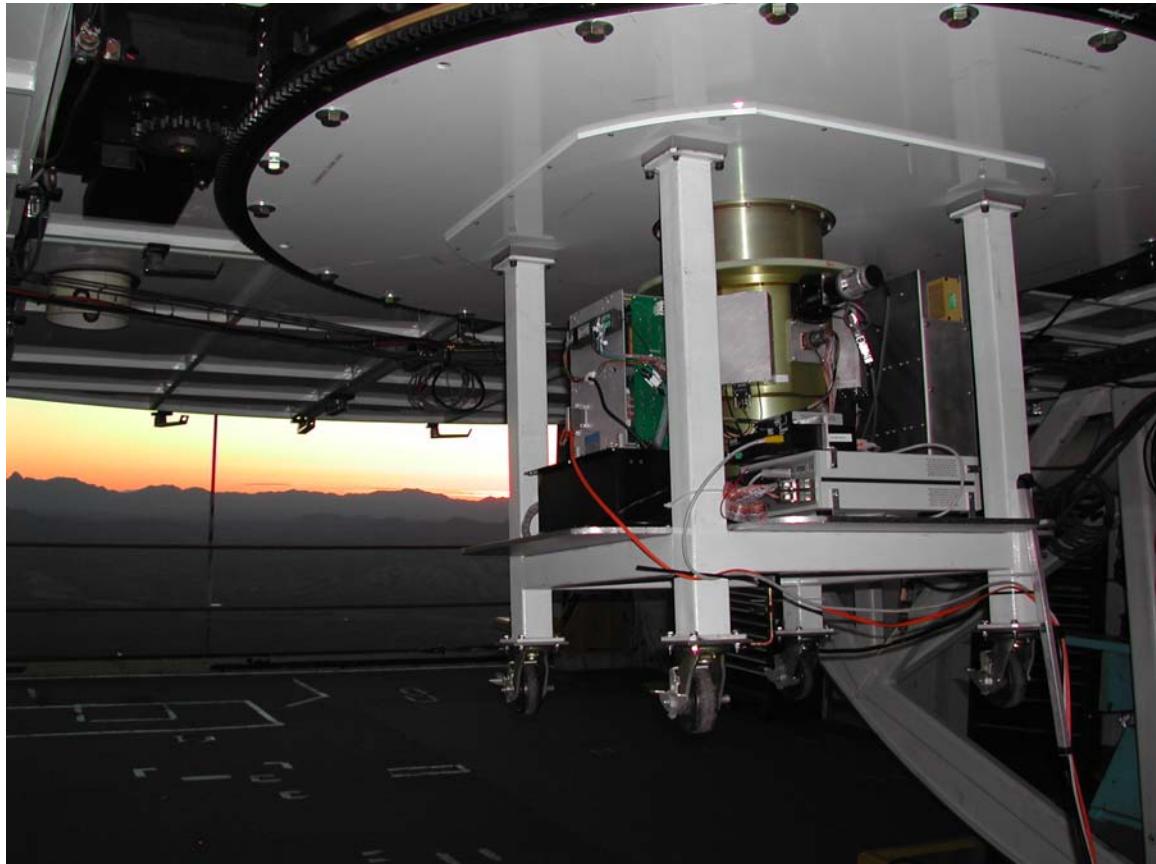


SAO Wide-field InfraRed Camera

(SWIRC)

Observer's Manual



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I. The SWIRC project

The SAO Widefield InfraRed Camera (SWIRC) operates at the f/5 focus of the MMT. Proposed in May 2003 and commissioned in June 2004, the goal of the instrument was to deliver quickly a wide field-of-view instrument with minimal optical elements and hence high throughput. Throughput is 2.5-3 times that of FLAMINGOS on the MMT. The trade-off was to sacrifice K-band capability by not having an internal, cold Lyot stop.

SWIRC has three science filters: Y-band ($1.02 \mu\text{m}$), J-band ($1.2 \mu\text{m}$), and H-band ($1.6 \mu\text{m}$) plus a dark slide. The instrument is based on a 2048x2048 pixel HAWAII-2 detector; its 0.15 arcsec/pixel plate scale fully samples the best seeing at the MMT, and provides a field of view of 5.12×5.12 arcmin. The user-interface operates under the MICE environment, similar to Megacam and other f/5 instruments developed at SAO. An exposure time calculator, data reduction software, this manual, and other information is available from SWIRC's homepage:

<http://www.cfa.harvard.edu/mmti/swirc>

SWIRC was made possible by significant efforts from the following people.

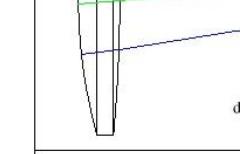
Principal Investigator:

Dr. Warren Brown

Co-Investigators:

Mr. Stephen Amato, Dr. Matt Ashby, Ms. Emily Bowsher, Dr. Giovanni Fazio, Dr. John Geary, Dr. Joe Hora, Dr. Brian McLeod, Dr. Tom Megeath, Dr. Michael Pahre, Dr. Andy Szentgyorgyi, Dr. Steven Willner, Mr. William Wyatt, Mr. Joseph Zajac

II. Instrument Characteristics

Secondary:	f/5	 <p>3D LAYOUT</p> <p>CAF2 / INFRASIL DOUBLET TUE JUL 1 2003</p>
Detector:	2048 x 2048 pix, HgCdTe Hawaii-2	
Pixel scale:	0.1500 arcsec/pix	
Field-of-view:	5.12 x 5.12 arcmin ²	
Electronics gain:	4.0 e-/DN	
Read-noise:	31 e-	
Full well:	~190,000 e-, or 48,000 DN	
Linearity:	Linear to 40,000 DN (linear to better than 0.1%)	
Dark current:	16 e-/s/pix	
Bias drifts:	The bias changes by 400 DN over 20 sec, <i>thus darks must be taken for every exposure time <20 sec.</i>	

Detected electrons for 15th mag star (Vega-relative):

Y-band: 26,000 e/s
 J-band: 33,000 e/s
 H-band: 37,000 e/s

Sky background:

Y-band: $650 \text{ e-/s/pix} = 14.9 \text{ mag/arcsec}^2$
 J-band: $470 \text{ e-/s/pix} = 15.5 \text{ mag/arcsec}^2$
 H-band: $2600 \text{ e-/s/pix} = 13.7 \text{ mag/arcsec}^2$

Exposure time for sky to reach 20,000 DN (half the linear regime): Y 90 sec, J 120 sec, H 20 sec.

Distortion: Very small

None between quadrants; very little in channels within a quadrant.

Flat-fieldin

Channel 4.5 suffers from RMS=19 DN bias variations.

Cosmetics:

High dark-current region in upper corners. The "scratch" and spot"

Cosmetics.

High-dark-current region in upper corners. The scratches on the cosmetics mask out well.

COSMETICS MAKE OUT WELL.

Images with the Hawaii-2 are taken by differencing a pair of non-destructive reads. There is no shutter in SWIRC; rather, each line is cleared before being read the first time. The Hawaii-2 is put in a continuous clear mode in-between exposures.

Readout: 32 channels; 8 channels per quadrants.

Readout time: 0.7 sec per readout; ~5 sec total overhead per exposure.

Exposure times: Must be integer seconds ≥ 1 sec.

Filters: Y, J, H, and dark position D1.

Filter focus offset from wavefront sensor focus: H = 0 micron, J = -40 micron, Y = -80 micron.

III. Quick Start

Introduction:

MICE (= MMT ICE) is a graphical interface for observing with SWIRC, very similar to that used for Megacam, Hectospec, and Hectochelle. MICE allows you to control filters, exposures times, and dither sequences, and is run on the computer “clark.” Status displays monitoring the telescope and instrument are provided on the monitor (“hudson”) located above clark.

To observe on clark:

1. Log into clark.mmt.arizona.edu with username **swirc** (password located in the drawer).
2. At a UNIX prompt run **go.go** to bring up the MICE interface and status display windows.
3. On the MICE Startup tab, click the buttons in order, waiting 15 seconds between each button press to give the servers time to initialize.
4. Click the “Standard Ops” or the “Catalog Ops” tab.
5. Select your exposure time, filter, and optionally a dither catalog.
6. Start observing!

At the end of each night:

1. Fill SWIRC dewar (takes ~10 minutes).
2. Note that images are automatically archived via ftp to the CfA, and will be available to the user at the end of the run.

Details on observing:

Section IV gives tips for observing at the MMT.

Section V discusses MICE in detail.

Section VI gives troubleshooting advice.

IV. Tips for Observing at the MMT

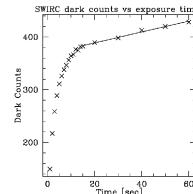
1. Getting Started

- a) **Password:** located in the drawer under the table at the observer station.
- b) Use the machine “hudson” to display status windows: press the button on the blue KVM box, located under clark’s monitors, to transfer keyboard & mouse control between clark and hudson.
- c) Data on “lewis” and “clark” are located at: **/data/ccd/SWIRC/<year>.<date>**

2. Calibrations

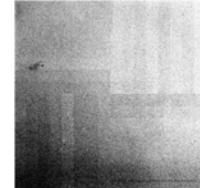
a) Darks:

- i) I recommend taking darks for each exposure time that you use.
- ii) You can take darks in the afternoon.
- iii) The darks are temperature sensitive, so make sure that the instrument has been powered on for at least 2 hours (ambient chip temp is 82 to 84 K).
- iv) Throw away the first 2 or 3 darks in a sequence. Amps on the HAWAII-2 device warm up when used, thus the first few darks have spurious statistics until the chip has equilibrated to the cadence of exposures you are taking.
- v) At the end of a night, you can create a script to take n darks for every exposure time by running the command `~/bin/darkscript.sc n` in the current data directory:
- vi) In Catalog Ops, load “dodarks.cat,” select object type “dark,” set the last number appropriately, and press “Go.”



b) Flats:

- i) Flats are done as sky flats.
- ii) Sky flats are taken in a 10 minute window starting ~5 minutes after sunset (or before sunrise).
- iii) Use object type “object” and change the rootname to skyflat.
- iv) Select a filter and set exptime to 1 second.
- v) The J and H filter come out of saturation around the same time. Y-band is last.
- vi) Saturating does not harm the detector.
- vii) Take ~10 exposures in each filter, once the images are no longer saturating.
- viii) Make sure telescope tracking is on during sky flats, and OFFSET between exposures
- ix) You can probably get 10 flats for each filter in the time available.



3. Typical Observing Procedure

- a) Take darks.
- b) Let the operator know you want to take sky flats (so the telescope is ready to go at sunset).
- c) Take sky flats.
- d) Go to your first target.
- e) About 45 min after sunset, it is dark enough to use the wavefront sensor to focus the telescope.
- f) Optional: you can more exactly align the optical axis to the center of SWIRC
 - i) Take a short exposure with SWIRC.
 - ii) Open the “fix pointing” task under the “Observe” menu on ds9.
 - iii) Drag the red “current” circle onto the star.

- iv) Click “OK” for a hexapod move.
- v) Ask the operator to write down this offset and apply it in the future, otherwise the next wavefront sensor focus will eliminate the offset.
- g) Go to your target.
- h) Ask the operator to track North (for SWIRC: 180 in the South, 0 in the North).
- i) Be sure to tell the operator to set focus for your current filter.
- j) On the Standard Ops tab select object type “setup” and take a pair of offset exposures in order to check focus and peak counts on your targets (the array is linear up to 40,000 counts).
- k) Note that the difference of the current and previous image is automatically displayed to ds9 frame 2; the current image is in frame 1 (press tab to cycle between the two ds9 frames).
- l) On the Catalog Ops tab, select object type “object” and with a dither catalog.
 Note: Total overhead between exposures is ~5 seconds (this includes the time for the double-correlated read, file handling, and telescope dither). Longer exposures will increase your observing efficiency, but watch out for good seeing saturating your objects.
- m) If you repeat dither patterns, offset the central pointing in RA/DEC coordinates with the paddle tool:



4. Focus

- a) A wavefront sensor focus is generally required:
 - i) if moving to a different part of sky,
 - ii) if the temperature changes by more than 1 degree C, or
 - iii) if more than a couple hours has elapsed since the previous wavefront focus.
- b) A wavefront sensor focus takes ~10 minutes, which is a significant investment of time.
- c) Monitor the FWHM and PSF shape of stars in your images as they are displayed in the ds9 window. If the PSF no longer looks peaked, or the FWHM changes substantially, you require a wavefront sensor focus.
- d) Remember, each filter has a focus offset from the wavefront sensor: 0 for H, -40 for J, and -80 for Y.

5. Lightening Protection

- a) Turn off instrument power: press the switch on the black power strip to the OFF position.
- b) Physically unplug the power cord on the cable drape.
- c) Unplug the ethernet cord from the black EDAS box on the instrument.

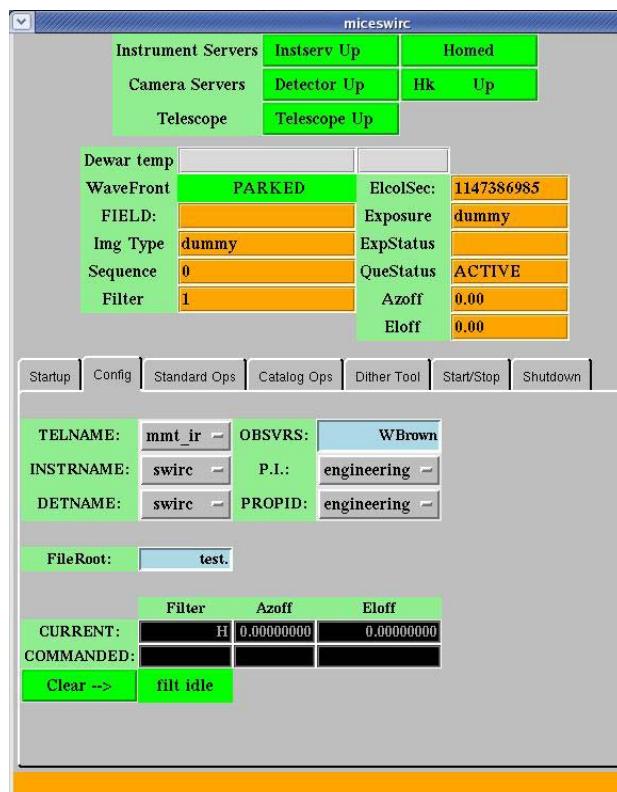
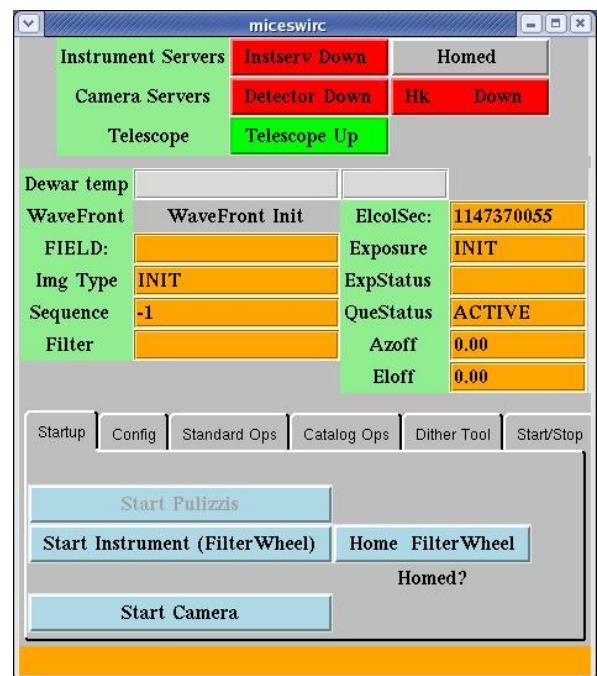
6. Maintenance

- a) **Refill the dewar each morning!**
- b) Filling dewar takes ~10 minutes.
- c) The dewar is very messy; the dewar is not full until a good fountain of LN₂ comes out.
- d) The fill tube has a quick release connector that freezes; wait ~10 minutes before removing it.
- e) Replace the little red cap onto the fill tube to prevent ice build-up on the fill tube.
- f) Dewar hold time is 36 hours with the power on; 48 hours with the power off.

V. How to Use the “MICE” Interface and Dither Catalogs

STARTUP

1. To reset the image sequence number to 1, run “resetseq” before starting Mice.
2. Run **go.go** or **domice** to start a Mice window.
3. Mice will start you in the “Startup” tab.
4. If the instrument has been turned off, or if the software servers are down, press the buttons
 - a) “Start Instrument”
 - b) “Home Filter Wheel”
 - c) “Start Camera”
- * Wait ~15 sec between each button press *
5. Note that the area above the “Startup” tab and the other tabs is for status displays; no information can be entered in those boxes.



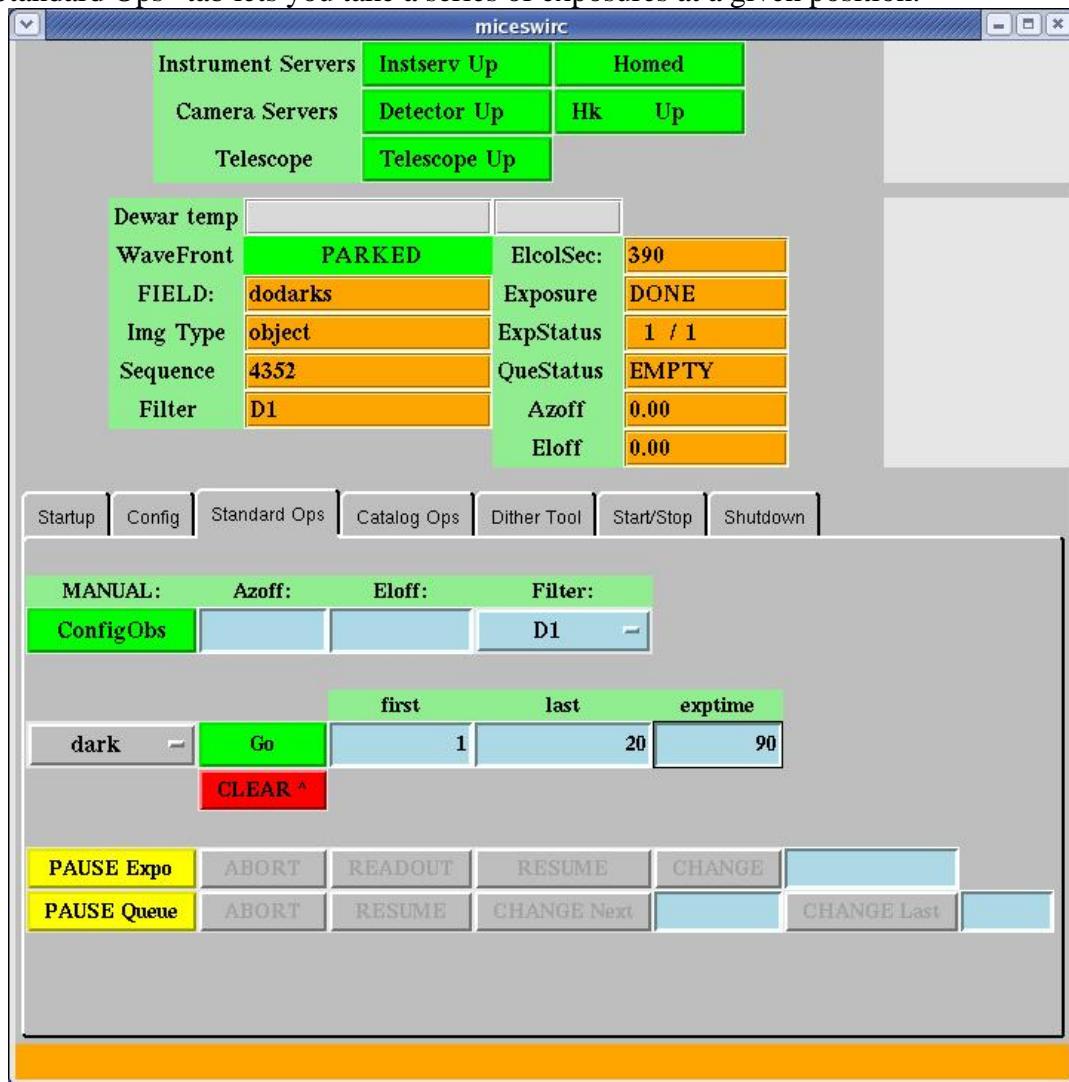
CONFIG

1. TELNAME should be set to “mmt_ir” to enable communication with the telescope.
2. INSTRNAME and DETNAME should be set to “swirc.”
3. OBSVRS must be filled in by the observer.
4. P.I. and PROPID are selected from pull-down menus.
5. The FileRoot is automatically taken from the MMT catalog object, but can be manually edited here.

Note that images are titled **fileroott.####.fits** and are located in /data/ccd/SWIRC/year.date, where year.date looks like 2006.0924.

OBSERVING

The “Standard Ops” tab lets you take a series of exposures at a given position.



To observe,

1. Select the Filter from the drop-down menu.
2. Clicking the “ConfigObs” button will immediately change the filter, otherwise the selected filter will be moved into position at the beginning of the next observation.
3. The drop-down menu on the lower left selects what type of image to take. Science images should be “object.” Selecting “dark” will automatically move the filter wheel to a dark position and name the fileroot dark.
4. Enter in the first and last numbers of the sequence.
5. Enter in the exposure time.
6. Press the green “Go” button to start.
7. BEWARE THE POP-UP WINDOW: type the object title and press return to start the sequence.
8. If you want to pause, abort, or change the length of the sequence, press the yellow “PAUSE Queue” button and then take the appropriate action with the buttons at the bottom of the screen.
9. Pause Expo does not work with SWIRC (the instrument has no shutter)!

DITHERING

Very similar to the “Standard Ops” window, “Catalog Ops” allows use of a dither catalog. This is how you normally observe with SWIRC, and the part of Mice you will be using the most.



1. Clicking on the DitherCat button allows one to load a dither catalog. Alternatively, clicking DitherCat and then Cancel will remove the current dither catalog.
2. If the filter is not specified in the dither catalog, select a filter with the drop-down menu.
3. If exptime is not specified in the dither catalog, enter in the exposure time
4. The “first” and “last” set the number of images to take. Setting “first=1” and “last=9” will do the first 9 positions in a dither catalog, for example.
5. Press “Go” to start the dither sequence; “Pause Queue” works the same as before.

Other points:

6. The “Title “ button allows you to enter the title (located in the .fits image header) before a sequence is started, however you will still be asked to confirm the title at the beginning of the next observation.
7. The red “Clear” button may be used to clear a hung exposure, but if you are in such a situation, closing mice and re-starting mice may be a better solution.

DITHER CATALOGS: IMPORTANT INFORMATION

Dither catalogs are starbase tables (<http://www.cfa.harvard.edu/~john/starbase/starbase.html>) with two primary columns: **azoff** and **eloff**.

Do not be confused by the names. Azoff and eloff are in fact offsets in the x- and y-directions, respectively, **in instrument pixel coordinates**. That is, azoff and eloff do not correspond to “azimuth” and “elevation,” nor the cardinal directions “east” and “north,” unless the MMT instrument rotator is set to track north.

The format of the starbase table is a header line titled azoff<tab>eloff, a separator line -----<tab>-----, and then lines with offsets **in units of arcseconds**. **Everything must be separated by tabs**. For example:

azoff	eloff
-----	-----
60	60
-60	60
60	-60
-60	-60

Loading this dither catalog, setting first=1 and last=4, and pressing “Go” will cause SWIRC to take 4 images at the indicated offsets from the catalog position. To take a second series of 4 images with the same dither catalog, but not centered on the catalog position, use the paddle to offset in RA/DEC coordinates (*not* INST coordinates) and then repeat the observation.

To re-iterate, dither offsets are applied in instrument coordinates, and do not alter the angle of the MMT rotator. The operator normally sets the MMT rotator so that it tracks North = up. Thus in normal operation the example dither catalog offsets are purely north-east-south-west. If you wish to map at a different angle, simply tell the telescope operator to have the rotator track at your desired angle (measured in degrees east of north=0).

The filter and exposure time used for a dither sequence are the filter and exposure time set on the MICE window. Alternatively, you can add columns **filts** and **exptime** to set the values yourself. For example:

azoff	eloff	filt	exptime
-----	-----	-----	-----
0	0	H	15
300	0	H	15
0	0	J	10
300	0	J	10

This dither catalog will cause SWIRC to take a 15 sec H-band image ON and OFF source, followed by a 10 sec J-band image ON and OFF source.

To repeat a dither sequence on a slightly offset position, use the paddle tool to offset your pointing in RA/DEC coordinates (not INST coordinates), and then run the dither sequence again.

DITHER TOOL

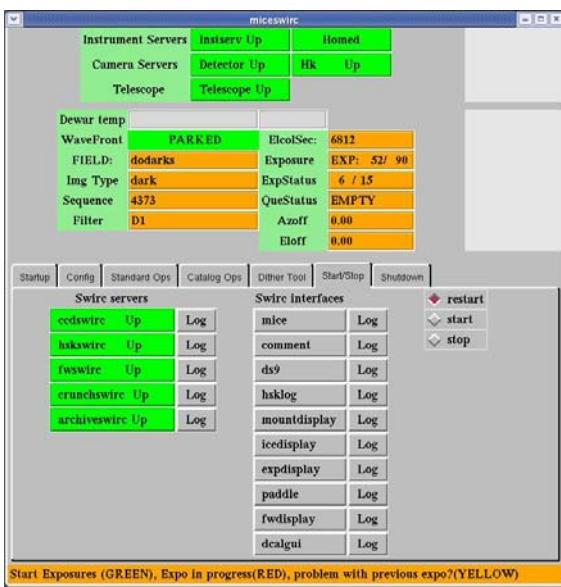
MICE can generate dither catalogs with its “Dither Tool” tab:



- a. Enter the size of the x and y offsets.
- b. Enter the number of x and y offsets.
- c. Enter the desired filter and exposure time **or** leave these blank so that the dither catalog will look to the current values on the MICE window.
- d. Press “Save” and enter the desired filename.
- e. You can now press “View” to review the generated catalog.

START/STOP

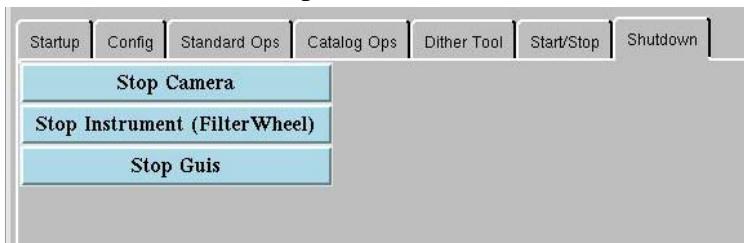
MICE provides you the ability to start and stop *all* of the instrument servers and *all* of the status windows via buttons on the Start/Stop tab. Server buttons are **green** when they are running, **red** when they are not running. Note that green buttons do not necessarily mean that things are working; **if power has been cycled on the instrument, the servers must be re-started**:



1. **ccdwirc** re-starts the detector server and re-initializes the electronics. Use this if the instrument has been turned off and turned back on.
2. **hskswire** re-starts the housekeeping (temperature monitor) server. Use this if the instrument has been turned off and turned back on.
3. **fwwirc** re-starts the filter wheel server. After pressing this, home the filter wheel (Startup tab).
4. **crunchswire** and **archiveswirc** are the two processes that archive images to the local disk farm and to the CfA, respectively.
5. The gray buttons on the right column allow you to re-start any status display window, and MICE itself.

SHUTDOWN

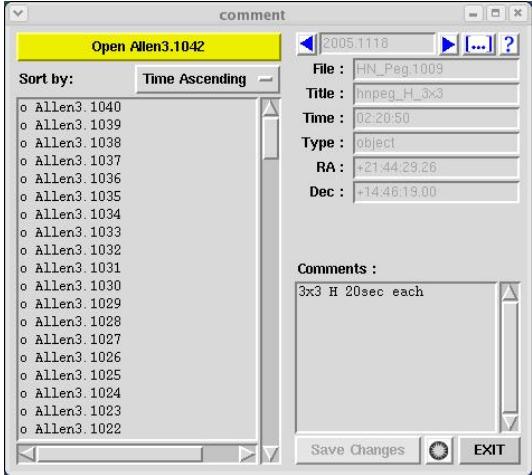
After the *final night* of the SWIRC run, when you are finished taking data and calibrations, use the shutdown tab to stop all of the SWIRC servers, status windows, and processes:



1. Stop Camera stops the detector server.
2. Stop Instrument stops the filter wheel and housekeeping servers.
3. Stop GUIs kills all the status displays.

OBSLOG TOOL

MICE automatically generates an observing log. Use the Obslog Tool to add comments and view the postscript file. Obslog Tool is a stand-alone program that is started when you run “go.go,” or can be started from the Mice Start/Stop tab, or started from the command line with “comment.”



1. To add a comment:
 - a. click a file.
 - b. type the comment in the “Comments” field.
 - c. press the Save Changes button, or click to another file.
2. To generate and view the postscript logfile: press the SAO symbol on the lower right.
3. Note that the log is generated with LaTeX, so avoid unhappy LaTeX symbols (& \ \$).

VI. Troubleshooting

1. Most problems are solved by closing the MICE window and running “domice” again.

Examples of such times are when:

- a) the exposure status says “exposing” or “readout” but nothing is happening.
- b) the “first” and “last” boxes or the “exptime” box are grayed-out (instead of blue), as happens after trying to cancel an exposure.

2. If one, or all three, computers hang, you must physically power-off and reboot the computers.

- a) Talk to the operator for assistance. If you reboot more than one computer, you must first reboot *clark*, wait 2 minutes, then reboot *lewis* and *hudson*.
- b) If *lewis* was rebooted, you must call Maureen Conroy or John Roll (their phone #s are behind the lewis monitors) to configure the computer.
- c) Finally, log into all three computers, run go.go on *clark*, and use the mice start/stop tab to start all the instrument servers (all the red buttons must be green). Home the filter wheel using the mice startup tab before observing.

3. If you have problems starting the instrument servers, the Ethernet connection to the instrument may be down.

- a) Make sure the instrument power is on, and the Ethernet cord plugged in.
- b) Ask the operator to make sure the *cell rack* is on.

4. If the instrument servers are not restarting properly (i.e. the server buttons do not cycle red, then green when re-started; or else they hang yellow), *hudson* may be down. Reboot *hudson*, and then start all the servers fresh.

5. On rare occasion the image readout becomes scrambled or has weird lines. To fix this:
 - a) Cycle the power on the instrument.
 - b) Re-initialize the electronics by pressing the **ccdswire** button on the Start/Stop tab.

VII. Reduction Pipeline

A data reduction pipeline optimized for SWIRC data is available through the link on the SWIRC homepage. Documentation for installing and running the pipeline is also on the web site. The pipeline is designed to run on CfA computers, and may be available on at MMT for the May 2006 run. Observers are responsible for the reduction of their own data, but W. Brown and B. Wyatt are available to consult. We are also interested in feedback, as the pipeline is still being perfected.

The data reduction pipeline runs through the following (rather standard) processing steps:

1. Combine darks for each set of exposure times, throwing away the first 3 darks in a series.
2. Combine flats, scaling on the median sky level, after subtracting darks from each skyflat.
3. Dark- and flat-correct individual science exposures.
4. Group science exposures by target and filter.
5. Create a sky for each science exposure by taking the median of the nearest n exposures.
6. Subtract sky from each science exposure.
7. Check for and possibly remove the bias fluctuation on channel 4.5.
8. Check for and possibly remove the “pinwheel” bias gradient on the quadrants.
9. Solve for the world coordinate system using *imwcs* with the 2MASS point source catalog.
10. Stack a group of science exposures using the WCS and mask file.