Fan Mountain Observatory Bench Spectrograph User's Manual

Jeffrey D. Crane
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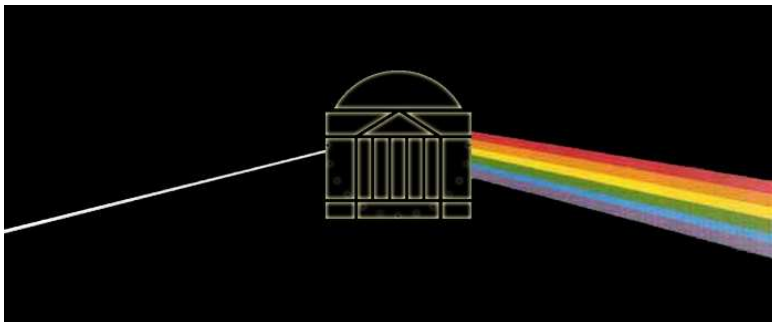

The Fan Mountain Observatory Bench Spectrograph (FMOBS) is a fiber–fed, bench–mounted, single–object spectrograph. The instrument is designed for observing point sources at low/medium resolution to $V \sim 14$, although extended objects can also be observed *if* knowledge of the precise spatial sampling is not important.

This manual is intended for the observer and gives the information required to operate the instrument night to night. Although the intention is to instruct a true beginner, reading the manual is absolutely no substitute for hands-on training. **NO PERSON** should attempt to use the instrument for the first time without having an experienced observer present for supervision. Ideally, anyone interested in using the instrument should accompany an experienced observer for one night prior to observing on their own. Additional detailed technical information can be found in the "FMOBS Technical Reference" or in Jeff Crane's dissertation.

Please e-mail Jeff with any suggestions concerning this manual or the instrument itself.

Contact	Phone	E-mail	Role
Jeff Crane	924-7935	jdc2k@virginia.edu	Instrument Designer
Steve Majewski	924-4893	srm4n@virginia.edu	Principal Investigator
David McDavid	924-4899	dam3ma@virginia.edu	40" & Instrument Support
Ricky Patterson	924-4914	rjp0i@virginia.edu	Co-Investigator

1. Instrument Overview

FMOBS is controlled from the 40" Control Room on the third floor of the observatory. Parts of the instrument itself are located on all four floors of the building. FMOBS can be broken up into three main components: the Focal Plane Module, the Fiber Train, and the Bench Spectrograph itself (See Figure 1).

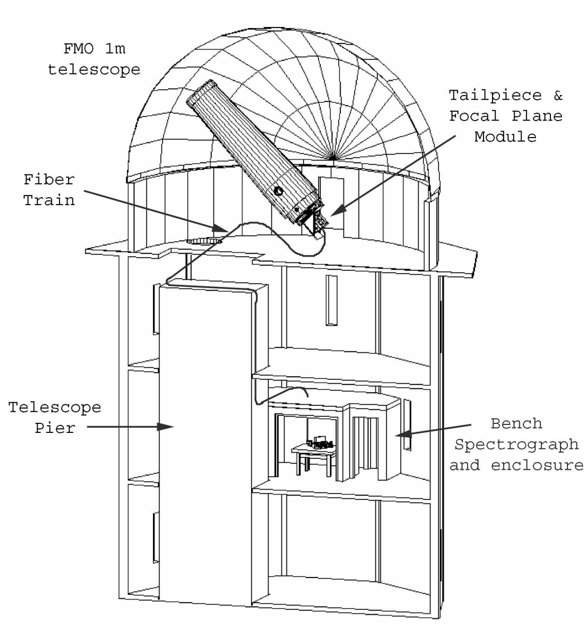

Figure 1. The complete FMOBS system is shown on the 1-meter telescope. The building and telescope pier are shown in cross-section. The fiber train runs from the Focal Plane Module through the telescope's polar axis (not shown) and down the side of the telescope pier to the Bench Spectrograph enclosure.

1.1. The Focal Plane Module

The Focal Plane Module (Figure 2) mounts to the base of the telescope tailpiece at the Cassegrain focus. Its functions include:

- Providing a mechanism for target/fiber alignment
- Providing calibration light for the spectrograph

A movable fold mirror carriage just above the telescope's focal plane enables three separate optical paths:

- Primary (coarse) Acquisition: The telescope image plane is demagnified 5× and viewed by an SBIG STV video camera, yielding a 6.0×4.4 arcmin field of view. The target

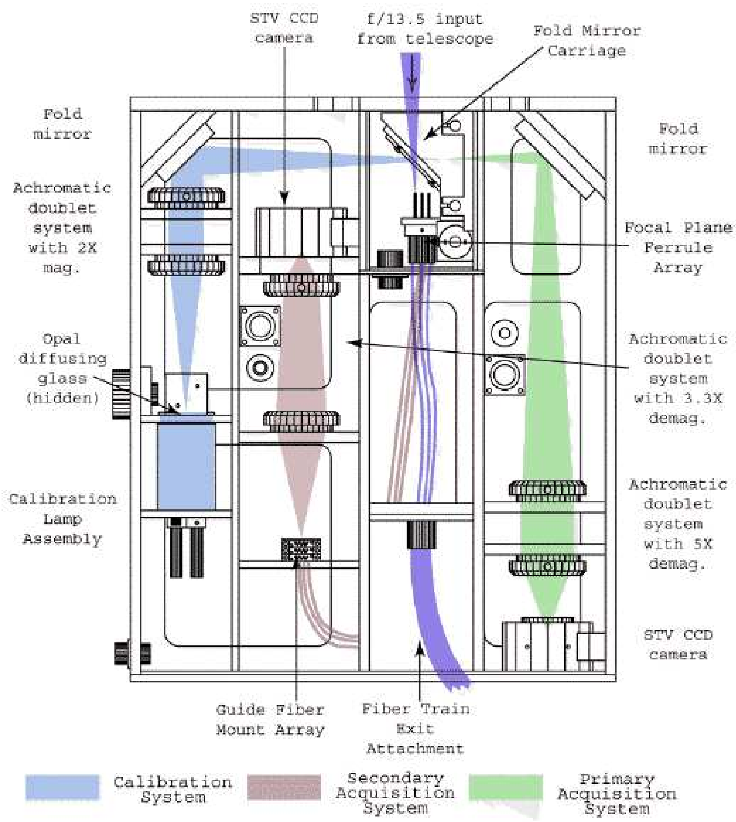

Figure 2. Diagram of the Focal Plane Module, viewed from the West side.

star can be viewed, identified, and roughly positioned on the fiber of choice. The approximate poisition of the preferred fiber (Fiber 1, positioned along the telescope's optical axis) is marked on the video monitor in the control room.

- Secondary (fine) Acquisition: Telescope light comes into focus in the plane of the fiber ferrules. The guide fibers (see section 1.2.) are monitored with a second SBIG STV camera while the alignment of the target star is fine-tuned. When alignment is achieved, the telescope autoguider may be engaged if necessary, and observing can begin.

- Calibration: Three arc lamps and a quartz-tungsten-halogen (QTH) lamp are available for calibrations. These lamps illuminate an opal diffusing glass, which in turn is imaged onto the plane of the Focal Plane Ferrules. Calibration light is then transmitted to the Bench Spectrograph.

1.2. The Fiber Train

The main length of the fiber train consists of 7 (redundant) "science fibers" that transmit light from the telescope to the Bench Spectrograph. In the telescope's focal plane, each science fiber is mounted in a ferrule (Figure 3) and surrounded closely by 6 short guide fibers, which can be used for fine-tuning the target alignment. Although there are several

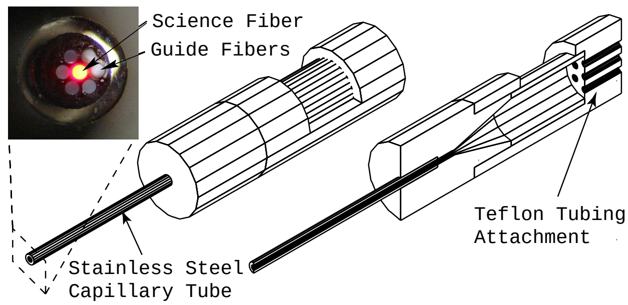

Figure 3. The focal plane fiber ferrule is shown in isometric projection in full and in cross-section. The teflon tube–encased fibers enter at the base where the teflon tubes are epoxied to the aluminum. The fibers themselves are then brought to a close–packed hexagonal array in the capillary tube extension.

fibers that run from the telescope's focal plane to the bench spectrograph, only one fiber may be used at a time to collect light from a target. The fibers are fixed and cannot be independently positioned. At present, only five of the seven science fibers are functional, and only two are optimized for observation of science targets; the remaining three are intended for collection of diffuse background (sky) emission for subtraction during data processing.

At the telescope level, power and communication cables are tethered to the fiber train as it drapes from the Focal Plane Module to the fork of the telescope (Figure 4). When the Focal Plane Module is attached to the telescope's tailpiece, the fiber train should always be attached to the left arm of the telescope fork using the eyebolts in the fork and snap hooks attached to the fiber train. When the Focal Plane Module is not in use, it should be parked on its lift system to the left of the fork and the fiber train should be detached from the four eyebolts.

It is **VERY** important to make sure that while slewing the telescope, the fiber train does not catch on any foreign objects, including the tailpiece or hardware attached to the telescope. Constructing the fiber train took several hundred hours of work, and great care should be taken to make sure it does not become damaged.

1.3. The Bench Spectrograph

The Bench Spectrograph (Figure 5) sits on a vibrationally isolated optical table in a stable, environmentally controlled enclosure.

The Fiber Train attaches to the Science Fiber Mount (Figure 6), where the science fibers are arranged in a linear, vertical array. By default, the fiber ends themselves define the "entrance slit". However, immediately in front of the ferrules is positioned a slot for an optional entrance slit mask. Following the slit position, there are two slots for optional interference filters and an opal glass used for making "milky flats". The instrument's shutter is attached to the front of the Science Fiber Mount.

The Collimator Mount holds a 100mm diameter, 350mm focal length achromatic doublet lens and an iris diaphragm. The focus of the collimator and iris diameter should not normally need to be adjusted by the observer during an observing run.

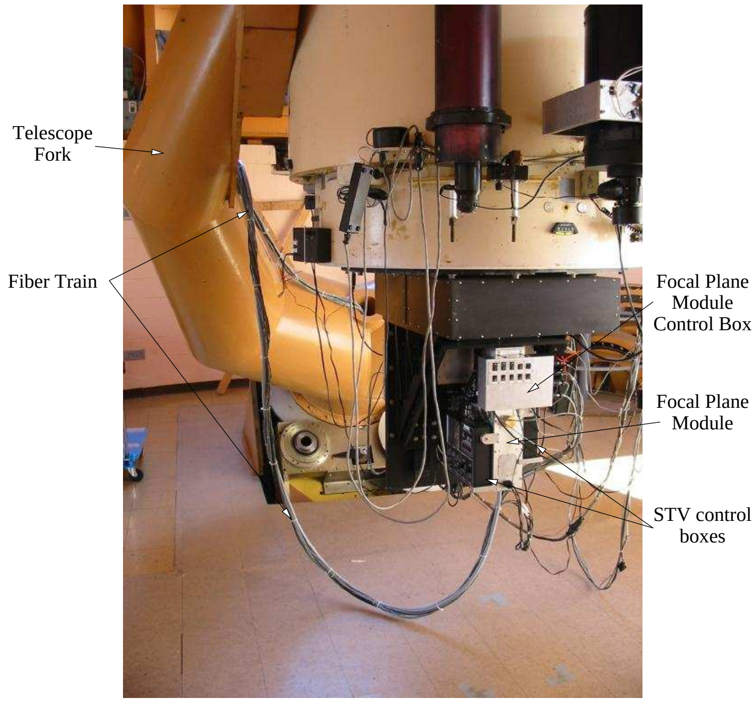

Figure 4. The Focal Plane Module is shown attached to the 40" tailpiece. The Fiber Train drapes freely to the left side of the telescope's fork, where it attaches to eye bolts using snap hooks. When the spectrograph is unmounted, the Fiber Train should be detached from the fork.

The Grating Mount contains a rotation stage that can hold one reflection grating from the inventory at a time. The primary setup [1] calls for a 100×100mm grating with 1200 lines/mm blazed for 6000Å.

The Dewar Mount rides on a linear rail that pivots directly under the diffraction grating's reflective surface. A 135mm f/2 SLR lens on the front of the Dewar Mount focuses diffracted light onto the CCD. The SLR lens front focus should always be set to ∞. The rear focus, once set by technical staff, should not be adjusted. The azimuthal rotation of the CCD with respect to the optical axis of the SLR lens may be adjusted using the micrometer on the top of the mount. This may be necessary to align the spectra along rows of the CCD. The azimuthal rotation of the CCD with respect to the optical table may be adjusted using a micrometer on the rear of the Dewar Mount. This may be necessary to account for tilt in the focal plane, but should not be adjusted after the start of a run.

The detector is a 2048×2048 SITe CCD with 24 μm square pixels operated by an SDSU CCD Laboratory (Bob Leach) Generation II controller.

[1] Throughout this manual, reference will be made to the "primary" setup, which is the instrument configuration designed for use by the Grid Giant Star Survey (GGSS): 4700Å$< \lambda <$6700Å coverage at $R \sim 1200$.

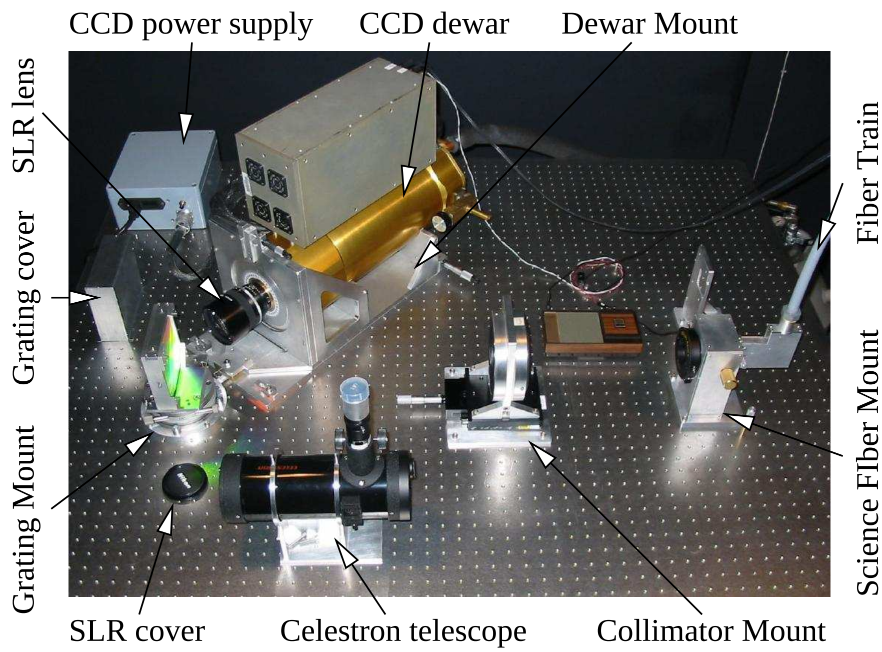

Figure 5. The Bench Spectrograph is shown from overhead. The fiber train attaches to the Science Fiber Mount assembly on the right. The CCD and camera rotate on a pivot arm (not visible in this view) to allow a range of collimator-grating-camera angles. The Celestron telescope is used by technical staff to focus the collimator.

2. Available Configurations

FMOBS was designed to collect low resolution spectra of candidate K giants for the Grid Giant Star Survey. Spectra collected for this project in the Southern hemisphere cover the region ∼4700 Å $< \lambda <$ 6700 Å with ∼1 Å/pixel dispersion. To match these spectra, one diffraction grating was chosen for work in first order with no interference filter necessary.

As the instrument's usability is demonstrated, additional diffraction gratings, interference filters, and optional slit masks may be added to the inventory to allow a variety of different configurations capable of covering the full optical wavelength range. As the inventory changes, this section will be expanded to more fully describe the various configurations available to observers.

Grating	Lines/mm	Blaze δ	Blaze λ	Ruled area
1200@211	1200	21.1°	6000 Å	100×100 mm
1200@267	1200	26.7°	7500 Å	154×128 mm

Table 1. FMOBS diffraction grating inventory. Grating 1200@267 should be available in November 2003.

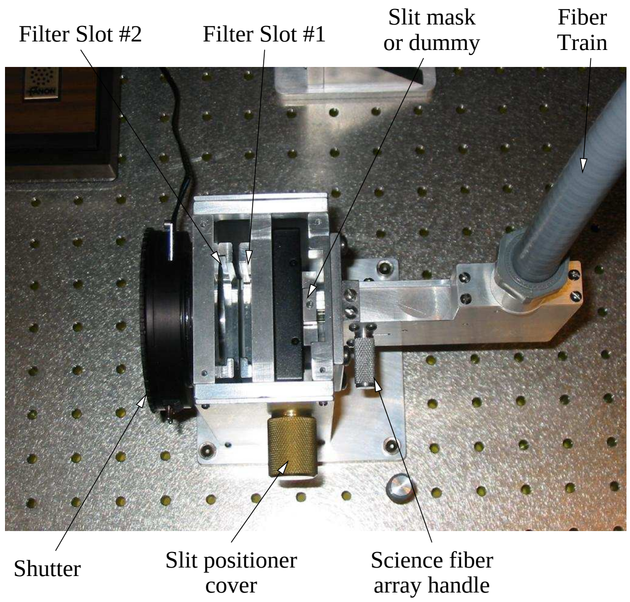

Figure 6. Science Fiber Mount shown from above with top cover removed.

Filter	Shape	Width	Thickness
GG-420	square	25.4 mm	3 mm
RG-610	round	25.4 mm	3 mm
Opal	square	25.4 mm	3 mm

Table 2. FMOBS filter inventory.

3. Setting Up

Please take care to keep the spectrograph room clean. Do not eat, drink, or smoke in the room. Every time you enter, clean the soles of your shoes by planting your feet firmly on the sticky mat in the entryway. If the mat does not feel sticky, step on a different area. When no sticky surfaces remain, peel off and dispose the top layer of the mat.

3.1. Filling the Dewar

In the spectrograph room, roll the 25ℓ dewar to the end of the optical table nearest the storage area. Insert the "stinger" into the CCD dewar's fill tube. Tighten the threaded connector with the spill vent pointing toward the wall and *away* from the spectrograph optics. Fill the CCD dewar until ℓN_2 begins to spill out of the connector's side vent. This will probably take about 10 minutes if the dewar is already cool. Allow the hose to thaw

Slit	Width	Throughput
None	200 μm	100%
1	100 μm	60.8%

Table 3. FMOBS slit mask inventory.

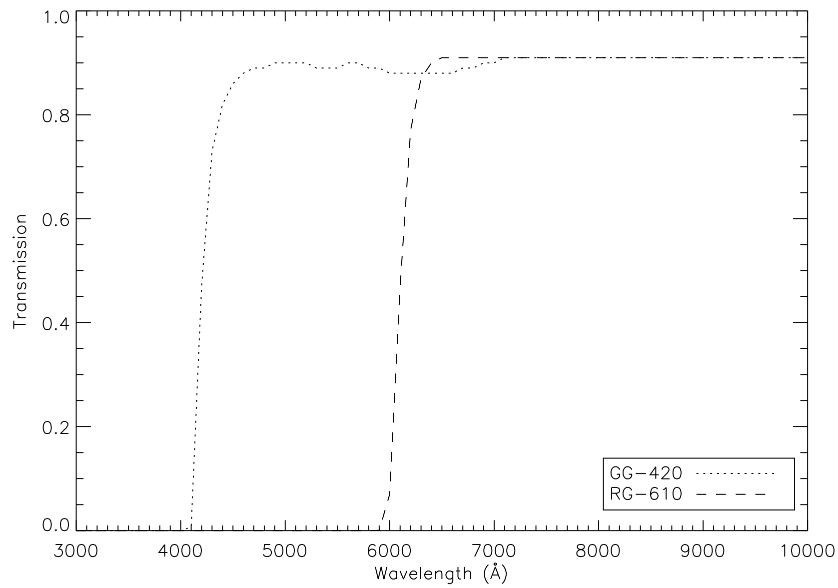

Figure 7. Total transmission through the interference filters.

until flexible *before* removing the stinger — otherwise you're likely to break the fill hose in two!

3.2. Enabling the Vibration Isolator

The Bench Spectrograph's optical table is mounted on a pneumatic vibration isolator. This provides some dampening of vibrations in the floor that would otherwise translate to vibrations in the optics on the table.

To enable the system, first make sure that the isolator's air tube is attached to the air compressor's air hose dangling from the ceiling of the spectrograph room. Insert the plastic air tube firmly into the brass and red plastic fitting on the end of the thick black air compressor hose. On the ground floor of the observatory next to the the telescope's support column, find the air compressor. Make sure that the water drain valve on the bottom of the air tank is closed. Open the regulator by turning it fully clockwise. Turn the `OFF/AUTO` lever to `AUTO` and let the tank's pressure build. The internal pressure should build to about 125 psi before the compressor will turn off. Now open the regulator to pressurize the hose leading to the spectrograph room to about 60 psi.

Return to the spectrograph room and make sure that the optical table has been elevated about 3/8". If the lift distance varies greatly from 3/8" the pressurizing or adjustment screws on the leveling arms of the isolator may need to be adjusted. Listen for air leaks in the supply line connection. If you hear one, you may need to tighten the connection.

3.3. Preparing the Spectrograph Room

Turn off the air conditioner and close and clamp the A/C door (Figure 8). Turn off the air cleaner and the dehumidifier. Turn on the power switch to the CCD (gray box next to the dewar on the optical table) if it is not already on. Grab a flashlight. Turn off the lights. Carefully remove the cover of the SLR lens on the front of the CCD dewar. Be careful not to rotate the SLR lens itself; the front focus of the SLR lens should always be set to ∞. Very carefully remove the grating cover and set it aside. Be *very, very careful* not to touch the diffraction grating. The grating cost several thousand dollars and cannot be cleaned! If you touch it, it will have your greasy fingerprints on it for the remainder of its lifetime. When you exit the room, turn off the light and pull both doors firmly closed behind you.

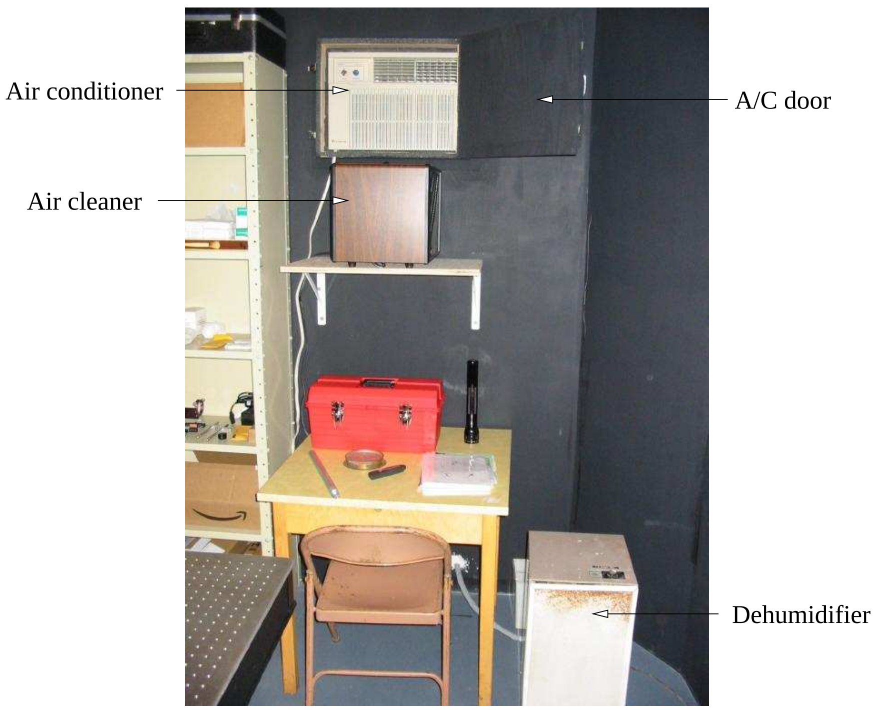

Figure 8. The back right corner of the spectrograph room. Environmental control devices should be turned off at dusk prior to observing, and the air conditioner frame door should be closed and latched. During the day when observing is not taking place, all environmental control devices should be turned on again.

3.4. Computer Start-up

Follow the standard start-up procedure for powering on the telescope and tailpiece. Turn on the Dell autoguider PC, making sure that the keyboard/monitor switch is turned to the correct position. Once the computer comes up, flip the monitor/keyboard switch and turn on the TCS computer. Start TCS. Turn on the CCTV monitors for the autoguider STV, dome camera, and FMOBS STVs. Turn on the FMOBS PC. Power on the Sun workstation named `crux`. Log in as user `FMOBS` with password `ggss&kz`. Start the Voodoo CCD control software, DS9, and IRAF in an xgterm. If it's not already on, turn on the FMO EMCS (Environment Monitoring and Control System) PC and start the EMCS software.

After the dome room has been prepared (Section 3.5.), establish a connection with the autoguider STV on the Autoguider PC, and with the two FMOBS STVs on the FMOBS PC. The FMOBS coarse acquisition STV communicates with the PC through the COM1 port while the Guide Fiber STV communicates through the COM2 port.

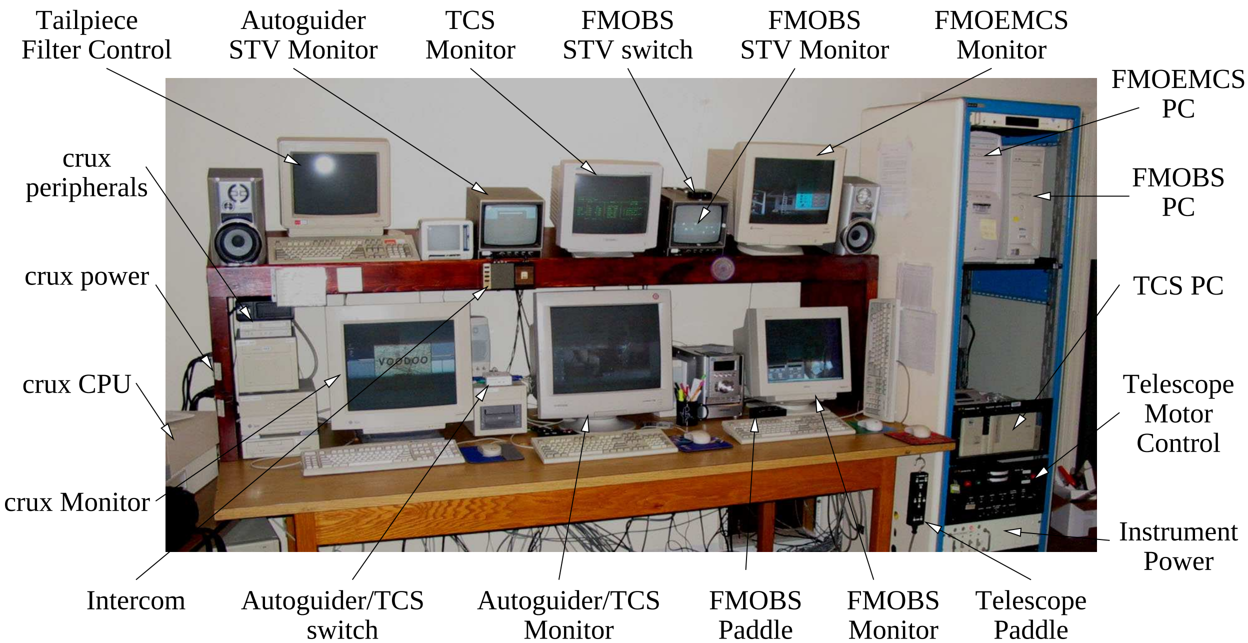

Figure 9. The 40” control center. All but the filter wheel control PC are used during operation of the spectrograph.

3.5. Preparing the Dome Room

Around sunset, prop the doors to the catwalk open. Open the dome slit and detach the power cord from the dome. Turn on the telescope tube fans if they are not already on. Check the fiber train to make sure that it is hanging properly. It should be attached to the left arm of the fork in several places, almost all the way to the telescope’s declination axis. Slew the telescope to the north and remove the cover. Remove the cover of the 8” autoguider telescope and send the telescope to zenith again. Turn on the power to the telescope autoguider STV control box on. Turn on the power to the spectrograph’s two STV cameras and the electronics control box. Note that the power switches at the bottom of the electronics rack in the control room must be turned on before power can be supplied to the Focal Plane Module and STV cameras. Make sure the spectrograph’s electronics control is set to “remote”. Open the in-tailpiece shutter using the switch on the black box attached to the left side of the primary mirror cell. Turn off the air conditioner power on the left wall of the dome room. Set the humidistat-controlled heat lamps to the off position. Turn off the lights and shut the door to the dome room on your way out.

3.6. Please please please...

Don’t touch the surface of diffraction grating, SLR lens glass, or collimator glass.

Don't crush, yank, or tightly bend the PVC pipe containing the fiber optics. The fleas of a thousand rabid camels will be set upon your carcass if you break the fiber optics.

4. Observing

4.1. What Data Should You Collect?

For any scientific target, it's a good idea to split up your observations into three separate exposures to be combined later. This simplifies cosmic ray removal.

To adequately calibrate your spectra, you will want to take the following additional data:

- Bias frames. Take at least one set of bias frames (zero second exposures) each night. A good rule of thumb is to take 10 frames and then median combine them later.
- Milky flats. During the evening before observing, insert the opal glass in Slot 2 in the Science Fiber Mount on the optical bench. Be sure to replace the cover on the mount. Move the fold mirror array in the Focal Plane Module to the "Calib" position and turn on the quartz (QTH) lamp. Take a few exposures of a few thousand counts each. In the primary setup, exposure lengths of about 5 minutes should suffice. These can be median combined later to produce a flat field image. You can also use the daytime sky or dome flat system to produce milky flats. These may result in more accurate determinations of the relative throughputs through the various fibers during data reduction. Remember to remove the opal glass when you are finished!
- Quartz lamp exposures. The quartz lamp spectra are bright continua that can be used to estimate fiber-to-fiber relative throughput differences and to determine reference traces for extracting faint object and arc lamp spectra. With the Focal Plane Module's fold mirror carriage in the "Calib" position, turn on the quartz (QTH) lamp. 1 second exposures should suffice. Ideally, the spectrograph should be stable enough that only a single QTH lamp exposure per night is required. However, until the instrument stability has been verified, it's a good idea to take several throughout the night.
- Camparison (arc lamp) exposures. Three independent comparison sources are available: Neon (Ne), Argon (Ar), and Xenon (Xe). Depending on your instrument setup, some lamp(s) may be more useful than others. In the primary setup, it appears that a 60-second exposure suffices, with the Ne lamp turned on for a fraction of a second (it is much brighter than the others). To accomplish this, turn on all three lamps, set the CCD exposure time at 60 seconds, and start the exposure. When you hear the shutter open through the intercom, immediately turn off the Ne lamp. Again, given good instrument stability, only one comparison lamp exposure per night should be necessary, but it is advised that multiple exposures be taken throughout the night until confidence in the stability has been established.
- Radial velocity standards. If you're doing radial velocity work, you will want to observe some number of radial velocity standards for comparison later. A good list is provided in the Astronomical Almanac.

- Flux standards. If you are doing work where the absolute flux of the star, or the relative flux between lines are required, you will want to observe flux standards so that the instrumental, wavelength-dependent efficiency profile can be removed. Multiple literature references are available for selecting flux standards, one of which is:
  Massey, Strobel, Barnes, and Anderson, 1988, ApJ, 328, 315.

4.2. Spectrograph Control System

During normal observing, the user will need to control the Focal Plane Module fold mirror carriage, wavelength calibration lamps, quartz lamp, coarse and fine acquisition cameras, autoguider camera and telescope, 40" telescope, and SITe CCD.

The fold mirror carriage and calibration lamps may be controlled either by using the electronics control panel attached to the Focal Plane Module or by using the remote paddle in the control room (Figure 9). A `Local/Remote` switch on the control panel determines which location has control. In both places may be found ON/OFF switches for each of the four calibration lamps (QTH, Ne, Ar, Xe) and three push buttons that send the mirror carriage to its three available positions.

The three carriage positions are labeled `Calib`, `Observe`, and `Acquire`. In the `Calib` position, a fold mirror enables the calibration lamp system. In the `Observe` position, the focal plane ferrules are exposed to light from the telescope. If a target is aligned on the end of a ferrule, light will find its way to the Guide Fiber STV camera and Bench Spectrograph. In the `Acquire` position, a fold mirror enables the primary acquisition (coarse) system and the Acquisition STV will show a 6'×4.4' telescope field of view. When the carriage is at any one position, the red LED above that button will glow. If the FP Module is powered on but none of these LEDs is lit, the carriage may be stuck between its three normal stops. In this case, a manual switch on the control panel can be used to drive the carriage until one of the LEDs lights up. If the carriage is run past the extreme positions toward its hard limits, limit switches will disable the motor. In this case, a limit override switch on the control panel must be depressed and the carriage driven manually back away from the limit. Be very careful not to drive the carriage to its hard limits! If you do, you may destroy the motor or drive nut.

The FMOBS STVs may be controlled by either the control boxes attached to the Focal Plane Module or by the STV Remote software on the FMOBS PC. Similarly, the autoguider STV may be operated by the control box attached to the telescope tailpiece or by the STV Remote software installed on the Autoguider PC. Other autoguider controls include a fine focus adjustment and East/West slew controlled by hand paddles in the control room. See the autoguider documentation for instructions about running that system.

The 40" telescope is controlled by the DFM Telescope Control System (TCS) and by hand paddles in the dome and control rooms. The SITe GenII CCD is controlled by the Sun workstation `crux`. See the manuals pertaining to those systems for more information.

4.3. Software Initialization

In an `xgterm` on the `crux` workstation, change to the `HOME$iraf/` directory and start IRAF with the `cl` command. Within IRAF, change to the `/data/fmobs/` directory and create a new directory named for today's date. Start the `ds9` software for image display. Note that because `crux` is set up for 24-bit color, `ximtool` and `SAOimage` will not work.

Refer to "The Gen II CCD Camera System" manual for detailed instructions about running the CCD control software, `Voodoo`. For spectrograph work, Amplifier A is preferred with Gain 1.0 and Slow Integration speed. For faint targets, other gain settings may be useful. Set the CCD for subarray readout with dimensions 2048×200 centered at [1024, 1000]. Leave the Bias position and width set to the default. In the `FITS` setup menu, load the file `/crux/fmobs/ccdsetup/fmobs-fits.par` and check the `TCS Link` box. These steps will ensure that your image headers have the keywords required for spectral reductions. Make sure the `Open Shutter`, `Beep`, `Display Image`, and `Save to Disk` boxes are checked in the main `Voodoo` window. Set the output directory to `/data/fmobs/date_today/` and initialize the file name to something like `ccd1001.fits`. Note that `IRAF` wants the image filename extensions to be "`fits`" and not "`fit`".

The STV cameras used in the spectrograph and with the autoguider may all be controlled using the `STV Remote` software. Run the software on the autoguider PC and connect to the guider STV through port COM1. On the FMOBS PC, run two instances of the software. Connect to the Acquisition STV through COM1 and the Guide Fiber STV through COM2. Refer to the 40" manual for further instructions about running the autoguider. For the spectrograph STVs, it is not important to set the correct Date/Time, telescope focal length, etc. However, if you wish to use the Acquisition STV to evaluate seeing conditions, you will want to set the telescope parameters for that system. If you choose to do so, remember that the effective focal length of the Acquisition system is 5× less than the telescope's effective focal length. The correct parameters are:

- Units = Inches
- Focal Length = 108"
- Aperture Diameter = 40"
- Telescope = Reflector

You may begin imaging with the STV cameras immediately after establishing successful links. Click `Image` and then click `Parameter` repeatedly to see the adjustable parameters. Set each parameter by clicking the `Value` button. Choose the "Normal" zoom mode and the ×2 gain setting. Finally, click `Image` again to start the continuous video stream to the monitor.

4.4. Calibration Lamp Exposures

You will want to take a set of calibration images during or before each night of observing. These should ideally be done after the spectrograph room has been prepared for observing and the air has settled (i.e. when the spectrograph room is in a state most similar to nighttime observing).

A set of milky flats should probably be taken shortly after the room is prepared in the evening. An opal glass filer must be placed in Filter Slot 2 (Figure 6) and the top of the Science Fiber Mount replaced. Move the mirror carriage to the `Calib` position and turn on the QTH lamp. Take a series of exposures with a few thousand counts each. Remove the opal glass filter and replace the top on the Sciene Fiber Mount. Allow some time for the room to settle before taking additional calibration or targeted spectra.

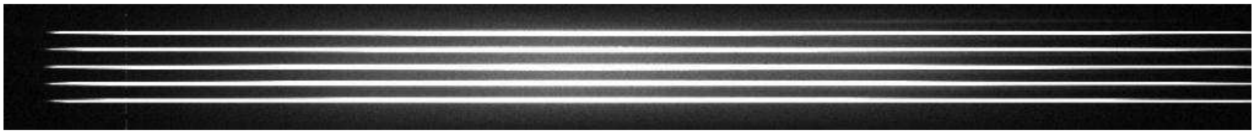

Figure 10. Full view of a 1 second QTH lamp exposure in a 2048×200 pixel subarray centered at [1024, 1000].

Ideally, the instrument should be so stable that a single QTH lamp spectrum and a single wavelength calibration lamp exposure taken at the beginning of the night would suffice to calibrate the entire night's data. However, until instrument stability can be established, it is advised the QTH and arc lamp exposures be taken several times during the night. To do so, make sure the mirror carriage is in the `Calib` position. To take a QTH exposure, turn on the QTH lamp and set the exposure time to something like 1 second. The wavelength calibration spectra are slightly trickier. In the primary instrument setup, the Neon lamp is considerably brighter than both the Argon and Xenon lamps. Set the exposure time to 60 seconds or more. Turn on all three arc lamps. Make sure the intercom to the spectrograph room is on and the volume is turned up. Start the exposure and listen for the shutter to open. As soon as the shutter opens, turn off the Neon lamp. Leave the other two on for the duration of the exposure.

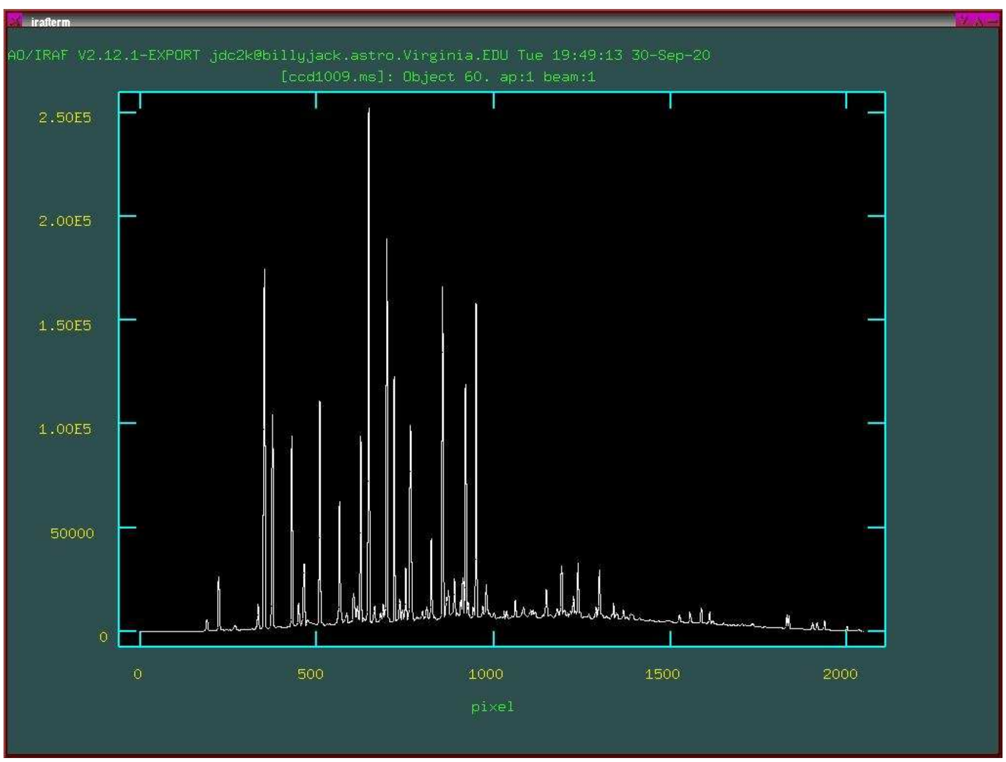

Figure 11. Extracted raw Neon/Argon/Xenon spectrum taken with the primary setup.

4.5. Telescope Coordinate Initialization

Following the normal start-up procedure for the 40" telescope, align the telescope on a known, bright star using the finder scope. Move the fold mirror carriage to the `Acquire` position and begin imaging with the Acquisition STV. Select input `1` for the FMOBS STV monitor. The bright star should be in view. Move the telescope using the hand paddle until the star is centered in the STV field of view. Now enter the star's coordinates in the TCS's telescope position initialization function.

Important: For the first few times the telescope is slewed to a new position, every time a large ($> 30°$) slew is performed, and especially when large slews toward or away from the Northwest are performed, walk up to the dome and make sure the fiber train does not get caught on the telescope, tailpiece, or any other foreign object.

4.6. Focal Plane Module Focus

The Focal Plane Module must be focused. This can be accomplished by moving the telescope's tailpiece focus until the bright star used for coordinate initialization is in focus. The distance from the fold mirror in the carriage to the focal plane ferrules is the same as the distance from the mirror to the object plane of the coarse acquisition system. Therefore, focusing the image on the STV camera has the effect of bringing the ferrules into the telescope's focal plane. Note that there are aberrations in the image produced by the very simple optical system used for coarse acquisition. Stars will appear point-like in some areas of the image, but may have a ringlike appearance with a bright, off-center core in other areas. When focusing the instrument, attention should be paid only to the bright core of the star. On 23 Sep 2003, with an exterior temperature of $\sim 70°$F, the spectrograph focus was at ~ 3050.

The star can be focused by eye, but perhaps a more accurate method is to use the "Optical Quality" mode built in to the STV controller. Move the telescope to position the star on the screen in an area where the optical aberrations appear minimal, but not too close to the edge. Press the `Monitor` button. Press the `Parameter` button until you see "OPTICAL QLTY". Push the `Value` button. The STV should detect the star and begin monitoring its profile. Adjust the telescope's focus while noting the change in the FWHM reported by the STV. Set the focus so that the FWHM is minimized. Note that the actual number reported is meaningless unless you enter the telescope parameters in the STV's `Setup` menu (not required, but may be interesting).

4.7. Coarse Acquisition

Once the telescope position has been initialized, coarse target acquisition may commence. Slew the telescope to the target's coordinates. Make sure the STV monitor switch is set to input `1`. The target should be in view. If it is relatively faint, you may need to bump up the STV exposure times to see it.

Two science fibers are available for targeted acquisition. These are fibers 1 and 4 in Figure 12. For each of these ferrules, the science fiber is intact and the guide fibers are properly aligned around them. Fibers 2, 3, and 5 have functional science fibers, but the guide fiber arrangements are flawed, so the prescribed fine alignment procedure will not work. However, these can be used to collect sky spectra for background removal during

Figure 12. Top view of the Focal Plane Ferrule array.

processing. Fibers 6 and 7 are completely nonfunctional. The positions of Fibers 1 and 4 have been marked on the TV monitor with a grease pencil, with Fiber 1 being nearest the center. Using the hand paddle, move the telescope to position the target over the desired focal plane ferrule position. Fiber 1 appears to have the best throughput, so it is preferred.

4.8. Fine Acquisition

When the star has been approximately aligned with the focal plane ferrule, move the fold mirror carriage to the `Observe` position. Switch the STV monitor to input `2`. You should see light coming through some/all of the guide fibers corresponding to the science fiber chosen (See Figure 13). If the target is faint, the integration time on this STV may need to be increased in order to see the signal.

Using the hand paddle, move the telescope slowly until the light coming through all of the guide fibers equalizes. This indicates that the source is centered, and therefore over the science fiber. This procedure will only work for point sources; extended objects can only be coarsely aligned. When the target's fine alignment has been established, engage the autoguider and begin the exposure.

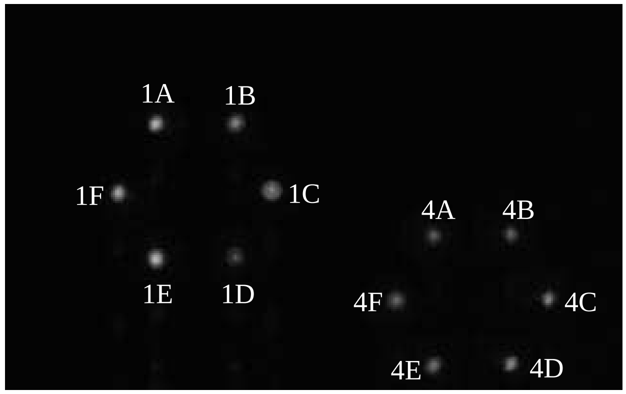

Figure 13. View through the Guide Fiber STV. For this picture, the Xenon lamp turned was turned on and the fold mirror carriage was in the “Calib” position. The hexagonal array in the upper left corresponds to the guide fibers around Science Fiber 1 (See Figure 12) while the array in the lower right correspond to Science Fiber 4.

5. Shutting Down

5.1. Disabling the Vibration Isolator

On the ground floor of the observatory, turn the air compressor’s `OFF/AUTO` switch to the `OFF` position. Turn the regulator counterclockwise to set the outlet pressure to zero. Detach the isolator’s air tube from the compressor’s air hose in the spectrograph room. To do this, press the the end of the red, plastic connector in while you detach the hoses from one another. Open the regulator on the compressor to depressurize the air tank. Close the regulator when the pressure reaches about 20 psi. Open the drain valve under the air tank to drain accumulated water. When the water has drained, close the drain valve.

5.2. Spectrograph Room

Carefully replace the cover on the grating and then the cap on the SLR lens. Fill the dewar using the same procedure outlined in section 3.1.. Open the A/C door and turn the A/C to Medium Cool. Turn on the air cleaner. Turn on the dehumidifier to the halfway point. When the dewar is full, turn off the lights and pull both doors firmly closed behind you.

5.3. Dome Room

Replace the telescope cover and send the telescope to zenith (turn off telescope tracking on the electronics rack in the control room first). Turn on the A/C power switch. Set the heat lamp control to “humidistat” and set the humidistat to $\sim$70%. Power off the spectrograph electronics control box, two STVs, and the autoguider STV. Close the in-tailpiece shutter. Close the exterior doors and dome slit. Turn off the lights and close the door when you leave.

5.4. Control Room

Back up your data. If you are at the end of a run, delete your files from the hard drive. After backing up your data, log off of `crux`. Shut down the autoguider and FMOBS PCs. Power off the TCS PC. Turn off the TV monitors. Send the Focal Plane Module fold mirror carriage to the `Calib` position. Power down the telescope and tailpiece in the standard way. Leave the FMOEMCS PC and software running. Turn the lights off and close the door when you leave.

A Neon/Argon/Xenon Spectral Line Identification Charts

Coming soon...