Appendix A

TECHNICAL DOCUMENTATION FOR THE CALTECH COLUMN OBSERVATORY

A.1 Summary

Three FTS observatories were assembled at Caltech during 2003 – 2006. These are currently deployed in Park Falls, Wisconsin (IFS1); Darwin, Australia (IFS2); and Pasadena, California (IFS3). Each observatory consists of a standard 20' x 8' x 8.5' steel shipping container, which has been modified by Martin Container according to our specifications to include reinforcement of the roof with 2.5" square steel tubing, addition of a 12" hole for the solar input beam, electrical wiring and breakout box, telephone wiring, heater/air conditioner, and welded nuts for mounting the Bruker IFS125.

A Bruker IFS125 spectrometer is installed in each container. The IFS125 feet are connected to 0.75" thick aluminum beams, which are then bolted onto I-beams. The I-beams are bolted to nuts which are welded to the container frame.

A fiberglass telescope dome is mounted on the reinforced section of the container roof. Inside the dome, a Bruker solar tracker is installed on an 8" diameter aluminum cylinder with 1" walls. This construction is intended to minimize any vibrations or misalignment. A network camera and weatherstation are also mounted on the roof.

The complete observatory consists of the IFS125 spectrometer, scroll pump, solar tracker, telescope dome, weatherstation, NTP-GPS satellite receiver, network camera, heaters (for IFS125, solar tracker, and scroll pump), temperature sensors, current and voltage sensors, and power systems. Each of these systems is monitored and/or controlled with a Diamond Systems Hercules board and an additional control board. The Hercules board includes four serial ports, used for communication with the solar tracker, telescope dome, weatherstation, and modem. The Hercules board includes 32 wide-range analog inputs for monitoring temperatures, voltage, currents, and pressure of the scroll pump. Five digital I/O lines of the Hercules board are used to command power to the solar tracker, telescope dome, modem, IFS125, and IFS125 reset line. The IFS125, network camera, NTP-GPS satellite time receiver, and uninterruptible power supply are commanded within the local area network.

Many of the observatory devices are commercial and have useful manuals. The original manual is the best starting point for troubleshooting a specific piece of the equipment, and I have not attempted to duplicate any of that information here. This appendix is meant to fill the remaining information gaps. For example, Bruker has provided no documentation for the IFS125. Similarly, the data acquisition software is entirely custom-written and does not have formal documentation.

A.2 Instrumentation

A.2.1 Bruker IFS125 Spectrometer

Model: Bruker Optics – IFS125
Bruker Optik GmbH
Rudolf-Plank-Str. 27
D-76275 Ettlingen
Germany
www.brukeroptics.com
Tel: (07243) 504 600
Fax:(07243) 504 698
Email: info@brukeroptics.de

Description:

The Bruker IFS125 Michelson interferometer with electronics based on the Brault method.

J.W. Brault (1996). New approaches to high-precision Fourier transform spectrometer design. *Applied Optics*, Vol. 35; No. 16; 2891 – 2896.

No manual exists for the IFS125.

Connection to Hercules Computer:

Network 192.168.1.101
Power is controlled by an optical fiber which is driven digitally.
Reset is controlled by an optical fiber which is driven digitally.

Direct Communication:

Use web browser to connect to 192.168.1.101

OPUS Registration Details

Name = "IFS 125HR"
Company = "CALIFORNIA INSTITUTE OF TECHNOLOGY"
Instrument = "BI020002"
OPUS Serial2 = "576168593"
Key2 = "4244244Z440Z"

IFS125 Serial Numbers

IFS1 (Park Falls) – SN02
IFS2 (Darwin) – SN13
IFS3 (Pasadena / Lamont) – SN20

A.2.1.1 Laser (Spectra-Physics 117A)

The laser signal is measured by two photodiode detectors, which Bruker refers to as Laser Detector A and Laser Detector B. These detectors are connected to the laser detector board in the interferometer compartment. The laser signal can be observed directly with an oscilloscope connected to LAS-A, LAS-B, and GND on the laser detector board.

The phase of the observed laser signal is offset by ±90 deg between Laser Detector A and Laser Detector B, due to the coating of the CaF_2 beamsplitter. This allows the IFS125 electronics to determine whether the scanner is moving in the forward or reverse direction.

The gain of the laser detectors is set in software through the IFS125 HTML menus, but does not take effect until the IFS125 is restarted. If the amplitude of the laser signal exceeds +15 VDC at a detector, the laser signal will be clipped and the quality of interferograms will be degraded.

If the laser has been powered off, the IFS125 will report a scanner error. This can be solved by reinitializing the scanner in the HTML Direct Control menu.

A.2.1.2 Scanner

The scanner consists of a voice-coil for fine motion and a motor for large motion. The scanner is connected to a stranded steel cable which is wound around the motor shaft under tension. Friction between the metal cable and the motor shaft cause the scanner assembly to be pulled as the motor turns. If the metal cable were to break, the released tension would cause a small limit switch to open and indicate an error.

Glued to the bottom of the motor assembly is a clear plastic disk edged with 10 µm chrome stripes. A Mercury 3000 encoder (MicroE Systems) measures the scanner position. This allows the scanner to obey the commands "Back Short Adjust" and "Front Short Adjust" in the absence of laser fringes. These commands are useful during alignment.

Optical limit switches at the front and back of the invar rods are designed to stop the scanner if it reaches the end of its travel. In addition, the IFS125_SN13 and IFS125_SN20 include physical stops at the end of the scanner travel.

A temperature sensor monitors the temperature of the scanner block.

A.2.1.3 Detectors

Spectral Range and Signal-to-Noise Ratio of Detectors

Detector	Spectral Range (cm^{-1})	SNR	Conditions
InGaAs	3,900 – 12,500	~900	Single solar scan at 45 cm OPD and 7.5 kHz velocity (6200 cm^{-1})
Si	9,500 – 25,000	~500	Single solar scan at 45 cm OPD and 7.5 kHz velocity (13,000 cm^{-1})
InSb	1,850 – 10,000		

Each IFS125 detector contains a detector element, a pre-amp electronics board, and an ADC electronics board.

Preamplifier Board:

Two gain settings are applied to each detector: the preamplifier gain setting (PGN) and the binary gain setting (GNS).

The binary gain may be set for both the master and slave detectors, using the GNS and SG2 commands. The binary gain settings are fixed. These choices are: 1, 2, 4, 8, and 16.

The preamp gain choices can be adjusted by changing resistors on the pre-amp electronics board. These resistors are labeled Ra, Rb, Rc, and Rd. In software, these choices appear as Ra = 0, Rb = 1, Rc = 2, and Ref = 3. Bruker has provided us with the preamp schematics.

For the IFS125 detectors, these values are currently:

	InGaAs	Si	InSb
Ra	3090 ohms	7680 ohms	1500 ohms
Rb	3650 ohms	9090 ohms	3600 ohms
Rc	750,000 ohms	1,500,000 ohms	25,000 ohms
Rd (ref)	2700 ohms	20,000 ohms	10,000 ohms

ADC Board:

This is a 24-bit, two-channel ADC with a maximum sampling frequency of 96 kHz. When taking two points per laser fringe (as required for wideband NIR work in dual-acquistion mode), this limits the maximum theoretical scanner velocity to 40 kHz. However, the Bruker data acquisition has struggled with other problems and has never achieved this 40 kHz potential.

To set the preamp gain, it is necessary to explicitly select the detector. For this reason, it is not possible to set the preamp gain of the slave detector. Bruker has implemented the DC channels in a peculiar way. One channel of the ADC is assigned to DC output and one channel is assigned to AC output. Dual-acqusition in DC mode records the InGaAs DC channel together with the Si DC channel as observed through the other (AC) InGaAs channel. Dual-acquisition in AC mode records the Si AC channel together with the InGaAs AC channel as observed through the other (DC) Si channel.

It necessary to explicitly select a detector in order to set its preamp gain. This strange dual-acquisition signal-forwarding makes it difficult to deteremine what gain is being changed. Here is a guide.

Detector Description	**Address**	**Action**
RT-Si Diode DC [Int Pos 1]	0x4020	Sets InGaAs gain
RT-InGaAs DC [Int Pos 1	0x4021	Sets InGaAs gain
RT-Si Diode DC + InGaAs DC [Int Pos 1]	0x4022	Sets InGaAs gain
RT-Si Diode AC [Int Pos 2]	0x4040	Sets Si gain
RT-InGaAs AC [Int Pos 2]	0x4041	Sets Si gain
RT-Si Diode AC + RT-InGaAs AC [Int Pos 2]	0x4042	Sets Si gain
LN-InSb FOV=30 [Int Pos 4]	0x40C0	Sets InSb gain

A.2.1.4 Tungsten Lamp

A +12 VDC power supply for the tungsten lamp is located in the front panel electronics unit. A potentiometer labeled Vadj allows the voltage of the power supply to be adjusted with a flathead screwdriver, which changes the temperature of the tungsten lamp. We have not adjusted this. The typical operating temperature for a tungsten filament is 3000 K.

A temperature sensor monitors the temperature of the metal block that contains the tungsten lamp. If the measured temperature exceeds 60 deg C, the tungsten lamp will be shut off.

Normally, a water circulation unit is connected externally to cool the source block. We have disconnected the water circulation units.

Time required for lamp stabilization

The drift of the lamp during the first ten minutes of operation appears to have little to do with the water circulation unit. The lamp needs 2-3 minutes to stabilize, regardless of whether the cooler is connected or not. The cooler does not appear to improve the lamp performance during minutes 3 - 10 of operation. Measurements of ZPD amplitude at one minute intervals (21 Jan 2004):

ZPD InGaAs at each minute without cooler:
0.413, 0.408, 0.406, 0.405, 0.405, 0.405, 0.405, 0.405, 0.406, 0.405, 0.405

ZPD InGaAs at each minute with cooler:
0.420, 0.412, 0.409, 0.410, 0.404, 0.398, 0.399, 0.394, 0.392, 0.396, 0.398

ZPD Si at each minute without cooler:
0.320, 0.307, 0.305, 0.304, 0.304, 0.304, 0.303, 0.303, 0.303, 0.303, 0.302

ZPD Si at each minute with cooler:
0.341, 0.329, 0.323, 0.321, 0.320, 0.320, 0.321, 0.319, 0.318, 0.321, 0.321

A.2.1.5 Valves and Vacuum System

The IFS125 includes four normally-closed valves. These allow separate evacuation and venting of the interferometer and sample compartment. After removing the sample compartment, we have capped the connections for evacuating and venting the sample compartment.

The valve for evacuating the IFS125 is a Leybold Vacuum Right Angle Valve. The valve has two terminal blocks, for power (orange) and for commanding the valve (green). We have connected the power input directly to the AC container power (220 VAC in Park Falls; 230 VAC in Darwin). In the case of power outage, the normally-closed valve will shut. The command line connects to the IFS125 and consists of two wires. The brown wire is connected to pin "a" of the terminal block; white wire is connected to pin "d" of the terminal block. In addition, a set of resistors connect pins "a" and "d". The valve is commanded directly through the IFS125 control software provided by Bruker (VAC=0; VAC=1).

The Leybold Vacuum Right Angle Valve failed in Darwin, after a lightning strike. We replaced it with a new valve. The damaged valve was repaired and installed in ifs125_3. After the repair, we were missing the necessary German parts for the fuse holder. The fuse and fuse holder are now soldered to the line voltage outside of the valve.

The IFS125 includes a Leybold Vakuum Thermovac Transmitter for measuring the pressure of the interferometer compartment.

There is a differential pressure gauge for measuring the relative pressure between the interferometer compartment and the sample compartment. The differential pressure gauge is located in the Electronics Panel. This gauge is unnecessary for us and we have disconnected its tubing.

A.2.1.6 Small Devices with Control Area Network Boards

Each small motor in the IFS125 is commanded by a Control Area Network (CAN) board. These include: the source selection mirror (source compartment), the tungsten flip mirror (source compartment), the field stop wheels (source and interferometer compartments), and the moving detector mirror (detector compartment).

Each CAN board has four connectors: CAN1, CAN2, MOT0, and MOT1, allowing it to control two motors. The addressing of the CAN boards is indicated by jumpers labeled either "JAD" or "JPADR". There are five grounding jumpers labeled 2, 4, 8, 16, 32. The setting of their jumpers matches the "Mot Number" in the pdf list of CAN devices. The source holder and vacuum control seem to have a different type of CAN board. The list of CAN devices can be found in the IFS125 "Full Report".

A.2.1.7 Electronics Systems

The front panel contains of the electronics box many connectors and blinkenlights.

Main Power Input – Upper Right Panel

Main input power connection with switch and indicator light – The main input power for the IFS125 is connected to the Uninterruptible Power Supply.
Power connection to the IFS125 electronics unit – A short power cable connects the main input power to the electronics unit.
Connection for sources – A D-sub connector supplies power and control to the tungsten lamp.
Connection for valves – Supplies power and control to the valves.
RJ45 connection for Leybold Vakuum Thermovac Transmitter
Connection for laser input – Connects to the laser power supply.

Power Supply for the Electronics Unit

The Power Supply Block for the Electronics Unit is powered by a short power cable from the Main Power Input Panel. Three LEDs indicate that the Electronics Unit has +5 VDC, +12 VDC, and -12 VDC power. These LEDs are normally on. The round CAN-bus connector is unused.

Electronics Unit

The electronics unit consists of three boards:

EWS15 – Embedded Web Server Electronics Board
Connection for "COM1" – An unused 9-pin D-sub connector. It is intended for commercial RS232 devices.
Connection for "LPT1" – An unused 25-pin D-sub connector. This connector contains various analog signal used for trouble-shooting. Because it might be useful, Bruker won't tell us what it does.
RJ45 connector for network – 10BASE-T ethernet communication to IFS125.
Status LEDs:

- RES – Resets the IFS125 electronics. Equivalent to switching off and on the power switch.
- TX – Ethernet transmission. Indicates that the IFS125 is actively communicating.
- RX – Ethernet reception.
- ST – Unknown
- SG – Unknown

SCT– Scanner Electronics Board

Interferometer LEDs:

ERR – Error (usually due to missing laser signal or problem with scanner)
FWD – Scanner direction forward
TKD – Acquiring data. In later versions of the firmware, the TKD light does not correctly indicate that data is being acquired.

ANA.25 – Analog Electronics Board

Connection to Scanner Motor "OMOT" – This cable connects to a flange under the scanner compartment. The cable enables power/communication both to the scanner motor and the MicroE Systems Mercury 3000 encoder.

Control Area Network, Icon, and Detector Signal Block

These connectors are located in the final block.
A 9-pin D-sub connector has been added to replace the sample compartment flaps.

A.2.1.8 HTML Software Interface

The IFS125 is commanded using an HTML interface. Connect a web browser to 192.168.1.101 for the IFS125 Direct Control Menus. This is the most direct communication with the IFS125. Both OPUS and the QNX data acquisition software send all commands via the HTML interface.

Measurement Menus

Measurement Status

Direct Command Entry

Messages

Diagnostics
- Status of Scanner, Detectors, HeNe Laser, IR Source, Automation Units, and Instrument Ready

Service
- View Instrument Configuration
- Full Report
- Log Buffer (buffer since IFS125 was turned on)
- Beep (beeps if IFS125 is communicating)
- List of commands (command names, their descriptions, and current values)
- Check Detectors (similar menu options for other components)
- Reset Instrument (one of three ways to reset the IFS125)
- Last CAN answer
- Edit hardware configuration
- EWS TCPIP Setup Menu (IP address assignment)
- Set Time & Date
- Service links

Direct Control Panel
- Current temperature and pressure
- Vacuum Control Commands
- Scanner Control Commands

A.2.1.9 IFS125 Direct Commands and Allowed Values

All commanding of the IFS125 occurs through the IFS125 HTML interface, using a series of direct commands. These consist of three letter acronyms which are defined by Bruker. The OPUS data acquisition software and Hercules data acquisition software are user-friendly overlays for this communication. At their heart, these programs simply send direct commands to the IFS125 through the HTML interface. The IFS125 direct commands and accepted values are compiled below. Although some of the commands are completely useless, they are included here for completeness.

Useful Direct Commands for IFS125

Command	Description	Accepted Values
ADM	Adjust modes	0=Reinit Scanner; 1=Fast Adjust Mode (40 kHz); 2=Stop Mode; 3=Slow Adjust Mode (5 kHz); 4=Front Short Adjust Mode (voice coil); 5=Back Short Adjust Mode (voice coil)
AMD	Acquisition mode	3=sliced data
AQM	Acquisition mode	DD=Double sided, forward-backward; SD=Single sided, forward-backward; DN=Double sided; SN=Single sided
AP2	Exit field stop	500=0.5 mm; 800=0.8 mm; 1000=1 mm; 1150=1.15 mm; 1300=1.3 mm; 1500=1.5 mm; 1700=1.7 mm; 2000=2 mm; 2500=2.5 mm; 3150=3.15 mm; 4000=4 mm; 5000=5 mm; 6300=6.3 mm; 8000=8 mm; 10000=10 mm; 12500=12.5 mm
APT	Input field stop	500=0.5 mm; 800=0.8 mm; 1000=1 mm; 1150=1.15 mm; 1300=1.3 mm; 1500=1.5 mm; 1700=1.7 mm; 2000=2 mm; 2500=2.5 mm; 3150=3.15 mm; 4000=4 mm; 5000=5 mm; 6300=6.3 mm; 8000=8 mm; 10000=10 mm; 12500=12.5 mm
BRK	Break	1=Abort; 2=Stop; 4=Skip waiting for delay; 8=Skip waiting for trigger; 16=Skip waiting for ready; 32=Stop
DTC	Detector setting (varies with instrument)	For ParkFalls_ifs1:16416=RT-InGaAs [Internal Pos.1]; 16417=RT -InGaAs (DC) [Internal Pos.1]; 16448=RT-Si Diode [Internal Pos.2]; 16449=slave [Internal Pos.2]; 16450=Si- Diode & Slave [Internal Pos.2]
GNS	Signal gain	1=x1; 2=x2; 4=x4; 8=x8; 16=x16
HFW	Wanted high frequency limit	[double]
HPF	High pass filter	0=Open; 1=On
LFW	Wanted low frequency limit	[double]
LPF	Low pass filter	5.00=5 kHz; 10.0=10 kHz; 20.0=20 kHz; 40.0=40 kHz; 40.0=Open
LSR	Laser on/off	0=Off; 1=On
LWN	Laser wavenumber	[double]
NSS	Number of scans	[int]
PGN	Preamplifier gain	0=A; 1=B; 2=C; 3=Ref
PHR	Phase resolution	[double]

RES	Resolution	[double]
SRC	Source	0=Off All; -104=NIR Off; 104=NIR; 201=Emission back parallel input
VAC	Vaccum control	0=Standby; 1=Evacuate; 2=Vent
SG2	Left channel signal gain	1=x1; 2=x2; 4=x4; 8=x8; 16=x16
VEL	Velocity	5.00=5 kHz; 7.50=7.5 kHz; 10.0=10 kHz; 15.0=15 kHz; 20.0=20 kHz; 30.0=30 kHz; 40.0=40 kHz; 60.0=60 kHz; 80.0=80 kHz

Unused Direct Commands for IFS125:

Command	Description	Accepted Values
CHN	Measurement channel	
FLP	Flaps control	Flaps not installed
IM0	Interferometer motor 0	
IM1	Interferometer motor1	
OF1	Optical filter at det. pos. 1 and 2	Optical filter not installed
OF2	Optical filter at det. pos. 3 and 4	Optical filter not installed
CPJ	I-factor outer motor control	
CPQ	P-factor outer motor control	
CPS	I-factor inner motor control	
CPT	P-factor inner motor control	
PLL	PLLdummy	
AAR	Automatic Accessory Recognition	
ABP	Absolute peak location	
BMS	Beamsplitter	
CHK	Check	
CMA	Correlation mask	
CNM	Operator name	
COR	Correlation	
CPF	Compensation filter	
CPI	Control parameter I	
CPP	Control parameter P	
DDM	Display during measurement	
DEL	Delay before measurement	
DLR	Delay between repeats	
DLY	Stabilization delay	
FMD	Filter mode	
FSS	Full scale scan	
ITS	Instrument test class	
ITI	Instrument test interval	
JMW	Test parameter	
LFT	Lifetime	
MAC	Macro	
MIN	Measurement time in minutes	
RDX	Ready mask	
RDY	Instrument ready status	

REP	Repeat the measurement	
SFM	Sample form	
SNM	Sample name	
SON	External trigger	
SOT	Scans or minutes	
TDL	FT to do list	
TRW	IR/TRW selection	
TSR	Tolerance scan range	
UWN	Channel specific LWN	
VLV	Valve control	
XND	XA delay in nsec	
XXA	DSP testcommand	
_EP	Send EWS parameter to DSP	
_GI	Get information	
_GP	Get intermediate result	
_GR	Get result	
_ME	Measure	
_MX	Multiplexer IR/TRW	
_PS	Periodic status request	
_SP	Set parameter	
_TR	Trigger measurement	

A.2.1.10 Alignment Procedure

It is necessary to realign the IFS125 after moving the observatory. The notes below provide a step-by-step procedure, based on the method of Jean-Francois Blavier.

Initial Alignment and Preparations

Re-assemble scanner, beamsplitter, and dichroic
Release locking screws of IFS125 base plates
Release locking screws of mirrors

After verifying that the interferometer is misaligned:
Check that the interferometer base plate is level with respect to top of the compartment.
Adjust scanner rods to be level, meaning equidistant from vacuum support bars.

Laser Alignment

Criteria:
- Laser beam position on round baseplate window.
- Laser beam position on upper prism.
- Laser beam position on cube corner
- Laser beam position on beamsplitter; must travel through notch in coating
- Laser modulation at detectors A and B

The first two criteria are controlled by adjusting the alignment of the lower prism. It may be necessary to compromise the adjustment between these two. The next two criteria are controlled by adjusting the alignment of the upper prism. The last criteria is controlled by alignment of interferometer.

Before making any adjustment:
- Laser must warm up for twenty minutes, regardless of laser beam appearance.
- Using a piece of paper, look at laser image on detectors A and B at different scanner positions.

Adjust position of laser within rectangular tube.
- Adjustment of laser was not necessary previously and is unlikely. Do this only if the lower prism can not be adjusted to bring it onto the round window and upper prism OR if the laser beam is not on the lower prism.
- If laser is misaligned, this can be compensated by adjusting the lower prism.

Adjustment of incoming laser beam at lower prism
- This positions the laser beam on the round interferometer baseplate window and face of upper prism.
- Laser spot should be aligned on round window of interferometer base plate and face center of upper prism. Use mirror to see upper prism.

Turn on IFS125 power.
- Connect oscilloscope to Gnd, Laser A, and Laser B on laser detector electronics board (second ground not necessary).

Adjustment of laser beam at upper prism
- This is the most likely to be misaligned
- Use Back Short Adjust Mode

- Cover detectors A and B with paper, so modulation is easily visible
- Adjust three alignment screws of upper prism so laser spots overlap and modulate at detectors A and B
- Proper modulation will appear as a round coincident spot, that blinks light and dark
- At Back Short Adjust, laser beam should fall within the cube corner and within notch of beamsplitter

Check that laser beam is positioned properly at detectors A and B

- Use Back Short Adjust Mode
- Check that laser beam is not clipped by notch in detector
- Adjust three sets of screws for detectors A and B to position laser beam at detectors
- Lock washers under the four mounting screws of detectors A and B can be used as tip-tilt adjustment
- Possible to translate beam by adjusting prisms in Back Short Adjust Mode:
  - If a vertical translation is necessary:
    - Translate upper prism down = beam into cube corner = beam up on parabolic laser mirror
- If a horizontal translation is necessary (beam on edge of detector notch, but detectors have no more play):
    - Translate upper and lower prisms together to move sideways on parabolic laser mirror
- When scanning, detectors A and B should peak together. Otherwise, this suggests that the beam is on the edge of an optic. It is likely to be the laser detector edge, because this is the smallest optic.
- To move the laser image sideways on the laser detector, if it necessary to tip/tilt the assembly in either the horizontal or vertical planes. It is easy to inadvertently tip/tilt the assembly in the horizontal plane while adjusting it.

Return to Front Short Adjust Mode and check laser beam overlap at detector A.

- If beams do not overlap and laser amplitude decreases toward ZPD, then there is a problem in the alignment of the fixed cube corner.* At ZPD, no adjustment of the prisms can not compensate for this error.
- Look for modulation on detectors as the scanner is still
- Check that beam is circular, with good overlap, and blinks light/dark.
- This shows that the laser is correctly aligned on the axes of the interferometer, assuming that the two axes of the interferometer are parallel.

*Necessary to adjust the fixed cube corner if any of the following are true:

- Lower amplitude at detectors A and B at ZPD than at Back Short Adjust
- Laser beam overlaps at Back Short Adjust, but not at ZPD
- Poor modulation of Si detector

The purpose of the upper prism is to align the laser beam parallel to the interferometer axis. This can be falsely accomplished at all positions of the moving cube corner, except ZPD. If there is misalignment of the interferometer, then each position will require a different adjustment of the moving cube corner. If the interferometer is correctly aligned, then the adjustment of the upper prism will be optimum for all positions of the moving cube corner.

This should not typically be necessary. If the fixed cube needs to be aligned:

- Release four locking screws on back of fixed cube corner
- Fine-threaded top and side adjustment screws determine alignment of fixed cube corner.

- Visually align laser beam to be coincident at detector A. If the amount of displacement is independent of path difference, then this adjustment can be done at any position of the moving cube corner.

- Look for circular spot, with good overlap, that blinks light/dark when scanner is still.
- Use oscilloscope to refine adjustment of fixed cube corner while watching amplitude of detector A in scanner Front Short Adjust Mode.
- Check amplitude of detector A in scanner Back Short Adjust Mode.
- When finished, tighten four locking screws of fixed cube corner while monitoring that this does not affect amplitude of detector A

Final result
- Expecting total amplitude to be ~15 V at detectors A and B with much less than 15% variability front-to-back.
- Total amplitude depends on laser detector gain and may be different between spectrometers.

Tungsten Beam Alignment

Criteria:
- Even illumination of entrance and exit optics
- Alignment of lamp beam on entrance and exit field stop wheels
- Detector signal peaked by adjusting detector focal optics
- Line depth maximized and line width minimized by adjusting interferometer entrance and exit mirrors

It is necessary to align the flat entrance and exit mirrors because the incoming beam may not be parallel to the interferometer axis. There are three steps to align the flat entrance and exit mirrors to center the field stop on the interferometer axis:
- Visual alignment of lamp image on exit field stop
- Visual alignment of laser image on entrance and exit field stops
- Fine, iterative alignment by recording lamp spectra and fitting HCl lines to determine width/ILS

While measuring modulation efficiency at DC testpoints on Si and InGaAs detectors, where modulation = ZPD peak value / ZPD average value:

Adjust entrance optics in source compartment
- With tungsten lamp on, adjust spherical mirror in source compartment to center filament image on field stop wheel.

Trace beam path and verify that optics are properly illuminated.
- Adjust exit optics in interferometer and detector compartments
- Look for obvious illumination errors, which suggest misalignment during transport
- If necessary, adjust off-axis parabolic mirror at exit of interferometer to center IR beam on flat exit mirror.
- Always adjust flat exit mirror to center IR beam on exit field stop.
- Finally adjust off-axis parabolic mirror in detector compartment (first mirror). If this mirror is not well illuminated, repeat the previous two steps.

Note that clipping the exit field stop image will decrease the linewidth because the effective field stop is smaller, but will introduce an ILS error.

Align off-axis parabolic detector mirrors

- Using OPUS or DC testpoints, adjust focal mirrors in detector compartment to peak detector signal

Return laser beam to source compartment with Tungsten lamp off

- Detectors A and B can be moved vertically. Pull the side tab to release the translation stage. This allows laser beam to return toward the source compartment for alignment purposes.
- Choose 0.5 mm field stop
- Lower detector A. Align flat interferometer exit mirror to center laser on exit field stop. Replace detector A.
- Lower detector B. Align flat interferometer entrance mirror to center laser on entrance field stop. Replace detector B.
- Turn on Tungsten lamp. If lamp beam is imaged from entrance field stop onto exit field stop, then the alignment has worked well.

Ideally, this technique would achieve the final alignment. However:

- The laser is too small for the 0.5 mm field stop.
- Need proper alignment in the near-IR, not at 15798 cm^{-1}.
- The prism and beamsplitter coating affect the laser beam and near-IR beam differently.

Iterative adjustment of flat entrance and exit mirrors to center field stop on interferometer axis using HCl lines.

- First record spectrum with no changes to alignment.
- Then iteratively adjust entrance and exit mirrors around this alignment, recording a spectrum at each position. Total will be five (original plus four adjustments).
- Top diagonal = horizontal adjustment; bottom diagonal = vertical adjustment
- The error which is corrected is less than ~1/4 diameter of solar image

I. Record two spectra with no changes to alignment

IIa. Adjust both top screws of flat exit mirror to fixed maximum value – This is DC value A (e.g. -1.954 V)
Adjust flat entrance mirror top diagonal CW to a lower fixed value – This is DC value B (e.g. -1.800 V)
Adjust flat exit mirror top diagonal – Return to DC value A (e.g. -1.954 V).
Record spectrum.

IIb. Adjust flat entrance mirror top diagonal CCW – Return to DC value B.
Adjust flat exit mirror top diagonal – Return to DC value A. This returns to alignment in I.

IIIa. Adjust flat entrance mirror top diagonal CCW – Return to DC value B.
Adjust flat exit mirror top diagonal – Return to DC value A.
Record spectrum.

IIIb. Adjust flat entrance mirror top diagonal CW – Return to DC value B.
Adjust flat exit mirror top diagonal – Return to DC value A.

IVa. Adjust flat entrance mirror bottom diagonal CW – Return to DC value B.
Adjust flat exit mirror bottom diagonal – Return to DC value A.
Record spectrum.

IVb. Adjust flat entrance mirror bottom diagonal CCW – Return to DC value B.
Adjust flat exit mirror bottom diagonal – Return to DC value A.

Va. Adjust flat entrance mirror bottom diagonal CCW – Return to DC value B.
Adjust flat exit mirror bottom diagonal – Return to DC value A.
Record spectrum.

- Use OPUS to fit average WHM for region of HCl lines. Previously used 5730 – 5780 cm^{-1}
- Would be preferable to also use peak depth, but this is not available with OPUS.
- From WHM, determine best alignment.
    - This assumes that the alignment is symmetrical, not skewed.

Re-iterate on steps I – V starting at the newly determined best position with smaller increments of adjustment.

Align off-axis parabolic detector mirrors again
- Using OPUS or DC testpoints, adjust focal mirrors to peak detector signal
- Measure modulation efficiency again

A.2.1.11 Previous Alignment Results

Using the DC testpoints on the IFS125 detectors, it is possible to directly observe the modulation efficiency at ZPD. Previous results are listed below.

For caltech_ifs1: InGaAs ~ 80% and Si ~80%.

For parkfalls_ifs1: InGaAs 84% and Si 77%.

For caltech_ifs2: DC testpoints were not added until late in the spring, and the modulation efficiency was not measured.

For darwin_ifs2: InGaAs 78% and Si 62%.

A.2.1.12 Acceptance Test Standards

The acceptance test is based on spectra of the 10 cm cell containing 5.0 hPa HCl gas. Typically, the cell is mounted in source compartment, but it can also be placed in the detector compartment.

Acceptance criteria:
Peak Amplitude of InGaAs and Si interferograms.
Width and "relative intensity" of HCl lines in the 5730 - 5780 cm-1 region.
Appearance of peak symmetry.
Signal-to-noise ratio

Results below were recorded in Park Falls, Wisconsin on 10 Aug 2004 using three different 10 cm HCl cells.
Parameters: Dual-acquisition spectrum with four scans (forward-reverse).
Resolution: 0.0125 cm^{-1}.
Zerofilling: 2.
Gains: Reference (InGaAs 2700 ohm; Si 20,000 ohm).
Scanner velocity: 10 kHz; high and low pass filters on.
Aperture: 1.3 mm.
Source: Tungsten lamp.
Water circulation disconnected during the recording of these spectra.
Air temperature: 20.0 deg C; Lamp temperature: 35 - 45 deg C.
IFS125 Pressure: < 2 mb

Cell #1 pa30040810l0aax_Cell1.2

Si Peak Amp (For; Rev)	InGaAs Peak Amp (For; Rev)	Wave number	Abs. Intens.	Rel. Intens.	Width	Thresh hold	S:N Ratio 5745 - 5746 cm^{-1}
12740; 12559	6995; 6688	5735.1369	0.160	0.058	0.0150	43.274	986.45
		5739.2901	0.084	0.134	0.0160	100.501	
		5749.8218	0.167	0.050	0.0150	37.425	
		5753.9924	0.096	0.120	0.0160	90.124	
		5763.2397	0.177	0.038	0.0150	28.831	
		5767.4248	0.118	0.097	0.0160	72.956	
		5779.5767	0.144	0.070	0.0150	52.340	
				Avg	0.0154		

Cell #2 pa30040810l0aax_Cell2.2

12478; 12301	6713; 6484	5735.1369	0.157	0.057	0.0150	43.173	1032.6
		5739.2901	0.081	0.132	0.0160	100.341	
		5749.8218	0.164	0.049	0.0150	37.343	
		5753.9924	0.094	0.118	0.0160	89.550	
		5763.2397	0.174	0.038	0.0140	28.883	
		5767.4248	0.116	0.096	0.0160	72.539	
		5779.5767	0.142	0.068	0.0150	51.849	
				Avg	0.0153		

Cell #3 pa30040810l0aax_Cell3.4

12775; 12562	6851; 6701	5735.1369	0.160	0.060	0.0150	43.593	1001.65
		5739.2901	0.081	0.138	0.0160	100.374	
		5749.8214	0.166	0.052	0.0150	37.885	
		5753.9924	0.093	0.124	0.0160	90.269	
		5763.2397	0.177	0.040	0.0150	28.866	
		5767.4248	0.115	0.101	0.0160	73.570	
		5779.5767	0.143	0.072	0.0150	52.395	
				Avg	0.0154		

A.2.1.13 HCl Cells

Bill O'Rourke
O'Rourke Enterprises
694 Main St.
P.O. Box 52
Lumberton, NJ 08048
USA
Tel: 609-265-0751
Fax: 609-265-1683
Email: None

Description:

The first three HCl cells have 4.9 cm diameter Infrasil windows (Esco Products), fused into 10.0 cm x 5.0 cm diameter silica with a graded quartz-to-pyrex seal between the tube and a teflon valve. The cells were manufactured by Rick Gerhart and filled with 5.0 hPa HCl at JPL by Kevin Hickson on 15-April-2004.

Infrasil HCl cells:
Cell #1 – (Park Falls)
Cell #2 – 5.02 hPa (Lauder)
Cell #3 – 5.14 hPa (currently in Darwin; unused)

The second three HCl cell have 4.0 cm diameter Sapphire windows (Esco Products) fused into 10.0 cm x 4.0 cm diameter tube with a graded quartz-to-pyrex seal between the tube and Teflon valve. The cells were manufactured by Bill O'Rourke and filled with 5.0 hPa HCl at JPL by Kevin Hickson.

Sapphire HCl cells:

Cell #4 – 5.0316 hPa (Caltech)
Cell #5 – 5.0196 hPa (Darwin)
Cell #6 – 5.1369 hPa (University of Bremen)

A.2.2 Bruker Solar Tracker

Bruker Optics – Solar Tracker
Bruker Optik GmbH
Rudolf-Plank-Str. 27
D-76275 Ettlingen
Germany
www.brukeroptics.com
Tel: (07243) 504 600
Fax:(07243) 504 698
Email: info@brukeroptics.de

Description:

The Bruker solar tracker consists of two mirrors that rotate in azimuth and elevation to obtain the calculated position of the sun. After the calculated position of the sun is achieved, a quadrant sensor is used for servoed tracking of the solar disk. More details are available in the suntracker manual. The configuration file from the DOS suntracker computer (strack.cfg) is stored in src/config/site/strack.cfg in the CVS archive, in case of mishaps.

Connection to Hercules Computer:

Serial connection to ser1

Direct Communication:

From Hercules computer:
```
qtalk –m /dev/ser1
```
To quit qtalk:
```
<CTRL>A; q
```

Communication Protocol:

Write Line Separator: LF
Write Terminator: LF
Read Terminator: CR or LF
Serial Port: COM1
Baud Rate: 4800
Data Bits: 8
Stop Bits: 1
Parity: No
Protocol: None

A.2.2.1 Solar Tracker Direct RS232 Commands

Command Syntax	Description	Reply
`TPG<param1>,<param2>`	Tracker Position Geo	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>
`TPL<param1>,<param2>`	Tracker Position Local	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>
`TP1<parm1>,<param2>`	Tracker Position 1	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>
`TP2<parm1>,<param2>`	Tracker Position 2	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>

`TPS`	Tracker Position Sun	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>
`TPM`	Tracker Position Moon	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle>
`TTM`	Tracker Track Mode	TPG_AZI: <current Geo azi angle> TPG_ELE: <current Geo ele angle> ST_MODUS: <current mode>
`INIT`	Initialize Solar Tracker	INIT
`FLIP<status>`	Change Flip Position	FLIP: <current flip position>
`TDG<level>`	Tracker Diode Gain	TDG: <current level>
`CDT<status>`	Cloud Detector	CDT: <previous status> T_INT: <quadrant diode>
`MIMA<min>,<max>`	Minimum and Maximum Auto Switch	MIN: <current value> MAX: <current value>
`ROA`	Read Offset Angle	OFFSET_AZI: <current azi offset> OFFSET_ETE: <curent ele offset>
`SDN`	Shutdown	SDN
`RES`	Reset shutdown	RES
`TIME<year>,<month>, <day>,<hour>, <minutes>,<seconds>`	Set time	TIME
`SSR`	Send Status Reports	Current values for STATUS, DATE, TIME, TPG_AZI, TPG_ELE, TPL_AZI, TPL_ELE, FLIP, ST_MODUS, TDG, T_INT, MIN_INT, MAX_INT, CDT, DOME, SLIT, FLAP, DOME_HEATING, RAIN, TEMP_OUT, HUMID_OUT, WIND_SPEED, SIX UNASSIGNED PARAMETERS, <Terminator 0x03>
`EXIT`	Exit software	Bye-Bye (if successful) EE (if not successful)

Solar tracker commands not implemented by Bruker in RS232:

`TMM` Tracker Manual Mode
`TOM` Tracker Offset Mode
`SOA` Set Offset Angle
`SPF` Set P-Factor
`BON` Warning Beep On
`BOF` Warning Beep Off
`HELP` Display Help
`INFO` Display version info

A.2.2.2 Solar Tracker Installation

This procedure assumes that the azimuth and elevation mirrors of the solar tracker are correctly aligned. The major sources of alignment error following this procedure are the leveling of the baseplate and the factory alignment of the azimuth and elevation mirrors.

1. To install the new solar tracker, first carefully level it. Remove the CaF_2 window from the roof.
2. Enter the correct latitude, longitude, pressure, and temperature in c:/soltr227/strack.cfg.
3. Set the time and date of the suntracker computer using an accurate clock and the DOS "date" command.
4. Remove the source input tube of the IFS125 and place a flat mirror on the floor and level it. Alternatively, an oil dish can be used. Start the soltr227.exe software. Set TOM to center the returning solar beam on itself, making the beam vertical.
5. Replace the CaF_2 window in the roof.
6. Put the solar tracker into TPS mode. Replace the source input tube and physically move the IFS125 to align the input tube directly under the incoming solar beam. Work quickly.
7. Adjust the 45 degree input tube mirror to center the solar beam on the flat entrance mirror in source compartment.
8. Adjust the flat entrance mirror in the source compartment to center the beam on the off-axis parabolic mirror.
9. Adjust the off-axis parabolic mirror in the source compartment, to center the beam exactly on the 4 mm field stop (4 mm is the approximate size of the solar image).
10. Use TTM and adjust the rectangular quadrant detector mirror so that in TTM mode, the solar beam is exactly centered on the 4 mm field stop.

A.2.3 Telescope Dome

Technical Innovations – Robodome
Jerry Smith
7851 Cessna Avenue
Gaithersburg, MD 20879
www.homedome.com
Tel: 301-977-9000
Fax: 301-977-1106
Email: domepage@erols.com

Description:

The Robodome consists of an electronics control box which controls a fiberglass telescope dome. The dome has motors for rotation and shutter. The dome can rotate infinitely in azimuth. The shutter motor circuit is completed by bronze loops that make electrical contact with the shutter motor only at the dome's "home" position.

The dome's azimuth position is sensed by an inexpensive light sensor that is positioned over a plastic disk with six holes. As the dome rotates, the plastic disk rotates and the light sensor produces a square wave. The dome electronics board counts the light sensor edges and compares this to the calibrated circumference of the dome to determine the current azimuth position. The dome's shutter position is sensed using limit switches at the top and bottom of shutter travel. The schematic diagram and other useful information are in the dome manual.

The OPEN/CLOSE/CW/CCW buttons on the hand control operate the motors directly, through two relays. The two relays and two motors give four possible combinations (OPEN/CLOSE/CW/CCW). The "HOME" button of the hand control requires operation of the main microprocessor on the dome's electronics board. The serial connection to the Hercules computer also requires operation of the main microprocessor on the dome's electronics board. For this reason, the "HOME" button of the hand control will not work while the data acquisition software is running.

The GINF dome information string is stored in src/config/site/README.site in the CVS archive, in case of mishaps.

Connection to Hercules Computer:

Serial connection to ser2

Direct Communication:

From Hercules computer:
```
qtalk –m /dev/ser2
```
To see what you are typing, turn on echo:
```
<CTRL>A; e
```
To quit qtalk:
```
<CTRL>A; q
```

Communication Protocol:

Write Line Separator: None
Write Terminator: None

Read Terminator: CR
Serial Port: COM1
Baud Rate: 9600
Data Bits: 8
Stop Bits: 1
Parity: No
Protocol: None

A.2.3.1 Dome Direct RS232 Commands:

The dome will not accept commands in lowercase letters.

`GINF` - Get Info
Sample Reply:
V4,228,223,2,223,0,2,1,0,220,227,0,128,255,255,255,255,255,255,255,999,1,0
(25 parameters describing current dome status)

`Gxxx` - Go to Azimuth position xxx in degrees
Sample Reply for 15 degree turn:
RP1 (R for clockwise or L for counter-clockwise)
P2 (Pnnnn updates of azimuth tick values as dome turns)
V4,228,223,2,8,0,2,0,1,220,227,0,128,255,255,255,255,255,255,255,999,1,0

`GHOM` - Go to Home
Sample Reply:
LP7 (format similar to Gxxx)
P6 (Pnnnn updates of azimuth tick values as dome turns)
V4,228,223,2,224,0,2,1,0,220,227,0,128,255,255,255,255,255,255,255,999,1,0

`GTRN` - Training Sequence
(Dome turns clockwise to home and then makes a full turn back to home.
Records HOME position, circumference, and coasting in memory.)
Sample Reply: P4
P5 (Pnnnn updates of azimuth tick values as dome turns)
V4,229,9,2,8,0,2,1,0,6,12,0,128,255,255,255,255,255,255,255,999,1,0

`GOPN` - Shutter Open
Sample Reply: OSZ18
SZ19 (SZnn updates as shutter moves)
V4,228,223,2,224,0,2,1,0,220,227,0,128,255,255,255,255,255,255,255,999,1,0

`GCLS` - Shutter Close
Sample Reply: CSZ22
SZ22 (SZnn updates as shutter moves)
V4,228,223,2,224,0,1,1,0,220,227,0,128,255,255,255,255,255,255,255,999,1,0

`GTST` - Test Data
No Reply: Should be 6 parameters for ADC values

A.2.4 Weather Station

Coastal Environmental Systems – Zeno 3200
820 First Avenue South
Seattle, WA 98134
www.coastalenvironmental.com
Tel: 206-682-6048
Fax: 206-682-5658
Email: Support@CoastalEnvironmental.com

Description:

The Zeno weather station consists of commercial weather sensors connected to a datalogger. The datalogger contains the conversion parameters for each of the weather sensors. The datalogger outputs the sensor values as a string over RS232 at 1 Hz. In Darwin and Lamont, we have added an RS232 optical line isolation unit, to prevent lightning damage. The datalogger contains a battery and charger, and is plugged directly into the AC container power. This means that the weatherstation and datalogger are fully isolated from the Hercules computer, in case of a lightning strike. The weatherstation configuration file is stored in src/config/site/README.site in the CVS archive, in case of mishaps.

Connection to Hercules Computer:

Serial connection to ser3

Direct Communication:

From Hercules computer:
```
qtalk –m /dev/ser3
```
To quit qtalk:
```
<CTRL>A; q
```
Administrator Password:
```
zeno
```

A.2.4.1 Direct RS232 Commands:

The Zeno data is continually output as a comma-delimited string at 1 Hz. Data format:
DATE TIME WSPD WDIR W_GUST W_SD AT RH SR BARO RAIN WETNESS VBATT BIT

To interrupt this output and enter the user menus:
```
"U" <enter>
```
See the Zeno manual for more details.

Total data logging memory: 127420
Max # of records: 4550
Size of each data record: 28

A.2.4.2 Barometric Pressure (S1080Z)

Manufacturer: Setra (Model 270)
Units: hPa
Accuracy: 0.3 hPa from -29 °C to +54 °C
Testing: Periodic comparison to mercury manometer.

Principle: Ceramic capsule that deforms with pressure. The capacitance between gold electrodes on the inside surface of the capsule varies proportionally with applied pressure.

A.2.4.3 Relative Humidity and Air Temperature (S1276Z)

Manufacturer: Vaisala (Humitter 50)
Units: °C and % RH
Accuracy: ±3% RH; ±0.1°C (0°C to +70°C); ±0.2°C (-30°C to +60°C)
Testing: Compared to calibrated lab RTD at 23.07°C for parkfalls_ifs1
RH not fully tested. parkfalls_ifs1 reports 98 – 100 % when fully saturated.
Principle: RH – Hygroscopic capacitative. Capacitance of thin film sensor varies with humidity.
Temperature – Thermistor. Small bead of semiconducting material whose resistance varies nonlinearly with temperature change.

A.2.4.4 Wind Speed and Direction (S1146Z)

Manufacturer: R.M. Young Company (Model 03002 Wind Sentry)
Units: m s^{-1} and degrees
Accuracy: Not indicated
Testing: Verified that wind speed changed with rotation of sensor.
Verified that wind direction varied approximately correctly with direction.
Principle: Wind speed – Magnetically induced AC voltage produced by rotating magnet on cup shaft.
Wind direction – Conductive potentiometer with 10K ohm resistance

A.2.4.5 Pyranometer (S1114Z)

Manufacturer: Li-Cor (Model LI-200SZ)
Units: W m^{-2}
Accuracy: ±5% in natural daylight
Testing: Verified that sensor values changed when exposed to light. Did not calibrate.
Principle: Silicon photovoltaic detector; converts light directly to current.

A.2.4.6 Precipitation Detector (S1391Z)

Manufacturer: Environmental Technology, Inc. (Model ES-1)
Units: Yes/No
Accuracy: NA
Testing: Verified that sensor correctly indicates presence of rain.
Principle: Presence of water changes either capacitance or resistance (not clear which) of grid.
The snow sensor has been connected in parallel with the rain sensor to detect all precipitation.

A.2.4.7 Leaf Wetness Sensor (S1169)

Manufacturer: Davis
Units: 1 – 15
Accuracy: NA
Testing: Verified that sensor correctly indicates presence of wetness.
Principle: Detection of electrical resistance between gold-plated elements of grid.

A.2.4.8 Mercury Manometer

Manufacturer: Princo Instruments (453 Weather Service Barometer)
Units: mm Hg

Testing: Purchased as an absolute calibration standard, with NIST-traceable calibration certificate.
Principle: Fortin mercury manometer. The mercury manometer is not connected to the Zeno datalogger. It is read manually.

A.2.5 Other laboratory instrumentation

A.2.5.1 NTP-GPS Receiver

Model: Masterclock – NTP100-GPS
2484 W Clay St
Saint Charles, MO 63301-2548
www.masterclock.com
Tel: 800-940-2248
Email: support@masterclock.com

Connection to Hercules Computer:

Network 192.168.1.106

Direct Communication:

Telnet to 192.168.1.106

A.2.5.2 Network Camera

Stardot Technologies – Netcam
6820 Orangethorpe Ave, Building H
Buena Park, CA 90620
www.stardot-tech.com
Tel: 888-782-7368
Fax: 714-228-9283
Email: help@stardot-tech.com

Description:

The Stardot Netcam is a small network camera with a fisheye lens that is mounted on the roof of the laboratory. The Netcam operating system is Linux and it is possible to reach the Netcam directly using telnet, if troubleshooting is required.

Connection to Hercules Computer:

Network 192.168.1.107

Direct Communication:

Use web browser to connect to 192.168.1.107:8080

A.2.5.3 Scroll Pump

Varian Inc. – TriScroll 300
121 Hartwell Avenue
Lexington, MA 02421
www.varianinc.com
Tel: 800-882-7426
Fax: 781-860-5437
Email: vtl.technical.support@varianinc.com

Description:

8.8 cfm dry scroll pump with an ultimate pressure of 1.3 x 10^{-2} hPa. One repair kit and one maintenance kit is located at Caltech

Connection to Hercules Computer:

Optical Fiber
Power is controlled by an optical fiber which is driven digitally

Direct Communication:

The pump is simply "on-off". It can be turned on and off from ifsdoit:

```
> Power Pump On
> Power Pump Off
```

A.2.5.4 Scroll Pump Pressure Sensor

Park Falls: Wenzel Electronics – Micropirani
Wenzel Electronics was purchased by MKS and no longer exists.

Darwin, Lamont: MKS – 925C Micropirani
MKS Instruments
90 Industrial Way,
Wilmington, Massachusetts 01887
www.mksinst.com
Tel: 800-227-8766 (in the USA),
Fax: 978-284-4999

Description:

The Micropirani is a thermal conductivity gauge measuring in the range of 10^{-5} hPa to 10^{3} hPa. The Wenzel Electronics and MKS Micropirani sensors are operationally similar, but have a different pinout for power and signal on their DB-9 connectors. To accommodate this change, we modified the cable between the Hercules computer and MKS Micropirani sensor so that it is no longer one-to-one.

Connection to Hercules Computer:

9-pin analog cable

Direct Communication:

The Micropirani pressure sensor is completely passive and does not accept commands.

A.2.6 Network and Communication

A.2.6.1 Network Information

Network Hardware

Park Falls: 16-port network switch
Darwin and Lamont: Linksys BEFsx41 router

Network Assignments

All network devices (except the Hercules computer) have the username "admin".

Address	Device
192.168.1.1	Programmable Router
192.168.1.101	IFS125
192.168.1.102	IFS125 Workstation
192.168.1.103	QNX Hercules2 Computer
192.168.1.104	QNX Hercules Computer
192.168.1.105	UPS-BD Web/SNMP Card
192.168.1.106	NTP100-GPS
192.168.1.107	StarDot Network Camera
192.168.1.109	Norton PPP dialup

A.2.6.2 Modem

US Robotics – 56K V.92 External Faxmodem
www.usr.com

Connection to Hercules Computer:

Serial connection to ser4

Direct Communication:

From Hercules computer:

```
qtalk –m /dev/ser4
```

To quit qtalk:

```
<CTRL>A; q
```

A.2.7 Power Systems

A.2.7.1 Uninterruptible Power Supply

Powerware – 9120 with ConnectUPS BD Network Card
8609 Six Forks Road
Raleigh, NC 27615
www.powerware.com
Tel: 1-800-356-5794
Email: info@powerware.com

Description:

The Powerware 9120 is a 1500 W UPS. The installed network card allows it to be monitored on the network.

Connection to Hercules Computer:

Network 192.168.1.105

Direct Communication:

Use web browser to connect to 192.168.1.105

A.2.8 Digital and analog inputs/output signals

The digital and analog communication with the Hercules computer is designed by Jean-Francois Blavier and summarized here.

A.2.8.1 Control Using Digital Lines

The Hercules port A is used in output mode to control the following subsystems:

Bit	Assignment	Values
0	IFS125 power	0 = Off; 1 = On
1	Modem power	0 = Off; 1 = On
2	Suntracker power	0 = Off; 1 = On
3	Dome power	0 = Off; 1 = On
4	Pump power	0 = Off; 1 = On
5	IFS125 reset	0 = Normal; 1 = Reset
6	Unused	
7	Unused	

The output of port A is not directly connected to the subsystem control. Instead an on-board latch is used to sample the value of port A. The latch is updated on the rising edge of bit 0 of port E. This was done to retain the power status of the various subsystems across computer resets.

The Hercules port B is used in input mode to read the contents of the latch. The correct way to modify one bit of the latch is to first read the full byte on port B, change the bit in the read value, write the modified value to port A, finally toggle bit 0 of port E.

A.2.8.2 Monitoring of Analog Inputs

Assignment of 32 ADC Channels

Channel	Units	Description
0	Temperature (°C)	Computer, disks
1	Temperature (°C)	Computer, center
2	Temperature (°C)	IFS125 motor compartment
3	Temperature (°C)	IFS125 scanner compartment
4	Temperature (°C)	IFS125 interferometer compartment
5	Temperature (°C)	IFS125 detector compartment
6	Temperature (°C)	IFS125 source compartment
7	Temperature (°C)	IFS125 input tube
8	Temperature (°C)	IFS125 laser cover
9	Temperature (°C)	IFS125 electronics box
10	Temperature (°C)	Suntracker leveling plate
11	Temperature (°C)	Suntracker azimuth assembly
12	Temperature (°C)	Suntracker elevation assembly
13	Temperature (°C)	Pump motor
14	Temperature (°C)	Pump body
15	Temperature (°C)	Zeno weatherstation datalogger
16	Temperature (°C)	Container air
17	Voltage (V)	Main 24 VDC
18	Voltage (V)	Heat 15 VDC
19	Voltage (V)	Unswitched 12 VDC

20	Voltage (V)	Switched 12 VDC
21	Voltage (V)	Computer 5 VDC
22	Voltage (V)	Dome 15 VDC
23	Voltage (V)	Laser 12 VDC
24	Voltage (V)	Micropirani +12 VDC
25	Voltage (V)	Micropirani -12 VDC
26	Current (A)	Main 24 VDC
27	Current (A)	Heat 15 VDC
28	Current (A)	Unswitched 12 VDC
29	Current (A)	Dome 15 VDC
30	Current (A)	Laser 12 VDC
31	Voltage (V)	Micropirani pressure sensor

The system is used in single-ended mode (differential mode would yield only 16 channels).

Because we have one negative voltage to monitor and because we need to properly measure values near zero, all inputs are operated in bipolar mode.

The temperature sensors (LM235A) have an output which is directly proportional to the absolute temperature: Vout = 10 mV / K. With a ±5 V input range, the ADC transfer function will be:

(32768DN / 5V) * (0.01V / K) = 65.536 DN/K

The system is designed to operate over a wide range for the "Main 24 V" and "Heat 15 V". The voltage sensing is done through a divide by 4 resistor network. This allows for a ±40 V sensing range.

Most other voltages ("Unswitched 12 V", "Switched 12 V", "Dome 15 V", "Laser 12 V", "MicroPirani +12 V", and "MicroPirani -12 V") are sensed through a divide by 2 network, for a range of ±20 V.

The lonely "Computer 5 V" is sent directly to the ADC input, for a range of ±10 V.

The current sensors have part numbers LTS15-NP for "Main 24 V", LTS25-NP for "Heat 15 V", and LTS6-NP for "Unswitched 12 V", "Dome 15 V", and "Laser 12 V", with the following transfer functions:

Vout = 2.500 + 0.0428 * Iin (for "Main 24 V")
Vout = 2.503 + 0.0254 * Iin (for "Heat 15 V")
Vout = 2.501 + 0.1064 * Iin (for "Unswitched 12 V")
Vout = 2.496 + 0.1096 * Iin (for "Laser 12 V")
Vout = 2.506 + 0.1080 * Iin (for "Dome 15 V")

A.2.8.3 Reference and Background Information

1. The latch in the digital control is needed because some subsystems take a long time to stabilize (e.g. the laser). Although we don't expect the computer to be reset often, it is good to avoid a 20 minutes wait after each computer reset.

2. The "Laser power" control and "Laser 12 V" monitor were originally designed to operate the laser because it is a critical component and is easily modified for DC-operation. This feature has since been renamed “Modem” and has been modified to control power to the network devices.

3. The LM235A have an accuracy of 1°C from -40°C to +125°C. (i.e., an accuracy of 1 K from 233 K to 398 K).

4. The "Computer, disks" sensor is used to control the fan in the computer box. The "IFS125HR, scanner compartment" and "IFS125HR, interferometer compartment" are used to control heaters on the instrument. The "Suntracker, azimuth assembly" and "Pump, motor" temperature sensors are also used to servo heaters. These controls run autonomously.

5. A temperature reading of 0 K indicates a short-circuit in the wiring. Whereas an over-range reading indicates a disconnected sensor (7.5 V for the servoed sensors and 12.3 V for all others, but these will be outside the ±5 V range).

6. The dividers for voltage sensing were done with DIP resistors network which were selected for a good match between individual resistors. The accuracy should be better than 0.5%.

7. The "Unswitched 12 V" is produced by a Vicor DC/DC converter which powers the Hercules. It is set for 12.5 V to better meet the Hercules and disk drives requirements.

The "Switched 12 V" and "Computer 5 V" are outputs from the Hercules

A.2.9 Laboratory structure

A.2.9.1 Container

Ken Martin
Martin Container Inc.
1400 S. Atlantic Ave.
Compton, CA 90221-0185
USA
www.container.com
Tel: (800) 221-3727, 310-638-6000
Fax: 310-638-0025
Email: ken@container.com

A.2.9.2 Heater – Air Conditioner Unit

Fedders "Y Chassis" (parkfalls_ifs1 and lamont_ifs3)
Fedders Corporation
http://www.fedders.com/catalog/appliances/roomac/fed_y.htm#

Connection to Hercules Computer:

Heater-AC is not connected to the Hercules computer.

Direct Communication:

There is no direct communication with the heater-AC.

Temperature Setpoint During Power Outages

Park Falls – The heater/AC control panel in Park Falls is powered by +5 VDC. We modified the control panel so that it receives its +5 VDC input from a power converter connected to the UPS. This prevents the heater/AC settings from being lost during power outages. Only the control panel is connected to the UPS, not the heater/AC itself.

Darwin – The AC control panel in Darwin contains a battery. This prevents the AC settings from being lost during power outages.

A.3 Data Acquisition Software

A.3.1 Data Acquisition Software Overview

The devices described previously are all monitored and/or controlled with a Diamond Systems Hercules board and an additional control board. As mentioned previously, the Hercules board includes four serial ports, used for communication with the solar tracker, telescope dome, weatherstation, and modem. The Hercules board includes 32 wide-range analog inputs for monitoring temperatures, voltage, currents, and pressure of the scroll pump. Five digital I/O lines of the Hercules board are used to command power to the solar tracker, telescope dome, modem, IFS125, and IFS125 reset line. The IFS125, network camera, NTP-GPS satellite time receiver, and uninterruptible power supply are commanded within the local area network.

The operating system of the Hercules computer is QNX, with custom data acquisition software written by Norton Allen. The data acquisition software continuously acquires data from the laboratory devices, over the serial, analog, digital, and network connections. All of this data is saved as binary telemetry data at 1 Hz, 0.5 Hz, or 0.125 Hz. There are a few exceptions. The Stardot Netcam files are saved directly as jpg files and the IFS125 interferograms are saved as “slices” in the original binary format.

On the Hercules computers, the source code is stored in /home/citco2/src. The executables are distributed to /home/citco2/bin. Zhonghua Yang’s overnight analysis code is in /home/citco2/src/dp. Past overnight analysis emails are stored in /home/citco2/anal. Data currently being written is saved to /data/citco2. After that data is processed by reduce, it is saved in a yymmdd directory, in /data/citco2/raw/flight.

The automated data acquisition is defined in src/TM/IFS.tma. Throughout the night, the acquisition software records weather and housekeeping data. When the calculated solar elevation angle reaches 0°, the scroll pump is commanded on and the FTS is evacuated to 0.5 hPa. Following the pumping sequence, the telescope dome opens and the solar tracker points to the calculated solar ephemeris. If the solar intensity is sufficient (~45 W m^{-2}), the solar tracker begins active tracking of the sun and the FTS begins acquisition of solar interferograms. The specific acquisition parameters, including the field stop diameter, detector gains, scanner velocity, and optical path difference, are set in src/site/IFSopts.pm. Throughout the scan, the solar intensity measured by the solar tracker quadrant sensor is recorded at 0.5 Hz. Since only spectra acquired under stable solar intensity are suitable for atmospheric retrievals, the standard deviation of the solar intensity is later used to evaluate spectral quality. Forward and reverse interferograms are analyzed separately to maximize the number of unobstructed scans. Acquisition of solar interferograms continues as long as the solar intensity is sufficient for active tracking of the sun. If the weather station detects rain, then the telescope dome closes and spectral acquisition ceases until weather conditions improve. When the calculated solar elevation reaches 0° at the end of the day, the telescope dome is closed.

Each night, interferograms recorded during the day are copied onto a removable hard disk. Overnight analysis software performs a Fourier transform to produce spectra from the interferograms, fits narrow HCl lines to verify the instrument lineshape, and calculates preliminary atmospheric column retrievals. These results are then emailed to Pasadena to monitor performance. At two month intervals, the removable hard disk is manually replaced with an empty one. The full disk is mailed to Pasadena for analysis and archiving. The operational data rate is ~50 GB $month^{-1}$.

The documentation below includes a description of the data acquisition source code files, a list of all telemetry data which is acquired, an explanation of the data directory structure, a list of commands accepted by the data acquisition software, information about the CVS archive, and other assorted information.

A.3.2 Data Acquisition Source Code Files

The data acquisition source code was written by Norton Allen. The source code files are located on the Hercules computers in /home/citco2/src and in the CVS archive at smirnov.jpl.nasa.gov. The table below summarizes the different source code files and their purpose. The subdirectories within /home/citco2/src (Modem, SunTracker, etc) are given in the left column.

Directories and Content of /home/citco2/src

	Filename	**File Type**	**Purpose**
Modem	Makefile		
	Doreport	Shell script	Opens PPP connection to send email
	Dosanity	Shell script	Runs from crontab once per 10 min to check modem
	inuse	Shell script	
	ip-down		
	ip-up		
	ppp.qcl	QCL script	Connection and login information for local ISP
	pppplan.txt		Documentation describing files in Modem
	ppprc.dialin		
	ppprc.dialout		
	qcl.doc		QCL documentation
	sanity.qcl	QCL script	
SunTracker	Dome.c	C code	Dome communication
	Dome.h		Definition of dome commands and telemetry data
	Dome.oui		
	Makefile		
	SunTrack.c	C code	Suntracker communication
	SunTrack.h		Definition of suntracker commands and telemetry data
	SunTrack.oui		
	Zeno.c	C code	Zeno datalogger communicationg
	Zeno.h		Definition of Zeno datalogger commands and telemetry data
	Zeno.oui		
	msg.oui		
	serqueue.c	C code	Queue of serial commands
	serqueue.h		
	serqueue.oui		
	todo.txt		
TM	Dome.cmd	Norton	Definition of dome commands in ifsdoit
	Dome.tmc	Norton	Definition of dome telemetry
	DomeDisp.tmc	Norton	Output display of dome
	Experiment.config		Filepaths for data acquisition
	IFS.cfg	Norton	Binary file
	IFS.cmd	Norton	Definition of IFS125 commands, except

			"direct" commands
	IFS.pcm	Norton	Verbose description of entire telemetry dataframe
	IFS.spec	Norton	Contains information used by appgen to create Makefile
	IFS.tbl	Norton	Defines console display appearance
	ITS.tma	Norton	Main data acquisition algorithm
	IFS2.tbl	Norton	Defines console 2 display appearance
	IFSDiag.tmc	Norton	Determines whether IFS125 diagnostics are "OK" or "fail"
	IFSctrl	Norton	
	IFSloop	Norton	Loop to initiate overnight analysis and then restart ifsdoit
	IFSq.c	C code	IFS125 command queue
	IFSq.oui	Norton	
	IFSq.pm	Norton	IFS125 command queue parameters
	IFSretr	Norton	Retrieves sliced data files from IFS125
	IFSretr.pm	Norton	IFS125 retrieval parameters
	IFStm.pm	Norton	
	ModemPower.c	C code	
	README.TM.txt		
	ST.cmd	Norton	Contains suntracker commands for ifsdoit
	ST.edf	Norton	Unused telemetry extraction format for suntracker
	ST.tmc	Norton	Definition of suntracker telemetry
	SW.cmd	Norton	Contains software commands, such as "Email Report"
	SZA.tmc	Norton	Definition of Sol_ele telemetry
	VERSION		Contains current version number
	Zeno.cmd	Norton	Definition of Zeno datalogger commands for ifsdoit
	Zeno.edf	Norton	Unused extraction format for Zeno datalogger
	Zeno.tmc	Norton	Definition of Zeno datalogger telemetry
	base.tmc	Norton	Definition of IFS125 telemetry
	catalog	PERL	Parses IFSretr.log and extracts list of first slice from each scan
	cceng.edf		Unused telemetry extraction format
	cceng1.edf		Telemetry extraction format
	cceng2.edf		Second part of telemetry extraction format
	cmdstat.tmc		Definition of power latch telemetry
	display.cfg		
	fields.cfg		
	herc_ad.c	C code	ADC inputs
	herc_ad.h		
	herc_ad.oui		
	herc_ad.tmc		Definition of ADC telemetry
	herc_dio.c	C code	DIO inputs
	herc_dio.oui		
	herc_hndlr.c		

	hercules.cmd		Hercules DIO commands
	idler.tmc		
	idlercol.tmc		
	ifs.doit		
	info.tmc		Telemetry extraction format for info files
	infoext.h		
	infoext.oui		
	interact		
	modem.txt		Readme file for modem and network devices
	pb.doit		
	solpos.c	C code	Calculate solar position in horizon coordinates
	solpos.h		
	solpos.tmc		
	sza_calc.c	C code	Calculate solar zenith angle
	sza_calc.h		
	szatest.c		
	tm.dac		
	todo.txt		Norton todo list (old)
anal	Makefile		
	OpusHdr		
	bin2csv		Converts binary telemetry data to comma separated variables
	csv	Directory	Contains bin2csv output definitions
	exam.ksh	Shell script	Spectral fitting analysis
	ifsreduce	Shell script	Overnight data processing, invokes exam.ksh
	slice-ipp	Directory	Contains slice-ipp source code
config/site_subdirectory	IFSopts.pm		IFS125 data acquisition parameters (scanner velocity, etc.)
	Makefile		
	READ.site		Text containing laboratory details and backup files
	boot		
	doreport.pm		Recipient list for emails
	etc		Backup of QNX system files
	flimit.ipp		Spectral file limits required by slice-ipp
	herc_cal.tmc		Calibration curves for current sensors and Micropirani
	location.h		Latitude, longitude, and altitude of container site
	preamps.h		IFS125 addressing of each detector
	slice-ipp.in		Input file for slice-ipp overnight analysis
	slice-ipp.top		Input file for slice-ipp overnight analysis
	strack.cfg		Backup of suntracker configuration file. This file must be physically copied to the suntracker computer.

The TM/Config subdirectory should be a soft-link to the appropriate instrument/location directory under Bruker/config (e.g. ln -s ../config/parkfalls_ifs1 Config).

A.3.3 Organization of Data

The original data acquired at each FTS site is organized in the directory structure /data/citco2/raw/flight/yymmdd.1. The sub-directories and files within the yymmdd directory are described below.

```
040909.1
|-- .MD5SUM             MD5SUM for this yymmdd directory
|-- Base                Documentation folder for data acquisition software
|   |-- location.h      Location of data collection [Optionally present]
|   |-- slice-ipp.in    [Optionally present]
|   |-- Dome.tmc        Telemetry specifications for dome
|   |-- IFS.tma         Data acquisition algorithm
|   |-- IFSCStat.tmc    Telemetry specifications for IFS125 status
|   |-- ST.tmc          Telemetry specifications for suntracker
|   |-- SZA.tmc         Telemetry specifications for solar calcs
|   |-- Zeno.tmc        Telemetry specifications for weather station
|   |-- base.tmc        Telemetry specifications for IFS125 commands
|   |-- herc_ad.tmc     Telemetry specifications for A/D
|   `-- idler.tmc       Telemetry specifications for computer (disk, cpu)
|-- IFS.pcm             Definition of telemetry frames
|-- IFSretr.log         Log of IFS125 data slice downloads
|-- VERSION             Version of data acquisition software
|-- citco2.log          Log of all software commands and actions
|-- dial.log            Log of modem/emails sent
|-- http.log            Log of communication with IFS125
|-- log0000             Telemetry data in binary format
|   |-- log0000
|   |-- log0001
|   |-- log0002
|   |-- log0003
|   |-- log0004
|   |-- log0005
|   |-- log0006
|   |-- log0007
|   |-- log0008
|   |-- log0009
|   |-- log0010  (truncated)
`-- scan                Directory with  igram slices and accompanying data
    |-- b270903.jpg
    |-- b270903.scd
    |-- b270904.0       First slice of interferogram
    |-- b270904.0.info  Information file for forward scan of interferogram
    |-- b270904.1.info  Information file for reverse scan of interferogram
    |-- b270904.jpg     Webcam image recorded at time of interferogram
    |-- b270904.scd     IFS125 parameters recorded at time of interferogram
    |-- b270905.0
    |-- b270906.0
    |-- b270907.0
    |-- b270908.0
    |-- b270909.0
    |-- b270910.0
    |-- b270911.0
    |-- b270912.0
    |-- b270913.0
    |-- b270914.0
    |-- b270915.0
    |-- b270916.0
    |-- b270917.0
```

```
    |-- b270918.0
    |-- b270919.0
    |-- b270920.0
    |-- b270921.0
    |-- b270922.0
    |-- b270923.0        First slice of interferogram
    |-- b270923.0.info   Information file for forward scan of interferogram
    |-- b270923.1.info   Information file for reverse scan of interferogram
    |-- b270923.jpg      Webcam image recorded at time of interferogram
    |-- b270923.scd      IFS125 parameters recorded at time of interferogram
    |-- b270924.0
    |-- b270925.0
    |-- b270926.0
    |-- b270927.0
    |-- b270928.0
    |-- b270929.0
    |-- b270930.0
    |-- b270931.0
    |-- b270932.0
    |-- b270933.0
    |-- b270934.0
    |-- b270935.0
    |-- b270936.0
    |-- b270937.0
    |-- b270938.0
    |-- b270939.0
    |-- b270940.0
    |-- b270941.0 (truncated)
|-- mail.log           Log of emails sent [Optionally present]
|-- sanity.log         Log of modem heartbeat monitor [Optionally present]
|-- saverun.log        Log indicating shutdown procedure
|-- tm.dac             Binary file specifying telemetry frame
|-- TM                 Directory of ascii telemetry files
    |-- 051022.1_1a.csv  1 Hz ascii telemetry files, labels in 1st row
    |-- 051022.1_1b.csv  1 Hz ascii telemetry files, labels in 1st row
    |-- 051022.1_1c.csv  1 Hz ascii telemetry files, labels in 1st row
    |-- 051022.1_1d.csv  1 Hz ascii telemetry files, labels in 1st row
    |-- 051022.1_2.csv   1/2 Hz ascii telemetry files, labels in 1st row
    |-- 051022.1_8.csv   1/8 Hz ascii telemetry files, labels in 1st row
```

During Oct 2005, we added a sub-directory within each yymmdd directory which is named "TM". "TM" contains comma-delimited text files with telemetry data. Apart from this addition in Oct 2005, every yymmdd directory has an identical structure to the one shown above.

The files which are necessary for processing the data are IFSretr.log and the contents of the scan directory.

A.3.4 Telemetry Data

The data acquisition software continuously acquires the following data. This data is used in real-time to make decisions according to the IFS.tma algorithm.

1 Hz Telemetry Data

	Telemetry Datum	Units	Description
	Sol_ele	Integer	Calculated elevation of the sun
	SWStat	Integer	Bit-mapped status word indicating IFS.tma states
Zeno Weatherstation	Zeno_WindSpeed	$m\ s^{-1}$	Young Co. 03002 Wind Sentry Reported by Zeno datalogger
	Zeno_WindDir	Degree	Young Co. 03002 Wind Sentry Reported by Zeno datalogger
	Zeno_Temp	°C	Vaisala Humitter 50 Reported by Zeno datalogger
	Zeno_RH	%	Vaisala Humitter 50 Reported by Zeno datalogger
	Zeno_SolarRadiance	$W\ m^{-2}$	Li-Cor LI-200SZ Reported by Zeno datalogger
	Zeno_Pressure	hPa	Setra 270 Reported by Zeno datalogger
	Zeno_Rain	Integer 0 = No Rain 1 = Rain	Environm. Tech. Inc. ES-1 Reported by Zeno datalogger
	Zeno_Lightning	Integer 0 = Very dry 15 = Very wet	Davis Leaf Wetness Sensor Reported by Zeno datalogger
	Zeno_VBatt	V	Battery voltage of Zeno datalogger battery Reported by Zeno datalogger
	Zeno_BIT	Integer	Contains error codes described in Zeno manual Reported by Zeno datalogger
	Zeno_Tdrift	s	Time difference between Zeno datalogger and Hercules computer
	ZENO_stale	s	Time since last reply from Zeno datalogger
Dome	DOME_azi	Degree	Dome “dticks” converted to degrees Reported by dome
	DOME_status	Integer 0 = Home 1 = Away	Bit-mapped word indicating dome status Reported by dome Bit 1: 0 = Home; 1 = Away Bit 2, 4: 0 = Unknown; 2 = Closed; 4= Open; 6 = Invalid Bit 8: 0 = Not moving; 1 = Moving
	DOME_stale	s	Time since last reply from dome
Suntracker	ST_t_int	Integer	Total intensity at quadrant sensor Reported by suntracker
	ST_tpg_azi	Degree	Azimuth position of suntracker in earth coordinates Reported by suntracker

	ST_stp_ele	Degree	Elevation position of suntracker in earth coordinates Reported by suntracker
	ST_flip	Integer	Indicates pointing orientation of suntracker 0 = Flip 0; 1 = Flip 1 Reported by suntracker
	ST_modus	Integer	Reported directly by suntracker
	ST_status		
	ST_Tdrift	s	Time difference between suntracker PC and Hercules computer
	ST_stale	s	Time since last reply from suntracker
	HercDioB	Integer	Bit-mapped word indicating Hercules DIO states
	Pump_P	mb	Pressure of pump line Reported by Micropirani as voltage
Bruker IFS125	IFS_P	mb	Leybold Vakuum Thermovac Transmitter Reported by IFS125
Bruker IFS125	IFSSrcT	°C	Source block temperature Reported by IFS125
Bruker IFS125	ScBlkT	°C	Scanner block temperature Reported by IFS125
Bruker IFS125	IFSCStat	Integer	Scanner status: idle, scanning, error Reported by IFS125
Bruker IFS125	IFSDT	s	Time difference between IFS125 and Hercules computer
Bruker IFS125	IFSRN	Integer	Slice request number
Bruker IFS125	IFSRStat	Integer	IFS125 status Reported by IFS125
Bruker IFS125	IFSSN	Integer	Scan number Reported by IFS125
Bruker IFS125	IFSSR	Integer	Scans remaining Reported by IFS125
Bruker IFS125	IFSSlR	Integer	Last slice file read (from IFSretr)
Bruker IFS125	IFSSlW	Integer	Last slice file written
Bruker IFS125	IFSStale	s	Time since last reply from IFS125
Bruker IFS125	IFSTR	Integer	Time remaining for requested scans Reported by IFS125
Bruker IFS125	LasAAF	mV	Laser A amplitude front Reported by IFS125
Bruker IFS125	LasAOF	mV	Laser A offset front Reported by IFS125
Bruker IFS125	LasBAF	mV	Laser B amplitude front Reported by IFS125
Bruker IFS125	LasBOF	mV	Laser B offset front Reported by IFS125
Bruker IFS125	IFSDiag		Diagnostic values Reported by IFS125
Bruker IFS125	IFSScan		
Analog	Air_T	°C	Container air temperature
Analog	IFS_SrcCT	°C	IFS125 source compartment temperature
Analog	IFS_DetCT	°C	IFS125 detector compartment temperature

	IFS_IntCT	°C	IFS125 interferometer compartment temperature
	IFS_ScnCT	°C	IFS125 scanner compartment temperature
	IFS_MtrCT	°C	IFS125 motor compartment temperature
	IFS_InpTT	°C	IFS125 input tube temperature
	IFS_LaserT	°C	IFS125 laser cover temperature
	Zeno_T	°C	Zeno datalogger temperature
	IFS_ElecT	°C	IFS125 electronics box temperature
	PC_CtrT	°C	Hercules computer temperature
	PCDiskT	°C	Hercules computer disk temperature
	Pump_BdyT	°C	Pump body temperature
	Pump_MtrT	°C	Pump motor temperature
	ST_AziT	°C	Suntracker azimuth temperature
	ST_EleT	°C	Suntracker elevation temperature
	ST_LvlPT	°C	Suntracker leveling plate temperature
Analog Inputs	Laser_12I	A	Current sensor
	Dome_15I	A	Dome current
	USx_12I	A	Unswitched 12 VDC current
	Hear_15I	A	Heater current
	Main_24I	A	Main 24 VDC current
	uP_M12V	V	
	uP_P12V	V	
	Laser_12V	V	
	Dome_15V	V	Dome 15 VDC
	PC_5V	V	Hercules 5 VDC
	Sw_12V	V	Switched 12 VDC
	USw_12V	V	Unswitched 12 VDC
	Heat_15V	V	Heater 15 VDC
	Main_24V	V	Main 24 VDC

0.5 Hz Telemetry Data

	Telemetry Datum	**Units**	**Description**
Hercules	CPUst	%	Hercules CPU usage
	MEMst		
	DISKst		
	Disk1st		
	Disk2st		
	Disk3st		

0.25 Hz Telemetry Data

	Telemetry Datum	**Units**	**Description**
ST	ST_off_azi	Degree	Offset between TTM and TPS solar pointing values Reported by suntracker
	ST_off_ele	Degree	Offset between TTM and TPS solar pointing values Reported by suntracker

A.3.5 Quick Command Tree for ifsdoit

This is a quick list to identify commands which are accepted by the data acquisition software. The letters which are capitalized must be typed. The others will be finished by command completion.

```
Dome
   Close shutter
   Exit
   Goto xxx
   Home
   Open shutter
EMail
   Error
   Report
   Warning
EXit
IFs
   Aerosol
   Cell
   Direct
   Exit
   IDlescan
   INsbidlescan
   ReAd status
   RePeat
    Aerosol
    Cell
    IDlescan
    INsbidlescan
   ReSet
    Hw
     Assert
     Release
    Sw
   SEt preamp gains x x
   SHortSolar
   SOlar
   SOlar Insb
   Timesynch
Log "string"
Power
   Dome
    ON
    OFf
   Ifs125hr
    ON
    OFf
   Modem
    ON
    OFf
   Pump
    ON
    OFf
   Suntracker
    ON
    OFf
Quit
SAvelog "string"
SUntracker
```

```
   Clouddetector
    OFf
    ON
   Exit
   Flip
    0
    1
   Goto x x
   Init
   SLeep
   SYnchronize time
   Track
    By diode
    To programmed sun position
SW status
   Calculate solar elevation
   Hold
   ReAd file
   ReInit
   SEt
   SHutdown
    Completely
    Instantly
    Quickly
   SImulate
    sunRise
    sunSet
   Timewarp
Telemetry
   Logging
    Suspend
    Restart
   Start
Zeno exit
```

A.3.6 Detailed Description of ifsdoit Commands

This is full description of the commands listed in the quick command tree above. Each menu has a series of subcommands and submenus. These are triggered by selecting the top level command with the first letter of its name – and subsequent letters if it is not a unique initial, and continuing to select from the presented options in the submenus. For example, the Dome menu would be selected by typing 'd' (the software then autofills the remainder of the word), while the IFS menu would need to be selected by typing 'if' to differentiate 'IFS' from 'IOMODE'.

`Dome`

`Close shutter`
Sends the dome to its home position and then closes the dome shutter

`Exit`
Terminates communication. Used as part of an orderly shutdown. Once this is done, the dome cannot receive further instructions until the program is restarted.

`Goto xxx` (azimuth Prompt): "Enter Azimuth in degrees"
Send the dome to point the opening at the azimuth angle entered. Can be performed with the dome open or closed.

`Home`
Send the dome to its home position. Can be performed with the dome open or closed.

`Open shutter`
Opens the dome shutter. The dome returns to the home position to execute this operation, and stays there once the dome is open.

`EMail`

`Error`

`File` Prompt: "Enter Filename"
Send a file to all recipients in /home/citco2/src/config/site/doreport.pm. The subject of the email will be "site Error" and the email will include the attachment.

`Message` Prompt: "Enter Message"
Send a message to all recipients in /home/citco2/src/config/site/doreport.pm. The message will have the subject "site Error" and the body will contain the message.

`Report`

`File` Prompt: "Enter Filename"

`Message` Prompt: "Enter Message"

`Warning`

`File` Prompt: "Enter Filename"

`Message` Prompt: "Enter Message"

`EXit`
Exits the user interface without ending data acquisition or the algorithm. Invoking IFSdoit again then brings up the user interface again without restarting the underlying control software. We do not use this command.

`IFs`

`Aerosol` Prompt: "Enter optional scan parameters"
Run the experiment type "Aerosol" in standard form, unless any options are entered to be performed differently. The normal scan parameters for 'Aerosol' are set in /home/citco2/src/config/site/IFSopts.pm

`Cell` Prompt: "Enter optional scan parameters"
Run the experiment type "Cell" in standard form, unless any options are entered to be performed differently. The normal scan parameters for 'Cell' are set in

/home/citco2/src/config/site/IFSopts.pm

`Direct` Prompt: "Enter Direct Parameters"

Sends a direct Bruker web interface command to the IFS. See alternative list for IFS125 acronyms. Three letter acronyms must be capitalized The allowed TLAs that can be sent to the IFS are defined in IFSopts.pm.

`Exit`

Terminates communication. Used as part of an orderly shutdown.

`IDlescan` Prompt: "Enter Optional Scan Parameters"

Run the experiment type "IdleScan" in standard form, unless any options are entered to be performed differently. The normal scan parameters for 'IdleScan' are set in /home/citco2/src/config/site/IFSopts.pm

`ReAd status`

Reads IFS parameters (Diagnostics, Laser, IFS boxes on main screen)

`RePeat`

Not operational.

`ReSet`

`HW`

`Assert`

`Release`

`SW`

`SEt preamp gains x x` Prompt: "Enter Binary Gain Index for InGaAs and Si"

`SHortCell` Prompt: "Enter Optional Scan Parameters"

Run the experiment type "ShortCell" in standard form, unless any options are entered to be performed differently. The normal scan parameters for 'ShortCell' are set in /home/citco2/src/config/darwin_ifs2/IFSopts.pm

`SHortSolar` Prompt: "Enter Optional Scan Parameters"

Run the experiment type "ShortSolar" in standard form, unless any options are entered tobe performed differently. The normal scan parameters for 'ShortSolar' are set in /home/citco2/src/config/site/IFSopts.pm

`SOlar` Prompt: "Enter optional scan parameters"

Run the experiment type "Solar" in standard form, unless any options are entered to be performed differently. The normal scan parameters for 'Solar' are set in /home/citco2/src/config/site/IFSopts.pm

`SOlar Insb`

`Time synch`

Synchronizes the time between the Hercules computer and the IFS125 (sets IFS time to be that of the Hercules, as it is correct via using the NTP server)

`IOmode`

Changes the auto-completion option of the user interface. It can be set to never auto-complete.

`LOG` Prompt: "Enter String to Log To Memo"

`Power`

`Dome`

`OFf` Turns the robodome power off

`ON` Turns the robodome power on

`Ifs125hr`

`OFf` Turns the IFS125 power off

`ON` Turns the IFS125 power on

`Modem`

`OFf` Turns the 12V power distribution box power off

`ON` Turns the 12V power distribution box power on

`Pump`

`OFf` Turns the pump power off

`ON` Turns the pump power on

`SunTracker`

`OFf` Turns the sun tracker power off

`ON` Turns the sun tracker power on

`Quit`

Ends software control of the instrument (shutting down both the data acquisition/control and the user interface), but does not attempt any shutdown of devices. The 'SW Shutdown' commands are preferred in normal operation.

`SAvelog` Prompt: “Enter Log Message”

Saves the logs – prompting a separate scanset. Appropriate to use after a failure. Note that it will trigger another processing run, and a second yymmdd directory.

`SUntracker`

`Cloud` detector – Not used.

`Exit`

Terminates communication. Used as part of an orderly shutdown.

`Flip`

`0` Go to sun tracker flip state 0

`1` Go to sun tracker flip state 1

`Goto` `xxx` (azimuth angle), Elevation Angle

Send the sun tracker to the azimuth/elevation coordinates entered.

E.g. SunTracker GoTo 0 -72 send the tracker to azi=0, ele=-72.

`Init`

`SLeep`

Send the sun tracker to the sleep position.

`SYnchronize Time`

`Track`

`By diode`

Start Tracker Track Mode (TTM), with corrections performed by the quadrant diode to center the sun on the input sample tube.

`To programmed`

`Moon position`

Send the tracker so the mirrors are pointed to the calculated moon position (TPM)

`Sun position`

Send the tracker so the mirrors are pointed at the calculated sun position (TPS)

`SW status`

Calculate solar elevation

`Hold`

Stop automatic runs and hold in a standard configuration. Note that this causes the dome to shut. It then allows the user to enter manual commands with no interference from IFS.tma.

`ReAd` file

Reads commands from the text file /data/citco2/IFS.tmas. This command is superfluous, because the algorithm reads from this file every 15 seconds. Commands can be written to this file and they will be executed within 15 seconds. If the commands are to be executed only once, the file should end with "Validate ReadFile_Delete;" To loop, you can include "Validate ReadFile;" If neither of these options is used, the ReadFile partition will stop at the end of the file, and an explicit "SW Status Read File" command will have to be issued on the console to re-execute the file.

The syntax of IFS.tmas is the same as the contents of a single State{} within a normal .tma file without any C-code (stuff in curly braces). e.g.:

```
> Dome Home
+10 > Dome Open
+30 > Dome GoTo Azimuth 102
Validate ReadFile_Delete;
```

You can't "hold until", but it is possible to "hold;" in conjunction with another partition.

`ReInit`

Reinitialize communications with all connected devices, and restart the automated software run.

`SEt` prompt: "Enter Integer (Decimal: 123, Hex: 0x123F, Octal: 0123)"

All of the SW status commands are implemented by setting the SWstatus variable to a specific value. This command exposes the underlying mechanism.

`SHutdown`

`Completely`

`Instantly`

Shuts down without waiting for the IFS to become idle.

`Quickly`

Waits until the IFS125 becomes idle (i.e. the end of the next scan) before shutting down and exiting.

`SImulate`

`sunRise`

Simulates the procedure for when the solar elevation becomes greater than 0 at sunrise. This is done by steadily increasing the solar elevation angle by 1 degree at a time. Good for testing that the software behaves as it should at this time, without having to wait until the next morning. Equivalent to the wake up procedure.

`sunSet`

Simulates the procedure for when the solar elevation becomes less than 0 at sunset. This is done by decreasing the solar elevation angle by 1 degree at a time through 0 degrees. Also good for testing software behavior. Equivalent to the bedtime procedure.

`Time warp`

Provides a means for testing algorithms with long time-sequences. A 30-minute delay can be written:

```
Hold until ( SWstatus == SWS_TIMEWARP ) or 30:00;
```

Then issuing the time warp command will jump ahead.

`Telemetry`

`Logging`

`Resume`

`Suspend`

Use of this command is frowned upon since it makes it impossible to reconstruct the exact state of the machine from the data log.

`Start`

Issued once automatically by the algorithm to get things going. Never required interactively.

`Zeno`

`Exit`

Terminates communication. Used as part of an orderly shutdown.

Other Notes:

There is no way to restart the automation after a failure without first exiting the software. Therefore, after a failure, type:

```
> SaveLog Failure Shutdown
```

A.3.7 Routine monitoring of the data acquisition

For routine monitoring, it is necessary to monitor the weather and to respond to "error" emails.

Actively monitoring the weather

Check weather each day. If winds are predicted to be >= 25 mph or if severe storms are predicted, then put the data acquisition in hold.

To put the container in hold:

If the data acquisition is left in hold for more than 48 hours without running 'reduce,' it will cause an error in the binary data extraction.

Connect to the Hercules computer. Use the commands

```
sudo ditto -k /dev/con1

> SW Status Hold
```

There will be no more Wakeup, Play, etc. The data acquisition will sit and wait, logging telemetry data.

Check that the dome status is "Close"

`<CTRL>E` then `q` to exit ditto

To return to normal data acquisition:

Connect to the Hercules computer. Then:

```
sudo ditto -k /dev/con1

> SW Status ReInit
```

`<CTRL>E` then `q` to exit ditto

Error Emails

A few places to look for clues, if there is an "error" email:

$ tail /data/citco2/citco2.log - to see the most recent events in the log

Look at netcam jpg - check to see if opening of dome is aligned with the shadows cast by the sun

A.3.8 Queuing directories to repeat the overnight analysis

Sometimes the overnight analysis is interrupted. It can be queued to begin again from scratch, after sunset.

In the comments at the top of /home/citco2/bin/anal/ifsreduce:

Analysis script to run under reduce as:
Analysis='bin/anal/ifsreduce background $analdir $directory'

Here $directory refers to the raw data directory and $analdir refers to the analysis directory where the log file is located. In interactive use, it works like this:

```
run=050201.1
analdir=/home/citco2/anal/$run
directory=/data/citco2/raw/flight/$run
cd /home/citco2
bin/anal/ifsreduce background $analdir $directory
```

To start the processing immediately, replace the last line with:

```
BEDTIME=yes bin/anal/ifsreduce background $analdir $directory
```

A.3.9 Hercules Computer Shutdown Instructions

1. Type "`sudo shutdown -b`", then your password.

2. When QNX says it is safe to turn power off, flip power switch on main 28 V supply. The computer is now running on batteries.

3. Unplug the battery cable at the main 28 V supply. The computer is now turned off.

4. Turn heater power supply off.

Follow these in reverse to bring the system back up

Remember to turn the 28 V power supply back on. Otherwise, the computer will run fine until the batteries are dead.

A.3.10 Useful QNX Commands

QNX system files:

/var/log/syslog
/etc/resolv.conf - contains DNS information
/etc/ntp.conf - contains NTP information
/etc/config/sysinit.4 - contains time zone information

QNX commands and processes:

`sin info`	System CPU and RAM usage
`sin tree`	System processes
`sin files`	System files
`sin -P perl files` `sin fd`	Reveals file current perl script is reading
`who`	Shows who is logged in
`use command`	Help for command
`sudo shutdown`	Restart system
`sudo shutdown –b`	Shutdown system

QNX utilities:

`qtalk -m /dev/serX/`	Terminal emulation program
`<CTRL>A; x`	Qtalk menu options (x to exit)
`ditto /dev/conX`	Echo QNX screen on local computer
`<ctrl>E; q`	Ditto menu options (q to exit)

Other details:

Manual extraction of info files:
```
   extract /data/citco2/raw/flight/040331.1 'infoext –d
/data/citco2/raw/flight/040331.1'
```

Manual extraction of other telemetry files:
```
   extract /data/citco2/raw/flight/yymmdd.1 cceng1ext
```

If IFS.tma runs for several days without ‘reduce’, then 'extract' will get stuck during the next time it is run. It will produce garbled error messages. To end the processes which are stuck:
```
   slay memo
   slay rdr
```

or find the offending process with `ps –ef` and then use “`kill -9`”

A.3.11 CVS Software Archive

The data acquisition software is maintained in a Version Control System on smirnov.jpl.nasa.gov. To access the CVS archive, the user's two local environmental variables must be defined as:

```
export CVSROOT=:ext:smirnov.jpl.nasa.gov:/usr/local/src/cvsroot
export CVS_RSH=ssh
```

Normal Use:

In normal use, the local source directory already exists, and the major uses of CVS are for archiving changes you make to the source code and incorporating changes that other people have made to the source code. To determine how your source code differs from the archived version, use:

```
cvs diff -r BASE -r HEAD
```

To commit a single file:

```
cvs commit cceng.edf
```

To synchronize your source code with the archived version:

```
cvs update
```

This will access the archive and compare your local sources to the latest version in the archive. If there are newer revisions available in the archive, your local copies will be updated to reflect those changes, and the files updated will be listed with a 'P' to indicate that they have been patched. If you have made changes locally, it will note those changes by listing the files you have modified with an 'M'. The output of CVS update might look like:

? newfile.txt
A other.txt
P base.tmc
C info.tmc
M cceng.edf

? newfile.txt
CVS doesn't know about this file. If it is a source file that should be in the archive, you should add it via:

```
cvs add newfile.txt
```

If it is some derived file, it should be added to the .cvsignore file.

A other.txt
This indicates that other.txt has been added via 'cvs add' but has not yet been committed to the archive.

P base.tmc
This indicates that base.tmc has been updated in the archive since you last updated and the changes have been merged into your local copy.

C info.tmc
This indicates that info.tmc has been updated in the archive since you last updated, but there was a conflict when trying to merge the changes with your local copy. You should edit the file and look for '>>>>' and '<<<<' lines which will show where the conflicts were found.

```
M cceng.edf
```

This indicates that cceng.edf has been modified in the local directory, but the changes have not been committed.

Once you have done and update and resolved any issues, you will probably want to commit your changes to the archive. Generally we like to commit changes after we've determined that the changes work, but sometimes it makes sense to commit changes so they can be accessed on other systems even though they are still under active development.

To commit your changes, you can issue:

```
cvs commit
```

which will commit all changes in the current directory subtree, or:

```
cvs commit cceng.edf
```

which will commit changes in cceng.edf only.

To check out the source code for the first time:

```
cvs checkout -d src Bruker
```

A.4 Data Transfer, Archive, and Processing

Due to the limitations of our network connections in Park Falls and Darwin, it is necessary to physically transfer data by disk. Once at Caltech, the data is copied to the RAID and to archive disks. The .MD5SUM of each copy is verified to make sure no data corruption has occurred. The sliced interferograms are Fourier transformed using software by Jean-Francois Blavier. The following sections describe the removable disks, the Caltech RAID, the slice-ipp software, the filenaming convention, and some other assorted information.

A.4.1 Removable Disks

General Information

The Hercules computer contains two disks: a permanent (or fixed) disk and a removable disk. Both disks are 200 GB Western Digital EIDE disks. Due to limitations of the QNX4 filesystem, the formatted capacity of the disks is only 137 GB.

The removable disk is mounted in Storcase DE-90 disk carrier. Each night, ifsreduce makes a copy of the day's data on the removable disk. When the fixed disk is ~100 GB full, we exchange the removable disk for an empty one. After the data from the removable disk has been transferred to permanent storage at Caltech/JPL, that data is deleted from the fixed disk.

Instructions for swapping the removable disk

IFSloop has to be stopped in order to unmount the disk, but it can be restarted after the disk is unmounted, and the physical swap can happen during normal data acquisition.

Unmount the disk remotely. This requires exiting and restarting IFSloop:

```
> SW Shutdown Quickly
sudo umount /dev/hd1.1t77
sudo umount /dev/hd1.1
IFSloop
```

On site:

1. Unpack the cardboard box. The removable hard disk is in the black plastic case. This removable disk is the "empty" one. The main computer is sitting on the folding table and has all the labels and blinking lights. The removable disks are inserted into the bay in the bottom right corner of the front panel.

2. There is a key in the front of the removable drive bay. Turn it clockwise one quarter turn.

3. Wait for the removable drive bay LEDs to stop blinking in opposition. This takes about 10 seconds.

4. Raise the handle of the "full" removable drive and gently pull it out.

5. Place the new "empty" drive from Pasadena in the bay. Make sure it is fully seated.

6. Turn key counter-clockwise one quarter turn.

7. Wait for LEDs to stop blinking in opposition.

8. Put the "full" removable into the anti-static bag. Put it into the black plastic case and pack it back into the cardboard box.

9. The mailing address is:

Mail Stop 150-21
Caltech
1200 E. California Blvd.
Pasadena, CA 91125

Remount the disk remotely. This does not require exiting IFSloop:

```
sudo mount -p /dev/hd1.1
sudo mount /dev/hd1.1t77 /removable]
```

A.4.2 RAID at Caltech

powraid_rd1 is a 1.8 TB mirrored RAID-1. It is controlled via a SCSI card installed in the powraid computer. powraid_rd1 is mounted on the GPS NFS and is available to GPS network users.

The powraid computer in 076 N. Mudd has bays for two removable drives.
IDE bus IDE0 contains the fixed powraid hard disk.
IDE bus IDE1 contains the two removable bays. The upper bay is master (end of cable) and the lower bay is slave (middle of cable).

Four 320 GB Western Digital disks:
- The disk jumper was set to "Master with Slave" for each.
- These should be placed in the upper bay.
- Formatted with one partition under EXT3.

Removable 137 GB QNX disks:
- Disk jumper set to "Cable Select".
- These should be placed in the lower bay.
- Formatted with one partition under QNX.

Three scripts (attached) on powraid in /usr/bin allow non-root users to find all removable drives, format an EXT3 disk in the upper bay, and dismiss all removable drives:

```
sudo removable-find-drives.sh*
sudo removable-format-ext3.sh*
sudo removable-dismiss-drives.sh*
```

To execute these files, the user must be listed with privileges in the powraid /etc/sudoers file.
This also gives the user privilege to run smartctl and badblocks

Useful utility for monitoring disk conditions:

```
smartctl -a /dev/hdc1 | less
```

Copying data to powraid

Insert QNX disk into bay of powraid. Mount disk on powraid:

```
sudo removable-find-drives.sh
```

Copy data from /removable_qnx4 to powraid_rd1 directory using "cp -pr" for recursive copy which preserves time-stamp of data. The commands for mounting
and copying the disk must be done from powraid computer. Other steps can be done from carbonio.

After the data copy is finished, remove write-access of new data on powraid:

```
cd /home/powraid_rd1/data/parkfalls_ifs1
chmod -R a-w 0604* 0605*
```

[-R is for "recursive" and a-w is remove "all" "write" permissions]

Run dircksum on the newest data:

```
cd /home/powraid_rd1/data/parkfalls_ifs1
nohup ~/scripts/dircksum 0604* 0605* >
~/your_organized_output/060401_060531_powraid_dircksum &
```

[~/scripts/dircksum is the path to where your copy of dircksum is saved]

Check whether dircksum is finished by looking at output:

```
cat ~/your_organized_output/060401_060531_powraid_dircksum
```

When it is finished and you see that the dircksums agree, remove the QNX disk from powraid. Create EXT3 backup copies, by copying from RAID to EXT3 hard disks and run dircksum on the EXT3 copies.

A.4.3 MD5SUM tool: dircksum

dircksum is a stand-alone PERL script which generates an MD5SUM. During the overnight analysis, dircksum is run on the data directory on the fixed disk. The result is saved as .MD5SUM in that day's data directory. After the data is copied to the removable disk, dircksum is run again. If the result differs from .MD5SUM, then this is reported in the ifsreduce email.

After receiving the removable disk at Caltech, is necessary to run dircksum on each copy that we make (there are three: the RAID and two Linux archive disks), to guarantee that there is no corruption.

For example:

```
nohup ~/scripts/dircksum /home/powraid_rd1/data/parkfalls_ifs1/050[8,9]*
> powraid_050801_050905_dircksum &
```

This will run dircksum on the new files and output a summary text file to powraid_050801_050905_dircksum. Then look at the text file to make sure there are no problems.

More information about dircksum:

$ use dircksum
dircksum [-w] [-o outputfile] [-v] [-c] dir [dir ...]
Generates a listing of CRCs of the contents of the directory and all its subdirectories. This file should be sensitive only to the file names and their contents, not to the dates and/or the order of the files in the directory.

-w indicates that the results should be written to a file named .MD5SUM or .CKSUM in the target directory. If -w is not specified and .MD5SUM or .CKSUM exists, the current output is compared to that file and the differences are reported.

If an output file is not specified with the -o flag, output may be written to a temp file. The temp file may not be removed if a comparison against the old .CKSUM shows a discrepancy.

-c indicates the cksum program should be used to generate the hash. By default, and MD5 hash is used. -c is implicit when -w is not specified and a .CKSUM file exists.

-v indicates that the results should be written to STDOUT in addition to any file specified via -w or -o or the temp file implicit if a .CKSUM file exists. If neither -w nor –o are specified and no .CKSUM file exists, -v is implicit.

A.4.4 Slice-IPP Fourier Transform Software

Explanation of three-digit version numbering for the code: X.Y.Z (e.g. slice-ipp 1.0.0):

"X" is the software architecture number.

"Y" is the major revision number. This number will change if the effect on the data will be significant. Examples of this would be corrections for the runs whose time info is affected by download stress or whose slices have been partly overwritten. When this number changes, some parts of the data set will need to be reprocessed.

"Z" is the minor revision number. This is essentially for bug fix purposes. For example, supporting the third instrument might bring new problems which would otherwise not affect the Park Falls or Darwin data.

A.4.4.1 Fourier-Transform Using Slice-IPP

1a. Run the "catalog" program. The catalog program parses the contents of IFSretr.log and generates a list of the first slice from each interferogram. The syntax for catalog is this:

```
   catalog /home/powraid_rd1/data/parkfalls_ifs1/040909.1/IFSretr.log >
040909.1_catalog
```

catalog can act on many directories at once:

```
   catalog /home/powraid_rd1/data/parkfalls_ifs1/04*/IFSretr.log >
04xxxx_catalog
```

1b. Concatenate slice-ipp.top and the catalog to create an input file named slice-ipp.in, which will be read by slice-ipp:

```
   cat slice-ipp.top 040909.1_catalog > slice-ipp.in
```

The slice-ipp.top file is carefully documented, and indicates the data directory path, the spectra output path, and other parameters for the Fourier transform. These must be modified appropriately.

1c. Execute slice-ipp:

```
   ./slice-ipp | tee slice-ipp_040909_output.txt
```

slice-ipp will read the slice-ipp.in file in the slice-ipp directory, and produce spectra.

A.4.4.2 Bruker Acronyms contained in the IFS125 spectral headers

```
Acquisition Parameter Block
AQM: Acquisition Mode
COR: Correlation Test Mode
DEL: Delay Before Measurement
DLY: Stabilization Delay
HFW: Wanted High Frequency Limit
LFW: Wanted Low Frequency Limit
NSS: Sample Scans
```

PLF: Result Spectrum
RES: Resolution
RGN: Signal Gain, Background
SGN: Signal Gain, Sample
TDL: To do list

Data Parameter Block - Spectrum
CSF: Y - Scaling Factor
DAT: Date of Measurement
DPF: Data Point Format
FXV: Frequency of First Point
MNY: Y – Minimum
MXY: Y – Maximum
NPT: Number of Data Points
TIM: Time of Measurement

Data Parameter Block - IgSm
CSF1: Y - Scaling Factor
DAT1: Date of Measurement
DPF1: Data Point Format
DXU1: X Units
FXV1: Frequency of First Point
LXV1: Frequency of Last Point
MNY1: Y - Minimum
MXY1: Y - Maximum
NPT1: Number of Data Points
TIM1: Time of Measurement

Data Parameter Block - IgSm/2.Chn
CSF2: Y - Scaling Factor
DAT2: Date of Measurement
DPF2: Data Point Format
FXV2: Frequency of First Point
LXV2: Frequency of Last Point
MNY2: Y - Minimum
MXY2: Y - Maximum
NPT2: Number of Data Points
TIM2: Time of Measurement

FT Parameter Block
APF: Apodization Function
HFQ: End Frequency Limit for File
LFQ: Start Frequency Limit for File
PHR: Phase Resolution
PHZ: Phase Correction Mode
SPZ: Stored Phase Mode
ZFF: Zero Filling Factor

Instrument Parameter Block
ABP: Absolute Peak Pos in Laser*2
AG2: Actual Signal Gain 2nd Channel
ARS: Number of Background Scans
ASG: Actual Signal Gain
ASS: Number of Sample Scans
DAQ: Data Acquisition Status
DUR: Scan time (sec)
FOC: Focal Length
GBW: Number of Good BW Scans
GFW: Number of Good FW Scans
HFL: High Folding Limit

INS: Instrument Type
LFL: Low Folding Limit
LWN: Laser Wavenumber
P2A: Peak Amplitude 2nd Channel
P2K: Backward Peak Location 2nd Channel
P2L: Peak Location 2nd Channel
P2R: Backward Peak Amplitude 2nd Channel
PKA: Peak Amplitude
PKL: Peak Location
PRA: Backward Peak Amplitude
PRL: Backward Peak Location
RDY: Ready Check
RSN: Running Sample Number
SSP: Sample Spacing Divisor

Optic Parameter Block
APT: Aperture Setting
BMS: Beamsplitter Setting
CHN: Measurement Channel
DTC: Detector Setting
HPF: High Pass Filter
LPF: Low Pass Filter
PGN: Preamplifier Gain
SON: External Synchronization
SRC: Source Setting
VEL: Scanner Velocity

Sample Parameter Block
CNM: Operator Name
EXP: Experiment
IST: Instrument Status
SFM: Sample Form
SNM: Sample Name

A.4.4.3 Additional Acronyms defined for the IFS125 spectral headers

Acquisition Parameter Block
OPL: Optical path difference on the long side in cm
OPS: Optical path difference on the short side in cm

Instrument Parameter Block
HUM: IFHum: (This became a Bruker item)
IDA: IFSDT_avg
ISS: ScanStatus(e.g. OK)
PIM: IFS_P (This became a Bruker item)
TLP: IFSSrcT (This became a Bruker item)
TSC: ScBlkl_T (This became a Bruker item)

Optic Parameter Block
FOV: Field of view in mrad
PGR: InGaAs_R or Si_R

Sample Parameter Block
ALT: Altitude
DAA: Dome_azi_avg
DSM: Dome_Status_max
HOU: Zeno_RH_avg
LAT: Latitude

```
LON: Longitude
POU: Zeno_Press_avg
SAA: ST_tpg_azi_avg
SDA: ST_Tdrift_avg
SEA: ST_tpg_ele_avg
SFM: ScanType(e.g. Solar; this is a Bruker item with special use)
SIA: ST_t_int_avg
SIS: ST_t_int_std
SOA: ST_off_azi_avg
SOE: ST_off_ele_avg
STM: ST_TPS_max
TOU: Zeno_Temp_avg
WDA: Zeno_WindDir_avg
WDS: Zeno_WindDir_std
WSA: Zeno_WindSpeed_avg
WSM: Zeno_WindSpeed_max
WSS: Zeno_WindSpeed_std
ZLM: Zeno_Lightning_max
ZRM: Zeno_Rain_max
ZSA: Zeno_SolarRadiance_avg
ZSS: Zeno_SolarRadiance_std
ZVA: Zeno_VBatt_avg
```

A.4.4.4 Filenaming Convention

Character	Description	Examples
1	Site	c=Caltech; l=Lauder; p=Park Falls; d=Darwin
2	Instrument	a=Park Falls 125HR; m=Lauder 120M; h=Lauder 120HR; b=Darwin 125HR
3 – 6	Year	2003, 2004, 2005, etc
7 – 8	Month	01=January, 02=February, etc
9 – 10	Day	01, 02, 03,.....31
11	Source	s=solar; m=moon; l=lamp; a=scattered sky
12	Cell	0=no cell; a, b, c, d=5 mbar HCl cells
13	Beamsplitter	a=Caltech CaF_2; b=Lauder CaF_2, c=Darwin CaF_2
14	Dichroic	a=Caltech; b=Lauder; c=Darwin
15	Filter	0=no filter; a=red color glass; b=Germanium; c=interference
16	Detector	a=InGaAs; b=Si, c=InSb, x=dual acquisition InGaAs+Si
17	"."	
18 – 21	Spectrum number	0000-9999

Example for Darwin:
db20060101seccax.000 for dual-acquisition spectra
db20060101secc0a.000 for InGaAs
db20060101seccab.000 for Si
db20060101secccc.000 for InSb

A.5 General Logistics

These sections describe logistic and site information specific to each of the laboratories.

A.5.1 Contact Information and Account Numbers

Caltech Account Numbers:

POW.00019-1-JPL.1263534 / P424704
POW.00021-1-NASA.000154 / P432845
POW.00023-1-JPL.1269365FAB / P456526

Shipping Account Numbers:

DHL Inbound Account Number (Yael Yavin / Coleen Roehl): 968716818
DHL General Account Number (Yael Yavin / Coleen Roehl): 788486140
DHL: 1-800-225-5345

FedEx Account Number (Caltech): 100945223

Caltech Shared Computer Accounts:

Username its.caltech.edu: tccon
Dial-up modem: 1-800-429-1113 or 626-685-7098

Caltech Campus Contact Information

Biology Stockroom, Pat Perrone: x4922
Central Engineering Stockroom, Corey Campbell: x4680, Moses X4720
Central Warehouse, Rick Germond: x4891
Electrical, Mike Anchondo: x4999
Glassblower, Rick Gerhart: x6518
Physics Machine Shop, Rick Paniagua: x6631 or x6641
RAID, David Kewley: x5767
Shipping and Receiving: x4893
Transportation: x4703/4
Telephone set up, Donna Sparks: x4735

Collaborator Contact Information

Gretchen Aleks: x6293, gka@gps.caltech.edu
Jean-Francois Blavier: 818-354-6665; blavier@mark4sun.jpl.nasa.gov
Geoff Toon: 818-354-8259; Geoffrey.C.Toon@jpl.nasa.gov
Rebecca Washenfelder: x6894, rebeccaw@caltech.edu
Paul Wennberg: x2447, wennberg@gps.caltech.edu
Zhonghua Yang: x6293; yangzh@gps.caltech.edu
Yael Yavin: x8552; yyavin@caltech.edu

A.5.2 Caltech FTS Site

A.5.2.1 Caltech Contact Information and Logistics

Location:

34.1342 N; 118.1261 W; 0.210 km

Mailing Address:

California Institute of Technology
1200 E. California Blvd. OR 391 S. Holliston Ave.
Pasadena, CA 91125

Container Access:

Container phone: 626-395-4662

A.5.2.2 Caltech Network Connectivity

TCP/IP Settings:

IP 131.215.199.42
Subnet 255.255.255.0
Gateway 131.215.199.254
DNS 131.215.139.100
NTP 131.215.254.252, 131.215.65.2, and 131.215.254.254
(ntp1.caltech.edu, ntp3.caltech.edu, and ntp4.caltech.edu)

The Linksys router (192.168.1.1 on LAN) has the following settings:

22 -> 192.168.1.104 (Hercules3)
8080 -> 192.168.1.107 (Stardot)

A.5.3 Park Falls FTS Site

A.5.3.1 Park Falls Contact Information and Logistics

Location:

45.9448 N; 90.2732 W; 0.442 km

Mailing Address:

WLEF-TV
W4551 State Road 182
Park Falls, WI 54552
USA

Contact Information:

Jeff Ayers, JAyers@ecb.state.wi.us
Roger Strand, RStrand@ecb.state.wi.us
WLEF Tel: 715-762-2611

Jeff Ayers home
Tel: 715-762-2490
Cell: 715-661-0011
Email: jayers@pctcnet.net

Local dial-up access in Park Falls:

715-762-1230
username: ctx19141

Travel Logistics:

Super 8
1212 Hwy 13 South
Park Falls, WI, 54552 US
715-762-3383
Super 8 has added free wireless access.

www.suncountry.com

Container Access:

Container phone: 715-762-8053

Natural Disasters:

The Park Falls site is at risk from giant ice chunks falling from the support cables of the WLEF tower. The laboratory is directly underneath the support cables. The container roof is reinforced with plywood, the heater/AC has a protective aluminum cover, and the dome has a unistrut cover. The aluminum cover of the unistrut protection must be moved forward at the end of October, so that the aluminum cover is flush with the steel structure on the northern edge. On March 1, the aluminum cover must be moved north by ~8". On April 15, the aluminum cover must be moved completely to the north, so that it does not obstruct the solar beam.

A.5.3.2 Park Falls Network Connectivity

The Park Falls FTS experiment is only available by modem PPP connection. The phone number is 715-762-8053; username: wennppp. There are two methods for connecting: using your own modem or using smirnov.jpl.nasa.gov

Instructions using personal modem:

To configure a Windows computer, use the "Create a New Connection" dialogue and select a dial-up connection.

From the Connection Properties Dialog:
"Options": Uncheck "Prompt for name and password".
"Security": Check "Show terminal window" in "Interactive logon and scripting"
"Networking": Select "Internet Protocol (TCP/IP)". Select "Properties" and in the ensuing dialog choose "Obtain an IP address automatically"; Select "Advanced" and de-select the option "Use default gateway on remote network".

Make connection. When it connects, you'll get a terminal window. Hit <Enter> and it will prompt you for a terminal type (which is moot because you're not in a terminal emulator, but you have to give it an answer it likes, so type 'ansi') then login as wennppp. After you've logged in, you should get a line of funny characters (seems to be spaces and parentheses... something like '({{ [[{ '. When you see that, select 'Done' and it should finish connecting. Then you can bring up an ssh connection.

Instructions using smirnov.jpl.nasa.gov modem:

Jean-Francois Blavier has setup the PPP client on smirnov.jpl.nasa.gov to call the container. This makes it possible to reach the container from computers that don't have a modem but are connected to the Internet. You must have an account on smirnov to use this connection.

1. Use SSH to connect to smirnov.

2. To initiate the connection to the container, type:

```
sudo ppp-go
```

This will return immediately to the command prompt, but the computer is actually dialing and negotiating the link in the background. After a few seconds, you will see:

```
Serial connection established.
Using interface ppp0
Connect: ppp0 <--> /dev/modem
not replacing existing default route to eth0 [137.78.163.1]
local  IP address 192.168.1.109
remote IP address 192.168.1.103
```

Occasionally, the connection to the container will fail, probably due to the poor quality of the phone line. In that case the message is:

Connect script failed

3. You can log into the Hercules with:

```
ssh hercules2
```

4. If your computer runs an X11 server and your SSH connection allows X11 tunneling, then you can simply run Netscape on smirnov and have the display sent to your local screen:

```
netscape http://stardotcam:8080/netcam.jpg
```

If you are not running an X11 server on your local computer, then you can download the webcam picture to your directory on smirnov:

```
wget http://stardotcam:8080/netcam.jpg
```

6. When you are done with the connection, do:

```
sudo ppp-stop
```

The system will quickly respond with a message similar to:

Terminating on signal 2.
PPP link to [ppp0] terminated.
Connection terminated.
Connect time 16.3 minutes.
Sent 15187 bytes, received 120233 bytes.
Connect time 16.3 minutes.
Sent 15187 bytes, received 120233 bytes.

Don't forget this last step, or the connection to the container will stay up.

A.5.4 Darwin FTS Site

A.5.4.1 Darwin Contact Information and Logistics

Location:

12.425 S; 130.891 E; 0.030 km

Mailing Address:

SSU NT
Bureau of Meteorology
525 Stuart Highway
Winnellie, NT 0821
Australia

Contact Information:

Rex Pearson, Lead Technician, r.pearson@bom.twp.arm.gov
Troy Culgan, Technician
Michael Alsop, Technician
Gary Eckert, Technician

Tel: 618-8947-3815
618-8984-4515 (workshop)
580-388-4083 (voice-over-IP)

Local dial-up access in Darwin:

Opusnet Account
019-833-1111
Username: acrs.3

Access to TWP ARM instrumental data:

198.129.82.242
Username: Oper

Travel Logistics:

Sky City, Darwin (has free ADSL access)
Gilruth Avenue, Mindil Beach
Darwin, NT
Australia
+61 8 8943 8888
www.skycitydarwin.com.au

Alatai Apartments
McMinn St (Cnr Finniss St)
Darwin, NT
Australia
+61 8 8981 5188 / 1800 628 833
www.alataiapartments.com.au

Collaborators:

Nicholas Deutscher
Work 02 4221 3196
Mobile 0421 992216
Home 02 4229 3973
Email nmd03@uow.edu.au

Natural Disasters:

Cyclones. Lightning strikes.

A.5.4.2 Darwin Network Connectivity

Unlike the Park Falls FTS laboratory, the Darwin FTS laboratory is available on the network.

TCP/IP Settings:

IP 198.129.82.248
Subnet 255.255.255.240
Gateway 198.129.82.241
DNS 134.178.6.5 and 146.137.100.120
NTP 198.129.82.74
Local SMTP 198.129.82.242

Dick Eagan (sysadmin at ARM) has allowed all IP addresses on ports 22 (ssh), 80 (html), 8080 (html), 8008 (html), 25 (smtp), 42 (nameserver), 53 (domain), and 123 (ntp) to reach our IP address.

The Linksys router (192.168.1.1 on LAN) has the following settings:

Port forwarding:
80 -> 192.168.1.101 (IFS125)
22 -> 192.168.1.104 (Hercules1)
8080 -> 192.168.1.107 (Stardot)

Packet filtering:
```
1. Smirnov        Allow Incoming --- 137.78.163.184 ~ 184  TCP 80 ~ 80
2. Bruce          Allow Incoming --- 130.130.56.126 ~ 126  TCP 80 ~ 80
3. ---            Allow Outgoing --- ---                   ALL ---
4. DNS            Allow Incoming --- 130.202.101.22 ~ 22   ALL ---
5. DNS2           Allow Incoming --- 146.137.100.120 ~ 120 ALL ---
6. NTP            Allow Incoming --- 198.129.82.74 ~ 74    ALL ---
7. Deny_80_In     Deny  Incoming --- ---                   TCP 80 ~ 80
8. Allow_Incoming Allow Incoming --- ---                   ALL ---
```

What the port forwarding and packet filtering means:

- Incoming DNS and NTP are allowed.
- Incoming ports 22, 80, and 8080 are forwarded. However:
- Only Smirnov and Bruce are allowed to visit port 80 (IFS125). All other IP addresses are denied. We can use lynx or netscape on Smirnov or Bruce to view the IFS125 webpage.
- Outgoing access is allowed, so we can use internet and network from inside the container.

- Incoming access is allowed. This is necessary for network access within the container, including ping.

Remote administration of the router is disabled, because it uses unsecure "http" instead of "https"