NSFCam
2048x2048 H2RG Infrared Array Camera

User's Guide
Version 1.0 (May 2013)

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Preface

0.1: Brief Description of the Instrument

NSFCAM is a 1-5 µm imager with a 2048x2048 H2RG detector. The plate scales is 0.04″/pixel, with a corresponding field of view of 82″. 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). Polarizing waveplates or grids can be inserted into the beam.

Images are recorded in FITS format. These are taken in basic stare mode using the main (object) and offset (sky) telescope beam positions. 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.

DV is a FITS viewer is run at the telescope that 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.

0.2: Crib Sheet for Basic Observing and Instrument Checkout

Section 1: Observer's Computer Accounts

1.1: Setting Up Your Guest Account

All observers at the IRTF are required to establish their own guest accounts for use while they are observing. These accounts are good for a time period starting 5.4 days prior to their observing run and ending 5.4 days after their run. Individuals who have split runs over the span of a month, or a couple of months, can request the IRTF System Administrator to keep their account alive over this time span. Individuals who would like to share accounts over a set of runs on the same instrument should also contact the IRTF System Administrator about keeping their account alive.

For remote observing, you create your guest in the same manner, logging in using ssh: `ssh addguest@stefan.ifa.hawaii.edu`

The rest of the procedure is the same. Please contact your support astronomer or the system administrator to get the addguest password.

Guest accounts are acquired in the following manner:

1. Login as "addguest" to any IRTF machine at Hale Pohaku, the Hilo remote room, or at the observatory. A script will run allowing you to establish a user account. Please ask the IRTF support staff for the "addguest" password. At HP, the password may be taped on the machines.

    ◦ At the login screen, select the "Other" option in the user list, and type "addguest" into the Username field and hit return. When the password prompt comes up, be sure to select "Failsafe_Terminal" from the "Sessions" dropdown at the bottom of the screen, and then enter the password. A dialog box with the message, "This is a Fail Safe terminal session..." may appear, hit "ok" to continue.

2. After loggin in, you will then be asked for your name and program number. Provide the name you would like to be identified by, and the program number (eg. 78) assigned to you by the IRTF when you were allocated time.

3. If you are within the time period when you may create an account, you will be assigned an account name between guest00 and guest40. You will be asked for a password. Provide the password you would like to use for your guest account. You will need to enter this password two (2) times.

4. An account will be created for you, complete with all the bells and whistles

necessary to run any of the software you will need. Any small files you need can be placed in this account. Large files, and all data, should be placed on one of the scratch disks.

5. You will be placed back at the login prompt. Simply log in using your new account and password. Please note, NIS may take serveral minutes to distribute your new password, so your account may not work for at most about 15 minutes after creating it. (see the FAQ below). After trying to login, if you see a "no shell" error, or recieve a message saying that the account is not active, wait 10 minutes and try again.

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 "starcat &" 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 "starcat" utility see the IRTF WWW page: http://irtfweb.hawaii.edu/~tcs3/starcat2/

1.3 Where to Put Your Data

Data are written to the scratch disk, /scrs1. The data path will automatically be set to send the data into the NSFCam directory, the a directory of your guest account, then a directory of that day. For example, the path might be /scrs1/nsfcam2/guest00/01jan. A full size NSFCAM frame requires 16.8 mbytes.

1.4 Data Retrieval and Archiving

When you take data using SpeX, NSFCam, CShell, or any other instrument, the data are written directly to /scrs1, the publically available data directory. /scrs1 (and /home/smokey) are hosted on our file server. The data in /scrs1 are compressed once they are five (5) days old and are deleted from /scrs1 after they are fourteen (14) days old. /home/smokey/data is not currently part of this automatic compression/removal schedule. The entire file server disk is mirrored daily and the mirror is permanently archived to tape weekly (Tuesdays). This means that all data on /scrs1 are backed up to tape at least twice before being deleted.

There are two options for transferring data to your home institution: You can download your data to your laptop while at the IRTF by 1) using ftp, sftp, scp, rsync, or by 2) mounting /scrs1 as a virual drive on your Windows laptop and copying the files over to your laptop. You can transfer your data to your home institution from the IRTF using ftp, sftp, scp, rsync if you are on the IRTF network. Our firewall does not block outgoing ftp or ssh connections. Our firewall blocks all incoming connections except ssh to specfic computers.

Section 2: Array Control

The NSFCam array can be controlled in a number of modes to suit different observing requirements. The pixel sampling time, gain, and well depth can be selected by the observer from a menu of options.

2.1 Pixel Sampling Time

The pixel sampling time is the amount of time that is allocated to read out a single pixel. The options are 3, 5 and 10 microseconds. The tradeoff is between readout speed and read noise. These values are summarized in the following table

Pixel Sampling Rate (microseconds)	Minimum read time (seconds)	Read Noise (NDR=1)	Readnoise (NDR=16)
3	0.44	15.3 e-	4.7 e-
5	0.8	11.8 e-	4.0 e-
10	1.6	9.3 e-	7.6 e- (NDR=9)

2.2 Gain and Well Depth

The gain and well depth are changed together so that the dynamic range of the detector is well sampled by the dynamic range of the AD electronics. In high gain mode, there are three well depths available (low, medium, and high). In low gain mode, the well depth is high. <u>We recommend using the high gain low well depth mode for observing faint targets</u> as that mode has the best mapping of low e- counts to ADUs. <u>We recommend using the low gain high well depth mode for observing bright targets and/or at a wavelength with a high background</u>. This mode was specifically created to allow observing Jupiter at M′. This mode is necessary since the low gain gives you more photons per e-, and the high well depth allows the collection of more e- before saturating. The gain also depends on the pixel sampling rate. The gains are summarized in the following table.

Pixel Sampling Rate (microseconds)	High Gain	Low Gain
3	8.25 uV/ADU	11.0 uV/ADU

	1.85 e-/ADU	2.55 e-/ADU
5	6.22 uV/ADU 1.4 e-/ADU	8.23 uV/ADU 1.91 e-/ADU
10	2.05 uV/ADU 0.46 e-/ADU	

Section 3: Remote Observing

3.1: VNC

All IRTF instruments are used via a VNC (Virtual Network Client) session, even when observations are done from the summit. Thus, observers have the same interaction with the instrument regardless of location.

For observers at the summit, use your guest account to log into one of the computers in the observers area of the control room. In an xterm, type 'vncviewer –shared stefan:3', since NSFCam is in VNC session #3 (#1 is bigdog, #2 is guidedog, etc.). You will then be prompted to enter the VNC password, which changes daily. Ask your operator or support astronomer for the password of the day.

Remote observers will need a VNC client on their own local computer. We recommend RealVNC (available from RealVNC.com). A free viewer client is available for download for PC, Mac, or Linux. To start the VNC session, display session stefan.ifa.hawaii.edu:3. .). You will then be prompted to enter the VNC password, which changes daily. Ask your operator or support astronomer for the password of the day.

3.2: Talking to the Telescope Operator

Although you can control the instrument via VNC, you will still need to be able to talk to the Telescope Operator (TO). The options are 1) speaker phone, 2) Polycom, and 3) Skype. To talk to the TOs via speaker phone, call (808) 974-4211. It is recommended to call the TO about half an hour before your observing session begins to let them know that you are standing by, and to convey any information. The summit control room has a Polycom that can be called from the outside. Its IP number is 128.171.165.81. Skype is by far the most common way to talk to the TOs. Their skype name is 'irtftos'.

Chapter 4: GUI Setup Window

Before starting observations with NSFCam, the observer should check the setup tab to make sure that the instrument is set up properly. This tab is shown in the figure below, configured when the instrument is in the stow position. When starting NSFCam, the following boxes should already be enabled: Enable DV1, Enable Pixelserver, Enable Cryostat Electronics, Enable T-Controller, Enable T-Monitor, Enable Mechanism Control, and Wait on Positioning. The observer should need to click on the 'Enable TCS interaction' button so that the telescope will move when the NSFCam software tells it to.

For the image to be displayed with north up and east to the left, make sure that…

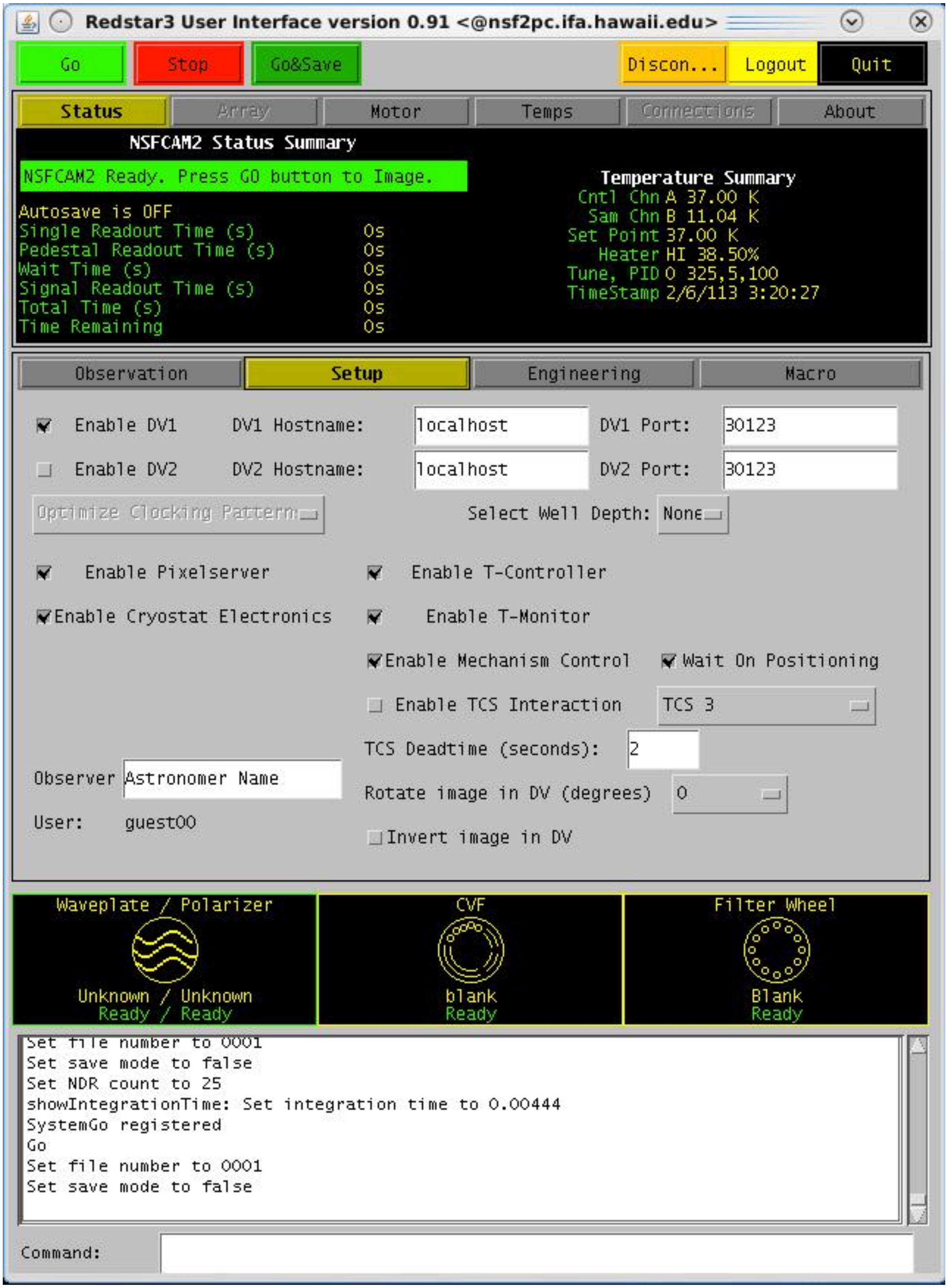

Figure 1: The setup tab of the XUI

Chapter 5: Using the Camera: GUI Observation Tab

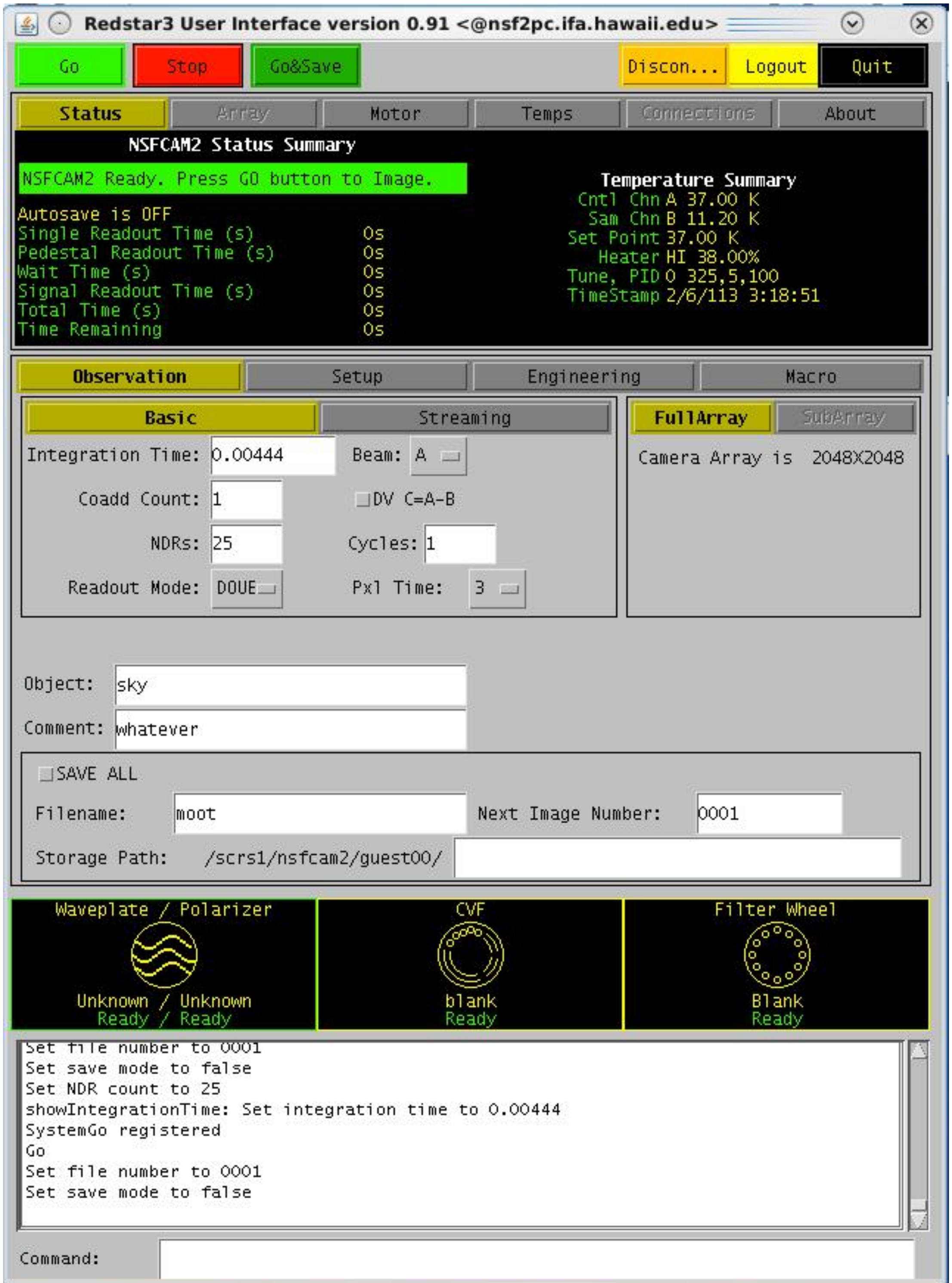

Figure 2: The XUI observation tab.

5.1 Buttons at the Top

Go: Takes an exposure, or series of exposures, using parameters shown in the XUI
Stop: Stop the exposure series. Won't stop in the middle of an exposure, but will stop between cycles. Will it stop a macro?
Go&Save: Takes an exposure and saves it to disk.
Connect/Disconnect: Connects or disconnects the XUI software from the instrument.

Observers shouldn't have to push this button.

Logout: Push to logout of observing session at end of the night
Quit: Push to quit the XUI. *Observers shouldn't have to push this button.*

5.2 Status

This part of the XUI shows the instrument status. A green bar is shown when the instrument is ready and standing by, and a red bar when the instrument taking data. A notice is shown when autosave is off. The status window also shows the array temperature.

5.3 Basic Mode

Integration time: Sets the integration time for individual exposures. Minimum full frame readout is X seconds.
Coadd Count: The number of exposures that are to be added together in a memory buffer, which is then displayed to DV and/or written to disk.
NDRs: The number of non-destructive reads that are to be used.
Readout Mode: NSFCam supports 4 readout modes.

Raw: The array is reset, then read out the number of times specified by NDRs. Each readout is written to an individual FITS file. Note that in raw mode, the image is a 'negative', i.e. more light results in lower ADUs. This is a result of how the array electronics detect photons.

Single. The array is reset, then read out the number of times specified by NDRs. Those reads are added, then written to a FITS file. This mode is most useful at L' and M' where the background is very high, and the instrument may saturate on the sky in the amount of time it takes to do a CDS read. In this case, NDR would be set to 1. Note that in single mode, the image is a 'negative', as it is in raw mode.

Double: The array is reset, then read out. If necessary, the software waits until reading out the array a second time. The two reads are differenced, and that difference is then displayed to DV or written to a FITS file. This readout mode is most useful in low background cases (e.g. J,H, or K band, or any narrow filters therein).

SUR: Sample up the ramp mode….

Beam: Can be set to 'A', 'B', or 'AB'. Choosing 'A' or 'B' will take a single image in either 'A' or 'B' beams, respectively. Choosing 'AB' will take an image in 'A' beam, command the telescope to switch to 'B' beam, then take an image

in the ‘B’ beam.
DV C=A-B: Check this box if you want DV to automatically show the difference in the ‘A’ and ‘B’ beams in data buffer ‘c’.
Cycles: The number of times that an integration (or integration pair, in the case of an AB beam switch) should be repeated.
Pxl Time: This is the amount of time allowed to read out a given pixel. The options are 3, 5 and 10 microseconds.
Object: This gets written to the FITS header, is for the benefit of the observer, and does not affect the instrument.
Comment: This gets written to the FITS header, is for the benefit of the observer, and does not affect the instrument.

5.4 Subarrays

5.5 Filename and path

Save All: Check this box to save all data to disk.
Filename: Sets the filename of the file written to disk
Next Image Number: The running number of the next file to be written to disk. This is
appended to the filename.
Storage Path: The directory to which the data will be written. This is usually
/scrs1/nsfcam2/guestXX/date, where guestXX is the user’s guest account number,
and ‘date’ is the date of the observation.

5.6 Mechanisms

5.6.1 Waveplate/Polarizer

The waveplate is a mechanism on top of the instrument, just above the entrance window. It has a transmissive optic that rotates the polarization of the output beam of light. The mechanism can be in or out, and the waveplate can be rotated to a number of position angles. If the observations do not involve polarimetry, this mechanism should be out

5.6.2 CVF

The CVF (circular variable filter) wheel has 3 CVF segments, as well as a polarizer (for use with the waveplate), a pair of neutral density filters, a PK50 filter, and an open position. The CVFs allow any wavelength to be selected with a 1.5% to 2% bandwidth. The bandpass of CVF1 goes from 1.51 to 2.52 microns. The bandpass of CVF2 goes from 2.70 to 4.25 microns. The bandpass of CVF3 goes from 4.45 to 5.50- microns. The polarizer is used with the waveplate to allow polarized observations to be taken at any polization angle, using any filter in the filter wheel. The two neutral density (ND) filters allow NSFCam to observe very bright targets. Their attenuations are 4.8 and 10.5 magnitudes at K-band. The PK50 blocker is stacked with several of the narrow band filters in the filterwheel to prevent long wavelength leaks.

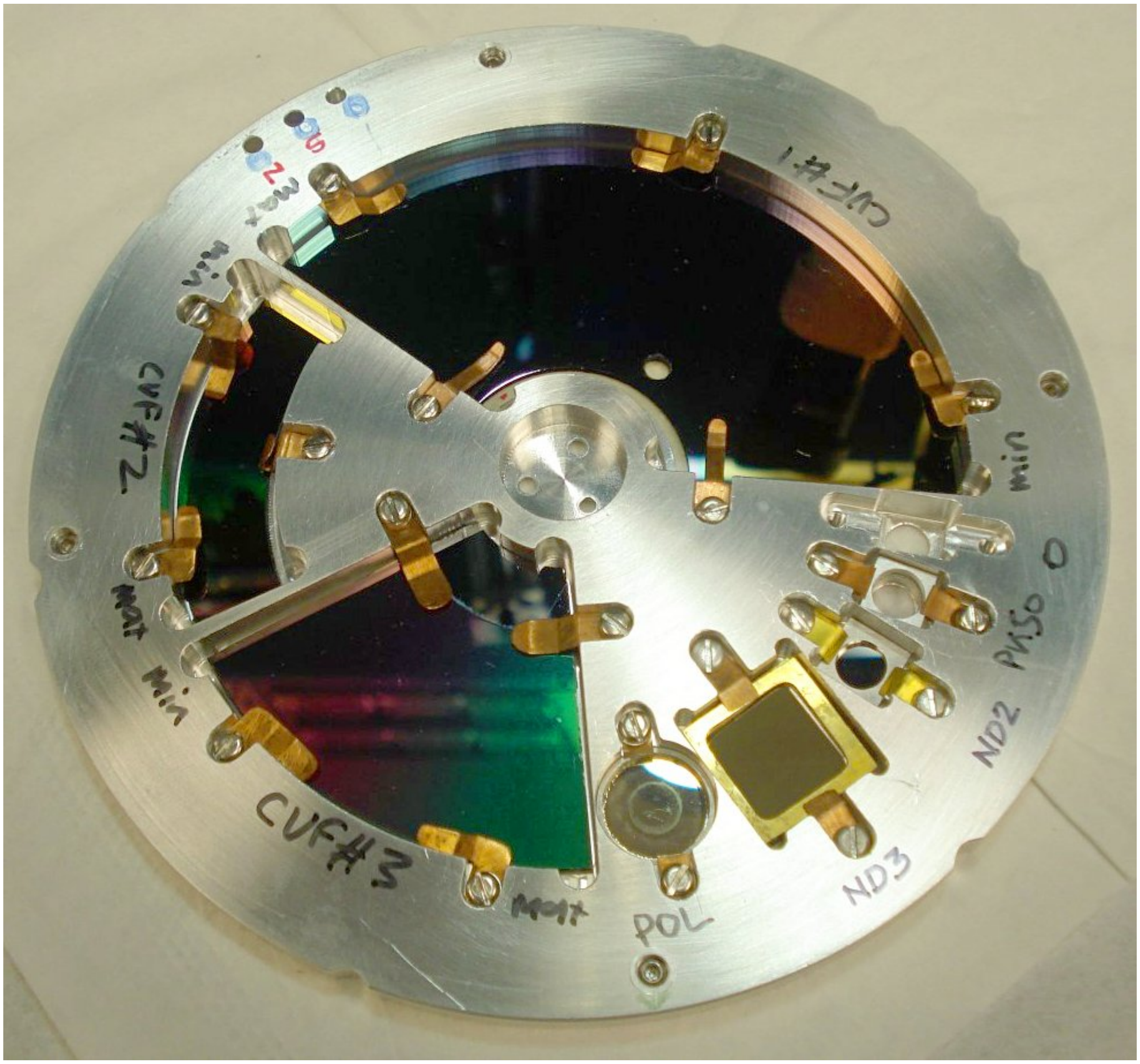

Figure 3: A photo of the CVF wheel

5.6.3: Filter Wheel

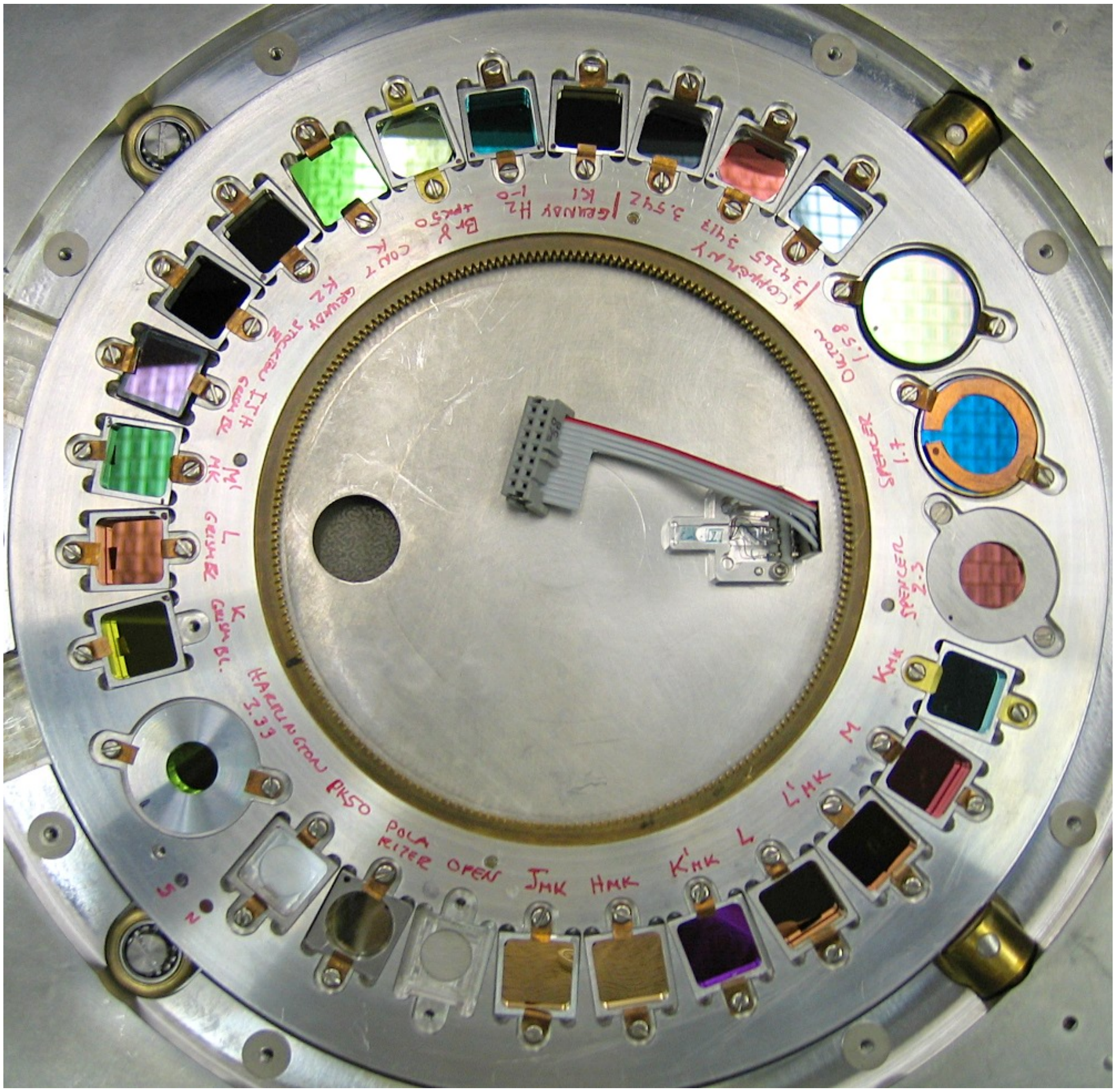

Figure 4: A photo of the filter wheel

The following filters are installed in the NSFCam filter wheel, as of March 2013:

Blank
Open
Stockton z 0.92-1.10
J_MK 1.16-1.33
H_MK 1.48-1.78
Orton 1.58
Spencer 1.7
K'_MK 1.95-2.30
K_MK 2.03-2.36
H2 s(1) 2.122

Brackett gamma 2.166 + PK50
Continuum K 2.26 (cracked)
Spencer 2.3
L 3.20-3.80
Harrington 3.33
L'_MK 3.42-4.12
Connerney 3.4265
Connerney 3.490
Connerney 3.542
M 4.54-5.16
M'_MK 4.56-4.80
IJH grism blocker
L grism blocker
K grism blocker
Grundy K1
Blocker PK50
Wire grid polarizer

5.7 Command

Text commands can be typed here, to be executed by the XUI or sent to the TCS. See the section on macros for the list of commands.

Section 6: DV

DV is the Data Viewer, and is the software that is used to view and interact with the data during observations. For more complete information on DV, see the DV web site: http://irtfweb.ifa.hawaii.edu/Facility/DV/

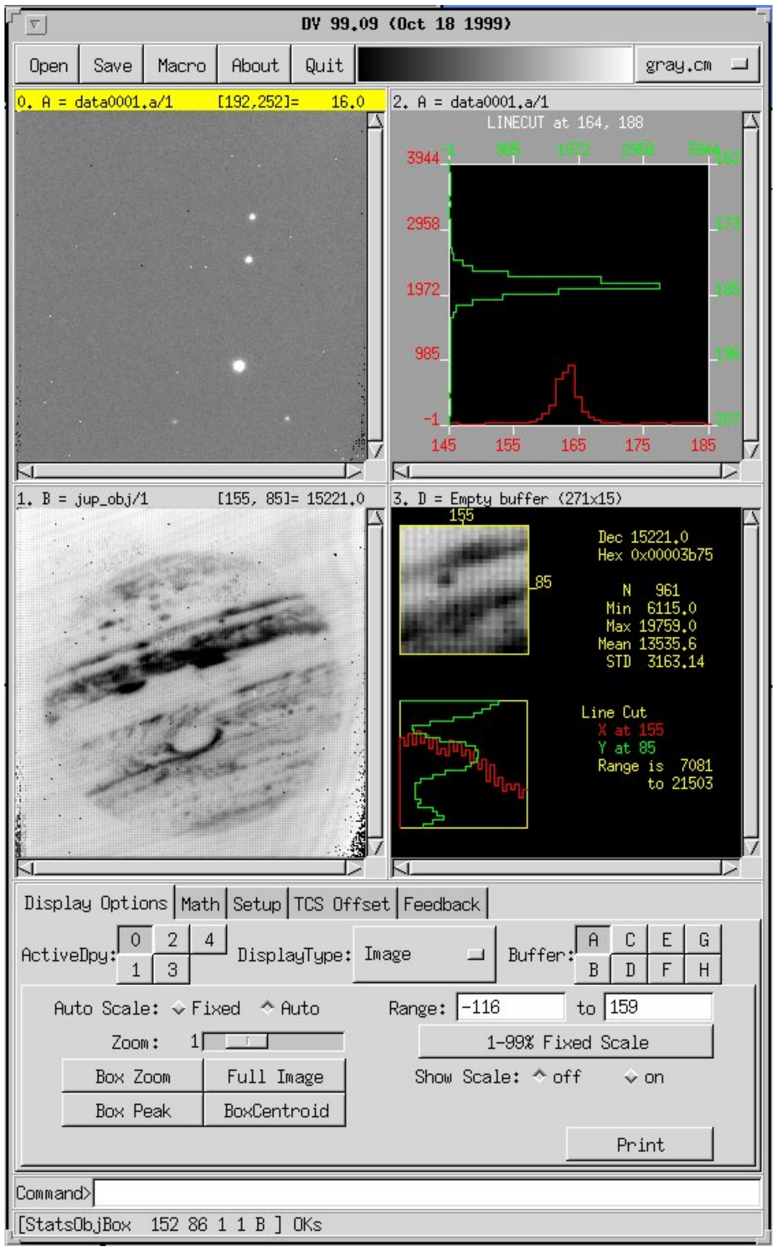

Figure: An old screen shot of DV

6.1 Default Operation and Mouse Control

DV starts up with four display canvasses. You can choose which is active by clicking on the 0, 1, 2, or 3 buttons below the canvasses in the 'Display Options' tab. The #4 frame is a large, separate, window. The color map is selected by the button on the upper right. By default the image will be autoscaled, however you can also fix the range using the commands in the lower part of the window. Holding and dragging the right mouse button will change the stretch of the display. If you see a black display when autoscaling try clicking on “fixed” then “auto” again. Moving the cursor over the images will result in the x and y and data value for the pixel being displayed at the top of the DV window. x values increase to the right, and y increases downwards. Unless the camera has been rotated at the telescope, North should be to the top and East to the left (to better than half a degree).

DV uses eight temporary data buffers for storing the image data. Each of the five canvasses is associated with a default buffer however each canvas can look at any buffer by selecting the appropriate buffer letter in the “Buffer” option in the lower part of the window, again in the ‘Display Options’ tab.

If you use the XUI observing window to take an “Object” frame (in A-beam) this image will be written to data buffer 0 and displayed in the top left canvas, “A”. If a “Sky” frame is taken (in B-beam) this will be written to buffer B and displayed in the lower left canvas, “1”. If “sub AB” is selected in the XUI then the difference of the object and sky frames will be written to buffer C and displayed in the “2” frame to the top right.
Holding down and dragging the middle mouse botton will draw a box on the image. You can then zoom in on this box (button in lower part of window) or get statistics for the box (see Section 6.4). Clicking with the left button will center any box on the cursor position.

6.2 Different Display Modes

As well as displaying images the “Display Type” button in the lower part of the window allows you to display the FITS header, merged columns or rows of the image (Spectra A, B), histograms, linecuts through the image, or image statistics. Here we will only mention the commonly used NSFCAM modes: image, header and xlinecut.

Selecting “Header” as the display mode will present the FITS header for the currently active canvas. We suggest you put this display into the #4 canvas, which enables you to see almost the entire header in one glance. Use the horizontal and vertical scroll bars to view the edges of the frame.

To perform a linecut through the image, display the image in one canvas, select another canvas and the “xlinecut” display option, and point that canvas to the same data buffer as the image. Go back to the image display; draw a line in the image where you want the line cut, such as over a star. To draw a line, hold down the shift key, then click and drag the middle mouse button. Select the canvas where the line cut will be displayed. To the lower left of the DV window, click on 'Set Endpoint from Line', and the line cut should appear. If you want to get a seeing estimage, draw a line over the star, display the line cut, then choose 'Gaussian fit'. This will give the FWHM in pixels.

6.3 Mathematical Operations

The "Math" tab on the bottom of the DV window allows mathematical operations (+ - * /) to be performed on the eight data buffers. You can also copy buffers, clear buffers, and rotate the images.

6.4 Telescope Offsetting

Clicking on "TCS Offset" allows you to select "TCS coordinates". This is a very useful way of offsetting the telescope. Ensure that the "Angle" and "Plate scale" values are correct for your chosen lens and orientation of NSFCAM (angle is the location of North measured clockwise from straight up on the DV display - it should be 0 unless you have requested that the camera be physically rotated at the telescope). Place the cursor on the current position of an object in the frame, click with the left button, and hit "f" (for "from"). The x and y values should be read into the TCS window. Move the cursor to the desired position, click and hit "t" (for "to"), or type in the desired x,y coordinates in the frame (for example 128, 128 to put an object in the center of the array). An easier way is to draw a line from where the star is to where you want it to go. You can draw a line by holding down and dragging the middle mouse button while pressing the shift key. Check that the offsets that are calculated are reasonable, then click on 'Offset telescope'. It is recommended to take a brief image to verify that the telescope moved as expected before taking data.

6.5 Reading and Saving Images

The "File" button on the top of the DV window allows you to read in a previous image to a buffer and display it, and also allows you to save a buffer.

Section 7: Target Acquisition and Off-axis Guiding

Targets are usually visually acquired using the on-axis TV camera. A mirror is put in and out of the beam by the operator. Targets need to be brighter than 17 in the red to be seen on the TV. After a large slew the operator may check pointing by going to a nearby bright star. The operator will then offset from that star to the target coordinates. If the target is visible, the operator will center it in the guider crosshairs, then remove the guider from the center of the beam. If the target is not visible, then the operator will remove the guider to allow the observer to verify that the target is in the field of view.

The TV camera can also be used as an offset guider for optical guiding during an integration. The guider has a field of view that is a U-shape (open at the north) with an inner radius of X" and an outer radius of Y". If you want to use off-axis guiding for a target, please inform the operator, who will find an off-axis guide star for you and start guiding.

Section 8: Calibration

8.1: Non-linearity

8.2: Standard stars

For observations at JHKL'M', the UKIRT Faint Standards list provides an excellent source of standard stars. These stars have been observed through the MKO filters, and their magnitudes are in the MKO photometric system. The UKIRT faint standard star list is here: http://www.jach.hawaii.edu/UKIRT/astronomy/calib/phot_cal/fs_izyjhklm.dat.

8.3: Flat fields

The sky background is usually high enough that, with an appropriate dither pattern, a 'sky flat' can be made from the science data itself. However, this is not a 'true' flat since thermal glow (at K band and longer) is an additive and not a multiplicative effect. A sky flat is usually sufficient for data reduction, but is necessary a proper flat can be made to take into proper consideration the thermal glow. At short wavelengths, or with narrow filters, the sky may not be dark enough or it may take too long to take sky-noise limited images. In this case, twilight or dome flats may be taken.

Section 9: XUI Macros

Where the macros live

The marcos are currently put in /home/nsfcam2/NSFCAM2/bin

How to edit a macro

There are several ways to edit a macro. First, you can edit the macro as a plain text file in a text editor, such as VI or emacs, Second, there is an 'Edit' button towards the bottom of the macro tab. Click on a macro, then click on the edir button. This opens a new window with a text editor for the selected macro.

Using the dither widget

It is common for observers to want to do a simple dither pattern when observering. Click on the 'Edit Dither' button to open a pull down menu. The options are "Edit Dither' and 'Do Dither'. In 'Edit Dither', the user can choose between a range of dither patterns(5 point, 3x3, 5x5, 9x9, square or circular patterns), and specify the offset between dither positions. Clicking on 'Save&Go' will immediately execute the dither pattern. 'Just Save' will store the dither pattern, which can later be executed with the 'Do Dither' button. Note: The dither offsets are relative to the telescope base position. If you offset the telescope to position an object in the field of view but do not zero the offsets, the dither pattern will start from the position before the offset. To dither from an offset location, you need to zero the user offsets in t3remote by clicking on the 'new base' button in the offsets tab. However, zeroing these offsets may cause the off-axis guider to loose its guide star.

The Function Buttons

Up to four macros can be assigned to the function buttons. To do this, click on a macro. Next to the 'm.setbutton' button, there is a pull down menu which has the numbers of the function buttons. From that menu, choose the number of the function button that you want to assign the macro to, then click on 'm.setbutton'. The name of that macro will appear in the function button, and pushing that function button will execute the macro.

Section 10: End of Night Procedure

At the end of the night, you must blank off either the filter whee or the CVF wheel. In the 'setup' menu, change the well depth to 'none', and un-check the 'enable TCS interaction' button. At this point, the instrument is safe. You do not need to quit or disconnect the XUI. The final step is to log out of the XUI, then quit your local VNC client.

Section 11: Troubleshooting

11.1 Dummy's Guide to NSFCam Troubleshooting

This is a checklist to do a Level 1 restart (described in detail below)

Symptom: There is a problem. Clicking on buttons (such as the setup tab) in the GUI still works.
Procedure:

1) Hit 'QUIT' in the upper right corner of the GUI. This will kill the GUI and also kill the terminal window that started the GUI.
2) Click on the 'NSFCam Client' button on the desktop. This will start a new terminal, and bring up a new GUI
3) Hit 'Connect' in the upper right corner of the GUI.
4) In the 'Setup' tab, set well depth to previous setting. Enable motor control and wait until motor positions come back and motor statuses are green. Enable TCS interaction

Symptom: There is a problem. Clicking on buttons (such as the setup tab) in the GUI does <u>NOT</u> work.
Procedure:

1) Move the NSFCam GUI to the side, to show the terminal behind it that started the GUI.

2) Click on the ‘x’ in the upper right corner of the terminal window to kill the terminal. The GUI should die at this time as well.
3) Click on the ‘NSFCam Client’ button on the desktop. This will start a new terminal, and bring up a new GUI
4) Hit ‘Connect’ in the upper right corner of the GUI.
5) In the ‘Setup’ tab, set well depth to previous setting. Enable motor control and wait until motor positions come back and motor statuses are green. Enable TCS interaction

11.2 Overview

NSFCam has seven elements:

- GUI
- ICSERVER (ICSERV)
- IARC SERVER (IARCSERV)
- DSP on ARC Controller (EMBEDDSP)
- TNAMESERV
- TEMPERATURE CONTROL SERVER (TEMPSERV)
- MOTOR CONTROL SERVER (MCSERV)

The EMBEDDSP runs on the ARC electronics on the camera. The GUI, ICSERV, IARCSERV, TNAMESERV, TEMPSERV, and MCSERV all run on the PC. There relationships (with respect to communications) is below:

ICSERV, IARCSERV, TNAMESERV, TEMPSERV, and MCSERV are all installed as system services on nsf2pc. This means that if you run them as root you can stop and start them using "`/sbin/service SERVICENAME stop`" and "`/sbin/service SERVICENAME start`"

The corresponding service names are (SERVICENAME is in fixed font):

ICSERV - `nsfcam2_iarcserverd`
IARCSERV - `nsfcam2_iarcserverd`
TNAMESERV - `nsf2tnameserv`
TEMPSERV - `nsf2tempd`
MCSERV - `nsf2smd`

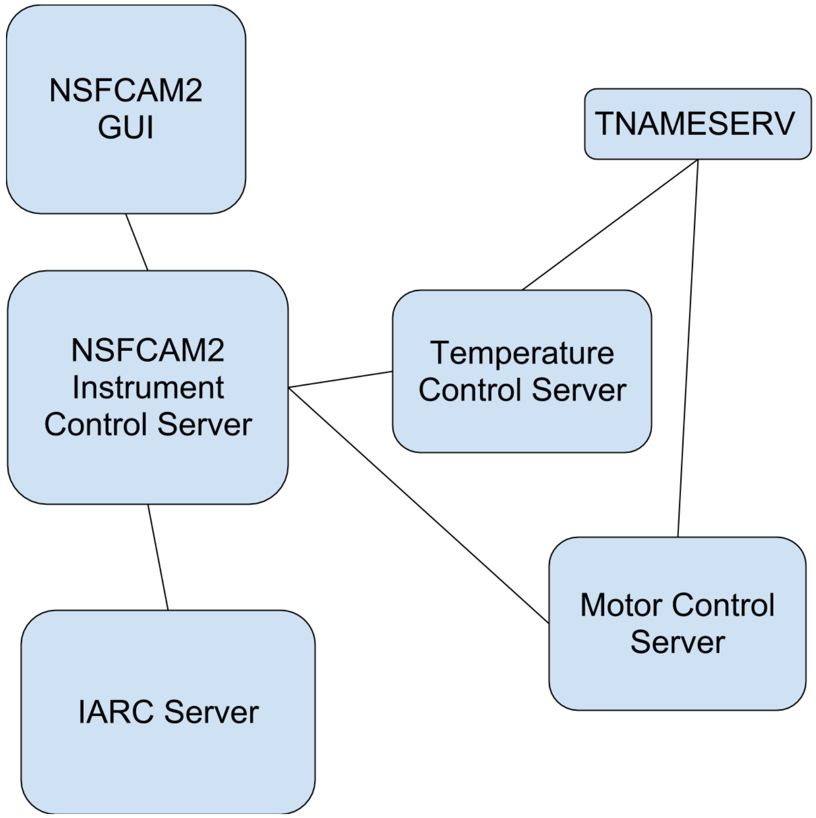

Figure: Diagram illustrating the communication between the different components of the NSFCam system.

11.3 SETUP

This assumes that the PC has just been booted and is up. These systems will be migrated to come up automatically, but until then, here are the instructions.

11.3.1 Bring up peripheral systems

1. Start TNAMESERV by running, as root, "/sbin/service nsf2tnameserv start"
2. Start TEMPSERV by running, as root, "/sbin/service nsf2tempd start"
3. Start MCSERV by running, as root, "/sbin/service nsf2smd start"

11.3.2 Bring up camera systems

1. Cycle power on the ARC electronics. Using wtipm, get the status of the outlets. Turn off Array_Power and Jump_pc, then turn on Array_Power and Jump_pc.
2. Start IARCSERV by running, as root, "`/sbin/service nsfcam2_iarcserverd start`"

11.3.3 Start GUI & ICSERV

1. Click the "NSFCAM2 Client" icon on the nsfcam2 user Desktop. This should start both the ICSERV and GUI.

11.4 TROUBLESHOOTING

Most problems will involve the GUI, ICSERV, and IARCSERV. TNAMESERV, TEMPSERV, and MCSERV are all peripheral services. The troubleshooting has been divided into different levels of problems.

11.4.1 LEVEL 1: GUI/ICSERV

The GUI and ICSERV are closely tied. To restart the GUI, the ICSERV must also be restarted. To restart the ICSERV, use the commands:

1. `/sbin/service nsfcam2_icserverd stop`
2. `/sbin/service nsfcam2_icserverd start`

However, the start up script associated with the "NSFCAM2 Client" on the nsfcam2 desktop has a ICSERV stop and start built in. This should make restarts very simple and straightforward.

11.4.2 LEVEL 2: GUI/ICSERV/IARCSERV

Level 2 is similar to Level 1, but involves an error with the IARCSERV as well. An IARCSERV error can either come from three sources:

1. IARCSERV software error: the IARCSERV software has failed in some way and needs to be restarted.
2. PCIe Card error: the PCIe interface card is in an errored state and can't be reset by restarting the IARCSERV software.
3. ARC Controller error: the ARC Controller is in an errored state, and can't be reset by restarting the IARCSERV software.

It can be very difficult to determine which of these three sources is causing the error condition. In the interests of both expediency and completeness, Level 2 is split into Level 2A and Level 2B. If Level 2A does not result in a working system, Level 2B must be performed.

11.4.2.1 Level 2A

1. Cycle power on the ARC electronics. Using wtipm, get the status of the outlets. Turn off `Array_Power` and `Jump_pc`, then turn on `Array_Power` and `Jump_pc`.
2. Restart the IARCSERV by running "`/sbin/service nsfcam2_iarcserverd stop`" then "`/sbin/service nsfcam2_iarcserverd start`"
3. Perform a LEVEL 1 recovery.

11.4.2.2 Level 2B

NOTE: Experiences using the ARC Controller with MIRSI often required a PC reboot. Level 2B represents a similar error condition. This condition has not occurred in our experiences with the ARC PCIe card, but if it does occur, it requires a reboot of the PC. For MIRSI, it occasionally required MULTIPLE reboots to clear the error condition, and on occasion for the power plug on the PC to be pulled, a ten second wait, then reapplied, then MULTIPLE reboots after that. MIRSI, however, used a PCI card, whereas the IRTF ARC systems use a PCIe card that seems much more reliable.

1. Reboot nsf2pc
2. When nsf2pc has booted, perform a PERIPHERAL SYSTEMS RECOVERY
3. Perform Level 2A.

11.4.3 PERIPHERAL SYSTEMS RECOVERY

The only time the TEMPSERV or MCSERV have required recovery have been when power or network connectivity to
temperature control or motor control systems has occurred. This is generally unlikely, however if either system needs to be recovered, both should be reset.

Restart TNAMESERV by running, as root, "`/sbin/service nsf2tnameserv stop`", then "`/sbin/service nsf2tnameserv start`"
Restart TEMPSERV by running, as root, "`/sbin/service nsf2tempd stop`", then "`/sbin/service nsf2tempd start`"
Restart MCSERV by running, as root, "`/sbin/service nsf2smd stop`", then "`/sbin/service nsf2smd start`". Once this has been restated, home the mechanisms.

Section 12: Dictionary of NSFCam Commands

absubenable STR: turns subabenable on/off
autosave STR: turns autosave on /off
beammode:
coadd N: sets the coadd count
cvf STR F: set cvf to position STR, if STR is an actual CVF (cvf1, cvf2, cvf3), F is wavelength. For example: 'cvf cvf2 4.00', or 'cvf polarizer'
cycles N: sets the cycles
dv
dv1host
dv1port
dv1enable
dv2host
dv2port
dv2enable
expmode STR: sets readout mode: arc_s, arc_d, sur
filename STR: sets file name
filenum N: sets file number

filter STR: set filter to STR
fitscomment STR: sets fits comment in fits file
fitsobject STR: sets fits object in fits file
fitsobserver STR: sets observer in fits file.
go: Starts an integration or series of integrations. Same as hitting the 'go' button
itime F: sets integration time, pedestal readout time should be included
m.wait N: insert a wait of N seconds
obsmode:
polarizer STR: set polarizer to STR: 0, 22.5, 45, 67.5, 90, 180, 270
savedatapath STR: sets data path
stop: Stops the current series of integrations. Same as hitting the 'stop' button
tcs STR: send STR to tcs

Chapter 13: Known Limitations, Common Problems, and Gotchas

13.1: CVF crash

This is a rare bug that we have been unable to reproduce. The NSFCam GUI software can crash when the user selects a custom CVF position. The crash happens when the user selects 'custom', which brings up a dialog box where the user can enter a wavelength. When the software crashes, the user cannot push buttons in the GUI. The recovery from this crash is a Level 1 restart.

13.2: Image orientation

Currently (May 2013), the image is not oriented north=up east=left. The default image orientation is north=right east=down, which is both rotated and flipped from the preferred orientation. Software is being tested to flip the image.

13.3: Negative Image

In raw and single readout mode, the image is a 'negative', i.e. more light results in lower counts. This is a result of how the array electronics detect photons. Each pixel is electrically like a capacitor, which gets charged to a certain voltage when the bias is set. Photons cause the voltage of the capacitor to decrease. This voltage is then readout and converted to a count value ADUs. It is important to be able to see the raw output from the detector for engineering purposes, which is why this 'feature' hasn't been changed. There are a few ways to deal with this:

1) Don't do anything. When doing an AB beam switch pair, the result is that which beam has the positive image and which beam has the negative image is switched from what would normally happen in double read mode.
2) Instead of C=A-B, do C-B-A. This flips things back the right way around.

Chapter 14: The FITS header

TELESCOP: NASA InfraRed Telescope Facility
INSTRUME: NASA IRTF's NSFCAM2
PXLSPD : IARC pixel speed
TC1: Array Temp
TC2: 2nd Stage Temp
CMMNT: Comment (set by observer)
TM1: TM1 Temp
TM2: TM2 Temp
TM3: TM3 Temp
TM4: TM4 Temp
ITIME: Integration time
READTIME: Time to complete a single read
OBJECT: Object (set by observer)
OBSERVER: Observer
GAIN: Controller Gain
BIAS: H2RG Bias Voltage
FLTWHL: Filter wheel position
CVFWHL: CVF wheel position
WAVEPLAT: Waveplate position
POLARIZR: Polarizer position
TBEAM: TCS BEAM
NDR: NDR (non-desctructive reads) count
IMGCNT: Image Count
RDOUTN: Readout number
COADD: Coadd Count
PIXELT: Pixel Time in microseconds
ITNDRS:
RDTIME: Time for single read
PATH: Data Path initially written
FNAME: Filename initially used
FNUM: Filenumber initially used
VOFFSET: IARC preamp offset in counts
VDD: IARC VDD in mV
VDDA: IARC VDDA in millivolts
VBG: IARC VBG in millivolts
VBP: IARC VPB in millivolts
VDSUB: IARC VDSUB in millivolts
VRST: IARC VRST in millivolts
TIME_GPS: system time readout started
DATE_OBS: system date
DIVISOR: DIVISOR (coadds * NDRs)
TOBJECT: TCS OBJECT
TCSCMNT: TCS COMMENT
TOBSRVR: TCS OBSERVER

TDISPRA: TCS DISP RA
TRA: TCS RA (decimal radians)
TDEC: TCS DEC (decimal radians)
THA: TCS HA (decomal radians)
TAIRMAS: TCS AIRMASS
TEPOCH: TCS EPOCH
TSTIME: TCS STIME
THST: TCS HST
TMOVING: TCS MOVING
T3MJDUTC: TCS3 Parameter, MJD UTC
T3MJDLOC: TCS3 Parameter, MJD LOCAL
T3_LAST: TCS3 Parameter, UTC LAST
T3_T_RA: TCS3 Parameter, TARGET RA (decimal radians)
T3_T_DEC: TCS3 Parameter, TARGET DEC (decimal radians)
T3_PMRA: TCS3 Parameter, PMRA
T3_PMDEC: TCS3 Parameter, PMDEC
T3_EPOCH: TCS3 Parameter, EPOCH
T3_EQUIN: TCS3 Parameter, EQUINOX
T3_CS: TCS3 Parameter, CS
T3_MNRA: TCS3 Parameter, MEAN RA (decimal radians)
T3_MNDEC: TCS3 Parameter, MEAN DEC (decimal radians)
T3OSTRA: TCS3 Parameter, OS TOTAL RA
T3OSTDEC: TCS3 Parameter, OS TOTAL DEC
T3OSURA: TCS3 Parameter, OS USER RA
T3OSUDEC: TCS3 Parameter, OS USER DEC
T3USEREN: TCS3 Parameter, OS BEAM ENABLE
T3OSBRA: TCS3 Parameter, OS BEAM RA
T3OSBDEC: TCS3 Parameter, OS BEAM DEC
T3OSBMEN: TCS3, OS BEAM ENABLE, 0 = A beam, 1 = B beam
T3OSSRA: TCS3 Parameter, OS SCAN RA
T3OSSDEC: TCS3 Parameter, OS SCAN DEC
T3OBSRA: TCS3 Parameter, OBS RA (decimal radians)
T3OBSDEC: TCS3 Parameter, OBS DEC (decimal radians)
T3OBSHA: TCS3 Parameter, OBS HA (decimal radians)
T3AIRMAS: TCS3 Parameter, AIRMASS
T3OBSZEN: TCS3 Parameter, OBS ZENITH
T3OBSAZI: TCS3 Parameter, OBS AZIMUTH
T3PARANG: TCS3 Parameter, PAR ANGLE
T3C2FDP : TCS3 Parameter, C2 FOCUS DPOS
T3C2FAP : TCS3 Parameter, C2 FOCUS APOS
T3C2FEN : TCS3 Parameter, C2 FOCUS ENABLE
TCS_OBJ : TCS3 Param, Object
TCS_MAG : TCS3 Param Magnitude
TCS_AIRT: TCS3 Param Air Temp

TCS_HUM : TCS3 Param Humidity, percent
TCS_WSP : TCS3 Param Wind spd, mph
TCS_WDIR: TCS3 Param Wind dir, deg
TCS_TD6 : TCS3 Param Dome temp TD6

Chapter 15: Appendices

Section 1: Instrument Performance

1.1 Read noise
1.2 Sky brightness
1.3 Limiting magnitudes
1.4 Magnitude zero points