Faculty and Staff Manual for Astronomy Equipment and Astrophotography

By Thad Szabo

Department of Physics, Astronomy, and Engineering

Cerritos College

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Course Requirements for ASTR C1001L

Beginning in Fall 2027, our astronomy labs will move from being referred to as ASTR 105L to ASTR C1001L. This is to bring the course in alignment with Common Course Numbering in California. To be in compliance with state requirements, the course needs to cover the following topics:

1. Celestial sphere
2. Orbits and Kepler's Laws
3. Spectroscopy
4. Lunar properties
5. Telescopes and optics
6. Hertzsprung-Russel Diagram
7. Sun features
8. Deep sky objects
9. Cosmic distance ladder

Resources for Teaching the Night Sky

On good nights when the air is fairly dry, you can see magnitude 3 stars from campus. I don't think I have ever been able to see anything fainter than this under normal conditions. There is a website of images of wide areas of the night sky taken from the observatory deck. The website has images for the months of August through May and includes a set of images with only stars and another set with annotations for each month. Each set has an image toward each of the four cardinal directions and toward the zenith. The constellations are not drawn according to Western conventions. The motivation was to avoid drawing lines to stars that are too faint to see from campus. When first learning the night sky, I feel it is better if students focus on what they can actually see rather than questioning why the view in the sky doesn't look like what is in pictures or on their planetarium apps. Stars are washed out almost entirely as you look closer to the horizon, so avoid asking students about objects in this murky area unless they are exceptionally bright.

There are labs that are written based on using Stellarium as the tool for exploring the sky. It is already installed on the podium computer in PST 124 and all the student laptops. Encourage students to download the free version for their laptop or desktop and install it. Discourage them from using just the web-based version since it is missing a lot of functionality. Stellarium is also available as an app for tablets and phones for a small fee. While the app version is very useful for identifying objects on the sky, it is very difficult to do lab activities with. Emphasize to students that they should use the desktop/laptop version for any lab activities.

If you are interested in taking the use of Stellarium a step further, there is an OER called *Distant Nature: Astronomy Exercises* designed for use with community college and lower level astronomy labs. As of this writing, we do not have the supporting software plugins to use this OER in our environment, but I felt it was worth mentioning for exploring the possibility of using it.

If you use Stellarium for quizzing students about the night sky, you can use the “Sky and Viewing Options” settings to turn off the names of stars and planets. You can also adjust the light pollution to have the view resemble the sky from campus.

Available Observatory Equipment

The primary equipment you will be using is the set of 8” Dobsonian telescopes that students should gain competency with throughout the semester. There are a set of 7 or 8 of these scopes stored in the observatory. They have a Telrad finder and a 9x50 mm finderscope. The Telrads take 2 AA batteries. Spare batteries are available in the stockroom.

There are additional 8” Dobsonians in the telescope room in PST. These may not have the finderscope attached, or they may be missing some parts. If you find that any pieces are missing from one of the scopes in the observatory, you can usually find the corresponding part that you need from one of these reserve scopes. The most common missing piece is the 2” to 1.25” adapter in the focusing mechanism. Students sometimes remove the whole adapter instead of just the eyepiece when changing eyepieces.

It is a good idea to make sure the Telrads and finderscopes are properly aligned with the main scope. You will likely need to make some adjustments during labs when you do observations. Circulate among the students to check that the alignment is good so that they can find whatever objects you assign without the frustration of equipment that is not working as intended.

Each group should get a box with the following eyepieces and tools:

- A 25 mm Plossl eyepiece
- A 15 mm wide-field eyepiece
- An 8.8 mm wide-field eyepiece
- A compass (for drawing circles)
- A moon filter

There are additional eyepieces available in the observatory on the top shelf of the cabinet. These include:

- 31 mm 2” Luminos wide-field eyepieces
- 14 mm wide-field eyepieces
- 5.5 mm wide-field eyepieces

There are also two Barlow lenses, one for 2x magnification and one for 3x. These are usually on the second shelf from the top.

The primary pieces equipment in the cabinet for the 14” Schmidt-Cassegrain telescope (SCT) are the dew shield (in the bottom of the cabinet), the controller for the mount, and the controller for the focuser. The two controllers should be in the narrow height shelf toward the middle of the cabinet. The focuser controller will need to be plugged in to provide power to the motor on the focuser knob.

There should also be a bulb blower on this shelf for removing dust from the corrector plate on the SCT.

Planetary cameras and adapters are on the second shelf from the top of the cabinet. These include:

- A ZWO ASI224MC color camera
- A Skyris 445C color camera
- A Skyris 618M monochrome camera
- A Point Grey Flea3 GigE color camera

The 2” to 1.25” adapter for the 14” SCT should also be on this shelf, along with a reticle eyepiece for helping to align the SCT on a target. There is also a 0.63x reducer and a ZWO Atmospheric Dispersion Corrector (ADC) on this shelf. You will also find the UV/IR cut filter for use with the cameras if you want to limit incoming light to visible wavelengths. This is also where the 2” to 3” adapter for the SBIG STXL6303E camera is.

The top shelf also has an Arduino based GPS flash timer for use with occultation timing.

There are miscellaneous light pollution and narrowband filters on the fourth shelf from the top.

At the far right on the fourth shelf from the top are two 1.25” diffraction gratings that can be threaded into the nosepiece of one of the planetary cameras. For greater sensitivity, they should be used with a 12-bit or 16-bit camera (not the Point Grey Flea3). Using a monochrome camera will eliminate the loss of signal due to color filtering. There is Star

Analyser 100 grating with 100 lines/mm and a second 200 lines/mm grating. I have only been able to get useful stellar spectra with the Star Analyser 100.

Additional counterweights for the 14” SCT are in the bottom of the cabinet. There is also a light panel for taking flat frames.

A Bahtinov mask for attaining a sharp focus during astrophotography and data gathering is also in the bottom of the cabinet.

In the boiler room north of the observation deck is a Celestron CGEM DX mount on a rolling tripod. There are shock absorber disks in the cabinet to place at the feet of the tripod when you are securing it into place. There should also be an extension cord and outlet strip. If you need a power supply for the CGEM DX, you may need to borrow the one that powers the mount for the 14” SCT.

There is an aperture limiting H-alpha filter to place over the front of the 14” SCT. It does not reduce the light enough on its own to be safe for visual observations. There is a second H-alpha filter that would be placed in the image train at the eyepiece to allow safe viewing.

However, there is not much visible with this system. We also have 3 60 mm Coronado H-alpha solar telescopes. They are in black cases in the telescope storage room in PST. The mounting hardware for the Coronado scopes is also on the shelves near the scopes. There is a hexagonal plate on the bottom that seats in one of Manfrotto tripods. One of those tripods is in the observatory and the others are in the telescope storage room.

There is one set of mounting hardware to allow a Coronado scope to be placed on the CGEM DX mount that is in the boiler room. If you want to do solar astrophotography, you’ll need that mount and the adapter.

Figure 1 - Losmandy plate with bracket for mounting a Coronado solar telescope on the CGEM DX equatorial mount

Figure 2 - Coronado H-alpha solar telescope in place on the CGEM DX mount

Visual Observations

Your starting point for visual observations should be the [Views of the Night Sky from Cerritos College website]. This is a nearly complete list of stars that can be seen with relative ease through the light pollution from campus. These are the stars and constellations that students should become familiar with throughout the semester.

The 8" Dobsonian telescopes are stored around the west and south walls of the observatory. The cabinet with additional equipment is in the southeast corner. There is also a dehumidifier next to the cabinet that has an outlet hose that runs under the south wall of the observatory. The floor of the observatory is the rooftop of the MCIS building, and the observatory does not sit flush with the roof. This allows water to run into the observatory when it rains, so the dehumidifier is needed. Also, when the roof is open, condensation often forms on the underside of the roof. This brings moisture back into the observatory when the roof closes. For the sake of preserving the electronics, the dehumidifier is kept running. It is set to start automatically when the relative humidity rises above 40%.

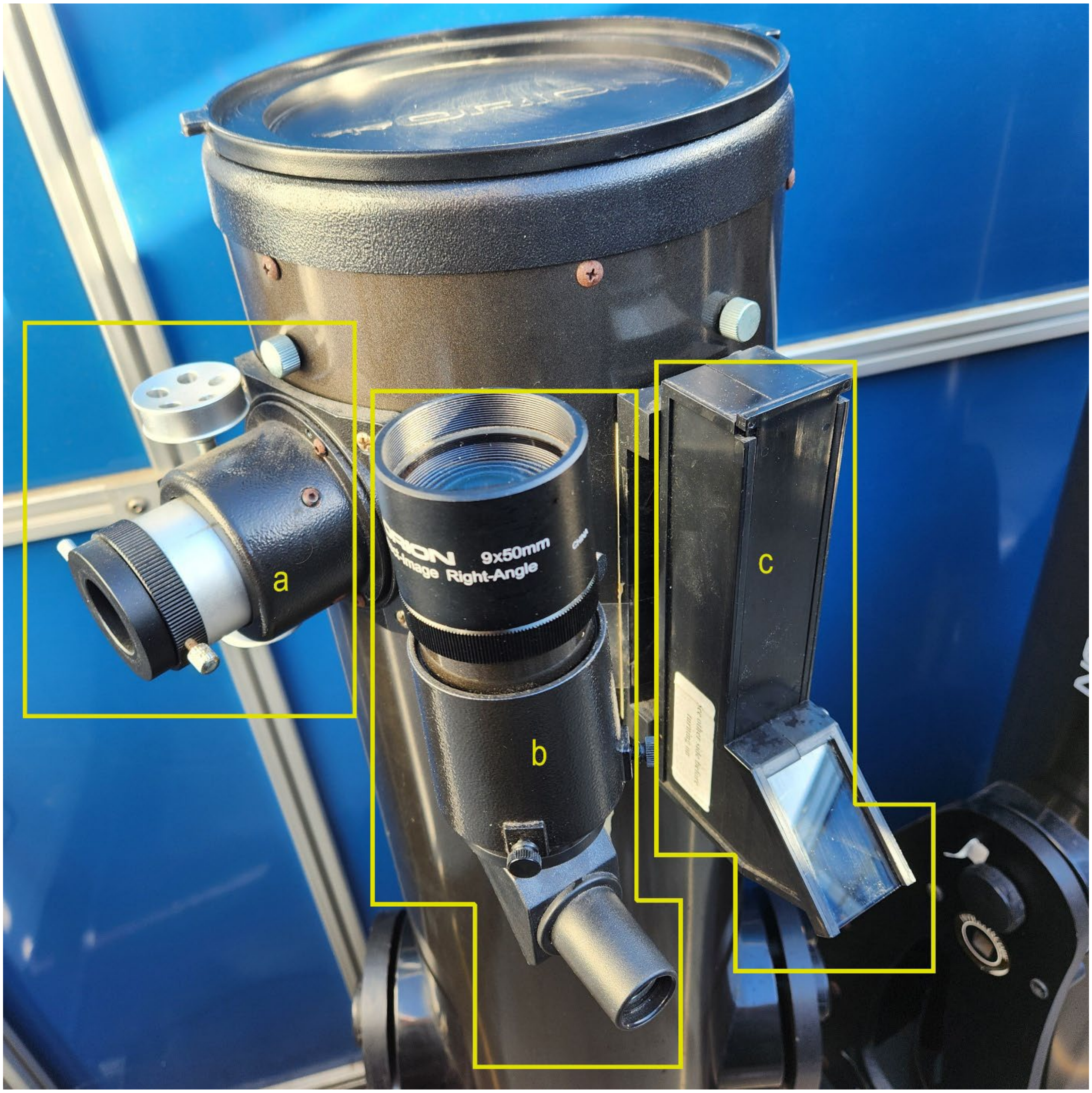

Figure 3- in the figure above, a is the focusing mechanism where eyepieces go; b) is the 9x 50 mm finderscope; and c) is the Telrad.

Before an observation session, check the batteries on each of the Telrads on the 8" scopes. There is a small switch on the right side of the Telrad. Rotate the switch clockwise to turn on the bullseye reticle in the Telrad. It will click when turned on. Adjusting how much the switch is turned adjusts how bright the bullseye is. If you do not see the bullseye illuminated when you look into the round window on the Telrad, you can change the battery by sliding the long panel on the top surface of the Telrad out toward the top of the telescope.

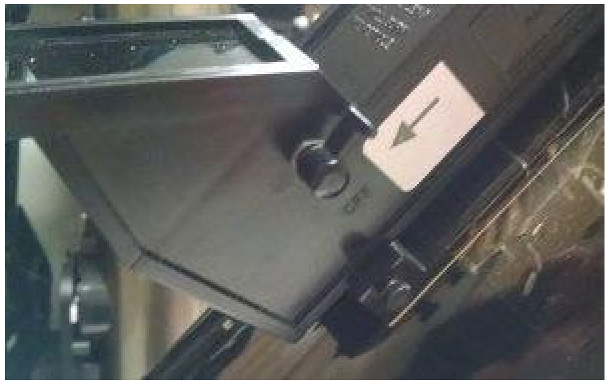

Figure 4 - Switch on the side of a Telrad finder in the "ON" position

The Telrads take AA batteries. If the bullseye is faint with the switch turned fully clockwise, replace the batteries. Students may not tell you if the bullseye is too faint for them to use. You should check for yourself.

If the bullseye is on the object in the view through the Telrad, but the object does not appear through the view in the telescope, the position of the bullseye needs to be adjusted. There are three screws on the back of the Telrad that move the position of the bullseye as you loosen and tighten them. (See Figure 5 for the location of the adjustment screws.) Position the object in the center of the view in the telescope. Adjust the screws until the center of the bullseye appears around the object. Be aware that if you take too long, the Earth's rotation will pull the object out of view. Use a low magnification eyepiece (long focal length eyepiece) when you are aligning the Telrad sight.

If you need to align the finderscope, you should already have the Telrad aligned and an object in view in the telescope. You can use a slightly higher magnification eyepiece in the telescope, if you want. The screws for adjusting the aim of the finderscope are around the outside of the circular bracket it is seated in. Look through the finderscope and adjust the screws until the object appears in the crosshairs.

If the finderscope is out of focus, rotating the objective (the front piece) of the scope will help get it in focus again. You may have to turn it many times. Be careful not to unscrew it completely as you do this.

Figure 5 - Use these three screws to adjust the position of the bullseye when viewing through the Telrad

The focuser on the 8” Dobsonian telescopes can take either 1.25” diameter eyepieces or 2” diameter eyepieces. The set of eyepieces that the students are given for an observation are 1.25” in diameter, so the adapter collar should be in place for them. Sometimes students put the adapter collar in the box with their eyepieces when they are done for the night. It is a good idea to check the boxes (or have a lab assistant check them) to see if that happened.

On the top shelf of the cabinet in the observatory, there are three 31 mm 2” diameter Luminos eyepieces. They give a very wide field of view (over 2°) when used with the 8” Dobsonian telescopes. This is an especially good combination for introducing students to deep sky objects like the Pleiades, the Orion Nebula, or the Beehive Cluster (M44). In Fall 2025, we were able to very faintly see the core of the Andromeda Galaxy with this configuration. Consider running one or two of the telescopes with this setup during an observation session. This combination is also good if you are doing public outreach. It will keep an object in view longer as you let people look through the telescope. See Figure 9 for how this eyepiece appears when it is in place.

Make sure the 31 mm 2” eyepieces are returned to the cabinet at the end of the session.

Figure 6 - Focuser on an 8" Dobsonian with no adapter and no eyepiece present

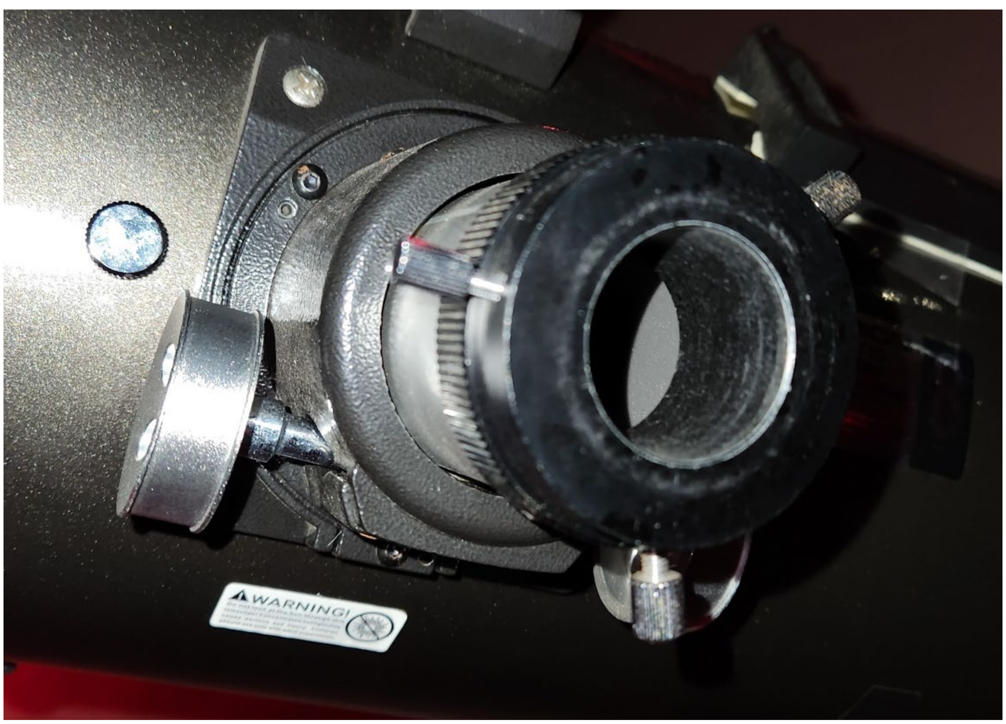

Figure 7 - Focuser on an 8" Dobsonian with the 1.25" adapter in place, but no eyepiece

Figure 8 - Focuser with the 1.25" adapter and a 1.25" diameter eyepiece in place. This is the most common configuration that students will use.

Figure 9 - An option for giving students a very wide-field view is to use one of the 2" diameter eyepieces from the top shelf of the cabinet in the observatory. Remove the adapter collar before inserting one of these eyepieces.

Although they aren't subject to a lot of handling since they stay on the roof, the 8" Dobsonian telescopes will need to be collimated occasionally. If you are observing with one and you notice asymmetry in the stars as they come into or out of focus, that is a collimation issue. The primary mirror is misaligned with the secondary mirror. You will also notice that you cannot get a sharp focus no matter what you try.

On the bottom of the tube of the scope are 3 pairs of bolts – a long, thinner one and a short one with a wider head. These screws are used to lock the mirror cell of the telescope in place. Get a bright star or planet in view in the telescope. Put it out of focus – it can be with the focus too near or too far. The dark circle that is the shadow of the secondary mirror will be off center from the ring of light from your out of focus object. Gently loosen the short, wide head screws about a quarter or half of a turn. Then, adjust the longer screws to change the tilt of the mirror cell. When the secondary shadow gets closer to the center of the defocused star, you're moving in the right direction. If the shadow gets farther off center, that's the wrong direction. If you've never done this before, be patient. Remember that the view through the telescope is inverted, so the changes you see may look like they are happening on the opposite side of the mirror from the side you are adjusting.

Once it looks like you have the secondary shadow centered, put the object our of focus in the other direction and check again. An off-center black dot means you need to continue making adjustments. If it stays centered as you go through a sharp focus and through to unfocused again, you've got it collimated. You should see your object look like a symmetrically shrinking circle as you focus on it, with no tail or protrusion in any direction. Lock the short, wide head screws in place again and do one more check to makes sure the collimation held.

You should not ever need to adjust the secondary mirrors of the Dobsonian telescopes.

Opening the roll-off roof

If there is a constant wind in the 15-20 mph range, don't open the roof of the observatory. It may be rated for higher wind speeds than that, but observing will be incredibly frustrating with that strong of a breeze blowing. If the wind gusts to a higher speed from that steady speed, there is a risk of damaging the rail system that moves the roof onto and off the observatory.

The panel that controls the roof is on the far side of the observatory from the door. It's a good idea to use a light, like on your phone, to find your way over there. There is a power strip mounted on the wall. Switching that on will turn on a red LED strip that goes around part of the top rim of the observatory.

Touch the screen on the gray box that is mounted on the same wall (east wall) as the power strip. This should activate the screen, which will give you the option to open the roof. After you touch to open the roof, it will ask for confirmation. The roof will roll open after you confirm that you want it to.

Unless this is fixed in the future, the roof stops about 2 or 3 inches short of being fully open. Use the touch screen and press “Open roof” again to get it fully open.

Our observatory was provided by Pier-Tech. It is a 10’ by 10.5’ Tele-Station 2.

Raising and lowering the 14” SCT pier

The height of the pier can be adjusted by a hand controller, shown in Figure 10. This can be useful for visual observations with students of different heights. It is also useful for being able to retract the pier so the scope is better protected by the observatory walls if you are trying to observe on a night when a breeze is blowing.

Figure 10 - Hand control for raising and lowering the telescope pier

Powering the mount for the 14” SCT

There is a lead-acid battery in a box with 2 12-volt sockets on the floor at the base of the pier. The battery is plugged into a battery tender to make sure it stays charged. The telescope mount is plugged into one 12-volt port, and the power for the dew heater controller is plugged into the other one. In the event of a power interruption, this will allow the telescope to stay aligned and tracking during an observing session. If you are not getting power to either the mount or the dew heaters, make sure the plugs are seated in their sockets.

Electronic focuser for the 14" SCT

You will need to attach the controller for the focuser on the C14 before beginning observations. You can provide power from the power strip that is mounted on the pier. The flat gray cord plugs into the focus motor. The focuser is designed to allow for very precise focusing, so it moves rather slowly. Pressing either of the buttons by themselves will give you fine focus control. For additional speed, press down one button to choose the direction of movement, then while holding the first button down, hold the second button as well. The focuser will still not move quickly, but it will shorten the time to bring the object in focus.

The electronic focuser is from Rigel Systems. You can get the full manual for the focuser here.

Closing the roll-off roof

- **Make certain that the pier is retracted to its lowest position.**
- **Make certain that the telescope is turned so that it will not be clipped by the roof as it closes.**
- **Make sure that the dew heaters are switched off.**
- **Cover the telescope and mount with the tarp before closing the roof.**

Check that the path is clear and there is no equipment extending above the roof. Activate the touch pad on the control box on the east wall and select the option to close the roof. As it did when opening, the roof will stop about 2 or 3 inches short of closing. Select the option to close it again to get it fully closed. There should be no gaps around the edges of the top of the observatory when the roof is fully closed.

Using the 14" SCT for Astrophotography

ASCOM Platform and Drivers

Our astrophotography setup requires a laptop to communicate with the telescope mount, cameras, focuser, and other hardware. The software layer that handles these communications is called ASCOM. ASCOM stands for Astronomy Common Object Model. The latest version should already be installed on the astrophotography laptop. When you start the laptop, if you are connected to a network, ASCOM will let you know if there is a new version to install. Unless you want to test the new version, I would skip the upgrade. It usually takes a while to complete, so if you are working with students at the time, it would be a less efficient use of your time to download and install the update.

Here is the site for downloading the ASCOM platform if you need to repair or reinstall anything. You may need to search elsewhere for drivers for some equipment. The Cloudy Nights forum is a great place to find answers to common equipment and software questions.

Planetary and lunar photography

Even the largest field of view when using the cameras for planetary photography is quite small – at most, a few arcminutes. It is a good idea to get the telescope aligned on the target before inserting the camera. Use the crosshair in the reticle eyepiece to make sure the planet is centered.

Be very gentle when setting up the imaging train for planetary photography. Make sure bolts are loosened well and elements slide together easily. Any small bump or push has the potential to knock your target out of view.

The first consideration for this type of photography is how wide of a field of view you need. Are you trying to survey larger portions of the Moon's surface, or are you trying to get as much detail as possible from a planet? If you need a wider field of view, install the 0.63x reducer on the back of the C14 first. The 2" to 1.25" adapter would go on after that. If you are using a color camera, the ZWO ADC should come next. The camera is inserted and secured in the ADC.

For any other configuration, the 2" to 1.25" adapter is the first element.

If you use a Barlow lens for higher magnification, it should be the adapter first with the Barlow next. The ADC and camera are inserted into the Barlow.

If you are using a color camera and want to achieve a more natural color balance, use the UV/IR cut filter with the camera. It threads into the nosepiece for the camera. Be careful not to cross the threads as you screw it into place.

FireCapture is the software for interfacing with the camera and the mount for planetary and lunar photography. No special privileges are needed on the laptop for running this software.

Figure 11 - This is what the stack of equipment looks like for taking wider field planetary and lunar images. The 0.63x reducer lens mounts to the back of the C14 first, followed by the 2" to 1.25" adapter, the ADC, and finally the camera.

When you first launch FireCapture, it may bring up a dialog window about the particular camera being used. You should be able to click “OK” and start your session. If there are any issues, you will need to ask the instructor about installing the appropriate updates that will allow the software to talk to the camera. A screenshot of the interface is shown in Figure 12.

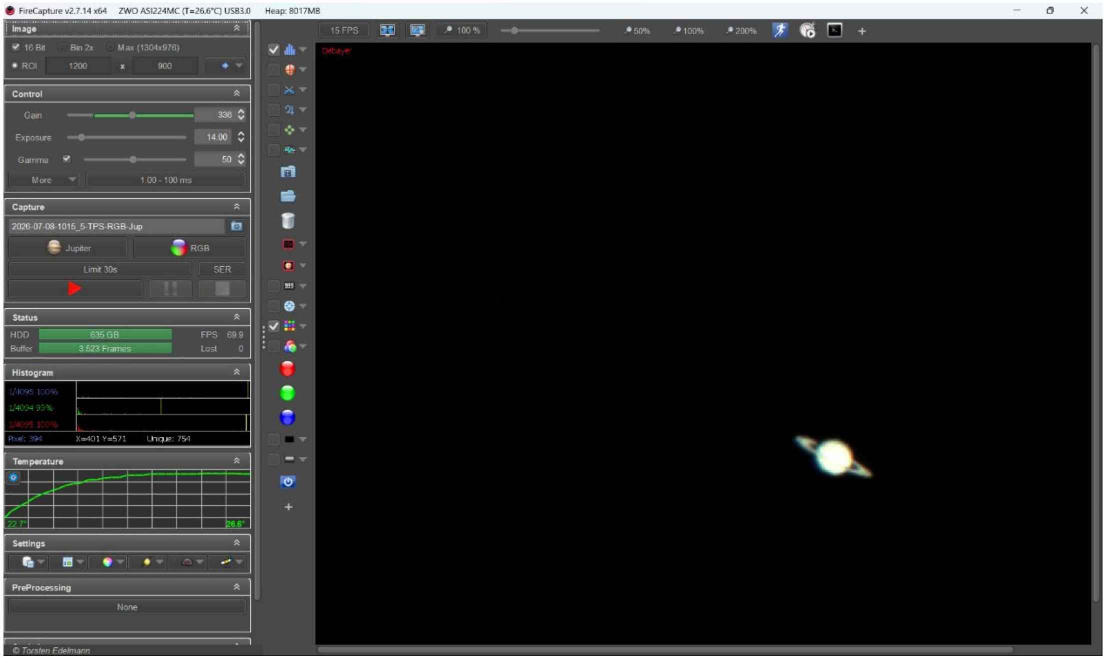

Figure 12 - How FireCapture appears when the program starts. Saturn is in focus in this view.

The view through the camera appears to the right. If you see a bright donut shape, it means the image is out of focus. You may not see anything, or only a faint flicker of light. That usually means the image is out of focus and the light from the object is too spread out. You should increase the gain, the length of the exposure, or both in order to see enough light to bring the object into focus.

There are tutorials on the [FireCapture website] that can walk you through examples of the settings to use. For reference, here are descriptions of the various controls on the left side of the screen.

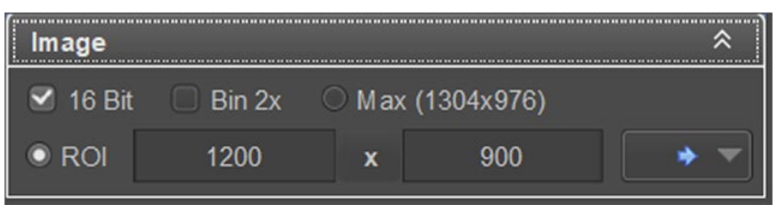

Figure 13 - Image dialog area in FireCapture

The "Image" box controls the size of the area (in pixels) of the camera detector used for imaging as well as the bit depth of the files produced. When you are first trying to locate or focus on an object, make sure that "16 Bit" is unchecked and "Max" resolution is checked. You can take more frames if you reduce the area of the chip being recorded. You can do that by setting the region of interest (ROI). In the example above, the ROI is set to 1200 x 900 pixels. Select "16 Bit" when you are taking SER movies of the planets for the richest detail. The blue arrow presents a drop-down menu with some preprogrammed choices for ROI.

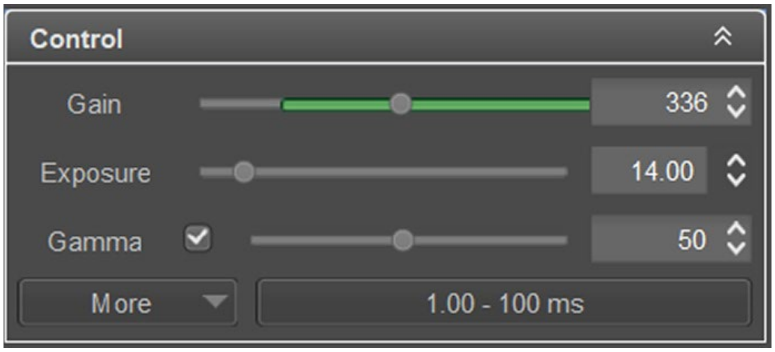

Figure 14 - Control dialog area in FireCapture

The “Control” box lets you set the parameters of the exposure. Note that if you set the “Gain” too high, it will introduce a lot of noise into your images. The exposure is typically listed in milliseconds (ms). Shorter exposures mean more frames per second can be recorded, and longer exposures give you fewer frames per second. The “Gamma” slider affects how the object is displayed within the program.

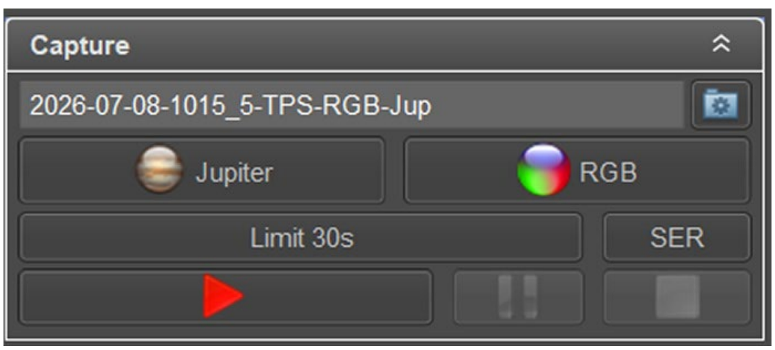

Figure 15 - Capture dialog area in FireCapture

The “Capture” section shows the name of the video file that will be created. You can click on the folder icon to see where files will be stored. You can click on the name of the planet to get settings that you used last time for that particular planet. If you are recording with a color camera, you want the filter section to show “RGB” like above. If you are using a monochrome camera and a set of filters mounted in a filter wheel, you can click on the filter button to select a particular color filter. The “Limit” can be set to either an amount of time or a number of frames when you click on that button. Record 16-bit SER files for the highest sensitivity to different light levels. Clicking the “Play” button starts a recording that you can then either pause or stop.

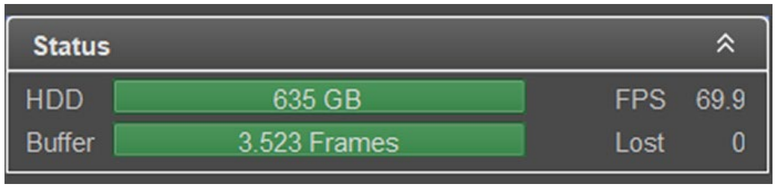

Figure 16 - Status dialog area in FireCapture

Through preferences elsewhere in the settings, you can choose where files will be stored. FireCapture will check and report on how much free space is left on that drive. At startup, FireCapture will set aside a memory buffer for recording videos. The “Status” panel will show how many frames are currently available. If you are recording a video of a specified number of frames or amount of time, the status panel will also show the progress of the recording as it runs. You can see the frame rate (69.9 frames per second or FPS in the example above). If you are running into issues with memory or hardware, frames might get dropped. This panel also reports those as “Lost” frames.

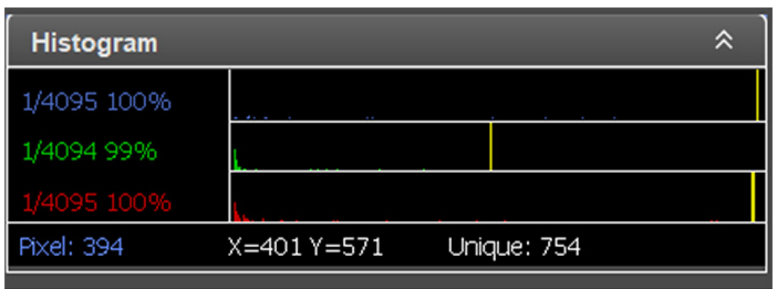

Figure 17 - Histogram monitoring area in FireCapture

The most important panel to pay attention to as you take images is the “Histogram” panel. If you see the bars shown here stretch to 100%, either your exposure is too long or your gain is too high (possibly both). Having pixels that are overexposed means that you are losing signal. The percentage value you get in each color depends on the object you are targeting, The main idea is to balance the gain and the noise it introduces with the exposure and the frame rate. Higher frame rates means that you will capture more data per second, but if you set the frame rate too high, you might not be getting much light in any single frame. You will use the information in the histogram panel to determine the best setting for gain, exposure, and frame rate.

Figure 18 - Setting control section in FireCapture

The “Settings” panel lets you launch various dialogs for controlling features of FireCapture. One of the options you will find allows you FireCapture to connect to the telescope mount via ASCOM. ASCOM stands for Astronomy Common Object Model. It is a platform for software that can communicate with astronomy hardware like mounts, cameras, and focusers. This will create a window on the screen that allows you to control the position and motion of the telescope. This is often considerably more convenient that trying to use the hand controller while taking SER movies.

One aspect of astrophotography that must always be considered for good results are calibration frames. (See the student manual lab on Astronomical Data and the section on Data Calibration.) Flat frames are more important for deep sky imaging, but you can use the setup like the one in Figure 25 if you want to take flat frames for lunar and planetary photography. Set the panel brightness and the exposure so that the histogram is between 30% and 70% for all colors. Run a movie that is 100 frames in length. Name the resulting file something that you can identify as the flat frame. Later, you will take the median of all the frames to create an image to use for your flat calibration. FireCapture has an option for recording a dark frame that is automatically subtracted from each frame as a movie file is captured. Look for the setting for “dark subtraction” or “hot pixel map” in the settings. Put the cover on the front of the telescope and follow the prompts given by the program after you select the option to “map hot pixels”. Make sure this option stays active while you are observing. It will reduce the overall noise in each of your frames, allowing you to capture finer detail more clearly.

After you acquire your target, use the telescope mount controls to move it into the upper left corner of the view, as shown in Figure 19. If you are focusing on the details on a planet, you want the ROI to be only a bit bigger than the planet. There will be some drift in the mount, so leave room for making adjustments to keep the planet close to center as you image it. To get an idea of a typical ROI, look at Figure 20. There is a way to get FireCapture to interface with the mount via ASCOM and take care of these position adjustments automatically, but I have not been able to implement this feature successfully. Once you change the size of the ROI, you can zoom in to get a better look at the planet.

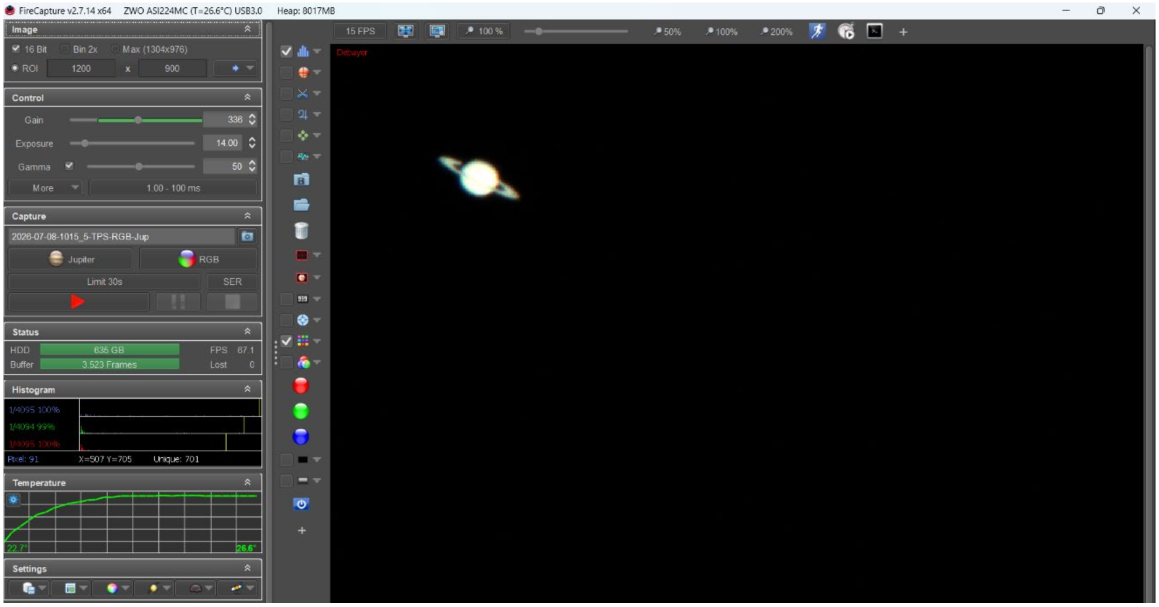

Figure 19 - After your planet is in focus, use the telescope controls to move it to the upper left corner of the view.

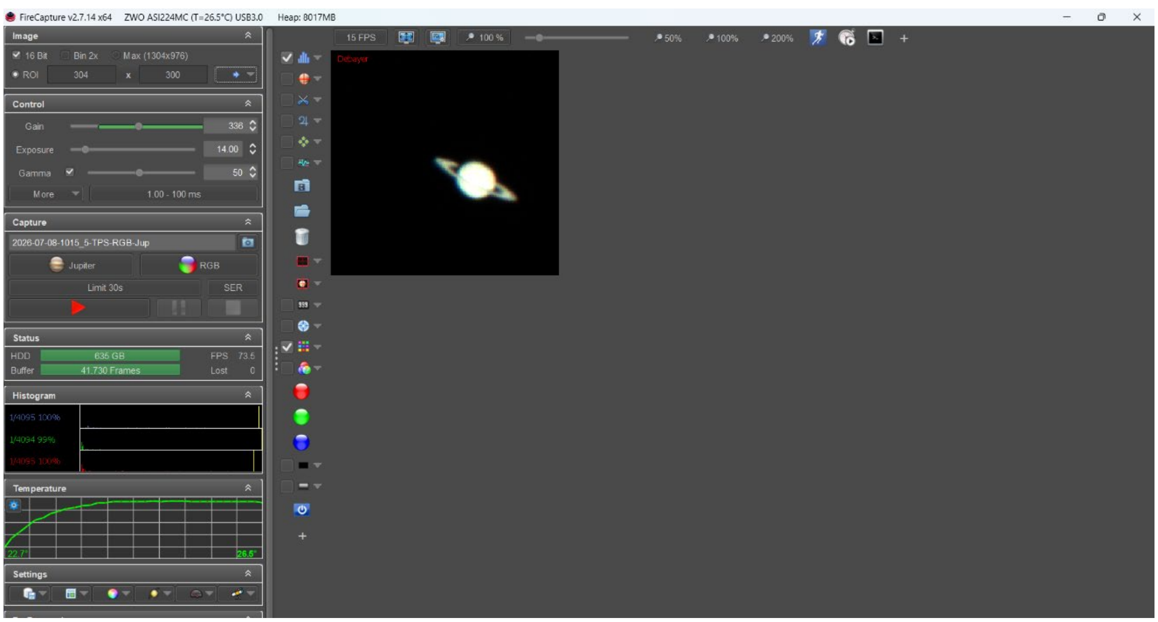

Figure 20 - Use the resolution settings in the "Image" part of the controls to fit the ROI tighter to the target.

If your target will be near the zenith for the entire imaging session, you won't need the ADC. If your target has an altitude less than 45° for part of your session, use the ADC. You will likely need to make adjustments to make sure the red image is aligned with the blue image. You may need to loosen how the ADC is seated in the Barlow or the adapter and rotate it. There are two levers on the side of the ADC. Click the button highlighted in green in Figure 21 to have FireCapture split the view of the red image and the blue image. Look at the pixel offset values in the x- and y-directions in the small square window that appears. Adjust the

ADC until those offset values are as close to zero as possible. Figure 22 shows a relatively good alignment.

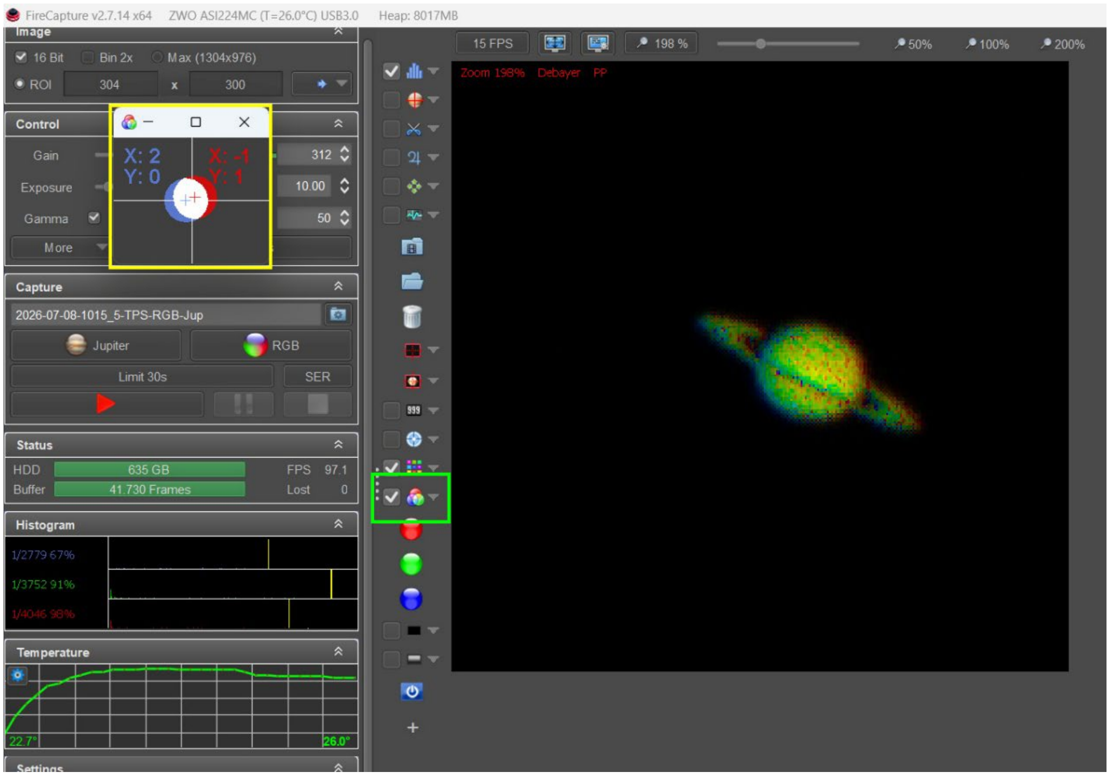

Figure 21 - Click the item with the three separated color circles to get the tool used for aligning different color channels (only needed for color cameras).

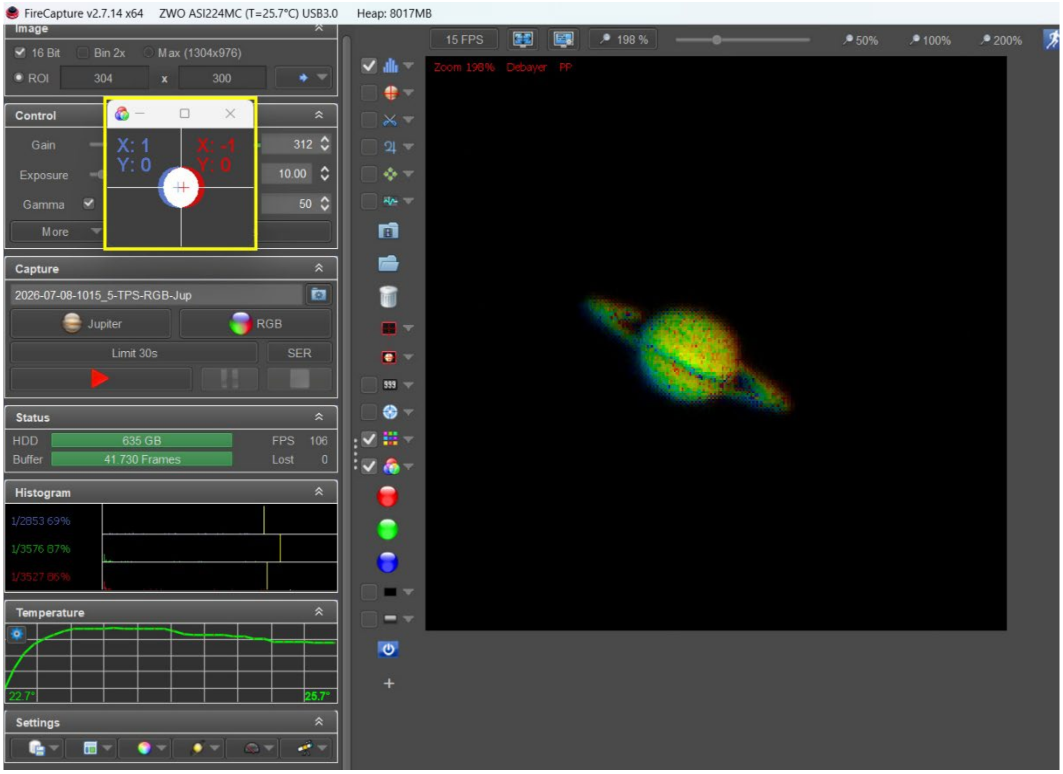

Figure 22 - Adjust the position of the levers on the ADC to reduce the offsets between red and blue images as much as possible. You may also need to rotate the ADC.

Once the color channels are aligned and the object is in focus, you're ready to begin recording SER files. After you select the object from the list in the "Capture" section, adjust the gain and exposure so that none of the pixels are saturated. When you look at the histogram for the video input, it should never reach 100%. A shorter exposure results in a higher frame rate, and that gives you a better chance of "freezing" the effects of seeing in Earth's atmosphere. However, if you set the gain too high, the image becomes noisy. It will take some experimenting to figure out the best settings depending on the planet, how high it is in the sky, and whether there are any clouds that night.

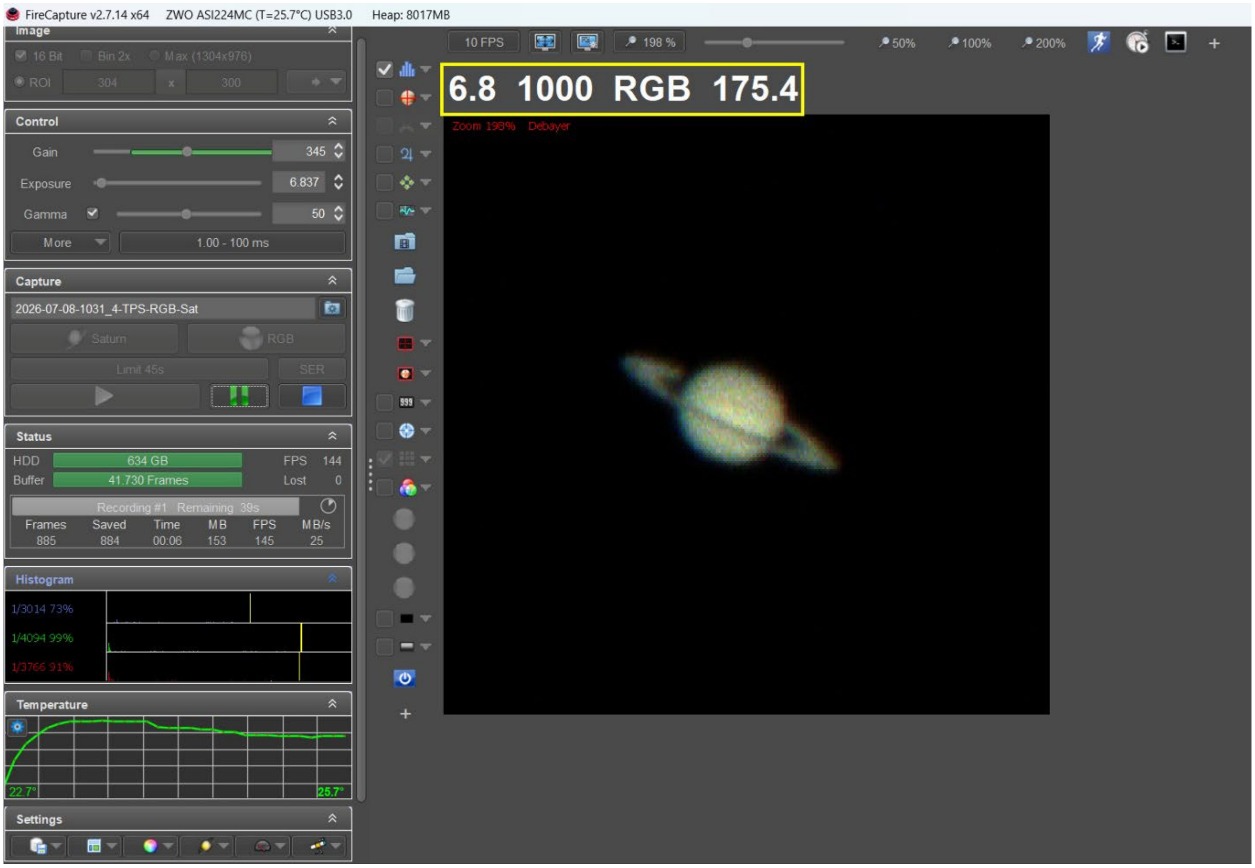

Figure 23 - When you record video, the area above the camera view will show the total time elapsed, the number of frames taken, the filter that you selected, and the number of frames per second being recorded.

Jupiter's Galilean moons are visible with the same settings as the planet. For Saturn, you'll be able to see Titan with same settings as for the planet, but the other moons are too small and faint. To see those moons, you'll need to set the gain higher and the exposure longer. This will make Saturn too bright, but it reveals the locations of the other moons.

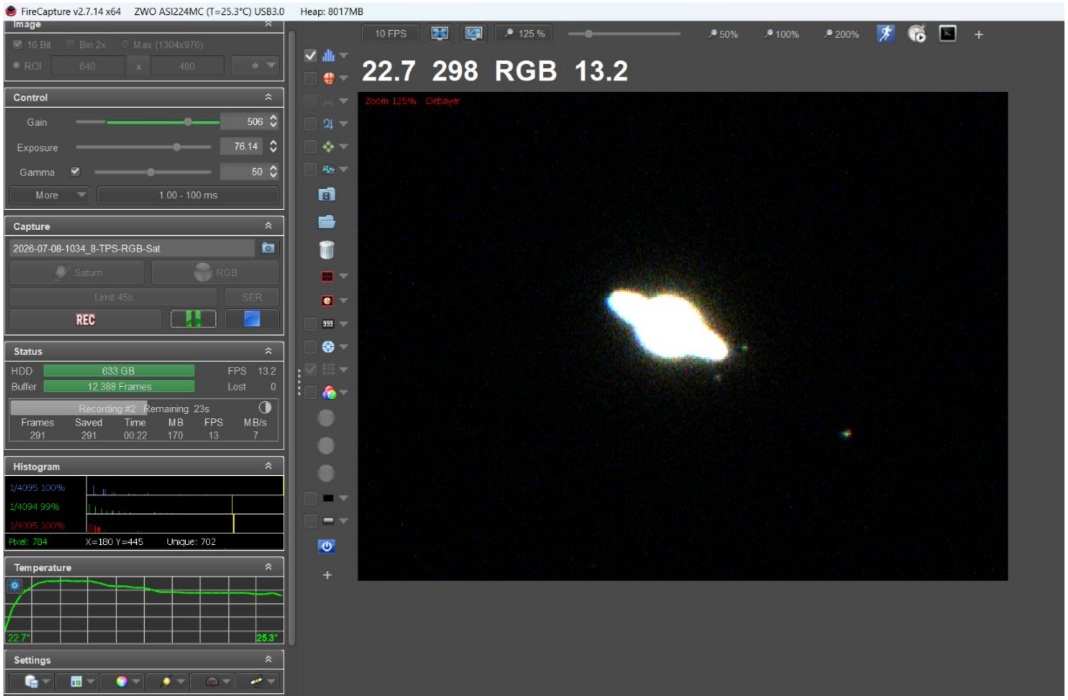

Figure 24 - To record the moons of Saturn, Uranus, or Neptune, you will need to overexpose the planet by increasing the gain and/or the exposure time.

An issue you will encounter when gathering data on planets is that they rotate. This means that the features that are visible change throughout the night. This limits the length of the SER recordings you should make since you don't want the features to move across the planet in any one video. Limit recordings of Jupiter to 30 seconds. You can use 60 second recordings for Mars and Saturn, but I usually do 45 seconds. Consider limiting videos for Uranus and Neptune to 120 seconds. They are so far away and appear so small that they won't show changes over that much time. You don't have to worry about rotation for Venus and Mercury since their rotation is so slow.

If the Moon is your target for the night, consider setting the tracking rate of the mount to "Lunar". The default is the sidereal rate, but because the Moon moves east relative to the stars, it will keep moving out of view if you stay with the sidereal rate. There's no concern about the Moon rotating as you image it, but unless you are focusing on just one particular feature, you will want to use the full frame as the ROI. Go to the "Image" dialog and click "Max" to achieve this.

Rather than taking movie frames for a specified amount of time, it is better to select a set number of frames per movie for the Moon. In the "Capture" dialog, click on the button that says "Limit". It will launch an interface for choosing whether you limit your movie by time or by number of frames, as shown in Figure 25. For most lunar imaging, 100 frames is fine. If you are trying to capture smaller details, try more frames. Because you are using the maximum size of the chip, the SER file that is produced can be mammoth in size if you let it run for too long.

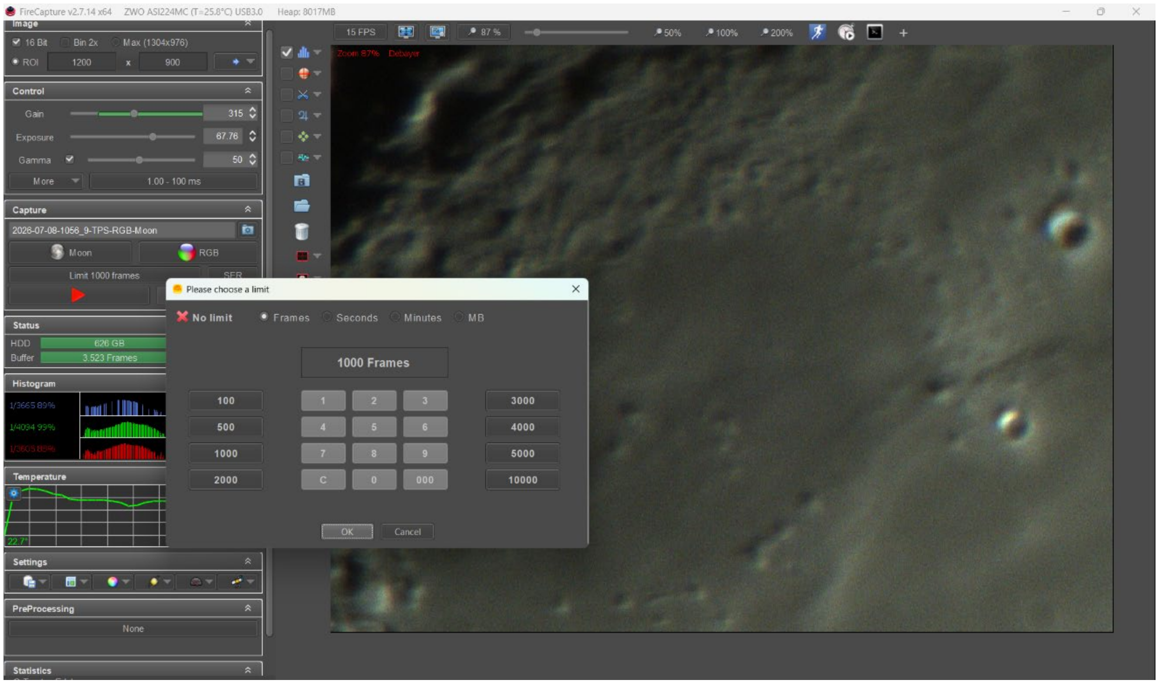

Figure 25 - Clicking "Limit" in the Capture dialog lets you select the option to stop recording afer a specified amount of time or a specified amount of frames.

I have the laptop setup to save files in the C:\observatory\fc folder. Under that folder, you will find folders with the names of the targets you select in the “Capture” dialog. Under each of these folders are folders with a date in YYYYMMDD format. The dates use Universal Time, so if you are taking images in the evening, the date will look like it is for the next day (i.e., taking images of Jupiter on the evening of 2024-04-15 will create a 20240416 subfolder in the “Jup” folder). Recording with FireCapture also creates a text file along with the SER file that has information about the settings used.

SER files can be huge – in excess of 1 GB each. When you are finished with your session, please copy the folders that were created to a portable hard drive and delete the originals from the laptop so there is room for the next user.

After you are finished taking data, you need to process it to make the highest resolution image possible. There are a variety of free software packages that will take you SER movies and average together the best frames to give you the clearest possible image. An older package that still works well is RegiStax. The last supported version is RegiStax6. You can find guides for using it elsewhere. The software we will use is AutoStakkert. It is also available as a free download. Search online for videos from Christopher Go and Damian Peach for examples of a workflow with these tools.

Deep sky photography

The software for running our SBIG 6303E camera is Maxim DL. It needs to be run as the administrator for the laptop, so you will need to be more involved if you are working with students on this. The camera has an SBIG FW8G-STXL filter wheel attached to it. This filter wheel has a separate imaging chip that is used to guide the scope during long exposures. The filters installed are Antlia filters. Their order and type within the filter wheel is as follows:

Slot	Filter
1	Red
2	Green
3	Blue
4	Clear (visible light)
5	H-alpha
6	[O-III]
7	[S-II]
8	Empty slot

The manuals are available through a Canvas course called "Astronomy with the Cerritos College Observatory". Ask to be added to that course if you do not already have access.

I plan to get a Johnson/Cousins Classic V photometry filter to round out the filter wheel.

The icon circled in green in Figure 26 launches the camera control dialog. There is a huge array of possible actions and information you can get from the camera controls. Here we will only go over some basics. Using the "Help" function in Maxim DL can guide you through a lot of other details. When it is first launched, the camera controls appear as they do in Figure 27. Make sure that "SBIG Universal" is listed under the "Setup Camera" button. "Dual Chip Mode" needs to be checked to use the guide camera in the filter wheel. When you click on "Options", you get the window that appears in Figure 28. Even though the guide chip is built into the filter wheel, you still need to select "External Remote" to have it work properly.

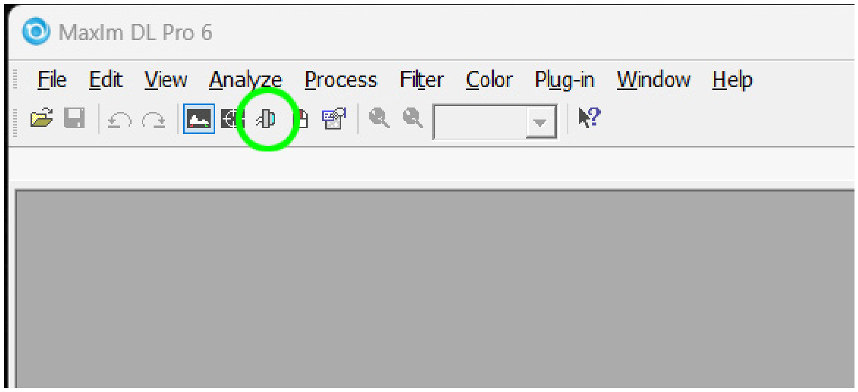

Figure 26 - This icon on the toolbar in Maxim DL launches the camera control dialog for connecting the camera, starting and stopping the camera cooler, setting and taking exposures, and setting up the guiding to keep the telescope on target.

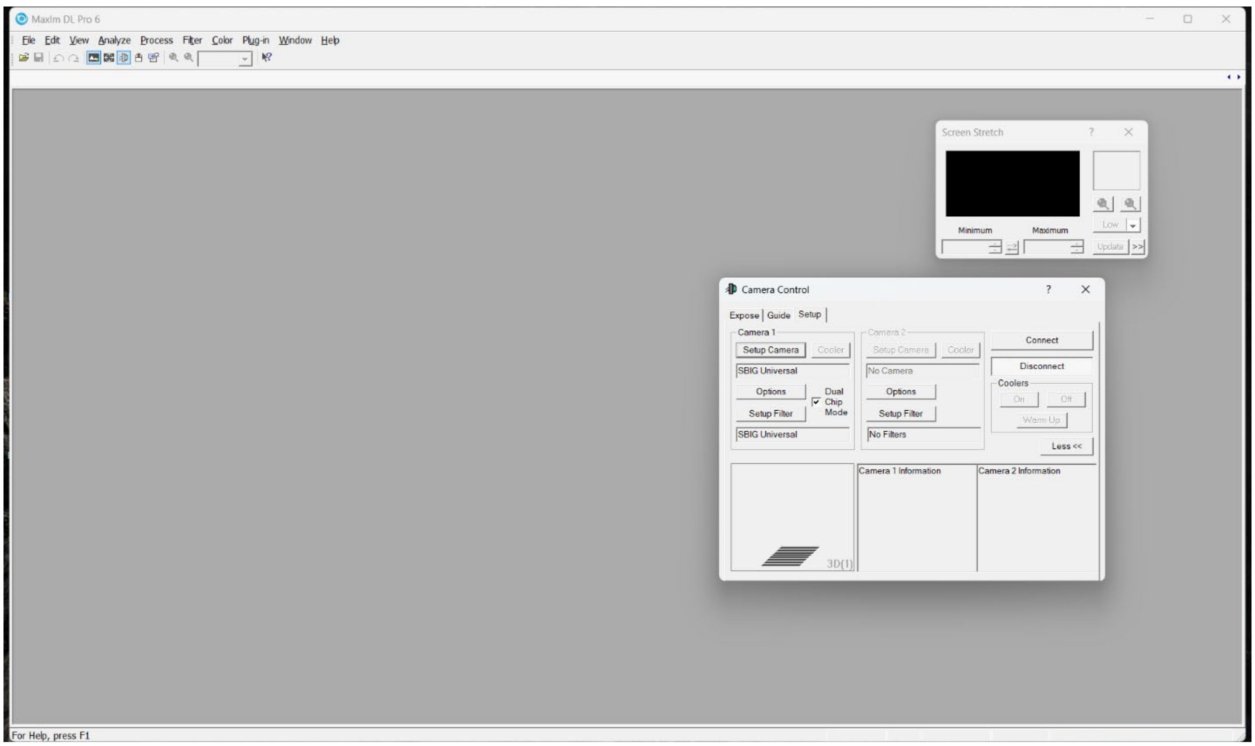

Figure 27 - This is what the camera control dialog window looks like when you first initiate it.

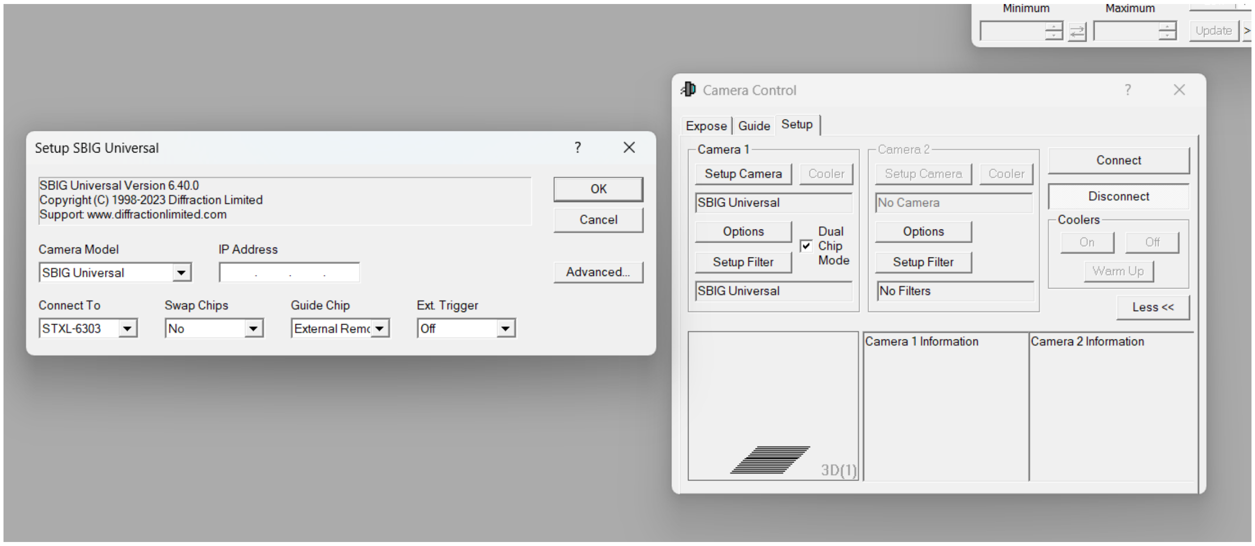

Figure 28 - When you click "Setup Camera", the dialog that appears should show that "External Remote" is selected for the Guide Chip. This is necessary for the guide camera in the filter wheel to work.

When you connect the camera, you should hear the filter wheel move the filter in slot 1 (the red filter) into place (unless it is already on the red filter). The information in the bottom sections of the “Setup” window will include the temperature of the CCD chip. Click “Cooler” and set the temperature to 30°C to 35°C *below the current temperature*. The colder that you make the sensor chip, the less noise will be present in your images. However, it is designed to cool only to 40°C below ambient temperatures. If you try to push it colder than that, it affects the power going to the sensor. This can degrade the quality of the images or make them unusable.

Click the tab that says “Expose” and try selecting different color filters. You will do this from the drop down menu under “Filter Wheel” (see Figure 29). You should hear the filter wheel move each time you select a new filter. Set the exposure time to between 2 and 5 seconds and click the “Continuous” radio button. You also want to make sure the radio button for “Camera 1” is selected. Click “Start” to start taking exposures, and adjust the focus to be as sharp as you can get it. We will do a final check on the focus once we enable guiding.

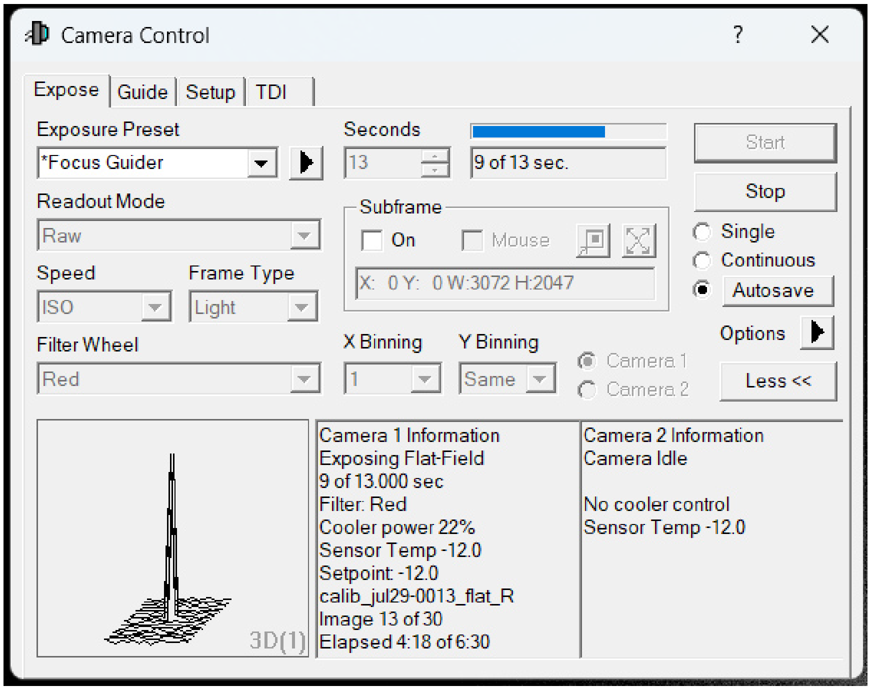

Figure 29 - Camera control showing "Expose" tab settings

To start guiding, click the “Guide” tab. Make sure the radio button for “Camera 2” is selected here. If you take an exposure, it will appear in a smaller window since the guide chip is smaller. If you got stars in focus with the main camera chip, they should also be in focus here. If not, the manual for the FW8G-STXL filter wheel has instructions for how to adjust the focus for the guide camera. If you are using the SBIG camera, you should have been added to the “Astronomy with the Cerritos College Observatory” Canvas course. The filter wheel manual is in the “Files” section of that course.

There needs to be at least one star that appears in the view for the guide camera. Maxim DL should indicate the X and Y pixel location of that star in the information on the “Guide” window. If it doesn’t find it, clicking on the star will put its location in that tool.

Before going further, you need to connect Maxim DL to the telescope mount. Click the icon in the top next to the camera that looks like an observatory dome. It is the icon immediately to the left of the one to start the camera control. The screen that comes up gives options for connecting Maxim DL to the telescope mount, the focuser, and other related equipment. For now, we just need to make sure the correct mount interface is selected and tell Maxim DL to connect. Maxim DL should call the ASCOM platform and allow you to control the mount from the laptop at this point.

Now, go back to the “Guide” window. Make sure the star is still visible in the guide camera exposure and the position of the star matches what is shown. Click the radio button marked “Calibrate”. When you click to start, you should see the camera take an exposure of the star, then the mount will move a little bit (probably too small to notice). On the next exposure, the star has moved somewhere else in the image. You should see a red line connecting its old position to its new one. For the next exposure, the star moves back closer to its starting point. Then, you should see the star move at a right angle relative to the first moves. Another red line will be drawn, and then the star should move back near the pixels where it started. This trains the program to know how much to turn the motors to get the guide star to move in response. Unless you choose to reset the calibration, Maxim DL will use the computed values for the rest of the session.

When you start guiding, you should see a small window appear that has an image of the guide star. In the information/status areas at the bottom of the camera control window, you should see the motions that the guide chip is detecting for the guide star. If these values are not appearing and changing very slightly every time the guide camera takes a new image, you are not successfully guiding. Try the calibration again.

Once you know the guiding works, you can stop it and then move the telescope to the target of your choice. Check with the “Expose” tab to make sure the object you want appears when you do a 10 to 30 s exposure. Adjust the position of the mount so your object appears how you want within the frame of the image. Then, switch to the “Guide” tab and take an exposure. If a star appears in the guide camera view and its position is listed in the areas for its X and Y position, you are ready to start guiding. If no guide star is present, you will have to make small adjustment in the mount position to find a star to guide by.

You can now do a final adjustment with the focus to make it as sharp as possible. There are tools within Maxim DL for this. When you click the arrow next to “Options” from the “Expose” view of the camera controls, one of the options it shows is “Big Statistics”. This will launch a window with large print information about a star in your image. Adjust the focuser so that FWHM is as small as possible in that statistic window. This means you are making the image of the star as sharp and as small as possible. You can then close the statistics window and start your imaging run.

Select the radio button for “Autosave”, then click the “Autosave” button. The controls shown in Figure 30 appear. Click in the area under “Autosave Filename” and type in an identifier for the object you are imaging. This will then appear in the names of all files created by this imaging run. Clicking on a Slot button activates the settings on that row. Set the “Type” to “Light”, then select the filter you want. For the suffix, type in something that will help you identify the filter. For example, if you are using the red filter, you could set the suffix to “_R” so that appears with all the filenames for images created with that filter. The exposure is listed in seconds. Binning should be 1 if you want to use the highest resolution. Setting a higher value for the binning concentrates more light but gives you a smaller final image. Leave the “Readout Mode” as “Raw”, then change “Repeat” to the number of exposures you want to take with that setting. Activate the slot and complete the row for every filter that you want to shoot with. When you are done, click “Apply” and “OK”. You will come back to the camera control window. At that point, make sure guiding is still working and click “Start”. That will begin your imaging run.

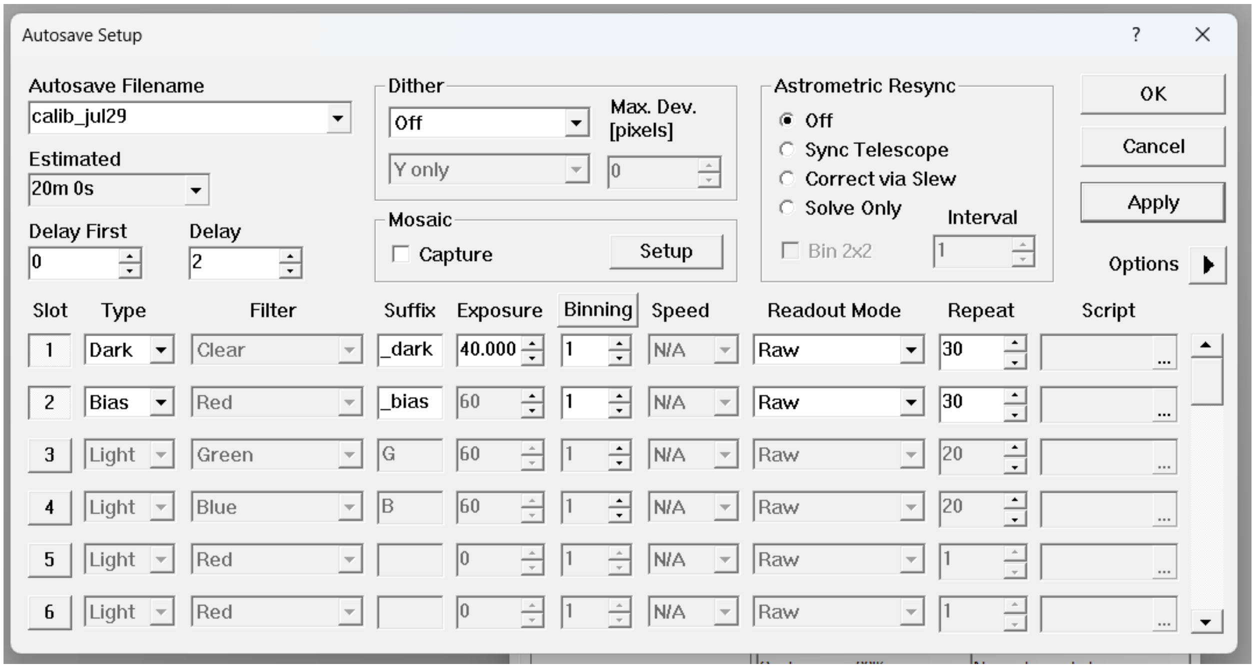

Figure 30 - This is the window that is launched by clicking "Autosave". You will set up your imaging run here.

Refer to the Astronomical Data lab and Data Calibration section of the student manual. You can take dark and bias frames while it is still light out. The STXL 6303 camera has a built-in shutter that will close while you take these calibration frames. Go into the controls with “Autosave” to setup taking your calibration frames. Name them something you will be able to identify easily later. I usually go with “calib_apr03” if I am taking these calibration frames for a session on April 3, for example. Change the “Type” to “Dark” for your dark frames and “Bias” for your bias frames. Set the exposure time equal to the exposure time for your light frames for your dark frames. I recommend taking at least 20 of each, but if you are taking long exposures for your light frames, you can get away with fewer dark frames. Always try to get at least 10 dark frames.

For flat frames, you need the scope to be focused the same way that it was for your light frames. Point the scope straight up and turn off the mount so that it doesn’t rotate as you are taking flats. Place the light panel from the bottom of the equipment cabinet on top of the telescope as shown in Figure 32 and adjust its brightness. You will need to take flat frames for every filter that you used. Before using the “Autosave” settings, you want to test the exposure settings for your flat frames. Go back to the “Expose” tab and set the mode to “Continuous”. Set the filter to the one whose exposure you want to check. Look at the “Screen Stretch” window (as shown in Figure 31. The camera reads out values between 0 and 65536 for each pixel. You want the counts for your flat frames to fall in the middle of this range, as is shown. The pixel values for your flat frames do not need to be exactly at 32,700, but they should be within a few thousand of that. Once you know what exposure to use for each filter, go back to “Autosave” and setup your run for flat frames. Make the suffix something along the lines of “_flat_G” as an example if you are taking flats with the green filter.

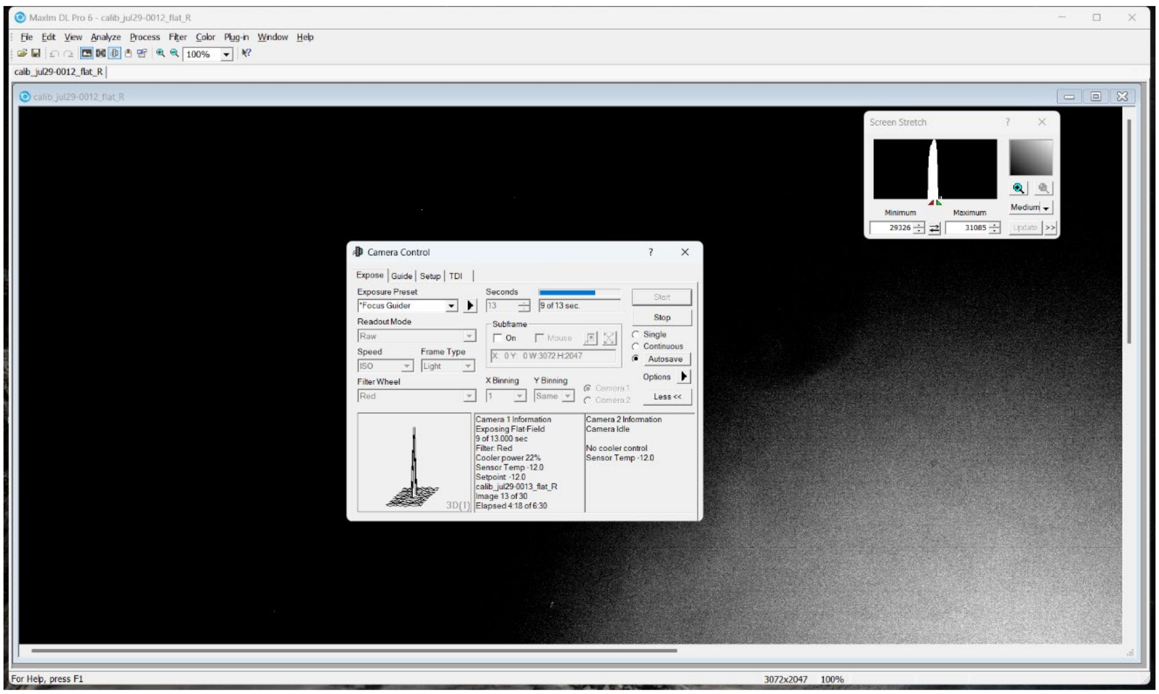

Figure 31 - Using the "Expose" tab to check the settings for taking flat frames

Once you have all your light frames and calibration frames, you’ll need a software package to turn this data into an astrophoto. Siril is freeware that is a common choice for this work. Deep Sky Stacker is another common choice for freeware for this task. There are lots of good online tutorials about how to use both of these programs. The package that I got excellent results from while processing data for this project was AIP4Win. This is written for Windows, but should run on a Mac or in Linux with an emulator. This is also freeware, and you can get it from the “Files/software” section of the “Astronomy with the Cerritos College Observatory” Canvas course. There is some questionable choice of wording in how images are related to each other in AIP4Win. I wish the programmer had gone with “primary” and “secondary” for referring to images instead of the terms he chose to use.

Figure 32 - Setup for taking flat frames with the C14; the light panel that is on top of the telescope can be found in the bottom of the cabinet in the observatory

A later version of this manual will have specific instructions for taking scientific data with our equipment. The student manual mentions some possible projects along these lines.