Introduction

FourStar contains about 2 Kg of activated charcoal that acts as a "getter" to trap water and other molecules that diffuse through the O-rings and/or are outgassed from chemicals within the vacuum enclosure. Operating together with the ion pump, the getter should keep the pressure around or below a few x 10-6 torr. Lately the vacuum has been deteriorating, as the following plot shows:

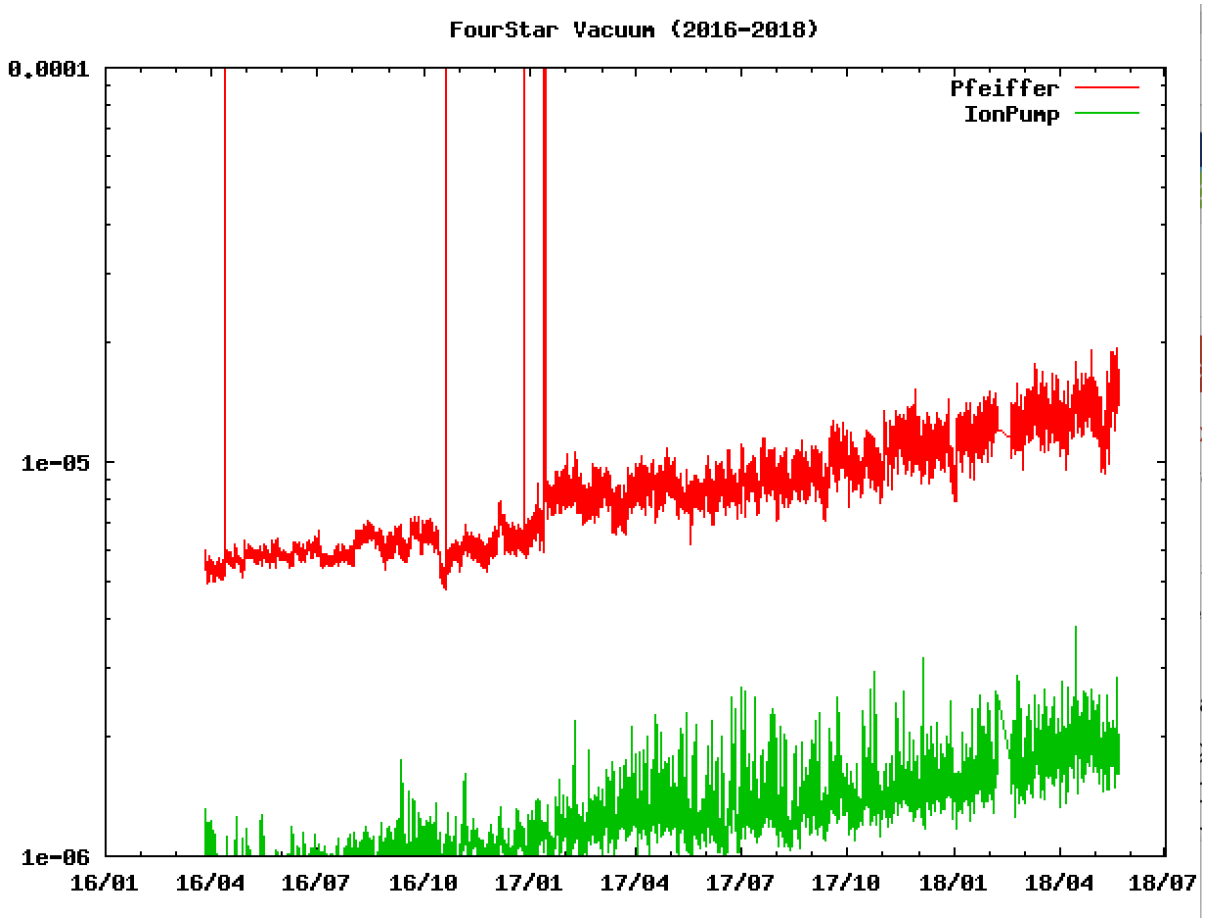

Figure 1. Current status. The x-axis is date; the y-axis is vessel pressure in torr. The red curve is the pressure reading from the inside of the vessel, and the green curve is the pressure as measured by the ion pump – ignore it. The last time the getter was reactivated (Nov 2015), the Pfeiffer gauge looked like:

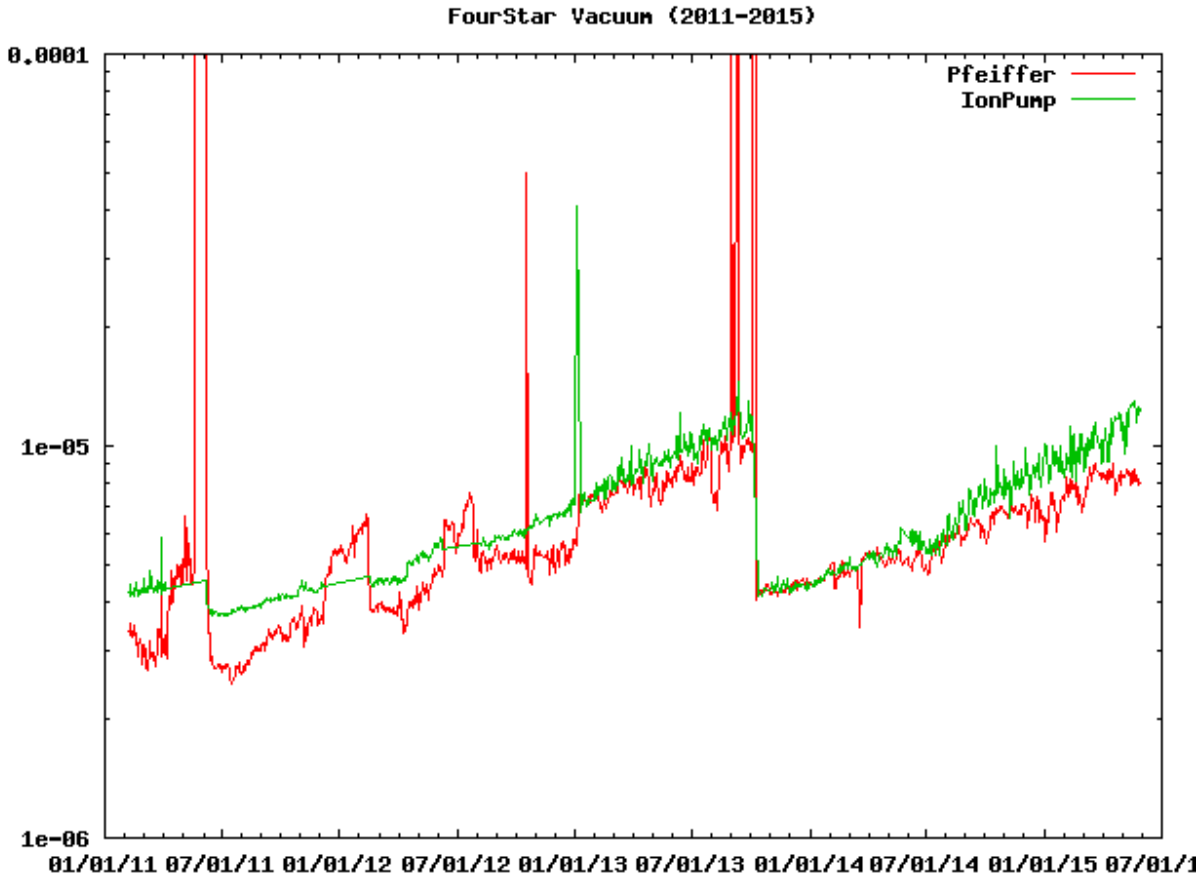

Figure 2. 2011 – 2015 pressure data. The sharp drop in late 2013 occurred when there was a near-catastrophic loss of vacuum. (The vessel was pumped on and operation was restored.)

Note the systematic deterioration of the vacuum currently. This is due to contamination of the getter, and must be corrected. Once this is accomplished, not only should the pressure remain below 10-5 torr for a few years, but the lighter load on the ion pump will mean that it will not have to be swapped out as often.

CONTACT NUMBERS: If there is a problem, or any doubt about a procedure, do not hesitate to contact either of us.

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IMPORTANT NOTES

The procedures for warming up the insides of the instrument are more inolved than in 2015. THE 2015 MANUAL SHOULD NOT BE USED THIS TIME. There is an extra step now – it is designed to keep the detector from being the coldest item inside the vessel. This condition would allow getter contaminants to adsorb on the detector – clearly a bad situation. In particular, the passive warmup period will be replaced by a two-phase controlled warmup.

In addition, we want to bring the insides up to ambient temperature as fast as is safely possible. This will give the longest possible time for the bakeout, whereby the shroud dewar and the getter are kept at 300 K while the turbo pump removes the contaminants.

Summary of Main Steps

1. Jul 31 – Aug 3, 2018. Inspect and control both dewar fill levels.
2. Aug 3. FourStar is disconnected from the telescope and pulled back.
3. Aug 3. Turbo-pump is connected and pumping commences.
4. Aug 3. Start Temperature Monitoring and Control.
5. Aug 3 – 9. Warmup of vessel interior; bakeout starts.
6. Aug 9 - 17. Bakeout at 300 K. The ion pump is replaced.
7. Aug 18 - 19. Start of Cooldown. The Shroud Dewar is filled with LN2.
8. Aug 20. The detector dewar is filled with LN2.
9. Aug 20. The turbo-pump is disconnected.
10. Aug 20. FourStar is reattached to the Conical Adaptor.
11. Aug 20. The Ion Pump is started.
12. Aug 20. The Data Acquisition System is Checked Out.
13. Aug 20 - 28. Cooling is monitored.
14. Aug 28. Operations settings.
15. Aug 29. New observer starts.

Stuff to collect in Preparation for the Steps to Follow

1. LakeShore 340 temperature control unit #3. It lives in a rack in the ASB. The whole rack should be brought to the Nasmyth platform.

2. Special cable that connects LakeShore 340 unit #3 to connector BE-6 on the vessel.
3. Turbo-pump including clamp hardware and wrenches, and special O-ring. The special O-ring is captured in an aluminum centering ring.
4. MKS vacuum gauge.
5. Wrenches for removing FourStar mounting bolts.
6. Replacement ion pump with correct KF-40 flange already installed.
7. A regular vacuum pump with long SSTL KF-40 hose for pumping out ion pump mounting hardware.
8. Circular cardboard cover that can be taped over the front flange of the instrument – used to mitigate against condensation on the front window.

Steps

1. Jul 31 – Aug 3, 2018. Inspect and control both dewar fill levels

In order to start the warmup as expeditiously as possible, it will be important to keep the detector dewar level as low as possible during the last few nights of observing, i.e., July 31 – Aug 2. The shroud dewar should be filled to <20% at the start of the procedure, i.e., Aug 3.

1.2 Keep the detector dewar LN2 supply tank on the platform; it will be needed for topping off the shroud dewar for awhile near the start of warmup.

2. Aug 3. FourStar is disconnected from the telescope and pulled back.

2.1 Close the valve of the shroud dewar LN2 supply tank and move the tank off to the side of the platform or off the platform completely. It won't be needed for many days. The supply line should be disconnected at the instrument end, not the tank end.

2.2 Rotate the guider to the home position of FourStar (-60 degrees).
The main vacuum port should be on the left side as viewed from the lift).

2.3 LOCK OUT THE TELESCOPE MOTION

2.4 Power down FourStar as follows:

2.4.1 Shut down the FourStar GUI running on the control Mac.

Figure 2. Electronics chassis in the 2 racks.

2.4.2 Rack 2: Turn off the Ion Pump (Vacion Controller) if it is on.

2.4.3 Rack 2: Turn off the LN2 Process Controller.

2.4.4 Rack 2: Turn off the Windows PC's by holding the power button for 2 seconds. This will cause a proper shut down.

2.4.5 Rack 1: Turn off the Windows PC's by holding the power button for 2 seconds.

2.4.6 Rack 1: Turn off both of the JADE power supplies (1/2 and 3/4).

2.4.7 Rack 1: Turn off the Motor Controller.
2.4.8 Check that the Nasmyth Mac on the FourStar cart is unplugged. Note: a green light is visible when there is power to the Mac - this does not mean the Mac is running and it is safe to unplug. If the light on the power button is on then the Mac is running. It can be powered off quickly by holding the power button until it powers off, then unplug it.
2.4.9 Make sure the main vessel power cable is disconnected.
2.4.10 Disconnect the Glycol lines at the quick-connect interface.
2.4.11 Disconnect the 24V autofill solenoid cable; P14 on rack 2.
2.4.12 Disconnect the (2) labeled fiber optics cables from rack 2.
2.4.13 Close valve 1 of the ion pump; see Fig. 8.

2.5 Pull FourStar back from the Telescope
2.5.1 Note that the motion away from the telescope is provided only by the four ball transfer units on the cart. It is not necessary to lower the cart wheels so as to be able to push FourStar around on the platform.
2.5.2 Mount the front support plate. This is the fixture with the two red hard plastic wheels.
2.5.3 Engage front wheel support by pulling the pin near the red handle and pulling the red handle.
2.5.4 Remove the 12 bolts from the front flange of FourStar / conical adaptor interface. Remove the dowel pins that locate the front flange of FourStar to the conical adaptor.
2.5.5 Release the 4 cart clamps (red-handles) and pull the instrument back 1 inch. It will roll within the four ball-transfer units.
2.5.6 Re-engage the 4 clamps.
2.5.7 Tape the temporary cardboard circular cover over the front flange of the instrument and make sure there is a flow of dry air from the platform supply entering the volume just in front of the window. This is important to reduce condensation on the window.
2.5.8 Dress all the supply lines that were removed to the guider wrap to prevent damage. **Make sure there are no interferences between the instrument rotator and FourStar**.

2.5.9 REMOVE TELESCOPE LOCK OUT.

2.6 Connect utilities for monitoring

Connect the platform air supply hose, the platform glycol lines, the platform power and the fixed platform fiber-optics to perform diagnostics on FourStar. Figure 3 shows the normal operating configuration. For the warmup, cable 1 from the platform Junction box will bypass the guider wrap and plug directly into the FourStar rack. Cable 2 doesn't matter as the Nasmyth Mac will not be used in the warmup.

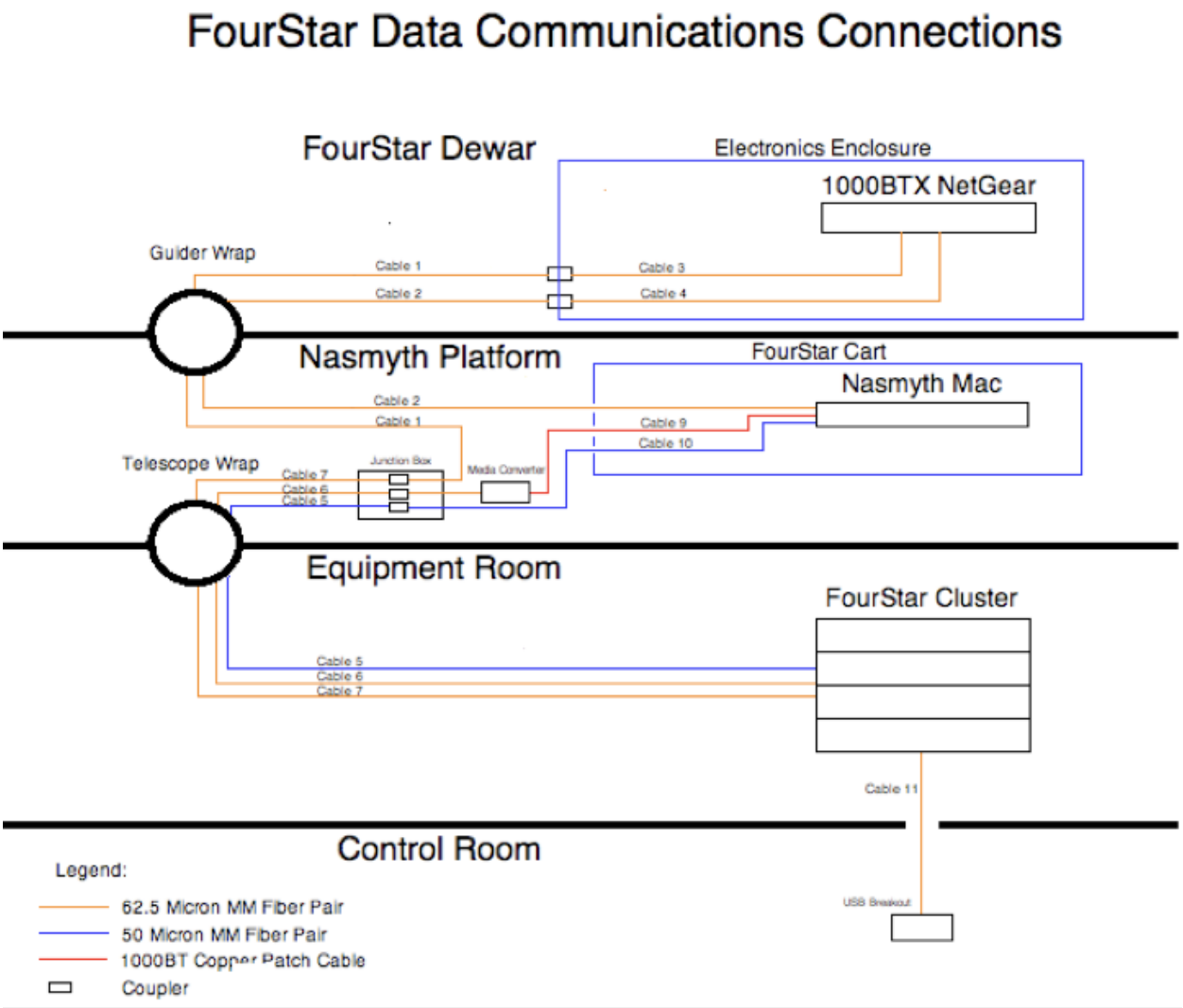


Figure 3. Data communications block diagram – normal operation.

3. Aug 3. Turbo-pump is connected and pumping commences.

WARNING: HIGH RISK. The safety cover is normally (always) over the vacuum gate valve as shown in Figure 4. This cover is in place to prevent the gate valve from accidental opening and to protect the O-ring surface from scratches. In the following operation the safety cover will be removed to allow pumping on the vessel interior.

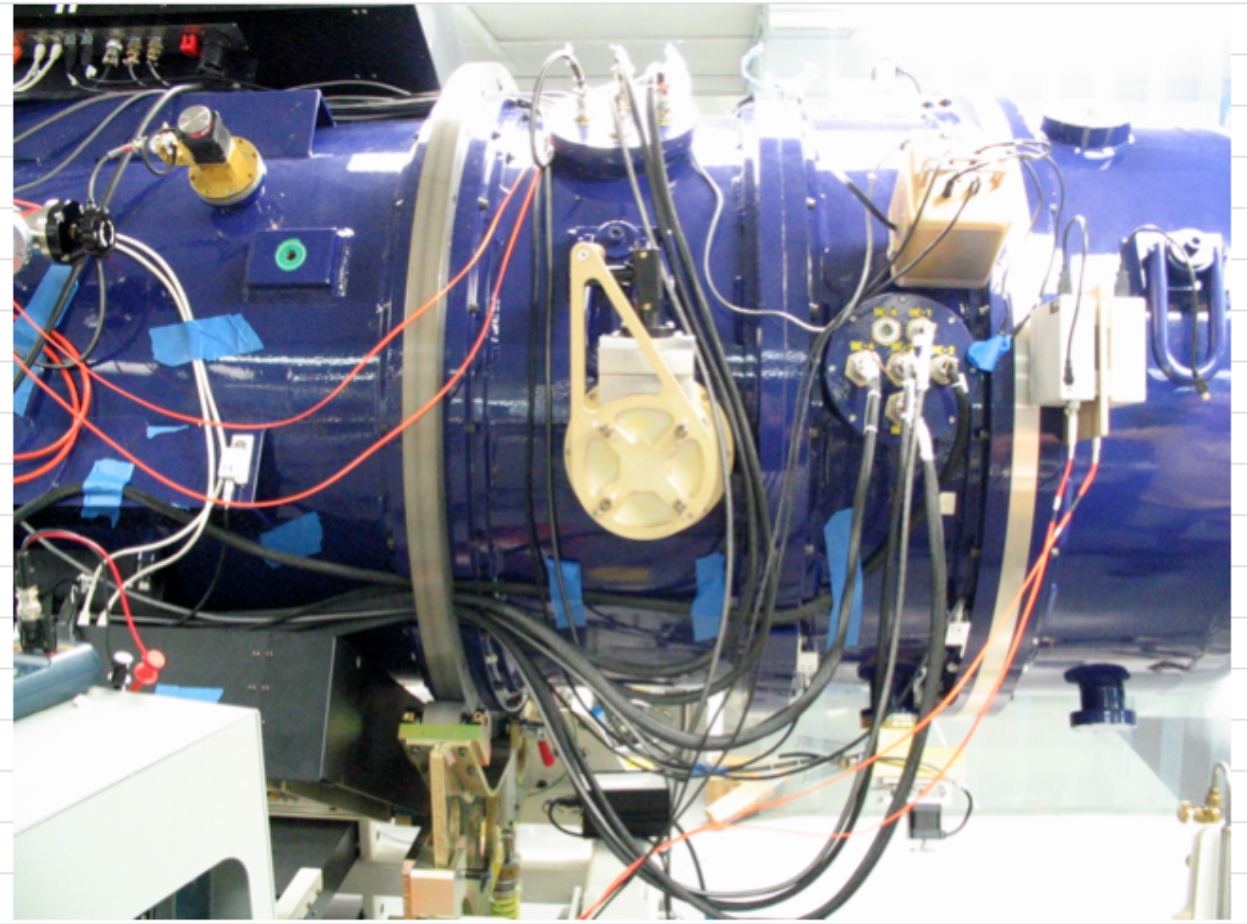


Figure 4. The main FourStar Vacuum port with the (gold-colored) safety cover in place.

3.1 Plug in and check function of the MKS vacuum gauge located under the FourStar cart to monitor the internal pressure.

3.2 FourStar should already be rotated so that the main vacuum port is accessible (the home position), i.e., to the left (9:00 PM) if you are facing the telescope.

3.3 Carefully remove the safety cover over the main vacuum port using the thumb-screws.

3.4 Maneuver the vacuum pump into place. Using the bolts and Kwik-flange O-ring secure the pump to the main vacuum flange. Note: the screws, wrench, and kwik-flange O-ring should all be located and kept with the vacuum pump cart. **KEEP THE MAIN GATE VALVE CLOSED!**

3.5 Start turbo-pump as follows:
3.5.1 Plug in the Vacuum cart using the power trip box and start the turbo pump. The power trip box is described in 3.5.2.

The main control panel is shown in Fig 5. Press the Start/Stop button to start. The scroll pump will rough out the volume up to the gate valve until a fan speed of 58K rpm is reached, at which point the turbo pump will start operating. The rough vacuum is monitored with a thermocouple gauge and is displayed on the front panel in the TC1 box. The high vacuum Ion Gauge (IG) display will show "OFF". Once a high vacuum is reached (58K rpm) the EMIS button can be pressed and after a minute a high vacuum reading will be displayed. The use of this gauge should be kept to a minimum; turn it off by pressing the EMIS button again.

Figure 5. Turbo-pump control panel.

3.5.2 Power-trip Box

If power is lost to the turbo pump while attached to the vessel a valve in the pump will close to prevent backfill into the vessel. This safety valve is normally closed and opens when the pump is powered. However, it takes a moment for the pump to reach a good vacuum. Thus for a moment when power is restored there is some backflow which is bad. To prevent this, a trip box is used that does not restore power to the pump until it is reset. This allows closing the main Gate valve to the vessel before allowing power to return to the pump. The pump can then 'pump on itself' until a good vacuum is obtained and then the main Gate valve to the vessel can be opened. See Figure 6.

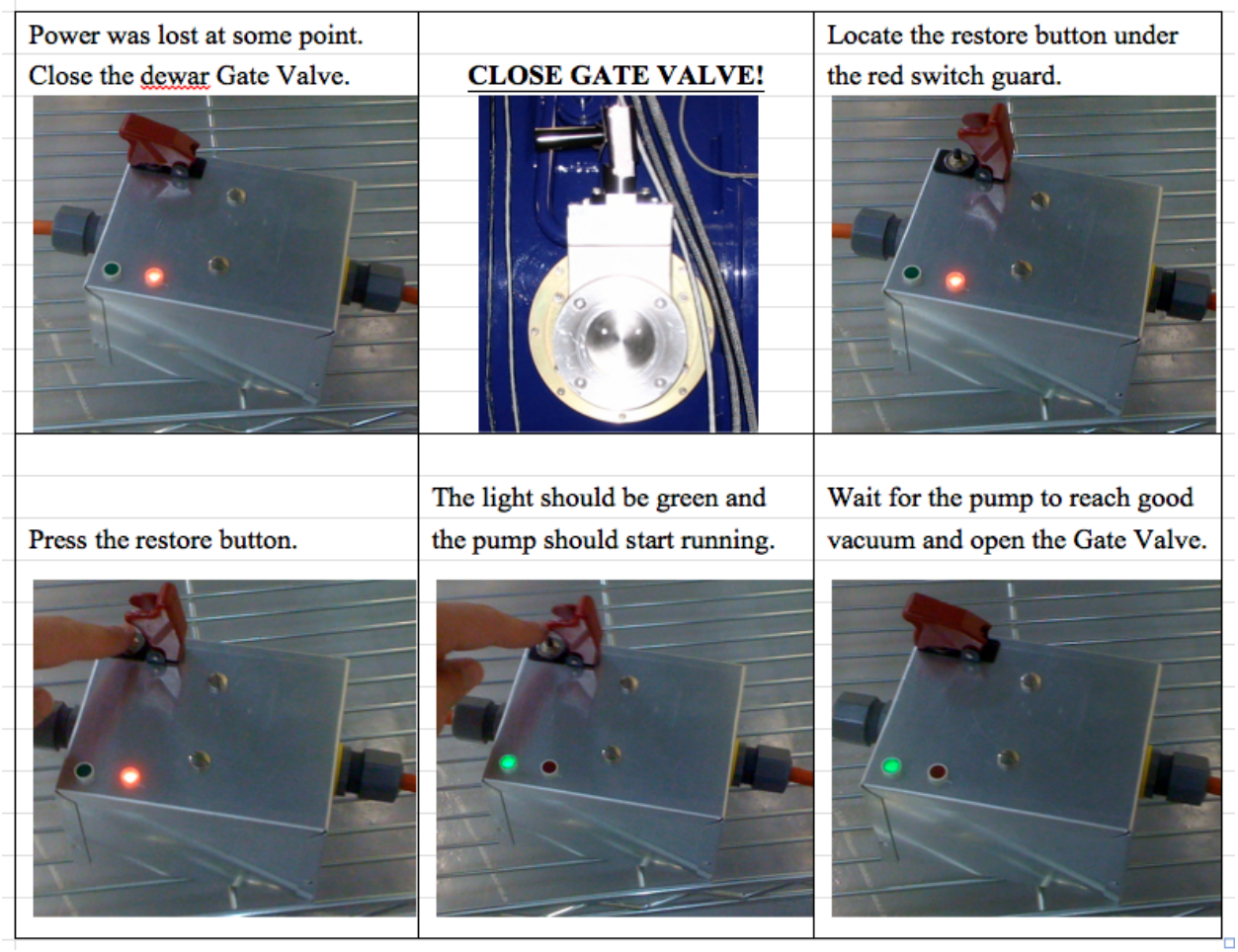


Fig. 6. Power trip box and steps to restart turbo-pump

3.5.3 - **Main Gate Valve** - **USE EXTREME CAUTION**

Once the Turbo-pump has reached a better vacuum than the MKS gauge then the Main Gate Valve can be opened. If this condition is not reached easily, then something is wrong with the turbo-pump or its connection to the vessel. If there is any doubt about this, call contact Persson.

The interior of the vessel will now warm up passively. The turbo-pump will be pumping on the vessel continuously until Aug 19.

4. Start Temperature Monitoring and Control

The internal temperatures will be monitored and controlled henceforth.

4.1 Connect main rack power cable and turn on.
4.2 Power on the two LakeShore controllers, the Netgear switch, and the process controller.
4.3 Position the lab electronics rack on the platform so that the special warmup cable can be plugged into connector BE-6 on the vessel. The other end plugs into the spare (or third) Lakeshore temperature controller (LS340 #3 in the rack that was brought over from the cleanroom) – one signal cable and one BNC.
4.4 Power up the third LakeShore controller.

4.5 Start the FourStar software on the control Mac, selecting the functions shown in Fig 7. It should be most convenient to do this sitting in the equipment room and using the monitor in the main rack there.

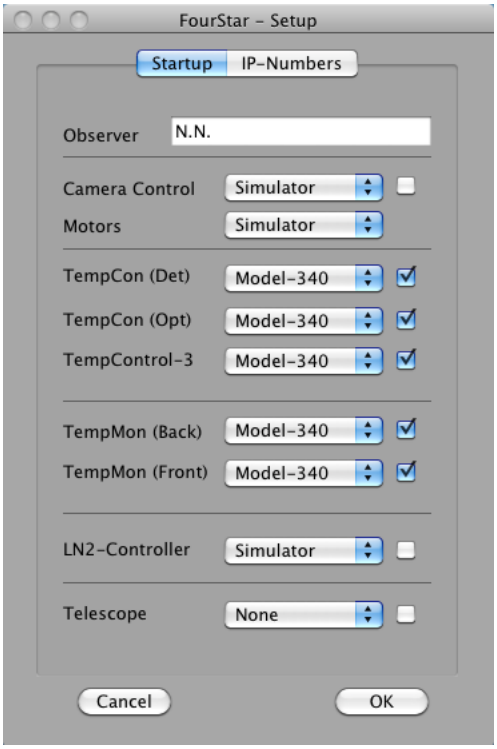


Fig. 7. Setup screen for Warmup and Bakeou*t.* The LN2-Controller should be set for Pass-Through.

5. Aug 3 – 9 Warmup of vessel interior; bakeout starts

5.1 Phase 1

Do manual partial fills of the shroud dewar to keep its level at ~15%. In this phase residual LN2 in the detector dewar will be boiled off, and the detector temperature will be raised 20K (from 80 to 100). Use the following settings on the controllers:

Temperature Controller Settings - Phase 1

Controller name	Detector	Optics	Shroud
Label	TC1	TC2	TC3
Target	100	220	77
Max (K/min)	0.02	0.02	--
Range	5	25	48
Meta	On	On	On

After some number of hours, which will depend on how empty the detector dewar actually was, phase 2 will begin when the detector temperature is 100 K. At this point the shroud dewar should be empty or nearly so.

Phase 1 should take ~24 hours, with large uncertainty.

5.2 Phase 2

Phase 2 begins when the detector reaches 100 K. Stop keeping the shroud dewar at 15% filled. Use the following settings on the controllers:

Temperature Controller Settings - Phase 2

Controller name	Detector	Optics	Shroud
Label	TC1	TC2	TC3
Target	280	290	300
Max (K/min)	0.04	0.02	0.04
Range	5	25	48
Meta	On	On	On

It is uncertain how long Phase 2 will take, probably ~70 hrs.

6. Aug 9 - 17. Bakeout at 300 K. The ion pump is replaced

There is little to do except monitor the temperatures and pressure. The detector temperature may start to creep up towards 300 K. Persson and Birk will be watching this and may ask for a lower Shroud target value.

In order to protect the detector from a thermal accident, shut off the detector heater by using the following settings on the controllers:

Temperature Controller Settings - Bakeout

Controller name	Detector	Optics	Shroud
Label	TC1	TC2	TC3
Target	280	290	300
Max (K/min)	0.04	0.02	0.04
Range	Off	25	48
Meta	Off	On	On

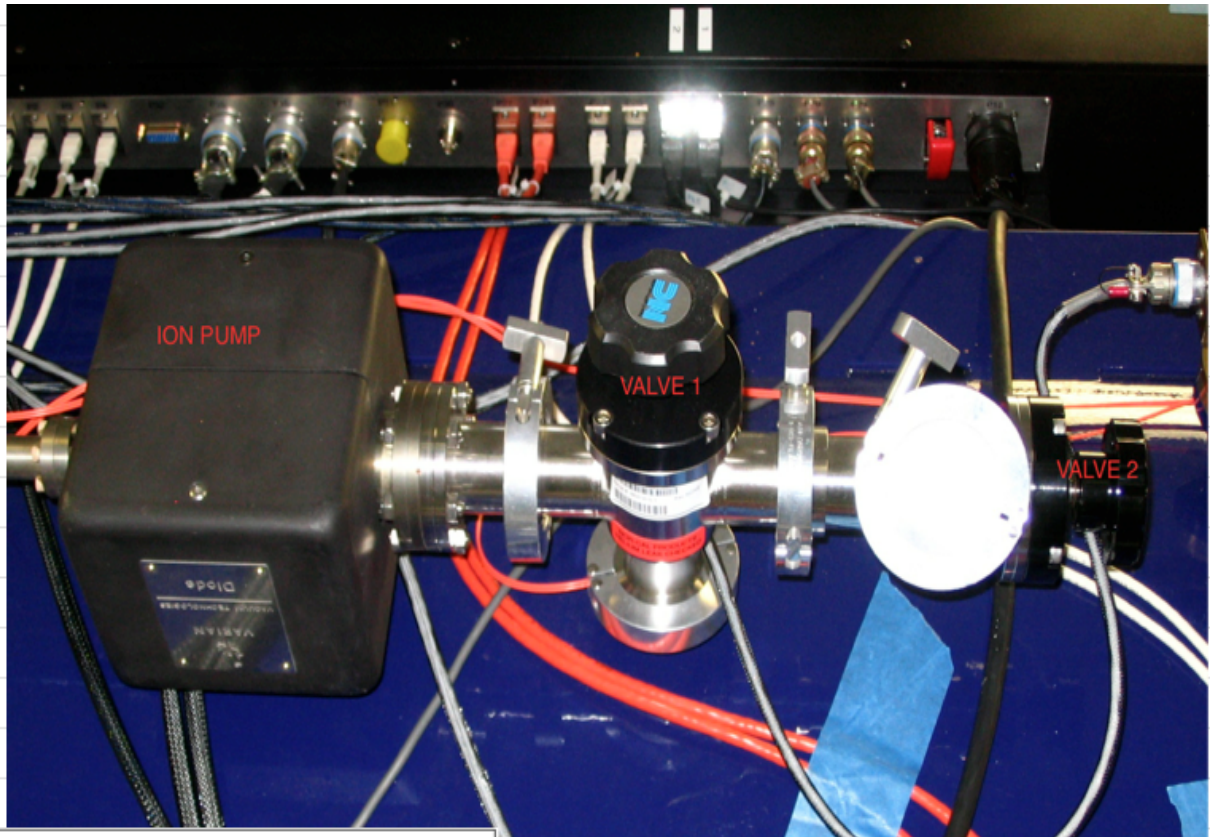
Replace the ion pump if a fresh one is available.

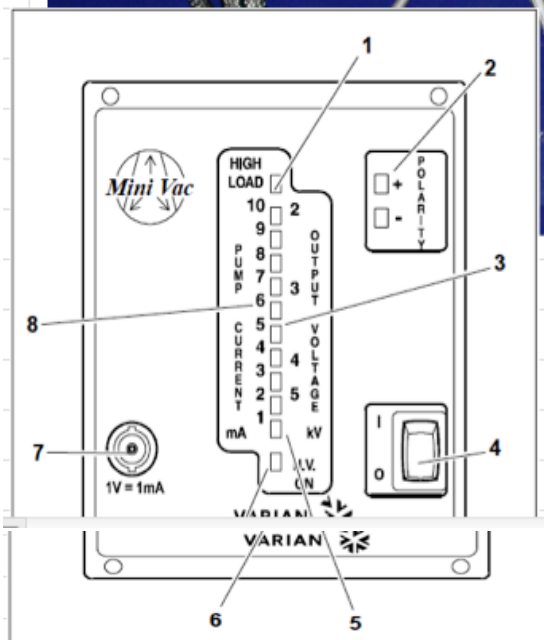
This can be done anytime in this period, but earlier is better in case any questions should arise.

6.1 **CAUTION, The Ion Pump is a high Voltage Device**

The Ion Pump is a sensitive piece of hardware that requires special attention and is not included in the general power-up sequence.

One of the spare ion pumps should be prepped as described below, before the current ion pump is replaced.





1. High Load LED, comes on when the current absorbed by the pump reaches 12 mA
2. Output selected polarity LED
3. Output voltage scale (KV)
4. Main ON/OFF switch
5. Voltage/current LED scale
6. H.V. LED ON
7. Output connector of the sSignal proportional to the current 1 V= 1 mA log
8. Current scale (mA)

Fig. 8. Ion pump and associated vacuum valves 1 and 2.

6.2 **Prepping the Spare Ion Pump**

There are 3 Ion pumps. The one attached to FourStar is definitely somewhat contaminated by now. The other 2 pumps should remain factory sealed until needed. Once needed, the factory sealed conflat (CF) fitting needs to be removed and replaced with a conflat to kwik-flange (CF to KF) adapter. This will result in breaking the factory seal and loss of vacuum so it should only be done just prior to replacement. The spare is now ready to be installed on FourStar. The contaminated ion-pump should be marked as such and sent back to Pasadena ASAP for refurbishment. Its CF to KF adapter should be removed and kept at LCO.

6.3 Check that the Vacion controller is off (it should have been turned off in step 2). Disconnect the high voltage cable from the Ion Pump.

6.4 Check that Valve 1 is closed (it should have been closed in step 2). When (eventually) powered on the Ion pump will immediately evaporate anything on its coils, thus to prevent contamination of the rest of the system the ion chamber is initially isolated.

6.5 Remove the KF fitting and blankoff cover from Valve 2. This takes a little force as it is under vacuum. Then, open Valve 2. This will make the next step easier.

6.6 Remove the Ion Pump at the KF fitting, and replace it with the prepared spare.

6.7 Attach a vacuum pump to Valve 2 (which must be open) and pump out the short section of pipe between Valve 2 and the new Ion Pump.

6.8 Close Valve 2 and replace the cover using the KF clamp.

6.9 Reconnect the high voltage cable to the new ion pump.

7. Aug 18 - 19. Start of Cooldown. The Shroud Dewar is cooled with LN2.

7.1 Both tanks should start off at ambient temperature. The turbo-pump should be pumping on the vessel and the ion pump off. **At no point during the cooldown should the shafts that connect motors to inside mechanisms be operated manually or under motor control**. Disconnect the special cable from BE-6 and remove the rack with LS340 #3 from the platform.

It is **important** that the **JADE power** be **off** during cooldown to avoid *trapping charges* in the H2RG arrays.

7.2 Start up the FourStar software selecting just the Detector- and Optics-Temperature controllers, Front- and Back-Temperature monitors, and LN2-Controller as shown in Fig 9.

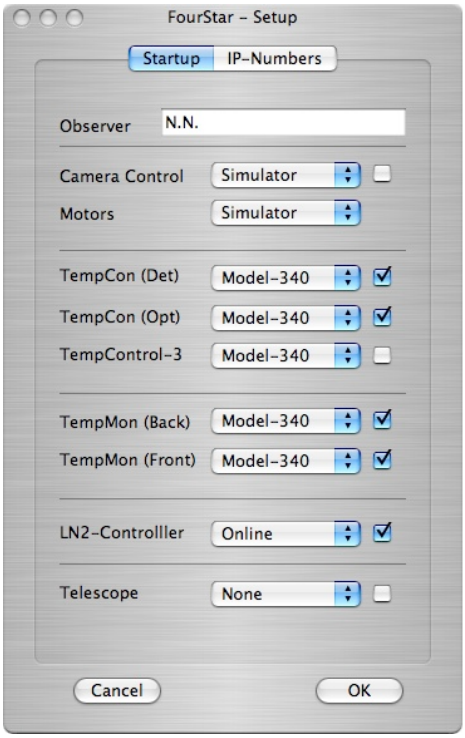


Fig. 9. Setup screen for cooldown.

Use the following settings for the temperature controllers:

Temperature Controller Settings for Shroud Dewar Cooldown

Setting	Detector	Optics
Label	TC1	TC2
Target (K)	75	199
Max(K/min)	0.4	0.02
Range (W)	Off	Off
Meta	On	On

7.3 The cooldown should start on Aug 18 (Saturday), with the critical steps not taking place until Aug 20. All that needs to happen on Aug 18 - 19 is that the shroud dewar be filled. **Do not fill the Detector Dewar.** Commence filling the shroud dewar manually from the large supply tank. Do not blast the interior of the shroud dewar with a powerful jet of LN2. Go slowly, i.e., top off the dewar about once an hour for several hours, then once every two hours, etc. This process can take at least a day.

7.4 Reattach a fresh shroud dewar supply tank and start up the LN2 controller software in auto-fill mode. Open the supply tank valve. The auto-fill system should now keep the shroud dewar filled while it is consuming LN2 at a high rate during cooldown. It is important that when the auto-fill system is first operated the supply tank be very full because it has to last the night.

8. Aug 20. The detector dewar is filled with LN2.

8.1 **Before** starting to fill the detector dewar you **must set** the *Detector Temp.Controller Range* to **50** [W]. This is also a good time to set the *Optics Temp.Controller Range* to 25 [W].

Temperature Controller Settings for Detector Dewar Cooldown

Setting	Detector	Optics
Label	TC1	TC2
Target (K)	75	199
Max(K/min)	0.4	0.02
Range (W)	50	25
Meta	On	On

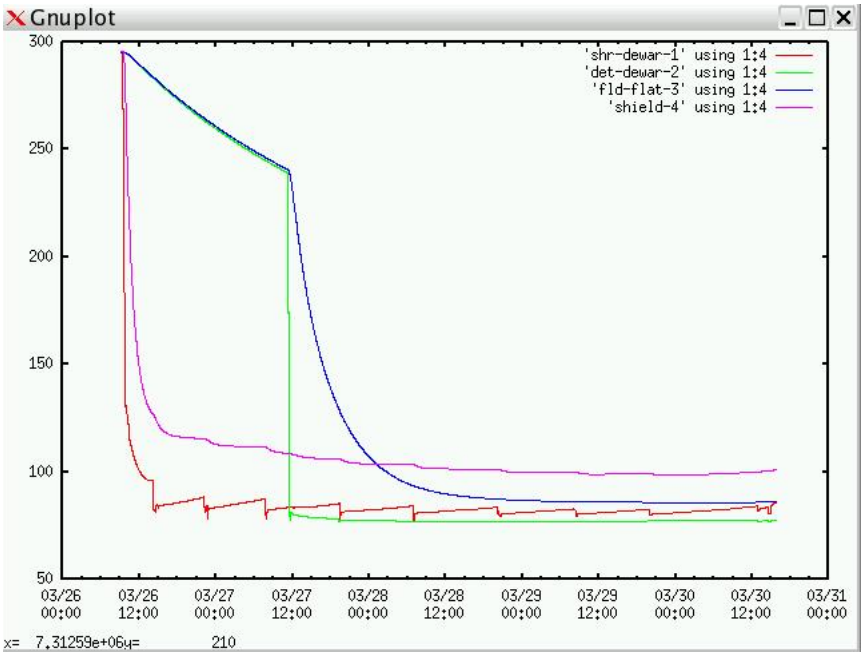
8.2 **Note**: The system must be under **constant supervision** during the detector dewar cooldown. This procedure takes about 4-6 hours, so please plan ahead.

8.3 Start filling the detector tank, while keeping an eye on the *Detector Heater* output. If the heater output starts oscillating then:
1. stop filling the tank and
2. set the *Target* temperature of the *Detector Temp.Controller* to the current temperature until the system stabilizes.
Filling the detector tank slowly during the first fill minimizes the likelihood of oscillations.

8.4 Once the *heater* output goes below 15% switch the *heater range* to 5 [W].

8.5 After about 5 hours the cooldown rate will be slowing down to a point where the heater will be effectively off, so switch the *Range* to the *off* position and let the detector temperature drift during the remainder of the cooldown procedure. Once this point is reached it is sufficient to only check the system status every few hours to ensure the dewars are not running out of LN2.

8.6 The diagrams below (Fig. 10) show a typical cooldown:



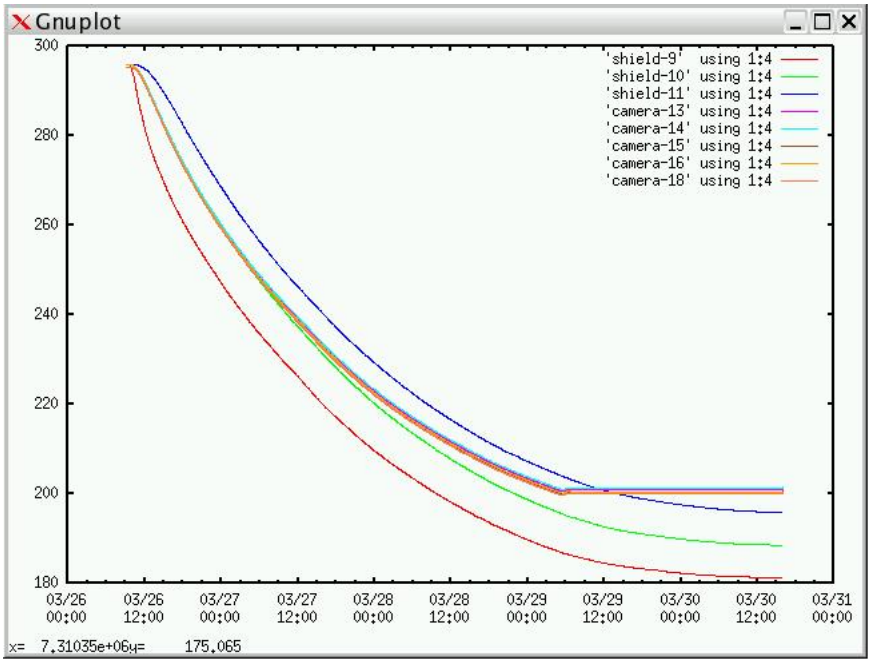


Fig. 10. Typical cooldown curves. Note the detector module is *not* shown.

8.7 Once both tanks are cold turn-on the *Ion-pump*.

8.7.1 Turn on the Vacion Controller located in Rack 1. The LED scale should light up to full scale.

8.7.2 In approximately one minute the LED scale should drop to below half scale. This means the Ion Chamber has successfully been pumped out and it is now okay to open Valve 1.
8.7.3 The Ion pump will report an independent Vacuum reading to the FourStar display GUI.

9. Aug 20. The turbo pump is disconnected.

9.1 **CAUTION** – this is a critical operation.

9.2 **Close the Gate valve** – see Figures 4 and 6.

9.3 Turn off the turbo-pump and wait a few minutes for it to spin down.

9.4 Turn off the power trip box.

9.5 Remove the clamps around the hose/o-ring/port junction and gently pry open to allow a little air to despin the turbo the rest of the way to 0 rpm.

9.6 Pull the turbo-pump cart back from the vessel.

9.7 Install the safety fixture so that the gate valve cannot be inadvertently opened. See Fig 4.

10. Aug 20. FourStar is reattached to the Conical Adaptor

10.1 Rotate the guider to the home position of FourStar (-60 degrees) as described in 2.2.

10.2 LOCK OUT THE TELESCOPE MOTION.

10.3 Remove the cardboard cover from the front flange. Release the 4 cart clamps (red-handles) and push the instrument forward until it makes contact.

10.4 Use the dowel pins (located in the drawer of Cart 1) to align the front flange of FourStar with the Conical Adapter.

10.5 Bolt FourStar to the conical adapter using the screws and tools located in the drawer of Cart 1.

10.6 Disengage front wheel support by pushing the red handle. There is a captured pull-pin that must be pulled in order to retract the handle. The red wheels should drop.

10.7 Remove the front support plate. This is necessary to provide clearance for the supply lines. There are 4 bolts on each side. The appropriate black hand-wrench is located in the drawer of Cart 1.

10.8 Feed the guider air supply hose through the conical adapter and turn on the flow of dry air.

10.9 Connect the guider wrap cables and lines to the instrument. Connect the (2) labeled fiber optics cables to rack 2. See Fig. 3.

10.10 Connect the 24V autofill solenoid cable; P14 on rack 2.

10.11 Connect the Glycol lines at the quick-connect interface.

10.12 Connect the main power cable to the main power bus on FourStar.

10.13 REMOVE TELESCOPE LOCK OUT.

11. Aug 20. The Ion Pump is Started

11.1 Turn on the Vacion Controller located in Rack 1. The LED scale should light up to full scale.

11.2 In approximately one minute the LED scale should drop to below half scale. This means the Ion Chamber has successfully been pumped out and it is now okay to open Valve 1. Do that.

11.3 The Ion pump will report an independent Vacuum reading to the FourStar display GUI.

12. Aug 20. The Data Acquisition System is Checked Out.

See section 4 (title: Instrument Specialist's Cookbook) of the Full Version of the FourStar Documentation at

http://instrumentation.obs.carnegiescience.edu/FourStar/Documents/FourStar_Documentation.pdf

13. Aug 20 - 28. Cooling is monitored.

Christoph and Eric will be keeping an eye on things during this period.

14. Aug 28. Operations Settings.

14.1 On about Aug 25, the optics temperature will have reached 199 K and the *Optics Heater* will have started controlling the temperature of the optics barrel. On Aug 25 adjust the *Target* temperature of the *Optics Temp.Controller* to 200. The operational temperature for the detector is 80 [K] with a *Detector Heater Range* of 0.5 [W]. Make sure the settings are as shown in the table below on Aug 27.

Temperature Controller Settings for Operations

Setting	Detector	Optics
Label	TC1	TC2
Target (K)	80	200
Max(K/min)	0.1	0.02
Range (W)	0.5	25
Meta	On	On

14.2 If possible, inspect stellar images on Aug 27 and/or 28. They should be in good focus.

15. Aug 29. New observer starts.