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THE CCD SPECTROGRAPH AND CAMERA AT THE NICKEL TELESCOPE

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1 IMPORTANT NUMBERS

These numbers are collected here for the convenience of users at the telescope. If you are reading this manual for the first time, please skip straight to the text.

Scale at Cassegrain Focus: 12.25 arcsec/mm

Sensitivity:

63 cts/sec/A at λ5480 (= V equiv)for mag 10 A0 at zenith with spectrograph, 420ℓgrism and TI 500x500 CCD. Bright limit on a clear night at the zenith with the 420 line grism and a two-pixel slit, average seeing; $\approx$mag 5 in one second.

Note: With the TI 500x500 CCD, don't exceed 22k counts in order to avoid $\sim$ 1% nonlinearities above that level (for some purposes you may not care).

Summary of instrumental configurations:

Code	description	pixel size arcsec*	field diameter arcmin
A	Spectrograph/grisms	2.4	–
B	Spectrograph/Direct		
	58mm Nikkor	2.6	21
	110mm Hasselblad	1.4	11
C	Filter ass'y + adapter	0.18	1.5
D	Filter ass'y + focal reducer	0.55	4.5
H	Comet Camera	50	430

Instrument**	position angle	dewar	tv orientation***	CCD orientation
A	0	N	N left, E down	slit N-S, N left
B	0	N	N left, E down	N left, E down
C	90	E	N top, E left	N up, E left
D1	90	W	N top, E left	N down, E right
D5	0	N	N left, E down	N top, E left

*Assumes 15μ pixels, except for the Comet Camera which reflects 27μ pixels of CCD #2. Reticon 400x1200 in dewar 9 will have 27μ pixels when available.
**Numerical suffix refers to CCDs from the list in the Appendix
***Assumes TV reverse switch is up

Grism specs:

Numbers in parenthesis are for 110mm lens.

Grism	Grooves per mm	Angstroms per pixel	Blaze	Angstroms Coverage	central wavelength x-stage(steps)*
1	300	8.0(4.2)	5500	4000(2100)	$-.390\lambda+3338$
2	600	2.6(1.4)	6500	1175(620)	$-1.033\lambda+7940$
3(not used)					
4	600	3.6(1.9)	4820	1800(950)	$-.848\lambda+5351$
5	300	7.7(4.0)	7800	3850(2000)	$-.147\lambda+2483$
6	420	5.5(2.8)	5600	2750(1450)	$-.547\lambda+4248$
7(echism)	150	2(1.1)		Order dependent	

*Enter desired central wavelength in angstroms, solve for x-stage setting. There are two conventions for talking about the grisms. One is to refer to, for example, "grism 2". The other is to refer to grism 2 as "the 600- line red". I have a strong preference for the latter, which though wordier is more descriptive.

Aperture wheel:

Slits are 3.6 arcmins in length, which projects to 97 pixels with the 58mm Nikkor lens and 185 pixels with the 110mm Hasselblad lens. In the list below, values in parentheses are for the 110mm lens.

Aperture	Pixel width	arcsec width	returns code
0	(empty)	(empty)	1250
1	1.3(2.5)	2.9	1550
2	1.6(3.0)	3.5	1850
3	2.1(4.0)	4.6	2150
4	2.5(4.7)	5.5	2450
5	3.0(5.7)	6.6	2750
6	4.0(7.6)	8.8	3050
7(pinhole)	0.7(1.2)	1.5	3350

Filter wheel:

Enter	for filter position	returns code
0	no filter	1413
1	1	1893
2	2	2373
3	3	2853
4	4	3333

X-Y Stage:

Increasing x decreases central wavelength at the rate of three stepping motor steps per pixel for 15μ pixels (one step $= 5\mu$).

Increasing y moves spectrum to lower column numbers at a rate of 1.66 pixels per unit on the micrometer, for 15μ pixels.

Grism tray:

Enter	for slot	returns code
0	open	7050
1	1	4900
2	2	2450
3	3	40

Ranges of stepping motors for spectrograph control:

Grating	0-7099*
Aperture	0-2499
X-Stage	0-2299*
Filters	0-1299
Focus	0-6899**

*Use -1 (for no change) if doing direct imaging

**Use -1 (for no change) if doing direct imaging, except configuration B.

Sensitivity of Acquisition and Guide TV Camera:

Faintest star seen with ~ 1/2 moon, average seeing, and:

minimum gain, no integration, ~ 11th mag
maximum gain, no integration, ~ 15th mag
maximum gain, full integration, ~ 20th mag

2 INTRODUCTION AND OVERVIEW

Here's what you should read before coming to the telescope for the first time, in the order in which we feel it makes most sense to read them:

- LOTR 36: *The Nickel Telescope User's Manual*
- This manual
- Vista Manual - At least look at it
- LOTR 50: *The VISTA Cookbook* - At least a look

This manual supplements the general information about the telescope presented in the *Nickel Telescope User's Manual*, LOTR 36. Since the telescope itself is complex, it is advisable to read both manuals before coming to the telescope. Some of the information below assumes familiarity with the contents of the telescope manual.

We don't try to tell you all ways to do everything in this manual, but we do try to tell you at least one simple way to do each major task. As you gain experience with the system you will no doubt discover alternative procedures and refinements of your own. We invite you to share useful additions to the lore through the "User's Log" at the telescope.

The Stover CCD Spectrograph/Camera at the Nickel Telescope is a modular instrument which may be configured in a variety of ways. The basic choice is to use it as a spectrograph or as a camera. In either mode, the throughput is quite high, but absorption in the CCD camera lens cuts off the UV response below ~3850 angstroms and the IR above ~8800 angstroms.

The spectrograph is a straight-through design (see Figure 1.) After passing through the slit aperture and the filter wheel, the light passes through the shutter and then through a collimating lens about midway down the body of the spectrograph. Travelling a roughly equal distance again, the collimated beam is dispersed by one of three remotely selected grisms, and then focused onto the CCD by the camera lens. Between the camera and the CCD is a manually operated dark slide, which is routinely rediscovered by many observers on the first night of each run. The CCD and its dewar are mounted on an x-y stage which allows choice of central wavelength and position of the spectrum on the CCD.

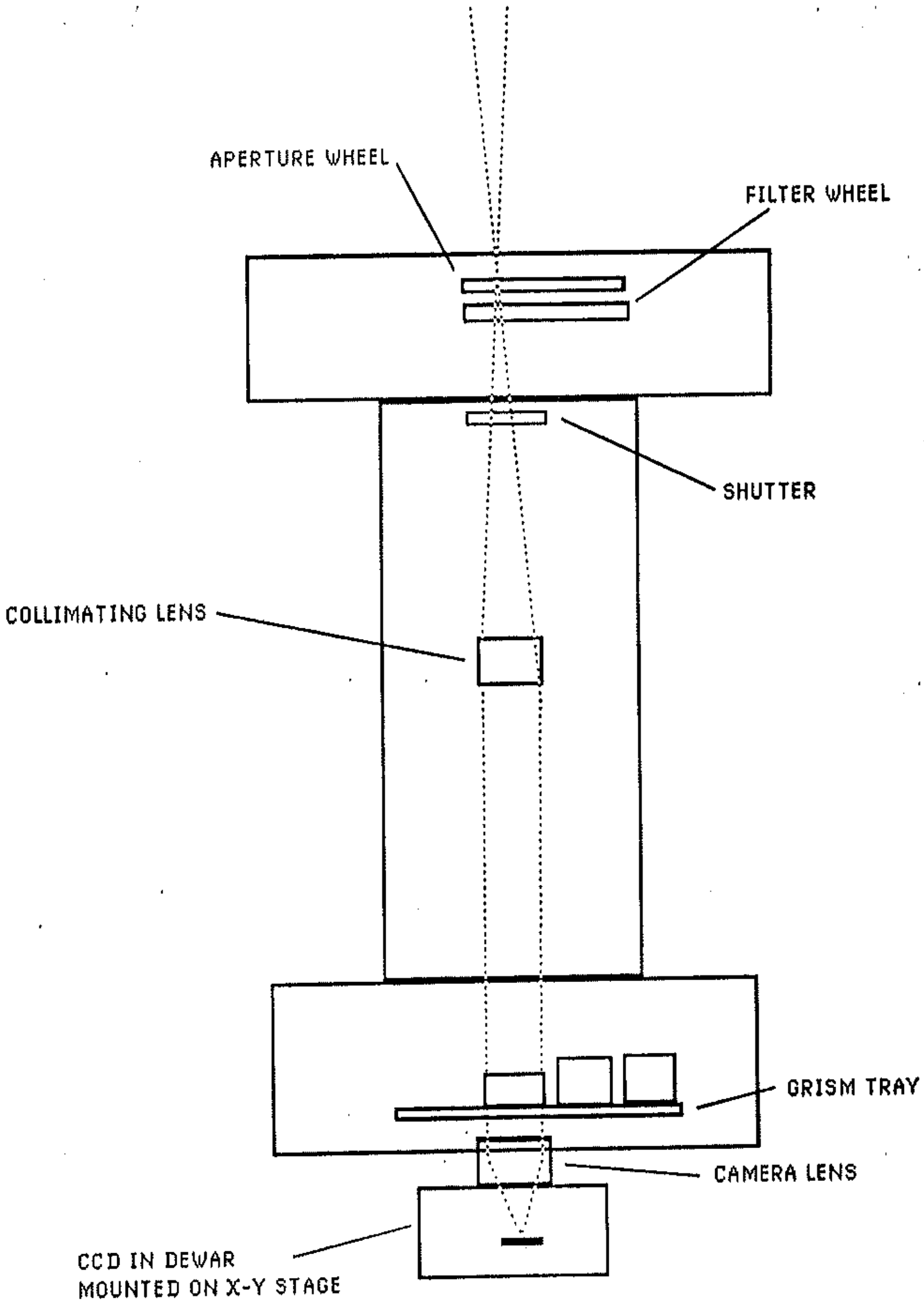

Figure 1: The Stover Spectrograph

A variety of direct camera configurations are available which are described in detail later, but their configurations are all conceptually variants of the spectrograph without the dispersers.

It is most unfortunate that one may not conveniently switch between spectroscopy and imaging. This is because the TV camera may not be offset, and spectroscopic guiding is done directly on the aluminized aperture plates, so if they are removed to allow a two dimensional image to fall on the CCD then guiding is no longer possible. If it is enough for you to have just an unguided snapshot of a field, that may be done.

The spectrograph/camera is controlled remotely from the readout room. At present, the only functions that cannot be controlled remotely are the manual darkslide and movement of the x-y stage in the y direction, perpendicular to dispersion. These are very small inconveniences, since the y stage setting usually stays constant during a given run, and the dark slide is usually only changed at the beginning and end of the night. Thus, the observer generally does not need to go onto the dome floor at night, but makes all required adjustments remotely.

Data taking and preliminary analysis is done from two terminals in the control room. The data taking process is a menu driven system, which most observers find to be extraordinarily user-friendly.

An ISI workstation is used for preliminary data analysis using Lick Observatory's locally developed language, VISTA. It is a command-driven system and features excellent help documentation, but it will be very useful if you acquire some prior familiarity with what is available by looking over the VISTA manual written by Stover and Terndrup. Also, a very useful publication is *The VISTA Cookbook*, LOTR 50. All that Vista stuff may seem a bit intimidating, particularly if you're an IRAF fan, for example, and you really don't want to learn VISTA. In fact there are only a few things that you really need to do at the telescope in VISTA, and if you're absolutely determined not to learn any more you can get by on what you are shown during your checkout. However, as with all things, what you get out of your time at the telescope will depend on what effort you put into it, and knowing some VISTA will open up many options to you in examining and perhaps reducing your data on the spot. Being thoroughly familiar with various ways to look at your data during the night might save you from acquiring a whole lot of junk data, so the general recommendation is: learn VISTA!

If you're still repelled by the whole idea of learning Vista, the most useful commands are rd (read disk), itv (interact with the TV), plot, and mash (mashes 2-D images into a spectrum, with or without sky subtraction). Type "help *command-name*" on the vista terminal for details, or more generally type "help" if you're not sure of the command you want.

Hardware is shared by the data taking and data analysis systems. Built by Integrated Solutions, Inc. (ISI), the VME-bus UNIX machine includes two 68030 CPU's, 48 Mbytes of memory, a 360-megabyte hard disk, nine-track 1600bpi tape drive, Exabyte tape drive, high resolution monochrome graphics monitor with mouse, an 8-plane color image display with a trackball, and a dot-matrix printer.

****IMPORTANT****

We wish to stress here an important and not-to-be-forgotten responsibility of the observer. The CCD response is enhanced and made more uniform by flooding it with UV light during a complicated cooling procedure. Once this flood is performed, the beneficial effects remain as long as the CCD is kept cold. *To keep the CCD cold is the observer's responsibility.* You may delegate the task, but it remains your responsibility if the task is not carried out, and it will cause hard feelings among those who will have to rush it to Santa Cruz for a reflood. So please be very careful to always keep the dewar cold. In particular, if you contemplate not using your assigned observing time for any reason, be absolutely certain to inform the dome crew at extension 51 or 53 in a timely way so they can keep the dewar filled. Just informing the diner that you will not show up, for example, is not adequate. Remember, it is *your* responsibility.

3 COMPONENTS IN THE TELESCOPE TUB

The order of discussion which follows will generally follow the light path through the system.

The Telescope Utilization Bin (TUB, or more colloquially, tub) is that portion of the telescope below the primary mirror cell. It contains the TV acquisition and guiding system, the diagonal mirror system and comparison lamp sources, as well as serving as a carrier for the cassegrain instrumentation which hangs below it. See Figure 2.

The tub can be rotated, but for a given instrumental setup, the tub position angle is preset by the maintenance crew to ensure proper balance of the telescope as a whole. The tub rotation is locked by three gold- anodized handles around the top outside perimeter of the tub. It's worth checking to be sure the tub is locked properly in order to prevent unexpected flexure at that joint. Tub rotation may not be changed by the user unless specifically arranged with the maintenance crew who will ensure that the non-standard position will not cause any serious difficulties with telescope balance. See the "Important Numbers" section at the front of this manual for a summary of the standard position angles used with the various configurations, and the resulting orientations of the acquisition TV and detector fields. If the tub is rotated, all of it's contents as well as the attached instrument rotate with it, so nothing changes except the relationship of the sky to the tub contents; that is, the orientation of the sky on the TV and detector will change together.

3.1 Diagonal Mirror.

There are two switch selectable positions for the diagonal mirror. The "in" position (see fig.3) puts a full surface flat mirror in the beam, which diverts all of the light to the TV for field acquisition; no light reaches the detector. A white card on the back of the mirror when in the "in" position directs light from the line lamps onto the slit for wavelength calibration. When the diagonal is out, the mirror is removed from the light path, but a periscope is in position to relay light from the slightly inclined aluminized slit apertures to the TV for guiding. When the mirror is moved from "in" to "out", you will notice that the field is reversed left to right and the scale is roughly

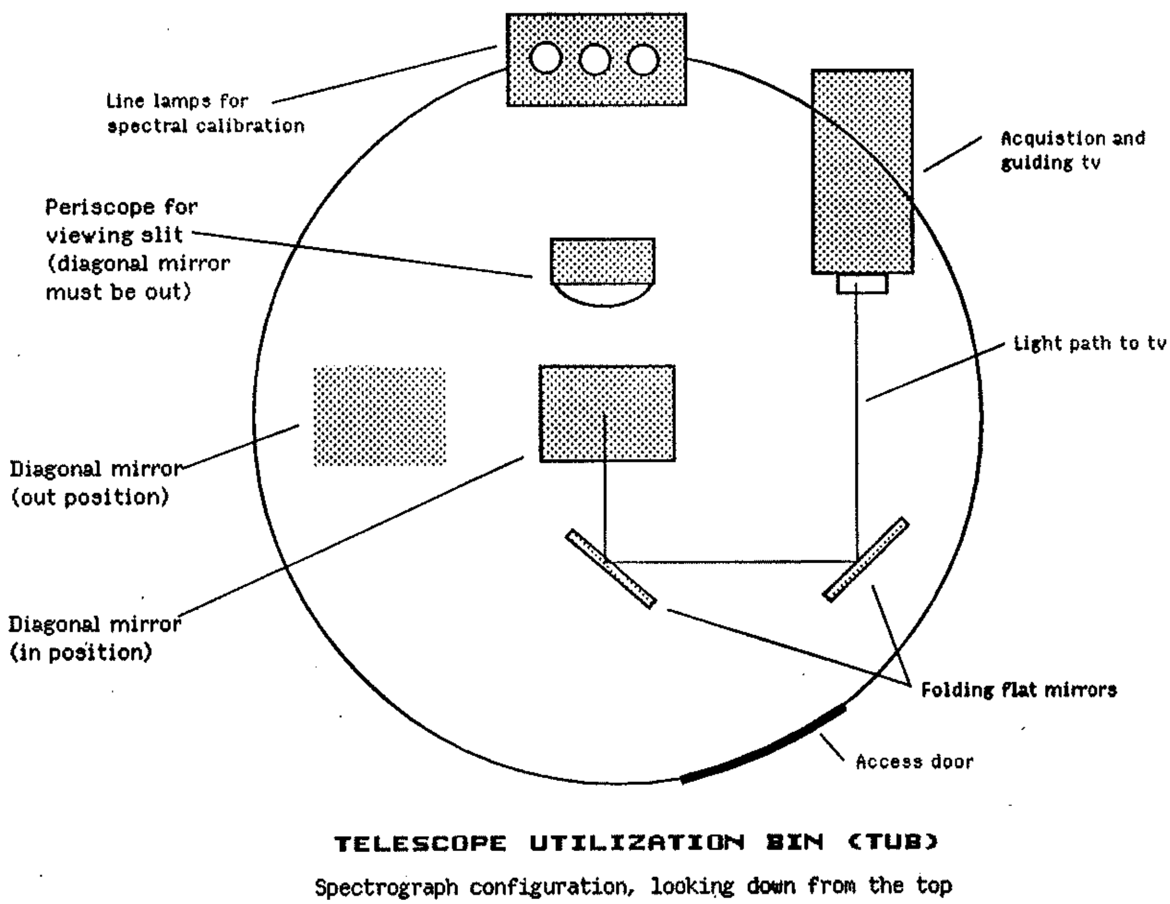

Figure 2: Telescope Utilization Bin (TUB)

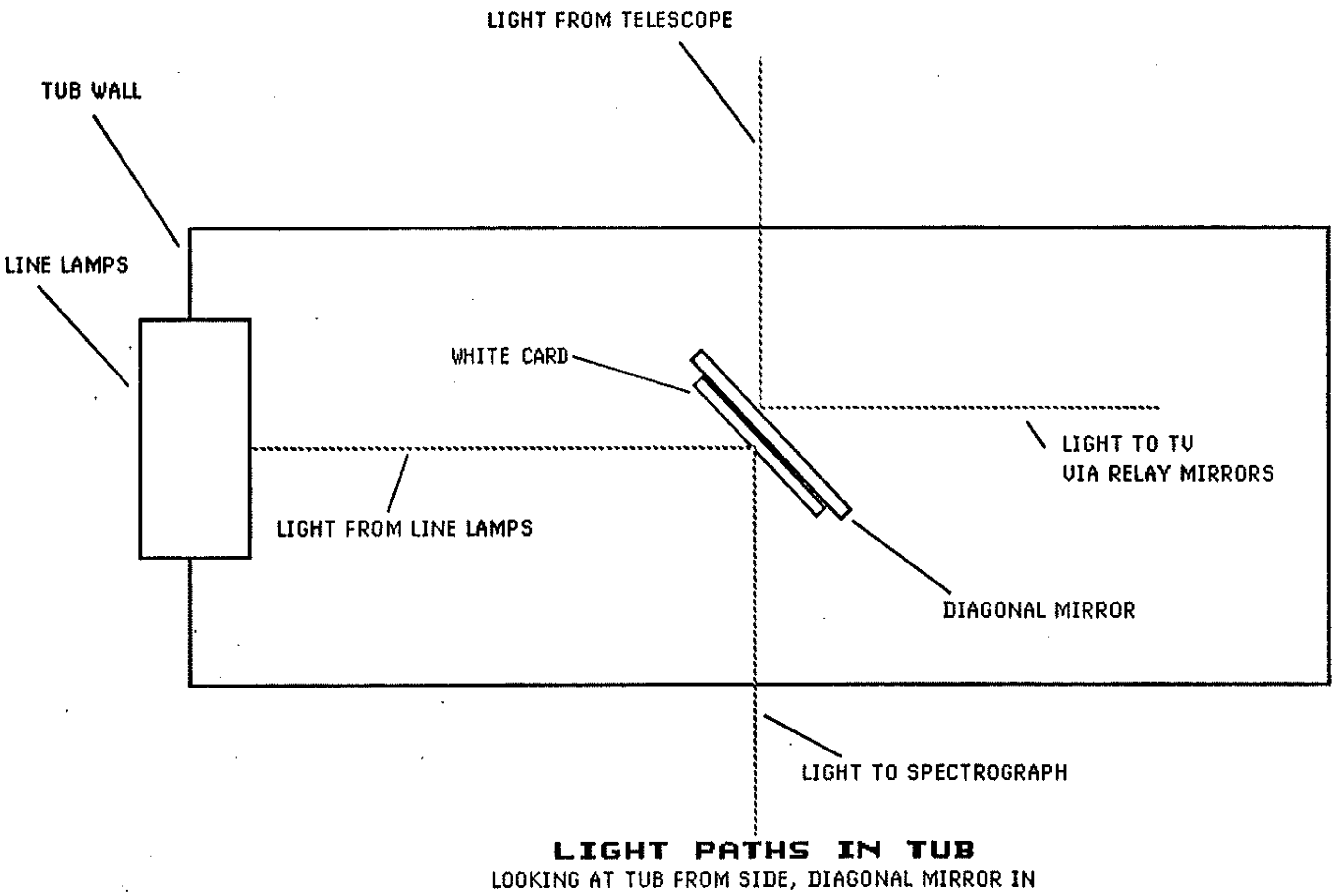

Figure 3: **Light Paths in Tub (side view)**

doubled, so objects appear to be twice as far apart.

For direct imaging, a different diagonal mirror is installed (Figure 4). In this arrangement, the object is initially acquired on an off-axis full surface portion of the mirror. After the object is identified and moved to a fiducial point on the TV display, the entire telescope is then offset so as to move the object on-axis, where there is a hole in the diagonal through which the light can pass onto the imaging CCD. The TV is still looking at the off-axis, full-surface portion of the mirror for guiding. The off-axis diagonal is thus left in the "in" position at all times when using the direct camera.

3.2 Folding Flat Mirrors.

The primary function of the folding flats (or relay mirrors) is to fold the light path around inside the tub from the diagonal mirror to the TV (see Figures 2 and 4). A secondary function of the folding flats is to allow compensation for various positions of the focal plane of the telescope which are required by different instruments. By moving the secondary mirror in or out, the telescope may be focused over a wide range which corresponds to about 12 inches of movement of the image plane. Because the TV is looking at the incoming beam from the telescope it is necessary to be able to make a compensating adjustment of the path-length to the TV so that the TV and the instrument may both be in focus simultaneously. This is done by altering the position of the folding flats, thereby shortening or lengthening the light path to the TV. The determination of the proper position for the flats for a given instrument is usually just done once when that instrument is first mounted at the telescope, and the correct position for the flats is recorded and thereafter reset by the dome crew whenever that instrument is remounted.

Despite the god-like reliability of the dome crew at making these adjustments, on very rare occasions they do forget. The symptom will be that the TV is out of focus when the instrument is in focus. The thing to adjust is the position of the flats. This is done through the small access door on the side of the tub (Figure 2 or 4). The two folding flat mirrors are mounted on a common stage. When you look in through the access door you will see a small black handle with a red button in the middle just in front of you in between the two folding flats. If you grasp the handle and press the button, the stage will disengage from its fine-adjustment screw and you can slide it

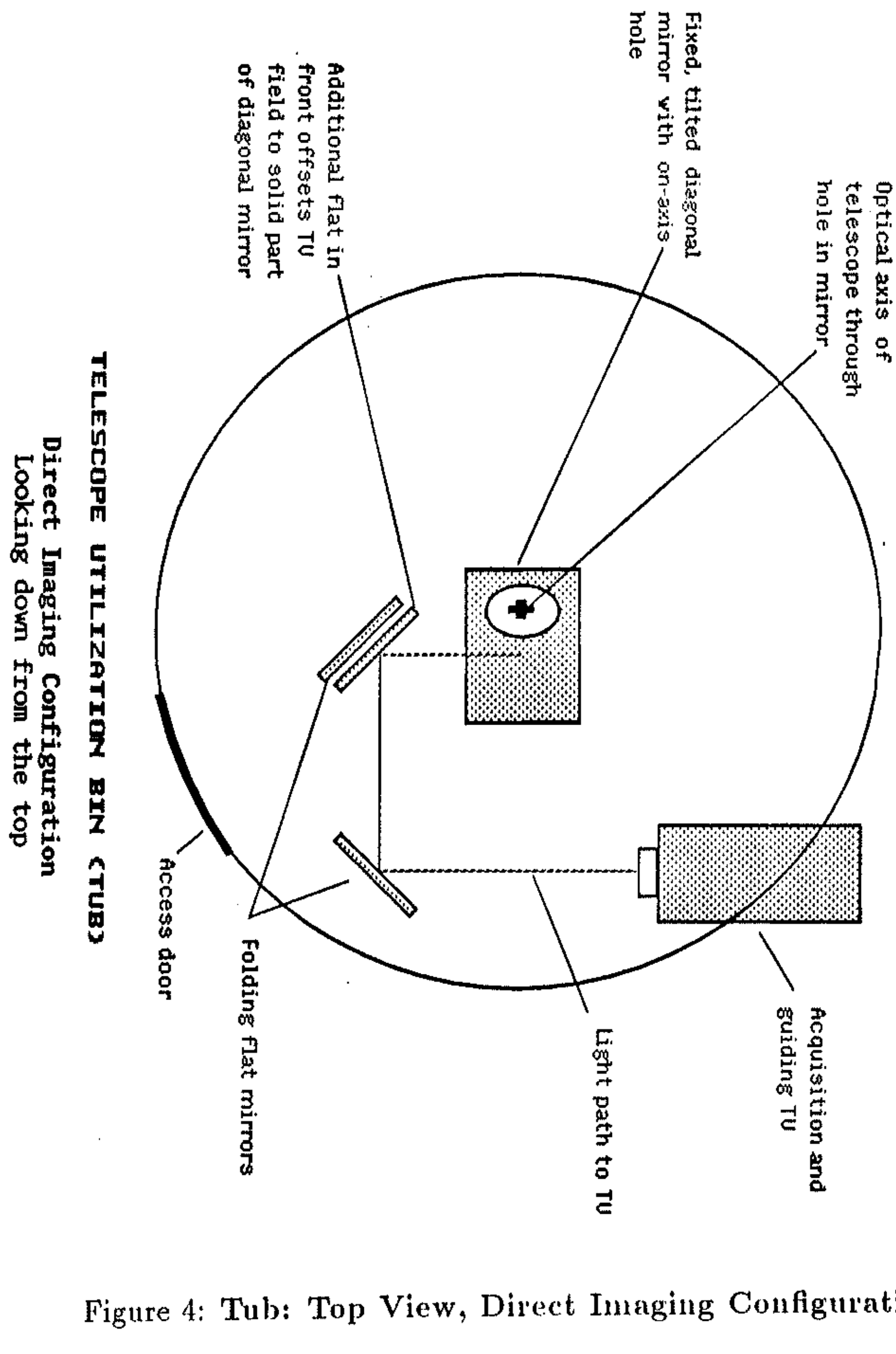

Figure 4: Tub: Top View, Direct Imaging Configuration

quickly and freely in or out. You can then make fine touchup adjustments by turning the screw with a knurled wheel which is at the outside end of the screw, out of sight just above the inside of the access door. If you know your instrument is in focus, just move the stage until stars are focused on the TV.

Possibly an easier approach to adjusting the folding flats is to set them to the recorded reference position used by the dome crew. The reference position is written in the dome crew's white binder which you can find in the cubbyhole to the left of the dome door; be sure to find the page which is for your instrument. On the bottom of the tub are three black panels mounted horizontally to fill in the space between the tub walls and the triangular instrument mounting plate. The panel to remove is the closest one on your left as you face the access door to the tub. Remove the panel and look up near the folding flats and you will see a metal machinist's rule fixed to the top of the tub. A crude pointer which looks like a nail provides the reference. Move the stage as described before until the pointer points to the setting in the book, and you're all set. Be sure to replace the bottom access panel and close the access door on the side of the tub.

If you don't like the sound of any of this, it's perfectly fair to call for help. The chances are slim that this will ever happen to you anyway, so don't worry.

The TV focus is much less sensitive than instrument focusing is, so the relatively minor focusing adjustments to the instrument do not significantly affect the TV.

3.3 TV.

An integrating CCD camera is used for object acquisition and guiding. The camera is relatively invulnerable to abuse. Room lights or even a flashlight pointed directly into it do not harm it. Looking directly at the sun would probably fry it; please do not do that experiment.

3.4 Line Lamps.

There are a variety of wavelength calibration lamps available in the tub. The user may select lamps singly or in any combination from the data taking system in the control room. Lamps available are He-Ar, Hg-Cd, and Ne.

Notice that for light from the wavelength calibration lamps to reach the slit, the diagonal mirror must be in the "in" position so that the light can bounce off the white card mounted on the back of the mirror.

Please keep the lamps turned off when not in use, because they tend to have short lives and are expensive. This applies particularly to cadmium lamps, which have useful lives of only a few hours and cost more than $200 apiece! If left on for more than 30 minutes, the computer will turn the lamps off automatically.

The cadmium lamp requires about two minutes warmup time in order to get any useful Cd emission (the mercury in the same lamp emits right away.) The neon and helium-argon lamps do not require any warmup time. Line strength ratios vary with age and lamp temperature, so if what you see varies moderately from what you have seen in the past or from the sample spectra in the Appendix, it is probably not a cause for worry.

Sample spectra are in a yellow binder in the control room. They are quite useful for finding where you are in wavelength and setting up your desired central wavelength.

4 INSTRUMENTAL CONFIGURATIONS

All instruments except the Comet Camera are fixed to the bottom of the tub. Nearly all components of the spectrograph or camera can be set by remote control using the data taking terminal in the control room, as described below.

We first describe the spectrograph configuration, and then describe in general terms the ways in which the cameras are different. The differences between the various camera configurations are relatively minor and mainly involve a choice of scale.

Figure 5 shows roughly what each configuration looks like.

Many people wonder why it is not as easy to switch between spectra and direct imaging here at the 40" as at the 120". This would effectively mean switching between configurations A and B, for example. The problem lies in the fact that the TV at the 40" cannot be moved freely in order to offset guide, and construction of a movable stage for the TV would cost many thousands of dollars. We allow offset guiding on one fixed field by having a tilted but fixed diagonal mirror in place for direct imaging, so the TV always looks at a fixed position off the optical axis, while the imaging CCD always sees the on-axis field. With this setup, one can offset guide at the same time as taking a direct image with an on-axis camera, but it is not possible to take any spectral line lamp calibrations, because that requires the white card mounted on the back of the solid diagonal. On the other hand, if the solid diagonal is mounted, that prohibits offset guiding for direct images.

A word or two on access to the various parts of the spectrograph must be said. Gain access to the filter wheel and aperture wheel by the panel on the west side of the spectrograph which has two connectors going into it. Please *do not* use the panel on the opposite, east side of the spectrograph, as some observers have done. The designer of the spectrograph intended that the west side be used and feels that inadvertent damage is less likely to result if access is made as he intended. It has happened once (only) that the wires in the west side access panel interfered with the free motion of the filter and aperture wheels, but that is easily avoided by exercising just the slightest care in their routing when replacing the panel.

DO NOT under any circumstances change the focus or position in their holders of the collimating and/or camera lenses. These are not the correct things to change in order to focus *any* of the instrumental options, and chang-

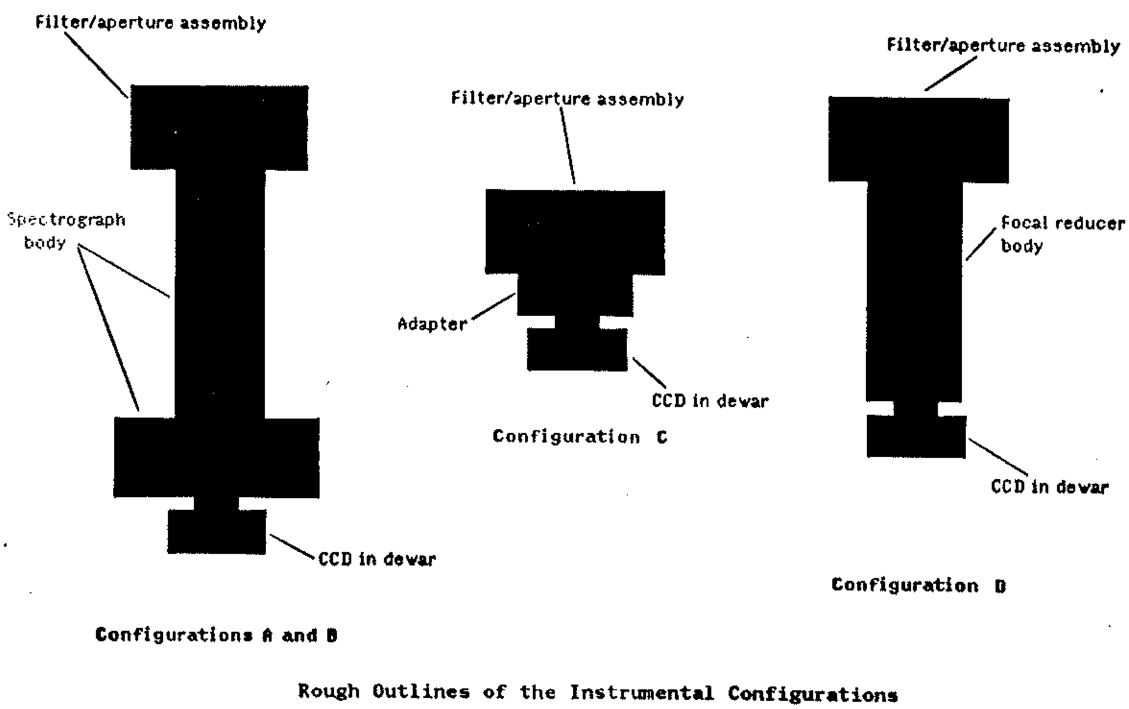

Figure 5: Instrumental Configurations

ing them will only make your life (and perhaps those who follow you on the telescope) more difficult and unhappy. All focusing for any instrument should *only* involve focusing the collimator remotely with the computer (never manually at the spectrograph), and focusing the telescope secondary. In short, don't screw around with the bits you're not authorized to adjust, 'cause it just makes problems for other users. Thanks!

4.1 Spectrograph.

4.1.1 Flexure.

Flexure at the CCD is measured at about ± 3 pixels over the whole sky with the locking screws for the x-y stage in place, or about ± 5 pixels without the locking screws. This is a real problem for spectroscopy with a chip which produces pronounced interference fringes such as the TI 500x500 in dewar number 1, since the fringes in the flat field will not match the fringes in the data unless a flat is done at the same position as each observed object. You may choose to ignore this source of error, or make a low frequency map of the flats and shift it to match the flexure, or not use flat fields at all, or take flats to match every object, or some other method of your own devising, but it will in any case require some consideration.

Similarly, the flexure will affect your wavelength calibration, but this may be corrected for by using skylines to redetermine the zero point for each observation. If you want maximum accuracy you may wish to do a line lamp calibration before and after each object observation. It's a nuisance, but they are fairly fast to do.

4.1.2 Apertures.

Rather than the usual slit/decker assembly, this spectrograph uses a preselected assortment of carefully machined slit shaped apertures mounted in a wheel. Any of the seven apertures in the wheel may be remotely selected and rotated into position using the data taking system.

Although we have a total of 14 aperture inserts available, the seven which are usually mounted in the wheel (listed in the "Important Numbers" section at the front of this manual) have proven to satisfy nearly everyone - no, literally everyone so far as we know. We are generally opposed to changing the contents of the wheel because of the danger of getting the apertures mixed up so subsequent observers end up using one other than the one they expect. (The computer knows what position of the wheel is selected, but not what is actually in that position.) It's not impossible to change them nor is it impossible to check them, but it's not really convenient to do either. Since we have them, we list the remaining apertures here, but we urge you not to use them!

Aperture Widths

millimeters	pixels*	arcsec
0.097	0.52	1.2
0.146	0.79	1.7
0.194	1.1	2.3
0.340	1.8	4.1
0.646	3.5	7.7
0.923	5.0	11.0
0.388	2.1	4.6

*for 15μ pixels and 58mm lens; divide by two for 110mm lens, and/or take appropriate ratio for a different pixel size.

All apertures except the last one listed and the pinhole aperture mounted in the wheel are 18mm (3.6 arcmins) long. The 0.388mm aperture above is 10mm long.

After all that, if you must use one of these other apertures, please ask the dome crew or a staff observer to install it for you. Furthermore, please ask that it be installed in a slot where it will be most obvious that it's not the aperture usually to be found there. This will help avoid its inadvertent use by others. Finally, please be absolutely certain the usual aperture is replaced before you leave the mountain. Thanks!

4.1.3 Filters.

There is one filter wheel, which is located just below the aperture wheel in the spectrograph (fig.1). One position of the wheel (position 0) is always empty. You may load any filter you can fit into our filter holders and slide any filter holder into any of the four useful positions of the filter wheel. They are numbered 1 through 4 on the wheel, and may be selected at any time from the data taking system.

The filter holders accept filters up to 2" square and 8mm deep. Empty holders are available in the steel cabinet in the 40" readout room, along with split rings to lock the filters into the holders. We have the following rather limited selection of filters available at the 40":

GG385 (=GG13)
GG455
GG495
RG715 (=RG10)
ND 1 (~2.5 mag)
ND 2 (~5 mag)
~B (1mmBG18+2mmGG385+1mmBG12)
~V (2mmBG18+2mmGG495)
~I (3mmRG9)
Rs (Spinrad night sky suppressor)

A much larger selection of interference filters is available at the 120" and may be borrowed by 40" observers only if specifically arranged with each and every 120" observer during your run. Obviously the 120" observer has priority for any filters. If you do borrow filters from the 120" please be faithful about returning them to their proper places promptly.

Any time you change filters it is very important to reinitialize the spectrograph with the data taking system, because the zero point for the filter wheel (and the apertures as well if you accidentally move them) is lost when the wheels are turned by hand.

4.1.4 Shutter.

The shutter which starts and stops exposures is mounted just below the filter/aperture section of the spectrograph. It's difficult to see up there and is also very delicate. If you are not getting light through the system and you've checked all of the obvious things (dark slide, mirror cover etc.), it's always worth listening to hear the shutter open and close. If you don't hear it operate when you're standing on the dome floor, call maintenance to check it. The minimum exposure time is 1 second, and timing errors are a few millisec; thus the timing error at the minimum exposure time should be less than 1%.

4.1.5 Collimator lens.

The collimating lens is identical to the one used at the 120". The spectrograph is focused remotely from the data taking system by moving the collimating lens with the computer. It should not be necessary for observers to ever touch this lens.

4.1.6 Grisms and grism tray.

Grisms are transmission gratings cemented to prisms. See the "Important Numbers" section for a list of the grisms available and their characteristics.

Two varieties of grism tray are available. One tray is flat and is used with the 58mm camera lens. The other is a rectangular box-like shape and is used to accomodate the much taller 110mm camera lens. Either of the two trays will accept either a slide which holds any three grisms, or a slide which holds the eschism (an eschism high-order grism disperser used as an eschelle) and its cross-dispersing grism, plus one other normal grism. The tray is repositioned remotely by the data taking system. Both trays include an empty position intended for direct imaging, but remember there is no way to guide unless an aperture is in place, as discussed at the beginning of Section 4..

Grisms will normally be mounted by the dome crew in accordance with your time request, but it's always highly advisable to check visually to be sure things are as you wish.

If you must change grisms yourself, please exercise extreme caution with them. The most delicate part is the grating which is cemented to the bottom of the grism, but the tops are optical surfaces as well, some of which have been coated, so treat them like any other optical surface – leave them alone and *DO NOT touch them* with anything. If you think one needs to be cleaned, for example, leave a note in the maintenance log and let the optician do it. That's what he gets paid for. We, for example, have never touched a grism surface and intend to maintain that record.

To remove the grism tray, close the dark slide (see below), then open the door to the grism compartment in the wide bottom section of the spectrograph by loosening the two bright thumbscrews at the bottom corners of the door. It is easiest to get at the tray if it is in one of the two middle positions (position 1 or 2). The grism trays are locked in by two screw posts, one at each end of the tray. Loosen the screws just a turn or so, then turn the metal tabs beneath the posts so as to allow the grism tray to come out. There's no need to take the posts all the way out; just rotate the tabs. Then pull up carefully on the tray in order to pop it out of its slot, and withdraw it. Again, do not let the grisms touch anything and do not touch the grisms.

In order to change the grisms, work in a well lighted room (e.g., the control room.) Be sure the table is clear of any small items, like screws, which might accidentally damage the grisms. Do not disturb the screws at the center of the grism's base that lock it into its holder at a particular angle – they have been carefully set. To remove a grism from the tray, remove only the two screws in the upper right and lower left corners of the metal frames, and lift the grism out carefully in its holder.

Fit the new grism in place. Be sure the prism's angled surface is oriented correctly or the spectrum will be reversed. There is a small schematic picture scratched into the rim of the grism tray to show you what the correct orientation is. If you only remove one grism at a time then you can use the others in the tray to ensure getting the orientation right. Be sure the grisms are properly seated in the cutouts in the tray, then tighten the corner screws.

Reinstall the tray carefully, sliding it into its recess in the tray holder. Press down on the edges of the tray to insure that it's properly seated. Rotate the tabs so they will hold the tray, and tighten the screwposts.

4.1.7 Camera Lens.

The camera lens is a specially coated 58mm f/1.2 Nikkor lens. The coating is supposed to give good transmission to 1.4μ, but in fact its transmission is very poor at least between about 0.88μ and 1.0μ. Response farther to the red has not been adequately explored. At the blue end, the glass is opaque to wavelengths shorter than 3850 angstroms. The focal plane is curved and will require focus compromises for long spectral ranges.

An alternative camera lens is the 110mm Hasselblad, which nearly doubles the scale at the CCD compared to the standard lens. It contains more elements and is somewhat less efficient than the Nikkor.

4.1.8 Manual dark slide.

The dark slide is between the camera lens and the dewar window. It is usually left open when actively using the CCD, and closed during the daytime or whenever the spectrograph is opened. It is a black anodized piece of metal that is just above the dewar level on the south side of the spectrograph. There is no remote indication of whether it is open or not. The first reminder of a closed dark slide is often an unexpectedly dark image. Do not forget to close the dark slide at the end of the night. It is natural to think of opening and closing it when you refill the dewar.

4.1.9 X-Y Stage Assembly.

The stage carries the chip in its dewar, the LN reservoir ("LN" is used generically to mean liquid nitrogen or liquid air - on the mountain it's usually liquid air which is produced locally), and some of the readout electronics. Its purpose is to permit the user to move the chip with respect to the fixed spectrum so as to allow selection of the desired central wavelength (motion in x), and to move the chip perpendicular to the dispersion so as to place the spectrum on the cosmetically cleanest part of the chip (motion in y).

The standard setup for the dewar has the spectrum along columns of the CCD. A movement of the stage in the x direction is parallel to the dispersion and is used to change the central wavelength. Think of the spectrum as being fixed with respect to the spectrograph and the CCD as being moved past it – since that is the way it works. This setup has an advantage over the one at the 120" in that the x stage may be conveniently changed at any time by the data taking system. Increasing the x setting results in a decrease of central wavelength. The x stage is moved remotely with the data taking system. A change of 3 units moves the spectrum by one pixel.

A move in the y direction is perpendicular to the dispersion. Most users agree on which part of a given chip is cosmetically best for the spectrum, so the y setting is rarely changed. Increasing y moves the spectrum to lower column numbers.

The y stage can only be moved manually. To do so, unlock the clamp on the west side of the stage, then move the stage with the knurled shaft near the clamp while reading the position on the micrometer dial. *Do not loosen the small knurled screw on the micrometer itself, or the zero point for* *the micrometer may be lost.* The position is read as a.bb, where a comes from the very small dial in the micrometer and bb is read from the larger dial. The scale is 1 mm per full turn of the big dial, or 1.66 pixels per dial unit. There may be backlash in the screw, but there should not be any in the spring loaded micrometer readout. Be sure to relock the stage firmly.

As described above under "flexure", there are two locking screws for the x-y stage which somewhat reduce, but do not eliminate, flexure in the stage assembly. These are two long, light grey thumbscrews which press against the stage from the east and west sides. If you decide to use them, the cost is that you cannot conveniently change stage settings during the night from the computer. There are two important cautions regarding their use: first, set up your central wavelength carefully before locking the stage in place, and once it's locked set the x-stage in the spectrograph setup routine of the data-taking system to -1 so you won't inadvertently ask the computer to move the locked stage; and second, be *certain* to loosen the screws *all the way* when you're through with them so the next observer won't encounter them accidentally during an x-stage move.

4.2 Direct Imaging

See the Important Numbers section for a summary of the different instrumental configurations, and Figure 5 for the rough shape of each of the configurations.

The same aperture, filter and shutter assemblies are installed for all instruments (except the Comet Camera), although for direct use the only setting of the aperture wheel will probably be to the empty position. Camera users please see paragraphs 4.1.2 thru 4.1.4 above for a description of these assemblies.

Configuration B is the same as the spectrograph configuration described above, but without the dispersers, and with the TV diagonal mirror with the hole replacing the solid diagonal in the tub. You might expect that you could ask for this setup and then slip in a grism and take a few spectra as desired; the problem is that you cannot take line lamp calibration spectra because that requires the white card which is mounted on the back of the solid diagonal, and the solid diagonal does not allow offset guiding for direct images.

The manual dark slide will be found only with configurations A and B.

Likewise, the 110mm Hasselblad camera lens may be used only with configurations A and B.

Configuration C consists of only the filter/aperture assembly, an adapter plate (spacer) and the selected CCD with camera lens.

Configuration D is the filter/aperture assembly, a long focal reducer assembly which contains a fixed collimator and a re-imaging camera lens, and the CCD assembly.

Notice that except in configurations A and B, the x-y stage and the grism tray are not physically present, and while there is a collimating lens in configuration D, it is fixed and cannot be moved. Thus, these items should be set to -1 in the data taking Z-5 setups so the computer will not try to move something which is either not there to move or firmly fixed in place.

The main difference between the spectrograph and the various direct modes lies in the actual observing procedure. These differences are described below in Section 7.

The Comet Camera is little used and so we don't discuss it much here. It gets mounted on the side of the telescope (not looking through the 40") and uses a 110mm Canon lens to feed the Tektronix 512x512 CCD in dewar number 2. The solid diagonal mirror is used so that the 40" TV camera can be used on-axis in order to center on the desired field and guide during the exposure.

5 ANCILLARY EQUIPMENT IN THE DOME

5.1 Ion Pump.

An ion pump is used to control any outgassing or minor leakage in the dewar. It should be on at all times. In case of a power failure it must be reset. The control box for the ion pump is mounted on the south side of the telescope above the tub level. If the red pilot light is not on, simply push and hold the black reset button until the red light comes on. If the pump does not come on within 30 seconds, release the reset button in order to avoid burning out the pump and call telescope maintenance for help. If the hold time of the dewar is short or if the outside of the dewar becomes very "sweaty", check the ion pump and reset if necessary.

5.2 Cooling.

The hold time of the dewar is very good. All that is required is to refill the LN reservoir every 8 hours or so. A conservative approach would be to fill it after lunch, when beginning observing, about midnight on long winter nights, and at the end of the night. Be sure to fill it first thing when you begin to set up on the first day of your run, since in general you won't really know when it was last filled. Above all, DON'T FORGET!

Remember too that liquid air can be quite hazardous to biological specimens such as you and me. If you splash a tiny amount on your skin it will evaporate practically instantaneously and do no harm, but if the contact is prolonged you're in real trouble. For this reason, be particularly careful not to spill it on your clothes which might hold it against your skin, and be extremely careful of your eyes.

5.3 CCD Controller

The controller is mounted on a rack attached to the east arm of the yoke of the telescope, and contains most of the readout and temperature control electronics for the CCD. It will be properly set up by the dome crew.

The only thing the observer need normally be concerned with on the controller is the temperature readout in the upper right corner of the panel. It reads the temperature near the chip in degrees Celsius. It should be stable to within ±0.1 degree. If the temperature wanders by more than 0.2 degree, start to worry. If the temperature starts to rise, check the LN; if it starts to fall the heater is failing to control the temperature properly and you should call for help. Since both the response and the noise of the chip are temperature sensitive, it is quite important that it remain constant.

If you have any really bizarre problems with the chip readout (a rare occurance), check to see that the green ready light on the controller is lighted. If not, turn the controller off for 30 seconds or so, then back on. If you still don't get the green light, call for help.

5.4 Flat Field Lamps.

The flat field lamps are mounted on the struts of the telescope a few feet below the secondary ring. Power is provided by a variable power supply on the floor to the right of the door. The lamps are 12 volt incandescents, so please don't exceed 12 volts on the supply voltage or they'll soon burn out. Changing the voltage allows you to change both the brightness and the color temperature, unfortunately not independently.

Dome flats are taken on the white patch on the inside of the shutter, or more usually just on the white windscreen. Irregularities on either surface may be ignored because they are so far out of focus. Do not forget that in order to get the flat field light to the detector, the secondary rainscreen halfway down the telescope must be open, the mirror cover must be open, the diagonal mirror must be in the out position, the manual dark slide must be open, and the aperture and filter wheels must be properly set. For the first try with a new setup, do a one second unrecorded exposure in order to scale the exposure time and/or lamp intensity to get a good result. If you're at the red end of the spectrum, you may choose to take a longer exposure at lower lamp intensity in order to get a more satisfactory ratio of light at the two ends of your spectrum, and vice versa for blue.

If taking direct images, take twilight sky flatfields. These are important because the CCD is not illuminated by the domeflats in the same way as by the sky; hence use of domeflats alone will leave a low-frequency non-flat scaling in the images. For broadband images, skyflats also tend to be better at flattening since the CCD pixels have wavelength-dependent sensitivity and sky exposures provide a better spectral match to the image fields than the domeflats do. For direct work, domeflats are basically for backup of sky flats.

Skyflats are of less value for spectroscopic work; they can be used for better flattening in the spatial dimension (along the slit), but sky features make them pretty hard to use in the dimension of dispersion. Most spectroscopists don't bother.

In general, one wants to have the flat fielding good to 1% or better. Often this means taking a number of flats and coadding them. If the electrons per DN is 2.5, then it takes a total of 4000 counts (10,000 electrons) to get 1% accuracy. At the weak ends of the spectral response of the chip, this means either taking lots of flats or compromising for lower accuracy. The traditional pattern is to take 3 or 4 flats for each setup at the beginning of the night, and again at the end for higher precision and as a check to be sure nothing changed during the night.

6 CONTROL ROOM

6.1 Terminals.

For a more in depth discussion, please see Richard Stover's *The New Lick Data Taking System* . Here we tell you just enough to turn on, log in, and get by for a typical (if there is such a thing) observing session.

6.1.1 Data Taking

The data taking terminal changes from time to time, but it most likely will be a Televideo 912. The power switch is upside down on the right (as viewed from the front) rear of the terminal. It's weirdly placed, so you may actually have to look at it the first time. So turn it on, hit return, and get a login prompt. Enter *user.* After various messages, you'll receive a user prompt; enter *d* (for data taking.) After some other system messages, you will be told what the the baseline value is, that it is low, and asked if you want to fix it. This is a glitch in the system. At the 40", the real acceptable range is between 300 and 1200, with about 1000 typical, so if it's within that range, just accept it and proceed. If it's outside that range (it rarely is, but it does happen), call for help to reset it. After you get by that, the data taking menu will appear.

The "main menu" or "calling menu" is first displayed, (Figure 6) and is the menu used to enter the integration time; select the area of the chip to be displayed and recorded; enter the name of the observed object; start, stop, pause or abort an observation, etc. To execute a particular function, simply type the single letter associated with that item on the menu (no carriage return is necessary) and it will execute. If additional input is required, you will be prompted for it.

At the top of the menu display is a header which contains the observer's name, the instrument in use and the CCD in use. The former two items may be changed as described below. Since the information is recorded in the tape header for each recorded image, you will wish to enter the information correctly. The CCD type is read automatically by the CCD controller as you log in, so examine this line carefully to be sure, first, that the chip you wanted is on the telescope, and second, that the CCD controller is getting the correct information. If the chip description is not correct, you will probably

```
Your Instrument            Ford 2048R X 2048C #1        Your Name

 MAG TAPE IS OFF-LINE


 A. Selection number:    1

 B. Integ. time:       5 s =   0.08 m          R. START
 C. Obs. Number:     115                       S. STOP
 D. Window:                                    T. ABORT
    Size     (R C)   500   100                 U. PAUSE
    Origin   (R C)     0   200                 V. CHANGE INTEG
 E. Binning (R C)      1     1                 W. CHANGE SELECTION
 F. Obs. type:    Normal slow                  X. COMMENTS
 G. Recording:    Disk and Tape                ?. HELP
 H. Display:      TV         3                 Z. SPECIAL
 I. Object: 600rlines
 J. Selection summary                          +. Cursor display
 K. Set spectrograph:  Unknown                 *. Run C-shell
 L. Lamps: 1 (he)=off  2 (hg)=off  3 (ne)=off
```

Figure 6: **Data Taking System – Main Menu**

need help.

To exit from submenus which replace the calling menu screen, press escape. Sometimes the system will advise you of other ways to do it, but escape always works.

If you want to get out of some option without making any change, answer something that makes no sense (often just a carriage return will do), and in most cases the input will be rejected and control will return to the menu.

During the readout sequence you cannot do other things from the data taking terminal, but you can do things from the Vista terminal.

Beginning with the second line of the main menu in a boxed off area, information regarding the status of the particular observation underway is displayed. This includes the remaining and elapsed exposure time, whether the exposure is in progress or complete, and whether the shutter is open or closed.

The major portion of the screen is the menu, and is divided into two halves. The left side generally contains the items which constitute the observational setup parameters, and the right side contains the operational choices. The parameters relevant to the data taking process such as the integration time and the window to use are read once at the beginning of the data taking cycle, and those items relevant to the disposition of the accumulated data such as object name, recording mode and display are read once as the integration is terminated.

We run through the choices here with our paragraph headings the same as those on the screen for easy reference. This doesn't follow the normal conventions for sequences of labelling for subtopics, but in this instance it seems useful to be deviant. It may help you become familiar with the layout of the various items on the screen if you refer to the appropriate figure as you go along. Start with the main menu (Figure 6).

A. Selection number. A complete set of choices for the operational parameters (items B through I in the left column of the main menu) constitutes a "selection", and up to 10 selections may be set up for instant recall during the night. To change selections, type *A* and then answer the prompt with the desired selection number. A given integration on the CCD will use the selection which is on the screen at the time the integration is begun. Changing the selection after the integration is started will not change the selection used for an integration in progress. If you belatedly realize that you have started a selection with incorrect selection parameters, you must change the selection number with option W as described below.

B. Integration time. Integration time is in seconds, one second minimum and 32k(!) max. Changing this after the integration has begun will not affect an integration in progress. However you can change the current integration time by using option V below.

C. Observation number. This is recorded and automatically incremented as each recorded observation is completed. It is not incremented for unrecorded observations. If two images are recorded with the same observation number, the later image will overwrite the earlier one on the disk. Logging out and back in will not change the current observation number, so some observers like to continue one sequence throughout a run.

D. Window. The window is that area of the chip which will be displayed and saved at the end of the integration. The numbers to enter are pixel rows and columns, with origin (0,0) at the upper left corner of the chip. The chip reads out from top to bottom, so it must read (but not necessarily record or display) all rows until the last row of interest. Occasionally one wants to minimize the total read time (for variable star photometry, for example), and this is best done by putting the object at the top of the chip and reading out as few rows as possible.

The characteristics of the chips change from time to time, particularly if a chip is reflooded. Some floods may leave hot columns, rows, or pixels which you may wish to exclude from all data with the window. Take a couple of test images, one with low light levels and one with high light levels to look the chip over and see if there are any areas you wish to exclude. It's not a big deal though, because you can always chop out bad data later.

E. Binning. To bin is to combine the data from adjacent pixels during readout. One may bin independently by rows and columns, and may bin by 1 (that is, no binning), or 2,3 or 4. One saves on readout noise and media storage but loses spatial resolution. If the source is very faint it might be worth it to bin, but usually it is not a good choice. Another disadvantage is that one's subsequent ability to exclude hot spots or partially blocked columns from the data is lost.

F. Observation type. The choices are normal (shutter open) or dark (shutter stays closed); and then a second set of prompts will inquire if you want fast or slow readout. Fast readout is intended for setups, and should readout in about one-quarter the time at the expense of higher readout noise. But at the time of writing it doesn't work and the data is simply lost, so

DON'T USE IT. Notice that keeping the shutter closed with the dark option may not sufficiently exclude light from the chip for a satisfactory dark exposure. The shutter is located pretty far from the chip in the spectrograph and the focal reducer configurations. Use the dark slide where available (spectrograph), and for directs you might try covering the camera with black cloth, or you may choose to wait until it's nearly dark outside in order to get a satisfactory dark exposure.

G. Recording. Choices are disk, tape, both or none. If you record only to disk, it is convenient to edit out unwanted integrations. The downside of that choice is that if anything goes wrong with the disk you may lose data. It is recommended that you record to both for all serious data taking, and to disk only or not at all during setups.

Images which are explicitly saved to disk are called "d" plus the observation number plus ".ccd". Thus image number 1 on the disk is referred to as "d1.ccd".

Scratch images, images for which recording mode "none" is selected, are still written to the disk in a scratch area, but are automatically overwritten by the next scratch image. To recall the most recent scratch image from disk with the VISTA rd command, use the image name /scratch/scr. If you wish to save the last scratch image, you may write it to tape with option Z.2.D. as described below.

H. Display. This allows choice of a parameter called the "bit select" that determines how the image intensities will be mapped into colors for display (it has no effect on the recorded data). The range allowed is -7 to +15, but the useful range is about -2 to +5, for most purposes. The sense is that for a very weak signal use a small number, and for a strong signal use a large number. This is only a cosmetic choice to make the picture convenient to look at. The choice determines the range of DN's which are mapped into each of the 8 bits (=256 colors) used for the color display. Usually one wants to choose this number so as to use the full range of colors but without rolling over to repeat the range (or at least not to roll over very often). Typically, 0-3 are most useful. The color mapping may also be changed with the Vista TV command.

I. Object. This allows entry of the name of the observed object for the tape header, e.g., "neon", "OJ287", etc. Terminate the label with a carriage return since it's a string of arbitrary length. 63 characters max are allowed for object names. Some people put all sorts of nice-to-have-handy information on this line, such as date, grism used, filter identification etc. since it often gets displayed with it's associated image.

J. Selection Summary. This will display the parameters for all ten selections (as set up with option A described above)in a columnar format.

K. Set spectrograph. Ten possible spectrograph (or camera) setups may be saved from submenu Z-5 yet to be described, and may be recalled with this option.

L. Lamps. The wavelength calibration lamps may be turned on and off with this option. Typing the appropriate lamp number toggles the lamp on or off.

M-Q. Not used

R. Start. Simply press R to start an integration using the selection parameters currently displayed.

S. Stop. Press S to stop the integration early and save the data. The actual integration time will be recorded. A prompt will require you to confirm your choice of this option before it will be executed.

T. Abort. To abort the integration and discard the data, use this. You will be required by a prompt to type "abort" to confirm your intention and prevent the inadvertent loss of good data.

U. Pause. This will pause the observation with the shutter closed and the integration suspended during the pause period. It's useful for clouds or recentering, for example. When pressed, the "Pause" name of option U becomes "Resume", so press U again to resume – cute, huh?

V. Change integration. If you wish to change an integration time during an integration, you *must* use this option. The initial integration time is taken from option B, but after the integration is started the program will not look at B anymore and changing B will have no effect. Don't make the mistake of using B instead of V at 3 AM when you're tired.

There is a persistent myth that use of this option without also changing the integration time with option B will result in the old incorrect integration time being left in the image header. This is not the case. Changing the integration time with option V correctly updates the header.

W. Change Selection. Similarly, to change selections during an integration you *must* use this or the system will use the selection with which the integration was started regardless of subsequent changes made with option A.

X. Comments. This allows adding up to five lines of comments which will be recorded with the image. If the first character of a line is an asterisk, that line will be recorded with all subsequent images until changed. If no leading asterisk is present, the line will be recorded with the next recorded image and then automatically erased.

?. Help. This has become sufficiently ubiquitous that we feel no further comment is necessary.

Y. Not used.

Z. Special. This is a catch-all which calls up one of five submenus as follows.

Z1. Display. (see Figure 7)

Z1A. Display bit select. This is the same as described under H on the main menu above.

Z1B.-D. Display window. Allows selection of a subset of the recorded image for display. Conventions are as before, with the origin at the upper left.

Z1E. Redisplay. Redisplays the image after changing display parameters.

Z1F. Cursor display. Creates a cursor on the image. The cursor may be moved with the trackball or with the keyboard keys h,j,k, and l. See the display screen for directions. The trackball is handiest for big moves of the cursor and the keyboard keys are the easiest way to move a small specific number of pixels. The pixel row and column numbers and the DN at that position are returned to the screen along with options for marking positions for later use in making telescope offsets, making row and column plots, and making a box for use by the display window option above.

Z1G. Histogram display. Supposed to create a histogram of intensities versus number of pixels. Unfortunately it no longer works with the present software.

Z1H. Select TV color map. Allows choice of black and white or color. Remember that you can choose different color maps from VISTA; but of course you know that already because you've been sleeping with the VISTA manual.

Z1I. Video memory size. The resolution of the color display is 480 rows by 640 columns, but the video memory space is 1024 by 1024. Here you can choose whether to compress your image into the 480 x 640 space at some possible loss of resolution, or to use the full video memory but perhaps

```
Your Instrument          Ford 2048R X 2048C #1      Your Name
 MAG TAPE IS OFF-LINE


 Type ESC key for main display, Z for another SPECIAL, or + for cursor

 A. Display bit select:     3
 B. Display window:      OFF
 C.      Window   size:  2048 2048
 D.      Window origin:     0 200
 E. Redisplay
 F. Cursor display
 G. Histogram display
 H. Select TV color map
 I. Video memory size:  480R X 640C
```

Figure 7: Data Taking System – Display Menu

need to pan around with the trackball in order to see the entire image. The real data is not affected.

Z2. Tape. (Figure 8) The first line of this short submenu displays the Tape Status; that is, it shows you the next image number to be written, or it will tell you if the tape is offline or write-locked.

Z2A. Initialize (clear) tape. Use this with caution, and only to start a new tape with no data on it that you wish to save.

Z2B. Rewind and position to end of old tape. This will do what it says, but in general it's faster to

Z2C. Read and position to end of tape, which doesn't require going all the way back to the beginning.

Z2D. Save last image to tape. It's worth remembering that this option is here. Occasionally one wants to save to tape an image recorded in the scratch area or only saved to disk.

Z2T. Select Tape Device: 9-Track or Exabyte. This option allows selection of the desired tape output type. See Section 6.3 below for more information on tapes.

Z3. Miscellaneous. (Figure 9)

Z3A. Observer. Here's where you enter your name for the tape headers.

Z3B. Instrument. Identify your instrument in whatever way makes sense to you. This will go in the tape header and in years to come will allow you to pin down the pixel scale, for example, when you show these historical images during your Nobel acceptance speech.

Z3C. Define CCD spectrum rotation. May be ignored at the 40" since the CCD can only be mounted to the spectrograph with one position angle per CCD/camera combination.

Z3D.-E. Not used.

Z3F. Open history file. Prints out a record of everything that happens during the run. We don't know anyone who still uses this option. It's noisy, wastes paper, proves not useful, and you end up carrying around and storing a lot of useless stuff.

Z3G. Close history file. If you don't use F you won't need G.

Z4. Tests. (Figure 10) These are mainly for maintenance use. There's nothing here that seems worth describing for this manual.

```
Your Instrument              TI CCD 500 R X 500 C        Your Name
  MAG TAPE IS OFF-LINE


  Type ESC key for main display, Z for another SPECIAL, or + for cursor


     Tape status : file = Unknown OFFLINE
  A. Initialize (clear) tape
  B. Rewind and position to end of old tape
  C. Read and position to end of tape
  D. Save last image to tape


  T. Select tape device: 9-track
```

Figure 8: Data Taking System – Tape Menu

```
Your Instrument            Ford 2048R X 2048C #1       Your Name
  MAG TAPE IS OFF-LINE


  Type ESC key for main display, Z for another SPECIAL, or + for cursor

  A. Observer  = Your Name
  B. Instrument= Your Instrument

  C. Define CCD spectrum rotation


  F. Open  history file
  G. Close history file
```

Figure 9: Data Taking System – Miscellaneous Menu

```
Your Instrument          Ford 2048R X 2048C #1          Your Name
MAG TAPE IS OFF-LINE

Type ESC key for main display, Z for another SPECIAL, or + for cursor

A. Continuous read-out

B. Noise measurement: slow mode, start column   -1 (centered)
C. Noise measurement
D. Horizontal clock noise
E. Voltages
F. Number of erases:   8
G. Baseline subtraction Enabled
H. MPP mode: ON
```

Figure 10: Data Taking System – Test Menu

Z5. Control. (Figure 11) You will use this submenu a lot for changing the instrumental setup, using options D through H below. See the Important Numbers section at the beginning of the manual for detailed specifications of the various spectrograph/camera components. Here we are only concerned with the mechanics of changing them.

Z5A. Position No. 1 (r,c). Allows entering a reference position by typing in the row and column number from the keyboard. Separate entries with a space. You may also enter a position from Z1A. These positions are used by option C below to move the telescope so as to position an object at a specific location on the image.

Z5B. Position No. 2 (r,c). As above.

Z5C. Move Telescope between positions. Allows moving between positions 1 and 2 as designated with A and B above. Notice that the correct scale for the CCD in use must be known to the program. Check this under S below. Scales for the different configurations are to be found in the Important Numbers section.

Z5D. Gratings. Well, really there aren't any, only grisms. Position zero is always empty, intended for direct imaging. Positions 1 through 3 will contain whatever you requested in the way of dispersers in your time request. Again, be sure to actually look to verify they were loaded correctly. If you're using a camera setup, enter -1 for the grating so the controller will not try to move a part of the spectrograph which isn't even there.

See the Important Numbers section at the beginning of the manual for specifications of the available grisms.

Z5E. Apertures. Enter the position number desired for the aperture wheel. For direct imaging enter 0 for the empty space in the wheel, and after that is in position use -1 for no further changes.

Z5F. Stage. This refers to the position of the x-stage, which determines the central wavelength in your spectrum. The numbers are actually stepping motor steps and so are arbitrary. See the Important Numbers section for equations to convert your desired central wavelength into stepping motor step numbers for each grism. Use -1 for direct setups.

Z5G. Filters.

Enter 0 for no filter or 1-4 for positions 1 through 4 of the filter wheel. Remember that the wheel may have any filter in any position, so be sure to check that what you want is actually where you want it. You must reinitialize this after any manual changes at the filter wheel.

```
Your Instrument              Ford 2048R X 2048C #1       Your Name
 MAG TAPE IS OFF-LINE


 Type ESC key for main display, Z for another SPECIAL, or + for cursor

 A. Position No. 1 (r,c) = Unknown
 B. Position No. 2 (r,c) = Unknown      S. Scale:  0.71 arcsec/pixel
 C. Move telescope between positions    T. Offset telescope
                Request    Actual
           (-1 disables) (Neg.=error code)
 D. Grating             1       0         L. Save a setup
 E. Aperture           -1       0         M. Recall a setup
 F. CCD Stage        1000       0         N. Set spectrograph
 G. Filter             -1       0         O. Make Requested=Actual
 H. Focus            1000       0         P. Saved-setup's summary
 .  Saved as setup:    1
 I. Lamps: 1 (he)=off  2 (hg)=off  3 (ne)=off


 Reading spectrograph setup
```

Figure 11: Data Taking System – Control Menu

Z5H. Focus. This moves the collimator lens in order to focus the aperture onto the chip. Remember that the adjustable collimator lens is only present in configurations A and B, which use the spectrograph body. Configurations C and D do not include an adjustable collimator.

For the spectrograph (configuration A), use the line lamps as a light source and move the collimating lens so as to focus the aperture onto the chip. Some compromise may be necessary if the wavelength range is large. Later, complete the focus procedure by using the secondary mirror focus in order to focus a star onto the slit.

For direct imaging with the spectrograph body (configuration B), use the pinhole aperture as a light source in order to move the collimating lens so as to focus the aperture onto the chip, and then use the telescope secondary to focus a star onto the aperture.

For the other direct configurations without the spectrograph body (configurations C and D), there is no collimating lens present and this focus should be set to -1. Just focus the telescope secondary on a star for best images at the chip. See the Observers Logbook for recent typical values.

Z5I. Lamps. Use this option to toggle the wavelength calibration lamps on and off. Remember that you can do the same thing from the main menu as well.

Z5J and K. Not used.

Z5L. Save a setup. This allows you to save a spectrograph or camera setup for later recall. 10 setups may be saved.

Z5M. Recall a setup. You may recall previously saved setups numbered 1 through 10. This will change the request list, but you *must* use the Set Spectrograph routine to actually change the physical settings of the spectrograph. It's easy to forget this when you're very tired.

Z5N. Set spectrograph. This will set the spectrograph or camera to the settings in the request list.

***** Notice *****

> Items D through H above allowed you to enter parameters for the remote control of the spectrograph or camera. Entry of parameters does not actually result in any change of the instrument directly; only the requested setup list is changed. To cause the requested parameters to actually change the spectrograph, it is necessary to use this routine as a separate step. The usual pro-

cedure is to use M above to recall a setup to the request list and then use N to actually change the setup of the instrument. It's incredibly easy to forget this second step at 3 A.M. when you're really tired. This is one reason to prefer the set spectrograph option on the main menu (option K), which will automatically prompt you for the desired setup number and then go on to the set spectrograph prompts.

Z5O.Make request list equal actual. This will update the request list to the actual spectrograph configuration. This is useful if you've been making changes piecemeal, and now have things the way you want them and wish to save the setup for later use. Use K to actually save the setup to disk.

Z5P. Saved setup summary. Displays the saved setups in columnar fashion. Handy if you're not sure which is which anymore.

Z5Q and R. Not used.

Z5S. Scale. Provides the scale in arcsecs per pixel to the offset programs Z5A-C. If you make a move and it doesn't move the correct distance, check to be sure the scale shown here is correct for your instrumental setup. Offsets under Z5T below are not affected, since it does not use pixel scale.

Z5T. Offset telescope. Allows offsets by seconds of time or seconds of arc in R.A., and by seconds of arc in dec.

Z5U-Z. Not used.

That's finally all for the submenus under option Z from the main menu. Just two items remain on the main menu.

+. Cursor display. Typing the plus sign will generate a cursor on the image display and yet another submenu on the data taking terminal. The trackball moves the cursor around, and the current row and column number and the DN's at that position on the image will be displayed at the bottom of the terminal screen.

If you want to setup for a telescope move in order to position an object in a direct image at another place on the chip, move the cursor over the object of interest and enter those CCD coordinates into the computer by typing either 1 or 2, then move the cursor to the desired new position on the chip and enter those coordinates by typing the unused choice of 1 or 2. Then go to Z-5 to make the telescope move. You will be given the option of moving from 1 to 2 or from 2 to 1. You may also enter pixel coordinates for an offset from Z5A and B.

Typing C or R will produce a row or column plot on the ISI terminal from the current cursor position. Plots produced in this way will show the peak DN but will not have a vertical scale, so if you'll want to know more than the peak DN numbers from the plot use ITV from VISTA instead. One useful feature available here which is not available from an ITV plot is that you can move the trackball in row space and get a continuously updated plot of the current row, which is sometimes useful for scanning across a profile of an object. Because of the way the data is stored, a similar scanning capability is not available in columns.

***. Run C-Shell.** Unix users will know what this means, and nobody else will care.

6.1.2 VISTA terminal (ISI Workstation).

The 19" ISI Workstation turns on with a switch on the lower right (as viewed from the front) rear of the monitor. Normally it comes on with a big ISI logo and a login prompt in the lower left corner. If you don't see that, try turning up the brightness , which is a roller adjustment on the right rear of the large square front section. Ignore the offline and keyboard locked lights on the keyboard, which often are on, but lying! Log in with *vista*. The logo will disappear, a number of icons will appear on the left, and a vista window will be created for you. To run other programs, use the mouse to position the cursor over the appropriate icon, then press the right mouse button. A new window will open to run your program. "Setel" (= set telescope) is a particularly useful program, and produces superior pointing corrections.

Use the left mouse button on the title bar of a window to move that window. To select any window as the active window, point the arrow at the body of the window and press any mouse button. The active window will always be on top and have a black title bar.

To change the size of a window (particularly handy for the VISTA plot window), point the arrow at the upper right hand corner of the window, press and hold the left button and drag the stretchy box around until it's as you like it. Let up on the mouse button and the window will resize.

To eliminate a window, point to the upper left corner (the tombstone symbol) and depress the right mouse buttonn; the process will stop and the window will disappear.

VISTA is available with all the bells and whistles, so if you're efficient (and like VISTA) you can do a good preliminary reduction of your data on the spot.

In addition to making a hardcopy of a plot with the VISTA "plot hard" sequence, any part of the ISI screen can be printed. Point the cursor to any unused background portion of the screen and press and hold the middle button. A pop-up menu will appear; select the "snapshot" option. The cursor will turn into a small camera. Move the camera to the upper left corner of the area you wish to copy. Press and hold the left mouse button and move the camera to the lower right corner of your intended hardcopy so that the stretchy box encloses the area to be copied. Let up on the button and the region to be copied will be saved as a file to the disk. Next, point the cursor to the bmprint (=bitmap print) icon, and run it with the right mouse button. A window will automatically open, the file produced by snapshot will be processed to produce a file that the printer can print, the job will be submitted to the print queue and the window will disappear, all without further action on your part. To change the size of a plot made from a window, merely change the window size as desired and remake the plot.

In order to log out of the workstation, point the mouse at any part of the background of the display (not occupied by a window or an icon) and press the middle mouse button. A menu will appear, the last item of which is logout. Select logout with the mouse and let up on the center button. Turn off the terminal when you're through with it.

This is just a brief outine of the ISI and its capabilities, but we believe it's all you really need for normal operation. If you wish to know more, see "The New Lick Data-Taking System" by Richard Stover.

6.2 Disk management

The disk is partitioned into various areas, and the data storage space is about 42 Mb, which is sufficient to store $\sim$ 50 500x500 images. When the data space is full, the program will automatically store data frames in the Vista image area, which is of comparable size. A new image which has the same observation number as an old image will overwrite the old image. The current observation number is not lost by logging out and back in. Thus, you will wish to reinitialize this number at the beginning of your run.

To see what images are in the data or vista storage areas, use the VISTA command dir (for data) or dir vista (for the vista area). Or, to just see how much space is available, use VISTA command df.

To erase the disk, open a c-shell window and type *rm /data/*.ccd* to erase the data disk, or *rm/vista/*.ccd* to erase the vista area. The default is to ask you to confirm each deletion. If you're sure you want to clear it all out, first type *unalias rm* to proceed without confirmation.

6.3 Tapes and Tape Drives.

Data can be recorded to the hard disk, on 9-track tape or to 8mm tape cartridges on an Exabyte tape drive, or to both the disk and your choice of tapes. Most users elect both, so that if one medium fails you'll automatically have the other as backup.

You can bring your own tapes, or buy them on the mountain (not for cash - they will be recharged to you). See the electronics people or night assistants to buy tapes.

After your tape is loaded and write enabled, see the options under Z2 from the data taking terminal to initialize your tape. It is important to know that the tape must be reinitialized (usually with options Z.2.B or Z.2.C.) every time the data taking program is reloaded. Such reinitialization will be required after a power failure, rebooting the computer, or if you have logged off from and back onto the data taking system. If you forget, the system will let you know with a message on the data taking terminal the next time you attempt to write to tape, but that image may be lost unless you have written it to the disk.

Please remove your tape from the tape drive at the end of each night.

If you use the 9-track tape drive, it is recommended that you clean the tape heads and rollers each night before mounting your tape. Q-tips and ethanol are provided for this purpose.

The Exabyte tape drive stores images on 8mm cassettes. Because of a limit on the size of the directory, you can only store 1600 images maximum per tape. About 1500 500x500 images will fill the tape anyway. An important caution regarding the Exabyte drive is that the directory is only updated during a normal dismount of the tape. This means that you should never manually dismount the tape with the eject button on the drive, and that in case of power failure or a computer crash you will have to take special steps to restore the directory (ask for help). Since restoring the directory may well take quite a bit of time, it's a good idea to always have a spare tape cartridge on hand so you can quickly get up and running again, and do the restoration later at your leisure.

6.4 Logsheets.

The tape headers are quite complete, but a log on paper is useful for recalling images during the night as well as just keeping track of what has happened. Log sheets are available sporadically in the readout room. It's best to bring them with you, or in a pinch you can get them from the 120" readout room. A couple of samples are reproduced in the appendices.

6.5 Guide and Acquisition Television.

The camera is a very sensitive CCD device. The field of view is approximately 5x7 arcmins, but recall that you do not get the full field in unbinned mode. There is an area of bad columns on the left and a few (4 or 5) hot spots, but generally it's pretty clean and the response is superb. On a dark night with full integration (30 seconds) and good seeing, you can see to the PSS red plate limit (mag about 20).

The camera is relatively invulnerable to damage. The only prohibition is do not look at the sun. It will not harm the camera even at max gain to turn on the room lights or comparison lamps, for example.

See *The Nickel Telescope User's Manual* , LOTR 36, for instructions on its use.

6.6 Guiding

In the spectrograph mode, guiding is done on the aluminized slit jaws. If you're lucky, there will be a star on the slit jaws bright enough for the autoguider to guide on. This is the case more often than not. But if there is no such star, then the only option left is to guide on the light from your object which spills out of the slit now and then.

For direct imaging, you must guide on the off-axis field that the camera happens to be looking at on the full surface mirror. There is no way to move the camera independently of the telescope, so you're stuck with whatever you get. Fortunately, in a 5 x 7 arcmin field there is almost always something to guide on.

7 STEP BY STEP PROCEDURES

7.1 Things to Bring

1. Object list with coordinates

2. Finding charts

3. Observing log forms. Availability in the dome is not guaranteed. There is a copier on the mountain, but it may be more convenient to bring them with you.

4. Magnetic tapes [$\sim$ 50 500x500 direct frames or 250 500x100 spectroscopic frames fit on one tape; take a couple of extra reels. Alternatively, you may obtain them on the mountain on a recharge basis].

5. Magnetic tape labels

6. 40-inch telescope manual (LOTR 36)

7. Standard-star finding charts and coordinates, if you're not sure they're available at the telescope

8. Pens and pencils

9. Flashlight (or borrow from the diner)

10. Calculator (an H-P is available at the telescope)

11. Reading material, for bad weather

Also handy: small alarm clock, if you have one (dorm clocks are sometimes unreliable); extra blanket (dorm rooms are sometimes cold).

7.2 Arriving at Lick

If you will require a checkout at the telescope, call a few days in advance to confirm and to arrange to meet when you arrive. You *must* receive an official checkout before proceeding on your own, without exception. The Director feels very strongly about this, and being checked out by a fellow astronomer, for example, does not suffice. Plan to arrive for lunch in order to have sufficient time for the checkout as well as the usual setup procedures. If for some reason you have not made a definite arrangement with the person who will check you out (usually Rem or Tony), call that person from the diner as soon as you arrive on the mountain in order to arrange a meeting time at the telescope.

The checkout typically takes a few hours, depending in part upon your prior experience and the complexity of your instrument, and includes setting up the instrument, help with calibrations and getting you off to a good start in the evening. You should be prepared to lose some time the first evening if things go more slowly than you expect. There's a fair amount to learn, especially if you are just starting your observational work.

If you are a return visitor, it will probably be adequate to arrive at Mt. Hamilton midafternoon, unless you have unusually complex setups to perform. The drive to Mt. Hamilton takes ~2 hours from Berkeley or Santa Cruz, or one hour from San Jose International Airport. Upon arrival, go to the dining hall and try to find someone to check you in. From this person you should get: 1) your dorm room assignment; 2) a set of keys, including your dorm room key, astronomer's master key, and additional 3-m key; 3) a parking permit to stick on the inside of your windshield; and 4) information on when lunch and dinner are served.

If you cannot find anyone at the diner, go to the Maintenance Shop (pale green building a short distance down the road), go inside the door if unlocked, and check the lower sections of the mail slots just inside the door to the left for an envelope with your name on it containing all items listed above. If this doesn't exist, ask anyone you can find inside this building about checking in. If this building is locked and you get no answer to a knock, you will probably have to wait around awhile for someone to appear. On weekdays the mountain staff gathers here at 3 p.m. for coffee break, so that's nearly guaranteed to produce someone. If no one appears by a bit past 3 p.m., you may want to go check around the dorm, or go to the 3-m building and ask them to try to reach someone to give you keys. (The staff area of the 3-m is locked but you can buzz the control room using a button located next to the southwest, lower-level door.)

After you get checked in, go check your dorm room and make sure your key opens the door. If it is winter, the room seems cold, and there are no spare blankets in any of the room closets, you may want to make inquiries at the diner about getting extra blankets. (Opening the radiator valve, if it exists, may also help.) If you think you might leave the mountain early due to bad weather, don't disturb anything in the room; this will avoid being charged for it if you don't actually end up sleeping there.

7.3 Setting Up

What follows is fairly detailed. If you just want a quick checklist, see the Appendices.

Go to the 40-inch and haul your stuff into the control room; you can park on the northeast side of the dome. Look at recent entries in the Observer's Logbook and the Trouble Log to see what's new with the telescope. If anything on the following check-list doesn't look right or you have problems, first see the trouble-shooting section which follows, reread the relevant portions of the manuals, and then if you still need help, call a technician at the 3-m (extension 51 or 53 on the mountain line) and make inquiries.

1. Look over the telescope. Make sure the instrumental configuration is as you requested (see Figure 5). Check the LED temperature reading on the east fork ($\sim -120.0°$ for the TI 500x500). If the reading is significantly different from what you expect, this may mean the ion pump is off; check this anyway. The ion pump control box is located on the west side of the tub with front end facing down; check that the red light is on. Also, turn the readout knob fully clockwise to 50μA and make sure the needle swings over on the readout dial (specific reading irrelevant); return the readout knob to its usual place, one click clockwise at 50 mA - *do not* leave it set fully ccw at 5kV.

2. Fill the dewar with liquid air and make sure there is enough liquid air to get through the night (i.e. three more fillings). Please do not put this off. In all likelihood your predecessor will have refilled the dewar

at the end of the night just past, but you probably won't know for sure that was done, so the most conservative thing to do is to refill it right away.

3. Press *reset* on the south pier junction box to enable telescope power.

4. If you're using the spectrograph, check to see that the grisms you requested are mounted, and notice in which slots they are; the permanently empty (leftmost) slot is position zero, and then from left to right the slot numbers are 1,2, and 3.

5. If you're using filters, load them in the filter wheel. Access to the filter wheel is through a vertical panel located underneath the tub. The correct panel to remove is the one which cables 7 and 8 go through. It can be removed after unscrewing thumbscrews at the panel corners. The Nickel telescope has its own filter holders which are preferred over 3-m filter holders because the filter detents (and hence dimples on the side of the filter holder) which hold the filter in position in the slot are in a different position at the 3-m. Check the filter slots to make sure the holders fit in snugly; if the sides of the slot are loose they can be tightened with screws on the underside of the slot. If there is any question about whether the filters are secure in the slot, *secure them with tape* so they don't slide out when you tip the telescope!

   A note on filters– *handle them with lens paper whenever possible.* Lens paper should be available in the control room or dome; if not, go to the 3-m and get some. *Use ONLY your fingers, separated from the filter by lens paper, when putting the filter in the holder and securing the retention ring.* Filters can be dusted using a squeeze bulb or canned "Effa-duster." (Use the bulb if possible– the can will shoot out fluid drops if you hold it the wrong way, and the propellant eats ozone.)

6. Open the manual dark slide, if present.

7. In the control room, first check the dew sensor. Be sure that the audio is on and that the sensitivity dial is set to 25. Then you can forget about this very important telescope protection item. If it rains on the telescope because you failed to check that the audio alarm was on, it may really be the fault of the (almost certainly unknown) person who

turned the audio off, but all people will remember is that *you* let it rain on the telescope.

8. Turn on the data-taking terminal (ordinary terminal usually located on the left side of the table) and login as *user*. At the prompt, type *d* to start data-taking program. Note that the *backspace* key should be used to delete characters when making typing corrections on this terminal. Turn on the workstation terminal and login as *vista*. Turn on the workstation image display (white color monitor located in rack to the right).

9. Initialize quantities on the data terminal:

   On z-3 menu, observer and instrument

   On z-5 menu, setups for the imaging system. You can save and recall these with commands in this menu; you can set the system to one of these saved combinations using "set spectrograph" (option K) on the main menu. Setup values for direct should be:

   grating = −1

   aperture = 0

   CCD stage = −1

   filter = 0 for no filter; 1 through 4 for corresponding filter slots.

   focus = −1 (except configuration B for which it is necessary to focus the collimator).

   (−1 settings indicate that this feature is not used for direct imaging.)

   For direct, a possible mnemonic system is to save the above parameters with filter = 1 as setup number 1, filter = 2 as setup number 2, and so forth.

   On main menu, set as appropriate, for example:

   window = 500 × 500 (tells how much of CCD to readout)

   binning = 1, 1 (tells how to bin CCD pixels)

   origin = 0, 0 (tells origin of the CCD window)

   observation number = 1

Multiple selections for the window parameters are possible by typing A from the Main menu, but the one described above is satisfactory for imaging of the full chip.

10. Underneath the workstation image display is the PET computer, with floppy-disk drive underneath the main unit. Turn on the PET power (light-type switch located on rack above and to the left of the PET). Push in the PET disk (should be sitting halfway in the drive slot) and close the drive door.

11. On PET, hold down SHIFT and press RUN key to enter the main program.

12. Turn on the telescope status monitor (left monitor of small CRT pair located in the right-hand rack). Turn the thumbwheel on the Telco board (located below telescope monitor) to *13* to obtain a cryptic display of autoguider information. One piece of information shown is the tub PA, which should give the tub position angle appropriate for your instrument (see "Important Numbers" at the front of the manual). If it says something else, try pressing reset on Telco. If that doesn't work, double check that the correct instrument is mounted, and call for help.

13. If doing direct imaging, initialize slit changer – type S on PET, then enter these values to the prompts: 550, 50, −550, −50. *Note that these values are at least approximately correct as of this writing but may change – check the Observer's Logbook.* Since you cannot guide directly on the object you're imaging, this feature shifts the telescope so that the object you have centered up on the TV is moved over onto the field of the CCD. With this setup, hit "<" to shift TV field to CCD and ">" to shift CCD field to TV. *Note that if you subsequently exit the main PET program and later restart it, the slit changer must be re-initilized.*

14. Turn on the tape drive and load a tape. In principal, you should clean the tape drive surfaces with some fluid in a red squirt bottle and swabs, usually located under the drive or on the control room bookshelves, but the vacuum column door has cheap plastic closures and it is sometimes difficult to regain a good seal after opening the door. In practice it is a

good idea to clean the tape drive, but make sure you have some spare time to monkey with it in case you subsequently have trouble loading a tape. Initialize a new tape or position to the end of an old tape using commands on submenu Z2 of the data-taking program.

15. On the VISTA window, type *dir* and *dir vista* to see if old files (images) from the previous observer are sitting around. If they are, get on the C-shell window and type:

    unalias rm (if you wish to confirm deletion of each image, then skip this step)

    rm /data/*.ccd

    rm /vista/*.ccd

    Check that there is plenty of disk space from the VISTA window using the command *df*.

16. For direct imaging, the diagonal mirror knob below the autoguider should remain in the "in" position. If it is in the "out" position, turn it to "in" unless the cover over the switch is closed, in which case call the maintenance people at the 3-m and ask if it's ok to change this setting. The diagonal mirror controls the light path within the telescope for the TV.

17. Take a short exposure and make sure it looks ok. If the dome is quite dark or the dark slide is closed you should see 64 DN plus or minus noise, or roughly 60 to 70 DN. Otherwise you should see light-leak, which looks like a smoothly increasing number of counts from the top to the bottom of the chip. The point here is to make sure that everything works as soon as possible, so if there is any problem you can get it fixed during normal working hours, and avoid any delay in getting underway for the night. Be sure the shutter opens and closes, that the chip reads successfully, and that the displayed image looks reasonable.

18. Set up an appropriate window on the chip. To determine the window, start with a full chip sized window, set up your device as appropriate for observing, and illuminate it with the flat field lamp (be careful not to overexpose). Take a short exposure, then plot from itv or cursor display to choose the smoothest, cleanest part of the chip. Use main

menu option D to reset the window as desired. If for some reason you will be using quite different windows during the night, remember that you can set them up as different selections for quick and convenient switching.

19. For spectroscopy, find the x-stage settings which will give you the desired central wavelength. Use the equations in the Important Numbers section under "Grism Specs" to find the correct settings, reset the stage with the computer, and take a line lamp spectrum to check the setting. Use the sample spectra in the yellow binder for comparison. If things are really screwy for some reason, the easiest feature to spot is the blue edge of the neon lines at about λ 5800.

20. Focus the instrument.

    Direct configurations: If no collimator is present (C and D), there's nothing you can do until you get a star. For configuration B which includes a collimator, use the pinhole aperture and focus the collimator for smallest image (*do not* under any circumstances move the collimator within its holder; move it only remotely with the data taking system). You might use the VISTA itv command and plot a cross-section through the image to count pixels at half-max, or the stellar statistics routine in itv. If using multiple filters, do not assume they are parfocal without testing them. In addition to variations in optical path length through filters of various thicknesses, focus is a function of wavelength due to the lenses in the system, so if your filters are widely separated in effective wavelength you should anticipate differences in focus.

    Spectrograph: use a small slit and an appropriate line lamp and focus for narrowest lines. Compromise may be necessary, especially if you are using low dispersion/long spectral range, since the focus is a function of wavelength. Find the best focus for each grism/central wavelength combination you will use. One quick way to look at the data is with the VISTA itv column plot option. With a bit of practice it will probably be sufficient to just look at the overall plot, but endless variations and levels of precision (and complexity, and time spent) are possible. Since one usually observes with a larger slit than one uses to focus, it's not clear that great effort on focusing is effort well spent, and we claim that great finesse is not required to get it close.

Smaller focus numbers improve focus towards the red; larger numbers improves the blue. It's hard to see much change in less than 100 units, and if you're not even close, try 500 or 1000 units at first.

21. Remember that you can record different instrumental setups for later quick recall, using Z5.

22. Start a log, and set the recording mode to both. Some people prefer to record to disk only during the night, and then to save it all to tape at the end, using VISTA totape. The advantage is that you can edit out junk; the disadvantage is that if anything goes wrong you risk losing everything, whereas the disk and tape back each other up if you record to both.

23. For configurations with a good dark slide, record at least one short and one long dark (perhaps one second for the base level and 1000 seconds for the time dependent component of hot spots) with the dome and dark slide closed. For configurations without a dark slide this will have to be done after dark.

24. If you are doing direct imaging, take dome flats using the lamps mounted high on the telescope tube; connect the plug on the wire dangling from near the bottom of the telescope to the power supply sitting on the floor west of the dome door. Turn on the power supply, but do not set the output to over 12 volts in order to conserve the life of the 12 volt bulbs used. Make sure both the rain-protector and pneumatic telescope cover are open. Close the mirror cover, and turn off the power supply when done. It is not necessary to disconnect the power supply.

    If you are doing spectroscopic work, you will have to wait until well after sunset to take flats in order to avoid contamination of the dispersed flat by solar features. Don't forget!

25. Spectroscopists may do line lamp calibrations before dinner if desired. The dark slide must be open and the diagonal mirror must be in, and don't forget to turn the expensive arc lamps off when you're through. Generally it's best to do all calibrations with the same setup you plan to observe with, but if you'll observe with a very large slit that may

degrade the resolution so badly you might prefer to do your lamp calibrations with a smaller slit (but at least two pixels for reasonably accurate determination of line centers), or perhaps with both a large and a small slit.

26. Weather permitting, you may choose to leave the dome open and the mirror exposed to the sky. That's fine, even recommended, but be very careful indeed about the weather. Fog can come out of nowhere here, so we recommend in particular that you do not leave the dome open and go take a nap. If the dome is open, stay alert and aware of the current weather situation so you can quickly close the dome if necessary. It's ok to leave it open while you have dinner, for example, but glance out the window now and then. Of course the weather is particularly likely to change suddenly in the winter, but even in summer it may surprise you. Be careful.

27. **DO NOT BE LATE TO DINNER.** While at dinner, tell the cook whether or not you will eat lunch the following day (she should ask). Pick up one of the loaner flashlights if you didn't bring one with you.

28. After dinner, remove the RA safety bar; replace the top pin in the bar to avoid losing it and stow the bar where you won't trip over it. Check telescope power on (hit the "reset" button on the south pier junction box if necessary) and make sure mirror covers are open.

29. If direct imaging, take twilight sky flatfields. It's hard to generalize about when to take them or how long it will take, beacause it will depend strongly on the passbands of your filters, how many filters you have, and how efficient you are. At least the first time, start early and expect it to take longer than you think! For skyflats, go into the dome and a) tip the telescope in the antisolar direction far enough away from the zenith that it is not vignetted by the dome, with a bit of extra space; b)open the dome slit; c) position dome so telescope looks out the slit; and d) lower the windscreen so that it does not vignette the telescope. In the control room, turn on the "autodome" and "tracking" switches. Take a test exposure of 1 second to estimate exposure time for the flat. Take flats; test count level with *itv* command in VISTA for each frame in order to estimate successive exposure times, keeping

in mind that the sky brightness changes roughly exponentially with time. *Move the telescope a short distance with the joystick between each exposure.* [In order to obtain a median flat field uncontaminated by stars, you want individual frames in which the stars don't move around (i.e. telescope tracking on) but with the stars in different positions in successive frames.]

30. For spectroscopy, do your dome flats as soon as it's dark enough not to worry about solar contamination.

31. TOP OFF THE DEWAR.

32. Check on the small Telco TV screen that the Telco time is correct. Telco time is displayed on the telescope status monitor, and WWV standard time is displayed on an LED readout above the TV acquisition monitor. If the two times disagree by more than a few seconds, the Telco time should be reset using an option on the PET's main program. Although Telco displays both PST and UT, when you reset the time from the PET, the program expects you to input *PST* in *24-hour* format. When you get satisfactory agreement between Telco and the time standard, the monitor might start flashing a message that the RA and HA are inconsistent with the sidereal time it has computed. Fix this by adjusting the LED display of hour angle near the top of the right-hand rack using the adjacent push-button and dial. The telescope monitor will tell you what this HA value should be.

33. Check the telescope pointing. Lower the windscreen and turn on the acquisition TV; the 2× binning mode is usually most convenient, which allows you to see the full 5x7 arcmin field of the TV. To take into account precession of coordinates, atmospheric refraction, and particularly flexure of the telescope, use one of the telescope setting programs. Although we refer to these generically as precession programs, the flexure corrections can be quite significant, so even coordinates which are very accurately precessed may not be adequate for good pointing. In general, always use these programs for all pointing, regardless of the epoch of your coordinates. The best program for this exists as a window on the workstation, and can be called up by clicking the mouse on the SETEL icon. Alternatively, the PET has a command on the main

menu that will ask for the coordinates at your choice of epoch for an object and then compute what the corresponding telescope coordinate readings should be. These readings are displayed on the "Next Object" window of the telescope monitor.

To check the telescope pointing, find a bright star (the brighter the better) in the *Astronomical Almanac* near the meridian and between the equator and plus 20° in declination (this positions the finding scopes so you can reach them conveniently). Run one of the pointing programs, and slew to the indicated position using the slew buttons under the LED position readout. Use the joystick for fine tuning. If you can't find an incredibly bright star on the TV, look in the Observer's Logbook for the current correspondence between the TV center and the position on the finder scope reticle for your instrumental configuration. None should be very far from center. Go out to the dome, find the brightest star on the finder scope (close, we hope, to the expected reticle position), and use the joystick to position the star to the appropriate reticle position. The reticle brightness is controlled by a knob on the telescope near the finder scope. After doing this, check the TV again. If you still don't see the star on the TV you will have to hunt around a bit; first try running the pointing command again and check for typos in coordinate positions you entered. If the finder reticle-TV correspondance has changed significantly from what the logbook says, enter the new info in the book and note to which configuration it applies.

After you get the star centered on the TV, adjust the LED coordinate readout of r.a. and dec until they match what the pointing program told you to point at. *If this is a large change, write down the initial and final coordinate readings so you can backtrack if you accidentally lined up on the wrong star.* The telescope monitor may begin to complain of disagreement between RA and HA, in which case adjust the LED readout of hour angle until this message goes away. If the pointing correction seemed large, check the pointing again with another star.

34. Adjust the secondary focus. This is controlled by a toggle switch with an LED readout next to the slew buttons.

    For the spectrograph or direct B configurations, the instrument has already been focused to the aperture plate from below, so this step is to focus the secondary so as to produce the smallest image on the aperture plates. With the diagonal mirror in the out position, look at the image of a moderately bright star on the aperture and focus the secondary for best image. Since the aperture plates are tilted a few degrees about a line through the long axis of the slit, keep the star close to the slit during focus. As the focus improves it may be necessary to reduce the TV gain in order to eliminate saturation of the TV image. One possible but rare problem may arise if the best focus of a star on the slit jaw does not coincide with the best focus of a star in the diagonal mirror "in" full field position. This probably means that the dome crew has not set the folding flats in the TUB correctly. Refer to section 3.2 if necessary to adjust the folding flats, or call for assistance.

For the direct configurations C or D, a recommended procedure is as follows. Find a moderately bright star on the TV, offset the telescope to put the star on the CCD, and take a quick exposure to make sure you get a reasonable count level within, say, 10 seconds. Run the focus reading down 10 to 20 units and then back up to something like 6 units below the approximate focus (this is to avoid backlash). Make sure the star is initially near one edge of the chip, then start an exposure of 60 seconds. Pause the exposure at 10 seconds, move the telescope with the joystick so the star shifts 10 arcseconds or more, and jog the focus up 2 units. Resume the exposure and repeat, moving the star in a line, until the exposure time is up– make sure you keep the star on the chip. After readout, use the *itv* command in VISTA to position the cursor on each star image and then type "*" to get statistics on the profile σ and peak count level. Note that this calculation of σ depends on the brightness of the star, so keep the integration time constant for each step in order to make accurate comparisons. When you find the best profile, run the focus reading back down 10 or 20 units and back to the corresponding best focus. Note that the focus readings do not always reproduce with good accuracy, so it is worthwhile to take one more quick test shot at this final setting before moving on.

If using multiple filters, do not assume they are parfocal without testing them. In addition to variations in optical path length through filters of various thicknesses, focus is a function of wavelength due to the lenses in the system, so if your filters are widely separated in effective wavelength you should anticipate differences in focus.

The telescope generally cools during the course of the night, necessitating changes in the focus setting to higher values in order to maintain good focus. Keep an eye on your stellar images and refocus as necessary; it's a good idea to check the focus occasionally even if the stellar images have changed little, since defocusing may have been compensated by improved seeing.

35. Measure the chip orientation. The tub position is usually well registered, but if, when direct imaging, it is important to you to know the precise orientation of the sky on the chip, you may wish to measure it. Do this by finding a moderately bright star, positioning it near one corner of the CCD, and then dragging the telescope successively in r.a. and dec so you make a big "L" image while exposing the CCD. *Make sure you write down the starting and ending telescope positions, and record the image to tape.* The positions are important to have in case there is some question later about the pixel scale. Make sure that the starting and ending points of the "L" are on the CCD, and that the signal in the "L" is good but not burned out. *Do this at the start of your run* so that if you lose time later you don't end up with data lacking a calibration of orientation.

36. Do standard stars. For spectrophotometry, there are charts for the usual standards in an orange binder in the control room.

7.4 During the Night

1. Fill the dewar around midnight.

2. Check the CCD temperature for constancy.

3. If your configuration has prevented you from doing so earlier, take several darks of varying length, up to maybe 5 minutes. Close the dome during darks to avoid problems with moonlight.

4. Check the weather occasionally.

5. Before starting each exposure, check: proper selection and setup, integration time, and object name.

7.5 At Dawn

1. Take more calibrations (wavelength calibrations; twilight sky and/or dome flats as appropriate).

2. Shutdown:

   Turn off tracking and autodome.

   Slew telescope to stow position (posted next to coordinate LED display). Or, you can do it visually from the dome floor; it should be almost straight up, centered under the windscreen and the black panel at the top of the dome so rain cannot leak onto it.

   Close dark slide if present.

   Install RA safety bar.

   Close pneumatic mirror cover and manual rain protector.

   Close dome and move to stow position.

   Push "panic" button on telescope power box.

   FILL DEWAR.

   If run is over, remove all filters.

   If run is over, loosen x-stage locking screws if used.

   Lock the dome door.

3. Turn off:

   All wavelength calibration lamps!!

   Both terminals after logging out. Logout of data taker by typing ctrl-Y, followed by *logout*. To logout of the workstation, move the mouse to a blank part of the screen, press the middle button on the mouse, then move the cursor to the word "logout" that appears and release the button.

Tape drive. To remove tape, the *rewind* button must be pressed twice: once to get a rewind to the load point, and a second time while at the load point to completely unload.

PET (open disk door and withdraw disk halfway before powerdown)

Image display monitor

Acquisition TV

Telescope monitor

Hardcopy printer

DEC tracking correction rates (i.e. set thumbwheels to 0)

Flat-field lamp, if you took any domeflats in the morning.

Check dew sensor audio on

4. Fill out the Observer's Logbook and Trouble Log and *sign* (initials are difficult to figure out).

5. **Call 3-m night assistant (ext. 51 or 53) and report the telescope condition even if you had no problems.**

6. Lock the doors to the control room and dome when you leave.

7.6 When you Leave

BE SURE TO DROP OFF KEYS, THERMOSES, AND BORROWED FLASHLIGHTS AT THE DINER.

8 PROBLEMS

1. **Don't be shy.** There are people around who *like* to help. If you can't solve the problem for yourself in a reasonable time, or if you just feel uncomfortable or uncertain about doing something, please call the 120" at extension 51 or 53. There is usually a technician on call there during the afternoon and evening. If that fails or if you think the problem may be a procedural one rather than an equipment fault, call one of the resident astronomers according to the schedule posted in the control room.

2. **General Rule for Fixing Practically Anything.** If none of the tips which follow apply to your problem, logic and common sense fail to provide an answer, and for some reason you cannot get the knowledgable help you need (like it's Christmas morning or something), GRFPA provides a better than even chance of working.

   (a) Log off/log on. If that doesn't work, then...

   (b) Log off, turn off power to offending equipment, wait 30-60 seconds, turn power back on, log back on. If that doesn't work then...

   (c) Reboot the computer. Go around to the computer, which is hidden behind the cabinets and sound-proofing in the southwest corner of the control room, and press both reset buttons. It will take 5-10 minutes for the autoboot to complete, and during some of that time it may look like nothing is happening. Wait patiently, and eventually you will be rewarded with the familiar ISI logo on the workstation. Log back in and reinitialize your tape if necessary. If this doesn't work, you'll really have to find some help, or go to bed early.

3. **Dome is stuck.** If the dome sticks, Telco will beep at you and tell you on the Telco screen what the problem is. Pause the exposure and turn off autodome on Telco. Go into the dome and use the dome control rocker switch to back the dome away a foot or two from the stuck position, then turn autodome back on and let Telco reposition it. Be sure to report this to maintenance, and the approximate azimuth of

the dome slit when it stuck will be helpful to them. This is a relatively rare occurance.

4. **Accidentally hit "CLR SPACE" key on the data-taker.** This screws up the terminal display. Hit a carriage return and ctrl-A to restore screen. If that doesn't work, see the following item.

5. **Data-taker terminal display is screwed up.** Hit ctrl-A. If this doesn't fix things, then logout, cycle the terminal power, logon as *user*, type *912c* followed by a linefeed (*not* carriage-return). The terminal then prompts: "next command:" to which you reply *d warm*. This should restore the terminal without destroying its memory of the tape drive status. This should be safe to do during an integration without loss of data or integration parameters, but we don't guarantee anything.

6. **Accidentally hit Caps Lock on the data-taker.** You will recognize this if everything on the data-taking terminal is in capital letters separated by slashes. Press Caps Lock again to release it, and try changing screens; if that doesn't work try ctrl-A; if that doesn't work proceed as described in the previous item.

7. **Humidity alarm goes off repeatedly when it is not obviously humid.** Call the 3-m and ask what the humidity level is. If it is not close to the limit, the alarm sensor may need to be cleaned. The sensor is located on the telescope tube; ask the 3-m technicians or consult the Observer's log for details on how to clean it. The sensor is usually pretty accurate. Be very cautious about doubting it. Above all, protect the mirror. You can cross-check the humidity by looking at the hygrometer in the southeast window of the control room. It has been cross-checked numerous times against a sling hygrometer, and has been found to be very accurate until it gets saturated when the humidity reaches 100%, after which it is slow to dry out.

8. **CCD images are in focus but stars are donuts on the TV.** The TV optical path includes a folding-flat mirror that may need adjustment in order for images on the TV to be in focus. The mirror position can be adjusted by a metal knob located just inside and above the small access door on the side of the tub. This adjustment is best done by two people, one to turn the knob and another to watch the TV.

9. **"Set Spectrograph" command aborts** with a message that the data-taker cannot communicate with the controller. Cycle the spectrograph controller by unplugging and reconnecting the controller power cable, a slim black cable to the right of the filter access door. On the data-taker, hit ctrl-Y, logout, then log back in. If problem persists, call technicians at the 120-inch.

10. **Autoguider is failing.**

    (a) Check that the autoguider knows the correct tub PA on the Telco display (13 selected on the Telco display thumbwheel). If the PA given is incorrect, try pressing reset on Telco.

    (b) Make sure the choice of reticle size, background position, and relative times of TV integration and autoguider sampling are as specified in the Nickel Telescope manual (LOTR 36, pp. 31-34).

    (c) Try changing the sensitivity setting on the autoguider. If the setting is fairly low, try increasing the setting to increase the scale factor for pointing corrections. If the setting is fairly high, the pointing corrections may be excessive and a lower setting may be appropriate.

    (d) Make sure the tracking rates specified with the thumbwheels in the Telco panel are appropriate – zero if no manual tracking corrections are desired, or nonzero to correct for systematic deviations in tracking (see Nickel Telescope manual p. 36). Standard rates are -0.040 in RA and 0.000 in dec, but these may change.

    (e) If it is extremely windy, try using the windscreen (but avoid telescope vignetting). Remember, the telescope controller does not know the position of the windscreen. If you're east of the meridian the telescope will be driving away from the windscreen so it's not such a worry; but if you're west of the meridian, don't forget the telescope is driving down towards the windscreen. Also, if the windscreen is clear for one object, don't forget it may occult another.

    (f) If guidestar is quite faint, increase TV integration time or try another star and see if tracking is better.

(g) When autoguider is on, check the autoguider display for any revealing messages. In particular, if the display indicates "JOYSTICK MOTION" when you aren't touching the joystick, this may indicate that wheels next to the joystick that can input joystick adjustments are not at their zero positions. Reset the wheels or press reset on Telco.

9 APPENDICES

9.1 Dewar Numbers and CCD Characteristics.

CCDs at Mt. Hamilton are identified by a number assigned to the dewar in which it is contained. The following list indicates which dewars may be used at the 40". When the observer logs onto the data-taking system, the computer senses which CCD is to be used, selects the appropriate readout parameters, and identifies the CCD at the top of the data-taking screen.

Dewar 1: Texas Instruments 500x500 thinned CCD. Used for spectroscopy and photometry. Good UV response of the chip down to the atmospheric cutoff is compromised by absorption in the camera lens, so the useful spectral range is $\lambda\lambda$3850-8800. The dewar must be kept cold at all times.
Read noise: 8 electrons rms   2.5 electrons/DN   15μ pixels
Full well: 30,000 DN, but nonlinearities of ~1% are seen above ~22,000 DN

Dewar 2: Tektronix 512x512 thinned CCD. Excellent charge transfer and uniformity. QE ~10% at 4000Å, ~50% at 7000Å. Used for photometry.
Read noise: 11 electrons rms   4.1 electrons/DN   27μ pixels
Full well: 450,000 DN

Dewar 5: GEC 385x576 CCD, with one half permanently masked for use as a frame buffer for high-speed photometry. Excellent charge transfer and uniformity. No response below about 4500Å.
Read noise: 6 electrons rms   5.4 electrons/DN   22μ pixels
Full well: >32,000 DN

Dewar 9: Reticon 400x1200 thinned CCD. Although not yet available, anticipated characteristics are excellent uniform UV response and good low- level charge transfer, 4 electrons rms read noise and 500,000 DN full well.

9.2 Logsheets.

Here are two examples of logsheets you may wish to use, or you may wish to design your own.

Lick Observatory

CCD LOG SHEET

page____ of____

DATE: ____________________ PROGRAM: ____________________

CCD: ____________________ OBSERVER: ____________________

DATA TAPE: ____________________

Obs	Object	Filter	Exp	Time	Comments

Nickel Telescope CCD Spectrograph

page ____ of__

Observer(s): __________ Program: __________ Lens: __________ Tape No. ______

Date: __________ Clouds/Clarity: __________ Stage: Y= ____ CCD: ______ CCD Temp: ____

Obs	File						Coll	CCD Stage	Grism Tray		Aperture		Filter Wheel		
No.	No.	Object	Exp	H.A.	PST	S"	Focus	(λ_C)	Set	ID	Set	ID	Set	ID	Remarks

9.3 Major Differences Between the 120" and 40"

Many observers come to the 40" with prior experience with the 120" CCD spectrograph, and vice versa. If you are used to the 120" setup, the major differences you will find are as follows:

- A night assistant is not provided, so you must be a lot more self-sufficient. In general you will be busier, but perhaps that's just as well because there's less outside stimulation to keep you awake! You must learn to do more things, such as entering the star coordinates into the telescope setting program, actually setting the telescope, using Telco and operating the autoguider.
- It is not possible to switch between direct and spectroscopic modes.
- At the 40" the TV is not mounted on a movable stage, so you cannot search around for an offset guide star. In spectroscopic mode you must guide off of the slit, and in direct mode you get one fixed offset field in which to find a guide star.
- There is not a fancy reticle projected onto a pellicle for the guide TV. There are the same three cursors (+) which you can move around on the TV, but most people just mark on the screen with a grease pencil.
- The line lamps at the 40" are switched from the data taking terminal main menu.
- At the 40" there is not a spectrograph controller like the one with the thumbwheels at the 120". All controlling of the spectrograph is done via the computer.
- The x-stage for the spectrograph is controlled by computer, which makes it easy to change central wavelength during the night.
- There is a choice of lenses for the CCD camera.
- There are only two diagonal mirror positions at the 40", which correspond to positions 2 and 4 at the 120".
- Perhaps most important of all, the 40" late night TV is crummier.

9.4 Checklist for Setting Up

- *REFILL DEWAR*
- Check grisms
- Mount filters if necessary
- Open manual dark slide
- Remove RA locking bar
- Turn on telescope power
- Be sure sufficient logsheets and mag tapes are on hand
- Log in on both terminals
- Start Telco program on PET
- Check dew sensor on, audio on, sensitivity 25
- Turn on the image display monitor
- Turn on Telco monitor, check time and date
- Update the DTS header (Z3)
- Load and initialize (Z2) a tape
- Take a test frame
- Set up CCD windows
- Determine grism stage settings
- Focus instrument
- Save setups
- Take darks
- Take flats and wavelength calibrations
- Weather permitting, leave mirror exposed to sky

9.5 Checklist for Observing

- Do any remaining calibrations
- *REFILL DEWAR*
- Check
  - dome open
  - windscreen down
  - rainscreen stowed
  - mirror cover open
  - *dome floor clear*
  - lights off
- Turn on TV, check tv reverse switch (normally up)
- Turn on telescope tracking and auto dome
- Check telescope coordinates
- Check dome centering
- Focus telescope
- For direct, verify TV to CCD offsets
- REFILL DEWAR as required during the night (probably once at mid-night)
- Keep an eye on the weather

9.6 Checklist for Closing

- Turn off telescope tracking and auto dome (leave Telco on)
- Turn off TV (leave on TV control panel and autoguider)
- Take flats and wavelength calibrations
- Be sure all calibration lamps are off
- Close manual dark slide
- Close mirror cover
- Close dome
- Raise windscreen
- Cover with rainscreen
- Install RA locking bar
- Turn dome to stow position
- Turn off telescope power with panic button
- *REFILL DEWAR*
- Remove data tape and turn off tape drive
- Log out and turn off both terminals
- Turn off display monitor
- Turn off printer
- Leave dew sensor on, audio on
- Fill out User's and Trouble Logs
- Call 120" (ext. 51 or 53) and report any malfunctions
- Take a last look around and be sure everything is off that should be off
- Lock both doors
- Ask yourself: Did you *really* fill the dewar?

Nature will tell you
a direct lie if she can.
—Charles Darwin