MMIRS Observers Manual

Contributors: B. McLeod, J. Bechtold, W. Brown, M. Conroy, F. DiMille, M. Hastie, V. Suc, A. Szentgyorgyi, D. Osip, J. Roll, Y. Beletsky, I. Chilingarian, S. Moran

Last update Nov 2022

Table of Contents

1. Introduction.

MMT and Magellan InfraRed Spectrograph (MMIRS) is a near infrared (NIR) imager and multi-object spectrograph with a 6.9'x 6.9' imaging field-of-view. The focal plane is a 2048x2048 pixel Hawaii-2RG detector with 18 micron pixels which subtend 0.2 arcsec on a F/5, 6.5m telescope. The instrument offers imaging, long-slit spectroscopy through a variety of slit widths, and multi-object spectroscopy over a 4' x 6.9' field of view. Grisms supporting spectroscopy at R=3000, R=2400 and R=1200 are available. The dual guide-probe/wavefront sensor enables continuously updated wavefront sensing. The major subsystems of MMIRS are shown in Figure 1.

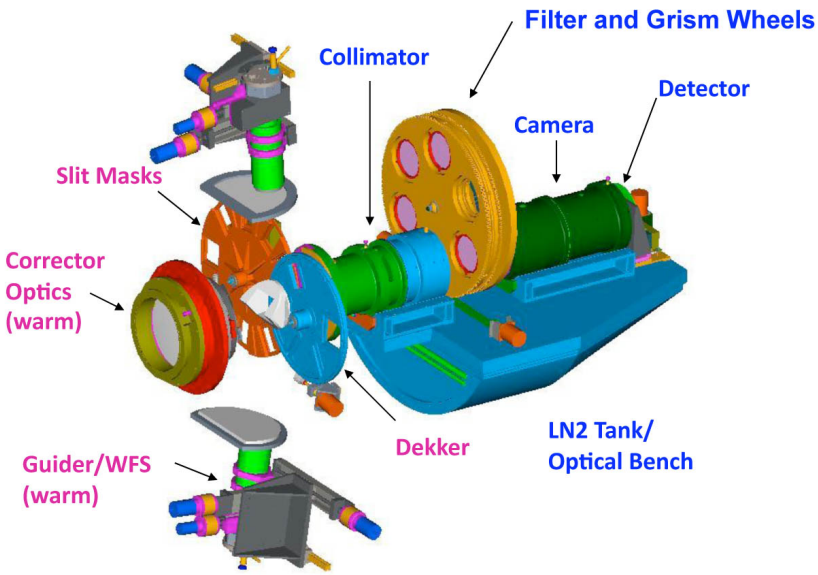


Figure 1 Cut-away CAD drawing of the MMIRS cryotstat components. Major features not shown are the gatevalve and the mask section LN2 tank.

The PI of the MMIRS program is Brian McLeod, CfA. He may be contacted at bmcleod@cfa.harvard.edu. The design, contruction and integration at the MMT and Magellan was the work of CfA scientists and engineers, especially from the SAO Central Engineering Department. MMIRS was constructed with funding from the National Science Foundation, Harvard College Observatory and the Smithsonian Astrophysical Observatory.

Web pages with complementary information about MMIRS are:

http://www.cfa.harvard.edu/mmti/mmirs.html Top level page

http://www.cfa.harvard.edu/mmti/mmirs/instrstats.html This page contains a description of the available filters and grisms.

See also McLeod, et al. (2012) MMT and Magellan Infrared Spectrograph, PASP, 124, 1318, **d/PASP_MMIRS_2012.pdf** Please cite this paper when publishing your MMIRS results.

MMIRS has been operated at both the MMT and the Clay (Magellan 2) Telescope at Las Campanas. It is currently available at the MMT.

2. Description of MMIRS.

MMIRS is a near infrared (NIR) spectrograph and imager that has a passband that extends from Y to K band (0.9-2.4 microns). The science detector is a Teledyne Hawaii-2RG, 2k x 2k, 18 micron pixel HgCdTe detector. The full well is 230,000 e- & the gain is 0.95 e-/ADU. The array is read out through 32 output amplifiers using the Teledyne SIDECAR ASIC controller.

The various modes and functions of MMIRS are selected with a combination of five independent wheels - the Dekker (aperture selection) wheel, the slit/slit mask, aka "MOS", wheel, two filter wheels, and the grism wheel (see Figure 1.). The MMIRS mask wheel has a combination of 9 slots for custom masks, 7 fixed long slits and 1 imaging aperture. The grism wheel can hold up to 5 grisms with one clear slot for imaging. At this time there are five grisms: H+K @ R=1200, J @ R=2400, H @ R=2400, J @ R=3000, and H @ R=3000. This spectral resolution is achieved with a 0.4" slit. The available long slits are 1, 2, 3, 4, 6, 8 and 12 pixels in width (each pixel is 0.2") - See Figure 2. The filter wheels can hold up to 10 filters with one clear slot for imaging. The current complement of filters are Y, J, H, Ks, Kspec plus blocking filters of 1.25-2.5 microns (HK), 1.25-2.34 microns (HK3) and 0.95-1.5 microns (zJ).

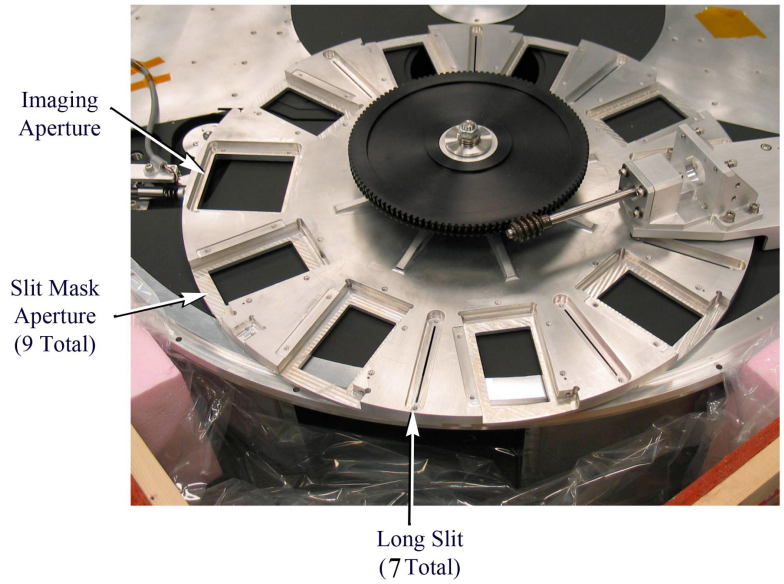


Figure 2 The MMIRS Mask Wheel

MMIRS has two guide/wavefront sensing (GWFS) units. Typically one unit is used for standard guiding while the other probe does continuous WFS and provides guide information for rotator guiding. There is no slit viewing camera.

The MMIRS cryostat is divided into two chambers - the slit mask (MOS) section and the camera section. The two dewar sections are separated by a gate valve. When the masks need to be changed out the gate valve is closed and the mask dewar is warmed up to room temperature using internal heaters The change over of slit masks will be completed by Observatory staff during the day and the MOS dewar will be returned to operating temperature before sunset. The gatevalve is operated by the Observatory staff. The second dewar, the camera dewar, remains at operating temperature through out the whole MMIRS run. Both dewars are cooled by LN2. The MOS dewar has a hold time of 36 hours when a MOS mask change is not done during the day and the camera dewar has a hold time of 48 hours. Observatory staff are responsible for keeping the dewars filled with LN2 - if you detect any change in operating temperature please inform the Observatory staff.

The salient features of MMIRS are tabulated in Table 1.

Detector Type	Teledyne Hawaii-2RG HgCdTe
Pixels	2048 x 2048
Pixel Size	18 microns
Field-of-View (imaging)	6.9 x 6.9 arcmin
Field-of-View (spec)	4 x 6.9 arcmin
Plate Scale at slit	0.169 mm/arcsec
Pixel Scale	0.2 arcsec/pixel
Readout Time	1.475 for a single read
Minimum Exposure time	1.475s
Typical overhead per exposure	7-17s (depending on size of file, dither size)
Typical spectroscopic overheads	5-10 min for acquisition and mask alignment 2-5 min for calibration frames (comps + flats) 5-10 min for telluric setup and data taking
Digitization	16 bit (65,536 ADU)
Gain	0.95 or 2.68 e-/ADU
Readnoise	11 e- per read
Median Detector QE	J:80%, H:80%, K:83%
Median Dark current	0.06e-/pix/sec
Full well	~230,000 e-
Fits File Size	approx 16804800 bytes per readout
Imaging Filters	Y, J, H, Ks
Spectroscopic Filters	HK, HK3, zJ, Kspec
Grisms available	R=1200@HK, R=2400@H, R=3000@H, R=2400@J, R=3000@J
Calibration lamps	Dim Incand, Bright Incand, Argon

Table 1.

There are two identical guide and wavefront sensing (GFWS) units mounted at the side of the instrument, external to the cryostat, which

are fed by a fixed pick off mirror which surrounds the science beam. The field of the GWFS is shown in Figure 3. Each of the GWFS units is mounted on a 2-axis translation stage to allow it to probe one half of the available field and the cameras can be focussed individually. A stage allows switching between guiding and Shack-Hartmann mode; normal operation will have one of the units operating in guiding mode while the other is deriving continuous wavefront information. Slow-speed guiding information can in principal be derived from the Shack-Hartmann data which can be used to control the instrument rotation angle. In practice at Magellan we have found it not to be necessary and is not part of the default operation. We are evaluating the rotator performance at MMT. The guider optics operate from 600nm to 900nm as MMIRS will primarily be a bright-time instrument. The field of view of the guide camera is 80" with a pixel size of 0.16" when binned 2x2.

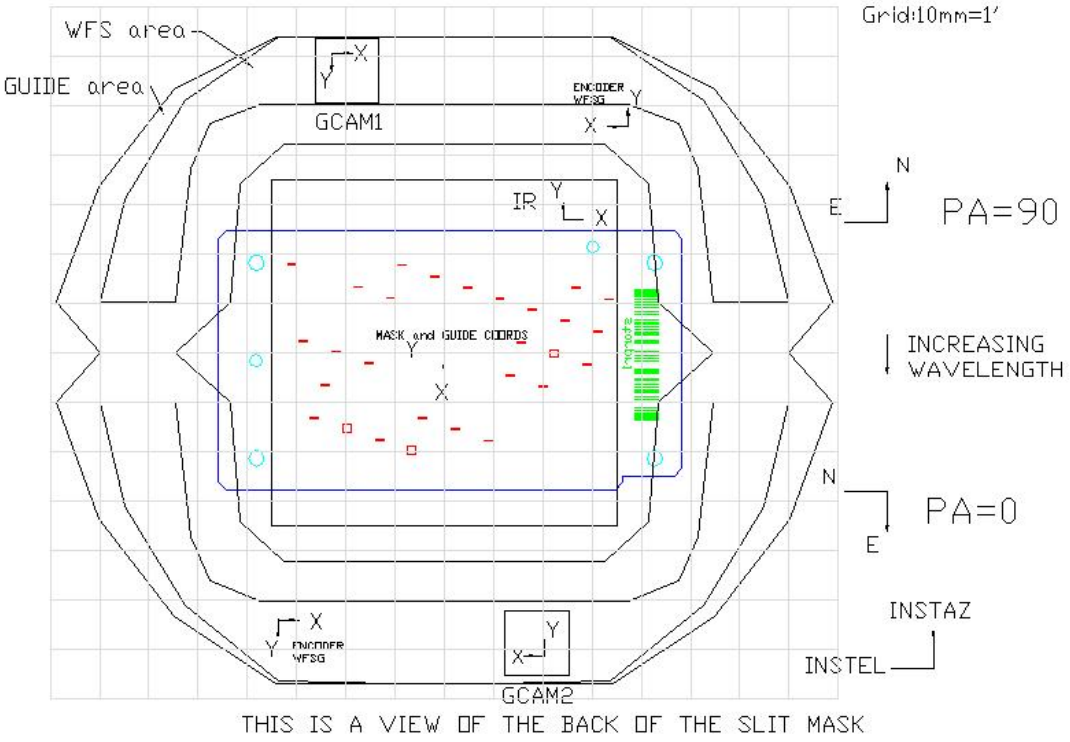


Figure 3 MMIRS field of view and coordinate systems. Full resolution PDF: **p/mmirs_coordinate_axes.pdf**

The origin of the instrument coordinate systems corresponds to pixel (1012,1007) on the science array. The center of the telescope rotator may differ from this instrument center by several arcseconds. The telescope rotation center will be determined at the start of each observing run by observatory personnel. When acquiring a new target, the telescope will first be pointed to place the target at the rotation center, and then offset to the instrument center.

A schematic representation of the status of all the instrument mechanisms can be seen in the **toppermmirs** display.

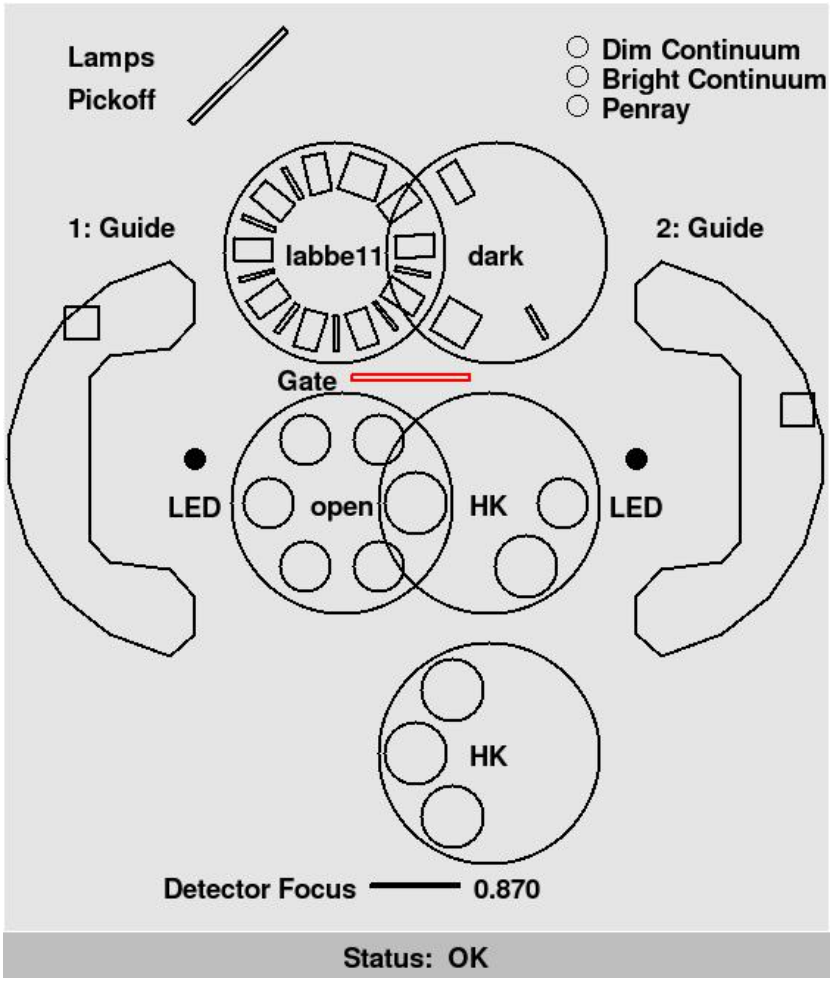


Figure 4 The **toppermmirs** display, showing the current status of the instrument. In this example the gatevalve is closed, as it would be during a slit mask exchange. The LEDs are used for calibrating the wavefront sensor and should normally be off, as they are shown here. Full resolution: **p/toppermmirs.jpg**

3. What's NEW 2022B.

1. Multiple up-the ramp exposures at a given dither position can now be taken with minimal overhead. See section 4.12 Imaging for details
2. A Region-of-interest mode is now available. See section 4.14 Region of Interest for details.

4. Observing Instructions.

4.1. Before your run.

1. Read this manual.
2. Read **MMIRS Observing Protocol**.
3. Read the other documents on the main MMIRS page **[1]**
4. Run the Exposure Time Calculator (ETC) if you need to (Appendix A).
5. Prepare your target catalog in the correct format: NEED DETAILS HERE

6. Figure out how you will take home your data (see below for your options).
7. If you are observing a multi-object spectroscopy program, follow the instructions in **MMIRS Mask Making**
8. Set up dither files or other scripts. The observing sequence can be automated very easily, and you can set up scripts to dither the telescope, run through the filters at a standard star field, etc. automatically. See instructions on setting up dither files, Appendix D.

4.2. The Computers in the Control Room.

The MMIRS instrument computer is **fields**, a virtual computer in the host computer **endeavour**, located in the 3rd floor west lab. The observer will sit in front of the MMT control room Mac **pixel**, OR the linux box **meerkat** and operate the instrument using **fields** from there.

4.3. Instrument Start Up Procedure.

The procedure to power-up the instrument is described here. **MMT+powerup+procedure** It will be performed by a staff-member. This should only be necessary at the beginning of the run or after a power shutdown.

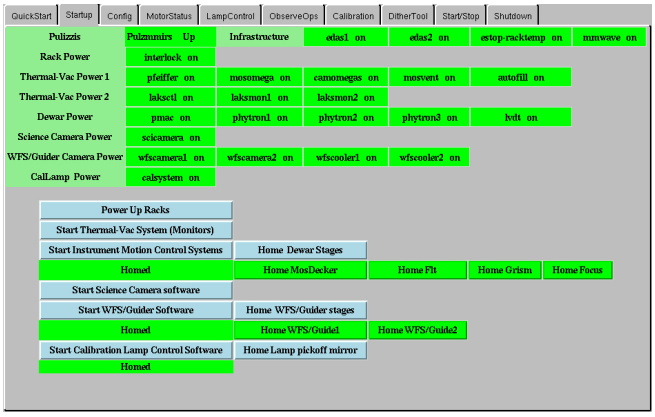


Figure 6 MMice startup tab. Full size image: **p/mmice-Startup.jpg**

4.4. Taking data with mmice.

Data taking is done through the Config and ObserveOps tabs in *mmice*. The Config tab is used to set up the instrument as needed. The ObserveOps tab allows for traditional observing (one image at a time) or for performing sequences of exposures allowing for efficient observing. The sequences are defined by an ascii catalog file which can be generated with a text editor or by using the DitherTool tab of *mmice*. Details on how to make catalog files, with examples, are given in Appendix D.

1. **Check that all the subsystems are happy.**

   In the previous section you should have gotten all the subsystems initialized. The status of each subsystem is indicated with color using the color convention of all the f/5 instruments; green means OK or RUNNING, yellow means HUNG (perhaps only temporarily), and red means NOT RUNNING. If any items are not green, go back to the Startup Procedures.

   The middle section (just above the tabs) is mostly informational. The first line displays the detector and MOS dewar temperatures. The detector temperature should be 82.00 and the MOS temperature should be 77K. The second line shows the status of the calibration lamps. The rest of the lines in this section display exposure status information including image type, exposure time, and exposure status, sequence, queue status, instrument configuration and telescope offsets.

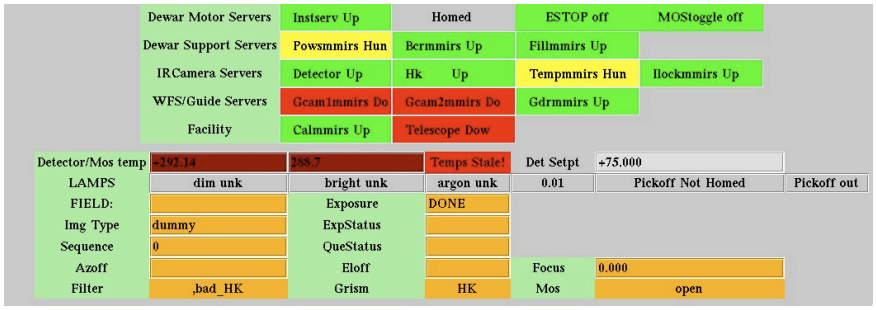


Figure 8 MMice status panel. Full size image: **p/mmice-Status.jpg** In this example we see that three servers are not running and two are hung. The recommended action would be to go to the Stop/Start page and restart them. Note that the telescope server will be started by the telescope operator at the beginning of the night.

2. **Next you'll go to the Config tab in mmice:**

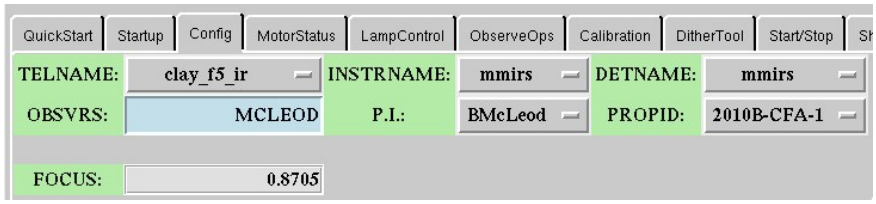


Figure 9 MMice Config tab. Full size image: **p/mmice-Config.jpg**

3. **Check that TELNAME AND INSTRNAME are set correctly**

```
   TELNAME=mmt_f5_ir
INSTRNAME = mmirs
```

IMPORTANT: For Science observations, make sure none of these indicates *Test* . For calibrations during the day where the telescope is not to be commanded, set TELNAME to 'test'. INSTRNAME should only be set to 'test' if you do not wish to move MMIRS devices.

4. **Select the correct PI and Observing Program.**

The program number information is important to enter correctly in order to be able straight-forwardly retrieve data from SAO later on. If your observing program is not in the list, contact the MMIRS instrument specialist. **If you switch programs during the night, don't forget to update the Observing Program and PI**.

5. **Type your name(s) into the OBSRVRS box.**

6. **Next you'll go to the ObserveOps tab which allows you to take images one at a time or a sequence.**

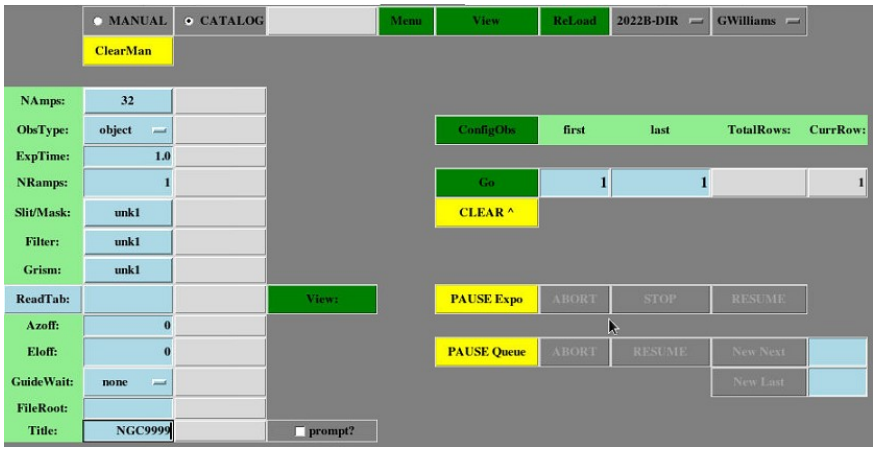


Figure 10 MMice ObserveOps tab. Full size image: **p/mmice-ObserveOps.jpg**

1. Manual/Catalog

   Manual means that all exposure parameters are directly set on this tab (although some software overrides may occur i.e. ObsType object will remove pickoff mirror). Catalog allows you to choose a catalog file that lists some or all of the parameters of a sequence of exposures. For example, you could have a list of dither positions to be observed in sequence. A full description of creating catalogs is provided in Appendix D. The file can be chosen by clicking on Menu.

2. NAMPS

   The new MMIRS detector is always operated in the 32-amp mode giving the fastest readouts (read intervals of 1.475s).

   Select the amplifier mode you wish to use:

   - 32-amp - the original default

3. ObsType

   Select the type of exposure from the following list:

   Table 2 MMIRS image types.

object	A normal image containing an observing target. The file is named using the object name from the telescope catalog.
setup	Like object, but names the file "setup"
skyflat	A dark or twilight sky flat field image.
comp	A comparison lamp Argon image.
flat	A continuum lamp image. The bright lamp is used for spectroscopic exposures, the dim lamp for imaging.
dark	A dark image.

4. Exptime

   Exposure time in seconds. Actual time will be at least 1.475s.

5. NRamps

   The number of up-the-ramp sequences to store in a single file. In spectroscopic exposures this should be set to 1. In imaging exposures it will be set to larger numbers automatically if you use the Random dither catalogs.

6. Slit/Mask

   Select which mask or long slit you want, or "Open" for imaging.

7. Filter

   Select which filter you want.

8. Grism

Select which grism you want, or "Open" for imaging.

9. ReadTab

   Unlike CCDs, infrared detectors can be read out without destroying the image already stored. This has three key advantages. 1) By reading out multiple times, the detector read noise can be averaged down. 2) By reading multiple time during the course of the exposure, pixels can be used even if they are saturated by the end of the exposure. 3) Cosmic rays can be identified by looking for discontinuities in the signal level of each pixel versus time. The 'ReadTab' button is used to select the readout mode for the IR detector. The recommended modes are ramp_1.475s, and ramp_4.5s, and fowler. The first two read out the detector once every 1.475 or 4.426 seconds. The data will be stored as a multi-extension FITS file with one readout per extension. The final readout is stored as the first extension, the first readout stored second, and the remaining in sequential order. The post processing script will display the difference of the last readout minus the first readout. If you select Fowler, or click on Cancel, you will get a simple double correlated image saved as a standard FITS file. This mode can be used for setup exposures.

10. Azoff/Eloff

    Allows for manual telescope Az & El instrument offsets to be set (e.g. for dither steps)

11. GuideWait

    This drop down box allows the user to choose one of several guiding modes. It controls how mmice interacts with the guider, but does not control whether guiding is turned on -- that is controlled from the telescope operator's "guistarsmmirs" panel.

    Here is a description of these modes:

    - *none* : In this mode, the data acquisition process will continue independently of what the guider is doing. Dither commands will be sent directly to the telescope and the guider will not follow the telescope dither offsets. The data acquisition will not attempt to wait until the guider reports that it is locked on the stars.

    - *autoguide* : In this mode, the guide camera will dither with the telescope offsets and attempt to maintain the lock on the guider star. This should work fine in spectroscopic mode when the dithers are small. The telescope operator controls whether the dithers are handled by moving the guidebox on the guide camera or by moving the entire guide camera stage. For dithers less than 5 arcsec, box mode is recommended. For larger offsets, stage mode is recommended. In imaging mode it is more difficult to find a guide star that will remain in the guider field of view during the larger image offsets. When running in autoguide mode -mmice~ will also query the guider as to whether it has locked onto the guide stars at the start of each exposure. Data acquisition will begin only after the guider is locked on the stars. This is currently the only option for guiding.

    The Guiding row in the **Exposure Status** window will show YES or NO during "object" exposure, depending on whether the guide corrections are being sent. Flickers of a few seconds are common, but if the NO state persists it would be wise to consult with the telescope operator to verify that all is working well.

    - *wfsonly* : In this mode, coordinated offsets are sent to the guider and telescope (as in autoguide mode), but mmice does not wait for the guider to report that it has locked. This mode is useful when carrying out imaging programs with short exposure times where the overhead of guiding is not desired, with dithers small enough so that a single wavefront sensor star remains available. This should be used if you are doing calibrations or imaging programs without autoguiding.

12. Fileroot:

    Default has it set as object name from catalogue through the telstat or set by exposure type being done.

13. Title By default *mmice* automatically queries the user for the title when the observer presses **Go** with a pop up window. This title goes into the data log and can be more descriptive than the fileroot. If the Prompt button is unchecked then no popup will appear and the user should enter the title in the entry box before pressing **Go**.

7. **Take an image by pressing *Go*.** The number of images taken is controlled by **first** and **last**. If you are using a dither catalog, these numbers refer to the lines in the catalog.

   The **Clear** button is used to clear the camera in the event of an error. If the **Go** button remains red because of an error during observing the user must press **Clear** to reset the system.

   Pause. Abort, Resume.

   The bottom 2 lines of the "ObserveOps" tab allow the user to "PAUSE" an exposure or to pause the QUEUE of exposures. "Pause Expo" enables the options: ABORT, STOP, RESUME, or CHANGE the exposure time. ABORT will discard the current exposure, whereas STOP will read out the camera for the current truncated exposure time. Pause QUEUE has no effect on the current exposure, but it allows you to alter the automated exposure sequence, usually by changing the "last" requested exposure. Because MMIRS has no shutter, it is not possible to actually pause and resume an exposure as one would with a camera with a shutter.

8. **Where's my data and what are the files called?**

   The raw images are stored on a 15 Tb disk array on fields, in multi-extension FITS format. A copy of each file is automatically made available for immediate analysis. Analysis directories are called /data/crunch/MMIRS/yyyy.mmdd (e.g., /data/crunch/MMIRS/2009.1014). The files themselves will have names like target.0001.fits, where target is the catalog

name supplied to the telescope.

4.5. Displaying an image.

After an exposure is finished, the postproc server will receive the incoming image and display it in ds9mmirs Frame1 on the console. It will also display the difference of the current image and the previous one in Frame2. The usual iraf programs such as imexamine will still work. In fact you can have imexamine running continuously as new images come in and they will be properly accessed.

The **ds9mmirs** window is intended to be dedicated to the near-realtime display. To look at previous images, we highly recommend opening a new ds9 window. To view previously displayed images, load them into ds9 using the File menu --> Open - or - from the commentmmirs GUI you may select the file of interest and press the Display Image button.

4.6. In The Afternoon.

As soon as the instrument specialist has completed the slit mask exchange procedure, take a test exposure to verify that the instrument is working properly.

- Go to the ObserveOps tab
- Select exposure type dark
- Select filter dark
- Click on ReadTab and then click on Cancel. This will give you a basic double correlated sampled image.
- Enter 1 for **first** and 3 for **last**
- Press **Go**

*

- In the Analysis IRAF window take the difference of the 2nd and 3rd images and compute statistics

```
   cd /data/crunch/MMIRS/YYYY.MMDD
imarith dark.MMMM.fits - dark.NNNN.fits diff.MMMM.fits
imstat diff.MMMM.fits nclip=2 lsigma=3 usigma=3
```

The mean should be near zero. The stddev should be near 4.

4.7. Start of the Night.

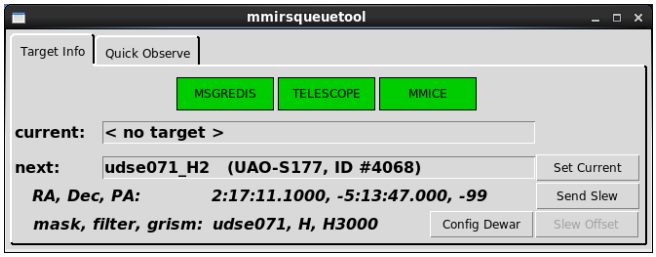
- For Imaging programs, flats can be taken during twilight at the beginning (and end) of the night prior to the acquisition of any stars.

- For initial pointing at the start of the night, ask the telescope operator to point to a 13th mag star near your first target.
- In mmice, select the setup.cat dither file, and take two 5 sec exposures, the first offset by 30 arcsec from the nominal position. Note that in twilight conditions you may need to take a 1 sec exposure to avoid saturation.
- Press "Draw Regions" in the **paddlemmirs** GUI.
- Move the green "Star" region to the image of the star near the center of the frame. If you are unclear about which star is which, select in ds9 Analysis->Catalogs->Infrared->2MASS. **Note that when the sky is still bright, the detector may saturate and you can end up with the star images being negative. The on-target stars will appear 150 pixels to the *left* of the offset position.**
- Press "Fix Pointing".
- This will have moved the target to the center of rotation. You can now proceed with your first science target.
- If you must check and confirm the position of the star, do the following:
- Press "Reload" for the setup catalog.
- Then press "Go" in mmice again. If the star is centered on the "rot" marker, you can move onto science target, otherwise do another iteration of centering the "Star" region and "Fix Pointing".
- Slew to your first target (see below) and ask the telescope operator to run Shack-Hartmann (wavefront sensing).

4.8. Selecting Targets and Slewing.

See instructions for selecting the next queue target through the Queue Operator's Interface web page.

When you have selected a target and clicked "Set Next Block" in the web interface, you should see a response in the **mmirsqueuetool** GUI.



The target you selected will be listed in the "next:" line in the GUI. To initiate a slew to this target, just click the "Send Slew" button. If this target was submitted to the PI's target catalog with an offset star, you can instead click "Slew Offset" to slew directly to the offset star. The operator must be running the 'slewauth' tool in order to approve the slew. Once approved, the target you are slewing to will become the "current:" target as well. The target listed as current is the target that mmice will record for bookkeeping purposes when a new exposure is initiated.

4.9. Long Slit Observing.

Please review **MMIRS Observing Protocol** to ensure that your data can be reduced by the MMIRS pipeline.

There are no slit viewing optics in mmirs so to get your target on the slit you must take images with the infrared detector to position your target in the correct place. You will use both **mmice** and **alignbox** to accomplish this.

After slewing to your target vis the mmirsqueuetool:

In the **mmicemmirs** window, tab **ObserveOps**, select the following:

- Select Catalog button
- Press "Menu" and select a dither catalog from the LongSlit submenu. Note that the offsets are applied in the "instrument" coordinate system so that the same offsets work no matter what position angle you are using.
- NAMPS = 32-amps
- ObsType = object
- Exptime = 300 (for typical exposures)
- Slit/Mask = your choice of slit
- Filter = your choice of filter
- Grism = your choice of grism
- ReadTab = ramp_1.475
- GuideWait = autoguide

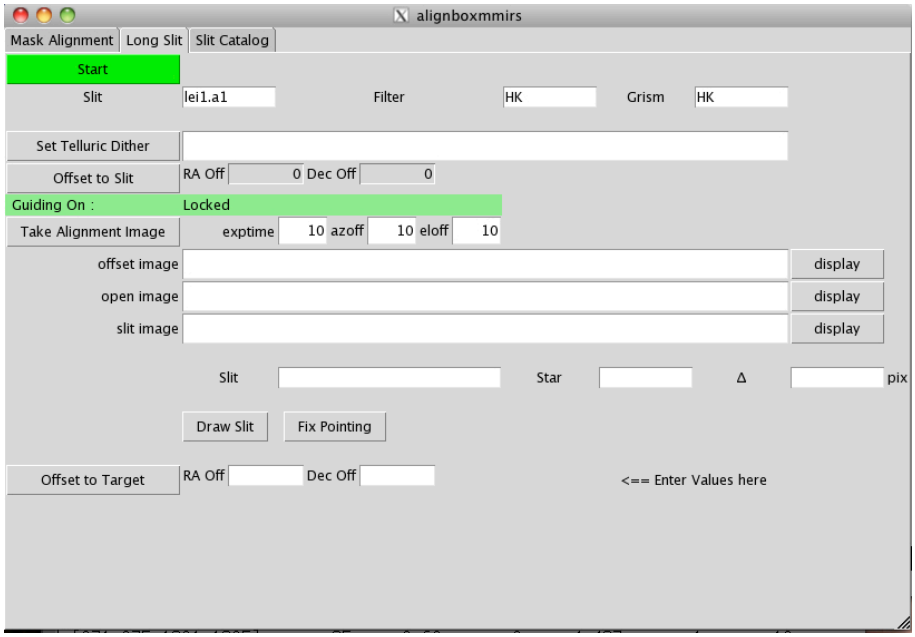


Figure 11 Longslit alignment tool. Full resolution image: **p/alignbox-LongSlit.jpg**

In **alignboxmmirs**:

- Select the **LongSlit** tab
- Press "Start" to retrieve the configuration parameters from mmicemmirs
- Press "Set LongSlit Dither" to select the dither catalog that you will use for your science target
- Press "Offset to Slit" to move the telescope to the nominal slit position
- Ask the telescope operator to ensure that "AUTO" is not selected on the guide setup interface.
- Ask the telescope operator to start guiding and wavefront sensing.
- **ALWAYS WAIT until the gui shows a green "Guiding ON" and "Locked" status before proceeding with taking images** In poor seeing or windy conditions the "Locked" status can be "twitchy" so you may have to settle for less than perfect locking.
- **NB: Be sure you have selected your dither catalog before aligning the slit. The dither catalogs will be correctly adjusted based on the alignment values.**
- press "Take Alignment Image". Three exposures will be taken, differenced, and displayed in ds9. The left panel shows the difference of the field minus an offset image. The right panel shows an image of the slit (minus the field). The software measures the location of the slit and the nearest object it can find and places markers on these positions in **ds9mmirs**.
- If the "star" marker is not well centered on your target, carefully center the marker on the target (you may want to resize the circle by draging one corner)
- Click on "Move to Slit" in **alignboxmmirs**.
- This acquisition process can be repeated to improve the centering of the object in the slit by pressing "Take Alignment Image"
- For all dithering, the default parameters that the Telescope operator selects should be Guider TweakType=Stage.
- Notes:
  - Your guide stars should be selected carefully to allow for large range of stage motions. If proplems occur with long dithers, it is always possible to instead repeat the setup for each desired dither.
  - You can change the exposure time by entering a time in seconds in the "exptime" box
  - If the offset position puts another object on top of your target, you can change the offset position with the "azoff" and "eloff" boxes

- If your target is too faint to see, and you are setting up using a nearby star, enter the offset from the star to the target in the "RA Off" and "Dec Off" boxes and press "Offset to Target"

Now you are ready to take data.

- If the field contains bright stars saturating the detector during the alignment (usually it is the case) it is highly recommended to execute a 10-sec long "object" exposure with ramp=1.475s in the 32-amp mode **before starting your science observations.** This will clear the detector from the persistence effect caused by saturated stars which may spoil your first science exposure.
- Ask the telescope operator to continue guiding and start Wave Front Sensing (WFS).
- Press "Go" in **mmicemmirs** to start observations

After the exposure sequence on the target is complete, you can take comp and flat exposures

- If you want to return directly to your science target after calibrations, it is necessary that the telescope and guide probes be returned to their starting positions before starting the calibrations. This can be done by selecting Manual in the ObserveOps tab, setting Azoff and Eloff to zero and GuideWait to autoguide, and pushing the ConfigObs button *twice*. Verify that inst Az and El are indeed 0.00 in the paddlemmirs GUI. (If the dither catalog ended at an offset of 0,0 this procedure can be skipped.)

- Ask the Telescope Operator to stop guide and Wave Front Sensor corrections.
- Load the dither file "Calibrations/AAamp/compflat_GG_FF", where GG and FF are the grism and filter you are using and AA is either 32 or 4 for the readout mode..
- Press "Go"

Follow the directions below for telluric standards.

4.10. Multi-Slit Mask Observing.

Please review **MMIRS Observing Protocol** to ensure that your data can be reduced by the MMIRS pipeline.

An observing catalog generated from the mask design files is automatically generated on the day of a mask change. It can be found on fields as /data/archive/MMIRS/Masks-YYYY.MMDD-MMT.cat. A catalog is generated for each Trimester and is sent to the MMT's hacksaw machine. Either of these can be used as a backup in case the mmirsqueuetool Slew function is not working.

After slewing to your target vis the mmirsqueuetool:

In the **mmicemmirs** window, tab **ObserveOps**, select the following:

- Press "Menu" and select a dither catalog from the Standard submenu. Note that the offsets are applied in the "instrument" coordinate system so that the same offsets work no matter what position angle you are using.
- NAmps = 32-amps
- ObsType = object
- Exptime = 300 (for typical exposures)
- Slit/Mask = your choice of mask
- Filter = your choice of filter
- Grism = your choice of grism
- ReadTab = ramp_1.475s
- GuideWait = autoguide

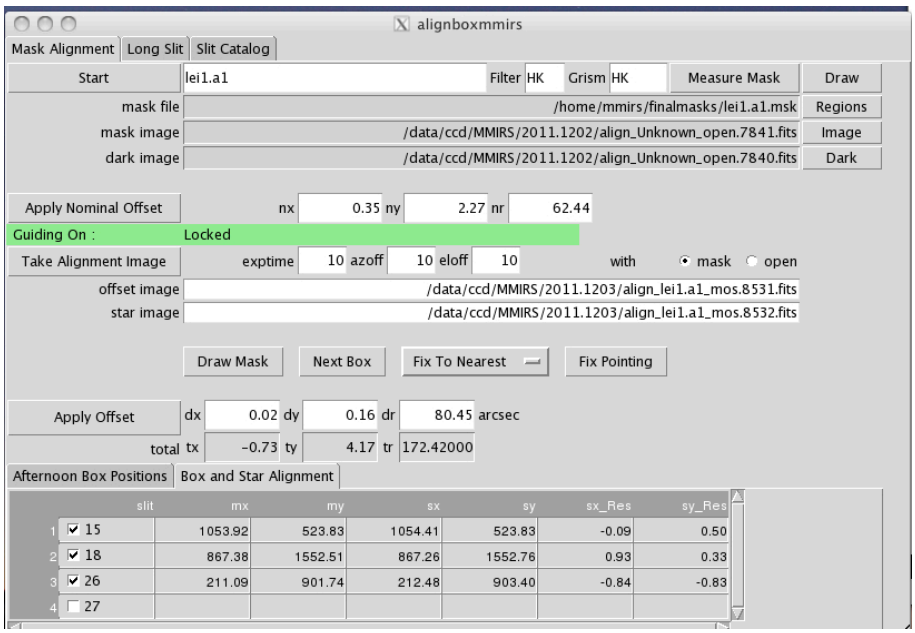


Figure 12 Mask alignment tool. Full resolution: **p/alignbox-MaskAlignment.jpg**

In **alignboxmmirs**:

- Select the **Mask Alignment** tab
- Verify you have selected the correct mask catalog in **mmicemmirs** - it will be corrected during the mask alignment procedure - but only if it is selected **BEFORE** you press start next.
- Press "Start" to retrieve the configuration parameters from mmicemmirs

  If the mask file and mask image file do not appear - please notify the Instrument Specialist. You may generate them now using the Measure Mask button - but they should have been generated during the afternoon.

- Ask the telescope operator to start guiding.
- Ask the telescope operator to ensure that "AUTO" is not selected on the guide setup interface.
- **ALWAYS WAIT until the gui shows a green "Guiding ON" and "Locked" status before proceeding with taking images** In poor seeing or windy conditions the "Locked" status can be "twitchy" so you may have to settle for less than perfect locking
- Press "Take Alignment Image" to take a dithered pair of images without the mask in. The difference image will be displayed automatically in **ds9mmirs**. The nominal positions of the slits and measured positions of the alignment stars will displayed as ds9 regions.
  - ***NOTE**: The mask catalog used for telluric dithers to various slits will be recreated each time an alignment image is taken.*
  - The recommended default EXPTIME is 10 seconds, which should give optimum alignment images. If the alignment stars are saturated, the exposure time can be set as low as 3 seconds (or 7 seconds for 4amp mode).
  - *Successful alignment is not guaranteed with exposure times below 3 seconds. A shorter exposure time may result in not all slits being successfully measured, in which case they will not appear in the telluric dither catalog.*
  - *The recommended alignment star magnitude range is 13.5 < H < 16 to avoid saturation.*

- You can zoom in on the alignment boxes in **ds9mmirs** by clicking on the "Next Box" button. Choose one of these two options depending on how close you are to the desired alignment:

  - OPTION 1, crude initial alignment. If the red circles are not on the stars, move the green "star" region onto its corresponding star, verify that "Fix to Nearest" is selected, and press "Fix Pointing". You only need to do this to ONE of the star/box pairs.

  - OPTION 2, accurate least square fit. If the red circles are on top of the stars, select the "Box and Star Alignment" tab. Examine the sx_Res and sy_Res columns and deselect any rows with residuals larger than 1 pixel. Then press "Apply Offset" to correct the alignment in both translation and rotation.

- Select "mask" and press "Take Alignment Image" to take an image with the mask in. The alignment stars should now be visible in the boxes and the red markers should be on the stars.
- Follow OPTION 2 above.
- Repeat "Take Alignment Image" until the recommended offsets reported in the "az", "el" boxes are less than 0.1" and "dr" is less than 100" in rotation. In general this will take 2-3 iterations. This process may generally take between 5 and 10 minutes.

Now you are ready to take data.

- Ask the telescope operator to continue guiding and start Wave Front Sensing (WFS).
- Press "Go" in **mmicemmirs** to start observations

After the exposure sequence on the target is complete, you can take comp and flat exposures

- If you want to return directly to your science target after calibrations, it is necessary that the telescope and guide probes be returned to their starting positions before starting the calibrations. This can be done by selecting Manual in the ObserveOps tab, setting Azoff and Eloff to zero and GuideWait to autoguide, and pushing the ConfigObs button *twice*. Verify that inst Az and El are indeed 0.00 in the paddlemmirs GUI. (If the dither catalog ended at an offset of 0,0 this procedure can be skipped.)

- Ask the Telescope Operator to stop guide and Wave Front Sensor corrections.
- Load the dither file "Calibrations/AAamp/compflat_GG_FF", where GG and FF are the grism and filter you are using and AA is either 32 or 4 for the readout mode.
- Press "Go"

Follow the directions below for telluric standards.

4.11. Telluric Standards.

Because the atmosphere has many strong absorption bands in the near IR it is necessary to observe standard stars at an airmass close to the airmass of your observations. An excellent description of telluric standards, can be found at **http://www.gemini.edu/?q=node/10165** . A typical observing sequence would be to start by observing the telluric standard. Then observe your object till it transits, and go back to the telluric, and then resume your observations. Telluric standards with K=9 are appropriately bright.

4.11.1. Selecting Telluric Standards.

The process for selecting telluric standards was developed by the FIRE spectrograph team, and is adapted here from the FIRE manual:

It is best practice to observe A0V telluric standard stars between science objects, to calibrate atmospheric absorption features. These observations are also used to perform flux calibration by the reduction software. There is a tool installed on **fields** which assists users in selecting tellurics from a large list of A0V standards. For each field required, run the following:

```
find tellurics --RA 14:47:17 --DEC +04:01:12 --UO 08:50 --UT 09:25
```

The program, find_tellurics, takes the following inputs:

```
-RA, DEC - The right ascension and declination of your science target
-UO - The central UT time of your science target observation (note this is the letter "O", not a zero)
-UT - The expected UT central time of observation for the telluric standard
```

The software will output a list of stars which are the closest match in airmass and sky angle:

```
Object: RA= 14:47:17, Dec= +04:01:12 airmass= 1.372 at lst 16:43:14
Best telluric matches:
(1): HD123309
Mag= 9.40 (Band= V) RA= 14:07:24 Dec= -23:28:29 Anguler Offset= 29.16 deg
This telluric: airmass = 1.364 at lst 17:18:14 airmass diff from source = 0.007. Match rating = 54.18
(2): HD125062
Mag= 9.98 (Band= V) RA= 14:17:29 Dec= -19:29:07 Anguler Offset= 24.62 deg
This telluric: airmass = 1.346 at lst 17:18:14 airmass diff from source = 0.025. Match rating = 30.37
(3): HD123426
Mag= 9.66 (Band= V) RA= 14:08:10 Dec= -24:33:51 Anguler Offset= 30.12 deg
This telluric: airmass = 1.354 at lst 17:18:14 airmass diff from source = 0.018. Match rating = 27.47
```

The "Match rating" field is a figure of merit for the quality of telluric match, and should be as large as possible with maximum 100. Once you've selected from the list presented, the telescope operators have the catalog file of all MMIRS A0V calibrators available in MMIRS_tellurics.cat. Slew to the object by giving the telescope operator the name of the star, e.g. HD123309.

4.11.2. Acquiring Telluric Standards.

In principle, it is possible to acquire the telluric standard without removing the mask by using the guider. **However this procedure is not working consistently, so proceed to the "Backup plan" below.**

The mask alignment process will generate a mask dither catalog that will offset the telescope to put the telluric standard on each slit of a mask if you follow this procedure.

- Masks

If you are observing the telluric standard before observing with the mask you must first take an image of the mask using **alignboxmmirs** before continuing. This will measure the exact location of the mask.

- Select the desired mask using **mmicemmirs**.
- Select the Mask tab in **alignboxmmirs**.
- Press "Start"
- Press "Take alignment image" (with "mask" checked, if using a mask).

Once the mask has been measured, or if you've just finished your science observations, then

- Ask the telescope operator to "Follow the telluric acquisition procedure, por favor". You will need to tell the operator which target to use. The operator will tell you when the telescope is pointed at the the telluric standard.
- In **mmicemmirs**, change the following settings,
  - Press "Menu" to select the dither catalog. For mask observations choose the catalog appropriate for you mask from the "Masks" submenu". The first 5 entries in the mask catalog put the star in the center, and top, bottom, left and rightmost slits.
  - NAmps = 32
  - ObsType = object
  - ExpTime = typically 10 for mag=8, or 30-60 for mag=10
  - ReadTab = ramp_1.475s
  - GuideWait = none
- Press "Go"

After taking the telluric spectra, you can return to the target you were just observing without realigning by asking the telescope operator to "Return to the science target, and restore the offsets, por favor". Reset the **mmicemmirs** parameters:

- ExpTime = ?? your desired exposure
- ReadTab = whatever you were using
- GuideWait = autoguide

Backup plan: If the telluric spectra do not appear, you may need to align the telluric manually.

- Follow the **Start of the Night.** procedure using the telluric standard instead of the pointing star.
- After you have successfully placed the telluric star on the center of rotation, ask the telescope operator to offset to the instrument center.
- In **mmicemmirs**, change the following settings,
  - Press "Menu" to select the dither catalog. For mask observations choose the catalog appropriate for you mask from the "Masks" submenu". The first 5 entries in the mask catalog put the star in the center, and top, bottom, left and rightmost slits.
  - NAmps = 32
  - ObsType = object
  - ExpTime = typically 10 for mag=8, or 30-60 for mag=10

- ReadTab = ramp_1.475s
- GuideWait = none

- Press "Go"

  - Take spectra with the settings given above.
  - If you have aligned manually, the slit will have been moved and you must take another set of compflats.

- LongSlit

  Please follow the standard longslit alignment procedure using either the same dither catalog as for your science target or a simple longslit_2.cat

4.12. Imaging.

It is recommended to use wavefront sensing for imaging projects. (You do not need to guide.) If you are observing extended objects you will need to use dithers larger than your object which will prevent wavefront sensing at all dither patterns. Take at least 60 sec worth of data between dither positions to maintain wavefront sensing.

The recommended maximum single exposure times for imaging are 30 sec for H and K and 200 sec for Y and J. At a minmum, you must remain at the same dither position for at least 15 seconds longer than the wavefront sensor exposure time (typically 30 seconds and not less than 15 seconds).

Using the "Logain/ramp_4.5s" readout mode is also recommended for imaging as it will give you increased dynamic range on bright stars and reduced noise in Y and J imaging.

The best deep images are obtained if the dither pattern is random, rather than a square or line. You can read all about dither patterns on the Spitzer Science Center web site, here **[2]**. A set of random dither patterns can be found on **fields** in /home/mmirs/Dither/Random. For example, random30.cat contains a set of dither patterns that fill a 30" box. To observer the same position twice sequentially at each position in a 120" box, you would use random2x_120.cat.

Starting in 2022-12, the catalogs in the Dither/Random directory are configured to take the sequential up-the-ramp exposures at each position as a unified exposure with minimal overhead between the individual ramps. They are stored as a single multiextension FITS file. For example, to take four 15 second exposure at each dither position in a 30 arcsec box you would select random30x4.cat with at 15 sec exposure time. This is unchanged from before. The part that is different is that where before four files were written, now only one file will be written. The readouts in the file are stored with the final readout as the first extension, and the others in increasing time order, e.g. Ramp4Exp4, Ramp1Exp1, Ramp1Exp2, Ramp1Exp3, Ramp1Exp4, Ramp2Exp1, Ramp2Exp2, Ramp2Exp3, Ramp2Exp4, Ramp3Exp1, Ramp3Exp2, Ramp3Exp3, Ramp3Exp4, Ramp4Exp1, Ramp4Exp2, Ramp4Exp3.

4.13. Dark Frames at the End of the Night.

At the end of the night you should take dark frames of every length of exposure that you took during the night. Fortunately you don't have to keep track of this yourself.

```
cd /data/ccd/MMIRS/YYYY.MMDD
darkscript 5

Checking exposure times on all      379 files
Please wait...

1.  Go to Config page and set telescope to TEST
2.  Go to the ObserveOps page and press Menu-->Darks-->darks-2011.1201
3.  Press GO and watch the darks go!
```

On the morning of a mask change procedure, please do not start the dark script until the GateValve has been closed and the mask change procedure has been begun by the instrument specialist. Leave a note in the online Astronomers Log asking that the darks be started after the warmup has begun.

4.14. Region of Interest Readout.

As of 2022-09 it is possible to rapidly read out a small Region-of-Interest of the detector to perform high speed photometry. This feature can be accessed using the ROI tab. Before going to the ROI tab, the target should be acquired, and the filter, etc. selected using the ObserveOps tab.

The parameters to be controlled are:

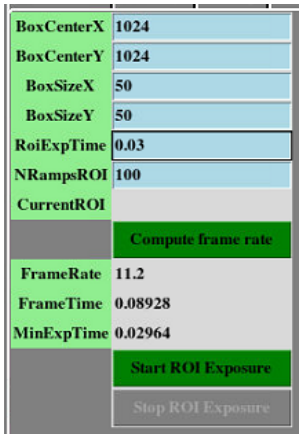
- BoxCenterX -- the X location of the center of the ROI
- BoxCenterY -- the Y location of the center of the ROI
- BoxSizeX -- the size of the ROI in pixels
- BoxSizeY -- the size of the ROI in pixels
- RoiExpTime -- the length of the exposure in seconds -- the minimum valid exposure time is (BoxSizeX+7) x (BoxSizeY+2) x 0.00001sec
- NRampsROI -- the number of ROI exposures to take and save in a single file

The frame rate is 2 x (BoxSizeX+7) x (BoxSizeY+2) x 0.00001sec + RoiExpTime

For example, for a 10x10 arcsec box (50x50 pixels) a frame rate of 11Hz can be achieved, using the minimum exposure time of 30msec.

Frame rate parameters for a given ROI size can be computed by pressing the "Compute frame rate" button. You should verify that the RoiExpTime is equal or greater than the MinExpTime.

ROI sequences are started by pressing "Start ROI Exposure". The sequence can be terminated early by pressing "Stop ROI Exposure"



5. Automatic Data Logging.

Please keep observing notes using the **comment** GUI which is started with **mmirs**. This will bring up a panel showing the fits files in the current data directory. You can highlight any one of the files and add comments to that log entry. To produce a nice postscript output click on **View Log** . The comments are archived along with the data and provide a valuable future reference.

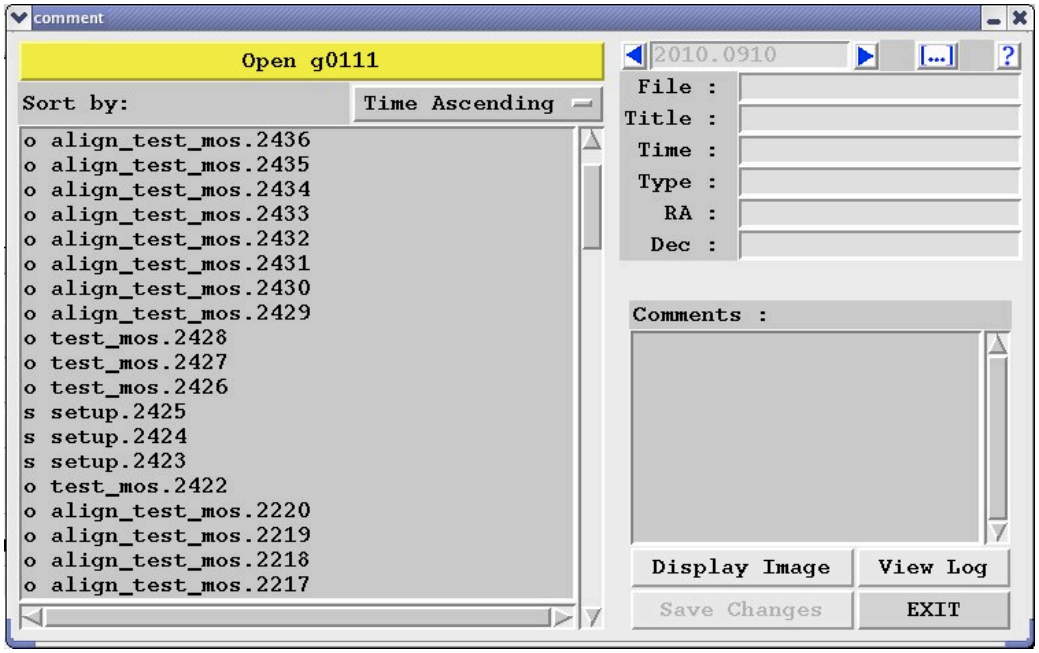


Figure 13 Comment GUI.

6. Filters.

The filter transmission data in text format are available at http://www.cfa.harvard.edu/mmti/mmirs/instrstats.html MMIRS has two filter wheels, one top and one bottom, which can accommodate 5 filters each. Installing a new filter in MMIRS requires disassembly of the cryostat -- a major operation -- and cannot be done without advance planning. Contact Brian McLeod for more information.

7. General Comments and Information.

7.1. Typical Count Levels.

The bias level in up-the-ramp data is typically 6000 ADU.

Please refer to the Exposure Time Calculator below for more estimates of background and counts expected at a given magnitude.

8. Problems and Troubleshooting.

1. **Troubleshooting during observing.**

   Many problems can be diagnosed using the *mmice* Status display. The top section shows the status of all the servers in the MMIRS

client/server system. Green indicates that the server is up. Red indicates that the server is not running. Yellow indicates that the server is up but not responding. Sometimes servers will go yellow briefly if they are very busy.

- If a server is red or yellow for a long time, the first step is to try restarting it, in the *mmice* Start/Stop tab, by clicking the 'restart' radio button, and then on the yellow/red button for the server you want to restart.

- **Trouble Restarting Servers** If a server refuses to restart, it's possible that the old process failed to kill properly; you can check for dead processes by typing 'ps -fA | grep <SERVERNAME>' into a terminal window. If you see a process there that you think should be dead, note its process id (PID), and then kill it manually with 'kill PID'. Then try the restart button again. Most servers can also be restarted from the command line with 'srvinit <SERVERNAME> restart'. This can sometime provide better error messages if something is stuck.

- **Server Logs** Every time a server (or GUI!) is restarted, a new log is started and stored in /data/log/mmirs/<SERVERNAME>.log. If a server or GUI is not starting for you, you can look at the end of the log file to see if there are any errors. Older logs are stored in the same place, with a timestamp in the log name. The log for telescope is in /data/log/mccd/telescope.log

Beyond dead servers, typical MMIRS observing problems can be divided into four main types:

- **Image Taking**

  Image taking with MMIRS is handled by two servers, **ccdmmirs** (aka hxrgmmirs; if doing a 'ps -fA', grep for hxrgmmirs, not ccdmmirs), and **hxrgserv**. **ccdmmirs** runs on fields, and writes images after they have been received from **hxrgserv**, which runs on the mmirs-hxrg computer, a virtual Linux computer that is hosted inside the *endeavor* server.

  - If *mmice* fails to take an image or the image is corrupted, try the following:
    - First try restarting hxrgserv and ccdmmirs on the Start/Stop tab of mmice.
    - If that fails tocorrect the problem, then on the Shutdown tab do Stop Science Camera Software (a second time if you get an error the first time). This shuts the power off to the detector hardware.
    - Then on the Startup tab: Start Science Camera Software
    - If hxrgserv or ccdmmirs servers don't start, then go to the Start/Stop tab and try again.

  - If the images appear on disk (/data/ccd/mmirs/<DATEDIR>), but do not get automatically displayed in ds9, try pressing the button to restart **ds9mmirs**. If the first image in a pair is displayed, but you are not seeing _dcorr or _diff images, you may need to restart the **crunchmmirs** server (or, rarely, the **archivemmirs** server).

    - When the exposure sequence number approaches 9999, it can be reset to 1 by doing the following:
      - Exit mmice
      - In a shell window:

        ```
        resetseq
        ```

      - To confirm, type: plist mmirs
      - Restart mmice and ccdmmirs server

- **Telescope Info/Dithering**

  The **telescope** server (aka telserver) provides information about the status of the telescope. Image header information comes from this server, and all dither/guiding moves are forwarded through it. If observe complains about no telescope information, set TELESCOPE=TEST on the Config tab. Don't forget to reset to the telname to mmt_f5_ir when the telescope is turned on or else your image headers will be missing information, dithering will fail, skyflats will fail!

  If dithers or paddle commands fail or timeout, you can try restarting **telescope**: the telescope operator has a button to do this in their guistars-mmirs interface. Sometimes the telescope indicator in *mmice* will still show green even when **telescope** server has stopped receiving updates from the telescope mount: if you do not see telescope parameters (e.g., LST) updating in mountdisplay, try restarting **telescope**.

- **Guiding**

  gcam1mmirs and **gcam2mmirs** are responsible for taking images on each of the two guide/wfs cameras. **gdrmmirs** calculates guider corrections from those images. Most guiding problems seem to involve lost coordination between the control GUI, **guistars-mmirs**, and its ds9 display. Please try restarting ds9 and/or guistars-mmirs before anything else. If guide/wfs images are still not displaying properly, try using the GUI to toggle camera1 and/or camera2 between guide and wfs mode. Then, try restarting the **gcam1mmirs**, **gcam2mmirs**, and/or **gdrmmirs** servers. **gcam1mmirs** and **gcam2mmirs** run on the *mmwave* computer in the mmirs instrument rack. If they do not start, please ensure the mmwave computer is on, and that it responds to ping.

- **Motor (PMAC) errors**

  Follow the following steps in sequence, trying again after each step:

  - Sometimes a move will fail with an error message; often you can try again and have it succeed.
  - Other times, it will be reported that a motor has lost its home position; in this case, you will need to try to re-home the motor. Easiest way to do this is to go back to the startup tab. If the buttons for Homing are greyed out, press the button for the previous step to enable them (**yes, it's ok**). Press the button just for the component that lost its home, if you can, **not** "Home all". Alternately, motors can be homed from the engineering interface by typing "mmx" in a shell window. Select the correct tab and press Home.

  - The cryogenic wheels (mos, dekker, filter1, filter2, grism) often fail to reach their position successfully if not enough time

has elapsed since they were cooled. This time scale is several hours for the mos and dekker wheels and a couple of days for filter and grism.

- Restart the pmacmmirs server from the Start/Stop tab of mmice
- If the above have not worked, cycle power on the stepper motor controllers using the Startup tab of mmice. Click the "phytron123? on" button buttons, wait till they turn red and then press them again. Then restart the pmacmmirs and powsmmirs servers from the Start/Stop tab.
- Cycle power on the pmac by pressing "pmac on" on the Startup tab. Restart the pmac server
- Call for help

Beyond the above categories, there are a number of indicators in *mmice* related to the status of the instrument:

- Homed indicates that the topbox has been initialized. If the indicator is red, which it will be following a full power-up, press the Home button.
- ESTOP indicates that the emergency stop button on MMIRS has been pressed. The ESTOP button is normally engaged when exchanging slit masks. If the power to the rack is turned off, the light will also turn red.
- LOAD turns red when the mask load switch on the instrument has been turned on. This switch is used to engage the manual advance button and lock out the computer for safety during slit mask changes.
- Occasional power glitches cause fields/endeavour to reboot themselves. If this happens, it will typically take 5 or more minutes for fields to fully boot up. Unfortunately, we have found that pmacmmirs does not recover properly without a hard power off/on of the pmac. This means you will need to re-home all motors and basically re-do the instrument power-up procedure.
- For items not covered here, see also the **Problem Solving** heading under **MMT+powerup+procedure**

2. **Calling for help**

The best person to call will depend on the type of problem you are having. In general, it is best to consult with Marc Lacasse first, unless it is obvious you need to jump straight to one of the other experts.

- For problems related to observing procedures, e.g., problems with alignbox, guide/WFS setup, please contact Igor first and then Brian.
- For problems related to computing infrastructure (fields VM, endeavour host, mmwave/mmirs-hxrg not up), or problems starting/restarting software components, call Sean.
- For problems related to instrument moves (grating wheel, guide/WFS camera stage), mask exchange/cooldown/warmup, consult with Marc and then call Brian.

3. **Report all problems**

All problems (weather not withstanding), comments and suggestions should be reported. The best way to do this is ask the professional observer to include your comment in their report or nightly email. Remember, if you don't report it, it can't be fixed!

9. Getting Your Data and Data Reduction.

All raw data is archived automatically to SAO in Cambridge. Raw data can be downloaded soon after it has been taken, from the same queue catalog website that was used to submit observation requests. Likewise, data is reduced automatically by SAO in Cambridge, and uploaded back to MMT within about a day, where it can also be downloaded via the queue catalog page. Please note that, for UAO observers, reduced data is provided strictly "as-is" without any additional vetting, and sometime the automatic pipeline run will fail for a variety of reasons. Thus, it may be worthwhile for PIs to download, install, and run the mmirs pipeline themselves. CfA observers will have their data inspected for basic quality control, but are also welcome to run the pipeline on their own. For data reduction questions, please email tdchelp@cfa.harvard.edu.

To reduce MMIRS data, please download and run the IDL pipeline available here: **http://tdc-www.harvard.edu/software/mmirs_pipeline.html**

For some (**possibly obsolete**) background on MMIRS data reduction see:

MMIRS Pipeline

Crude combination of dithered mask or longslit data can be accomplished as follows: On fields:

```
ur_setup   # Setup python
cd /data/crunch/MMIRS/YYYY.MMDD
refpix.py yourfiles.????.fits  # This takes the raw data files and computes the up-the-ramp slope (in ADU/sec) for each pixel
~/bin/coadd.py yourfiles.????.slp.fits  # Compute differences of dithered pairs and shifts them
```

In an IRAF session on fields:

```
cd /data/crunch/MMIRS/YYYY.MMDD
imcombine coadd??.fits comb.fits combine=average reject=sigclip
```

10. Appendices.

10.1. APPENDIX A: The Exposure Time Calculator, or ETC.

Exposure Time Calculator

This calculator uses the information contained in the previous section.

Imaging: **http://www.cfa.harvard.edu/mmti/mmirs/exptime.html**

Spectroscopy **http://www.cfa.harvard.edu/mmti/mmirs/Calibration/SNMMIRS/index.html**

10.2. APPENDIX B: How to plot the detector and guider footprint on an image in ds9.

DS9 templates for MMIRS are available in /home/mmirs/ds9templates, or can be downloaded here:

- Imaging: **mmirs_image.tpl**
- Mask: **mmirs_mask.tpl**
- Longslit: **mmirs_longslit.tpl**

Save the downloaded files to a convenient location. Then in ds9 go to the Regions menu and select Template-->Load. Then just click in your image to put the template region on your image. To edit the center position and position angle, double click on the region. In the Composite window, select Coordinate-->WCS, and optionally Coordinate-->Sexagesimal. Then you can edit the position angle and center position.

10.3. APPENDIX C: How to list guide stars available for your target.

Guide star availability can be checked by installing the **MMIRS Mask Making** software. Create a TAB DELIMITED file with a single ra/dec pair, e.g. tester.targets

```
ra dec
-- ---
12:00:00 -37:00:00
```

Then invoke the program as follows:

```
xfitmask tester tester.targets -check_boxes no -start_date XXXX
```

The GUI will appear and list all valid rotation angles.

10.4. APPENDIX D: How to set up dither catalog files.

Rather than entering separate, time-consuming commands to do things such as change the filter, enter an exposure time, and type in an object name, the Catalog Ops refers to an established catalog to perform all those functions, and more. A series of exposures for a given target can be planned in advance and executed without astronomer intervention, in principle. Dither catalogs can be generated manually or with the DitherTool tab of mice. Though they are referred to as "dither" catalogs, they do not have to control the telescope offset, but may instead or in addition specify any of several instrument parameters.

The catalog can be very versatile as it allows you to offset the telescope, specify filters for each image, and specify exposure times for each image.

The catalogs are TAB delimited tables. Columns in the table are delimited by the TAB character. The first line contains the column names. The second contains dashes separated by tabs. See **[3]** for information on manipulating tables of this format. The available column names are

```
exptime     The exposure time
filts       The filter name
disperse            The grism name
aperture    The name of the mask or slit
obstype     object, comp, flat, or dark
azoff       The azimuth instrument offset
eloff       The elevation instrument offset
readmode    e.g. /home/mmirs/ReadMode/ramp_7sec.cat
guidemode   autoguide, none, or wfsonly
namps       4 or 32
title       Description of the exposure
```

If you create your own custom files please put them in the directory /home/mmirs/Dither/User/yourname

10.4.1. DitherTool

You can create your own cat files in a text editor. However, the Dither Tool allows you to create cat files easily.

To use the dither tool, bring up the dithertool tab:

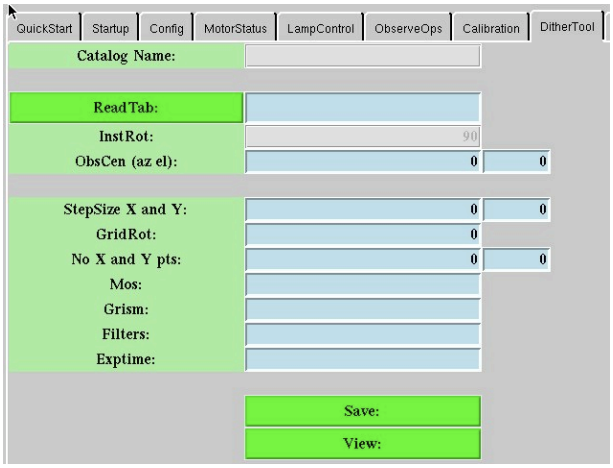


Figure 14 mice DitherTool tab. Full size image: **p/mmice-DitherTool.jpg**

The output of the dither tool is saved to a tab delimited text file which can be viewed or modified with any editor. Some examples of the output of the dither tool are shown below.

10.4.1. Dither examples

The first example is a spectral calibration file for the HK grism + the K filter. It takes several 10 second spectral line comparison exposures, followed by continuum flat exposures. It specifies the readout mode to be up-the-ramp, reading every second, using 32 output amplifiers. Make your browser window wide to see the whole file.

```
title           obstype exptime disperse        filts   readmode                                guidemode       namps
---------       ------- ------- --------        -----   ---------------------------------       ---------       -----
chipclear       comp         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
comp            comp         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
comp            comp         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
flat            flat         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
flat            flat         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
flat            flat         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
flat            flat         10 HK              K       /home/mmirs/Readout/ramp_1sec.tab       none               32
```

The next example is useful for taking a dithered pair of images in imaging mode for verifying that you are setup correctly on a field. It is located in the Standard directory.

```
setup.cat
azoff           eloff   obstype disperse        aperture
---------       -----   ------- --------        --------
0.0333129          30   setup   open            open
0                   0   setup   open            open
```

This next example loads 2 filters that are not normally used together to create a narrow bandpass, useful if for some reason you need to set up on a very bright source and don't want to saturate the detector. (This will minimize image persistence.) The only way to select two filters together is from a dither catalog -- it's not possible from mmice.

```
setup-bright.cat
azoff           eloff   obstype disperse        aperture        filts
--------        -----   ------- --------        ----    -----
-1.69105           30   setup   open            open    zJ,H
 0                  0   setup   open            open    zJ,H
```

10.4.2. Check your dither catalog files.

If you create your own dither file it is important to verify that the formatting, especially the white space, is correct before using it. To verify the formatting type:

```
justify < filename.cat
```

which should produce the output neatly aligned in columns. Remember columns in the table must be separated by tabs.

11. Archives.

Picture/Image Archive: **p**

Document Archive: **d**

Attachment	Author	Date	Size	Actions
MMIRS.ObsManual.2010Sep.txt	maginst	06-11-2024	54K	Delete
mmirs_image.tpl	amatthew	06-11-2024	2.6K	Delete
mmirs_longslit.tpl	amatthew	06-11-2024	2.6K	Delete
mmirs_mask.tpl	amatthew	06-11-2024	2.6K	Delete