

INSTRUCTION MANUAL

Orion® StarShoot™ G Series CMOS Cameras

#51452 G10
#51454 G10 EU/UK
#51457 G16 Mono
#51458 G26 APS-C

#54290 G21
#51883 Mini 6.3 Color
#51884 Mini 6.3 Mono



#51452



#51883

 **ORION**
TELESCOPES & BINOCULARS
AN EMPLOYEE-OWNED COMPANY

Corporate Offices: 89 Hangar Way, Watsonville CA 95076 - USA
Toll Free USA & Canada: (800) 447-1001
International: +1(831) 763-7000
Customer Support: support@telescope.com

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Welcome to the exciting world of astro-imaging. Your new StarShoot™ CMOS Imaging Camera is capable of capturing professional quality astro-images of your favorite celestial objects. You can showcase spectacular images on your computer, share them on the internet, or print them. The camera's large pixel array provides very high resolution images which are great for publishing in large prints. Please read this instruction manual before attempting to use the camera or install the needed software. This manual covers installation of your camera along with basic functions of acquiring images using the included software. To get the most out of your camera using 3rd party dedicated astronomy apps coupled with the universal ASCOM driver for the G Series Camera, please consult the software help files and manuals included with the individual software packages available on the market. Some of our favorite programs are mentioned below. Note: This manual covers the StarShoot Mini cameras as well as the larger format cooled G series cameras. Some features will only be available on specific models.



Figure 1. The back panel, with USB ports and LED indicator lights of the G10

The StarShoot CMOS Camera (G10 and larger)

The StarShoot Camera is a high resolution CMOS imager with a dual-stage, regulated thermoelectric cooler to enable maximum imaging performance. It is very sensitive and capable of detecting faint deep sky objects in a short exposure; and longer exposures or higher gain settings can reveal extremely deep fields with subtle nebulosity and galaxies in the background. The unique versatility of CMOS chip lets you take advantage of the densely-packed pixel array. 1x1 mode utilizes the full resolution of the camera, providing the most detailed images and largest possible prints. The one-shot-color versions offer the easiest path to a full color image, with the Bayer matrix over the chip to encode the color data without having to shoot through individual filters. The Monochrome versions are the most sensitive StarShoot cameras, because of that monochromatic nature of the chip, but will need to shoot through different color filters in order to produce a full color image. Binning in 2x2 mode or higher shortens the exposures necessary and full well capacity of each pixel at the expense of resolution. Binning in 2x2 mode can be especially useful for longer focal length and higher focal ratio telescopes, as well offers super-fast downloads when focusing with a Bahtinov mask or V-curve assisted motorized focuser.

Feature Highlights

- **Simple interface:** A USB 3.0 port and power port are all that are needed to power and connect to the Camera (**Figure 1**).
- **Dual-stage thermoelectric cooler:** Dramatically reduces thermal noise in all images, down to approximately 35 degrees C from ambient temperature.



Figure 2a. All of the included parts of the Starshoot G10 and above. Note: AC cable will differ in EU and UK.

- **Regulated cooling:** Enables you to set the exact temperature within the cooling range of the camera. This allows you to take calibration images like dark frames at the exact same temperature as your light frames, making for the cleanest images possible. Additionally, since you can match the CMOS temperature at any time (within the range of the cooler), you have the freedom to take dark frames when it's most convenient for you, so you don't have to use up valuable imaging time to take dark frames.
- **High speed USB 3.0 interface and internal memory buffer:** The 512 megabyte on-board memory buffer ensures a

clean image download each time, even if the system resources of your PC are temporarily compromised.

- **Two port USB 2.0 hub (Figure 1):** means cable management is much easier. Plug up to two other USB devices (such as an autoguider and electronic filter wheel into the camera, and only have the USB 3.0 cable and power cable coming off the telescope.

- **Status indicator lights (Figure 1):** Shows connection to the camera, data transfers (flashing light), power to the electronics, TEC (thermoelectric cooler) and fan.



Figure 2b. The included parts of the StarShoot Mini.

The StarShoot Mini CMOS camera

The StarShoot Mini cameras (6.3mp Color and Monochrome) are lower cost alternatives to the larger G10 and above cameras. They are not cooled which means that while the inherent noise will be a bit higher, the size, cost, and power requirements are considerably reduced. The StarShoot Mini cameras are based around the Sony IMX 178 CMOS chip, and excel at planetary imaging because of the super-fast frame rates and the tiny 2.4 micron pixels. In addition, they are capable of deep-sky imaging with exposures up to 1000 seconds. They also feature a standard SBIG autoguider port, so they can be used as a very sensitive autoguider while imaging through a different camera. For the most sensitive guiding, the mono version is recommended. All subsequent sections of this manual (including the deep-sky imaging section) pertain to the StarShoot Mini cameras as well, but some features such as the TEC cooler and AC power requirements, do not apply. The Mini cameras are powered fully by the USB 3.0 port on your computer.

2. Getting Started

Parts List

- StarShoot G Series camera
- 1.25" nosepiece (Mini), 2" nosepiece (G10 and above)
- USB 3.0 cable
- SBIG guide cable (Mini only)
- DC power adapter and cable (G10 and above, and different AC plugs provided in EU/UK versions)
- External desiccant plug (G10 and above)

- Hard carrying case (G10 and above)

Telescope

The StarShoot can be used with most telescopes on the market. The Mini cams slip into a 1.25" focuser, and the larger format cameras into a 2" focuser (Figure 3a). The cameras are also compatible with any focuser that includes male 42mm T-threads (G10 and above) or male c-mount threads (StarShoot Mini).

Caution: Be sure to always firmly tighten the thumbscrew(s) that secure the camera in the telescope focuser, or it could fall out and onto the ground! If your telescope has T or C threads for direct camera attachment, a more secure connection can be made. First, unthread the 1.25" or 2" nosepiece from the camera body to expose the C or T threads on the camera front housing. Then simply thread the camera onto your telescope (Figure 3b).

Back-focus Requirement (G10 and above)

The camera requires 17.5mm (0.689") of back-focus. This is the distance from the front of the T-threads to the CMOS sensor. This is necessary info to have when calculating spacers to put behind a Coma Corrector or Field Flatteners, which usually require 55mm of space for optimum performance.

Mount

Deep sky imaging with the G Series usually requires an equatorial mount with a right ascension (R.A.) motor drive. The goal for your mount is to seamlessly track the apparent movement of the sky as the Earth rotates. The tracking must be very accurate, or the object you want to image will drift and blur across the camera's field of view while the exposure is taken. Even a small amount of drift will cause a star to look oblong instead of round. We recommend using a high-quality equatorial mount which utilizes periodic error correction (PEC) or has the ability to interface with an autoguider.

Computer

The camera requires a Windows PC to operate the camera. For astro-imaging in the field at night, a laptop computer is highly recommended. The included software requires Windows 7, 8, 10, and for full data speed, a USB 3.0 port is required. A large



Figure 3a. The Camera, installed in a 2" focuser using the included 2" nozzle



Figure 3b. T-threads for direct threaded connection (G10 and above). StarShoot Mini cameras slip into 1.25" focuser, or use c-mount threads

hard drive is also recommended, as the individual image files are quite large, and can take up a lot of disk space.

Power (G10 and above only)

The camera requires 12 volts DC (12VDC) to run the TE cooler. Power to the cooler and fan is supplied by the included 3amp AC/DC transformer when plugged into an AC outlet. Imaging in the field away from AC power usually requires the use of a portable field battery to supply power. Make sure the power supply provides at least 3 amps of current for the duration of your imaging session. This allows the camera's TEC to use 100% of its potential cooling power. The 12v input port accepts a standard 5.5mm/2.1mm DC TIP POSITIVE plug.

Software and Driver Installation

The software and driver must first be downloaded from the Orion website before plugging in the camera. Please go to: www.telescope.com/Gseries to download all the relevant software for your camera. Downloadable files include:

- **StarShoot Image Capture:** camera control program
- **G series direct driver:** for DirectShow applications
- **G series ASCOM driver:** for camera control in 3rd part astro-imaging software.

Note it is HIGHLY recommended to install the ASCOM platform and download the G series ASCOM driver to use with the camera. Dedicated 3rd party camera control programs are available online which will unlock the full astro-imaging potential of the camera. To install the ASCOM platform, visit www.ascom-standards.org and click the download button. Don't forget to also install the G series ASCOM driver from Orion's website **AFTER** you install the main ASCOM platform. When connecting to the camera in a 3rd party program using ASCOM, choose "ASCOM camera" from the camera selection menu, and then the G series camera should appear in the ASCOM camera selection window if the driver is properly installed.

1. Download all relevant files from the Camera download page
2. Double-click on the install .exe for the Image Capture program, the driver, and the ASCOM driver, and follow the onscreen directions for installation. Do not plug the camera in until the drivers have been installed for the camera.
3. Once the driver and software has been installed, plug the camera into an available USB 3.0 port, and connect the AC power cord to the DC input on the camera (**Figure 1**), and connect to AC power (G10 and above only).
4. Windows will take a moment to recognize the USB device plugged in, and once that is complete, you can open up the StarShoot Image Capture program to connect to the Camera.

Hardware setup

Now that the camera drivers and software are installed, it's time to connect the camera to the telescope, and open up the software. Install the camera into your focuser, and for the G10 and above: connect any peripheral devices to the two USB 2.0 ports on the camera, and connect the camera to power. Please note

the AC/DC transformer has a relatively short DC cable length. This prevents 12v voltage from dropping over longer runs, but you may find it difficult to reach an AC outlet depending on your scope setup. Use of an extension cord on the AC side of the adapter is suggested, and the DC transformer itself can rest on the tripod accessory tray, or secured with Velcro or some other method directly to the tube wall or telescope rings. If you need to extend the 12v side of the power cable, a 5.5mm/2.1mm DC extension cable (available from your local electronic supply) can be used, but please try to keep the length of the cable as short as possible. Finally, for all cameras including the Mini, connect the USB 3.0 cable from the camera to an available USB 3.0 port on the computer.

Focusing the camera for the first time can be tricky, since the camera may focus at a completely different place from where an eyepiece focuses. It is recommended that you first center a bright star in a 25mm eyepiece before attaching the camera, to be sure the camera is centered on the star. Even very far out of focus, you should be able to see a fat disk (the out-of-focus star), to determine which way to turn the focus knob to bring the star down to a focused point.

4. Software

The next section with document connecting to the camera and basic image downloads. The included software will run the basic astro-imaging steps including image download, cooler control, exposure controls and such, but please note that this software only touches on the basic functions of acquiring astro images. To get the best results with more advanced processes such as stacking multiple long exposures together to reduce noise, manual dark frame subtractions, flat field and dark frame stacking for smoother calibration frames, and other processes, it is HIGHLY recommended to control the camera with an ASCOM compatible capture program. Some are free on the web, others are paid, but there is a vast array of programs available that will be compatible with the camera. Here are some of our favorites:

DeepSkyStacker: <http://deepskystacker.free.fr/> - Excellent free program for pre-processing that simplifies the alignment and stacking of your images. Automatically monitors a directory where images are saved, and processes on the fly. Add all the calibration frames, including darks, flats, biases, and step back while the software does the rest giving you output ready for post processing in programs such as PhotoShop.

RegiStax: www.astronomie.be/registax/ - Excellent free program for aligning, stacking and processing of AVI video files, ideal for capturing lunar and planetary video, splitting the video into individual frames, analyzing each frame and aligning/stacking/processing the best ones for pulling out fine details.

SharpCap: sharpcap.co.uk - Free camera control and capture program. Features include video and long exposure control, flat field and dark frame subtractions, histogram control, excellent focus assist routines including Bahtinov mask overlays and FWHM measurements, and MUCH more!

Sequence Generator Pro: mainsequencesoftware.com - free 45 day trial. Excellent Image Capture suite to control all aspects of your setup. Create sequences of exposures of different

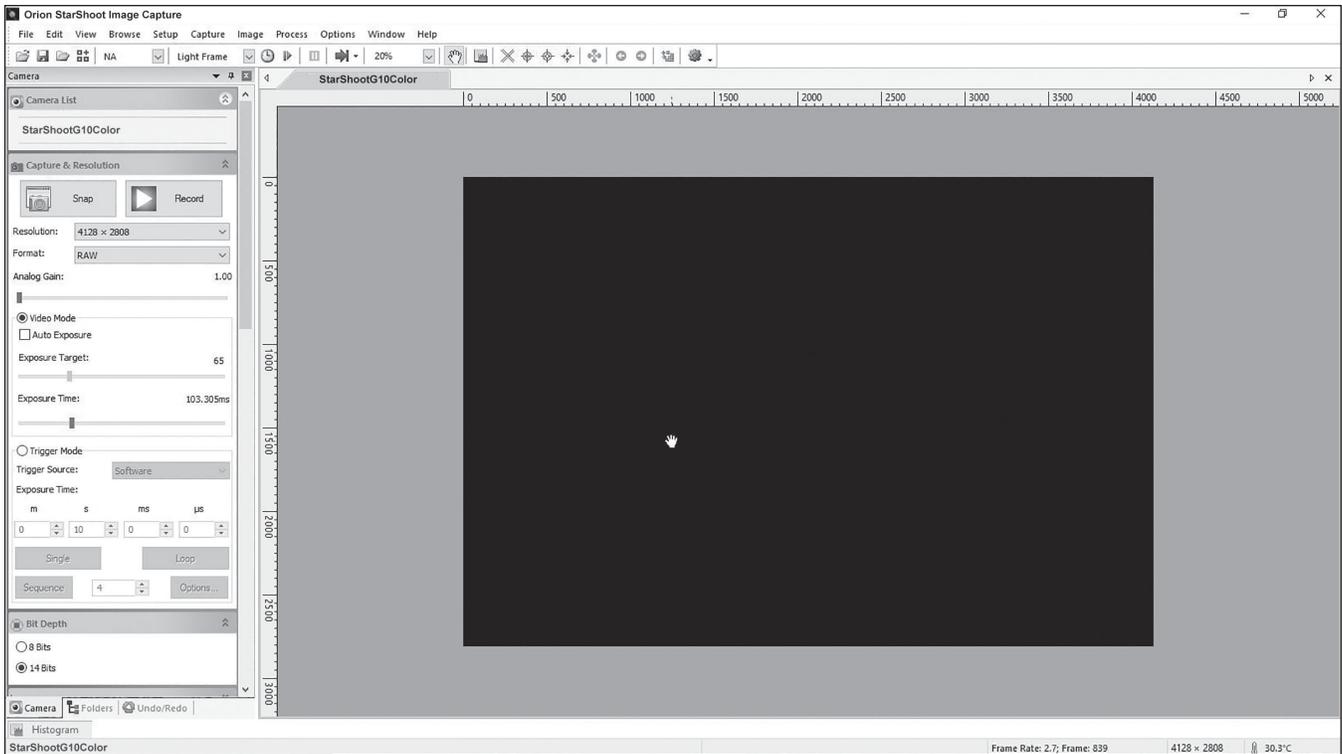


Figure 4. Primary software screen.

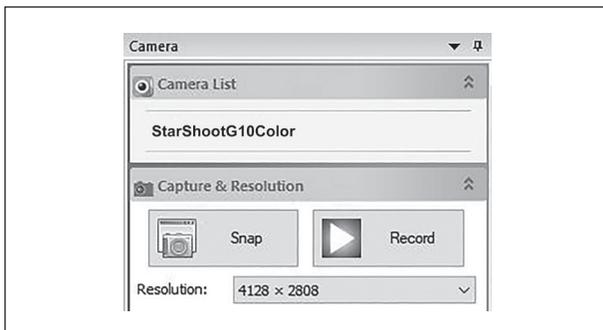


Figure 4a. Camera model – click this text to connect to the camera and start the preview.

lengths, control a Go-To mount for automatic pointing and auto-centering in any part of the image, auto v-curve focusing with a compatible electronic focuser (without having to re-center to a target star), autoguider control, and a host of other features.

Nebulosity: stark-labs.com – free demo available to try. Powerful, yet very easy to use image capture and processing program. Excellent processing routines such as aligning/stacking and dark/flat/bias handling. An excellent choice for the beginning astro-photographer getting into processing, yet will carry over for more advanced users as well.

Orion StarShoot Image Capture

Plug the camera into the USB 3 port, and into AC power. When you open Orion Starshoot Image Capture, you'll be presented with the main preview window on the right, and the control

options on the left-hand side. (Figure 4). On the top of the left-hand side, click the camera name to start a video preview (Figure 4a). Scrolling down the left-hand side, you'll find all the controls for operating the camera. The primary window to control the exposure and to use first is the Capture and Resolution window (Figure 5). In this window, you can set either video or still image mode (trigger mode), as well as set the resolution and gain of the camera and set single, looping, or sequence shots to be saved automatically in a chosen directory.

Scrolling down further along the left side, you'll find windows for other camera attributes including bit depth (always choose the highest bit depth to get the most detail and quality out of the image), binning control (1x1 is full camera resolution), histogram, and cooler control. There are other windows present, but the ones

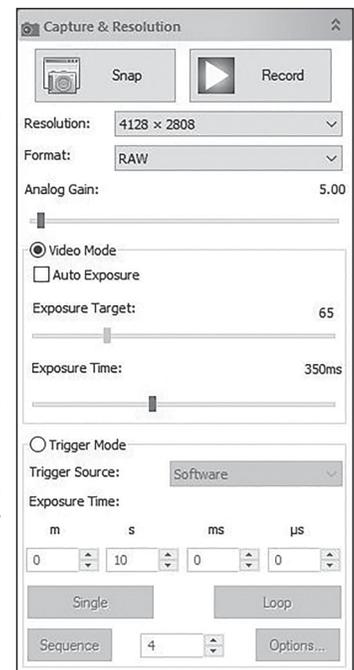


Figure 5. The Capture and Resolution window pane

listed above are the most important ones when taking your first image. Some windows are not applicable to astro-imaging, and can be shut off by going into the Options>preferences menu.

To take your first image, focus must be achieved. With a CMOS camera, one of the quickest and easiest ways to focus is to point the camera at a bright star, and choose a fast video frame rate with higher gain settings so you can watch the star in real time, and focus until the star becomes a point.

Focusing

1. Make sure the camera is in preview mode – if not, click the camera name in the top left window, to turn on streaming preview mode.
2. In the Capture and Resolution window (**Figure 5**), set the resolution to full, the gain to somewhere in the middle of the slider, and the exposure to video mode with “auto exposure” unchecked, and an exposure time to somewhere around 200-500 milliseconds. This should provide you with several frames per second, enough to see a real time focus preview.
3. This should be good enough to see a bright star like Vega, provided it’s in the field of view, and relatively close to focus. If you see nothing, but are sure the star is in the center of the field, adjust your focus in and out because a very out of focus star will spread out and become quite dim.
4. Once you acquire the star, center it, and focus until it looks like a tiny point. At this point you are probably over exposing the star, and can back off on the exposure time and gain settings. If the star is in the middle of the field, you can also reduce the resolution setting on the chip, in order to speed up the frame rate, to get a super responsive live focus. Readjust focus until the star is as tiny as possible. At this point, everything including the moon and a distant galaxy will be in focus.
5. If you wish to fine tune the focus further, a Bahtinov mask is an ideal method of focusing with Orion StarShoot Capture, as it is quite an accurate method using medium brightness stars. Contact Orion or search for Bahtinov mask on www.telescope.com for more details, and to purchase a Bahtinov mask for your specific telescope.

Your First Lunar/Planetary Image

The moon is perhaps the easiest object to get your first image, as it is very bright, and easy to find. Planets are also easier than nebulae to capture, since you’ll be streaming a video file, and can use programs such as Registax to process the video file.

1. Go to the Options menu, click preferences, and under the Record heading, choose a directory location for your saved files, naming convention of your choice, and make sure the file type is set to AVI.
2. In the Capture and Resolution window pane, check Video Mode, uncheck auto exposure, and use the Exposure Time slider to find an exposure that looks good. Planets do well with lots of short exposures, so if the exposure time is too long, experiment with raising the gain, and lowering the exposure value. It will be more noisy, but the

frame rate will be higher, and the exposure time will be lower.

3. When ready to record, press the record button and press it again when your video is the desired length. In the Options menu, under Record preferences, you can set limits to time of the video, as well as number of frames.
4. You can then load your AVI file into a 3rd party program such as RegiStax, in order to process the lunar or planetary details present in the video file.

Auto Exposure can be used if desired, but manually adjusting the exposure values provides the best control over the image. Check the “Auto Exposure box, and drag the box over an area you wish the system to measure. You can resize the box accordingly. Then set the Exposure Target, and the system will try to keep the exposure close to that target exposure value by adjusting the exposure time automatically.

Your First Deep Sky Image

1. Now that you’re focused, slew to an object you wish to take a picture of, and the exposure and gain settings will need to be adjusted for best the best possible result. For longer nebulae exposures, trigger mode is recommended.
2. For a nebula or star cluster, choose something bright for your first target, and ideally an autoguider is already locked on and tracking a star, so your resulting images are well guided. Pick an object like the Ring Nebula (M57), Dumbbell (M27), or Orion Nebula (M42) since they are all very bright and easy to see in short exposures to make

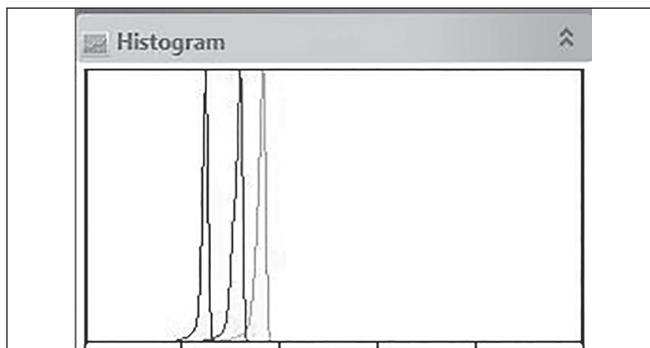


Figure 6a. Live histogram with “humps” in the normal range (left of center) for a target deep sky exposure

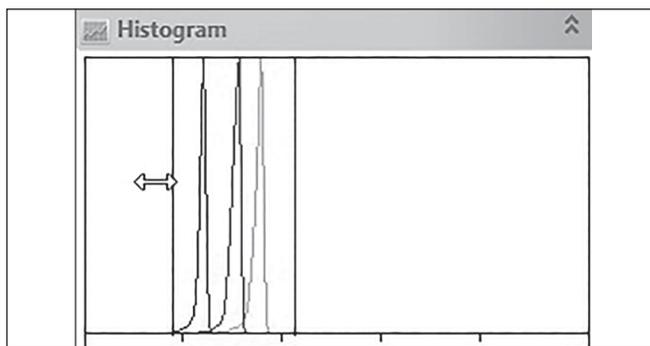


Figure 6b. Histogram window showing the screenstretch adjustment bars

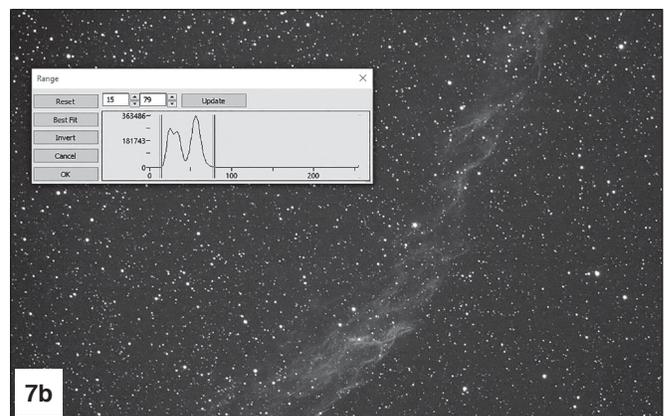
sure the framing is correct. Center the object and proceed to set the exposure.

3. Set the analog gain slider to around 25% from the left (around 40), and a trigger mode exposure of 30 seconds, and make sure the bit depth is set to the highest bit depth possible. This is just a starting point, these numbers may have to be adjusted depending on your resulting image.
4. Click Single and wait for the image to download. You should see a rather grainy looking image of your target in the preview window on the right. Now is the time to look at the histogram window, and determine what needs to change in order to get the best exposure. Scroll down the left side panel to find the histogram window.
5. The histogram shows a graphical representation of the number and brightness of the pixels in the image. The far left of the histogram is black, or no light on a given pixel, and the far right is full white, or fully maxed brightness for those pixels. A normal astrophoto has a lot of black in it, so the histogram bump should be left of center (approximately near the left 1/4 to 1/3 of the histogram for the hump) for a properly exposed photo of a nebulae with a lot of black sky around it (**Figure 6a**). If the hump is too far to the right, either the exposure or the gain is set too high, and you're recording too much background light pollution.
6. Adjust the exposure to somewhere between 30 seconds and 180 seconds. For a CMOS chip like the G Series, individual exposures probably do not need to be longer than 180 seconds, especially when you'll be stacking many shots together for the best results. The G16 color and G21 color camera are not quite as sensitive as the G10 color, so exposures longer than 180 seconds may be possible and advantageous to gather more light. The G16 mono is the most sensitive of all -- but since it is a monochromatic camera, in order to obtain a full color image you'll need to shoot through red, green, and blue filters, and process the resulting frames together to produce a color image. If the histogram still doesn't fall into the proper area, the gain can also be adjusted. Higher gain setting means more noise in the image, but it will provide more sensitivity for a given exposure. Finding the right exposure vs. gain combination is a matter of trial and error, and will vary depending on the telescope focal ratio and sky conditions.
7. If you want to "screen stretch" the histogram, meaning change the black and white points in the image in order to see what kind of faint detail you have captured, grab the left and right edges of the histogram window, and slide the vertical bars closer to the histogram bump. Moving the right edge bar closer to the end of the hump will raise the brightness of the entire image, and moving the left edge bar closer to the start of the hump will darken down the black point, boosting the contrast. (**Figure 6b**). Note that the live histogram stretching will NOT change a trigger image that is displayed on the right. It will affect the NEXT image that downloads from the camera, so take another exposure and check the results.

8. Once you've dialed in the right histogram, it's time to start a sequence so you can stack several images together. Remember that each individual image will have lots of noise, and only by stacking many images together will you get a smooth low noise image.
9. In the Capture and Resolution window, click "Options" in the lower right corner of the window and choose a file location to save your resulting images. Make sure to save them as .fit files so 3rd party astro-imaging software can read them (.fit is a standard in the astro-imaging community). Verify that the resolution you wish to image at is set, and also make sure RAW is set for the file type. RAW fits files are saved before color converting so other programs can read the raw files and provide the best data from the camera. Also, make sure "Light Frame" is selected in the window across the top, so the correct meta-data is saved in the .fit file header. Many programs look to the fits header to determine the type of file (Light, Dark, Flat...), so they can be automatically processed correctly without the user specifying the type of image.
10. Once everything is set and your autoguider is up and running locked on and tracking a star, choose a number



Figure 7a. 120 second "raw" image of the Veil with no histogram stretch. Note the faint details that are barely visible.



7b. After adjusting the Range bars to just wider than the histogram hump, more detail appears.

of shots in the sequence, then click sequence and sit back and let the camera collect the images. Later, when processing, if you find your stacked images too noisy, you'll want to stack a larger number of shots together to reduce the noise.

11. When those exposures are finished, you might also want to collect some dark frames, so you can subtract them from the light frames in your 3rd party astro-imaging software. Choose "dark frame" instead of "light frame," and take at least one dark frame with the cap on the telescope that you will later subtract from the light frames in your other software. Darks should be taken at the same exposure, temperature, and gain setting as the lights you previously took. See below for more discussion on calibration frames such as darks and flats.

Congratulations, you've just taken your first series of deep-sky images with your new camera! It's now time to do some processing in some of those other suggested programs such as DeepSkyStacker or Nebulosity in order to get the cleanest final image possible. It's not uncommon to shoot dozens of light images, especially when imaging something faint that hides in the background noise. The greater the number of images, the more you can push the processing and pull out the detail. Even dark frames can benefit from averaging many together. A master dark or flat made of many individual frames has significantly less noise than only one.

Also, make sure to adjust the histogram to show some of the faint detail that may not be visible upon first downloading an image. Previously, the "Live Histogram" adjustment was shown, but there's another way to adjust the histogram of a saved image. **Figure 7a** and **7b** show a downloaded 120 second image of the Veil Nebula. **Figure 7a** shows the full range (select Menu>Process>Range to bring up a histogram of that image). Notice how faint the nebulae looks? That's not uncommon for a nebula to look like this right out of the camera, as it is just barely brighter than the background light pollution. **Figure 7b** is a Range adjusted shot, to show fainter detail. Notice how the left and right range lines are set just outside each end of



Figure 8. Veil after pre-processing in DeepSkyStacker (dark frames, flats, and stacking) and post-processing in Photoshop (levels, curves, and more).

the histogram? The background is brighter, but ready for more processing in Photoshop to reset the black point and clean the image up. **Figure 8** is a finished image, with dark frames subtracted and a stack of thirty 120 second light frames, 9 dark frames, processed in DeepSkyStacker and Photoshop.

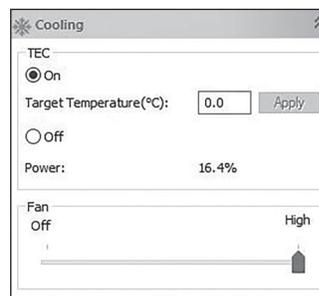
Imaging with a Mono camera

One shot color cameras are relatively easy to get a final image from because there is less processing involved. But color chip cameras suffer from less sensitivity to light than a monochrome camera does. The reason is due to the Bayer Matrix over the chip. The pixels are arranged in squares of alternating colors (for example RGGB in the G10). This means that for every four pixels in a square, only one of them is sensitive to red light, and only one to blue. But in a monochrome chip, every pixel sees ALL of the photons of light across the visible spectrum. The result is a much more sensitive chip. This is much more versatile, because you can put any kind of filter in front of the camera, depending on the wavelength of light you want to capture. And not just Red, Green and Blue -- consider narrow-band imaging with Hydrogen-Alpha, Oxygen-III, and Sulfur II filters as your RGB channels. This can dramatically boost the contrast on nebulae, and also allow imaging even in more severe light pollution than otherwise would be possible. Also consider a motorized filter wheel such as the Orion StarShoot 2" Motorized USB Filter Wheel to automate the process of switching filters between exposures.

5. Cooling – for less noise!



Figure 9a. Current temperature of chip. Shown in the very bottom right corner of the software screen.



9b. Cooler control window. Set a specific temperature that is somewhere less than 35 degrees below the ambient temp

The TEC in your G10 and above is designed to reach temperatures of up to 35 degrees below the ambient temperature. As the chip gets colder, noise becomes less pronounced, so the resulting image is cleaner. In StarShoot Image Capture, you can find the current temperature of the chip in the lower right-hand corner of the screen, next to the current resolution (**Figure 9a**). Cooler control is located down the list in the left hand windowpane (**Figure 9b**). Note the current temperature of the camera, then turn the cooler on, set a target tempera-

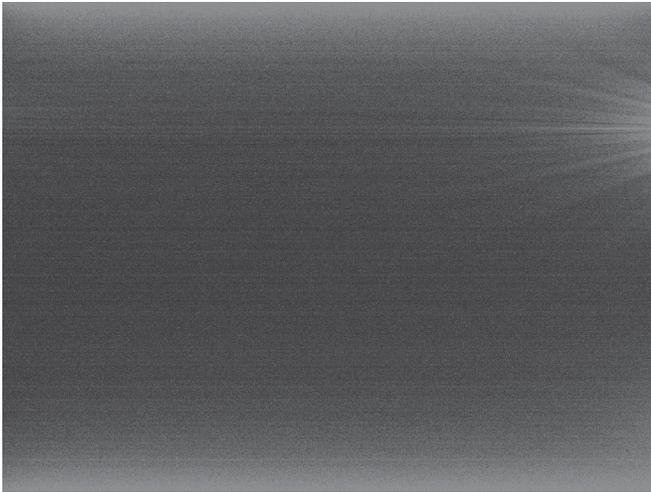


Figure 10. A 120 second dark frame, from a G10. Note the amp glow on the upper right side, this is standard for the ICX294 chip, and is removed from light images during dark frame subtraction. The G16 will show a different dark frame amp glow signature, and the G26 has ZERO amp glow!

ture, and wait for the chip to reach that target temp. Please note that the colder the chip, the more prone to internal dew. The CMOS chamber has been purged of moisture at the factory, but pushing the cooler to its limit may still cause whatever moisture remains to condense on the chip. You'll notice this in the image as a circular pattern that grows in the image, and a major loss of detail.

If the chip dews over, raise the target temperature and give the chip a few minutes to acclimatize. Raising the temp to 0 degrees C should remove any dew after a few minutes. It's good to reduce the temperature of the chip, but it doesn't have to be all the way down to 35 degrees below ambient. Somewhere between 15-25 degrees below ambient still provides a great noise reduction, but with much less chance of the chip dewing over. Once the target temp is reached and is stable, proceed with taking your light and dark frames. They must both be at the same exposure length and temperature for the darks to correctly calibrate. Since the cooler is regulated, you can also use these darks in subsequent imaging sessions, as long as you keep the target temperature the same night to night for your light frames. This is another good reason not to reduce the temperature to its lowest possible setting. If the next night is warmer, it won't be possible to drop the cooler as far from ambient temperature.

Conversion Gain

Along the left hand pane is a window for conversion gain, and options (if your specific camera supports both options) for LCG and HCG -- low and high gain. LCG should be used most of the time, especially when a lower gain setting is used. However, if you are boosting the gain up high to keep exposures times lower, try switching to HCG and readjusting gain, which can reduce read noise in the chip without losing as much dynamic range in the image. But when in doubt, stay in LCG mode, and

your images will turn out fine. The ASCOM driver also includes LCG/HCG settings when in 3rd party control programs.

Dark Frames

Dark frames are images taken with no light coming into the camera. A dark frame is typically taken with the telescope cap attached. The only data in the image is the inherent camera noise. The noise contains the dark current (background noise level), read noise (noise introduced during camera readout and download) hot pixels (bright dots in the image) and amp glow (**Figure 10**). All of this noise exists in your raw astro-image too, which distracts from the detail you want to see. To eliminate most of the camera noise, you can take several dark frames, average them together, then subtract this "master dark" from your "light" astro-images. **Note: Make sure the cooler set point and camera temperature are the same as they were when you took your light frames.** Dark frames are handled through most of the 3rd party control programs listed previously.

Flat Field Frames

Flat Frames are more advanced, and mentioned here as a point of reference. A flat field is an image taken with uniform featureless light entering the telescope, such as a blue sky in the early morning or after sunset. Flat fields solve a number of issues in your astroimages:

Vignetting

Vignetting in a telescope reveals edge-darkening in the astro-image. Vignetting is more apparent when the telescope's illuminated field is not large enough to illuminate the full area of the chip. As a result, more light is detected in the center of the image compared to the edge.

Dust and Particles

Dust and particles will inevitably show up in your raw astro-images. Large particles on the camera optical window sometimes look like unfocused circles or doughnuts in your images. It's too late to clean your camera if you are already imaging in the field at night. And even when the camera is clean, dust usually finds a way to show up in your images.

Telescope Artifacts

Very large particles or other artifacts in your telescope can affect your astro-images. Insufficient telescope baffling or poor collimation can also cause unsymmetrical field illumination in your images.

To take a flat field image:

1. Ensure that the telescope is focused and ready for astro-imaging.
2. Point the telescope at a uniform and featureless light source, like the sky at dusk or dawn, or a blank white sheet of paper. Make sure the camera orientation is exactly the same as it is or was for astro-imaging (Although the telescope is pointing at a featureless surface, the focus and orientation must be set as it normally would be for astro-images.)

3. Set the Frame Type in your imaging control program to Flat Field for correct meta data flagging in the fits header.
4. Set the exposure to result in a histogram which has a hump at around 1/3 to 1/2 of full exposure.

Import your Darks and Flats into the programs mentioned above for full image calibration of your astro-photos.

Image Processing

It's not uncommon to use 3-4 programs to tweak the astro-images you've taken to get the best possible final result. Please delve into the manuals for the other programs listed above, along with output for Photoshop, Lightroom, or other standard image processing programs. The images taken for this manual and on telescope.com were all taken using a combination of StarShoot Image Capture, SharpCap, DeepSkyStacker, and PhotoShop.

Color Conversion (one shot color cameras only)

It was mentioned previously to save the images in the RAW .fit format, for later processing in 3rd party software. RAW is a "black and white" format with a "screen door effect" laid over the image. This screen door is the Bayer Matrix, and contains the color data. When you convert the RAW format to a color format, the screen effect disappears and you're left with a full color image. The preview window in StarShoot Image Capture shows a color image, but if you set the saved file type to RAW, you will save an unconverted black and white image in the .fit format.

To convert to color, see the instructions included with the 3rd party software packages, but you'll have to also determine the X and Y offset, in order to reproduce correct colors. This is different in each software program and usually requires experimenting in order to correctly convert. Color balance may also have to be adjusted to correctly display the image from a chip that is most sensitive in Green, and less sensitive in blue. For example, in DeepSkyStacker, we found the best setting was "generic RGGB" for the Bayer matrix filter, and "Bi-linear Interpolation". After that, color balance could be used to rebalance the background levels to a neutral color.

NOTE: the G16 Color Bayer Matrix is arranged GRBG or BGGR (depending on the software you are using), instead of RGGB in the others. X and Y offsets are different.

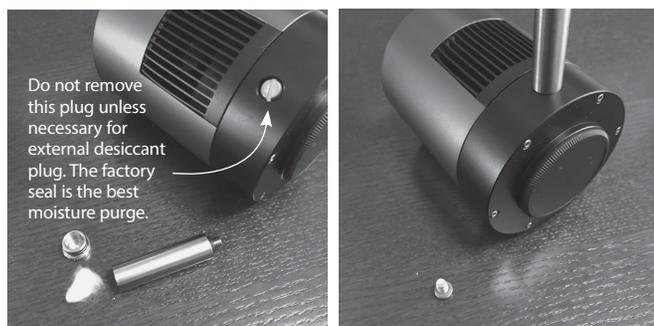


Figure 11a. The desiccant plug. Do not remove the screw plug on the camera body unless you specifically want to use the external desiccant plug. **b.** The desiccant plug installed in the port. Wait 24 hours for best moisture reduction.

ASCOM Driver

The ASCOM driver allows the camera to be used with any of the programs listed above, along with any others that support ASCOM cameras. Please download the ASCOM platform from ascom-standards.org and make sure to install the camera ASCOM driver from Orion's website. When in 3rd party camera control programs, the camera gain settings can be controlled in the ASCOM setting window for the camera. Open the ASCOM camera settings, adjust the gain, and experiment with exposures as detailed above. Remember, low gain results in low noise but a longer exposure. High gain boosts the chips sensitivity so the result is a more sensitive camera in a given exposure, at the cost of higher noise. Since stacking reduces noise, it can be beneficial to have a bit more noise in the image, if it helps keep the exposure times down. One last thing to note, some programs may use a percentage for gain, others may use the actual gain numbers. If the gain range is 0-100, it's using a percentage of total gain.

Desiccant plug (G10 and above)

The camera has been baked in an industrial oven in order to purge the CMOS chip chamber of as much moisture as possible. This prevents dew from forming as the TEC lowers the temperature of the chip. However, at the extreme end of the TEC cooling range, the tiniest amount of moisture may cause the chip to dew over, and it's impossible to remove 100% of the atmospheric moisture. Raise the target cooler temperature if this occurs, and the dew should dissipate, while still being relatively noise free.

We include an external desiccant plug with o-ring if you wish to try reducing the moisture in the chamber yourself. We do not recommend using this plug compared with the pre-baked internal environment of the housing, as the purged interior is most likely drier than what can be attained with external desiccant. However, after many years of use, if you notice the chip dewing over at higher temperatures, the external plug may help. Remove the cap to the desiccant plug (**Figure 11a**) and insert a small fragment of a cotton ball all the way into the plug. The hole inside the plug is very small but it's best to add cotton, as you don't want desiccant balls falling into the internal camera chamber! Once the bit of cotton is inserted fully, fill the canister with dry desiccant balls and cap it shut. Remove the camera chamber plug cap screw from the camera (**Figure 11a**), and install the desiccant plug into the threaded hole (**Figure 11b**). It will probably take 24 hours to dry the chamber out as much as the desiccant will allow.

Specifications

Sensor:	G10 Sony IMX 294 color CMOS, 4/3 format
Resolution:	Up to 4128x2808
Pixel Size:	4.63 microns
Diagonal size of chip:	23.1mm
Bayer Matrix pattern:	RGGB arrangement
Exposure range:	0.1ms – 1000s
Shutter:	Rolling Shutter
Partial frame download:	Region of interest and Sub-frame download supported
Binning:	1x1, 2x2, 3x3, 4x4 hardware and software binning
ADC:	14 bit
QE peak:	76%
Read Noise:	1.12e@HCG Mode
Full Well:	66.6ke
Image Buffer:	512MB memory buffer
Interface:	USB3.0/USB 2.0
Front nozzle threads:	42mm T-threads
CMOS chip window:	IR blocking, 380-690nm
Dimensions:	80mm x 103mm
Weight:	535g
Back Focus:	17.5mm
Cooling:	Regulated Two Stage TEC, ~35 deg C from ambient
Camera electronic power:	DC 5v from PC USB port
Cooler power:	12v/3a

Sensor:	G16 Mono Panasonic MN34230 CMOS, 4/3 format
Resolution:	Up to 4640x3506
Pixel Size:	3.8 microns
Diagonal size of chip:	22.1mm
Bayer Matrix pattern:	BGGR/GRGB (depending on software)
Exposure range:	0.15ms – 3600s
Shutter:	Rolling Shutter
Partial frame download:	Region of interest and Sub-frame download supported
Binning:	1x1, 2x2, 3x3, hardware and software binning
ADC:	12 bit
QE peak:	60%
Read Noise:	1.2e@HCG Mode
Full Well:	20ke
Image Buffer:	512MB memory buffer
Interface:	USB3.0/USB 2.0
Front nozzle threads:	42mm T-threads
CMOS chip window:	IR blocking, 380-690nm spectral range bandpass (Color). AR coated window, non IR blocking (Mono)
Dimensions:	80mm x 103mm
Weight:	535g
Back Focus:	17.5mm
Cooling:	Regulated Two Stage TEC, ~40 deg C from ambient
Camera electronic power:	DC 5v from PC USB port
Cooler power:	12v/3a

Sensor:	G21 Sony IMX 269 CMOS, 4/3 format
Resolution:	Up to 5280x3956
Pixel Size:	3.3 microns
Diagonal Size of chip:	21.8mm
Bayer Matrix patter:	RGGB
Exposure Range:	0.1ms - 3600s
Shutter:	Rolling Shutter
Partial frame download:	Region of interest and Sub-frame download supported
Binning:	1x1, 2x2, 3x3, 4x4 hardware and software binning
ADC:	12 bit
QE peak:	84%
Read Noise:	1.62e@LCG Mode
Full Well:	23ke
Image Buffer:	512MB memory buffer
Interface:	USB3.0/USB 2.0
Front Nozzle threads:	42mm T-threads
CMOS chip window:	IR blocking 380-690nm spectral range bandpass
Dimension:	80mm x 103mm
Weight:	535g
Back Focus:	17.5mm
Cooling:	Regulated Two Stage TEC, ~40 deg C from ambient
Camera electronic power:	DC 5v from PC USB port
Cooler power:	12v/3a

Sensor:	G26 Sony IMX571 CMOS, APS-C format
Resolution:	Up to 6224 x 4168
Pixel Size:	3.76 microns
Diagonal size of chip:	28.3mm
Bayer Matrix pattern:	RGGB
Exposure Range:	0.1ms - 3600s
Shutter:	Rolling Shutter
Partial frame download:	Region of interest and Sub-frame download supported
Binning:	1x1, 2x2, 3x3, hardware and software binning
ADC:	16 bit
QE peak:	80%
Read Noise:	1.16e@HCG Mode
Full Well:	51ke
Image Buffer:	512MB memory buffer
Interface:	USB3.0/USB 2.0
Front Nozzle threads:	42mm T-threads
CMOS chip window:	IR blocking 380-690nm spectral range bandpass
Dimension:	80mm x 103mm
Weight:	556g
Back Focus:	17.5mm
Cooling:	Regulated Two Stage TEC, ~35 deg C from ambient
Camera electronic power:	DC 5v from PC USB port
Cooler power:	12v/3a

StarShoot Mini 6.3mp cameras

Sensor:	IMX 178 (Color and Mono)
Resolution:	Up to 3040 x 2048
Pixel Size:	2.4 microns
Diagonal Size of chip:	8.86 mm
Bayer Matrix Pattern:	RGGB arrangement
Exposure Range:	0.244ms – 1000s
Partial frame download:	Region of interest and Sub-frame download supported
Binning:	1x1, 2x2
ADC:	14 bit
QE peak:	78%
Read Noise:	1.4e – 2.2e (depending on gain setting)
Interface:	USB3.0
Front Nosepiece threads:	C-mount
CMOS chip window:	IR blocking 380-690nm bandpass (Color version), AR coated, non IR blocking, 350-1050nm bandpass (Mono version).
Dimension:	72.4mm x 37mm
Weight:	61g
Camera power:	DC 5v from PC USB port

One-Year Limited Warranty

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Corporate Offices: 89 Hangar Way, Watsonville CA 95076 - USA
Toll Free USA & Canada: (800) 447-1001
International: +1(831) 763-7000
Customer Support: support@telescope.com

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