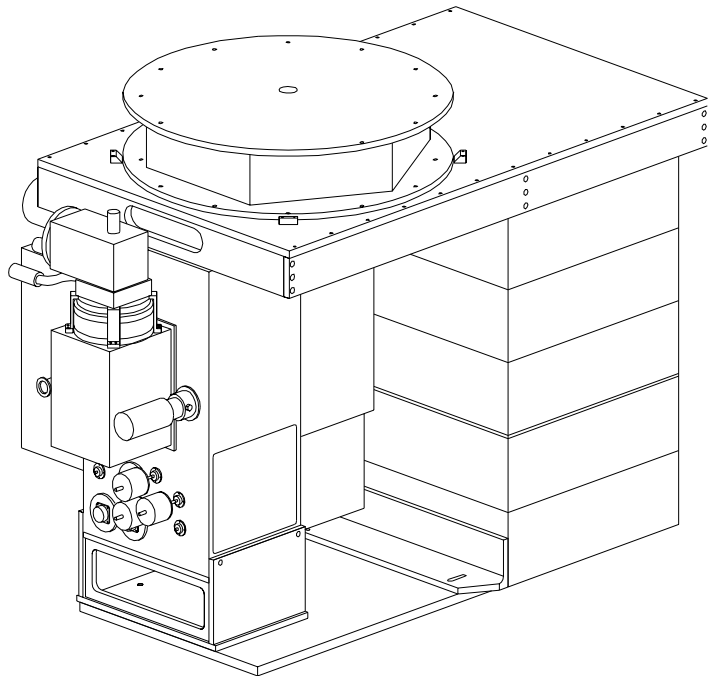## Infrared Telescope Facility
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CSHELL: NASA IRTF

Cryogenic Echelle Spectrograph

USER'S MANUAL

Revision 2.0.1

16 August 1994

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Table of Contents: IRTF CSHELL User's Manual

I. Introduction

This document is meant to be a reference to the CSHELL spectrometer for IRTF observers, operators, and staff. Sections I and II of this document are also intended to serve as a guide to introduce new users to the instrument. These first two sections prepare the user, describe the instrument, and cover the basics of system startup, wavelength calibration, and data acquisition. Section III is a detailed reference to instrument operation, observing techniques, spectral line selection, data archiving, and data reduction. The appendices in § IV include data log sheets, spectral line setup forms, instrument hardware information, a troubleshooting guide, temperture controller setup instructions, and a summary of changes implemented in the 1994 CSHELL Upgrade.

CSHELL users control the instrument through a Sun workstation computer using data acquisition and quick look reduction software under the Sun Open Windows graphical user interface (GUI). The Sun computer communicates via TCP/IP over the observatory Ethernet network to an instrument control (IC) computer mounted on the telescope with CSHELL. Normally the IC machine is always on and running the CSHELL software, but the observer logs onto the Sun machine each night to use the user interface software. Users must use a mouse, windows, and icons on the Sun computer to acquire and look at CSHELL data. The IRTF staff has endeavored to make the user interface programs as intuitive as possible, and they are fully documented in § III A.

Using the programs can be frustrating, however, if one is not familiar with the Open Windows mouse button conventions. Briefly, the left mouse button is used for selecting items such as text fields, buttons in windows, and default menu choices. The right mouse button is used to display a menu of choices by clicking it when the mouse is positioned on any object that displays a small down-pointing triangle indicative of further choices. A menu of options appears once this is done, and menu items are selected by again pressing the right mouse button when the mouse pointer is positioned on top of them. Default menu items are circled by ovals; they can be selected by either the above procedure or else by just clicking the left button when the mouse pointer is over the original object associated with the menu. Text can be selected with the left button in several ways.   The mouse pointer can be positioned at the desired insertion point and the left mouse button clicked to select that point for text insertion. This selected position will be the active insertion point whenever the mouse pointer is positioned in the parent window of that text field. Alternatively, the mouse pointer can be positioned in a text field and the left mouse button can be double- or triple-clicked (rapidly) to select either a portion or all of the text in that field. Text can also be selected by positioning the pointer, clicking the left button, and dragging the pointer over the desired text. Selected text is highlighted and will be replaced by whatever new text is typed on the Sun keyboard. All text changes and commands must be followed by carriage returns to make them effective. *This is a very important and often overlooked item!*

The two columns of keys at the left edge of the sun keyboard can also be used to manipulate windows that the mouse pointer is on top of. Most of these are toggles, so pressing the "Front" key will alternately place the window under the pointer either in front of or behind all other displayed windows. See § III.A of this manual for further details on the CSHELL software.

A. Preparations Before Coming to the IRTF

a. Read this manual (§ I and § II)

b. Contact your support scientist if you have any questions.

c. Retrieve and read the *cshellxui* (CSHELL user interface) and *vf* (quick look data reduction) software guides if you are not a computer WIMP (Windows, Icons, and Mouse Person). If possible, get the vf quick look data reduction program installed at your home institution and practice using it. Instructions on how to obtain these user guides and programs electronically is given in § III E. Alternatively, the vf programs is accessible at HP on the IRTFs Sun workstation. Practicing with this program before your run can greatly improve observer efficiency. Your support scientist will usually go over the operation of CSHELL and help you take calibration lamp data at Hale Pohaku in the first afternoon of your run.

d. Bring the following with you:

     • Offset guide stars if required. The offset guider has a field-of-view that is an annulus with inner radius 100" and outer radius ~200", and it can reach V= 12 mag in 1 second with no moon. Note that the CSHELL on-axis CCD camera permits guiding while integrating, has a field-of-view of ~60", and it can reach V= 16 mag stars under typical conditions. Contact your support scientist about using this camera to guide on visible objects.

     • Slit rotation information. CSHELL can be rotated ± 90° to a few degrees accuracy, but the process takes up to half an hour.

     • 8 mm or 4 mm tapes. It is recommended to bring one tape per night to permit backing up each night's data on a separate tape. Bring enough tapes for enough copies of the entire data set. We find the video grade tapes to be of insufficient quality; bring data grade tapes.

B. Instrument Description

CSHELL is a long-slit spectrograph which uses a 31.6 lines/mm, 63.5° echelle with narrow band circular variable filters that isolate a single order (orders from 11 to 56). The spectrograph can achieve resolving powers up to 42000, or 7 km/s, over the 1-5 μm spectral region. CSHELL originally had both Rockwell 256x256 NICMOS3 HgCdTe and Huhes SBRC 58x62 InSb detector arrays, but both have been now replaced with a single Huhes SBRC 256x256 InSb device sensitive from 1-5.5 μm. The instrument also has a direct imaging mode, described below. Further technical information on the design and performance can be found in Greene et al. (1993, Proc. SPIE, vol. 1946, p. 313) and Tokunaga et al. (1990, Proc. SPIE, vol. 1235, p.131). ***The Greene et al. (1993) paper must be cited in all publications of CSHELL data!***

CSHELL was constructed with funds from the NSF and NASA. Its design and construction was achieved by a team of IRTF and IfA personnel. The principal specifications and technical features of CSHELL are summarized below:

Table1: General Specifications

Array: SBRC InSb; 256 spectral by 160 spatial pixels

Pixel Size: 0.20 arcsec; 2.7 km/s per pixel at blaze angle

Wavelength Range: 1.08 - 5.6 μm

Free Spectral Range: $\approx 2.5 \times 10^{-3}$ λ

Resolving Power (R)	43000	21500	14300	10800	5400
Slit width (arcsec)	0.5	1.0	1.5	2.0	4.0
Pixels/slit	2.5	5	7.5	10	20

$R = \lambda / \Delta\lambda$

Slit: 30" in length. Discrete slit widths of 0.5", 1.0", 1.5", 2.0" and 4.0".
The 4" slit has been provided to permit spectrophotometry on point sources.
The slit orientation may be changed by manually rotating the spectrograph with
the instrument rotator on the telescope.

Table 2: Key Technical Features

Optics	f/13.67 beam at the slit
Collimator type	Off-axis cassegrain
Collimated beam diameter	8.0 cm
Material	Zerodur
Grating	Milton Roy 31.6 lines / mm echelle, 63.5° blaze angle
Object acquisition capability	Visible CCD and direct IR imaging of the focal plane
Cooling method	Closed-cycle cooler with Nitrogen regulation
Overall dimensions	Inner cold box 56 cm × 19 cm × 18 cm
	Outer vacuum case 64 cm × 35 cm × 27 cm

Direct Imaging Mode

CSHELL has a direct imaging mode in which a plane mirror substitutes for the
grating and provides an image of the 30" field-of-view on the infrared array.
This mode is useful for viewing the field in the infrared, acquiring sources,

and centering them in the slit. Images of the field may be recorded for reference with either narrow band or standard photometric filters, though the system is not meant to provide high quality photometric images.

Calibration Lamps

Argon, krypton and xenon spectral lamps and a continuum lamp are provided for wavelength calibration and flat fields.

Software

On-line quick look data reduction software is available for use with the instrument. It allows examination of the data by providing sky subtraction, flat fielding, and simple spectral extraction. Raw or reduced FITS format data files are recorded in tar format on 4 mm or 8 mm tape.

Predicted Sensitivity

The spectrograph sensitivity F in $W/m^2/\mu m$ is given by

$$F = \frac{F_0 \cdot S \cdot R}{\lambda^2} \sqrt{\frac{N \cdot (n_r^2 + n_b \cdot t)}{T \cdot t}}$$

Other parameters are

F_0 = 2.4×10^{-19} $\lambda < 3$ μm (16.5% throughput @ blaze angle)

        = 3.2×10^{-19} $\lambda > 3$ μm

S = signal-to-noise ratio

R = resolving power

λ = wavelength in μm

N = total number of pixels summed (spatial + spectral directions, including sky)

n_r = electronics noise (readout and other sources) in electrons

n_b = dark current and background in electrons/sec

t = individual exposure time

T = total observation time

Below we present the sensitivity for $S = 10$, $R = 21500$ (1.0" slit), and $T = 1$ hour. Calculations are for a point source in which sky subtraction is achieved by nodding the telescope along the slit such that the object remains in the slit; for the surface brightness sensitivity, the telescope is nodded to blank sky. Pixels are summed 1" along the slit and over one resolution element along the dispersion direction; therefore, the results are per

resolution element, not per pixel. The numbers below may be scaled to other cases using the above formula, but longer (guided) exposures can improve sensitivities.

We use a system electronics noise of 35 electrons. This is representative of (almost) the entire array (including high dark current pixels) for 240 s exposures with 6 samples (Fowler MCS technique) at 325 mV applied bias. For wavelengths short of 2.5 μm we take n_b = 5 electrons / sec and t = 240 sec. At 3.4 μm, n_b = 28 electrons / sec and t = 120 sec. At 4.8 μm, n_b = 1000 electrons / sec and t = 10 sec, usually short enough for good sky subtraction. We sum 5 pixels in the dispersion direction by 5 pixels (1") in the spatial direction .

Sensitivities with SBRC 256x256 InSb Array

λ μm	Continuum (W/m^2/μm)	Mag.	Line Flux (W/m^2 / resol)	Surface Brightness (W/m^2/sq. arcsec)
1.25	9.6×10^{-15}	13.8	5.6×10^{-19}	7.9×10^{-19}
1.65	5.6×10^{-15}	13.3	4.3×10^{-19}	6.1×10^{-19}
2.2	3.2×10^{-15}	12.8	3.2×10^{-19}	4.6×10^{-19}
3.4	3.2×10^{-15}	10.9	5.1×10^{-19}	7.2×10^{-19}
4.8	8.2×10^{-15}	8.5	1.8×10^{-18}	2.6×10^{-18}

NOTE: The above estimates do not account for observing overhead. Be sure to allow for acquiring objects, guiding inefficiencies, changing wavelengths, rotating the slit, observing the sky (you can not nod *extended* objects within the slit, so use the above Surface Brightness numbers), and calibrations (e.g. flats, lamp lines, and standard stars at each wavelength) when estimating the total time required for making a set of observations. ***CHECK IRTF ONLINE FOR UPDATED PERFORMANCE INFORMATION!***

Instrument Design Overview

Figures 1 and 2 show the light path through the instrument. The incoming beam from the IRTF is f/35, and the beam is converted to f/13.67 by the input lens, a plano-convex BaF$_2$ lens. The input lens forms an image of the focal plane at the slit while forming an image of the pupil at the secondary mirror of the collimator. Alignment with the optical axis of the telescope is achieved by translating and rotating the input lens and flat number 1 together as a unit.

A dichroic mirror reflects the IR to the slit while permitting the visible light to be viewed with a visible CCD (not shown). This permits acquisition and guiding on objects with a visible light counterpart. The order-separating CircularVariable Filter (CVF) wheels are positioned at a suitable distance from the slit, such that the width of the incoming beam is not wider than a single resolution element of theCVF. This maintains the spectral purity of the beam through the CVF.

The CVFs were selected from the stock catalog of Optical Coatings Lab Inc. These CVFs cause ripples in CSHELL spectra with amplitudes of 10 - 20% peak-to-peak and periods of 2 - 10 cycles per frame due to optical interference in their substrates. This is CSHELL's most severe remaining instrumental problem. However, we have constructed discrete He I 1.083 μm and HI Br γ 2.167 μm filters which do not exhibit this fringing and are also investigating replacing the CVFs with ones that will not exhibit fringing. The λ < 2.5 μm CVFs also have small leaks from adjacent grating orders, with maximum leak amplitudes at their shortest wavelenghts (2% at 1.1 μm).

After the filter wheels, the beam passes through an off-axis Cassegrain collimator designed to produce a collimated beam 8.0 cm in diameter. The effective focal length of the collimator is 109 cm, and its design is such that its optical axis has been translated by 0.56 cm from that of the incoming beam. This produces a 1.12-cm displacement of the incoming and outgoing beams. The dispersed light is directed to flat number 3. The distance between the secondary and primary mirrors of the collimator is 12.6 cm, which is enough for installation of a "direct imaging mirror" (shown in Figure 2). When inserted into the beam, this mirror sends the beam back to the collimator, forming an image of the focal plane at the IR array. The telescope focal plane can thus be viewed directly in the IR, and the slit positioned before a spectrum is taken. It is also be possible to record an image of the field if desired.

There is little room for placement of an IR array at the image of the spectrum, so we allow the dispersed light to expand to a spherical relay mirror via flat number 4. The relay mirror forms the final image of the spectrum on the IR array. A pupil image is located about 3 cm in front of the IR array where there is a stop and pupil mask to reject stray light.

The closed-cycle cooler allows continuous operation for three weeks or longer on the telescope. We are using a CTI Cryogenics Model 350 CP closed-cycle cooler that provides acooling capacity of 20 watts at 77K and 2 watts at 13K. A vibration-damping mount was developed to reduce compressor-induced microphonics.

CSHELL now uses a single Hughes SBRC 256 x 256 InSb pixel IR array to acquire all infrared photons. Its performance and operating parameters in CSHELL are tabulated below. See also Appendix F for linearity data.

Table 3: CSHELL SBRC 256 x 256 InSb Array Performance

Read Noise:	55 electrons @ 1 sample, 22 electrons @ 6 samples (Fowler MCS)
Electrons / ADU:	11.0
Background Limit:	~ 100 ADU in 240 s exposure @ 6 samples
Int. Time:	≥ 76 ms Fowler sampling; 50 ms Fast Mode
Temperature:	30 K
Dark Current:	~ 0.5 electrons / second
Quantum Efficiency:	~ 80% for 1 μm < λ < 3 μm; ~ 60% for 3 μm < λ < 5.5 μm
Pixel size:	30 μm
"1% linear" Well Size:	55,000 e⁻ @ 325 mV bias; 92,400 e⁻ @ 500 mV bias; 170,000 @ 800 mV bias; 234,000 e⁻ @ 1.0 V bias (see § III.C, IV.F)
Device Artifacts:	~ 1000 icky pixels (high dark current), tachyons (re. Fowler)

Echelle

Spherical relay mirror

Secondary

Flat #4

Collimator primary

Slit wheel

IR detector array

Filter wheel #2

Flat #3

Filter wheel #1

Incoming light

Input lens

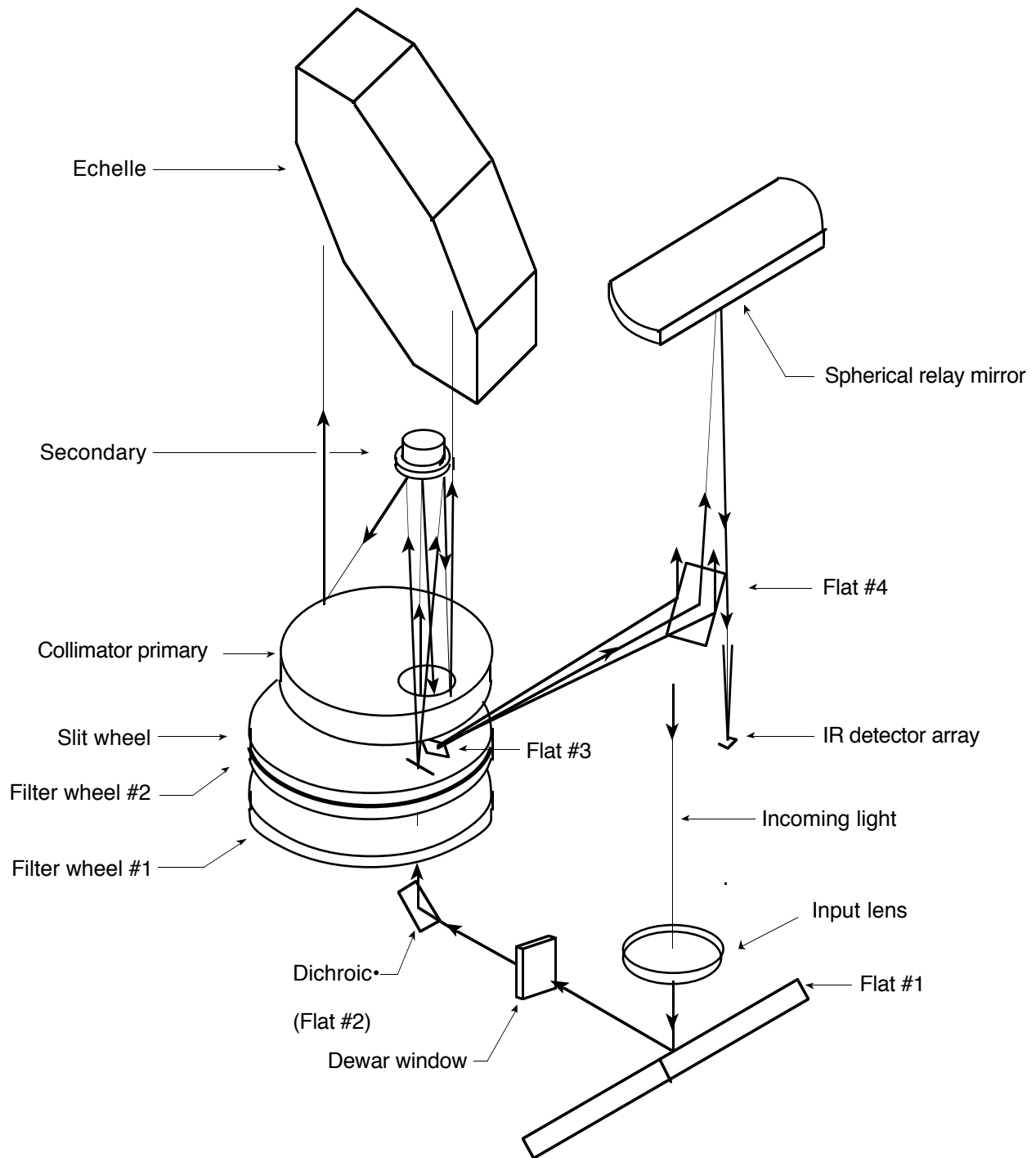Dichroic•

Flat #1

(Flat #2)

Dewar window

Figure 1. CSHELL optical layout. The CCD is mounted behind the dichroic but is not shown.
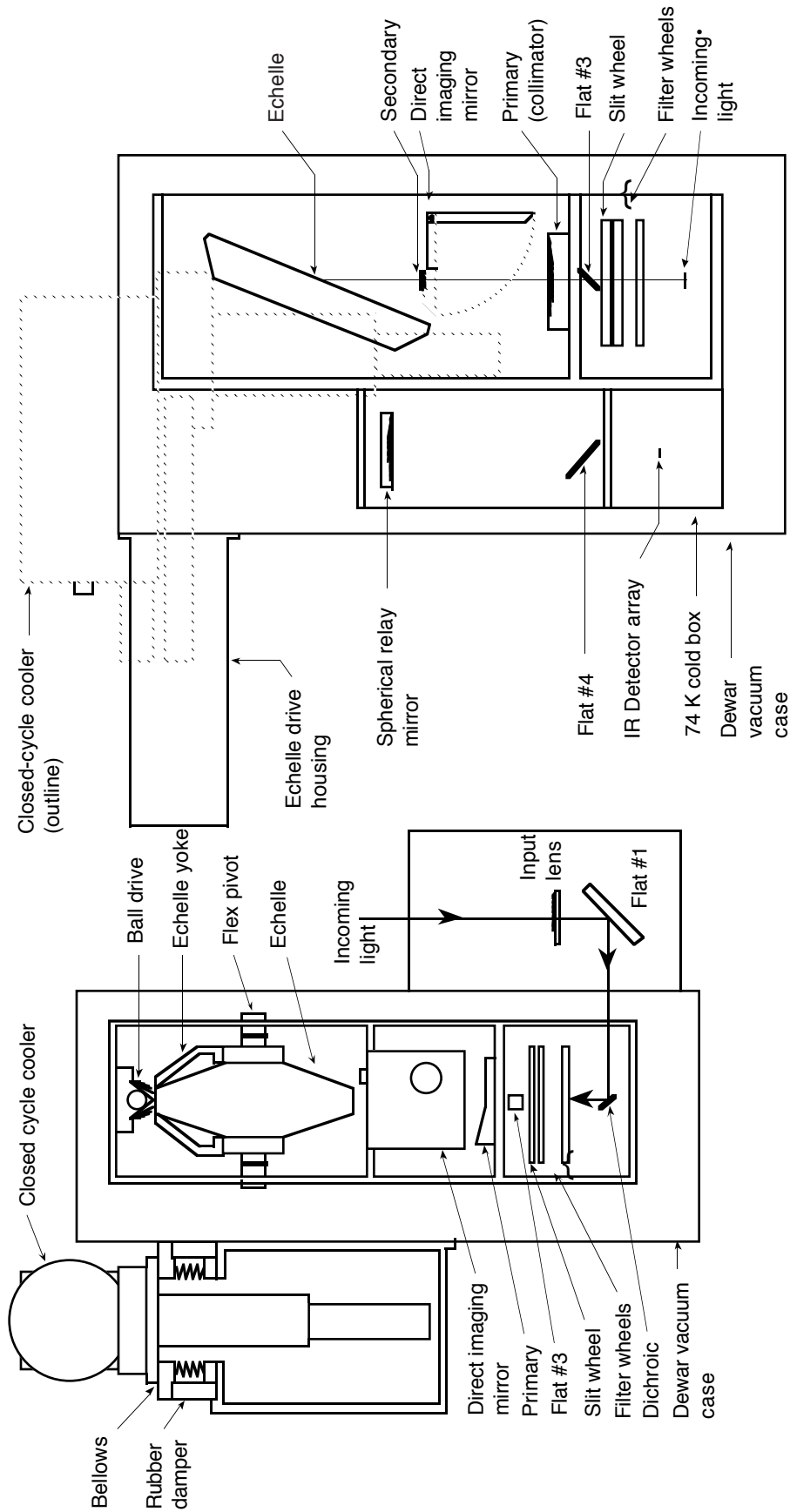
Figure 2. Front and side views of CSHELL. The length of the dewar vacuum case (tom to bottom) is 64 cm. The inner cold box is thermally isolated and mechanically supported by fiberglass tabs (not shown).

II. Using CSHELL

NOTE: This section assumes the user is familiar with the basic function of the *cshellxui* (data acquisition) and *vf* (quick look data reduction) programs. See the cshellxui and vf documentation (§ III.A) for information on the details of this software.

Powering up CSHELL and starting its software (explained in § III.B) initializes the instrument in a "safe" state: the calibration lamps are off, the lamp mirror is out, the filters and slit are in closed "blank" positions, and the shutter is closed. This is done by the telescope operator, day crew, or support scientist. No light enters the spectrometer or falls on the infrared array in this initialized configuration, but the internal CCD can see out through the telescope. This configuration is graphically represented by the cshellxui Observing Parameters Window icons representing the elements in the instruments optical path. Icons representing elements exposed to light are colored yellow, ones not in the light path are gray, and the filter wheel is colored blue when the CVF has been manually changed to select a grating order different from the one of the entered wavelength.

One must select the proper states of each mechanism by selecting from each icon's menu with the mouse (right button for menu). Typical mouse menu operations with the icons are turning the calibration lamps on and off, moving the lamp mirror in and out of the beam, selecting the desired filter, choosing a slit size, switching between imaging and spectroscopic modes, open and closing the shutter, and switching between the detector arrays. It is best to evaluate and change the states of the icons from right to left order as displayed in the window. Different observing modes are selected by changing the configurations of CSHELL's mechanisms. Open the shutter if you wish the detector array to be exposed to incident light, but close it if you wish to acquire dark images. The direct Imaging Mirror must be moved into the light path if one wants an image of the focal plane, and it must be out of the light path if one wishes to acquire a spectrum. Spectra are usually taken through a 30" long slit of selected width (the slit width determines flux and resolution), and images can be taken of a large field (30" × 30") through the open slit position or else through a narrower slit .

Filters must be selected for the desired wavelengths, and the grating is automatically positioned at the correct angle when wavelengths are entered into the cshellxui software. Calibration lamps must be turned on (and the lamp mirror moved in) to take wavelength calibration (e.g. Argon or Krypton lamp) or flat field (continuum lamp) frames. All lamps should be off (and the mirror moved out) when acquiring astronomical data. The calibration lamps and mirror are usually used just when taking spectral calibration data, and the lamp mirror is moved in and out by repeatedly selecting the lamp that is on. The filter wheels are usually set to the CVF / Open ($\lambda > 1.57$ μm) or CVF / Blocker ($\lambda \leq 1.57$ μm) position unless one is observing lines for which we have discrete filters installed.

Be sure to enter your name, institution, etc. in the Setup Parameters Frame (Window) each time you restart the cshellxui software. The (vacuum) wavelength or wave number to be observed is entered into the Observing Parameters Frame. Parameters such as integration time, the number of coadds per frame, and the number of frames (or Cycles) to be acquired are also entered into this window's text fields.

Data can be acquired in either stare mode (single frame; ".a" appended to the filename) or else in nodding mode. The nodding mode moves the telescope between frames and stores each frame separately with a ".a" or ".b" name extension to indicate beam polarity. A single cycle in nodding mode acquires one frame in position "A" and another frame in position "B." Multiples of two cycles cause data to be acquired in the "ABBA..." position sequence. The nod direction and magnitude are set to your request by the telescope operator. Newly acquired data goes into one of several buffers and may also be automatically saved. The LastFrame buffer in the Observing Parameters Frame indicates which buffer new data will go into. Buffer b0 is the default new data buffer, and the vf quick look program displays this buffer by default in its Canvas A. This is the standard configuration for data to be displayed in the top left canvas of the vf quick look program. A MeanFrame buffer can be selected so that a VF window shows the mean of a sequence of cycles (e.g. mean "A-B" in Nod mode or mean "A" frame in Stare mode).

Autosave must be enabled for data to be automatically written with the concatenated filename and number shown on the bottom line of the Observing Parameters Frame. Autosave is enabled by checking its box; this ensures that the data files will be saved onto the Sun (XUI) computer's disk in FITS disk format. The data in a buffer can also be saved by the vf quick look program. The Save Data option of the vf File menu will save a selected buffer as a FITS data file, but will omit the instrument and telescope information from the file header. Therefore it is best to have Autosave enabled *before* acquiring any data if you wish to save it. The Object and Comment fields in the Observing parameters Frame are also written into the file header.

One must issue a "Go" command to take an exposure. This is usually done by selecting "Go Obs" from the Go menu of the cshellxui Base Frame (main window). This is also the default for that menu so "Go Obs" can also be selected by clicking the left mouse button when the pointer is positioned over the "Go" menu. The data goes into the chosen buffer (default LastFrame buffer is b0) and is written to a disk file only if Autosave is enabled. The data buffer can be displayed in a canvas of the vf window (Canvas A displays buffer b0 by default). The current image coordinate and data value of the image pixel beneath the mouse cursor is displayed at the top of the image. The image can be zoomed, rescaled, or restretched in its vf display window canvas, and it can also be redisplayed as a spectral cut, histogram, or file header in any vf canvas. See the vf documentation in § III.A for details.

A. Before Night Time Observing

System Checkout

The IRTF day crew checks the basic wavelength calibration, sensitivity, and overall functionality of CSHELL each time it is mounted on the telescope, but you can also check these parameters when you do wavelength calibrations at the start of each night. The presence of the calibration lamp lines at the proper locations and intensities as well as the proper appearance of the flat field and dark frames are adequate assurances of the proper functioning of the instrument. The IRTF day crew and support staff have priority in using CSHELL between 9:00 am and 3:15 pm, while observers have usage priority at other times. Before the first night's observing (starting after 3:15 pm), we recommend that the signal and dark frame noise checks and the wavelength calibrations be performed either at HP or at the telescope. This will provide you with hands-on experience with using the instrument before taking astronomical data and allow you to spot any problems early on.

Call the IRTF summit before starting any work with the instrument from Hale Pohaku - the day crew or other staff may be using it!

First start up the cshellic, cshellxui, and vf software (see § III.A-B or get assistance from the IRTF staff). Once the cshellxui software is up, you should check the main window's status panel for proper instrument operation. Remember to type "xuihostname wien" in the command line of the cshellxui window if observing from the IRTF workstation (wien) at Hale Pohaku. All of the status items should be "OK" or "READY" (green). The IR array temperature should be 30.0 ± 0.2 K. The CCD array temperature should be 190 ± 20 K. The coldbox temperature should be 72.5 ± 2 K. There should not be any warning messages in the cshellxui feedback window. **The IR array bias voltages must also be set (select Set Programmable Voltages button in Setup Parameters Window) whenever the software is started.**

Signal and Noise Checks

Check the array noise performance by taking a 2.0 second dark (shutter closed) exposure. Check the array noise by selecting the stats item in the vf Options menu. Refer to Table 4 to see the means and standard deviations you should getting in a sub-region box of a given size. The array has adequate dark and noise performance if your numbers are consistent with the table values, and you can now evaluate its response to signals. Take a 2 second spectroscopic exposure of the 2.19085 μm Krypton line through the 1" slit and check if your peak signal values are consistent with those in Table 4. The Krypton line should be in column 128 ± 5.

Table 4: Signal & Noise Check

	Dark Frame	Kr Line Frame
Int. time (sec)	2.0	2.0
Slit	Blank	1 ''
Mean (ADUs)	0.0 ± 10 (50 x 50 pixel box)	-
Std. Dev. (ADUs)	3-5 (50 x 50 pixel box)	-
Peak Signal(ADUs)	-	~ 1200

Wavelength Calibrations & Dispersion Measurement

You must take wavelength calibration data each night by either observing rare gas discharge lamps or else by using telluric emission or absorption lines in your data itself. CSHELL uses *vacuum* wavelengths and *vacuum* wave numbers only. Be sure to correct rest wavelengths for any velocity shifts in your objects *before* entering them into the CSHELL software. The first step of the discharge lamp wavelength calibration process is selecting which calibration lamp lines to use. Lines must be selected for calculation of the spectral zero point and dispersion at each observational wavelength (grating position) selected.

CSHELL's spectral range is only 1/400 of the central wavelength .This narrow range dictates that the lines of the calibration lamps rarely fall on the arrays when the instrument is set up to observe lines of astronomical interest. We can trick CSHELL into observing these calibration lines at the same grating position as used for astronomical lines, however. The procedure is to select the (vacuum)

wavelength which you wish to fall near the center of the array for your astronomical observations, and then select a different grating order so that the desired calibration lines are visible without moving the grating. This is accomplished by moving the CVF filter to select different orders after the grating has already been positioned for the desired astronomical wavelength. This technique is explained below.

An auxiliary program, `cal_lines`, is used to determine which calibration lamp lines are to be used at a given wavelength selected for observation. This program is run from either a UNIX command line window on an IRTF workstation, or else from the PC in the IRTF office at Hale Pohaku. Instructions on using the program and a description of its output are given in §III.D.

Which calibration lines should you observe? The purpose of the lines is to determine the wavelength zero point and dispersion for each observational wavelength (grating position). In practice, one should observe a single calibration line for each desired wavelength as well as several lines distributed across many columns of the array for at least one wavelength setting at the start of each night. The single line at each grating position (selected wavelength) directly allows the determination of the wavelength of the illuminated array column, and observing several lines over a range of columns on the array allows the determination of the dispersion at that grating setting. It is best to observe at least 3 lines which span at least half of the array (128 columns). We wish to observe these lines at the same grating position used for the object observation wavelength, so we must select the proper CVF wavelength for each line (see Cal_lines Table, §III.D) without moving the grating. This is done by entering the new CVF wavelength into the proper text field of the Observing Parameters Frame. The calibration lines must also be sufficiently bright to observe in a reasonable amount of time (e.g. 60 seconds). Line intensities can be looked up in the copy of the elemental spectral atlas (by M. Outred) kept with the CSHELL documentation at the telescope. Lines must be looked up within each element's listing by wave number (the atlas gives air wavelengths and we use vacuum ones), and we find that lines with intensities of 100 units or above can be adequately observed in 60 seconds or less. Most lines listed by `cal_lines` can be observed in 15 s or less. If you are observing in order n_{obs} and the calibration line (wavelength λ_l) appears in some column in order n_l , then λ_{obs} ,the wavelength of that column in the astronomical spectrum (order n_{obs}), is:

$$\lambda_{obs} = \lambda_l \, n_l \, / \, n_{obs} \, .$$

λ_{obs} is given in column 3 and n_l is given in column 4 of the Cal_lines Table (see also §III.D). The expected position of a line on the SBRC 256×256 array is listed in `col(SBRC256)` in the table. The dispersion at one grating position is related to that at another position by:

$$\Delta\lambda(\mu m \, / \, pixel) = C \cdot \frac{\lambda(\mu m)}{2 \cdot \tan(\theta)}$$

where C is a different constant for each detector array and is the grating angle at each desired observational wavelength. The grating angle can be found in the cshellxui window and it is also recorded in the FITS file headers (see §III.F). We recommend that you measure the zero-point for all observed wavelengths and the dispersion for at least one wavelength each night of your run.

It is also a good idea to look at the CSHELL Atmospheric Atlas kept at the telescope (kindly provided by John Lacy @ UT) or the KPNO Solar Spectral Atlas (Livingston, W., and Wallace, L. *An Atlas of the Solar Spectrum from 1850 - 9000 cm-1 (1.1 to 5.4 μm)*, NSO Technical Report #91-001, National Solar Observatory) as part of the wavelength calibration procedure. These atlases are useful for evaluating the strengths and locations of any telluric absorption lines in the wavelength ranges which you will observe. This will show you if any telluric lines will land on or near your astronomical ones, and these lines may also be used as accurate wavelength references for interpretation of your data while observing. You may also observe the sky at twilight to see if the telluric lines occur in their predicted places in your spectra. Finally, OH sky emission lines can be also used as a wavelength check (See §III.D).

Example: Setup for HI Br γ, 2.16609 μm

Suppose that you want to observe the HI Br γ line at the 2.16609 μm wavelength (given as an example in §III.D). First select CVF/ Open from the Filter icon menu, then type this wavelength into the Wavelen text field of the cshellxui Observing Parameters Frame. The grating is automatically positioned to the correct angle for observation, and the CVF is moved to the selected wavelength. Next choose the slit size you wish to observe with, and make sure that the grating is selected (e.g. direct imaging mirror is out of the optical path) and the shutter is open. Note that the Kr lamp has strong lines that are predicted to land at columns 50, 95, and 212 of the array (see Cal_lines Table in § III.D). Each of these lines must be observed to adequately measure the dispersion at the 2.16609 μm wavelength. Remember to change the CVF wavelength to the correct value (see Cal_lines Table in § III.D) before observing each calibration line. The spectral zero point and dispersion at the 2.16609 μm wavelength may be calculated by performing a linear fit to the apparent line wavelengths (λ_{obs} , column 3 of Cal_lines Table in §III.D) and the array columns in which they appear at the row of interest. It is best to repeat this procedure for each wavelength you plan to observe, but it is possible to only observe single lines at each wavelength (for spectral zero-point information) and compute the dispersion from the Br γ dispersion using the above formulae. Be sure to record the grating angle for each line, which can be read from the cshellxui program's main window. This angle is also in the FITS file headers (see §III.F). Repeat this calibration procedure each night of your run.

B. Observing at the Telescope

Once you arrive at the telescope you may want to enter the coordinates of your target objects and standard stars into the user star catalog of the IRTF DAS. This will save you from doing so later while you are observing. Your telescope operator or support scientist can help you type in the coordinates. The Telescope Operator will fill CSHELL with liquid nitrogen and bring up the CSHELL software each night for you. Be sure to ask the telescope operator to rotate CSHELL to your desired slit angle (default is East - West with North to the left on the VF display) as well as configure the telescope focus, off-axis guider, and on-axis TV camera (focus and crosshair position) for CSHELL. Select the proper detector and perform the system, signal, and noise checks as well as the wavelength calibrations detailed in §II.A if you have not already done so.

General Observing Procedures

The general observing procedure is to image the field of your object after completing a telescope slew. Next you must position the telescope so that your object is on the slit of the spectrometer and then switch to spectroscopic mode. Note the position of your object on the CCD camera display and ask the operator to start auto-guiding on it. You may use an off-axis guide star if your object is invisible on the CCD. You will usually acquire spectral data in frame pairs, with frames on and off of the object. It is convenient to nod the telescope by about 15" along the slit between the "on" and "off" frames. This allows the object to be observed in both frames of a pair if the object is not spatially extended. Be sure to nod far enough away from the object so that pixels seeing the object in the "on" frame see nothing but blank sky in the "off" frame. The telescope operator can enter the magnitude and direction of the nod for you, and the cshellxui software will automatically nod the telescope between exposures if you observe in nodding mode. Keep exposure times short initially (120-240 seconds per frame) to be sure that the telescope is tracking and guiding properly. The telescope operator can alter the tracking rates to correct for consistent drifts.

You must select the CVF/Blocker Option and also use the shutter wheel blocker (SPF) when observing with the 1.1 - 1.57 µm CVF! This CVF transmits $\lambda > 2.5$ µm radiation, causing significantly increased background in your data if not blocked as prescribed. The blockers impart about a 10% reduction in flux over the 1.1 - 1.6 µm region.

You must observe celestial standard stars to correct for telluric absorption. Find a bright (V < 6) standard from either the Yale Bright Star Catalog or the IRTF standard tables. Be sure that the star is of a satisfactory spectral type so that it does not contain any spectral features that you are attempting to observe in your objects. You need to observe standards at a minimum of two different airmasses to be able to fit their telluric corrections to the airmass range of your objects. Also try to observe the standards at the same array location (row) as your objects; this will minimize CVF fringing in your data as well as simplify both your quick look and final data reductions.

The SBRC InSb detector saturates at different count levels depending on its bias voltage (see table below); try to keep your data values below the 1% linearity deviation for your selected bias. Using a single fixed bias (as done with the old NICMOS array) is inappropriate because of non-linearities and *icky pixel* artifacts in the SBRC 256 x 256 InSb arrays. Larger biases allow more electrons to be collected before saturation, but they also cause increased numbers of high dark current pixels (*icky pixels)* and low-level non-linearities. Fortunately, the *icky pixels* mostly disappear when object and sky frames are subtracted. See § III.C.1 and Appendix F for more information on selecting appropriate detector bias voltages.

Remember to transfer your data to magnetic tapes; it is best to do this at the end of each night at Hale Pohaku. See §III.E for details. Also remember that telescope operators are allowed to work no more than 12 hours at a time on the summit; plan your calibrations, observations, and data archiving accordingly. You may stay to archive data after the operator leaves. Be sure to set the CSHELL filter and slit wheels to their Blank positions and terminate the cshellxui software program at the end of each night. Ask the operator to shut down the instrument if there is a danger of lightning. See §III.B for details. See the following Observing Checklist for more details. Next we consider some details of the observing procedure. We present a reference of observing techniques in §III.C.

CSHELL Observing Checklist

<u>Before Leaving Home</u>
>Produce Objects, Standards, and Guide Stars Lists
>Calculate Integration Times for Desired Sensitivities
>Determine Slit Orientations
>Get one 4mm or 8 mm tape for each night of your run
>Read §I and §II of this manual

<u>Daytime at Hale Pohaku or the Summit</u>
>Obtain an IRTF guest observer account (log into IRTF workstation as "guests")
>Select Calibration Lamp lines with `cal_lines`
>Start the CSHELL Software and Check the System Status
>Set Programmable Voltages (Setup Parameters Frame)
>Take Signal and Noise Test Data
>Take Calibration Line Data for all Grating Settings that night

<u>At The Summit</u>
>Request CSHELL Rotation, Focus, Guider, and Crosshair Configurations
>Enter Personal and Instrument Setup Information into CSHELLXUI and VF Software
>Select bias macro and Set Programmable Voltages (Setup Parameters Frame)
>Select First Wavelength
>Image Sky or Ar lamp through Slit and Record its Column Position (Direct Imaging Mode)
>Take Flat Field and Dark Frames (Spectroscopic Mode)
>Slew to Object
>Image Object
>>Move Slit to "Open" and Select Direct Imaging Mode
>>Choose Nod Vector for Imaging
>>Take Image Frame Pair of Object
>>Move to Slit using VF TCS Coordinates Window
>Take Object Spectra
>>Insert Slit and Select Spectroscopic Mode
>>Locate Object along Slit and Choose Nod Vector
>>Guide with CCD Camera
>>Take First Spectrum (short exposure) and Evaluate Signal
>>Take More Spectra (longer exposures)
>Slew to Standard
>Image Standard
>>Move Slit to "Open" and Select Direct Imaging Mode
>>Choose Nod Vector for Imaging
>>Take Image Frame Pair of Object
>>Move to Slit using VF TCS Coordinates Window
>Take Standard Spectra, Darks, and Flats
>>Insert Slit and Select Spectroscopic Mode
>>Locate Standard along Slit and Choose Nod Vector
>>Take Spectrum
>>Close Shutter, Take Dark Frames, Open Shutter
>>Select Continuum Lamp and Mirror
>>Take Flat Field Frames
>Repeat Flat, Object, and Standard Observations at other Wavelengths Until Done
>Take any missing Calibration, Flat Field, or Dark Frame Data
>Blank CSHELL Filter and Slit from cshellxui
>Quit CSHELLXUI, VF , and Guider Software; logout from Sun
>Archive Data (4 mm tape drive at summit, 8 mm tape drive at Hale Pohaku)

Flat Field and Dark Frames

Uniform celestial illumination does not exactly illuminate the detector arrays uniformly due to imperfections in the telescope and instrument optics. Each detector pixel also responds to illumination differently, causing further departures from a uniform system response. However, dividing astronomical data by a *flat field* made by exposing CSHELL to a uniform illumination source should correct for these response abnormalities as long as the system responds to light linearly. The continuum lamp is a good source of spatially and spectrally uniform illumination, and CSHELL behaves linearly as long as each pixel has about the same number of counts in both object and flat filed data. Therefore we can take flat field frames by observing the continuum lamp with the same instrument state used for astronomical observations. In practice this means that you should acquire several frames of the continuum lamp's spectrum at each wavelength and slit size employed in your astronomical observations. Continuum lamp spectra exposure times of about 5 seconds result in about 2000 counts through a 1" slit. You may take many flat frames (10+) by typing the number of frames in the Cycles text field of the Observing Parameters Frame. The first step in this process is resetting the grating order or CVF wavelengths of CSHELL from those used for calibration lines to those used for your astronomical observations. All flat field and data frames should be taken without moving the grating or CVF between exposures.

All exposures include a *dark current* contribution from the detector arrays. This current can be a significant fraction of the signal from astronomical objects since CSHELL operates at very high resolution. Objects are normally observed in frame pairs (on and off the source) which are subtracted to remove this dark current contribution from the data. We must observe separate *dark frames* to remove this component from the flat fields, however. This is done by turning off the calibration lamps and closing the shutter before acquiring frames of exposure time equal to the flat field frames. Again, many (5-10) dark frames should be acquired at a time in this manner.

Astronomical Observations

You are ready to acquire astronomical data once you have completed your calibration lamp, flat field, and dark frame observations. All flat field and data frames should be taken without moving the grating or CVF between exposures. The next step is to find the array column which corresponds to the location of the slit. Do this by acquiring a *direct image* of the slit; insert the direct imaging mirror (selecting imaging mode) into the light path. You may illuminate the sit with either they sky or a discharge lamp. Record the array column which the slit is centered on; you must position your objects on this column to observe them with the spectrometer. This is a good time to enter the slit position, the plate scale, and slit rotation angle into the TCS Coordinates frame of the VF program (Options menu item). VF will use this information to calculate position offsets to move the telescope so that your objects fall on the slit.

Imaging

Bright objects (K < 9) are easily imaged in single exposures of 1 second or less. Fainter objects require longer exposures and are best observed in a nodding mode in order to subtract the sky background. Be sure to check the focus several times a night by imaging non-saturated objects at different focus positions, using either a FWHM or peak pixel focus evaluation criterion. Evaluate

several exposures or coadds at each focus position to integrate over seeing effects. You should be able to achieve a 1" or better FWHM source profile on nights of good seeing.

You must position your object on the slit once you have found it in the imaging field (30" on each side). This is easily done by displaying the field in a pane of the VF program and selecting the TCS Coordinates item from the VF Option menu. Be sure that the plate scale, slit rotation angle, and slit position are correct, then click the left mouse button while the pointer is at the center of your object. Next press the "F" key on the Sun keyboard to enter the mouse coordinates, and click on the "Calculate Offset" button to calculate how far to offset the telescope. Then offset the telescope by pressing the Offset TCS button.

It is a good idea to acquire a frame at the new telescope position to ensure that your object will be on the slit. Once this frame is acquired (and saved if desired) you should switch to your desired slit size and select spectroscopic observing mode (removing the direct imaging mirror).

Spectroscopy

It is best to move the telescope in the direction of the slit to position your object away from the array center and nod about half a slit length in the opposite direction in order to observe your source in both A and B beam positions. For example, if the slit is oriented East - West (default orientation), then you may wish to move the telescope 7.5" east and use a 15" West nod between frames if you are observing a point source. This would position your source spectrum nearly equally displaced from the array center in both the on and off (A and B) frames when observing in a nod mode. It is in your best interest to guide the telescope using a guide star in the field of either the internal CCD or offset guider camera. Guiding is required for good signal to noise ratios. The mean of the A-B data pairs can be accumulated in a buffer if you are taking many spectra of an object. The MeanFrame buffer is initially set to "N/A" to disable this feature. To turn it on, select an unused buffer from its list in the Observing Parameters Frame. This buffer will then contain the mean A-B for the current set of cycles.

Command Files

The cshellxui and VF programs can read command files which automatically configure CSHELL. This is a great advantage over the manual configuration of each mechanism for commonly used instrument setups. For example, one can create and execute a command file which selects a detector bias for spectroscopy, puts in a slit, switches to spectroscopic mode, and sets the integrations. This is in fact what the *spect* command does, and it can be used to automatically configure CSHELL for spectroscopic observations. Likewise, *image* will configure CSHELL for imaging, and a VF command file can subtract 2 buffers and divide the result by the Flat Field buffer.

Command files maybe be created and edited in several ways. The current state of all CSHELL mechanisms may be recorded into a command file by selecting the "Save Parameters" item in the cshellxui Parameters menu. Command files may be loaded, edited, and saved with this window also. Commands may be entered into files by either recording your real-time manipulations of the spectrometer (check "Record" button in the Commands frame) or typing the text commands into the edit window of the Commands frame. Command syntax is identical to the cshellxui / cshellic and VF command line syntax; see §III.A.

Cshellxui command files are stored in the macro/cshellxui directory of your guest observer account, and VF command files are in the macro/vf directory . These are the default directories that the

programs use to load and save command files. There are more macros in the ~cshell/macro directories, and you may copy ones from there to your guest account. The most commonly used command files are godark, goflat, image, and spect. These commands execute a series of dark exposures, a series of flat field exposures, set up for a pair of nodded images, and set up for a pair of nodded spectra, respectively. Command files starting with *go* (*e.g.* godark, goflat, godark) have "Go Obs" as their last commands so exposures are actually taken when they are executed Command file names without *go* (*e.g.* image, obs) do not contain "Go Obs" statements; exposure times or other parameters may be modified before starting exposures if you are using these files. The commands in these files are listed in §III.C.11. Command file execution may be usually repeated by simply pressing the "Go" button in the cshellxui main menu; you need not re-load and re-execute the file since the state of CSHELL has already been set by the command file. It is most efficient to use command files for all of your observations, but keep a close eye on the exposure time, Autosave status, and other instrument parameters; it is quite easy to start an integration with the instrument in the wrong state. For example, you may wish to save images of the field, but the *image* command files turns Autosave off.

Common VF Quick Look Techniques

The data in any buffer can be examined using the VF program. For example, suppose a spectral frame is stored in buffer b0 and canvas A of VF is set to display an image of the buffer b0 data. Canvas C can also be set to point to buffer b0 and its display mode set to "SpectraA" or "Spectra B" in order to show a binned spectrum of the data over some range in coordinate values. Draw a box on the image in canvas A and select the "Obj Box" and the "X-scale" buttons in the canvas C panel to show the spectrum of the data in the canvas A box in a graph in canvas C. These and other techniques are described in the VF documentation, §III.A. A hard copy of the image or the spectrum shown in the selected canvas can be obtained by selecting the print button at the bottom right of the VF window.

You may also perform frame arithmetic on and rotate images with VF. For example, you can co-add images to evaluate the quality of your data, divide data by standard stars to remove telluric lines, or rotate a spectrum 180° so that you can compare it to a frequency spectrum. You can also combine the data of the A and B beams in a differenced spectrum with the Spectra A or Spectra B displays. If your object is in both beams in a differenced spectral image (you are nodding along the slit), then define a box enclosing the A beam as the object and a box enclosing the B beam as the sky and select "subtract sky" to see a display of the summed data.

VF also can edit and execute command files. This feature is convenient for performing frame arithmetic on and displaying data once they are loaded into buffers. Several VF command files are provided for your use.

III. CSHELL Instrument Reference

A. CSHELLXUI and VF Software Description and Reference

B. Turning CSHELL On and Off

C. Observing Techniques

D. Observing Spectral Lines

E. IRTF Computer Services

F. CSHELL Data and its Reduction

G. Using the CSHELL CCD Guider Camera

A. CSHELLXUI and VF Software Description and Reference

What is the IC and XUI?

The software for CSHELL consist of 2 applications, the Instrument Control (IC) program and the X User's Interface (XUI). The Instrument Control is named "cshellic", or commonly referred to as the IC. The IC executes on a 386PC computer located on the telescope platform, and is responsible for the real-time control of the instrument and its electronics.

The user's interface is provided by the program named "cshellxui", or commonly referred to as the XUI. The XUI executes from a SUN workstation, and provides a friendly interface to the camera. These two programs communication over an ethernet network allowing you to control and view data produce by the instrument from any IRTF's SUN workstations. Figure 1 illustrates this setup.
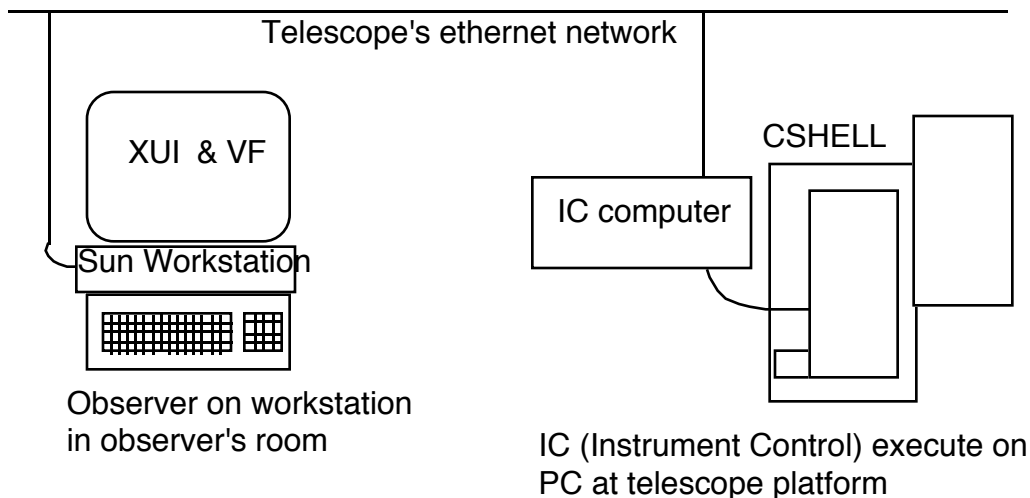
Figure 1 -IC and XUI diagram

A word about initialization files and environment variables.

This section describes the initialization files for the IC and XUI program. Normally you will not need to modify these files since default values are automatically setup for your account. They are described here so that you may modify them as needed. Or so you can check them if thing are not working.

An environment variable CSHELLXUI identifies the location of the XUI executable and associated information file. For example, if the cshellxui application is stored in /usr/local/cshell/XUI the following line in your .cshrc file would correctly setup this variable

```
setenv CSHELLXUI /usr/local/cshell/XUI
```

The IC, XUI, and VF all use a similar method to initialize parameters when starting up. Each program look for a special text file and execute the commands stored in that file. These file are plain text file which contain one command per line. You may modify them using your favorite UNIX editor. The available commands set are documented in the Command Dictionary for each application (IC, XUI, and VF).

This IC program uses ".cshellic-init" from in your current working directory.
The XUI program uses ".cshellxui-init" from your home directory. i.e.: ~/.cshellxui-init.
The VF program uses ".vf-init" from your home directory. i.e.: ~/.vf-init.

Starting the Software

This section outlines the procedures for starting up the software. Note that there are two version of the software:

1. Observers version - This version is the last version of the software which has been tested in an actual observing night at the telescope.

2. Engineering version - This version is under development or testing. This version may contain new features, but has not been fully tested yet.

<u>You should use the observers version, unless you were specifically told by your support scientist to use the Engineering version of the software.</u> The following sections describe how to start up both the observer and the engineering version.

Starting the IC

Normally the Instrument Technician will start the IC program for you. However, in case of computer crashes or other problems, the procedure is explained here. Note only one person at a time can start the IC program. Please check with the Telescope Operator or Instrument Tech before staring up the IC program. The procedures for starting the IC program are as follows:

1. Log in on the IC computer (host name is cshell) as the user 'cshellic'.

a. Find the keyboard & screen for the cshell IC computer. Login as the user "cshellic". There is no password for this account.

```
login: cshellic
```

After hitting return, it takes about 90 seconds for the software to startup and display the status screen. See Figure 2 for an example of the IC's status screen. Once this screen is display and all mechanisms show "READY", you may go ahead and start the XUI. If any of the status show an "ERROR" state, you should try to reinitialize the item using the ??init command (i.e.: FilterInit, GOInit, GratingInit, etc..). If this fails, ask assistance from the T.O. or support scientist to trouble shoot this failure.

```
CSHELL Instrument Control 2.0 (Apr 27 1994)              Time 14:09:22
      Acq OK          CycLeft 0           Filter OK      Grating OK
      Slit OK         Shutter OK          DIMirror OK
      VCCD OK         Lamp OK             SocketIO OK

      Itime 1.000         GPos 200000      SetPt/Heat 28.00/3.10
    Samples 1         EncoderPos 200000        Temp1 26.00
      Coadd 1             GWLen 1.39013        Temp2 51.00
                         GAngle 61.89    SetPt/Heat 4.00 /0.00
     ObMode Stare (A)      Order 40            Temp1 55.00
     Cycles 1            Opt Odr 28            Temp2 62.00
   InstMode 0 (S  )         Slit 5 (Blank)
    Shutter 0 (Close )      VCCD 0 (Out)        DTime 2.00
    CVFWlen 1.40000    LampMirror 0 (Out)     Tbl_usec 0
     Filter 5 (Blank     ) Lamp 0 (Off )      DSPLdTbl 1

   AutoSaveIC Off      Filename data          ImageNumber 0001
   AutoSaveXUI Off     ICPath /home/wirth/denault/data/28apr
```

Figure 2 - IC program Sample Screen

Starting the XUI

Once the IC program is running and all status is READY, you may start the XUI program. The XUI program is an X windows applications. Here are the steps to start the cshellxui.

1. Login on the IRTF's sun workstation and start Openwindows. Your support scientist should have given you instruction on obtaining an account. To start Openwindows, type "openwin" at the UNIX prompt.

```
% openwin
```

2. From OpenWindows, bring up the workspace menu by clicking the right mouse button on the workspace area. Under "CSHELL", select the "Cshell XUI" item.
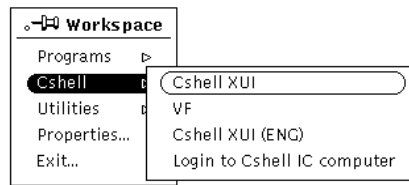
Figure 3 - Starting the XUI from the Workspace Menu

For those of you who were told to start up the engineering version, select the menu item " CShell XUI (ENG)" from the menu (Figure 3).

If all goes well, the following window should appear on your screen.
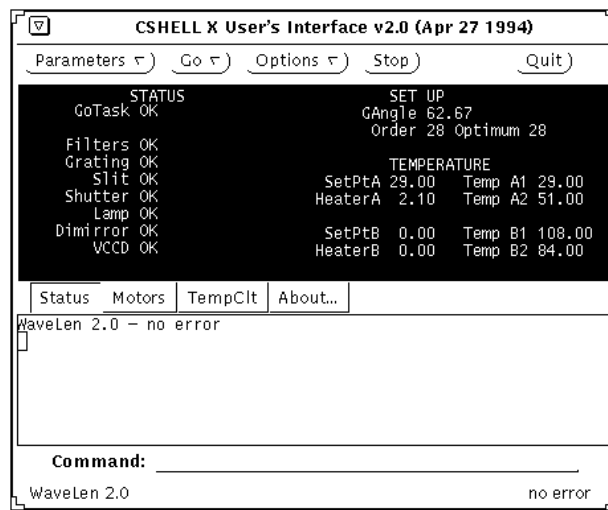
Figure 4 - XUI program Sample Screen.

3. Start VF. At this point you should also start VF. Access the workspace menu, under the "CSHell", select the "VF" menu item. VF should start up immediately.

Shutting down the XUI & IC

1. To quit the XUI program by selecting the "Quit" button on the cshellxui window.

2. Backup your data (every night) with the 8 mm Exabyte tape drive to prevent data loss in case of a disk failure.

! Stop here. Normally quitting the XUI is enough. The T.O. or day crew can terminate the IC program. The remaining steps, will terminate the IC program.

3. Enter the "die" command on the IC computer. This will terminate the IC program. The message "CSHELL is down!" message is display when all programs are terminated.

The CSHELLXUI Main Menu

The Main Menu provides you access to the command frames and other functions. Figure 5 illustrates the menu's selections and give a brief summary of its purpose.
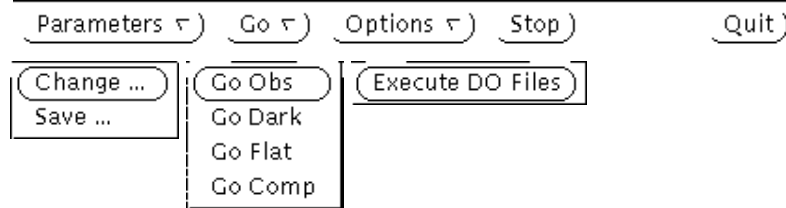
Figure 5 Main Menu

Parameters - The select button selects the 'Change..' item. The menu button bring up the sub-menu.

> **Change...** - Brings up the 'Parameters' window which allow you to view and change the many CSHELL observing, Setup, and Engineering parameters.

> **Save..** - Brings up the 'Save Parameters as a Macro File' dialog window. This window allows you to write the current setup as a macro file.

Go - The select button select the 'Go Obs' item. The menu button brings up the GO sub menu.

> **Go Obs** -Starts an integration creating files with the '.a' or '.b' extensions, and IMAGETYP = object in the header.

> **Go Dark** - Starts an integration creating files with the '.dk' extension, and IMAGETYP = dark in the header.

> **Go Flat** - Starts an integration creating files with the '.fl' extension, and IMAGETYP = flat in the header.

> **Go Comp** - Starts an integration creating files with the '.cll' extension, and IMAGETYP = object in the header.

Options - The select button selects the 'Execute Do Files' item. The menu button brings up the sub menu.

> **Execute DO Files** - Brings up the Edit Command Files window. This window provides the ability to create, edit, save, load, and execute macro files.

Stop - The stop button will abort the current GO operation.

Quit - The quit button will exit the application.

The Status Canvas

The Status Canvas is used to display the current state and configuration of CSHELL. A number of formats are available to you. To change the format, select an item from the status canvas menu panel item.
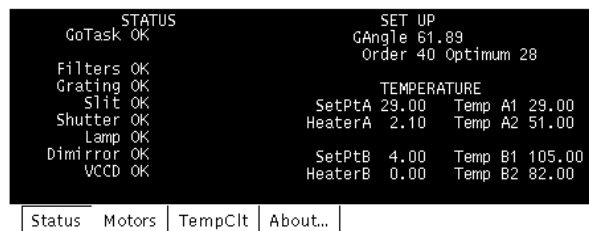
Figure 6 - Status Canvas display 'Status'

Selecting 'status' from the status canvas menu, specifies a format similar to figure 4. This is the default selection. The information is grouped in 3 sections labeled STATUS, SET UP and TEMPERATURE. Under Status, there is a list of the various components of CSHELL which can take some time to change (moving the filter from point A to point B) or should be monitored (like the amount of time left in an integration). Each item may show 3 possible states.

OK - This item is ready to receive commands.

BUSY 99% - This item is currently in motion or in use. A new command concerning this item cannot be issued until it has completed its current motion.

ERROR - A malfunction has occurred either in software or hardware. The software task should be initialized after inspecting the hardware related to that item.

For example, a filter command will be accepted only when the filter status is OK. After the command is accepted, its status will change to BUSY. While the filter is moving, no new filter commands will be accepted and the percentage complete is updated to provide visual feedback. When the filter has reached its new position, the status will return to OK.

The SETUP shows some important setup parameters. In the example, the CSHELL is currently using the SBRC array.

TEMPERATURE displays the current temperature readings from the sensors. There are 4 sensors and their values are shown in Kelvin.

Under the Status Canvas, there are 4 buttons labeled **Status**, **Motors**, **TempCntl**, **About...**. Selecting the different buttons will allow you to view the different status screen available. There different format are not explained in detailed here, but it is suggested you check them out.

The Parameter's frame.

The Parameters frame allows you to view and edit the most common CSHELL parameters. These parameter are separated into 3 groups: Observing, Setup, and Engineering. The first set of blue buttons on the Parameter's frame allows you to switch between these groups. You may view/edit each set of parameter by selecting the proper group. Each time you select a group the Parameter's frame appearance will change to display the appropriate parameters.

The Observing Parameters.

When you select the 'Observing' button on the Parameter's frame, it will display the most common parameters used while observing. Figure 6 is an illustration of the frame for Observing.
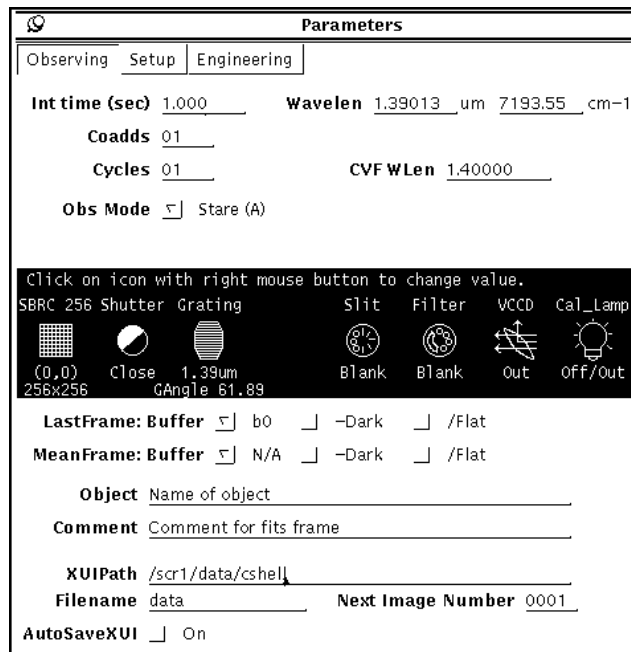
Figure 7 - Observing Parameter Frame

The row of icons in the middle of the window represent mechanical components in the optical path. From left to right, each icon represents a component which can alter/redirect/block the light as it enters the CSHELL and travels through it. On top of each icon, the name of the component is shown. On the bottom, its current value or setting is shown. For example, look at the shutter's icon and you can see it is currently open. Each icon is colored gray or yellow. Yellow shows that an item is in the optical path, while gray shows you that an item is either blocked or moved out of the optical path. For example, if the Filter is set to blank, all the icons to the left will be gray since the filter is blocking the light.

The other prompts and menu are usually self-explanatory. For a detailed explanation of each options, refer to the CSHELL Command Dictionary. For example if you wish to know what happens when you change the value for 'CVFWlen', look up 'CVFWlen' in the dictionary. A detailed explanation is provided.

Special Notes:

1. Input a wavelength or wave number into the "Wavelen" parameter to move the grating to the desired wavelength. The CVF is also automatically changed to the proper wavelength.

2. Coadds is the number of coadds per beam.

3. Cycles determines the number of times an observing mode is repeated.

4. "ObsMode" determine how many beam switches are done.

5. After the 'Lastframe' label you are presented with 3 panel items: Buffer, -Dark, /Flat. These items control how the data is sent to the VF program upon reading out the array. In stare observing mode, data is sent to the buffer specified. In nod observing mode, after each object-sky pair, the difference frame is sent to the VF program. If the -Dark or /Flat is checked, a dark frame is subtracted from the data and it is divided by a flat frame.

The 'MeanFrame' is also contain similar panels. If you do a GO with cycles greater than 1, you can calculate the mean of all the frames sent to VF.

If a MeanBuffer is specified, each time data is placed into Lastframe-buffer, the mean of all the frame in the current cycle is calculated an placed into this buffer. The -Dark and /Flat, specifies the processing done when calculating the mean frame.

In VF, there are two special buffers, a dark buffer and a flat buffer. You must load data into these buffers if you specify the -Dark or /Flat options.

The Set Up Parameters.

When you select the 'Setup' button on the Parameter's frame, it will display parameter not normally used while observing, but which should be reviewed during setup. Figure 7 is an illustration of the frame for 'Setup'.
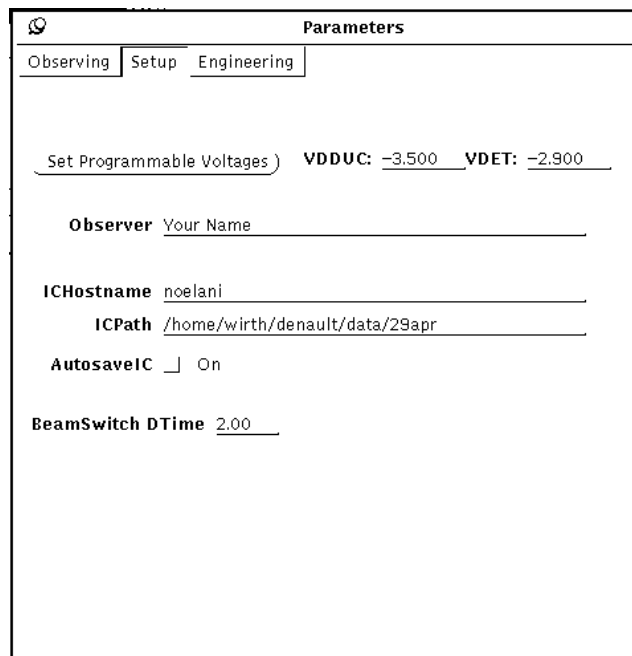
Figure 8 - Calibration/Set Up Frame

The items are usually self-explanatory. For a detailed explanation of each options, refer to the CSHELL Command Dictionary.

Special Notes:

Always select the **Set Programmable Voltage** button on the Setup page. The user's must set these voltages manually before take data with the SBRC array.

The Engineering Parameters.

When you select the 'Engineering' button on the Parameter's frame, the engineering parameter are displayed. These are parameters which should not be changed by casual observer. The Instrument Technician or support scientist can change them after inputting the password. You can view these parameters at anytime, but they can only be changed after the password has been entered. Figure 8 is an illustration of a sample frame.
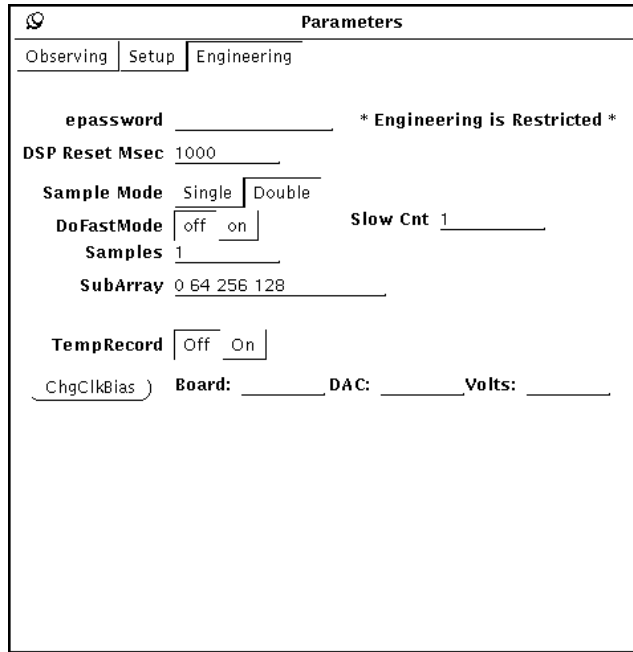
Figure 9 - Engineering Parameters Frame

For a detailed explanation of the options for each panel item, see the CSHELL Command Dictionary.

The Save Parameters as a Macro File frame.

Selecting the 'Save Parameter' menu item from the `Parameters' sub menu causes the Save Parameters as a Macro File command frame to appear. Through this frame, you can create a macro file of the current setting of the following parameters:
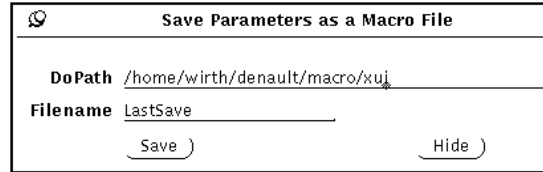
Figure 10 - Save Parameters Frame

The panel items inside this frame are:

DoPath - This text panel item identifies the sub directory used for accessing command or macro files. You may change this directory by editing this panel item.

Filename - The macro file is created using this filename. You may change the filename by editing this field.

Save - Selecting this button will execute the 'SaveSetUp' command, which crates a macro file using your current setup.

Hide - Selecting this button will cause the frame to disappear from the computer screen.

The Edit and Execute Files frame.

XUI provides a way of creating and executing macro files. A macro file is a text file containing commands. There should be 1 command per line and the syntax for commands are defined in the CSHELL XUI Command Dictionary. In the Options sub menu, the choice 'Execute command files' brings up a command frame to create or edit files, and execute them.
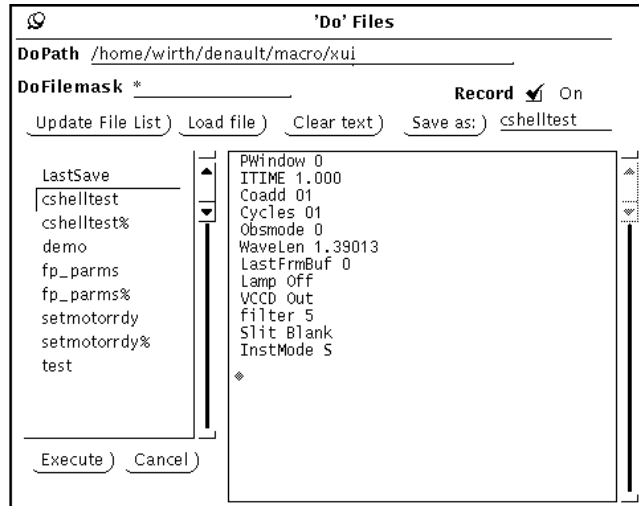
Figure 11 - 'Do' Files command frame

The following panel items will help you read, edit, and save the contents of macro file:

DoPath - This text panel identifies the sub directory where your macro files are stored.

DoFileMask - The file mask is a regular expression used with the path to determine the names of the files displayed in the file list. Selecting **Update File List** will re-initialize the list.

Load File - Selecting this reads the file selected in the file list and places the text in the edit window.

Clear text - Clear the edit windows buffer.

Save as - Selecting this button writes the current text in the edit window into the filename shown in the text panel item.

Record - This check box panel item controls the recording function. When the box is checked, any commands executed by XUI will also be written to the edit window. This allows you to write macro files using the mouse and panels items.

The file list is identical to the one in the Execute Command Files frame. The sub directory and file mask is specified by the DoPath and DoFileMask variable which are shown in the Execute frame.

To execute a command file, select the file in the list then click on the **Execute** button. XUI will read the file and execute each line. The commands and its error message ('Error None' when successfully executed) will be written to the Feedback panel on the Application's base frame so you can see what's happening. If you wish to abort a macro file in progress, click on the **Cancel** button.

Moving the IC computer between the Summit & Manoa

Because the PC is used both at the summit and Manoa, there are changes in some of the setup file which need to be done to allow it to work properly at each location. The manoa host name is 'cshell-manoa'. The summit host name is 'cshell'. This page identifies the changes required. This is mostly just a reminder for the IRTF programmer or technical staff. Cshell users can ignore this page.

File: **/bin/rc**

a. At the bottom of the file the rdate program is called to initialization the date and time at boot time. Additional line call programs at boot time to initialize the DIO board and PC-38 to mode friendly with CSHELL.

Change the comment to use the approriation line. For example, on the summit it would be:

```
#--------------------------------------------------------------
# Addition startup command added by Tony Denault, IRTF Programmer
#--------------------------------------------------------------
/usr/local/bin/rdate herschel
#/usr/local/bin/rdate wirth

# These lines initializes the DIO48 board. It set the mode to
# 0x82 (output, input, output) and write 0's to ports A, C.
#
/usr/local/bin/pc38io -o 643 -d 130
/usr/local/bin/pc38io -o 640 -d 0
/usr/local/bin/pc38io -o 642 -d 0
# This line initialize the PC-38 to power automatic mode.
/usr/local/bin/pc38io  ` rs;arpa;aspa;atpa;aupa;avpa;axpa;aypa;'
```

File: **/net/rc.network**

a. Insure the host name is correct. nsfpc is used on the summit. irlabpc is the manoa hostname. Look for the following lines and comment appropriately.

```
hostname cshell
#hostname cshell-manoa
```

b. Look for the following line:

```
#  Mount remote NFS directories using the following format:
#  mount remhost:rem_dir_path_name local_dir_path_name

mount wirth:/home/wirth /home/wirth
```

The mount command should be commented on the summit.

CSHELL XUI / IC Command Reference

Array - Set the size and location of sub-arrays to be readout for r the next GO. These coordinate are relative to the physical device. You data is normally viewed rotated 90˚ clockwise.

Prompt	Array_icon on the Parameters screen, OBS page.
Range	x y wid hgt - The (x,y) location of the upper left corner and its width and hgt is specified. Please note that these values must be multiples of 8.
Initial	Full size (0 0 256 256).
Syntax	ARRAY x y wid hgt

AutoSaveIC - Determines whether the data is saved by the IC program.

Prompt	Parameters window in the Setup page,
Range	Off - Data is not saved by the IC.
	On - The IC program on the PC saves the data.
Initial	Off
Syntax	AutoSaveIC { off l on }

AutoSaveXUI - Determines whether the data is saved by the XUI program.

Prompt	'AutosaveXUI' on the observing parameter's Obs page.
Range	Off - Data is not saved by the XUI.
	On - The XUI program on the SUN saves the data.
Initial	Off
Syntax	AutoSaveXUI { off l on }

CamMode - Specifies the clocking and readout modes in the GO sequence.

Prompt	N/A
Range	Basic- Acquires single images with just the basic options.
	SIM- Simulation mode. Allows the software to be used with out the actual camera hardware.
Initial	Basic
Syntax	CAMMODE { basic l sim }

ChgClkBias -.Changes the bias voltage to the clock/bias DAC. This is an engineering command.

Prompt	'ChgClkBias' button on the Observing Parameter's Engineering page.	
Range	Board	1 to 4.
	DAC	1 to 16.
	Volts:	-10 to 10.
Initial	N/A	
Syntax	CHGCLKBIAS board dac volt	

CoAdd - The number of intergrations summed together per beam or chop position in a GO.

Prompt	'Coadd' on the observing parameter's Obs page.
Range	1 ti 32000
Initial	1
Syntax	COADD num

Color - Indicate to the IC program whether the console supports color for text output. The character attributes for color or monochrome are selected based on this parameter.

Prompt	None
Range	OFF or ON.
Initial	OFF
Syntax	COLOR { off l on }

Comment - Specifies a string to be place in the fits header of the saved file as a comment.

Prompt	'Comment' on the observing parameter's Obs page.
Range	Any string up to 40 characters.
Initial	Undefined.
Syntax	COMMENT string

Cycles - Cycles is a repeat factor in a GO sequence under basic mode. For the ObsMode NoiseImage, Cycles indicates how many frames will be used to calculate the noise.

Prompt	'Cycles' on the observering parameter's Obs page.
Range	1 to 1000.
Initial	1
Syntax	CYCLES num

CVFwlen - When a CVF filter is selected, this parameter specifies the wavelenght for the CVF filter. Setting the CVFWlen update the user's order, which specifies which

order to be used by grating to observe at the wavelen specified by CVFwlen.

Prompt	'CVFWLen' on the Filter Wheel Dialog Box.
Range	1.0 to 2.449, or 2.46 to 5.6
Initial	2.20
Syntax	CVFWLEN num

Die - This command stops the execution of the IC program. This command can only be executed from the IC program.

Syntax	DIE

DiMirrorInit - The command to initialize the Direct Imaging Mirror. The DiMirror places the insturment in spectrscopic or imaging mode.

Syntax	DIMIRRORINIT

Display - This command selects the various screen layouts on the IC program. This command can oly be executed form the IC program.

Prompt	XUi_PROMPTS
Range	0 - Displays the most common observing parameters.
	1 - Display the descriptive text parameters.
	2 - Display the engineering parameters.
Initial	0
Syntax	DISPLAY num

DoFastMode - Select the fast or slow clocking mode by setting Fastmode on or off. This is an engineering command.

Prompt	'DoFastMode' on the observing parameter's Eng page.	
Range	Off	- Slow clocking mode.
	On	- Fast clocking mode.
Initial	Off	
Syntax	DOFASTMODE { off l on }	

DoFile - This command starts exection of a macro file.

Prompt	See Execute Command File in the XUI User's manual.
Syntax	DOFILE filename

DoFileMask - This command sets the pattern string used in creating the file list on the Edit and Executed File

window in the XUI program. This command can only be executed from the XUI program.

Prompt	'DoFileMask' on the Execute Do Files window.
Range	Any string.
Initial	*
Syntax	DOFILEMASK string

DoPath - This path identifies the subdirectory where the XUI program will search for DO or macro files. The $HOME and $DATE macros are supported. This command can only be executed from the XUI program.

Prompt	'DoPath' on the Execute Do Files window.
Range	Any legal UNIX subdirectory
Initial	$HOME/macro/camxui
Syntax	DOPATH string

DSPResetMSec - Specifies the amount of time in millisecond between array reset. Array resets are performed during idle periods.

Prompt	'DSP Reset Msec' on the observing parameter's Eng page.
Range	500 to 10000 milliseconds
Initial	1000
Syntax	DSPRESECMSEC num

DSPSampleMode - Specifies the sampling mode used to readout the array during a GO.

Prompt	'Sample Mode' on the observing parameter's Eng page.
Range	Single - A single sample is done by reseting the array. After the integration time has passed the array is readout to produce an image.
	Double - After an array reset, a pedestal image is readout. After the intergration time, a sample image is readout. The final image is the result of the sample minus the pedestal readout.
Initial	Double
Syntax	DSPSAMPLEMODE { single l Double }

DTime - Specifies the dead time after a beam swith in seconds.

Prompt	'Beamswitch DTime' on the observing parameter's Setup page.
Range	0 to 10 seconds.

Initial   2

Syntax   DTIME sec

EPassWord - The Epassword command allows you to enter a password. After entering the password sucessfully, any restrictive parameters (ie engineering) can be modified. Issing the command with an invalid password will cause those parameters to be restricted.

Prompt   'epassword' on the observing parameter's Eng page.

Range   Any string

Syntax   EPASSWORD string

Filename - The filename's prefix is used ot create filenames when saving data to disk. New filenames are constructed by concatendating Filename with the Image Number, then adding a file extension. For example, if Filename is '01jan' and image number is 45, the data file saved could be '01jan045.a'.

Prompt   'Filename' on the observing parameter's Obs frame.

Range   A string of 8 characters

Initial   The current date in the form DDMMM

Syntax   FILENAME string

Filter - Select a filter combination using the 2 filter wheels. The selection are indicated by the index values.

Prompt   Click on the FIlter Icon on the observing parameters window.

Range   0 - CVF Wlen & Open

                1 - 2.35 um NBF & Open

                2 - 4.05 um NBF & Open

                3 - He 1.083 & Open

                4 - HI 2.167 & Open

                5 - Both wheels blank

                6 - CVF Wlen & Open

                7 - 2.35 um NBF & Blocker

                8 - 4.05 um NBF & Blocker

                9 - 2.5 um Blocker

                10 - 4.1 um Blocker

Initial   Blank Blank 2.20

Syntax   FILTER { 0 I 1 I 2 I 3 I 4 I 5 I 6 I 7 I 8 I 9 I 10 }

FilterInit - This command will initialize the filter wheels by moving them to their limit switches and then moving them to their initial position.

Syntax   FILTERINIT

FIlterPos - Allows you to position the filter wheels to any step position. Normaily you may only offset the wheel position -100 or +100 steps from its normal location. After entering the engineering password, this restrictions is removed, but be careful of flashing the array in this mode.

Range   1 to 40000 .

Syntax   FILTERPOS { A I B } step# [{AIB} step# }]

Go - Performs a GO, which is a set of integrations. The GO command can take an optional parameter which determines the type extension for filenames in basic mode. Please read the section description of CamModes for a more complete description.

Syntax   GO [{ obs I dark I flat I comp }]

GoInit - Initializies the go task in the IC program. The go task is responsible for controlling the DSPs and Array's electornics.

Syntax   GOINIT

GoReset - Places the DSP in a reset operation mode. The go task's state will be change to ERROR.

Syntax   GORESET

GratingInit - Initializes the grating. The grating is initialized by reading the step position from the encoder to set the step postion of the grating's stepper motor.

Syntax   GRATINGINIT

GratingPos - Commands the grating's stepper motor to move to a specific step position.

Syntax   GRATINGPOS

Range   100000 to 400000

GratingRMove - Moves the grating from its current position by a relative number of steps.

Range   -2000 to 2000

Syntax   GRATINGRMOVE steps

GWLen - Moves the grating to the indicated wavelenght. First the optimum order is calculated. The user's order is set to the optimum order. Then the step position of the grating is determined from the inputted wavelenght and this order. The grating is moved to this position.

Prompt   See 'WaveLen' command.

Range	1.0 to 6.0.	
Syntax	GWLEN micons	

ICHostName - The XUI program uses this hostname when initiating network communication to the IC program. This command can only be executed from the XUI program.

Range	Enter the hostname of the IC computer
Initial	cshell
Syntax	ICHOSTNAME name

ICPath - The path identifies the subdirectory the IC program uses when writing data files. This command will create new subdirectories if path doesn't exist. Supports the $DATE and $HOME macors.

Range	Any legal unix subdirectory. 80 chars max.
Initial	$HOME/data/$DATE
Syntax	ICpath string

ImageNumber - An ID number used to create the filename. See Filename for an example.

Prompt	'Next Image Number' on the observing parameters Obs page.
Range	1 to 9999
Initial	1
Syntax	IMAGENUMBER num

InstMode - Places the instrument in Spectrocopic or Direct Imaging mode by moving the Direct Imaging mirror out or in.

Prompt	'Instrument Mode' menu is accessed by clicking on the Grating or DiMirror icon on Parameter's Observing page.
Range	S (Spectroscopic) Optical path is through grating.
	D (Direct Imaging) Blocks the grating
Initial	S
Syntax	INSTMODE { S I D }

Itime - The amount of time the array is exposed between readouts, or the time interval for 1 Coadd. The minimum value is determined by the readout rate.

Prompt	'Itime' on the observing parameter's Obs page.
Range	0.1 to 3600.0 seconds
Initial	1

Syntax	ITIME sec

Lamp - Turn off/on the calbration lamps This command automaticly move the lamp mirror out when the lamps are turned off, and in when the lamps are on.

Prompt	'Cal_Lamp' icon on the Parameter window's Observing page.
Range	off
	AR - Argon Lamp
	KR - Krypton Lamp
	XE - Xenon Lamp
	Cont - Continuum Lamp
Initial	Blank
Syntax	LAMP { off I AR I KR I XE I Cont }

LampInit - The command to initialize the lamp and lamp mirror by turning the lamp off and moving the mirror out of position.

Syntax	LAMPINIT

LampMirror - More a mirror so the calibration lamp are out or in the optical light path.

Range	Out - lamps are out of optical path.
	In - lamp are in optical path.
Syntax	LAMPMIRROR { out I in }

LastFrmBuf, LastFrmSubDark, LastFrmDivFlat - These are switches used by the XUI program to process each frame of data during a GO operation. LastFrmBuf identifies the buffer in the VF program which will display the data. When set, LastFrmSubDark and LastFrmDivFlat will cause some processing of the data frame by subtracting a dark and dividing by a flat. The dark and flat frames are identified by the VF program as the data loaded into buffer 5(Dark) and 6(Flat).

Prompt	'LastFrame' on the Calibration/Setup frame.
Range	N/A
Initial	Buf = b0, -Dark and /Flat are off.
Syntax	LastFrmBuf {0 I 1 I 2 I 3 I 4 I 5 }
	LastFrmSubDark {off I on }
	LastFrmDivFlat { off I on }

MeanFrmBuf, MeanFrmSubDark, MeanFrmDivFlat - During a GO you have the option of accumulating the data and displaying a mean frame at the end of each cycles. These parameters allow you control over this option. The MeanFrmBuf identifies the buffer in

the VF program uses to display the mean frame. If set, MeanFrmSubDark and MeanFrmDivFlat will cause some processing of the mean frame by subtracting a dark and dividing by a flat frame. The dark and flat frame are identified by the vf program as the data loaded into buffers 5(Dark) and 6(Flat).

Note: This option consumes much of the CPU's execution time and should only be used during GO with long integration times(greater than 15 seconds).

Prompt	'Meanframe' on the Calibration/Setup frame.
Range	N/A
Initial	Buf = N/A, -Dark and /Flat are off.
Syntax	MeanFrmBuf {0 I 1 I 2 I 3 I 4 I 5 }
	MeanFrmSubDark {off I on }
	MeanFrmDivFlat { off I on }

Object Name - This information identifies the object you are observing and is placed in the fits header.

Prompt	'Object' on the observing parameter's Obs page.
Range	Any string up to 40 characters.
Initial	'Name of Object'
Syntax	OBJECT string

Observer - This information identifies the observers and is placed in the fits header.

Prompt	'Observer' on the observing parameter's Obs page.
Range	Any string up to 40 characters.
Initial	'Your name'
Syntax	OBSERVER string

ObsMode - The observing mode determines the beam switch pattern performed in a GO sequence and when in the sequence the files are saved. The obmode is identified by an index number

Prompt	'Obs Mode' on the observing parameter's Obs page.
Range	0 - Obj(A) integrates at the present beam position. This data is treated as an 'object' frame.
	1 - Sky (B) integrates at the present beam position. This data is treated as a 'sky' frame.
	3 - Pair (AB). In this mode, a pair of frames are taken. First the telescope is position at

the A beam and a 'object' frame is taken. Then the telescope is positioned a the B beam and a 'sky' frame is taken.

4 - Noise Image. This is a special mode used to produce noise images. For each cycle a image is readout. Using these images, the standard deviation of each pixel is calculated. A frame is produced where each pixel position contains the standard deviation of that pixel position. These value are multipled by 100 to preserve decimal information.

Initial	0
Syntax	OBSMODE num

Order - Set the user's order. The grating wavelenght is calculated based on the grating angle (step position) and an implied order. This implied order is called the user's order. Normal the user's order is set to the optimum order for a given wavelenght. This command allows you to change the user's order.

Prompt	None. Enter command at prompt.
Range	8 to 60
Initial	Optimum order
Syntax	ORDER num

PVoltage - Sets the user programmable voltage's VDDUC and VDET on the clock bias board.

Prompt	The observing parameter's Setup page contains prompts for set the voltages. First input the appropriate values in VDDUC and VDET. Then select the 'Set Programmable Voltages' with the mouse to send these values.
Range	VDDUC range is -3.75 to -2.505 volts.
	VDET range is -3.75 to -2.505 volts.
	In addition, vdet >= vdduc and (vdet-vdduc)<=1.5 volts.
Initial	Undefined. You must initialize the voltage as part of your startup procedures.
Syntax	PVOLTAGE vdduc vdet

PWindow - The PWindow variable indicates which parameter page should be displayed in the Observing Parameters frame.

Prompt	Set of Blue colored button in the upper-right corner of the Observing Parameter frame.
Range	1 - Obs. Displays is most commonly changed Observing parameters.

2 - Setup. Displays the setup parameters. These parameters should be examine at the start of you observing session.

3 - Eng. Displays the engineering parameters. These are restricted parameters mostly dealing with the array electronics.

Initial	0
Syntax	PWINDOW { 0 I 1 I 2 }

RotateImage - This option automaticly rotates the image clockwise 90° in the obsmode Stare and Nod.

Prompt	None. Enter command at command prompt.
Range	Off - No rotation performed.
	On - Rotates the image.
Initial	On
Syntax	ROTATEIMAGE { Off I ON }

Samples - This parameter identifies the number of samples or times the array is readout to obtain the image for 1 coadd. Note that increased the number of samples will lower you noise, but will also increase you minimum integration time. This is a engineering or restricted command.

Prompt	'Samples' on the Observing Parameter's Eng page.
Range	1 to 256.
Initial	1
Syntax	SAMPLES num

SaveSetUp - Ceates a macro file of some of the current parameter in the dofile directory. This command is used only by the XUI program.

Prompt	'Save Parameters' on the main menu access the Save Parameters as a Macro file Frame.
Syntax	SaveSetUp filename

SetMotorRdy - This command sets the status for all the motorized items (filter, dit, len, pplate) to the READY state. This command is intended for engineering purposes only. Since all item must in in a ready state before a GO is accepted, this command clears any ERROR condition due to mechnical failures. Do not attempt to move any motors which has been set ready using this command. This is an engineering or restricted command.

Syntax	SETMOTORDY

Shutter - Selects a shutter wheel position.

Prompt	Shutter
Range	Open
	Close
	2.5SPF
Initial	Close
Syntax	SHUTTER {Close I Open I 2.5SPF }

ShutterInit - This command initializes the shutter wheel by searching for it limit switch, then moving the shutter to the closed position.

Prompt	None. Enter command at command prompt.
Syntax	ShutterInit

ShutterPos - Allows you to move the shutter to an absolute step position.

Prompt	None. Enter command at command prompt.
Range	0 to 4999
Syntax	ShutterPos step#

Slit - Select and moves to a slit wheel position.

Prompt	Slit
Range	0.5, 1.0, 1.5, 2..0, 4.0, Blank, Open, J, H, K, L, L', M
Initial	Blank
Syntax	Slit {0.5 I 1.0 I 1.5 I 2..0 I 4.0 I Blank I Open I J I H I K I L I L' I M }

SlitInit - Initializes the slit wheel by moving it into the limit and then setting it to BLANK.

Prompt	None. Enter command at command prompt.
Syntax	SlitInit

SlitPos- Move the slit wheel to a step position

Prompt	None. Enter command at command prompt.
Range	0 to 64000
Syntax	SlitPos step#

SlowCnt - When DoFastMode is OFF, the SlowCnt variable specifies the numbers of NOP's or delays in the DSP clocking algorithm. This effectively slows down the clocking pattern which lowers the readout rate and read noise. This is an engineering or restricted command.

Prompt	'SlowCnt' on the Observing Parameter's Eng page.
Range	1 to 100.

Initial   1

Syntax   SLOWCNT num

Stop - During an integration or GO cycle, the stop command is used to abort the acquisition.

Prompt   'Stop' button on the XUI's command frame.

Syntax   STOP

SubArray - Load the size and position of the default subarray. These parameters are used when setting the subarray from the XUI's array icon on the Parameter's Observing page. These parameter refer to an unrotated image. This is an engineering command.

Prompt   'SubArray' on the Parameter's Engineering Page.

Range   x, y, wid, hgt must be a multiple of 8.

Syntax   SUBARRAY x y wid hgt

TCS - Using this command you may send a string to the Telescope Control System (TCS). This string is assumed to be a correct TCS command with a 40 character maximum limit.

Range   Any legal TCS command.

Syntax   TCS string

TCSHostName - Identifies the computer host accepting TCS commands.

Range   The current TCS host is 'planck'

Initial   'planck'

Syntax   TCSHOSTNAME name

TempCmd - Sends a commands to any of CShell's two Temperature Controllers. Any string after the TempCmd is send to the temperature controller. Please refer to the Description of Hardware section or the temperature controller's manual for the correct syntax for the temperature control commands.

Range   Any legal controller command

Syntax   TEMPCMD { A | B } string

TempRecord - TempRecord allows you to switch OFF/ON the recording to temperature information. When ON, the temperature information is appended to the file 'temper.log'. The recording interval is once every 5 minutes.

Prompt   'TempRecord' on the Observing parameter's Eng page.

Range   OFF or ON.

Initial   OFF

Syntax   TEMPRECORD { off | on }

VCCD - Selects the position for the visible CCD dichroic/Netural Density filter assembly.

Prompt   Click on the VCCD Icon on the observing parameters window.

Range   Out - VCCD Dichroic and ND filter out of light path.

            In - Places the VCCD Dichroic and ND filter in light path.

Initial   Out

Syntax   VCCD { out | in }

VCCDInit - The command to initialize the visible CCD dichroic/Netural Density filter assembly.

Syntax   VCCDINIT

VF - Commands VF from the XUI program. This command can only be executed from the XUI program.

Range   Any legal VF command. See the Command Dictionary for the VF program for syntax.

Syntax   VF command

Wait - Sets the acquire or Go task busy for a time interval specified seconds.

Range   0.1 to 60.0 seconds

Initial   N/A

Syntax   WAIT sec

Wavelength- This command changes the value of the CVFWlen and GWLen. It is provide to allow the use to change the grating and CVF wavelenght with a single command.

Prompt   WaveLen on the Parameters window Observing Page.

Range   1.10 to 2.449, 2.46 to 5.60 microns

Syntax   WAVELEN num

XUIHostName - The IC program uses this hostname when initiating network communication to the XUI program.

Range   Enter the hostname of the workstation running the XUI interface.

Initial   Planck

Syntax   XUIHOSTNAME name

XUIPath - This path identifies the subdirectory the XUI programs uses when reading and writing data file.

Prompt	'XUIPath' on the Observing Parameter's Obs page.
Range	Any legal UNIX subdirectory
Initial	/scr1/nsfcam/data/DDMMM. Where DDMMM is the current date. For example, /scr/nsfcam/data/01jan.
Syntax	XUIPATH string

Command - Describe_command.

Prompt	XUi_PROMPTS
Range	describe_parameters.
Initial	N/A
Syntax	SYNTAX

What is VF?

The VF software is a tool used to View Fits data files. A brief description of its capabilities are:

- Manipulate fits images of up to 2048 by 2048 pixels using 32 bits per pixel.

- Provides 8 buffers and 5 canvases for holding and viewing.

- Provide various mode of display such as imaging, histogram, line cut, plus other specialized modes.

- Allows the user to perform arithmetic operation on the fits data.

- Provides tools the calculate box photometry and statistics on pixels.

- Produces postscript files of graphics for hard copy output.

- Provides the ability for the instrument control software to send commands and data to VF.

VF runs on a Sun Workstation under Sun's Openwindows software. It is an X windows application developed using the XView tool kit by the NASA Infrared Telescope Facility. The user interface conforms to the Openlook GUI Specifications. Before using VF, you should become familiar the Openlook User Interface.

If you have questions or comments concerning VF, you may contact the author of the software via email at denault@.ifa.hawaii.edu or by calling the IRTF at (808)956-8101.

Setting up your user account

Since VF is an IRTF in-house software application, it is already installed on IRTF all workstations. If you wish to have this application installed on your own workstation, please see the IRTF computer staff for more information. This section will cover the setup information needed on you user account to run this application. To setup your account, you will need to know where the application is stored on the hard disk. Normally the IRTF will install it in /usr/local/VF, however you should check with the computing staff on this. The directory /usr/local/VF will be used as an example in this document.

1) Setting the environment variable $VFHOME.

Create a environment variable $VFHOME to equal the name of the sub directory where the application is stored on your hard disk. For example, each user can place the following line in the .login file to set VFHOME to '/usr/local/VF':

```
setenv VFHOME /usr/local/VF
```

2) Startup configuration file .vf-init.

This step is optional, but highly recommended. When VF starts up, it searches for the file .vf-init in your home directory. If this file exist, VF expects it to contain VF commands. See VF Command Dictionary for the syntax. Using an text editor you can place instructions in this file to configure when it starts up VF. For example, the file may contain the following instruction to setup the directory paths and printer name.

```
Path $HOME/protodat
FileMask *.img
DoPath $HOME/macro/vf
DoFilemask *
```

```
printer irlabpr
```

Starting VF

The VF program is a Xwindows application. You should be running an X server on your console. Openwindows is the default X server for sun workstations. There are two methods to start VF:

1. Starting VF using the workspace menu. The workspace menu has been configured to include a selection to start up an instance of the VF program. Press the menu (or right) mouse button on the workspace to bring up the workspace menu. Then click on 'Cshell" with the menu button to display its submenu. Select 'VF' with the select (left) button to begin execution of the VF program.

2. To start VF from a xterm or shelltool window, type 'vf' in the window.

 unix% vf &

At this point the base window of the application should appear on your screen. Sometimes the following message may appear in your console window.

 Run VF without Sockets? (y or n) <CR>:

If you are running VF with the instrumentaion software, you must run VF with sockets. Otherwise you may run

VF without sockets. When VF starts it tries to establish a socket to allow data and commands to be sent to it from the instrumentation program. This message can appear because:

1) VF is already running on the machine.

2) The operating system has not cleared the socket a previous version was using. If you just exit the program, it will take the operating system a few minutes to destroy the socket. During this period, you cannot establish another VF socket. Just wait 30 seconds and try again. (And maybe again).

The Base Frame

When VF starts a window called the base frame appears on your screen. Figure 1 is an illustration of the base frame. The base window consist of the Main Menu, 4 Viewing Canvases, the Main Panel and a Feedback Panel.
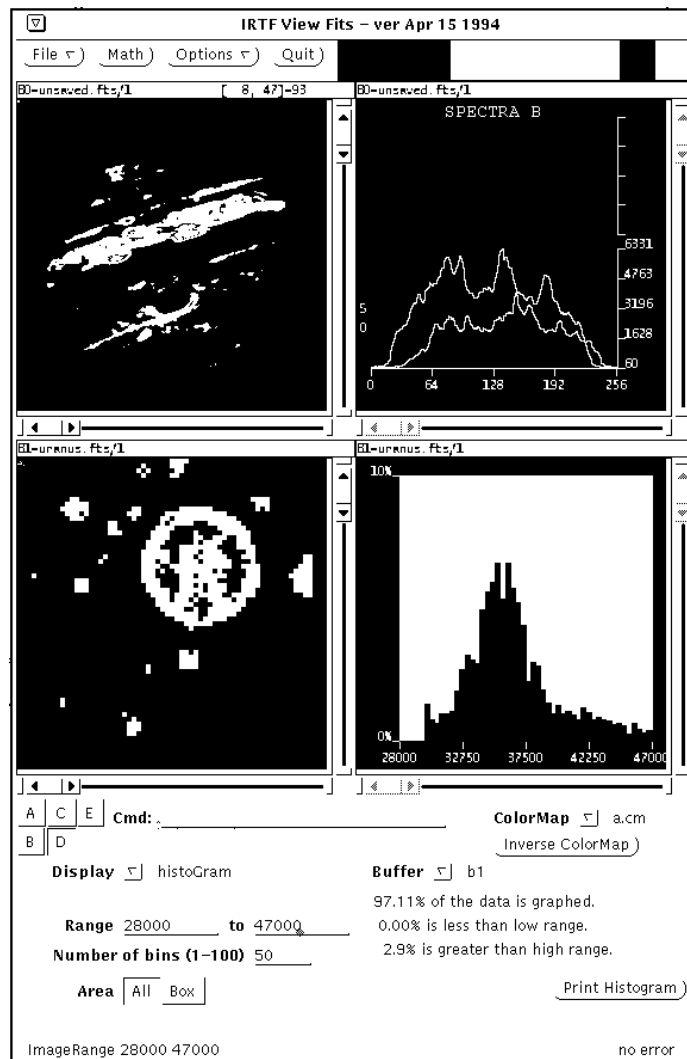
Figure 1 - The Base Frame

The **Main Menu** - The main menu and its submenu selections are shown below with a summary their purposes.
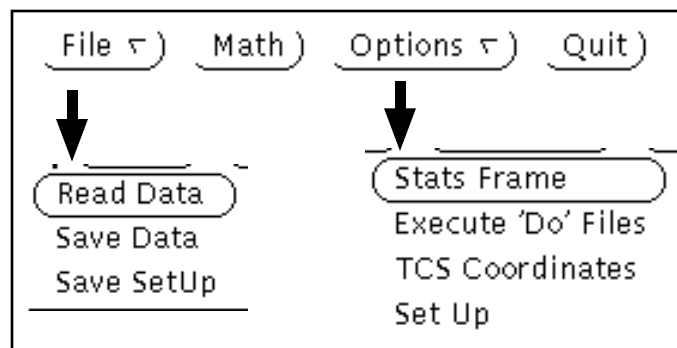
Figure 2 - Main Menu

Description of Menus - Here is a description of the menuing hierarchy.

   File - Brings up the file menu.

      Read Data - Brings up the Read Data File dialog box.

      Save Data - Brings up the Save Data File dialog box.

      Save Setup - Brings up the Save Setup dialog box.

   Math - Brings up the Math command window.

   Options - Brings up the Options menu.

      Stats Frame - Brings up the Stats window.

      Execute 'Do'Files - Brings up thewindow to edit and execute DO files.

      TCS Coordinates - Brings up the dialog box to send offset commands to the TCS.

      Set Up - Brings up the Setup window.

   Quit

The **Color Map Canvas** shows the current color map in use.

Four **Canvases**. Located on the base frame are 4 Canvases with horizontal and vertical scrollbars. They are used to display the data stored in VF's data buffers.

The **Main Panel**. The main panel is used for control or changing the various display options.

The **Feedback Panel**. Selecting buttons or changing values of the various menu or panel item usually generates a command to VF to manipulate the data or change the display. These commands and the error message from vf are displayed in the Feedback Panel. In this way you can see the commands and responses generated by your actions.

The Canvas

The canvases are used to display the data. There are 5 canvases identified by the letters A, B, C, D and E. Canvases A to D are 256 by 256 pixels in size and are located on the base frame. Canvas E is located in a command frame window which can be re-sized. To bring up Canvas E, select its panel button on the main panel. An example of a canvas shown in figure 3.

The **information area** shows some textual information about the data. The left hand side shows the buffer, the filename, and the divisor variable. For example, "B1=01jan0092.fts / 6" means this canvas is displaying the data in Buffer B1, which contains the file "01jan0092.fts", and that the data is represented at 1/6 of its true value. On the right side, additional information about the data or display is shown. This information depends on the display type and is described in Table A.

The **vertical and horizontal scrollbars** allow you to scroll the display if the image is larger than the canvas. Only the image and header display types can be scrolled. All other display types are scaled to the size of the canvas.

The **Canvas** is used to show a representation of the data according to the display parameters. In addition the canvas can capture mouse and keyboard events which can affect the display. See Table A - Description of Canvas Events for a description of the types of events for each display type.

Image Canvas event	Action
Cursor Movements	Display the x,y location and value fo the pixel in the information area. The text is usually displayed in black. However, if the pixel is bad and the bad pixel mask is on, the text is colored red.
Dragging the cursor and pressing the menu (right) mouse button.	This causes the colormap to be stretched and shifted. Vertical movements affect the strech. Horizontal movements shift the color map.
Dragging the cursor and pressing the adjust (middle) mouse button.	The dragging motion rubberbands a group of pixels. These pixels are known as the Object Box.
Dragging the cursor, pressing the adjust (middle) button & holding down the shift key.	Draws a line from he starting pixel until the dragging motion is completed. The end points of this line is copy to the 'From' and 'To' prompts in the TCS coordinates frame.
Pressing the select (left) mouse button.	Center the Object Box at the cursor's x,y location.
Press "F" or "T" in the image display	If the current active canvas is display an image, pressing 'F' or 'T' will update the From or To coordinates in the TCS coordinates frame.
Press "L" in the image display	If the current active canvas is displaying a linecut from the same buffer as the image, pressing "L" will set a new X,Y axis for the line cut.

Table A - Description of Canvas Events

The Main Panel

The main panel contains buttons, prompts and menu items to control the display type and their options. For each canvas there is a main panel as shown below: Selecting the Display menu gives the following options: Image, SpectraA, SpectraB, Header, Histogram, LineCut, and XLineCut.
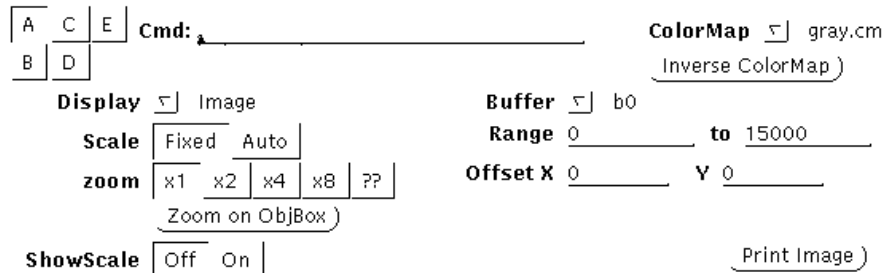
Figure 4 - The Main Panel

The panel items display in figure 5 will never change. These are described below:
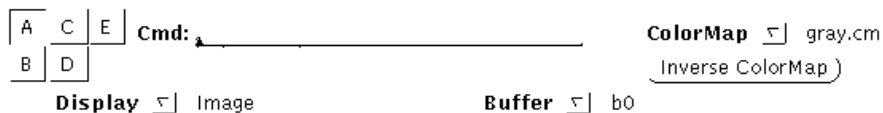
Figure 5

Active Canvas Buttons - The selected button identifies the active canvas. The remaining panel items reflect the set up of the active canvas. Changing the values of any of the panel items only affects the active panel items.

Command Line - This text panel item allows you to type commands to vf. The vf commands are listed in the VF Command Dictionary.

Colormap - This list item allows you to select one of the may predefined colormap defintions.

Inverse ColorMap - This button inverse the current colormap.

Display - This pop-up menu item selects the display type for the active canvas. The display types are Image, SpectrA, SpectraB, Header, HistoGram, Linecut, and XLinecut.

Buffer - Each canvas will display the data from this buffer. You can view the data in a different buffer by changing this panel item.

However, the rest of the panel may change depending on the Display parameter. For each display type a different set of parameters is displayed. These panel items reflect the parameters of the current active canvas and display type. A description of the panel items for each display type is given below with an illustration of its panel.

The **Image Display** options has of the following item:
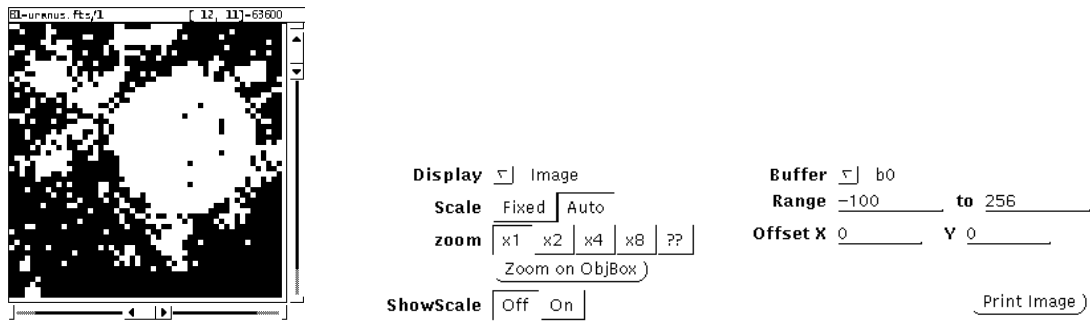
Figure 6 - The Image display & panel items.

Image Scale - The scale options are fixed or auto. When auto is selected the Image Range is automatically adjusted to the minimum and maximum values of the data displayed in the canvas. This adjustment occurs whenever the data in the buffer changes. For fixed scale, the program will never change the Image Range.

Image Zoom - The zoom sets the zoom factor for the display. Select x1, x2, x4, or x8 to set the zoom to 1:1, 1:2, 1:4 or 1:8 data pixels per screen pixels.

Zoom on box - This button sets the zoom and adjust the scrollbars of the canvas so that the Object Box is centered in the canvas and all the pixels within the Object Box is display at the highest zoom level.

ShowScale - Determines if an arcsecond scale is displayed along with the image. Note that the necessay information is also needed in the fits header or else the scale cannot be displayed.

Image Range - The color to the pixels are found by mapping the colormap to the minimum and maximum values of the Image Range.

ImageOffset X & Y - Indicates which pixel is display on the upper-left corner of the canvas.

Print Image - Select this button to get a hardcopy from the laser printer.

The **SpectraA** Graph is produced by grouping columns of pixels and producing a set of points where each point is the mean value of a row. These points are graphed as a line. The SpectrA panel consist of the following items.
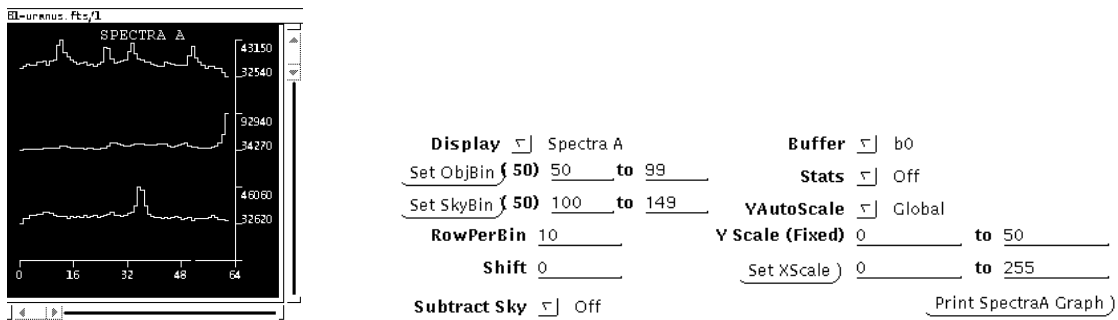
Figure 7 - The SpectraA display & panel items

SetObjBin - Pressing SELECT on this button will cause the beginining and ending rows of the Object Box to be entered into the ObjBin parameters. To the right of this button are text panel items which allow manual entry. The number in parentheses equal to the number of rows in the ObjBin.

SetSkyBin - Pressing SELECT on this button will cause the begining and ending rows of the Object Box to be entered into the SkyBin parameters. To the right of this button are text panel input prompts which displays these values. The number in parentheses equal to the number of row in the SkyBin.

RowPerBin - This number represent the number of rows to bin together. Each bin is used to create 1 line in the graph.

Subtract Sky - When the subtract sky option is on, each spectra line graph is the result of the object lines minus the sky line. Note that the summing of columns in the ObjBin and SkyBin occurs before the subtraction.

Shift - Enter a positive (shift to the right) or negative (shift to the left) number to shift the x axis in the graph.

Stats - When the stats flag is on, the graph is replaced by a table. This table displays, for each bin, the row making up the bin, the number of data point in the bin, the mean value of those points, the standard deviation of the point, and the ratio of the mean and standard deviation.

YAutoScale - Y Autoscale , whichcan be fixed, local, or globol, indicates how the scale for the Y axis of the graph is determined.

Y Scale (Fixed) - This is the range of the Y axis when YAutoScale is fixed.

X Scale - These values control the minimum and maximum values of the X Axis.

Print SpectraA Graph - Select this button to prints the Spectra A graph.

The **SpectraB** Graph is produced by binning two rows of pixels. One bin is the Object and the other is the Sky. The mean value for each column can be displayed. The Object graph is the mean column value of the object bin. The Difference graph is the mean column value of the object bin minus the sky bin. The SpectraB panel consists of the following items.
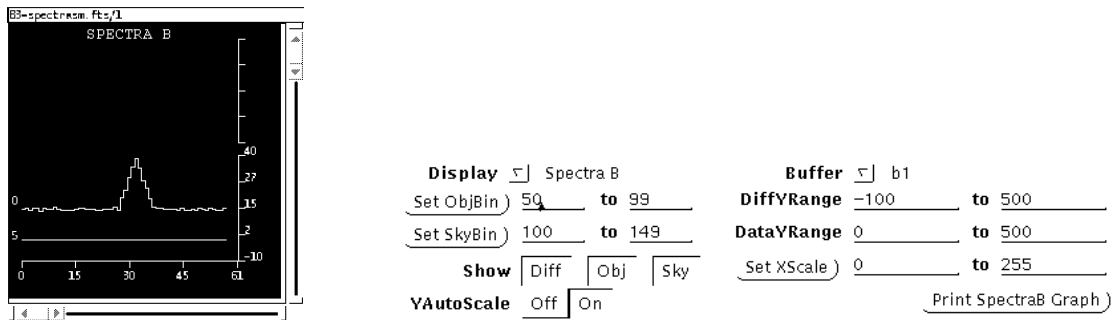
Figure 8 - The SpectraB display & panel items

SetObjBin - Pressing SELECT on this button will cause the begining and ending rows of the Object Box to be entered into the ObjBin parameters. To the right of this button are text panel input prompts which displays these values.

SetSkyBin - Pressing SELECT on this button will cause the begining and ending rows of the Object Box to be entered into the SkyBin parameters. To the right of this button are text panel input prompts which displays these values.

Show - You may specify the data to be plotted for the SpectraB graph.

Y AutoScale - This switch determines whether to autoscale the Y axis or use the fixed scales for the appropriate graph.

DiffYRange - These values provide the fixed scale of the Y axis for the graph of the Difference.

DataYRange - These values provides the fixed scale of the Y axis for the object and sky graphs.

Set XScale - Selecting the 'Set XScale' button sets the x axis to the begining and ending columns of the object bos. Your may also type the pixel value in the prompt to set the range for the X axis.

Print SpectraB Graph - Select this button to print the Spectra B graph.

The **Header** display shows the text of the fits header in the canvas. The Header panel consists of the following items.
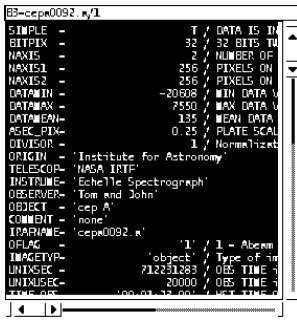
Figure 9 - The Header display & panel items

Starting Row & Column -- Identifies the first character and line to be display in the upper-left corner of the canvas. It's more convenient to use the scrollbars rather than change these values.

The **Histogram** display draws a histogram on the canvas and its panel consist of the following items.
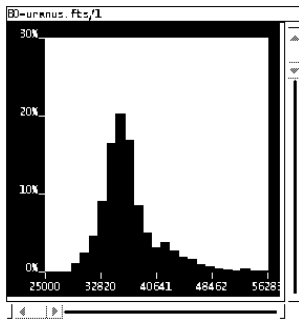
Figure 10 - The Histogram display & panel items

Range - These values determine the minimum and maximum values of the X axis of the histogram, and will be equal to the ImageRange. Changing the histogram range will change the ImageRange and vice versa.

Num of Bins - This is the number of bars on the histogram. The size of bin is determined by dividing the range by the number of bins.

Area - These control allow you to indicate the pixel used in creating the histogram. You may use the entire image (All) or just the pixel specified by the ObjBox (Box).

Print Histogram - Select this button to produce a hardcopy of the histogram.

The **Linecut** display will show a graph of the pixel values along the x and y axes. The Linecut panel consist of the following panel items.
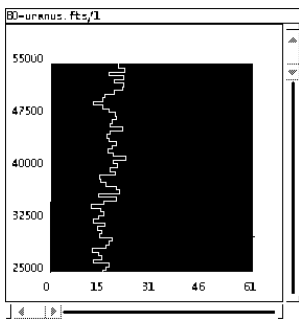
Figure 11 - The LineCut display & panel items

X Axis - Identifies the X axis used to draw the line cut.

Y Axis - Identifies the Y axis used to draw the line cut.

AutoScale - This switch determines whether to autoscale the graph or use Range to determine the scale.

Range - These values determine the minimum and maximum values of the scale when autoscale if off.

Area - The area along with the X & Y Axis variables defines the pixel domain for the graph. The options are All and Box. When All is selected, the entire frame is plotted. When Box is selected, the Object box is used to define the region to be plotted.

Print LineCut - Select this button to produce a hardcopy of the graph displayed in the canvas.

The **XLinecut** displays a single linecut graph between 2 points or pixels. The XLinecut panel consist of the following panel items.
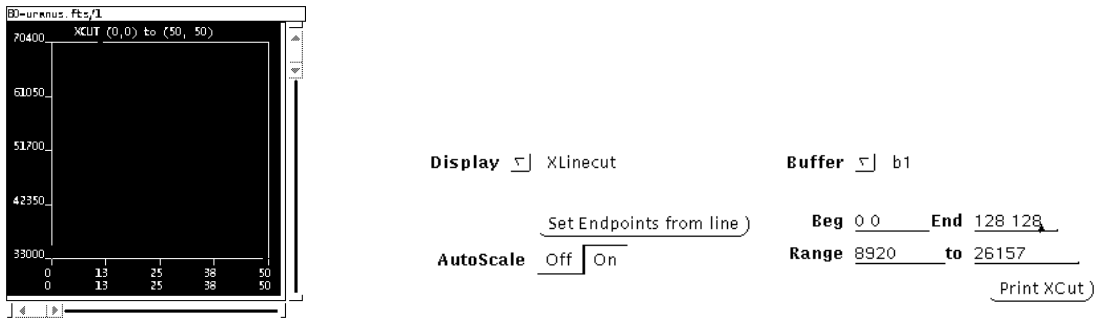
Figure 12 - The XLineCut display & panel items

Set Endpoints from line - SELECT this button to use the coordinates of a line drawn on the image to be entered as the endpoints of the graphs.

AutoScale - This switch determines whether to autoscale the graph or use the range to determine the scale.

Beg to End - These coordinates identify the endpoints of the line of pixels used to construct the XLineCut graph.

Range - When autoscale is off, these values define the scale on the data axis.

Print XCut - Select this button to produce a hardcopy of the graph.

The **Noise** display is an engineering tool to display statistic on a group of pixels organized by columns. The mod parameter would indicate the number of output in the system. The min, max, mean, and standard deviation could then be displayed for each output. Graph 1 display the Min, Max, and Mean of the pixels. The I bar shows the min and max while the point represents the mean pixel value. Graph2 display the standard deviation for each mod.
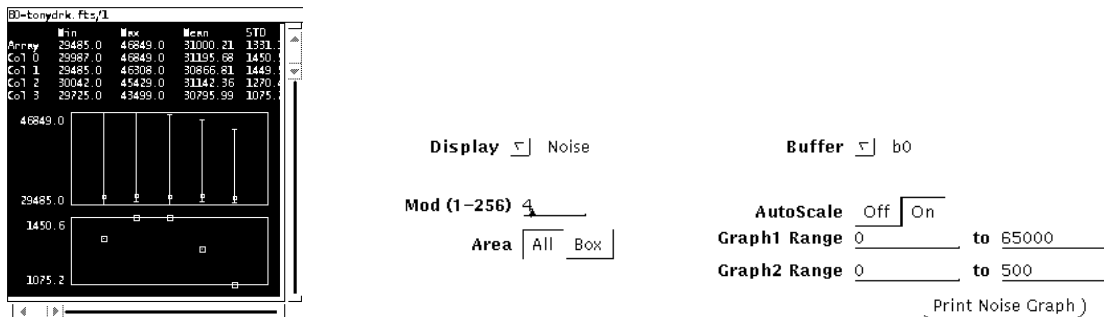
Figure 13 - Noise display & panel items

Mod - control how columns are group together. For example 4 would group every 4th colmun giving stats on 4 different groups of pixels.

Area - This control allow you to indicate the pixels used in creating the graph. You may use the entire image (All) or just the pixel specified by the ObjBox (Box).

AutoScale - The Y axis is automatically scaled when on, or scaled using the range values when off.

Graph1 Range - When autoscale is off, these values define the Y scale for the Min, Max, Mean graph.

Graph2 Range - When autoscale is off, these values define the Y scale for the standard deviation graph.

The Read Data Frame

Selecting Read Data from the File submenu will causes the Read Data command frame to appear on the screen. This command frame enables you to read data into the data buffers.
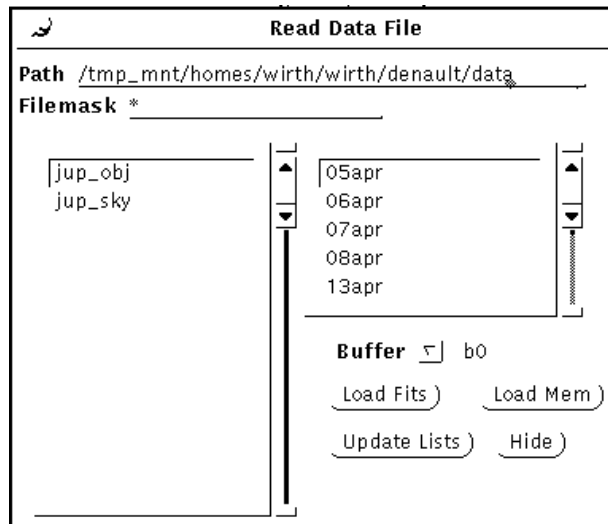
Figure 13 - The Read Data frame

There are two lists on this window. On the left is the file list, which list all the files in the Path matching the Filemask string pattern. You may select filename with the mouse to identify the file you wish to read. On the right is the directory list. The directory list display the name of the directory in the current path. Using the mouse you can double click on these name to change the Path.

The other Panel items inside this command frame are:

Path - This text panel item identifies the subdirectory containing the file you wish to read. You may change the Directory by editing this text panel item.

Filemask - This filemask determines which filename from the Directory are displayed in the list panel item. Filemask is normally set to a regular expression to allow only those filenames matching the pattern to be included in the list. For example,'*.fts' will allow any filename that ends with '.fts' to be include in the filelist. You may change the filemask by editing this panel item. Use the cursor to select the file you wish to read.

Buffer - The data will be read into the buffer idenified by this panel item. Select the desired buffer from the menu.

Load Fits - Clicking on the 'Load Fits' button will command VF to read in the select FITS image.

Load Mem - Protocam mem files may also be loaded. Selecting this button will load the highlighted mem file.

Update List - This button will update the filelist. (This is necessary because UNIX is a multitasking operating system and a file can be created or deleted or renamed without the knowledge of the VF program).

Hide - Selecting this button will cause the command frame to disappear.

The Save Data fame

Selecting Save Data from the File submenu will cause the Save Data command frame to appear on the screen. This command frame enables you save or write the data from a buffer to a file.
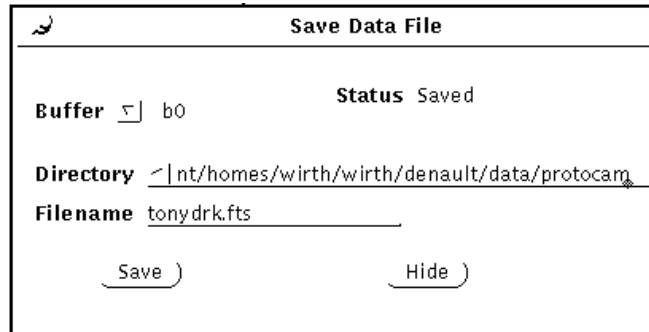
Figure 14 - The Save Data frame

The Panel items inside this command frame are:

Buffer - This panel menu item identifies the buffer holding the data to be written. Select the buffer you wish to save.

Directory - This text panel item identifies the subdirectory containing the file you wish to write to. You may change the Directory by editing this text panel item.

Filename - The data will be written to this filename. You may change the filename by editing this field.

Save - Selecting this button commands VF to write the data to the file.

Hide - Selecting this button will cause the command frame to disappear.

The Math Frame

Selecting the Math button from the Main menu will cause the Math command frame to appear on the screen. This command frame allows 3 types of operations: 1) Arithmetic on the pixel values, 2) Transferring data between buffers, 3)Deleting data from a buffer, and 4) Rotating an image. Note that there are buttons labeled 'Math', 'CopyBuf' , 'Clear' and two icons while contain rotation directions. These icon performs the operations. Near these buttons are various panel items used to identify the buffer or other parameters for each operation.
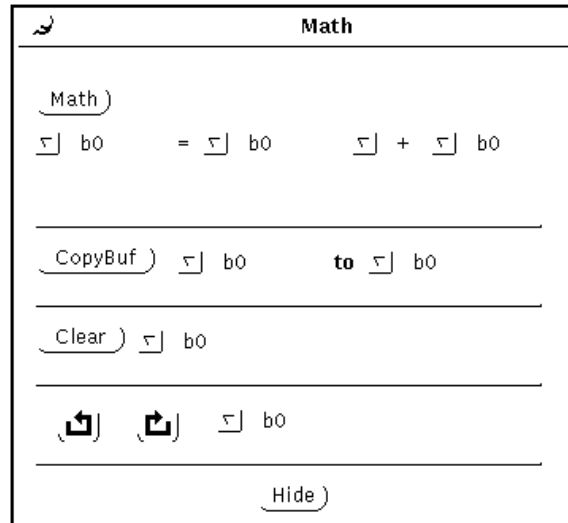
Figure 15 - TheMath frame

For buffer Arithmetic, form an expression by selecting a destination buffer, operation (+-*/), and the operands. The first operand is always a buffer index, the second can be a buffer index or a constant. Selecting 'constant' from the menu allows you to enter a value for the second operand. Two examples of math expressions are shown.

`b2 = b0 - b1' will subtract buffer 1 from buffer 0 and store the results in buffer 2.

'b2 = b2 * 100' will multiply every pixel in buffer 2 by 100 and place the results in buffer 2.

When you are done forming your expression, selecting the **Math** button to perform the operation.

To **copy** data from one buffer to another use the middle set of panel items. First select the destination and source buffers. Select the CopyBuf button to perform the transfer.

To **clear** a buffer data in the buffer, identify the buffer by selecting a button to the right of the clear button, then SELECT the Clear button to delete.

The **rotate** operation allows you to rotate the data to the left or right. Select the desired buffer, then press one of the rotate buttons to rotate in the desired direction.

The **Hide** button will cause the command frame to disappear from the computer's screen

.

The Stats frame

The stats command frame provides the means for you to view elementary statistical information on groups of pixels and calculate box photometry values.
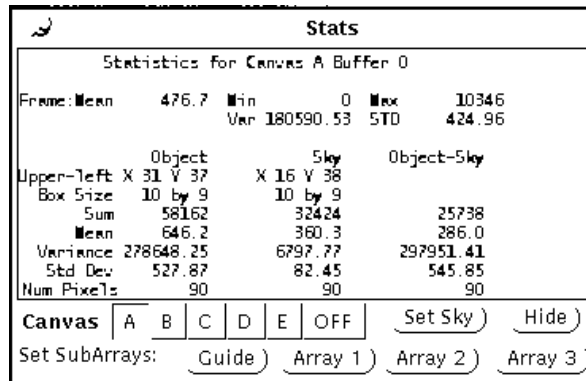
Figure 16 -The Stats frame

The stats command frame consists of an information area and a panel area. The information area displays the sum, mean, and standard deviation of the data display in a canvas. The mean, variance, and standard deviation for the entire frame is displayed on the top row. Below this are 3 columns labeled 'Object', 'Sky', and 'Object-Sky', with statistical values for each column. The object column displays the value on the object box. The sky column displays statistics on the sky box. If the object and sky box are of equal dimension, the object-sky column will display statistics on the pixel values obtained by subtracting the object box from the sky box. The Stats frame's panel contains the following control items.

The **Canvas** button identifies the canvas. The data display in this canvas is used to generate the statistical information.

Selecting the **Set Sky** button sets the location and size of the sky box to be equal to the object box.

Clicking on the **Hide** button will cause the frame to disappear.

On the bottom row are special button used with NSFCAM. There button allow a user to set the size and position of the subarrays used in the various mode of NSFCAM. The position and size of the ObjectBox is sent to NSFCAM's Guide array or SubArray #1, 2, or 3 when you select the **Guide**, **Array1**, **Array2** or **Array3** bottons.

The Edit and Execute Command Files frame

VF provides a way of creating and executing Do files. A Do (or macro) file is a text file containing commands. There should be 1 command per line and the syntax for commands are defined inthe VF Command Dictionary. In the Options submenu, the choices 'Execute Do files' brings up a window to allow you to create, edit, and execute Do files. This frame contains a text edit window. a feedback window, and a group of panel items.
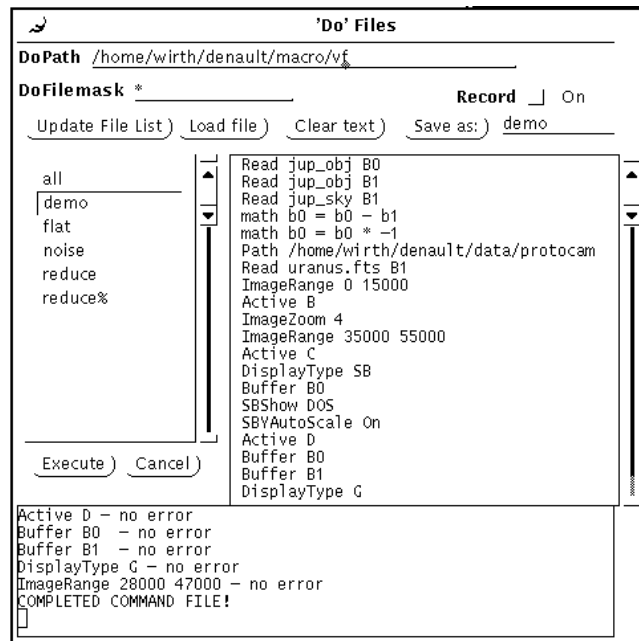
Figure 17 - The DO Files frame

The following panel items will help you read, edit, and save the contents of DO file:

DoPath - This text panel identifies the subdirectory where your macro files are stored.

DoFileMask - The filemask is a regular expression used with the path to determine the names of the files displayed in the filelist. Selecting **Update File List** will re-initialize the list.

Load File - Selecting this reads the file selected in the filelist and places the text in the edit window.

Clear text - Clear the edit windows buffer.

Save as - Selecting this button writes the current text in the edit window into the filename shown in the text panel item.

Record - This check box panel item controls the recording function. When the box is checked, any commands executed by VF will also be written to the edit window. This allows you to create macro files using the mouse and panels items.

To execute a macro file, select the file in the list then click on the **Execute** button. VF will read the file and execute each line. The commands and its error message ('Error None' when successfully executed) will be written to the Feedback area located on the bottom of this frame. If you wish to abort a macro file in progress, click on the **Cancel** button.

The TCS Coordinates

The TCS Coordinates frame allow you to calculate the relative offsets in RA and DEC between 2 pixel in an image. This offset can be transmitted to the Telescope Control Sytem, thus providing a convient way to position objects on the array. To bring the frame up, select the 'TCS Coordinate' menu item from mainmenu's 'Options' button


```
                        TCS Coordinate

          Angle 270          PlateScale 0.28

  From (x,y) 12 34           To (x,y) 50 125

  Calculate Offset )  Offset is (ra,dec) −25.48 10.64

  Offset TCS  )
```

Figure 18 - The TCS Coordinates frame

The following steps outline the procedures for offsetting the TCS.

1. Enter the **Angle** and **PlateScale** information. This information varies with the array and instrument used. The following table contains the value for the IRTF Facility Instruments. Please confirm these values with the Telescope operator during your run.

Instrument	Angle	PlateScale
CSHELL	270	0.20
NSFCAM	?	0.3, 0.15 or 0.06 User definable

2. Identify the **From** and **To** points in terms of their x,y pixel location on the image. This can be accomplisted by the following method:

   a. Manual type in the coordinated values.

   b. Drawing the XOR line on the image. First, place the cursor in the image at the **From** pixel location. While pressing the SHIFT key, press the middle mouse button and drag the cursor to the **To** location. While you are dragging the mouse a line should be drawn between the two points. The act of drawing this line updates the **From** and **To** coordinates values in the TCS Coordinates frame.

   c. Place the cursor in the image. Click the left or SELECT mouse button to focus keyboard input into the canvas. Now when you press the 'F' to 'T' key on the keyboard, the coordinates of the cursor will be written to the **From** or **To** prompts in the TCS Coordinates frame.

3. Press the **Calculate Offset** button. Using the From, To, Angle and Plate Scale information, the RA and DEC offsets are calculated. The results as display in the **Offset is (ra,dec)** prompt.

4. If you agree with the offset coordinates in the **Offset is (ra,dec)** prompt, press **Offset TCS** button. Pressing this button will sent a command to the TCS to offset its position by the indicated coordinates.

Note: The TCS command issued by VF to perform the offset is " 0 ra dec 0 C.PEAK".

The Set Up frame

The Set Up Parameters frame contains panel items which are not likely to be changed very often. The item are usually self-explanatory. For a detailed explaination of each option, refer to the VF Command Dictionary.

```
┌──────────────────────────────────────────────────┐
│  ↲              Set Up                            │
│  ─────────────────────────────────────────────   │
│                                                  │
│        Path  /scr1/data_____  │
│                                                  │
│     Printer  irtfpr_____           │
│                                                  │
│ Printer Type  ▽|  B&W Postscript                 │
│                                                  │
│                                                  │
│  Div by coadd │ OFF   ON │           │ b0  b2  b4│
│                                                  │
│     BadMask  │ OFF   ON │  Set Bad Mask: ) b1  b3│
│                                                  │
│ TCShostname  planck_____          │
│                                                  │
│                                                  │
│                                                  │
│                                                  │
└──────────────────────────────────────────────────┘
```
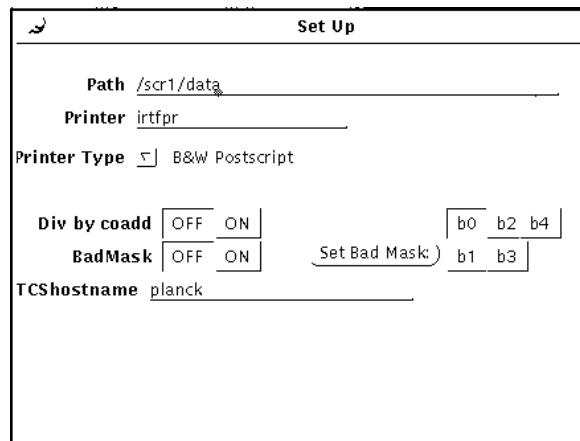
Figure 19 - The Set Up frame

Special Notes:

To set up a bad pixel mask, read in the fits file representing your bad mask into any buffer. Pixels with a value of zero are considered good pixels, while non-zero values represent bad pixels. Indicate the buffer holding the bad pixel mask by selecting its buffer index from items to the right of the 'Set Bad Mask' button. Selecting the 'Set Bad Mask' will cause VF to scan the buffer and initialize the bad pixel mask. Once the bad pixel mask is installed, its effects can be turned off or on using the BadMask buttons. See the command 'BadMask' for more information.

VF Source and Docs from IRTF-online

An anonymous FTP site has be setup at the Institute for Astronomy at the University of Hawaii. The IRTF has made available to the community various manuals, forms, programs, etc via this FTP site. This has come to be know as IRFT-Online. A copy the this manual and the source code to VF is available from IRTF-online. To access IRTF-Online:

1. Perform an anonymous FTP to irtf.ifa.hawaii.edu.

2. cd to pub/IRTF

3. Download and review the README.txt file. This contains a brief description of all files in IRTF Online.

In the directory pub/IRTF/VF are the files related to the VF application. Here is the README.txt file

from this directory.

```
Hello, this readme file contains note for those IRTF-online users who are
interested in VF.  VF is a simple FITS viewer. it was developed by the
NASA Infrared Telescope Facility for use with their data acquistion systems.
We are making the binaries and source code available on IRTF-online.
IRTF-online is an anonymous ftp site.  Irtf-online is located on
irtf.ifa.hawaii (128.171.79.135).

The pub/IRTF/VF in this directory are:
```

```
        REAME.txt - This file.
        vf.source.tar.Z - The source code necessary to compile vf.
        vf.doc.tar.Z - The user guide to vf in MS Word (MAC) and a
                                            Postscript format.
```

Notes on VF's Docmentations
============================

The file vf.doc.tar.Z contains a copy of VF User's Guide in MS Word for the
MAC and postscript format.

1. ftp the vf.doc.tar.Z to your home directory.

2. uncompress and un-tar this file. ie:
```
        % uncompress vf.source.tar.Z
        % tar xvf vf.source.tar
```

3. A vf/doc directory will be created with the following files:

```
        vf.rtf - Rich Text Format copy of the User's Guide.
        vf.ps  - A postscript version of the User's Guide.
```

Notes on VF's Source Code
============================

The file vf.source.tar.Z contains the sources to the View Fits (VF) program.
I have made the source code available to those who are interested in porting
or running VF at their home institution. And for those who are curious
to seeing how the software is written.

VF wase developed on a SPARC station running Openwindows.
They are compiled using sun's acc compiler and XVIEW. It was not intended
to be very portable, but if your workstation has an ANSI compiler and
the XVIEW libraries you should be able to compile these programs.

These instruction assume you have some knowledge in developing programming
in an unix enviroment. If not, you will probably need assistance from
a programmer-type.

To install and compile the source:

1. ftp the vf.source.tar.Z to your home directory.

2. uncompress and un-tar this file. ie:
```
        % uncompress vf.source.tar.Z
        % tar xvf vf.source.tar
```

   The following files/directories should be created in you home directory:

```
        .vf-init            - startup file for VF
        mylib/              - This directory contains the source to libraries
                              needed to compile the IC, XUI, and Vf.
        vf/                 - This directory contains the source the VF.
```

3. Make the libraries.

   There are 2 set of libraries:

       /mylib/addlib - additional libraries
       /mylib/fitslib - fits libraries

   In each of these directories there is a makefile. Use the make utility
   to compile these libraries. Currently there are 3 different makefile
   depending on your OS (makefile.sun, makefile.lynx, makefile.linux).
   If you are compiling these programs on a SUN, there command would
   do the job:

```
% cd ~/mylib/addlib
% make -f makefile.sun
% cd ~/mylib/fitslib
% make -f makefile.sun
```

4. After the libraries are done. You can compile the VF application. Go to
   the VF directory and type make to compile the program. Note: You may
   need to modify the makefile to compile in your enviroment.

```
% cd ~/vf
% make
```

5. Edit the following startup files for each application:

   ~/.vf-init   - VF's startup file.

   Please refer to the VF user manual for further details.

If you have question/comments, please contact me. I would be happy to
help you.

Tony Denault
IRTF Programmer

email: denault@galileo.ifa.hawaii.edu
Telephone: 808-956-8101
Mail: Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822

VF Command Reference

Active - Sets the active canvas..

    Prompt   (None). Buttons on the base window allows you to change the active canvas.

    Range   A, B, C, D, or E

    Initial   A

    Syntax   ACTIVE id

BadMask - Enables/disables the Bad Pixel Mask.

    Prompt   BadMask

    Range   OFF or ON

    Initial   OFF

    Syntax   BadMask { OFF I ON }

Comments

Events/Display Modes	BadMask ON	BadMaskOFF
Tracking cursor in image window	Estimate bad pixel values. Display text in red.	Display actual pixel values. Display text in black.
Display Type: canvas	Estimate bad pixel values.	Display Actual pixel values. Mark Bad pixles with 'X'
Display Type: SpectraA, SpectraB, Histogram, Line Cut XLine Cut	Estimate bad pixel values.	Use actual values.
Frame and box statistics	Estimate bad pixel values.	Use actual values.

Boxzoom - Set the Image Zoom on the active canvas so that the object box fills as much as the canvas as possible..

    Prompt   'Zoom on ObjBox' on main panel.

    Range   N/A

    Initial   N/A

    Syntax   BOXZOOM

Buffer - Changes the data buffer associated with the active canvas..

    Prompt   'Buffer' on the main panel

    Range   b0 to b7

    Initial   Canvas A displays Dframe 0, Canvas B displays Dframe 1,   ect...

    Syntax   Buffer B#

Clear - A command to set a data buffer to empty.

    Prompt   'Clear' button on Math frame.

    Range   b0 to b7

    Initial   Undefined

    Syntax   CLEAR B#

cminverst - Inverse the current colormap definitions.

    Prompt   'Inverse Colormap' prompt on base window.

    Syntax   CMINVERSE

ColorMap - Reads in a colormap definition from a file.

    Prompt   'Colormap' on the main panel.

    Range   Standard colormap files are ...

    Initial   a.cm

    Syntax   COLORMAP filename

CopyBuf - A command to copy data from one buffer to another.

    Prompt   'Copy' button on Math sub-window

    Range   B0 to B7

    Initial   (Undefine)

    Syntax   COPYBUF B# to B#

DarkFlat - A command to compute dest = (src - DARK) * mean(FLAT) / FLAT, where DARK is buffer 5 and FLAT is buffer 6.

    Prompt   N/A

    Range   b# must be gereral buffer, b0 to b4.

    Initial   N/A

    Syntax   DarkFlat b# to b# [DF]

             Note: the DF flags are specified to prevent processing.

DisplayType -Determines what is display in the active canvas.

    Prompt   `Display' on main window.

Range	I	Image
	SA	Spectra A Graph
	SB	Spectra B Graph
	H	Fits Header
	G	histoGram
	L	Line cut
	X	XLineCut
	N	Noise Image

    Initial   I

    Syntax   DisplayType { I I SA I SB I H I G I L I X}

DivByCoadd - Enables/disables the divide by coadd option. Enabling the option cauxe the representation of

the data to be divide by the number of coadds in the the data frame (DFrame).

Prompt   `DivByCoadd' on the Math sub-window.
Range   OFF or ON
Initial   OFF
Syntax   DivByCoadd {OFF | ON}

DoFile - Execute command from a file.

Prompt   The subwindow 'CommandFile' allows selection and execution   of a macro file.
Range   N/A
Initial   N/A
Syntax   DoFile filename

DoFileMask - Set the filemask variable for the filelist showing in the Execute Command File and Edit Command File Frames.

Prompt   'Filemask' on the Execute Command File Frame.
Range   Any string.
Initial   '*'
Syntax   DoFileMask string

DoPath - The Dopath identifies the subdirectory where you will read and wirte command or macro files. The filelist on the Execute Command File and Edit Command file Frames is build using this directory.

Prompt   'Path' on the Execute Command File Frame..
Range   Any legal unix subdirectory
Initial   N/A
Syntax   DoPath string

FileMask - Set the filemask variable for the File - Read subwindow.

Prompt   Filemask
Range   Any string.
Initial   '*.fts'
Syntax   FileMask string

HeaderCol - For the Active Canvas, it sets the starting column of the fits header to be displayed.

Prompt   (none)
Range   0 to 50
Initial   0
Syntax   HeaderCol num

HeaderRow - For the Active Canvas, it sets the first lint of the fits header to be displayed.

Prompt   (none)
Range   0 to 50
Initial   0
Syntax   HeaderRow num

HistArea - Sets the range of pixels to be included in the histogram.

Prompt   'HistArea' on main panel.
Range   All - All the pixels in the frame are used.
         Box - The pixels include in the ObjBox are used.
Initial   All
Syntax   HistArea {All | Box}

HistBin - For the Active Canvas, it sets the number of bins for a hisogram display.

Prompt   Histbin
Range   1 to 100
Initial   20
Syntax   HistBin num

ImageOffset - For the Active Canvas, it determines which pixel is displayed the the upper-left corner for a image display. 0, 0 identifies the first pixel of the fits data.

Prompt   'Offset X' and 'Y'. Also these values can be controlled a canvas's scrollbar.
Range   0 to size of axis in the fits frame.
Initial   0, 0
Syntax   ImageOffset offx offy

ImageRange - For the Active Canvas, it sets the minimum and maximum values for the colormap.

Prompt   'Range`
Range   -2^31 to 2^31-1
Initial   0 to 65000
Syntax   ImageRange min max

ImageScale - For the Active Canvas, it set the autoscaling on or off. When autoscale is on the ImageRange is automatically adjusted to the minimum and maximum values of the data displaying in the canvas. This adjustment occures whenever new the data in the buffer changes.

Prompt   'Scale' on the main panel for Image display.
Range   A (autoscale) or F (fixed scale)
Initial   F
Syntax   ImageScale {A | F}

ImageShowScale - For the Active Canvas, it indicates whether to display an arcsecond scale along side the image display.

    Prompt   'ShowScale' on the main panel for Image display.

    Range   OFF or ON

    Initial   OFF

    Syntax   ImageShowScale { off l on }

ImageZoom - For the Acitve Canvas, it sets the zoom factor for an image display. This value determines the number of screen pixels each array pixel occupies. For example, a value of 4 will draw each array pixel on a 4x4 area in the canvas.

    Prompt   'zoom' on the main panel for Image display.

    Range   1 to 20.

    Initial1

    Syntax   ImageZoom num

LineCutArea - Set the range of pixels to be include in the line cut graph.

    Prompt   'Area' on the main panel for LineCut display.

    Range   All - The entire array is used.

              Box - The subarray defined by the object box is used.

    Initial   All

    Syntax   LineCutArea { All l Box }

LineCutScale - Turns the automatic autoscaling feature off or on for line cut graphs.

    Prompt   'AutoScale' on the main panel for LineCut display.

    Range   Off or On

    Initial   Off

    Syntax   LineCutScale {off l on}

LineCutXY - For the Active Canvas, it determines the X and Y axis for a line cut graph..

    Prompt   'X Axis' and 'Y Axis' on the main panel for LineCut display.

    Range   X and Y must be from 0 to 255..

    Initial   0

    Syntax   LineCutXy x y

Math - Performs simple artimetric on the images.

    Prompt   'Math' button on the Math subwindow

    Range   N/A

    Initial   N/A

    Syntax   Math B# = B# { * l / l + l - } { B# l num }

NoiseArea - Sets the range of pixels to be included in the Noise Display.

    Prompt   'Area' on the main panel Noise display.

    Range   All   - Include all the pixel in the image

              Box   - Select the pixels in the object box.

    Initial   All

    Syntax   NOISEAREA { All l Box }

NoiseAutoScale - Sets the autoscale option of the noise graph.

    Prompt   'AutoScale' on the mail panel Noise display.

    Range   { off l on }.

    Initial   Off

    Syntax   NOISEAUTOSCALE { off l on }

NoiseMod - Sets the modual value for the noise display. This value control how the columns are grouped together..

    Prompt   'Mod' on the mail panel's Noise display.

    Range   1 to 256.

    Initial   4

    Syntax   SYNTAX

NoiseG1Range - Sets the range of the Y axis for the Max/Min/Mean Noise Graph.

    Prompt   'Graph1Range' on the main panel's Noise display.

    Range -2^{31} to $2^{31}-1$.

    Syntax   NOISEG1RANGE min max

NoiseG2Range - Sets the range of the Y axis for the Standard deviation Noise Graph.

    Prompt   'Graph2Range' on the main panel's Noise display.

    Range -2^{31} to $2^{31}-1$.

    Syntax   NOISEG2RANGE min max

Path - The path identifies the subdirectory where you will read and wirte data files..

    Prompt   'Path' on read subwindow.

    Range   Any legal unix subdirectory

    Initial   'data'

    Syntax   Path string

Print - This command produces a postscript file of the graph or image in a canvas window and sent this file to the

---

printer specified by the printer variable. This postscript file is named 'lastprint'.

Prompt   Each printable graph has a 'Print' button on the main panel.

Range   A to E

Initial   (N/A)

Syntax   Print{A I B I C I D I E }

Printer - Identifies the printer used by the print command.

Prompt   'Printer' on the setup subwindow

Range   Enter the name of a postscript printer on the network.

Initial   (N/A)

Syntax   Printer name

PrinterType - For hardcopy of image, this command specifies either a color or black&white postscript output.

Prompt   'Printer Type' on the setup subwindow

Range   0 - B&W Postscript printer

1 - Color Postscript printer.

Initial   0

Syntax   PRINTERTYPE { 0 I 1 }

Quit - Exits the vf program.

Prompt   'Quit' on the main menu.

Range   N/A

Initial   N/A

Syntax   Quit

Read - Read a fits file from the current path into the buffer.

Prompt   The 'Load Fits' button on the Read Data File frame.

Range   filename - Name of file to read. This file must exist in the subdirectory defined by PATH.

B# - Any valild buffer, for example 'b0'

Initial   N/A

Syntax   Read filename B#

ReadMem - Reads a ProtoCam .mem file from the current path into the buffer.

Prompt   The 'Load Mem' button on the Read Data File frame.

Range   filename - Name of file to read. This file must exist in the subdirectory defined by PATH.

B# - Any valild buffer, for example 'b0'

Initial   N/A

Syntax   ReadMem filename buffer#

ReadSock - Read a fits file from the current socket connection.

Prompt   N/A

Range   B# - Any valid buffer, for example 'b0'

Initial   N/A

Syntax   ReadSock buffer#

RotateBuf - Rotate s the data in a buffer by translating the X and Y axis. The buffer can be rotated in the clockwise or counter-clockwise direction.

Prompt   Rotate CW & CCW buttons on the Math frame.

Range   N/A

Initial   N/A

Syntax   RotateBuf B# {cw I ccw}

SAObjBin - Sets the range of rows to be used as the object bin in the Spectra A graph.

Prompt   'OBjBin' on main panel for SpectraA display.

Range   0 to 255

Initial   0

Syntax   SAObjBin min max

SARowPerBin - Sets the number of rows per bin for a Spectra A graph.

Prompt   'RowPerBin' on the main panel for SpectraA display.

Range   1 to 255

Initial   10

Syntax   SARowPerBin num

SAShift - Specifies the amount of shift in the x axis to be applied when converting pixel columns to wavelenght.

Prompt   'Shift' on the main panel for SpectraA display.

Range   -25 to 25 pixel units

Initial   0

Syntax   SaShift num

SASkyBin - Sets the range of rows to be used as the sky bin in the Spectra A graph.

Prompt   'SkyBin' on main panel for SpectraA display.

Range   0 to 255

Initial   0

Syntax   SASkyBin min max

SAStats - Indicated whether to show the graph or a table of statistical information for each line.

Prompt   'Stats' on the main panel for SpectraA
display.

Range   OFF - Displays the graph.

ON - Display the table.

Initial   OFF

Syntax   SAStats { off l on }

SASubtractSky - This flag indicates whether to subtract the mean sky values from each object bin in the SpetraA graph.

Prompt   'SASubtractSky' on the main panel for
SpectraA display.

Range   Off or ON

Initial   ON

Syntax   SASubtractSky { off l on }

SAXScale - Sets the range of the X axis of a Spectra A graph

Prompt   'XScale' on the main panel for SpectraA
display.

Range   0 to 255

Initial   V

Syntax   SAXScale min max

SAYAutoscale - Select which option is used for determining the maximum and minimum values of the Y scale.

Prompt   'YAutoScale' on the main panel for SpectraA
display.

Range   Fixed - Used the asYScale values.

Local - Each spectra graph used its own
maximum and   minimum value to set the y
scale.

Globol - A maximum and minimum value from
all the spectra   lines is found and is used for
the Y ax.s

Initial   Globol

Syntax   SAYAutoscale {Fixed l Local l Globol }

SAYScale - Sets the range of the Y axis of a Spectra A graph when the autoscale option is fixed.

Prompt   'Y Scale (Fixed)' on the main panel for
SpectraA display.

Range   0 to 255

Initial   N/A

Syntax   SAYScale min max

SaveSetup - Saves some setup information to a file in the DoPath directory. This file consisted of macor commands.

Prompt   'Save Setup as a Marco File' Frame.

Range   Setup can be save using an legal filename.

Initial   N/A

Syntax   SaveSetup filename

SBDataYRange - Sets the range of the Y axis of a Spectra B graph of the object and sky bin data.

Prompt   P

Range   -2^32 to 2^32-1

Initial   V

Syntax   SBDataYRange min max

SBDiffYRange - Sets the range of the Y axis of a Spectra B graph of the difference between the obj and sky bins.

Prompt   'DiffYRange' on the main panel for SpectraB
display.

Range   -2^32 to 2^32 -1

Initial   V

Syntax   SBDiffYRange min max

SBObjBin - Sets the bin range of the object data for a Spectra B graph.

Prompt   'ObjBin' on the main panel for SpectraB
display.

Range   0 to 255

Initial   N/A

Syntax   SBObjBin min max

SBShow - Specifies the data to be ploted for a Spectra B graph.

Prompt   'Show' on the main panel for SpectraB
display.

Range   D   Display a plot of the difference
(object-sky) bin.

O   Display a plot of the Object bin.

S   Display aplot of the Sky bin.

InitialDOS

Syntax   SBShow { D l O l S }

Note: The letter DOS can be ORed
inclusively.

SBSkyBin - Sets the bin range of the sky data for a spectra B graph.

Prompt   'SkyBin' on the main panel for SpectraB
display.

Range   0 to 255

Initial   V

Syntax   SBSkyBin min max

SBXRange - Sets the range of the X axis of the Spectra B graph.

    Prompt   'XRange' on the main panel for the SpectraB display.

    Range   0 to 255

    Initial   V

    Syntax   SBXRange min max

SBYAutoScale - Sets the Y axis autoscale flag for the spectraB graph

    Prompt   'YAutoScale' on the main panel for SpectraB display.

    Range   OFF - Use DiffYRange and DataYRange to set scales.

            ON - Auto scale the graph using max and min of data.

    Initial   off

    Syntax   SBYAutoScale { off | on }

SetBadMask - Exams a frame and builds the bac pixel mask definition from it. Good pixel are represented by 0's, the rest are bad pixels.

    Prompt   GetBadMask

    Range   Index to Dframe. 0 thur 4.

    Initial   All pixels are good

    Syntax   GetBadMask num

SetPixel - Changes the value of the pixel located at [x,y] in the buffer on the active canvas.

    Prompt   N/A

    Range   N/A

    Initial   N/A

    Syntax   SetPixel x y value

StatsCanvas - Identifies the buffer used to in calculating the stats values by selecting the canvas holding the data.

    Prompt   N/A

    Range   0 to 4

    Initial   0

    Syntax   StatsCanvas {A|B|C|D|E}

StatsObjBox - Set the size and position of the rectangle area which identifies the pixels call the ObjectBox.

    Prompt   N/A

    Range   0 to 255 for x, y, wid, and hgt.

            0 to 4 for dframe.

    Initial   0, 0, 1, 1

    Syntax   StatsObjBox x, y, wid, hgt[, dframe]

StatsSetSky - This command sets the SkyBox position and skze to be equal to the ObjectBox.

    Prompt   N/A

    Range   N/A

    Initial   N/A

    Syntax   StatsSetSky

StatsXORLine - Set the XOR line postion on the image canvas.

    Prompt   N/A

    Range   X and Y must be from 0 to 255

    Initial   0,0 to 1,1

    Syntax   StatsXORLIne x1, y1, x2, y2

TCSHostname - Identifies the host used to handle communications to the TCS.

    Prompt   'TCSHostname' on the Setup Frame.

    Range   Enter a valid hostname

    Initial   N/A

    Syntax   TCSHostname host

UseHex - The pixel values are display on the upper right corner of the canvas on Image display mode. These values can be based in decimal or Hexadecimal.

    Prompt   None. Type command a command prompt.

    Range   Off - Show values as decimal

            ON - Show values as Hexadecimal.

    Initial   Off

    Syntax   USEHEX { off | on }

Write - Writes the content of a buffer to a fits file in the current Path. Specifying a filename is optional. If a filename is not specified, the program will the name assigned with the data.

    Prompt   P

    Range   N/A

    Initial   N/A

    Syntax   write buf# [filename]

XCutAutoScale - Sets the autoscale flag of the XLineCut graph.

    Prompt   'AutoScale' on the main panel for XLineCut display.

    Range   OFF - Use Range for scale

            ON - Autoscale the range based on data.

    Initial   Off

Syntax   XCutAutoScale { off | on }

XCutSet - This command identifies the endpoints of the
line of pixels used to construct the XLineCut graph.

Prompt   'Beg' and 'End' on the main panel for
             XLineCut display.

Range   x & y must be from 0 to 255

Initial   N/A

Syntax   XCutSet x1, y1, x2, y2

B. Turning CSHELL and its CCD Camera On and Off

The day crew should power on the instrument and run checks. Power is left on continuously except for conditions that may lead to abandonment of the summit or lightning. The cshellic software is usually left running on the IC computer. These procedures are for the Telescope Operators and support scientists. Observers should not attempt to power CSHELL on or off.

All software can be started up from your user account on an IRTF Sun workstation at the summit (planck) or HP (wien). **Remember to type "xuihostname wien" in the command line of the CSHELL XUI program if running from that HP workstation.** The CSHELL and CASSPC (the guider pc) Instrument control (IC) Intel architecture computers can also be logged into from their directly connected keyboard / monitor consoles. The new calibration lamp program is called *cal_lines* which should be typed in from a UNIX prompt.

A. CSHELL Startup

0) Turn on CSHELL boxes #2 - #5 in numerical order (done at start of run by day crew)
1) Log into your Guest Account (IRTF staff can use *cshell* account)
2) Type "openwin" and <CR> at the UNIX prompt
3) Hold down the right mouse button on the blue desktop
4) *If the IC program is **not** already running* (ASK a T.O. or Support Astronomer), Either:
      i) Select "Start CSHELL IC Software!" from the CSHELL menu
    or ii) Log into CSHELL IC console as "cshellic"
5) Select "Cshell XUI" from the CSHELL menu
6) Select "VF" from the CSHELL menu
7) Turn on the CSHELL Array Power Supplies (left on if cshellic is running)
8) Set Programmable Voltages in Setup Parameters XUI Window

B. CSHELL Shutdown

1) Quit VF
2) Move Shutter, Slit, and Filter to "Blank" Position. Spectroscopic mode, turn lamps off.
3) Quit XUI software
4) *Leave in this configuration unless powering off* (proceed further only if powering off)
5) Turn off the CSHELL Array Power Supplies
6) Type "die" and <CR> in CSHELL IC window. Halt Lynx by logging in as "shutdown"; login as "reboot" if you only want to reboot the IC computer.

C. CCD Guider Camera

Startup: 1) Follow Steps A0 - A3.
              2) Select "Login to CASSPC Guider PC" from CSHELL menu
              3) Type "gic" and <CR> in the casspc window
              4) Select "Guider XUI" from CSHELL menu

Shutdown: 1) Quit Guider XUI
              2) Type "die" and <CR> in GIC (casspc) window; exit window
              3) Power Off Only: Login as *oroot* or *sroot* and type "reboot -ah"
                   before power off or just type "reboot -a" to reboot only.

1. Setting IR Array Bias Voltages

The IR detector bias must be programmed to match the observing application. Using a single fixed bias (as done with the old NICMOS array) is inappropriate because of non-linearities and *icky pixel* artifacts in the SBRC 256 x 256 InSb arrays. Larger biases allow more electrons to be collected before saturation, but they also cause increased numbers of high dark current pixels (*icky pixels)* and low-level non-linearities. Fortunately, the *icky pixels* mostly disappear when object and sky frames are subtracted. Dark frames with exposure times equivalent to flat fields should be taken to subtract these pixels from your flats. The SBRC InSb arrays are not particularly linear near the tops or the bottoms of their integrating wells (see Appendix F), but linearity problems can be avoided if you expose your flats so that they have similar data counts to your object frames. You may coadd many flats to achieve high S/N. I recommend that you pick one of four following detector bias settings for you observations:

Observation	Bias (mV)	Well	VDDUC	VDET	XUI Do File
Most Spectroscopy	325	5000	-3.7	-3.375	small
Bright Thermal Spectroscopy	500	8400	-3.7	-3.200	medium
Bright or Thermal Imaging	800	15,500	-3.7	-2.900	large
Thermal Imaging with very high backgrounds	1000	21,300	-3.7	-2.700	huge

Notes:

Well: The maximum number of ADU counts (**1 ADU = 11.0 electrons**) that can be collected while not departing more than 1% from the linearity relation of the mid-well range.

VDET & VDDUC are detector biases (Volts) that can be typed into the SETUP Parameters frame of the CSHELL XUI Application.

XUI Do File is the name of a command file that can be executed from the Options menu of the CSHELL XUI application. These files automatically set the indicated bias levels.

The bias voltages must also be set (execute DO File or push button in Setup Parameters Window) when the software is started. You must also use blockers if you ovbserve with the 1.10 - 1.57 μm CVF (see #9 this section).

2. Check For Read-Noise Limit and Saturation

The minimum background-limited data value of each array is equal to the square of its read noise (in electrons) divided by the number of electrons per ADU. This value is approximately 100 for the SBRC InSb array in CSHELL as listed in § I Table 3. Try to keep your data numbers above these values to avoid being limited by array read noise.

The SBRC InSb array saturates at a level that is a function of detector bias as listed in the above table. Try to keep raw data values below the listed 1% linearity departure levels. It is good practice to check unsubtracted exposures for saturation. This may occur in frames with low mean counts if there is a bright OH line or thermal telluric line that is not seen in the A-B images.

NOTE: When using the Direct Imaging Mode, you may find a black spot in the center of a bright star. This is a manifestation of gross saturation, and the numbers in the black area are meaningless.

3. Flat-fielding

Flat-fielding is accomplished by taking spectra of a continuum source (usually a light bulb) that illuminates an integrating sphere (the same one that is used for the calibration lamps). One typically should obtain flats at the beginning of the night, whenever standards are measured, and at the end of the night. Flat fields should be taken for each observed wavelength observed. **The grating and the CVF should not be moved between observing objects and flats** in order to minimize wavelength shifts and ripples in spectra caused by interference in the CVFs. For most work, obtaining about 10 flats at an exposure of 1000 counts should suffice. They have similar data counts to your object frames if you are very concerned about linearity. For work requiring $S/N \geq 100$ one should strive to get 25-30 flats at a time. Flats must be acquired with the same detector bias setting as your object data.

We usually use the continuum lamp to generate flat fields at wavelengths $\lambda < 2.5$ μm. The lamp does not produce many photons in the $\lambda \sim 3.5$ μm range (due to opaque glass) but it usable. Its glass bulb is warm enough to provide an abundance of photons in the $\lambda > 4$ μm region. You may also wish to try taking flats at $\lambda > 4$ by using the thermal emission of the dome or mirror covers. You can try either taking long exposures of the continuum lamp or mirror covers for 3 μm $< \lambda < 4$ μm, or else observing the dome target with the dome lights on. We do not yet have much experience in acquiring good flats at $\lambda > 3$ μm wavelengths.

4. Focus And Collimation

The collimation settings should be the same as that used for NSFCAM. Check with the T.O. to make sure that this is the case. The focus should be checked on a 7 - 9th magnitude star which the T. O. can find in the on-line SAO catalog. Use the Direct Imaging Mode, slit in the "open" position, and a few seconds of exposure time - using several coadds of shorter integrations if necessary - to integrate over seeing. At the beginning of the night, the focus is usually about +270 with the "chipped" secondary ($\sim$ +2.10 with the milled secondary) and it systematically drops (as the temperature drops) to about +2.30 (+1.85 with milled secondary) by the end of the night. The stellar image is typically less than 1 arcsec full-width-half-maximum (less than 5 pixels FWHM).

5. Tweaking the CVF for a Flatter Flat

Whenever a new wavelength is entered, the grating and CVF are moved. The CVF suffers from internal reflections which cause an interference pattern in all spectra. The amplitude of this pattern varies from about 10 - 20% peak-to-peak, and it is quite sensitive to small changes in CVF position. If this fringing is particularly bad in your object or flat field data, you can try to minimize it by moving the CVF wheel (no more than ±40 steps total) in small increments (5 or 10 steps). Be sure, however, to acquire all data (object and flats) for each wavelength at the exact same CVF and grating positions - do not move the grating or CVF in between data frames unless changing wavelengths.

The CVF position can be seen in the "Motors" frame of the main cshellxui window. The CSHELL command *Filterpos* can be issued to move the CVF filter wheel a small amount. Consult the Hardware Reference (Appendix B) for the command syntax and to determine which CVF and wheel should be moved.

6. Darks

Darks should be taken whenever flats are taken and the exposure time should be the same as the flats. Dark current is normally subtracted from object data when differencing object and sky frames acquired in Nod mode. Flat fields must have their dark current (and icky pixels) removed during the reduction process by subtracting separate dark frames. Darks must be acquired with the same detector bias setting as your object and flat field data. Close the shutter before taking dark frames.

7. Acquiring Objects

To acquire objects, first determine the position of the slit on the array that you are using. Take an image of the slit in the Direct Imaging Mode looking at the sky or a discharge lamp (Kr or Ar). You should get an image of the slit with an integration time of a few seconds or less. Record the central column of the slit. It will change at each cool-down of the CSHELL, but it is usually near column 100.

Move the telescope to the object you wish to acquire. Move the slit to the "open" position. Take an image of the field, and note the position of your object on the array (x,y coordinates). Use the Options menu of the VF program and select TCS. Use this window to compute the telescope offsets you need to center the object on the slit (the center of the slit will be near row 100). Note the position of the object in the CCD camera field when it is centered in the slit. You may mark this position on the TV monitor. Remember to insert the CCD filter (VCCD icon in CSHELLXUI) if the CCD bleeds due to excessive object brightness.

8. Slit Rotation

The slit is normally positioned in the East-West direction. The primary reason for this is that tracking errors will not usually lead to a loss of signal. To obtain any other rotation angle, the entire instrument must be rotated using the IRTF instrument rotator. This requires manually rotating the instrument, a procedure taking at least 15 minutes and not something to do often. The default East-West slit position causes North to be located to the left and East down in the VF image display on the Sun workstation. The top of the slit (as seen in VF) is then rotated 270° East of North, and this angle is the default value in the VF TCS Coordinates frame. The slit location in the VF coordinate system is drawn on the bottom of the CSHELL cryostat for easy reference while rotating the instrument. Once the slit is rotated, enter the angle as defined in this convention in the TCS Coordinates frame of VF. This will allow you to easily position any object in the imaging field onto the slit by pushing the mouse buttons (see § II.B and § III.A for details). Please consult with your Support Scientist or Telescope Operator if you need to rotate the instrument.

9. Integrations and Nodding

Prior to integrating, check the XUI path for the proper data location and change all of the appropriate parameters in the Setup Parameters window frame. These items need be checked only once each time the cshellxui software is started up.

Next check and change (if necessary) the following parameters:

•Integration time:	Seconds per exposure
•Coadds:	Number of exposures per beam
•Cycles:	Number of iterations of the selected observing mode
•Observing Mode:	Stare or Nod
•LastFrame Buffer:	Buffer into which the last exposure is stored
•MeanFrame Buffer:	Buffer into which the average of the cycles are stored
•AutoSave:	Check to have data stored into XUIpath directory

EXAMPLE: Take the case of:

•Integration time:	2.0
•Coadds:	1
•Cycles:	4
•Observing mode:	Nod
•LastFrame Buffer:	b0
•MeanFrame Buffer:	b1

This will generate 2.0 sec exposures, one exposure per beam, and 4 AB pairs (for a total of 8 separately stored exposures in ABBAABBA sequence). The last exposure is in buffer b0 and the running average of the AB pairs will appear in buffer b1. For each AB pair the telescope "nods" from position A to position B on the sky. The amount the telescope nods is set by the Telescope Operator, so inform him about how far you wish to nod (in arcsec). Motion E/W or N/S or both directions is possible for the nod. We recommend that you nod point sources along the slit with a throw of about 15" in order to acquire object data in both the A and B frame positions.

You must select the CVF/Blocker Option and also use the shutter wheel blocker (SPF) when observing with the 1.1 - 1.57 μm CVF! This CVF transmits λ > 2.5 μm radiation, causing significantly increased background in your data if not blocked as prescribed. The blockers impart about a 10% reduction in flux over the 1.1 - 1.6 μm region.

NOTE: Every exposure is stored onto the disk if the Autosave is enabled. The exposures are automatically named by the filename and the image number. For example if the filename is set to "data" and the image number is "0010", then the above example produces 8 files named "data0010.a", "data0011.b", "data0012.a", ..., "data0017.b". The extensions ".a" and ".b" refer to the A and B beams.

10. Observing Extended Objects

When observing extended objects there will be additional concerns. First if the object fills the slit, the object must be moved off the slit for observations of the sky. Note that the sky exposure also contains ark current and other detector artifacts. These must be removed and therefore sky measurements are required. However, one loses about half of the total available observing time because of this.

Second, any standard star measurement will cover only a few of the rows that the extended object covers. Hence the quality of the results may depend more on the quality of the flat-fields than anything else. It may be advantageous to use the Moon as a flat-field source if it is an appropriate standard, and you might want to drift-scan over it during exposures to smooth over any spatial features. However, keep in mind that the Moon has many solar absorption lines and it has albedo variations along the slit. It is far from being a satisfactory flat-field, but it may be handy for spectral regions that are relatively free of solar lines if you can find a relatively uniformly illuminated patch of the Moon. The moon should make a good telluric calibration source in the thermal IR ($\lambda > 3$ μm).

It is possible to automatically move the telescope a specified amount between exposures in order to map extended objects. For example, you can move in a vector parallel to the slit and 1 slit width in size between each exposure. This is done by writing CSHELLXUI macros (Do Files) that include TCS commands. Consult your support scientist or T.O. for help with this.

11. Command Files

After taking data with the CSHELL you will find that many tasks are repetitive, such as switching to the imaging mode and back to the spectroscopic mode, setting up to peak up, setting up to observe, etc. These repetitive tasks can be put into an cshellxui "command file" and executed, thus saving time. More than saving typing, these command files can prevent loss of data by not having an important parameter set properly (like turning on auto save). See the CSHELLXUI and VF software guides (§III.A) for more information on using command files.

EXAMPLE: The following command files switch between imaging and spectroscopic modes and set the detector bias appropriately. They are the default *image* and *spect* macros:

image	*spect*
PVoltages -3.700 -3.200	PVoltages -3.700 -3.375
ITIME 0.1	InstMode S
Cycles 1	Slit 1.0
Coadd 10	ITIME 10
InstMode D	Coadd 1
Slit Open	Cycles 20
AutoSaveXUI Off	AutoSaveXUI On

Other commands may be included in command files, such as a Go command to actually start a sequence of exposures. The most commonly used command files, *image*, *spect*, *goflat*, and *godark* are in the directory ~cshell/macro/cshellxui . These files configure CSHELL to take images, take spectra, take flats, and take dark frames, respectively. The *goflat* and *godark* files contain a Go command, so they actually start a sequence of exposures once they are executed. Be sure to review the contents of a command file (by Loading it) before execution to make sure that it configures CSHELL properly and does exactly what you want.

Commands to move the telescope (TCS commands) can also be included in CSHELLXUI Do Files. See the IRTF document, *Computer to TCS ASCII Communications* for a complete listing of TCS commands. As an example, the following macro will take an exposure, offset the telescope 1" N, expose again, offset again, expose again, and then return to the original position:

```
tcs ABEAM
tcs 1 0.0 0.0 -1 C.SCN
echo Base Position
go
tcs 1 0.0 1.0 1 C.SCN
wait 2
echo Moved 1 arcsec N of Base
go
tcs 1 0.0 2.0 1 C.SCN
wait 2
echo Moved 2 arcsec N of Base
go
tcs 1 0.0 0.0 1 C.SCN
echo Done; Returned to Base
```

D. Observing Spectral Lines

1. Popular Astronomical Line List

The following table lists the vacuum rest wavelengths of some commonly observed near-IR lines and band heads:

Material	Transition	Name	λ (μm)
HI	5-3	Pβ	1.2822
HI	10-4		1.7367
HI	9-4		1.8179
HI	4-3	Pα	1.8756
HI	8-4	Bδ	1.9451
H$_2$	1-0	S(2)	2.0388
HeI	2P-2S		2.0587
HeI	4S-3P		2.1126
H$_2$	1-0	S(1)	2.1218
HI	7-4	Bγ	2.1661
HeII	10-7		2.1891
H$_2$	1-0	S(0)	2.2233
H$_2$	2-1	S(1)	2.2477
CO	2-0	bh	2.2935
H$_2$	1-0	Q(3)	2.4237
HI	10-5		3.0392
HeII	7-6		3.091
H$_2$	1-0	O(5)	3.2349
HI	9-5	Pfδ	3.2970
HI	8-5	Pfγ	3.7406
H$_2$	1-0	O(7)	3.8074
H$_2$	0-0	S(13)	3.8462
HeI	5-4		4.0490
HI	5-4	Bα	4.0522
HI	7-5	Pfβ	4.6538
H$_2$	0-0	S(9)	4.6946

2. Night Sky OH Lines

The following table list some night sky OH⁻ lines in the J, H, and K windows that might be useful for wavelength calibration or other checks. Observed wavelengths are in vacuum, *bl* denotes a blend, and intensities are in units of photons s^{-1} arcsec^{-2}. These data are taken from Ramsay, Mountain, and Geballe, 1992, *M.N.R.A.S.* 259, 751. Also see this reference for more lines.

λ (μm)	Transition	v'' - v'	Intensity	λ (μm)	Transition	v'' - v'	Intensity
1.0063	*Q*	9-5	3399.6	1.6489	*R branch*	5-3	2021.5
1.0263	*Q*	4-1	2276.3	1.6692	*Q*	5-3	6461.6
1.0824	*Q*	5-2	676.9	1.6891	*P$_1$(1)*	5-3	3466.8
1.1430	*Q*	6-3	825.7	1.6944	*P$_2$(2)*	5-3	1366.0
1.2092	*Q*	7-4	758.7	1.6992	*P$_1$(2)*	5-3	3839.3
1.2660	*R branch*	8-5	801.1	1.7061	*P$_2$(3)*	5-3	1217.0
1.3072	*P(2) bl*	8-5	602.5	1.7101	*P$_1$(3)*	5-3	2706.9
1.4501	*P(1) bl*	2-0	937.4	1.7235	*P(4),R bl*	5-3,6-4	1649.0
1.4582	*P(2) bl*	2-0	929.9	1.7367	*P(5), R(2)*	5-3,6-4	1917.2
1.4818	*P(4) bl*	2-0	825.8	1.7418	*R(1) bl*	6-4	1917.2
1.4873	*R(1)-R(7)bl*	3-1	1123.3	1.7639	*Q*	6-4	5821.0
1.5170	*P$_2$(1)*	3-1	1082.9	1.9685	*R(1) bl*	8-6	1031.6
1.5235	*P$_1$(1)*	3-1	3884.0	1.9756	*R$_1$(0)*	8-6	1638.8
1.5319	*P(2) bl*	3-1	3556.2	1.9845	*R$_2$(0)*	8-6	620.8
1.5403	*P(3) bl*	3-1	2572.8	2.0270	*P$_1$(1)*	8-6	2162.8
1.5524	*P(4) bl*	3-1	2259.9	2.0315	*P$_2$(2)*	8-6	1019.6
1.5578	*R(2) bl*	4-2	1708.6	2.0400	*P$_1$(2)*	8-6	2710.5
1.5622	*R(1) bl*	4-2	2483.4	2.0897	*P$_1$(5)*	8-6	811.3
1.5814	*Q*	4-2	6715.0	2.1110	*R(2) bl*	9-7	853.5
1.5946	*P$_2$(1)*	4-2	1038.2	2.1183	*R(1) bl*	9-7	883.2
1.6018	*P$_1$(1)*	4-2	3749.9	2.1250	*R$_1$(0) bl*	9-7	1044.0
1.6059	*P$_2$(2)*	4-2	1634.2	2.1518	*Q*	9-7	2201.2
1.6108	*P$_1$(2)*	4-2	4375.7	2.1792	*P$_1$(1)*	9-7	1533.7
1.6217	*P(3) bl*	4-2	2960.2	2.1938	*P$_1$(2)*	9-7	1550.6
1.6330	*P(4) bl*	4-2	1678.8	2.2108	*P$_1$(3)*	9-7	1461.3
1.6434	*P(5) bl*	4-2	1574.5	2.2309	*P$_1$(4)*	9-7	1081.7

3. Using Calibration Lamps and cal_lines

CSHELL has three discharge lamps, Argon, Krypton, and Xenon. The Xenon lamp is mounted behind one of the other lamps, so its lines are very faint. Therefore the Ar and Kr calibration lamps in CSHELL are most useful for wavelength calibration of spectra. The following table lists their stronger lines (s = strong and m = medium intensity):

Lamp	λ (μm)	Lamp	λ (μm)	Lamp	λ (μm)
Ar	1.2706m	Ar	2.154m	Ar2	3.1988m
Ar	1.2806m	Kr	2.1908s	Ar2	3.2882m
Ar	1.2960s	Ar	2.2083m	Ar2	3.3489m
Ar	1.3012s	Kr	2.2492m	Ar2	3.3890s
Ar	1.6945s	Ar	2.3140s	Ar2	3.490m
Ar	1.7450m	Ar	2.3852s	Ar2	3.5839s
Ar	1.7920s	Ar	2.3973s	Kr2	3.6345s
Kr	1.8172s	Ar	2.5132s	Ar3	3.8117m
Kr	1.8701m	Kr2	2.8861s	Ar3	3.8419m
Ar	1.9823m	Kr2	2.9477s	Ar3	4.0112s
Kr	2.0215m	Ar2,H	3.0101m	Ar3	4.0524s
Ar	2.0323m	Ar2	3.0354m	Ar3	4.0879s
Ar	2.0622s	Kr2	3.0488s	Ar2	4.6279s
Ar	2.0992s	Kr2	3.0678s	Kr2	4.6694m
Kr	2.1171s	Ar2	3.1808m	Ar2	4.7703s

Beware that the discharge tube quartz envelopes absorb much of the radiation long-ward of 3 -4 μm; lines in the above table with wavelengths greater than 3 μm are difficult to detect due to this absorption as well as thermal emission by the envelopes.

An auxiliary program, `cal_lines`, is used to determine which calibration lamp lines are to be used at a given wavelength selected for observation. The narrow spectral range of CSHELL usually prevents observing a calibration lamp in the same order as your object spectra, and `cal_lines` determines which order the lamp lines must be observed in. Position the mouse pointer in a UNIX text window on the Sun XUI computer, selecting it with the left button and bringing it forward if necessary. Type the following command in this window to display a list of calibration lamp lines which can fall on the InSb array when the grating is positioned for observing your astronomical line:

```
cal_lines λ(μm) | more
```

where λ (μm) is the desired central wavelength on the array. The list of available lines can be scrolled through by pressing the space bar on the keyboard. Alternately, this list can be printed by the laser printer with the following command in the UNIX window:

```
cal_lines λ(μm) | lpr
```

These commands are also available on IRTF the workstation at H.P. One can print calibration line lists at H.P. by specifying the name of the H.P. laser printer (uh88pr) :

```
     cal_lines λ(μm) | lpr -Puh88pr
```

Now consider an example of using these commands to determine which calibration lines to observe if one is using the UNIX window on the Sun XUI computer. If we wish to observe HI Br γ, λ = 2.16609 μm wavelength, we issue the command:

```
     cal_lines 2.16609 | lpr
```

which prints the following `cal_lines` table on the system printer:

```
Central Vacuum Wavelength = 2.166090 microns:  4616.613 cm-1;  order = 26

 waveno     line(vac. um) obs(um)     order  CVF(um)  col(SBRC 256)

Argon lines
 6040.898  1.655383      2.164732      34  1.6564      56
 6040.500  1.655492      2.164874      34  1.6564      63
 7287.392  1.372233      2.163906      41  1.3736      15
 7457.021  1.341018      2.166260      42  1.3409     133
 7456.983  1.341025      2.166271      42  1.3409     134


Krypton lines
 5321.816  1.879058      2.168144      30  1.8773     228
 5321.150  1.879293      2.168415      30  1.8773     242
 5502.887  1.817228      2.166695      31  1.8167     155
 5502.884  1.817229      2.166696      31  1.8167     155
 5856.639  1.707464      2.167166      33  1.7066     179
 5856.272  1.707571      2.167302      33  1.7066     186
 5856.275  1.707570      2.167300      33  1.7066     185
 6032.254  1.657755      2.167833      34  1.6564     212
 6393.989  1.563969      2.165496      36  1.5644      95
 6573.027  1.521369      2.165025      37  1.5221      71
 6929.652  1.443074      2.164611      39  1.4441      50
 6929.652  1.443074      2.164611      39  1.4441      50
 7276.638  1.374261      2.167104      41  1.3736     176
 7276.638  1.374261      2.167104      41  1.3736     176


Xenon lines - Very Faint!
 5321.059  1.879325      2.168452      30  1.8773     243
 5856.272  1.707571      2.167302      33  1.7066     186
 5856.275  1.707570      2.167300      33  1.7066     185
 6039.008  1.655901      2.165409      34  1.6564      90
```

The first line of the output lists the central (vacuum) wavelength and wave number as well as the corresponding grating order for the astronomical line. The ensuing table lists the wave number, actual wavelength, apparent wavelength, grating order, CVF (order sorting filter) central wavelength, and approximate SBRC array column of each calibration lamp line. Note that no lines in the above example list fall in the same order (26) as the desired astronomical spectrum. We can observe lines in other orders by simply changing the CVF wavelength as explained in §II.A.

E. IRTF Computer Services

1. IRTF Mauna Kea Computer Facilities

The current IRTF computer facilities on Mauna Kea include a Sun workstation, several PCs, and a PostScript laser printer on an ethernet network at the summit. These machines are also on a summit network that includes other Mauna Kea telescopes and the machines at Hale Pohaku. Currently the IRTF has a Sun workstation at Hale Pohaku that is available for data archiving, reduction, etc. during your run. These machines on the summit network are only reachable through U.H. Manoa machines via Internet, so you must make arrangements with your support astronomer if you need access to them before or after your CSHELL observing run. You should obtain a guest observer account when you arrive at Hale Pohaku by logging into the IRTF workstation as *guests*. Use this account for all activities while at the IRTF. It will expire 3 days after your run.

2. Archiving Your Data

The recommended data archiving procedure is to copy each night's data files onto a separate 4 mm or 8 mm tape. Additionally, we recommend that you archive the data from all nights of your run onto a single tape if you have time at the end of your last night. This will ensure redundancy of your data in case some of your tapes are unreadable at your home institution. Our current housekeeping procedure is to keep data on the Sun computer's (herschel.ifa.hawaii.edu) disk for 1 week, then compress the data (UNIX format) and retain it for another week before erasing it. Be sure to read your data tapes as soon as you get back to your institution; your data will be completely erased from our computer two weeks from the date it was taken! Be sure to bring plenty of tapes (at least 1 per night + 1) for your run.

We use the UNIX tar command (Tape ARchive) to transfer CSHELL data onto the tapes. Data are stored in FITS format and are readable by IRAF. The following procedures for data archiving, listing tape contents, and restoring tapes require that you issue their proper UNIX commands from the Sun console or other UNIX window. The 8 mm tape drive is located adjacent to the IRTF workstation named wien at Hale Pohaku, so 8 mm tapes must be written from Hale Pohaku. Wien's UNIX device name for the 8 mm tape drive is /dev/rst0 (or /dev/nrst0). The 4 mm tape drive is located adjacent to the IRTF summit workstation named Herschel, so 4 mm tapes must be written on the summit. Herschel's UNIX device name for the 4 mm tape drive without compression is /dev/rst0 (or /dev/nrst0). Tar writes data into 20 block records by default. The following examples show how to archive your data onto either drive. Sometimes we store data in other directories besides `/scr1/cshell/data` illustrated below; if your data is in a different directory you must substitute its name in the following commands.

ARCHIVING 1 NIGHT'S DATA

Commands:
```
cd /scr1/cshell/data
ls
tar -cvf /dev/rst0 directory
```

These commands will switch to the CSHELL data directory, list the nights there, and copy your night's data onto the tar tape. You must substitute your night's data directory name for *directory* in the above tar command. You should see the name of this directory when you execute the above ls command. These directory names are usually of the form *ddmon*, e.g. 30aug .

ARCHIVING SEVERAL NIGHTS' DATA

Commands: `cd /scr1/cshell/data`
            `ls`
            `tar -cvf /dev/rst0 date1 date2 ...`

PRINTING A TAPE'S TABLE OF CONTENTS

Commands: `tar -tvf /dev/rst0`
   or: `tar -tvf /dev/rst0 | lpr`

The first command will list the names of the files of a tape archive to the Sun computer screen. The second command will print the names of the files on the system (laser) printer. The second command may take 10 - 20 minutes to execute without any confirmation until the pages are printed and the tape is rewound - be patient!

SEVERAL ARCHIVES ON 1 TAPE

You may append data onto a pre-existing data tape, but this creates a new archive at the end of the existing one rather than appending the old one. This makes the tapes more confusing to write and read, and we do not recommend using his technique unless you must. It is most convenient to use the drive without rewinding it (use the /dev/nrst0 device name) if you go this route. Sequentially enter any of the above commands (once for each archive) using /dev/nrst0 instead of /dev/rst0. Rewind the tape manually when you are done:

    `mt -f /dev/nrst0 rewind`

READING YOUR DATA TAPES

You can usually read your data onto your home UNIX computer with the command:

    `tar -xvf /dev/rstx`

where /dev/rstx is the device name of your 8 mm tape drive.

3. Anonymous FTP and WWW Site Information

The IRTF maintains an anonymous FTP site called IRTF On-line, providing remote access to documentation and data reduction aids for IRTF observers. This site is on the machine irtf.ifa.hawaii.edu (128.171.79.135), and the information on it is accessible through the FTP (File Transfer Protocol) service of the Internet. If you have access to a machine on the Internet, then you may retrieve copies of this information. This archive is also reachable through the IRTF World Wide Web (WWW) home page (http://irtfweb.ifa.hawaii.edu/). Check it out!

All CSHELL information is kept in the directory /pub/IRTF/CSHELL . This directory contains instrument documentation (including this manual), data reduction information, and some IRAF scripts and bad pixel masks that are useful in reducing CSHELL data. The current directory contents are kept in the README.txt file. Currently the CSHELL directory contains two directories, one for documentation and one for IRAF data reduction aids. The Docs directory contains the files:

starting.ps	§ I and II of this CSHELL User's Manual
swref.ps.Z	CSHELLXUI and VF documentation (§ III.A of this manual)
data.txt	Text of Data Reduction Guide in § III.F.2 of this manual
line_form.ps	CSHELL Line Set Up Form (from Appendix A of this manual)
logsheet.ps	CSHELL Logsheet (from Appendix A of this manual)
manual_v2.ps.Z	This entire CSHELL User's Manual
manual_v2.word.Z	CSHELL User's Manual in MS Word format (Macintosh 5.1)

Here is how to access the information in IRTF On-line. First log on to IRTF On-line by typing the following commands on your Internet host:

> `ftp irtf.ifa.hawaii.edu` (or `ftp 128.171.79.135`)
> (use "`anonymous`" when prompted for "Name" and use your email address as a password)

Now switch to the CSHELL directory:

> `cd /pub/IRTF/CSHELL`

List the files in the directory:

> `ls`

Retrieve the README.txt file which describes the CSHELL archive contents:

> `get README.txt`

End your session:

> `quit`

You may read the README.txt file on your local machine to see what is in the archive, and then FTP back to hubble.ifa.hawaii.edu to get the files you want. We plan to update the archive contents regularly, and we welcome your submissions.

F. CSHELL Data and its Reduction

1. CSHELL FITS File Header Example

```
SIMPLE   =                       T / DATA IS IN FITS FORMAT
BITPIX   =                      16 / bits per pixel. Two comp. Integers
NAXIS    =                       2 / NUMBER OF AXIS
NAXIS1   =                     256 / PIXELS ON 1st MOST VARYING AXIS
NAXIS2   =                     256 / PIXELS ON 2nd MOST VARYING AXIS
DATAMIN  =                     -82 / MIN DATA VALUE IN FILE
DATAMAX  =                    2795 / MAX DATA VALUE IN FILE
DATAMEAN=                      12 / MEAN DATA VALUE IN FILE
ASEC_PIX=                    0.20 / PLATE SCALE in arcseconds/pixel
DIVISOR  =                       1 / Normalization value
ORIGIN   = 'Institute for Astronomy'
TELESCOP= 'NASA IRTF'
INSTRUME= 'CShell Spectrograph'
OBSERVER= 'Your Name'
OBJECT   = 'HD129653 K=6.92'
COMMENT = 'Comment for fits frame'
IRAFNAME= 'hd1290019.a'
BEAM     =                     'A' / Object(A) or sky(B)
IMAGETYP=                'object' / Type of image
TIME_OBS=        '11:50:38.06' / UT TIME OF ACQISTION ('hh:mm:ss.ss')
DATE_OBS=          '07/05/94' / UT DATE OF ACQUISITION ('dd/mm/yy ')
ITIME    =                 60.0000 / INTEGRATION TIME IN SECONDS
CO_ADDS  =                       1 / NUMBER OF INTEGRATIONS
OBSMODE  =                       1 / obsmode is Nod (AB)
CYCLES   =                       1 / Number of cycles
INSTMODE=                       0 / Instrument Mode is S
GPOS     =                  235523 / Grating step position
GANGLE   =                  63.509 / Grating Angle
ORDER    =                      26 / User's Order
GWLEN    =                 2.17000 / Grating's wavelength
FILTER   =                       0 / Filter is CVF Wlen/Open
CVFWLEN  =                  2.1700 / CVF Wavelength
FILTERA  =          'AF4 (Open)' / StepPos 1166
FILTERB  =     'BCVF1 (1.33 to 2.449 CVF)' / StepPos 4540
SLIT     =                       3 / Slit Wheel is 2.0
LMIRROR  =                       0 / Lamp Mirror is Out
LAMP     =                       0 / Lamp is Off
SHUTTER  =                       1 / Slit Wheel is Open
VCCD     =                       0 / VCCD is Out
ARRAY    =           0,0,256,256 / x,y,wid,hgt of data array
SAMPLES  =                       6 / Number of Samples
SAM_MODE=                       2 / 1=SINGLE, 2=DOUBLE
FRM_RATE=                       6 / In msec. Fastmode=Off SlowCnt=1 Samples=6
RESET_MS=                    1000 / Idle Resets in msec.
TEMP01   =                   30.00 / A_T1 InSb Array Temp
TEMP02   =                   72.20 / A_T2 Grating Temp
TEMP03   =                  180.00 / B_T1 CCD Temp
TEMP04   =                   71.40 / B_T2 ColdBox Temp
TPD      = '  14:40:38.81  36:58:26.5  01:49:28.21 1.143 1950.0 -O'
RA       =            14:40:38.81 / Right Ascension
```

```
DEC      =           36:58:26.5 / Declination
HA       =           01:49:28.21 / Hour Angle
AIRMASS  =                 1.143 / Air Mass
EPOCH    =                1950.0 / Epoch
VDDUC    =                -3.700 / Programmable voltage VVDUC
VDET     =                -3.375 / Programmable voltage VDET
END      =                       / the end
```

2. Data Reduction Guide with IRAF Examples

Point Source Data Reduction

Note: Data should have been taken in nod mode (AB or ABBA, object is in both A and B beams and nodding along the slit)

1) Flat Fields
      a) combine the flat-field images: e.g. IRAF function 'imcombine' with avgsigclip
      b) combine dark images: e.g. IRAF 'imcombine'
      c) flat = a) - b) :   e.g. IRAF 'imarith'
      d) fix badpixels using the badpixel mask: e.g. use fix.cl IRAF script
      e) normalize the flat-field, producing a frame called 'normflat'

2) Object Data
      a) form differences A1-B1, A2-B2, ...B1-A1, B2-A2, ...: e.g. IRAF 'imarith'
      b) combine the differences for each beam to give an A image and a B image:
             e.g. IRAF 'imcombine'
      c) divide each by the normalized flat-field: e.g. IRAF 'imarith'
      d) correct for badpixels with the mask: e.g. use fix.cl IRAF script
      e) Examine the images for any additional bad pixels or other problems
      f) You may save disk space by stripping out NICMOS image areas where there is no data
             e.g. use strip.cl IRAF script

3) Do the same for the standard star data, if any.

4) Extract the Spectra
The IRAF *noao.twodspec.apextract* package is well-suited to this. The three extraction steps can be done interactively at once with the APALL task (dispaxis = 1) :
      a) EDIT the aperture and width (and any background regions subtract)
      b) TRACE the aperture, defining its position as a function of position across the frame
      c) EXTRACT the one-D spectrum from the frame

5) Extract Calibration Spectra (based on spectral lamp data)
      Assuming n>=1 images with n>=2 lamp lines (often in different orders):
      a) combine the images to be used: e.g. IRAF 'imcombine' or 'imcopy'

b) extract a calibration spectrum for each beam (A,B) such that the calibration data are extracted from the same part of the image as the object data. Do this using APALL, setting 'referen' and 'profile' to the object data image, and do not edit or trace the aperture.

We now have 1-dimensional spectra

6) Wavelength Scale Data (using *noao.onedspec* IRAF tasks)
   a) for each line in calibration spectra, convert the line wavelength to the equivalent wavelength in that order (done in `cal_lines` program)
   b) use 'IDENTIFY' to fit a wavelength scale to the spectrum
   c) use 'REFSPEC' to assign that wavelength scale to object spectrum (careful to apply the A calibration to the A spectrum, etc.)
   d) use 'DISPCOR' to produce a dispersion correct spectrum for each beam

7) Reduce the standard star data in the same way

8) Divide each object spectrum beam by the appropriate standard star beam

9) Combine All Spectra
Since the A, B beams will have, in general, different wavelength scales, use the function 'COMBINE' (*noao.onedspec* IRAF task), which will resample the spectra and average them. This is the final spectrum.

10) Plot the final spectrum using SPLOT (*noao.onedspec* IRAF task), which can compute equivalent widths, display wavelenght and intensity units, etc.

Extended Emission

If your object is extended along the length of your slit, then the standard point source spectral extraction technique outlined above will probably not work optimally. First perform the frame arithmetic outlined in steps 1) - 3) above. Divide the object and standard star data by the normalized flat. Telluric correction: you may divide the flat-fielded object data by a flat-fielded standard star frame which has been artificially extended along the slit direction, but it is best to rotate the images first so that the slit is exactly perpindicular to the dispersion axis. Additional background subtraction can be done with BACKGROUND (IRAF *noao.twodspec.longslit* task), and then you should register all frames by moving them along the slit direction. IDENTIFY (IRAF *noao.twodspec.longslit* task) will allow you to measure the centroid of flux peaks interactively, and IMSHIFT (IRAF *images* task) allows you to shift the images to a common center. Combine all shifted images with IMCOMBINE (IRAF *images* task). What you do from here depends on what you want to get out of the data as well as its morphology.

G. Using the CSHELL CCD Guider Camera

The CSHELL CCD is now a scientific-grade Tektronix 512 x 512 pixel CCD which is operated via IC and XUI programs like other IRTF instruments. Its startup and shutdown instructions are given in § III B. It can be operated in a continuous mode for acquisition, a single exposure mode, or an auto-guide mode. The CCD is clocked at a rate of 333,000 pixels / sec, so it takes just under 1 second to read a frame; this limits the minimum exposure time also.

The CCD views the same field as the IR array and is not obstructed by the slit or other apertures. It looks through an IR-reflecting dichroic which has a pass band similar to an R-band filter. A 1000x attenuation filter can be switched in front of the CCD for observing bright objects (VCCD icon in CSHELLXUI). Pixels can be binned in software (1x1, 2x2, 4x4, or 8x8) to improve signal-to-noise. N is up and E is to the left on the CCD monitor (or in VF) when CSHELL is mounted in its normal E-W slit configuration. The CCD has a 55" (E-W) x 65" (N-S) FOV, 0.15"/pixel plate scale, and V=17 mag limit.

CCD images can be automatically sent to VF for display by selecting the View IC Data checkbox. Once in VF, they can be saved as FITS files via the VF Save Data menu choice. It takes several seconds to send each frame to VF, so continuous readout mode will slow considerably if this option is selected. The guider should be operated as follows.

1) The TO should start the gic program (on max) at the start of each night. The observer should not start the gic. Starting the gic is done by logging into casspc with the login "guider" (no password). Then type "gic" and a carriage return to start the gic.

2) The observer should start the Guider XUI software (by selecting "Guider XUI" from the CSHELL OpenWindows menu) whenever he wishes to take images with the CCD for guider acquisition. He should optimize exposure time, set the proper binning (e.g. 2x2 or 4x4 for better sensitivity in bad seeing or 8x8 to be able to guide on Jupiter's or Saturn's large disk), select the 1000x CCD filter if needed (Cshell XUI), return the software to "Single Shot" frame mode, and then QUIT the Guider XUI before asking the TO to View or automatically guide with the CSHELL CCD. The observer should repeat this step whenever a new object is acquired. The observer will not be notified of CCD hardware timeouts or be annoyed by guider frame beeps when the Guider XUI is not running. This is a good thing!

3) The TO should use the IRTF guide program to autoguide with CSHELL. The rotation angle for the CSHELL CCD guider should now be approximately (within 3 degrees) the same as the CSHELL IR slit rotation angle entered into the VF TCS Coordinates Window by the observer. This angle is the position angle on the sky of the top of the CSHELL slit as seen in VF.

4) If the gic software has a hard failure (e.g. unrecoverable socket errors), then the TO should shut down the gic software (type "die" and a <CR> in the gic window) and restart the gic. If errors recur, then shut down the gic, exit from cass pc, login to cass pc as oroot, and then reboot casspc with the "reboot -a" command. Wait a minute or so and then login to casspc as guider and restart gic.

The guider software commands follow:

GIC / GUIDER XUI Command Reference

do_stats() - Sets the calculation of stats on the DSP
   Syntax: stats { Off | On }

do_array() - Sets the array type
   Syntax: array { 64 | 512 }

do_scale() - Sets the type of scaling on the DSP
   Syntax: scale { None | Fixed | Auto | Slice}

do_autodata() - Sets the transfer of 32 bit data from the DSP
   Syntax: autodata { Off | On}

do_cammode() - specify clocking and readout program.
   Syntax: cammode {singleshot | simulation}

do_coadd() - Set number of coadds on DSP
   Syntax: coadd {n}

do_color - determine what character attributes the kbio process uses to update the parms window on stdout.
   syntax: color { no | yes }

do_cycles() - Set the number of image cycles on the DSP
   Syntax: cycles {n}

do_die() - quits the program.
      Syntax: die

do_go() - Performs a GO. (starts integration sequence)
syntax: go

do_goinit() - send a init message to the GO task. GO can be initialized at anytime.
syntax: GOInit

do_goreset() - send a RESET message to the GO task.
syntax: GoReset

do_itime() - Set integration time in seconds
      Syntax: itime {seconds}

do_zoom() - Sets the display window zoom factor
   Syntax: Zoom {mag}

o_window() - Sets the size and location of the stats/display window. Only this part of the array will be scaled and displayed.
   Syntax: Window xoffset xsize yoffset ysize

do_range() - Sets the range for fixed scaling
   Syntax: range {min} {max}

ddo_senddata8() - Asks guider to send 8 bit data. Writes data to file "guider.img"
   Syntax: Senddata8

do_sendinfo() - Send status information. Just a dummy, since info is always sent.
   Syntax: Sendinfo

do_register() - Set up the array control signals
      Syntax: register {0xnn}

do_sync() - Synchronizes the DSP and TEK DEV.
      Syntax: sync

do_slice() - Sets the LSB for slice.
   Syntax: Slice {bitslice}

do_simulate() - Set the simulation on the DSP
   Syntax: simulate { Off | On }

do_status()

do_stop() - Stop the latest integration
      Syntax: stop

do_tcs() - Send a string to the TCS computer. This string is assumed to be a correct TCS Command w/ 40 chars max. This command uses the GO task to communication with the TCS. Thus the GO task must be ready before continuing.
      Syntax: tcs {command string}

do_tcshostname() - the host providing the data socket port.
      Sytnax: tcshostname {hostname}

do_viewicdata() - Sets the viewicdata mode for the IC program
   Syntax: viewicdata { Off | On }

do_wait() - Sets the acq task busy for N seconds.
      Syntax: wait {seconds}

do_xuihostname() - the host providing the data socket port.
      Syntax: xuihostname {hostname}

IV. Appendices

A. Observing Log Sheet and Line Settup Form

CSHELL LOGSHEET

Observers _____

Directory _____

U.T. Date _____

Page Number _____

File Name	Number	Object	λ or ν	Slit	Mode	Exposure	U. T.	Airmass	Comments

CSHELL Line Setup Form

Line Name _____   λ _____ μm   ν _____ cm^{-1}

Order _____

θ_g _____

N_g _____

Filt. Pos. _____

Lamp	ν (cm^{-1})	λ (μm)	λ_{obs} (μm)	Order	λ_{CVF} (μm)	col_{pred}	col_{obs}
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____
_____	_____	_____	_____	____	_____	_____	_____

Other Lines

Line (telluric, object, or sky)	λ (μm)	col_{obs}
_____	_____	____
_____	_____	____
_____	_____	____

Dispersion: _____ (μm/pixel)   _____ (km/sec/pixel)

Comments: _____

_____

B. CSHELL Hardware Reference

Filter Wheel #1 (A)

AF5 - Blank

AF6 - 4.1 µm SPF

AF4 - Open

AF3 - HI 2.166 µm

AF7 - 2.5 µm SPF

AF2 - He I 1.083 µm

AF1 - Unused (Blank)

0

12833   0°

1166

330°   30°

11666   2100

300°   54°   2722

10966   282°   70°   3344

86°   3966

102°

ACVF1 - 1.1 to 1.57 µm CVF

Filter Wheel #2 (B)

BF5 - Blank

BF4 - Open

BF6 - 2.5 µm SPF

BF3 - Unused (Blank)

BF2 - 4.05 µm NBF

BF1 - 2.35 µm NBF

0

12833   0°

1166

330°   30°

11900

306°   2022

11277   52°

290°

10636   273.5°

BCVF1 - 1.33 to
2.449 µm CVF

258°

10033

228°   136°

BCVF1 - 4.27 to
5.6 µm CVF

8860   255°   143°   5288

8750   5561
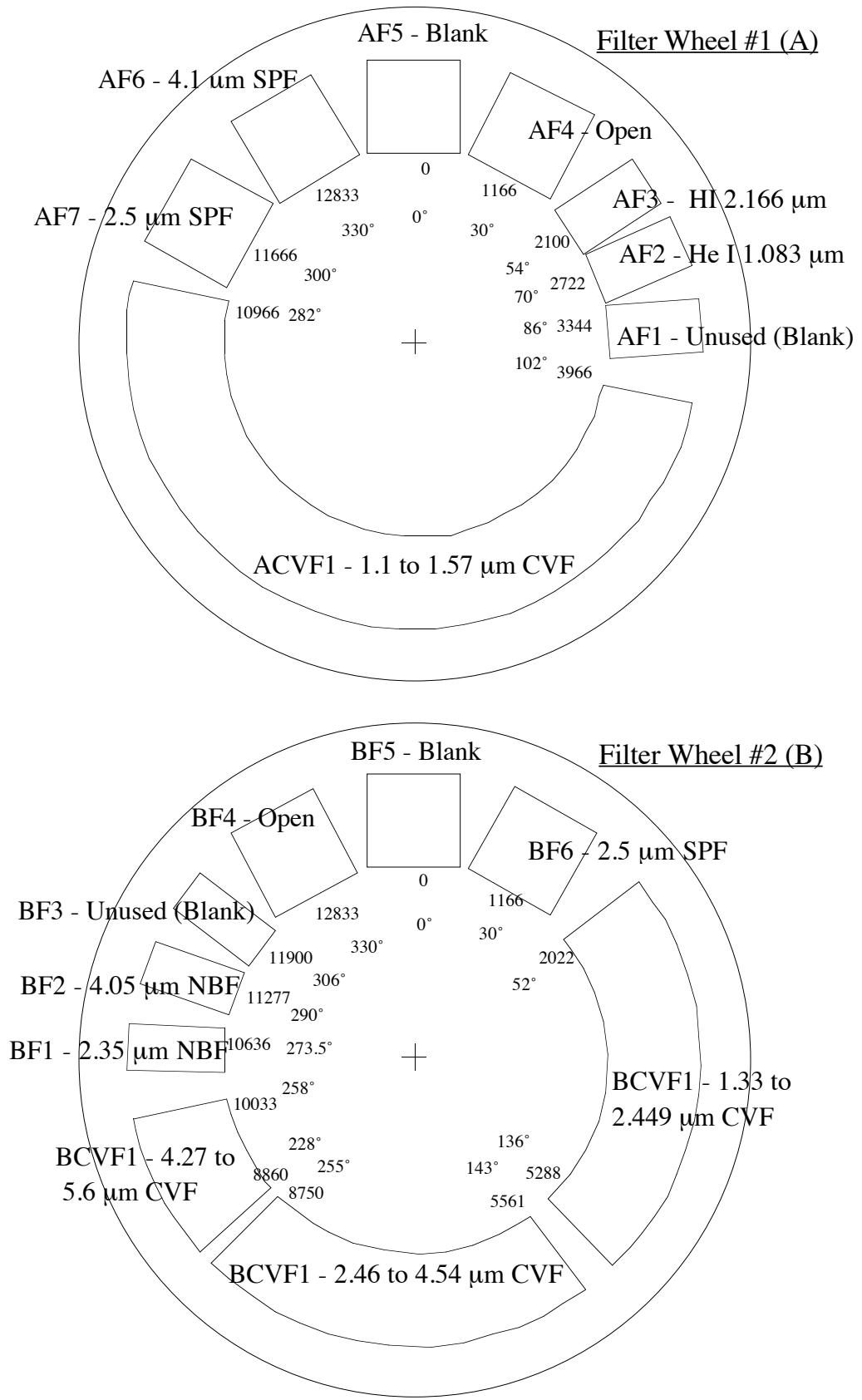
BCVF1 - 2.46 to 4.54 µm CVF

Figure 1. CSHELL Filter Wheels. Inner numbers are degrees, outer ones are motor step positions.

The filter wheel are controlled from the PC-38.

      Filter A is on the 'r' axis.

      Filter B is on the 's' axis.

The following tables display the name and position of the filters on Filter A and FilterB:

.

Filter B		Tot. Steps=	14000
Name	Description	Degrees	Step Pos
BF1	2.35 NBF	273.5	10636.1
BF2	4.05 NBF	290	11277.8
BF3	Unused	306	11900.0
BF4	Open	330	12833.3
BF5	Blank	0	0.0
BF6	2.5 um SPF	30	1166.7
BCVF1	1.33 to 2.449 CV	52	2022.2
		136	5288.9
BCVF2	2.46 to 4.54 CVF	143	5561.1
		225	8750.0
BCVF3	4.27 to 5.60	228	8866.7
		258	10033.3

Filter A		Tot. Steps=	14000
Name	Description	Degrees	Step Pos
AF1	Unused	86	3344.4
AF2	He I 1.083	70	2722.2
AF3	Unused	54	2100.0
AF4	Open	30	1166.7
AF5	Blank	0	0.0
AF6	4.1 um SPF	330	12833.3
AF7	2.5 um SPF	300	11666.7
ACVF1	1.10 to 1.57 CVF	102	3966.7
		282	10966.7

The filter menu selection and the position of wheel A & B are indicated by this table.

Menu Index	Description	Filter A position	Filter B position
0	CVF & Open	See CVF Position Table	
1	2.35um NBF/Open	AF4	BF1
2	4.05um NBF/Open	AF4	BF2
3	He 1.083/Open	AF2	BF4
4	HI 2.167/Open	AF3	BF4
5	Blank	AF5	BF5
6	Open	AF4	BF4
7	CVF & Blocker	See CVF Position Table	
8	2.35um NBF/Blocker	AF7	BF1
9	4.05um NBF/Blocker	AF6	BF2
10	2.5um Blocker	AF7	BF4
11	4.1um Blocker	AF6	BF4

When menu index 0 or 7 are select in order to use the CVFs, the positions of the wheels are calculated from the following tables. Search the table until you found the first row which include the wavelenght you are using. The "CVF Used" column indicated which filter is used. The step position are calculated from the coefficients found in the columns "Motor Position Equations Terms". For the other filter, the Blocker or Open position is given by the "Position of Other Wheel" column.

From	To	CVF Used	Position of Other Wheel		Motor Position Equations Terms		
			Blocker	Open			
1.100	1.570	ACVF1	BF6	BF4	-10609.83	13495.61	0
1.570	2.449	BCVF1	AF7	AF4	-1625.66	2838.23	1.48
2.460	4.100	BCVF2	AF6	AF4	2450.57225	1380.7596	0
4.100	4.350	BCVF2	AF4	AF4	Same as above		
4.350	5.600	BCVF3	AF4	AF4	5354.37862	860.7481	0

Figure 2. CSHELL Slit Wheel. Inner numbers are degrees, outer ones are motor step positions.
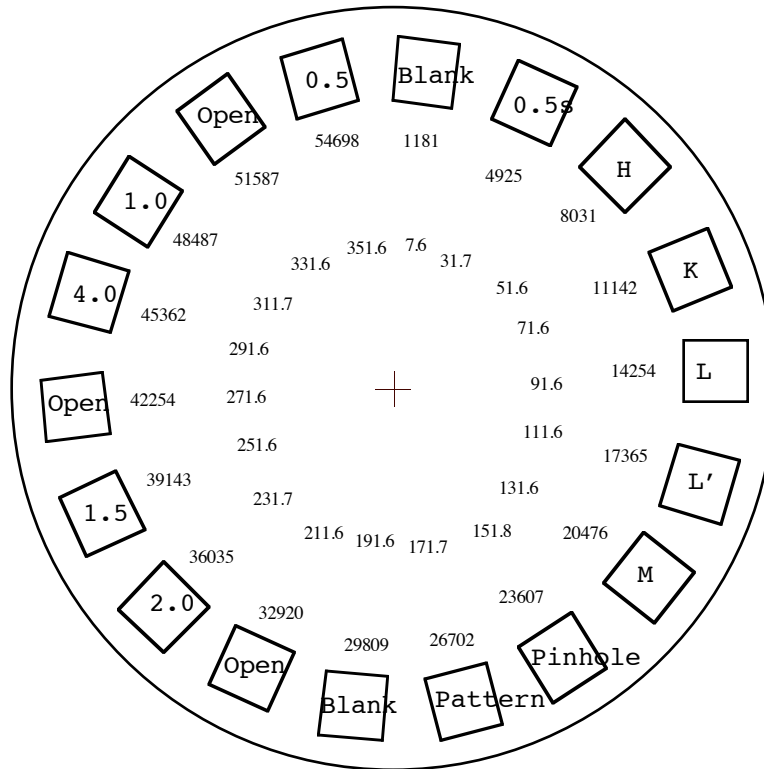
The Slit wheel is control from the PC-38 from the 't' axis. Note the slit wheel has multiple Blank and Open positions. When selecting a Blank or Open, the software will move the wheel to the nearest Blank or Open.

	Wheel Size = 56000		
Menu Index	Description	Step	Degrees
0	0.5	54698	351.6
1	1.0	48487	311.7
2	1.5	39143	251.6
3	2.0	36035	231.7
4	4.0	45362	291.6
5	Blank	1181	7.6
5	Blank	29809	191.6
6	Open	32920	211.6
6	Open	42254	271.6
6	Open	51587	331.6
7	H	8031	51.6
8	K	11142	71.6
9	L	14254	91.6
10	L'	17365	111.6
11	M	20476	131.6
12	0.5s	4925	31.7
13	Pattern	26702	171.7
14	Pinhole	23607	151.8

Shutter Wheel

Switch

4. Blocker

Light path

1. Initial (Blank)

3. Blank

2. Open

Light path

Shaft

SBRC
Array

Unused
Bay
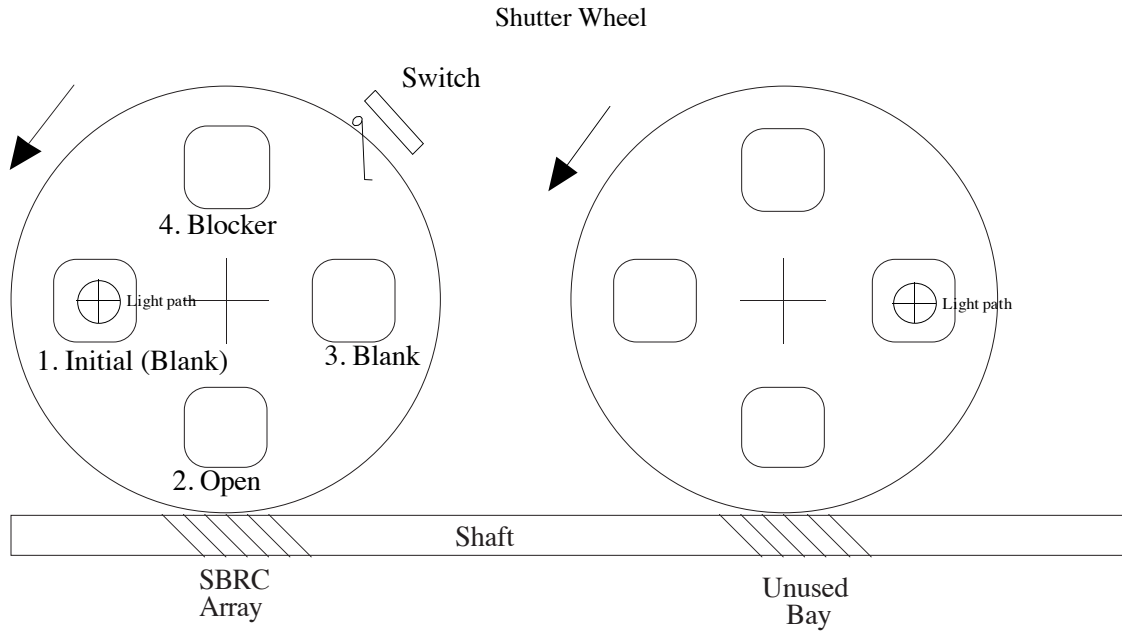
1. View is from side in whcih filters are installed
2. Switch engaged at postion 1 (Both blank).
3. Blank in position 3 is used to blank off instrument.
4. Motor shown is direction moved when motor turns shaft clockwise.

The Shutter wheel is controlled from the PC-38 from the 'v' axis.

Wheel Size = 5000			
Menu Index	Description	Step	Degrees
0	Blank	125	9.0
1	Open	1375	99.0
2	2.5 SPF	3875	279.0

RS-232   Devices

To communication with serial devices the CSHELL IC computer is equipped with a 4-COM Serial Port Adapter by STB Systems, Inc (214-234-8750). The configuration of the serial board is as follows:

Port	I/O Base	IRQ	Comments
COM1	0x3f8	IRQ4	Atttached to TC#1
COM2	0x2f8	IRQ3	Attached to TC#2
COM3	0x3e8	IRQ10	Attached to Encoder
COM4	unassigned		

Temperature Controller

CSHELL uses two series 9620 Temperature Controller by Scientific Instruments, Inc. The controller communicates to the IC computer via the serial ports. The TempCmd command allows you to communicate with the temperature controller using its native instructions outlined in its manual. These instructions are summaried here for your convinence.

FUNCTION	SYNTAX	EXAMPLE
Input the Setpoint	Snnn	'S400' sets the setpoint to 40.0 Kelvin.
Input Proportional Term	Pnn	'P50' sets the proportional term to 50.
Input Integral Term	Inn	'I20' sets the integral term to 20.
Input Derivative Term	Dnn	'D20' sets the derivative term to 20.
Get Temperature Setpoint	S	'S' will return the Setpoint.
Get Proportional Term	P	'P' will return the proportional term.
Get Integral Term	I	'I' will return the integral term.
Get the Derivative Term	D	'D' will return the derivative term.
Get Heater Ouput	H	'H' will return the heater output.
Get Temperature T1	T	'T' will return the T1 temperature.
Get Temperature T2	t	't' will return the T2 temperature.
Toggle Control Mode	X	'X' will toggle the heater off/on.

Please note that the syntax is case senitive.
The syntax for the command to the IC to sent temperature commands is: *TEMPCMD {A | B} command*

Encoder

The default encoder parameters are:

```
SN = 0
SP = 01
SE = 0
AR = 0
SD = 0
SO = 0
SF = 025000
```

CSHELL's RACKMOUNT SETUP

CSHELL Instrument Control computer is a 20 slot 386/20 Rackmount PC-AT computer. This section attempts to documents the setup the various peripheral board install in the PC.

Ethernet Card

The ethernet card for the PC is a SMC EtherCard Plus Elite16. This is the default card supported by lynxOS. We have configured the board to be compatiable with Lynx. The board is setup as follows:

	A	B	C	D	E
1	Adapter	I/O Base Addr	DMA Channel	IRQ	Other Notes
2	WD EtherCard Plus Elite	0x240-0x25f	N/A	5	ROM Based addr = None/Disabled. Shared RAM at CC000.

MM-96 Detailed Setup

CSHELL uses two MM-96 DSP to provide clocking and buffer board functions. The clock DSP make no use of any DRAM. While the BCARD DSP uses the additional DRAM (up to 16Mwords) in speckle and movie mode.

	A	B	C
1		**Clock DSP**	**Bcard DSP**
2	PC I/O Address	0x148 (NFNFNNFN)	0x158 (NFNFNFFN)
3	DMA	No DMA - H1 & H2 Unlinked	No DMA - H1 & H2 Unlinked
4	H3 - IRQ	11 (Connect 7 & 8)	12 (Connect 5&6)
5	H4 - DSPnet Address	0 (connect pins 5 & 6)	0 (connect pins 5 & 6)
6	H5 - Hyperbus Port A	Delay = 0. ( ]]])	Delay = 0. ( ]]])
7	H6 - Hyperbus Port B	Delay = 0. ( ]]])	Delay = 0. ( ]]])
8	H7 - Real-time Clock/DRAM Speed	No clock int. Slow DRAM mem. (: : :)	No clock int. Slow DRAM mem. (: : :)
9	M1/M2 - Outer SRAM B	64k x 4	64k x 4
10	M3/M4 - Outer SRAM A	64k x 4	64k x 4
11	M5/M6 - Inter SRAM	64k x 4	64k x 4

The CSHELL project purchased the following DSP boards. Two full boards were initially purchased.

	A	B	C	D
1	Serial NUMBER	Use	SRAM configuration	DRAM configuration
2	1052	Clock	64 K words in all 3 banks	256 Kwords or 1 MBtye
3	1054	Buffer	64 K words in all 3 banks	256 Kwords or 1 MBtye
4				

PC-38 Stepper Motor Controller

An Oregon Micro System's PC38-8 board is installed to control the stepper motors for NSFCAM. The board is configured as follows:

	A	B	C	D
1	Adapter	I/O Base	DMA Channel	IRQ
2	PC-38	0x0320	n/a	n/a

J47 Limit sense jumpers: `[:]  :   :   :   :   :  [:] [:]`

J15 Address Select Jumbers: `[:] [:] [:]  :  [:] [:]  :   : = 0x320`

J17 Interrupt and DMA Jumpers: `:   :   :   :   :   :   :   : No  Ints.`

J67 User I/O Pull-up Jumpers: `:   :   :   :   :   :   :   :`

J57 I/O Configuration Jumpers: `[:]  :  [:]`   `0-3  inputs`
                                                    `8-11  outputs`
                                                    `4-7  inputs`

DIO48

CSHELL make use the the DIO48 Digital I/O board to provide additional I/O bits. Cshell only utilities/programs 1 or the 2 available 8255 for digital I/O. The timera are not used. (Note: The wire wrap between the timer and some DIO lines are left in place from the echellc I project (NICMOS & SBRC 64 control).

    I/O Base: 0x280
    Interrupts: None
    The 8255 #1 connected to J0 is initilaized using Mode 0x82.
        Port A - Output
        Port B - Input
            PB0 - Lamp_limit_off
            PB1 - Lamp_limit_on
            PB2 - vccd_limit_off
            PB3 - vccd_limit_on
            PB4 - dimirror_limit_off
            PB5 - dimirror_limit_off
        Port C - Output
            PC0 - Lamp_mirror_cntl
            PC1 - vccd_cntl
            PC2 - dimirror_cntl
            PC3 - UNUSED
            PC4 - AR Lamp*
            PC5 - KY Lamp*
            PC6 - Xe Lamp*
            PC7- Cont. Lamp*

`* Note currently the DIO48 is onlu used on control the Lamps. The additional definition are specified incase we switch the DC motor control from the PC-38 IO bits to the DIO48.`

SVGA Board

CSHELL uses the SVGA board as a text only output device. Any generic VGA board will do.

C. Troubleshooting

CSHELL is a mighty instrument but is not immune to failure. We have attempted to identify common possible failures, and here we list their modes and possible fixes. Always get help from your support scientist, telescope operator, or other IRTF staff person. We now examine some possible failures and their fixes.

Mojo Motor Madness

Each CSHELL mechanism is controlled by a stepper motor or other actuator. Sometimes these motors, their mechanisms, or their electronics fail in various ways. Sometimes a mechanism will never become READY at startup of the cshellic software; it will stay in the INIT or ERROR modes instead. Most mechanisms may be initialized by commands typed in from the cshellic or cshellxui machine keyboards; see § III.A for details. For example, if the Slit process shows an ERROR or INIT condition that never clears in the cshellxui status window at startup, then you can attempt to clear the condition by issuing the *SlitInit* command. Sometimes such initialization commands must be repeated several times to clear an ERROR or INIT state.

These initialization commands may also be executed if a mechanism generates an ERROR or continuous INIT state during normal operation. INIT states sometimes take 2 or 3 minutes to clear to READY; wait some time before attempting to re-initialize the mechanism. If a more serious errors occurs, such as the filter or slit wheels not moving to the correct locations, the shut down and restart CSHELL as directed in § III.B. If this clears your errors, then CSHELL is safe to operate. If it does not clear your errors, then you can force CSHELL to ignore the problem by issuing a *setmotorrdy* command (see III.A). CSHELL will be OK to use if you do not need to move the offending mechanism. The nature of a failure should be reported, investigated and documented

Filter and Slit Wheels

Positions of filter wheels and the grating can be examined from the cshellxui Motors frame of the program's main window pane. Motors can be commanded to go to specific step positions (see commands in § III.A). It is useful to try to move them forward as well backward in order to isolate the failure. Beware that filter wheel A is labeled wheel 1 and filter wheel B is labeled wheel 2 on the CSHELL dewar. See Figure 1 in the CSHELL Hardware Description (Appendix B) for positions of the various filters on each wheel (also see the *CSHELL Filters* notebook), and see Figure 2 in the CSHELL Hardware Description (Appendix B) for positions of the slit wheel. The conversions between wavelength and step position are given for each CVF in the following table:

CSHELL CVF Position Table

CVF	Wavelength Range	Wavelengths Used	Motor Position Equation
ACVF1	1.10 - 1.57 (µm)	1.10 - 1.569 (µm)	$13495.61 \cdot \lambda(\mu m) - 10609.83$
BCVF1	1.33 - 2.50 (µm)	1.57 - 2.449 (µm)	$1.480 \cdot \lambda^2(\mu m) + 2838.225 \cdot \lambda(\mu m) - 1625.656$
BCVF2	2.46 - 4.54 (µm)	2.46 - 4.35 (µm)	$1570.229 \cdot \lambda(\mu m) + 1674.65$
BCVF3	4.27 - 5.60 (µm)	4.35 - 5.60 (µm)	$\dfrac{\lambda(\mu m) + 6.22061}{1.16178 \times 10^{-3}}$

Other Problems

CSHELL can experience other problems also. The following table lists some possible problems and suggested remedies.

Symptom	*Solution*	*Manual Sect.*
Array or Cold box Temperature is wrong	Check dewar for liquid nitrogen, make sure closed-cycle cooler is on, check controllers.	§ II.A, Appendix D
No Calibration Lamp lines	Check cshellxui status window, check filter wheel positions in Motors window, make sure lamps are on (look in holes in cal box), check instrument power and cables	
IR Array Data Values are Funny or near-zero Excessive or Intermittent Noise	Program bias voltages with Set Programmable Voltages (Setup) Check cable connections, re-route data cables away from stepper motor cables.	§ II.C

CSHELL Grating Equations

1. Grating Step N as a function of angle θ:

$$N = -1{,}056{,}268 + 18{,}634.80 \cdot \theta + 26.85632 \cdot \theta^2 \qquad (\sim 22 \text{ steps / IR array pixel})$$

2. Wavelength to grating angle:

$$\lambda\ (\mu m) = \frac{2 \cdot \sigma \cdot \sin\theta}{n} \ ; \qquad n = \text{order}; \ \sigma = \text{groove spacing: } \mathbf{31.5195\ \mu m\ cold}$$

3. Order Calculation:

$$n = \frac{2 \cdot \sigma \cdot \sin\theta}{\lambda\ (\mu m)} \qquad \text{(nearest integer)};$$

$$n_{opt} = \frac{2 \cdot \sigma \cdot \sin\theta_B}{\lambda\ (\mu m)} = \frac{56.416}{\lambda\ (\mu m)} \ \mathbf{cold} \qquad \text{(Integer Order closest to Blaze angle } \theta_B = 63°.5)$$

4. Dispersion:

$$\Delta\lambda\ (\mu m/\text{pixel}) = \frac{C \cdot \lambda\ (\mu m)}{2 \cdot \tan\theta}$$

Verifying CSHELL Throughput

CSHELL is measured to have 16.5% total throughput (including telescope & atmosphere) at 1.25 - 2.2 μm (2% CVF), and 12% throughput at 3.4 (1% CVF) - 4.8 μm (2% CVF) in spectroscopic mode. You can use an Elias standard or the continuum lamp flux as a more convenient check.

λ (μm)	Elias Std (2" slit, 63°.5 gr)	Image (* - sky ADU)	spec (10w x20pxl)
1.2537	HD 161903 J= 7.17	55558 in 2 sec	3864 ADU in 60 sec
2.1698	HD 161903 K=7.02	101,981 in 2 sec	2906 ADU in 60 sec
3.526	HR 8143 L= 3.71	40,500 in 0.25 sec	26,400 ADU in 30 sec
4.701	HR 8143 M=3.72	8970 in 0.1 sec	4323 ADU in 10 sec

λ (μm)	Max ADU/pixel in 5 sec Spect of Continuum Lamp (1" slit)
1.2537	1300 (with blockers in)
1.6593	2709
2.1698	2906
3.5260	635
4.701	3807

D. Temperatures and Controllers

The CSHELL dewar and optics are cooled by a liquid nitrogen bath which must be filled once per day, usually at the start of each night. A closed cycle cooler provides additional cooling for the arrays. The arrays are maintained at their optimal operating temperatures by temperature controllers which apply small amounts of resistive heating to the devices. It is the user's responsibility to keep an eye on the array, cold box, and grating temperatures. The temperatures will drift if CSHELL runs out of liquid nitrogen, if the controllers get reset, or if the closed cycle cooler fails. The cold box should be 72.5 ± 2 K. *Temperatures any higher will cause focus and dispersion changes*. The grating is cooled by the same bath as the cold box, so its temperature will usually follow the cold box. Follow the troubleshooting procedures in Appendix B if the cold box temperature is out of its range. *The following procedures for resetting the temperature controllers should be performed by an IRTF operator or staff member only:*

The detector array temperature controllers are located on the front side of Box 5 which is mounted on the telescope along with CSHELL. The controllers usually have their set points reset to 0 K when powered off, and their heaters are off when the controllers are initially powered on. The arrays will cool to 20 K and will not be operational if the set points are not set and if the heaters are not turned on. The day crew properly sets the array temperatures and powers on the heaters when they mount CSHELL on the telescope, but you must set up the controllers if you have powered down Box 5 due to approaching lightning or as part of a troubleshooting procedure. The following procedure illustrates how to read the array temperatures, set the set points, and turn on the heaters. Controller A controls the SBRC InSb array temperature (30.0 K set point) and Controller B controls the TEK CCD array temperature (175 K set point). The controllers may be set up either via their front panel controls (Procedure A) or else via software (Procedure B).

Procedure A: Front Panel Configuration

Read Array Temperature on controller front panel LCD display (T1 probe).
Press ENTER button until set point field is selected (S xxx.x on display)
Press ENTER to change the set point temperature
Press SCROLL to change current digit, press ENTER to accept and move to next digit
Press RETURN to enter the displayed temperature as the set point.
Press RETURN to activate the heater. The green HEATER LED should light.

Procedure B: Software Control

Alternatively, you can read and set the array temperatures via the cshellxui software:

• Read the array temperatures and set points in the cshellxui main window
• Change the set points by typing the "tempcmd A S300" or "tempcmd B S1750" commands on the cshellxui command line for the IR array and CCD, respectively. See § III.A for details.
• Turn the heaters on or off by typing the "tempcmd A X" or "tempcmd B X" (see p. 98) command on the cshellxui command line. Heater status in the cshellxui window will display "ERROR" if the heater is off or the heater voltage if it is on. See § III.A.

E. Summary of Upgrade Changes for Previous CSHELL Users

CSHELL Upgrade User Documentation Addendum

I. New InSb Array

CSHELL now has a single IR detector array, a 256 x 256 pixel Hughes SBRC InSb device. It performs at least as well as the old NICMOS-3 array in nearly all respects, while it also has increased spectral response, better quantum efficiency, and reduced artifacts (less residual image and no corner glow). The new array results in the following performance parameters:

- 1 - 5.6 μm response; 16.5% total spectroscopic throughput @ 2.2 μm
- 700 km/s spectral range per exposure when grating at blaze angle
- 0.20 arcsec/pixel and 2.7 km/s/pixel
- R.N. ≤ 33 e-
- Idark ≅ 0.5 e-/ADU

The new array also requires some operational changes. Foremost, the detector bias must be programmed to match the observing application. Using a single fixed bias (as done with the NICMOS array) is inappropriate because of non-linearities and *icky pixel* artifacts in the SBRC 256 x 256 InSb arrays. Larger biases allow more electrons to be collected before saturation, but they also cause increased numbers of high dark current pixels (*icky pixels)* and low-level non-linearities. Fortunately, the *icky pixels* mostly disappear when object and sky frames are subtracted. Dark frames with exposure times equivalent to flat fields should be taken to subtract these pixels from your flats. Linearity problems can be avoided if you expose your fats so that they have similar data counts to your object frames. You may coadd many flats to achieve high S/N. I recommend that you pick one of four following detector bias settings for you observations:

Observation	Bias (mV)	Well	VDDUC	VDET	XUI MACRO
Most Spectroscopy	325	5000	-3.7	-3.375	small
Bright Thermal Spectroscopy	500	8400	-3.7	-3.200	medium
Bright or Thermal Imaging	800	15,500	-3.7	-2.900	large
Thermal Imaging with very high backgrounds	1000	21,300	-3.7	-2.700	huge

Notes:

Well: The maximum number of ADU counts (**1 ADU = 11.0 electrons**) that can be collected while not departing more than 1% from the linearity relation of the mid-well range.

VDET & VDDUC are detector biases (Volts) that can be typed into the SETUP Parameters frame of the CSHELL XUI Application.

XUI MACRO is the name of a command file that can be executed from the Options menu of the CSHELL XUI application. These files automatically set the indicated bias levels.

There are also some other operational changes resulting from the new array. Most importantly, *you must select the CVF/Blocker Option and also use the shutter wheel blocker (SPF) when observing with the 1.1 - 1.57 μm CVF!* This CVF transmits λ > 2.5 μm radiation, causing significantly increased background in your data if not blocked as prescribed. The blockers impart about a 10% reduction in flux over the 1.1 - 1.6 μm region. Now exposures can be as short as .076 s or even less. **The bias voltages must also be set (DO File or push button in Setup Parameters Window) when the software is started.**

II. New Tek 512 x 512 Acquisition & Guide CCD

The old surveillance CCD has been replaced with a scientific-grade Tektronix 512 x 512 pixel CCD. The CCD is operated via IC and XUI programs like other IRTF instruments. It can be operated in a continuous mode for acquisition, a single exposure mode, or an auto-guide mode. Use of the guider software is described in § III. G of this manual. The CCD is clocked at a rate of 333,000 pixels / sec, so it takes just under 1 second to read a frame; this limits the minimum exposure time also. A 1000x attenuation filter can be switched in front of the CCD for observing bright objects. Pixels can be binned (1x1, 2x2, 4x4, or 8x8) to improve signal-to-noise. N is up and E is to the left on the CCD monitor (or in VF) when CSHELL is mounted in its normal E-W slit configuration. The CCD has a 55" (E-W) x 65" (N-S) FOV, 0.15"/pixel plate scale, and V=15 mag limit. CCD frames may be viewed in VF and saved as FITS files. The CCD looks through an IR-reflecting dichroic which has a bandpass similar to an R band filter.

III. Startup and Shutdown Software Notes

All software can be started up from your user account on an IRTF Sun workstation at the summit (planck) or HP (wien). Just remember to type "xuihostname wien" in the command line of the CSHELL XUI program if running from that HP workstation. The CSHELL and CASSPC (the guider pc) Instrument control (IC) Intel architecture computers can also be logged into from their directly connected keyboard / monitor consoles. The new calibration lamp program is called *cal_lines* which should be typed in from a UNIX prompt.

A. CSHELL Startup

       0) Turn on CSHELL boxes #2 - #5 in numerical order
       1) Log into your Guest Account
       2) Type "openwin" and <CR> at the UNIX prompt
       3) Hold down the right mouse button on the blue desktop
       4) *If the IC program is not already running* (ASK a T.O. or Support Astronomer), Either:
                i) Select "Start CSHELL IC Software!" from the CSHELL menu
          or ii) Log into CSHELL IC console as "cshellic"
       5) Select "Cshell XUI" from the CSHELL menu
       6) Select "VF" from the CSHELL menu
       7) Turn on the CSHELL Array Power Supplies
       8) Set Programmable Voltages in Setup Parameters XUI window

B. CSHELL Shutdown

       1) Quit VF
       2) Move Shutter, Slit, and Filter to "Blank" Position. Spectroscopic mode, turn lamps off.
       3) Quit XUI software
       4) *Leave in this configuration unless powering off* (proceed further only if powering off)
       5) Turn off the CSHELL Array Power Supplies
       6) Type "die" and <CR> in CSHELL IC window. Halt Lynx by logging in as "shutdown";
            login as "reboot" if you only want to reboot the IC computer.
       7) Turn off boxes #2 - #5 in reverse numerical order

C. Guider Software

       Startup: 1) Follow Steps A0 - A3.
                         2) Select "Login to CASSPC Guider PC" from CSHELL menu
                         3) Type "gic" and <CR> in the casspc window
                         4) Select "Guider XUI" from CSHELL menu

       Shutdown: 1) Quit Guider XUI
                         2) Type "die" and <CR> in GIC (casspc) window; exit window

F. IR Array Linearity Data

14 April 1994 lab data: CSHELL SBRC InSb SCA #052 Science Grade Array

Vdduc	-3.7	VGG	-1.5/-1.0	switched off between rows
V3	-2.9	11.0	e-/ADU	

VDET = -3.4
BIAS= -300   mV

t (sec)	ADU	%	e-
0.1	231.6	86.5	2539.55
0.25	575.8	96.4	6313.77
0.5	1144	99.8	12538.7
0.75	1706	100.6	18706.7
1	2263	100.8	24808.8
1.25	2811	100.6	30823.2
1.5	3346	100.1	36689.6
1.75	3863	99.3	42358.6
2	4343	97.8	47622
2.25	4737	95.0	51942.3
2.5	5004	90.4	54870
3	5256	79.2	57633.2
5	5238	47.5	57435.8

slope	2196	ADU/s
offset	48.03	
r	1	

Charge Dump: 178   mV

Bias = 300 mV
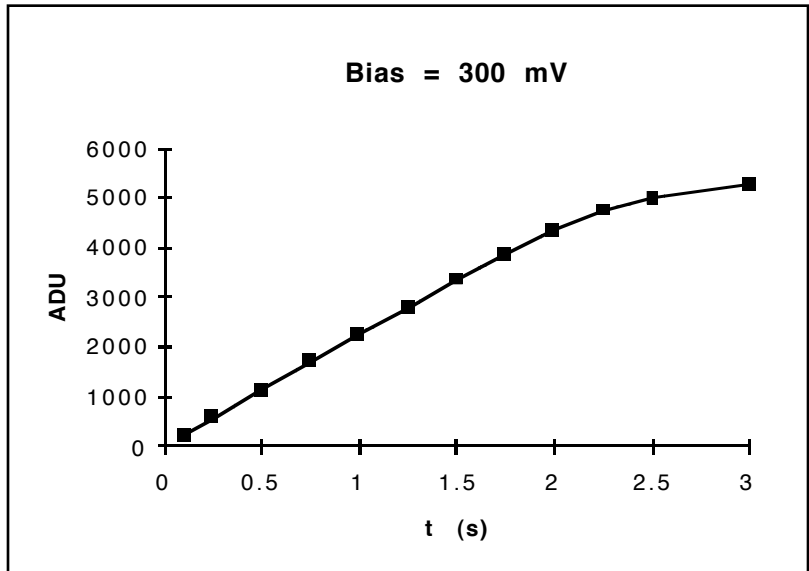
VDET= -3.38
BIAS= -325   mV

t (sec)	ADU	%	e-
0.1	224.7	83.7	2463.89
0.25	559.5	95.3	6135.04
0.5	1114	99.6	12209.8
0.75	1659	100.6	18193.5
1	2203	101.1	24156.4
1.5	3266	100.7	35812.4
2	4307	100.1	47227.2
2.25	4807	99.4	52709.8
2.5	5271	98.2	57797.7
3	5987	93.1	65648.8
5	6254	58.6	68576.5
slope	2124	ADU/s	
offset	55.93		
r	1		

325 mV Linearity
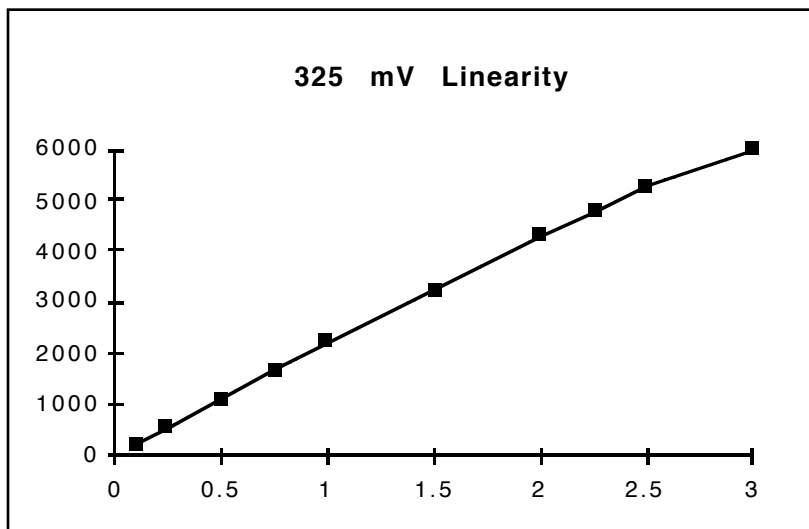
VDET= -3.3
BIAS= -400   mV

t (sec)	ADU	%	e-
0.1	244.6	85.9	2682.09
0.25	607.6	96.0	6662.47
0.5	1209	99.6	13260.2
1	2397	100.9	26283.6
1.5	3566	100.8	39102
2	4705	100.2	51591.4
2.5	5830	99.5	63927.2
3	6923	98.6	75912.2
3.5	7998	97.8	87699.8
5	9565	82.0	104882
10	9450	40.6	103621
slope	2323	ADU/s	
offset	52.43		
r	1		

400 mV Linearity
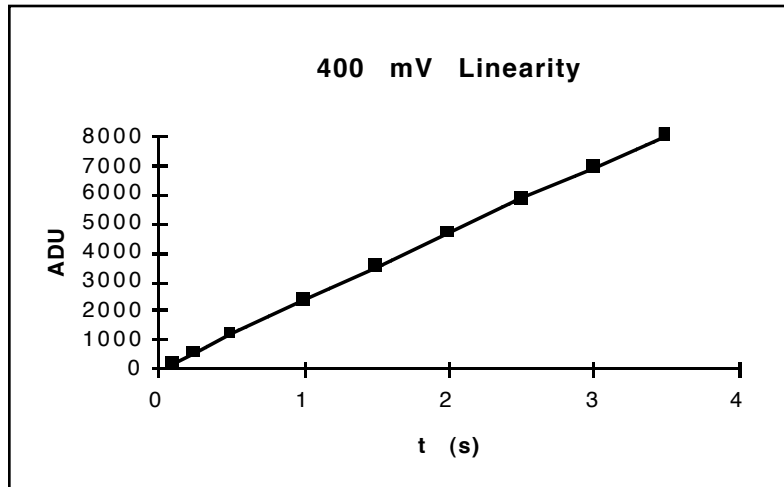
VDET= -3.2
BIAS= -500   mV

t (sec)	ADU	%	e-
0.1	255.3	77.1	2799.42
0.5	1261	97.5	13827.1
1	2501	100.2	27424
1.5	3723	100.7	40823.5
2	4928	100.6	54036.6
2.5	6107	100.1	66964.6
3	7273	99.6	79750.1
3.5	8421	99.0	92338.1
4	9544	98.3	104652
5	11710	96.7	128403
10	13471	55.8	147712
slope	2405	ADU/s	
offset	90.53		
r	1		

500 mV Linearity
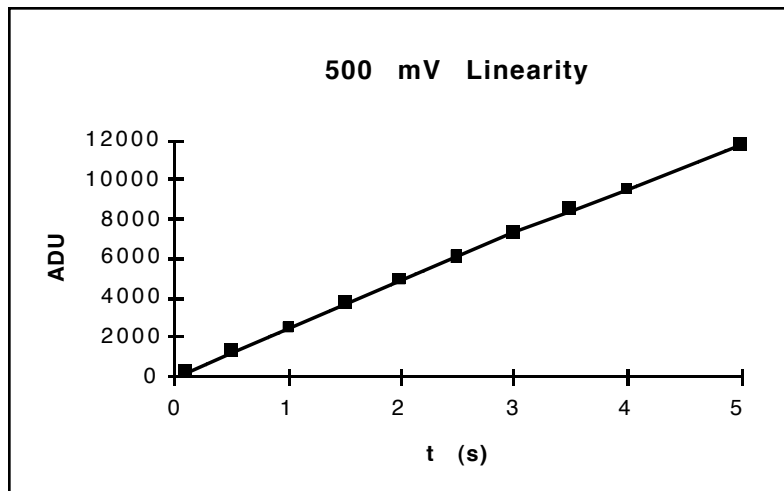
VDET= -3.1
BIAS= -600   mV

t (sec)	ADU	%	e-
0.1	264.6	67.2	2901.4
0.5	1308	95.2	14339.2
1	2593	99.8	28427.3
2	5113	101.3	56065.2
3	7567	101.0	82973.8
4	9943	100.0	109027
5	12252	98.9	134346
6	14469	97.5	158656
7	16507	95.5	181003
15	17590	47.7	192878
slope	2448	ADU/s	
offset	148.8		
r	1		

600 mV Linearity
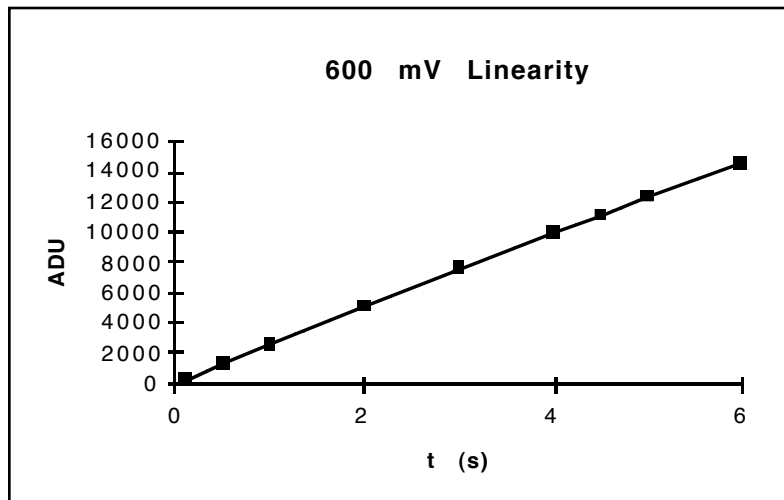
VDET= -2.9
BIAS= -800   mV

t (sec)	ADU	%	e-
0.1	1076	83.3	11798.6
0.25	2670	96.1	29277.1
0.5	5280	100.4	57892
0.75	7814	101.0	85682.2
1	10304	100.9	112986
1.25	12719	100.2	139467
1.5	15053	99.2	165059
1.75	17289	98.0	189578
2	19369	96.3	212385
2.25	20884	92.4	228998
3	23580	78.5	258560

slope	9911	ADU/s
offset	300.9	
r	1	

800 mV Linearity
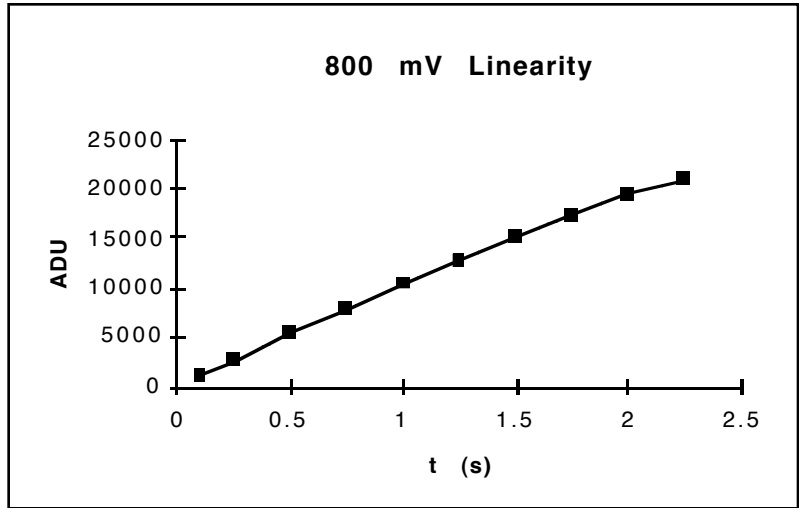
VDET= -2.7
BIAS= -1000   mV

t (sec)	ADU	%	e-
0.1	1217	112.1	13344.7
0.5	5907	112.4	64771.6
1	11245	110.1	123304
1.5	16260	107.2	178294
1.75	18678	105.9	204808
2	20667	102.7	226618
2.25	21902	96.9	240160
2.5	22973	91.6	251904
5	25866	51.9	283626

slope	10861	ADU/s
offset	0	
r	0.995	

1000 mV Linearity