

# 1.0-m Telescope Control Software

A User's Guide

Version 3  
February 2010

Stephen Potter  
Hannah Worters

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## 0.1 Introduction

This manual describes the use of the Telescope Control Software (TCS) for acquisition and autoguiding using the 1.0-m telescope at the SAAO. The camera uses a dye-coated EEV CCD and is operated via a transputer-based controller. It has a broad wavelength response from roughly 0.35 to 1.0  $\mu\text{m}$  with a peak around 0.7  $\mu\text{m}$ . The image scale is approximately 0.5 arc-sec/pixel.

The TCS is written in C using XFORMS to create the Graphical User Interface (GUI). The software runs on a PC running real-time linux. The TCS allows the control of the acquisition and guiding (A/G) camera; certain telescope functions (not including slewing and opening/closing of the mirror covers) and the dome (excluding opening and closing of the shutters and control of the windblind).

## 0.2 Todos and not todos

There are **no** automatic switches to prevent the telescope overshooting safe limits in RA and Dec, **it is possible to crash the telescope tube into the catwalk railings, and to run the instrument into the pier.** It is up to the observer to make sure the telescope is operated safely. The following guidelines should be adhered to in addition to being generally aware of the status of the telescope at all times:

- **It is vital to make sure the RA and Dec drives are set to FAST before switching off the telescope power.** If not set to FAST, **the telescope will swing down and crash** when the power is switched off. The telescope power switch is located just inside the entrance to the dome.
- **Do not reboot the TCS PC.** The PC should only be rebooted if the LINUX operating system hangs or crashes.
- **Do not exit the TCS program.** The TCS is best left running as it reports the status of the telescope etc.
- **Do not run any other software on the TCS PC.** The TCS PC is devoted to operating the telescope and the A/G camera. Running any other software on this PC may disrupt the operation of the TCS and obscure important information on the TCS GUI.

## 0.3 Starting the TCS

Ideally there should be no reason to exit the TCS. It is written such that if there is any breakdown in communications between the TCS PC and the A/G camera or the PLC, then appropriate error messages or warning indicators will be displayed in the GUI. These error messages will remain until the problems are fixed. Switching the telescope off, for example, will not crash the TCS. Instead the TCS will display blanks in the fields that are no longer being updated.

However, if the TCS PC is switched off, the following steps should be followed:

1. Switch on the TCS PC. The PC should automatically boot up into real-time linux and present the user with a login prompt.
2. Login as **ccd** using the usual password (consult support astronomer or technician).
3. Once X windows is up and running, the screen you will be presented with will be empty except for a Sputnik icon. Click on the Sputnik to start the TCS.

Upon a successful startup one will be presented with the TCS GUI as shown in Figure 1. A few other points to note:

- An xterm is available on the vertical task bar (move cursor to left edge of screen). This should only be used to transfer (e.g. by ftp) any saved data files.
- The TCS PC is running a dual monitor setup. This means that the mouse arrow can 'fall' off the right edge of the main TCS screen and end up on the RA, Dec display monitor. Just move it to the left to bring it back onto the main screen.

## 0.4 The TCS position and status display

The top section of the TCS GUI **reports the current status** of the telescope and dome. During normal observing, all of these boxes should be green; they will turn red to indicate something that may need your attention. The display area will be blank if the telescope power is switched off, or if communications between the TCS PC and the PLC are lost. Each subsection of the position and status display is explained below, from left to right:

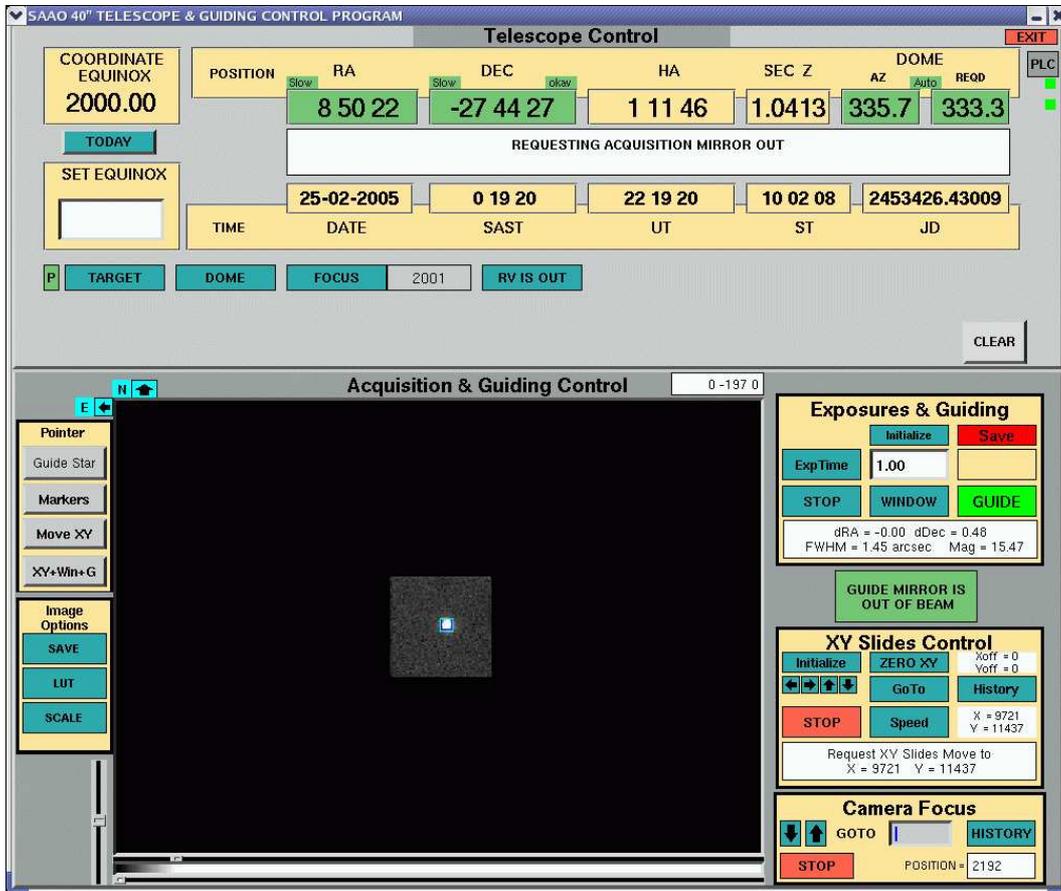


Figure 1: The TCS user interface.

### 0.4.1 Coordinate equinox

This box displays the equinox of the displayed RA and Dec. It can be changed to the current date by clicking on **TODAY**, or to any other date by inserting a value into the **SET EQUINOX** box and pressing ENTER on the TCS PC keyboard.

### 0.4.2 Position display

The position display panel reports on the right ascension (**RA**), declination (**DEC**), hour angle (**HA**) and airmass (**secZ**) of the current telescope position. The **RA** and **DEC** boxes turn red or green when the telescope is set to either FAST (slew) or SLOW (set), respectively. This is indicated by smaller flags above the coordinate display, stating **FAST** or **SLOW**. The **DEC** box

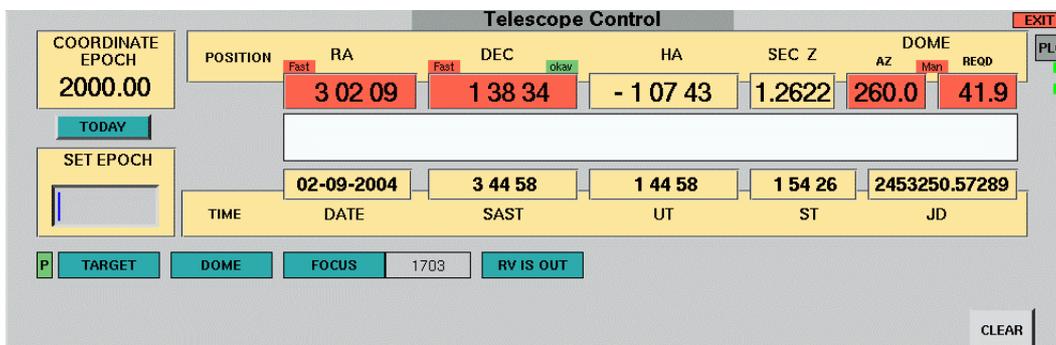


Figure 2: The TCS position and status display. Messages and warnings are displayed in the central white box.

has an additional flag indicating the position of the declination worm gear. If this turns red, the dec drive needs to be switched to FAST (slew) in order for the dec worm to be recentered.

### 0.4.3 Dome status

The **DOME** section on the right-hand side is populated with the following indicators (from top to bottom):

- A **rotation control status flag** indicating whether dome rotation is in Manual mode (red) or Automatic (green). It should be set to **Auto** while observing to allow the dome to rotate as the telescope tracks. Switching between manual and auto is done using a button on the blue control panel on the North pier.
- The **current and required azimuth of the dome shutters** for the telescope to point out of the open shutter. These are green during normal operation, but turn red when the difference between the two is more than a few degrees.

### 0.4.4 Time display

Below the position information is a time panel, which displays the current date, South African Standard Time (**SAST**), Universal Time (**UT**), local sidereal time (**ST**) and the Julian date (**JD**). The current time server is highlighted in green and should be **SAAO**. The TCS gets the SAST and local sidereal time directly from the SAAO time service via a time card

in the TCS PC. UT, JD, RA, HA and secZ are calculated using this time card. However the date (day, month and year) are taken from the PC clock. Therefore if the PC clock is running slow the change in date may occur a few seconds after local midnight.

### 0.4.5 Normal and Error messages

The main message display area is the long box located between the position and time display areas. Normal messages appear here, e.g. confirmation of user requests to change zero points, or the status of the guide mirror. New messages appear with a red background. The background remains red for 2 seconds before turning white. The message remains in the display.

Error messages appear in the same way. For an ongoing error, the message area will remain red until the associated problem has been fixed.

### 0.4.6 EXIT

Pressing on the  button in the top right-hand corner will bring up a pull-down confirmation menu. Please do not exit the TCS unless absolutely necessary.

## 0.5 Operations Panel

Below the position display is an Operations panel consisting of two menus. One menu is visible at a time. Click on the left-hand  or  button to toggle between the Parameter Panel and Operations Panel, respectively.



Figure 3: The TCS Operations panel.

The Operations Panel consists of buttons for three functions: ,  and . Clicking on one of these buttons will deactivate the other two until the  button on the right is pressed.

### 0.5.1 The **TARGET** button

Clicking on **TARGET** brings up text boxes to allow the user to enter the RA and Dec of a target. The coordinates will then be displayed on the monitor above the TCS PC in the warm room and by the telescope control panel on the North pier, thus they will be visible to the observer when slewing the telescope.

### 0.5.2 The **DOME** button

Clicking on the **DOME** button will reveal a pull-down menu that allows you to rotate the dome to a given azimuth using the “*Move*” option. This will only work if dome rotation is set to **manual**. The dome can also be moved using the handsets. Be very aware of the position of the telescope when moving the dome manually.

### 0.5.3 The **FOCUS** button

The **FOCUS** button allows the user to enter a telescope focus. Upon pressing **GO** the telescope focus will move to the specified focus position. Next to the **FOCUS** button the current focus position is displayed. This box turns red when adjusting the focus. The telescope can also be focussed using the handsets.

### 0.5.4 The **RV** button

This controls the rear view (RV) mirror, allowing the user to move the mirror in and out of the beam. The button also displays the current status of the mirror. If the mirror is moving the box turns grey and becomes deactivated until it has completed its movement.

## 0.6 Parameter Panel

The Parameter Panel consists of buttons that allow the user to change various operational parameters. It is accessed by clicking on the **P** button. As with the operations buttons, selecting any parameter button will grey out and deactivate the other parameter buttons until the **CLEAR** button is clicked. The options are given in the following subsections.



Figure 4: The TCS Parameter Panel.

### 0.6.1 **SET REVERSE**

Upon clicking the **SET REVERSE** button the current orientation of the telescope is highlighted in green. The default is for the telescope to be East of pier. To inform the TCS that the telescope has been reversed, click on **WEST**. This ensures that the autoguider will function correctly.



Figure 5: The **SET REVERSE** button.

### 0.6.2 **ZERO POINTS**

Clicking on **ZERO POINTS** reveals a pull-down menu with options for three different scenarios:

#### 1. **Centring on a bright star**

Once a star has been centred in the field of view of the acquisition camera, an offset can be applied to the pointing, which can be applied to aid acquisition of stars in that part of the sky. Selecting “**Enter RA and DEC of Star**” reveals two input fields that allow the user to enter the **catalogue** RA and DEC of the star that the telescope is pointing to. Make sure the **correct Equinox** set. On clicking **ENTER** the TCS will recalculate and set the zero points. The RA and Dec zero points will be displayed in the message box and should be noted down for future use. Different sets of zero points will be needed for different parts of the sky.

#### 2. **Known zero points**

If the zero points for a particular part of the sky are known, for example by following the procedure above, these can be entered into the TCS



Figure 6: ZERO POINTS → “Enter RA & Dec of Star”.

by selecting **“Enter Zeros Directly”**. Three input boxes appear, showing the current settings of the RA and DEC zero points and the collimation coefficient. These can be edited and then set by clicking **ENTER**. The defaults can be restored by selecting the **DEFAULTS** button, see below.



Figure 7: ZERO POINTS → “Enter Zeros Directly”.

### 3. Two Star Collimation

This option reveals two input fields that allows the user to enter the catalogue coordinates of a star that the telescope is pointing to, preferably either close to the equator or to the pole. Upon clicking **ENTER** the telescope should be pointed to a second star (again either near the equator or the pole), the RA and DEC of which should be entered into a second set of input boxes. Clicking **ENTER** enables new RA and DEC zero points and a collimation coefficient to be calculated and set. The defaults can be restored by selecting the **DEFAULTS** button, see below.



Figure 8: ZERO POINTS → “Two Star Collimation”.

### 0.6.3 POINTING

Clicking **POINTING** reveals buttons that allow the user to switch on/off the pointing model. The pointing model is an analytic model that takes into account effects such as atmospheric refraction. As a default, it should be ON.

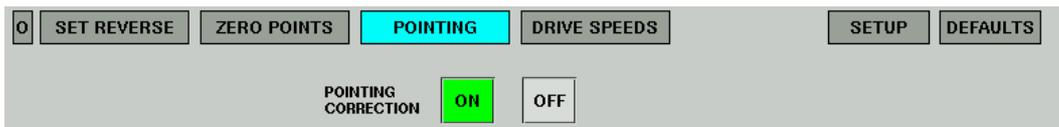


Figure 9: The **POINTING** button allows the user to switch on/off the pointing correction.

### 0.6.4 DRIVE SPEEDS

Clicking **DRIVE SPEEDS** reveals five input fields that display and allow the user to edit the current RA “SET”, “GUIDE” and “TRACK” rates, as well as the DEC “SET” and “GUIDE” rates. The specified values will be set upon clicking the **ENTER** button. The defaults can be restored by clicking on **DEFAULTS**.



Figure 10: Adjustments to RA & Dec motion can be made using the **DRIVE SPEEDS** button.

### 0.6.5 SETUP

Clicking **SETUP** opens a FileSelector window that allows the user to select a file containing RA and DEC zero points, collimation coefficient, RA SET, GUIDE and TRACK speeds and DEC SET and GUIDE speeds. A sample file can be found in `/home/ccd/setup.tcs` which contains the default values.

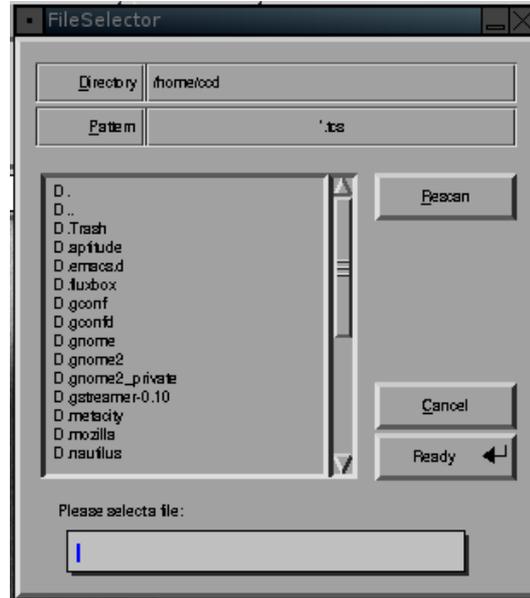


Figure 11: Parameters can be set using a `SETUP` file.

### 0.6.6 `DEFAULTS`

Clicking `DEFAULTS` reveals four further buttons. If these buttons are pressed, the `ZERO POINTS` (RA, DEC and COLLIMATION COEFFICIENT); `DRIVE SPEEDS` or `DOME` zero points will be reset to their respective default values. Clicking `DISPLAY DEFAULTS` will display the defaults but NOT set them.

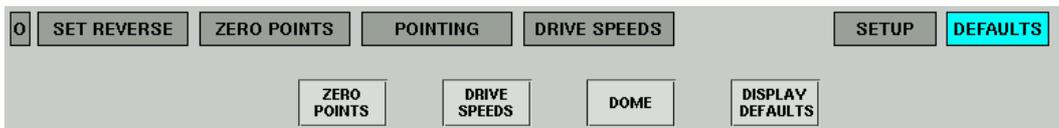


Figure 12: Some or all parameters can be reset using the `DEFAULTS` button.

### 0.6.7 The `PLC` button

This button is for diagnostic purposes and displays more information than is required during normal observations. It is most useful for error handling or

problem solving. A red box would indicate a problem. To exit the diagnostic panel, click **FINISH**.

## 0.7 Acquisition and Guiding Control

The Acquisition and Guiding Control occupies the lower portion of the TCS GUI and is responsible for the control of the acquisition and guiding camera and the XY slides. It consists of the main image viewing area, an Exposures and Guiding panel, a Guide Mirror control button, an XY Slides Control panel, a Camera Focus panel, a Pointer panel and an Image Options panel.

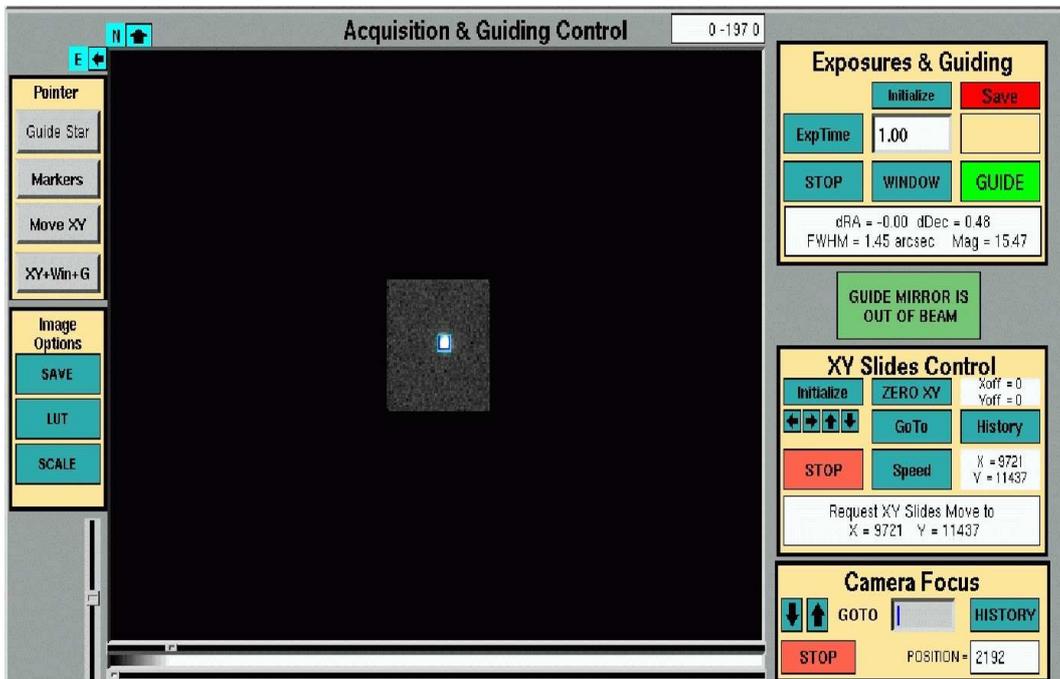


Figure 13: The image display area as seen while guiding.

### 0.7.1 The main image viewing area

Once the A/G camera is integrating, the most recent image is posted here. If the A/G camera is operated in a smaller windowing mode then the smaller image will appear in the center of the image display area. A colour bar is located at the bottom of the image area showing the colour range and colour table. The two sliders above and below the colour bar can be used to change

the upper and lower limits of the colour range. Swapping their positions will invert the colour table. The vertical bar to the left can be used to change the gamma correction of the colour scale. On a bright night, it may help to slide to more negative values on the gamma bar.

The **pixel coordinates and counts** at the location of the cursor on the image are displayed in a box at the top right of the image area. This box turns green if the mouse pointer is within a red marker, thus giving the image coordinates of the red marker.

The **orientation** of the image is displayed on the top left of the image display area. The image can be reversed East-West and or North-South by pressing on the light cyan arrows.

## 0.7.2 Image options

The image properties can be adjusted from the Image Options panel to the lower left of the main image, which consists of the following buttons:



Figure 14: The “Image Options” panel.

- A **SAVE** button, allowing the user to save the current image to a file in fits format. Upon clicking, a window appears requesting the name of the file to write to. Only the raw data is saved to file; any markers or scaling of the colour table is ignored. The **SAVE** button only works when the A/G camera is not exposing.
- A **LUT** button, which reveals a pull-down menu allowing the user to select from a variety of colour tables.
- A **SCALE** button, which reveals a pull-down menu allowing either a linear scale or histogram equalization of the colour table. The colour

table may also be scaled between minimum and maximum values defined by the two **sliders** at the top and bottom of the colour scale bar.

### 0.7.3 Exposures and Guiding

The acquisition camera is controlled from the Exposures & Guiding panel to the top right of the image display. Its functions are detailed below.

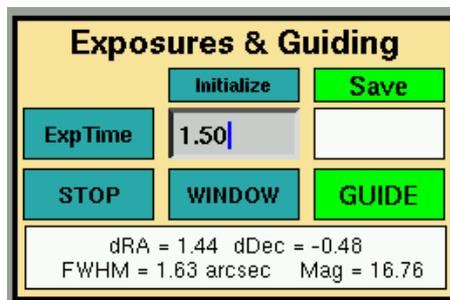


Figure 15: The “Exposures & Guiding” panel.

- The Initialize button brings up a pull-down menu revealing two options:
  - **Hard Reset** will send a command to the Merlin controller to perform a hard reset. If the PLC is switched off (as is the case if the telescope power is off) then the Hard Reset option will not work. The red button on the Merlin controller itself (the small blue box by the A/G camera on the telescope) can be used instead. A hard reset is necessary if the Merlin controller has crashed for some reason.
  - **Boot Merlin** After issuing a hard reset it is necessary to boot the Merlin by selecting the this option on the Initialize pull-down menu. If booting is successful, a Merlin ID version number will appear in the Exposures & Guiding message area. If it is not operating correctly, an error message will be posted in the message area suggesting a HARD RESET. The camera will still operate when the telescope power is off.
- The SAVE button allows the user to save the guide rate errors, FWHM and magnitude estimates of the guide star to a file during guiding. The

**SAVE** button will turn green when activated and produce a pop-up window requesting a file name into which to record the data. To switch off saving click on **SAVE** once more and it will turn red to show that saving is not activated. New data is appended to already existing files. The A/G camera is not a science grade camera and therefore these estimates should only be used for indication purposes only. Furthermore, all values are estimates and have not been calibrated.

- The **ExpTime** button reveals a pull-down menu with several exposure times in seconds. Once one is selected, the A/G camera will repeatedly expose and readout to the image display area. Next to the **ExpTime** button is a user input area where an exposure time can be entered via the keyboard. The new exposure time will be applied once the current image has been read out and displayed. Next to the input area is a display area which counts down the exposure time.
- The **STOP** button stops the exposures. The current image will be read out and displayed. The **STOP** button turns red when the A/G camera is not exposing and dark cyan when it is exposing.
- The **WINDOW** button is a pull-down menu allowing the user to reduce the area of the CCD in use, thus reducing the readout time. Options available are “*Full Frame*”, “*256X256*”, “*218x128*” and “*64x64*”. 64x64 pixels can be used while guiding with the guide star centred on the image. The display should be set to Full frame for acquisition.
- The **GUIDE** button is used to start and stop guiding on a star. Guiding will only start if the user has selected a star on which to guide on. See the “Pointer” section below. If a star has been selected and it is possible to guide, guiding will start and the **GUIDE** button will turn green. It turns red if guiding is lost or stopped. Guide rate errors, FWHM and magnitude estimate of the guide star are posted to the Exposures & Guiding message box and are saved to a user specified file if the **SAVE** option has been activated.

#### 0.7.4 Guide Mirror

The **GUIDE MIRROR** button displays the current status of the guide mirror. The status can be changed between either IN BEAM or OUT OF BEAM by clicking on the **GUIDE MIRROR** button. If the guide mirror is moving it is reported by the button, which will remain deactivated until the requested state has been reached. During normal observing the guide mirror should be

green indicating that the mirror is out of the beam and allowing light from the target through to the science instrument.



Figure 16: The `GUIDE MIRROR` button also acts as a status flag.

### 0.7.5 XY Slides Control

XY slide operations are performed using the buttons in the lower right panel:

- `Initialize` allows the user to initialize the XY slides, i.e. force the XY slides to locate the 'real' centre. If no offset values (see below) have been set then the centre will have the coordinates  $X=0, Y=0$ . If offset coordinates have been set to anything other than 0,0 then the `GOTO` button needs to be used to send the XY slides to the user defined 0,0 position.

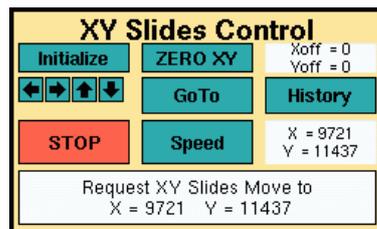


Figure 17: The “XY Slides Control” panel.

The `Initialize` button turns red when the telescope power has been turned off or communications have been lost to the PLC. Once power or communications are restored, the button remains red until it has been pressed, thus initializing the XY slides and turning dark cyan. The XY slides will operate without initialization, however the XY coordinates will probably be incorrect.

- Clicking on an **arrow** button below  will send the XY slides in the indicated direction. It is possible to move in X and Y at the same time and change direction at any time without stopping first.
- Use the  button to stop the XY slides moving. They will also stop once they hit a software limit. If the XY slides have not been initialized, they may go beyond the software limits and hit a hardware limit. If this happens, the XY slides have to be “backed off” from the hardware limit by pressing the **XY SLIDE RESET** button located above the emergency stop button on the observing floor. It is then necessary to press the  button on the TCS GUI to recentre the XY slides.
- The  button allows the user to alter the X and Y offset values, therefore relocating X=0 and Y=0. This is very useful as it allows the user to set X=0, Y=0 with the center of the **science instrument**. This is achieved by first centering the target in the science instrument. Then view the target in the A/G camera by putting the guide mirror into the beam. Next move the XY slides (use the  button - see Pointers section) so that the target is centered on the A/G screen. Finally press  to define the current XY slide position as X=0, Y=0. This process is essential for finding guide stars, using the guide star software (see below) when the science instrument and A/G camera have a large misalignment.
- The **X and Y offset values** are reported in the top right of the XY Slides Control panel, whilst the **X and Y coordinates** are reported in the bottom right of the XY Slides Control panel. When the XY slides are moving this box turns red and the XY coordinates are continually updated.
- The  button allows the user to enter X and Y coordinates to which the XY slides must be moved, i.e. the XY slide coordinates of the guide star. The speed of XY slide movement can also be set. The TCS will check that the values entered are within the software limits.
- The  button can be used to display a history of XY slide positions. It can be dismissed by clicking on the  button. The XY Slides Control will remain hidden until the history display has been dismissed.
- The  button allows the user to set the speed of the XY slide motion. This must be in the range 0-3000. **100-200 are recom-**

**mended speeds for scanning for guide stars.** Higher speeds (> 1000) are recommended if using the `GOTO` button to go to known XY coordinates of guide stars.

- Messages and errors pertaining to the functioning of the XY slides are reported in the XY Slides Control panel message box.

### 0.7.6 Camera Focus

This panel allows the user to change the focus of the A/G camera and consists of the following features:

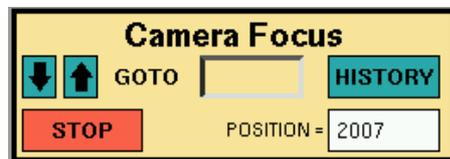


Figure 18: The A/G “Camera Focus” panel. The telescope should be focussed using the science detector before adjusting the A/G camera focus.

- **Arrow buttons**, which change the focus in the directions indicated
- A **user input area**, which can be used to specify a focus position by entering a value and pressing `ENTER` on the keyboard.
- The “**Position=**” box, displaying the current position of the A/G focus. This box turns red when the A/G focus camera motor is on and the focus is changing.
- A `STOP` button, which can be pressed at any time to stop the camera focus motor. The focus motor will also stop moving if a hardware limit is reached. It is then only possible to move the A/G camera focus in a direction away from the hardware limit. The “Position=” box will remain displaying “LIMIT+” or “LIMIT-” for a few seconds after reaching a hardware limit, due to hysteresis in the hardware switches.
- A `HISTORY` button, which reveals a history of the A/G camera focus settings. This will obscure the camera focus area until the `DISMISS` button has been clicked.

Note the following:

- Upon starting the TCS, the A/G **focus buttons will not work the first time**. This problem is fixed by sending any other command eg initialize the XY slides. The problem is then fixed.
- The focus position is not absolute, but relative. The camera focus position may change due to temperature, etc. Therefore, **the reported position can change over time and accumulate a large error**.
- The camera focus motor is finely geared, thus **requiring a large change in focus reading to produce a noticeable change in focus**.
- **Do not use the A/G camera to focus the telescope**. The telescope should first be focused on the science instrument before focussing the A/G camera.

### 0.7.7 Pointer

This panel is used to activate mouse pointer functions on the image display area. If all four buttons are grey then clicking the mouse pointer on the image display area will do nothing. Only one button can be activated at any one time. Thus clicking on one will deactivate an already active button. The Pointer buttons work in the following ways:



Figure 19: The “Pointer” panel facilitates operations that involve clicking on the image display area.

- Upon clicking the Guide Star button it will turn green to indicate that this function is active. Clicking the mouse pointer on the image tells the TCS to find a guide star on or near the selected pixel. If

the TCS finds an appropriate star, a small blue square will appear on the star and will remain fixed in the image display area, signifying a guide point. If the **GUIDE** button is now pressed in the “Exposures & Guiding” area, guiding will commence on the selected star. While guiding, the TCS will draw a light blue square around the guide star. When guiding well, the light blue box is approximately coincident with the dark blue guide point box. If the guide star is lost during guiding, guiding will stop and the ‘GUIDE’ box will turn red.

- Clicking the **Markers** button reveals a pull-down menu with options allowing the user to place, move and remove a red marker on the image. This is useful for marking a particular point on the A/G image corresponding to the desired location for a star on the science CCD. Up to 10 red markers can be drawn. The markers serve only as labels and have no effect on guiding or any other aspect of the TCS. These buttons are activated and turn green when clicked, and the selected operation (e.g. adding a red marker) will be performed when the mouse pointer is clicked somewhere on the image display, i.e.:
  - **Add a Red Marker:** click the button, then click the desired marker position on the image display. A red square will appear over this position and remain there until removed. It is advisable to make a note of the marker coordinates as the marker will disappear if the TCS is reset.
  - **Move a Red Marker:** click the button, click on the red marker to be moved, then click the new location for the marker. The red box will move with the mouse pointer.
  - **Remove a Red Marker:** click the button, then click on the marker to be removed, which will then disappear.
  - **Remove all Red Markers:** click the button; does exactly what is says on the tin.
- On clicking the **Move XY** button and subsequently clicking on a point in the image display area, the XY slides move such that the clicked region will move to the centre of the image display. This is useful for moving a possible guide star to the centre of the image display area.
- The **XY+Win+G** button is used to initiate guiding once a potential guide star has been located. First click on the button, then place the pointer over the preferred guide star on the image area and click the left mouse button. The TCS will then move the XY slides such that the

star appears in the centre of the image area; the window will shrink to its smallest size and guiding will begin on the now centred guide star.

## 0.8 Guide stars

In order to use the autoguider, the user must enter the XY slide positions of a suitable star into the TCS. The easiest way to find a guide star is to use Steve Potter's "hacked" DS9 program.

### 0.8.1 Running the guiders program

1. Open an xterm on s40
2. Type `cd /data/ccd/guiders`
3. Type `source runit`

You will then be presented with the usual DS9 interface with an example field already loaded and a green circle representing the boundary outside which you may search for guide stars. The circle has a radius of about 7500 XY slide units. The information display area gives the RA and DEC at the location of the mouse on the image, and most importantly it also gives the XY slides coordinates of any point on the image.

### 0.8.2 Loading the required field

To load your required field, do the following:

1. Click on the  option on the top right of the DS9 interface.
2. Select **DSS Server** about half way down the pull-down menu. This will open another window, the DSS Server.
3. Enter the RA and DEC of your target into the DSS Server window, and check the following (which should all be defaults):
  - **Units of RA and Dec must be separated by colons**, see Fig. 5.
  - **Current frame** must be selected in the "Prefs" menu.
  - **Width and Height** must each be set to 10 arcmin (to 1dp).

- **Regions** must be selected under the “Preserve During Load” menu.
4. Finally, click `Retrieve`.
  5. **If an error occurs**, select an alternative server from the pull-down “DSS Server” menu in the DSS Server coordinates window.

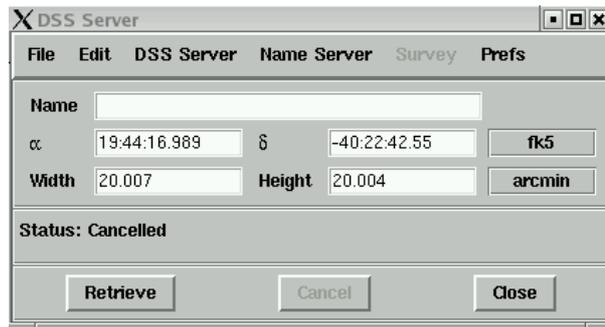


Figure 20: The DSS Server coordinate input box on s40. The width and height should both be set to 20 arcmin. Note the use of colons.

### 0.8.3 Selecting a guide star

After a short wait, your requested field will be displayed centred on your target.

1. Put the mouse over a possible guide star outside the green circle and read its XY slide coordinates from the information panel above the image. A suitable star will have coordinates of  $-13000 < XY < +13000$ .
2. Click `GOTO` on the XY Slides Control area of the TCS GUI and enter the XY slides coordinates into the appropriate boxes.

Note the following:

- **The XY coordinates given by DS9 are calculated assuming that the science target is centered both on the science instrument and the A/G camera.** This is achieved by using the `ZERO XY` button (see above).

- For some instruments (e.g. the UCT CCD), when you have centred your target on the instrument it may not necessarily be centered on the A/G CCD but instead is slightly off the screen. In such instances, when you  a guide star it will also appear slightly off the screen. Use the  button in the “Pointer” panel to move the XY slides to the off screen position. This offset can be zeroed by using the  button (see above).
- The guide star image should be strong, at least 2 times the background if possible, but unsaturated. Brighter stars are necessary under poor conditions. Faint stars can be used for guiding but integration times longer than 4 or 5 seconds are needed should be avoided
- **When the telescope is reversed** (West of the pier), the XY coordinates require a change of sign.
- New fields can be loaded by simply editing the RA and DEC in the DSS server window.
- All the other resources offered by DS9 are available via the menus.

## 0.9 Acquisition and guiding recipes

### 0.9.1 Setting the zero points

To improve the pointing, telescope offsets in RA and Dec can be determined and new zero points applied to the pointing. Different zero points will be required in different parts of the sky. This recipe describes how to determine the zero points.

1. Click  in “XY Slides Control”.
2. Using the Astronomical Almanac or Sutherland Almanac, select a bright star near your science target.
3. Type in the “COORDINATE EQUINOX” of the bright star coordinates and press ENTER on the keyboard.
4. With  in beam, slew to and acquire the bright star.
5. With  set to “Full Frame” and   $\approx 0.05$  s in “Exposures & Guiding”, place the bright star in the centre of the image display area.

6. Click  then  and in “Enter RA & DEC of Star” type the **catalogue coordinates** of the bright star and click .
7. The X & Y zero points will be set and displayed in the white message box. Note them down for future use in that part of the sky. These zero points will need to be re-entered in case of a TCS restart (see point 9 below).
8. **Ensure that the COORDINATE EQUINOX is set back to those of your target coordinates.**
9. **To use previously determined zero points:**  
Click  then  and select “Enter zero points directly”.

## 0.9.2 Acquiring a target

1. Click `TARGET` and input the RA & DEC; click `SET` and `CLEAR`.
2. Check that “COORDINATE EQUINOX” is set to that of your target coordinates (type it in and press ENTER on the keyboard).
3. Slew the telescope to target coordinates, which are displayed on the monitor on the observing floor.
4. Set the following on the TCS:
  - Move `GUIDE MIRROR` IN BEAM.
  - In “Exposures & Guiding” set `WINDOW` to “Full Frame” and adjust `ExpTime`
  - In “Image Options” select the preferred `LUT` and `SCALE`
  - Use the horizontal sliders to adjust the colour scale and the vertical slider to apply gamma correction until stars are easily visible
5. Identify the target star in the image display by comparing to a finder chart and making find adjustments in RA & Dec using the handset.
6. If known, place the target at the location on the image display corresponding to the desired position on the science CCD.
7. Move `GUIDE MIRROR` OUT OF BEAM to direct the beam to the science detector. Check the position of the target and adjust RA & Dec as required using the handset.
8. Once the star is well positioned on the science detector, move the `GUIDE MIRROR` into the beam. In the “Pointer” panel, select `Markers` and “Add a Red Marker”. Click on the star and a red box will appear. Placing subsequent targets in this box will position them in the correct place on the science CCD. Make a note of the red marker coordinates; all red markers will disappear in the event of a TCS restart. Move `GUIDE MIRROR` OUT OF BEAM to begin observing.

### 0.9.3 Setting up a guide star

On s40 PC:

- Open an xterm
- Type `cd /data/ccd/guiders`
- Type `source runit`

In the DS9 interface:

- From the “Analysis” pull-down menu, select “DSS Server”.
- Enter RA & Dec of target (using colons to separate coordinate units) in 20’x20’ field of view and click `RETRIEVE`.
- Once the field loads with the target in the centre, choose a relatively bright star outside the circle. Place the mouse cursor over the star and read off the XY slide coordinates.

On the TCS:

- Make sure `GUIDE MIRROR` is OUT OF BEAM.
- In “Exposures & Guiding” set `ExpTime`  $\sim 2$  s.
- In “XY Slides Control”, click `Go To` and enter X and Y slide coordinates of chosen guide star.
- In “Pointers” click `XY+Win+G` then click the chosen guide star. This will centre the guide star on the image, window the chip and begin guiding.
- To stop or restart guiding (e.g. after brief intervals of cloud), press `GUIDE`

At the end of an observation:

- Click `Initialize` in “XY Slides Control”.
- In “Exposures & Guiding” set `WINDOW` to “Full Frame”.
- Move `GUIDE MIRROR` into beam to acquire next target.

At the end of the night:

- In “XY Slides Control”, click  to cease A/G camera integrations.
- In “XY Slides Control”, click  to reset XY slides.