NICFPS Operations Manual

Date:	03/07/06
Document Number:	NICFPS-OM-001
Revision:	A

Prepared By: Fred Hearty — 03/07/06
Stéphane Béland — Date

Reviewed By: ______________________ ________
Date

Reviewed By: ______________________ ________
Date

Approved By: ______________________ ________
Date

Approved By: ______________________ ________
Date

Approved By: ______________________ ________
Date

Center for Astrophysics & Space Astronomy
University of Colorado
Campus Box 593
Boulder, Colorado 80309

REVISIONS					
Letter	ECO No.	Description	Check	Approved	Date
		Initial Release			
A		Ion Pump removal section added		S.B.	03/07/06

Original Release Name	Date	
Drawn:		**THE UNIVERSITY OF COLORADO** At Boulder **The Center for Astrophysics and Space Astronomy**
Reviewed:		NICFPS Operations Manual
Approved:		

Size	Code Indent No.	Document No.	Rev
A			
Scale: N/A			

Table of Contents

NICFPS Operations Manual

Operations Manual

1. Scope

This Manual describes the operation and maintenance of the Near Infrared Camera and Fabry-Perot Spectrometer (NICFPS). It is primarily focused on the opto-mechanical system, including the liquid nitrogen (LN2) cooled Dewar, the optical components, and the control electronics. It is intended as an aid to Observatory Staff for routine and periodic support activities – a parallel Users' Manual is provided for to aid Observers and Observing Specialists with NICFPS science operations.

2. Instrument Description

The Near Infrared Camera and Fabry-Perot Spectrometer (NICFPS) is a multi-mode near infrared instrument (0.85-2.4 microns) using a Rockwell H1RG detector or Focal Plane Array (FPA). A cut-away view of the instrument is included as Figure 1 with the optics shown in Figures 2 and 3. The instrument is mounted at the Nasmyth 2 port for operations.

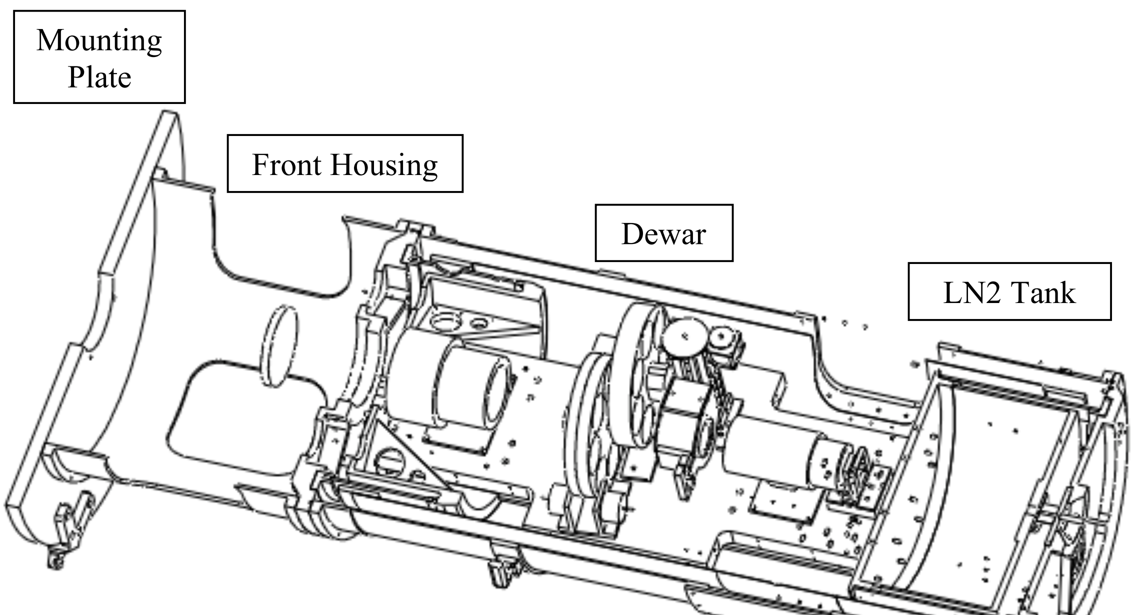


Figure 1. Cut-away view of the NICFPS instrument

Instrument optics, which include in order, entrance window, collimator (three lenses in a single housing), three filter wheels, Lyot stop, Fabry-Perot etalon, camera (five lenses in a single housing) and the FPA, are located beyond the telescope focus. A warm slit mechanism is currently positioned at the telescope focus which is 8.25 inches beyond the rotator face in the warm section of the instrument called the front housing. The FPA and optics are maintained at vacuum and at operational temperatures of <100 degrees Kelvin in a large cryogenic Dewar. NICFPS electronics are also located in the front housing or in an instrument rack located in the 3.5 Meter enclosure building mid-level.

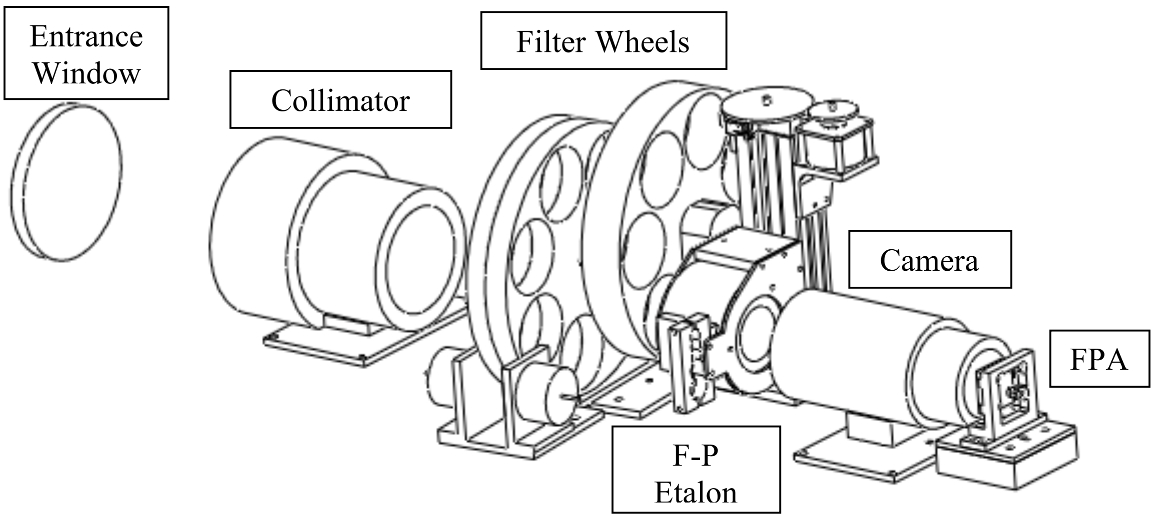


Figure 2. The physical layout of the optical components shows the collimator (3 elements) and camera (5 elements) housings, the double and single filter wheels, and the etalon in the optical path.

3. Normal Operations

3.1 Cooldown

Cooldown to operational conditions is a multi-day process, including one to three days for pumping/drying the Dewar, one for cooling to normal operating temperatures and one for equalizing temperatures throughout the instrument optics. One operator is needed for one half day and then only periodically for the next day to perform this procedure. In outline form (used throughout this manual), the main steps of cooldown are as follows.

CAUTION
The FPA and/or the F-P etalon may be damaged if operated at intermediate vacuum levels (between a few Torr and 10^{-4} Torr) or if room air is admitted into a cold Dewar. Only vacuum system experienced personnel should perform this procedure.

- Verify that the power is off to the Leach controller power supply (grey box atop the Dewar) and the F-P etalon (CS100 located at mid level). Warm functional checks of the FPA and/or etalon will need to be conducted before deenergizing the component(s) if maintenance was performed that disturbed their cabling.

- After the instrument is closed and the bolting is torqued (especially the housing doors), start the vacuum pump-down using the observatory pumping station. Pumping should continue until ion gage pressures in the low 10^{-5} range are achieved. Dewar internal pressures are approximately one decade higher than indicated on the pumping station.
- Conduct instrument (filter wheels, RTDs, etalon mover, heaters) warm functional testing to verify that all internal connections are properly made up.
- Start the ion pump and verify that the red high load light is out. A brief (10-20 minute) pressure rise is usually seen when the ion pump is started.
- Demonstrate the integrity of the pump port isolation valve (gate valve) by shutting the valve, stopping the vacuum pump, breaking the vacuum connection at the gate valve, and verifying the high load light remains out. Reestablish vacuum pumping on the Dewar.
- Start the temperature log on the NICFPS computer in the computer room. A remote desktop view of the temp log can be maintained on the observing level computer console.

CAUTION
Excessive cooldown rate (greater than 2°/min.) may damage the FPA or optical components.

- Begin cooling by <u>slowly</u> admitting LN2 to the LN2 tank to maintain a cooldown rate of less than or equal to one degree per minute at the bench/detector (RTD #2). Any high pitched flow noise from the gas escaping the tank indicates that the flow is too high.
- Adjust LN2 throttle position as needed to establish and maintain between 0.5 and 1.0 degrees per minute cooldown rate. Note that the site LN2 Dewars have poor "liquid" throttling capability, so setting the flow rate is by trial and error. Once set, though, little or no adjusting needs to be done for most of the cooldown.
- Monitor the temp log for the duration of the cooling process. About three hours of throttled flow are required to approach LN2 temperatures in the tank.
- When tank temperature is approximately 90° K, LN2 flow can be increased to normal tank filling flow until tank is topped off. The topping off will cause an increased cooldown rate at the bench for a few minutes.
- Refill the tank as necessary to maintain cooldown. Normal hold durations during cooldown are approximately 3, 5-6, and 10-12 hours for the first three tanks of LN2.
- After 24 hours from start of cooldown, the instrument pressure should be in the low 10^{-6} range as indicated on the ion pump controller and low 10^{-7} range on the pump station ion gage. Isolate the Dewar by shutting the pump port gate valve. A small

rise in ion pump pressure should be experienced, but the pressure should stabilize in the low 10^{-6} range.

- Stop the vacuum pump.
- Carefully break vacuum in the section of flex hose between the gate valve and the pump station isolation valve. Ion pump pressure should not be affected by this step – if pressure deteriorates, a leak in the isolation gate valve seat is indicated. Install the blank at the pumping port after pressure is verified to be stable.
- Stop the temperature log.
- Energize the Leach controller power supply.
- Secure and restart the ICS.
- Conduct instrument cold functional testing.

3.2 Science Operations

During normal science operations, minimal instrument support should be required. The LN2 tank should be filled twice daily. Instrument temperatures and pressure should be monitored and maintained in the normal operating bands.

3.3 Heatup

Heatup to room temperature conditions is a single-day process. If only heating up for annual pumping/drying, the nitrogen pressurization steps can be skipped. One operator is needed, periodically for one day, to perform this procedure.

- Verify that the power is off to the Leach controller power supply (grey box atop the Dewar) and the F-P etalon (CS100 located at mid level).
- Start the temperature log on the NICFPS computer in the computer room. A remote desktop view of the temp log can be maintained on the observing level computer console.
- Unplug the LN2 tank boil-off connection.
- Energize the heaters to boil off remaining LN2. Verify approximately 2.6 amps at a setting of 60 volts are indicated on the power supply. After the LN2 is gone (up to two hours, depending on the tank level), the tank temperatures will start to increase.
- Start vacuum pumping using the observatory pumping station.
- Monitor instrument temperatures and pressure periodically during heatup.
- Stop the ion pump and if the pressure rises to reach the red high load light.
- After about 10-12 hours of heating, temperatures should be in the 225-250° K range. At this point, if the Dewar is to be opened, isolate and stop the ion and vacuum pumps, and pressurize the Dewar with 5-10 Torr of dry nitrogen through the back-fill port in the front housing.
- After 24 hours from start of heatup, the instrument temperature should be near room temperature of ~290° K.

CAUTION

The Dewar should not be opened or filled with moist air until temperatures are well over the dew point temperature to avoid condensation on the optics or FPA.

- Re-pressurize the Dewar with dry nitrogen until equalized with atmospheric pressure as indicated by a vacuum component (like the pump port blank) becoming unseated. Note that some sort of overpressure protection or indication needs to be used to prevent pressurizing the Dewar.
- De-energize the heaters.
- Stop the temperature log.

4. Periodic Maintenance

4.1 Annual Pumping and Drying

An annual warming and drying of each Dewar is routinely conducted during Summer shutdown at APO. For NICFPS, the instrument should be taken out of service and warmed as described in the Heatup procedure above, with the exception that the Nitrogen back-fill will not be used. The Dewar should approach room temperature after approximately 24 hours and then continue to be pumped for several days to a week. At the end of this period, warm Dewar pressure should be better than 1.0×10^{-5}. Finally, instrument is cooled to normal operating conditions per the Cooldown Procedure.

4.2 Dewar Internal Maintenance

4.2.1 Disassembly Sequence

When the instrument must be opened for internal maintenance, filter changes, or other similar activities, the instrument must be warmed in accordance with the Heatup procedure until <u>all</u> internal temperatures are near room temperature (~290-295°K) before being opened and the instrument must be transferred to the SDSS lab. Transfer steps are as follows:

- De-energize the ion pump, heater power supply, Lakewood temperature controller, and motor controller power supplies at mid-level.
- De-energize and disconnect the two Leach controller power supply cables outside the front housing.
- Reaching through the opening in the mounting plate, unbolt the slit warm assembly from the mounting plate (2 #8-32 socket head cap screws -SHCSs) and place it on the motor controllers. Take care to not move it near the exposed entrance window.
- Unbolt and remove the mounting plate with the power supply still attached. Task requires two people. Access to the strain relief plate in the front housing is better with the mounting plate removed.
- Secure the slit assembly with a tie wrap or two to prevent its contacting the entrance window or straining the attached motor control leads.

- Remove the two lower side doors and the slide back the bottom door where the cable bundle enters the housing.
- Disconnect the following set of cables (after verifying that they have been de-energized):
    - Ion pump (red cable)
    - Leach controller fiber optics (orange double fiber)
    - 48 and 60 volt power leads (terminated wires)
    - Etalon control cable (multiple connectors)
    - RTD cable (55 pin PAVE feed-through)
    - 120 volt power to the Leach power supply (orange cable)
- After noting the physical arrangement of the incoming cable harness, remove the set of #8-32 SHCSs and cable restraints attached to the strain relief plate to free the above cables for removal from the front housing.
- Carefully withdraw the set of cables and their connectors from the front housing.
- Reinstall the mounting plate for balance and mechanical protection during instrument transfer to the lab.
- Install two motorcycle straps around the Dewar to secure it to the yellow cart.
- Attach the four-point lifting rig (from SDSS) with one strap around each of the cart corner posts.
- Lower the cart platform to lower the instrument's center of gravity and then secure the hand crank with tape or bungie to avoid a drop hazard during lifting.
- Verify that there are no tools or other loose items on the instrument cart that may fall during the lift.
- Transfer the cart and instrument as a unit to the ground level and then to the lab.

Disassembling the instrument to expose the optic bench is a several hour task requiring 2-3 people. Relatively clean (e.g. SDSS laboratory) conditions should be maintained overall, and vacuum clean tools, gloves, hair covers, and gowns shall be used for work inside the vacuum volume. Clean plastic and/or foil must be available for clean lay down areas and clean containers (e.g. beakers) should be available for bolting material. Disassembly steps are as follows:

- Raise the internal pressure of the Dewar to atmospheric by back-filling with nitrogen. Make sure that a pressure relief path is available to avoid over pressurizing.
- Unbolt the housing doors (#8-32 SHCSs) and remove them (with o-rings still attached) to a clean location
- Remove small MLI blankets from internal radiation shield. Each blanket is marked with one or two notches to orient the blanket and ensure installation on the correct side of the Dewar.
- After removing <u>only</u> <u>the</u> <u>center</u> #6-32 SCHS from top and bottom of thermal shield door, remove doors to clean location. Doors are easily removed by inserting finger

through center hole and leveraging lower or upper end off of the remaining two SHCSs on each end.

- Disconnect the pair of heater connectors and remove tape from the bench end of the leads to free them from the LN2 tank
- Remove tape from the RTDs attached to the LN2 tank and radiation shield and clean the excess Apiezon N (using acetone) from the RTD and attach point surface
- Break away and remove the #1/4-20 bolts from the thermal straps listed below:
    - Bench straps – 4 bolts x 2 straps
    - Beam straps – 4 bolts x 2 straps
    - Shield straps – 1 bolt x 4 straps (do not disconnect the strap at the shield end)
- Visually check that all LN2 tank and shield attachments are disconnected and pulled back from the tank/shield removal travel path
- Remove all but an opposing pair of 1/4-20 bolts from the LN2 tank
- Unbolt and remove the LN2 tank to a clean horizontal surface. Provision must be made to ensure the tank is removed straight back from the housing and does not drop onto or catch on the radiation shield.
- With three people available, prepare to remove the Dewar housing by positioning the pair of motorcycle straps on the front housing. The straps can remain loosely attached until directed in the steps below.
- Remove all but an opposing pair of 1/4-20 bolts from the housing
- Unbolt the instrument support from the yellow cart at the tank end. This support will be removed to cantilever the instrument for housing removal.
- While manually lifting the tank end of the Dewar (a few inches) remove the instrument support, and then tighten the motorcycle straps until the instrument is in a secure cantilevered position. This step is made considerably easier if the mounting plate or the test plate is attached as a counterweight and at least one of the straps is as close to the plate as possible.
- With a person on each side of the Dewar lifting on the housing handles, remove the housing to a convenient storage location. One person should guide the housing from the tank end, ensuring that it clears all optic bench components.
- Cover the exposed optic bench and cold standoff with a clean plastic drape and/or move the instrument to a filtered air enclosure

The exposed optic bench is shown in Figure 3 below.

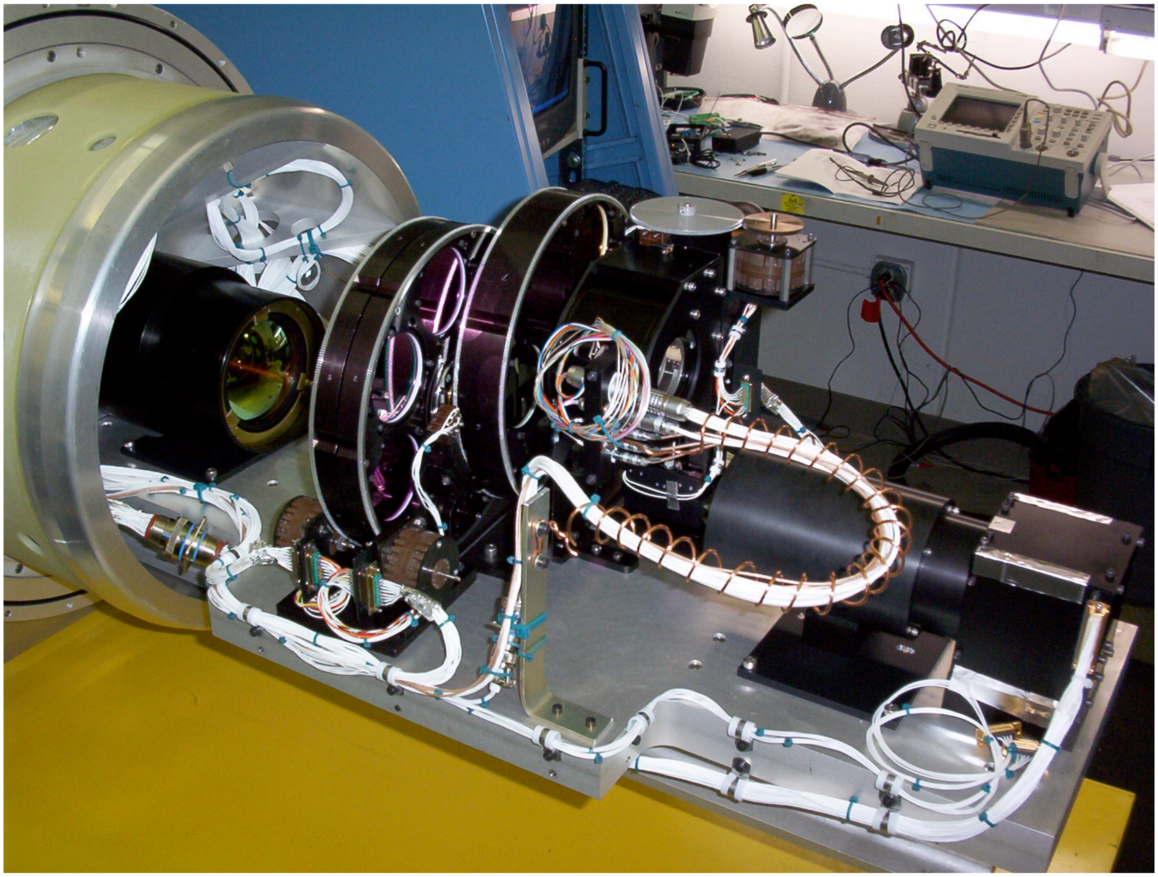


Figure 3. The fully integrated optic bench is shown prior to installing the Dewar housing. Components as labeled in Figure 2. Note the fully cantilevered bench, cold standoff, and G10 ring.

4.2.2 FPA Removal and Reinstallation

Although there is no planned maintenance for the FPA, the need may arise to remove the detector. When handling the FPA, the main concerns are electrostatic discharge (ESD) and mechanical damage. The first is avoided by always following proper ESD procedures such as using ESD mats, gloves, and wrist ground straps, controlling the humidity in the work area, and ensuring the proper grounding of equipment when making or breaking any electrical connector. Grounding plugs are supplied with NICFPS spares for this purpose. If the FPA is not connected to the Leach controller, outside the vacuum bulkhead, grounding plugs must be installed before disconnecting or connecting the D-connectors at the FPA fan-out board. Mechanical damage is avoided by simple careful handling and understanding/following the removal procedure.

At least two individuals are required for this procedure and clean room procedures are in effect throughout. The removal sequence is as follows:

- Remove all light sealing aluminum tape form the detector enclosure
- While observing proper ESD procedures, disconnect each of the D-connectors attached to the fan-out board
- Remove the back plate of the enclosure
- Remove the top plate of the enclosure
- Remove each side plate with attached semi-circular front plate that fit around the camera assembly
- Remove the two button-head cap screws (modified allen wrench required due to limited access) on the FPA base plate
- Disconnect the small ribbon strip connector from the fan-out board
- Remove the fan-out board assembly (top block, fan-out board, base block, and front plate) by removing the #8-32 SHCSs at its base
- Remove the two ¼-20 SHCSs on the FPA base plate. The FPA assembly (base plate, moly mount, and FPA) is now freed for removal
- Carefully lift (some slight prying may be needed) the FPA assembly vertically off the alignment pins and slide away from the Camera assembly. Place the assembly in a clean, protected location.
- While observing proper ESD procedures, detach the FPA from the moly mount by removing the four Teflon core nuts
- Mount the FPA in its shipping container (supplied with FPA by Rockwell)

Reinstalling the FPA simply uses the same sequence of steps in reverse.

4.2.3 Filter Changes and Filter Wheel Maintenance

Filter changes are not simple operations with the current mounting design. First, the filter wheel must be removed from the bench and remounted in a location where it is accessible from both sides, such as on an optic bench. Because of the possibility of double threading the mounting #4-40 SHCS between the filter holder and the wheel itself, pressure needs to be placed on the rear of the filter assembly (easiest done by inserting a ball driver in the back-side SHCSs) while carefully backing out the SHCS from the front. On the double wheel, it may be necessary to remove one of the wheels to gain access to the other. Recommend that when a filter is removed, the three helicoils be removed from the filter assembly to avoid future double threading issues.

4.2.4 Fabry-Perot Etalon Maintenance

(Later. The current design requires little or no "planned" maintenance other that a possible flexing cable replacement, but are unsure if this will be the final design.)

4.2.5 Optics Removal and Reinstallation

The camera is removed after the FPA to avoid damaging the surface of the detector. A pair of alignment pins on the optic bench allow precise positioning of the assembly with no additional alignment needed. The collimator is removed in a like manner, but the alignment is a bit trickier. Only a single pin is currently installed in the optical bench (due to an interference discovered during assembly) so that the assembly is not fully constrained when on the pin. Therefore, after placing the assembly on the pin, it must be aligned by setting it parallel to the edge of the optic bench. This can be done with machine parallels and a micrometer or caliper. (A second pin could be placed in the bench and a matching alignment hole in the collimator base plate if the instrument is ever disassembled for another purpose.) Of course, care should be taken to protect the exposed optical surfaces during handling.

4.2.6 Reassembly Sequence

Dewar reassembly is simply a reverse of the disassembly sequence described above. Several issues should be noted before starting into this sequence.

- O-rings should be inspected for cuts and wiped clean with ethanol or isopropyl alcohol before installation. O-ring seating surfaces should also be wiped clean.
- A torque wrench with range from 19-190 inch-pounds should be available. Torque settings in the cold volume are as follows (black oxide-BO, stainless-SS):
    - #6-32 BO 34 in-lbs
    - #6-32 SS 19 in-lbs
    - #8-32 BO 60 in-lbs (also used for exterior access door bolts)
    - #6-32 SS 35 in-lbs
    - ¼-20 BO 190 in-lbs (also used for exterior flange bolts)
    - ¼-20 SS 119 in-lbs
    - Pave Jam nuts 12-20 ft-lbs (not needed during normal reassembly)

  Some of these values represent 125% of normal torque values as determined by torque testing as sufficient to account for differential CTEs of the bolting and mounted materials.
- Helium leak checks can be done after the instrument is at a vacuum of approximately 100 mTorr
- The Dewar should be pumped until acceptable vacuum is reached in the lab before transferring the instrument to the observing level where the Cooldown procedure will occur. Since there is no passive (adsorber) pumping system installed, the cold Dewar must remain on the ion pump at all times.
- Dewar should be placed back on the pump after transfer to the observing level.
- All cables should be reattached and warm functional tests on the filter wheels, etalon mover, and RTDs should be performed before Cooldown is started

4.3 Ion Pump Installation

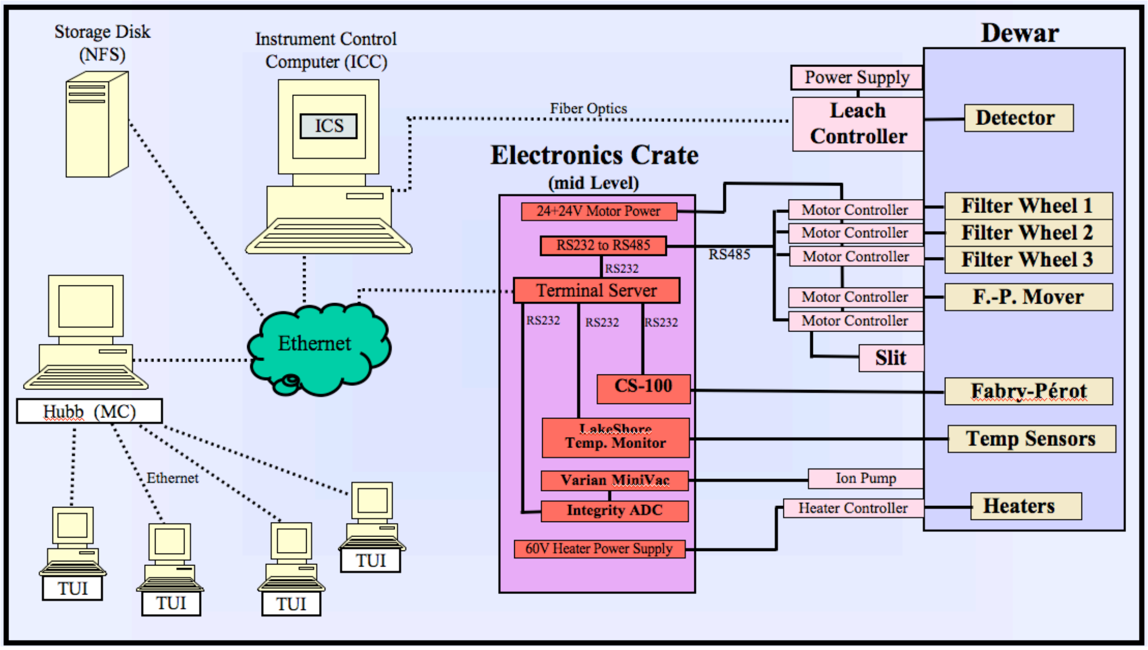
Make sure that the power to the ion pump controller is off and disconnected before proceeding with the installation or removal of the pump. High voltage from the controller can be very dangerous.

The 20 liters/sec VacIon Starcell ion pump is attached to the front of the instrument on one of the ports of the right electrical feedthrough box. There is currently no isolation valve to the pump. Removal of the pump requires that the instrument be warmed up and brought to ambient pressure as described in the section 3 above. If the maintenance only involves the ion pump, there is no need to disconnect the instrument and its components, since the work can most likely be performed in the dome. The front telescope mounting plate will have to be removed to have access to the ion pump. Removing the mounting plates involves disconnecting the power cord and cable to the Leach controller as well as removing the two screws that hold the slit assembly to the inside of the mounting plate as described in section 4 above.

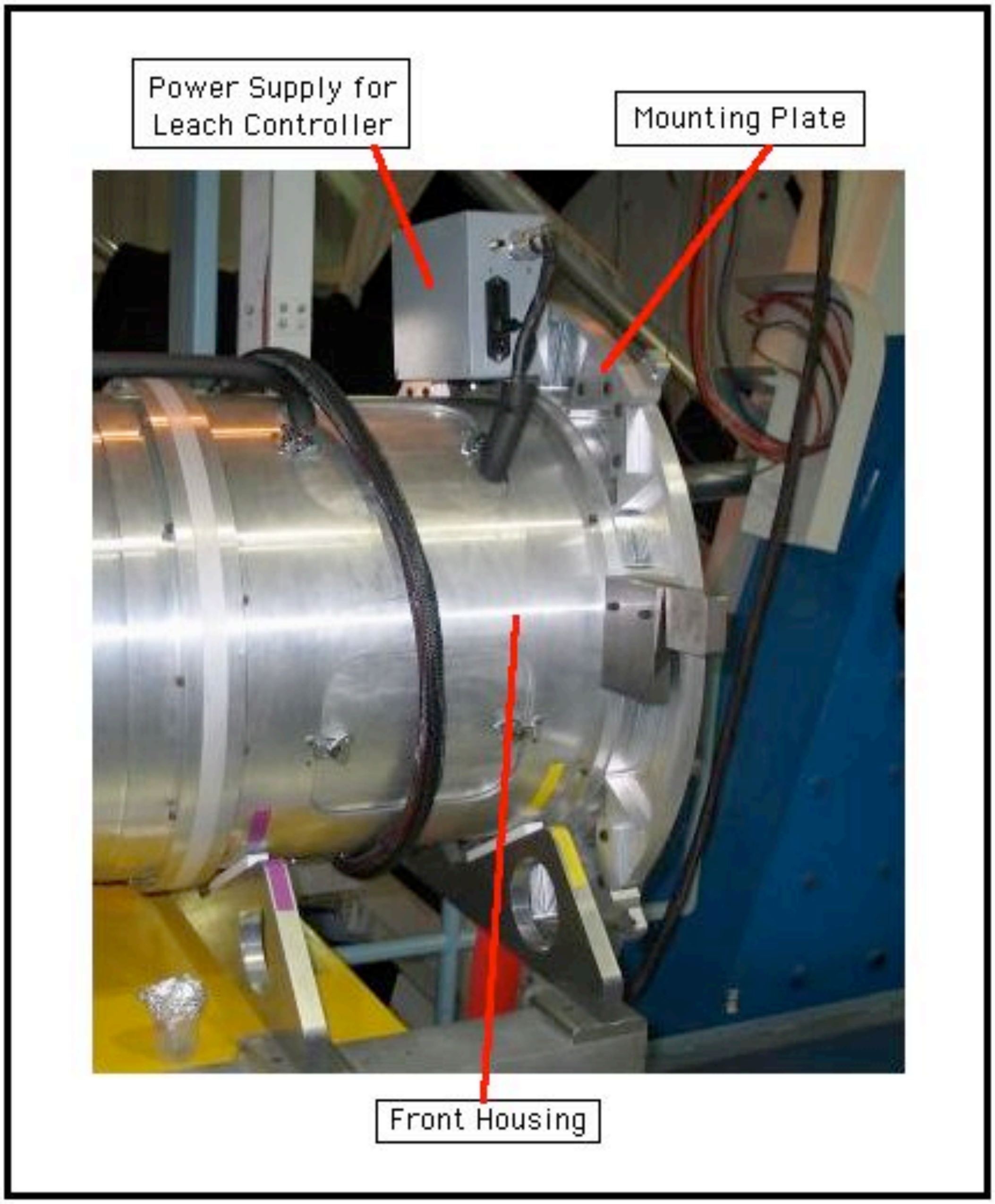
The ion pump is attached to the instrument with a ConFlat 40 flange. A standard stainless steel ring with a viton o-ring is used as a seal between the pump and the flat aluminum box. The ion pump is held and sealed with two small clamps that cover the ConFlat flange and are bolted into the electronics feedthrough box with 6 hex screws. A short hex wrench is required to access the screws. There are also four long screws extruding from the box and are only used to support the ion pump squarely on the flange, acting as a stress relief. To remove the pump simply remove all six screws, while supporting its weight, then simply pull it out. To install an ion pump, simply reverse this process.

5. External Equipment

The figure below shows the different electrical components and connections that make up NICFPS. They are divided in four groups according to their location: internal to the Dewar, attached to the outside of the Dewar, on the mid level floor and in the computer room.

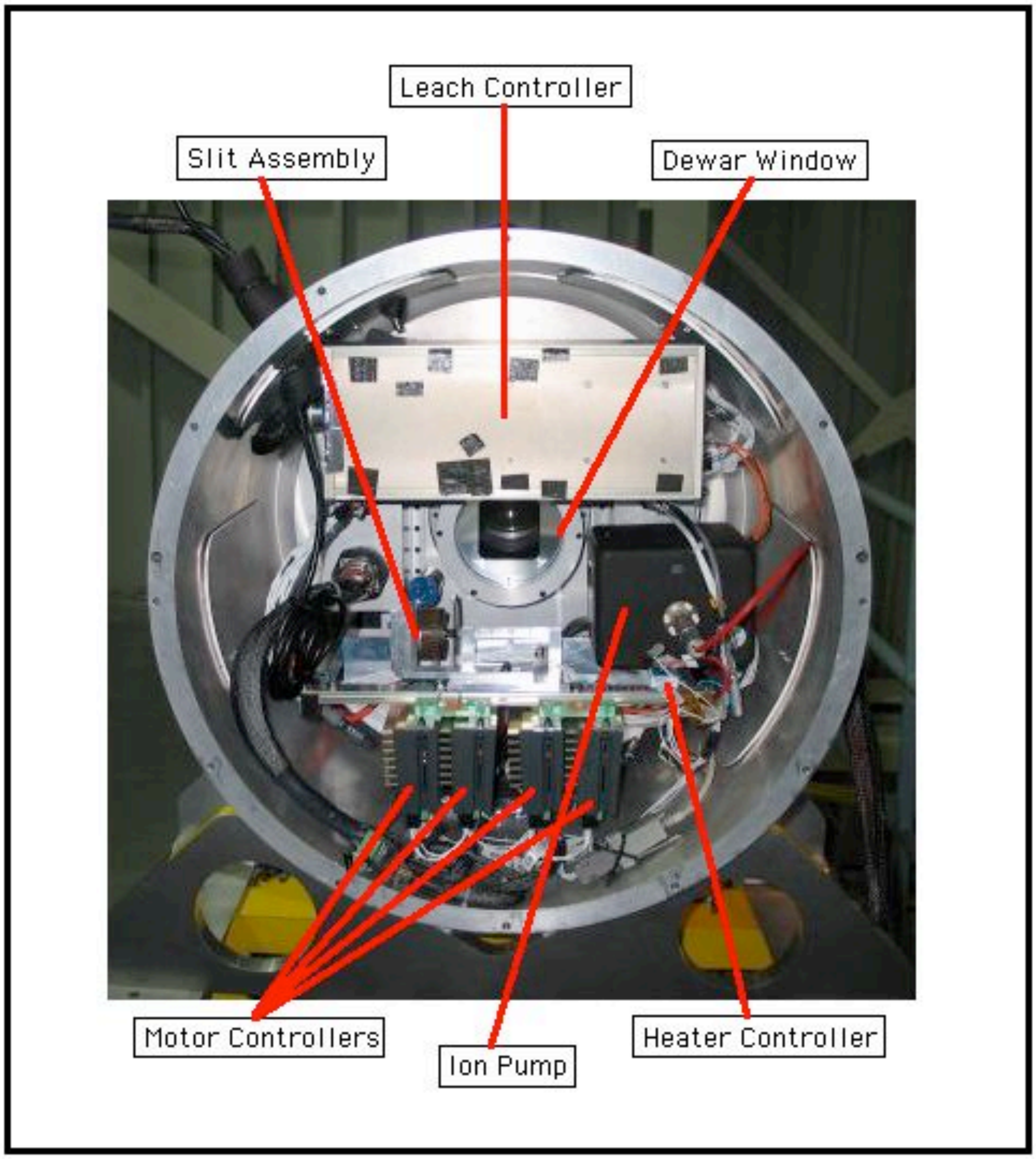


The Instrument Control Software (ICS) communicates to each of the components of the instrument. This software runs on a personal computer running Windows XP, which is located in the computer room at APO: the Instrument Control Computer (ICC). A PCI card inside the ICC talks to the Leach controller and receives the data from the detector via a fiber optics cable. All the other components are commanded through an Ethernet connection to the Terminal Server located at the mid-level of the observatory. More details about the ICS can be found in the "NICFPS ICS Manual" document.



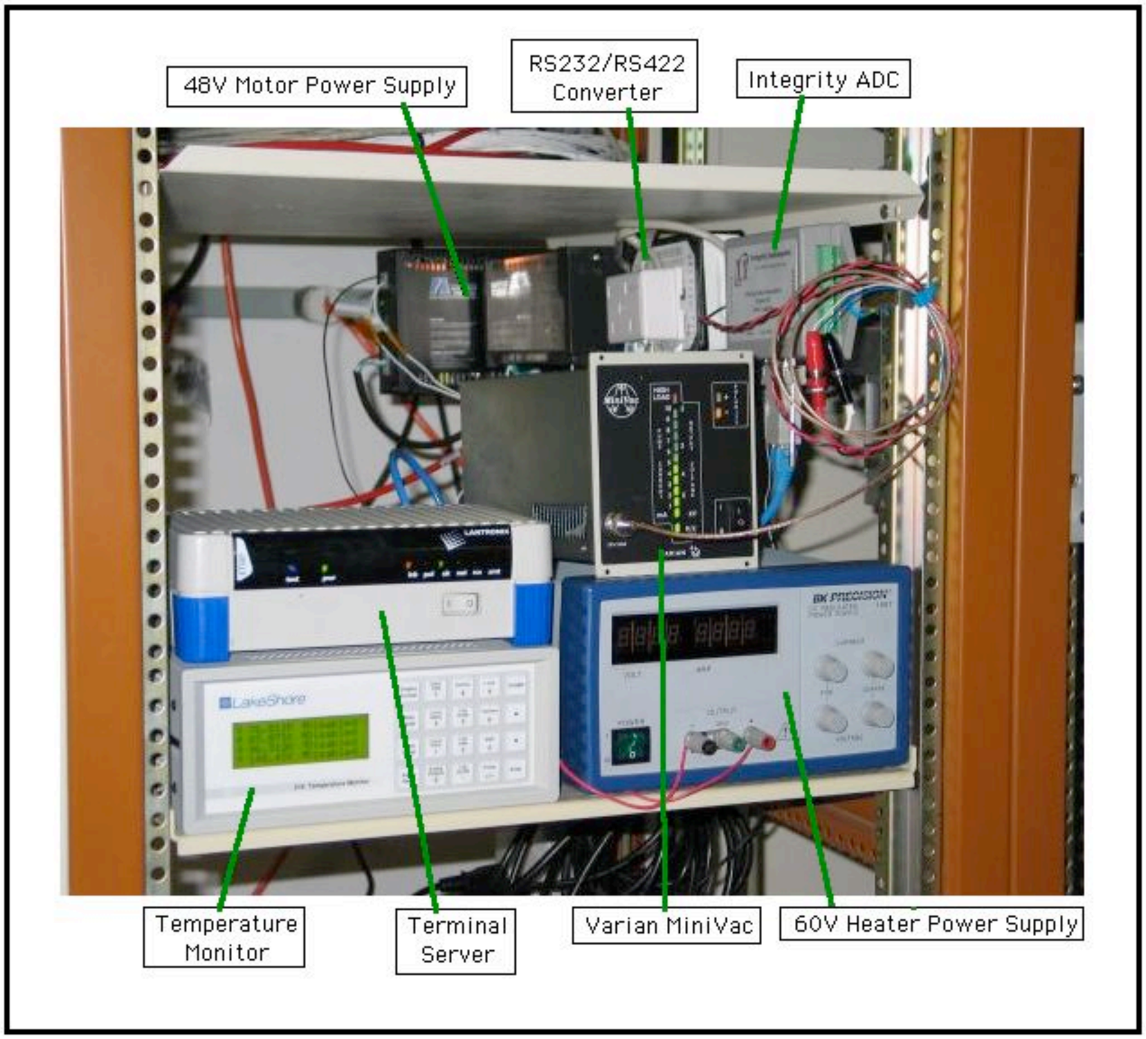
The components inside the Dewar operate at vacuum and cryogenic temperature: the detector, the stepper motors for the three filter wheels and the etalon mover, the etalon itself, the resistive temperature detectors (RTD), and the liquid nitrogen container's heating pad.

The detector power supply is attached to the instrument mounting plate and the rest of the equipment on the outside of the Dewar is mounted in the front housing. These include the Leach controller, a motor controller for each motor, the slit assembly, the ion pump and the heating pads controller.



The rest of the equipment resides in an electronic crate on the mid-level at APO. The decision to install some of the equipment at mid-level was motivated by the effort to minimize the heat load on the observing floor and by the longest possible length of the cables needed for the equipment in/on the Dewar. The mid-level equipment consists of: a

48Volts power supply for the stepper motors and their controllers, the 60Volts power supply to the heating pads, the CS-100 etalon controller, the Lakeshore 218 temperature monitor, the Varian MiniVac controller for the ion pump and the associated Integrity Instrument Analog to Digital converter, the Lantronix Terminal Server and the RS232-to-RS485 converter used with the motor controllers.



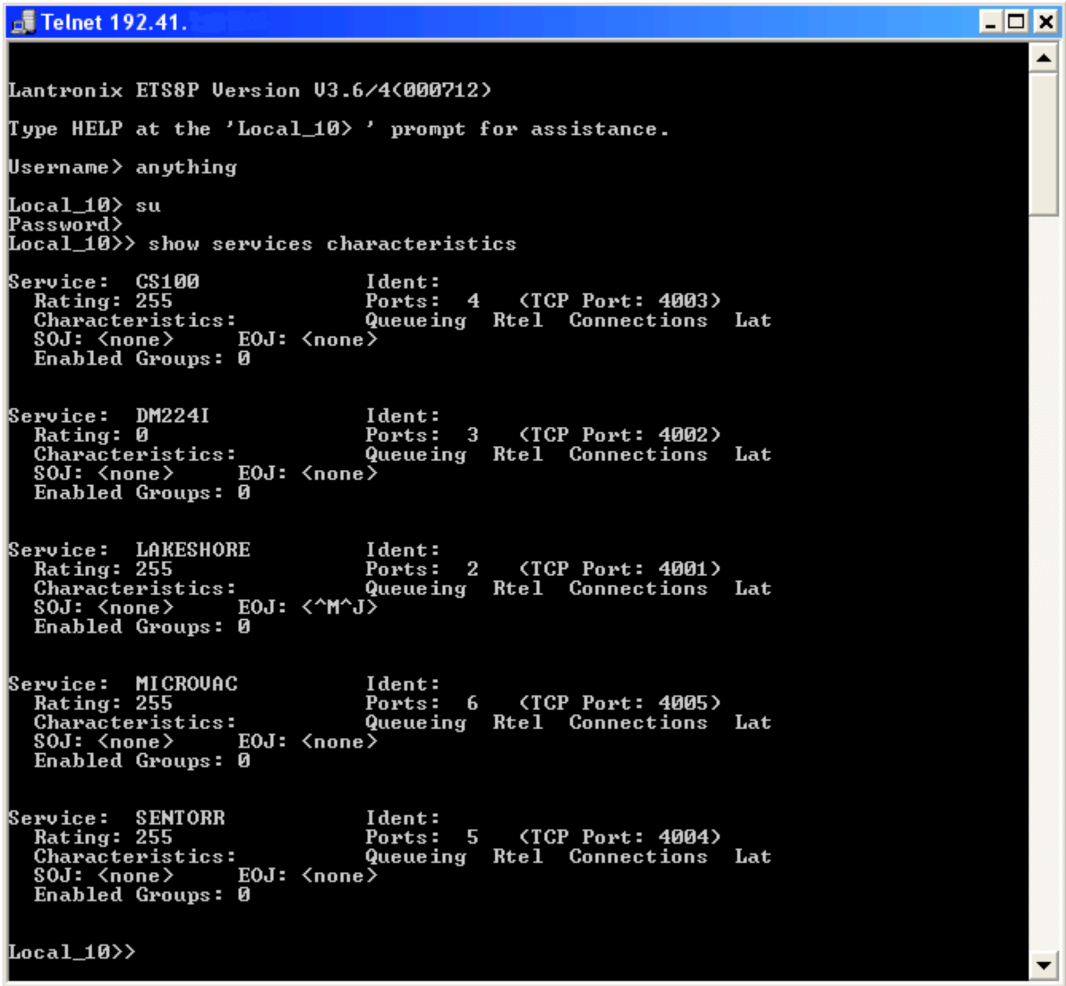
The Lantronix Terminal Server has eight serial ports available. A serial device is connected to a pre-configured port of the terminal server and these are accessed through the Ethernet using the fix IP address of the terminal server and the port number corresponding to the output port on which the device is attached. Below is a series of commands used to connect, query and configure the serial port number # of the terminal server to communicate with the stepper motor controllers (API DM-224i).

You need to login as super-user (login as "su") on the Lantronix to make any changes and save them. The system administrator has the password and controls who is allowed to make changes.

```
Unix> telnet nicfps_ts.apo.nmsu.edu
Lantronix ETS8P Version V3.6/4(000712)
Type HELP at the "Local_10> " prompt for assistance

Username> anything
Local_10> su
Password>
Local_10>> define Port 3 name "API_DM224i"
Local_10>> define Port 3 speed 19200
Local_10>> define Port 3 character 8
Local_10>> define Port 3 parity none
Local_10>> define Port 3 flow none
Local_10>> define Port 3 stop 1
Local_10>> define Port 3 access dynamic
Local_10>> set service DM224i port 3 LAT enabled
Local_10>> set service DM224i banner disabled
Local_10>> set service DM224i formfeed disabled
Local_10>> set service DM224i netware disabled
Local_10>> set service DM224i TCPPORT 4002
Local_10>> save service DM224i
Local_10>> logout
```

The figure below shows the currently defines ports and services on the terminal server. These include the etalon controller CS100, the stepper motors controller DM224i, the Lakeshore temperature monitor. The now obsolete SenTorr pressure monitor (cold cathode) and the Varian MicroVac pressure are still defined in case of future usage.



```
Telnet 192.41.

Lantronix ETS8P Version V3.6/4(000712)

Type HELP at the 'Local_10> ' prompt for assistance.

Username> anything

Local_10> su
Password>
Local_10>> show services characteristics

Service:  CS100              Ident:
  Rating: 255                Ports:  4   (TCP Port: 4003)
  Characteristics:           Queueing  Rtel  Connections  Lat
  SOJ: <none>     EOJ: <none>
  Enabled Groups: 0

Service:  DM224I             Ident:
  Rating: 0                  Ports:  3   (TCP Port: 4002)
  Characteristics:           Queueing  Rtel  Connections  Lat
  SOJ: <none>     EOJ: <none>
  Enabled Groups: 0

Service:  LAKESHORE          Ident:
  Rating: 255                Ports:  2   (TCP Port: 4001)
  Characteristics:           Queueing  Rtel  Connections  Lat
  SOJ: <none>     EOJ: <^M^J>
  Enabled Groups: 0

Service:  MICROVAC           Ident:
  Rating: 255                Ports:  6   (TCP Port: 4005)
  Characteristics:           Queueing  Rtel  Connections  Lat
  SOJ: <none>     EOJ: <none>
  Enabled Groups: 0

Service:  SENTORR            Ident:
  Rating: 255                Ports:  5   (TCP Port: 4004)
  Characteristics:           Queueing  Rtel  Connections  Lat
  SOJ: <none>     EOJ: <none>
  Enabled Groups: 0

Local_10>>
```

6. Drawings and Wiring Diagrams

A full set of mechanical drawings is provided in hard copy. Electronic files in Pro-E are also available (on CD) that provide the full parametric models for instrument components, assemblies, and mechanical drawings for part manufacture. Many file formats are available (.iges, .drw, etc.) in Pro-E, but it is something of trial and error to find the format that works well with other CAD software (such as Autocad, Mechanical Desktop, etc.). "Student" versions of Pro-E are inexpensive and suitable for (were used for) creating, manipulating, and saving files in new formats. Unfortunately, the initial set-up of this software is not easy.

Wiring diagrams for all cable sets are provided in hard copy.

7. Spare Parts and Parts List

Spare parts for anticipated failures are provided for NICFPS. As much as possible, these parts are provided in a "plug-and-play" condition to minimize instrument down time. The following basic set of spare parts is to be stored at APO:

- Full sets of o-rings (2)
- Pump down port isolation valve rebuild kits (2)
- Full set of cables (to mid-level)
- Etalon cryo flexing cable
- Entrance window
- Filter holders and teflon spacers (3 sets)
- Lyot stop
- LN2 tank heaters and controllers (2)
- LN2 tank over-pressure relief valves (2)
- Bellows assembly (bellows being welded)
- Cryo motor (spare used for slit assembly and new part being ordered)
- Cryo motor controller (spare used for slit assembly and new part being ordered)
- Power supply (installed as heater power supply)

Several of these items have already been used to replace failed components during commissioning and have been replaced as they were consumed. As new needs emerge for spares, they should be procured and included on this list.

A full parts list is being prepared for the instrument and will be forwarded in electronic and hard copy.

8. Troubleshooting

8.1 Detector and Leach Controller

When an image is read, the Leach controller converts voltage levels read from the detector at each pixel position, in 16 bit digital values from 0 to 65535. The voltage value corresponding to the zero point in digital value (no photons on the detector) can be adjusted in the controller software. This zero offset is dependant on the operating temperature of the detector. It is currently optimized for the operating temperature of the H1RG close to liquid nitrogen temperature (77ºK). At a higher temperature, the offset will slowly increase with the temperature up to saturation level. If the image appears to be either saturated (all values at 65535) or null (all values at 0), check that the detector is not currently flooded with light and that its temperature is within operating range.

Communication problems from the computer room ICC and the Leach controller are reported as errors in the TUI window. Potential sources include: powered off controller, disconnected or misconnected fiber optics cables at the PCI card or at the Leach controller's end. In rare instances, the PCI card will either hang or behave erratically. A reboot of the ICC, power cycling the Leach controller and restarting the ICS are necessary in these cases.

8.2 Filter Wheels

The filter wheels currently have a single home position that is electronically identified by the trigger of a micro switch (two switches connected in parallel for redundancy). A specific filter is moved in place by stepping the motor and rotating the wheel to a calculated number of steps in the closest direction (clockwise or anticlockwise) to get to the final position. Each motor controller keeps track internally of its current absolute step position. If the power to the controller turned off and on again, the stored step position is reset to 0. Before any filter move is requested, the ICS gets the current step position. If the returned position is 0, the ICS assumes that controllers have been turned off and that the current step position is invalid, since a step position of 0 doesn't correspond to any valid filter position. The ICS will then automatically move every wheel back to their corresponding Home position, where the micro switch is physically triggered and reset the controller stored step position to the value at Home (42 steps). This has proven to be a very reliable method to move the filter wheels accurately.

If the user has any doubts about the location of any of the filter wheels, the command "nicfps filters home=all" can be issued from the TUI command line. This will move every wheel to their Home position. If the Home position can not be found on a wheel, the Home command will time out and a failure message will be displayed on the TUI.

This failure is a very serious since every filter position relies on the knowledge of its Home position. There can only be three sources for this problem: both micro switches identifying the Home position failed, the micro switches moved far away enough from their nominal position to not get triggered or the cable connecting the micro switches to the controller got disconnected. The most likely source is the latest. The connector attaches to the underside of the controller in the front housing. It can be inadvertently disconnected when accessing some of the equipment in the tight space of the front housing. The other two possibilities will require warming up and opening the Dewar to find the exact problem.

A problem was seen where the stepper motors were commanded and the number of steps increased as expected but the wheel would not move. The source of this problem was found to be an insufficient voltage supply to the controllers. The manual claims that the controller runs with a voltage supply anywhere between 12 and 48 volts. We have found that the controllers and the motors only run reliably at 48 volts.

It is often very useful to listen to the stepper motors and visually inspect the motion of the wheels through the Dewar window. A stuck wheel or a low voltage supply can be distinguished from the normal operation and from each other fairly easily this way.

8.3 Vacuum

Normal operating range for vacuum is better than $1.0x10^{-5}$ and should remain in the low 10^{-6}s or better under normal conditions. If conditions deteriorate below this level, two immediate checks must be made:

- Verify that the LN2 tank has been filled by checking the following temperatures:
  - LN2 Tank 75°<T<80°
  - Bench/Detector 80°<T<90°

  At the instrument, check that boiloff is continuing by removing the fill plug. These items indicate LN2 is present in the tank. If the LN2 tank is empty and the Bench/Detector temperature is less than 100° (unlikely), refill the tank per normal fill procedure. If over 100°, refill the tank slowly, using throttled LN2 as in the cooldown procedure. When the LN2 tank reaches 90°, normal fill rate can be used to top off the tank. Verify that pressure recovers to the normal operating range.
- Verify that the Ion Pump controller is energized (high volts light illuminated) and the high load red light is out. Attempt to reenergize the ion pump controller

and/or rap smartly (using the plastic end of a large screw drive, for instance) the inlet flange of the ion pump to potentially dislodge any wiskers of electrode metal that may have built up.

If the red high load light remains lit or the controller cannot be energized, place the instrument on the pumping station per site procedures. If all ten LEDs are lit and the temperatures are normal in the above checks, then no immediate vacuum collapse is indicated. Continue to monitor the situation and place the instrument on the pumping station if pressure deteriorates. Warm the instrument per the Heatup procedure and investigate the loss of vacuum.

8.4 Miscellaneous

The TUI will report errors when an attempt at writing the FITS file fails. We have encountered this problem when either the disk on which the FITS file is written is full or when the NFS mount of the target disk has failed. If this happens, contact the APO systems administrator.

The communication to the stepper motor controllers uses the RS422 protocol. A converter between the Terminal Server and the motor controllers transforms the RS232 signal to the RS422 format. This has proven to be more reliable over the long distance (60 feet) to the motor controllers. This converter has been very reliable.

The Varian MiniVac ion pump controller is used to monitor the Dewar's pressure. We use the MiniVac plotter's output, which has a logarithm scale from voltage (0 to 10 volts) to pressure up to 2.23×10^{-5} Torr. Any pressure higher than this will still read this value. If this pressure is reached, it is recommended to connect a different gauge and start pumping on the Dewar to bring the pressure back to its normal operating band. (Loss of power to the ion pump controller causes the pressure to read 5.604×10^{-8}.)

The Lakeshore temperature monitor uses four RTDs inside the Dewar. If all four fails, this could indicate a problem with the external cable coming from the Dewar to the Lakeshore unit. If a single sensor fails this is more likely to be a broken wire inside the Dewar. These are extremely small gauge and very delicate. Good luck in re-soldering a broken lead on any of the RTD.