The WIYN Mini-Mosaic Imager

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1 Introduction

The WIYN Mini-Mosaic Imager consists of two SITe 4096×2048 CCDs separated by a tiny gap mounted in a dewar. The CCDs have excellent cosmetics, high quantum efficiency, and allow good sampling (0.14"/pixel) and a large field of view (9.6 × 9.6 arcmin). Each of the two CCDs is read out through 2 amplifiers, resulting in a modestly short readout time for the 4096×4096 equivalent array. The dewar is mounted on the WIYN "Filter Shutter Assembly" (FSA), which holds 8 4-inch×4-inch filters. The FSA is itself mounted on the imager Nasmyth port, which rotates as the telescope tracks. The system takes advantage of the powerful ARCON CCD controllers, and benefits from the extensive software observing and reduction tools designed for the NOAO Mosaic cameras. Previous users of the WIYN imager will appreciate the better sampling, larger FOV, and greater ease of use.

2 Observing Overview: Taking the Data

2.1 The Only Command You Really Need: *observe*

With the ARCON software, one takes data with a single command: **observe**. The astronomer will be prompted for the information necessary for controlling the exposure. This includes the following:

- **Exposure type:** Can be "zero", "dark", "object", "comp", "pflat", "dflat", "sflat", or "focus". (Note that IRAF refers to a "bias" as a "zero"; "dflat" stands for "dome flat" and "sflat" for "sky flat".) If the exposure type is anything other than "zero" (which always has a zero-second exposure time), then the user is prompted for the integration time. For exposures in which the shutter opens, then by default the observer is also asked for a filter position and focus value; it is possible for these queries to be shut off, as we will describe in Section 3.2.

- **Number of exposures to take:** This allows a simple way of entering multiple identical exposures.

- **Title of picture:** This is the title put in the image header.

- **Filter in wheel one:** This is the filter position you would like; "wheel one" refers to the physical filter wheel, of which there are three; only one is mounted at any time.

- **Telescope focus:** This is the telescope focus you would like; it is to be specified in "absolute" position, not relative to the present position. **Note that this is a change from the old WIYN imager software.** A typical focus value is 4800 for the V filter, say, although this will be both telescope position and temperature

```
cl> observe
Exposure type (|zero|dark|object|comp|pflat|dflat|sflat|focus) (zero): object
Number of exposures to take (1:) (1):
Exposure time (0.:) (5.): 300
Title of picture (bias this afternoon): Shakbazian I
Filter in wheel one (B): V
Telescope focus (0.): 4800.
WIYN command - 65a1 filter position move 2
Got filter move completion from FSA 2
Setting shutter mode to normal
Got filter move completion from FSA 2
Filter1 = V
WIYN command - 65a5 telescope focus move 4800.00000
Now Moving secondary to 50 microns
..... focus = 4800.00000

Image obj003
MM2 [1:4096, 1:4096] bin=[1:1], gain 1
```

Figure 1: Making a 300 second exposure of type "object" through the "V" filter with the telescope focus set to 4800 microns.

dependent. (We expect a change in focus of about $+40$ μm for every -1°C change in temperature; this is quite a significant change, about twice as much as one might tolerate.)

An example of taking a 300 second object exposure is shown in Figure 1. Note that in each query the user is also presented with a default value that s/he could invoke simply by hitting [CR]; these default values are just the previous entries. Once the title is entered, the user is informed what the name of the image will be; this name can *either* consist of the exposure type as a root name (such as "obj") with a consecutive number attached, *or* of a single root name (such as "n1") with a consecutive number appended, depending upon how the *obspars* parameters are set (Section 3.3).

If all goes well, the user will be given a one-line reminder of what the image name will be, followed by a one line "status" report, which gives the CCD name (MM2 in the case of the WIYN Mini-Mosaic), the format, the binning, and the gain setting.

NOTE: All observing commands must be issued from the "DATA ACQUISITION window" and **NOT** *from the "DATA REDUCTION" window. We will describe these windows in Section A.2.*

2.1.1 Useful Windows: Exposure in Progress!

As the exposure progresses, the alert observer will notice several other windows of potential interest. In the upper left corner the exposure time will begin counting down, displayed in

easy-to-read large green lettering.

Another window of interest is the "ARCON Status" window, also in the upper left, which shows which picture is in progress, the dewar temperatures, how many pictures remain in the sequence, and a status of what is happening. ("INTEGRATING", "READING", or "CONTINUOUSLY_ERASING".)

There is also a long skinny window listing the 8 filters loaded into the filter wheel, with the current filter high-lighted. Although it looks tempting to try to change filters by clicking on this window, that will not work.

2.1.2 Coming to the End

At the end of the exposure, several things will occur:

- The exposure time counter will read "0".
- The ARCON Status window will display "READING" and show how many buffers have been read and how many are still to go.
- The image will shortly begin to be displayed on the other monitor.

On the other monitor, you will find the "DCA Console Monitor" and a standard IRAF ximtool window.

The "Data Capture Agent" (DCA) is the means by which the data is "captured" from the ARCON CCD controller and moved to the user-friendly IRAF environment. Of interest in the DCA Console is the image file name, the filter name in use, and the fraction of the image that has been captured, and the amount of disk space you've used. Depending upon the exposure type, the DCA will see to it that appropriate "on-the-fly" reductions are done to make the display in the ximtool more meaningful. For instance, an "object" exposure will have a bias level subtracted and then divided by one of the standard flat-field exposures of the appropriate filter. This is all done purely for display purposes; your data are not actually altered in any way. The image will be displayed in the ximtool as the data is captured, so that shortly after the read-down completes you can have a very good impression of what your data actually looks like.

2.2 Doing More with *more*

Did you like that last exposure and want to do some more just like it? There is a command to help you out: *more*. To do two more exposures with the same parameters (exposure type, filter setting, telescope setting, exposure length, title) of the previous **observe** command, do a

more 2

and you will be told what images are being written to disk.

2.3 DOOBS: Your Way to Easier Data Collection

Often you may wish to execute a series of exposures through various filters and of various times. Perhaps you know that you want a series of 5 exposures of the dome flat through each of 3 filters, each with a different time.

You could also use **doobs** on a series of object exposures; however, it would require you to enter the *relative* focus *offset* you desire, corresponding to each filter in the parameters for **wheel1**. *This is one of the unresolved issues listed in Sect. F; we will revise this when it is working correctly.*

A sample run is shown in Fig. 2.

2.4 Interrupting, Changing, or Terminating an Exposure

The ARCON software allows you to pause and resume an exposure, change the exposure time, or terminate an exposure right then, with the following commands:

- **pause** This command will close the shutter and stop the exposure count-down.
- **resume** This command will open the shutter and resume the exposure from when you **pause**d.
- **stop** This command immediately closes the shutter and reads down the chip; the data is saved. Unlike the ICE software, the ARCON software insists that the **stop** command be issued on an exposure that is in progress. In other words, if you have paused an exposure to wait for clouds to go away, and it's begun raining, you can issue the **stop** command, but you will need to do a **resume** for it to take effect.
- **abort** The command does what you might expect: terminates the exposure and does *not* read out the chip or save the data.
- **tchange** The command will allow you to increment or decrease the exposure time.

In the event that you have asked for a series of integrations (either by using **more** or by specifying multiple exposures via the **observe** command, **stop** and **abort** will end the entire series. The **tchange** command will operate only on the current image, and not affect subsequent exposures in the sequence; i.e., if you change the exposure time of the second exposure of a series of five dome flats from 60 sec to 30 seconds, the third, fourth, and fifth ones will exposed for 60 sec. Thus if you are really unhappy with the exposure times, you will need to use **stop** or **abort** and reissue the **observe** command.

```
doobs
Exposure type (|object|dflat|sflat|): dflat
Number of exposures to take in each filter (1:) (1): 5
list of filters in wheel1: U,B,V
List of exposure times: 30,2,1

The following pictures will be taken:

Pictures          Filter1            Exposure
      15 - 19     U                  30
      20 - 24     B                  2
      25 - 29     V                  1

Title for pictures: afternoon flats


WIYN command - 5381 filter position move 1
WIYN command - 5382 telescope focus move 4800.00000
Now adjusting secondary by 30 microns
Filter1 = U             Telfocus = 4800.00000

Images dflat015 - dflat019
MM2 [1:4096, 1:4096] bin=[1:1], gain 1

1: cmd=E48 event=131072 stat=0 buf=

Single character sub-commands:

   A   Abort exposure
   P   Pause exposure
   R   Resume paused exposure
   S   Stop exposure
   T   Change exposure title (current exposure ONLY)
   X   Change exposure time (current exposure ONLY)
   Q   Interrupt task (optionaly aborting exposure)

1: cmd=E48 event=512 stat=0 buf=
1: cmd=E48 event=32 stat=0 buf=
```

Figure 2: A sample run of **doobs**, where we requested five dome flats taken through each of 3 filters, with a different exposure time corresponding to each filter.

2.5 How to Get Help

IRAF comes with on-line documentation that gives the nitty-gritty of each command. Simply type **help more** to see the help page for the **more** command. You can get a hard-copy of this help page by directing the output to the laser writer:

help more | lprint

3 The Parameters Files

The ARCON software has made it easy for you to observe by providing a single word for data-collection: **observe**. However, this ease has not come at the cost of flexibility; instead, all the options have been buried in the parameter files. There are four of these parameter files which must be properly set, but which you will likely leave alone throughout the course of your run:

detpars This parameter file controls the fundamentals of how the CCD **det**ectors are read. All items in this parameter file are crucial for correct operation of the CCDs.

instrpars This is the **instr**ument parameter file, and it is mostly useful for specifying whether or not you want to be asked for filter and focus values for each exposure.

obspars This is the parameter file that is used by the astronomer to tailor the observe command to his/her liking, and in particular to specify how the root name of the exposures are constructed.

telpars This parameter file is used only to specify the protocol needed to communicate with the telescope computer in order to allow proper transfer of header information (time, telescope position and particulars) to the ARCON software.

These parameter files can each be listed using the **lpar** command, e.g.,

lpar detpars

and may be edited using the parameter editor **epar**, e.g.,

epar detpars

However, the change will not take effect (for **detpars**) unless you then run **setdet**.

```
cl> lpar detpars
        (gain = 1)              Gain setting
    (preflash = 0.)             Preflash time (seconds)
        (xsum = 1)              pixels summed in X direction
        (ysum = 1)              pixels summed in Y direction
      (xstart = 1)              Start of ROI in X
      (ystart = 1)              Start of ROI in Y
       (xsize = 4096)           Size  of ROI in X
       (ysize = 4096)           Size  of ROI in Y
      (extend = "separate")     Method of extending ROI to include overscan
      (xskip1 = 0)              X pixels to skip at start of overscan
      (xskip2 = 0)              X pixels to skip at end   of overscan
      (xtrim1 = 0)              X pixels to trim at start of data
      (xtrim2 = 0)              X pixels to trim at end   of data
      (ytrim1 = 0)              Y pixels to trim at start of data
      (ytrim2 = 0)              Y pixels to trim at end   of data
  (amplifiers = "lowerfour")    Readout amplifiers to be used
     (pixsize = 15.)            Pixel size in microns
    (nxpixels = 4096)           Detector size in X
    (nypixels = 4096)           Detector size in Y
   (noverscan = 64)             Number of overscan pixels
     (detname = "MM2")
        (mode = "ql")
```

Figure 3: Parameter file **detpars.**

3.1 *detpars*

The detector parameter file **detpars** allows the astronomer to specify how the chip is to be formatted, which amplifiers are in use, and so on. It also contains additional "readonly" information which is inserted into the headers, such as the pixel size in microns. There are two gain settings for Mini-Mosaic. The default gain (1.4 e/ADU) does an excellent job of mapping the full linearity range (70,000 e) to the 16-bit range of the A/D converter (65,000). The second gain setting gives 0.9 e/ADU and nominally slightly lower readnoise. We recommend that you leave **detpars** alone. If you do choose to change anything in **detpars** it will not take effect until you then run **setdet**, which regenerates the waveforms which run the CCDs.

3.1.1 Digression: The Power of *ccdinfo*

Once your **detpars** is setup, you can verify all of these important parameters by simply typing the command

ccdinfo

You will get a response that resembles that of Figure 4.

3.2 *instrpars*

this parameter is currently useful at WIYN only for turning on or off the queries for filter and focus. Eventually this will allow you to specify a base and reference temperature and have the focus adjusted for changing temperature. The default listing is shown in Figure 5.

3.3 *obspars*

The parameter file *obspars* allows the astronomer to specify details of how the images will be named and contains other information that will be passed on for the headers. A sample **obspars** can be seen in Figure 6.

3.4 *telpars*

The final relevant parameter file used by the ARCON software is **telpars.** It serves primarily as the memory of the answers you gave during the most recent focus frame. The telescope name needs to be right, and there are a few "readonly parameters" which are there to provide information for the headers.

4 Dealing with the Data

4.1 What Multiple Amps Means for You

Each of the two CCDs is read-down through two amplifiers, and IRAF treats each exposure as if it were four exposures, taking full advantage of the multiextension IRAF format developed for Mosaic. Because there are four different amplifiers in use, each section will have a slightly different gain and slightly different bias level. However, these differences disappear completely in the reduction process (Section 4.3), and one should relax and not worry about it. The charge transfer efficiency is sufficiently similar that we have not seen differences in the point-spread-function between the left side and the right side of a CCD. (Nor have we seen them between the left CCD or and the right CCD; the CCDs are very co-planar.) However, if you look at a dome flat exposure you should not be surprised to see four different levels. This should not normally appear in the object exposures that are automatically displayed through the DCA, as the display has been flat-fielded. The difference in gain between the four amplifiers is small ($\pm 7\%$), but enough to be disconcerting to the first-time user.

```
ccdinfo
        (gain = 1)              Gain setting
    (preflash = 0.)             Preflash time (seconds)
        (xsum = 1)              pixels summed in X direction
        (ysum = 1)              pixels summed in Y direction
      (xstart = 1)              Start of ROI in X
      (ystart = 1)              Start of ROI in Y
       (xsize = 4096)           Size  of ROI in X
       (ysize = 4096)           Size  of ROI in Y
      (extend = "separate")     Method of extending ROI to include overscan
      (xskip1 = 0)              X pixels to skip at start of overscan
      (xskip2 = 0)              X pixels to skip at end   of overscan
      (xtrim1 = 0)              X pixels to trim at start of data
      (xtrim2 = 0)              X pixels to trim at end   of data
      (ytrim1 = 0)              Y pixels to trim at start of data
      (ytrim2 = 0)              Y pixels to trim at end   of data
  (amplifiers = "lowerfour")    Readout amplifiers to be used
     (pixsize = 15.)            Pixel size in microns
    (nxpixels = 4096)           Detector size in X
    (nypixels = 4096)           Detector size in Y
   (noverscan = 64)             Number of overscan pixels
     (detname = "MM2")
        (mode = "ql")


                        *** Table of gain values ***

       Detector = Mini-Mosaic, 4160 x 4096 (64 overscan)

       dcsT  GAIN   Read_Noise        Gain      Readout Time
       (us)   #        (e-)         (e-/ADU)      (sec)
        ---  ---   -------------   -----------   --------
 1:    5      3         6.0           1.4         182
 2:    8      4         4.5           0.9         207

               Default Gain setting is #3

        *** Select gain setting from the first column

        *** The current gain setting is 1
```

Figure 4: The command **ccdinfo** produces a listing of the current parameters in effect, and reminds you of the gain.

```
cl> lpar instrpars
      filter1 = "B"             Filter in wheel one
       (wheel1 = "")            Filter info. pset for wheel one\n\n# SELECTING F
  (setfilters = "yes")          Query and set filters?\n\n# SETTING FOCUS FOR EA
    (setfocus = "yes")          Query and set focus?
 (temperature = 10.)            Telescope temperature (C)
   (basefocus = INDEF)          Telescope focus base value
     (reftemp = 10.)            Telescope temperature for base focus value (C)
    (tfrcoefs = "")             Coeficients of Temperature-Focus relationship\n\n
    (tv1focus = 0.)             Focus for camera 1
    (tv2focus = 0.)             Focus for camera 2\n\n# SHUTTER READY POSITION
(shutter_read = "auto")         Position of shutter when NOT exposing\n
   (instrname = "mosaic")       Instrument name
        (mode = "ql")
```

Figure 5: The rather uninteresting parameter file **instrpars.**

```
cl>lpar obspars
      picture = 15              Picture number of first exposure
    (template = "")             Image name template
  (autopicnum = yes)            Generate picture number automatically ?
   (detupdate = no)             Update detector parameters automatically ?\n\n#
     (postpic = "")             Post processing command for single picture
     (postseq = "")             Post processing command for sequences
     (restart = yes)            Restart the server on every command ?\n\n# ADDIT
   (observers = "Armandroff & Massey") Observers
      (propid = "99ZQV-083")    Observing proposal ID
    (comments = "")             Comments
     (comfile = "")             Observer header comments file
        (mode = "ql")
```

Figure 6: An example of **obspars** is shown.

```
cl> lpar telpars
     telfocus = 4805.          Telescope focus
       nfexpo = 7              Number of focus exposures
   freference = 4800.          Focus value
       fdelta = -20.           Focus increment
   (ra_offset = 0.)            RA Offset (arcsec)
  (dec_offset = 0.)            Declination Offset (arcsec)\n\n# PARAMETERS FOR
      (shtype = "detector")    Shift type
  (fra_offset = 0.)            Focus offset in RA
 (fdec_offset = 20.)           Focus offset in Declination
      (fnrows = 30)            Focus number of rows to reverse shift
       (refis = "middle")      Reference is first, middle or last exposure?
     (focmode = "auto")        Focus mode\n\n# FOR INFORMATION ONLY
     (telname = "wiyn")        Telescope name
     (station = "nf")          Focal station
      (fratio = "f/6.4")       Focal ratio
  (platescale = 9.374)         Plate scale (arseconds/mm)
        (mode = "ql")
```

Figure 7: The rather uninteresting parameter file **telpars** primarily contains the focus parameters. However, these are most easily entered during the queries in an actual focus expsoure.

4.2 Examining Your Data

Because the Mini-Mosaic uses the multiextension format, you must specify which extension you mean in order to use the usual IRAF commands, i.e.,

implot obj007.fits[1]

would plot the middle row (line 2048) of the first 2048 column numbers of the "left" CCD. Similarly

implot obj007.fits[2]

would plot the right half of the left chip. Even a command like **imhead** requires you to specify which CCD you are talking about, [1] or [2]. (**imhead obj007.fits[0]** will show you a global header associated with the frame.)

However, you will probably find it considerably more useful to take advantage of special commands that have been written to treat the data as if it were a single image. For instance, although you could display the left side of the right CCD by using **display obj007.fits[3]**, you would probably find the following much more useful:

mscdisplay obj007

This will display all four extensions arranged in the proper geometry; i.e., so that you will see two 2048×4096 images with a modest gap between them.

Furthermore, you can now interact with this displayed image using certain tools that will act as if you are indeed looking at a single large image. For instance, the multiextension version of the familiar *imexamine* is **mscexamine.** If you run **mscexamine** you can move the cursor around, pick out a star, and do a radial plot using "r" just as you would have with a single CCD and *imexamine*.

4.2.1 Using *mscexamine*

The **mscexamine** task provides some of the most powerful diagnostic quick-look tools within IRAF. If an image that you wish to examine is already displayed in the ximtool window, simply type **mscexamine.** Wait patiently *without moving the mouse* and a blinking, round cursor will appear on the display. Place the cursor over a star, and strike the **r** key, and you will be presented with a radial plot of the star, along with the values of a fit to the stellar profile. The last number displayed is the FWHM in pixels, quite useful for determining the best focus. Other very useful commands include **l** for making a line plot at the position of the cursor, and **c** for making a column plot at the position of the cursor. Other useful cursor strokes are shown below.

r - Make a radial profile of the star near the cursor. The FWHM will be the last number shown in the plot.

a - Print FWHM without showing the radial plot.

c - Plot the column nearest the image cursor

l - Plot the line nearest the image cursor

j - Fit a 1-d Gaussian in the x direction, centered near the cursor

k - Fit a 1-d Gaussian in the y direction, centered near the cursor

m - Print the statistics in a box around the image cursor

e - Make a contour plot of a region around the image cursor

h - Plot the histogram of a region around the image cursor

s - Make a surface plot of a region around the image cursor

:c N - Plot column N when in graphics mode

:l N - Plot line N when in graphics mode

:naverage M - ave M columns (or lines) during plots

x - Print the x, y, z values of the pixel nearest the image cursor

z - Print a 10 by 10 grid of pixels around the image cursor

o - Overplot

g - Go to the graphics window from the ximtool window

i - Return to the ximtool window from the graphics window

? - Print help

q - Quit **imexamine**

:epar r - Edit the radial profile plot parameters

:epar c - Edit the column plot parameters

:epar e - Edit the contour plot parameters

:epar h - Edit the histogram plot parameters

:epar l - Edit the line plot parameters

:epar s - Edit the surface plot parameters

4.2.2 Subtle Issue About the Display

By default, the size of the image buffer for the display is 2048×2048, so that when the DCA automatically displays a new image, or you manually issue a **mscdisplay image**, you are not seeing individual pixels when you expand on the image tool. You see a larger area, and what you do see is the average of several adjacent pixels. We find this is a good compromise. However, if you really would like to see individual pixels, (or close to it), do a **set stdimage=imt4096** in the window from which you are issuing the display commands. You can also use the DCA monitor to change the default display buffer, but changing it will mean it takes longer to display. (To do so, select "edit" and then "display params". A GUI screen will appear that allows a change in **stdimage** for the autodisplay.) Note that there will be some slight "aliasing" at the default imt2048; your bias frames may appear to have a cross-hatched pattern. Careful examination of your data will reveal this is an aliasing artifact from the display.

4.3 Reducing Your Data

If you are familiar with how to reduce CCD data with IRAF, the WIYN Mini-Mosaic will present no challenge. Special versions of **flatcombine**, **zerocombine**, **ccdlist**, and **ccdred** have all been made in order to deal with the multiextension formats transparently. (Tololo observers familiar with **quadproc** will be happy to find the higher efficiency of **ccdproc**.)

If you are unfamiliar with **ccdred**, you should consult "A User's Guide to CCD Reductions with IRAF", available on the Web from:

http://iraf.noao.edu/iraf/ftp/iraf/docs/ccduser3.ps.Z.

Here are the basic steps you will need to reduce your data.

mscred Loads the special Mosaic version of the reduction tasks. This should already be automatically loaded at WIYN in the Data Reduction task.

setinstrument. Answer the questions with "kpno", "wiyn", and "minimosaic", for the site, telescope, and instrument, respectively.

ccdlist Makes sure that the different exposure types and filter names are being translated correctly.

zerocombine Combines bias frames.

flatcombine Combines dome flats filter-by-filter

sflatcombine Combines dark sky flats (if any) filter-by-filter

Decide which flats are the best match to your object exposures by using **mscarith.** In most cases, dome flats seem to do a good job of flattening the data at WIYN to (<1%); see Sec. 8. However, if you are interested in the best possible flat-fielding, you will likely need to correct your dome flats for a slight mis-match in illumination function. To do this, there is a "standard" IRAF task **mkskyflat.** Unfortunately, there is no msc-friendly version of the task. We suggest that you try the generic **msccmd**; see the help page.

ccdproc Does the processing.

5 Filters

WIYN has an extensive collection of standard 4-inch×4-inch filters. A list of these filters, along with plots, can be found on the filter information page from Kitt Peak on the Web: *http://www.noao.edu/kpno/filters/filters.html.*

6 Focusing

When you take a focus frame with the ARCON software at WIYN, you typically take a short (3-10 sec) exposure of a 11-12th mag star, clock the charge down 30 rows, decrease the focus value, take another exposure, clock down the charge, decrease the focus, etc., for a series of 7–9 exposures. The frame is then read down, the the image examined with **mscfocus** to determine the best focus value. **Note that the double-space gap occurs after the first exposure.** A sample run is shown in Fig. 8.

7 Writing Your Data To Tape

At WIYN both Exabytes and DATs are available: *mtb* is the Exabyte drive, and *mtc* is the DAT drive. Because of the multiextension format of Mini-Mosaic data, you must use the **mscwfits** and **mscrfits** commands.

allocate mtb

The parameters for **mscwfits** are shown in Figure 9.

In order to check to see what is on the tape, you can list the titles quite easily. Simply do a

mscrfits mtb 1-999 list+ short+ original+

to see what's there. To direct this output into a file, you can add a > **tapelist** to the end, and then you can print that list on the lineprinter by a simple **lprint tapelist.**

```
cl> observe
Exposure type (|zero|dark|object|comp|pflat|dflat|sflat|focus) (object): focus
Exposure time (0.:) (3.): 9
Title of picture (test field V): V focus frame
Number of focus exposures (7):
Middle exposure (number 4) of sequence to have Focus value (4800.):
Focus increment (-20.):
Filter in wheel one (V):
WIYN command - 65a1 filter position move 2
Got filter move completion from FSA 2
Setting shutter mode to normal
Got filter move completion from FSA 2
Filter1 = V
WIYN command - 65a5 telescope focus move 4860.00000
Now Moving secondary to 50 microns
..... focus = 4860.00000
First focus exposure finished...
WIYN command - 65a6 telescope focus move 4840.00000
Now Moving secondary to -19 microns
..... focus = 4840.00000
...additional focus exposure finished...
WIYN command - 65a7 telescope focus move 4820.00000
Now Moving secondary to -20 microns
..... focus = 4820.00000
...additional focus exposure finished...
WIYN command - 65a8 telescope focus move 4800.00000
Now Moving secondary to -20 microns
..... focus = 4800.00000
...additional focus exposure finished...
WIYN command - 65a9 telescope focus move 4780.00000
Now Moving secondary to -20 microns
..... focus = 4780.00000
...additional focus exposure finished...
WIYN command - 65aa telescope focus move 4760.00000
Now Moving secondary to -20 microns
..... focus = 4760.00000
...additional focus exposure finished...
WIYN command - 65ab telescope focus move 4740.00000
Now Moving secondary to -20 microns
..... focus = 4740.00000

REMINDER: The double space marks the beginning of the sequence!
```

Figure 8: A focus run centered upon a typical focus value (4800) with a reasonable step size (-20).

```
cl> lpar mscwfits

cl> lpar mscwfits
        input =                 Mosaic FITS files
       output =                 Output tape
      newtape =                 Blank tape?
   (shortlist = yes)            Short listing?
    (longlist = no)             Long listing?
        (mode = "ql")
```

Figure 9: Parameters for **mscwfits.**

NOTE: If you do write additional files to an "old tape" (one containing useful data but which had previously been removed from the drive), make certain that the software (IRAF and Unix) is aware that the tape has been rewound before starting to write to the tape—-or your old data may be overwritten! To safeguard against this possibility we suggest that you *ALWAYS* swap tapes by first:

- **deallocate mtb** (or mtc)
- Physically swap tapes
- **allocate mtb** (or mtc)

7.1 Safe Taping

We recommend the following "safe taping" procedures.

1. Each night write data to tape.
2. Read the tape using **mscrfits mtb list+** to substantiate everything is there.
3. Deallocate the drive, remove the tape, and *stick it under your pillow.*
4. Make a second copy of your tape. (This tape could be an accumulative copy of the data throughout your run.) Check this tape with **mscrfits!**
5. Only now delete the data from disk if necessary.

7.2 Save-the-Bits!

All data taken at WIYN (and the other Kitt Peak telescopes) are automatically saved to tape. Extracting a night's worth of data from these tapes is laborious and labor-intensive, and we strongly emphasize the need for the "safe taping" procedures above. But

if you ever do need to recover a night's worth of data, take heart! You can send email to "kpno@noao.edu".

8 Calibration Recommendations

The Mini-Mosaic is, at this writing, brand new. You certainly won't go wrong if you obtain 10 biases every night, and 5 dome flats through each filter (aiming for a count of 20,000e each, or 30,000 ADUs, say). We believe that this will then flatten your data to better than 1%. If you want even better flats, you will need to use dark-sky flats.

The following table gives reasonable lamp settings and exposure times.

Dome-Flat Exposure Times and Lamp Settings

Filter	High Lamp Setting	Exp. Time
U	3200	15s
B	2500	3s
V	1500	4s
R	1000	3s
I	1000	1s

A Logging In, What It Looks Like, and How to Get Out

A.1 Logging on

Mini-Mosaic is controlled from the WIYN computer *pearl*; its terminal is sitting in the corner of the control room. The login name is **wiyn_ccd**; the password should be posted on the terminal.

A.2 What Windows Go Where: What Your Desktop Looks Like

Once past this hurdle, the astronomer will find numerous windows have been opened. Among them are:
On monitor 1:

ARCON Acquisition (startACQU) window. This is the window in which all your commands for running the ARCON should be issued. When the system first starts up, it will ask you if you wish to "synchronize the parameters". **Always answer "yes" to this question**, unless of course you know something we don't. If you to exit this window, you must do so by choose "End ARCON session" from the root menu.

Arcon_user window. This is in some ways a misnomer; this window is primarily the source of technical information about what the controller is doing. Some observers prefer to close (but don't quit!) this window.

A long skinny window containing the list of the filters. The one in use will be high-lighted; although it looks tempting, you *cannot* change filters by clicking on a filter name.

fsa Motor. This is another hardware technobabble window; one could close it, and inspect it if there seems to be a problem changing filters.

ARCON Status. This is a very useful window that reports dewar and camera temperatures, CCD status, number of pictures remaining in a series, current picture number, and so on.

Large green 0. This window is the exposure time counter; during an integration it will count down.

IRAF Reduction window. Parameters for this window are kept separately from those in the acquistion window.

Various minor windows: clock, CPU meter, virtual desktop icon, read-only console window.

On monitor 2:

DCA Console Monitor. The Data Capture Agent monitor tells reports the image name, the image type, the filter, the data directory, what percentage of the image has been captured from the ARCON controllers, and even how much disk space you're using.

ximtool. The basic image display window appears on this second monitor.

A.3 Logging Out

The cleanest and safest way of exiting is the following:

1. In the background root menu, click on "End ARCON session".
2. Type **logout** in each of your remaining IRAF windows.
3. Move the mouse to a blank area of the screen and hold down the right mouse button; select "Quit Windows".

We recommend that you log out at least once a day. Unix memory management is such that allocated blocks of memory are never truly freed for reuse until a process dies. IRAF, on the other hand, will arrange to keep a process around indefinitely (even after a task exits) to avoid the rather stiff startup penalties that sometimes apply.

B At The Very Beginning of Your Run: *obsetup* and *obsinit*

Note: If the previous user has not been using the Mini-Mosaic camera, but rather the old "S2KB" CCD, you should first do an obsetup. *Normally this will not be needed. However, we are mentioning this command, as it may be needed during the short transitional phase as Mini-Mosaic replaces the old WIYN imager.*

At the very beginning of your observing run, you should clean off all of the previous observer's images and files, and reinitialize all of the parameters to their default values. You or the instrument assistant can accomplish this by the following:

- Log in using **wiyn_ccd** and password posted on the machine.

- In the background menu, choose "End ARCON session". This should kill off the multiple ARCON windows.
- In any remaining IRAF windows, type **logout**.
- Select "Unix Xgterm" from the root menu. (Move the mouse to any blank area of the screen, and hold down the right mouse button. Slide the mouse down to "Unix Xgterm".)
- In the new window, type **obsinit** and answer the questions appropriately (Fig. 10).

The reason for the above procedure is that you cannot have IRAF running during an *obsinit* or parameters will not be correctly reset. Make sure that you have logged out of each IRAF window before running *obsinit*.

An example of using *obsinit* is given in Figure 10. Note that the user has the option of selecting whether **CNTL-z** or **CNTL-d** will be the default for an end-of-file command; the former is the standard at NOAO, but the latter is the standard at many other places. Finally, note that it is possible to run *obsinit* WITHOUT deleting any files or images! If you simply wish to set the ARCON parameters back to their default values, you may run this in the middle of your observing run without losing any files.

C Changing filters

Filters should be changed only by authorized WIYN personnel. After a change, the new filter name, and a description, needs to be entered into the software by doing an **epar wheel1**. When done, the system must be initialized by doing a **motor init**.

D Problems?

Very occasionally (almost never, in fact) you may experience some sort of of ARCON hang-up or problem. The way we like to deal with this is the following.

1. In the background menu, select (Re)start ARCON. This will kill off any of the ARCON processes, and restart them. **Note: Whenever the ARCON software asks you if you want to synchronize parameters, always answer "yes" unless you have a good reason to do otherwise!**
2. If that doesn't fix the problem, it's possible that the ARCON controllers themselves will need to be reset. Call for help!

```
OBSINIT deletes all images and files, and replaces the startup files.
  There is a prompt later if you want to only replace the files.

  Initialize the 'wiyn_ccd' account? (yes): yes

  OBSINIT needs to kill any netscape windows now to avoid turning
  them into zombie processes later.

  Kill 'wiyn_ccd' account netscape windows? (yes):


The names of the observers and the KPNO/NSO proposal IDs are needed
  by the NOAO archive to preserve the paper trail.  Please enter the
  names of the ACTUAL OBSERVERS for this run, separated by commas.
  SPELLING & CAPITALIZATION count.  First names & initials may be used.

  Observer(s): Armandroff & Massey


PLEASE CHECK THE PROPOSAL ID CAREFULLY (see the posted copy of the
  observing schedule).  Note that special projects (e.g., synoptic
  or queue observing) may have non-numeric proposal IDs.

  Proposal ID: 99ZQV-083


OBSINIT thinks node 'navajo' means the minimosaic configuration.


Enter the imdir directory name (HDR$pixels/):


Default interrupt characters are ^Z(eof), ^X(susp) (not UNIX standard).
  Change these to the standard values ^D(eof), ^Z(susp) instead? (no): yes


OBSINIT replaces a large number of the observer's unix and iraf
  configuration files while defining the complete appearance of
  all of the acquisition and reduction windows.

  Do you also want to DELETE ALL IMAGES AND FILES? (yes): yes

    ...deleting the images and files, be patient
    ...restoring the default login and startup files
    ...restoring the observing scripts package
    ...configuring wiyn_ccd account for minimo
    ...unpacking minimosaic observing account snapshot (ver 1999-10-14)
    ...updating observer and propid


Logout and login again for all of these changes to take effect.
```

Figure 10: Running *obsinit* will reset all parameters back to their default values.

E SUMMARY OF FACTS

CCDs: Two SITe 2048×4096 thinned, science-grade devices

Pixel size: 15μm

Scale: 0.141 arcsec/pixel

Gap: 50.5 pixels (7.12 arcsec) are missing between the chips

Orientation: N is to the left, and E is down (with the default rotator setting)

FOV: 9.6 × 9.6 arcmin

0.1% linearity: 70,000 e (INSERT: what is listed for the Mosaic chips)

Default gain: 1.4 e/ADU

Nominal read-noise at default gain: 6.0 e

Read-time: 182 sec

Number of 4-inch×4-inch filters: 8

Count rate (e/sec/image) from $U = B = V = R = I = 20$— U: 20::, B: 165:, V: 215, R: 260, I: 140.

F Unresolved Issues As of This Writing

We are still learning about Mini-Mosaic, and hammering out a few software issues. Here they are.

- **Cross-talk.** There is some minor cross-talk between the chips; this should calibrate out as easily as it does with the NOAO MosaicI and MosaicII cameras. We are currently working on determining the cross-talk coefficients. Stay tuned!
- **Filter offsets.** The offset values in for the filters in Wheel1 do not work. This limits the usefulness of *doobs* when run with instrpars.setfocus=auto, as the focus cannot be adjusted automatically when changing filters. We suggest that you leave instrpars.setrfocus="yes".

- **Temperature coefficients.** We don't know good values for the temperature coefficients of the focus, and haven't checked that the software takes these into account with instrpars.setfocus=auto. We suggest that you leave instrpars.setfocus="yes" and refocus as needed. We do expect that for every 1 degree C *colder* it gets that the focus probably needs to be *increased* by 40μm or so. Since a 10μm change is obvious in good seeing, refocus often!

- **Count rates.** The "B" count rate seems rather low. The "U" count rate is extroplated.

- **Safe exposure speed.** We do not recommend extremely short shutter speeds, and recommend you keep your standard star exposures reasonably long (5 secs?) unless you determine the shutter correction for yourself.