

Hectospec Observers Reference Manual

Draft of April 9, 2004

Daniel Fabricant

Nelson Caldwell

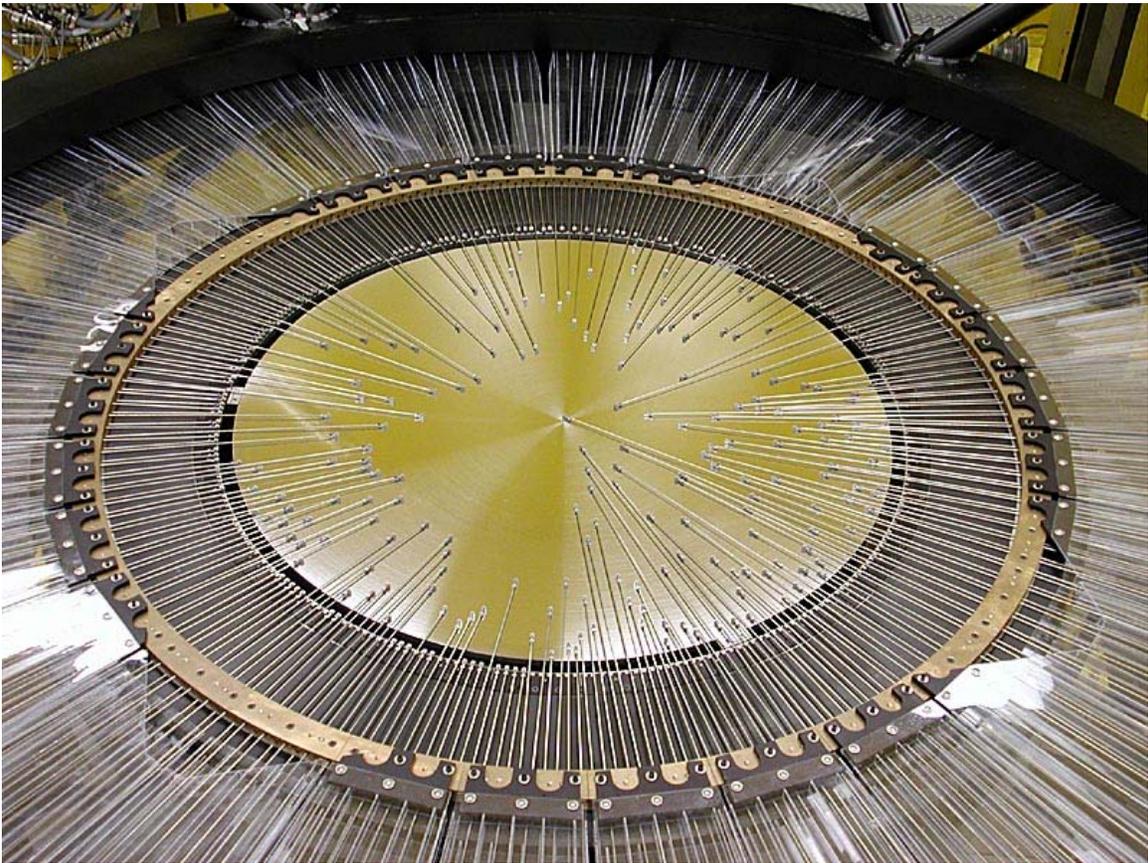


Figure 1. Hectospec focal surface.

1	INTRODUCTION.....	4
2	HECTOSPEC SPECTROGRAPH DESIGN.....	5
2.1	INTRODUCTION	5
2.2	BENCH SPECTROGRAPH OPTICAL DESIGN	6
2.2.1	<i>OPTICAL DESIGN PARAMETERS</i>	6
2.2.2	<i>SPECTROGRAPH OPTICAL PRESCRIPTION (MM)</i>	6
2.3	GRATING CHOICES	7
3	SPECTROGRAPH PERFORMANCE	10
3.1	CALCULATED THROUGHPUT	10
3.2	MEASURED THROUGHPUT	10
4	FITTING FIBERS TO TARGETS	11
4.1	INPUT CATALOG.....	11
4.2	HECTOSPEC ROBOT TV GUIDERS AND GUIDE PROBES	12
4.3	ASSIGNING GUIDE STARS	14
	RUNNING XFITFIBS.....	16
5	BENCH SPECTROGRAPH.....	22
5.1	PUMPING OUT AND FILLING THE DEWAR WITH LN2.....	22
5.2	BENCH SPECTROGRAPH & FIBER REFERENCE.....	30
5.2.1	<i>MOVING FIBER SHOE BETWEEN HECTOSPEC AND HECTOHELLE</i>	30
5.2.2	<i>FIBER SHOE LAYOUT</i>	32
5.2.3	<i>CCD AND DEWAR</i>	32
5.3	GETTING BENCH READY AT BEGINNING OF A NEW RUN.....	34
6	HECTOSPEC OBSERVING PROCEDURES.....	36
6.1	INTRODUCTION	36
6.2	START UP PROCEDURE.....	37
6.2.1	<i>TURNING ON THE COMPUTERS IN THE CONTROL ROOM</i>	37
6.2.2	<i>TURNING ON THE COMPUTERS IN THE F/5 STORAGE ROOM</i>	38
6.2.3	<i>STARTING UP THE SOFTWARE</i>	40
6.2.4	<i>TURNING ON THE POWER AND HOMING THE ROBOTS</i>	42
6.3	STARTING UP THE WAVEFRONT SENSOR	46
6.4	STARTING UP THE WIDE FIELD CORRECTOR.....	50
6.5	MOUNT STATUS DISPLAY	51
6.6	OPERATING THE FIBER POSITIONER	52
6.6.1	<i>SETTING UP FOR WAVELENGTH CALIBRATION, DOMEFLATS, ETC.</i>	54
6.6.2	<i>SETTING UP A CONFIGURATION FOR OBSERVATION</i>	55
6.7	OPERATING THE BENCH SPECTROGRAPH	57
6.7.1	<i>AT THE BEGINNING OF EACH NIGHT</i>	57
6.7.2	<i>INITIALIZING THE SPECTROGRAPH MOTORS</i>	58
6.7.3	<i>STARTING UP "SPICE" DATA ACQUISITION AND EXPOSURE STATUS GUI</i>	60
6.7.4	<i>STARTING UP THE CALIBRATION LAMPS</i>	61
6.8	TAKING DATA WITH SPICE.....	63

6.8.1	<i>SPICE DETAILS</i>	64
6.8.2	<i>EXPOSURE STATUS GUI</i>	67
6.8.3	<i>DATA FORMAT</i>	68
6.8.4	<i>DS9 BASICS</i>	68
6.9	AT THE END OF THE NIGHT	69
6.10	COMPLETE SHUTDOWN PROCEDURE.....	69
	6.10.1 <i>POWERING DOWN THE DOME CALIBRATION BOXES FOR LIGHTNING</i> <i>PROTECTION</i>	72
	72	
6.11	AT THE END OF THE RUN.....	35
7	LOW LEVEL FIBER POSITIONER SOFTWARE.....	73
7.1	FIBER POSITIONER CONTROL SOFTWARE	73
	7.1.1 <i>MID LEVEL COMMANDS</i>	73
	7.1.2 <i>LOW LEVEL COMMANDS</i>	73

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 one grating for Hectospec, a 270 line mm^{-1} grating blazed at $\sim 5000 \text{ \AA}$. We have on order a 600 line mm^{-1} grating blazed at $\sim 6000 \text{ \AA}$ that should arrive in late 2004. 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 ~ 42 pixels at the detector.

2 HECTOSPEC SPECTROGRAPH DESIGN

2.1 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.

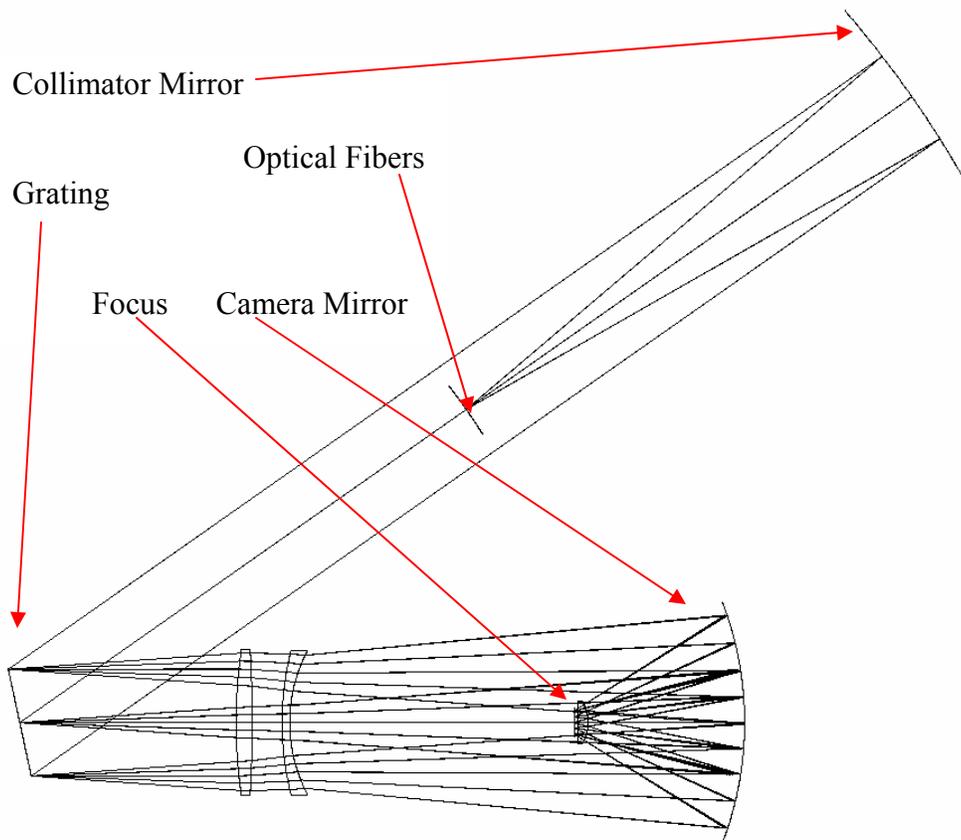


Figure 2. Optical layout of the bench spectrograph. The fibers are arranged in a line perpendicular to the plane of the page.

2.2 BENCH SPECTROGRAPH OPTICAL DESIGN

2.2.1 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

2.2.2 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

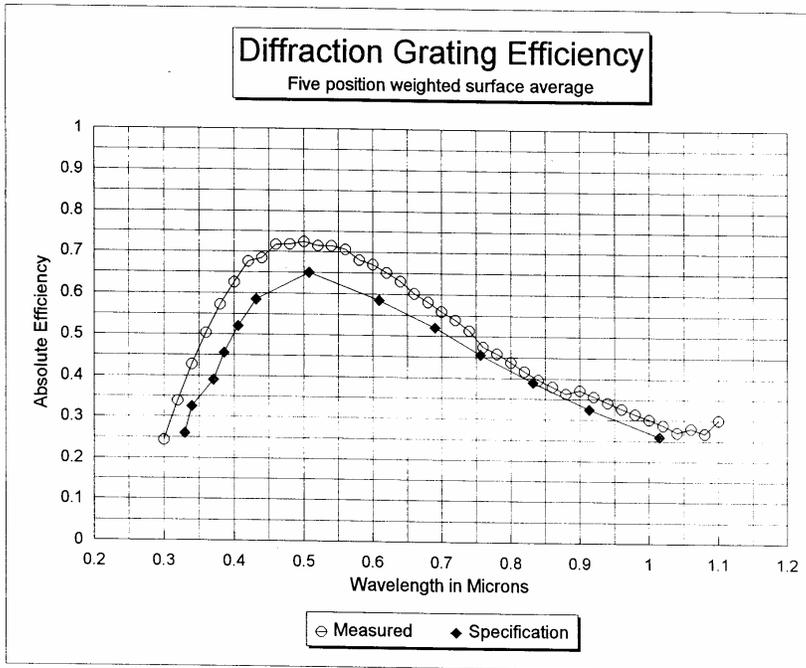
For a central wavelength of 6563 Å:

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°

2.3 GRATING CHOICES

The initial grating is a 270 groove/mm grating blazed at 5200 Å purchased from David Richardson Grating Laboratory. The spectral coverage, spectral resolution, anamorphic magnification, grating angles and RMS image diameters with this grating and two possible higher dispersion gratings, all set up with H α as the central wavelength, are shown below. 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 these may be available in late 2004.

Ruling Density (gpm)	Spectral Coverage (Å)	Spectral Resolution (Å)	Anamorph. Mag.	Angle of Incidence	Angle of Diffraction	RMS Image Diameter (pixels)
270	4488-8664	6.2	1.06	22.83	12.17	1.3-1.8
600	5609-7522	2.6	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



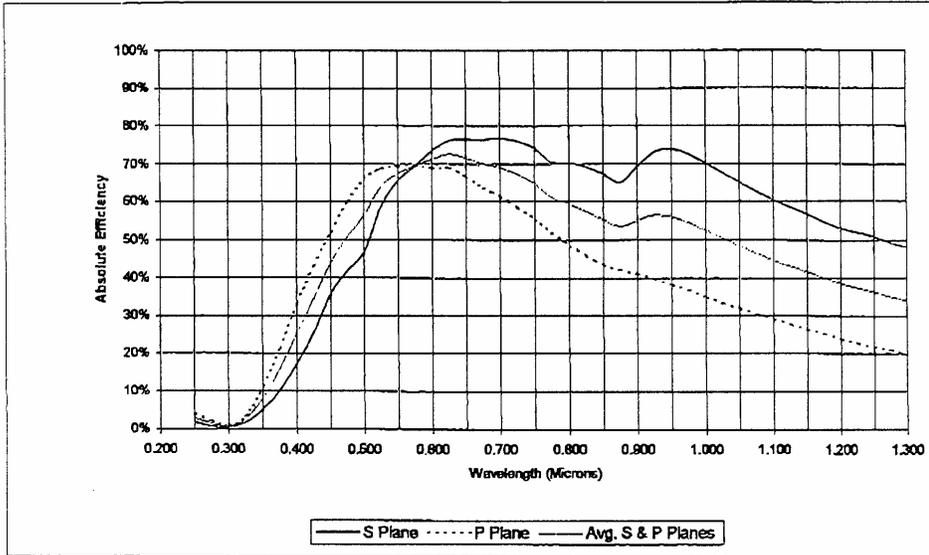
Serial Number:	MR192-1-1-1	Nominal Littrow Blaze:	530 nm
Grooves/mm:	270	Blaze angle:	4.1 degrees
Grating Coating:	Aluminum	Order:	First
Test Date:	09/09/98	Slits:	50 um (UV) 500 um (IR)
		Aperture:	10 mm
		Operator:	MA

Notes:

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

Figure 3. 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 4. The efficiency of the 600 line grating.

3 SPECTROGRAPH PERFORMANCE

3.1 CALCULATED THROUGHPUT

The Hectospec optical layout is simple enough that very high throughput can be achieved if good reflective coatings are used on the mirrors (2 surfaces) and good antireflection coatings are used on the lenses (6 fused silica surfaces). We have used the same dielectrically-enhanced silver reflective coatings and Sol-gel antireflection coatings that we used in the efficient FAST spectrograph. Our predictions for Hectospec's overall throughput with the 270 line grating are shown below. The column labeled "Add. Fiber Losses" includes FRD, end reflection losses, and the losses from misalignments of the fiber axis with respect to the chief ray at the f/5 focal surface. This table does not include aperture losses at the fiber input, which will depend on the seeing and the quality of the astrometry of the targets and the guide stars.

Wave	Mirror Refl. (2 surf)	Lens Thrput (6 surf)	Fiber Thrput (26 m)	Add. Fiber Losses	CCD Effic.	Cam Vign.	Grat Effic.	Tele Refl + 10 cor surf)	Final Throughput, Hectospec plus Telescope Optics
3650	0.90	0.89	0.70	0.80	0.66	0.80	0.37	.66	0.06
4000	0.90	0.92	0.80	0.80	0.80	0.80	0.49	.70	0.12
5000	0.91	0.98	0.90	0.80	0.85	0.80	0.66	.79	0.23
6000	0.92	0.98	0.94	0.80	0.80	0.80	0.61	.79	0.21
7000	0.92	0.98	0.96	0.80	0.75	0.80	0.53	.75	0.17
8000	0.92	0.95	0.98	0.80	0.60	0.80	0.43	.66	0.09
9000	0.92	0.91	0.98	0.80	0.30	0.80	0.37	.65	0.04

3.2 MEASURED THROUGHPUT

4 FITTING FIBERS TO TARGETS

4.1 INPUT CATALOG

This section describes the fiber assignment and guide star assignment software. The process begins with a Starbase format input catalog. Starbase documentation can be found at <http://cfa-www.harvard.edu/~jroll/starbase/starbase.html>, but the short story is that this is a tab-delimited ascii format table with a header line:

ra	dec	object	rank	type
-----	-----	-----	-----	-----
2:55:40.217	12:58:42.419	galaxy1	1	target
2:55:43.304	13:05:04.912	galaxy2	2	fiducial

ra is in hours:min:sec although decimal hours are also okay. dec is in degrees:min:sec although decimal degrees are also okay.

The *type column* allows the user to insert objects of type *fiducial* that are used for cross-matching with the 2MASS catalog for guide star selection, but are not assigned to fibers. The default type is *target* for objects to be assigned to fibers.

The *object column* is optional, but allows the user to name the object.

The *rank column* gives the target priority; a rank of 1 is highest. Decimal ranks are acceptable.

Additional columns must have a header, but will be not be used by the subsequent fiber assignment software. The input catalog must have a .stars, .targets, or .gal extension.

4.2 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 brightnesses 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.

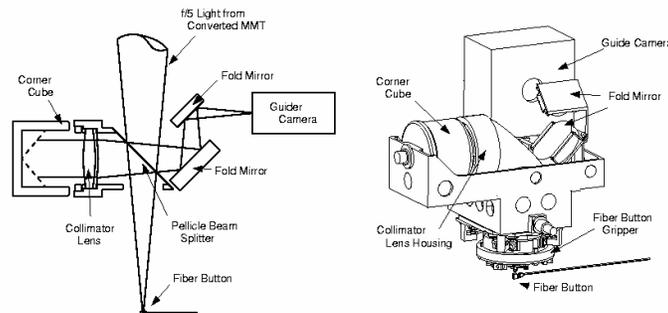


Figure 5. Robot TV guiders that can view the sky and backlit buttons simultaneously.

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

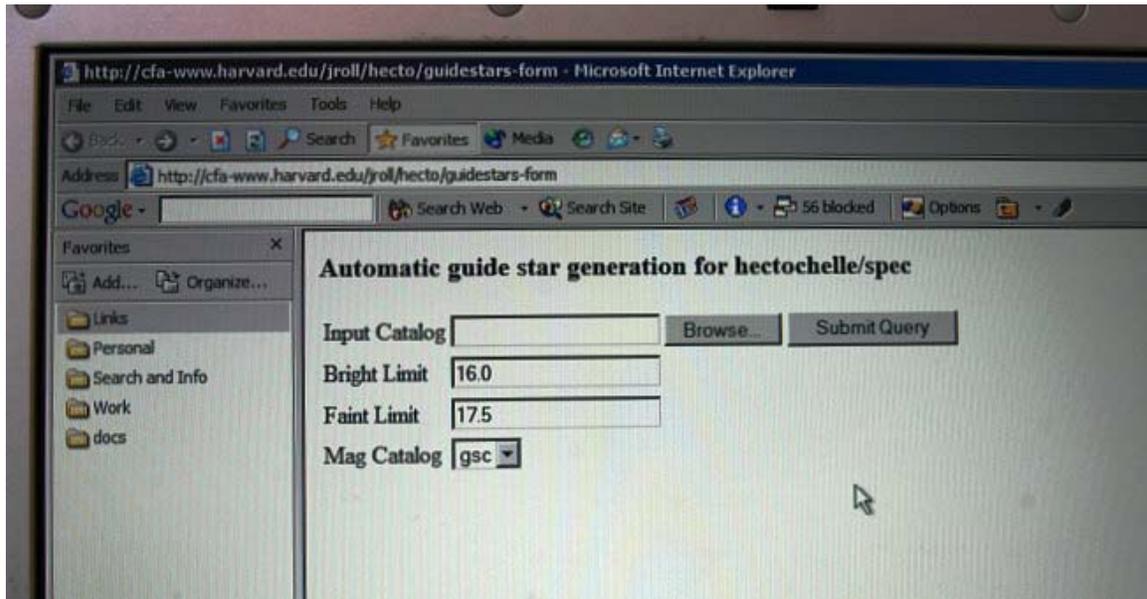
CCD (each pixel is $11.13 \mu\text{m}$). The cameras in the fiber positioning robots have a field of view of $\sim 60'' \times 80''$, while the three coherent bundle guiders each have a field of view of $\sim 30'' \times 60''$.



Figure 6. Photo of trifurcated coherent bundle and guide probes from beneath the focal surface.

4.3 ASSIGNING GUIDE STARS

The fiber positioner needs guide stars, and these can be added using a web-based form that can be found at <http://cfa-www.harvard.edu/~john/hecto/guidestars-form>.



This web-based form is fairly simple. The first step is to submit the input catalog using the browse button to find the appropriate file on the local computer. The bright limit and faint limit refer to the magnitudes of the desired guide stars that will be appended to the input catalog. Try to keep the magnitude range narrow since the guide stars are viewed by a single guide camera. If at all possible choose a range no wider than 1 to 1.5 magnitudes. A faint limit of 17.5 will allow easy guiding if the seeing is imperfect, a few clouds float by, or if the moon is up. Use of fainter guide stars will increase the risk of guiding loss and increased setup time. If the gsc option is selected, the magnitudes will be the average of the optical J and F magnitudes from the HST GSC2 catalog. If the tmc (2MASS) option is chosen, the optical R magnitude will be estimated from the 2MASS infrared colors.

The guide star software works as follows:

1. Objects in the input catalog are matched to the positions of objects in the 2MASS catalog, and an offset and rotation between the two catalogs is measured. The 2MASS astrometry is the best currently available for a large area catalog.
2. All of the 2MASS objects in the region of interest, judged from the extent of the input catalog, are matched to the GSC2 catalog to make the star/other classification. This step removes galaxies, etc., from the 2MASS list.

3. The final guide star list, trimmed of close pairs, is transformed to the coordinates of the input catalog and is appended to the input catalog. The guide stars have type = Guide.
4. Save the output file using the web browser “save as” command. The output file must be saved with a .cat extension.

We soon plan to add the option of using the GSC2 catalog exclusively since the requirement of matching to the 2MASS catalog may eliminate too many guide stars near $R=17.5$ to 18.

RUNNING XFITFIBS

An important fiber assignment note: the field center is reserved for the fiber robots to measure the telescope pointing offset. Any fiber placed within $\sim 30''$ of the field center will be parked by the software prior to fiber configuration. This is of particular importance when setting up for standard star fields. All robot configurations, even those for single objects should be set up with the standard XFITFIBS software, and include guide stars.

The program XFITFIBS must be obtained from John Roll (jroll@cfa.harvard.edu) and installed on a local UNIX computer.

`xfitfibs fieldname.cat`

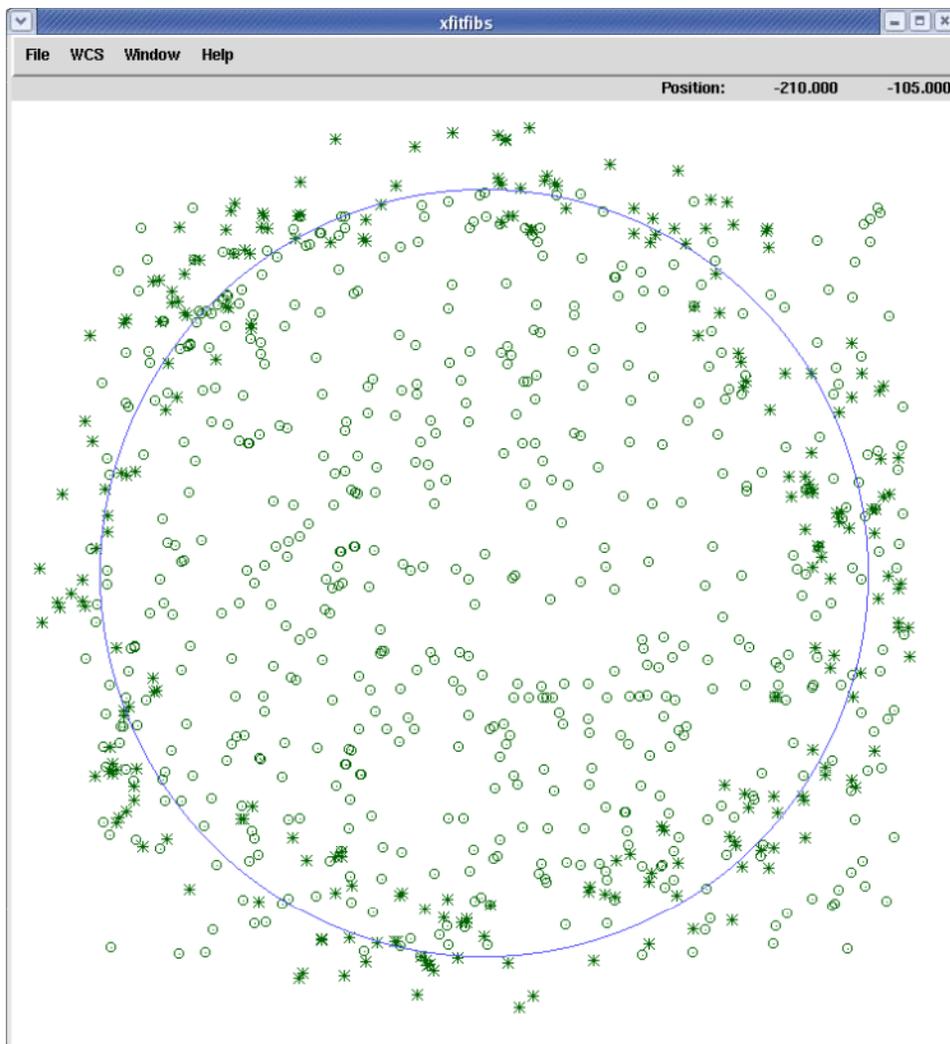


Figure 7. Xfitfibs starting screen. Circles are targets and stars are guide stars.

Go to the top pull down menu, to **Window**, and get **Field**. The default will come up with a field center calculated to be appropriate for your catalog, and it will assume one position setup.

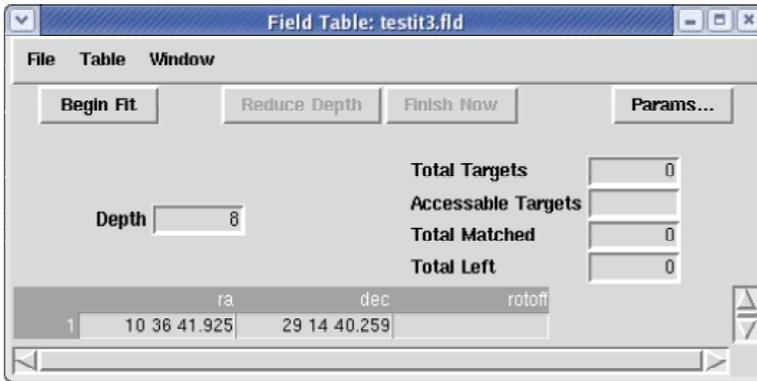


Figure 8. Xfitfibs Field window.

Now click on **Params**.

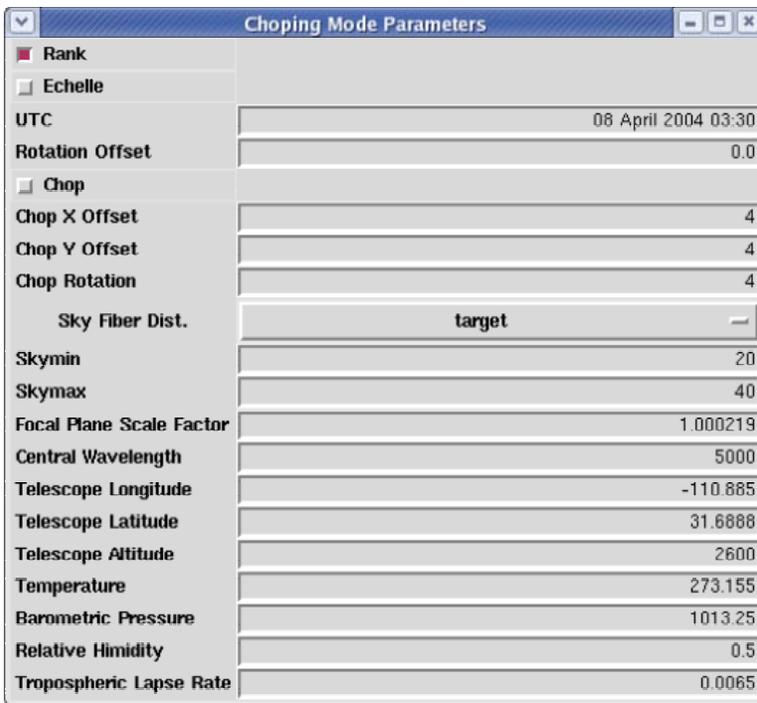


Figure 9. Xfitfibs Param window.

First, you want to push the **Rank** button, which allows the program to use the rank you put in your catalog. Then if you are using Hectochelle you need to click the **Echelle** button. This accounts for the smaller number of fibers accessible to Hectochelle.

Now, fill in the UTC. Your options are “now”, “NONE” (all caps), or a UTC appropriate to the time of observation. The problem with “now” is that if you run this thing during the

day, “now” probably corresponds to a time when the object is occulted by the Earth. If you choose “NONE” the object is placed on the meridian.

The other thing you might want to set is the minimum and maximum sky fibers for the program to fit. For now, we are recommending 20 to 40 sky fibers.

You can now click on **Begin fit** in the field window. First enter 8 in the depth position. When this is done the field window will show how many targets you matched. The display will show targets fitted and those not fitted. It will also show a circle around the field which corresponds to the limit of the field. Along this circle you will see additional stars which are the guide stars. Some of these are accessible, others not. Now you see why you needed a lot of potential guide stars; the accessible region is an annulus about 1' wide.

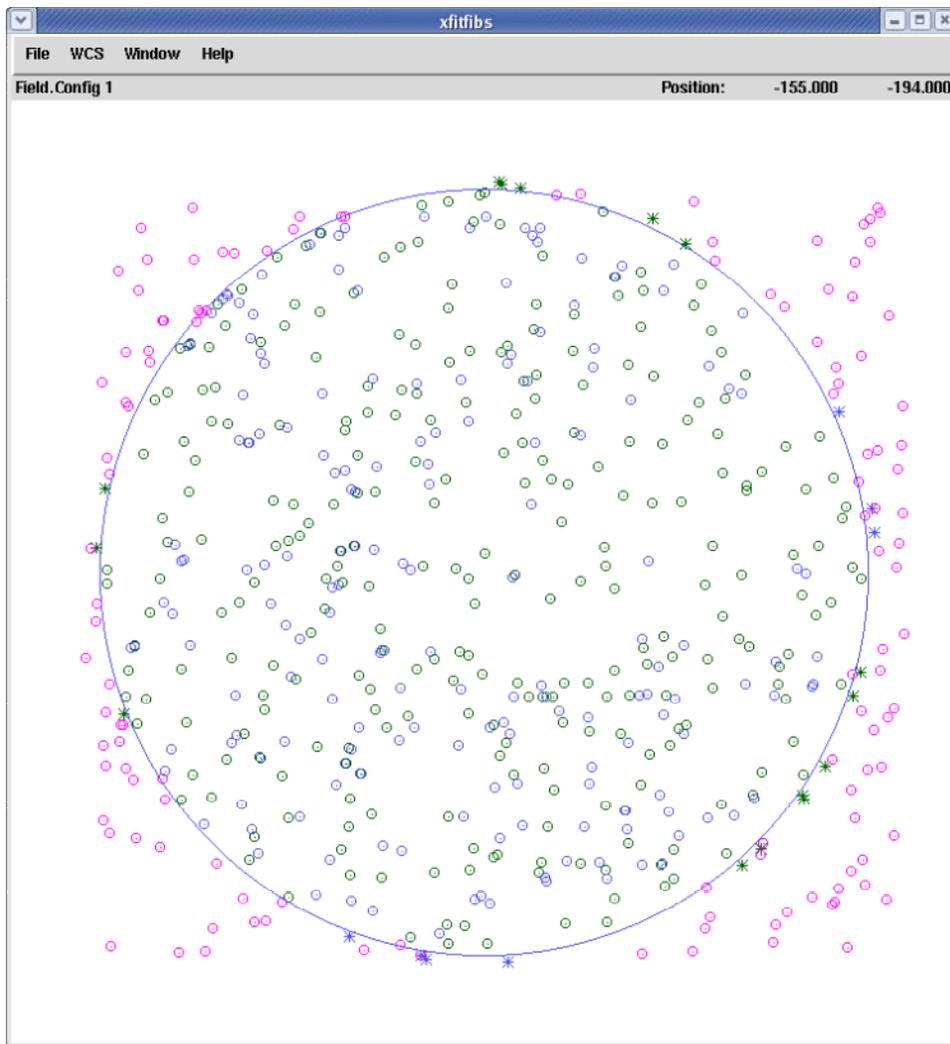


Figure 10. Xfitfibs display after fitting. The green circles are fitted targets, the blue circles are unfitted targets, and the magenta circles are inaccessible targets. The green stars are assigned guide stars (potential guide stars). The blue stars are guide stars that can't be used.

Next, set the rotation offset. The rotation offset is the same as the PA (position angle). Look at the .cfg file that was just created. We are aiming for a rotator angle that is zero at the midpoint of the observation. The rotoff to accomplish this is $\text{parang} - \text{pa}$, in this case -76.956 . Enter this value in the **Field** window. Refit by pressing **Begin fit**.

```

mmtobs@alewife:~
spec packrat 24> more fieldname.cfg
Config1

utc      Apr  8 03:30:00 2004
ra       10:36:41.925
dec      29:14:40.259
ha       -1:23:31.830
airmass  1.052
parang   -76.956
usepar   1
skyoff   -187.890
pa       0.000
rotator  -76.956
scale    1.000219
wavelen  5000.000
xfile
skydst   radius
skymin   20
skymax   40
chop     no
telepoly 0      599,508 7,25994 0      73,5279 0      -40,5352

GuideStars  Guide Star Table
GuideStars
GuideStars  ra      dec      platex  platey  radius  probe  angle  mag
GuideStars  ---      ---      -----
GuideStars  10:38:57.716  29:21:09.182  -307.864  -24.708  308,854  2  18
--More--(2%)

```

Figure 11. First pass at fieldname.cfg

Field Table: testit2.fld

File Table Window

Begin Fit Reduce Depth Finish Now Params...

Depth

Total Targets
 Accessible Targets
 Total Matched
 Total Left

	ra	dec	rotoff	Targets	Matched	SkyFibs
1	10 36 41.925	29 14 40.259	-76.956	455	271	29

Figure 12. The Field window with the correct rotoff entered.

If you pull down **Catalog** from **Window** in the main window, you will get the catalog with which fiber got assigned (or a field saying “UNASSIGNED”). If you pull down **Display** from the catalog window, you can figure out which color/symbol corresponds to assigned or unassigned stars and to usable or non-usable guide stars (at the specified time of observation).

The screenshot shows a window titled "Catalog: testit3.cat" with a menu bar containing "File", "Table", "Display", and "Window". The main area contains a table with the following data:

	ra	dec	object	rank	type	config	fiber
47	10 34 35.190	28 49 46.832		7	target	NO ACCESS	
48	10 34 36.066	29 28 32.439		5	target	NO ACCESS	
49	10 34 36.193	29 21 57.838		7	target	1	289
50	10 34 36.639	28 48 40.805		1	target	NO ACCESS	
51	10 34 37.202	28 59 54.136		9	target	NO ACCESS	
52	10 34 37.391	28 48 30.649		9	target	NO ACCESS	
53	10 34 37.425	29 12 16.139		1	target	1	6
54	10 34 37.899	29 36 43.919		9	target	NO ACCESS	
55	10 34 41.267	29 25 13.326		3	target	1	283
56	10 34 41.710	29 40 35.909		7	target	NO ACCESS	
57	10 34 41.944	29 16 39.900		3	target	1	298
58	10 34 42.040	29 32 36.075		3	target	NO ACCESS	
59	10 34 42.407	29 08 03.337		7	target	UNASSIGNED	
60	10 34 43.025	29 11 14.258		1	target	1	7
61	10 34 43.725	29 05 53.801		6	target	UNASSIGNED	
62	10 34 44.155	29 05 40.260		6	target	UNASSIGNED	
63	10 34 44.591	28 49 08.099		2	target	NO ACCESS	
64	10 34 46.098	29 21 08.420		3	target	1	290
65	10 34 46.561	29 14 31.552		8	target	UNASSIGNED	
66	10 34 47.588	28 58 46.453		5	target	1	28
67	10 34 47.849	29 12 48.878		4	target	1	5
68	10 34 49.503	29 14 55.805		1	target	1	2
69	10 34 51.038	29 16 02.073		1	target	1	299

Figure 13. Xfitfibs Catalog window.

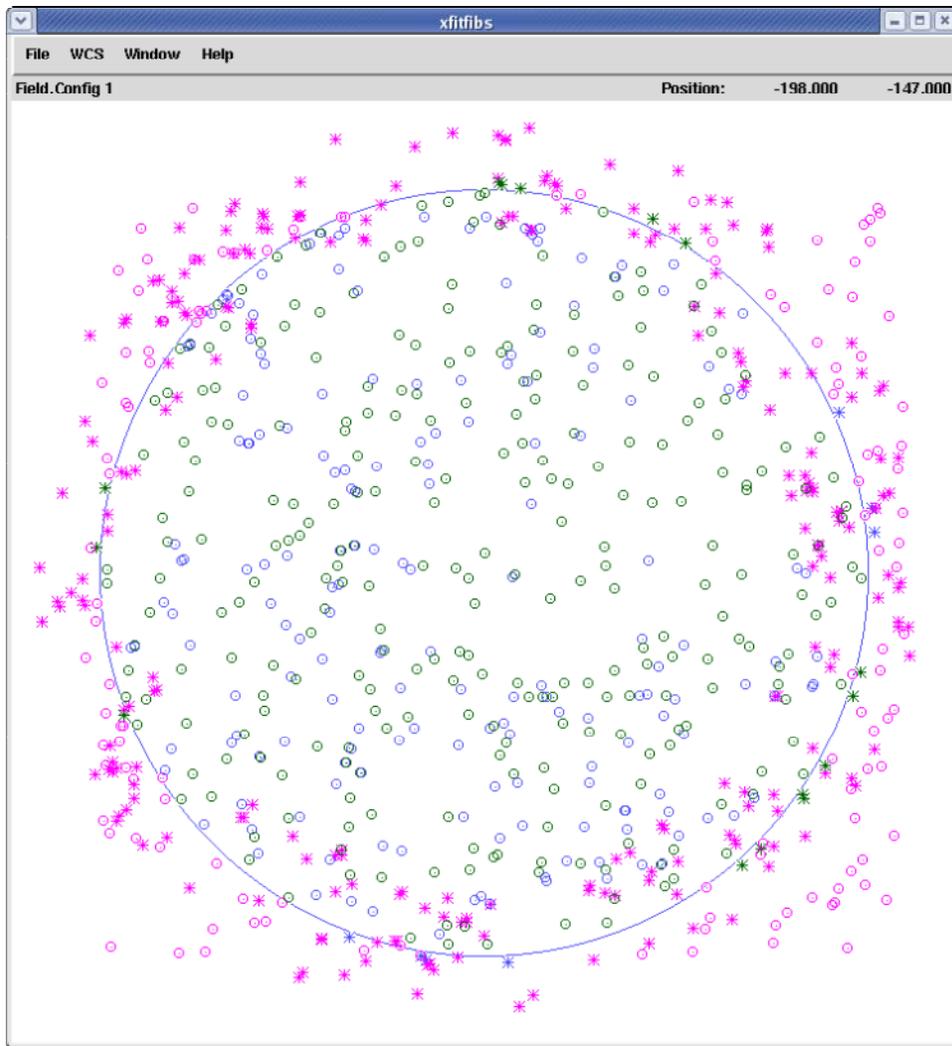


Figure 14. Same as Figure 10 except with inaccessible guide stars shown, as selected from the Catalog window, under Display.

If you don't like how the field is centered, you can use your mouse with left button to select and drag the circle over and then do another "Begin fit".

If you want another position setup for the same field, go to the field window and pull down **Insert row** from **Table**. You will see another circle in the display window. Then if you do **Begin fit** again, the program will work out two position setups.

At some point you might want to reassign ranks to get your favorite objects.

When you're done, pull down **Quit** from **File** in the main window. You will have made a **fieldname.cfg** configuration file. This file will have your multiple position setups, and is what you need to have at the MMT for observing. Bring along your original .cat files in case problems are encountered.

5 BENCH SPECTROGRAPH

5.1 PUMPING OUT AND FILLING THE DEWAR WITH LN2



Figure 15. Pump station.



Figure 16. 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.

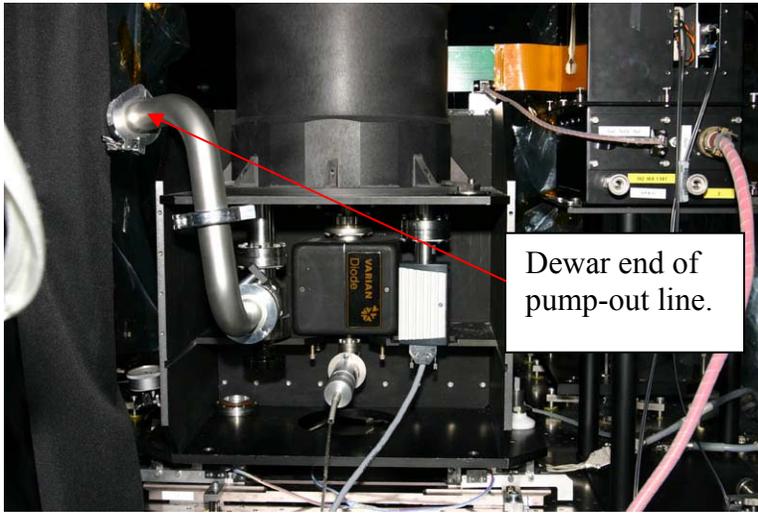


Figure 17. Hectospec Dewar.



Figure 18. Pump station end of pump-out line.

For Hectospec, install the long flexible hose hung on the central post. For Hectochelle, 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 19. Dewar valve.

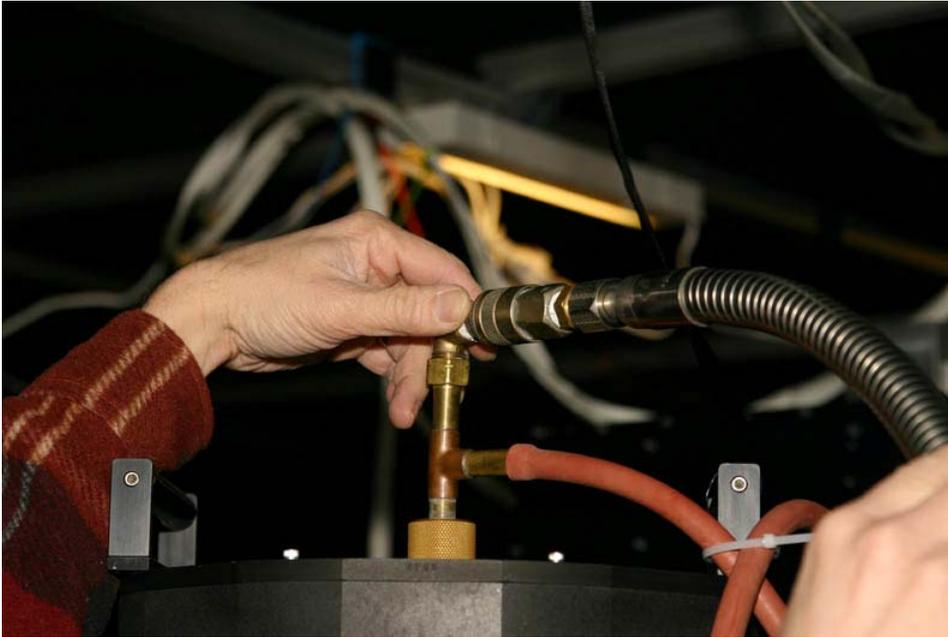


Figure 20. Dewar end of LN2 fill line.



Figure 21. LN2 reservoir end of LN2 fill line.



Figure 22. Hectospec ion pump is on the left, vacuum gauge is in the middle.



Figure 23. Power for the ion gauge.

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 24. 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.

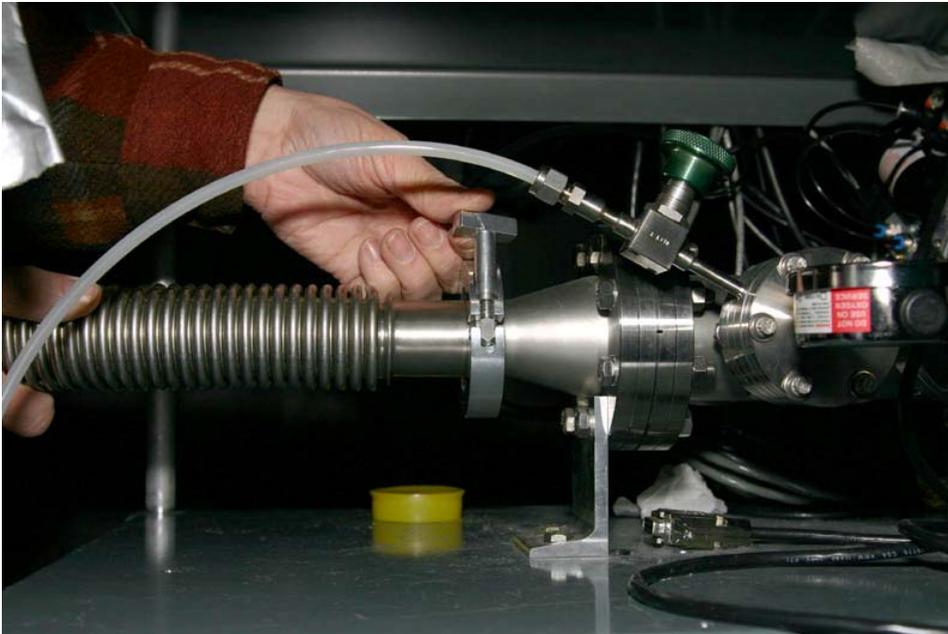


Figure 25. The cutoff valve is the green valve to the upper right.

5.2 BENCH SPECTROGRAPH & FIBER REFERENCE

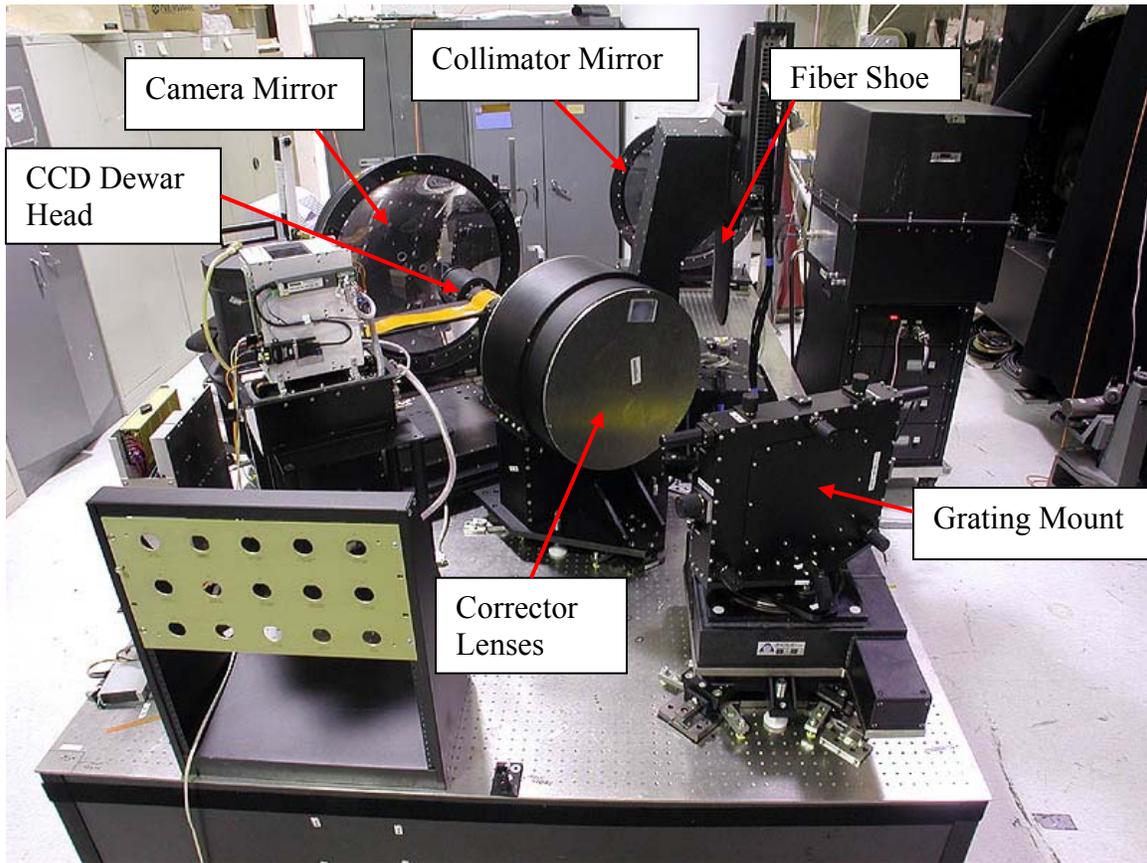


Figure 26. Hectospec Bench Spectrograph in the lab just prior to shipment.

5.2.1 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 do the shutter's electrical cable. Switches on the shoe mounts allow remote sensing of fiber shoe/dummy shoe/no shoe conditions.

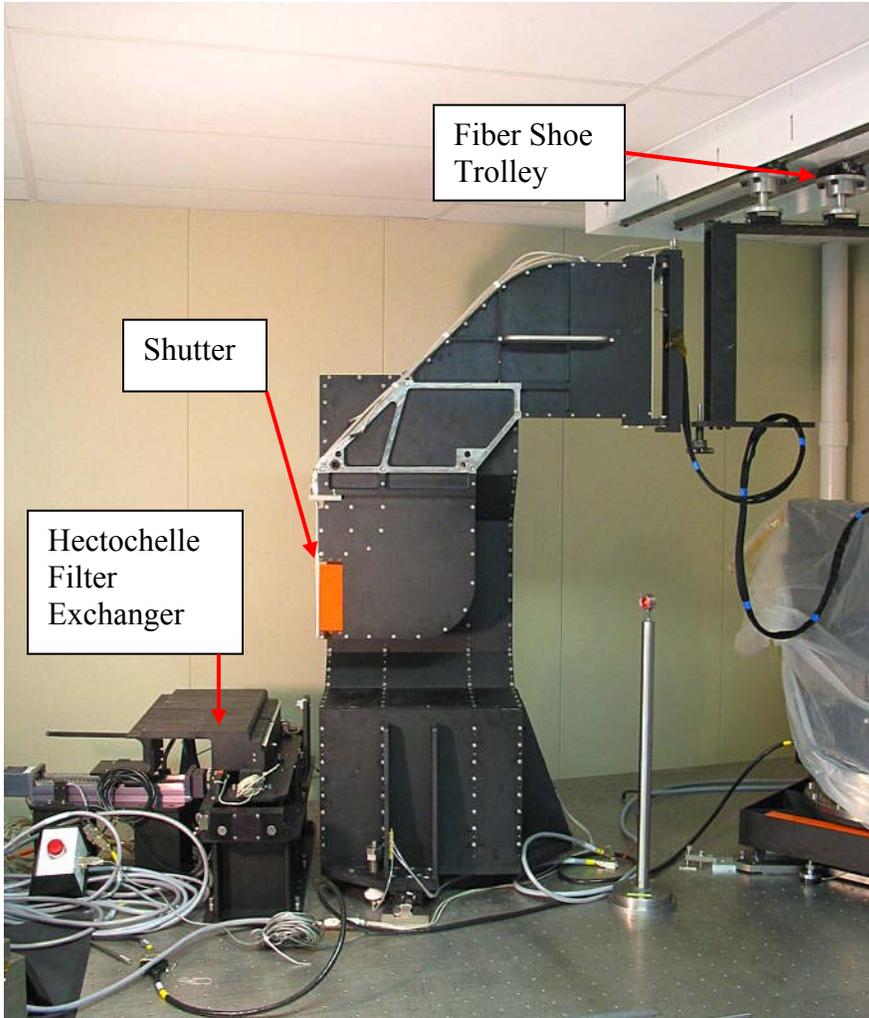


Figure 27. Fiber shoe and trolley. The fiber chain is not installed in this picture.

5.2.2 FIBER SHOE LAYOUT

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

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.

5.2.3 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.

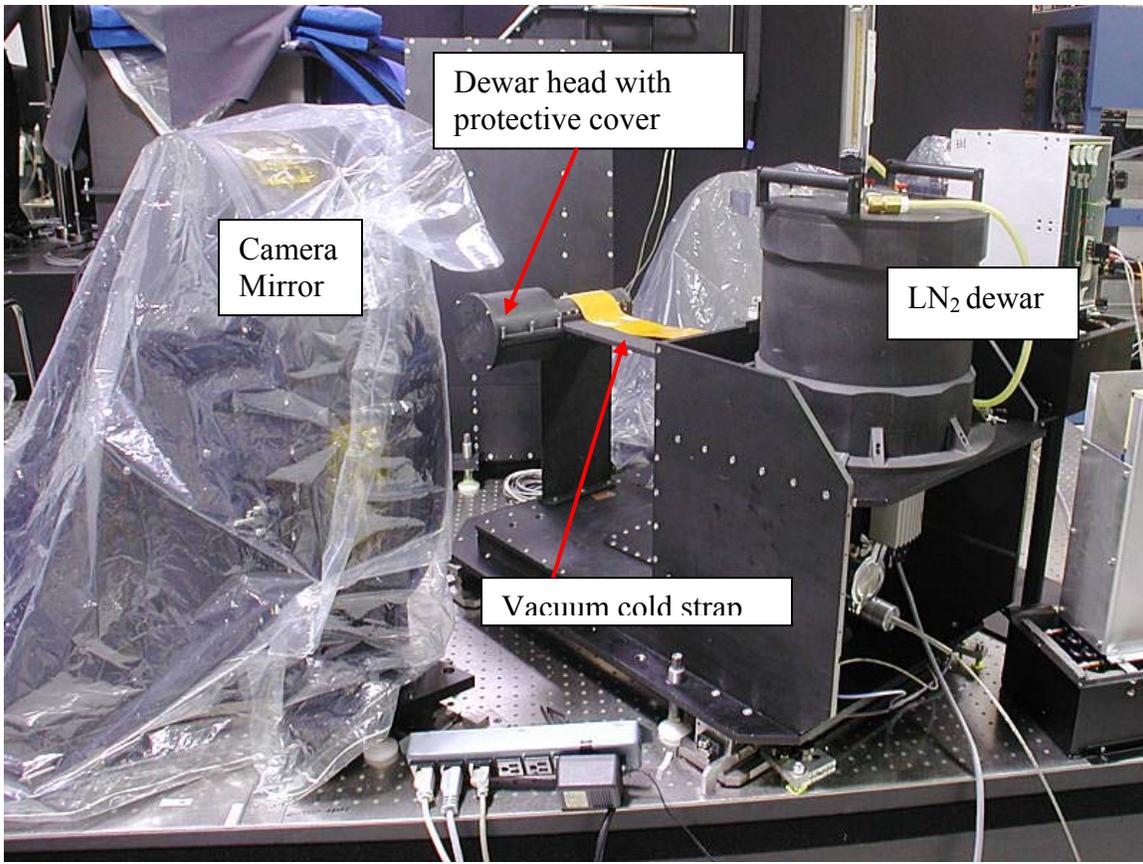


Figure 28. Dewar assembly. The field flattener is covered with a protective enclosure.

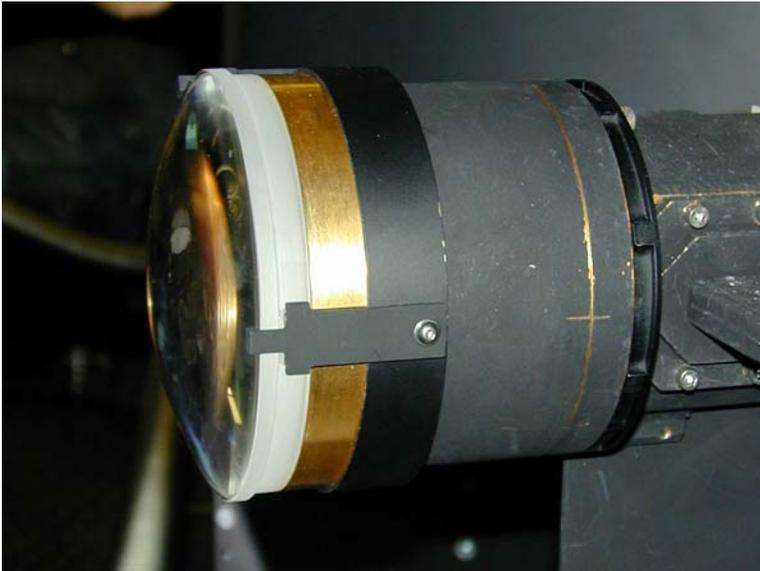


Figure 29. Closeup of dewar head and the field flattener lens that serves as the dewar window.

5.3 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.. Slowly sit on the bench near the fiber shoe, and slide over near the CCD camera. 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 placed on the other bench, or on the spec bench as well. 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.

You may now get off of the bench, slowly. 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.

5.4 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.

6 HECTOSPEC OBSERVING PROCEDURES

6.1 INTRODUCTION

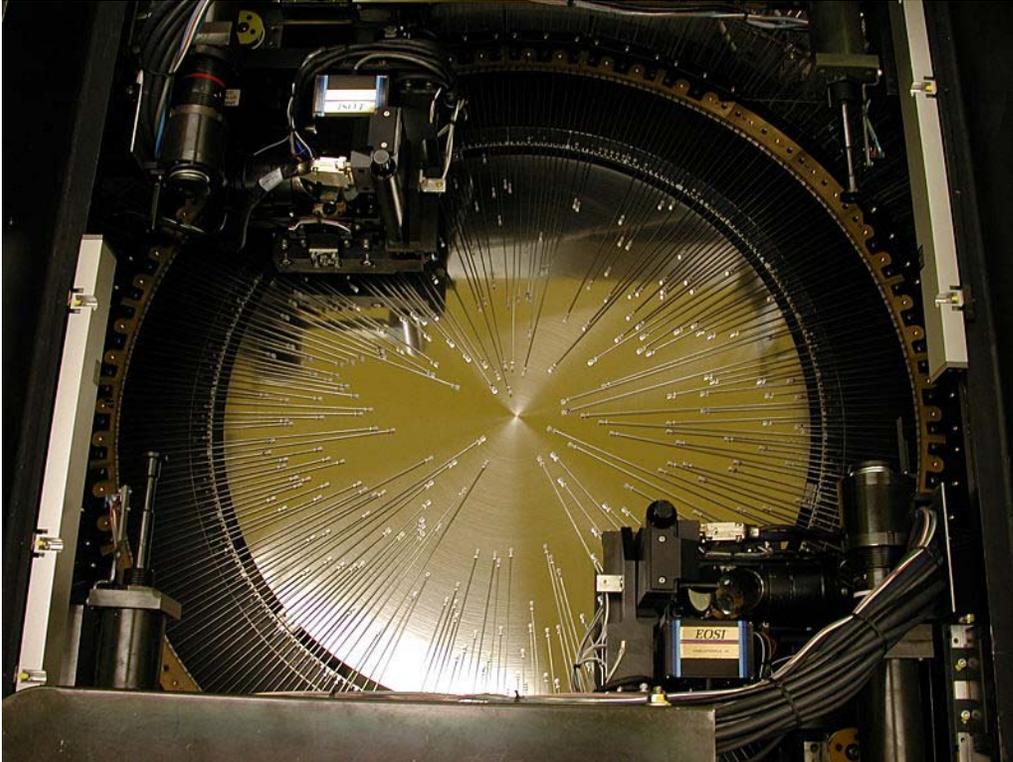


Figure 30. Looking down at the focal surface from above with the entrance window removed. The two positioning robots are visible to the upper left and lower right.

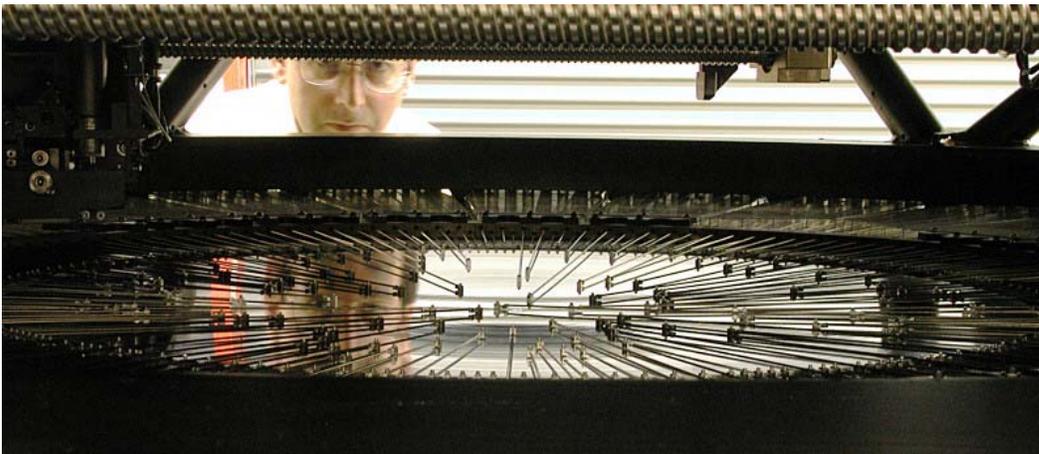


Figure 31. Looking at the focal surface from the side with the covers removed. One robot is visible to the top left.

6.2 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.

6.2.1 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 32. Turning on Fiber. Computer is located behind the large monitors.

6.2.2 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 33. Main power switch.

Next, the orange cord should be plugged into clean power to the left of the electronics rack, and the UPS plug should be plugged into dirty power nearby.



Figure 34. Plugging in.

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



Figure 35. 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. Now go to the control room and start up the software.

6.2.3 STARTING UP THE SOFTWARE

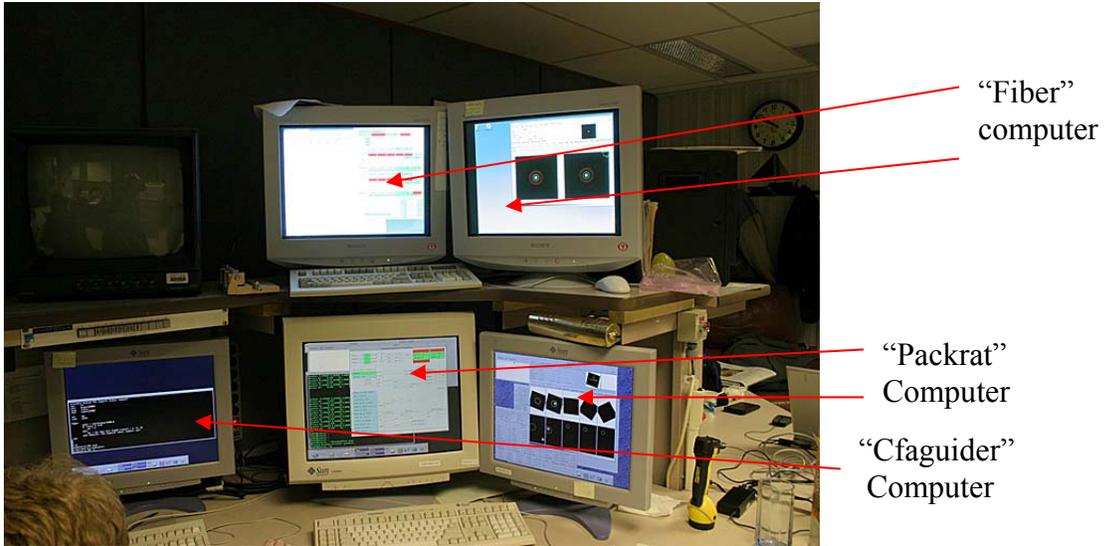


Figure 36. Fiber positioner control computers.

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` Push the Images button at the top center of the status display. The robot camera guide display on the right Fiber display will then come up.

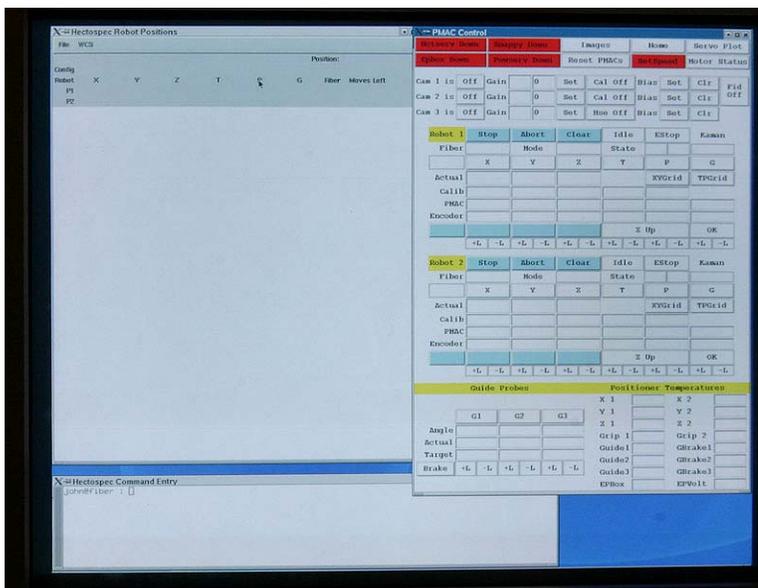


Figure 37. Fiber display.

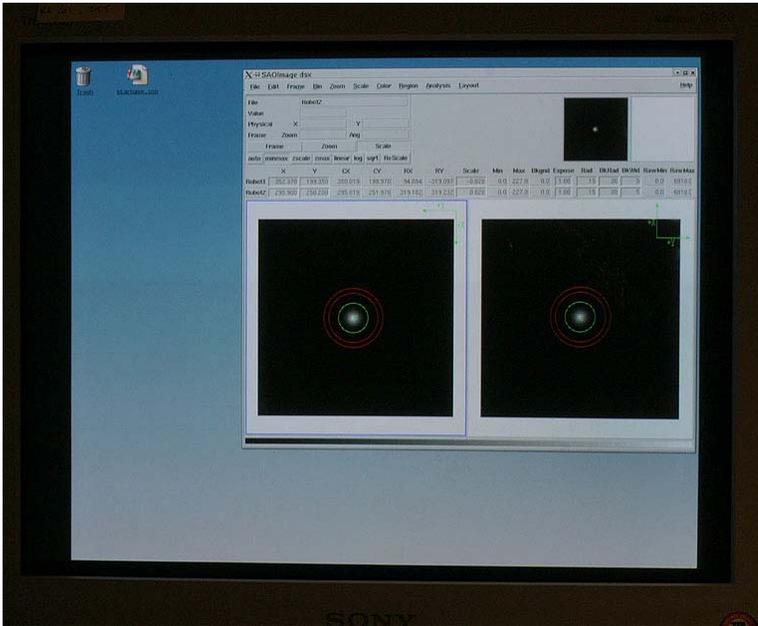


Figure 38. Robot camera display on second (rightmost) Fiber monitor. This display comes up after the Images button on the Hecto display is pressed.

2. Log onto Packrat as spec or chelle depending on which spectrograph is in use. Start a shell and type: `> hobserve` Then start the three servers by pressing the appropriate buttons on the user interface. (Hctserv, Snappy, and Epbox)

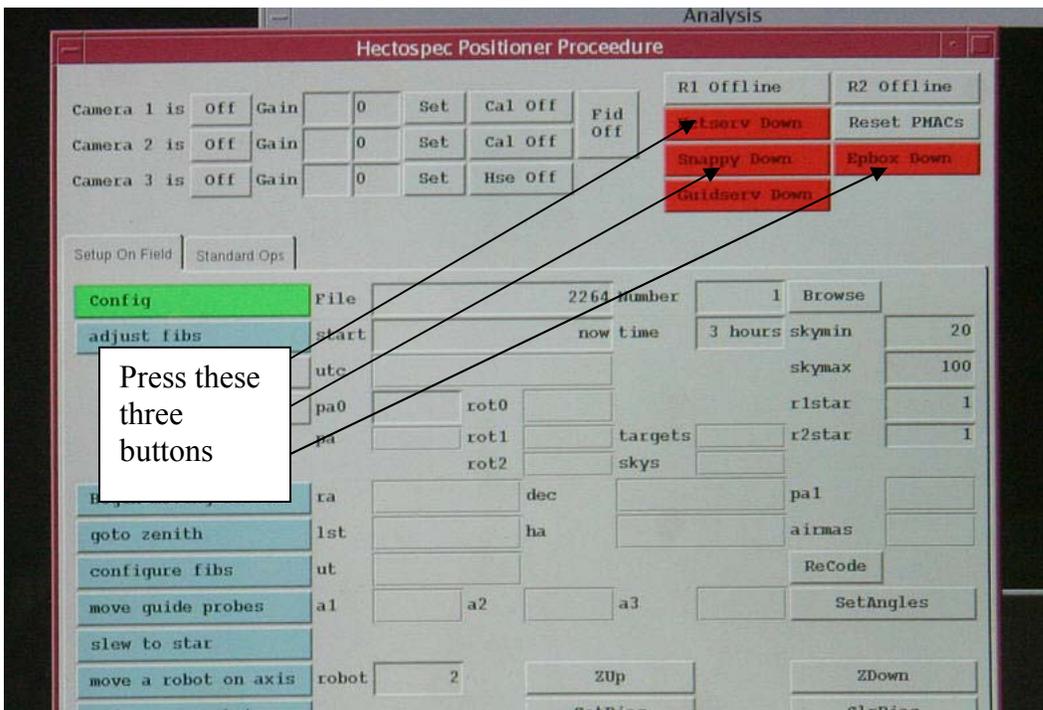


Figure 39. Hobserve display.

6.2.4 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.

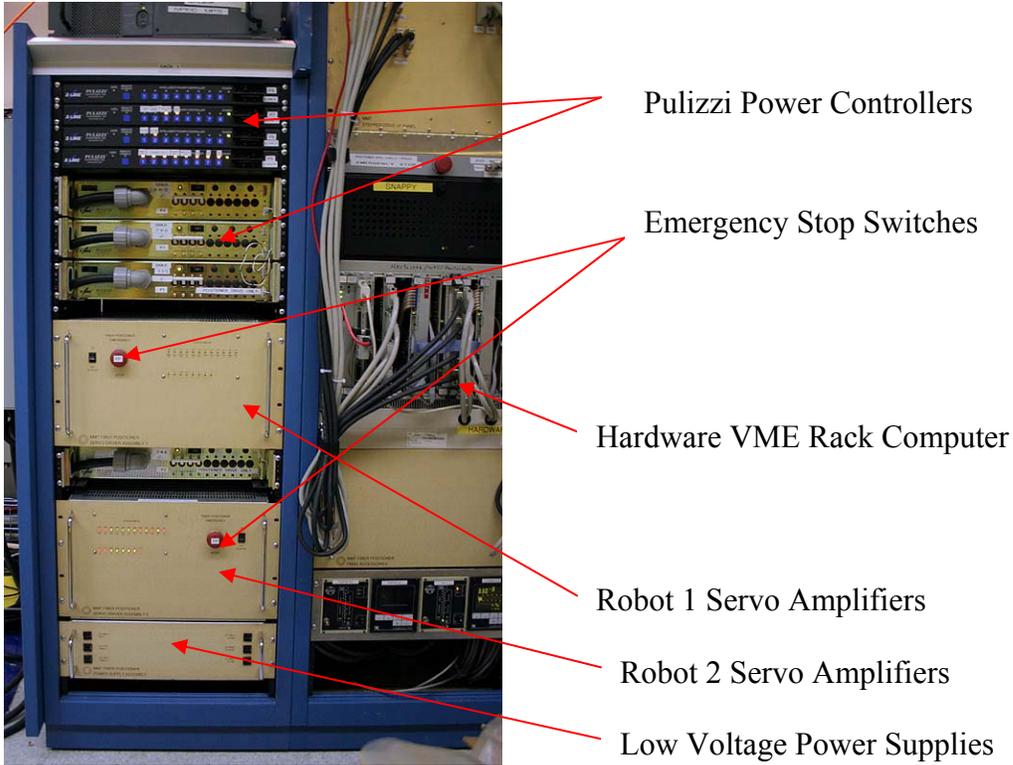


Figure 40. The fiber positioner electronics rack.

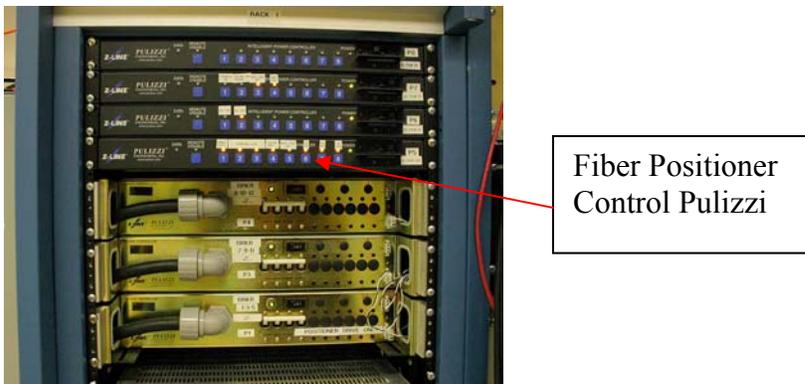
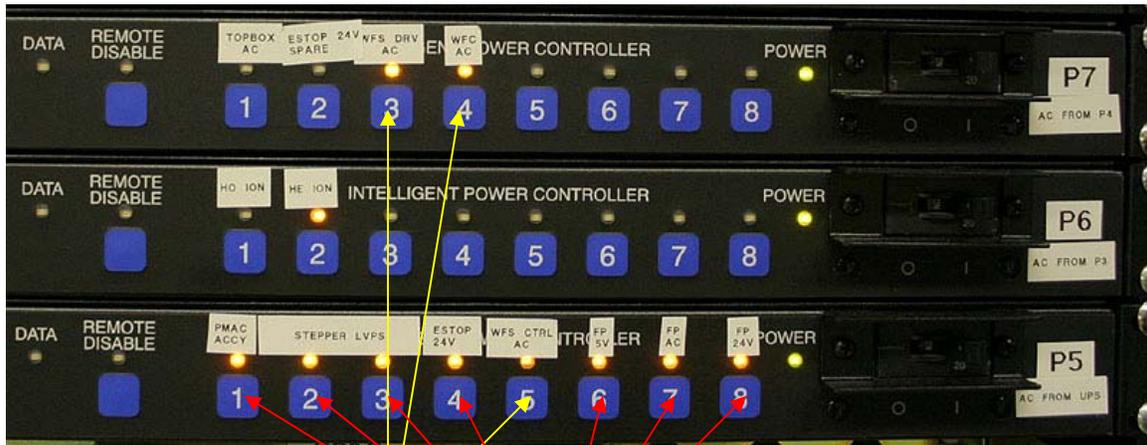


Figure 41. Closeup of upper portion of the fiber positioner electronics rack.



Normally these buttons for the WFS (Wave Front Sensor) and WFC (Wide Field Corrector) will be turned on as these units are tested following their installation.

These must be turned on to run the fiber positioner. (Buttons 1, 2, 3, 4, 6, 7, 8 on P5)

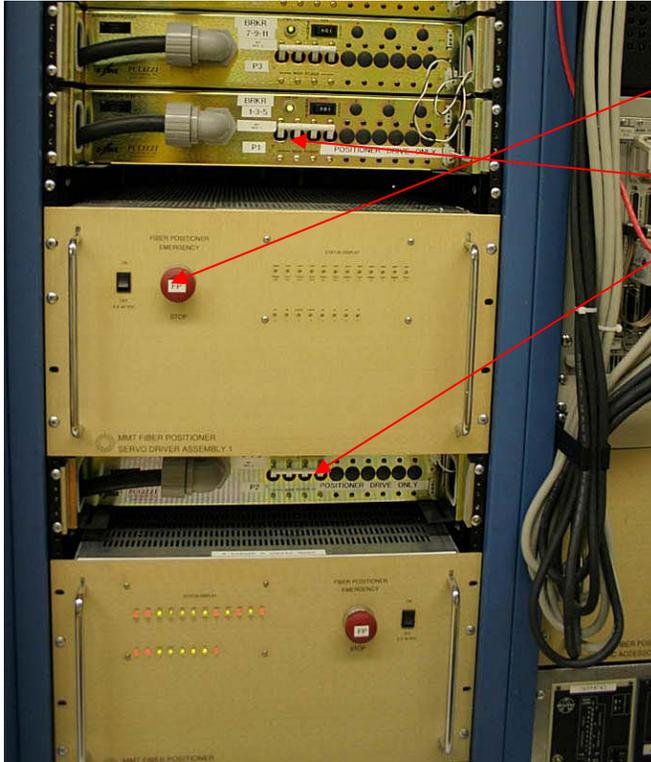
Figure 42. Closeup of individual power controls for fiber positioner.

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.
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 release the E-stop button.

You are now 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.

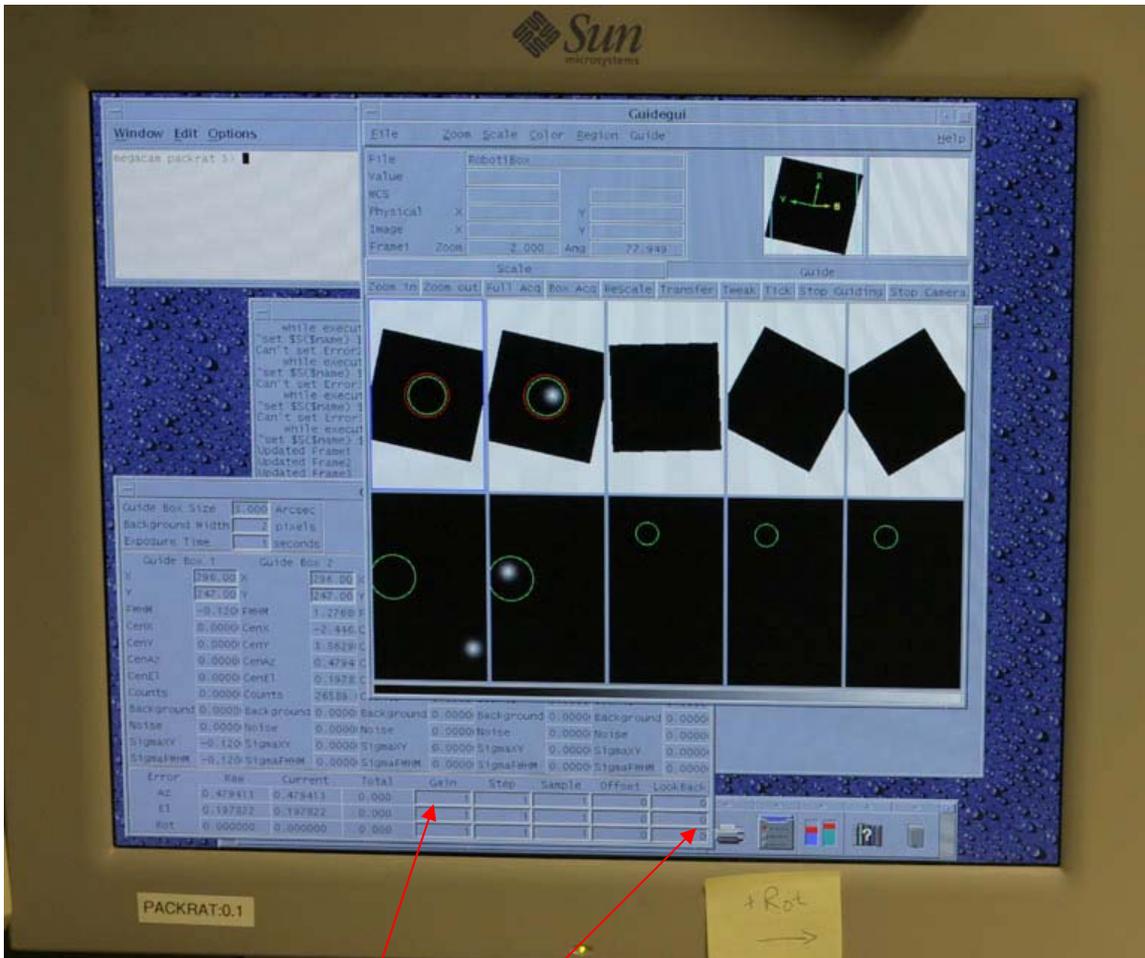
You can now press the Guideserv button on the Hobserve GUI. The button should turn green. Scan the mouse over to the rightmost of the two Packrat monitors and select a terminal window. In this window type:

```
> ssh john@snap2
```

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

```
> ./guidegui
```

The guider windows will then startup.



1. Set AZ and EL gains to 0.25, Rot gain to 0.1
2. Set all three lookbacks to 4

6.3 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 43. VNC session to wavefront after waveserv is started.

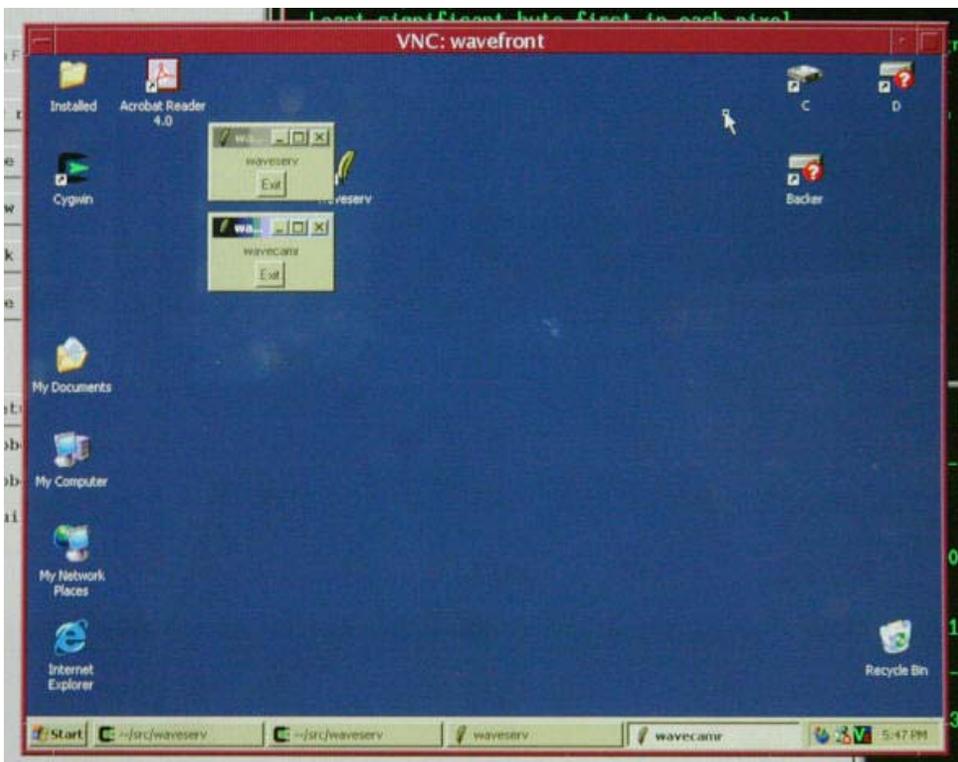


Figure 44. VNC session after both servers are started up and the cygwin windows are minimized.

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.

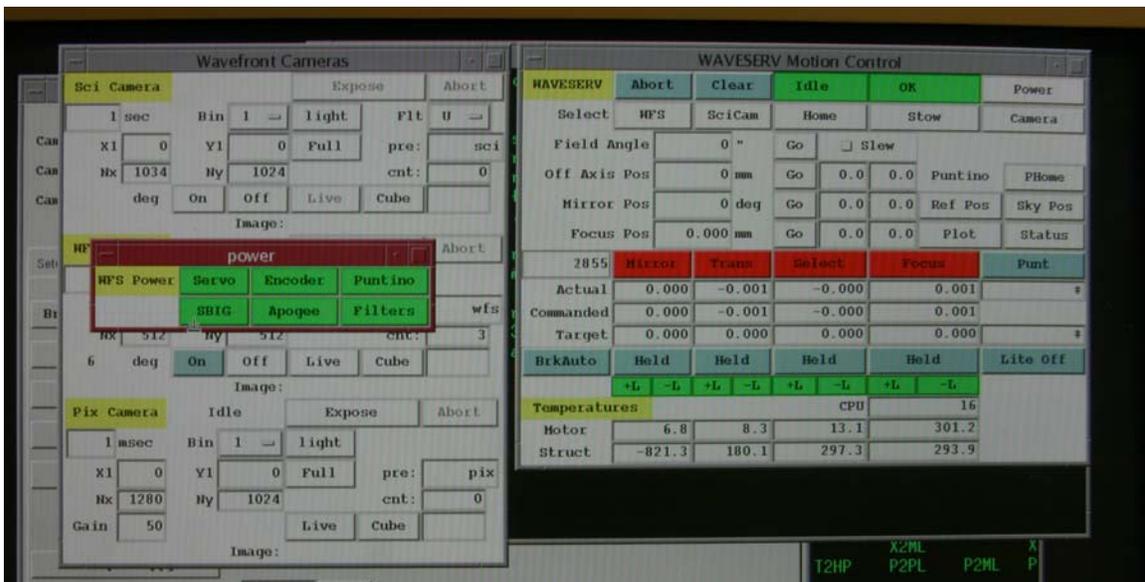


Figure 45. Wavefront windows on packrat after the encoder and servo power is turned on. The power window is brought up by pressing the Power button on the top right. The power window can be closed after these are turned on. The remaining four functions come up on by default.

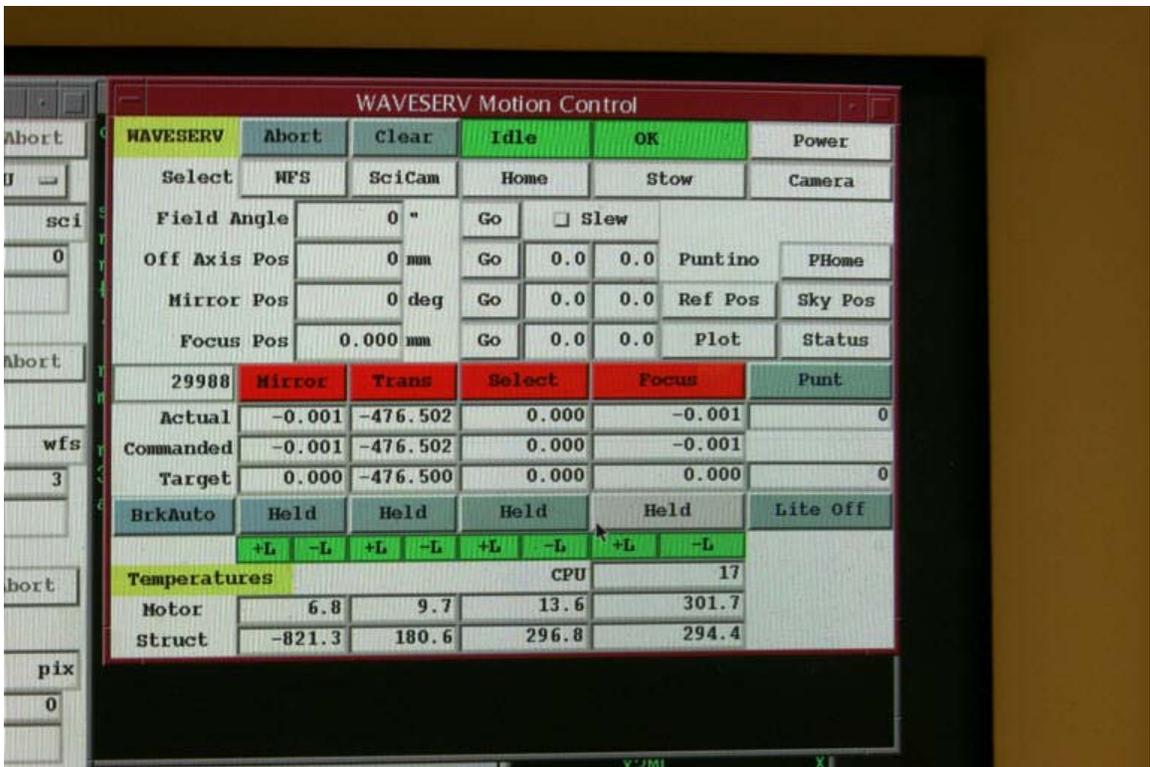


Figure 46. Waveserv display on packrat after the main stages are homed. If a "#" appear in the Punt (Puntino) column, press the PHome button. If the Wavefront Camera display is lost, press the Camera button to restore it.

6.4 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 Cfaguiders 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. In another terminal window, login into the hardware computer to reset the steppers:

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

Then, press the WFC Power button on the top right

Then, press the ADC Reset button.

Then, press the WFC Home button.

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.

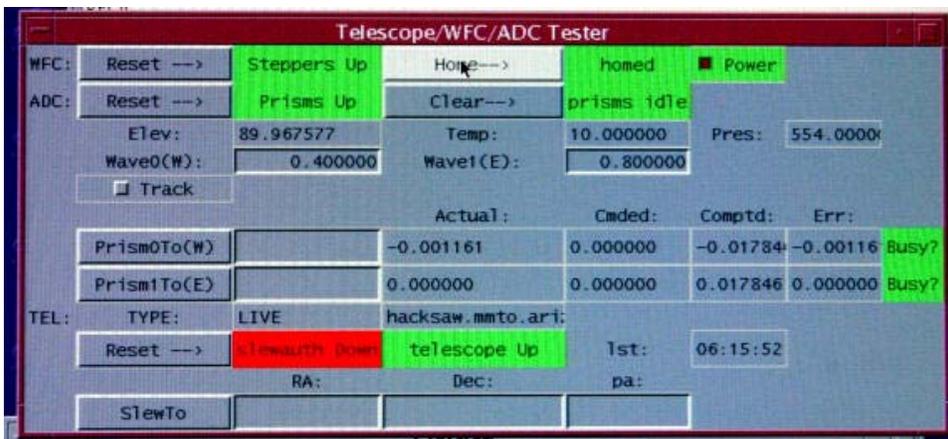


Figure 47. Wide field corrector ADC prism control window.

6.5 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 48. The mount status display.

6.6 OPERATING THE FIBER POSITIONER

Operating the fiber positioner is carried with two GUIs: Hobserve and the guider 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 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.

The screenshot shows the Hobserve GUI field setup page. At the top, there are camera status controls for Camera 1, 2, and 3, each with an 'Off' button and 'Gain' fields. To the right, a status panel shows 'R1 Offline' and 'R2 Offline' in red, and several green buttons: 'Hctserv Up', 'Snappy Up', 'Guidserv Up', 'Reset PHACs', and 'Ephox Up'. Below this, there are tabs for 'Setup On Field' and 'Standard Ops'. The main area contains a grid of configuration fields and buttons. The 'adjust fibs' button is highlighted in green. Other buttons include 'Begin moving robots', 'goto zenith', 'configure fibs', 'move guide probes', 'slew to star', 'move a robot on axis', 'gain up on robot', 'slew to field', 'robots to guide', 'gain up on all', 'guide transfer', 'stow robots', 'gain down on guides', and 'Start Over'. The configuration fields include 'File' (1200p5000), 'Number' (1), 'start' (6 time), 'UseUTC' (Apr 8 06:00:00 2004), 'BestPA' (pa0: 171.488, rot0: 16.757, pa: -167.000, rot1: -1.916, rot2: -22.179), 'ra' (12:00:01.789), 'dec' (49:59:20.847), 'lst' (10:57:18), 'ha' (-1:02:43.789), 'ut' (05:13:38), 'a1' (345.85), 'a2' (183.54), 'a3' (80), 'SetAngles', 'robot' (2), 'ZUp', 'ZDown', 'SetBias', 'ClrBias', 'rx1' (-312.204), 'ry1' (-19.324), 'rx2' (301.091), 'ry2' (-75.905), 'GuideOnRobots', 'r1box' (4), 'r2box' (3), and 'TransferBoxes'.

Figure 49. Main Hobserve GUI page (field setup page).

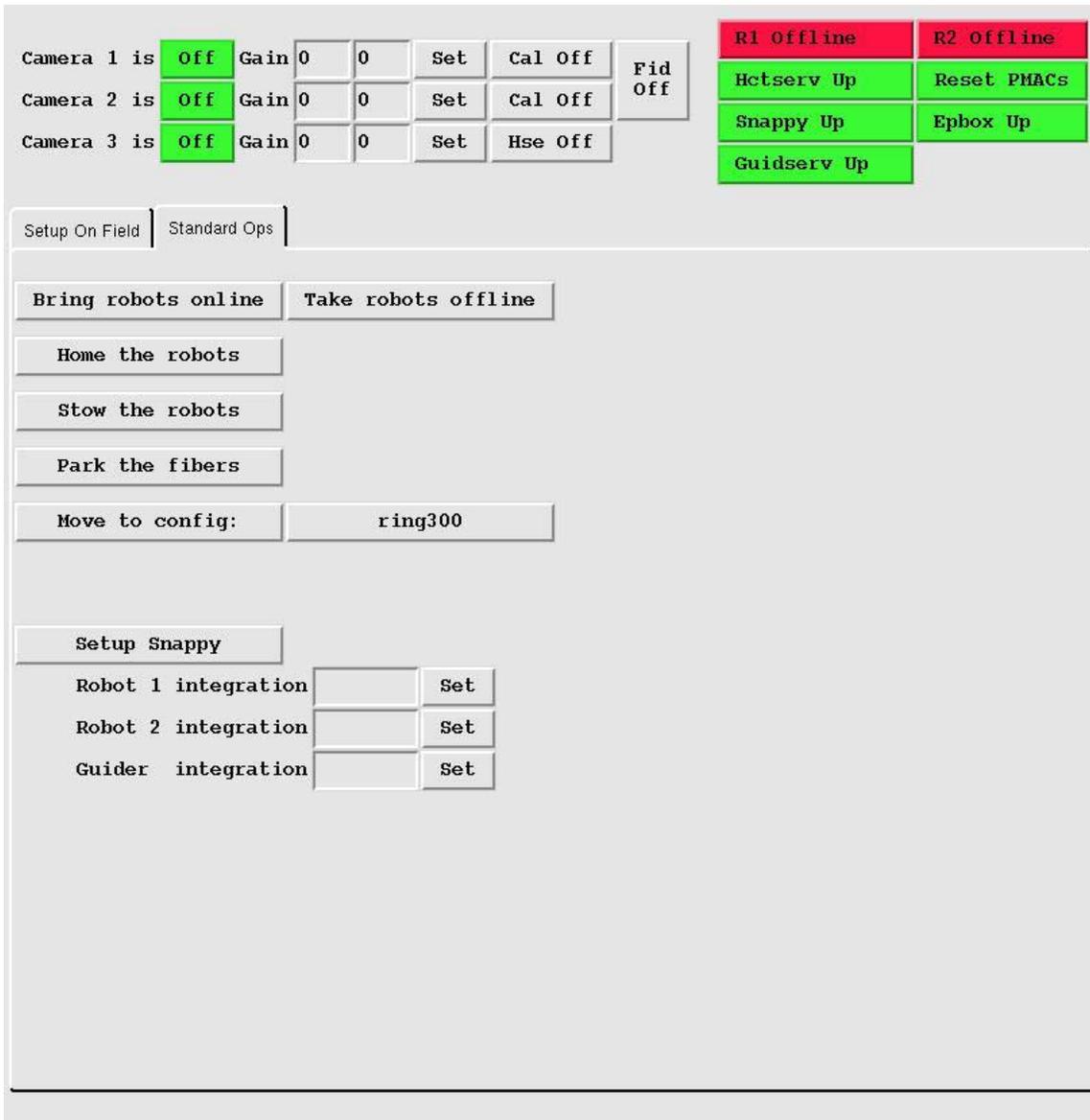


Figure 50. Hobserve standard operations Gui page.

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.**

6.6.1 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.

6.6.2 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 hector 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.



Figure 51. Guider Display

6.7 OPERATING THE BENCH SPECTROGRAPH

6.7.1 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.

6.7.2 INITIALIZING THE SPECTROGRAPH MOTORS

The Hectospec bench spectrograph has 3 motors that need to be powered up and initialized at the beginning of a run, and often at the beginning of each night as well, if power has been shut off for safety. These motors control the CCD dewar focus stage, the grating angle, and the High Speed Shutter (mounted on the fiber shoe). The CCD electronics control and the dome calibration lamps must also be powered up and initialized.



Figure 52. Hectospec bench spectrograph status display.

The packrat computer provides the control for most of these functions, but as its screens are typically in use by the fiber positioner GUIs, we will assume that packrat must be accessed through the alewife computer. The instrument rack on the 2nd floor must be powered up as described above.

1. Login to alewife using the mmtobs account.
2. In a shell window, type:

```
> vncviewer packrat:1
```

You will either be greeted by the Solaris CDE login, in which case you should login as spec, or only by the query for the password for the spec account which already owns the vnc window. In either case, you now have a desktop on packrat, logged in as spec. You will need a few shell windows, which can be started via the first mouse button pull-down menu, if necessary.

3. We now need to start one process manually, using the mccd account. So in a window:
 - > su – mccd (give passwd)
 - > start-daemon pulzinit
 - > exit
4. Likewise, we need to start another process manually on the hardware computer (one that starts the “pulizzi” power controller):
 - > rlogin -l mccd hardware
 - > ./specstart
 - > logout
5. Now we'll bring up some control windows. In a shell window, bring up the gui that controls the spectrograph motors, called “Hectospec Status” by typing:
 - > spec
6. You can now iconify the shell window. In the Hectospec Status window (where you'll see a number of red boxes, which will turn gray when the mouse is placed over them, as well as a few boxes that are always gray. The gray color indicates that pressing the button will change the state.
7. On the CCD row, press Reset. Wait for the Pulizzi box to turn green.
8. Press all the power buttons in the row labeled "StepPower"
9. In the row labeled Bench Power, turn on “Step”, “Shut”, and “Cam” . Leave off the “Bench”)
10. Press CCD/Reset again. This row should show green boxes indicating “Detector Up”, “Keithley Up,” and “Pulizzi Up”. “Callamps” (which refers to lamps locating in the spectrograph room and not the dome lamps) should remain down. You may occasionally need to press CCD/Reset more than once to get the Detector up.
11. In the SPEC row. press the Power button. The motors should now all be powered up.
12. The shutter, grating, and focus stages can now be homed, by pressing “Home”, which will do all three, or also by using the specific home buttons. Homing does

not need to be done for the grating or the focus stage if you do not plan on moving them from their previous state. For instance, if the power failed in the afternoon, but you don't want to move the grating and focus, then you can skip homing those two, and limit the homing to the shutter. With any luck, this window won't be needed again during the night, so you may iconify it.

The CCD temperature is controlled via a heater in the CCD dewar. The software to run this is started up when you press the **CCD Reset** button. If the CCD electronics have been off for a while, say since the previous morning, the temperature will be colder than nominal and thus the heater will come on for an extended period till the temperature reaches 20C. Thus, for critical measurements, you may wish to monitor this temperature until it reaches nominal, as shown in the Hectospec Status GUI.

6.7.3 STARTING UP “SPICE” DATA ACQUISITION AND EXPOSURE STATUS GUI

1. To bring up the data acquisition window, go to yet another shell window and type:
 > spice &
And also:
 > expdisplay &
which starts up the exposure status window. We describe the use of spice below.
2. Other diagnostic windows can be started via:
 > hkdisp & (CCD and CCD electronics temperatures)
 > spectemp & (to get bench/motor temperatures)
A typical observing run won't require these, but if things go wrong, these contain useful information.

6.7.4 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 53. 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..

```
> cd /data/mmti/src/powserv
> stop-daemon domecal.tcl
> ./domecal.tcl &
> wish dcalgui.tcl
```

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

6.8 TAKING DATA WITH SPICE

The Spice GUI provides exposure control for the CCD, as well as limited control of the spectrograph and the dome lamps. The control is based on the ICE system.

An exposure is taken by clicking on one of the green boxes labeled “object”, “comp” etc. The number of exposures and the exposure time are taken from the columns to the right of the green box. The user is prompted for a title. The Exposure Status gui shows the progress (note that the countdown stops at 30 seconds though). Upon readout completion, a beep is issued and the file is automatically displayed into a ds9 window (called “spec9”).

	Shutter	Grating	Focus	ZeroOrder	
Clear -->	shut idle	grat idle	focus idle		
CURRENT:	INIT	-1.926000	0.917575		
TARGET:		-1.926	1.00		
CALIBRATION:	-90	-1.926	1.00		
FIELD:	ring300	ConfigBench			
TELNAME:	test	INSTRNAME:	spec	DETNAME:	specs
PROPID:	Engineering	OBSVRS:	Caldwell	P.I.:	Engineering
PAUSE	ABORT	STOP	RESUME	CHANGE	
	count	exptime	intcal		
object	1	25	0		
skyobject	1	900	0		
skyflat	1	10	0		
comp	1	90	0	HeNeAr off PenRay Init	
domeflat	1	30	0	Continuum on	
boxcal	1	0	10	HeNeAr off	
boxflat	1	0	0.04	Continuum off	
milkyflat	1	10	0		
focus	7	120		start <input type="text"/> step <input type="text"/>	
benchflat	1	10	0		
dark	1	300			
bias	3				
RESET ^					

Figure 55. Spice display for taking spectra.

6.8.1 SPICE DETAILS

The first group of items pertains to the bench motors:

Row 1: Status of the 3 motors or stages (idle or busy).

Row 2: *Current* settings of those (e.g., open or closed for the shutter)

Row 3: *Target* (unused for Hectospec)

Row 4: *Calibration*. These are the desired operating values of the shutter, grating operating angle, focus position and the grating zero order angle. Upon startup, the values appearing here are the most recent values stored (after logging off or doing a “ConfigBench”), below. Different values for the focus may be entered if desired, **but the grating value should always be left at -1.926.**

Row 5: The *ConfigBench* button will move the stages to the values entered in the Calibration boxes above. These values will also be stored such that they are recalled if the system is restarted. *Field* automatically displays the most recent fiber configuration name. If there is no current configuration, a valid name must still be entered here to take any data. In this case, you should manually enter the name “parked”.

The next group of buttons pertains to your particular project.

TELNAME: If the telescope is operating, this should be set to **mmt_f5_adc**. For exposures during the day (cal lamps etc), set this to **test** otherwise the exposure may stall, waiting for telescope information.

INSTRNAME: Normally set to **spec**. For exposures with the bench motors off, set this also to **test**.

DETNAME: Normally set to **specs**. This specifies the bench shutter (high speed shutter). Occasional tests do not use that shutter, so **specn** or **test** may be selected, though it is not expected regular users will need this.

The next 3 items should be entered via the keyboard.

PROPID: The number of your proposal from the schedule. This should be correct as it is used by the SAO TDC for data reduction purposes.

OBSRVS: Your favorite people.

P.I.: Your favorite person.

The rest of the gui contains exposure control items.

PAUSE: Closes the shutter and allows further the actions of aborting, reading out the exposure prematurely, resuming, and changing the exposure time (you can only increase the time).

The next set of controls will take the specified type of exposure, using count for the number of exposures, and exptime for the exposure time. *INTCAL* is not used for the Hectospec spectrograph. File names will have the naming convention of TYPE.nnnn.fits, where TYPE is the fiber configuration name for OBJECT exposures (see above) or the type of exposure for all others, and nnnn is a running count number among all types of frames. **The files are stored in directories created automatically for each night, with the form: /SPEC/year.monthday. E.G., /SPEC/2004.0409**

OBJECT : prompts for a title, opens the shutter, writes “object” as imagetype in the header.

SKYOBJEC : prompts for a title, opens the shutter, writes “skyobject” as imagetype in the header. Used for blank sky fields taken between object fields.

SKYFLAT: prompts for a title, opens the shutter, writes “skyflat” as imagetype in the header. Use this for twilight sky exposures.

COMP: prompts for a title, opens the shutter, writes “comp” as imagetype in the header. Use this for dome exposures of HeNeAr etc. Startup the dome lights with the **dcalgui** (there is also a button for this purpose on this line, but it is not yet functional). For HeNeAr, exposure times of about 600seconds are recommending, thus requiring multiple exposures (3-5) to eliminate cosmic rays. With the PenRay HgNeAr combination, shorter exposure times may be used (30seconds or so).

DOMEFLAT: prompts for a title, opens the shutter, writes “flat” as imagetype in the header. Turn on the dome continuum lamps with the **dcalgui**. For the dome continuum exposures with hectospec, an exposure time of 3 or 4 seconds is still below saturation. Shorter exposures may suffer from shutter vignetting, and thus would not be useful for throughput corrections, though the files should still be ok for pixel-pixel flattening.

BOXCAL: prompts for a title, opens the shutter, writes “boxcal” as imagetype in the header. Used for testing only.

BOXFLAT: prompts for a title, opens the shutter, writes “boxflat” as imagetype in the header. Used for testing only.

MILKYFLAT: prompts for a title, opens the shutter, writes “object” as imagetype in the header. Not yet implemented.

FOCUS: Enter the number of exposures desired, the starting focus value, and the focus step between exposures. This routine will take a sequence of frames, at the requested sequence of focus values for the spectrograph. Typically, one uses the dome calibration HeNeAr lamps for this purpose, though night sky emission lines work well also. The focus step size should be about 0.04. Exposure times of the dome HeNeAr should be about 180 sec or longer. Currently, there is no automated routine to choose the best focus, so inspection of the images via iraf imexamine should be used. Bear in mind however, that the in focus images are not Gaussian; rather they are somewhat flat-topped with steep wings (example below). Using imexam “r” will show a profile of emission lines – look for a flat top and a clean, not noisy profile. The FWHM of these profiles should be less than 5 pixels. The focus is the same at all wavelengths and all fibers, though the profiles vary with wavelength (going from FWHM 4.1 in the red to 4.8 in the blue). There is also a slight difference in the PSF in the two CCDs, though the difference is only about 0.2 pixels in width. Recall that the dispersion is about $1.2 \text{ \AA pixel}^{-1}$.

BENCHFLAT: prompts for a title, opens the shutter, writes “benchflat” as imagetype in the header. Not yet implemented.

DARK: prompts for a title, does not open the shutter, writes “dark” as imagetype in the header. There are light leaks around the shutter, so darks should be taken with the chamber lights off. The dark rate is extremely low, and in normal circumstances does not need to be measured. Be aware that the fluorescent lights in the spectrograph room will elevate the dark count significantly for about an hour after they are turned off.

BIAS: prompts for a title, leaves shutter closed, writes “zero” as imagetype in the header. There is some structure to the bias, so we recommend taking a handful of these at the beginning of the night.

The ccd dewar vacuum gauge is turned off for all exposures, due to a light source in the gauge itself. This cycling can be monitored with the spice window.

6.8.2 EXPOSURE STATUS GUI

The Exposure Status GUI shows the progress (note that the time countdown stops at 30 seconds). Upon readout completion a beep is issued, and the file is automatically displayed into a ds9 window (called “spec9”).

Camera	specs
Shoe	YES
Config	ring300
Exposure Status	DONE
Time left	0 sec
Total time	30 sec
File name	dome.0230
Directory	2004.0408
Filters	
Image type	skyobject
Guiding	
Grating	270_gpm
WaveLength	Wb
Focus	0.917575
TiltPos	-1.926000
Collimator	0.000000
Guide	Details
Boxes	NO
Box1	unlocked
Box2	unlocked
Correcting	NO
GValid	NO

Figure 56. Exposure status display.

6.8.3 DATA FORMAT.

The A/D converter is 16bit, so saturation occurs at 65536. There are 2 amplifiers per CCD, and thus the data are stored in FITS extension format, with 5 extensions (0 being the main file header). Among other things, this means that in iraf, you will occasionally have to refer to the file as filename[1] or [2], say when using imheader (though not imexamine).

The data from the different amplifiers are not flipped to the same orientation before writing to disk, but the header keywords allow ds9 to display the files correctly. We *hope* that all the file keywords are correct, and that programs like iraf mscred will work, but we can't guarantee this at this time.

As already written, the data files are stored in directories of the format /SPEC/year.monthday. The files are also archived both on the packrat computer as well as back in Cambridge (more slowly).

Along with the data files are stored the fiber configuration files ("filename.map"). Eventually this information will also be stored in the FITS file.

6.8.4 DS9 BASICS

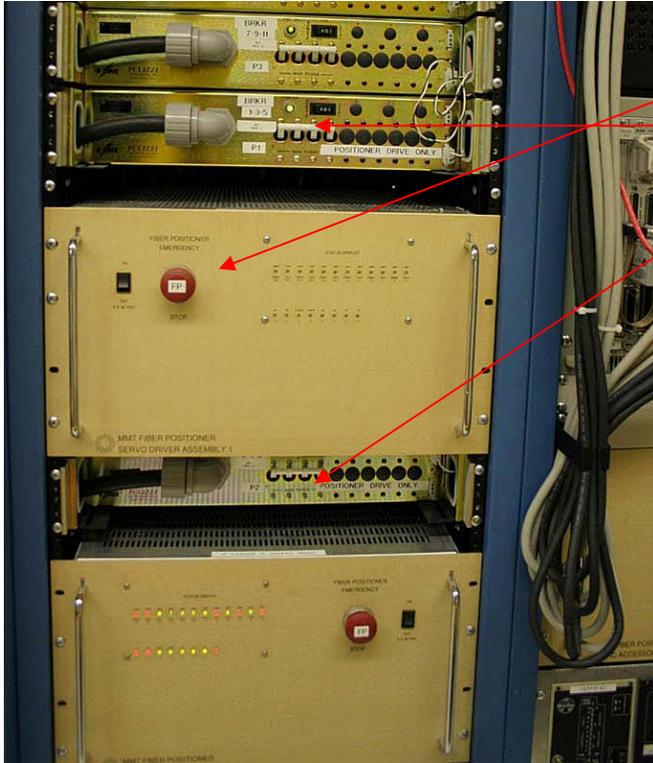
Each new file is automatically displayed into the active frame of ds9 (named spec9 here to avoid conflicts with other ds9 programs that may be running). To load files off the disk, select FILE:OPEN OTHER: OPEN MOSAIC IRAF, and then find your directory and filename. You may load files into different frames via creating a new frame: FRAME:NEW. Run through frames via Tab. Do not use msdisplay in iraf.

The contrast can be changed with the right mouse button. For further contrast levels, select Scale:Scale Parameters from the top bar menu. You'll get a histogram of the data – high and low values may be selected by moving the red and green vertical lines with the mouse.

Note that the files are shown with blue on the left, thus requiring the XY coordinate system to be non-standard. Image coordinates refer to individual extensions (one per amplifier), and thus start over when crossing into a new extension, while the detector coordinates refer to the combined image. The default display also excludes the overscan areas. To see these, select SCALE and turn off DATASEC. However, some of the overscans will display over that from the next image extension...

Imexamine works as is with these files; there is no need to use msceexamine. Make sure you start up iraf in a gxterm window.

6.9 AT THE END OF THE NIGHT



1. Press the E-stop
2. Turn off the two servo Pulizzis.
3. Normally, you will leave on the low voltage power. If bad weather (lightning) is expected, follow the complete turn off procedure.

6.10 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 57. 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 58. 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 61. Main disconnect to the left of the electronics racks.

6.10.1 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 LOW LEVEL FIBER POSITIONER SOFTWARE

7.1 FIBER POSITIONER CONTROL SOFTWARE

7.1.1 MID LEVEL COMMANDS

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>

7.1.2 LOW LEVEL COMMANDS

POSITIONER CONFIGURATION STATE

stowedsafe

init

config

status

statusof <fiber>

atpark <fiber>

atxy <fiber> <x> <y>

caste <robot> <x> <y>

casteon

OPERATING ON FIBER CONFIG FILES

seqfibs

fitfibs

adjfibs

cfgdump

chkfibs

prkfibs

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> <on|off>

yhome <robot>
ymove <robot> <y>
ybrake <robot> <on|off>

zhome <robot>
zmove <robot> <z>
ztagup <robot>
zup <robot>
zdown <robot>
zbrake <robot> <on|off>

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>

MISCELLANEOUS

checktrouble <on|off>
clear
comp
hconfig
pmac
pulzpow
state
testnumber
usetpgrid
usexygrid
value