Standard Operating Procedure

Auto Guiding Unit (AGU)

Authors	
	Name
Prepared by	Geeta Rangwal Ashish Devaraj
Approved by	—- —

Change records		
Issue	**Date**	**Remarks**
1	20 January 2025	Draft issue
2	25 January 2025	Revised (information about offsets included)
3	04 April 2025	Revised the method of setting the guiding star and included the method for removing the guider offsets.

Scope

This document provides the standard operating procedure for performing observations in closed-loop guiding using the Auto Guiding Unit mounted on the 3.6m Devasthal Optical Telescope.

Contents

1 Basic parameters of the Instrument

AGU parameters	
Parameter	**Values**
Mount position	Above the focal plane of the telescope
Detector	Kodak KAF-0402ME
Array size	768×512 pixel^2
Pixel size	9×9 μm^2
Digital resolution	16 bits
Bus	USB2.0/Fiber
Cooling	TE
Stable temperature	-20^{o}C
Mean QE	75%
Readout noise	15 e$^-$
Dark current at 0^{o}C	1e$^-$/pixel/s.
Field of view	1'55" × 1'17"
Minimum exposure time	1s
Limiting magnitude	V~ 12
Alloted area in the telescope field of view	Annulus having radii of 15.5' and 17.5' from the center.
Guiding star position for TANSPEC	Between 5' to 17.3' from source
Guiding star position for TIRCAM2	Between 3' to 17.3' from source
Guiding star position for SPIM	Between 10' to 17.3' from source
Guiding star position for IMAGER	Between 10' to 17.3' from source
Guiding star position for ADFOSC	Between 15' to 17.3' from source

2 Introduction

The Auto Guiding unit (AGU) of 3.6m Devasthal optical telescope is mounted before the focal plane of the telescope. It consists of four optical components:

1. Pick off mirror and folding mirror (POM and Fold POM) to send light towards the guider and Wavefront sensor (WFS).
2. The guider for tracking and acquisition.
3. The WFS for M1 active optic control.
4. The beam splitter to share beam the guider and WFS.

The two rotational movements make the selection of a guide star with the help of the adaptor and turn table, which moves the pickoff mirror in the telescope field of view (FOV). A translation table is located under the guider, and WFS enables the adjustment of the focus of these devices wrt the telescope focus.

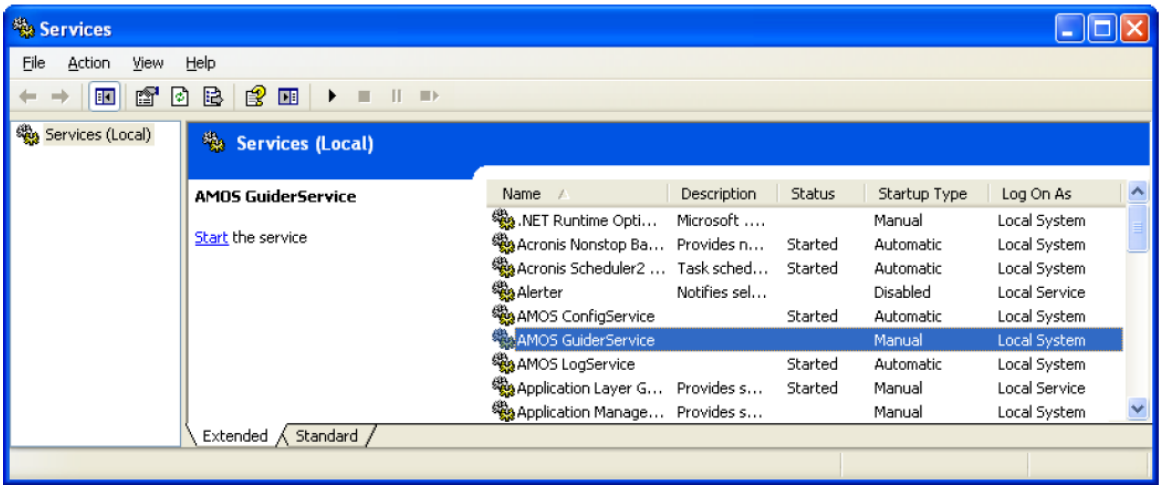


Figure 1: The administrative tool to start the guider services.

3 Prepation before the scheduled observations

- Load the desired pointing model in TCS according to the instrument used for the observation.
- Check the "collimation offsets" in the "Target Data" section of TCS. If there are large offsets from the guider, then go to the "AGU" section of the "engineering" panel and click "clear corrections" to remove them.
- Open the GUI of AGU, which is in the AOS computer. If it shows any error, then check if the guider service has been started or not. Go to the control panel –> Administrative Tools –> Services to check this. Check if AMOS Guider Service is started; if not, click "Start the service" as shown in Fig. 1.
- The AGU screen after launching the GUI is shown in Fig. 2. After opening the GUI the AGU will be connected, this can be checked by the green light in TCS for AGU.
- Now check if the camera and TCS are connected, which can be indicated by the green lights on the left side in AGU as shown in Fig. 2. Check the temperature of CCD, and it should be -20^{o}C.
- Create a blank csv file in /: $c/GuiderFiles/Aries/Logs/$. There is no specific format for this, but we will make it like "YYYMMDD.csv".
- In the AGU GUI, open "Calibration Mode" and click "Radiometric calibrations" as shown in Fig. 3. As seen in this figure, several options are available for these corrections. Select the desired corrections. Currently, we will use "Dark Field and Flat Field". The guiding should be done within an exposure time of 1 second for TANSPEC and 2 seconds for ADFOSC, so select the dark and flat image of the same exposure here.
- Now go to the "Centroids Logging" and load the CSV file created in the logs folder as shown in Fig. 4.

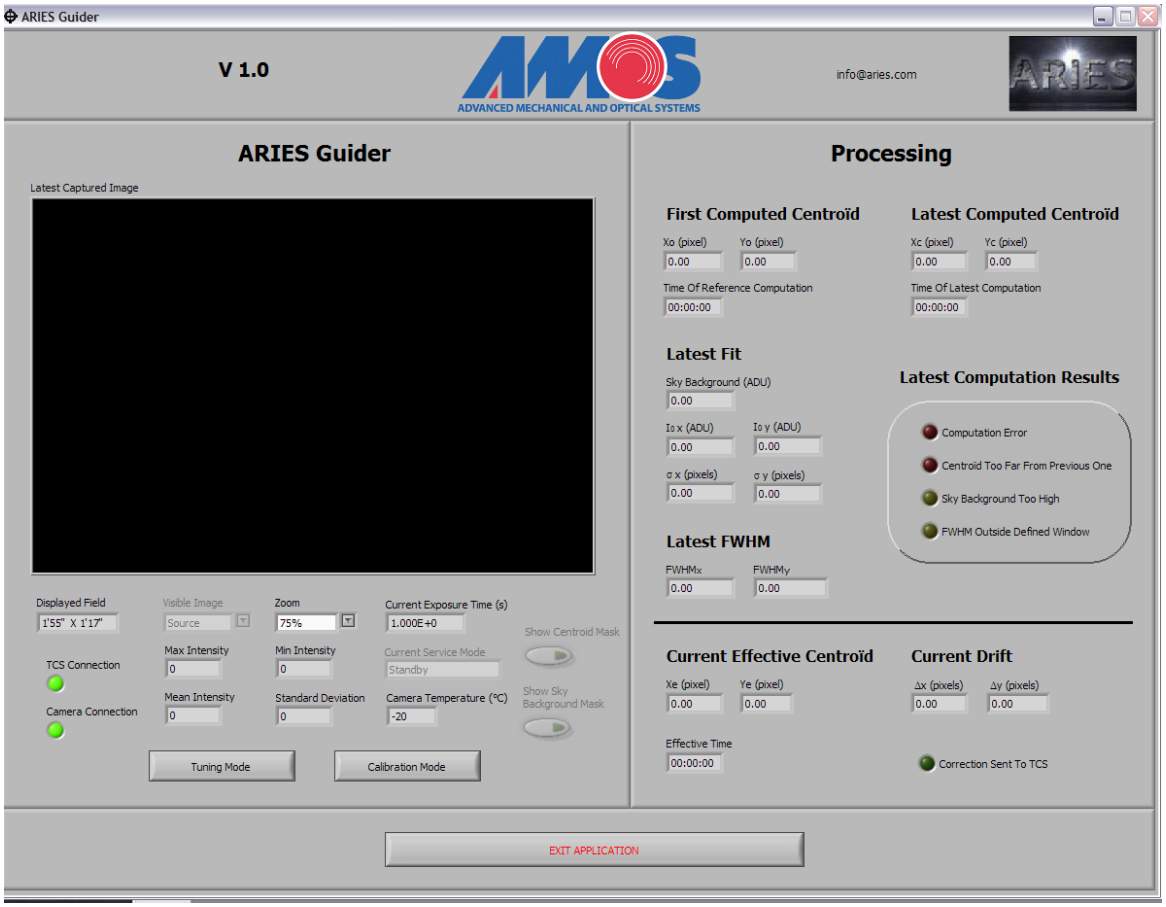


Figure 2: The screen of AGU is shown here after launching the GUI.

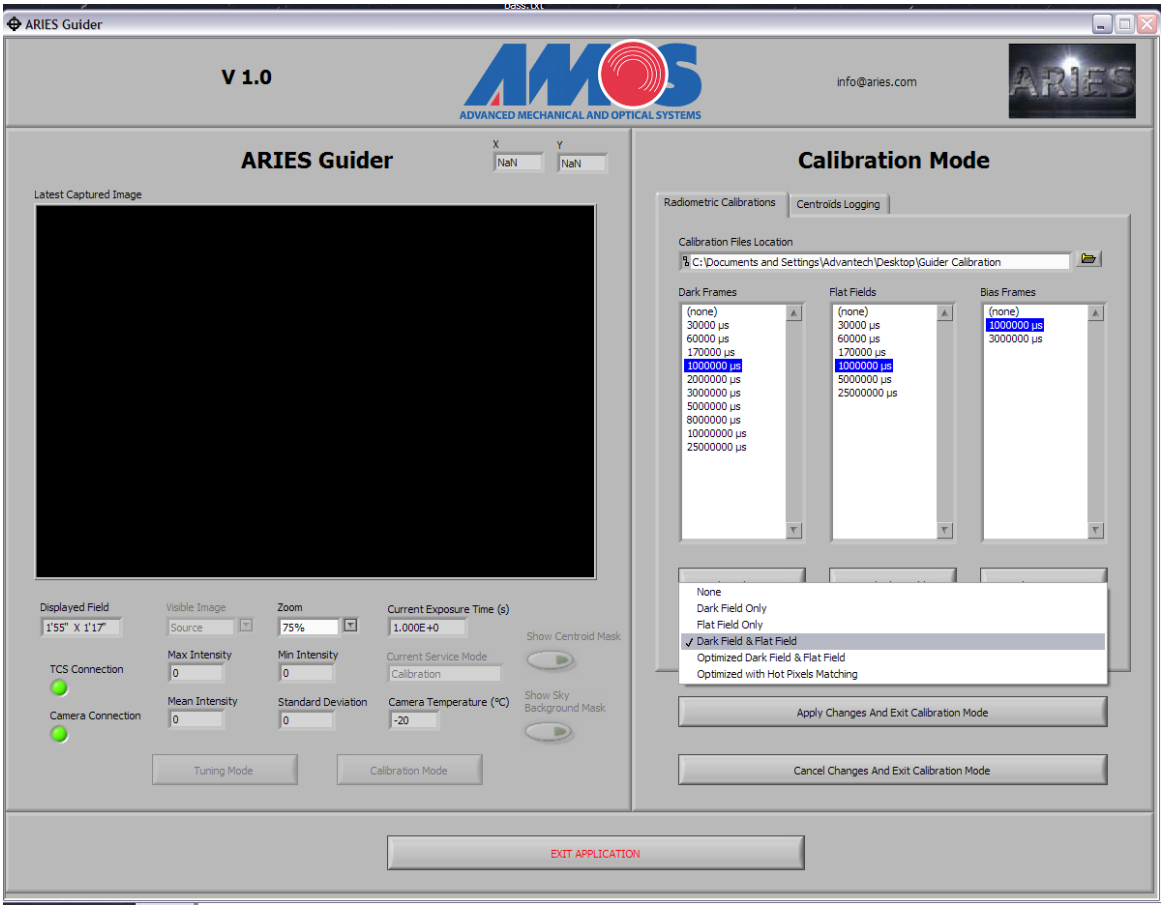


Figure 3: The radiometric calibrations can be made in the calibration mode.

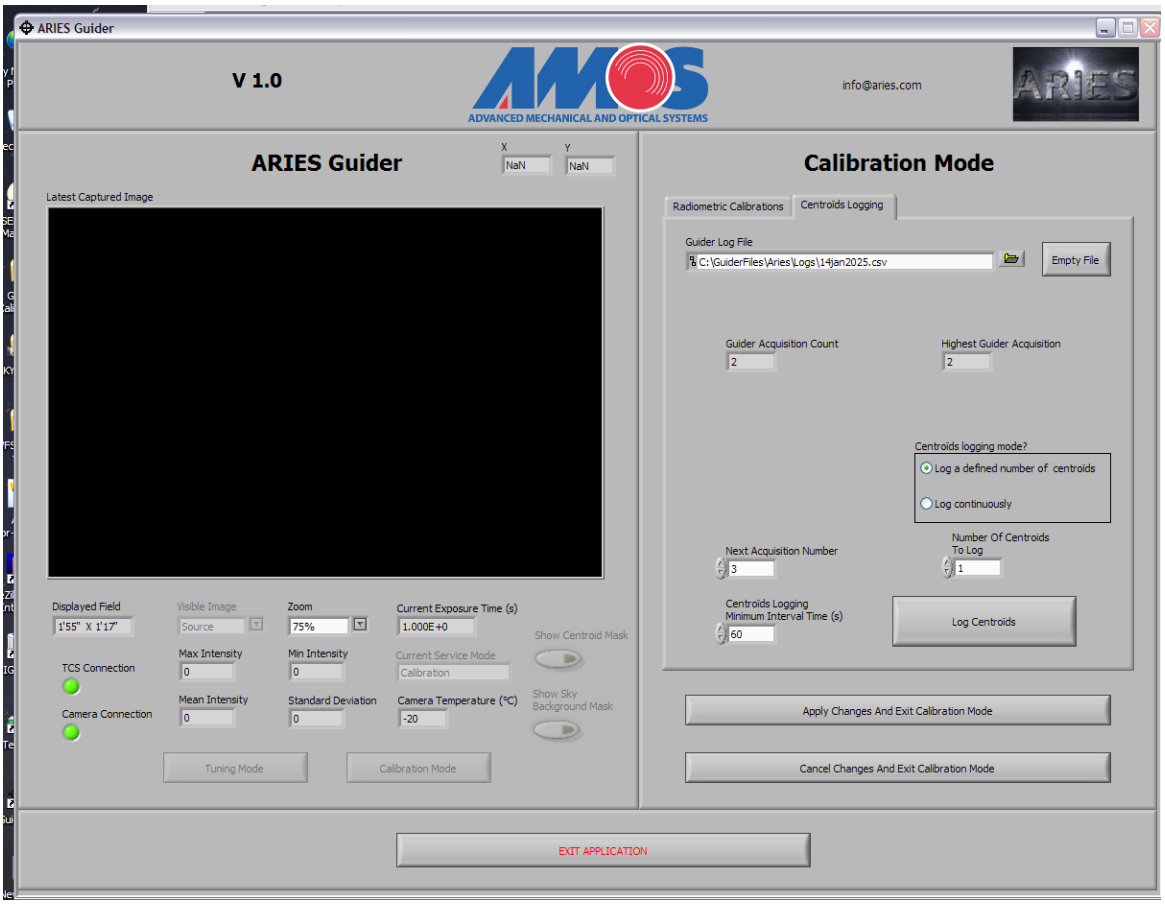


Figure 4: The csv file for centroid logging can be uploaded here.

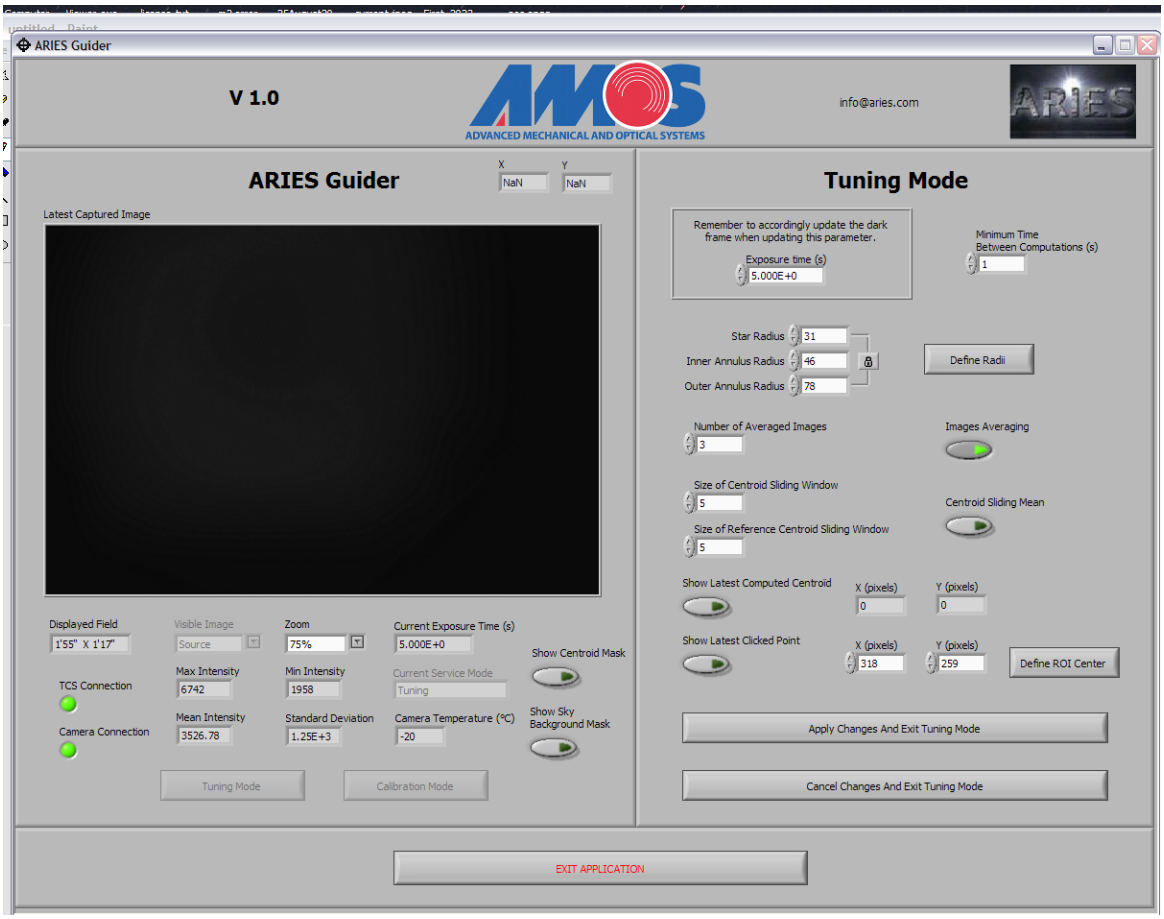


Figure 5: The tuning mode of the AGU can be modified from here.

- Save and exit the "Calibration Mode" by clicking "Apply changes and exit calibration mode".
- Go to "Tuning mode" as shown in Fig. 5, and give an exposure time of 5 seconds. Now turn on the "Image averaging" and give a value of 3 for "Number of Averaged images,". If the guiding star is faint ~ 12 V mag, the number of images can be increased to 5 or 6. Enter the value of "Minimum Time between computations" as 1, then exit tuning mode by saving the entries.
- Point to a bright star from TCS and expose it in the instrument to be planned for the observations. Set the focus for the instrument.
- Go to "Guider Axes" in the "Command-Panel" of TCS, give an initial offset to the "SAF" as shown in Fig. 6, and disable it. The initial focus offset values can be 25 mm, 20 mm, and 15 mm for TANSPEC, SPIM, and ADFOSC, respectively.
- To check the status of AGU, go to the "Guider Data" section in the "Data-Panel" of TCS as shown in the upper panel of Fig. 7. Select "Guider Data" from here. It will show the information about the guider as shown in the lower panel of this figure.
- Go to the "Guider" section in the "Command-Panel" of TCS as shown in the upper panel

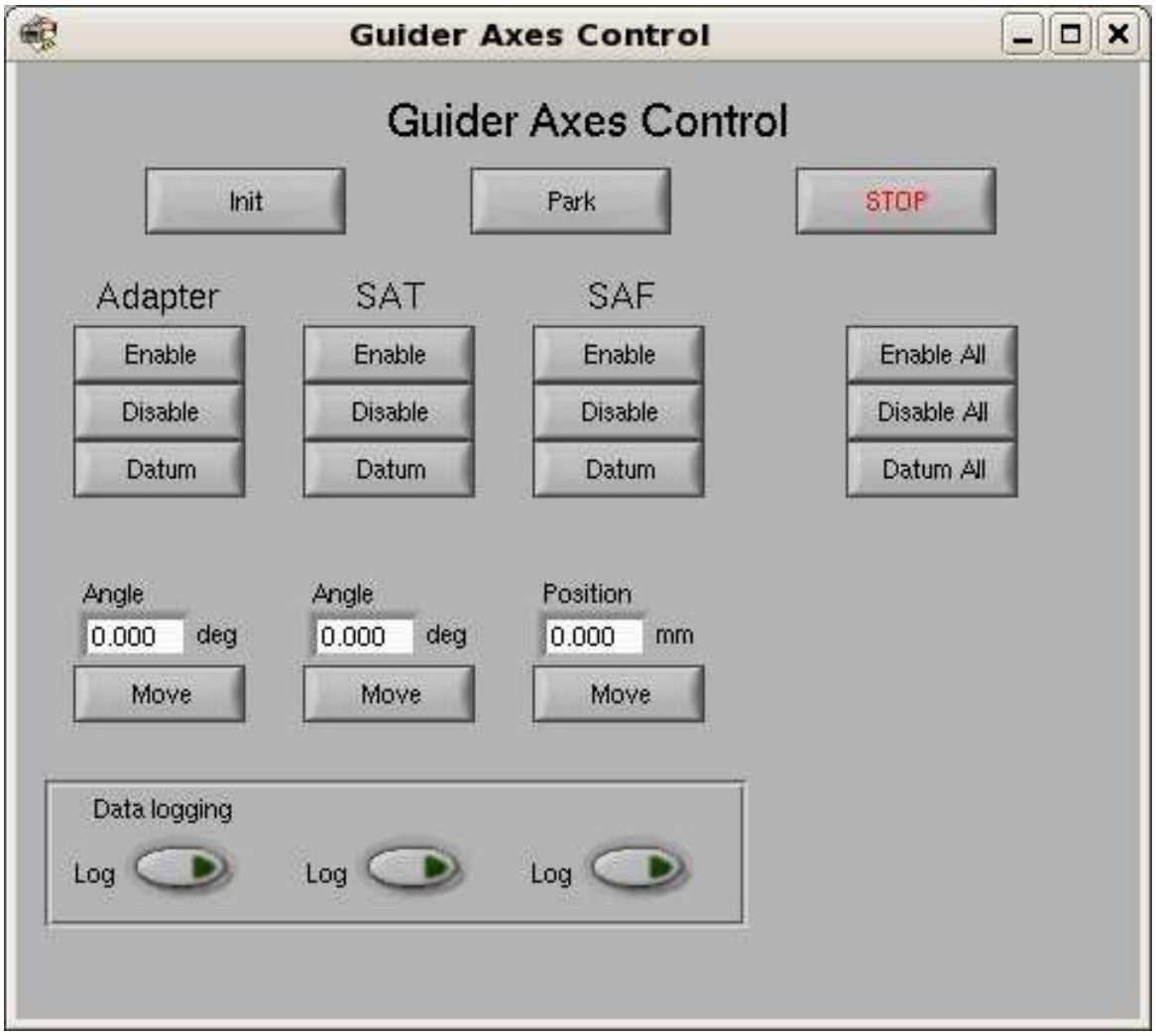


Figure 6: The focus of AGU can be changed here.

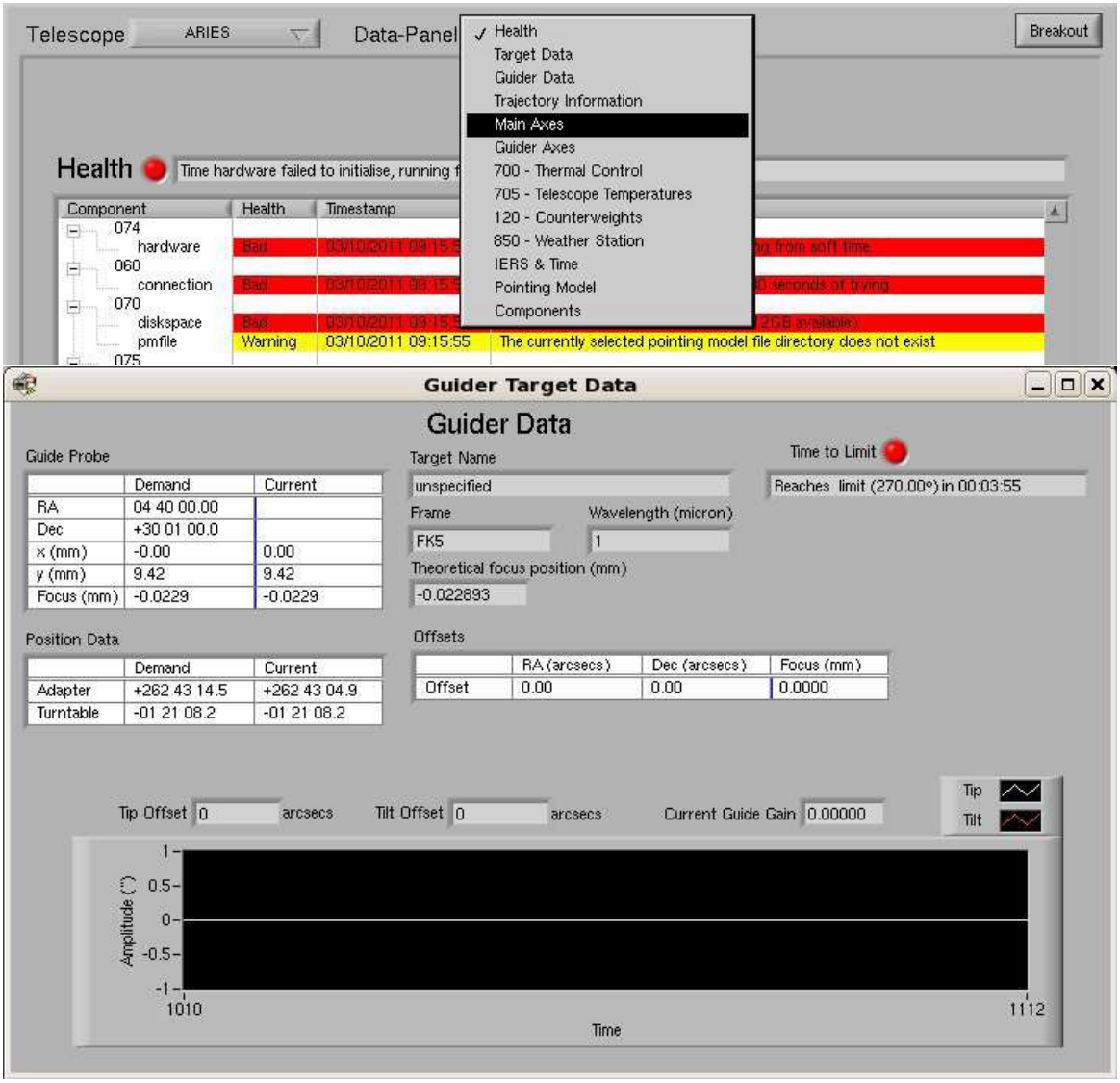


Figure 7: The information of the guider can be monitored here.

of Fig. 8. Now click "Copy Science Target" followed by clicking "Enter Target" as shown in the lower panel of this figure.

- Go to tuning mode; the star should appear in the display area as shown in Fig. 9. If the star is not focused, enable the "SAF" and change the focus offset. After setting a reasonable focus, disable it.
- Click the "On" button for "Guider Tracking" followed by "Corrections" as shown in Fig. 8 to start the guider corrections.
- After completion of the exposure, the star will appear on AGU display as shown in Fig. 10. AGU has two modes for the display, as seen in this figure; if no radiometric corrections are applied, use "Filtered" mode to display the star; otherwise, use "Source" mode.

4 Steps to be followed for close loop guiding

1. Point the telescope to the target star.
2. Now search the guiding star; this can be done in two ways:
   - **Manually:** Type the coordinates of the target star in the Aladin application installed in the 3.6m laptop 2. Search a star according to the criteria mentioned in the table for AGU parameters.
   - **Using the Guiding star finder:** A GUI for finding the guiding star is installed on the Desktop of the 3.6m laptop 2. Execute it by double-clicking the icon. The GUI will be open as shown in Fig. 11. Select the instrument for which the guiding star is required from the drop-down button. Click the "Fetch coordinates from TCS" button or type the RA and DEC coordinates of the target star (the RA should be in (HH:MM:SS) and DEC should be in (DD:MM:SS) format). Now click the "Get guide stars" button. It will display a list of possible guiding stars for the current target (further improvements in this GUI are in progress and will be notified when achieved).
3. Go to the "Guider" section in TCS as shown in Fig. 8 and insert the coordinates of the guiding star. Click the "Enter target" followed by the "On" button for "Guider Tracking".
4. Go to "Tuning Mode" and set the exposure time. The desired exposure time for a star brighter than 9 V mag is 5 seconds; for fainter stars, it is 10 sec; try 20 sec for fainter stars. Click the "save changes and exit" button.
5. Again, go to tuning mode and check if the star is visible in the display area.
6. Simultaneously check the science target in the instrument and bring it to the center of the CCD for imaging or into the slit for spectroscopic mode.
7. Now check the position of the star in AGU. The desired central coordinates of the guiding star are (318, 259) pixels. For a radius value of 31, the coordinates can have a range of 270 to 369 pixels in X and 192 to 304 pixels in Y. Put the cursor in the star position, and the current position will be displayed at the top of the display area in the GUI.

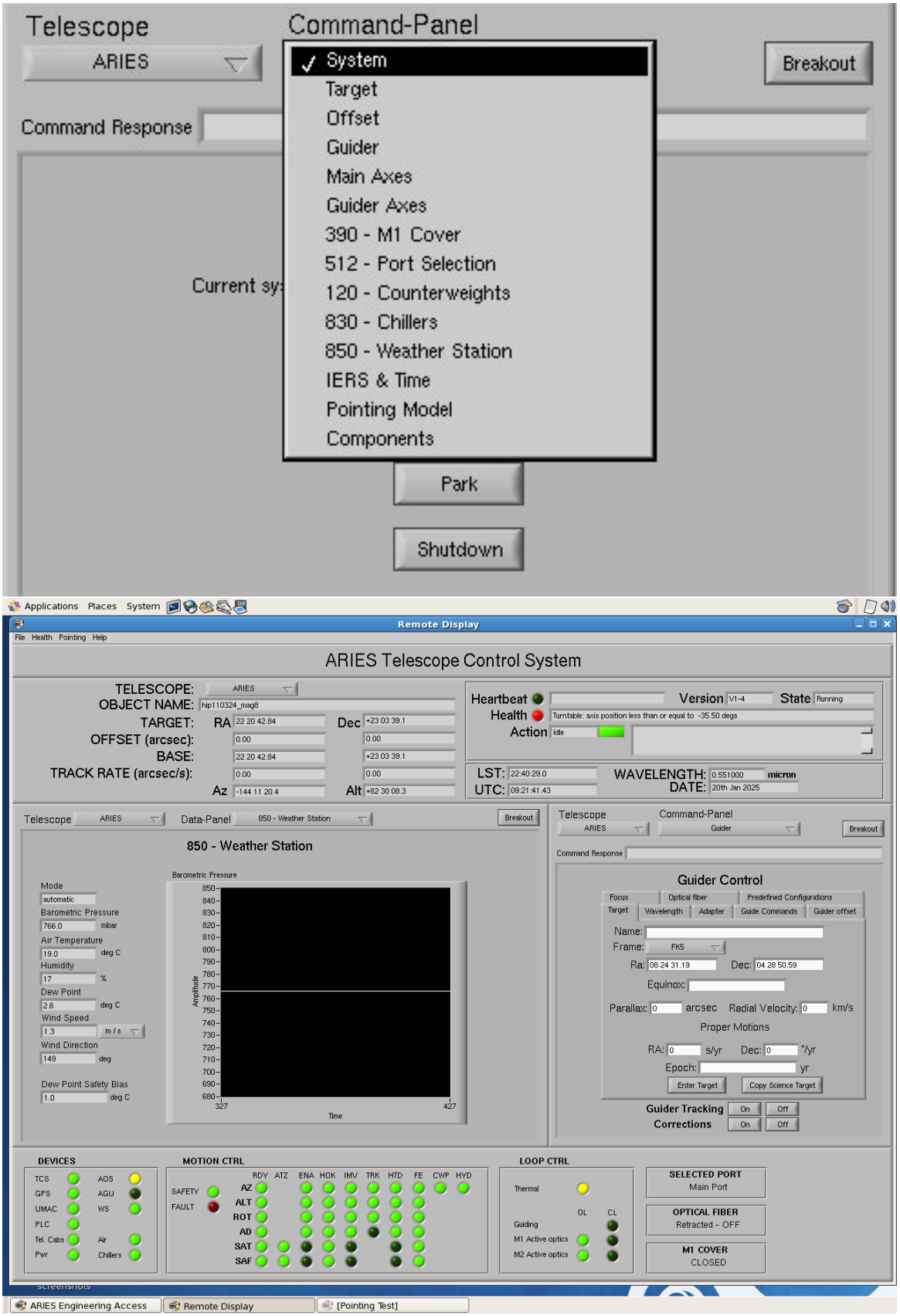


Figure 8: The guiding star coordinates and correction can be started from here.

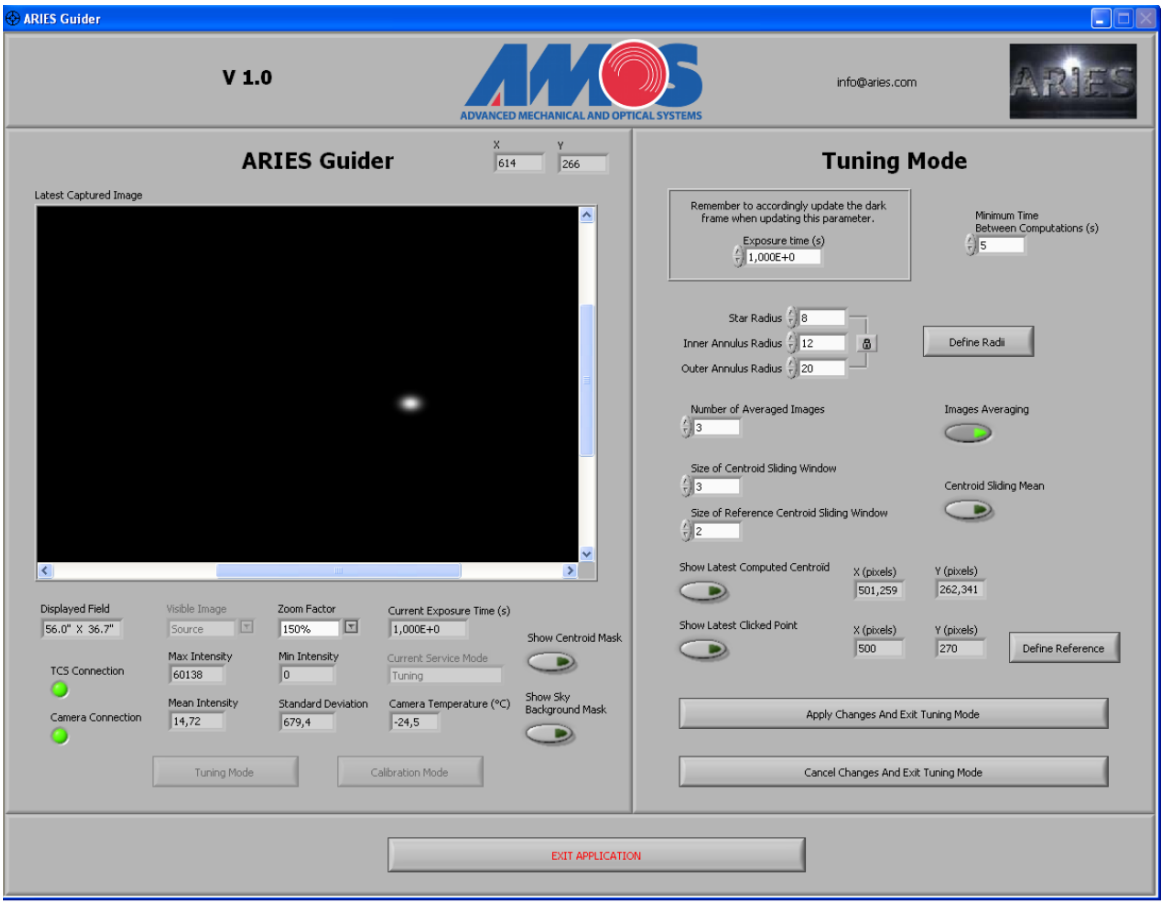


Figure 9: The star is visible in the AGU display area in tuning mode.

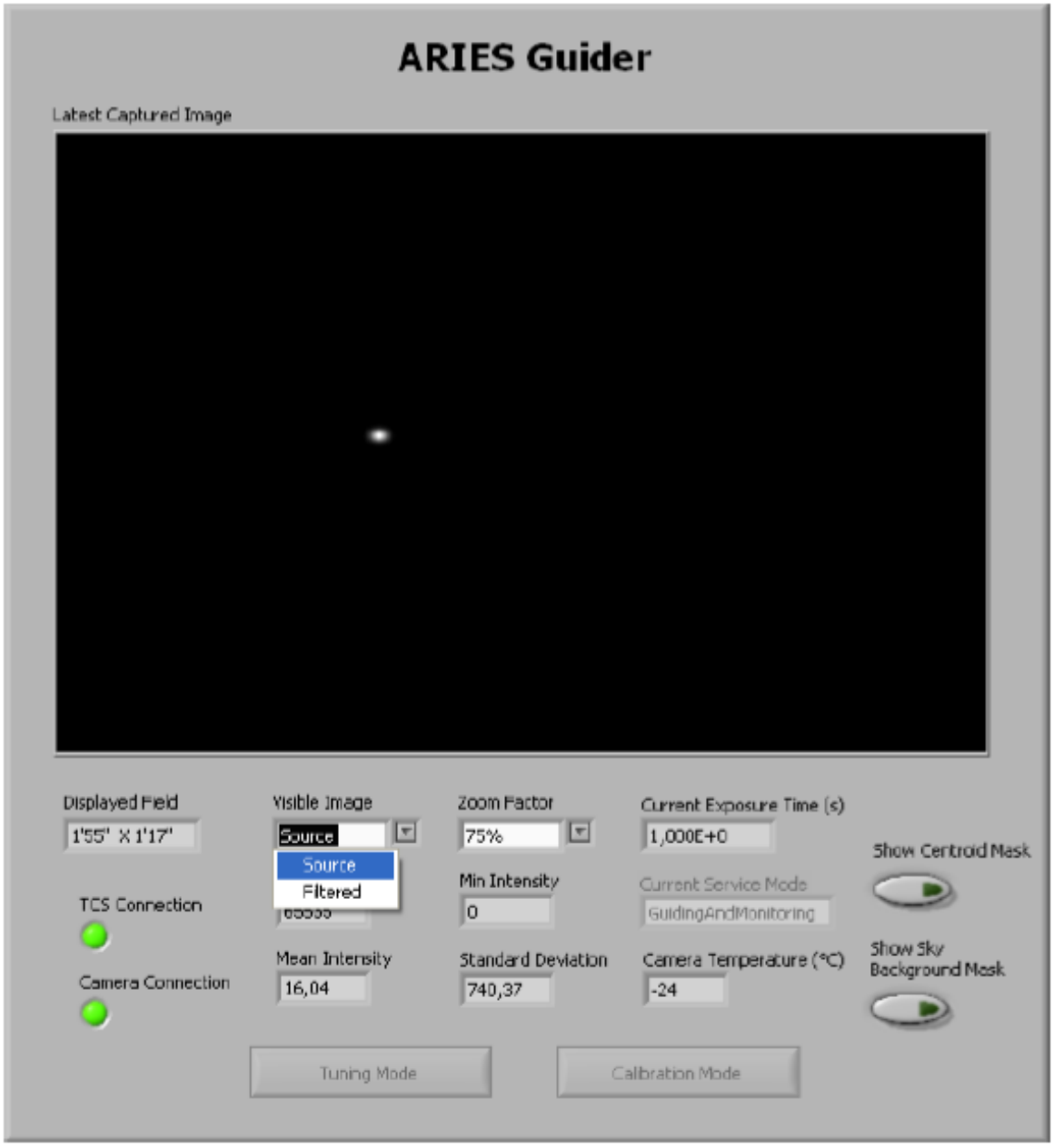
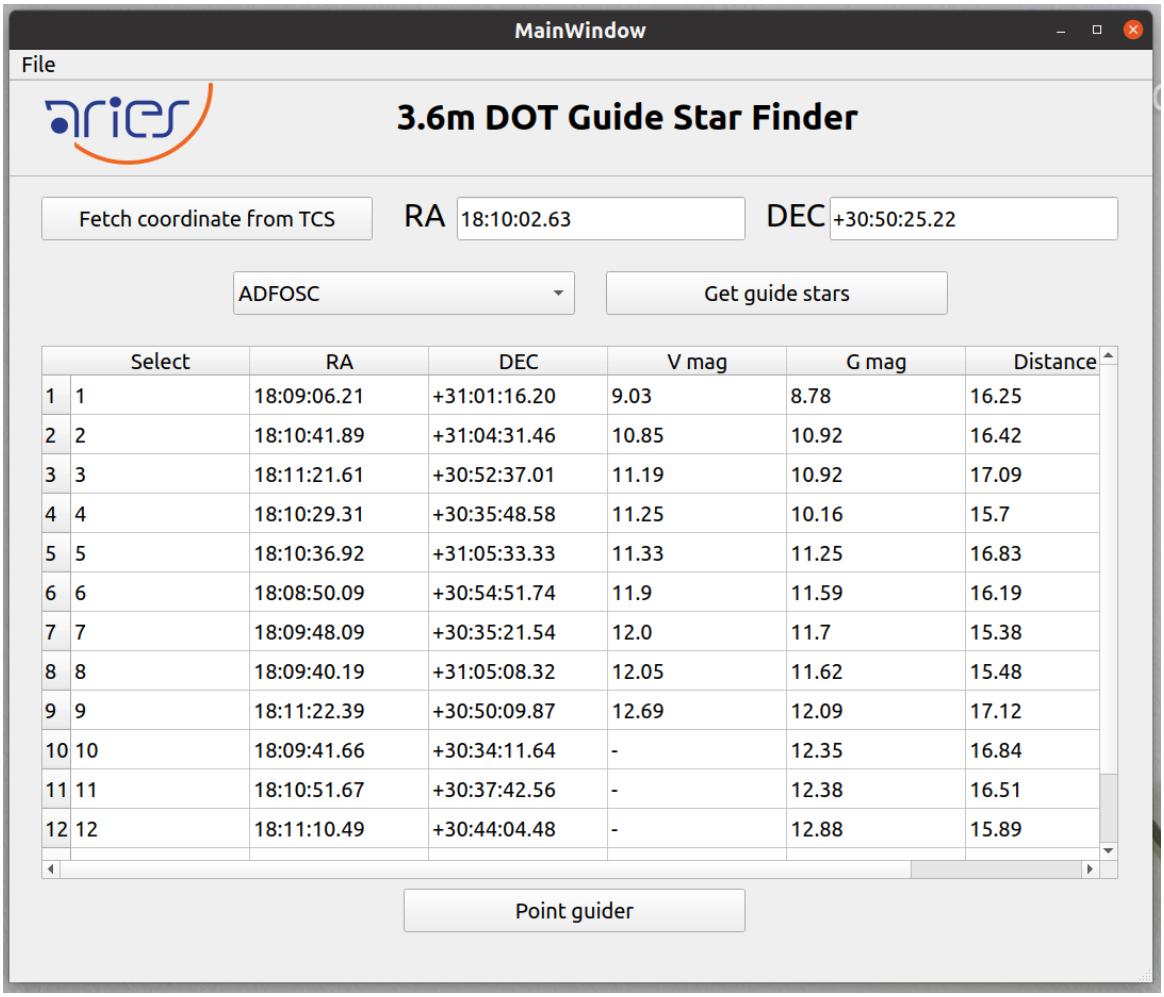


Figure 10: The guiding star is visible in the AGU display.



	Select	RA	DEC	V mag	G mag	Distance
1	1	18:09:06.21	+31:01:16.20	9.03	8.78	16.25
2	2	18:10:41.89	+31:04:31.46	10.85	10.92	16.42
3	3	18:11:21.61	+30:52:37.01	11.19	10.92	17.09
4	4	18:10:29.31	+30:35:48.58	11.25	10.16	15.7
5	5	18:10:36.92	+31:05:33.33	11.33	11.25	16.83
6	6	18:08:50.09	+30:54:51.74	11.9	11.59	16.19
7	7	18:09:48.09	+30:35:21.54	12.0	11.7	15.38
8	8	18:09:40.19	+31:05:08.32	12.05	11.62	15.48
9	9	18:11:22.39	+30:50:09.87	12.69	12.09	17.12
10	10	18:09:41.66	+30:34:11.64	-	12.35	16.84
11	11	18:10:51.67	+30:37:42.56	-	12.38	16.51
12	12	18:11:10.49	+30:44:04.48	-	12.88	15.89

Figure 11: The guiding star can be searched from this GUI.

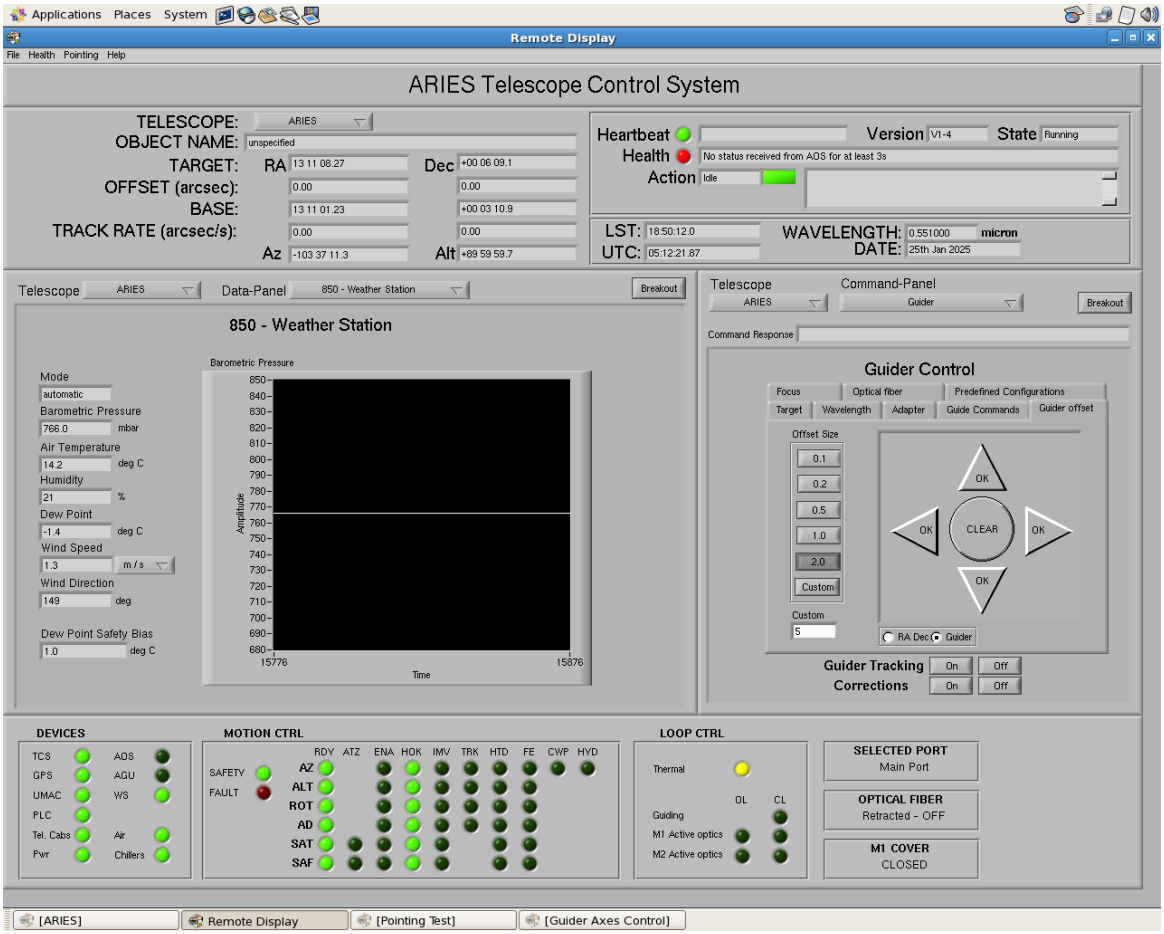


Figure 12: The guiding star can be moved to the desired position in the AGU display by giving offsets from the TCS in guider mode.

8. If the star is not at the desired position, apply offsets to bring it there. To apply offset on the guiding star, go to "Guider control" and click "Guider offset" as shown in Fig. 12. Now, opt for "Guider" mode, which is displayed at the bottom. Apply offsets towards the desired direction and value. The east-west directions in the "Guider offset" are the same as the AGU display directions, but the north-south directions are reversed.

9. If the target and guiding stars are at their desired positions, edit the exposure time of AGU to 1 or 2 seconds. Click the star in the display, click "Define ROI Center," then exit the tuning mode by saving the changes.

10. Now start the corrections from TCS. The AGU will begin guiding. This can be confirmed by opting for the star and field masks from AGU GUI, as shown in Fig. 13. The masks should be on the star, and the "Current Drift" shown at the bottom right of AGU should be less than 1 pixel for TANSPEC and less than 3 pixels for ADFOSC. The "CL" green light will turn on in the TCS, which confirms the close loop guide.

11. Continuously monitor the "Current drift" in AGU and health in TCS to avoid errors during the close loop guiding.

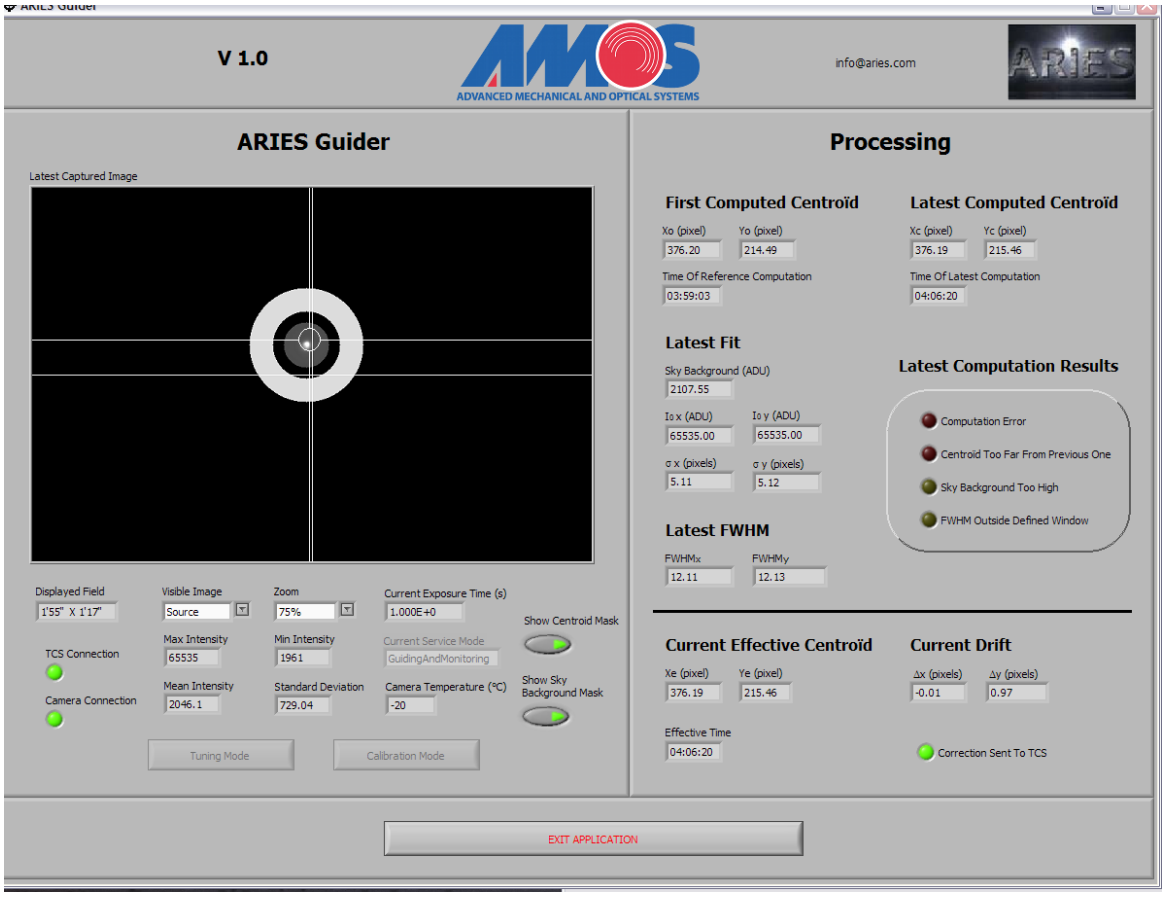


Figure 13: The guiding star with centroid and sky mask on during the close loop guiding. The position of the guiding star should be close to the position shown in this figure. This

5 Shutting down the AGU

1. If the guider is imaging the target star, then park the guider; if not, there is no need to park it every time.
2. Exit the AGU GUI, the guider will be disconnected. This status can be checked from the TCS.

6 Points to be taken care

- The AGU can only function if the pointing is accurate. Try to generate a good pointing model for every instrument. If the accurate pointing model is unavailable for any instrument, use the best one for any other instrument.
- The tuning and calibration modes of the AGU can be accessed only if the correction is off from TCS.
- AGU will stop guiding if 10 exposures have shifts of more than 5 pixels.
- Use "filtered" mode to display the star if no radiometric corrections are applied.
- The star will only be visible in the AGU if the optimum focus offset is applied.
- Disable the "SAF" arm after giving the offset for the focus; otherwise, the focus will be changed after any movement of the telescope or AGU.
- AGU will only calculate reasonable centroids if the star is close to the center in the second or third quadrants of the AGU display.
- The directions of the offsets in "RA DEC" mode are not clear right now, so always opt for the "Guider" mode to apply offsets in the guiding star position.
- The east-west directions in the "Guider offset" are the same as the AGU display directions, but the north-south directions are reversed.
- The live temperature of the AGU CCD can be seen in the tuning mode.

7 Troubleshooting

- If the indicator light for AGU in TCS turns "red" then check if any indicator on AGU window for different errors turned red. If not, check whether the turntable's position is out of range. If not, turn off the "corrections" and "Guiding" from TCS, restart the AGU GUI, and check the camera temperature. This might be due to the camera's high temperature. If so, close the AGU and inform the technical staff about the issue.
- The "First Computed Centroid" and "Latest Computed Centroid" can be seen in the top right of the AGU window as shown in Fig. 13. If "First Computed Centroid" and "Latest Computed Centroid" shown in AGU GUI have a larger difference, then stop the corrections from TCS and go to the "Calibration mode" in AGU as shown in Fig. 4. Click

"Empty file" followed by "Log Centroid" then abort it. Now, wait a few seconds, and the star will be visible in the AGU display. Click it and again click the "Log Centroid." After it is complete, save the changes and exit this mode.

- If the star is visible in the AGU but shows a "sky background high" error for a longer time, then check if all the settings in the "tuning mode" have the desired values mentioned above. If not, then edit them. If it still shows this error, check whether radiometric corrections are being applied. If not, then apply them.

- If the AGU cannot detect the star, check the following cases:

  1. If there are offsets in the "collimation offset" section, remove them.
  2. Give offset to the guider by clicking the north offset button. If some offsets are applied to the previous guiding star, the guide star will be brought to the AGU display area.
  3. If the telescope has offset, look at the target position on the CCD to check this. It should be at the optical center. If the offsets are small, then the AGU star can be checked by giving offsets in the north direction of the AGU display. If the offsets are significant, then we can not use AGU.

- If the camera connection indicator is not turning on, then go to the engineering window for AGU and turn on the camera power of AGU, followed by restarting the guide GUI in AOS. If the problem persists, switch the camera from SHSWorks in AOS PC.

- If the "TCS connection" indicator in the AGU GUI is not green, the AGU cannot set up connections with the TCS. Check if the guider service is started or not; if it is active, then try to restart it. If this step does not solve the problem, then check the engineering screen for the AGU and see if the AGU is connected or not. If the connection is not showing, then restart the AOS PC. Check all fiber connections at LIU. If needed, then remove and reconnect them. Check the connection between the switch box and the AOS PC and restart the AOS.