How to Use the Harken Observatory

Harken Observatory at the Pewaukee Public Library

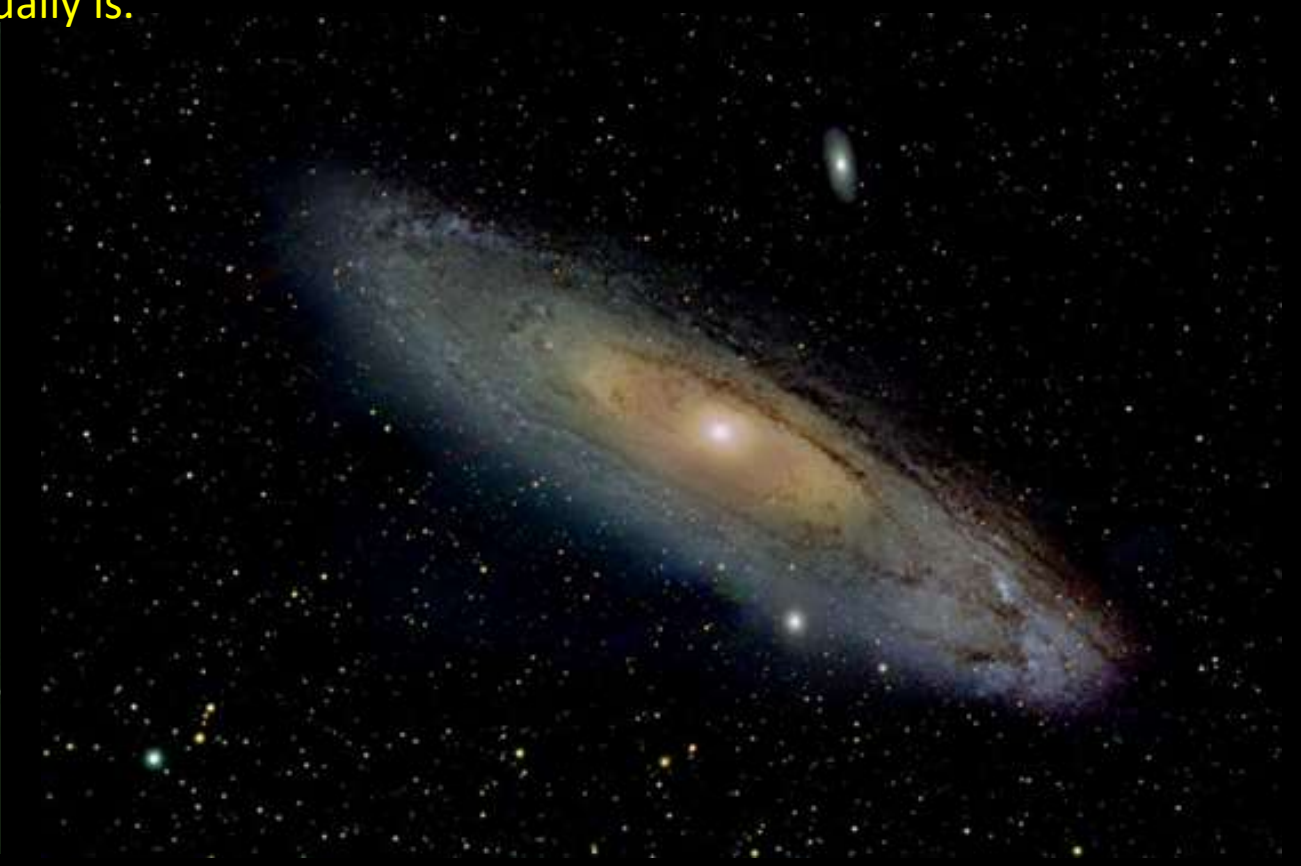
May 10th, 2025

If our eyes worked like an electronic camera … this is what M31 would look like compared to the Moon!

In reality, its not likely you would even see a starlike core of this galaxy at dawn or dusk.

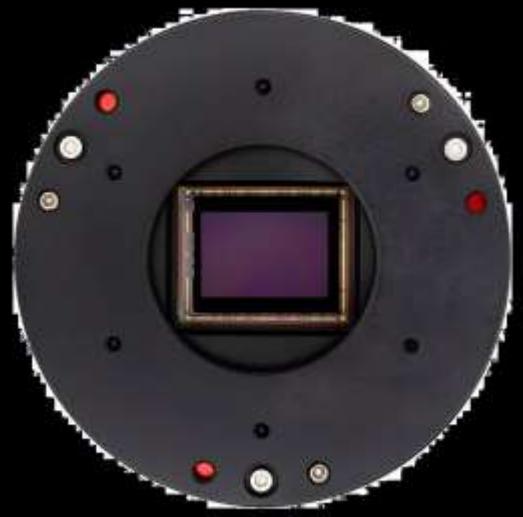
Fun fact - the Andromeda galaxy might be the furthest object you will ever see with your naked eye!

M31 spans about 220,000 light-years across and contains approximately one trillion stars. The galaxy is approximately 2.54 million light-years away from Earth and has an apparent magnitude of 3.4, making it visible to the naked eye under dark skies. But your eyes are not very sensitive to light. To them it appears as a diffuse, oval shape, with a slightly brighter center that may resemble a star. Even looking through a telescope you would not see much more than a fuzzy oval. Nothing like the incredible arrangement of swirling arms of stars and dust lanes that it actually is.



Still, human eyes are pretty incredible. The iris changes size to adjust to the relative brightness of a situation. In a very dark sky location, the human eye can see stars down to the 5th or 6th magnitude. But our eyes can only work over a limited range at a time. Our iris will narrow and our optical nerves respond to brighter light. They only handle a 100:1 ratio of brightest to darkest at any one time. It takes time for our eyes to "adjust" to the darkness.

We cannot perceive tiny differences or perform "time exposures" with our eyes.



Our electronic cameras are very different than our eyes! The camera sensor responds to individual photons of light and adds up the tiny amounts of charge that they deposit in each pixel of the electronic device.

A huge advantage of electronic imaging like this is that multiple frames of the image may be combined together by addition. As long as the numbers added were not saturated, the sum total will be an accurate "charge count" for the combined exposure time. Total exposure time can be extended to hours and days if desired.

We never "look through the eyepiece" of our telescope. It is setup for electronic imaging to make pictures to show all.

Electronic imaging reveals incredible details in the sky above.

Multiple images will need to be aligned/registered pixel by pixel if an accurate summation is to be made. Camera sensors have their own sources of “noise” that need to be dealt with.

The telescope and optics may have subtle defects that previously would have gone unnoticed by the human eye. Calibration techniques are necessary to achieve the best image quality.

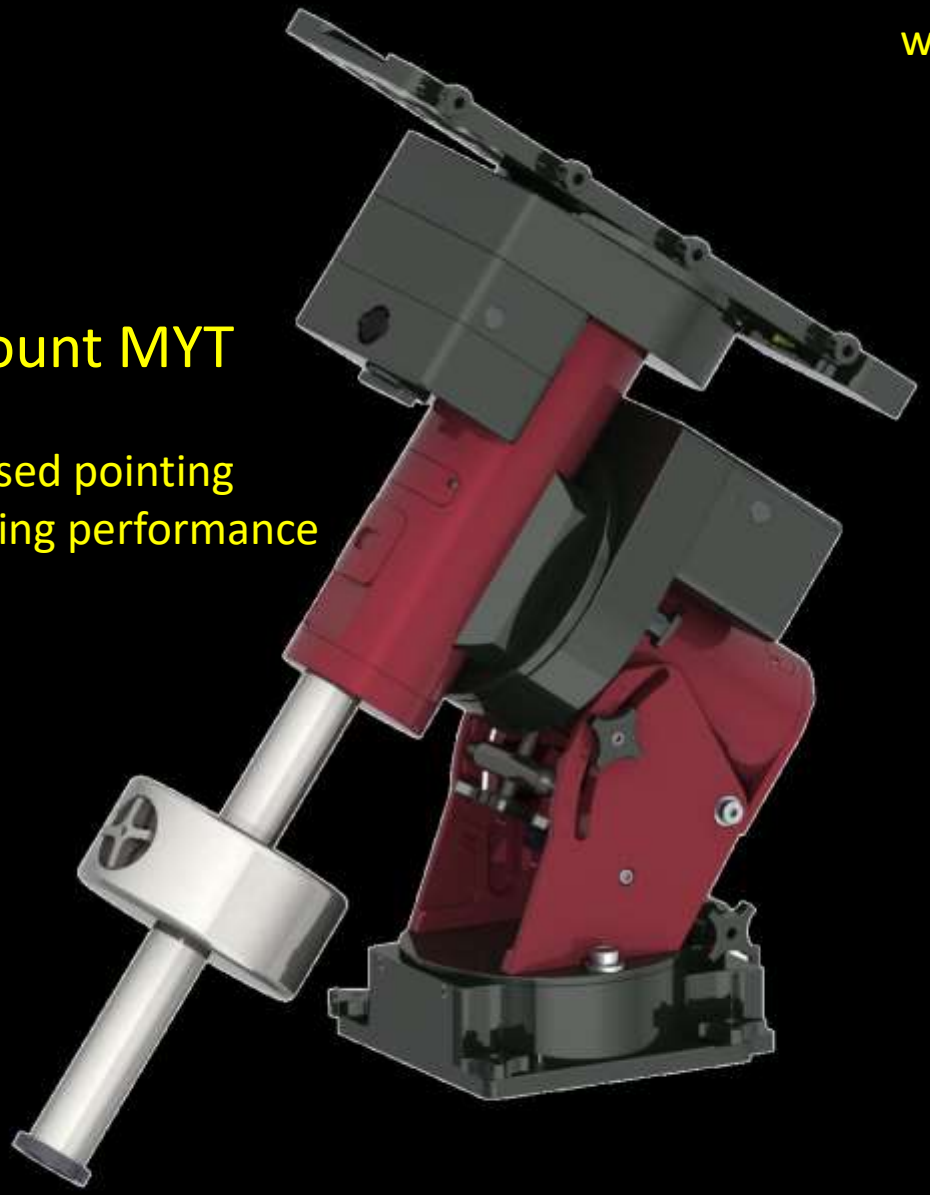
A final step, perhaps more art than science, is that the beauty of the objects needs to be displayed or printed in such a way that our limited eye CAN discern the details in form and color as the astrophotographer tried to convey.

YOU can learn to use the equipment here to study celestial objects in the night sky!

Our scope is a 5” refractor Stellarvue SVA-130, it gathers about 400 times more light than the smaller human eye.

Paramount MYT

unsurpassed pointing
and tracking performance

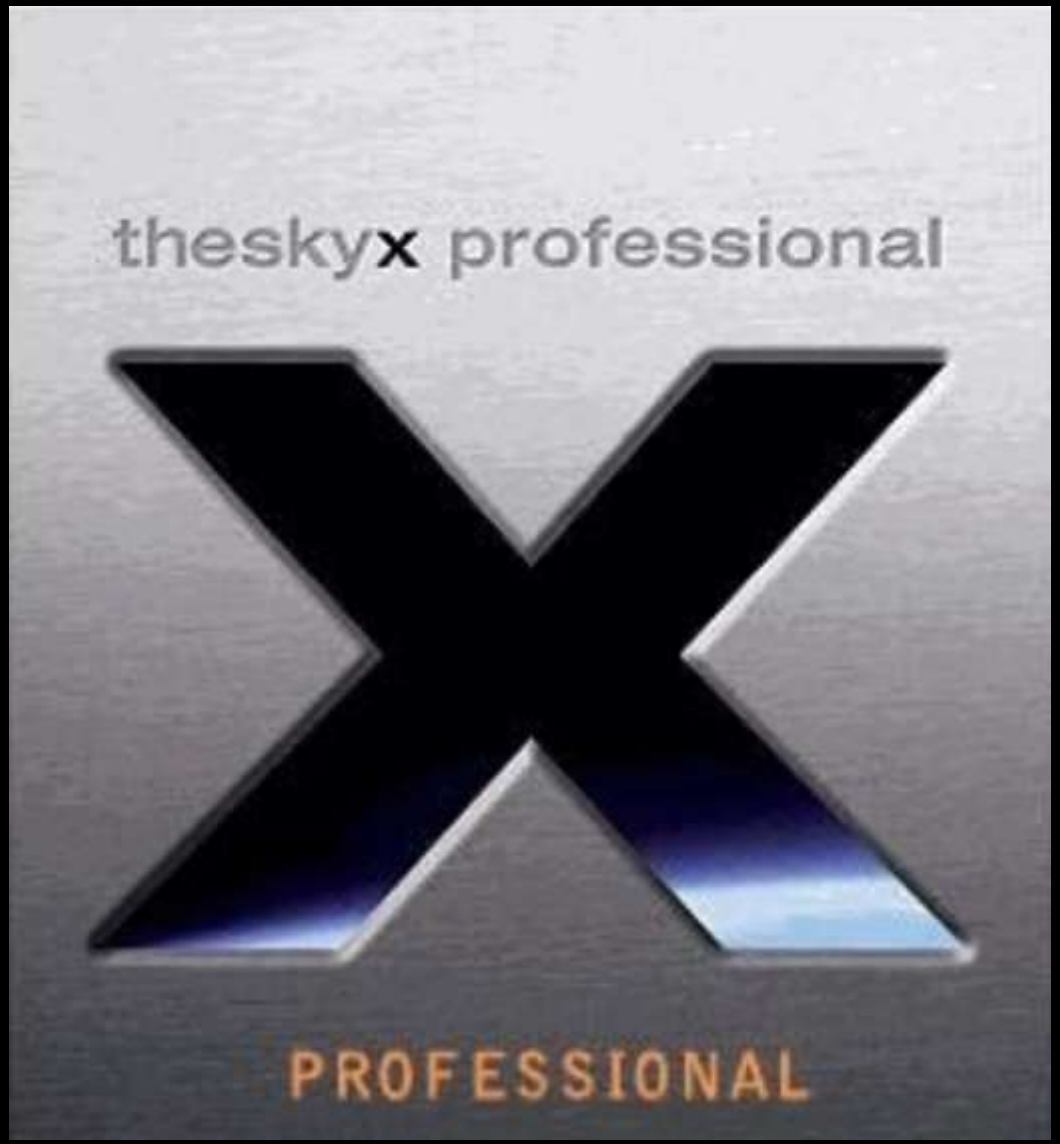


ZWO ASI2600MC PRO Color Camera
with 2-stage thermoelectric cooling

FOV
88.6 x 59.2 arc-min
(about 1.5 x 1.0 degrees)

Sensor	SONY IMX571 CMOS
Diagonal	28.3mm
Resolution	26 Mega Pixels 6248*4176
Pixel Size	3.76μm
Image area	23.5*15.7mm
Max FPS at full resolution	3.51FPS
Shutter	Rolling shutter
Exposure Range	32μs-2000s
Read Noise	1.0-3.3e
QE peak	Above 80% (OSC) Around 91%(mono)
Full well	50ke
ADC	16bit

Software Bisque (software publisher)



ASCOM (Astronomy Common Object Model)
a set of API specifications for astronomical devices and applications

The SkyX software integrates control of all of the observatory components using ASCOM standard drivers running on a 64-bit Windows computer.

Getting Prepared!

When you come to the Harken Observatory, you will use the telescope and camera to gather images of your choice. There are step-by-step procedures for opening the observatory dome, starting up the equipment and commanding the telescope to point to your desired target in the sky.

But what will you image? Prior to coming to the observatory, you might wish to do a bit of planning.
Is the object of interest in the current night-time sky? When does it come up over the eastern horizon? Is it high enough over the horizon to be above the trees and buildings of Pewaukee? Is it now so late that your desired object has fallen *below* the western horizon?

There are many resources available to you on your PC or phone to simulate what is up in the night sky with you.
Popular free planetarium software includes Stellarium, KStars, and Cartes du Ciel.
Stellarium is known for its well-structured interface and wide use. KStars is another free, open-source option with a strong focus on accuracy and simulation of the night sky. Cartes du Ciel is another popular option available on various platforms.

Each RAW image file that you will take requires about 51 megabytes in storage space! You will be going home with Gigabytes of data! You will need to have your own, personal flash drive/memory stick to take your image data home with you for image processing. Free image processing software will be demonstrated in this presentation.

There is an observatory start-up and shut down checklist that has existed for a few years. We will endeavor to expand that to an illustrated “operations manual” over the next few months. Pictures of the equipment and screen shots of the observatory computer screen for each step will be helpful. At this point in time, club members all have some familiarity with these processes. A club member who is also a library key holder must be present to use the equipment.

We don’t currently have a defined process for scheduling use of the observatory. Appointments will be necessary to ensure that a trained club member/key holder is available. Of course, the weather needs to be cooperative!

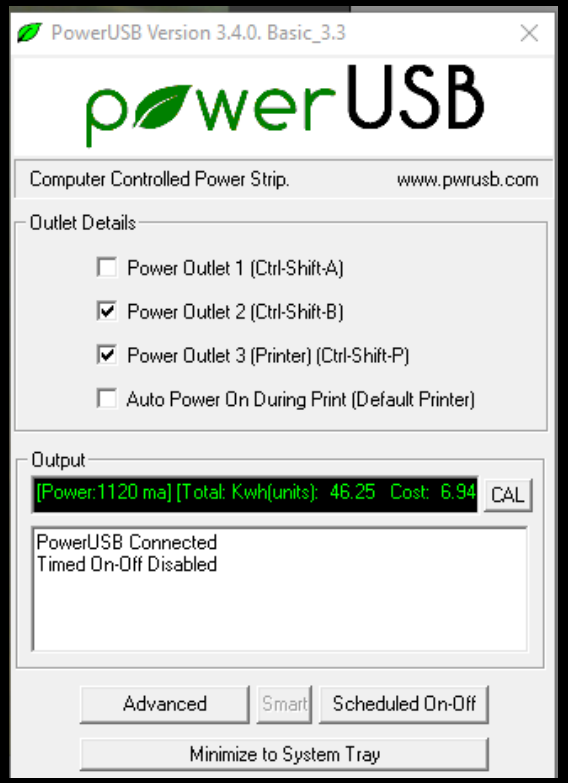
We are organized as the he Pewaukee Astronomy Club (http://pewaukeeastro.com). Its free for anyone to join. The club meets the second Monday of each month (next meeting is May 12th) at 6:30PM in the conference room of the library. Contact Mike Paquette at the email address below.

Steps to Take Images (after physical opening of the dome)

The computer, display, keyboard and mouse are located within a rolling wooden cabinet that is parked beneath the spiral staircase that leads to the dome. Observing sessions are typically done from the Pewaukee public library multipurpose room which is handicapped accessible. The spiral staircase and the ship's ladder to the dome are not handicap accessible. There is no reason why anyone who wants to use the observatory would need to make those climbs. Keyholders are expected to facilitate the public in this regard.

Roll the cabinet out from storage into the multipurpose room. Plug the power cable into the nearest library electrical outlet. Be careful not to "run-over" the data cables that attached to the cabinet. The cabinet must be unlocked by a keyholder.

Turn on the computer and wait for it to startup.
Find and open the powerUSB app on the computer desktop.
Click on the checkboxes labelled Outlet 2 and Outlet 3.



Outlet 2 turns on a service light up in the dome that is useful to see if the telescope is pointed at the open dome shutter.

Outlet 3 turns on power to the telescope mount, cameras, dome control and communication hardware that is in the dome. This must be turned on before starting The SkyX program.

Steps to Take Images (continued)

Next startup the iSPY app on the desktop. This program will connect a web camera that is attached to the front of the telescope facing the dome. With the service light on, this camera will show that the telescope and dome are rotating when they should be and that the telescope s pointing out of the dome through the open shutter.

You may size and drag ths window as you wish.

Remember to turn Outlet 2 (service light) OFF again before you image.

You are now ready to startup the SkyX program. Click on the desktop icon.

Startup the Telescope using SkyX

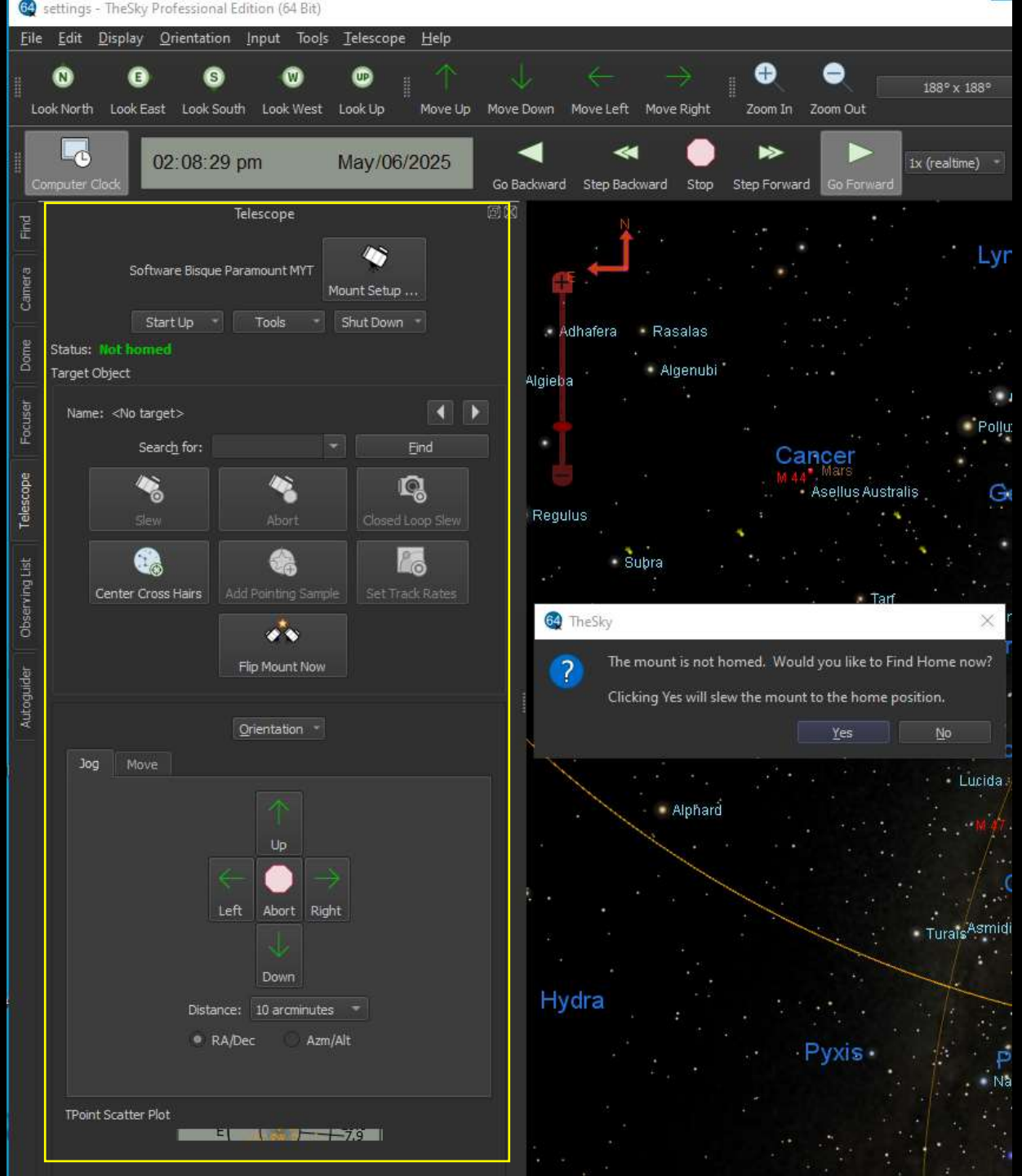
The upper left corner of the SkyX desktop is shown here -→ There are tabs down the left side of the screen. Locate the tab labeled “Telescope” and click on it. Under it, you will see three tabs: Startup, Tools and Shutdown The enclosed area will change to show telescope items. At this point, the scope is not yet connected. Click the “Startup” button.

The status is probably “Not Connected” . We need to connect the software to the telescope, so click on Telescope > Connect.

After a few seconds, status should change to “Connected”.

Another message will likely pop up saying that the telescope is not “homed” and ask if you want to find home. Answer yes to this question. This directs the telescope mount to move to its internal, factory calibrated mechanical position. The mount contains a GPS receiver and is capable of pointing to any visible object in the sky after that.

After finding home position, status will read as “Tracking at sidereal rate” (appropriate for stellar objects)



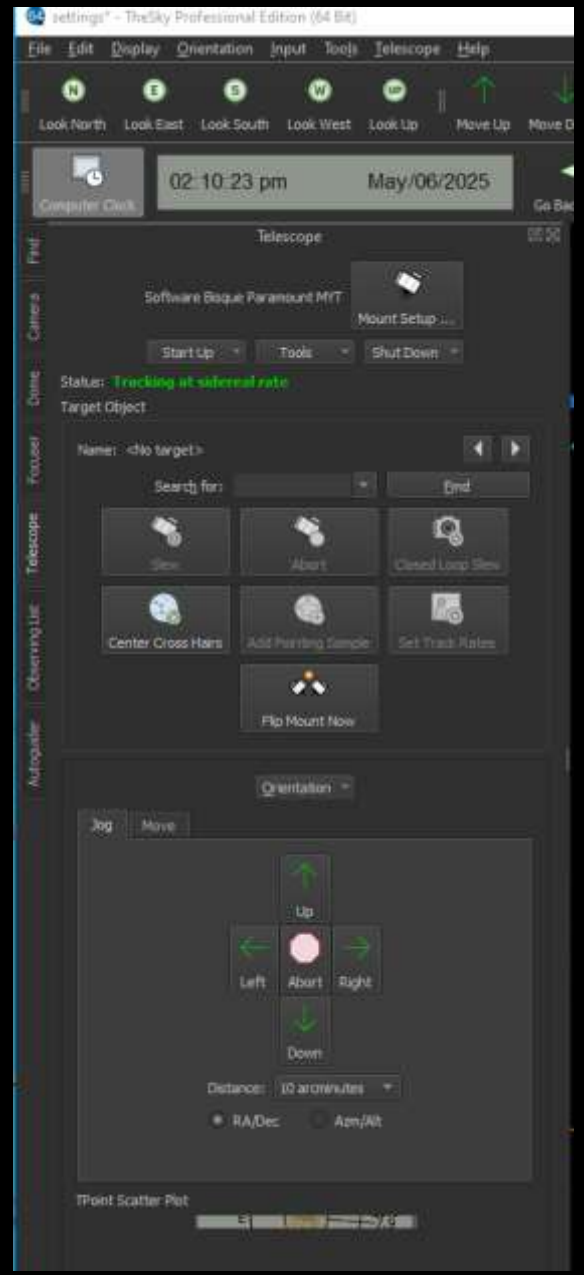
Telescope *not* connected

under Start Up: Telescope > Connect

Telescope is connected but needs to find Home before can track

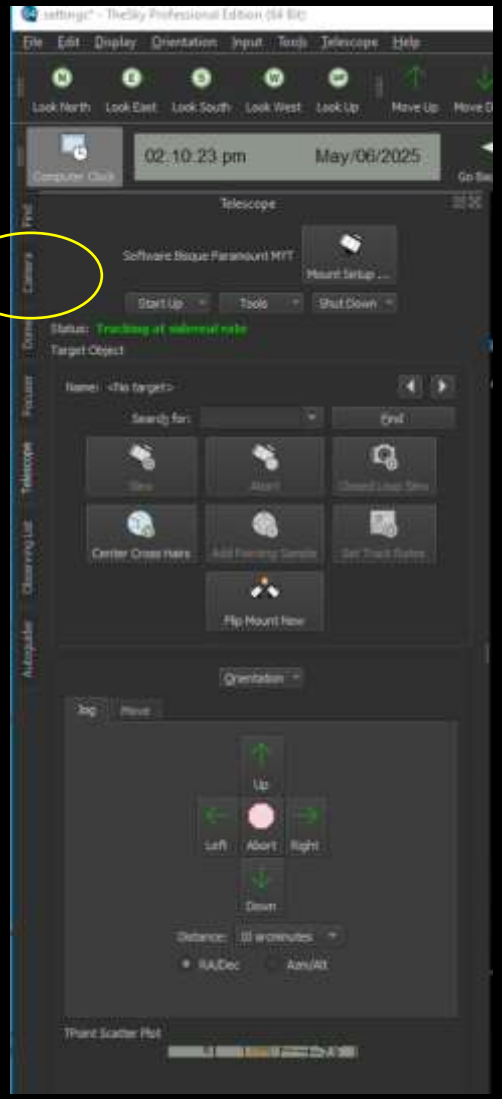
under Start Up: Telescope > Home

Telescope is connected and tracking

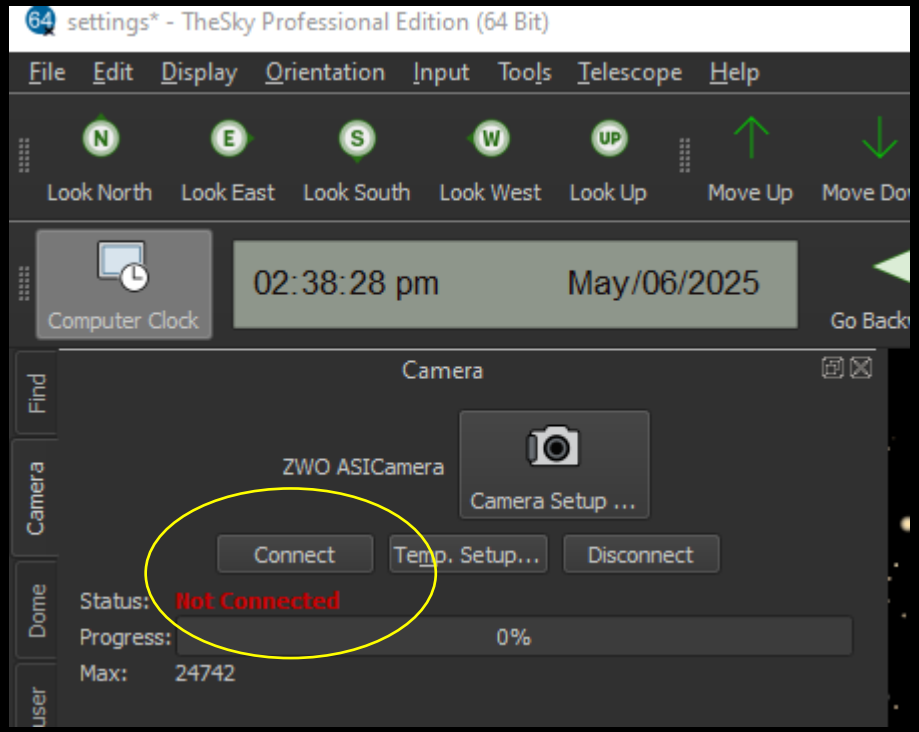


Ready for object selection

Connect the Camera to the SkyX software



Click on the Camera Tab

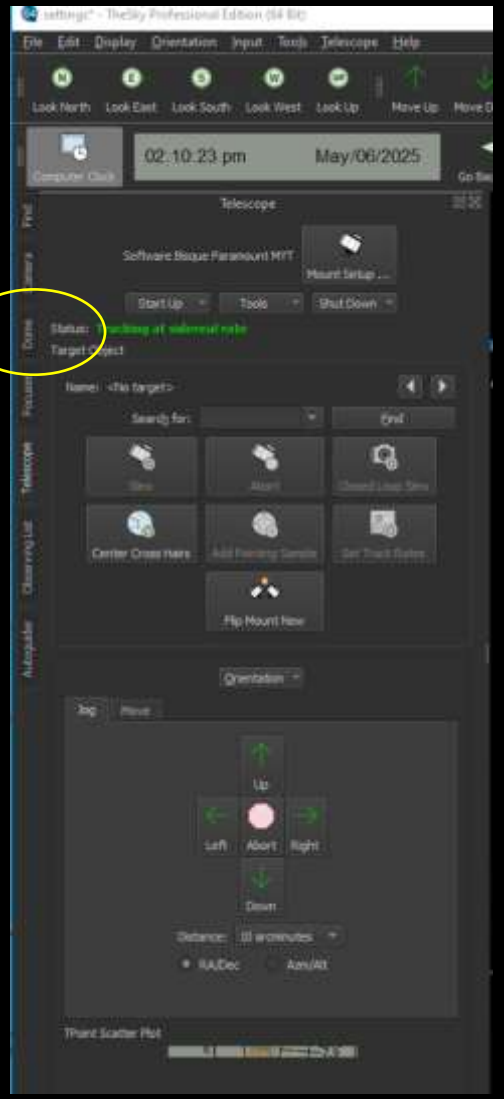


Click on “Connect”

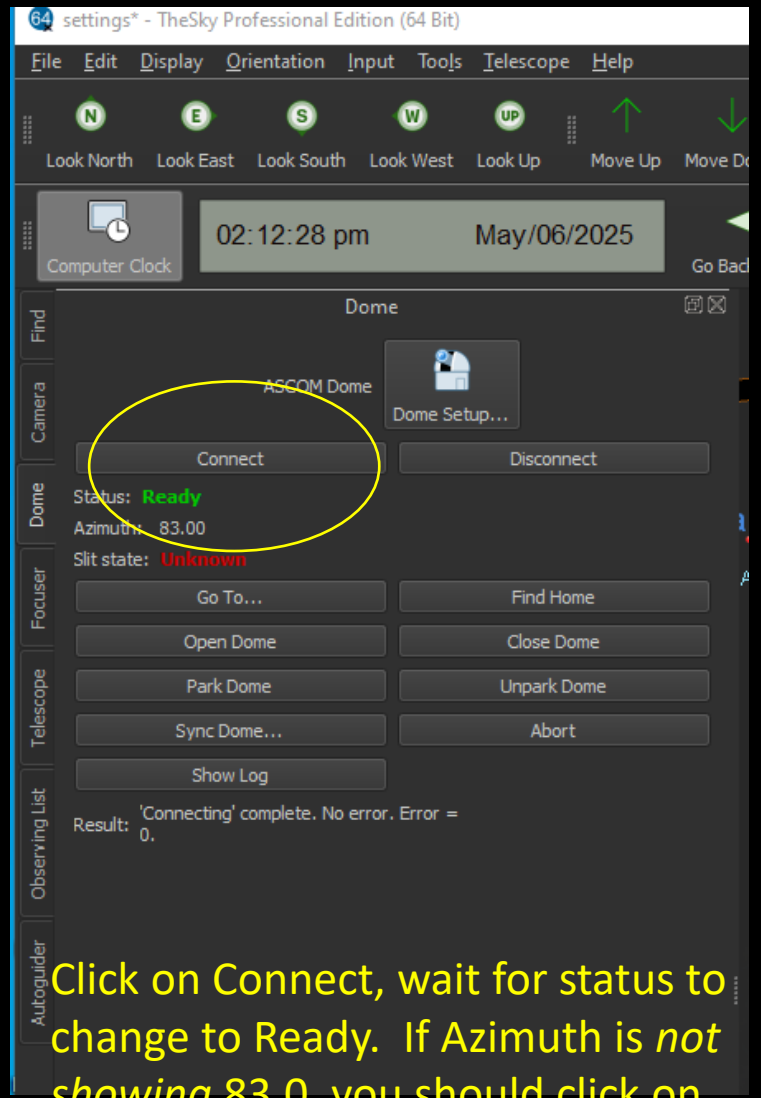
Camera Status will change to Connected

Our ZWO ASI2600MC is a thermoelectrically cooled camera. The temperature of the imaging sensor will be regulated to about 0 degrees C automatically. Actual temperature values will be included in the FITS image file header.

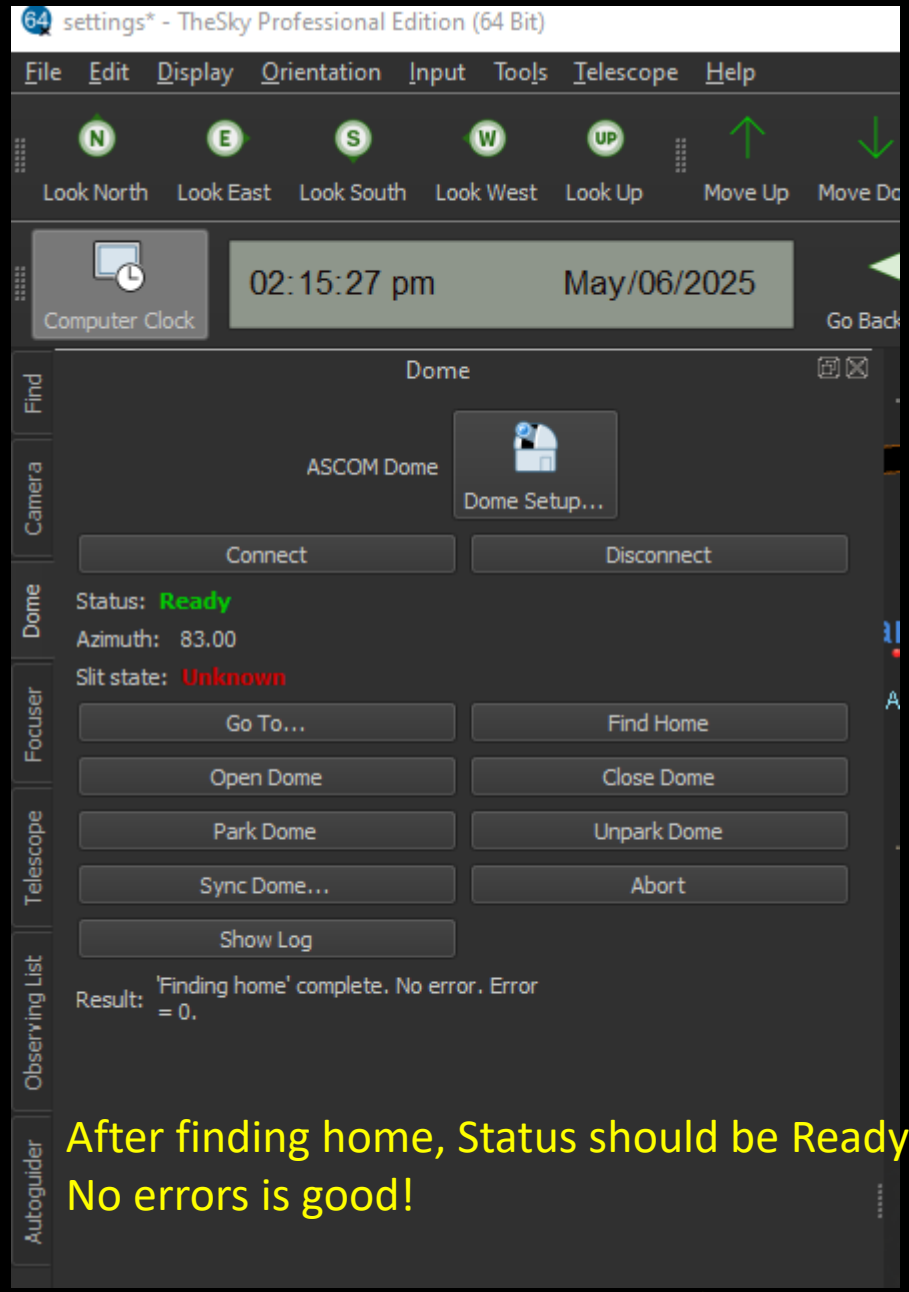
Connect the Dome to the SkyX software



Click on the Dome Tab



Click on Connect, wait for status to change to Ready. If Azimuth is *not showing* 83.0, you should click on "Find Home". (may take a while as the dome may rotate up to 360 deg)

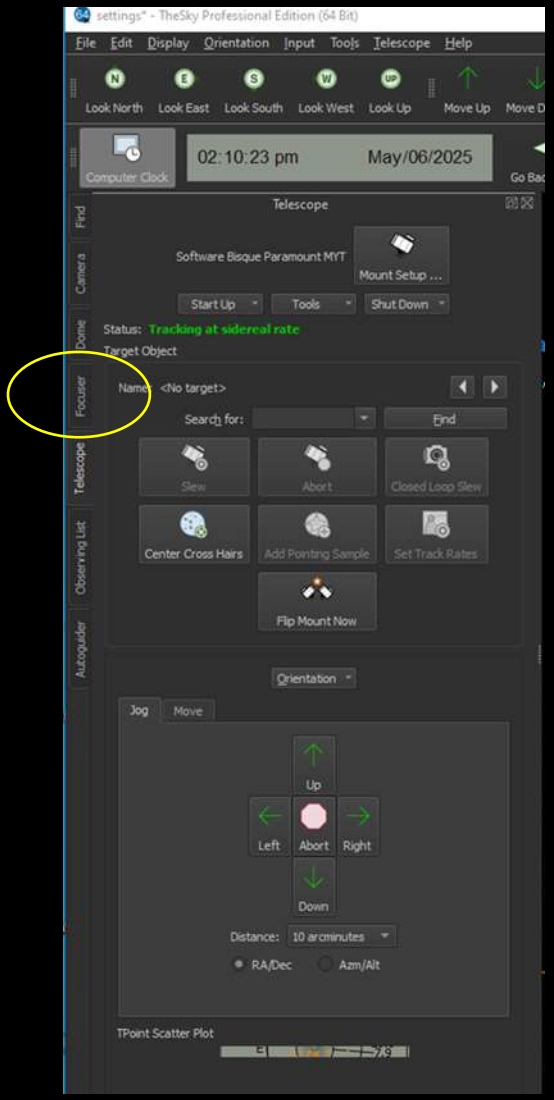


After finding home, Status should be Ready. No errors is good!

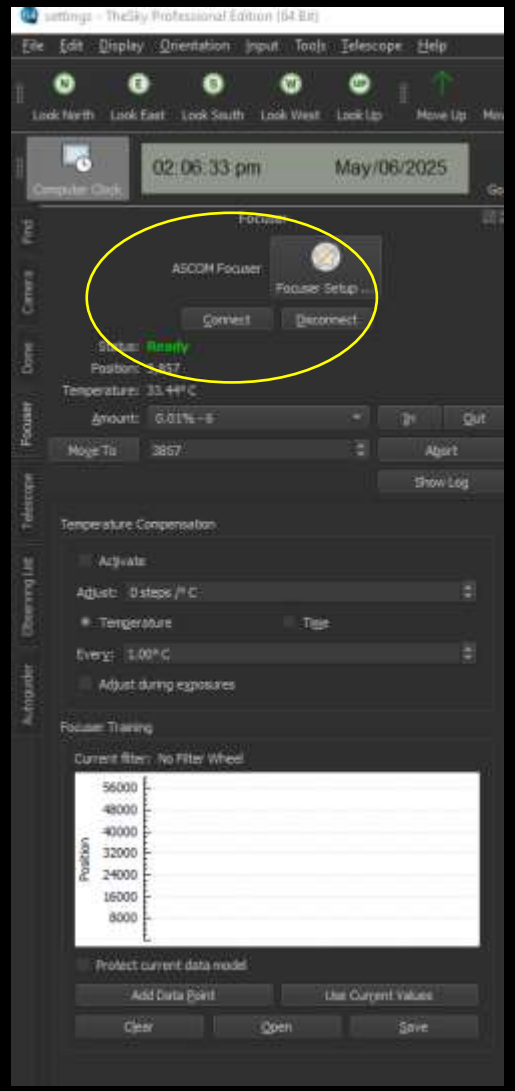
Need to check that dome is sync'd to scope -RB

Connect the Focuser to the SkyX software

The observatory has computer controlled, automated focusing and a motor to adjust the focus knob (Microtouch)



Click on the Focuser Tab

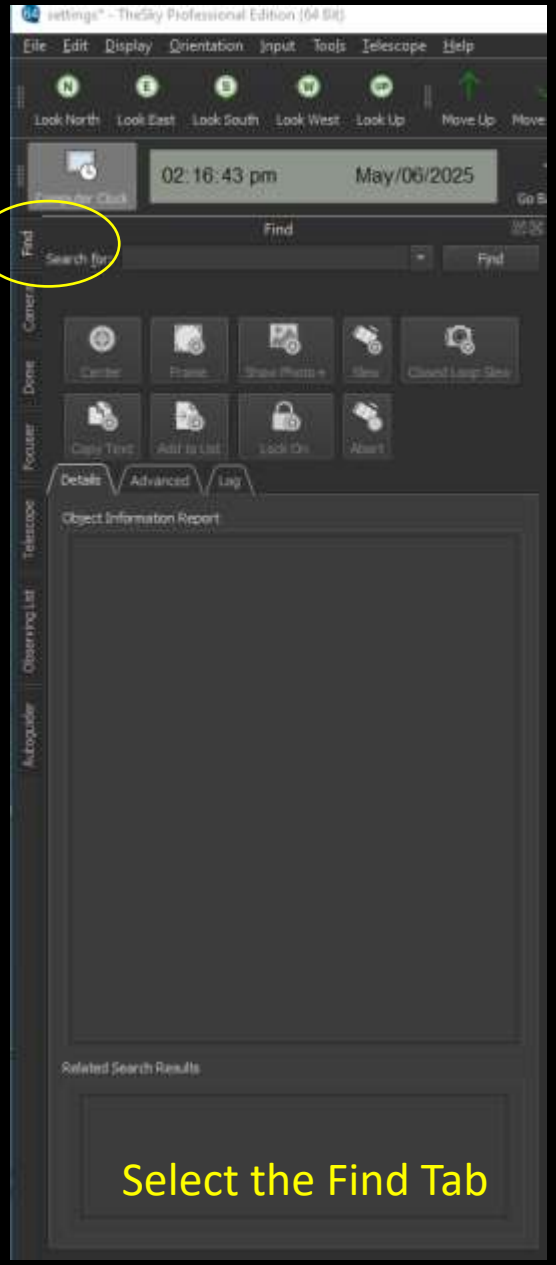


Click on “Connect”

The Focuser Status will change to Ready and the position of the focuser will be displayed.

The process of starting an automated focus adjustment will be described later. Generally, for a given observing session this only needs to be done once at the beginning of your session. The focus of the telescope on stellar objects is not dependent on the object as much as the temperature of the telescope. Focus will be different in the summer than on a cold winter’s night when the length of the scope has contracted a fraction of a millimeter.

Ready to Select an Object to Image – Find by Name



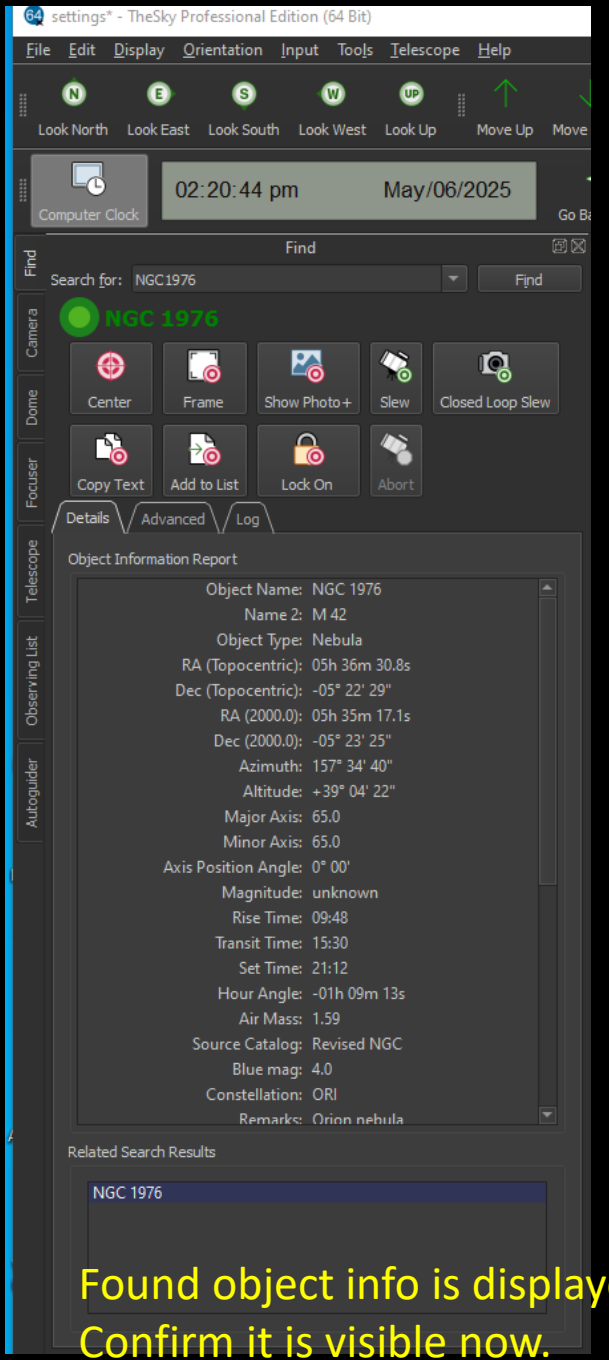
One way to find an object is to enter its *name* (e.g. Aldebaran) in the ***Search For*** text input. You can enter the names of comets, minor planets, and auxiliary objects that appear in any active Sky Database. You do not have to know the correct spelling. The Find command shows you matching names.

Ready to Select an Object to Image – Advanced Searches

Finding by Object Type

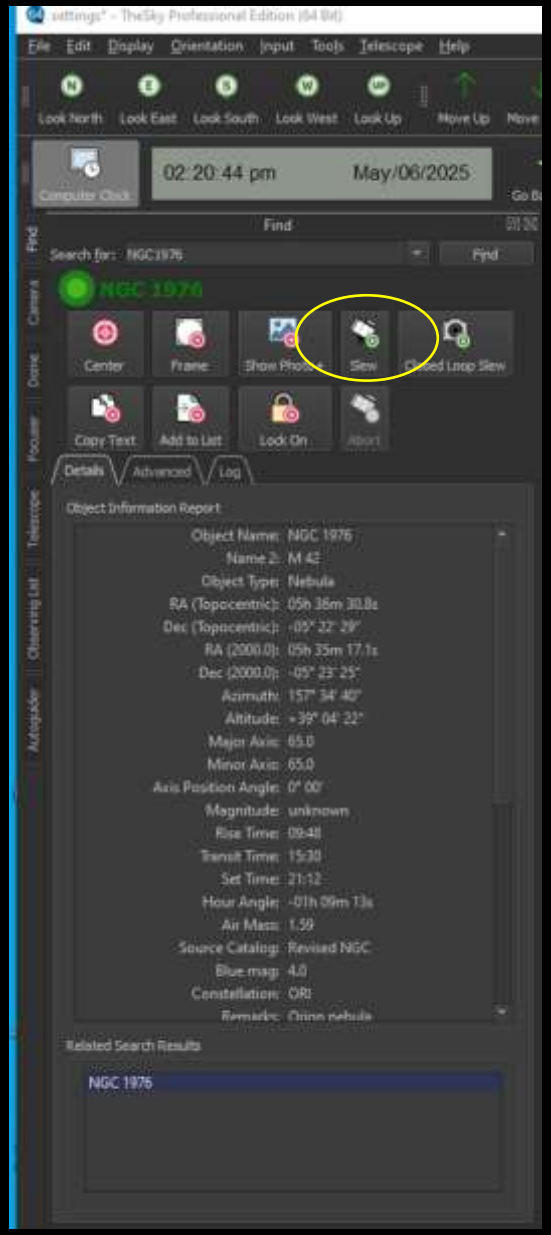
Objects are categorized by type in the Find by Name or Catalog Number list on the advanced tab of the Find window. Example: type NGC1976 or M42 in search for line… and click on Find.

Object Type	Catalog/Cross Reference	Description
Non-stellar Objects		Lists databases of non-stellar objects.
	Caldwell	Caldwell Catalog objects.
	Common Names	Names of common non-stellar objects.
	Herschel	Herschel 400 catalog.
	IC	Index Catalog.
	Lorenzin	Tomm Lorenzin Catalog.
	Messier	Messier Catalog.
	NGC	New General Catalogue.
	PGC	Principal Catalog of Galaxies.
	PGC cross reference	Cross references to the Principal Catalog of Galaxies.
	PLN	Planetary Nebulae.
	SAC*	Saguaro Astronomy Club Deep Space Object catalog.

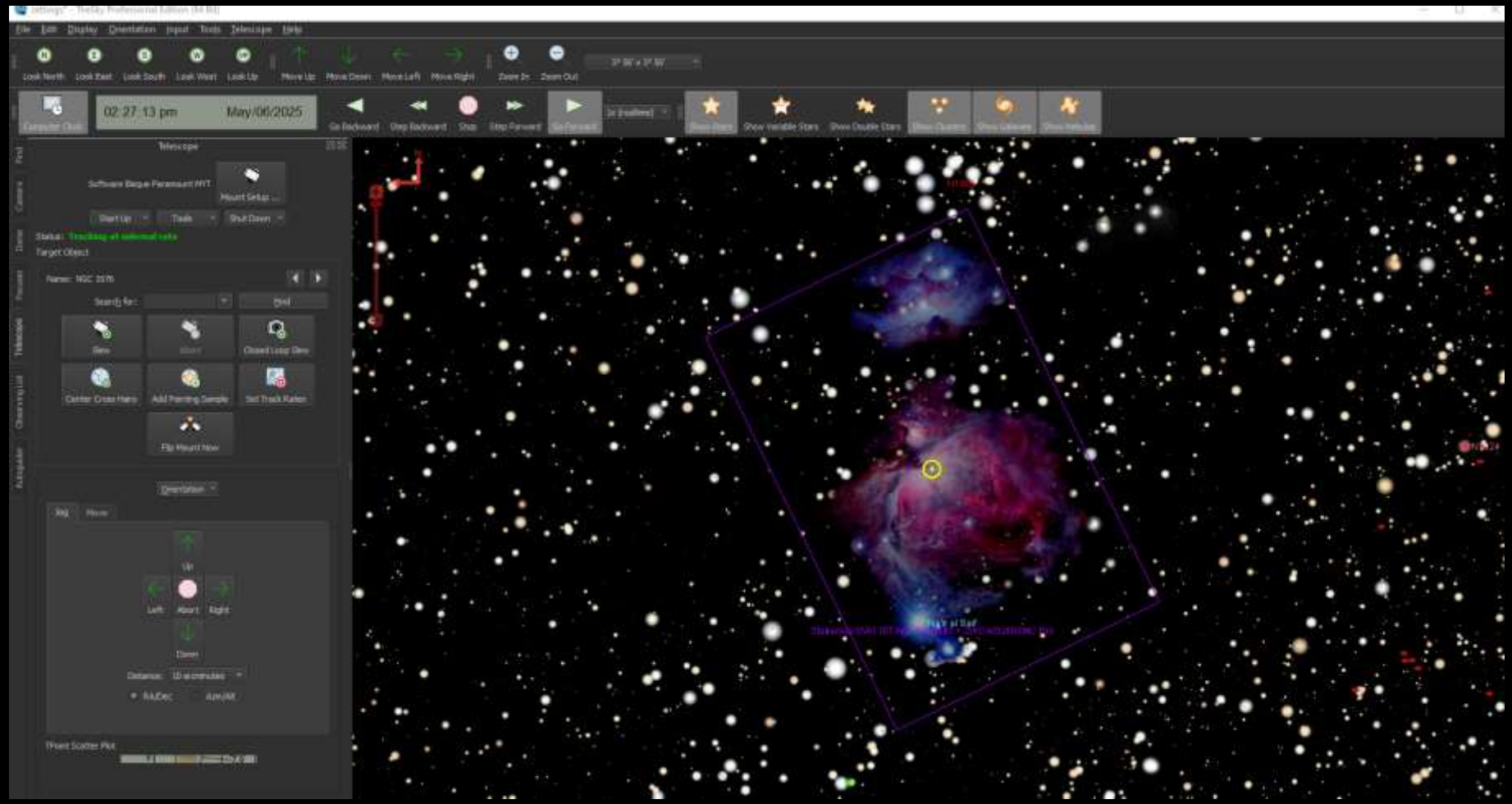


Found object info is displayed. Confirm it is visible now.

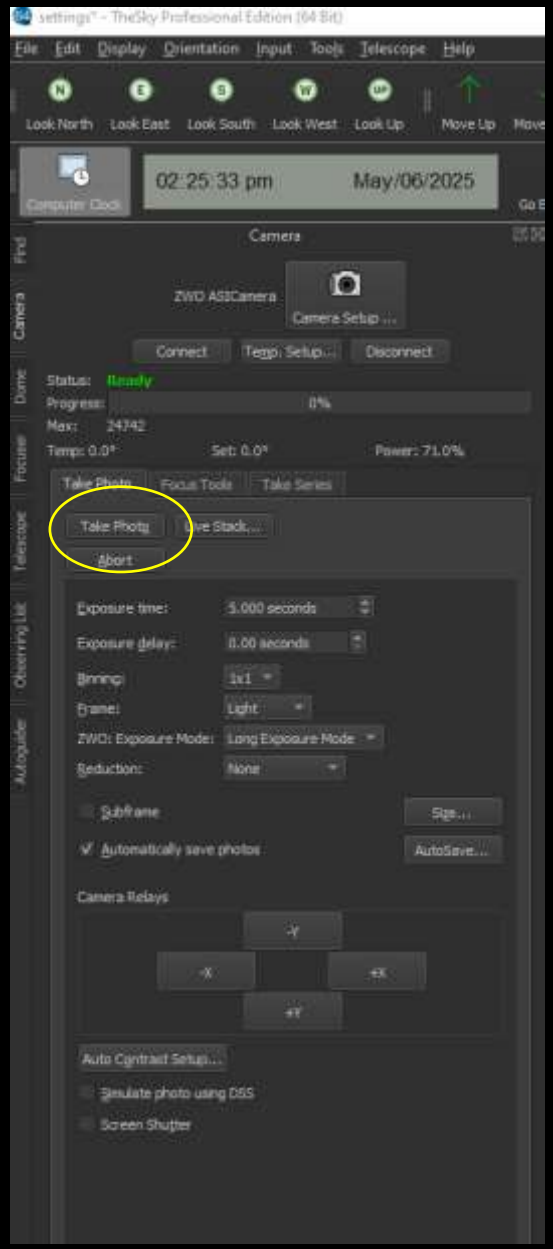
Target Selected – tell the mount to point the telescope there



Click on the “Slew” button and the telescope will point to the catalog coordinates.
The skychart of the program will update as the telescope is moving. The pointer on the chart will show where the telescope is looking. The mouse wheel allows one to zoom out and in.
When zoomed in far enough, a box representing the camera field of vew will be displayed.



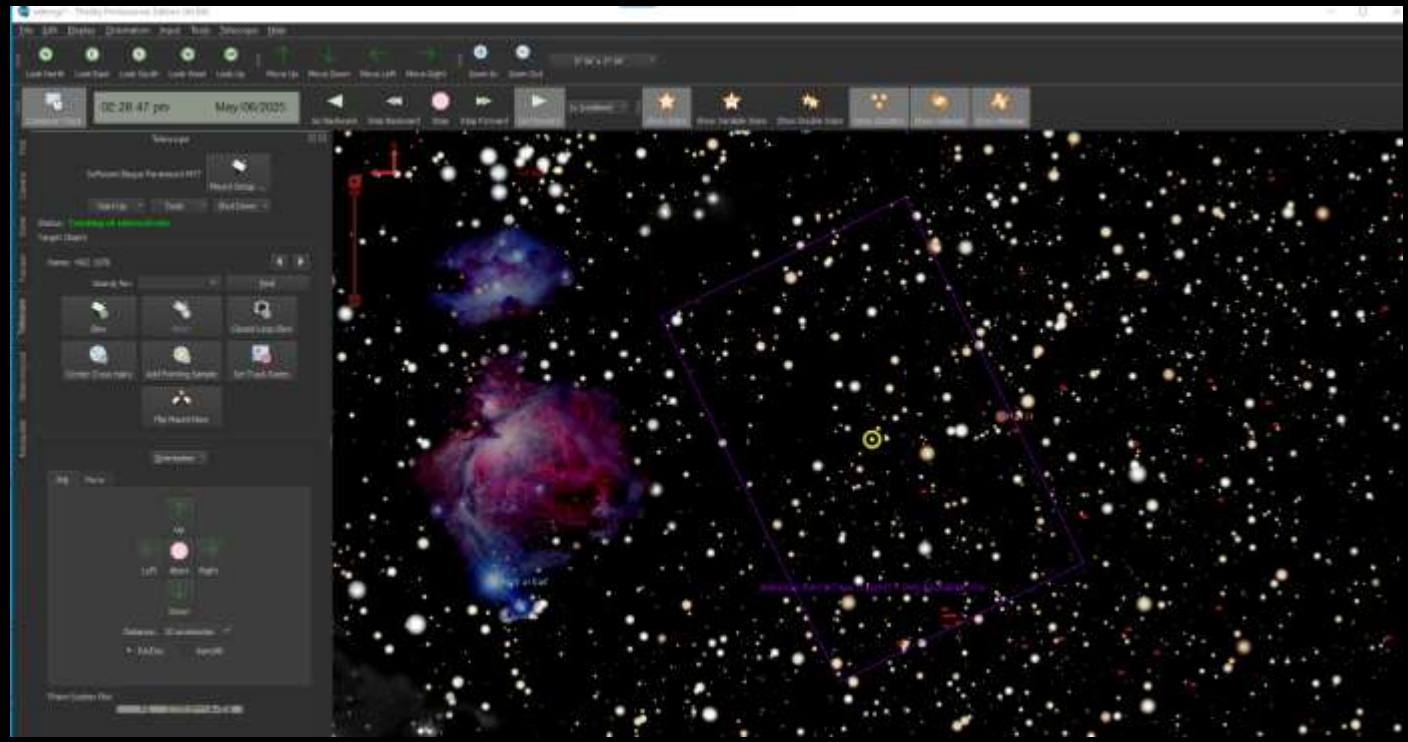
Target Located – Take a trial camera exposure to confirm and prepare for optimal focusing



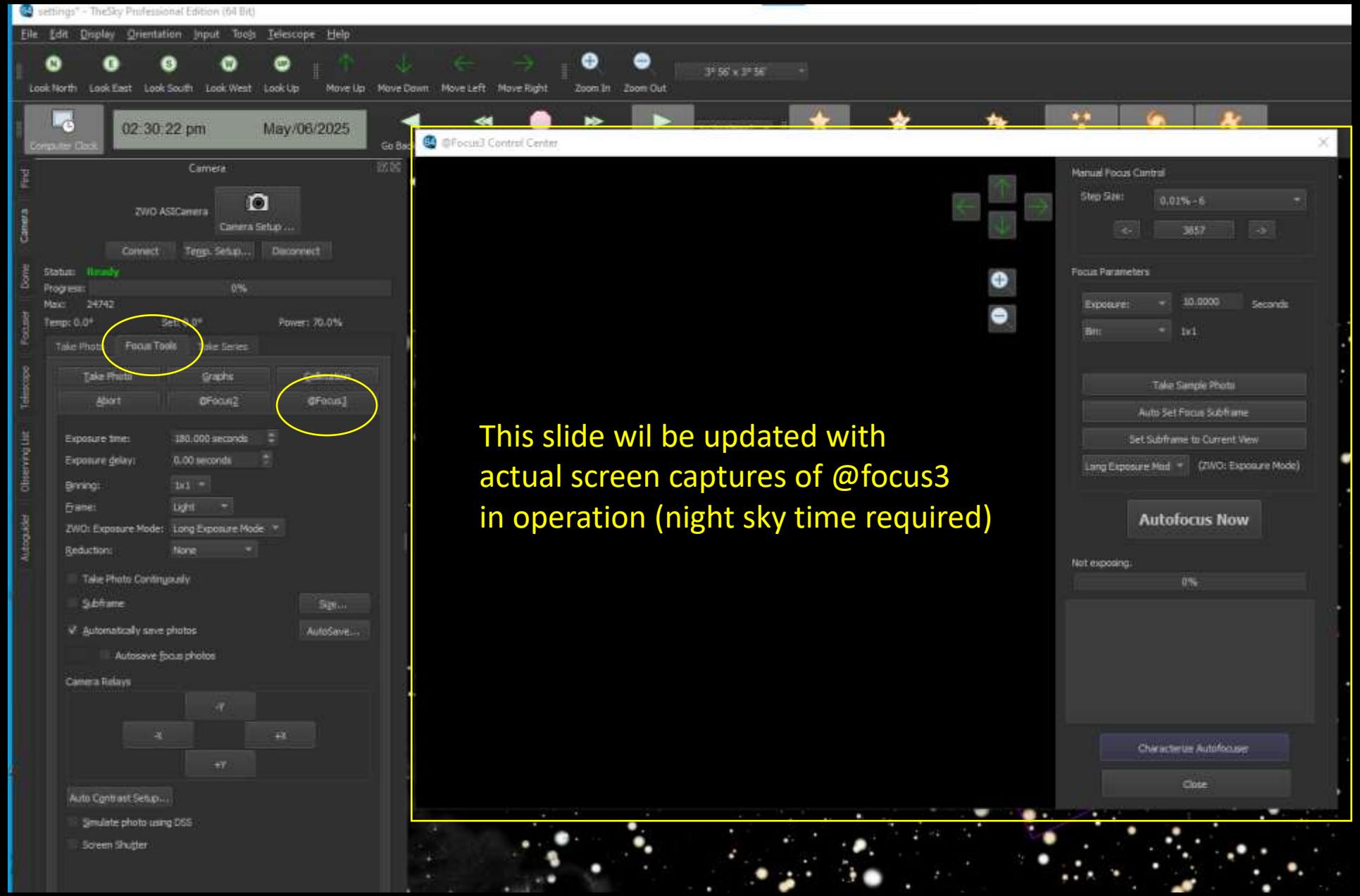
Back on the Camera Tab, on the Take Photo sub-tab, enter an appropriate short exposure time. Make sure the frame type is set to “Light”. 1x1 Binning is normal. Click on “Take Photo”.

The progress bar will fill during the exposure duration. Shortly after that an image will be shown. Is it what you want to image? Is the focus good? This may be a good time to perform an auto-focus operation. SkyX can automatically make the stars as sharp as possible, but it might be confused when looking at a diffuse nebula such as NGC1976. I often nudge the scope a little to the side to a star-only frame for the focus step.

Use the “jog” buttons on the Telescope tab and additional trial exposures until only stars are visible.



Using @focus3 on the Camera Tab -> Focus Tools sub-tab opens @focus3 Control Center Window



Select an exposure time for focus images and take a Sample Photo

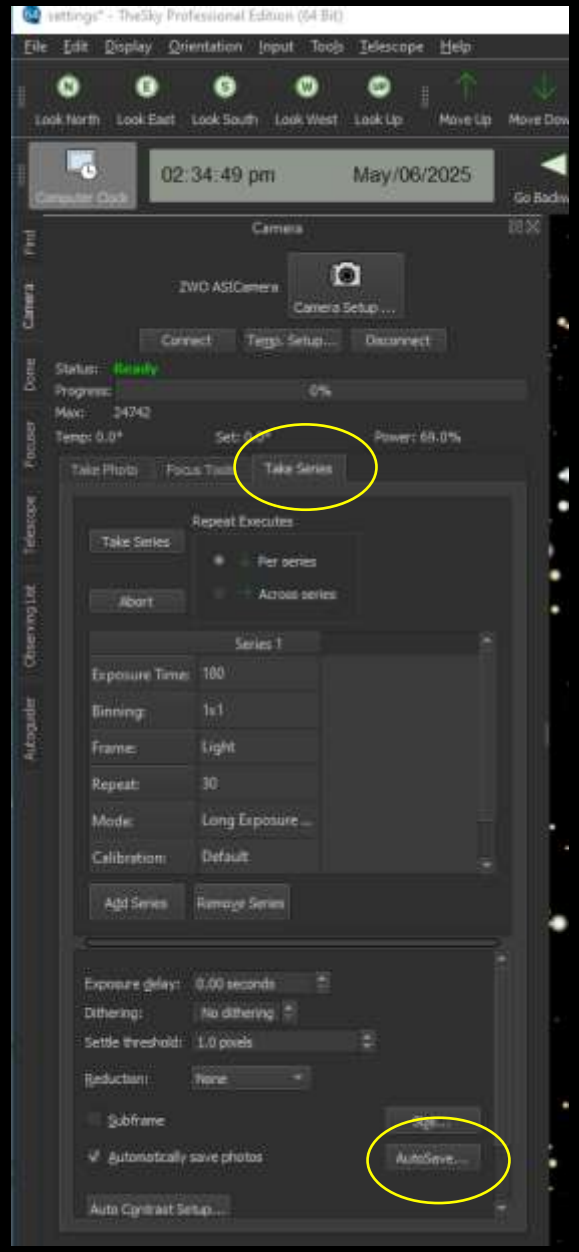
Click
Auto Set Focus Subframe

Click Autofocus Now

This process will take some time to complete. A range of focus settings will run and sharpness will be optimized.

Allow this process to complete. The best focus setting will be retained and used going forward.

Take your Final Target Images – Take Series and AutoSave the Image Files



"Take Series" is the third tab under the Camera Window. Multiple series may be defined.

Exposure Time – it is important that nothing of interest is saturated. For brighter objects (like the moon) this time may be milliseconds. 180 seconds is a practical max in Pewaukee.

Binning – 1x1 means every pixel is used, 2x2 means 4 pixels are combined to one

Frame type – Light used for images, Bias, Dark, Flat are used to tag calibration frames. The type flag is stored in FITS header. Programs like SIRIL can read these and automatically process the calibration data and apply calibrations to the Light frames.

Repeat count – How many times to take the same frame. For Light frames, your total exposure time is Repeat count x Exposure Time . (40) three minute exposures is 120 minutes. For Dark, Bias and Flat frames where the goal is to characterize the noise *statistics*, 30 frames is sufficient. More on calibrations later.

The AutoSave button is used to setup how the frames are to be named and where they are to be save. Our convention is to put all images under the PAC folder, under a calendar date sub-folder. File names are automatically created from the Object name and Time.

To start the Series, click on "Take Series" button under "Repeat Executes".

Take your Calibration Frames – Take Series and AutoSave the Calibration Files

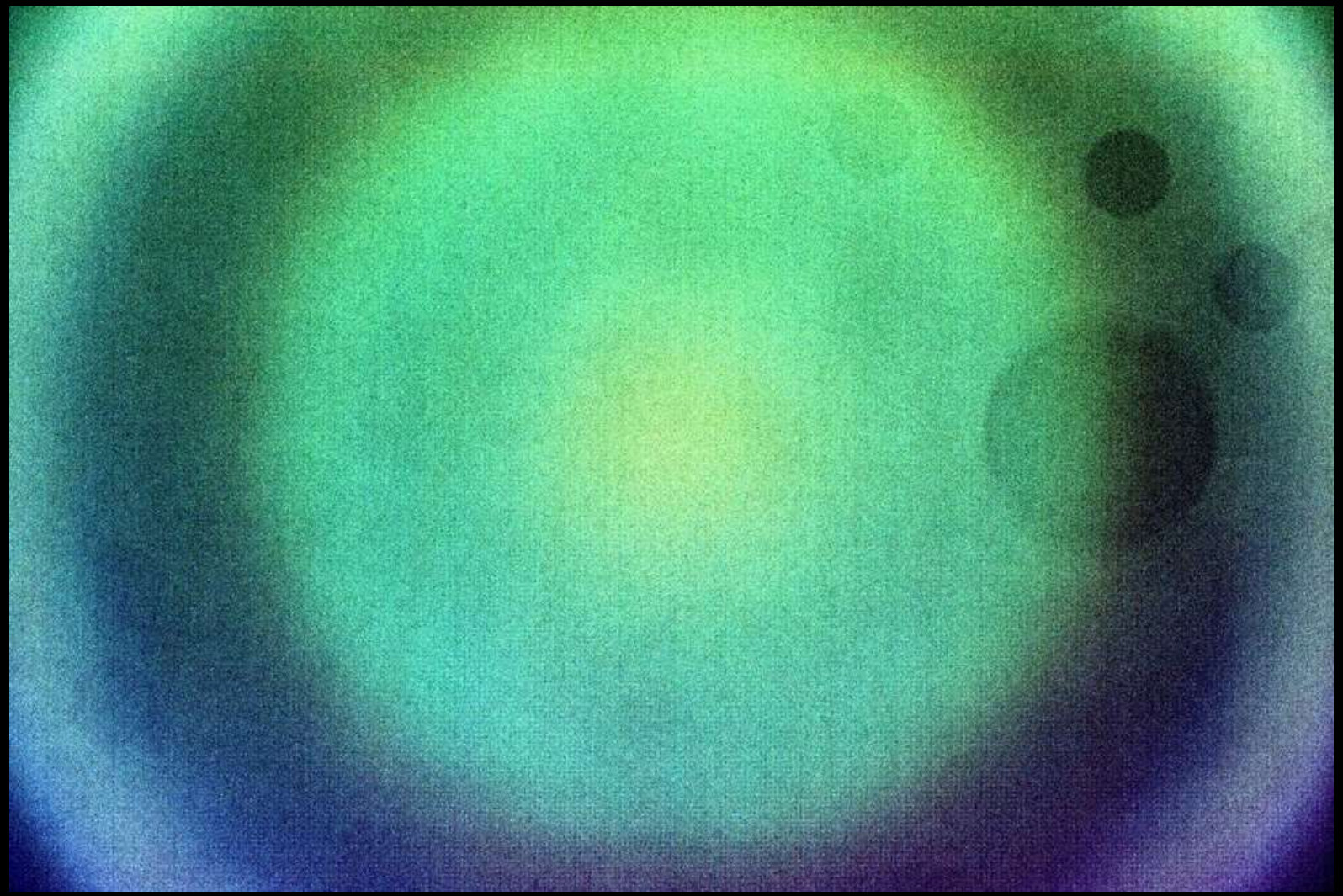
You now have waited for your image series to complete. Depending on what you are doing, it may take hours! Hopefully, no clouds have drifted across your target in the sky. Don't be surprised if a satellite or airplane has painted a bright line across some of your frames. If the dome is setup to slave to the telescope tracking correctly, it should have moved to keep the slot aligned. You are getting sleepy and thinking about skipping those calibration steps…..

DON'T! They *are* necessary!

Flats and Bias Frames don't take too much time to complete. Flats correct for "dust devils" which can change day by day. Dark frames correct for temperature and time dependent noise from the camera chip. It helps that our camera is temperature regulated. Your dark exposure time must match the light exposure times. Compromise in number of repeats only if you must. Standardized exposure times will increase the probability that a recent, useable dark frames could be found on the computer.

In the same way that you setup a Series of Light frames in "Take Series", setup and execute a series of 30 repeats for Darks, Bias and Flats. A fixture has been created to attach to the front of the telescope to facilitate calibrations. It is a "lens cap" to which a flat light source has been added on the inside surface facing the lens. When powered, it produces a very uniform illumination for the flat field frame creation. Flat exposure time using it is only 0.1 second.

Flat Calibrations are the most important as these defects are the most serious



Vignetting is a gradual darkening towards the edges and corners of the image, considerably different from the center of the image. It is caused by limitations of the telescope lens/optical path.

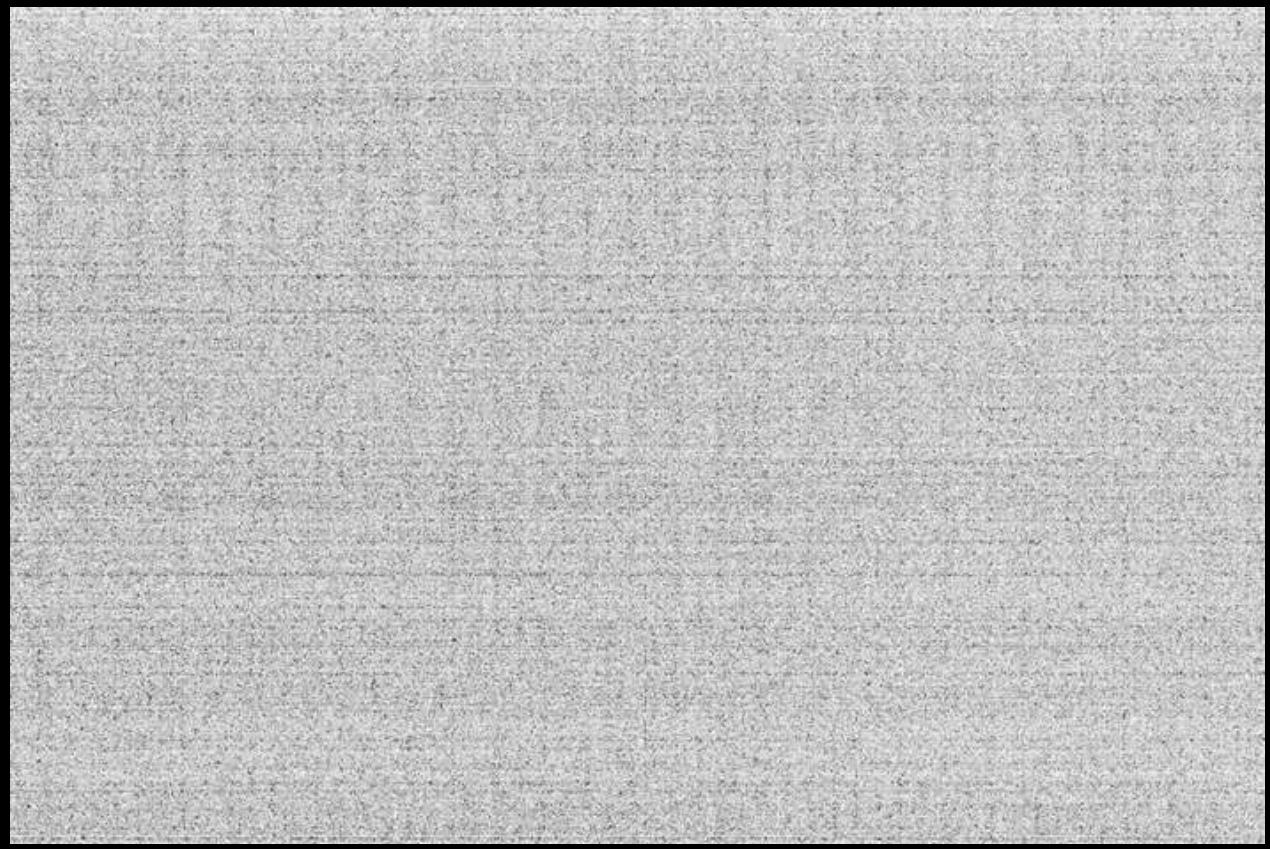
The dark circles are caused by dust specs and sometimes are referred to as dust devils. It is almost impossible to remove all the dust that may fall on any of the optical surfaces.

Creating a master flat and applying it to the lights will get rid of these artifacts.

Dark Noise and Bias (Readout) Noise are less noticeable, but detract from the image.

Above: Example of “Dark” Noise – exaggerated here to show a grey baseline “average” level that could cover up faint details. Also see “hot pixels” that could be mistaken for stars. This noise is a function of temperature and time.

Below: Example of “Bias” Noise – exaggerated here to show spatially periodic structure. It is caused by the electronic readout of the imaging chip. Readout noise has been greatly reduced in today’s newer devices.



Newly built calibration tool fits on scope in place of the lens cap of the telescope.

Electroluminescent panel mounted inside of a replacement dust cover. Silver box is its power supply. Turn it on by plugging in 12VDC power cord coming from the Paramount accessory outlet into the silver box.

Power is connected for flat generation, un-plugged for darks and biases.

Handle this tool carefully!

When gathering Light images remove it from the front of the telescope as you would remove the lens cap.

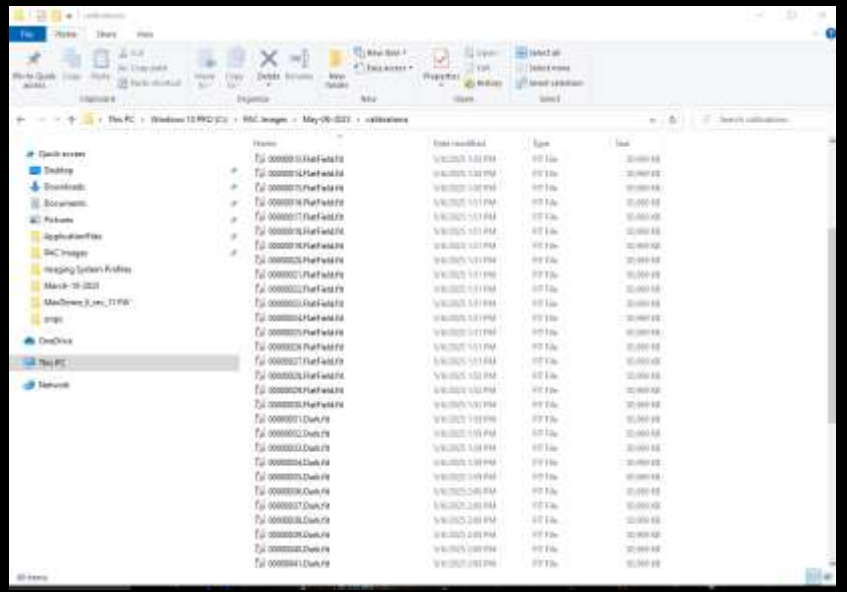
It may be carefully stored in its bag.

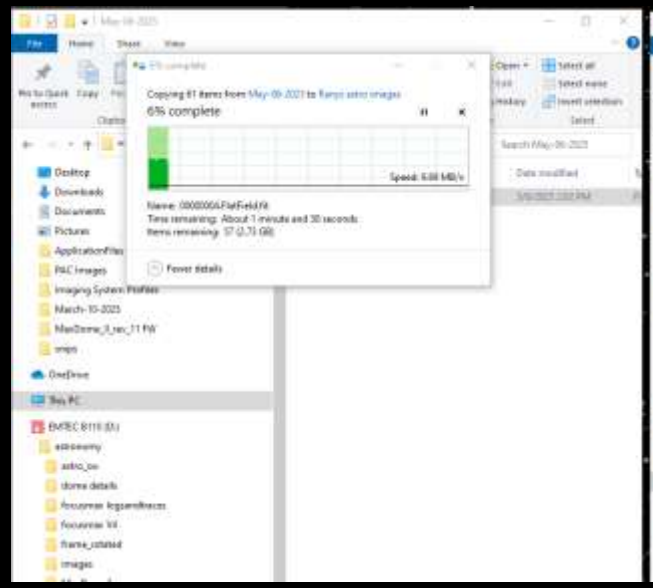
Original telescope dust cover is permanently replaced

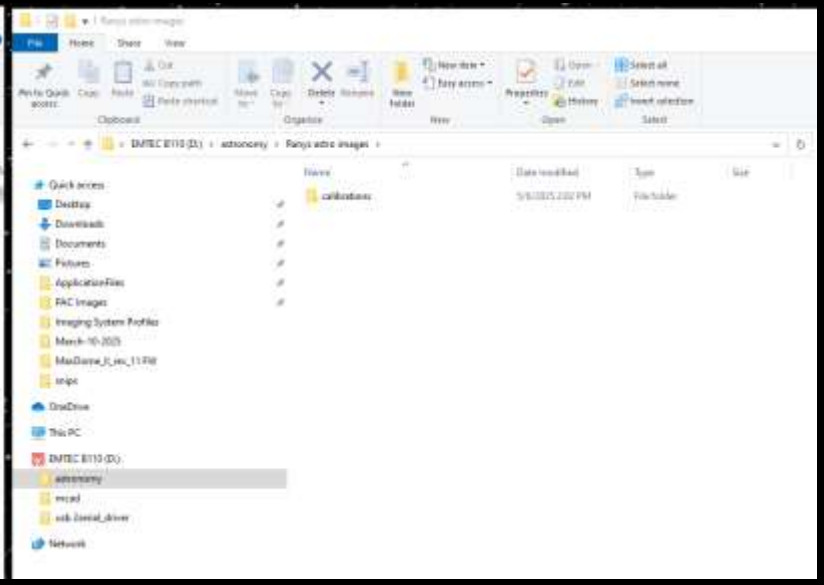
Taking the Bias, Flats and Dark Series may be done even before the sky is dark enough to image. Just take them with the calibration fixture in place (but unplugged for darks and biases). You must have decided what your exposure times will be for imaging later and stick to that for the darks.

For flats, just plug in the 12VDC aux power into the calibration fixture. Set the exposure time for the flats series to 0.100 seconds and complete the Take Series operation.

If you properly set the frame type flag for each calibration series they will be properly identified in the FITS header for image processing. Be sure to copy your image and calibration data from the specific PAC folder you had created to your USB flash drive to take home. Our computer runs the Windows operating system, so the standard “File Explorer” utility will be used. I usually open two windows – one for the PAC folder and another for the USB drive. Drag and drop folder or groups of files from one to the other.

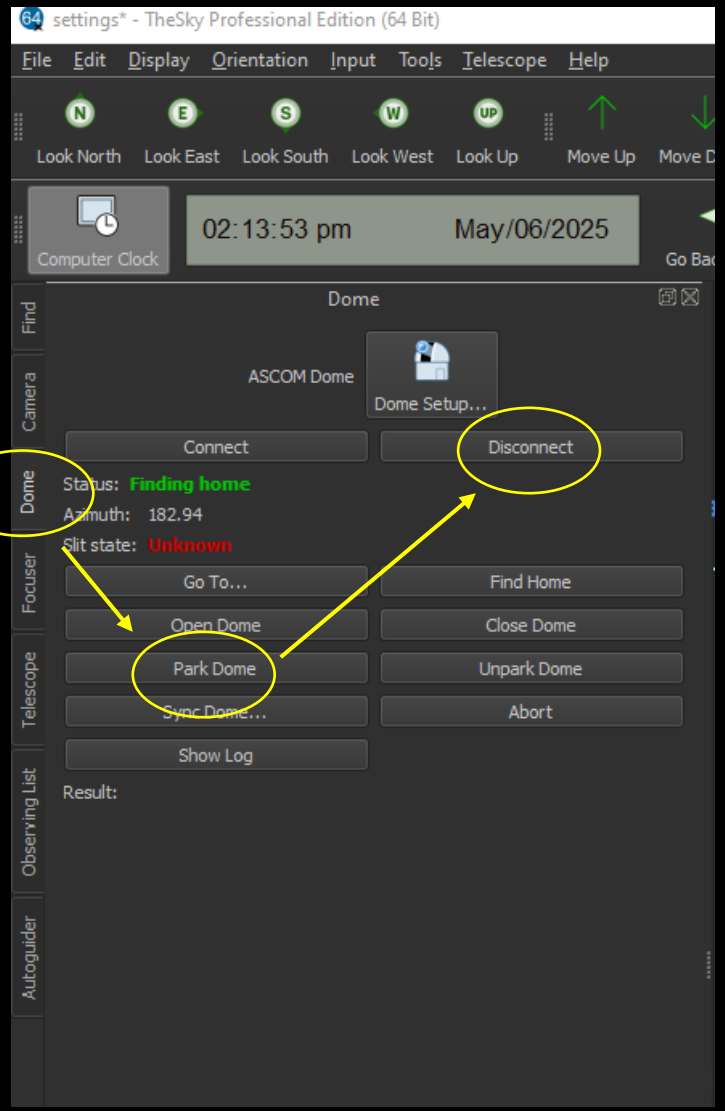






Finishing your Observing Session – shutting down the equipment again

Parking and Disconnecting the Dome



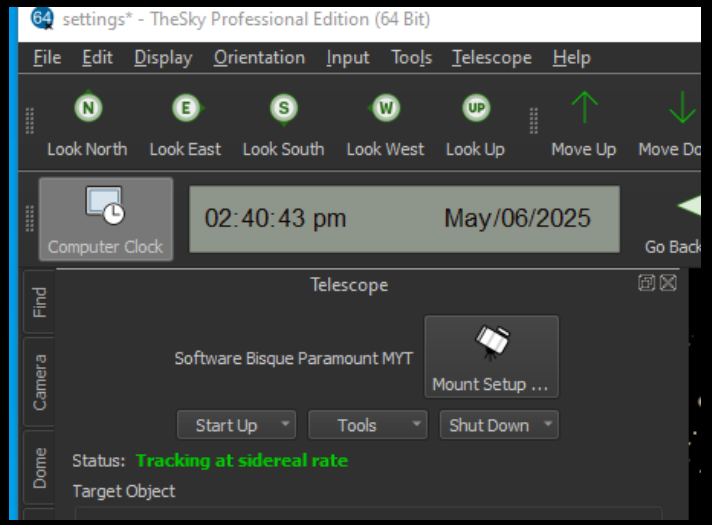
- Go back to the Dome tab on the left.
- Click on Park Dome (the dome should move to Home at Azimuth 83 degrees)
- When complete, click on Disconnect

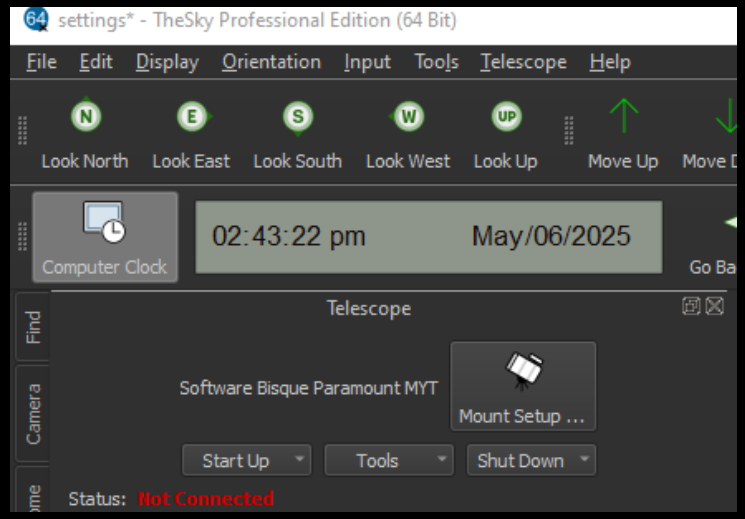
The home position is the proper place for the dome tie-downs to be applied to secure the dome from strong winds. Swing the hook end of the turnbuckle into the dome bracket and tighten as far as it will go (CCW rotation tightens) Secure both the North and South tie downs.

Close and re-latch the shutter on the dome

Finishing your Observing Session – shutting down the equipment again

Parking and Disconnecting the Telescope



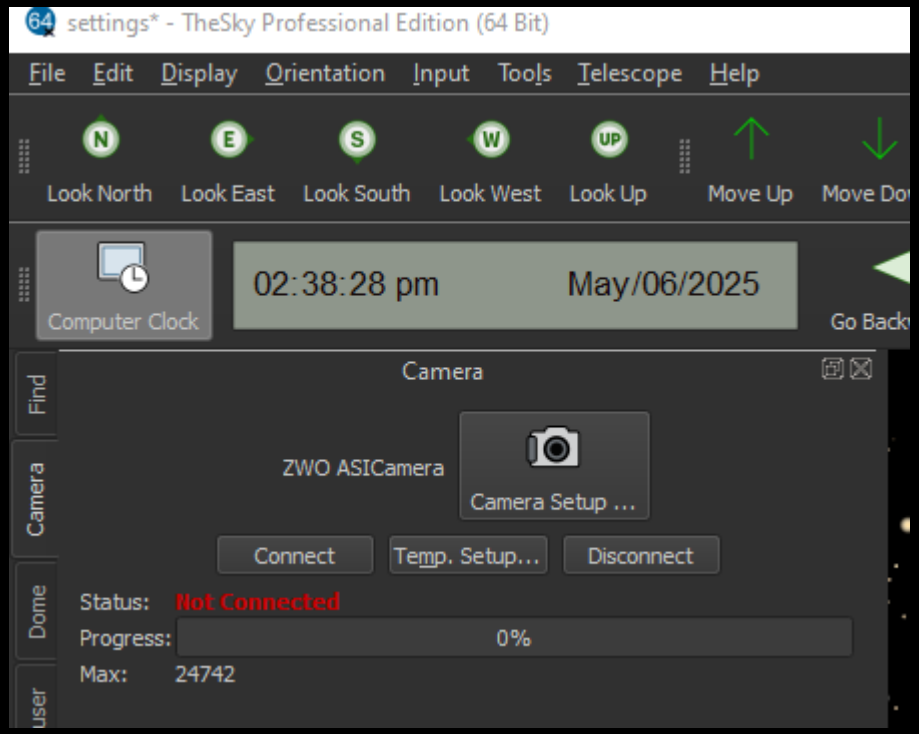


- Go back to the Telescope window
- Under the Shutdown tab, select “Park Telescope”. The telescope mount will move to the Park position.
- When complete, click on Disconnect (also under the Shutdown tab)

In the Park position, the front of the telescope is pointed to the West with a horizontal orientation. It is now very easy to re-apply the calibration fixture/lens cap to the telescope. If you still haven’t taken your calibration frames, now would be a good time to do them!

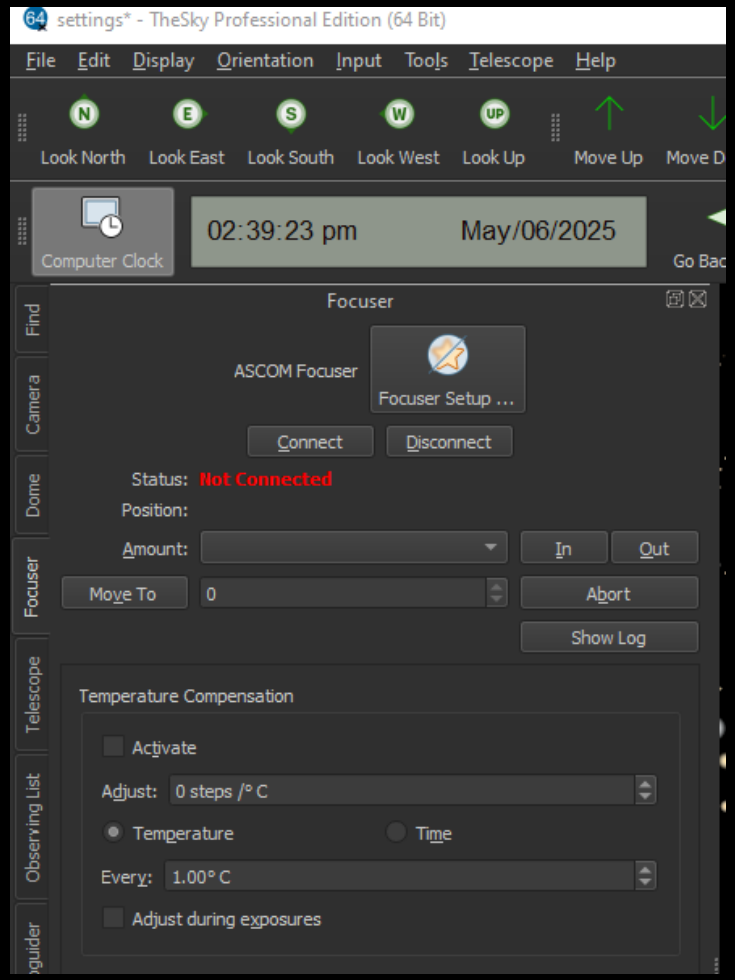
Finishing your Observing Session – shutting down the equipment again (continued)

Disconnecting the Camera and Focuser



- Open the Camera window
- Click on Disconnect

Status should change to Not Connected



- Open the Focuser window
- Click on Disconnect

Status should change to Not Connected

Finishing your Observing Session – shutting down the equipment again (final steps)

Double check !

- Did your file save/transfer to your flash drive finish? You may have gigabytes of data!
- Are all the files that you need on your flash drive? All Objects you imaged? Calibrations?
- Properly “Eject” your flash drive from Windows and Physically Remove It to take it with you

- On the SkyX desktop, Select Exit under the File Tab to Shutdown the program
- Close the iSPY camera app by clicking the “X” in the upper Right corner of its window
- Turn off the power to scope/dome by removing the checks next to Outlet 2 and Outlet 3 in the PowerUSB
- Close the PowerUSB app by clicking the “X” in the upper Right corner of its window

There should be no open windows left on the Desktop.

Shutdown the Windows PC
LCD screen goes blank and Fans stop making noise

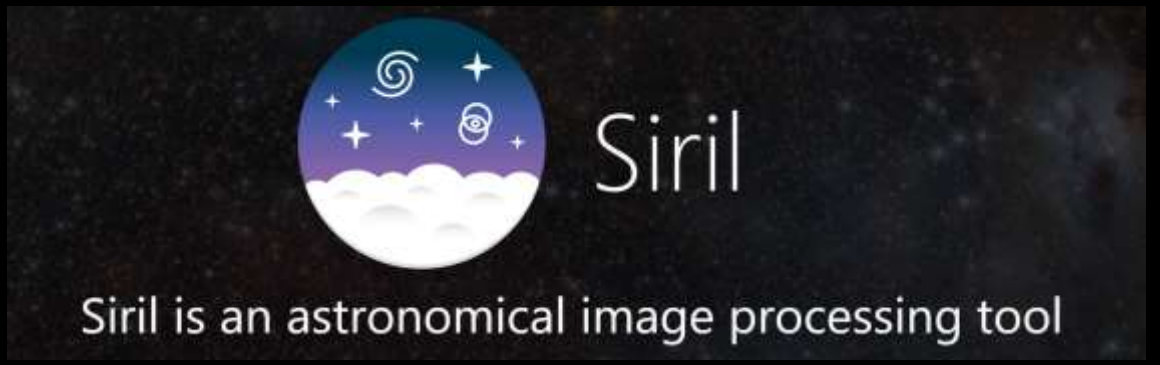
Lock up the cabinet and re-store it under the spiral staircase

Make sure that the cabinet is atleast 3 feet away from the library circuit panels

Image Processing Using SIRIL – what to do with your image data now!

SIRIL is a powerful and versatile software package for astrophotography image processing.
This free astrophotography processing software is capable of supporting the entire workflow, from stacking data to managing background gradients and color saturations afterwards. A good introduction may be found here:
https://www.skyatnightmagazine.com/astrophotography/siril-stacking
by Iain Todd Published: August 14, 2024 at 4:35 am
BBC Sky at Night Magazine

Where to get SIRIL software?
1) May be included in this distribution disk/flash drive
2) At this URL on the web: https://siril.org/tutorials/tuto-scripts/
3) https://siril.readthedocs.io/en/stable/Installation.html



Installation
Each version of Siril are distributed for the 3 most common platforms (Windows, MacOS, GNU / Linux) and can be downloaded on the Siril website. https://siril.org/download/

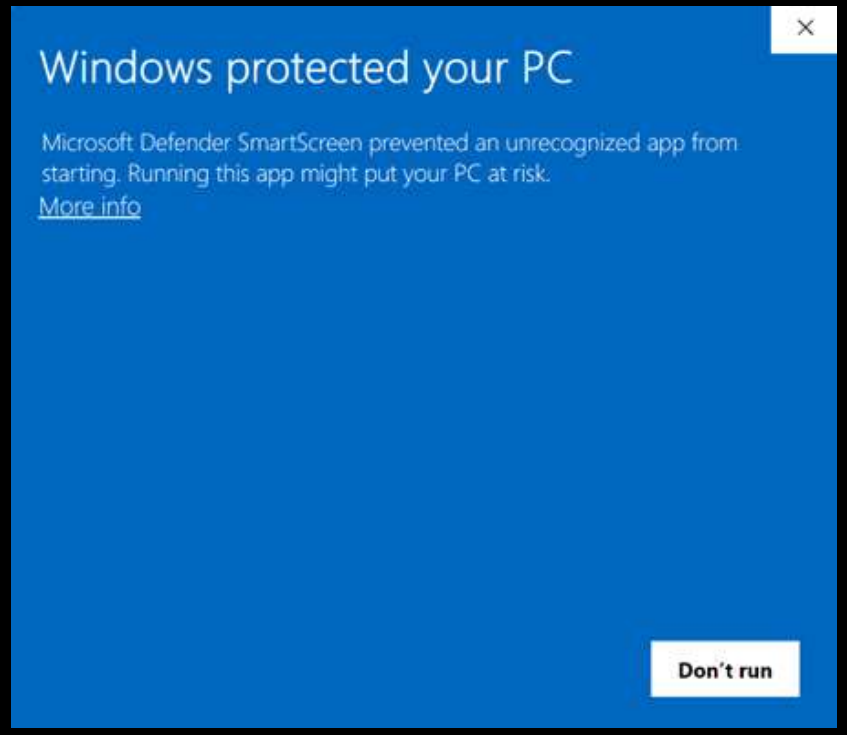
I have downloaded the latest version that was available: Siril 1.2.6 January 22, 2025.
I downloaded the release for 64-bit Windows. MacOS and Linux builds are available.

Siril is free, but if you like it and would like too make a donation towards its future enhancements, follow ths link:
Siril - Donate https://siril.org/donate/?dl=1

Look for the downloaded file in your Windows downloads folder. To install, double click on the exe file.

"C:\.....\Downloads\siril-1.2.6-setup.exe"

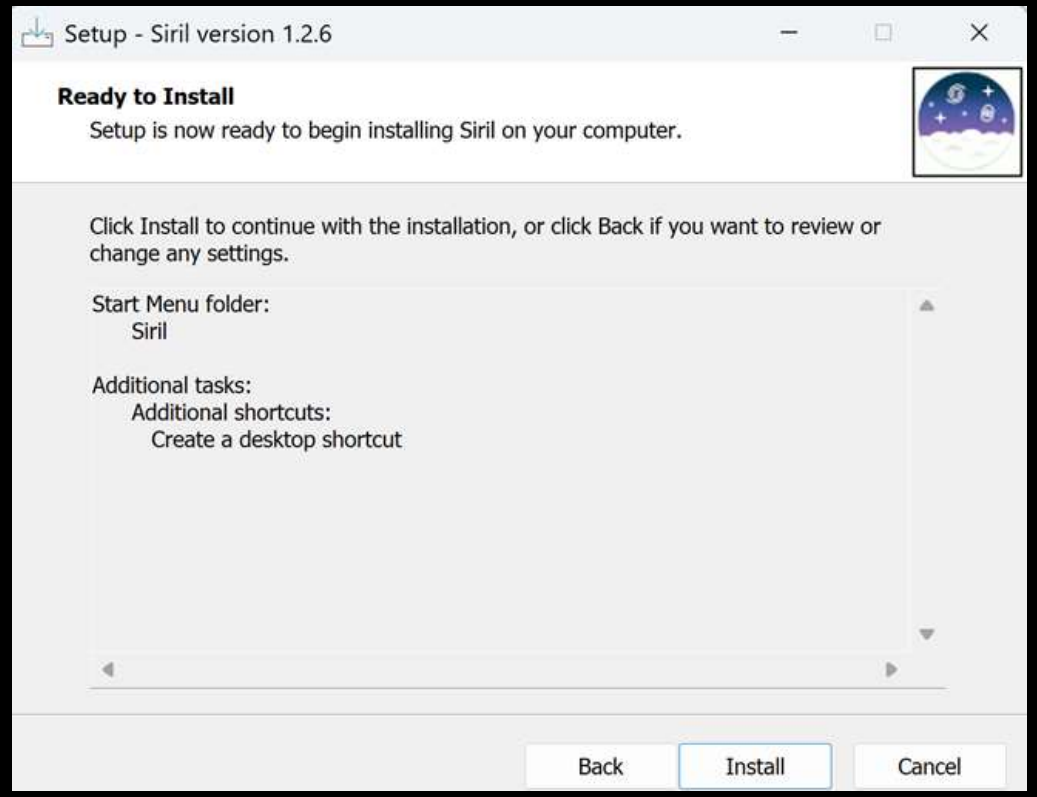
You may see a Windows Security Message
… click More info,

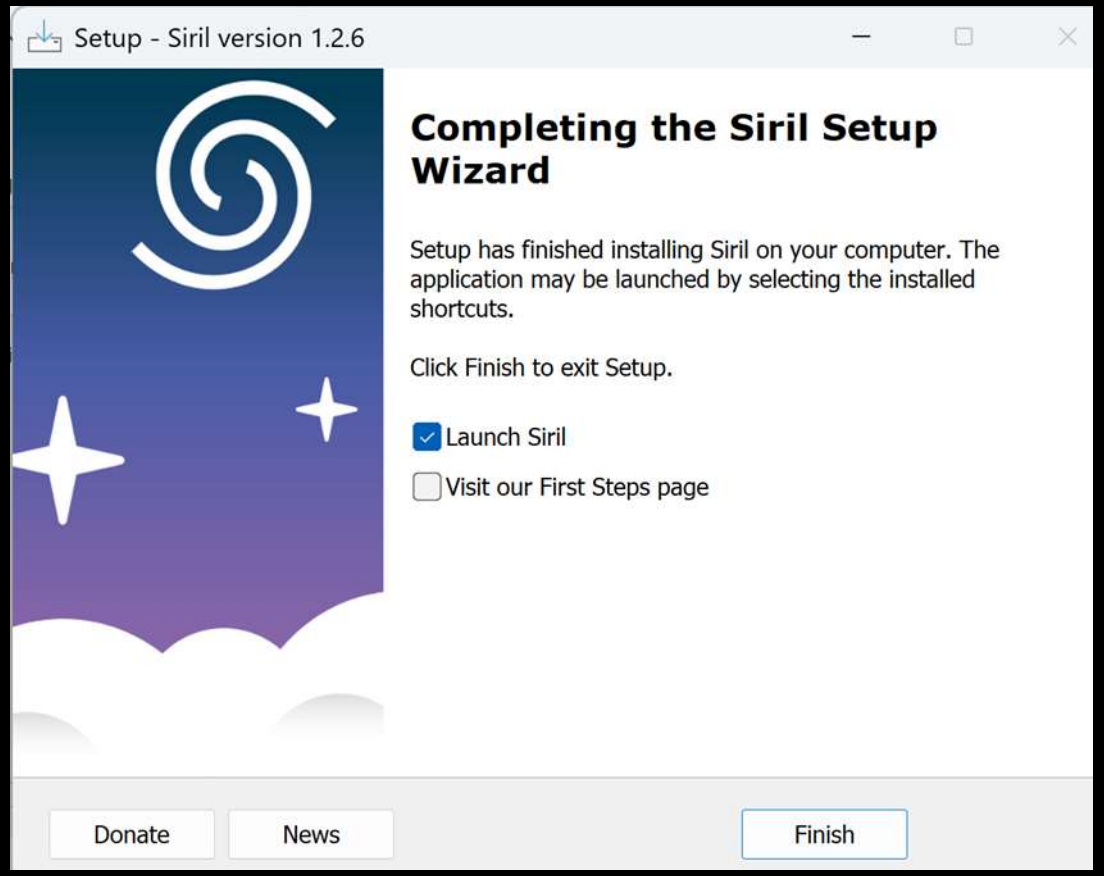


Then allow it to Run Anyway

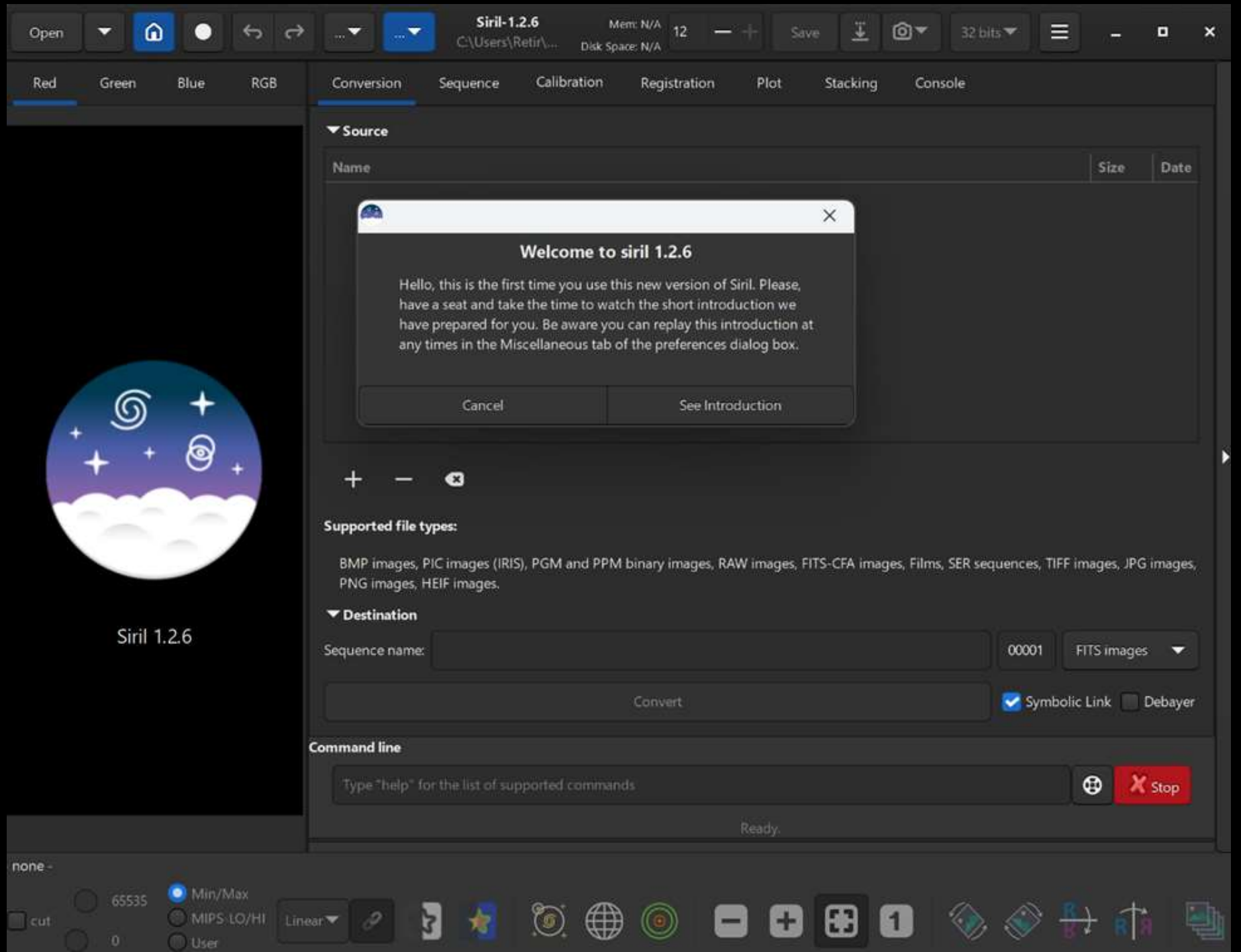
Say YES to allow it to run on the next screen…..
I selected English as my language choice…..
Accept the GNU General Public License Agreement….. Next
By default, the installer will create the program's shortcuts in the Windows Start Menu…
(if you change this be sure to remember where you told the installer to place it) click Next
Create a desktop shortcut too if you want to …. Click Next

You should now be ready to install Siril…. Click Install





If all goes well, installation completes and you will be ready to start using Siril!
Click Finish and the program will startup.



It may be worth your time to watch the short Introduction video that is included.

It highlights the functionality of the many control buttons on the GUI.

Using SIRIL

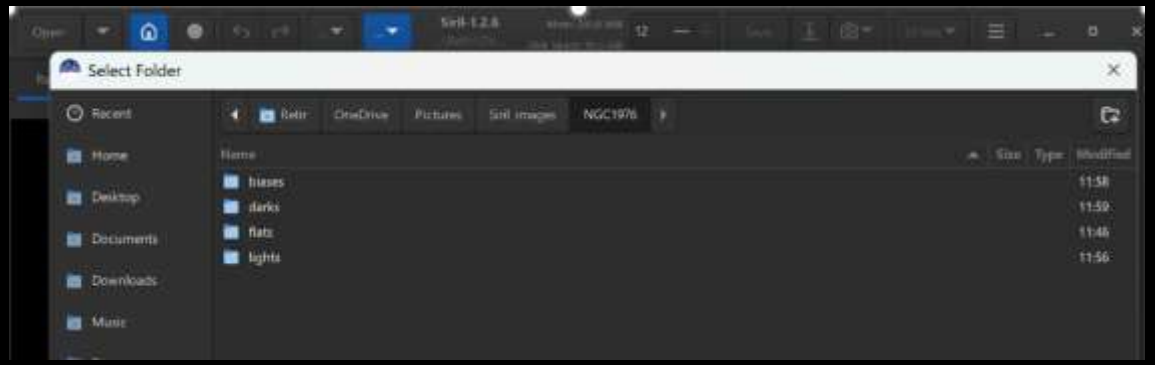
Open Siril and set the working directory (the location where our image data would be stored) to ensure that when you run the stacking script, Siril knows where to collect the data from.

To do this, clicked on the home icon (see image below), navigate to the image folder on our computer and click ‘Open’.

Put lights, darks, flats and biases in separate folders, under a common folder with the name of the object

Example: Pictures -> Siril_images -> NCG1976
We have to ensure that our image folders are stored and named in a way that Siril’s stacking script will recognise each set of light and calibration images.

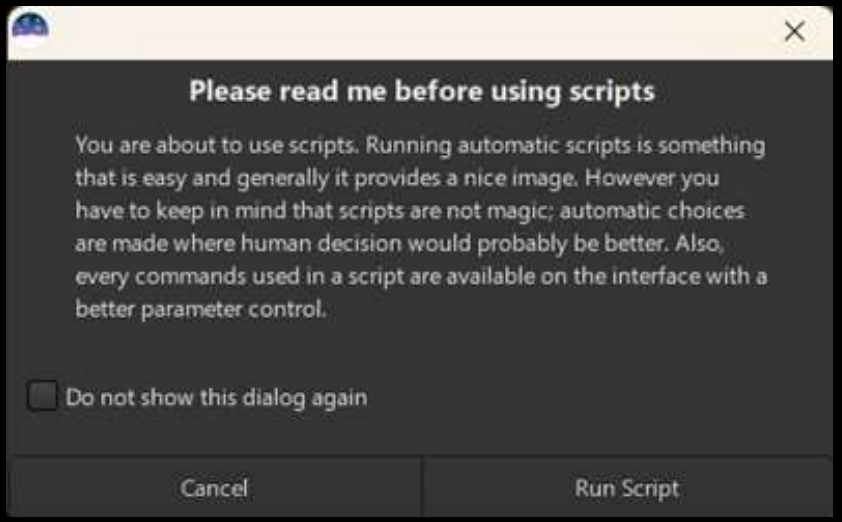
The image below shows the correct layout of this folder system: the main target images are stored in a ‘lights’ folder, bias frames are in a folder called ‘biases’, dark frames in ‘darks’
and flat frames in ‘flats’.



Once you’ve set your working directory, put all your frames from your flash drive into the correct folders.
These must be named ‘lights’, ‘darks’, ‘biases’ and ‘flats’ for the program to work properly and should be the only folders present in the working directory, or the script won’t be able to execute.

Once done, we ran Siril’s stacking script by clicking Scripts > OSC_Preprocessing (see image below).

You may see this message the first time you run this. Go ahead and click on "Run Script"

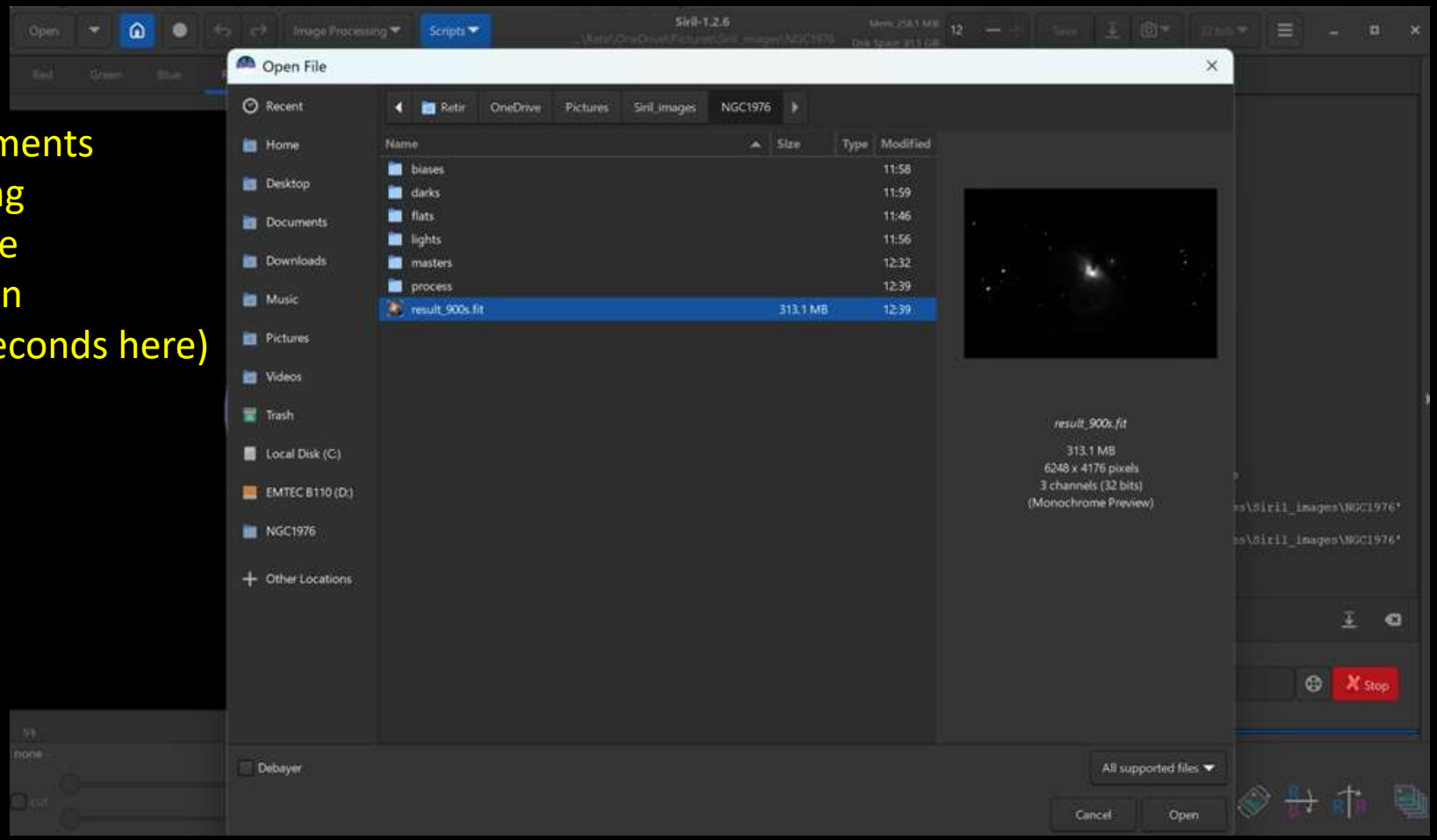


You'll see the script start to run in the Console on the right-hand side of the screen. Many lines will be displayed one after another as the script runs.

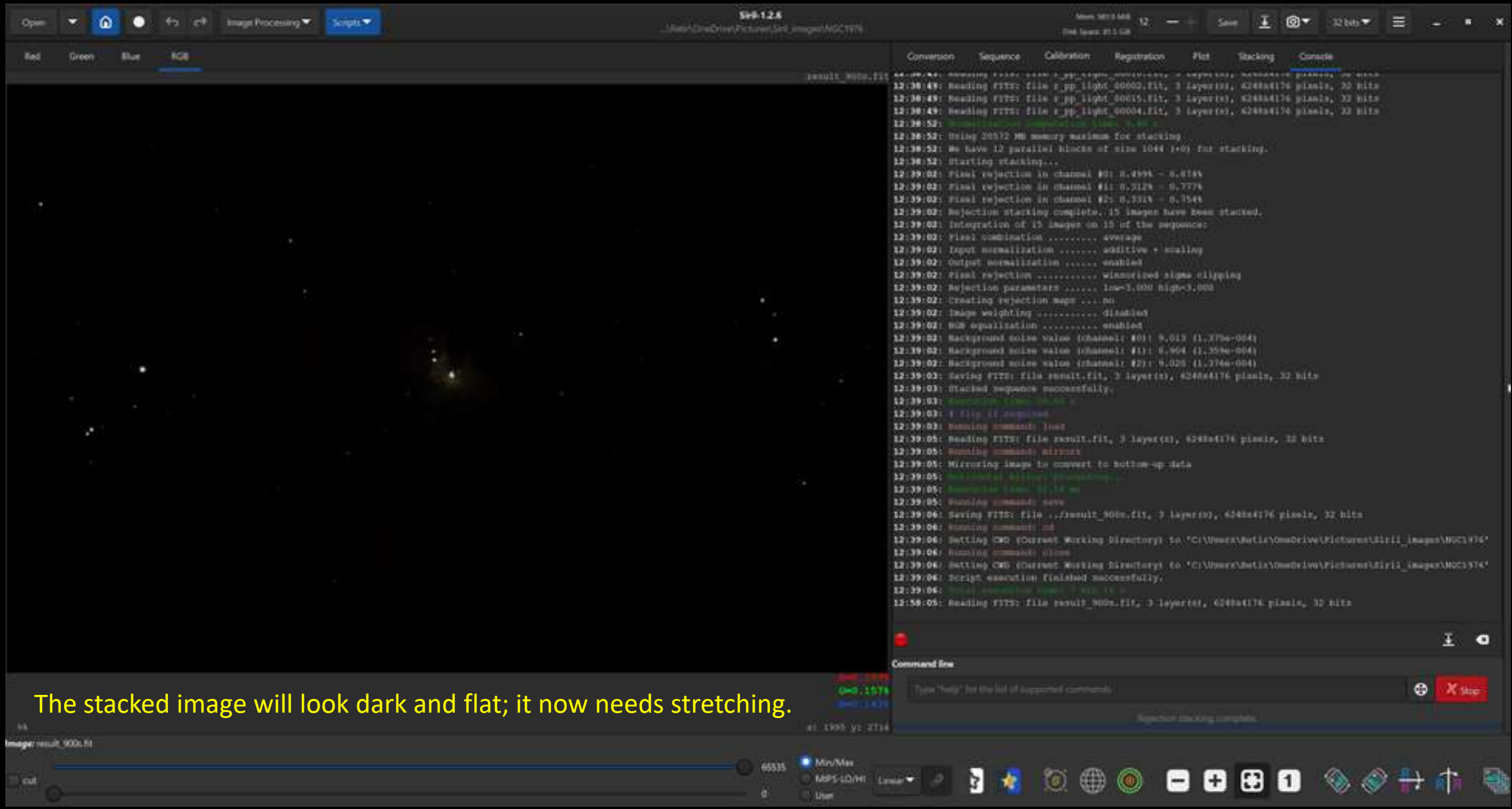
Siril first creates Master files for each of the calibration frames before aligning and then stacking with the light frames by subtracting the noise and vignetting.

Once complete, the Console read ‘Script execution finished successfully’ and will show the total execution time. The time taken will depend on how many light frames and stars there are.
For the NGC1976 nebula image, it took over 7 minutes to finish on my laptop.

Stacking complete, now for the final adjustments
We then open the stacked file in our working directory, titled ‘result_[number]s.fit’, where [number] refers to the total exposure time in seconds taken for all stacked images (900 seconds here)

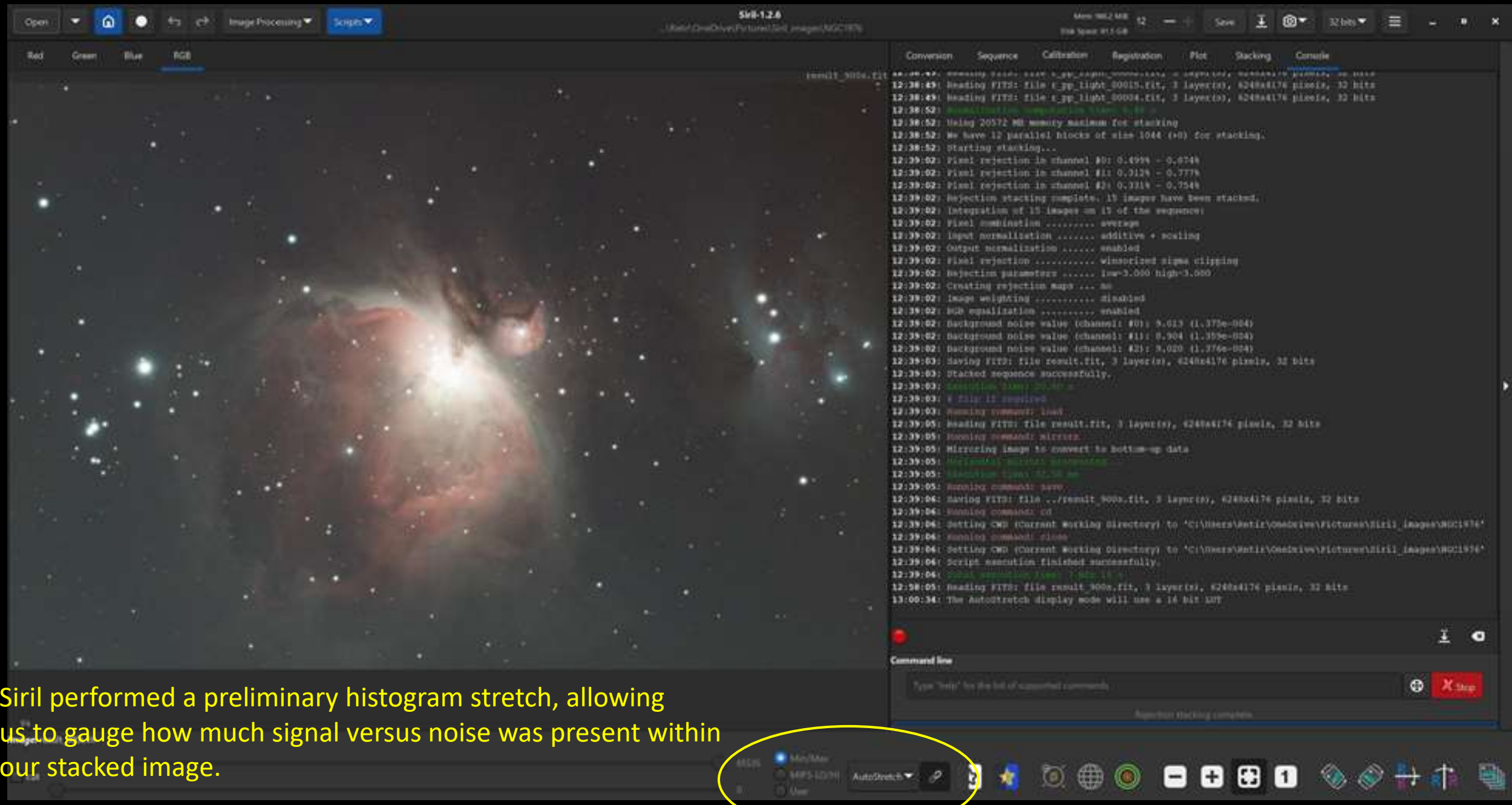


Click “Open” in the bottom right corner.



The stacked image will look dark and flat; it now needs stretching.

We do this initially by clicking on the ‘linear’ dropdown box and selecting ‘AutoStretch’



Siril performed a preliminary histogram stretch, allowing us to gauge how much signal versus noise was present within our stacked image.

There is Much More that SIRIL Can Do! (and always much more that we can learn)

What has been described so far just scratches the surface asto what SIRIL can do. You have just begun to learn about image processing, now able to perform calibrations and stacking. The art comes as you learn to enhance your images. Enhancement is the art of refining the image data, putting it in a form that our human eye can perceive.

Beyond SIRIL, there are other tools that can help you to get the most out of your images.
Often people turn to Photoshop or GIMP. PixInsight is a tool that has been designed to solve the problems specific to astrophotography. There exists software that uses artificial intelligence (AI) to remove noise, sharpen images, and enlarge images without the expected detail loss. Many such programs are available and they come as plug-ins to other programs or as standalone programs in some cases. Some programs tackle one of these issues (denoise, sharpen, enlarge), enhance) and some tackle them all. They don't eliminate the need for a general image processing program like Siril or Gimp or whatever you use.

There are now AI based training tools to teach you advanced skills.
AI Astrophotography Coach is astrophotography course, powered by AI and available for iPhone
https://www.astronomy.com/observing/let-ai-teach-you-how-to-take-great-astrophotos/

Like you, I have only begun to explore this field.

Thank you for coming to the Harken Observatory tonight!

http://pewaukeeastro.com/