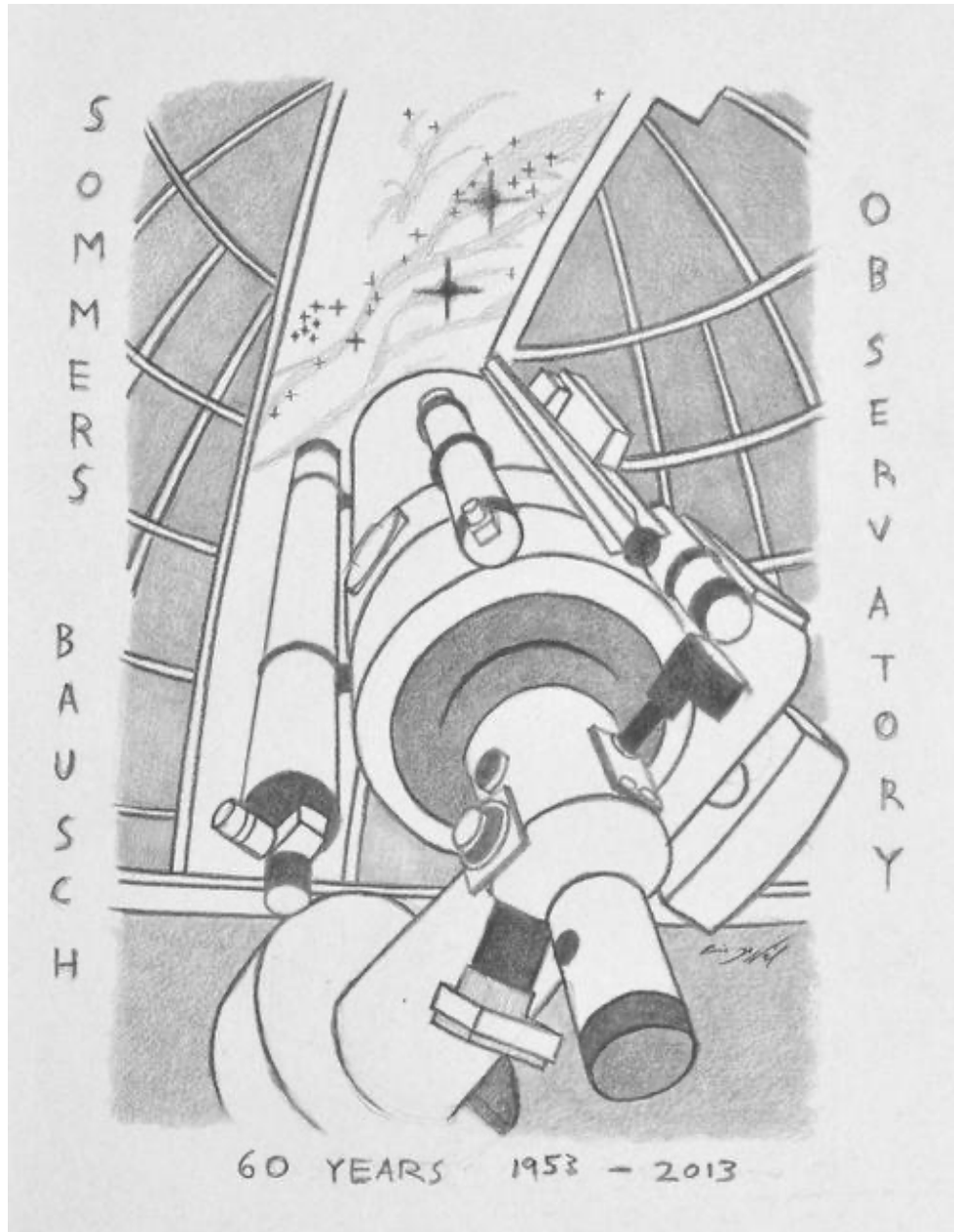


Sommers-Bausch Observatory 24" Telescope

Imaging Manual



IMPORTANT: THIS MANUAL IS FOR REFERENCE ONLY. DO NOT OPERATE THE TELESCOPES WITHOUT ATTENDING AN OFFICIAL TRAINING SESSION.

NEVER attempt to disassemble the instruments or remove/change their attached cords.

Last Modified: 25/11/19

TROUBLESHOOTING STEPS

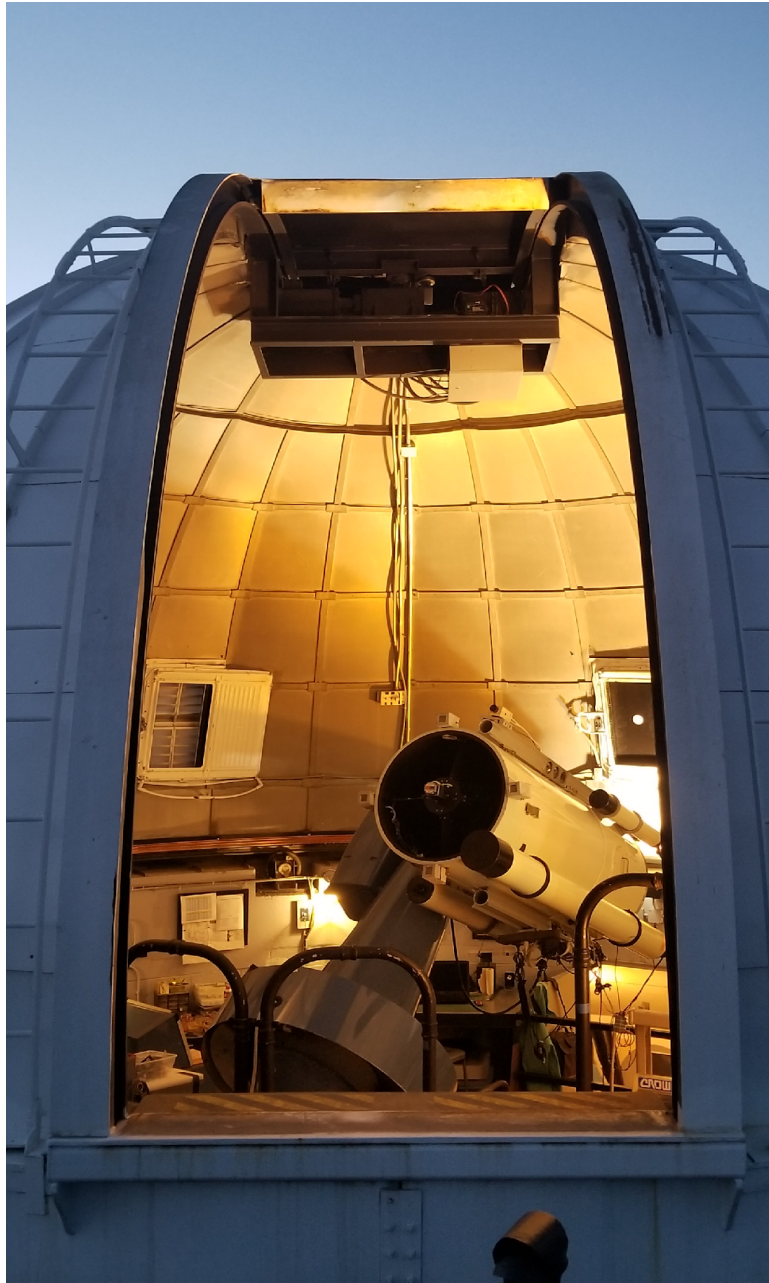
- **Remote desktop session closed / crashed**
 - Double click on the “Start Remote Desktop” icon on the desktop of the local computer.
- **Telescope is not responding to slew commands**
 - Ensure that the telescope is still connected to TheSky. Look for a status message explaining that the telescope is at its software limits. Finally, check if the telescope is in the hardware limits by checking if it is pointed very close to the horizon. In this case, you must call SBO staff.
- **Telescope is not pointing at the correct objects**
 - Use the “Find Home” command on the Sky View toolbar to return to home, then try to go back to your object. If the problem persists, contact SBO staff.
- **Scorpius terminal is frozen or not appearing (Aux Computer)**
 - If frozen, double click on the “ScorpiusForceQuit.sh” file on the desktop to run it.
 - If not appearing, double click on the “ScorpiusConnect.sh” to open the terminal.

GENERAL TELESCOPE USE

- **Telescope Status**
- The status of the telescope can be found in the Telescope pane. The text will either be red or green. The possible telescope statuses are:
 - **Not Connected:** The computer is currently not communicating with the control system. You must press “Connect” on the Sky View Toolbar.
 - **Tracking Off:** The telescope is currently not following objects on the sky; the motors are not moving, slew to an object start tracking, if it does not click on “Tools” in the Telescope pane and then press “Turn Sidereal Tracking On”.
 - **Not Homed:** The telescope has not been homed since being powered off. Select “Startup” in the telescope pane and press “Find Home”.
 - **Tracking at ...:** The telescope is tracking an object, usually (but not always) “sidereal rate”.
 - **Slewing to target:** The telescope is currently moving to a new target.
 - **Parking:** The telescope is currently going to it’s park position (this is different than home).
 - **Parked:** The telescope is in the park position. It will not respond to slews until “Unpark” and “Find Home” are pressed again.
- **Emergencies**
 - Please be very familiar with these procedures before using the telescope.
 - **Weather Emergencies (Sudden rain, snow, hail, or heavy winds)**
 - Immediately work as a team to park and cover the telescope and close the dome slit as fast as possible, in parallel. Then continue the shutdown procedures as normal.
 - **Movement Emergencies**
 - If the telescope is ever behaving in an unsafe fashion, such as going to the hardware limits, **PRESS THE RED STOP BUTTON ON THE LOWER CONTROL PANEL (HARD ENOUGH TO HEAR THE CLICK).**

Opening Procedure

24-Inch Telescope



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Note: Please read each step in its entirety before executing the instructions in that step. Some steps have additional information that may affect how you complete the step, or additional warnings for things to look out for.

Location: Control Room

1. Checks and System Startup

- a) Before starting, check in with anyone who may be on the deck, so they know to be careful with lights, and to not bring visitors up to the dome. When they leave, they should completely lock up and close the building, but it never hurts to double check.
- b) Ensure the door to the rest of the observatory (with the card swipe) is closed.
- c) If desired, turn on the heater or chain open the catwalk door.
- d) Verify that there are no keys present on the control panel.

Note: These keys are used to control the hard limits of the telescope. This system prevents the telescope from turning itself over and destroying the mirror. Unauthorized use of these keys can result in damage to the telescope. Only SBO staff members are allowed to use these keys.

- e) Turn on auxiliary computer using the covered switch on the left of the telescope control panel. *Note these switches act like buttons and should not be forced to stay in the up position.* Put the covers back down to prevent accidental contact.
- f) On the telescope control panel, flip up the cover on the **[Mode]** switch and flip the switch into the upper, **[Check]**, position. Leave the cover up.
- g) On the control panel, press the green **[START]** button to turn on the telescope. You must press hard enough to hear and feel a heavy click.
- h) On the control panel, verify the **[Telescope Power]** indicator is illuminated.
- i) On the control panel, press and hold the **[Test]** button. Verify the **[Telescope Power]** indicator is not illuminated, the **Emergency Light** is on, and the **Warning Buzzer** is sounding. Then, release the **[Test]** button.

If the **[Telescope Power]** indicator, **Emergency Light**, or **Warning Buzzer** do not behave as described above please press the **[STOP]** button immediately and contact SBO Staff for assistance. Failure to do so can put the telescope at risk of damage.

- j) On the control panel, firmly close the **[Mode]** switch cover, which automatically moves the switch into the **[Run]** position.
- k) In the internet browser on the auxiliary computer, login to the observing session. Switch to the other tabs in the internet browser to double check the weather forecast for the evening.
- l) Turn on TCS computer using the covered switch on the left of the control panel.

Location: Dome

2. Prepare and Cool Dome

- a) Turn on the **[Dome Rotation Power]** switch on the eastern wall.
- b) If low altitude observing (<30°) is required, rotate the dome to an accessible position, and couple the lower door section to the slit using the pins. Make sure the door is secure before operating. Remember that the slit will not allow observing near zenith if the lower door is attached. *Please do not attempt this unless you have been trained by SBO staff on this procedure.*

Note: Never operate the dome when there are people present on the mezzanine. Please do not attempt to move dome components by hand, and do not touch the orange strip that goes around the dome itself.

- c) Turn on the **[Dome Slit Power]** switch on the western wall.
- d) Turn the **[Ventilation Fan Power]** knob on the eastern wall to "High".
 - i. The switches on either side of the knob should be on, turn them on if they are not.

Location: Control Room

3. Open Dome and Setup Telescope and Instrumentation

- a) On the top monitor, press the **[Full Screen]** button in the bottom right corner.
- b) Open the slit by pressing the **[Open]** button on the iPad. If the iPad is not working correctly, open the slit and windows using the switches up on the mezzanine. Note: you must wait until the slit fully opens to open the windows. *Never open the slit only part way, only all the way open or all the way closed.* Once you open the slit do not turn on the white lights in the dome as it will interfere with observations on the observing deck.
- c) Open the dome windows using the iPad, you must wait for the slit to fully open.
- d) Unplug and plug back in the blue cable on the back of the computer mounted on the bottom of the 24" tube, with the label on it that says, "Cable to replug"
- e) Open TheSky by clicking on the blue circle on the task bar with "64".
- f) Press "Ok" or wait for the time to expire.
- g) Home the telescope by pressing **[Find Home]** on the TheSky's toolbar. Allow the telescope to finish finding the home position, which will be signaled by the telescope status switching to "Tracking at sidereal rate".
- h) In the camera pane, press the **[Temp. Setup...]** button, and change the camera set point to 20°C BELOW ambient rounded to the nearest 5°C, and no lower than -20°C. (There is a temperature readout on the dome control iPad.) Also, ensure that both checkboxes are checked. Press **[OK]** to exit the set-point window. *Please refer to the [Data Acquisition section for instructions on how to manage the temperature of the camera.](#)*
- i) In the camera pane, ensure that **[Automatically Save Photos]** is **[checked]**.
- j) Click on **[AutoSave...]**, then **[Choose...]**, then **[ASTR3510]** in the navigation bar, and then select your team's name from the list. Press **[Select Folder]** and **[Ok]**.

Location: Dome

4. **Uncover and Prepare the Telescope**

- a) If needed: use the stepladder to remove the 4" finder scope cover. Store the cover out of the way, making sure the cover is upside down to prevent the accumulation of dust and debris.
- b) Using the stairs, climb up to the mezzanine and remove the 24" primary cover by supporting the bottom with one hand and gripping the handle with the other. *IMPORTANT: Pull the cover straight off to avoid damaging the focus mechanism.*
- c) Remove the 6" guide scope cover.
- d) Store the covers out of the way and upside down on the mezzanine.
- e) Center the 6" guide scope by turning the **[Translation Stage Knobs]** until *both* white "guide" labels are aligned.
- f) Pull the **[Selector Rod]** all the way out on the back of the guide scope to select guide mode.
- g) Turn off the [Ventilation Fan Power] knob to prevent seeing artifacts. Also turn off all extraneous light sources (only the phone screen and skirt power light should be on). Close the curtain to the dome.

Note: From this point on, the dome should be in science collection mode. All extraneous light sources should be off. Ventilation fans should be off. The curtain at the bottom of the stairs should be closed.

Location: Control Room

5. Focus the Telescope

- a) Slew to a star between magnitude 5 and 6 either selecting the star in the sky view, or searching for it, then pressing [**Slew**] in the Telescope or Find windows. *This object should be somewhat nearby to your science target to ensure optimal focus.*
- b) In the [**Camera**] pane select [**Focus Tools**] -> [**@Focus3**].
- c) Set the [**Exposure Time**] to 1 second, [**Binning**] to 2x2, and the [**Filter**] to r (Sloan r').
- d) Press [**Take Sample Photo**] and wait for the image to download.
- e) Press the [**+ Magnifying Glass**] button until it says 1:1 in the top left corner of the @Focus3 window, and then center the brightest star.
- f) Press [**Set Subframe to Current View**].
- g) Press [**Autofocus Now**]. The system will now attempt to automatically focus the camera. This should take about 2 to 3 minutes. If it is having trouble, please use the legacy camera method.
- h) Switch to the [**Take Photo**] tab, not button, to collect data. Failure to do this will prevent your data from being saved.

The telescope is now ready for taking data! Please refer to the "Data Acquisition" section of the manual for details on how to use the camera/spectrograph functionality.

Note: Throughout the night, there will be times when the telescope needs to be refocused. You can end up refocusing the telescope a fair number of times, even during a short observing session. You should refocus the telescopes in the following cases:

1. The object has changed significantly in air-mass.
2. The weather, transparency, or seeing has changed significantly.
3. The temperature outside has changed significantly.
4. You have slewed to a new object that is far away from the previous object.
5. It has been a significant enough amount of time for thermal expansion to take effect.

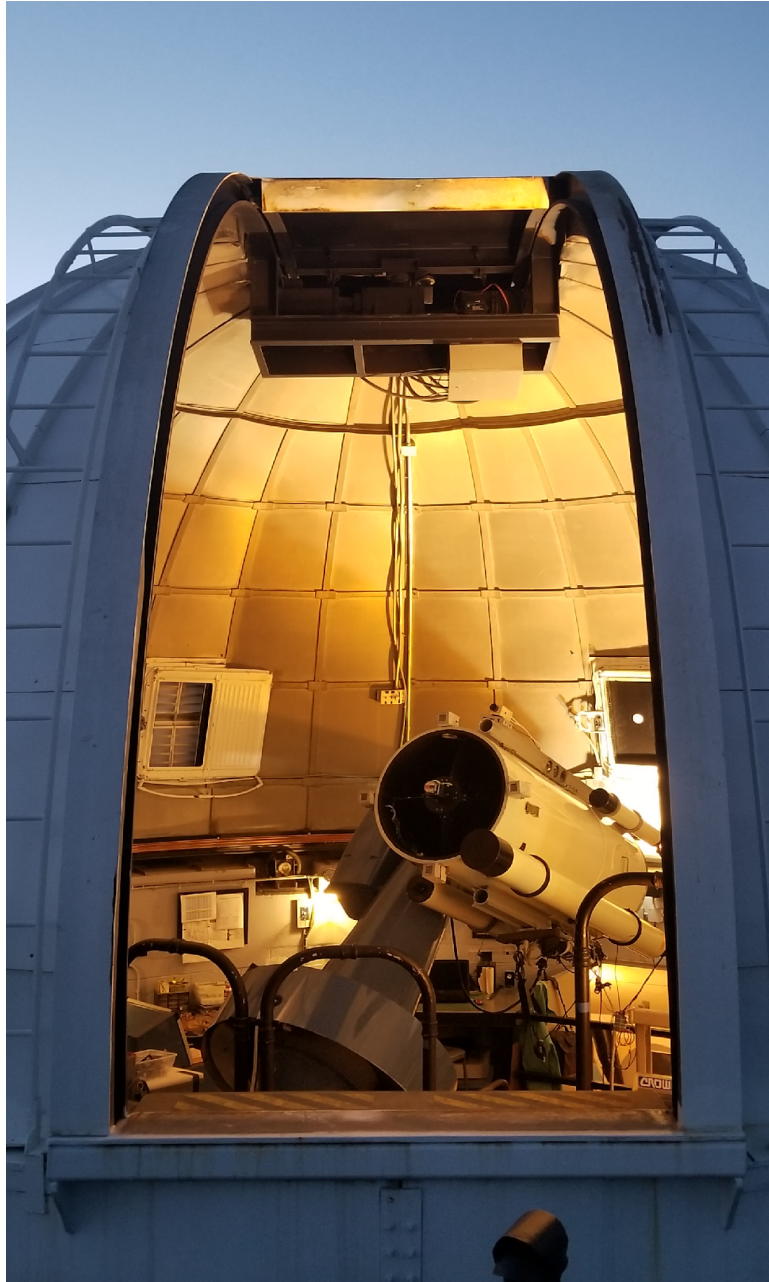
Most importantly, keep an eye on your data, and refocus if the image is getting 'soft.'

Legacy Focusing Method

- a) From the telescope home position, place the Bahtinov Mask on the telescope.
- b) Slew to a star between magnitude 0 and 3 either selecting the star in the sky view, or searching for it, then pressing [**Slew**] in the Telescope or Find windows. *This object should be somewhat nearby to your science target to ensure optimal focus.*
- c) In the Filter Wheel Pane, set the filter to "r" (Sloan r).
- d) In the Camera pane, switch to the [**Focus Tools**] tab, and set the exposure to 1 sec with 2x2 binning. *Depending on the brightness of the star, you may need to adjust the exposure time.*
- e) Uncheck [**Take Photo Continuously**]
- f) Press [**Take Photo**].
- g) Click on the **Subframe** icon in the image window and then drag a box around the star (being sure to capture *all* of the diffraction spikes.) *(The Subframe checkbox should automatically turn on in the [**Focus Tools**] tab.)*
- h) Check [**Take Photo Continuously**]
- i) Then press [**Take Photo**].
- j) Using the Focuser pane, perform a Bahtinov focus for the telescope.
 - i. Move the focuser (using the focuser pane) in steps of 200 counts, until the central diffraction spike evenly bisects the "X".
- k) Stop the focus series using the [**Abort**] button and uncheck [**Subframe**].
- l) Home the telescope and remove the Bahtinov Mask.

Data Acquisition

24-Inch Telescope



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CAMERA SETTINGS (TheSky)

- **Camera Pane**
 - The only two tabs in the camera pane that operators typically use are the “Take Photo” and “Focus Tools” tabs. They both have similar options.
 - **Frame:** This controls the frame type.
 - **Reduction:** Leave this at “None”. The other options will produce images that are not suitable for science.
 - **Subframe:** Additional options for sub framing can be found in the “Size...” menu.
 - **Automatically save photos:** This will create a lot of data. It is fine to use this mode, but you must log each science quality image.
 - **Camera Window:** Temperature Setup
 - The temperature setup can be found by pressing [**Temp. Setup...**] on the camera window.
 - The standard set-point for the camera is 20°C BELOW ambient.
 - If the camera has stabilized at >75% power, you must raise your set-point until it can stabilize at or below 75% power. Raise the temperature by 5°C at a time.
- **Filter Wheel Pane**
 - The filter wheel pane will always show you the current selected filter, and you can use the dropdown and click [**Move Now**] to change the filter. The camera will always make sure the selected filter is inserted before taking images.

FITS VIEWER (TheSky)

- The FITS Viewer Window will open as soon as an image is taken if the window is not already open.
- Under the [**Photo**] button is the menu for saving the image.
- The next button (looks like a graph) opens the stretch panel, where you can apply and adjust stretch functions to the image. In the bottom right corner select heuristic from the dropdown for DS9 like controls.
- The next three buttons control what mouse clicks do on the image.
- The last important button, which looks like a rectangle with a mouse cursor, is used to draw custom subframe sizes in the image, when [**Subframe**] is checked in the Camera window.
- Finally, the [**File Information**] tab at the top allows you to view the FITS header.

TELESCOPE MOVEMENT

- There are four ways that the telescope can be moved to point at a target:
 - **Left Clicking in Sky View:** This will set the object as active in the Find window, where you can check properties and send slew commands.
 - **Searching:** You can search for objects in the Find window as well. Make sure to press **[Find]** to populate the object as the target, otherwise it will continue to use the old target.
 - **Coordinates:** If you know the coordinates of the object, you can enter them in the **[Telescope Pane]** by pressing **[Tools]** and then **[Slew to Coordinates]**. Enter the coordinates, including the equinox, into the “Equatorial Coordinates” panel. *BEFORE SLEWING, PRESS [Center Chart on RA/Dec] TO ENSURE THAT THE OBJECT IS INSIDE THE HORIZON LIMITS.* After checking, you can press **[Slew To RA/Dec]** to actually perform the slew.
 - **Manually:** Using the hand paddle in the dome, or the green arrow keys in the Telescope pane, you can manually move the telescope. This is only really used for fine-tuning positioning after a computer slew.
- Additionally, there is the ability to stop tracking at any point by pressing **[Turn Tracking Off]**. This will stop the telescope from tracking the sky, which will cause trailing in the image.
 - Once the telescope has stopped tracking, you must either click on **[Turn Sidereal Tracking On]** or slew to a new object to re-enable sidereal tracking rate.
- If the telescope is ever parked, it will not respond to any slew commands, or to manual move commands from the hand paddle or TheSky. The first step after the telescope is parked is to find home by pressing the **[Find Home]** button in the Sky View toolbar. This will unpark the telescope, as well as give it an accurate pointing model.
- ***Always remember to double check that your object is within the horizon limits to prevent a call to SBO staff to fix the telescope.***
- ***IF AT ANY TIME THE TELESCOPE IS BEHAVING IN AN UNSAFE OR UNEXPECTED MANOR, HIT THE ABORT BUTTON IN TheSky VIEW TOOLBAR. IF THAT DOES NOT WORK, PRESS THE RED STOP BUTTON ON THE LOWER CONTROL PANEL.***

TAKING FLATS

- To prepare to take dome flats, the telescope must be pointing at the flat field panel on the dome. This is accomplished in two steps:
 - Turn on the dome lights and park the telescope by pressing the **[Park]** button in the Sky View toolbar. *Note: The telescope will move immediately after pressing the [Park] button.*
 - Rotate the dome back to home position, by lining the slit up with the “Dome” label and centering the flat field panel in the circle in the status camera monitor.
- Turn on the flat field lamps on the telescope (switches on the bottom labeled “WHITE SPOT”), and make sure all other light sources in the dome are off.
- Proceed to take the flat fields just like any other light frame image but select the **[Frame]** type **[Flat Field]**. Aim for 20K-30K counts in the brightest part of the image (ignoring hot pixels).
- Remember that the flat fields can be done at the end of the night, *but the camera must remain at the same temperature for both data and calibration images.*

Remember that you *can* also take sky flats, which avoids this procedure. The explanation for these flat types, however, is outside the scope of this manual.

USING THE AUTOGUIDER

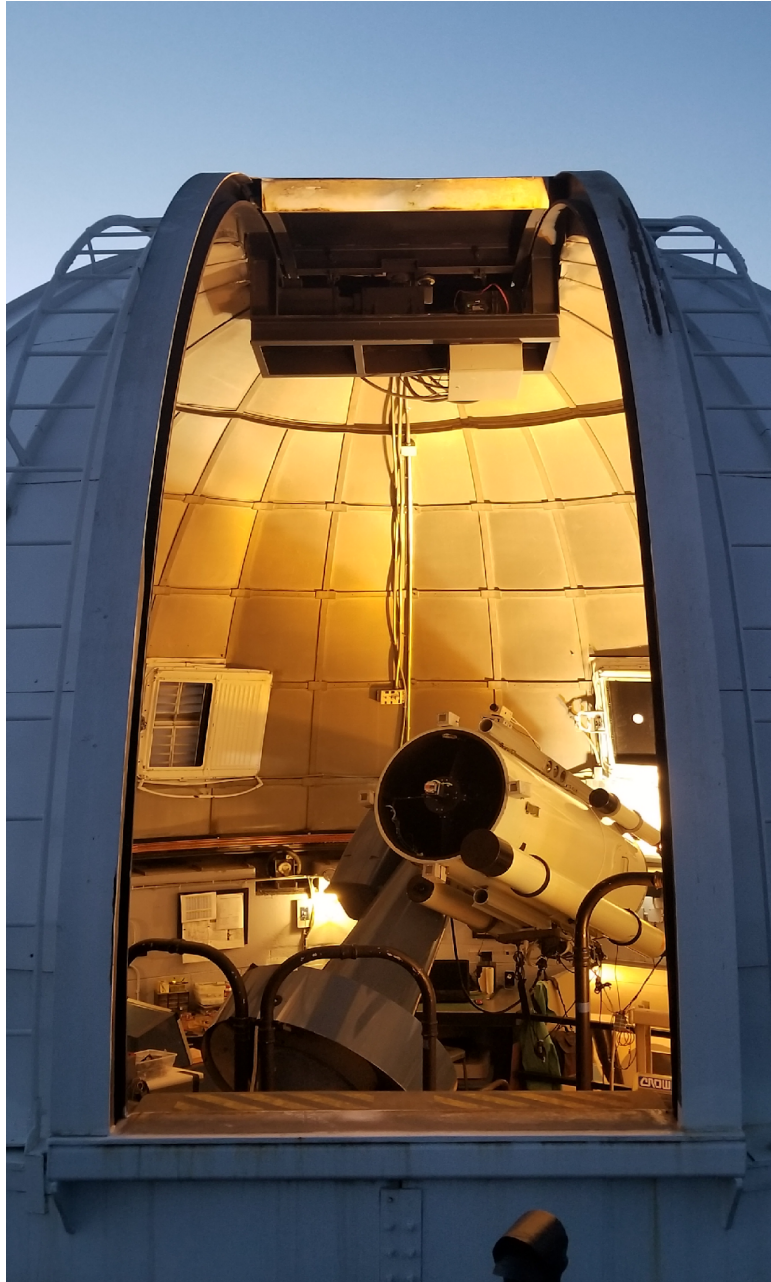
- Without using the autoguider, you are limited to exposures of 5 to 10 minutes (depending on the part of the sky being pointed at) before you start to notice smearing in the image. This is because of slight imperfections in the pointing and tracking accuracy of the telescope. With the autoguider running, you can boost your exposures to around an hour (perhaps higher, but it's best to take multiple exposures at that point).
 - The autoguider on the 24" is a separate CMOS camera on the guide scope. The field of view of the guider is similar to the main camera and should be aligned with it. Using the translation stage on the guide scope you can expand the area of sky available for guiding.
1. Slew to a 3rd to 4th magnitude star, ideally close to zenith.
 2. (*Location: Dome*) Pull the **[Selector Rod]** on the back of the guide scope all the way out and use the translation stage knobs to align the guide stickers.
 3. Switch to the **[Autoguider]** pane, and **[Autoguide]** tab, and set the **[Exposure Time]** to 0.01s, then press **[Take Photo]**.
 - a. Adjust the exposure time as needed so the 3rd to 4th magnitude star has good signal to noise but is not saturated.
 4. In the autoguider image (blue window background), **double click** on the star. You should see a grey box flash around the star.
 5. Press **[Calibrate]** to enter the calibration routine, verify the **[Calibrate X (and Y) Relay for]** field is set to 450 arcseconds and press **[OK]**. This should move the star down, up, left, right to calibrate how motor movements equate with star movements.
 6. If the calibration is successful and accurate there will be 4 green arrows, on the chart in the confirmation window, that all start at the same point and are at right angles pointing in 4 directions and have approximately the same length.
 - a. If the chart is not as described or it says the calibration failed there are three likely causes. If you cannot identify a possible cause run the calibration again and closely watch the images it takes.
 - i. The star moved off the guider detector while calibrating.
 1. Center the star in the Guider FOV using the translation stage knobs.
 - ii. The star is saturated.
 1. Reduce exposure time.
 - iii. The signal to noise is too low.
 1. Increase exposure time.
 7. Slew to your science target.
 8. In the **[Autoguider]** pane, select the **[Focus Tools]** tab and set the **[Exposure Time]** to 1 second, verify that **[Subframe]** is unchecked, and **[Take Photo Continuously]** is checked.
 9. Press **[Take Photo]**, and make sure that there is a usable guide star (>2,000 counts above background, the higher the better, but not saturated) in the field, that is isolated from other stars and the edge of the image by at least 200 pixels. If you do not have such a star, try the two solutions below.
 - a. (*Location: Dome*) Turn on the monitor in the dome to see the images from the autoguider. Move the translations stage knobs to locate a suitable star.
 - b. Increase the exposure. You should not need more than 10 seconds.
 10. In the **[Autoguider]** pane and **[Focus Tools]** tab, press **[Abort]**.
 11. In the autoguider image (blue window background), **double click** on your chosen guide star. You should see a grey box flash around the star.
 12. Press **[Autoguide]**. The autoguider will start to take a series of images using a small frame centered on the selected guide star.

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13. Begin your science exposure in the **[Camera]** pane.
14. Watch both the autoguider image and the "Guide error" numbers on the autoguider window.
 - a. The star should remain in the center of the guide image, and the guide error numbers should stay within 10 pixels of zero. Additionally, you can press **[Graphs]**, in the **[Autoguider]** pane, and **[Focus Tools]** tab, to bring up handy plots of the guiding error (use the mouse scroll bar to adjust all three graphs to range from -10 to 10 pix). If it stops guiding well, you will need to start again from step 8.
15. When you are done autoguiding, or if you are moving to a new object, simply press **[Abort]** in the **[Autoguider]** pane, and **[Autoguide]** tab. **You must abort guiding before moving to a new object.**

Closing Procedure

24-Inch Telescope



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CLOSING PROCEDURE

1. Park the telescope by pressing the **[Park]** button on the Sky View toolbar. Wait for the telescope to stop moving before proceeding.
2. Return the dome to its home position by rotating the dome until the slit is lined up with the yellow/black "dome" label, and the flat field panel is lined up with the circle in the telescope status cameras.

If you are taking flats in imaging mode, do so here, then finish the shutdown procedure.

3. Close TheSky.
4. Shutdown the Windows 10 Telescope Control Computer in the **remote session**.
5. If you used the heater in the control room, turn the heater off by turning the knob counterclockwise.
6. *(Location: Dome)* Replace the telescope covers, for the 24" telescope, 6" guide scope, and 4" finder scope. *The main cover should make a substantial click when it is properly in place.*
7. Using the iPad, close the dome windows and dome slit.
8. Power off the dome slit by switching the **[Dome Slit Power]** switch to the off position.
9. If you observed at low altitudes and attached the lower door to the slit, please detach the lower door by moving the slit to over the mezzanine and following the proper procedure. Be sure to return the dome to its home position when you are done.
10. Power off the dome rotation by switching the **[Dome Rotation Power]** switch to the off position.
11. *(Location: Control Room)* Press the red [STOP] button on the Lower Control Panel. You will need to press hard enough to hear and feel a heavy click in the switch.
12. On the Auxiliary computer, complete the logout form, and close the browser.
13. **If there were any issues, either one you fixed yourself, called us for, or is unresolved please also complete the problem report form.**
14. If you logged into Scorpius, log out of Scorpius.
15. Shut down both computers.
16. If you opened the catwalk door, close and lock it now.
17. Turn off the lights in both the dome and the control room. Remember that the dome has two individual light switches, including the red stair lights.
18. For both the dome and control room: stop, look, and listen. There should be no strange sounds or lights coming from inside the dome, save for the phone screen and perhaps a few power lights. The control room should only have the clock, status camera box, phone, and a few small computer lights.
19. If you are the last observers of the evening, please ensure that all the lights in the observatory are off, all doors closed, and all external doors should be locked. If you used the resource room to make coffee or food, please ensure that all appliances are off, and *please clean up after yourself. Remember: DON'T MAKE IT SOMEONE ELSE'S PROBLEM.*

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