Hectospec Observers Reference Manual

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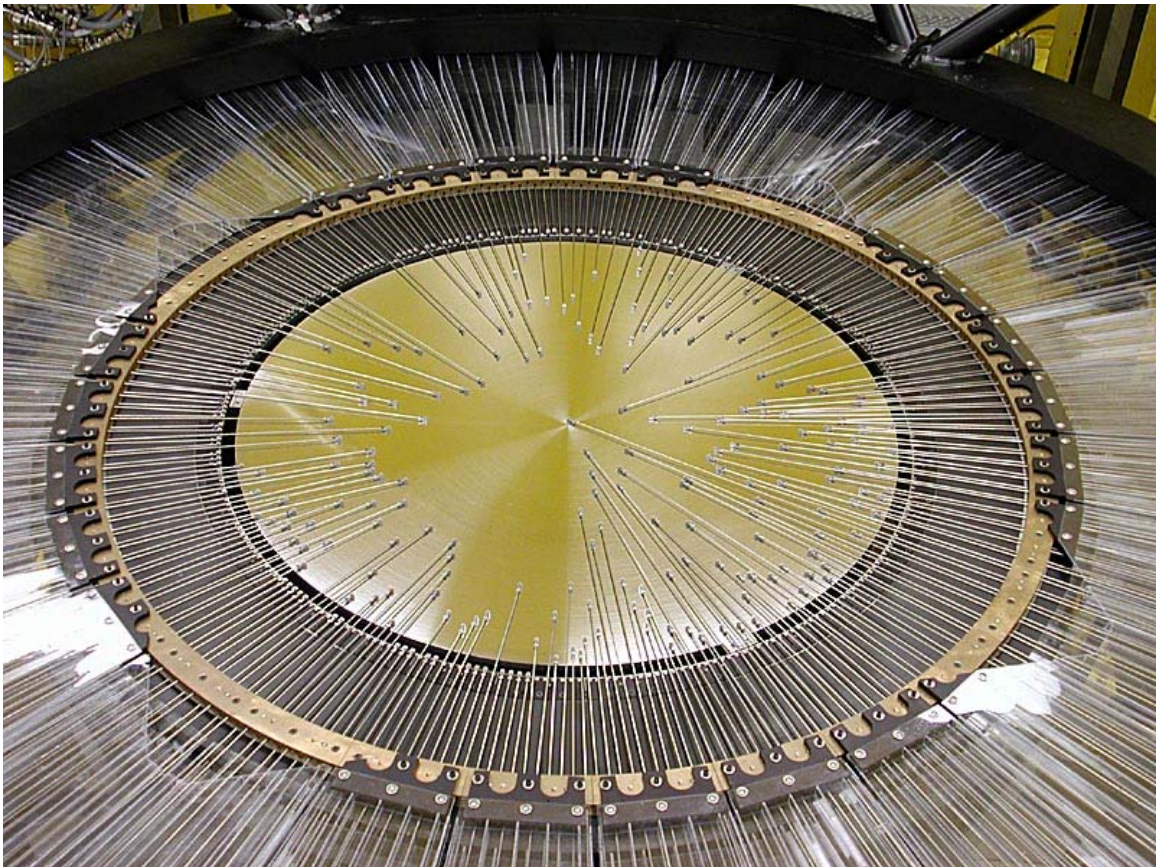**Nelson Caldwell**

Figure 1. Hectospec focal surface.

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 ~25 μm. Each fiber has a core diameter of 250 μm, 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 ~5000 Å. We have on order a 600 line mm^{-1} grating blazed at ~6000 Å 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 Å, with a dispersion of 1.21 Å pixel^{-1}. The image FWHM is slightly less than 5 pixels, or ~6 Å.
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 WHAT TO EXPECT AT THE TELESCOPE

This manual contains a great deal of reference information and the volume of this material may intimidate a new user. In fact, much of the material past Section 6 of the manual is mainly of interest to the SAO/CfA personnel who will operate the fiber positioner and make sure that the spectrograph is in operating order. Perry Berlind or Mike Calkins will normally be present during your observing run (very occasionally another CfA person will substitute) to operate the fiber positioner and to provide advice on operating the spectrograph. The CfA robot operator will fill the dewar once a day. Their decisions on operating the fiber positioner safely are not negotiable, and are based on previous operating experience.

The observer's main responsibilities are to prepare the fields for observation with the planning software, to take data with the spectrograph, and to help replan observations during the night if conditions require a change.   Observers should be familiar with the planning software and the instrument constraints described in the next few sections.

The most common error that we have encountered is poor choice of guide stars, including guide stars that are too faint or that are in fact compact galaxies. We strongly recommend guide stars brighter than R=15.5. Observers should use the preview feature in the XFITFIBS software to eliminate galaxies.

Hectospec will be operated in queue mode. Observers may therefore expect to receive a fraction of the clear observing time during each run equivalent to their fraction of allotted time during that run.   We try, if at all possible, to observe some of the officially scheduled observer's fields during their run. If observers are not prepared with valid configuration and catalog files, observations cannot be made.

Currently Nelson Caldwell is responsible for queue scheduling. Nelson attempts to review the submitted files to see if they are valid.

3   DUTIES FOR HECTOSPEC OBSERVERS

We believe that the queue observing mode for Hectospec and Hectochelle has been a scientific and operational success. Up until 2005, the Hecto team and FLWO staff have supported the operation of the queue in four ways: (1) SAO scientists and engineers have maintained and serviced the instruments as necessary, (2) Nelson Caldwell has scheduled the queue observations, (3) Perry Berlind and Mike Calkins have operated the robots, and (4) a Hecto team member has typically been present to provide nightly scientific supervision. For now, we intend to keep the first three elements in place, but hope to turn the nightly scientific supervision over to trained observers from the pool of those with assigned Hectospec and Hectochelle time. We have requested that observers come to the telescope during their assigned time in the past, but would now like to clarify what is expected of observers and have them come to the telescope in blocks of time that make better sense for queue operation.

We would plan to divide each Hecto run into blocks of ~3 nights which would be managed by one or two observers. The nights will not necessarily correspond to the assigned nights on the telescope schedule. We have the freedom to shift the times around for the convenience of observers and the queue. During the assigned nights, the astronomer would attend to the following items, which center around insuring that good quality data are obtained.

Observer Responsibilities

1. Run the spectrograph/CCD acquisition control software

2. Annotate the data logs (now under automation), with comments on conditions, data quality, problems encountered, etc.

3. Check the operation of the spectrograph/CCD at the beginning of the night, and monitor readout noise, spectrograph focus, thermal flexure, etc. Normally, the actual focusing would be done by the robot operators, Perry and Mike, who would also fill the CCD dewar.

4. Be knowledgeable about the fiber assignment code "xfitfibs", in particular with regard to the restrictions on rotator position and guide star selection, to the extent of being able to run the program at the telescope should the need arise.

5. Be knowledgeable about the normal sequence of operating the positioner and acquiring fields, so that when problems with   acquiring a field occur, the robot operators can be advised as to how to proceed (e.g., moving on to another field because of poor guide stars). This would not include actually operating the positioner; that task would remain in the capable hands of trained personnel.

6. Do quick look reductions of data as it appears, checking for overall quality, and in particular insuring that the spectra fulfill program goals. E.g., are objects detected at all (coords ok?), are objects underexposed or overexposed, etc.

7. Help make decisions regarding the queue during times of marginal weather or seeing, choosing targets from the nightly list.

To aid the on-site astronomers, each group with Hectospec time will be expected to supply a brief summary of their data and calibration requirements.

In order to facilitate scheduling of observing blocks, we will ask people with allocations for their availability to go to the telescope. Any team member is eligible.

4   FITTING FIBERS TO TARGETS

4.1   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.
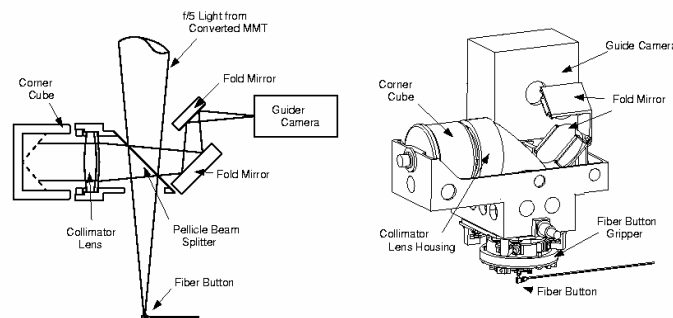
Figure 2. Robot TV guiders that can view the sky and backlit buttons simultaneously.

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″.

Coherent bundle (one of three)

Relay optics
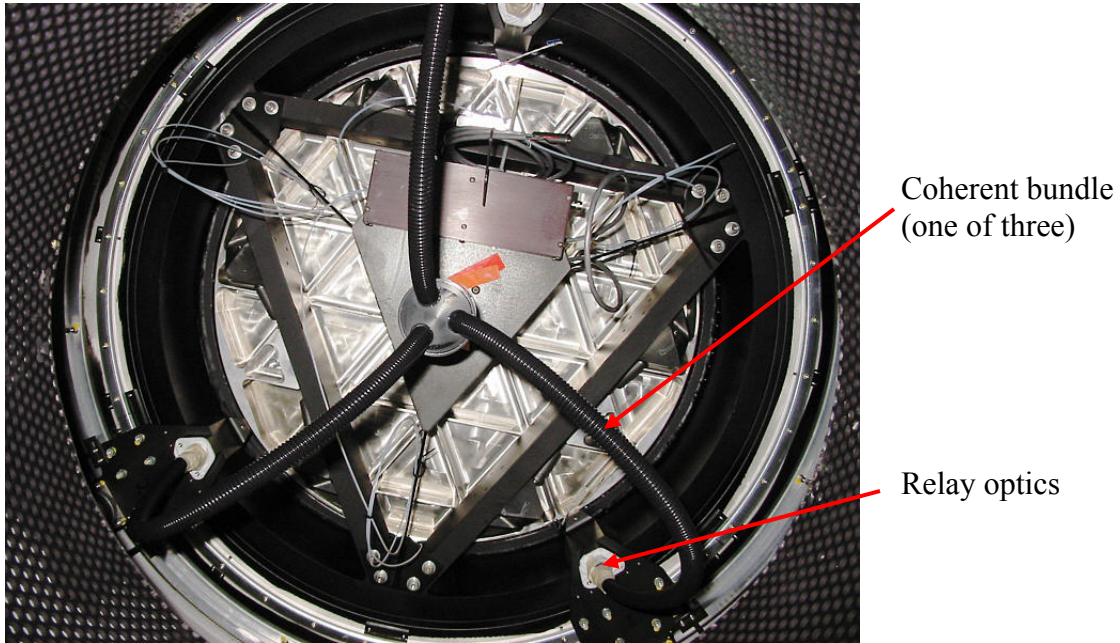
Figure 3. Photo of trifurcated coherent bundle and guide probes from beneath the focal surface.
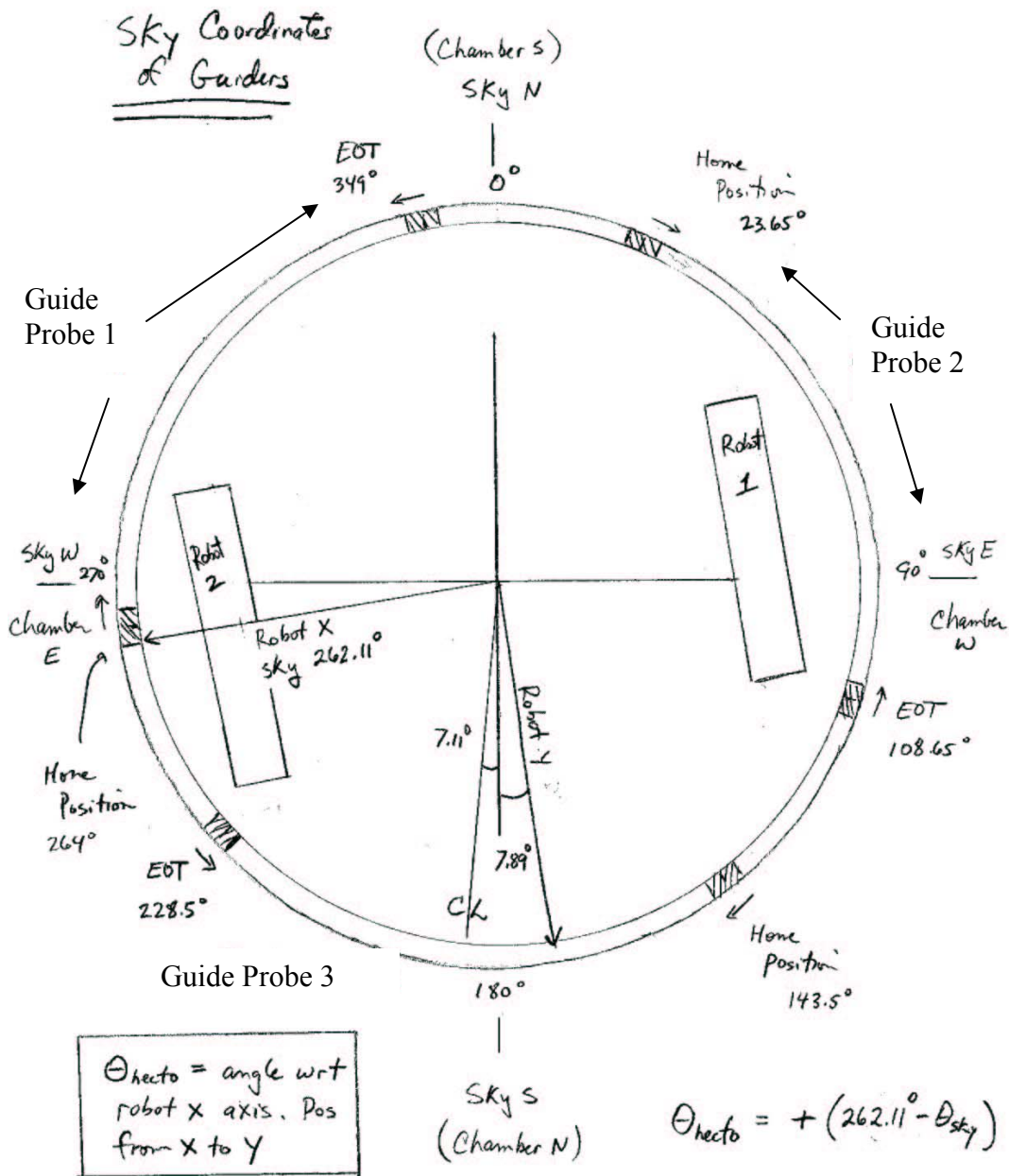
Figure 4. Position of robots and guiders with respect to sky when rotator angle is 0°.
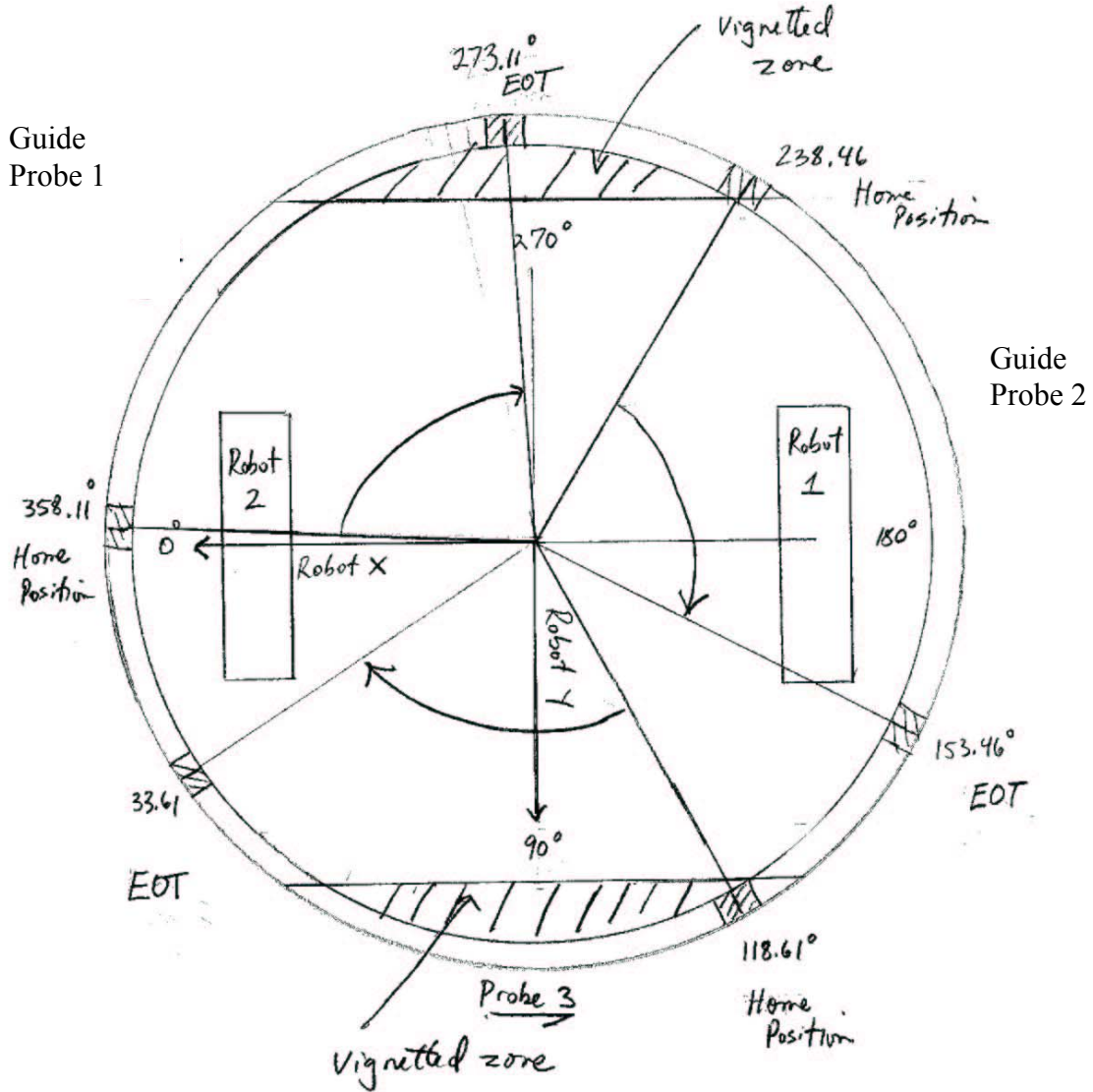
Figure 5. Position of robots and guide probes in Hectospec specific coordinates.

4.2   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 +/-45° to minimize wear and tear on Hectospec's electrical cables and optical fibers. We have hard limits set near +/-100° 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° declination or south of +15° 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.**
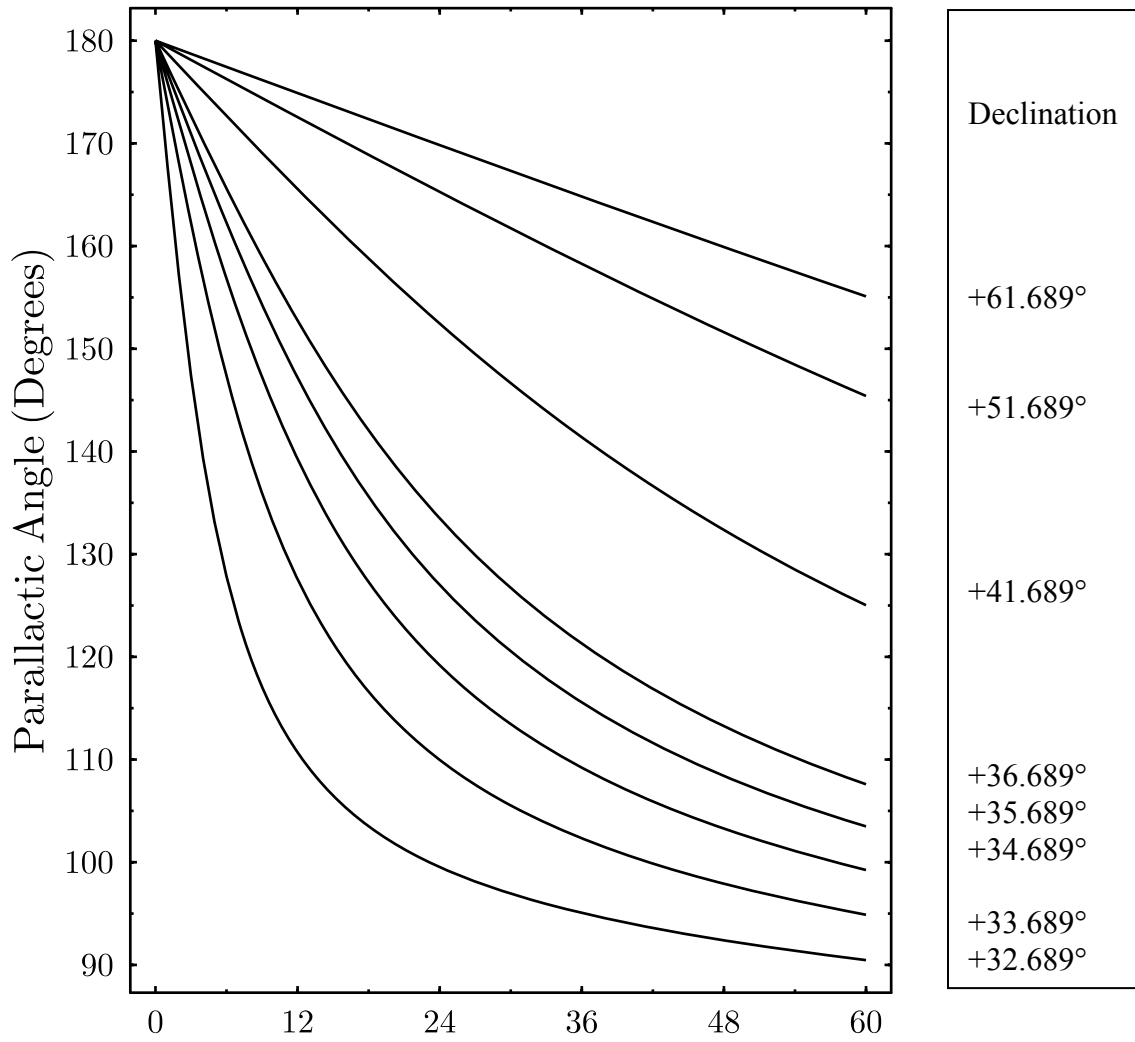
Figure 6. **The parallactic angle as a function of time in minutes past transit for Northern targets.**

Declination

+61.689°

+51.689°

+41.689°

+36.689°
+35.689°
+34.689°

+33.689°
+32.689°
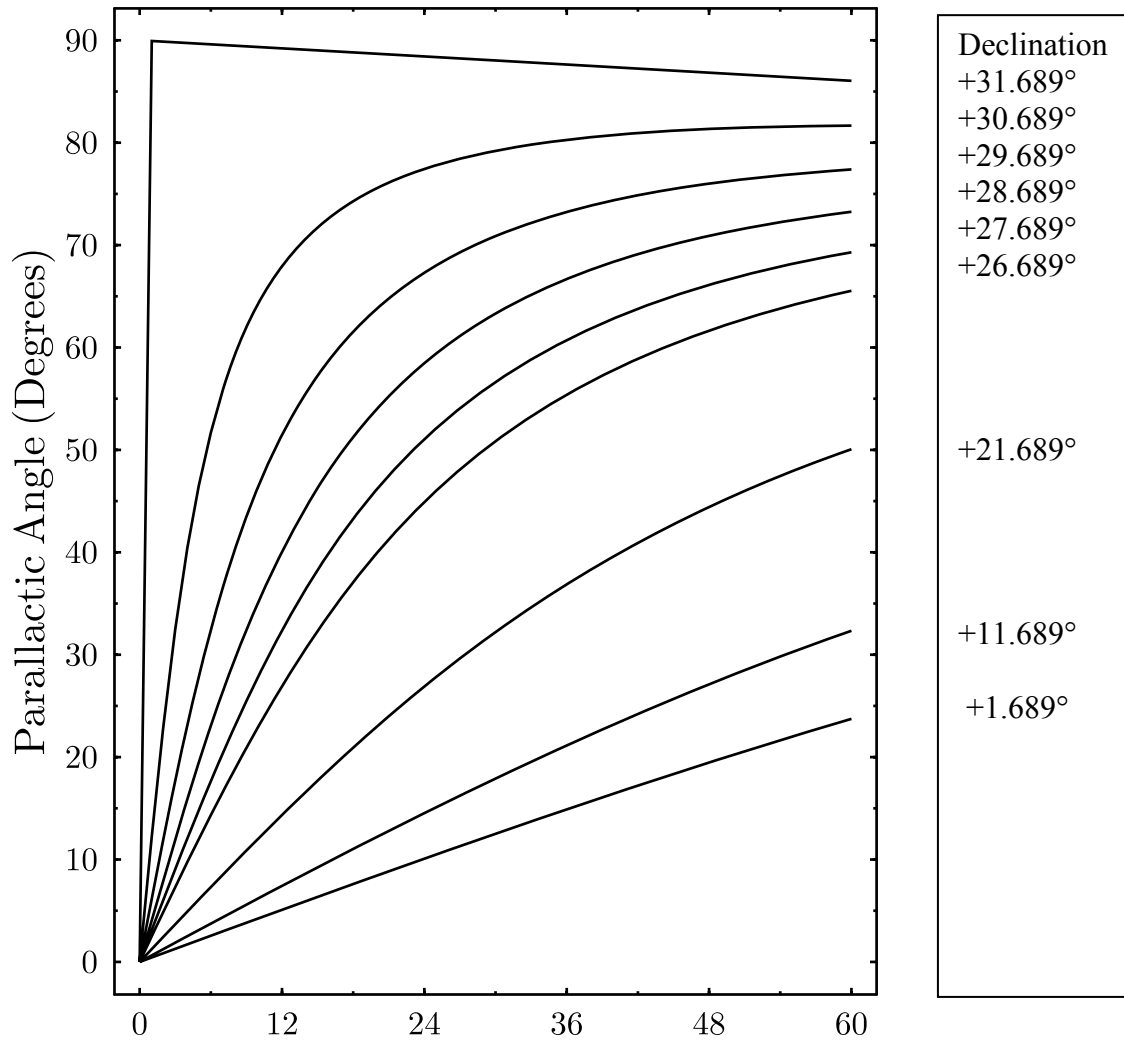
Figure 7.   The parallactic angle as a function of time in minutes past transit for Southern targets.

4.3   RUNNING XFITFIBS

4.3.1   INTRODUCTION

The PI makes a catalog of objects, which may be ranked in preference. The catalog must also include guide stars on the same coordinate system. Guiding is done at the edge of the Hectospec field, not on the surface where the object fibers are positioned. Thus, there are very stringent requirements on guide stars by the small area of sky available and the limited range of magnitudes allowed by the TV cameras.

The 2MASS and GSC II catalogs can be used where an observer catalog has few stars. In that case, the program **tmcguidestars** should be used. This program searches the 2MASS catalog for coincidences with the observer catalog, and computes a coordinate transformation. 2MASS and GSC II stars are selected in the field, transformed to the observers' catalog coordinate system, and added to the catalog. **tmcguidestars** is not yet ready for export. It does run on CfA computers, in a command line mode. External projects should contact instrument scientists if they need help with guide star selection.

The PI downloads the configuration program http://cfa-www.harvard.edu/~john/xfitfibs/ , possibly transforms his catalog coordinates to the GSC system via the 2MASS catalog, and runs the **xfitfibs** program for approximate dates of observation. In this process, guide stars are checked for suitability using a number of criteria (magnitude range, not a galaxy, no neighbors, etc).

xfitfibs requires information such as date and length of observation and number of exposures which will be used in scheduling. The output of the program is a number of files which would now be sent to a CfA computer for human checking, via the **Submit** button.

The configuration file is modified a few minutes before the observation takes place, in order to update positions, rotation angles, random sky selections, and guide stars.

Please submit your configuration files at least 10 days before the run starts.

4.3.2   BRIEF INSTRUCTIONS

The **xfitfibs** program itself contains many pages of help for particular items, and after going through these steps, one should consult those pages for detailed help.

4.3.2.1 START BY MAKING A CATALOG.

Starbase documentation can be found at:
http://cfa-www.harvard.edu/~john/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	mag
2:55:40.217	12:58:42.419	galaxy1	1	target	20.5
2:55:43.304	13:05:04.912	galaxy2		fiducial	15.0
2:55:55.454	13.10:05.234			guide	

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. Type *guide* is for guide stars.

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.

It is essential that the targets and guide stars be on the same coordinate system.

The coordinate transformation program is:
http://cfa-www.harvard.edu/jroll/hecto/guidestars-form You will have difficulty running the program if the field is dense in stars due to the web interface time out limit.

4.3.2.2 LOAD THE CATALOG AND SELECT FIELD CENTERS

Start up **xfitfibs** to bring up the drawing window and the field window. Load a file with the pull down menu. This will draw the objects and a circle centered on the objects' centroid, and will also make a target center in the **fld window**.

In the **fld window**, enter the start time in UT, e.g.: 3 March 2005 03:00:00

Enter an exptime in minutes and nexp (number of exposures), e.g., 15 and 3.

If you need sky offsets, please enter those with this format:
alt_offset az_offset exptime_in_seconds, e.g., 5 5 500

Click on the box next to the config number (beginning of line) and it will turn red indicating it is being operated on.

In the drawing window you may now move the circle to where you want it by clicking and dragging, or enter new coordinates by hand. You may add fields by using the table pull down menu. For each entry in the field table, enter a priority which will be used in the schedule.

When you are through moving things around, you should turn those buttons off. You may display the guide stars with the obvious button.

Click on parameters, and set the number of sky fibers. Once you are happy with your field centers, we need to select candidate guide stars.

4.3.2.3   SELECT CANDIDATE GUIDE STARS

Click on **Fit Guides** tab, then begin fit.

The number of guide stars will appear at the far right of the fld table row. A red background means too few stars available. You may have to move the circle center or change the mag limit on the guide stars (at the peril of them not being seen at the telescope).

It may also be the case that the rotator angles are red, even though there are enough guide stars. In this case you can change those angles by clicking on **toggle guide annuli**, going to the drawing window clicking on the (faint) red circle at the ends of any of the 3 annuli and dragging the annuli around until r0, r1 and r3 are green.

Next you need to classify the guide stars to remove double stars, stars that are too faint, and plain old galaxies. Click on **classify candidate.** After a while a message will come back with the results. Some stars may be rejected. Click on **ok** to rerun the guide star selection.

You can view the guide stars by bringing up the **Guide** window. Use **view** to select each configuration in turn. Clicking on **show** will start up ds9 and display all the guide stars in different frames. Nixed stars may also be seen by using view. If you are left with no guide stars, you may try to lower the faint magnitude limit in the parameters menu, but please advise us that you have done so, and expect some trouble at the telescope.

4.3.2.4 FIT FIBERS

Click on **fit fibers**, select rank, make depth=7 and begin fit.

Note that all the field centers you have entered in the fld table are fit at once, such that no target is assigned more than once. If you create two different output files from the same catalog, by running **xfitfibs** at different times with different field centers, then you may have duplicates.

Check to see that you have fit the number of targets you expected, otherwise, change your sky fiber numbers in parameters. Ranking may be changed by using the rank window.

4.3.2.5   SUBMIT

Now you ready to submit. Click on the **Send** tab. Pick the current trimester (e.g., 2005a), pick the PI number, click **send.** You may get a warning about changed parameters in the field table, which can be ignored. A number of files are then sent to CfA, where they are checked again before being sent out to Mt. Hopkins. Note that sending a config file (the one actually used at the telescope) directly to Mt Hopkins is discouraged, since such a file would not have the program number identified, that being added during the "send" process.

Questions should be addressed to John Roll `john@cfa.harvard.edu` or Nelson Caldwell `caldwell@cfa.harvard.edu`

5　TAKING DATA WITH SPICE

5.1.1　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.

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. (P3 and the UPS must be on.)

1. Login to alewife using the mmtobs account.

2. In a shell window, type:

    > vncviewer packrat:5

    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 on Packrat, using the mccd account. So in a window type:
    > su – mccd (give passwd)
    > start-daemon pulzinit
    > exit

4. Now go over to the Cfaguider window and type in a window:
    > stop-daemon domecal
    > start-daemon domecal

5. Start up the dome calibration lamp GUI by typing in a Packrat terminal:
    > dcalgui

6. Start up the main spectrograph GUI by typing in a Packrat terminal:

> dospice &

7. Start up the exposure status window by typing:
> expdisplay &

8. Occasionally, you may need to bring up the engineering GUI called "Hectospec Status". On a Packrat terminal type:
> spec   (or type chelle for Hectochelle)

Now we are ready to take some data

Figure 8. Spice Startup page. Use this to initialize software and home the three spectrograph motors. After this process is complete, return to the startup page for observing.

There are several tabs in this menu, which can be selected as needed. Initially of course, select "Startup," which is used to initialize the spectrograph. The general order is proceed down the list, and then complete items on the current line from left to right. The sequence is: Start Pulizzis, Start Bench, Home Bench, Start CCD. Do not press Start Calbox; this refers to an internal calibrator not normally used with Hectospec.

The CCD temperature is controlled via a heater in the CCD dewar. If the CCD electronics have been off for a while, say since the previous morning, the temperature will be colder than nominal (perhaps as low as -135 °C) and thus the heater will come on for an extended period till the temperature reaches -120 °C. Thus, for critical

measurements, you may wish to monitor this temperature until it reaches nominal, as shown on the Spice upper panel.

The "Standard Ops" page 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. Upon readout completion, a beep is issued and the file is automatically displayed into a ds9 window (called "spec9").
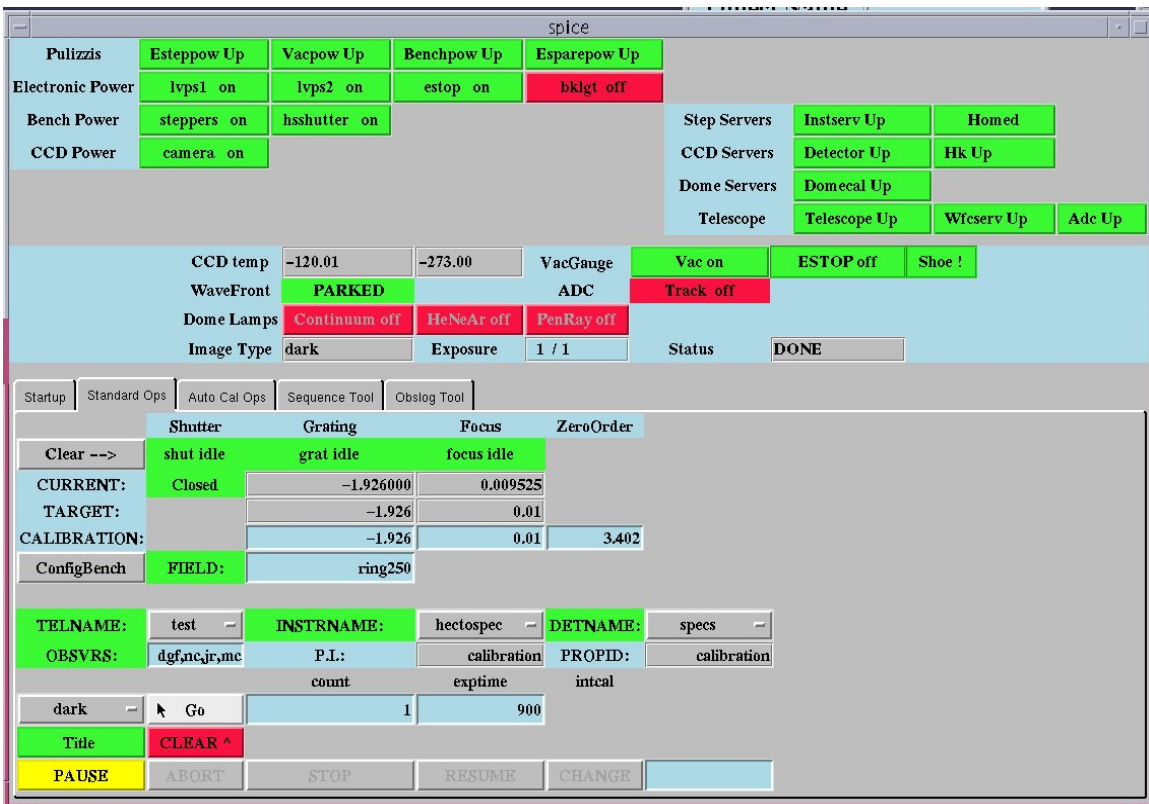
Figure 9. Spice Standard Ops page for taking spectra. If the box on the lower left above the Pause button is selected, a pull down menu of observation types appears to select the exposure type.
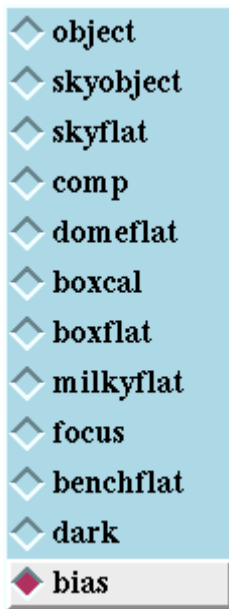
Figure 10. Pull down Spice menu of exposure types.

5.1.2 SPICE DETAILS

The first group of items on the Standard Ops page pertains to the bench motors:

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

Row 2: *Current* values of stage positions as read back from the hardware (e.g., open or closed for the shutter)

Row 3: *Target* values for stage positions. These are not set by the user but reflect the issued commands when ConfigBench is pressed.

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 stored values. 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.

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.

PROPID: entered automatically when a new configuration is loaded.

P.I.: likewise

The next item should be entered via the keyboard.

*OBSRVS***:** Your favorite people.

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 (If Hectochelle is in use, CHELLE replaces SPEC.)**

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

SKYOBJECT: 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 5x300 seconds are recommended, multiple exposures are useful to eliminate cosmic rays. With the PenRay HgNeAr combination, shorter exposure times may be used (30 seconds or so).

DOMEFLAT: prompts for a title, opens the shutter, writes "domeflat" 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 2 seconds is recommended. 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 "milkyflat" as imagetype in the header. Not yet implemented.

QFOCUS: Enter the number of exposures desired, the center focus value, and the focus step between exposures.   Good values for those are 7, 4, and -0.04. This routine will take a sequence of exposures, at the requested sequence of focus values for the spectrograph, which can then be analyzed.   Typically, one uses the dome calibration PenRay lamps for this purpose, though night sky emission lines work well also. *The exposure can also be done while the mirror is covered.*   This program uses the grating in zero order, and the charge is moved between the exposures, thus only one file is produced. The image will have one spot per fiber, per exposure.   So the image will have 300 rows of n spots, where n is the number of exposures. Bearing in mind that the in-focus images are not Gaussian but rather flat-topped, a script has been written that analyzes the data frame and produces a plot. On the Alewife computer, type this command perl bin/focus_red.pl filename.fits.   A plot in **gv** will be produced showing image concentration as a function of focus position. Different fibers are shown as different symbols. Higher concentrations are better.

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 Å 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.

5.1.3 DATA LOGGING

The obslog tab in spice is used to create and maintain the data logs, which are mostly automatic. The one thing the observer can add is a comment when needed. In particular, it useful to comment on the seeing and cloud presence during the night, and any problems with particular files. To do so, first insure that the correct data has been selected (recall that we use the UT date). To comment on an existing file, click on its name in the right panel. The basic information will appear to the right, and you can now type into the comments panel. Click on **Save Changes**. To edit an ongoing exposure, click on **Open Current** and then enter comments. To view the data logs, click on the sunburst button at the bottom right. A postscript file is created and the displayed using **gv**. Exit gv using **q**.
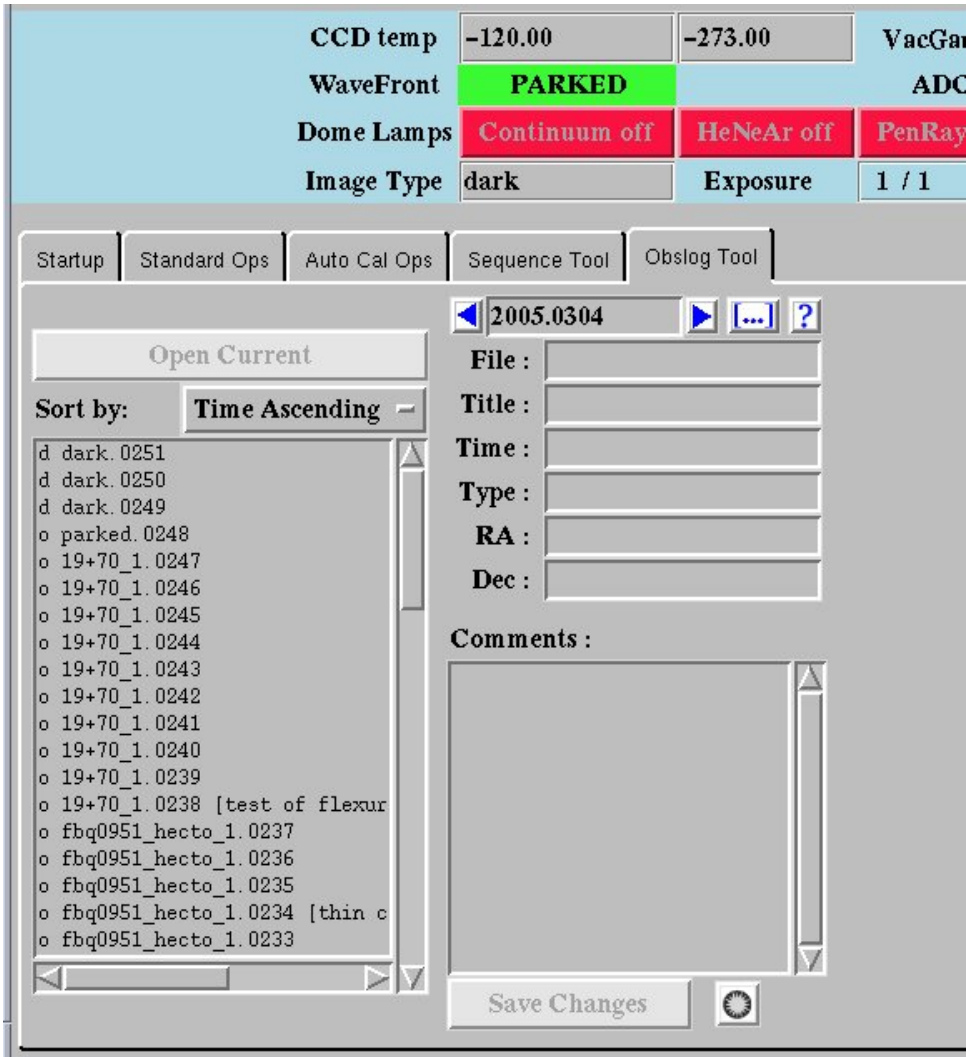
Figure 11 Portion of Spice, showing the obslog tab.

Figure 12 Example data log.

5.1.4 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 13. Exposure status display.

5.1.5 DATA FORMAT

The A/D converter is 16 bit, 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's **mscred** will work, but we can't guarantee this at this time. The SAO version of NOAO's **mscdb** package must be installed to use **mscred**.

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

The fiber mapping files ("filename_map") are stored along with the data files. This information is also stored in the FITS file.

5.1.6 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 mscdisplay 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 an 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 **mscexamine**. Make sure you start up IRAFin a xgterm window.

6   DATA REDUCTION

The data obtained by CfA PIs will be reduced by the Telescope Data Center (TDC) unless the spectrograph operation mode is inconsistent with the standard pipeline or unless the PI wishes to reduce his or her data. For non-CfA users the TDC will make the pipeline software available. Check the TDC website (http://tdc-www.harvard.edu/) to download this software. Doug Mink (dmink@cfa.harvard.edu) may be able to provide advice about this software in case of difficulty. Nelson Caldwell is very familiar with the operation and characteristics of the spectrograph, and has a good deal of experience with data reduction. He is willing to provide a limited amount of help to users; he may be contacted at ncaldwell@cfa.harvard.edu.

All Hectospec or Hectochelle data will be archived nightly by the TDC.

7   QUICK LOOK SPECTRAL EXTRACTION

A fairly fast method of extracting all 300 fiber spectra from Hectospec images is provided by a command that runs a series of PERL and IRAF scripts. The input is a series of raw images, which are processed as described in this document <http://cfa-www.harvard.edu/oir/MMT/MMTI/hectospec/hecto-reductions.htm>. The calibration files used are stored in a subdirectory, and may need to be remade for every observing run (but not every night). The output is a FITS file containing wavelength calibrated, sky-subtracted spectra in multispec format. The program currently runs on **alewife** and on **homer**. It is not installed on **packrat**, partly because we don't want to interfere with the data acquisition on **packrat**, and partly because **packrat** runs Solaris.

The data disks are cross mounted between **packrat** and **alewife**, and we copy the files over to local disks, and so don't clutter up the data directories, nor are the raw data files altered. Here is what you need to do:

1. Login to **alewife** or **homer** using the spec account. You will need a terminal, which if not there, can be opened with the right mouse button. In this window, type >xgterm &. This will open up an xgterm, needed to run IRAF. You may resize the font via shift-middle mouse button. Start up IRAF with >cl.

2. You'll need to know the names of the files you want to combine. The IRAF command >ldata will list the files in the current data directory (which is on **packrat**). The output files will be written in /home/spec on **alewife**.

3. If you have only one image you want to work with, the program will extract that and try to remove cosmic rays during the extraction. For multiple files, the program detects the cosmic rays by comparing images, and interpolates across them in individual frames, The frames are then averaged together before extraction begins.

4. In the IRAF window, you would type :

     >qspec file1,file2,file3 [skyfile]

    where the files are of the form listed from the >ldata command, e.g.,
    halostar9:30pm_1.1121.fits. The .fits extension is unnecessary. The files must be
    separated by commas with no spaces. The optional skyfile would be used when
    there are sky fibers in the data that are marked as objects ("sky-objects"). The
    format of this file is simply a list with one sky-object aperture per line.

5. The program takes 1-3 minutes, the longer time being for the case of one image,
    since the cosmic ray detection for a single file takes longer. The files used in the
    process are then listed, along with the names of the output files. If the output file
    existed already, the program will prompt for deletion.

6. To look at the spectra, use splot (you may need to load imred and then specred
    first, though they are supposed to be loaded automatically). To run through the
    spectra one by one, use the **(** and **)** keys. The X and Y scales have been fixed to
    display low signal spectra well; to scale to the entire range of the spectum, type **w**
    and then **a** while viewing a spectrum. To smooth, type **s**.

Details: The PERL files are stored in the /home/spec/bin directory. The main file is
called dohecto.pl, and this may be run by itself without IRAF, via perl ~/bin/dohecto.pl
filename. This program creates a file with a list of IRAF commands called dohecto.cl,
which is then run by the perl script.

These files, along with the IRAF uparm files are stored in a tar file in case they have been
messed with. To restore the files, go to the home directory in a shell window and type tar
-xvf restore.tar.

Trouble may ensue if there are no sky fibers in apertures 1-150 or 151-300.

A ds9 regions file can be brought up to identify all the apertures and which fibers they
correspond to. Click on regions, and load regions, and select the file /h/spec/specaps.reg.

8 HECTOSPEC SPECTROGRAPH DESIGN

8.1 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.
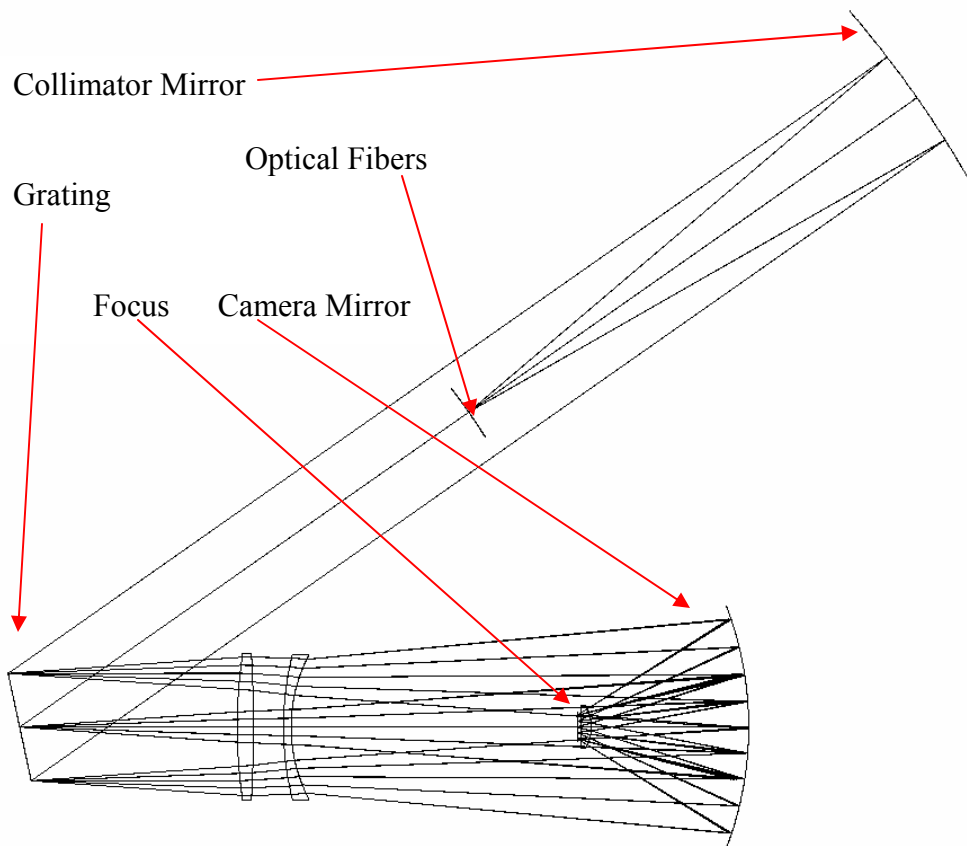

Figure 14. Optical layout of the bench spectrograph. The fibers are arranged in a line perpendicular to the plane of the page.

8.2 BENCH SPECTROGRAPH OPTICAL DESIGN

8.2.1 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

8.2.1.1

8.2.2 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°
```

8.3   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 Hα 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 they could be installed.

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

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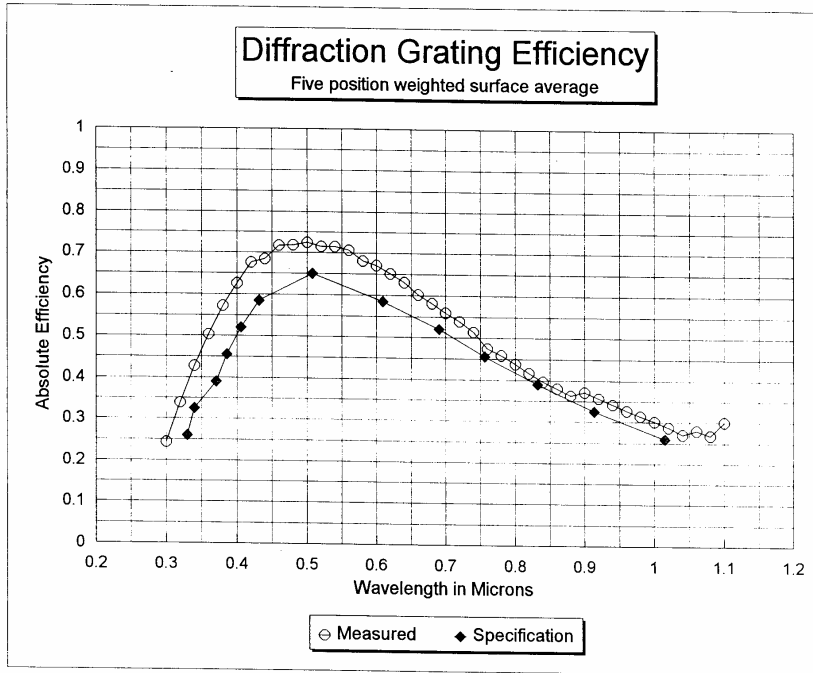
Serial Number:	MR192-1-1-1	Nominal Littrow Blaze:	530 nm
Grooves/mm:	270	Blaze angle:	4.1 degrees
Grating Coating:	Aluminum	Order:	First
Test Date:	09/09/98	Slits:	50 um (UV)
			500 um (IR)
		Aperture:	10 mm
		Operator:	MA

Notes:

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

Figure 15. The efficiency of the 270 line grating

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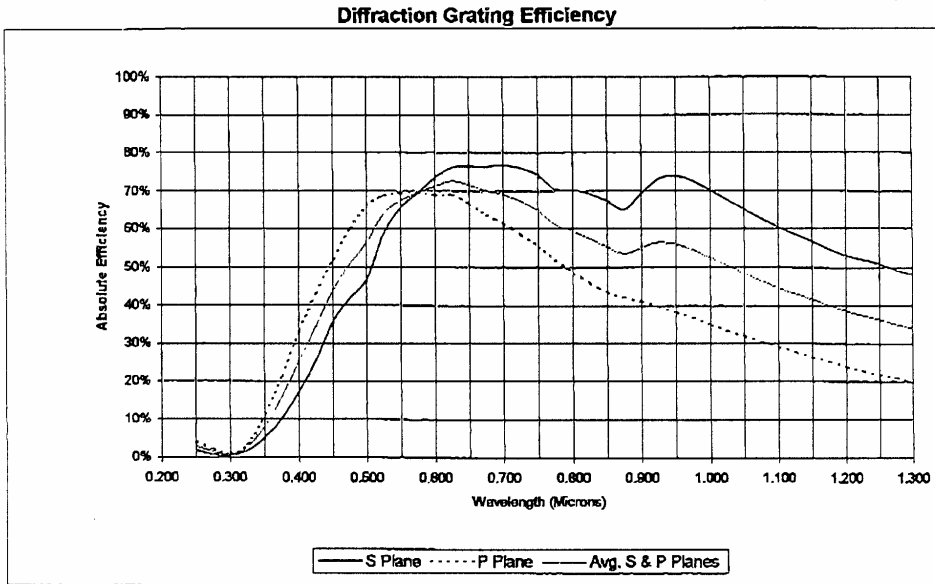
Serial Number:	MR225M	Blaze Order:	1st
Catalog Number:	53045ZD01-xxxR	Slits:	50 um
G/mm:	600	I.R. Slits:	500 um
Grating Type:	Ruled Plano	Aperture:	7 mm
Coating:	Aluminum	Operator:	RPI
		Test Date:	8/5/2003

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

Figure 16.   The efficiency of the 600 line grating.

9   SPECTROGRAPH PERFORMANCE

9.1   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

9.2 MEASURED PERFORMANCE

We can compare the throughput predictions with measurements of a spectrophotometric flux standard star BD+284211 in 1″ seeing. BD+284211 was stepped across a fiber entrance aperture to find the position where we detected the maximum flux.
For an apples to apples comparison we need to correct the measurement for the aperture loss.
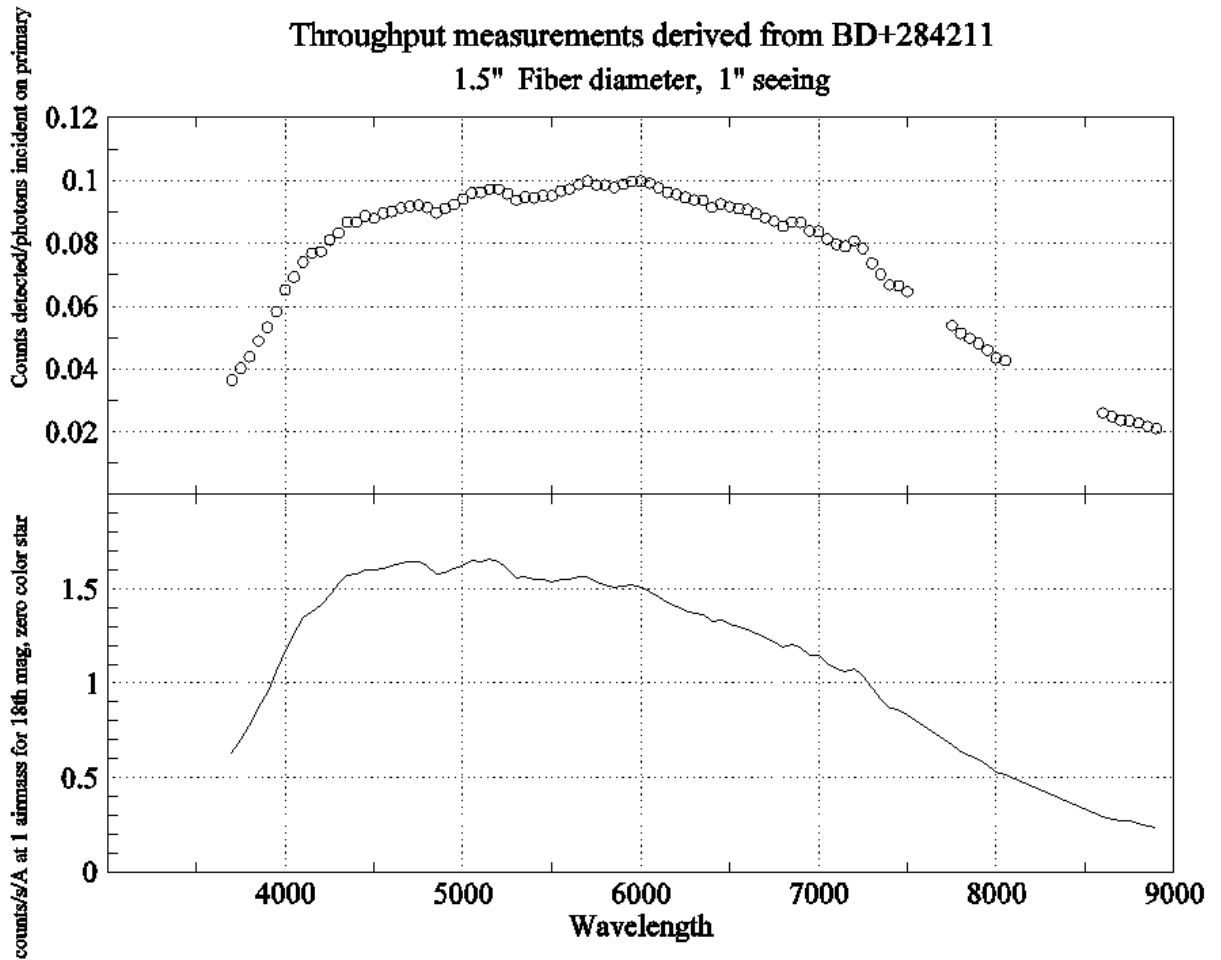

Figure 17.   Measured throughput in 1″ seeing not corrected for aperture losses.

The appropriate aperture correction for the plots above (measured with Megacam images) is about 1.7 (ratio of flux within a 20″ diameter aperture to the flux within a 1.5″ diameter aperture). Therefore, the peak throughput for light that hits the fiber aperture is about 17% (to be compared with the prediction of 23%) . If we average over wavelength, the measured throughput is about 75% to 80% of the predicted numbers.

We present two "real-world" performance plots: the SNR pixel[-1] for a 15 minute exposure as a function of aperture magnitude and the absorption line SNR (1+R) for 45 minutes of exposure as a function of aperture magnitude.
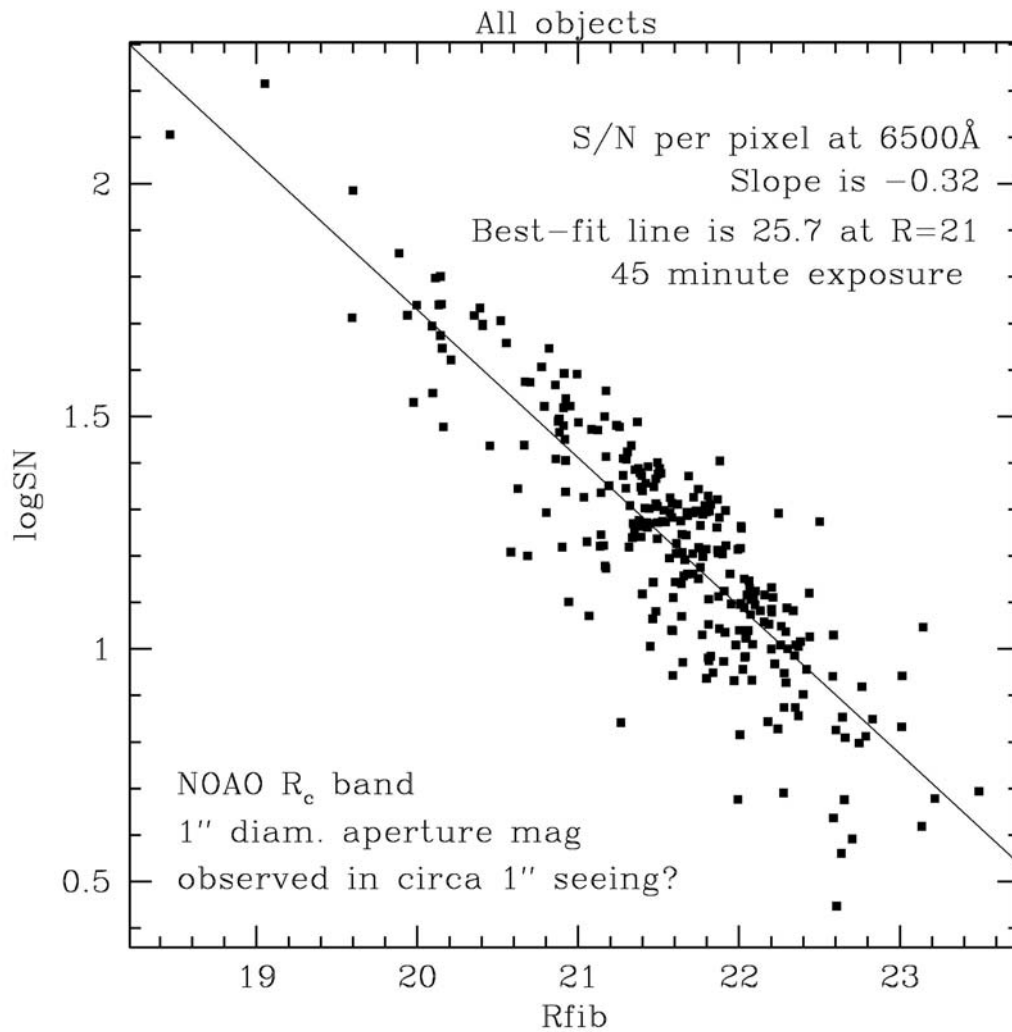

Figure 18. The signal-to-noise ratio per pixel for a 45 minute exposure as a function of aperture magnitude (1″ diameter aperture.) The SNR per pixel is ~26 at R=21. The relations for 4500 Å and 8500 Å have the similar slopes, but show a SNR per pixel of ~9 at an aperture magnitude of R=21 for the same exposure length. Improvements in sky subtraction techniques may allow improvement at 8500 Å . Analysis and plot courtesy of Daniel Eisenstein.
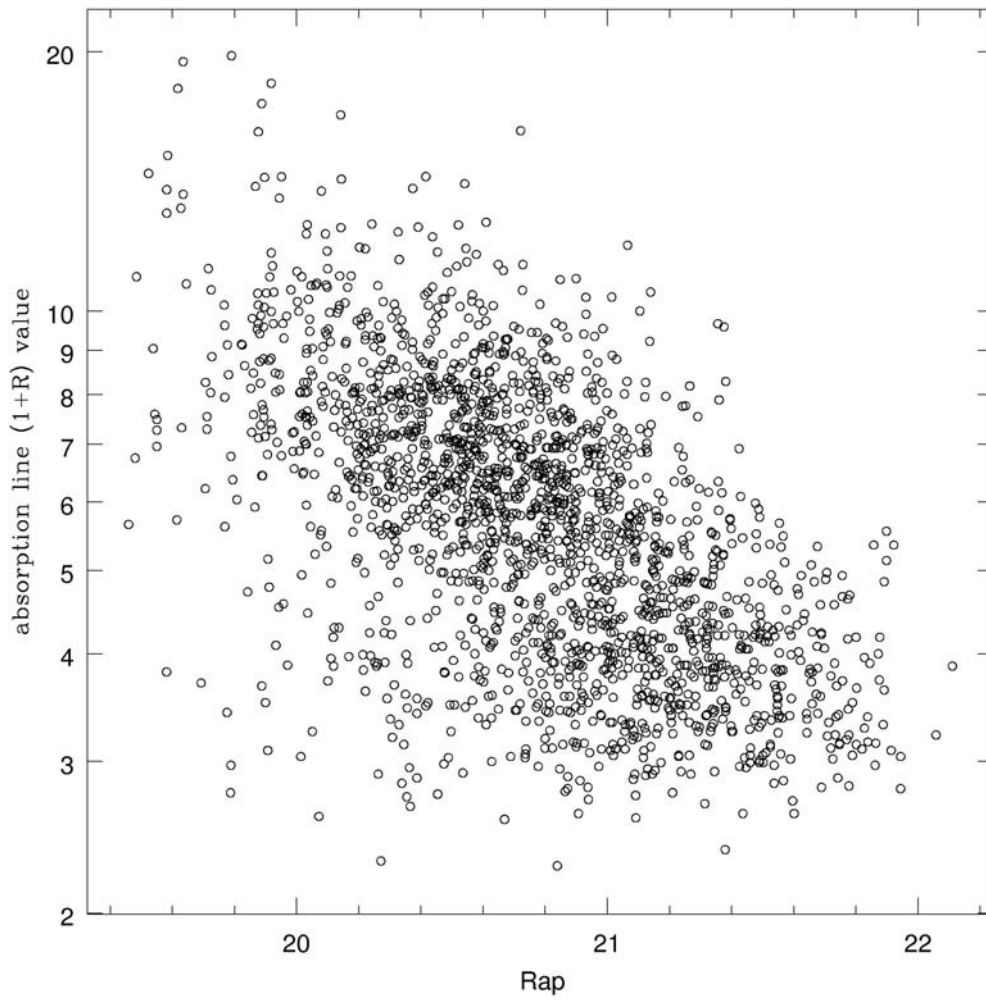
Figure 19. The absorption line cross-correlation signal-to-noise ratio (~1+R) for 45 minutes of exposure as function of R aperture magnitude (2.6″ diameter aperture). All of the 1974 galaxies in this plot had reliable redshifts. The SNR ratio shown here is reduced somewhat by the use of templates from the FAST spectrograph. Better cross-correlation templates will be created. Courtesy of Michael Kurtz.

10   BENCH SPECTROGRAPH

10.1   PUMPING OUT AND FILLING THE DEWAR WITH LN2

Figure 20. Pump station.

Figure 21. 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.
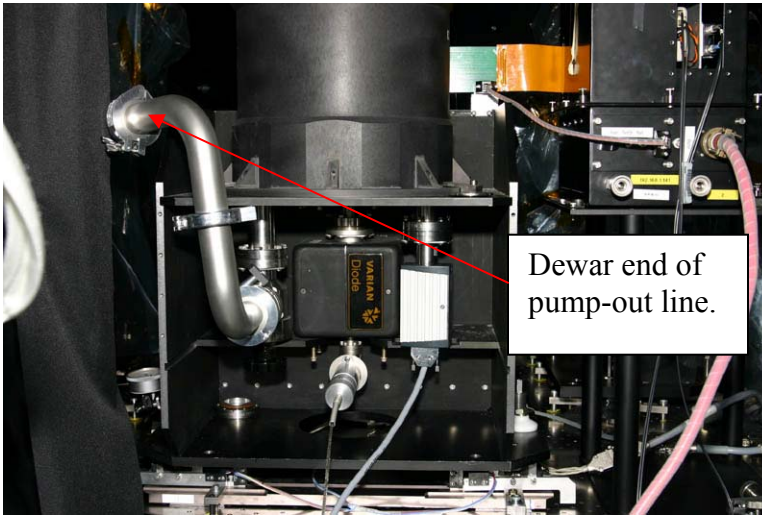
Figure 22. Hectospec Dewar.

Figure 23. 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 x 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.
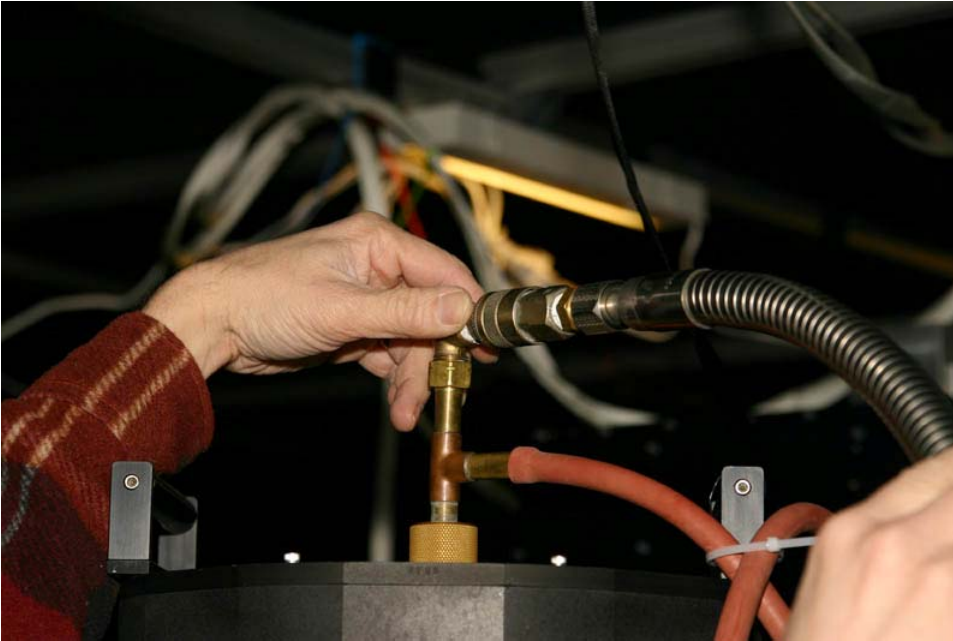

Figure 24. Dewar valve.

Figure 25. Dewar end of LN2 fill line.

Figure 26. LN2 reservoir end of LN2 fill line.

Figure 27. Hectospec ion pump is on the left, vacuum gauge is in the middle.

Figure 28. 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 x 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 N_2 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 N_2 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 29. 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.
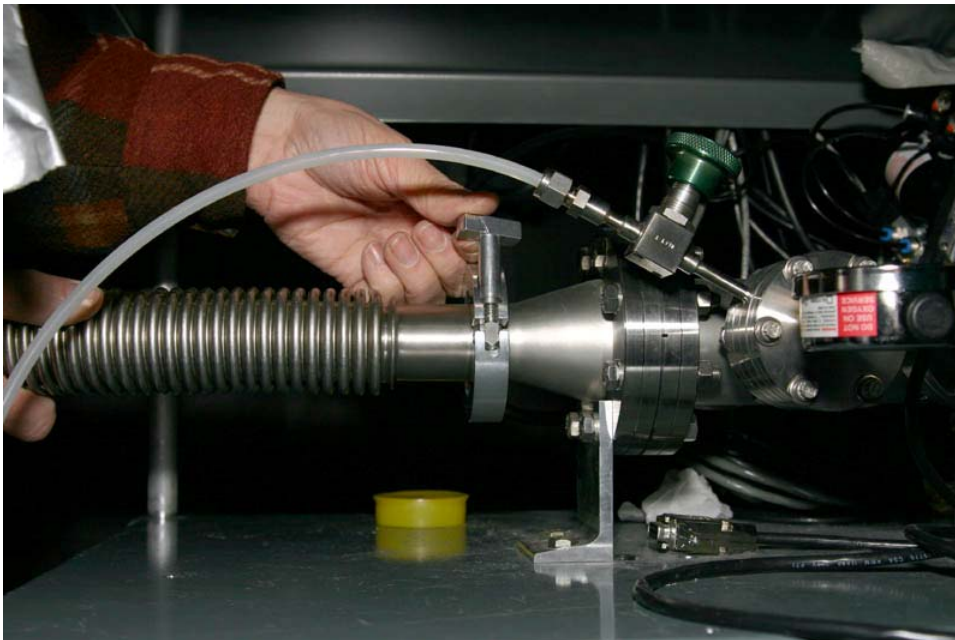

Figure 30. The cutoff valve is the green valve to the upper right.

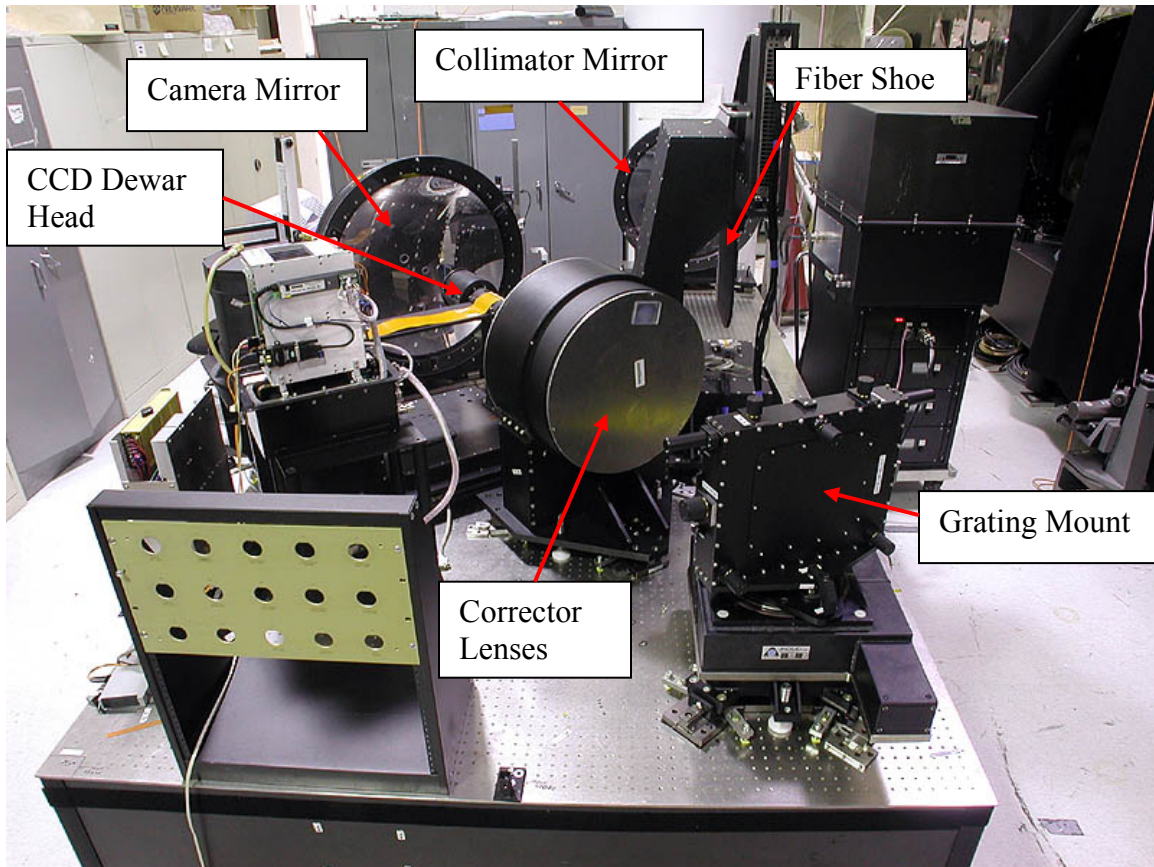## 10.2 BENCH SPECTROGRAPH & FIBER REFERENCE

Figure 31. Hectospec Bench Spectrograph in the lab just prior to shipment.

10.2.1 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.
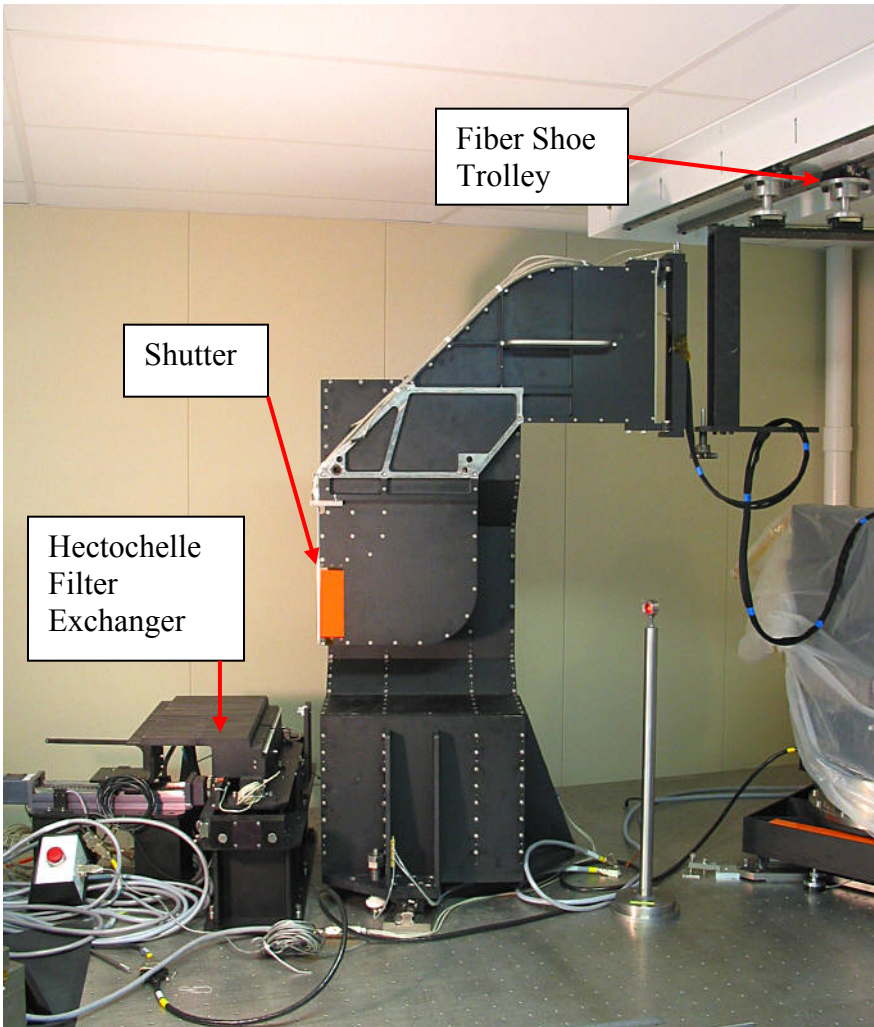
Figure 32. Fiber shoe and trolley. The fiber chain is not installed in this picture.

10.2.2 FIBER SHOE LAYOUT

10.2.2.1 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

10.2.2.2 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.

10.2.3 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.
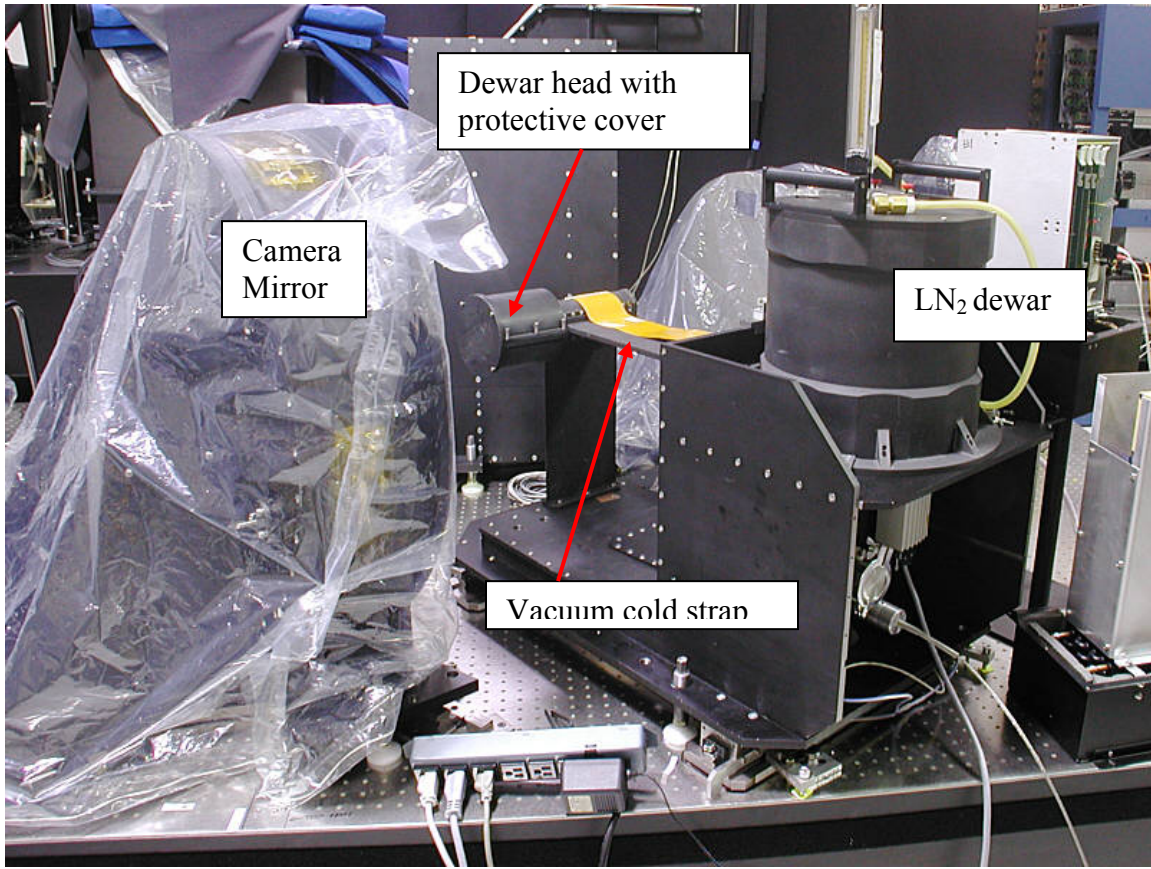
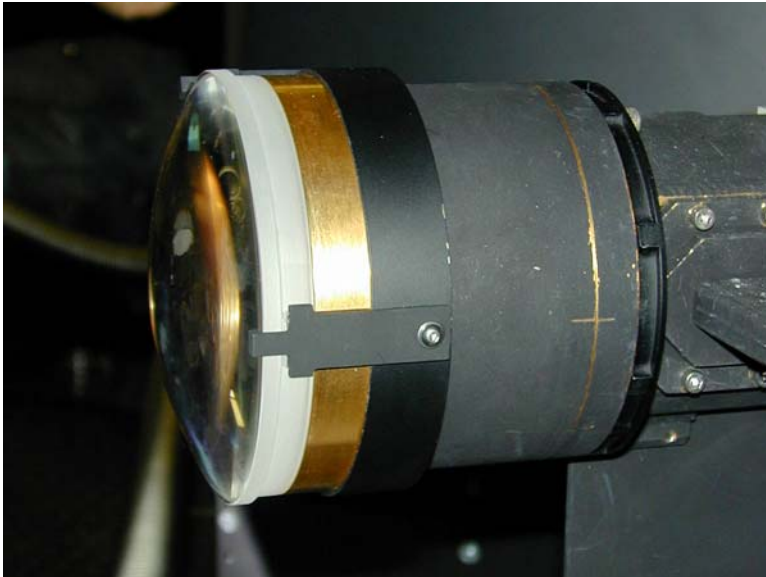**Figure 33. Dewar assembly. The field flattener is covered with a protective enclosure.**

Figure 34. Closeup of dewar head and the field flattener lens that serves as the dewar window.

10.3 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 connecter 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.

10.4 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.

11 HECTOSPEC OBSERVING PROCEDURES
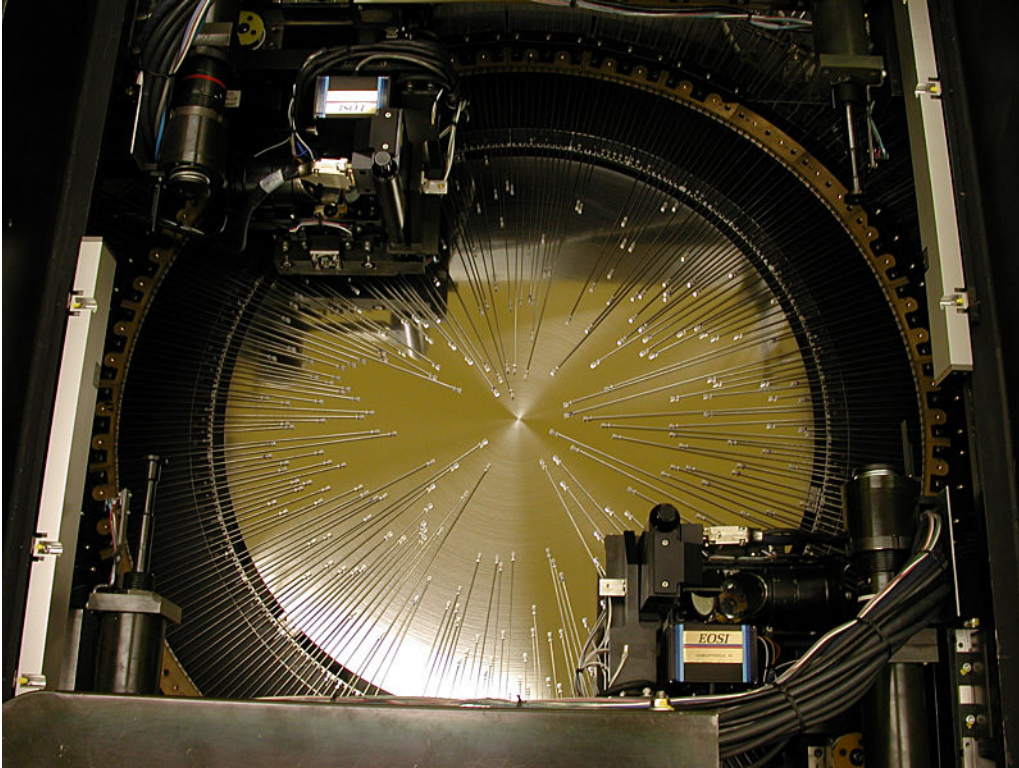
11.1 INTRODUCTION

Figure 35. 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.
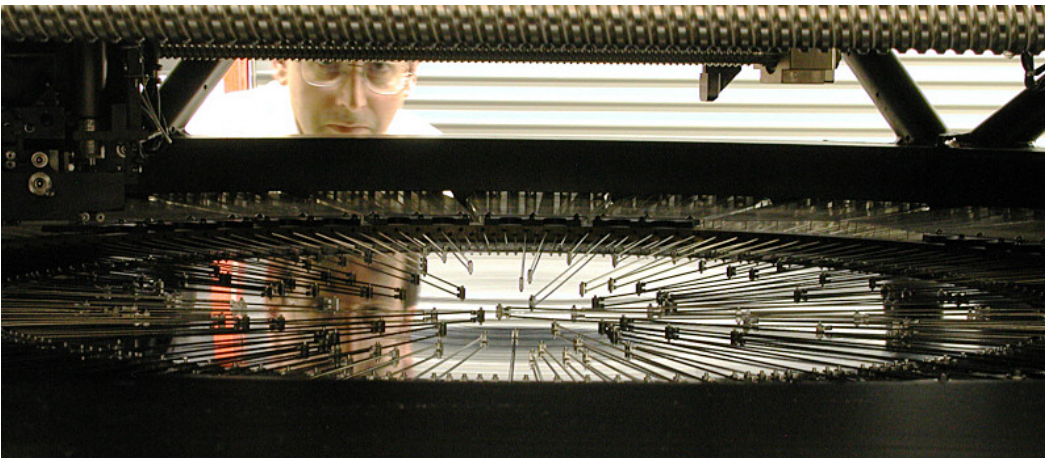

Figure 36. Looking at the focal surface from the side with the covers removed. One robot is visible to the top left.

11.2 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.

11.2.1 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 37. Turning on Fiber. Computer is located behind the large monitors.

11.2.2 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 38. 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.
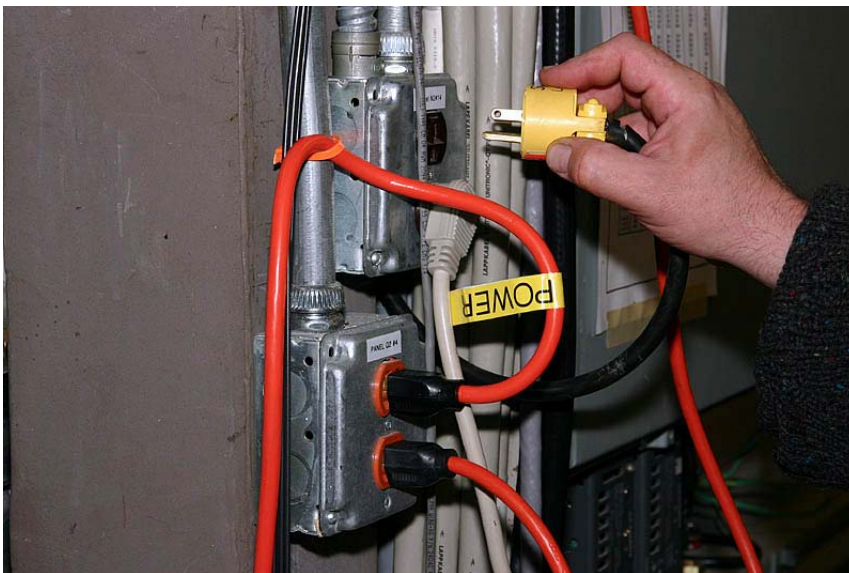

Figure 39. Plugging in.

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

Figure 40. 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 41. SNAPPY (snap2) computer with cover closed.
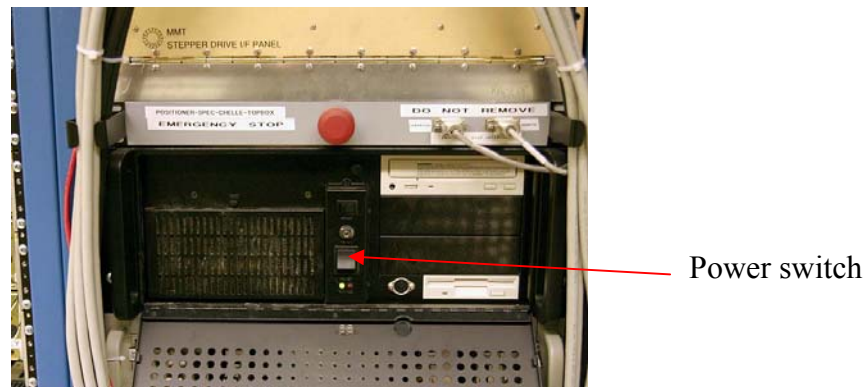

Power switch

Figure 42. 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.

11.2.3 STARTING UP THE SOFTWARE

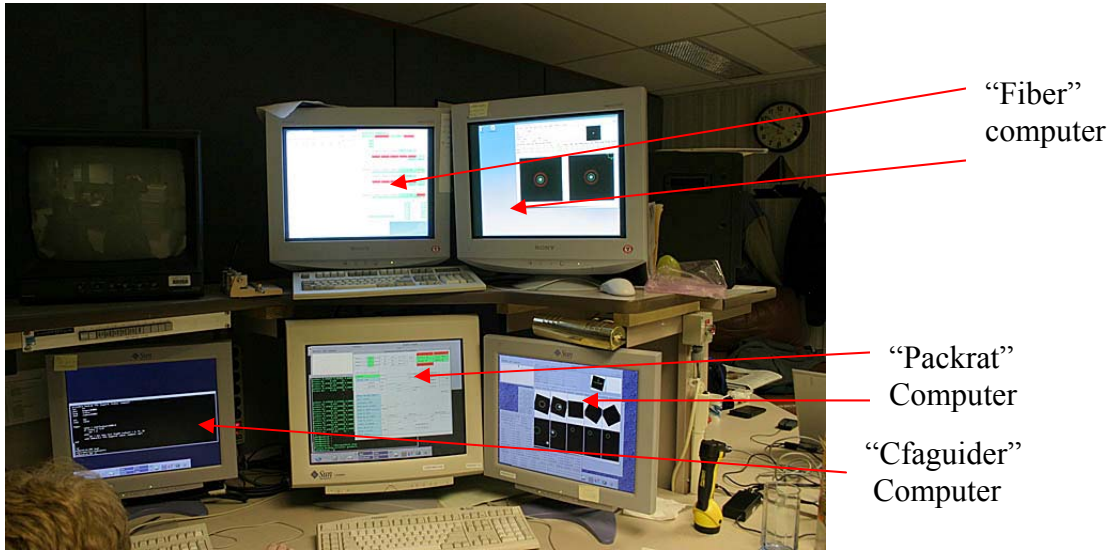**Figure 43.   Fiber positioner control computers.**

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.
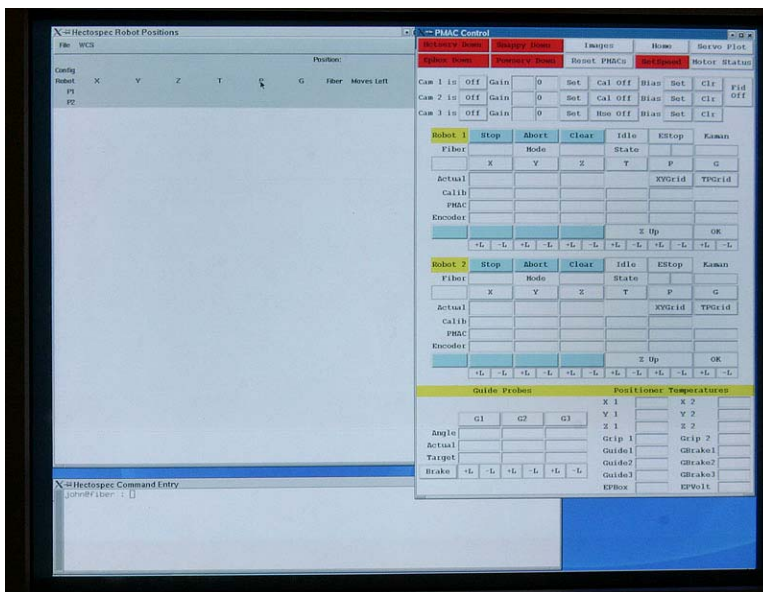
Figure 44. Fiber display.

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".
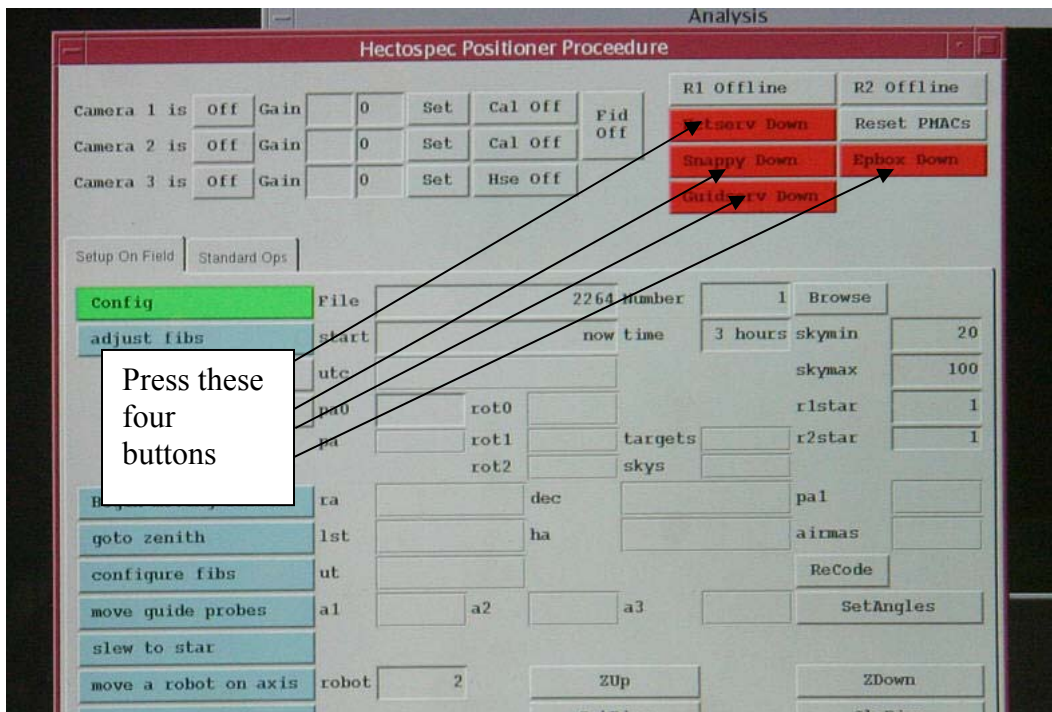
Figure 45.   Hobserve display.

Figure 46. Robot camera display on second (rightmost) Fiber monitor.   This display comes up after the Images button on the Hecto display is pressed.

11.2.4 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.

Pulizzi Power Controllers

Emergency Stop Switches

Hardware VME Rack Computer

Robot 1 Servo Amplifiers

Robot 2 Servo Amplifiers

Low Voltage Power Supplies

Figure 47.   The fiber positioner electronics rack.

Fiber Positioner
Control Pulizzi

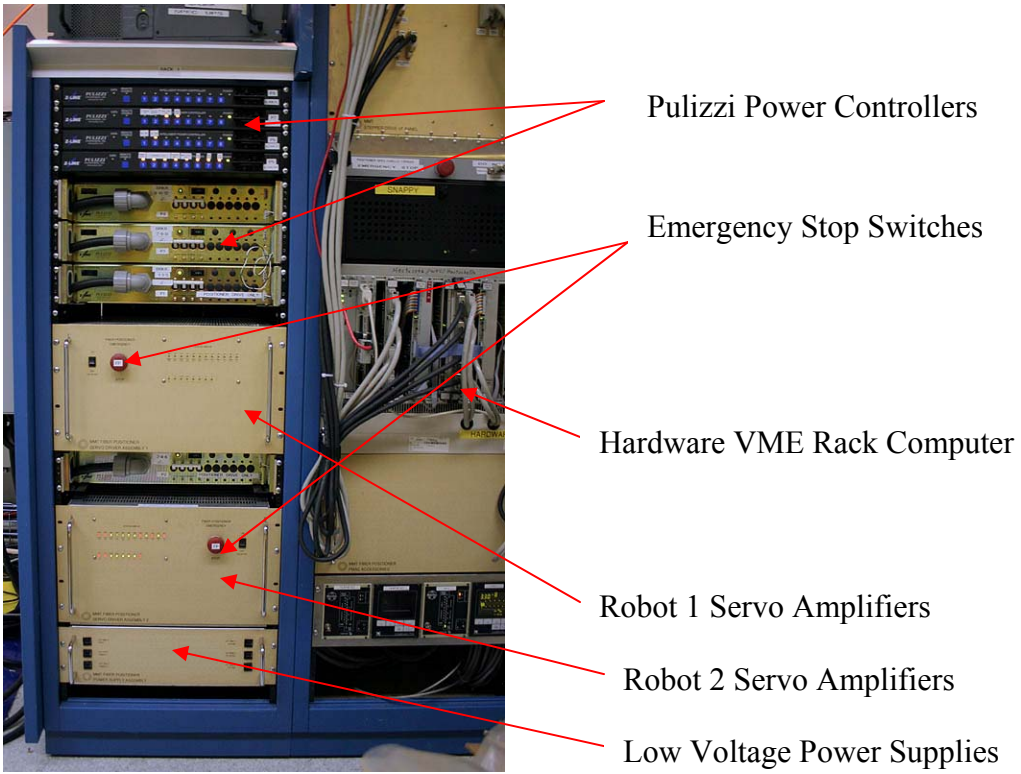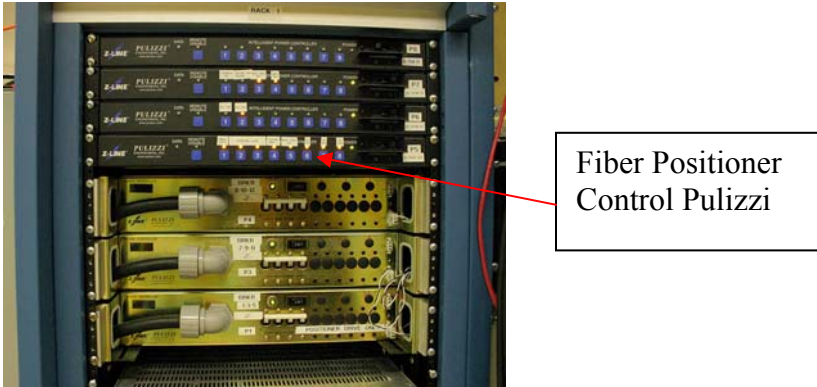**Figure 48.   Closeup of upper portion of the fiber positioner electronics rack.**
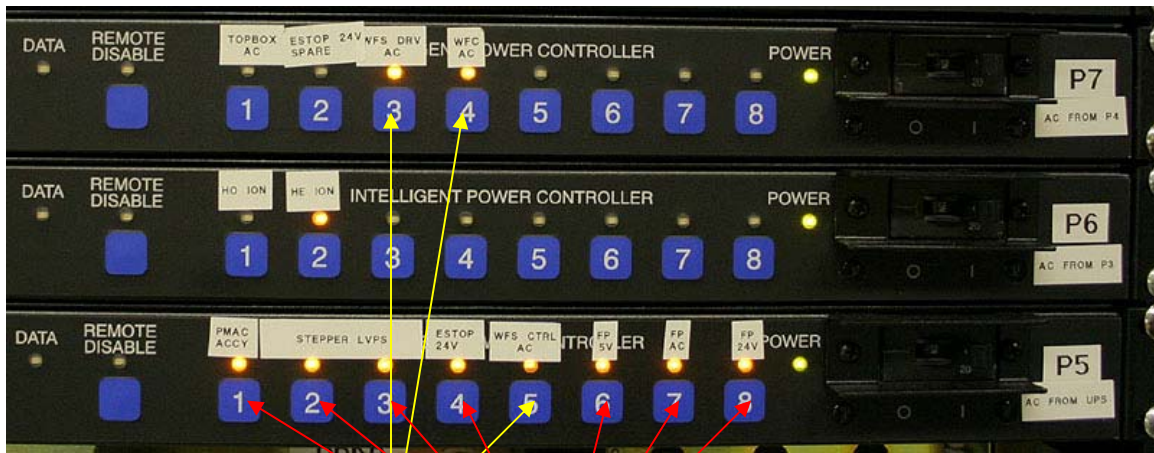
Normally these buttons for the WFS (Wave Front Sensor) and WFC (Wide Field Corrector) will be turned on as these units are tested following their installation.

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

Figure 49. 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.
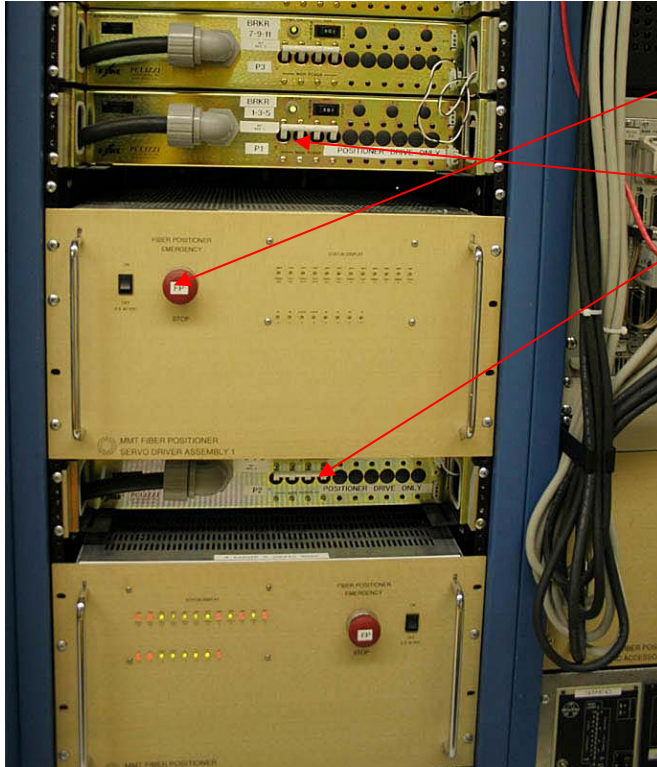
1. Press the E-stop button if it is not already depressed.

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 release the E-stop button.

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.

11.2.5 STARTING THE GUIDEGUI
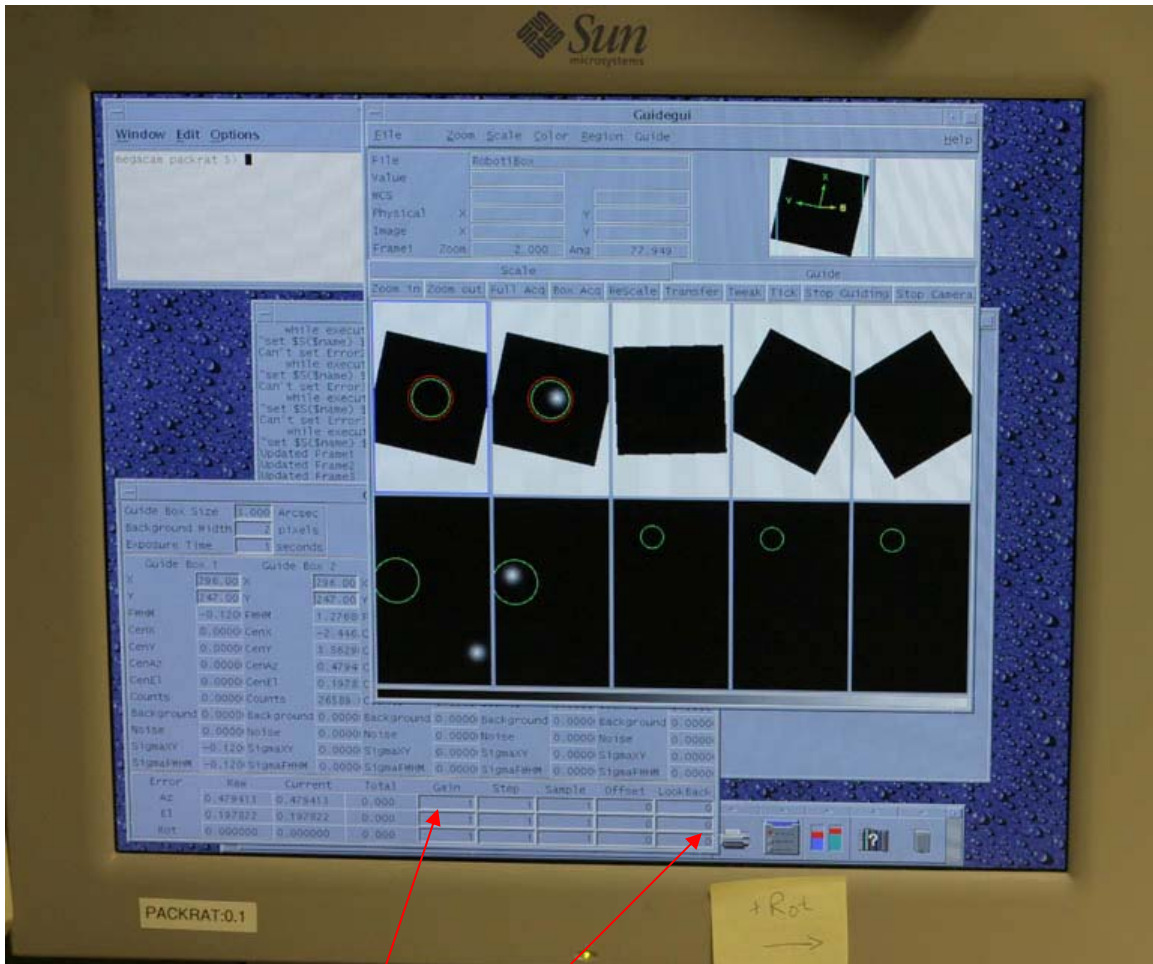
Scan the mouse over to the rightmost of the two Packrat monitors and select a terminal window. In this window type:
> ssh john@snap2

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.**

11.3 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 Cfaguider 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.
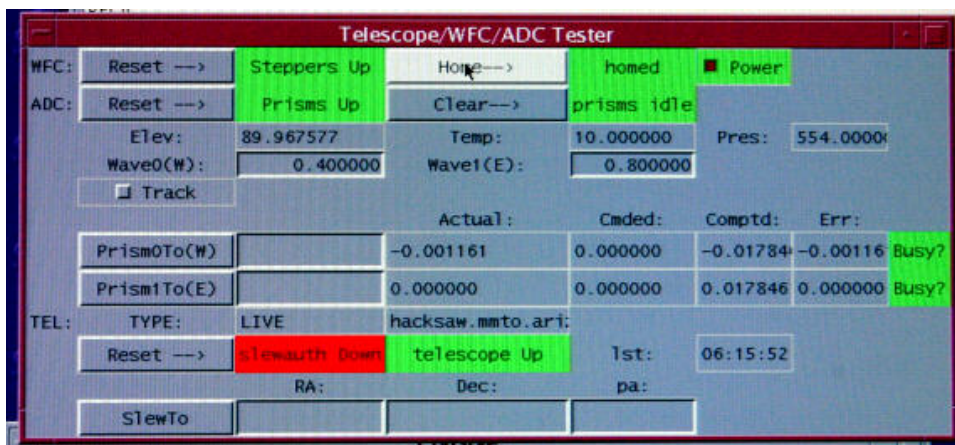Then, press the WFC Home button.

Figure 50. 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.

11.4 MOUNT STATUS DISPLAY

On Cfaguider, 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 51. The mount status display.

12   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.

Figure 52. Main Hobserve GUI page (field setup page).
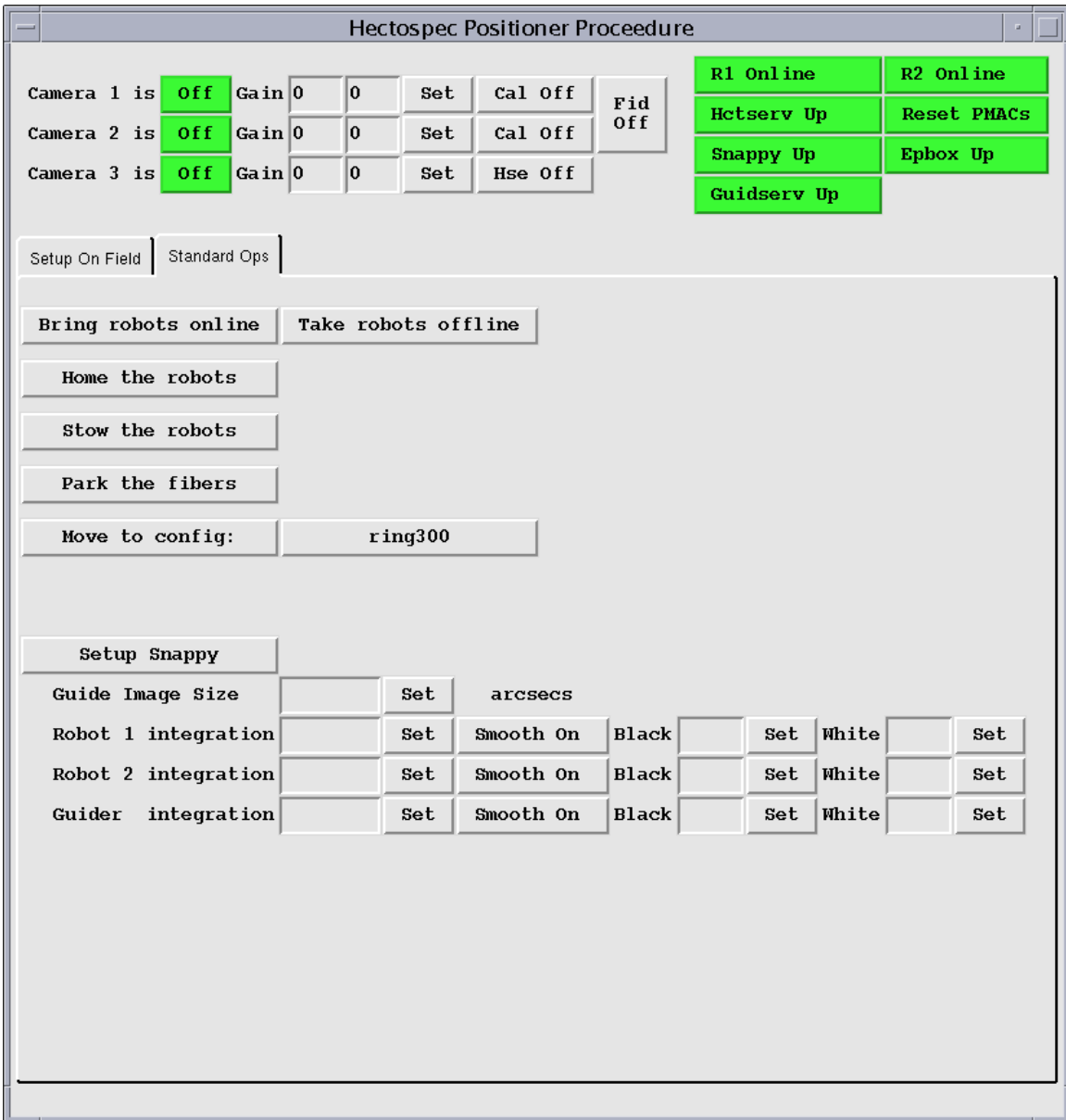
Figure 53. Hobserve standard operations Gui page.

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.**

12.1.1 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.

12.1.2 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.
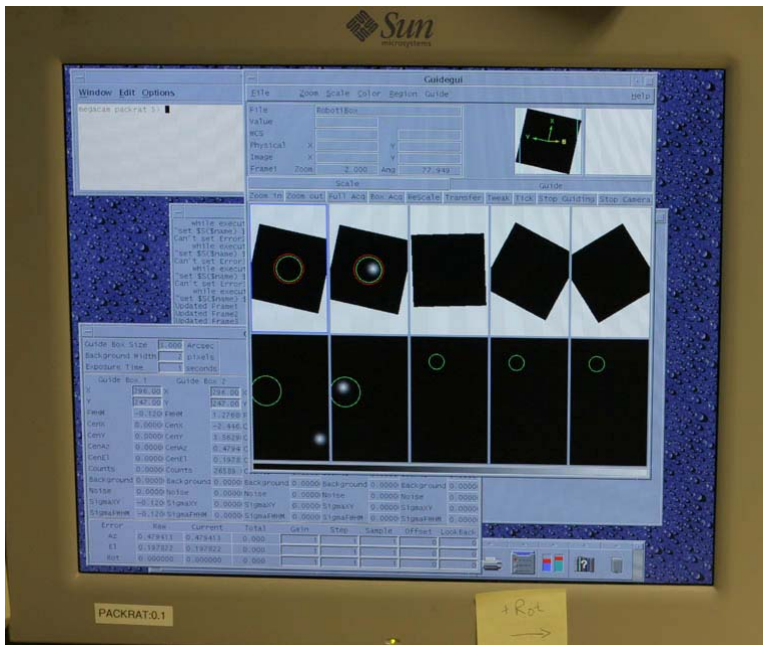
Figure 54. Guider Display

12.2 OPERATING THE BENCH SPECTROGRAPH

12.2.3 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.

12.2.4 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 55. 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 cfaguider window (logged on as mccd). You can also vncviewer into cfaguider: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 56. Dcalgui with power on to all boxes and with the continuum lamps on.

12.3 AT THE END OF THE NIGHT
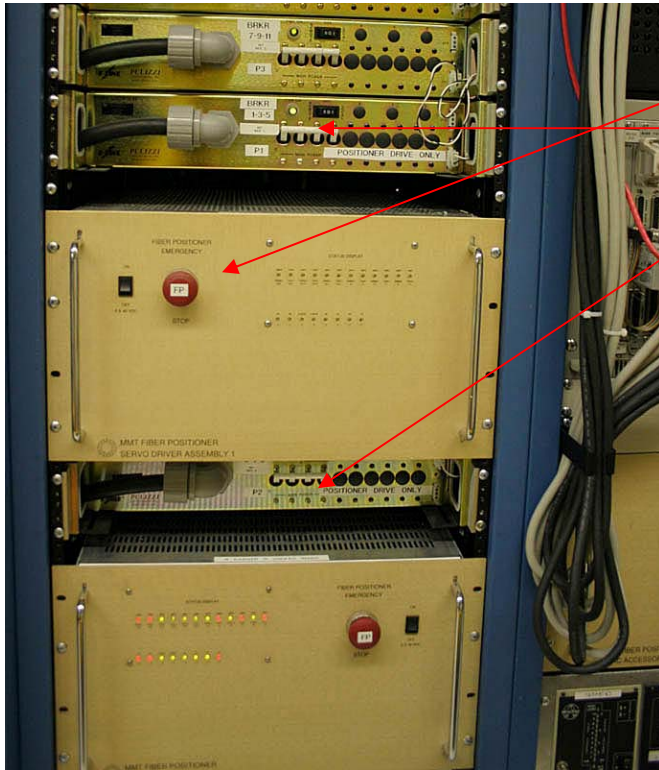
1. Press the E-stop

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.

12.4   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 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 59. 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 60. 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 61. 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.

13 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.

13.1 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.

13.1.1 LIMIT SWITCH ACTIVATED

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

13.1.2 GRIPPER EMPTY

13.1.3 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.

13.2 ROBOTS LEFT OFF-LINE

14 LOW LEVEL FIBER POSITIONER SOFTWARE

14.1 FIBER POSITIONER CONTROL SOFTWARE

14.1.1 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>

14.1.2 LOW LEVEL COMMANDS

14.1.2.1 POSITIONER CONFIGURATION STATE
stowedsafe

init
config
status
statusof <fiber>

atpark   <fiber>
atxy   <fiber> <x> <y>
caste   <robot> <x> <y>
casteon

14.1.2.2 OPERATING ON FIBER CONFIG FILES
seqfibs
fitfibs
adjfibs

cfgdump
chkfibs
prkfibs

14.1.2.3 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> <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>

14.1.2.4 MISCELLANEOUS

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

15 FLEXURE MEASUREMENTS

15.1 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.

15.2 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 30º and 60º, and the rotator angles were chosen to align the Y axis with the gravity vector (+15º rotator angle) and to align the X axis with the gravity vector (-75º 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 +15º (Y) results are intuitive, but the -75º (X) results are not.

Fitted Offsets from Calibration Grid Test

Test Sequence	Robot	Rotator	Elevation	X offset (mm)	Y offset (mm)
5826	1	+15º (Y)	60º	-0.004	0.024
5829	1	+15º (Y)	30º	0.000	0.039
5827	2	+15º (Y)	60º	-0.003	0.023
5830	2	+15º (Y)	30º	-0.005	0.042
5831	1	-75º (X)	60º	0.015	-0.013
5833	1	-75º (X)	30º	0.021	-0.008
5832	2	-75º (X)	60º	0.000	0.027
5834	2	-75º (X)	30º	0.006	0.032

16   APPENDIX

16.1 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:
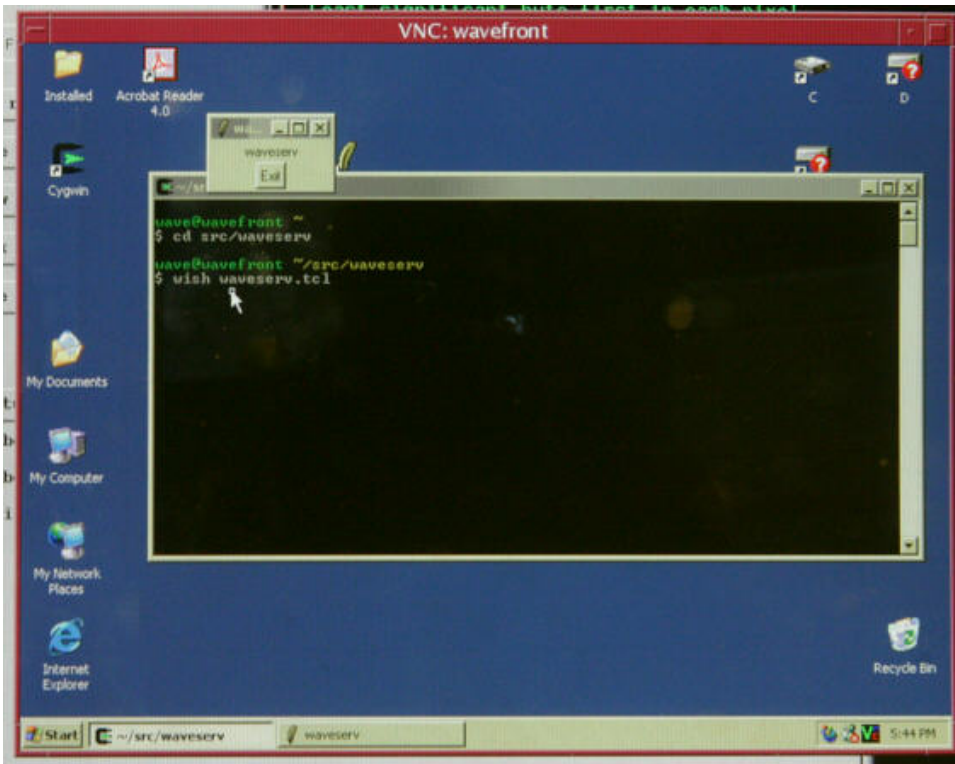
> cd src/waveserv
> wish wavecamr.tcl

Figure 62. VNC session to wavefront after waveserv is started.
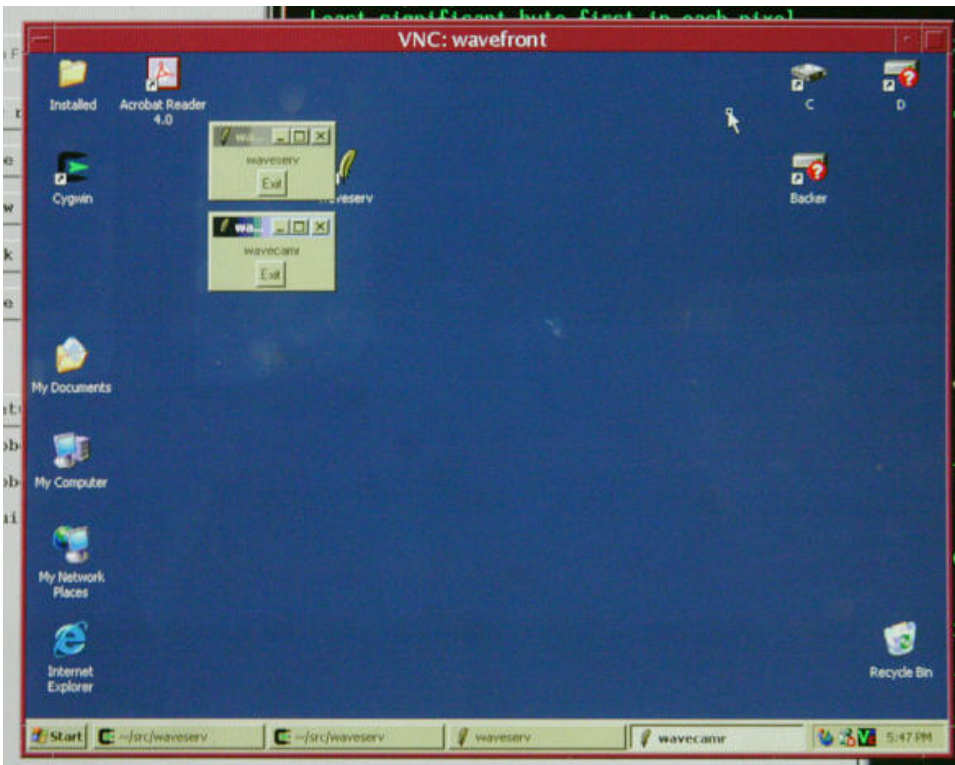

Figure 63. VNC session after both servers are started up and the cygwin windows are minimized.

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, fine 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.
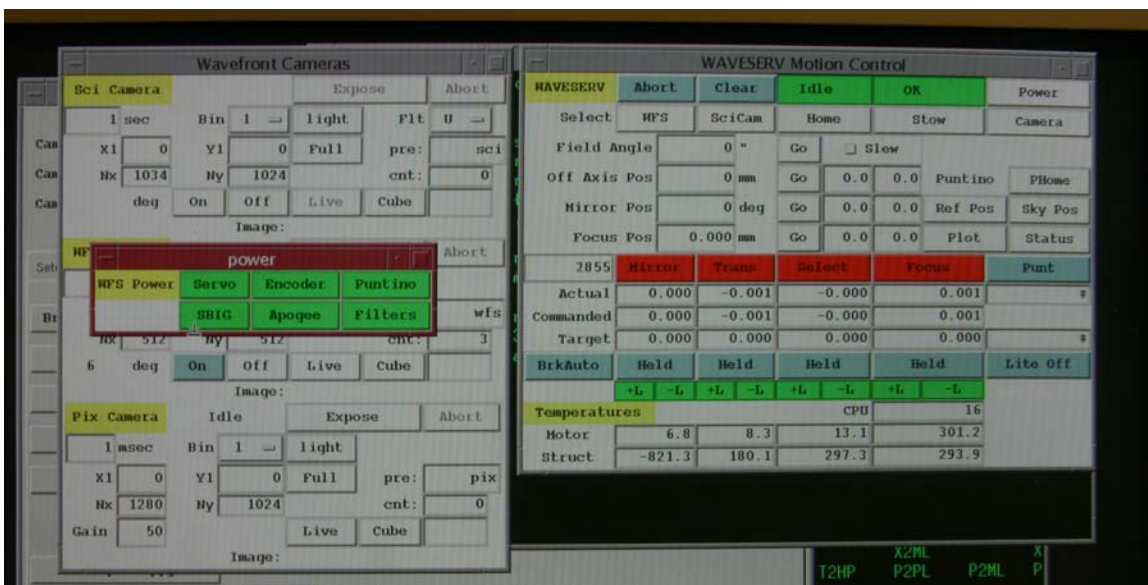

Figure 64. Wavefront windows on packrat after the encoder and servo power is turned on. The power window is brought up by pressing the Power button on the top right. The power window can be closed after these are turned on. The remaining four functions come up on by default.
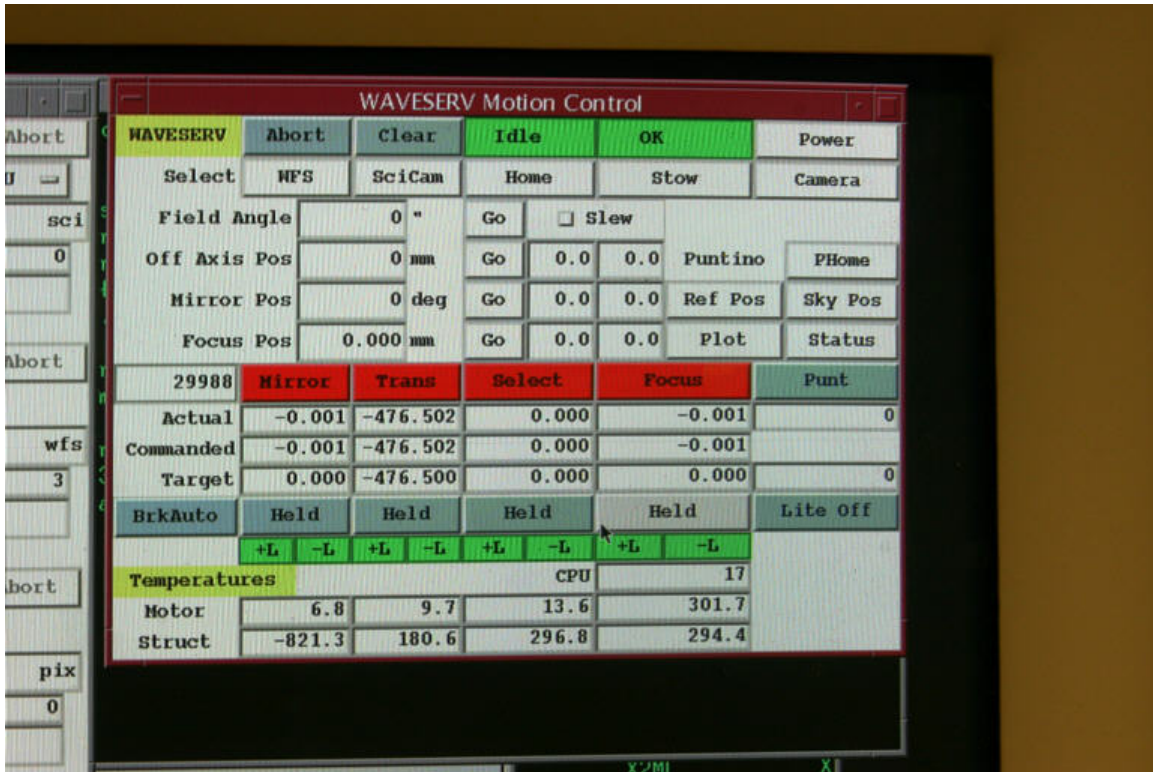
Figure 65. Waveserv display on packrat after the main stages are homed. If a "#" appear in the Punt (Puntino) column, press the PHome button. If the Wavefront Camera display is lost, press the Camera button to restore it.