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.

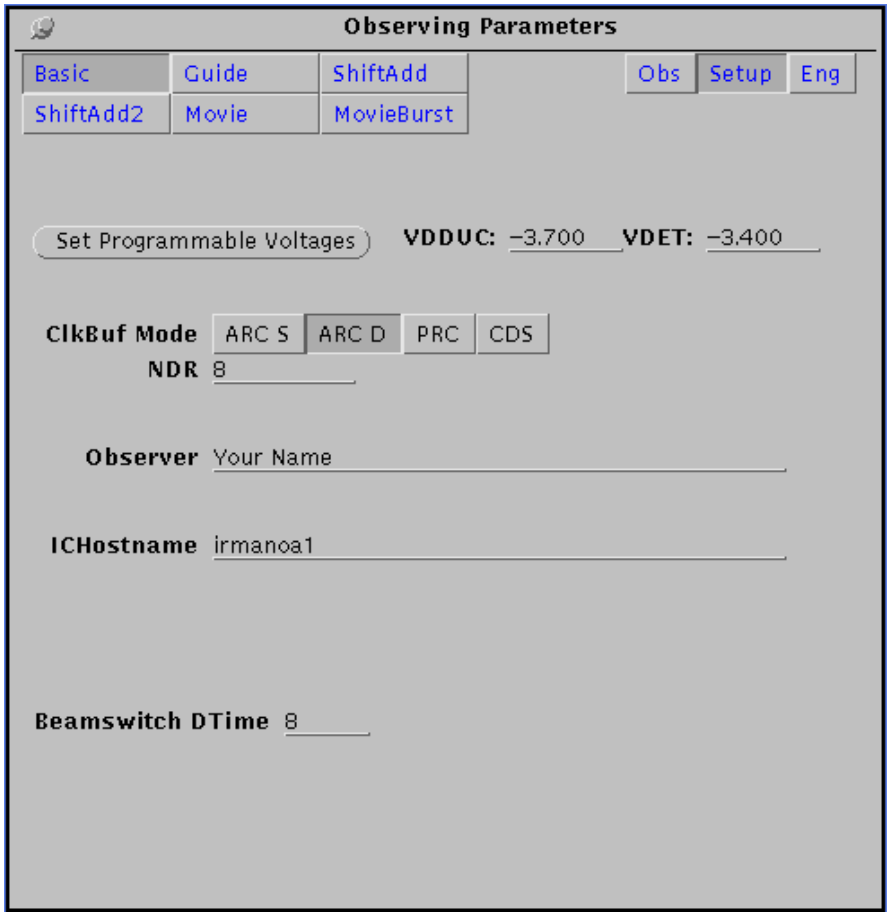


FIGURE 4.1: Observing Parameters Setup Window
At the Summit ICHostname=Nsfpc and Beamswitch Dtime=2

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.

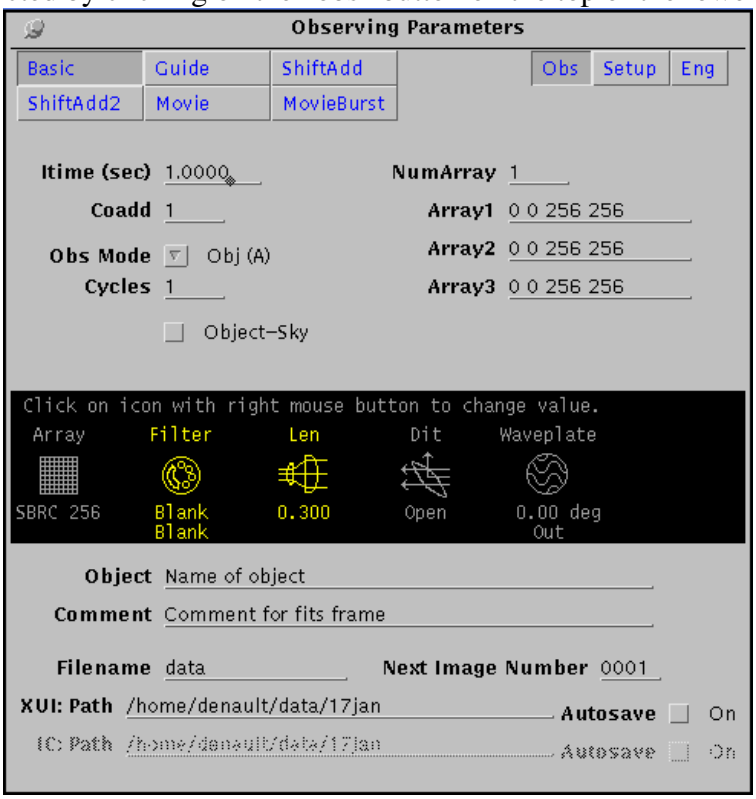


FIGURE 5.1: XUI Observing Parameters Window for Basic Mode

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%.

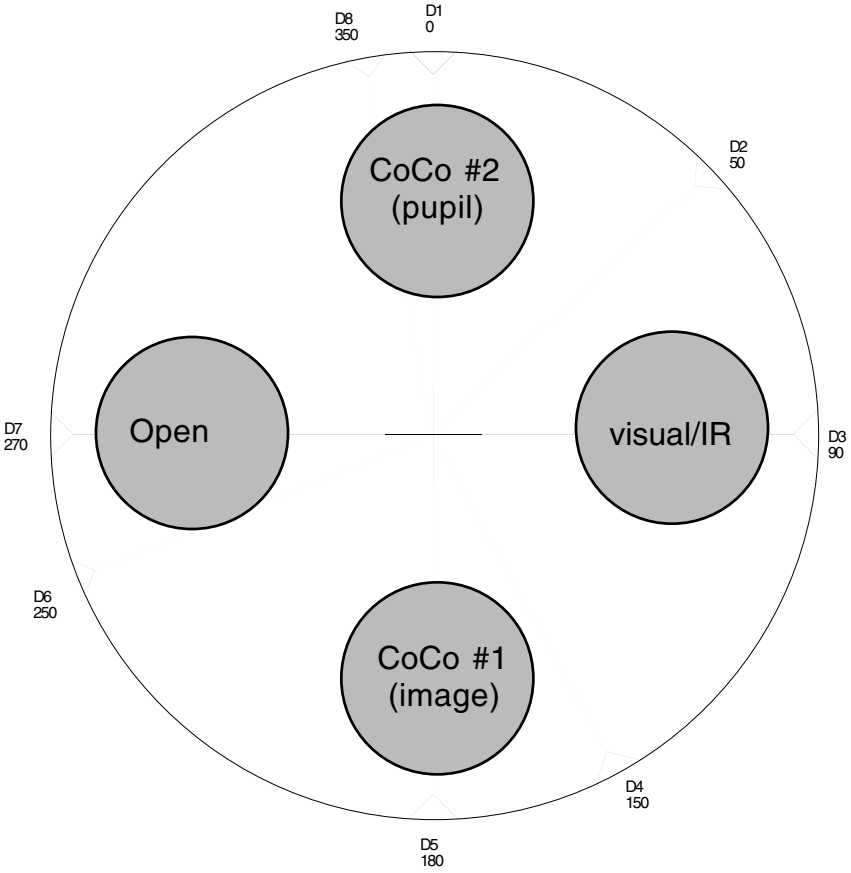


FIGURE 5.2: Dichroic Turret

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 (pupil)	2500	180
3	CoCo #2 (image)	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).

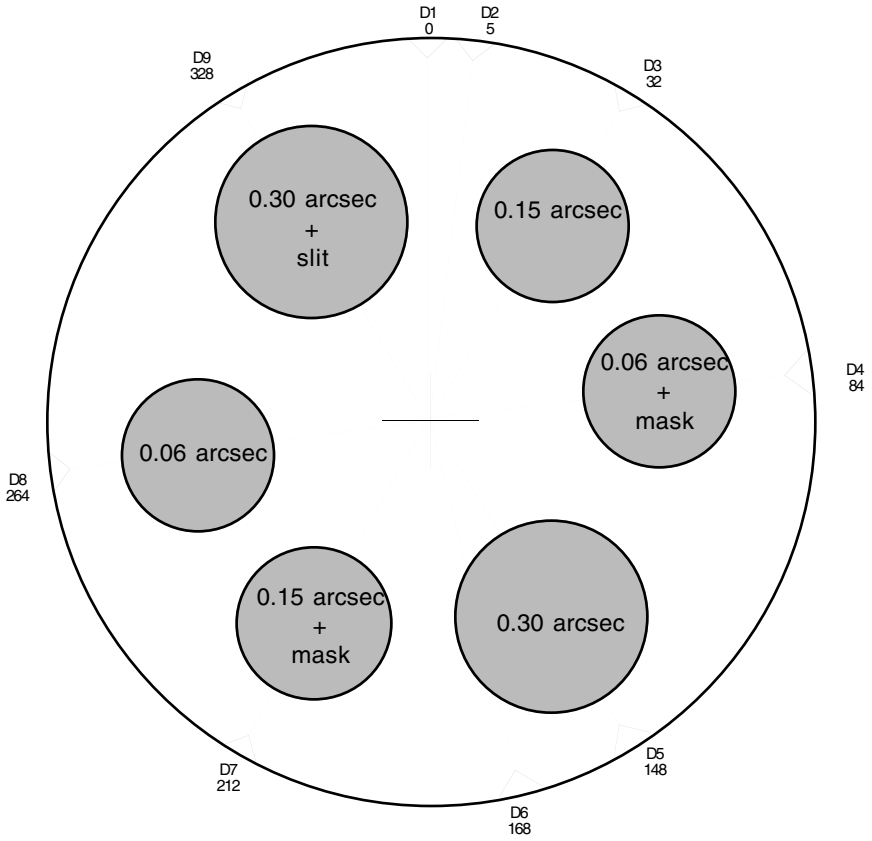


FIGURE 5.3: Lens Turret

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

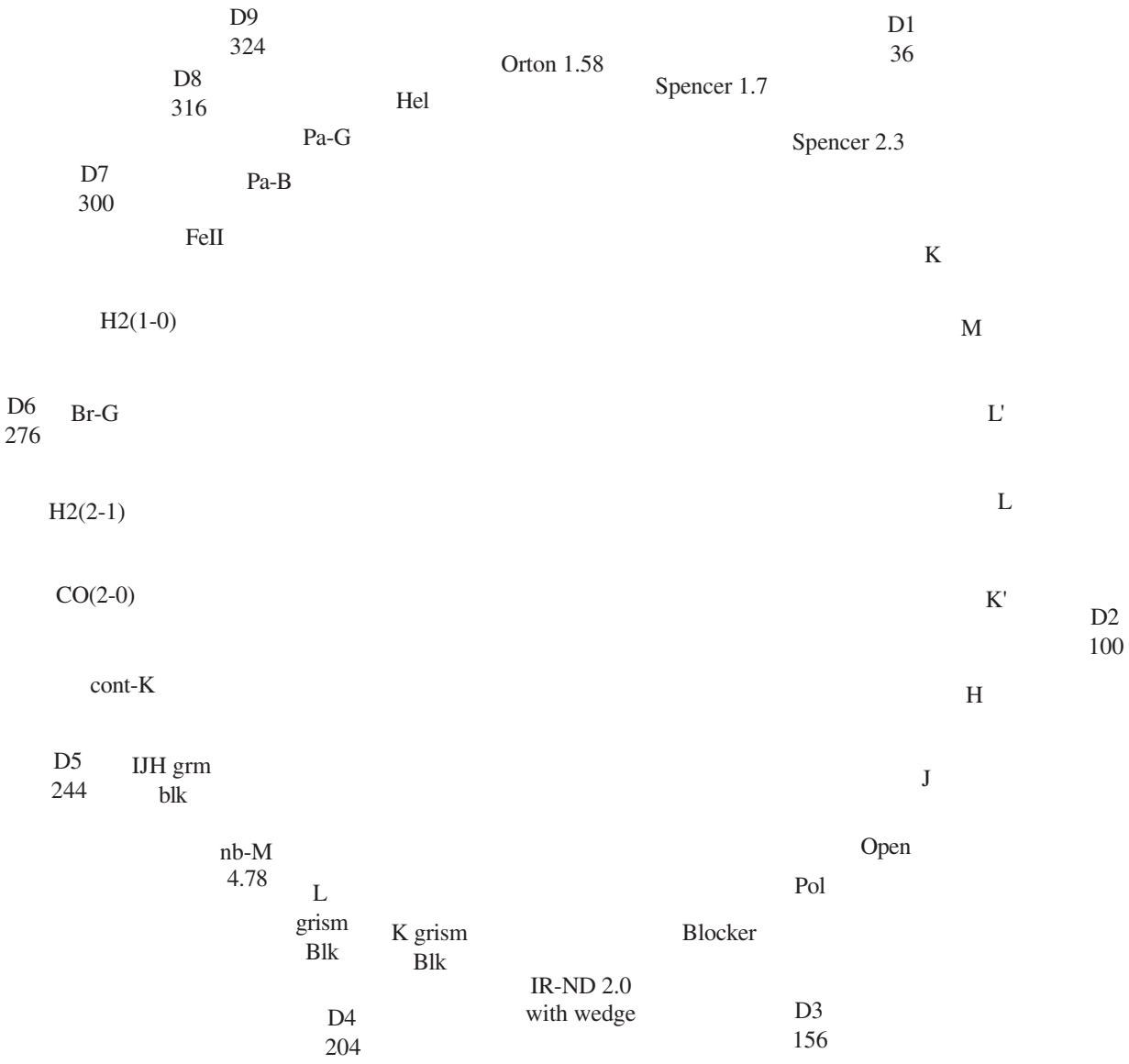
To reinitialize the lens assembly use the XUI command “leninit”.

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

When you use the icon to select a filter or CVF wheel position the software will move the wheel to the required position when the "move" button is hit, and will automatically move the other wheel to either the open or long-wave blocker position. The blocker is required in some instances to prevent long wavelength light leaks. The blocker is used in the filter wheel if the CVF wavelength is shorter than 2.53 microns. The blocker is used in the CVF wheel for the following filters: J, K', Orton 1.58, HeI 1.083, Paschen beta and gamma, FeII 1.644, H2 (1-0) and (2-1), CO (2-0) and continuum K. The K' filter was designed for a NICMOS array and has severe longwave leaks.


D9
324
D8
316
D7
300
D6
276
D5
244
D4
204
D3
156
D2
100
D1
36
Orton 1.58
Spencer 1.7
Hel
Pa-G
Pa-B
FeII
H2(1-0)
Br-G
H2(2-1)
CO(2-0)
cont-K
IJH grm
blk
nb-M
4.78
L
grism
Blk
K grism
Blk
IR-ND 2.0
with wedge
Blocker
Pol
Spencer 2.3
K
M
L'
L
K'
H
J
Open