

Observing and Data Reduction Software for a 256x256 Camera

Version 1.7
Steward Observatory

March 2, 1993

Note for this version: Be aware that the PC disk directory can hold only 512 files. If you are taking many frames during a night you may need to create and switch to separate subdirectories. You can check on the number of files in the current directory by doing a "dir" command.

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0. Equipment Travel and Setup Notes

The following describes moving and setting up the 256x256 IR camera. There are minor differences between the 61-inch and 90-inch which are noted.

A. Moving Equipment

- 1) The computer automatically parks its disk drive so no extra precautions are needed.
- 2) The dewar should always ride on the floor of vehicles, and it should be situated so it cannot tip over nor have anything fall on it.
- 3) The rest of the equipment should be placed on foam pads. The liquid nitrogen dewar should be tied down. The tool box and boxes with only cables need not be placed on foam pads.
- 4) Whenever the dewar is uncabled, the yellow grounding wire should be in place and the power to all components should be off.
- 5) When disconnecting 50-pin ribbon cables, please be careful since the various boxes do not have cable ejectors, and it is easy to pull a cable apart. Place the 50-pin scrap cable in the dewar connector before transporting the dewar.
- 6) Please return guider box mounting bolts to the tool box and all other mounting bolts should be placed back into their holes on the guider box.

B. Setting Up the Camera

- 1) At the 61-inch, the hoist may be used to move equipment upstairs. The dewar, guider box, dewar electronics power supply, filter wheel stepper supply, and camera control chassis go upstairs while the computer and its monitor go to the kitchen.
- 2) At the 90-inch, the computer and monitor are placed in the Control Room along with the f/45 focus control. The dewar, guider box, dewar electronics power supply, filter wheel stepper supply, and camera control chassis sit on the observing platform.
- 3) The guider box is bolted on to the telescope with the opening for the dewar facing north and the bolt circle for the TV facing south. The dewar is installed using a lift cart. Before installing the dewar, remove the lens cap (clean lens with dry air and/or lens tissue if dirty) and the cover to the TV port on the front side of the dewar. The TV may be bolted on at this time. At the 90-inch, install a hose for the dry air flow over the lens.
- 4) After the dewar is bolted on, its electrical isolation from the telescope must be checked. Unless the G10 facing on the guider box has been removed or unless one of the G10 bolt collars have been lost, the dewar should be isolated. However, for safety reasons and for signal quality reasons, it is imperative that the following check be

carried out. This check should be done before installing the cables to the computer. Get an ohmmeter and touch one probe to metal on the dewar and the other probe to metal on the guider box. If the electrical isolation is still intact, the ohmmeter should read "OL" or otherwise indicate the maximum resistance that the meter can report. If a low value is indicated such as would be seen if the two probes were touched to each other, check the G10 facings and bolt collars. Do not proceed until the isolation is restored.

5) The cabling to the dewar may now be installed. The first cable to be attached from the chassis to the dewar should be the yellow wire with alligator clips at each end. This insures that a good ground exists between the dewar and the control chassis. The control chassis should be plugged into the white surge protector box but no switches should be turned on yet. After the yellow wire is attached, the other cables may be installed. There is no preferred order for installing cables. Note also that all connectors are keyed and the only duplicates on the 9-pin D for the filter wheel and the similar connector used to go between the two boxes on the dewar.

6) After the dewar cables are attached, the yellow grounding wire should be removed because it is too short to leave in place during observing. Duct tape should be used to secure the filter wheel cable and especially the 50-pin cable to the dewar.

7) A 50-pin ribbon cable runs from the observing floor to the camera computer in the kitchen or control room. At the 61-inch, a gray cable with a white cable union in it is used. It is run through the hole in the platform and through the small cable hatch in the kitchen wall. At the 90-inch, a multi-colored cable is used. It is run along the observing floor and then along side the telescope mount and into the control room through the opening near the cable tray. See Figure 0a. for a cabling diagram.

8) Install cables to the computer and attach its keyboard. At the 90-inch, the tan ethernet cable should also be attached. At the 61-inch, the ethernet cable coming from the small gray box on the wall should be attached. This cable remains attached to the Sun at the 61-inch. See Ethernet Set-Up instructions for details.

9) Turn the computer on. After it boots, type "ncd 256x256". Then type either 90tele or 61tele. A program menu will appear. Select 2 for the observing menu.

10) At this point the array may be turned on following the instructions given on page 8. Turn the filter wheel to read "1".

11) Take a picture using choice 1 from the observing menu. It should resemble Figure 0b.

12) Change the filter using choice 6 -- indicate in response to the first question that the filter is at 1. Then ask to move to K.

13) Leave the observing menu. Select the diagnostic menu.

14) Select the option to check the A-to-D converter bits. Hit return a couple of times. The program will take a few moments to return with data. When it returns you

will see a collection of 1s and 0s similar to that shown below.

```
0101111010110110 0001010110101111  
0101101101010111 0010111010101010  
and so on.
```

Check that each vertical column contains at least 1 one and 1 zero. This check demonstrates that all the bits are changing. The left most column may not be seen to change. This is OK as this is the most significant bit and changes only for very high signal levels. Hit return if you want to see more samples and hit ESC to leave this test. If a bit appears stuck, try changing the ribbon cables between the computer and the control chassis. You will need to re-run the test from its start after swapping cables. If changing cables does not fix the stuck bit, call for help.

15) The camera is now ready to turn over to the observer.

Ethernet Set-up Instructions

I. Minimum Setup Needed for Data Transfer to Sun

A. At the 90-inch: Connect the tan ethernet cable from the back of the PC to a user ethernet jack on the strip along the wall of the control room. You may need to use tape to secure the cable.

At the 61-inch: Connect the cable from the small gray box on the wall to the connector on the back of the PC.

B. After the PC has booted up, type the following commands which are underlined:

```
C:\>ncd 3c503
```

```
C:\3C503>mountain      (if you are at the 90-inch)
```

or

```
C:\3C503>bigelow      (if you are at the 61-inch)
```

(computer will indicate that it is doing some copies of files)

C. Re-boot the computer after it returns to the DOS prompt by pressing CTRL-ALT-DEL simultaneously.

D. Continue with bringing up the camera control program as described elsewhere in the program.

II. Use of get_ir2 and Related Scripts

The following instructions should not be needed as both the 90-inch and 61-inch Suns should have the get_ir2, etc., already in place. All that you should need to know is that the raw PC data reside in a subdirectory called "rawdata" and that you can use the IRAF command "bigget filename" in the rawdata subdirectory to convert "filename" to IRAF .imh format. Note that "filename" may include wildcards (? to match a single character, * to match a block of characters) to convert many files at once.

=> Following in informational only. Necessary files should already exist on Sun!<=

To examine data using IRAF, the data files need to be converted from PC format to IRAF ".imh". The easiest way to accomplish this conversion is to use "get_ir2". The source code for this program is stored under e:\fits on the PC. This version has "cbind.c" included in it. Use ftp to transfer get_ir2.c to the Sun. On the Sun compile get_ir2:

```
cl>!fc get_ir2.c -o get_ir2
```

If you are satisfied with converting a single image at a time, get_ir2 can be used in this

manner:

```
cl>!get_ir2 filename
```

which will produce filename.imh. Note that if this is all you do, get_ir2 will need to be present in the data directory.

If you would like to be able to process multiple images using wildcard filenames, transfer bigget.cl and getbunch.cl from the PC to the Sun as you did for get_ir2.c. To use these scripts, edit loginuser.cl so that it appears as shown on the attached listing (again, this should already be in place). You can then logout of cl and login again to use these scripts. Use getbunch to process a multiple frame set of the filename.nnn sort. "bigget" is more flexible and will process all files matching a wildcard:

```
cl>bigget file???.*
```

The scripts need not reside in the data directory.

III. Use of FTP to Transfer Files to the Sun

The following commands may either be executed using choice 5 of the camera control program's master menu or from the DOS prompt. They are shown here as though you were typing at the DOS prompt; you should type the underlined material. If you take data using the special "gridmode" command (aka pseudo-speckle), you should use this method to transfer data from the PC to the Sun. It can also be used if you forget to turn the ethernet on from the observing menu.

(this assumes that you are typing from the PC directory containing the data files)

```
L:\datannnn>ftp bok or ftp bigelow
```

(Hit return to accept the default user name of bokobs or bigobs)

When prompted for a password, enter the Sun password from the board in the control room.

```
ftp>cd rawdata (This switches you to the usual data  
directory on the Sun)
```

```
ftp>binary (THIS IS CRUCIAL -- DATA WILL BE  
TRASHED OTHERWISE!!)
```

```
ftp>put filename
```

(if asked about name on remote machine, just hit return)

Computer will send the file which make a few seconds depending on the size. When finished it will give you a report.

Note that DOS wild cards (eg. object.0?? for all files in a multiple frame set with

basename object, or *.* for everything in a subdirectory) may be used. If you take advantage of this feature use mput in place of put.

To quit:

ftp>quit

IV. Extracting Frames from Gridmode Files

To use "gridsplt" you first need to copy the source code to the Sun. It is located on e:\fits on the PC. The program is called "gridsplt.c". Use the instructions above to FTP this file to the Sun. Compile using the Unix command cc gridplit.c -o gridsplt. Remember to place "!" before cc if executed from within IRAF. To run type gridsplt filename on the Sun. It will create files named filename.001, filename.002, etc. These files are still in PC format and must be converted using get_ir2, nlfit256, or nsfit256.

I. Introduction

A program for controlling data acquisition with a Rockwell 256x256 switched MOSFET array has been created for use with a 80386/486 computer. The basic function of the program is control of camera exposures and recording of the data frames on the computer's hard disk. The control program will acquire camera frames in several automatic modes with a choice of telescope beam switching patterns. The program includes not only control functions but also routines for data reduction, and diagnostic routines for checking hardware performance. The program is menu driven so that the user does not have to learn or memorize a command structure. Other programs support archiving of data to tape, batch mode reductions, creation of bad pixel ("mask") frames, and creation of FITS tapes or Unix tar tapes.

The current observing computer uses a hard disk with a data capacity of over 600 Mbytes. With the 16-bit format used with the camera data, one image requires 132 Kbytes of disk space. Many nights worth of data will fit on the disk.

The data reduction menu contains routines for flatfielding, removing bad pixels, averaging frames, and computing statistics. It also has a contour plotting and gray scale routines with interactive features which allow positioning of a cursor and an aperture for photometry. This set of routines can calculate first moments of an image, the flux within a variable size aperture, and can mark bad pixels. Reduced frames can be saved to disk. This package does not include functions such as median filtering, shifting of frames for positional registration or mosaicing. Transfer to IRAF is suggested for these needs.

The program runs under the MS-DOS operating system using the Pharlap DOS-Extender for running the 80386/486 CPU in protected mode. The user will have an easier time understanding some of the functions and conventions if he understands basic MS-DOS commands such as DIR, MKDIR, and CD. A basic knowledge of the MS-DOS directory structure, files, and filenames will also be helpful. See the MS-DOS manual included in the observing documentation.

BEFORE YOUR RUN:

Data archiving is achieved by transferring data to the Sun and archiving using the Exabyte tape drive. One Exabyte tape will hold many nights worth of data although it is convenient to have an Exabyte per night. For safety's sake, making two Exabyte tape copies is advised. Be sure to buy Sony P6-120MP tapes.

Summary of Array Parameters

Minimum Integration Time: (currently must use minimum of 0.40 secs)	0.265 seconds
Gain:	15.3 electrons/ADU
Read Noise:	62 electrons (quad 1) 73 electrons (quad 2) 60 electrons (quad 3) 54 electrons (quad 4)
Signal Needed for background noise = read noise	348 ADUs (quad 2)
Maximum counts for linear operation	≈20,000 ADUs for end value
"Dark" Current	≈40 electrons/sec (with coarse scale) ≈70 electrons/sec (with fine scale)

Observing Hints

- 1) Select the filter to be used. Check the focus and make a notation of the focus setting for each filter to be used.
- 2) Either before beginning observing or at the end of the night, take dark frames with the filter wheel set at one of the blank positions. These dark frames should include a set of 20 at each of the exposure times at which you take data. This procedure is necessary because of an integration time dependence in the bias of the detector.
- 3) At the beginning of the night and periodically throughout the night (especially if the ambient temperature changes, thin clouds are seen, or if objects at high airmass are observed), check the signal levels in a single, non-coadded exposure. Display the test image and check that the signal levels do not exceed those for linear operation.
- 4) Before beginning a long observing sequence, check that the values in the header display are what you want. The multiple frame mode can be interrupted by hitting ESC. The sequence will terminate at the end of the current exposure. If you make a mistake and inadvertently start a very long exposure, you will have to re-boot using CTRL-ALT-DEL or switching the computer power off then on.
- 5) The Elias et al. standards are too bright for straightforward use with the NICMOS3 array. Use the "s" mode with the gray scale picture to check the end data values to check that no end value exceeds 20,000 counts. You will probably need to defocus the telescope slightly to observe these stars. Also take some sky frames using the same exposure times as for the standards.

Useful Keys in Gray Scale Mode

The following keys are useful when mode 12 of the observing menu is being used to examine a gray scale representation of an image:

before hitting c any
key exits

c	Enables cursor mode
DEL after c	Exit
Home	Moves cursor towards upper left
↑	Moves cursor up
PgUp	Moves cursor towards upper right
←	Moves cursor to left
→	Moves cursor to right
End	Moves cursor to lower left
↓	Moves cursor down
PgDn	Moves cursor to lower right
0-9	Changes cursor step size by 2^n
f	focus mode - displays 5x5 grid of pixel values
s	saturation mode - displays start and end data values
^i	total counts in aperture of requested radius

II. Quick Guide to the Camera Dewar

This section provides an overview of turning and using the NICMOS3 256x256 camera dewar. It is assumed that the camera is already mounted on the telescope and cabled up (see Section VIII. for the camera installation procedure). The dewar uses liquid nitrogen and has a hold time of about 24 hours. It is recommended that the nitrogen be topped off every 12 hours in case the molecular sieve in the dewar loses its efficacy. The dewar can now be filled on the telescope using the plastic transfer hose, copper fill pipe, and self-pressurized storage dewar. A bicycle tire pump can be attached to the small valve to help increase pressure during transfers. Insert the fill pipe in the dewar and open the valve on the storage dewar. It will take several minutes for the dewar to fill -- the full indication consists of liquid coming out the top. Usually there will be a tank of pressurized nitrogen which can be used in place of the tire pump to help with the nitrogen transfer. Check with the telescope operator at the 90-inch or Jim Grantham at the 61-inch if you don't see a nitrogen tank.

A. Array Power Up/ Power Down Sequence

The turn on procedure for the camera needs to be followed carefully to prevent damage to the chip. Follow these steps:

- 1) Turn on the computer and load the observing program.
- 2) Select the observing menu in the observing program.
- 3) Go to the camera electronics control box on the observing platform.
- 4) Turn on switch 1 on the control box. Wait a minute. A pattern of square dots should be apparent on the orange screen monitor.
- 5) Turn on switch 2 on the control box. The scan pattern should change to a relatively uniform bright pattern. If it doesn't push the reset button on the left side of the box.
If a scan pattern is not seen, shut down and call for help.
- 6) Turn on switch 3 on the control box. The orange monitor will appear to go nearly dark with only a few bad pixels visible.
- 7) Turn on the filter control power box if it is being used.

To turn the array off at the end of the night, reverse these steps. If there is no likelihood of an electrical storm, please unplug the white surge suppressor box that the camera control box is plugged into. If the computer is plugged into a UPS system, it may be left on, but if you are unsure of its state, please turn it off and unplug it.

B. Filters and Lens Actuators

The dewar is currently equipped with six filters, J(1.25 μ m), H(1.6 μ m), K(2.2 μ m), K_s and CO(2.3 μ m) which is a narrow-band filter, .01 μ m wide filter at 2.22 μ m, and a separate slide containing narrowband 2 μ m filters used in series with K. The filters on this slide are not yet ready for regular use, and the slide should be kept in the fully down (or out) position. The K_s filter has a shorter length wavelength cutoff than the regular K filter. On warm nights this may give better signal to noise, but will not be beneficial for relatively red sources. Tracings of the J,H,K and .01 μ m filters are included in the documentation. The other positions on the filter wheel are filled with blanks (useful for bias/dark frames) or open holes. The procedure for changing filters is use menu selection on the computer under the observing menu. Check what number is showing in the little window on the side of the dewar; you will need to use this number to set or reset the computer's filter counter. Note that when changing the filter under computer control there is no feedback of the filter location. You will need to look at the filter window on the side of the dewar if you need to check anything. Both the number in the window and the arrow on the leftmost gear need to be correct -- arrow points down and number correct for the selected filter. Filters may be moved manually if the filter motor power is off -- it takes two turns to move from one filter to the next.

	BLANK(B2)	OPEN	BLANK(B2)	J	H	K	K _s	CO	BLANK(B1)	.01 μ m
Number	9	8	7	6	5	4	3	2	1	0

You must also select the correct pupil stop setting -- the actuator (which is the one second in from the front of the dewar) should be all the way up for the short wavelengths (J and H) and all the way down for long wavelengths (.01 μ m, K_s, K and CO). See chart on dewar for correct positioning of this actuator.

The dewar has two plate scales now -- approximately 0.6"/pixel and 0.2"/pixel at the 90-inch or 0.9"/pixel and 0.3"/pixel at the 61-inch. The scale-changing actuators should be up for the fine scale and down for the coarse scale. See chart on dewar for the correct positioning of the actuators to select between the two scales.

If the humidity should go over 70% in the dome, please install the heater plate in the side of the dewar when you are finished observing. Plug it in. If the big front lens frosts over or has condensation on it, you will not be able to observe. It is also advantageous to hook up the compressed air flow at the 90-inch or the cylinder of nitrogen at the 61-inch.

III. Quick Guide to Computer Operations

This section is intended as a shortcut to bringing up the control program and acquiring a data frame. See the chapters on the individual menus for more detailed information. The camera dewar itself is described in Section II.

Whenever the computer is turned on or re-booted (either by hitting CTRL-ALT-DEL or by being turned on) it will leave control at the DOS prompt in the root directory of drive C. Load the observing program using the following sequence. Note that commands must be followed by hitting the "ENTER" key. In the following, what you should type will be underlined while what the computer displays will not be underlined.

- 1) Switch to the subdirectory containing the observing program:

```
C:\>ncd 256x256    ( ncd is a Norton Utility which
                    permits changing of directo-
                    ries between any parts of a
                    tree)
```

- 2) Load the DOS-Extender and the observing program:

```
C:\256x256>90tele   or   61tele
```

depending on which telescope you are using. See Section VII. for setup of the Sun.

The following menu should appear (see Figure 1 on next page):

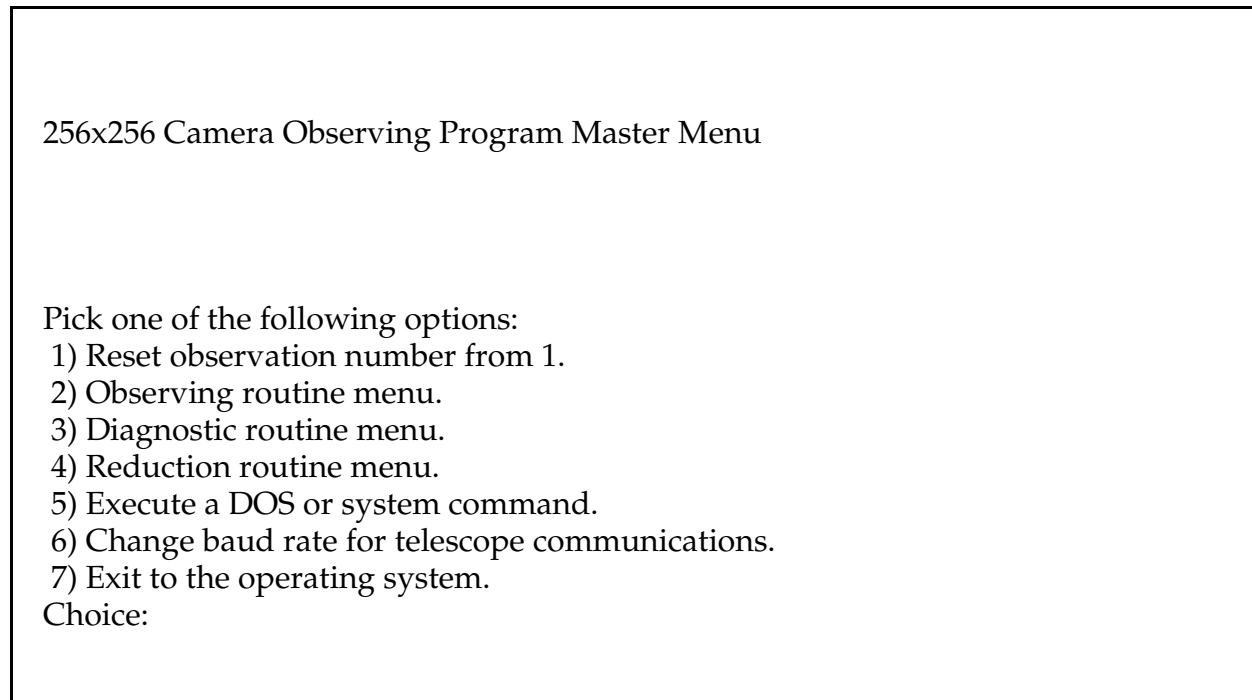


Figure 1: Master Menu (appears after loading the program)

Choice 6 for changing the baud rate should not need to be used, but be sure that the 90-inch operator verifies that the baud rate is 9600 (you can use choice 6 to change to whatever baud rate the telescope is to -- 90-inch should expect 9600 while the 61-inch expects 2400 which 61tele sets upon loading.

Use choice 5 to set up a data directory. Use of a separate directory for each night's data simplifies archiving later. See Section VII. for setting directories on the Sun at the 90-inch. Because the hard drive is subdivided into drives C through L, an entire drive may be used for a night's observing. Very occasionally part of a second drive may be needed. When questioned, enter the commands as shown in Figure 2 to switch data

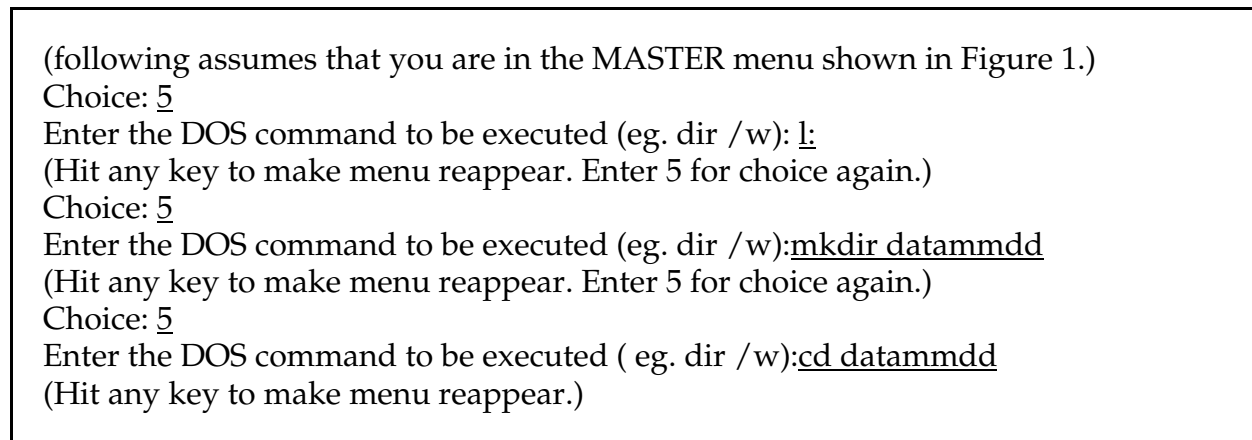


Figure 2: Setting the directory before data taking

recording to drive L (recommended because of its large size), for example. If old data are present, use the DOS command del *.* using the same method as shown in Figure 2 (see appendix C to see what to do if you accidentally erase files). For now, don't use drive K as it contains development software. Drives F,G,H,I,J, and L are all available. If the program has been exited and restarted during an observing session, follow the procedure in Figure 3 to ensure that the data directory is set correctly. The name of the subdirectory can be any combination of up to 8 letters and/or numbers. If you want to remove a subdirectory, use choice 5 from one level above the subdirectory to be removed and enter rmdir subdir_name.

Once the data directory is set correctly, leave the MASTER menu and enter the observing menu by entering 2 at the "Choice" prompt. This command will make the

<p>Observing Menu 0 Obs. No.= 1 File: Itime:1.00 Wob:OFF Mask: Flat: Pmin: 0 Pmax: 100 Ascale:ON Add : 1 Ethn:ON Filt: Enter your choice below. 1) Acquire a single frame. 2) Acquire multiple frames. 3) Turn wobble on/off. 4) Change the integration time. 5) Change number of frames in addition mode. 6) Change or reset the filter. 7) Difference data and flat frames and display result. 8) Display a histogram of pixel counts. 9) Fetch a frame from disk. 10) Send a wobble pulse only. 11) Change WAIT state for multiple frames. 12) Display the data frame as a grayscale image. 13) Change grayscale image parameters. 14) Draw a contour plot. 15) Acquire frames in mapping mode. 16) Toggle saving via Ethernet. 17) Difference flat and data frames and display result. 18) Return to the master menu.</p>
<p>Choice: (following assumes that you are in the MASTER menu shown in Figure 1.)</p> <p>Choice:5 Enter the DOS command to be executed (eg. dir /w): <u>dir/w</u></p>
<p>Figure 4: Observing Menu (A directory display will appear. If the directory is not set to the correct data directory, use choice 5 and select the drive by letter and repeat choice 5 using the cd command to select the correct subdirectory.)</p>

Figure 2: Checking the data directory

observing menu, see Figure 4, appear. To take a test frame, be sure that the start up procedure for the camera given in Section II. has been followed and that a picture is visible on the orange screen monitor. The default integration time is one second; leave at this value for a test. Enter 1 at the choice prompt to take a frame. Note that if the camera and its readout electronics are not turned on and functioning when the computer attempts to take a frame, the computer will be stuck in a loop waiting for the pixel data to arrive. The only way currently to recover from this is to re-boot. Assuming that the camera electronics were functioning and that a frame was obtained, either option 12 or 14 can be used to inspect the data. Option 12 will produce a grayscale picture scaled logarithmically between the values P_{min} and P_{max} as shown in the third line of the display or scaled between the minimum and maximum values of the data. Use choice 13 to change these parameters if desired. See the observing menu section for more details on options available with the gray scale image. The grayscale image can be terminated by hitting any letter key to return to the observing menu.

This completes the quick instruction section. Read the individual menu sections for more information -- many more observing modes and analysis possibilities exist than described here. Of particular importance is the first part of Section V which describes the basic observing routine.

IV. The Master Menu

The main or MASTER menu, shown below and in Figure 1, is mostly self-explanatory. This menu appears when the program is first loaded and is the point to which you return whenever a menu is exited -- you cannot go between the menus listed in the MASTER menu without returning to the MASTER menu. One option which requires some explanation is choice 5. This selection allows the execution of any command which can be executed at the DOS system prompt provided sufficient free memory is available to execute that command while retaining the observing program in memory. Because the observing program is quite large, only relatively short programs may be executed. Any of the built-in DOS commands such as DIR can be executed. This option actually leaves the protected mode observing program and runs another copy of the DOS shell COMMAND.COM. Remember to hit any key the end of any action taken under choice 5 to return to the menu.

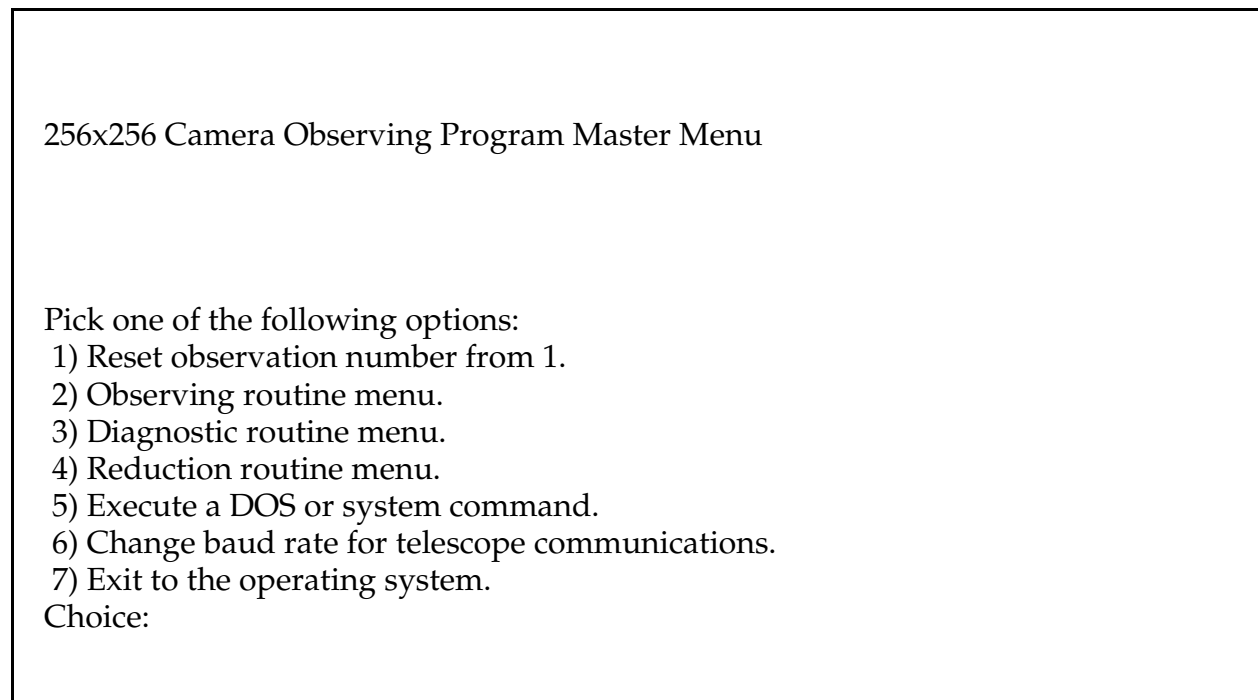


Figure 5: The Master Menu

Master Menu

V. The Observing Menu

The observing menu, shown below and in Figure 4 is the menu which will be used most often during an observing session. The observing menu presumes that you want to flatfield by using sky frames interleaved with object frames. The use of dome flats or twilight sky flats has been shown to be unsatisfactory. If mapping of relatively bright sources is being undertaken, some exceptions to this rule can be made. This point will be discussed later when discussing the mapping mode option. The parameters in the header section will be described first followed by a description of each of the menu options. In these descriptions, "pixel value" refers to the Analog-to-Digital converter units recorded by the computer. One ADU = 15.3 electrons.

```
Observing Menu  0  Obs. No.= 1
File:          Itime:1.00 Wob:OFF Mask:          Flat:
Pmin:  0  Pmax: 100  Ascale:ON Add : 1  Ethn:OFF Filt:
Enter your choice below.
1) Acquire a single frame.
2) Acquire multiple frames.
3) Turn wobble on/off.
4) Change the integration time.
5) Change number of frames in addition mode.
6) Change or reset the filter.
7) Difference data and flat frames and display result.
8) Display a histogram of pixel counts.
9) Fetch a frame from disk.
10) Send a wobble pulse only.
11) Change WAIT state for multiple frames.
12) Display the data frame as a grayscale image.
13) Change grayscale image parameters.
14) Draw a contour plot.
15) Acquire frames in mapping mode.
16) Toggle saving via Ethernet.
17) Difference flat and data frames and display result.
18) Return to the master menu.
Choice:
```

Figure 6: The Observing Menu

A. Observing Menu Header Parameters

File: the DOS filename used for saving the most recently acquired image or the filename of the last data file retrieved using option 9.

Itime: the integration time currently in effect in seconds.

This value can be changed by option 4. The default when the program is loaded is 1 second. Fractions are allowed; the shortest time which can be used is 0.4 sec. The

longest that the program can time is about 4294 seconds.

Wob: Indicates whether wobbling is enabled. Change with option 3.

Mask: the DOS filename for the mask frame used in removing bad pixels. See the data reduction menu section for instructions on creating this file. Used only with reduction menu commands.

Flat: the DOS filename for the flat field frame used in removing pixel to pixel variations. Usually is a sky frame taken close in time to the data frame. Select a frame using choice 9; do this before using choice 7.

Pmin: the minimum pixel value used in the scaling of a grayscale image by option 7. If autoscaling is in effect, after a grayscale picture is drawn, Pmin will indicate the minimum value in the image. Default is 0 and may be changed using choice 13.

Pmax: same as Pmin except this is the maximum value. Default is 100.

Ascale: indicates whether autoscaling (ON) or scaling between fixed values (OFF) for the grayscale display is in effect. Default value is ON. Change using choice 13.

Add: indicates the number of integrations co-added before an image is written to disk. Change using choice 5. Note that values which are saved are now the AVERAGE of the co-added values rather than the sum as in earlier versions.

Wait: a flag indicating whether the computer will wait for a key push before beginning the next frame in a multiple frame sequence. Waiting would permit guiding updates before beam-switching the telescope (mainly useful at the MMT. Default value is OFF and is changed using choice 11.

Filt: an indication of which filter is currently selected. Change using choice 6.

The number to the right of the Observing Menu title indicates the average counts in the last readout taken. A new number will appear for each readout (a new number will appear for each of the individual readouts that comprise a co-added image).

Ethn: An indicator showing whether automatic transfer of data frames over the ethernet connect to the Sun is enabled. Change using choice 16.

Obs. No.: A running number indicating the sequential number of the next frame to be written to disk. May be set to any number by using choice 1 on the master menu.

B. Detailed Description of Observing Menu Choices

Choice 1: Acquire a single frame.

This choice will take one exposure with the integration time specified by Itime. When this option is invoked, a filename is requested (should be an MS-DOS filename of the form XXXXXXXX.EEE with a maximum of 8 characters in the XXXXXXXX section and a maximum of 3 in the EEE section which is optional). A title will also be asked for. When the "ENTER" key is hit after entering a title, the exposure cycle will begin. One exposure means one frame, the setting of the co-addition parameter is ignored here. If you have given a filename that already exists, you will be prompted to enter a new name. If you want to write over the old data with the newly acquired frame, just hit return. The title, filter, exposure time, and time and date of the end of the exposure are also written. See the section on data file formats to see the structure of the information written to disk. After an exposure is finished and written to disk, control is returned to the observing menu. At this point, the data just acquired are still in the computer's memory and can be viewed with either options 12 or 14. The observing menu could also be exited and the data reduction menu entered for other processing of the data.

Choice 2: Acquire multiple frames.

This observing mode takes frames in the same basic style as choice 1, but allows many frames to be taken without the need for someone to type in filenames for each exposure. The number of frames specified by the co-addition parameter will be in effect. This mode is the workhorse for most observing programs. When this choice is executed, the number of frames needed is requested. This number is the total number of images to be written to disk including sky frames if wobbling is turned on. For example, if 10 object frames and 10 sky frames are needed, enter 20. Remember that each "frame" will consist of the number of co-adds specified under Add each of length Itime seconds. Next, a filename is requested. For this mode enter only a maximum of 8 characters (the XXXXXXXX portion) with no . or EEE portion. The program adds ".001" for the first frame in a sequence, ".002" for the second and so on. If wobbling is enabled, object frames will be odd numbered and skies will be even numbered. All other parameters set for use in the single frame mode apply to the multiple frame mode. An indicator of the multiple frame mode is given in the header where the phrase "# of frames =NN" appears on the right hand side of the header where NN=the total number of frames to be acquired. Compare this number with the last part of the current filename to see how far into a multiple frame sequence the program has progressed. The average counts/pixel for each individual readout will be displayed just to the right of the "Observing Menu" header. Keeping an eye on this will give a rudimentary check that the system is functioning correctly.

If one of the jitter wobble modes has been selected and wobbling is enabled, the

program will request wobbling parameters at this point. These only need to be entered once (or whenever declination is changed at the 61-inch). The terms "base RA" and "base DEC" refer to the amount to wobble to the center of the sky frame while amplitude and minimum refer to the maximum and minimum random amounts for the jittering.

Choice 3: Turn wobble on/off.

This choice will turn wobbling on or off and also allows selection of the wobbling mode. In single frame mode (Choice 1), the setting of the wobble parameter has no effect. The choices of wobbling mode are "normal", "jitter wobble", and "double-jitter wobble". Normal wobble means that the wobble vector is set in the telescope's wobble vector register and applies throughout the observing sequence. This means that the beam-switching will occur between two fixed positions on the sky. Jitter wobble is useful when observing extended objects where a star in the sky frame would cause a "hole" in the object frame. If this mode is selected, the telescope will be beam-switched between a fixed object position and a randomly varying sky position. The amplitude and minimum amount of change will be requested when entering the multiple frame mode. Use of IRAF median filtering routines on these "jittered" sky frames should remove any stars and still allow good flatfielding. The double jitter moves both object and sky; you will be queried for the same parameters as in the jitter wobble mode. When using this mode be aware of the fact that this mode is a random walk, and you should re-center your object whenever you start a new batch of frames.

This menu choice will also ask for a wobble delay -- this is a delay to allow the telescope to settle after wobbling. The units of this delay are currently arbitrary, but a value of 100 should be satisfactory (most of the delay time is provided by the time taken to send the last image over the ethernet link).

Choice 4: Change the integration time.

This option asks you to enter the exposure time in seconds. The exposure is timed with a resolution of 976 microseconds and the maximum exposure time possible is 4294.96 seconds (1.19 hrs, far longer than the time to fill the wells of the readout with any of the filters provided). Fractional seconds are permitted so times such as .34 seconds or 15.65 seconds are acceptable. Once a time is entered, it applies to all subsequent data frame exposures until a new time is entered. The time is recorded with each data frame.

Choice 5: Change the number of frames in addition mode.

Because the well-depth of the NICMOS3 array is only about 300,000 electrons, the wells may fill in a periodic as short as 5 seconds depending on ambient temperature and telescope being used. It would be inefficient to record each read out to disk. This

mode allows selection of co-addition of individual exposures so that fewer frames are recorded. Set this number so that a dump to disk will occur about once a minute. When using narrowband filters or the J filter, frame co-addition may not be necessary. The values which are saved are the average of the co-added values. Note that frame co-addition does not apply in single frame mode where only a single exposure will be taken regardless of the number specified here.

Choice 6: Change or reset the filter.

This option allows you to select the filter to be used. The filter name that you enter is recorded with the data frame. This option sends pulses to a motor which must be turned on. At the beginning of the night, this routine must also be initialized (it will ask if the computer has been powered down; use "reset" otherwise) with the current number in the filter window on the dewar. The arrow on the gear at the left of the window should point down also. Because there is no feedback other than the window display, when operating remotely, watch the average counts/pixel displayed which will give a check as to whether the filter changed correctly. Remember to change focus when changing filters (especially when using coarsest scale). You will also need to change the pupil if switching between J and H and K and CO.

Choice 7: Difference data and flat frames and display result.

This choice will either difference frames read into data and flat manually or will subtract the last even numbered frame from the last odd numbered frame in a multiple set. The result will automatically be displayed as though choice 12 were used. Set scaling options before using choice 7; if the image needs to be re-displayed, use choice 12 rather than re-running choice 7.

Choice 8: Display a histogram of pixel counts.

Does nothing currently.

Choice 9: Fetch a frame from disk.

Any frame which has been previously recorded to disk can be returned to the computer's memory using this option. When invoked, choice 9 will ask you to enter either d, m, or f for a data frame, mask frame, or flat frame respectively. Enter your choice which then tells the computer which memory buffer should receive the frame being read in. You will then be asked to enter the filename -- enter the entire name including any number portion added by the multiple frame mode. You will then be queried as to whether an integer or floating point frame is being fetched. Floating point frames are those saved from the data reduction menu. All other frames including mask

frames are integer frames. Enter i or f. The disk will then be read and the frame you requested will be placed in the appropriate buffer.

Choice 10: Send a wobble pulse only.

This will send a wobble command to the telescope. Select 1 if you want the telescope to move to beam 1 or 2 for the opposite. The wobble vector set in the telescope display will be used. Moving to beam 2 adds the vector to the current position while moving to beam 1 subtracts it.

Choice 11: Change the WAIT state for multiple frames.

This choice toggles waiting for a key hit after a frame on or off. It applies only to the multiple frame mode and is useful if some change such as guiding or beam switching needs to be made between acquiring frames.

Choice 12: Display the data frame as a grayscale image.

After a frame is taken or a frame is read in using option 10, it may be displayed as a grayscale picture. The scaling or "stretch" in the image is set by Pmin and Pmax or automatically if autoscaling is in effect. To leave the display, hit any key except "c". If "c" is hit, you will enter cursor mode where individual pixel values can be examined by moving the cursor using the arrow keys. The arrow keys on the keypad and "Home", "PgUp", "End", and "PgDn" can be used to move the cursor around the frame. Note that the "NumLock" light must be off (hit NumLock key if it is not) for this to function. Hitting a number will change the speed of the cursor motion. In the upper right corner a numerical display will appear when the cursor is moved. This display shows the x and y coordinates (0-127) of the pixel that the cursor is positioned on as well as the value in that pixel. This mode is extremely useful for getting a sense of the range of values in a frame. If cursor mode has been entered, hit the "Del" key near the arrow keys to leave. See the list of useful keys near the beginning of this manual.

Choice 13: Change grayscale image parameters.

Use this command before choice 12 to set the optimum display parameters. You will first be asked if you want autoscaling -- the statement "def=N" means that the default is no and hitting return will result in no autoscaling. You should enter y if you want the program to set the maximum and minimum for you from the data. If you have opted for no autoscaling, you will be asked to enter minimum and maximum (Pmin and Pmax in the header) values to be used in the calculation of the scaling of the display. These values may be smaller or greater than the range in the data; experiment to see what effect they have on the display.

Choice 14: Draw a contour plot.

This command will plot the data using contours to indicate brightness. You will be asked how many contours should be used; a good starting point is 10. A maximum of 100 may be used. It will also ask if coarse or fine contours are desired. Fine looks better but takes much longer. The program then inspects the data to determine the maximum and minimum, displays these values, and then asks if you want to change them. As with the grayscale display, some experimentation with the contouring limits will give different impressions of the data. Once a contour plot is on the screen, hitting c will enable a cursor mode with a cross appearing in the center of the frame. The arrow keys on the keypad and "Home", "PgUp", "End", and "PgDn" can be used to move the cursor around the frame. Note that the "NumLock" light must be off (hit NumLock key if it is not) for this to function. Hitting a number will change the speed of the cursor motion. In the upper right corner a numerical display will appear when the cursor is moved. This display shows the x and y coordinates (0-127) of the pixel that the cursor is positioned on as well as the value in that pixel. This mode is extremely useful for getting a sense of the range of values in a frame. See the data reduction menu description for other features available in the cursor mode. To leave the contour plot, hit the Del key if the cursor mode has been enabled, any key but "c" otherwise.

Choice 15: Acquire frames in mapping mode.

This will enable a special form of the multiple frame mode where frames can be taken in a raster pattern. One frame dump consisting of the prevailing number of co-adds will be taken at each raster position. You will be asked for mapping parameters such as the step between frames, step between rows or columns and how many steps should be taken in row or column. Flatfielding for this mode can be achieved in different ways depending on the sensitivity limits needed and on the crowding of the fields being observed. If relatively sparse fields are being studied, a flat constructed from the median of each row or column will give good results. If a crowded field is being observed, a separate batch of sky frames will be required. This will generally lead to somewhat reduced sensitivity but which is acceptable in many cases.

Choice 16: Changes the state of ethernet transfer of files to the Sun.

Choice 17: This is similar to choice 7 but it subtracts the last odd numbered frame from the last even numbered frame.

Choice 18: Return to the master menu.

This returns control to the master menu where other options can be selected as listed in Figure 5.

Observing Menu

VI. Data Reduction Menu

Data Reduction Menu		
Zero:	Mask:	Flat:
Data:		
Pick one of the following courses of action		
1) Mask,debias, and flat field.		
2) Do a contour plot.		
3) Change data frame.		
4) Change flat frame.		
5) Change mask frame.		
6) Change bias frame.		
7) Mask a frame only.		
8) Remove bias from a frame only.		
9) Mask and flat field only.		
10) Compute statistics on an entire frame.		
11) Add frames together and average.		
12) Display frame as a gray scale image.		
13) Change gray scale parameters.		
14) Save a processed frame to disk.		
15) Save an altered mask frame to disk.		
16) Execute a DOS or system command.		
17) Return to the master menu.		
Choice:		

Figure 7: The Data Reduction Menu

This menu provides the bulk of the data analysis functions available in the observing program. These routines are not meant to be a substitute for a complete reduction package but should suffice for inspecting data at the telescope and checking on the photometric accuracy. Figure 7 shows the data reduction menu. The operation of several of these commands is very similar to those used in the observing menu. Choices 3,4, and 5 operate identically to the options under choice 9 on the observing menu, for example. The function of most choices is described below.

Choice 1: Mask, debias, and flat field.

Because of the high sky backgrounds present in the infrared, accurate flat fielding is essential when attempting to observe faint objects. Experience at Arizona observing sites has shown that the best results come when frequent beam switching to adjacent pieces of sky is used. This choice will ratio an object (data) frame by a sky (flat) frame to remove pixel-to-pixel variations and other throughput variations which may be caused by flexure. A bias frame will be subtracted first from both the object and flat frames. The masking process uses a mask frame which is just a table of bad pixels to remove "hot" or dead pixels. These are removed by replacing them with the average of their surrounding pixels. The mask frame is created outside the observing program using a routine called MASK256. See Section IX. for instructions on running this program. An old mask acceptable for most purposes is available in C:\256x256 and is called mask.dat. After the masking and flat fielding are complete, the newly modified frame is left in the computer's memory for display with choice 2 or 12. It may be saved to disk using choice 14 -- note that it will be saved in floating point format.

Choice 2: Do a contour plot.

This choice is identical to the contour plotting function available from the observing menu. The extra features present from the contour plot will be described completely below.

After a contour plot has been drawn, hitting c will enable a cursor mode with a cross, which serves as the cursor, appearing in the center of the screen. The mode described in the observing menu section is now in effect. The arrow keys and "Home", "PgUp", and the other keys on the keypad will move the cursor around on the contour plot -- check that the "NumLock" light is out to ensure that this mode will function properly. Hitting a number key will change the speed at which the cursor moves. A display in the upper right corner shows the x,y coordinates of the cursor's location (pixels numbered from 0 to 127) and the value in that pixel. Many other functions are also available from this cursor mode as listed below. These functions are activated by hitting the "Ctrl" key (indicated by ^ below) simultaneously with a letter which selects the function.

Key to Hit Function Invoked Comments

^B	Centroid and aperture photometry	Will request a radius in pixels for the aperture. Fractional pixels enclosed by the aperture are properly taken into account. The center of the aperture is placed at centroid determined by the routine.
----	----------------------------------	---

Data Reduction Menu

^F	Mark a bad pixel	Bad pixel will be marked, save mask frame to preserve marking.
^I	Aperture photometry only	The aperture is fixed at the cursor location -- the centroid is not used.
^M	Centroid only	Centroid is also referred to as the moment.
^R	Redraw the contour plot	Useful if ^B has been used many times.

If a contour plot is drawn but the cursor mode has not been entered, hitting any key will return you to the reduction menu. If the cursor mode has been enabled, hit Del to return to the reduction menu. If you decide while a contour plot is being drawn that a bad choice of contour levels has been made, hit Esc to return to the reduction menu without having to wait for the completion of the plot.

Choice 3: Change data frame.

This will ask for the name of a file to enter into the computer's memory as the object frame. After entering the name, enter i if a raw data frame or f if the picture has been saved from this menu or was created using Choice 8 on this menu.

Choice 4: Change flat frame.

This will ask for the name of a frame to be used as the divisor in flatfielding. Enter i or f as needed. This frame is typically sky frame taken close to the object frame.

Choice 5: Change mask frame.

This will ask for the name of a mask frame. See the utilities section for instructions on creating this frame. It is frame of 1s and 0s where 0 denotes a bad pixel. In the masking step, any pixel denoted as bad in the mask is replaced by the average of the 4 surrounding pixels or the average of the 40 lowest pixels in the frame if too few surrounding pixels are good.

Choice 6: Change bias frame.

This will ask for the name of a bias frame. This frame should be a short, dark

exposure or an average of a set of short exposures calculated using choice 11.

Choice 7: Mask a frame only.

This will remove bad pixels using the mask frame. The data frame is modified in memory, but the disk copy is not changed unless the modified frame is saved to disk using choice 14.

Choice 8: Remove bias from a frame only.

This will difference the data and bias frames and leave the result in memory.

Choice 9: Mask and flat field only.

This will perform only the mask and flatfielding steps just as choice 8 on the observing menu. Of limited utility.

Choice 10: Compute statistics on an entire frame.

This will compute the mean, standard deviation, and standard deviation of the mean of all pixels in the data frame.

Choice 11: Add frames together and average.

This routine will average frames together. It can accept either raw frames or processed frames saved from this menu. It will first ask for the number of frames to average. Enter an integer. It will ask for an eight character name XXXXXXXX for the output which will be named XXXXXXXX.ave and XXXXXXXX.sig. These two frames will contain the average and standard deviation computed on a pixel-by-pixel basis. The routine will ask the user to enter i or f depending on the type of frames to be co-added. The program will then ask for s or m for single frame name entry or multiple frame name entry. In single frame mode, the full name of each file to be co-added must be entered when the user is asked. In multiple frame mode, the user must only enter the basename (8 character) and two numbers specifying the first and last numbers of the files to be co-added. To use multiple frame mode, files must have names like XXXXXXXX.001, XXXXXXXX.002, etc. Names of this type are automatically created when using multiple frame mode at the observing menu. The .ave and .sig files created are of processed or f format.

Choice 12: Display frame as a gray scale.

This functions the same as the gray scale display at the observing menu. The cursor mode described above also works from the grayscale display.

Data Reduction Menu

Choice 13: Change gray scale parameters.

Again this works the same as the observing menu choice. Use it to adjust the appearance of the gray scale display.

Choice 14: Save a processed frame to disk.

If a data frame is to be retained after masking and/or flatfielding, it must be written back to disk using this command. A filename will be requested -- it is safest to use a name different from the data's original name. Note that files save from this choice are now processed or f format.

Choice 15: Save an altered mask frame to disk.

If the ^F choice has been used from the cursor mode with a mask frame in memory, the change can be made permanent by saving the mask frame using this choice.

Choice 16: Execute a DOS or system command.

This is identical to choice 4 at the master menu and is handy for checking directories and the like.

Choice 17: Return to the master menu.

This returns the user the master menu.

VII. Archiving Data

A. Using Exabyte Tapes on a Sun

If ethernet link was turned on and automatic transfer of data files to the Sun was enabled, data may be archived using Exabyte tapes. Note that a subdirectory on the Sun, /u1b/bokobs/rawdata (90-inch) or /u1b/bigobs/rawdata (61-inch), must exist to receive the data. Log on to the Sun and create a subdir if necessary before beginning to observe (rawdata should normally already exist). Note that no overwrite protection exists for Sun files so use different filenames. It is probably most convenient to archive the contents of rawdata each night rather than appending an entire run's worth to that subdirectory. The name of the Sun subdirectory is currently hardwired in the PC-program.

To archive using the Exabyte drive from within IRAF, follow these steps:

1) If using a new Exabyte tape:

- a. Change to login directory on Sun (/u1b/bokobs or /u1b/bigobs) and change to rawdata by cd rawdata.
- b. Type alloc mtc. Put tape in the drive and wait about 35 seconds.
- c. Type !mt -f /dev/rst1 rew
- d. Type !tar cvbf 127 /dev/rst1 .
- e. Type dealloc mtc.
- f. After about 20 secs, remove tape from the drive.

2) If using an old tape containing nn files:

- a. Change to login directory on Sun (/u1b/bokobs or /u1b/bigobs) and change to rawdata by cd rawdata.
- b. Type alloc mtc. Put tape in the drive and wait about 35 seconds.
- c. Type !mt -f /dev/rst1 rew
- d. Type !mt -f /dev/nrst1 fsf nn.
- e. Type !tar cvbf 127 /dev/rst1 .

f. Type dealloc mtc.

g. After about 20 secs, remove tape from the drive.

3) To check that tape is readable:

a. Type !mt -f /dev/nrst1 fsf nn. (Needed only to space over existing tar files).

b. Type !tar tvbf 127 /dev/rst1

4) To recover files from a tape:

a. Type !mt -f /dev/nrst1 fsf nn. (Needed only to space over existing tar files).

b. Type !tar xvbf 127 /dev/rst1 ./file1 ./file2 ./subdir
(./file1 -- a file to be restored,
./subdir -- an entire subdirectory to be restored).

Note that !mt -f /dev/rst1 rew should always be executed between any tape commands to ensure proper spacing forward.

Everything necessary for converting PC format images to IRAF should already exist on the Sun. If "bigget" is gone or you wish to convert to fits directly from PC format, ftp the files "d:\fits\nsfit256.c", "d:\fits\nlfit256.c" or "d:\fits\get_ir2.c" to the Sun. Compile using the Unix command cc nsfit256.c -o nsfit256 -lm. Substitute nlfit256 or get_ir2 for nsfit256 if you intend on using one of them. These programs will convert PC-format frames to FITS format or directly to IRAF format. The nsfit256 version creates FITS format and works on a multiple frame set. Invoke as a Unix command by nsfit256 basename no. The basename and number refer to the PC-filenames generated by multiple frame or mapping modes. When nsfit256 asks, say that you want bytes swapped. The nlfit256 version is invoked by nlfit256 ./directory where directory is the name of the subdirectory containing the files to be converted to FITS. This program will bomb if other than PC-format image files reside in the directory. The last version is invoked by get_ir2 filename where filename is the name of the image to be transformed directly into IRAF image format. This command can be used within IRAF scripts although you must either make it an IRAF task or precede the command with "!".

B. Using the PC's Tape Drive

If a Sun and Exabyte tape drive are not available, the QIC-40 drive on the PC may be

Archiving Data

used. These small tape cassettes need to be formatted before use. This takes about 40 minutes per tape. Formatting is done by running the tape controller program and selecting the tape utility to format a tape.

To archive data, switch to the \ARCHIVE directory on drive C. Run the tape controller program by typing QS. Select the menu choices for backing up data. When you are asked for a password, just hit return. The title option is handy for identifying the backup with a particular night. To archive a full 40 MBytes will take about 20 minutes. The program is well-protected and it is safe to append more data to a partially used tape.

After returning downtown, see Marcia and schedule a time when the observing computer will be available to convert the tape cassettes to FITS format. The first step consists of reading the tape cassette back on to the PC. Use the QS program in the C:\ARCHIVE directory. Select the restore choice and specify restoring to E:,F:,G:,H:,I; or J:. Restoration will take about as long as the original creation of the tape files did.

After transferring files from the cassettes, use type 3c503 and use ftp to send the files to the machine of your choice. See Marcia for fits converter software.

VIII. The Diagnostic Menu

This menu consists mainly of items useful for troubleshooting, although taking frames in the grid mode is more generally useful. The grid mode will take up to 14x14 images in any rectangular arrangement -- you will be queried for the mapping parameters. The data will be taken as one very large file (about 25 Mbytes for 14x14). This file will **not** be sent over the ethernet link automatically. You will have to ftp it manually. You will also need to use "gridsplt" to split the large file into its constituent frames after which "bigget" may be used to convert to IRAF format.

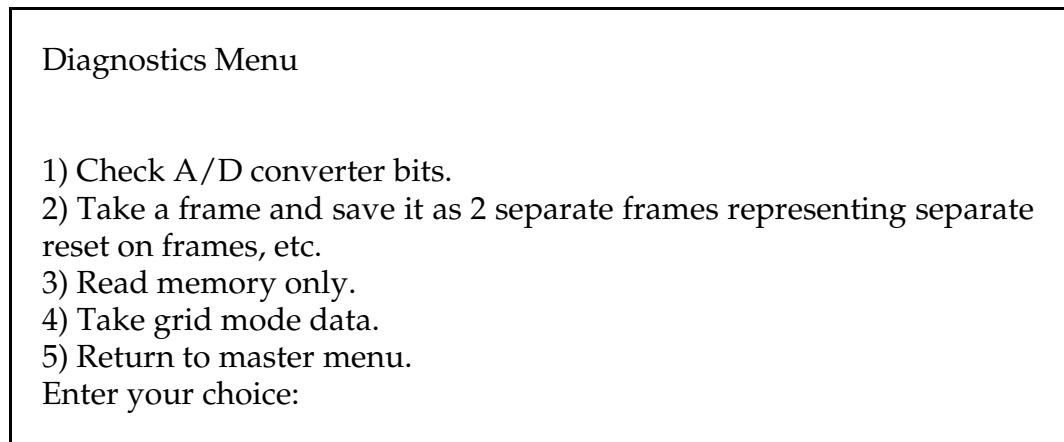


Figure 8: The diagnostics menu.

Figure 9: Layout of Integer Pixel Data in Data Files

The binary format used for integers consists of a two's complement 32-bit number with the bytes in low byte followed by the high byte order. The byte order is not standard among computers. The order used here is standard for MS-DOS machines and VAX computers but is opposite that used by Motorola 68000 series based machines such as Suns and opposite to that used by Data General machines such as MV10000s. The floating point format is more complicated and less standardized. Floating point frames such as those saved from the reduction menu are saved in the same order as shown in Figure 9.

B. Creating Mask Frames with MASK256

To run MASK256, enter the following at the DOS prompt (you should be in the correct subdirectory containing the datafile)

```
run386 C:\256x256\mask256 datafile type outfile
```

The term datafile refers to the name of the file containing a typical frame -- an average of several blank sky frames is a good choice. The term type refers to whether the datafile is in integer or floating format; an *i* or *f* should be entered. The term outfile refers to the name you want assigned to the mask file being created. The program will read in the datafile and then list a table of numbers on the screen showing essentially a histogram of the pixel values in the datafile. Imagine that you are trying to set about ± 3 -sigma limits and select the highest and lowest values for valid pixels. The program will ask for these values and then create a mask file with the *x,y* locations of pixels lying outside the valid range being marked as bad. Do not be afraid to experiment to get good results.

X. Compilation and Assembler Notes

The majority of the observing program is written in 'C' and has been compiled using the Metaware HighC Compiler. Assembling and linking were done using the Pharlap Tools 386 Linker and 386 Assembler. The main programs are run using the Pharlap DOS-386 Extender. These programs permit the creation and execution of protected mode 80386 code. The following "MAKE" file was used with the Microsoft Make Utility to automate the compiling, assembling, and linking steps. Some of the utility programs were compiled using Microsoft C Version 6.0.

The compiling, assembling, and linking steps for creating master are summarized by this listing of the make file `m256_90.mak`:

(91master called by 90tele is created by `make m256_90.mak` while 61master called by

61tele is created by make m256_61.mak)

```
90mast.obj: 90mast.hc printbin.hc
             hc386 -c -g 90mast.hc
```

```
90obsmen.obj: 90obsmen.hc 90comm.hc amoment.hc sfluxit.hc cursor.hc filt256.hc
              gridmode.hc
              hc386 -c -g 90obsmen.hc
```

```
twocard3.obj: twocard3.asm
              386asm twocard3 -twoc
```

```
90master.exp: 90mast.obj 90obsmen.obj twocard3.obj
              386link @m256_90.lnk
```

Link prescription (contained in m256_90.lnk or m256_61.lnk):

```
-twoc
-sym
-pack
-minreal 7000
-maxreal 7000
90mast.obj
90obsmen.obj
twocard3.obj
-lib k:\highc\hcaddon
-lib k:\highc\small\hcna
-lib k:\highc\small\hc386
-lib k:\highc\small\hc387
-exe
90master.exp
-map
90master.map
```

Appendix A: Menu Listings

MASTER MENU:

256x256 Camera Observing Program Master Menu

Pick one of the following options:

- 1) Reset observation number from 1.
- 2) Observing routine menu.
- 3) Diagnostic routine menu.
- 4) Reduction routine menu.
- 5) Execute a DOS or system command.
- 6) Change baud rate for telescope communications.

7) Exit to the operating system.

Choice:

OBSERVING MENU

Observing Menu 0 Obs. No.= 1

File: Itime:1.00 Wob:OFF Mask: Flat:

Pmin: 0 Pmax: 100 Ascale:ON Add : 1 Ethn:OFF Filt:

Enter your choice below.

- 1) Acquire a single frame.
- 2) Acquire multiple frames.
- 3) Turn wobble on/off.
- 4) Change the integration time.
- 5) Change number of frames in addition mode.
- 6) Change or reset the filter.
- 7) Difference data and flat frames and display result.
- 8) Display a histogram of pixel counts.
- 9) Fetch a frame from disk.
- 10) Send a wobble pulse only.
- 11) Change WAIT state for multiple frames.
- 12) Display the data frame as a grayscale image.
- 13) Change grayscale image parameters.
- 14) Draw a contour plot.
- 15) Acquire frames in mapping mode.
- 16) Toggle saving via Ethernet.
- 17) Difference flat and data frames and display result.
- 18) Return to the master menu.

Choice:

DATA REDUCTION MENU

Data Reduction Menu

Zero: Mask: Flat:
Data:

Pick one of the following courses of action

- 1) Mask,debias, and flat field.
- 2) Do a contour plot.
- 3) Change data frame.
- 4) Change flat frame.
- 5) Change mask frame.
- 6) Change bias frame.
- 7) Mask a frame only.
- 8) Remove bias from a frame only.
- 9) Mask and flat field only.
- 10) Compute statistics on an entire frame.
- 11) Add frames together and average.
- 12) Display frame as a gray scale image.
- 13) Change gray scale parameters.
- 14) Save a processed frame to disk.
- 15) Save an altered mask frame to disk.
- 16) Execute a DOS or system command.
- 17) Return to the master menu.

Choice:

DIAGNOSTIC MENU

Diagnostics Menu

- 1) Check A/D converter bits.
- 2) Take frame and save it as 2 separate frames representing separate reset on frames, etc.
- 3) Read memory only.
- 4) Take grid mode data.
- 5) Return to master menu.

Enter your choice:

Program Listings

Appendix B: Program Listings

Not included to save paper. See Marcia if you're curious.

Appendix C: Accidental Erasure of PC Files

If you accidentally erase some data files which have not been transferred to the Sun or otherwise archived, leave the observing program. Select the disk and directory where the erased files were located. Type qu *.* or a wildcard specification that matches the erased data (avoid using *.*; attempt to get close to the erased names because using *.* will force you to hunt through many irrelevant files). The program will then present a series of names with the first letter missing. Answer yes and supply the correct first letter for files that you want restored. Note that this unerase works best if done right after the erasure and before anything else is written to the disk.