass fractions, Shot 2621

	T^* K	Unit Re^* 1/m
1D 100 cm	1635	4.46×10^{6}
72 cm	1606	5.89×10^{6}

Table 520: Dorrance reference conditions, Shot 2621

65.5 Stability Computations

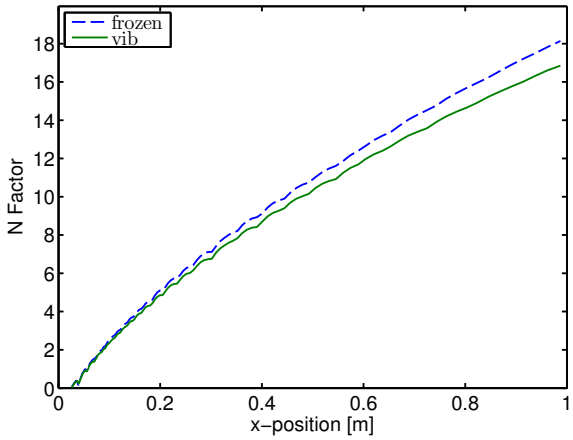


Figure 193: Locus of maximum N factor with and without vibrational energy transfer, Shot 2621

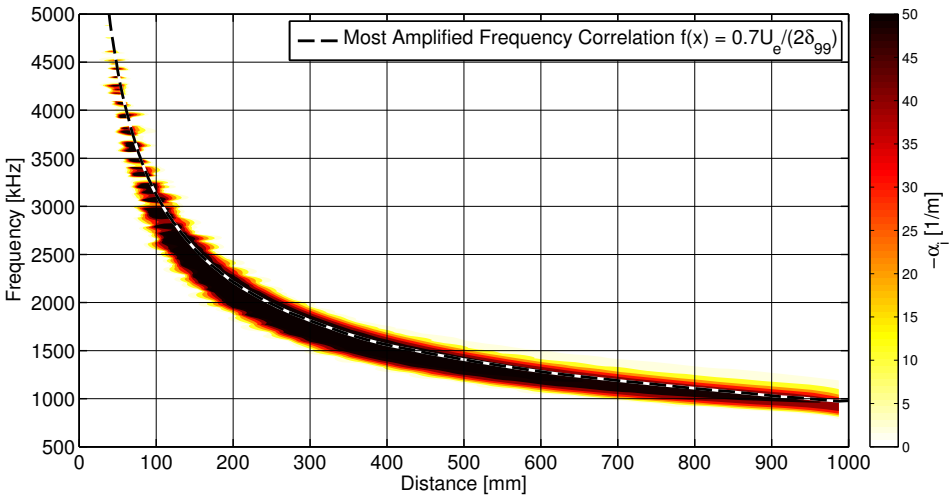


Figure 194: Stability diagram with vibrational energy transfer, Shot 2621. Dashed line indicates $0.7U_e/(2\delta_{99})$.

65.6 Heat Transfer Results

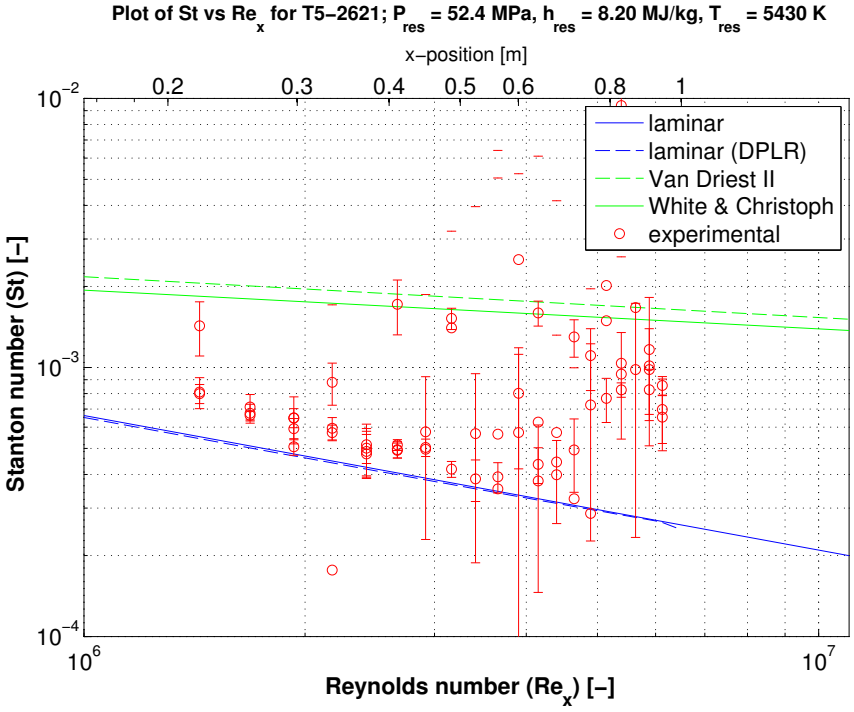


Figure 195: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

66 Shot 2623

Experiment 2623 was performed in T5 on 1 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

66.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	114.90	kPa
Reservoir Pressure	P_{res}	49.3	MPa

Table 521: Measured quantities, Shot 2623

66.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5376	K
Reservoir Density	ρ_{res}	29.73	kg/m^3
Reservoir Enthalpy	h_{res}	8.11	MJ/kg

Table 522: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2623

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	8.25×10^{-2}	0	1.38×10^{-1}	0	1.46×10^{-3}	7.66×10^{-2}

Table 523: Computed reservoir species mass fractions, Shot 2623

66.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3698	1174.0	1174.0	5.50	21.4	0.063	5.03×10^{6}
72 cm	3676	1185.7	1191.6	5.30	24.8	0.072	5.71×10^{6}

Table 524: Computed freestream conditions, Shot 2623

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.20×10^{-2}	0	0	1.02×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.59×10^{-2}	0	2.47×10^{-10}	5.16×10^{-3}

Table 525: Computed freestream species mass fractions, Shot 2623

66.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3662	1285.5	1285.5	5.20	31.0	0.083	6.22×10^{6}
72 cm	3614	1351.2	1348.7	4.88	35.8	0.092	6.58×10^{6}

Table 526: Computed boundary layer edge conditions, Shot 2623

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.20×10^{-2}	0	0	1.02×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.59×10^{-2}	0	1.90×10^{-9}	5.05×10^{-3}

Table 527: Computed boundary layer edge species mass fractions, Shot 2623

	T^* K	Unit Re^* 1/m
1D 100 cm	1618	4.24×10^{6}
72 cm	1590	5.59×10^{6}

Table 528: Dorrance reference conditions, Shot 2623

66.5 Stability Computations

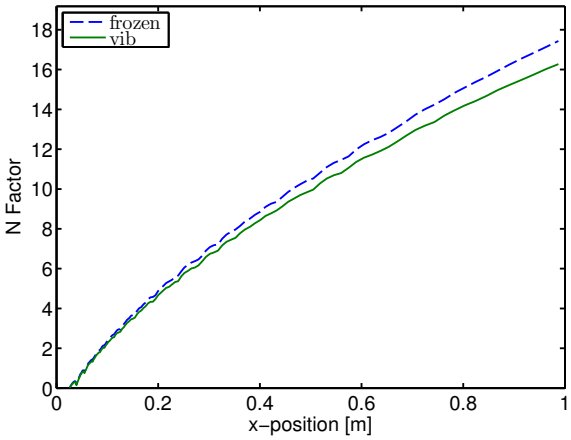


Figure 196: Locus of maximum N factor with and without vibrational energy transfer, Shot 2623

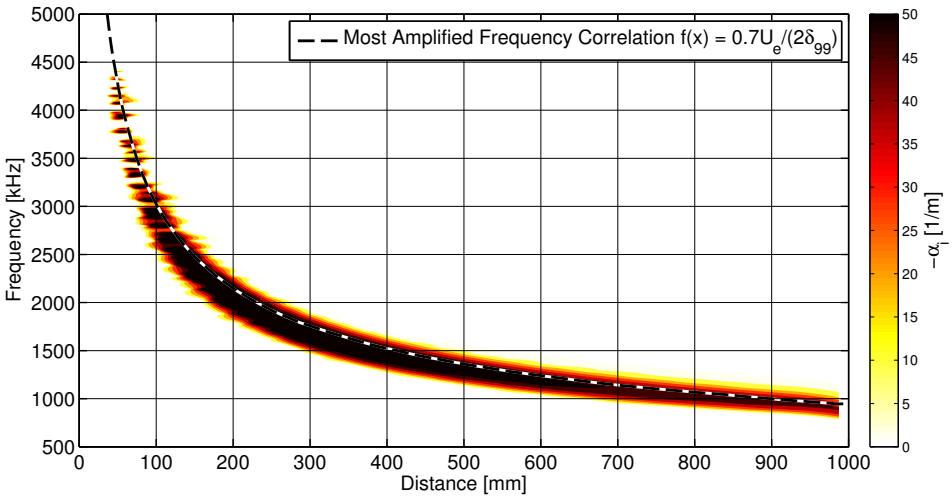


Figure 197: Stability diagram with vibrational energy transfer, Shot 2623. Dashed line indicates $0.7U_e/(2\delta_{99})$.

66.6 Heat Transfer Results

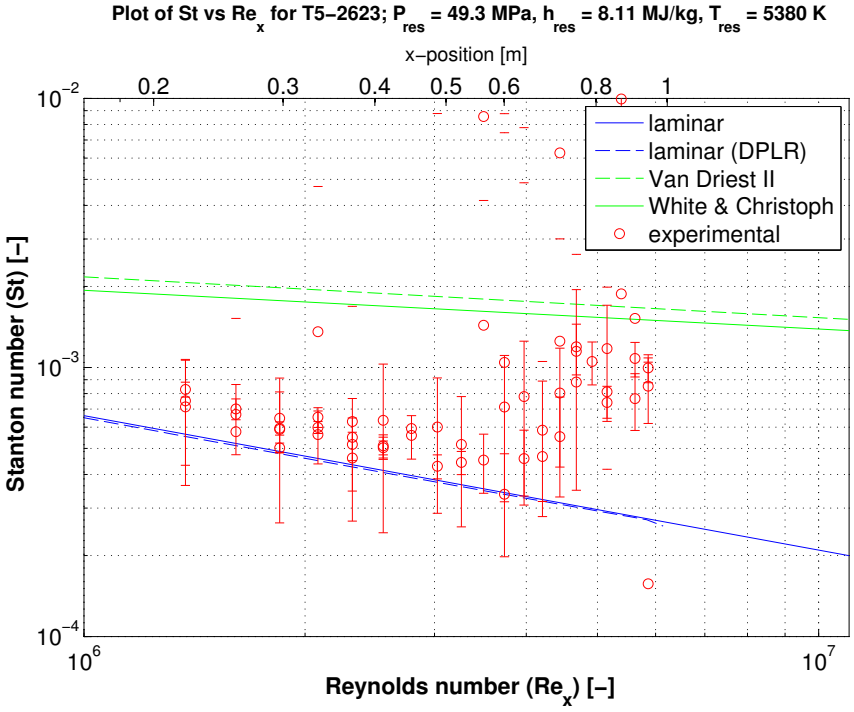


Figure 198: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

67 Shot 2624

Experiment 2624 was performed in T5 on 2 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

67.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	114.95	kPa
Reservoir Pressure	P_{res}	49.7	MPa

Table 529: Measured quantities, Shot 2624

67.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5357	K
Reservoir Density	ρ_{res}	30.11	kg/m^3
Reservoir Enthalpy	h_{res}	8.06	MJ/kg

Table 530: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2624

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	8.38×10^{-2}	0	1.38×10^{-1}	0	1.40×10^{-3}	7.53×10^{-2}

Table 531: Computed reservoir species mass fractions, Shot 2624

67.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3687	1164.0	1164.0	5.50	21.4	0.063	5.08×10^6
72 cm	3667	1176.7	1182.3	5.31	25.0	0.073	5.80×10^6

Table 532: Computed freestream conditions, Shot 2624

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.21×10^{-2}	0	2.33×10^{-10}	9.85×10^{-3}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.61×10^{-2}	0	2.10×10^{-10}	4.93×10^{-3}

Table 533: Computed freestream species mass fractions, Shot 2624

67.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3651	1275.1	1275.1	5.21	31.0	0.084	6.29×10^6
72 cm	3605	1341.8	1339.3	4.89	36.0	0.093	6.67×10^6

Table 534: Computed boundary layer edge conditions, Shot 2624

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.21×10^{-2}	0	2.33×10^{-10}	9.85×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.61×10^{-2}	0	1.68×10^{-9}	4.83×10^{-3}

Table 535: Computed boundary layer edge species mass fractions, Shot 2624

	T^* K	Unit Re^* 1/m
1D 100 cm	1609	4.27×10^6
72 cm	1582	5.66×10^6

Table 536: Dorrance reference conditions, Shot 2624

67.5 Stability Computations

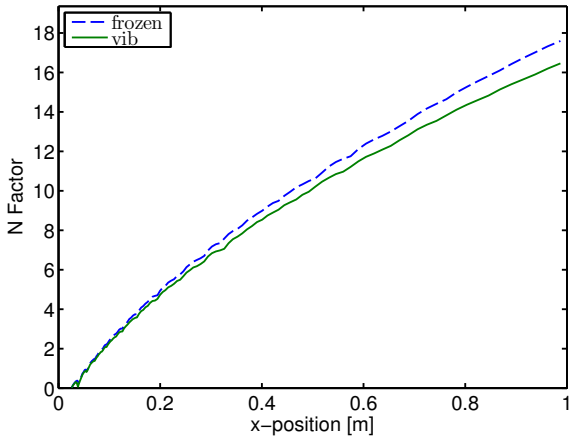


Figure 199: Locus of maximum N factor with and without vibrational energy transfer, Shot 2624

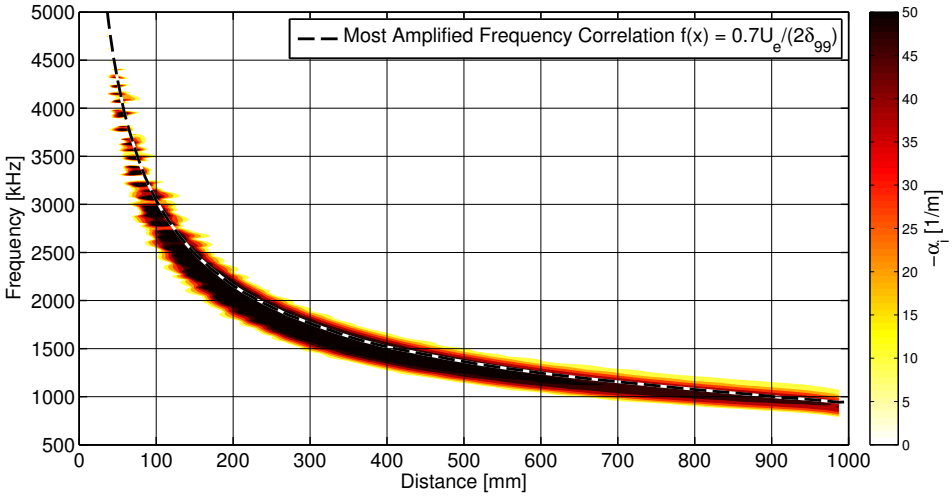


Figure 200: Stability diagram with vibrational energy transfer, Shot 2624. Dashed line indicates $0.7U_e/(2\delta_{99})$.

67.6 Heat Transfer Results

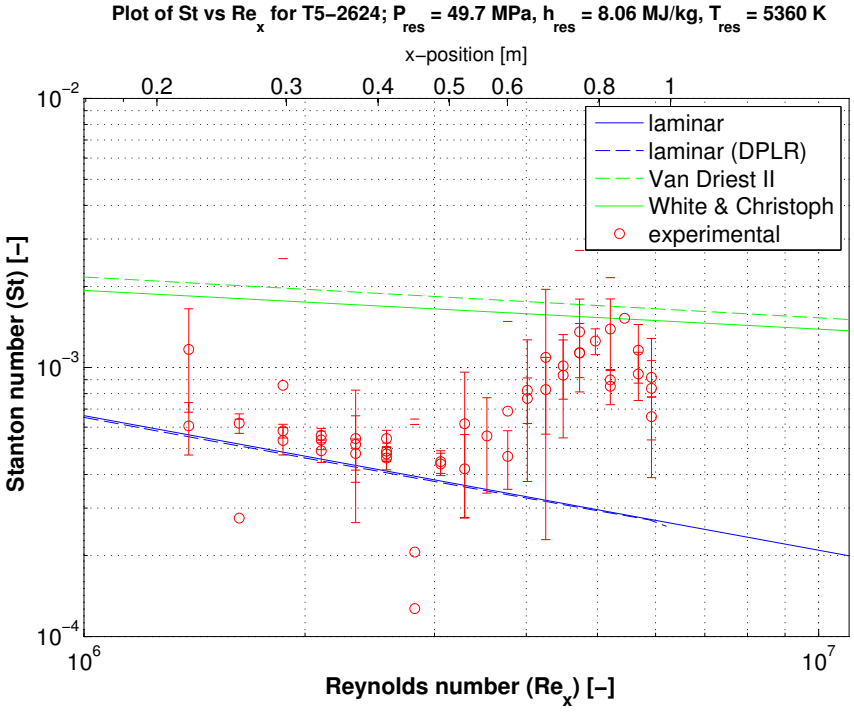


Figure 201: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

68 Shot 2625

Experiment 2625 was performed in T5 on 3 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

68.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3030	m/s
Shock Tube Fill Pressure	P_1	114.85	kPa
Reservoir Pressure	P_{res}	50.1	MPa

Table 537: Measured quantities, Shot 2625

68.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5523	K
Reservoir Density	ρ_{res}	29.16	kg/m^3
Reservoir Enthalpy	h_{res}	8.46	MJ/kg

Table 538: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2625

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.45×10^{-2}	0	1.38×10^{-1}	0	1.95×10^{-3}	8.46×10^{-2}

Table 539: Computed reservoir species mass fractions, Shot 2625

68.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3768	1235.0	1235.0	5.46	22.3	0.062	4.91×10^{6}
72 cm	3743	1250.7	1257.7	5.25	25.8	0.071	5.55×10^{6}

Table 540: Computed freestream conditions, Shot 2625

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	7.98×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	6.72×10^{-10}	6.42×10^{-3}

Table 541: Computed freestream species mass fractions, Shot 2625

68.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3731	1350.7	1350.7	5.17	32.1	0.082	6.05×10^{6}
72 cm	3680	1421.5	1419.1	4.84	37.1	0.090	6.36×10^{6}

Table 542: Computed boundary layer edge conditions, Shot 2625

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	7.98×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	4.09×10^{-9}	6.26×10^{-3}

Table 543: Computed boundary layer edge species mass fractions, Shot 2625

	T^* K	Unit Re^* 1/m
1D 100 cm	1676	4.21×10^{6}
72 cm	1646	5.50×10^{6}

Table 544: Dorrance reference conditions, Shot 2625

68.5 Stability Computations

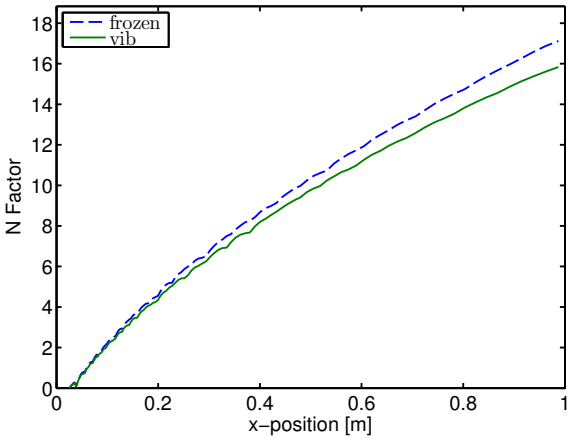


Figure 202: Locus of maximum N factor with and without vibrational energy transfer, Shot 2625

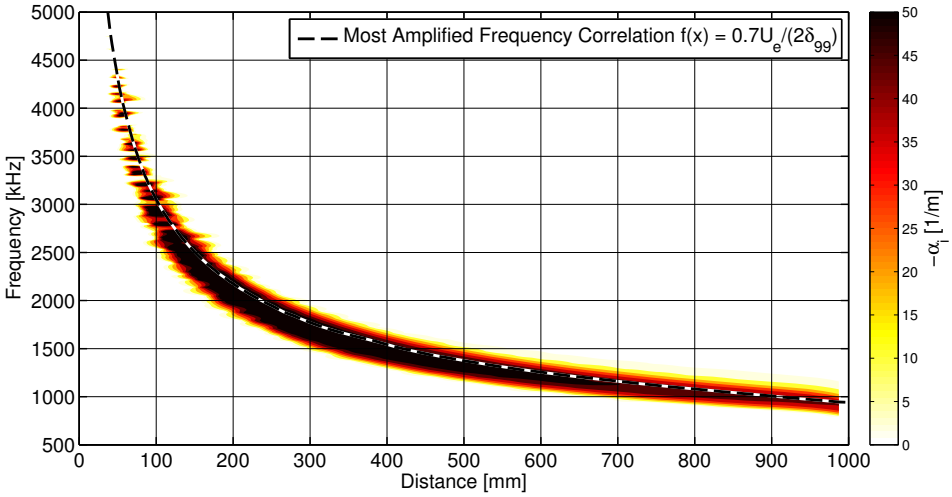


Figure 203: Stability diagram with vibrational energy transfer, Shot 2625. Dashed line indicates $0.7U_e/(2\delta_{99})$.

68.6 Heat Transfer Results

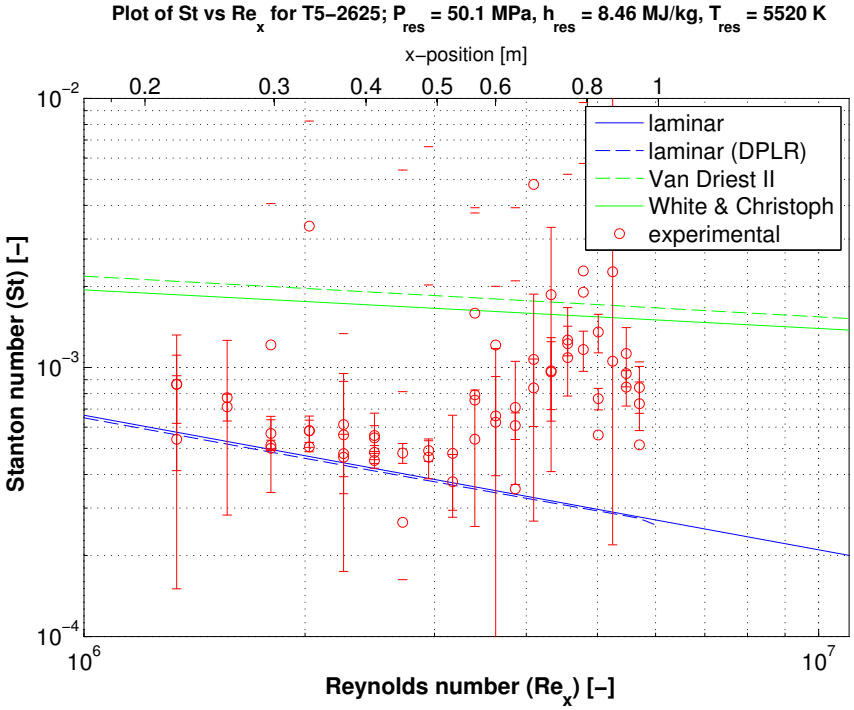


Figure 204: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

69 Shot 2626

Experiment 2626 was performed in T5 on 3 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

69.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2830	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	51.9	MPa

Table 545: Measured quantities, Shot 2626

69.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5197	K
Reservoir Density	ρ_{res}	32.69	kg/m^3
Reservoir Enthalpy	h_{res}	7.67	MJ/kg

Table 546: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2626

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	9.42×10^{-2}	0	1.38×10^{-1}	0	9.71×10^{-4}	6.51×10^{-2}

Table 547: Computed reservoir species mass fractions, Shot 2626

69.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3612	1101.0	1101.0	5.54	22.1	0.069	5.63×10^{6}
72 cm	3590	1102.3	1105.7	5.37	25.3	0.079	6.39×10^{6}

Table 548: Computed freestream conditions, Shot 2626

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	0	7.47×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	0	3.44×10^{-3}

Table 549: Computed freestream species mass fractions, Shot 2626

69.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3577	1208.2	1208.2	5.24	32.1	0.092	6.99×10^{6}
72 cm	3529	1261.6	1259.1	4.94	36.8	0.101	7.37×10^{6}

Table 550: Computed boundary layer edge conditions, Shot 2626

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	0	7.47×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	5.92×10^{-10}	3.38×10^{-3}

Table 551: Computed boundary layer edge species mass fractions, Shot 2626

	T^* K	Unit Re^* 1/m
1D 100 cm	1549	4.63×10^{6}
72 cm	1518	6.13×10^{6}

Table 552: Dorrance reference conditions, Shot 2626

69.5 Stability Computations

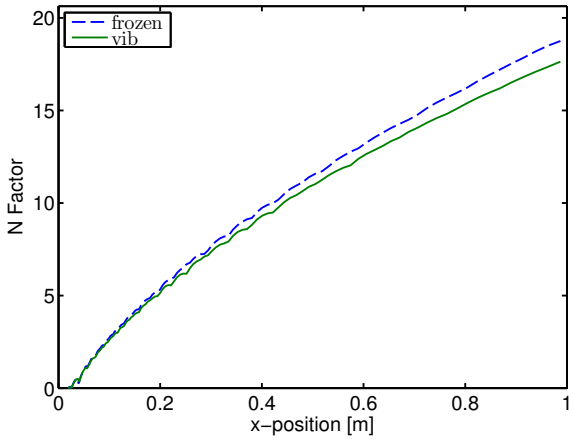


Figure 205: Locus of maximum N factor with and without vibrational energy transfer, Shot 2626

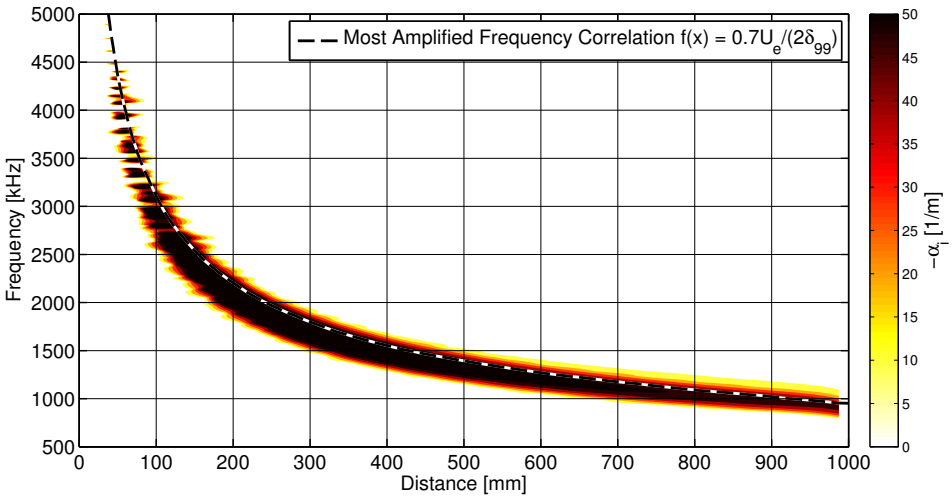


Figure 206: Stability diagram with vibrational energy transfer, Shot 2626. Dashed line indicates $0.7U_e/(2\delta_{99})$.

69.6 Heat Transfer Results

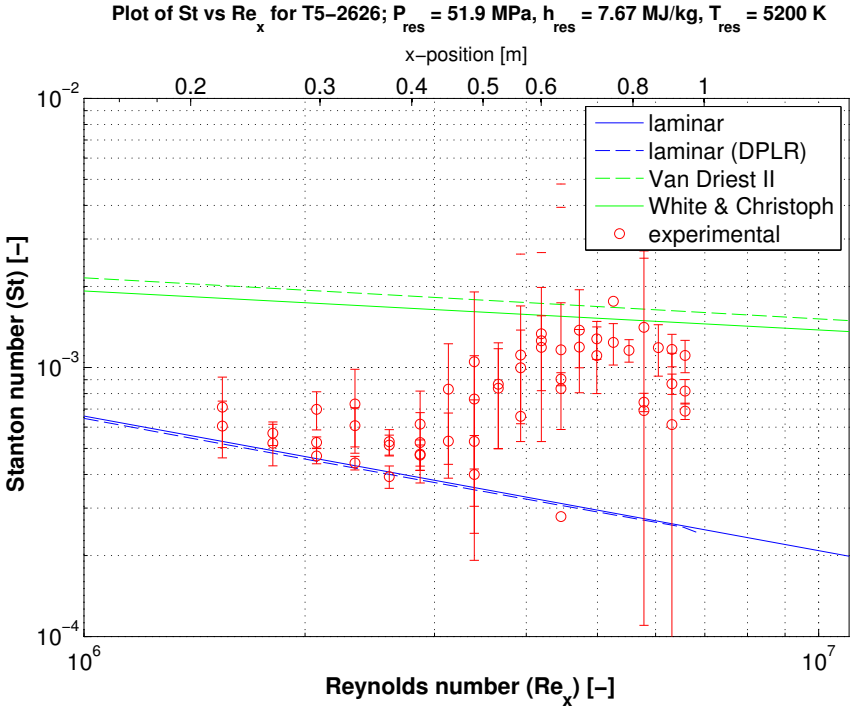


Figure 207: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

70 Shot 2627

Experiment 2627 was performed in T5 on 9 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

70.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2840	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.4	MPa

Table 553: Measured quantities, Shot 2627

70.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5245	K
Reservoir Density	ρ_{res}	33.25	kg/m^3
Reservoir Enthalpy	h_{res}	7.77	MJ/kg

Table 554: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2627

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	9.18×10^{-2}	0	1.39×10^{-1}	0	1.06×10^{-3}	6.70×10^{-2}

Table 555: Computed reservoir species mass fractions, Shot 2627

70.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3630	1117.0	1117.0	5.53	22.7	0.070	5.67×10^6
72 cm	3611	1121.3	1125.0	5.36	26.2	0.081	6.48×10^6

Table 556: Computed freestream conditions, Shot 2627

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.23×10^{-2}	0	0	7.71×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.70×10^{-2}	0	0	3.60×10^{-3}

Table 557: Computed freestream species mass fractions, Shot 2627

70.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3595	1224.7	1224.7	5.23	32.9	0.093	7.03×10^6
72 cm	3550	1282.2	1279.9	4.93	38.1	0.103	7.48×10^6

Table 558: Computed boundary layer edge conditions, Shot 2627

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.23×10^{-2}	0	0	7.71×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.70×10^{-2}	0	7.29×10^{-10}	3.53×10^{-3}

Table 559: Computed boundary layer edge species mass fractions, Shot 2627

	T^* K	Unit Re^* 1/m
1D 100 cm	1564	4.69×10^6
72 cm	1535	6.25×10^6

Table 560: Dorrance reference conditions, Shot 2627

70.5 Stability Computations

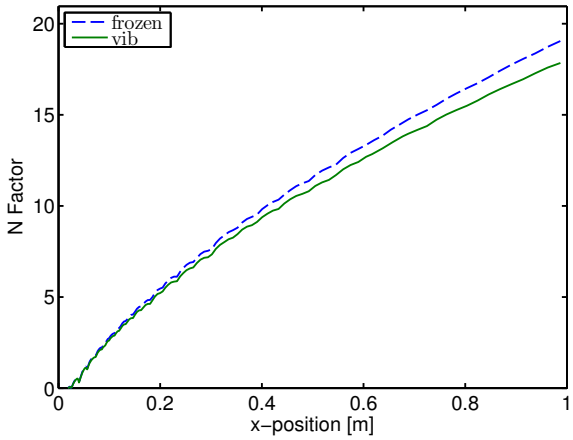


Figure 208: Locus of maximum N factor with and without vibrational energy transfer, Shot 2627

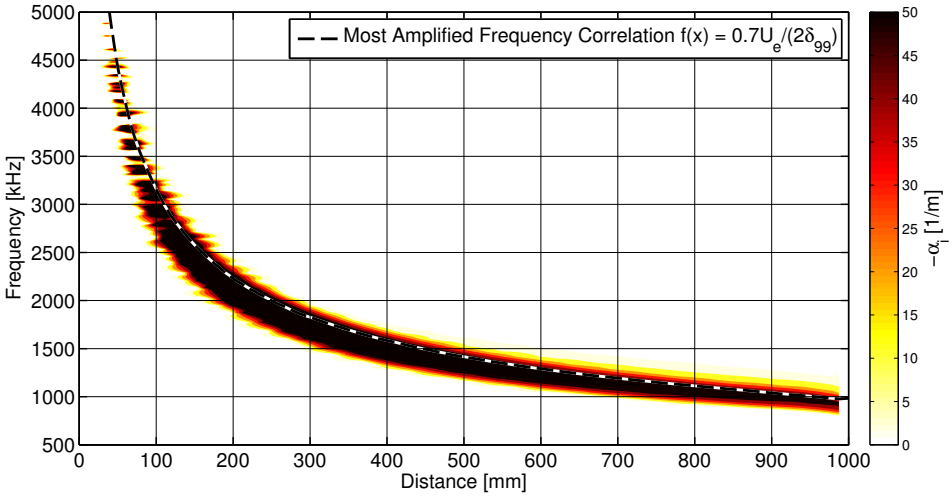


Figure 209: Stability diagram with vibrational energy transfer, Shot 2627. Dashed line indicates $0.7U_e/(2\delta_{99})$.

70.6 Heat Transfer Results

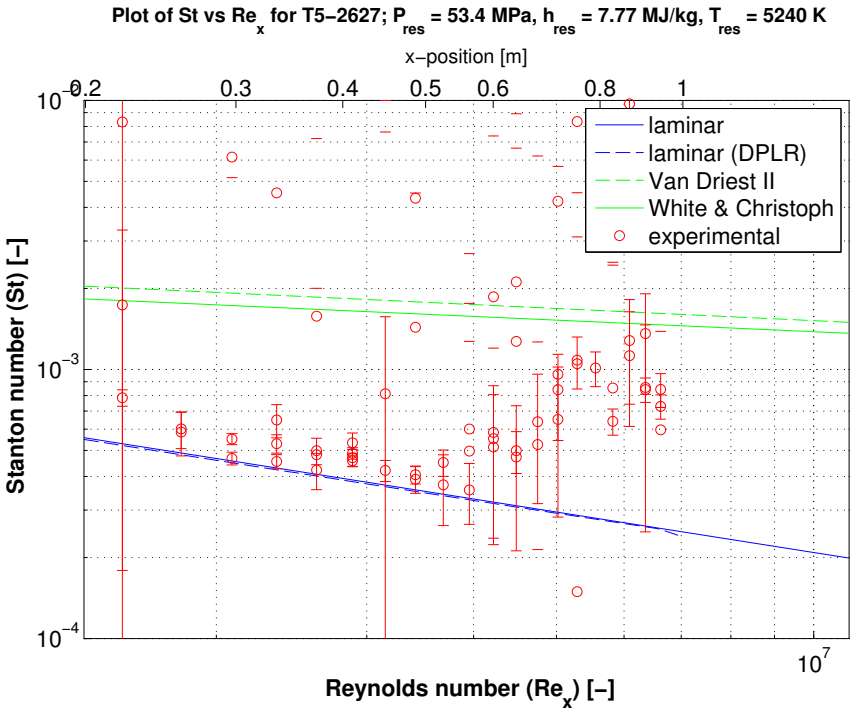


Figure 210: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

71 Shot 2628

Experiment 2628 was performed in T5 on 10 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

71.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2840	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	49.1	MPa

Table 561: Measured quantities, Shot 2628

71.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5173	K
Reservoir Density	ρ_{res}	31.06	kg/m^3
Reservoir Enthalpy	h_{res}	7.63	MJ/kg

Table 562: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2628

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	9.45×10^{-2}	0	1.37×10^{-1}	0	9.49×10^{-4}	6.52×10^{-2}

Table 563: Computed reservoir species mass fractions, Shot 2628

71.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3604	1094.0	1094.0	5.55	20.9	0.066	5.35×10^{6}
72 cm	3581	1096.2	1099.8	5.38	23.9	0.075	6.06×10^{6}

Table 564: Computed freestream conditions, Shot 2628

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.25×10^{-2}	0	0	7.77×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.75×10^{-2}	0	0	3.60×10^{-3}

Table 565: Computed freestream species mass fractions, Shot 2628

71.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3569	1200.4	1200.4	5.24	30.4	0.087	6.65×10^{6}
72 cm	3521	1254.9	1252.3	4.94	34.7	0.096	7.00×10^{6}

Table 566: Computed boundary layer edge conditions, Shot 2628

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.25×10^{-2}	0	0	7.77×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.75×10^{-2}	0	6.00×10^{-10}	3.54×10^{-3}

Table 567: Computed boundary layer edge species mass fractions, Shot 2628

	T^* K	Unit Re^* 1/m
1D 100 cm	1542	4.40×10^{6}
72 cm	1512	5.81×10^{6}

Table 568: Dorrance reference conditions, Shot 2628

71.5 Stability Computations

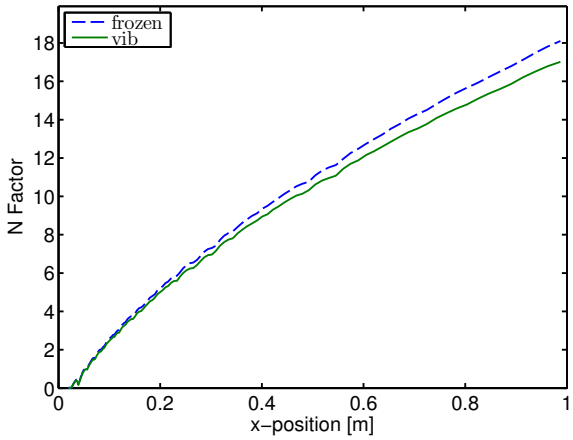


Figure 211: Locus of maximum N factor with and without vibrational energy transfer, Shot 2628

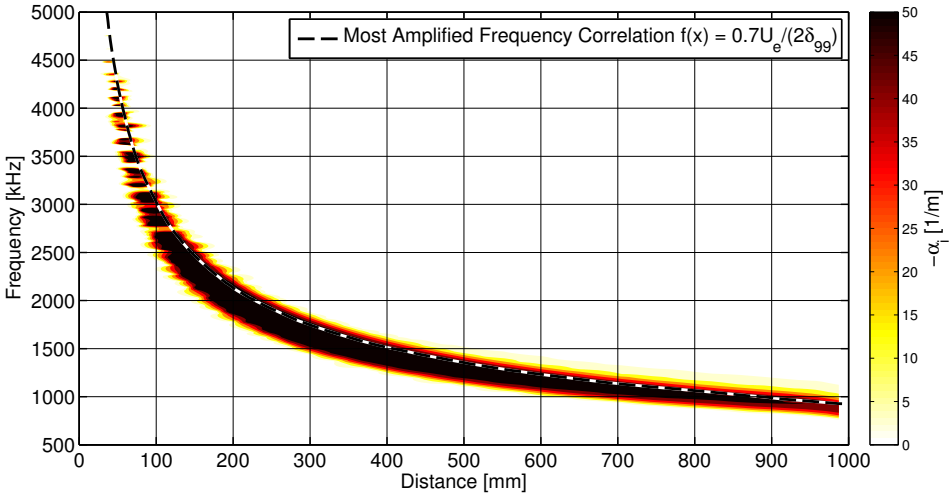


Figure 212: Stability diagram with vibrational energy transfer, Shot 2628. Dashed line indicates $0.7U_e/(2\delta_{99})$.

71.6 Heat Transfer Results

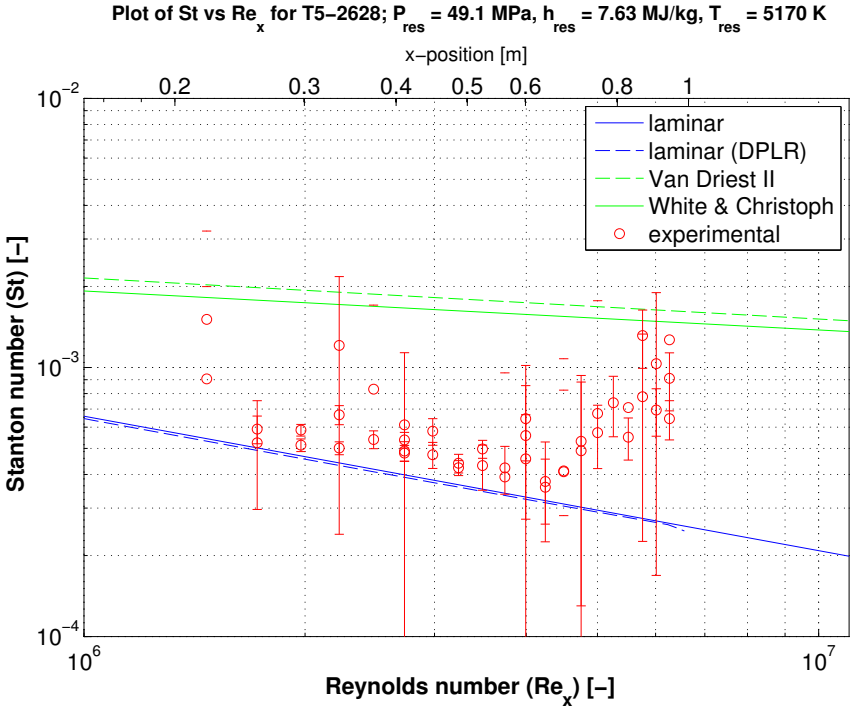


Figure 213: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

72 Shot 2629

Experiment 2629 was performed in T5 on 12 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

72.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2760	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	47.9	MPa

Table 569: Measured quantities, Shot 2629

72.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5017	K
Reservoir Density	ρ_{res}	31.49	kg/m^3
Reservoir Enthalpy	h_{res}	7.28	MJ/kg

Table 570: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2629

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.03×10^{-1}	1.04×10^{-1}	0	1.35×10^{-1}	0	6.72×10^{-4}	5.72×10^{-2}

Table 571: Computed reservoir species mass fractions, Shot 2629

72.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3528	1030.0	1030.0	5.59	19.8	0.066	5.48×10^{6}
72 cm	3507	1029.4	1030.7	5.44	22.6	0.076	6.21×10^{6}

Table 572: Computed freestream conditions, Shot 2629

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.28×10^{-2}	0	5.34×10^{-10}	6.38×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.81×10^{-2}	0	0	2.77×10^{-3}

Table 573: Computed freestream species mass fractions, Shot 2629

72.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3494	1132.8	1132.8	5.28	29.0	0.088	6.83×10^{6}
72 cm	3447	1183.5	1180.6	4.98	33.1	0.097	7.18×10^{6}

Table 574: Computed boundary layer edge conditions, Shot 2629

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.28×10^{-2}	0	5.34×10^{-10}	6.38×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.81×10^{-2}	0	2.57×10^{-10}	2.73×10^{-3}

Table 575: Computed boundary layer edge species mass fractions, Shot 2629

	T^* K	Unit Re^* 1/m
1D 100 cm	1482	4.40×10^{6}
72 cm	1454	5.84×10^{6}

Table 576: Dorrance reference conditions, Shot 2629

72.5 Stability Computations

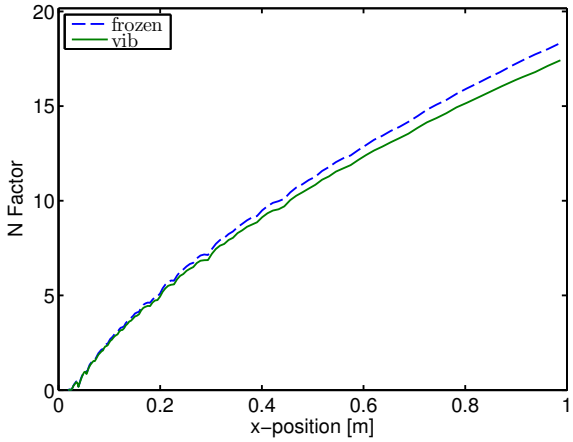


Figure 214: Locus of maximum N factor with and without vibrational energy transfer, Shot 2629

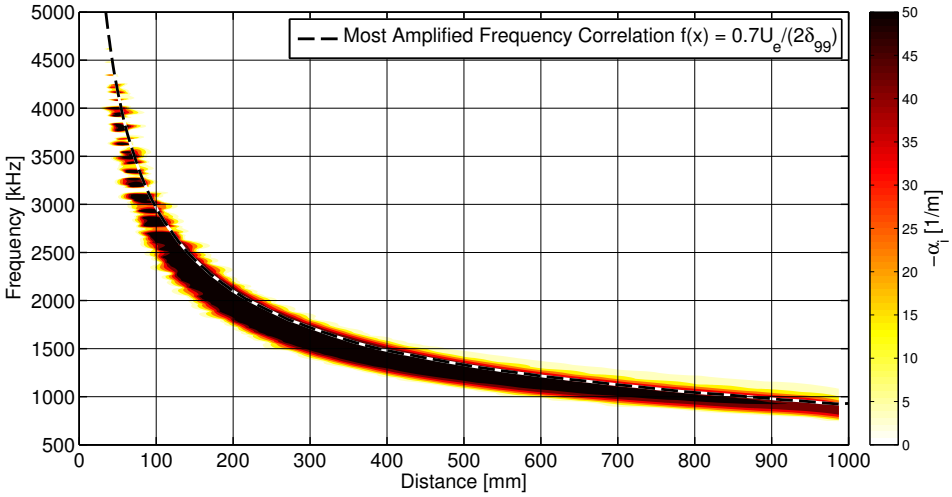


Figure 215: Stability diagram with vibrational energy transfer, Shot 2629. Dashed line indicates $0.7U_e/(2\delta_{99})$.

72.6 Heat Transfer Results

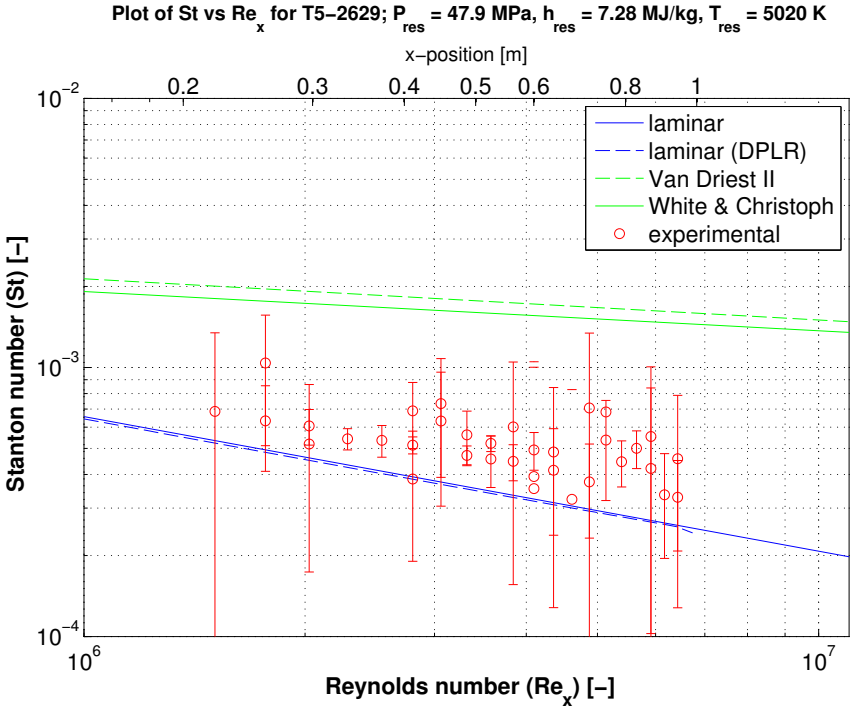


Figure 216: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

73 Shot 2630

Experiment 2630 was performed in T5 on 15 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

73.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	48.8	MPa

Table 577: Measured quantities, Shot 2630

73.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5192	K
Reservoir Density	ρ_{res}	30.73	kg/m^3
Reservoir Enthalpy	h_{res}	7.68	MJ/kg

Table 578: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2630

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	9.33×10^{-2}	0	1.37×10^{-1}	0	9.92×10^{-4}	6.64×10^{-2}

Table 579: Computed reservoir species mass fractions, Shot 2630

73.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3615	1103.0	1103.0	5.54	20.9	0.065	5.31×10^6
72 cm	3590	1104.9	1108.7	5.37	23.8	0.074	5.99×10^6

Table 580: Computed freestream conditions, Shot 2630

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	3.82×10^{-10}	8.04×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.74×10^{-2}	0	0	3.77×10^{-3}

Table 581: Computed freestream species mass fractions, Shot 2630

73.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3580	1210.1	1210.1	5.24	30.4	0.087	6.59×10^6
72 cm	3529	1264.5	1261.9	4.93	34.6	0.095	6.91×10^6

Table 582: Computed boundary layer edge conditions, Shot 2630

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	3.82×10^{-10}	8.04×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.74×10^{-2}	0	6.83×10^{-10}	3.70×10^{-3}

Table 583: Computed boundary layer edge species mass fractions, Shot 2630

	T^* K	Unit Re^* 1/m
1D 100 cm	1551	4.37×10^6
72 cm	1519	5.75×10^6

Table 584: Dorrance reference conditions, Shot 2630

73.5 Stability Computations

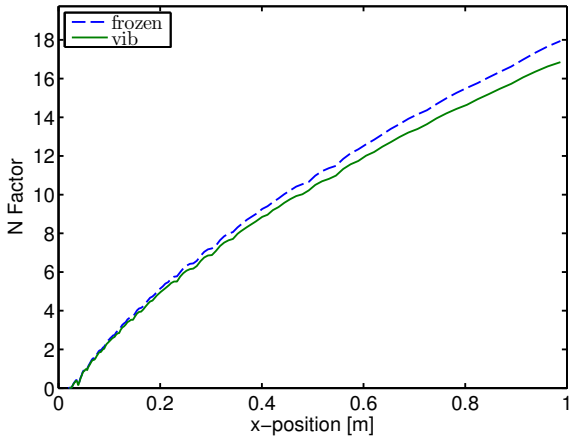


Figure 217: Locus of maximum N factor with and without vibrational energy transfer, Shot 2630

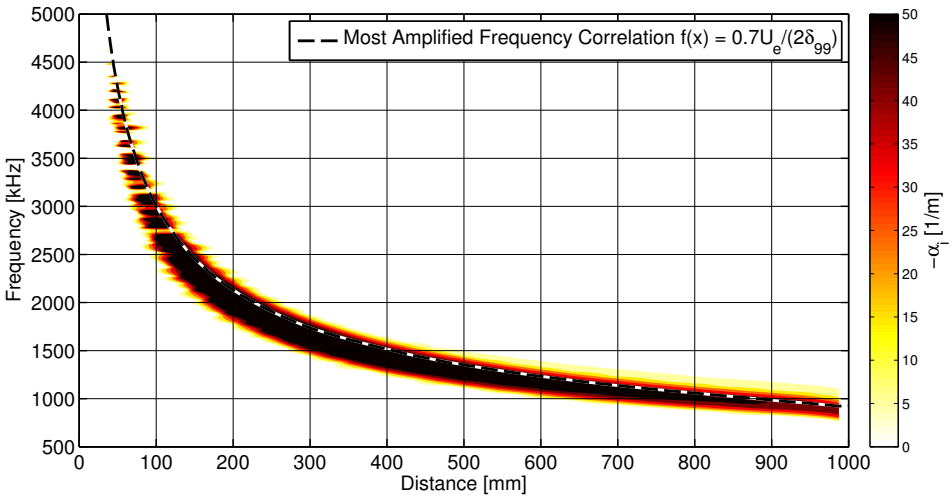


Figure 218: Stability diagram with vibrational energy transfer, Shot 2630. Dashed line indicates $0.7U_e/(2\delta_{99})$.

73.6 Heat Transfer Results

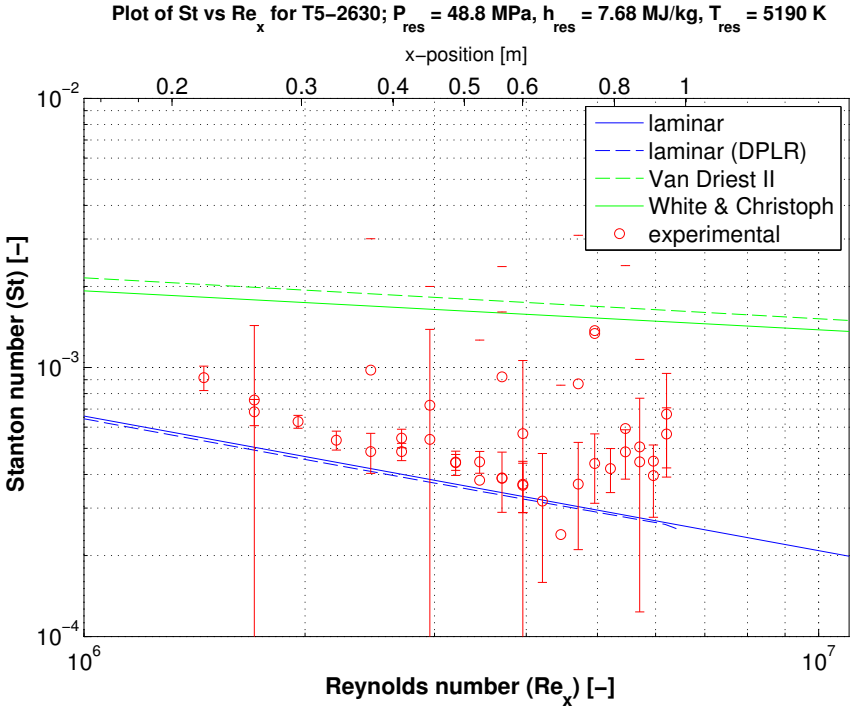


Figure 219: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

74 Shot 2631

Experiment 2631 was performed in T5 on 16 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

74.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3020	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	49.8	MPa

Table 585: Measured quantities, Shot 2631

74.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5490	K
Reservoir Density	ρ_{res}	29.22	kg/m^3
Reservoir Enthalpy	h_{res}	8.38	MJ/kg

Table 586: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2631

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.63×10^{-2}	0	1.38×10^{-1}	0	1.83×10^{-3}	8.29×10^{-2}

Table 587: Computed reservoir species mass fractions, Shot 2631

74.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3753	1222.0	1222.0	5.47	22.1	0.062	4.93×10^{6}
72 cm	3728	1236.0	1242.8	5.26	25.5	0.071	5.57×10^{6}

Table 588: Computed freestream conditions, Shot 2631

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.45×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	5.43×10^{-10}	6.15×10^{-3}

Table 589: Computed freestream species mass fractions, Shot 2631

74.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3716	1336.3	1336.3	5.18	31.8	0.082	6.08×10^{6}
72 cm	3665	1405.5	1403.1	4.85	36.7	0.090	6.40×10^{6}

Table 590: Computed boundary layer edge conditions, Shot 2631

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.45×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	3.46×10^{-9}	6.00×10^{-3}

Table 591: Computed boundary layer edge species mass fractions, Shot 2631

	T^* K	Unit Re^* 1/m
1D 100 cm	1664	4.21×10^{6}
72 cm	1634	5.50×10^{6}

Table 592: Dorrance reference conditions, Shot 2631

74.5 Stability Computations

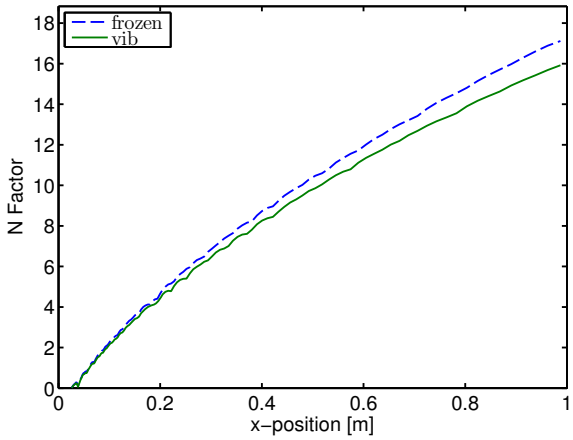


Figure 220: Locus of maximum N factor with and without vibrational energy transfer, Shot 2631

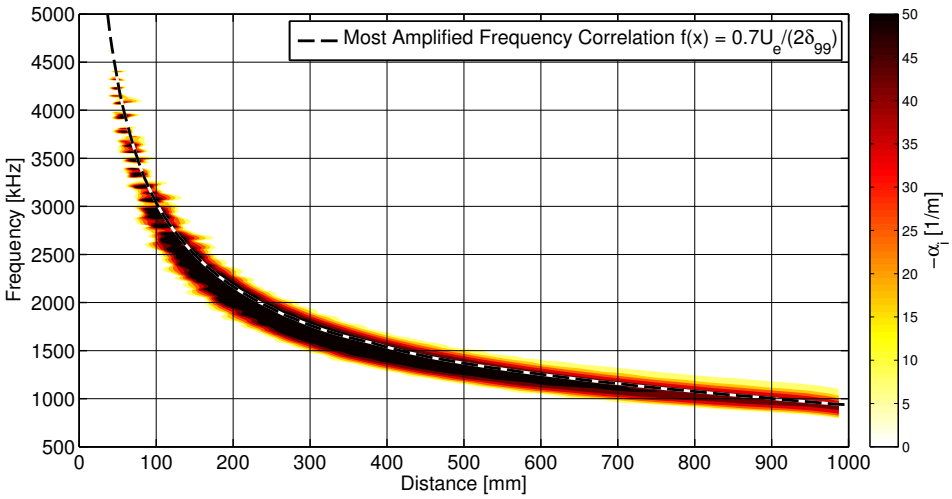


Figure 221: Stability diagram with vibrational energy transfer, Shot 2631. Dashed line indicates $0.7U_e/(2\delta_{99})$.

74.6 Heat Transfer Results

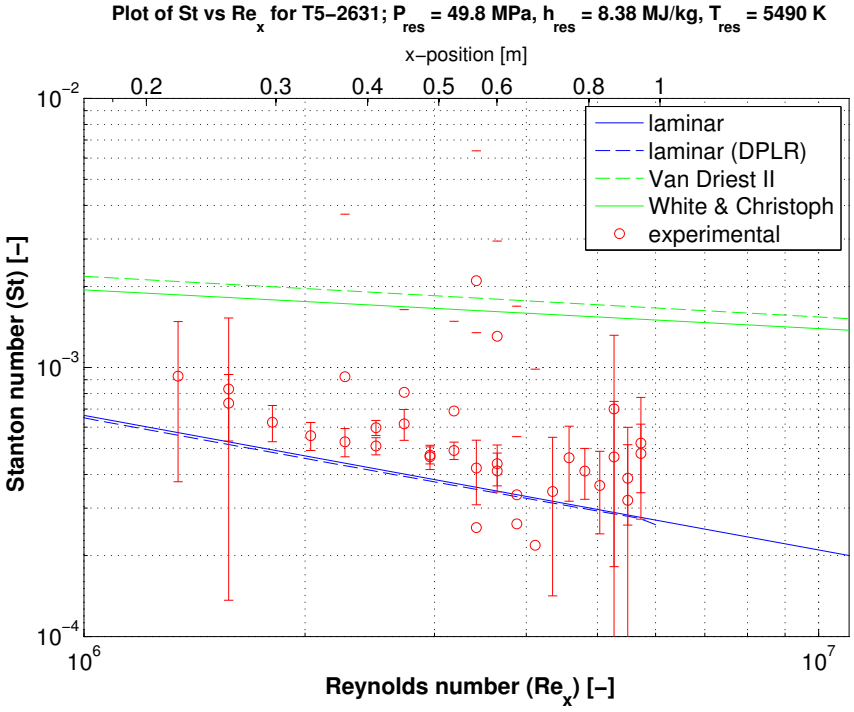


Figure 222: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

75 Shot 2632

Experiment 2632 was performed in T5 on 18 November 2010. The test article was a 1 m 5-degree half-angle cone with a sintered metal porous (MG10: 10 micron) injector section. The initial shock tube composition was 100% air by mass.

75.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3030	m/s
Shock Tube Fill Pressure	P_1	115.45	kPa
Reservoir Pressure	P_{res}	52.0	MPa

Table 593: Measured quantities, Shot 2632

75.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5554	K
Reservoir Density	ρ_{res}	30.09	kg/m^3
Reservoir Enthalpy	h_{res}	8.51	MJ/kg

Table 594: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2632

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.36×10^{-2}	0	1.39×10^{-1}	0	2.03×10^{-3}	8.52×10^{-2}

Table 595: Computed reservoir species mass fractions, Shot 2632

75.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3774	1241.0	1241.0	5.46	22.9	0.063	5.00×10^{6}
72 cm	3755	1261.8	1268.7	5.24	26.9	0.073	5.72×10^{6}

Table 596: Computed freestream conditions, Shot 2632

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	2.51×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.44×10^{-2}	0	7.52×10^{-10}	6.37×10^{-3}

Table 597: Computed freestream species mass fractions, Shot 2632

75.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3737	1357.2	1357.2	5.17	32.9	0.083	6.16×10^{6}
72 cm	3692	1433.1	1430.8	4.84	38.6	0.093	6.56×10^{6}

Table 598: Computed boundary layer edge conditions, Shot 2632

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	2.51×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.44×10^{-2}	0	4.39×10^{-9}	6.20×10^{-3}

Table 599: Computed boundary layer edge species mass fractions, Shot 2632

	T^* K	Unit Re^* 1/m
1D 100 cm	1682	4.29×10^{6}
72 cm	1657	5.68×10^{6}

Table 600: Dorrance reference conditions, Shot 2632

75.5 Stability Computations

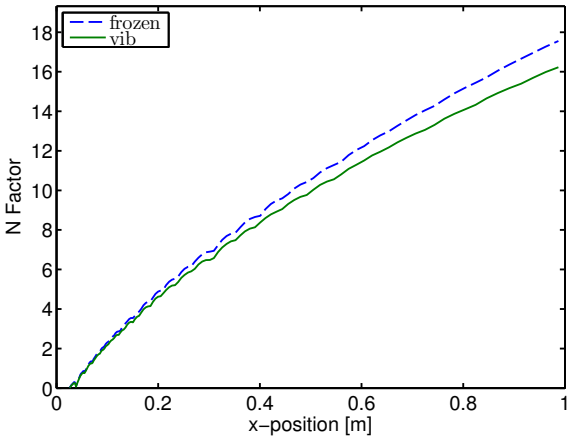


Figure 223: Locus of maximum N factor with and without vibrational energy transfer, Shot 2632

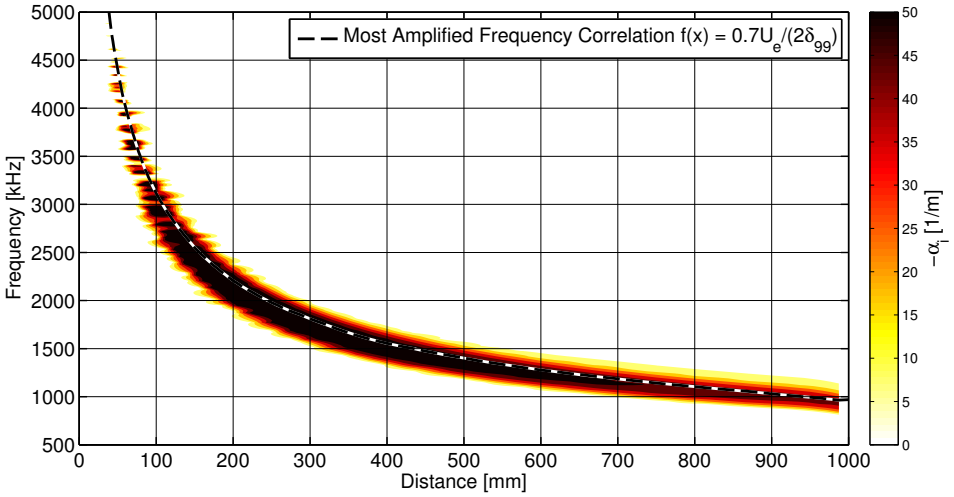


Figure 224: Stability diagram with vibrational energy transfer, Shot 2632. Dashed line indicates $0.7U_e/(2\delta_{99})$.

75.6 Heat Transfer Results

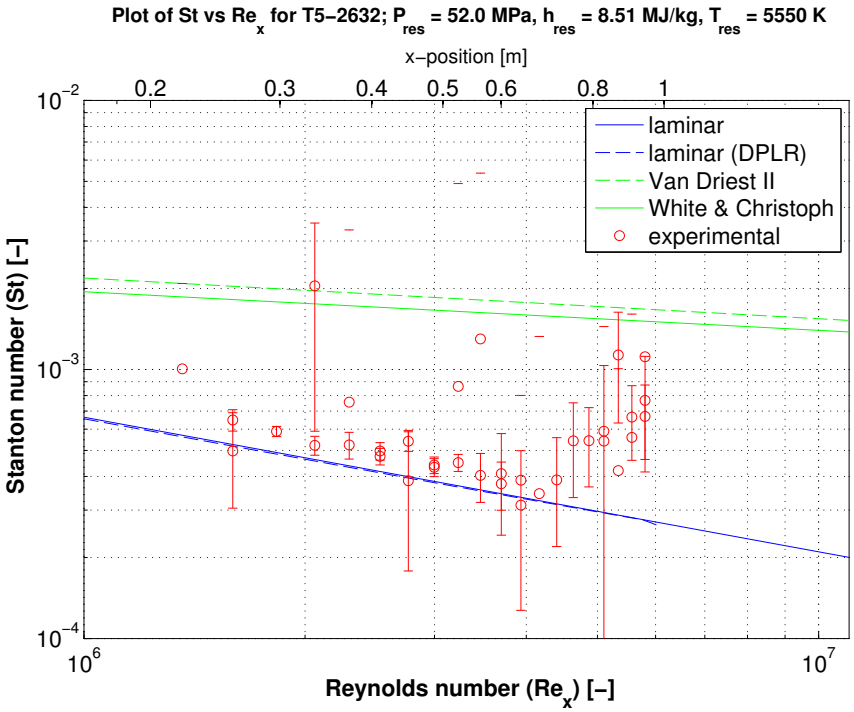


Figure 225: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

76 Shot 2633

Experiment 2633 was performed in T5 on 21 January 2011. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

76.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	115.40	kPa
Reservoir Pressure	P_{res}	54.1	MPa

Table 601: Measured quantities, Shot 2633

76.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5377	K
Reservoir Density	ρ_{res}	32.66	kg/m^3
Reservoir Enthalpy	h_{res}	8.07	MJ/kg

Table 602: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2633

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.43×10^{-2}	0	1.40×10^{-1}	0	1.40×10^{-3}	7.40×10^{-2}

Table 603: Computed reservoir species mass fractions, Shot 2633

76.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3695	1172.0	1172.0	5.50	23.5	0.069	5.54×10^6
72 cm	3672	1179.5	1184.6	5.31	27.2	0.080	6.31×10^6

Table 604: Computed freestream conditions, Shot 2633

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.20×10^{-2}	0	1.64×10^{-10}	9.07×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.60×10^{-2}	0	1.97×10^{-10}	4.49×10^{-3}

Table 605: Computed freestream species mass fractions, Shot 2633

76.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3658	1283.7	1283.7	5.20	34.0	0.091	6.85×10^6
72 cm	3610	1345.0	1342.7	4.89	39.3	0.101	7.26×10^6

Table 606: Computed boundary layer edge conditions, Shot 2633

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.20×10^{-2}	0	1.64×10^{-10}	9.07×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.60×10^{-2}	0	1.53×10^{-9}	4.38×10^{-3}

Table 607: Computed boundary layer edge species mass fractions, Shot 2633

	T^* K	Unit Re^* 1/m
1D 100 cm	1616	4.66×10^6
72 cm	1585	6.16×10^6

Table 608: Dorrance reference conditions, Shot 2633

76.5 Stability Computations

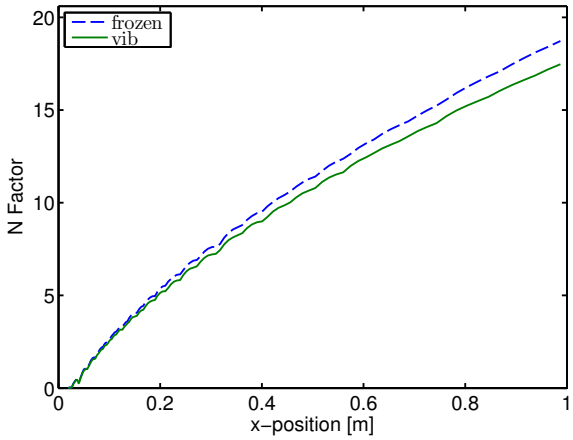


Figure 226: Locus of maximum N factor with and without vibrational energy transfer, Shot 2633

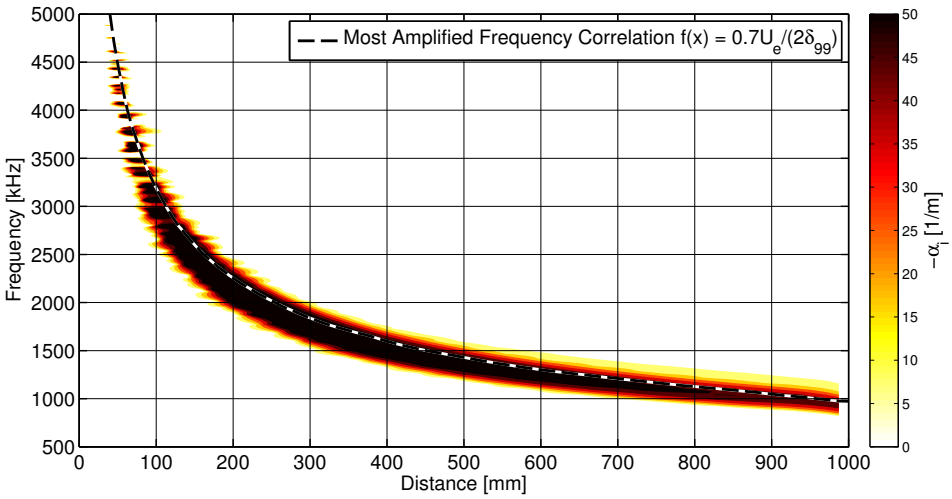


Figure 227: Stability diagram with vibrational energy transfer, Shot 2633. Dashed line indicates $0.7U_e/(2\delta_{99})$.

76.6 Heat Transfer Results

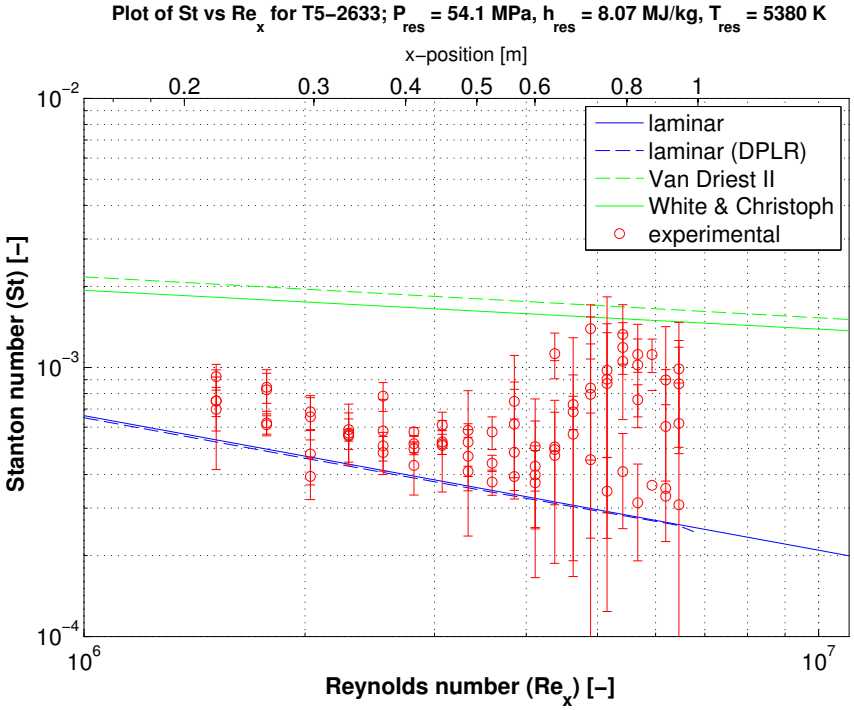


Figure 228: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

77 Shot 2634

Experiment 2634 was performed in T5 on 26 January 2011. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

77.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2930	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	52.8	MPa

Table 609: Measured quantities, Shot 2634

77.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5385	K
Reservoir Density	ρ_{res}	31.84	kg/m^3
Reservoir Enthalpy	h_{res}	8.10	MJ/kg

Table 610: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2634

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	8.34×10^{-2}	0	1.40×10^{-1}	0	1.44×10^{-3}	7.51×10^{-2}

Table 611: Computed reservoir species mass fractions, Shot 2634

77.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3704	1180.0	1180.0	5.49	23.3	0.068	5.44×10^6
72 cm	3677	1184.7	1190.1	5.31	26.6	0.078	6.14×10^6

Table 612: Computed freestream conditions, Shot 2634

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.20×10^{-2}	0	3.31×10^{-10}	9.43×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.59×10^{-2}	0	2.22×10^{-10}	4.71×10^{-3}

Table 613: Computed freestream species mass fractions, Shot 2634

77.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3667	1291.9	1291.9	5.20	33.7	0.090	6.73×10^6
72 cm	3615	1350.3	1347.9	4.89	38.4	0.098	7.07×10^6

Table 614: Computed boundary layer edge conditions, Shot 2634

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.20×10^{-2}	0	3.31×10^{-10}	9.43×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.59×10^{-2}	0	1.68×10^{-9}	4.60×10^{-3}

Table 615: Computed boundary layer edge species mass fractions, Shot 2634

	T^* K	Unit Re^* 1/m
1D 100 cm	1623	4.59×10^6
72 cm	1589	6.01×10^6

Table 616: Dorrance reference conditions, Shot 2634

77.5 Stability Computations

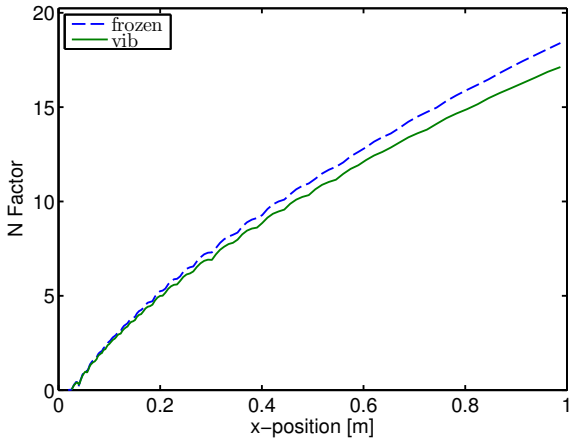


Figure 229: Locus of maximum N factor with and without vibrational energy transfer, Shot 2634

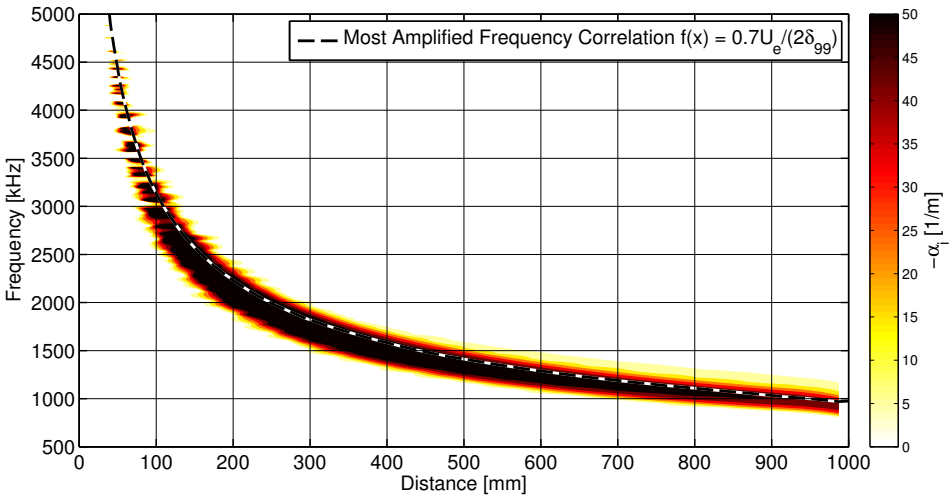


Figure 230: Stability diagram with vibrational energy transfer, Shot 2634. Dashed line indicates $0.7U_e/(2\delta_{99})$.

77.6 Heat Transfer Results

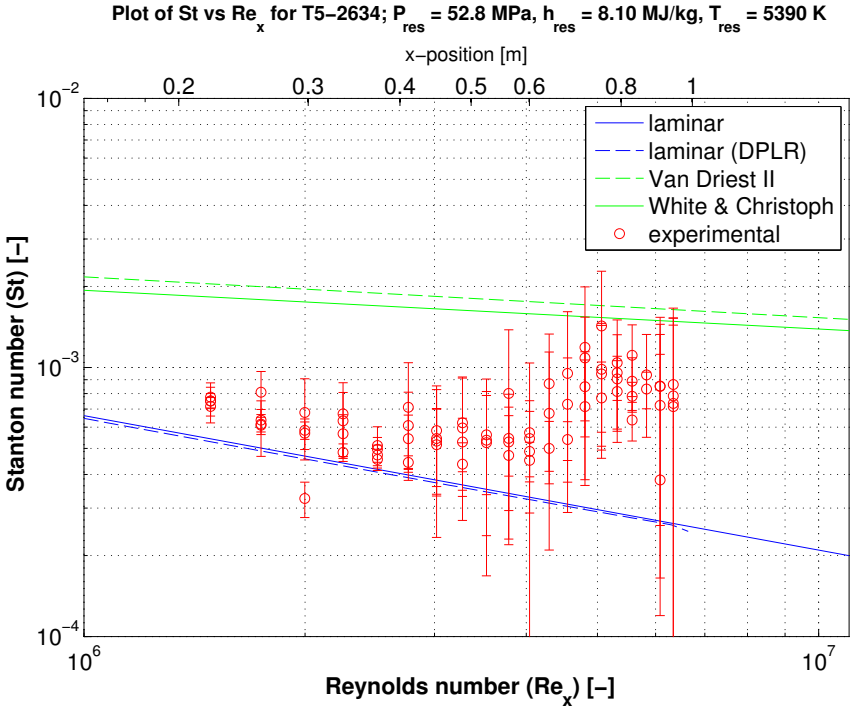


Figure 231: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

78 Shot 2635

Experiment 2635 was performed in T5 on 1 February 2011. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

78.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2870	m/s
Shock Tube Fill Pressure	P_1	115.30	kPa
Reservoir Pressure	P_res	51.5	MPa

Table 617: Measured quantities, Shot 2635

78.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5261	K
Reservoir Density	ρ_res	31.97	kg/m^3
Reservoir Enthalpy	h_res	7.82	MJ/kg

Table 618: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2635

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_NO	Y_CO	Y_N	Y_O
7.01×10^{-1}	9.02×10^{-2}	0	1.39×10^{-1}	0	1.12×10^{-3}	6.88×10^{-2}

Table 619: Computed reservoir species mass fractions, Shot 2635

78.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3647	1130.0	1130.0	5.52	22.4	0.068	5.52×10^6
72 cm	3621	1131.5	1135.7	5.35	25.5	0.078	6.21×10^6

Table 620: Computed freestream conditions, Shot 2635

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.23×10^{-2}	0	0	8.24×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.69×10^{-2}	0	0	3.93×10^{-3}

Table 621: Computed freestream species mass fractions, Shot 2635

78.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3611	1239.4	1239.4	5.22	32.5	0.090	6.84×10^6
72 cm	3559	1292.9	1290.5	4.92	36.9	0.099	7.17×10^6

Table 622: Computed boundary layer edge conditions, Shot 2635

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.23×10^{-2}	0	0	8.24×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.69×10^{-2}	0	8.80×10^{-10}	3.85×10^{-3}

Table 623: Computed boundary layer edge species mass fractions, Shot 2635

	T^* K	Unit Re^* 1/m
1D 100 cm	1577	4.58×10^6
72 cm	1543	6.01×10^6

Table 624: Dorrance reference conditions, Shot 2635

78.5 Stability Computations

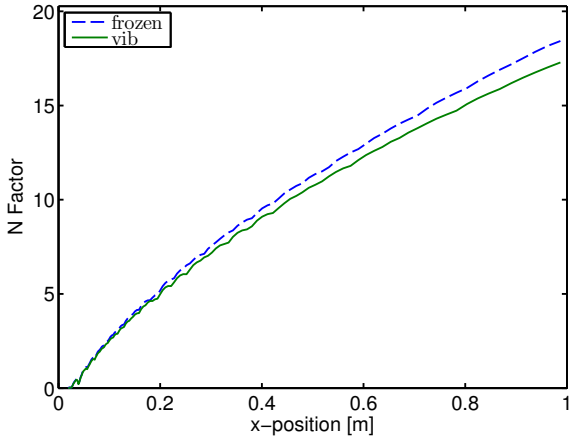


Figure 232: Locus of maximum N factor with and without vibrational energy transfer, Shot 2635

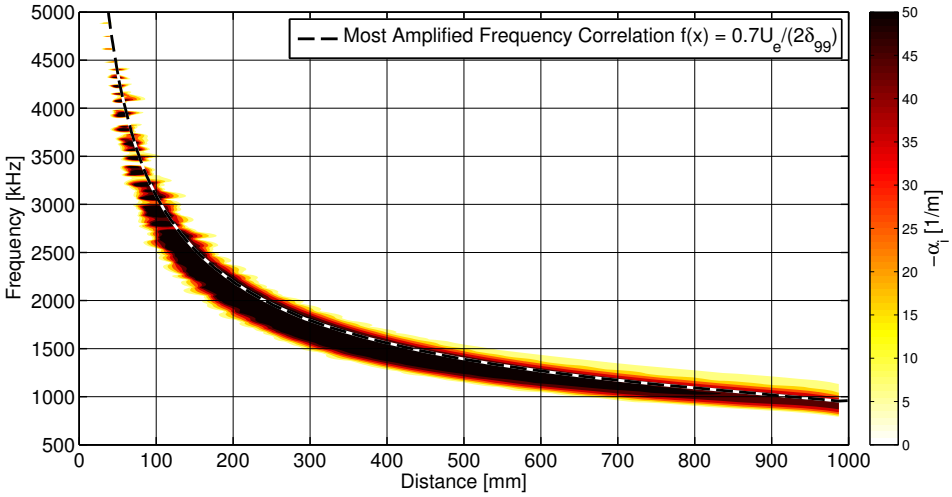


Figure 233: Stability diagram with vibrational energy transfer, Shot 2635. Dashed line indicates $0.7U_e/(2\delta_{99})$.

78.6 Heat Transfer Results

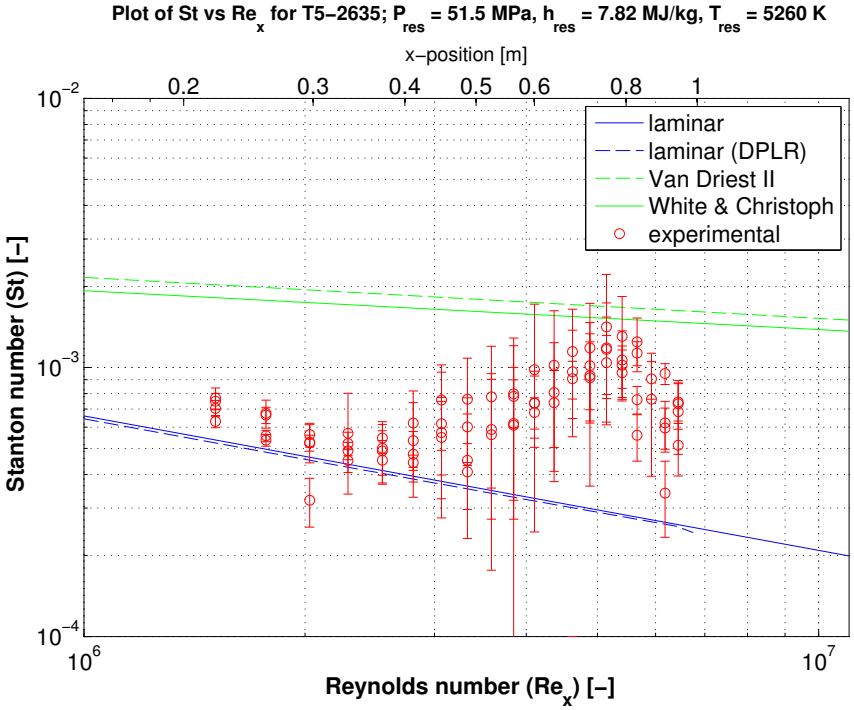


Figure 234: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

79 Shot 2636

Experiment 2636 was performed in T5 on 8 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

79.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 625: Measured quantities, Shot 2636

79.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5419	K
Reservoir Density	ρ_{res}	31.88	kg/m^3
Reservoir Enthalpy	h_{res}	8.18	MJ/kg

Table 626: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2636

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.17×10^{-2}	0	1.40×10^{-1}	0	1.53×10^{-3}	7.67×10^{-2}

Table 627: Computed reservoir species mass fractions, Shot 2636

79.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3718	1193.0	1193.0	5.48	23.6	0.068	5.43×10^{6}
72 cm	3692	1199.1	1204.7	5.29	27.0	0.078	6.13×10^{6}

Table 628: Computed freestream conditions, Shot 2636

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	1.87×10^{-10}	9.74×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.56×10^{-2}	0	2.78×10^{-10}	4.92×10^{-3}

Table 629: Computed freestream species mass fractions, Shot 2636

79.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3682	1305.8	1305.8	5.19	34.1	0.090	6.71×10^{6}
72 cm	3630	1365.6	1363.3	4.88	39.0	0.099	7.06×10^{6}

Table 630: Computed boundary layer edge conditions, Shot 2636

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	1.87×10^{-10}	9.74×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.56×10^{-2}	0	1.99×10^{-9}	4.80×10^{-3}

Table 631: Computed boundary layer edge species mass fractions, Shot 2636

	T^* K	Unit Re^* 1/m
1D 100 cm	1636	4.60×10^{6}
72 cm	1602	6.02×10^{6}

Table 632: Dorrance reference conditions, Shot 2636

79.5 Stability Computations

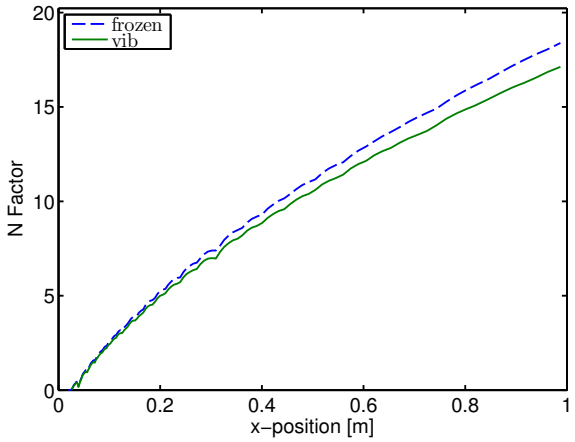


Figure 235: Locus of maximum N factor with and without vibrational energy transfer, Shot 2636

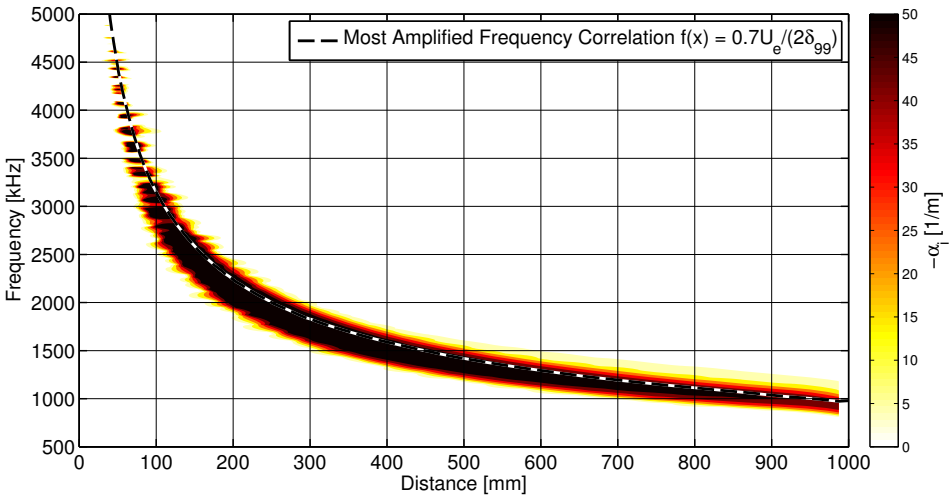


Figure 236: Stability diagram with vibrational energy transfer, Shot 2636. Dashed line indicates $0.7U_e/(2\delta_{99})$.

79.6 Heat Transfer Results

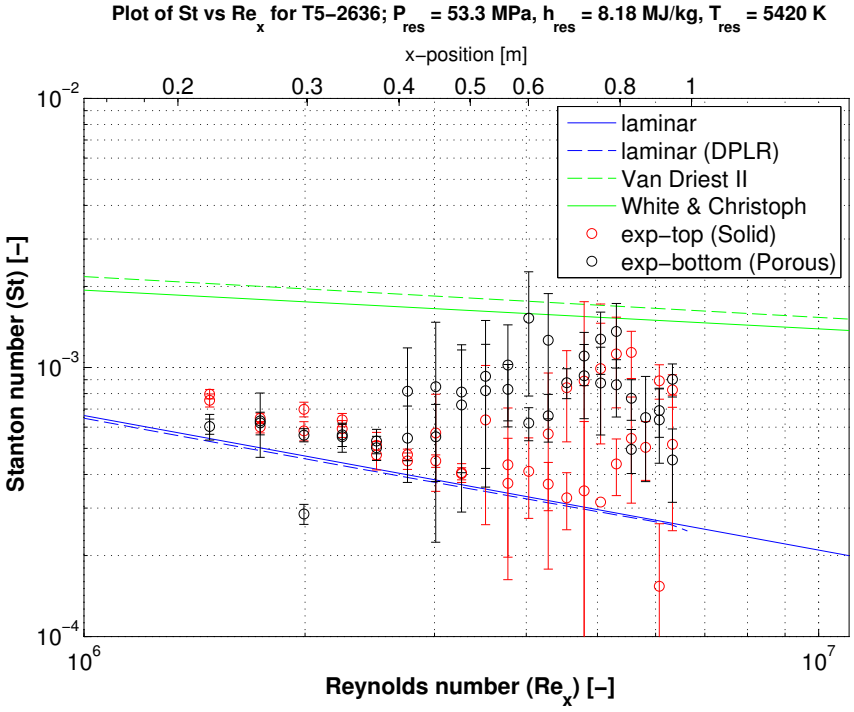


Figure 237: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

80 Shot 2637

Experiment 2637 was performed in T5 on 9 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

80.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	115.45	kPa
Reservoir Pressure	P_{res}	53.8	MPa

Table 633: Measured quantities, Shot 2637

80.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5424	K
Reservoir Density	ρ_{res}	32.13	kg/m^3
Reservoir Enthalpy	h_{res}	8.19	MJ/kg

Table 634: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2637

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.16×10^{-2}	0	1.40×10^{-1}	0	1.54×10^{-3}	7.68×10^{-2}

Table 635: Computed reservoir species mass fractions, Shot 2637

80.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3719	1194.0	1194.0	5.48	23.7	0.068	5.46×10^6
72 cm	3694	1200.8	1206.3	5.29	27.3	0.078	6.18×10^6

Table 636: Computed freestream conditions, Shot 2637

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	1.36×10^{-10}	9.70×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	2.82×10^{-10}	4.90×10^{-3}

Table 637: Computed freestream species mass fractions, Shot 2637

80.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3682	1306.4	1306.4	5.19	34.3	0.090	6.75×10^6
72 cm	3632	1367.5	1365.3	4.88	39.3	0.099	7.11×10^6

Table 638: Computed boundary layer edge conditions, Shot 2637

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.19×10^{-2}	0	1.36×10^{-10}	9.70×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.55×10^{-2}	0	2.01×10^{-9}	4.78×10^{-3}

Table 639: Computed boundary layer edge species mass fractions, Shot 2637

	T^* K	Unit Re^* 1/m
1D 100 cm	1636	4.63×10^6
72 cm	1603	6.07×10^6

Table 640: Dorrance reference conditions, Shot 2637

80.5 Stability Computations

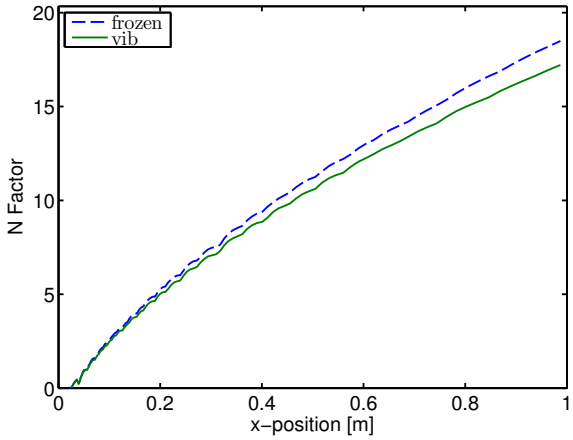


Figure 238: Locus of maximum N factor with and without vibrational energy transfer, Shot 2637

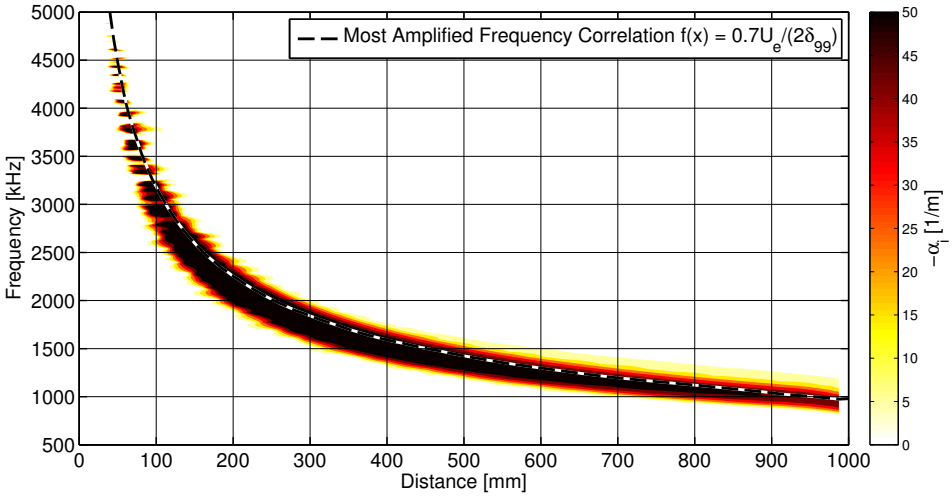


Figure 239: Stability diagram with vibrational energy transfer, Shot 2637. Dashed line indicates $0.7U_e/(2\delta_{99})$.

80.6 Heat Transfer Results

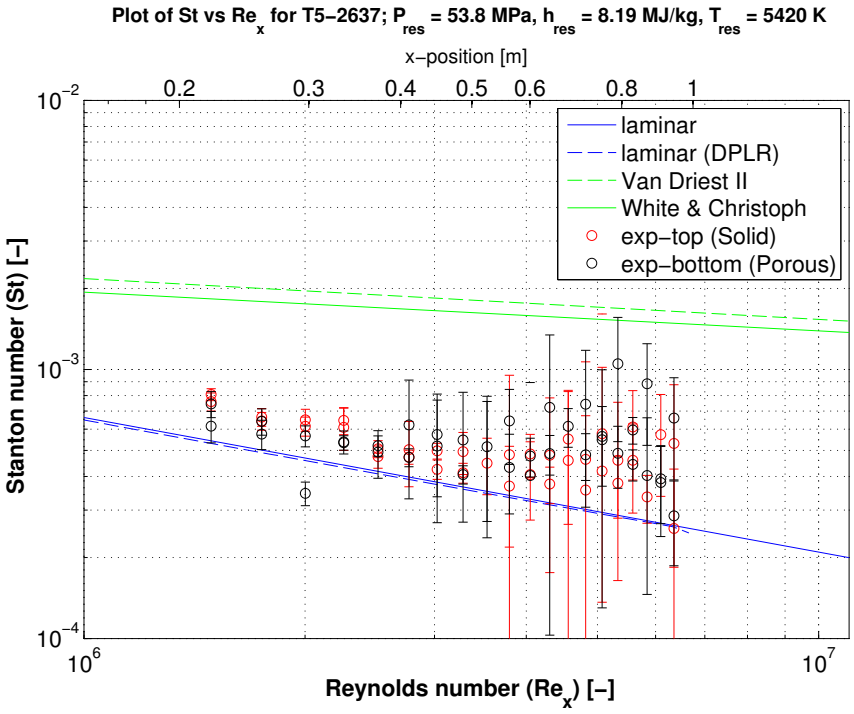


Figure 240: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

81 Shot 2638

Experiment 2638 was performed in T5 on 10 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

81.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 641: Measured quantities, Shot 2638

81.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5211	K
Reservoir Density	ρ_{res}	34.10	kg/m^3
Reservoir Enthalpy	h_{res}	7.68	MJ/kg

Table 642: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2638

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	9.41×10^{-2}	0	1.39×10^{-1}	0	9.80×10^{-4}	6.47×10^{-2}

Table 643: Computed reservoir species mass fractions, Shot 2638

81.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3619	1107.0	1107.0	5.54	23.3	0.073	5.89×10^{6}
72 cm	3594	1105.2	1108.4	5.37	26.5	0.083	6.67×10^{6}

Table 644: Computed freestream conditions, Shot 2638

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.23×10^{-2}	0	0	7.18×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	0	3.30×10^{-3}

Table 645: Computed freestream species mass fractions, Shot 2638

81.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3583	1214.2	1214.2	5.24	33.8	0.096	7.31×10^{6}
72 cm	3533	1264.9	1262.6	4.94	38.5	0.105	7.70×10^{6}

Table 646: Computed boundary layer edge conditions, Shot 2638

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.23×10^{-2}	0	0	7.18×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	5.73×10^{-10}	3.23×10^{-3}

Table 647: Computed boundary layer edge species mass fractions, Shot 2638

	T^* K	Unit Re^* 1/m
1D 100 cm	1554	4.86×10^{6}
72 cm	1521	6.40×10^{6}

Table 648: Dorrance reference conditions, Shot 2638

81.5 Stability Computations

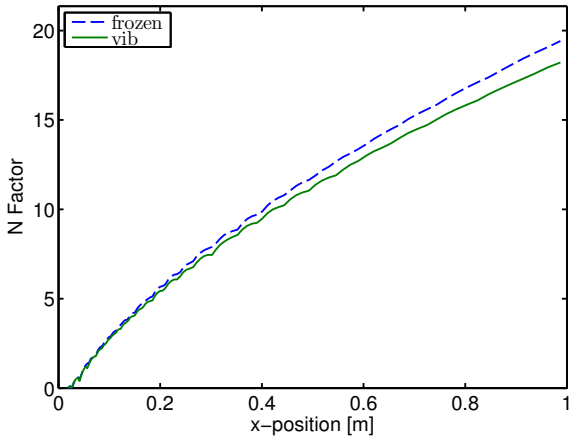


Figure 241: Locus of maximum N factor with and without vibrational energy transfer, Shot 2638

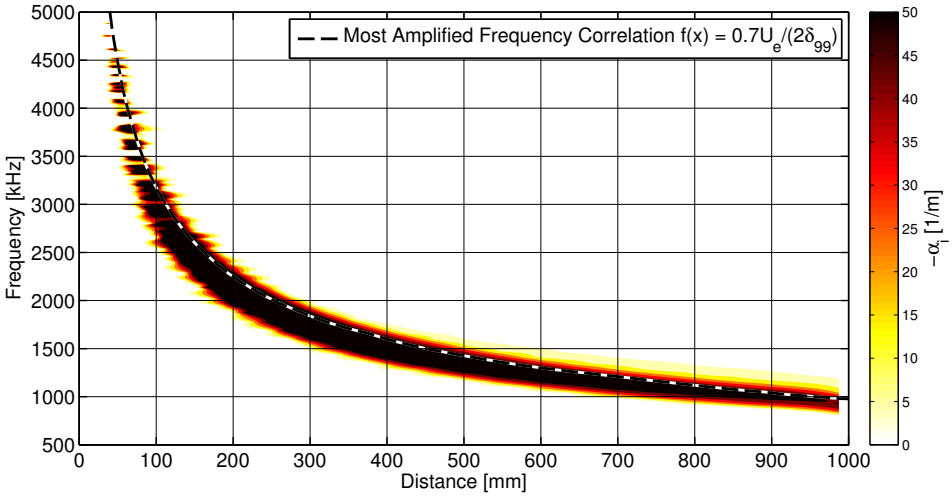


Figure 242: Stability diagram with vibrational energy transfer, Shot 2638. Dashed line indicates $0.7U_e/(2\delta_{99})$.

81.6 Heat Transfer Results

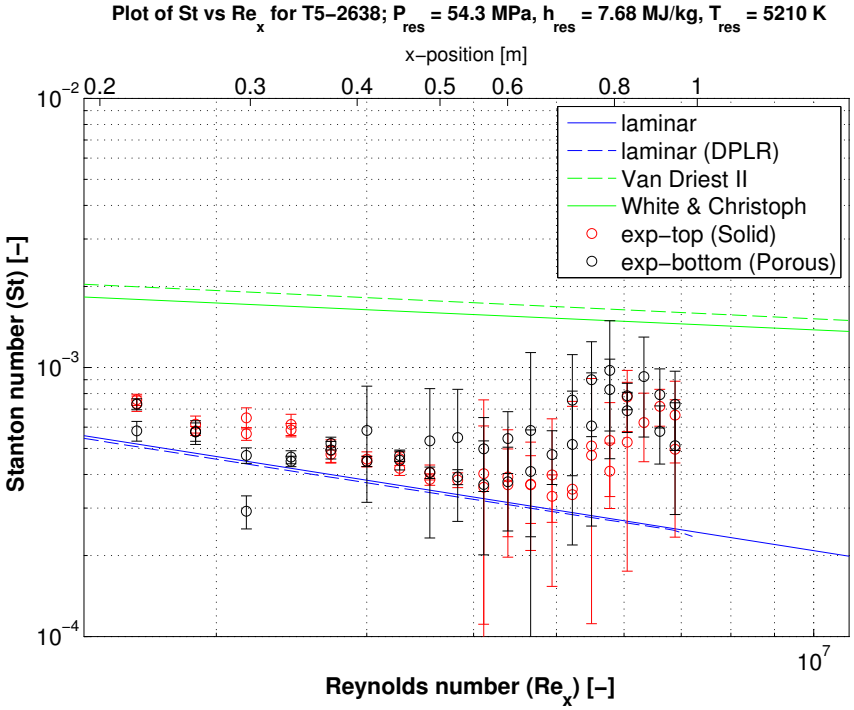


Figure 243: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

82 Shot 2639

Experiment 2639 was performed in T5 on 11 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

82.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3030	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 649: Measured quantities, Shot 2639

82.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5580	K
Reservoir Density	ρ_{res}	30.69	kg/m^3
Reservoir Enthalpy	h_{res}	8.56	MJ/kg

Table 650: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2639

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.28×10^{-2}	0	1.39×10^{-1}	0	2.11×10^{-3}	8.58×10^{-2}

Table 651: Computed reservoir species mass fractions, Shot 2639

82.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3790	1256.0	1256.0	5.45	23.8	0.065	5.14×10^{6}
72 cm	3765	1271.6	1278.5	5.24	27.7	0.075	5.83×10^{6}

Table 652: Computed freestream conditions, Shot 2639

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.15×10^{-2}	0	4.98×10^{-10}	1.19×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.42×10^{-2}	0	8.38×10^{-10}	6.38×10^{-3}

Table 653: Computed freestream species mass fractions, Shot 2639

82.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3752	1372.4	1372.4	5.16	34.3	0.086	6.33×10^{6}
72 cm	3702	1443.6	1441.4	4.83	39.7	0.095	6.69×10^{6}

Table 654: Computed boundary layer edge conditions, Shot 2639

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.15×10^{-2}	0	4.98×10^{-10}	1.19×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.42×10^{-2}	0	4.73×10^{-9}	6.21×10^{-3}

Table 655: Computed boundary layer edge species mass fractions, Shot 2639

	T^* K	Unit Re^* 1/m
1D 100 cm	1695	4.43×10^{6}
72 cm	1665	5.80×10^{6}

Table 656: Dorrance reference conditions, Shot 2639

82.5 Stability Computations

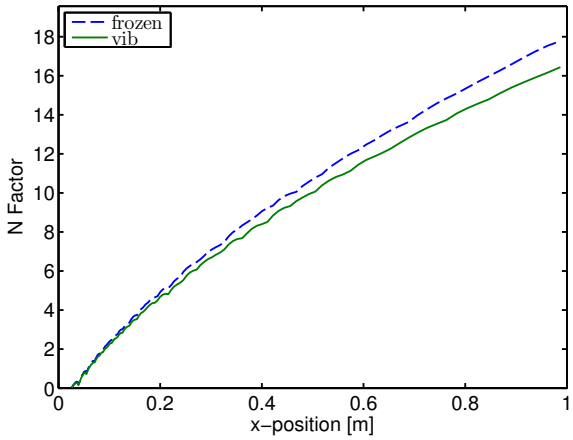


Figure 244: Locus of maximum N factor with and without vibrational energy transfer, Shot 2639

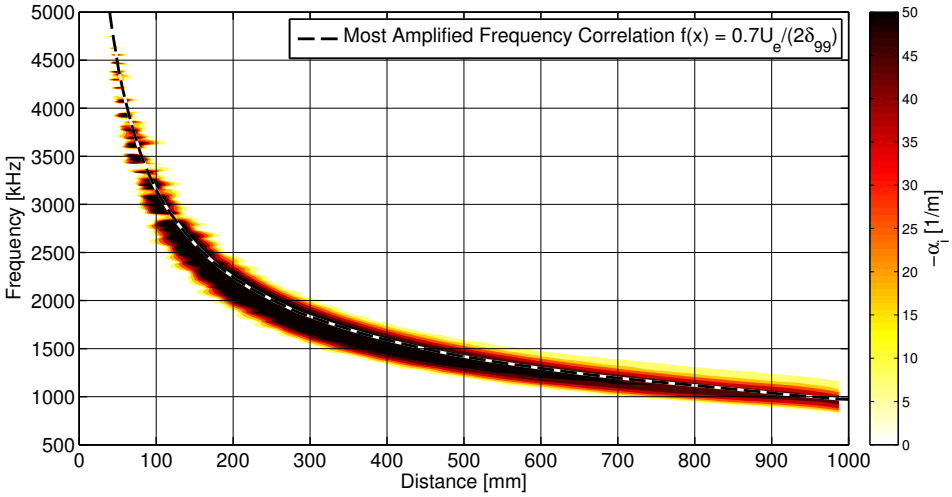


Figure 245: Stability diagram with vibrational energy transfer, Shot 2639. Dashed line indicates $0.7U_e/(2\delta_{99})$.

82.6 Heat Transfer Results

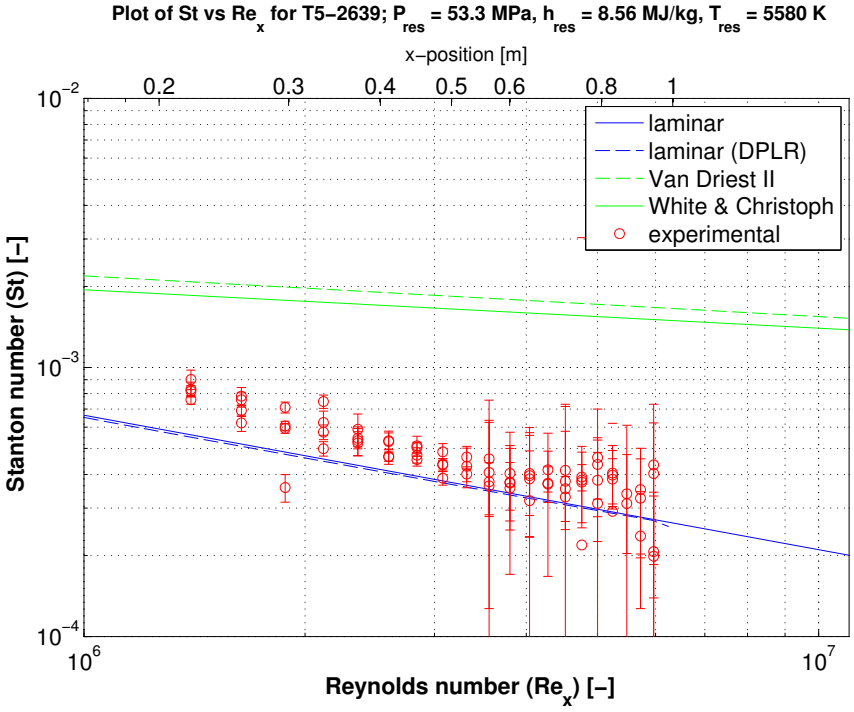


Figure 246: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

83 Shot 2640

Experiment 2640 was performed in T5 on 15 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

83.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3000	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 657: Measured quantities, Shot 2640

83.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5525	K
Reservoir Density	ρ_{res}	31.07	kg/m^3
Reservoir Enthalpy	h_{res}	8.43	MJ/kg

Table 658: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2640

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.58×10^{-2}	0	1.40×10^{-1}	0	1.89×10^{-3}	8.27×10^{-2}

Table 659: Computed reservoir species mass fractions, Shot 2640

83.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3762	1232.0	1232.0	5.46	23.5	0.066	5.20×10^{6}
72 cm	3740	1246.7	1253.2	5.26	27.4	0.076	5.93×10^{6}

Table 660: Computed freestream conditions, Shot 2640

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	2.55×10^{-10}	1.12×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	5.82×10^{-10}	5.86×10^{-3}

Table 661: Computed freestream species mass fractions, Shot 2640

83.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3725	1346.7	1346.7	5.17	33.9	0.086	6.42×10^{6}
72 cm	3677	1417.3	1415.0	4.85	39.4	0.096	6.80×10^{6}

Table 662: Computed boundary layer edge conditions, Shot 2640

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	2.55×10^{-10}	1.12×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	3.56×10^{-9}	5.71×10^{-3}

Table 663: Computed boundary layer edge species mass fractions, Shot 2640

	T^* K	Unit Re^* 1/m
1D 100 cm	1672	4.46×10^{6}
72 cm	1643	5.87×10^{6}

Table 664: Dorrance reference conditions, Shot 2640

83.5 Stability Computations

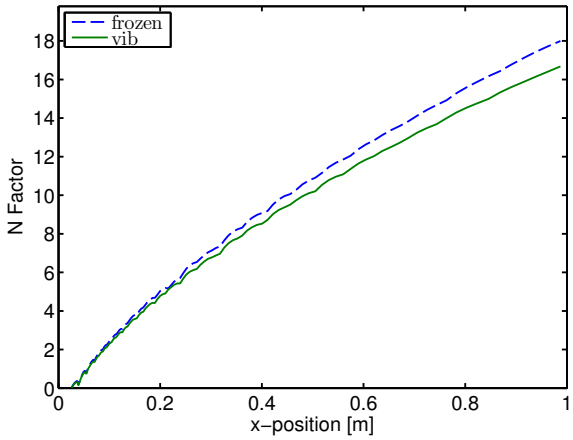


Figure 247: Locus of maximum N factor with and without vibrational energy transfer, Shot 2640

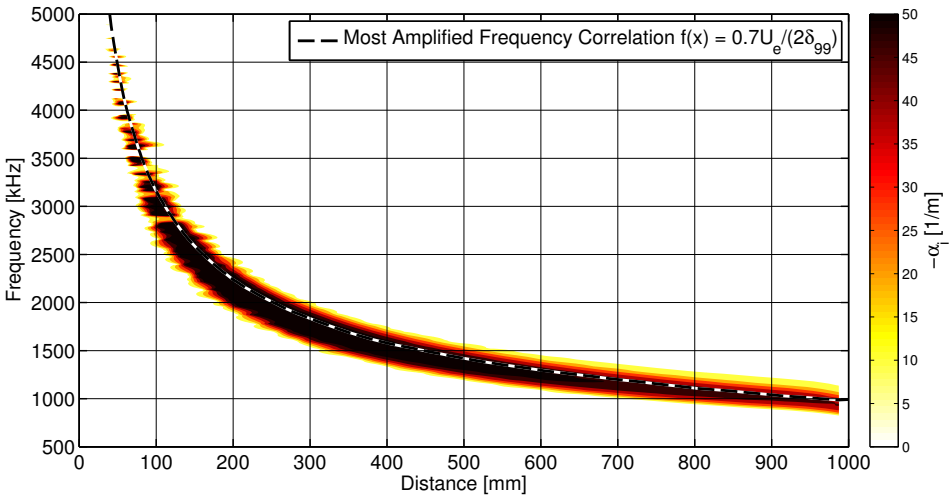


Figure 248: Stability diagram with vibrational energy transfer, Shot 2640. Dashed line indicates $0.7U_e/(2\delta_{99})$.

83.6 Heat Transfer Results

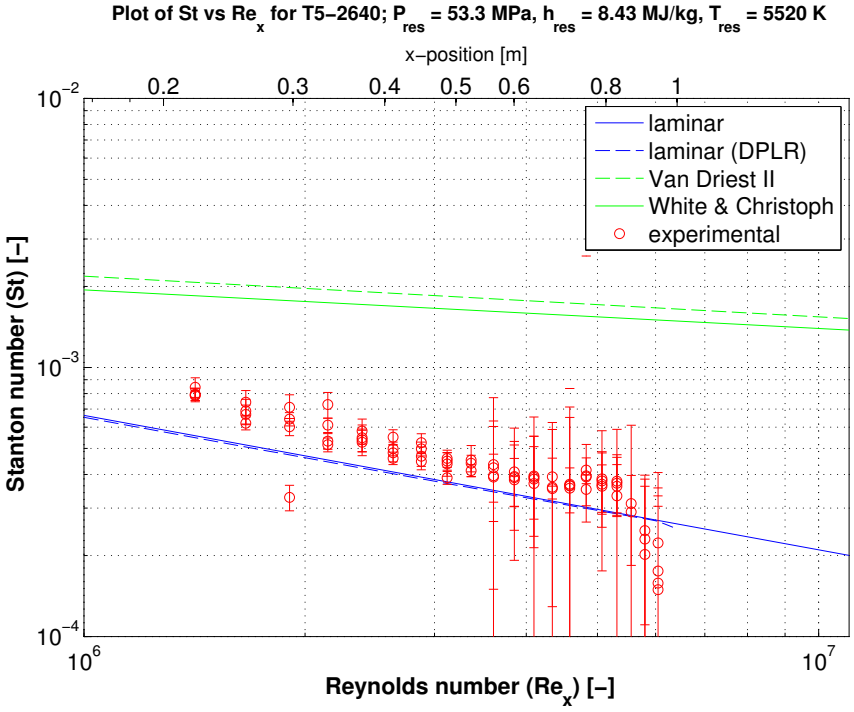


Figure 249: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

84 Shot 2641

Experiment 2641 was performed in T5 on 16 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

84.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2990	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	53.6	MPa

Table 665: Measured quantities, Shot 2641

84.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5503	K
Reservoir Density	ρ_{res}	31.42	kg/m^3
Reservoir Enthalpy	h_{res}	8.38	MJ/kg

Table 666: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2641

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.71×10^{-2}	0	1.40×10^{-1}	0	1.81×10^{-3}	8.13×10^{-2}

Table 667: Computed reservoir species mass fractions, Shot 2641

84.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3750	1221.0	1221.0	5.47	23.5	0.066	5.25×10^{6}
72 cm	3730	1236.5	1242.8	5.27	27.5	0.077	6.01×10^{6}

Table 668: Computed freestream conditions, Shot 2641

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	2.08×10^{-10}	1.08×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.48×10^{-2}	0	4.96×10^{-10}	5.61×10^{-3}

Table 669: Computed freestream species mass fractions, Shot 2641

84.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3713	1335.4	1335.4	5.18	33.9	0.087	6.48×10^{6}
72 cm	3667	1406.5	1404.3	4.85	39.6	0.097	6.90×10^{6}

Table 670: Computed boundary layer edge conditions, Shot 2641

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.89×10^{-1}	0	6.17×10^{-2}	0	2.08×10^{-10}	1.08×10^{-2}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.48×10^{-2}	0	3.13×10^{-9}	5.46×10^{-3}

Table 671: Computed boundary layer edge species mass fractions, Shot 2641

	T^* K	Unit Re^* 1/m
1D 100 cm	1662	4.48×10^{6}
72 cm	1635	5.93×10^{6}

Table 672: Dorrance reference conditions, Shot 2641

84.5 Stability Computations

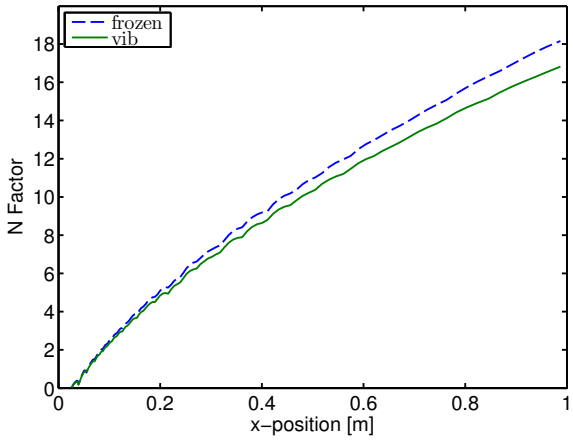


Figure 250: Locus of maximum N factor with and without vibrational energy transfer, Shot 2641

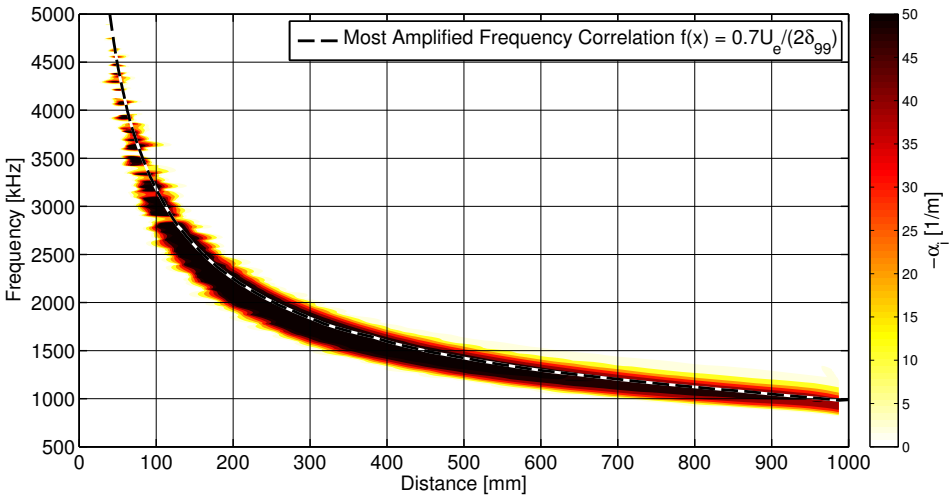


Figure 251: Stability diagram with vibrational energy transfer, Shot 2641. Dashed line indicates $0.7U_e/(2\delta_{99})$.

84.6 Heat Transfer Results

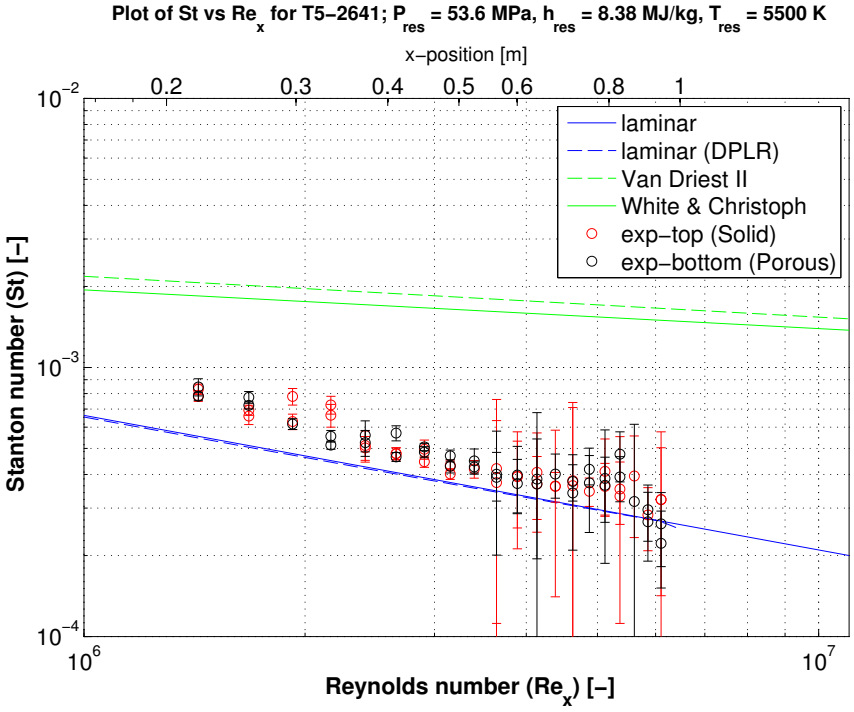


Figure 252: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

85 Shot 2642

Experiment 2642 was performed in T5 on 17 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

85.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3190	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 673: Measured quantities, Shot 2642

85.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6135	K
Reservoir Density	ρ_{res}	27.69	kg/m^3
Reservoir Enthalpy	h_{res}	9.89	MJ/kg

Table 674: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2642

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.73×10^{-2}	0	1.33×10^{-1}	0	5.53×10^{-3}	1.15×10^{-1}

Table 675: Computed reservoir species mass fractions, Shot 2642

85.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4029	1472.0	1472.0	5.34	25.5	0.059	4.46×10^6
72 cm	4000	1511.4	1520.6	5.09	30.3	0.069	5.06×10^6

Table 676: Computed freestream conditions, Shot 2642

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.97×10^{-2}	0	6.67×10^{-9}	2.10×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	1.52×10^{-8}	1.28×10^{-2}

Table 677: Computed freestream species mass fractions, Shot 2642

85.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3989	1602.1	1602.1	5.07	36.3	0.077	5.44×10^6
72 cm	3933	1704.6	1702.5	4.71	42.8	0.086	5.75×10^6

Table 678: Computed boundary layer edge conditions, Shot 2642

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.97×10^{-2}	0	6.67×10^{-9}	2.10×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.30×10^{-2}	0	5.37×10^{-8}	1.23×10^{-2}

Table 679: Computed boundary layer edge species mass fractions, Shot 2642

	T^* K	Unit Re^* 1/m
1D 100 cm	1902	4.07×10^6
72 cm	1876	5.23×10^6

Table 680: Dorrance reference conditions, Shot 2642

85.5 Stability Computations

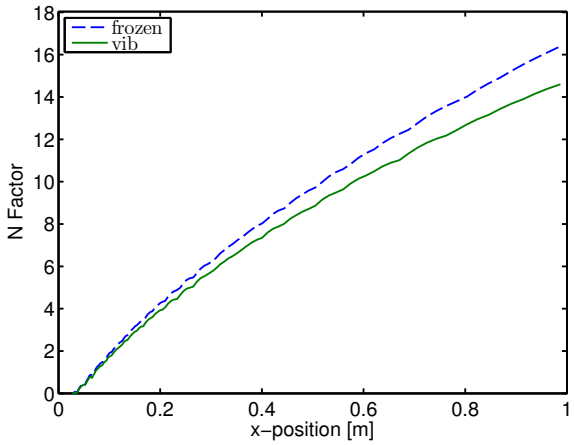


Figure 253: Locus of maximum N factor with and without vibrational energy transfer, Shot 2642

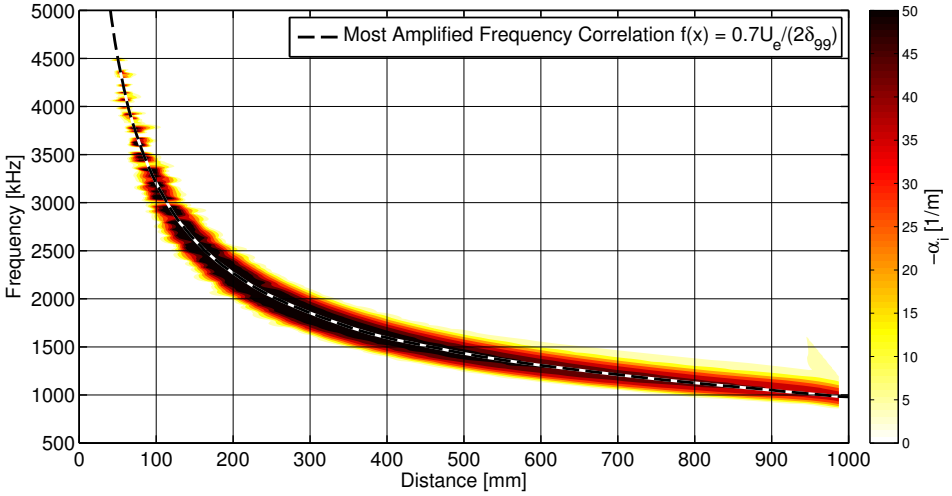


Figure 254: Stability diagram with vibrational energy transfer, Shot 2642. Dashed line indicates $0.7U_e/(2\delta_{99})$.

85.6 Heat Transfer Results

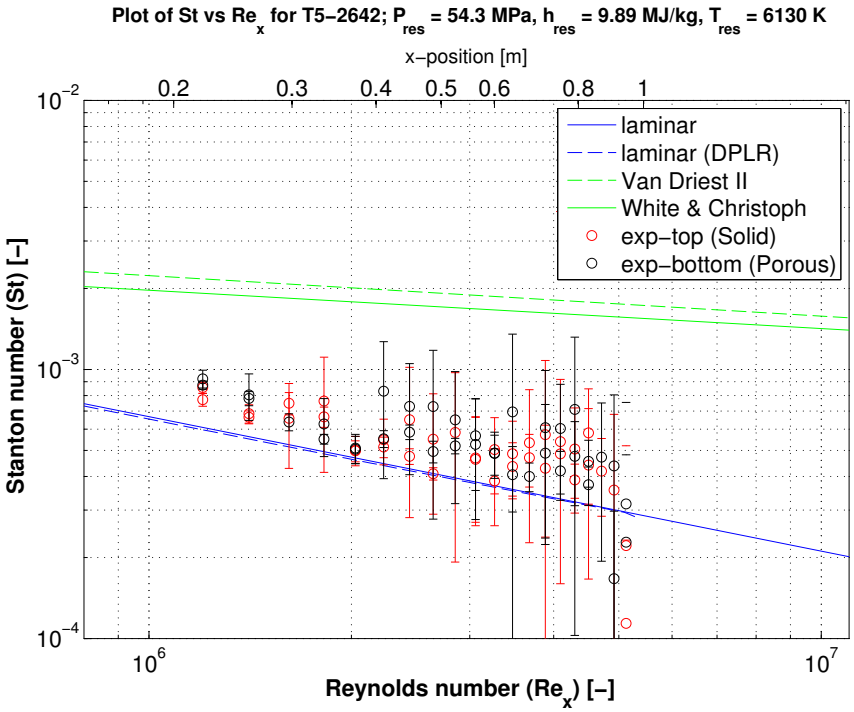


Figure 255: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

86 Shot 2643

Experiment 2643 was performed in T5 on 18 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

86.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	55.5	MPa

Table 681: Measured quantities, Shot 2643

86.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5872	K
Reservoir Density	ρ_{res}	29.99	kg/m^3
Reservoir Enthalpy	h_{res}	9.24	MJ/kg

Table 682: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2643

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	5.90×10^{-2}	0	1.38×10^{-1}	0	3.52×10^{-3}	1.00×10^{-1}

Table 683: Computed reservoir species mass fractions, Shot 2643

86.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3910	1365.0	1365.0	5.39	25.2	0.063	4.87×10^{6}
72 cm	3890	1397.6	1405.8	5.16	30.0	0.074	5.59×10^{6}

Table 684: Computed freestream conditions, Shot 2643

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.07×10^{-2}	0	1.69×10^{-9}	1.58×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.29×10^{-2}	0	4.14×10^{-9}	9.03×10^{-3}

Table 685: Computed freestream species mass fractions, Shot 2643

86.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3872	1488.6	1488.6	5.11	36.0	0.083	5.96×10^{6}
72 cm	3825	1580.1	1578.0	4.77	42.8	0.093	6.37×10^{6}

Table 686: Computed boundary layer edge conditions, Shot 2643

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.07×10^{-2}	0	1.69×10^{-9}	1.58×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.29×10^{-2}	0	1.74×10^{-8}	8.73×10^{-3}

Table 687: Computed boundary layer edge species mass fractions, Shot 2643

	T^* K	Unit Re^* 1/m
1D 100 cm	1799	4.32×10^{6}
72 cm	1775	5.67×10^{6}

Table 688: Dorrance reference conditions, Shot 2643

86.5 Stability Computations

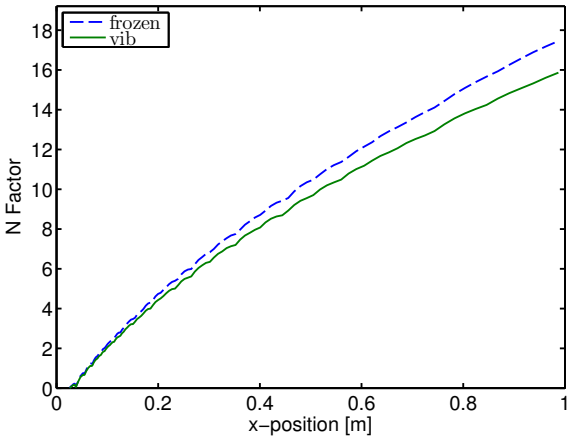


Figure 256: Locus of maximum N factor with and without vibrational energy transfer, Shot 2643

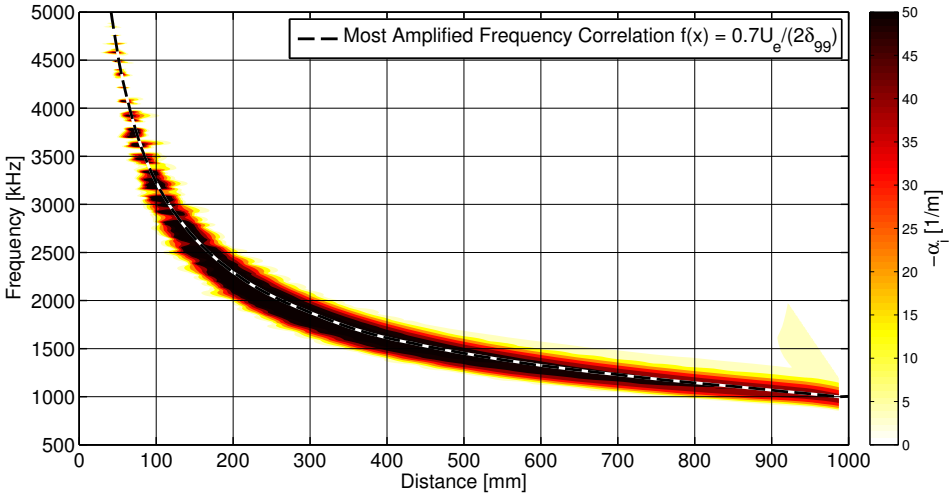


Figure 257: Stability diagram with vibrational energy transfer, Shot 2643. Dashed line indicates $0.7U_e/(2\delta_{99})$.

86.6 Heat Transfer Results

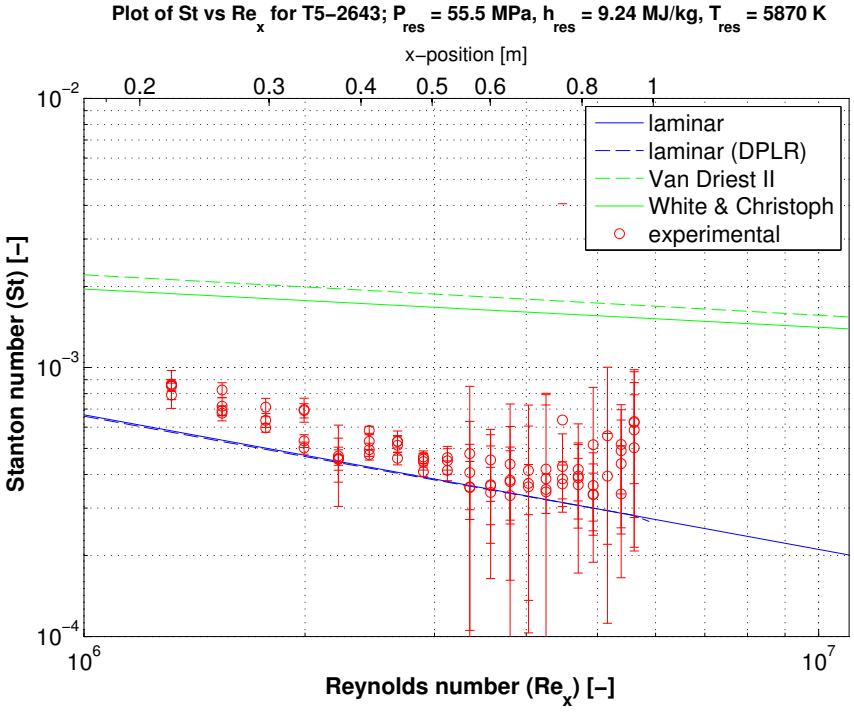


Figure 258: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

87 Shot 2644

Experiment 2644 was performed in T5 on 23 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

87.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	55.1	MPa

Table 689: Measured quantities, Shot 2644

87.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5690	K
Reservoir Density	ρ_{res}	30.97	kg/m^3
Reservoir Enthalpy	h_{res}	8.81	MJ/kg

Table 690: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2644

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	6.77×10^{-2}	0	1.39×10^{-1}	0	2.55×10^{-3}	9.09×10^{-2}

Table 691: Computed reservoir species mass fractions, Shot 2644

87.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3835	1297.0	1297.0	5.42	24.8	0.066	5.12×10^{6}
72 cm	3812	1318.0	1325.3	5.21	29.1	0.076	5.84×10^{6}

Table 692: Computed freestream conditions, Shot 2644

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.12×10^{-2}	0	6.74×10^{-10}	1.31×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.35×10^{-2}	0	1.52×10^{-9}	7.14×10^{-3}

Table 693: Computed freestream species mass fractions, Shot 2644

87.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3797	1415.9	1415.9	5.14	35.5	0.086	6.30×10^{6}
72 cm	3748	1494.2	1492.1	4.81	41.6	0.096	6.68×10^{6}

Table 694: Computed boundary layer edge conditions, Shot 2644

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.12×10^{-2}	0	6.74×10^{-10}	1.31×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.35×10^{-2}	0	7.63×10^{-9}	6.92×10^{-3}

Table 695: Computed boundary layer edge species mass fractions, Shot 2644

	T^* K	Unit Re^* 1/m
1D 100 cm	1734	4.47×10^{6}
72 cm	1705	5.85×10^{6}

Table 696: Dorrance reference conditions, Shot 2644

87.5 Stability Computations

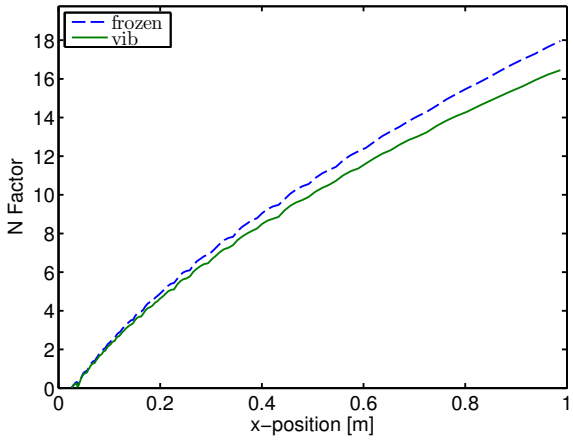


Figure 259: Locus of maximum N factor with and without vibrational energy transfer, Shot 2644

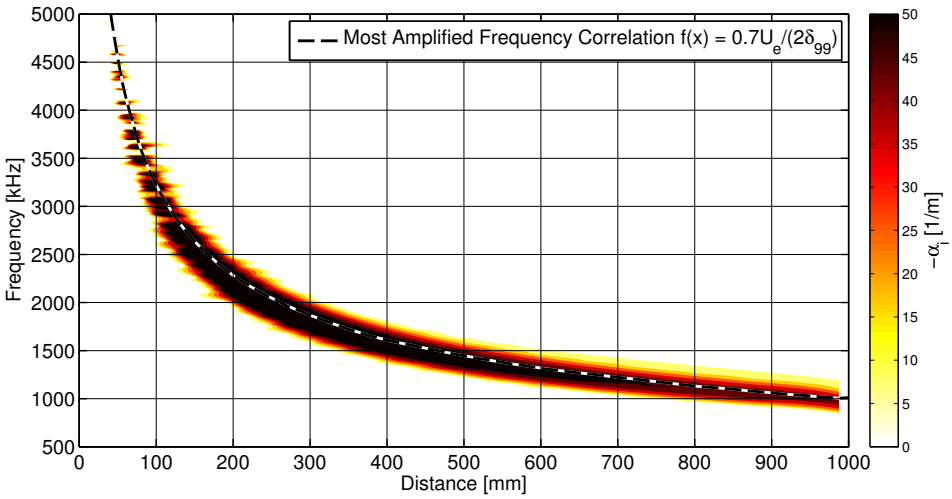


Figure 260: Stability diagram with vibrational energy transfer, Shot 2644. Dashed line indicates $0.7U_e/(2\delta_{99})$.

87.6 Heat Transfer Results

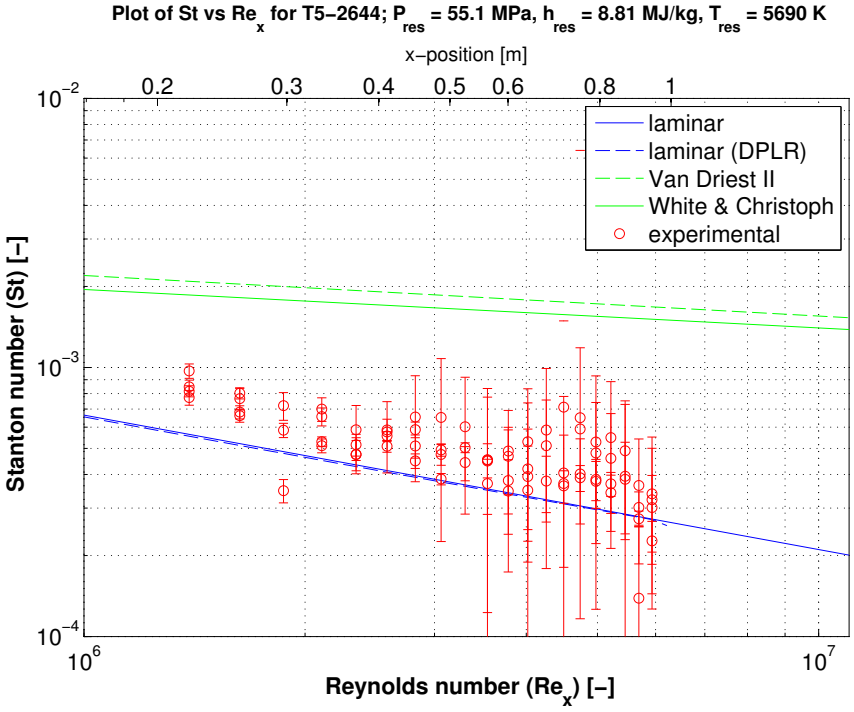


Figure 261: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

88 Shot 2645

Experiment 2645 was performed in T5 on 24 February 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

88.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	85.35	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 697: Measured quantities, Shot 2645

88.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6166	K
Reservoir Density	ρ_{res}	27.53	kg/m^3
Reservoir Enthalpy	h_{res}	9.96	MJ/kg

Table 698: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2645

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.61×10^{-2}	0	1.32×10^{-1}	0	5.81×10^{-3}	1.16×10^{-1}

Table 699: Computed reservoir species mass fractions, Shot 2645

88.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4043	1485.0	1485.0	5.33	25.7	0.059	4.43×10^{6}
72 cm	4013	1524.5	1533.7	5.08	30.4	0.068	5.02×10^{6}

Table 700: Computed freestream conditions, Shot 2645

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.96×10^{-2}	0	7.75×10^{-9}	2.16×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	1.74×10^{-8}	1.32×10^{-2}

Table 701: Computed freestream species mass fractions, Shot 2645

88.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4002	1615.7	1615.7	5.06	36.4	0.077	5.41×10^{6}
72 cm	3946	1718.7	1716.7	4.71	43.0	0.086	5.71×10^{6}

Table 702: Computed boundary layer edge conditions, Shot 2645

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.80×10^{-1}	0	5.96×10^{-2}	0	7.75×10^{-9}	2.16×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	6.02×10^{-8}	1.27×10^{-2}

Table 703: Computed boundary layer edge species mass fractions, Shot 2645

	T^* K	Unit Re^* 1/m
1D 100 cm	1914	4.05×10^{6}
72 cm	1888	5.20×10^{6}

Table 704: Dorrance reference conditions, Shot 2645

88.5 Stability Computations

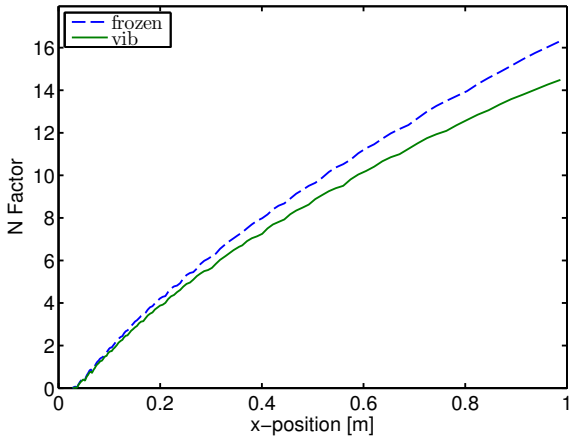


Figure 262: Locus of maximum N factor with and without vibrational energy transfer, Shot 2645

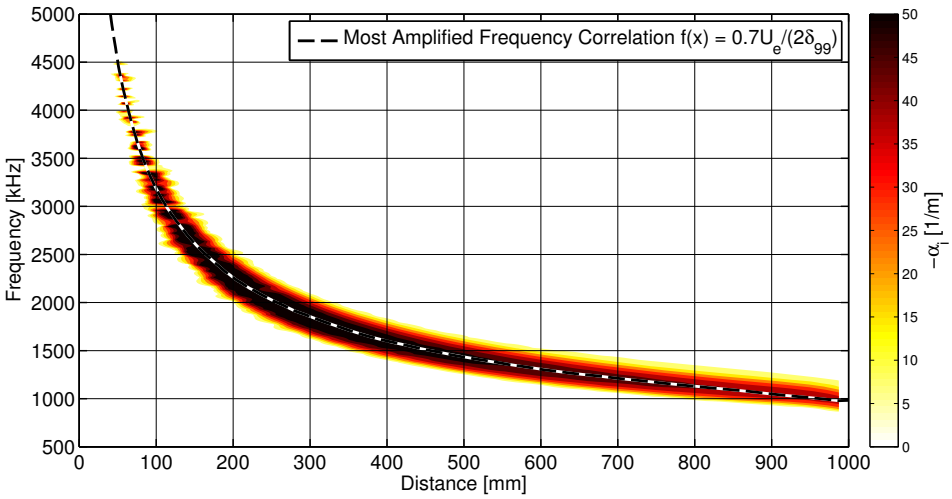


Figure 263: Stability diagram with vibrational energy transfer, Shot 2645. Dashed line indicates $0.7U_e/(2\delta_{99})$.

88.6 Heat Transfer Results

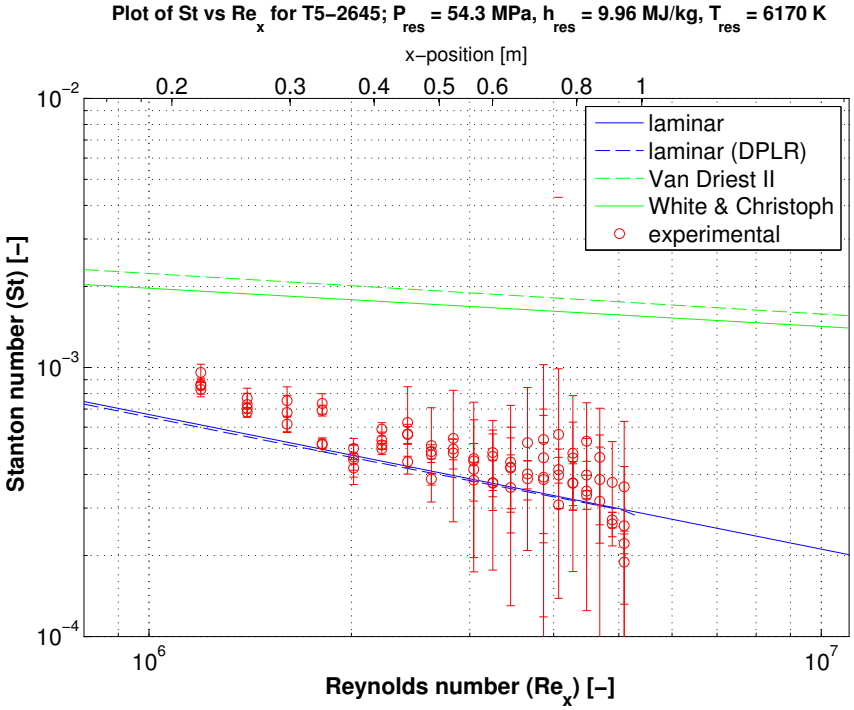


Figure 264: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

89 Shot 2646

Experiment 2646 was performed in T5 on 1 March 2011. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

89.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3260	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	53.7	MPa

Table 705: Measured quantities, Shot 2646

89.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6259	K
Reservoir Density	ρ_{res}	26.66	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 706: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2646

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.23×10^{-2}	0	1.30×10^{-1}	0	6.77×10^{-3}	1.21×10^{-1}

Table 707: Computed reservoir species mass fractions, Shot 2646

89.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4080	1517.0	1517.0	5.32	25.3	0.057	4.25×10^6
72 cm	4052	1564.2	1573.6	5.06	30.3	0.066	4.83×10^6

Table 708: Computed freestream conditions, Shot 2646

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.92×10^{-2}	0	1.14×10^{-8}	2.38×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.30×10^{-2}	0	2.63×10^{-8}	1.49×10^{-2}

Table 709: Computed freestream species mass fractions, Shot 2646

89.4 Boundary Layer Edge and Reference Conditions

	U_e	T_e	Tv_e	M_e	P_e	ρ_e	Unit Re_e
	m/s	K	K	-	kPa	kg/m^3	1/m
1D 100 cm	4039	1650.4	1650.4	5.05	35.9	0.074	5.18×10^6
72 cm	3983	1762.6	1760.5	4.69	42.8	0.083	5.49×10^6

Table 710: Computed boundary layer edge conditions, Shot 2646

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.78×10^{-1}	0	5.92×10^{-2}	0	1.14×10^{-8}	2.38×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	8.66×10^{-8}	1.43×10^{-2}

Table 711: Computed boundary layer edge species mass fractions, Shot 2646

	T^*	Unit Re^*
	K	1/m
1D 100 cm	1947	3.91×10^6
72 cm	1924	5.03×10^6

Table 712: Dorrance reference conditions, Shot 2646

89.5 Stability Computations

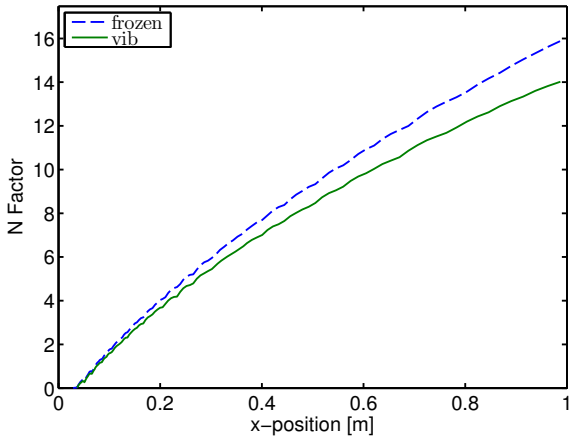


Figure 265: Locus of maximum N factor with and without vibrational energy transfer, Shot 2646

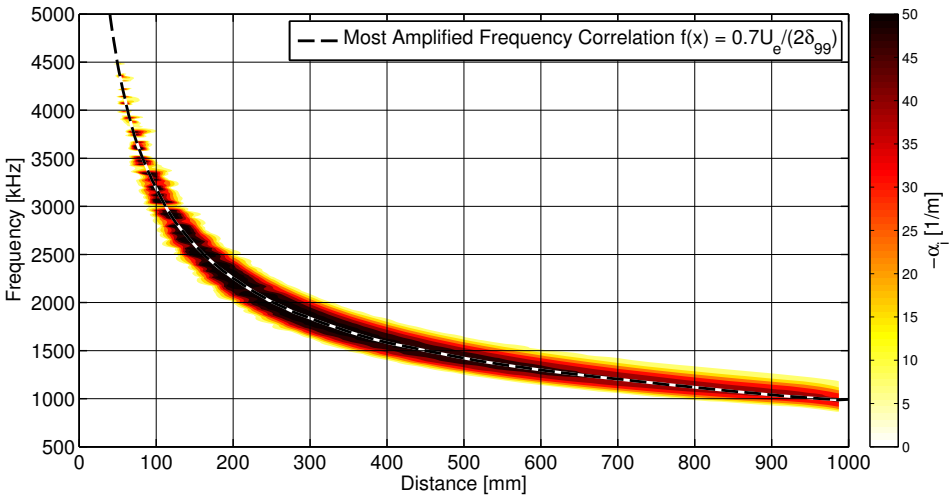


Figure 266: Stability diagram with vibrational energy transfer, Shot 2646. Dashed line indicates $0.7U_e/(2\delta_{99})$.

89.6 Heat Transfer Results

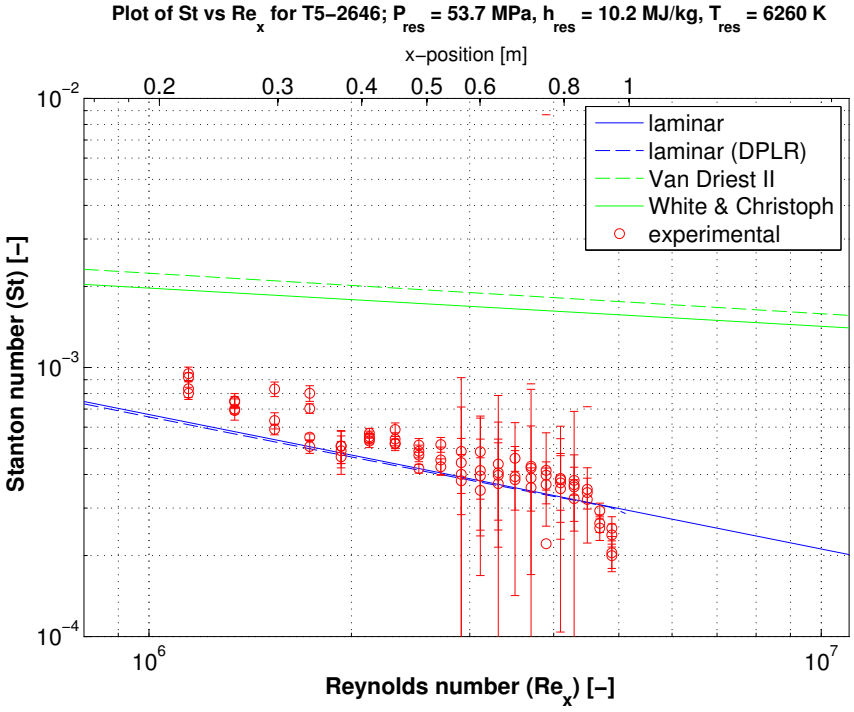


Figure 267: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

90 Shot 2647

Experiment 2647 was performed in T5 on 4 March 2011. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

90.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2420	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_res	30.6	MPa

Table 713: Measured quantities, Shot 2647

90.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	4258	K
Reservoir Density	ρ_res	24.32	kg/m^3
Reservoir Enthalpy	h_res	5.70	MJ/kg

Table 714: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2647

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_NO	Y_CO	Y_N	Y_O
7.15×10^{-1}	1.46×10^{-1}	0	1.11×10^{-1}	0	1.04×10^{-4}	2.79×10^{-2}

Table 715: Computed reservoir species mass fractions, Shot 2647

90.3 Freestream Conditions

	U_∞ m/s	T_∞ K	$T\mathrm{v}_\infty$ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3161	753.0	753.0	5.81	11.3	0.052	4.59×10^6
72 cm	3143	733.9	738.3	5.78	11.7	0.055	4.91×10^6

Table 716: Computed freestream conditions, Shot 2647

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.95×10^{-1}	0	6.42×10^{-2}	0	3.93×10^{-10}	3.24×10^{-3}
72 cm	7.32×10^{-1}	1.91×10^{-1}	0	7.52×10^{-2}	0	0	1.45×10^{-3}

Table 717: Computed freestream species mass fractions, Shot 2647

90.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3131	838.6	838.6	5.46	17.0	0.070	5.75×10^6
72 cm	3089	868.0	859.0	5.22	17.7	0.071	5.59×10^6

Table 718: Computed boundary layer edge conditions, Shot 2647

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.95×10^{-1}	0	6.42×10^{-2}	0	3.93×10^{-10}	3.24×10^{-3}
72 cm	7.32×10^{-1}	1.91×10^{-1}	0	7.52×10^{-2}	0	0	1.45×10^{-3}

Table 719: Computed boundary layer edge species mass fractions, Shot 2647

	T^* K	Unit Re^* 1/m
1D 100 cm	1214	3.22×10^6
72 cm	1193	4.07×10^6

Table 720: Dorrance reference conditions, Shot 2647

90.5 Stability Computations

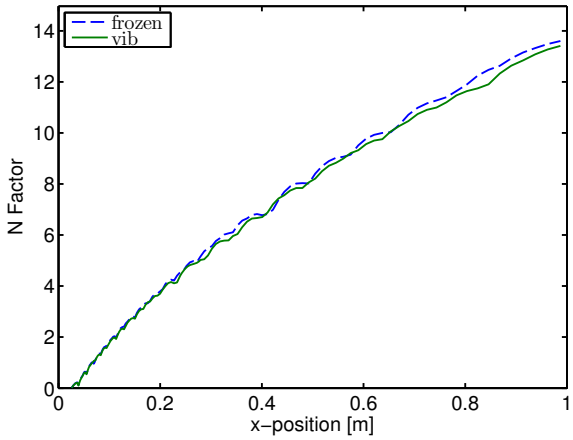


Figure 268: Locus of maximum N factor with and without vibrational energy transfer, Shot 2647

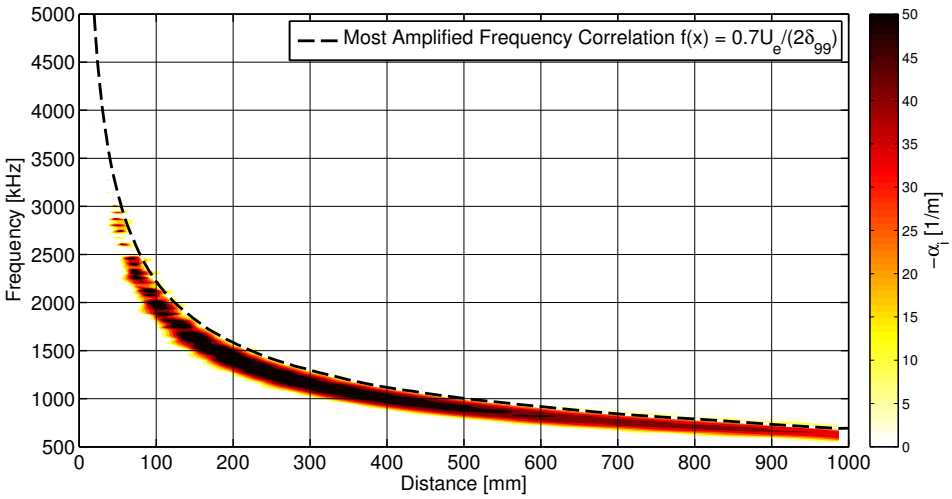


Figure 269: Stability diagram with vibrational energy transfer, Shot 2647. Dashed line indicates $0.7U_e/(2\delta_{99})$.

90.6 Heat Transfer Results

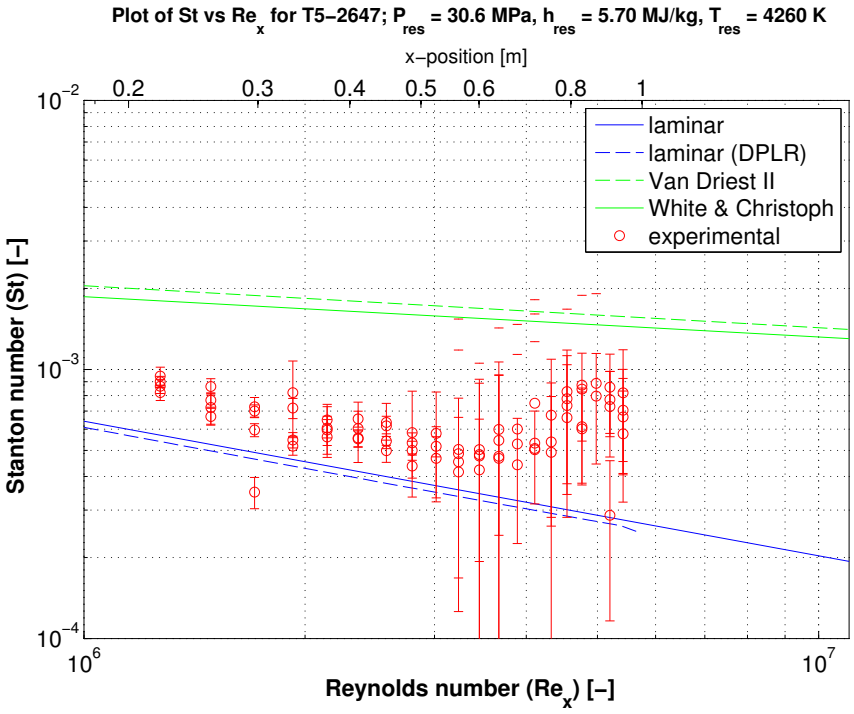


Figure 270: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

91 Shot 2648

Experiment 2648 was performed in T5 on 11 March 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

91.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2170	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_{res}	14.0	MPa

Table 721: Measured quantities, Shot 2648

91.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3377	K
Reservoir Density	ρ_{res}	14.29	kg/m^3
Reservoir Enthalpy	h_{res}	4.06	MJ/kg

Table 722: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2648

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.36×10^{-1}	1.91×10^{-1}	0	6.61×10^{-2}	0	4.35×10^{-6}	7.00×10^{-3}

Table 723: Computed reservoir species mass fractions, Shot 2648

91.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2723	497.0	497.0	6.11	4.5	0.032	3.17×10^6
72 cm	2710	443.2	629.2	6.42	3.5	0.027	2.95×10^6

Table 724: Computed freestream conditions, Shot 2648

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.45×10^{-1}	2.06×10^{-1}	0	4.73×10^{-2}	0	0	1.62×10^{-3}
72 cm	7.39×10^{-1}	2.00×10^{-1}	0	6.06×10^{-2}	0	0	6.95×10^{-4}

Table 725: Computed freestream species mass fractions, Shot 2648

91.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2698	562.6	562.6	5.69	7.1	0.043	3.97×10^6
72 cm	2662	558.2	600.9	5.61	5.7	0.035	3.20×10^6

Table 726: Computed boundary layer edge conditions, Shot 2648

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.45×10^{-1}	2.06×10^{-1}	0	4.73×10^{-2}	0	0	1.62×10^{-3}
72 cm	7.39×10^{-1}	2.00×10^{-1}	0	6.06×10^{-2}	0	0	6.95×10^{-4}

Table 727: Computed boundary layer edge species mass fractions, Shot 2648

	T^* K	Unit Re^* 1/m
1D 100 cm	934	1.75×10^6
72 cm	914	1.95×10^6

Table 728: Dorrance reference conditions, Shot 2648

91.5 Stability Computations

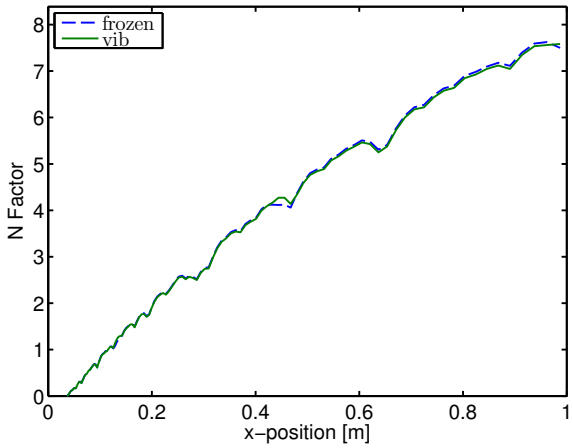


Figure 271: Locus of maximum N factor with and without vibrational energy transfer, Shot 2648

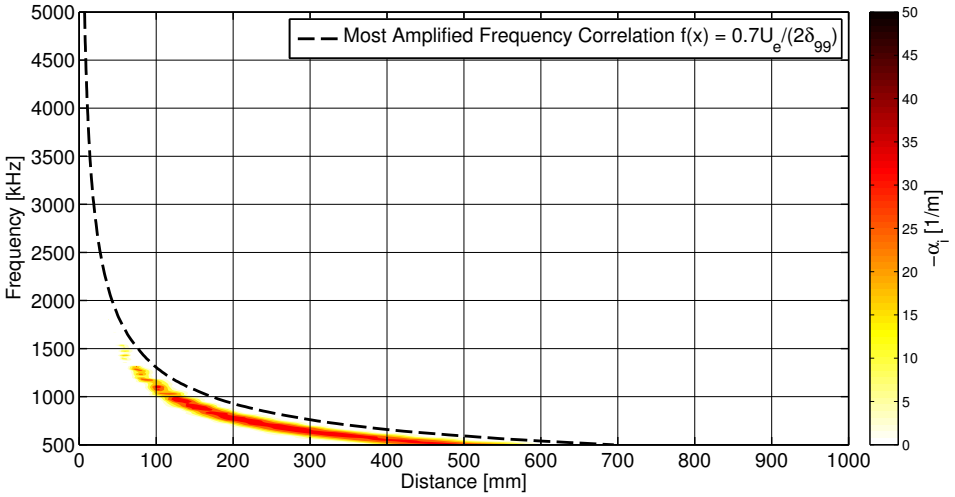


Figure 272: Stability diagram with vibrational energy transfer, Shot 2648. Dashed line indicates $0.7U_e/(2\delta_{99})$.

91.6 Heat Transfer Results

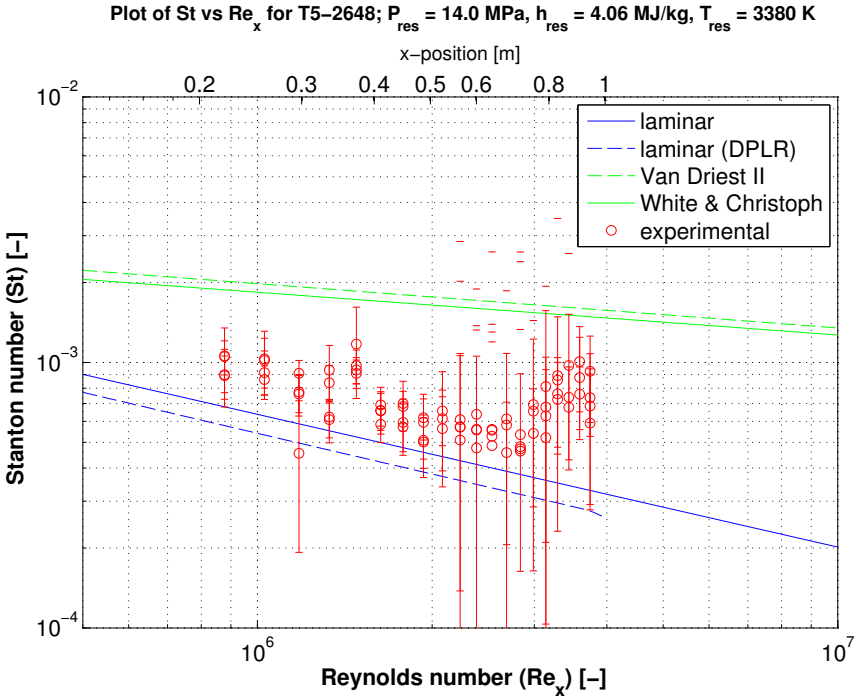


Figure 273: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

92 Shot 2649

Experiment 2649 was performed in T5 on 17 March 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

92.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2260	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_{res}	22.2	MPa

Table 729: Measured quantities, Shot 2649

92.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3785	K
Reservoir Density	ρ_{res}	20.10	kg/m^3
Reservoir Enthalpy	h_{res}	4.78	MJ/kg

Table 730: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2649

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.26×10^{-1}	1.72×10^{-1}	0	8.81×10^{-2}	0	2.21×10^{-5}	1.42×10^{-2}

Table 731: Computed reservoir species mass fractions, Shot 2649

92.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2923	604.0	604.0	5.97	7.6	0.044	4.13×10^6
72 cm	2913	558.2	639.5	6.14	6.6	0.041	4.02×10^6

Table 732: Computed freestream conditions, Shot 2649

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.98×10^{-1}	0	6.10×10^{-2}	0	0	2.04×10^{-3}
72 cm	7.35×10^{-1}	1.95×10^{-1}	0	6.88×10^{-2}	0	0	9.14×10^{-4}

Table 733: Computed freestream species mass fractions, Shot 2649

92.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2895	678.0	678.0	5.58	11.7	0.060	5.16×10^6
72 cm	2862	684.0	676.4	5.44	10.3	0.052	4.45×10^6

Table 734: Computed boundary layer edge conditions, Shot 2649

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.98×10^{-1}	0	6.10×10^{-2}	0	0	2.04×10^{-3}
72 cm	7.35×10^{-1}	1.95×10^{-1}	0	6.88×10^{-2}	0	0	9.14×10^{-4}

Table 735: Computed boundary layer edge species mass fractions, Shot 2649

	T^* K	Unit Re^* 1/m
1D 100 cm	1057	2.55×10^6
72 cm	1037	2.93×10^6

Table 736: Dorrance reference conditions, Shot 2649

92.5 Stability Computations

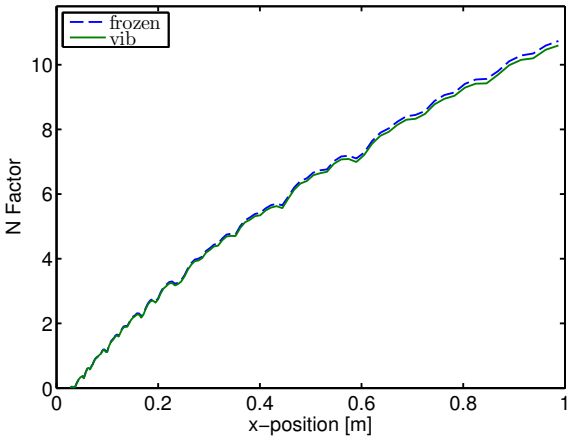


Figure 274: Locus of maximum N factor with and without vibrational energy transfer, Shot 2649

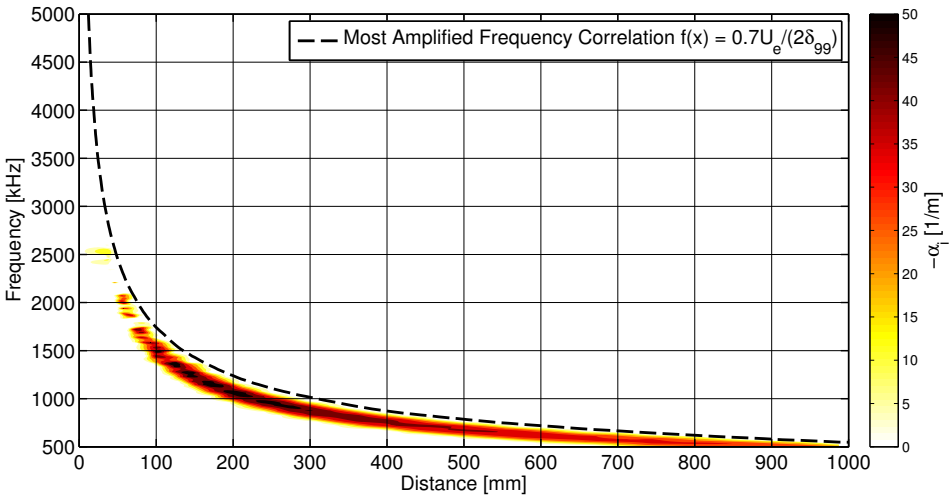


Figure 275: Stability diagram with vibrational energy transfer, Shot 2649. Dashed line indicates $0.7U_e/(2\delta_{99})$.

92.6 Heat Transfer Results

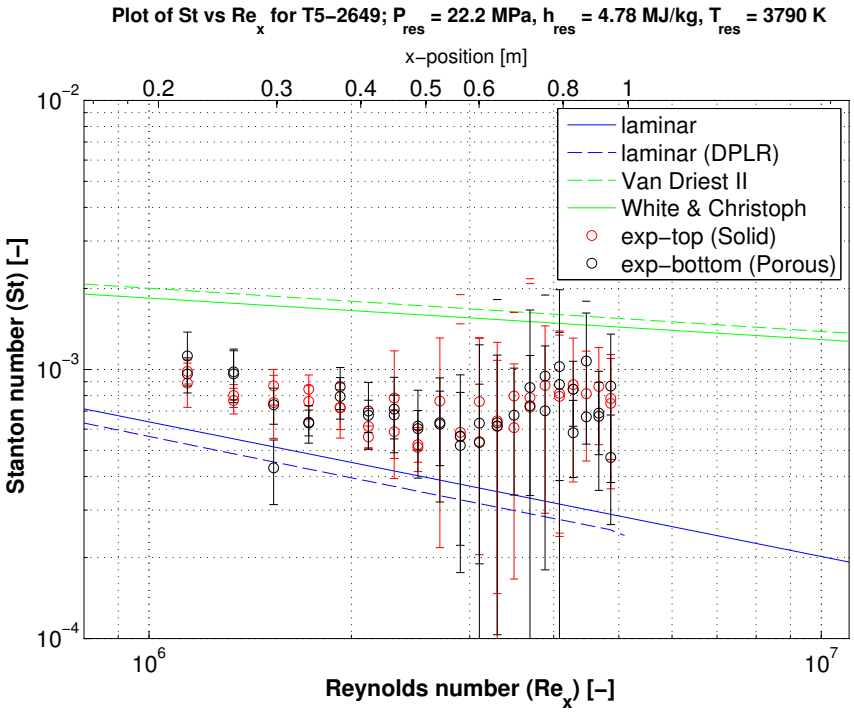


Figure 276: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

93 Shot 2650

Experiment 2650 was performed in T5 on 18 March 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

93.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_{res}	51.5	MPa

Table 737: Measured quantities, Shot 2650

93.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6001	K
Reservoir Density	ρ_{res}	26.96	kg/m^3
Reservoir Enthalpy	h_{res}	9.59	MJ/kg

Table 738: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2650

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.16×10^{-2}	0	1.34×10^{-1}	0	4.57×10^{-3}	1.10×10^{-1}

Table 739: Computed reservoir species mass fractions, Shot 2650

93.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3973	1418.0	1418.0	5.36	23.7	0.057	4.36×10^6
72 cm	3948	1457.6	1466.9	5.12	28.3	0.067	4.96×10^6

Table 740: Computed freestream conditions, Shot 2650

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	3.85×10^{-9}	1.97×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.29×10^{-2}	0	9.16×10^{-9}	1.18×10^{-2}

Table 741: Computed freestream species mass fractions, Shot 2650

93.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3933	1545.0	1545.0	5.09	33.8	0.075	5.33×10^6
72 cm	3882	1646.4	1644.2	4.73	40.1	0.084	5.64×10^6

Table 742: Computed boundary layer edge conditions, Shot 2650

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	6.01×10^{-2}	0	3.85×10^{-9}	1.97×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.29×10^{-2}	0	3.52×10^{-8}	1.14×10^{-2}

Table 743: Computed boundary layer edge species mass fractions, Shot 2650

	T^* K	Unit Re^* 1/m
1D 100 cm	1851	3.92×10^6
72 cm	1829	5.08×10^6

Table 744: Dorrance reference conditions, Shot 2650

93.5 Stability Computations

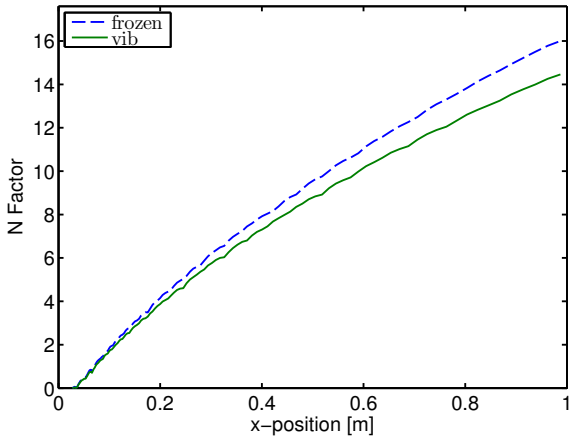


Figure 277: Locus of maximum N factor with and without vibrational energy transfer, Shot 2650

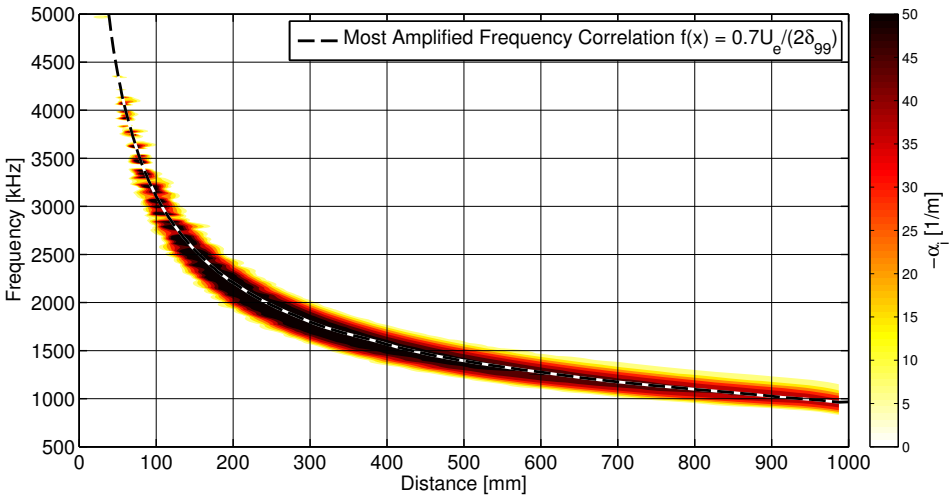


Figure 278: Stability diagram with vibrational energy transfer, Shot 2650. Dashed line indicates $0.7U_e/(2\delta_{99})$.

93.6 Heat Transfer Results

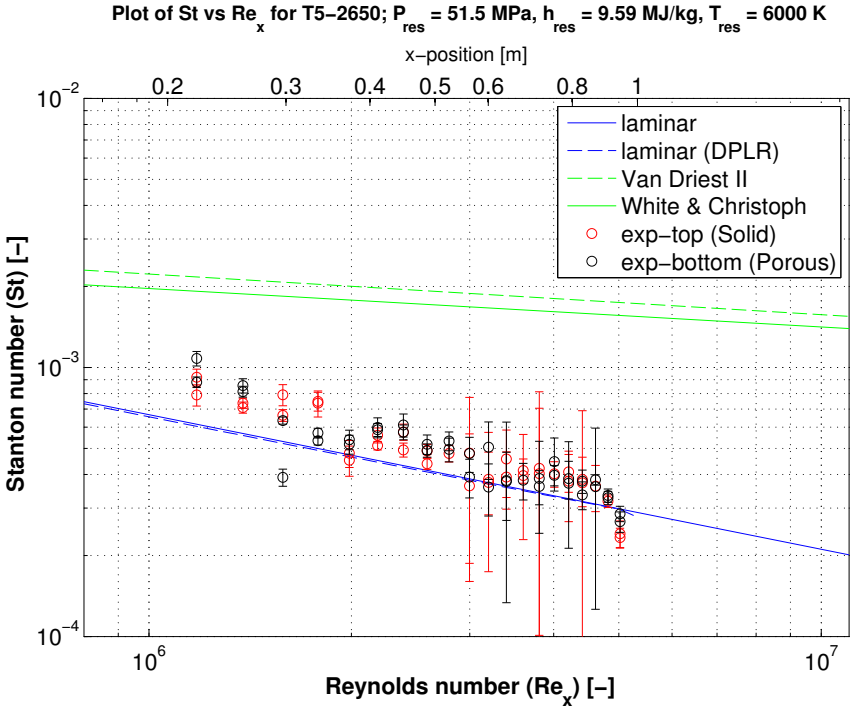


Figure 279: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

94 Shot 2651

Experiment 2651 was performed in T5 on 4 April 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

94.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	85.05	kPa
Reservoir Pressure	P_{res}	51.9	MPa

Table 745: Measured quantities, Shot 2651

94.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6116	K
Reservoir Density	ρ_{res}	26.52	kg/m^3
Reservoir Enthalpy	h_{res}	9.87	MJ/kg

Table 746: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2651

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.71×10^{-2}	0	1.32×10^{-1}	0	5.50×10^{-3}	1.15×10^{-1}

Table 747: Computed reservoir species mass fractions, Shot 2651

94.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4023	1464.0	1464.0	5.34	24.3	0.057	4.28×10^6
72 cm	3995	1505.5	1515.0	5.09	28.8	0.066	4.85×10^6

Table 748: Computed freestream conditions, Shot 2651

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.97×10^{-2}	0	6.40×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	1.52×10^{-8}	1.33×10^{-2}

Table 749: Computed freestream species mass fractions, Shot 2651

94.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3983	1594.0	1594.0	5.07	34.6	0.074	5.22×10^6
72 cm	3928	1698.5	1696.3	4.71	40.9	0.083	5.51×10^6

Table 750: Computed boundary layer edge conditions, Shot 2651

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.97×10^{-2}	0	6.40×10^{-9}	2.17×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.29×10^{-2}	0	5.42×10^{-8}	1.28×10^{-2}

Table 751: Computed boundary layer edge species mass fractions, Shot 2651

	T^* K	Unit Re^* 1/m
1D 100 cm	1896	3.89×10^6
72 cm	1871	5.00×10^6

Table 752: Dorrance reference conditions, Shot 2651

94.5 Stability Computations

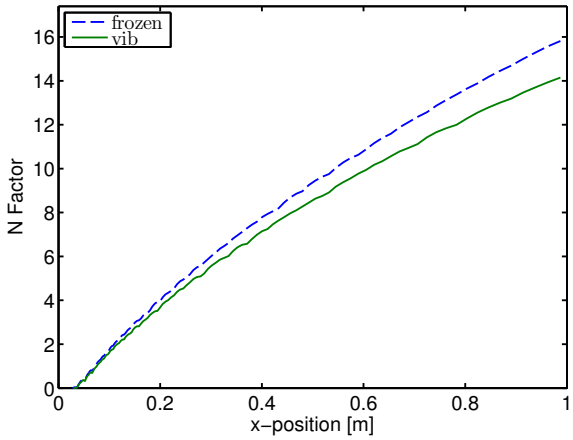


Figure 280: Locus of maximum N factor with and without vibrational energy transfer, Shot 2651

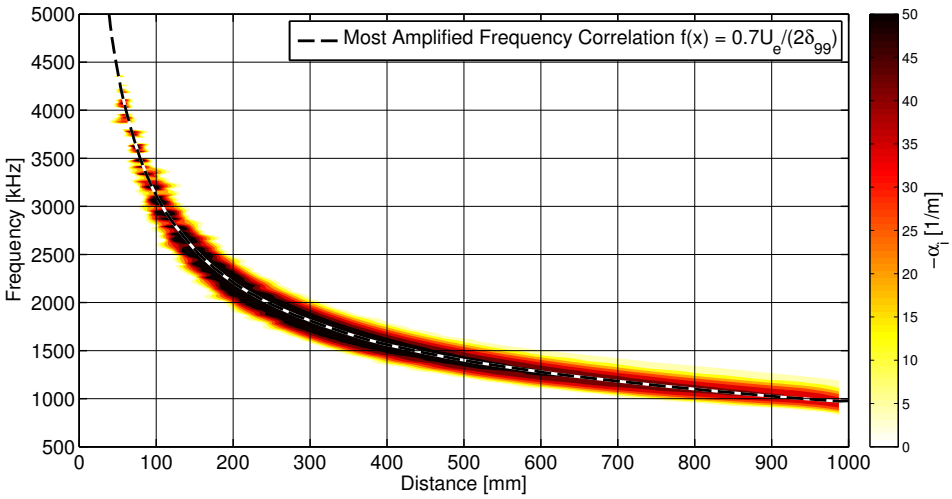


Figure 281: Stability diagram with vibrational energy transfer, Shot 2651. Dashed line indicates $0.7U_e/(2\delta_{99})$.

94.6 Heat Transfer Results

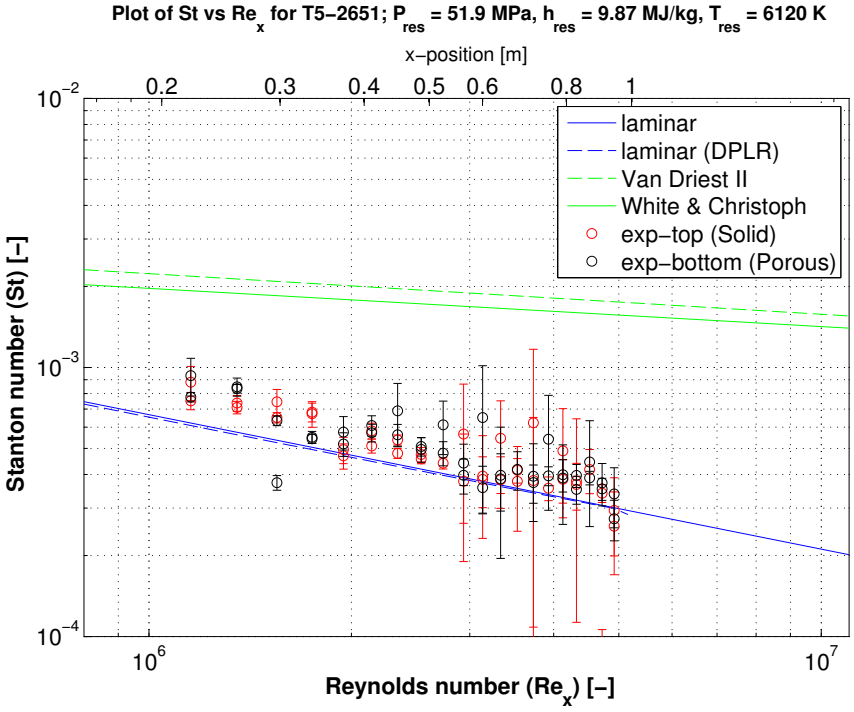


Figure 282: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

95 Shot 2652

Experiment 2652 was performed in T5 on 2 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

95.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	103.20	kPa
Reservoir Pressure	P_{res}	72.5	MPa

Table 753: Measured quantities, Shot 2652

95.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6353	K
Reservoir Density	ρ_{res}	35.62	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 754: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2652

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	4.48×10^{-2}	0	1.37×10^{-1}	0	6.69×10^{-3}	1.15×10^{-1}

Table 755: Computed reservoir species mass fractions, Shot 2652

95.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4102	1557.0	1557.0	5.30	34.7	0.076	5.63×10^6
72 cm	4074	1589.2	1596.5	5.06	41.4	0.089	6.49×10^6

Table 756: Computed freestream conditions, Shot 2652

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.93×10^{-2}	0	1.24×10^{-8}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.33×10^{-2}	0	2.27×10^{-8}	1.11×10^{-2}

Table 757: Computed freestream species mass fractions, Shot 2652

95.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4061	1691.9	1691.9	5.03	49.1	0.099	6.86×10^6
72 cm	4006	1787.6	1786.1	4.69	58.4	0.112	7.39×10^6

Table 758: Computed boundary layer edge conditions, Shot 2652

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.93×10^{-2}	0	1.24×10^{-8}	1.87×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	7.07×10^{-8}	1.05×10^{-2}

Table 759: Computed boundary layer edge species mass fractions, Shot 2652

	T^* K	Unit Re^* 1/m
1D 100 cm	1976	5.27×10^6
72 cm	1943	6.79×10^6

Table 760: Dorrance reference conditions, Shot 2652

95.5 Stability Computations

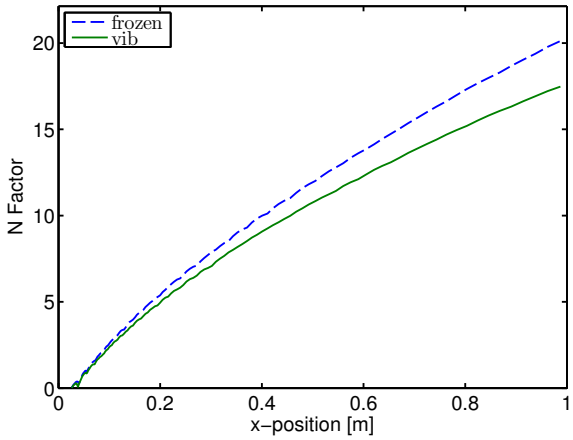


Figure 283: Locus of maximum N factor with and without vibrational energy transfer, Shot 2652

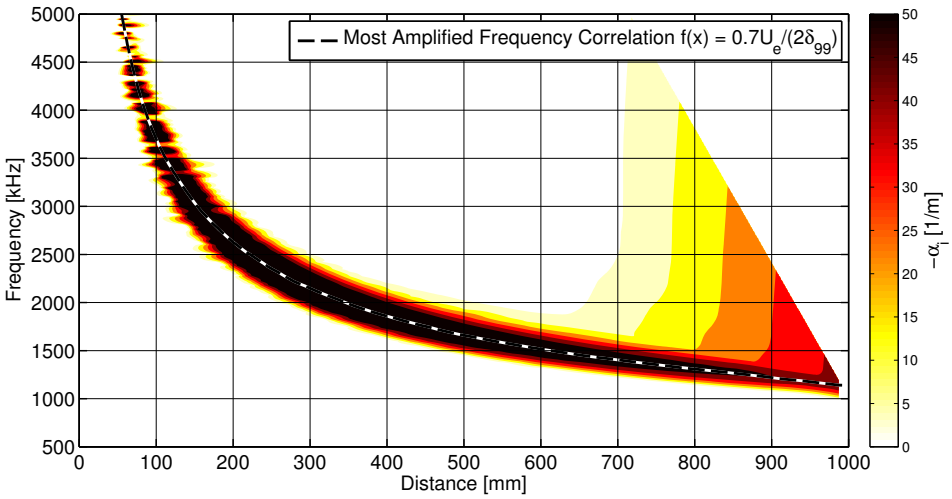


Figure 284: Stability diagram with vibrational energy transfer, Shot 2652. Dashed line indicates $0.7U_e/(2\delta_{99})$.

95.6 Heat Transfer Results

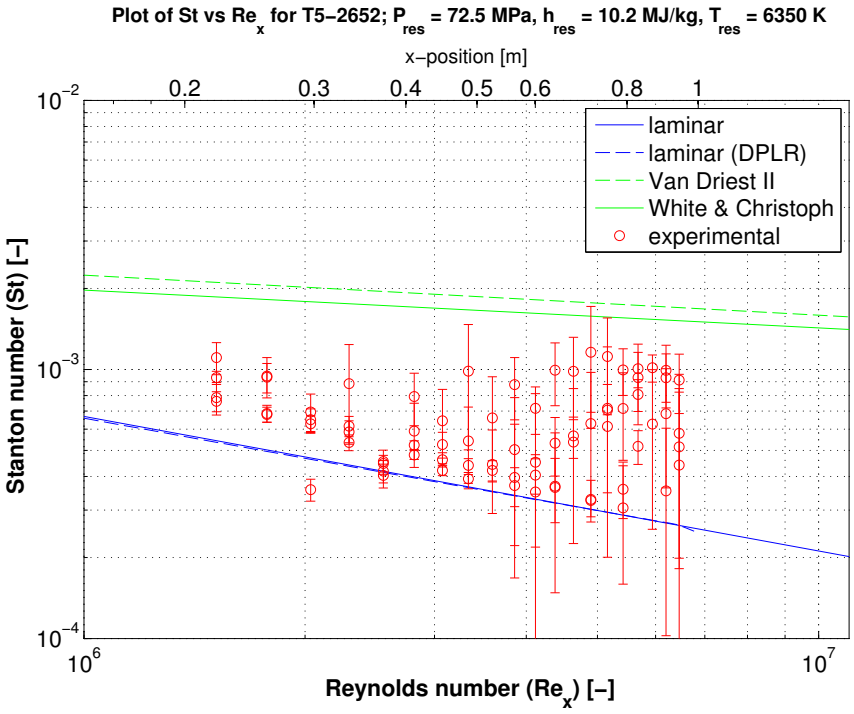


Figure 285: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

96 Shot 2653

Experiment 2653 was performed in T5 on 4 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

96.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	103.20	kPa
Reservoir Pressure	P_{res}	73.1	MPa

Table 761: Measured quantities, Shot 2653

96.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6259	K
Reservoir Density	ρ_{res}	36.63	kg/m^3
Reservoir Enthalpy	h_{res}	10.0	MJ/kg

Table 762: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2653

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	4.84×10^{-2}	0	1.39×10^{-1}	0	5.76×10^{-3}	1.11×10^{-1}

Table 763: Computed reservoir species mass fractions, Shot 2653

96.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4058	1514.0	1514.0	5.32	34.3	0.077	5.78×10^{6}
72 cm	4036	1547.4	1554.5	5.08	41.4	0.092	6.72×10^{6}

Table 764: Computed freestream conditions, Shot 2653

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.97×10^{-2}	0	7.89×10^{-9}	1.70×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.32×10^{-2}	0	1.49×10^{-8}	9.80×10^{-3}

Table 765: Computed freestream species mass fractions, Shot 2653

96.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4017	1646.3	1646.3	5.05	48.6	0.101	7.04×10^{6}
72 cm	3968	1742.1	1740.7	4.71	58.5	0.115	7.65×10^{6}

Table 766: Computed boundary layer edge conditions, Shot 2653

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	5.97×10^{-2}	0	7.89×10^{-9}	1.70×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.32×10^{-2}	0	4.90×10^{-8}	9.33×10^{-3}

Table 767: Computed boundary layer edge species mass fractions, Shot 2653

	T^* K	Unit Re^* 1/m
1D 100 cm	1935	5.35×10^{6}
72 cm	1906	6.99×10^{6}

Table 768: Dorrance reference conditions, Shot 2653

96.5 Stability Computations

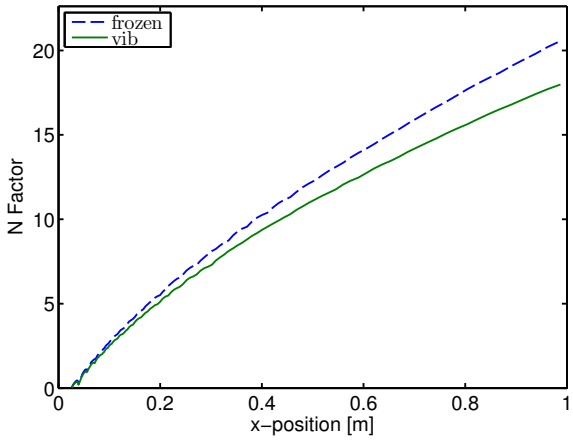


Figure 286: Locus of maximum N factor with and without vibrational energy transfer, Shot 2653

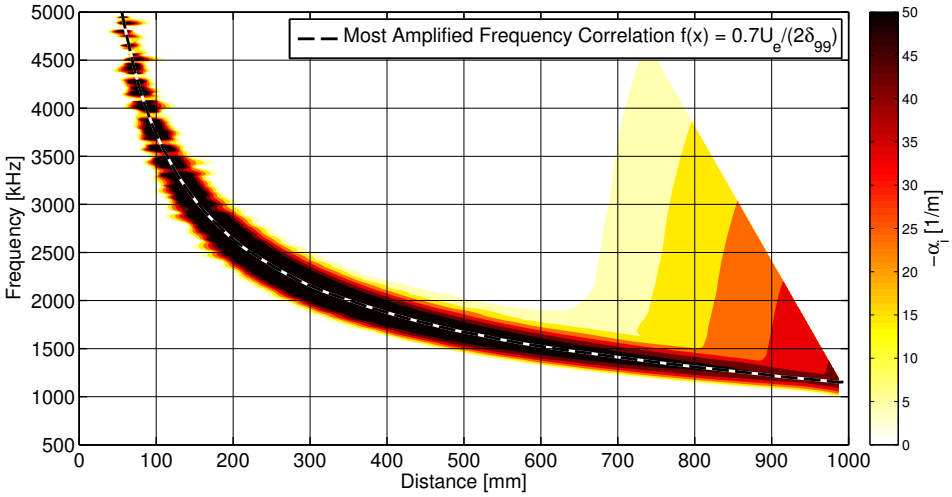


Figure 287: Stability diagram with vibrational energy transfer, Shot 2653. Dashed line indicates $0.7U_e/(2\delta_{99})$.

96.6 Heat Transfer Results

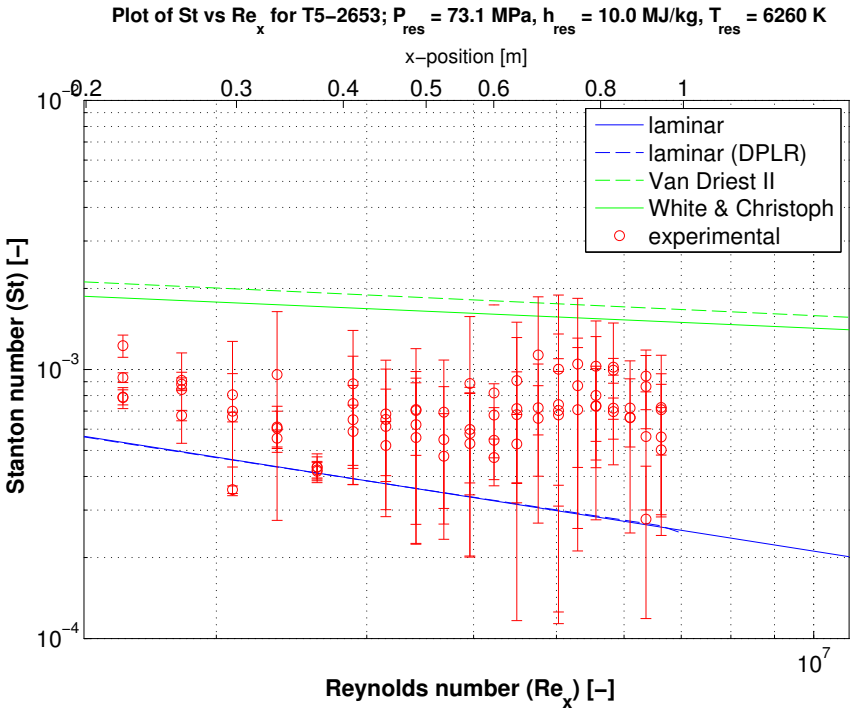


Figure 288: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

97 Shot 2654

Experiment 2654 was performed in T5 on 6 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

97.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3240	m/s
Shock Tube Fill Pressure	P_1	103.20	kPa
Reservoir Pressure	P_{res}	74.1	MPa

Table 769: Measured quantities, Shot 2654

97.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6414	K
Reservoir Density	ρ_{res}	36.03	kg/m^3
Reservoir Enthalpy	h_{res}	10.4	MJ/kg

Table 770: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2654

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	4.31×10^{-2}	0	1.36×10^{-1}	0	7.23×10^{-3}	1.17×10^{-1}

Table 771: Computed reservoir species mass fractions, Shot 2654

97.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4123	1579.0	1579.0	5.29	35.5	0.077	5.65×10^{6}
72 cm	4097	1614.0	1621.2	5.05	42.6	0.091	6.54×10^{6}

Table 772: Computed freestream conditions, Shot 2654

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.82×10^{-1}	0	5.91×10^{-2}	0	1.51×10^{-8}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.33×10^{-2}	0	2.78×10^{-8}	1.15×10^{-2}

Table 773: Computed freestream species mass fractions, Shot 2654

97.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4082	1714.6	1714.6	5.03	50.2	0.100	6.88×10^{6}
72 cm	4028	1814.7	1813.2	4.68	60.1	0.114	7.44×10^{6}

Table 774: Computed boundary layer edge conditions, Shot 2654

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.82×10^{-1}	0	5.91×10^{-2}	0	1.51×10^{-8}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	8.41×10^{-8}	1.09×10^{-2}

Table 775: Computed boundary layer edge species mass fractions, Shot 2654

	T^* K	Unit Re^* 1/m
1D 100 cm	1996	5.31×10^{6}
72 cm	1965	6.87×10^{6}

Table 776: Dorrance reference conditions, Shot 2654

97.5 Stability Computations

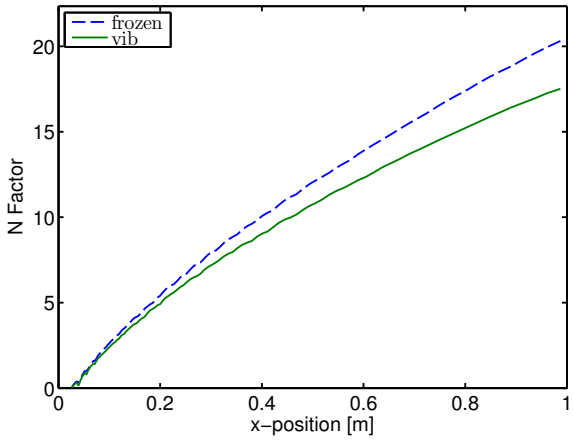


Figure 289: Locus of maximum N factor with and without vibrational energy transfer, Shot 2654

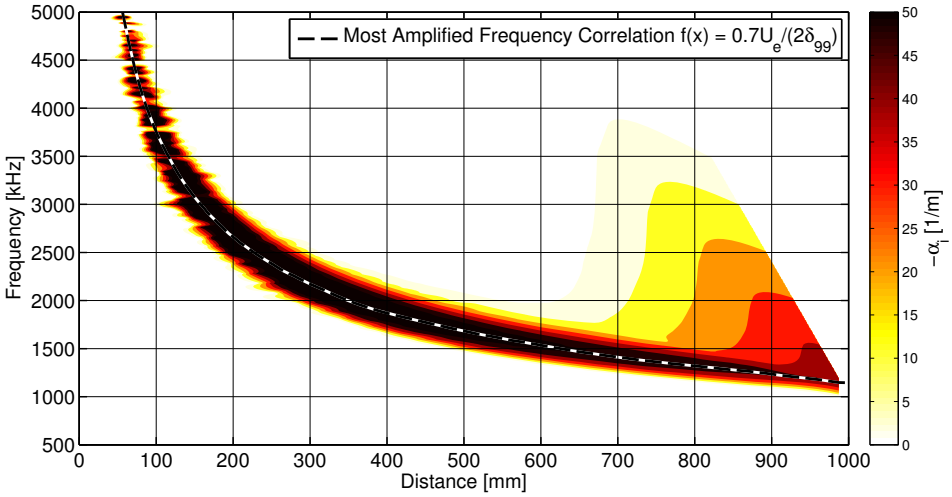


Figure 290: Stability diagram with vibrational energy transfer, Shot 2654. Dashed line indicates $0.7U_e/(2\delta_{99})$.

97.6 Heat Transfer Results

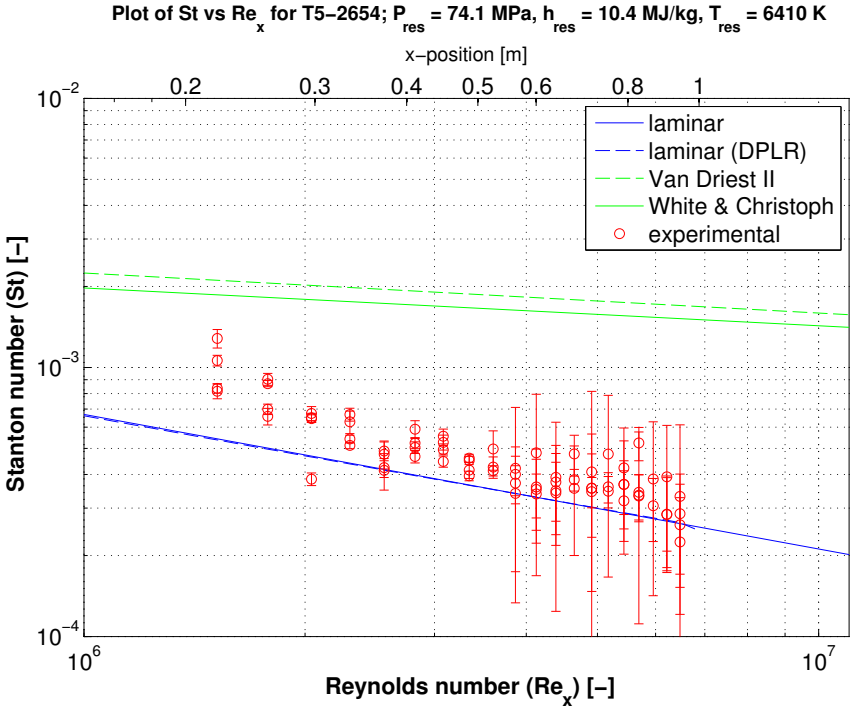


Figure 291: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

98 Shot 2655

Experiment 2655 was performed in T5 on 9 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

98.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3240	m/s
Shock Tube Fill Pressure	P_1	103.15	kPa
Reservoir Pressure	P_{res}	73.7	MPa

Table 777: Measured quantities, Shot 2655

98.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6407	K
Reservoir Density	ρ_{res}	35.85	kg/m^3
Reservoir Enthalpy	h_{res}	10.4	MJ/kg

Table 778: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2655

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	4.32×10^{-2}	0	1.36×10^{-1}	0	7.18×10^{-3}	1.17×10^{-1}

Table 779: Computed reservoir species mass fractions, Shot 2655

98.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4122	1577.0	1577.0	5.29	35.3	0.076	5.63×10^{6}
72 cm	4095	1611.6	1618.8	5.05	42.3	0.090	6.51×10^{6}

Table 780: Computed freestream conditions, Shot 2655

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.82×10^{-1}	0	5.91×10^{-2}	0	1.47×10^{-8}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.33×10^{-2}	0	2.74×10^{-8}	1.15×10^{-2}

Table 781: Computed freestream species mass fractions, Shot 2655

98.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4081	1713.0	1713.0	5.03	50.0	0.099	6.86×10^{6}
72 cm	4026	1812.2	1810.7	4.68	59.7	0.113	7.41×10^{6}

Table 782: Computed boundary layer edge conditions, Shot 2655

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.82×10^{-1}	0	5.91×10^{-2}	0	1.47×10^{-8}	1.93×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	8.33×10^{-8}	1.09×10^{-2}

Table 783: Computed boundary layer edge species mass fractions, Shot 2655

	T^* K	Unit Re^* 1/m
1D 100 cm	1995	5.29×10^{6}
72 cm	1963	6.84×10^{6}

Table 784: Dorrance reference conditions, Shot 2655

98.5 Stability Computations

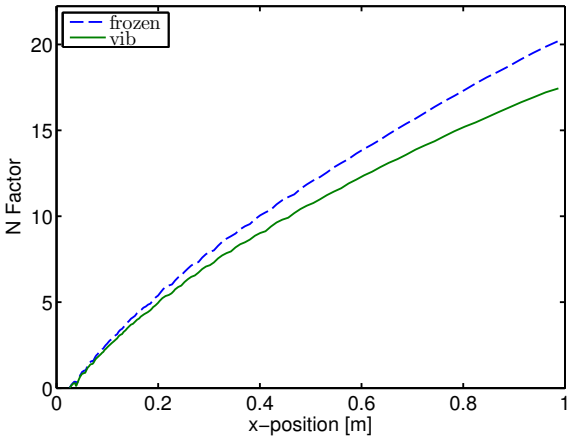


Figure 292: Locus of maximum N factor with and without vibrational energy transfer, Shot 2655

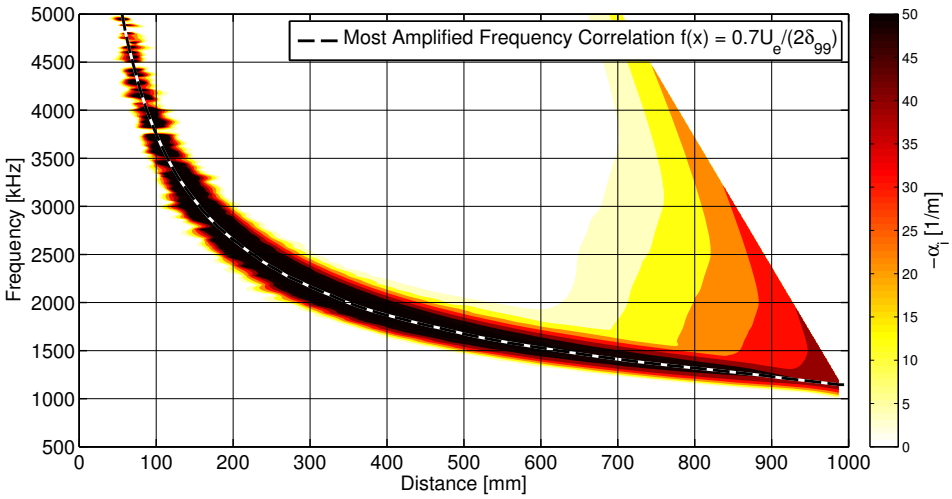


Figure 293: Stability diagram with vibrational energy transfer, Shot 2655. Dashed line indicates $0.7U_e/(2\delta_{99})$.

98.6 Heat Transfer Results

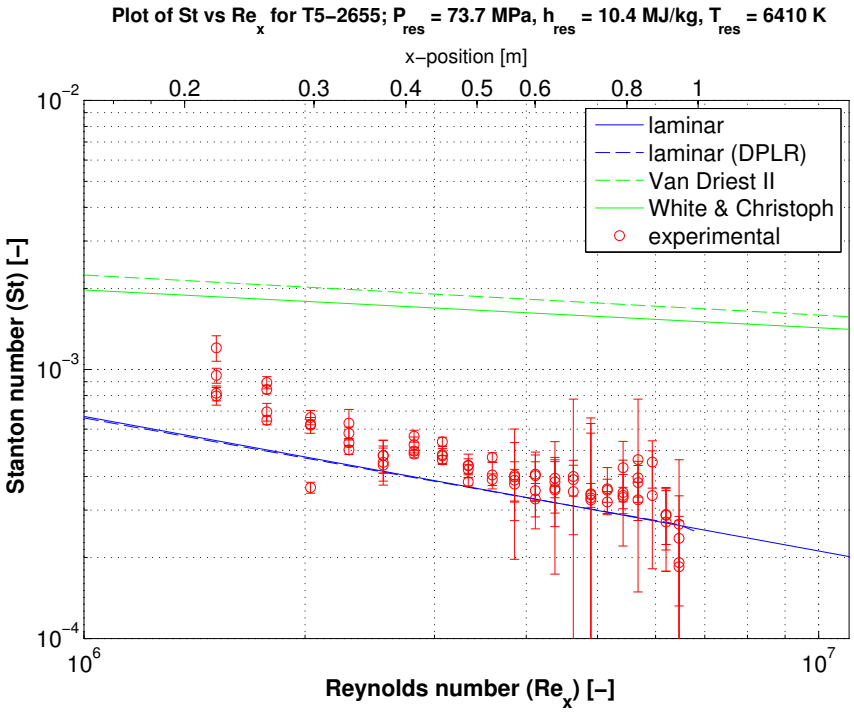


Figure 294: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

99 Shot 2656

Experiment 2656 was performed in T5 on 12 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

99.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2730	m/s
Shock Tube Fill Pressure	P_1	168.50	kPa
Reservoir Pressure	P_{res}	78.4	MPa

Table 785: Measured quantities, Shot 2656

99.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5102	K
Reservoir Density	ρ_{res}	50.95	kg/m^3
Reservoir Enthalpy	h_{res}	7.30	MJ/kg

Table 786: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2656

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	1.07×10^{-1}	0	1.42×10^{-1}	0	6.36×10^{-4}	5.02×10^{-2}

Table 787: Computed reservoir species mass fractions, Shot 2656

99.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3547	1047.0	1047.0	5.58	32.9	0.109	8.93×10^{6}
72 cm	3529	1026.5	1024.6	5.48	36.9	0.124	1.02×10^{7}

Table 788: Computed freestream conditions, Shot 2656

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.22×10^{-2}	0	0	3.64×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.75×10^{-2}	0	0	1.44×10^{-3}

Table 789: Computed freestream species mass fractions, Shot 2656

99.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3512	1150.4	1150.4	5.28	48.1	0.144	1.11×10^{7}
72 cm	3469	1181.1	1179.5	5.02	54.0	0.159	1.18×10^{7}

Table 790: Computed boundary layer edge conditions, Shot 2656

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.22×10^{-2}	0	0	3.64×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.75×10^{-2}	0	0	1.41×10^{-3}

Table 791: Computed boundary layer edge species mass fractions, Shot 2656

	T^* K	Unit Re^* 1/m
1D 100 cm	1498	7.22×10^{6}
72 cm	1459	9.59×10^{6}

Table 792: Dorrance reference conditions, Shot 2656

99.5 Stability Computations

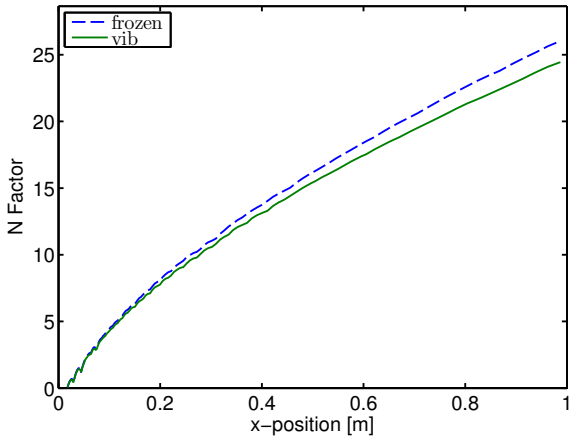


Figure 295: Locus of maximum N factor with and without vibrational energy transfer, Shot 2656

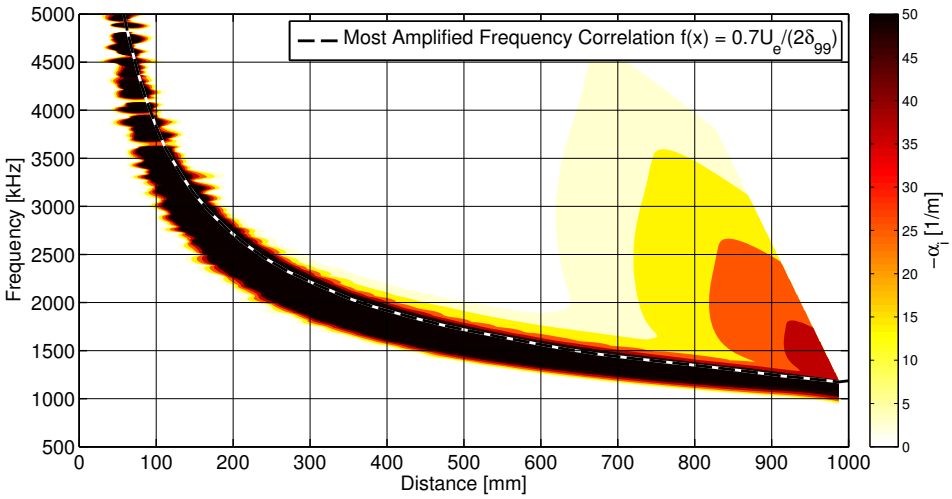


Figure 296: Stability diagram with vibrational energy transfer, Shot 2656. Dashed line indicates $0.7U_e/(2\delta_{99})$.

99.6 Heat Transfer Results

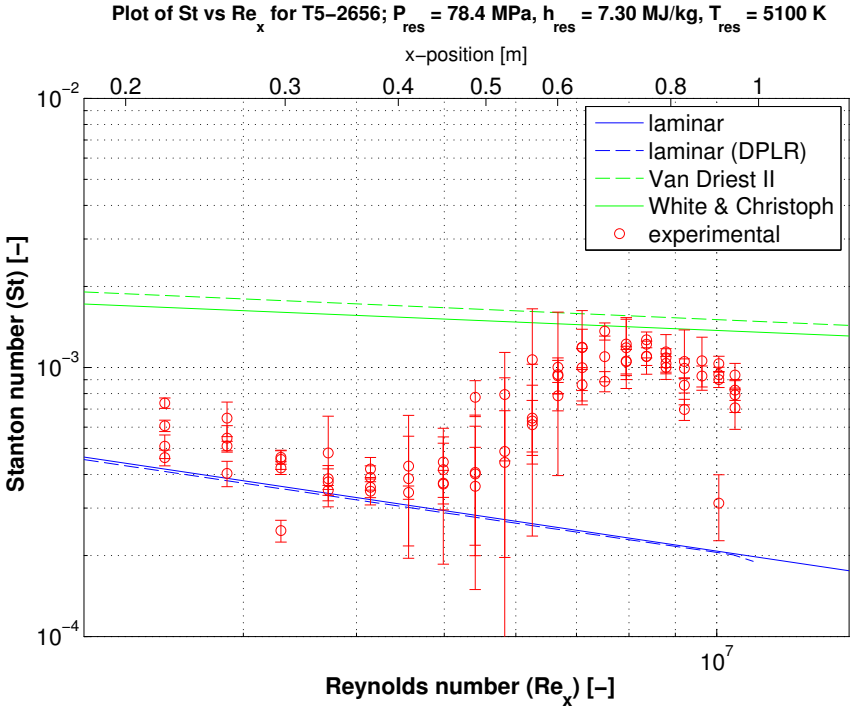


Figure 297: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

100 Shot 2657

Experiment 2657 was performed in T5 on 17 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

100.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2900	m/s
Shock Tube Fill Pressure	P_1	140.50	kPa
Reservoir Pressure	P_{res}	78.3	MPa

Table 793: Measured quantities, Shot 2657

100.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5549	K
Reservoir Density	ρ_{res}	45.91	kg/m^3
Reservoir Enthalpy	h_{res}	8.31	MJ/kg

Table 794: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2657

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	8.23×10^{-2}	0	1.46×10^{-1}	0	1.62×10^{-3}	7.25×10^{-2}

Table 795: Computed reservoir species mass fractions, Shot 2657

100.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3744	1220.0	1220.0	5.47	33.9	0.096	7.59×10^{6}
72 cm	3732	1225.1	1228.5	5.30	40.3	0.114	8.94×10^{6}

Table 796: Computed freestream conditions, Shot 2657

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.16×10^{-2}	0	1.48×10^{-10}	6.96×10^{-3}
72 cm	7.32×10^{-1}	1.90×10^{-1}	0	7.44×10^{-2}	0	2.49×10^{-10}	3.28×10^{-3}

Table 797: Computed freestream species mass fractions, Shot 2657

100.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3707	1334.0	1334.0	5.18	48.8	0.126	9.37×10^{6}
72 cm	3669	1394.1	1392.6	4.88	58.1	0.144	1.03×10^{7}

Table 798: Computed boundary layer edge conditions, Shot 2657

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.16×10^{-2}	0	1.48×10^{-10}	6.96×10^{-3}
72 cm	7.32×10^{-1}	1.90×10^{-1}	0	7.44×10^{-2}	0	1.52×10^{-9}	3.17×10^{-3}

Table 799: Computed boundary layer edge species mass fractions, Shot 2657

	T^* K	Unit Re^* 1/m
1D 100 cm	1659	6.50×10^{6}
72 cm	1629	8.81×10^{6}

Table 800: Dorrance reference conditions, Shot 2657

100.5 Stability Computations

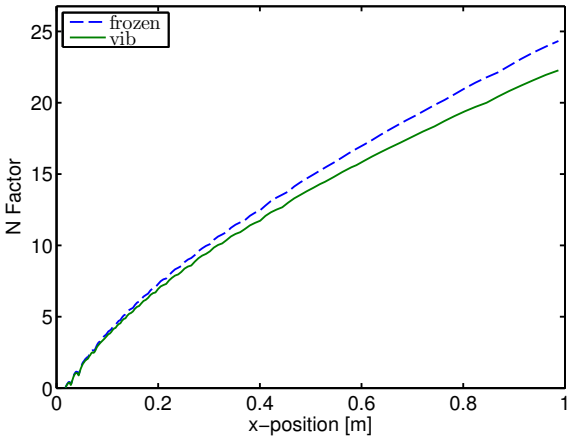


Figure 298: Locus of maximum N factor with and without vibrational energy transfer, Shot 2657

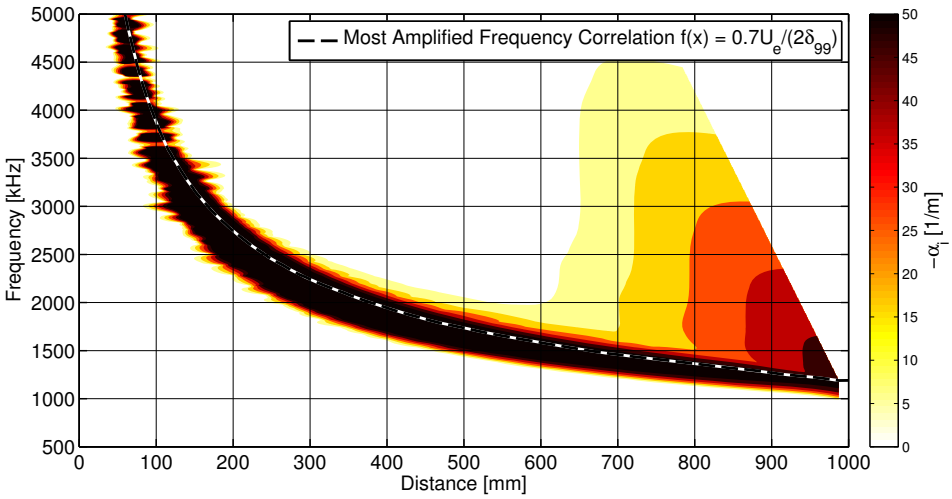


Figure 299: Stability diagram with vibrational energy transfer, Shot 2657. Dashed line indicates $0.7U_e/(2\delta_{99})$.

100.6 Heat Transfer Results

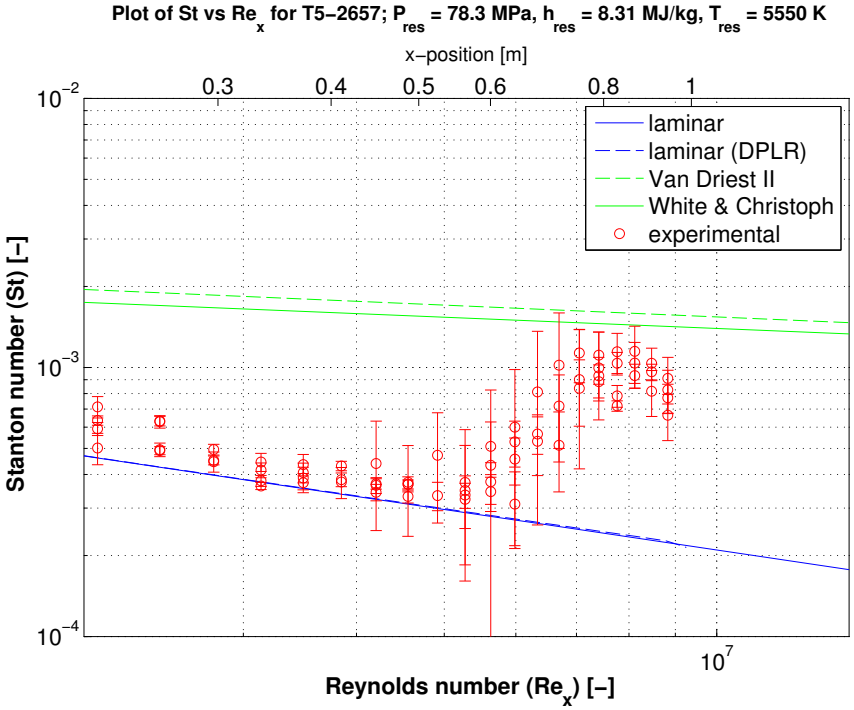


Figure 300: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

101 Shot 2658

Experiment 2658 was performed in T5 on 18 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

101.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2830	m/s
Shock Tube Fill Pressure	P_1	140.10	kPa
Reservoir Pressure	P_{res}	64.8	MPa

Table 801: Measured quantities, Shot 2658

101.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5253	K
Reservoir Density	ρ_{res}	40.46	kg/m^3
Reservoir Enthalpy	h_{res}	7.71	MJ/kg

Table 802: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2658

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	9.51×10^{-2}	0	1.42×10^{-1}	0	9.79×10^{-4}	6.23×10^{-2}

Table 803: Computed reservoir species mass fractions, Shot 2658

101.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3629	1117.0	1117.0	5.53	28.0	0.086	7.00×10^6
72 cm	3606	1109.1	1111.2	5.38	31.8	0.099	7.97×10^6

Table 804: Computed freestream conditions, Shot 2658

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.22×10^{-2}	0	0	5.98×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.70×10^{-2}	0	0	2.67×10^{-3}

Table 805: Computed freestream species mass fractions, Shot 2658

101.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3594	1225.5	1225.5	5.23	40.6	0.114	8.68×10^6
72 cm	3545	1269.0	1267.1	4.95	46.1	0.126	9.21×10^6

Table 806: Computed boundary layer edge conditions, Shot 2658

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.22×10^{-2}	0	0	5.98×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.70×10^{-2}	0	4.47×10^{-10}	2.61×10^{-3}

Table 807: Computed boundary layer edge species mass fractions, Shot 2658

	T^* K	Unit Re^* 1/m
1D 100 cm	1564	5.80×10^6
72 cm	1526	7.66×10^6

Table 808: Dorrance reference conditions, Shot 2658

101.5 Stability Computations

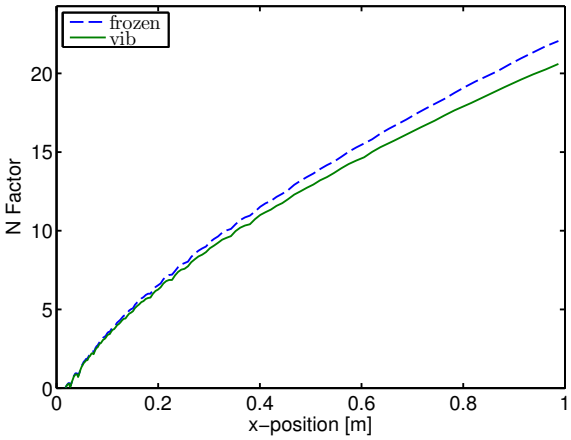


Figure 301: Locus of maximum N factor with and without vibrational energy transfer, Shot 2658

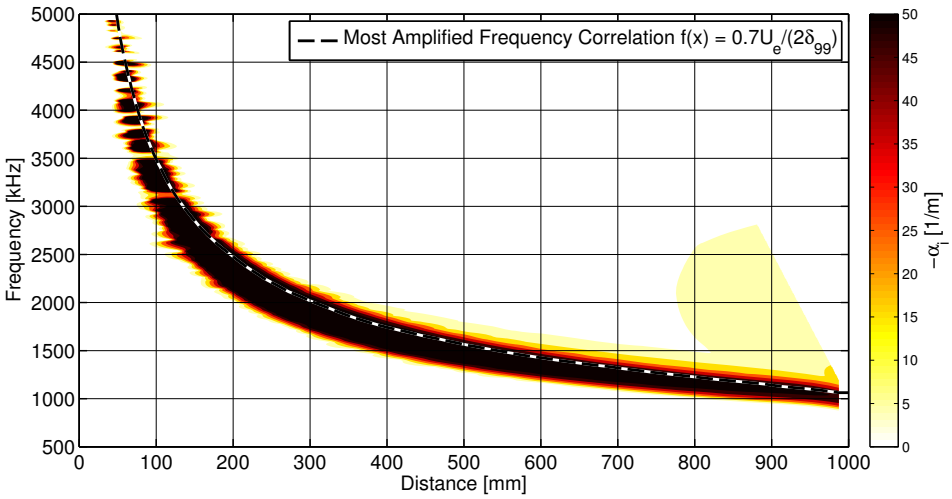


Figure 302: Stability diagram with vibrational energy transfer, Shot 2658. Dashed line indicates $0.7U_e/(2\delta_{99})$.

101.6 Heat Transfer Results

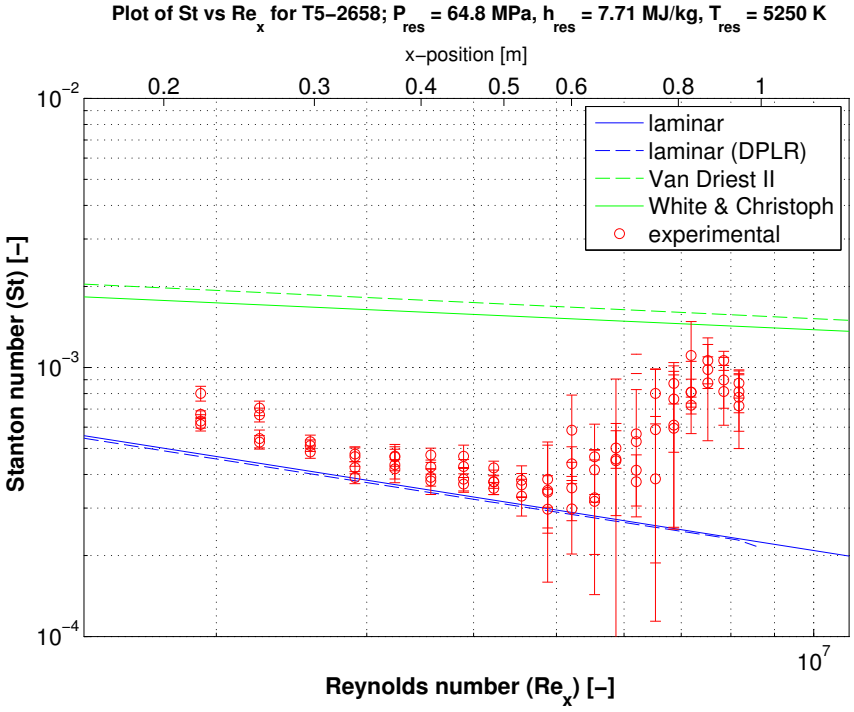


Figure 303: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

102 Shot 2659

Experiment 2659 was performed in T5 on 20 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

102.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2840	m/s
Shock Tube Fill Pressure	P_1	140.90	kPa
Reservoir Pressure	P_{res}	68.2	MPa

Table 809: Measured quantities, Shot 2659

102.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5319	K
Reservoir Density	ρ_{res}	42.03	kg/m^3
Reservoir Enthalpy	h_{res}	7.84	MJ/kg

Table 810: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2659

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	9.22×10^{-2}	0	1.43×10^{-1}	0	1.10×10^{-3}	6.44×10^{-2}

Table 811: Computed reservoir species mass fractions, Shot 2659

102.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3651	1136.0	1136.0	5.52	29.1	0.088	7.13×10^{6}
72 cm	3634	1134.2	1136.6	5.37	33.8	0.103	8.26×10^{6}

Table 812: Computed freestream conditions, Shot 2659

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.21×10^{-2}	0	0	6.13×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.65×10^{-2}	0	0	2.77×10^{-3}

Table 813: Computed freestream species mass fractions, Shot 2659

102.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3615	1245.6	1245.6	5.22	42.2	0.117	8.84×10^{6}
72 cm	3573	1296.0	1294.2	4.93	49.1	0.131	9.54×10^{6}

Table 814: Computed boundary layer edge conditions, Shot 2659

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.21×10^{-2}	0	0	6.13×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.65×10^{-2}	0	5.77×10^{-10}	2.70×10^{-3}

Table 815: Computed boundary layer edge species mass fractions, Shot 2659

	T^* K	Unit Re^* 1/m
1D 100 cm	1582	5.95×10^{6}
72 cm	1549	7.99×10^{6}

Table 816: Dorrance reference conditions, Shot 2659

102.5 Stability Computations

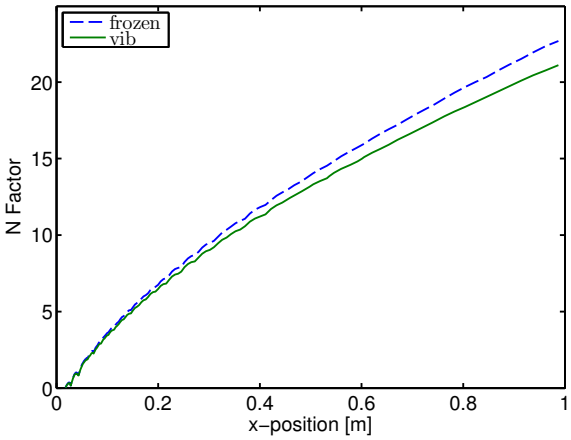


Figure 304: Locus of maximum N factor with and without vibrational energy transfer, Shot 2659

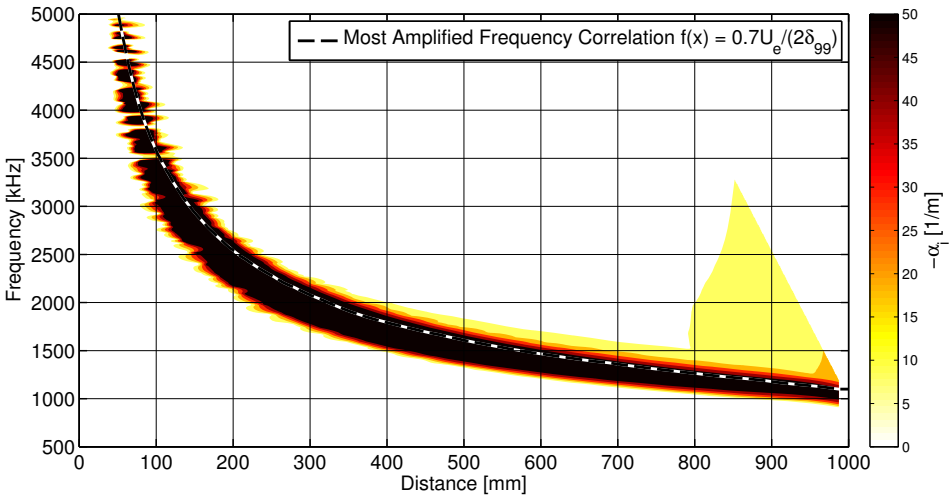


Figure 305: Stability diagram with vibrational energy transfer, Shot 2659. Dashed line indicates $0.7U_e/(2\delta_{99})$.

102.6 Heat Transfer Results

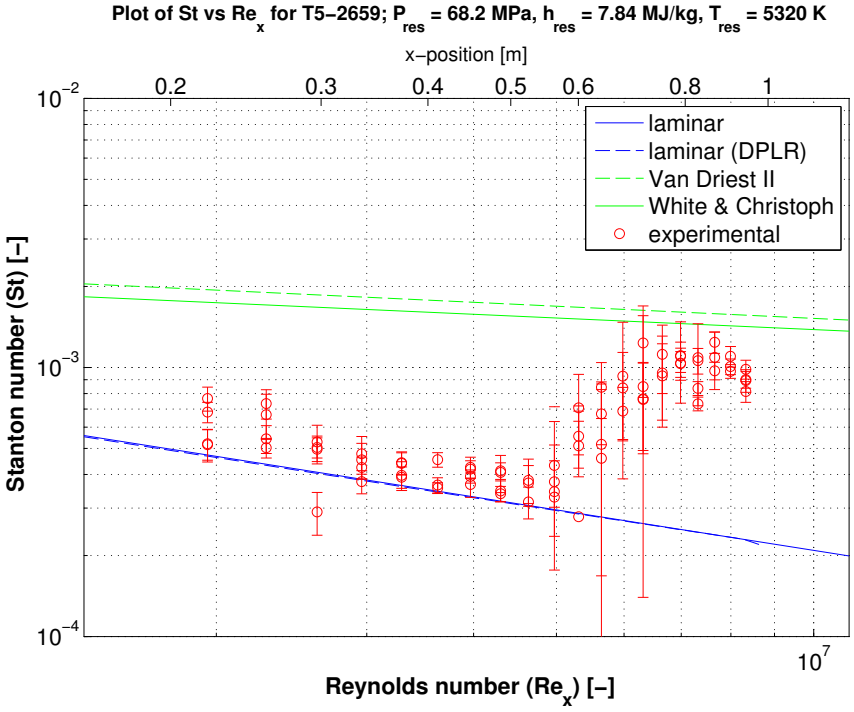


Figure 306: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

103 Shot 2660

Experiment 2660 was performed in T5 on 23 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

103.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	139.90	kPa
Reservoir Pressure	P_{res}	71.7	MPa

Table 817: Measured quantities, Shot 2660

103.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5319	K
Reservoir Density	ρ_{res}	44.20	kg/m^3
Reservoir Enthalpy	h_{res}	7.82	MJ/kg

Table 818: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2660

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	9.32×10^{-2}	0	1.44×10^{-1}	0	1.07×10^{-3}	6.31×10^{-2}

Table 819: Computed reservoir species mass fractions, Shot 2660

103.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3651	1137.0	1137.0	5.52	30.9	0.094	7.55×10^{6}
72 cm	3632	1129.6	1131.6	5.37	35.5	0.109	8.72×10^{6}

Table 820: Computed freestream conditions, Shot 2660

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.20×10^{-2}	0	0	5.72×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.65×10^{-2}	0	0	2.55×10^{-3}

Table 821: Computed freestream species mass fractions, Shot 2660

103.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3615	1245.6	1245.6	5.22	44.7	0.124	9.37×10^{6}
72 cm	3570	1291.3	1289.7	4.94	51.5	0.138	1.01×10^{7}

Table 822: Computed boundary layer edge conditions, Shot 2660

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.20×10^{-2}	0	0	5.72×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.65×10^{-2}	0	5.02×10^{-10}	2.48×10^{-3}

Table 823: Computed boundary layer edge species mass fractions, Shot 2660

	T^* K	Unit Re^* 1/m
1D 100 cm	1582	6.30×10^{6}
72 cm	1545	8.41×10^{6}

Table 824: Dorrance reference conditions, Shot 2660

103.5 Stability Computations

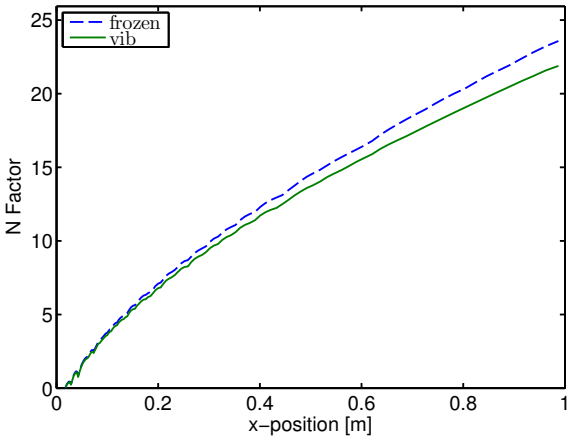


Figure 307: Locus of maximum N factor with and without vibrational energy transfer, Shot 2660

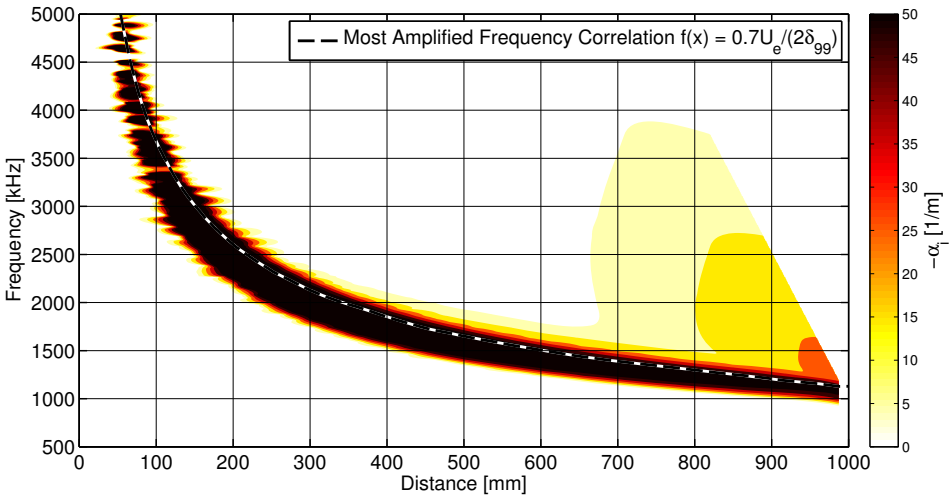


Figure 308: Stability diagram with vibrational energy transfer, Shot 2660. Dashed line indicates $0.7U_e/(2\delta_{99})$.

103.6 Heat Transfer Results

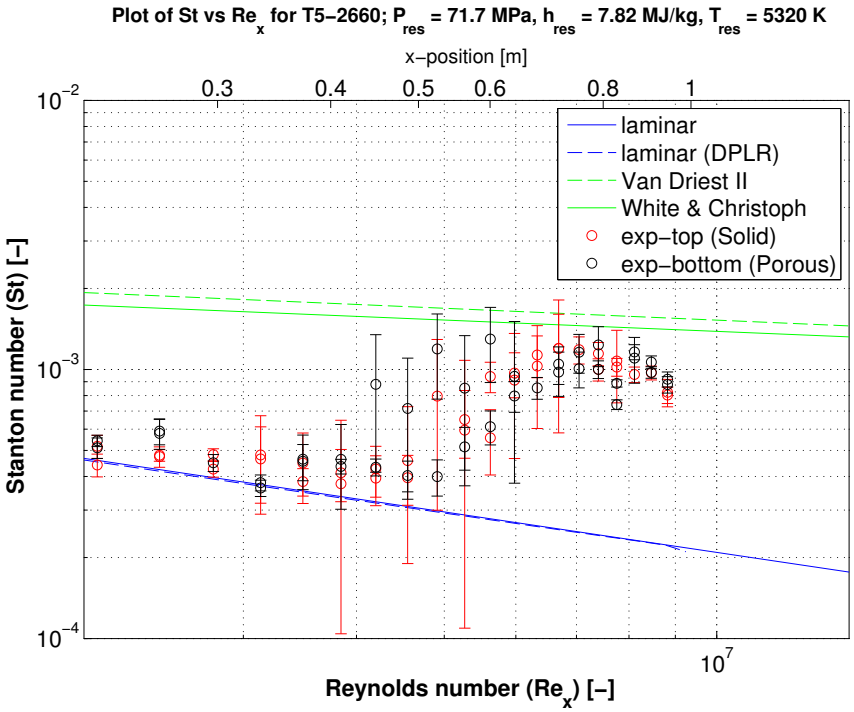


Figure 309: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

104 Shot 2661

Experiment 2661 was performed in T5 on 24 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

104.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	140.50	kPa
Reservoir Pressure	P_{res}	69.9	MPa

Table 825: Measured quantities, Shot 2661

104.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5367	K
Reservoir Density	ρ_{res}	42.57	kg/m^3
Reservoir Enthalpy	h_{res}	7.94	MJ/kg

Table 826: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2661

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	9.00×10^{-2}	0	1.44×10^{-1}	0	1.20×10^{-3}	6.63×10^{-2}

Table 827: Computed reservoir species mass fractions, Shot 2661

104.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3669	1153.0	1153.0	5.51	29.8	0.089	7.16×10^{6}
72 cm	3655	1153.4	1156.2	5.35	34.9	0.105	8.35×10^{6}

Table 828: Computed freestream conditions, Shot 2661

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.20×10^{-2}	0	0	6.36×10^{-3}
72 cm	7.32×10^{-1}	1.89×10^{-1}	0	7.61×10^{-2}	0	0	2.91×10^{-3}

Table 829: Computed freestream species mass fractions, Shot 2661

104.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3633	1262.8	1262.8	5.21	43.1	0.118	8.87×10^{6}
72 cm	3594	1316.6	1314.9	4.92	50.5	0.133	9.64×10^{6}

Table 830: Computed boundary layer edge conditions, Shot 2661

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.20×10^{-2}	0	0	6.36×10^{-3}
72 cm	7.32×10^{-1}	1.90×10^{-1}	0	7.61×10^{-2}	0	7.20×10^{-10}	2.83×10^{-3}

Table 831: Computed boundary layer edge species mass fractions, Shot 2661

	T^* K	Unit Re^* 1/m
1D 100 cm	1597	6.00×10^{6}
72 cm	1566	8.10×10^{6}

Table 832: Dorrance reference conditions, Shot 2661

104.5 Stability Computations

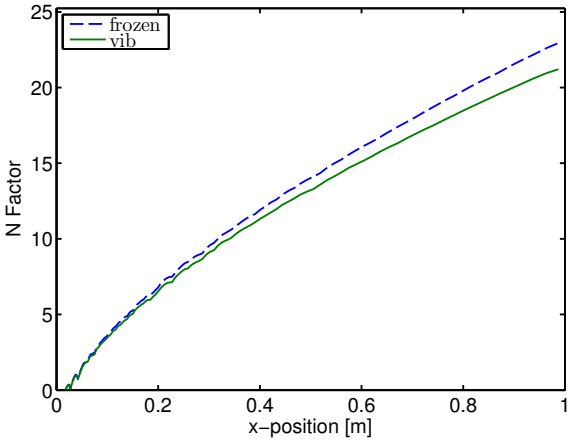


Figure 310: Locus of maximum N factor with and without vibrational energy transfer, Shot 2661

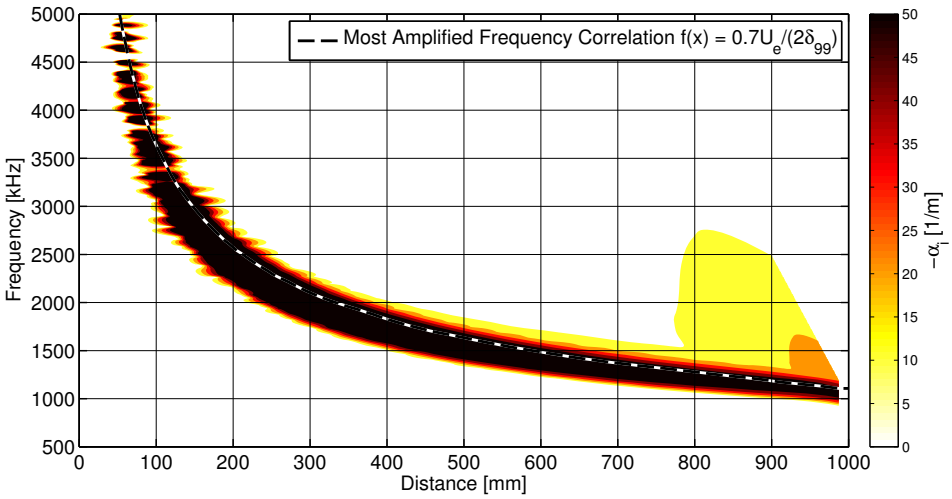


Figure 311: Stability diagram with vibrational energy transfer, Shot 2661. Dashed line indicates $0.7U_e/(2\delta_{99})$.

104.6 Heat Transfer Results

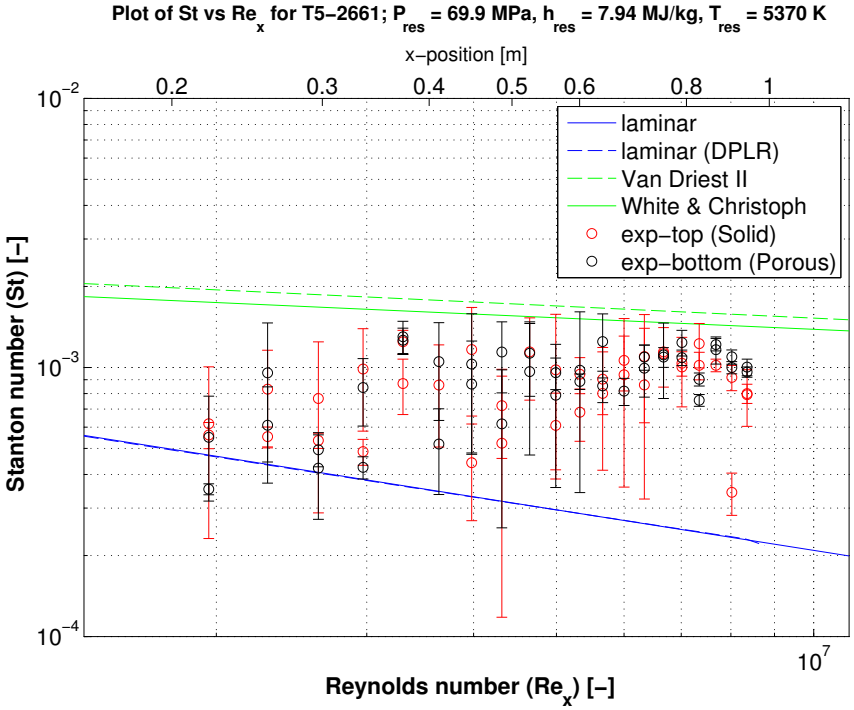


Figure 312: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

105 Shot 2662

Experiment 2662 was performed in T5 on 26 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

105.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2830	m/s
Shock Tube Fill Pressure	P_1	140.20	kPa
Reservoir Pressure	P_{res}	61.4	MPa

Table 833: Measured quantities, Shot 2662

105.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5207	K
Reservoir Density	ρ_{res}	38.75	kg/m^3
Reservoir Enthalpy	h_{res}	7.62	MJ/kg

Table 834: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2662

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	9.68×10^{-2}	0	1.41×10^{-1}	0	9.10×10^{-4}	6.12×10^{-2}

Table 835: Computed reservoir species mass fractions, Shot 2662

105.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3607	1098.0	1098.0	5.55	26.1	0.082	6.68×10^6
72 cm	3586	1093.0	1095.0	5.39	29.9	0.094	7.63×10^6

Table 836: Computed freestream conditions, Shot 2662

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.23×10^{-2}	0	0	6.03×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.73×10^{-2}	0	0	2.67×10^{-3}

Table 837: Computed freestream species mass fractions, Shot 2662

105.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3572	1205.0	1205.0	5.24	38.0	0.109	8.29×10^6
72 cm	3525	1251.8	1249.8	4.95	43.5	0.120	8.82×10^6

Table 838: Computed boundary layer edge conditions, Shot 2662

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.23×10^{-2}	0	0	6.03×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.73×10^{-2}	0	3.91×10^{-10}	2.61×10^{-3}

Table 839: Computed boundary layer edge species mass fractions, Shot 2662

	T^* K	Unit Re^* 1/m
1D 100 cm	1546	5.49×10^6
72 cm	1512	7.30×10^6

Table 840: Dorrance reference conditions, Shot 2662

105.5 Stability Computations

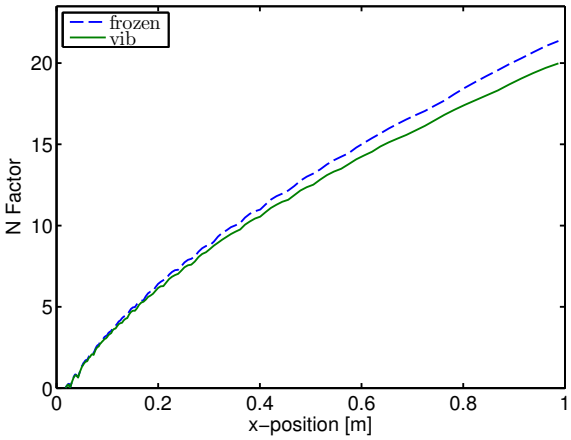


Figure 313: Locus of maximum N factor with and without vibrational energy transfer, Shot 2662

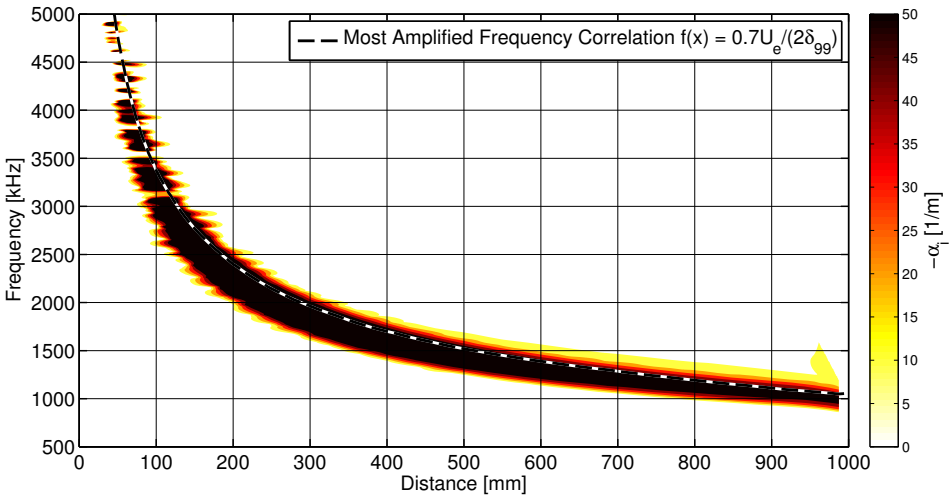


Figure 314: Stability diagram with vibrational energy transfer, Shot 2662. Dashed line indicates $0.7U_e/(2\delta_{99})$.

105.6 Heat Transfer Results

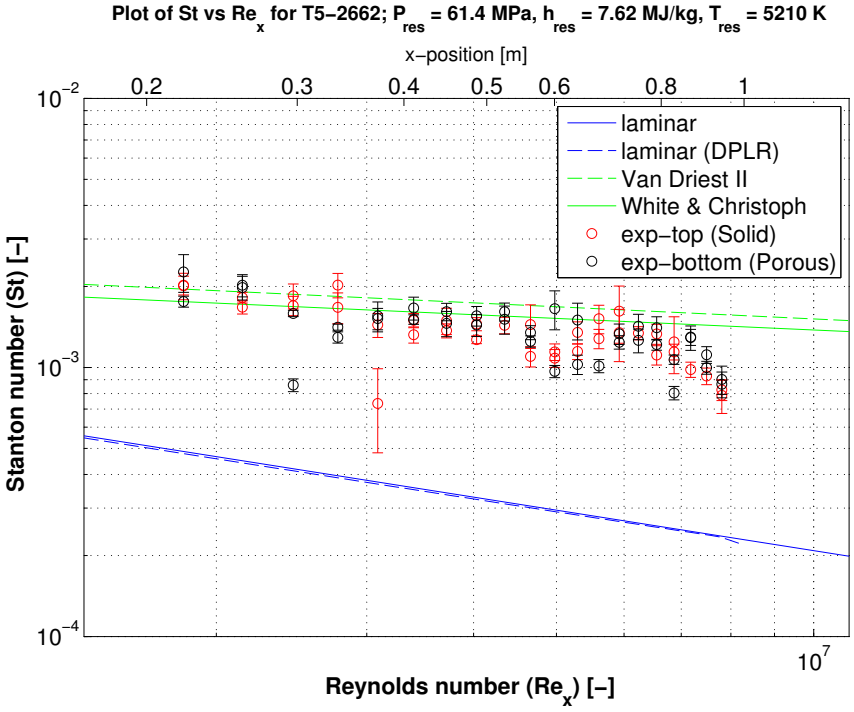


Figure 315: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

106 Shot 2663

Experiment 2663 was performed in T5 on 27 May 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

106.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	140.10	kPa
Reservoir Pressure	P_{res}	67.1	MPa

Table 841: Measured quantities, Shot 2663

106.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5333	K
Reservoir Density	ρ_{res}	41.16	kg/m^3
Reservoir Enthalpy	h_{res}	7.88	MJ/kg

Table 842: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2663

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	9.11×10^{-2}	0	1.43×10^{-1}	0	1.14×10^{-3}	6.56×10^{-2}

Table 843: Computed reservoir species mass fractions, Shot 2663

106.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3662	1146.0	1146.0	5.52	29.0	0.087	7.03×10^{6}
72 cm	3641	1141.7	1144.4	5.36	33.4	0.101	8.08×10^{6}

Table 844: Computed freestream conditions, Shot 2663

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.20×10^{-2}	0	0	6.40×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.64×10^{-2}	0	0	2.92×10^{-3}

Table 845: Computed freestream species mass fractions, Shot 2663

106.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3626	1255.5	1255.5	5.22	42.0	0.115	8.71×10^{6}
72 cm	3580	1304.1	1302.3	4.93	48.3	0.128	9.32×10^{6}

Table 846: Computed boundary layer edge conditions, Shot 2663

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.20×10^{-2}	0	0	6.40×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.64×10^{-2}	0	6.58×10^{-10}	2.85×10^{-3}

Table 847: Computed boundary layer edge species mass fractions, Shot 2663

	T^* K	Unit Re^* 1/m
1D 100 cm	1590	5.88×10^{6}
72 cm	1555	7.82×10^{6}

Table 848: Dorrance reference conditions, Shot 2663

106.5 Stability Computations

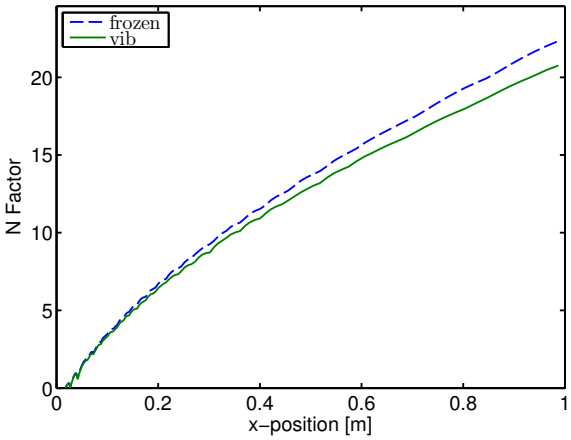


Figure 316: Locus of maximum N factor with and without vibrational energy transfer, Shot 2663

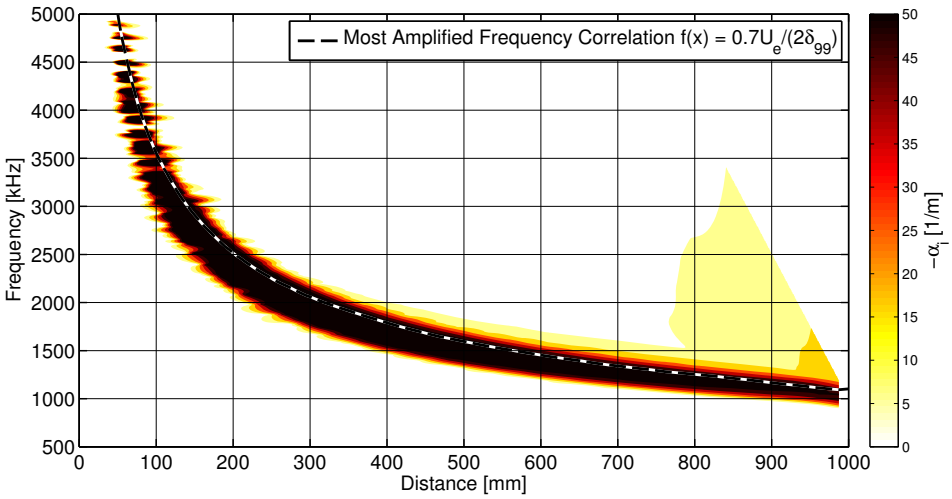


Figure 317: Stability diagram with vibrational energy transfer, Shot 2663. Dashed line indicates $0.7U_e/(2\delta_{99})$.

106.6 Heat Transfer Results

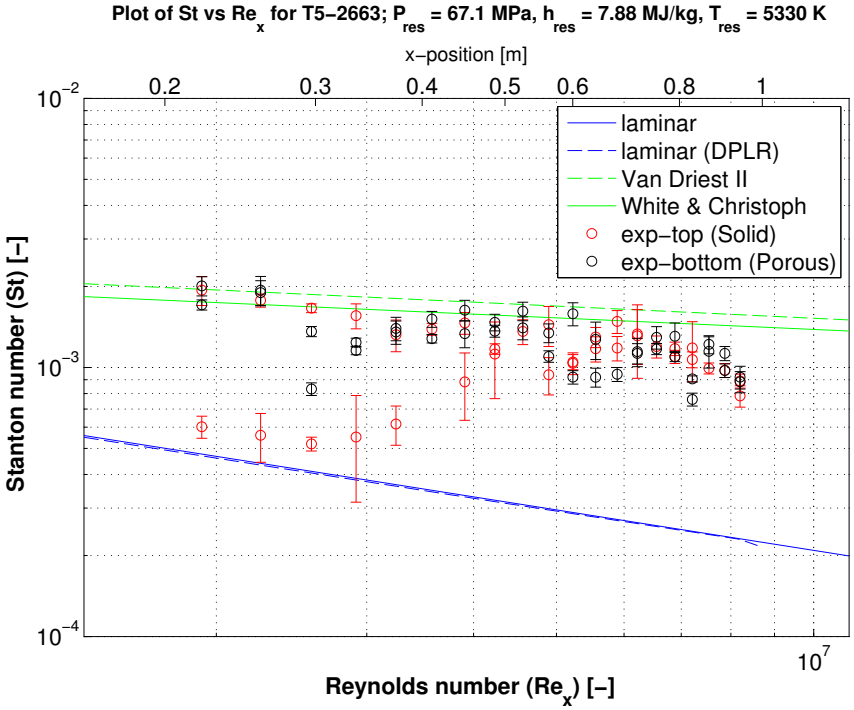


Figure 318: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

107 Shot 2664

Experiment 2664 was performed in T5 on 2 June 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

107.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	140.05	kPa
Reservoir Pressure	P_{res}	72.0	MPa

Table 849: Measured quantities, Shot 2664

107.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5499	K
Reservoir Density	ρ_{res}	42.56	kg/m^3
Reservoir Enthalpy	h_{res}	8.23	MJ/kg

Table 850: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2664

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	8.33×10^{-2}	0	1.45×10^{-1}	0	1.54×10^{-3}	7.24×10^{-2}

Table 851: Computed reservoir species mass fractions, Shot 2664

107.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3728	1205.0	1205.0	5.48	31.1	0.089	7.08×10^{6}
72 cm	3714	1210.3	1214.0	5.31	36.8	0.105	8.28×10^{6}

Table 852: Computed freestream conditions, Shot 2664

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.17×10^{-2}	0	1.83×10^{-10}	7.31×10^{-3}
72 cm	7.32×10^{-1}	1.90×10^{-1}	0	7.49×10^{-2}	0	2.22×10^{-10}	3.48×10^{-3}

Table 853: Computed freestream species mass fractions, Shot 2664

107.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3691	1318.1	1318.1	5.19	44.9	0.117	8.75×10^{6}
72 cm	3651	1377.6	1376.0	4.89	53.0	0.133	9.54×10^{6}

Table 854: Computed boundary layer edge conditions, Shot 2664

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.17×10^{-2}	0	1.83×10^{-10}	7.31×10^{-3}
72 cm	7.32×10^{-1}	1.90×10^{-1}	0	7.49×10^{-2}	0	1.43×10^{-9}	3.37×10^{-3}

Table 855: Computed boundary layer edge species mass fractions, Shot 2664

	T^* K	Unit Re^* 1/m
1D 100 cm	1646	6.03×10^{6}
72 cm	1615	8.14×10^{6}

Table 856: Dorrance reference conditions, Shot 2664

107.5 Stability Computations

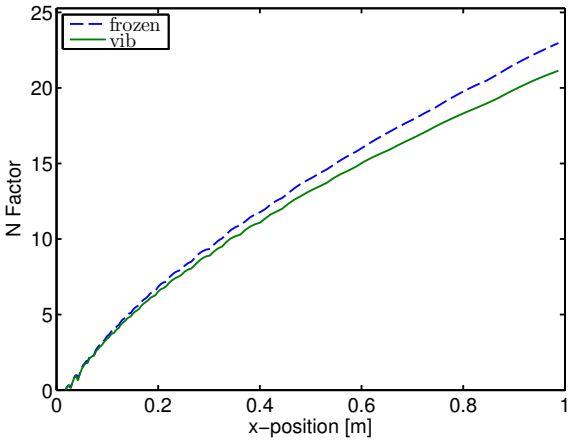


Figure 319: Locus of maximum N factor with and without vibrational energy transfer, Shot 2664

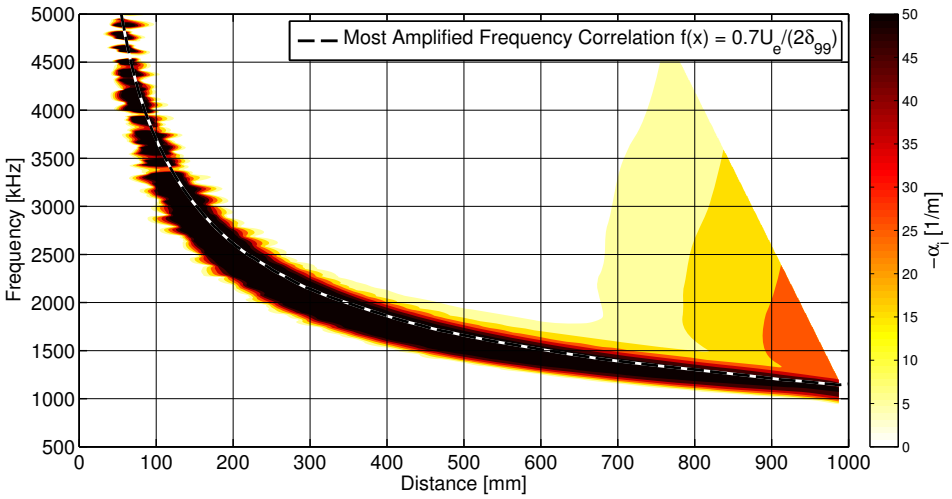


Figure 320: Stability diagram with vibrational energy transfer, Shot 2664. Dashed line indicates $0.7U_e/(2\delta_{99})$.

107.6 Heat Transfer Results

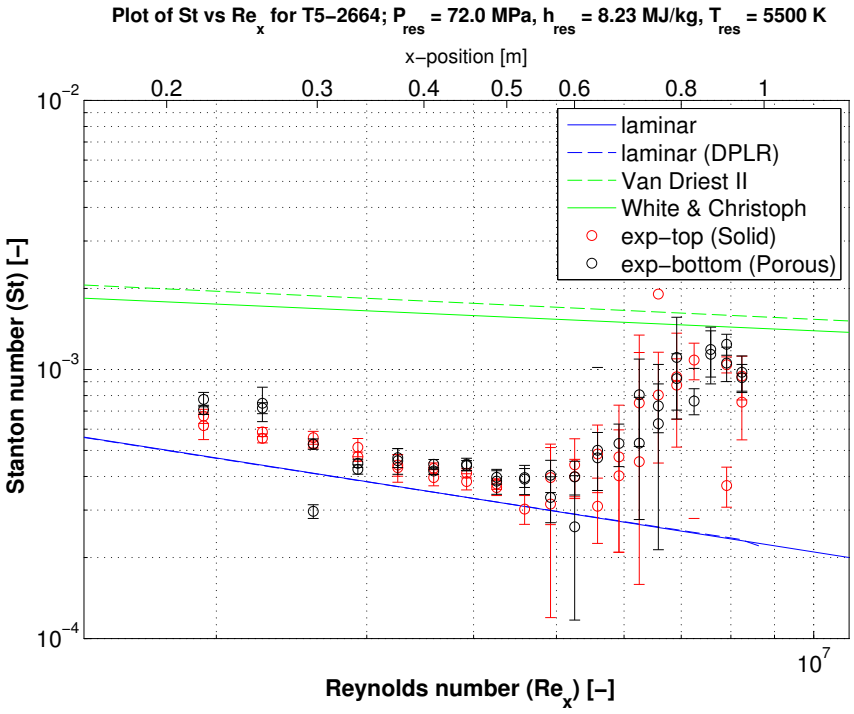


Figure 321: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

108 Shot 2665

Experiment 2665 was performed in T5 on 17 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

108.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	140.00	kPa
Reservoir Pressure	P_{res}	72.0	MPa

Table 857: Measured quantities, Shot 2665

108.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6314	K
Reservoir Density	ρ_{res}	38.12	kg/m^3
Reservoir Enthalpy	h_{res}	8.04	MJ/kg

Table 858: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2665

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.93×10^{-1}	0	0	0	0	7.29×10^{-3}	0

Table 859: Computed reservoir species mass fractions, Shot 2665

108.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3795	1071.0	1071.0	5.82	26.6	0.084	7.70×10^6
72 cm	3789	725.3	2593.8	6.91	14.5	0.067	7.68×10^6

Table 860: Computed freestream conditions, Shot 2665

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	3.65×10^{-4}	0
72 cm	1.00	0	0	0	0	2.50×10^{-4}	0

Table 861: Computed freestream species mass fractions, Shot 2665

108.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3759	1185.3	1185.3	5.48	39.7	0.113	9.66×10^6
72 cm	3727	920.5	2573.5	6.03	24.3	0.089	8.79×10^6

Table 862: Computed boundary layer edge conditions, Shot 2665

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	3.65×10^{-4}	0
72 cm	1.00	0	0	0	0	0	0

Table 863: Computed boundary layer edge species mass fractions, Shot 2665

	T^* K	Unit Re^* 1/m
1D 100 cm	1611	5.71×10^6
72 cm	1424	5.68×10^6

Table 864: Dorrance reference conditions, Shot 2665

108.5 Stability Computations

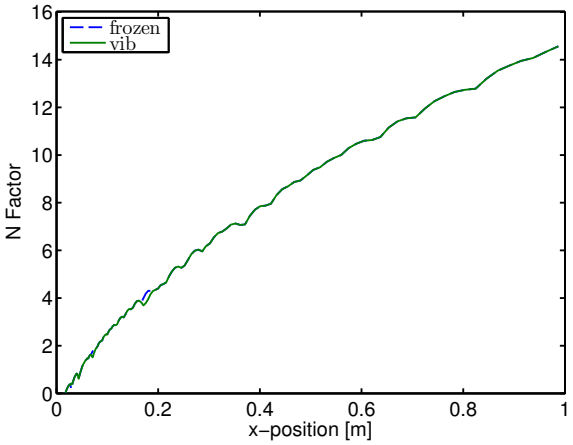


Figure 322: Locus of maximum N factor with and without vibrational energy transfer, Shot 2665

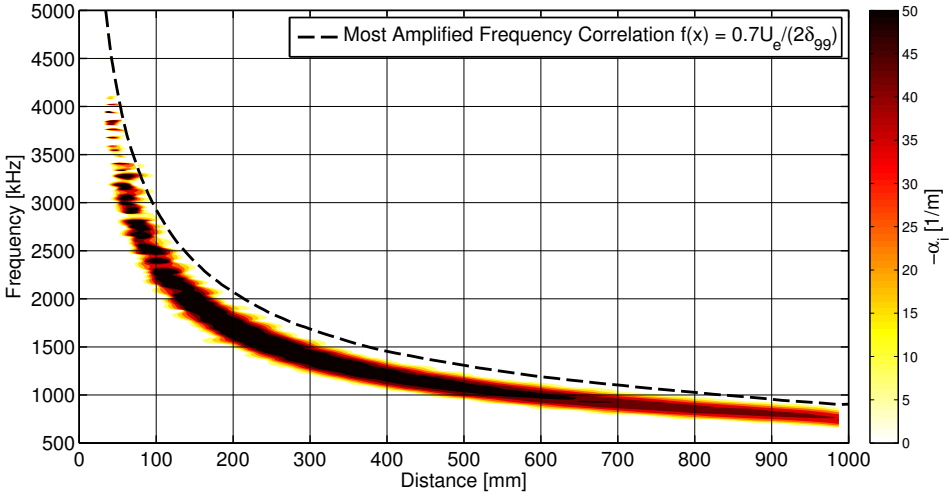


Figure 323: Stability diagram with vibrational energy transfer, Shot 2665. Dashed line indicates $0.7U_e/(2\delta_{99})$.

108.6 Heat Transfer Results

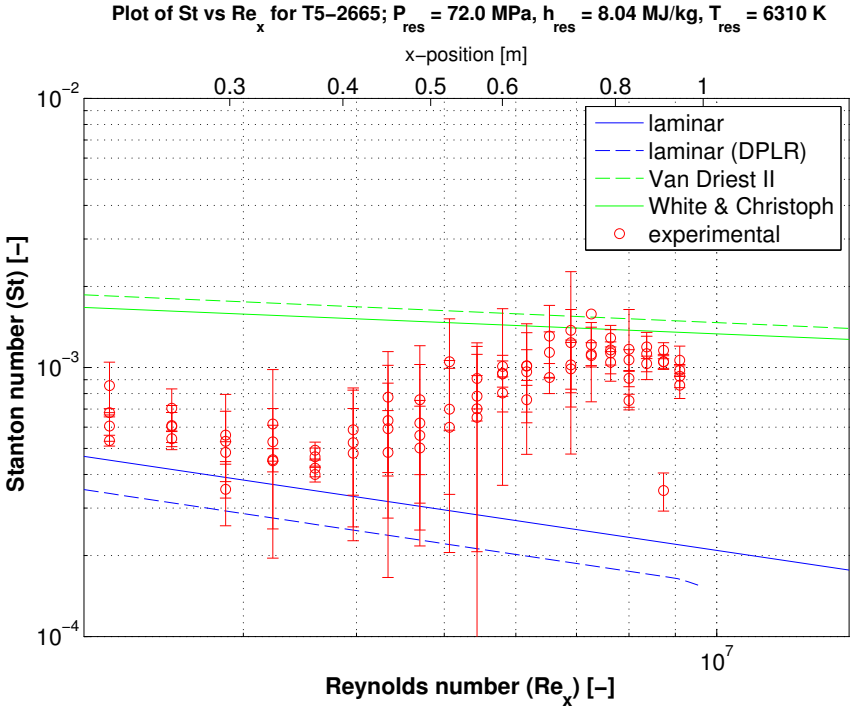


Figure 324: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

109 Shot 2666

Experiment 2666 was performed in T5 on 18 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

109.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	140.00	kPa
Reservoir Pressure	P_{res}	72.6	MPa

Table 865: Measured quantities, Shot 2666

109.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6416	K
Reservoir Density	ρ_{res}	37.79	kg/m^3
Reservoir Enthalpy	h_{res}	8.22	MJ/kg

Table 866: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2666

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.92×10^{-1}	0	0	0	0	8.45×10^{-3}	0

Table 867: Computed reservoir species mass fractions, Shot 2666

109.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3824	1092.0	1092.0	5.81	26.3	0.081	7.44×10^6
72 cm	3827	747.8	2617.6	6.87	14.9	0.067	7.61×10^6

Table 868: Computed freestream conditions, Shot 2666

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	4.10×10^{-4}	0
72 cm	1.00	0	0	0	0	2.83×10^{-4}	0

Table 869: Computed freestream species mass fractions, Shot 2666

109.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3788	1207.6	1207.6	5.48	39.3	0.110	9.33×10^6
72 cm	3765	946.9	2596.9	6.00	25.0	0.089	8.72×10^6

Table 870: Computed boundary layer edge conditions, Shot 2666

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	4.10×10^{-4}	0
72 cm	1.00	0	0	0	0	0	0

Table 871: Computed boundary layer edge species mass fractions, Shot 2666

	T^* K	Unit Re^* 1/m
1D 100 cm	1633	5.56×10^6
72 cm	1451	5.69×10^6

Table 872: Dorrance reference conditions, Shot 2666

109.5 Stability Computations

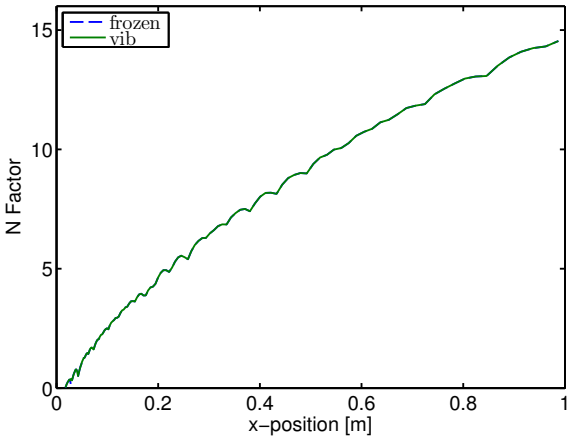


Figure 325: Locus of maximum N factor with and without vibrational energy transfer, Shot 2666

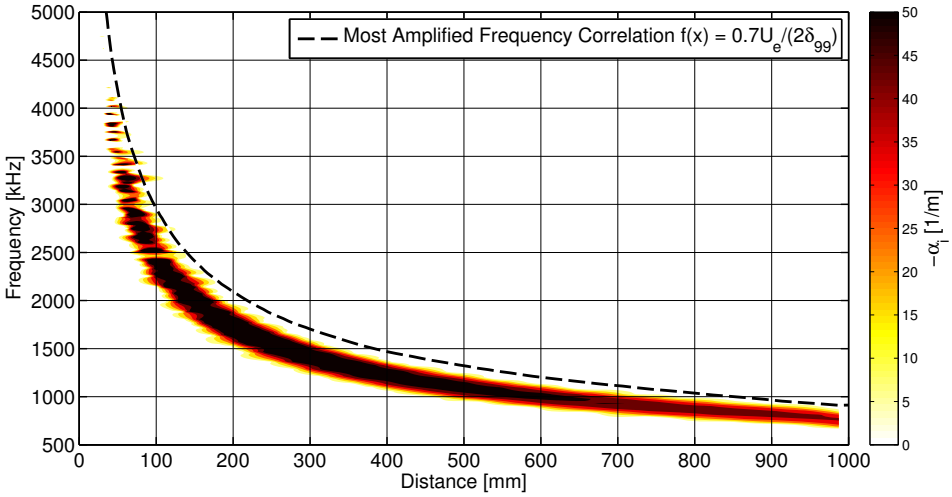


Figure 326: Stability diagram with vibrational energy transfer, Shot 2666. Dashed line indicates $0.7U_e/(2\delta_{99})$.

109.6 Heat Transfer Results

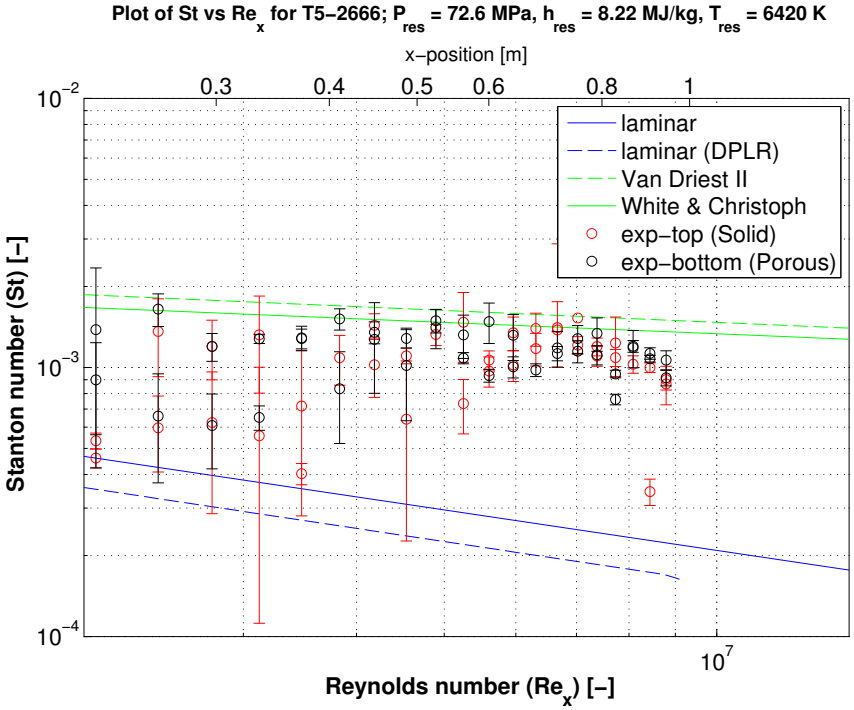


Figure 327: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

110 Shot 2667

Experiment 2667 was performed in T5 on 19 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

110.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3170	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	52.2	MPa

Table 873: Measured quantities, Shot 2667

110.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7177	K
Reservoir Density	ρ_{res}	23.86	kg/m^3
Reservoir Enthalpy	h_{res}	9.95	MJ/kg

Table 874: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2667

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.73×10^{-1}	0	0	0	0	2.69×10^{-2}	0

Table 875: Computed reservoir species mass fractions, Shot 2667

110.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4180	1369.0	1369.0	5.70	20.8	0.051	4.41×10^6
72 cm	4143	990.9	2941.4	6.45	13.9	0.047	4.95×10^6

Table 876: Computed freestream conditions, Shot 2667

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.88×10^{-3}	0
72 cm	9.99×10^{-1}	0	0	0	0	1.40×10^{-3}	0

Table 877: Computed freestream species mass fractions, Shot 2667

110.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4140	1503.2	1503.2	5.39	30.7	0.069	5.46×10^6
72 cm	4076	1224.5	2915.3	5.71	22.5	0.062	5.60×10^6

Table 878: Computed boundary layer edge conditions, Shot 2667

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.88×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 879: Computed boundary layer edge species mass fractions, Shot 2667

	T^* K	Unit Re^* 1/m
1D 100 cm	1919	3.58×10^6
72 cm	1691	4.05×10^6

Table 880: Dorrance reference conditions, Shot 2667

110.5 Stability Computations

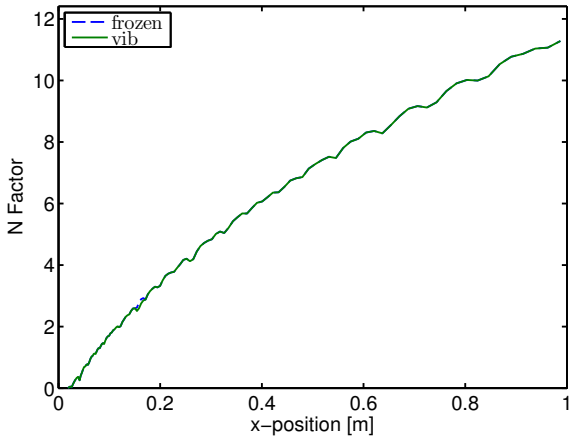


Figure 328: Locus of maximum N factor with and without vibrational energy transfer, Shot 2667

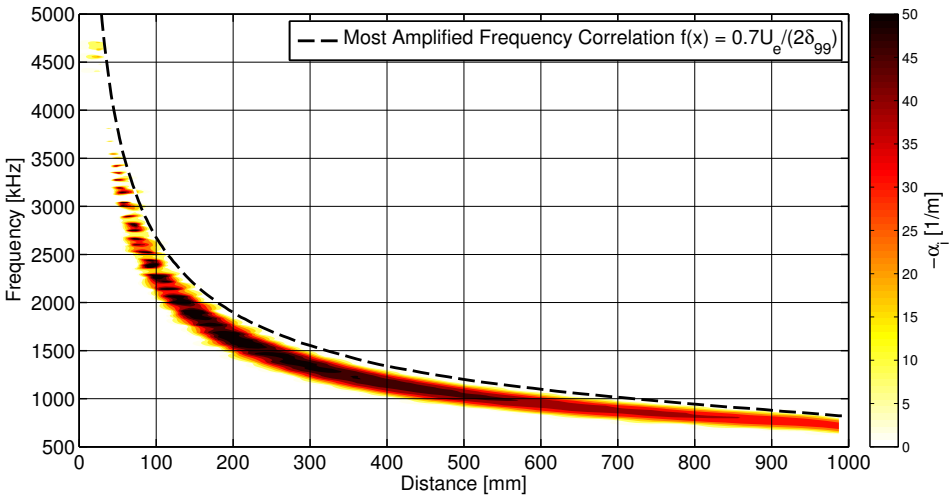


Figure 329: Stability diagram with vibrational energy transfer, Shot 2667. Dashed line indicates $0.7U_e/(2\delta_{99})$.

110.6 Heat Transfer Results

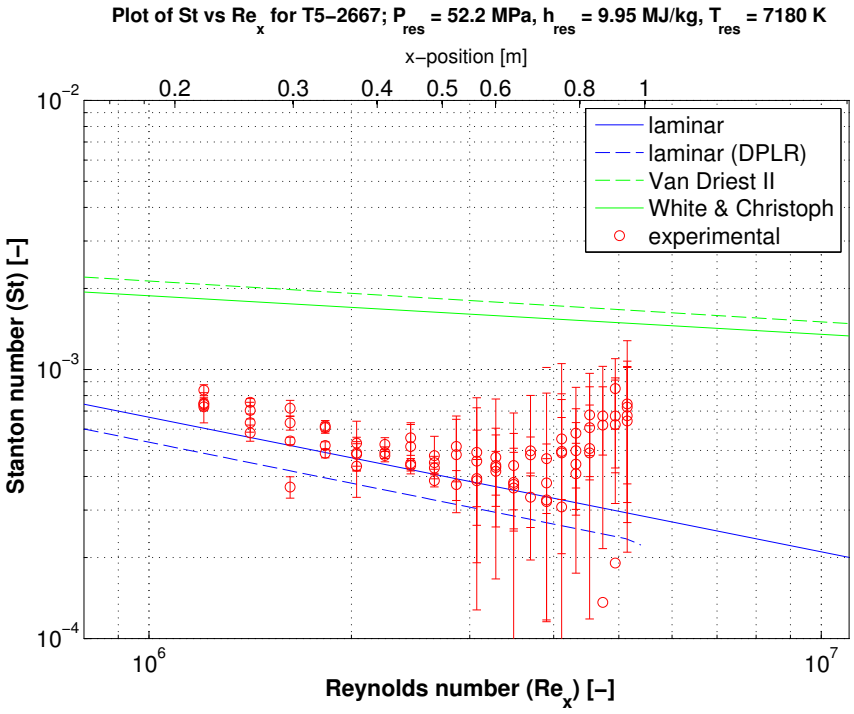


Figure 330: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

111 Shot 2668

Experiment 2668 was performed in T5 on 22 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

111.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	51.8	MPa

Table 881: Measured quantities, Shot 2668

111.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7259	K
Reservoir Density	ρ_{res}	23.33	kg/m^3
Reservoir Enthalpy	h_{res}	10.2	MJ/kg

Table 882: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2668

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.70×10^{-1}	0	0	0	0	2.97×10^{-2}	0

Table 883: Computed reservoir species mass fractions, Shot 2668

111.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4218	1401.0	1401.0	5.69	20.7	0.050	4.24×10^6
72 cm	4180	1029.2	2970.1	6.39	14.4	0.047	4.88×10^6

Table 884: Computed freestream conditions, Shot 2668

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.14×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.59×10^{-3}	0

Table 885: Computed freestream species mass fractions, Shot 2668

111.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4177	1538.0	1538.0	5.38	30.4	0.066	5.25×10^6
72 cm	4112	1267.6	2942.8	5.66	23.2	0.061	5.50×10^6

Table 886: Computed boundary layer edge conditions, Shot 2668

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.14×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 887: Computed boundary layer edge species mass fractions, Shot 2668

	T^* K	Unit Re^* 1/m
1D 100 cm	1951	3.48×10^6
72 cm	1726	4.04×10^6

Table 888: Dorrance reference conditions, Shot 2668

111.5 Stability Computations

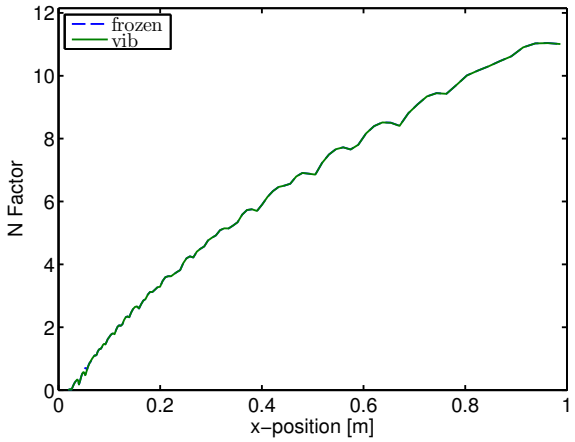


Figure 331: Locus of maximum N factor with and without vibrational energy transfer, Shot 2668

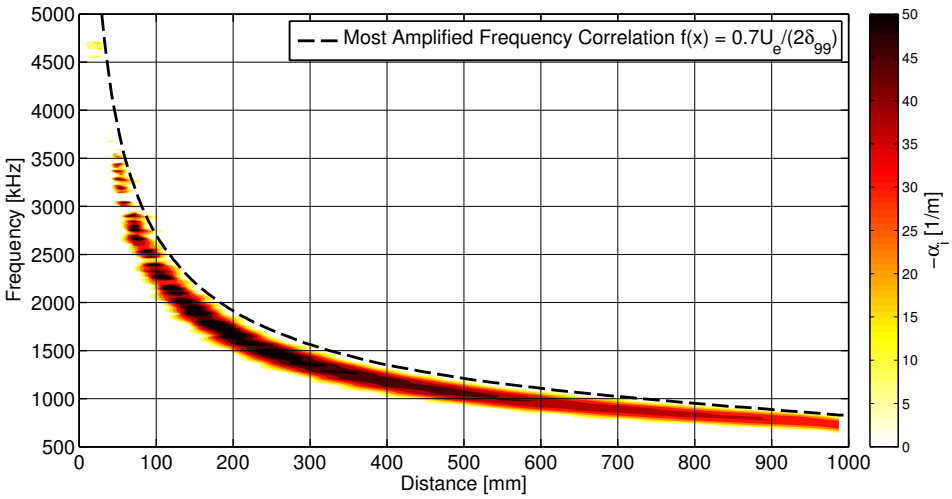


Figure 332: Stability diagram with vibrational energy transfer, Shot 2668. Dashed line indicates $0.7U_e/(2\delta_{99})$.

111.6 Heat Transfer Results

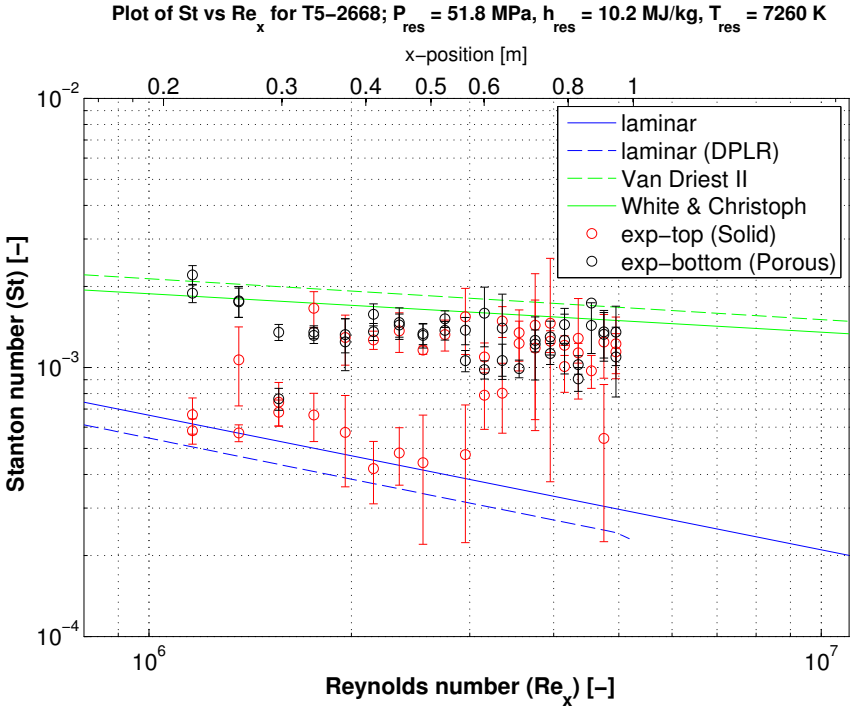


Figure 333: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

112 Shot 2669

Experiment 2669 was performed in T5 on 26 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

112.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	50.7	MPa

Table 889: Measured quantities, Shot 2669

112.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7067	K
Reservoir Density	ρ_{res}	23.60	kg/m^3
Reservoir Enthalpy	h_{res}	9.69	MJ/kg

Table 890: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2669

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.76×10^{-1}	0	0	0	0	2.39×10^{-2}	0

Table 891: Computed reservoir species mass fractions, Shot 2669

112.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4132	1328.0	1328.0	5.72	20.1	0.051	4.44×10^6
72 cm	4096	946.5	2919.6	6.53	12.8	0.045	4.85×10^6

Table 892: Computed freestream conditions, Shot 2669

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.69×10^{-3}	0
72 cm	9.99×10^{-1}	0	0	0	0	1.26×10^{-3}	0

Table 893: Computed freestream species mass fractions, Shot 2669

112.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4092	1460.0	1460.0	5.40	29.7	0.068	5.50×10^6
72 cm	4028	1176.5	2893.9	5.76	20.9	0.060	5.50×10^6

Table 894: Computed boundary layer edge conditions, Shot 2669

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.69×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 895: Computed boundary layer edge species mass fractions, Shot 2669

	T^* K	Unit Re^* 1/m
1D 100 cm	1878	3.55×10^6
72 cm	1651	3.92×10^6

Table 896: Dorrance reference conditions, Shot 2669

112.5 Stability Computations

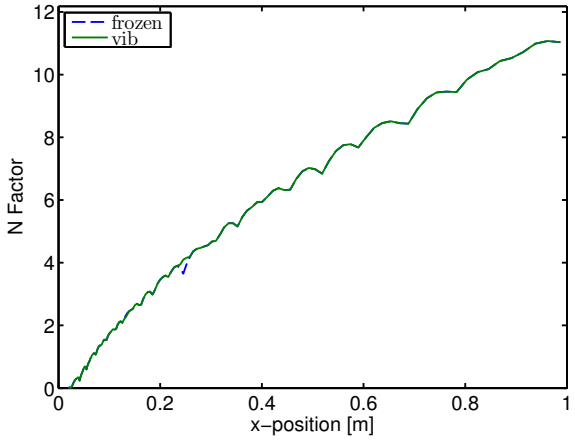


Figure 334: Locus of maximum N factor with and without vibrational energy transfer, Shot 2669

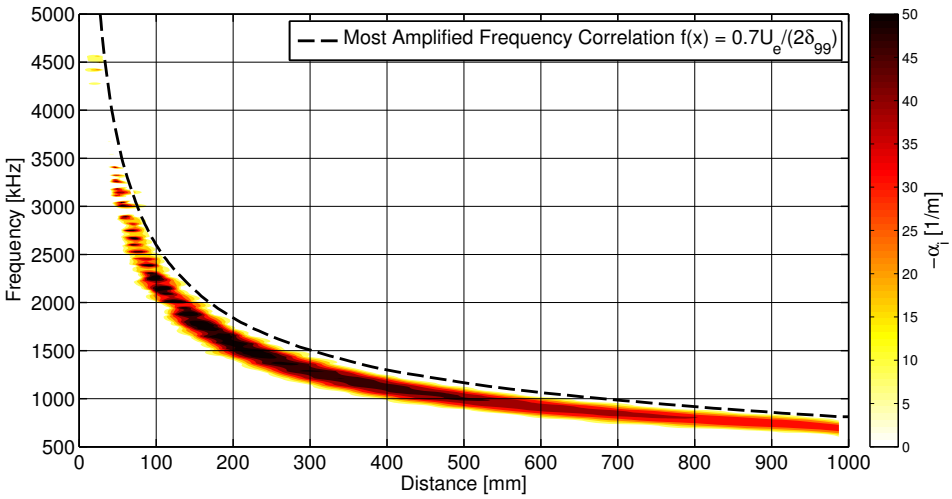


Figure 335: Stability diagram with vibrational energy transfer, Shot 2669. Dashed line indicates $0.7U_e/(2\delta_{99})$.

112.6 Heat Transfer Results

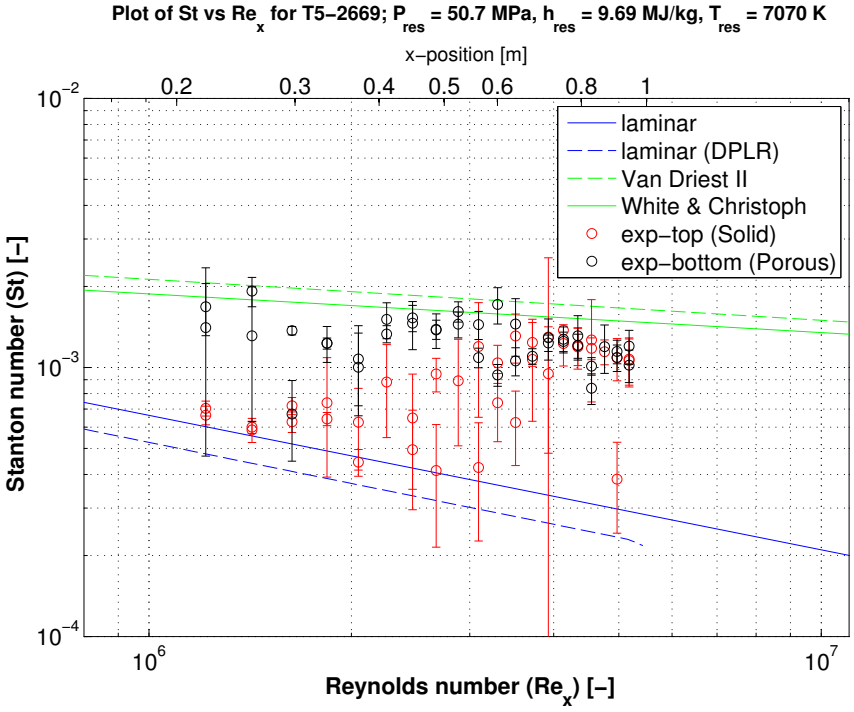


Figure 336: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

113 Shot 2670

Experiment 2670 was performed in T5 on 28 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

113.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	48.3	MPa

Table 897: Measured quantities, Shot 2670

113.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7187	K
Reservoir Density	ρ_{res}	22.01	kg/m^3
Reservoir Enthalpy	h_{res}	10.0	MJ/kg

Table 898: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2670

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.72×10^{-1}	0	0	0	0	2.83×10^{-2}	0

Table 899: Computed reservoir species mass fractions, Shot 2670

113.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4192	1380.0	1380.0	5.70	19.4	0.047	4.06×10^6
72 cm	4151	1000.4	2975.5	6.43	13.0	0.044	4.58×10^6

Table 900: Computed freestream conditions, Shot 2670

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.16×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.63×10^{-3}	0

Table 901: Computed freestream species mass fractions, Shot 2670

113.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4152	1514.7	1514.7	5.39	28.5	0.063	5.03×10^6
72 cm	4083	1236.3	2948.5	5.69	21.0	0.057	5.17×10^6

Table 902: Computed boundary layer edge conditions, Shot 2670

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.16×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 903: Computed boundary layer edge species mass fractions, Shot 2670

	T^* K	Unit Re^* 1/m
1D 100 cm	1929	3.31×10^6
72 cm	1699	3.76×10^6

Table 904: Dorrance reference conditions, Shot 2670

113.5 Stability Computations

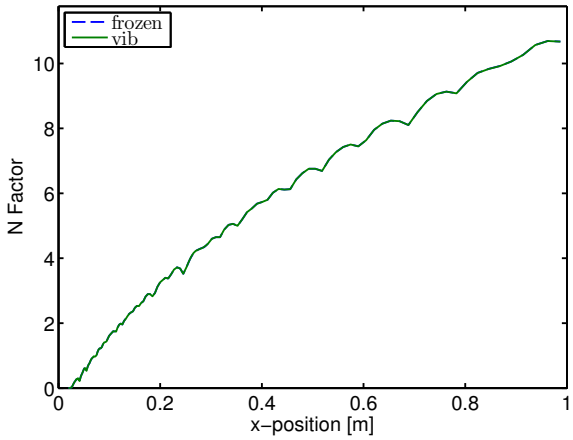


Figure 337: Locus of maximum N factor with and without vibrational energy transfer, Shot 2670

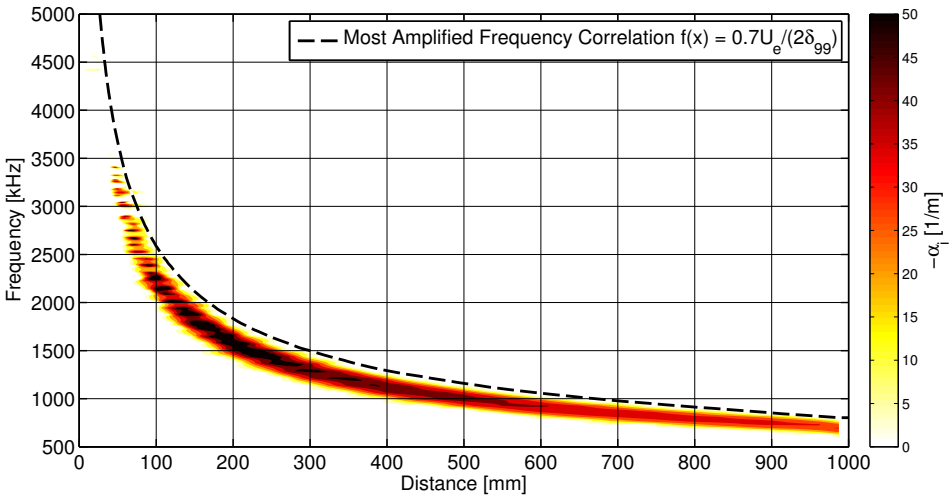


Figure 338: Stability diagram with vibrational energy transfer, Shot 2670. Dashed line indicates $0.7U_e/(2\delta_{99})$.

113.6 Heat Transfer Results

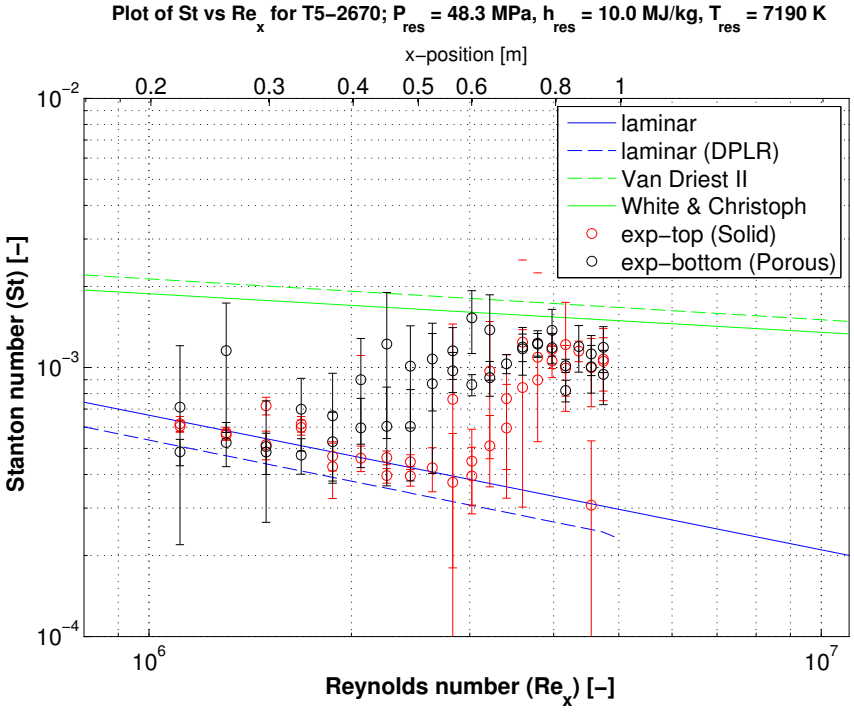


Figure 339: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

114 Shot 2671

Experiment 2671 was performed in T5 on 30 August 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

114.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	46.7	MPa

Table 905: Measured quantities, Shot 2671

114.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7001	K
Reservoir Density	ρ_{res}	21.99	kg/m^3
Reservoir Enthalpy	h_{res}	9.56	MJ/kg

Table 906: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2671

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.77×10^{-1}	0	0	0	0	2.30×10^{-2}	0

Table 907: Computed reservoir species mass fractions, Shot 2671

114.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4106	1307.0	1307.0	5.73	18.5	0.047	4.15×10^6
72 cm	4069	924.4	2930.4	6.57	11.6	0.042	4.51×10^6

Table 908: Computed freestream conditions, Shot 2671

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.75×10^{-3}	0
72 cm	9.99×10^{-1}	0	0	0	0	1.32×10^{-3}	0

Table 909: Computed freestream species mass fractions, Shot 2671

114.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4066	1437.2	1437.2	5.41	27.2	0.064	5.15×10^6
72 cm	4004	1149.7	2905.5	5.79	18.9	0.055	5.13×10^6

Table 910: Computed boundary layer edge conditions, Shot 2671

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.75×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 911: Computed boundary layer edge species mass fractions, Shot 2671

	T^* K	Unit Re^* 1/m
1D 100 cm	1856	3.31×10^6
72 cm	1628	3.62×10^6

Table 912: Dorrance reference conditions, Shot 2671

114.5 Stability Computations

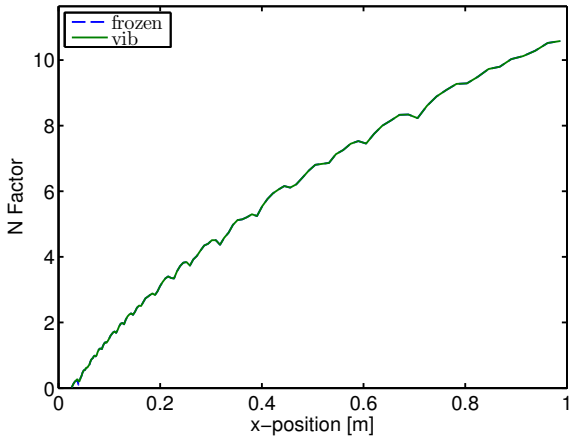


Figure 340: Locus of maximum N factor with and without vibrational energy transfer, Shot 2671

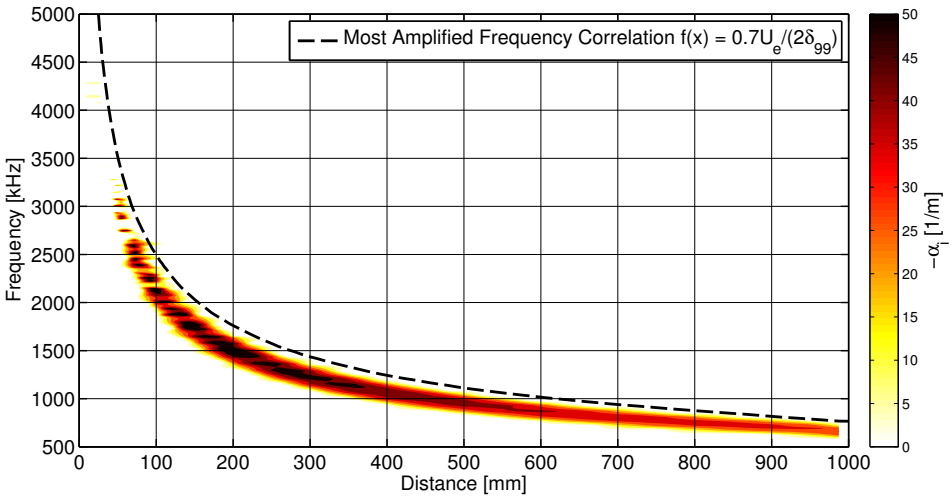


Figure 341: Stability diagram with vibrational energy transfer, Shot 2671. Dashed line indicates $0.7U_e/(2\delta_{99})$.

114.6 Heat Transfer Results

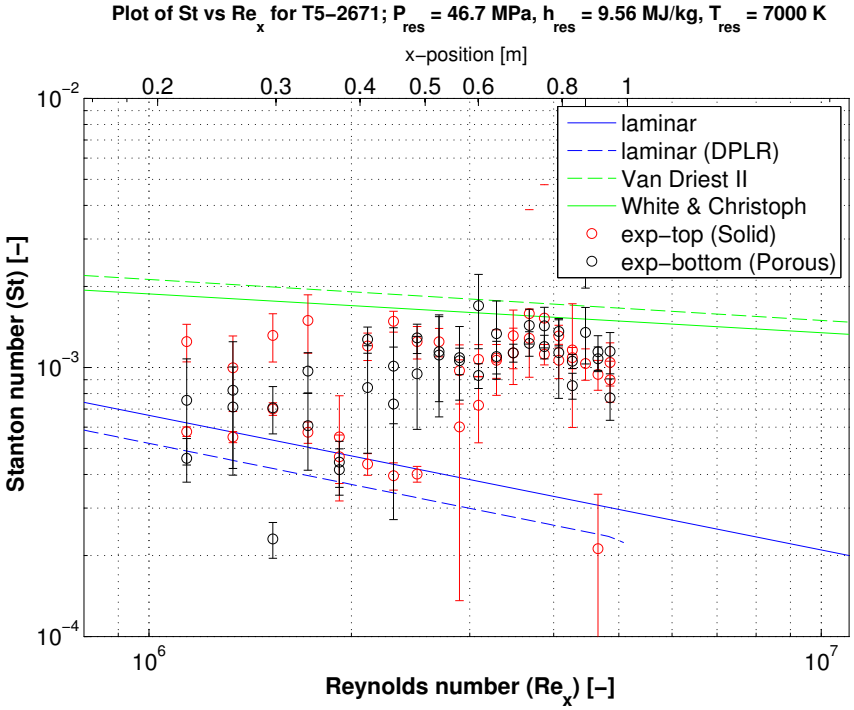


Figure 342: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

115 Shot 2672

Experiment 2672 was performed in T5 on 1 September 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

115.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3280	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	49.0	MPa

Table 913: Measured quantities, Shot 2672

115.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7295	K
Reservoir Density	ρ_{res}	21.94	kg/m^3
Reservoir Enthalpy	h_{res}	10.3	MJ/kg

Table 914: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2672

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.68×10^{-1}	0	0	0	0	3.18×10^{-2}	0

Table 915: Computed reservoir species mass fractions, Shot 2672

115.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4245	1426.0	1426.0	5.68	20.0	0.047	4.00×10^6
72 cm	4199	1050.5	3003.3	6.35	14.0	0.045	4.62×10^6

Table 916: Computed freestream conditions, Shot 2672

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	1.12×10^{-10}	0	2.45×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.84×10^{-3}	0

Table 917: Computed freestream species mass fractions, Shot 2672

115.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4204	1563.6	1563.6	5.37	29.3	0.063	4.95×10^6
72 cm	4130	1292.5	2974.8	5.63	22.5	0.058	5.18×10^6

Table 918: Computed boundary layer edge conditions, Shot 2672

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	1.12×10^{-10}	0	2.45×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 919: Computed boundary layer edge species mass fractions, Shot 2672

	T^* K	Unit Re^* 1/m
1D 100 cm	1975	3.30×10^6
72 cm	1744	3.84×10^6

Table 920: Dorrance reference conditions, Shot 2672

115.5 Stability Computations

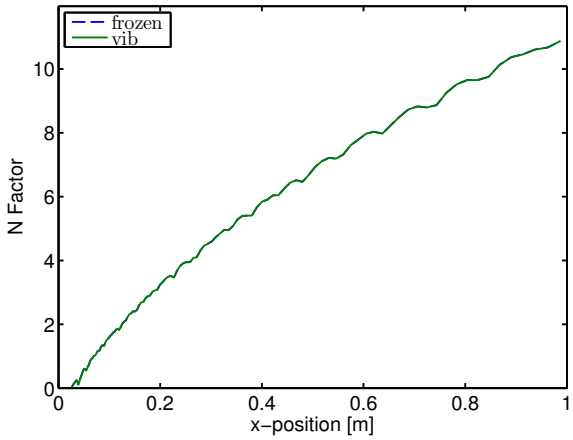


Figure 343: Locus of maximum N factor with and without vibrational energy transfer, Shot 2672

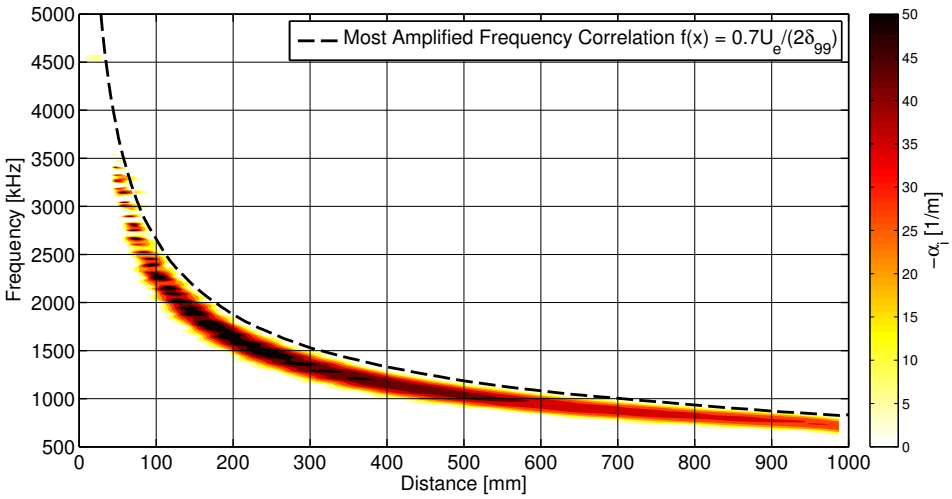


Figure 344: Stability diagram with vibrational energy transfer, Shot 2672. Dashed line indicates $0.7U_e/(2\delta_{99})$.

115.6 Heat Transfer Results

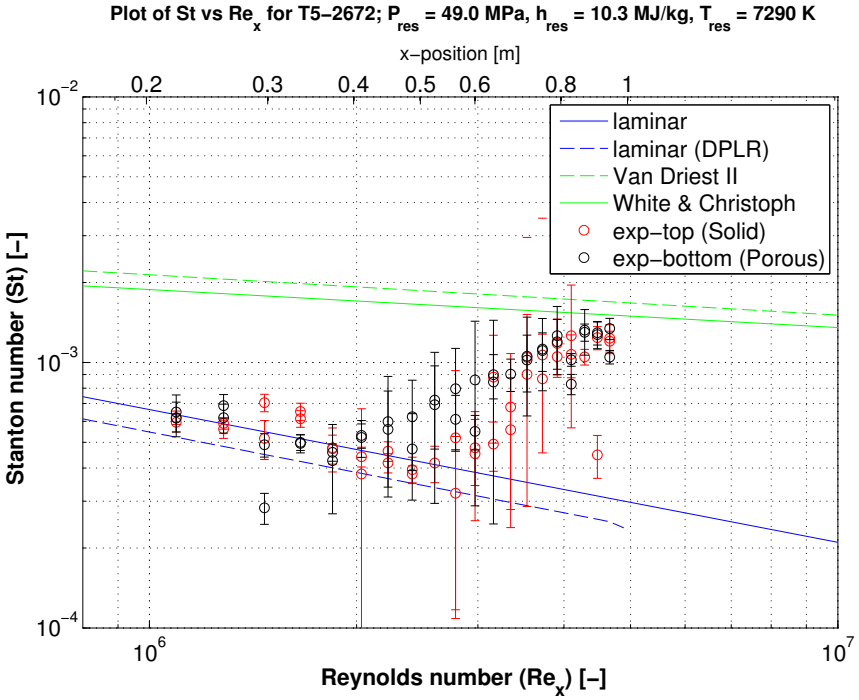


Figure 345: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

116 Shot 2673

Experiment 2673 was performed in T5 on 2 September 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

116.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3260	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	51.0	MPa

Table 921: Measured quantities, Shot 2673

116.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7304	K
Reservoir Density	ρ_{res}	22.79	kg/m^3
Reservoir Enthalpy	h_{res}	10.3	MJ/kg

Table 922: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2673

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.68×10^{-1}	0	0	0	0	3.15×10^{-2}	0

Table 923: Computed reservoir species mass fractions, Shot 2673

116.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4246	1426.0	1426.0	5.68	20.8	0.049	4.15×10^6
72 cm	4201	1052.2	2990.5	6.35	14.6	0.047	4.80×10^6

Table 924: Computed freestream conditions, Shot 2673

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.34×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.74×10^{-3}	0

Table 925: Computed freestream species mass fractions, Shot 2673

116.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4205	1564.4	1564.4	5.37	30.4	0.065	5.14×10^6
72 cm	4133	1292.8	2962.5	5.63	23.4	0.061	5.39×10^6

Table 926: Computed boundary layer edge conditions, Shot 2673

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.34×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 927: Computed boundary layer edge species mass fractions, Shot 2673

	T^* K	Unit Re^* 1/m
1D 100 cm	1976	3.43×10^6
72 cm	1745	3.99×10^6

Table 928: Dorrance reference conditions, Shot 2673

116.5 Stability Computations

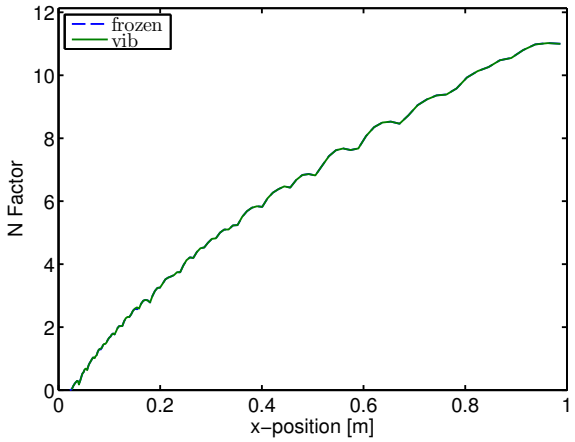


Figure 346: Locus of maximum N factor with and without vibrational energy transfer, Shot 2673

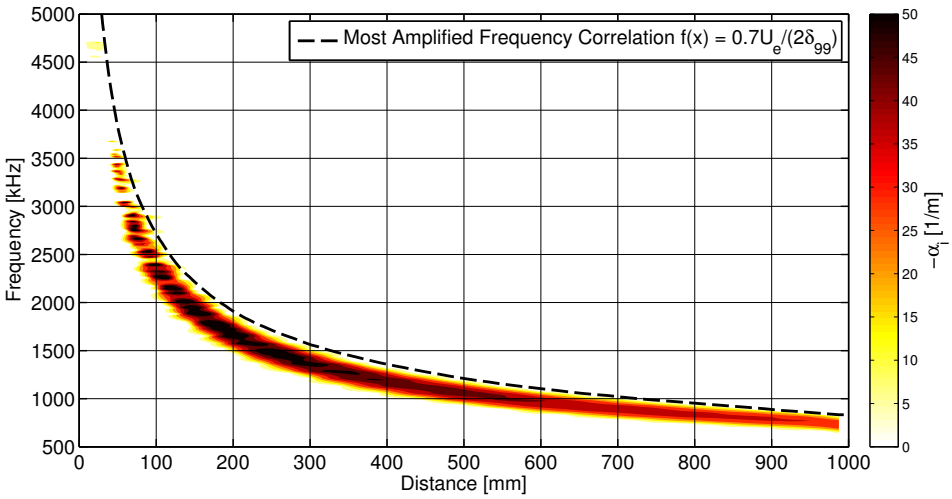


Figure 347: Stability diagram with vibrational energy transfer, Shot 2673. Dashed line indicates $0.7U_e/(2\delta_{99})$.

116.6 Heat Transfer Results

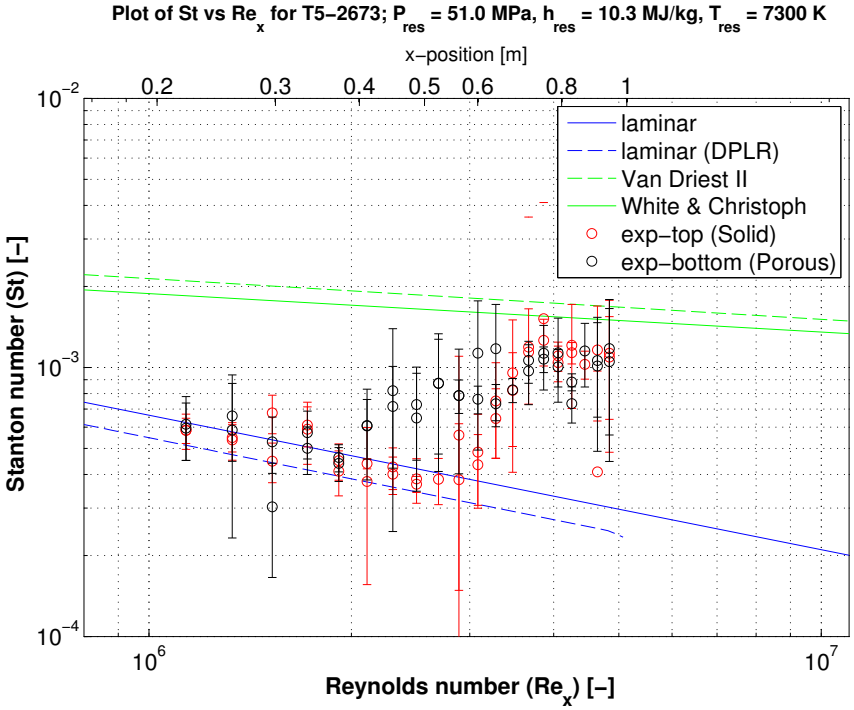


Figure 348: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

117 Shot 2674

Experiment 2674 was performed in T5 on 13 September 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

117.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	50.2	MPa

Table 929: Measured quantities, Shot 2674

117.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7227	K
Reservoir Density	ρ_{res}	22.73	kg/m^3
Reservoir Enthalpy	h_{res}	10.1	MJ/kg

Table 930: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2674

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.71×10^{-1}	0	0	0	0	2.91×10^{-2}	0

Table 931: Computed reservoir species mass fractions, Shot 2674

117.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4209	1394.0	1394.0	5.69	20.3	0.049	4.18×10^6
72 cm	4167	1016.2	2972.6	6.41	13.8	0.046	4.75×10^6

Table 932: Computed freestream conditions, Shot 2674

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.14×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.61×10^{-3}	0

Table 933: Computed freestream species mass fractions, Shot 2674

117.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4169	1530.4	1530.4	5.38	29.8	0.065	5.18×10^6
72 cm	4099	1254.2	2945.2	5.67	22.2	0.059	5.34×10^6

Table 934: Computed boundary layer edge conditions, Shot 2674

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	2.14×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 935: Computed boundary layer edge species mass fractions, Shot 2674

	T^* K	Unit Re^* 1/m
1D 100 cm	1944	3.42×10^6
72 cm	1714	3.91×10^6

Table 936: Dorrance reference conditions, Shot 2674

117.5 Stability Computations

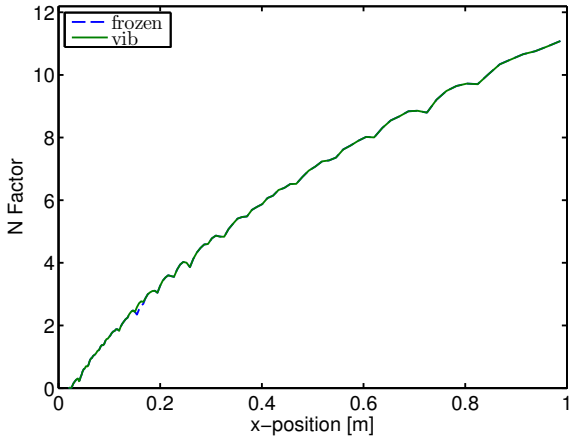


Figure 349: Locus of maximum N factor with and without vibrational energy transfer, Shot 2674

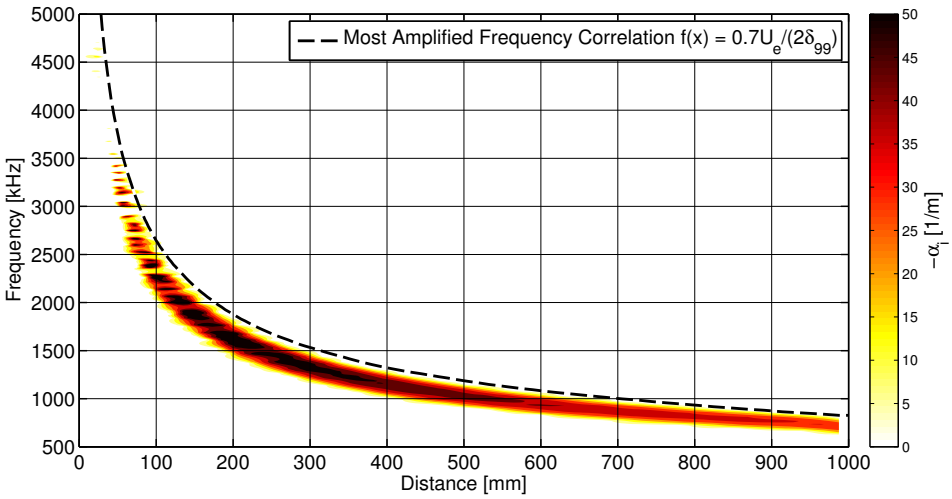


Figure 350: Stability diagram with vibrational energy transfer, Shot 2674. Dashed line indicates $0.7U_e/(2\delta_{99})$.

117.6 Heat Transfer Results

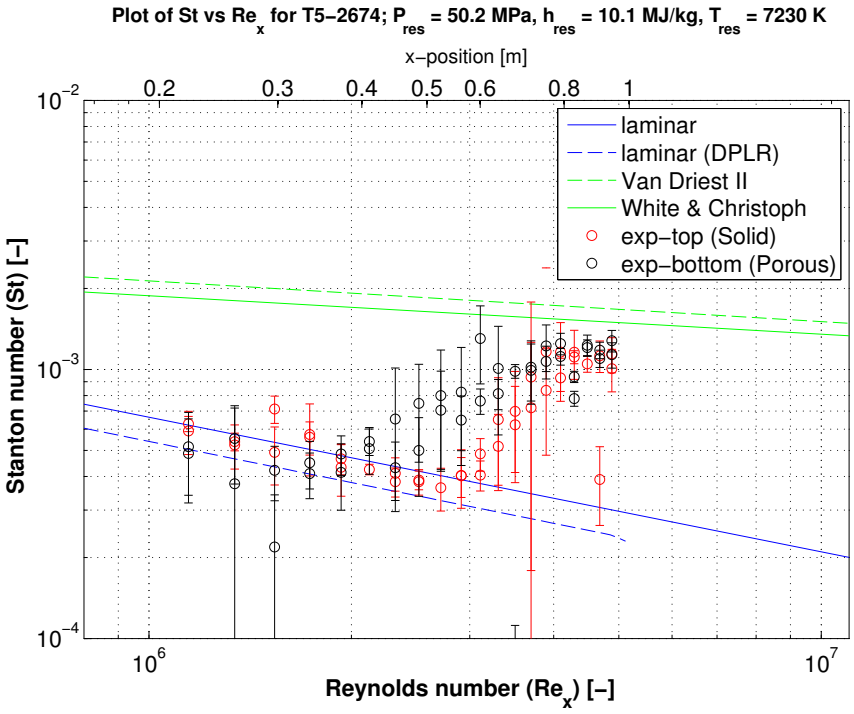


Figure 351: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

118 Shot 2675

Experiment 2675 was performed in T5 on 16 September 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% N_2 by mass.

118.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3060	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	50.2	MPa

Table 937: Measured quantities, Shot 2675

118.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6926	K
Reservoir Density	ρ_{res}	23.95	kg/m^3
Reservoir Enthalpy	h_{res}	9.35	MJ/kg

Table 938: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2675

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.80×10^{-1}	0	0	0	0	2.02×10^{-2}	0

Table 939: Computed reservoir species mass fractions, Shot 2675

118.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4064	1273.0	1273.0	5.74	19.5	0.052	4.55×10^6
72 cm	4035	894.4	2880.8	6.62	12.0	0.045	4.88×10^6

Table 940: Computed freestream conditions, Shot 2675

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.99×10^{-1}	0	0	0	0	1.41×10^{-3}	0
72 cm	9.99×10^{-1}	0	0	0	0	1.05×10^{-3}	0

Table 941: Computed freestream species mass fractions, Shot 2675

118.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4025	1400.8	1400.8	5.42	28.9	0.069	5.65×10^6
72 cm	3969	1116.9	2856.2	5.82	19.7	0.059	5.56×10^6

Table 942: Computed boundary layer edge conditions, Shot 2675

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.99×10^{-1}	0	0	0	0	1.41×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 943: Computed boundary layer edge species mass fractions, Shot 2675

	T^* K	Unit Re^* 1/m
1D 100 cm	1821	3.59×10^6
72 cm	1601	3.88×10^6

Table 944: Dorrance reference conditions, Shot 2675

118.5 Stability Computations

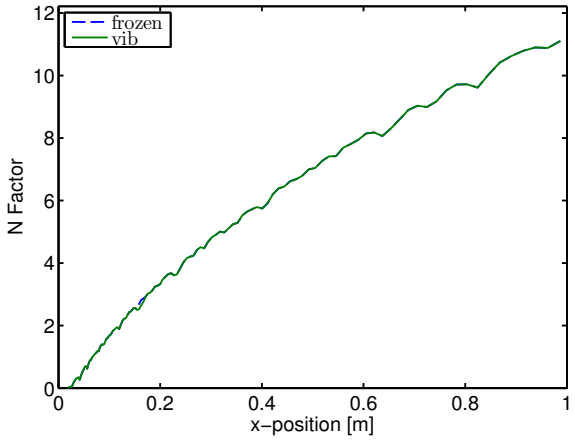


Figure 352: Locus of maximum N factor with and without vibrational energy transfer, Shot 2675

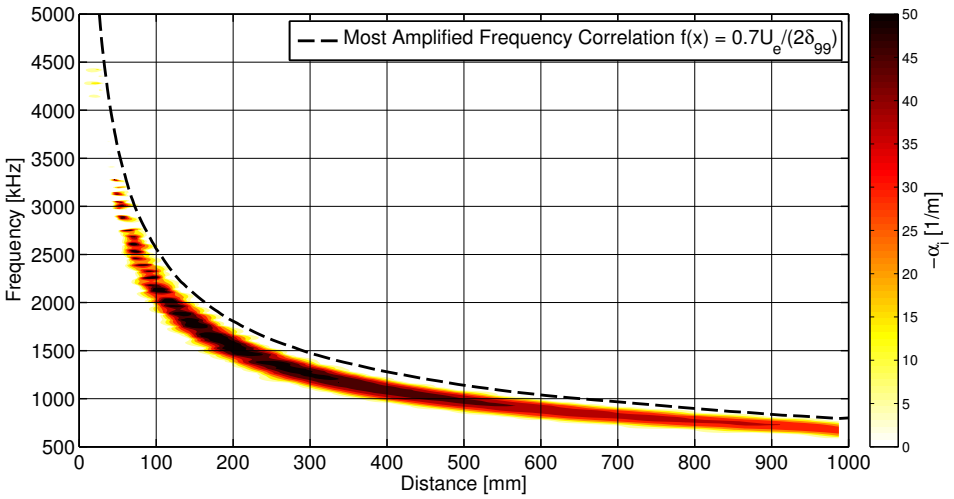


Figure 353: Stability diagram with vibrational energy transfer, Shot 2675. Dashed line indicates $0.7U_e/(2\delta_{99})$.

118.6 Heat Transfer Results

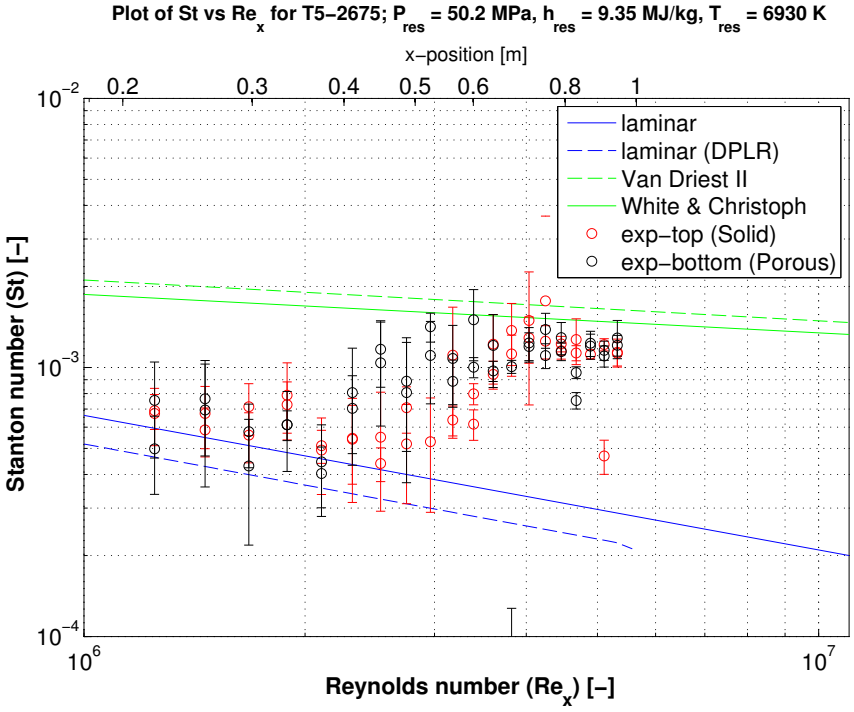


Figure 354: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

119 Shot 2676

Experiment 2676 was performed in T5 on 28 September 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

119.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2970	m/s
Shock Tube Fill Pressure	P_1	84.85	kPa
Reservoir Pressure	P_{res}	51.0	MPa

Table 945: Measured quantities, Shot 2676

119.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5648	K
Reservoir Density	ρ_{res}	28.90	kg/m^3
Reservoir Enthalpy	h_{res}	8.75	MJ/kg

Table 946: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2676

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.82×10^{-2}	0	1.38×10^{-1}	0	2.45×10^{-3}	9.10×10^{-2}

Table 947: Computed reservoir species mass fractions, Shot 2676

119.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3824	1286.0	1286.0	5.43	23.1	0.062	4.83×10^{6}
72 cm	3798	1304.9	1312.6	5.21	26.8	0.071	5.45×10^{6}

Table 948: Computed freestream conditions, Shot 2676

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.13×10^{-2}	0	1.21×10^{-10}	1.36×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.37×10^{-2}	0	1.41×10^{-9}	7.53×10^{-3}

Table 949: Computed freestream species mass fractions, Shot 2676

119.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3787	1404.1	1404.1	5.15	33.2	0.081	5.94×10^{6}
72 cm	3734	1480.0	1477.7	4.81	38.4	0.089	6.24×10^{6}

Table 950: Computed boundary layer edge conditions, Shot 2676

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.13×10^{-2}	0	1.21×10^{-10}	1.36×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.37×10^{-2}	0	7.38×10^{-9}	7.32×10^{-3}

Table 951: Computed boundary layer edge species mass fractions, Shot 2676

	T^* K	Unit Re^* 1/m
1D 100 cm	1724	4.20×10^{6}
72 cm	1694	5.45×10^{6}

Table 952: Dorrance reference conditions, Shot 2676

119.5 Stability Computations

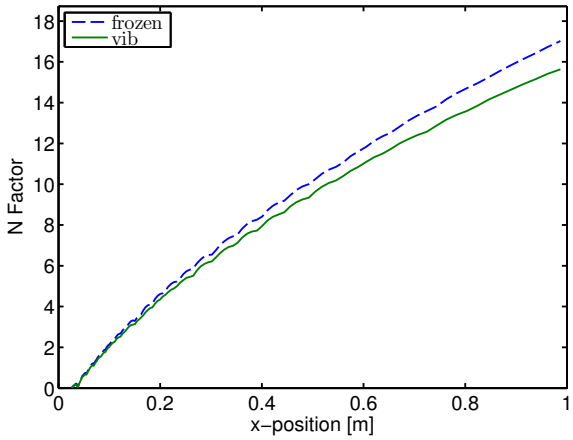


Figure 355: Locus of maximum N factor with and without vibrational energy transfer, Shot 2676

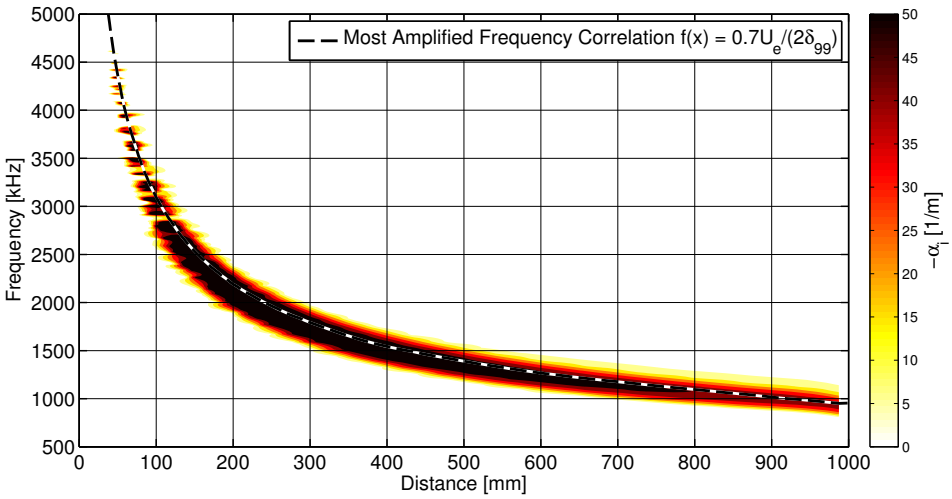


Figure 356: Stability diagram with vibrational energy transfer, Shot 2676. Dashed line indicates $0.7U_e/(2\delta_{99})$.

119.6 Heat Transfer Results

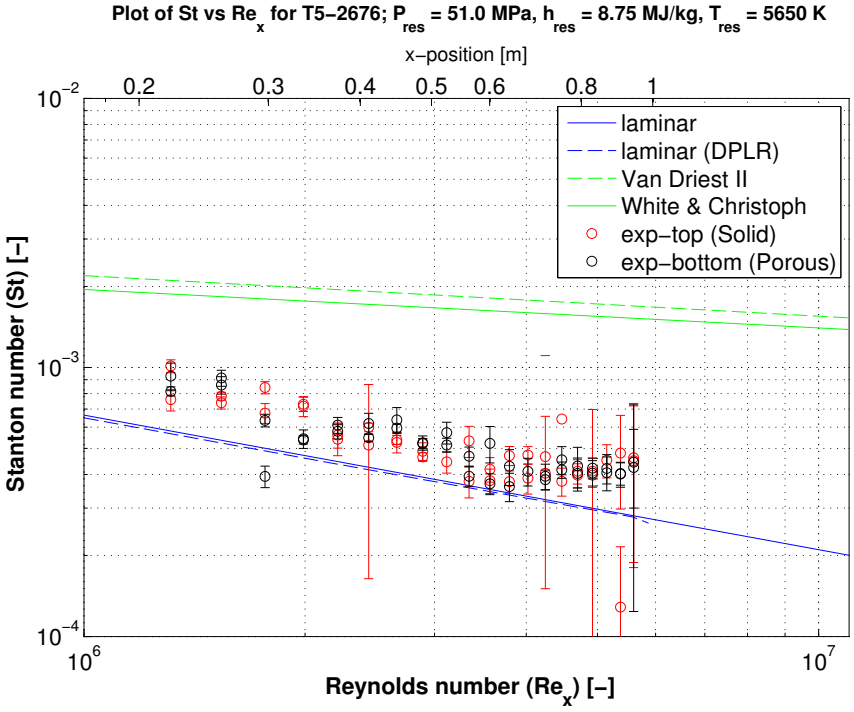


Figure 357: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

120 Shot 2677

Experiment 2677 was performed in T5 on 3 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

120.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3090	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 953: Measured quantities, Shot 2677

120.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5922	K
Reservoir Density	ρ_{res}	28.44	kg/m^3
Reservoir Enthalpy	h_{res}	9.38	MJ/kg

Table 954: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2677

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.59×10^{-2}	0	1.36×10^{-1}	0	3.93×10^{-3}	1.05×10^{-1}

Table 955: Computed reservoir species mass fractions, Shot 2677

120.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3936	1386.0	1386.0	5.38	24.3	0.060	4.61×10^6
72 cm	3914	1421.9	1430.6	5.14	29.0	0.070	5.27×10^6

Table 956: Computed freestream conditions, Shot 2677

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.05×10^{-2}	0	2.20×10^{-9}	1.75×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	5.82×10^{-9}	1.02×10^{-2}

Table 957: Computed freestream species mass fractions, Shot 2677

120.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3896	1511.0	1511.0	5.10	34.7	0.079	5.64×10^6
72 cm	3848	1606.8	1604.6	4.75	41.3	0.088	6.00×10^6

Table 958: Computed boundary layer edge conditions, Shot 2677

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.05×10^{-2}	0	2.20×10^{-9}	1.75×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	2.36×10^{-8}	9.86×10^{-3}

Table 959: Computed boundary layer edge species mass fractions, Shot 2677

	T^* K	Unit Re^* 1/m
1D 100 cm	1820	4.11×10^6
72 cm	1797	5.37×10^6

Table 960: Dorrance reference conditions, Shot 2677

120.5 Stability Computations

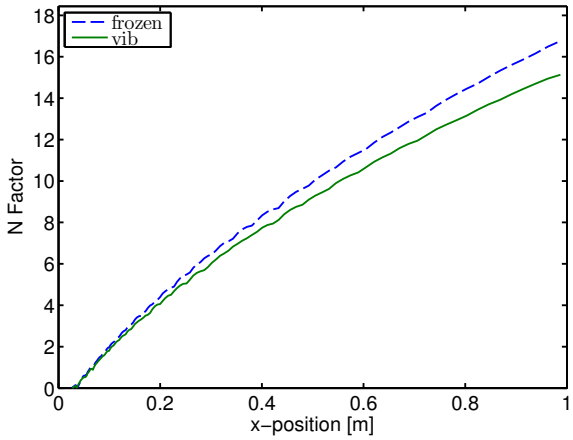


Figure 358: Locus of maximum N factor with and without vibrational energy transfer, Shot 2677

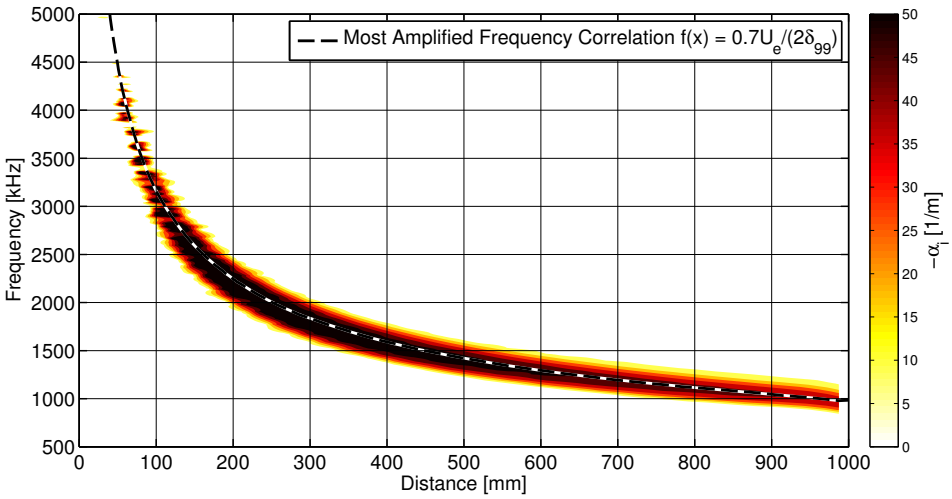


Figure 359: Stability diagram with vibrational energy transfer, Shot 2677. Dashed line indicates $0.7U_e/(2\delta_{99})$.

120.6 Heat Transfer Results

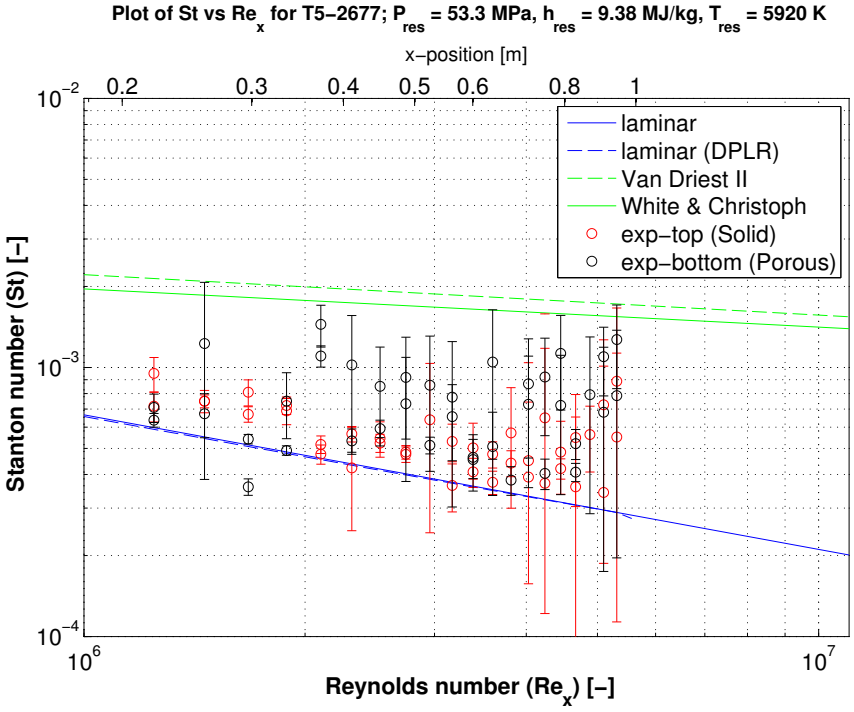


Figure 360: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

121 Shot 2678

Experiment 2678 was performed in T5 on 7 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

121.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3030	m/s
Shock Tube Fill Pressure	P_1	84.90	kPa
Reservoir Pressure	P_{res}	52.0	MPa

Table 961: Measured quantities, Shot 2678

121.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5780	K
Reservoir Density	ρ_{res}	28.63	kg/m^3
Reservoir Enthalpy	h_{res}	9.05	MJ/kg

Table 962: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2678

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.20×10^{-2}	0	1.37×10^{-1}	0	3.10×10^{-3}	9.77×10^{-2}

Table 963: Computed reservoir species mass fractions, Shot 2678

121.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3875	1331.0	1331.0	5.41	23.4	0.060	4.68×10^6
72 cm	3854	1361.6	1369.9	5.18	27.8	0.070	5.35×10^6

Table 964: Computed freestream conditions, Shot 2678

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.09×10^{-2}	0	1.51×10^{-9}	1.55×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	2.90×10^{-9}	8.79×10^{-3}

Table 965: Computed freestream species mass fractions, Shot 2678

121.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3836	1451.9	1451.9	5.13	33.5	0.079	5.74×10^6
72 cm	3789	1541.7	1539.5	4.78	39.7	0.089	6.11×10^6

Table 966: Computed boundary layer edge conditions, Shot 2678

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.85×10^{-1}	0	6.09×10^{-2}	0	1.51×10^{-9}	1.55×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	1.33×10^{-8}	8.52×10^{-3}

Table 967: Computed boundary layer edge species mass fractions, Shot 2678

	T^* K	Unit Re^* 1/m
1D 100 cm	1767	4.12×10^6
72 cm	1744	5.40×10^6

Table 968: Dorrance reference conditions, Shot 2678

121.5 Stability Computations

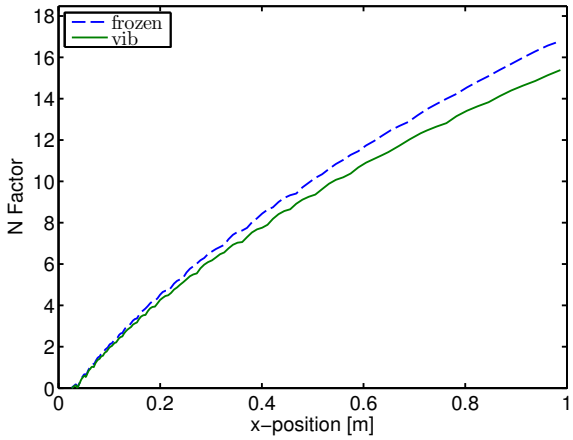


Figure 361: Locus of maximum N factor with and without vibrational energy transfer, Shot 2678

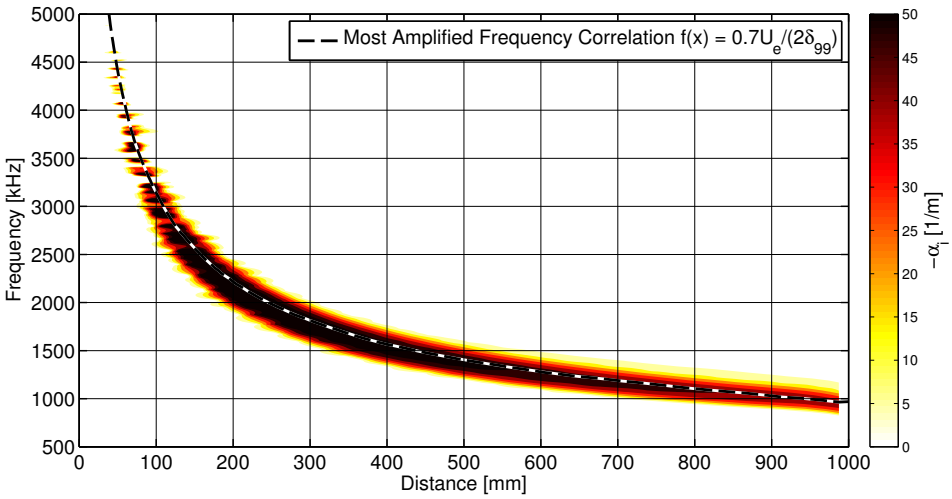


Figure 362: Stability diagram with vibrational energy transfer, Shot 2678. Dashed line indicates $0.7U_e/(2\delta_{99})$.

121.6 Heat Transfer Results

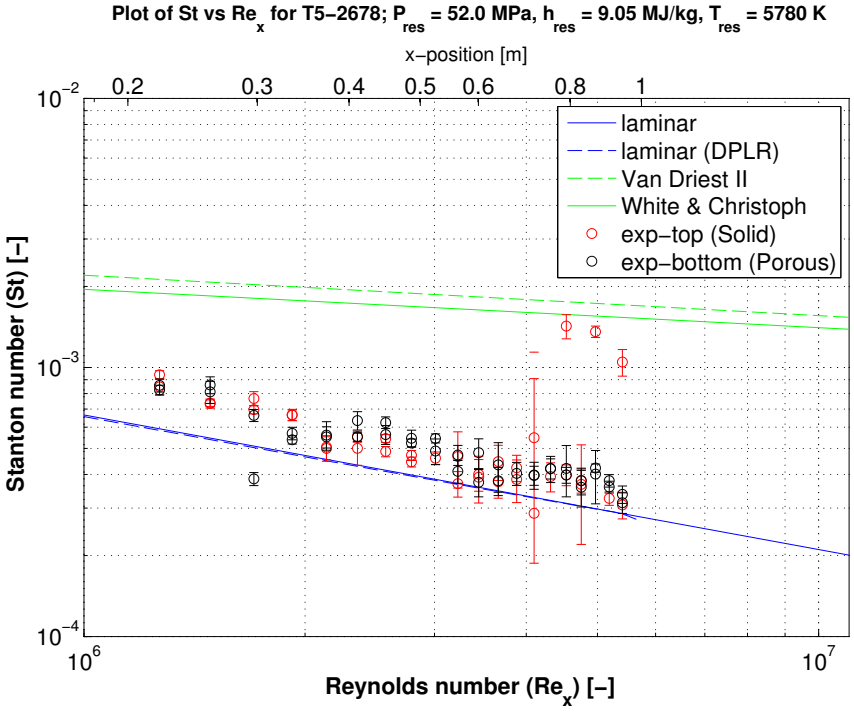


Figure 363: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

122 Shot 2679

Experiment 2679 was performed in T5 on 12 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

122.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3000	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	50.5	MPa

Table 969: Measured quantities, Shot 2679

122.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5693	K
Reservoir Density	ρ_{res}	28.32	kg/m^3
Reservoir Enthalpy	h_{res}	8.86	MJ/kg

Table 970: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2679

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.57×10^{-2}	0	1.37×10^{-1}	0	2.68×10^{-3}	9.39×10^{-2}

Table 971: Computed reservoir species mass fractions, Shot 2679

122.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3840	1299.0	1299.0	5.42	22.7	0.060	4.68×10^6
72 cm	3818	1325.4	1333.5	5.20	26.7	0.069	5.32×10^6

Table 972: Computed freestream conditions, Shot 2679

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.11×10^{-2}	0	2.93×10^{-10}	1.45×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.35×10^{-2}	0	1.89×10^{-9}	8.14×10^{-3}

Table 973: Computed freestream species mass fractions, Shot 2679

122.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3802	1418.6	1418.6	5.14	32.5	0.079	5.75×10^6
72 cm	3753	1502.6	1500.3	4.80	38.2	0.087	6.08×10^6

Table 974: Computed boundary layer edge conditions, Shot 2679

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.11×10^{-2}	0	2.93×10^{-10}	1.45×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.35×10^{-2}	0	9.42×10^{-9}	7.91×10^{-3}

Table 975: Computed boundary layer edge species mass fractions, Shot 2679

	T^* K	Unit Re^* 1/m
1D 100 cm	1737	4.08×10^6
72 cm	1712	5.33×10^6

Table 976: Dorrance reference conditions, Shot 2679

122.5 Stability Computations

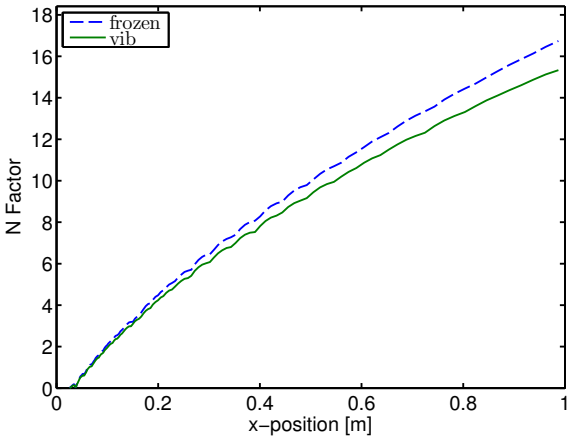


Figure 364: Locus of maximum N factor with and without vibrational energy transfer, Shot 2679

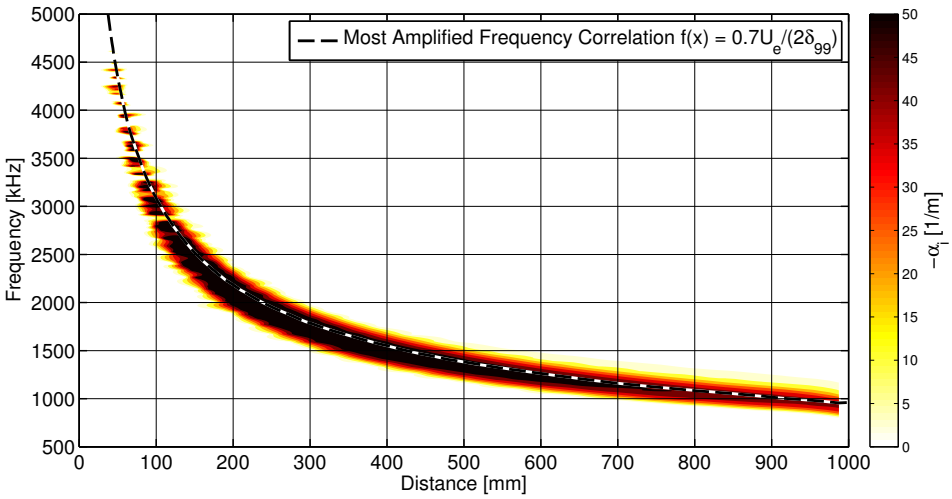


Figure 365: Stability diagram with vibrational energy transfer, Shot 2679. Dashed line indicates $0.7U_e/(2\delta_{99})$.

122.6 Heat Transfer Results

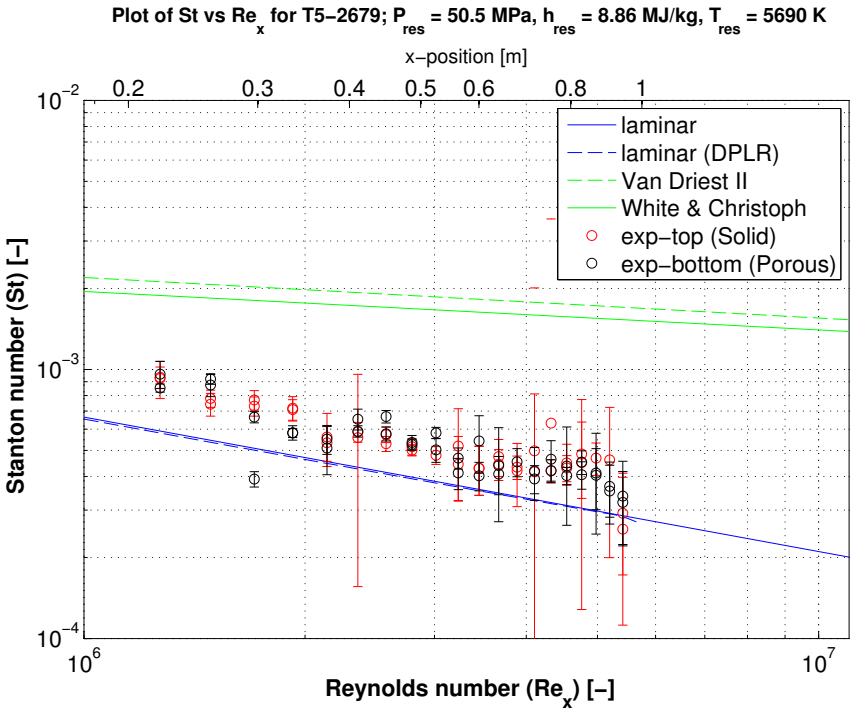


Figure 366: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

123 Shot 2680

Experiment 2680 was performed in T5 on 13 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

123.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3020	m/s
Shock Tube Fill Pressure	P_1	104.00	kPa
Reservoir Pressure	P_{res}	71.2	MPa

Table 977: Measured quantities, Shot 2680

123.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5907	K
Reservoir Density	ρ_{res}	38.43	kg/m^3
Reservoir Enthalpy	h_{res}	9.19	MJ/kg

Table 978: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2680

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	6.26×10^{-2}	0	1.43×10^{-1}	0	3.29×10^{-3}	9.41×10^{-2}

Table 979: Computed reservoir species mass fractions, Shot 2680

123.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3914	1377.0	1377.0	5.38	32.7	0.082	6.26×10^6
72 cm	3892	1394.8	1401.1	5.17	38.6	0.096	7.24×10^6

Table 980: Computed freestream conditions, Shot 2680

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.88×10^{-1}	0	6.07×10^{-2}	0	1.51×10^{-9}	1.22×10^{-2}
72 cm	7.33×10^{-1}	1.88×10^{-1}	0	7.28×10^{-2}	0	2.86×10^{-9}	6.54×10^{-3}

Table 981: Computed freestream species mass fractions, Shot 2680

123.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3875	1500.7	1500.7	5.11	46.7	0.107	7.66×10^6
72 cm	3827	1576.6	1575.0	4.78	55.1	0.121	8.26×10^6

Table 982: Computed boundary layer edge conditions, Shot 2680

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.88×10^{-1}	0	6.07×10^{-2}	0	1.51×10^{-9}	1.22×10^{-2}
72 cm	7.33×10^{-1}	1.88×10^{-1}	0	7.28×10^{-2}	0	1.19×10^{-8}	6.28×10^{-3}

Table 983: Computed boundary layer edge species mass fractions, Shot 2680

	T^* K	Unit Re^* 1/m
1D 100 cm	1806	5.60×10^6
72 cm	1773	7.34×10^6

Table 984: Dorrance reference conditions, Shot 2680

123.5 Stability Computations

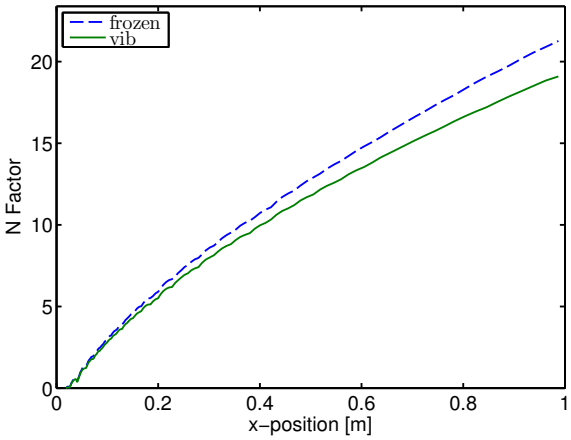


Figure 367: Locus of maximum N factor with and without vibrational energy transfer, Shot 2680

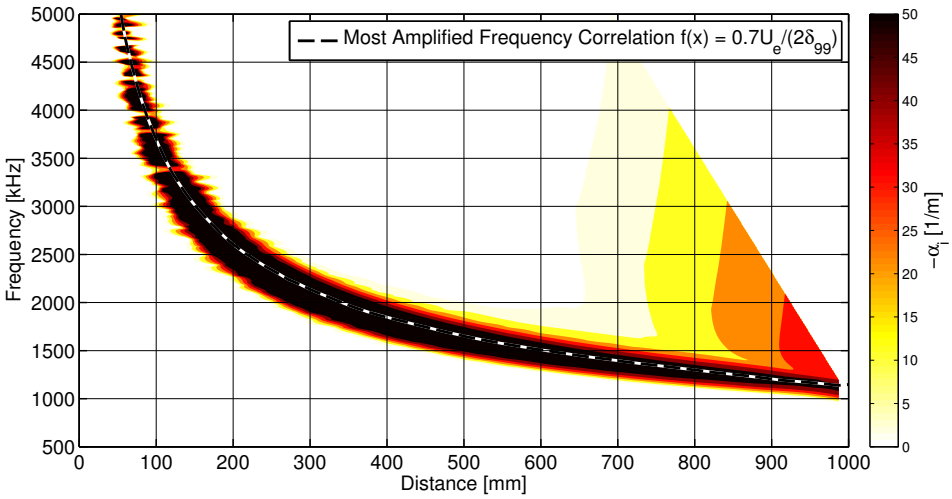


Figure 368: Stability diagram with vibrational energy transfer, Shot 2680. Dashed line indicates $0.7U_e/(2\delta_{99})$.

123.6 Heat Transfer Results

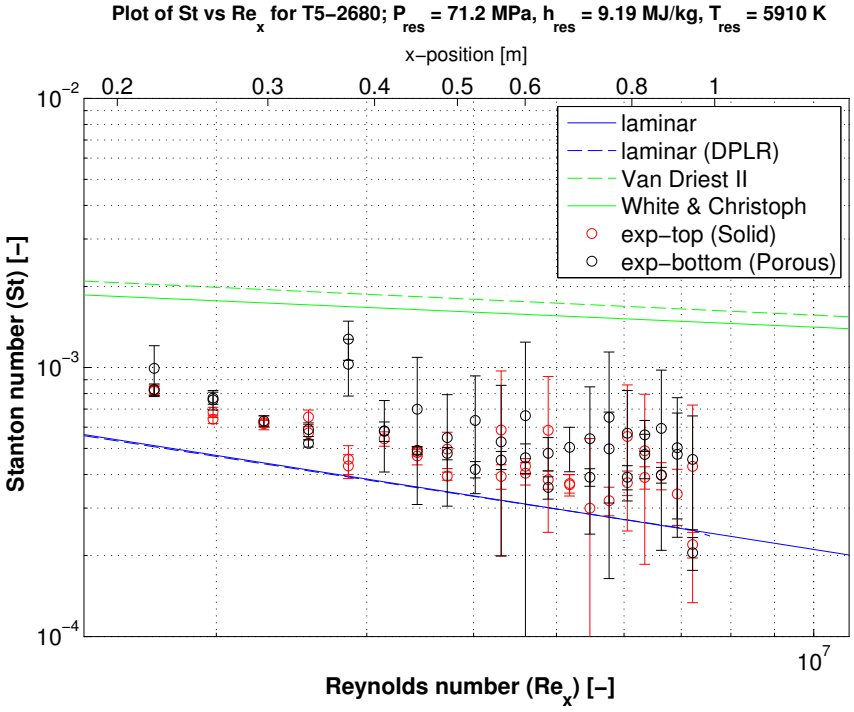


Figure 369: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

124 Shot 2681

Experiment 2681 was performed in T5 on 17 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

124.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2670	m/s
Shock Tube Fill Pressure	P_1	141.00	kPa
Reservoir Pressure	P_{res}	70.7	MPa

Table 985: Measured quantities, Shot 2681

124.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5028	K
Reservoir Density	ρ_{res}	46.73	kg/m^3
Reservoir Enthalpy	h_{res}	7.17	MJ/kg

Table 986: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2681

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	1.10×10^{-1}	0	1.39×10^{-1}	0	5.64×10^{-4}	4.89×10^{-2}

Table 987: Computed reservoir species mass fractions, Shot 2681

124.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3518	1023.0	1023.0	5.60	29.6	0.100	8.25×10^{6}
72 cm	3497	1003.3	1000.9	5.49	33.0	0.113	9.37×10^{6}

Table 988: Computed freestream conditions, Shot 2681

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.24×10^{-2}	0	4.43×10^{-10}	3.75×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.77×10^{-2}	0	0	1.47×10^{-3}

Table 989: Computed freestream species mass fractions, Shot 2681

124.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3484	1125.1	1125.1	5.29	43.3	0.133	1.03×10^{7}
72 cm	3437	1156.0	1154.3	5.03	48.3	0.145	1.09×10^{7}

Table 990: Computed boundary layer edge conditions, Shot 2681

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.24×10^{-2}	0	4.43×10^{-10}	3.75×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.77×10^{-2}	0	0	1.44×10^{-3}

Table 991: Computed boundary layer edge species mass fractions, Shot 2681

	T^* K	Unit Re^* 1/m
1D 100 cm	1475	6.62×10^{6}
72 cm	1437	8.73×10^{6}

Table 992: Dorrance reference conditions, Shot 2681

124.5 Stability Computations

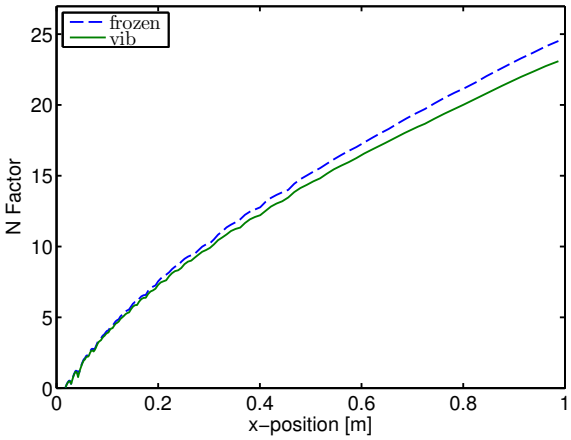


Figure 370: Locus of maximum N factor with and without vibrational energy transfer, Shot 2681

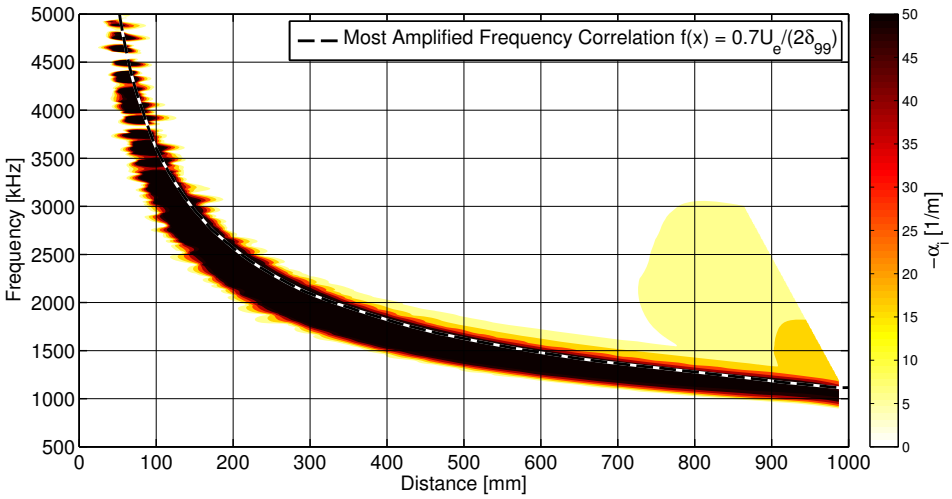


Figure 371: Stability diagram with vibrational energy transfer, Shot 2681. Dashed line indicates $0.7U_e/(2\delta_{99})$.

124.6 Heat Transfer Results

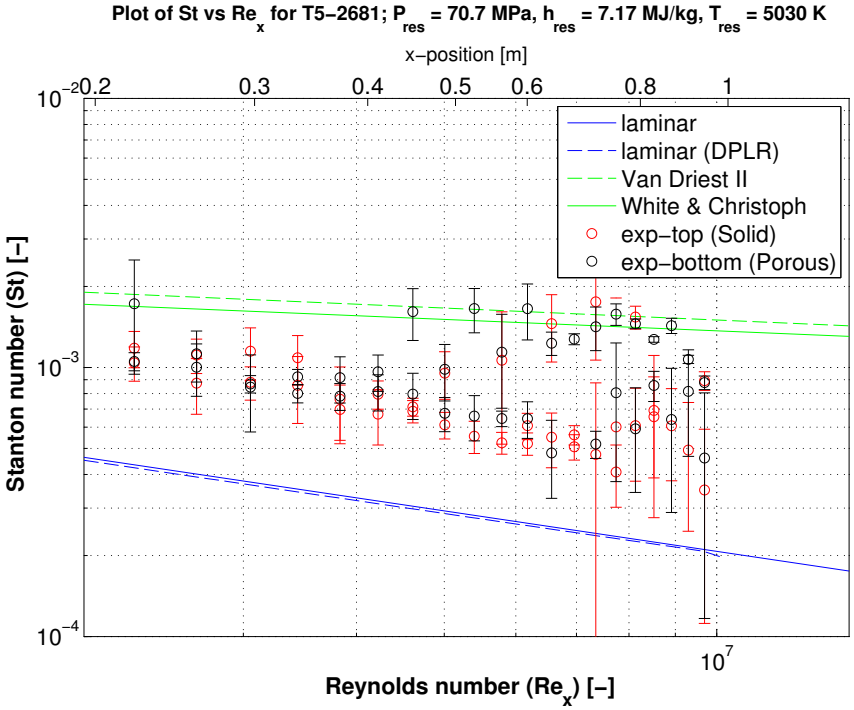


Figure 372: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

125 Shot 2682

Experiment 2682 was performed in T5 on 25 October 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

125.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2670	m/s
Shock Tube Fill Pressure	P_1	140.00	kPa
Reservoir Pressure	P_{res}	67.7	MPa

Table 993: Measured quantities, Shot 2682

125.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4996	K
Reservoir Density	ρ_{res}	45.02	kg/m^3
Reservoir Enthalpy	h_{res}	7.11	MJ/kg

Table 994: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2682

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	1.11×10^{-1}	0	1.38×10^{-1}	0	5.36×10^{-4}	4.83×10^{-2}

Table 995: Computed reservoir species mass fractions, Shot 2682

125.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3499	1007.0	1007.0	5.61	27.7	0.095	7.87×10^6
72 cm	3484	993.4	990.8	5.50	31.4	0.109	9.03×10^6

Table 996: Computed freestream conditions, Shot 2682

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.25×10^{-2}	0	0	3.81×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.78×10^{-2}	0	0	1.48×10^{-3}

Table 997: Computed freestream species mass fractions, Shot 2682

125.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3465	1108.8	1108.8	5.30	40.6	0.127	9.82×10^6
72 cm	3425	1144.9	1143.1	5.03	46.0	0.139	1.05×10^7

Table 998: Computed boundary layer edge conditions, Shot 2682

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.96×10^{-1}	0	6.25×10^{-2}	0	0	3.81×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.78×10^{-2}	0	0	1.46×10^{-3}

Table 999: Computed boundary layer edge species mass fractions, Shot 2682

	T^* K	Unit Re^* 1/m
1D 100 cm	1461	6.28×10^6
72 cm	1428	8.38×10^6

Table 1000: Dorrance reference conditions, Shot 2682

125.5 Stability Computations

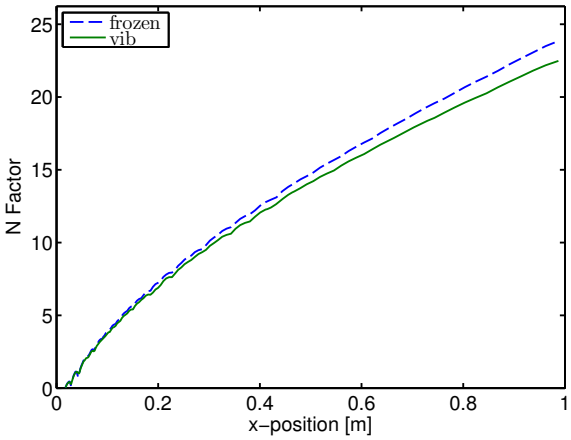


Figure 373: Locus of maximum N factor with and without vibrational energy transfer, Shot 2682

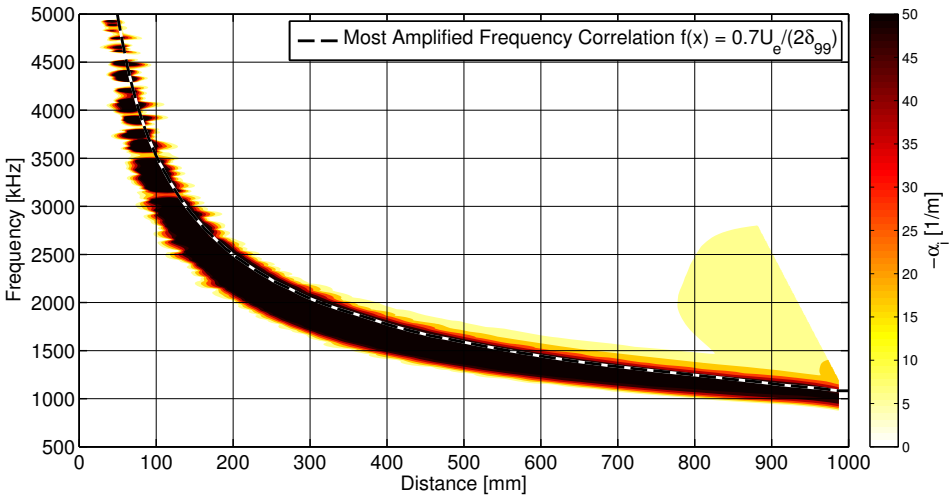


Figure 374: Stability diagram with vibrational energy transfer, Shot 2682. Dashed line indicates $0.7U_e/(2\delta_{99})$.

125.6 Heat Transfer Results

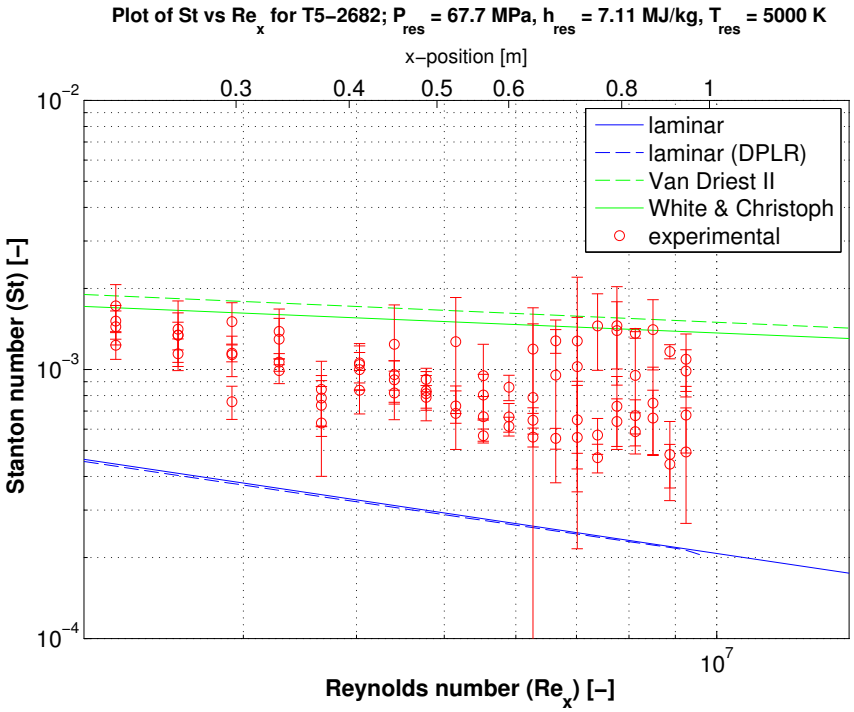


Figure 375: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

126 Shot 2683

Experiment 2683 was performed in T5 on 2 November 2011. The test article was a 1 m 5-degree half-angle cone. The injector section was half sintered metal porous (MG10: 10 micron), half solid (smooth). The initial shock tube composition was 100% air by mass.

126.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	44.8	MPa

Table 1001: Measured quantities, Shot 2683

126.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5250	K
Reservoir Density	ρ_{res}	27.77	kg/m^3
Reservoir Enthalpy	h_{res}	7.85	MJ/kg

Table 1002: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2683

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	8.80×10^{-2}	0	1.36×10^{-1}	0	1.18×10^{-3}	7.21×10^{-2}

Table 1003: Computed reservoir species mass fractions, Shot 2683

126.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3649	1130.0	1130.0	5.52	19.4	0.059	4.78×10^6
72 cm	3622	1136.9	1142.3	5.34	22.1	0.067	5.36×10^6

Table 1004: Computed freestream conditions, Shot 2683

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.23×10^{-2}	0	1.07×10^{-9}	9.73×10^{-3}
72 cm	7.31×10^{-1}	1.87×10^{-1}	0	7.69×10^{-2}	0	1.20×10^{-10}	4.79×10^{-3}

Table 1005: Computed freestream species mass fractions, Shot 2683

126.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3613	1238.9	1238.9	5.22	28.2	0.078	5.93×10^6
72 cm	3561	1299.1	1296.2	4.91	32.0	0.085	6.18×10^6

Table 1006: Computed boundary layer edge conditions, Shot 2683

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.23×10^{-2}	0	1.07×10^{-9}	9.73×10^{-3}
72 cm	7.31×10^{-1}	1.87×10^{-1}	0	7.69×10^{-2}	0	1.20×10^{-9}	4.71×10^{-3}

Table 1007: Computed boundary layer edge species mass fractions, Shot 2683

	T^* K	Unit Re^* 1/m
1D 100 cm	1577	3.97×10^6
72 cm	1547	5.19×10^6

Table 1008: Dorrance reference conditions, Shot 2683

126.5 Stability Computations

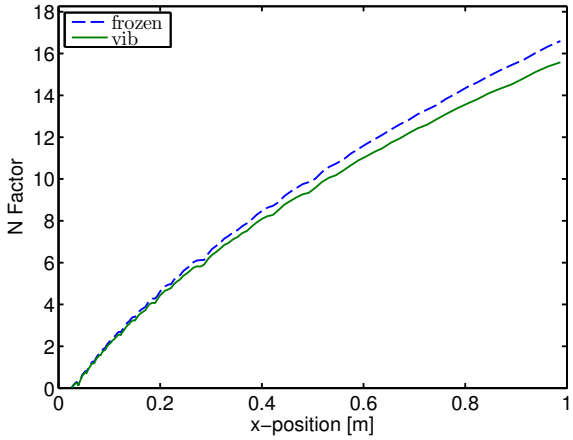


Figure 376: Locus of maximum N factor with and without vibrational energy transfer, Shot 2683

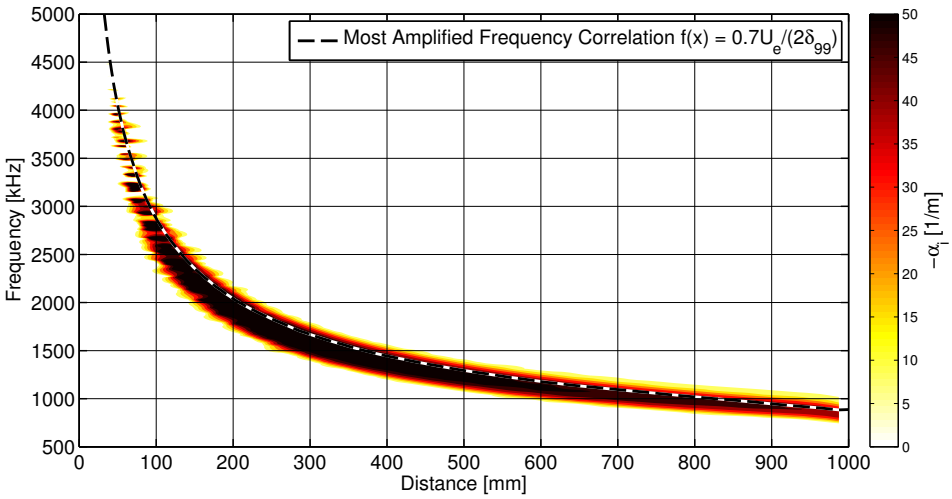


Figure 377: Stability diagram with vibrational energy transfer, Shot 2683. Dashed line indicates $0.7U_e/(2\delta_{99})$.

126.6 Heat Transfer Results

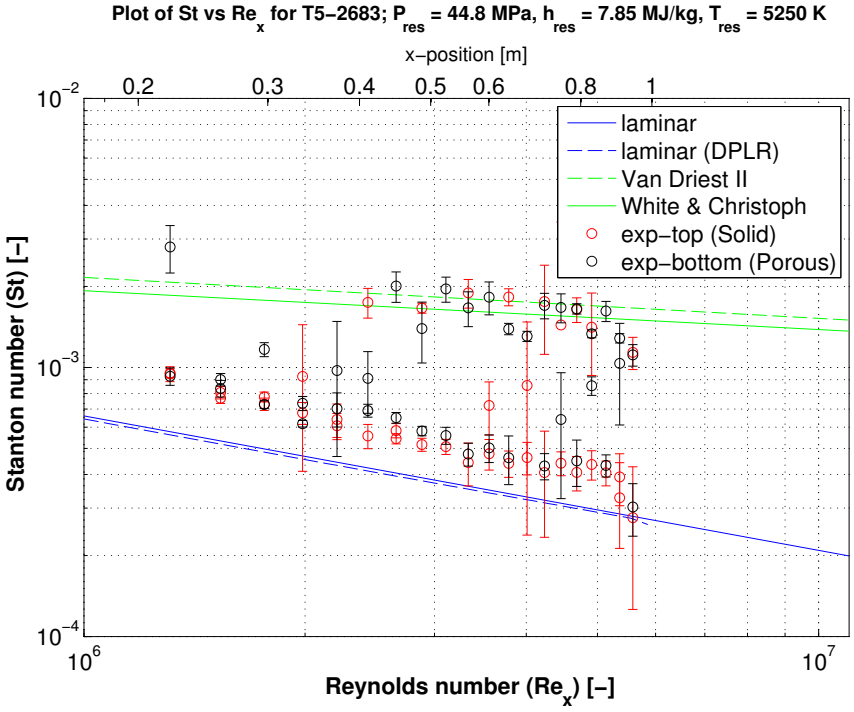


Figure 378: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

127 Shot 2695

Experiment 2695 was performed in T5 on 3 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

127.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2650	m/s
Shock Tube Fill Pressure	P_1	115.10	kPa
Reservoir Pressure	P_{res}	48.4	MPa

Table 1009: Measured quantities, Shot 2695

127.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4834	K
Reservoir Density	ρ_{res}	33.30	kg/m^3
Reservoir Enthalpy	h_{res}	6.85	MJ/kg

Table 1010: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2695

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.05×10^{-1}	1.15×10^{-1}	0	1.32×10^{-1}	0	4.28×10^{-4}	4.73×10^{-2}

Table 1011: Computed reservoir species mass fractions, Shot 2695

127.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3437	957.0	957.0	5.64	19.5	0.070	5.89×10^6
72 cm	3417	950.0	947.1	5.52	22.0	0.080	6.64×10^6

Table 1012: Computed freestream conditions, Shot 2695

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.95×10^{-1}	0	6.30×10^{-2}	0	0	4.72×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.80×10^{-2}	0	0	1.91×10^{-3}

Table 1013: Computed freestream species mass fractions, Shot 2695

127.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3404	1055.2	1055.2	5.32	28.7	0.094	7.36×10^6
72 cm	3359	1098.3	1095.2	5.04	32.3	0.102	7.68×10^6

Table 1014: Computed boundary layer edge conditions, Shot 2695

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.95×10^{-1}	0	6.30×10^{-2}	0	0	4.72×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.80×10^{-2}	0	0	1.89×10^{-3}

Table 1015: Computed boundary layer edge species mass fractions, Shot 2695

	T^* K	Unit Re^* 1/m
1D 100 cm	1413	4.60×10^6
72 cm	1385	6.09×10^6

Table 1016: Dorrance reference conditions, Shot 2695

127.5 Stability Computations

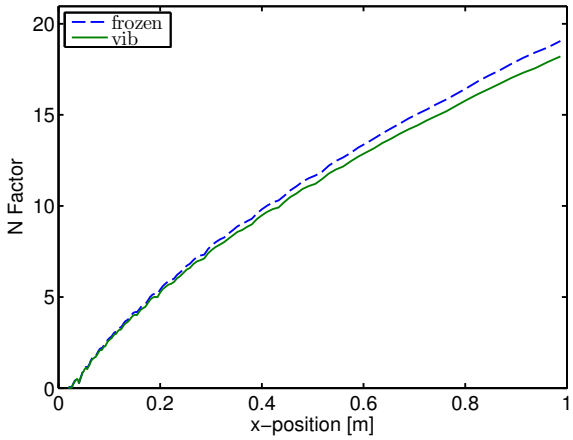


Figure 379: Locus of maximum N factor with and without vibrational energy transfer, Shot 2695

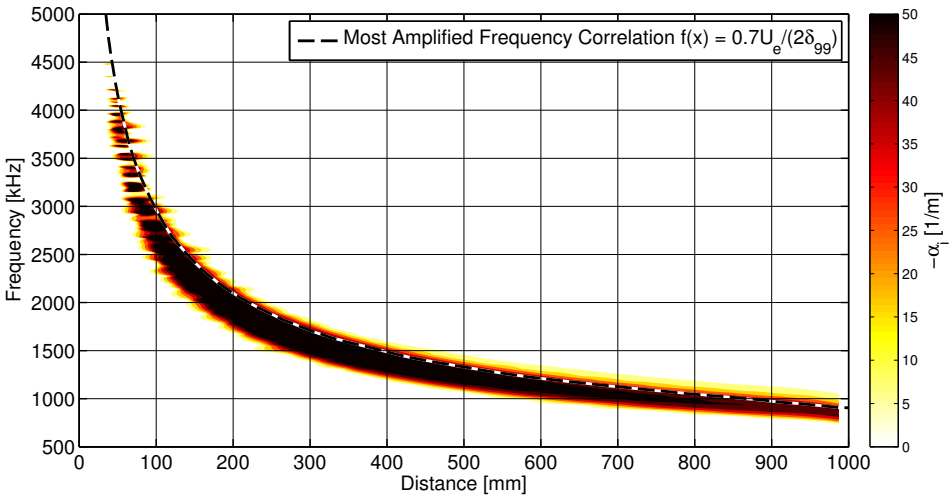


Figure 380: Stability diagram with vibrational energy transfer, Shot 2695. Dashed line indicates $0.7U_e/(2\delta_{99})$.

127.6 Heat Transfer Results

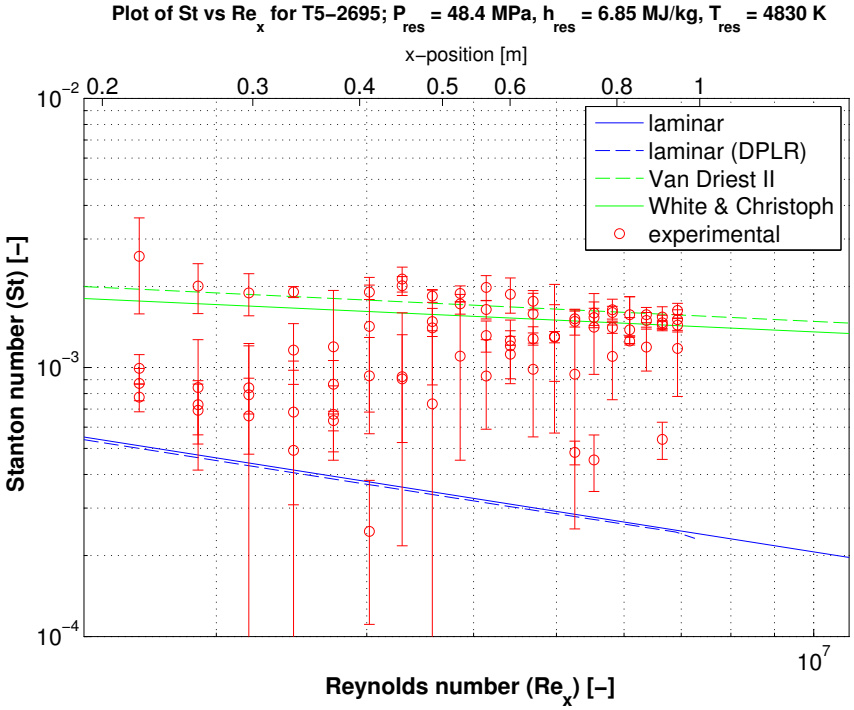


Figure 381: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

128 Shot 2696

Experiment 2696 was performed in T5 on 6 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

128.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2700	m/s
Shock Tube Fill Pressure	P_1	114.65	kPa
Reservoir Pressure	P_{res}	46.0	MPa

Table 1017: Measured quantities, Shot 2696

128.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4880	K
Reservoir Density	ρ_{res}	31.28	kg/m^3
Reservoir Enthalpy	h_{res}	6.97	MJ/kg

Table 1018: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2696

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.05×10^{-1}	1.12×10^{-1}	0	1.32×10^{-1}	0	4.92×10^{-4}	5.07×10^{-2}

Table 1019: Computed reservoir species mass fractions, Shot 2696

128.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3464	978.0	978.0	5.63	18.8	0.066	5.53×10^6
72 cm	3442	973.0	971.7	5.49	21.2	0.075	6.21×10^6

Table 1020: Computed freestream conditions, Shot 2696

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.30×10^{-2}	0	3.95×10^{-10}	5.44×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	0	2.27×10^{-3}

Table 1021: Computed freestream species mass fractions, Shot 2696

128.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3431	1077.6	1077.6	5.31	27.6	0.088	6.90×10^6
72 cm	3383	1122.5	1119.4	5.02	31.0	0.096	7.19×10^6

Table 1022: Computed boundary layer edge conditions, Shot 2696

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.30×10^{-2}	0	3.95×10^{-10}	5.44×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	1.33×10^{-10}	2.25×10^{-3}

Table 1023: Computed boundary layer edge species mass fractions, Shot 2696

	T^* K	Unit Re^* 1/m
1D 100 cm	1433	4.35×10^6
72 cm	1405	5.74×10^6

Table 1024: Dorrance reference conditions, Shot 2696

128.5 Stability Computations

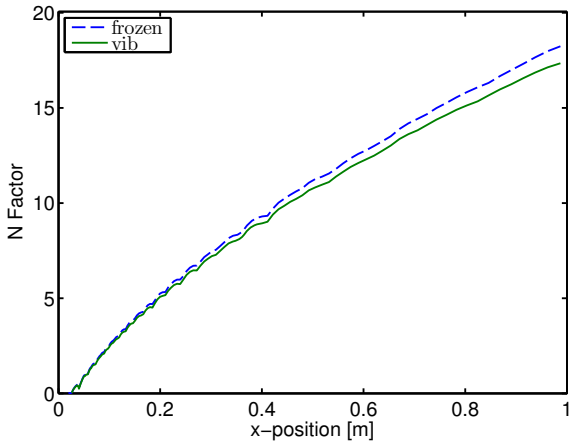


Figure 382: Locus of maximum N factor with and without vibrational energy transfer, Shot 2696

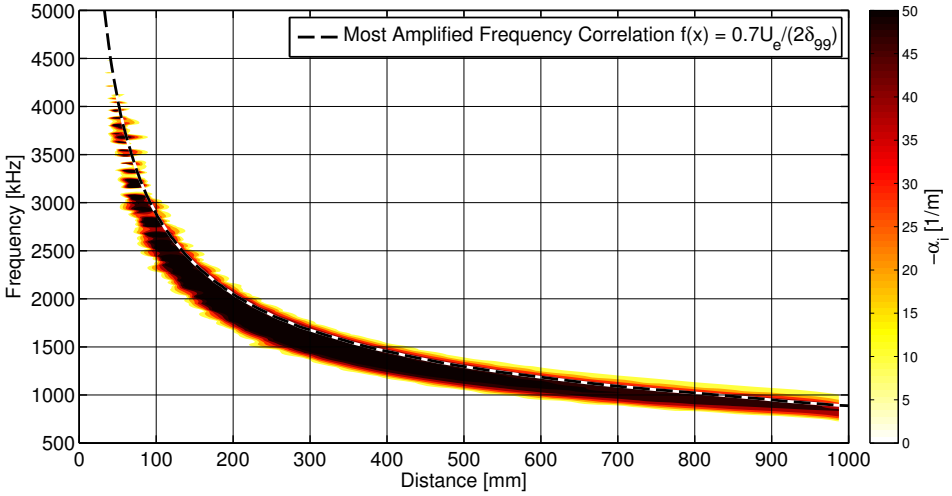


Figure 383: Stability diagram with vibrational energy transfer, Shot 2696. Dashed line indicates $0.7U_e/(2\delta_{99})$.

128.6 Heat Transfer Results

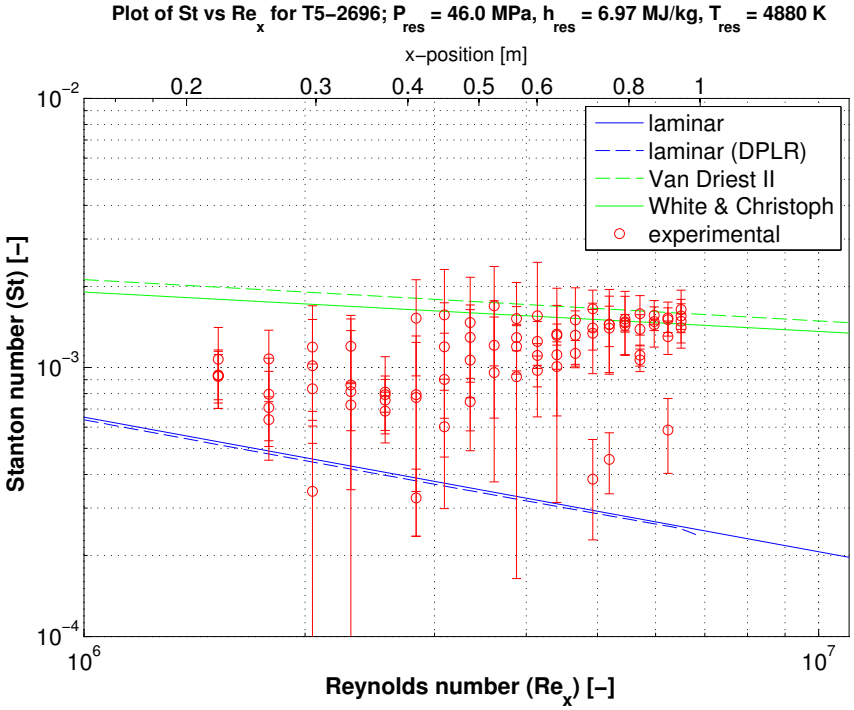


Figure 384: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

129 Shot 2697

Experiment 2697 was performed in T5 on 7 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

129.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2900	m/s
Shock Tube Fill Pressure	P_1	85.05	kPa
Reservoir Pressure	P_{res}	49.3	MPa

Table 1025: Measured quantities, Shot 2697

129.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5482	K
Reservoir Density	ρ_{res}	28.99	kg/m^3
Reservoir Enthalpy	h_{res}	8.36	MJ/kg

Table 1026: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2697

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.65×10^{-2}	0	1.38×10^{-1}	0	1.81×10^{-3}	8.27×10^{-2}

Table 1027: Computed reservoir species mass fractions, Shot 2697

129.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3751	1220.0	1220.0	5.47	21.9	0.062	4.91×10^6
72 cm	3725	1233.0	1239.9	5.26	25.2	0.071	5.53×10^6

Table 1028: Computed freestream conditions, Shot 2697

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.48×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.50×10^{-2}	0	5.26×10^{-10}	6.15×10^{-3}

Table 1029: Computed freestream species mass fractions, Shot 2697

129.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3714	1334.4	1334.4	5.18	31.6	0.081	6.06×10^6
72 cm	3662	1402.4	1399.9	4.85	36.3	0.089	6.35×10^6

Table 1030: Computed boundary layer edge conditions, Shot 2697

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.48×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.50×10^{-2}	0	3.40×10^{-9}	6.00×10^{-3}

Table 1031: Computed boundary layer edge species mass fractions, Shot 2697

	T^* K	Unit Re^* 1/m
1D 100 cm	1662	4.19×10^6
72 cm	1631	5.46×10^6

Table 1032: Dorrance reference conditions, Shot 2697

129.5 Stability Computations

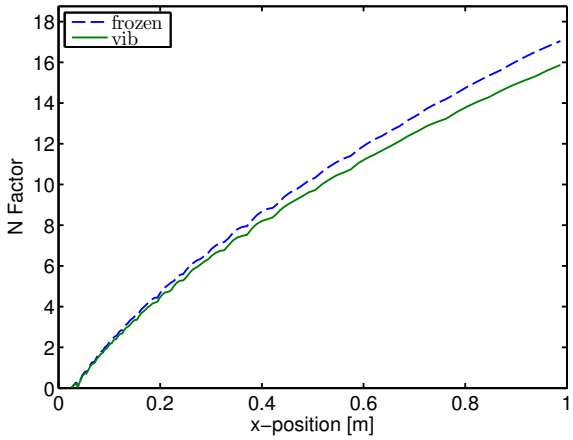


Figure 385: Locus of maximum N factor with and without vibrational energy transfer, Shot 2697

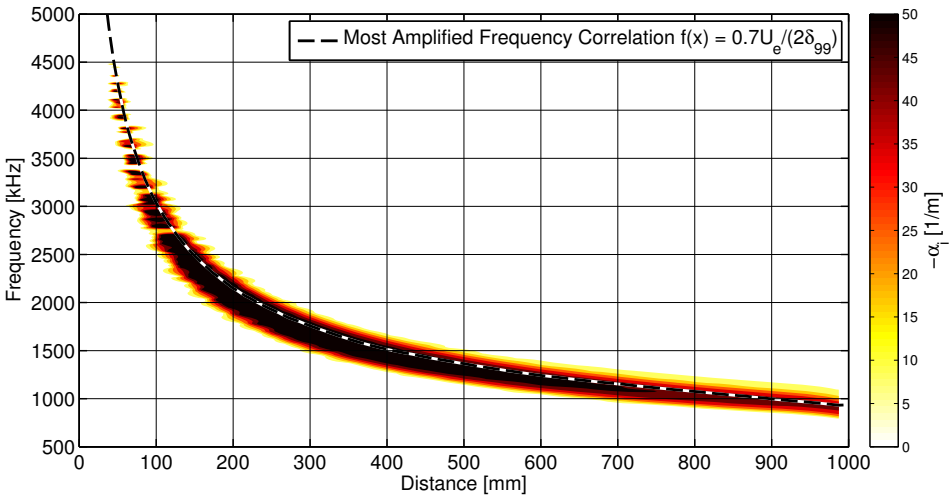


Figure 386: Stability diagram with vibrational energy transfer, Shot 2697. Dashed line indicates $0.7U_e/(2\delta_{99})$.

129.6 Heat Transfer Results

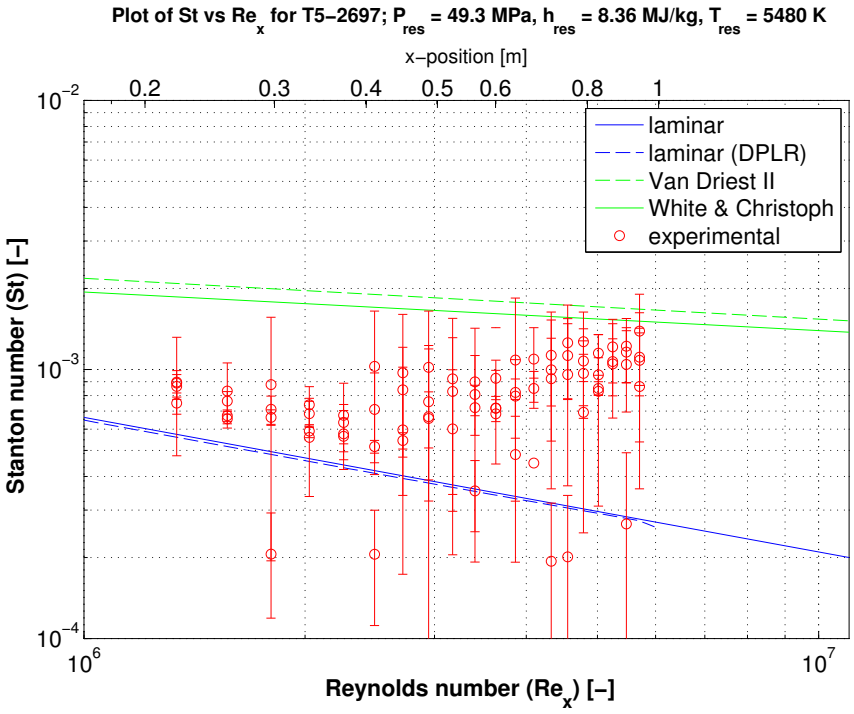


Figure 387: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

130 Shot 2698

Experiment 2698 was performed in T5 on 8 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

130.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2900	m/s
Shock Tube Fill Pressure	P_1	85.25	kPa
Reservoir Pressure	P_{res}	50.1	MPa

Table 1033: Measured quantities, Shot 2698

130.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5495	K
Reservoir Density	ρ_{res}	29.39	kg/m^3
Reservoir Enthalpy	h_{res}	8.39	MJ/kg

Table 1034: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2698

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.61×10^{-2}	0	1.39×10^{-1}	0	1.84×10^{-3}	8.29×10^{-2}

Table 1035: Computed reservoir species mass fractions, Shot 2698

130.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3754	1223.0	1223.0	5.47	22.2	0.062	4.95×10^{6}
72 cm	3730	1237.8	1244.6	5.26	25.7	0.072	5.60×10^{6}

Table 1036: Computed freestream conditions, Shot 2698

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.21×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	5.53×10^{-10}	6.13×10^{-3}

Table 1037: Computed freestream species mass fractions, Shot 2698

130.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3717	1337.2	1337.2	5.18	32.0	0.082	6.10×10^{6}
72 cm	3667	1407.8	1405.3	4.85	37.0	0.091	6.43×10^{6}

Table 1038: Computed boundary layer edge conditions, Shot 2698

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.21×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	3.52×10^{-9}	5.98×10^{-3}

Table 1039: Computed boundary layer edge species mass fractions, Shot 2698

	T^* K	Unit Re^* 1/m
1D 100 cm	1664	4.22×10^{6}
72 cm	1635	5.54×10^{6}

Table 1040: Dorrance reference conditions, Shot 2698

130.5 Stability Computations

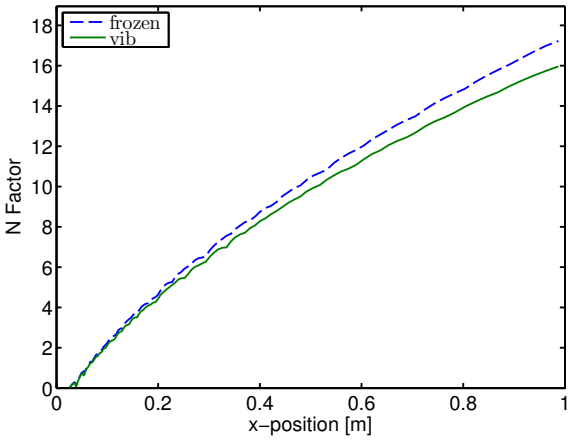


Figure 388: Locus of maximum N factor with and without vibrational energy transfer, Shot 2698

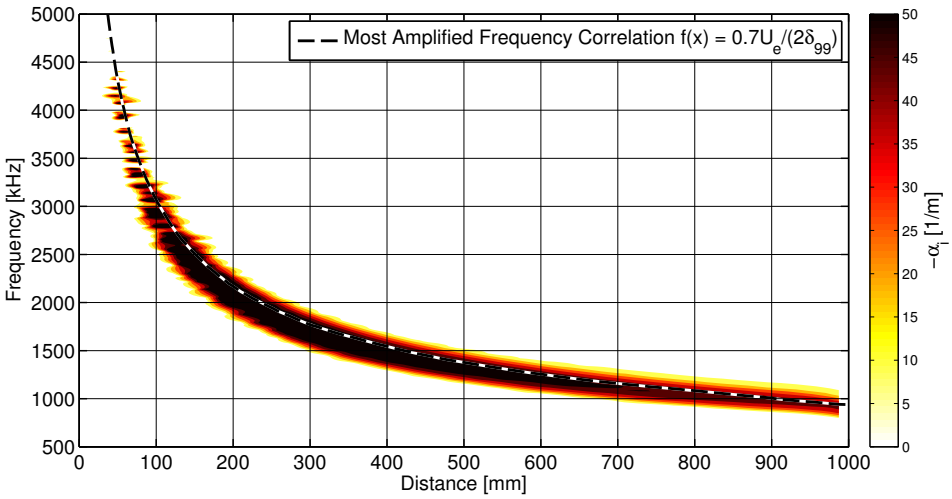


Figure 389: Stability diagram with vibrational energy transfer, Shot 2698. Dashed line indicates $0.7U_e/(2\delta_{99})$.

130.6 Heat Transfer Results

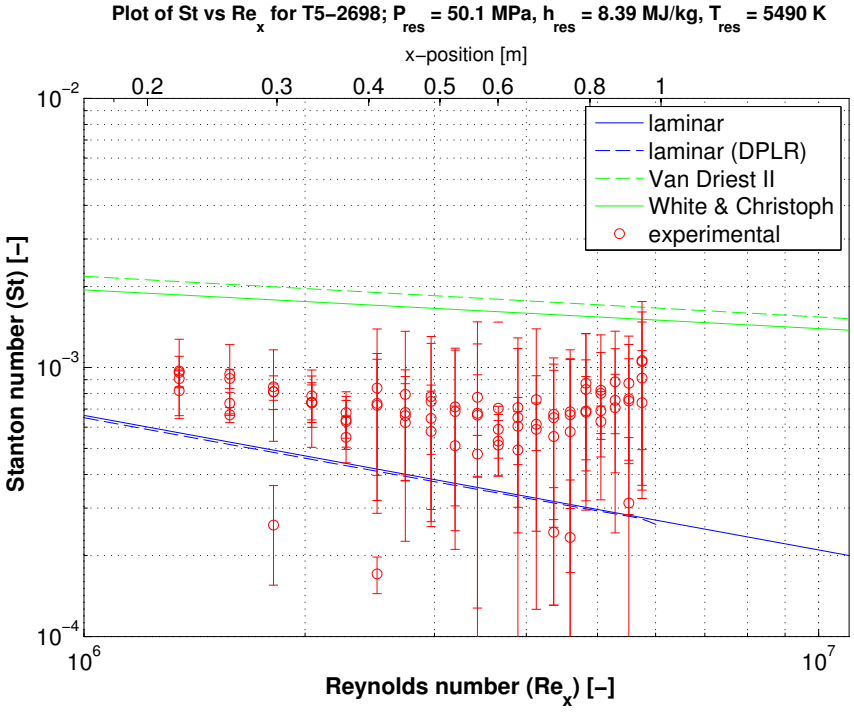


Figure 390: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

131 Shot 2699

Experiment 2699 was performed in T5 on 9 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

131.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	85.10	kPa
Reservoir Pressure	P_{res}	50.3	MPa

Table 1041: Measured quantities, Shot 2699

131.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5525	K
Reservoir Density	ρ_{res}	29.30	kg/m^3
Reservoir Enthalpy	h_{res}	8.46	MJ/kg

Table 1042: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2699

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.45×10^{-2}	0	1.39×10^{-1}	0	1.95×10^{-3}	8.45×10^{-2}

Table 1043: Computed reservoir species mass fractions, Shot 2699

131.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3768	1235.0	1235.0	5.46	22.4	0.062	4.92×10^{6}
72 cm	3744	1251.2	1258.2	5.25	25.9	0.071	5.57×10^{6}

Table 1044: Computed freestream conditions, Shot 2699

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	3.22×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	6.72×10^{-10}	6.40×10^{-3}

Table 1045: Computed freestream species mass fractions, Shot 2699

131.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3731	1350.6	1350.6	5.17	32.2	0.082	6.07×10^{6}
72 cm	3680	1422.2	1419.8	4.84	37.3	0.090	6.39×10^{6}

Table 1046: Computed boundary layer edge conditions, Shot 2699

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	3.22×10^{-10}	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.46×10^{-2}	0	4.10×10^{-9}	6.24×10^{-3}

Table 1047: Computed boundary layer edge species mass fractions, Shot 2699

	T^* K	Unit Re^* 1/m
1D 100 cm	1676	4.22×10^{6}
72 cm	1647	5.52×10^{6}

Table 1048: Dorrance reference conditions, Shot 2699

131.5 Stability Computations

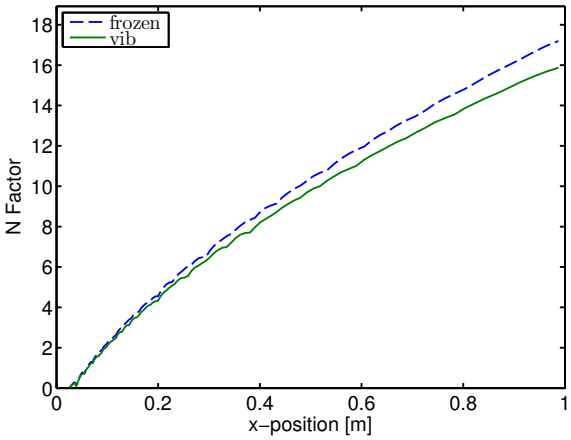


Figure 391: Locus of maximum N factor with and without vibrational energy transfer, Shot 2699

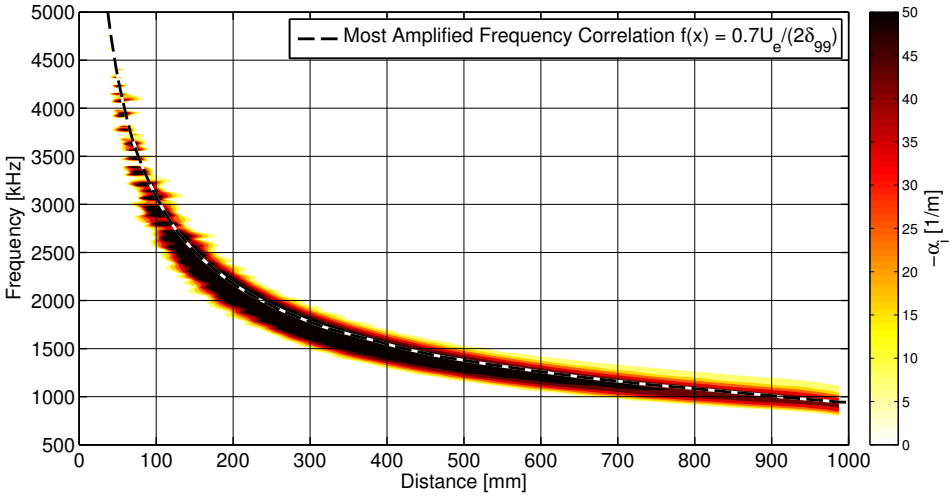


Figure 392: Stability diagram with vibrational energy transfer, Shot 2699. Dashed line indicates $0.7U_e/(2\delta_{99})$.

131.6 Heat Transfer Results

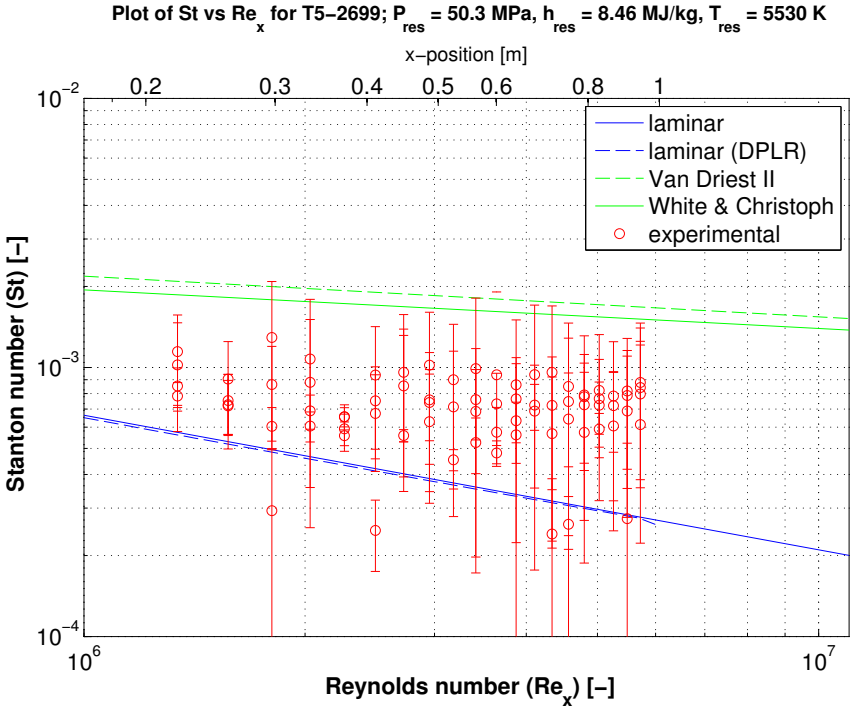


Figure 393: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

132 Shot 2700

Experiment 2700 was performed in T5 on 10 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

132.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3680	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	49.4	MPa

Table 1049: Measured quantities, Shot 2700

132.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7425	K
Reservoir Density	ρ_{res}	19.52	kg/m^3
Reservoir Enthalpy	h_{res}	13.4	MJ/kg

Table 1050: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2700

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.89×10^{-1}	1.46×10^{-2}	0	9.77×10^{-2}	0	3.26×10^{-2}	1.66×10^{-1}

Table 1051: Computed reservoir species mass fractions, Shot 2700

132.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4578	1933.0	1933.0	5.21	24.4	0.042	2.95×10^6
72 cm	4528	2031.0	2039.9	4.88	30.0	0.049	3.34×10^6

Table 1052: Computed freestream conditions, Shot 2700

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.43×10^{-1}	1.45×10^{-1}	0	5.19×10^{-2}	0	4.70×10^{-7}	5.98×10^{-2}
72 cm	7.35×10^{-1}	1.52×10^{-1}	0	6.81×10^{-2}	0	1.01×10^{-6}	4.48×10^{-2}

Table 1053: Computed freestream species mass fractions, Shot 2700

132.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4532	2097.6	2097.6	4.95	34.2	0.054	3.56×10^6
72 cm	4452	2289.6	2287.2	4.53	41.8	0.061	3.74×10^6

Table 1054: Computed boundary layer edge conditions, Shot 2700

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.43×10^{-1}	1.45×10^{-1}	0	5.19×10^{-2}	0	4.70×10^{-7}	5.98×10^{-2}
72 cm	7.35×10^{-1}	1.54×10^{-1}	0	6.78×10^{-2}	0	2.39×10^{-6}	4.26×10^{-2}

Table 1055: Computed boundary layer edge species mass fractions, Shot 2700

	T^* K	Unit Re^* 1/m
1D 100 cm	2386	2.86×10^6
72 cm	2379	3.60×10^6

Table 1056: Dorrance reference conditions, Shot 2700

132.5 Stability Computations

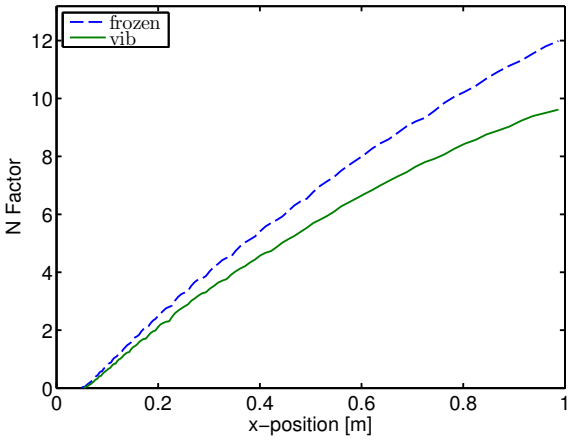


Figure 394: Locus of maximum N factor with and without vibrational energy transfer, Shot 2700

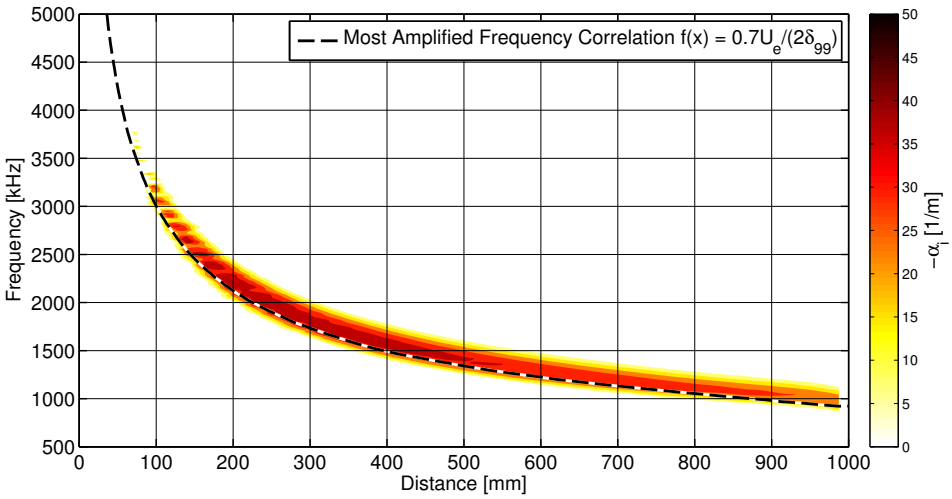


Figure 395: Stability diagram with vibrational energy transfer, Shot 2700. Dashed line indicates $0.7U_e/(2\delta_{99})$.

132.6 Heat Transfer Results

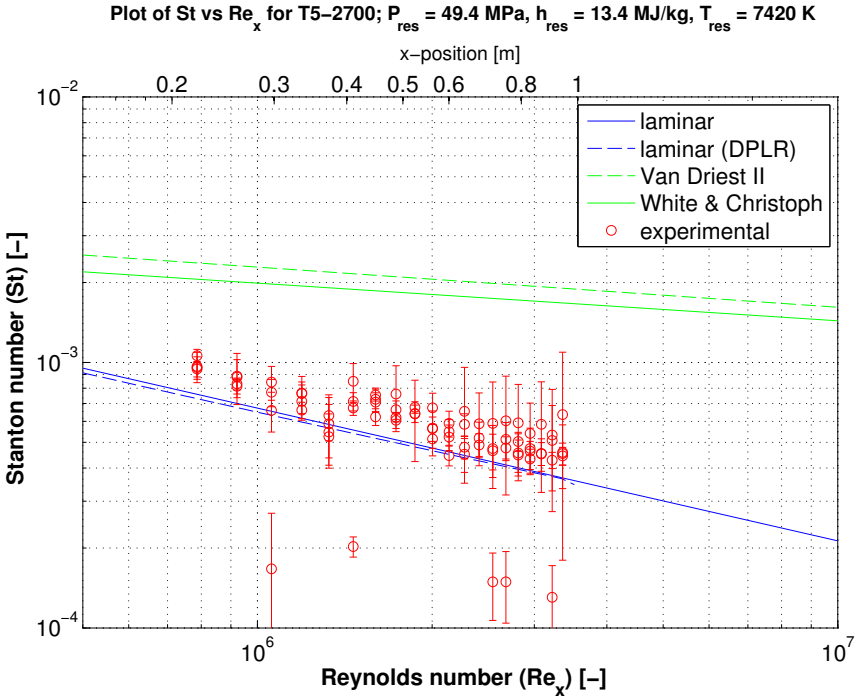


Figure 396: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

133 Shot 2701

Experiment 2701 was performed in T5 on 13 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

133.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	48.5	MPa

Table 1057: Measured quantities, Shot 2701

133.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5572	K
Reservoir Density	ρ_{res}	27.94	kg/m^3
Reservoir Enthalpy	h_{res}	8.59	MJ/kg

Table 1058: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2701

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.12×10^{-2}	0	1.38×10^{-1}	0	2.18×10^{-3}	8.83×10^{-2}

Table 1059: Computed reservoir species mass fractions, Shot 2701

133.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3791	1255.0	1255.0	5.45	21.7	0.059	4.68×10^{6}
72 cm	3766	1274.2	1281.9	5.23	25.2	0.068	5.29×10^{6}

Table 1060: Computed freestream conditions, Shot 2701

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.15×10^{-2}	0	8.63×10^{-10}	1.32×10^{-2}
72 cm	7.32×10^{-1}	1.86×10^{-1}	0	7.43×10^{-2}	0	9.87×10^{-10}	7.24×10^{-3}

Table 1061: Computed freestream species mass fractions, Shot 2701

133.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3754	1371.2	1371.2	5.16	31.2	0.078	5.77×10^{6}
72 cm	3703	1446.9	1444.4	4.83	36.2	0.086	6.06×10^{6}

Table 1062: Computed boundary layer edge conditions, Shot 2701

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.15×10^{-2}	0	8.63×10^{-10}	1.32×10^{-2}
72 cm	7.32×10^{-1}	1.86×10^{-1}	0	7.43×10^{-2}	0	5.63×10^{-9}	7.06×10^{-3}

Table 1063: Computed boundary layer edge species mass fractions, Shot 2701

	T^* K	Unit Re^* 1/m
1D 100 cm	1695	4.03×10^{6}
72 cm	1667	5.26×10^{6}

Table 1064: Dorrance reference conditions, Shot 2701

133.5 Stability Computations

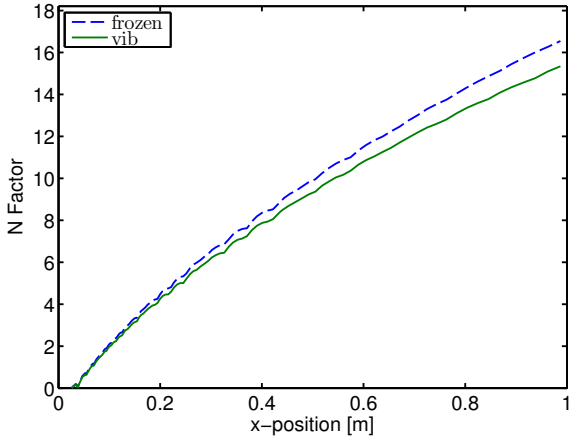


Figure 397: Locus of maximum N factor with and without vibrational energy transfer, Shot 2701

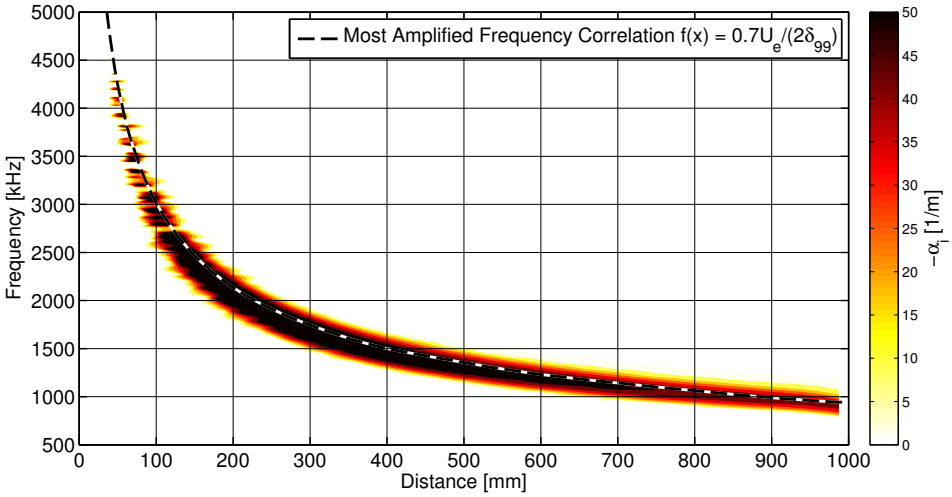


Figure 398: Stability diagram with vibrational energy transfer, Shot 2701. Dashed line indicates $0.7U_e/(2\delta_{99})$.

133.6 Heat Transfer Results

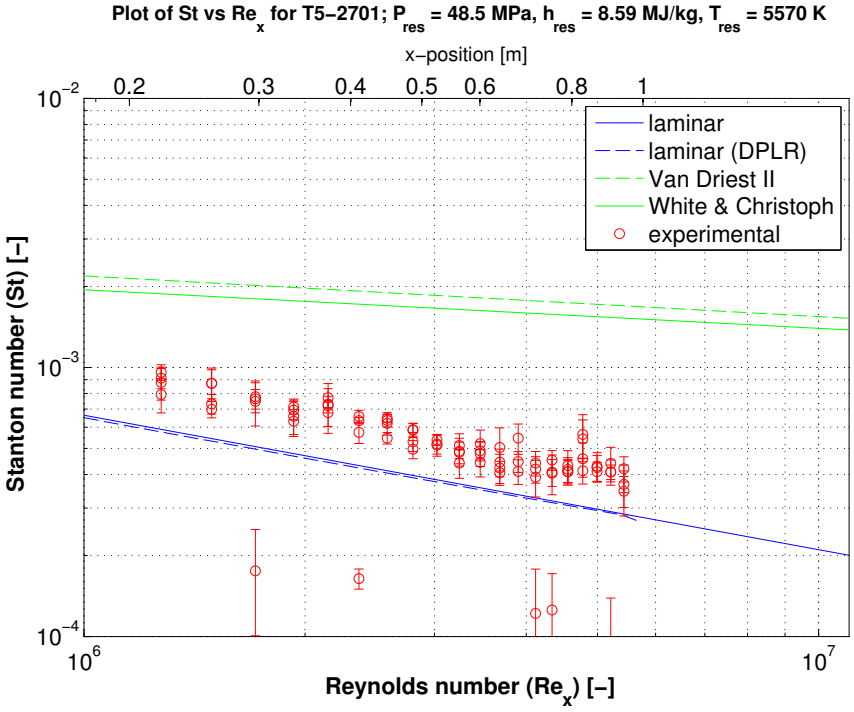


Figure 399: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

134 Shot 2702

Experiment 2702 was performed in T5 on 14 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

134.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	49.9	MPa

Table 1065: Measured quantities, Shot 2702

134.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5518	K
Reservoir Density	ρ_{res}	29.08	kg/m^3
Reservoir Enthalpy	h_{res}	8.45	MJ/kg

Table 1066: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2702

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.47×10^{-2}	0	1.38×10^{-1}	0	1.93×10^{-3}	8.44×10^{-2}

Table 1067: Computed reservoir species mass fractions, Shot 2702

134.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3766	1234.0	1234.0	5.46	22.2	0.062	4.90×10^{6}
72 cm	3741	1248.6	1255.6	5.25	25.7	0.071	5.53×10^{6}

Table 1068: Computed freestream conditions, Shot 2702

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	0	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.47×10^{-2}	0	6.55×10^{-10}	6.41×10^{-3}

Table 1069: Computed freestream species mass fractions, Shot 2702

134.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3729	1349.1	1349.1	5.17	32.0	0.081	6.05×10^{6}
72 cm	3678	1419.2	1416.8	4.84	36.9	0.090	6.35×10^{6}

Table 1070: Computed boundary layer edge conditions, Shot 2702

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	0	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.47×10^{-2}	0	4.01×10^{-9}	6.25×10^{-3}

Table 1071: Computed boundary layer edge species mass fractions, Shot 2702

	T^* K	Unit Re^* 1/m
1D 100 cm	1675	4.20×10^{6}
72 cm	1644	5.48×10^{6}

Table 1072: Dorrance reference conditions, Shot 2702

134.5 Stability Computations

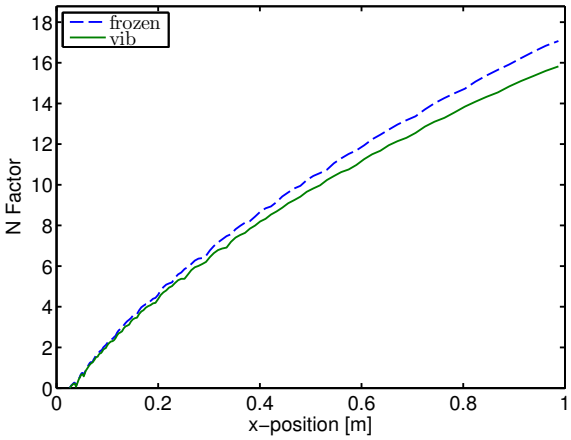


Figure 400: Locus of maximum N factor with and without vibrational energy transfer, Shot 2702

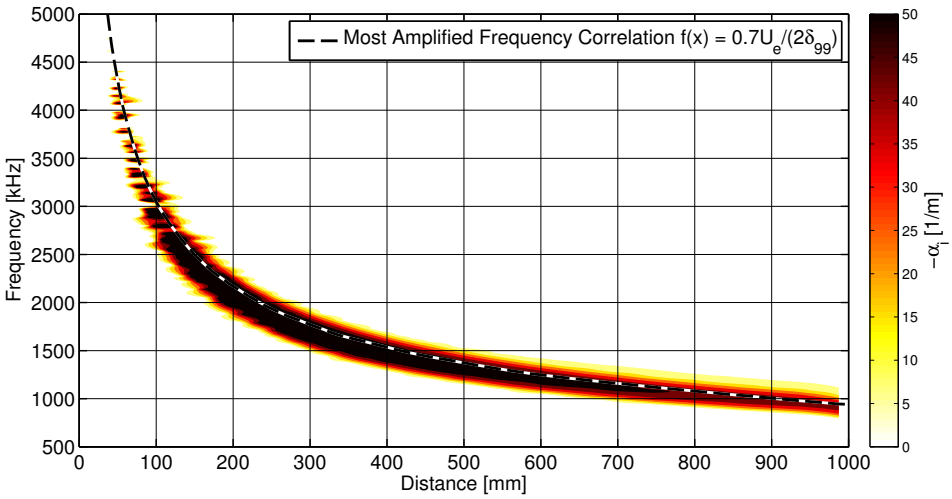


Figure 401: Stability diagram with vibrational energy transfer, Shot 2702. Dashed line indicates $0.7U_e/(2\delta_{99})$.

134.6 Heat Transfer Results

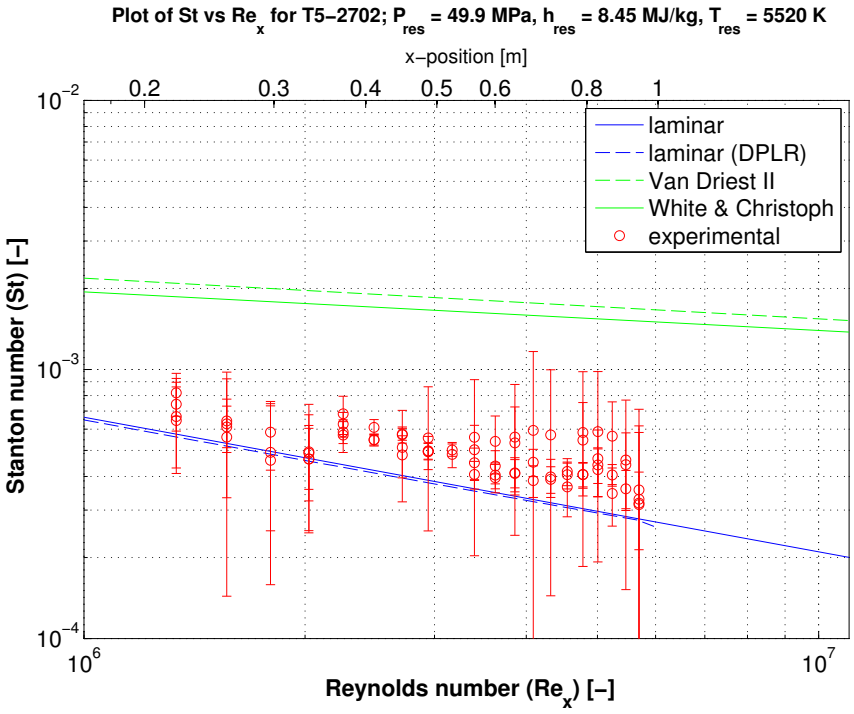


Figure 402: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

135 Shot 2703

Experiment 2703 was performed in T5 on 16 February 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

135.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2930	m/s
Shock Tube Fill Pressure	P_1	85.15	kPa
Reservoir Pressure	P_{res}	48.5	MPa

Table 1073: Measured quantities, Shot 2703

135.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5517	K
Reservoir Density	ρ_{res}	28.25	kg/m^3
Reservoir Enthalpy	h_{res}	8.46	MJ/kg

Table 1074: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2703

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.42×10^{-2}	0	1.38×10^{-1}	0	1.96×10^{-3}	8.52×10^{-2}

Table 1075: Computed reservoir species mass fractions, Shot 2703

135.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3765	1231.0	1231.0	5.46	21.4	0.060	4.74×10^{6}
72 cm	3742	1250.1	1257.4	5.25	25.0	0.069	5.37×10^{6}

Table 1076: Computed freestream conditions, Shot 2703

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	3.46×10^{-10}	1.24×10^{-2}
72 cm	7.32×10^{-1}	1.86×10^{-1}	0	7.47×10^{-2}	0	6.96×10^{-10}	6.68×10^{-3}

Table 1077: Computed freestream species mass fractions, Shot 2703

135.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3728	1346.5	1346.5	5.17	30.9	0.079	5.84×10^{6}
72 cm	3678	1421.2	1418.7	4.84	35.9	0.087	6.16×10^{6}

Table 1078: Computed boundary layer edge conditions, Shot 2703

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	3.46×10^{-10}	1.24×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.47×10^{-2}	0	4.28×10^{-9}	6.51×10^{-3}

Table 1079: Computed boundary layer edge species mass fractions, Shot 2703

	T^* K	Unit Re^* 1/m
1D 100 cm	1673	4.05×10^{6}
72 cm	1646	5.31×10^{6}

Table 1080: Dorrance reference conditions, Shot 2703

135.5 Stability Computations

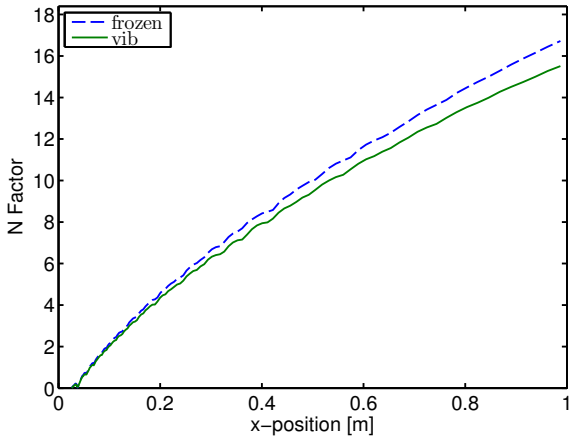


Figure 403: Locus of maximum N factor with and without vibrational energy transfer, Shot 2703

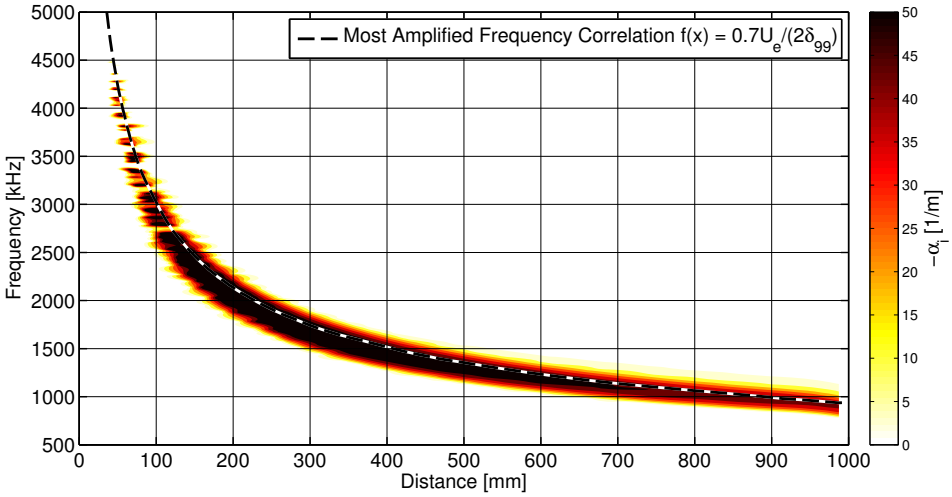


Figure 404: Stability diagram with vibrational energy transfer, Shot 2703. Dashed line indicates $0.7U_e/(2\delta_{99})$.

135.6 Heat Transfer Results

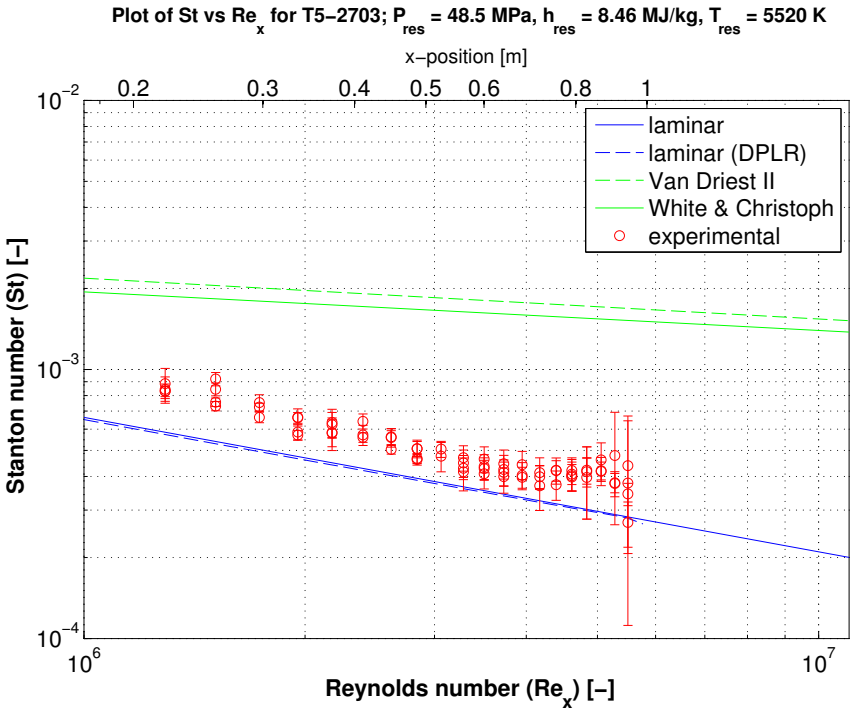


Figure 405: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

136 Shot 2704

Experiment 2704 was performed in T5 on 5 April 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

136.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	49.5	MPa

Table 1081: Measured quantities, Shot 2704

136.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5512	K
Reservoir Density	ρ_{res}	28.91	kg/m^3
Reservoir Enthalpy	h_{res}	8.43	MJ/kg

Table 1082: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2704

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.49×10^{-2}	0	1.38×10^{-1}	0	1.92×10^{-3}	8.43×10^{-2}

Table 1083: Computed reservoir species mass fractions, Shot 2704

136.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3765	1232.0	1232.0	5.46	22.1	0.062	4.89×10^{6}
72 cm	3738	1246.1	1253.2	5.25	25.5	0.070	5.50×10^{6}

Table 1084: Computed freestream conditions, Shot 2704

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	0	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.47×10^{-2}	0	6.37×10^{-10}	6.41×10^{-3}

Table 1085: Computed freestream species mass fractions, Shot 2704

136.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3728	1347.4	1347.4	5.17	31.9	0.081	6.03×10^{6}
72 cm	3675	1416.8	1414.3	4.84	36.6	0.089	6.31×10^{6}

Table 1086: Computed boundary layer edge conditions, Shot 2704

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.16×10^{-2}	0	0	1.20×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.47×10^{-2}	0	3.96×10^{-9}	6.25×10^{-3}

Table 1087: Computed boundary layer edge species mass fractions, Shot 2704

	T^* K	Unit Re^* 1/m
1D 100 cm	1674	4.18×10^{6}
72 cm	1642	5.44×10^{6}

Table 1088: Dorrance reference conditions, Shot 2704

136.5 Stability Computations

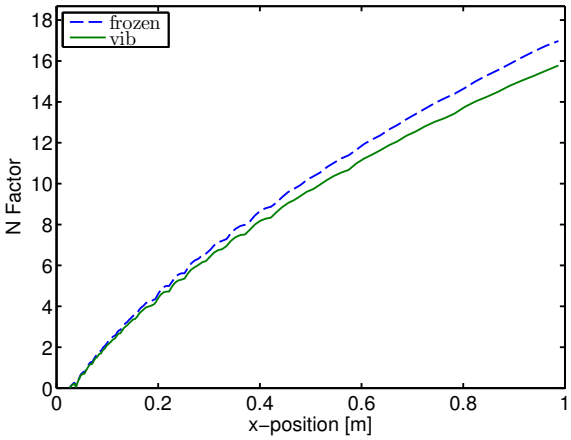


Figure 406: Locus of maximum N factor with and without vibrational energy transfer, Shot 2704

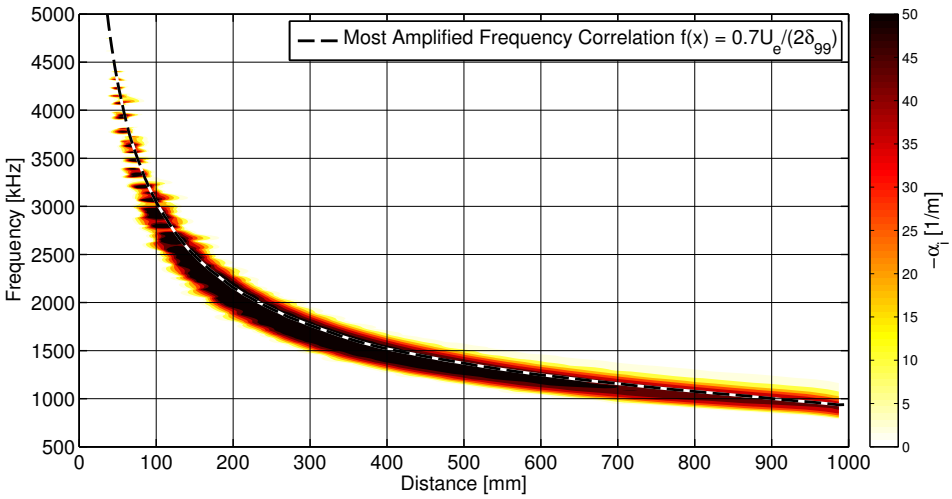


Figure 407: Stability diagram with vibrational energy transfer, Shot 2704. Dashed line indicates $0.7U_e/(2\delta_{99})$.

136.6 Heat Transfer Results

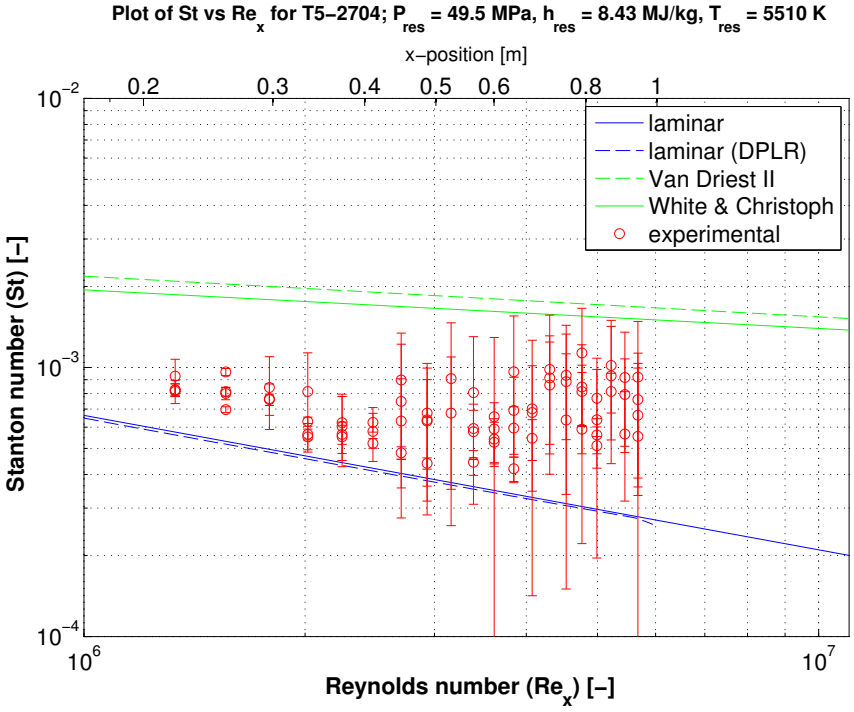


Figure 408: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

137 Shot 2705

Experiment 2705 was performed in T5 on 6 April 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

137.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2900	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	50.0	MPa

Table 1089: Measured quantities, Shot 2705

137.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5494	K
Reservoir Density	ρ_{res}	29.31	kg/m^3
Reservoir Enthalpy	h_{res}	8.39	MJ/kg

Table 1090: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2705

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	7.61×10^{-2}	0	1.38×10^{-1}	0	1.84×10^{-3}	8.30×10^{-2}

Table 1091: Computed reservoir species mass fractions, Shot 2705

137.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3754	1223.0	1223.0	5.47	22.1	0.062	4.94×10^{6}
72 cm	3730	1237.8	1244.6	5.26	25.6	0.071	5.59×10^{6}

Table 1092: Computed freestream conditions, Shot 2705

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.77×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	5.55×10^{-10}	6.15×10^{-3}

Table 1093: Computed freestream species mass fractions, Shot 2705

137.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3717	1337.6	1337.6	5.18	31.9	0.082	6.09×10^{6}
72 cm	3667	1407.7	1405.2	4.85	36.9	0.090	6.41×10^{6}

Table 1094: Computed boundary layer edge conditions, Shot 2705

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.17×10^{-2}	0	2.77×10^{-10}	1.16×10^{-2}
72 cm	7.32×10^{-1}	1.87×10^{-1}	0	7.49×10^{-2}	0	3.53×10^{-9}	6.00×10^{-3}

Table 1095: Computed boundary layer edge species mass fractions, Shot 2705

	T^* K	Unit Re^* 1/m
1D 100 cm	1665	4.22×10^{6}
72 cm	1635	5.52×10^{6}

Table 1096: Dorrance reference conditions, Shot 2705

137.5 Stability Computations

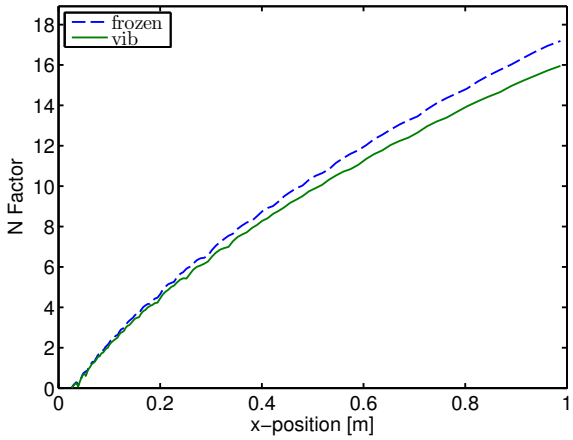


Figure 409: Locus of maximum N factor with and without vibrational energy transfer, Shot 2705

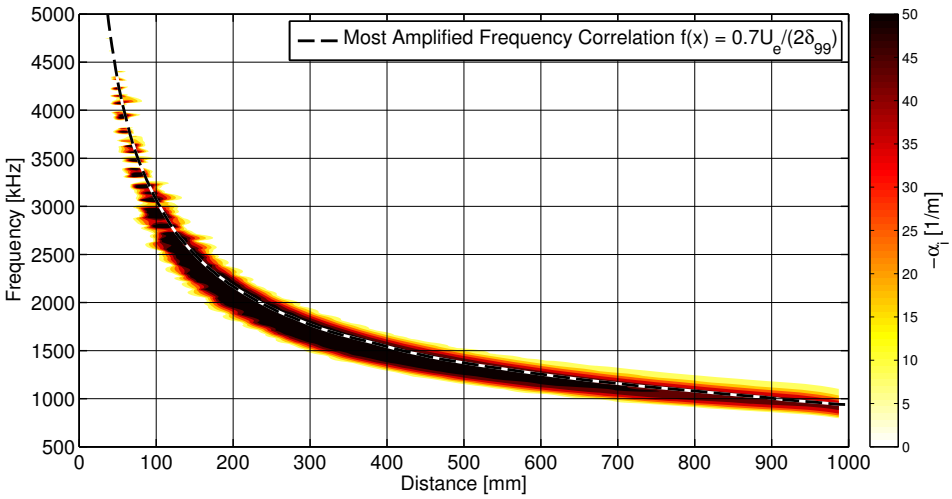


Figure 410: Stability diagram with vibrational energy transfer, Shot 2705. Dashed line indicates $0.7U_e/(2\delta_{99})$.

137.6 Heat Transfer Results

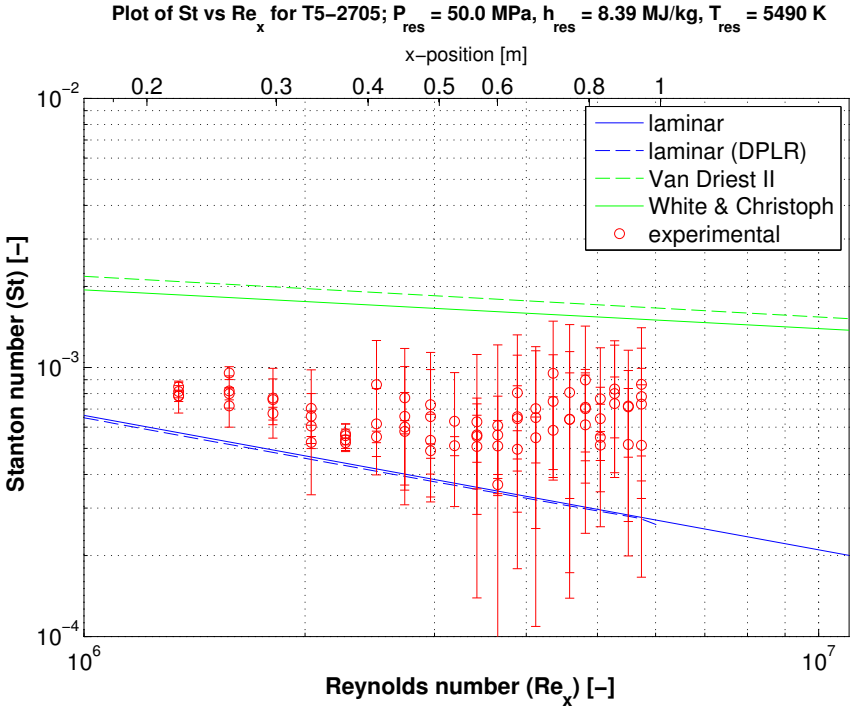


Figure 411: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

138 Shot 2706

Experiment 2706 was performed in T5 on 9 April 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

138.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3090	m/s
Shock Tube Fill Pressure	P_1	84.75	kPa
Reservoir Pressure	P_{res}	49.0	MPa

Table 1097: Measured quantities, Shot 2706

138.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5842	K
Reservoir Density	ρ_{res}	26.56	kg/m^3
Reservoir Enthalpy	h_{res}	9.24	MJ/kg

Table 1098: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2706

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	5.78×10^{-2}	0	1.35×10^{-1}	0	3.57×10^{-3}	1.03×10^{-1}

Table 1099: Computed reservoir species mass fractions, Shot 2706

138.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3910	1360.0	1360.0	5.39	22.5	0.057	4.37×10^6
72 cm	3884	1392.0	1401.2	5.15	26.4	0.065	4.94×10^6

Table 1100: Computed freestream conditions, Shot 2706

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.06×10^{-2}	0	1.82×10^{-9}	1.77×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.30×10^{-2}	0	4.57×10^{-9}	1.04×10^{-2}

Table 1101: Computed freestream species mass fractions, Shot 2706

138.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3872	1483.7	1483.7	5.11	32.2	0.074	5.35×10^6
72 cm	3819	1574.9	1572.5	4.76	37.6	0.082	5.62×10^6

Table 1102: Computed boundary layer edge conditions, Shot 2706

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	6.06×10^{-2}	0	1.82×10^{-9}	1.77×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.30×10^{-2}	0	1.97×10^{-8}	1.01×10^{-2}

Table 1103: Computed boundary layer edge species mass fractions, Shot 2706

	T^* K	Unit Re^* 1/m
1D 100 cm	1796	3.87×10^6
72 cm	1771	5.00×10^6

Table 1104: Dorrance reference conditions, Shot 2706

138.5 Stability Computations

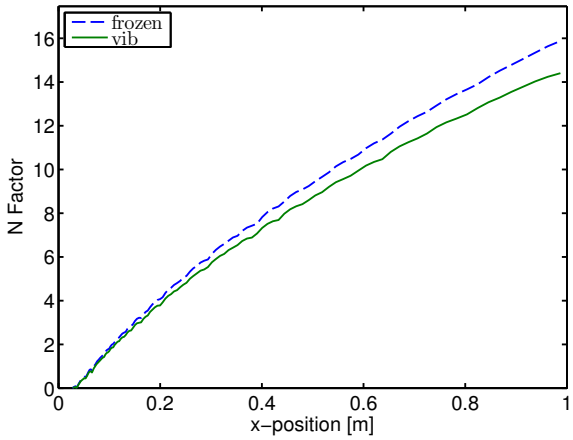


Figure 412: Locus of maximum N factor with and without vibrational energy transfer, Shot 2706

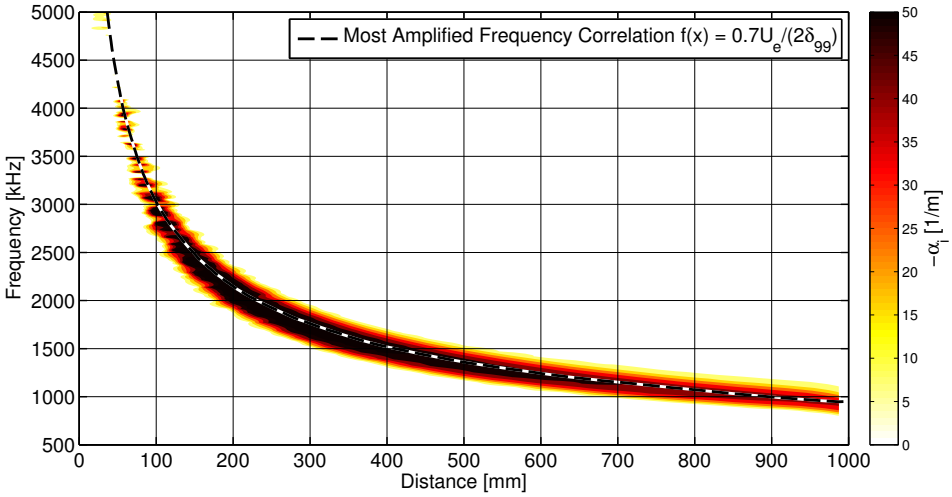


Figure 413: Stability diagram with vibrational energy transfer, Shot 2706. Dashed line indicates $0.7U_e/(2\delta_{99})$.

138.6 Heat Transfer Results

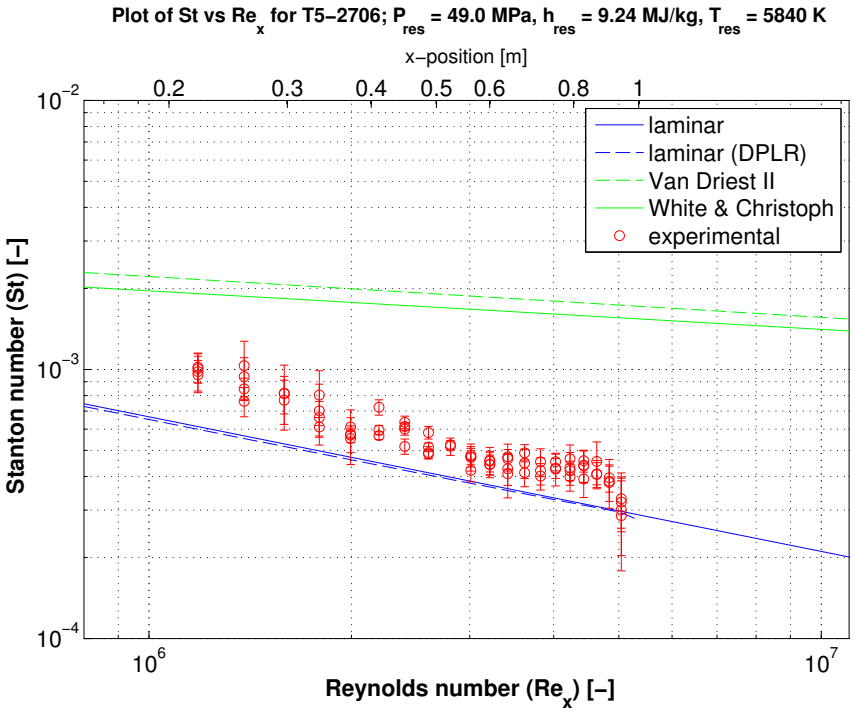


Figure 414: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

139 Shot 2707

Experiment 2707 was performed in T5 on 24 April 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

139.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3060	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	49.5	MPa

Table 1105: Measured quantities, Shot 2707

139.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5789	K
Reservoir Density	ρ_{res}	27.13	kg/m^3
Reservoir Enthalpy	h_{res}	9.10	MJ/kg

Table 1106: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2707

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	6.05×10^{-2}	0	1.36×10^{-1}	0	3.23×10^{-3}	9.99×10^{-2}

Table 1107: Computed reservoir species mass fractions, Shot 2707

139.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3883	1336.0	1336.0	5.40	22.4	0.057	4.45×10^6
72 cm	3861	1368.4	1377.2	5.17	26.5	0.066	5.06×10^6

Table 1108: Computed freestream conditions, Shot 2707

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.08×10^{-2}	0	1.26×10^{-9}	1.65×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.31×10^{-2}	0	3.38×10^{-9}	9.55×10^{-3}

Table 1109: Computed freestream species mass fractions, Shot 2707

139.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3845	1458.0	1458.0	5.12	32.0	0.075	5.45×10^6
72 cm	3796	1549.0	1546.6	4.78	37.8	0.084	5.77×10^6

Table 1110: Computed boundary layer edge conditions, Shot 2707

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.08×10^{-2}	0	1.26×10^{-9}	1.65×10^{-2}
72 cm	7.33×10^{-1}	1.85×10^{-1}	0	7.31×10^{-2}	0	1.53×10^{-8}	9.27×10^{-3}

Table 1111: Computed boundary layer edge species mass fractions, Shot 2707

	T^* K	Unit Re^* 1/m
1D 100 cm	1773	3.92×10^6
72 cm	1750	5.11×10^6

Table 1112: Dorrance reference conditions, Shot 2707

139.5 Stability Computations

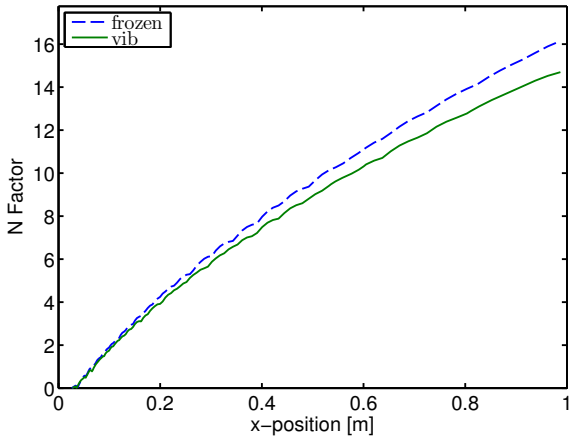


Figure 415: Locus of maximum N factor with and without vibrational energy transfer, Shot 2707

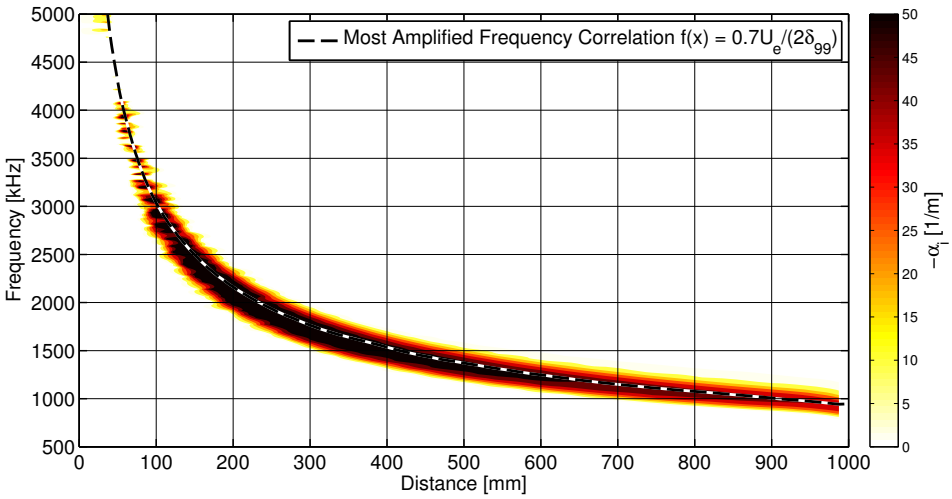


Figure 416: Stability diagram with vibrational energy transfer, Shot 2707. Dashed line indicates $0.7U_e/(2\delta_{99})$.

139.6 Heat Transfer Results

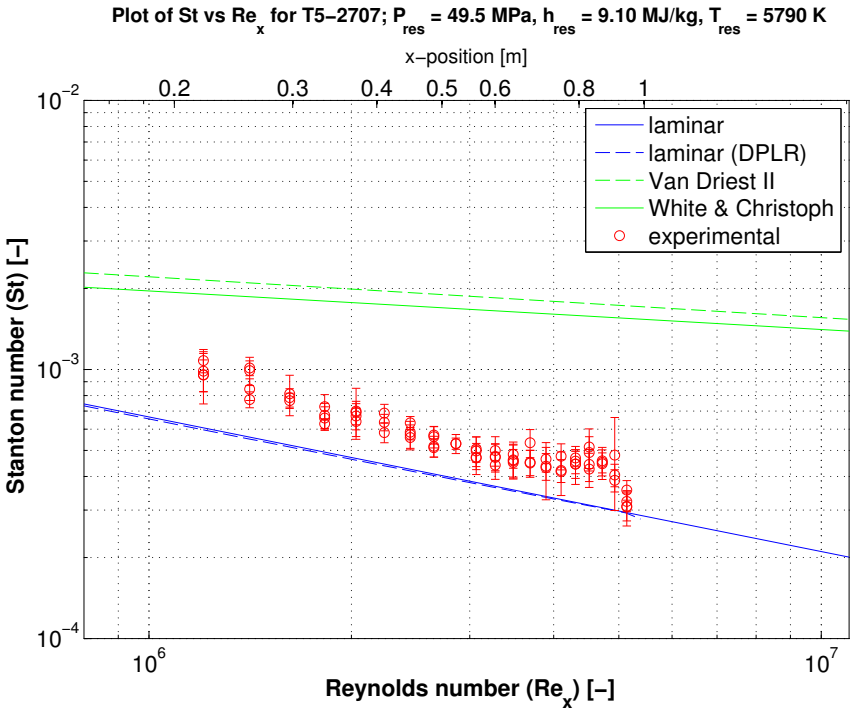


Figure 417: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

140 Shot 2708

Experiment 2708 was performed in T5 on 25 April 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

140.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2800	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	49.6	MPa

Table 1113: Measured quantities, Shot 2708

140.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5205	K
Reservoir Density	ρ_{res}	31.13	kg/m^3
Reservoir Enthalpy	h_{res}	7.70	MJ/kg

Table 1114: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2708

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	9.28×10^{-2}	0	1.38×10^{-1}	0	1.01×10^{-3}	6.67×10^{-2}

Table 1115: Computed reservoir species mass fractions, Shot 2708

140.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3618	1106.0	1106.0	5.54	21.1	0.066	5.35×10^6
72 cm	3596	1109.3	1113.2	5.36	24.2	0.075	6.06×10^6

Table 1116: Computed freestream conditions, Shot 2708

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	0	8.02×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	0	3.76×10^{-3}

Table 1117: Computed freestream species mass fractions, Shot 2708

140.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3583	1213.0	1213.0	5.24	30.7	0.087	6.64×10^6
72 cm	3535	1269.2	1266.6	4.93	35.2	0.096	7.00×10^6

Table 1118: Computed boundary layer edge conditions, Shot 2708

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.24×10^{-2}	0	0	8.02×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.73×10^{-2}	0	7.05×10^{-10}	3.69×10^{-3}

Table 1119: Computed boundary layer edge species mass fractions, Shot 2708

	T^* K	Unit Re^* 1/m
1D 100 cm	1554	4.41×10^6
72 cm	1524	5.83×10^6

Table 1120: Dorrance reference conditions, Shot 2708

140.5 Stability Computations

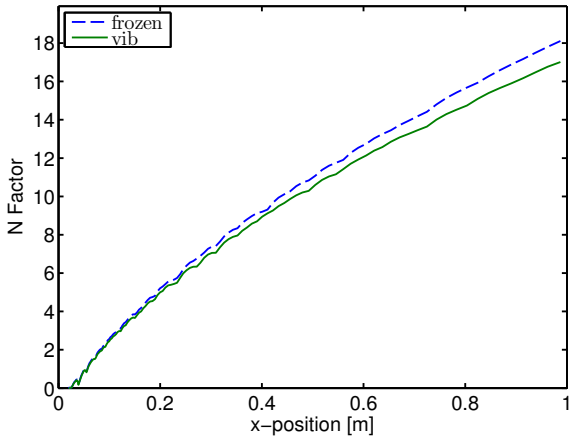


Figure 418: Locus of maximum N factor with and without vibrational energy transfer, Shot 2708

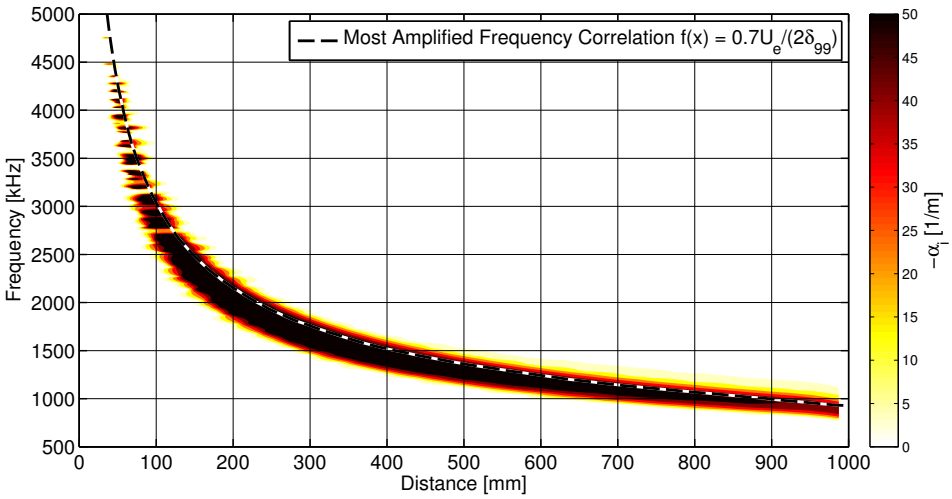


Figure 419: Stability diagram with vibrational energy transfer, Shot 2708. Dashed line indicates $0.7U_e/(2\delta_{99})$.

140.6 Heat Transfer Results

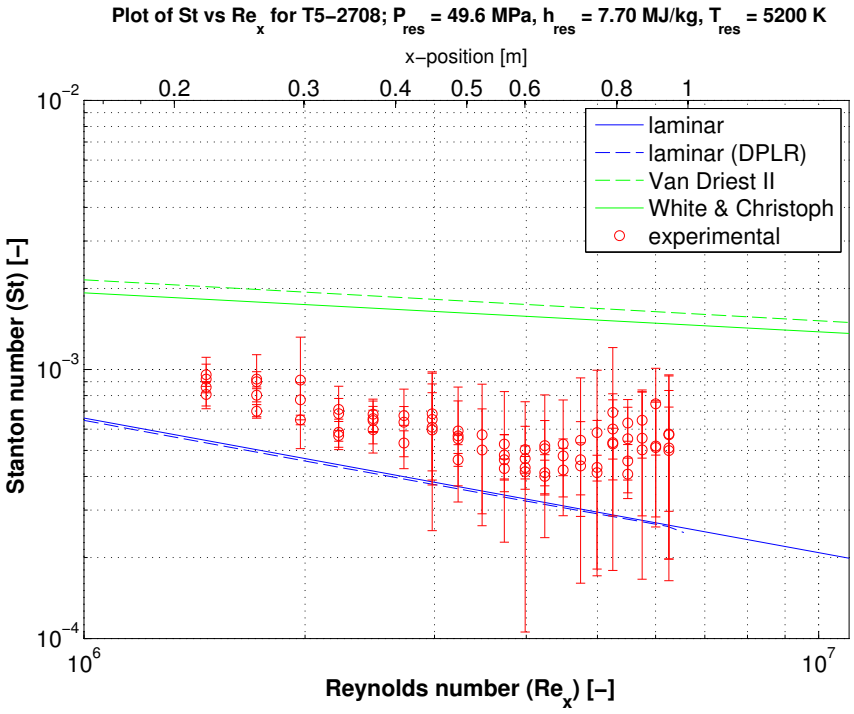


Figure 420: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

141 Shot 2709

Experiment 2709 was performed in T5 on 4 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

141.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2840	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	47.9	MPa

Table 1121: Measured quantities, Shot 2709

141.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5246	K
Reservoir Density	ρ_{res}	29.77	kg/m^3
Reservoir Enthalpy	h_{res}	7.82	MJ/kg

Table 1122: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2709

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	8.96×10^{-2}	0	1.37×10^{-1}	0	1.13×10^{-3}	7.00×10^{-2}

Table 1123: Computed reservoir species mass fractions, Shot 2709

141.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3639	1123.0	1123.0	5.53	20.5	0.063	5.09×10^6
72 cm	3617	1130.2	1135.0	5.34	23.6	0.072	5.77×10^6

Table 1124: Computed freestream conditions, Shot 2709

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.23×10^{-2}	0	0	8.89×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.70×10^{-2}	0	0	4.29×10^{-3}

Table 1125: Computed freestream species mass fractions, Shot 2709

141.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3604	1231.3	1231.3	5.23	29.7	0.083	6.31×10^6
72 cm	3556	1291.7	1289.0	4.91	34.2	0.092	6.65×10^6

Table 1126: Computed boundary layer edge conditions, Shot 2709

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.23×10^{-2}	0	0	8.89×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.70×10^{-2}	0	9.80×10^{-10}	4.21×10^{-3}

Table 1127: Computed boundary layer edge species mass fractions, Shot 2709

	T^* K	Unit Re^* 1/m
1D 100 cm	1570	4.22×10^6
72 cm	1542	5.57×10^6

Table 1128: Dorrance reference conditions, Shot 2709

141.5 Stability Computations

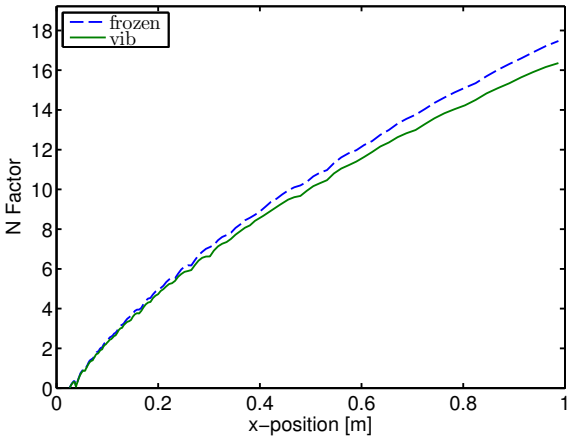


Figure 421: Locus of maximum N factor with and without vibrational energy transfer, Shot 2709

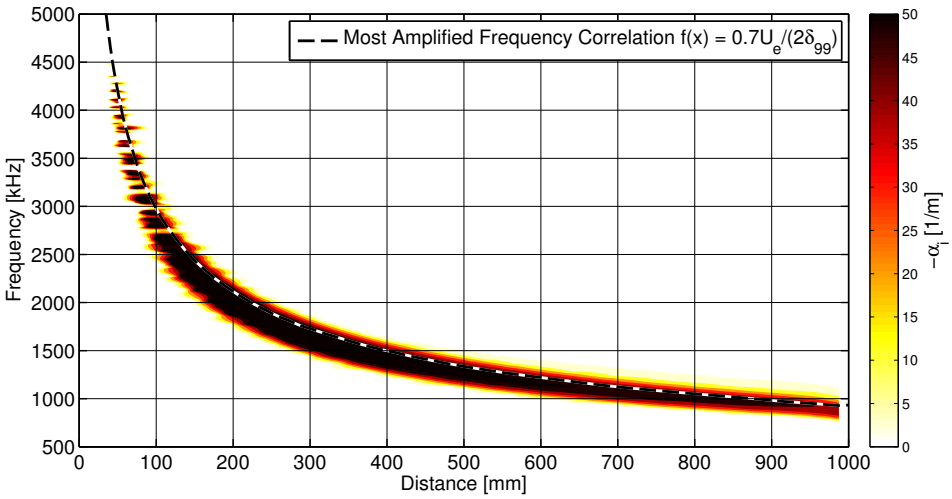


Figure 422: Stability diagram with vibrational energy transfer, Shot 2709. Dashed line indicates $0.7U_e/(2\delta_{99})$.

141.6 Heat Transfer Results

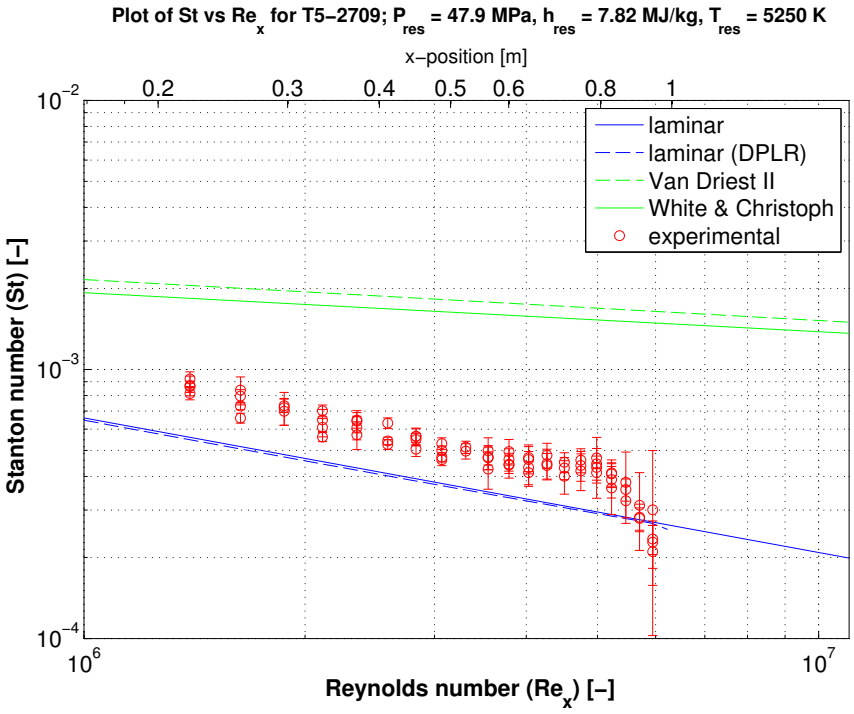


Figure 423: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

142 Shot 2710

Experiment 2710 was performed in T5 on 7 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

142.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2730	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	45.9	MPa

Table 1129: Measured quantities, Shot 2710

142.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4917	K
Reservoir Density	ρ_{res}	30.90	kg/m^3
Reservoir Enthalpy	h_{res}	7.06	MJ/kg

Table 1130: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2710

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.04×10^{-1}	1.09×10^{-1}	0	1.33×10^{-1}	0	5.41×10^{-4}	5.28×10^{-2}

Table 1131: Computed reservoir species mass fractions, Shot 2710

142.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3485	995.0	995.0	5.61	19.0	0.066	5.46×10^6
72 cm	3460	989.5	989.2	5.47	21.3	0.074	6.12×10^6

Table 1132: Computed freestream conditions, Shot 2710

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.29×10^{-2}	0	0	5.79×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	0	2.45×10^{-3}

Table 1133: Computed freestream species mass fractions, Shot 2710

142.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3451	1095.3	1095.3	5.30	27.8	0.088	6.81×10^6
72 cm	3401	1140.5	1137.4	5.01	31.2	0.095	7.08×10^6

Table 1134: Computed boundary layer edge conditions, Shot 2710

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.29×10^{-2}	0	0	5.79×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	1.66×10^{-10}	2.42×10^{-3}

Table 1135: Computed boundary layer edge species mass fractions, Shot 2710

	T^* K	Unit Re^* 1/m
1D 100 cm	1449	4.33×10^6
72 cm	1419	5.69×10^6

Table 1136: Dorrance reference conditions, Shot 2710

142.5 Stability Computations

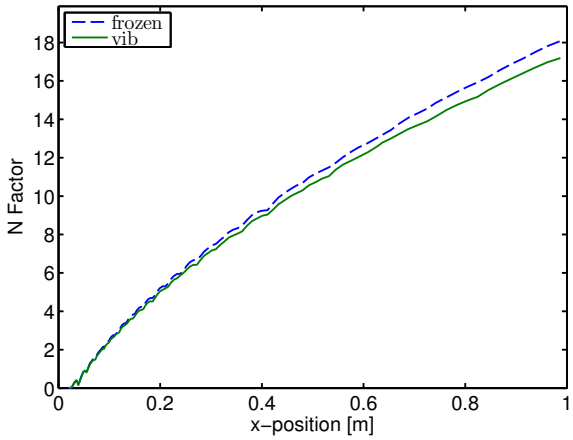


Figure 424: Locus of maximum N factor with and without vibrational energy transfer, Shot 2710

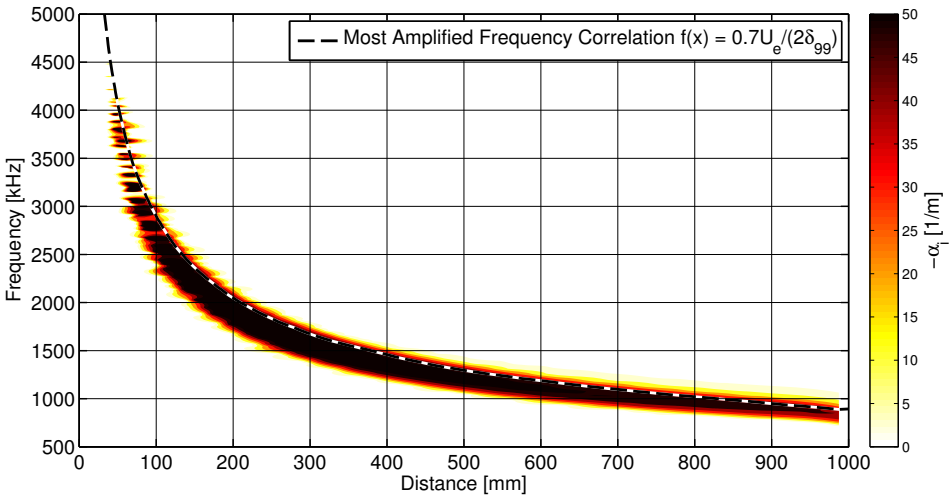


Figure 425: Stability diagram with vibrational energy transfer, Shot 2710. Dashed line indicates $0.7U_e/(2\delta_{99})$.

142.6 Heat Transfer Results

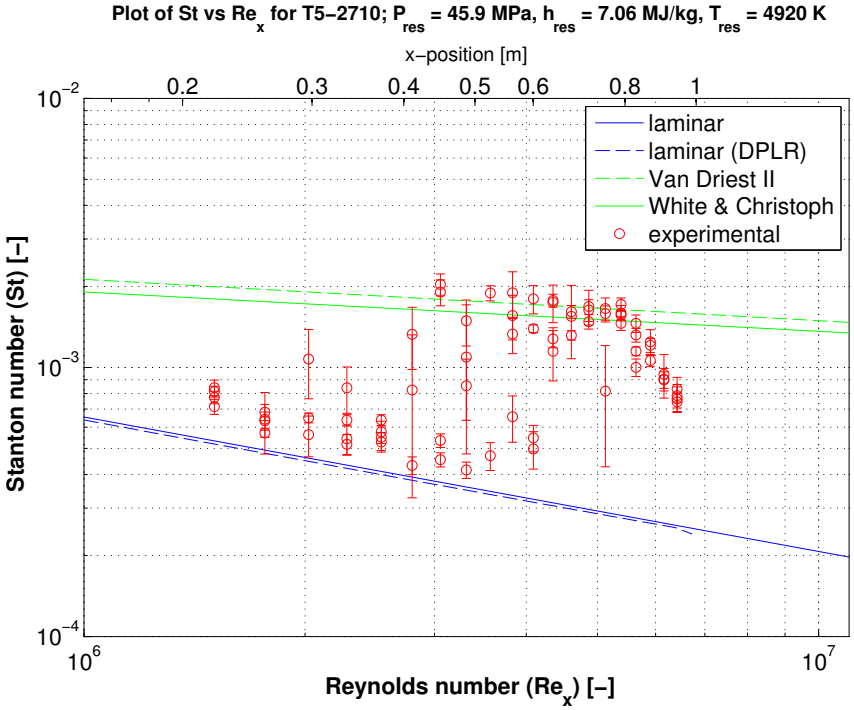


Figure 426: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

143 Shot 2711

Experiment 2711 was performed in T5 on 8 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

143.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2730	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	46.1	MPa

Table 1137: Measured quantities, Shot 2711

143.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4921	K
Reservoir Density	ρ_{res}	31.02	kg/m^3
Reservoir Enthalpy	h_{res}	7.07	MJ/kg

Table 1138: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2711

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.04×10^{-1}	1.09×10^{-1}	0	1.33×10^{-1}	0	5.45×10^{-4}	5.29×10^{-2}

Table 1139: Computed reservoir species mass fractions, Shot 2711

143.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3486	995.0	995.0	5.61	19.0	0.066	5.47×10^6
72 cm	3462	990.8	990.4	5.47	21.4	0.075	6.14×10^6

Table 1140: Computed freestream conditions, Shot 2711

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.29×10^{-2}	0	1.95×10^{-10}	5.79×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	0	2.45×10^{-3}

Table 1141: Computed freestream species mass fractions, Shot 2711

143.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3452	1096.2	1096.2	5.30	27.9	0.088	6.83×10^6
72 cm	3403	1141.7	1138.6	5.01	31.3	0.095	7.11×10^6

Table 1142: Computed boundary layer edge conditions, Shot 2711

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.29×10^{-2}	0	1.95×10^{-10}	5.79×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.82×10^{-2}	0	1.67×10^{-10}	2.42×10^{-3}

Table 1143: Computed boundary layer edge species mass fractions, Shot 2711

	T^* K	Unit Re^* 1/m
1D 100 cm	1450	4.34×10^6
72 cm	1420	5.71×10^6

Table 1144: Dorrance reference conditions, Shot 2711

143.5 Stability Computations

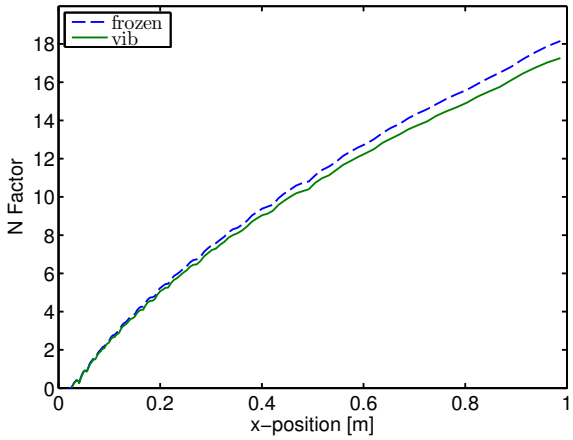


Figure 427: Locus of maximum N factor with and without vibrational energy transfer, Shot 2711

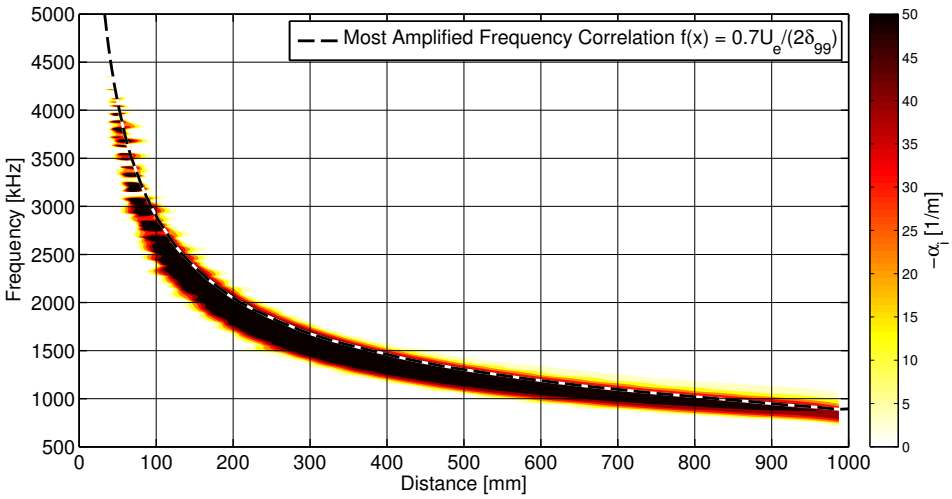


Figure 428: Stability diagram with vibrational energy transfer, Shot 2711. Dashed line indicates $0.7U_e/(2\delta_{99})$.

143.6 Heat Transfer Results

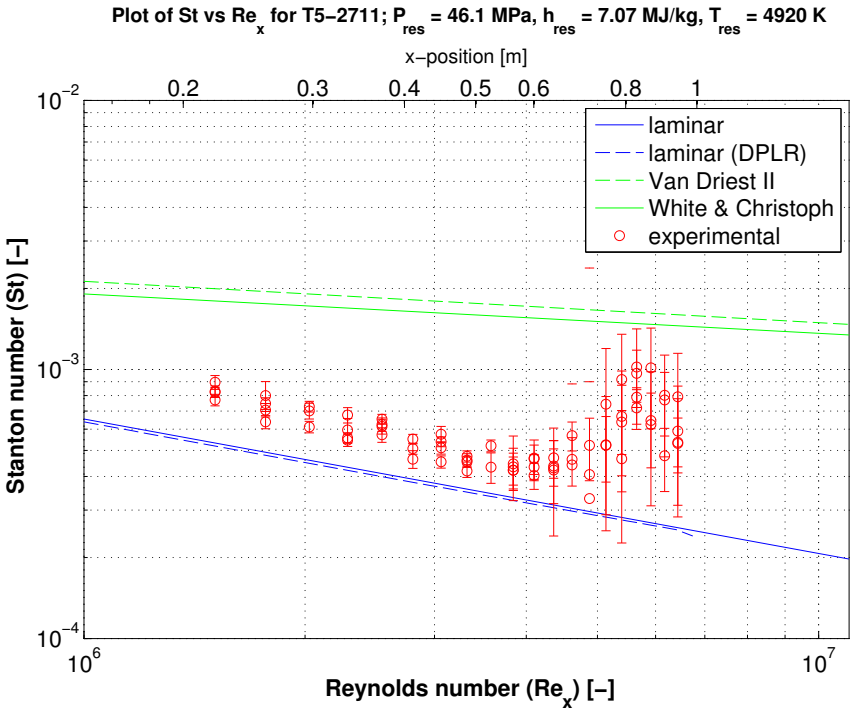


Figure 429: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

144 Shot 2712

Experiment 2712 was performed in T5 on 10 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

144.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2710	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	42.4	MPa

Table 1145: Measured quantities, Shot 2712

144.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4923	K
Reservoir Density	ρ_{res}	28.48	kg/m^3
Reservoir Enthalpy	h_{res}	7.10	MJ/kg

Table 1146: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2712

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.05×10^{-1}	1.08×10^{-1}	0	1.32×10^{-1}	0	5.71×10^{-4}	5.49×10^{-2}

Table 1147: Computed reservoir species mass fractions, Shot 2712

144.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3490	998.0	998.0	5.61	17.4	0.060	5.00×10^6
72 cm	3466	997.4	998.0	5.46	19.7	0.068	5.62×10^6

Table 1148: Computed freestream conditions, Shot 2712

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.30×10^{-2}	0	0	6.50×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.82×10^{-2}	0	0	2.83×10^{-3}

Table 1149: Computed freestream species mass fractions, Shot 2712

144.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3456	1098.7	1098.7	5.30	25.6	0.080	6.24×10^6
72 cm	3407	1148.9	1145.4	5.00	28.9	0.087	6.50×10^6

Table 1150: Computed boundary layer edge conditions, Shot 2712

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.30×10^{-2}	0	0	6.50×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.82×10^{-2}	0	2.15×10^{-10}	2.79×10^{-3}

Table 1151: Computed boundary layer edge species mass fractions, Shot 2712

	T^* K	Unit Re^* 1/m
1D 100 cm	1452	3.97×10^6
72 cm	1425	5.24×10^6

Table 1152: Dorrance reference conditions, Shot 2712

144.5 Stability Computations

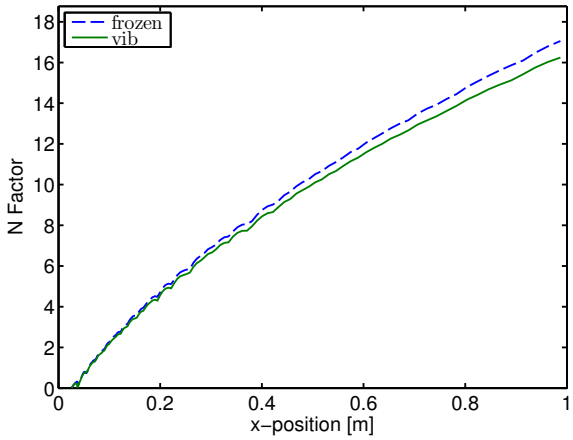


Figure 430: Locus of maximum N factor with and without vibrational energy transfer, Shot 2712

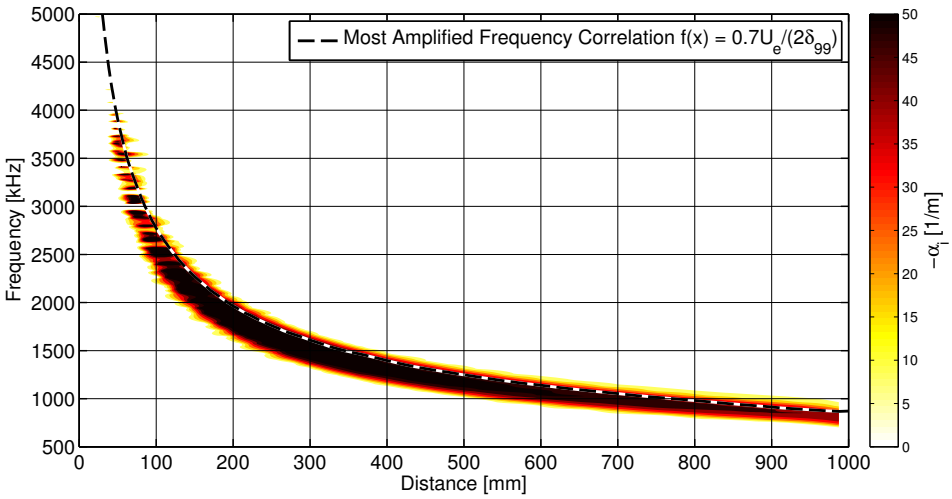


Figure 431: Stability diagram with vibrational energy transfer, Shot 2712. Dashed line indicates $0.7U_e/(2\delta_{99})$.

144.6 Heat Transfer Results

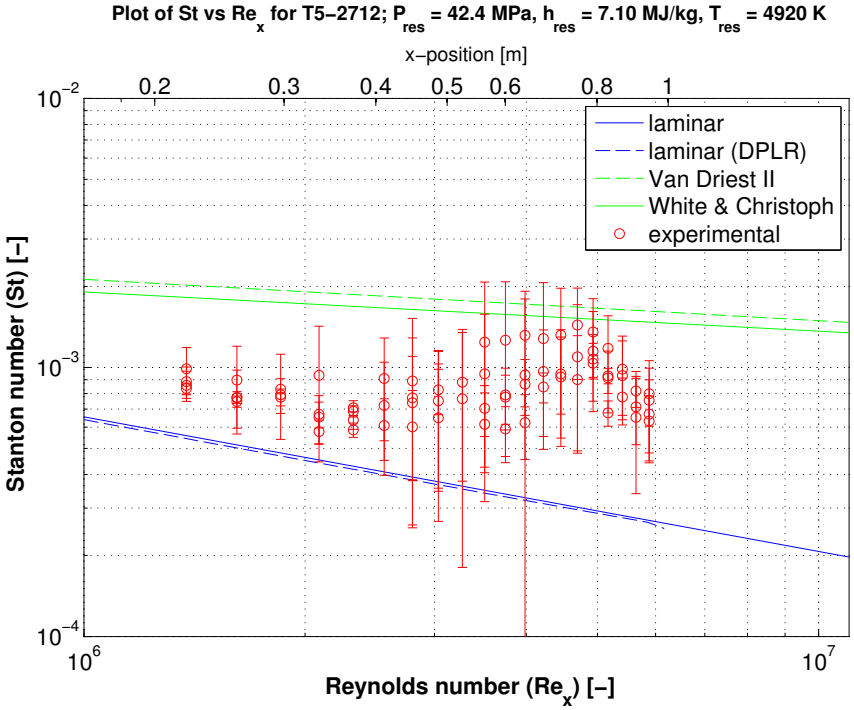


Figure 432: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

145 Shot 2713

Experiment 2713 was performed in T5 on 14 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

145.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3060	m/s
Shock Tube Fill Pressure	P_1	60.00	kPa
Reservoir Pressure	P_{res}	39.0	MPa

Table 1153: Measured quantities, Shot 2713

145.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4191	K
Reservoir Density	ρ_{res}	38.94	kg/m^3
Reservoir Enthalpy	h_{res}	8.37	MJ/kg

Table 1154: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2713

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.52×10^{-1}	5.26×10^{-1}	0	3.02×10^{-1}	0	2.02×10^{-2}

Table 1155: Computed reservoir species mass fractions, Shot 2713

145.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3104	1797.0	1797.0	4.56	29.0	0.075	4.33×10^{6}
72 cm	3080	1764.6	1764.9	4.21	33.1	0.087	5.03×10^{6}

Table 1156: Computed freestream conditions, Shot 2713

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.98×10^{-2}	7.21×10^{-1}	0	1.77×10^{-1}	0	1.42×10^{-3}
72 cm	0	1.00×10^{-1}	7.18×10^{-1}	0	1.79×10^{-1}	0	2.30×10^{-3}

Table 1157: Computed freestream species mass fractions, Shot 2713

145.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3070	1874.1	1874.1	4.42	37.6	0.093	5.15×10^{6}
72 cm	3032	1863.3	1863.2	4.04	42.9	0.107	5.86×10^{6}

Table 1158: Computed boundary layer edge conditions, Shot 2713

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.98×10^{-2}	7.21×10^{-1}	0	1.77×10^{-1}	0	1.42×10^{-3}
72 cm	0	1.00×10^{-1}	7.19×10^{-1}	0	1.79×10^{-1}	0	1.98×10^{-3}

Table 1159: Computed boundary layer edge species mass fractions, Shot 2713

	T^* K	Unit Re^* 1/m
1D 100 cm	1627	6.59×10^{6}
72 cm	1529	7.13×10^{6}

Table 1160: Dorrance reference conditions, Shot 2713

145.5 Stability Computations

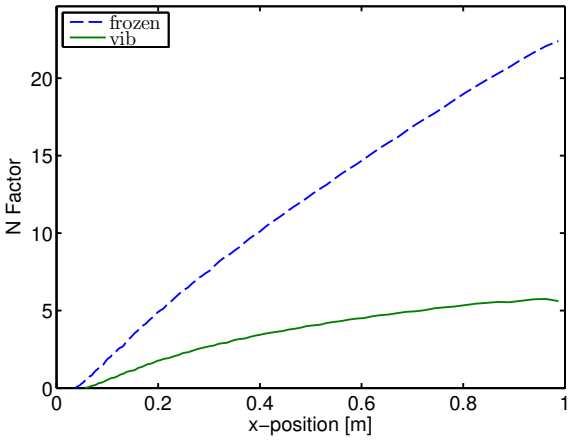


Figure 433: Locus of maximum N factor with and without vibrational energy transfer, Shot 2713

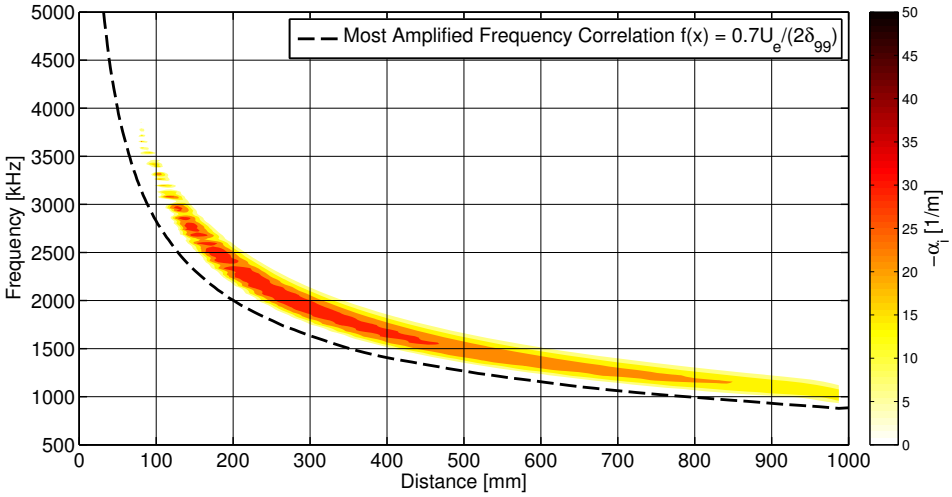


Figure 434: Stability diagram with vibrational energy transfer, Shot 2713. Dashed line indicates $0.7U_e/(2\delta_{99})$.

145.6 Heat Transfer Results

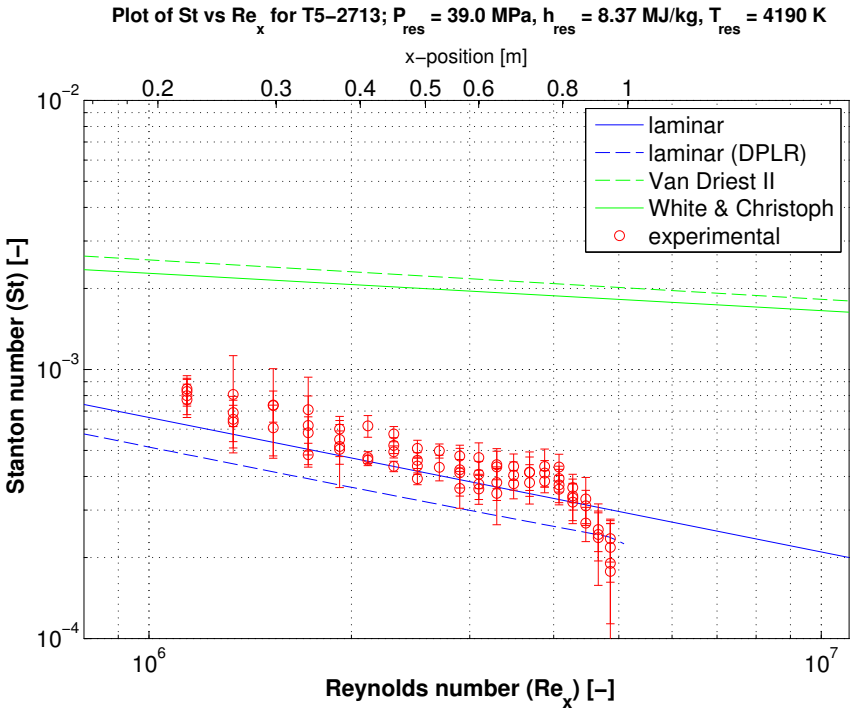


Figure 435: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

146 Shot 2714

Experiment 2714 was performed in T5 on 15 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

146.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3110	m/s
Shock Tube Fill Pressure	P_1	105.20	kPa
Reservoir Pressure	P_{res}	67.1	MPa

Table 1161: Measured quantities, Shot 2714

146.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6023	K
Reservoir Density	ρ_{res}	35.27	kg/m^3
Reservoir Enthalpy	h_{res}	9.50	MJ/kg

Table 1162: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2714

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	5.62×10^{-2}	0	1.40×10^{-1}	0	4.13×10^{-3}	1.02×10^{-1}

Table 1163: Computed reservoir species mass fractions, Shot 2714

146.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3961	1419.0	1419.0	5.36	30.6	0.074	5.63×10^{6}
72 cm	3944	1450.5	1457.6	5.13	37.0	0.088	6.56×10^{6}

Table 1164: Computed freestream conditions, Shot 2714

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.04×10^{-2}	0	3.96×10^{-9}	1.48×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.29×10^{-2}	0	5.95×10^{-9}	8.32×10^{-3}

Table 1165: Computed freestream species mass fractions, Shot 2714

146.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3922	1545.5	1545.5	5.09	43.6	0.097	6.88×10^{6}
72 cm	3877	1637.0	1635.4	4.75	52.5	0.111	7.47×10^{6}

Table 1166: Computed boundary layer edge conditions, Shot 2714

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.04×10^{-2}	0	3.96×10^{-9}	1.48×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.29×10^{-2}	0	2.26×10^{-8}	7.98×10^{-3}

Table 1167: Computed boundary layer edge species mass fractions, Shot 2714

	T^* K	Unit Re^* 1/m
1D 100 cm	1847	5.09×10^{6}
72 cm	1822	6.23×10^{6}

Table 1168: Dorrance reference conditions, Shot 2714

146.5 Stability Computations

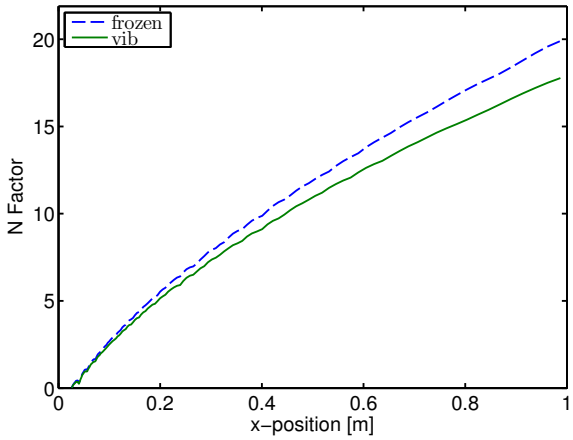


Figure 436: Locus of maximum N factor with and without vibrational energy transfer, Shot 2714

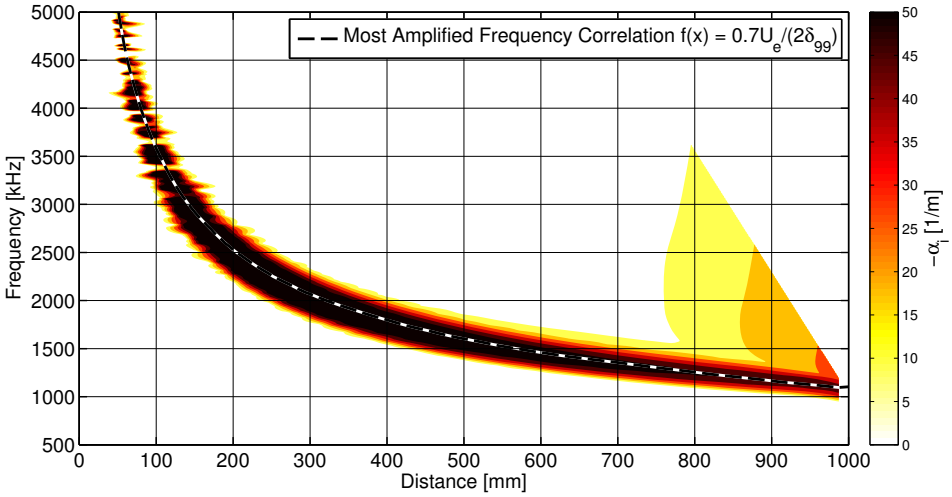


Figure 437: Stability diagram with vibrational energy transfer, Shot 2714. Dashed line indicates $0.7U_e/(2\delta_{99})$.

146.6 Heat Transfer Results

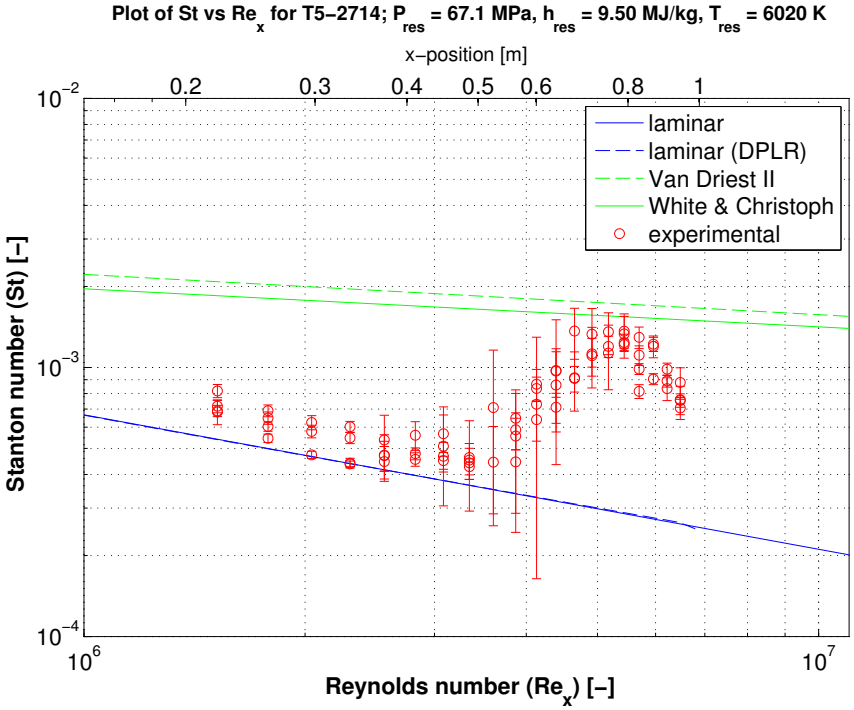


Figure 438: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

147 Shot 2715

Experiment 2715 was performed in T5 on 16 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

147.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	87.00	kPa
Reservoir Pressure	P_{res}	68.8	MPa

Table 1169: Measured quantities, Shot 2715

147.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6439	K
Reservoir Density	ρ_{res}	33.21	kg/m^3
Reservoir Enthalpy	h_{res}	10.5	MJ/kg

Table 1170: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2715

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	4.09×10^{-2}	0	1.33×10^{-1}	0	7.80×10^{-3}	1.21×10^{-1}

Table 1171: Computed reservoir species mass fractions, Shot 2715

147.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4133	1583.0	1583.0	5.29	32.5	0.070	5.15×10^6
72 cm	4111	1629.5	1637.2	5.03	39.7	0.083	6.00×10^6

Table 1172: Computed freestream conditions, Shot 2715

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.80×10^{-1}	0	5.89×10^{-2}	0	1.74×10^{-8}	2.15×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.32×10^{-2}	0	3.52×10^{-8}	1.30×10^{-2}

Table 1173: Computed freestream species mass fractions, Shot 2715

147.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4092	1719.2	1719.2	5.02	45.9	0.091	6.27×10^6
72 cm	4042	1832.0	1830.4	4.67	55.9	0.105	6.82×10^6

Table 1174: Computed boundary layer edge conditions, Shot 2715

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.80×10^{-1}	0	5.89×10^{-2}	0	1.74×10^{-8}	2.15×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.31×10^{-2}	0	1.05×10^{-7}	1.24×10^{-2}

Table 1175: Computed boundary layer edge species mass fractions, Shot 2715

	T^* K	Unit Re^* 1/m
1D 100 cm	2002	4.84×10^6
72 cm	1980	5.98×10^6

Table 1176: Dorrance reference conditions, Shot 2715

147.5 Stability Computations

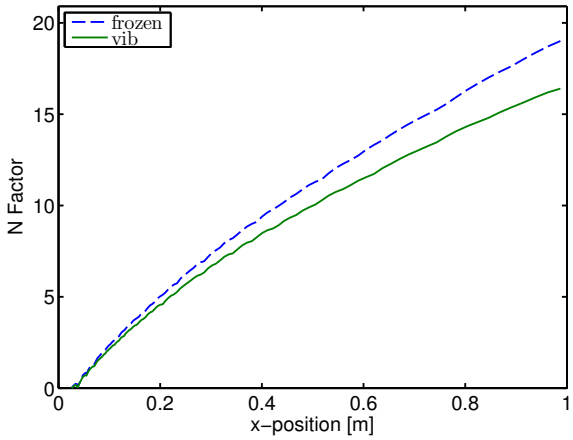


Figure 439: Locus of maximum N factor with and without vibrational energy transfer, Shot 2715

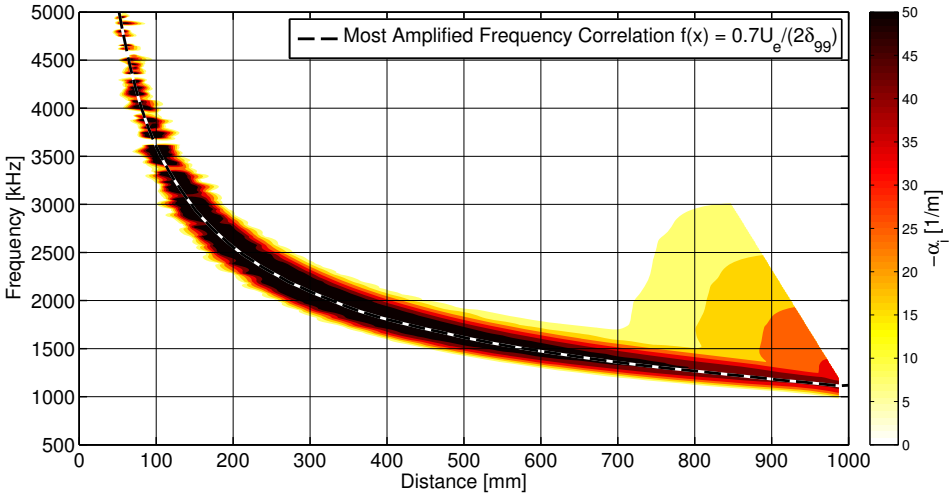


Figure 440: Stability diagram with vibrational energy transfer, Shot 2715. Dashed line indicates $0.7U_e/(2\delta_{99})$.

147.6 Heat Transfer Results

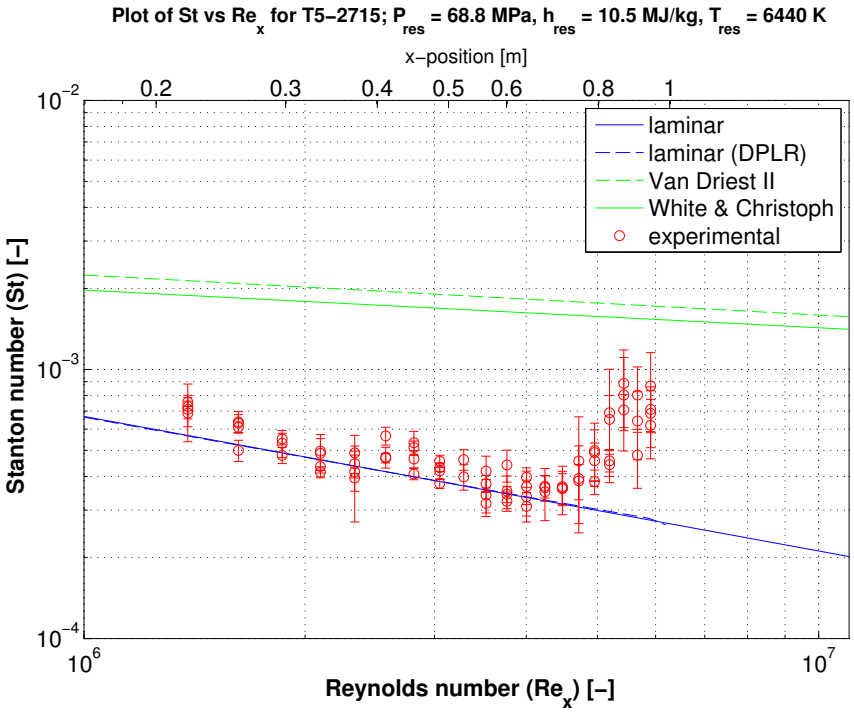


Figure 441: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

148 Shot 2716

Experiment 2716 was performed in T5 on 18 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

148.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3260	m/s
Shock Tube Fill Pressure	P_1	80.00	kPa
Reservoir Pressure	P_{res}	67.4	MPa

Table 1177: Measured quantities, Shot 2716

148.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6557	K
Reservoir Density	ρ_{res}	31.71	kg/m^3
Reservoir Enthalpy	h_{res}	10.8	MJ/kg

Table 1178: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2716

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	3.67×10^{-2}	0	1.30×10^{-1}	0	9.35×10^{-3}	1.27×10^{-1}

Table 1179: Computed reservoir species mass fractions, Shot 2716

148.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4182	1627.0	1627.0	5.27	31.9	0.067	4.88×10^{6}
72 cm	4159	1681.1	1689.0	5.01	39.2	0.080	5.68×10^{6}

Table 1180: Computed freestream conditions, Shot 2716

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.84×10^{-2}	0	2.77×10^{-8}	2.43×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.29×10^{-2}	0	5.68×10^{-8}	1.52×10^{-2}

Table 1181: Computed freestream species mass fractions, Shot 2716

148.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4140	1766.3	1766.3	5.01	45.1	0.087	5.93×10^{6}
72 cm	4089	1889.6	1888.0	4.65	55.1	0.100	6.45×10^{6}

Table 1182: Computed boundary layer edge conditions, Shot 2716

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.84×10^{-2}	0	2.77×10^{-8}	2.43×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.29×10^{-2}	0	1.63×10^{-7}	1.44×10^{-2}

Table 1183: Computed boundary layer edge species mass fractions, Shot 2716

	T^* K	Unit Re^* 1/m
1D 100 cm	2046	4.62×10^{6}
72 cm	2026	5.72×10^{6}

Table 1184: Dorrance reference conditions, Shot 2716

148.5 Stability Computations

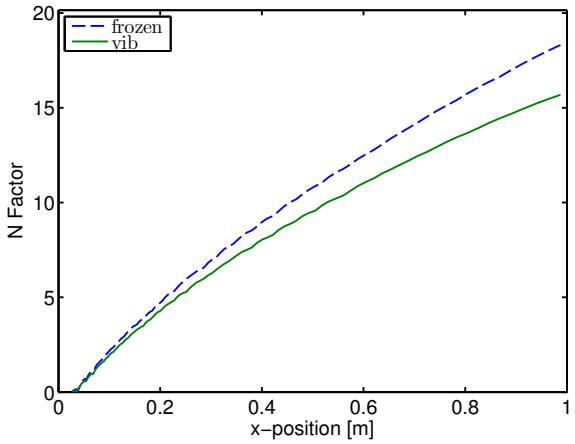


Figure 442: Locus of maximum N factor with and without vibrational energy transfer, Shot 2716

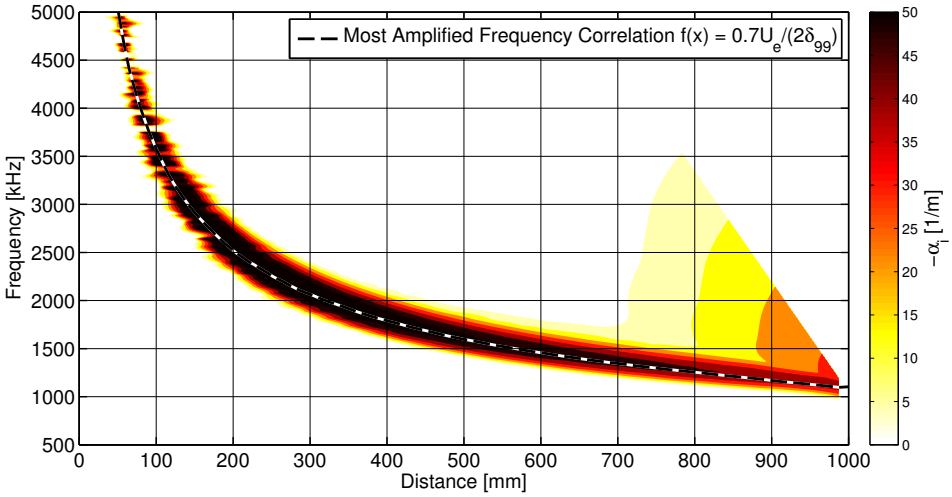


Figure 443: Stability diagram with vibrational energy transfer, Shot 2716. Dashed line indicates $0.7U_e/(2\delta_{99})$.

148.6 Heat Transfer Results

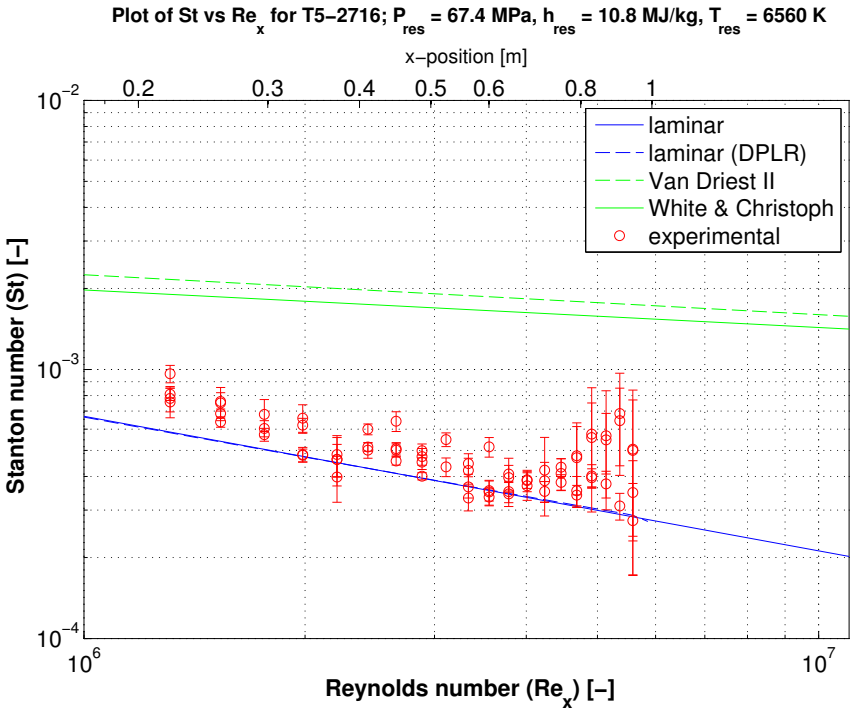


Figure 444: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

149 Shot 2717

Experiment 2717 was performed in T5 on 23 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

149.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	82.00	kPa
Reservoir Pressure	P_{res}	70.0	MPa

Table 1185: Measured quantities, Shot 2717

149.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6507	K
Reservoir Density	ρ_{res}	33.32	kg/m^3
Reservoir Enthalpy	h_{res}	10.6	MJ/kg

Table 1186: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2717

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	3.90×10^{-2}	0	1.33×10^{-1}	0	8.53×10^{-3}	1.23×10^{-1}

Table 1187: Computed reservoir species mass fractions, Shot 2717

149.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4159	1608.0	1608.0	5.28	33.1	0.070	5.14×10^6
72 cm	4137	1657.7	1665.3	5.02	40.6	0.084	6.00×10^6

Table 1188: Computed freestream conditions, Shot 2717

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.79×10^{-1}	0	5.87×10^{-2}	0	2.21×10^{-8}	2.24×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.31×10^{-2}	0	4.43×10^{-8}	1.37×10^{-2}

Table 1189: Computed freestream species mass fractions, Shot 2717

149.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4118	1746.4	1746.4	5.02	46.8	0.091	6.25×10^6
72 cm	4068	1863.1	1861.6	4.66	57.1	0.105	6.81×10^6

Table 1190: Computed boundary layer edge conditions, Shot 2717

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.79×10^{-1}	0	5.87×10^{-2}	0	2.21×10^{-8}	2.24×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.31×10^{-2}	0	1.29×10^{-7}	1.30×10^{-2}

Table 1191: Computed boundary layer edge species mass fractions, Shot 2717

	T^* K	Unit Re^* 1/m
1D 100 cm	2027	4.85×10^6
72 cm	2005	6.33×10^6

Table 1192: Dorrance reference conditions, Shot 2717

149.5 Stability Computations

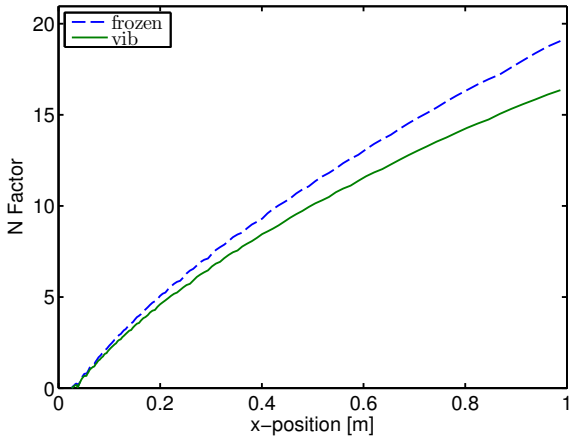


Figure 445: Locus of maximum N factor with and without vibrational energy transfer, Shot 2717

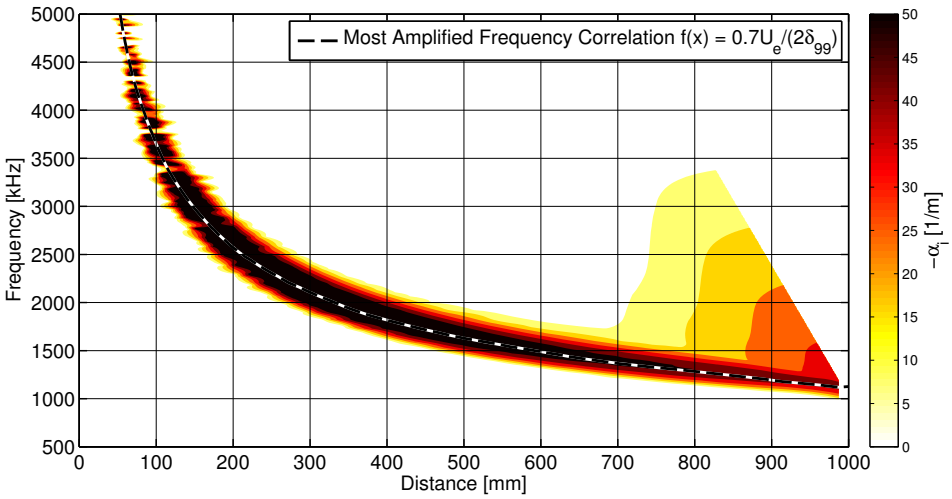


Figure 446: Stability diagram with vibrational energy transfer, Shot 2717. Dashed line indicates $0.7U_e/(2\delta_{99})$.

149.6 Heat Transfer Results

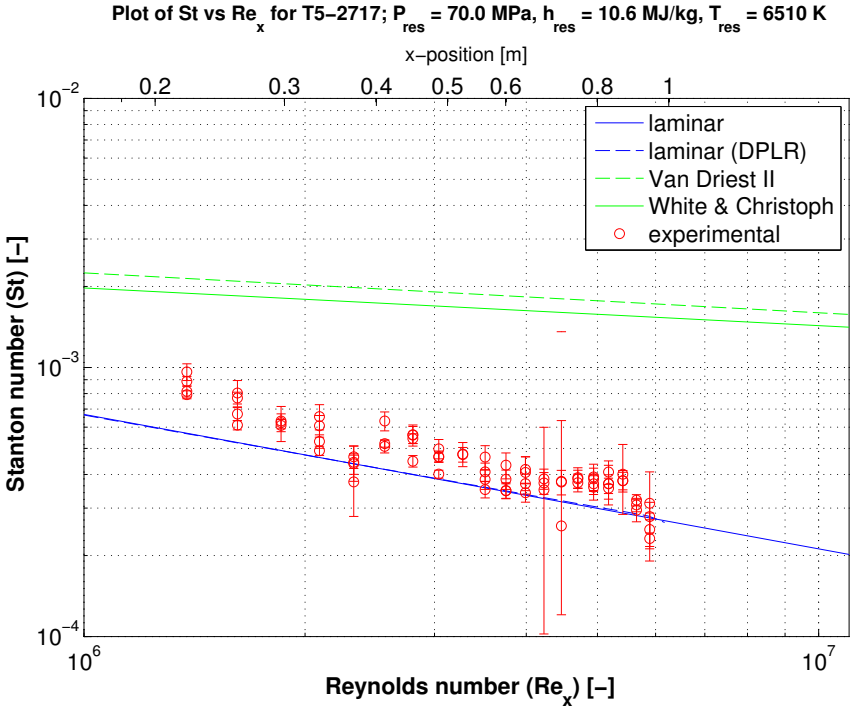


Figure 447: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

150 Shot 2718

Experiment 2718 was performed in T5 on 30 May 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

150.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	82.00	kPa
Reservoir Pressure	P_{res}	70.1	MPa

Table 1193: Measured quantities, Shot 2718

150.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6301	K
Reservoir Density	ρ_{res}	34.78	kg/m^3
Reservoir Enthalpy	h_{res}	10.1	MJ/kg

Table 1194: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2718

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	4.60×10^{-2}	0	1.37×10^{-1}	0	6.28×10^{-3}	1.14×10^{-1}

Table 1195: Computed reservoir species mass fractions, Shot 2718

150.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4077	1530.0	1530.0	5.31	32.9	0.073	5.46×10^6
72 cm	4055	1568.6	1576.1	5.07	39.8	0.087	6.35×10^6

Table 1196: Computed freestream conditions, Shot 2718

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.95×10^{-2}	0	9.80×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	1.94×10^{-8}	1.09×10^{-2}

Table 1197: Computed freestream species mass fractions, Shot 2718

150.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4036	1663.5	1663.5	5.04	46.6	0.096	6.65×10^6
72 cm	3987	1765.2	1763.7	4.70	56.3	0.110	7.23×10^6

Table 1198: Computed boundary layer edge conditions, Shot 2718

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.83×10^{-1}	0	5.95×10^{-2}	0	9.80×10^{-9}	1.85×10^{-2}
72 cm	7.33×10^{-1}	1.83×10^{-1}	0	7.32×10^{-2}	0	6.22×10^{-8}	1.04×10^{-2}

Table 1199: Computed boundary layer edge species mass fractions, Shot 2718

	T^* K	Unit Re^* 1/m
1D 100 cm	1952	5.07×10^6
72 cm	1925	6.63×10^6

Table 1200: Dorrance reference conditions, Shot 2718

150.5 Stability Computations

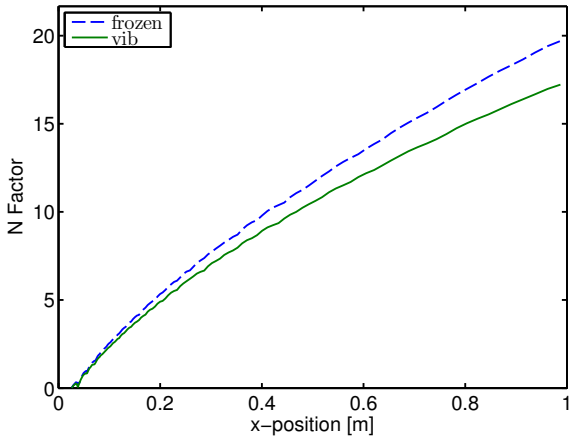


Figure 448: Locus of maximum N factor with and without vibrational energy transfer, Shot 2718

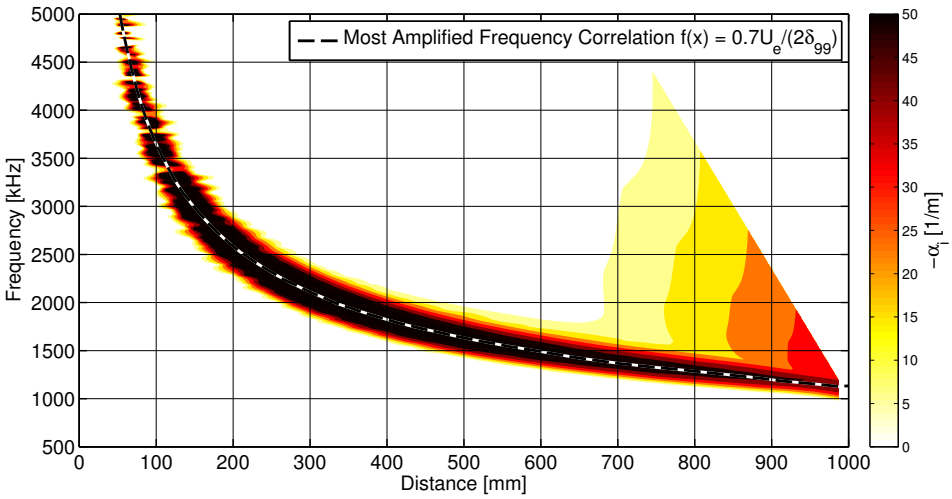


Figure 449: Stability diagram with vibrational energy transfer, Shot 2718. Dashed line indicates $0.7U_e/(2\delta_{99})$.

150.6 Heat Transfer Results

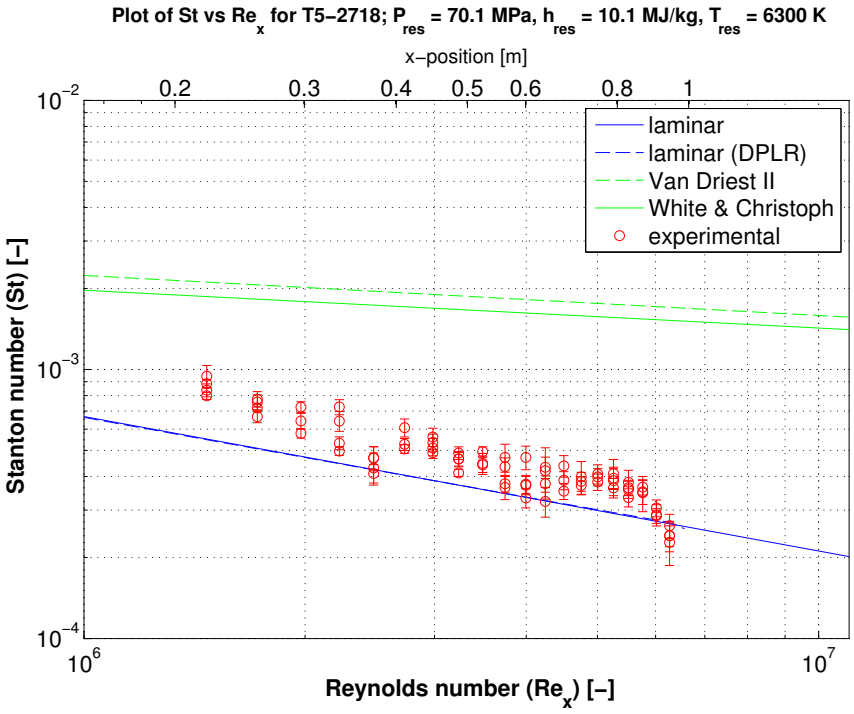


Figure 450: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

151 Shot 2719

Experiment 2719 was performed in T5 on 4 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

151.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2970	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	44.8	MPa

Table 1201: Measured quantities, Shot 2719

151.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4075	K
Reservoir Density	ρ_{res}	47.48	kg/m^3
Reservoir Enthalpy	h_{res}	7.74	MJ/kg

Table 1202: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2719

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.36×10^{-1}	5.87×10^{-1}	0	2.63×10^{-1}	0	1.42×10^{-2}

Table 1203: Computed reservoir species mass fractions, Shot 2719

151.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3010	1715.0	1715.0	4.58	32.2	0.089	5.18×10^{6}
72 cm	2998	1716.9	1717.2	4.20	38.3	0.106	6.12×10^{6}

Table 1204: Computed freestream conditions, Shot 2719

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	7.18×10^{-4}
72 cm	0	8.48×10^{-2}	7.64×10^{-1}	0	1.50×10^{-1}	0	1.18×10^{-3}

Table 1205: Computed freestream species mass fractions, Shot 2719

151.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2977	1787.9	1787.9	4.44	41.8	0.110	6.18×10^{6}
72 cm	2952	1807.1	1807.1	4.04	49.7	0.130	7.15×10^{6}

Table 1206: Computed boundary layer edge conditions, Shot 2719

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	7.18×10^{-4}
72 cm	0	8.47×10^{-2}	7.64×10^{-1}	0	1.50×10^{-1}	0	9.82×10^{-4}

Table 1207: Computed boundary layer edge species mass fractions, Shot 2719

	T^* K	Unit Re^* 1/m
1D 100 cm	1553	7.89×10^{6}
72 cm	1479	10.14×10^{6}

Table 1208: Dorrance reference conditions, Shot 2719

151.5 Stability Computations

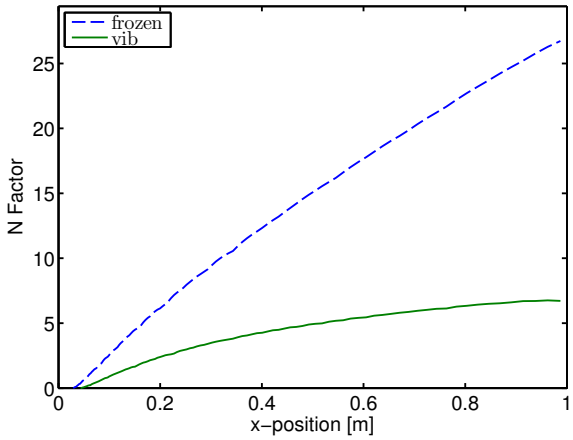


Figure 451: Locus of maximum N factor with and without vibrational energy transfer, Shot 2719

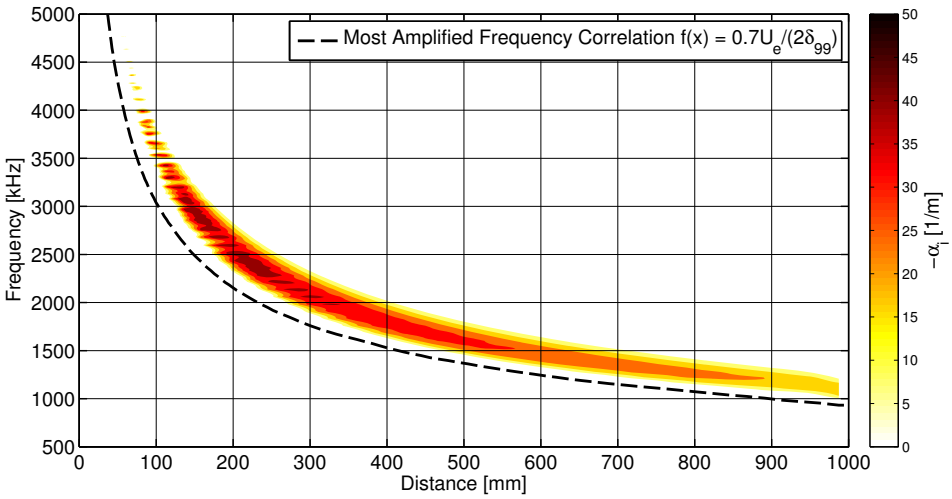


Figure 452: Stability diagram with vibrational energy transfer, Shot 2719. Dashed line indicates $0.7U_e/(2\delta_{99})$.

151.6 Heat Transfer Results

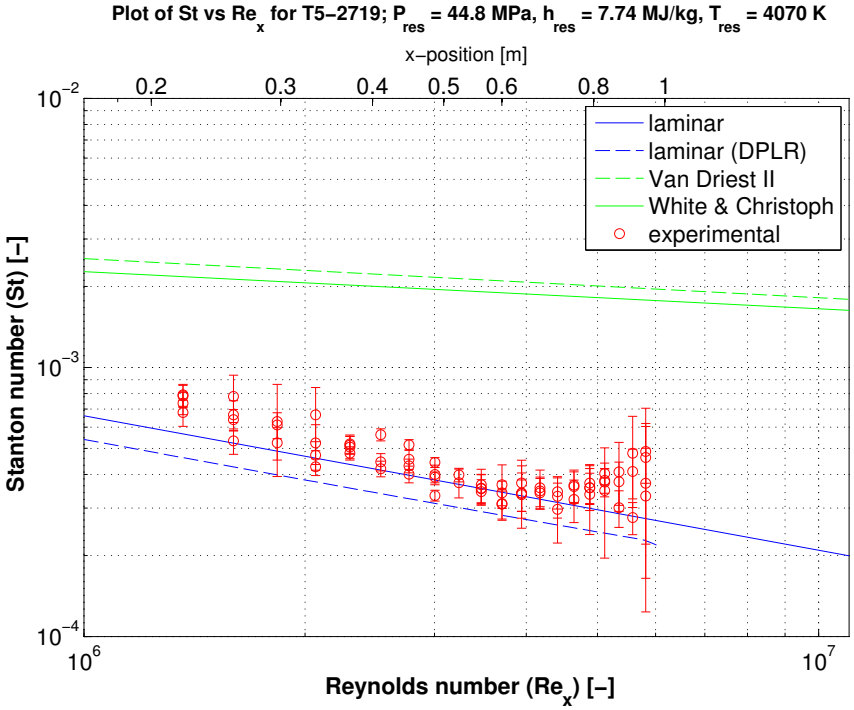


Figure 453: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

152 Shot 2720

Experiment 2720 was performed in T5 on 14 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

152.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	55.00	kPa
Reservoir Pressure	P_{res}	59.3	MPa

Table 1209: Measured quantities, Shot 2720

152.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4563	K
Reservoir Density	ρ_{res}	51.75	kg/m^3
Reservoir Enthalpy	h_{res}	9.65	MJ/kg

Table 1210: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2720

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.73×10^{-1}	4.33×10^{-1}	0	3.61×10^{-1}	0	3.27×10^{-2}

Table 1211: Computed reservoir species mass fractions, Shot 2720

152.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3308	2090.0	2090.0	4.47	46.0	0.100	5.50×10^6
72 cm	3282	2008.5	2008.8	4.16	52.8	0.119	6.65×10^6

Table 1212: Computed freestream conditions, Shot 2720

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.12×10^{-1}	6.86×10^{-1}	0	2.00×10^{-1}	0	2.36×10^{-3}
72 cm	0	1.15×10^{-1}	6.73×10^{-1}	0	2.08×10^{-1}	0	3.70×10^{-3}

Table 1213: Computed freestream species mass fractions, Shot 2720

152.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3272	2178.1	2178.1	4.33	59.1	0.124	6.51×10^6
72 cm	3231	2133.4	2133.4	3.98	68.3	0.145	7.65×10^6

Table 1214: Computed boundary layer edge conditions, Shot 2720

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.12×10^{-1}	6.86×10^{-1}	0	2.00×10^{-1}	0	2.36×10^{-3}
72 cm	0	1.15×10^{-1}	6.76×10^{-1}	0	2.06×10^{-1}	0	2.92×10^{-3}

Table 1215: Computed boundary layer edge species mass fractions, Shot 2720

	T^* K	Unit Re^* 1/m
1D 100 cm	1844	8.69×10^6
72 cm	1717	9.51×10^6

Table 1216: Dorrance reference conditions, Shot 2720

152.5 Stability Computations

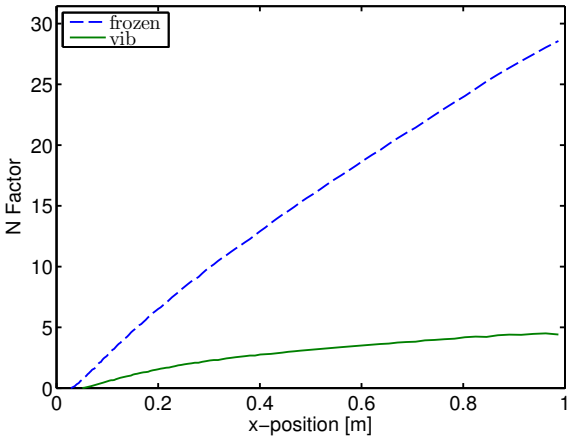


Figure 454: Locus of maximum N factor with and without vibrational energy transfer, Shot 2720

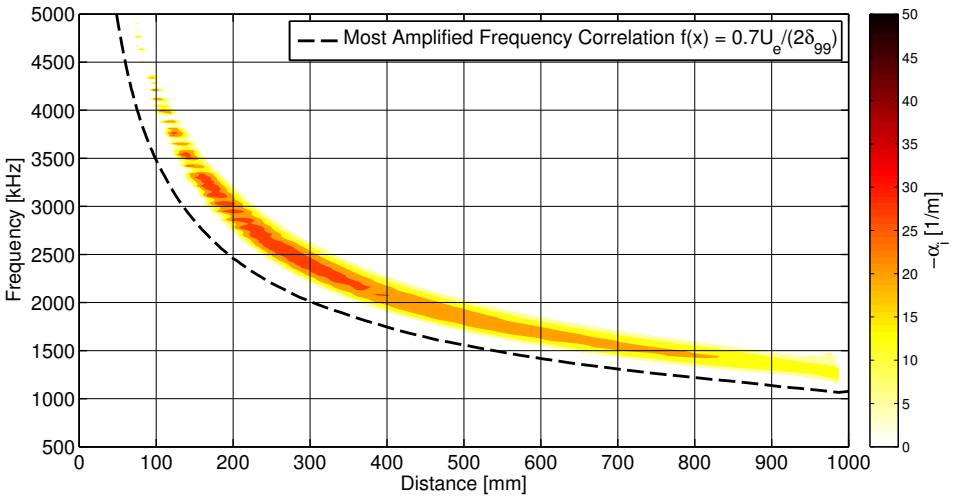


Figure 455: Stability diagram with vibrational energy transfer, Shot 2720. Dashed line indicates $0.7U_e/(2\delta_{99})$.

152.6 Heat Transfer Results

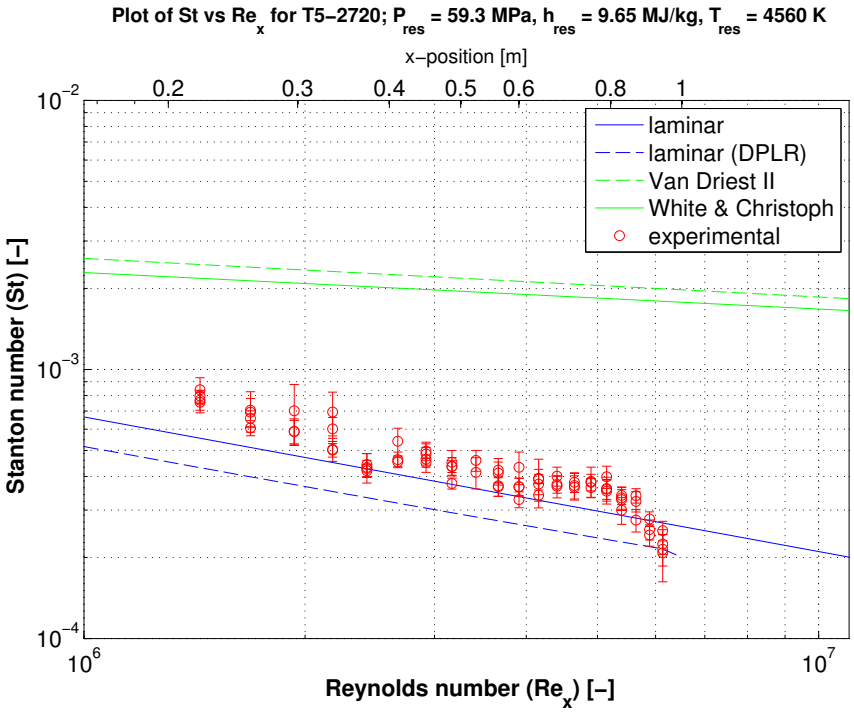


Figure 456: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

153 Shot 2721

Experiment 2721 was performed in T5 on 15 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

153.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	60.90	kPa
Reservoir Pressure	P_{res}	58.3	MPa

Table 1217: Measured quantities, Shot 2721

153.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4433	K
Reservoir Density	ρ_{res}	53.66	kg/m^3
Reservoir Enthalpy	h_{res}	9.09	MJ/kg

Table 1218: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2721

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.64×10^{-1}	4.78×10^{-1}	0	3.32×10^{-1}	0	2.59×10^{-2}

Table 1219: Computed reservoir species mass fractions, Shot 2721

153.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3224	1989.0	1989.0	4.50	44.0	0.102	5.68×10^6
72 cm	3205	1937.3	1937.6	4.17	51.6	0.122	6.89×10^6

Table 1220: Computed freestream conditions, Shot 2721

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.03×10^{-1}	7.12×10^{-1}	0	1.83×10^{-1}	0	1.61×10^{-3}
72 cm	0	1.05×10^{-1}	7.03×10^{-1}	0	1.89×10^{-1}	0	2.62×10^{-3}

Table 1221: Computed freestream species mass fractions, Shot 2721

153.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3189	2071.9	2071.9	4.36	56.7	0.126	6.74×10^6
72 cm	3155	2050.3	2050.3	3.99	66.8	0.150	7.97×10^6

Table 1222: Computed boundary layer edge conditions, Shot 2721

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.03×10^{-1}	7.12×10^{-1}	0	1.83×10^{-1}	0	1.61×10^{-3}
72 cm	0	1.05×10^{-1}	7.05×10^{-1}	0	1.88×10^{-1}	0	2.06×10^{-3}

Table 1223: Computed boundary layer edge species mass fractions, Shot 2721

	T^* K	Unit Re^* 1/m
1D 100 cm	1763	8.92×10^6
72 cm	1654	9.88×10^6

Table 1224: Dorrance reference conditions, Shot 2721

153.5 Stability Computations

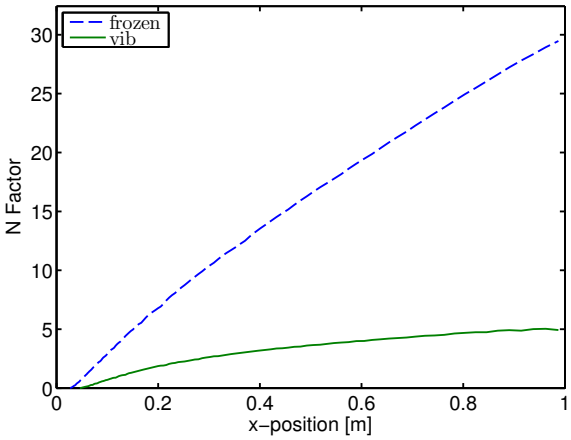


Figure 457: Locus of maximum N factor with and without vibrational energy transfer, Shot 2721

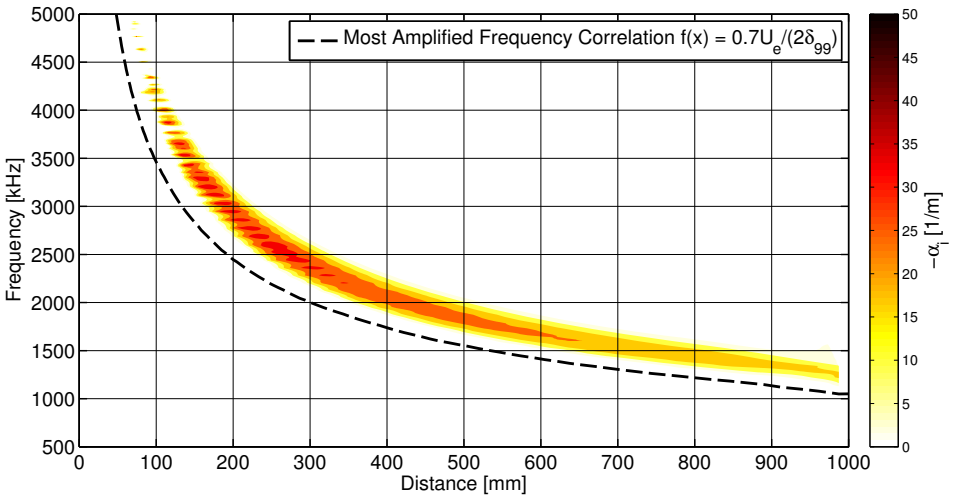


Figure 458: Stability diagram with vibrational energy transfer, Shot 2721. Dashed line indicates $0.7U_e/(2\delta_{99})$.

153.6 Heat Transfer Results

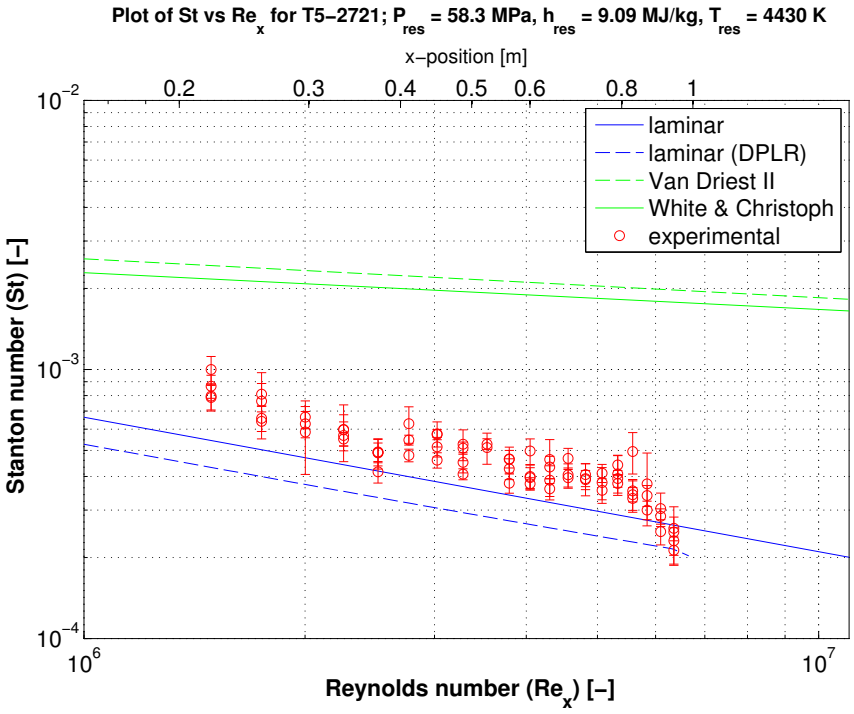


Figure 459: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

154 Shot 2722

Experiment 2722 was performed in T5 on 18 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

154.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3060	m/s
Shock Tube Fill Pressure	P_1	66.00	kPa
Reservoir Pressure	P_{res}	60.3	MPa

Table 1225: Measured quantities, Shot 2722

154.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4356	K
Reservoir Density	ρ_{res}	57.47	kg/m^3
Reservoir Enthalpy	h_{res}	8.72	MJ/kg

Table 1226: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2722

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.56×10^{-1}	5.10×10^{-1}	0	3.12×10^{-1}	0	2.18×10^{-2}

Table 1227: Computed reservoir species mass fractions, Shot 2722

154.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3174	1939.0	1939.0	4.51	45.8	0.110	6.15×10^6
72 cm	3156	1899.7	1899.9	4.17	53.5	0.131	7.37×10^6

Table 1228: Computed freestream conditions, Shot 2722

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.64×10^{-2}	7.32×10^{-1}	0	1.71×10^{-1}	0	1.17×10^{-3}
72 cm	0	9.76×10^{-2}	7.26×10^{-1}	0	1.74×10^{-1}	0	1.95×10^{-3}

Table 1229: Computed freestream species mass fractions, Shot 2722

154.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3140	2019.3	2019.3	4.37	59.0	0.136	7.31×10^6
72 cm	3107	2006.2	2006.1	4.00	69.1	0.160	8.55×10^6

Table 1230: Computed boundary layer edge conditions, Shot 2722

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.64×10^{-2}	7.32×10^{-1}	0	1.71×10^{-1}	0	1.17×10^{-3}
72 cm	0	9.75×10^{-2}	7.28×10^{-1}	0	1.73×10^{-1}	0	1.50×10^{-3}

Table 1231: Computed boundary layer edge species mass fractions, Shot 2722

	T^* K	Unit Re^* 1/m
1D 100 cm	1720	9.66×10^6
72 cm	1618	10.60×10^6

Table 1232: Dorrance reference conditions, Shot 2722

154.5 Stability Computations

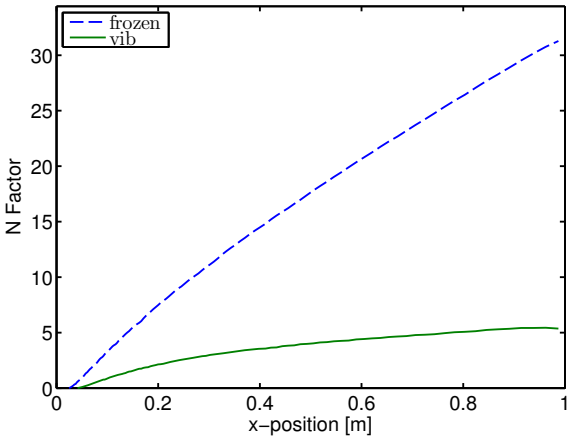


Figure 460: Locus of maximum N factor with and without vibrational energy transfer, Shot 2722

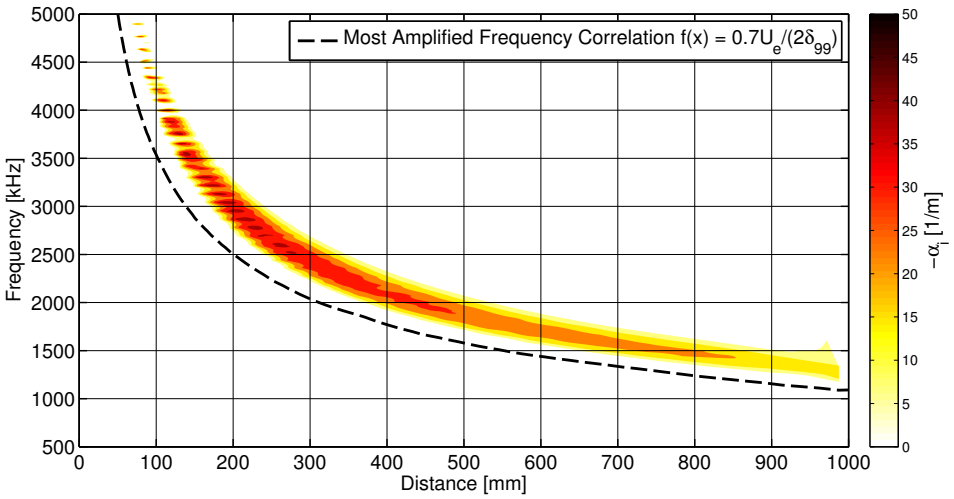


Figure 461: Stability diagram with vibrational energy transfer, Shot 2722. Dashed line indicates $0.7U_e/(2\delta_{99})$.

154.6 Heat Transfer Results

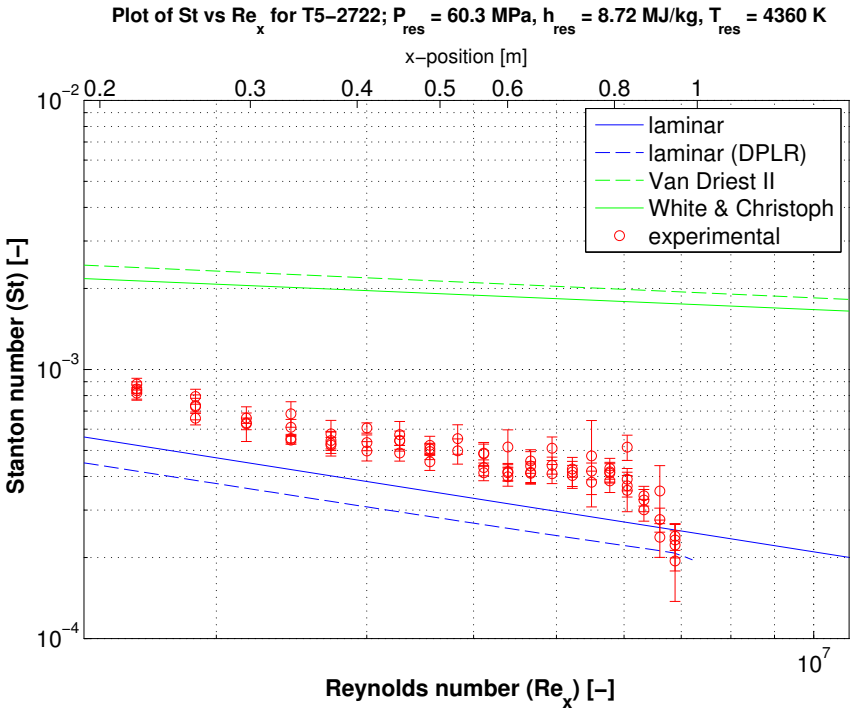


Figure 462: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

155 Shot 2723

Experiment 2723 was performed in T5 on 19 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

155.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	71.00	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 1233: Measured quantities, Shot 2723

155.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4160	K
Reservoir Density	ρ_{res}	55.94	kg/m^3
Reservoir Enthalpy	h_{res}	7.97	MJ/kg

Table 1234: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2723

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.40×10^{-1}	5.73×10^{-1}	0	2.72×10^{-1}	0	1.53×10^{-2}

Table 1235: Computed reservoir species mass fractions, Shot 2723

155.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3051	1783.0	1783.0	4.55	39.3	0.104	5.99×10^6
72 cm	3042	1781.8	1782.0	4.19	47.3	0.126	7.19×10^6

Table 1236: Computed freestream conditions, Shot 2723

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	6.97×10^{-4}
72 cm	0	8.51×10^{-2}	7.63×10^{-1}	0	1.51×10^{-1}	0	1.17×10^{-3}

Table 1237: Computed freestream species mass fractions, Shot 2723

155.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3019	1857.9	1857.9	4.41	50.9	0.129	7.13×10^6
72 cm	2995	1875.5	1875.5	4.02	61.2	0.154	8.38×10^6

Table 1238: Computed boundary layer edge conditions, Shot 2723

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	6.97×10^{-4}
72 cm	0	8.51×10^{-2}	7.63×10^{-1}	0	1.51×10^{-1}	0	9.24×10^{-4}

Table 1239: Computed boundary layer edge species mass fractions, Shot 2723

	T^* K	Unit Re^* 1/m
1D 100 cm	1600	9.25×10^6
72 cm	1523	10.32×10^6

Table 1240: Dorrance reference conditions, Shot 2723

155.5 Stability Computations

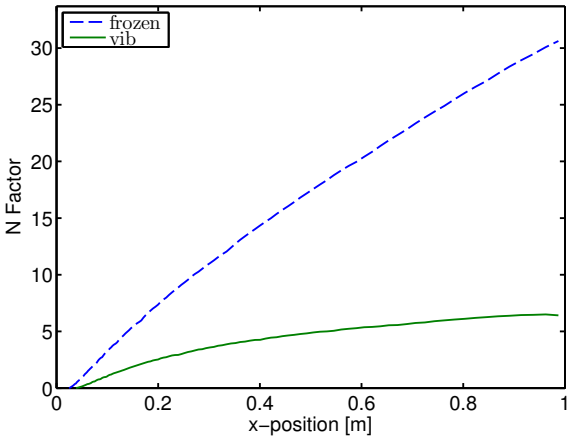


Figure 463: Locus of maximum N factor with and without vibrational energy transfer, Shot 2723

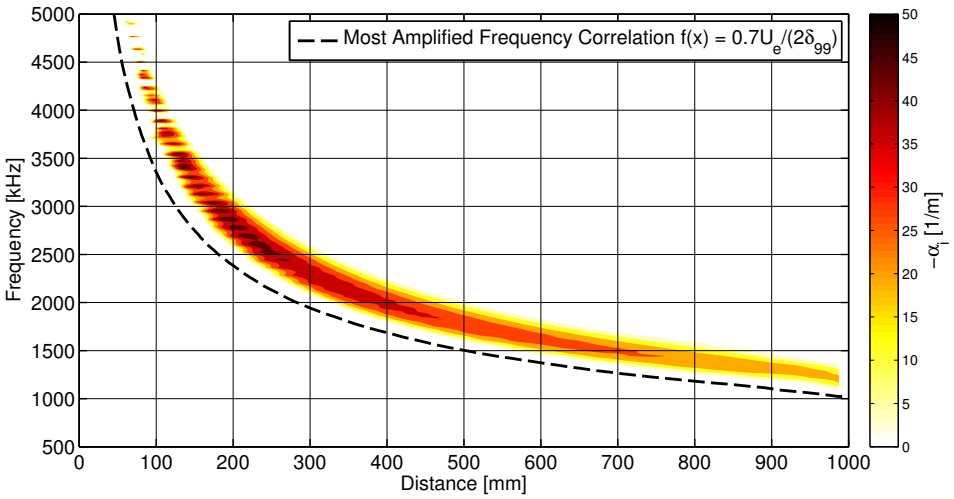


Figure 464: Stability diagram with vibrational energy transfer, Shot 2723. Dashed line indicates $0.7U_e/(2\delta_{99})$.

155.6 Heat Transfer Results

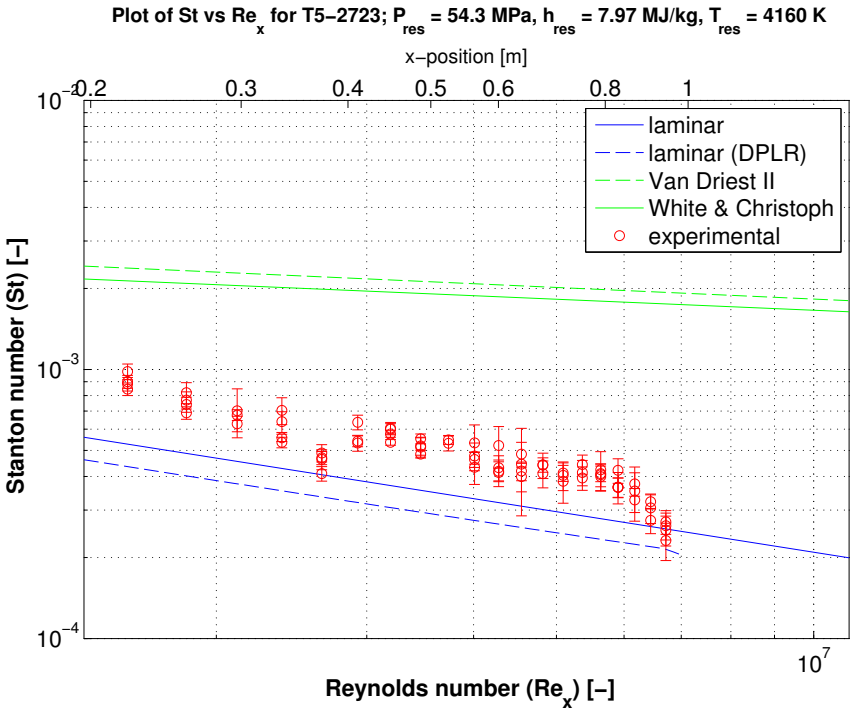


Figure 465: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

156 Shot 2724

Experiment 2724 was performed in T5 on 20 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

156.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	75.15	kPa
Reservoir Pressure	P_{res}	53.2	MPa

Table 1241: Measured quantities, Shot 2724

156.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4140	K
Reservoir Density	ρ_{res}	55.27	kg/m^3
Reservoir Enthalpy	h_{res}	7.89	MJ/kg

Table 1242: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2724

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.38×10^{-1}	5.79×10^{-1}	0	2.68×10^{-1}	0	1.48×10^{-2}

Table 1243: Computed reservoir species mass fractions, Shot 2724

156.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3040	1769.0	1769.0	4.56	38.7	0.103	5.96×10^6
72 cm	3030	1768.3	1768.6	4.19	46.3	0.124	7.11×10^6

Table 1244: Computed freestream conditions, Shot 2724

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.50×10^{-2}	7.64×10^{-1}	0	1.50×10^{-1}	0	6.67×10^{-4}
72 cm	0	8.41×10^{-2}	7.66×10^{-1}	0	1.49×10^{-1}	0	1.12×10^{-3}

Table 1245: Computed freestream species mass fractions, Shot 2724

156.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3008	1843.5	1843.5	4.42	50.1	0.128	7.10×10^6
72 cm	2983	1861.2	1861.2	4.02	59.9	0.152	8.29×10^6

Table 1246: Computed boundary layer edge conditions, Shot 2724

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.50×10^{-2}	7.64×10^{-1}	0	1.50×10^{-1}	0	6.67×10^{-4}
72 cm	0	8.40×10^{-2}	7.66×10^{-1}	0	1.49×10^{-1}	0	8.88×10^{-4}

Table 1247: Computed boundary layer edge species mass fractions, Shot 2724

	T^* K	Unit Re^* 1/m
1D 100 cm	1589	9.19×10^6
72 cm	1513	10.19×10^6

Table 1248: Dorrance reference conditions, Shot 2724

156.5 Stability Computations

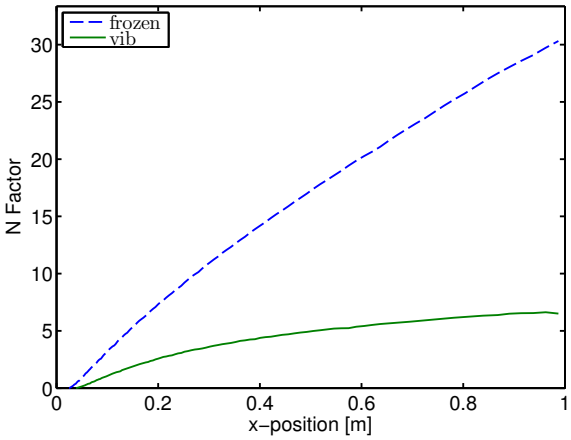


Figure 466: Locus of maximum N factor with and without vibrational energy transfer, Shot 2724

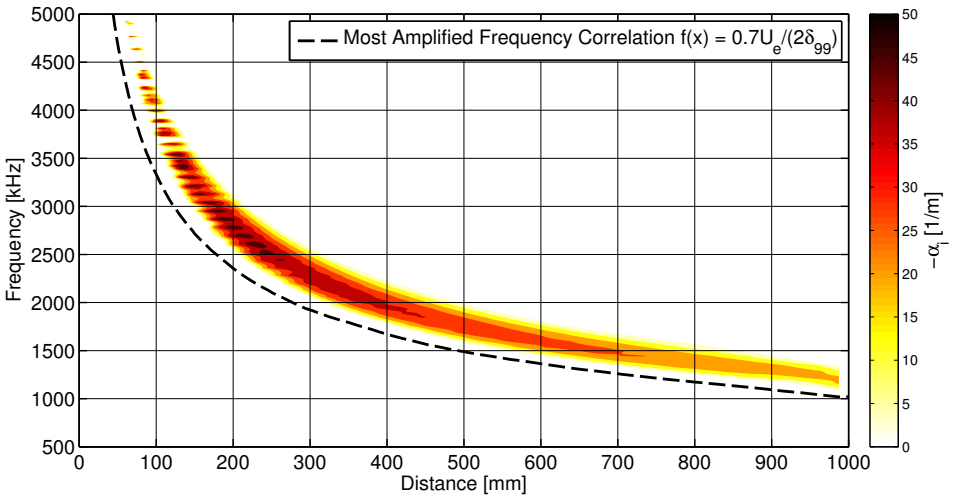


Figure 467: Stability diagram with vibrational energy transfer, Shot 2724. Dashed line indicates $0.7U_e/(2\delta_{99})$.

156.6 Heat Transfer Results

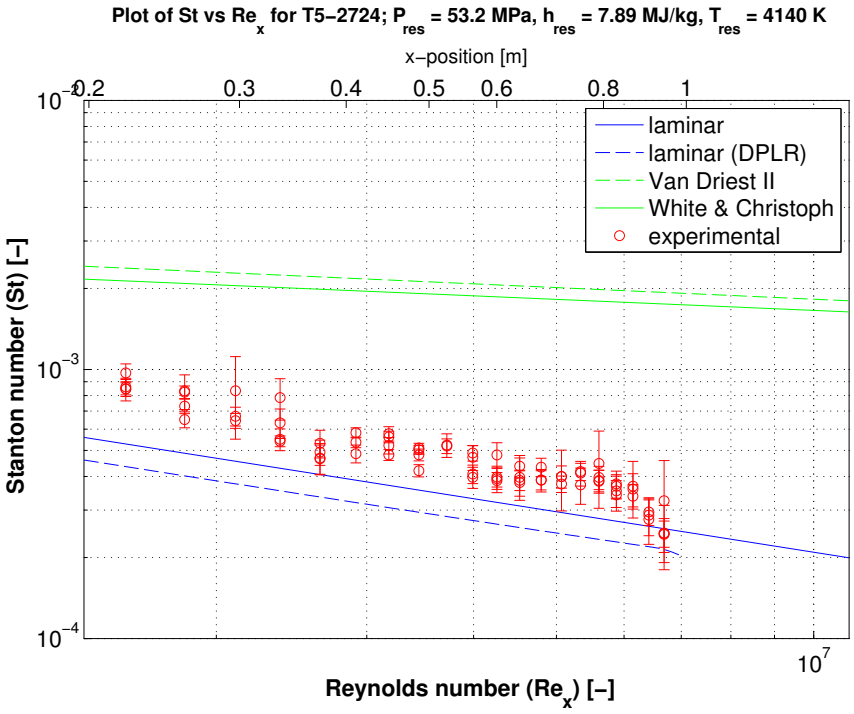


Figure 468: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

157 Shot 2725

Experiment 2725 was performed in T5 on 21 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

157.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2930	m/s
Shock Tube Fill Pressure	P_1	82.00	kPa
Reservoir Pressure	P_{res}	57.0	MPa

Table 1249: Measured quantities, Shot 2725

157.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4132	K
Reservoir Density	ρ_{res}	59.60	kg/m^3
Reservoir Enthalpy	h_{res}	7.81	MJ/kg

Table 1250: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2725

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.35×10^{-1}	5.89×10^{-1}	0	2.61×10^{-1}	0	1.39×10^{-2}

Table 1251: Computed reservoir species mass fractions, Shot 2725

157.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3032	1769.0	1769.0	4.56	41.7	0.112	6.44×10^6
72 cm	3022	1769.9	1770.1	4.18	49.8	0.134	7.66×10^6

Table 1252: Computed freestream conditions, Shot 2725

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.22×10^{-2}	7.72×10^{-1}	0	1.45×10^{-1}	0	5.67×10^{-4}
72 cm	0	8.10×10^{-2}	7.74×10^{-1}	0	1.44×10^{-1}	0	9.51×10^{-4}

Table 1253: Computed freestream species mass fractions, Shot 2725

157.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2999	1842.8	1842.8	4.42	54.0	0.139	7.67×10^6
72 cm	2975	1861.6	1861.6	4.02	64.4	0.165	8.94×10^6

Table 1254: Computed boundary layer edge conditions, Shot 2725

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.22×10^{-2}	7.72×10^{-1}	0	1.45×10^{-1}	0	5.67×10^{-4}
72 cm	0	8.10×10^{-2}	7.75×10^{-1}	0	1.43×10^{-1}	0	7.41×10^{-4}

Table 1255: Computed boundary layer edge species mass fractions, Shot 2725

	T^* K	Unit Re^* 1/m
1D 100 cm	1586	9.96×10^6
72 cm	1511	11.02×10^6

Table 1256: Dorrance reference conditions, Shot 2725

157.5 Stability Computations

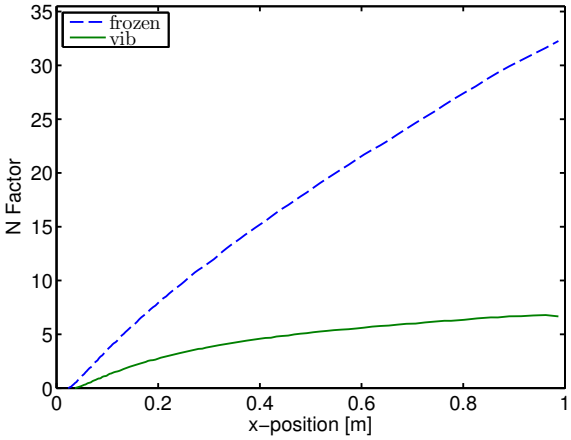


Figure 469: Locus of maximum N factor with and without vibrational energy transfer, Shot 2725

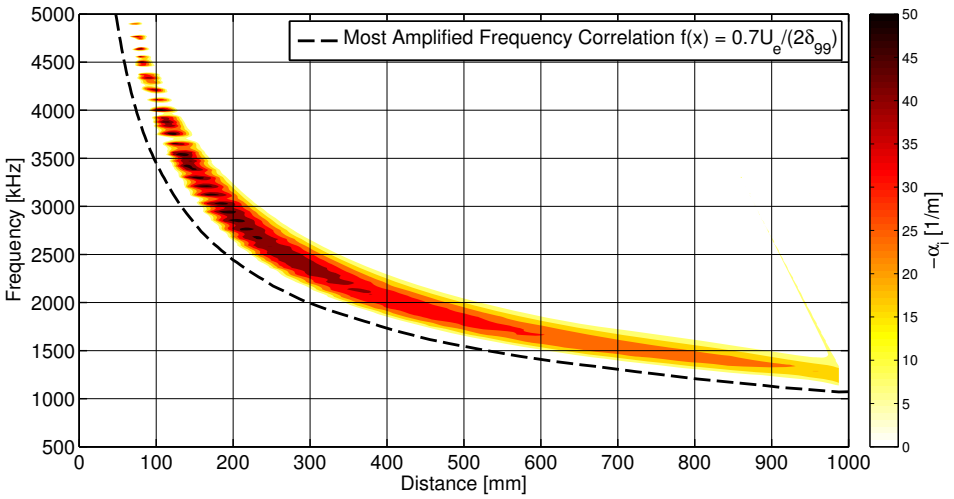


Figure 470: Stability diagram with vibrational energy transfer, Shot 2725. Dashed line indicates $0.7U_e/(2\delta_{99})$.

157.6 Heat Transfer Results

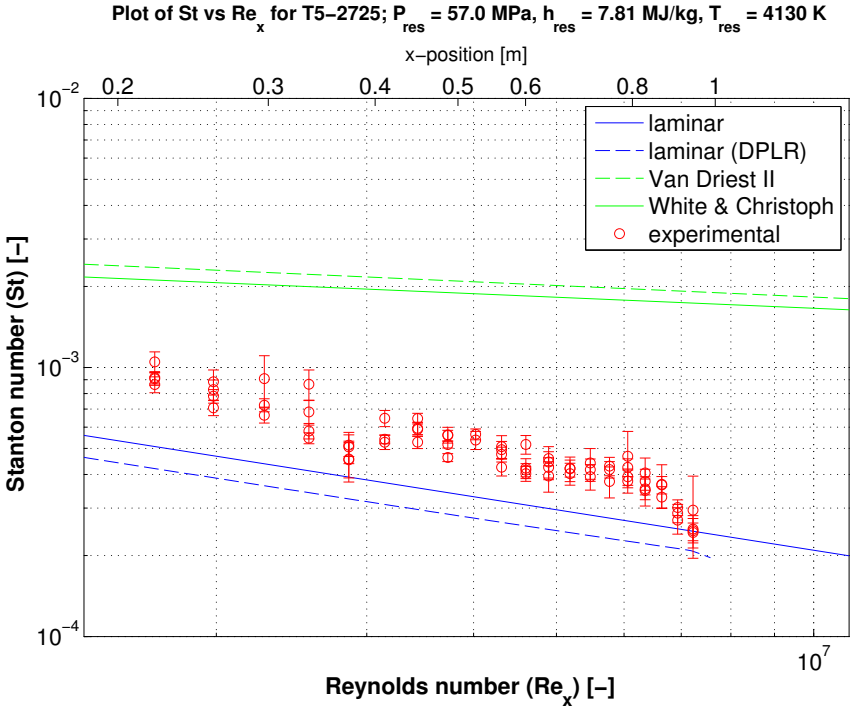


Figure 471: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

158 Shot 2726

Experiment 2726 was performed in T5 on 22 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

158.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2830	m/s
Shock Tube Fill Pressure	P_1	95.00	kPa
Reservoir Pressure	P_{res}	57.8	MPa

Table 1257: Measured quantities, Shot 2726

158.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4000	K
Reservoir Density	ρ_{res}	64.12	kg/m^3
Reservoir Enthalpy	h_{res}	7.24	MJ/kg

Table 1258: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2726

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.20×10^{-1}	6.41×10^{-1}	0	2.28×10^{-1}	0	1.01×10^{-2}

Table 1259: Computed reservoir species mass fractions, Shot 2726

158.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2946	1679.0	1679.0	4.58	42.4	0.121	7.07×10^6
72 cm	2940	1693.1	1693.3	4.19	50.3	0.143	8.28×10^6

Table 1260: Computed freestream conditions, Shot 2726

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	7.23×10^{-2}	8.00×10^{-1}	0	1.27×10^{-1}	0	3.20×10^{-4}
72 cm	0	7.00×10^{-2}	8.06×10^{-1}	0	1.23×10^{-1}	0	5.12×10^{-4}

Table 1261: Computed freestream species mass fractions, Shot 2726

158.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2915	1749.0	1749.0	4.44	54.9	0.151	8.44×10^6
72 cm	2894	1777.7	1777.7	4.03	65.0	0.176	9.69×10^6

Table 1262: Computed boundary layer edge conditions, Shot 2726

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	7.23×10^{-2}	8.00×10^{-1}	0	1.27×10^{-1}	0	3.20×10^{-4}
72 cm	0	7.00×10^{-2}	8.06×10^{-1}	0	1.23×10^{-1}	0	3.94×10^{-4}

Table 1263: Computed boundary layer edge species mass fractions, Shot 2726

	T^* K	Unit Re^* 1/m
1D 100 cm	1512	10.88×10^6
72 cm	1447	11.90×10^6

Table 1264: Dorrance reference conditions, Shot 2726

158.5 Stability Computations

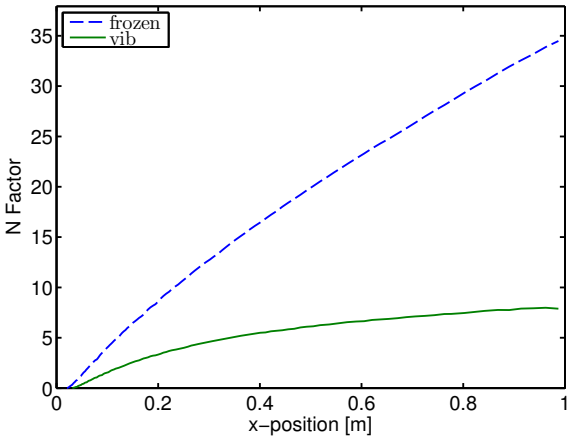


Figure 472: Locus of maximum N factor with and without vibrational energy transfer, Shot 2726

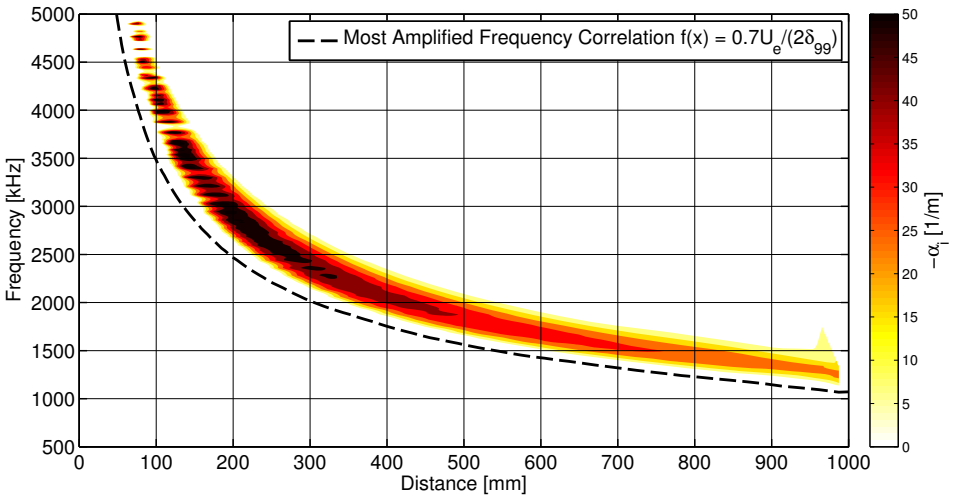


Figure 473: Stability diagram with vibrational energy transfer, Shot 2726. Dashed line indicates $0.7U_e/(2\delta_{99})$.

158.6 Heat Transfer Results

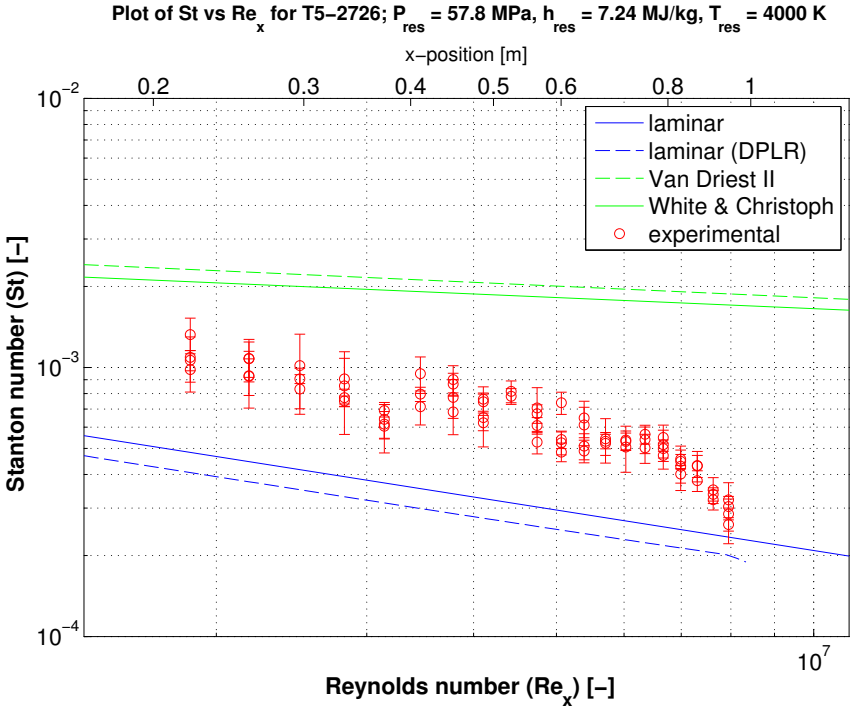


Figure 474: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

159 Shot 2727

Experiment 2727 was performed in T5 on 29 June 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

159.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2750	m/s
Shock Tube Fill Pressure	P_1	115.00	kPa
Reservoir Pressure	P_{res}	57.1	MPa

Table 1265: Measured quantities, Shot 2727

159.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3870	K
Reservoir Density	ρ_{res}	66.98	kg/m^3
Reservoir Enthalpy	h_{res}	6.73	MJ/kg

Table 1266: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2727

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.06×10^{-1}	6.88×10^{-1}	0	1.98×10^{-1}	0	7.24×10^{-3}

Table 1267: Computed reservoir species mass fractions, Shot 2727

159.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2858	1583.0	1583.0	4.60	40.5	0.125	7.38×10^{6}
72 cm	2858	1608.8	1609.0	4.21	49.2	0.149	8.75×10^{6}

Table 1268: Computed freestream conditions, Shot 2727

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.39×10^{-2}	8.24×10^{-1}	0	1.12×10^{-1}	0	1.88×10^{-4}
72 cm	0	6.12×10^{-2}	8.31×10^{-1}	0	1.08×10^{-1}	0	2.58×10^{-4}

Table 1269: Computed freestream species mass fractions, Shot 2727

159.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2828	1648.3	1648.3	4.46	52.6	0.155	8.83×10^{6}
72 cm	2814	1687.6	1687.6	4.04	63.7	0.184	1.03×10^{7}

Table 1270: Computed boundary layer edge conditions, Shot 2727

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.39×10^{-2}	8.24×10^{-1}	0	1.12×10^{-1}	0	1.88×10^{-4}
72 cm	0	6.12×10^{-2}	8.31×10^{-1}	0	1.07×10^{-1}	0	1.98×10^{-4}

Table 1271: Computed boundary layer edge species mass fractions, Shot 2727

	T^* K	Unit Re^* 1/m
1D 100 cm	1436	11.24×10^{6}
72 cm	1382	12.53×10^{6}

Table 1272: Dorrance reference conditions, Shot 2727

159.5 Stability Computations

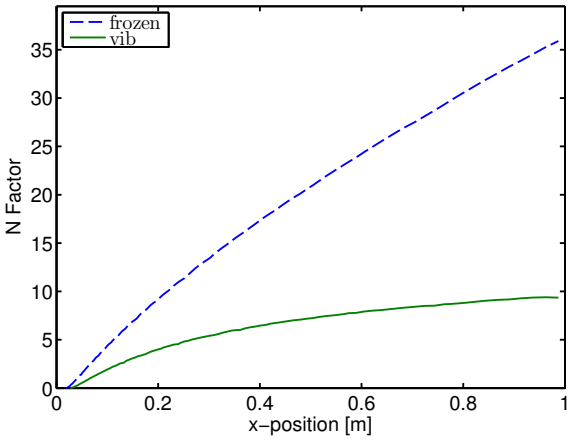


Figure 475: Locus of maximum N factor with and without vibrational energy transfer, Shot 2727

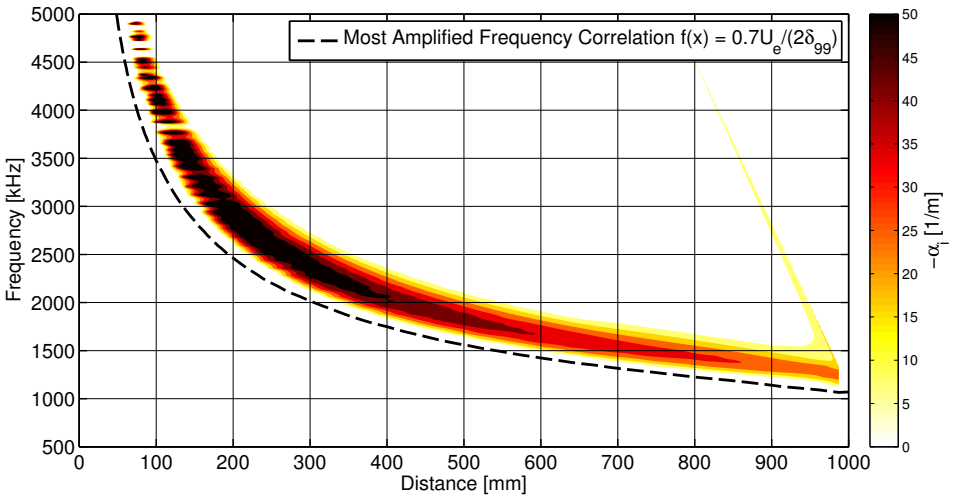


Figure 476: Stability diagram with vibrational energy transfer, Shot 2727. Dashed line indicates $0.7U_e/(2\delta_{99})$.

159.6 Heat Transfer Results

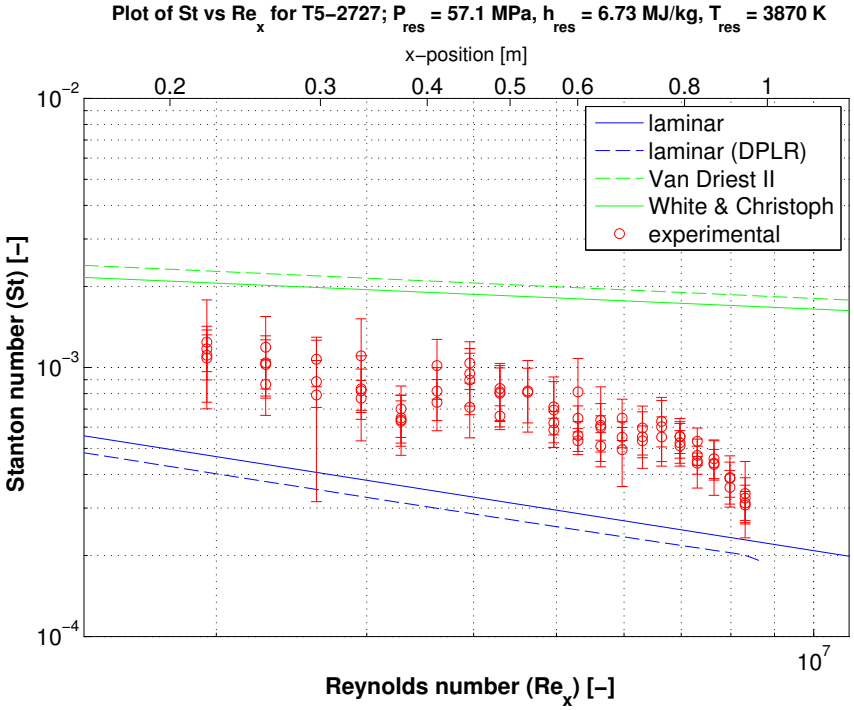


Figure 477: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

160 Shot 2728

Experiment 2728 was performed in T5 on 2 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 25% air, 75% CO_2 by mass.

160.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	92.60	kPa
Reservoir Pressure	P_{res}	56.6	MPa

Table 1273: Measured quantities, Shot 2728

160.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4190	K
Reservoir Density	ρ_{res}	54.15	kg/m^3
Reservoir Enthalpy	h_{res}	7.52	MJ/kg

Table 1274: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2728

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1.69×10^{-1}	1.37×10^{-1}	4.15×10^{-1}	5.00×10^{-2}	2.13×10^{-1}	2.74×10^{-5}	1.62×10^{-2}

Table 1275: Computed reservoir species mass fractions, Shot 2728

160.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3137	1587.0	1587.0	4.72	37.8	0.104	6.51×10^6
72 cm	3130	1581.4	1581.7	4.40	43.7	0.121	7.56×10^6

Table 1276: Computed freestream conditions, Shot 2728

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.81×10^{-1}	1.03×10^{-1}	5.88×10^{-1}	2.44×10^{-2}	1.03×10^{-1}	1.67×10^{-9}	8.53×10^{-4}
72 cm	1.78×10^{-1}	9.83×10^{-2}	5.93×10^{-1}	3.01×10^{-2}	9.98×10^{-2}	1.45×10^{-9}	9.31×10^{-4}

Table 1277: Computed freestream species mass fractions, Shot 2728

160.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3104	1666.4	1666.4	4.55	49.9	0.131	7.79×10^6
72 cm	3080	1683.7	1683.6	4.19	57.7	0.150	8.81×10^6

Table 1278: Computed boundary layer edge conditions, Shot 2728

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.81×10^{-1}	1.03×10^{-1}	5.88×10^{-1}	2.44×10^{-2}	1.03×10^{-1}	1.67×10^{-9}	8.53×10^{-4}
72 cm	1.78×10^{-1}	9.83×10^{-2}	5.93×10^{-1}	3.01×10^{-2}	9.95×10^{-2}	2.30×10^{-9}	7.70×10^{-4}

Table 1279: Computed boundary layer edge species mass fractions, Shot 2728

	T^* K	Unit Re^* 1/m
1D 100 cm	1544	8.89×10^6
72 cm	1472	10.08×10^6

Table 1280: Dorrance reference conditions, Shot 2728

160.5 Stability Computations

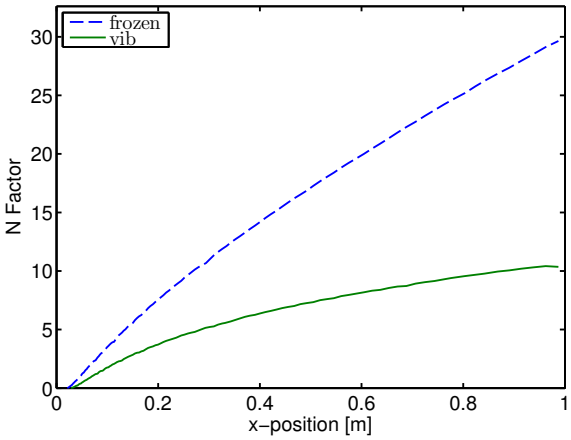


Figure 478: Locus of maximum N factor with and without vibrational energy transfer, Shot 2728

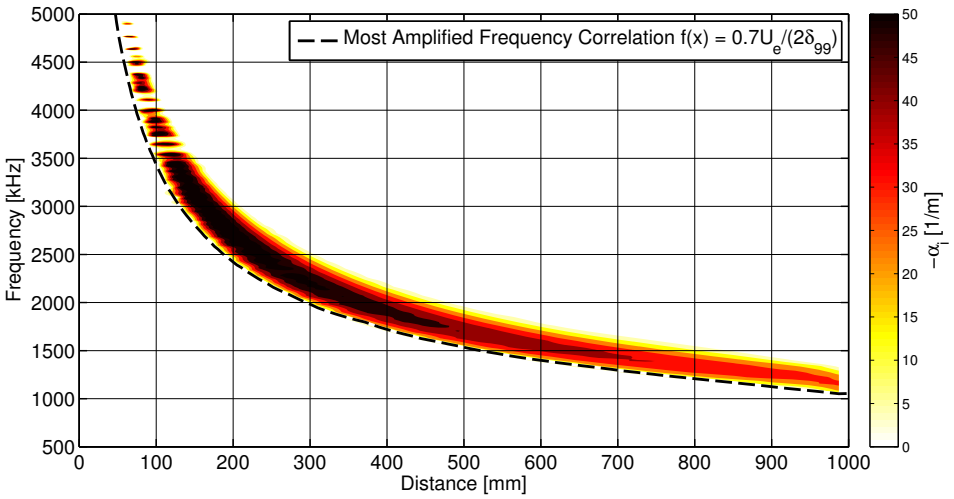


Figure 479: Stability diagram with vibrational energy transfer, Shot 2728. Dashed line indicates $0.7U_e/(2\delta_{99})$.

160.6 Heat Transfer Results

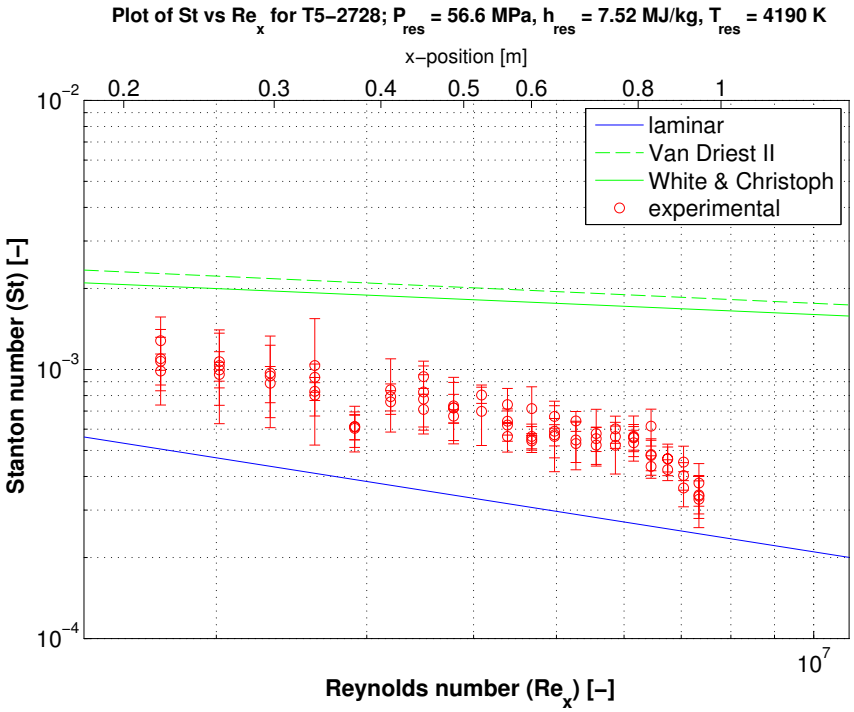


Figure 480: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

161 Shot 2729

Experiment 2729 was performed in T5 on 3 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

161.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	103.20	kPa
Reservoir Pressure	P_{res}	57.7	MPa

Table 1281: Measured quantities, Shot 2729

161.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4661	K
Reservoir Density	ρ_{res}	44.49	kg/m^3
Reservoir Enthalpy	h_{res}	8.45	MJ/kg

Table 1282: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2729

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.39×10^{-1}	1.45×10^{-1}	1.81×10^{-1}	9.45×10^{-2}	2.03×10^{-1}	1.67×10^{-4}	3.69×10^{-2}

Table 1283: Computed reservoir species mass fractions, Shot 2729

161.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3446	1612.0	1612.0	4.84	36.2	0.089	5.81×10^6
72 cm	3426	1572.3	1573.1	4.60	39.9	0.101	6.65×10^6

Table 1284: Computed freestream conditions, Shot 2729

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.43×10^{-1}	3.62×10^{-1}	3.93×10^{-2}	8.77×10^{-2}	4.03×10^{-9}	3.00×10^{-3}
72 cm	3.61×10^{-1}	1.39×10^{-1}	3.62×10^{-1}	4.74×10^{-2}	8.81×10^{-2}	4.43×10^{-9}	2.76×10^{-3}

Table 1285: Computed freestream species mass fractions, Shot 2729

161.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3410	1708.3	1708.3	4.65	48.5	0.112	6.97×10^6
72 cm	3371	1705.0	1704.9	4.34	53.8	0.125	7.67×10^6

Table 1286: Computed boundary layer edge conditions, Shot 2729

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.43×10^{-1}	3.62×10^{-1}	3.93×10^{-2}	8.77×10^{-2}	4.03×10^{-9}	3.00×10^{-3}
72 cm	3.61×10^{-1}	1.39×10^{-1}	3.62×10^{-1}	4.74×10^{-2}	8.76×10^{-2}	8.78×10^{-9}	2.39×10^{-3}

Table 1287: Computed boundary layer edge species mass fractions, Shot 2729

	T^* K	Unit Re^* 1/m
1D 100 cm	1686	7.13×10^6
72 cm	1596	8.59×10^6

Table 1288: Dorrance reference conditions, Shot 2729

161.5 Stability Computations

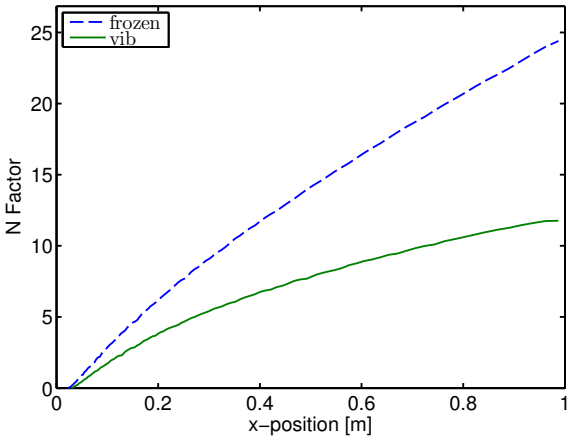


Figure 481: Locus of maximum N factor with and without vibrational energy transfer, Shot 2729

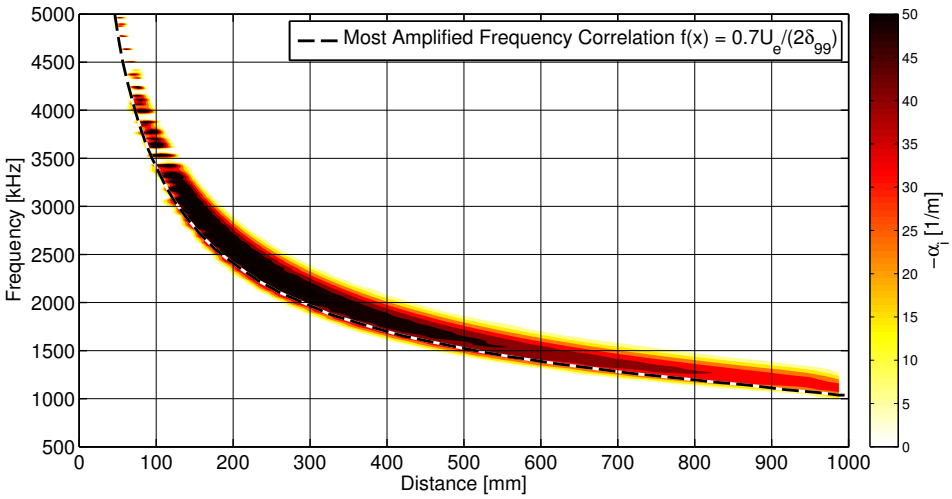


Figure 482: Stability diagram with vibrational energy transfer, Shot 2729. Dashed line indicates $0.7U_e/(2\delta_{99})$.

161.6 Heat Transfer Results

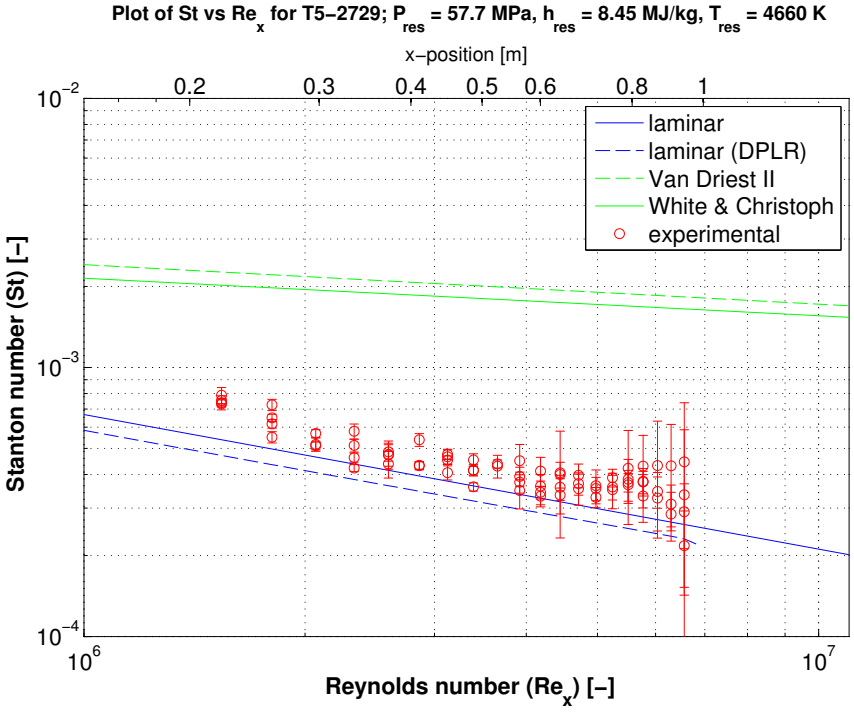


Figure 483: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

162 Shot 2730

Experiment 2730 was performed in T5 on 5 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

162.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2940	m/s
Shock Tube Fill Pressure	P_1	120.00	kPa
Reservoir Pressure	P_{res}	58.1	MPa

Table 1289: Measured quantities, Shot 2730

162.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4472	K
Reservoir Density	ρ_{res}	47.69	kg/m^3
Reservoir Enthalpy	h_{res}	7.80	MJ/kg

Table 1290: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2730

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.43×10^{-1}	1.46×10^{-1}	2.17×10^{-1}	8.64×10^{-2}	1.80×10^{-1}	9.73×10^{-5}	2.75×10^{-2}

Table 1291: Computed reservoir species mass fractions, Shot 2730

162.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3340	1499.0	1499.0	4.88	35.8	0.095	6.38×10^6
72 cm	3324	1476.5	1477.5	4.63	39.5	0.107	7.22×10^6

Table 1292: Computed freestream conditions, Shot 2730

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.37×10^{-1}	3.83×10^{-1}	3.82×10^{-2}	7.46×10^{-2}	9.43×10^{-10}	1.97×10^{-3}
72 cm	3.62×10^{-1}	1.31×10^{-1}	3.87×10^{-1}	4.68×10^{-2}	7.22×10^{-2}	1.35×10^{-9}	1.66×10^{-3}

Table 1293: Computed freestream species mass fractions, Shot 2730

162.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3305	1590.1	1590.1	4.69	48.1	0.121	7.68×10^6
72 cm	3270	1599.6	1599.6	4.37	53.3	0.133	8.35×10^6

Table 1294: Computed boundary layer edge conditions, Shot 2730

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.37×10^{-1}	3.83×10^{-1}	3.82×10^{-2}	7.46×10^{-2}	9.43×10^{-10}	1.97×10^{-3}
72 cm	3.62×10^{-1}	1.31×10^{-1}	3.87×10^{-1}	4.68×10^{-2}	7.19×10^{-2}	2.84×10^{-9}	1.44×10^{-3}

Table 1295: Computed boundary layer edge species mass fractions, Shot 2730

	T^* K	Unit Re^* 1/m
1D 100 cm	1590	7.68×10^6
72 cm	1513	9.19×10^6

Table 1296: Dorrance reference conditions, Shot 2730

162.5 Stability Computations

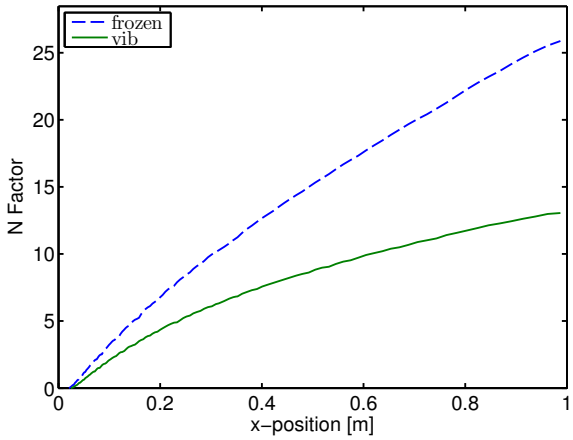


Figure 484: Locus of maximum N factor with and without vibrational energy transfer, Shot 2730

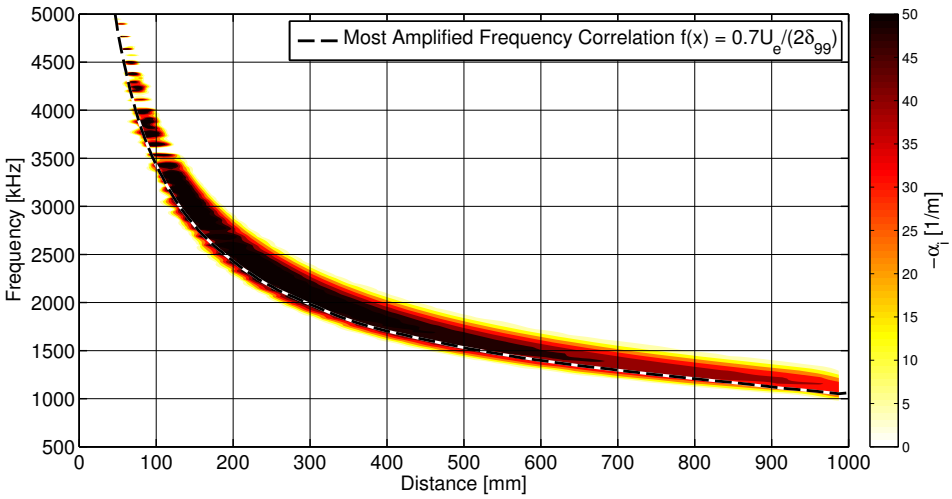


Figure 485: Stability diagram with vibrational energy transfer, Shot 2730. Dashed line indicates $0.7U_e/(2\delta_{99})$.

162.6 Heat Transfer Results

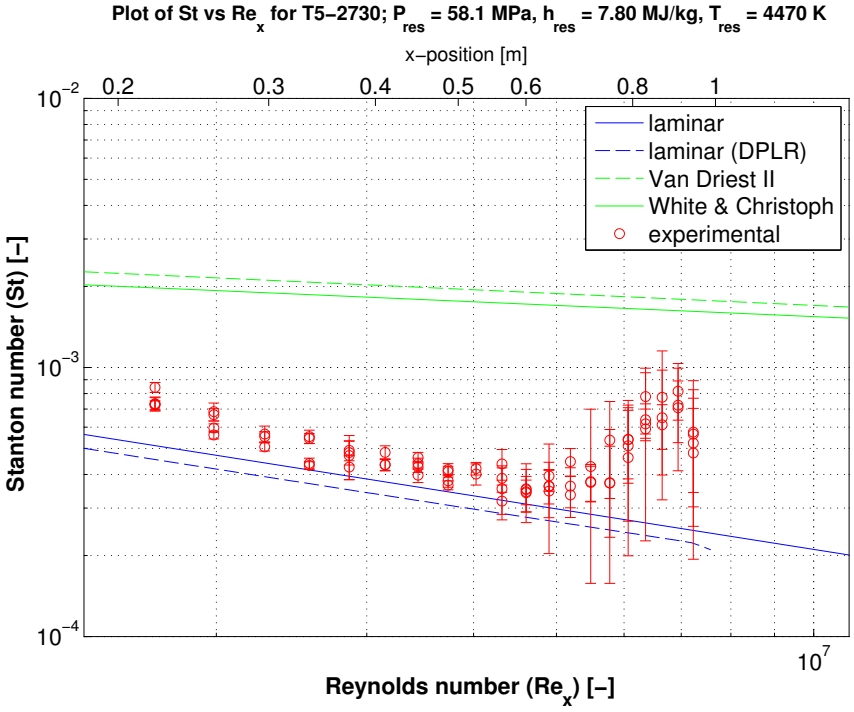


Figure 486: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

163 Shot 2731

Experiment 2731 was performed in T5 on 5 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 25% air, 75% CO_2 by mass.

163.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	88.30	kPa
Reservoir Pressure	P_{res}	59.0	MPa

Table 1297: Measured quantities, Shot 2731

163.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4557	K
Reservoir Density	ρ_{res}	49.12	kg/m^3
Reservoir Enthalpy	h_{res}	8.95	MJ/kg

Table 1298: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2731

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1.62×10^{-1}	1.53×10^{-1}	3.10×10^{-1}	6.36×10^{-2}	2.80×10^{-1}	8.31×10^{-5}	3.13×10^{-2}

Table 1299: Computed reservoir species mass fractions, Shot 2731

163.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3360	1837.0	1837.0	4.63	41.2	0.095	5.69×10^6
72 cm	3341	1782.9	1783.2	4.35	47.0	0.112	6.78×10^6

Table 1300: Computed freestream conditions, Shot 2731

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.79×10^{-1}	1.21×10^{-1}	5.32×10^{-1}	2.68×10^{-2}	1.39×10^{-1}	1.40×10^{-8}	2.26×10^{-3}
72 cm	1.77×10^{-1}	1.20×10^{-1}	5.26×10^{-1}	3.23×10^{-2}	1.43×10^{-1}	1.32×10^{-8}	2.79×10^{-3}

Table 1301: Computed freestream species mass fractions, Shot 2731

163.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3324	1928.0	1928.0	4.47	53.9	0.119	6.78×10^6
72 cm	3288	1907.3	1907.2	4.15	61.9	0.138	7.82×10^6

Table 1302: Computed boundary layer edge conditions, Shot 2731

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.79×10^{-1}	1.21×10^{-1}	5.32×10^{-1}	2.68×10^{-2}	1.39×10^{-1}	1.40×10^{-8}	2.26×10^{-3}
72 cm	1.77×10^{-1}	1.20×10^{-1}	5.27×10^{-1}	3.23×10^{-2}	1.42×10^{-1}	1.98×10^{-8}	2.27×10^{-3}

Table 1303: Computed boundary layer edge species mass fractions, Shot 2731

	T^* K	Unit Re^* 1/m
1D 100 cm	1750	8.02×10^6
72 cm	1644	9.08×10^6

Table 1304: Dorrance reference conditions, Shot 2731

163.5 Stability Computations

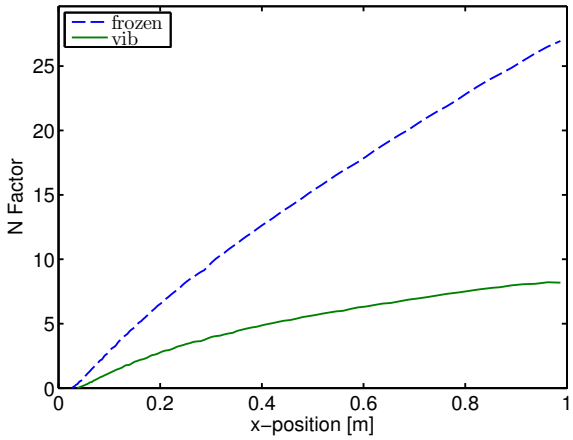


Figure 487: Locus of maximum N factor with and without vibrational energy transfer, Shot 2731

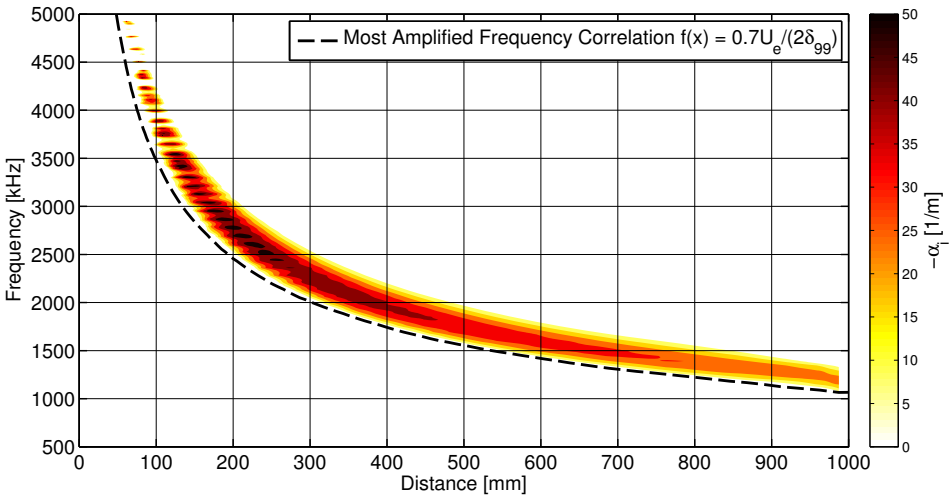


Figure 488: Stability diagram with vibrational energy transfer, Shot 2731. Dashed line indicates $0.7U_e/(2\delta_{99})$.

163.6 Heat Transfer Results

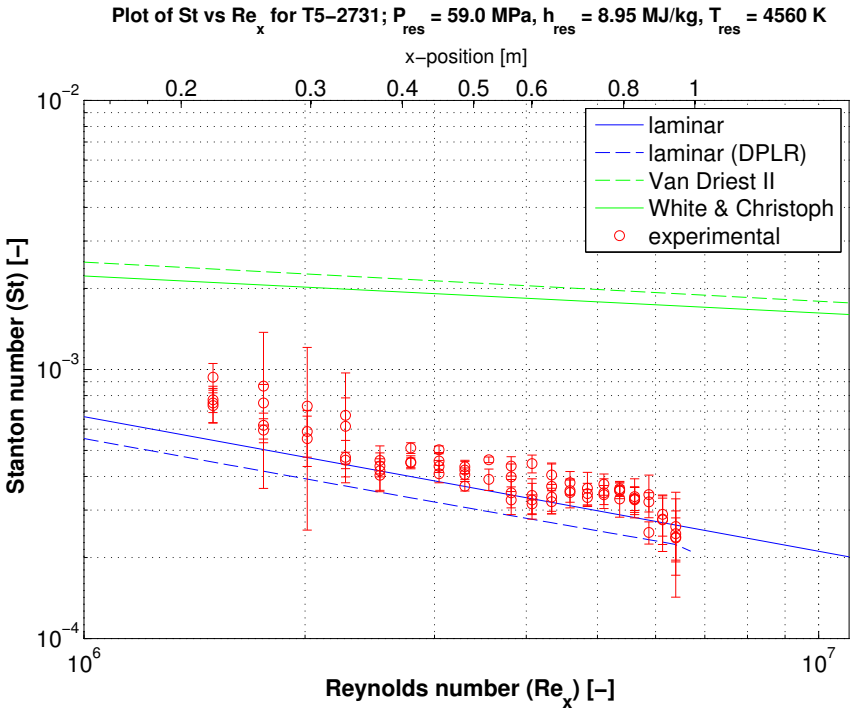


Figure 489: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

164 Shot 2732

Experiment 2732 was performed in T5 on 6 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

164.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	120.25	kPa
Reservoir Pressure	P_{res}	57.0	MPa

Table 1305: Measured quantities, Shot 2732

164.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4480	K
Reservoir Density	ρ_{res}	46.59	kg/m^3
Reservoir Enthalpy	h_{res}	7.84	MJ/kg

Table 1306: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2732

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.43×10^{-1}	1.46×10^{-1}	2.14×10^{-1}	8.67×10^{-2}	1.82×10^{-1}	1.00×10^{-4}	2.81×10^{-2}

Table 1307: Computed reservoir species mass fractions, Shot 2732

164.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3340	1495.0	1495.0	4.89	34.2	0.091	6.12×10^6
72 cm	3329	1479.1	1480.1	4.63	38.7	0.105	7.05×10^6

Table 1308: Computed freestream conditions, Shot 2732

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.37×10^{-1}	3.81×10^{-1}	3.83×10^{-2}	7.61×10^{-2}	1.26×10^{-9}	2.07×10^{-3}
72 cm	3.62×10^{-1}	1.32×10^{-1}	3.84×10^{-1}	4.70×10^{-2}	7.37×10^{-2}	1.46×10^{-9}	1.75×10^{-3}

Table 1309: Computed freestream species mass fractions, Shot 2732

164.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3305	1585.7	1585.7	4.70	46.0	0.116	7.37×10^6
72 cm	3275	1601.9	1601.9	4.37	52.2	0.130	8.16×10^6

Table 1310: Computed boundary layer edge conditions, Shot 2732

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.37×10^{-1}	3.81×10^{-1}	3.83×10^{-2}	7.61×10^{-2}	1.26×10^{-9}	2.07×10^{-3}
72 cm	3.62×10^{-1}	1.32×10^{-1}	3.85×10^{-1}	4.70×10^{-2}	7.34×10^{-2}	3.05×10^{-9}	1.53×10^{-3}

Table 1311: Computed boundary layer edge species mass fractions, Shot 2732

	T^* K	Unit Re^* 1/m
1D 100 cm	1588	7.35×10^6
72 cm	1517	8.97×10^6

Table 1312: Dorrance reference conditions, Shot 2732

164.5 Stability Computations

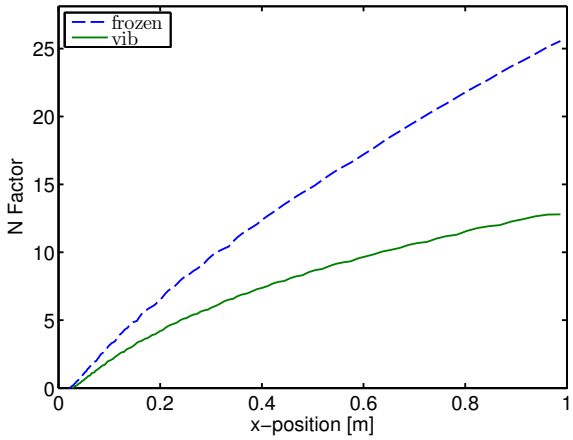


Figure 490: Locus of maximum N factor with and without vibrational energy transfer, Shot 2732

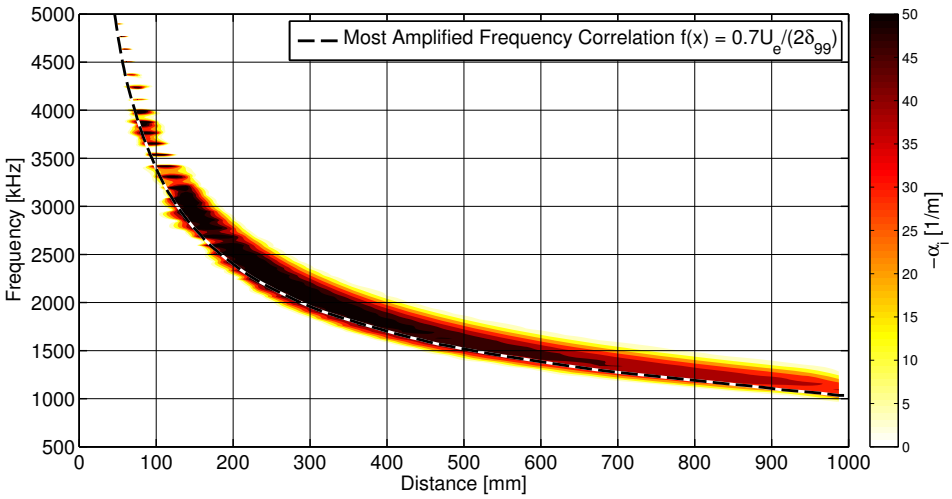


Figure 491: Stability diagram with vibrational energy transfer, Shot 2732. Dashed line indicates $0.7U_e/(2\delta_{99})$.

164.6 Heat Transfer Results

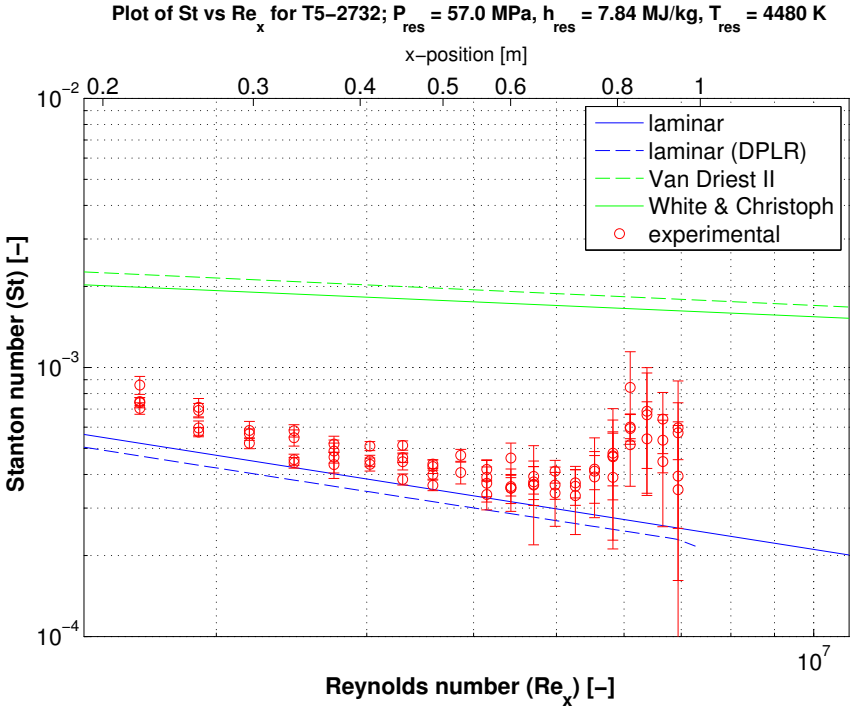


Figure 492: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

165 Shot 2733

Experiment 2733 was performed in T5 on 9 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

165.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2860	m/s
Shock Tube Fill Pressure	P_1	135.00	kPa
Reservoir Pressure	P_{res}	56.6	MPa

Table 1313: Measured quantities, Shot 2733

165.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3944	K
Reservoir Density	ρ_{res}	64.26	kg/m^3
Reservoir Enthalpy	h_{res}	7.03	MJ/kg

Table 1314: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2733

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.15×10^{-1}	6.60×10^{-1}	0	2.16×10^{-1}	0	8.85×10^{-3}

Table 1315: Computed reservoir species mass fractions, Shot 2733

165.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2911	1639.0	1639.0	4.59	41.2	0.122	7.13×10^6
72 cm	2906	1656.8	1657.0	4.20	49.0	0.143	8.33×10^6

Table 1316: Computed freestream conditions, Shot 2733

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.91×10^{-2}	8.09×10^{-1}	0	1.21×10^{-1}	0	2.63×10^{-4}
72 cm	0	6.65×10^{-2}	8.16×10^{-1}	0	1.17×10^{-1}	0	4.02×10^{-4}

Table 1317: Computed freestream species mass fractions, Shot 2733

165.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2879	1707.1	1707.1	4.45	53.4	0.151	8.52×10^6
72 cm	2860	1738.8	1738.8	4.04	63.4	0.177	9.76×10^6

Table 1318: Computed boundary layer edge conditions, Shot 2733

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.91×10^{-2}	8.09×10^{-1}	0	1.21×10^{-1}	0	2.63×10^{-4}
72 cm	0	6.65×10^{-2}	8.16×10^{-1}	0	1.17×10^{-1}	0	3.11×10^{-4}

Table 1319: Computed boundary layer edge species mass fractions, Shot 2733

	T^* K	Unit Re^* 1/m
1D 100 cm	1481	10.92×10^6
72 cm	1419	13.91×10^6

Table 1320: Dorrance reference conditions, Shot 2733

165.5 Stability Computations

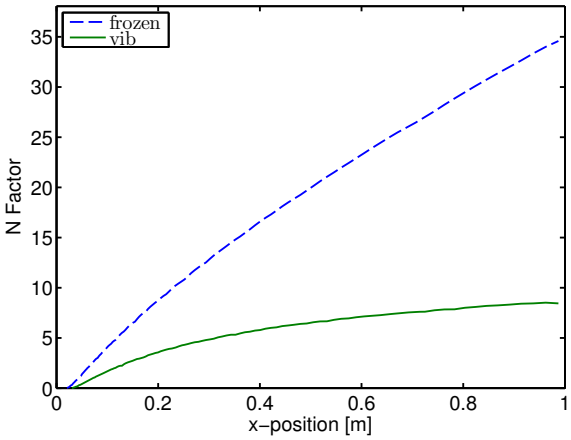


Figure 493: Locus of maximum N factor with and without vibrational energy transfer, Shot 2733

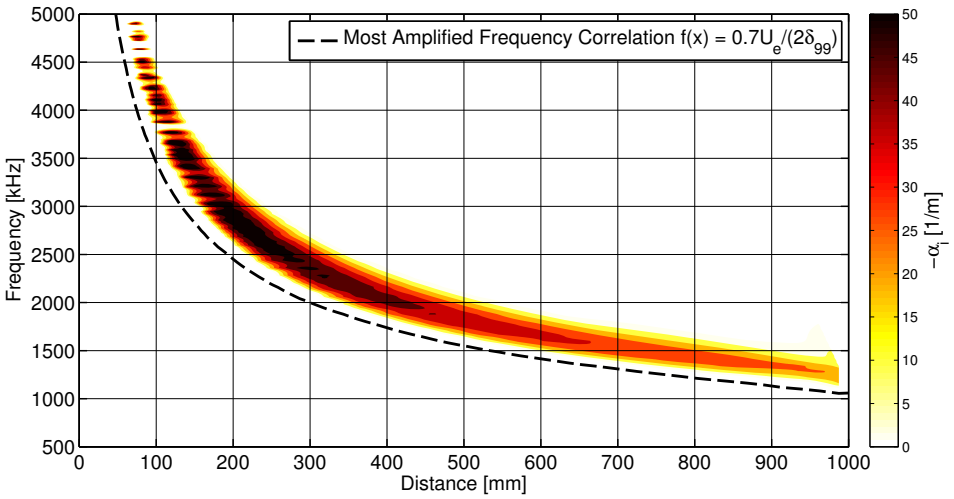


Figure 494: Stability diagram with vibrational energy transfer, Shot 2733. Dashed line indicates $0.7U_e/(2\delta_{99})$.

165.6 Heat Transfer Results

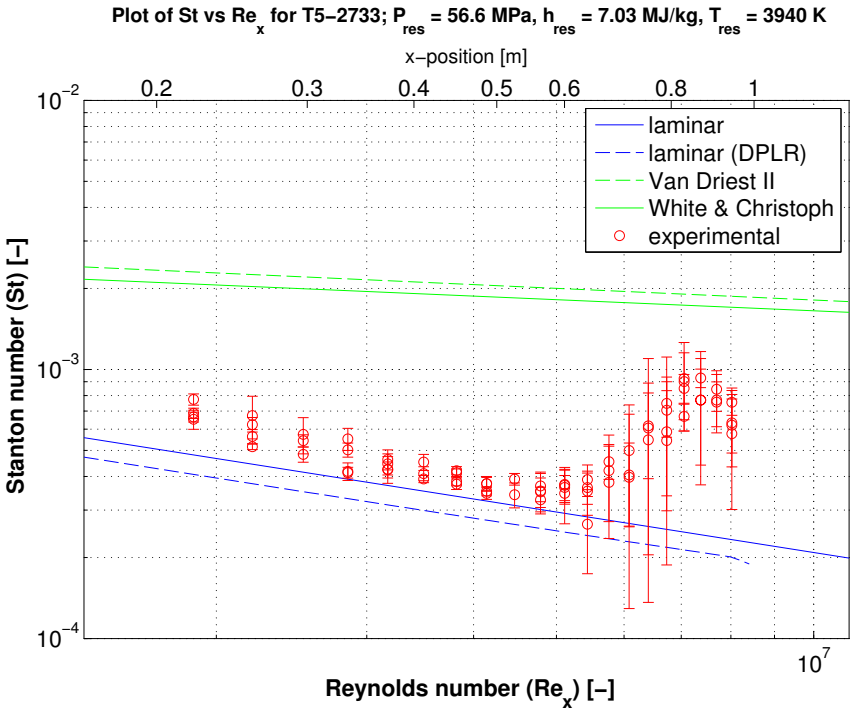


Figure 495: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

166 Shot 2734

Experiment 2734 was performed in T5 on 10 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

166.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2630	m/s
Shock Tube Fill Pressure	P_1	134.85	kPa
Reservoir Pressure	P_{res}	54.4	MPa

Table 1321: Measured quantities, Shot 2734

166.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3688	K
Reservoir Density	ρ_{res}	68.97	kg/m^3
Reservoir Enthalpy	h_{res}	6.06	MJ/kg

Table 1322: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2734

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.67×10^{-2}	7.49×10^{-1}	0	1.60×10^{-1}	0	4.46×10^{-3}

Table 1323: Computed reservoir species mass fractions, Shot 2734

166.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2740	1455.0	1455.0	4.63	37.5	0.127	7.71×10^6
72 cm	2743	1482.4	1482.6	4.23	46.2	0.154	9.25×10^6

Table 1324: Computed freestream conditions, Shot 2734

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.37×10^{-2}	8.52×10^{-1}	0	9.41×10^{-2}	0	9.20×10^{-5}
72 cm	0	5.15×10^{-2}	8.58×10^{-1}	0	9.03×10^{-2}	0	8.48×10^{-5}

Table 1325: Computed freestream species mass fractions, Shot 2734

166.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2711	1516.1	1516.1	4.49	48.7	0.158	9.23×10^6
72 cm	2700	1554.9	1554.8	4.07	59.9	0.190	1.09×10^7

Table 1326: Computed boundary layer edge conditions, Shot 2734

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.37×10^{-2}	8.52×10^{-1}	0	9.41×10^{-2}	0	9.20×10^{-5}
72 cm	0	5.15×10^{-2}	8.58×10^{-1}	0	9.02×10^{-2}	0	6.47×10^{-5}

Table 1327: Computed boundary layer edge species mass fractions, Shot 2734

	T^* K	Unit Re^* 1/m
1D 100 cm	1336	11.36×10^6
72 cm	1287	13.13×10^6

Table 1328: Dorrance reference conditions, Shot 2734

166.5 Stability Computations

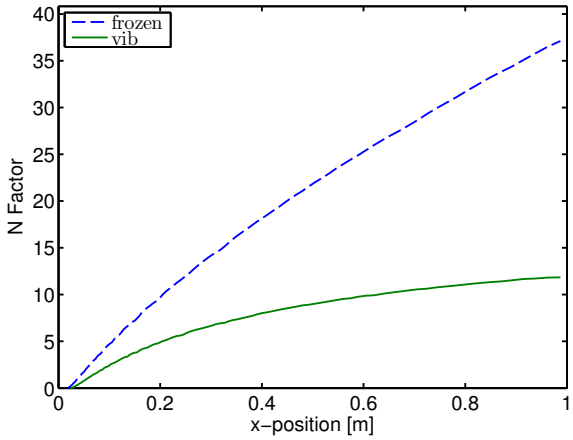


Figure 496: Locus of maximum N factor with and without vibrational energy transfer, Shot 2734

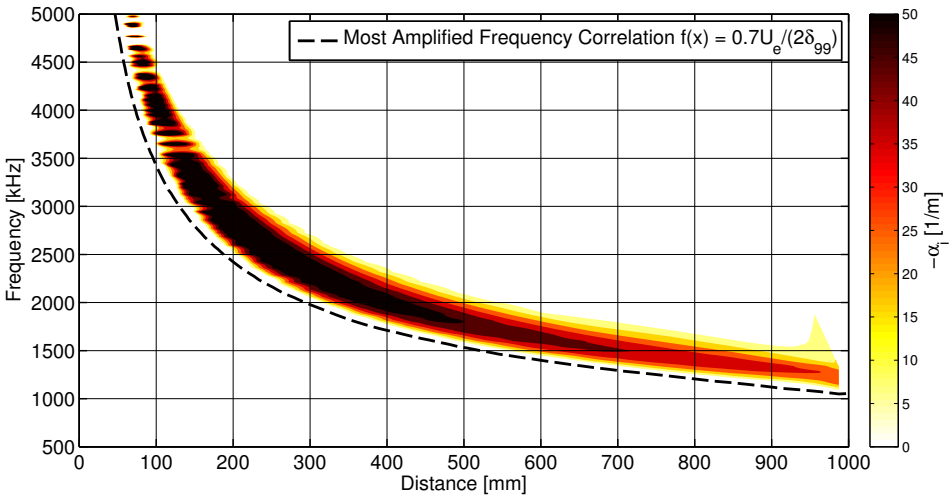


Figure 497: Stability diagram with vibrational energy transfer, Shot 2734. Dashed line indicates $0.7U_e/(2\delta_{99})$.

166.6 Heat Transfer Results

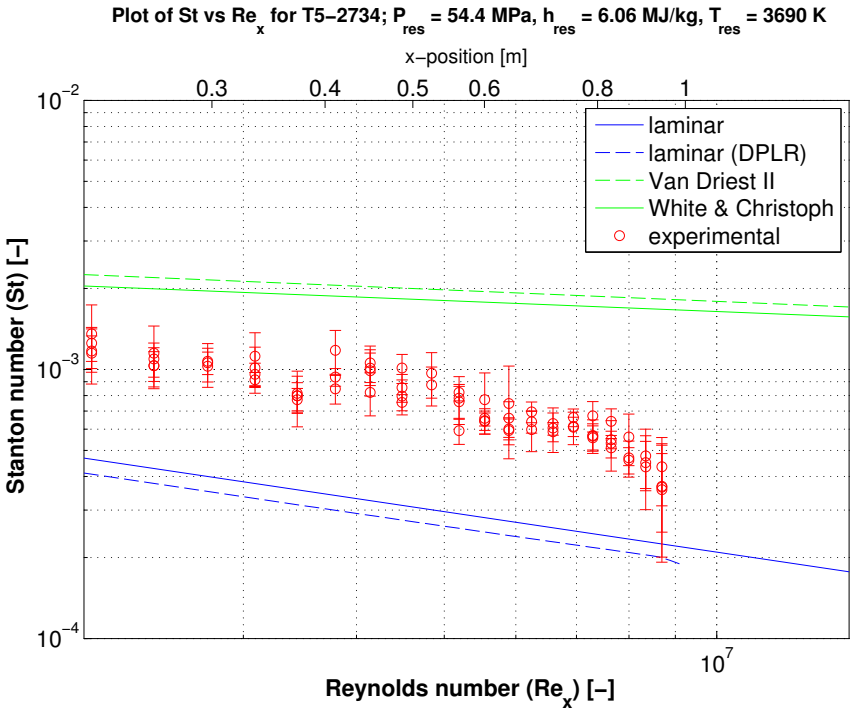


Figure 498: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

167 Shot 2735

Experiment 2735 was performed in T5 on 10 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

167.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2710	m/s
Shock Tube Fill Pressure	P_1	134.75	kPa
Reservoir Pressure	P_{res}	58.2	MPa

Table 1329: Measured quantities, Shot 2735

167.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4152	K
Reservoir Density	ρ_{res}	53.28	kg/m^3
Reservoir Enthalpy	h_{res}	6.71	MJ/kg

Table 1330: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2735

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.50×10^{-1}	1.41×10^{-1}	2.86×10^{-1}	7.13×10^{-2}	1.36×10^{-1}	3.52×10^{-5}	1.56×10^{-2}

Table 1331: Computed reservoir species mass fractions, Shot 2735

167.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3146	1299.0	1299.0	4.97	33.8	0.106	7.31×10^6
72 cm	3138	1295.1	1296.3	4.70	38.3	0.120	8.32×10^6

Table 1332: Computed freestream conditions, Shot 2735

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.27×10^{-1}	4.16×10^{-1}	3.60×10^{-2}	5.38×10^{-2}	1.07×10^{-10}	9.23×10^{-4}
72 cm	3.63×10^{-1}	1.21×10^{-1}	4.22×10^{-1}	4.46×10^{-2}	4.98×10^{-2}	0	5.20×10^{-4}

Table 1333: Computed freestream species mass fractions, Shot 2735

167.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3114	1380.3	1380.3	4.77	45.8	0.135	8.94×10^6
72 cm	3087	1403.6	1403.6	4.44	52.0	0.150	9.83×10^6

Table 1334: Computed boundary layer edge conditions, Shot 2735

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.27×10^{-1}	4.16×10^{-1}	3.60×10^{-2}	5.38×10^{-2}	1.07×10^{-10}	9.23×10^{-4}
72 cm	3.63×10^{-1}	1.21×10^{-1}	4.22×10^{-1}	4.46×10^{-2}	4.97×10^{-2}	2.00×10^{-10}	4.56×10^{-4}

Table 1335: Computed boundary layer edge species mass fractions, Shot 2735

	T^* K	Unit Re* 1/m
1D 100 cm	1422	8.51×10^6
72 cm	1363	10.12×10^6

Table 1336: Dorrance reference conditions, Shot 2735

167.5 Stability Computations

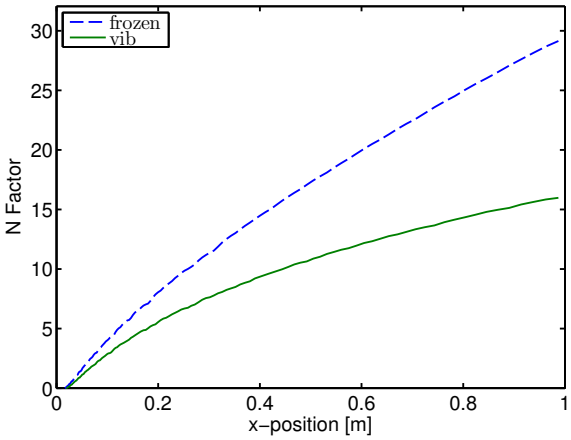


Figure 499: Locus of maximum N factor with and without vibrational energy transfer, Shot 2735

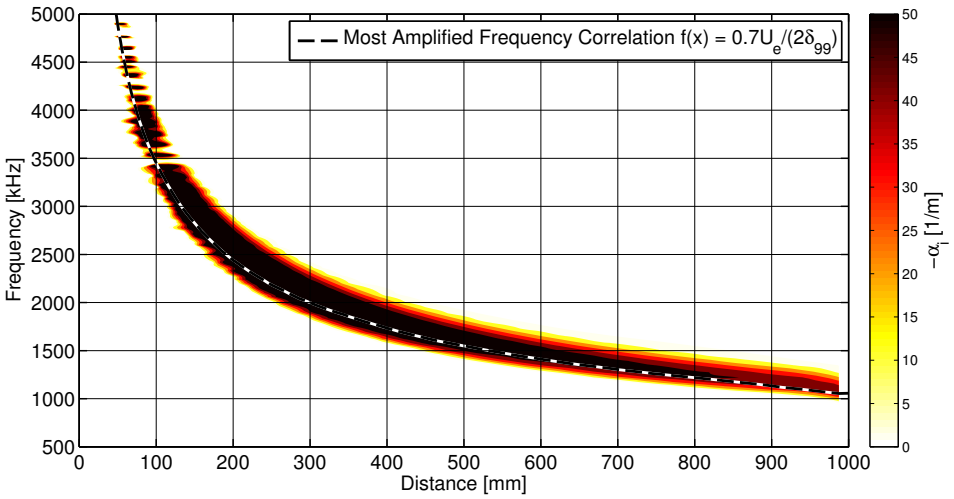


Figure 500: Stability diagram with vibrational energy transfer, Shot 2735. Dashed line indicates $0.7U_e/(2\delta_{99})$.

167.6 Heat Transfer Results

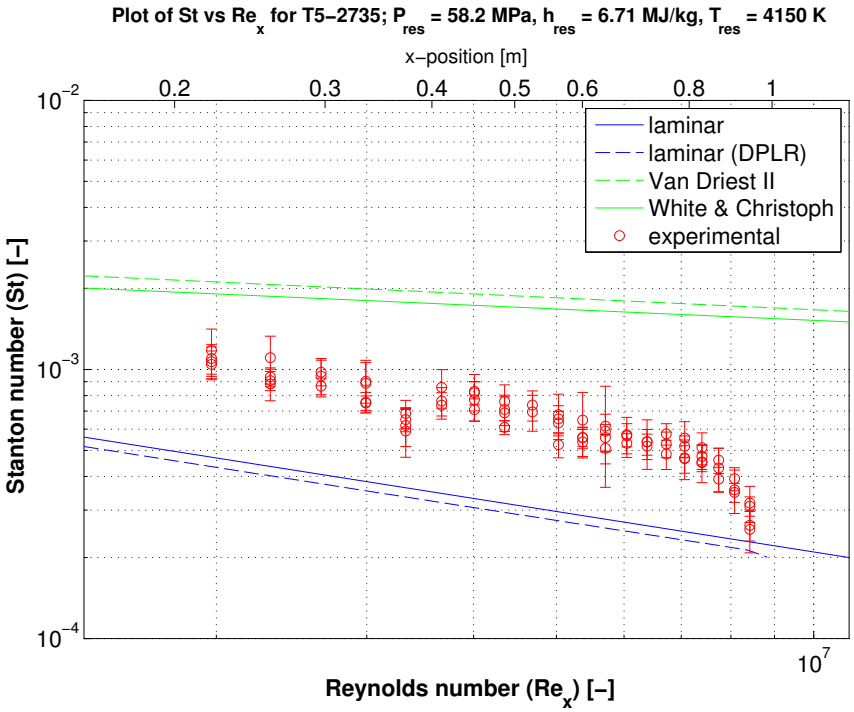


Figure 501: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

168 Shot 2736

Experiment 2736 was performed in T5 on 11 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 25% air, 75% CO_2 by mass.

168.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	117.00	kPa
Reservoir Pressure	P_{res}	57.0	MPa

Table 1337: Measured quantities, Shot 2736

168.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4242	K
Reservoir Density	ρ_{res}	53.40	kg/m^3
Reservoir Enthalpy	h_{res}	7.73	MJ/kg

Table 1338: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2736

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1.68×10^{-1}	1.40×10^{-1}	4.00×10^{-1}	5.19×10^{-2}	2.23×10^{-1}	3.24×10^{-5}	1.79×10^{-2}

Table 1339: Computed reservoir species mass fractions, Shot 2736

168.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3171	1624.0	1624.0	4.70	38.5	0.103	6.40×10^6
72 cm	3161	1611.4	1611.7	4.39	44.2	0.119	7.43×10^6

Table 1340: Computed freestream conditions, Shot 2736

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.80×10^{-1}	1.06×10^{-1}	5.80×10^{-1}	2.48×10^{-2}	1.08×10^{-1}	1.80×10^{-9}	9.87×10^{-4}
72 cm	1.78×10^{-1}	1.01×10^{-1}	5.84×10^{-1}	3.05×10^{-2}	1.06×10^{-1}	2.10×10^{-9}	1.12×10^{-3}

Table 1341: Computed freestream species mass fractions, Shot 2736

168.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3137	1705.2	1705.2	4.54	50.7	0.129	7.66×10^6
72 cm	3111	1716.3	1716.2	4.19	58.3	0.148	8.65×10^6

Table 1342: Computed boundary layer edge conditions, Shot 2736

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.80×10^{-1}	1.06×10^{-1}	5.80×10^{-1}	2.48×10^{-2}	1.08×10^{-1}	1.80×10^{-9}	9.87×10^{-4}
72 cm	1.78×10^{-1}	1.01×10^{-1}	5.84×10^{-1}	3.05×10^{-2}	1.05×10^{-1}	3.29×10^{-9}	9.22×10^{-4}

Table 1343: Computed boundary layer edge species mass fractions, Shot 2736

	T^* K	Unit Re* 1/m
1D 100 cm	1575	8.80×10^6
72 cm	1497	10.97×10^6

Table 1344: Dorrance reference conditions, Shot 2736

168.5 Stability Computations

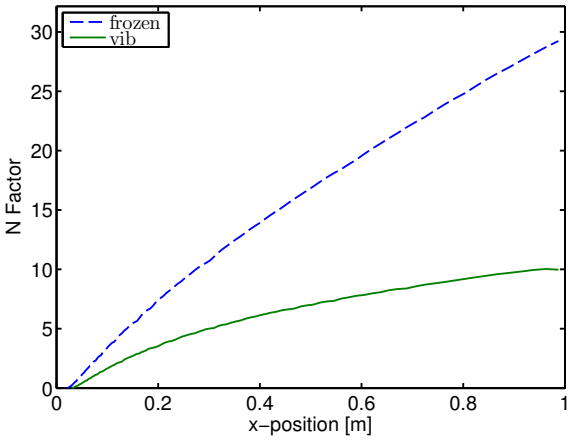


Figure 502: Locus of maximum N factor with and without vibrational energy transfer, Shot 2736

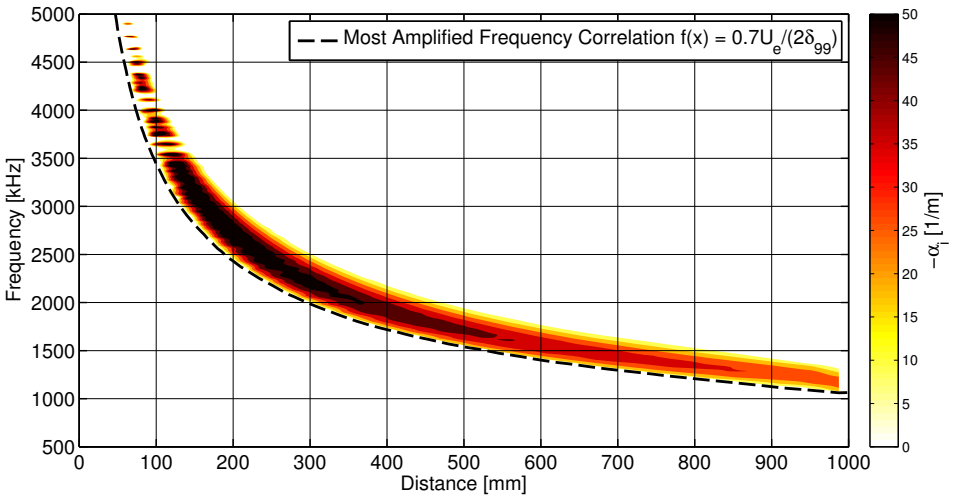


Figure 503: Stability diagram with vibrational energy transfer, Shot 2736. Dashed line indicates $0.7U_e/(2\delta_{99})$.

168.6 Heat Transfer Results

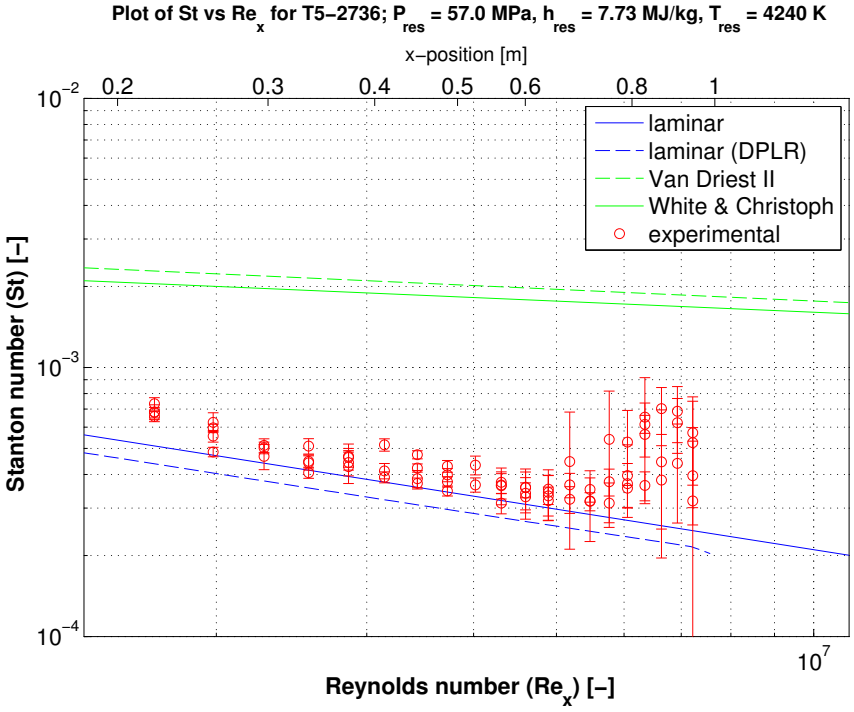


Figure 504: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

169 Shot 2737

Experiment 2737 was performed in T5 on 11 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 25% air, 75% CO_2 by mass.

169.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	117.00	kPa
Reservoir Pressure	P_{res}	56.1	MPa

Table 1345: Measured quantities, Shot 2737

169.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4080	K
Reservoir Density	ρ_{res}	56.03	kg/m^3
Reservoir Enthalpy	h_{res}	7.10	MJ/kg

Table 1346: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2737

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1.71×10^{-1}	1.30×10^{-1}	4.49×10^{-1}	4.57×10^{-2}	1.91×10^{-1}	1.88×10^{-5}	1.29×10^{-2}

Table 1347: Computed reservoir species mass fractions, Shot 2737

169.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3064	1508.0	1508.0	4.74	36.4	0.106	6.75×10^{6}
72 cm	3063	1514.9	1515.2	4.41	42.9	0.125	7.91×10^{6}

Table 1348: Computed freestream conditions, Shot 2737

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.81×10^{-1}	9.77×10^{-2}	6.05×10^{-1}	2.36×10^{-2}	9.21×10^{-2}	1.19×10^{-9}	6.17×10^{-4}
72 cm	1.78×10^{-1}	9.24×10^{-2}	6.11×10^{-1}	2.91×10^{-2}	8.81×10^{-2}	5.89×10^{-10}	5.96×10^{-4}

Table 1349: Computed freestream species mass fractions, Shot 2737

169.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3032	1584.1	1584.1	4.58	48.1	0.133	8.10×10^{6}
72 cm	3015	1611.9	1611.9	4.21	56.6	0.155	9.23×10^{6}

Table 1350: Computed boundary layer edge conditions, Shot 2737

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.81×10^{-1}	9.77×10^{-2}	6.05×10^{-1}	2.36×10^{-2}	9.21×10^{-2}	1.19×10^{-9}	6.17×10^{-4}
72 cm	1.78×10^{-1}	9.24×10^{-2}	6.12×10^{-1}	2.91×10^{-2}	8.79×10^{-2}	9.59×10^{-10}	4.95×10^{-4}

Table 1351: Computed boundary layer edge species mass fractions, Shot 2737

	T^* K	Unit Re^* 1/m
1D 100 cm	1480	9.11×10^{6}
72 cm	1419	10.49×10^{6}

Table 1352: Dorrance reference conditions, Shot 2737

169.5 Stability Computations

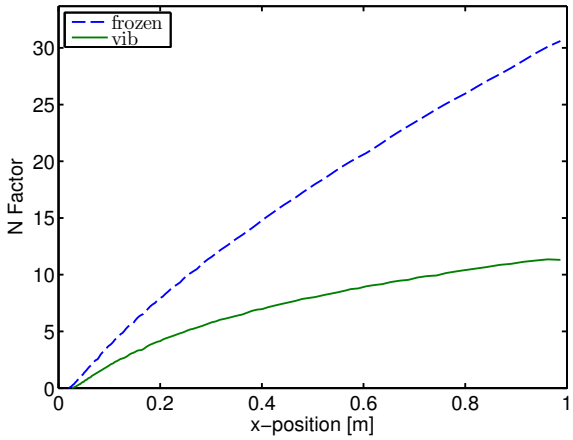


Figure 505: Locus of maximum N factor with and without vibrational energy transfer, Shot 2737

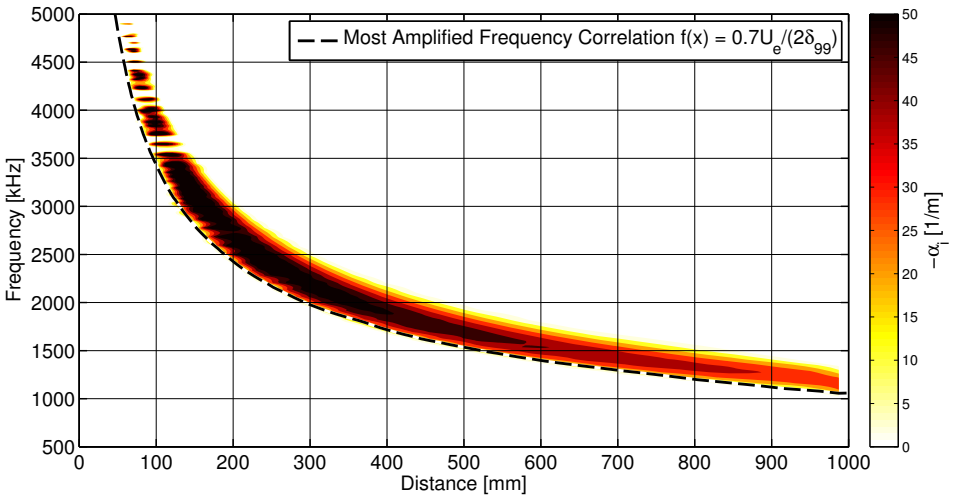


Figure 506: Stability diagram with vibrational energy transfer, Shot 2737. Dashed line indicates $0.7U_e/(2\delta_{99})$.

169.6 Heat Transfer Results

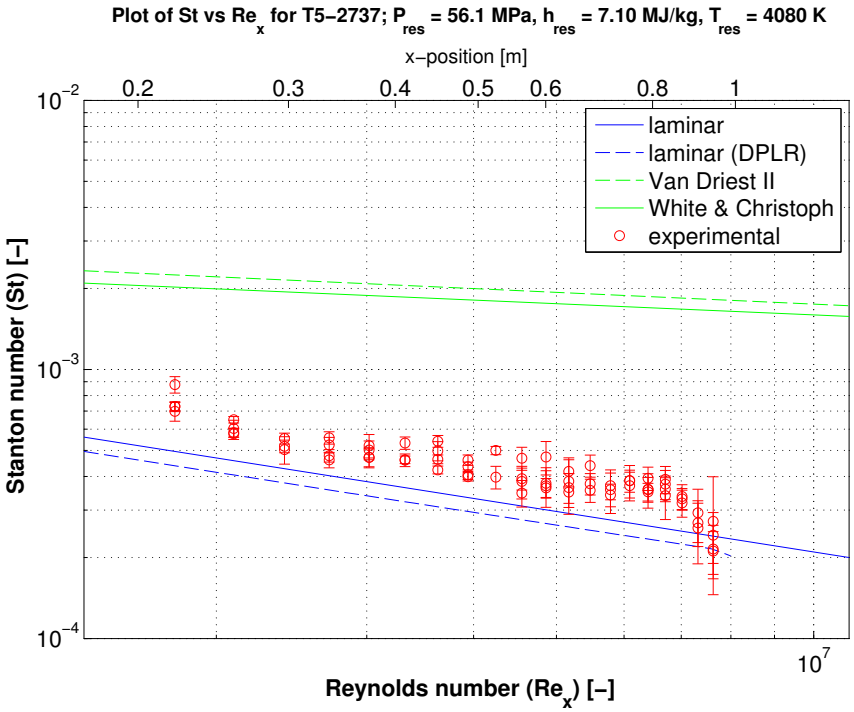


Figure 507: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

170 Shot 2738

Experiment 2738 was performed in T5 on 12 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 25% air, 75% CO_2 by mass.

170.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	97.00	kPa
Reservoir Pressure	P_{res}	56.6	MPa

Table 1353: Measured quantities, Shot 2738

170.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4395	K
Reservoir Density	ρ_{res}	50.04	kg/m^3
Reservoir Enthalpy	h_{res}	8.34	MJ/kg

Table 1354: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2738

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1.65×10^{-1}	1.48×10^{-1}	3.53×10^{-1}	5.78×10^{-2}	2.53×10^{-1}	5.27×10^{-5}	2.41×10^{-2}

Table 1355: Computed reservoir species mass fractions, Shot 2738

170.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3264	1724.0	1724.0	4.67	38.6	0.096	5.87×10^6
72 cm	3250	1694.1	1694.4	4.37	44.5	0.113	6.92×10^6

Table 1356: Computed freestream conditions, Shot 2738

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.80×10^{-1}	1.14×10^{-1}	5.55×10^{-1}	2.59×10^{-2}	1.24×10^{-1}	5.83×10^{-9}	1.56×10^{-3}
72 cm	1.77×10^{-1}	1.11×10^{-1}	5.54×10^{-1}	3.16×10^{-2}	1.25×10^{-1}	5.66×10^{-9}	1.88×10^{-3}

Table 1357: Computed freestream species mass fractions, Shot 2738

170.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3230	1809.7	1809.7	4.51	50.7	0.120	7.01×10^6
72 cm	3199	1807.9	1807.9	4.17	58.6	0.139	8.03×10^6

Table 1358: Computed boundary layer edge conditions, Shot 2738

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.80×10^{-1}	1.14×10^{-1}	5.55×10^{-1}	2.59×10^{-2}	1.24×10^{-1}	5.83×10^{-9}	1.56×10^{-3}
72 cm	1.77×10^{-1}	1.11×10^{-1}	5.54×10^{-1}	3.16×10^{-2}	1.24×10^{-1}	8.69×10^{-9}	1.54×10^{-3}

Table 1359: Computed boundary layer edge species mass fractions, Shot 2738

	T^* K	Unit Re* 1/m
1D 100 cm	1658	8.15×10^6
72 cm	1568	10.27×10^6

Table 1360: Dorrance reference conditions, Shot 2738

170.5 Stability Computations

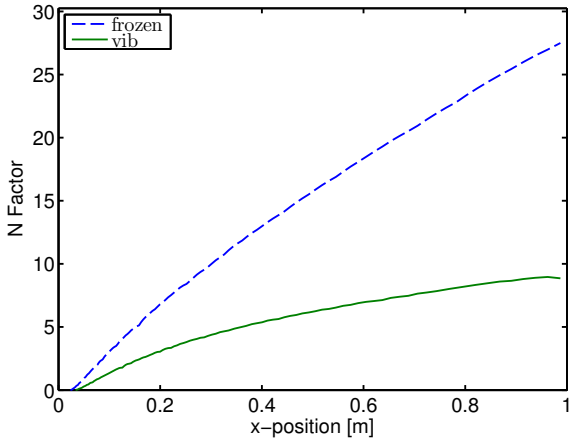


Figure 508: Locus of maximum N factor with and without vibrational energy transfer, Shot 2738

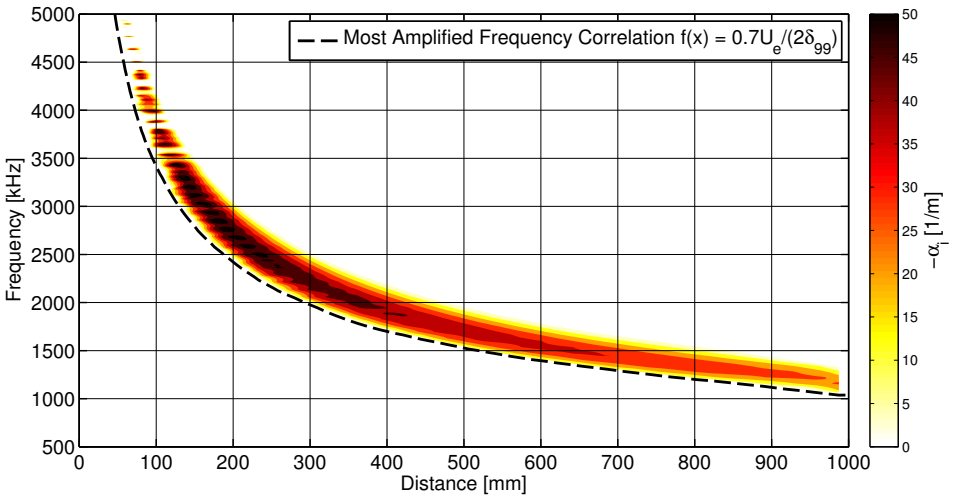


Figure 509: Stability diagram with vibrational energy transfer, Shot 2738. Dashed line indicates $0.7U_e/(2\delta_{99})$.

170.6 Heat Transfer Results

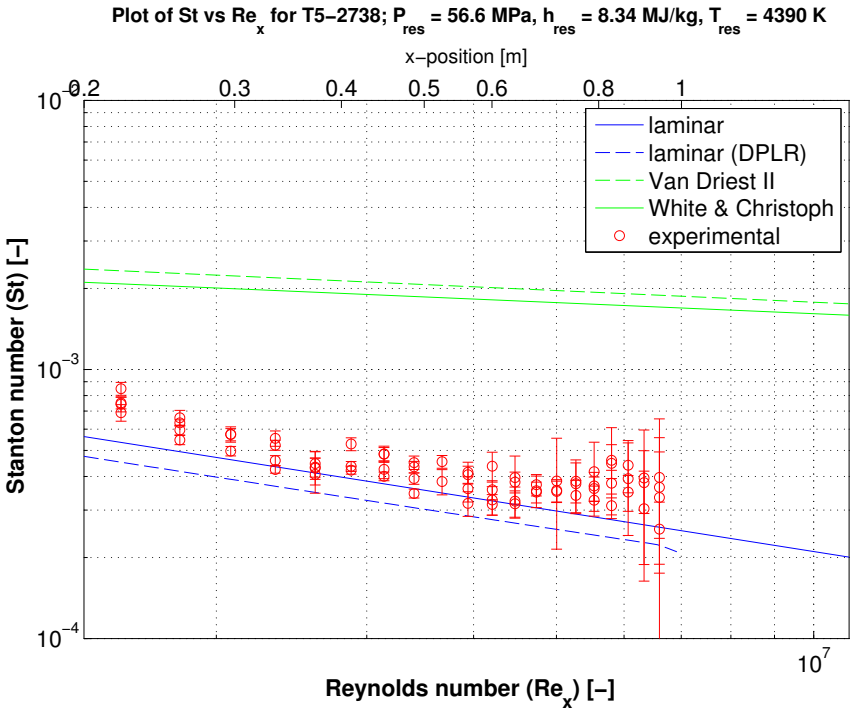


Figure 510: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

171 Shot 2739

Experiment 2739 was performed in T5 on 17 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

171.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2930	m/s
Shock Tube Fill Pressure	P_1	130.00	kPa
Reservoir Pressure	P_{res}	57.5	MPa

Table 1361: Measured quantities, Shot 2739

171.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5374	K
Reservoir Density	ρ_{res}	34.78	kg/m^3
Reservoir Enthalpy	h_{res}	8.04	MJ/kg

Table 1362: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2739

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.58×10^{-2}	0	1.41×10^{-1}	0	1.34×10^{-3}	7.21×10^{-2}

Table 1363: Computed reservoir species mass fractions, Shot 2739

171.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3688	1167.0	1167.0	5.50	24.9	0.073	5.88×10^{6}
72 cm	3668	1173.2	1177.7	5.32	28.9	0.085	6.74×10^{6}

Table 1364: Computed freestream conditions, Shot 2739

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.20×10^{-2}	0	1.80×10^{-10}	8.35×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.60×10^{-2}	0	1.63×10^{-10}	4.05×10^{-3}

Table 1365: Computed freestream species mass fractions, Shot 2739

171.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3652	1278.3	1278.3	5.20	36.0	0.097	7.28×10^{6}
72 cm	3606	1337.5	1335.4	4.90	41.7	0.108	7.77×10^{6}

Table 1366: Computed boundary layer edge conditions, Shot 2739

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.91×10^{-1}	0	6.20×10^{-2}	0	1.80×10^{-10}	8.35×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.60×10^{-2}	0	1.27×10^{-9}	3.95×10^{-3}

Table 1367: Computed boundary layer edge species mass fractions, Shot 2739

	T^* K	Unit Re^* 1/m
1D 100 cm	1611	4.95×10^{6}
72 cm	1580	5.88×10^{6}

Table 1368: Dorrance reference conditions, Shot 2739

171.5 Stability Computations

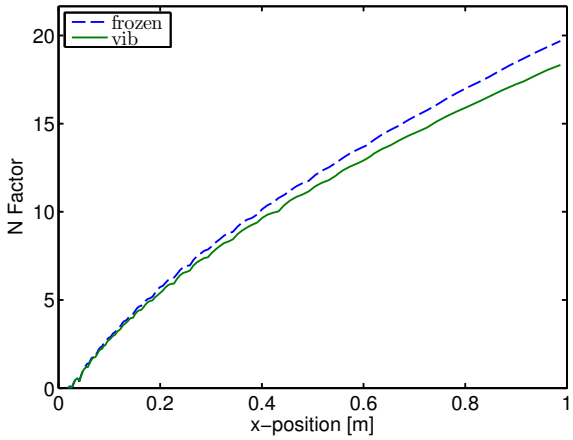


Figure 511: Locus of maximum N factor with and without vibrational energy transfer, Shot 2739

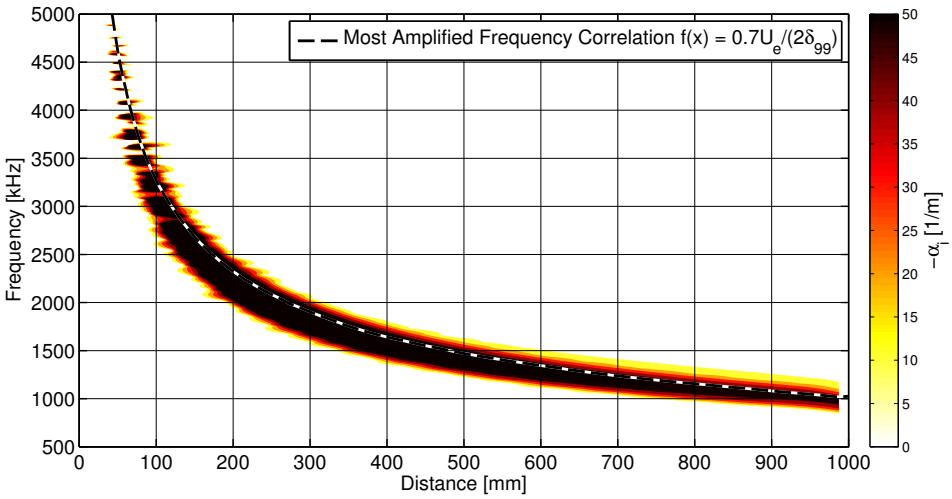


Figure 512: Stability diagram with vibrational energy transfer, Shot 2739. Dashed line indicates $0.7U_e/(2\delta_{99})$.

171.6 Heat Transfer Results

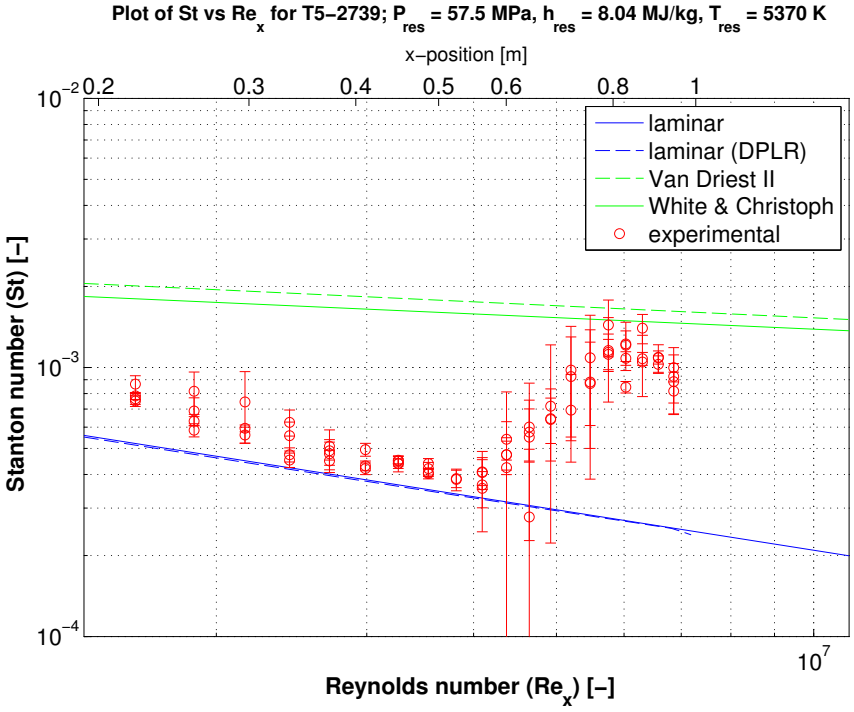


Figure 513: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

172 Shot 2740

Experiment 2740 was performed in T5 on 18 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

172.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2910	m/s
Shock Tube Fill Pressure	P_1	130.00	kPa
Reservoir Pressure	P_{res}	57.3	MPa

Table 1369: Measured quantities, Shot 2740

172.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5346	K
Reservoir Density	ρ_{res}	34.92	kg/m^3
Reservoir Enthalpy	h_{res}	7.97	MJ/kg

Table 1370: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2740

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	8.73×10^{-2}	0	1.41×10^{-1}	0	1.27×10^{-3}	7.06×10^{-2}

Table 1371: Computed reservoir species mass fractions, Shot 2740

172.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3674	1156.0	1156.0	5.51	24.7	0.074	5.91×10^{6}
72 cm	3655	1160.8	1165.1	5.33	28.6	0.085	6.78×10^{6}

Table 1372: Computed freestream conditions, Shot 2740

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.21×10^{-2}	0	1.47×10^{-10}	8.07×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.63×10^{-2}	0	1.33×10^{-10}	3.87×10^{-3}

Table 1373: Computed freestream species mass fractions, Shot 2740

172.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3638	1265.9	1265.9	5.21	35.7	0.097	7.32×10^{6}
72 cm	3593	1324.4	1322.3	4.91	41.4	0.108	7.82×10^{6}

Table 1374: Computed boundary layer edge conditions, Shot 2740

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.92×10^{-1}	0	6.21×10^{-2}	0	1.47×10^{-10}	8.07×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.62×10^{-2}	0	1.09×10^{-9}	3.78×10^{-3}

Table 1375: Computed boundary layer edge species mass fractions, Shot 2740

	T^* K	Unit Re^* 1/m
1D 100 cm	1600	4.96×10^{6}
72 cm	1569	5.89×10^{6}

Table 1376: Dorrance reference conditions, Shot 2740

172.5 Stability Computations

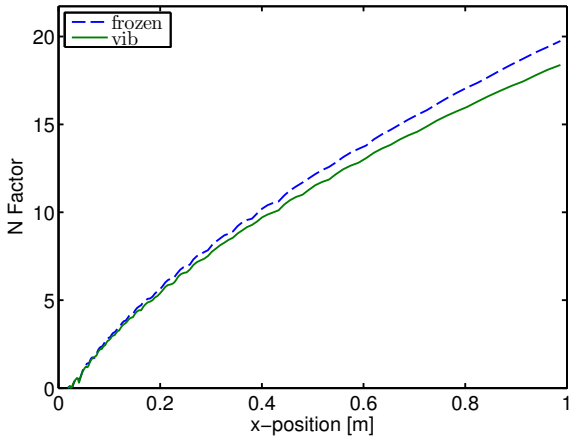


Figure 514: Locus of maximum N factor with and without vibrational energy transfer, Shot 2740

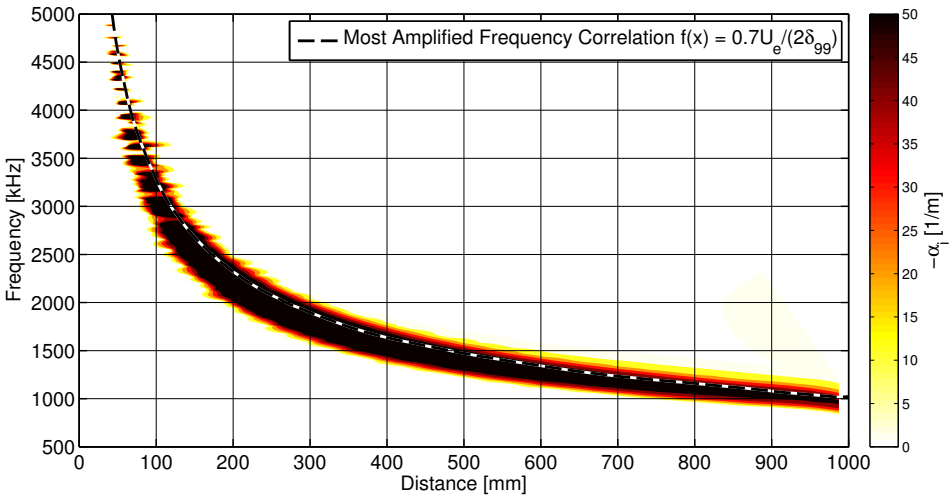


Figure 515: Stability diagram with vibrational energy transfer, Shot 2740. Dashed line indicates $0.7U_e/(2\delta_{99})$.

172.6 Heat Transfer Results

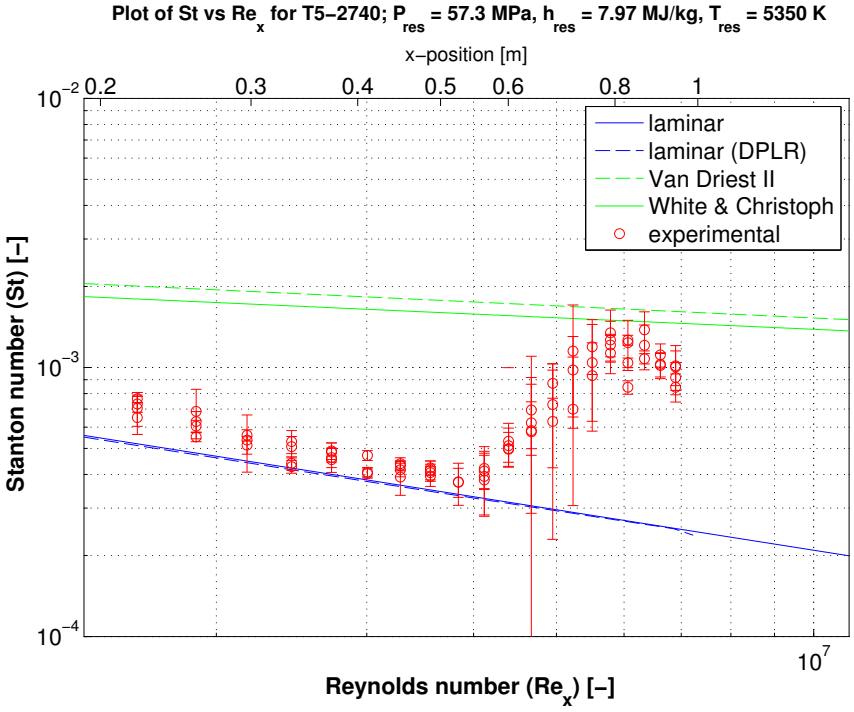


Figure 516: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

173 Shot 2741

Experiment 2741 was performed in T5 on 18 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

173.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2970	m/s
Shock Tube Fill Pressure	P_1	120.00	kPa
Reservoir Pressure	P_{res}	56.9	MPa

Table 1377: Measured quantities, Shot 2741

173.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5501	K
Reservoir Density	ρ_{res}	33.43	kg/m^3
Reservoir Enthalpy	h_{res}	8.34	MJ/kg

Table 1378: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2741

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.85×10^{-2}	0	1.41×10^{-1}	0	1.74×10^{-3}	7.94×10^{-2}

Table 1379: Computed reservoir species mass fractions, Shot 2741

173.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3744	1216.0	1216.0	5.47	24.8	0.070	5.57×10^{6}
72 cm	3726	1230.8	1236.5	5.27	29.2	0.082	6.41×10^{6}

Table 1380: Computed freestream conditions, Shot 2741

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.18×10^{-2}	0	1.70×10^{-10}	9.98×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.49×10^{-2}	0	4.19×10^{-10}	5.09×10^{-3}

Table 1381: Computed freestream species mass fractions, Shot 2741

173.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3707	1330.4	1330.4	5.18	35.7	0.092	6.87×10^{6}
72 cm	3663	1399.5	1397.5	4.86	42.0	0.104	7.38×10^{6}

Table 1382: Computed boundary layer edge conditions, Shot 2741

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.90×10^{-1}	0	6.18×10^{-2}	0	1.70×10^{-10}	9.98×10^{-3}
72 cm	7.32×10^{-1}	1.88×10^{-1}	0	7.49×10^{-2}	0	2.65×10^{-9}	4.96×10^{-3}

Table 1383: Computed boundary layer edge species mass fractions, Shot 2741

	T^* K	Unit Re^* 1/m
1D 100 cm	1657	4.75×10^{6}
72 cm	1630	5.70×10^{6}

Table 1384: Dorrance reference conditions, Shot 2741

173.5 Stability Computations

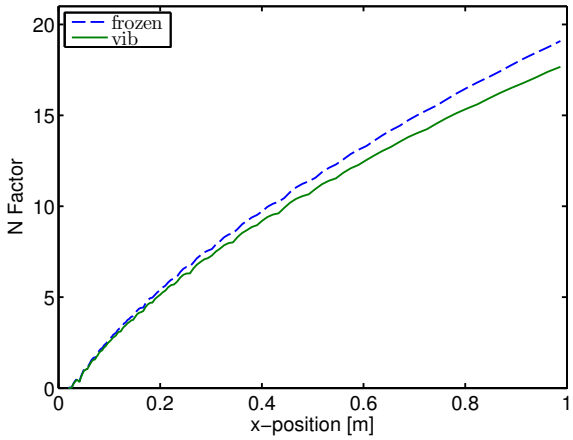


Figure 517: Locus of maximum N factor with and without vibrational energy transfer, Shot 2741

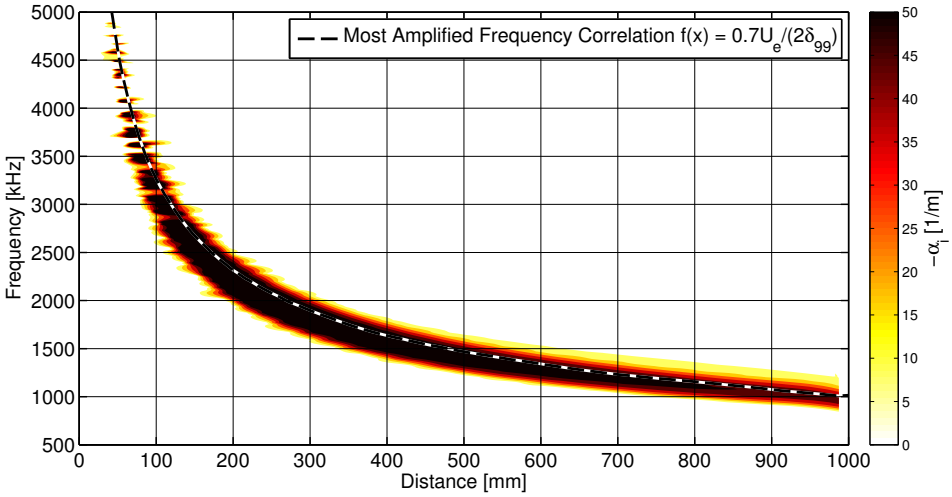


Figure 518: Stability diagram with vibrational energy transfer, Shot 2741. Dashed line indicates $0.7U_e/(2\delta_{99})$.

173.6 Heat Transfer Results

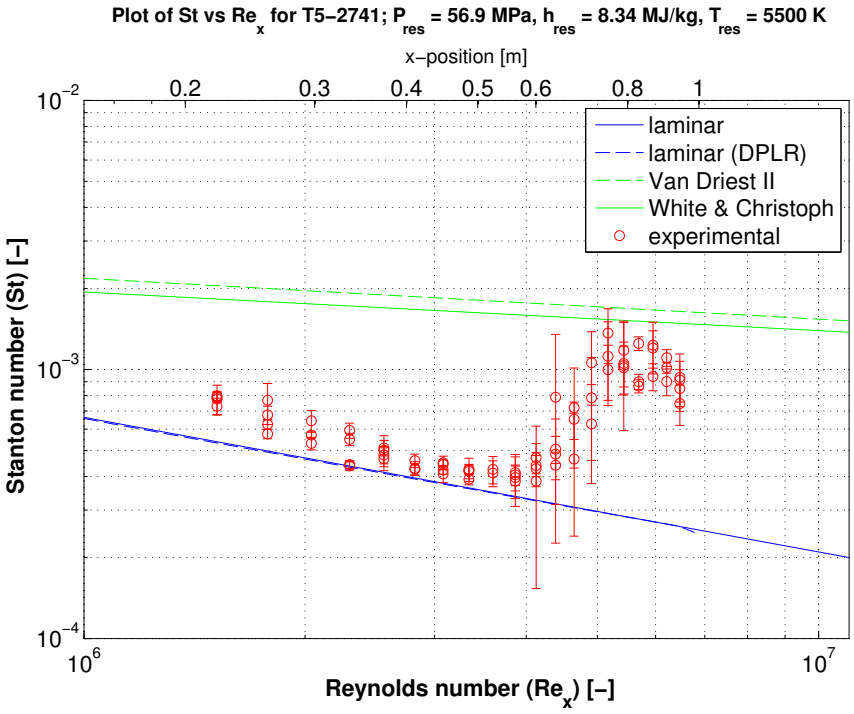


Figure 519: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

174 Shot 2742

Experiment 2742 was performed in T5 on 19 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

174.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3020	m/s
Shock Tube Fill Pressure	P_1	110.50	kPa
Reservoir Pressure	P_{res}	55.7	MPa

Table 1385: Measured quantities, Shot 2742

174.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5623	K
Reservoir Density	ρ_{res}	31.81	kg/m^3
Reservoir Enthalpy	h_{res}	8.64	MJ/kg

Table 1386: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2742

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	7.14×10^{-2}	0	1.40×10^{-1}	0	2.24×10^{-3}	8.68×10^{-2}

Table 1387: Computed reservoir species mass fractions, Shot 2742

174.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3808	1274.0	1274.0	5.44	25.2	0.068	5.34×10^{6}
72 cm	3782	1287.4	1294.1	5.23	29.1	0.078	6.04×10^{6}

Table 1388: Computed freestream conditions, Shot 2742

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.14×10^{-2}	0	6.46×10^{-10}	1.19×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.39×10^{-2}	0	9.86×10^{-10}	6.36×10^{-3}

Table 1389: Computed freestream species mass fractions, Shot 2742

174.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3771	1391.5	1391.5	5.15	36.2	0.089	6.57×10^{6}
72 cm	3718	1461.0	1458.8	4.83	41.7	0.099	6.92×10^{6}

Table 1390: Computed boundary layer edge conditions, Shot 2742

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.14×10^{-2}	0	6.46×10^{-10}	1.19×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.39×10^{-2}	0	5.32×10^{-9}	6.18×10^{-3}

Table 1391: Computed boundary layer edge species mass fractions, Shot 2742

	T^* K	Unit Re^* 1/m
1D 100 cm	1712	4.63×10^{6}
72 cm	1678	5.47×10^{6}

Table 1392: Dorrance reference conditions, Shot 2742

174.5 Stability Computations

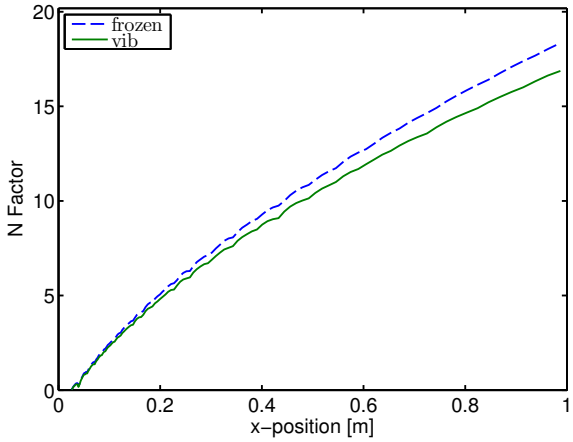


Figure 520: Locus of maximum N factor with and without vibrational energy transfer, Shot 2742

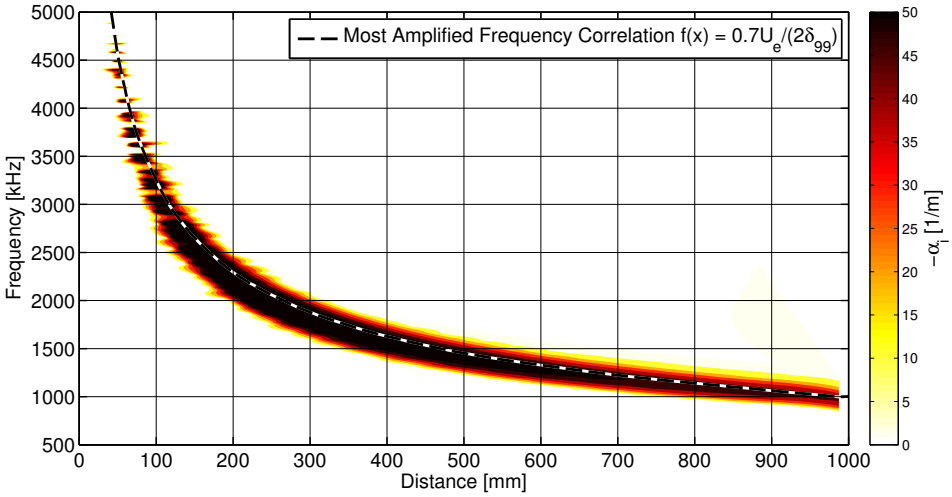


Figure 521: Stability diagram with vibrational energy transfer, Shot 2742. Dashed line indicates $0.7U_e/(2\delta_{99})$.

174.6 Heat Transfer Results

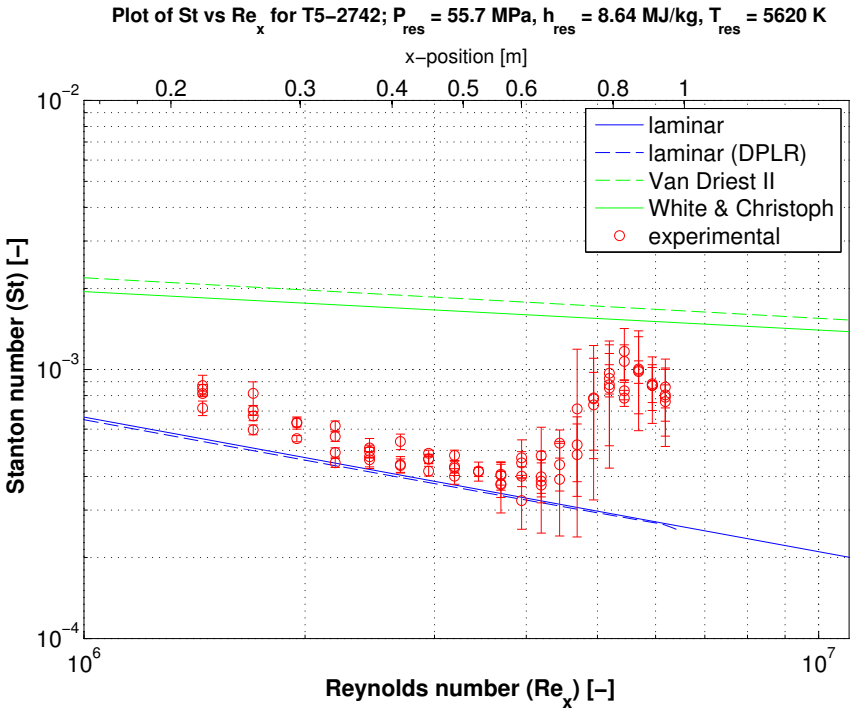


Figure 522: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

175 Shot 2743

Experiment 2743 was performed in T5 on 19 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

175.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3080	m/s
Shock Tube Fill Pressure	P_1	101.00	kPa
Reservoir Pressure	P_{res}	56.3	MPa

Table 1393: Measured quantities, Shot 2743

175.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5816	K
Reservoir Density	ρ_{res}	30.80	kg/m^3
Reservoir Enthalpy	h_{res}	9.10	MJ/kg

Table 1394: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2743

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	6.20×10^{-2}	0	1.39×10^{-1}	0	3.17×10^{-3}	9.70×10^{-2}

Table 1395: Computed reservoir species mass fractions, Shot 2743

175.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3889	1347.0	1347.0	5.40	25.7	0.065	5.06×10^{6}
72 cm	3866	1372.2	1380.0	5.17	30.2	0.076	5.77×10^{6}

Table 1396: Computed freestream conditions, Shot 2743

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.08×10^{-2}	0	1.30×10^{-9}	1.46×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.30×10^{-2}	0	2.98×10^{-9}	8.22×10^{-3}

Table 1397: Computed freestream species mass fractions, Shot 2743

175.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3851	1469.1	1469.1	5.12	36.7	0.086	6.20×10^{6}
72 cm	3801	1552.5	1550.4	4.78	43.1	0.096	6.58×10^{6}

Table 1398: Computed boundary layer edge conditions, Shot 2743

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.86×10^{-1}	0	6.08×10^{-2}	0	1.30×10^{-9}	1.46×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.30×10^{-2}	0	1.32×10^{-8}	7.95×10^{-3}

Table 1399: Computed boundary layer edge species mass fractions, Shot 2743

	T^* K	Unit Re^* 1/m
1D 100 cm	1781	4.47×10^{6}
72 cm	1753	5.36×10^{6}

Table 1400: Dorrance reference conditions, Shot 2743

175.5 Stability Computations

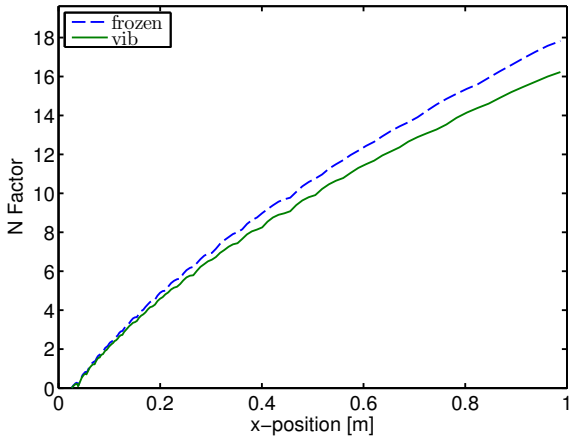


Figure 523: Locus of maximum N factor with and without vibrational energy transfer, Shot 2743

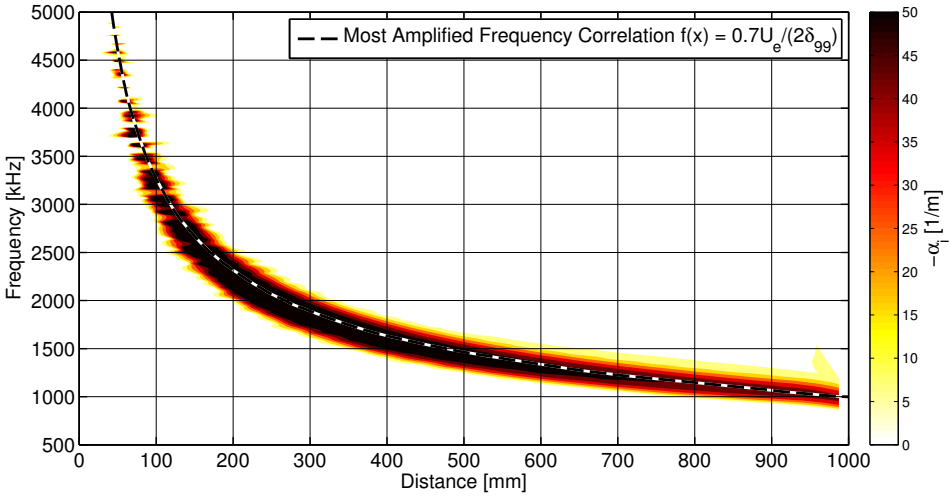


Figure 524: Stability diagram with vibrational energy transfer, Shot 2743. Dashed line indicates $0.7U_e/(2\delta_{99})$.

175.6 Heat Transfer Results

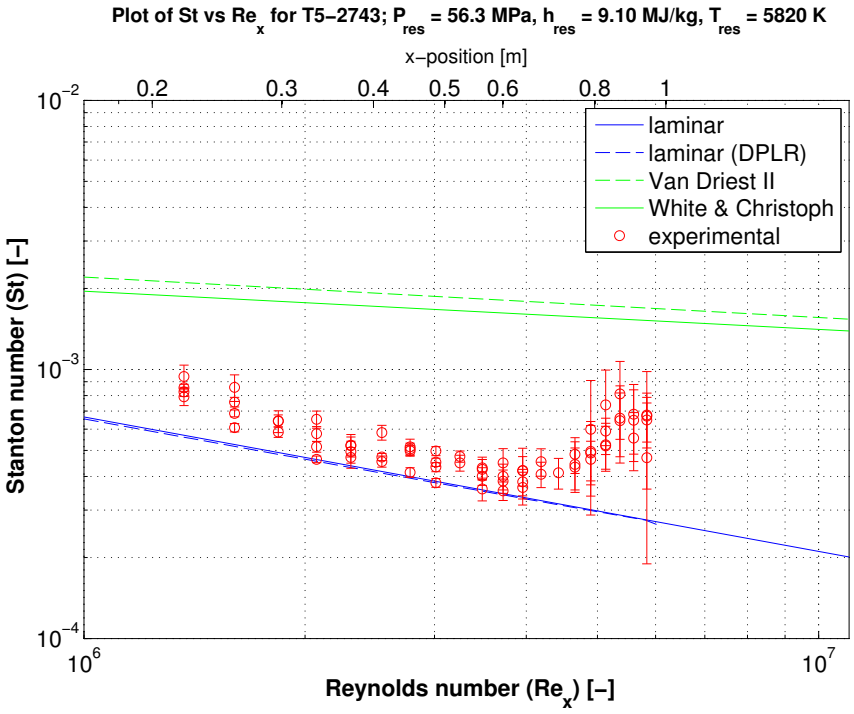


Figure 525: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

176 Shot 2744

Experiment 2744 was performed in T5 on 20 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

176.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2840	m/s
Shock Tube Fill Pressure	P_1	137.80	kPa
Reservoir Pressure	P_{res}	60.7	MPa

Table 1401: Measured quantities, Shot 2744

176.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5232	K
Reservoir Density	ρ_{res}	38.04	kg/m^3
Reservoir Enthalpy	h_{res}	7.69	MJ/kg

Table 1402: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2744

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	9.50×10^{-2}	0	1.41×10^{-1}	0	9.68×10^{-4}	6.29×10^{-2}

Table 1403: Computed reservoir species mass fractions, Shot 2744

176.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3623	1112.0	1112.0	5.54	26.2	0.081	6.58×10^6
72 cm	3599	1105.3	1107.8	5.38	29.7	0.093	7.47×10^6

Table 1404: Computed freestream conditions, Shot 2744

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.23×10^{-2}	0	2.53×10^{-10}	6.35×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.71×10^{-2}	0	0	2.86×10^{-3}

Table 1405: Computed freestream species mass fractions, Shot 2744

176.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3588	1219.3	1219.3	5.24	38.0	0.107	8.17×10^6
72 cm	3538	1264.6	1262.6	4.95	43.1	0.118	8.64×10^6

Table 1406: Computed boundary layer edge conditions, Shot 2744

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.93×10^{-1}	0	6.23×10^{-2}	0	2.53×10^{-10}	6.35×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.71×10^{-2}	0	4.71×10^{-10}	2.80×10^{-3}

Table 1407: Computed boundary layer edge species mass fractions, Shot 2744

	T^* K	Unit Re^* 1/m
1D 100 cm	1559	5.44×10^6
72 cm	1522	6.36×10^6

Table 1408: Dorrance reference conditions, Shot 2744

176.5 Stability Computations

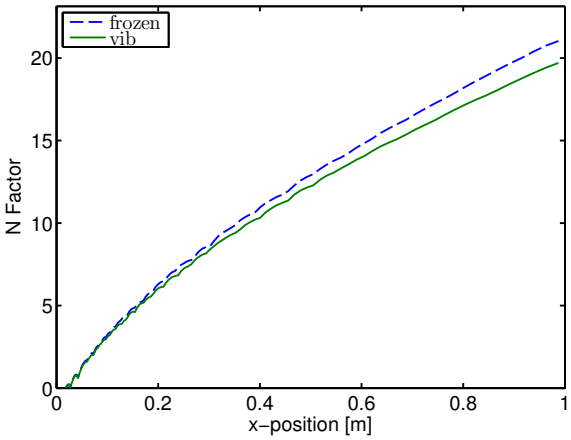


Figure 526: Locus of maximum N factor with and without vibrational energy transfer, Shot 2744

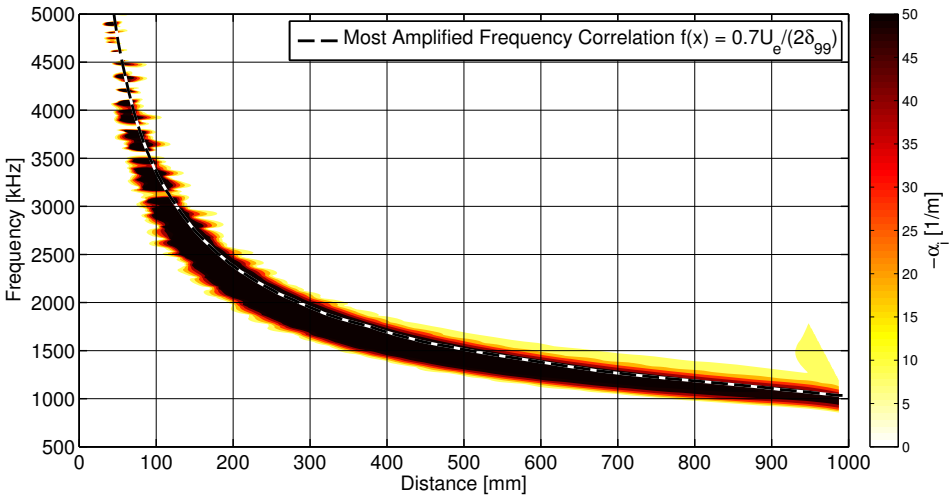


Figure 527: Stability diagram with vibrational energy transfer, Shot 2744. Dashed line indicates $0.7U_e/(2\delta_{99})$.

176.6 Heat Transfer Results

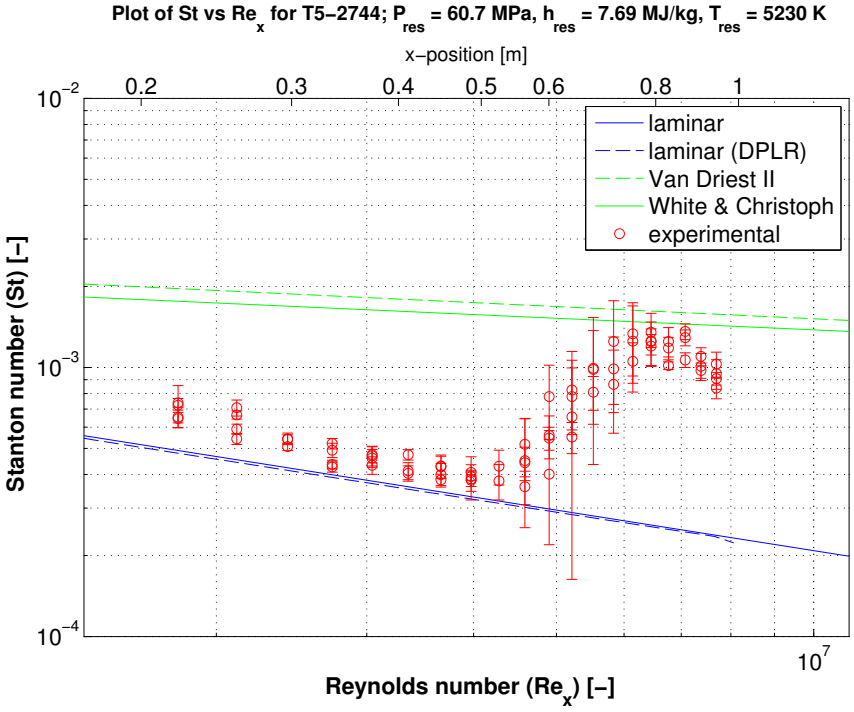


Figure 528: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

177 Shot 2745

Experiment 2745 was performed in T5 on 25 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

177.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3260	m/s
Shock Tube Fill Pressure	P_1	67.90	kPa
Reservoir Pressure	P_{res}	58.5	MPa

Table 1409: Measured quantities, Shot 2745

177.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4564	K
Reservoir Density	ρ_{res}	51.03	kg/m^3
Reservoir Enthalpy	h_{res}	9.67	MJ/kg

Table 1410: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2745

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.74×10^{-1}	4.31×10^{-1}	0	3.62×10^{-1}	0	3.30×10^{-2}

Table 1411: Computed reservoir species mass fractions, Shot 2745

177.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3304	2077.0	2077.0	4.47	43.9	0.096	5.30×10^6
72 cm	3283	2007.0	2007.3	4.16	52.0	0.117	6.56×10^6

Table 1412: Computed freestream conditions, Shot 2745

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.12×10^{-1}	6.84×10^{-1}	0	2.01×10^{-1}	0	2.43×10^{-3}
72 cm	0	1.16×10^{-1}	6.71×10^{-1}	0	2.09×10^{-1}	0	3.78×10^{-3}

Table 1413: Computed freestream species mass fractions, Shot 2745

177.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3268	2164.5	2164.5	4.34	56.5	0.119	6.28×10^6
72 cm	3232	2132.2	2132.2	3.98	67.3	0.143	7.55×10^6

Table 1414: Computed boundary layer edge conditions, Shot 2745

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.12×10^{-1}	6.84×10^{-1}	0	2.01×10^{-1}	0	2.43×10^{-3}
72 cm	0	1.16×10^{-1}	6.74×10^{-1}	0	2.08×10^{-1}	0	2.99×10^{-3}

Table 1415: Computed boundary layer edge species mass fractions, Shot 2745

	T^* K	Unit Re^* 1/m
1D 100 cm	1836	8.35×10^6
72 cm	1718	9.37×10^6

Table 1416: Dorrance reference conditions, Shot 2745

177.5 Stability Computations

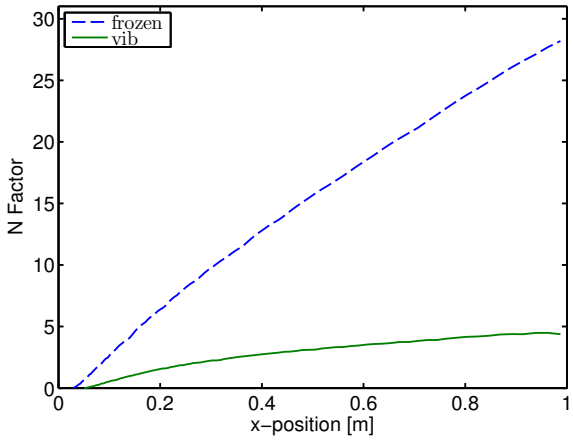


Figure 529: Locus of maximum N factor with and without vibrational energy transfer, Shot 2745

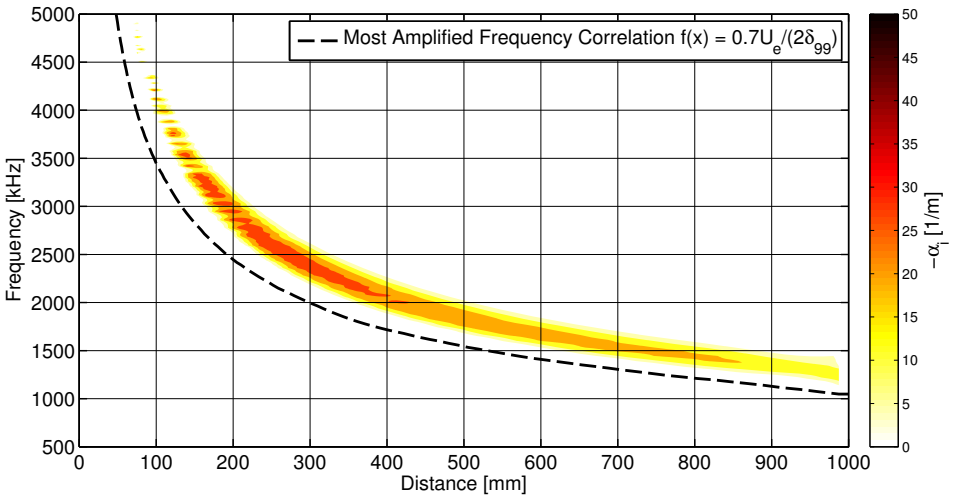


Figure 530: Stability diagram with vibrational energy transfer, Shot 2745. Dashed line indicates $0.7U_e/(2\delta_{99})$.

177.6 Heat Transfer Results

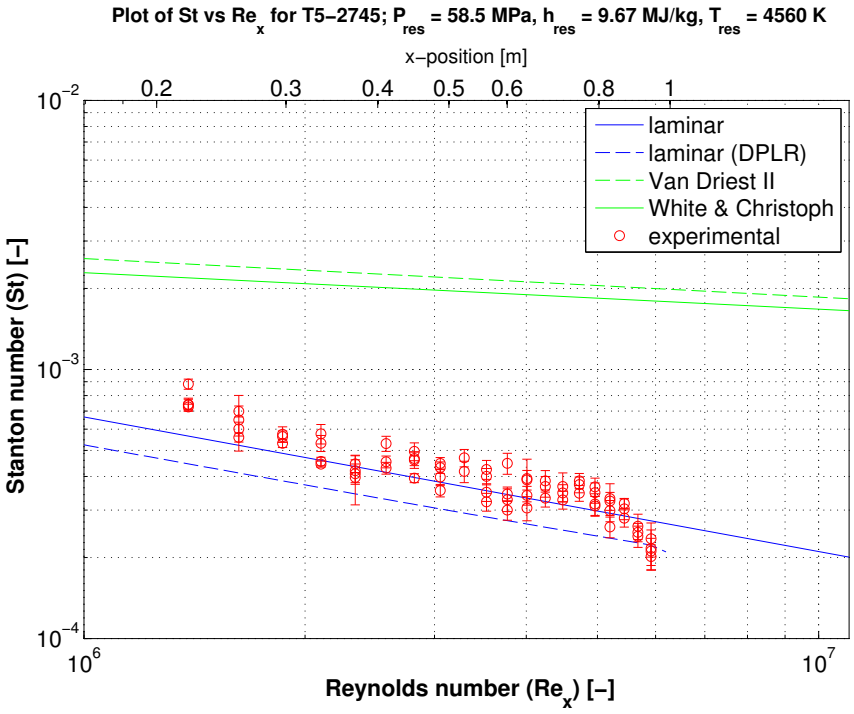


Figure 531: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

178 Shot 2746

Experiment 2746 was performed in T5 on 30 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

178.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	159.85	kPa
Reservoir Pressure	P_{res}	61.9	MPa

Table 1417: Measured quantities, Shot 2746

178.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5105	K
Reservoir Density	ρ_{res}	40.03	kg/m^3
Reservoir Enthalpy	h_{res}	7.39	MJ/kg

Table 1418: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2746

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.01×10^{-1}	1.03×10^{-1}	0	1.39×10^{-1}	0	7.22×10^{-4}	5.57×10^{-2}

Table 1419: Computed reservoir species mass fractions, Shot 2746

178.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3554	1052.0	1052.0	5.58	25.6	0.084	6.88×10^6
72 cm	3538	1047.8	1048.2	5.44	29.5	0.097	7.94×10^6

Table 1420: Computed freestream conditions, Shot 2746

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.25×10^{-2}	0	1.71×10^{-10}	5.13×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.77×10^{-2}	0	0	2.15×10^{-3}

Table 1421: Computed freestream species mass fractions, Shot 2746

178.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3519	1156.5	1156.5	5.27	37.3	0.111	8.56×10^6
72 cm	3478	1203.2	1201.2	4.99	43.1	0.124	9.19×10^6

Table 1422: Computed boundary layer edge conditions, Shot 2746

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.94×10^{-1}	0	6.25×10^{-2}	0	1.71×10^{-10}	5.13×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.77×10^{-2}	0	2.05×10^{-10}	2.12×10^{-3}

Table 1423: Computed boundary layer edge species mass fractions, Shot 2746

	T^* K	Unit Re^* 1/m
1D 100 cm	1503	5.58×10^6
72 cm	1474	7.50×10^6

Table 1424: Dorrance reference conditions, Shot 2746

178.5 Stability Computations

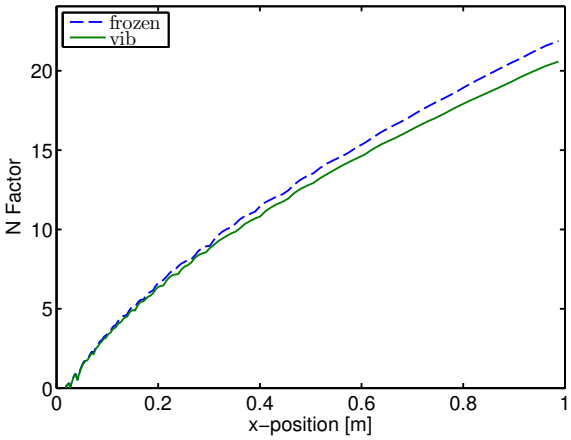


Figure 532: Locus of maximum N factor with and without vibrational energy transfer, Shot 2746

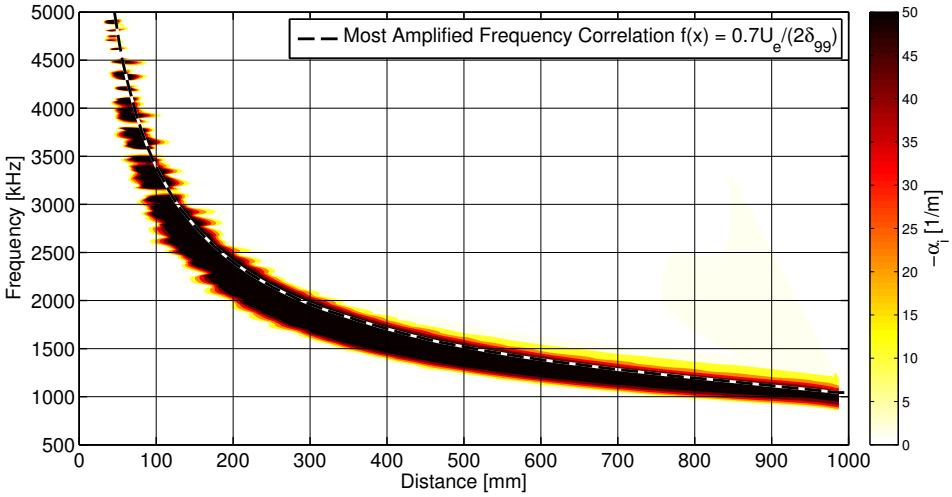


Figure 533: Stability diagram with vibrational energy transfer, Shot 2746. Dashed line indicates $0.7U_e/(2\delta_{99})$.

178.6 Heat Transfer Results

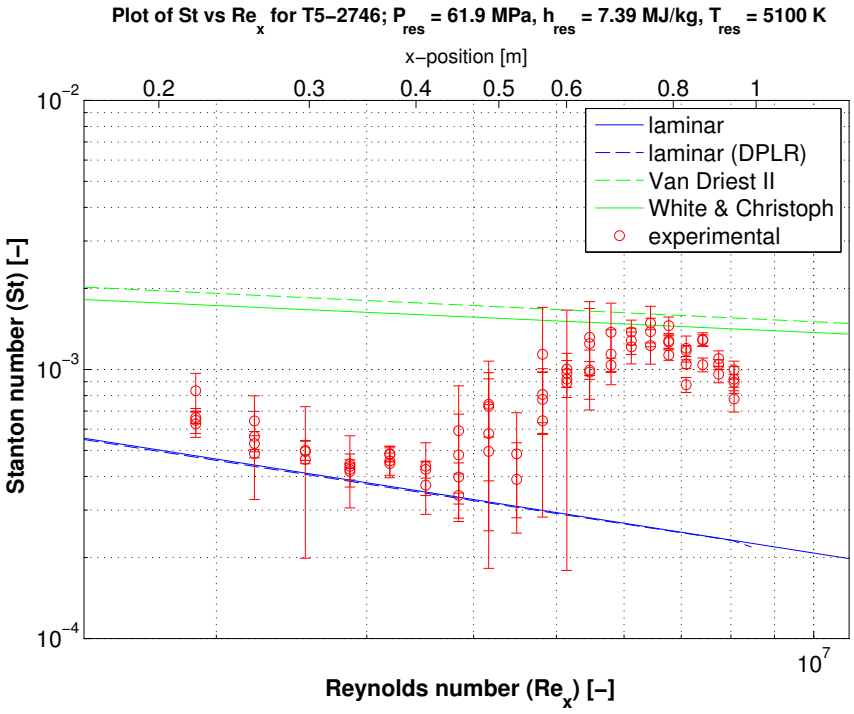


Figure 534: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

179 Shot 2747

Experiment 2747 was performed in T5 on 31 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

179.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3190	m/s
Shock Tube Fill Pressure	P_1	68.00	kPa
Reservoir Pressure	P_{res}	60.3	MPa

Table 1425: Measured quantities, Shot 2747

179.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4501	K
Reservoir Density	ρ_{res}	54.12	kg/m^3
Reservoir Enthalpy	h_{res}	9.36	MJ/kg

Table 1426: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2747

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.68×10^{-1}	4.57×10^{-1}	0	3.46×10^{-1}	0	2.89×10^{-2}

Table 1427: Computed reservoir species mass fractions, Shot 2747

179.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3264	2039.0	2039.0	4.48	45.6	0.103	5.68×10^6
72 cm	3244	1978.4	1978.7	4.16	53.8	0.124	6.95×10^6

Table 1428: Computed freestream conditions, Shot 2747

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.07×10^{-1}	7.01×10^{-1}	0	1.90×10^{-1}	0	1.90×10^{-3}
72 cm	0	1.09×10^{-1}	6.91×10^{-1}	0	1.97×10^{-1}	0	3.03×10^{-3}

Table 1429: Computed freestream species mass fractions, Shot 2747

179.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3228	2124.2	2124.2	4.34	58.8	0.127	6.73×10^6
72 cm	3193	2097.2	2097.2	3.99	69.5	0.152	8.02×10^6

Table 1430: Computed boundary layer edge conditions, Shot 2747

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.07×10^{-1}	7.01×10^{-1}	0	1.90×10^{-1}	0	1.90×10^{-3}
72 cm	0	1.09×10^{-1}	6.93×10^{-1}	0	1.95×10^{-1}	0	2.37×10^{-3}

Table 1431: Computed boundary layer edge species mass fractions, Shot 2747

	T^* K	Unit Re^* 1/m
1D 100 cm	1802	8.95×10^6
72 cm	1688	9.96×10^6

Table 1432: Dorrance reference conditions, Shot 2747

179.5 Stability Computations

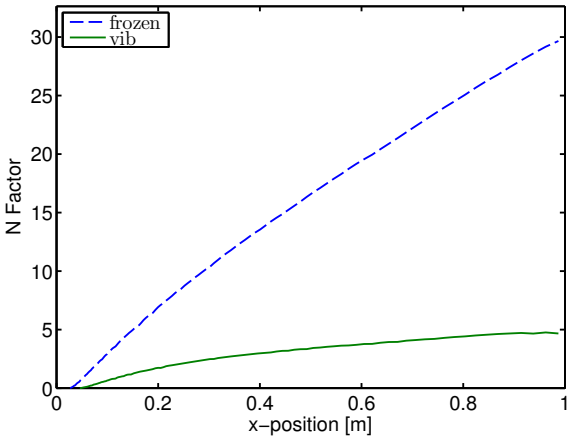


Figure 535: Locus of maximum N factor with and without vibrational energy transfer, Shot 2747

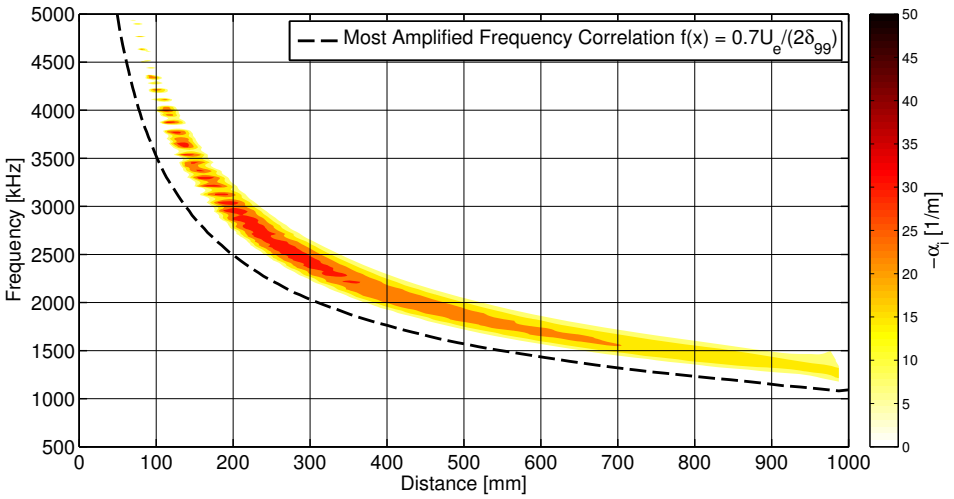


Figure 536: Stability diagram with vibrational energy transfer, Shot 2747. Dashed line indicates $0.7U_e/(2\delta_{99})$.

179.6 Heat Transfer Results

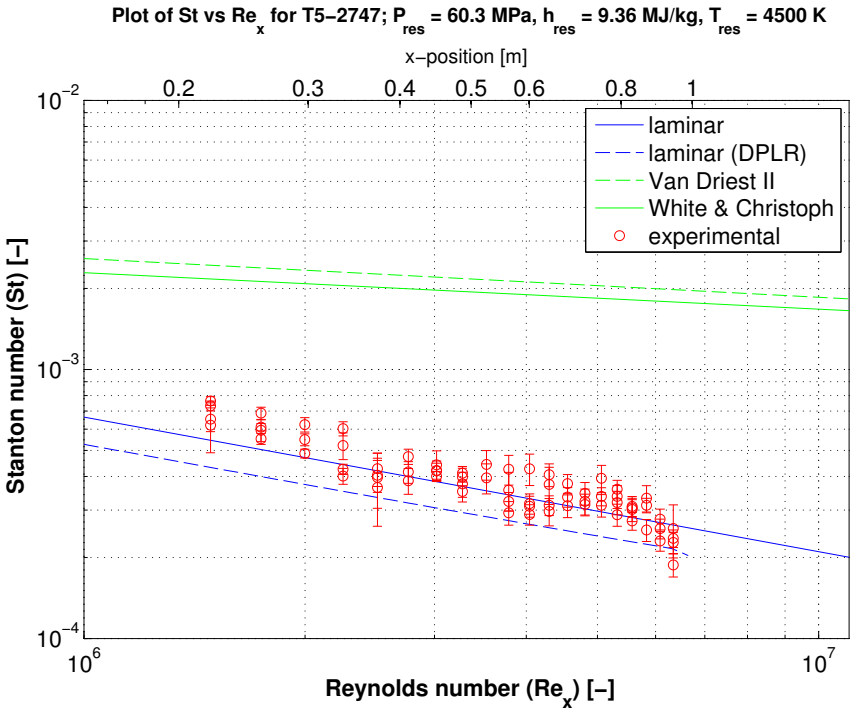


Figure 537: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

180 Shot 2748

Experiment 2748 was performed in T5 on 31 July 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

180.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2900	m/s
Shock Tube Fill Pressure	P_1	80.00	kPa
Reservoir Pressure	P_{res}	61.4	MPa

Table 1433: Measured quantities, Shot 2748

180.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4595	K
Reservoir Density	ρ_{res}	48.48	kg/m^3
Reservoir Enthalpy	h_{res}	8.19	MJ/kg

Table 1434: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2748

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.41×10^{-1}	1.46×10^{-1}	1.96×10^{-1}	9.17×10^{-2}	1.93×10^{-1}	1.35×10^{-4}	3.24×10^{-2}

Table 1435: Computed reservoir species mass fractions, Shot 2748

180.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3405	1573.0	1573.0	4.85	38.1	0.096	6.34×10^6
72 cm	3389	1543.4	1544.2	4.60	42.4	0.110	7.27×10^6

Table 1436: Computed freestream conditions, Shot 2748

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.39×10^{-1}	3.73×10^{-1}	3.86×10^{-2}	8.05×10^{-2}	2.85×10^{-9}	2.38×10^{-3}
72 cm	3.62×10^{-1}	1.35×10^{-1}	3.75×10^{-1}	4.68×10^{-2}	7.95×10^{-2}	2.80×10^{-9}	2.12×10^{-3}

Table 1437: Computed freestream species mass fractions, Shot 2748

180.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3369	1667.0	1667.0	4.66	51.1	0.122	7.61×10^6
72 cm	3334	1672.0	1672.0	4.35	57.1	0.136	8.40×10^6

Table 1438: Computed boundary layer edge conditions, Shot 2748

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.39×10^{-1}	3.73×10^{-1}	3.86×10^{-2}	8.05×10^{-2}	2.85×10^{-9}	2.38×10^{-3}
72 cm	3.62×10^{-1}	1.35×10^{-1}	3.76×10^{-1}	4.68×10^{-2}	7.91×10^{-2}	5.55×10^{-9}	1.81×10^{-3}

Table 1439: Computed boundary layer edge species mass fractions, Shot 2748

	T^* K	Unit Re* 1/m
1D 100 cm	1650	7.75×10^6
72 cm	1568	8.96×10^6

Table 1440: Dorrance reference conditions, Shot 2748

180.5 Stability Computations

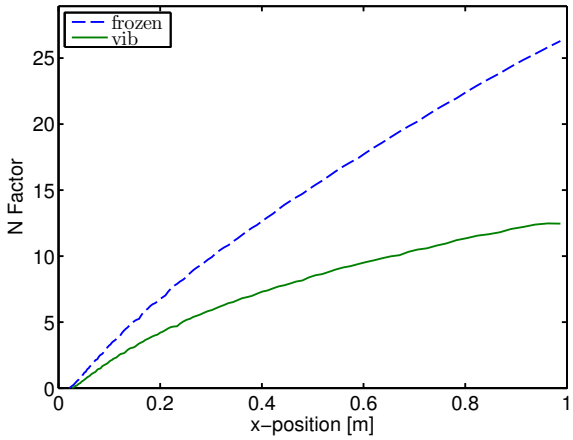


Figure 538: Locus of maximum N factor with and without vibrational energy transfer, Shot 2748

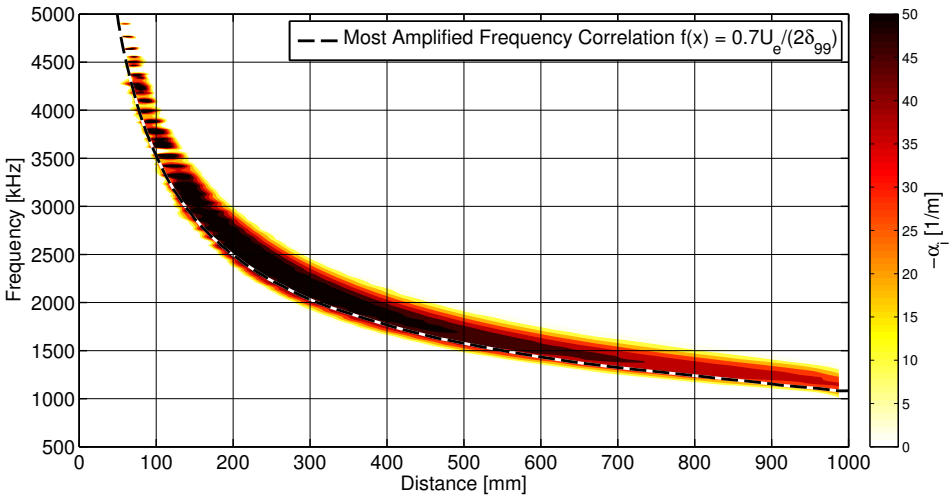


Figure 539: Stability diagram with vibrational energy transfer, Shot 2748. Dashed line indicates $0.7U_e/(2\delta_{99})$.

180.6 Heat Transfer Results

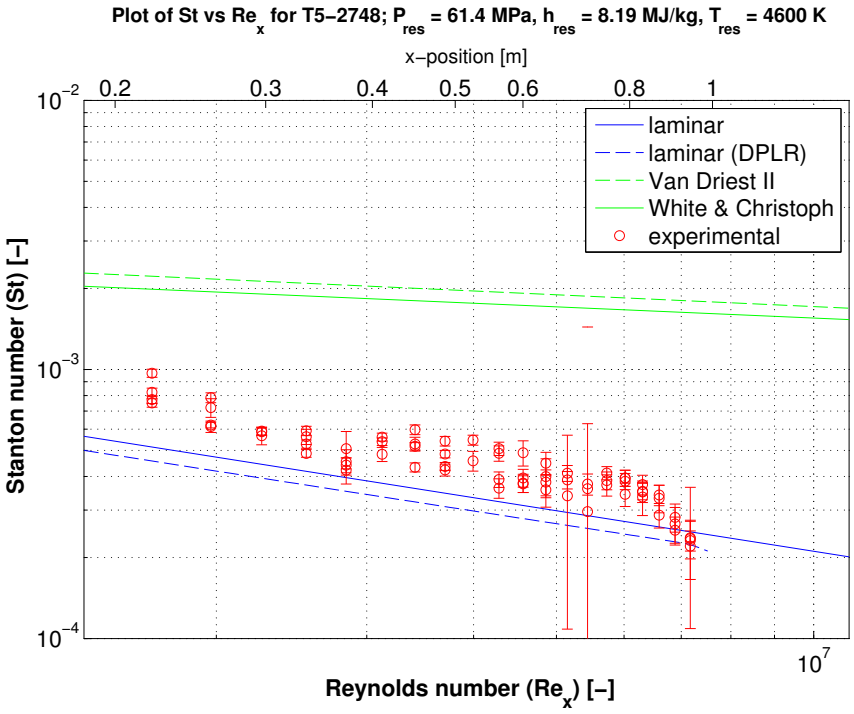


Figure 540: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

181 Shot 2749

Experiment 2749 was performed in T5 on 1 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

181.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3160	m/s
Shock Tube Fill Pressure	P_1	70.00	kPa
Reservoir Pressure	P_{res}	60.4	MPa

Table 1441: Measured quantities, Shot 2749

181.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5006	K
Reservoir Density	ρ_{res}	41.83	kg/m^3
Reservoir Enthalpy	h_{res}	9.60	MJ/kg

Table 1442: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2749

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.33×10^{-1}	1.38×10^{-1}	1.29×10^{-1}	1.07×10^{-1}	2.36×10^{-1}	3.92×10^{-4}	5.65×10^{-2}

Table 1443: Computed reservoir species mass fractions, Shot 2749

181.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3625	1813.0	1813.0	4.76	38.9	0.084	5.26×10^6
72 cm	3599	1740.6	1741.2	4.55	43.1	0.096	6.18×10^6

Table 1444: Computed freestream conditions, Shot 2749

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.51×10^{-1}	3.30×10^{-1}	4.07×10^{-2}	1.08×10^{-1}	2.37×10^{-8}	5.48×10^{-3}
72 cm	3.61×10^{-1}	1.50×10^{-1}	3.21×10^{-1}	4.84×10^{-2}	1.14×10^{-1}	2.34×10^{-8}	5.36×10^{-3}

Table 1445: Computed freestream species mass fractions, Shot 2749

181.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3587	1919.5	1919.5	4.58	51.8	0.105	6.28×10^6
72 cm	3541	1894.6	1894.6	4.29	57.9	0.119	7.07×10^6

Table 1446: Computed boundary layer edge conditions, Shot 2749

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.51×10^{-1}	3.30×10^{-1}	4.07×10^{-2}	1.08×10^{-1}	2.37×10^{-8}	5.48×10^{-3}
72 cm	3.61×10^{-1}	1.51×10^{-1}	3.22×10^{-1}	4.84×10^{-2}	1.13×10^{-1}	4.30×10^{-8}	4.54×10^{-3}

Table 1447: Computed boundary layer edge species mass fractions, Shot 2749

	T^* K	Unit Re^* 1/m
1D 100 cm	1856	6.65×10^6
72 cm	1744	7.68×10^6

Table 1448: Dorrance reference conditions, Shot 2749

181.5 Stability Computations

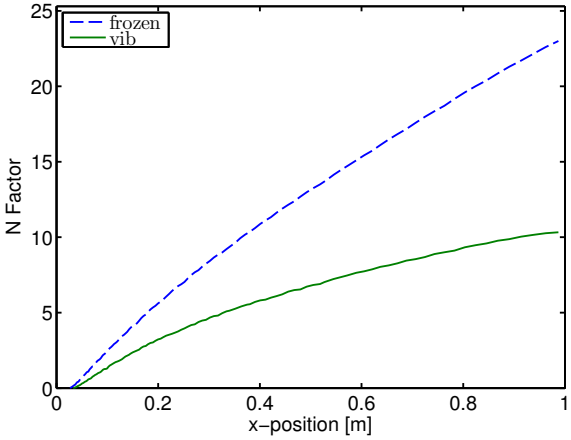


Figure 541: Locus of maximum N factor with and without vibrational energy transfer, Shot 2749

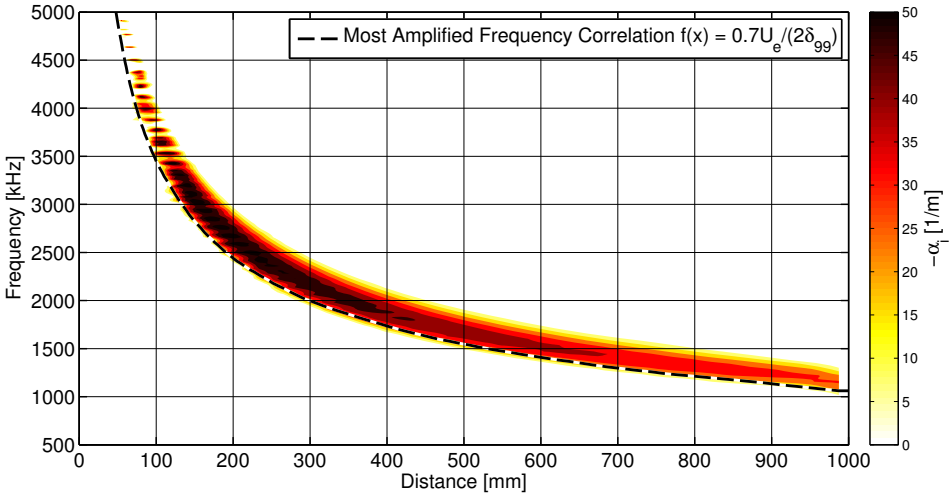


Figure 542: Stability diagram with vibrational energy transfer, Shot 2749. Dashed line indicates $0.7U_e/(2\delta_{99})$.

181.6 Heat Transfer Results

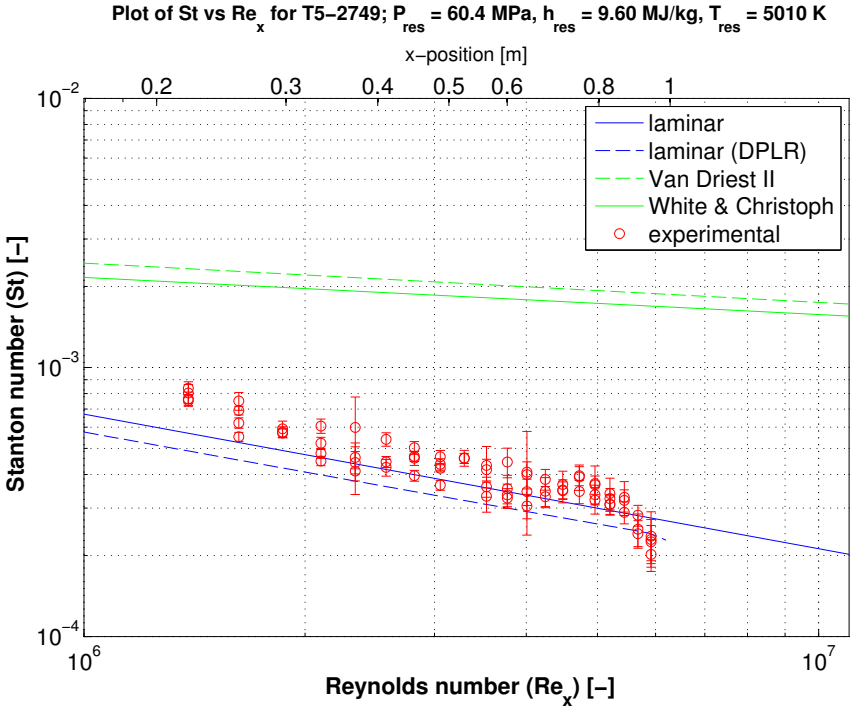


Figure 543: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

182 Shot 2750

Experiment 2750 was performed in T5 on 6 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

182.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3080	m/s
Shock Tube Fill Pressure	P_1	79.75	kPa
Reservoir Pressure	P_{res}	60.0	MPa

Table 1449: Measured quantities, Shot 2750

182.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4831	K
Reservoir Density	ρ_{res}	43.90	kg/m^3
Reservoir Enthalpy	h_{res}	9.01	MJ/kg

Table 1450: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2750

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.36×10^{-1}	1.43×10^{-1}	1.54×10^{-1}	1.01×10^{-1}	2.20×10^{-1}	2.55×10^{-4}	4.56×10^{-2}

Table 1451: Computed reservoir species mass fractions, Shot 2750

182.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3537	1716.0	1716.0	4.79	38.5	0.088	5.65×10^6
72 cm	3512	1657.7	1658.4	4.57	42.3	0.100	6.51×10^6

Table 1452: Computed freestream conditions, Shot 2750

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.47×10^{-1}	3.47×10^{-1}	4.00×10^{-2}	9.72×10^{-2}	1.01×10^{-8}	3.98×10^{-3}
72 cm	3.61×10^{-1}	1.44×10^{-1}	3.42×10^{-1}	4.77×10^{-2}	1.00×10^{-1}	1.04×10^{-8}	3.81×10^{-3}

Table 1453: Computed freestream species mass fractions, Shot 2750

182.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3500	1817.6	1817.6	4.61	51.4	0.111	6.76×10^6
72 cm	3455	1800.7	1800.7	4.31	56.8	0.124	7.48×10^6

Table 1454: Computed boundary layer edge conditions, Shot 2750

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.65×10^{-1}	1.47×10^{-1}	3.47×10^{-1}	4.00×10^{-2}	9.72×10^{-2}	1.01×10^{-8}	3.98×10^{-3}
72 cm	3.61×10^{-1}	1.45×10^{-1}	3.44×10^{-1}	4.76×10^{-2}	9.95×10^{-2}	1.97×10^{-8}	3.25×10^{-3}

Table 1455: Computed boundary layer edge species mass fractions, Shot 2750

	T^* K	Unit Re^* 1/m
1D 100 cm	1772	7.06×10^6
72 cm	1669	8.07×10^6

Table 1456: Dorrance reference conditions, Shot 2750

182.5 Stability Computations

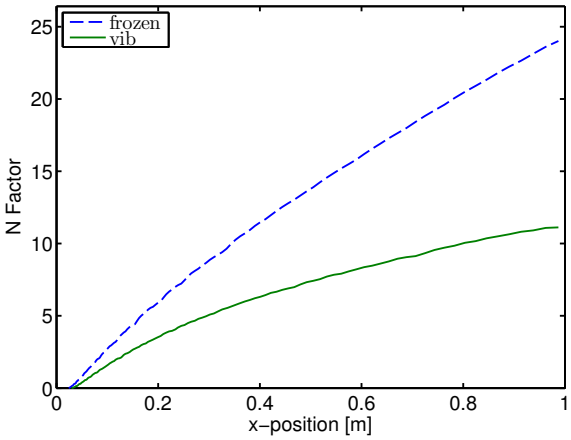


Figure 544: Locus of maximum N factor with and without vibrational energy transfer, Shot 2750

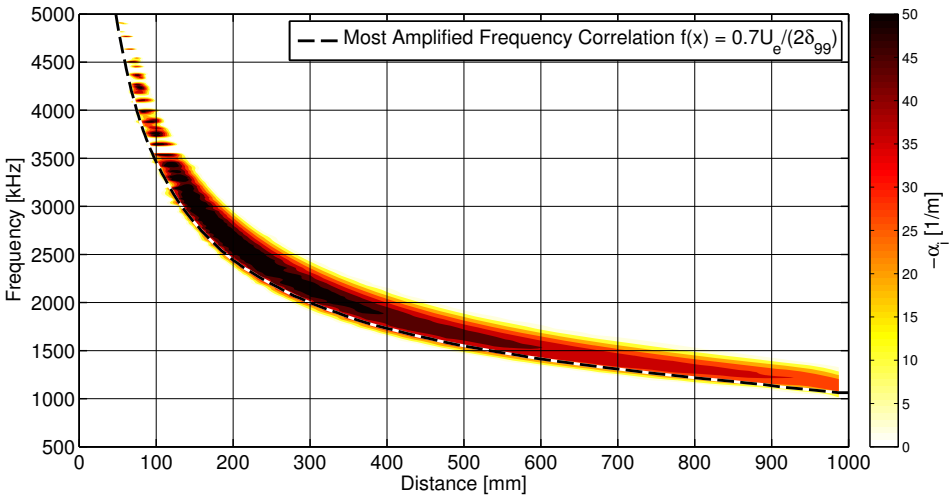


Figure 545: Stability diagram with vibrational energy transfer, Shot 2750. Dashed line indicates $0.7U_e/(2\delta_{99})$.

182.6 Heat Transfer Results

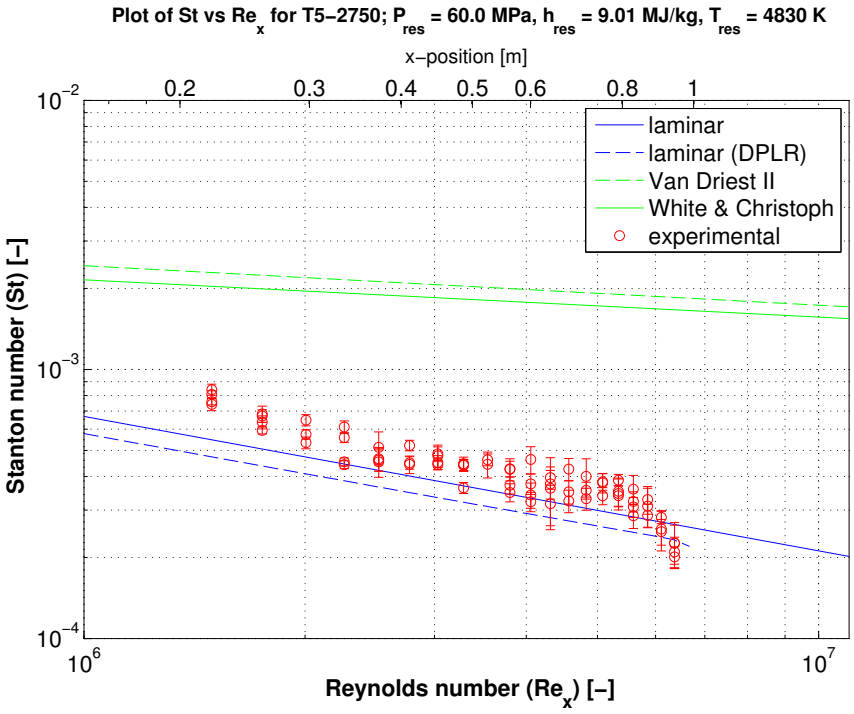


Figure 546: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

183 Shot 2751

Experiment 2751 was performed in T5 on 8 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

183.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	71.85	kPa
Reservoir Pressure	P_{res}	60.2	MPa

Table 1457: Measured quantities, Shot 2751

183.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4429	K
Reservoir Density	ρ_{res}	55.64	kg/m^3
Reservoir Enthalpy	h_{res}	9.04	MJ/kg

Table 1458: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2751

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.63×10^{-1}	4.83×10^{-1}	0	3.29×10^{-1}	0	2.52×10^{-2}

Table 1459: Computed reservoir species mass fractions, Shot 2751

183.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3216	1981.0	1981.0	4.50	44.7	0.104	5.81×10^6
72 cm	3200	1939.3	1939.5	4.17	53.5	0.127	7.14×10^6

Table 1460: Computed freestream conditions, Shot 2751

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.02×10^{-1}	7.16×10^{-1}	0	1.81×10^{-1}	0	1.51×10^{-3}
72 cm	0	1.04×10^{-1}	7.08×10^{-1}	0	1.86×10^{-1}	0	2.46×10^{-3}

Table 1461: Computed freestream species mass fractions, Shot 2751

183.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3181	2064.4	2064.4	4.36	57.6	0.129	6.89×10^6
72 cm	3150	2051.8	2051.7	3.99	69.2	0.156	8.26×10^6

Table 1462: Computed boundary layer edge conditions, Shot 2751

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.02×10^{-1}	7.16×10^{-1}	0	1.81×10^{-1}	0	1.51×10^{-3}
72 cm	0	1.03×10^{-1}	7.10×10^{-1}	0	1.85×10^{-1}	0	1.91×10^{-3}

Table 1463: Computed boundary layer edge species mass fractions, Shot 2751

	T^* K	Unit Re^* 1/m
1D 100 cm	1756	9.12×10^6
72 cm	1654	10.25×10^6

Table 1464: Dorrance reference conditions, Shot 2751

183.5 Stability Computations

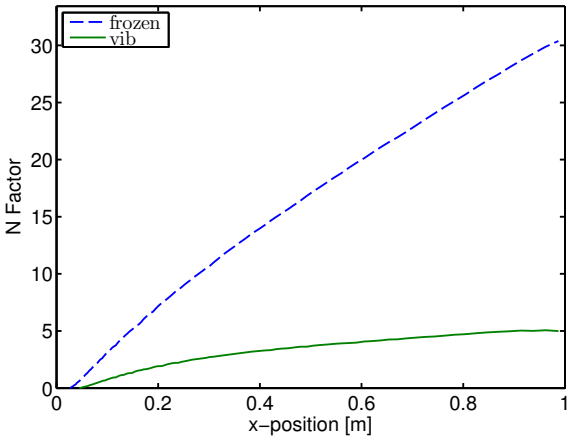


Figure 547: Locus of maximum N factor with and without vibrational energy transfer, Shot 2751

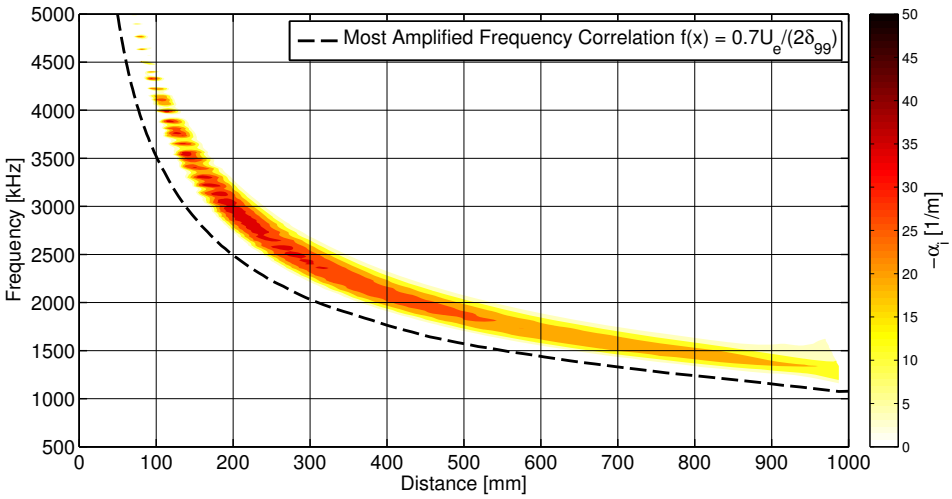


Figure 548: Stability diagram with vibrational energy transfer, Shot 2751. Dashed line indicates $0.7U_e/(2\delta_{99})$.

183.6 Heat Transfer Results

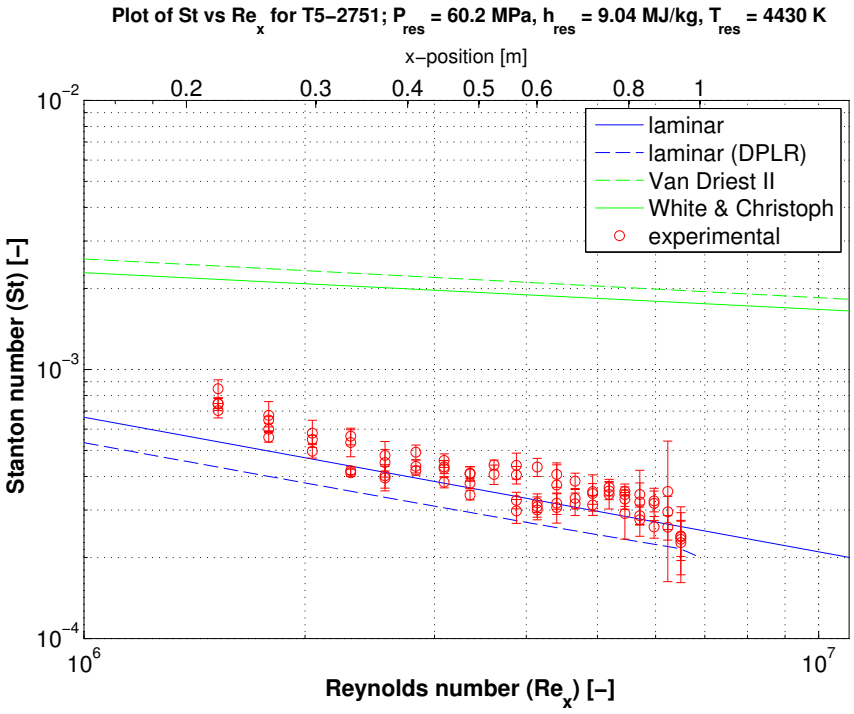


Figure 549: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

184 Shot 2752

Experiment 2752 was performed in T5 on 13 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

184.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2990	m/s
Shock Tube Fill Pressure	P_1	101.00	kPa
Reservoir Pressure	P_{res}	61.5	MPa

Table 1465: Measured quantities, Shot 2752

184.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5731	K
Reservoir Density	ρ_{res}	34.35	kg/m^3
Reservoir Enthalpy	h_{res}	8.85	MJ/kg

Table 1466: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2752

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	6.80×10^{-2}	0	1.41×10^{-1}	0	2.60×10^{-3}	8.96×10^{-2}

Table 1467: Computed reservoir species mass fractions, Shot 2752

184.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3846	1310.0	1310.0	5.42	27.8	0.073	5.67×10^6
72 cm	3825	1328.2	1334.8	5.21	32.6	0.085	6.50×10^6

Table 1468: Computed freestream conditions, Shot 2752

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.88×10^{-1}	0	6.11×10^{-2}	0	4.25×10^{-10}	1.20×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.33×10^{-2}	0	1.50×10^{-9}	6.41×10^{-3}

Table 1469: Computed freestream species mass fractions, Shot 2752

184.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3808	1430.1	1430.1	5.13	39.8	0.095	6.96×10^6
72 cm	3760	1504.8	1502.9	4.81	46.6	0.107	7.43×10^6

Table 1470: Computed boundary layer edge conditions, Shot 2752

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.88×10^{-1}	0	6.11×10^{-2}	0	4.25×10^{-10}	1.20×10^{-2}
72 cm	7.33×10^{-1}	1.88×10^{-1}	0	7.33×10^{-2}	0	7.25×10^{-9}	6.20×10^{-3}

Table 1471: Computed boundary layer edge species mass fractions, Shot 2752

	T^* K	Unit Re^* 1/m
1D 100 cm	1745	4.97×10^6
72 cm	1714	6.52×10^6

Table 1472: Dorrance reference conditions, Shot 2752

184.5 Stability Computations

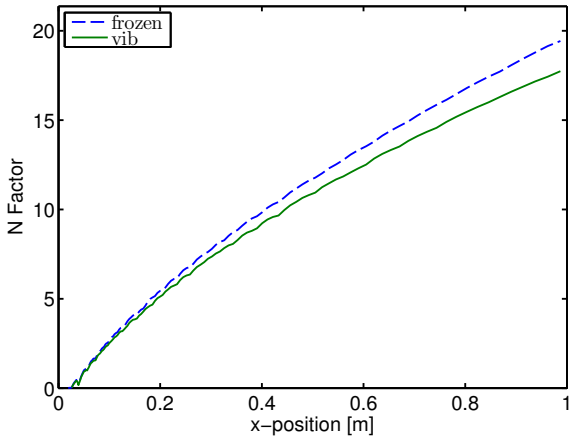


Figure 550: Locus of maximum N factor with and without vibrational energy transfer, Shot 2752

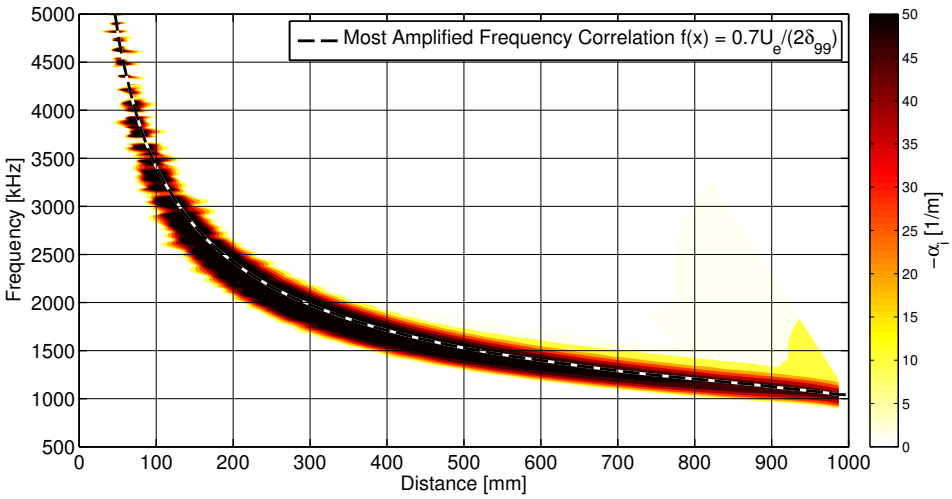


Figure 551: Stability diagram with vibrational energy transfer, Shot 2752. Dashed line indicates $0.7U_e/(2\delta_{99})$.

184.6 Heat Transfer Results

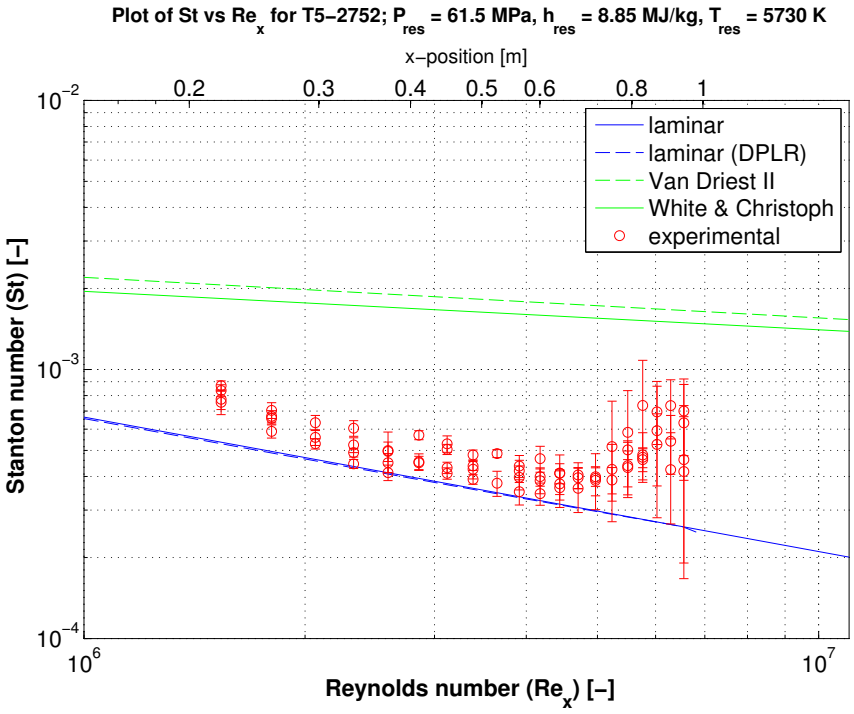


Figure 552: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

185 Shot 2753

Experiment 2753 was performed in T5 on 15 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

185.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2990	m/s
Shock Tube Fill Pressure	P_1	94.90	kPa
Reservoir Pressure	P_{res}	52.1	MPa

Table 1473: Measured quantities, Shot 2753

185.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5619	K
Reservoir Density	ρ_{res}	29.72	kg/m^3
Reservoir Enthalpy	h_{res}	8.67	MJ/kg

Table 1474: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2753

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	7.02×10^{-2}	0	1.39×10^{-1}	0	2.30×10^{-3}	8.87×10^{-2}

Table 1475: Computed reservoir species mass fractions, Shot 2753

185.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3805	1269.0	1269.0	5.44	23.2	0.063	4.93×10^{6}
72 cm	3784	1290.4	1297.7	5.22	27.2	0.073	5.62×10^{6}

Table 1476: Computed freestream conditions, Shot 2753

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.14×10^{-2}	0	7.35×10^{-10}	1.29×10^{-2}
72 cm	7.33×10^{-1}	1.86×10^{-1}	0	7.39×10^{-2}	0	1.13×10^{-9}	7.00×10^{-3}

Table 1477: Computed freestream species mass fractions, Shot 2753

185.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3768	1386.4	1386.4	5.15	33.3	0.082	6.07×10^{6}
72 cm	3720	1464.7	1462.4	4.82	39.0	0.092	6.43×10^{6}

Table 1478: Computed boundary layer edge conditions, Shot 2753

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.87×10^{-1}	0	6.14×10^{-2}	0	7.35×10^{-10}	1.29×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.39×10^{-2}	0	6.11×10^{-9}	6.80×10^{-3}

Table 1479: Computed boundary layer edge species mass fractions, Shot 2753

	T^* K	Unit Re^* 1/m
1D 100 cm	1708	4.27×10^{6}
72 cm	1681	5.10×10^{6}

Table 1480: Dorrance reference conditions, Shot 2753

185.5 Stability Computations

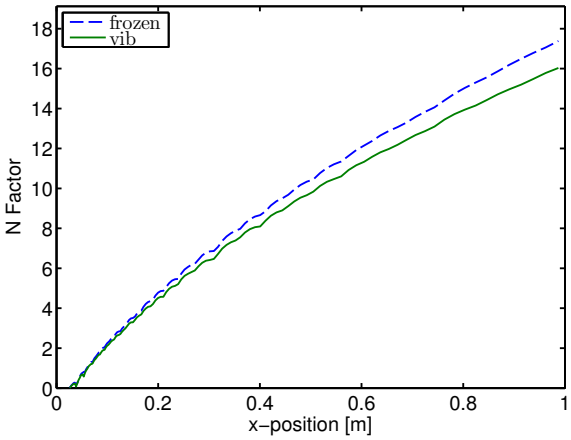


Figure 553: Locus of maximum N factor with and without vibrational energy transfer, Shot 2753

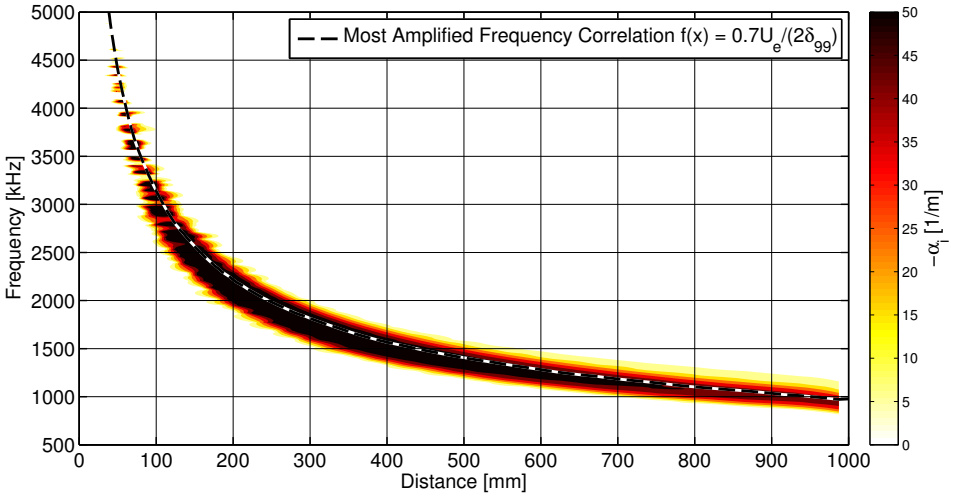


Figure 554: Stability diagram with vibrational energy transfer, Shot 2753. Dashed line indicates $0.7U_e/(2\delta_{99})$.

185.6 Heat Transfer Results

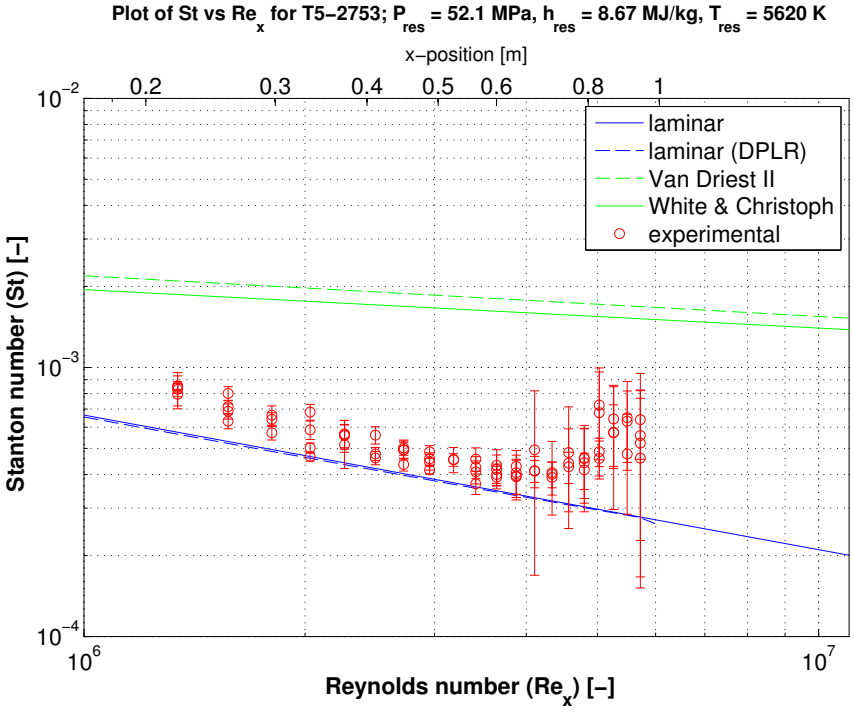


Figure 555: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

186 Shot 2754

Experiment 2754 was performed in T5 on 16 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

186.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	62.00	kPa
Reservoir Pressure	P_{res}	53.4	MPa

Table 1481: Measured quantities, Shot 2754

186.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4486	K
Reservoir Density	ρ_{res}	47.81	kg/m^3
Reservoir Enthalpy	h_{res}	9.41	MJ/kg

Table 1482: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2754

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.70×10^{-1}	4.48×10^{-1}	0	3.51×10^{-1}	0	3.03×10^{-2}

Table 1483: Computed reservoir species mass fractions, Shot 2754

186.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3269	2027.0	2027.0	4.49	41.0	0.093	5.13×10^{6}
72 cm	3243	1953.9	1954.2	4.18	47.0	0.109	6.15×10^{6}

Table 1484: Computed freestream conditions, Shot 2754

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.10×10^{-1}	6.90×10^{-1}	0	1.97×10^{-1}	0	2.21×10^{-3}
72 cm	0	1.13×10^{-1}	6.79×10^{-1}	0	2.05×10^{-1}	0	3.50×10^{-3}

Table 1485: Computed freestream species mass fractions, Shot 2754

186.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3234	2112.5	2112.5	4.35	52.8	0.114	6.08×10^{6}
72 cm	3192	2072.4	2072.4	4.00	60.8	0.134	7.10×10^{6}

Table 1486: Computed boundary layer edge conditions, Shot 2754

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.10×10^{-1}	6.90×10^{-1}	0	1.97×10^{-1}	0	2.21×10^{-3}
72 cm	0	1.13×10^{-1}	6.81×10^{-1}	0	2.03×10^{-1}	0	2.82×10^{-3}

Table 1487: Computed boundary layer edge species mass fractions, Shot 2754

	T^* K	Unit Re^* 1/m
1D 100 cm	1799	8.03×10^{6}
72 cm	1676	8.78×10^{6}

Table 1488: Dorrance reference conditions, Shot 2754

186.5 Stability Computations

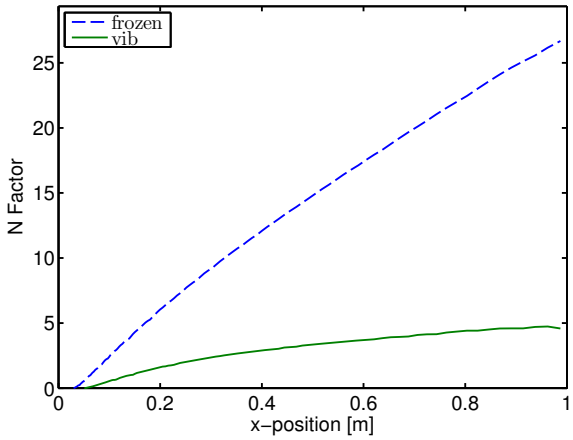


Figure 556: Locus of maximum N factor with and without vibrational energy transfer, Shot 2754

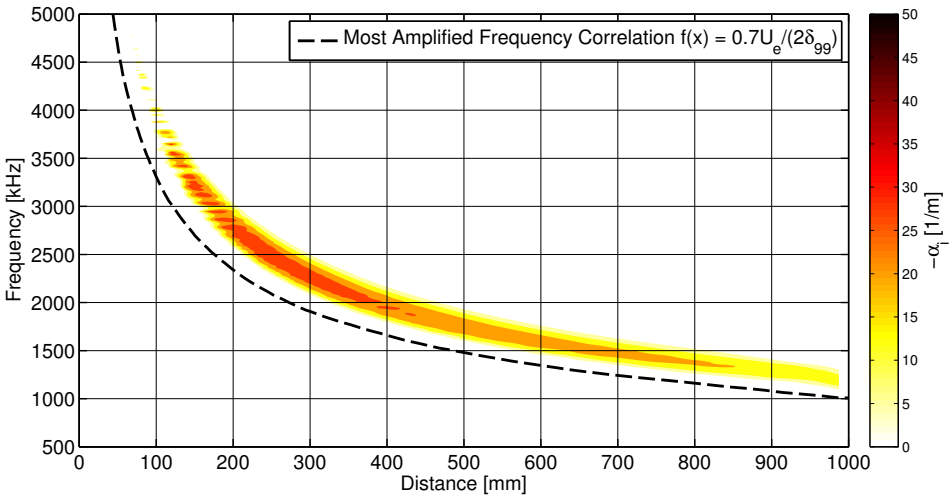


Figure 557: Stability diagram with vibrational energy transfer, Shot 2754. Dashed line indicates $0.7U_e/(2\delta_{99})$.

186.6 Heat Transfer Results

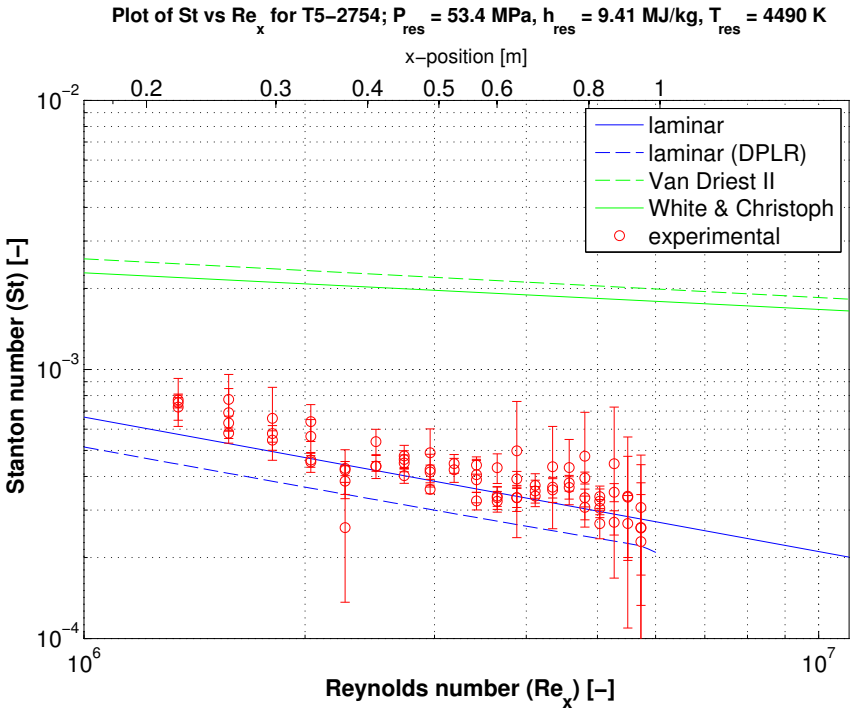


Figure 558: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

187 Shot 2755

Experiment 2755 was performed in T5 on 17 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

187.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2990	m/s
Shock Tube Fill Pressure	P_1	92.00	kPa
Reservoir Pressure	P_{res}	56.7	MPa

Table 1489: Measured quantities, Shot 2755

187.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5722	K
Reservoir Density	ρ_{res}	31.66	kg/m^3
Reservoir Enthalpy	h_{res}	8.87	MJ/kg

Table 1490: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2755

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	6.67×10^{-2}	0	1.40×10^{-1}	0	2.66×10^{-3}	9.17×10^{-2}

Table 1491: Computed reservoir species mass fractions, Shot 2755

187.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3843	1305.0	1305.0	5.42	25.3	0.066	5.19×10^{6}
72 cm	3825	1330.2	1337.4	5.20	30.0	0.078	5.97×10^{6}

Table 1492: Computed freestream conditions, Shot 2755

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.12×10^{-2}	0	7.22×10^{-10}	1.31×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.33×10^{-2}	0	1.72×10^{-9}	7.16×10^{-3}

Table 1493: Computed freestream species mass fractions, Shot 2755

187.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3805	1424.6	1424.6	5.14	36.2	0.087	6.37×10^{6}
72 cm	3760	1507.1	1505.0	4.80	43.0	0.098	6.82×10^{6}

Table 1494: Computed boundary layer edge conditions, Shot 2755

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.87×10^{-1}	0	6.12×10^{-2}	0	7.22×10^{-10}	1.31×10^{-2}
72 cm	7.33×10^{-1}	1.87×10^{-1}	0	7.33×10^{-2}	0	8.34×10^{-9}	6.93×10^{-3}

Table 1495: Computed boundary layer edge species mass fractions, Shot 2755

	T^* K	Unit Re^* 1/m
1D 100 cm	1741	4.54×10^{6}
72 cm	1716	5.99×10^{6}

Table 1496: Dorrance reference conditions, Shot 2755

187.5 Stability Computations

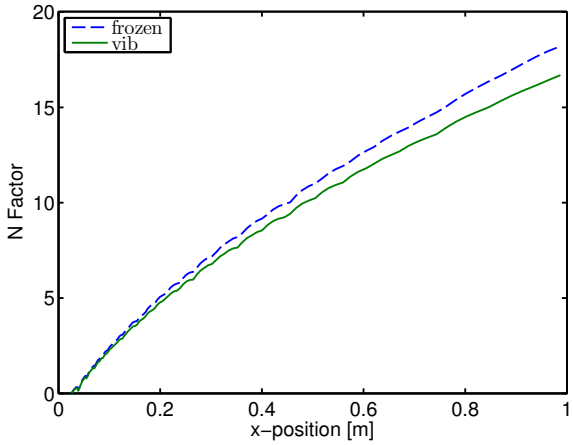


Figure 559: Locus of maximum N factor with and without vibrational energy transfer, Shot 2755

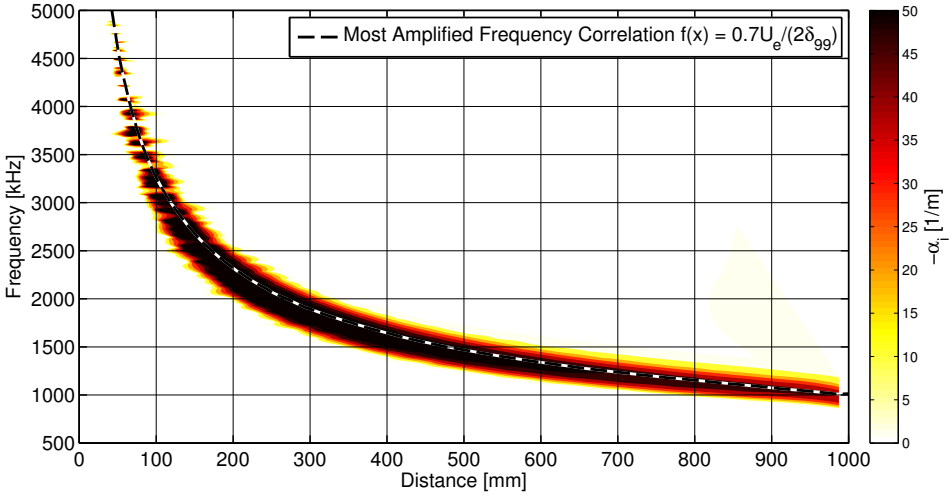


Figure 560: Stability diagram with vibrational energy transfer, Shot 2755. Dashed line indicates $0.7U_e/(2\delta_{99})$.

187.6 Heat Transfer Results

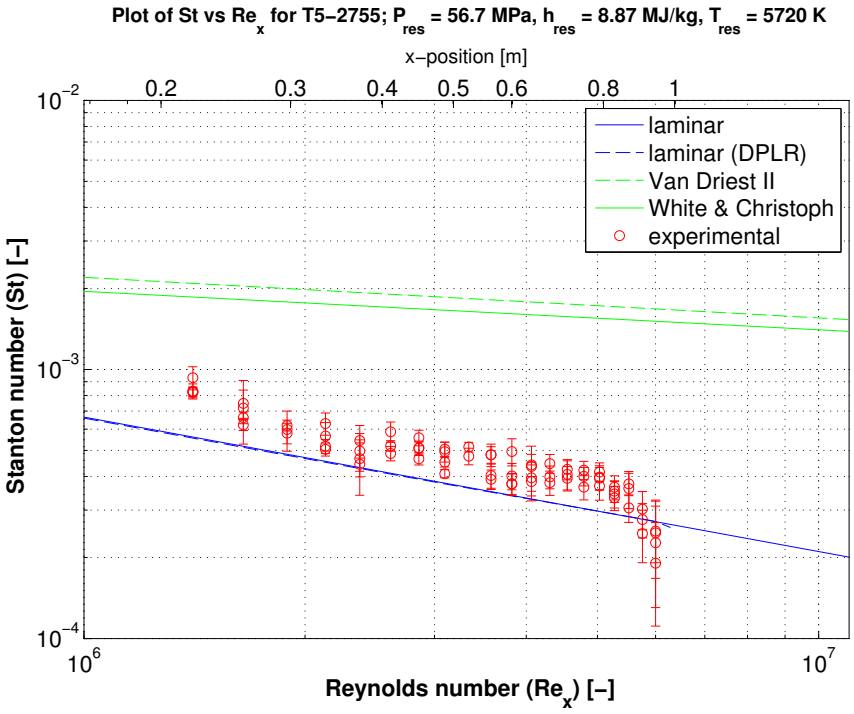


Figure 561: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

188 Shot 2756

Experiment 2756 was performed in T5 on 20 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

188.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3080	m/s
Shock Tube Fill Pressure	P_1	68.00	kPa
Reservoir Pressure	P_{res}	57.5	MPa

Table 1497: Measured quantities, Shot 2756

188.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4348	K
Reservoir Density	ρ_{res}	54.81	kg/m^3
Reservoir Enthalpy	h_{res}	8.73	MJ/kg

Table 1498: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2756

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.57×10^{-1}	5.08×10^{-1}	0	3.13×10^{-1}	0	2.21×10^{-2}

Table 1499: Computed reservoir species mass fractions, Shot 2756

188.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3170	1923.0	1923.0	4.52	42.7	0.103	5.80×10^6
72 cm	3154	1890.3	1890.5	4.17	50.7	0.124	7.04×10^6

Table 1500: Computed freestream conditions, Shot 2756

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.76×10^{-2}	7.28×10^{-1}	0	1.73×10^{-1}	0	1.24×10^{-3}
72 cm	0	9.88×10^{-2}	7.23×10^{-1}	0	1.77×10^{-1}	0	2.05×10^{-3}

Table 1501: Computed freestream species mass fractions, Shot 2756

188.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3136	2003.9	2003.9	4.38	55.1	0.128	6.89×10^6
72 cm	3105	1996.5	1996.5	4.00	65.6	0.153	8.16×10^6

Table 1502: Computed boundary layer edge conditions, Shot 2756

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	9.76×10^{-2}	7.28×10^{-1}	0	1.73×10^{-1}	0	1.24×10^{-3}
72 cm	0	9.87×10^{-2}	7.24×10^{-1}	0	1.76×10^{-1}	0	1.61×10^{-3}

Table 1503: Computed boundary layer edge species mass fractions, Shot 2756

	T^* K	Unit Re^* 1/m
1D 100 cm	1711	9.07×10^6
72 cm	1613	10.10×10^6

Table 1504: Dorrance reference conditions, Shot 2756

188.5 Stability Computations

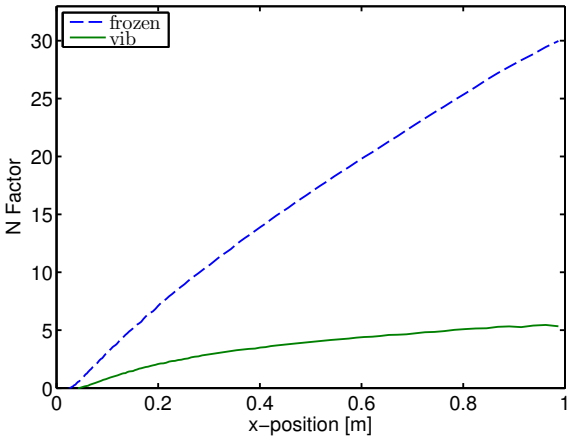


Figure 562: Locus of maximum N factor with and without vibrational energy transfer, Shot 2756

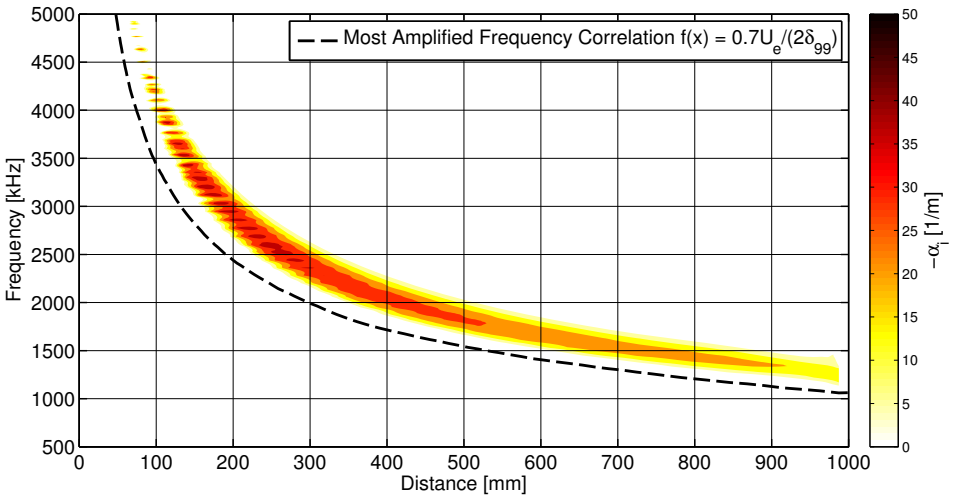


Figure 563: Stability diagram with vibrational energy transfer, Shot 2756. Dashed line indicates $0.7U_e/(2\delta_{99})$.

188.6 Heat Transfer Results

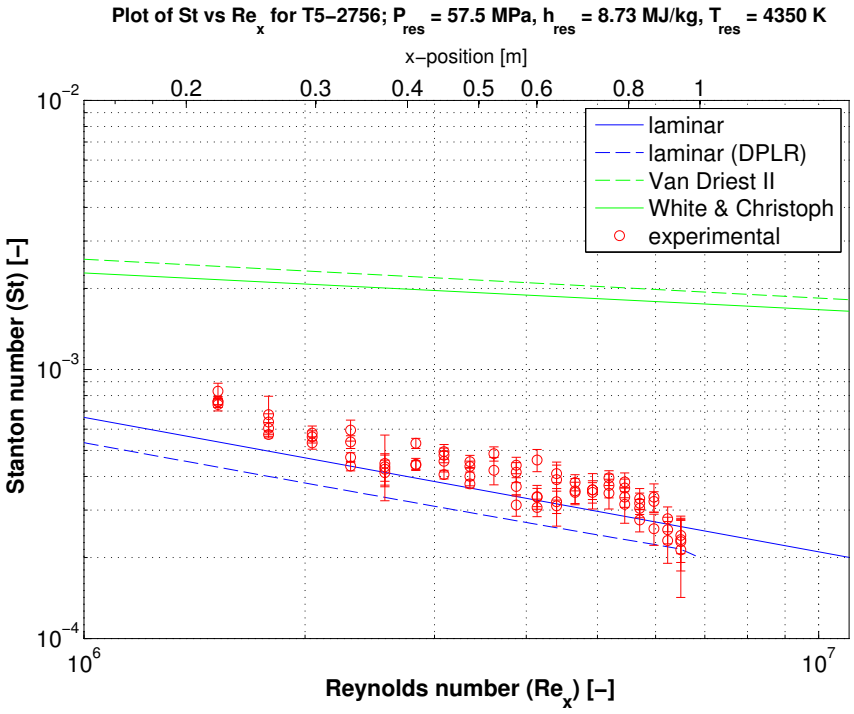


Figure 564: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

189 Shot 2757

Experiment 2757 was performed in T5 on 29 August 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

189.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3200	m/s
Shock Tube Fill Pressure	P_1	92.40	kPa
Reservoir Pressure	P_{res}	60.7	MPa

Table 1505: Measured quantities, Shot 2757

189.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6207	K
Reservoir Density	ρ_{res}	30.59	kg/m^3
Reservoir Enthalpy	h_{res}	10.0	MJ/kg

Table 1506: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2757

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	4.67×10^{-2}	0	1.35×10^{-1}	0	5.86×10^{-3}	1.14×10^{-1}

Table 1507: Computed reservoir species mass fractions, Shot 2757

189.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4051	1499.0	1499.0	5.33	28.6	0.065	4.89×10^{6}
72 cm	4024	1536.7	1545.1	5.08	34.1	0.076	5.59×10^{6}

Table 1508: Computed freestream conditions, Shot 2757

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.96×10^{-2}	0	8.08×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.31×10^{-2}	0	1.71×10^{-8}	1.20×10^{-2}

Table 1509: Computed freestream species mass fractions, Shot 2757

189.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4011	1630.6	1630.6	5.06	40.6	0.085	5.95×10^{6}
72 cm	3956	1731.5	1729.7	4.70	48.3	0.096	6.35×10^{6}

Table 1510: Computed boundary layer edge conditions, Shot 2757

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.81×10^{-1}	0	5.96×10^{-2}	0	8.08×10^{-9}	1.99×10^{-2}
72 cm	7.33×10^{-1}	1.82×10^{-1}	0	7.31×10^{-2}	0	5.76×10^{-8}	1.15×10^{-2}

Table 1511: Computed boundary layer edge species mass fractions, Shot 2757

	T^* K	Unit Re^* 1/m
1D 100 cm	1925	4.49×10^{6}
72 cm	1898	5.80×10^{6}

Table 1512: Dorrance reference conditions, Shot 2757

189.5 Stability Computations

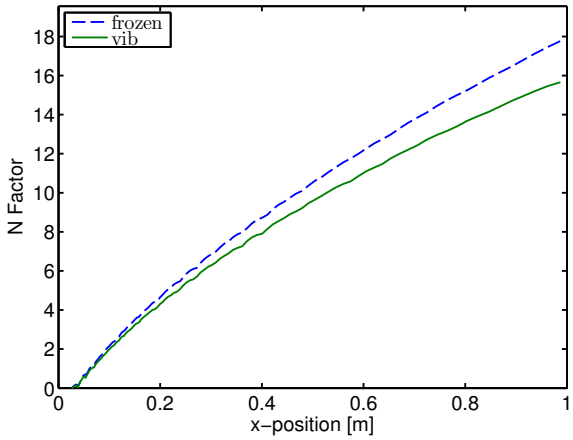


Figure 565: Locus of maximum N factor with and without vibrational energy transfer, Shot 2757

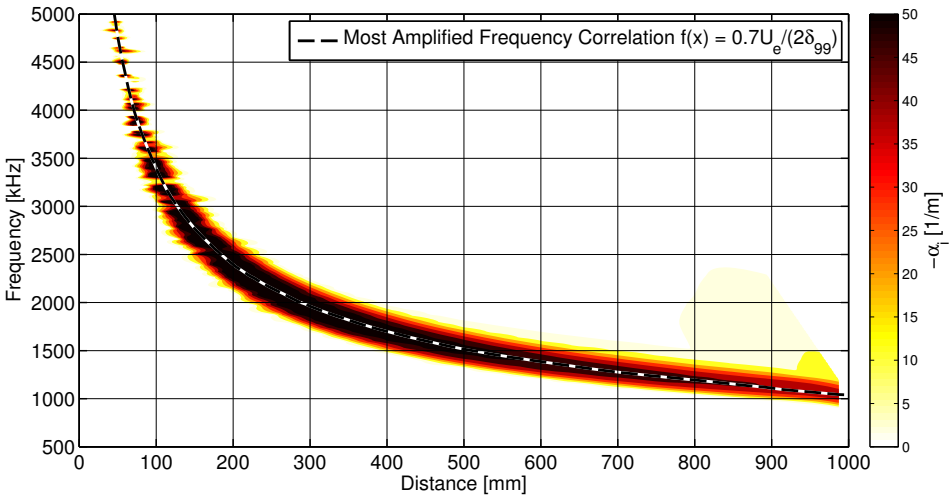


Figure 566: Stability diagram with vibrational energy transfer, Shot 2757. Dashed line indicates $0.7U_e/(2\delta_{99})$.

189.6 Heat Transfer Results

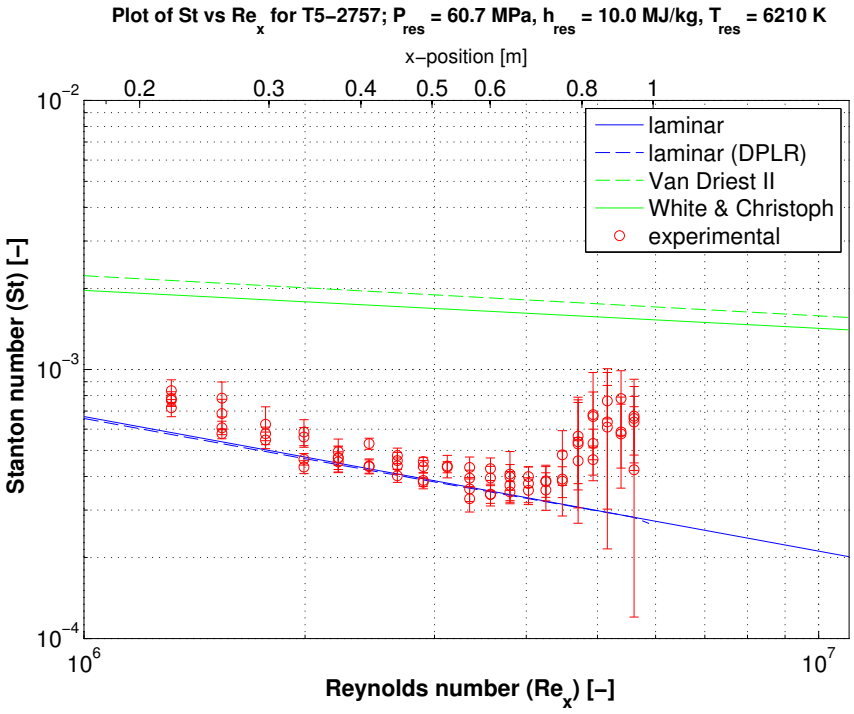


Figure 567: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

190 Shot 2758

Experiment 2758 was performed in T5 on 26 September 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

190.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3300	m/s
Shock Tube Fill Pressure	P_1	82.00	kPa
Reservoir Pressure	P_{res}	72.0	MPa

Table 1513: Measured quantities, Shot 2758

190.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6688	K
Reservoir Density	ρ_{res}	33.12	kg/m^3
Reservoir Enthalpy	h_{res}	11.1	MJ/kg

Table 1514: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2758

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	3.41×10^{-2}	0	1.29×10^{-1}	0	1.08×10^{-2}	1.30×10^{-1}

Table 1515: Computed reservoir species mass fractions, Shot 2758

190.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4232	1680.0	1680.0	5.25	34.6	0.070	5.06×10^{6}
72 cm	4207	1734.2	1741.7	4.99	42.5	0.084	5.90×10^{6}

Table 1516: Computed freestream conditions, Shot 2758

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.79×10^{-2}	0	4.20×10^{-8}	2.52×10^{-2}
72 cm	7.33×10^{-1}	1.78×10^{-1}	0	7.28×10^{-2}	0	8.10×10^{-8}	1.59×10^{-2}

Table 1517: Computed freestream species mass fractions, Shot 2758

190.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4190	1822.9	1822.9	4.99	48.7	0.091	6.14×10^{6}
72 cm	4136	1947.4	1945.9	4.63	59.6	0.105	6.69×10^{6}

Table 1518: Computed boundary layer edge conditions, Shot 2758

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.77×10^{-1}	0	5.79×10^{-2}	0	4.20×10^{-8}	2.52×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.27×10^{-2}	0	2.20×10^{-7}	1.50×10^{-2}

Table 1519: Computed boundary layer edge species mass fractions, Shot 2758

	T^* K	Unit Re^* 1/m
1D 100 cm	2096	4.84×10^{6}
72 cm	2074	6.01×10^{6}

Table 1520: Dorrance reference conditions, Shot 2758

190.5 Stability Computations

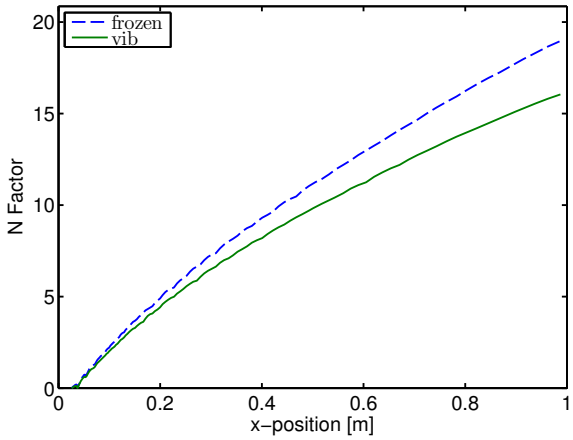


Figure 568: Locus of maximum N factor with and without vibrational energy transfer, Shot 2758

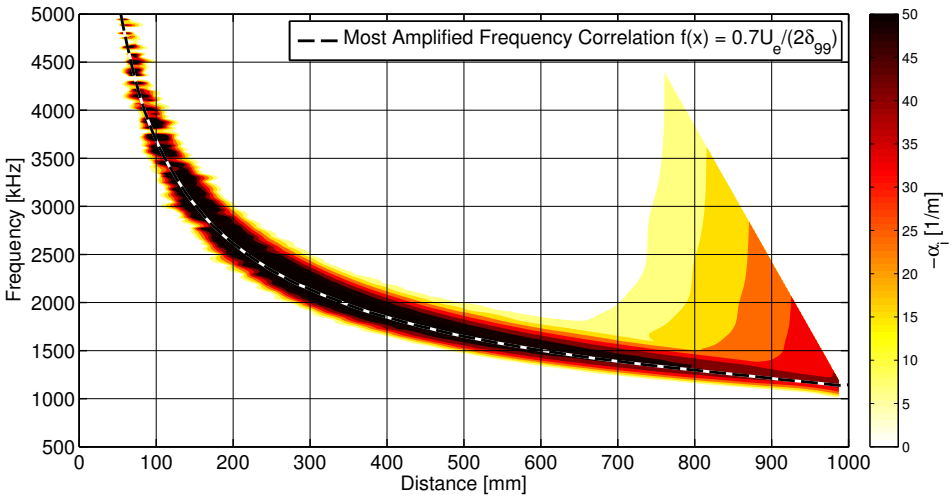


Figure 569: Stability diagram with vibrational energy transfer, Shot 2758. Dashed line indicates $0.7U_e/(2\delta_{99})$.

190.6 Heat Transfer Results

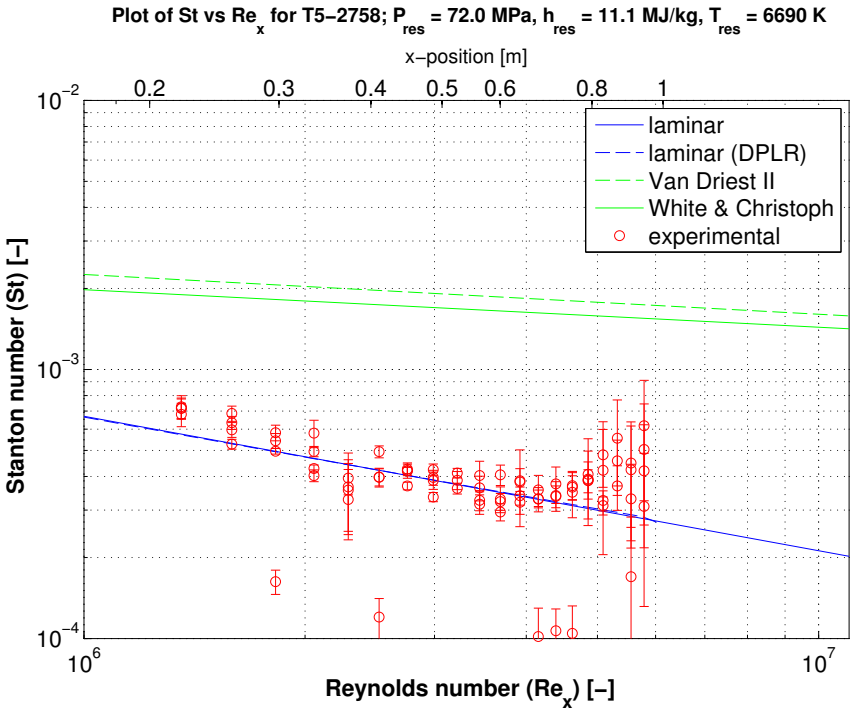


Figure 570: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

191 Shot 2759

Experiment 2759 was performed in T5 on 10 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

191.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	92.20	kPa
Reservoir Pressure	P_{res}	60.4	MPa

Table 1521: Measured quantities, Shot 2759

191.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6051	K
Reservoir Density	ρ_{res}	31.48	kg/m^3
Reservoir Enthalpy	h_{res}	9.62	MJ/kg

Table 1522: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2759

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	5.29×10^{-2}	0	1.37×10^{-1}	0	4.56×10^{-3}	1.07×10^{-1}

Table 1523: Computed reservoir species mass fractions, Shot 2759

191.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3981	1433.0	1433.0	5.36	27.8	0.066	5.04×10^6
72 cm	3961	1469.8	1477.9	5.12	33.4	0.078	5.81×10^6

Table 1524: Computed freestream conditions, Shot 2759

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.02×10^{-2}	0	3.76×10^{-9}	1.72×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	8.48×10^{-9}	1.00×10^{-2}

Table 1525: Computed freestream species mass fractions, Shot 2759

191.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3942	1560.9	1560.9	5.08	39.5	0.087	6.15×10^6
72 cm	3894	1658.8	1657.0	4.73	47.4	0.098	6.61×10^6

Table 1526: Computed boundary layer edge conditions, Shot 2759

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.02×10^{-2}	0	3.76×10^{-9}	1.72×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.29×10^{-2}	0	3.15×10^{-8}	9.63×10^{-3}

Table 1527: Computed boundary layer edge species mass fractions, Shot 2759

	T^* K	Unit Re^* 1/m
1D 100 cm	1862	4.56×10^6
72 cm	1839	5.55×10^6

Table 1528: Dorrance reference conditions, Shot 2759

191.5 Stability Computations

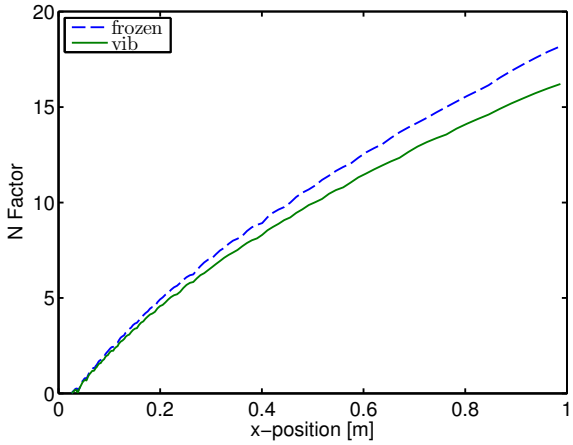


Figure 571: Locus of maximum N factor with and without vibrational energy transfer, Shot 2759

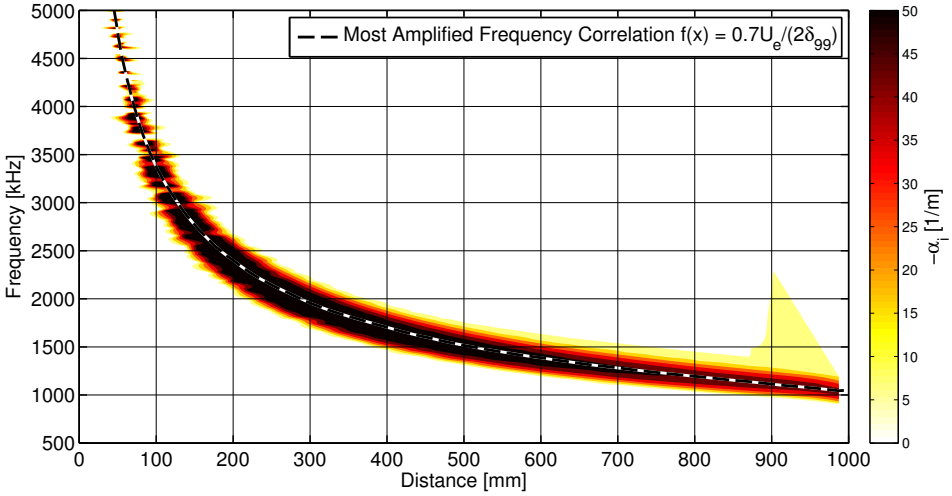


Figure 572: Stability diagram with vibrational energy transfer, Shot 2759. Dashed line indicates $0.7U_e/(2\delta_{99})$.

191.6 Heat Transfer Results

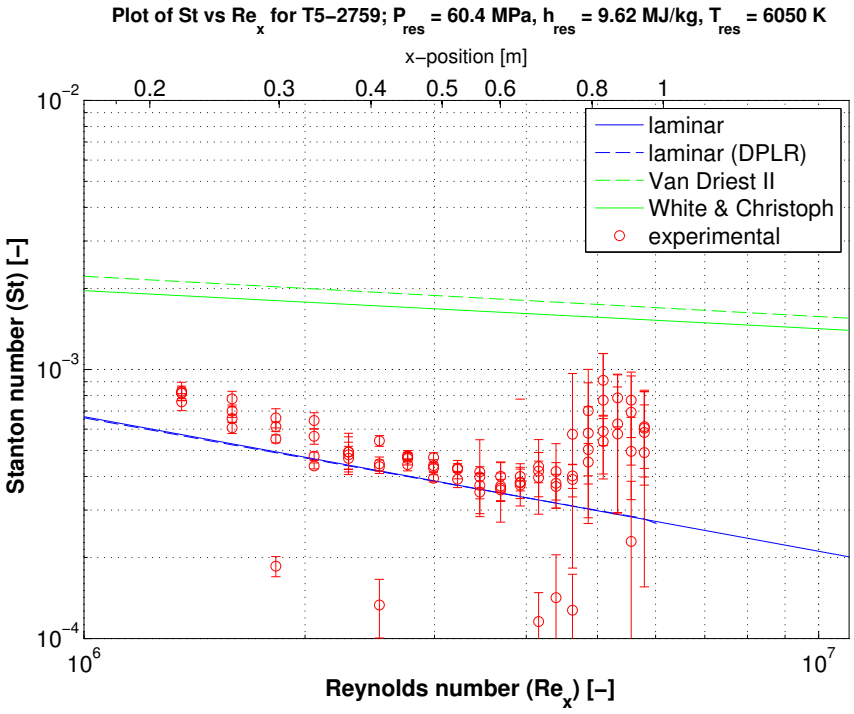


Figure 573: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

192 Shot 2760

Experiment 2760 was performed in T5 on 11 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

192.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2630	m/s
Shock Tube Fill Pressure	P_1	90.00	kPa
Reservoir Pressure	P_{res}	27.2	MPa

Table 1529: Measured quantities, Shot 2760

192.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4515	K
Reservoir Density	ρ_{res}	20.16	kg/m^3
Reservoir Enthalpy	h_{res}	6.30	MJ/kg

Table 1530: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2760

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.11×10^{-1}	1.27×10^{-1}	0	1.19×10^{-1}	0	2.43×10^{-4}	4.20×10^{-2}

Table 1531: Computed reservoir species mass fractions, Shot 2760

192.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3304	852.0	852.0	5.72	10.6	0.043	3.69×10^6
72 cm	3278	849.8	849.1	5.59	11.7	0.047	4.04×10^6

Table 1532: Computed freestream conditions, Shot 2760

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.93×10^{-1}	0	6.40×10^{-2}	0	0	6.02×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.75×10^{-2}	0	0	2.83×10^{-3}

Table 1533: Computed freestream species mass fractions, Shot 2760

192.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3272	943.9	943.9	5.39	15.8	0.058	4.63×10^6
72 cm	3221	991.5	983.0	5.09	17.4	0.061	4.64×10^6

Table 1534: Computed boundary layer edge conditions, Shot 2760

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.93×10^{-1}	0	6.40×10^{-2}	0	0	6.02×10^{-3}
72 cm	7.31×10^{-1}	1.89×10^{-1}	0	7.75×10^{-2}	0	0	2.82×10^{-3}

Table 1535: Computed boundary layer edge species mass fractions, Shot 2760

	T^* K	Unit Re^* 1/m
1D 100 cm	1313	2.74×10^6
72 cm	1292	3.06×10^6

Table 1536: Dorrance reference conditions, Shot 2760

192.5 Stability Computations

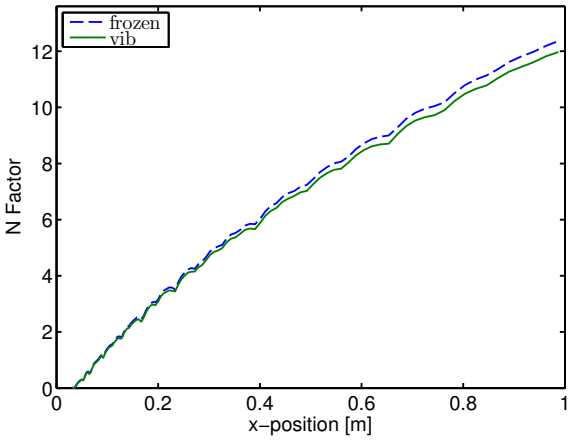


Figure 574: Locus of maximum N factor with and without vibrational energy transfer, Shot 2760

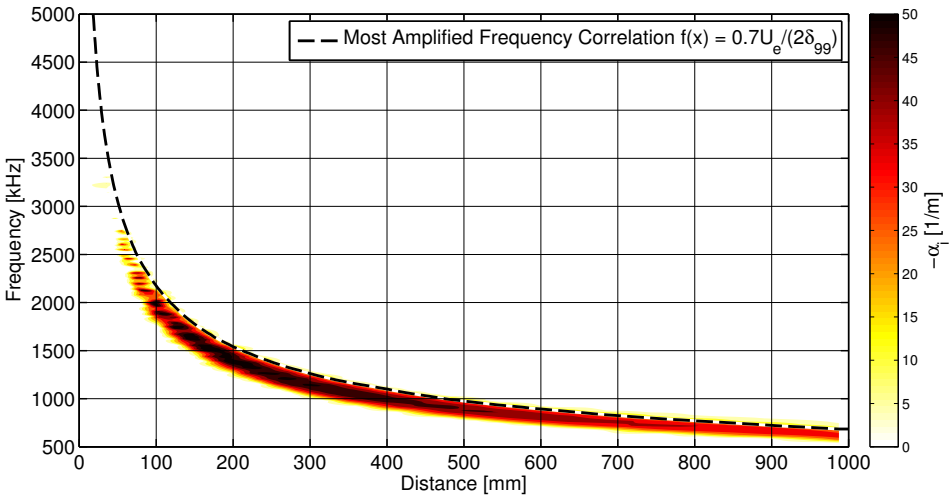


Figure 575: Stability diagram with vibrational energy transfer, Shot 2760. Dashed line indicates $0.7U_e/(2\delta_{99})$.

192.6 Heat Transfer Results

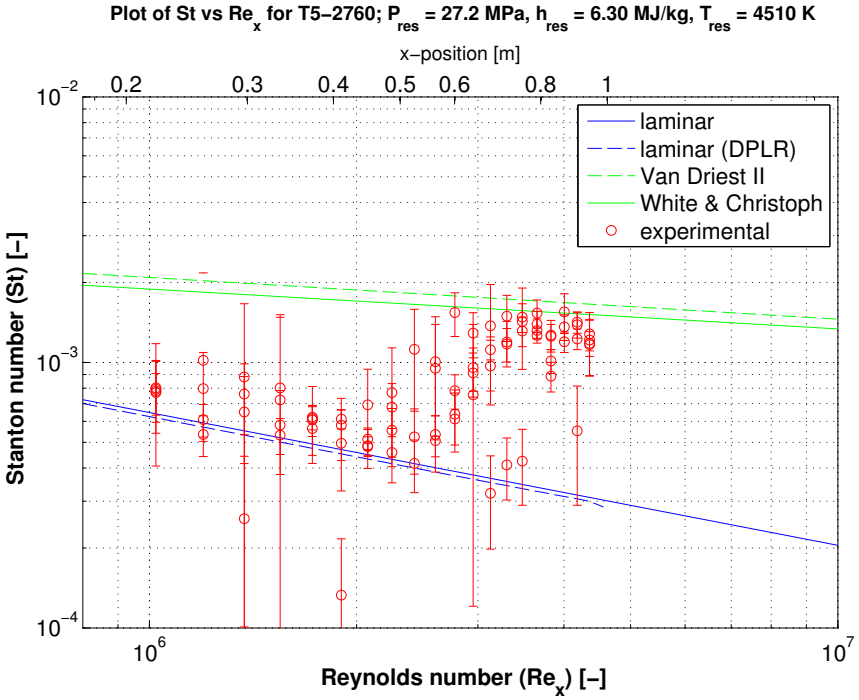


Figure 576: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

193 Shot 2761

Experiment 2761 was performed in T5 on 12 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

193.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2390	m/s
Shock Tube Fill Pressure	P_1	90.10	kPa
Reservoir Pressure	P_res	28.2	MPa

Table 1537: Measured quantities, Shot 2761

193.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	4154	K
Reservoir Density	ρ_res	23.02	kg/m^3
Reservoir Enthalpy	h_res	5.49	MJ/kg

Table 1538: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2761

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.17×10^{-1}	1.52×10^{-1}	0	1.06×10^{-1}	0	7.71×10^{-5}	2.46×10^{-2}

Table 1539: Computed reservoir species mass fractions, Shot 2761

193.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3112	720.0	720.0	5.85	10.3	0.050	4.44×10^6
72 cm	3092	694.2	709.6	5.84	10.3	0.051	4.64×10^6

Table 1540: Computed freestream conditions, Shot 2761

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.42×10^{-2}	0	0	2.98×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.43×10^{-2}	0	0	1.36×10^{-3}

Table 1541: Computed freestream species mass fractions, Shot 2761

193.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3082	803.1	803.1	5.48	15.6	0.067	5.55×10^6
72 cm	3039	827.1	816.6	5.26	15.6	0.066	5.24×10^6

Table 1542: Computed boundary layer edge conditions, Shot 2761

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.96×10^{-1}	0	6.42×10^{-2}	0	0	2.98×10^{-3}
72 cm	7.32×10^{-1}	1.92×10^{-1}	0	7.43×10^{-2}	0	0	1.35×10^{-3}

Table 1543: Computed boundary layer edge species mass fractions, Shot 2761

	T^* K	Unit Re^* 1/m
1D 100 cm	1180	3.04×10^6
72 cm	1158	3.10×10^6

Table 1544: Dorrance reference conditions, Shot 2761

193.5 Stability Computations

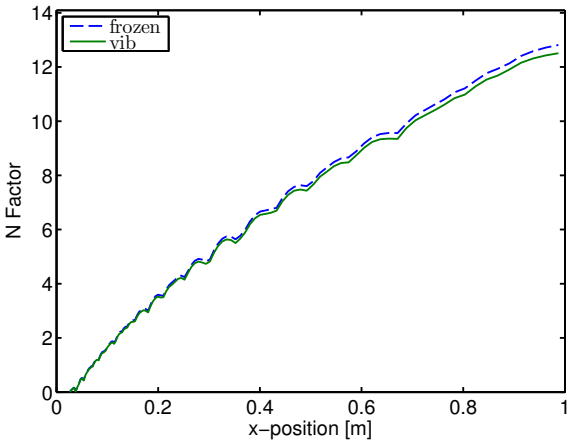


Figure 577: Locus of maximum N factor with and without vibrational energy transfer, Shot 2761

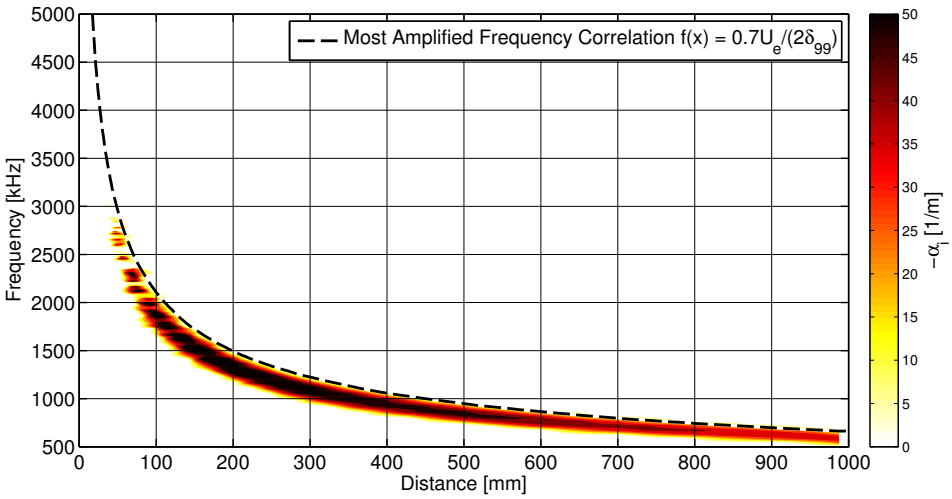


Figure 578: Stability diagram with vibrational energy transfer, Shot 2761. Dashed line indicates $0.7U_e/(2\delta_{99})$.

193.6 Heat Transfer Results

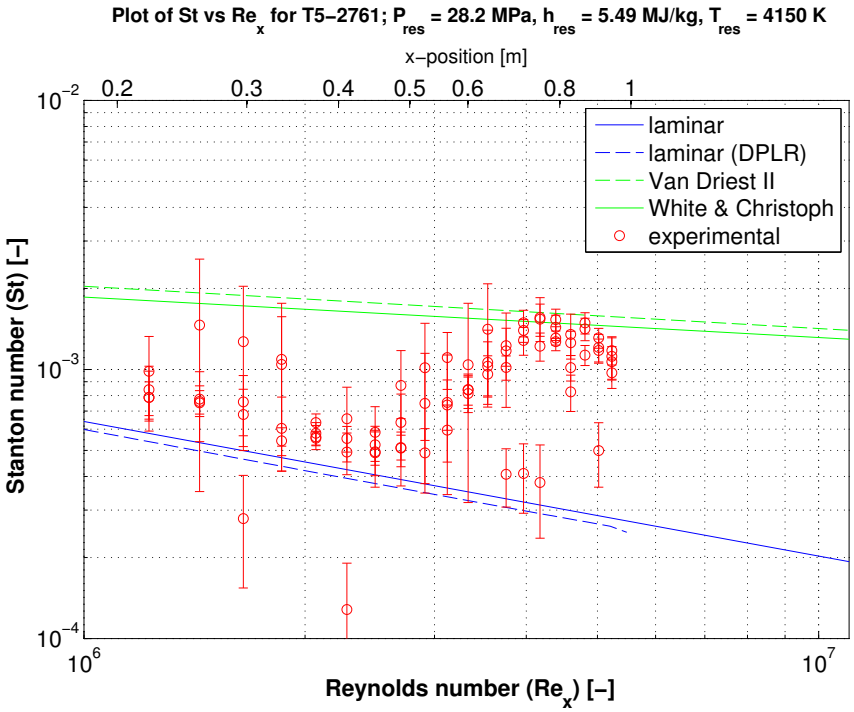


Figure 579: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

194 Shot 2762

Experiment 2762 was performed in T5 on 15 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

194.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2490	m/s
Shock Tube Fill Pressure	P_1	75.00	kPa
Reservoir Pressure	P_{res}	27.8	MPa

Table 1545: Measured quantities, Shot 2762

194.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4414	K
Reservoir Density	ρ_{res}	21.13	kg/m^3
Reservoir Enthalpy	h_{res}	6.06	MJ/kg

Table 1546: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2762

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.13×10^{-1}	1.35×10^{-1}	0	1.16×10^{-1}	0	1.78×10^{-4}	3.65×10^{-2}

Table 1547: Computed reservoir species mass fractions, Shot 2762

194.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3252	816.0	816.0	5.76	10.7	0.046	3.94×10^6
72 cm	3225	805.8	805.5	5.65	11.5	0.049	4.25×10^6

Table 1548: Computed freestream conditions, Shot 2762

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.42×10^{-2}	0	0	4.91×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.68×10^{-2}	0	0	2.28×10^{-3}

Table 1549: Computed freestream species mass fractions, Shot 2762

194.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3221	905.1	905.1	5.41	16.0	0.061	4.94×10^6
72 cm	3169	944.0	935.0	5.13	17.2	0.063	4.89×10^6

Table 1550: Computed boundary layer edge conditions, Shot 2762

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.42×10^{-2}	0	0	4.91×10^{-3}
72 cm	7.31×10^{-1}	1.90×10^{-1}	0	7.68×10^{-2}	0	0	2.27×10^{-3}

Table 1551: Computed boundary layer edge species mass fractions, Shot 2762

	T^* K	Unit Re^* 1/m
1D 100 cm	1277	2.87×10^6
72 cm	1253	3.13×10^6

Table 1552: Dorrance reference conditions, Shot 2762

194.5 Stability Computations

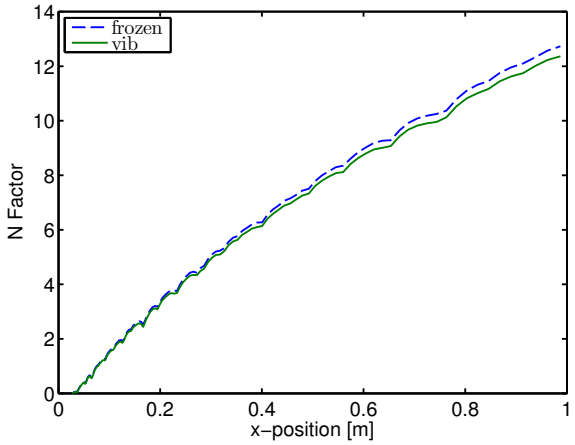


Figure 580: Locus of maximum N factor with and without vibrational energy transfer, Shot 2762

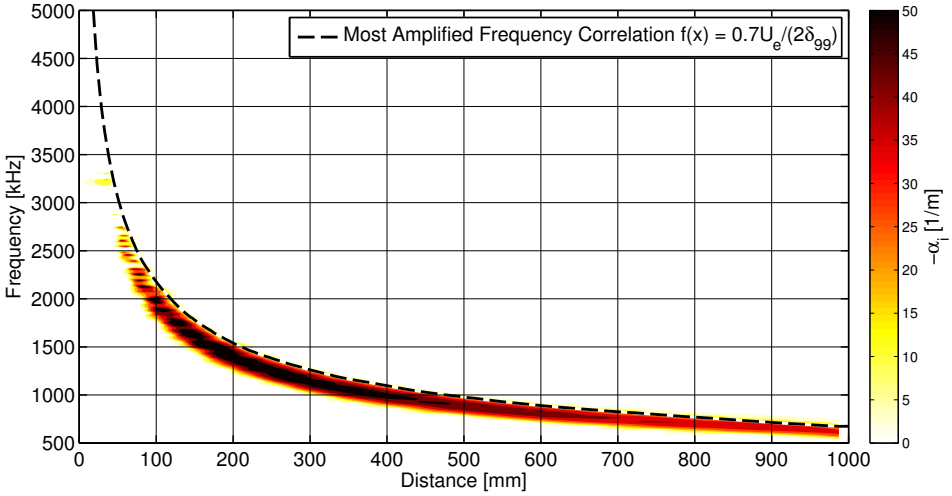


Figure 581: Stability diagram with vibrational energy transfer, Shot 2762. Dashed line indicates $0.7U_e/(2\delta_{99})$.

194.6 Heat Transfer Results

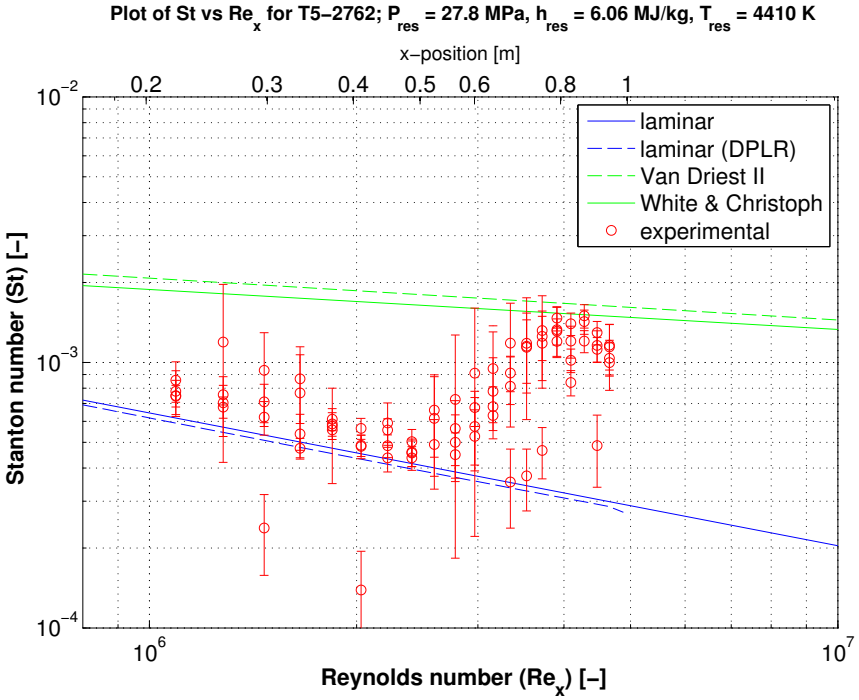


Figure 582: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

195 Shot 2763

Experiment 2763 was performed in T5 on 15 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

195.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2560	m/s
Shock Tube Fill Pressure	P_1	60.00	kPa
Reservoir Pressure	P_{res}	27.2	MPa

Table 1553: Measured quantities, Shot 2763

195.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4630	K
Reservoir Density	ρ_{res}	19.50	kg/m^3
Reservoir Enthalpy	h_{res}	6.57	MJ/kg

Table 1554: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2763

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.10×10^{-1}	1.19×10^{-1}	0	1.22×10^{-1}	0	3.36×10^{-4}	4.84×10^{-2}

Table 1555: Computed reservoir species mass fractions, Shot 2763

195.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3364	896.0	896.0	5.69	10.8	0.042	3.53×10^{6}
72 cm	3338	899.0	899.4	5.53	12.0	0.046	3.87×10^{6}

Table 1556: Computed freestream conditions, Shot 2763

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.92×10^{-1}	0	6.38×10^{-2}	0	0	7.32×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.81×10^{-2}	0	0	3.49×10^{-3}

Table 1557: Computed freestream species mass fractions, Shot 2763

195.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3332	991.1	991.1	5.36	16.0	0.056	4.42×10^{6}
72 cm	3281	1043.7	1035.8	5.05	17.8	0.059	4.47×10^{6}

Table 1558: Computed boundary layer edge conditions, Shot 2763

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.92×10^{-1}	0	6.38×10^{-2}	0	0	7.32×10^{-3}
72 cm	7.31×10^{-1}	1.88×10^{-1}	0	7.81×10^{-2}	0	1.67×10^{-10}	3.46×10^{-3}

Table 1559: Computed boundary layer edge species mass fractions, Shot 2763

	T^* K	Unit Re^* 1/m
1D 100 cm	1356	2.68×10^{6}
72 cm	1336	3.02×10^{6}

Table 1560: Dorrance reference conditions, Shot 2763

195.5 Stability Computations

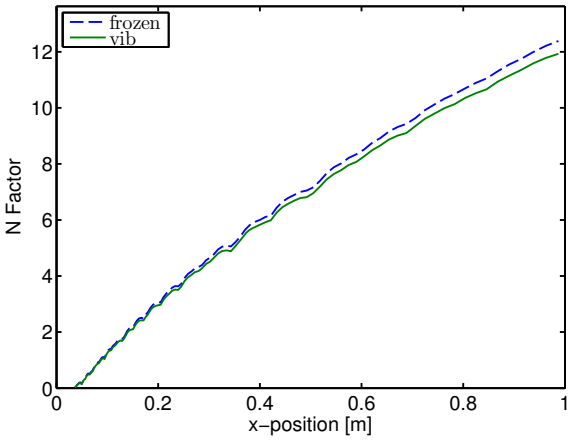


Figure 583: Locus of maximum N factor with and without vibrational energy transfer, Shot 2763

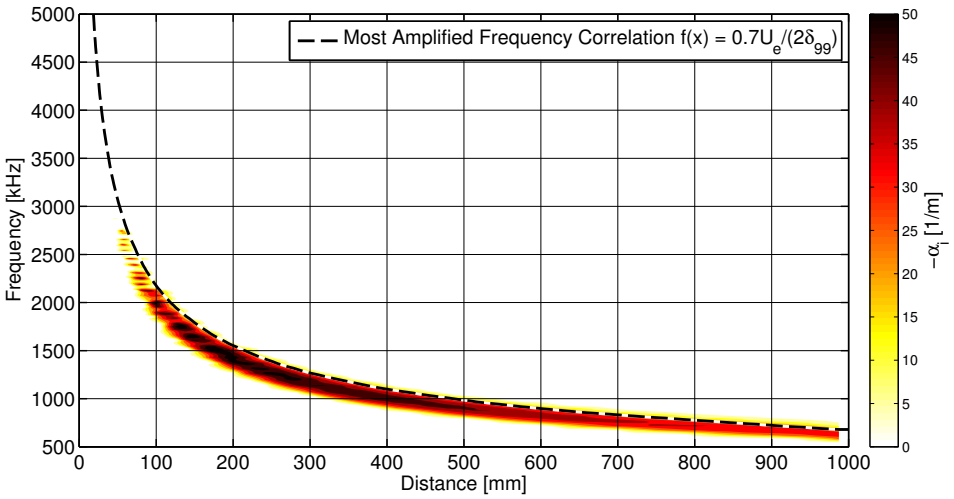


Figure 584: Stability diagram with vibrational energy transfer, Shot 2763. Dashed line indicates $0.7U_e/(2\delta_{99})$.

195.6 Heat Transfer Results

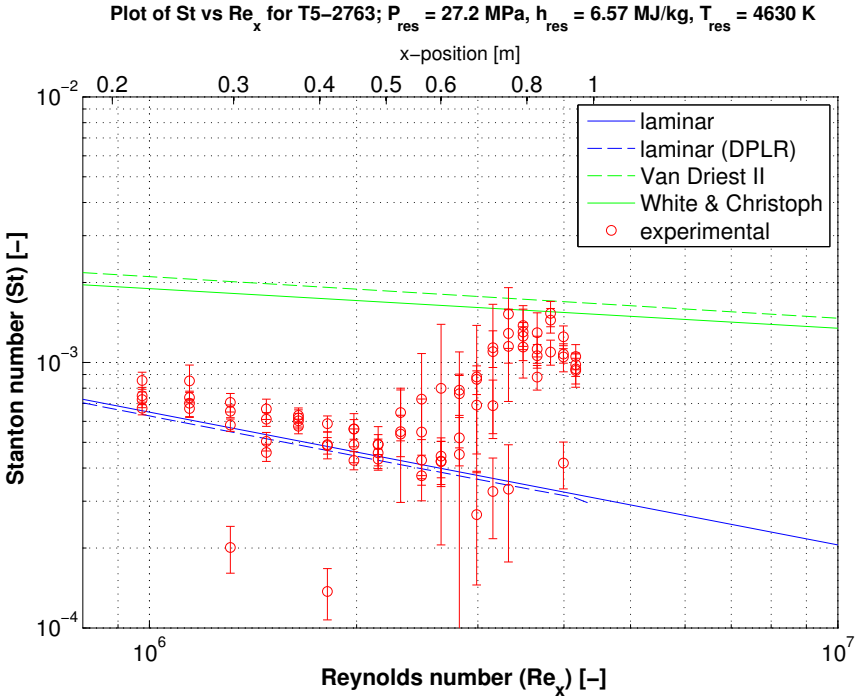


Figure 585: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

196 Shot 2764

Experiment 2764 was performed in T5 on 18 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

196.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2370	m/s
Shock Tube Fill Pressure	P_1	60.10	kPa
Reservoir Pressure	P_{res}	16.5	MPa

Table 1561: Measured quantities, Shot 2764

196.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4008	K
Reservoir Density	ρ_{res}	13.97	kg/m^3
Reservoir Enthalpy	h_{res}	5.28	MJ/kg

Table 1562: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2764

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.21×10^{-1}	1.56×10^{-1}	0	9.80×10^{-2}	0	6.05×10^{-5}	2.49×10^{-2}

Table 1563: Computed reservoir species mass fractions, Shot 2764

196.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3051	678.0	678.0	5.89	6.0	0.030	2.77×10^6
72 cm	3028	658.1	717.0	5.87	5.9	0.031	2.86×10^6

Table 1564: Computed freestream conditions, Shot 2764

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.44×10^{-2}	0	1.83×10^{-10}	4.66×10^{-3}
72 cm	7.33×10^{-1}	1.91×10^{-1}	0	7.36×10^{-2}	0	0	2.34×10^{-3}

Table 1565: Computed freestream species mass fractions, Shot 2764

196.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3022	758.5	758.5	5.52	9.0	0.041	3.46×10^6
72 cm	2974	790.9	776.2	5.26	9.1	0.040	3.20×10^6

Table 1566: Computed boundary layer edge conditions, Shot 2764

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.94×10^{-1}	0	6.44×10^{-2}	0	1.83×10^{-10}	4.66×10^{-3}
72 cm	7.33×10^{-1}	1.91×10^{-1}	0	7.36×10^{-2}	0	0	2.34×10^{-3}

Table 1567: Computed boundary layer edge species mass fractions, Shot 2764

	T^* K	Unit Re^* 1/m
1D 100 cm	1138	1.83×10^6
72 cm	1122	1.85×10^6

Table 1568: Dorrance reference conditions, Shot 2764

196.5 Stability Computations

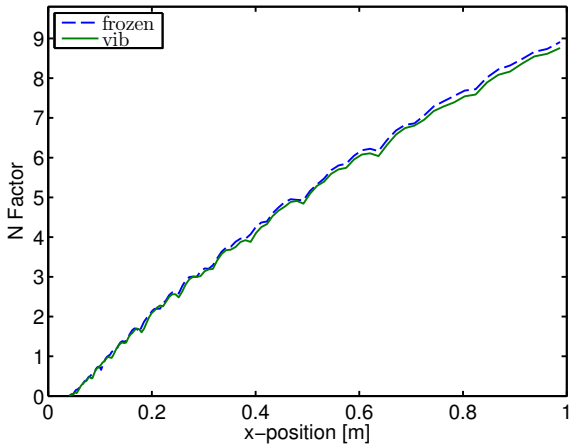


Figure 586: Locus of maximum N factor with and without vibrational energy transfer, Shot 2764

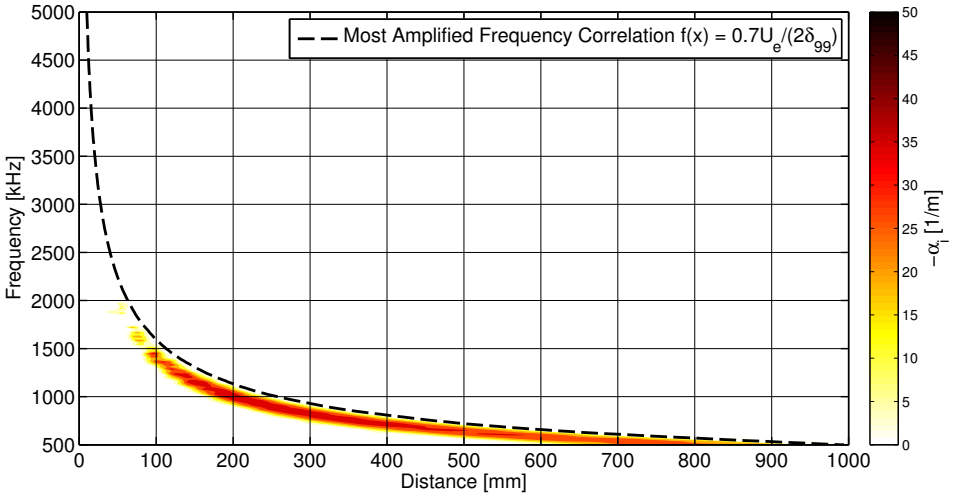


Figure 587: Stability diagram with vibrational energy transfer, Shot 2764. Dashed line indicates $0.7U_e/(2\delta_{99})$.

196.6 Heat Transfer Results

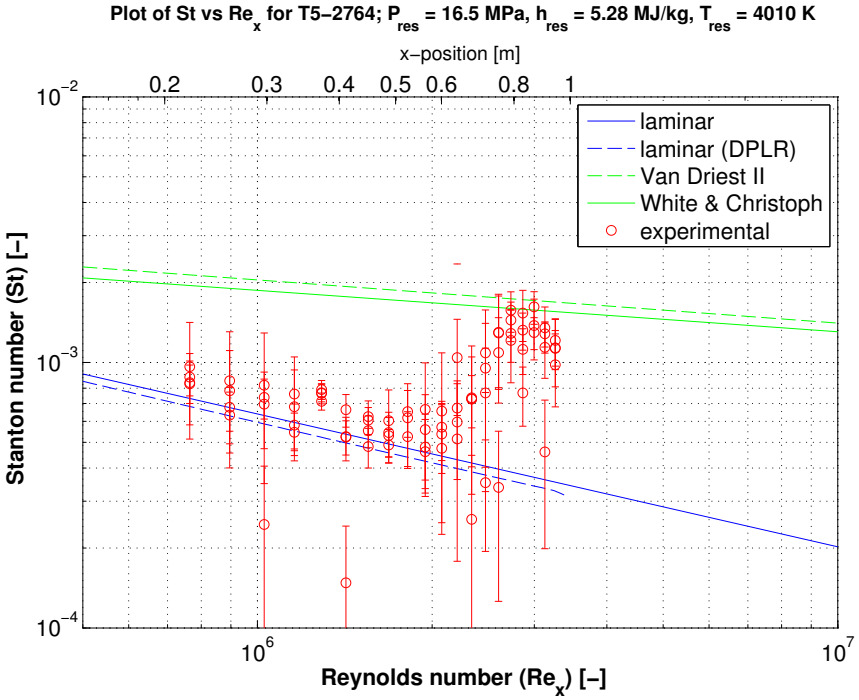


Figure 588: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

197 Shot 2765

Experiment 2765 was performed in T5 on 19 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

197.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2690	m/s
Shock Tube Fill Pressure	P_1	60.00	kPa
Reservoir Pressure	P_{res}	17.5	MPa

Table 1569: Measured quantities, Shot 2765

197.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4532	K
Reservoir Density	ρ_{res}	12.79	kg/m^3
Reservoir Enthalpy	h_{res}	6.48	MJ/kg

Table 1570: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2765

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.13×10^{-1}	1.19×10^{-1}	0	1.16×10^{-1}	0	3.19×10^{-4}	5.22×10^{-2}

Table 1571: Computed reservoir species mass fractions, Shot 2765

197.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3334	867.0	867.0	5.71	6.9	0.027	2.36×10^{6}
72 cm	3305	877.2	888.9	5.54	7.7	0.030	2.54×10^{6}

Table 1572: Computed freestream conditions, Shot 2765

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.88×10^{-1}	0	6.41×10^{-2}	0	0	1.08×10^{-2}
72 cm	7.31×10^{-1}	1.85×10^{-1}	0	7.80×10^{-2}	0	0	5.85×10^{-3}

Table 1573: Computed freestream species mass fractions, Shot 2765

197.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3302	960.8	960.8	5.38	10.3	0.037	2.95×10^{6}
72 cm	3248	1022.5	1008.4	5.04	11.4	0.038	2.92×10^{6}

Table 1574: Computed boundary layer edge conditions, Shot 2765

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.37×10^{-1}	1.88×10^{-1}	0	6.41×10^{-2}	0	0	1.08×10^{-2}
72 cm	7.31×10^{-1}	1.85×10^{-1}	0	7.80×10^{-2}	0	3.13×10^{-10}	5.82×10^{-3}

Table 1575: Computed boundary layer edge species mass fractions, Shot 2765

	T^* K	Unit Re^* 1/m
1D 100 cm	1331	1.76×10^{6}
72 cm	1317	1.95×10^{6}

Table 1576: Dorrance reference conditions, Shot 2765

197.5 Stability Computations

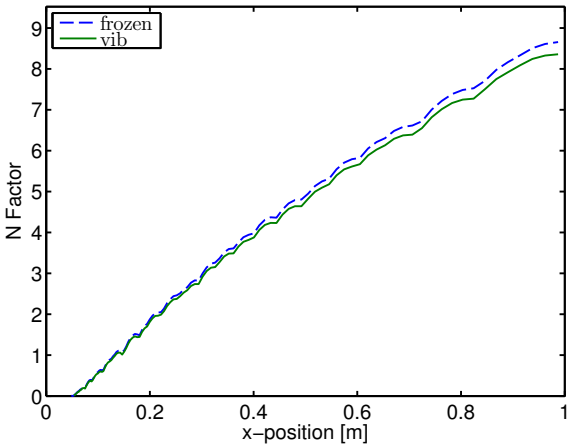


Figure 589: Locus of maximum N factor with and without vibrational energy transfer, Shot 2765

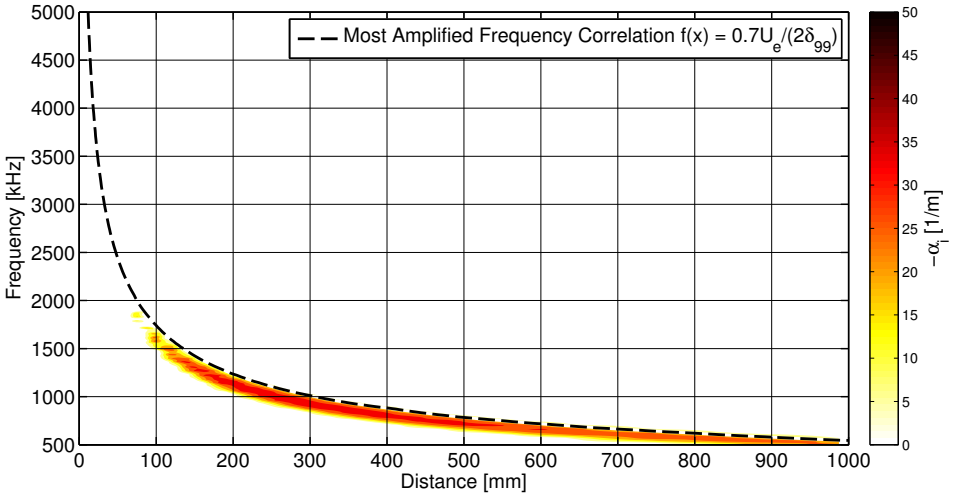


Figure 590: Stability diagram with vibrational energy transfer, Shot 2765. Dashed line indicates $0.7U_e/(2\delta_{99})$.

197.6 Heat Transfer Results

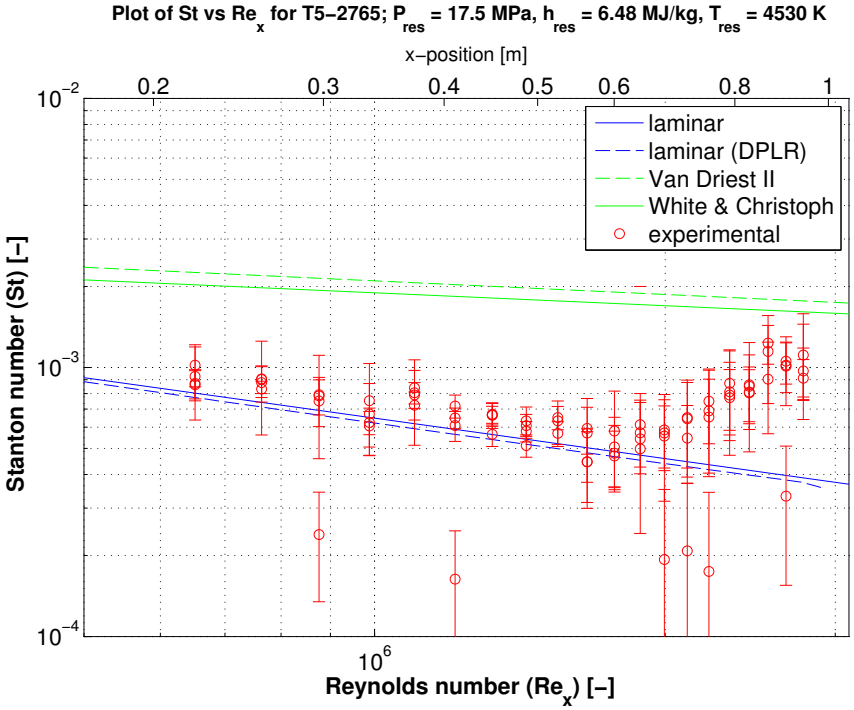


Figure 591: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

198 Shot 2766

Experiment 2766 was performed in T5 on 19 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

198.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2870	m/s
Shock Tube Fill Pressure	P_1	45.10	kPa
Reservoir Pressure	P_{res}	17.0	MPa

Table 1577: Measured quantities, Shot 2766

198.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4949	K
Reservoir Density	ρ_{res}	11.08	kg/m^3
Reservoir Enthalpy	h_{res}	7.55	MJ/kg

Table 1578: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2766

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.10×10^{-1}	8.69×10^{-2}	0	1.21×10^{-1}	0	9.76×10^{-4}	8.17×10^{-2}

Table 1579: Computed reservoir species mass fractions, Shot 2766

198.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3554	1024.0	1024.0	5.60	7.1	0.024	1.98×10^{6}
72 cm	3527	1056.5	1070.3	5.37	8.0	0.026	2.12×10^{6}

Table 1580: Computed freestream conditions, Shot 2766

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.79×10^{-1}	0	6.26×10^{-2}	0	5.16×10^{-10}	2.03×10^{-2}
72 cm	7.31×10^{-1}	1.80×10^{-1}	0	7.76×10^{-2}	0	1.13×10^{-10}	1.19×10^{-2}

Table 1581: Computed freestream species mass fractions, Shot 2766

198.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3520	1127.8	1127.8	5.29	10.4	0.032	2.46×10^{6}
72 cm	3467	1216.3	1204.3	4.92	11.7	0.033	2.43×10^{6}

Table 1582: Computed boundary layer edge conditions, Shot 2766

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.79×10^{-1}	0	6.26×10^{-2}	0	5.16×10^{-10}	2.03×10^{-2}
72 cm	7.31×10^{-1}	1.80×10^{-1}	0	7.76×10^{-2}	0	2.57×10^{-9}	1.18×10^{-2}

Table 1583: Computed boundary layer edge species mass fractions, Shot 2766

	T^* K	Unit Re^* 1/m
1D 100 cm	1489	1.56×10^{6}
72 cm	1481	1.76×10^{6}

Table 1584: Dorrance reference conditions, Shot 2766

198.5 Stability Computations

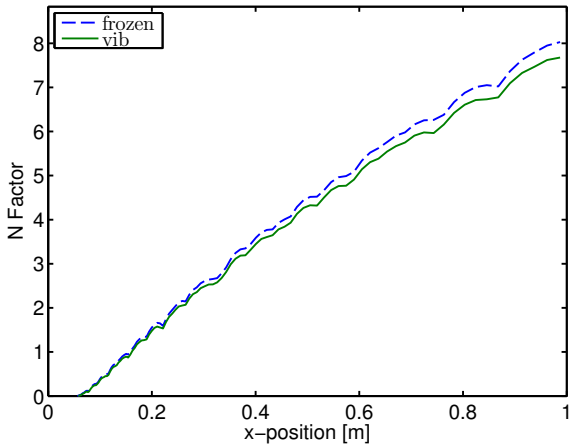


Figure 592: Locus of maximum N factor with and without vibrational energy transfer, Shot 2766

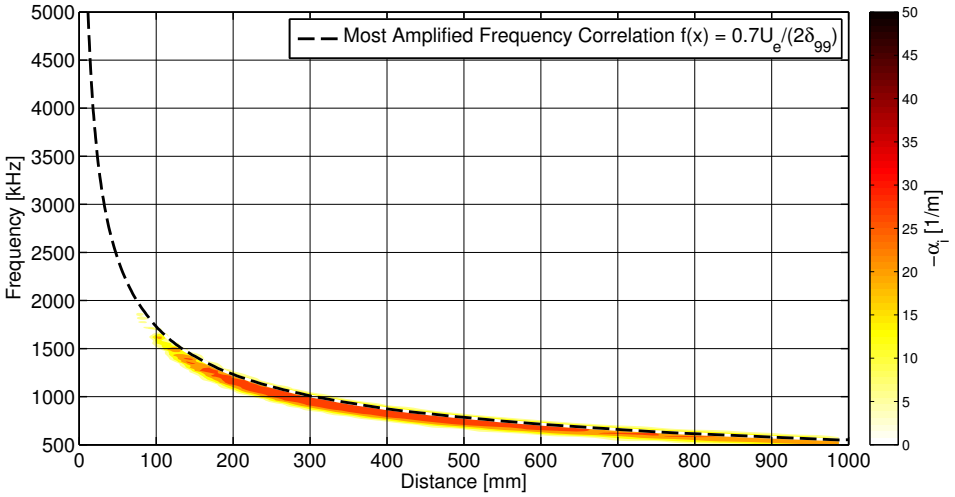


Figure 593: Stability diagram with vibrational energy transfer, Shot 2766. Dashed line indicates $0.7U_e/(2\delta_{99})$.

198.6 Heat Transfer Results

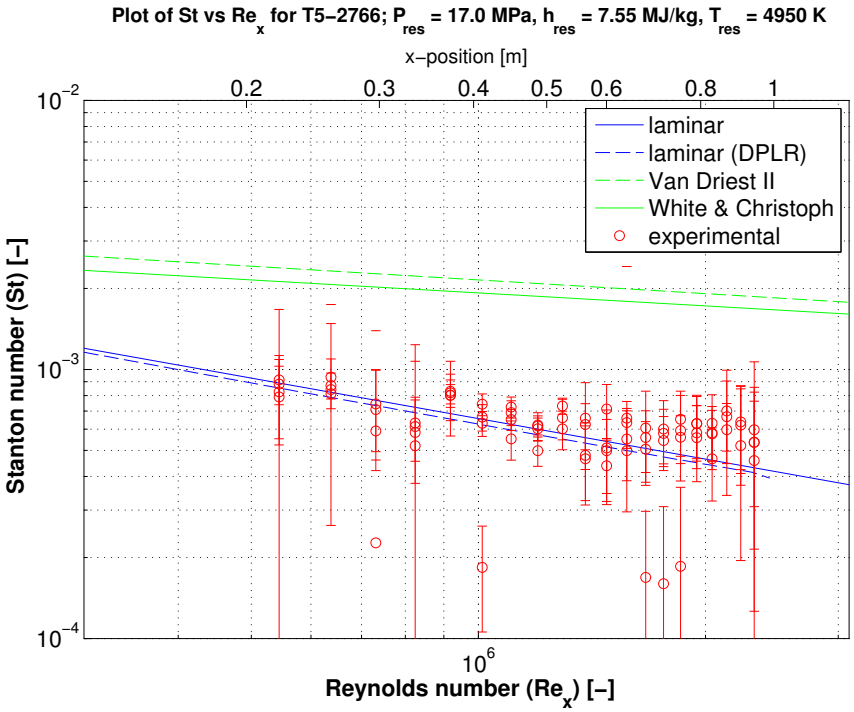


Figure 594: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

199 Shot 2767

Experiment 2767 was performed in T5 on 23 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

199.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	35.00	kPa
Reservoir Pressure	P_{res}	16.6	MPa

Table 1585: Measured quantities, Shot 2767

199.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5513	K
Reservoir Density	ρ_{res}	9.38	kg/m^3
Reservoir Enthalpy	h_{res}	9.02	MJ/kg

Table 1586: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2767

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.10×10^{-1}	5.05×10^{-2}	0	1.14×10^{-1}	0	3.39×10^{-3}	1.22×10^{-1}

Table 1587: Computed reservoir species mass fractions, Shot 2767

199.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3820	1210.0	1210.0	5.51	7.2	0.020	1.64×10^{6}
72 cm	3797	1276.2	1295.2	5.22	8.4	0.022	1.75×10^{6}

Table 1588: Computed freestream conditions, Shot 2767

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.63×10^{-1}	0	5.99×10^{-2}	0	7.31×10^{-10}	3.80×10^{-2}
72 cm	7.33×10^{-1}	1.68×10^{-1}	0	7.28×10^{-2}	0	4.27×10^{-9}	2.57×10^{-2}

Table 1589: Computed freestream species mass fractions, Shot 2767

199.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3783	1327.7	1327.7	5.21	10.5	0.027	2.02×10^{6}
72 cm	3732	1458.0	1447.6	4.80	12.1	0.028	1.99×10^{6}

Table 1590: Computed boundary layer edge conditions, Shot 2767

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.63×10^{-1}	0	5.99×10^{-2}	0	7.31×10^{-10}	3.80×10^{-2}
72 cm	7.33×10^{-1}	1.69×10^{-1}	0	7.28×10^{-2}	0	3.04×10^{-8}	2.54×10^{-2}

Table 1591: Computed boundary layer edge species mass fractions, Shot 2767

	T^* K	Unit Re^* 1/m
1D 100 cm	1686	1.35×10^{6}
72 cm	1692	1.71×10^{6}

Table 1592: Dorrance reference conditions, Shot 2767

199.5 Stability Computations

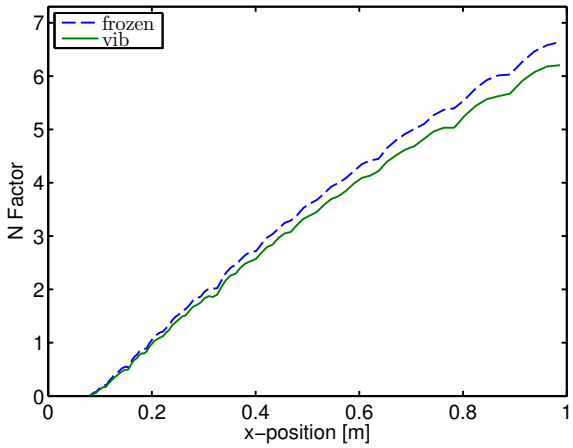


Figure 595: Locus of maximum N factor with and without vibrational energy transfer, Shot 2767

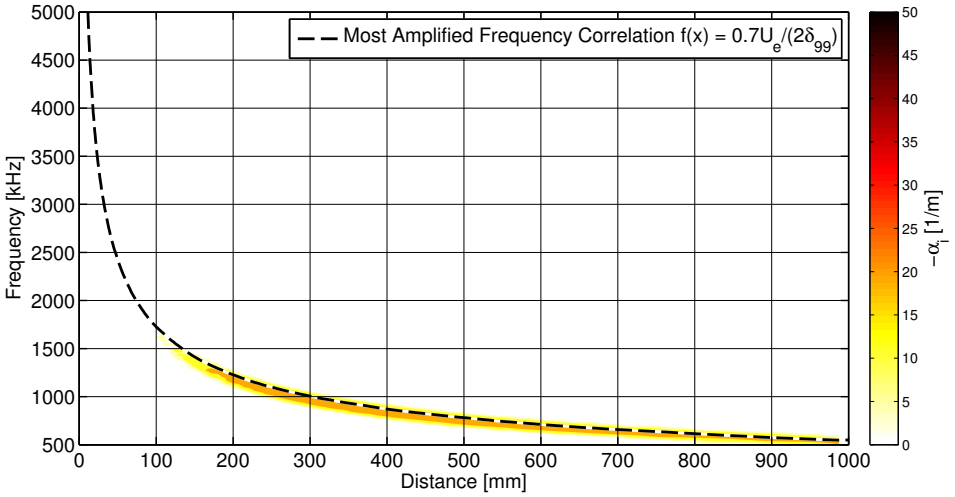


Figure 596: Stability diagram with vibrational energy transfer, Shot 2767. Dashed line indicates $0.7U_e/(2\delta_{99})$.

199.6 Heat Transfer Results

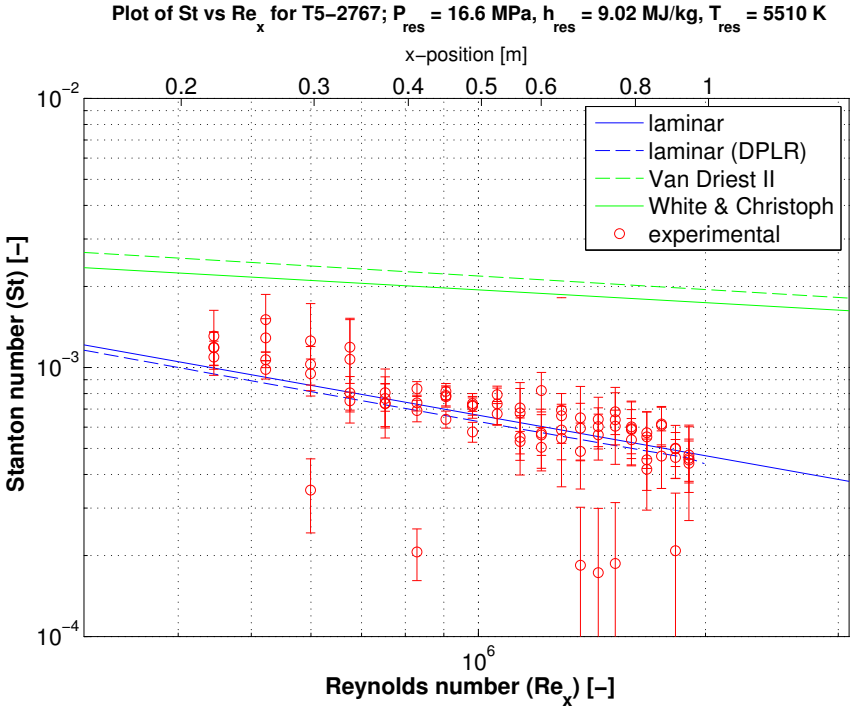


Figure 597: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

200 Shot 2768

Experiment 2768 was performed in T5 on 24 October 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

200.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3130	m/s
Shock Tube Fill Pressure	P_1	45.00	kPa
Reservoir Pressure	P_{res}	25.2	MPa

Table 1593: Measured quantities, Shot 2768

200.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5726	K
Reservoir Density	ρ_{res}	13.73	kg/m^3
Reservoir Enthalpy	h_{res}	9.32	MJ/kg

Table 1594: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2768

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.07×10^{-1}	4.89×10^{-2}	0	1.20×10^{-1}	0	4.10×10^{-3}	1.20×10^{-1}

Table 1595: Computed reservoir species mass fractions, Shot 2768

200.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3898	1305.0	1305.0	5.44	11.4	0.029	2.33×10^{6}
72 cm	3869	1361.1	1376.2	5.16	13.3	0.033	2.54×10^{6}

Table 1596: Computed freestream conditions, Shot 2768

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.70×10^{-1}	0	5.99×10^{-2}	0	1.91×10^{-9}	3.14×10^{-2}
72 cm	7.33×10^{-1}	1.73×10^{-1}	0	7.27×10^{-2}	0	7.56×10^{-9}	2.08×10^{-2}

Table 1597: Computed freestream species mass fractions, Shot 2768

200.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3859	1427.9	1427.9	5.15	16.4	0.039	2.86×10^{6}
72 cm	3804	1546.7	1541.1	4.76	18.9	0.042	2.88×10^{6}

Table 1598: Computed boundary layer edge conditions, Shot 2768

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.70×10^{-1}	0	5.99×10^{-2}	0	1.91×10^{-9}	3.14×10^{-2}
72 cm	7.33×10^{-1}	1.74×10^{-1}	0	7.27×10^{-2}	0	3.85×10^{-8}	2.05×10^{-2}

Table 1599: Computed boundary layer edge species mass fractions, Shot 2768

	T^* K	Unit Re^* 1/m
1D 100 cm	1764	2.00×10^{6}
72 cm	1756	2.54×10^{6}

Table 1600: Dorrance reference conditions, Shot 2768

200.5 Stability Computations

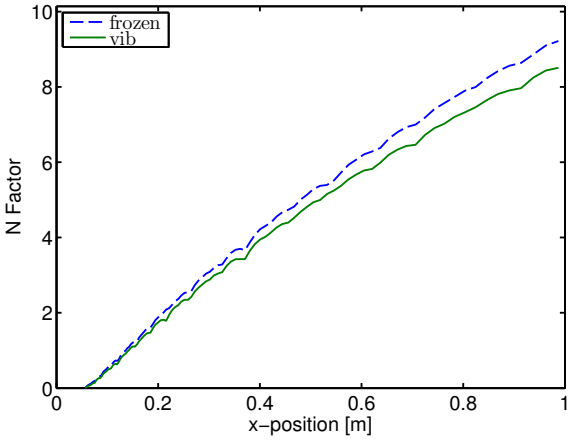


Figure 598: Locus of maximum N factor with and without vibrational energy transfer, Shot 2768

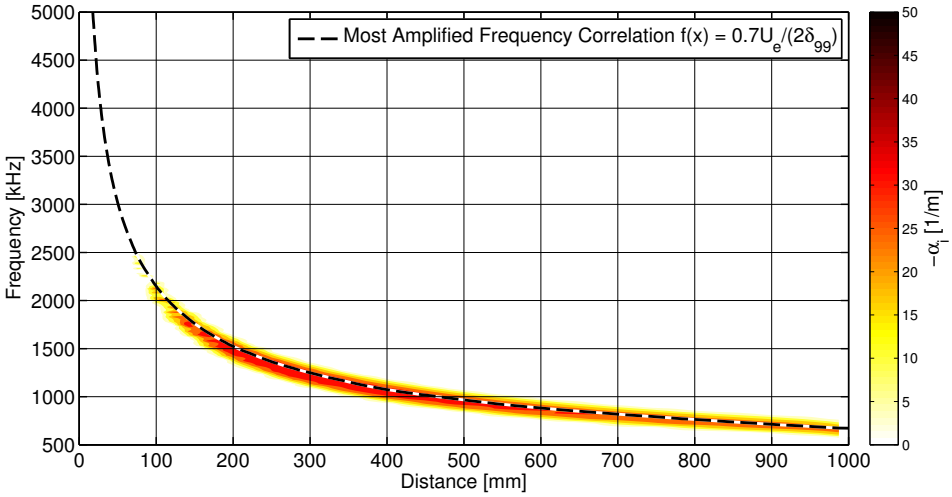


Figure 599: Stability diagram with vibrational energy transfer, Shot 2768. Dashed line indicates $0.7U_e/(2\delta_{99})$.

200.6 Heat Transfer Results

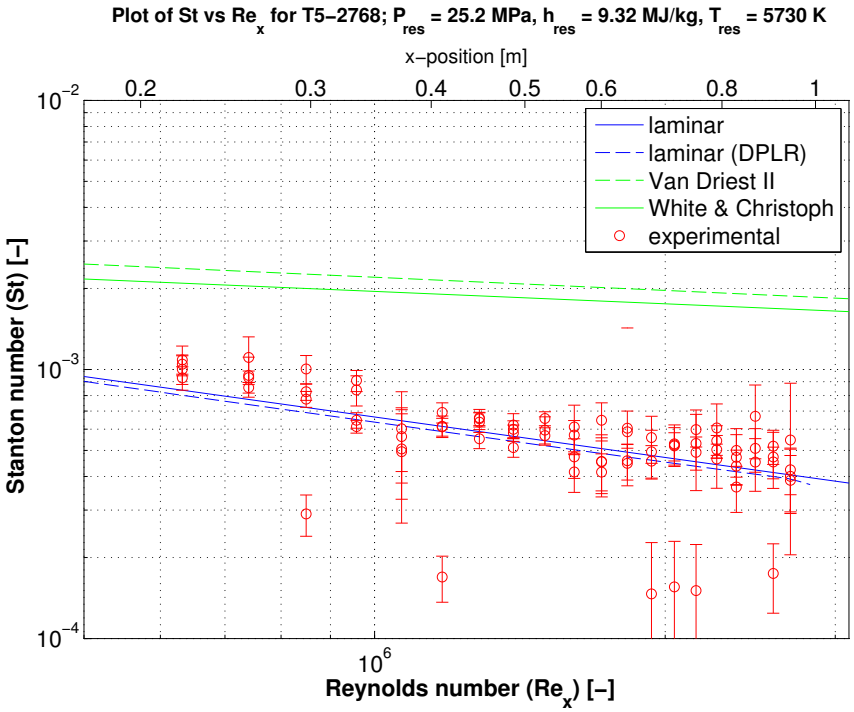


Figure 600: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

201 Shot 2769

Experiment 2769 was performed in T5 on 2 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

201.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3210	m/s
Shock Tube Fill Pressure	P_1	75.00	kPa
Reservoir Pressure	P_{res}	60.8	MPa

Table 1601: Measured quantities, Shot 2769

201.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6397	K
Reservoir Density	ρ_{res}	29.48	kg/m^3
Reservoir Enthalpy	h_{res}	10.5	MJ/kg

Table 1602: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2769

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	3.99×10^{-2}	0	1.31×10^{-1}	0	7.82×10^{-3}	1.23×10^{-1}

Table 1603: Computed reservoir species mass fractions, Shot 2769

201.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4127	1569.0	1569.0	5.30	28.9	0.063	4.63×10^{6}
72 cm	4100	1617.3	1625.9	5.04	34.8	0.074	5.32×10^{6}

Table 1604: Computed freestream conditions, Shot 2769

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.78×10^{-1}	0	5.89×10^{-2}	0	1.73×10^{-8}	2.36×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.30×10^{-2}	0	3.69×10^{-8}	1.47×10^{-2}

Table 1605: Computed freestream species mass fractions, Shot 2769

201.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4086	1705.3	1705.3	5.03	40.9	0.081	5.64×10^{6}
72 cm	4032	1819.6	1817.9	4.67	49.1	0.092	6.04×10^{6}

Table 1606: Computed boundary layer edge conditions, Shot 2769

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.78×10^{-1}	0	5.89×10^{-2}	0	1.73×10^{-8}	2.36×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	1.13×10^{-7}	1.40×10^{-2}

Table 1607: Computed boundary layer edge species mass fractions, Shot 2769

	T^* K	Unit Re^* 1/m
1D 100 cm	1993	4.32×10^{6}
72 cm	1970	5.28×10^{6}

Table 1608: Dorrance reference conditions, Shot 2769

201.5 Stability Computations

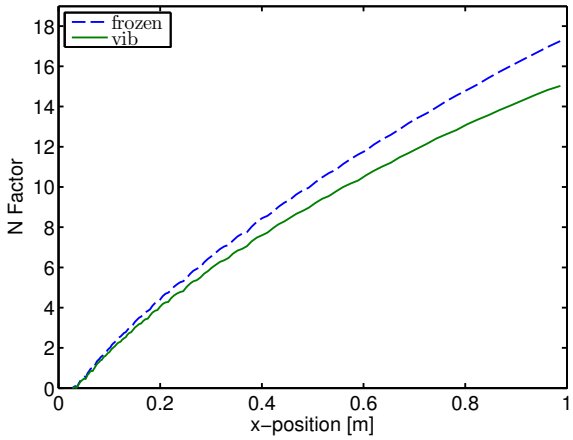


Figure 601: Locus of maximum N factor with and without vibrational energy transfer, Shot 2769

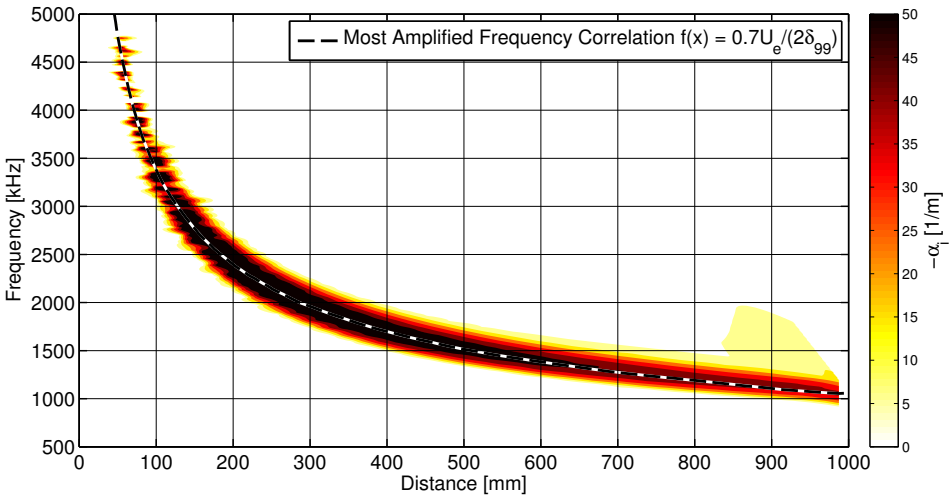


Figure 602: Stability diagram with vibrational energy transfer, Shot 2769. Dashed line indicates $0.7U_e/(2\delta_{99})$.

201.6 Heat Transfer Results

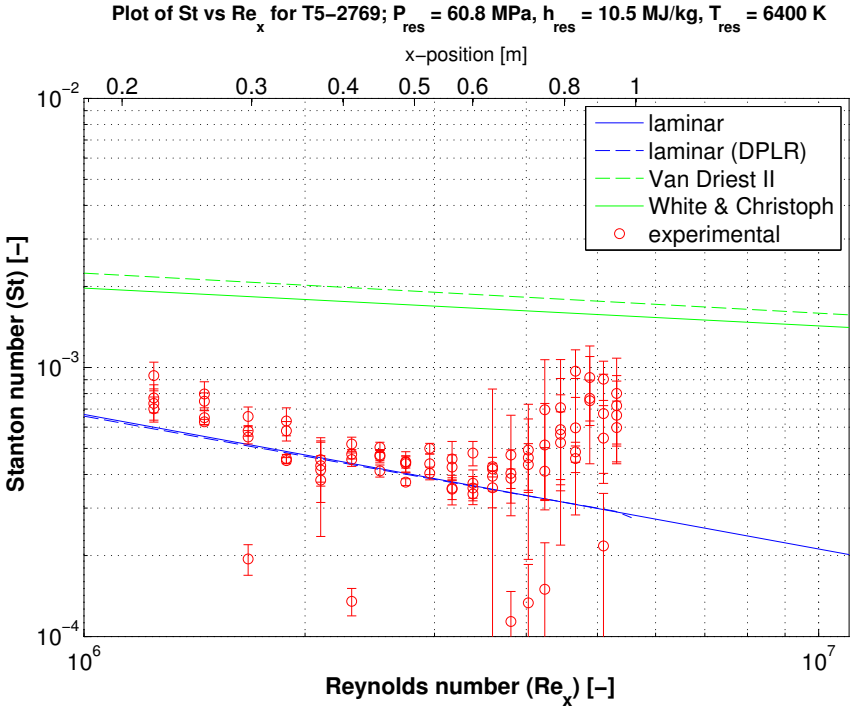


Figure 603: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

202 Shot 2770

Experiment 2770 was performed in T5 on 5 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

202.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3340	m/s
Shock Tube Fill Pressure	P_1	72.95	kPa
Reservoir Pressure	P_{res}	59.5	MPa

Table 1609: Measured quantities, Shot 2770

202.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6650	K
Reservoir Density	ρ_{res}	27.41	kg/m^3
Reservoir Enthalpy	h_{res}	11.1	MJ/kg

Table 1610: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2770

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	3.19×10^{-2}	0	1.24×10^{-1}	0	1.14×10^{-2}	1.35×10^{-1}

Table 1611: Computed reservoir species mass fractions, Shot 2770

202.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4229	1660.0	1660.0	5.27	28.4	0.058	4.22×10^6
72 cm	4202	1723.8	1732.6	4.99	34.8	0.069	4.87×10^6

Table 1612: Computed freestream conditions, Shot 2770

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.72×10^{-1}	0	5.77×10^{-2}	0	4.29×10^{-8}	2.97×10^{-2}
72 cm	7.33×10^{-1}	1.75×10^{-1}	0	7.25×10^{-2}	0	9.47×10^{-8}	1.94×10^{-2}

Table 1613: Computed freestream species mass fractions, Shot 2770

202.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4187	1802.0	1802.0	5.00	40.1	0.075	5.13×10^6
72 cm	4131	1937.6	1935.8	4.63	48.9	0.086	5.51×10^6

Table 1614: Computed boundary layer edge conditions, Shot 2770

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.72×10^{-1}	0	5.77×10^{-2}	0	4.29×10^{-8}	2.97×10^{-2}
72 cm	7.33×10^{-1}	1.76×10^{-1}	0	7.24×10^{-2}	0	2.63×10^{-7}	1.85×10^{-2}

Table 1615: Computed boundary layer edge species mass fractions, Shot 2770

	T^* K	Unit Re^* 1/m
1D 100 cm	2084	4.00×10^6
72 cm	2068	5.17×10^6

Table 1616: Dorrance reference conditions, Shot 2770

202.5 Stability Computations

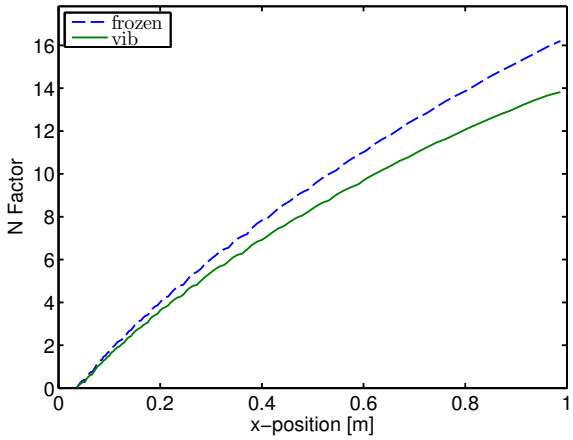


Figure 604: Locus of maximum N factor with and without vibrational energy transfer, Shot 2770

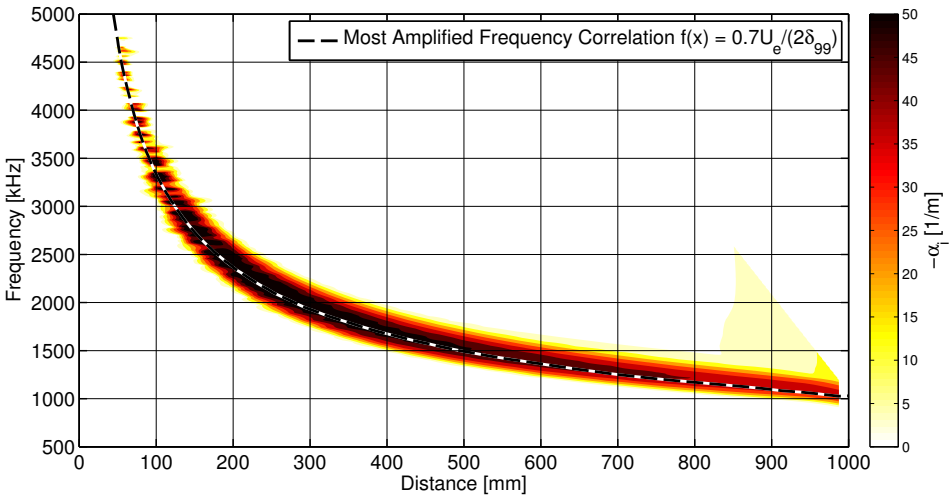


Figure 605: Stability diagram with vibrational energy transfer, Shot 2770. Dashed line indicates $0.7U_e/(2\delta_{99})$.

202.6 Heat Transfer Results

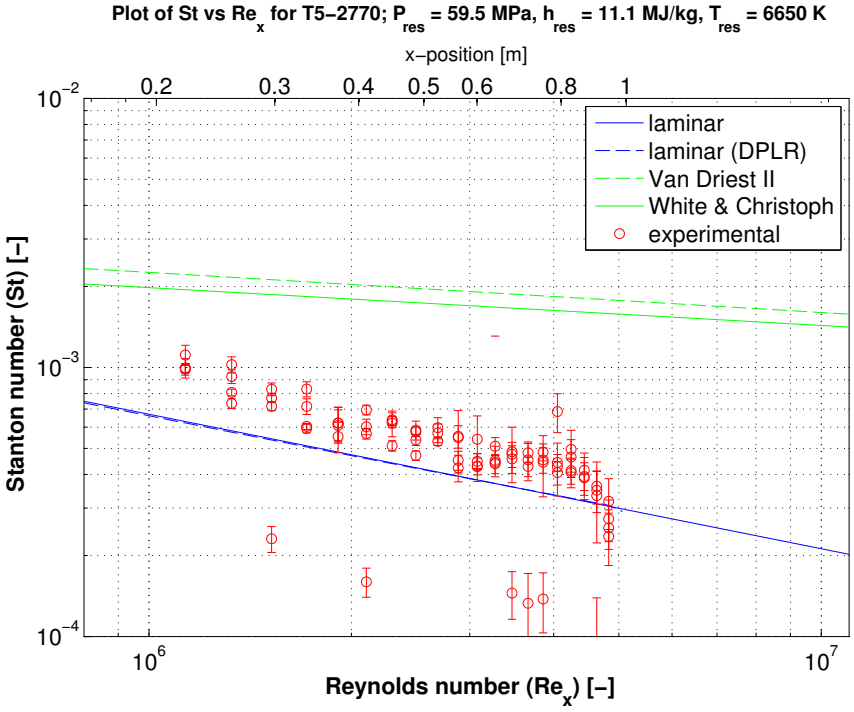


Figure 606: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

203 Shot 2771

Experiment 2771 was performed in T5 on 6 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

203.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3260	m/s
Shock Tube Fill Pressure	P_1	83.00	kPa
Reservoir Pressure	P_{res}	60.6	MPa

Table 1617: Measured quantities, Shot 2771

203.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6415	K
Reservoir Density	ρ_{res}	29.26	kg/m^3
Reservoir Enthalpy	h_{res}	10.5	MJ/kg

Table 1618: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2771

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.98×10^{-1}	3.93×10^{-2}	0	1.30×10^{-1}	0	8.05×10^{-3}	1.24×10^{-1}

Table 1619: Computed reservoir species mass fractions, Shot 2771

203.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4137	1577.0	1577.0	5.29	28.9	0.062	4.60×10^{6}
72 cm	4108	1625.1	1633.8	5.03	34.8	0.073	5.27×10^{6}

Table 1620: Computed freestream conditions, Shot 2771

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.78×10^{-1}	0	5.88×10^{-2}	0	1.85×10^{-8}	2.40×10^{-2}
72 cm	7.33×10^{-1}	1.79×10^{-1}	0	7.30×10^{-2}	0	3.98×10^{-8}	1.50×10^{-2}

Table 1621: Computed freestream species mass fractions, Shot 2771

203.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4095	1714.1	1714.1	5.03	40.9	0.081	5.60×10^{6}
72 cm	4039	1828.6	1826.8	4.66	49.0	0.092	5.98×10^{6}

Table 1622: Computed boundary layer edge conditions, Shot 2771

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.78×10^{-1}	0	5.88×10^{-2}	0	1.85×10^{-8}	2.40×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	1.21×10^{-7}	1.44×10^{-2}

Table 1623: Computed boundary layer edge species mass fractions, Shot 2771

	T^* K	Unit Re^* 1/m
1D 100 cm	2001	4.30×10^{6}
72 cm	1977	5.53×10^{6}

Table 1624: Dorrance reference conditions, Shot 2771

203.5 Stability Computations

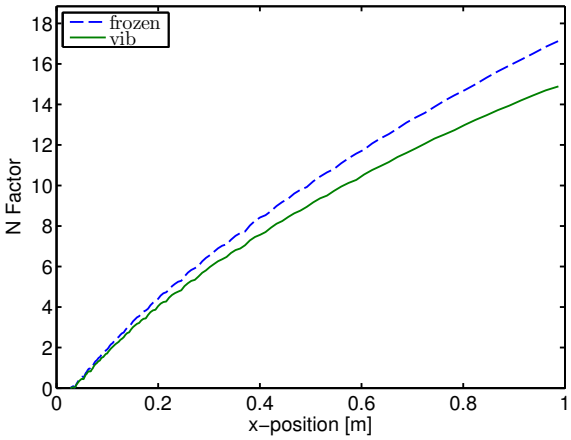


Figure 607: Locus of maximum N factor with and without vibrational energy transfer, Shot 2771

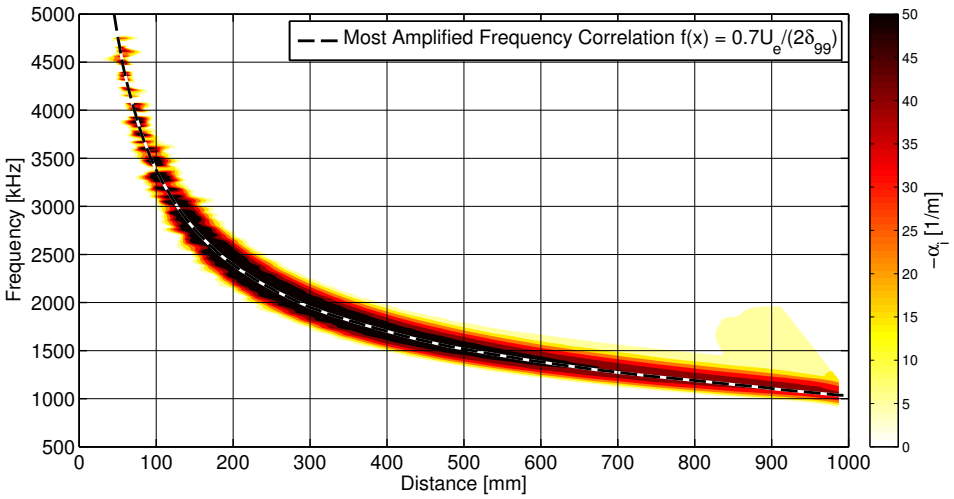


Figure 608: Stability diagram with vibrational energy transfer, Shot 2771. Dashed line indicates $0.7U_e/(2\delta_{99})$.

203.6 Heat Transfer Results

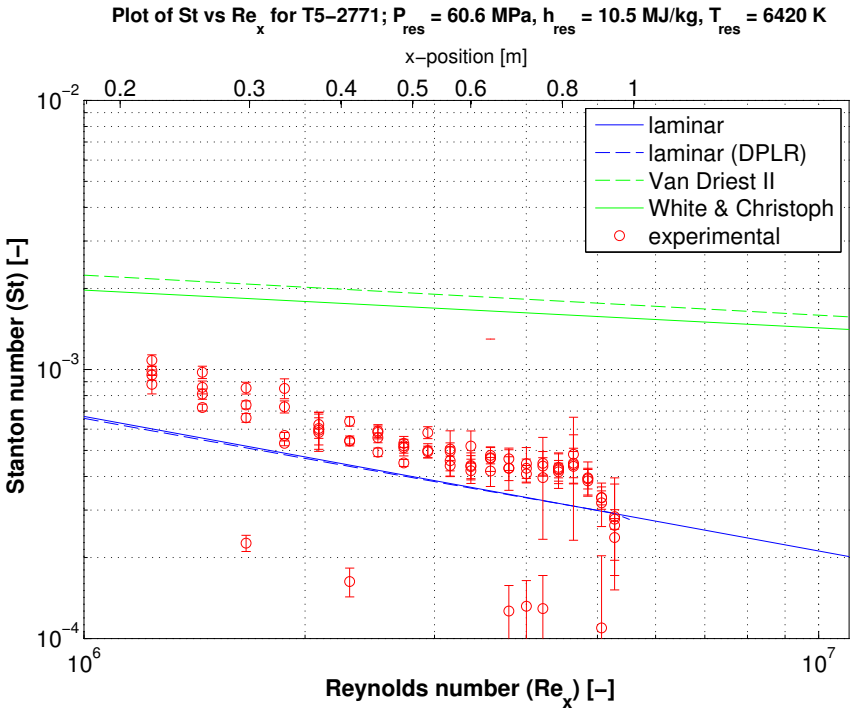


Figure 609: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

204 Shot 2772

Experiment 2772 was performed in T5 on 8 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

204.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	44.95	kPa
Reservoir Pressure	P_{res}	16.7	MPa

Table 1625: Measured quantities, Shot 2772

204.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6163	K
Reservoir Density	ρ_{res}	9.05	kg/m^3
Reservoir Enthalpy	h_{res}	8.00	MJ/kg

Table 1626: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2772

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.88×10^{-1}	0	0	0	0	1.20×10^{-2}	0

Table 1627: Computed reservoir species mass fractions, Shot 2772

204.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3774	1054.0	1054.0	5.83	6.2	0.020	1.83×10^6
72 cm	3728	683.8	3037.2	6.99	3.2	0.015	1.82×10^6

Table 1628: Computed freestream conditions, Shot 2772

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.97×10^{-1}	0	0	0	0	2.52×10^{-3}	0
72 cm	9.98×10^{-1}	0	0	0	0	1.88×10^{-3}	0

Table 1629: Computed freestream species mass fractions, Shot 2772

204.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3738	1166.4	1166.4	5.49	9.3	0.027	2.30×10^6
72 cm	3668	872.0	3012.8	6.09	5.4	0.021	2.08×10^6

Table 1630: Computed boundary layer edge conditions, Shot 2772

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.97×10^{-1}	0	0	0	0	2.52×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1631: Computed boundary layer edge species mass fractions, Shot 2772

	T^* K	Unit Re^* 1/m
1D 100 cm	1593	1.35×10^6
72 cm	1377	0.99×10^6

Table 1632: Dorrance reference conditions, Shot 2772

204.5 Stability Computations

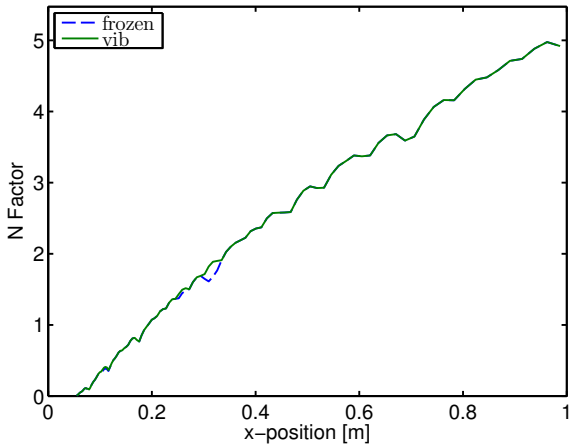


Figure 610: Locus of maximum N factor with and without vibrational energy transfer, Shot 2772

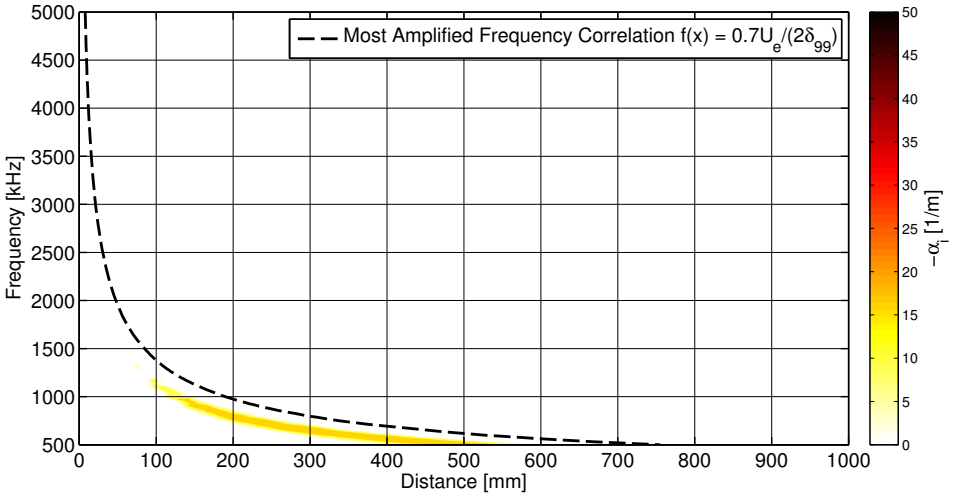


Figure 611: Stability diagram with vibrational energy transfer, Shot 2772. Dashed line indicates $0.7U_e/(2\delta_{99})$.

204.6 Heat Transfer Results

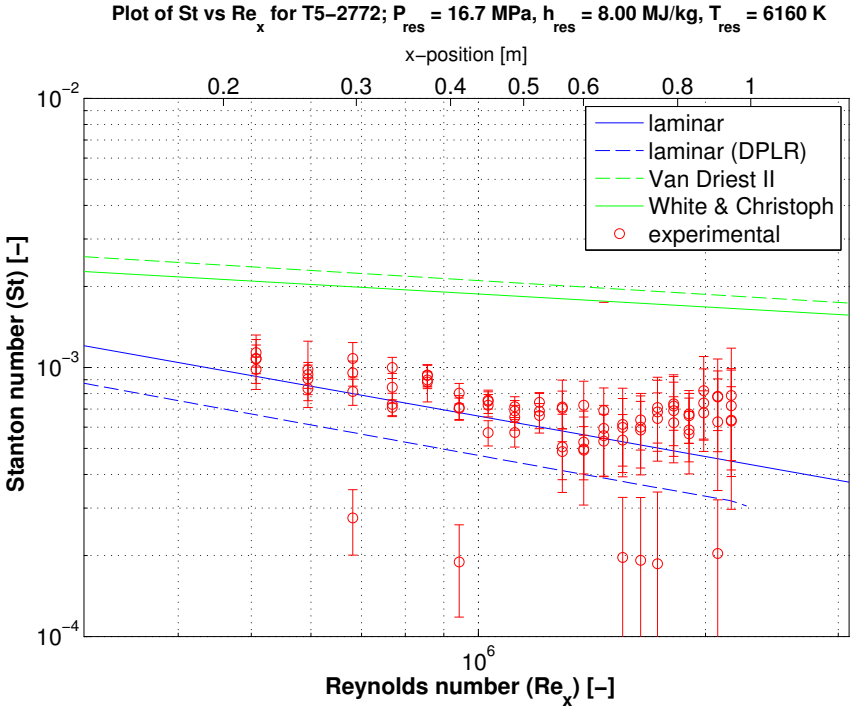


Figure 612: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

205 Shot 2773

Experiment 2773 was performed in T5 on 8 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

205.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3140	m/s
Shock Tube Fill Pressure	P_1	40.00	kPa
Reservoir Pressure	P_{res}	16.7	MPa

Table 1633: Measured quantities, Shot 2773

205.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6601	K
Reservoir Density	ρ_{res}	8.34	kg/m^3
Reservoir Enthalpy	h_{res}	8.99	MJ/kg

Table 1634: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2773

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.77×10^{-1}	0	0	0	0	2.29×10^{-2}	0

Table 1635: Computed reservoir species mass fractions, Shot 2773

205.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3974	1197.0	1197.0	5.77	6.5	0.018	1.63×10^6
72 cm	3923	803.4	3162.5	6.78	3.6	0.015	1.68×10^6

Table 1636: Computed freestream conditions, Shot 2773

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.95×10^{-1}	0	0	0	0	4.69×10^{-3}	0
72 cm	9.96×10^{-1}	0	0	0	0	3.66×10^{-3}	0

Table 1637: Computed freestream species mass fractions, Shot 2773

205.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3936	1320.4	1320.4	5.44	9.6	0.024	2.02×10^6
72 cm	3859	1014.4	3135.9	5.93	6.0	0.020	1.92×10^6

Table 1638: Computed boundary layer edge conditions, Shot 2773

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.95×10^{-1}	0	0	0	0	4.69×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1639: Computed boundary layer edge species mass fractions, Shot 2773

	T^* K	Unit Re^* 1/m
1D 100 cm	1745	1.25×10^6
72 cm	1510	0.99×10^6

Table 1640: Dorrance reference conditions, Shot 2773

205.5 Stability Computations

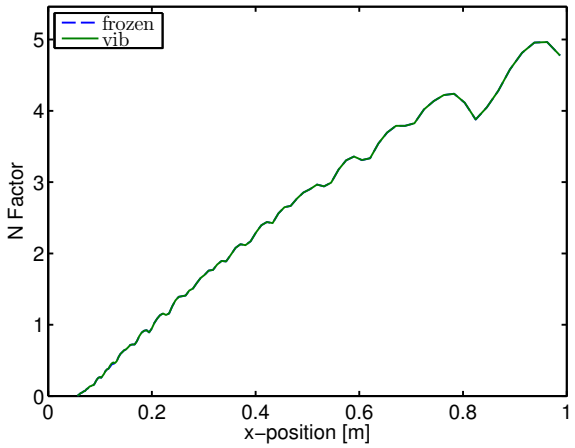


Figure 613: Locus of maximum N factor with and without vibrational energy transfer, Shot 2773

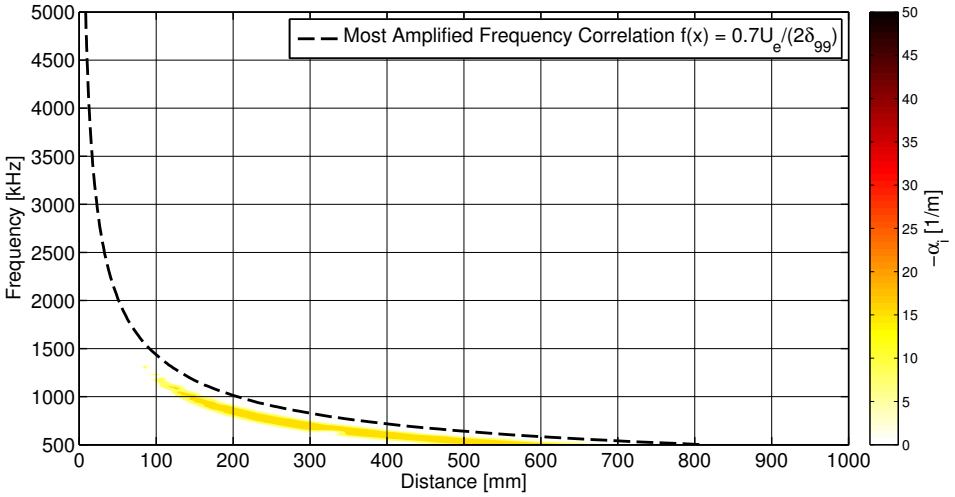


Figure 614: Stability diagram with vibrational energy transfer, Shot 2773. Dashed line indicates $0.7U_e/(2\delta_{99})$.

205.6 Heat Transfer Results

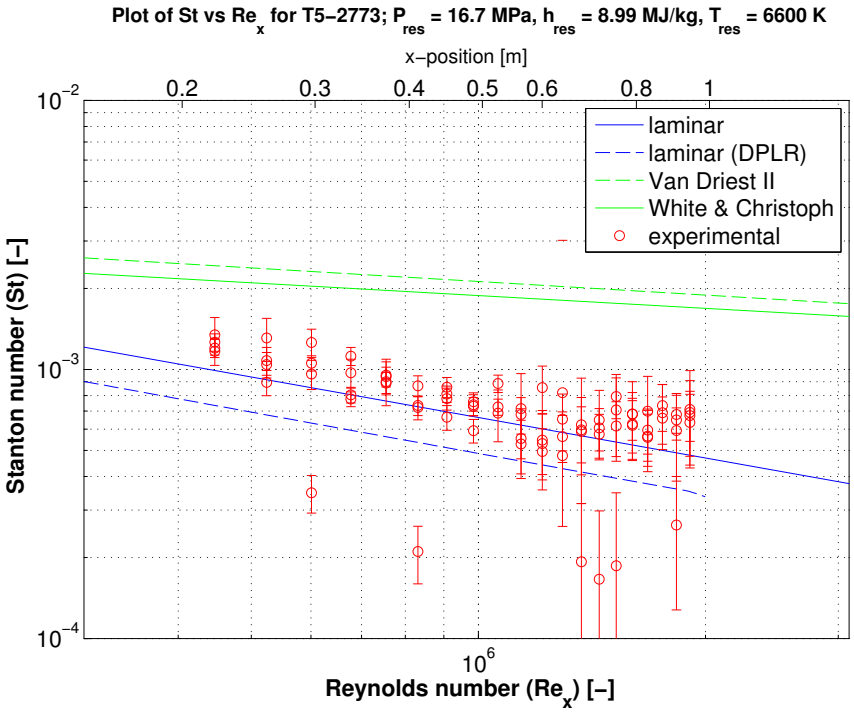


Figure 615: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

206 Shot 2774

Experiment 2774 was performed in T5 on 12 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

206.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3340	m/s
Shock Tube Fill Pressure	P_1	35.00	kPa
Reservoir Pressure	P_{res}	16.7	MPa

Table 1641: Measured quantities, Shot 2774

206.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7009	K
Reservoir Density	ρ_{res}	7.75	kg/m^3
Reservoir Enthalpy	h_{res}	10.1	MJ/kg

Table 1642: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2774

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.61×10^{-1}	0	0	0	0	3.88×10^{-2}	0

Table 1643: Computed reservoir species mass fractions, Shot 2774

206.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4181	1360.0	1360.0	5.70	6.8	0.017	1.44×10^6
72 cm	4119	963.4	3331.1	6.48	4.4	0.015	1.63×10^6

Table 1644: Computed freestream conditions, Shot 2774

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.92×10^{-1}	0	0	3.34×10^{-10}	0	8.26×10^{-3}	1.78×10^{-10}
72 cm	9.93×10^{-1}	0	0	0	0	6.72×10^{-3}	0

Table 1645: Computed freestream species mass fractions, Shot 2774

206.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4141	1494.2	1494.2	5.39	10.0	0.022	1.78×10^6
72 cm	4052	1194.8	3302.7	5.73	7.2	0.020	1.84×10^6

Table 1646: Computed boundary layer edge conditions, Shot 2774

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.92×10^{-1}	0	0	3.34×10^{-10}	0	8.26×10^{-3}	1.78×10^{-10}
72 cm	1.00	0	0	0	0	0	0

Table 1647: Computed boundary layer edge species mass fractions, Shot 2774

	T^* K	Unit Re^* 1/m
1D 100 cm	1914	1.16×10^6
72 cm	1666	1.32×10^6

Table 1648: Dorrance reference conditions, Shot 2774

206.5 Stability Computations

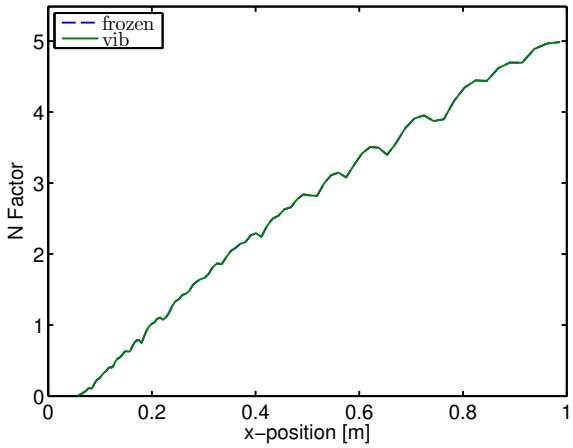


Figure 616: Locus of maximum N factor with and without vibrational energy transfer, Shot 2774

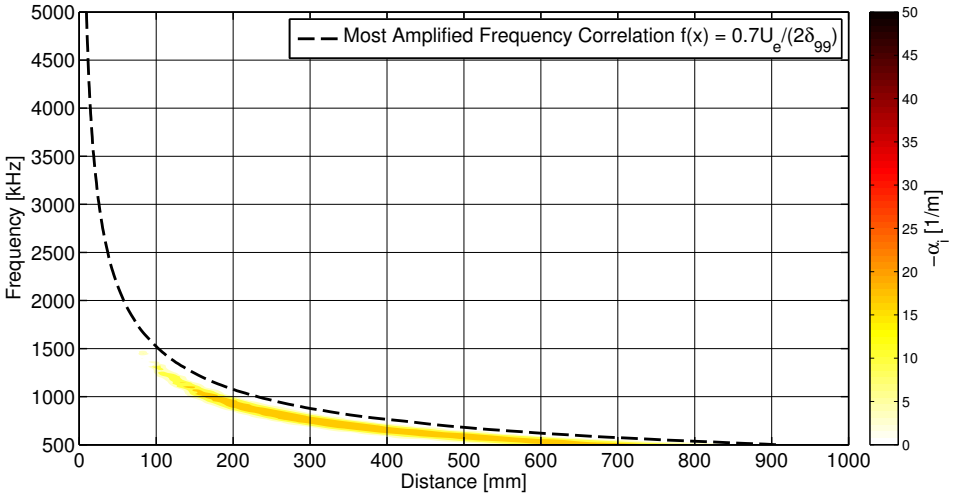


Figure 617: Stability diagram with vibrational energy transfer, Shot 2774. Dashed line indicates $0.7U_e/(2\delta_{99})$.

206.6 Heat Transfer Results

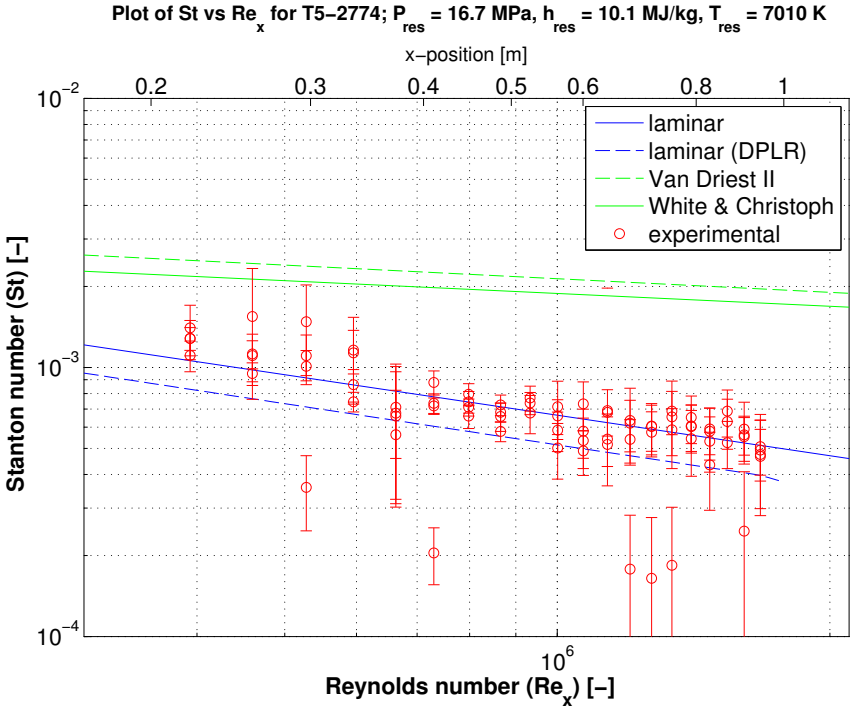


Figure 618: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

207 Shot 2775

Experiment 2775 was performed in T5 on 13 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

207.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2820	m/s
Shock Tube Fill Pressure	P_1	52.00	kPa
Reservoir Pressure	P_{res}	17.4	MPa

Table 1649: Measured quantities, Shot 2775

207.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5778	K
Reservoir Density	ρ_{res}	10.08	kg/m^3
Reservoir Enthalpy	h_{res}	7.26	MJ/kg

Table 1650: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2775

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.94×10^{-1}	0	0	0	0	6.19×10^{-3}	0

Table 1651: Computed reservoir species mass fractions, Shot 2775

207.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3613	948.0	948.0	5.87	6.2	0.022	2.08×10^6
72 cm	3569	603.9	2947.8	7.13	3.0	0.017	2.05×10^6

Table 1652: Computed freestream conditions, Shot 2775

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.99×10^{-1}	0	0	0	0	1.34×10^{-3}	0
72 cm	1.00	0	0	0	0	9.87×10^{-4}	0

Table 1653: Computed freestream species mass fractions, Shot 2775

207.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3579	1052.7	1052.7	5.52	9.4	0.030	2.63×10^6
72 cm	3511	779.5	2923.2	6.17	5.2	0.023	2.30×10^6

Table 1654: Computed boundary layer edge conditions, Shot 2775

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.99×10^{-1}	0	0	0	0	1.34×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1655: Computed boundary layer edge species mass fractions, Shot 2775

	T^* K	Unit Re^* 1/m
1D 100 cm	1478	1.49×10^6
72 cm	1281	1.04×10^6

Table 1656: Dorrance reference conditions, Shot 2775

207.5 Stability Computations

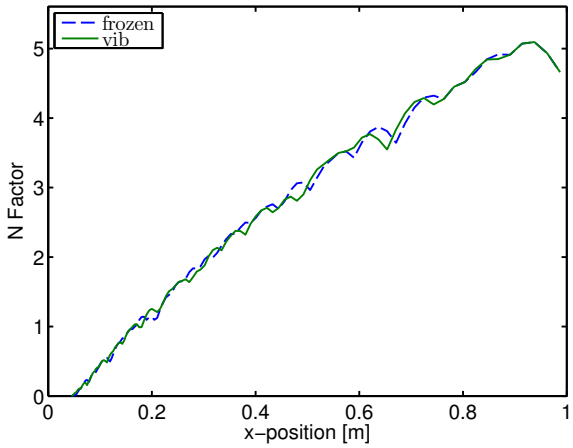


Figure 619: Locus of maximum N factor with and without vibrational energy transfer, Shot 2775

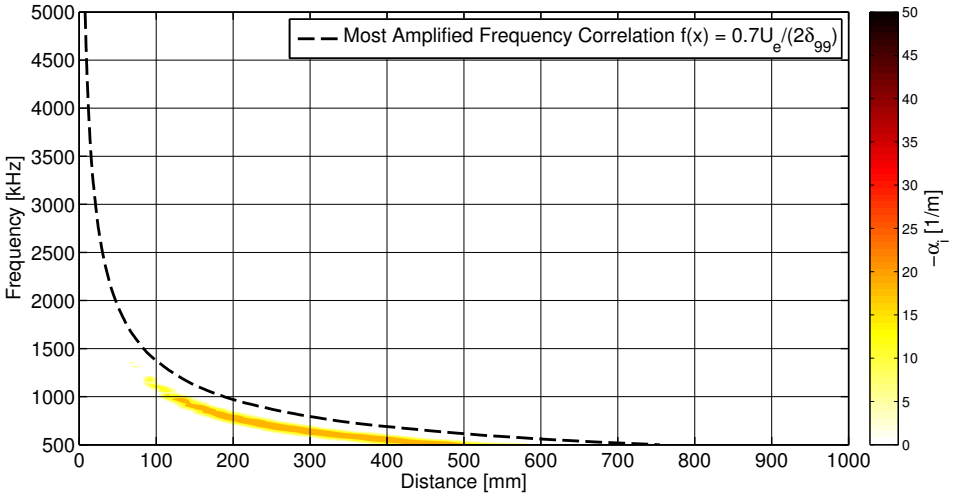


Figure 620: Stability diagram with vibrational energy transfer, Shot 2775. Dashed line indicates $0.7U_e/(2\delta_{99})$.

207.6 Heat Transfer Results

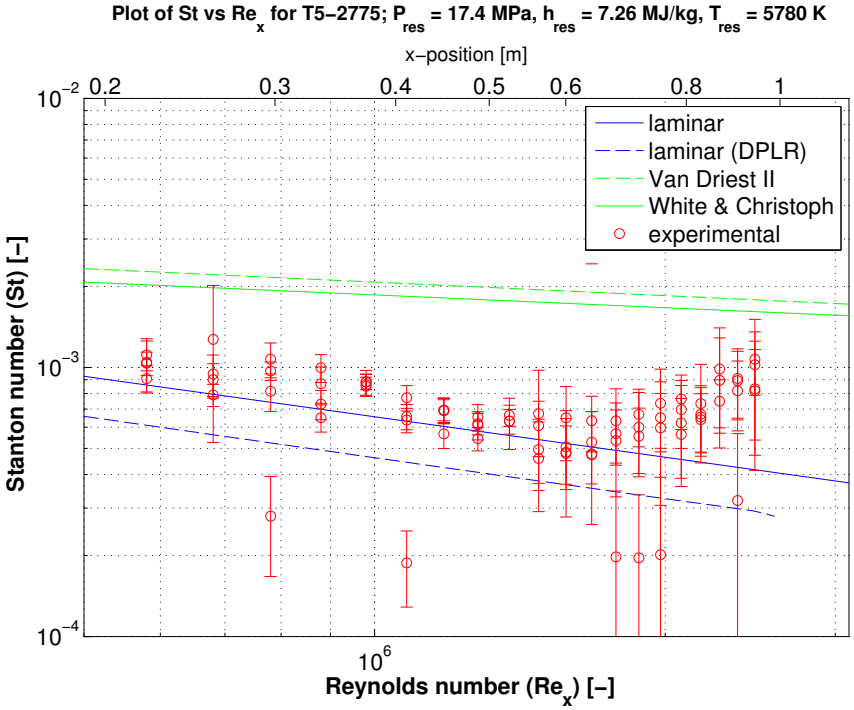


Figure 621: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

208 Shot 2776

Experiment 2776 was performed in T5 on 14 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

208.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2770	m/s
Shock Tube Fill Pressure	P_1	130.00	kPa
Reservoir Pressure	P_{res}	45.9	MPa

Table 1657: Measured quantities, Shot 2776

208.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5769	K
Reservoir Density	ρ_{res}	26.69	kg/m^3
Reservoir Enthalpy	h_{res}	7.17	MJ/kg

Table 1658: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2776

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.96×10^{-1}	0	0	0	0	3.75×10^{-3}	0

Table 1659: Computed reservoir species mass fractions, Shot 2776

208.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3595	938.0	938.0	5.87	16.3	0.059	5.53×10^6
72 cm	3581	619.1	2583.1	7.07	8.3	0.045	5.41×10^6

Table 1660: Computed freestream conditions, Shot 2776

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	3.60×10^{-4}	0
72 cm	1.00	0	0	0	0	2.40×10^{-4}	0

Table 1661: Computed freestream species mass fractions, Shot 2776

208.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3561	1042.2	1042.2	5.52	24.6	0.079	6.97×10^6
72 cm	3524	792.4	2563.6	6.14	14.2	0.060	6.13×10^6

Table 1662: Computed boundary layer edge conditions, Shot 2776

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	1.00	0	0	0	0	3.60×10^{-4}	0
72 cm	1.00	0	0	0	0	0	0

Table 1663: Computed boundary layer edge species mass fractions, Shot 2776

	T^* K	Unit Re^* 1/m
1D 100 cm	1466	3.94×10^6
72 cm	1295	2.79×10^6

Table 1664: Dorrance reference conditions, Shot 2776

208.5 Stability Computations

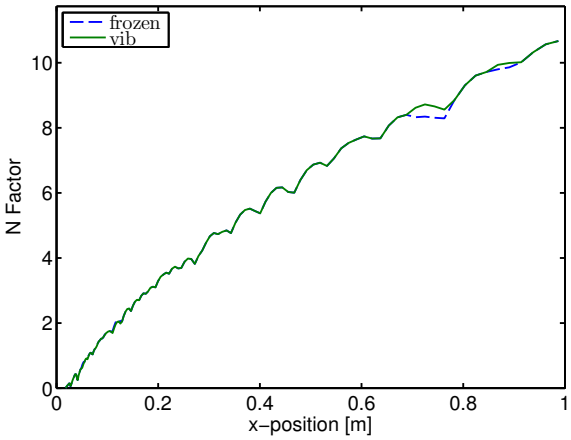


Figure 622: Locus of maximum N factor with and without vibrational energy transfer, Shot 2776

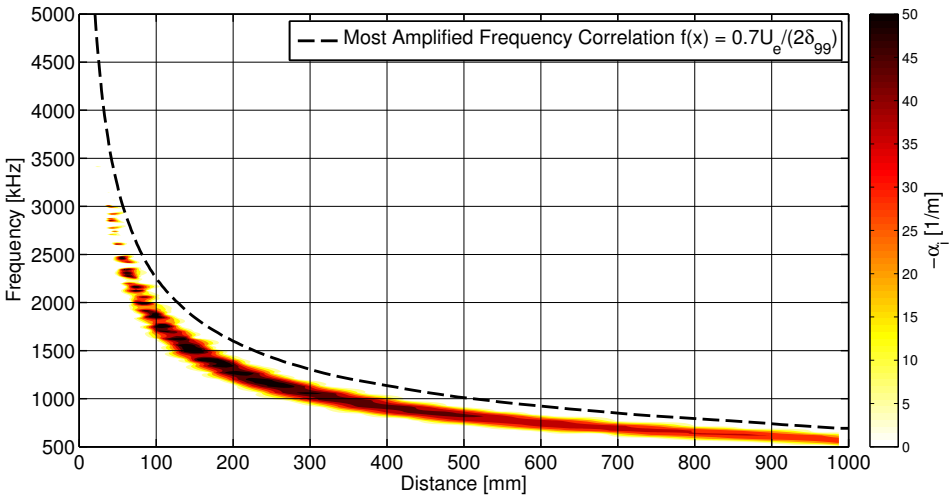


Figure 623: Stability diagram with vibrational energy transfer, Shot 2776. Dashed line indicates $0.7U_e/(2\delta_{99})$.

208.6 Heat Transfer Results

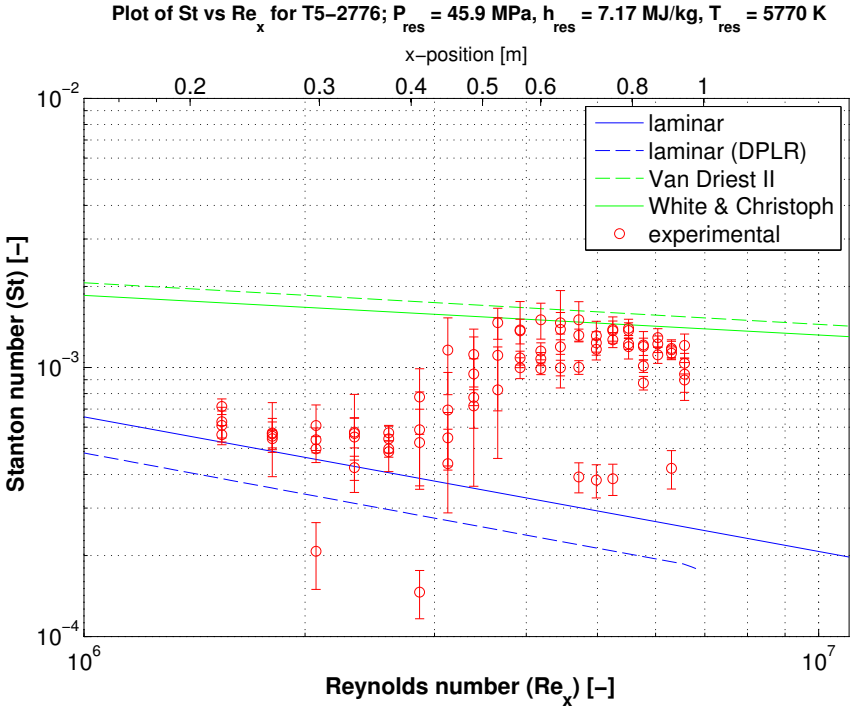


Figure 624: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

209 Shot 2777

Experiment 2777 was performed in T5 on 15 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

209.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3080	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	38.9	MPa

Table 1665: Measured quantities, Shot 2777

209.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6691	K
Reservoir Density	ρ_{res}	19.26	kg/m^3
Reservoir Enthalpy	h_{res}	8.91	MJ/kg

Table 1666: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2777

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.83×10^{-1}	0	0	0	0	1.69×10^{-2}	0

Table 1667: Computed reservoir species mass fractions, Shot 2777

209.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3974	1203.0	1203.0	5.77	14.9	0.042	3.75×10^6
72 cm	3940	824.7	2897.6	6.73	8.6	0.035	3.89×10^6

Table 1668: Computed freestream conditions, Shot 2777

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.53×10^{-3}	0
72 cm	9.99×10^{-1}	0	0	0	0	1.15×10^{-3}	0

Table 1669: Computed freestream species mass fractions, Shot 2777

209.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3936	1325.7	1325.7	5.44	22.2	0.056	4.67×10^6
72 cm	3876	1038.4	2873.1	5.90	14.3	0.046	4.44×10^6

Table 1670: Computed boundary layer edge conditions, Shot 2777

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.98×10^{-1}	0	0	0	0	1.53×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1671: Computed boundary layer edge species mass fractions, Shot 2777

	T^* K	Unit Re^* 1/m
1D 100 cm	1748	2.89×10^6
72 cm	1529	2.32×10^6

Table 1672: Dorrance reference conditions, Shot 2777

209.5 Stability Computations

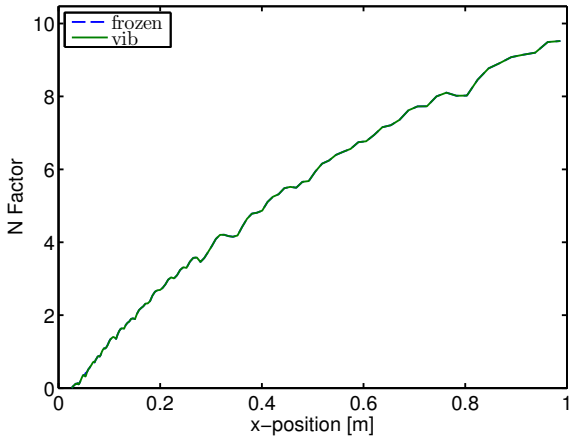


Figure 625: Locus of maximum N factor with and without vibrational energy transfer, Shot 2777

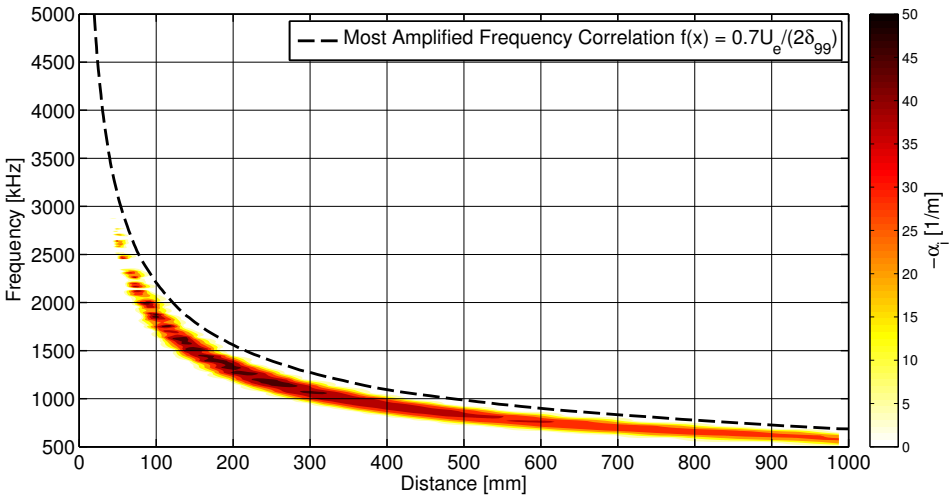


Figure 626: Stability diagram with vibrational energy transfer, Shot 2777. Dashed line indicates $0.7U_e/(2\delta_{99})$.

209.6 Heat Transfer Results

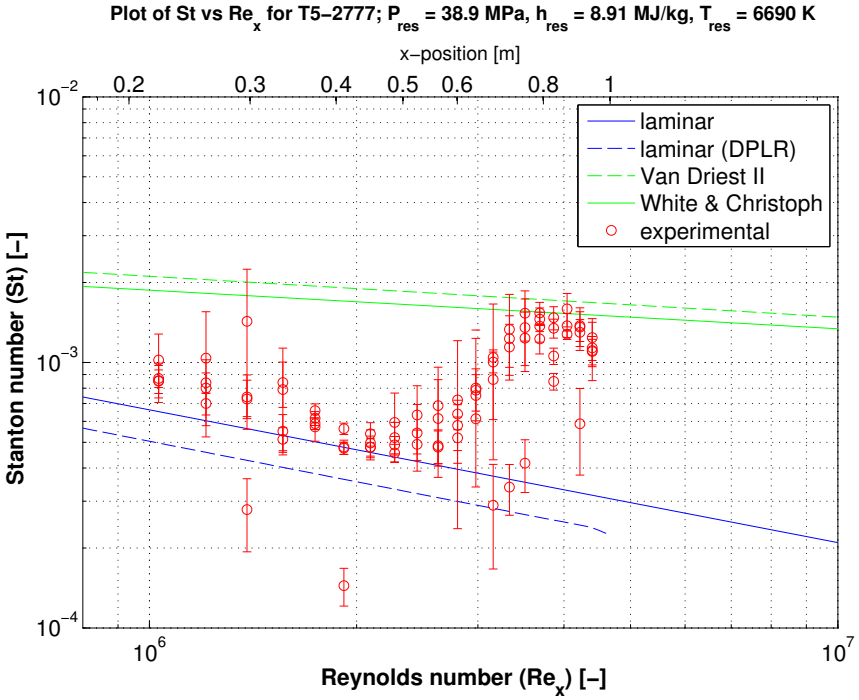


Figure 627: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

210 Shot 2778

Experiment 2778 was performed in T5 on 16 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

210.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3370	m/s
Shock Tube Fill Pressure	P_1	72.00	kPa
Reservoir Pressure	P_{res}	41.4	MPa

Table 1673: Measured quantities, Shot 2778

210.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7411	K
Reservoir Density	ρ_{res}	18.11	kg/m^3
Reservoir Enthalpy	h_{res}	10.7	MJ/kg

Table 1674: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2778

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.61×10^{-1}	0	0	0	0	3.94×10^{-2}	0

Table 1675: Computed reservoir species mass fractions, Shot 2778

210.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4319	1493.0	1493.0	5.65	17.2	0.039	3.23×10^6
72 cm	4263	1123.6	3112.6	6.23	12.9	0.039	3.87×10^6

Table 1676: Computed freestream conditions, Shot 2778

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.96×10^{-1}	0	0	0	0	3.81×10^{-3}	0
72 cm	9.97×10^{-1}	0	0	0	0	2.91×10^{-3}	0

Table 1677: Computed freestream species mass fractions, Shot 2778

210.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4278	1635.6	1635.6	5.34	25.2	0.052	3.99×10^6
72 cm	4193	1374.2	3081.3	5.54	20.5	0.050	4.30×10^6

Table 1678: Computed boundary layer edge conditions, Shot 2778

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.96×10^{-1}	0	0	0	0	3.81×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1679: Computed boundary layer edge species mass fractions, Shot 2778

	T^* K	Unit Re^* 1/m
1D 100 cm	2042	2.72×10^6
72 cm	1806	2.68×10^6

Table 1680: Dorrance reference conditions, Shot 2778

210.5 Stability Computations

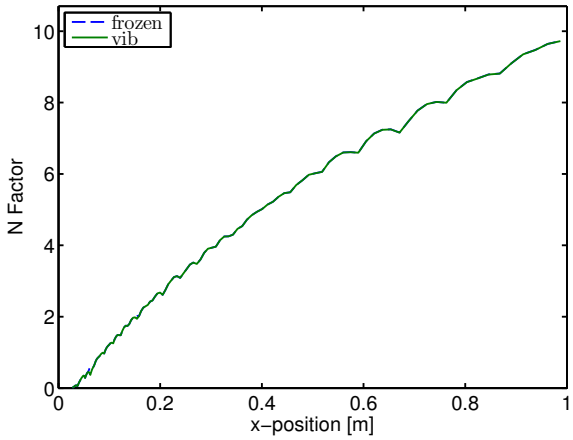


Figure 628: Locus of maximum N factor with and without vibrational energy transfer, Shot 2778

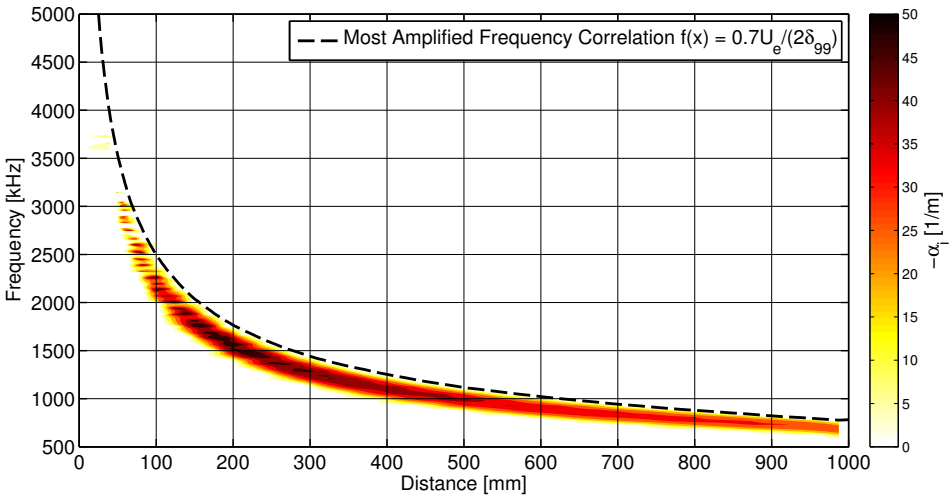


Figure 629: Stability diagram with vibrational energy transfer, Shot 2778. Dashed line indicates $0.7U_e/(2\delta_{99})$.

210.6 Heat Transfer Results

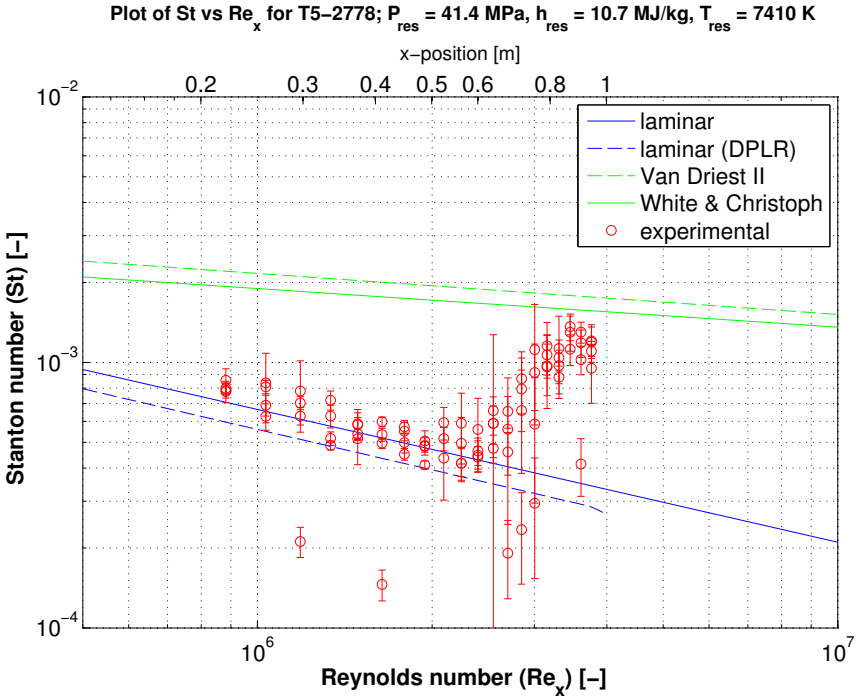


Figure 630: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

211 Shot 2779

Experiment 2779 was performed in T5 on 19 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

211.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3530	m/s
Shock Tube Fill Pressure	P_1	60.00	kPa
Reservoir Pressure	P_{res}	42.3	MPa

Table 1681: Measured quantities, Shot 2779

211.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7800	K
Reservoir Density	ρ_{res}	17.26	kg/m^3
Reservoir Enthalpy	h_{res}	12.0	MJ/kg

Table 1682: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2779

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.41×10^{-1}	0	0	0	0	5.87×10^{-2}	0

Table 1683: Computed reservoir species mass fractions, Shot 2779

211.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4529	1696.0	1696.0	5.56	18.4	0.036	2.90×10^6
72 cm	4463	1343.6	3245.8	5.96	15.7	0.039	3.65×10^6

Table 1684: Computed freestream conditions, Shot 2779

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.93×10^{-1}	0	0	0	0	6.61×10^{-3}	0
72 cm	9.95×10^{-1}	0	0	0	0	4.84×10^{-3}	0

Table 1685: Computed freestream species mass fractions, Shot 2779

211.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4485	1851.6	1851.6	5.27	26.7	0.048	3.57×10^6
72 cm	4389	1627.9	3200.0	5.32	24.3	0.050	3.96×10^6

Table 1686: Computed boundary layer edge conditions, Shot 2779

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.93×10^{-1}	0	0	0	0	6.61×10^{-3}	0
72 cm	1.00	0	0	0	0	0	0

Table 1687: Computed boundary layer edge species mass fractions, Shot 2779

	T^* K	Unit Re^* 1/m
1D 100 cm	2239	2.56×10^6
72 cm	2007	2.75×10^6

Table 1688: Dorrance reference conditions, Shot 2779

211.5 Stability Computations

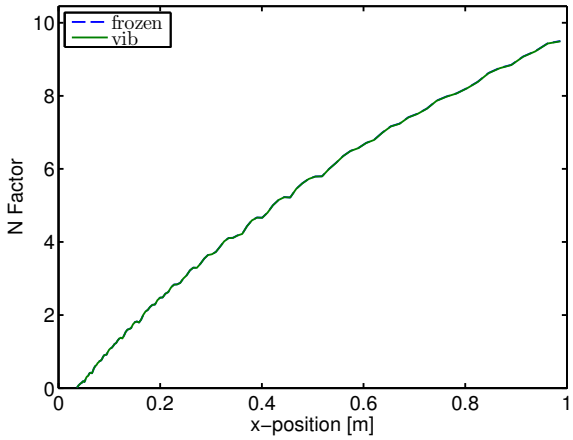


Figure 631: Locus of maximum N factor with and without vibrational energy transfer, Shot 2779

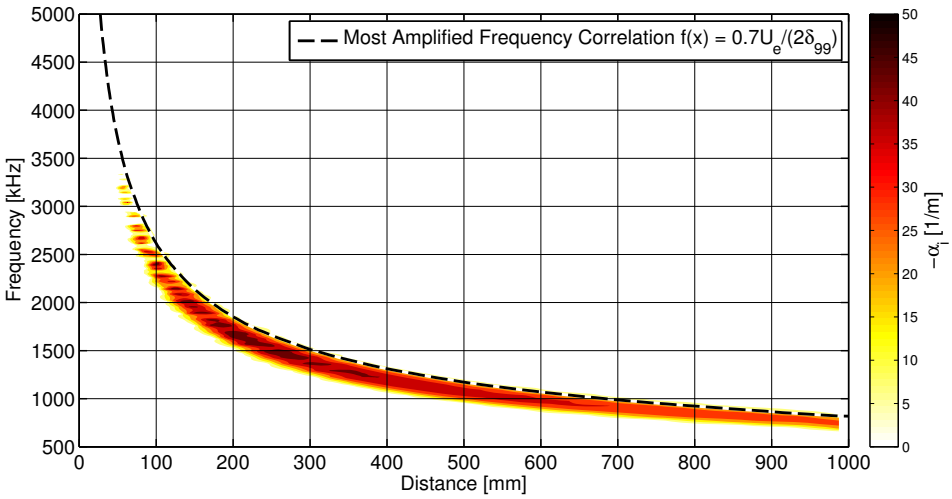


Figure 632: Stability diagram with vibrational energy transfer, Shot 2779. Dashed line indicates $0.7U_e/(2\delta_{99})$.

211.6 Heat Transfer Results

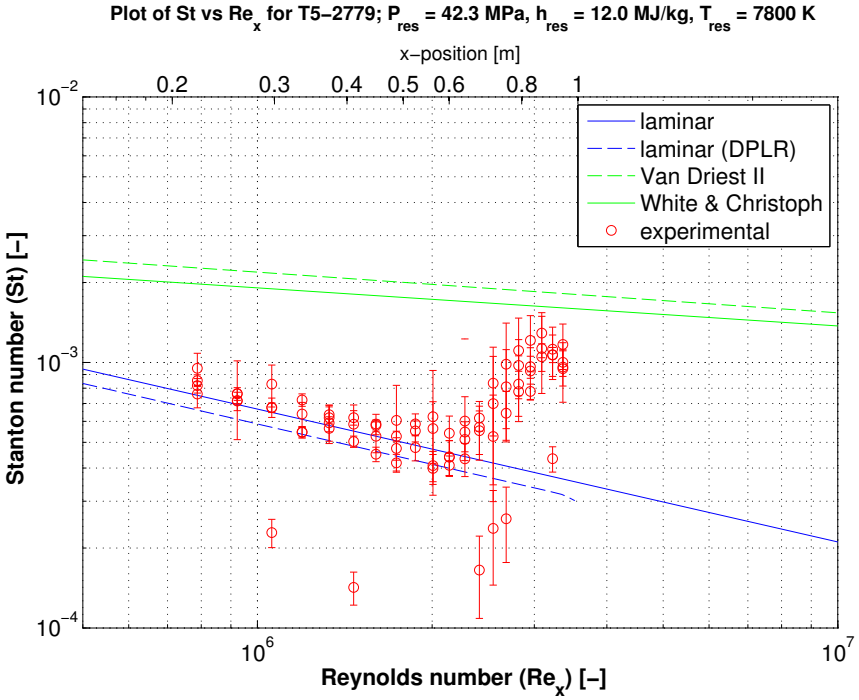


Figure 633: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

212 Shot 2780

Experiment 2780 was performed in T5 on 28 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

212.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3730	m/s
Shock Tube Fill Pressure	P_1	50.05	kPa
Reservoir Pressure	P_{res}	44.5	MPa

Table 1689: Measured quantities, Shot 2780

212.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8230	K
Reservoir Density	ρ_{res}	16.79	kg/m^3
Reservoir Enthalpy	h_{res}	13.6	MJ/kg

Table 1690: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2780

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
9.14×10^{-1}	0	0	0	0	8.60×10^{-2}	0

Table 1691: Computed reservoir species mass fractions, Shot 2780

212.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4775	1962.0	1962.0	5.44	20.6	0.035	2.63×10^6
72 cm	4703	1623.7	3387.4	5.70	18.8	0.039	3.31×10^6

Table 1692: Computed freestream conditions, Shot 2780

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.88×10^{-1}	0	0	0	0	1.17×10^{-2}	0
72 cm	9.92×10^{-1}	0	0	0	0	8.20×10^{-3}	0

Table 1693: Computed freestream species mass fractions, Shot 2780

212.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4728	2133.9	2133.9	5.17	29.5	0.046	3.23×10^6
72 cm	4625	1953.6	3300.5	5.11	28.5	0.048	3.55×10^6

Table 1694: Computed boundary layer edge conditions, Shot 2780

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.88×10^{-1}	0	0	0	0	1.17×10^{-2}	0
72 cm	1.00	0	0	0	0	0	0

Table 1695: Computed boundary layer edge species mass fractions, Shot 2780

	T^* K	Unit Re^* 1/m
1D 100 cm	2491	2.46×10^6
72 cm	2266	2.74×10^6

Table 1696: Dorrance reference conditions, Shot 2780

212.5 Stability Computations

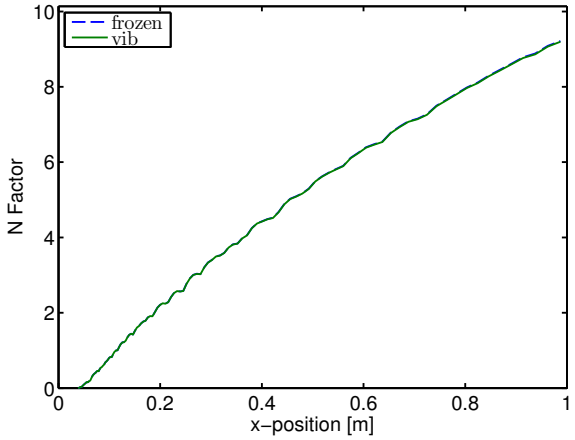


Figure 634: Locus of maximum N factor with and without vibrational energy transfer, Shot 2780

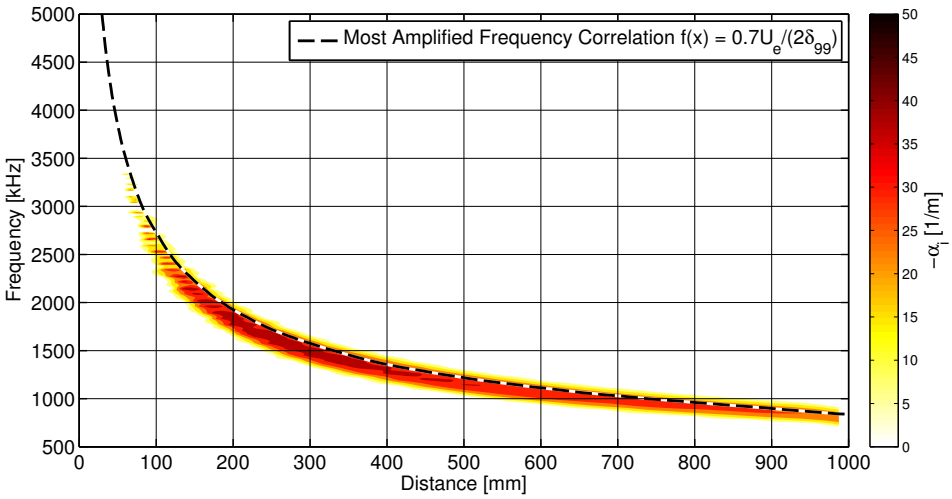


Figure 635: Stability diagram with vibrational energy transfer, Shot 2780. Dashed line indicates $0.7U_e/(2\delta_{99})$.

212.6 Heat Transfer Results

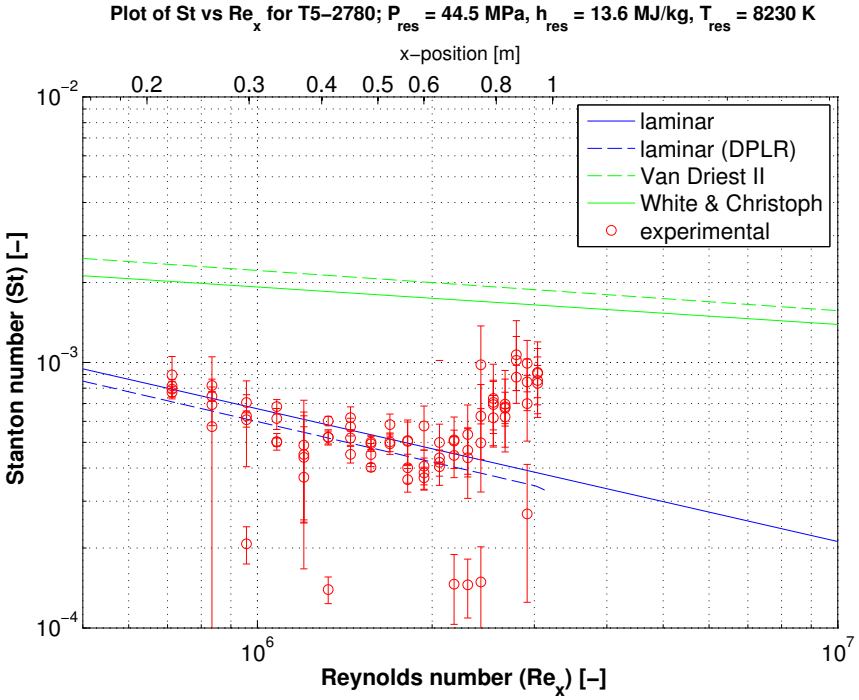


Figure 636: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

213 Shot 2781

Experiment 2781 was performed in T5 on 29 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

213.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3980	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	43.4	MPa

Table 1697: Measured quantities, Shot 2781

213.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8506	K
Reservoir Density	ρ_{res}	15.48	kg/m^3
Reservoir Enthalpy	h_{res}	15.0	MJ/kg

Table 1698: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2781

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
8.89×10^{-1}	0	0	0	0	1.11×10^{-1}	0

Table 1699: Computed reservoir species mass fractions, Shot 2781

213.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4952	2165.0	2165.0	5.36	20.9	0.032	2.32×10^6
72 cm	4876	1839.3	3502.2	5.53	19.8	0.036	2.88×10^6

Table 1700: Computed freestream conditions, Shot 2781

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.82×10^{-1}	0	0	6.49×10^{-10}	0	1.85×10^{-2}	3.46×10^{-10}
72 cm	9.87×10^{-1}	0	0	0	0	1.31×10^{-2}	0

Table 1701: Computed freestream species mass fractions, Shot 2781

213.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4902	2349.4	2349.4	5.09	29.7	0.042	2.83×10^6
72 cm	4794	2212.4	3362.9	4.96	29.5	0.044	3.04×10^6

Table 1702: Computed boundary layer edge conditions, Shot 2781

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.82×10^{-1}	0	0	6.49×10^{-10}	0	1.85×10^{-2}	3.46×10^{-10}
72 cm	1.00	0	0	0	0	0	0

Table 1703: Computed boundary layer edge species mass fractions, Shot 2781

	T^* K	Unit Re^* 1/m
1D 100 cm	2683	2.24×10^6
72 cm	2469	2.72×10^6

Table 1704: Dorrance reference conditions, Shot 2781

213.5 Stability Computations

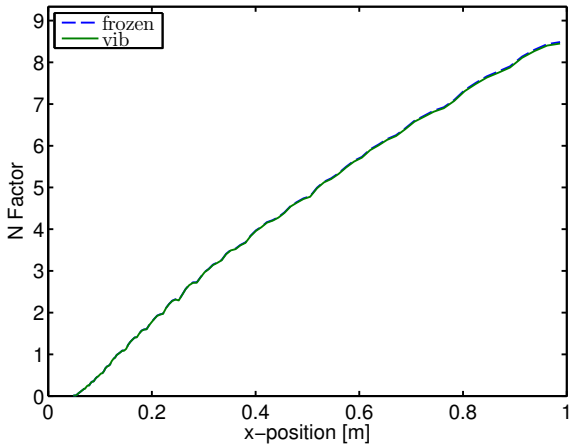


Figure 637: Locus of maximum N factor with and without vibrational energy transfer, Shot 2781

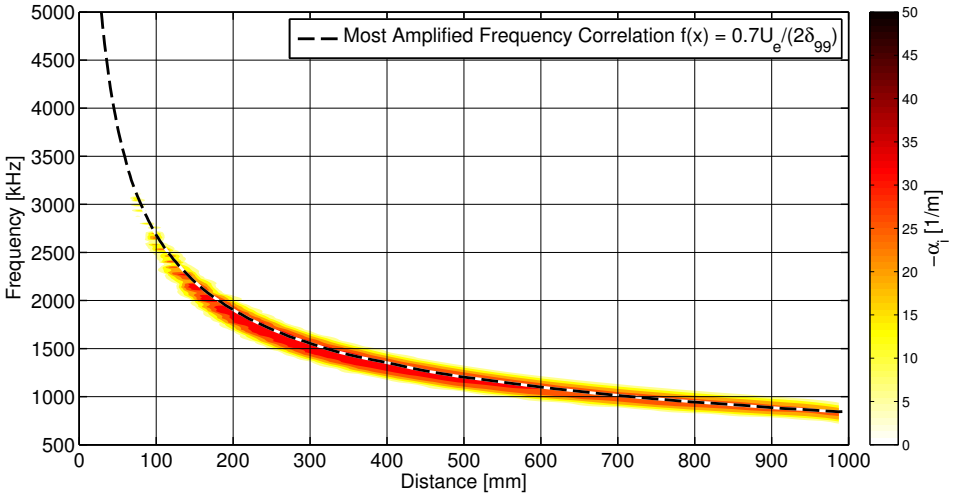


Figure 638: Stability diagram with vibrational energy transfer, Shot 2781. Dashed line indicates $0.7U_e/(2\delta_{99})$.

213.6 Heat Transfer Results

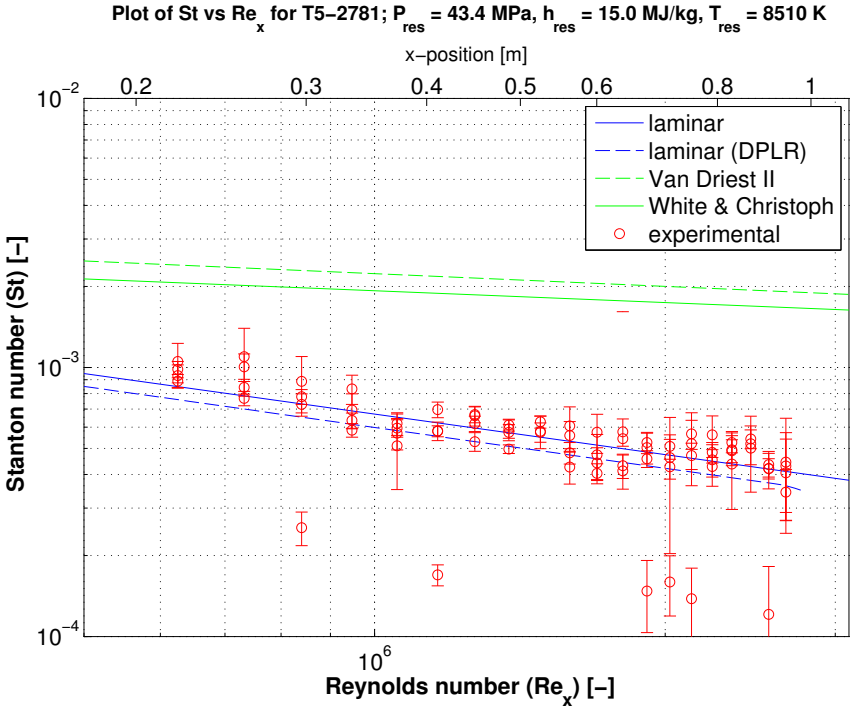


Figure 639: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

214 Shot 2782

Experiment 2782 was performed in T5 on 30 November 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

214.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3850	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	53.9	MPa

Table 1705: Measured quantities, Shot 2782

214.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8565	K
Reservoir Density	ρ_{res}	19.18	kg/m^3
Reservoir Enthalpy	h_{res}	14.8	MJ/kg

Table 1706: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2782

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
8.95×10^{-1}	0	0	0	0	1.05×10^{-1}	0

Table 1707: Computed reservoir species mass fractions, Shot 2782

214.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4944	2169.0	2169.0	5.36	25.7	0.039	2.85×10^6
72 cm	4874	1852.5	3409.8	5.52	24.8	0.045	3.59×10^6

Table 1708: Computed freestream conditions, Shot 2782

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.86×10^{-1}	0	0	0	0	1.44×10^{-2}	0
72 cm	9.90×10^{-1}	0	0	0	0	9.95×10^{-3}	0

Table 1709: Computed freestream species mass fractions, Shot 2782

214.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4895	2353.7	2353.7	5.10	36.5	0.051	3.47×10^6
72 cm	4791	2229.8	3252.8	4.95	37.0	0.055	3.78×10^6

Table 1710: Computed boundary layer edge conditions, Shot 2782

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.86×10^{-1}	0	0	0	0	1.44×10^{-2}	0
72 cm	1.00	0	0	0	0	0	0

Table 1711: Computed boundary layer edge species mass fractions, Shot 2782

	T^* K	Unit Re^* 1/m
1D 100 cm	2682	2.76×10^6
72 cm	2476	3.15×10^6

Table 1712: Dorrance reference conditions, Shot 2782

214.5 Stability Computations

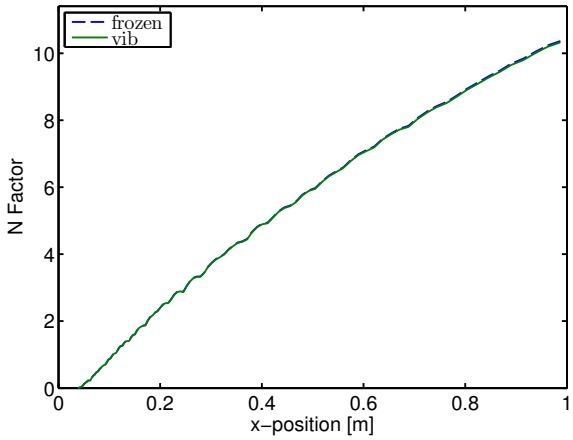


Figure 640: Locus of maximum N factor with and without vibrational energy transfer, Shot 2782

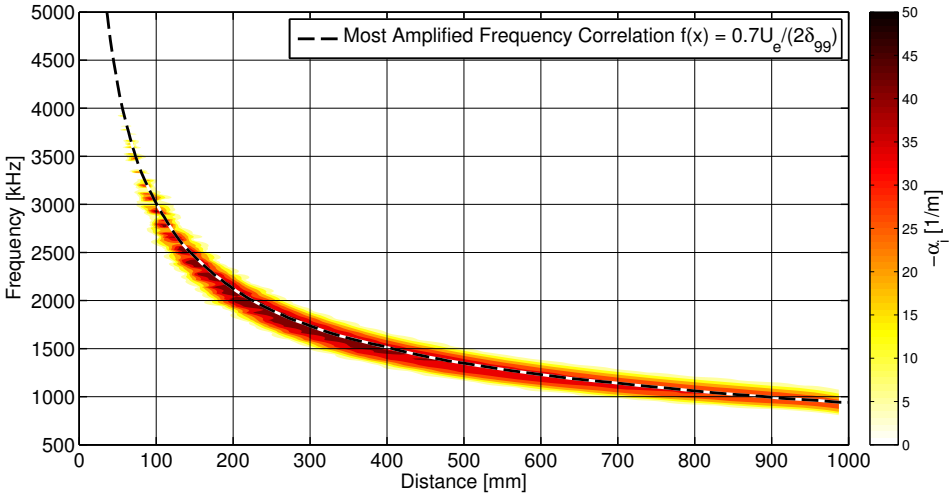


Figure 641: Stability diagram with vibrational energy transfer, Shot 2782. Dashed line indicates $0.7U_e/(2\delta_{99})$.

214.6 Heat Transfer Results

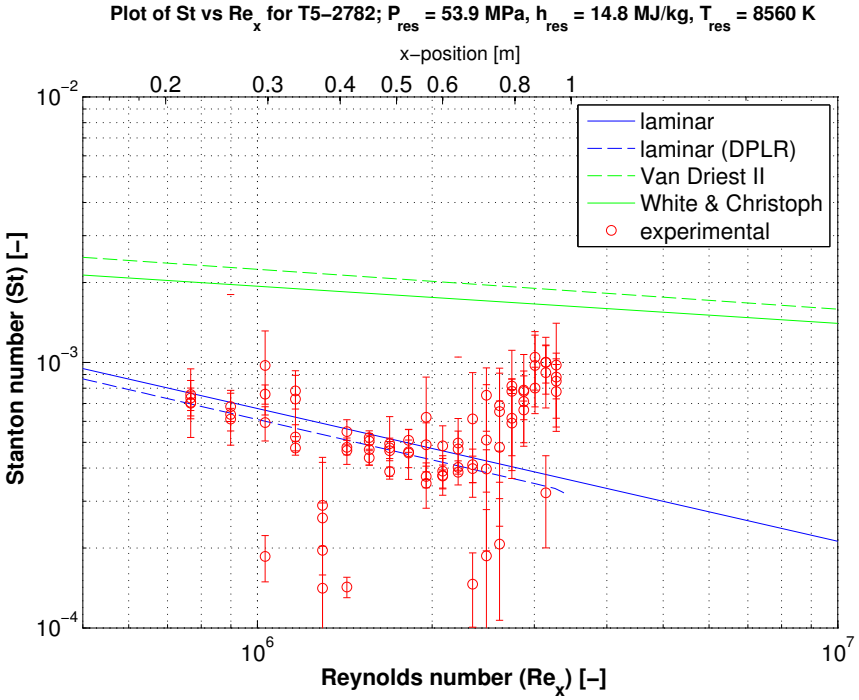


Figure 642: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

215 Shot 2783

Experiment 2783 was performed in T5 on 3 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

215.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	4030	m/s
Shock Tube Fill Pressure	P_1	50.10	kPa
Reservoir Pressure	P_{res}	53.3	MPa

Table 1713: Measured quantities, Shot 2783

215.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8767	K
Reservoir Density	ρ_{res}	18.21	kg/m^3
Reservoir Enthalpy	h_{res}	15.9	MJ/kg

Table 1714: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2783

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
8.76×10^{-1}	0	0	0	0	1.24×10^{-1}	0

Table 1715: Computed reservoir species mass fractions, Shot 2783

215.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	5078	2336.0	2336.0	5.29	26.5	0.037	2.63×10^6
72 cm	4999	2024.7	3478.6	5.40	25.7	0.042	3.25×10^6

Table 1716: Computed freestream conditions, Shot 2783

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.80×10^{-1}	0	0	0	0	1.97×10^{-2}	0
72 cm	9.86×10^{-1}	0	0	0	0	1.41×10^{-2}	0

Table 1717: Computed freestream species mass fractions, Shot 2783

215.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	5028	2530.3	2530.3	5.03	37.4	0.049	3.20×10^6
72 cm	4915	2441.5	3263.4	4.84	38.0	0.051	3.37×10^6

Table 1718: Computed boundary layer edge conditions, Shot 2783

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.80×10^{-1}	0	0	0	0	1.97×10^{-2}	0
72 cm	1.00	0	0	0	0	0	0

Table 1719: Computed boundary layer edge species mass fractions, Shot 2783

	T^* K	Unit Re^* 1/m
1D 100 cm	2836	2.62×10^6
72 cm	2637	2.95×10^6

Table 1720: Dorrance reference conditions, Shot 2783

215.5 Stability Computations

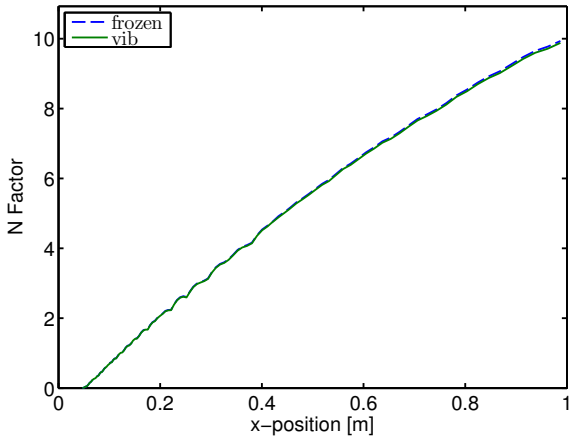


Figure 643: Locus of maximum N factor with and without vibrational energy transfer, Shot 2783

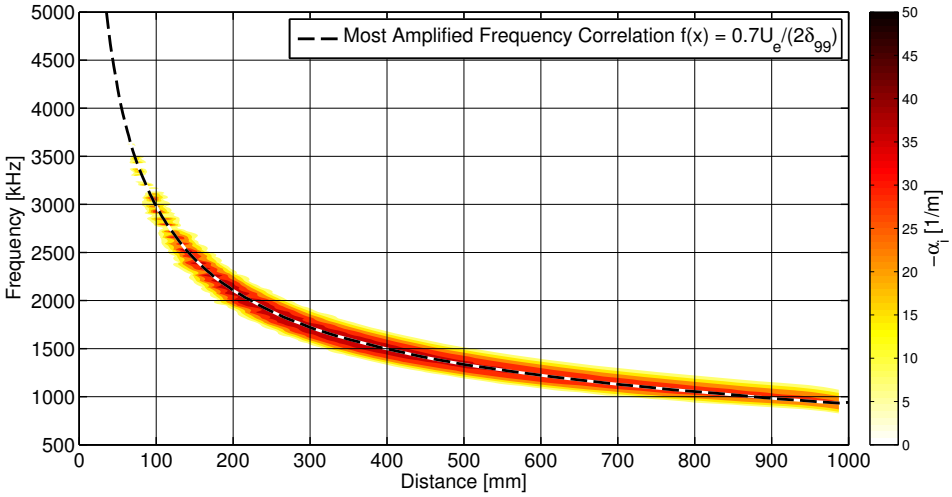


Figure 644: Stability diagram with vibrational energy transfer, Shot 2783. Dashed line indicates $0.7U_e/(2\delta_{99})$.

215.6 Heat Transfer Results

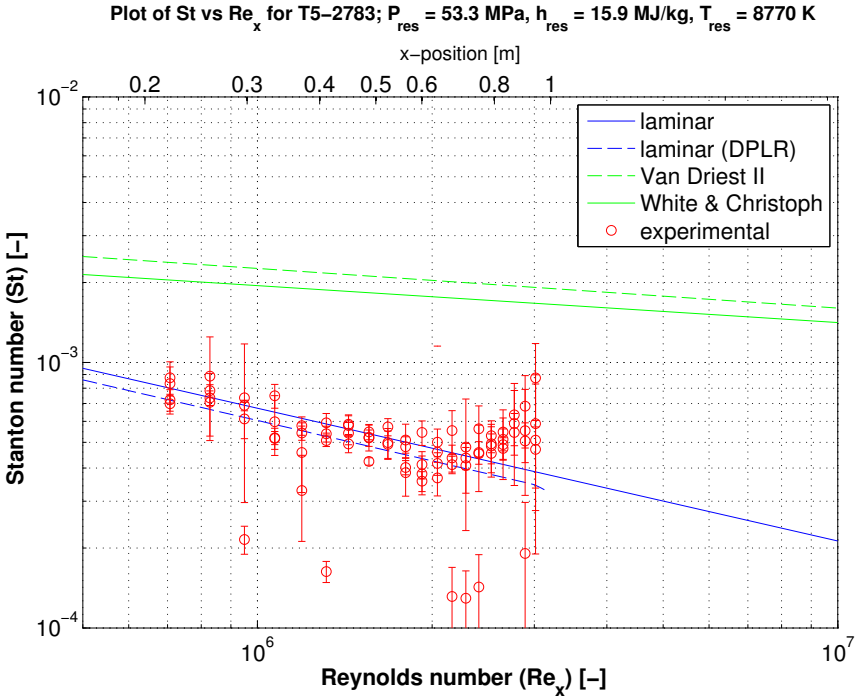


Figure 645: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

216 Shot 2784

Experiment 2784 was performed in T5 on 4 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

216.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	4000	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	60.4	MPa

Table 1721: Measured quantities, Shot 2784

216.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8862	K
Reservoir Density	ρ_{res}	20.39	kg/m^3
Reservoir Enthalpy	h_{res}	16.1	MJ/kg

Table 1722: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2784

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
8.74×10^{-1}	0	0	0	0	1.26×10^{-1}	0

Table 1723: Computed reservoir species mass fractions, Shot 2784

216.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	5109	2385.0	2385.0	5.27	30.0	0.042	2.90×10^6
72 cm	5033	2084.5	3440.1	5.37	29.7	0.047	3.60×10^6

Table 1724: Computed freestream conditions, Shot 2784

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.81×10^{-1}	0	0	1.24×10^{-10}	0	1.86×10^{-2}	0
72 cm	9.87×10^{-1}	0	0	0	0	1.32×10^{-2}	0

Table 1725: Computed freestream species mass fractions, Shot 2784

216.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	5058	2581.9	2581.9	5.02	42.2	0.054	3.51×10^6
72 cm	4948	2516.0	3194.1	4.80	43.8	0.057	3.72×10^6

Table 1726: Computed boundary layer edge conditions, Shot 2784

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.81×10^{-1}	0	0	1.24×10^{-10}	0	1.86×10^{-2}	0
72 cm	1.00	0	0	0	0	0	0

Table 1727: Computed boundary layer edge species mass fractions, Shot 2784

	T^* K	Unit Re^* 1/m
1D 100 cm	2877	2.91×10^6
72 cm	2689	3.48×10^6

Table 1728: Dorrance reference conditions, Shot 2784

216.5 Stability Computations

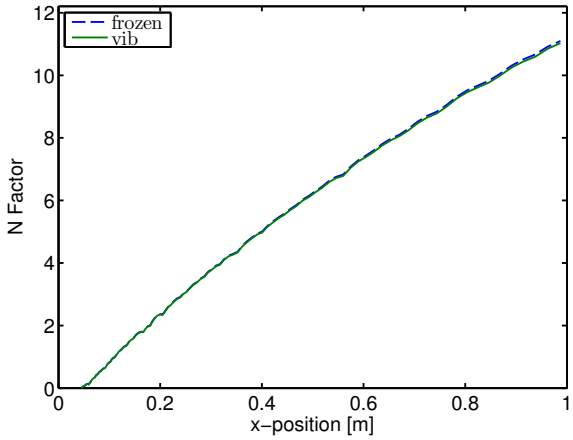


Figure 646: Locus of maximum N factor with and without vibrational energy transfer, Shot 2784

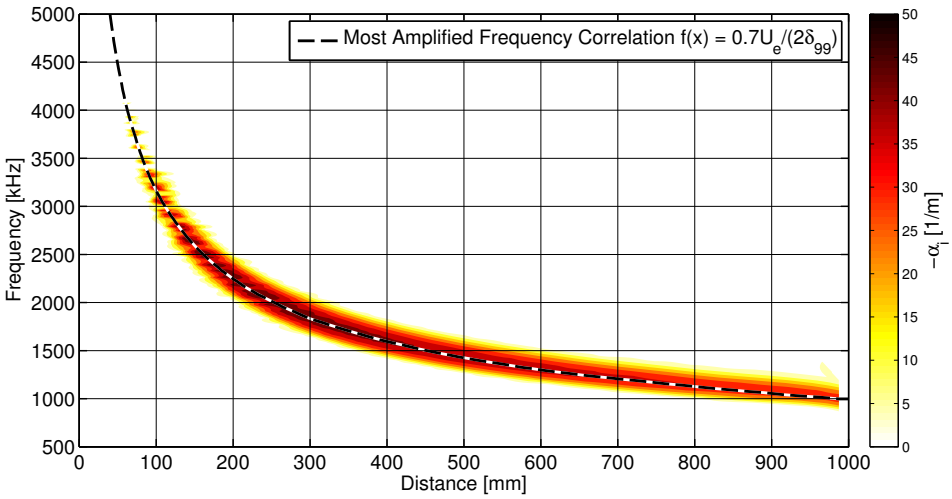


Figure 647: Stability diagram with vibrational energy transfer, Shot 2784. Dashed line indicates $0.7U_e/(2\delta_{99})$.

216.6 Heat Transfer Results

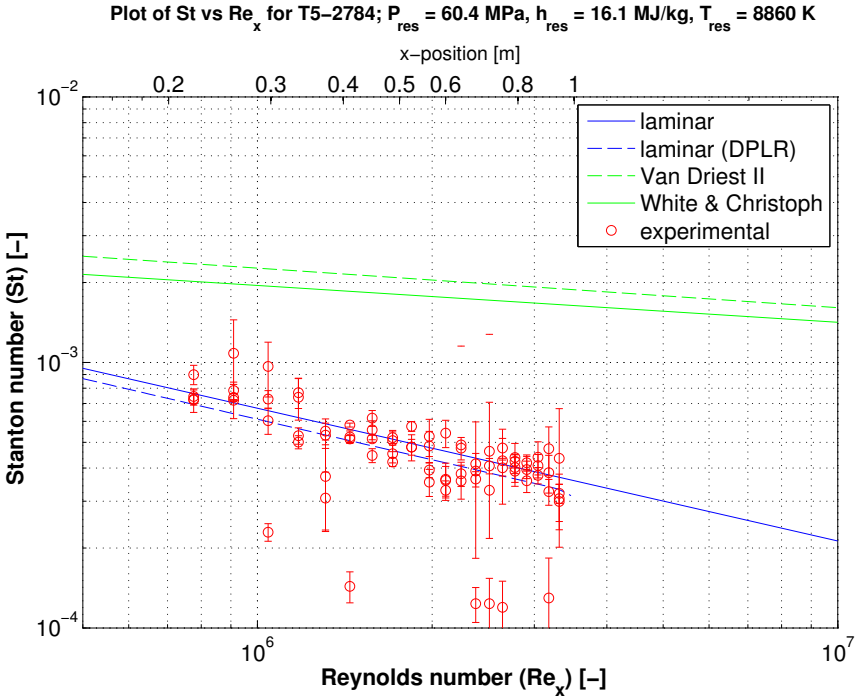


Figure 648: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

217 Shot 2785

Experiment 2785 was performed in T5 on 5 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% N_2 by mass.

217.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	4000	m/s
Shock Tube Fill Pressure	P_1	49.95	kPa
Reservoir Pressure	P_{res}	61.8	MPa

Table 1729: Measured quantities, Shot 2785

217.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	8886	K
Reservoir Density	ρ_{res}	20.80	kg/m^3
Reservoir Enthalpy	h_{res}	16.2	MJ/kg

Table 1730: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2785

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
8.73×10^{-1}	0	0	0	0	1.27×10^{-1}	0

Table 1731: Computed reservoir species mass fractions, Shot 2785

217.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	5122	2404.0	2404.0	5.27	30.9	0.043	2.96×10^6
72 cm	5044	2101.4	3434.5	5.36	30.5	0.048	3.66×10^6

Table 1732: Computed freestream conditions, Shot 2785

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.81×10^{-1}	0	0	0	0	1.86×10^{-2}	0
72 cm	9.87×10^{-1}	0	0	0	0	1.32×10^{-2}	0

Table 1733: Computed freestream species mass fractions, Shot 2785

217.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	5071	2602.1	2602.1	5.01	43.6	0.055	3.59×10^6
72 cm	4959	2533.6	3181.3	4.80	45.0	0.058	3.78×10^6

Table 1734: Computed boundary layer edge conditions, Shot 2785

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	9.81×10^{-1}	0	0	0	0	1.86×10^{-2}	0
72 cm	1.00	0	0	0	0	0	0

Table 1735: Computed boundary layer edge species mass fractions, Shot 2785

	T^* K	Unit Re^* 1/m
1D 100 cm	2894	2.98×10^6
72 cm	2703	3.55×10^6

Table 1736: Dorrance reference conditions, Shot 2785

217.5 Stability Computations

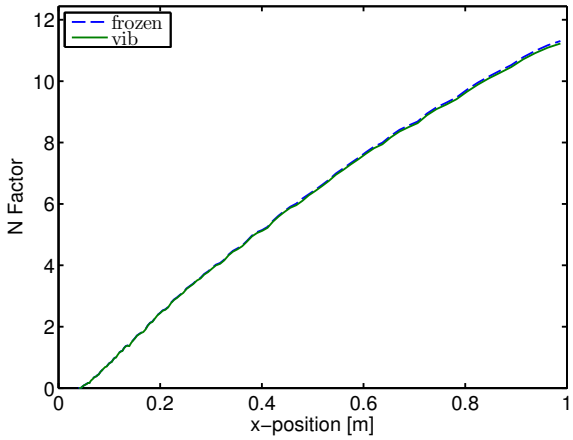


Figure 649: Locus of maximum N factor with and without vibrational energy transfer, Shot 2785

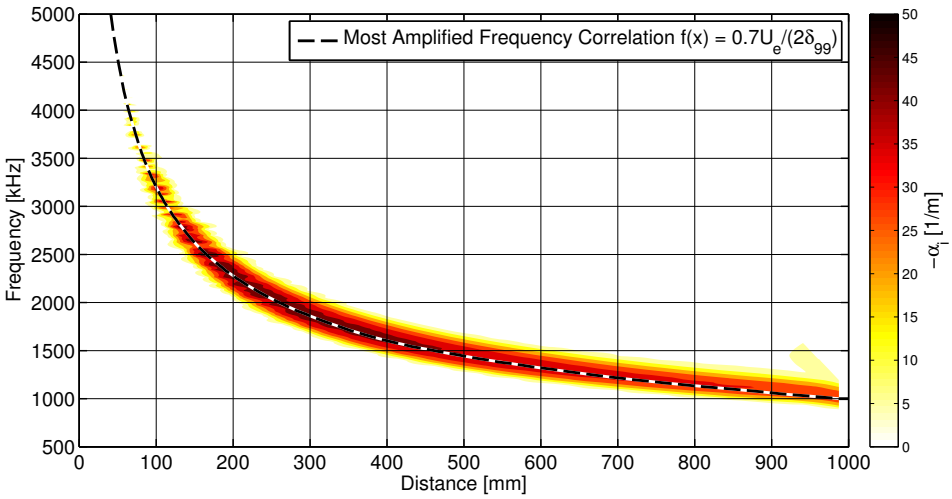


Figure 650: Stability diagram with vibrational energy transfer, Shot 2785. Dashed line indicates $0.7U_e/(2\delta_{99})$.

217.6 Heat Transfer Results

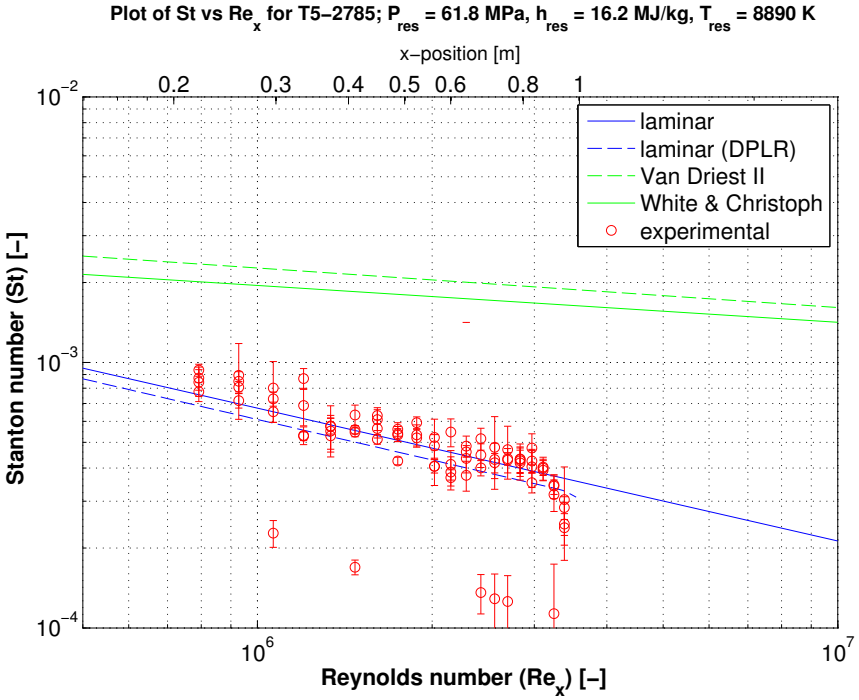


Figure 651: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

218 Shot 2786

Experiment 2786 was performed in T5 on 6 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

218.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3230	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_res	53.6	MPa

Table 1737: Measured quantities, Shot 2786

218.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6193	K
Reservoir Density	ρ_res	26.98	kg/m^3
Reservoir Enthalpy	h_res	10.0	MJ/kg

Table 1738: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2786

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.00×10^{-1}	4.47×10^{-2}	0	1.31×10^{-1}	0	6.12×10^{-3}	1.18×10^{-1}

Table 1739: Computed reservoir species mass fractions, Shot 2786

218.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4051	1490.0	1490.0	5.33	25.0	0.057	4.30×10^{6}
72 cm	4025	1536.8	1546.2	5.07	30.0	0.067	4.91×10^{6}

Table 1740: Computed freestream conditions, Shot 2786

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.52×10^{-9}	2.25×10^{-2}
72 cm	7.33×10^{-1}	1.80×10^{-1}	0	7.30×10^{-2}	0	2.01×10^{-8}	1.39×10^{-2}

Table 1741: Computed freestream species mass fractions, Shot 2786

218.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4010	1621.8	1621.8	5.06	35.6	0.075	5.25×10^{6}
72 cm	3957	1732.5	1730.5	4.70	42.5	0.084	5.58×10^{6}

Table 1742: Computed boundary layer edge conditions, Shot 2786

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.79×10^{-1}	0	5.95×10^{-2}	0	8.52×10^{-9}	2.25×10^{-2}
72 cm	7.33×10^{-1}	1.81×10^{-1}	0	7.30×10^{-2}	0	6.85×10^{-8}	1.34×10^{-2}

Table 1743: Computed boundary layer edge species mass fractions, Shot 2786

	T^* K	Unit Re^* 1/m
1D 100 cm	1920	3.94×10^{6}
72 cm	1899	4.77×10^{6}

Table 1744: Dorrance reference conditions, Shot 2786

218.5 Stability Computations

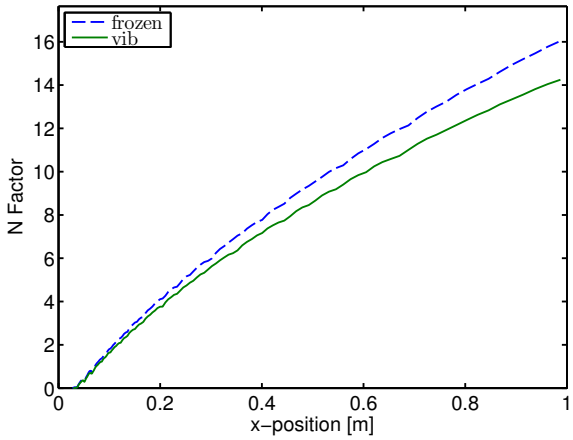


Figure 652: Locus of maximum N factor with and without vibrational energy transfer, Shot 2786

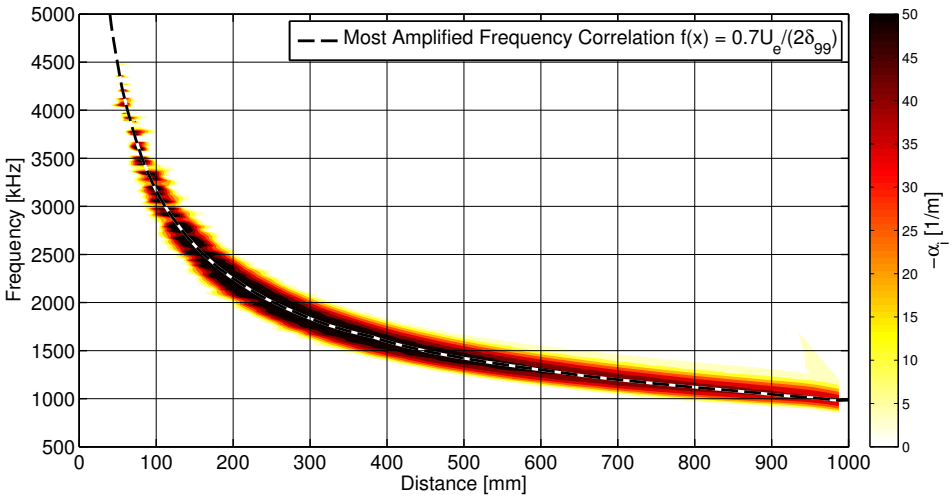


Figure 653: Stability diagram with vibrational energy transfer, Shot 2786. Dashed line indicates $0.7U_e/(2\delta_{99})$.

218.6 Heat Transfer Results

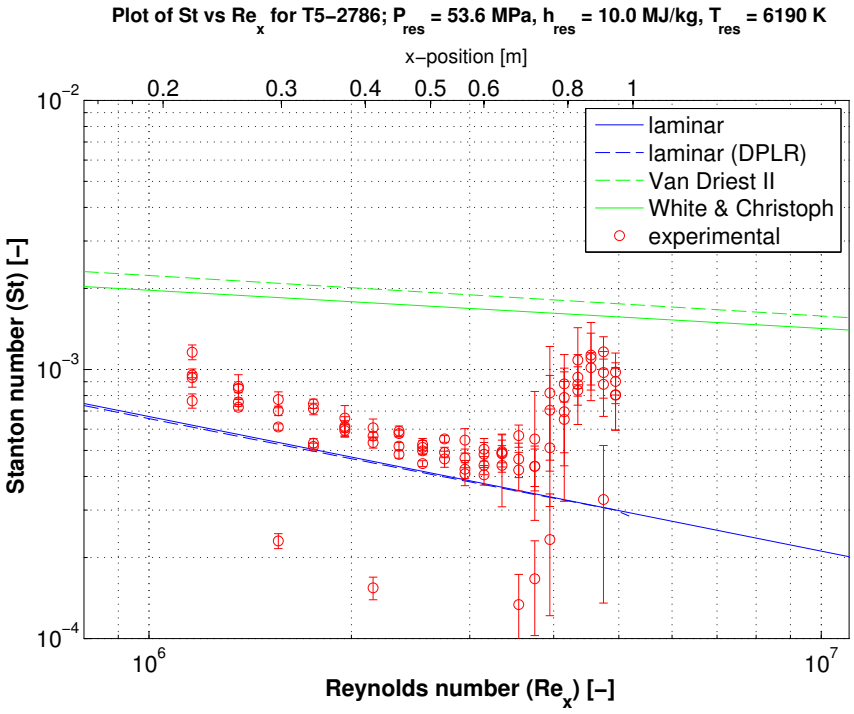


Figure 654: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

219 Shot 2787

Experiment 2787 was performed in T5 on 7 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

219.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3340	m/s
Shock Tube Fill Pressure	P_1	80.00	kPa
Reservoir Pressure	P_res	54.7	MPa

Table 1745: Measured quantities, Shot 2787

219.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	6479	K
Reservoir Density	ρ_res	25.99	kg/m^3
Reservoir Enthalpy	h_res	10.7	MJ/kg

Table 1746: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2787

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.99×10^{-1}	3.54×10^{-2}	0	1.26×10^{-1}	0	9.32×10^{-3}	1.31×10^{-1}

Table 1747: Computed reservoir species mass fractions, Shot 2787

219.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4166	1595.0	1595.0	5.29	25.9	0.055	4.07×10^{6}
72 cm	4138	1654.7	1664.1	5.02	31.5	0.065	4.65×10^{6}

Table 1748: Computed freestream conditions, Shot 2787

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.74×10^{-1}	0	5.83×10^{-2}	0	2.54×10^{-8}	2.82×10^{-2}
72 cm	7.33×10^{-1}	1.76×10^{-1}	0	7.27×10^{-2}	0	5.90×10^{-8}	1.82×10^{-2}

Table 1749: Computed freestream species mass fractions, Shot 2787

219.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4125	1733.7	1733.7	5.03	36.7	0.072	4.95×10^{6}
72 cm	4069	1862.3	1860.3	4.65	44.3	0.081	5.27×10^{6}

Table 1750: Computed boundary layer edge conditions, Shot 2787

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.40×10^{-1}	1.74×10^{-1}	0	5.83×10^{-2}	0	2.54×10^{-8}	2.82×10^{-2}
72 cm	7.33×10^{-1}	1.77×10^{-1}	0	7.27×10^{-2}	0	1.76×10^{-7}	1.75×10^{-2}

Table 1751: Computed boundary layer edge species mass fractions, Shot 2787

	T^* K	Unit Re^* 1/m
1D 100 cm	2024	3.80×10^{6}
72 cm	2007	4.64×10^{6}

Table 1752: Dorrance reference conditions, Shot 2787

219.5 Stability Computations

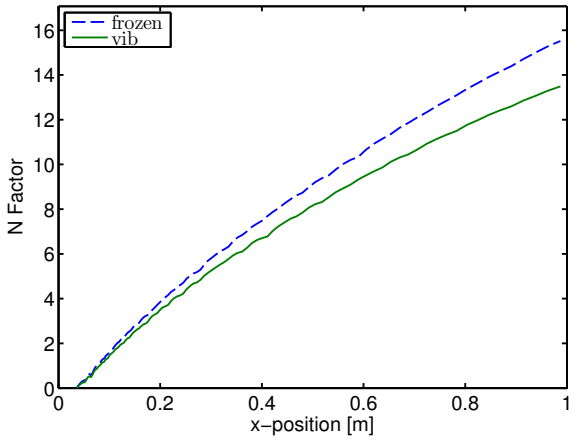


Figure 655: Locus of maximum N factor with and without vibrational energy transfer, Shot 2787

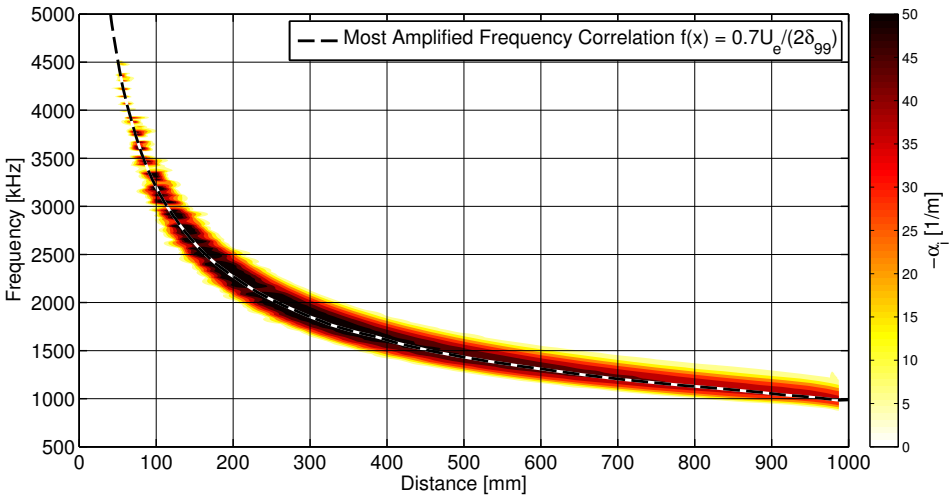


Figure 656: Stability diagram with vibrational energy transfer, Shot 2787. Dashed line indicates $0.7U_e/(2\delta_{99})$.

219.6 Heat Transfer Results

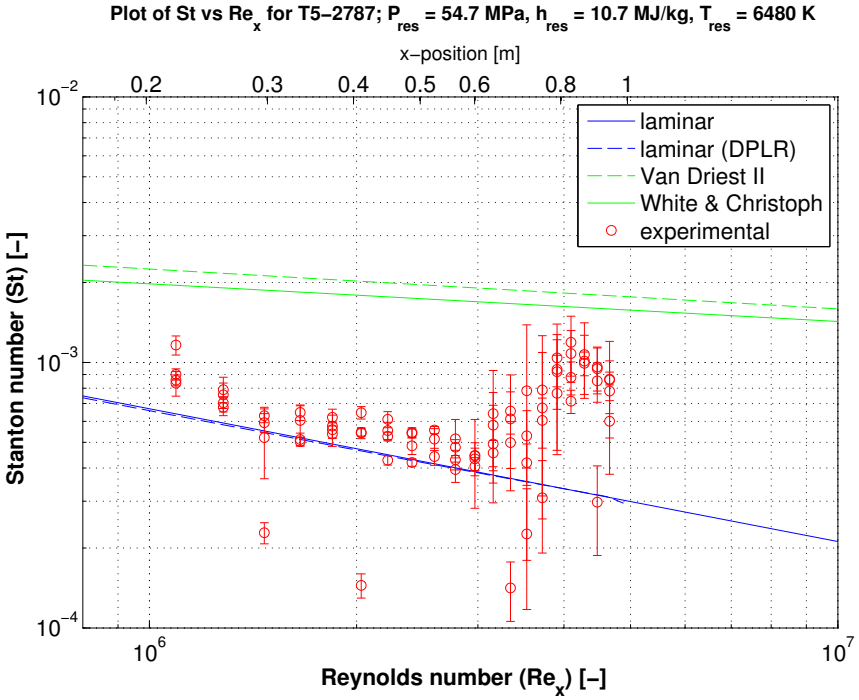


Figure 657: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

220 Shot 2788

Experiment 2788 was performed in T5 on 7 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

220.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3710	m/s
Shock Tube Fill Pressure	P_1	65.00	kPa
Reservoir Pressure	P_{res}	54.7	MPa

Table 1753: Measured quantities, Shot 2788

220.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	7375	K
Reservoir Density	ρ_{res}	21.89	kg/m^3
Reservoir Enthalpy	h_{res}	13.1	MJ/kg

Table 1754: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2788

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.90×10^{-1}	1.63×10^{-2}	0	1.03×10^{-1}	0	2.92×10^{-2}	1.62×10^{-1}

Table 1755: Computed reservoir species mass fractions, Shot 2788

220.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4550	1932.0	1932.0	5.19	27.3	0.047	3.31×10^6
72 cm	4499	2018.1	2026.3	4.88	33.3	0.055	3.74×10^6

Table 1756: Computed freestream conditions, Shot 2788

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.42×10^{-1}	1.52×10^{-1}	0	5.27×10^{-2}	0	4.11×10^{-7}	5.33×10^{-2}
72 cm	7.35×10^{-1}	1.57×10^{-1}	0	6.90×10^{-2}	0	8.25×10^{-7}	3.91×10^{-2}

Table 1757: Computed freestream species mass fractions, Shot 2788

220.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4504	2094.8	2094.8	4.94	38.4	0.061	4.00×10^6
72 cm	4423	2272.0	2269.9	4.53	46.4	0.069	4.20×10^6

Table 1758: Computed boundary layer edge conditions, Shot 2788

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.42×10^{-1}	1.52×10^{-1}	0	5.27×10^{-2}	0	4.11×10^{-7}	5.33×10^{-2}
72 cm	7.35×10^{-1}	1.59×10^{-1}	0	6.87×10^{-2}	0	1.94×10^{-6}	3.71×10^{-2}

Table 1759: Computed boundary layer edge species mass fractions, Shot 2788

	T^* K	Unit Re^* 1/m
1D 100 cm	2371	3.23×10^6
72 cm	2356	4.05×10^6

Table 1760: Dorrance reference conditions, Shot 2788

220.5 Stability Computations

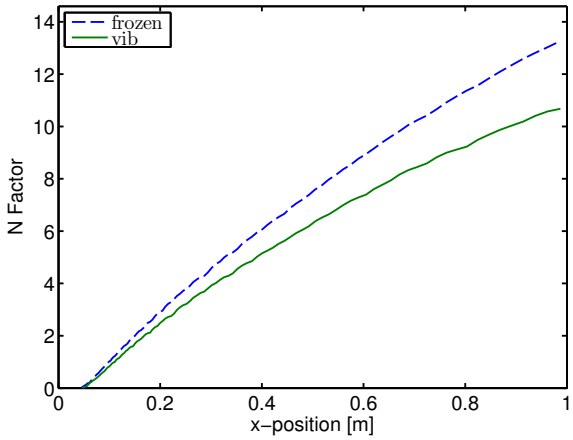


Figure 658: Locus of maximum N factor with and without vibrational energy transfer, Shot 2788

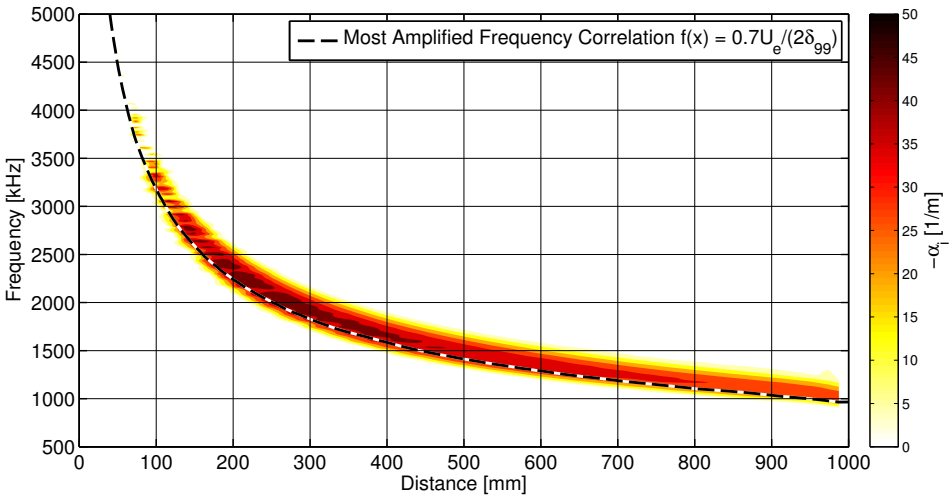


Figure 659: Stability diagram with vibrational energy transfer, Shot 2788. Dashed line indicates $0.7U_e/(2\delta_{99})$.

220.6 Heat Transfer Results

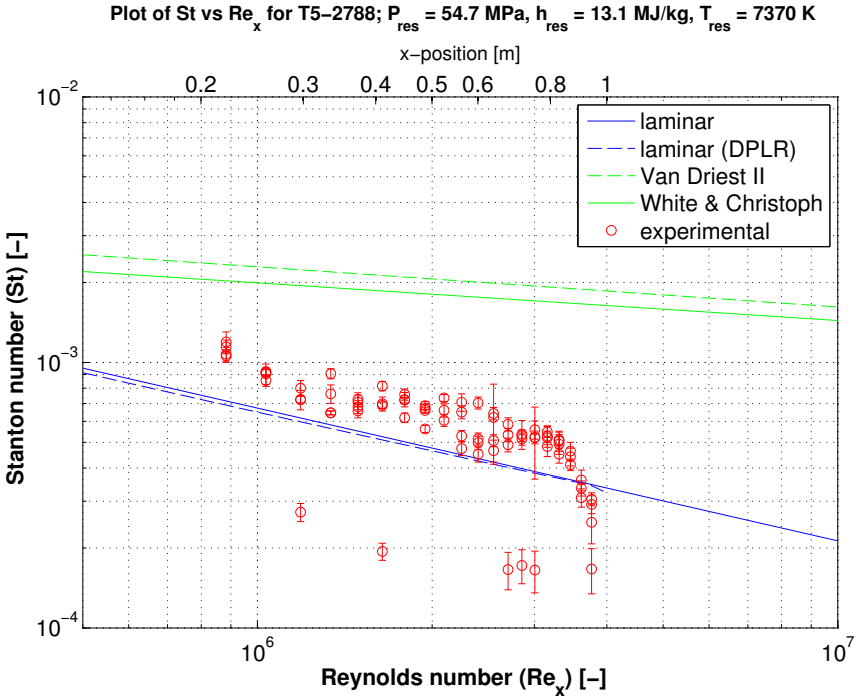


Figure 660: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

221 Shot 2789

Experiment 2789 was performed in T5 on 10 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

221.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3490	m/s
Shock Tube Fill Pressure	P_1	70.30	kPa
Reservoir Pressure	P_{res}	56.4	MPa

Table 1761: Measured quantities, Shot 2789

221.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6932	K
Reservoir Density	ρ_{res}	24.56	kg/m^3
Reservoir Enthalpy	h_{res}	11.9	MJ/kg

Table 1762: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2789

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.96×10^{-1}	2.43×10^{-2}	0	1.15×10^{-1}	0	1.69×10^{-2}	1.47×10^{-1}

Table 1763: Computed reservoir species mass fractions, Shot 2789

221.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4355	1767.0	1767.0	5.23	27.6	0.052	3.77×10^6
72 cm	4316	1839.5	1848.4	4.94	33.6	0.062	4.29×10^6

Table 1764: Computed freestream conditions, Shot 2789

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.41×10^{-1}	1.65×10^{-1}	0	5.60×10^{-2}	0	1.15×10^{-7}	3.85×10^{-2}
72 cm	7.34×10^{-1}	1.68×10^{-1}	0	7.13×10^{-2}	0	2.44×10^{-7}	2.66×10^{-2}

Table 1765: Computed freestream species mass fractions, Shot 2789

221.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4311	1917.3	1917.3	4.97	38.9	0.068	4.57×10^6
72 cm	4244	2068.2	2066.3	4.58	47.0	0.077	4.85×10^6

Table 1766: Computed boundary layer edge conditions, Shot 2789

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.41×10^{-1}	1.65×10^{-1}	0	5.60×10^{-2}	0	1.15×10^{-7}	3.85×10^{-2}
72 cm	7.34×10^{-1}	1.70×10^{-1}	0	7.12×10^{-2}	0	6.27×10^{-7}	2.53×10^{-2}

Table 1767: Computed boundary layer edge species mass fractions, Shot 2789

	T^* K	Unit Re^* 1/m
1D 100 cm	2195	3.63×10^6
72 cm	2178	4.43×10^6

Table 1768: Dorrance reference conditions, Shot 2789

221.5 Stability Computations

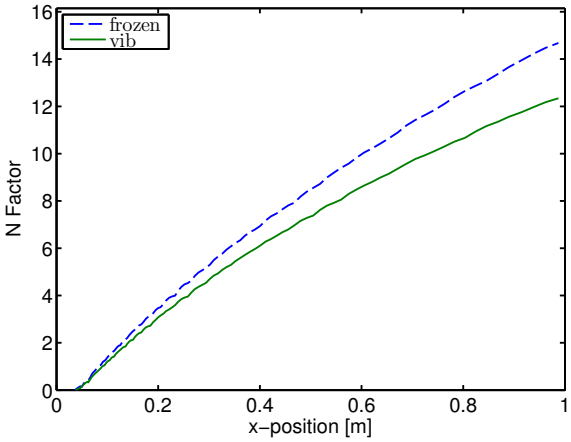


Figure 661: Locus of maximum N factor with and without vibrational energy transfer, Shot 2789

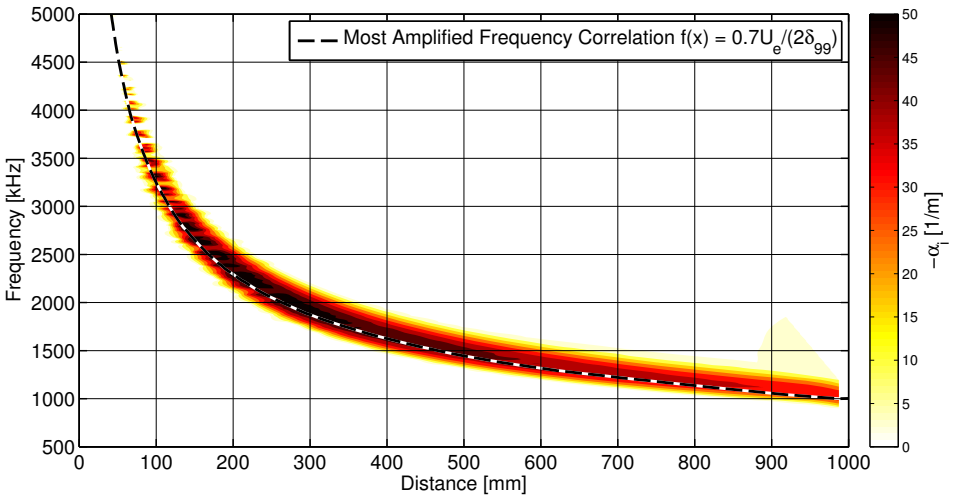


Figure 662: Stability diagram with vibrational energy transfer, Shot 2789. Dashed line indicates $0.7U_e/(2\delta_{99})$.

221.6 Heat Transfer Results

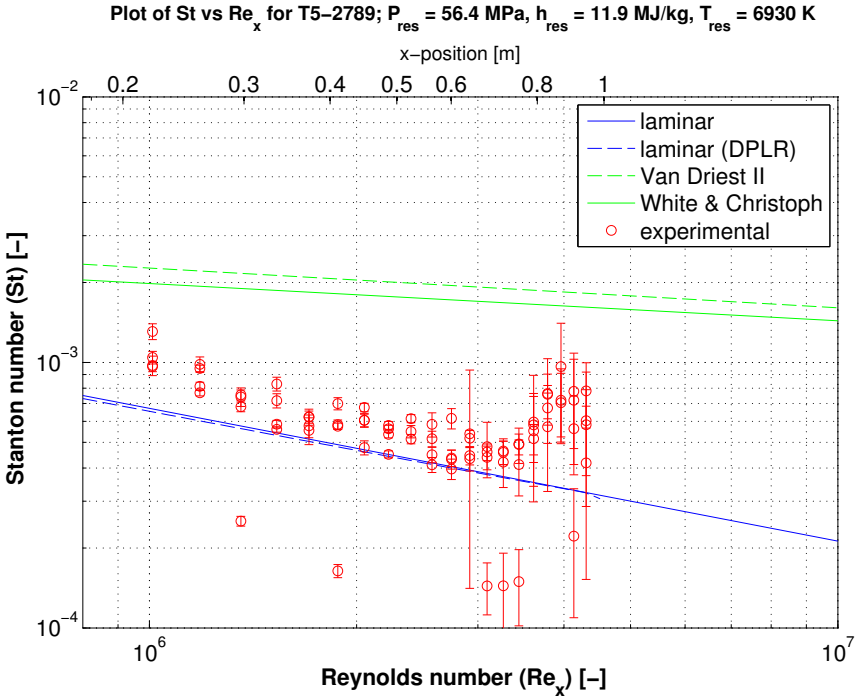


Figure 663: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

222 Shot 2790

Experiment 2790 was performed in T5 on 11 December 2012. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

222.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3450	m/s
Shock Tube Fill Pressure	P_1	75.00	kPa
Reservoir Pressure	P_{res}	57.4	MPa

Table 1769: Measured quantities, Shot 2790

222.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	6818	K
Reservoir Density	ρ_{res}	25.57	kg/m^3
Reservoir Enthalpy	h_{res}	11.6	MJ/kg

Table 1770: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2790

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
6.97×10^{-1}	2.71×10^{-2}	0	1.19×10^{-1}	0	1.45×10^{-2}	1.42×10^{-1}

Table 1771: Computed reservoir species mass fractions, Shot 2790

222.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	4306	1726.0	1726.0	5.25	28.0	0.055	3.95×10^{6}
72 cm	4270	1793.0	1801.9	4.96	34.0	0.064	4.50×10^{6}

Table 1772: Computed freestream conditions, Shot 2790

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.41×10^{-1}	1.68×10^{-1}	0	5.67×10^{-2}	0	8.00×10^{-8}	3.49×10^{-2}
72 cm	7.34×10^{-1}	1.71×10^{-1}	0	7.18×10^{-2}	0	1.70×10^{-7}	2.36×10^{-2}

Table 1773: Computed freestream species mass fractions, Shot 2790

222.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	4263	1873.1	1873.1	4.98	39.4	0.071	4.79×10^{6}
72 cm	4198	2015.7	2013.8	4.60	47.6	0.080	5.08×10^{6}

Table 1774: Computed boundary layer edge conditions, Shot 2790

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.41×10^{-1}	1.68×10^{-1}	0	5.67×10^{-2}	0	8.00×10^{-8}	3.49×10^{-2}
72 cm	7.34×10^{-1}	1.72×10^{-1}	0	7.17×10^{-2}	0	4.49×10^{-7}	2.24×10^{-2}

Table 1775: Computed boundary layer edge species mass fractions, Shot 2790

	T^* K	Unit Re^* 1/m
1D 100 cm	2152	3.78×10^{6}
72 cm	2134	4.61×10^{6}

Table 1776: Dorrance reference conditions, Shot 2790

222.5 Stability Computations

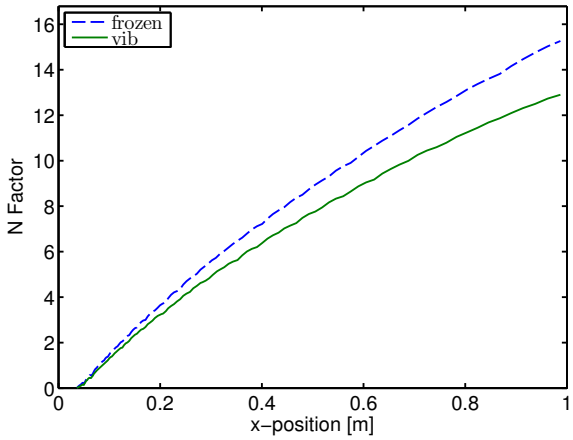


Figure 664: Locus of maximum N factor with and without vibrational energy transfer, Shot 2790

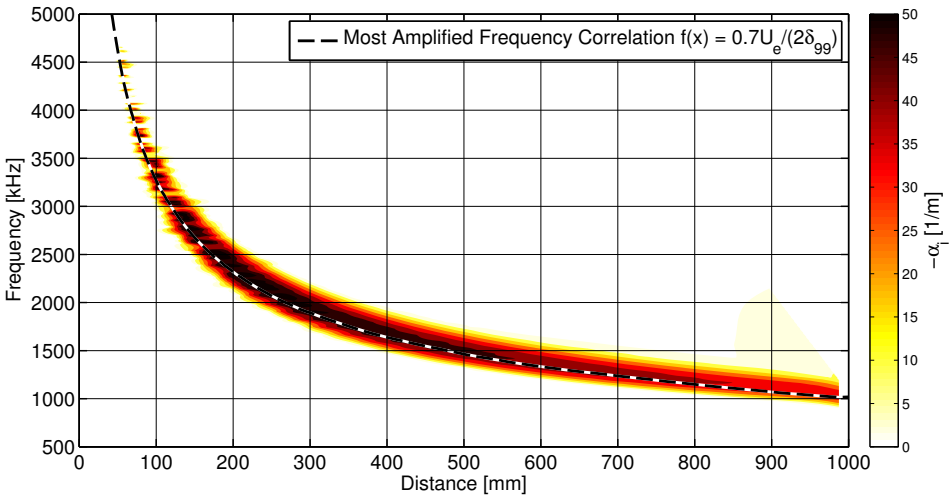


Figure 665: Stability diagram with vibrational energy transfer, Shot 2790. Dashed line indicates $0.7U_e/(2\delta_{99})$.

222.6 Heat Transfer Results

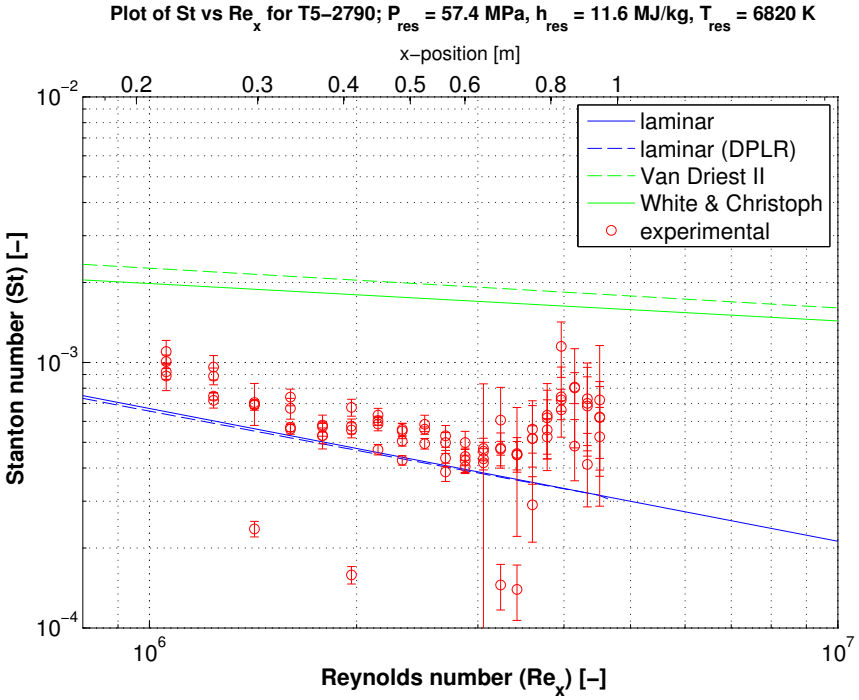


Figure 666: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

223 Shot 2791

Experiment 2791 was performed in T5 on 16 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

223.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3110	m/s
Shock Tube Fill Pressure	P_1	22.00	kPa
Reservoir Pressure	P_{res}	17.6	MPa

Table 1777: Measured quantities, Shot 2791

223.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4135	K
Reservoir Density	ρ_{res}	17.25	kg/m^3
Reservoir Enthalpy	h_{res}	8.83	MJ/kg

Table 1778: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2791

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.67×10^{-1}	4.60×10^{-1}	0	3.43×10^{-1}	0	2.89×10^{-2}

Table 1779: Computed reservoir species mass fractions, Shot 2791

223.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3128	1685.0	1685.0	4.64	12.6	0.033	2.02×10^6
72 cm	3091	1619.6	1620.5	4.32	13.8	0.038	2.32×10^6

Table 1780: Computed freestream conditions, Shot 2791

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.25×10^{-1}	6.44×10^{-1}	0	2.27×10^{-1}	0	4.19×10^{-3}
72 cm	0	1.28×10^{-1}	6.32×10^{-1}	0	2.34×10^{-1}	0	5.72×10^{-3}

Table 1781: Computed freestream species mass fractions, Shot 2791

223.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3094	1764.2	1764.2	4.48	16.5	0.042	2.41×10^6
72 cm	3042	1721.1	1721.0	4.13	18.1	0.047	2.70×10^6

Table 1782: Computed boundary layer edge conditions, Shot 2791

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	1.25×10^{-1}	6.44×10^{-1}	0	2.27×10^{-1}	0	4.19×10^{-3}
72 cm	0	1.28×10^{-1}	6.33×10^{-1}	0	2.34×10^{-1}	0	5.44×10^{-3}

Table 1783: Computed boundary layer edge species mass fractions, Shot 2791

	T^* K	Unit Re^* 1/m
1D 100 cm	1585	2.90×10^6
72 cm	1468	3.16×10^6

Table 1784: Dorrance reference conditions, Shot 2791

223.5 Stability Computations

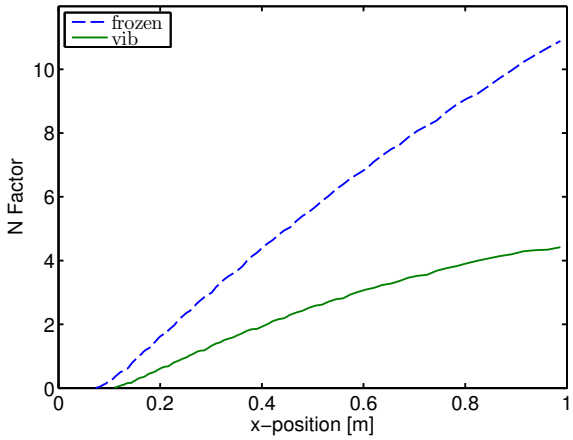


Figure 667: Locus of maximum N factor with and without vibrational energy transfer, Shot 2791

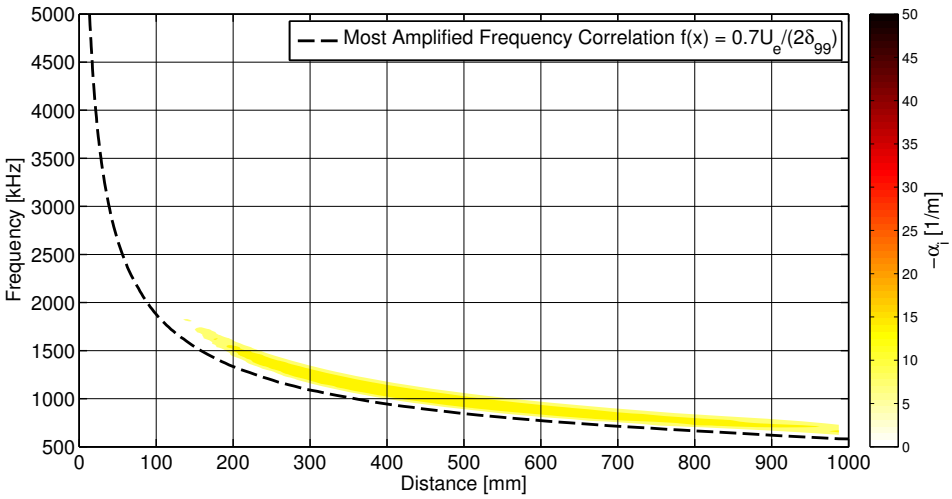


Figure 668: Stability diagram with vibrational energy transfer, Shot 2791. Dashed line indicates $0.7U_e/(2\delta_{99})$.

223.6 Heat Transfer Results

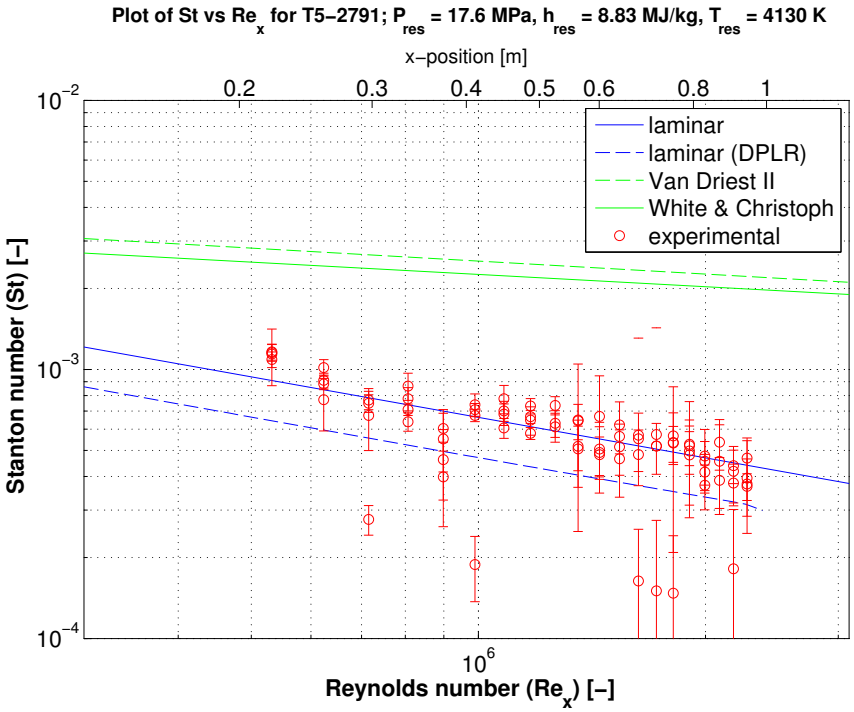


Figure 669: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

224 Shot 2792

Experiment 2792 was performed in T5 on 17 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

224.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2740	m/s
Shock Tube Fill Pressure	P_1	32.00	kPa
Reservoir Pressure	P_{res}	18.3	MPa

Table 1785: Measured quantities, Shot 2792

224.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3717	K
Reservoir Density	ρ_{res}	21.87	kg/m^3
Reservoir Enthalpy	h_{res}	6.80	MJ/kg

Table 1786: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2792

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	1.18×10^{-1}	6.48×10^{-1}	0	2.24×10^{-1}	0	9.82×10^{-3}

Table 1787: Computed reservoir species mass fractions, Shot 2792

224.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2820	1431.0	1431.0	4.68	12.7	0.042	2.62×10^6
72 cm	2795	1419.1	1420.1	4.31	14.4	0.048	2.99×10^6

Table 1788: Computed freestream conditions, Shot 2792

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	8.13×10^{-4}
72 cm	0	8.68×10^{-2}	7.59×10^{-1}	0	1.54×10^{-1}	0	9.79×10^{-4}

Table 1789: Computed freestream species mass fractions, Shot 2792

224.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2790	1495.8	1495.8	4.53	16.6	0.052	3.14×10^6
72 cm	2752	1498.0	1498.0	4.13	18.9	0.059	3.50×10^6

Table 1790: Computed boundary layer edge conditions, Shot 2792

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	8.59×10^{-2}	7.62×10^{-1}	0	1.52×10^{-1}	0	8.13×10^{-4}
72 cm	0	8.68×10^{-2}	7.59×10^{-1}	0	1.54×10^{-1}	0	9.28×10^{-4}

Table 1791: Computed boundary layer edge species mass fractions, Shot 2792

	T^* K	Unit Re^* 1/m
1D 100 cm	1354	3.70×10^6
72 cm	1277	4.10×10^6

Table 1792: Dorrance reference conditions, Shot 2792

224.5 Stability Computations

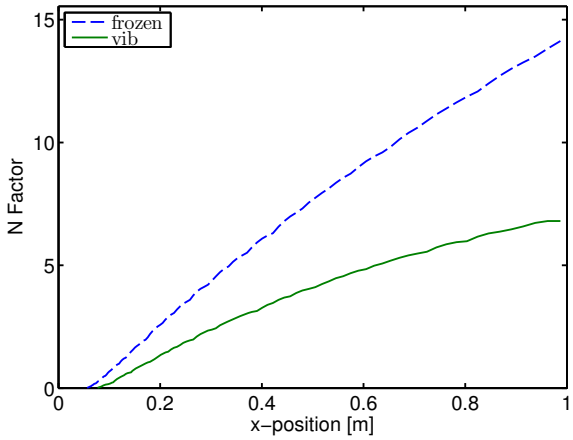


Figure 670: Locus of maximum N factor with and without vibrational energy transfer, Shot 2792

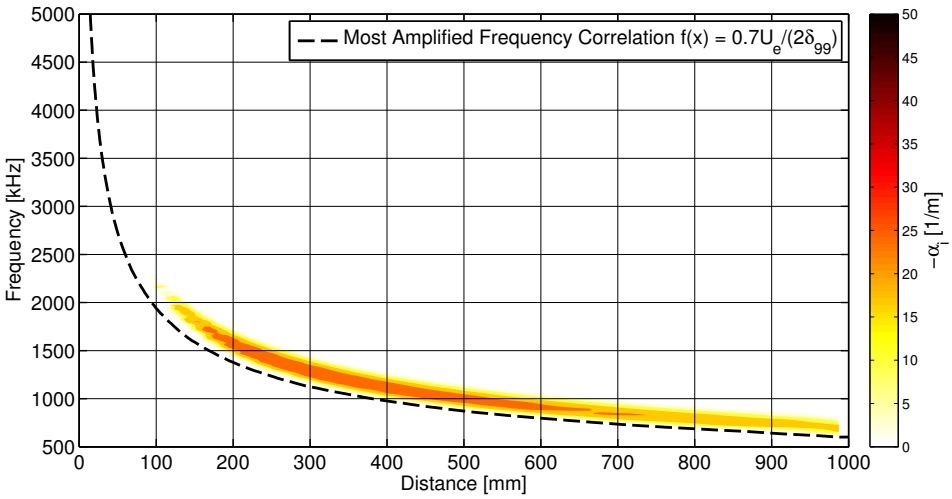


Figure 671: Stability diagram with vibrational energy transfer, Shot 2792. Dashed line indicates $0.7U_e/(2\delta_{99})$.

224.6 Heat Transfer Results

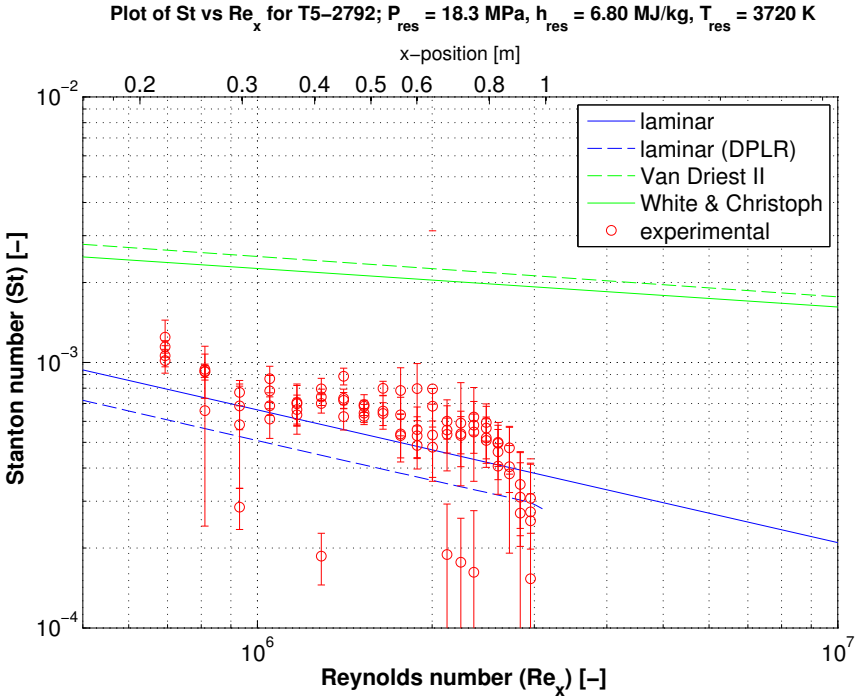


Figure 672: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

225 Shot 2793

Experiment 2793 was performed in T5 on 24 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

225.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2220	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	22.7	MPa

Table 1793: Measured quantities, Shot 2793

225.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3179	K
Reservoir Density	ρ_{res}	35.28	kg/m^3
Reservoir Enthalpy	h_{res}	4.61	MJ/kg

Table 1794: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2793

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	4.94×10^{-2}	8.60×10^{-1}	0	8.88×10^{-2}	0	1.32×10^{-3}

Table 1795: Computed reservoir species mass fractions, Shot 2793

225.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2449	1141.0	1141.0	4.71	15.4	0.068	4.18×10^6
72 cm	2440	1163.8	1164.8	4.29	18.1	0.078	4.78×10^6

Table 1796: Computed freestream conditions, Shot 2793

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	3.88×10^{-2}	8.93×10^{-1}	0	6.80×10^{-2}	0	4.87×10^{-5}
72 cm	0	3.68×10^{-2}	8.99×10^{-1}	0	6.45×10^{-2}	0	1.83×10^{-5}

Table 1797: Computed freestream species mass fractions, Shot 2793

225.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2423	1191.1	1191.1	4.57	20.2	0.085	5.09×10^6
72 cm	2401	1224.3	1224.3	4.12	23.6	0.097	5.70×10^6

Table 1798: Computed boundary layer edge conditions, Shot 2793

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	3.88×10^{-2}	8.93×10^{-1}	0	6.80×10^{-2}	0	4.87×10^{-5}
72 cm	0	3.68×10^{-2}	8.99×10^{-1}	0	6.45×10^{-2}	0	1.69×10^{-5}

Table 1799: Computed boundary layer edge species mass fractions, Shot 2793

	T^* K	Unit Re^* 1/m
1D 100 cm	1099	5.71×10^6
72 cm	1058	7.04×10^6

Table 1800: Dorrance reference conditions, Shot 2793

225.5 Stability Computations

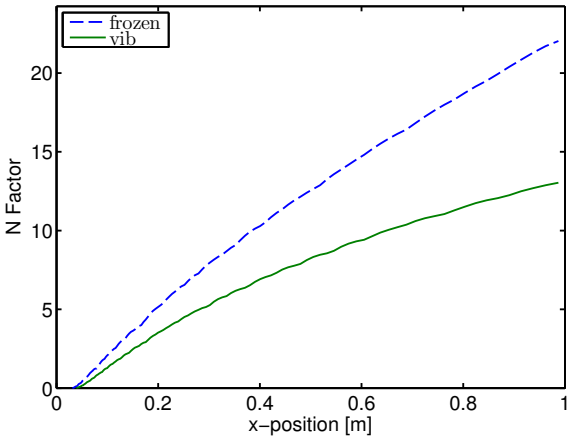


Figure 673: Locus of maximum N factor with and without vibrational energy transfer, Shot 2793

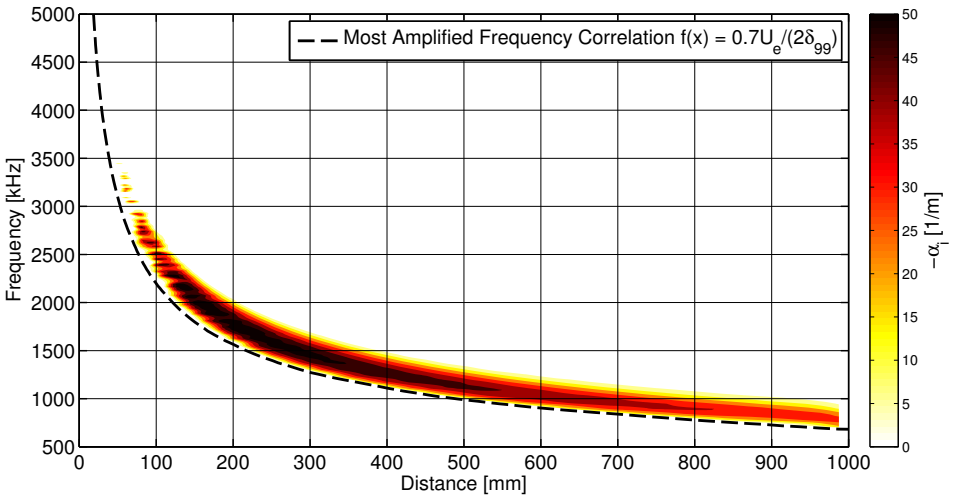


Figure 674: Stability diagram with vibrational energy transfer, Shot 2793. Dashed line indicates $0.7U_e/(2\delta_{99})$.

225.6 Heat Transfer Results

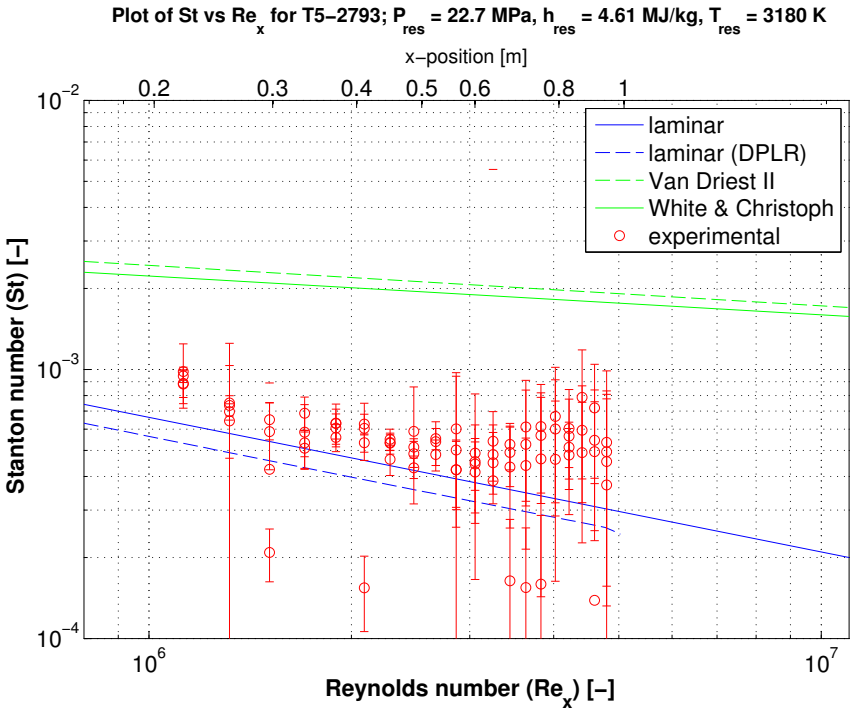


Figure 675: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

226 Shot 2794

Experiment 2794 was performed in T5 on 25 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

226.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2390	m/s
Shock Tube Fill Pressure	P_1	47.00	kPa
Reservoir Pressure	P_{res}	23.2	MPa

Table 1801: Measured quantities, Shot 2794

226.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3375	K
Reservoir Density	ρ_{res}	32.92	kg/m^3
Reservoir Enthalpy	h_{res}	5.27	MJ/kg

Table 1802: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2794

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	6.97×10^{-2}	8.01×10^{-1}	0	1.27×10^{-1}	0	2.78×10^{-3}

Table 1803: Computed reservoir species mass fractions, Shot 2794

226.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2572	1240.0	1240.0	4.71	15.9	0.063	3.94×10^6
72 cm	2560	1258.8	1259.7	4.29	18.5	0.073	4.46×10^6

Table 1804: Computed freestream conditions, Shot 2794

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.23×10^{-2}	8.56×10^{-1}	0	9.18×10^{-2}	0	1.10×10^{-4}
72 cm	0	5.03×10^{-2}	8.62×10^{-1}	0	8.81×10^{-2}	0	7.29×10^{-5}

Table 1805: Computed freestream species mass fractions, Shot 2794

226.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2544	1293.8	1293.8	4.56	20.9	0.080	4.80×10^6
72 cm	2519	1324.8	1324.8	4.12	24.1	0.090	5.32×10^6

Table 1806: Computed boundary layer edge conditions, Shot 2794

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.23×10^{-2}	8.56×10^{-1}	0	9.18×10^{-2}	0	1.10×10^{-4}
72 cm	0	5.03×10^{-2}	8.62×10^{-1}	0	8.81×10^{-2}	0	6.73×10^{-5}

Table 1807: Computed boundary layer edge species mass fractions, Shot 2794

	T^* K	Unit Re^* 1/m
1D 100 cm	1182	5.46×10^6
72 cm	1134	6.22×10^6

Table 1808: Dorrance reference conditions, Shot 2794

226.5 Stability Computations

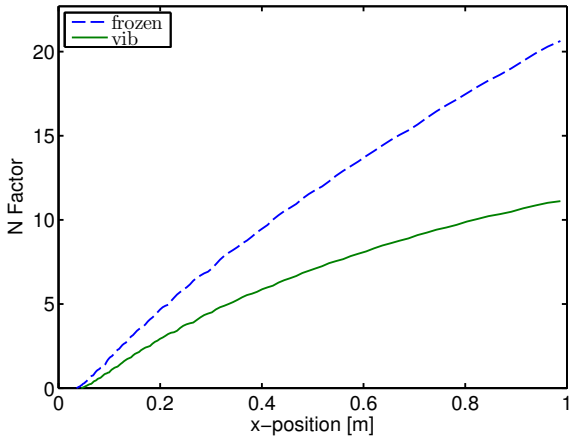


Figure 676: Locus of maximum N factor with and without vibrational energy transfer, Shot 2794

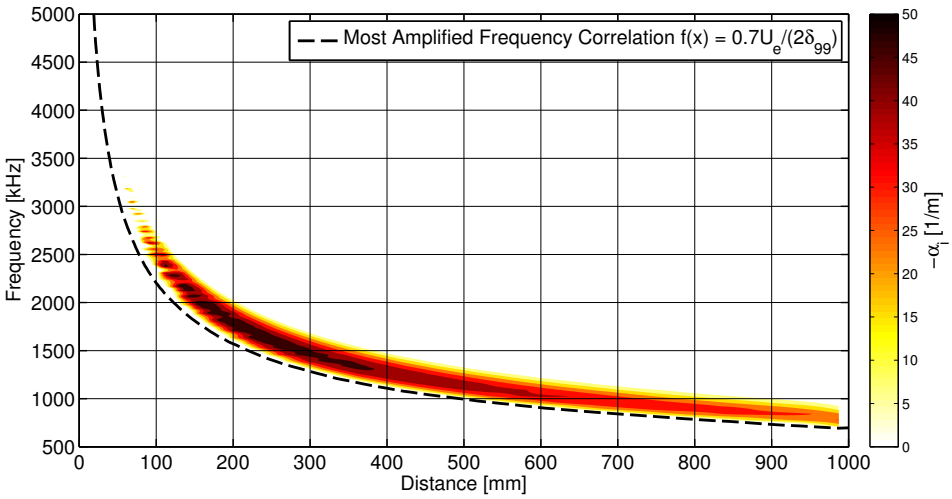


Figure 677: Stability diagram with vibrational energy transfer, Shot 2794. Dashed line indicates $0.7U_e/(2\delta_{99})$.

226.6 Heat Transfer Results

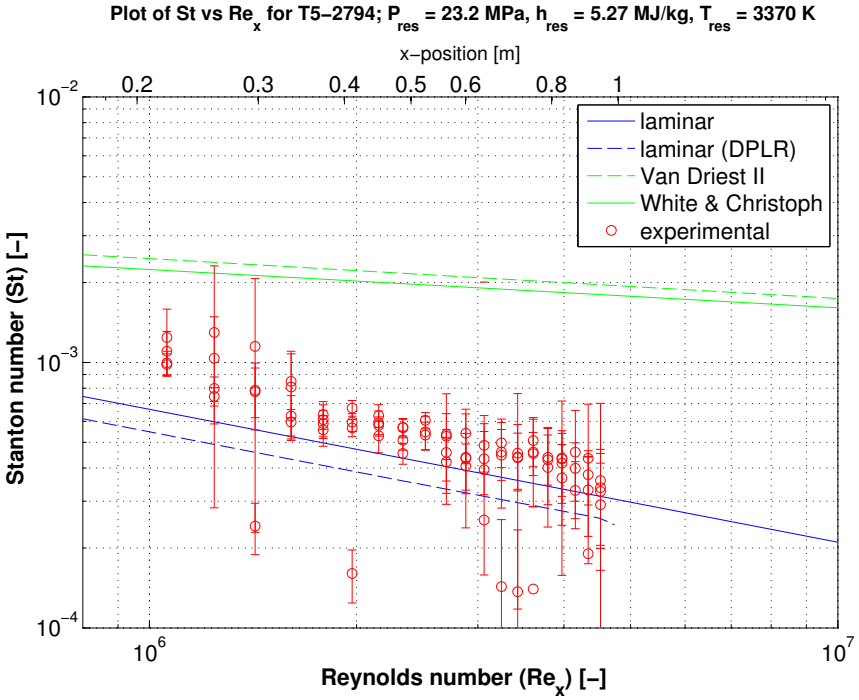


Figure 678: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

227 Shot 2795

Experiment 2795 was performed in T5 on 26 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

227.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2430	m/s
Shock Tube Fill Pressure	P_1	41.00	kPa
Reservoir Pressure	P_{res}	22.6	MPa

Table 1809: Measured quantities, Shot 2795

227.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3433	K
Reservoir Density	ρ_{res}	31.27	kg/m^3
Reservoir Enthalpy	h_{res}	5.50	MJ/kg

Table 1810: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2795

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	7.70×10^{-2}	7.79×10^{-1}	0	1.41×10^{-1}	0	3.47×10^{-3}

Table 1811: Computed reservoir species mass fractions, Shot 2795

227.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2611	1272.0	1272.0	4.70	15.6	0.060	3.75×10^6
72 cm	2598	1287.3	1288.2	4.29	18.0	0.069	4.25×10^6

Table 1812: Computed freestream conditions, Shot 2795

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.71×10^{-2}	8.43×10^{-1}	0	1.00×10^{-1}	0	1.51×10^{-4}
72 cm	0	5.54×10^{-2}	8.47×10^{-1}	0	9.71×10^{-2}	0	1.16×10^{-4}

Table 1813: Computed freestream species mass fractions, Shot 2795

227.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2584	1327.4	1327.4	4.55	20.4	0.076	4.56×10^6
72 cm	2558	1354.6	1354.6	4.12	23.5	0.085	5.07×10^6

Table 1814: Computed boundary layer edge conditions, Shot 2795

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.71×10^{-2}	8.43×10^{-1}	0	1.00×10^{-1}	0	1.51×10^{-4}
72 cm	0	5.54×10^{-2}	8.47×10^{-1}	0	9.71×10^{-2}	0	1.07×10^{-4}

Table 1815: Computed boundary layer edge species mass fractions, Shot 2795

	T^* K	Unit Re^* 1/m
1D 100 cm	1210	5.22×10^6
72 cm	1158	5.93×10^6

Table 1816: Dorrance reference conditions, Shot 2795

227.5 Stability Computations

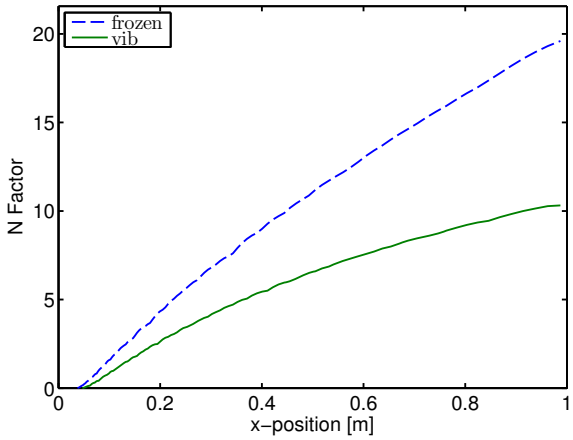


Figure 679: Locus of maximum N factor with and without vibrational energy transfer, Shot 2795

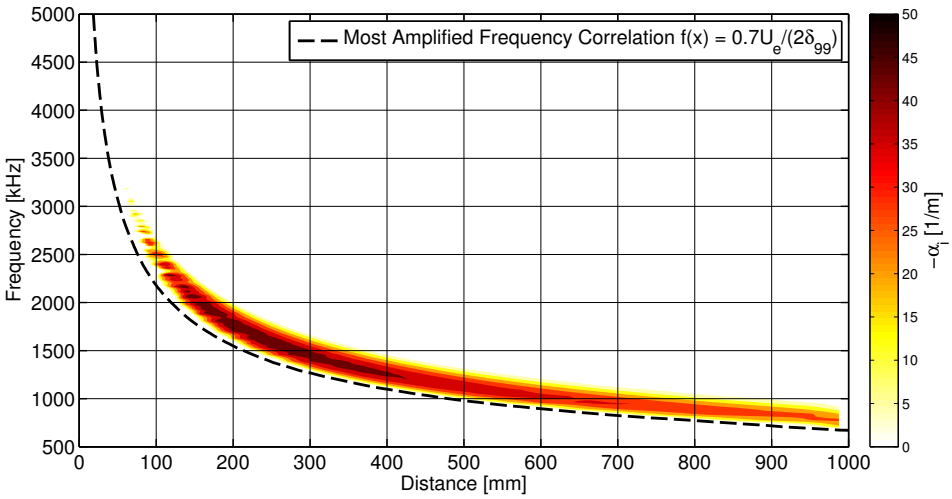


Figure 680: Stability diagram with vibrational energy transfer, Shot 2795. Dashed line indicates $0.7U_e/(2\delta_{99})$.

227.6 Heat Transfer Results

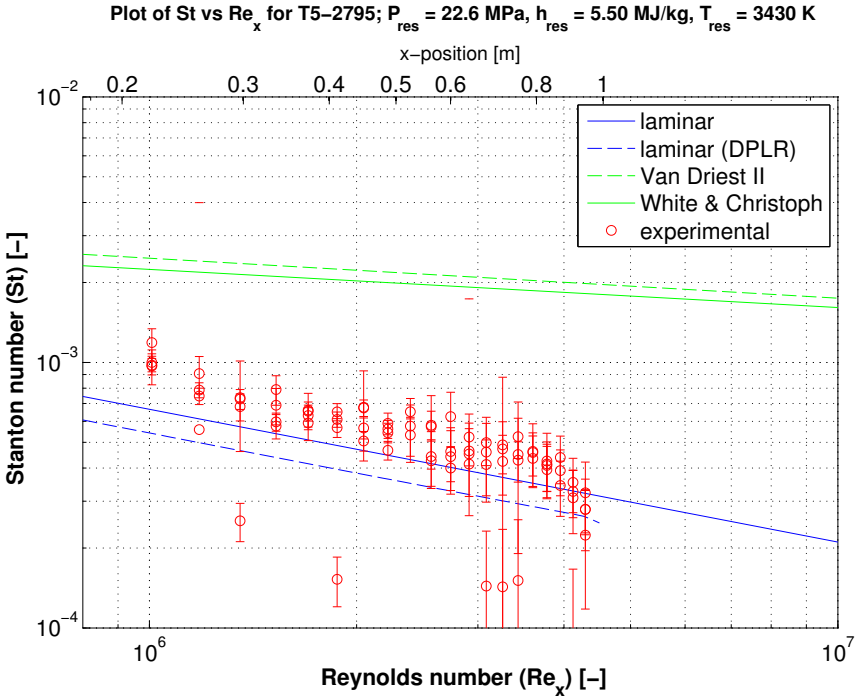


Figure 681: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

228 Shot 2796

Experiment 2796 was performed in T5 on 28 January 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

228.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2400	m/s
Shock Tube Fill Pressure	P_1	47.00	kPa
Reservoir Pressure	P_{res}	23.1	MPa

Table 1817: Measured quantities, Shot 2796

228.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3383	K
Reservoir Density	ρ_{res}	32.66	kg/m^3
Reservoir Enthalpy	h_{res}	5.31	MJ/kg

Table 1818: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2796

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	7.08×10^{-2}	7.97×10^{-1}	0	1.29×10^{-1}	0	2.87×10^{-3}

Table 1819: Computed reservoir species mass fractions, Shot 2796

228.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2574	1240.0	1240.0	4.71	15.6	0.062	3.85×10^6
72 cm	2566	1263.0	1263.9	4.29	18.4	0.072	4.43×10^6

Table 1820: Computed freestream conditions, Shot 2796

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.30×10^{-2}	8.54×10^{-1}	0	9.31×10^{-2}	0	1.16×10^{-4}
72 cm	0	5.10×10^{-2}	8.59×10^{-1}	0	8.94×10^{-2}	0	7.82×10^{-5}

Table 1821: Computed freestream species mass fractions, Shot 2796

228.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2547	1294.6	1294.6	4.56	20.4	0.078	4.68×10^6
72 cm	2526	1328.8	1328.7	4.12	24.0	0.089	5.29×10^6

Table 1822: Computed boundary layer edge conditions, Shot 2796

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.30×10^{-2}	8.54×10^{-1}	0	9.31×10^{-2}	0	1.16×10^{-4}
72 cm	0	5.10×10^{-2}	8.60×10^{-1}	0	8.94×10^{-2}	0	7.23×10^{-5}

Table 1823: Computed boundary layer edge species mass fractions, Shot 2796

	T^* K	Unit Re^* 1/m
1D 100 cm	1184	5.33×10^6
72 cm	1138	6.17×10^6

Table 1824: Dorrance reference conditions, Shot 2796

228.5 Stability Computations

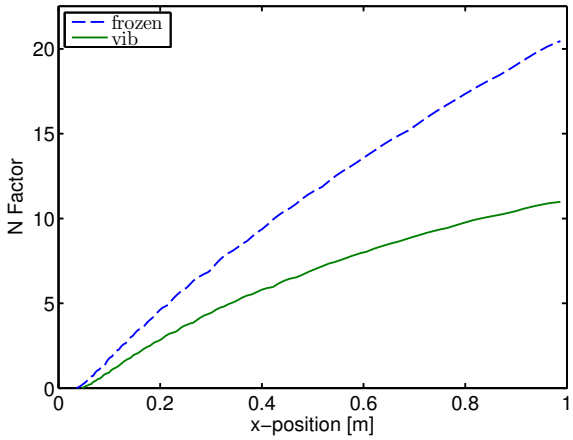


Figure 682: Locus of maximum N factor with and without vibrational energy transfer, Shot 2796

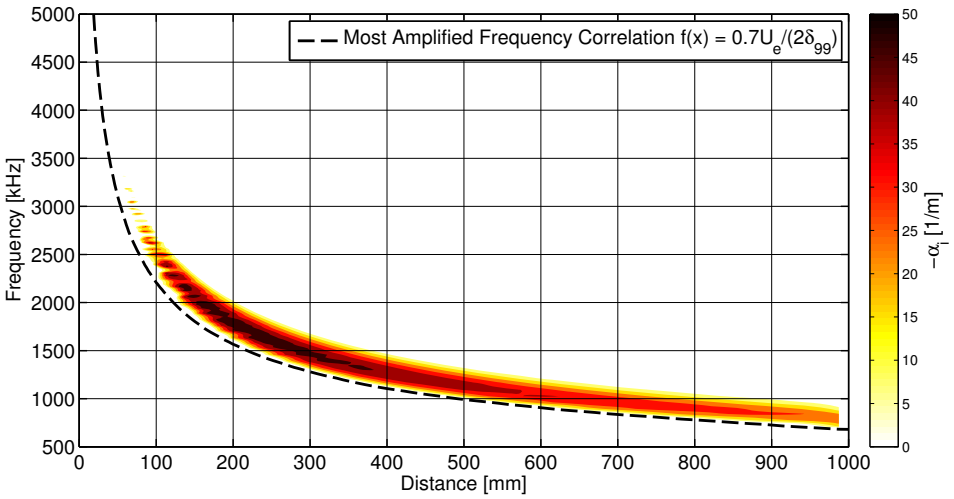


Figure 683: Stability diagram with vibrational energy transfer, Shot 2796. Dashed line indicates $0.7U_e/(2\delta_{99})$.

228.6 Heat Transfer Results

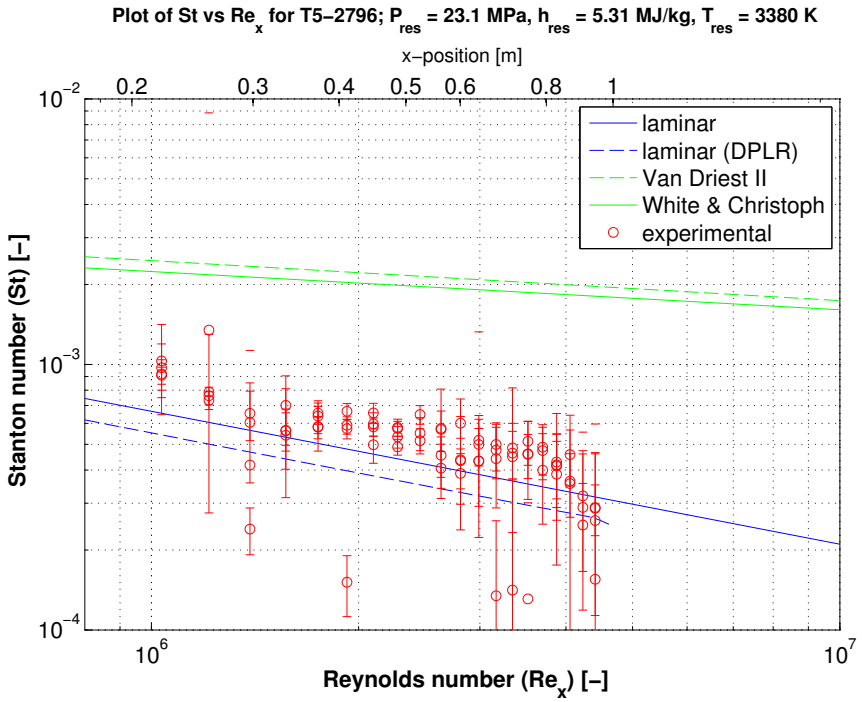


Figure 684: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

229 Shot 2797

Experiment 2797 was performed in T5 on 1 February 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

229.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2590	m/s
Shock Tube Fill Pressure	P_1	100.65	kPa
Reservoir Pressure	P_{res}	56.7	MPa

Table 1825: Measured quantities, Shot 2797

229.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3718	K
Reservoir Density	ρ_{res}	71.04	kg/m^3
Reservoir Enthalpy	h_{res}	6.15	MJ/kg

Table 1826: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2797

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.90×10^{-2}	7.42×10^{-1}	0	1.64×10^{-1}	0	4.74×10^{-3}

Table 1827: Computed reservoir species mass fractions, Shot 2797

229.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2913	1068.0	1068.0	5.69	6.5	0.030	2.21×10^6
72 cm	2937	1021.0	1026.0	5.44	5.4	0.026	1.99×10^6

Table 1828: Computed freestream conditions, Shot 2797

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.03×10^{-2}	8.33×10^{-1}	0	1.06×10^{-1}	0	2.16×10^{-4}
72 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.20×10^{-4}

Table 1829: Computed freestream species mass fractions, Shot 2797

229.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2885	1132.7	1132.7	5.47	9.2	0.040	2.87×10^6
72 cm	2892	1114.6	1114.2	5.12	7.8	0.034	2.51×10^6

Table 1830: Computed boundary layer edge conditions, Shot 2797

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	6.03×10^{-2}	8.33×10^{-1}	0	1.06×10^{-1}	0	2.16×10^{-4}
72 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.18×10^{-4}

Table 1831: Computed boundary layer edge species mass fractions, Shot 2797

	T^* K	Unit Re^* 1/m
1D 100 cm	1225	2.56×10^6
72 cm	1146	2.44×10^6

Table 1832: Dorrance reference conditions, Shot 2797

229.5 Stability Computations

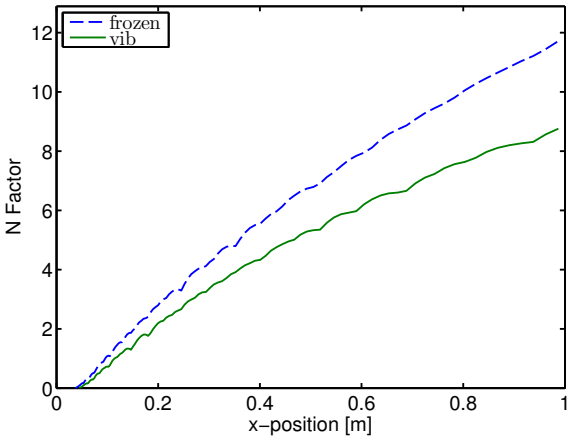


Figure 685: Locus of maximum N factor with and without vibrational energy transfer, Shot 2797

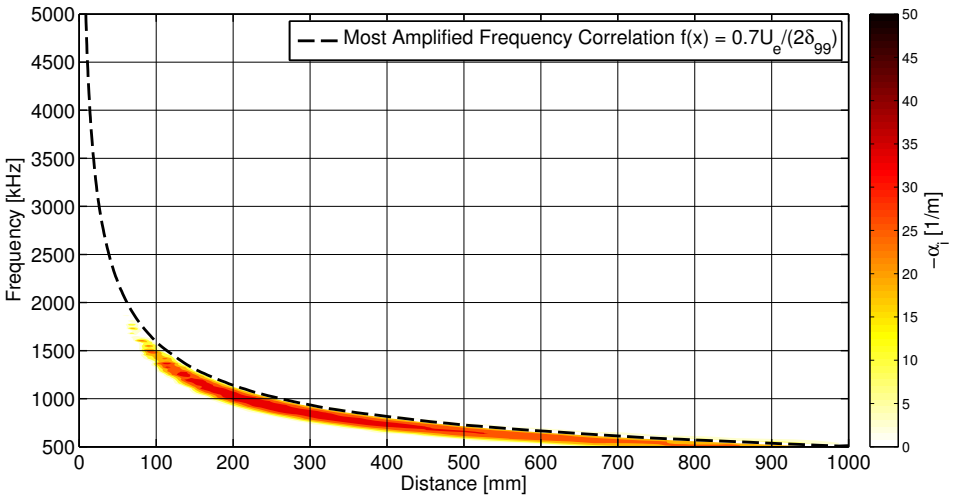


Figure 686: Stability diagram with vibrational energy transfer, Shot 2797. Dashed line indicates $0.7U_e/(2\delta_{99})$.

229.6 Heat Transfer Results

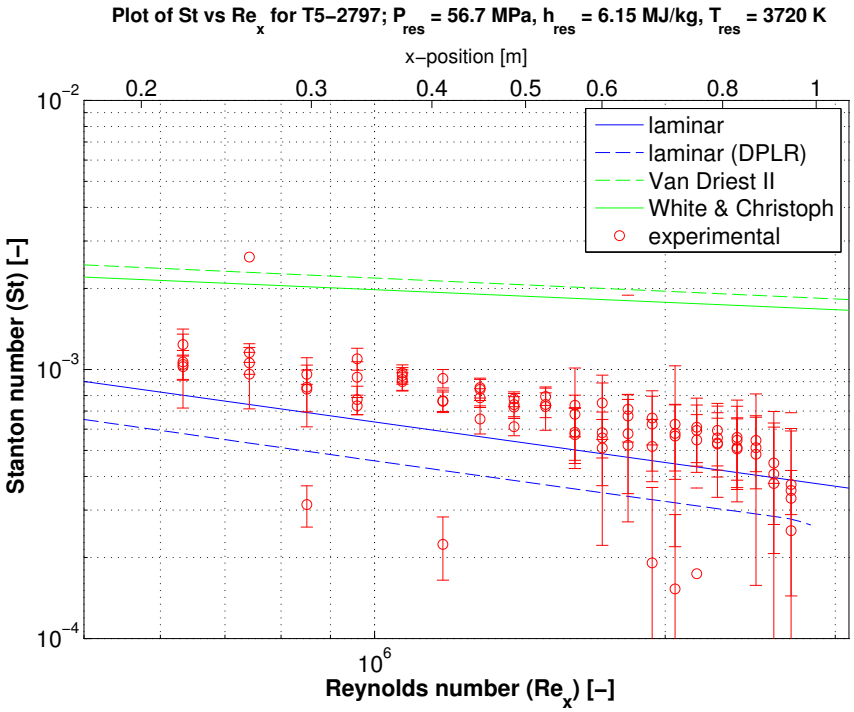


Figure 687: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

230 Shot 2798

Experiment 2798 was performed in T5 on 25 February 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

230.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2560	m/s
Shock Tube Fill Pressure	P_1	100.60	kPa
Reservoir Pressure	P_{res}	54.4	MPa

Table 1833: Measured quantities, Shot 2798

230.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3668	K
Reservoir Density	ρ_{res}	69.66	kg/m^3
Reservoir Enthalpy	h_{res}	5.98	MJ/kg

Table 1834: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2798

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.44×10^{-2}	7.56×10^{-1}	0	1.55×10^{-1}	0	4.19×10^{-3}

Table 1835: Computed reservoir species mass fractions, Shot 2798

230.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2881	1046.0	1046.0	5.70	6.2	0.029	2.18×10^6
72 cm	2904	996.6	1002.1	5.45	5.2	0.025	1.96×10^6

Table 1836: Computed freestream conditions, Shot 2798

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.87×10^{-4}
72 cm	0	5.61×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	9.27×10^{-5}

Table 1837: Computed freestream species mass fractions, Shot 2798

230.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2854	1109.0	1109.0	5.48	8.9	0.039	2.83×10^6
72 cm	2859	1089.1	1088.7	5.13	7.5	0.034	2.46×10^6

Table 1838: Computed boundary layer edge conditions, Shot 2798

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.87×10^{-4}
72 cm	0	5.61×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	9.14×10^{-5}

Table 1839: Computed boundary layer edge species mass fractions, Shot 2798

	T^* K	Unit Re^* 1/m
1D 100 cm	1204	2.52×10^6
72 cm	1125	2.39×10^6

Table 1840: Dorrance reference conditions, Shot 2798

230.5 Stability Computations

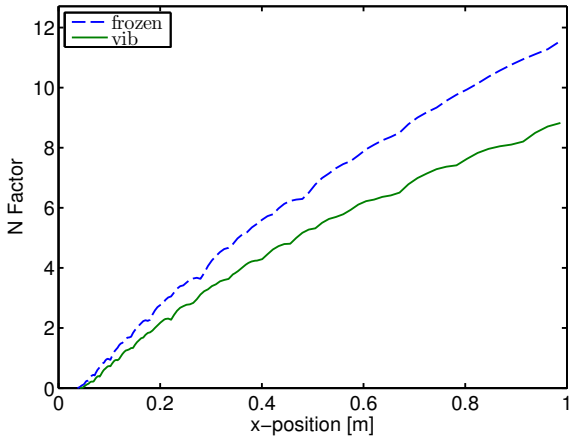


Figure 688: Locus of maximum N factor with and without vibrational energy transfer, Shot 2798

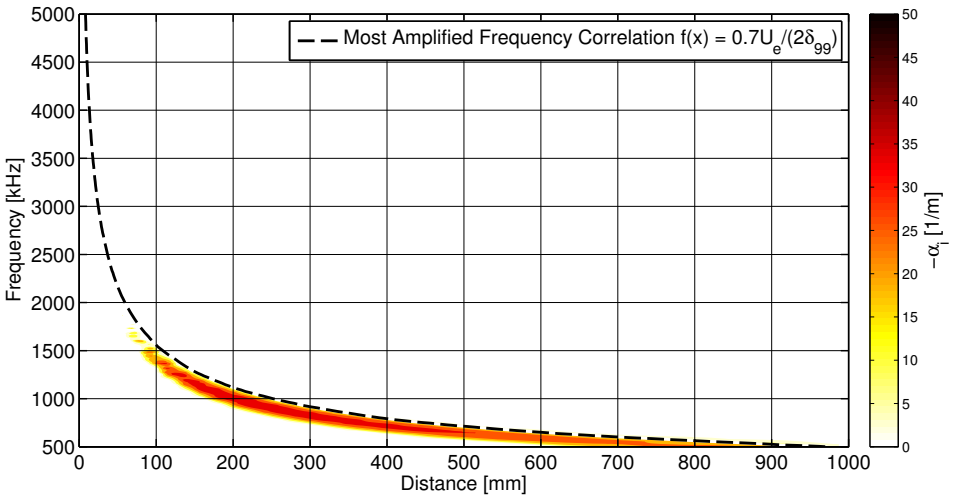


Figure 689: Stability diagram with vibrational energy transfer, Shot 2798. Dashed line indicates $0.7U_e/(2\delta_{99})$.

230.6 Heat Transfer Results

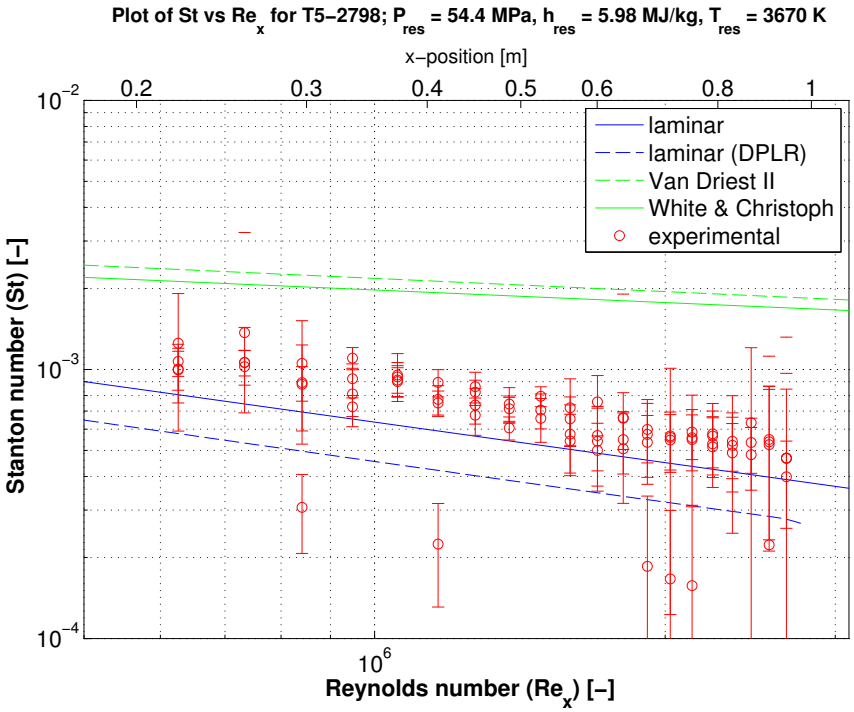


Figure 690: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

231 Shot 2799

Experiment 2799 was performed in T5 on 26 February 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

231.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2560	m/s
Shock Tube Fill Pressure	P_1	100.20	kPa
Reservoir Pressure	P_{res}	55.1	MPa

Table 1841: Measured quantities, Shot 2799

231.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3672	K
Reservoir Density	ρ_{res}	70.34	kg/m^3
Reservoir Enthalpy	h_{res}	5.99	MJ/kg

Table 1842: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2799

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.47×10^{-2}	7.55×10^{-1}	0	1.56×10^{-1}	0	4.22×10^{-3}

Table 1843: Computed reservoir species mass fractions, Shot 2799

231.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2883	1047.0	1047.0	5.70	6.3	0.029	2.20×10^6
72 cm	2907	999.4	1004.7	5.45	5.2	0.026	1.98×10^6

Table 1844: Computed freestream conditions, Shot 2799

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.87×10^{-4}
72 cm	0	5.61×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	9.33×10^{-5}

Table 1845: Computed freestream species mass fractions, Shot 2799

231.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2856	1110.9	1110.9	5.48	9.0	0.039	2.85×10^6
72 cm	2861	1092.3	1091.9	5.13	7.6	0.034	2.49×10^6

Table 1846: Computed boundary layer edge conditions, Shot 2799

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.81×10^{-2}	8.40×10^{-1}	0	1.02×10^{-1}	0	1.87×10^{-4}
72 cm	0	5.61×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	9.19×10^{-5}

Table 1847: Computed boundary layer edge species mass fractions, Shot 2799

	T^* K	Unit Re^* 1/m
1D 100 cm	1206	2.53×10^6
72 cm	1127	2.41×10^6

Table 1848: Dorrance reference conditions, Shot 2799

231.5 Stability Computations

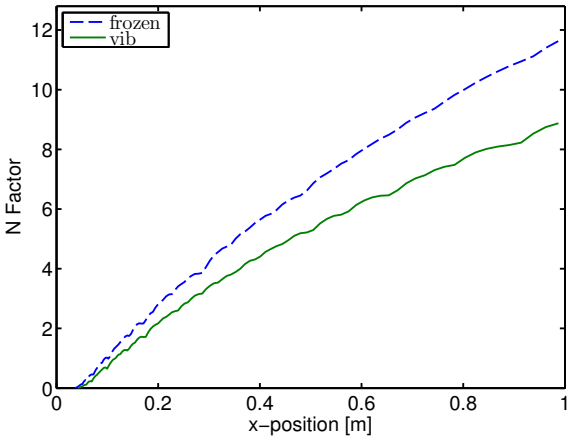


Figure 691: Locus of maximum N factor with and without vibrational energy transfer, Shot 2799

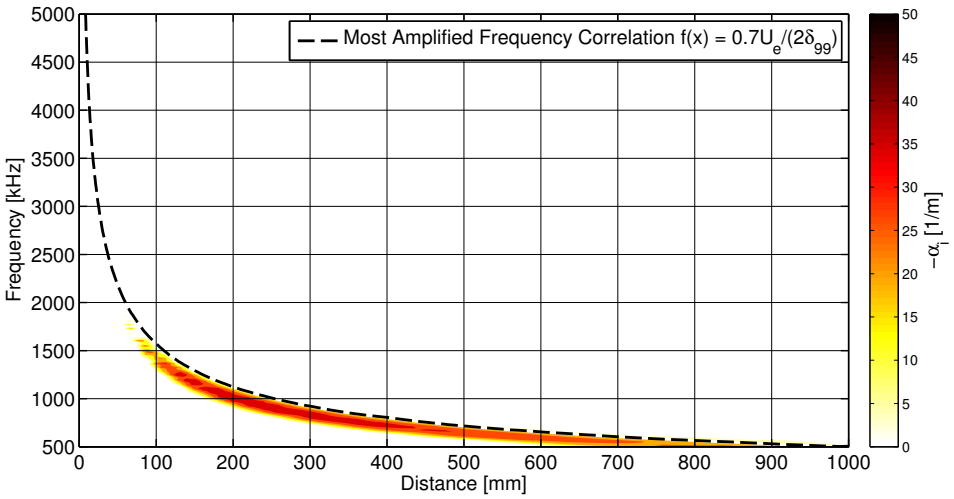


Figure 692: Stability diagram with vibrational energy transfer, Shot 2799. Dashed line indicates $0.7U_e/(2\delta_{99})$.

231.6 Heat Transfer Results

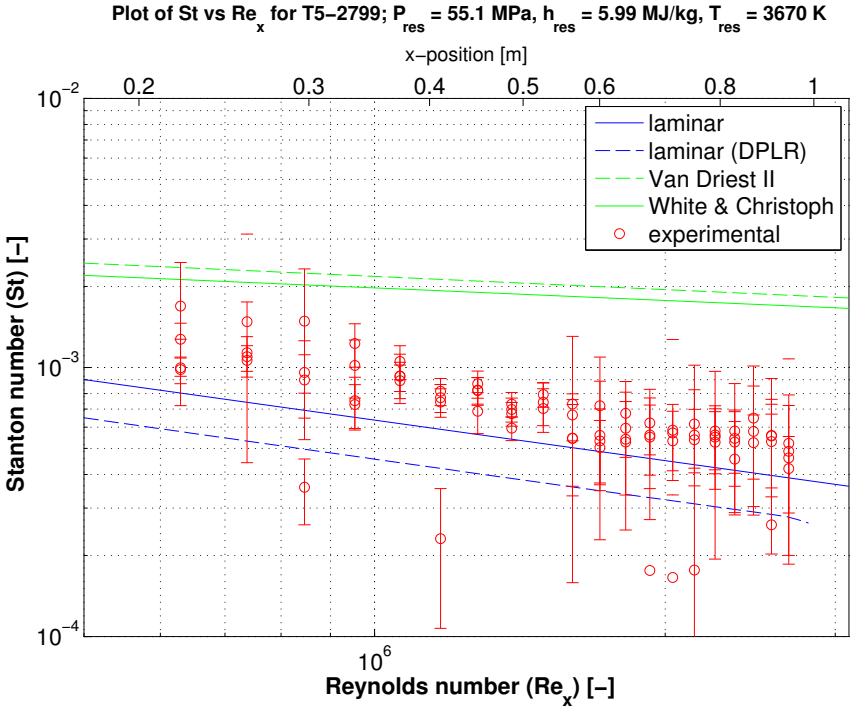


Figure 693: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

232 Shot 2800

Experiment 2800 was performed in T5 on 1 March 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

232.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2520	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	53.7	MPa

Table 1849: Measured quantities, Shot 2800

232.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3629	K
Reservoir Density	ρ_{res}	69.86	kg/m^3
Reservoir Enthalpy	h_{res}	5.85	MJ/kg

Table 1850: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2800

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.05×10^{-2}	7.68×10^{-1}	0	1.48×10^{-1}	0	3.75×10^{-3}

Table 1851: Computed reservoir species mass fractions, Shot 2800

232.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2855	1027.0	1027.0	5.70	6.1	0.029	2.19×10^6
72 cm	2878	979.3	985.0	5.46	5.1	0.025	1.96×10^6

Table 1852: Computed freestream conditions, Shot 2800

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.60×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	1.62×10^{-4}
72 cm	0	5.41×10^{-2}	8.51×10^{-1}	0	9.48×10^{-2}	0	7.24×10^{-5}

Table 1853: Computed freestream species mass fractions, Shot 2800

232.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2828	1089.8	1089.8	5.48	8.7	0.039	2.84×10^6
72 cm	2832	1070.7	1070.3	5.13	7.4	0.034	2.47×10^6

Table 1854: Computed boundary layer edge conditions, Shot 2800

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.60×10^{-2}	8.45×10^{-1}	0	9.84×10^{-2}	0	1.62×10^{-4}
72 cm	0	5.41×10^{-2}	8.51×10^{-1}	0	9.48×10^{-2}	0	7.14×10^{-5}

Table 1855: Computed boundary layer edge species mass fractions, Shot 2800

	T^* K	Unit Re^* 1/m
1D 100 cm	1187	2.51×10^6
72 cm	1109	2.38×10^6

Table 1856: Dorrance reference conditions, Shot 2800

232.5 Stability Computations

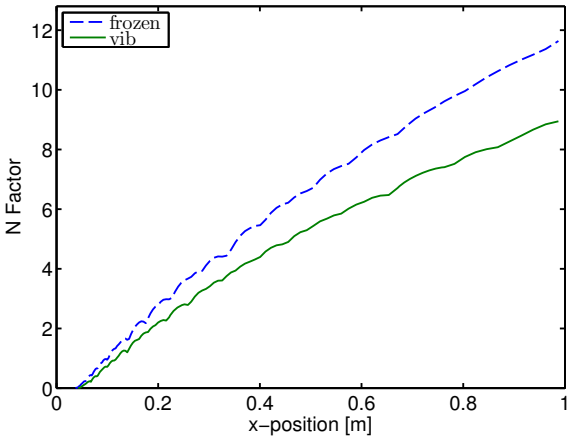


Figure 694: Locus of maximum N factor with and without vibrational energy transfer, Shot 2800

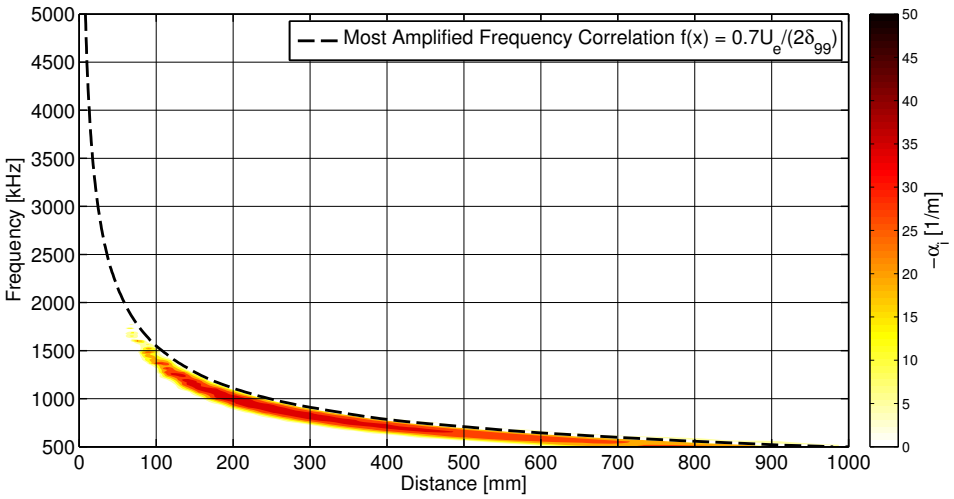


Figure 695: Stability diagram with vibrational energy transfer, Shot 2800. Dashed line indicates $0.7U_e/(2\delta_{99})$.

232.6 Heat Transfer Results

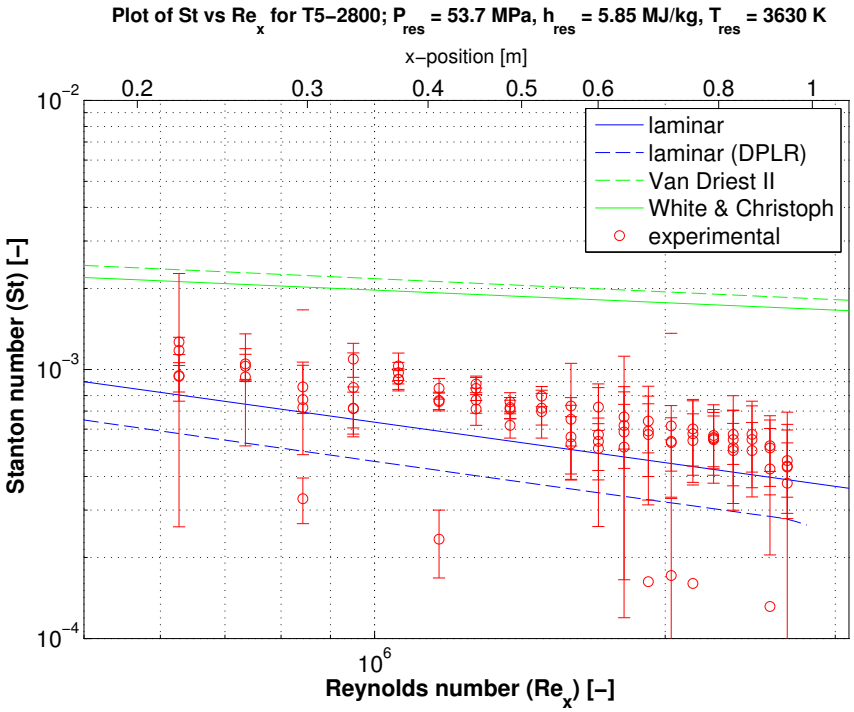


Figure 696: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

233 Shot 2801

Experiment 2801 was performed in T5 on 2 May 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

233.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2540	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	54.9	MPa

Table 1857: Measured quantities, Shot 2801

233.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3660	K
Reservoir Density	ρ_{res}	70.52	kg/m^3
Reservoir Enthalpy	h_{res}	5.95	MJ/kg

Table 1858: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2801

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	8.34×10^{-2}	7.59×10^{-1}	0	1.53×10^{-1}	0	4.07×10^{-3}

Table 1859: Computed reservoir species mass fractions, Shot 2801

233.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2875	1041.0	1041.0	5.70	6.2	0.029	2.20×10^6
72 cm	2899	993.8	999.3	5.45	5.2	0.026	1.98×10^6

Table 1860: Computed freestream conditions, Shot 2801

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.74×10^{-2}	8.42×10^{-1}	0	1.01×10^{-1}	0	1.79×10^{-4}
72 cm	0	5.54×10^{-2}	8.47×10^{-1}	0	9.72×10^{-2}	0	8.58×10^{-5}

Table 1861: Computed freestream species mass fractions, Shot 2801

233.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2847	1104.6	1104.6	5.48	8.9	0.040	2.85×10^6
72 cm	2853	1086.0	1085.6	5.13	7.6	0.034	2.49×10^6

Table 1862: Computed boundary layer edge conditions, Shot 2801

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.74×10^{-2}	8.42×10^{-1}	0	1.01×10^{-1}	0	1.79×10^{-4}
72 cm	0	5.54×10^{-2}	8.47×10^{-1}	0	9.72×10^{-2}	0	8.46×10^{-5}

Table 1863: Computed boundary layer edge species mass fractions, Shot 2801

	T^* K	Unit Re^* 1/m
1D 100 cm	1200	2.53×10^6
72 cm	1122	2.41×10^6

Table 1864: Dorrance reference conditions, Shot 2801

233.5 Stability Computations

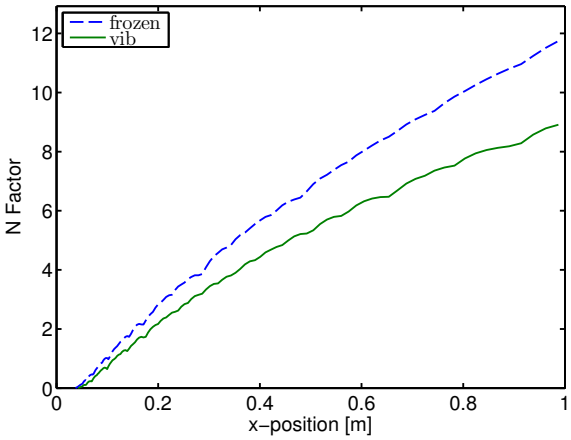


Figure 697: Locus of maximum N factor with and without vibrational energy transfer, Shot 2801

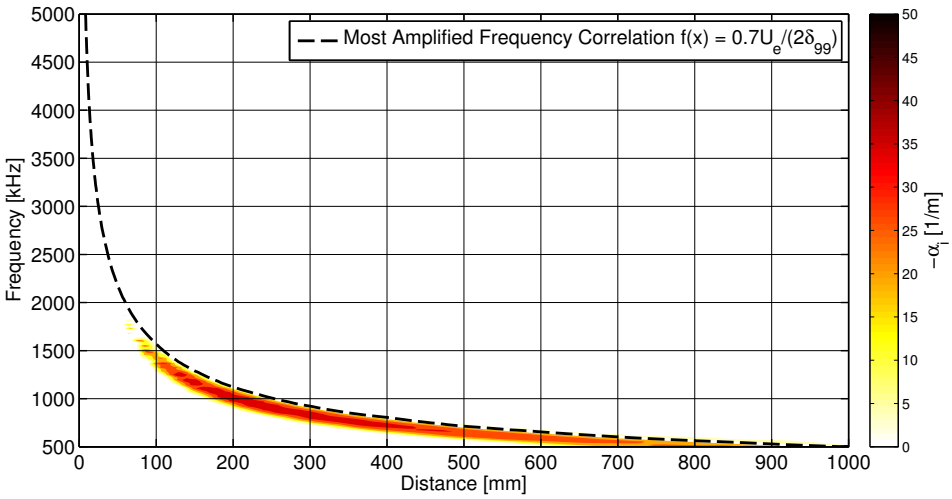


Figure 698: Stability diagram with vibrational energy transfer, Shot 2801. Dashed line indicates $0.7U_e/(2\delta_{99})$.

233.6 Heat Transfer Results

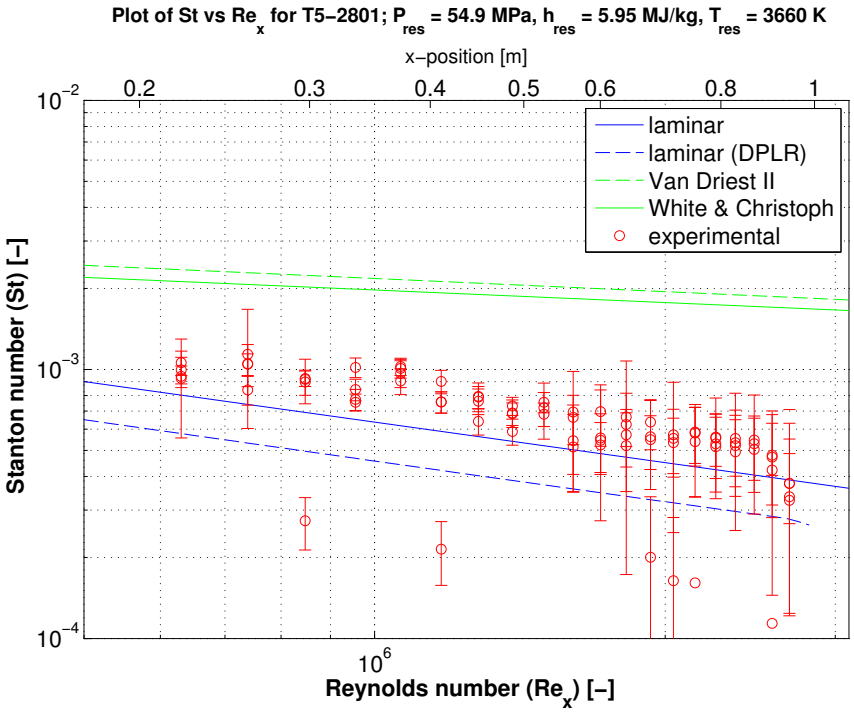


Figure 699: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

234 Shot 2802

Experiment 2802 was performed in T5 on 3 May 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

234.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2460	m/s
Shock Tube Fill Pressure	P_1	115.05	kPa
Reservoir Pressure	P_{res}	54.7	MPa

Table 1865: Measured quantities, Shot 2802

234.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3540	K
Reservoir Density	ρ_{res}	74.01	kg/m^3
Reservoir Enthalpy	h_{res}	5.52	MJ/kg

Table 1866: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2802

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	7.06×10^{-2}	7.98×10^{-1}	0	1.28×10^{-1}	0	2.79×10^{-3}

Table 1867: Computed reservoir species mass fractions, Shot 2802

234.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2788	984.0	984.0	5.71	6.0	0.030	2.27×10^6
72 cm	2816	943.3	949.2	5.46	5.1	0.027	2.08×10^6

Table 1868: Computed freestream conditions, Shot 2802

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.04×10^{-2}	8.61×10^{-1}	0	8.83×10^{-2}	0	1.07×10^{-4}
72 cm	0	4.83×10^{-2}	8.67×10^{-1}	0	8.46×10^{-2}	0	3.55×10^{-5}

Table 1869: Computed freestream species mass fractions, Shot 2802

234.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2761	1043.7	1043.7	5.49	8.6	0.041	2.94×10^6
72 cm	2771	1031.9	1031.5	5.14	7.5	0.036	2.61×10^6

Table 1870: Computed boundary layer edge conditions, Shot 2802

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	5.04×10^{-2}	8.61×10^{-1}	0	8.83×10^{-2}	0	1.07×10^{-4}
72 cm	0	4.83×10^{-2}	8.67×10^{-1}	0	8.46×10^{-2}	0	3.49×10^{-5}

Table 1871: Computed boundary layer edge species mass fractions, Shot 2802

	T^* K	Unit Re^* 1/m
1D 100 cm	1145	2.57×10^6
72 cm	1075	2.51×10^6

Table 1872: Dorrance reference conditions, Shot 2802

234.5 Stability Computations

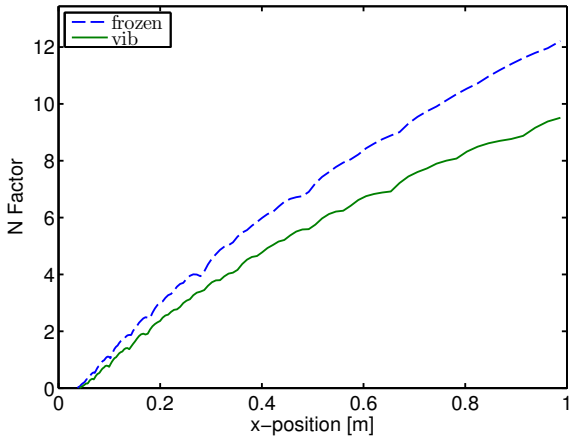


Figure 700: Locus of maximum N factor with and without vibrational energy transfer, Shot 2802

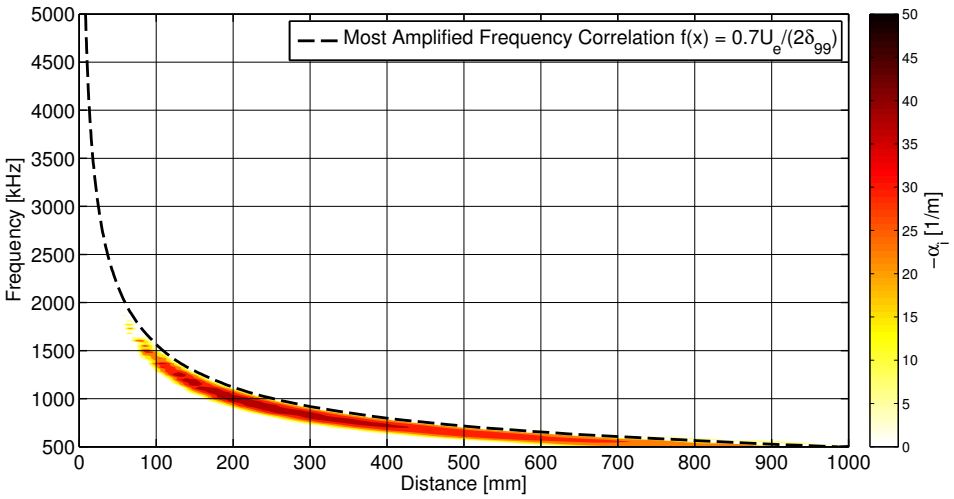


Figure 701: Stability diagram with vibrational energy transfer, Shot 2802. Dashed line indicates $0.7U_e/(2\delta_{99})$.

234.6 Heat Transfer Results

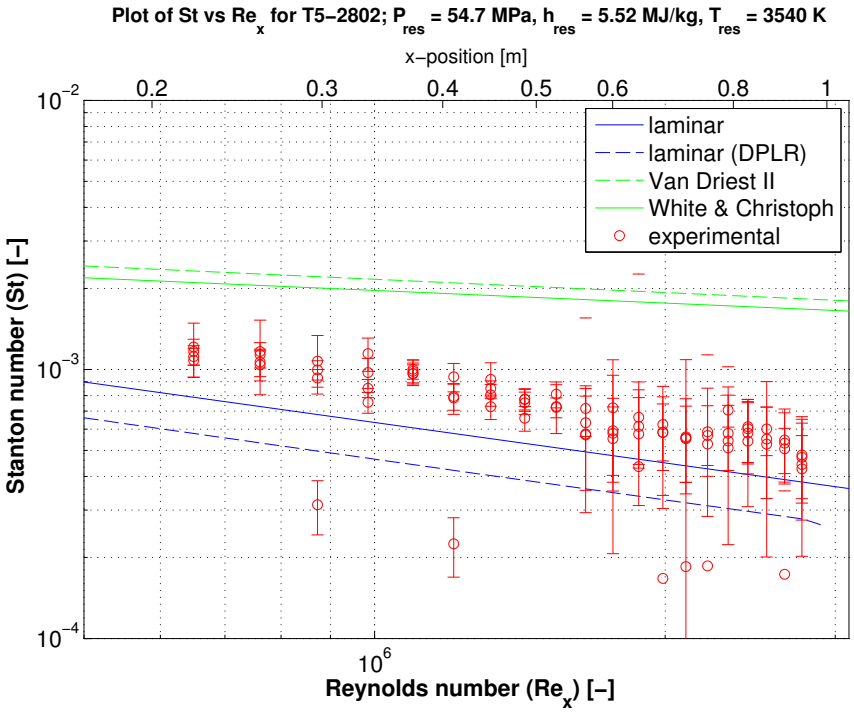


Figure 702: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

235 Shot 2803

Experiment 2803 was performed in T5 on 4 May 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

235.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2390	m/s
Shock Tube Fill Pressure	P_1	130.00	kPa
Reservoir Pressure	P_{res}	54.5	MPa

Table 1873: Measured quantities, Shot 2803

235.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3433	K
Reservoir Density	ρ_{res}	77.29	kg/m^3
Reservoir Enthalpy	h_{res}	5.16	MJ/kg

Table 1874: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2803

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	5.99×10^{-2}	8.30×10^{-1}	0	1.08×10^{-1}	0	1.94×10^{-3}

Table 1875: Computed reservoir species mass fractions, Shot 2803

235.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2713	936.0	936.0	5.72	5.9	0.031	2.33×10^6
72 cm	2746	901.8	908.2	5.47	5.1	0.028	2.17×10^6

Table 1876: Computed freestream conditions, Shot 2803

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.42×10^{-2}	8.78×10^{-1}	0	7.75×10^{-2}	0	6.86×10^{-5}
72 cm	0	4.20×10^{-2}	8.84×10^{-1}	0	7.36×10^{-2}	0	1.59×10^{-5}

Table 1877: Computed freestream species mass fractions, Shot 2803

235.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2687	993.0	993.0	5.50	8.4	0.042	3.02×10^6
72 cm	2702	987.4	987.0	5.14	7.4	0.038	2.73×10^6

Table 1878: Computed boundary layer edge conditions, Shot 2803

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.42×10^{-2}	8.78×10^{-1}	0	7.75×10^{-2}	0	6.86×10^{-5}
72 cm	0	4.20×10^{-2}	8.84×10^{-1}	0	7.36×10^{-2}	0	1.56×10^{-5}

Table 1879: Computed boundary layer edge species mass fractions, Shot 2803

	T^* K	Unit Re^* 1/m
1D 100 cm	1099	2.61×10^6
72 cm	1037	2.60×10^6

Table 1880: Dorrance reference conditions, Shot 2803

235.5 Stability Computations

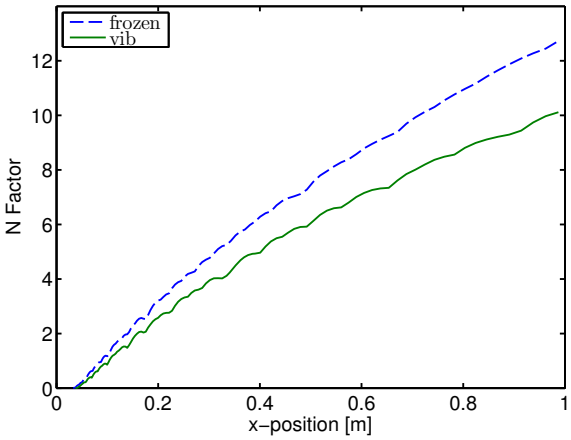


Figure 703: Locus of maximum N factor with and without vibrational energy transfer, Shot 2803

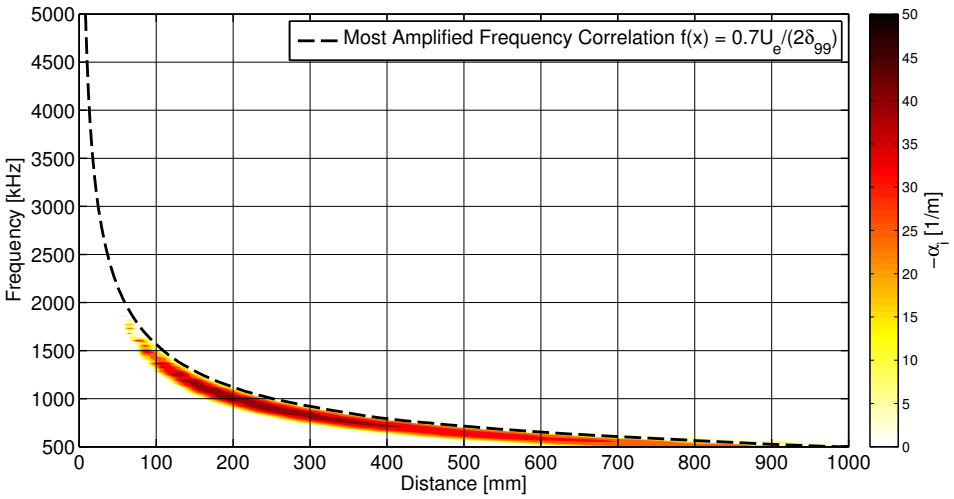


Figure 704: Stability diagram with vibrational energy transfer, Shot 2803. Dashed line indicates $0.7U_e/(2\delta_{99})$.

235.6 Heat Transfer Results

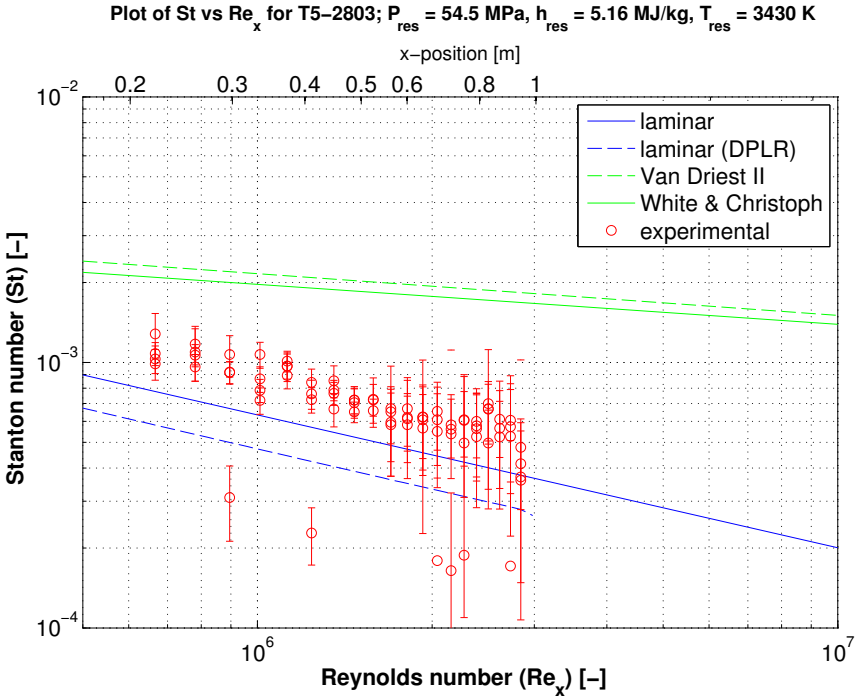


Figure 705: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

236 Shot 2804

Experiment 2804 was performed in T5 on 8 May 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass. This shot was performed with a nozzle throat yielding 400:1 area ratio.

236.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2320	m/s
Shock Tube Fill Pressure	P_1	150.00	kPa
Reservoir Pressure	P_{res}	52.7	MPa

Table 1881: Measured quantities, Shot 2804

236.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3306	K
Reservoir Density	ρ_{res}	78.82	kg/m^3
Reservoir Enthalpy	h_{res}	4.77	MJ/kg

Table 1882: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2804

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	4.87×10^{-2}	8.63×10^{-1}	0	8.75×10^{-2}	0	1.25×10^{-3}

Table 1883: Computed reservoir species mass fractions, Shot 2804

236.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2642	895.0	895.0	5.72	5.9	0.033	2.46×10^6
72 cm	2667	854.9	862.1	5.48	4.9	0.029	2.21×10^6

Table 1884: Computed freestream conditions, Shot 2804

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	3.74×10^{-2}	8.97×10^{-1}	0	6.56×10^{-2}	0	4.28×10^{-5}
72 cm	0	3.55×10^{-2}	9.02×10^{-1}	0	6.21×10^{-2}	0	6.68×10^{-6}

Table 1885: Computed freestream species mass fractions, Shot 2804

236.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2617	949.4	949.4	5.50	8.4	0.045	3.19×10^6
72 cm	2625	936.5	936.1	5.15	7.1	0.038	2.78×10^6

Table 1886: Computed boundary layer edge conditions, Shot 2804

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	3.74×10^{-2}	8.97×10^{-1}	0	6.56×10^{-2}	0	4.28×10^{-5}
72 cm	0	3.55×10^{-2}	9.02×10^{-1}	0	6.21×10^{-2}	0	6.57×10^{-6}

Table 1887: Computed boundary layer edge species mass fractions, Shot 2804

	T^* K	Unit Re^* 1/m
1D 100 cm	1058	2.73×10^6
72 cm	992	2.62×10^6

Table 1888: Dorrance reference conditions, Shot 2804

236.5 Stability Computations

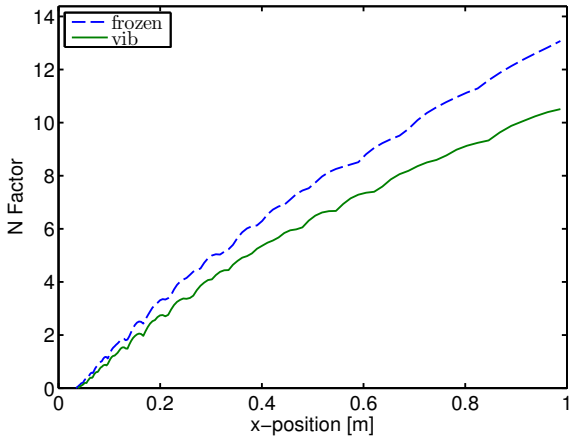


Figure 706: Locus of maximum N factor with and without vibrational energy transfer, Shot 2804

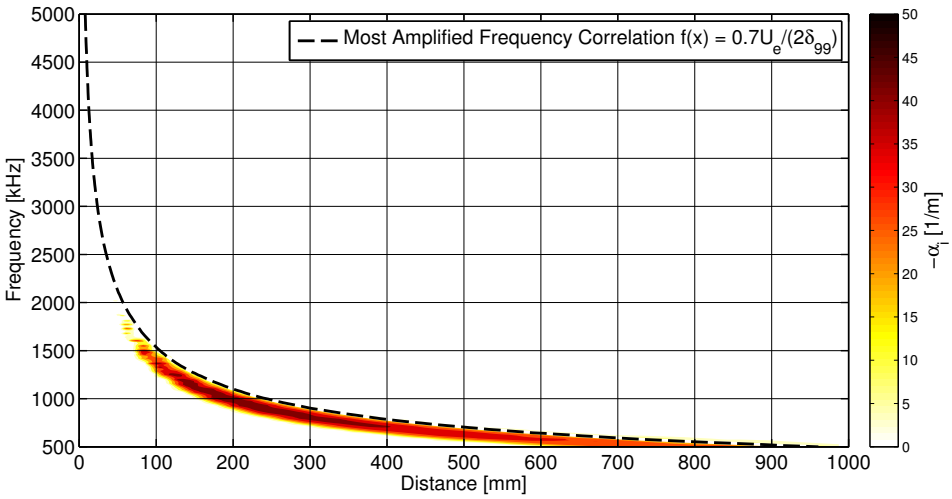


Figure 707: Stability diagram with vibrational energy transfer, Shot 2804. Dashed line indicates $0.7U_e/(2\delta_{99})$.

236.6 Heat Transfer Results

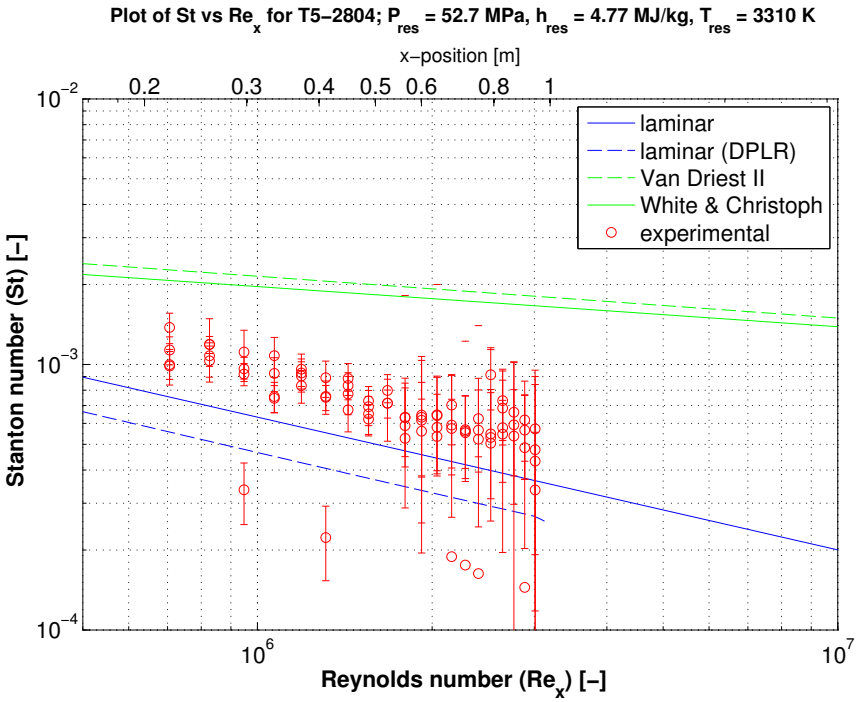


Figure 708: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

237 Shot 2805

Experiment 2805 was performed in T5 on 4 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

237.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2430	m/s
Shock Tube Fill Pressure	P_1	86.35	kPa
Reservoir Pressure	P_{res}	41.4	MPa

Table 1889: Measured quantities, Shot 2805

237.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3467	K
Reservoir Density	ρ_{res}	57.33	kg/m^3
Reservoir Enthalpy	h_{res}	5.38	MJ/kg

Table 1890: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2805

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	6.85×10^{-2}	8.04×10^{-1}	0	1.25×10^{-1}	0	2.63×10^{-3}

Table 1891: Computed reservoir species mass fractions, Shot 2805

237.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2614	1315.0	1315.0	4.67	29.0	0.110	6.76×10^6
72 cm	2609	1332.9	1333.3	4.27	34.1	0.128	7.81×10^6

Table 1892: Computed freestream conditions, Shot 2805

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.65×10^{-2}	8.72×10^{-1}	0	8.15×10^{-2}	0	5.55×10^{-5}
72 cm	0	4.44×10^{-2}	8.78×10^{-1}	0	7.78×10^{-2}	0	3.33×10^{-5}

Table 1893: Computed freestream species mass fractions, Shot 2805

237.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2586	1370.4	1370.4	4.53	37.8	0.137	8.21×10^6
72 cm	2568	1399.7	1399.6	4.10	44.4	0.158	9.32×10^6

Table 1894: Computed boundary layer edge conditions, Shot 2805

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.65×10^{-2}	8.72×10^{-1}	0	8.15×10^{-2}	0	5.55×10^{-5}
72 cm	0	4.44×10^{-2}	8.78×10^{-1}	0	7.78×10^{-2}	0	2.74×10^{-5}

Table 1895: Computed boundary layer edge species mass fractions, Shot 2805

	T^* K	Unit Re^* 1/m
1D 100 cm	1230	9.60×10^6
72 cm	1180	11.93×10^6

Table 1896: Dorrance reference conditions, Shot 2805

237.5 Stability Computations

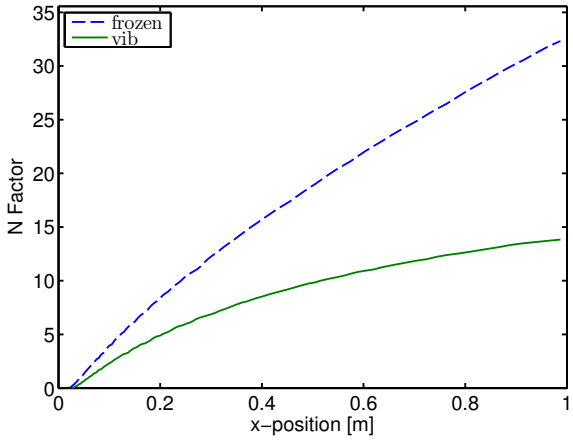


Figure 709: Locus of maximum N factor with and without vibrational energy transfer, Shot 2805

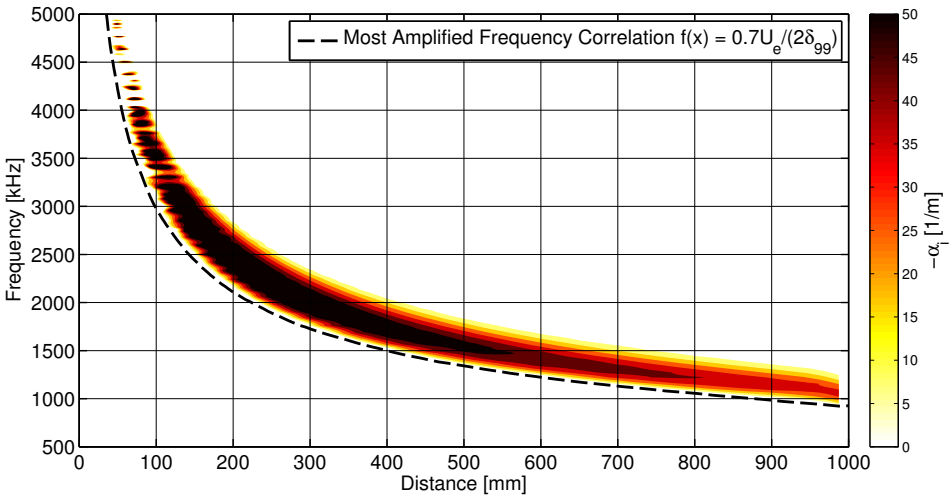


Figure 710: Stability diagram with vibrational energy transfer, Shot 2805. Dashed line indicates $0.7U_e/(2\delta_{99})$.

237.6 Heat Transfer Results

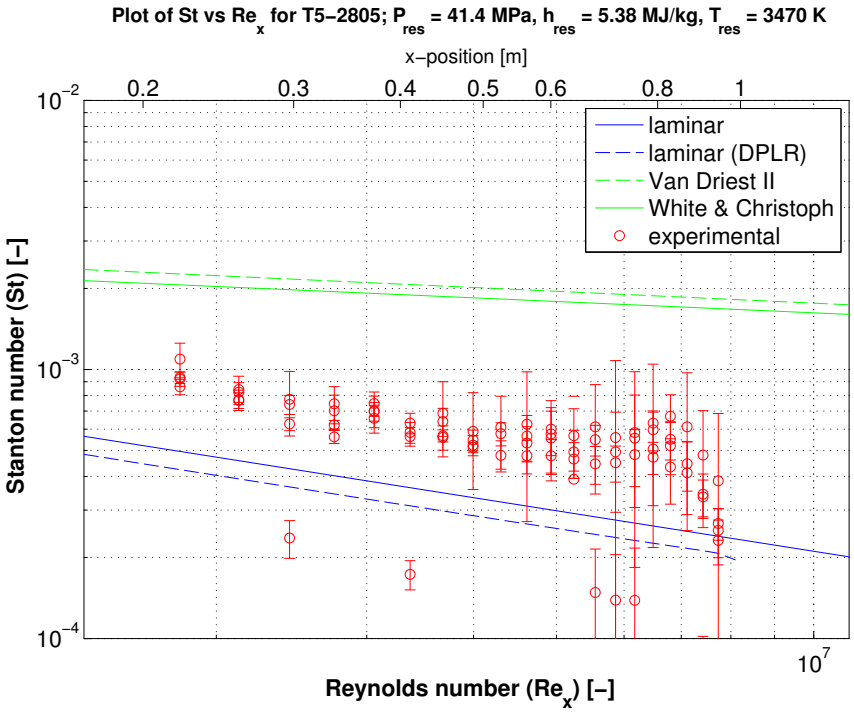


Figure 711: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

238 Shot 2806

Experiment 2806 was performed in T5 on 5 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

238.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2450	m/s
Shock Tube Fill Pressure	P_1	131.00	kPa
Reservoir Pressure	P_{res}	53.0	MPa

Table 1897: Measured quantities, Shot 2806

238.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3488	K
Reservoir Density	ρ_{res}	73.25	kg/m^3
Reservoir Enthalpy	h_{res}	5.36	MJ/kg

Table 1898: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2806

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	6.58×10^{-2}	8.12×10^{-1}	0	1.19×10^{-1}	0	2.39×10^{-3}

Table 1899: Computed reservoir species mass fractions, Shot 2806

238.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2615	1330.0	1330.0	4.66	36.6	0.138	8.45×10^6
72 cm	2618	1353.4	1353.7	4.26	44.4	0.164	1.00×10^7

Table 1900: Computed freestream conditions, Shot 2806

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.29×10^{-2}	8.82×10^{-1}	0	7.52×10^{-2}	0	3.70×10^{-5}
72 cm	0	4.07×10^{-2}	8.88×10^{-1}	0	7.12×10^{-2}	0	1.96×10^{-5}

Table 1901: Computed freestream species mass fractions, Shot 2806

238.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2588	1386.0	1386.0	4.52	47.7	0.172	1.03×10^7
72 cm	2577	1420.0	1419.9	4.09	57.7	0.204	1.19×10^7

Table 1902: Computed boundary layer edge conditions, Shot 2806

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.29×10^{-2}	8.82×10^{-1}	0	7.52×10^{-2}	0	3.70×10^{-5}
72 cm	0	4.07×10^{-2}	8.88×10^{-1}	0	7.12×10^{-2}	0	1.47×10^{-5}

Table 1903: Computed boundary layer edge species mass fractions, Shot 2806

	T^* K	Unit Re^* 1/m
1D 100 cm	1237	12.09×10^6
72 cm	1191	15.44×10^6

Table 1904: Dorrance reference conditions, Shot 2806

238.5 Stability Computations

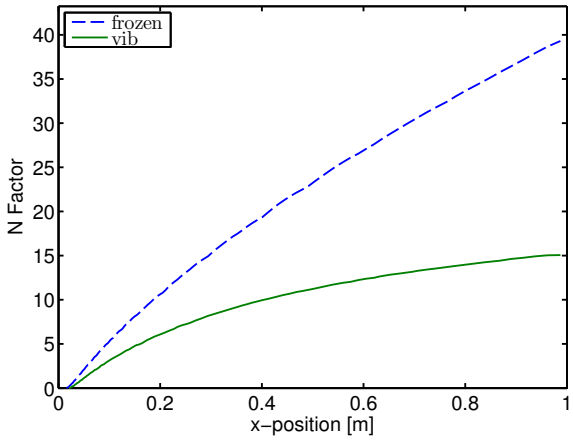


Figure 712: Locus of maximum N factor with and without vibrational energy transfer, Shot 2806

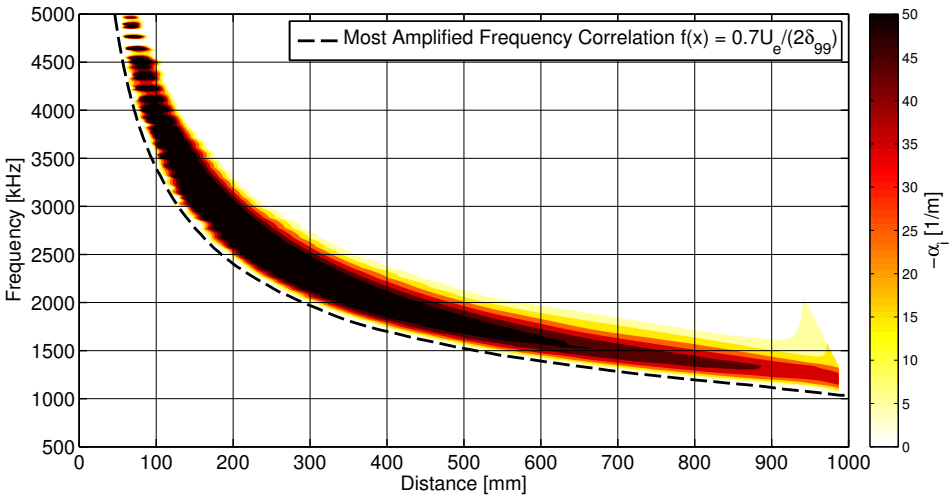


Figure 713: Stability diagram with vibrational energy transfer, Shot 2806. Dashed line indicates $0.7U_e/(2\delta_{99})$.

238.6 Heat Transfer Results

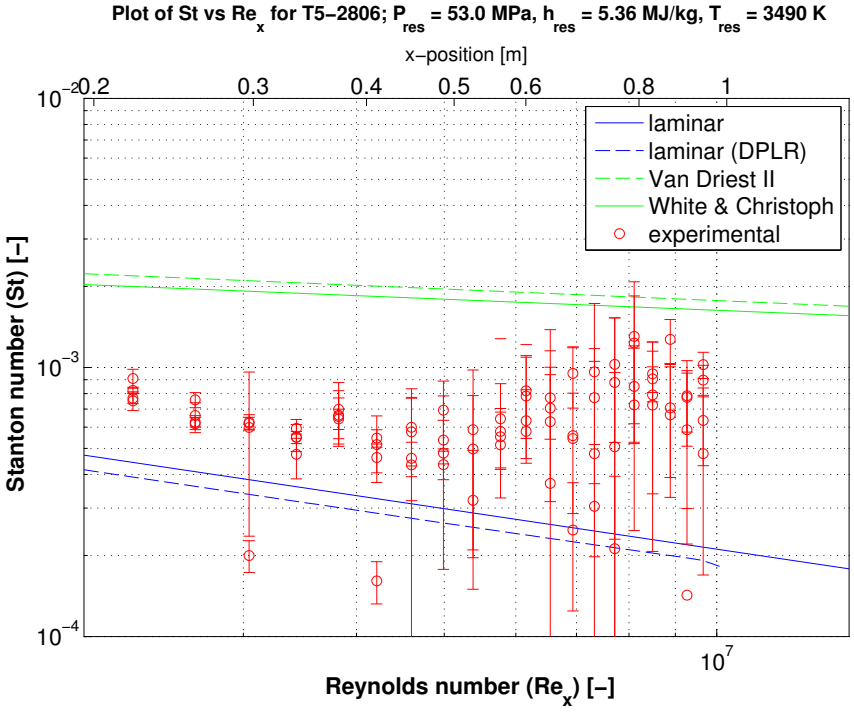


Figure 714: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

239 Shot 2807

Experiment 2807 was performed in T5 on 6 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

239.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2450	m/s
Shock Tube Fill Pressure	P_1	100.30	kPa
Reservoir Pressure	P_{res}	54.3	MPa

Table 1905: Measured quantities, Shot 2807

239.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3553	K
Reservoir Density	ρ_{res}	73.11	kg/m^3
Reservoir Enthalpy	h_{res}	5.57	MJ/kg

Table 1906: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2807

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	7.21×10^{-2}	7.94×10^{-1}	0	1.31×10^{-1}	0	2.92×10^{-3}

Table 1907: Computed reservoir species mass fractions, Shot 2807

239.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2656	1373.0	1373.0	4.65	37.8	0.137	8.43×10^{6}
72 cm	2658	1394.1	1394.4	4.25	45.8	0.164	1.00×10^{7}

Table 1908: Computed freestream conditions, Shot 2807

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.59×10^{-2}	8.74×10^{-1}	0	8.04×10^{-2}	0	4.80×10^{-5}
72 cm	0	4.38×10^{-2}	8.79×10^{-1}	0	7.67×10^{-2}	0	3.03×10^{-5}

Table 1909: Computed freestream species mass fractions, Shot 2807

239.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2628	1429.9	1429.9	4.51	49.2	0.171	1.02×10^{7}
72 cm	2616	1462.5	1462.5	4.09	59.4	0.203	1.18×10^{7}

Table 1910: Computed boundary layer edge conditions, Shot 2807

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.59×10^{-2}	8.74×10^{-1}	0	8.04×10^{-2}	0	4.80×10^{-5}
72 cm	0	4.38×10^{-2}	8.79×10^{-1}	0	7.67×10^{-2}	0	2.28×10^{-5}

Table 1911: Computed boundary layer edge species mass fractions, Shot 2807

	T^* K	Unit Re^* 1/m
1D 100 cm	1270	12.15×10^{6}
72 cm	1221	14.11×10^{6}

Table 1912: Dorrance reference conditions, Shot 2807

239.5 Stability Computations

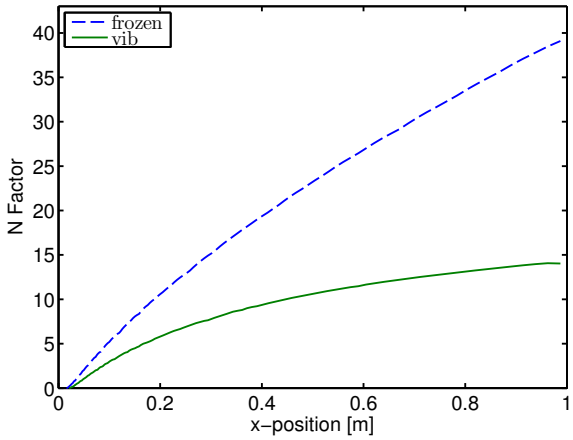


Figure 715: Locus of maximum N factor with and without vibrational energy transfer, Shot 2807

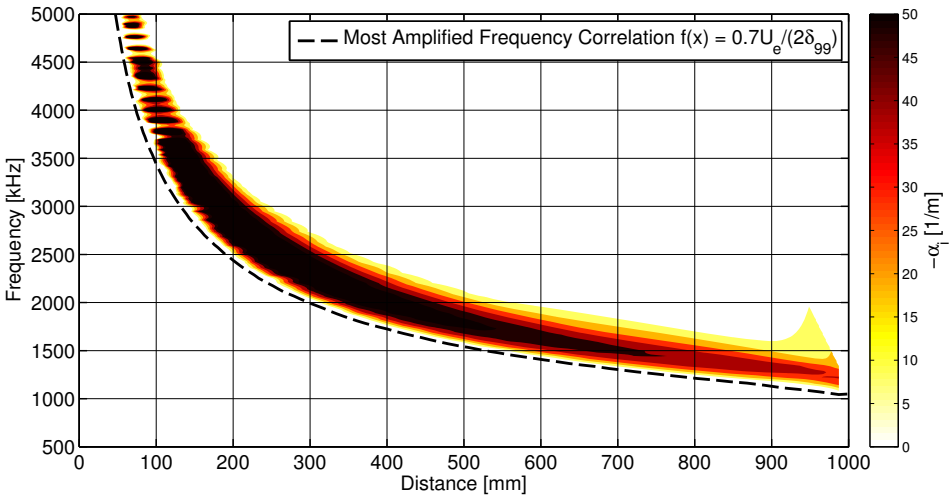


Figure 716: Stability diagram with vibrational energy transfer, Shot 2807. Dashed line indicates $0.7U_e/(2\delta_{99})$.

239.6 Heat Transfer Results

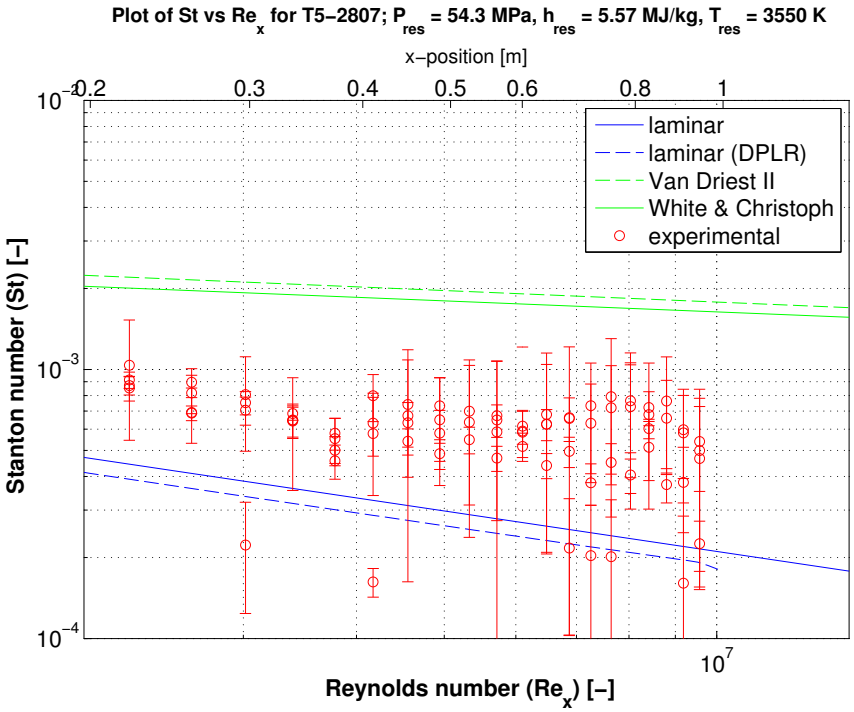


Figure 717: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

240 Shot 2808

Experiment 2808 was performed in T5 on 7 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% CO_2 by mass.

240.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2460	m/s
Shock Tube Fill Pressure	P_1	99.55	kPa
Reservoir Pressure	P_{res}	54.5	MPa

Table 1913: Measured quantities, Shot 2808

240.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3567	K
Reservoir Density	ρ_{res}	72.96	kg/m^3
Reservoir Enthalpy	h_{res}	5.62	MJ/kg

Table 1914: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2808

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
0	7.35×10^{-2}	7.89×10^{-1}	0	1.34×10^{-1}	0	3.05×10^{-3}

Table 1915: Computed reservoir species mass fractions, Shot 2808

240.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2665	1382.0	1382.0	4.65	38.1	0.137	8.42×10^6
72 cm	2667	1403.1	1403.3	4.25	46.0	0.163	9.98×10^6

Table 1916: Computed freestream conditions, Shot 2808

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.66×10^{-2}	8.72×10^{-1}	0	8.16×10^{-2}	0	5.09×10^{-5}
72 cm	0	4.45×10^{-2}	8.78×10^{-1}	0	7.79×10^{-2}	0	3.35×10^{-5}

Table 1917: Computed freestream species mass fractions, Shot 2808

240.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2637	1439.6	1439.6	4.51	49.5	0.171	1.01×10^7
72 cm	2625	1471.8	1471.7	4.08	59.7	0.202	1.17×10^7

Table 1918: Computed boundary layer edge conditions, Shot 2808

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	0	4.66×10^{-2}	8.72×10^{-1}	0	8.16×10^{-2}	0	5.09×10^{-5}
72 cm	0	4.45×10^{-2}	8.78×10^{-1}	0	7.79×10^{-2}	0	2.51×10^{-5}

Table 1919: Computed boundary layer edge species mass fractions, Shot 2808

	T^* K	Unit Re^* 1/m
1D 100 cm	1277	12.15×10^6
72 cm	1228	15.50×10^6

Table 1920: Dorrance reference conditions, Shot 2808

240.5 Stability Computations

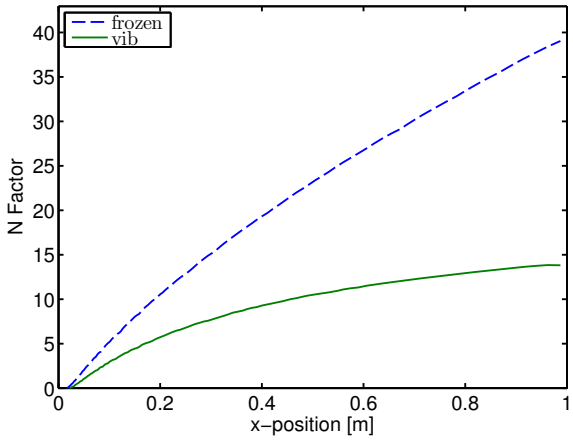


Figure 718: Locus of maximum N factor with and without vibrational energy transfer, Shot 2808

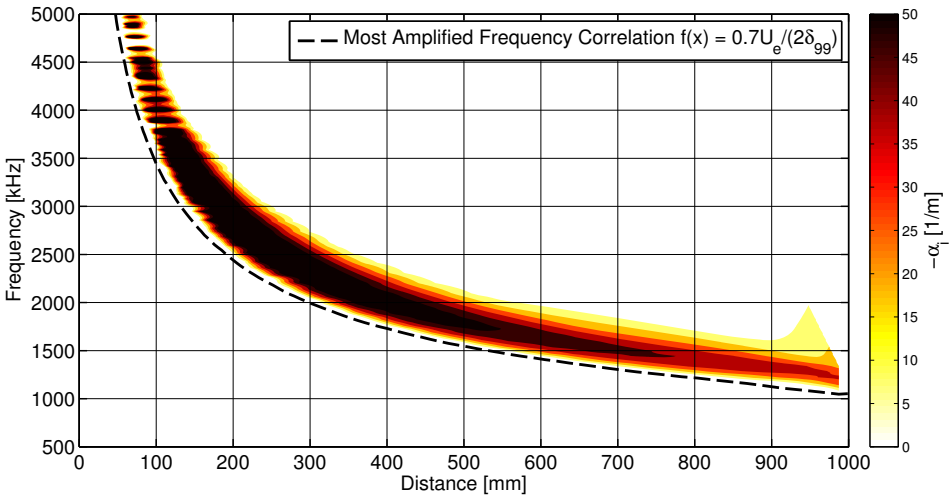


Figure 719: Stability diagram with vibrational energy transfer, Shot 2808. Dashed line indicates $0.7U_e/(2\delta_{99})$.

240.6 Heat Transfer Results

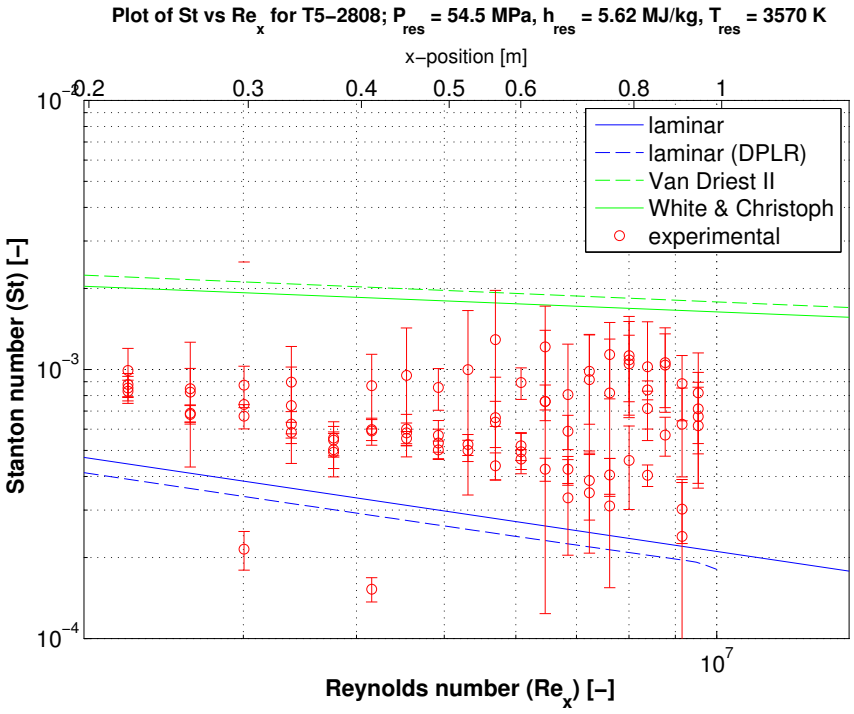


Figure 720: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

241 Shot 2809

Experiment 2809 was performed in T5 on 12 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

241.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2870	m/s
Shock Tube Fill Pressure	P_1	103.30	kPa
Reservoir Pressure	P_{res}	57.1	MPa

Table 1921: Measured quantities, Shot 2809

241.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4429	K
Reservoir Density	ρ_{res}	47.56	kg/m^3
Reservoir Enthalpy	h_{res}	7.66	MJ/kg

Table 1922: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2809

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.44×10^{-1}	1.46×10^{-1}	2.25×10^{-1}	8.44×10^{-2}	1.75×10^{-1}	8.62×10^{-5}	2.58×10^{-2}

Table 1923: Computed reservoir species mass fractions, Shot 2809

241.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3316	1473.0	1473.0	4.89	35.0	0.095	6.41×10^6
72 cm	3300	1452.3	1453.3	4.64	38.6	0.107	7.23×10^6

Table 1924: Computed freestream conditions, Shot 2809

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.36×10^{-1}	3.86×10^{-1}	3.80×10^{-2}	7.24×10^{-2}	9.70×10^{-10}	1.83×10^{-3}
72 cm	3.62×10^{-1}	1.30×10^{-1}	3.91×10^{-1}	4.68×10^{-2}	6.95×10^{-2}	1.01×10^{-9}	1.50×10^{-3}

Table 1925: Computed freestream species mass fractions, Shot 2809

241.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3282	1562.3	1562.3	4.70	47.2	0.121	7.72×10^6
72 cm	3247	1573.5	1573.5	4.38	52.2	0.133	8.37×10^6

Table 1926: Computed boundary layer edge conditions, Shot 2809

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.36×10^{-1}	3.86×10^{-1}	3.80×10^{-2}	7.24×10^{-2}	9.70×10^{-10}	1.83×10^{-3}
72 cm	3.62×10^{-1}	1.30×10^{-1}	3.91×10^{-1}	4.68×10^{-2}	6.93×10^{-2}	2.17×10^{-9}	1.31×10^{-3}

Table 1927: Computed boundary layer edge species mass fractions, Shot 2809

	T^* K	Unit Re* 1/m
1D 100 cm	1568	7.67×10^6
72 cm	1493	9.15×10^6

Table 1928: Dorrance reference conditions, Shot 2809

241.5 Stability Computations

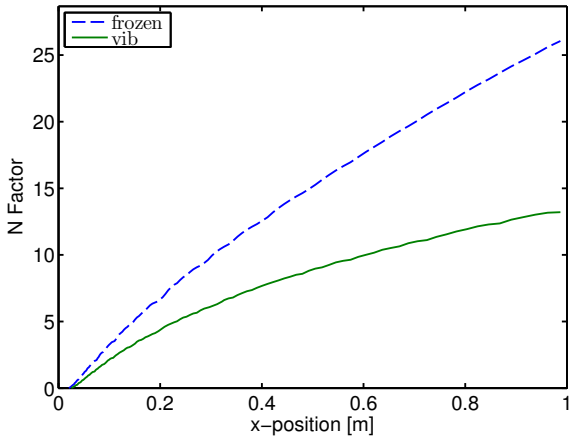


Figure 721: Locus of maximum N factor with and without vibrational energy transfer, Shot 2809

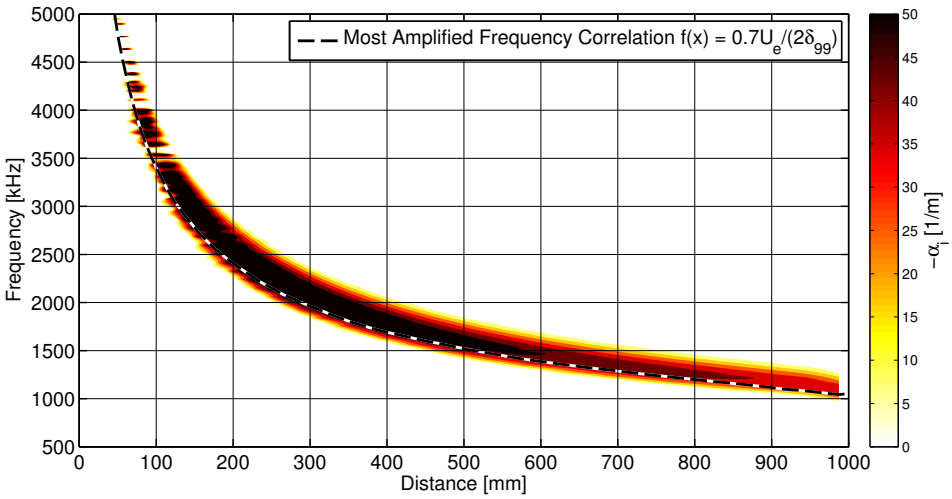


Figure 722: Stability diagram with vibrational energy transfer, Shot 2809. Dashed line indicates $0.7U_e/(2\delta_{99})$.

241.6 Heat Transfer Results

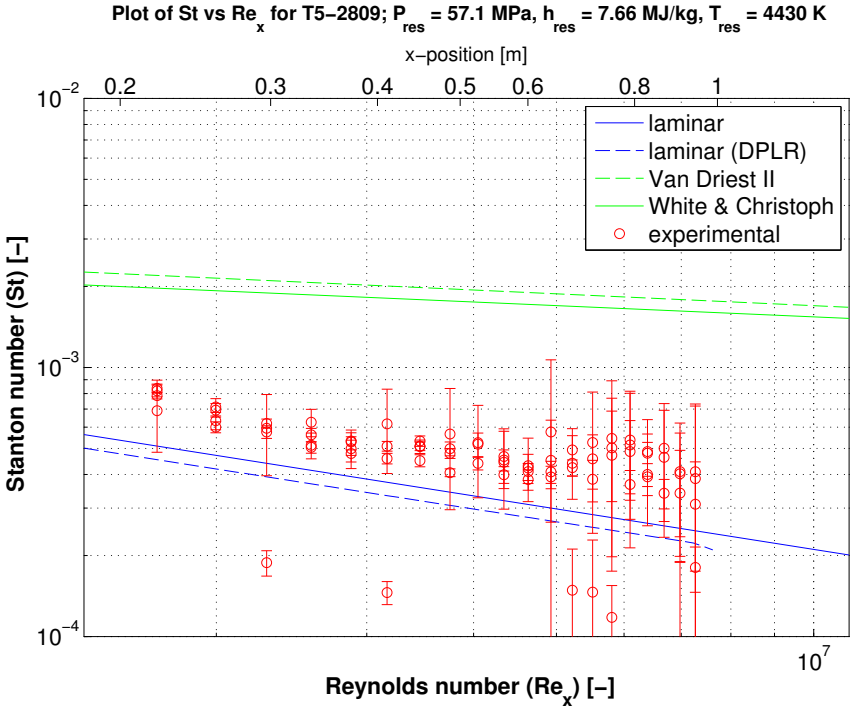


Figure 723: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

242 Shot 2810

Experiment 2810 was performed in T5 on 13 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

242.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2700	m/s
Shock Tube Fill Pressure	P_1	120.75	kPa
Reservoir Pressure	P_{res}	58.2	MPa

Table 1929: Measured quantities, Shot 2810

242.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4176	K
Reservoir Density	ρ_{res}	52.86	kg/m^3
Reservoir Enthalpy	h_{res}	6.79	MJ/kg

Table 1930: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2810

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.50×10^{-1}	1.41×10^{-1}	2.81×10^{-1}	7.24×10^{-2}	1.40×10^{-1}	3.81×10^{-5}	1.63×10^{-2}

Table 1931: Computed reservoir species mass fractions, Shot 2810

242.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3162	1315.0	1315.0	4.97	34.1	0.105	7.26×10^6
72 cm	3152	1309.0	1310.2	4.69	38.4	0.119	8.24×10^6

Table 1932: Computed freestream conditions, Shot 2810

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.28×10^{-1}	4.13×10^{-1}	3.62×10^{-2}	5.52×10^{-2}	1.14×10^{-10}	9.76×10^{-4}
72 cm	3.63×10^{-1}	1.21×10^{-1}	4.20×10^{-1}	4.49×10^{-2}	5.12×10^{-2}	1.06×10^{-10}	5.76×10^{-4}

Table 1933: Computed freestream species mass fractions, Shot 2810

242.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3129	1396.4	1396.4	4.77	46.2	0.134	8.87×10^6
72 cm	3101	1418.7	1418.6	4.43	52.1	0.149	9.70×10^6

Table 1934: Computed boundary layer edge conditions, Shot 2810

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.28×10^{-1}	4.13×10^{-1}	3.62×10^{-2}	5.52×10^{-2}	1.14×10^{-10}	9.76×10^{-4}
72 cm	3.63×10^{-1}	1.21×10^{-1}	4.20×10^{-1}	4.49×10^{-2}	5.11×10^{-2}	2.53×10^{-10}	5.05×10^{-4}

Table 1935: Computed boundary layer edge species mass fractions, Shot 2810

	T^* K	Unit Re* 1/m
1D 100 cm	1435	8.47×10^6
72 cm	1375	10.01×10^6

Table 1936: Dorrance reference conditions, Shot 2810

242.5 Stability Computations

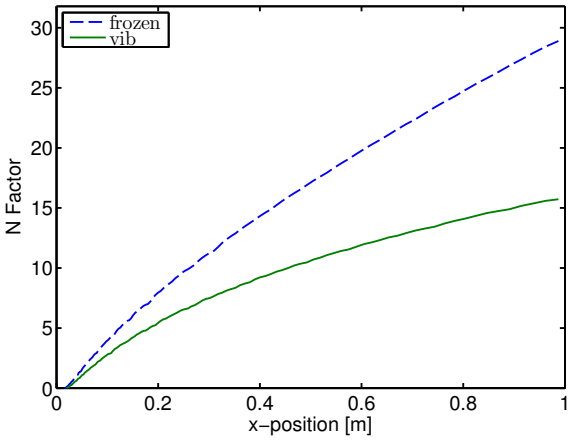


Figure 724: Locus of maximum N factor with and without vibrational energy transfer, Shot 2810

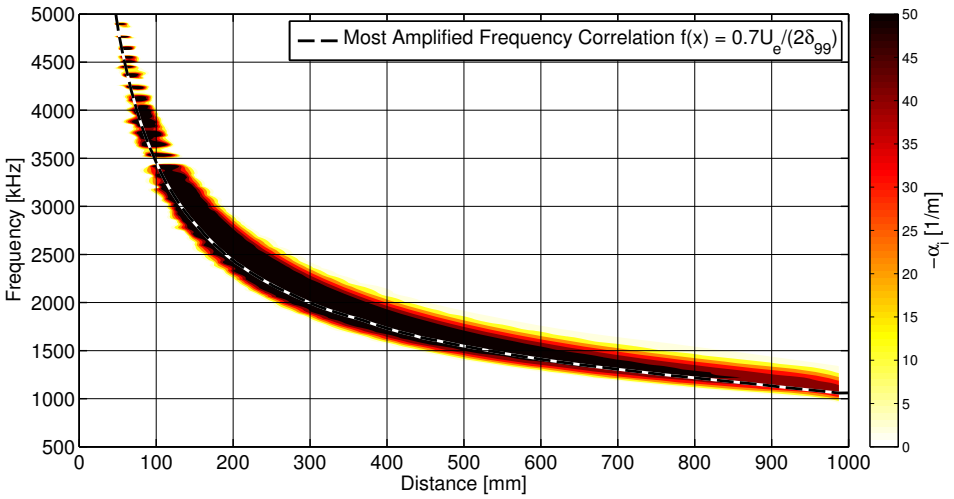


Figure 725: Stability diagram with vibrational energy transfer, Shot 2810. Dashed line indicates $0.7U_e/(2\delta_{99})$.

242.6 Heat Transfer Results

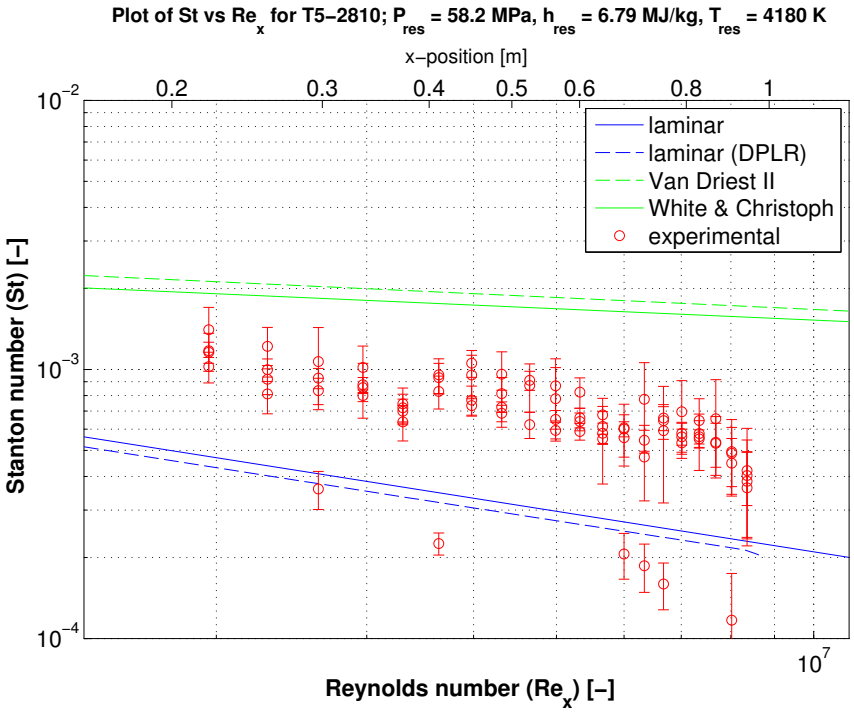


Figure 726: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

243 Shot 2811

Experiment 2811 was performed in T5 on 14 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

243.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2750	m/s
Shock Tube Fill Pressure	P_1	120.00	kPa
Reservoir Pressure	P_{res}	56.3	MPa

Table 1937: Measured quantities, Shot 2811

243.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4223	K
Reservoir Density	ρ_{res}	50.28	kg/m^3
Reservoir Enthalpy	h_{res}	6.96	MJ/kg

Table 1938: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2811

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.49×10^{-1}	1.43×10^{-1}	2.68×10^{-1}	7.48×10^{-2}	1.48×10^{-1}	4.53×10^{-5}	1.81×10^{-2}

Table 1939: Computed reservoir species mass fractions, Shot 2811

243.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3188	1339.0	1339.0	4.96	32.7	0.099	6.81×10^6
72 cm	3181	1335.3	1336.5	4.68	37.3	0.113	7.79×10^6

Table 1940: Computed freestream conditions, Shot 2811

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.30×10^{-1}	4.07×10^{-1}	3.67×10^{-2}	5.94×10^{-2}	1.16×10^{-10}	1.15×10^{-3}
72 cm	3.62×10^{-1}	1.23×10^{-1}	4.13×10^{-1}	4.55×10^{-2}	5.55×10^{-2}	1.79×10^{-10}	7.46×10^{-4}

Table 1941: Computed freestream species mass fractions, Shot 2811

243.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3155	1421.7	1421.7	4.76	44.3	0.126	8.29×10^6
72 cm	3129	1447.1	1447.0	4.42	50.5	0.141	9.13×10^6

Table 1942: Computed boundary layer edge conditions, Shot 2811

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.30×10^{-1}	4.07×10^{-1}	3.67×10^{-2}	5.94×10^{-2}	1.16×10^{-10}	1.15×10^{-3}
72 cm	3.62×10^{-1}	1.23×10^{-1}	4.13×10^{-1}	4.55×10^{-2}	5.54×10^{-2}	4.20×10^{-10}	6.57×10^{-4}

Table 1943: Computed boundary layer edge species mass fractions, Shot 2811

	T^* K	Unit Re* 1/m
1D 100 cm	1456	7.95×10^6
72 cm	1397	9.69×10^6

Table 1944: Dorrance reference conditions, Shot 2811

243.5 Stability Computations

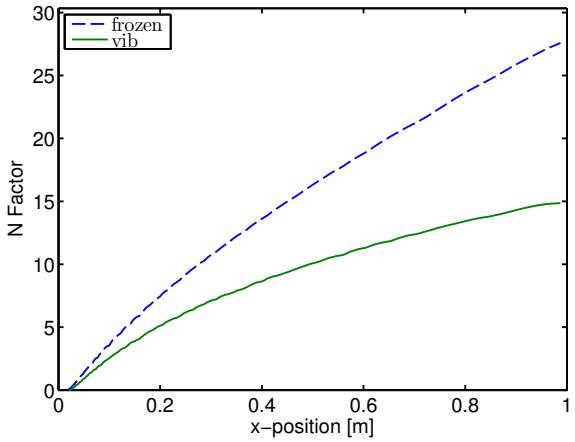


Figure 727: Locus of maximum N factor with and without vibrational energy transfer, Shot 2811

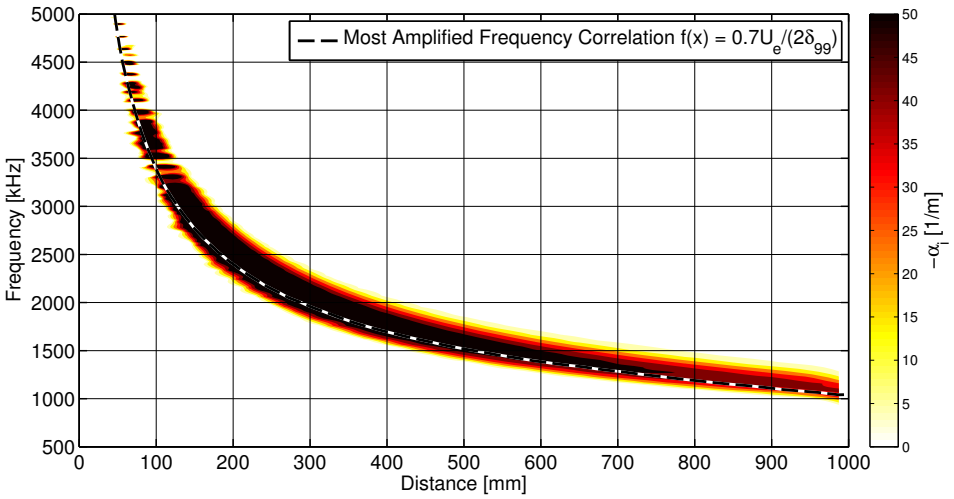


Figure 728: Stability diagram with vibrational energy transfer, Shot 2811. Dashed line indicates $0.7U_e/(2\delta_{99})$.

243.6 Heat Transfer Results

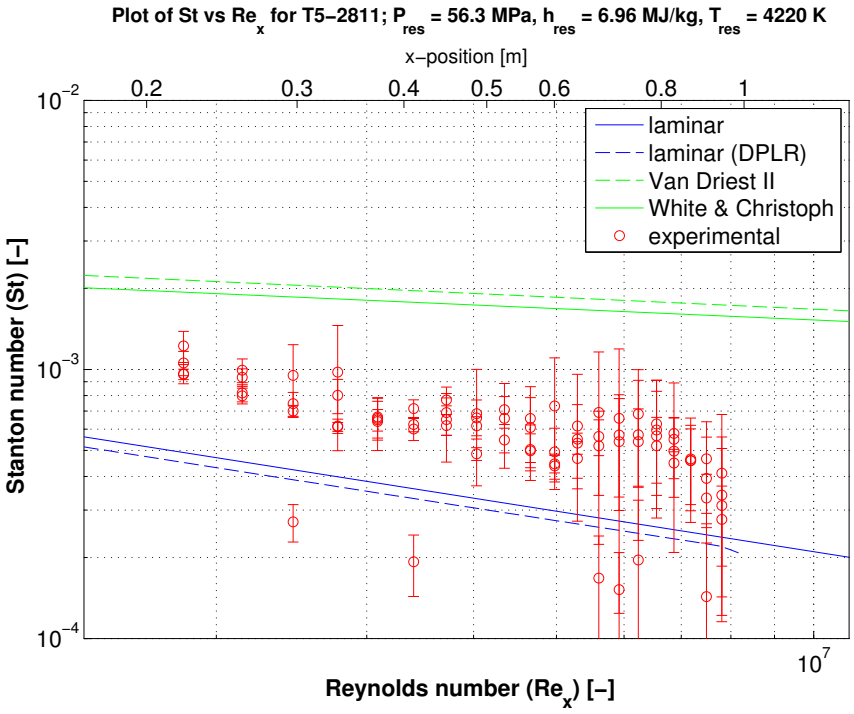


Figure 729: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

244 Shot 2812

Experiment 2812 was performed in T5 on 17 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

244.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2600	m/s
Shock Tube Fill Pressure	P_1	50.00	kPa
Reservoir Pressure	P_{res}	22.3	MPa

Table 1945: Measured quantities, Shot 2812

244.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3886	K
Reservoir Density	ρ_{res}	21.89	kg/m^3
Reservoir Enthalpy	h_{res}	6.26	MJ/kg

Table 1946: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2812

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.55×10^{-1}	1.44×10^{-1}	2.94×10^{-1}	6.08×10^{-2}	1.31×10^{-1}	2.19×10^{-5}	1.52×10^{-2}

Table 1947: Computed reservoir species mass fractions, Shot 2812

244.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3017	1120.0	1120.0	5.09	12.2	0.044	3.13×10^6
72 cm	2993	1110.2	1113.9	4.81	13.6	0.049	3.49×10^6

Table 1948: Computed freestream conditions, Shot 2812

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.34×10^{-1}	3.91×10^{-1}	3.86×10^{-2}	6.93×10^{-2}	5.82×10^{-10}	1.73×10^{-3}
72 cm	3.62×10^{-1}	1.31×10^{-1}	3.92×10^{-1}	4.54×10^{-2}	6.90×10^{-2}	0	1.01×10^{-3}

Table 1949: Computed freestream species mass fractions, Shot 2812

244.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	2987	1195.9	1195.9	4.87	16.8	0.056	3.85×10^6
72 cm	2943	1214.4	1214.2	4.52	18.7	0.062	4.12×10^6

Table 1950: Computed boundary layer edge conditions, Shot 2812

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.34×10^{-1}	3.91×10^{-1}	3.86×10^{-2}	6.93×10^{-2}	5.82×10^{-10}	1.73×10^{-3}
72 cm	3.62×10^{-1}	1.31×10^{-1}	3.92×10^{-1}	4.54×10^{-2}	6.89×10^{-2}	0	9.68×10^{-4}

Table 1951: Computed boundary layer edge species mass fractions, Shot 2812

	T^* K	Unit Re* 1/m
1D 100 cm	1295	3.41×10^6
72 cm	1236	4.02×10^6

Table 1952: Dorrance reference conditions, Shot 2812

244.5 Stability Computations

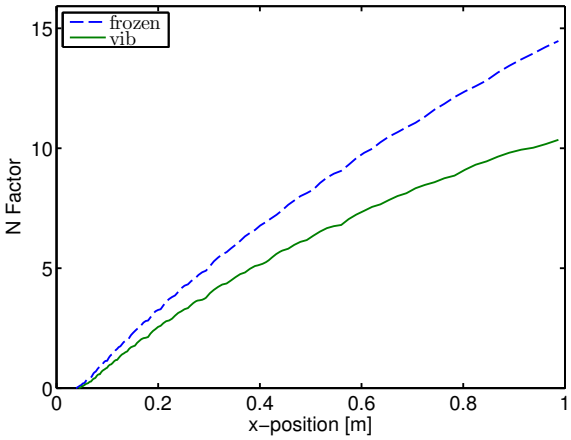


Figure 730: Locus of maximum N factor with and without vibrational energy transfer, Shot 2812

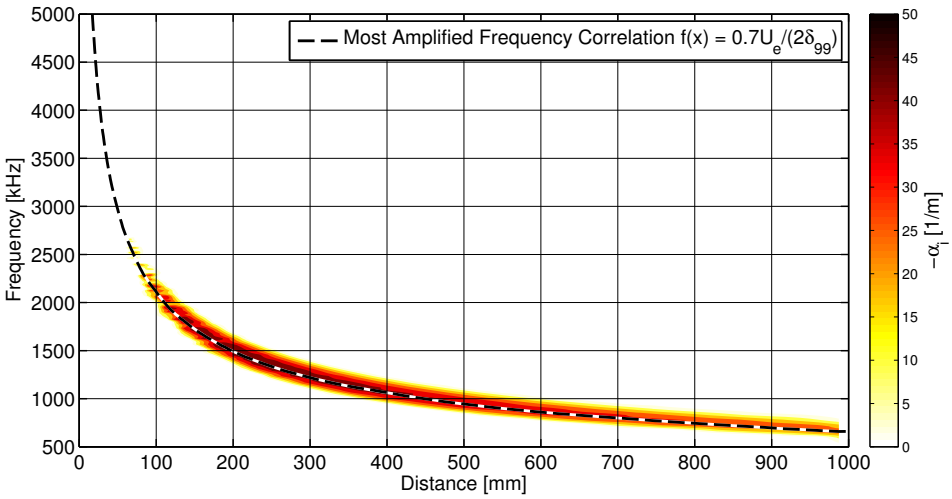


Figure 731: Stability diagram with vibrational energy transfer, Shot 2812. Dashed line indicates $0.7U_e/(2\delta_{99})$.

244.6 Heat Transfer Results

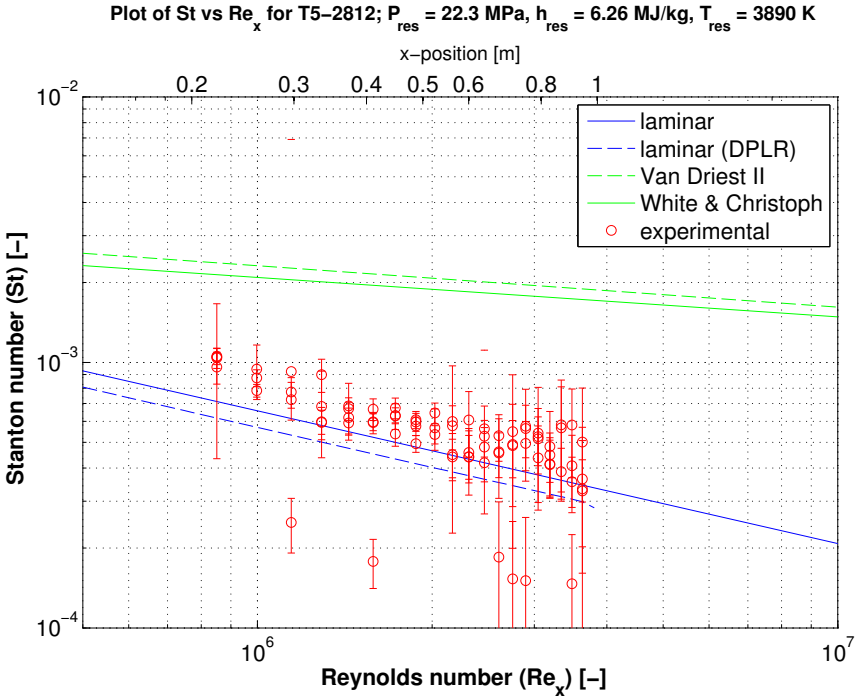


Figure 732: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

245 Shot 2813

Experiment 2813 was performed in T5 on 18 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

245.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2380	m/s
Shock Tube Fill Pressure	P_1	75.00	kPa
Reservoir Pressure	P_{res}	23.3	MPa

Table 1953: Measured quantities, Shot 2813

245.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3557	K
Reservoir Density	ρ_{res}	25.94	kg/m^3
Reservoir Enthalpy	h_{res}	5.12	MJ/kg

Table 1954: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2813

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.62×10^{-1}	1.31×10^{-1}	3.77×10^{-1}	4.52×10^{-2}	7.86×10^{-2}	5.30×10^{-6}	6.67×10^{-3}

Table 1955: Computed reservoir species mass fractions, Shot 2813

245.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2799	947.0	947.0	5.17	12.3	0.053	3.83×10^{6}
72 cm	2783	962.1	965.8	4.85	14.0	0.060	4.27×10^{6}

Table 1956: Computed freestream conditions, Shot 2813

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.68×10^{-1}	1.23×10^{-1}	4.32×10^{-1}	3.33×10^{-2}	4.32×10^{-2}	3.98×10^{-10}	6.74×10^{-4}
72 cm	3.66×10^{-1}	1.18×10^{-1}	4.40×10^{-1}	3.82×10^{-2}	3.84×10^{-2}	0	2.58×10^{-4}

Table 1957: Computed freestream species mass fractions, Shot 2813

245.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2770	1013.9	1013.9	4.94	17.0	0.068	4.73×10^{6}
72 cm	2737	1054.6	1054.4	4.56	19.3	0.075	5.04×10^{6}

Table 1958: Computed boundary layer edge conditions, Shot 2813

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.68×10^{-1}	1.23×10^{-1}	4.32×10^{-1}	3.33×10^{-2}	4.32×10^{-2}	3.98×10^{-10}	6.74×10^{-4}
72 cm	3.66×10^{-1}	1.18×10^{-1}	4.40×10^{-1}	3.82×10^{-2}	3.84×10^{-2}	0	2.48×10^{-4}

Table 1959: Computed boundary layer edge species mass fractions, Shot 2813

	T^* K	Unit Re^* 1/m
1D 100 cm	1141	3.97×10^{6}
72 cm	1105	4.71×10^{6}

Table 1960: Dorrance reference conditions, Shot 2813

245.5 Stability Computations

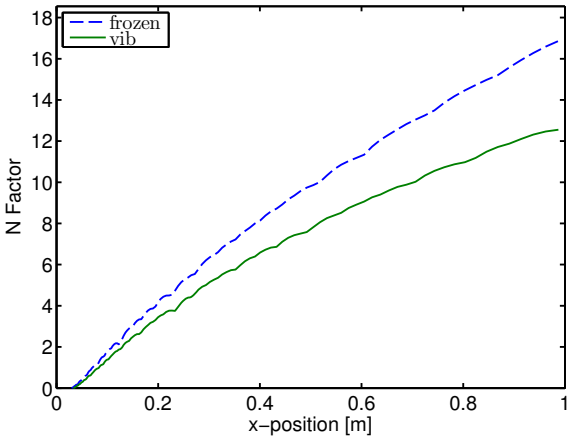


Figure 733: Locus of maximum N factor with and without vibrational energy transfer, Shot 2813

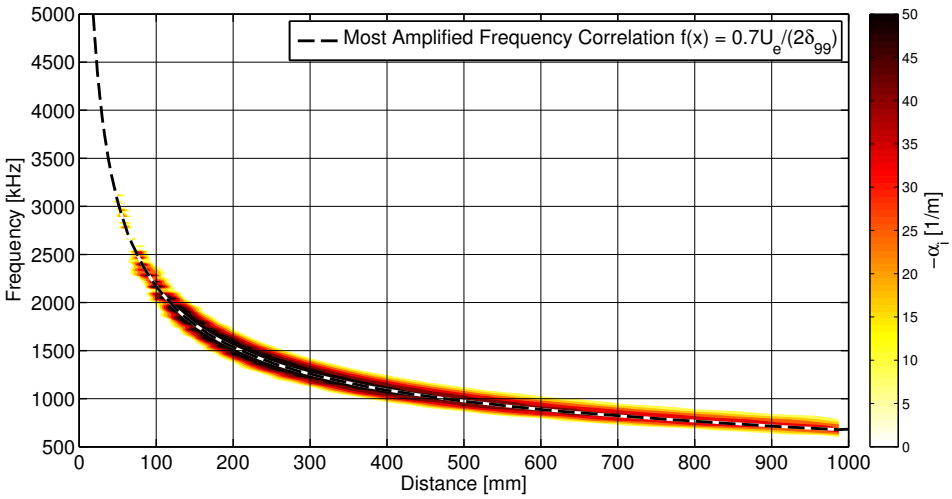


Figure 734: Stability diagram with vibrational energy transfer, Shot 2813. Dashed line indicates $0.7U_e/(2\delta_{99})$.

245.6 Heat Transfer Results

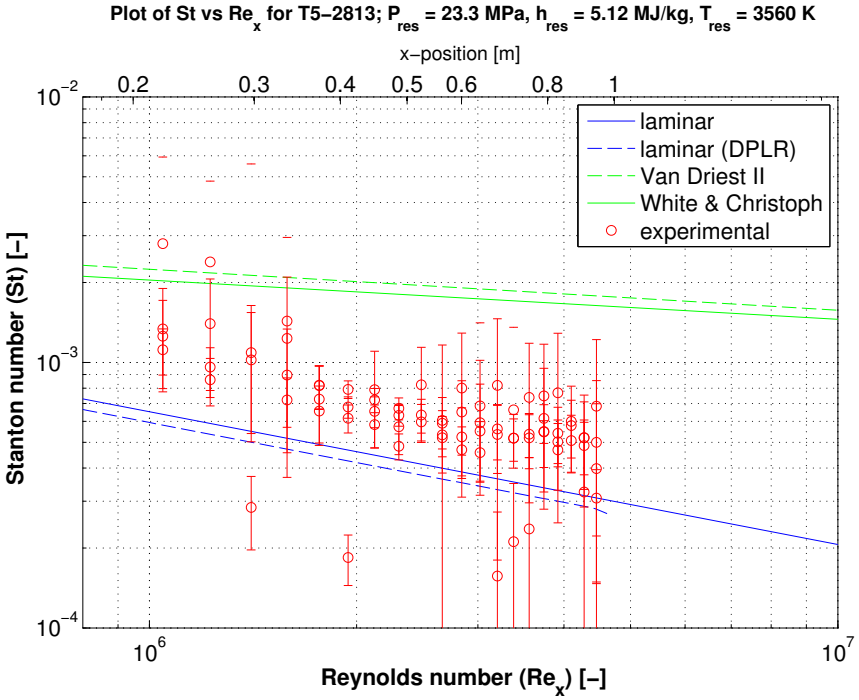


Figure 735: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

246 Shot 2814

Experiment 2814 was performed in T5 on 20 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

246.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2310	m/s
Shock Tube Fill Pressure	P_1	91.85	kPa
Reservoir Pressure	P_{res}	22.5	MPa

Table 1961: Measured quantities, Shot 2814

246.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3409	K
Reservoir Density	ρ_{res}	26.51	kg/m^3
Reservoir Enthalpy	h_{res}	4.68	MJ/kg

Table 1962: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2814

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.65×10^{-1}	1.25×10^{-1}	4.07×10^{-1}	3.89×10^{-2}	5.90×10^{-2}	2.64×10^{-6}	4.52×10^{-3}

Table 1963: Computed reservoir species mass fractions, Shot 2814

246.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2703	876.0	876.0	5.20	11.5	0.054	3.93×10^6
72 cm	2691	897.6	901.3	4.87	13.5	0.062	4.45×10^6

Table 1964: Computed freestream conditions, Shot 2814

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.70×10^{-1}	1.19×10^{-1}	4.47×10^{-1}	2.96×10^{-2}	3.35×10^{-2}	0	5.03×10^{-4}
72 cm	3.67×10^{-1}	1.14×10^{-1}	4.55×10^{-1}	3.49×10^{-2}	2.85×10^{-2}	0	1.55×10^{-4}

Table 1965: Computed freestream species mass fractions, Shot 2814

246.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2676	939.1	939.1	4.97	15.9	0.070	4.86×10^6
72 cm	2646	985.7	985.6	4.57	18.6	0.078	5.25×10^6

Table 1966: Computed boundary layer edge conditions, Shot 2814

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.70×10^{-1}	1.19×10^{-1}	4.47×10^{-1}	2.96×10^{-2}	3.35×10^{-2}	0	5.03×10^{-4}
72 cm	3.67×10^{-1}	1.14×10^{-1}	4.55×10^{-1}	3.49×10^{-2}	2.85×10^{-2}	0	1.50×10^{-4}

Table 1967: Computed boundary layer edge species mass fractions, Shot 2814

	T^* K	Unit Re^* 1/m
1D 100 cm	1077	3.96×10^6
72 cm	1049	4.93×10^6

Table 1968: Dorrance reference conditions, Shot 2814

246.5 Stability Computations

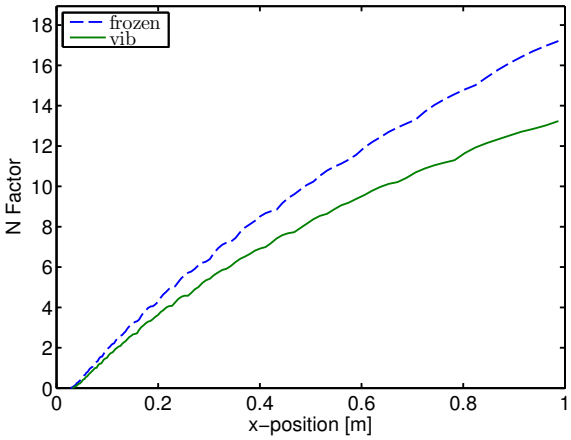


Figure 736: Locus of maximum N factor with and without vibrational energy transfer, Shot 2814

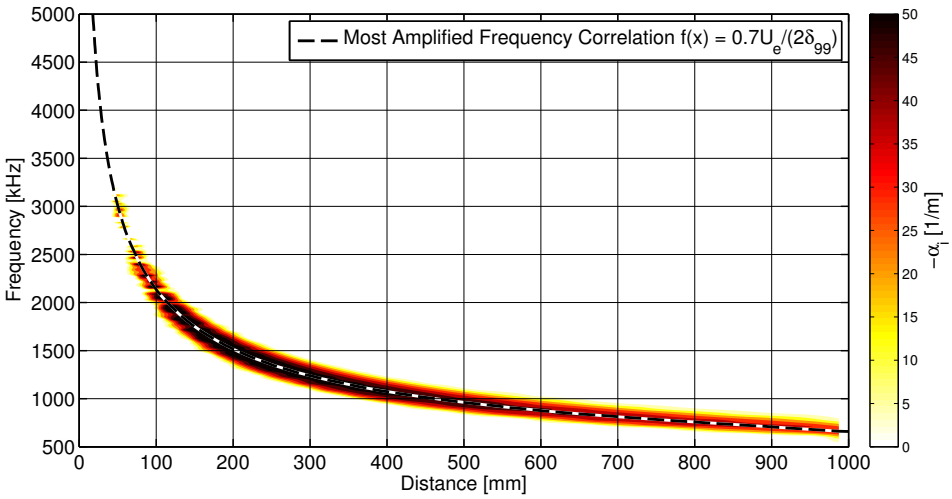


Figure 737: Stability diagram with vibrational energy transfer, Shot 2814. Dashed line indicates $0.7U_e/(2\delta_{99})$.

246.6 Heat Transfer Results

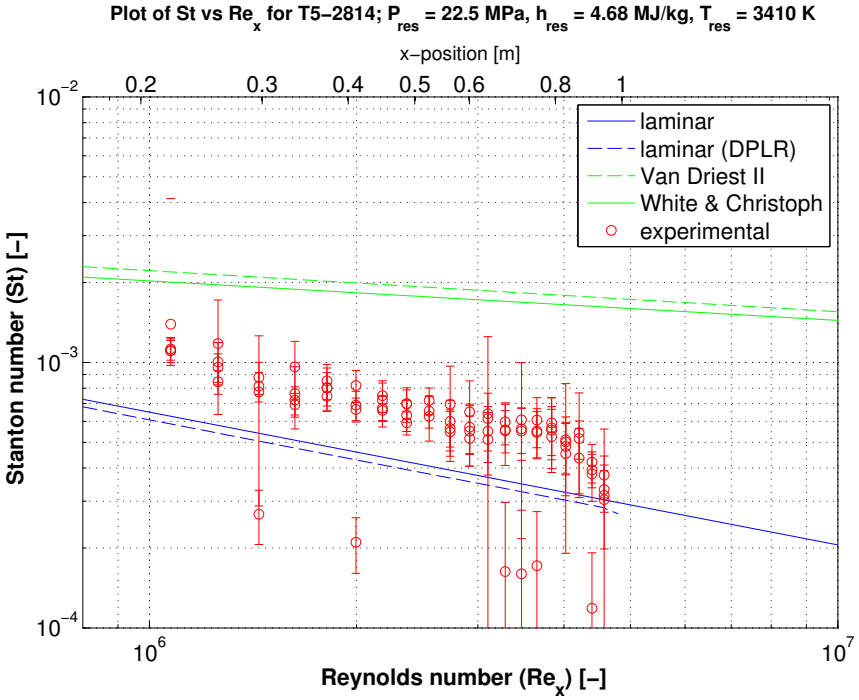


Figure 738: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

247 Shot 2816

Experiment 2816 was performed in T5 on 25 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

247.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2260	m/s
Shock Tube Fill Pressure	P_1	92.00	kPa
Reservoir Pressure	P_{res}	23.0	MPa

Table 1969: Measured quantities, Shot 2816

247.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3355	K
Reservoir Density	ρ_{res}	27.77	kg/m^3
Reservoir Enthalpy	h_{res}	4.52	MJ/kg

Table 1970: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2816

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.66×10^{-1}	1.23×10^{-1}	4.19×10^{-1}	3.66×10^{-2}	5.17×10^{-2}	1.98×10^{-6}	3.81×10^{-3}

Table 1971: Computed reservoir species mass fractions, Shot 2816

247.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2670	854.0	854.0	5.21	11.7	0.056	4.12×10^6
72 cm	2658	875.5	879.1	4.88	13.8	0.065	4.70×10^6

Table 1972: Computed freestream conditions, Shot 2816

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.70×10^{-1}	1.18×10^{-1}	4.54×10^{-1}	2.81×10^{-2}	2.93×10^{-2}	1.04×10^{-10}	4.39×10^{-4}
72 cm	3.68×10^{-1}	1.12×10^{-1}	4.62×10^{-1}	3.35×10^{-2}	2.45×10^{-2}	0	1.18×10^{-4}

Table 1973: Computed freestream species mass fractions, Shot 2816

247.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2643	915.2	915.2	4.98	16.2	0.073	5.10×10^6
72 cm	2614	961.7	961.6	4.58	19.1	0.082	5.54×10^6

Table 1974: Computed boundary layer edge conditions, Shot 2816

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.70×10^{-1}	1.18×10^{-1}	4.54×10^{-1}	2.81×10^{-2}	2.93×10^{-2}	1.04×10^{-10}	4.39×10^{-4}
72 cm	3.68×10^{-1}	1.12×10^{-1}	4.62×10^{-1}	3.35×10^{-2}	2.45×10^{-2}	0	1.14×10^{-4}

Table 1975: Computed boundary layer edge species mass fractions, Shot 2816

	T^* K	Unit Re^* 1/m
1D 100 cm	1056	4.11×10^6
72 cm	1029	5.00×10^6

Table 1976: Dorrance reference conditions, Shot 2816

247.5 Stability Computations

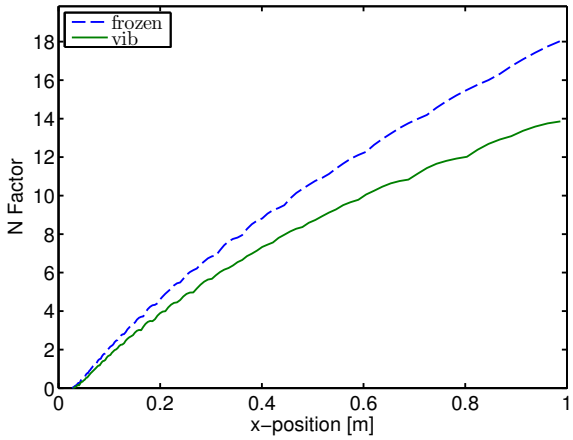


Figure 739: Locus of maximum N factor with and without vibrational energy transfer, Shot 2816

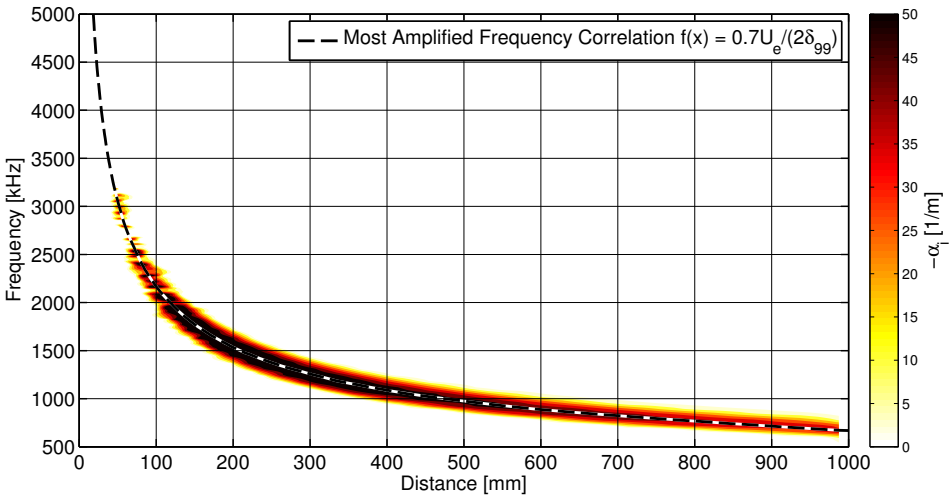


Figure 740: Stability diagram with vibrational energy transfer, Shot 2816. Dashed line indicates $0.7U_e/(2\delta_{99})$.

247.6 Heat Transfer Results

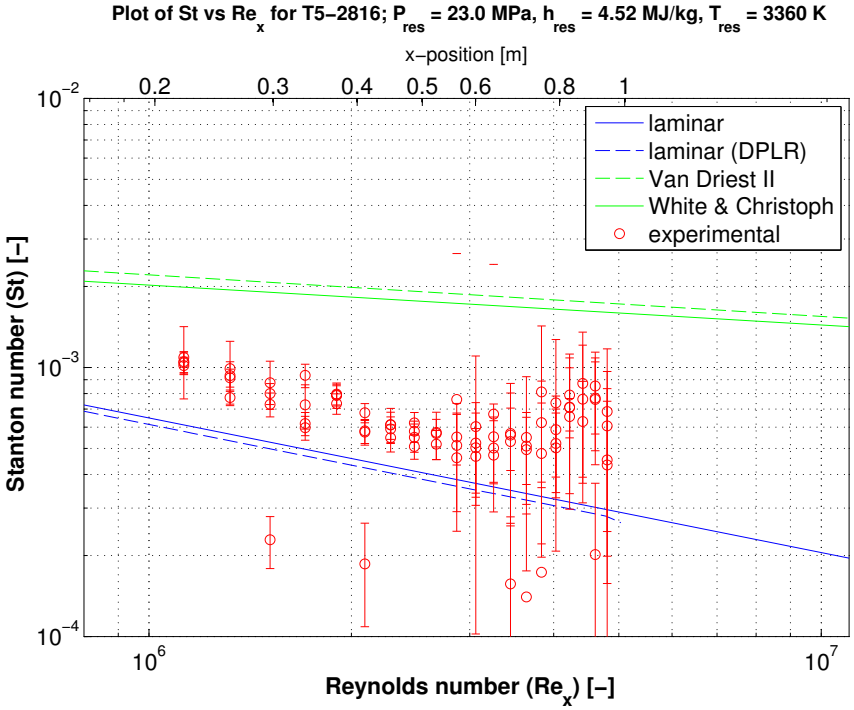


Figure 741: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

248 Shot 2817

Experiment 2817 was performed in T5 on 26 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

248.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2180	m/s
Shock Tube Fill Pressure	P_1	120.00	kPa
Reservoir Pressure	P_{res}	23.3	MPa

Table 1977: Measured quantities, Shot 2817

248.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3193	K
Reservoir Density	ρ_{res}	29.93	kg/m^3
Reservoir Enthalpy	h_{res}	4.08	MJ/kg

Table 1978: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2817

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.69×10^{-1}	1.17×10^{-1}	4.47×10^{-1}	3.05×10^{-2}	3.40×10^{-2}	8.13×10^{-7}	2.30×10^{-3}

Table 1979: Computed reservoir species mass fractions, Shot 2817

248.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2577	792.0	792.0	5.23	11.7	0.061	4.52×10^6
72 cm	2561	809.9	813.2	4.90	14.0	0.072	5.18×10^6

Table 1980: Computed freestream conditions, Shot 2817

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.73×10^{-1}	1.14×10^{-1}	4.70×10^{-1}	2.34×10^{-2}	1.90×10^{-2}	0	3.25×10^{-4}
72 cm	3.70×10^{-1}	1.09×10^{-1}	4.75×10^{-1}	2.97×10^{-2}	1.56×10^{-2}	0	6.20×10^{-5}

Table 1981: Computed freestream species mass fractions, Shot 2817

248.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2551	849.9	849.9	5.00	16.3	0.079	5.59×10^6
72 cm	2519	891.6	891.5	4.59	19.3	0.090	6.10×10^6

Table 1982: Computed boundary layer edge conditions, Shot 2817

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.73×10^{-1}	1.14×10^{-1}	4.70×10^{-1}	2.34×10^{-2}	1.90×10^{-2}	0	3.25×10^{-4}
72 cm	3.70×10^{-1}	1.09×10^{-1}	4.75×10^{-1}	2.97×10^{-2}	1.56×10^{-2}	0	6.01×10^{-5}

Table 1983: Computed boundary layer edge species mass fractions, Shot 2817

	T^* K	Unit Re^* 1/m
1D 100 cm	999	4.38×10^6
72 cm	971	5.36×10^6

Table 1984: Dorrance reference conditions, Shot 2817

248.5 Stability Computations

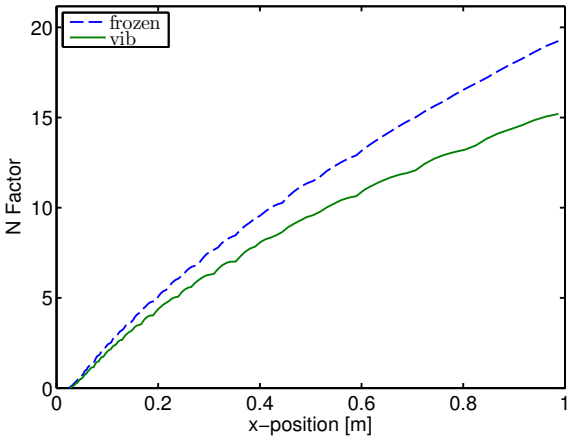


Figure 742: Locus of maximum N factor with and without vibrational energy transfer, Shot 2817

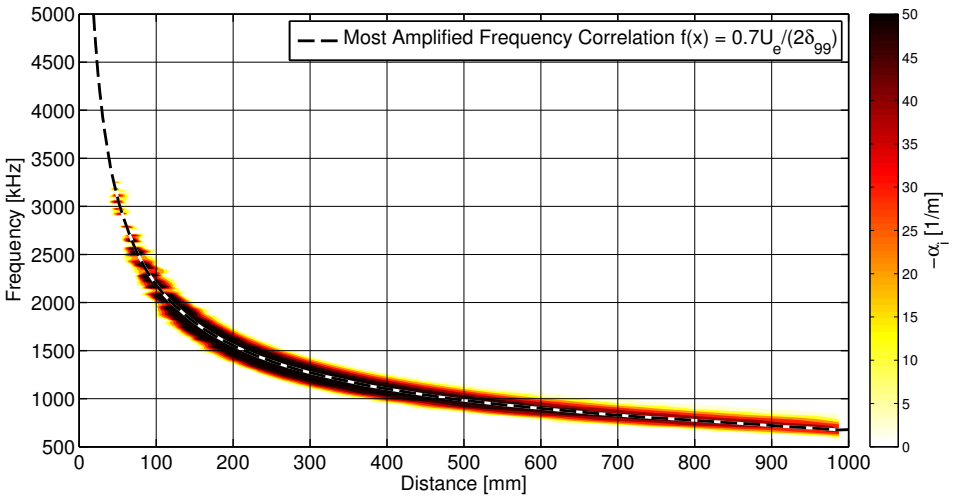


Figure 743: Stability diagram with vibrational energy transfer, Shot 2817. Dashed line indicates $0.7U_e/(2\delta_{99})$.

248.6 Heat Transfer Results

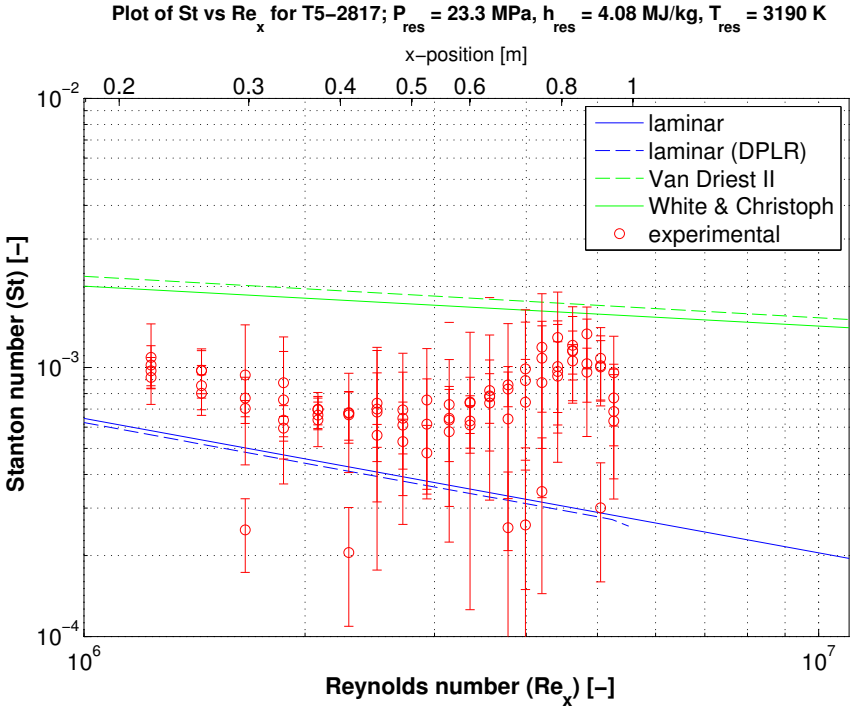


Figure 744: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

249 Shot 2818

Experiment 2818 was performed in T5 on 27 June 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

249.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2590	m/s
Shock Tube Fill Pressure	P_1	120.00	kPa
Reservoir Pressure	P_{res}	40.7	MPa

Table 1985: Measured quantities, Shot 2818

249.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3879	K
Reservoir Density	ρ_{res}	40.76	kg/m^3
Reservoir Enthalpy	h_{res}	5.96	MJ/kg

Table 1986: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2818

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.56×10^{-1}	1.37×10^{-1}	3.29×10^{-1}	5.90×10^{-2}	1.09×10^{-1}	1.56×10^{-5}	1.07×10^{-2}

Table 1987: Computed reservoir species mass fractions, Shot 2818

249.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2987	1128.0	1128.0	5.06	22.4	0.081	5.71×10^{6}
72 cm	2976	1129.8	1131.8	4.78	25.7	0.093	6.52×10^{6}

Table 1988: Computed freestream conditions, Shot 2818

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.24×10^{-1}	4.24×10^{-1}	3.57×10^{-2}	4.81×10^{-2}	0	7.58×10^{-4}
72 cm	3.64×10^{-1}	1.19×10^{-1}	4.29×10^{-1}	4.25×10^{-2}	4.54×10^{-2}	0	2.87×10^{-4}

Table 1989: Computed freestream species mass fractions, Shot 2818

249.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2956	1202.5	1202.5	4.85	30.6	0.103	7.02×10^{6}
72 cm	2927	1230.4	1230.3	4.50	35.1	0.116	7.72×10^{6}

Table 1990: Computed boundary layer edge conditions, Shot 2818

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.24×10^{-1}	4.24×10^{-1}	3.57×10^{-2}	4.81×10^{-2}	0	7.58×10^{-4}
72 cm	3.64×10^{-1}	1.19×10^{-1}	4.29×10^{-1}	4.25×10^{-2}	4.54×10^{-2}	0	2.63×10^{-4}

Table 1991: Computed boundary layer edge species mass fractions, Shot 2818

	T^* K	Unit Re^* 1/m
1D 100 cm	1286	6.34×10^{6}
72 cm	1236	7.67×10^{6}

Table 1992: Dorrance reference conditions, Shot 2818

249.5 Stability Computations

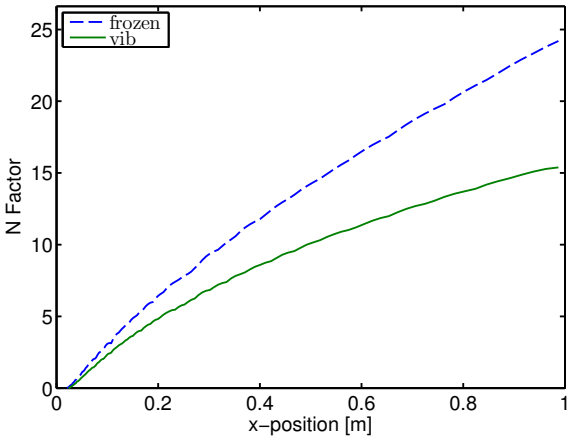


Figure 745: Locus of maximum N factor with and without vibrational energy transfer, Shot 2818

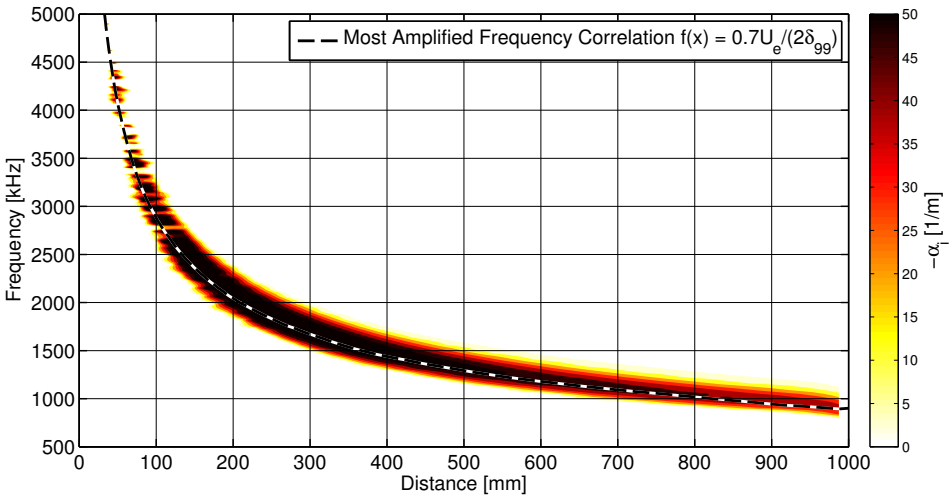


Figure 746: Stability diagram with vibrational energy transfer, Shot 2818. Dashed line indicates $0.7U_e/(2\delta_{99})$.

249.6 Heat Transfer Results

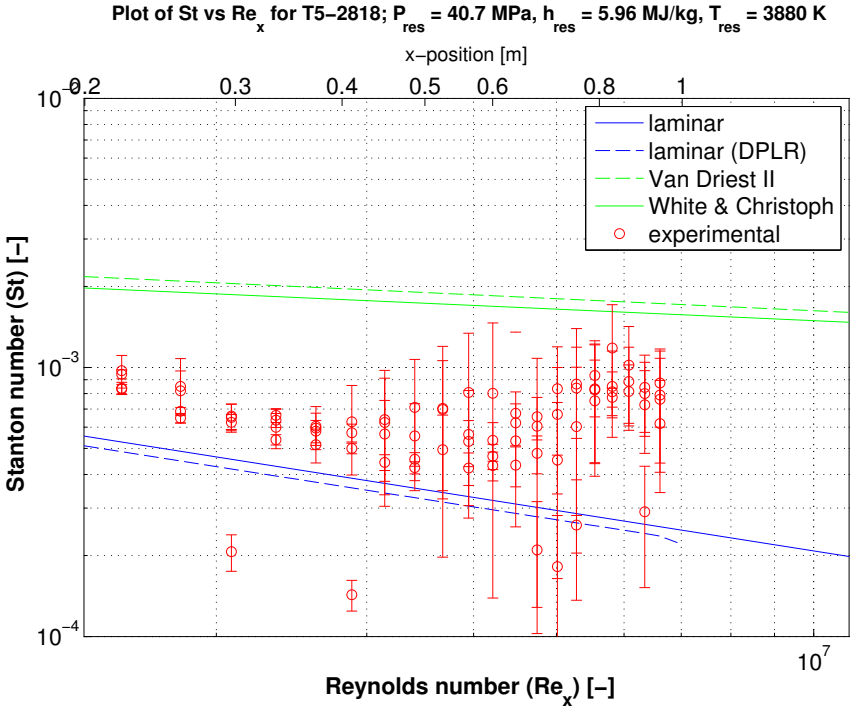


Figure 747: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

250 Shot 2819

Experiment 2819 was performed in T5 on 1 July 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

250.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2570	m/s
Shock Tube Fill Pressure	P_1	146.00	kPa
Reservoir Pressure	P_{res}	39.8	MPa

Table 1993: Measured quantities, Shot 2819

250.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	3784	K
Reservoir Density	ρ_{res}	41.19	kg/m^3
Reservoir Enthalpy	h_{res}	5.66	MJ/kg

Table 1994: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2819

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.58×10^{-1}	1.33×10^{-1}	3.49×10^{-1}	5.45×10^{-2}	9.59×10^{-2}	1.08×10^{-5}	8.74×10^{-3}

Table 1995: Computed reservoir species mass fractions, Shot 2819

250.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	2925	1073.0	1073.0	5.09	21.4	0.081	5.79×10^6
72 cm	2917	1080.8	1082.9	4.80	24.9	0.094	6.66×10^6

Table 1996: Computed freestream conditions, Shot 2819

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.22×10^{-1}	4.32×10^{-1}	3.49×10^{-2}	4.31×10^{-2}	1.23×10^{-10}	6.11×10^{-4}
72 cm	3.64×10^{-1}	1.17×10^{-1}	4.38×10^{-1}	4.09×10^{-2}	3.97×10^{-2}	0	1.91×10^{-4}

Table 1997: Computed freestream species mass fractions, Shot 2819

250.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	2895	1144.1	1144.1	4.88	29.3	0.105	7.13×10^6
72 cm	2869	1178.5	1178.5	4.52	34.1	0.118	7.88×10^6

Table 1998: Computed boundary layer edge conditions, Shot 2819

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.67×10^{-1}	1.22×10^{-1}	4.32×10^{-1}	3.49×10^{-2}	4.31×10^{-2}	1.23×10^{-10}	6.11×10^{-4}
72 cm	3.64×10^{-1}	1.17×10^{-1}	4.38×10^{-1}	4.09×10^{-2}	3.96×10^{-2}	0	1.76×10^{-4}

Table 1999: Computed boundary layer edge species mass fractions, Shot 2819

	T^* K	Unit Re^* 1/m
1D 100 cm	1239	6.33×10^6
72 cm	1196	7.71×10^6

Table 2000: Dorrance reference conditions, Shot 2819

250.5 Stability Computations

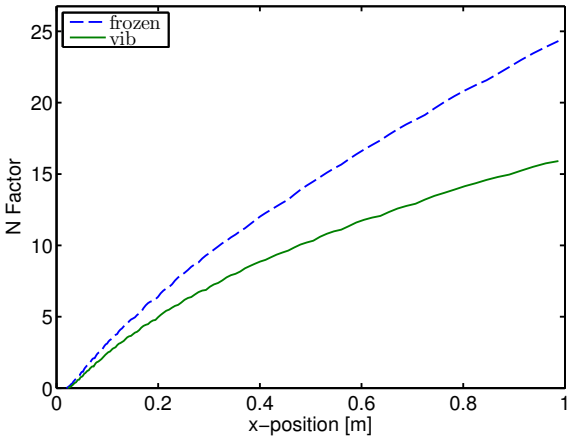


Figure 748: Locus of maximum N factor with and without vibrational energy transfer, Shot 2819

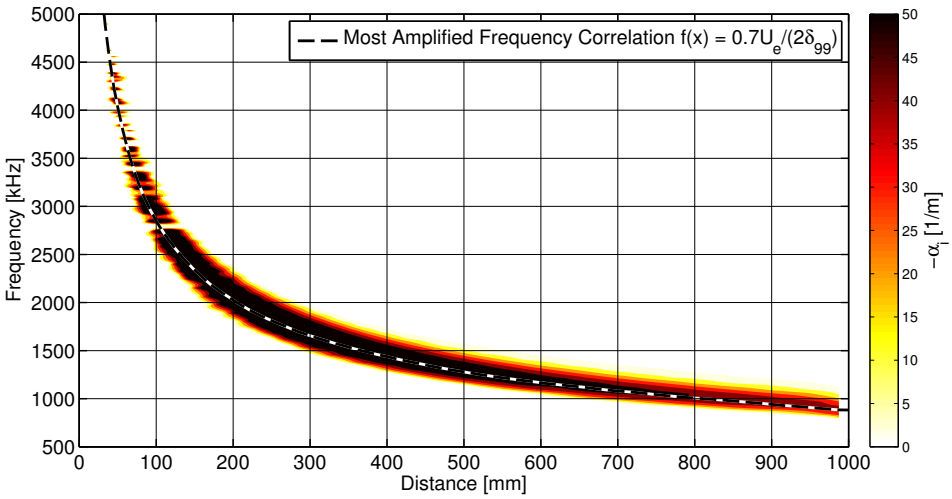


Figure 749: Stability diagram with vibrational energy transfer, Shot 2819. Dashed line indicates $0.7U_e/(2\delta_{99})$.

250.6 Heat Transfer Results

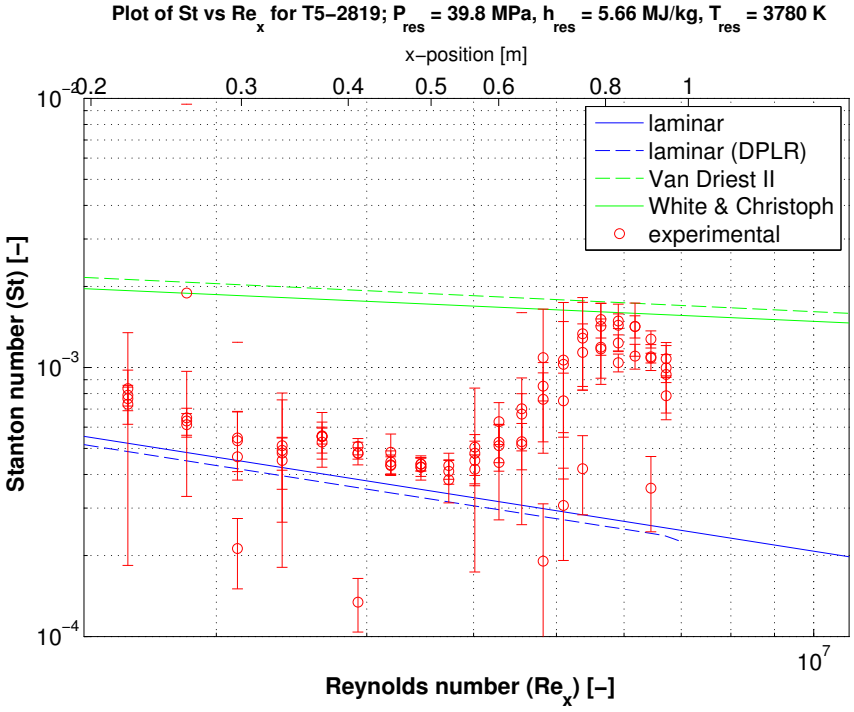


Figure 750: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

251 Shot 2820

Experiment 2820 was performed in T5 on 2 July 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

251.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2810	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	41.3	MPa

Table 2001: Measured quantities, Shot 2820

251.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4246	K
Reservoir Density	ρ_{res}	36.19	kg/m^3
Reservoir Enthalpy	h_{res}	7.22	MJ/kg

Table 2002: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2820

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.48×10^{-1}	1.46×10^{-1}	2.44×10^{-1}	7.66×10^{-2}	1.63×10^{-1}	5.74×10^{-5}	2.24×10^{-2}

Table 2003: Computed reservoir species mass fractions, Shot 2820

251.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re$_\infty$ 1/m
1D 100 cm	3218	1346.0	1346.0	4.96	23.9	0.071	4.93×10^6
72 cm	3202	1332.5	1334.1	4.69	26.9	0.081	5.59×10^6

Table 2004: Computed freestream conditions, Shot 2820

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.36×10^{-1}	3.86×10^{-1}	3.84×10^{-2}	7.28×10^{-2}	1.36×10^{-10}	1.90×10^{-3}
72 cm	3.61×10^{-1}	1.30×10^{-1}	3.88×10^{-1}	4.74×10^{-2}	7.11×10^{-2}	3.28×10^{-10}	1.40×10^{-3}

Table 2005: Computed freestream species mass fractions, Shot 2820

251.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re$_e$ 1/m
1D 100 cm	3185	1430.5	1430.5	4.76	32.4	0.091	5.99×10^6
72 cm	3151	1447.0	1446.9	4.43	36.4	0.101	6.54×10^6

Table 2006: Computed boundary layer edge conditions, Shot 2820

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.36×10^{-1}	3.86×10^{-1}	3.84×10^{-2}	7.28×10^{-2}	1.36×10^{-10}	1.90×10^{-3}
72 cm	3.61×10^{-1}	1.30×10^{-1}	3.89×10^{-1}	4.74×10^{-2}	7.10×10^{-2}	8.14×10^{-10}	1.29×10^{-3}

Table 2007: Computed boundary layer edge species mass fractions, Shot 2820

	T^* K	Unit Re* 1/m
1D 100 cm	1472	5.70×10^6
72 cm	1405	6.88×10^6

Table 2008: Dorrance reference conditions, Shot 2820

251.5 Stability Computations

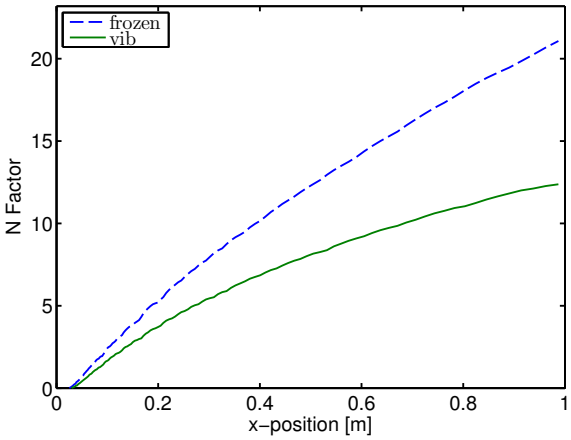


Figure 751: Locus of maximum N factor with and without vibrational energy transfer, Shot 2820

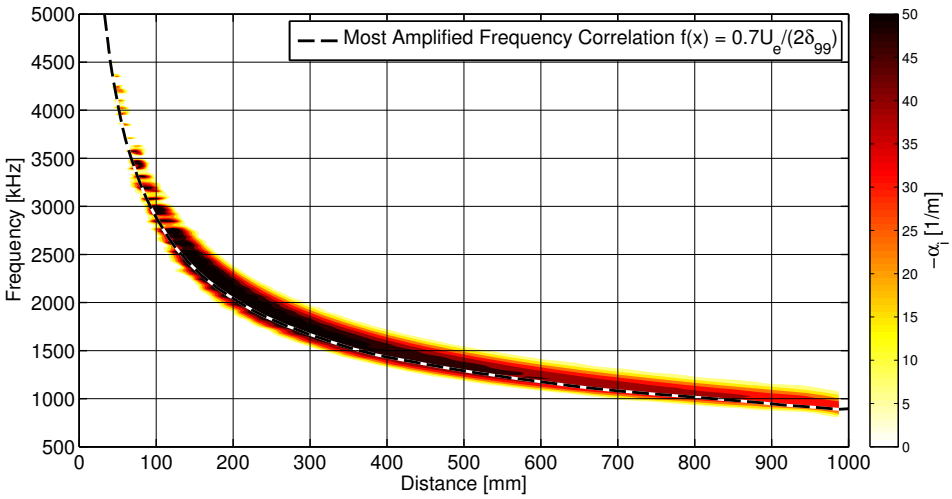


Figure 752: Stability diagram with vibrational energy transfer, Shot 2820. Dashed line indicates $0.7U_e/(2\delta_{99})$.

251.6 Heat Transfer Results

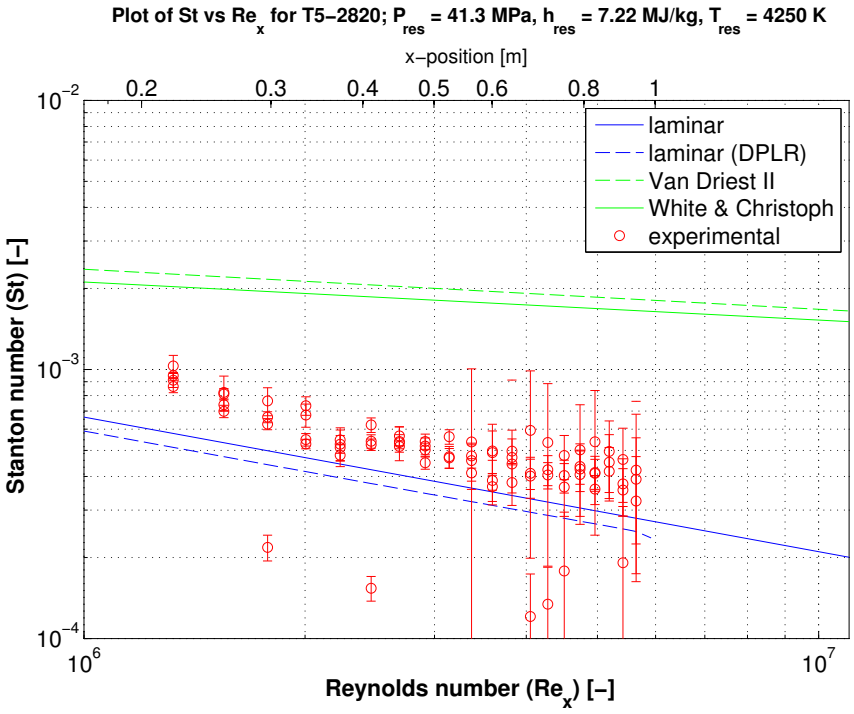


Figure 753: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

252 Shot 2821

Experiment 2821 was performed in T5 on 3 July 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 50% air, 50% CO_2 by mass.

252.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2720	m/s
Shock Tube Fill Pressure	P_1	100.00	kPa
Reservoir Pressure	P_{res}	42.5	MPa

Table 2009: Measured quantities, Shot 2821

252.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	4102	K
Reservoir Density	ρ_{res}	39.23	kg/m^3
Reservoir Enthalpy	h_{res}	6.70	MJ/kg

Table 2010: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2821

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
3.51×10^{-1}	1.43×10^{-1}	2.79×10^{-1}	6.97×10^{-2}	1.41×10^{-1}	3.48×10^{-5}	1.68×10^{-2}

Table 2011: Computed reservoir species mass fractions, Shot 2821

252.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3132	1266.0	1266.0	5.00	24.6	0.078	5.47×10^6
72 cm	3114	1253.3	1255.1	4.72	27.3	0.088	6.13×10^6

Table 2012: Computed freestream conditions, Shot 2821

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.30×10^{-1}	4.04×10^{-1}	3.72×10^{-2}	6.14×10^{-2}	0	1.27×10^{-3}
72 cm	3.62×10^{-1}	1.25×10^{-1}	4.07×10^{-1}	4.57×10^{-2}	5.95×10^{-2}	0	7.52×10^{-4}

Table 2013: Computed freestream species mass fractions, Shot 2821

252.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3100	1346.8	1346.8	4.79	33.4	0.100	6.69×10^6
72 cm	3063	1362.5	1362.4	4.46	37.2	0.110	7.23×10^6

Table 2014: Computed boundary layer edge conditions, Shot 2821

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	3.66×10^{-1}	1.30×10^{-1}	4.04×10^{-1}	3.72×10^{-2}	6.14×10^{-2}	0	1.27×10^{-3}
72 cm	3.62×10^{-1}	1.25×10^{-1}	4.07×10^{-1}	4.57×10^{-2}	5.94×10^{-2}	2.04×10^{-10}	6.87×10^{-4}

Table 2015: Computed boundary layer edge species mass fractions, Shot 2821

	T^* K	Unit Re^* 1/m
1D 100 cm	1402	6.29×10^6
72 cm	1337	7.44×10^6

Table 2016: Dorrance reference conditions, Shot 2821

252.5 Stability Computations

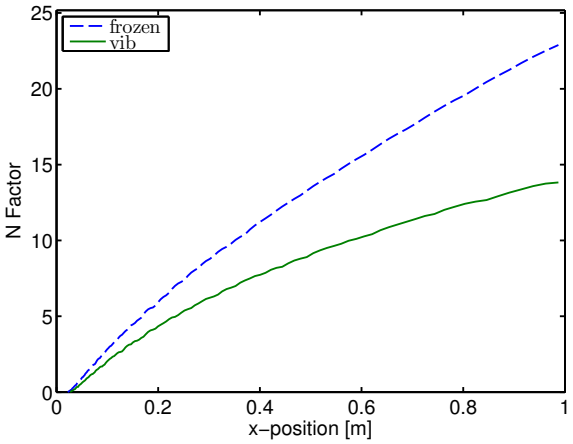


Figure 754: Locus of maximum N factor with and without vibrational energy transfer, Shot 2821

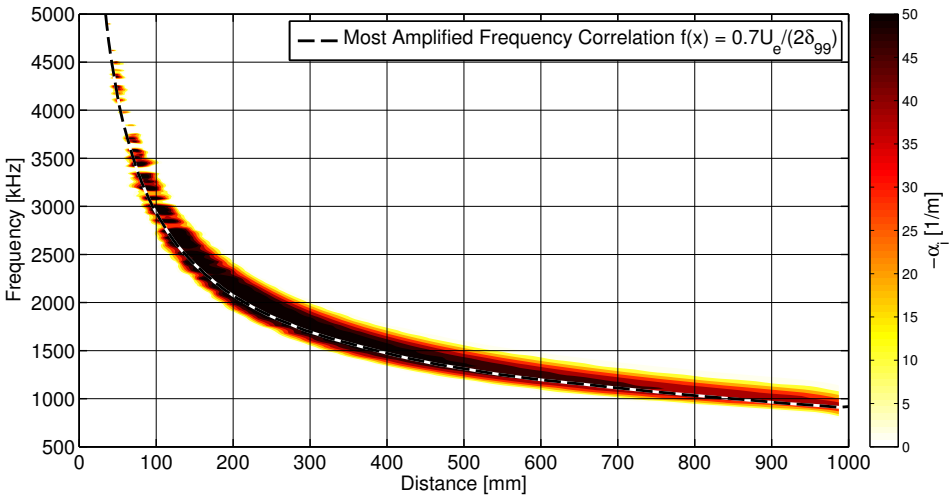


Figure 755: Stability diagram with vibrational energy transfer, Shot 2821. Dashed line indicates $0.7U_e/(2\delta_{99})$.

252.6 Heat Transfer Results

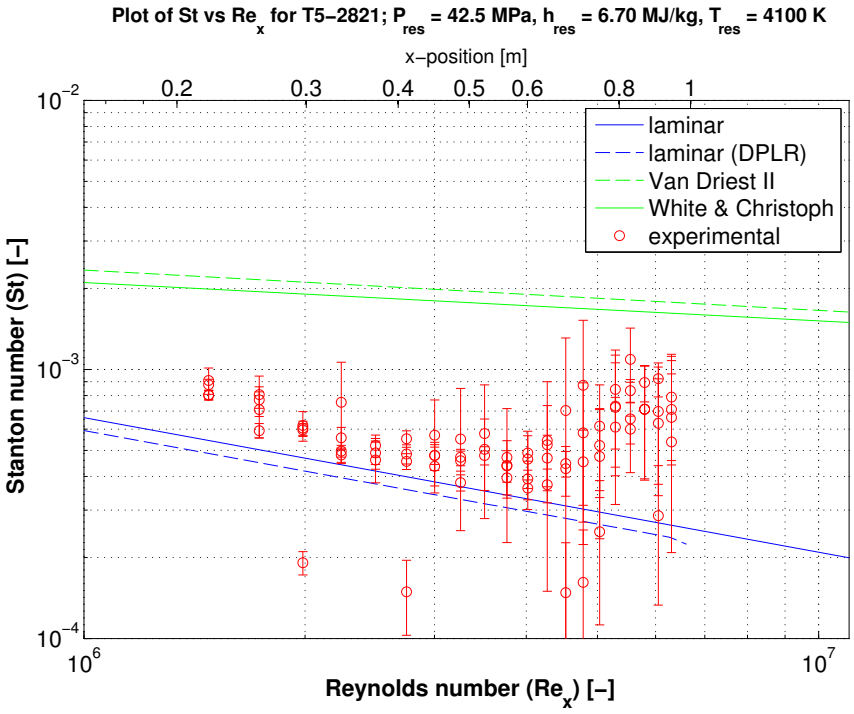


Figure 756: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

253 Shot 2822

Experiment 2822 was performed in T5 on 8 July 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

253.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	2960	m/s
Shock Tube Fill Pressure	P_1	96.50	kPa
Reservoir Pressure	P_res	42.9	MPa

Table 2017: Measured quantities, Shot 2822

253.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_res	5376	K
Reservoir Density	ρ_res	25.75	kg/m^3
Reservoir Enthalpy	h_res	8.18	MJ/kg

Table 2018: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2822

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	7.96×10^{-2}	0	1.36×10^{-1}	0	1.57×10^{-3}	8.08×10^{-2}

Table 2019: Computed reservoir species mass fractions, Shot 2822

253.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3708	1180.0	1180.0	5.49	18.8	0.055	4.37×10^{6}
72 cm	3684	1195.9	1203.1	5.29	21.6	0.062	4.91×10^{6}

Table 2020: Computed freestream conditions, Shot 2822

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.20×10^{-2}	0	1.70×10^{-10}	1.21×10^{-2}
72 cm	7.32×10^{-1}	1.86×10^{-1}	0	7.58×10^{-2}	0	3.52×10^{-10}	6.38×10^{-3}

Table 2021: Computed freestream species mass fractions, Shot 2822

253.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3672	1291.7	1291.7	5.20	27.1	0.072	5.41×10^{6}
72 cm	3621	1363.0	1360.0	4.87	31.2	0.079	5.65×10^{6}

Table 2022: Computed boundary layer edge conditions, Shot 2822

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.38×10^{-1}	1.88×10^{-1}	0	6.20×10^{-2}	0	1.70×10^{-10}	1.21×10^{-2}
72 cm	7.32×10^{-1}	1.86×10^{-1}	0	7.58×10^{-2}	0	2.71×10^{-9}	6.25×10^{-3}

Table 2023: Computed boundary layer edge species mass fractions, Shot 2822

	T^* K	Unit Re^* 1/m
1D 100 cm	1625	3.68×10^{6}
72 cm	1599	4.32×10^{6}

Table 2024: Dorrance reference conditions, Shot 2822

253.5 Stability Computations

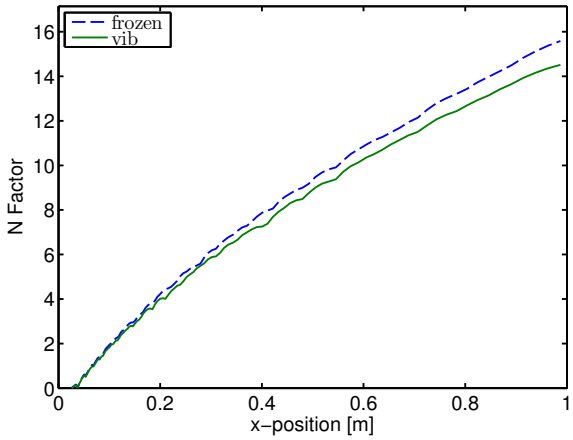


Figure 757: Locus of maximum N factor with and without vibrational energy transfer, Shot 2822

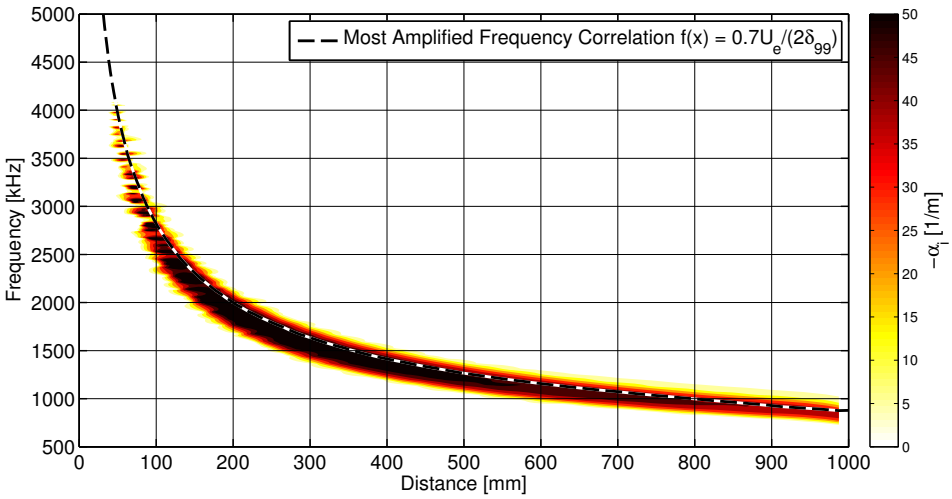


Figure 758: Stability diagram with vibrational energy transfer, Shot 2822. Dashed line indicates $0.7U_e/(2\delta_{99})$.

253.6 Heat Transfer Results

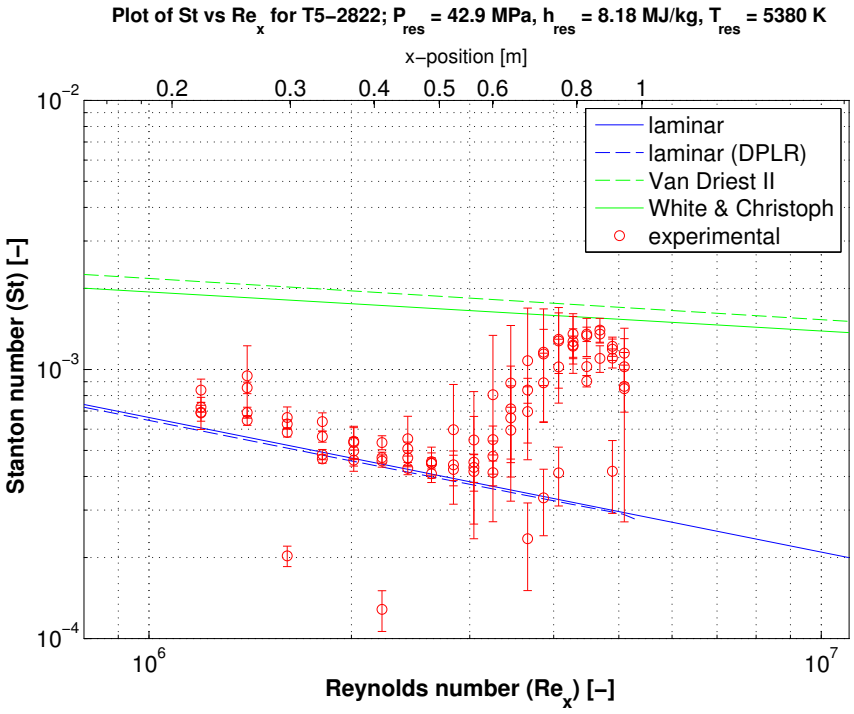


Figure 759: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

254 Shot 2823

Experiment 2823 was performed in T5 on 31 July 2013. The test article was a 1 m 5-degree half-angle cone with a sharp tip and no injector (smooth). The initial shock tube composition was 100% air by mass.

254.1 Measured Quantities

Measurement	Symbol	Value	Units
Shock Speed	U_s	3050	m/s
Shock Tube Fill Pressure	P_1	85.00	kPa
Reservoir Pressure	P_{res}	42.6	MPa

Table 2025: Measured quantities, Shot 2823

254.2 Reservoir Conditions

Computed Quantity	Symbol	Value	Units
Reservoir Temperature	T_{res}	5620	K
Reservoir Density	ρ_{res}	24.14	kg/m^3
Reservoir Enthalpy	h_{res}	8.77	MJ/kg

Table 2026: Computed (Cantera/SD Toolbox) reservoir conditions, Shot 2823

Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
7.02×10^{-1}	6.58×10^{-2}	0	1.34×10^{-1}	0	2.56×10^{-3}	9.54×10^{-2}

Table 2027: Computed reservoir species mass fractions, Shot 2823

254.3 Freestream Conditions

	U_∞ m/s	T_∞ K	Tv_∞ K	M_∞ -	P_∞ kPa	ρ_∞ kg/m^3	Unit Re_∞ 1/m
1D 100 cm	3824	1279.0	1279.0	5.44	19.3	0.052	4.06×10^{6}
72 cm	3795	1303.8	1313.0	5.21	22.3	0.059	4.53×10^{6}

Table 2028: Computed freestream conditions, Shot 2823

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.12×10^{-2}	0	6.72×10^{-10}	1.63×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.39×10^{-2}	0	1.78×10^{-9}	9.39×10^{-3}

Table 2029: Computed freestream species mass fractions, Shot 2823

254.4 Boundary Layer Edge and Reference Conditions

	U_e m/s	T_e K	Tv_e K	M_e -	P_e kPa	ρ_e kg/m^3	Unit Re_e 1/m
1D 100 cm	3786	1397.0	1397.0	5.15	27.7	0.068	5.00×10^{6}
72 cm	3731	1479.5	1476.6	4.81	31.9	0.074	5.17×10^{6}

Table 2030: Computed boundary layer edge conditions, Shot 2823

	Y_{N_2}	Y_{O_2}	Y_{CO_2}	Y_{NO}	Y_{CO}	Y_N	Y_O
1D 100 cm	7.39×10^{-1}	1.84×10^{-1}	0	6.12×10^{-2}	0	6.72×10^{-10}	1.63×10^{-2}
72 cm	7.33×10^{-1}	1.84×10^{-1}	0	7.39×10^{-2}	0	9.57×10^{-9}	9.17×10^{-3}

Table 2031: Computed boundary layer edge species mass fractions, Shot 2823

	T^* K	Unit Re^* 1/m
1D 100 cm	1720	3.51×10^{6}
72 cm	1693	4.12×10^{6}

Table 2032: Dorrance reference conditions, Shot 2823

254.5 Stability Computations

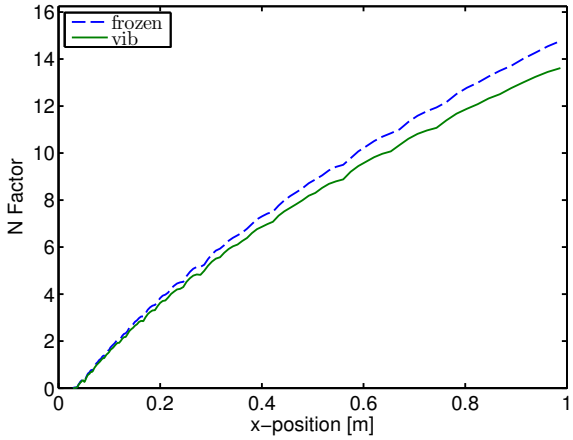


Figure 760: Locus of maximum N factor with and without vibrational energy transfer, Shot 2823

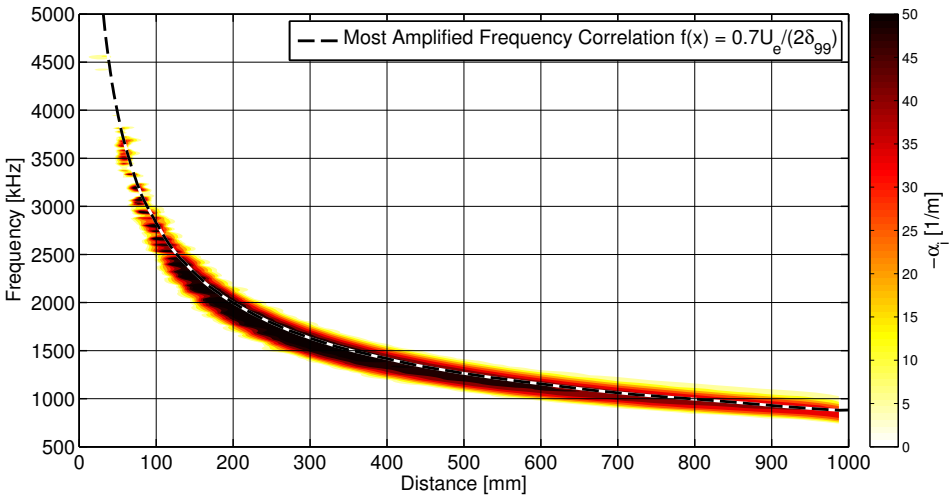


Figure 761: Stability diagram with vibrational energy transfer, Shot 2823. Dashed line indicates $0.7U_e/(2\delta_{99})$.

254.6 Heat Transfer Results

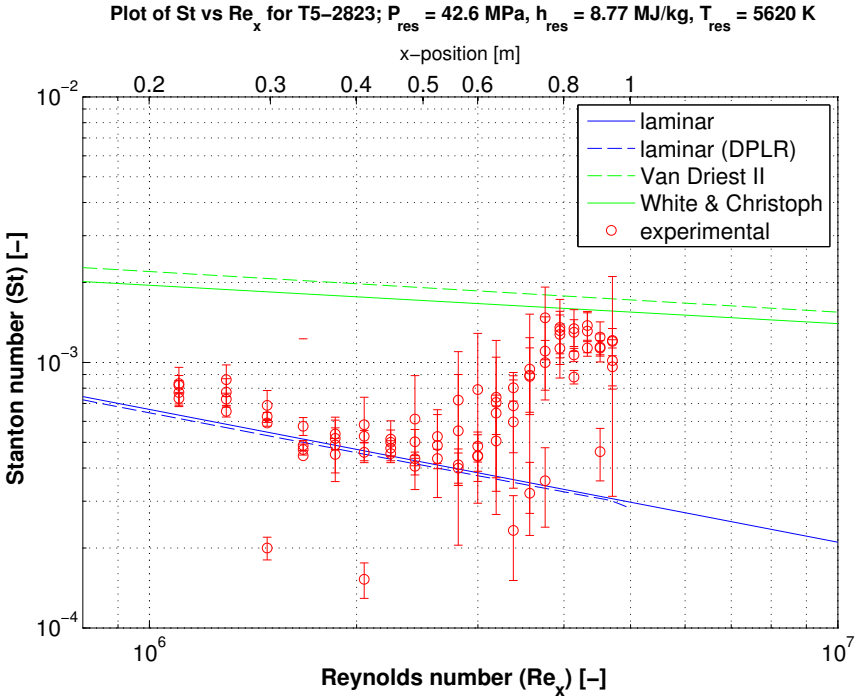


Figure 762: St vs. Re with laminar and turbulent correlations and laminar computation. Error bars are RMS for each gauge.

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J. S. Jewell. *Boundary-Layer Transition on a Slender Cone in Hypervelocity Flow with Real Gas Effects*. PhD thesis, California Institute of Technology, Pasadena, CA, 2014. 1