

1.9-m Telescope Control Software

A User's Guide

Version 10.2

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0.1 Introduction

This manual describes the use of the Telescope Control Software (TCS) for acquisition and autoguiding using the 1.9-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 μm with a peak around 0.7 μm . 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 telescope (except for slewing); the acquisition and guiding (A/G) camera; and the dome (including opening and closing of the shutters and control of the windblind, as of December 2009).

0.2 Todos and not todos

Although there are automatic switches to prevent the telescope overshooting safe limits in RA and Dec, **it is still possible to crash the telescope tube into the Newtonian carriage and the dome shutters, 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 SLOW before switching off the telescope power.** If not set to SLOW, **the telescope will swing down and crash** when the power is switched off. The telescope power switch is located just outside the warm room door at the top of the staircase.
- **Keep the slow motion drive switched off when not observing and telescope power is on.** This is to prevent the telescope from tracking. The SMD switch is on the electronics rack located in the warm room, next to the door leading to the dome floor.
- **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, except for the HA-Dec live plot and the guiders program.** 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 you will be presented with an empty screen. Right-click on the background and select **TCS Menu** → **START TCS74**.

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 from the menu by right-clicking on the background. This should only be used to transfer (e.g. by ftp) any saved data files (TCS data, not science data - this not relevant to typical observing).
- 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.

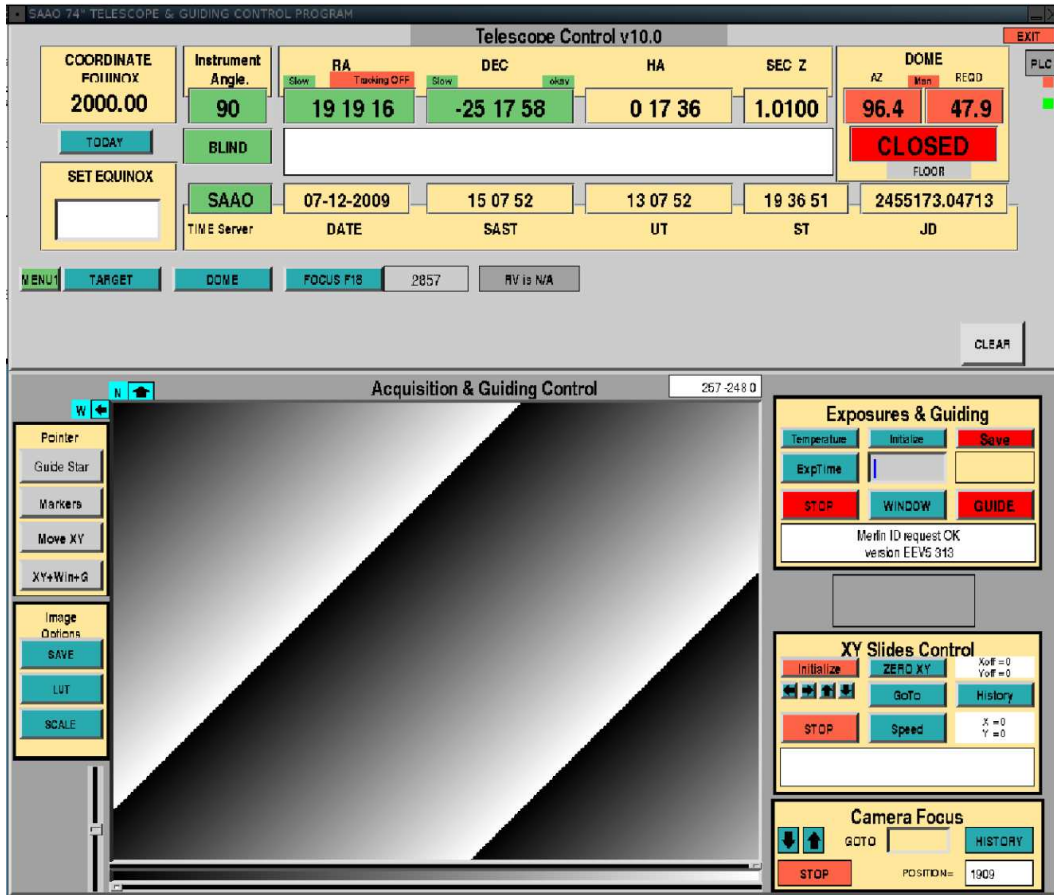


Figure 1: The TCS user interface.

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:

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

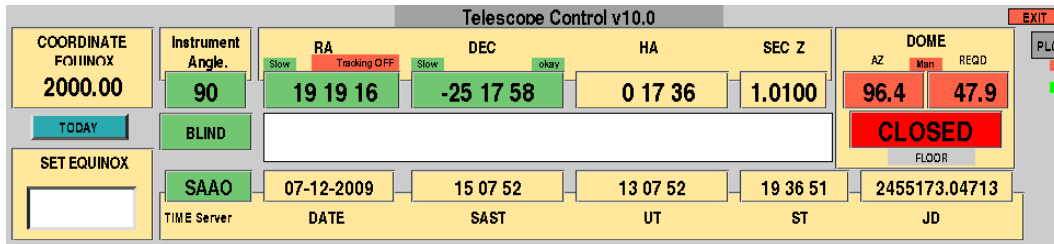


Figure 2: The TCS position and status display. Messages and warnings are displayed in the central white box.

a value into the SET EQUINOX box and pressing ENTER on the TCS PC keyboard.

0.4.2 Instrument angle

The instrument can be rotated on the telescope with the assistance of a technician. During normal operations with the instrument in the default position, the **Instrument Angle** is reported as 90 degrees. The box is green when the instrument is stationary and turns red during rotation. The A/G camera functions at any instrument angle, providing that the correct angle is indicated in this box. If you have not intentionally rotated the instrument and the TCS reports an instrument angle not equal to 90, the acquisition camera will not function correctly. Call a technician to remedy this.

0.4.3 Wind blind

The **BLIND** box below the Instrument Angle indicator shows the status of the wind blind: red indicates movement and green means it is stationary. The wind blind can be operated from the DOME pull-down menu (see Section 0.5).

0.4.4 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 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.

0.4.5 Dome status

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

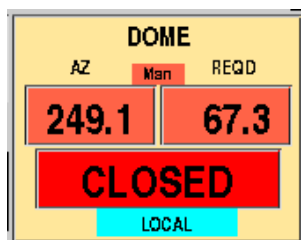


Figure 3: The dome status panel.

- 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.
- The **dome shutter status**, whether OPEN (green), CLOSED (red), PART OPEN (red) or MOVING (red), i.e. opening or closing.
- A **shutter control status flag** indicating whether control of the dome shutters and wind blind is LOCAL (cyan), i.e. can be operated via the TCS software, or FLOOR (grey), which means the panel by the North pier on the observing floor has control. To control the shutters and blind from the observing FLOOR, press the red “Request Local Control” button on the grey panel on the North pier. LOCAL (TCS) control can be gained using the pull-down **DOME** menu (see next section).

0.4.6 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.

0.4.7 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.

0.4.8 EXIT

Pressing on the EXIT 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 MENU 1 / MENU 2 button to toggle between menus.



Figure 4: The TCS Operations panel ‘MENU 1’.

MENU 1 consists of three operations buttons: **TARGET**, **DOME** and **FOCUS**. Clicking on one of these buttons will deactivate the other two until the **CLEAR** 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 operate the dome, shutters, wind blind and some of the lights from the TCS using the following options:

- If the shutter status control flag reads FLOOR, first select “*Request Local Control*” at the bottom of the dome pull-down menu. The flag will turn cyan and allow control of the shutter and wind blind from the TCS.
- Three dome shutter operations can be performed from this menu: “*Shutters OPEN*”, “*Shutters CLOSE*” and “*Shutters STOP*”. To open or close the dome, click once on the appropriate option. The motors will stop when fully open or closed. The shutter movement can be stopped part-way by selecting “*Shutters STOP*”.
- The wind blind can be raised or lowered using the “*Blind RAISE*” and “*Blind LOWER*” options. The wind blind will continue to move in the requested direction until the user selects the “*Blind STOP*” option.
- The top ring of fluorescent lights in the dome can be operated using the “*Lights ON*” and “*Lights OFF*” options. Note that there is a second, lower ring of fluorescent lights (the switch is in the right-hand side of the circuit breaker cabinet on the West wall of the observing floor), and a ring of incandescents (switch behind the North pier by the grating room door), which cannot be controlled from the TCS.

- The dome can be rotated to a given azimuth using the “*Move*” option. This option 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. The telescope will collide with the Newtonian carriage or part of the wind blind mechanism in some circumstances.

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. The mirror is not in use when the spectrograph is mounted, so this button will be disabled and give the message **RV is N/A**.

0.6 Parameter Panel

MENU 2, the Parameter Panel, consists of buttons that allow the user to change various operational parameters. **MENU 2** can be accessed by clicking on the **MENU 1** button, and vice versa. 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 5: The TCS Parameter panel ‘MENU 2’.

0.6.1 **SET REVERSE**

This function has been disabled. Its purpose was to allow the user to tell the TCS which side of the pier the telescope was mounted, to ensure correct functioning of the autoguider. Following the accident in late 2006, the telescope is always on the east side of the polar axis.

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.

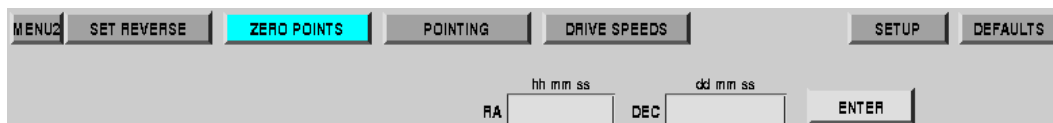


Figure 6: **ZERO POINTS** → “Enter RA & Dec of Star”.

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 by selecting “**Enter Zeros Directly**”. Three input boxes appear, showing the current settings of the RA and DEC zero points and the collimation coefficient. Any input into the collimation coefficient box will be ignored, but the RA and Dec can be edited and then set by clicking **ENTER**. The default values can be restored by selecting the **DEFAULTS** button, see below.

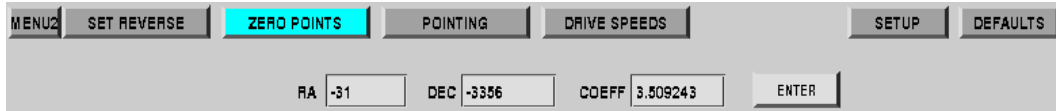


Figure 7: **ZERO POINTS** → “Enter Zeros Directly”.

0.6.3 **POINTING**

The option to switch the **POINTING** model on/off has been disabled.

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 8: 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.

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 **DOMES** zero points will be reset to their

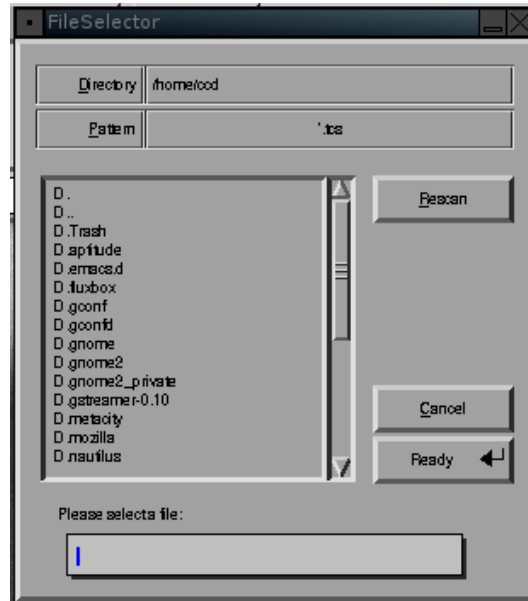


Figure 9: Parameters can be set using a **SETUP** file.

respective default values. Clicking **DISPLAY DEFAULTS** will display the defaults but NOT set them.



Figure 10: 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.

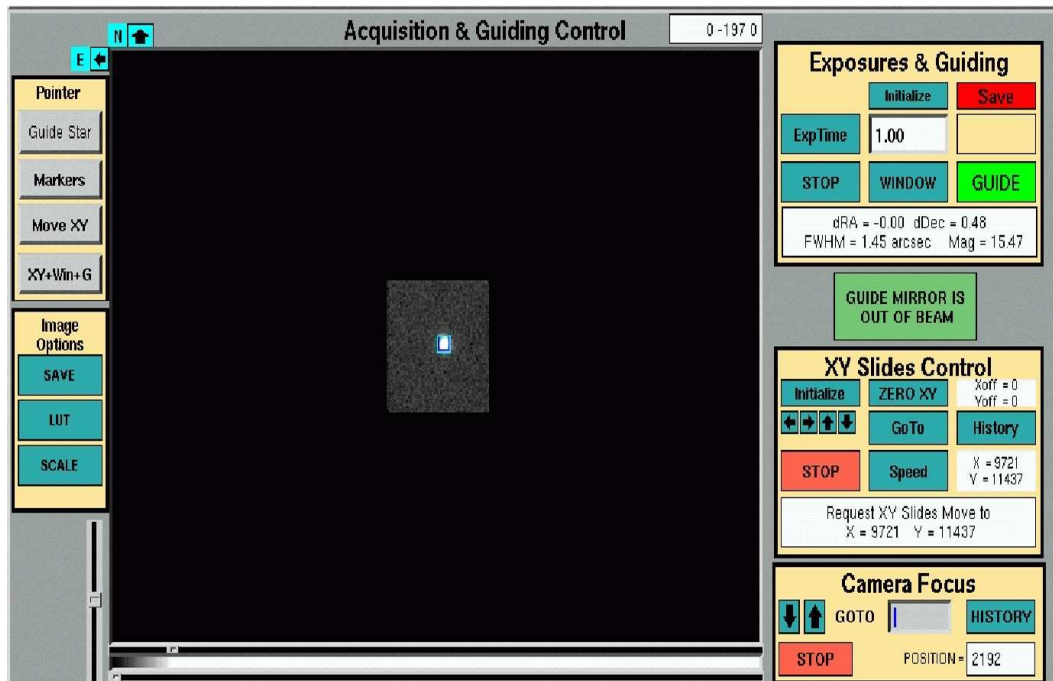


Figure 11: The image display area as seen while guiding.

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 12: 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.

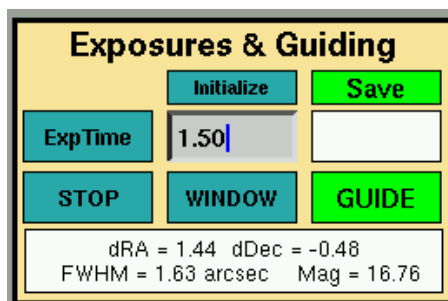


Figure 13: The “Exposures & Guiding” panel.

- 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 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 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 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 button stops the exposures. The current image will be read out and displayed. The button turns red when the A/G camera is not exposing and dark cyan when it is exposing.
- The 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 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 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 option has been activated.

0.7.4 Guide Mirror

The 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 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. **The button is deactivated when the spectrograph is in use.** The guide mirror is then operated from the spectrograph control panel.

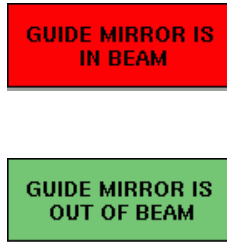


Figure 14: The `GUIDE MIRROR` button also acts as a status flag.

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.

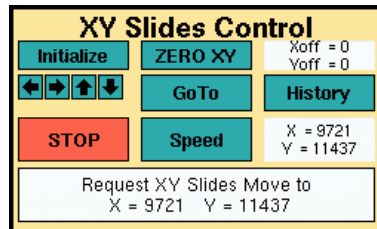


Figure 15: The “XY Slides Control” panel.

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 `Initialize` 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 **STOP** 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 **Initialize** button on the TCS GUI to recentre the XY slides.
- The **ZERO XY** 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 **MOVE XY** button - see Pointers section) so that the target is centered on the A/G screen. Finally press **ZERO XY** 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 offset.
- 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 **GoTo GS** button sends the XY-slides to the position of a guide star that is clicked upon in the DSS image - i.e. semi-automated guide star acquisition.
- The **GoTo** 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 **HISTORY** button can be used to display a history of XY slide positions. It can be dismissed by clicking on the **DISMISS** button. The XY Slides Control will remain hidden until the history display has been dismissed.
- The **SPEED** 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 16: 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, e.g. 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 17: 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 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 HA-Dec live plot

There is an add-on programme to the TCS that plots the position of the telescope over the past 30 mins and displays it within the permitted observing envelope. This software is started by right-clicking on the blank background of the TCS and selecting “START HA-DEC Live Plot”.

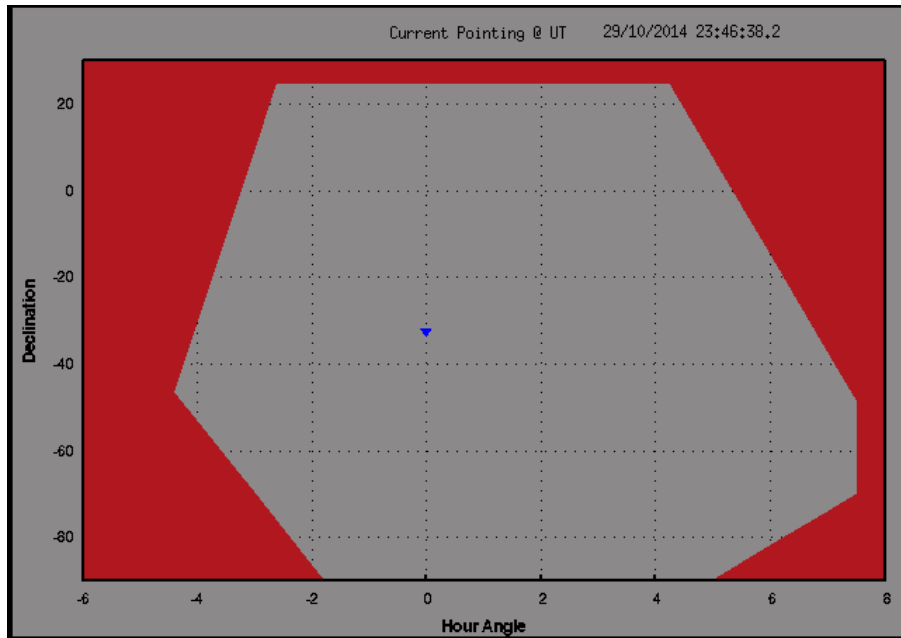


Figure 18: TCS add-on software to show telescope position (blue triangle) within the telescope’s feasible observing envelope (grey area). Physical obstructions enforce the telescope limits (red). When the telescope is in use, the past half hour’s tracking or slewing motion is shown in green dots.

0.9 New guide star software

As of October 2014, the guide star location programme has been incorporated into the TCS, so it is no longer necessary to run the guiders software from

Itsp, or to type the required XY-slide coordinates into the TCS manually.

To find a guide star:

1. If you do not see a DSS image window and “DSS Server” coordinates box on the TCS monitor, right-click with the mouse on an empty part of desktop to bring up a drop-down menu.
2. Select “START NEW Guiders Software”, and two windows will appear.
3. In the “DSS Server” window, type the RA and dec (J2000.0) of the centre of the FOV of interest (use colon delimiters, i.e. HH:MM:SS). Click . A 10x10 arcmin image of your field will appear in the larger window.
4. Place the cursor over a potential guide star (a relatively bright star outside the green circle in the DSS image), and left click with the mouse. This will pass the XY-slide coordinates of the desired guide star to the TCS, no need to type them in.
5. Ensure that the acquisition camera is exposing (select an exposure time from the pull down menu in the “Exposures & Guiding” area).
6. In the “XY Slides Control” panel of the TCS, press the button to move the XY-slides to the location of the guide star.
7. In “Pointers” click then click on the chosen guide star in the acquisition camera image. This will centre the guide star on the image, window the chip and begin guiding. If you do not wish to window the CCD, click then click on the guide star to centre it, then click .
8. To stop or restart guiding (e.g. after cloud brief intervals of cloud), press .

Note the following:

- **The XY coordinates obtained from the DSS image 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 button (see above).

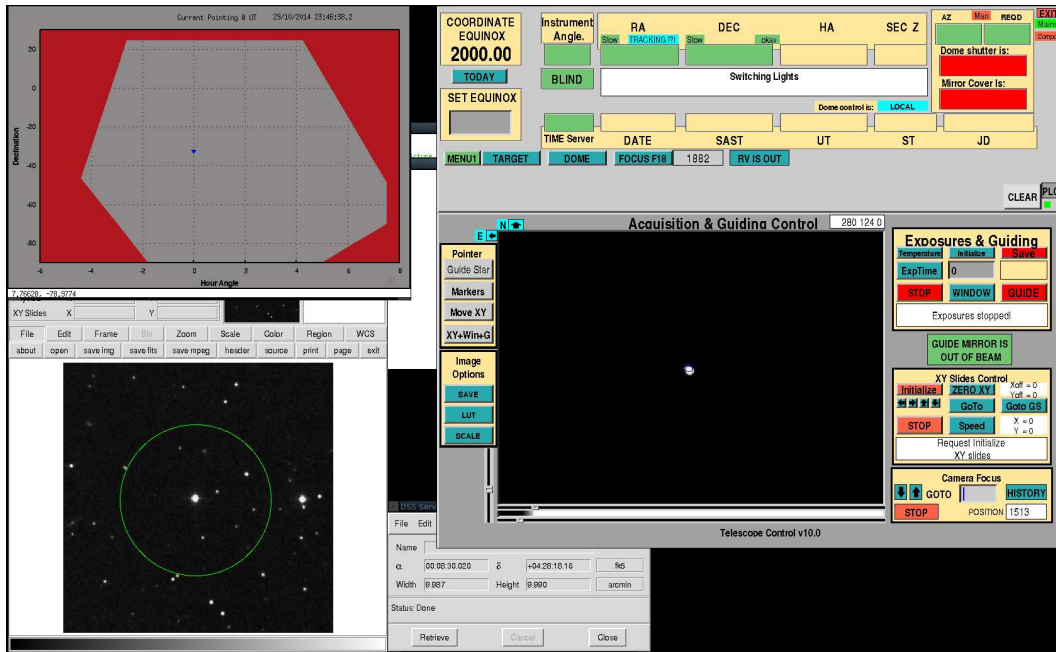


Figure 19: The TCS, showing the DSS image-based guiders program, adapted to communicate the XY-slide coordinates to the TCS. The width and height in the DSS Server window should both be set to 10 arcmin. Note the use of colons.

- For some instruments, 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 **GOTO GS** it will also appear slightly off the screen. Use the **MOVE XY** button in the “Pointer” panel to move the XY slides to the off-screen position. This offset can be zeroed by using the **ZERO XY** 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.
- **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.

0.10 Acquisition and guiding recipes

0.10.1 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 `Initialize` 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 `GUIDE MIRROR` in beam, slew to and acquire the bright star.
5. With `WINDOW` set to “Full Frame” and `ExpTime` ≈ 0.05 s in “Exposures & Guiding”, place the bright star in the centre of the image display area.
6. Click `MENU 1` then `ZERO POINTS` and in “Enter RA & DEC of Star” type the **catalogue coordinates** of the bright star and click `ENTER`.
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 `MENU 1` then `ZERO POINTS` and select “Enter zero points directly”. Do not enter anything into the collimation coefficient box as it will be ignored.

0.10.2 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. When doing spectroscopy, the guide mirror is moved into the beam by pushing either the “Towards” or “Away” button in for ~ 10 s on the Spectrograph Control Panel. The mirror can be seen moving across the image display area. The other button will then move the mirror back out of the beam. When “Centred” is illuminated it indicates the guide mirror is OUT OF 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 and check the position of the target and adjust RA & Dec as necessary 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 for observing.

0.10.3 Setting up a guide star

On the TCS:

- Make sure `GUIDE MIRROR` is OUT OF BEAM.
- In “Exposures & Guiding” set `ExpTime` ~ 2 s.
- In “DSS Server” window, enter J2000 RA & Dec of target object (using colons to separate coordinate units) in 10'x10' 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 left-click.
- Click `Goto GS` and watch guide star appear in acquisition camera FOV.
- In “Pointer” click `XY+Win+G`, then click on the chosen guide star in the acquisition camera FOV. 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 `STOP` to cease A/G camera integrations.
- In “XY Slides Control”, click `Initialize` to reset XY slides.