NSFCAM
256x256 InSb Infrared Array Camera

User's Guide

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NSFCAM USER'S GUIDE

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Preface

0.1 Brief Description of the Instrument

NSFCAM is a 1-5 μm imager with a 256x256 InSb detector. Simultaneous optical imaging is possible via an optical port. Three different magnifications can be selected by rotating different cold lens assemblies into the beam. These give plate scales of 0.3"/pixel, 0.15"/pixel and 0.06"/pixel, with corresponding fields of view of 76.8", 37.9" and 14.1" respectively. Images can be obtained through a variety of broad- and narrow-band filters, and low-resolution spectroscopy can also be carried out using the circular variable filters (CVFs) or grisms. Polarizing waveplates or grids can be inserted into the beam. Two cold coronograph masks are also available.

Images are recorded onto a Sun workstation in FITS format. These are taken in basic stare mode using the main (object) and offset (sky) telescope beam positions; software is available to shift-and-add series of images together to study fine image structure. It is also possible to take frames rapidly in movie mode, storing them directly to the instrument computer and saving overheads in time-critical observations.

A FITS viewer is run at the telescope which provides basic image manipulation utilities. Both the camera and the image viewer can be given series of commands using simple ascii macro files. These commands can include offsetting the telescope to make image mosaics.

In the near future we hope to have the IRTF tip-tilt system working in conjunction with NSFCAM for active image control. Meanwhile an off-axis visible camera is available for guiding on nearby (relatively bright) stars.

0.2 Crib Sheet for Basic Observing and Instrument Checkout*

This section is designed for those of you that just need a brief reminder on how to get basic mode images with the camera, or how to do a quick checkout of the instrument. Checkout-only instructions are indicated by *.

Before observing:

1. Get a guest account by logging on to one of the IRTF machines as "guests" [Section 1.1].

2. Prepare your target list and input it into the xstarcat utility [Section 1.2]. If guiding will be crucial then use xstarcat to check that guide stars are available for your targets.

3. If you will be saving data then check there is room on the scratch disks (and on Nsfpc if you'll be using movie mode) [Section 1.3]. Make sure you have blank tapes.

4. Think about which plate scales and filters you'll be using, and the appropriate bias settings and integration times for your required signal to noise [Sections 4.2 and 7.3].

5. Write or edit any macros you want to use [Chapter 10].

At the telescope:

1. Log on to the Planck workstation as guest or nsfcam and type "openwin". *

2. Put the mouse cursor onto the background and click with the right button. Click on NSFCAM with the right button and select XUI with the left button. *

3. Repeat above but select VF from the NSFCAM menu. *

4. Move the cursor to the top left button on the XUI window, PARAMETERS, and click with the left button. *

5. Select the SETUP option from the lower XUI PARAMETERS window and enter your name as the observer and the required detector voltage. For checkout purposes and for observing in the non-thermal regime set VDET to -3.4 and click on SET VOLTAGES. *

6. Go back to the OBS option for the PARAMETERS window and enter your data directory pathname. It will probably be something like /scr/s1/name/date.

7. Blank off both lens and filter by clicking on the icons with the right mouse button and choosing these options with the left button. Remember to hit "move" to move the filter. *

8. Set ITIME=1.0, COADD=1, CYCLES=1, OBS MODE=PAIR (right mouse button to get menu and select with left button), set OBJ-SKY on, and hit GO on the top XUI window. *

9. You should get three images displayed in VF. Click with the right button on OPTIONS at the top of the VF window and select STATS with the left button. Draw a box in the central region of both the top left and the top right images, by holding and dragging the middle mouse button. Click on canvas A then C in the STATS display and check the mean and standard deviation values for the box in each case. For canvas A you should get a mean of 6-12 counts and for canvas C the mean should be around 0 with standard deviation around 2. *

10. Move the 0.3"/pixel lens into the beam by clicking on the icon (right button then left). *

11. Move the K filter in by clicking on the icon (right button then left then MOVE). *

12.Take an image of the camera window cover : ITIME=10.0, COADD=1, CYCLES=1, OBS MODE=OBJ, OBJ-SKY off, hit GO. You should get a nice image of the window cover with its central bolt. Counts will depend on dome temperature but the background should be around 1200 and the bright center should be around 2000. *

13. Continue observing by asking the operator to open the window cover and to go to either the domeflat position or your first object. Select lens, filter, detector bias voltage, itime, coadd, cycles, to suit. Click AUTOSAVEXUI on if you're taking useful data.

14. When done blank off lens and filter and log off Planck. *

Chapter 1 Observers' Computer Accounts

1.1 Setting Up Your Guest Account

On arrival at the Hale Pohaku mid-level facility you should log on to the IRTF's workstation Wien and create your guest account. This can be done on the summit workstations also if necessary. NSFCAM must be run from your guest account which will automatically select the current version of the camera software, provide access to macros, etc.

Log on as "guests". You will be prompted for your name and telescope run number. You will also be prompted for a password which you will have to enter a few times. After setting up the account you will be automatically logged off and you will need to log back on with the appropriate guest account number and password. These accounts are valid for a limited time period which starts three days before your run and ends three days after your run. If you need to extend this time frame contact Eric Pilger at pilger@irmanoa1.ifa.hawaii.edu. If you have other unusual computing or networking requirements you will also need to contact Eric well before the start of your run.

The guest accounts provide access to all programs necessary to run the IRTF instruments, and also allow you to receive and send email. Data and large files should be put on scratch disks (see the following Section).

More information on guest accounts is provided on the IRTF's WWW site (http://irtf.ifa.hawaii.edu/User_support.html) and in the September 1995 IRTF Newsletter.

1.2 Creating a Source List

If you will be observing a large number of targets then it would be efficient to prepare a file giving the names and coordinates of your sources. You will input this file into the "xstarcat" utility so that objects can be sent to the telescope operator.

The source file is a simple ascii file consisting of lines with the following format:

name hh:mm:ss.ss dd:mm:ss.s s.ssss a.aaaa m.mmm eeee.e

"Name" must be less than 19 characters with no imbedded spaces. White spaces can be any combination of spaces or tabs. "s.ssss" is the RA proper motion in seconds of time per year, "a.aaaa" is dec proper motion in seconds of arc per year. These values can be set to zero if not known. "m.mmm" is the source magnitude, and this can also be set to zero. "eeee.e" is equinox in years for the given coordinates. Indicate negative values by e.g. "-dd".

At the telescope type "xstarcat &" in an xterm window on a workstation and enter the name of the file under "userfile". Your targets will be displayed in alphabetical order of name. For more information on the "xstarcat" utility see the IRTF WWW page:
http://irtf.ifa.hawaii.edu/online/IRTF/VisitorInfo/xstarcat.txt

1.3 Where to Put Your Data

Before observing determine which of the scratch disks has the most space available for your data. At any of the IRTF workstations type the command "dfscr" and identify the emptiest disk. These drives are recognised by all the machines by their generic names: /scr/s1, /scr/s2, /scr/s3. You will probably use /scr/s1 which is the largest disk. We suggest that you store your data in a directory such as /scr/s1/your_name/observing_date. This would be the pathname entered on the XUIPath line in the Observing Parameters window of the user interface (see Section 3). A full size

NSFCAM frame requires about a quarter of a mbyte; the amount of space required for subarrays can be calculated by multiplying the number of pixels by four.

If you want to save a particular image for distribution to the IRTF staff (for example to demonstrate an imaging problem or a new scientific discovery) you can save images to /data/unique.

1.4 Data Archiving

A DAT tape drive is available at the summit and both DAT and Exabyte drives are available for your use at Hale Pohaku. We suggest you back up each night's data on the subsequent afternoon, using the Wien workstation at HP. The Exabyte tape drive at Wien is rst0 or nrst0 (for no rewind); the names of the other drives are given in the IRTF online or WWW VisitorInfo. Your guest account is only active for three days after your run ends. Your data remains on the disk, but is compressed after about a week and then written to a general archive tape after another week. It would be difficult to retrieve your data from the telescope archive, and with the possibility of serious disk failures it is imperative that you perform a nightly backup. You will need to supply your own tapes.

Use the UNIX "tar" command to put your data on tape. The images are stored in FITS format and are readable by IRAF. Here are some examples of using "tar":

cd /scr/s4/your_name
tar -cvf /dev/nrst0 observing_date

this will backup one night's data onto the tape in a single tar file, listing each image it writes to the file. The tape will not be rewound if you use a device name starting with "nr", and so you can reissue this command to write several nights onto one tape. To rewind the tape use the "mt" command:

mt -f /dev/nrst0 rewind

To list the contents of a tar file type:

tar -tvf /dev/nrst0

To skip over tar files type:

mt -f /dev/nrst0 fsf

Don't worry if you get an "unexpected end of file" error message, just repeat the command. To extract your data off tape and back onto disk type:

tar -xvf /dev/rstx

where rstx is the name of your home tape drive.

Chapter 2 Restarting the Instrument

In normal operation the camera is left up and running and you are only required to start up the X-windows user interface, as described in the following chapter. Skip to that chapter unless you are sure you need to restart the instrument.

2.1 Terminology

The camera is run from a PC which is located out at the telescope. You can communicate with this PC, called Nsfpc, via a monitor and keyboard in the control room (to the right of the Planck workstation), or by logging on to Nsfpc from a workstation. Often both the computer and the software which runs the camera are referred to as the "IC", for Instrument Computer.

Before doing anything to the IC you must talk with the support astronomer and either the night operator or the day crew.

2.2 Killing the Instrument Computer

Quit out of the XUI and VF applications on the Planck workstation.

Power off the array: there is a small box to the right of the IC monitor with two switches, one labeled "computer" the other "preamp". Turn the preamp power off.

Check that the selector switch on the PC box between Planck and the PC monitor is switched to Nsfpc. Type "die" on the IC keyboard. (Sometimes the monitor blinks as you strike a key - just ignore this.)

2.3 Starting up the Instrument Computer

Wait for a ">" prompt on the IC monitor.

If you have been logged off completely, log back on as "nsfpc" with the usual NSFCAM password (written on the board in the control room).

Type on the IC keypad (ignore any blinking of the monitor as you hit a key):

cd v1.0 (or current version)
camic

This starts the IC program running. Check that the version to use is still Version 1.0. If you want to use an engineering version of the software go the appropriate directory. You can check which is the correct directory by contacting Tony Denault or Sandy Leggett. (Alternatively, if you are completely logged off the IC, you can bring up the default version of the program by logging on to the IC as the user "camic" or by selecting "camic" from NSFCAM's workstation menus.)

Wait for the IC to run up. The monitor should show various status reports and the clock in the upper right of the monitor should be running.

Restart the XUI and VF applications on Planck.

If the IC or the XUI shows a dichroic, lens or filter error, type "ditinit", "leninit" or "filterinit" either on the XUI command line or the IC keyboard.

Power on the array: there is a small box to the right of the IC monitor with two switches, one

labeled “computer” the other “preamp”. Turn the preamp power on.

Check the array temperature value on the XUI status window. If the array suddenly and rapidly starts heating up recycle the power to the array.

Reset the array voltages from the XUI by going to the Setup window. The voltages will not be in a desirable state and you will get a strange looking image if you forget to reset them.

Chapter 3 Starting up the Applications

3.1 X-Windows

Log on to any of the workstations with your guest account name. Type "openwindows". When using the mouse clicking with the right hand button will display a menu of options one of which can be selected by clicking with the left button.

3.2 User Interface: XUI

Put the cursor onto a background area and use the right hand mouse button to bring up the menu options. Select NSFCAM and then Cam XUI using the left button.

When the XUI window is open select the "Parameters" option from the top of the window with the right hand button and then the "change" option with the left button.

You should have two windows open. The upper window displays the status of the instrument and the lower window allows you to choose various parameters to operate the camera. The "go" button at the top of the top window will start an integration going using the parameters of the lower window. The default display for the top window is general instrument status; you can also click on the "motors" button in this window to look at the filter, lens and waveplate motor positions, or the "TempCtl" button to look at the array and cold box temperature controllers data.

If you are not running this application from the Planck workstation on the summit, go to the top window and the command line at the bottom of this window and type "xuihostname wien" if, for example, you are running from Wien. Setting the hostname will send any images to the VF display running on the named machine and send any error messages to the named machine (and only to that machine). You can run the camera interface from any of the IRTF's workstations.

It is possible to run more than one copy of the XUI simultaneously. However whenever another copy of the XUI is run up the software automatically sets for example the detector voltages and the data pathname so it will impact any application already running. In other words do not run up the XUI from for example HP in the day time unless you have talked to whoever is on the summit.

When entering any command, or typing over any values in the XUI windows, remember to hit carriage return. This is very easy to forget at 3am and you will find that the camera is not doing what you thought you told it to do! Watch the top XUI window for your commands to be echoed without any report of errors.

More information on XUI is given in the next two chapters.

3.3 Image Display: ViewFits

Put the cursor onto a background region and use the right mouse button to bring up the menu. Select NSFCAM then VF using the left button. You should get a window with four display regions. You can choose the color map using the options in the lower right of the window.

Using VF is described in Chapter 6. VF is a quick-look utility which is quite powerful; however for final data reduction you will probably want to use IRAF or IDL. Both of these are available on the IRTF workstations at HP and the summit.

3.4 Observing/XUI/Temperature Logs

Blank observing log sheets can be printed out by typing

print_nsfcam_logsheet

A log file will be automatically created recording every XUI command that you issue. The file camxui.log will be in the top directory of your account. Commands that have scrolled off the top of the XUI window can be read using this file.

The "temprecord" XUI command will produce a log file of the cold box and array temperatures on Nsfpc in the default directory (currently /v1.0) called temper.log. You can use the engineering window of the XUI to set the time interval between records; the default is 100000 seconds (27 hours). There is also a standalone program on Nsfpc called "recordtemp" that will write a temper.log file to the default directory. This program has two parameters:

-s {sec} sample period in seconds; default is 300 (5 minutes)
-v turns on verbose mode, default is verbose off

These log files are designed for engineering purposes - the current temperatures are displayed automatically by the XUI and usually this will be sufficient information.

Chapter 4 XUI Setup Window

This window is selected by clicking on the "setup" button on the "Observing Parameters" window.

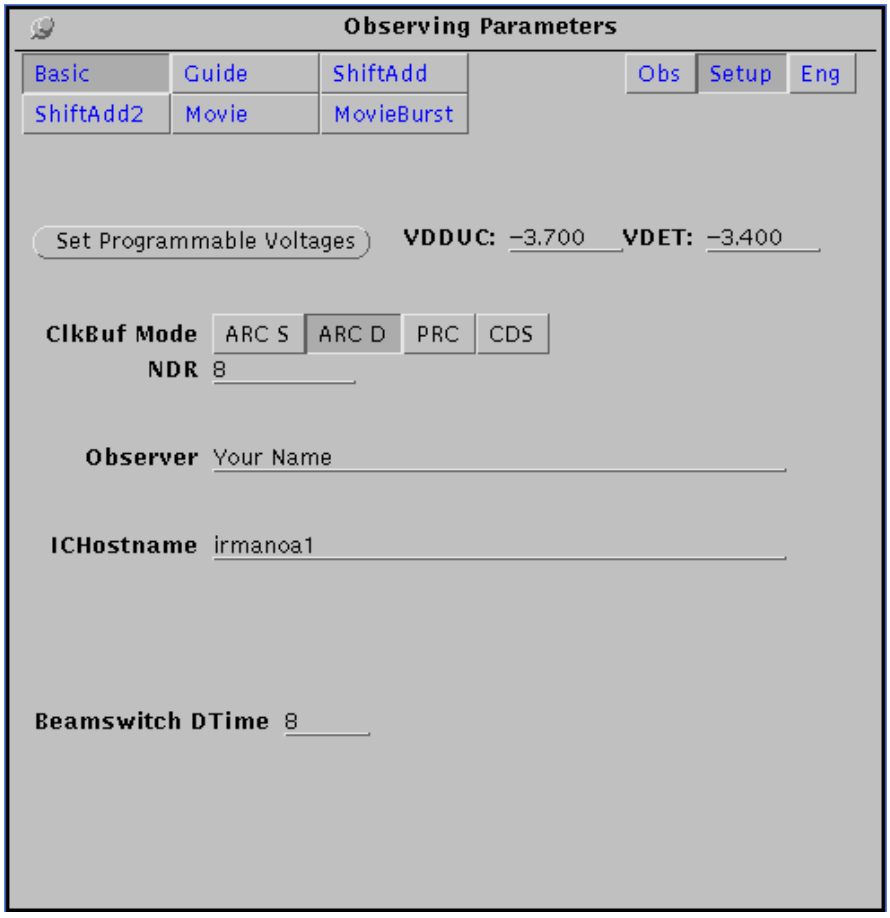

FIGURE 4.1: Observing Parameters Setup Window
At the Summit ICHostname=Nsfpc and Beamswitch Dtime=2

4.1 Information for FITS Header

The information entered on the Observer's prompt will be written to the FITS headers of your data.

4.2 Programmable Voltages

Do not change the VDDUC voltage - it should always be set to -3.7. You may need to change VDET from its default value of -3.4, depending on your observing conditions. Always reset the voltages after powering off and on the array preamp power by clicking on the "set programmable voltages" button. If you forget to do this the voltages will be in a peculiar state and your images will probably show the checkerboard effect with no objects visible.

The default value for VDET of -3.4 implies a 300mV bias across the array (-3.4 - -3.7). This works well in the non-thermal regime and where the background is not high, i.e. through narrow filters or for the CVF. Increasing the bias across the array, i.e. increasing VDET, will increase the well depth allowing you to reach higher counts before entering the non-linear regime, but it will

also rapidly increase the number of bad pixels and the dark current. Hence the best value of VDET is a compromise between well depth and increasing bad pixels, and it may vary from night to night; getting the correct value will probably require some experimentation at the telescope. You can reduce the number of counts per pixel and the non-linearity problem by using a smaller pixel scale, if your program will allow this. Non-linearity is discussed further in Section 9.1.

Some typical voltage settings that are used are:

TABLE 4.1: Examples of VDET Settings

Filter:	all λ<3μm CVF λ<4μm	L, L' CVF λ>4μm at 0.15"	M', M at 0.06" or 0.15"+Polarizer
VDET:	-3.4	-3.1	-3.1 to -2.7
=> bias	300 mV	600 mV	600 mV to 1 V

4.3 Non-Destructive Reads (NDR) and Read Noise

A non-destructive read consists of reading each pixel without resetting its value. Increasing the number of reads per image reduces the read noise and for this reason the default value of NDR is set to 8. For the CSHELL array (also a SBRC 256x256 InSb) it was found that the read noise was 55 electrons (or 5 DN) for NDR=1, and 22 electrons (2 DN) for NDR=6. For NSFCAM the gain has been measured to be 10 electrons/DN.

The higher the number of NDR the longer the minimum integration time, as each read requires about 0.077 seconds. The number of NDR will be set automatically to the maximum number possible (up to 8) for your requested integration time (see following Section). The maximum possible value of NDR (currently 8) as well as the number used on the last "Go" is displayed on the top User Interface window.

Occasionally we have found that the camera cannot seem to cope with short integrations (less than about half a second), giving "go task" errors. This is probably due to network problems and sometimes it can be cured by forcing the maximum number of NDR to a smaller value using the Setup window.

4.4 Readout Modes, Integration Times and Data Numbers

In the near future we will be making a choice of readout modes available. These different modes are selected by clicking on the buttons in the setup window: "ARC_S", "ARC_D", "PRC" and "CDS". Currently however you are restricted to "ARC_D" unless you have engineering privileges.

"ARC_D" stands for "array reset clocking, double sample". The entire array is readout once (called pedestal sampling) and then after the requested integration time has elapsed the array is readout again (sampled). The difference between these two reads is displayed in VF and saved to disk if Autosave is selected. The minimum integration time is a function of array size:

TABLE 4.2: Minumum Integration Time for ARC_D

array size:	256 x 256	176 x 176	128 x 128	64 x 64
min. int. sec:	0.0768	0.0369	0.0199	0.0053

If more than one NDR is done, the pedestal value is read out many times (set by the value of NDR) and the final sample value is read many times. The integration time is the time from the first read of the pedestal to the first read of the sample. The frame that is stored is the difference between the sum of the pedestal read and the sum of the sample reads. Hence the number of counts in the frame will be increased by a factor equal to the number of NDR. If more than coadd has been requested then this entire process is repeated for the number of coadds, and the frame that is stored is the sum of the frames. Hence when reducing your data the counts in each frame need to be divided by the number of NDR and the number of coadds. This value is given in the FITS header as "Divisor". The quick-look utility VF will automatically divide the counts in the image by this value.

As described above, read noise decreases with increasing NDR. Hence the maximum number of NDR possible within your requested integration time (up to 8) will be carried out. For full arrays this means for example that the value of NDR will be equal to the integer value of: (integration time) / 0.0768.

The other readout modes are not operational however briefly they work as follows. ARC_S (Array Reset Clocking Single Sample) follows the same procedure as ARC_D however no pedestal value is subtracted. PRC (Pixel Reset Clocking) mode is similar to ARC_S however instead of reading the entire array every integration interval, the pixels are read out on an individual basis. Similarly CDS (Correlated Double Sample) reads the pixels on an individual basis but subtracts a pedestal value for each pixel. These last two modes effectively increase the well depth of the pixels as each pixel is not left integrating up in counts while the entire array is being sampled. They will be useful modes for observing in the thermal regime when they are operational.

Chapter 5 Using the Camera: XUI Observing Window

This window is selected by clicking on the “obs” button on the top of the lower XUI window.

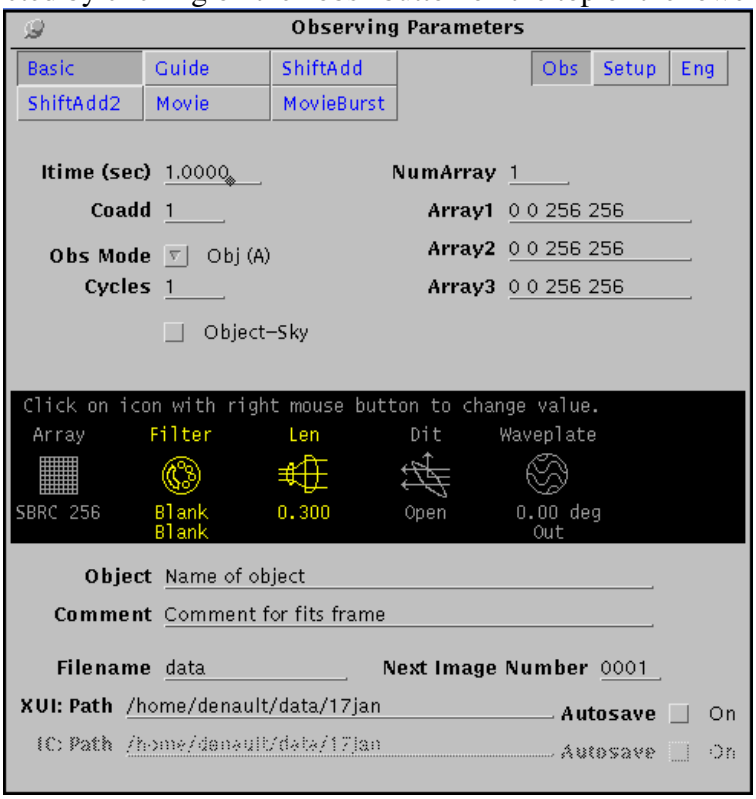

FIGURE 5.1: XUI Observing Parameters Window for Basic Mode

5.1 The Icons

In the central region of the Observing Parameters window are five icons: array, filter, lens, dichroic and waveplate. Clicking on these icons with the right mouse button will bring up a menu of options, which you select with the left mouse button. The icons will turn yellow to indicate that light has reached that part of the optical path.

5.1.1 Waveplate Polarizer

A half-wave plate is available for polarizing work with NSFCAM. To date only Mark Shure has taken data in this mode and he can be contacted for more information (shure@chara.gsu.edu). The menu for this icon allows you to choose various orientations for the waveplate or to move the entire assembly out of the beam. The latter is the default arrangement.

The assembly can also be controlled by the XUI commands WPAssy, PPlate, PPlatePos and PPlateInit via the user interface command line in the top window, or through XUI macros. See Chapter 13 for more information on these commands.

Polarizing grids are also available in both the CVF and filter wheels (see Section 5.1.4).

5.1.2 Dichroic

The first cold optical element in the light path is the dichroic assembly. There are four turrets currently containing: an open aperture (default position), a visual/infrared dichroic, and two lenses for the cold coronograph instrument CoCo (contact Doug Toomey on the IRTF staff for more information on CoCo). Clicking on this icon will allow you to choose one of these options and rotate the appropriate turret into position. The infrared/visual dichroic reflects light with wavelengths shorter than about 0.9μm towards the optical port of the camera, and transmits longer wavelength light to the array, with a transmission of about 90%.

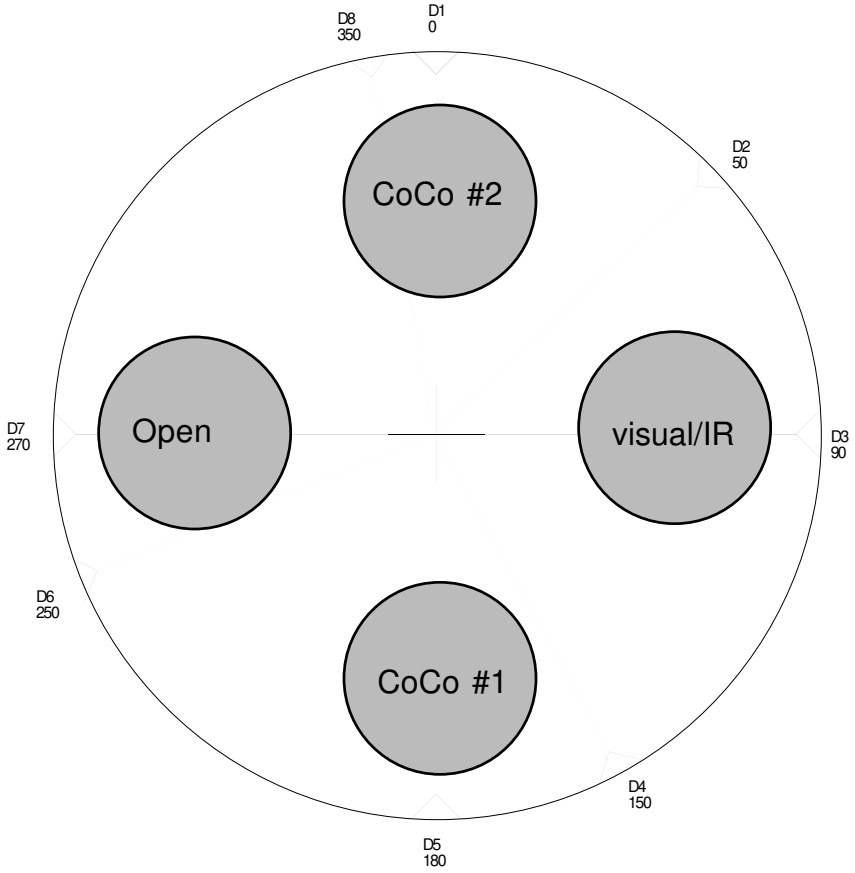

FIGURE 5.2: Dichroic Turret

You can also move the dichroic by typing in an XUI command such as “dit 0” for example to select the open position (or 1 for the dichroic and 2 or 3 for the CoCO lenses). This command can be typed on the top XUI window command line, or used in XUI macros.

If necessary the dichroic assembly can be moved to a specific step position using the XUI command “DitPos”. There are 5000 steps to one revolution and the current step positions for the four elements are given in the following table:

TABLE 5.1: Dichroic Positions

Index	Name	Step	Degree
0	open	3750	270
1	visual/IR	1250	90
2	CoCo #1	2500	180
3	CoCo #2	0	0

To reinitialize the dichroic type “ditinit”.

5.1.3 Lens (& Grism Slit & Coronograph Masks)

The optical element below the dichroic is the lens turret assembly. Clicking on the “len” icon will allow you to choose one of six lenses or to blank off the instrument by positioning the lens assembly between turrets. You must blank off the lenses at the end of each night.

There are three plate scales available chosen by selecting the appropriate lenses; the focus position for each scale is different (see Section 7.2). The three scales are: 0.055”/pixel, 0.148”/pixel and 0.300”/pixel, giving fields of view of 13”, 35” and 72” (allowing for bad edges to the array). There are coronograph masks available for the two smaller scales and a grism slit available with the largest plate scale. More information on the grism is given in Section 5.1.4.2. The coronograph masks are centrally located on the array and have diameters of 4” (for the 0.055” scale) and 6” (for the 0.148” scale).

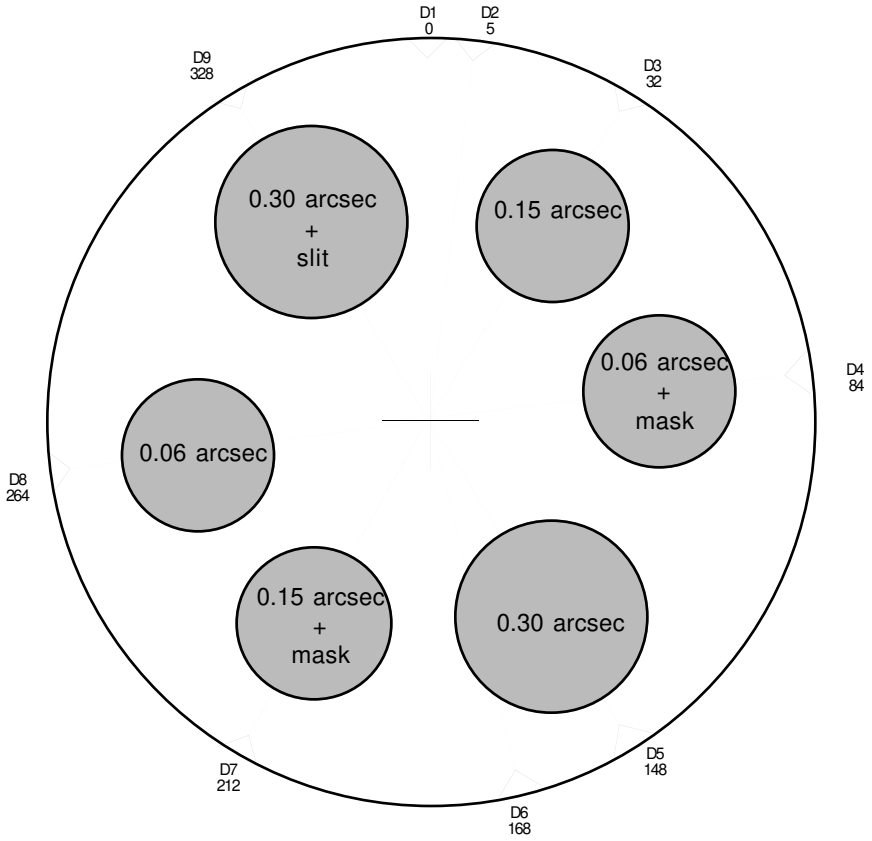

FIGURE 5.3: Lens Turret

The lenses can be selected from the icon menu or by index or by step number using the XUI commands “len” or “lenpos”. For example “len 0” or “lenpos 2333” would select the blank-off position between two of the lens assemblies (there are 5000 steps per complete revolution). These commands can be entered on the XUI command line in the top window or used in XUI macros.

TABLE 5.2: Lens Positions

Index	Name	Step	Degree
0	blank	2333	168
1	0.30"/pix	2056	148
2	0.15"/pix	444	32
3	0.06"/pix	3667	264
4	0.30+slit	4556	328
5	0.15+mask	2944	212
6	0.06+mask	1167	84

To reinitialize the lens assembly use the XUI command “leninit”.

5.1.4 Filter

The last optical elements before the detector are the filter and CVF wheels. Clicking on the filter icon brings up the Filter Wheel Dialog Box which allows you to select any of the 27 filters in the filter wheel (or the blank position between filters) or the CVF (Circular Variable Filter with resolution ~2%), one of the grisms, polarizer, blocking filter, or open position in the CVF wheel (or blank position). The software will start up with both wheels at the blank position and you must blank off the filter wheel at the end of each night. With a lot of advance notice it is possible to place other filters in these wheels and if this is necessary for your run contact your support astronomer.

5.1.4.1 Filter and CVF Wheels

The software will automatically select the blocking filter or open position in the CVF wheel as appropriate for the filter wheel selection. Similarly the blocker in the filter wheel will be automatically selected for the CVF. (The blockers are necessary in some cases to prevent long-wavelength light leaks). All you need do is select your filter or the CVF and type in the required CVF wavelength with the latter. After making your selection from the filter and CVF menus you must click on the “move” button before the wheels will be moved.

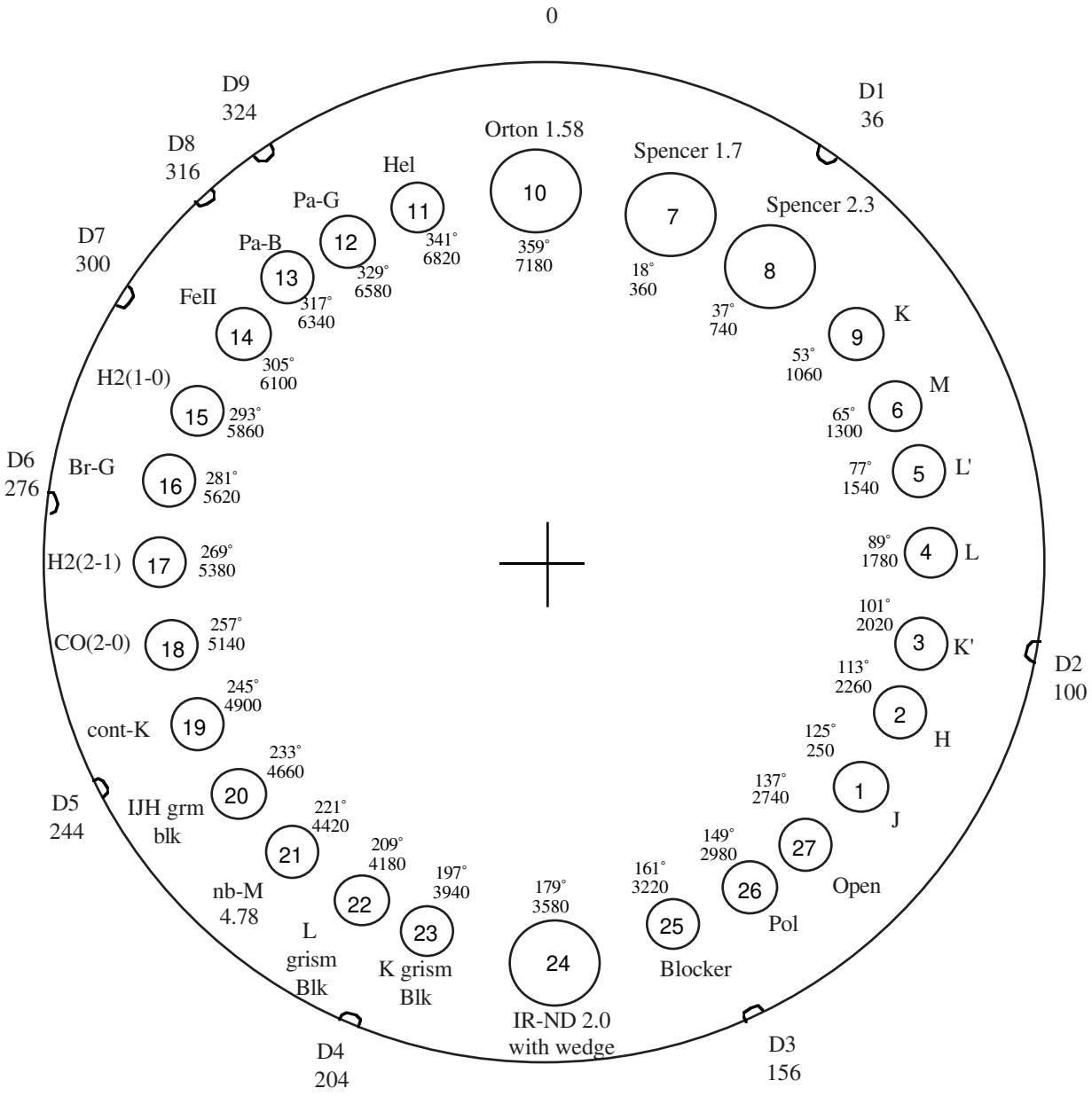

FIGURE 5.4: Filter Wheel

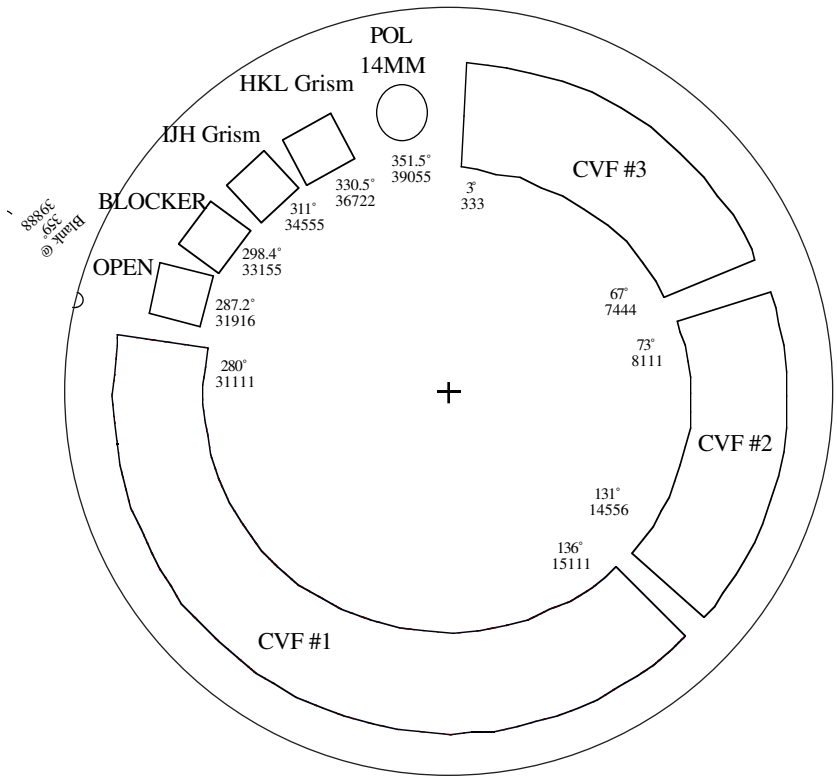

FIGURE 5.5: The CVF Wheel

The filter and CVF wheels can also be moved using the “filter” and “filterpos” commands on the XUI command line or by using these commands in XUI macros. “Filter” requires three parameters: the index for the CVF position, the index for the filter position, and the CVF wavelength, in that order. CVF wavelength is ignored unless the CVF is selected. For example, “filter 6 9” will put the K filter into the beam. Index numbers are given in the table below. “filterpos cvf 31916” will move the CVF to the open position, and “filterpos flt 1060” will move the filer wheel to the K position. Other step positions are given in the Table below. Use “filterinit” to initialize both wheels.

TABLE 5.3: CVF Index and Step Positions
(40000 steps per revolution)

Index	Name	Step	Degree
0	blank	39888	359
1	CVF	31111 to 333	280 to 3
2	polarizer	39055	351.5
3	HKL grism	36722	330.5
4	IJH grism	33455	311
5	blocker	33155	298.4
6	open	31916	287.2

TABLE 5.4: Relationships for CVF l to Step Position

Filter	Beginning Wavelength	Ending Wavelength	Microns to Step Relation
CVF1	1.51	2.52	step = -15318.81187*microns + 54082.99121
CVF2	2.7	4.25	step = -4517.767327*microns + 27111.42742
CVF3	4.45	5.5	step = -6772.380952*microns + 37581.09524

TABLE 5.5: Filter Index and Step Positions
(7200 steps per revolution)

Index	Name	Step	Degree	Central λ μm	FWHM μm
0	blank	80	4		
1	J	2500	125	1.26	0.31
2	H	2260	113	1.62	0.28
3	K′	2020	101	2.12	0.34
4	L	1780	89	3.50	0.61
5	L′	1540	77	3.78	0.59
6	M	1300	65	4.85	0.62
7	Spencer 1.7	360	18	1.73	0.10
8	Spencer 2.3	740	37	2.28	0.17
9	K	1060	53	2.21	0.39
10	Orton 1.58	7180	359		
11	HeI 1.083	6820	341	1.08	0.01
12	Paschen χ 1.094	6580	329	1.09	0.01
13	Paschen β 1.282	6340	317	1.28	0.01
14	FeII 1.644	6100	305	1.64	0.02
15	H2 v=1-0 S1 2.122	5860	293	2.12	0.02
16	Brackett χ 2.166	5620	281	2.16	0.02
17	H2 v=2-1 s1 2.248	5380	269	2.25	0.02
18	CO bandhead 2.295	5140	257	2.30	0.03
19	CO continuum K	4900	245	2.26	0.05
20	IJH grism blocker	4660	233		
21	nbM	4420	221	4.77	0.23
22	L grism blocker	4180	209	3.52	1.65
23	K grism blocker	3940	197	2.25	0.54
24	IR ND=2.0	3580	179		
25	Blocker	3220	161	T<10%@λ>	2.8μm
26	Polarizer	2980	149		
27	Open	2740	137		

Filter scans are available on the IRTF Online site and via NSFCAM's WWW page (http://irtf.ifa.hawaii.edu/Online.html).

5.1.4.2 Grism Spectroscopy

Two grisms are available to NSFCAM users: the IJH or "asteroid" grism, and the HKL grism. We are still in the process of establishing flat-field procedures for the grisms; contact John Rayner of the IRTF staff for more information. An Argon lamp is available for wavelength calibration although atmospheric lines or a bright planetary nebula are easier to use.

The grism slit is only available with the 0.3"/pixel plate scale. Select the slit using the lens icon. Slitless spectroscopy is possible but the smearing of the image will result in degraded resolution. The slit will lie on about column 150 of the array with a length equal to the field of view or 72". The slit has three widths - for the top ~80 rows the slit width is 4 pixels or 1.2"; for the central

~100 rows the width is 2 pixels or 0.6"; for the bottom ~80 rows the width is 3 pixels or 0.9". You can choose your resolution by placing your target in different regions of the array. Using the off-axis guider will probably be necessary to keep targets on the slit (see Chapter 8).

The IJH grism is not fully commissioned and potential users should contact Rick Binzel (rpb@astron.mit.edu). This grism is designed to produce a spectrum with resolution R~100 covering the wavelength range 0.9μm to 1.9μm; the entire spectrum is obtained in a single image. Select the "IJH grism" in the CVF wheel and the "IJH grism blocker" in the filter wheel.

The HKL grism will produce spectra with a resolution R~145 using the broadest slit, R~190 using the middle slitwidth, and R~290 using the central narrowest part of the slit. Select the "HKL" grism in the CVF wheel and the "H" filter for 4th order H spectra (1.45-1.80μm), the "K blocker" for 3rd order K spectra (1.98-2.52μm), or the "L blocker" for 2nd order L spectra (2.70-4.35μm).

5.1.5 Array (and Subarrays)

You are not constrained to reading out the full array of the camera - smaller subarrays can be used. You can also store an image made up of up to three non-overlapping subarrays. There are various ways of defining which regions of the array you want read out.

In the Observing Parameters window you can use the Array 1/2/3 lines to explicitly define the subarrays. You would enter the x,y coordinates of the top left of the region (the top left corner of the full array is 0,0), followed by the width and height of the region in pixels. The width and height must be divisible by 8, and the software should round off your numbers to the nearest permissible value. In this window "num array" is the value of the total number of regions you want read out in a single frame.

Another way of defining your subarrays is to click on the "array" icon. A dialog box will appear where you can sketch out each subarray by holding down and dragging the middle mouse button.

A third option is to use an image in the ViewFits display, bring up the "Stats" box from the "Options" menu, draw a box in the region of interest by holding down and dragging the middle mouse button and click on the "set subarray" buttons.

5.2 Saving Data and Data Pathnames

If you are in basic or shift&add operation mode (buttons at the top of the Observing Parameters window) "autosavexui" will be highlighted. Click "on" if you want to save your data - a tick mark will appear in the box and "autosavexui on" will appear in the top window status display. Click again to stop saving data and the top status display will show autosave "off" in yellow. It is very easy to forget to save data at 3am - try to get into the habit of looking for the tick mark before hitting "go" to take any useful data. If you forget to save data or change your mind, then the last image buffer can be saved from VF (see Section 6.6). If data is being saved the image number will increment on each exposure.

If you are in movie mode then the software expects to save data in its most rapid mode only, i.e. directly to Nsfpc and not to the Sun workstation disk. Hence "autosave IC" will be highlighted and not "autosavexui". Click "on" to save data.

The directory pathnames should be something like /scr/s1/name/date for the XUI (see Section 1.2) and /usr/nsfcam/data/date for the IC. The filename can be specified and the name will be created by appending the image number to the filename prefix and adding ".a" for an object beam exposure or

".b" for a sky beam exposure, e.g. "data0222.a". Movieburst mode creates its own special files (see Section 5.7.2).

5.3 Information for FITS Header

The "object" and "comment" lines are to be used for entering image identification information; the text entered (don't forget to hit carriage return!) will be in the FITS header of your data. A blank line cannot be entered; enter a period or something similar instead.

5.4 Object and Sky Beams

If you click with the right hand mouse button on the "Obs Mode" button you will bring up a menu of options allowing to take an exposure with the telescope at the current position (Obj) or to take an exposure after nodding the telescope to the offset beam position (sky). You can also automatically do a pair of exposures, one at the main beam position and the other at the nod position. The nod will be set up for you by the telescope operator. The ViewFits image program will display these frames and the difference between them if the "object-sky" button is clicked on with a tick mark in the box (see section 6.1). The object and sky images will be saved if "autosavexui" is on, but the differenced image is only displayed in VF, i.e. it is not saved to disk.

If the XUI hangs on you when you are trying to take a "pair" exposure then it is likely that the telescope control system is not up and running. Ask the operator to check that the TCS is on.

5.5 Integration Times, Coadds, Cycles

The integration time is specified in seconds on the "itime" line in the window. The minimum integration time is about 0.077 seconds for a full array; the minimum time for smaller subarrays was given in Section 4.4. The software will automatically go to the smallest possible value if your value is below this limit. The actual integration time will be displayed and written in the FITS header.

The longest possible integration time will be set by the requirements of: not getting the counts up to the non-linear regime (see Section 9.1) and not sitting on any science target for longer than the sky stability period (see Section 9.2).

Setting the number of coadds greater than one will result in repeated reads with your selected integration time, added together, with the sum written out as a single image. This was also described in Section 4.3 and 4.4 where the connection between integration time, number of NDRs, and coadds was discussed. VF automatically divides the counts in your image by the number of NDR and coadds, so that you can easily check for non-linearity.

Typically you will set your integration time to the maximum value possible to still remain safely in the linear regime, using either a bright science object in the field or the sky background if your objects are faint. Then you will set your coadds so that the total time is about equal to sky stability time (one or two minutes at JHK, 20 seconds at longer wavelengths). Keep your counts greater than ~100 to avoid being limited by read noise.

Selecting more than one "cycle" just means that the entire process will be repeated many times with many images being written out (as opposed to a single image if coadds >1). If "pair" is selected as the "Obs Mode" then cycles will repeat in a ABBA... pattern.

5.6 Shift & Add

5.6.1 Procedure

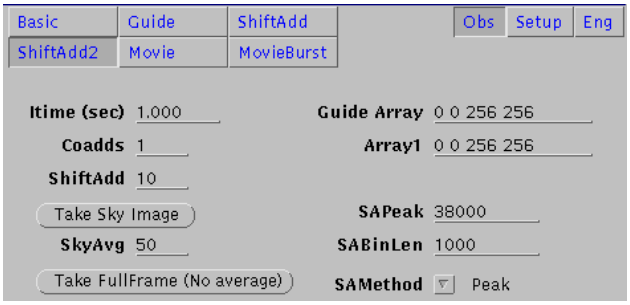

FIGURE 5.6: XUI Observing Parameters Window for ShiftAdd2 Mode

There are two shift-and-add observing modes, “ShiftAdd2” and “ShiftAdd”. These are selected using the buttons on the top of the Observing Parameters window. ShiftAdd2 automatically subtracts a sky frame from each image and so will probably be the most frequently used mode. However as ShiftAdd does not subtract a sky frame it has more memory available and can handle full size arrays; ShiftAdd2 is limited to data arrays smaller than 176x176 and guide arrays smaller than 128x128.

Set up your data and guide arrays using one of the methods described in Section 5.1.5. The guide array will be the region used for the shifting and brightness-binning of images, but the images stored will be defined by the data array. Choose the guide array so that it is clear of bad pixels and give the guide object a little space around it to allow for tracking drifts. Use the “take full frame” option to get a picture for defining your subarray regions.

You can use either a peak pixel or a centroiding algorithm for shifting (i.e. aligning) the frames. This is selected using the “SAMethod” button on the parameters window. The peak pixel algorithm can be fooled by hot pixels.

Usually you will be running in this mode to get rid of atmospheric effects and to study the image in detail. For this reason you will probably want to use the smallest plate scale and a very short integration time such as 0.02 seconds or whatever the size of your data array will allow (see Section 4.4), with only a single coadd so as not to smear out the seeing.

Take a sky image if you are using ShiftAdd2. Use a few of them to make the average, say around 50 (set by the “skyavg” value). When taking real data you will probably want to take a new sky frame before each set of data as the sky may have varied.

For a first experiment just take a few images, by setting the “shiftadd” parameter to a fairly small value, for a few seconds on the target. Hit the “go” button. The software will calculate the peak count value in the guide array and a suitable bin width to sample the observed distribution in brightness, and display these values in the top XUI window. Type these suggested values or something similar into the “SAPeak” and “SABinLen” lines in the observing parameters window. Set the number of images to something larger using the “ShiftAdd” line, say so you are integrating for a few minutes, and hit “go”. The end result should be seven images of degrading brightness or sharpness where the total number of images have been divided amongst these seven bins, shifted, and coadded in.

5.6.2 Output Files

The seven images will have file extensions ".bin0" to ".bin6" where bin0 will be the fuzziest image and bin6 the sharpest. The population of each bin will be given in the top XUI window on completion of the integration. Try to adjust the SAPeak and SABinLen parameters until all bins are populated. Coadded "bin" images will not be saved if they are blank, i.e. if there were no shift-and-add images whose guide object fell into the appropriate brightness bin.

Three other files will be created: ".xypeak", ".spinfo" and ".loc". The "xypeak" file contains: x and y offsets for each image, as well as the peak value and sum of every pixel in the guide array. It is a FITS file but can be converted to an ascii file using the program "xypeak2asc". The "spinfo" file is a text file giving the names of every file produced by the shift-and-add. It is used in the viewing utilities described below. The "loc" file is a plot of the x and y offsets, and is a FITS file. The offsets are measured from the peak or centroid of the first image taken.

5.6.3 Viewing Utilities

ShiftAdd(2) will automatically display the best coadded image in ViewFits buffer B2, i.e. the top right canvas assuming you have the VF utility open. Images will also be displayed showing the peak values and the relative x,y movement in buffers B0 and B1. To display each binned image you can either load the file into VF using the "read" option or you can use the S&A-specific utilities "SAV" and "FATVF". You will probably want to run these window-intensive utilities up on another workstation. You can bring them up using the NSFCAM menu or by just typing in their names on the terminal. Do not run both VF and FATVF simultaneously on the same workstation.

SAV will display a list of the binned images created and the number of images in each bin. It will also plot graphs of: the sum of pixels divided by the peak pixel as a function of time, to give an indication of image quality; a histogram of the peak pixel values; and a graph of the x and y shifts as a function of time. You will need to enter the data directory name into the "path" prompt, and the utility will look for the "SPinfo" file.

FATVF is equivalent to the usual VF (see following chapter) but instead of four canvasses, eight are displayed so that every binned image can be seen. Use the "read data" option of the "file" menu to enter the data directory pathname, and using the "Do Files" option run the "fatvf.setup" macro. Hit the "load images to VF" button in SAV.

5.7 Movie Modes - Rapid Data Sampling

The two movie modes - Movie and MovieBurst - are designed to minimize data transfer overhead for rapid data sampling in time critical observations. In Basic mode, each image is transferred from the instrument PC, Nsfpc, to the Sun workstation, displayed on ViewFits, and, if "autosavexui" is on, saved to the workstation disk. In Movie mode, each image is saved as a FITS file directly on Nsfpc (if "autosaveic" is on) and only observer-selected images are transferred over for displaying on VF. In MovieBurst mode a stream of images are written directly to RAM on Nsfpc and no images are brought over for displaying on VF. The RAM storage is virtually instantaneous. The observer selects the number of images taken but this is limited by the available storage space on the PC. When the Burst is complete the PC will write the images out as a three-dimensional FITS image cube.

Every mode has an intrinsic overhead given by the array readout time; for a full size array this is

0.077 seconds, and for subarrays it is slightly less (see Section 4.4). The measured total overhead per image for Basic and Movie (with no VF display) are:

TABLE 5.6: Overhead Time per Basic or Movie Image

Image Size	256 x 256	128 x 128	64 x 64
Basic, sec	2	1.2	0.6
Movie, sec	1	0.4	0.25

Apart from the array readout time, MovieBurst, writing to RAM, has effectively no additional overhead until the Burst is complete and the images written to the Fits cube.

5.7.1 Movie Mode

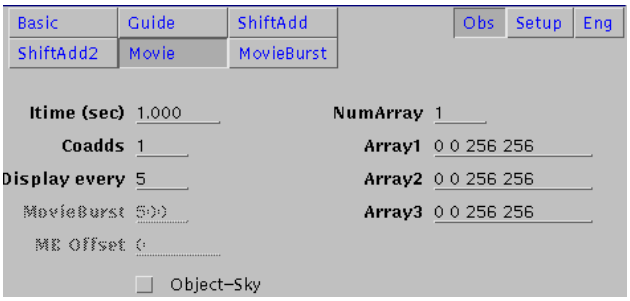

FIGURE 5.7: Movie Mode Parameters Window

To run in Movie mode click on the "movie" button at the top of the Observing Parameters window. Set up your required integration parameters (probably you want to do this in Basic mode first by displaying test frames to VF), and choose the frequency with which you want the images brought over to the workstation and displayed in VF. Enter this number in the "Display every" line in the window. If you want to run as fast as possible and not display any images then enter a large number for this parameter. If you want to display sky subtracted images, then take a "sky" frame using Basic mode before you start the Movie, and click the "obj-sky" button. Every Movie frame is an "object" frame i.e. the telescope is not nodded during the movie.

If you want to save the Movie data remember to set "autosaveic" on, and if you want to save the files brought over to the workstation during the Movie (if any) then set "autosavexui" on. Log on to Nsfpc to determine how much space is available. Log on as the user Nsfcam with password as given on the board in the control room. Type "df" and the number of free blocks will be displayed. Each block is equivalent to 512 bytes. Each full size frame requires a quarter of a mbyte; the amount of space required for subarrays can be calculated by multiplying the number of pixels by four. If there is not enough space left on Nsfpc ask the telescope operator if any of the files can be deleted.

Hit "go" to start. The "cycles left" display will give you the number of images taken (the number will increment). Hit "stop" when you have enough images.

Log on to Nsfpc as the user NSFCAM, the password is on the whiteboard in the control room. FTP your data across to the workstation; it will be in the form of the usual two-dimensional FITS images in the directory /usr/nsfcam/data/date.

When you are finished turn off “autosaveic”.

5.7.2 MovieBurst Mode

To go into MovieBurst mode click on this button at the top of the Parameters window. The window will look very similar to “Movie” mode (Figure 8) but with different options highlighted. Enter your required integration time and coadds, and array dimensions. You may want to decide on these beforehand using Basic mode. Make sure that your (useful) data counts are inside the range -32768 and +32767, including any multiplication by coadds or NDR (especially if you are working in the thermal regime and only using single sampling) . If your raw frame counts are outside of this range use “MBOffset” to subtract a constant to put the counts within this range.

Log on to the Nsfpc to determine how much space is available. Log on as the user Nsfcam with password as given on the board in the control room. Type “df” and the number of free blocks will be displayed. Each block is equivalent to 512 bytes; the amount of space required can be calculated by multiplying the number of pixels in each frame by two. (For MovieBurst mode the data are stored as 16 bits as opposed to all other camera data which are stored as 32 bits.) If there is not enough space left on Nsfpc ask the telescope operator if any of the files can be deleted. For MovieBurst mode you are also limited by the amount of RAM which is 64 Mbytes; hence the absolute maximum number of full size images that can be taken in this mode is 512.

Enter how many images you require (or can fit on disk) as the “movieburst” parameter. Hit “go” to start the movie burst. The telescope will not be nodded and no sky frame will be subtracted.

When the requested number of images have been taken, a three-dimensional image cube will be created on the PC. The file will be in the directory specified by the “ICPath” in the Parameters window (probably /usr/nsfcam/data/date), and named something like data0001.movie. Transfer this file over to a Sun workstation using FTP.

A utility exists for extracting two-dimensional FITS images from this cube; the utility also writes a ViewFits macro so that these images can be displayed in sequence as a movie. The utility is called “movie2fits” and is run from any of the workstations by typing the command:

movie2fits [-s skip_value -g get_only_value] filename

You can skip every “skip_value” images to extract for example only every 10th image from the cube, or you can explicitly extract for example only image number 26 from the cube. The extracted images will be called something like data0001.movie.0010, where the last numbers are the sequential image number from the burst.

A VF macro file will have been written in your data directory on the workstation. Click on “execute Do files” in the VF window and execute the macro. Every extracted two-dimensional image will be displayed in sequence.