4. Instrument Preparation and Installation

The procedures described in this section cover preparation of the instrument for installation on the telescope, removal from the telescope, and preparation for service. The sub-sections are grouped by discipline. The sequence of operations required for installation on the telescope is as follows:

- Evacuation (4.2.2)
- Cool-Down (4.2.3 and 4.2.4)
- Installation on ISS (4.3.1)
- Electronics and Software Start-Up (4.1.1 and 4.1.2)

It is strongly recommended that the cool-down be done while monitoring temperatures (this is *essential* if the liquid nitrogen pre-cool is used), and that a preliminary check-out be done prior to installation on the ISS. This requires that the electronics and software start-up be done prior to the cool-down.

Removal from the telescope requires the following steps:

- Electronics and Software Shut-Down (4.1.3)
- Removal from ISS (4.3.2)

The instrument can be maintained cold after removal, although it may be desirable to warm it up for maintenance (see 5.1.1 for recommendations) if it is to be off the telescope for an extended period. Procedures to warm up the instrument and bring it to ambient pressure (if required) are outlined in sections 4.2.5 and 4.2.6 respectively.

Procedures to adjust the instrument alignment and to adjust the instrument weight and center of gravity are described in sections 4.3.3 and 4.3.4 respectively. Alignment should *not* be necessary each time the instrument is installed on the telescope, unless a major disassembly has occurred. However, alignment checking is strongly recommended. Similarly, the ballast weights should only require fine-tuning on successive installations.

4.1 Electronics and Software Start-Up

The procedures described in this section are needed to start up the electronics and software once the instrument is installed on the telescope at the ISS (4.3). The same procedures are used to run the instrument in the lab. For work in the lab, it is not necessary to mount the thermal enclosures on their trusses.

The sequence of operation is as follows:

- Verify all connections for the electronics
- Turn on mains (non-UPS) power on the GNAAC controller and wait 5 minutes. This establishes the Ethernet connection.
- Start up the software
- Complete powering on the two thermal enclosures

4.1.1 GNIRS Power Up/Down Thermal Enclosures

This is the procedure for powering up the instrument Thermal Enclosures (TE) *with* the Glycol cooling system attached to both the Array Controller (TE #1 or GNAAC) and the Component Controller (TE #2). This procedure applies to starting either TE from a completely OFF condition, or cold-start.

AC Power Sources

There are 3 sources of AC power available from the ISS Service Panels.

1) MAINS: "dirty" power used for loads external to the dewar,
2) UPS: "clean" power used for electronics and loads internal to the dewar,
3) Cryohead power from the Helium Protection System.
   WARNING: the cryohead 220VAC power can be switched OFF/ON inside the TE by front-panel switches *or* by external user command, but the 110VAC source is potentially <u>always</u> energized when connected to the ISS Service Panel connector.

Connections

The following connections should be complete to the GNAAC and CC Thermal Enclosures. Drawing 89-NOAO-4201-0800 is the external cabling diagram for GNIRS.

- Glycol cooling loop
- MAINS, UPS, and Cryohead power
- Data and Control LAN Ethernet connections to TE #1 (GNAAC)
- All other electrical connections at the TE rear connector panel

All GNIRS cables are labeled with a Wxxx number that matches the mating connectors (Jxxx or Pxxx or Sxxx) at both ends. All GNIRS external cabling is wired 1 to 1 on all functional pins.

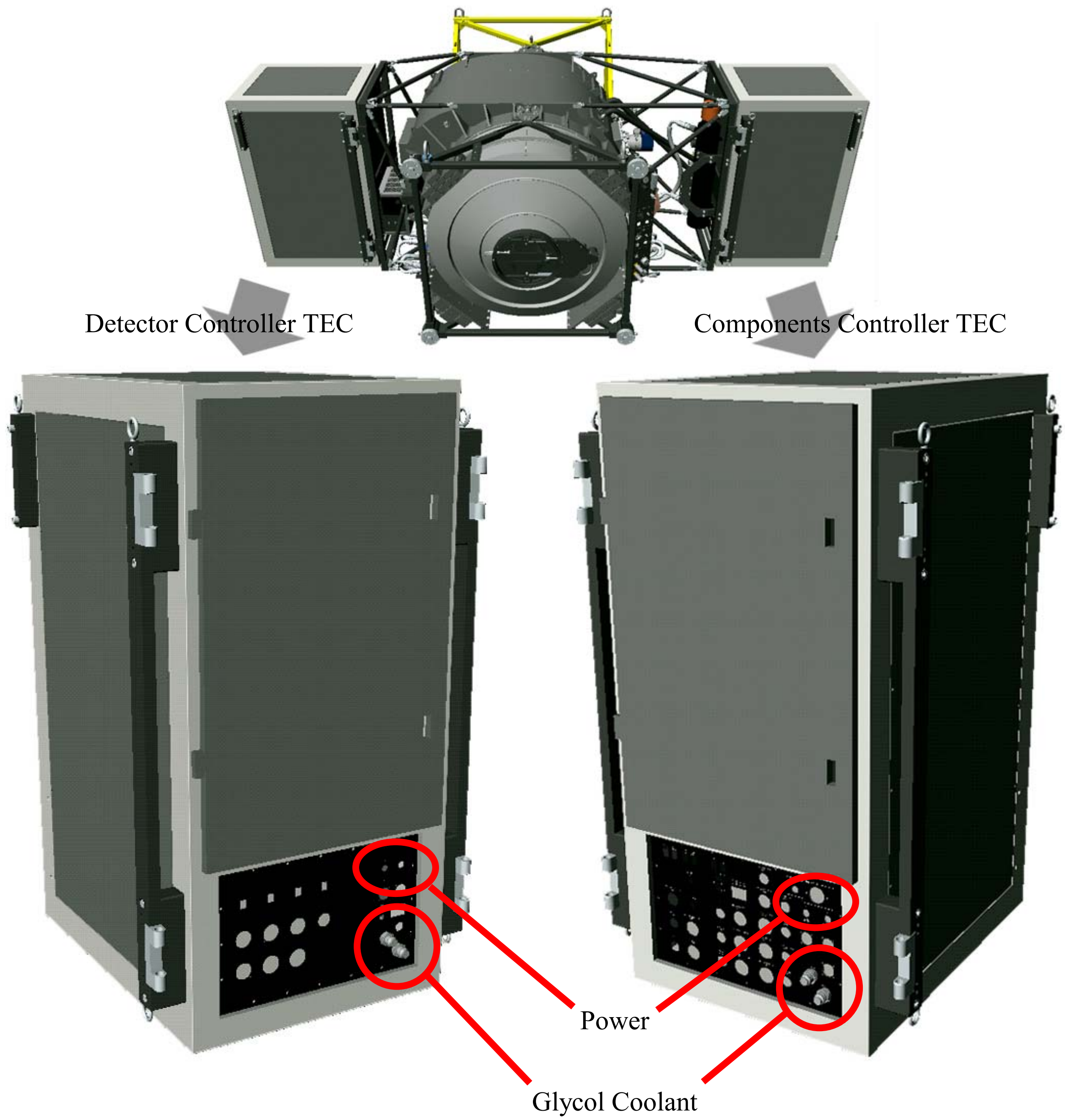
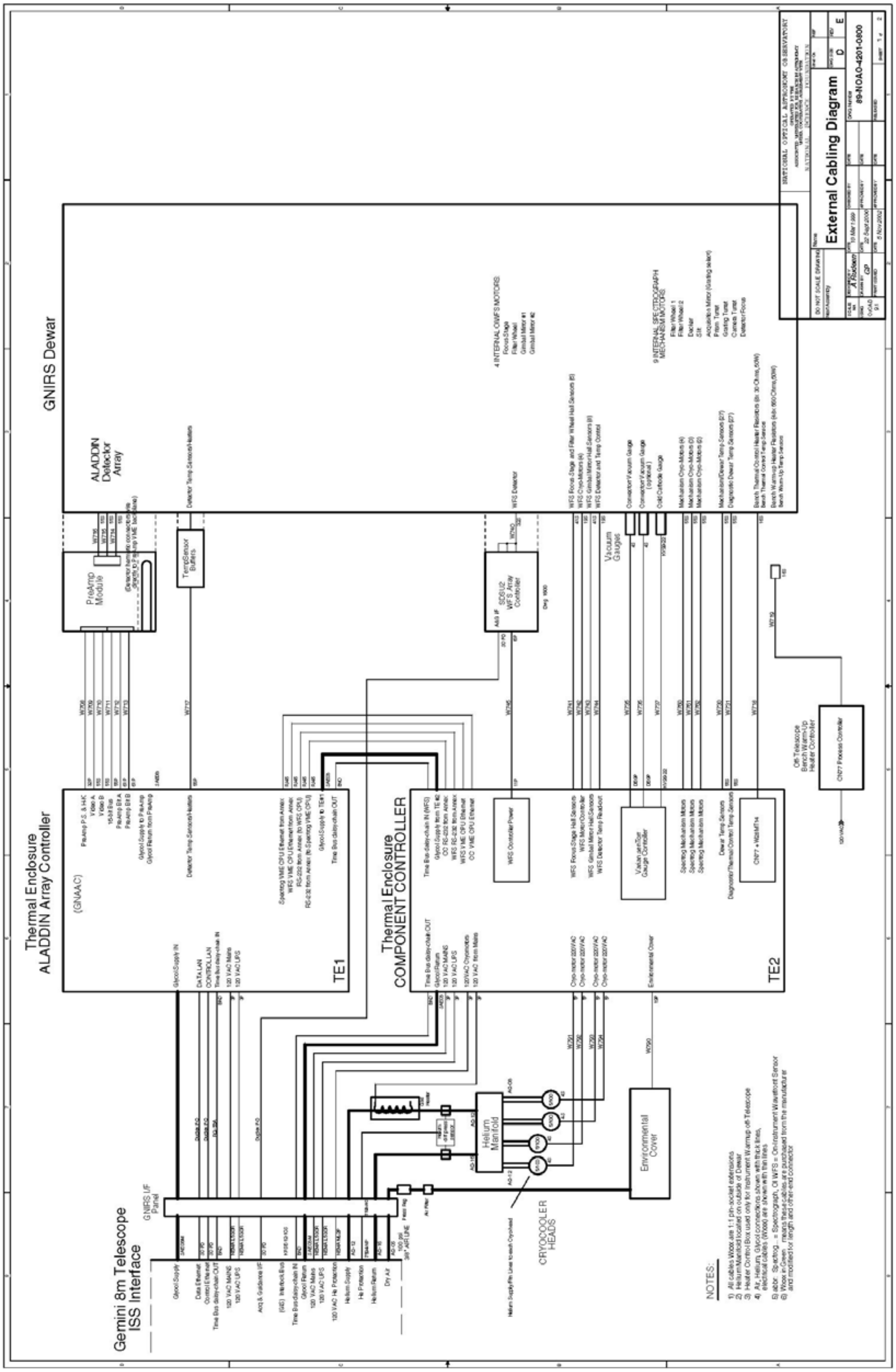


Figure 4.1.1. Thermal Enclosure Cabinets (TEC)



Drawing 89-NOAO-4201-0800

ESD Protection

Users and handlers of GNIRS electronics or cables should be grounded to the GNIRS TE chassis or other local ground using a standard ESD wrist strap.

Procedure

1) Connect the Glycol cooling loop through both Thermal Enclosures and confirm coolant flow. Coolant flow is required if the TE doors are closed, but may be off if the TE access doors are open and the system temperature monitored by the operator.

2) Confirm the interface connectors to the instrument are connected. The Data LAN and Control LAN Ethernet fiber-optic cables must be connected for the PowerPC computers to successfully boot up.

3) Turn on the MAINS AC power at the power switch on the connector panel. MAINS power is usually left on, as it powers the cooling fans and the Ethernet switch in the GNAAC (TE #1).

4) Turn on the UPS AC power at the power switch. This powers the majority of the components in each TE, and starts the boot-up of the PowerPC computers.

5) Cryohead power (110VAC) from the Helium Protection system is *not* switched in the TE. The He Protection power is supplied continuously to the Component Controller Cryohead Motor Drive in crate 2 as long as the Differential Pressure Switch (DPS) mounted on the GNIRS He manifold indicates the He pressure difference is greater than 90 psi (measured). The DPS contacts are monitored by the ISS which switches the He Protection AC power to the instrument in response to changes in He pressure difference. Operation of the He Protection system is described in the Gemini Helium Protection System document of July 2001 and on the drawing Gemini He Safety System, Cold Heads Protection Stand Alone Box.

   Power (220VAC) to the cryohead motors is switched either manually by crate 2 front-panel switches or by software command through the XVME-240 digital I/O board. See Section 6.5 for a description of crate 2.

6) To power down either TE, just turn off the UPS AC power at the switch on the connector panel. For a complete power down, then turn off the MAINS AC power. If the helium pressure remains adequate and the He Protection AC power is connected, then there is still 110VAC and 220VAC in the Component Controller crate 2. To ensure a completely off crate 2, disconnect the AC power cable to the He Protection AC connector either at the ISS or at TE #2.

4.1.2 Software Start-Up

The windows for the GNIRS engineering interface are EPICS dm screens, which can be used to monitor and modify EPICS variables. Type **nirsStart** (script located in {BASE}/bin/solaris) to start the top dm screen and the 4 console windows that are connected to the four vxWorks machines associated with GNIRS. The diagnostic windows are an interface to the CAD, CAR, APPLY records, and also show the current status of the system. Several display buttons will display a menu when right clicking with the mouse. Some of these menus are dynamically loaded, so if the system is rebooted, or the menu is reloaded after the dm screen is already displayed, the right click menu won't be updated. This is easily fixed by exiting the affected window and re-displaying it from its parent window.

It is desirable, but not necessary, to perform this step before turning on the thermal enclosures (4.1.1), as one can monitor the VxWorks computers as they boot up.

Descriptions of the windows and their uses can be found in the Software Maintenance Manual, section 3.2 of the User's Manual, or sections 6.1 and 7.2 of this manual (troubleshooting and calibration). An abbreviated description follows:

The window shown below (Fig. 4.1.2.1) is the top-level engineering window for GNIRS. This window needs to be kept open, though it can be minimized. The other, lower-level windows can be closed if not being used. If you do close the top-level window by accident, type **nirsStart** to recover.

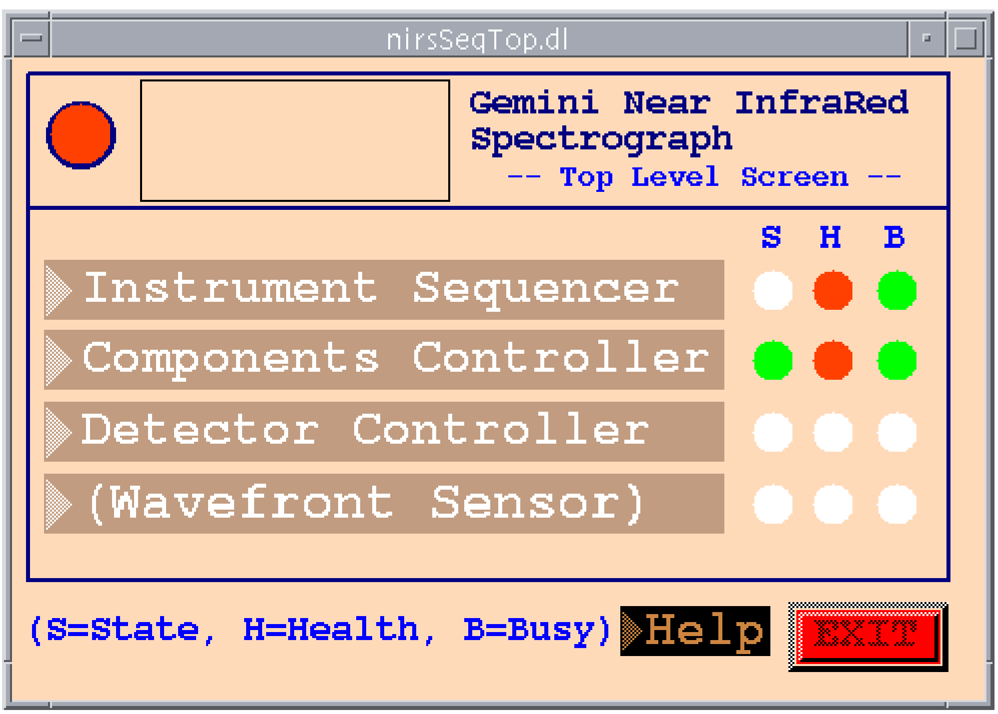


Figure 4.1.2.1. GNIRS top level engineering window

On this window, there are four buttons, which correspond to the four major components of the system:

- Instrument Sequencer - The instrument sequencer controls the system most like the OCS would. It communicates with all the other systems except for the Wavefront Sensor. This is not normally used as a direct interface to the instrument, except to open the mechanism control window.
- Components Controller - The Components Controller monitors temperature and pressure. It also controls the mechanisms, the detector and bench temperature, and the cryo-motors.
- Detector Controller - The detector controller controls and monitors all functions related to taking an image.
- Wavefront Sensor – This displays the windows which control and monitor the mechanisms in the Wavefront sensor.

The "help" button will give a description of what all the colors on the windows correspond to. "EXIT" kills all dm windows. The colored S/H/B indicators correspond to “state,” “health” and “busy.”

The Components Controller window is shown in Figure 4.1.2.2. This is where all functions related to temperature pressure and mechanism position can be controlled or monitored.

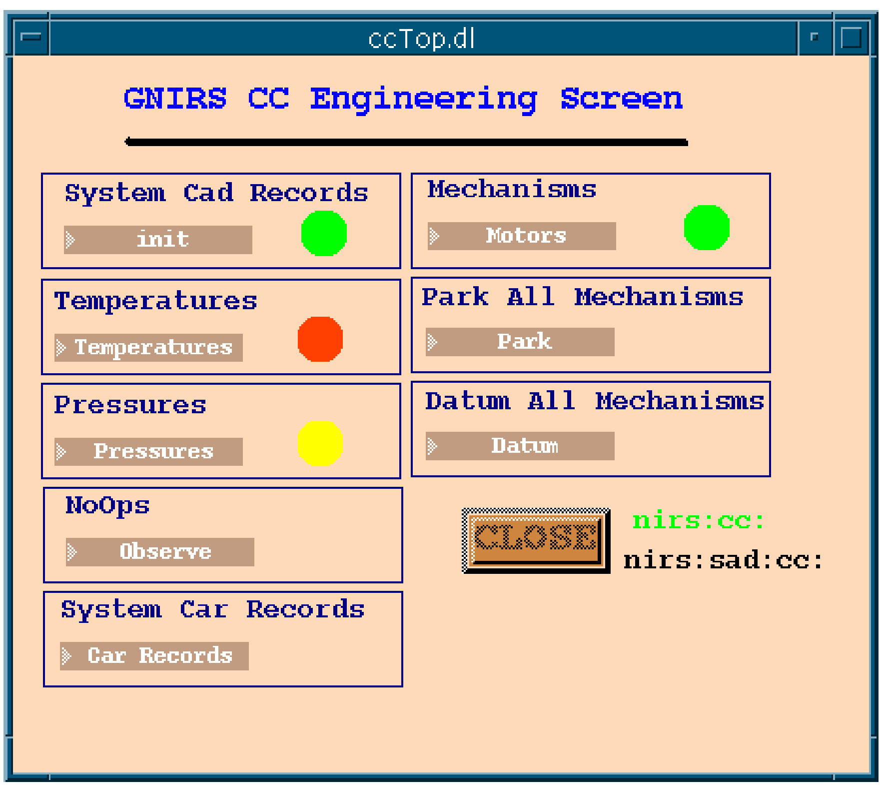


Figure 4.1.2.2. GNIRS Components Controller window.

The most useful buttons on the Components Controller window are listed below:

- Temperatures – This button starts one of three temperature monitor windows. A right mouse click will drop down a menu for the user to pick one of the windows.
- Pressures – The pressure monitor window is displayed with this button. Only two of the three sensors are actually in the system.
- Mechanisms – Starts a display window that will allow the user to run any of the CAD diagnostic windows related to the ten mechanisms. There is one window per mechanism; use the mechanism control window (see below) as an alternative.
- Park – This performs a park command on all ten mechanisms.
- Datum – This performs a datum command on all ten mechanisms.

The opto-mechanical configuration of the instrument can be controlled from a single Mechanism Control screen (Figure 4.1.2.3). This is opened by first opening the Instrument Sequencer screen from the top-level screen (above), and then opening the Mechanism Control screen from the IS screen. The IS screen can then be closed.

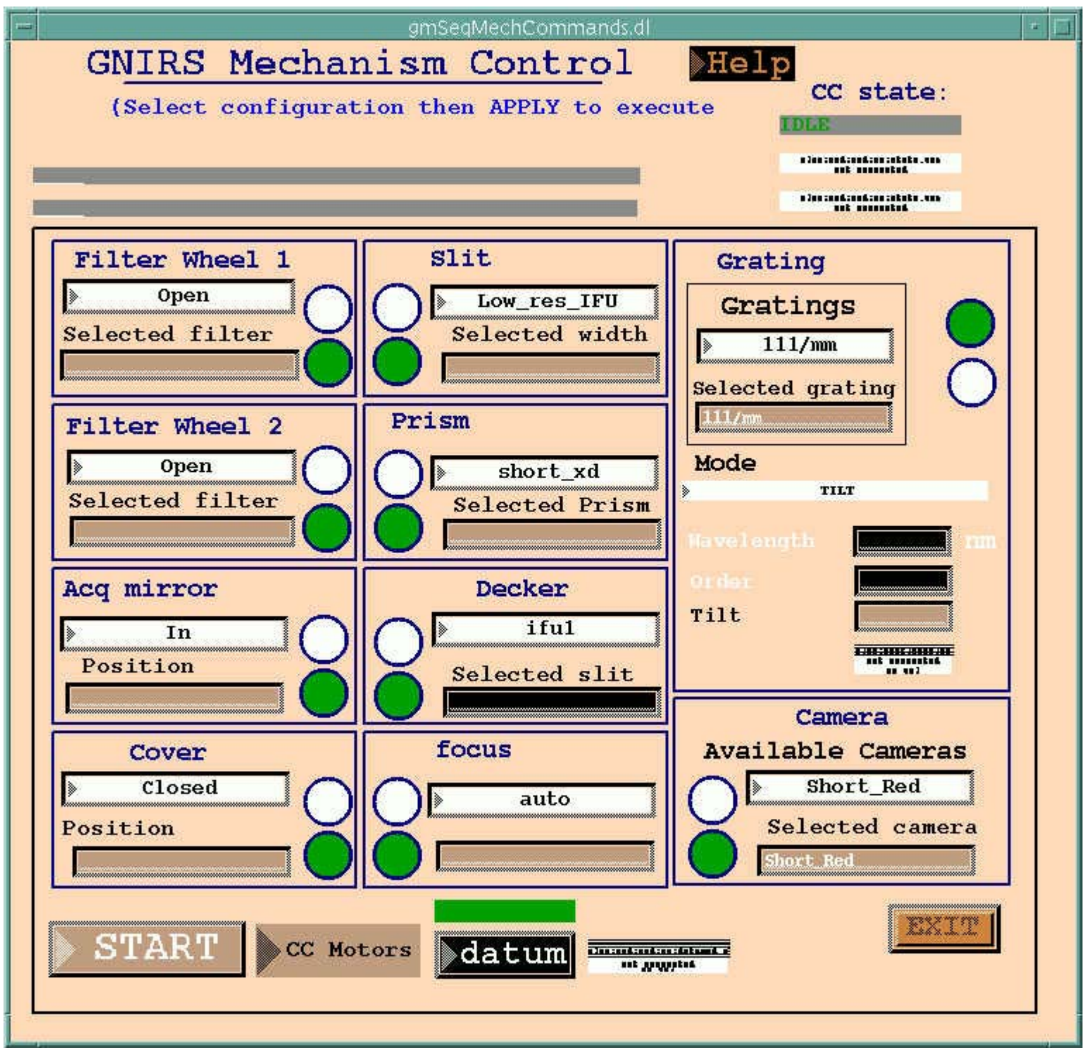


Figure 4.1.2.3. Mechanism Control screen. This provides control for all mechanisms.

The Detector Controller engineering display is displayed below (Figure 4.1.2.4).

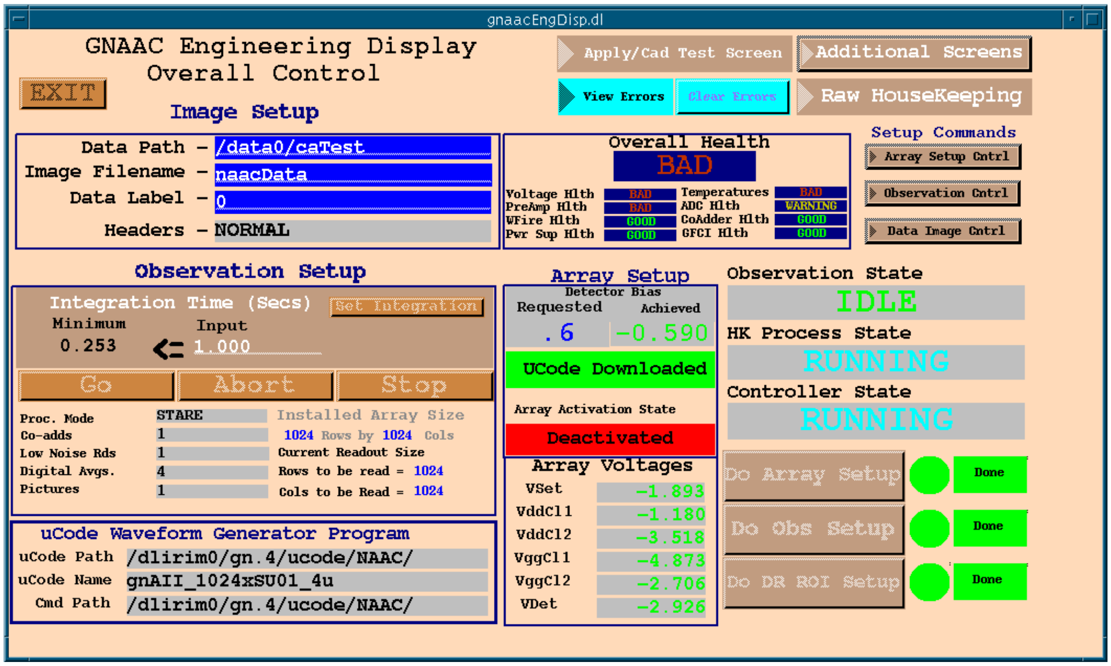


Figure 4.1.2.4. Detector controller (GNAAC) window.

The most relevant areas on the screen are as follows:

- Image Setup – Not used with the DHS.
- Observation Setup – Shows current state of observation parameters such as: coadds, low noise reads, digital averages, number of pictures, and integration time. In addition the integration time can be modified here. The obsSetup CAD must be run for the change to take effect. ("Do Obs Setup" button, or from "Observation Cntrl" in "Setup Commands" area.) The Observation can be started, stopped or aborted here also.
- Overall Health – Displays health of the system.
- Array Setup – Displays detector status such as the activation, uCode download state, and bias level. (These values can be changed from the "Array Setup Cntrl" or "Observation Cntrl" windows)
- Additional Screens – Right mouse click pulls down a menu that has a list of useful windows.
- Setup Commands – Bring up windows that allow the user to setup all the necessary parameters in the Detector Controller:
  - Array Setup Cntrl – Download ucode, and set array voltages.
  - Observation Cntrl - Set array activation, digital averages, co-adds, number of pics, proc mode, HK process state, header detail, header timing, readout size, and integration time.
  - Data Image Cntrl – Setup simulation patterns or array readout.

– The associated CAD must be started for any changes to take effect. They can be run from their respective windows, or from the “Do Array Setup”, “Do Obs Setup”, and “Do DR ROI Setup” buttons.

The top level OIWFS screen is shown in Figure 4.1.2.5.

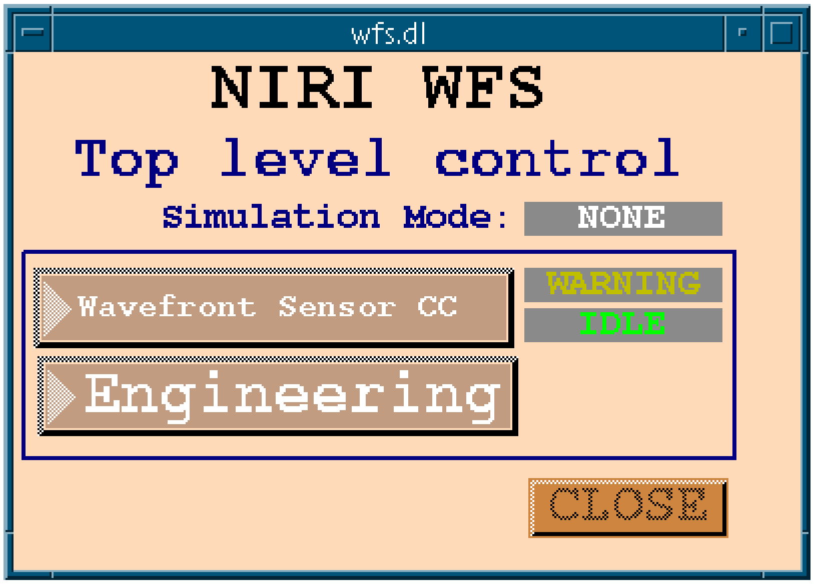


Figure 4.1.2.5. Top-level OIWFS screen.

The "Wavefront Sensor CC" uses the standard CAD/CAR record structure to run the system. This is most similar to how the A&G system will run the OIWFS.

4.1.3 Shutdown

The electronics/software shutdown procedure for GNIRS is fairly simple:

- Move all mechanisms to the "park" position (see Section 6.2).
- Deactivate the detector (see GNAAC manual; also see Section 4.1.2).
- Disconnect cryocooler helium lines (Section 4.2.3)
- Turn off all power on the thermal enclosures (mains and UPS).

Note: if access to the slit mask or an IFU position is desired, the slit slide can be moved to the appropriate limit position (see Section 5.2.3 or 8.5.10).

The cryocooler lines should be removed *prior* to turning off power (see 4.2.3). Failure to follow this sequence can lead to over-pressure in the cryocoolers as they warm up.

This shutdown procedure is required *only* if the instrument is being moved. If the instrument is going to be kept cold in the same location, only carry out the first two steps, then turn off the GNAAC UPS power (but *not* GNAAC MAINS).

4.2 Vacuum and Cryogenic Procedures

This section covers the procedures required to evacuate (Section 4.2.2) and cool down (Sections 4.2.3 and 4.2.4) the instrument prior to use on the telescope or in the lab, as well as the procedures to warm it up (Section 4.2.5) and bring it to ambient pressure (Section 4.2.6) prior to servicing.

The cool-down process can be carried out with the cryocoolers alone or with an initial liquid nitrogen pre-cool (see Section 4.2.4 for details).

Prior to performing these procedures, read the safety section (Section 4.2.1).

4.2.1 Vacuum and Cryogenic Safety

4.2.1.1 Vacuum Safety

The dewar is normally under vacuum. Loss of vacuum or deliberate pressurization while cold can lead to damage to optics, detectors, and possibly other components. It is important to pressurize the dewar *only* when the insides are near ambient temperature, and to do so slowly. See Section 4.2.6 for details.

It is also important to ensure that the instrument does not leak (see Section 6.4), since such leaks will lead to an eventual loss of vacuum, and possible contamination of optics or detectors.

If the dewar is sealed, verify that it is at ambient pressure before attempting to remove dewar shells, covers, etc. Damage to components and even injury to people is possible if this is not done. Note that variations in ambient pressure over time or between sea level and the telescope are significant for an instrument this size; always verify that pressure has been equalized immediately prior to any disassembly procedures.

4.2.1.2 Cryocooler Safety

The primary cooling for GNIRS is provided by four cryocoolers, which operate using high-pressure, high-purity helium. Failure to follow proper procedures (Sections 4.2.3 and 5.1.2) can lead to contamination of the telescope helium supply system, and possible damage to cold heads on GNIRS and other instruments using the system. In addition, the high pressures involved (peak values around 300 psi) pose a potential risk during disassembly of the instrument or disassembly of the cryocoolers; follow the specified procedures. In particular, it is important to turn off power to the cryoheads *after* disconnecting helium lines, which *must* be done in the correct sequence (see Section 4.2.3). Otherwise, substantial over-pressures can develop in the heads as they warm up.

4.2.1.3 Liquid Nitrogen Safety

If the liquid nitrogen precool system is used for initial cooling of the instrument (Section 4.2.4), large quantities (approximately 1000 liters) of liquid nitrogen are involved. These large volumes require not only the precautions appropriate when handling cryogenic liquids, but also adequate ventilation to avoid asphyxiation. In addition, operation of the pre-cool system presents a noise hazard, and hearing protection is strongly recommended. Specifically:

- Use insulated gloves when handling the cryogen lines and connections.
- Ensure that liquid emerging from the pre-cool system is collected in a suitable storage dewar. Avoid spilling liquid on the floor or spraying it around the room.
- Ensure that the area where the pre-cooling is being done is very well ventilated. The pre-cool system initially generates gas volumes at rates of 30-40 cubic meters per hour (roughly 18-25 SFCM). The ventilating system must have a minimum capacity in excess of this range. Use of an oxygen monitor is recommended.
- Operation of the pre-cool system drives resonances in the system, and produces intense, high-pitched noise. Hearing protection (earplugs) should be used when working on or around the pre-cool system when it is in operation.

4.2.2 Evacuation of GNIRS

Obtaining a good vacuum within GNIRS is essential to achieving and maintaining the operating temperature for the instrument over the course of an extended observing session. Because of the volume and large surface area within the instrument, even a small degradation in the vacuum can provide an additional heat load sufficient to compromise the instrument operation. Also, the large number of closely spaced volumes (between the passive radiation shields, within the main bench, etc.) represent "virtual leaks" which will require a long time to achieve the required vacuum.

While the cryocooler second stages (and the molecular sieve) can cryopump residual sources of outgassing, we strongly recommend achieving a good vacuum on the instrument prior to cooldown, rather than using the cryopumping action of the molecular sieve to compensate for a poor vacuum. Taking the time to achieve a good vacuum on the instrument will act as a diagnostic for potential leaks and make the initial cooldown (before the cold heads have achieved a sufficiently low temperature to act as efficient cryopumps) proceed more quickly.

4.2.2.1 Philosophy

Assuming no leaks, a major component of outgassing during the pumpdown results from the tendency of molecules, particularly H_2O, to adhere to the surfaces within the instrument. These molecules can be removed much more efficiently during the initial evacuation from atmospheric pressure, where the viscous flow at high pressures will dislodge them and drag them along. The recommended procedure thus involves several cycles of pumpout and backfilling with N_2 gas to flush out as much of the residual H_2O as possible. If the instrument has been opened up and exposed to atmosphere, we recommend a “bakeout” using the warmup resistors to heat the interior of the instrument to ~ 60 C to accelerate the removal of residual molecules from the surfaces.

4.2.2.2 Preparation and Special Equipment

GNIRS has three valved ports (Fig. 4.2.2.2): one has a Turbomolecular pump permanently installed; another is a port for initial (rough) evacuation; the third is used for backfilling or venting the instrument. The Turbo pump is never removed from the instrument and requires a mechanical “backing” pump on the output to operate. One uses a mechanical pump to evacuate the instrument to a pressure of a few mTorr, at which point the Turbo pump will begin to operate efficiently. The roughing port is then closed, the mechanical pump is switched to the output of the Turbo pump, which is used to achieve the high vacuum required. **Do not evacuate the instrument from atmospheric pressure through the Turbo pump. This is not only very inefficient but will damage or contaminate the Turbo pump.**

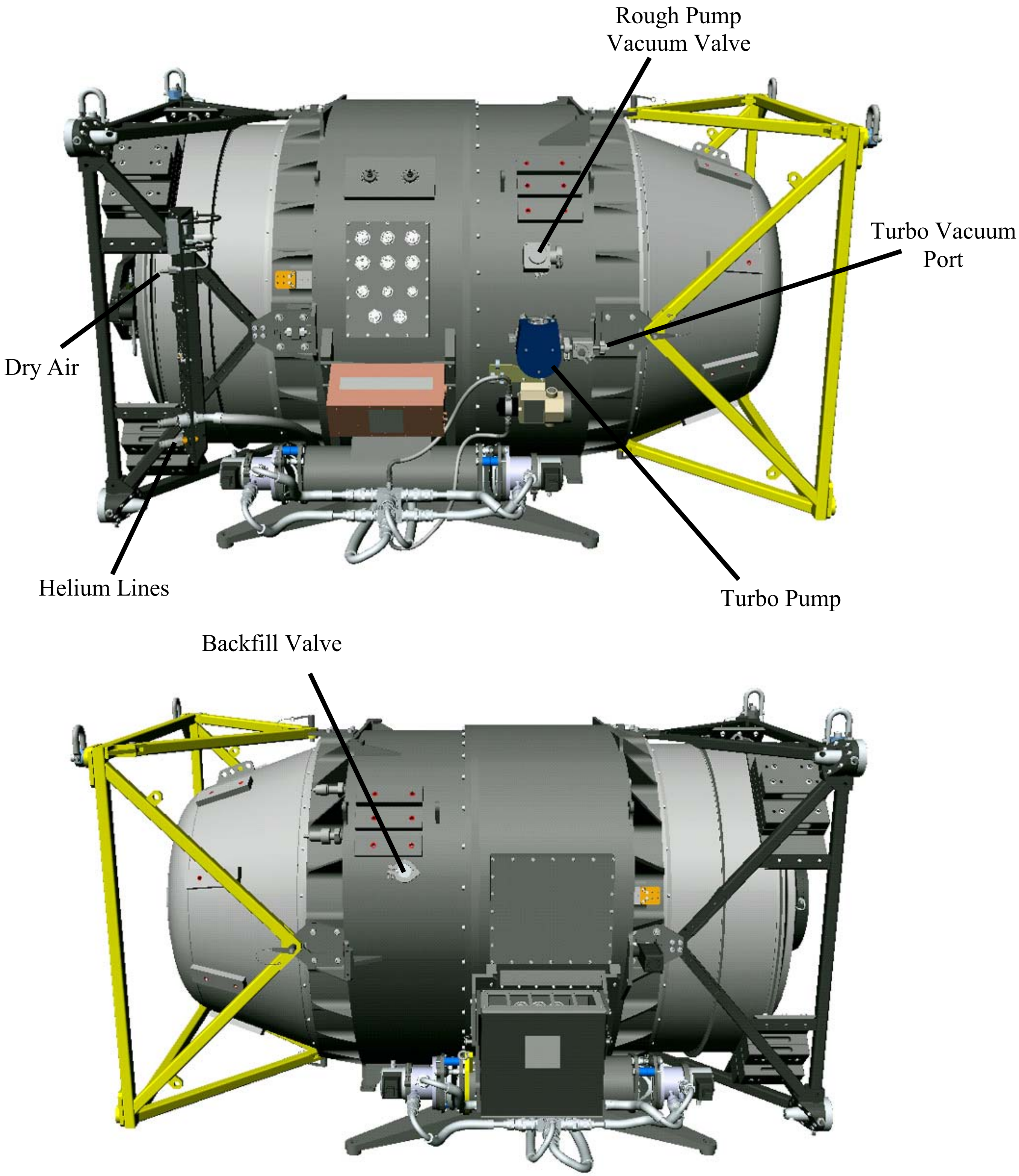


Figure 4.2.2.2. Vacuum and cryo-cooler connections.

A medium capacity mechanical pump is required for both the rough pumping and backing for the Turbo pump. An oil-free Scroll pump is highly recommended. A conventional mechanical pump can be used, but it carries the risk of oil backstreaming into the instrument and will also generate a lot of oil "smoke" during the initial pumpdown from atmospheric pressure because of the volume of gas being pumped.

The mechanical pump should have a "fail-safe" solenoid valve to close off the pump from the instrument in the event of a power failure.

A source of N_2 gas is required for backfilling and venting. The ~ $2m^3$ volume of GNIRS is equivalent to about 70 cf, or 1/3 of a standard "220 scfm laboratory" cylinder. The use of air for this procedure is not recommended, since even dried air contains some H_2O.

The mechanical pump must have a flexible stainless vacuum line with adapters to fit the roughing port and the backing valve port on the Turbo pump.

4.2.2.3 Evacuation and Backfilling

Three basic vacuum scenarios, in order of complexity, are:

- "hardening" the vacuum prior to an observing session, after a period of repose at room temperature.
- Pumping down the instrument after a brief maintenance task, such as changing a filter.
- Pumping down the instrument after major maintenance requiring disassembly and/or an extended period open to the atmosphere.

4.2.2.3.1 Pumping on an Existing Vacuum

If the instrument has been sitting around warm under vacuum for a while, one should pump out the vacuum jacket to remove any residuals from outgassing or diffusion prior to cooling down, as it is always a good idea to begin the cooldown with as good a vacuum as possible.

Unless the internal pressure, as measured with the Convectorr gauge on the instrument, is less than 10 – 20 mTorr, it is a good idea to pump the instrument to that level with the mechanical pump prior to using the Turbo pump.

Attach the mechanical pump to the roughing port. The line should be short in length and as large in diameter as possible for maximum pumping efficiency.

Turn on the mechanical pump and open the roughing valve. Monitor the pressure; when it reaches about 10 mTorr, close the roughing valve, turn off the mechanical pump, and reconnect it to the output port valve on the Turbo pump. Attaching to the small valve will require an adapter on the vacuum line.

Turn on the mechanical pump and open the output valve on the Turbo pump. Turn on the power to the Turbo pump. It will take several minutes for the Turbo pump to spool up to maximum speed—this is programmed into its controller.

Continue pumping until the dewar pressure has reached the level at which cooling may be safely started. If conditions permit, continue pumping during the cooldown to evacuate as much as possible the outgassing from the warm surfaces such as the interior of the outer shell and the passive radiation shields.

4.2.2.3.2 Pumping Down from Ambient Pressure

If the instrument has been at ambient pressure for a short time and has not been extensively disassembled, it should be possible to evacuate it without the need for baking out. However, if time permits, one should remove the back shell and bake out the molecular sieve (section 5.3) to help maintain the long-term vacuum integrity.

If the instrument has been opened for a longer period or the ambient conditions are humid, we recommend baking out the instrument during the pumpdown (section 4.2.2.3.3).

Attach the mechanical pump to the roughing port. The line should be short in length and as large in diameter as possible for maximum pumping efficiency.

Turn on the mechanical pump, keeping the roughing valve closed. Open the roughing valve slightly to begin pumping. Monitor the pressure with the Convectorr gauge on the instrument. As the pressure decreases, gradually open the roughing valve; once 10 – 20 Torr has been achieved, the valve can be fully opened. This gradual procedure prevents overloading of the mechanical pump and is particularly important if an oil pump is used.

Continue pumping for an hour or so, noting the dewar pressure. The rate of pump-down depends somewhat on the set-up available. Initially, the pump should be throttled back using the vaccum valve, so that the rate is 50 T/min or less. Once the pressure reaches 100-200 T, you will probably be able to open the valve all the way. The time to reach a pressure of ~1 T should be about half an hour (depends on pump). The pressure should be well below 1 T after another half hour or so. Stalling at a high pressure could indicate a leak or serious contamination (Section 6.4).

Once a pressure of ~ 100 mTorr is reached, close the roughing valve, turn off the mechanical pump, and backfill the instrument with N_2 gas through the bleed port until a pressure near atmospheric is achieved.

Re-evacuate the instrument. We recommend at least two, and preferably three of these cycles if the instrument is being pumped down from atmospheric pressure. On subsequent cycles, the time to achieve a given pressure level should decrease as the primary outgassing constituents are flushed out of the instrument.

After the final backfilling, continue pumping until the pressure reaches ~ 10 mTorr. Close the roughing valve, turn off the mechanical pump, and reconnect it to the output port on the Turbo pump.

Turn on the mechanical pump and open the output valve on the Turbo pump. Turn on the power to the Turbo pump. It will take several minutes for the Turbo pump to spool up to maximum speed—this is programmed into the controller.

Continue pumping until the dewar pressure has reached the level at which cooling may be safely started. If conditions permit, continue pumping during the cooldown to evacuate as much as possible the outgassing from the warm surfaces such as the interior of the outer shell and the passive radiation shields.

4.2.2.3.3 Pumping Down after Disassembly

After the instrument has been disassembled or exposed to atmospheric conditions for an extended time, it will be necessary to bake out the instrument during the evacuation process to get rid of the significant amounts of H_2O (as well as other contaminants) which will inevitably have been adsorbed onto the surfaces of the internal components.

Follow the procedure outlined in section 4.2.2.3.2 to pump out and backfill the instrument with N_2 gas. Carry out this procedure twice and leave the instrument backfilled with N_2.

Hookup the external power supply to the warmup resistors and enter a setpoint of 333 K (60 C). Turn on the heaters and bake out the instrument for at least 24 hours.

NOTE: There is a reason for having the system near atmospheric pressure during this stage of the bakeout. The N_2 gas will ensure more or less isothermal heating of the entire instrument, including the passive radiation shields, and prevent any outgassing products from condensing on relatively thermally isolated and cooler surfaces, such as the optics.

Once the instrument has baked out for at least 24 hours, hook up the mechanical pump and evacuate the instrument, while leaving the heaters powered on. The pumpdown will probably be considerably slower than the norm, since the outgassing of contaminants from the internal surfaces will continue at a good rate as the pressure falls.

If time permits, continue the heating for another 24 hours. Once the pressure drops below 10 mTorr, one can switch over to the Turbo pump and continue the pumpout as described in section 4.2.2.3.2.

4.2.3 Cryocooler Operation

This procedure covers the installation and removal of the He cryo lines to a cryohead, as well as cryocooler operation. Note that the cryohead motor and gas compressor should be “ON” during these procedures. Always remove the high-pressure line before the return line and install the return line before the high-pressure line to avoid a potentially dangerous over-pressure situation in the cryohead.

4.2.3.1 Connecting Aeroquip Fittings

Never apply lubricants to Aeroquip fittings!

Isopropyl alcohol is the only recommended anti-seize aid; it evaporates quickly and it doesn’t contaminate the fittings. Ensure that the fittings on both mating surfaces are *clean*. Use a clean swab to wipe any dirt or particles from the threads and O-rings. Isopropyl alcohol and a brass bristle brush may be used if necessary on the threads, then wipe off with a clean dry wipe. Also use a flat stick to remove the male half fitting flat seal and clean it and the groove. **Do not assemble fittings with wet face seal surfaces!**

Be sure the dust cap/plug is clean as well. When installing the gas lines, start the fittings by hand and hold the line straight to avoid cross threading. Then add some isopropyl alcohol to the coupling between the nut and body, and on the male end’s threads. Tighten the fitting until it seats, using the appropriate wrenches. **Do not over-tighten the fittings!**

4.2.3.2 Instrument Start-Up

1) Connect the cryohead electronics, verify the compressor is operational and ready (i.e., chilled water, power, static gas pressure, etc.). Start the compressor and then the cryohead motors. Check the return and supply lines as detailed below and, if no contamination is detected, connect them to the instrument in that order.
2) Return side: remove the dust plug from the return hose and dust cap from the instrument. Check all pieces for dirt and/or oil. Use a UV long wave lamp to check each piece for compressor oil contamination. If fittings fluoresce under the UV lamp, the system is contaminated and the instrument should not be connected. If no contamination is detected, connect line to the instrument.
3) Pressure side: remove the dust plug from the pressure hose and dust cap from the instrument. Check all pieces for dirt and/or oil. Use a UV long wave lamp to check each piece for compressor oil contamination. If fittings fluoresce under the UV lamp, the system is contaminated and the instrument should not be connected.

4.2.3.3 Instrument Shutdown

1) Pressure side: remove pressure hose from the instrument. Check all pieces for dirt and/or oil. Use a UV long wave lamp to check each piece for compressor oil contamination. If fittings fluoresce under the UV lamp, the system is contaminated. Install dust plug on hose end and dust cap on instrument.
2) Return side: remove return hose from the instrument. Check all pieces for dirt and/or oil. Use a UV long wave lamp to check each piece for compressor instrument oil contamination. If fittings fluoresce under the UV lamp, the system is contaminated. Install dust plug on hose end and dust cap on instrument.

3) Shut down the cryohead motors and then the compressor, disconnect the cryohead electronics. Verify the compressor static gas pressure and note this for the next time the system is run. It is a good way to check for a system gas leak.

4.2.4 GNIRS Cool-Down Procedure

This section describes procedures for cooling down the instrument, both with and without use of the liquid nitrogen pre-cool system. The pre-cool system shortens the overall cool-down time by approximately 1 week, but requires more operator intervention, the use of 800 liters of liquid nitrogen, and appropriate safety precautions.

4.2.4.1. Cool-Down with Pre-Cool

This is an outline of the procedure for cooling down the instrument *with* the pre-cool system.

4.2.4.1.1. Safety

WARNING: Asphyxiation risk. Use of the liquid nitrogen pre-cool system generates up to 1 cubic meter of nitrogen gas per minute. Operation of the pre-cool system should always take place in a well-ventilated area, preferably while using an oxygen monitor.

WARNING: Cryogenic liquids. Standard safety message for liquid nitrogen

WARNING: Noise hazard. Operation of the pre-cool system can generate noise at damaging frequencies and intensities. Suitable hearing protection may be required.

WARNING? Anything associated with the cryocooler lines.

4.2.4.1.2 Theory of Operation

Cool-down with the pre-cool system functions in two stages. In the first stage, the primary means of cooling is the pre-cool system, although the cryocoolers are also operated to prevent their acting as a "heat leak".

The pre-cool system is a length of corrugated stainless steel tubing which runs around the circumference of the cold structure (bench) and is attached to it at various points by copper clamps. Liquid nitrogen flows into this tube and evaporates, cooling the bench through the attachment points. The flow rate is regulated to evaporate all (or nearly all) liquid that enters the system, to minimize waste of liquid nitrogen.

The pre-cool system efficiency decreases as the bench temperature approaches the temperature of liquid nitrogen, and at this point the pre-cool system is purged and back-filled with helium gas, and further cooling is provided by the cryocoolers alone.

The purge and back-fill leave the pre-cool system with a slight over-pressure, which can be monitored to detect slow leaks. This procedure ensures that water or other condensables do not enter the pre-cool system and form a plug.

The cryocoolers cool the bench through a connection between their first stages and the bench, which consists of 8 heavy copper straps connected to the bench at different points on its center section. Additional straps are connected to the active shield.

There is also a connection from the second stages of heads 1 and 2, which cools the detector mount and the getter (molecular sieve) below 35K.

Once the instrument reaches the desired temperature, the bench temperature control can be turned on (section 7.3).

4.2.4.1.3 Preparation

Cool-down should not be initiated until the instrument vacuum has reached a pressure below 10^{-3} T. If the instrument is to be used for an extended period of time, a pressure 1-2x10^{-4}T is recommended.

The instrument control electronics should be turned on. Verify that the dewar temperatures and pressure are being correctly monitored.

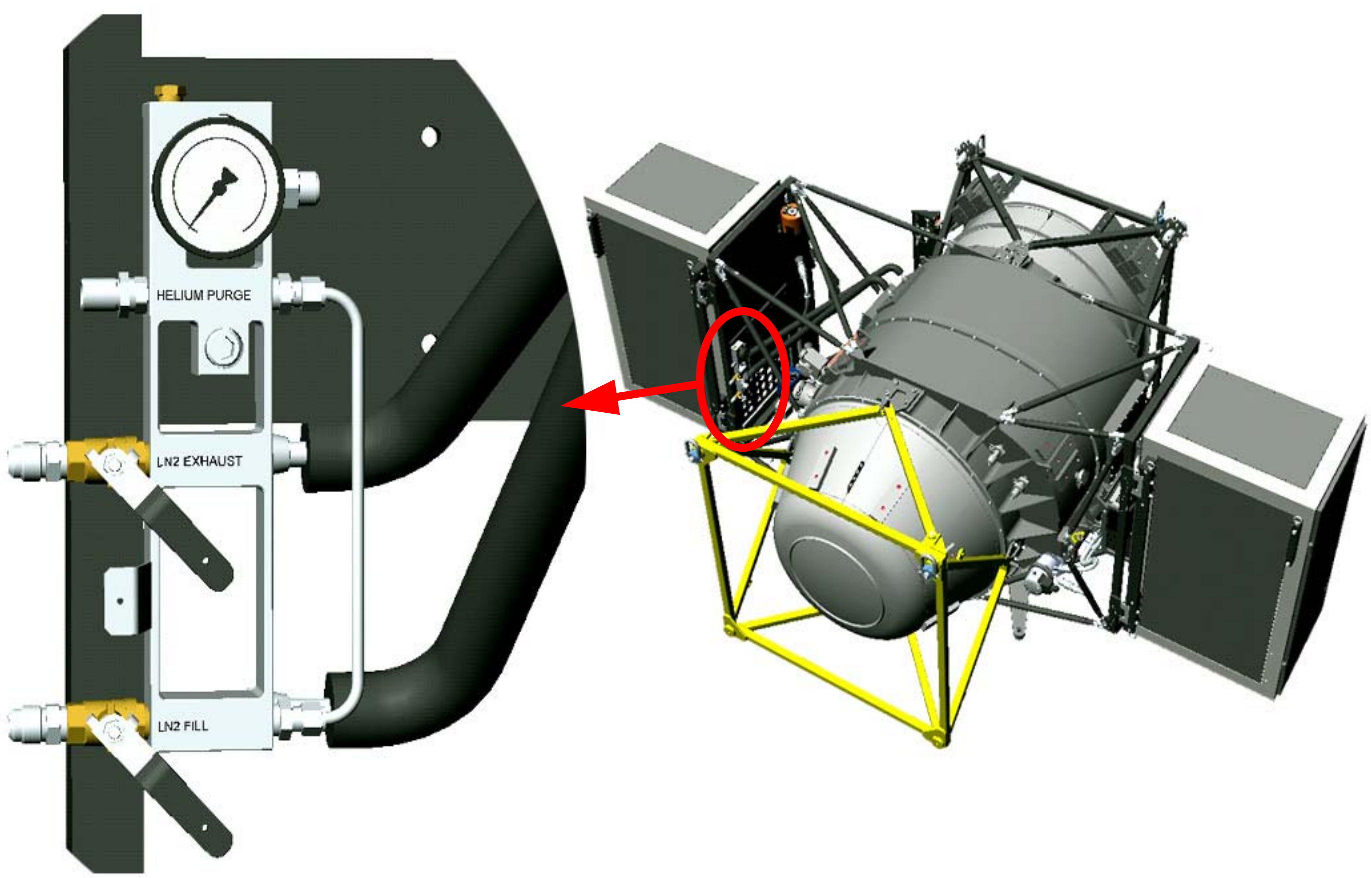


Figure 4.2.4.1.3. LN_2 Pre-cool Manifold.

Connect the high-pressure helium lines to the instrument connector panel (Section 4.2.3). If the instrument has been disassembled, verify that all connections from the panel to the cryocoolers have been made. Also verify that power connections have been made between the instrument controller enclosure and the cryocoolers.

Connect a flexible fill line from a storage dewar (160 liters or greater capacity recommended) to the fill port on the pre-cool system. Remove the pressure gauge/pop-off fitting from the vent port on the pre-cool system. Attach a flexible line to the vent port and allow it to vent into a suitable receptacle (empty nitrogen dewar).

The pre-cool procedure will produce substantial condensation on the fill and vent lines, so they should be insulated with foam pipe insulation, or wrapped with towels or something similar to protect electronics cabinets and cables from water. Note that the fill lines from the pre-cool manifold to the dewar are already insulated.

If you insulate the fill line, it will increase efficiency slightly. Also, you can increase the time between storage dewar changes by connecting two dewars with a “T” connection. This is especially useful for running the pre-cool overnight.

Dry nitrogen/dry air should be connected to the dewar window (connect at instrument connector panel, check connections between panel and window cover). The window cover should be closed. Set the gas flow rate to 5lpm using the control on the connector panel.

4.2.4.1.4 Cryocooler Start

Turn on the cryocoolers using the manual controls inside the instrument controller thermal enclosure. Make sure that all four heads are operating.

Operate for approximately 20 minutes. The output lines on all four heads should feel distinctly warm to the touch, and should be at roughly similar temperatures. If this is not the case, proceed to Section 6.3 on cryocooler troubleshooting.

After 20 minutes, the temperature sensors on the cryocoolers should indicate a temperature drop of 20K or more.

4.2.4.1.5 Pre-Cool Start

Open the valve to the storage dewar partially. Flow through the fill line should be audible, but do not open the valve all the way. Wait a minute or two. If there is no liquid emerging from the vent line, open the valve somewhat more. If there is liquid emerging, proceed to the next step.

Assuming that there is liquid emerging from the vent line (it may only be dripping), close the valve on the storage dewar *slightly*. Allow a couple of minutes, and if liquid is still emerging, close the valve some more. The point of this procedure is to set the flow rate just below the point where liquid nitrogen makes it through the system without evaporating.

At this optimal flow rate, the pre-cool system will usually produce a loud and annoying whistle. If you are going to be working in the vicinity, use hearing protection.

Check on the pre-cool system after half an hour or so to confirm that the flow rate remains optimal. If there is gas flow but no whistling, flow rate is probably too low. If there is liquid dripping, the flow rate is too high. It is difficult to exactly optimize the flow rate; a very slow drip will not waste too much nitrogen, and will ensure maximum cooling.

At the optimal flow rate, liquid consumption is approximately 35 l/hour. Check on the level in the storage dewar to monitor consumption, since this number is approximate.

Also check on the bench temperatures as the pre-cool operates. The rate of cooling should be ~13 K/hour initially, decreasing gradually to 10K/hour as the bench temperature drops below 200K. The rate as the bench approaches 100K will decrease to ~5/K hour.

When the storage dewar is empty, it should be disconnected and replaced (or refilled). Adjust the flow rate for the new dewar in the same way.

4.2.4.1.6 Pre-Cool Stop

Once the bench temperature approaches 100K, pre-cool efficiency will decrease and it will be necessary to cut back the flow rate. This point will not be reached until 15+ hours have passed.

The initial flow rate is expected to be in the vicinity of 30 l/hour, which will empty a small storage dewar in ~5 hours or a large one in ~8 hours. As the cooling efficiency decreases, the optimum flow rate will also decrease.

The pre-cool system functions well down to bench temperatures approaching 80K. It should therefore be allowed to operate until one of the following occurs:

- A bench temperature point reaches 77K
- Bench temperature points are all below 85K

At this point the liquid nitrogen valve should be closed.

4.2.4.1.7 Pre-Cool Purge and Back-Fill

The pre-cool input should now be connected to a source of dry nitrogen (*do not use dry air for this purpose*). A reasonable source is the "vent" valve on the liquid nitrogen storage dewar.

It will almost certainly be necessary to use a heat gun to melt ice in order to change the connections.

Open the vent valve all the way. Blow nitrogen through the pre-cool system until all liquid has been blown out; run for roughly another minute.

Now close the nitrogen valve and connect a helium bottle to the helium gas fitting. Lab grade helium (not high purity) is adequate for this purpose. Purge the pre-cool system with helium gas for 30-60 seconds, then close the valve on the output (vent) of the pre-cool system. Allow the pre-cool system to pressurize to approximately 5 psi or until the pop-off valve activates.

The pressure in the line will initially increase as the bench temperature equalizes and warms the pre-cool line slightly; it will then decrease as the bench cools further. The pressure drop from 80 to 60K is almost 5 psi.

Monitor the pre-cool pressure as the instrument cooling progresses, and top off with additional He if the pressure drops below 2 psi. Rapid drops in pressure, or decreases once the instrument temperature has stabilized, are indicative of a leak.

After this step, all cooling will be provided by the cryocoolers. The bench should reach a temperature <65K after about 3 days of cooldown.

4.2.4.1.8 Final Cooling with Cryocoolers

The cryocoolers are already functioning, so no steps are needed beyond monitoring the temperature. Cooling from 80 to 60 K requires ~1 day. The bench temperature control can be turned on at any time once the bench is at or below 80 K (see Section 7.3)

4.2.4.2. Cool-Down without Pre-Cool

This section describes the procedures for cooling down the instrument without using the pre-cool system, using the cryocoolers only.

4.2.4.2.1 Safety

WARNING? Anything associated with the cryocooler lines.

4.2.4.2.2 Theory of Operation

The cryocoolers cool the bench through a connection between their first stages and the bench, which consists of 8 heavy copper straps connected to the bench at different points on its center section. Additional straps are connected to the active shield.

There is also a connection from the second stages of heads 1 and 2, which cools the detector mount and the getter (molecular sieve) below 35K.

Once the instrument reaches the desired temperature, the bench temperature control can be turned on (Section 6.5.4).

4.2.4.2.3 Preparation

Cool-down should not be initiated until the instrument vacuum has reached a pressure below 10^{-3}T. If the instrument is to be used for an extended period of time, a pressure less than 1-2x10^{-4}T is recommended.

The instrument control electronics should be turned on. Verify that the dewar temperatures and pressure are being correctly monitored.

Connect the high pressure helium lines to the instrument connector panel. If the instrument has been disassembled, verify that all connections from the panel to the cryocoolers have been made. Also verify that power connections have been made between the instrument controller enclosure and the cryocoolers.

Connect a helium bottle to the helium fitting on the pre-cool system manifold. Verify that the pressure reading on the pre-cool system is 5 psi or greater. If it is lower, the system should be purged and back-filled with helium gas, as follows:

- Open the vent valve on the pre-cool system.
- Purge the system for 30-60 seconds
- Close the vent valve and allow the system to pressurize to 5 psi or until the pop-off valve operates.

Dry nitrogen/dry air should be connected to the dewar window (connect at instrument connector panel, check connections between the panel and window cover). The window cover should be closed. Set the gas flow rate to ~2 liters/minute using the control on the connector panel. Set the pressure gauge to ~3 psi.

4.2.4.2.4 Cryocooler Start

Turn on the cryocoolers using the manual controls inside the instrument controller thermal enclosure. Make sure that all four heads are operating.

Operate for approximately 20 minutes. The output lines on all four heads should feel distinctly warm to the touch, and should be at roughly similar temperatures. If this is not the case, proceed to Section 6.3 on cooler troubleshooting.

After 20 minutes, the temperature sensors on the cryocoolers should indicate a temperature drop of 20K or more.

4.2.4.2.5 Cryocooler Cooling

The cryocoolers will operate unattended. The cooling rate is initially ~30K/day (estimated) decreasing to ~20K/day.

The pressure in the pre-cool system will decrease as the system temperature decreases, and if unattended will drop below atmospheric pressure. This should be avoided since there is then a potential for condensibles to enter the pre-cool line. Therefore, the pressure should be checked roughly once a day and the pre-cool system should be topped off with helium gas if the pressure has dropped below 3 psi (see section 4.2.4.2.3 above). It is not necessary to purge the pre-cool system unless pressure has dropped to zero (below atmosphere).

Total cool-down time is estimated as 10 days. (The cooldown mode has not been tested.)

The bench temperature control can be turned on once both the Offner and collimator temperature sensors reach 80K (see section 6.5.4).

4.2.5 GNIRS Warm-Up Procedure

This section describes the procedure for warming up the instrument using the stand-alone heater box.

4.2.5.1. Warm-Up Procedure

4.2.5.1.1 Safety

There are no particular safety concerns provided the warm-up is done according to the instructions in this section.

4.2.5.1.2 Theory of Operation

The warm-up box warms up the instrument using 48 resistors distributed over the internal cold structure. When the heater circuits are on, these resistors dissipate approximately 1000W. Some additional heating occurs from radiation through the shields, and conduction down the cold straps from the warm cryocoolers.

In order to minimize risk to the optics from thermal shock, the heater box monitors the rate of change of the bench temperature at the control diode, and limits heating to 10K/hour or less.

This results in a warm up time of slightly over 1 day.

It is recommended that the dewar be connected to a vacuum pump during warm up, as this helps remove contaminants as they outgas from the coldheads and the molecular sieve.

4.2.5.1.3 Operation

The cryocoolers should be turned off, and may be disconnected; see Section 4.2.3.3.

Connect a roughing pump to the turbo-pump and turn it on. Once line pressure has stabilized, plug in the turbo-pump (it will turn on automatically). Although this step is strongly recommended, it is possible to carry out the warm up without it. The pump can be connected prior to turning off the cryocoolers. The instrument controller electronics need to be on to read pressure, unless alternative connections are made to the gauges.

The dewar electronics can be left on, though this is not required. If the electronics are turned off, there is no way to log temperature or monitor pressure for the warm-up.

The stand-alone heater box should be connected to the heater connector (J719 on the starboard [right] forward side of the bulkhead). Before connecting the heater box cable, verify that the connector on the bulkhead is free of condensation. If there is condensation, use a heat gun to dry the connector. *Do not* overheat the connector as this can damage the O-ring seal or the connector itself.

Turn on the warmup controller, which is described further in Section 6.5.5. Select a set point using the switches on the front panel (4 possible temperatures using combinations of switches 1 and 2). A set point somewhat above room temperature is recommended in order to maximize removal of contaminants. However, if the intent is to immediately open the instrument, then the set point should be set close to room temperature to minimize the risk of thermal shock to the optics.

If all circuits are operational, all 6 lights on the face of the box should illuminate. Note that the temperature control is an "on-off" control, so if the warm up rate needs to be limited, or if the set point is approached, the circuits will turn off intermittently. The duty cycle during initial stages of the warm-up may be as low as 25% "on." If the warm-up box is operating normally, the circuit should start applying power at a 50% duty cycle immediately at turn on. The duty cycle will initially be about 5 to 10 seconds. If the power remains on continuously (more than 1 minute), turn the box off immediately and then check the programming of the Omega controller [Described in Section 7.3].

WARNING: *Do not* attempt to re-program the heater box unless you are prepared to monitor the instrument temperatures on the next use, and you understand what you are doing, and why. The heaters are capable of warming the instrument up at a rate that poses a risk to the optics.

Once the internal temperature reaches the set point that was selected, the box will stop heating the instrument. If the set point is higher than ambient, the box will turn power on as needed to maintain the higher temperature. If the next step is to open the instrument, see Section 8 of the service manual.

If the next step is to put GNIRS into storage (waiting for next use), continue pumping the dewar until a pressure of 10^{-3} Torr is reached. Then turn off and disconnect the heater box, then turn off and close the backing valve on the turbo-pump and remove the backing pump (Section 4.2.2.2.)

4.2.6. Backfilling the Instrument Prior to Maintenance

If the instrument is to be warmed up for maintenance, follow the warmup procedure outlined in section 4.2.5 or, if time permits, simply allow the instrument to return naturally to ambient temperature.

Prior to opening up the instrument, backfill to atmospheric pressure with N_2 gas. If the instrument will be opened for only a short time (for replacing a filter or the window), backfilling with N_2 will minimize the adsorption of H_2O onto the internal surfaces and greatly facilitate the subsequent pump down. Even if extensive maintenance or disassembly is intended, the N_2 backfill will be of some help in limiting H_2O adsorption on the surfaces.