UNIVERSITY OF CALIFORNIA

LICK OBSERVATORY TECHNICAL REPORTS

No. 66

THE KAST DOUBLE SPECTROGRAPH

Joseph S. Miller

Remington P.S. Stone

Santa Cruz, California

September, 1994

SUMMARY

GENERAL
Scale at cass focus = 3.86 arcsec/mm
Arcsecs/pixel = 0.78
Range of good performance:
Blue camera 3000-7000 Å
Red camera 4000-11000 Å

SLIT (p.20)
Slit setting =
10288-200(slit width(mm)) =
10288-51.82(slit width(arcsec))
Max opening = 145 arcsec.

Position	Name
0	open
1	.5 arcsec
2	1 arcsec
3	1.5 arcsec
4	2 arcsec
5	2.5 arcsec
9	9 arcsec

COLLIMATORS (pp. 25, 27)

side	typical	min	max
blue	40000	3500	71500
red	20000	4700	45000

FILTER WHEELS (pp. 21-23)

pos	upper	lower	user's
0	open	open	open
1	--	BG14++	--
2	Spinrad NS	OG570	--
3	ND5.0	ND6.25	--
4	ND1.25	GG455	--
5	ND7.5	$CuSO_4$	(n/a)
6	ND2.5	GG385	(n/a)
7	calcite	GG495	(n/a)

DECKER (p. 18)
Max opening = 145 arcsec.

Position	Name
0	open
2	spect
3	finger

DICHROICS and MIRROR (p. 23)

To get	Type
clear	out
dichroic	D46 or D55
mirror	mirror

X-Y STAGES (pp. 26, 29)
Increasing setting (37 pixels/large dial rotation (1 mm)) moves *to*:

side	x (λ)	y (row)
blue	lower	higher
red	higher	lower

DIRECT WINDOWS (pp. 27, 30)

side	window
blue	210, 200, 0, 530
red*	200, 200, 25, 450

*mirror tilt = 19000

FILTER TRAYS (pp. 25, 29)

pos	blue	red
0	open	open
1	U	GG455
2	wide G	GG495
3	empty	OG550
4	(n/a)	Spinrad NS

LOGIN: user/password/kast
user/password/dx vista/password

GRISMS (p. 25)

grism	grooves/blaze	str. thru	Å/pix	range	nominal coverage
1	452/3306	4780	2.54	3050	3150-6200
2	600/4310	4340	1.85	2220	3300-5520 (matches D55)
3	830/3460	3880	1.13	1350	3200-4550 (matches D46)

GRATINGS (p. 28) The total range for the tilt is 5400-35400.

grating	grooves/blaze	Å/pix	range	tilt	useful range (approx.)
1	600/5000	2.35	2820	$2.21(\lambda_c)+5631$	3800-10000
2	600/7500	2.32	2780	$2.29(\lambda_c)+4980$	3800-10000
3*	830/8460	1.70	2040	$3.15(\lambda_c)+5097$	3800-10000
4	1200/5000	1.17	1404	$4.72(\lambda_c)+4178$	3800-7310
5	300/4230	4.59	5508	$1.10(\lambda_c)+5716$	3800-11000
6	300/7500	4.60	5520	$1.09(\lambda_c)+5742$	3800-11000

*830/8460 second order: 0.85 Å/pix, range 1020 Å; $6.51(\lambda_c)+4260$; 5293Å max.

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"He who meddles in the study of the heavenly bodies runs the risk of losing his sanity as completely as Anaxagoras, who took an insane pride in his explanation of the divine machinery."

-Socrates
(as quoted by Xenophon)

"I'm astounded by people who want to 'know' the universe, when it's hard enough to find your way around Chinatown."

-Woody Allen

NOTICE TO THE READER

Things are bound to change from time to time in response to changing needs of the community or just normal improvements, so if the configuration for a component given by the Kast controller differs from that described here, the controller will probably be correct. In such a case, you may wish to check visually, or by looking in the User's Logbook, or by asking a knowledgeable person. Just because something is written here doesn't mean it will remain true for all time, but we will try to keep things as consistent as possible.

We sincerely thank Tony Misch for his superb 3-D drawing of the optical layout of the Kast spectrograph.

TABLE OF CONTENTS

I. INTRODUCTION

The double spectrograph at the Shane 3-meter telescope was made possible by a generous gift from William and Marina Kast. It was designed by Joe Miller, based somewhat loosely on the previous Lick cassegrain spectrograph and on the low resolution spectrograph for the Keck Telescope, but with many major improvements. It went into operation in early 1992.

Many features of the instrument will be familiar in concept to users of the prior cass spectrographs, but in reality not much remains unmodified. The data taking and analysis systems are quite similar in appearance to the prior versions, and should be easy to adapt to. The main differences facing former users are having both the red and blue sides of the spectrograph available semi-independently, the use of an x-terminal for the data taking system, and the new and greatly improved spectrograph controller.

A very convenient aspect of the instrument which has been retained from earlier versions is the ability to switch quickly between direct imaging and spectroscopic modes of operation. This capability, combined with a good telescope offset program, is sometimes crucial for centering the spectrograph on very faint objects.

Light Paths

Please refer to the superb 3-D drawing by Tony Misch (facing page). The converging light from the telescope is focused at the slit of the slit-decker assembly, and then passes through three independent filter wheels known for historical reasons as the upper, lower, and user wheels. These components are in common for both sides of the spectrograph.

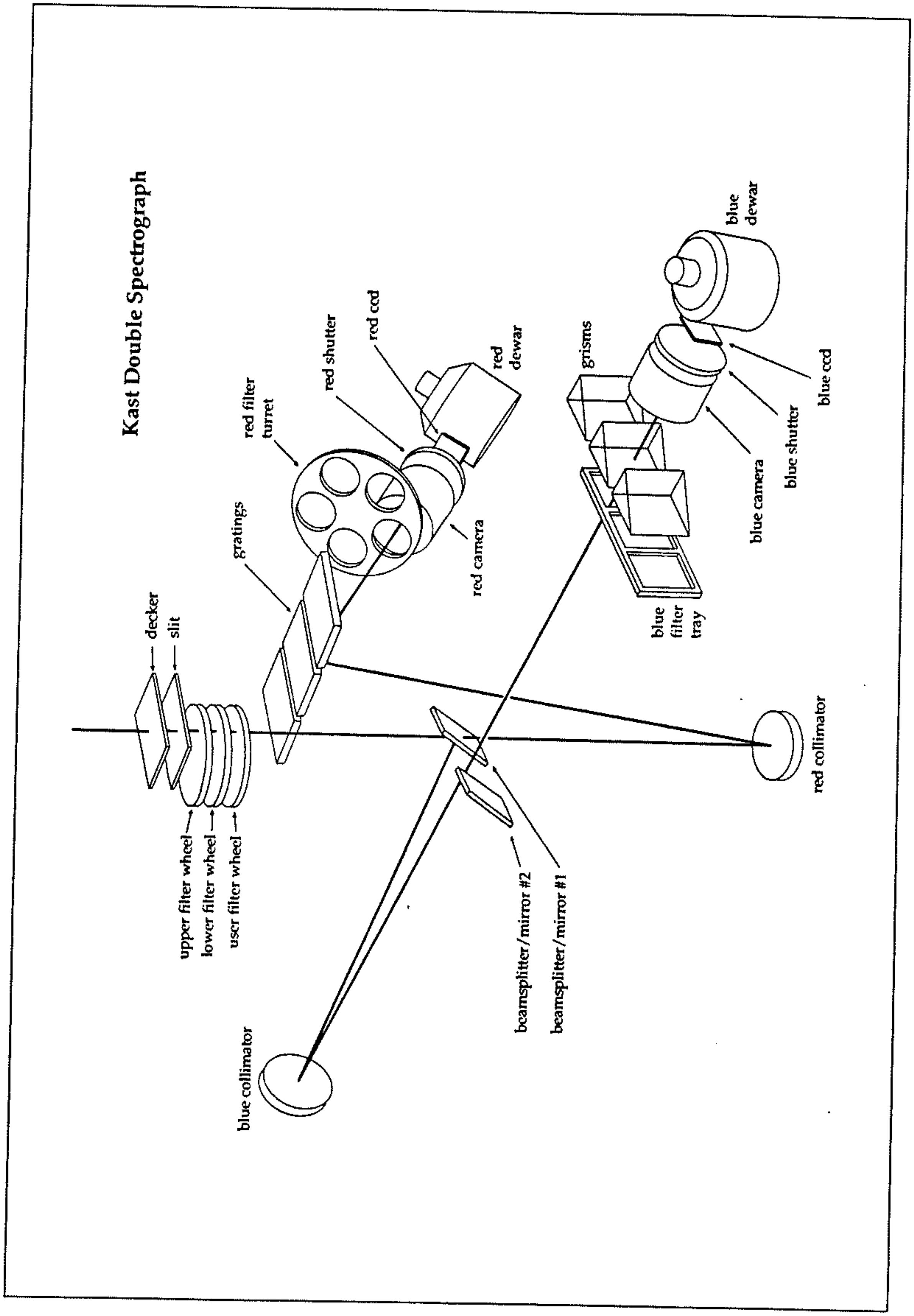
The beam then passes through a region where one of three possibilities may occur. The light can (1) strike a dichroic mirror which passes the long wavelength light (the "red side") and reflects the shorter wavelengths (the "blue side"), (2) the light may strike an aluminized mirror which reflects all the light to the blue side, or (3) nothing can be in the beam, which allows all of the light to go to the red side. These options may be selected remotely.

On the red side, after striking a silvered collimator, the beam proceeds to a reflectance grating and then passes through a filter wheel that can accommodate four filters up to 5.5-in. in diameter, and then goes on to the camera-shutter-dewar assembly. Any of three positions in the grating carrier can be selected and tilted by remote control, and the user may have either three gratings, or two gratings and a flat mirror (for direct imaging), mounted in the carrier. The dewar is mounted on an x-y stage to allow positioning of the spectrum on the CCD.

The blue-side light path consists of an identical but aluminized rather than silvered collimator, followed by a filter slide capable of holding three filters up to 4.5-in. in size. The light then passes through one of three remotely selectable grisms (or no grism for direct work) and then to the camera-shutter-dewar assembly. This dewar is also mounted on an x-y stage, but since the Reticon 1200x400 CCD can record very nearly the entire useful spectral range produced by the camera, translating the dewar in the dispersion direction will not gain much. However, it is not uncommon to move the blue side stage in the x-direction in order to gain a hundred or two angstroms at one end or the other.

There are no manual dark slides. The shutters are quite close to the CCDs and are pretty light-tight with respect to the dome lights, at least.

The scale is very nearly the same on the two sides.


Kast Double Spectrograph
red filter turret
red shutter
red ccd
red dewar
gratings
red camera
decker
slit
upper filter wheel
lower filter wheel
user filter wheel
grisms
blue dewar
blue ccd
blue shutter
blue camera
blue filter tray
red collimator
beamsplitter/mirror #2
beamsplitter/mirror #1
blue collimator

System response

The cameras on both sides are all-refractive. The camera lenses are temperature controlled; focus is a function of lens temperature. The focal planes on both sides appear to be quite flat. You may observe some small-scale variations in the focus due to irregularities of the chip.

Blue: The design range of the camera is 3000-7000Å. It looks good to atmospheric cutoff. Peak efficiency of the entire system including the telescope is between 5 and 20%, depending on setup. The blue side operates in first order, and due to the wavelength coverage, red leak should not be a problem. If you're imaging on the blue side, remember that the lens performance deteriorates past 7000Å.

Red: The design range of the camera is 4000-11000Å. Peak system efficiency is in the vicinity of 30-40%, depending on configuration. Response is decreasing rapidly by 10,500Å, but successful observations have been made out to 10,830Å. You will need to suppress second order if you go beyond twice the effective cut-on point of the dichroic you use. Remember that the old filter wheels are in common for both beams, so use the 5.5" round filters in the red camera filter wheel. Noticeable fringing on the red side starts at about 7000Å. For most objects, red exposures will probably go faster. Do multiple reds if necessary to avoid red saturation during one blue exposure.

Hardware and Software

If you are a first-time user (or just feeling a bit rusty), please ask for help on your time request. A resident astronomer will be assigned to orient you and help you get started.

The computer in use at time of writing is the now aging but often upgraded ISI, a VME-bus UNIX machine which incorporates two 68030 CPU's. This computer serves as the data taking device, the spectrograph controller, and the data analysis system. Attached components are 32 Mbytes of memory, a gigabyte hard disk (with about 150Mb reserved for image storage), an 8-plane color display, 9-track and Exabyte tape drives, and an Apple Laserwriter. Various monitors are attached, including an X-terminal for the data taking system.

An effective scheme seems to be to run Vista from the old monochrome workstation, the data taking system from the new x-terminal, and the spectrograph controller from the small VT-100 terminal.

Both the data taking system (DTS) and the spectrograph controller are menu driven, and are quite friendly. You will probably find them to be nearly self-explanatory. Generally, you type the letter which corresponds to the function you wish to perform, and it will prompt you for any additional information required.

The data analysis system available on the mountain is a subset of VISTA, an image analysis system developed here at Lick. If you are not familiar with Vista, a complete manual is available in software. Most users perform rather limited analysis at the telescope, and use only a few of the many features available in VISTA. The point is, if you're an IRAF person, you can quickly learn enough to take a quick look at your data without learning a whole lot of VISTA. The most commonly used functions are

rd (read disk into buffer)

tv (displays image from a buffer)

itv (interact with the image - presents a submenu)

mash (combine image rows and background subtract for a spectrum)

plot (either to the screen or hard copy)

For help, on the VISTA terminal type help for a general listing, or help <name of function> for more specific assistance.

Telescope Technicians and Night Assistants

All Telescope Technicians (TTs) can operate the telescope and all Night Assistants (NAs) are TTs, but on a given night one TT will be assigned as the "night assistant." The NA's primary duties are to 1) protect the telescope, and 2) help you get as much astronomy done as possible. Please notice the priorities. The NA does have the authority (as well as the responsibility) to terminate the observing at any time in order to protect the telescope or equipment. Usually this means closing the dome in case of high humidity, or ash fallout from a nearby forest fire, or high winds. Please read the Director's

Memo of 30 March 1983 reproduced in the Appendix, which outlines some of the mutual responsibilities of the TTs and observers.

In general, the NAs are extremely helpful and cooperative. Ask for what you want, and they will try hard to provide it.

One occasional source of friction is the TV (that is, the late-late show TV). Some observers like to watch it, while others detest it. If it is interfering with your work, ask for it to be turned down, or that headphones be used, or that it be turned off. The science has clear priority. Generally the NAs will be sensitive to your needs, so it probably won't be a problem.

The present scheduling practice is to also provide a TT for the first half of the night. The TT's primary duty is to provide expert technical repairs as needed, and then to carry out other tasks, usually maintenance or fabrication. However, they can help out with NA functions if the assigned NA is temporarily unavailable.

II. Components on the Telescope

After the initial remarks on safety, the order of discussion in this chapter will generally follow the light path through the system.

Safety

Every observer will have to get access to some items on the telescope when setting up, if for no other reason than to check them. It is necessary to use the mobile lift platform known as "the cherry picker" for some of this access. There are possible dangers to both the astronomer and the telescope in its use. Do not attempt to use it unless you have been checked out on it.

The biggest danger to the astronomer is in falling off. There is a rail which goes all the way around, but at two points there are portions of the rail which swing up out of the way to permit you to board the platform. Always swing *both* of these back into position after you board, as they may save you from a possibly lethal fall.

Another hazard to the astronomer would occur if someone moves the telescope into you while you are up there 10 or 15 feet above the dome floor. This nearly happened once, and we have instituted procedures to guard against it, but if the night assistant is present in the control room, you should mention what you're planning to do.

More likely than damage to the astronomer is damage to the telescope. The cherry-picker is a massive vehicle, and it can be moved pretty fast, so in case of a collision with the relatively delicate spectrograph and telescope, a great deal of damage could result. Move very carefully and slowly when close to the telescope. There is a "deadman switch" which you must stand on to make the thing move, and bear in mind that you can always make an emergency stop just by raising your foot off of that switch.

When you raise the cherry-picker platform, it's important to keep a very sharp lookout to be sure that none of the parts of the lift or platform strike anything. When you get up close to the instrument, it's often best to switch to slow lift speed in order to maintain better control.

We also have some gray metal stairs-on-wheels, and if they are tall enough to reach what you need, their use is preferred just because they pose less of a hazard.

Flat Field Lamps

There are two flat field sources mounted on top of the secondary mirror housing so that they shine up onto the dome. Irregularities on the dome surface may be ignored since they are so far out of focus. In order for these lights to reach the detectors, the primary mirror cover must be open, and the diagonal mirror must be in position 3 or 4. Be aware that in position 4, the edge of the periscope may partially occult a full field direct window, so for directs position 3 is recommended.

One lamp is rather dim and red, suitable for wide or intermediate band direct flats, and the other is much brighter and better suited for dispersed or narrow band direct flats. They are controlled by two buttons in the control room which are on the tub control panel. One button selects either the bright ("blue") lamp or the dim ("red") lamp, and the other turns on power to whichever lamp is selected.

Tub

The *T*elescope *U*tilization *B*in (TUB) is that portion of the telescope below the primary mirror cell. It acts as a carrier for the cassegrain instrumentation, including the TV acquisition and guiding system, the diagonal mirror system, various lamp sources and the spectrograph itself.

Diagonal Mirror

There are four switch-selectable positions for the diagonal mirror carrier. Position 1 may be completely empty, or it may contain components of private instruments; its use is not recommended. Position 2 puts a full surface flat mirror into the beam, which diverts all the light to the TV for field acquisition; no light reaches the detector. A white card on the back of the mirror in position 2 directs light from the tub quartz and/or line lamps onto the slit for setting up or wavelength calibration. In position 3, a portion of the diagonal mirror that has a hole in it is positioned so that light from the object passes through the hole to the detector, and the surrounding mirror is available for offset guiding. Finally, in position 4, the mirror is entirely out of the way, but a periscope is in position to view the slit. The slit jaws are tilted slightly, and light reflected from them is directed to the periscope, which passes the light on to the TV for guiding.

Acquisition and Guide TV

A very sensitive integrating CCD camera is used for object acquisition and guiding. It is mounted on a remotely controlled x-y stage for offset guiding.

Line and continuum lamps

First let's dispose of the in-the-tub continuum lamp, because you probably should never use it. The reason is that it illuminates the slit in a very different way than sources in the sky, so it can be quite misleading. If all you need is a source of light, that's fine; but bear its deficiencies in mind. More sky-like continuum illumination is provided by the flat field lamps mounted on the secondary ring.

There are a variety of lamps available in the tub. A switch panel mounted on the tub allows the user to preselect various combinations of line lamps to be operated from the readout room. Each lamp is controlled by a 3-position toggle: up for "relay 1", center for off, and down for "relay 2". Relay 1 is operated by a push-button in the control room arbitrarily marked "HeHgA", and relay 2 is controlled by a button marked "Ne". In fact, of course, you can put whatever combination of lamps you want on either relay. Here is a list of the lamps available in left to right order on the tub switch panel:

1. Helium
2. Mercury - Cadmium
3. Mercury - Argon
4. (unused)
5. Neon
6. Helium - Argon
7. Argon

A few sample spectra are presented in the Appendix.

Please keep the lamps turned off when not in use, because they have short useful lives, and they are very expensive. This applies particularly to the cadmium lamp, which has a life of only a few hours, and costs over $200 per copy!

The cadmium lamp takes about 2 minutes to warm up enough to get satisfactory cadmium emission, although the mercury component is apparent in just a few seconds. The other lamps are usually ready within seconds, but as they get old their characteristics may change. Line strength ratios vary with age and 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.

Tub rotation

The entire tub can be rotated remotely from the control room. The usual reason for doing this is to put the slit at some preferred position angle. For example, you may wish to have the slit at the mean angle of atmospheric dispersion, and a program available on the VISTA terminal will calculate this for you. All the tub contents and the spectrograph rotate with the tub, so nothing changes except the relationship of the sky to the tub contents; thus, sky orientations on the TV and on the CCD rotate as the tub rotates. This makes manual centering and guiding a bit more of a challenge, but the autoguider takes account of tub angle and is unaffected.

The standard tub position angle (and the angle at which it is usually stowed) is 90°, which puts the slit east-west. The position angle is read most easily from the telescope status display - ask the night assistant to show you where to look. It is not possible to rotate through position angle = 20° from either side (this is a precaution to keep the cables from being wound too far). Any position angle can be reached, but it may require going around the long way. In many cases, using the supplementary angle will save time.

III. Spectrograph

GENERAL SPECTROGRAPH PARAMETERS

Scale at Cassegrain focus	3.86 arcsec/mm
Maximum slit opening	145 arcsec
Maximum decker opening	145 arcsec
Monochromatic beam size (both sides)	82.6 mm
Collimator focal length (both sides)	1416 mm
Camera focal length (both sides)	188.7 mm
Arcsecs/pixel (neglecting anamorphic mag)	0.78
Approximate range of good performance:	
Blue camera 3000-7000 Å	
Red camera 4000-11000 Å	

The spectrograph is fixed to and rotates with the tub. Nearly all components of the spectrograph can be set remotely from the control room via the spectrograph control terminal. The only exceptions are the x-y stages, and of these only the blue x motion is routinely changed, so you may wish to plan your program so as to avoid the necessity of resetting the blue x-stage during the night.

The convention followed in this manual and on the spectrograph controller is the same; that is, to list and discuss the spectrograph components in the same order as the light flows through the spectrograph, and with the blue side before the red side. Another convention followed wherever possible (but not invariably) is that fully open (or clear, or empty) for each device is position number zero. The goal is to make everything as easy as possible at 3 AM, when even the most stalwart of us may become groggy.

Control of the spectrograph is accomplished from a terminal in the control room, and is discussed in detail in the next section. However, in order to understand the information in the following tables which summarize the various components of the spectrograph, we mention here that components may be referred to and selected in a variety of ways. The spectrograph controller allows use of names (e.g., "OG570" or "mirror"), ordinal positions (e.g., "7" for the seventh position in the upper filter wheel), or the actual number of stepping motor steps from the fiducial required (as in "10184" to achieve a 2 arcsec wide slit). This is why, in the tables following, we list these apparently redundant options.

Items in Common for Both Sides:

Waveplate

This is part of the spectropolarimeter, and is neither a public item nor usually present; ignore it.

Decker

The decker is a long reflective plate which overlies the slit. The observer may select a variety of options including slits of varying length, rectangular blockers of varying widths, circular blockers of various diameters, a set of non symmetric slots for bizarre sky subtraction schemes, or the decker may be withdrawn completely for unobstructed direct imaging. One position called "the finger" places the end of the rectangular blocker just off of the slit for use as a reference for positioning objects at the center of the slit length (it's usually a convenience in the reduction if everything falls along the same rows).

Twenty named positions are available, of which 0-3 are protected and may not be renamed by users.

Notice that there are two full length positions (0 and 2). Position 0 may be used for either spectroscopic or direct. Position 2 will allow a full length slit for "normal" slit sizes, but will be partially obstructed by adjacent portions of the decker if the slit is fully open, as for a direct window. Position 2 is closer physically to the normally used finger (position 3), so if you are switching between large and small spectroscopic slits, you may wish to use these adjacent positions. In fact the decker moves very rapidly, so 0 will work just as well. But don't use 2 for directs. A full-length decker on the Reticon 400x1200 chips with 27μ pixels is 185 pixels = 145 arcsecs. This corresponds, of course, to the full length of the slit itself.

The decker slide is presently configured as follows:

Position*	Name*	Contents	Step number
0	open	fully open	350
		asymmetric slots	560
		"	610
		"	660
		"	710
1	2 arcsec	2 arcsec long	815
		15 " "	840
		30 " "	865
		60 " "	890
2	spect	full length, not for directs	940
3	finger	end of blocker near slit	980
		2 arcsec rectangular blocker	990
		4 " " "	1010
		6 " " "	1030
		8 " " "	1045
**		9 arcsec circular blocker	1160
**		6 " " "	1335
**		3 " " "	1507

*Named positions of the decker (positions 0-3) are not user changeable

**The occulting disks are aluminized spots on a quartz plate which is *not* AR coated.

Slit

The aluminized slit opens bilaterally, and the smallest available step is a tiny fraction of a pixel. For convenience, the most commonly used slit sizes may be selected from the spectrograph controller simply by typing in the desired size in arcsecs according to the table below. Alternatively, you may compute the step numbers for any size you wish and enter them directly, so the result is very flexible for the observer.

The scale should be very nearly (but not precisely) the same on the red and blue sides. Note that the slit gets smaller for larger numbers, and is fully closed at 10288. Remember that you need at least a two pixel slit to minimize aliasing problems with narrow emission lines.

There are 20 named slit positions, of which 0-9 are protected and may not be renamed by users.

scale at slit = 3.86 arcsec/mm
1mm = 3.86 arcsec = 4.936 pixels = 200 stepper motor steps
1 pixel = 0.78 arcsec = 0.2026mm = 40.52 steps
1 arcsec = 1.28 pixels = 0.259mm = 51.82 steps
slit setting = 10288-200(slit width(mm))
= 10288-51.82(slit width(arcsec))

Position	Name	Step number
0	open	2250
1	.5 arcsec	10262
2	1 arcsec	10236
3	1.5 arcsec	10210
4	2 arcsec	10184
5	2.5 arcsec	10158
6	3 arcsec	10133
7	4 arcsec	10081
8	5 arcsec	10029
9	9 arcsec	9822

Filter Wheels

There are three stacked filter wheels called, from top to bottom, the upper, lower, and user's wheels. One position of each wheel (position 0) is always empty.

Filters in the top three wheels will affect both beams of the spectrograph. If you want to use different filters on the two sides, they must be installed in the holders in front of the cameras. Since these later filters are in the collimated beam they must be bigger than 3.5 inches in diameter in order to avoid vignetting for direct imaging (a 2" square filter will reduce the effective aperture to about 1-meter; if this is your plan, it would surely be more politic to ask for one-meter time in the first place).

Order separating filters should not be necessary in typical double-beam use, except in the far red.

Upper Filter Wheel

Position	Name	Contents	Step number
0	open	empty	257
1	(n/a)	(not in use)	457
2	Spinrad NS	Spinrad night sky*	657
3	ND5.0	neutral density 5.0 mag	857
4	ND1.25	neutral density 1.25 mag	1057
5	ND7.5	neutral density 7.5 mag	1257
6	ND2.5	neutral density 2.5 mag	1457
7	calcite	calcite prism	22

*Spinrad night sky filter pass band is ~6100 - 7600Å.

Lower Filter Wheel

Position	Name	Contents	Step number
0	open	empty	288
1	BG14++	BG 14++	488
2	OG570	OG 570	688
3	ND6.25	Neutral Density 6.25	888
4	GG455	GG 455	1088
5	CuSO4	$CuSO_4$*	1288
6	GG385	GG 385	1488
7	GG495	GG 495	88

* This is a new, good quality, full slit length crystal.

User's Filter Wheel

The user's filter wheel accepts up to four filters of your choice mounted in our 2" square holders. Filters may be up to 8mm deep. Someone will definitely need to show you how to mount the filters on the first occasion. There's a card in the control room on which you may note which filter is in which position. Please remove your filters at the conclusion of your run. It's definitely safest *not* to assume that if the card is blank there are no filters in place. We suggest always setting this wheel to the open position if you're not using it, just in case.

We have a fairly large library of narrow and intermediate band interference filters available, mostly on loan from astronomers within the UC system. It's clearly best not to assume that any specific filter will be here when you need it, as the owners are certainly free to remove them at will, and they may on occasion be loaned out. Since they're not really ours, we don't really control them. Any arrangement to take them elsewhere should be made with the owners, and duly recorded on the mountain as well.

The user's filter wheel is set up like this:

Position	Name	Contents	Step number
0	open	empty	230
1	--	(user determined)	550
2	--	(" ")	870
3	--	(" ")	1190
4	--	(" ")	1510

Dichroics and Mirror

There are two separate carriers, either one of which (or neither, but not both) may be in the beam. Either carrier may contain one of the overcoated dichroics, or an aluminized flat mirror. The carrier called 1 is the one farthest away from the door, and moves in an E-W sense with the tub at its standard position angle (or left-right as seen from the access door); number 2 is closer to the door and moves N-S (or toward and away from the door).

Crossover for the blue dichroic (D46) is about 4650Å, and for the red dichroic (D55) it is about 5500Å. About 200 angstroms of the spectrum are affected by the crossover of the dichroic. Additional dichroic filters with different crossovers will be available in the future.

Insertion or removal of the D46 dichroic shifts the red spectrum by less than one pixel, but the D55 dichroic shifts the spectrum vertically upward by about 10 pixels.

If you're only using one side at a time, in order to switch sides move the mirror **in** for blue or **out** for red (and don't forget to swap ccds!)

To get	Type	Side illuminated
clear	out	red
dichroic	D46 or D55	both
mirror	mirror	blue

Changing dichroics and the mirror

The dichroics are expensive and fragile. The AR coating is very soft. *We definitely prefer that you ask a member of the telescope staff to change them.* Changing the #2 carrier, the one by the access door, is easy if it is in the **out** position. By contrast, changing the reflector in position 1 (the one away from the door, which moves E-W with the tub at 90 degrees) is very tricky.

To change the #1 dichroic, the grating tilt should be at 5400, the grating load position, to make enough room to lift out the reflector. It will be much easier to access the #1 carrier and keep the #2 reflector safer from an accident if you move the #2 carrier to the in position first, where it will be more out of the way. Turn the top cam 1/2 turn ccw, loosen the bottom locking screw just one turn, and very carefully grasp the dichroic slide by the top. Slide it up and out of the carrier. You'll probably want to hold it by the sides as you get it part way out of the carrier. Be extremely careful not to touch the surface (with *anything, ever*). Store it immediately in the wooden box provided.

Items On The Blue Side:

Collimator (blue side)

A typical focus value is presently about 40000 (but this could change radically). Initially, try increments of 5000 units to focus. The range is 3500 to 71,500. The focus does not appear to be affected by the presence of the dichroic. The off-axis paraboloid is aluminized and overcoated.

Filter Tray (blue side)

There is provision for three square filters up to 4.5" in size, plus an open position. Presently, a liquid $CuSO_4$ + UG-2, which approximates a Johnson U band, and a "wide G" (4700/1200) are mounted. Notice that small filters here in the collimated beam will drastically reduce the effective aperture of the telescope.

Position	Name	Contents	Step number
0	open	empty	20600
1	U	$CuSO_4$+UG2	4800
2	G	wide G	10000
3		empty	15300

Grisms (blue side)

Blue is left in the spectra as displayed on the terminal. To select a grism, type the grism number desired, or 0 for none. We have three grisms and they are all always in place, easily damaged, and carefully positioned, so we see no reason why observers should ever have occasion to touch them. If you think there is a problem with them, *please* do not attempt to solve it yourself; please ask for help.

grism	grooves/blaze	str. thru	Å/pix	range	nominal coverage
1	452/3306	4780	2.54	3050	3150-6200
2	600/4310	4340	1.85	2220	3300-5520 (match D55)
3	830/3460	3880	1.13	1350	3200-4550 (match D46)

X-Y Stage (blue side)

For each direction of movement (x and y), there is one thumbscrew lock, a large black knob with which to move the stage, and a dial micrometer to read the position. Notice that each stage lock actually locks "the other side"; the locking screw near the x-stage micrometer locks the y-stage motion, and vice-versa. This makes sense if you realize that the stage locks are sideways clamps, but the micrometers and handles that move the stages are mounted on the ends of the stages which they push or measure, and what is the end of one stage is the side of the other. Be sure to relock both stages firmly. The clamps are surprisingly effective.

Though there is slop in the screws which move the stages, the micrometers are spring-loaded, so backlash should not affect the reading of the position. One turn is one millimeter, and the scale is 37 pixels per millimeter. The micrometers are read as *aa.bb*, where *aa* comes from the very small dial, and *bb* is read from the large dial.

The two dials for each camera are labeled x and y, and the convention adopted is that x moves along the dispersion, and y moves perpendicular to it. The "normal" y position for each is so that the spectrum falls near the top of the chip for most efficient readout.

The x position for the blue side is carefully chosen to position the chip in the center of the usable image from the camera. This usable image area closely matches the size of the chip. You may be able to make small departures if you wish to extend the coverage to one side or the other of the normal range, but if you move it very far you should expect the new spectral region accessed to have degraded resolution and vignetting.

For the blue side, the sense of the micrometers is that (x) larger numbers moves the spectrum right (shorter central wavelength), and (y) larger numbers moves the spectrum down on the chip (larger central row number).

To summarize the blue side x-y stage motions (scale 37 pixels/turn):

	blue side	
	nominal	+ moves to
x	10.00	lower wavelength
y	10.00	higher row number

Directs (blue side)

A good window for blue directs with the mirror in the dichroic carrier and the blue x-y stage at the nominal settings is: number of rows = 210, number of columns = 200, start row = 0, start column = 530. Check it with the top lights, not the tub lights.

Items On The Red Side:

Collimator (red side)

A typical focus value is presently about 20000. The range is 4700 to 45000. The focus does not appear to be affected by removing or inserting the dichroic. The off-axis paraboloid is silvered and overcoated.

Gratings (red side)

Blue is left in the displayed spectra. The total range for the tilt is 5400-35400. A flat mirror may be inserted into the grating tray for direct imaging on the red side. The tilt to use for access to the grating tray is 5400.

Access to the grating tray is via a long black door just above the red side dewar. It is held closed by two captive screws, and it's hinged at the bottom. Each grating is clearly labeled on the end facing the door, so it's easy to see which ones are there without the necessity of taking them out. Be particularly careful of the fragile ion pump.

The grating positions in the tray are numbered 0, 1, 2, from left to right. A reinforcing plate blocks the position in the middle of the access door, so you may need to change the grating tray position (with the spectrograph controller) in order to check all three gratings. Select position 1 to see the two outside gratings (positions 0 and 2), and either end position to see the center grating.

There is a "Current Setup" card in the control room where you may record which gratings are in which tray positions. We suggest that you always look for yourself to verify that the gratings you requested are where you think they are. If you don't check yourself, don't blame anyone else if the setup is not what you thought.

It is strongly preferred that observers do not change their own gratings. The entire community depends on their good condition, and the replacement cost is thousands of dollars each, not to mention the time involved. If you must do it yourself, do not under any circumstances do so without being explicitly checked out on the procedure. The tilt to use for loading the grating tray is again 5400, and you will need to move the tray in order to gain access to all three tray positions, as previously described. Never place a grating anywhere except in the spectrograph or in the grating file. Again, we prefer that the technicians make any changes required.

grating	grooves/blaze	Å/pix	range	tilt	useful range (approx.)
1	600/5000	2.35	2820	$2.21(\lambda_c)+5631$	3800-10000
2	600/7500	2.32	2780	$2.29(\lambda_c)+4980$	3800-10000
3*	830/8460	1.70	2040	$3.15(\lambda_c)+5097$	3800-10000
4	1200/5000	1.17	1404	$4.72(\lambda_c)+4178$	3800-7310
5**	300/4230	4.59	5508	$1.10(\lambda_c)+5716$	3800-11000
6**	300/7500	4.60	5520	$1.09(\lambda_c)+5742$	3800-11000

*830/8460 grating in second order yields 0.85 Å/pix, range is 1020Å, and the second order central wavelength is given by $6.51(\lambda_c)+4260$. The max tilt of 35,400 restricts lambda < 5293 in 2nd order.

** Note that the 300/7500 is more efficient than the 300/4230 for all lambda greater than ~5400 Å.

Filter Wheel (red side)

There is provision for four round filters up to 5.5 inches in diameter, plus an open position. Notice that small filters here in the collimated beam will drastically reduce the effective aperture of the telescope.

Position	Name	Contents	Step number
0	open	empty	23900
1	GG455	GG 455 (3mm)	4700
2	GG495	GG 495 (3mm)	9500
3	OG550	OG 550 (3mm)	14300
4	NS	Spinrad NS	19100

X-Y Stage (red side)

We assume that you have read the general description of the stages given above in the section "X-Y Stage (blue side)", so we won't repeat that here.

Please be clear on the fact that the observer should not find it necessary to move the x-y stage on the red side. The two dials are labeled x and y, and the convention adopted is that x moves along the dispersion, and y moves perpendicular to it. The nominal y position is so that the spectrum falls near the top of the chip for most efficient readout. The red side x position is set to the middle of the range of good camera imaging. It should never be advisable to move this, since you can get the same effect by moving the grating tilt, and the grating tilt equations are derived for this particular setting.

For the red side, higher numbers in x move to longer central wavelength, and higher numbers in y move the spectrum higher on the chip; that is, to lower row numbers.

To summarize the red side x-y stage motions (scale 37 pixels/turn):

	red side	
	nominal	+ moves to
x	10.00	higher wavelength
y	10.00	lower row number

Directs (red side)

A good window for red side directs using no splitter and the tilted mirror in the grating tray (tilt = 19000) is: number of rows = 200, number of columns = 200, start row = 25, start column = 450. Check it with the top lights, not the tub lights.

More Stuff in Common

Shutters

The Ilex shutter has a minimum exposure time of 1 sec, with timing errors of a few milliseconds.

CCDs

Both sides use uv-flooded Reticon 1200x400 devices with 27 micron pixels, which corresponds to about 0.8 arcsec per pixel. These have excellent UV response (QE at 3200Å ~40%) and are relatively free of blemishes.

The CCDs must be kept cold to preserve the flood, and they should be protected from unnecessary exposure to bright lights. The telescope technicians are responsible for keeping the dewars cold.

The full well depth is in excess of 200,000, but the ADC saturates at about 32k minus the baseline, or usually about 27,000 DN. An easy to remember not-to-exceed number might be 25,000 DN. Gain on both sides is about 3.8 e-/DN. The readout noise is about 6 e-.

On each side there is a 3db attenuator in the output line which doubles the dynamic range at the expense of under sampling the read noise and very faint signals. If you are observing at low signal-to-noise ratios, you may wish to have the attenuators removed. In that case, the gain will be half of the nominal value, or 1.9e-/DN. The usual choice, and the default, is to operate with the attenuators in place. Ask the TA's for help if you wish to remove them.

Suggested operating temperature for both sides is in the range -110 to -125. A warmer temperature will increase the dark current but diminish charge transfer inefficiencies, and vice versa.

In general, if you don't have any prior knowledge of the expected exposure time, a good practice is to take a one second exposure (not recorded), and then scale that to the desired count level to determine the exposure time. It's best not to overexpose the CCDs. Although no permanent harm will be done, it may take some time to completely flush the extra charge.

Eventually the plan is to replace the present chips with Reticon 2048x2048 chips which have 13.5 micron pixels. While the wavelength coverage will be slightly less, the smaller pixels will mean more over sampling, higher spectral resolution (if one wants to narrow the slit), and more optimal pixel size (0.4 arcsec) for direct imaging.

This is a small point, but perhaps worth mentioning. The saturation level is determined not by the well depth, but by the limitation imposed by the 15 bit A-D converter. Thus, if you bin pixels, you may need to reduce the exposure time correspondingly to stay within the 32k capacity of the A-D. Remember too that the actual dynamic range available is not 32k, but 32k minus the baseline. (The baseline is displayed during startup of the DTS).

CCD controllers

There is a separate controller for each side. They are mounted one above the other in a rack near the dewars. They contain most of the temperature and readout electronics for the CCDs, and will be set up by the dome crew. The only thing the observer needs to be concerned about is the temperature readout in the upper right corner of each controller. It reads in degrees Celsius to the nearest 1/10th degree at a location in the dewar near the chip. It should be fairly stable, and in the range -110 to -125 for the Reticon 400x1200 chips.

Ion pumps

There is an ion pump for each dewar, which helps to control any outgassing or minor leakage. They should always be on, and need to be reset in case of a power failure. The dome crew will normally see to this.

If the outside of the dewar starts to get wet ("sweat") it may be due to a bad vacuum, and that in turn may indicate a problem with the ion pump. You can check the vacuum by reading the current through the ion pump on the big gauge on its power supply mounted near it. If the sensitivity for the gauge is at its most sensitive setting, the gauge should read about mid-scale if the vacuum is good. If it reads very much higher, ask a tech to check it.

Dewars

Responsibility for keeping the dewars cold now rests with the telescope crew. The hold time is good, but they MUST be topped off at least every twelve hours, and perhaps more often if you go to large zenith distances and spill nitrogen.

Flexure and Fringing

The flexure situation is considerably better than it was, but is not completely resolved. There is still about three to five pixels of total shift on each side, moving between extreme positions on the sky.

The blue side may shift as much as five pixels parallel to dispersion, but fringing will not generally be a concern, and the shift may ordinarily be accounted for by reference to skylines.

The red side may also shift as much as five pixels in the dispersion direction, and because of fringing this may be a more serious problem than on the blue side. The usual red fringes start to appear at about 7000Å. This may become a particular problem due to the flexure described just above, because if observations at large zenith distances are flattened with straight up flats, the object and flat fringes may not match. If this is a concern, you may wish to take "local" flats.

IV. CONTROL ROOM

Log Sheets

The tape image headers are quite complete, but a paper log is useful for recalling images during the night as well as just keeping track of what happened. Log sheets are available from the telescope techs, or help yourself from the bottom right-hand drawer of the night assistant's desk. See the Appendices for samples. Feel free to design your own, and if you think it's a real winner, leave us some for others to use.

Terminals

Spectrograph Controller

The controller for the Kast spectrograph is operated via a software interface. Use the small screen terminal to the right of the larger VISTA and x-term monitors, or the ISI terminal. An argument against doing everything from multiple windows on the x-terminal is the danger of being in the wrong window and inadvertently resetting the spectrograph, for example, when you meant to start an integration (both require an "r" from the keyboard).

To start the controller, log in as user, then at the user prompt type kast. You will be presented with a menu like that at the top, opposite. The controller will display the current spectrograph setup, and will allow you either to change individual parameters, or to reconfigure using stored setups.

The spectrograph controller operates three separate motor controllers which work in parallel, and devices may be queued up for all three of them. This means that if you want to change a number of items, you should not wait until one is done before requesting the next change. Make as many changes as you wish as quickly as you wish, and the controller will get it all done as soon as possible. The display will inform you what the status is of each item; queued, moving, or move completed.

Immediate mode

The controller comes up in the immediate change mode (top, opposite page). In this mode, you select an item by typing in the letter on the screen which corresponds to the item you wish to change. You will then be prompted to enter a code for the change you wish to make. The code might be an ordinal number corresponding to a filter position, for example, or it might be a precise position in terms of stepping motor steps, or it might be a name which corresponds to the contents of the position you desire.

Entering a number alone, such as xx, will set that item to an ordinal position. A decimal point after a number, as xx., will cause a move to a specific stepping motor step. Adding two exclamation points to an entry, like xx!!, will cause that item to reset during the move. To make incremental moves in stepping motor steps, add an explicit sign, e.g., +xx.

Named entries are probably most convenient just because they're easier to remember. For items which are not user changeable, see the tables in this manual for the names of various positions.

```
Common:                      Current      Setup: None  Device Status
  A. Waveplate               Unavailable               Unknown
  B. Decker                  940.                      Move completed
  C. Slit                    1 arcsec                  Move completed
  D. Upper Filter Wheel      open                      Move completed
  E. Lower Filter Wheel      open                      Move completed
  F. User  Filter Wheel      open                      Move completed
  G. Beam Splitter           out                       Move completed

Blue Side:
  H. Blue Collimator         38000.                    Move completed
  I. Grism                   600/4310                  Move completed
  J. Blue Filter Tray        open                      Move completed

Red Side:
  K. Red Collimator          32000.                    Move completed
  L. Grating                 0                         Move completed
  M. Grating tilt            18825.                    Move completed
  N. Red Filter Wheel        open                      Move completed

                          S. Select Setup                  Z. More...
```

ABOVE: The Kast controller menu in immediate mode. Notice that the third column is empty. See text opposite.

BELOW: Kast controller in setup mode. The bottom line shows which setup is in use (number 1) , and the third column shows that setup.

```
  A. Waveplate               Unavailable  Unavailable  Unknown
  B. Decker                  940.         940.         Move completed
  C. Slit                    1 arcsec     2 arcsec     Move completed
  D. Upper Filter Wheel      open         open         Move completed
  E. Lower Filter Wheel      open         open         Move completed
  F. User  Filter Wheel      open         open         Move completed
  G. Beam Splitter           out          d55          Move completed

Blue Side:
  H. Blue Collimator         38000.       38000.       Move completed
  I. Grism                   600/4310     600/4310     Move completed
  J. Blue Filter Tray        open         open         Move completed

Red Side:
  K. Red Collimator          32000.       30000.       Move completed
  L. Grating                 0            2            Move completed
  M. Grating tilt            18825.       14100.       Move completed
  N. Red Filter Wheel        open         open         Move completed

  R. Set Spectrograph   S. Select Setup                    Z. More..
s New setup (1-20), 0 to remove setup, -1 to make setup=current: 1
```

For user changeable items (user's filter wheel, dichroic carriers, and gratings) you may name them anything you wish. This is done with the Z-1 option (type Z and get a submenu, then type 1 to select the configuration option). For example, if you wish to change the name of user's filter wheel position number 3, type F to select the user's filter wheel, then 3 for position 3. You will be prompted for a position number (in this case it's a redundant 3, but in some non-user naming it's not a redundant question - sorry), and then for a name. Usually it makes sense to give sensible names, like h-alpha, but there's nothing to stop you from naming it Dr. Spock if you wish. When you have the names assigned as you want them, type escape to get back to the calling screen.

Setup mode

During your initial setup of the instrument, it's usually most convenient to operate in the immediate mode. Saved setups are usually recorded after you have the instrument pretty much tweaked up, for quick recall later in the night or the next day.

In the setup mode, you may use any of 20 setups (see bottom example, previous page). To select the setup mode, type S. Then you will be asked to select a setup number between 1 and 20. The setup you selected will be displayed (if it's your first night, it'll probably be a left over setup from some prior observer). Then you can operate on the setup list, rather than directly on the spectrograph. This is convenient if you wish to modify the request list and save it to disk without actually changing the spectrograph, for example. To go back to the direct mode, type S for setups, then 0; this will save all setups and remove the setup list from the screen.

If you are working with a setup list, numbers entered change the list but not the spectrograph. You must type R to actually change the spectrograph setup. It is very important to fix in your mind that recalling a setup does not change the spectrograph. More than one tired astronomer has recalled the setup but forgotten to set the spectrograph, with the unfortunate result of observing with the wrong setup.

If you are working with a setup, but nevertheless wish to force an immediate spectrograph change, add an exclamation to the entry, e.g., xx!. Entering * in the setup list will cause that item to be ignored (including by the reinitialize command).

You may change the naming conventions which the program expects from submenu Z-2 ("options"). Type A, and you will be given three choices for naming positions: Match Setup (1), Physical (2), and Name/Ordinal/Physical (3). Choose the option you want by number. "Match Setup" means that the program will accept whatever naming convention you have adopted for that item in your setup. "Physical" means it will accept only stepping motor step numbers. "Name/Ordinal/Physical" means you can enter any of those three types of names and it will try to figure out what you want.

Ctrl-C aborts moves, Ctrl-Y exits.

X-Terminal

Do not run x-term on the monochrome (ISI) workstation.

To turn on the x-term (rightmost of the two large monitors), press the power button on the lower right front of the monitor.

On the x-term, the mouse cursor must be in the active window. The middle mouse button brings up help relevant to the location of the cursor.

F1 brings a back window to the front, F2 does the opposite. F3 toggles the current window between normal and full screen size.

To move a window, click and hold the left mouse button on the window title bar as you move the window to the new location. To resize, click and hold on the upper right corner of the window. A curious oddity is that before making a window smaller in either dimension, you must first make it larger.

You may print any window on the x-terminal by typing "prwindow" in the x-term window (not the DTS window), then left click on the window you wish to print. The window to print must not be obstructed by other windows.

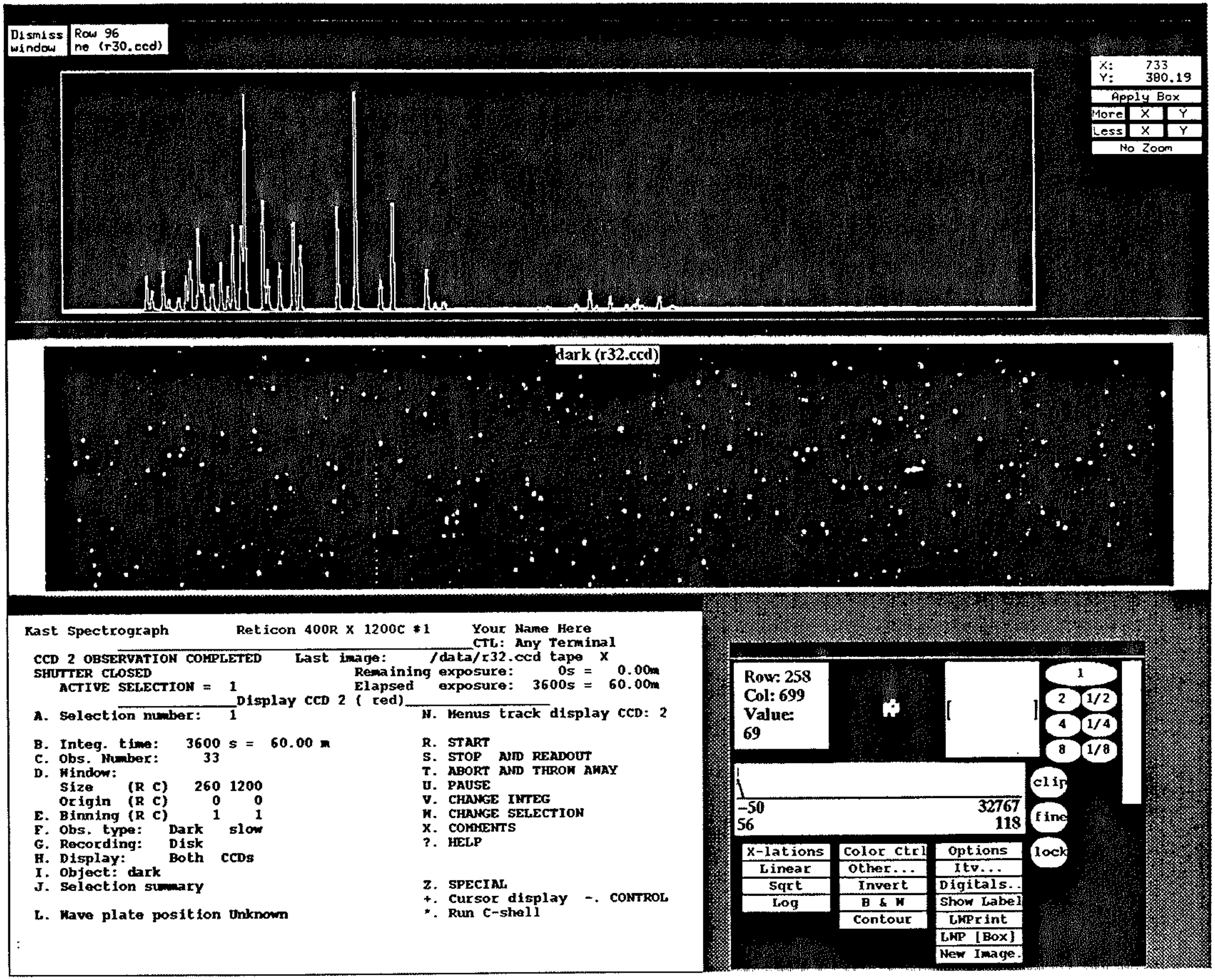
To exit from all the x-term stuff which you have going, click and hold the left or center mouse button with the cursor on the display background, and from the menu which appears, choose "exit everything".

Data Taking System (DTS)

To start the data taking system (DTS), log in as user. Two windows will be created, an xterm window and a dtake window. In the dtake window, type dx. It will take about a minute for the DTS to initialize. During this period do not do anything (like move or resize windows, or even just diddling the mouse impatiently, for example) or the initialization sequence is likely to hang up.

You're free of course to arrange the windows as you wish, but an arrangement which has found general favor is to leave the dtake window in the lower left corner where it comes up, move the display options window to the lower right, grab the upper right corner of the CCD data display window and make it maximum length and minimum height across the middle of the screen, thus leaving the top of the screen for a long plot window which will appear the first time you make a plot from the data display window (sample opposite).

A sample DTS screen is shown on the next page. This screen will be familiar to most users from prior incarnations of the DTS. The red and blue sides are currently run independently, with a separate set of display parameters for each; a tandem option will appear later. The screen refers to only one of the two CCDs, either blue ("CCD 1") or red ("CCD 2"). The CCD in use is identified in the middle of the sixth line of the screen display, as you can see in the example. To switch between CCDs, simply press the number 1 or 2 from the numbers at the top of the keyboard.


Dismiss window
Row 96
ne (r30.ccd)
X: 733
Y: 380.19
Apply Box
More X Y
Less X Y
No Zoom
dark (r32.ccd)
Kast Spectrograph
Reticon 400R X 1200C #1
Your Name Here
CTL: Any Terminal
CCD 2 OBSERVATION COMPLETED
Last image: /data/r32.ccd tape X
SHUTTER CLOSED
Remaining exposure: 0s = 0.00m
ACTIVE SELECTION = 1
Elapsed exposure: 3600s = 60.00m
Display CCD 2 (red)
A. Selection number: 1
N. Menus track display CCD: 2
B. Integ. time: 3600 s = 60.00 m
C. Obs. Number: 33
D. Window:
Size (R C) 260 1200
Origin (R C) 0 0
E. Binning (R C) 1 1
F. Obs. type: Dark slow
G. Recording: Disk
H. Display: Both CCDs
I. Object: dark
J. Selection summary
L. Wave plate position Unknown
R. START
S. STOP AND READOUT
T. ABORT AND THROW AWAY
U. PAUSE
V. CHANGE INTEG
W. CHANGE SELECTION
X. COMMENTS
?. HELP
Z. SPECIAL
+. Cursor display -. CONTROL
*. Run C-shell
Row: 258
Col: 699
Value:
69
1
2 1/2
4 1/4
8 1/8
-50 32767
56 118
clip
fine
lock
X-lations
Linear
Sqrt
Log
Color Ctrl
Other...
Invert
B & W
Contour
Options
Itv...
Digitals..
Show Label
LWPrint
LWP [Box]
New Image.

To either initiate an action or to change an observing parameter, simply type the letter corresponding to that function. For example, type "r" (not case sensitive) to start an exposure. If the option selected involves a choice, you will be prompted at the bottom of the screen. It's an exceedingly easy to use system. What follows are brief comments just to get you oriented.

Option A on the DTS screen allows you to choose between up to 10 selections. A selection consists of those items specified by lines B, and D through I. A common reason to specify more than one selection might be if you wish to intersperse direct and spectral observations during the night, which require very different areas of the chip to be read out. It's easier to switch between, say, selection 1 for spectra and 2 for directs, than to continually change the window specifications under line D.

The integration time (option B), may be 1 to 32,000 seconds. Fractional seconds are not allowed. Exposure lengths can be different for the two sides, and they must be started independently, so it could turn out (for example), that several red-side exposures are taken and read out while the less sensitive blue side is taking a single exposure.

The observation number (C) is arbitrary (that is, start your own number sequence wherever you wish), and is incremented only when an observation is recorded. Observations from both sides are numbered in a single sequence in order of readout, but each image number is prefixed by a color code; e.g., b105.ccd and r106.ccd. The only caution is that an image already on the disk will be overwritten by a new image with the same observation number. Backups are made only at the conclusion of each observer's run, so you may wish to avoid overwriting disk images during an observing run.

During setup you may wish to use the fast readout mode (option F). This will read out the chip significantly faster, but at the expense of increased read noise. During setup the read noise is usually irrelevant, but don't forget to switch back to slow mode before recording any real data.

To make your data taking window follow your choice of CCD, type n, then t for track; the window will then track your CCD selection.

Object name (I), may be a string of up to 63 characters in length. This field is examined by the DTS only at the beginning of readout, so except in the case of very short exposures, it will probably be more efficient to get the exposure under way before recording the name of the object.

If you have already started an observation, and realize you wish to change either the integration time or the selection, you must use options V or W to revise your choice. The system looks at A and B only when an observation is first initiated.

Option Z ("Special"), will prompt you for a choice of five submenus. The ones commonly used are Z-2 for tape functions such as initializing your data tape, Z-3 for header information, and Z-5 for telescope offsets.

Under Z-3, update the observer's name and the instrument name as you would like them to appear in the tape header. Most people keep these entries simple, but others like to add all sorts of relevant information here.

Another way to add information to the header is via the option X for comments. It allows you to add up to five comment lines to the header. If you precede a line with an asterix, it will be retained and added to every image; otherwise it will be added to the next image to read out, and then discarded.

The Reticon 400x1200 chips read out pretty fast (about 15 secs). However, if either CCD is reading out, there may be a surprising delay from the data taking window in which you are working, because readout has precedence over any other function.

You can start more than one DTS if you wish, but beware of screen clutter! From the description above, you will already have four windows, and as you proceed, you will find that many options create additional windows. There is often not enough room on the large screen for all windows even with just one DTS running...but how you choose to run things is of course up to you.

Image Display Window

The image last read out is displayed in a window on the x-term, which we have described here as being in the center of the screen. Of course this location is arbitrary.

Plot window

There are a number of ways in which you may interact with a displayed image. The simplest is to make a plot of a single row or column. Put the mouse cursor at the location in the image where you wish to make the plot, and type r for a row plot or c for a column plot. The plot will be displayed in a new window at the top of the screen, as white on a blue background.

The plots are unfortunately not scaled, but you may easily read the x and y coordinates at any point by positioning the cursor at that point and reading the values in the small box at the upper right of the plot window.

Blow up any portion of the plot by positioning the cursor at the upper left corner of the region desired, click and hold the left mouse button, and create a stretchy box around the region you wish to see. If the box is satisfactory, click left on the "Apply Box" region at the upper right to execute the blow-up. To undo the box and return to the full plot, click on "No Zoom."

Display Options (Control Panel) Window

The display options or control panel window offers a broad range of choices for display.

In the upper left corner is a box which displays the row and column numbers and the DN value of the location in the image display chosen by the cursor.

Next to the right is a region where you can obtain a quick-look 5x blow-up of any region of the image you may wish to examine. Simply point to the desired location in the image with the cursor, and click left on the image. To pan around the image with the zoom window, click left once in the zoom window, then pan about with the cursor on the image; click left again in the zoom window to exit the pan mode.

One more step to the right in the Display Options Window will bring you to a small graphic which illustrates the total area of the image as read out (green box), and the region of the current display (black box). You may recenter the current display window by clicking left at the center of the new display area desired.

One further step to the right you will see a series of ovals with integers and fractions in them. These are multiplication factors for zooming in and out. Just click on the desired factor, and the image will redisplay, and the black box will reposition on the green box to show the new area displayed.

You can scroll the color map by placing the cursor in the color bar at the right edge of the Display Options Window and holding the left mouse button, as you move the mouse up and down to scroll through the colors. To restore your original color map, hold down the left button as you move off of the color bar to the right. To select a new zero, move off to the left.

The two long gray regions in the middle of the Display Options window show information about the DNs which make up the image. In the top region is a bar which graphically illustrates the range of DNs currently displayed. Underneath it is a bumpy line which is a crude logarithmic histogram of the DNs (based on a very small, but hopefully representative, subset of the image). In the bottom region of this portion of the display, the top two numbers show the minimum and maximum DN values allowed in the current image display (that is, the range of values mapped into the full range of colors available, and the bottom two numbers are the min and max actually represented in the image being displayed.

You can change the range and zero point for the color map of the image by grabbing the top bar with the mouse (left button), and dragging the left end of the bar to the right or left to increase or decrease the zero point of the display, or the right end to change the range.

Just under the magnification buttons are three buttons which affect the way the image is displayed. The clip button causes any values outside of the range for the selected color map to be remapped to the minimum or maximum values of the map, rather than "rolling over." The fine button remaps some small range of DN values which you may have selected into the full range of the color map, thus giving you finer color resolution for that range of values. The lock button locks in whatever color display you have set up so that it will be used for display of subsequent images, until lock is deselected by you.

At the bottom of the window are three columns of rectangles. The first, labeled X-lations, allows three choices of mapping the DN levels to colors; linear (the default), square-root, or log. Just click on the desired box to change.

The color control choices allow you to select from a variety of color maps with "Other...", or to invert the map, choose black and white, or make a contour map of the image.

The Options column starts with ITV (which stands for "interact with the TV"). A left click here will generate another window, with options for creating, deleting, and displaying from a number of user defined boxes in the image; zapping (that is, median filtering) hot pixels, cosmic rays and the like; or doing "stellar statistics", which analyses a small portion of the image (and presents the results in yet another window!), and which includes a focusing routine described farther along in this manual.

The "Digitals.." option will list DN values within a region of the image which you select.

"Show Label" will display or suppress the label (this is the name for the image which you created with option I of the DTS) at the top of the image being displayed .

"LWPrint" will print the current image to the Laser Writer. "LWP (box)" will (you guessed it) print a subset of the image.

Finally, "New Image" will allow you to select another image on the disk for display. This option will again generate a new window, and present you with point and click means of selecting from the Data and Vista directories, and long and short file descriptions. Click on a file description to display the image.

Again, use the middle mouse button for context-sensitive help.

To exit from just the DTS, you can type Ctrl-Y; or more commonly to exit from the entire x-term system, click and hold the left or center mouse button with the cursor on the x-term background, and from the menu which appears, choose "exit everything".

VISTA

VISTA is Lick Observatory's locally developed image analysis package. It is usually run on the ISI workstation, which is the large monochrome terminal on the left, but the adventurous may choose to run it in a window on the x-terminal. Turn the terminal on with a red rocker switch on the right rear of the monitor. Normally it will come 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 "off-line" and "keyboard locked" lights on the keyboard; they lie. Log in with "vista". The logo will disappear, a number of icons will appear on the screen, and a VISTA window will open for you.

The VISTA terminal is high resolution monochrome, but you can display images on the color monitor in the rack behind the x-terminal.

If you are not familiar with VISTA, there is complete on-line help available. Type "help" for a complete listing, or "help [command]" for details of a particular function.

You can make quick row and column plots from the x-term, so you probably won't use VISTA for that anymore. One common use is to mash spectra, with a sequence such as

rd 1 r99.ccd (read red exposure 99 to disk buffer 1)

mash 2 1 sp=47,53 bk=40,60 (mash the spectrum in rows 47-53 and subtract surrounding background) plot 2 (plot the result).

Another common use is to make nicely labeled hard copies on the laser printer with the "plot hard" command. A few keen VISTA users are able to reduce their data as they go.

If you wish to run Vista on the x-terminal, log in Vista with the usual password, then type xt at the first Vista prompt. Again, beware of getting too many windows and screwing up because of it.

Exit with the command "quit".

Tapes and Tape Drives

Data may be recorded to hard disk, tape, or both. For tape, you may choose between 9-track or Exabyte. The selection is made from the data taking window, under option Z-2. Type T, and you will be prompted to choose between the two available tape formats. We recommend that you always write to both disk and tape, so that if either medium fails, you will have the other as a backup.

After you have loaded your tape on the appropriate drive, it must be initialized under Z-2. The Exabyte takes a couple of minutes to initialize a new tape. A very important warning to Exabyte users is, do not unload your tape directly from the tape drive. The directory is only updated at unload time, so that step must be done from the DTS under Z-2, or you will have the data but no directory for it.

Please dismount your tape at the end of each night so the drive may be used by others during the day.

The hard disk is backed up to Exabyte at the conclusion of each observer's run, and the backups are saved indefinitely.

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

Tub Control Panel

The tub control panel includes a number of controls for the calibration lamps, diagonal mirror, and TV.

Line and Flat Field Lamps

In this section we assume you've already chosen the lamps you want to use, and that you've set up the lamp selection panel on the tub correctly.

The lamps are switched from the tub control panel in the readout room. The lamps are controlled by a set of six switches in the center of the panel.

Recall that there are two flat field lamps, a dim ("red") one for wide-band directs, and a bright ("blue") one for dispersed or narrow band flats. Unfortunately, those are the only two choices; neither is continuously variable. The upper left switch allows you to choose which of the lamps you want to use, and then the upper right switch turns on the power to whichever one has been selected.

The lower three switches control the lamps inside the tub. The left switch actuates whatever lamps you have selected for "relay 1" on the tub panel, and the center switch operates "relay 2" lamps. Although the switches are labeled "HeHgAr" and "Neon" respectively, remember that you can set them up any way you like at the tub selection panel. Both switches may be operated at once for a combined spectrum.

The lower right switch of the six operates the very bright tub quartz lamp. Remember that, as pointed out previously, the tub quartz does not illuminate the slit in the same way as the sky, so if that is important, use the dome flat field lamps. In fact the tub quartz is rarely if ever used.

Please keep the line lamps turned off when not in use, because they tend to have short useful lives, and they are very expensive. This applies particularly to the cadmium lamp, which has a life of only a few hours, and costs over $200 per copy!

The cadmium lamp takes about 2 minutes to warm up enough to get satisfactory cadmium emission, although the mercury is apparent in just a few seconds. The other lamps are usually ready within seconds, but as they get old their characteristics may change. Line strength ratios vary with age and 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.

Diagonal Mirror

The diagonal mirror is controlled by a knife switch just below the tub lamp switches. See the section on the diagonal mirror in Chapter 2 for a description of the various mirror positions. Remember to use position 2 for tub lamps, position 3 for direct flats, and either 3 or 4 for dispersed flats.

Reticle and TV Stage Controls

The reticle for the acquisition TV and the TV itself are both mounted on x-y stages. They may be controlled independently or in slave mode by a joystick. Three speeds are available, x1, x10, and x100. The reticle stage has precise digital position readouts, whereas the TV (appropriately) has only relatively coarse analog position readouts. For the normal tub position angle of 90°, a reticle move in x is a move E-W, and in y is N-S. In mirror position 2 and 3 (but not in 4), one unit in the reticle stage readout is 0.1 arcsec. Be sure to turn off power after a motion is completed, in order to avoid unnecessary generation of heat in the tub.

Field Size and Orientation

The long slit capability of the spectrograph is very useful for extended objects as well as collinear ones. For these sorts of observations, one nearly always wants to rotate the instrument tub to some predetermined (or in some cases, determined on the spot from the TV or CCD direct frames) position angle. It's useful to know which directions are which, for various position angles, in order to plan setups and verify that they are correct.

On the TV, the scale and orientation varies with diagonal mirror position. If the tub is at the standard position angle of 90°, then in mirror position 2 one sees a field about 2 arcmin across on the TV, with north at the top and east left. When offset guiding in position 3, this remains the same. In position 4, the field size is roughly halved to about 1 arcmin, and there's a left-right flip of the image on the TV because of an extra reflection, so north remains at the top, but west is left.

In position 4 as you look at the slit, then, for position angle 90°, the slit runs left and right on the TV with west to the left. About half of the total slit length is seen on the TV at a given TV position, but you can move the TV on its stage to view locations farther along the slit if necessary.

On the CCDs, with the tub at position angle 90°, north is right and east is at the top (both sides). It could be worse; at least these are simple rotations of most charts. The slit is of course still E-W, so on the CCDs the slit appears vertical, with east at the top, and dispersion is thus along rows.

For different position angles of the tub, the relative orientations of the TV, slit and CCDs are unchanged, since they all move together. The effect of going to a higher position angle (that is, in the usual sense of north through east) is to rotate images on both the TV and CCDs clockwise.

Object Acquisition and Guiding

Guide Camera

The integrating CCD guide cameras were initially designed and developed here at Lick under the leadership of Lloyd Robinson, and are so successful that they are now copied at many major observatories, and even sold commercially (but not by us, unfortunately). On a dark night with maximum integration and good seeing, one can see objects as faint as 22nd magnitude. The field of view is about 2 arcmins diagonally.

The camera is relatively impervious to abuse. The only prohibition is, don't point it at the sun. It will not harm the camera even at max gain to turn on the room lights or comparison lamps, for example.

The night assistant will operate the camera for you, or you may do it yourself. The controls are very simple. The gain and integration are self-explanatory. Use all of the available gain before using any integration. The chip more than fills the screen if unbinned (binning = 1); about 2/3 of the chip area is seen, but at the best resolution for the most accurate guiding. Binning 2 by 2 maps the entire chip onto the screen for the largest visible field for object acquisition. Guiding with 2 x 2 binning is adequate for most purposes. If you are not binning, and hence are seeing only part of the chip, the display switch allows you to select which quadrant of the chip you are displaying; c for center, bl for bottom left, etc. Finally, the offset control affects the zero point and dynamic range of the display. Usually it's not necessary to adjust it, but in high contrast situations you may be able to improve the picture. If the TV seems to be performing very poorly, check that the offset is about midrange.

Autoguider

There is a good autoguider, which is the most likely solution to the guiding problem. It produces a reticle of its own on the TV, which the night assistant will position over a guide star. The reticle is divided into four quadrants. The autoguider senses what fraction of the light from the guide star falls into each of the quadrants, and then guides the telescope so as to maintain that balance. The autoguider is a pretty good device, but not infallible, so you should watch it from time to time to make sure it's doing the job. Fall asleep at your own risk. Ask the night assistant to explain the autoguider history display to you; it's a useful check on performance. You can use the telescope guide paddle to recenter the guide star image on the autoguider reticle at any time, and the autoguider will automatically reinitialize. (Do not make the mistake

of using the autoguider reticle joystick to recenter the reticle on the star, since if the star has wandered, it's in the wrong position, not the reticle!) Because autoguiding with an integrating TV is not always straightforward, the autoguider may have to be tweaked for some situations for best performance. See your friendly night assistant for assistance.

Other Guiding Aids

The finger does not refer to a digit on your hand, nor to anything rude; it refers to the rectangular blocking portion of the decker when it's positioned just off the slit, and used as a reference for positioning objects at the middle of the slit length. It is usually desirable in order to have maximum balanced sky on both sides, and to insure that objects are at the same place on the chip as flux calibrators. In theory, flattening will mean it doesn't matter, and for extended or multiple objects you have to hope that's true, but the smart money says keep everything the same as much as you can. Another reason to keep your object carefully at one location along the slit is that the fewer the rows summed for the final spectrum, the lower the readout noise in the result.

There are various other ways to mark the TV screen for reference purposes. A cross generator provides three crosses (+) which can be positioned anywhere on the screen. They are pretty stable, but they may creep over a period of time.

Grease pencils are another option; two colors are usually available. Grease pencil marks are guaranteed not to creep across the screen (unless you sabotage the air conditioner), but there may be some small flexure in the camera mounting or periscope, so the image may appear to move even if the grease pencil marks are stable.

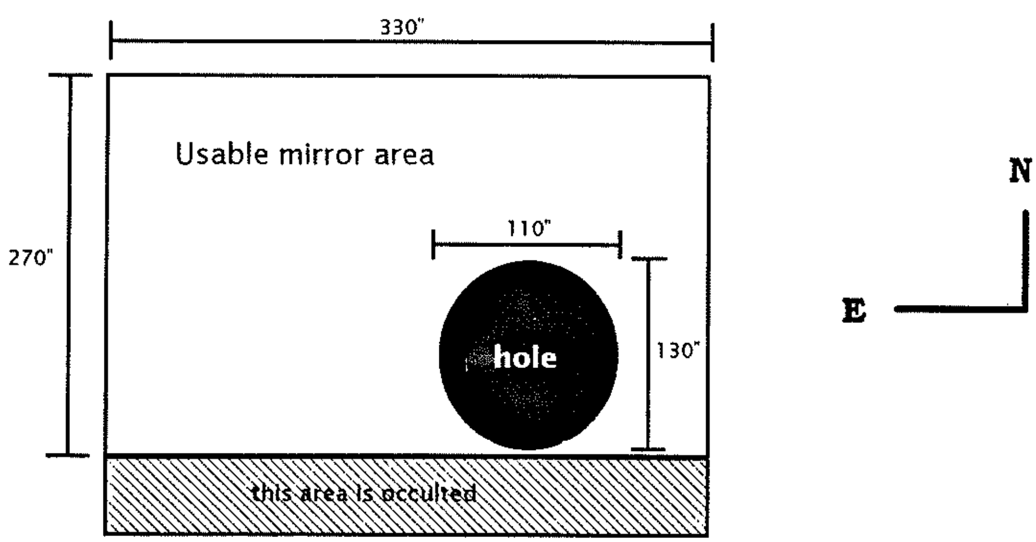
There is a reticle which may be projected onto a pellicle and thereby mixed into the TV image. The pellicle is highly stable with respect to the slit when mirror positions 2 or 3 are used, but in position 4 the periscope may cause some wander of the apparent slit image relative to the reticle.

The most worry free situation is if your object is bright enough to see directly on the slit. If you can guide on that portion of the light that does not make it down through the slit, then at least you are assured of where the rest of the light is going. In many cases your object will be too faint to guide on the lost light, in which case you may be able to guide on some nearby object which happens to fall onto the slit jaws, or you may have to resort to offset guiding.

Offset guiding

Offset guiding is done in mirror position three, which enables the camera to focus on the solid portion of the diagonal mirror, while an on-axis hole in the mirror passes the light from the object on down to the spectrograph.

The night assistant will operate the x-y stage for the camera for you, and help you find a guide star. Usually one just scans around randomly until one finds a suitable star, but in rare instances it may be helpful to know which way to look for a likely candidate which appears on your finding chart. The useful area of the mirror is approximately as shown here:



Manual guiding

Yes, it is still possible! The standard Lick guide paddle provides a joystick and has three switches. The (computer) enable/disable switch should always be left on enable, so the computer can move the telescope for offsets, for example. The set/normal switch allows fast (set) or slow (normal = guide) speeds. Finally, the normal/reverse switch allows you to reverse the sense of the joystick in the RA direction, so you can set it to your liking.

The paddle provides aural feedback, which is a surprisingly useful feature. Each click represents one step of the stepping motor, and corresponds to about 0.05"(cos δ) in RA, and about 0.07" in dec. Occasionally these might be useful for making small precise corrections in setting, but usually it is easier to use one of the offset programs. Generally, the aural feedback feature is useful in a less precise way, like if a bunch of clicks went twice as far as you wanted, then half a bunch back should be about right.

Centering on very faint objects

If the object is too faint to visually center it on the slit, then a major advantage of this spectrograph design becomes apparent. In almost any case one might imagine, you can dead reckon the object to within an arc minute or so of the slit center. Then, take a direct image of the object while offset guiding to prevent drift, identify your object (down to 23rd mag is not unusual), and use the telescope offset routine to move the telescope so as to center the object in the slit for a spectroscopic observation. The offset routine is under Z-5. You type in the row and column numbers, and then the offset routine offers you the choice of moving from position 1 to position 2 or vice versa; you only have to remember which way you want to go. It works, and it's really nice. Here are two important hints: 1) be sure to turn off the autoguider during moves, and 2) all of the experienced observers take another direct image after the move to verify that the telescope moved as desired.

Another option is to use the telescope offset program to move a premeasured distance from a bright offset star. It is possible to make very long moves this way (something like 32,000 arcsecs!), but it's not very fast, so keep it reasonable; a few arcmins is no problem. The program (under Z-5) accepts RA in either units of time or arc. Accuracy is roughly 0.1 arcsec over an arc minute; less for longer moves.

Flat Fields

In general, you will need a number of flats well exposed at the red end in order to get a reasonable total number of counts at the blue end. When you are calculating the statistical accuracy of your flats, remember to convert from DNs to electrons.

When doing low resolution dispersed flats, in order to keep the red end of a spectrum from saturating so soon, you may wish to use the filter stack called BG 14++ in position 1 of the lower filter wheel.

Direct Imaging

Direct images may be taken on both sides.

Use setting 350 (or "open") for a wide open decker, and 2250 (or "open") for a wide open slit. The unvignetted field of view is about 145 arcsec square (185 pixels at ~0.78 arcsec/pixel).

A suggested blue-side window using the direct mirror is number of rows = 210, number of columns = 200; start row = 0, start column = 530. For the red side, with the tilted flat mirror in the grating tray at grating tilt 19000, use window 200, 200, 25, 450. Check direct windows with the top lights, not the tub lights.

An obvious difficulty is that most of our filters are 2" square and must go in the user's filter wheel. Their use instead in the red or blue side filter holders where the beam is 3.5" in diameter will reduce the effective aperture to about a meter; you may as well use the 40" and avoid the wrath of Practically Everybody. A more reasonable course is to put the 2" filters in the users filter wheel, which will utilize the full beam, and just use one side for the observation.

V. SETTING UP AND OBSERVING

This section is not exactly a checklist, but rather an orderly discussion of what needs to be done in the usual case, with some hints. We do assume that you have read the descriptive material which precedes. The aim here is to be more complete than the one page checklist in the rear of the manual, so if you have never observed with the Kast you can get a good idea of what to expect, or if you haven't observed with it for six months or so, you can quickly remind yourself of how things work.

Obviously what we present here are only suggestions. There may be many other ways to accomplish the same thing, and some of those may be better for you. We don't pretend to be exhaustive nor to stifle your creativity, but merely to tell you enough so that you can do everything you need to do in at least one reasonable way.

First Principle

Some of the most experienced observers in the world observe with the Shane, but in recent years the telescope has become available to a much wider community, some of whom are not so experienced. It is to this less experienced segment of the community that we address the following advice.

The Shane is not a difficult telescope to use, because the instrumentation (and particularly the Kast) is user friendly, and knowledgeable help is usually readily available. However, if you have not observed with a world-class telescope before, please appreciate what a valuable commodity observing time is on such an instrument. It is only fair to yourself, the TAC, and the UC astronomical community if you try hard to maximize the use of the time which has been assigned to you.

With this in mind, we state here the First Principle of Big-Time Observing: try to keep the telescope busy at all times. Come to the telescope as fully prepared as possible. It should be a very unusual circumstance that requires you to make a finding chart during the night. The time to plan your strategy is not between observations, but the week before, or before the night begins, or at the very latest, during a prior exposure. When one observation has ended, you should already know what you are going to do next, so you can quickly start a new data taking cycle. If you are debating what to do next, it's usually better to start *something,* so at least some data is rolling in while you're fretting over the next move; but if you're planning ahead well, this will rarely happen. If the next move depends on the outcome of the present observation, don't wait for the observation to conclude to consider the alternatives; have your contingency plans already made, so you are prepared to make a quick decision.

Checkout

If it's your first time with the Kast, or if it's been a long time and you feel you need a refresher, call the person who will check you out in advance to arrange a time to meet. This service is free, ***required on your first visit***, and strongly recommended if you have any doubts later. Our point of view is that we want to do everything we can to make the science successful, and to protect the equipment for the entire community.

Tapes

You may bring your own 9-track or Exabyte tapes, or you may get them from the telescope techs on the mountain and be recharged for them.

At the Tub

Go out to the telescope, where there are six things to do.

There are four things to look at, and two to set up for yourself. The look at items are 1) make sure the CCD temperatures for both chips are reasonable; 2) check that the x-y stage settings are properly set (probably to the nominal 10.0); 3) visually check the dichroics to be sure the ones you want are where you expect; and 4) visually check the grating tray contents (tilt must be at 5400). The two things to set up on the tub are 1) insert any user filters you'll need, and 2) check to see that the comparison lamps are set up as you wish.

Current Setup List

Back in the control room, update the handwritten "Current Setup" list to reflect your grating choices and dichroics/mirror selection. This list hangs on the racks behind the data-taking terminals.

Log onto Terminals

Turn on the three observer's terminals (Kast controller, x-term, and VISTA), and the color display for the VISTA workstation. Log in on the x-term and the Kast controller with "user", and on the VISTA terminal with "vista". On the Kast controller, type "kast", and the x-term select the dtake window (by moving the mouse cursor into the window area) and type "dx". Leave the x-term alone while it initializes.

Initialize Spectrograph Controller

Although it has never been clearly necessary, it just seems to us to be good practice to reinitialize the spectrograph controller at the beginning of each run, or following a power failure. This is done by loading any setup which does not include any asterisks (which would cause that item to be skipped), select R (for "Set Spectrograph"), and answer yes to the reinitialize question.

Update Header

When you get a data taking window on the x-term, update the header with the observer's name and the instrument under Z-3. This information will be added to every image header.

Start your Tape

Load your tape, and initialize it under Z-2 (be sure to select your tape format, also under Z-2).

Trial Integration

As soon as possible after you have things started, do a short integration to be sure everything is ok. The most complete check is to read the whole window for both chips, and write them to disk and to tape (you may want to use a scratch tape if you already have data on the tape you plan to use). Be sure the shutters open and close, and that the chips read and display correctly. The point is, of course, to find any serious problems early enough to get them fixed before observing time.

Scratch Buffers

For the rest of the setup, you will probably not want to record until you get to the point of doing calibrations. If you do not record, the last image will always be saved in the scratch area until it gets overwritten by a new one. The scratch buffers are /scratch/bscr for the blue side and /scratch/rscr for red.

Spectroscopic Windows

Set up the spectroscopic windows. This is best done by illuminating a full length slit with the blue flat field lamp, mirror cover open, diagonal mirror position 3 or 4, and reading out the whole chips (or you can just check the windows left by the last observer if they look reasonable). In particular for the gratings, the dispersed illuminated areas may not be precisely the same, although they should be close. You will probably choose to use one window which covers only the area of overlap, or one all-inclusive window.

Order separators

Select any order separating filters you may require. On the red side, you will need to suppress second order if you go beyond twice the effective cut-on point of the dichroic you use. If you are not using a dichroic, the glass in the lenses cuts off at about 3800Å, and therefore will suppress any second order below 7600Å, but beyond that you will need to suppress with an order separator.

Spectral Coverage

Check the wavelength coverage with the line lamps. Sample spectra are available in the Control Room to help you identify the wavelength region.

Direct Windows

Determine where the direct windows are. Use decker setting 350 (or "open") for a wide open decker, and slit setting 2250 (or "open") for a wide open slit, no disperser. A suggested blue side window (option D in the DTS window) is 210, 200, 0, 530. For the red side, with the tilted flat mirror in the grating tray at grating tilt 19000, use window 200, 200, 25, 450. (These may change if the dewar x-y stages are changed from their nominal positions.) Check direct windows with the top lights, not the tub lights.

Slit Center

If you will be using the direct mode to find and center faint objects, you will need to know the row and column number of the center of the slit. Close the slit to spectroscopic size, and with illumination from the dome continuum lamps (not the tub lamps!), take a direct (undispersed) frame. Use the cursor to find the center, and record it for later use.

Focusing

On each side, focusing is accomplished by moving the collimators. If you are using the spectrograph, focus with a narrow slit; if direct, make an artificial star with a small slit and decker. There are a number of ways to analyze the quality of the image. Some experienced observers simply look at the whole spectrum (or star image), and are able to see at once where the lines are sharp and where they are not. Others like to count pixels at two or three locations along the spectrum (perhaps down to FWHM), either from the screen or from hard plots. A third approach is to overplot a particular line (with the Vista plot command and noerase keyword) with an x offset between plots at different foci. Fourth, there is a focus routine available from the options window on the x-term. (*Please note that this routine will only work properly if you start with the least focus value and work up.*) To use it, make a spectrum, select ITV (interact with the TV) from the options window, and type "*" to start the stellar statistics routine. Select a box size (11x11 seems to work well), type "-" to erase the focus file, then mark a location for the box (on a good isolated line near the middle, perhaps), type "*" to analyze the line width, "a" to add to focus file, then answer the question about focus which will appear in a small prompting box. Then change the focus (probably by 5000 units or so), and the box will default to where you positioned it before, so you only need to type *, then a for add, and fill in the focus value. As soon as you have three points, the program will try to fit them and give you the best focus value. You may need more, or a better distribution either side of focus, in order to get a good fit. Well, it's easier when you're right there doing it.

Any of these techniques can work well. Don't forget to look at the whole spectrum at some point, in case the focus is not flat; you may need to make some compromise. The Reticon chips are fairly, but not perfectly, flat. If a spectral region of particular concern to you is less well focused than most of the chip, you may choose to adjust the focus to favor that area, or make a compromise, or (on the red side), move the grating tilt to move that part of the spectrum to a better place. Also consider that for observing you'll probably use a wider slit than that you focused with, so small focus differences will wash out anyway.

Record your Setups

It is useful both as a convenience and as a precaution to record your setups. You might want to do this both on paper for future reference, and on the disk for quick recall during the night. A paper form is available from the NAs, and a sample is reproduced here in the Appendix with the sample logsheets. The Kast controller allows you to store up to 20 (!) different setups.

Start a Log

Logsheets are in the bottom right-hand drawer of the NA's desk.

Wavelength calibration spectra

Use mirror position 2, dispersed setup, and record to disk and tape. For the best solution, use a two-pixel slit or greater to avoid aliasing.

Most people who are doing "ordinary" spectroscopy (that is, not trying for accurate radial velocities), do a set of line lamps at the beginning and (just as a check) another set at the end of the night. Remember that between San Jose and night sky emission, there are comparison spectra available for zero point corrections on every frame, except possibly the shortest exposures.

Direct flats

Red dome lamp (unless very narrow band), mirror cover open, diagonal mirror position 3, direct setups.

Dispersed flats

Wait until after sunset to do dispersed flats so as to avoid the possibility of getting solar features in your flat. Use the blue dome lamp, mirror cover open, mirror position 4 (or 3), dispersed setups. For low resolution setups, you may need the BG 14++ filter stack. If you do use the BG 14++, be sure to remove it from the light path when done.

Opening the Dome

It is ordinary practice to open the dome in mid- to late afternoon, weather permitting, in order to let the inside air reach equilibrium with the outside. If you're working in the control room setting up, the night assistant will probably ask you when it will be convenient for you to have the dome opened. There's a Plexiglas plate on the inside of the door to the control room where you can write this information if you wish. If you are not around, the night assistant will normally open the dome anyway as soon as the outside temperature begins to be less than that inside the dome.

Focus Star

At the beginning of the night, the night assistant will choose a bright star with good coordinates from Apparent Places, and set to it first. You may focus the telescope if you wish, or the NA will do it for you. The NA will put the focus star in the center of the slit and reset the telescope coordinates, then will mark the location on the TV in mirror position 2 which corresponds to the center of the slit.

Object Coordinates

You may give the object coordinates to the NA one by one, or as a complete list, whichever is convenient for you. The NA will run the coordinates (any epoch) through a computer program which will correct for precession, nutation, aberration, refraction, the cost of living index, and (most important of all) flexure. Usually the telescope points well, but it would be wise to come with well-prepared charts to avoid errors.

Tub Rotation

You may wish to choose some preferred position angle for the tub, perhaps to get more than one object at once, or to position the slit along some nebulosity, or (most likely) to position the slit along the angle of atmospheric dispersion. There is a program on the ISI terminal to determine the position angle of the spectrum due to the atmospheric refraction. Ask the TA to rotate the tub for you.

Prepare to Expose

Before each exposure, be sure the spectrograph setup and selection is appropriate. Set the integration time and object name. Try to anticipate the need for an offset guide star so the NA can be setting that up while you are setting up the spectrograph.

Exposing

The autoguider is nearly always used and will be set up by the night assistant, so there is not usually much that's required of you during an exposure, except to check the guiding now and then.

End of the Night

Do line lamp and flats as required. Remove your data tape (if it's an Exabyte, you *must* dismount it with the software from Z-2 in order to have the directory updated properly) and (9-track only) turn off drive. Log out from the Kast controller (ctrl-Y, then "logout"); from the x-term (center button on the background, select "exit everything"); and the Vista terminal (center button on the background, select "logout"). Turn off the Vista color display, and all three terminals.

Report any discrepancies with the equipment to the NA. Finally, please fill out the "Cassegrain Spectrograph User's Logbook." This is particularly important if you have discovered any previously undocumented quirks in the equipment which may be of use to observers who follow you.

APPENDICES

APPENDIX 1: Director's Memo: Policies with Respect to Observations

Lick Observatory
University of California
Santa Cruz 95064

Shane (3-m) Telescope Technicians
Shane (3-m) Telescope Observers

Re: Policies with Respect to Observations, etc.

Dear Technicians and Observers:

It is a good idea to restate from time-to-time, some of the policies governing the relationship between TT's and observers. As we are all aware, members of the staff change, new astronomers come aboard, people forget things, certain misunderstandings develop with time among persons having the best of intentions. So we touch on several matters here; this set of remarks is not meant to be exhaustive, and will be updated from time-to-time.

1) When should a TT be available to begin work? This depends on the nature of the observing, the season of the year, etc. For example a coude observer may well want to start observations on a clear night in the winter as early as 4:30 or 5 PM. To provide an avenue for communication between the observer and technician on this matter we are setting aside a small area of the Readout Room bulletin board for the purpose. On arrival at Mt. Hamilton observers will please enter, in the space provided, the time they wish the technician to appear so that observations may be initiated. If the astronomer does not provide this information, the technician will proceed on the basis of current practice.

2) Leaving the Readout Room at night. Technicians will please not leave the readout room at any time without first checking with the observer. This is crucial for prime focus operations; it is also obviously inconvenient and wasteful of telescope time if a coude observer must come upstairs to hunt for a TT. Permission to leave to check the weather or dome, use the toilet, etc., etc., will normally be given by the observer unless he/she is at some crucial point in the work, e.g., about to conclude an exposure and set to another star, etc.

3) If Unable to Open Because of Weather. The normal practice is to have one telescope technician (TT) work for the entire observing night. On nights when it is not possible to open because of observing conditions, the TT should be available to assist the astronomer if he or she needs some assistance in tests, calibrations, or whatever. Otherwise the TT can go about normal tasks, but the TT should keep the astronomer informed of his or her whereabouts. At some time during the night the TT may have worked a full shift. The TT will inform the astronomer when this will occur, and at that time the astronomer can release the TT if the remainder of the night looks hopeless. The TT can then go home, saving the Observatory some money.

4) [Deleted: no longer applicable.]

5) Dome opening. Astronomers have different views on the advisability of opening the dome in the afternoon or early evening. Consequently, on arrival at the 3.0-m dome, astronomers are asked to enter this information also in the space provided on the readout room bulletin board. Of course, the TT is expected to use discretion and keep the dome closed if there is imminent danger of rain, snow, etc., regardless of the time posted.

6) Readout Room doors and other doors. As you know, we are trying to keep warm air from flowing into the dome area. Consequently, I would be grateful if observers and TTs would keep the two sets of doors between the readout room and the dome floor closed tightly at all times when passage is not required. [Remainder of section deleted; no longer applicable.]

7) Disagreements. Rules regarding normal operations involving, e.g., accessibility of certain parts of the sky, humidity limits, wind speed limits, etc., are set by the Director and his advisors; these are known to the TTs, and astronomers are asked to cooperate with the TTs in seeing that these rules are observed. However, in case of disagreement between TT and observer on some matter not covered in the ordinary regulations, TTs should accede to the astronomer's request, unless in so doing the TT judges that failure of the telescope or dome is imminent, or a life-threatening situation will develop. In such cases, the Superintendent (or his designee in his absence) will be called out and will have final immediate authority.

Non emergency disagreements will normally be adjudicated in the daytime by the Superintendent, who has "on-the-spot" authority in such matters. However, general matters of policy in these areas will be decided by the Director, in consultation with the Assistant Director, the Mountain Superintendent, and others as the Director deems appropriate.

Sincerely yours,
/s/

Robert P. Kraft
Director

APPENDIX 2: Sample Logsheet and Setup Record

These are reproduced at ¾ original size. Full size copies are available in the Control Room.

Kast Spectrograph Log

Program: ______ Date: ______ Page ___ of ___ Tape ___ of ___

Observer(s): ______ Clouds/Clarity: ______ Blue X/Y-stage: ___/___

Telefocus: ______ Red X/Y-stage: ___/___

Obs No.	Tape No.	Object	B/ R	D/ S	EXP (S)	PST/UT PST/UT	HA AM	SET -UP	TUB SEE	COMMENTS

Kast Double Spectrograph: Setup Record & Windows

Date:__________ Program:__________ Observers:__________

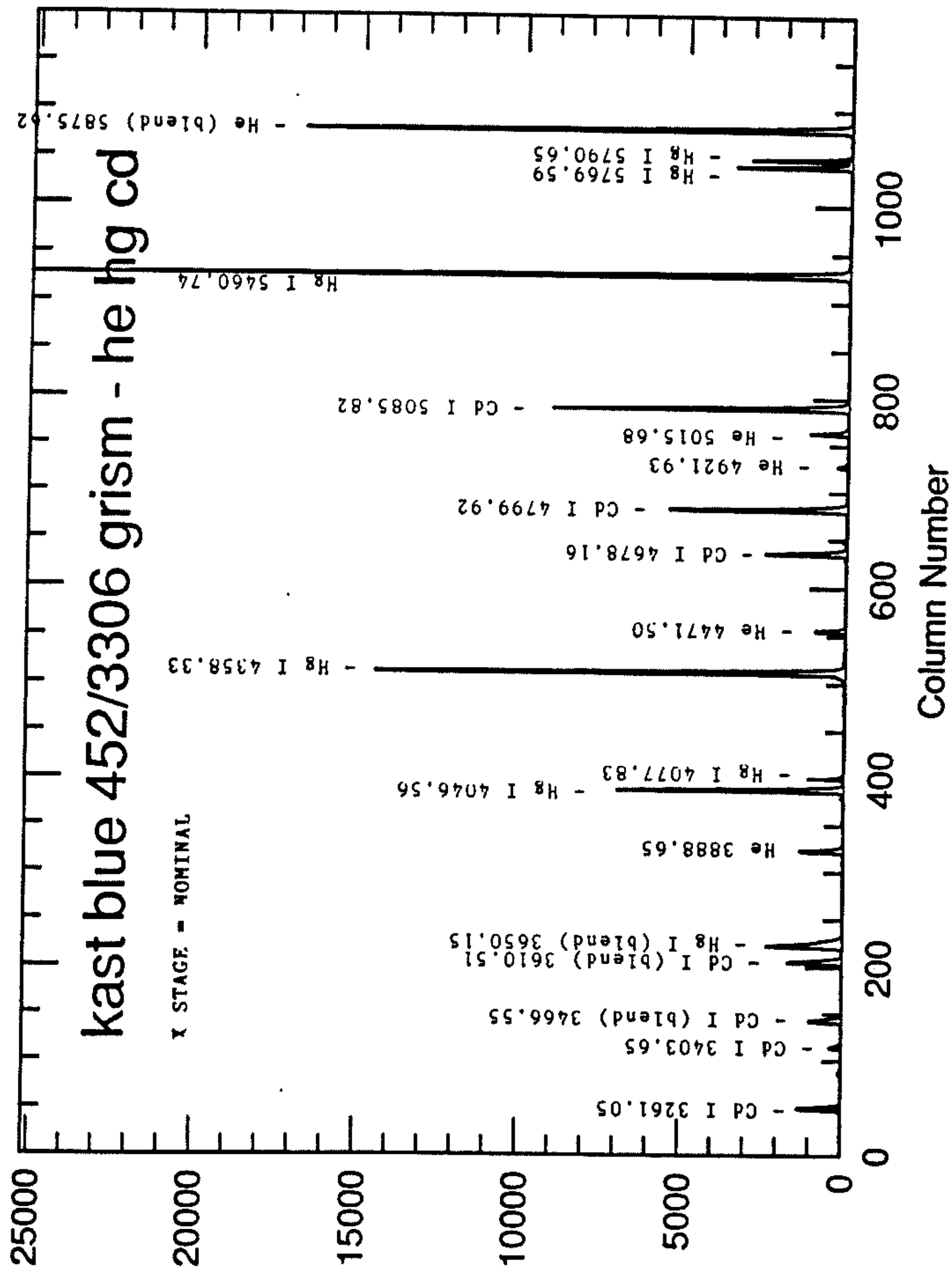
		Setup 1	Setup 2	Setup 3	Setup 4	Setup 5	Setup 6
Common:	A. Waveplate						
	B. Decker						
	C. Slit						
	D. Upper Filter						
	E. Lower Filter						
	F. User Filter						
	G. Beam Splitter						
Blue Side:	H. Blue Collimator						
	I. Grism						
	J. Blue Filter Tray						
Red Side:	K. Red Collimator						
	L. Grating						
	M. Grating Tilt						
	N. Red Filter Wheel						

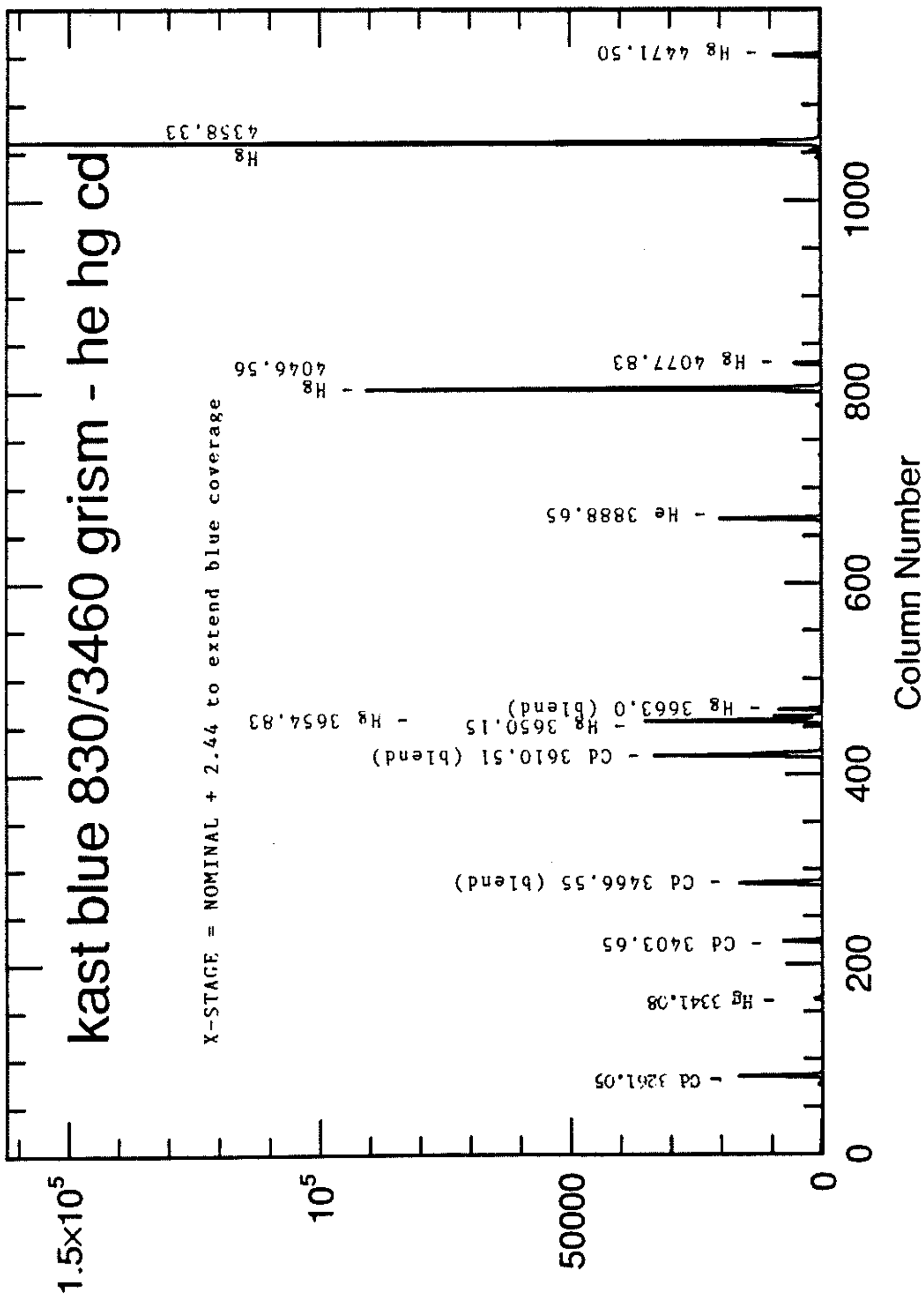
CCD Windows:

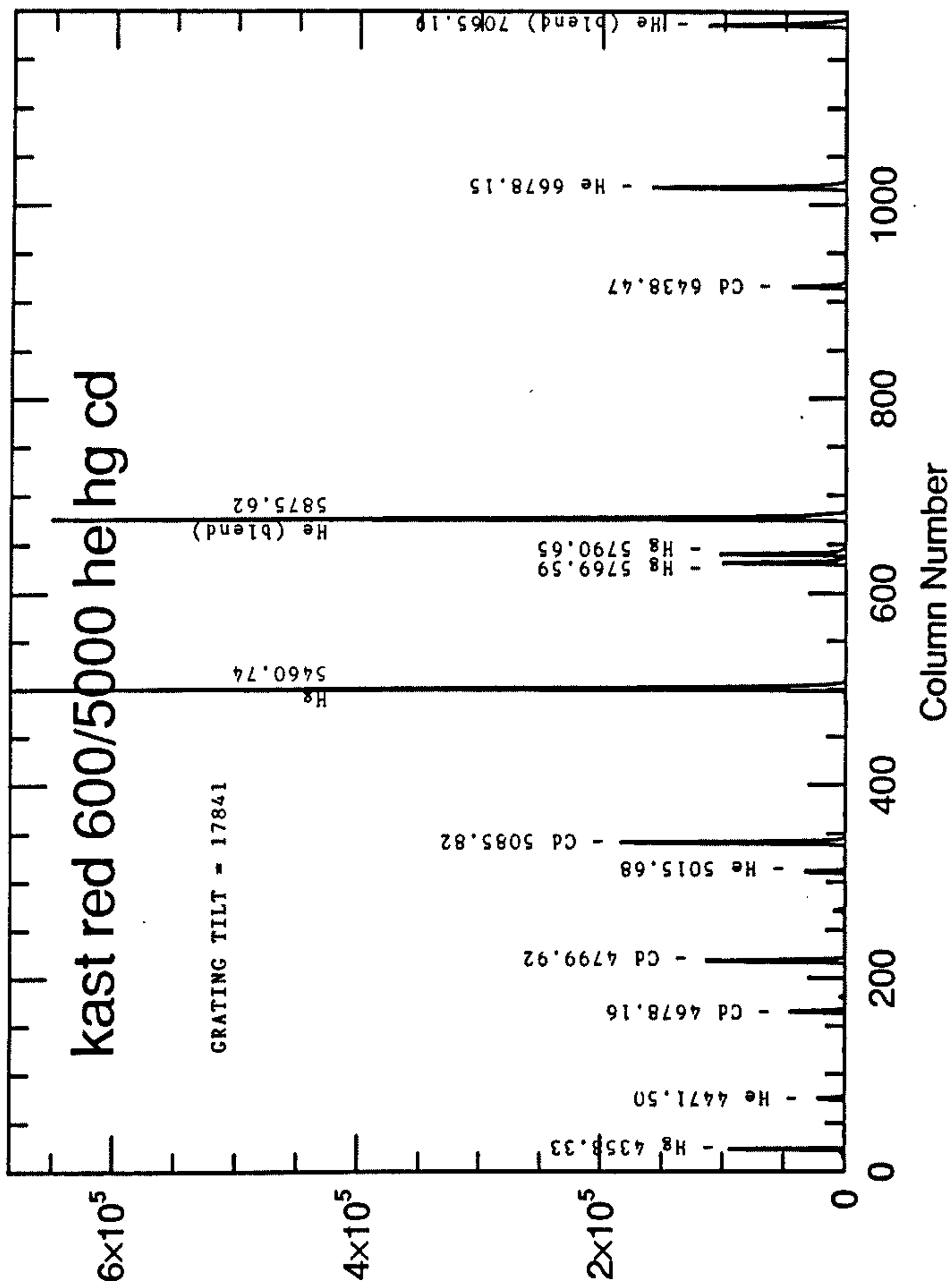
1. size (RxC) __________ origin (RxC) __________
2. size (RxC) __________ origin (RxC) __________
3. size (RxC) __________ origin (RxC) __________
4. size (RxC) __________ origin (RxC) __________

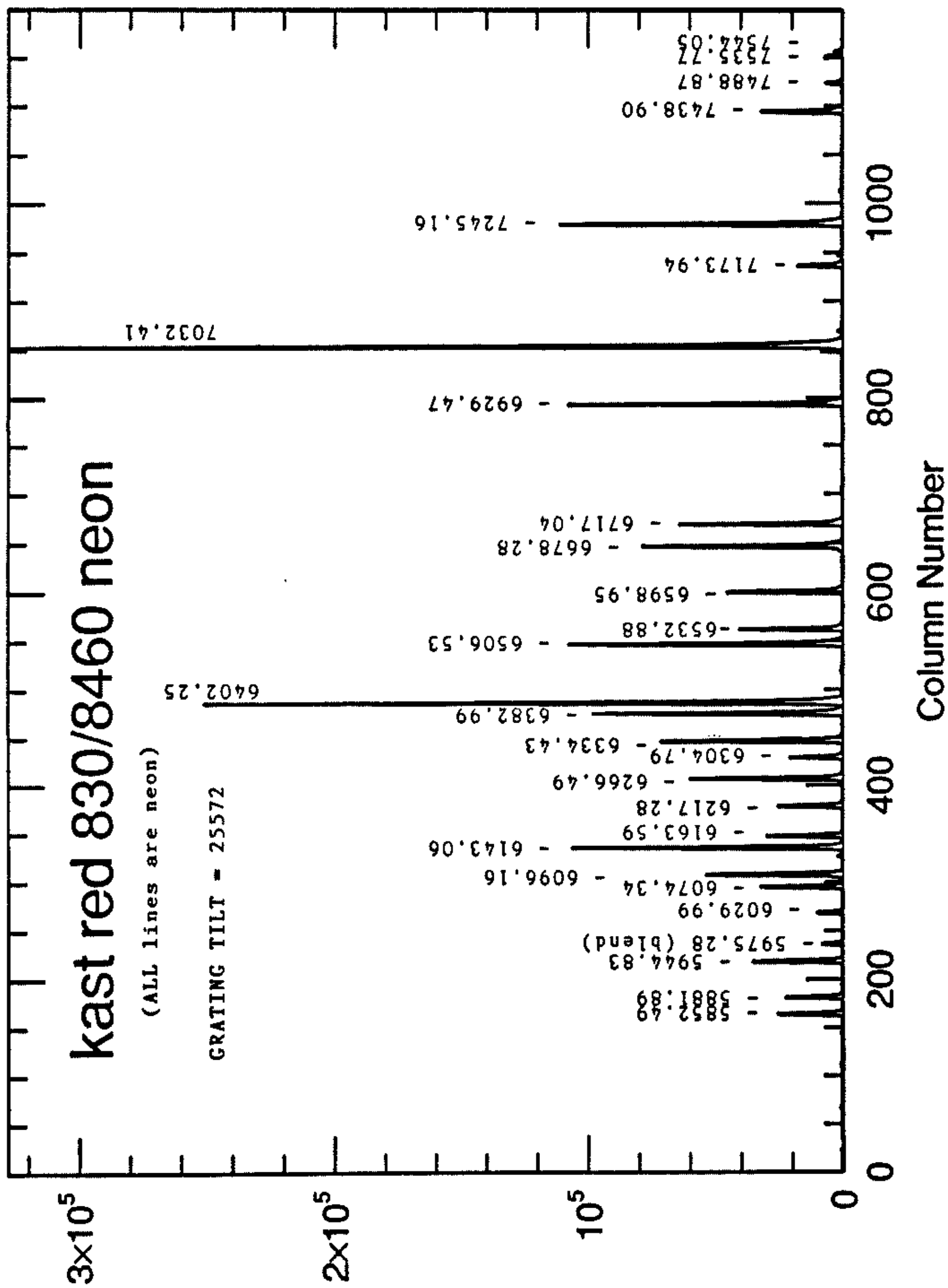
APPENDIX 3: Sample Calibration Spectra

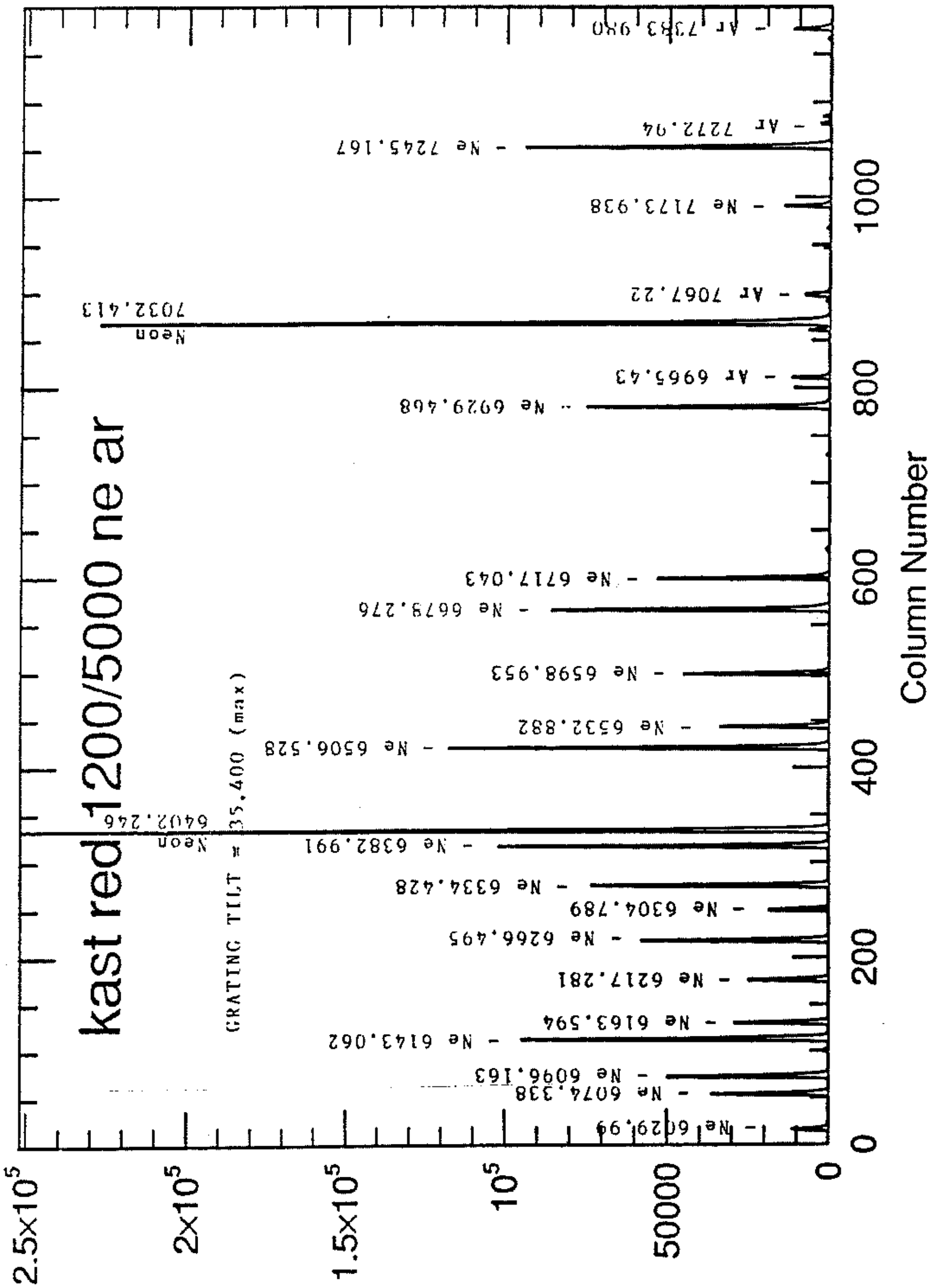
Additional spectra are available for reference in a yellow binder in the Control Room.




kast blue 830/3460 grism - he hg cd
X-STAGE = NOMINAL + 2.44 to extend blue coverage
Cd 3261.05
Hg 3341.08
Cd 3403.65
Cd 3466.55 (blend)
Cd 3610.51 (blend)
Hg 3650.15
Hg 3654.83
Hg 3663.0 (blend)
He 3888.65
Hg 4046.56
Hg 4077.83
Hg 4358.33
Hg 4471.50
1.5×10^5
10^5
50000
0
0
200
400
600
800
1000
Column Number


kast red 600/5000 he hg cd
GRATING TILT = 17841
Hg 4358.33
He 4471.50
Cd 4678.16
Cd 4799.92
He 5015.68
Cd 5085.82
Hg 5460.74
Hg 5769.59
Hg 5790.65
He (blend) 5875.62
Cd 6438.47
He 6678.15
He (blend) 7065.19
0
200
400
600
800
1000
Column Number
0
2×10^5
4×10^5
6×10^5


kast red 830/8460 neon
(ALL lines are neon)
GRATING TILT = 25572
Column Number
3×10^5
2×10^5
10^5
0
200
400
600
800
1000
5852.49
5881.89
5944.83
5975.28 (blend)
6029.99
6074.34
6096.16
6143.06
6163.59
6217.28
6266.49
6304.79
6334.43
6382.99
6402.25
6506.53
6532.88
6598.95
6678.28
6717.04
6929.47
7032.41
7173.94
7245.16
7438.90
7488.87
7535.77
7544.05


kast red 1200/5000 ne ar
GRATING TILT = 35.400 (max)
Column Number
0
200
400
600
800
1000
0
50000
10^5
1.5×10^5
2×10^5
2.5×10^5
Ne 6029.99
Ne 6074.338
Ne 6096.163
Ne 6143.062
Ne 6163.594
Ne 6217.281
Ne 6266.495
Ne 6304.789
Ne 6334.428
Ne 6382.991
Neon 6402.246
Ne 6506.528
Ne 6532.882
Ne 6598.953
Ne 6678.276
Ne 6717.043
Ne 6929.468
Ar 6965.43
Neon 7032.413
Ar 7067.22
Ne 7173.938
Ne 7245.167
Ar 7272.94
Ar 7383.980

INDEX

SUMMARY

GENERAL
Scale at cass focus = 3.86 arcsec/mm
Arcsecs/pixel = 0.78
Range of good performance:
Blue camera 3000-7000 Å
Red camera 4000-11000 Å

SLIT (p.20)
Slit setting =
10288-200(slit width(mm)) =
10288-51.82(slit width(arcsec))
Max opening = 145 arcsec.

Position	Name
0	open
1	.5 arcsec
2	1 arcsec
3	1.5 arcsec
4	2 arcsec
5	2.5 arcsec
9	9 arcsec

COLLIMATORS (pp. 25, 27)

side	typical	min	max
blue	40000	3500	71500
red	20000	4700	45000

FILTER WHEELS (pp. 21-23)

pos	upper	lower	user's
0	open	open	open
1	--	BG14++	--
2	Spinrad NS	OG570	--
3	ND5.0	ND6.25	--
4	ND1.25	GG455	--
5	ND7.5	$CuSO_4$	(n/a)
6	ND2.5	GG385	(n/a)
7	calcite	GG495	(n/a)

DECKER (p. 18)
Max opening = 145 arcsec.

Position	Name
0	open
2	spect
3	finger

DICHROICS and MIRROR (p. 23)

To get	Type
clear	out
dichroic	D46 or D55
mirror	mirror

X-Y STAGES (pp. 26, 29)
Increasing setting (37 pixels/large dial rotation (1 mm)) moves *to*:

side	x (λ)	y (row)
blue	lower	higher
red	higher	lower

DIRECT WINDOWS (pp. 27, 30)

side	window
blue	210, 200, 0, 530
red*	200, 200, 25, 450

*mirror tilt = 19000

FILTER TRAYS (pp. 25, 29)

pos	blue	red
0	open	open
1	U	GG455
2	wide G	GG495
3	empty	OG550
4	(n/a)	Spinrad NS

LOGIN: user/password/kast
user/password/dx vista/password

GRISMS (p. 25)

grism	grooves/blaze	str. thru	Å/pix	range	nominal coverage
1	452/3306	4780	2.54	3050	3150-6200
2	600/4310	4340	1.85	2220	3300-5520 (matches D55)
3	830/3460	3880	1.13	1350	3200-4550 (matches D46)

GRATINGS (p. 28) The total range for the tilt is 5400-35400.

grating	grooves/blaze	Å/pix	range	tilt	useful range (approx.)
1	600/5000	2.35	2820	$2.21(\lambda_c)+5631$	3800-10000
2	600/7500	2.32	2780	$2.29(\lambda_c)+4980$	3800-10000
3*	830/8460	1.70	2040	$3.15(\lambda_c)+5097$	3800-10000
4	1200/5000	1.17	1404	$4.72(\lambda_c)+4178$	3800-7310
5	300/4230	4.59	5508	$1.10(\lambda_c)+5716$	3800-11000
6	300/7500	4.60	5520	$1.09(\lambda_c)+5742$	3800-11000

*830/8460 second order: 0.85 Å/pix, range 1020 Å; $6.51(\lambda_c)+4260$; 5293Å max.

KAST SPECTROGRAPH CHECKLIST

Please read "if needed" or "if desired" where appropriate.

I. SETUP

A. Tub

It is no longer the user's responsibility to change gratings or dichroics, but it's <u>absolutely essential</u> to look for yourself to be sure the setup is as advertised.

1. Check x-y stage settings
2. Check beam splitters
3. Install user filters
4. Check line lamps
5. Check gratings (grating tilt = load)
6. Check the CCD temperatures

B. Control Room

1. Update the "Current Setup" card
2. Obtain tapes and logsheets
3. Read the User's Logbook to catch up on any hot news
4. Start spectrograph controller
5. Start data taking system (DTS)
6. Start Vista terminal and image display
7. Update the DTS header
8. Take a test frame on each side
9. Set the spectroscopic window
10. Set central wavelengths
11. Choose order separators
12. Set direct window
13. Find r,c for slit center (for blind offsets)
14. Focus for each setup
15. Save setups
16. Load and initialize a tape
17. Take calibration spectra and flat fields

II. CLOSING

1. Take calibration spectra and flat fields
2. Be sure all line and flat field lamps are off
3. Dismount Exabyte with DTS, remove data tape from drive (either drive) and turn off drive (9-track only)
4. Log out and turn off all three terminals
5. Turn off Vista color display monitor
6. Fill out User's Logbook
7. Take a last look around to be sure everything you're responsible for is off.