SAAO CCD Camera Control Program version 1.2

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1 Introduction

This program controls the SAAO CCD camera used on the 1.0-m telescope via a standard SAAO interface card and a Merlin crate. It is intended to run under Real Time Linux on an industrial PC. The code is written entirely in C and makes use of the Xforms library for the observer's graphical interface.

In order to present a uniform interface to observers, the program should be run within the KDE window manager(WM). This is ensured if the instructions below are followed carefully. If you want to use some other window manager, the results are not guaranteed, though the program will probably run successfully.

1.1 Log On

If the KDE WM is running you are probably in the right place to proceed. The WM must have been started and therefore be owned by user ccd. If in doubt, exit to the login prompt in text mode. Then log on as follows (you type the boldface items):
host login: **ccd**
Password: (consult local expert)
startx
In about 20 seconds a blue background will appear, probably with one **xterm** window, and an icon bar at the bottom of the screen (see the Appendix for a brief description of the icons). If there is no **xterm** window, click on the shell icon at the bottom of the screen.

If necessary, create a subdirectory using whatever name you like. Change to that subdirectory. It is important that you be in this subdirectory each time you start the program since various useful files pertaining to your run that it requires will be stored - in particular, the next file number to be used for an image.
(**mkdir abcd**)
cd abcd

In the **xterm** window, start the program by typing:
RunImage
The **Startup Panel** will appear. Fill in the details of your run, or amend them as necessary. Click on **Continue** and the **Main Panel** will appear. That is where you take control of the CCD camera. The various panels are described in the next few sections.

A Note of Warning: When exiting any window displayed by the spectrograph program, you can use only the appropriate Exit or Quit button on that panel. If you try to exit via the usual buttons at the top left and right (X) of a window then nothing will happen - the program has been instructed to ignore those exit routes.

In case of Program Hang-up

If the mouse pointer moves when you move the mouse, but there is no response

to commands you issue, then the best thing to do is press the Stop button to stop the program. Then, go outside an press the Merlin reset button before restarting the program.

If there is no response at all from the mouse, the only remedy is to switch off the power to the PC and reboot - this will take a while ($\sim$ 2.5 minutes) since the disk will be checked for inconsistencies and errors before rebooting.

This program is relatively new, so there are probably still some bugs in it. Please report any bugs you find, or suggest any changes or additions to jwm@saao.ac.za.

2 Startup Panel

The **Startup** Panel displays the details of the current observer's run, and allows various items to be changed prior to starting the control program proper (Fig 1). Most of this information is incorporated in the FITS headers of data files (see section 8).

At the beginning of an observing run, a template panel is shown containing dummy values which should be replaced to reflect the details of the current run. When the panel is closed, the current information is stored in a file in the user's subdirectory. On subsequent logins, the current values are shown in all fields, and will probably not require adjustment.

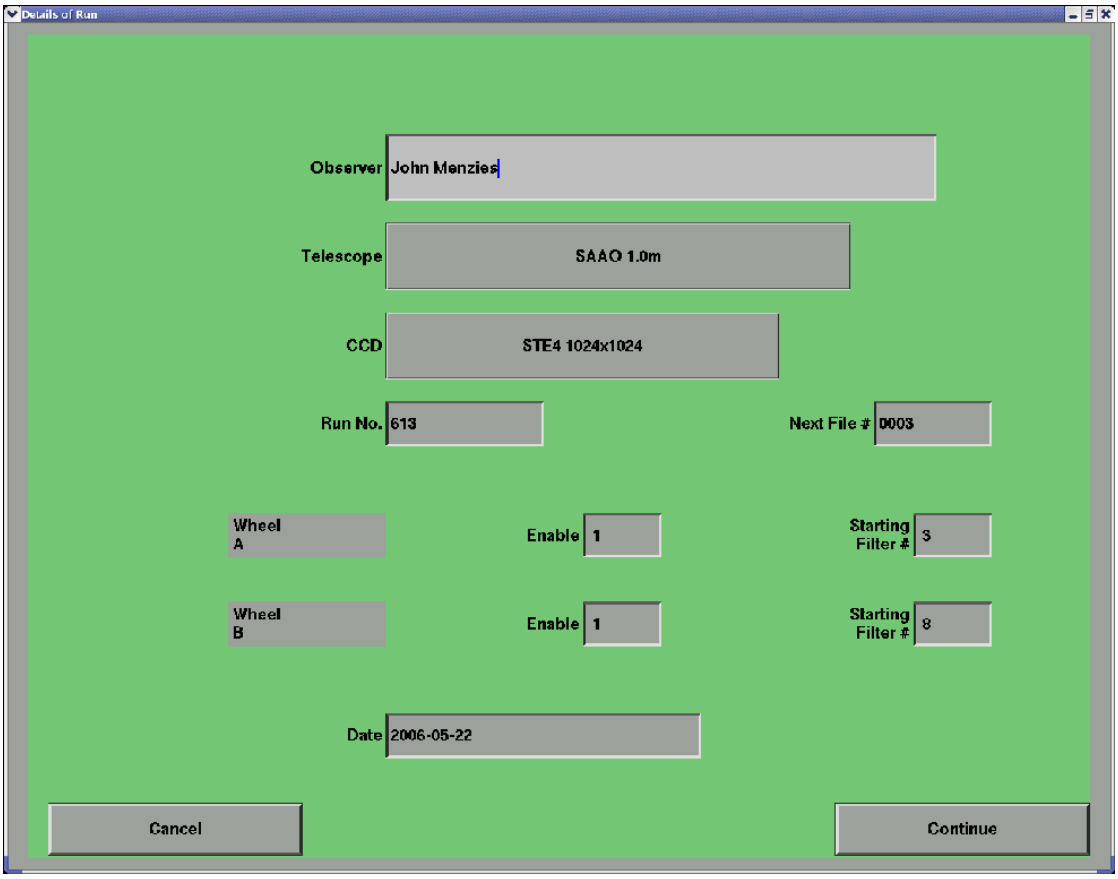

Figure 1: Setup Panel for CCD Spectrograph control program

The contents of the various entry fields and details of how to change them are given in the following section.

2.1 Data fields

These should be checked carefully each time you start up, in particular the **Next File** field. The only time you can change the items on this panel is at start up.

Observer The observer's name can be entered here. This is recorded in the FITS header and displayed on the Main Panel as described later. The Backspace and Delete keys can be used, or the field can be highlighted by positioning the cursor, pressing and holding down the left mouse button, while sliding the mouse left or right as appropriate; the field will be highlighted in reverse video. Start typing and the highlighted area will be replaced by the new entry. Pressing Enter will move the cursor down to the next entry field (Run No.).

Telescope This is a popup menu, and the only relevant entry is 1.0-m.

CCD This is a popup menu. The CCD currently (2006 May) used in the SAAO CCD camera is STE4, a 1024x1024 pixel SITe chip.

Run No. This is a running number which characterises the observing run. Look in the log book for the appropriate value, which should be entered in the window. The number should lie in the range 0 - 999.

Next File This is the part of the output file number that increments automatically as successive images are stored. Images are saved in the **/data/ccd/image** subdirectory (which is normally mounted on the **/data/ccd/image** directory on **s40**. Files are automatically transferred to **s40** ; images are not normally stored on the control computer's disk). The number ranges from 1 to 9999. File names have the form, **aXXXyyyy.fits**, where XXX is the run number and yyyy is the running file number, which is incremented every time a new file has been written.

Wheel A, Wheel B The two filter wheels are usually loaded with standard filter sets: Wheel A has **[U B V R I Hα blank blank]** in the 8 positions, respectively, while Wheel B generally has **[Stromgren u v b y Hβ blank blank blank]**. The wheels are normally enabled with 1 in the Enable box, though they can be disabled for testing or if a wheel is not actually in the filter box, by entering 0. After initialisition, the wheels can each be made to put a particular filter in the beam; the numbers are entered in the Starting filter # boxes.

Date This is read from the control computer and should not normally need to be changed. Change the date if necessary, but make sure the format is as in the figure.

2.2 Completion

Once all data are entered and you are satisfied, press **Continue** to carry on, or **Exit** to abort the process. The data are saved in a file, **setup_data.dat**, in the observer's subdirectory. It is thus important to start the control program from this subdirectory on subsequent occasions for the data to be recovered properly.

Before displaying the main control panel, the program checks that the Merlin crate is responding and that the fibre communications link is operating correctly. If there is a problem, there will be an error message, which suggests various actions to take to rectify the problem. Press **OK** on the message panel, whereupon control will be returned to the window manager. On the other hand, if all is well, the **Startup Panel** will disappear, to be replaced by the **Main Panel**.

3 Main Panel

The **Main Panel** allows the observer to interact with the camera, to display images and various plots spectra (Fig 2). The panel comprises four distinct areas which will be described in turn below. The **Status** area at top left shows the details of the current or just-completed exposure; images are displayed in the **Image** area at top right; the plots are shown in the **Plot** area at bottom right; the observer controls the camera and filters from the **Control** panel buttons at bottom left.

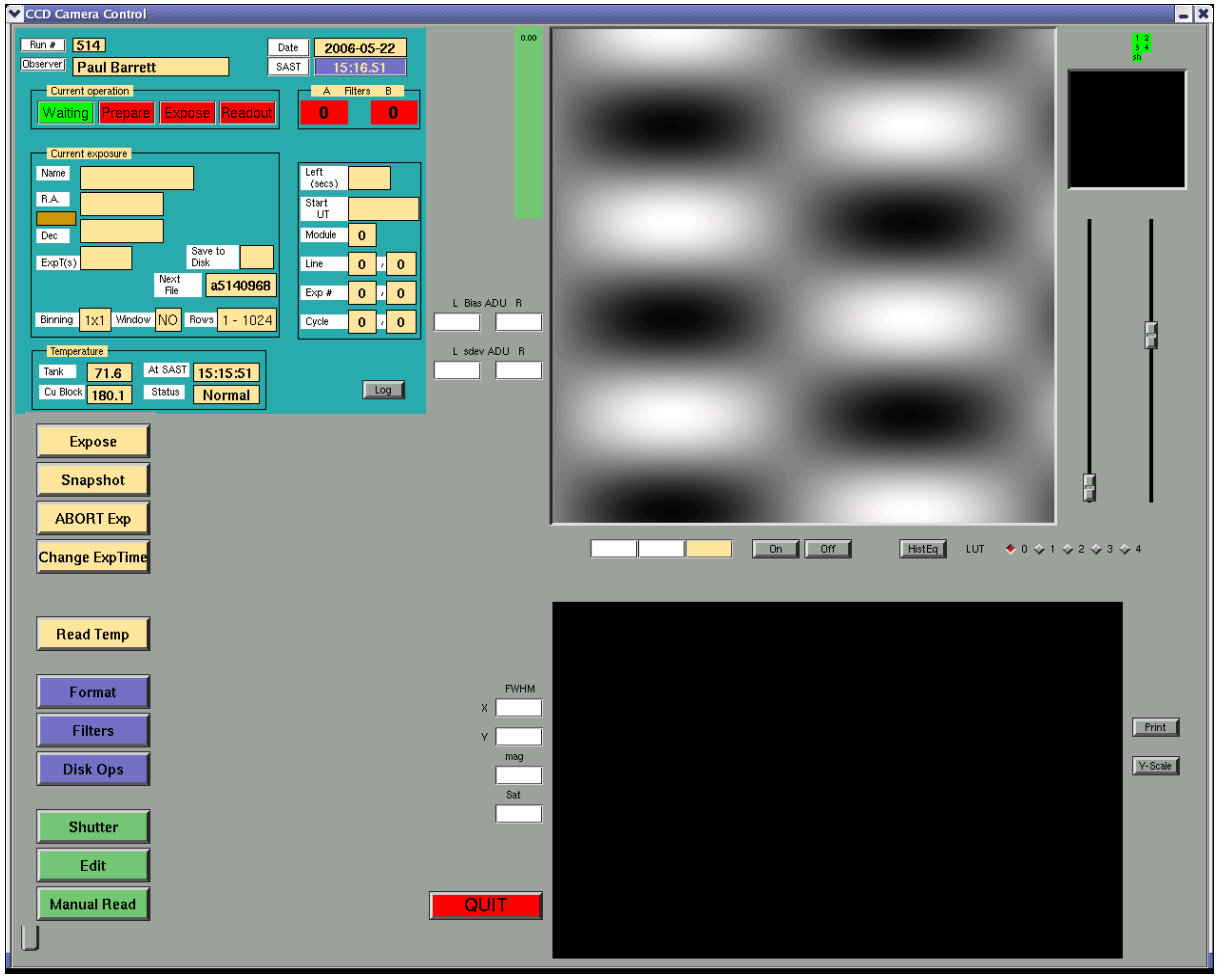

Figure 2: Main Control Panel for CCD Camera.

A small set of indicators to the top right of the **Image** area should be green; these are for diagnostic purposes only.

To exit the program click on the **STOP** button at the bottom middle of the screen. You will be asked to verify that you meant to do it, to guard against accidental choice of this option.

At startup, a warning message will be displayed to remind you to initialise the filters . You can still do snapshot exposures, but the filter positions will be indeterminate; the filters would normally only be left uninitialised while testing other parts of the system. Click OK when ready to proceed.

3.1 Status

There are various parts to this area (figure 3). The run number, observer's name, date and current SAST are displayed at the top of the screen. As with the rest of the **Status Panel**, there is no interaction possible. It is an area where information is displayed only.

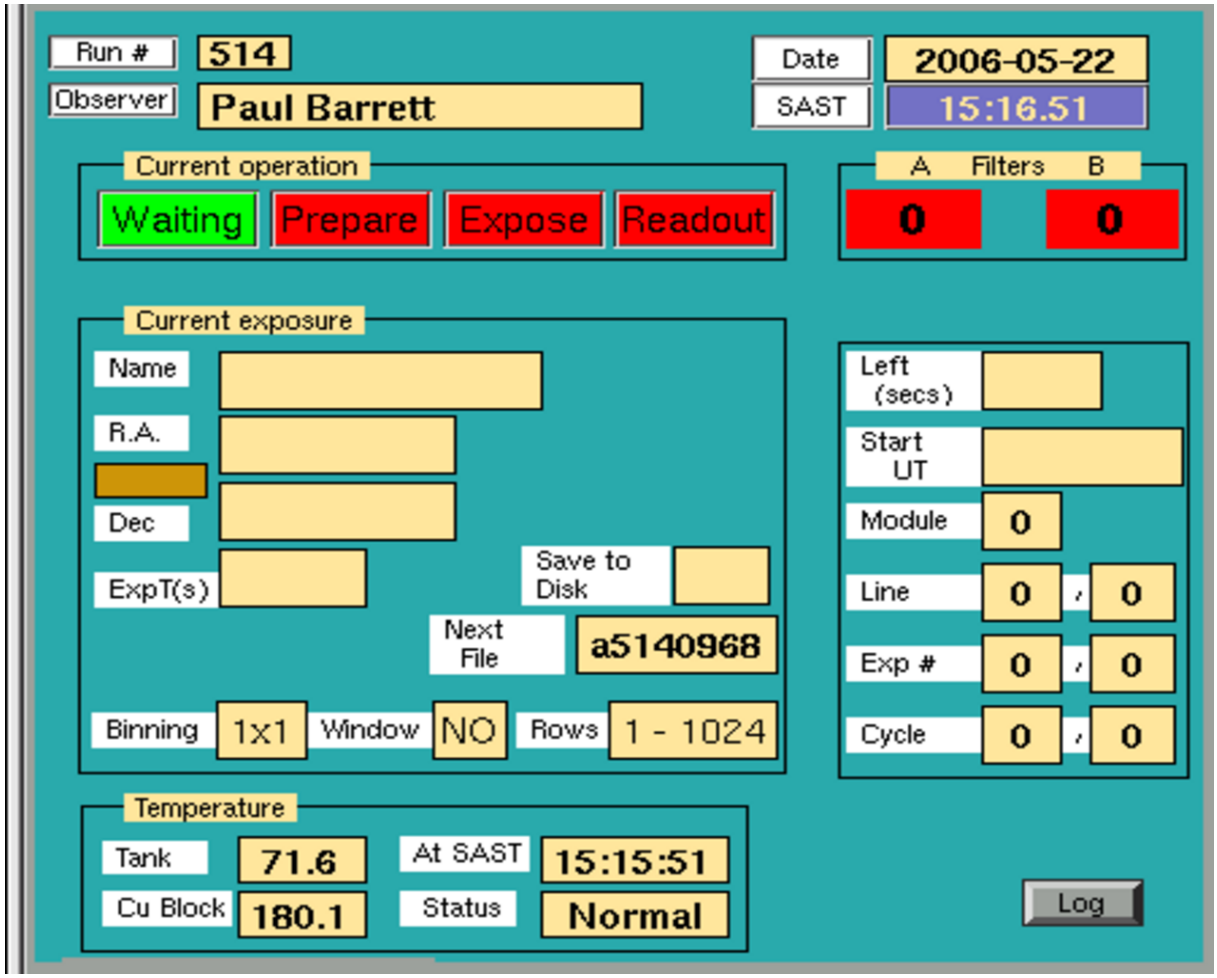

Figure 3: Status Panel.

Current operation refers to the activity in the Merlin/CCD system. Four panels indicate whether the system is quiescent (**Waiting**); preparing the chip for an exposure (**Prepare**) by clearing the image area of residual charge; collecting photons (**Exposing**); returning an image to the control computer (**Readout**). The panel is green when the relevant action is taking place, red otherwise.

The **Filter** box shows the current positions of the filters - with a green background if they are initialised, but red otherwise. When initialisation is occurring, a particular box will first be red, and the number will increase until the reference position is found. Then the box becomes green and the numbers thereafter reflect the true position of the filter wheel.

Current exposure refers to the exposure in progress(if photons are being collected) or to the last exposure (when **Waiting**). The object name, RA, Dec, equinox and exposure time are displayed on the left side. The file name in which the **next** image will be stored and whether the image is to be stored on disk appear on the right of the box. File names are incremented automatically, and are not controllaable by the observer, except at startup time. At the bottomi, the current binning state (1x1 or 2x2), whether the readout is windowed or not, and the number of rows that will be read out are displayed. Binning and windowing are mutually exclusive.

To the right of the Current exposure box, you can see the time remaining for the current exposure, the Module numberi (with a green background if the Module is current or red otherwise), and the current position within the Module. **Line** refers to the line in the Module block, the left box being the current position, the right box giving the total number in the block. **Exp #** refers to the number of times the setup in the line has been carried out. **Cycle** refers to the number of times the entire Module has been accessed.

The CCD cryostat temperature is determined regularly, and in any case at the end of each exposure. The results are logged in subdirectory ($\sim$ **/.Tlog**) and displayed in the **Temperature** box on the **Status panel**. The time at which the last measurement was made is also shown, together with an indicator that reads '**Normal**' when the liquid nitrogen tank temperature is within acceptable limits, or '**Hot**' when it goes outside that range. In the latter case, the tank has run out of liquid nitrogen and an attempt should be made to find out why. Provided the CuBlock temperature is less that 240K the tank should be filled immediately. Otherwise, there is a danger of water condensing on the chip, in which case the cryostat should be left to warm up for re-pumping.

The small button labelled **Log** allows a pad to be displayed on which a continuous log of operations is recorded. This is really only useful for diagnostic purposes. When the pad is displayed two buttons appear, one allowing the contents of the log to be printed, the other returning to a display of the **Status** panel.

3.2 Image

The image panel displays a 512 column x 512 row image of the data last read out from the CCD (Fig 4). This means that the 1024x1024 chip is shown at half size.

Figure 4: Image Display area.

The small **On** and **Off** buttons control a cursor. When the cross-shaped cursor is on the image, its x,y coordinates (column, row) and the count in that particular pixel are displayed in the three boxes to the left.

The **HistEq** button applies a histogram equalisation lookup table to the image which shows the image at high contrast. The array of buttons labelled **LUT** 0 to 4 allow the image to be displayed with different lookup tables. The basic lookup (0) is simply represents the minimum data value encountered during the readout as black and the maximum as white. The white level is adjusted to represent the

maximum count seen so far in the data as the image is being read out. The image is read out and displayed in blocks of 7 rows at a time. A red bar to the left of the image shows where the last row read out is displayed. LUT 1 sets the white level to 512, suitable for very low signals, while for LUTs 1, 2, 3 the white level is set to 2048, 8192 and 32767, respectively. The current LUT is indicated by a red symbol.

At the end of an exposure, the four boxes to the left of the Image area show the mean bias level (ADU) and the standard deviation (ADU) of the under/overscan strips respectively.

The vertical green box displays the state of the readout as an expanding red bar with the fraction completed written at the top during the readout of an image.

The **Program panel** is where the interaction with the camera takes place (Fig **??**). A number of buttons on the panel allow different types of exposure to be made as well as readout modes to be set. Some of them are discussed in more detail in later sections. The buttons are grouped with the most frequently ones at the top, those used not so often in the middle, and least frequently used ones at the bottom. Their functions are as follows:

Expose Initiate an exposure. A pop-up screen appears, allowing exposure details to be adjusted. Object names can be selected from a browser window, names can be added or removed, and details can be edited. See section 4 for details.

Snapshot For an exploratory look at an image, a no-frills exposure can be made, the only input being the exposure time. It is also possible to do short exposures continually, by selecting **Video**. In this case, the chip is automatically put into prebinned (2x2) mode. This mode is useful when adjusting the position of the object of interest on the chip. Don't forget to go back to 1x1 binning at the end. Press the **Stop** button to halt the readouts after the current one is complete.

Change Exp Time With an exposure under way, the exposure time can be changed. because it takes the controller some time to respond to the request, it is not possible to change when too close to the originally expected end of exposure.

ABORT Exp Terminate the current exposure prematurely. The readout will continue to the end, but the image will be lost.

Read Temp To obtain a measurement of the temperatures in the cryostat. This is useful also as a simple way of confirming that the communications with the Merlin crate are working properly.

Format Pressing this button displays a two-item menu allowing the readout format to be changed.

[Window] To request that a subset of the total number of rows be read out, unbinned.

[Prebin] To switch binning on or off. Only 1x1 and 1x2 binning are implemented.

Filters This brings up a two-item menu that give control of the filters.

[Initialise] This allows the filter wheels to be initialised. This should only be necessary at the beginning of observing.

[Move] The filter wheels can be moved individually to bring particular filters into the beam This is normally done within a module, but it may be useful when doing a Snapshot exposure.

DiskOps This controls 3 functions relating to disk files.

[DiskLog]Details of exposures are kept in a log file in your own subdirectory. The contents of the log can be viewed by choosing thei item.

[From Disk] This allows you to retrieve an image that had previously been obtained with the camera. A browser pops from which the file can be selected.

[To Disk] To save the latest image to disk (for example after a Snapshot). Its name will be the next in th current series as displayed in the Status panel.

Shutter This allows manual control of the shutter. When Open is selected the Time left count increments steadily, and it stops when Closed is selected. This is normally only used for testing.

Edit This allows Modules and the list of Objects to be edited independently of any imaging operation.

Manual Read This pops a two-item menu allowing the CCD to be read out independently of a normal exposure. DMA Read is the normal mode, while ReadPix is much slower. Again, these are normally only used for testing.

3.2.1 Plots Area

The **Plots Area** (Fig **??**) allows various types of diagnostic plot to be displayed. At the end of each readout, the counts in pixels along the middle row are displayed as a confidence check. The other plots are controlled by a combination of cursor position and an F button on the keyboard.

F1+cursor Displays a plot of counts along the row under the cursor. Hold down F1 and move the cursor vertically to see particular rows.

F2+cursor Displays a plot of counts along the column under the cursor. Hold down F2 and move the cursor horizontally to see particular columns.

F5+cursor Displays a contour plot of the star image under the cursor. This is very useful for judging the state of focus.

F6+cursor Displays a radial profile of the star image under the cursor. At the same time, the profiles in the X and Y directions are fitted and the result in pixels displayed in the two so-named boxes beside the plot. The number of saturated pixels is also shown together with the integrated count in the image expressed in magnitudes with an arbirary zero point (based loosely on measures of E-region stars).

Figure 5: General plotting area.

The displayed plot can be printed on the default printer by clicking on the **Print** button.

4 Making an exposure

Exposures are initiated in several ways, using the buttons at the left of the Program panel. Clicking on **Exposure** will bring up a panel in which details of the exposure are entered. A quick exposure can be done by selecting **Snapshot**, where only the exposure time is required.

WARNING:
At present, there is no check of whether the acquisition camera viewing mirror is in the beam. Be sure to check the mirror's position before starting a long exposure if you don't want to waste valuable observing time on blank images.

4.1 Exposure

The **Exposure panel** (Fig 6) calls for the following details, most of which will be displayed on the status panel when the exposure begins:

Exposure Time The required exposure time in seconds.

Number of Exposures The number of consecutive exposures to be made on this object.

Save to Disk Select the required option by clicking on the button. It is also possible to save an image at the end of an exposure by using the **To Disk** button on the **Program panel**.

Type Choose one of **Object, Arc, Flat** or **Bias**. If **Object** is selected, a browser window will appear allowing a name and coordinates to be chosen. This is described in detail below. If it is an **Arc**, choose the particular lamp (CuAr, CuNe, Both) from the pulldown menu to the right of the title, **Lamp**. If **Flat** is selected, choose its type (Dome or Sky) from the pulldown next to the title, **Flat**.

Ready/Cancel When everything is set up correctly choose **Ready**. **Cancel** will merely return to the main **Control panel**.

4.1.1 Object details

If there is a file called "**objects.dat**" in your startup subdirectory, its contents will be displayed in a browser window, allowing you to choose the object to observe by clicking on the line with its details (Fig 7).

This browser can also be used to enter new objects, and edit or remove existing ones. The format of a line is, in C notation, "%15s %6.6d %+6.6d %6.1f", or in FORTRAN notation, (A15,1X,I6.6,2X,I7.6,1X,F6.1). A typical line is:

```
T0146-2651    014626  -265100 1950.0
```

Observers can supply their own files conforming to this format, or can enter names and coordinates via the browser. New object names and coordinates are typed in the boxes at the bottom of the browser (which initially contain examples in the proper formats), and the entries are validated before being accepted. It is necessary to click on one of **Add**, **Insert** or **Replace** before the new name is accepted into the body of the browser. Additions and alterations to the file are saved to the original file name and a copy of the old file is kept in "**objects.dat.bak**".

Add Enter Star name, RA, Dec, Equinox, press **Add**. Data will be validated, added to the end of the file, and the line highlighted.

Insert Highlight the line **before** which the new line is to be inserted (by placing the arrow cursor on it and clicking the left mouse button). Enter data as for **Add**, press **Insert**. If no line is selected, put the new line at the top of the list.

Replace Highlight line to be replaced, enter data and press **Replace**. If no line is highlighted, do nothing.

Delete Highlight line and press **Delete**.

Quick Find If you can't find your object in a long list, or simply want to choose it quickly, enter the name in the box at bottom left and press **Enter**. If the object is in the list, the browser will put its details in the boxes at the bottom and highlight the line. This is useful if you want to edit an object's details.

A spectrophotometric standard star file is maintained in the CCD subdirectory (**/usr/local/data/CCD**) and this can be loaded into the browser by clicking on the relevant button. This file cannot be altered.

Click on **Choose** to return the object's details to the program and return control to the **Exposure panel**.

4.2 Snapshot

When this button is selected, a simple panel appears, into which you should enter the required exposure time. If you later decide to save the image to disk, the object will have the name "DUMMY" and coordinates (0,0,2000.0) in the FITS header.

4.3 Changing exposure time

While an exposure is in progress, it may be possible to alter the exposure time. Whether that is possible depends on how long the original exposure still has to

run. It takes time to get the Merlin crate to respond to a command, so there is a certain minimum time remaining, beyond which no change can be made. When the **ChangeExpTime** button is clicked, a panel appears which continuously displays the minimum allowed new exposure time. Enter your required value in the box and click on **Ready**. The counter on the **Status panel** will reflect the time now remaining, given the new exposure time.

4.4 Repeating exposures

To save time and typing, the **Repeat Last Object** button will initiate an exposure of an object with the same exposure time, name, RA, Dec, storage to disk option and number of repeats as the last object observed. There can be one or more intervening arc exposures since the last object, but still its details will be used. A panel pops up requesting confirmation to guard against accidental selection. The same considerations apply when **Repeat Last Arc** button is pressed. There can be several intervening object exposures since the last arc.

4.5 Abort exposure

Once an exposure is under way, that is, after the Prepare stage and before Readout commences, it can be terminated prematurely. **The image will be lost.** If you think you might want to save the image, it is better to use **ChangeExpTime** as described above.

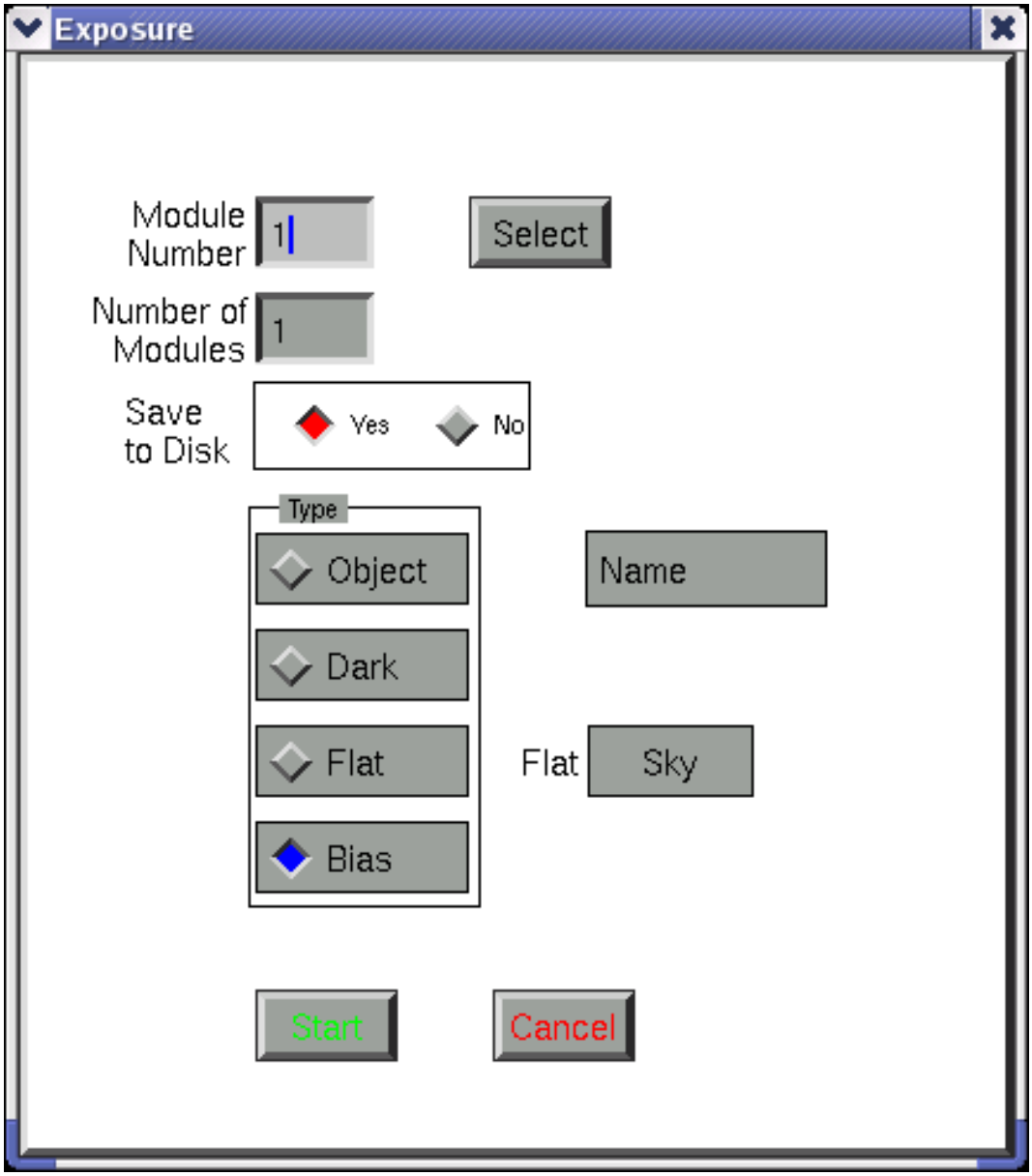

Figure 6: Entry Panel for Exposure Details.

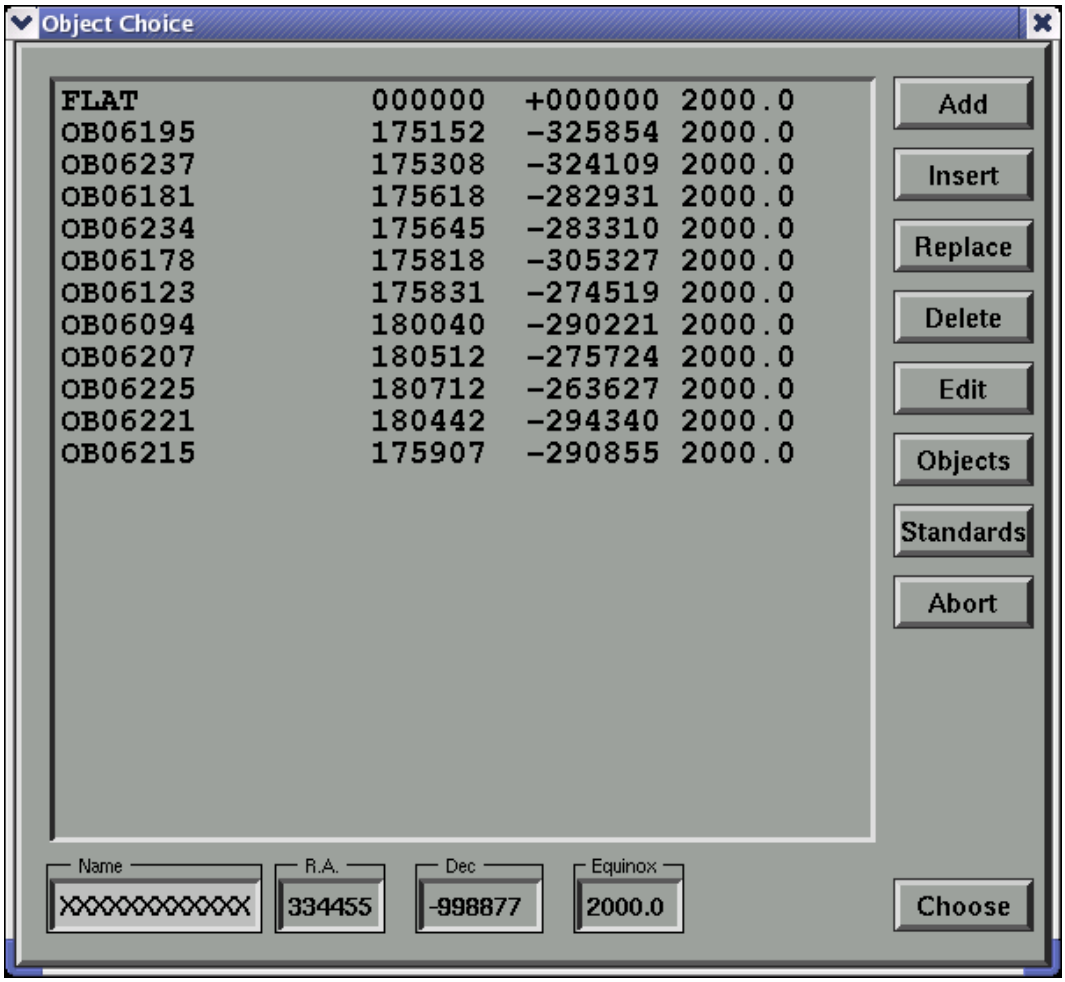

Figure 7: Object name and coordinate browser.

5 Select Module

Exposures are normally done with the aid of a Module, which describes the filters to be used, the integration times and the number of cycles of observation.

When the main program starts up, it looks in the current directory for files with names like Module01, Module02, etc. It reads the header line in each file (a description of what the module is for) and assembles them in a file called Modules.dat.

5.1 Choose Module number

In the first stage of selecting a module, these headers are presented in a browser window as in the figure (Fig 9) below. A series of buttons on the right side allow various actions, but only those with green or black labels are active at this stage. Thus, it is only possible to Choose a module, to add a new one, to Edit a header line, or to Choose the highlighted module. Pressing the 'help' button displays a concise guide to what can be done and how to do it.

To select an existing module, move the highlight to the relevant line using the up and down arrow keys. Click on Choose. The browser will change to show the details of the chosen module. If that is satisfactory, press Continue and the browser disappears to reveal the Exposure panel. The selected Module number now appears in the top box.

If you need to create a new Module, the you need first to enter a header in the boxes at the bottom of the Selector - a number and a title. Then press New to have the header added to the list in the browser. Make sure the line is highlighted and click Choose. An error message will appear noting that there are no lines in the Module. The browser will change and only the new header line is displayed. If you click New without doing anything else, an error message will appear, telling you what to do next.

6 Modifying the Module

Note that in the second stage, the label colours change again, but as before only the green and black ones have any effect. The data entry boxes are at the bottom of the browser, with dummy values entered.

Add a line Enter the filter numbers and exposure time (seconds) and the number of times this line should be acted on (normally 1). Press Add, to make the line appear in the browser panel. Continue in this way until all lines have

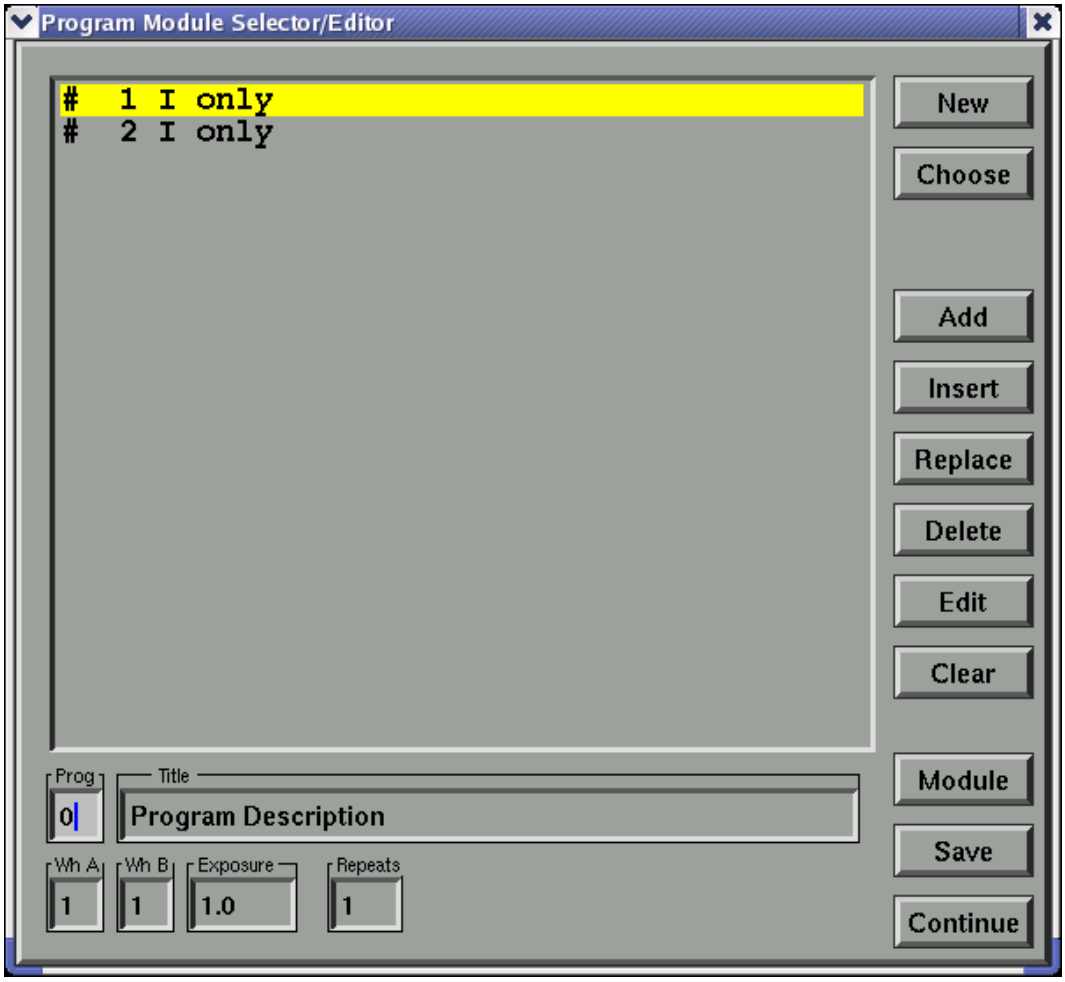

Figure 9: Selection of Module for observing the current object

been added. Each time you press Add, the line contents are checked for validity before being accepted. When finished press Save and then Continue to return to the Exposure menu.

Edit a line Highlight the line and press Edit. The values are transferred to the boxes below, where values can be changed. Press Replace to re-insert the line into the browser.

Insert a new line Highlight the line before which the new line is to be inserted. Enter the values in the boxes below, and press Insert.

Delete a line Highlight the relevant line and press Delete.

Save changes Click Save to have the browser contents stored in the relevant Module file.

Continue Once you are happy with your module, press Continue to return to the Exposure menu.

Miscellaneous [Modules] to go back to the first stage, press Modules.

[Clear] This clears the browser window completely.

7 Data Storage

Image files are saved into the **/data/ccd/image** directory. This directory is normally NFS mounted on s40, allowing data reduction to be done on that computer without interfering with the control program. If the NFS mount has not been done, the images will stay on the computer where the control program resides. To check the status, type:
df
and you should see something like the following, where the last line tells you that the image directory is indeed mounted on s74.

```
Filesystem           1k-blocks      Used Available Use% Mounted on
/dev/hda2               521780    115740    379536  24% /
/dev/hda6             14049536    483128  12852724   4% /data
/dev/hda1               513776       208    513568   1% /dos
/dev/hda5              4032092   3615180    212088  95% /usr
s40:/data/ccd/image    8016832   5557888   2051700  74% /data/ccd/image
```

Image files have names in the form, **aXXXyyyy.fits**, where XXX is the run number and yyyy is a running number that increments automatically after each image is saved.

8 FITS header

A typical FITS header produced by this program is as follows:

```
SIMPLE  =                    T         /
BITPIX  =                   16         /
NAXIS   =                    2         /
NAXIS1  =                 1056         / columns
NAXIS2  =                 1024         / rows
OBSERVAT= 'SAAO    '                   / observatory source
TELESCOP= 'SAAO 1.0m'                  /
OBSERVER= 'John Menzies              ' / observer
INSTRUME= 'STE4 CCD'                   /
DATE-OBS= '2006-05-26'                 / UT date
OBJECT  = 'OB06236                   ' /
IMAGETYP= 'object    '                 / IRAF image type
FILTERS =                   58         / Filters 10*A+B
RA      = ' 17:55:50'                  / ra
DEC     = '-29:55:20'                  / dec
RA_OBS  =             268.9583         / ra in degrees
DEC_OBS =             -29.9222         / dec in degrees
EPOCH   =               2000.0         / Equinox of RA,Dec
UT      = '21:28:15'                   / UT at Exposure star
ST      = '15:08:43'                   / Siderial time at St
MJD-OBS =          53881.89462         / JD-2400000.5 at Sta
EXPTIME =              700.036         / integration time in
SECZ    =                1.229         / Air mass at start e
TRIMSEC =  '[  19:1039,   1:1024]'     / Useful part of data
BIASSEC =  '[   4:  14,   1:1024]'     / Overscan region
BSCALE  =                  1.0         / DATA=BSCALE*INT+BZE
BZERO   =                32768         /
GAIN    =                  2.8         / e-/ADU
RDNOISE =                  6.0         / e-(rms) read noise
CCD-TEMP=                180.0         / CCD Cu block temper
COMMENT =
END
```

Contents