

Hectospec Observers Reference Manual

Oct 2007

Daniel Fabricant

Nelson Caldwell

***NOTE: THE SECTIONS ON POSITIONER OPERATION HAVE NOT YET BEEN
UPDATED***

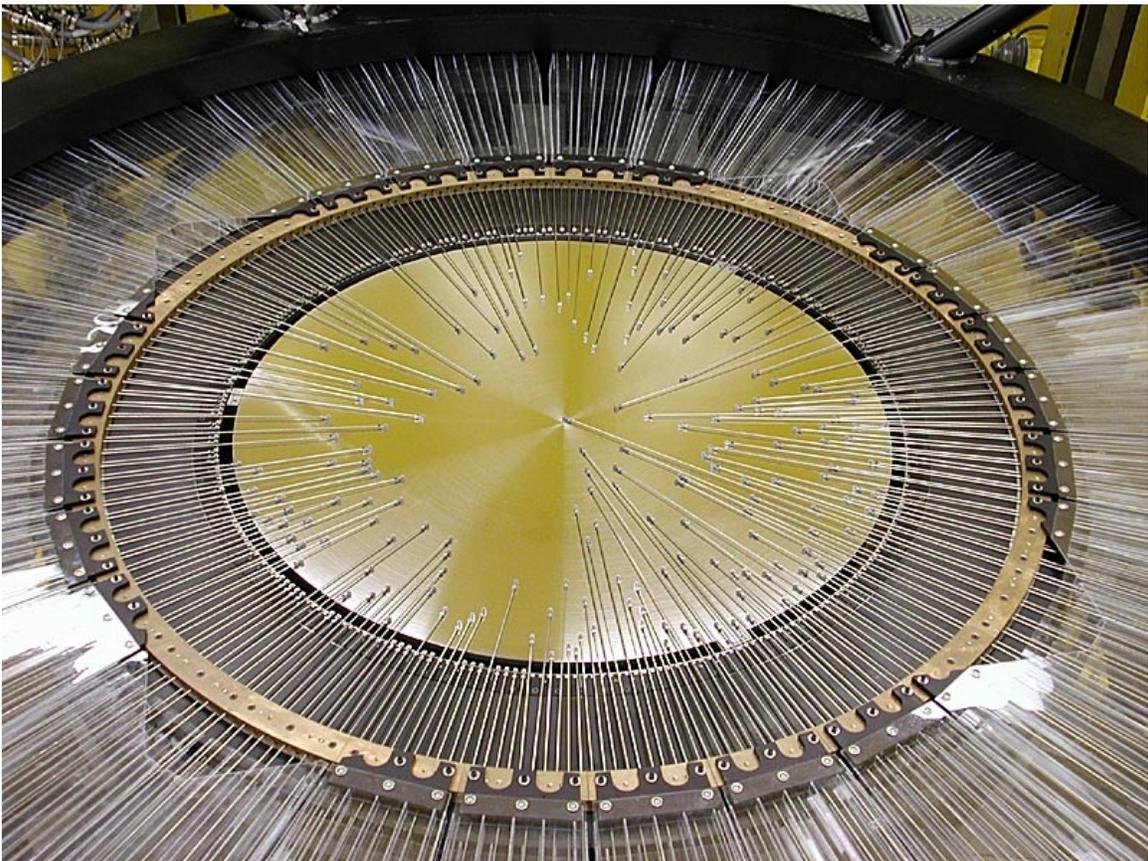


Figure 1. Hectospec focal surface.

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1 INTRODUCTION

The Hectospec is a multiobject, moderate-dispersion spectrograph that uses a pair of six-axis robots to position 300 optical fiber probes at the $f/5$ focus of the converted MMT. The converted MMT's $f/5$ focus uses a refractive corrector designed by Harland Epps to provide a 1° diameter field optimized for fiber-fed spectroscopy. The Hectospec consists of three major parts: (1) the fiber positioning unit that is mounted on the telescope, (2) a large stationary spectrograph mounted on a 1.8x3.7 m Invar-surfaced optical bench and (3) a 26 m-long bundle of optical fibers connecting the fiber positioner and spectrograph.

The fiber robots position 300 fibers in 300 s to an accuracy of $\sim 25 \mu\text{m}$. Each fiber has a core diameter of $250 \mu\text{m}$, subtending $1.5''$ on the sky. Adjacent fibers can be spaced as closely as $20''$, but the positioning constraints are complicated due to the tube extending from the fiber button to the edge of the focal surface.

Currently we possess a 270 line mm^{-1} grating blazed at $\sim 5000 \text{ \AA}$ and a 600 line mm^{-1} grating blazed at $\sim 6000 \text{ \AA}$. The efficiency curves are shown in Figures 2 and 3.

The detector array consists of two butted EEV CCDs, each with 2048 (spatial dimension) by 4608 (wavelength dimension) pixels. The gap is parallel to a dispersed spectrum. With the 270 line mm^{-1} grating the spectral coverage is 5770 \AA , with a dispersion of $1.21 \text{ \AA pixel}^{-1}$. The image FWHM is slightly less than 5 pixels, or $\sim 6 \text{ \AA}$. The fibers are mounted in two rows; images of even and odd fibers are separated by ~ 30 pixels (in the wavelength direction) at the detector.

Most of the information in this document is for the benefit of the observing staff and the SAO and MMTO personnel responsible for operating the instrument. **The astronomer's duties are limited to preparing the robot configurations for observing and taking data with the bench spectrograph.** MMTO and SAO staff will prepare the spectrograph for observing and will fill the dewar.

2 FITTING FIBERS TO TARGETS

2.1 HECTOSPEC ROBOT TV GUIDERS AND GUIDE PROBES

The ease with which the fibers can be initially aligned with respect to the observation targets and the accuracy with which they are kept aligned will affect the overall observing efficiency with Hectospec. Hectospec is guided with at least two guide stars at all times to measure instrument rotator errors as well as telescope altitude and azimuth pointing errors. To avoid occulting prime observing real estate, guiding is performed with three independently actuated probes at the circumference of the focal surface. The probes move along three 86° arcs and each contains relay optics to carry the guide star image to coherent fiber bundles. The three coherent bundles form a trifurcated assembly; the three bundles are brought together to form a single bundle at the input to an intensified CCD guide camera. Because a single guide camera views all of the guide stars, keeping the guide star brightness matched within ~ 1 magnitude is highly desirable.

In addition, each fiber robot carries an intensified CCD camera that is capable of simultaneously viewing a target object and a backlit fiber through a beam splitter. This feature was introduced on the Argus multi-object spectrograph at CTIO. After the fibers are positioned for a given observation, the gripper heads will be sent to the intended position of the guide stars and the rotation and pointing errors of the telescope will be removed. The guide stars will then be acquired in the coherent bundles and guiding can begin. If desired, the gripper heads can then be commanded to one or more target objects and the alignment can be checked with reference to a backlit fiber.

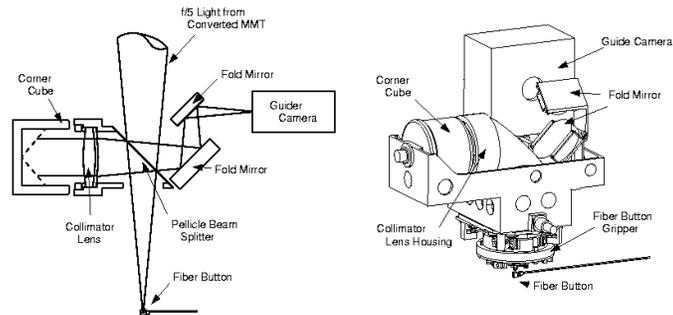


Figure 2. Robot TV guiders that can view the sky and backlit buttons simultaneously.

The guide cameras, manufactured by Electro-Optical Services, Inc., use Gen III image intensifiers with maximum gains of 70,000 and quantum efficiencies of >20% from 4250 to 8750 Å. The camera receiving the trifurcated coherent bundle has its image intensifier photocathode deposited on the back surface of its fiber optic input to avoid defocusing at the photocathode. The image intensifiers are coupled through a reducing fiber optic (1.6:1 ratio for the robot cameras and 2.3:1 for the guide camera) to a 768x493 pixel CCD (each pixel is 11 by 13 μm). The cameras in the fiber positioning robots have a field of view of ~60"x80", while the three coherent bundle guiders each have a field of view of ~30"x 60".

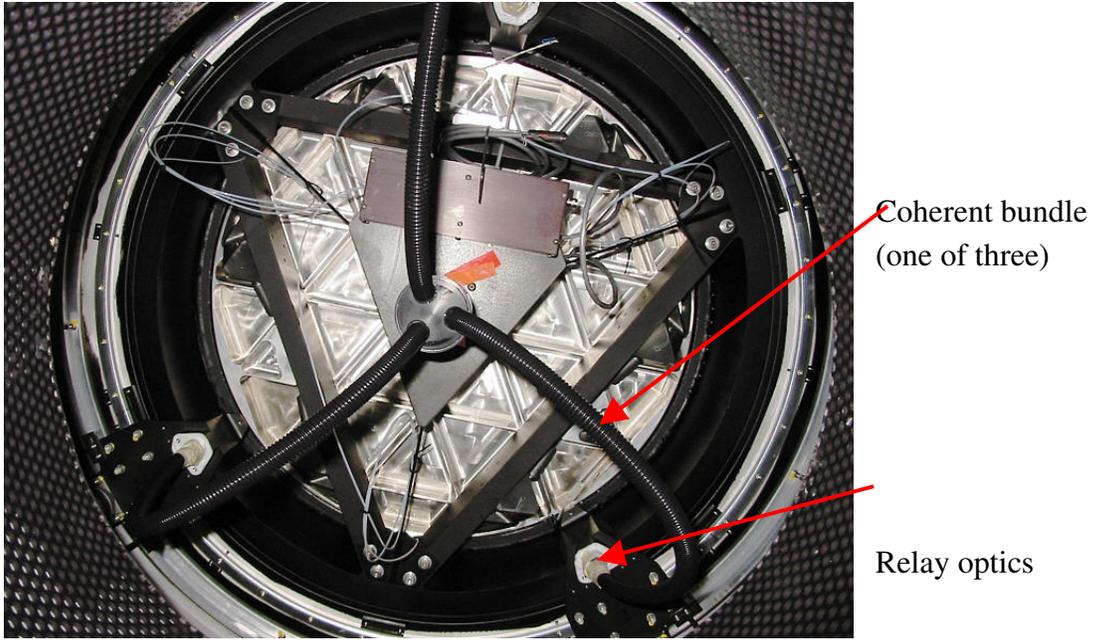


Figure 3. Photo of trifurcated coherent bundle and guide probes from beneath the focal surface.

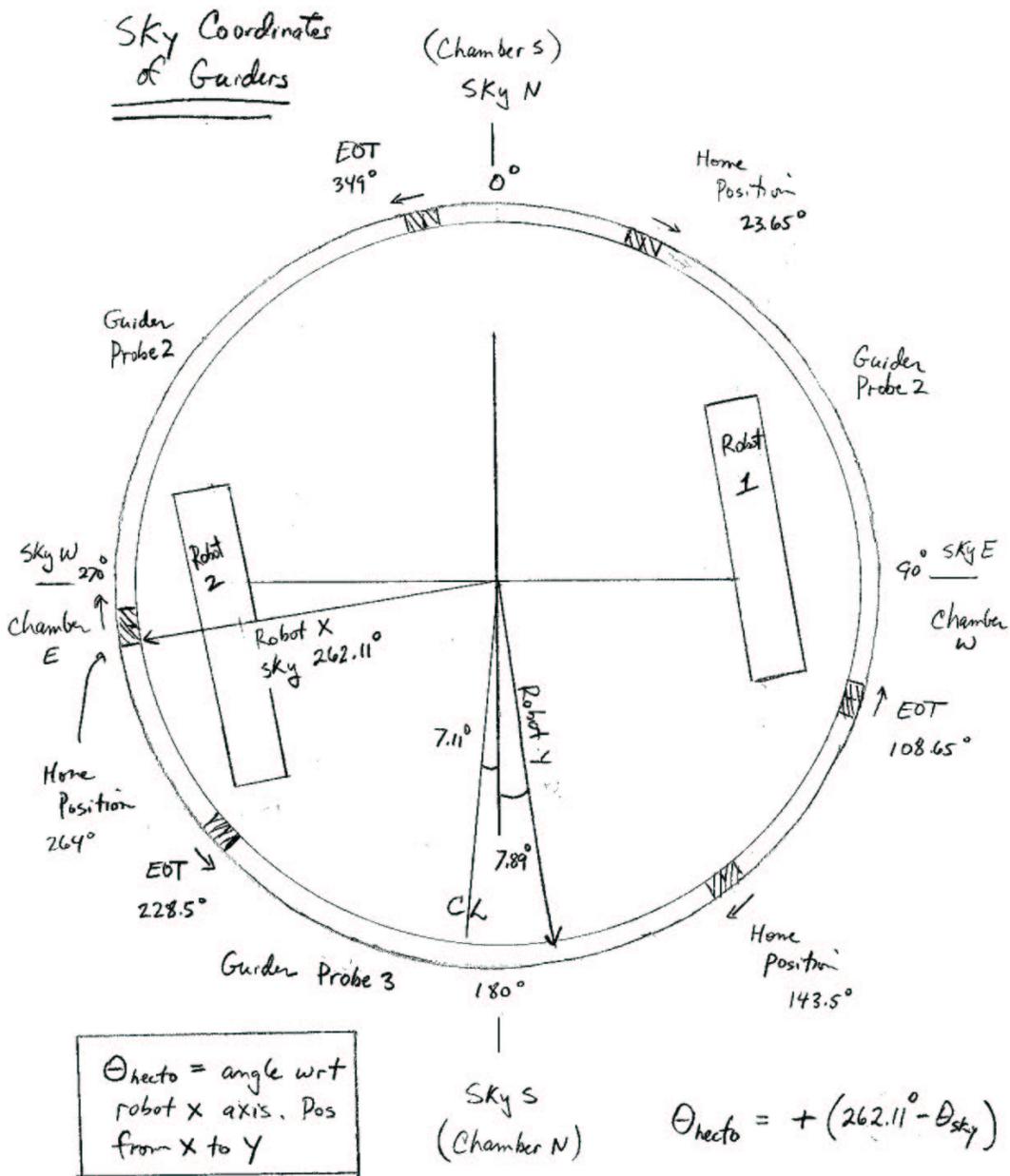
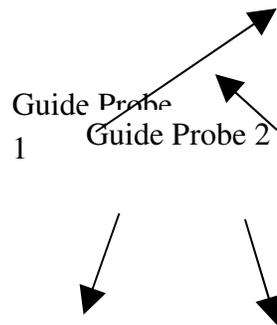
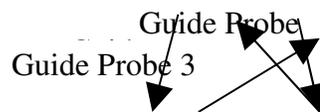


Figure 4.



Guide Probe 3

Position of robots and guiders with respect to sky when rotator angle is 0°.



Hecto Coordinates of Guiders

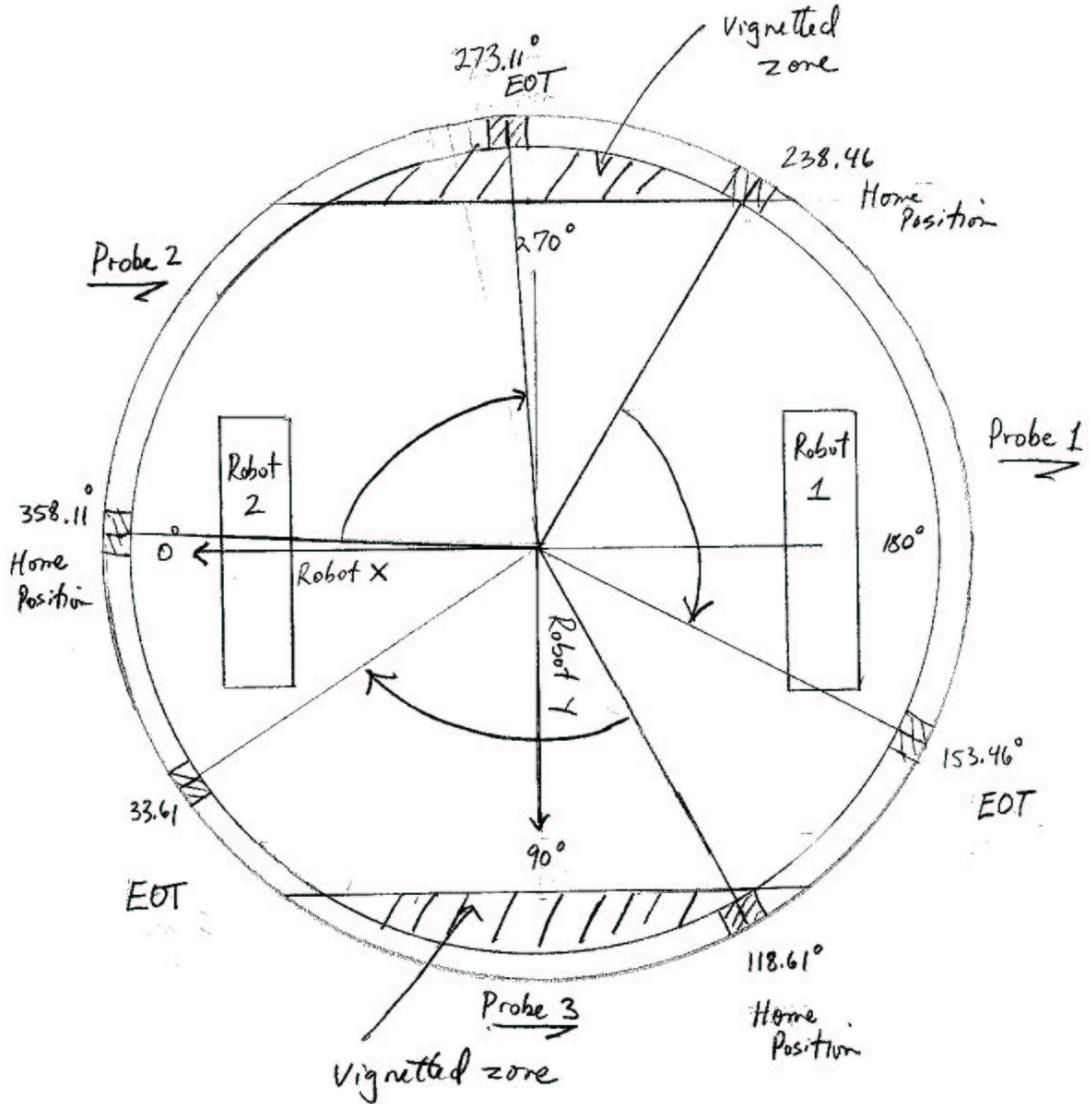


Figure 5. Position of robots and guide probes in Hectospec specific coordinates.

Guide Probe 1

Guide
Probe 2

2.2 MINIMIZING ROTATOR ANGLES

The instrument rotator must track the changing parallactic angle, and the parallactic changes rapidly as a target with a declination near the MMT's latitude (31.689°) transits. (The parallactic angle is the angle between two line segments originating from the target position, one pointing at the pole, the other at the zenith.) We wish to maintain rotator angles between $\pm 45^\circ$ to minimize wear and tear on Hectospec's electrical cables and optical fibers. We have hard limits set near $\pm 100^\circ$ but we don't wish to exercise these limits. Please plan accordingly by breaking up observations into a rising and setting segment if necessary. In any case, the rotator tracking errors increase to an unacceptable level within about 15-20 minutes of transit for targets with declinations within a few degrees of the MMT's latitude. If your target is north of $+50^\circ$ declination or south of $+15^\circ$ declination, you generally do not have to worry about excessive changes of rotator tracking angles unless your exposure exceeds 2 hours in length. **You do always need to be sure that guide stars are available for a rotator angle near 0° at the time of observation regardless of the declination.**

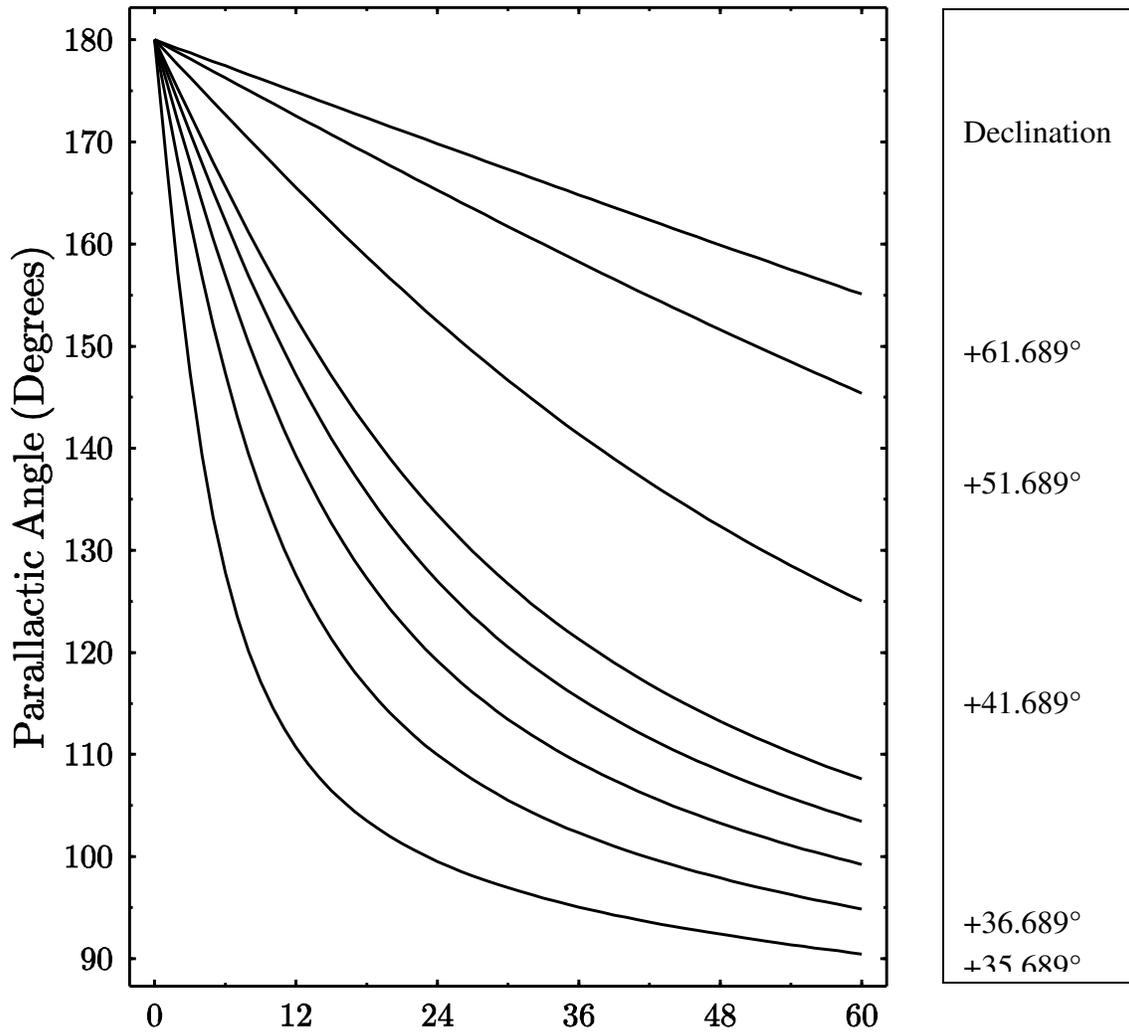


Figure 6. The parallactic angle as a function of time in minutes past transit for Northern targets.

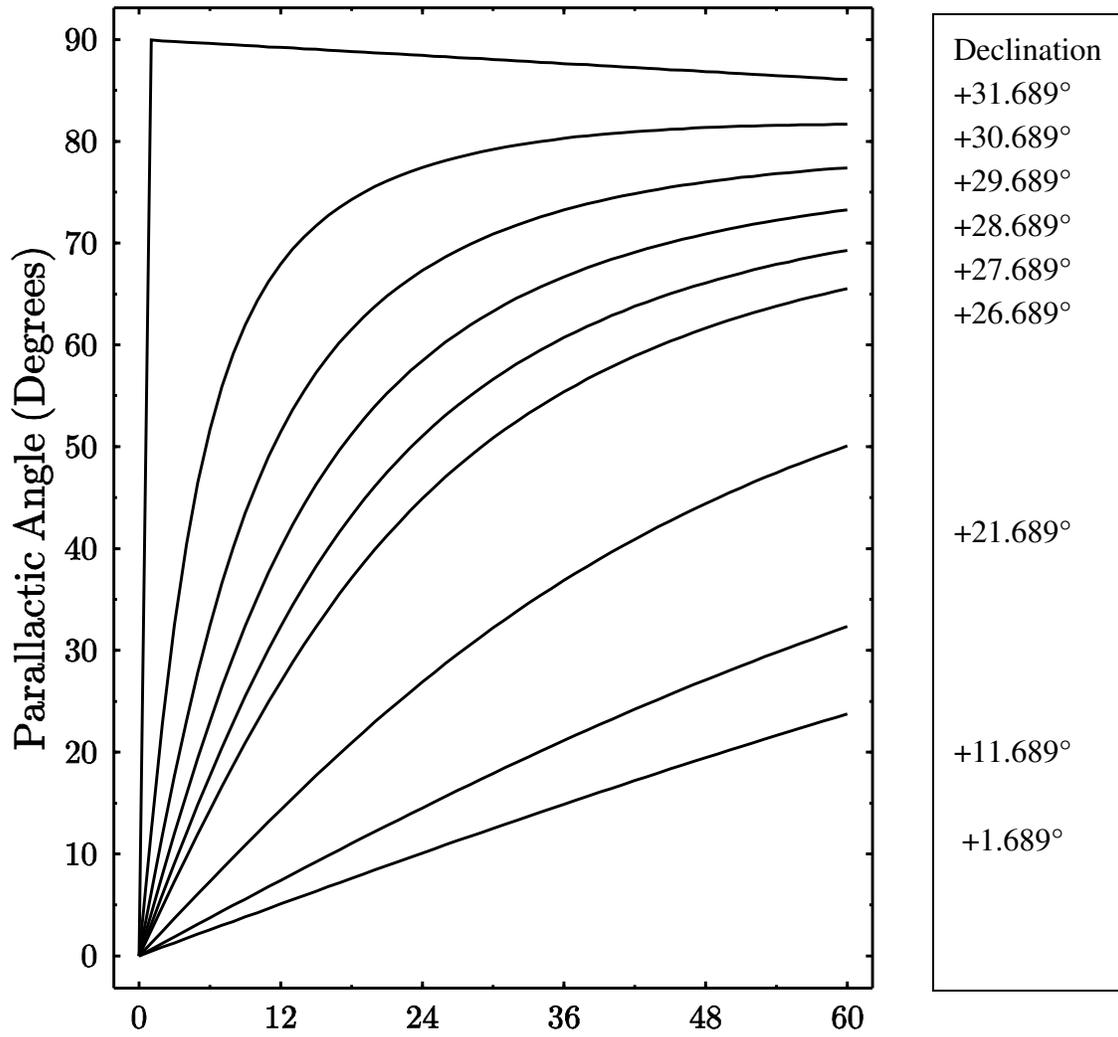


Figure 7. The parallax angle as a function of time in minutes past transit for Southern targets.

2.3

3 HECTOSPEC SPECTROGRAPH DESIGN

3.1 INTRODUCTION

The optics of the bench spectrograph are quite simple. A spherical collimator mirror operating at $f/5.4$ is used because the imaging is independent of field angle if the fibers are arranged so as to point at the local normal to the mirror. At $f/5$ the spherical aberration is negligible. The camera is also a reflective system with a spherical mirror and two all-spherical silica corrector lenses and a silica field flattener lens that serves as the dewar window. The camera is based on the Keck HIRES camera, and was designed by Harland Epps.

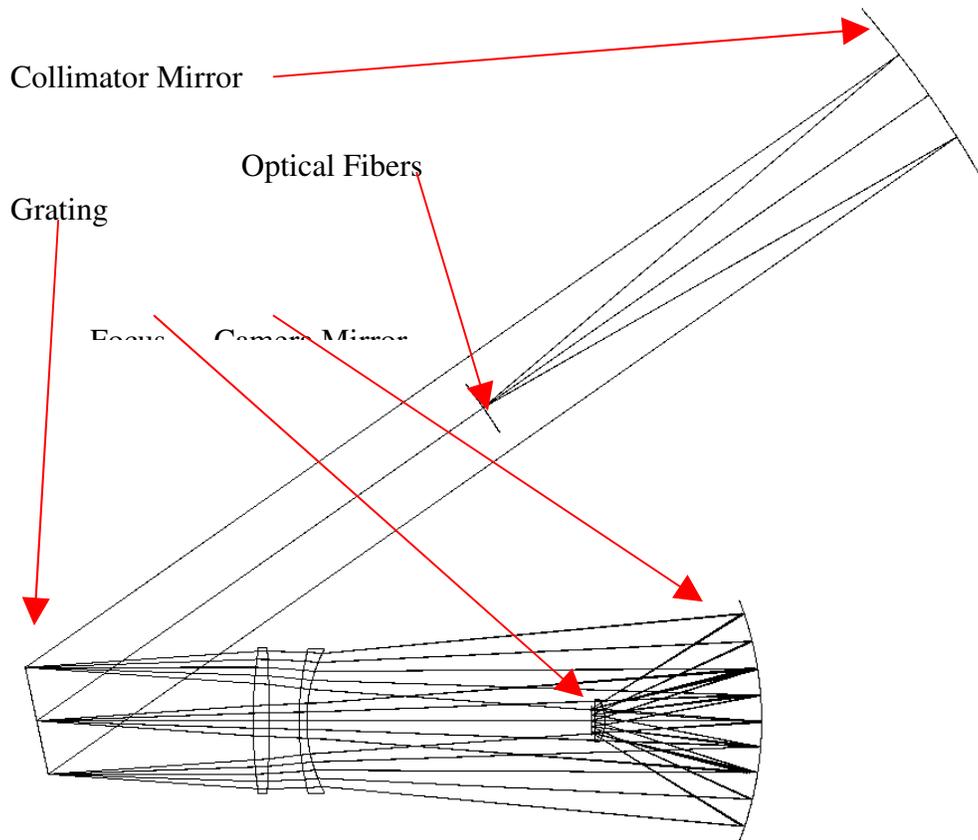


Figure 8. Optical layout of the bench spectrograph. The fibers are arranged in a line perpendicular to the plane of the page.

3.2 BENCH SPECTROGRAPH OPTICAL DESIGN

3.2.1 OPTICAL DESIGN PARAMETERS

Collimated beam diameter	259 mm
Camera focal length	397 mm
Fiber core/cladding/buffer	250/275/300 μm
Fiber subtends on the sky	1.5"
Reduction (spatial)	3.45
CCD format (max)	4608x4096 pixels
CCD format (nominal)	3400x3400 pixels

CCD pixel size	13.5 μm
250 μm fiber sampling	5.4 pixels
Max. monochromatic beam to camera	259x344 mm
Camera field radius	4.7°
Camera-collimator angle	35°
Camera-grating distance	546 mm
Camera entrance aperture	411 mm

3.2.1.1

3.2.2 SPECTROGRAPH OPTICAL PRESCRIPTION (MM)

File : C:\docs\Zemax_Files\hecto\R815_270_as_built_thk.ZMX
 Title: HECTOSPEC, RUN 815, 5/17/94
 Date : WED MAR 19 2003

Surf	Type	Radius	Thickness	Glass	Diameter	Conic
OBJ	STANDARD	-1375.105	-1371.600		148.345	0
STO	STANDARD	Infinity	1371.600		254.000	0
2	STANDARD	-1375.105	1373.060		148.350	0
3	STANDARD	-2748.153	-2748.788	MIRROR	548.278	0
4	COORDBRK	-	0	-	-	
5	DGRATING	Infinity	0	MIRROR	275.647	0
6	COORDBRK	-	546.100	-	-	
7	STANDARD	1247.082	40.749	SIL5C	364.794	0
8	STANDARD	-3195.945	75.446		365.375	0
9	STANDARD	748.157	19.164	SIL5C	363.988	0
10	STANDARD	387.373	1147.005		357.365	0
11	STANDARD	-844.093	-394.829	MIRROR	605.782	0
12	STANDARD	-102.083	-25.105	SIL5C	106.132	0
13	STANDARD	-582.981	-9.446		90.059	0
IMA	STANDARD	Infinity			71.338	0

For a central wavelength of 6563 Å:

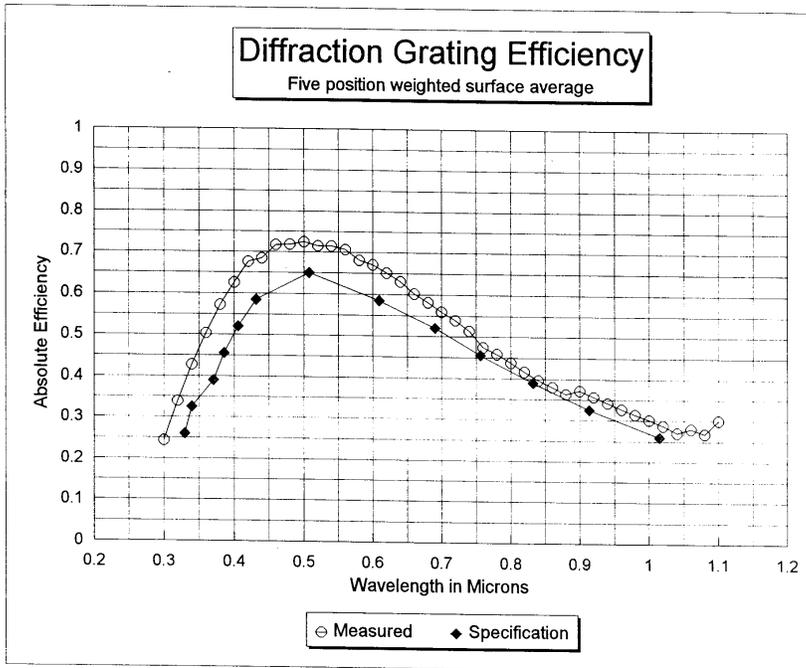
Coordinate Break Surface 4: Tilt About X : 22.83°
 Diffraction Grating Surface 5: Lines / Micron : 0.27
 Coordinate Break Surface 6: Tilt About X : 12.17°

3.3 GRATING CHOICES

We currently have available a 270 groove/mm grating blazed at 5200 Å, and a 600 gpm grating blazed at 6000 Å, both purchased from David Richardson Grating Laboratory. The spectral coverage, spectral resolution, anamorphic magnification, grating angles and

RMS image diameters for these gratings and as well as a possible 1200 gpm grating, all set up with H α as the central wavelength, are shown below. The 1200 gpm grating does not actually exist, and there is no plan to purchase it due to its cost. The spectral coverages in this table refer to the nominal 3400 pixel format. However, the image quality holds up quite well over the whole 4608 pixel format, and the full spectral coverage is ~1.35 times that shown in the table. Remember that second order contamination may be an issue for some applications. Currently, we do not have order blocking filters, but they could be installed. The spectral resolutions quoted are as measured with arc lines, with the first number referring to wavelengths around 4500 Å, while the second refers to 7000 Å.

Ruling Density (gpm)	Spectral Coverage (Å)	Spectral Resolution (FWHM Å)	Anamorph. Mag.	Angle of Incidence	Angle of Diffraction	RMS Image Diameter (pixels)
270	4488-8664	5.8-5.0	1.06	22.83	12.17	1.3-1.8
600	5609-7522	2.2-1.9	1.14	29.41	5.59	1.3-1.8
1200	6084-7038	1.1	1.33	41.89	-6.89	1.4-1.7



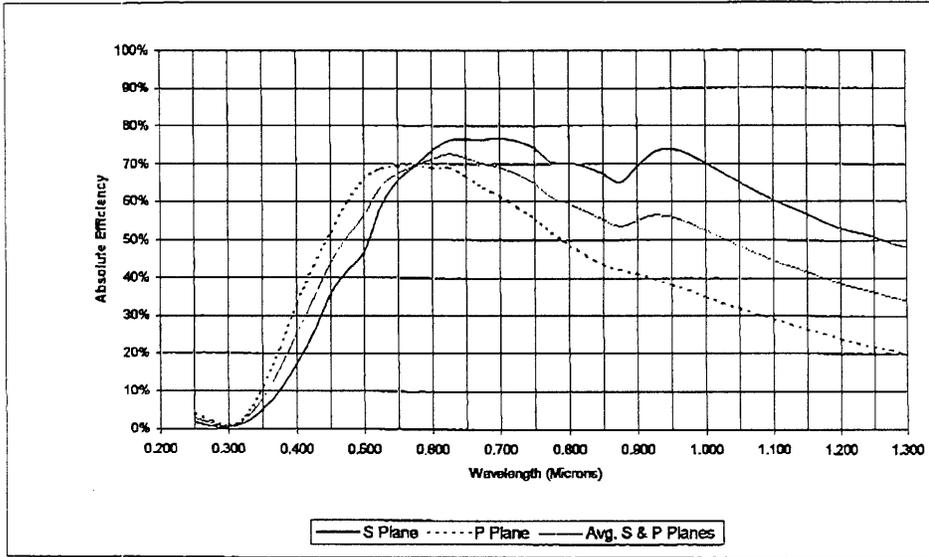
Serial Number:	MR192-1-1-1	Nominal Littrow Blaze:	530 nm
Grooves/mm:	270	Blaze angle:	4.1 degrees
Grating Coating:	Aluminum	Order:	First
Test Date:	09/09/98	Slits:	50 um (UV) 500 um (IR)
		Aperture:	10 mm
		Operator:	MA

Notes:

Glan Taylor Polarizer - Average of S & P
 Absolute Efficiency Reference
 Measured with 35 degrees between incident and diffracted beams

Figure 9. The efficiency of the 270 line grating

Diffraction Grating Efficiency



Serial Number: MR225M	Blaze Order: 1st
Catalog Number: 53045ZD01-xxxR	Slits: 50 um
G/mm: 600	I.R. Slits: 500 um
Grating Type: Ruled Plano	Aperture: 7 mm
Coating: Aluminum	Operator: RPI
	Test Date: 8/5/2003

Measured and Reported Absolute.
Glan Taylor Polarizer
S & P Plane Polarization
Reversed Arrow, 35 Degrees Between Beams.
Start of Ruled Area

Figure 10. The efficiency of the 600 line grating.

4 BENCH SPECTROGRAPH

4.1 PUMPING OUT AND FILLING THE DEWAR WITH LN2



Figure 11. Pump station.

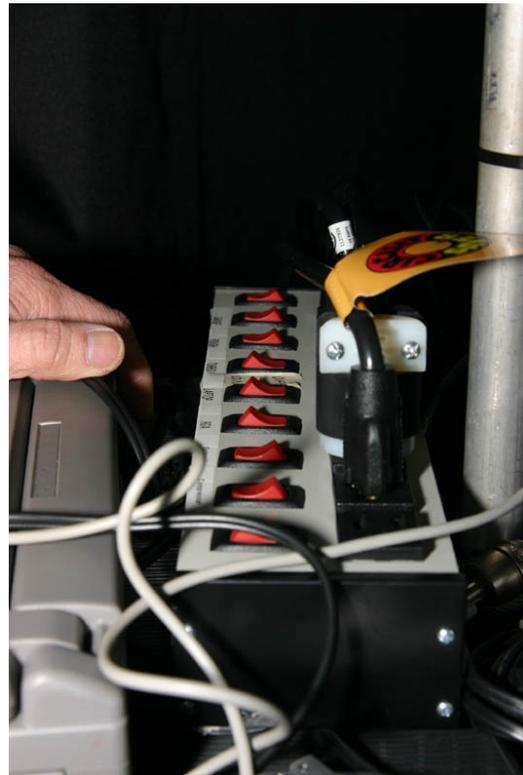


Figure 12. Power strip on pump station.

Make sure all the switches on the power strip are in the “Off” position.



Push the reset button on the Safe Start (yellow plastic box in the power line). This will deliver power to the power strip, unless one of the power strip buttons is already on.

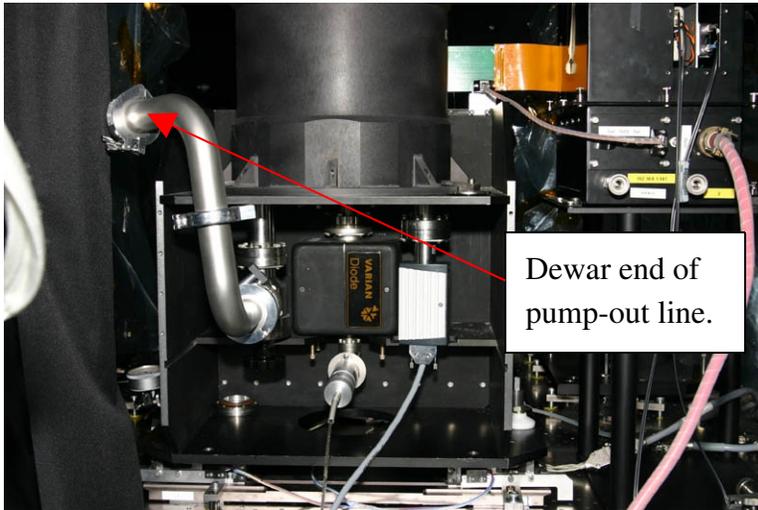


Figure 13. Hectospec Dewar.



Figure 14. Pump station end of pump-out line.

For Hectospec, install the long flexible hose hung on the central post. For Hectochele, use the short hose. Make sure the quick flange connections are tight.

Follow this procedure if the dewar already has some kind of vacuum. Otherwise, see below.

1. Turn on the power strip
2. Turn on the compressor
3. Turn on the pressure gauge
4. Turn on the Gate Valve
5. Turn on the Roughing Pump
6. After a couple of minutes, turn on the Turbo pump. The coarse gauge on the pump will show pressures down to 10^{-3} Torr. The fine gauge doesn't always work, but if the coarse gauge has shown 10^{-3} for a few minutes, the pressure is in fact below 10^{-3} .
7. Open the dewar valve. Within about 30 minutes the pressure should be on the 10^{-4} Torr scale. The best thing is to read the dewar vacuum gauge, located in the instrument storage room, to get the dewar pressure.
8. When the pressure is around a few $\times 10^{-4}$ torr, you can fill the dewar with LN2. The first fill takes about 10-15 minutes. Subsequent fills take about 5 minutes.
9. Close the dewar valve.
10. Turn on the Ion pump, located in the instrument storage room.



Figure 15. Dewar valve.

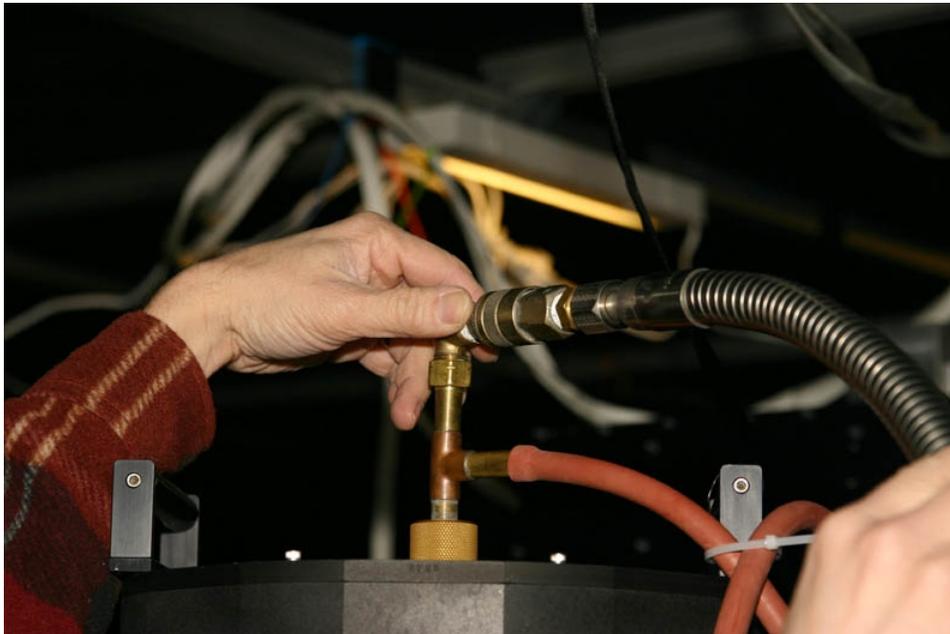


Figure 16. Dewar end of LN2 fill line.

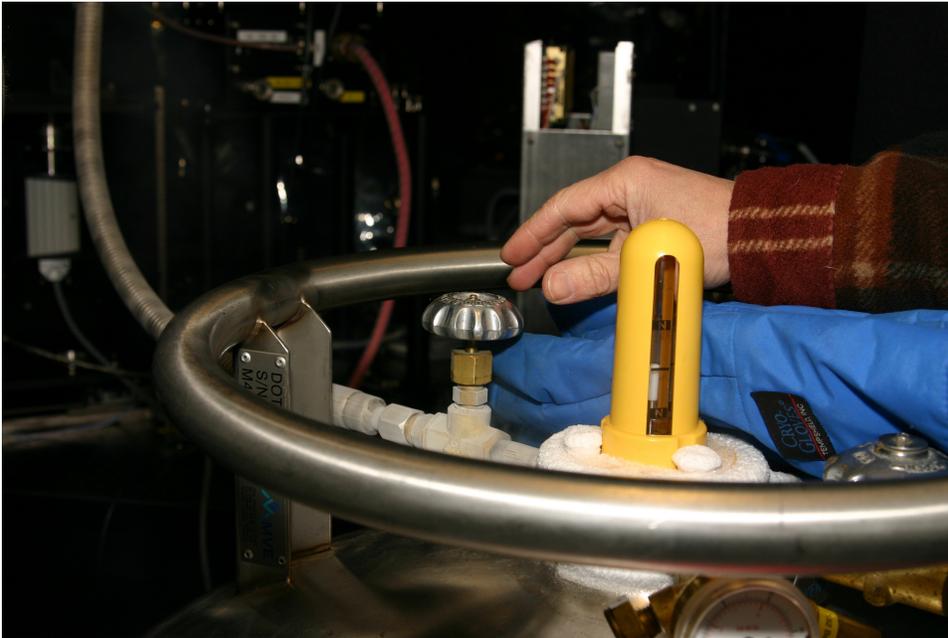


Figure 17. LN2 reservoir end of LN2 fill line.



Figure 18. Hectospec ion pump is on the left, vacuum gauge is in the middle.



Figure 19. Power for the ion gauge. The main switch on P3 (gold-colored Pulizzi) must be on to power P6.

If the dewar is at atmosphere pressure, follow this procedure.

1. Turn on the power strip
2. Turn on the compressor
3. Turn on the pressure gauge
4. Turn on the Gate Valve
5. Open the Dewar Valve
6. Turn on the Roughing Pump
7. After a couple of minutes, turn on the Turbo pump. The coarse gauge on the pump will show pressures down to 10^{-3} Torr. The fine gauge doesn't always work, the best thing is to read the dewar vacuum gauge, located in the instrument storage room, to get the dewar pressure. You may have to turn this on via a pulizzi button labeled as such above and to the left of the gauge. It may take an hour or more of pumping.
8. When the pressure is around a few $\times 10^{-4}$ you can fill the dewar with LN2. The first fill takes about 10-15 minutes. Subsequent fills take about 5 minutes.
9. Turn on the Ion pump, located in the instrument storage room.
10. After about 30 minutes, or better yet when the CCD temperature as displayed in the HectoSpec Status display gui is below 0C, you may close the dewar valve. Monitor the vacuum gauge to insure that the pressure does not increase. If it does increase, open the valve again and wait another 30 minutes or so. If it still does not stay down, refer to an expert. Eventually, the gauge should read a vacuum on the minus 8 scale.

Turning off the pump:

Letting ambient air into the pump can diminish its effectiveness, so we like to fill the pump with bottled nitrogen. There are 4 valves for the backfill system: one on the N₂ tank itself, a pressure regulator next to that (large blue knob), a low pressure valve (small blue knob), and a green cutoff valve at the end of the white plastic tubing. The large blue knob should not be adjusted; the other 3 should be in the off position at this point, which is CW.

1. Close the dewar valve
2. Turn off the turbo pump. Wait till it spins down, about 5 minutes.
3. Turn off the roughing pump.

4. Open the N₂ tank valve and the low pressure valve.
5. Watch the gauge on the pump station and very slowly crack open the green cutoff valve. Go slowly until the turbo (high pitched whine) is fully spun down. At the point where the pressure is on the 10⁺⁰² scale, the pressure gauge next to the green valve will start to move to zero. Close the green valve when this gauge reads zero.
6. Close the gate valve now.
7. Turn off the compressor.
8. Close the backfill valves on the N₂ tank.
9. Remove the vacuum lines from the pump and the dewar. The flexible line at the dewar can be placed on the bench, but be sure to cover the ends.



Figure 20. Back fill bottle. The middle blue valve is the pressure regulator control and normally should not be adjusted or turned. The backfill valves are the main bottle valve and the right hand blue valve.

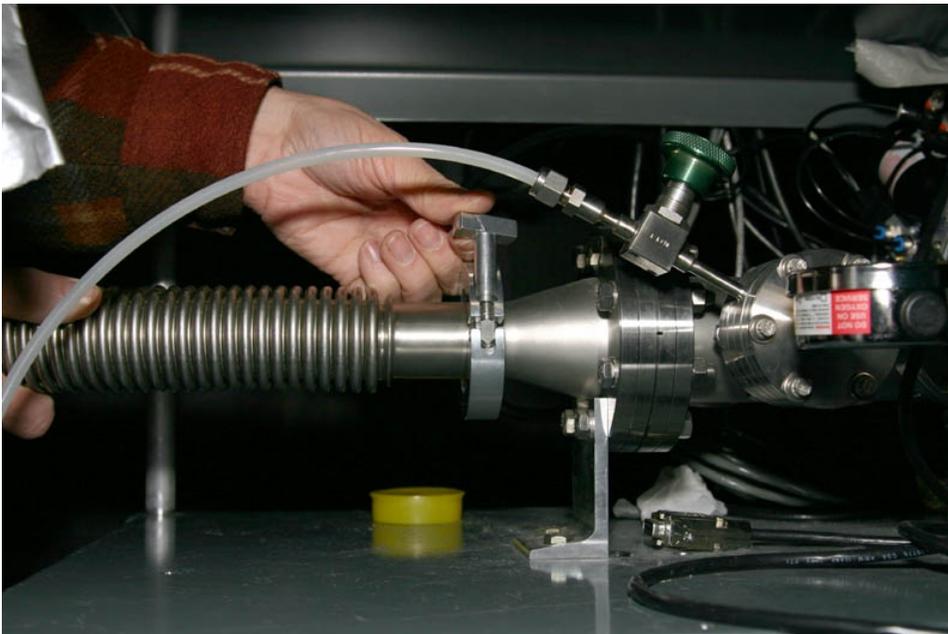


Figure 21. The cutoff valve is the green valve to the upper right.

4.2 BENCH SPECTROGRAPH & FIBER REFERENCE

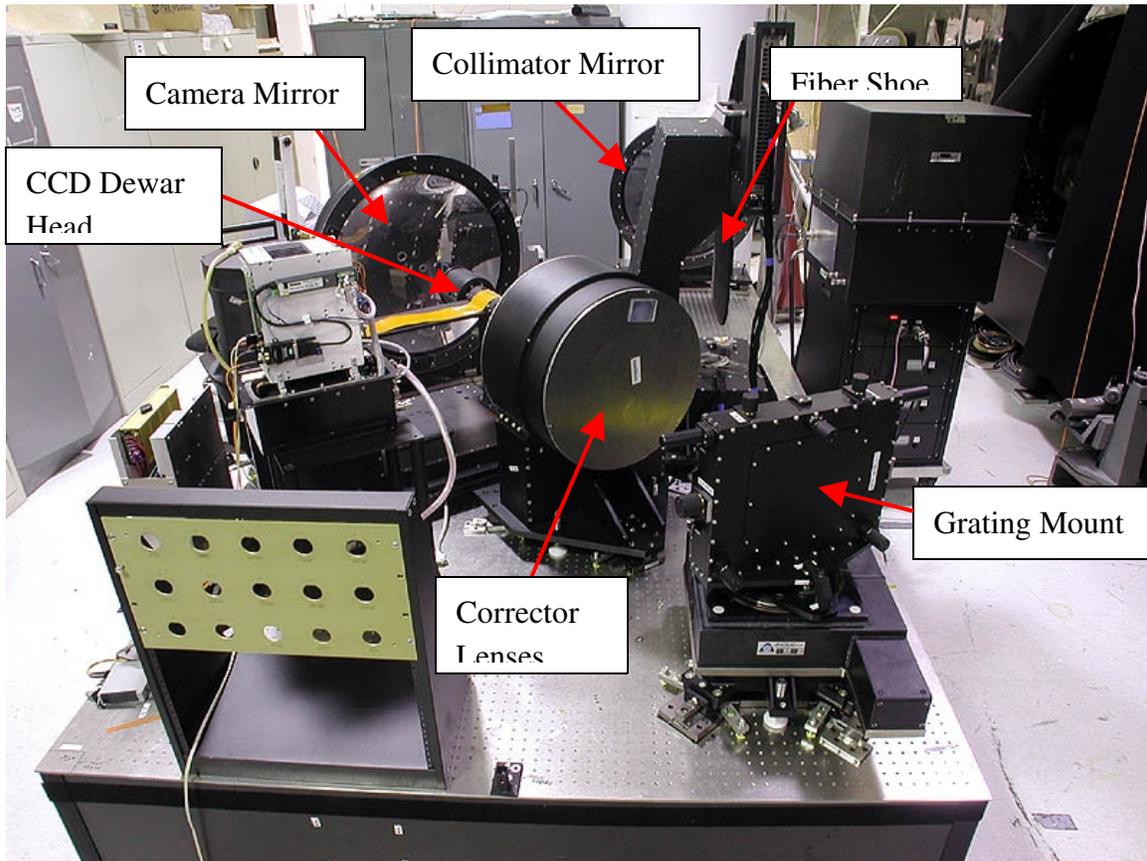


Figure 22. Hectospec Bench Spectrograph in the lab just prior to shipment.

4.2.1 MOVING FIBER SHOE BETWEEN HECTOSPEC AND HECTOCHELLE

The fiber shoe is mounted on a trolley mechanism that supports the fiber shoe and fiber chain when it is moved between Hectospec and Hectochelle. The shutter travels with the shoe, and so does the shutter's electrical cable. Switches on the shoe mounts allow remote sensing of fiber shoe/dummy shoe/no shoe conditions.

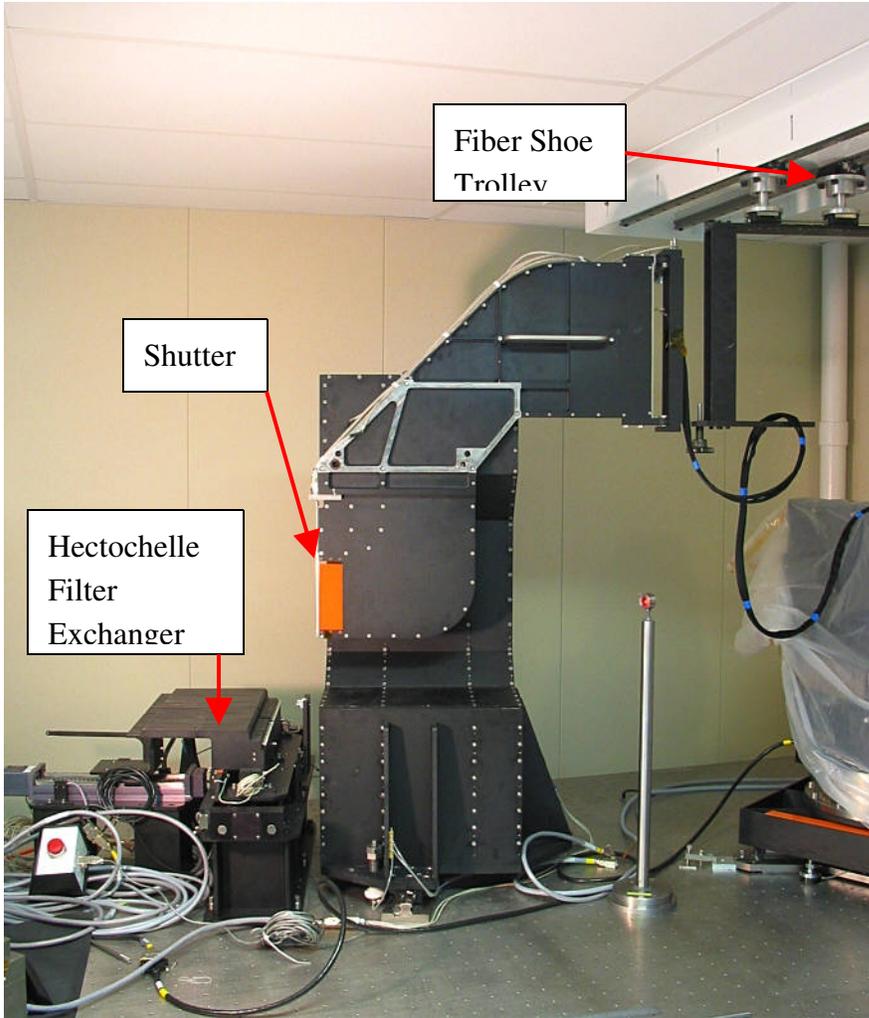


Figure 23. Fiber shoe and trolley. The fiber chain is not installed in this picture.

4.2.2 FIBER SHOE LAYOUT

4.2.2.1 AT THE SHOE THERE ARE TWO ROWS OF 150 FIBERS

- Radius of Curvature of Fiber Ends (Fiber Direction): 54.138 inches
- Separation between rows is 0.065 inches equivalent to 0.0688 deg, +/-0.0344 deg. The left row is on your left as you face the collimator.
- In each row, the fibers are spaced by 0.040098 degrees but the rows are offset such that the fiber to fiber spacing in opposite rows is 0.020049 degrees.
- The gap at the center of the fiber shoe is larger to accommodate the gap between the CCDs. This gap is 0.212666 degrees.

Left Row Positive angles are rotations away from the optical bench.

+3.093634 deg for outermost top fiber
+0.126382 innermost positive
-0.106333 innermost negative
-3.073585 deg outermost negative fiber

Right Row

+3.073585 deg for outermost fiber
+0.106333 innermost positive
-0.126382 innermost negative
-3.093634 outermost negative fiber

4.2.2.2 AT THE CCD

- The fiber images are spaced by 0.1379 mm center-to-center in the spatial direction at the center of the field. This corresponds to 10.2 pixels.

4.2.3 CCD AND DEWAR

The CCDs are mounted in a dewar head at the end of a long cold strap to minimize the vignetting in the on-axis camera.

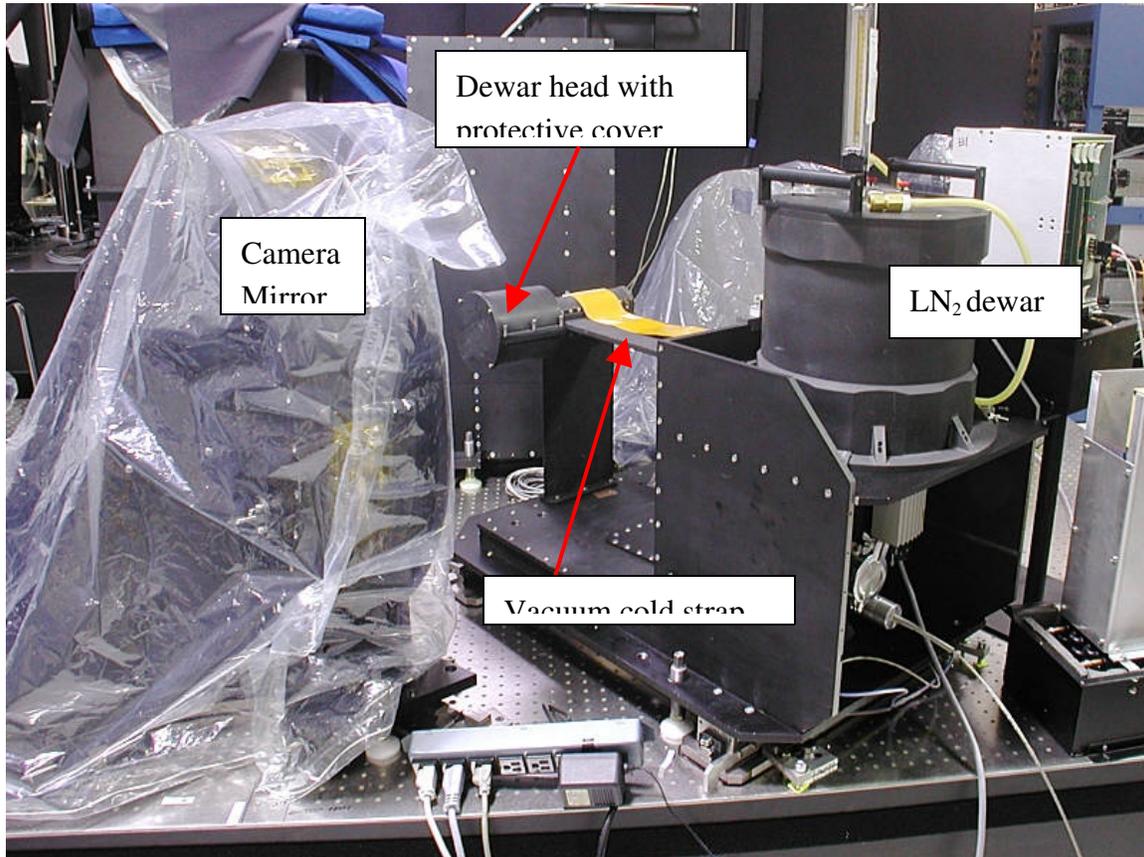


Figure 24. Dewar assembly. The field flattener is covered with a protective enclosure.

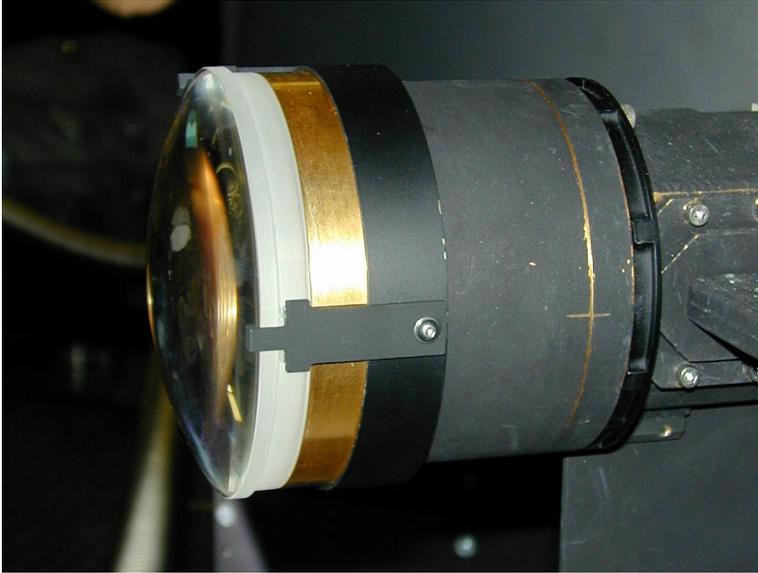


Figure 25. Closeup of dewar head and the field flattener lens that serves as the dewar window.

4.3 GETTING BENCH READY AT BEGINNING OF A NEW RUN

After the dewar has been pumped down, and the vacuum line disconnected, the bench may be readied for observations. *A face mask should always be worn when working around uncovered optics in this room to avoid accidentally contaminating the optics..*

The spectrograph may be accessed via the annex door (where the tool box is), and entering the tent (there is a power strip that controls some fluorescent lights sitting on the floor), or by the 3rd floor catwalk door (a light switch that controls the entryway light only is on the wall to the left). In the latter case, pull back the vertical tent panel from left to right, minding the Velcro attachments. The panel can be held back via some clips.

Check the following connections first:

- The CCD has a long, yellow, flex cable running along the cold finger, where it connects to an adapter next to the LN₂ reservoir. In turn, a shorter flex cable runs from the adapter to the CCD electronics box. Visually insure these connections are good.
- The back end of the Ebox should have two sets of fibers coming out, one D-connector type cable going over to the dewar adapter connection (this is the heater cord) and a round connector cable going to the power supply. The top of

the Ebox now has a 3” cooling conduit line running out. Make sure these are all in place.

- The power supply, sitting next to the Ebox should have the round connector cable hooked up to the Ebox, and a 110VAC cord which should be plugged into the 4-plug receptacle located on the floor, **and into the side labeled “Camera”**. That receptacle is controlled by the pulizzi.
- The two ventilator fans, now located on the floor, should also be plugged into the floor receptacle labeled Camera (via a power strip). This insures that when the Ebox is on, the fans are also on.
- The Calibration boxes could also be plugged in to the floor receptacle, in the plugs labeled “Bench”, though they are no longer used by Hectospec.
- The Bench flotation air supply comes from one of the two N2 bottles located near the door. There is a quick release connection located under the bench below the power supply. Check this, the connection at the bottle, and insure that the pressure in the line is 45 pounds. A good test is to lean on the bench slowly but firmly. Air should be released, but you should not feel the bench hit its hard stops if the pressure is set right.
- Make sure the E-stop buttons, located on each bench are not depressed.

Now remove any of the plastic bags that may be covering the optics, but leave in place the plexiglass covers. The bags should be stowed in yet another bag, and kept outside of the tent.

We will next check the grating, focus and shutter motors by homing them. **Note that the focus stage should not be moved if the dewar has been filled within the last 20 minutes, due to the stiffness of the LN2 line.** Assuming these connections are nominal, startup the HectoSpec Bench Status window (see below), and power up the pulizzis and the bench stepper motors. This is best done on the radar computer, so that you can monitor the motion in the spectrograph room. Home the three stages by pressing the Home button, and monitor their movements. There should be no problems, but it’s always good to look for obstructions left behind by nefarious forces.

Assuming that went well, the optics may now be uncovered. From the annex side, pull back the black material far enough to allow access to the camera mirror and the dewar. First remove the camera mirror cover, which has three socket head screws holding it on to the mount. The screws should be finger tight only. The cover can be leaned against the bench, outside of the tent. Now remove the dewar cap, by lightly

holding the cap from below and loosening the three captive screws. When they are loose, fold over the clamshell cover, away from you, and lower the cap away from the lens. Usually, only the two lower screws hold the end cover on, but if all four are in, you should remove the upper two before loosening the captive screws. This cover can be placed in back of the camera mirror.

Now go over to the other side of the bench (via the stairs or elevator, not under the bench). Stand on a foot stool and remove the back cover of the corrector (the one towards the dewar). There are three short screws that hold this in place, which are best found by feel. Now remove the front cover.

Next remove the grating cover by unscrewing just the top two clamps, and rotating them outboard. Tilt the cover down and remove it. Then screw the two clamps back on.

Remove the collimator cover., and the fiber cover.

Lastly, make sure there are no obstructions in the beam.

Turn out all the lights and close up the tent. It may take a few hours for the dark current to calm down in the CCDs after being exposed to the fluorescent lights, so their use after the initial setup is discouraged.

4.4 COVER THE OPTICS AT THE END OF THE RUN

The bench spectrograph needs to be shut down at the end of a run.

- Put the covers back on the optics, in reverse order to that listed above (fiber cover, collimator cover, grating cover, corrector covers, dewar cover and lastly camera mirror cover).
- Put the plastic bags back over the grating, corrector, camera mirror and collimator.
- Turn off the ion pump down in the rack. There is a switch on the front. You can also unplug the power cord. The dewar is allowed to warm up passively.

4.5 CHANGING GRATINGS

Note : this operation should only be done by trained personnel, specifically N Caldwell, M Calkins or P Berlind.

This operation requires two people.

- 1) In Spice, move the grating to the removal angle (120 degrees). You may need to use the engineering spice to do this: select the Focus tab, set the angle to 120degrees, save, and then go to the configure tab and configure the bench.
- 2) In the spectrograph room, install the grating cover.
- 3) Remove the three dogs that hold the grating to the rotary turret.
- 4) While standing on a small stool, lift the grating by the handles straight up, and remove it from the bench. Store it at the end of the Hectospec bench. The Hectochele bench may also be used for short periods.
- 5) Lift the new grating up over the rotary turret. Have the second person guide the grating cell legs into the sockets on the turret as the grating is slowly lowered into place.
- 6) Install the dogs.
- 7) Remove the cover.
- 8) Return to the control room, home the grating, and then configure the bench.

5 HECTOSPEC OBSERVING PROCEDURES

5.1 INTRODUCTION

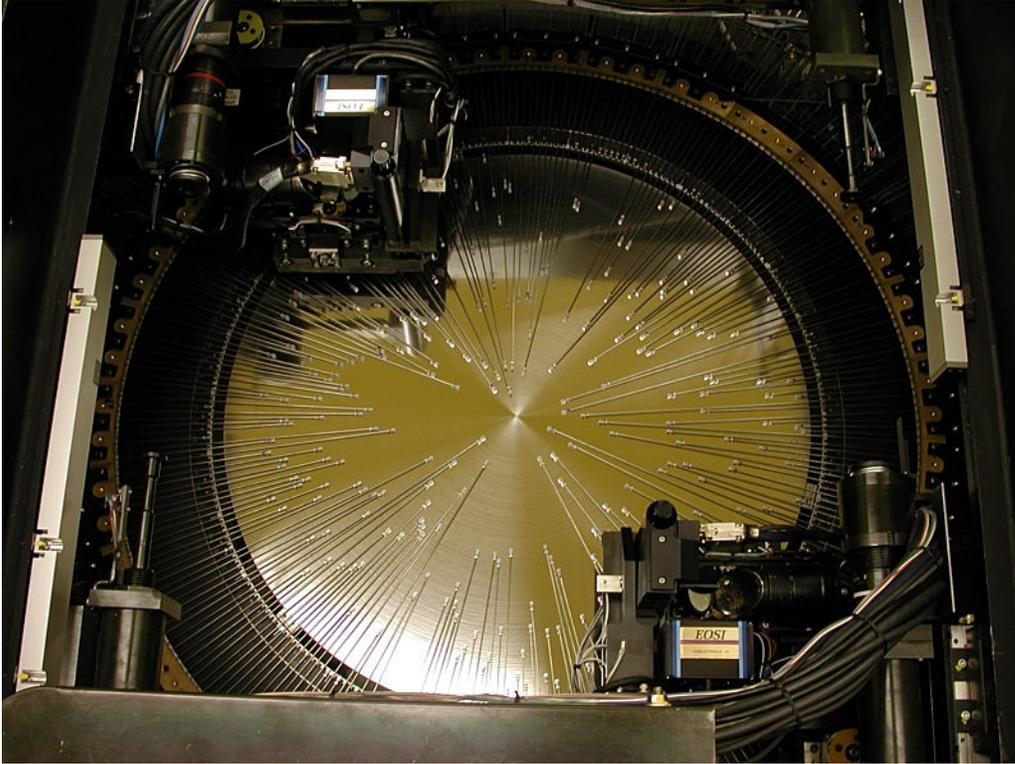


Figure 26. Looking down at the focal surface from above with the entrance window removed. The two positioning robots are visible to the upper left and lower right.

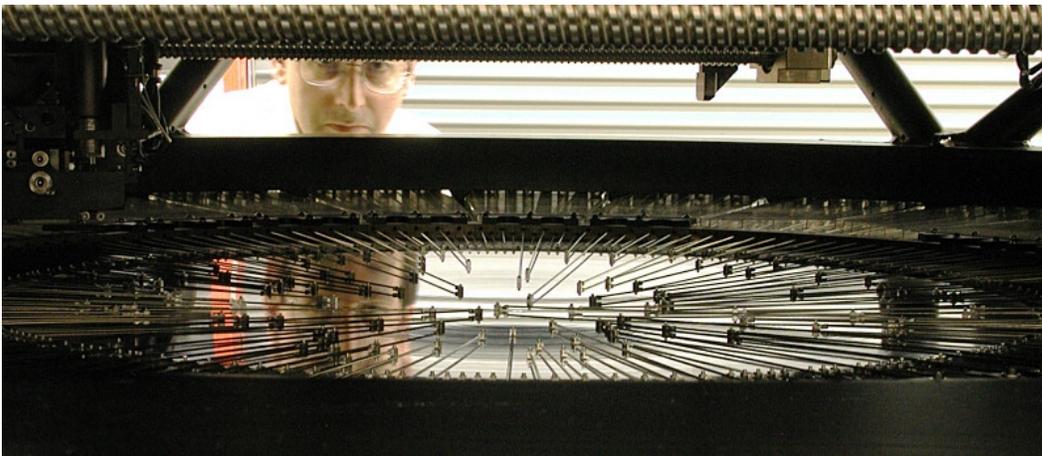


Figure 27. Looking at the focal surface from the side with the covers removed. One robot is visible to the top left.

5.2 START UP PROCEDURE

There are two aspects of starting up the Hectospec: turning on the power to the fiber positioner and bench spectrograph and then initializing (homing) the stages in both the fiber positioner and the bench spectrograph. The broad-brush steps are:

1. Turn on the computers in the control room including Fiber and Packrat
2. Turn on the computers in the electronics rack
3. Start up the four software servers (Hctserv on Hardware, Snappy and Epbox on Snappy, and Guidserv on Packrat.)
4. Turn on power to the stepper and servo electronics.

It is important to follow the steps above in order because if the Hctserv server is not running and the stepper LVPS is on, the guider stepper motors may be energized at an unsafe power level. We are working to make this safer, but the electronics to do so are not yet in place.

If Hardware is rebooted, the power to the stepper LVPS (Pulizzi P5, switches 2 and 3) should be turned off first. Hardware should be rebooted, and Hctserv started up before the stepper LVPS is turned back on.

5.2.1 TURNING ON THE COMPUTERS IN THE CONTROL ROOM

The computers in the control room (except Fiber) will come on automatically when power to the UPS is restored. Fiber must be turned on manually, see picture below.



Figure 28. Turning on Fiber. Computer is located behind the large monitors.

5.2.2 TURNING ON THE COMPUTERS IN THE F/5 STORAGE ROOM

The first step is to turn on the main power disconnect around the corner on the left side of the electronics rack. This will be turned off for lightning protection.



Figure 29. Main power switch.

Next, the UPS plug should be plugged into dirty power nearby. The Hectospec dewar ion pump is usually left plugged into dirty power at all times. This is the grey power cord in the picture below.



Figure 30. Plugging in.

Next, turn on the UPS on the top of rack 1. Rack numbering is from left to right.



Figure 31. UPS on the top of rack 1. Rack numbering is from left to right.

The two VME crates containing the Hardware and Topper computers will boot up automatically. You will need to boot up the SNAPPY computer (snap2) manually.



Figure 32. SNAPPY (snap2) computer with cover closed.



Power switch

Figure 33. SNAPPY (snap2) computer with cover open. Press power switch to boot up. The green power light below the switch should come on and the red disk light (to right of the power light) should begin to flash.

Now go to the control room and start up the software.

5.2.3 STARTING UP THE SOFTWARE

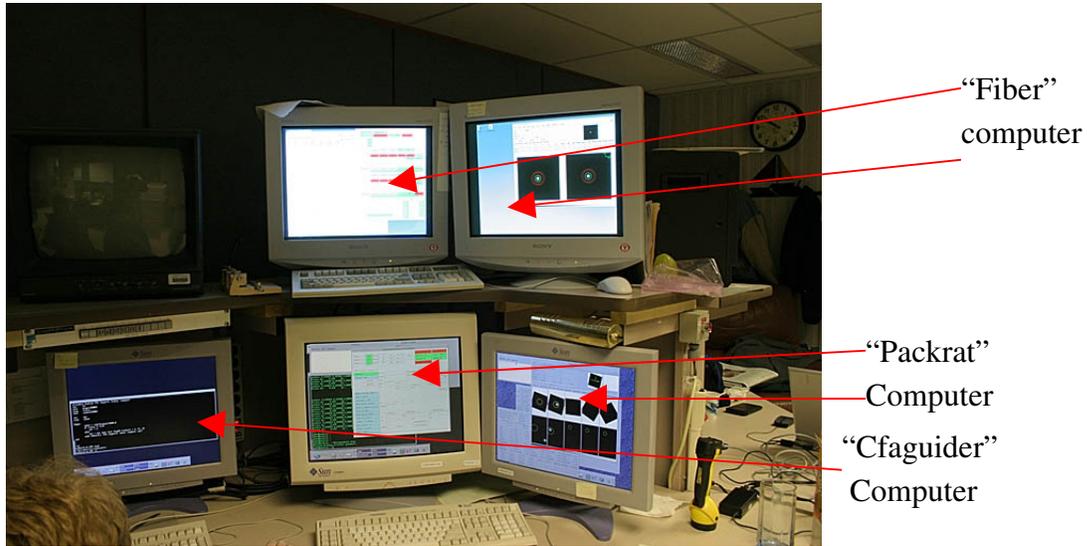


Figure 34. Fiber positioner control computers.

Bringing up the GUIs

1. Log onto Fiber with user name john. The password will be available at the mountain. Start a shell and type:

```
> hecto
```

Two GUIs are created: “Hectospec Robot Positions” & “PMAC Control”. In PMAC Control press the “Images” button to bring up an SAOImage on the adjacent monitor.

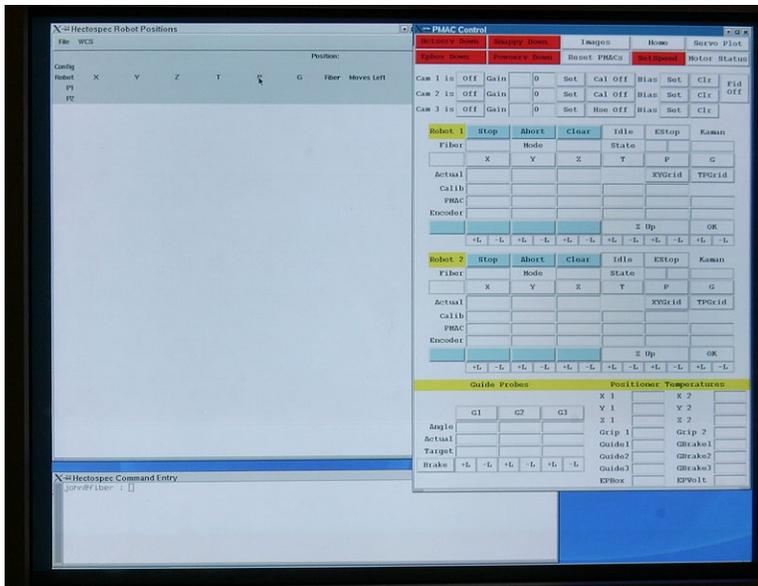


Figure 35. Fiber display.

2. Log onto Packrat as spec or chelle depending on which spectrograph is in use. Start a shell and type: `> hobserve`
A GUI called “Hectospec Positioner Procedure” will pop up.
3. In the “Hectospec Positioner Procedure” GUI start the four servers by pressing the appropriate buttons on the top right of the user interface. (Hctserv, Snappy, Epbox, and Guidserv) When the servers come up, the buttons will turn green and the status will be displayed, e.g. “Hctserv Up”.

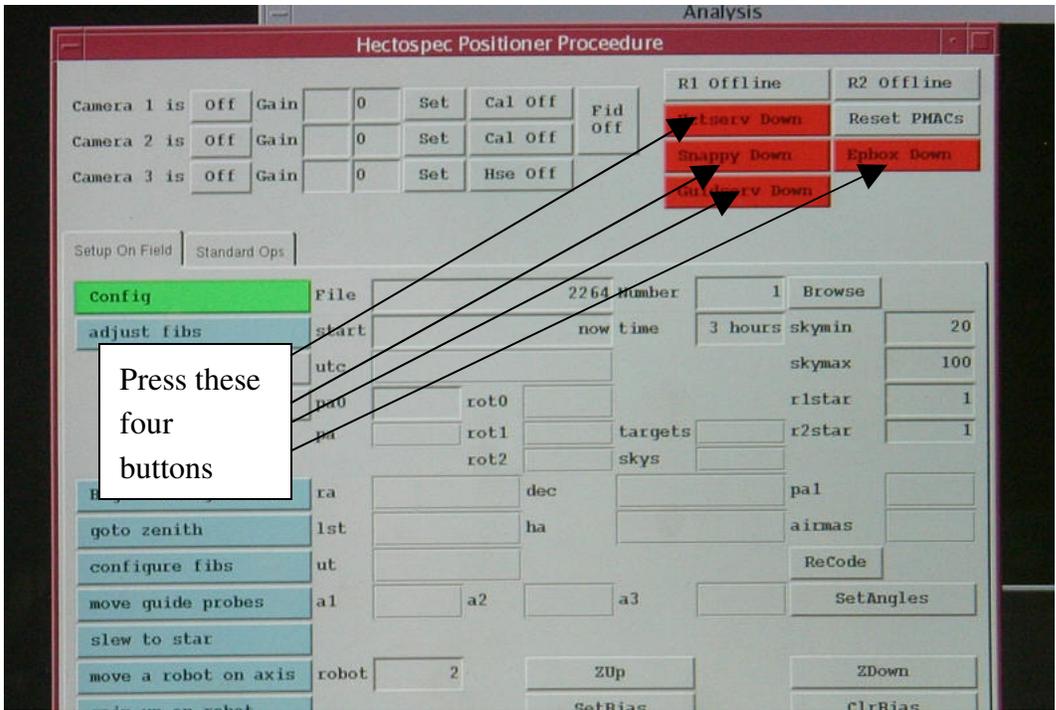


Figure 36. Hobserve display.

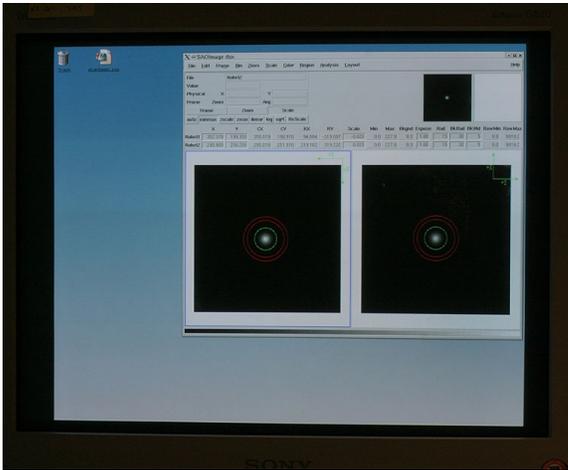


Figure 37. Robot camera display on second (rightmost) Fiber monitor. This display comes up after the Images button on the Hecto display is pressed.

5.2.4 TURNING ON THE POWER AND HOMING THE ROBOTS

At this point it is safe to start turning on the power to the positioner. The power for the positioner low voltage power supplies is located on the lowest of the four black Pulizzi power controllers at the top of the leftmost electronics rack.

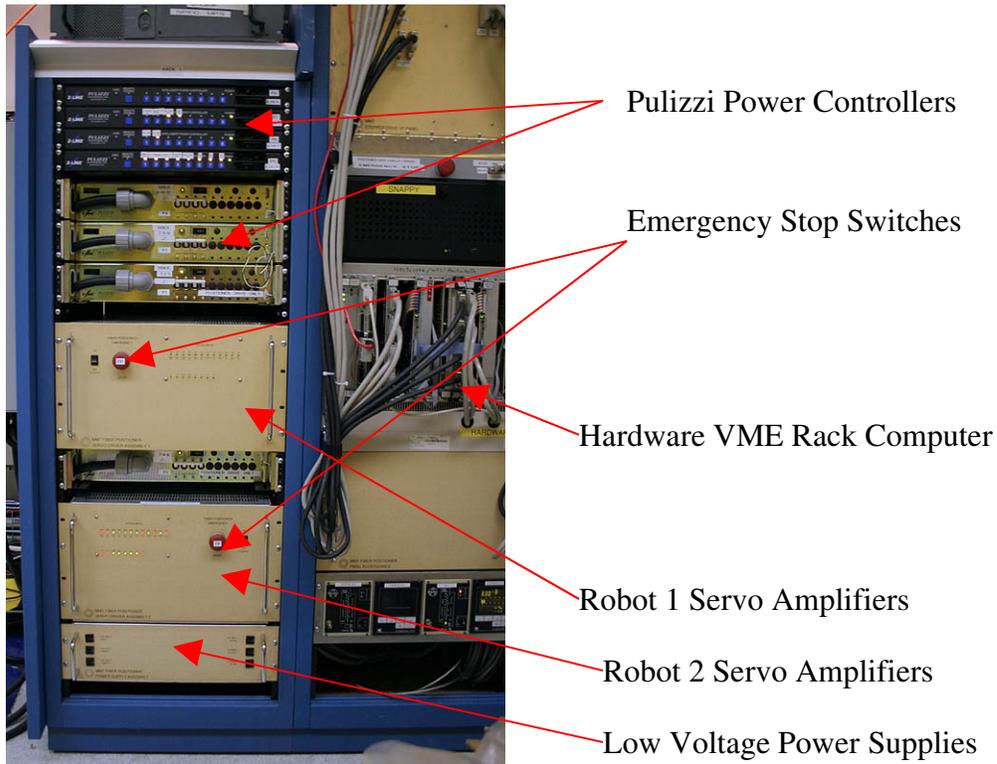


Figure 38. The fiber positioner electronics rack.

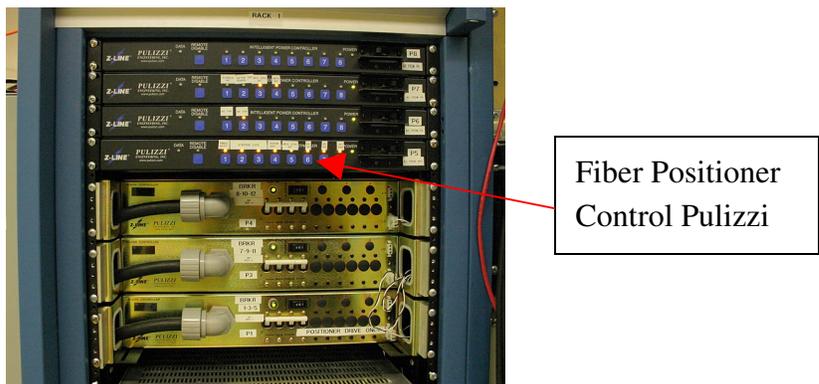


Figure 39. Closeup of upper portion of the fiber positioner electronics rack.

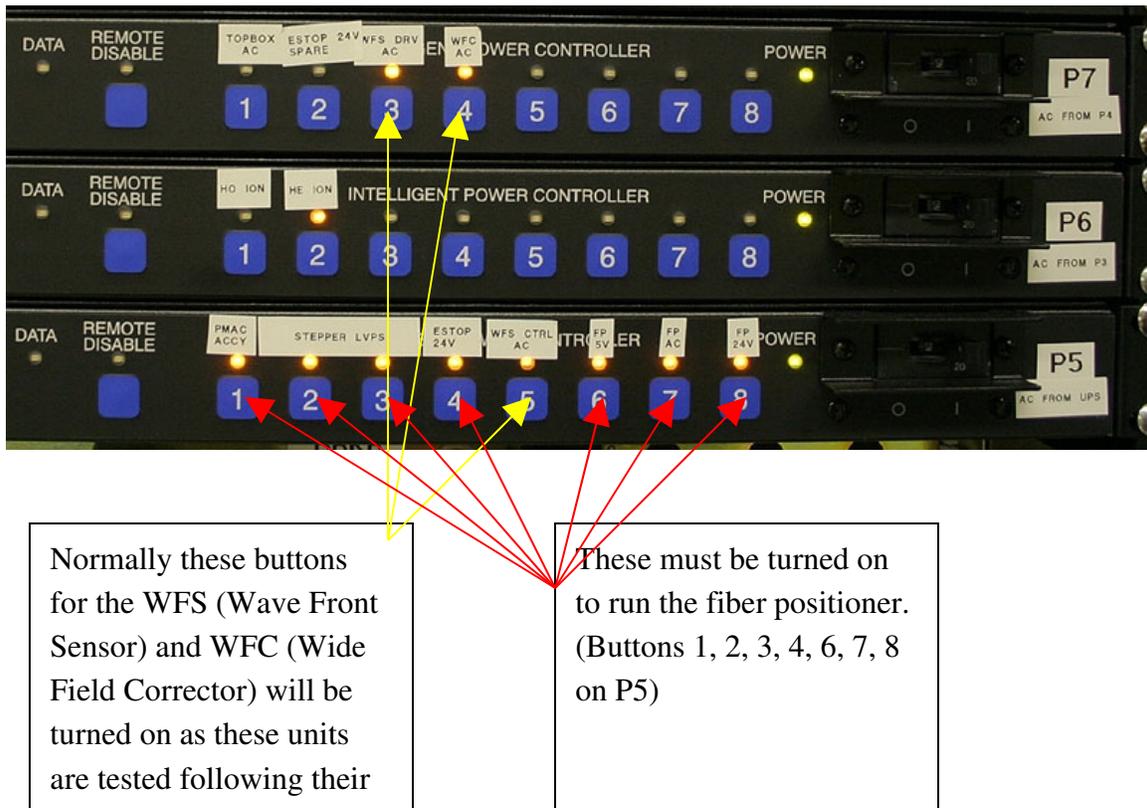


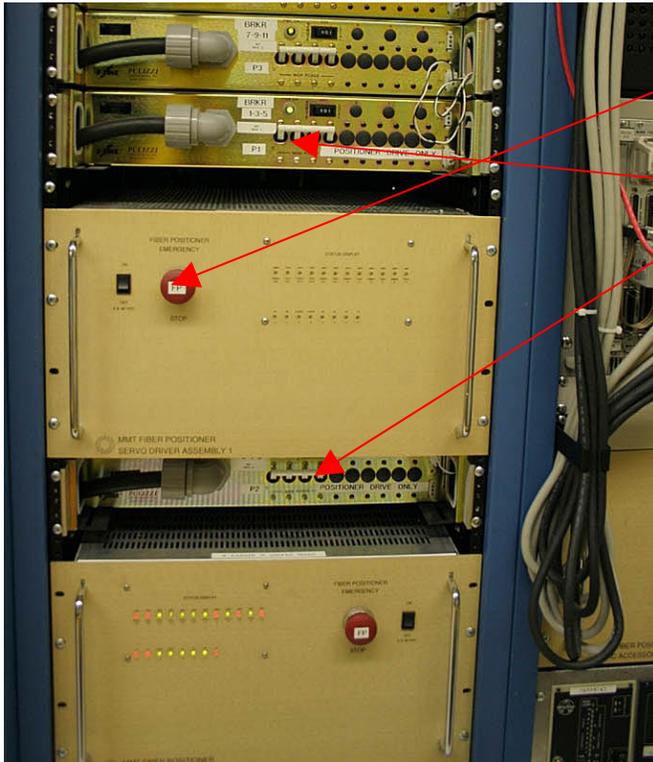
Figure 40. Closeup of individual power controls for fiber positioner. The main power switches on P3 and P4 (gold-colored Pulizzis) must be on to power P6 and P7.

All of the power to Pulizzi P5 and the Hardware and Topper computers is supplied by the small grey UPS on the top of rack 1.

If the power to the wide field corrector’s ADC prism stepper motors is not already on, turn it on while turning on the Hectospec power. This is switch 4 on P7.

If the power to the wavefront sensor is not on already, the process is to turn on the WFS CTRL AC, switch 5 on P5. Wait 30 seconds and then turn on WFS DRV AC, switch 3 on P7.

After the buttons on the P5 Pulizzi (see above) are turned on for five minutes, the power for the servo boxes can be turned on. First, press the red e-stop button on the top servo box if it is not already depressed.



1. Press the E-stop button if it is not already depressed.
2. Turn on breakers for servo power.
3. Wait five minutes.
4. On the Hobserve screen, press the Reset PMACs button. It should turn green and the position displays (Fiber Computer) should zero out.
5. Return upstairs and

After waiting ten minutes or so for the servos to warm up, you are ready to home the robots. On the Hobserve GUI, select the Standard Ops page and press the “Home Robots” buttons. Robot 1 and Robot 2 will home in sequence. You can watch the progress of the homing on the Fiber displays. After the home is completed, the robots are ready to position fibers as needed.

5.2.5 STARTING THE GUIDE GUI

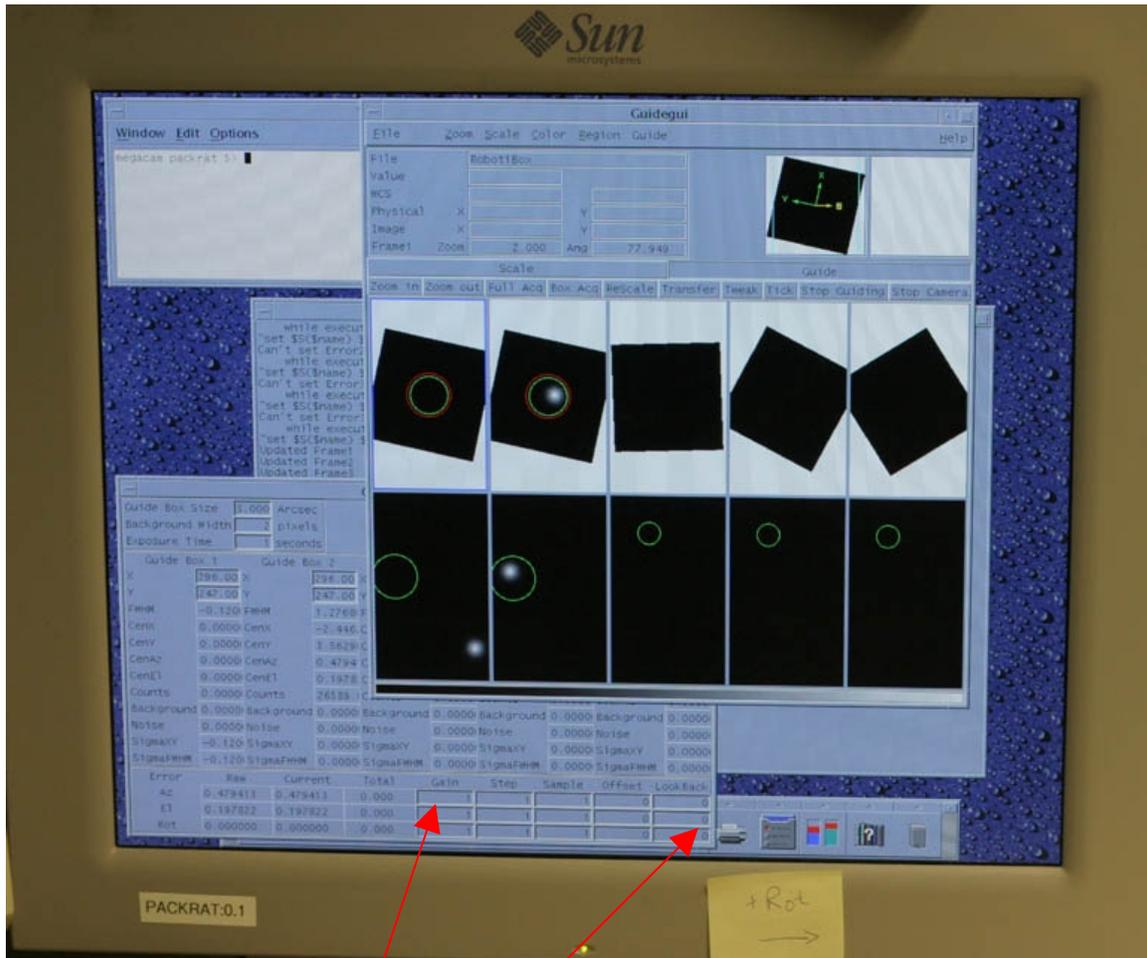
Scan the mouse over to the rightmost of the two Packrat monitors and select a terminal window. In this window type:

```
> ssh john@snap2
```

The password will be available on the mountain. On snap2, type:

>./guidegui

The guider windows will then start up.



1. Set AZ and EL, and Rot gains to 0.25
2. Set all three lookbacks to 4
3. On the standard ops page of Hobserve, press **Setup Snappy**.

5.3 STARTING UP THE WIDE FIELD CORRECTOR

Before starting make sure that the power to the WFC is on (switch 4 on P7, see procedure above.) Logon to the Cfaguide computer as mccd. The password will be available on the mountain.

In a terminal window, type:

```
> telgui
```

This will start up the ADC prism control GUI.

Then, press the WFC Power button on the top right of the telgui.

Then, press the WFC Reset button on the top left. The Steppers Up button should turn green.

If the green Steppers Up button doesn't come on , follow this procedure:

```
> rlogin -l mccd hardware (that's the letter "el", not the number 1)
> stop-daemon /sbin/wfcserv
> start-daemon /sbin/wfcserv
> logout
```

Otherwise, skip to:

Then, press the ADC Reset button.

Then, press the WFC Home button.

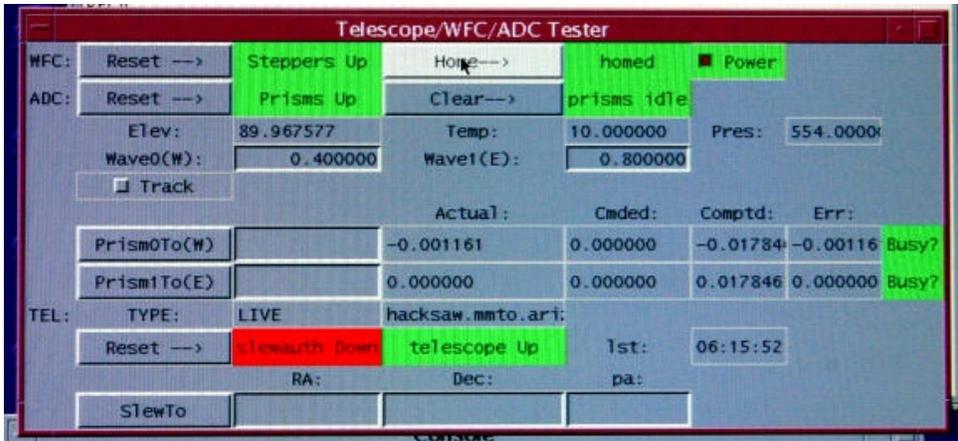


Figure 41. Wide field corrector ADC prism control window.

The E prism will home, then the W prism. You can follow the homing moves on the display; the units are degrees. The home procedure consists of 5 passes in each of two directions with a Hall Effect sensor. The bidirectional procedure allows greater home precision.

If the telescope server is up and observing is underway, the track button can be pressed and the ADC prisms will automatically move to the correct position. Turn the track button off when the telescope is slewed.

5.4 MOUNT STATUS DISPLAY

On Cfaguidr, you will also want to start up the Mount display GUI to keep track of UT, sidereal time, elevation, and etc. In a terminal window, type:

```
> mountdisplay &
```

Object Name	
Catalog RA	-01:00:00.00
Catalog Dec	-100:00:00.00
Epoch	0.00
Pos Ang	0.71
Az Offset	0.00
El Offset	0.00
InstAzOff	0.00
InstElOff	0.00
RA Offset	0.00
Dec Offset	0.00
RA total	-01:00:00.00
Dec total	-100:00:00.00
Par Ang	0.7123
Hour Ang	-00:00:00.034
Airmass	1.00
Azimuth	180.1158
Elevation	89.9700
Rot Ang	-0.0002
Focus	14871
Date	2004-04-08
MJD	53103.22171
UT	05:19:15
LST	11:02:56.674

Figure 42. The mount status display.

6 OPERATING THE FIBER POSITIONER

Operating the fiber positioner is carried out with two GUIs: Hobserve and the Guide GUI, both running on Packrat. Hobserve is used to configure the fibers for the observation, set up the guide probes, and operate the intensified cameras (one on each of the robots and one that view all three of the guide probes). The Guide GUI controls all of the guiding functions.

The Hobserve GUI is set up so that the next step is indicated with a green button, leading the observer through the correct sequence of operations.

Camera 1 is	Off	Gain	0	0	Set	Cal Off	Fid Off	R1 Offline	R2 Offline
Camera 2 is	Off	Gain	0	0	Set	Cal Off		Hctserv Up	Reset PMACs
Camera 3 is	Off	Gain	0	0	Set	Hse Off		Snappy Up	Epbox Up
								Guidserv Up	

Setup On Field	Standard Ops
----------------	--------------

Config	File	1200p5000		Number	1	Browse
adjust fibs	start	6		time	1 hours	skymin 20
UseUTC	utc	Apr 8 06:00:00 2004				skymax 40
BestPA	pa0	171.488	rot0	16.757		r1star 1
	pa	-167.000	rot1	-1.916	targets 174	r2star 1
			rot2	-22.179	skys 50	
Begin moving robots	ra	12:00:01.789	dec	49:59:20.847	pa1	-167.000
goto zenith	lst	10:57:18	ha	-1:02:43.789	airmas	1.1
configure fibs	ut	05:13:38			ReCode	
move guide probes	a1	345.85	a2	183.54	a3	80
slew to star						
move a robot on axis	robot	2		ZUp	ZDown	
gain up on robot				SetBias	ClrBias	
slew to field						
robots to guide	rx1	-312.204	ry1	-19.324	rx2	301.091
					ry2	-75.905
gain up on all					GuideOnRobots	
guide transfer	r1box	4	r2box	3	TransferBoxes	
stow robots						
gain down on guides						
Start Over						

Figure 43. Main Hobserve GUI page (field setup page).

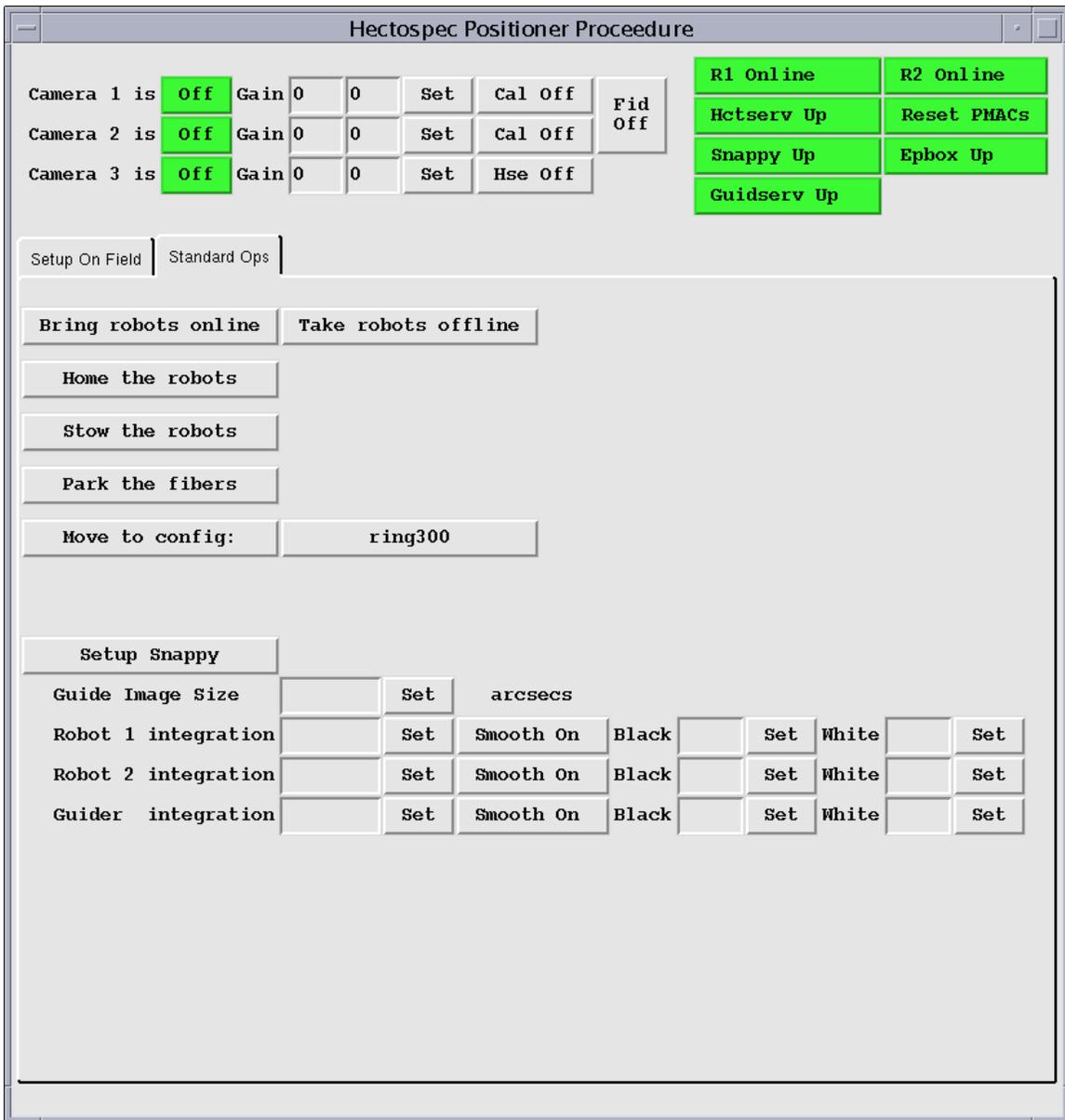


Figure 44. Hobserve standard operations Gui page.

Important to know before you start:

- 1. Follow the turn on procedures given above carefully. Do not attempt to configure fibers if the robots are not homed and all of the necessary software is initialized.**
- 2. The fibers should only be configured when the telescope is zenith pointing. The configure fibers command will pop up a prompt window to remind you not to configure fibers if the elevation angle of the telescope is less than 88°. Do not override this reminder unless instructed by Daniel Fabricant or John Roll.**
- 3. The guide probes should only be configured when the telescope is zenith pointing. The configure fibers command will pop up a prompt window to remind you not to move the guide probes if the elevation angle of the telescope is less than 88°. Do not override this reminder.**
- 4. The guide cameras should not be turned on unless the dome is dark. Excessive illumination may damage the image intensifiers in the guide cameras, possibly disabling the instrument. Turn the gain of all three guide cameras down to 0 before slewing. Don't turn the gain up on the guide cameras above the minimum needed to get a decent signal.**

6.1.1 SETTING UP FOR WAVELENGTH CALIBRATION, DOMEFLATS, ETC.

Typically, in the early evening before observing you will want to take some calibration data using the lightboxes illuminating the dome. The inside of the shutters have been painted with a special high-reflectivity white paint that diffuses the incident light. The fibers can be placed in the ring300 configuration that is accessible from the standard ops page of Hobserve. You will need to make sure that the lightbox GUI is up (dcalgui). The dome may not be dark enough during the day for best results with most types of calibrations.

6.1.2 SETTING UP A CONFIGURATION FOR OBSERVATION

1. Make sure that all of the GUIs are started up and that the robots are homed as described above.
2. Select the Setup On Field page of the Hobserve GUI. The **Config** button should be green.
3. Use the **Browse** button to select the correct .cfg file for the next observation and then press the **Config** button. A number of fields should update including rotator angles, ra, dec, etc.
4. Type the desired UT start time for the observation into the **start** window and the desired observation duration into the **time** window. The fibers will be placed to account for atmospheric refraction at midpoint of the observation.
5. Press the **BestPA** button to select the best rotator angle for the observation and then press the **adjust fibs** button. The fiber assignments will be adjusted for the chosen rotator angle and guide stars will be selected from the catalog to accommodate the guide probe placement constraints. The rotator demand angles at the beginning, middle, and end of the observation will be displayed in the **rot0**, **rot1**, and **rot2** boxes, respectively. The **Begin moving robots** button will light up.
6. Make sure that the telescope is zenith pointed (azimuth is not important) and press the **goto zenith** button.
7. When the telescope is at the zenith, press the **configure fibers** button, and answer **ok** to the dialog box. You can watch the fibers position on fiber's Hecto display.
8. When the configuration is complete, the **move guide probes** button will turn green. Press the **move guide probes** button and answer the dialog box with **ok**. The guide probes will home sequentially and then move to the selected positions in unison. You can watch the positions of the guide probes on the hecto guide probes display.
9. Give the ra and dec of the field center to the telescope operator, as well as the desired position angle (displayed in the **pa1** window next to ra and dec).
10. When the guide probe motion is complete, the **slew to star** button will turn green. Press it and slew to an 8th to 9th magnitude star near the field center.
11. Have the operator use the wavefront sensor to adjust the telescope collimation and primary figure.

12. On the Standard Ops page, press the **Setup Snappy** button and set all of the integration times to 2 seconds if this is the first field of the night.
13. When the telescope has finished slewing to the guide star and the rotator is tracking at the selected position angle, type 2 into the **robot** window and press the green **move a robot on axis** button. This will place robot 2 on axis in position to center up on the star. Turn on camera 2 and set its gain to 20 with the **set** button. The desired gain should be typed in next to the set button, not next to the display only gain window. Answer the dialog box to verify the gain setting. The star should be visible in the right hand fiber monitor.
14. Have the operator center up the star on the central small green square using the secondary hexapod, or very small mount offsets. When this is complete, press the **ZUp** button on the move a robot on axis line. The robots should be up before any slew.
15. Press the **slew to field** button and offset to the field position.
16. When the telescope and rotator are in position, press the green **robots to guide** button. The robots will move to the guide star positions at the edge of the field. Turn on any camera that are off, and slowly increase the gains on the cameras until the guide stars are visible on the right hand fiber monitor in both robot cameras. Typical gain values for faint stars are 70 to 80. 90 is the highest gain.
17. Press the **Start Cameras** button on the guider display. Make sure that the gain and lookback values are correct (see startup procedure).
18. Press the **GuideOnRobots** button on the Hobserve GUI. Green circles should appear in the leftmost two panels of the guider display. Have the telescope operator apply offsets to get the stars near the green circles, then press the **Start Guiding** button on the guider display.
19. When the guide stars are centered in the circles (and centered on the green squares in the fiber monitor, use the mouse to drag the green circles in the lower right panels of the guider display over the guide stars. Then press the **TransferBoxes** button on the Hobserve GUI.
20. Press the **guide transfer** button to start guiding on the guide probes. Check that the guiding is good by watching the robot camera displays. Repeat from step 18 if necessary.
21. When satisfied, press the **stop guiding** button on the guider display and press the **stow robots** button on the Hobserve GUI.
22. When the robots have completed stowing, press the **start guiding** button on the guider display. Begin the exposure.

6.2 OPERATING THE BENCH SPECTROGRAPH

6.2.1 AT THE BEGINNING OF EACH NIGHT

Aside of turning the power on and homing motors, covered below, the CCD dewar must be filled every night. It is probably best to do this in the afternoon. The current hookup uses the large MMT dewar and lines long enough so that the tent does not have to be breached, and thus darkness can be maintained. An exhaust tube is located on the floor next to the input LN2 line.

You should leave the access door to the chamber open so that nitrogen doesn't build up in the room. Open the LN2 dewar valve slightly more than a crack, such that air is flowing out of the exhaust line rapidly but not extremely fast. The dewar should be filled within about 5 minutes, as can be verified when liquid starts coming out of the exhaust line. Turn off the valve. You do not need to disconnect anything, but also **do not move the focus stage for at least 20 minutes, due to the stiffness of the frozen fill line.**

Turn off the lights and close the door. Good luck!

The level of the large dewar should be monitored, and when it is below 1/3 full, take it out of the room and ask the MMT staff to fill it.

6.2.2 STARTING UP THE CALIBRATION LAMPS

First make sure that the power lines are connected in the third floor east lab (BK's area) and that the calibration lamp Pulizzi is on.



Figure 46. Dome calibration control. To operate the dome calibration lamps make sure that the green-coded power connector on the bottom of the rack is connected and that the Pulizzi at the top of the rack is on.

To start up the dome calibration software, start in a cfaguidr window (logged on as mccd). You can also vncviewer into cfaguidr:1 from alewife, though this brings up a lot of other windows as well..

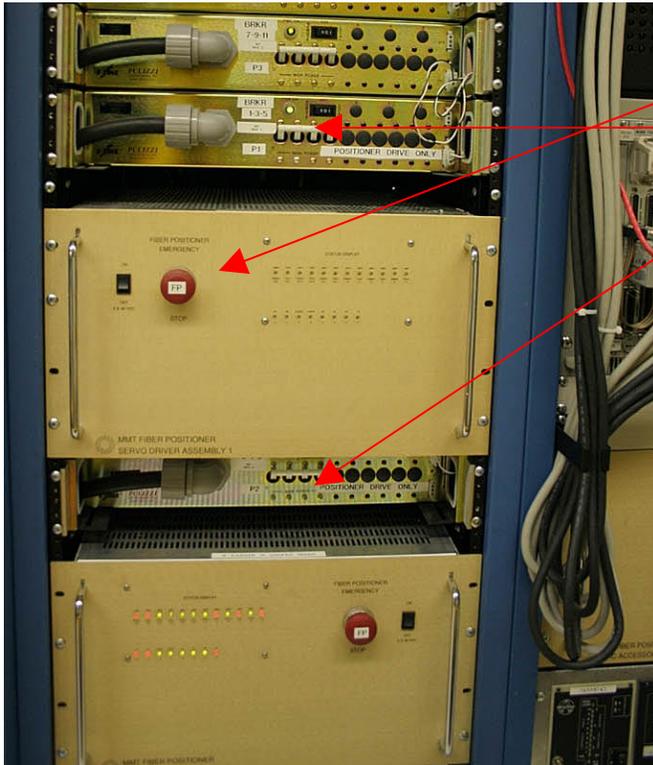
```
> stop-daemon domecal  
> start-daemon domecal
```

On the domecal GUI, the four top buttons turn on power to the four dome calibration boxes. The buttons at the side turn on/off the selected lamps. The HeNeAr and ThAr lamps have gain settings at the bottom of the GUI. Run these at gain setting 3 for now. Enter 3 into the space and press either the thar-ctrl or the henear-ctrl button.

	nw		sw		ne		se	
temp-degc	-10.5		-8.9		-9.8		-7.3	
continuum	6.0	5.9	5.9	5.9	5.9	5.9	6.0	5.9
henear	0.1	2	0.0	1	0.1	1	0.0	2
thar	0.0	2	0.0	-1	0.0	-1	0.0	1
mercury	0.0		-0.0		-0.0		-0.0	
xenon	0.0		-0.0		0.0		0.0	
krypton	-0.0		0.0		0.0		0.0	
argon	0.0		-0.0		-0.0		0.0	
neon	-0.0		0.0		0.0		0.0	
thar-ctrl								
henear-ctrl								

Figure 47. Dcalgui with power on to all boxes and with the continuum lamps on.

6.3 AT THE END OF THE NIGHT



6.4 COMPLETE SHUTDOWN PROCEDURE

This procedure will also shut down all the bench spectrograph electronics.

1. The first step is to follow the “At the End of the Night” procedure to turn off the servo power to the robots.
2. Open a vncviewer window to the wavefront computer as described above. Press the exit buttons on the waveserv and wavecamr icons. Close the cygwin windows. Press the Windows Start button at the lower left and press the Turn off computer button. When the dialog box appears, complete the Windows shutdown procedure.

3. Turn off power on switch 3 on P7 (WFS DRV AC). Turn off power on switch 4 on P7 (WFC AC).
4. Turn off switch 5 on P5 (WFS CTRL AC)
5. Turn off switches 8, 7, 6, and 1 on P5. Then turn off switches 4, 3, and 2 on P5.



Figure 48. Pulizzi layout.

6. Turn off all of the switches on P9 for spectrograph power. These are located in Rack 3 behind the blue door.



Figure 49. Pulizzi 9 and the Hectochelle grating controller.

Now, turn off the UPS sitting on top of rack 1. This will turn off the Hardware and Topper computers.



Figure 50. Turning off the UPS on the top of rack 1.

Now, unplug the UPS plug from dirty power. In this picture, the grey plug is left in all the time (ion pump on Hectospec dewar). Check with the operator about unplugging any of the plugs in the orange outlets (clean power).

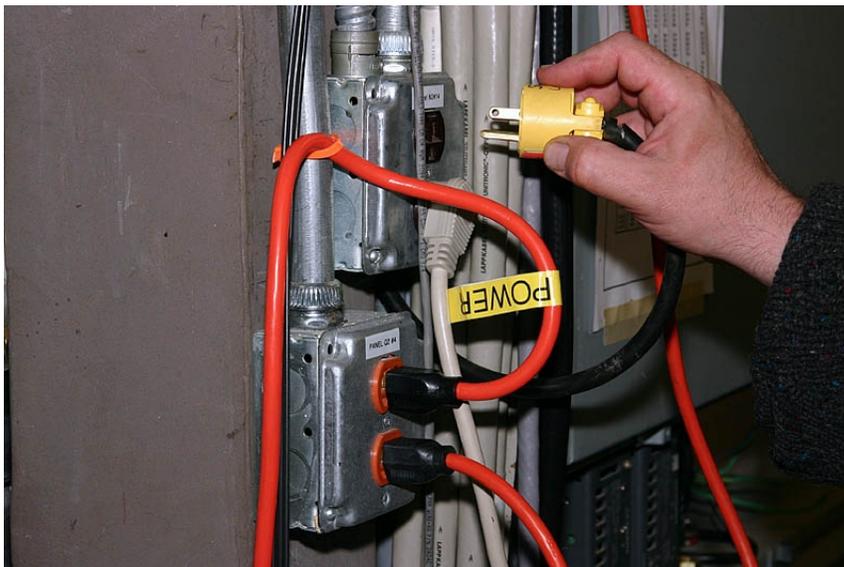


Figure 51. Unplugging. The fourth grey plug is normally not present.

Finally, flip the large switch on the main panel to the left of the plugs to off.



Figure 52. Main disconnect to the left of the electronics racks.

POWERING DOWN THE DOME CALIBRATION BOXES FOR LIGHTNING PROTECTION



Turn off the Pulizzi at the top of the rack on the east side of the third floor east electronics lab near BK's desk and disconnect the green-coded power cable at the bottom of the rack.

7 RECOVERY FROM FIBER POSITIONER ERRORS

It is our sincere hope that you never have to refer to this section of the manual. For completeness, however, we include a brief discussion of how to deal with fiber configuration sequences that fail to complete.

The configuration sequence could stop either between moving fibers or with fibers still in the grippers. The robots could be left on-line if one of the limit switches is activated or put off-line (servo loop opened) if a following error, power failure, or amp failure is encountered.

7.1 ROBOTS LEFT ON-LINE

The configuration sequence will be halted with the robots left on-line if any of the following conditions occur: (1) limit switch on any axis is activated or (2) the gripper is empty when the software thinks a fiber should be held, or (3) the linear and rotary encoders on the X and Y axes do not match within tolerances.

The most likely limit switch error would be associated with the Z-axis limit switch in the gripper fingers that could be triggered by foreign matter on the focal surface (ladybug or moth), button collisions or a damaged button. Other limit switch activations would likely indicate a hardware problem. If the gripper empty error is activated either the gripper has failed, a button cannot be found at the expected position, or a button has been dropped. If the linear and rotary encoders do not agree, the most likely problem is a failed encoder.

The operator could not recover from hardware failures, but it may be possible to recover from misplaced or dropped buttons and foreign matter on the focal surface.

7.1.1 LIMIT SWITCH ACTIVATED

Look at the Hecto display and see if any of the limit switches are red (excepting the normal gripper limits).

7.1.2 GRIPPER EMPTY

7.1.3 ROTARY COMPARE ERROR

First make sure that the telescope is zenith pointing. If it is not, first return the telescope to the zenith.

The red **BUSY** light will be on, but the axis lights will still be green indicating that the robots are on-line. The first step is to press **CLEAR** on each robot. **Do not press ABORT!**

The Hobserve GUI has a tab labeled “**Error Recovery**”. Select that tab and use the park commands to park fibers that may still be in the grippers. Then stow the robots.

Go up to the telescope chamber, remove the Velcro cover and the access panel. Look inside for dropped fibers or signs of trouble. If all looks okay, replace the panel and cover.

Park the fibers by using the **PARK** command. This park sequence may also fail due to the original misplaced fiber. In this case the error is likely to be failure to pick up a button at the expected position.

7.2 ROBOTS LEFT OFF-LINE

8 LOW LEVEL FIBER POSITIONER SOFTWARE

8.1 FIBER POSITIONER CONTROL SOFTWARE

8.1.1 MID LEVEL COMMANDS

8.1.2

zregs

placert <robot> <fiber> <radius> <angle>

place <robot> <fiber> <x> <y>

pick <robot> <fiber>

park <robot> <fiber>

gobtn <robot> <button>

gofid <robot> <fiducial>

goidle <robot>

8.1.3 LOW LEVEL COMMANDS

8.1.3.1 POSITIONER CONFIGURATION STATE

stowedsafe

init

config

status

statusof <fiber>

atpark <fiber>

atxy <fiber> <x> <y>

caste <robot> <x> <y>

casteon

8.1.3.2 OPERATING ON FIBER CONFIG FILES

seqfibs

fitfibs
adjfibs

cfgdump
chkfibs
prkfibs

8.1.3.3 POSITIONER AXES

sequence

mxytp <robot> <x> <y>
mxytprt <robot> <fiber> <radius> <angle>

xymov <robot> <x> <y>
rtmov <robot> <fiber> <radius> <angle>
xyz <robot> <x> <y> <x>
xyzd <robot> <x> <y> <x>

tpmov <robot> <t> <p>
phome <robot>
thome <robot>
tmove <robot> <t>
pmove <robot> <p>

xhome1 <robot>
xhome2 <robot>
xmove <robot> <x>
xbrake <robot> <onloff>

yhome <robot>
ymove <robot> <y>
ybrake <robot> <onloff>

zhome <robot>
zmove <robot> <z>
ztagup <robot>
zup <robot>
zdown <robot>

zbrake <robot> <onloff>

ghome <robot>

gmove <robot> <g>

gopen <robot>

gclose <robot>

gripoff <robot>

gforceopen <robot>

g1home

g2home

g3home

g1move <angle>

g2move <angle>

g3move <angle>

g123move <angle1> <angle2> <angle3>

8.1.3.4 MISCELLANEOUS

checktrouble <onloff>

clear

comp

hconfig

pmac

pulzpow

state

testnumber

usetpgrid

usexygrid

value

9 FLEXURE MEASUREMENTS

9.1 INTRODUCTION

The purpose of this section is to summarize progress towards flexure compensation in the Hectospec fiber positioner. This information is mainly for the internal use of the Hectospec team, but may be of interest to Hectospec observers.

Flexure potentially causes misalignment of the guide stars with respect to the fibers. The fibers and guide probes are positioned when the instrument is zenith pointing. The instrument is then tipped down in elevation to acquire the field and begin tracking. The key flexure concern is that the positioning robots are used to acquire the guide stars and to establish the tracking position that is then maintained by the guide probes. Any flexure in the robots from zenith to the observing elevation angle will be reflected in errors in aligning the guide stars. Initial flexure in the guide probes from zenith to the elevation angle at the start of observing drops out, but subsequent flexure in the guide probes from that point on is also relevant.

9.2 AUGUST 2003 GRID TESTS

During the early stages of Hectospec commissioning at the MMT (on August 27, 2003) we installed the large calibration grid and observed the shift of the grid dots with respect to the grid at the zenith pointing position with each of the two robots at two rotator angles and at two elevation angles. The elevation angles were 30° and 60°, and the rotator angles were chosen to align the Y axis with the gravity vector (+15° rotator angle) and to align the X axis with the gravity vector (-75° rotator angle).

The flexure is well described by solid body offsets. After removing an X and Y shift, the residuals for each of the eight tests (2 rotator angles x 2 robots x 2 elevations) were 9 μm or less with maximum residuals of 21 μm at any point. Some of the individual measurements may be affected by noise. The +15° (Y) results are intuitive, but the -75° (X) results are not.

Fitted Offsets from Calibration Grid Test

Test Sequence	Robot	Rotator	Elevation	X offset (mm)	Y offset (mm)
5826	1	+15° (Y)	60°	-0.004	0.024

5829	1	+15° (Y)	30°	0.000	0.039
5827	2	+15° (Y)	60°	-0.003	0.023
5830	2	+15° (Y)	30°	-0.005	0.042
5831	1	-75° (X)	60°	0.015	-0.013
5833	1	-75° (X)	30°	0.021	-0.008
5832	2	-75° (X)	60°	0.000	0.027
5834	2	-75° (X)	30°	0.006	0.032

10 APPENDIX

10.1 STARTING UP THE WAVEFRONT SENSOR

The wavefront sensor (WFS) software consists of three components: (1) two programs (servers) that run on a Windows XP PC built into the wavefront sensor, (2) a GUI that typically runs on Packrat, and (3) a series of GUIs that the operator runs on the Alewife computer. The first step is to turn on power to the WFS if it was not already turned on; see the procedure above. After the power is turned on, wait 10 minutes for the wavefront sensor computer to boot up before proceeding.

On Packrat, find a free terminal window and type:

```
> vncviewer wavefront
```

You will be asked for a password that will be available on the mountain.

Once you are on the VNC window cancel any offers by Windows to install USB drivers or update Windows. When the screen is clear, start up a cygwin window by clicking on the cygwin icon. Inside the cygwin window type:

```
> cd src/waveserv
```

```
> wish waveserv.tcl
```

Start up a second cygwin window and type:

```
> cd src/waveserv
```

```
> wish wavecamr.tcl
```

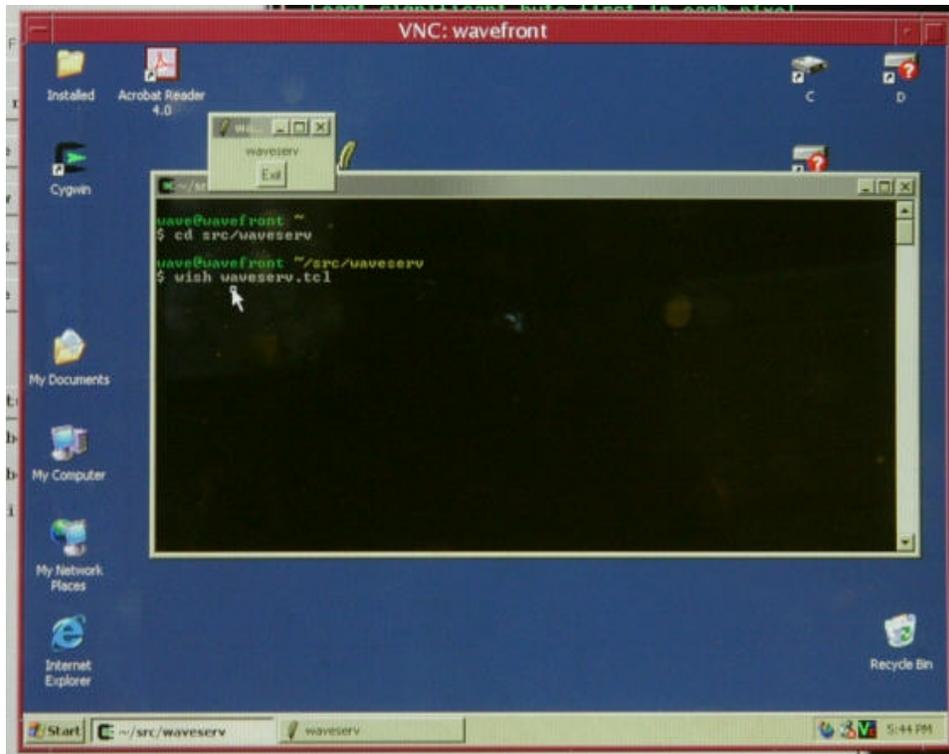


Figure 53. VNC session to wavefront after waveserv is started.



Figure 54. VNC session after both servers are started up and the cygwin windows are minimized.

You can now minimize the VNC window. You will need to access a VNC window again to shut down the wavefront computer before turning off the power.

On Packrat, fire another free terminal window to start up the WFS GUI and type:

```
> wavedisplay
```

Wait a minute for the GUI to start up. Press the Power button and after a moment a small power window will come up. All of the buttons should be green (on) except the encoder and the servo buttons which will be red. Press the encoder button and answer the dialog to turn on the encoder power. The encoder button will turn green. Then repeat this procedure for the servo power.

Press the Home button to home the four WFS axes. This will take a few minutes. After homing the WFS will be stowed to the off-axis position. If the Puntino display doesn't show a "0", then press PHome to home the Puntino.

The SBIG camera can be started cooling by pressing the “On” button. It should cool to ~ -20 °C after 10 minutes or so.

The WFS can now be controlled from the operator’s GUI. The operator should try taking a reference Shack Hartmann image.

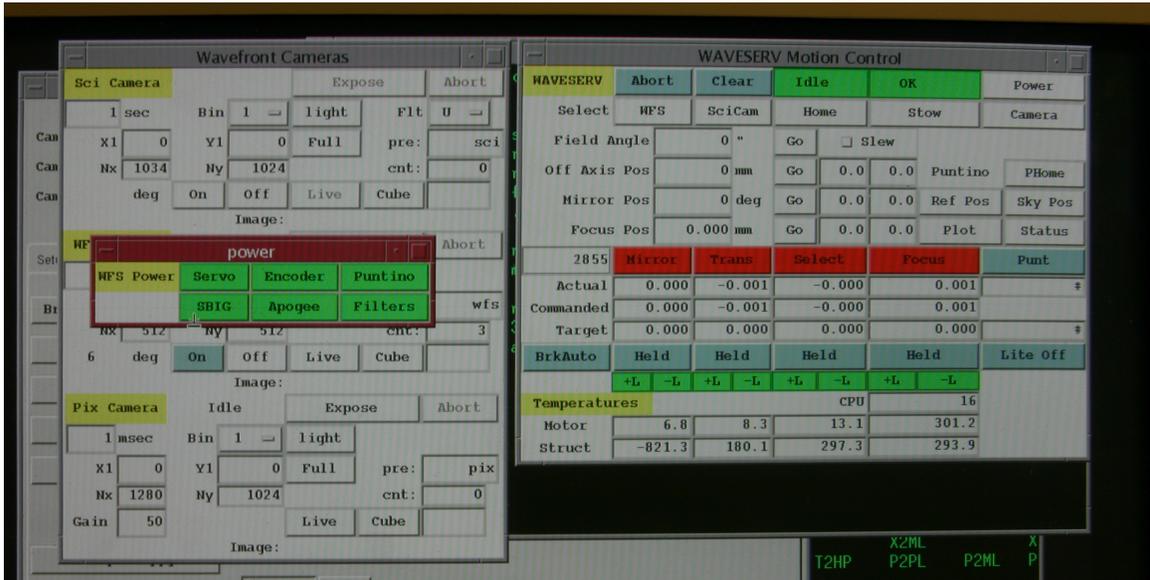


Figure 55. Wavefront windows on packrat after the encoder and servo power is turned on. The power window is brought up by pressing the Power button on the top right. The power window can be closed after these are turned on. The remaining four functions come up on by default.

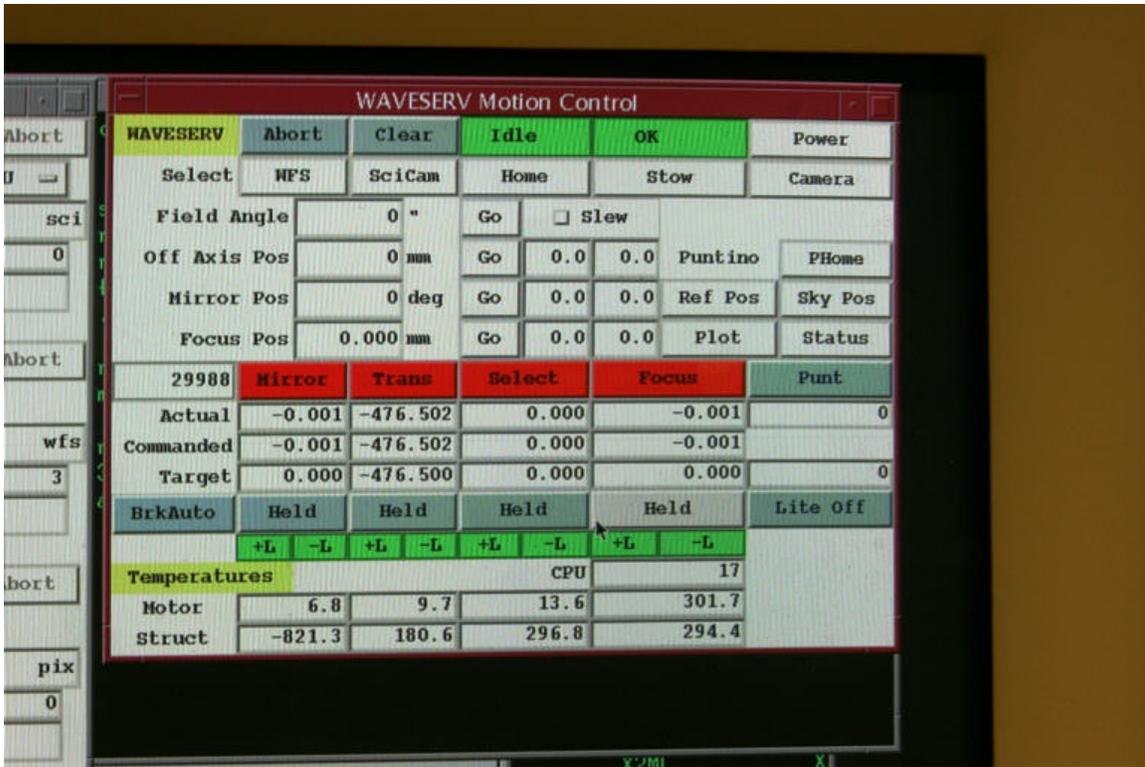


Figure 56. Waveserv display on packrat after the main stages are homed. If a "#" appear in the Punt (Puntino) column, press the PHome button. If the Wavefront Camera display is lost, press the Camera button to restore it.

