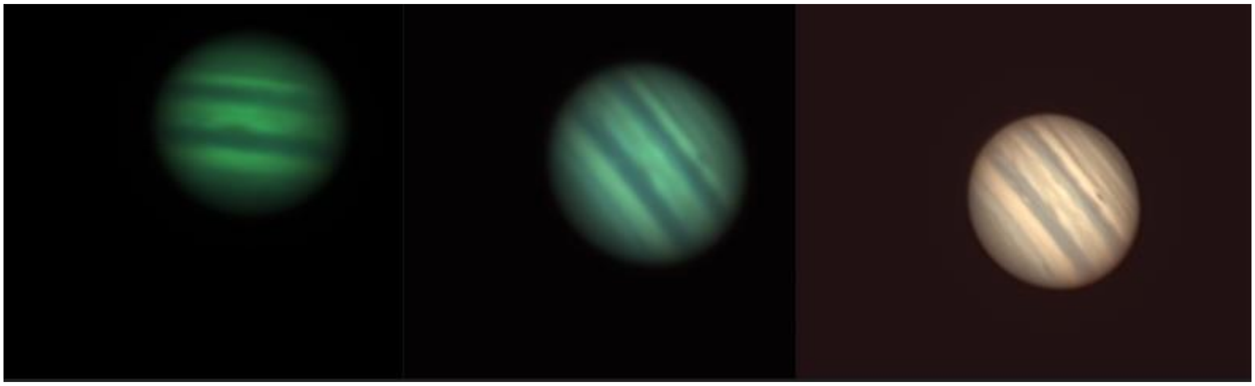
Telescope Focus



Focus is the difference between getting the picture on the left (which is “close enough”) and the picture on the right (which is “exact”.)

Contents

Overview

Focusing is the process of adjusting the optical path to obtain the best possible image.

Useful Range

Most telescopes can be used both for astronomy (looking at stars) and terrestrial (looking at mountains, birds, etc.) applications. However, most people who buy telescopes want to use them for one, or the other, application and not both.

As a result, part of the focuser range is wasted and it is important to know this when focusing so you don't waste time trying focus settings that are not applicable to your application. Some telescopes (like my RedCat 71) use about 80% of the focus movement for close objects and only the remaining 20% of the focus movement is used for celestial objects.

NOTE: I was originally excluding the terrestrial focus ranges when I was doing more manual focus work, but since I have gotten all of the auto focusing working properly, I stopped doing this. Now I set the lower focus stop position one focuser turn from the bottom, and the high focus stop position roughly one turn from the top.

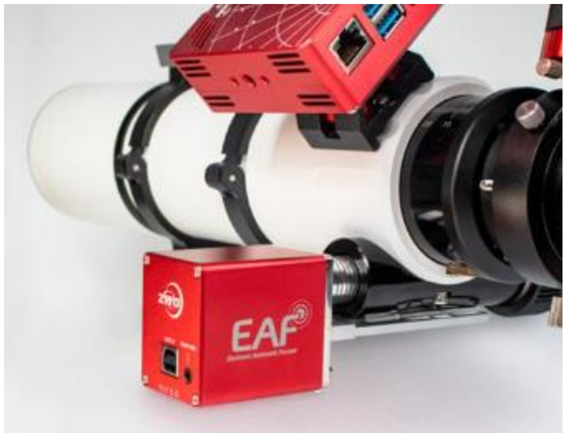
Determining Useful Range for Astronomy

Follow these simple steps to determine the focuser **low/high positions**.

- Using an eyepiece (or camera) on your scope, adjust the focus from 0 up to infinite and observe where distant things (like the moon) start to come into focus.
    - A good rule of thumb is this is usually around 70% focus movement from zero.
- If your focuser has a printed scale, you might observe that from 0 to 6 the moon is blurry, but after 6 it starts to come into focus.
- In this example you would want to use the focuser setting of 6 as the '**low position'**, and the focuser setting of infinite – minus a little bit so you don't hit the end of the focuser range - as your '**high position**' setting.

EAF – Electronic Auto Focus

EAF replaces you having to manually turn the focus knob to focus the telescope. Instead, it uses a small motor (the EAF unit) connected to the focus knob, a camera, and a computer system. The computer looks at the camera image and using advanced algorithms, determines how far to adjust the focus knob.



At first, I thought this was just a luxury for people who were too lazy to focus the telescope. However, I now see this as an essential part of astrophotography for the following reasons:

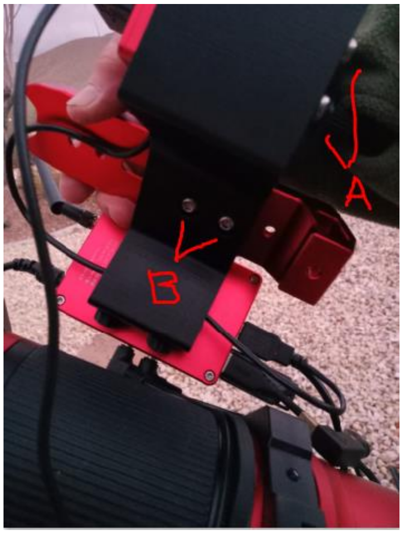
- The EAF can move the knob in extremely tiny increments – almost to 0.001", whereas your hand can not get anywhere near this level of precision.
- If the focus is not exact, the computer plate solving will often fail even though you have clear stars. This makes polar alignment and finding objects painfully slow with many retries.
- Manually focusing requires you to move the knob and visually see if it looks "better." Often times your eye can't tell the difference between one position and the next. This is painfully slow and very inaccurate.
- The camera and computer can detect minute differences in focus and apply advanced algorithms to determine the exact best position for focus.
- Because of the limited Focuser Useful Range, the focus on stars has to be very precise.
- An EAF focused telescope can see stars even through light clouds, whereas a manually focused telescope will only be able to see the stars on a clear night.

EAF Brackets & Mounting

Be aware that you will need a custom bracket for each different type of telescope to mount the EAF. I recommend BuckeyeStargazer for these brackets (made of plastic, but are cheaper) when they are relatively small, but would use the metal brackets from the EAF vendor for larger applications for more stability.

Bracket Issue – Screws Getting Loose Over Time

Make sure that you really tighten all of the mounting screws for the bracket. I had been using a BuckeyeStargazer bracket on my RedCat71 for quite some time and it had been working well. One day the EAF motor started getting 'stuck' between the 3 and 4 focuser positions and the belt started slipping on the EAF pulley. I checked the mounting screws ('A' below) and they were tight.



I tried assisting the motor by hand and was able to get it past this sticky spot. I ended up concluding that my focuser had developed a rough spot and that I might have to have the telescope serviced. I eliminated that spot from the focuser range, but later ran into more problems and realized that the entire bracket was loose because the 'B' mounting screw (see above) had become loose. This is much more difficult to see because they are underneath the main guide rail – I only noticed this because the BuckeyeStargazer bracket was moving around slightly when the EAF was activated.

After tightening the 'B' screws, the EAF resumed working properly and there was no longer any spot where the focuser would stick.

These may need to be re-tightened periodically.

EAF Initial Configuration

Since the EAF unit is just a motor, it knows nothing about your particular telescope and how it is focused. Therefore, you need to configure it before your first use.

In this example I am using an ASIAir controller, but the idea is the same for any controller. Configuration involves setting up the following values for the EAF unit in your computer software.

- ‘Current Position’ – this is, as the name describes, the current position of the motor in the telescope focuser range.
- ‘Limit’ – this is the upper limit position of the focuser range. The range goes from 0 to this value.

In order to set these values, you should follow the appropriate workflow below. That’s it! After you are done, the motor will only use the focuser settings you have configured as valid for astronomy viewing on this telescope.

On most EAF units the configuration settings are stored in the EAF unit (and not in the controller.) So you are better off dedicating an EAF unit to each of your scopes rather than sharing them (because you will need to re-do the initial configuration each time you do a switch.)

Telescopes that have a Focuser 'Knob' directly connected to the EAF

Typically, there is no way to tell when you are about to hit the end of the focus range except to 'feel' with your fingers that it got harder to turn the knob. For this reason, this method is safer to use in this case and avoids the risk of driving the motor past the end of range and damaging the focuser.

- Determine the 'useful focus range' on your telescope.
- Using your hand to manually adjust the focus, count how many 'turns' it takes to move the focuser knob from the '**low position**' to the '**high position**.' This is **'#of EAF turns**'
- Check if the EAF rotation direction is correct
    - Hook up the EAF to your controller (but not to the focus knob.)
    - Move the focuser to a higher position using the EAF tools and observe if it is moving clockwise or counter-clockwise. **Important** – you must think of how the rotating shaft would turn the knob when hooked up – and not how it is rotating when you look at the shaft head-on.
    - Determine which way is up (focus on farther objects) on the focuser
        - Around the knob is typically a graphic showing the focuser direction. Turning the knob in the arrow direction of the arrow (towards the ∞) moves the focus to objects that are farther away.
            - something like this "∞ ←" for counter-clockwise.
            - something like this "→ ∞" for clockwise.
        - If there is no graphic, and the documentation doesn't say, then try focusing on two different distant objects and see which way you need to turn to get from the closer object to the further object.
    - If the EAF and focuser knob rotation directions don't match, then flip the 'reverse' direction option in the EAF configuration.
- Look in the EAF documentation and find the **'#of stops per EAF rotation'**. This is typically 5760 for ZWO EAF units.
- Set the focus knob to the '**high position**'
- Connect the EAF motor to your telescope focus knob without moving the knob position.
- In your computer EAF configuration set **both** the 'Current Position' and 'Limit' values as follows:
    - = **'#of EAF turns'** * **'#of stops per EAF rotation'**

Telescopes that are connected to the EAF with a drive belt and visible focus scale

- Determine the 'useful focus range' on your telescope.
- Set the focus knob to the '**low position**'
- Connect the EAF motor to your telescope focus knob.
- In your computer EAF configuration set the 'Current Position' setting to 0. This will ensure that the focuser will never go below this point.
- Using your computer EAF tools, make the motor move the focus knob to the '**high position**'. You may have to flip the 'Reverse' setting if the motor is going in the wrong direction. Don't forget to hit the 'Stop' button when it gets to the end or the motor may try to tear the knob off.
- In your computer EAF configuration set the 'Limit' value to the value currently being displayed in the 'Current Position.'

Sharing EAF motors between telescopes

Ideally, because you have to spend time calibrating the EAF for the particular telescope, it is better if you can purchase an EAF (you don't need a separate computer because the EAF configuration settings are stored in the EAF motor unit – not the computer) for each scope – and NOT share them.

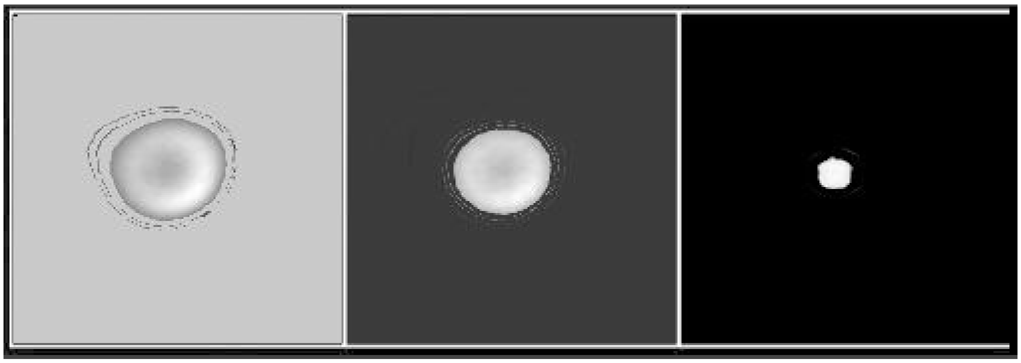
However, you can share a single EAF unit between multiple telescopes using the following steps.

- Before removing the EAF unit from the current scope, move the current position to zero.
- Lock the scope focus ring/knob (if the scope has this feature) so the zero position is not lost.
- Write down the configuration 'Limit' and 'Reverse' values for this scope so they can be re-entered when you start using this scope again later.
- Physically move the EAF unit from this scope to the new scope you want to use. This can be tedious and may involve taking apart lots of stuff.
- If the new scope was already configured (otherwise you will need to configure it – see Configuration Section) do these steps:
    - Get its previous 'Limit' and 'Reverse' values from your records and enter them into the EAF 'Limit' and 'Reverse' configuration value.
    - Unlock the focus ring/knob if it has a lock, otherwise make sure it is still at the zero position manually.

You should now be ready to go. As should be obvious, this process introduces more error margin and slowly degrades your equipment every time you do it due to wear and tear.

Focusing using the Electronic Focuser

Disclosure: the images below are actually from the internet and depict images of an atom using an electron microscope. However, at this point they are the closest images I could find to what star focus looks like. I retouched the backgrounds to show that an out of focus star looks almost like the background and is very hard to find. Only when it comes into focus does the contrast increase.



Out of Focus Better Focus In-Focus

The auto-focus feature uses the fact that an out of focus star has a big "halo" surrounding the center star image – this is what it refers to as star "size". The "size" becomes smaller as the star comes into focus. The other characteristic (which these images don't capture) is that the star becomes "brighter" as it comes into focus.

The auto-focus process measures the "size" and "brightness" of the star on a camera image. It then adjusts the focus motor one way or the other, and determines if the "size" and "brightness" have gone up or down. In this way it can determine which direction needs to be used to focus properly, and by charting the "size" to focus position values, build a chart (which looks like a parabola) and determine the proper focus point as the minimum on the parabola.

The problem with all this is that you can't just press the auto-focus button and expect it work like a magic wand. If the telescope is really far out of focus, there won't be enough contrast between the star halo and the surrounding space – which is almost the same color as the halo – to determine what is a star and what isn't for the computer. If you are doing this and seeing star sizes like 350, 500, 750, ... this means you are WAY out of focus. Star sizes should be in the 0-20 range generally.

So, what you need to do BEFORE using the auto-focus feature is to use the manual focus buttons and get the focus roughly correct first. This is very simple, and consists of capturing an image, pressing the manual up/down focus buttons, repeat until the stars look reasonably in-focus. Then you can run the auto-focus and it will set the focus with pin-point accuracy.

Generally, you only need to do this manual focus step when first setting the scope up (or any time you alter the light path – like adding filters.) Once the scope is focused on one star, you can generally use the auto-focus feature on the next star.

Histograms

At first, I didn't understand the benefit of histograms, and after reading this excellent article I realize that histograms are the most essential part of determining if your camera settings are correct for the object you are photographing.

[Signal noise and histograms]

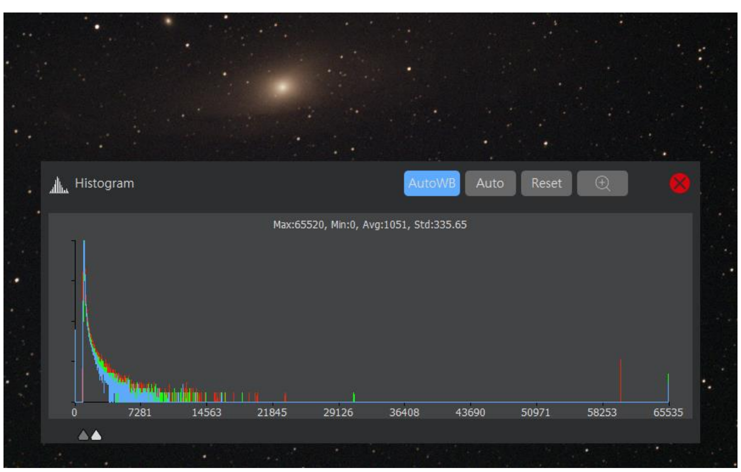
Gain and binning together are like a camera's ISO setting. The higher the gain and binning the more sensitive the camera will be to light (technically gain does not collect more photons, but binning does.) They should generally be used roughly as follows:

- Bright objects (moon, etc…) – no binning, gain 0, short exposures.
- Less bright objects – no binning, medium gain, medium exposures.
- Dim objects – no binning, higher gain, longer exposures.
- Very Dim objects – lower binning, higher gain, longer exposures.
- Extremely Dim objects – higher binning, higher gain, very long exposures.

You should adjust these settings using 'Auto' mode so that the histograms black/white limit markers are adjusted automatically. After you get a good histogram curve, then you can play with the black/white limit markers to try and fine tune things – like trying to make the background 'blacker', etc.

Additionally, I was thinking that a gain of 0 on my camera (each one is different) would be the camera sensor operating with NO gain. However, it appears that a gain of 100 is the sensor operating with NO gain, and a gain of 0 is actually applying a NEGATIVE gain to the sensor values.

So, what you need to do is play around with these settings in 'Preview' mode until you get the histogram to look correct for the object you are photographing, and only then move to 'Live' mode and start the stacking process to capture an actual image. Of course, make sure that your 'Live' mode settings match your ideal 'Preview' mode settings where you got the histogram to look good. The following is an example of a 'Poor' quality histogram.



Gain & Exposure Time

Here is an excellent article about gain and exposure time that I wish I had read earlier as I thought that using gain of zero would reduce noise, but the opposite is actually true.

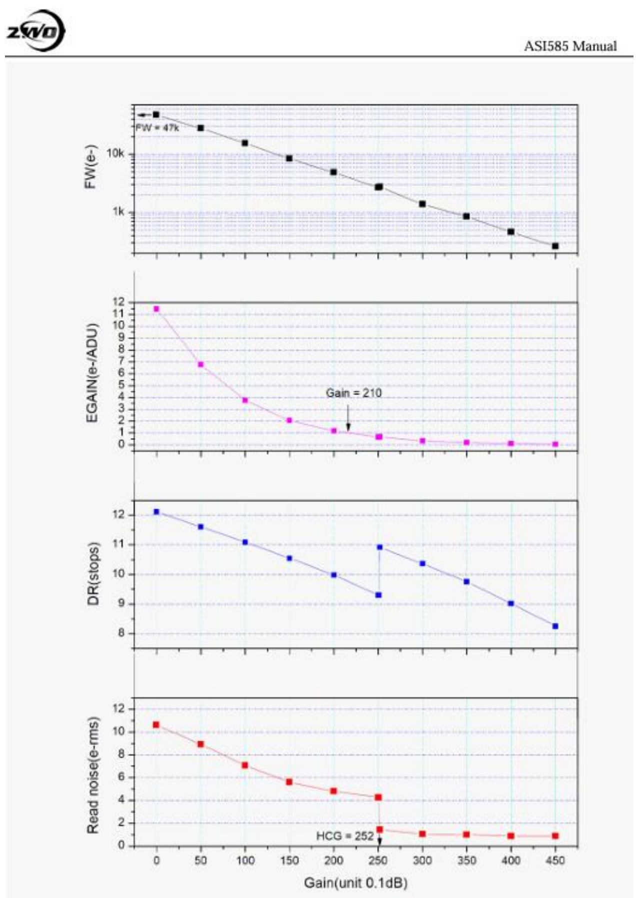
[How to set astronomy CMOS camera gain (part I) - astrojolo]

Another important point is that the number you use to specify gain in your camera is NOT linear – in other words changing the gain from 100 to 200 will NOT double the gain (in fact it almost quadruples it.) On ZWO cameras increasing the gain by 60 essentially doubles the gain. Here is a good article that explains this.

[Is gain linear? - ZWO User Forum (zwoastro.com)]

It is also important to find and review your camera specifications (my ZWO ASI585MC specs are shown to the right) to see if there are any “sweet spots.” In my case the camera dynamic range and read noise dramatically improve at a camera gain of 252.

So naturally you would want to try and keep the camera gain above this spot, if possible, to improve the quality of your pictures.



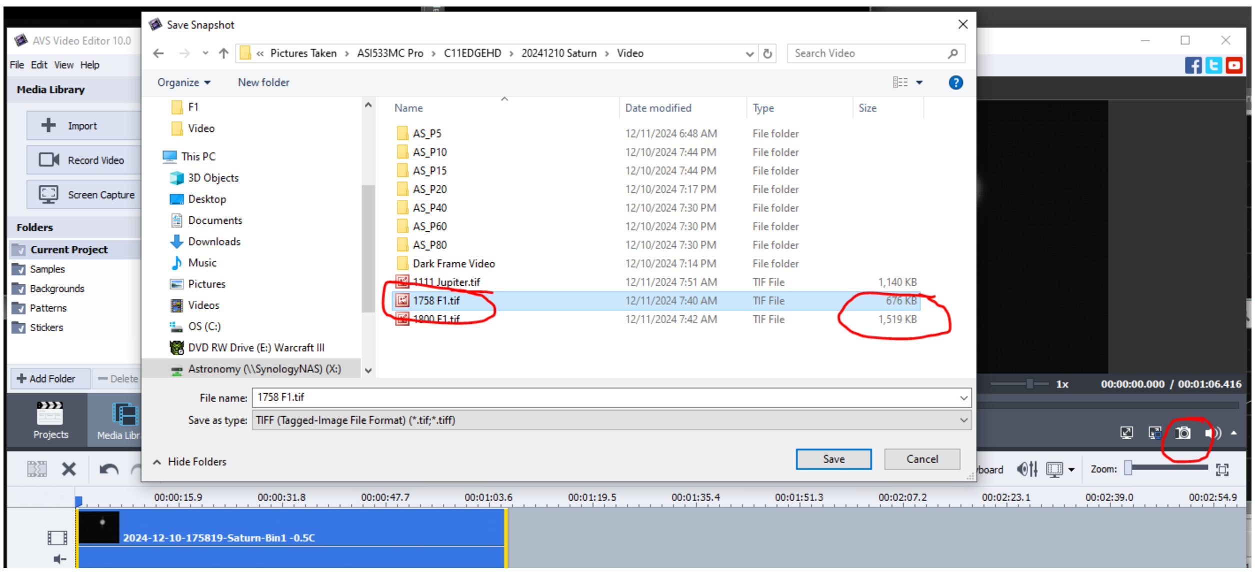
Effect on ASIAir Video Recordings – Color vs Mono

Apparently, the ASIAir determines whether video recordings should be done in color or mono based upon the gain & exposure time settings. If there is not enough ‘brightness’ it defaults to recording in mono, otherwise it records in color (assuming you are using a color camera of course.)

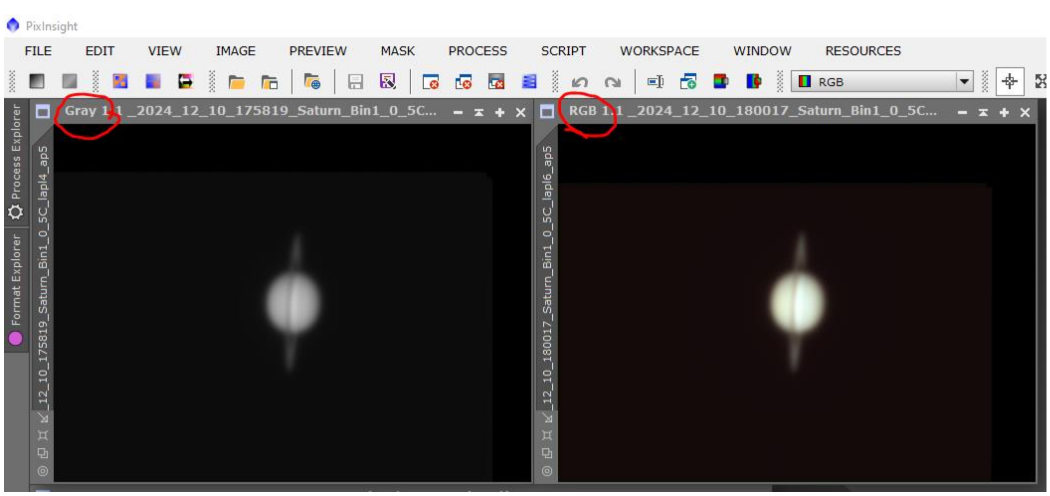
This was extremely frustrating as it initially seemed like a problem with subsequent image processing software, and it took some time to track down.

Here are two videos taken minutes apart of Saturn using an 533MCPro camera – one was recorded in mono and the other in color by the ASIAir, with no choice on my part.

I was finally able to track this down by capturing the first frame of the two videos using AVS Video Editor (see below.) You can immediately see that the 1800 frame size is 3x bigger than the 1758 frame – indicating that the 1800 is encoded in color and the 1758 is not.



Further evidence of this is shown when viewing the frame files in PixInsight



Below you can see the different settings used to record the two AVI videos on ASIAir (1758 left, 1800 right.)

```
[ZWO ASI533MC Pro]
Bin = 1
Capture Area Size = 480 * 360
Colour Format = RAW8
Exposure = 0.006 Sec
Flip = None
Gain = 398
StartX = 1264
StartY = 1324
Temperature = -0.5 C
Bayer = RG
Debayer Type = RGGB
White Balance (B) = 95
White Balance (R) = 52
Duration=66 Sec
```

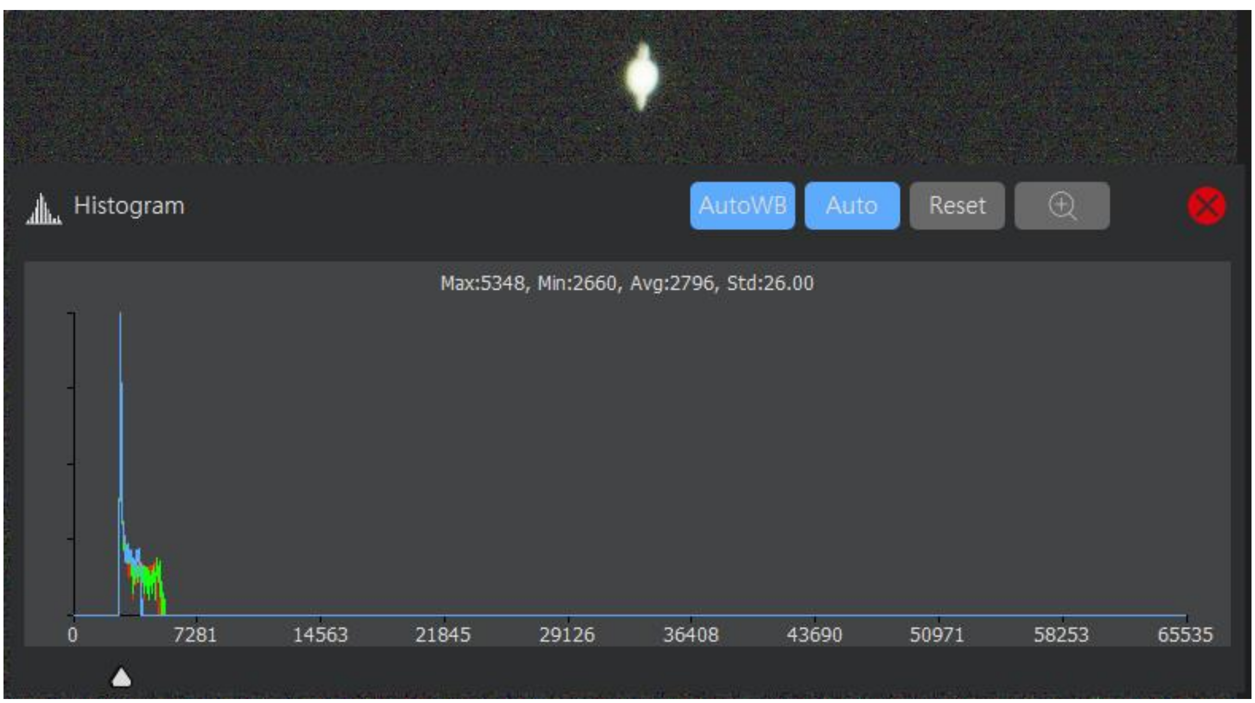
```
[ZWO ASI533MC Pro]
Bin = 1
Capture Area Size = 480 * 360
Colour Format = RAW8
Exposure = 0.015 Sec
Flip = None
Gain = 346
StartX = 1264
StartY = 1324
Temperature = -0.5 C
Bayer = RG
Debayer Type = RGGB
White Balance (B) = 95
White Balance (R) = 52
Duration=120 Sec
```

As can be seen, the gains are close, but the exposure time of the 1800 video is 2.5 times longer.

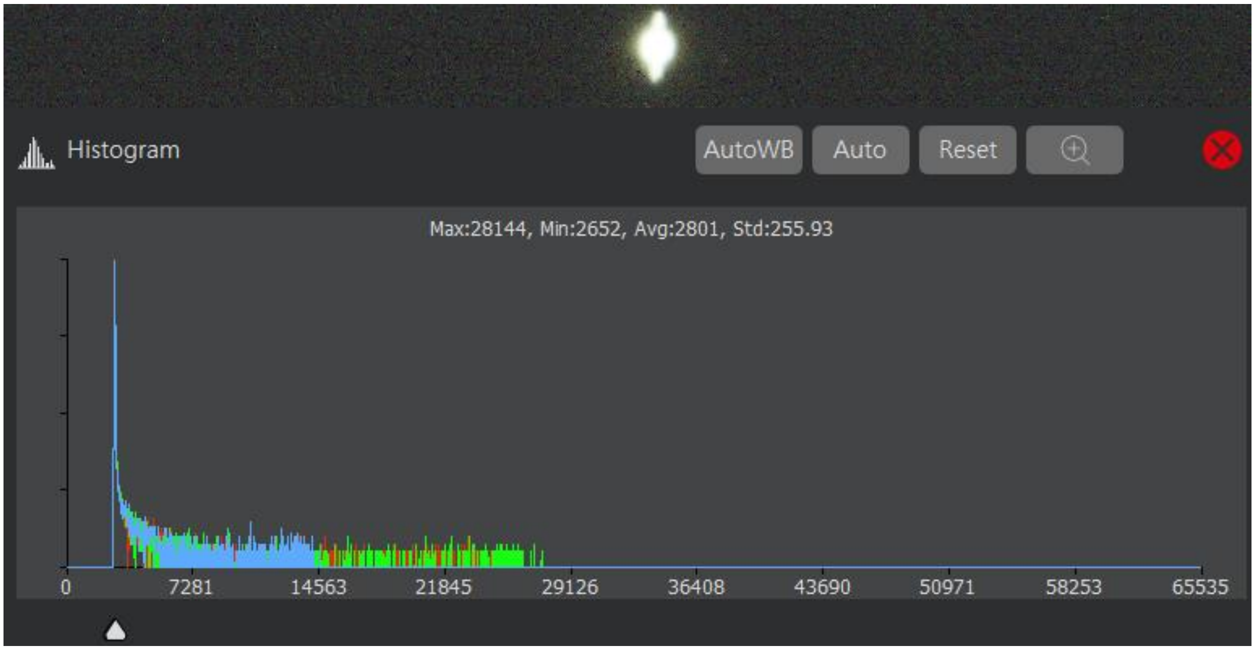
The bottom line here is – **<u>don't assume your video will be in color because you are using a color camera.</u>**

Here are the histograms for still shots of Saturn that same night.

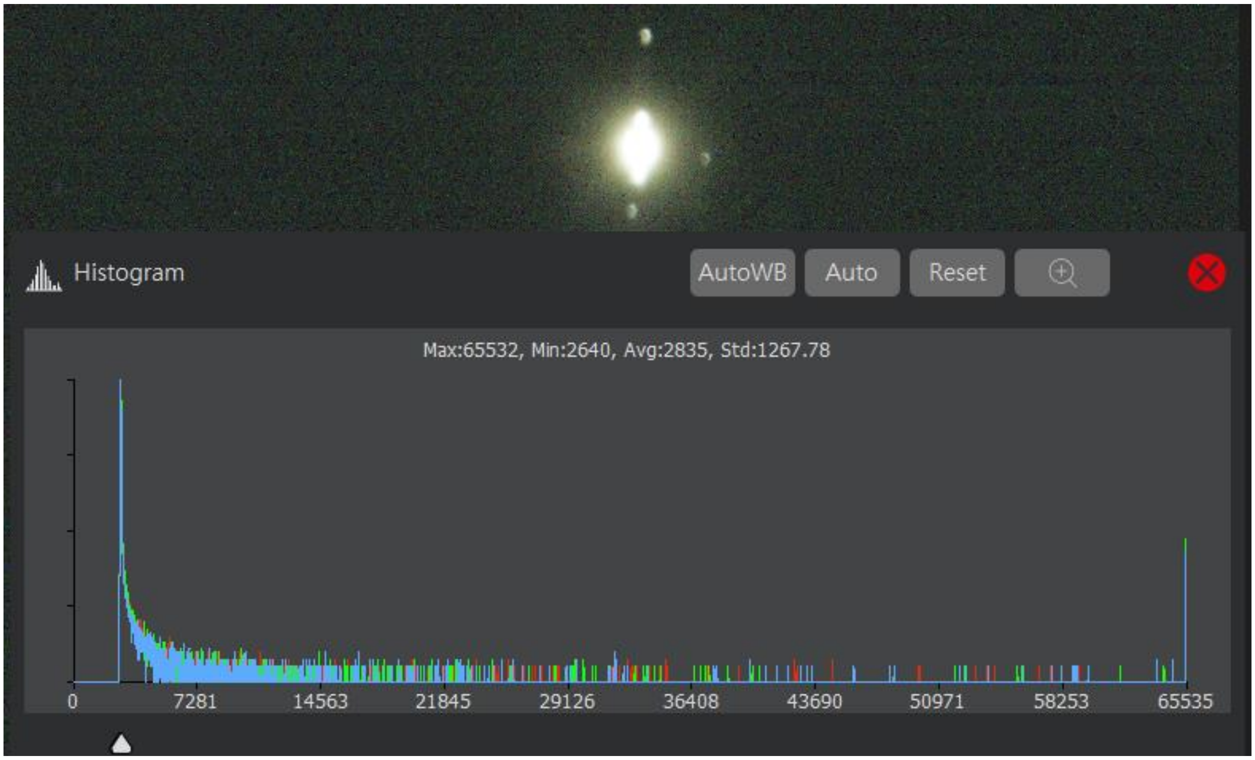
10ms Gain 100



100ms Gain 100



1sec Gain 100



Example Images with Histograms

Here are some images and histograms of M33 (Triangulum Galaxy – magnitude 5.72) taken at different gain and exposure times on an ASI585MC camera. These have not been Debayer'd. If you have been doing this a while, you will say that these are obvious, but for a beginner, these are helpful to visualize what happens with different setting values.

Note that it is hard to see the actual stars in these small images (generally the stars look clearer as the gain/exposure increases) but you can see how the images get washed out. I'm more focused on the histograms here as a means of comparison.

As can be seen, similar results can be obtained using different gains and exposure times. For example, the 'Gain 0, Exposure 1800' image is very similar to the 'Gain 120, Exposure 600' image. Given the previous article (Is gain linear? - ZWO User Forum (zwoastro.com)) that showed that increasing ZWO gain number by 60 doubled the pixel value, it is odd that going from 0 to 120 gain (2 x 60, or 4 x pixel value) would be the same as multiplying the exposure time by 3 (600 to 1800 seconds.) I would have expected to have to bump the exposure time up to 2400 (600 x 4) to get this result.

Reasons to use Less Gain/Exposure

As gain/exposure is increased the left side of the histogram starting point is pushed to the right – essentially reducing the dynamic range of the image.

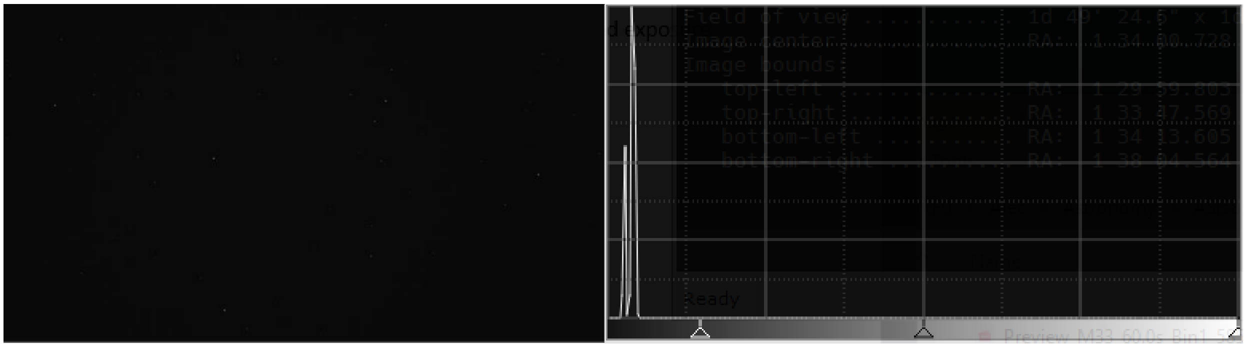
As gain is increased the "speed" with which the histogram moves to right side increases. This effectively reduces the number of exposure settings that are "usable."

Reasons to use More Gain and Less Exposure

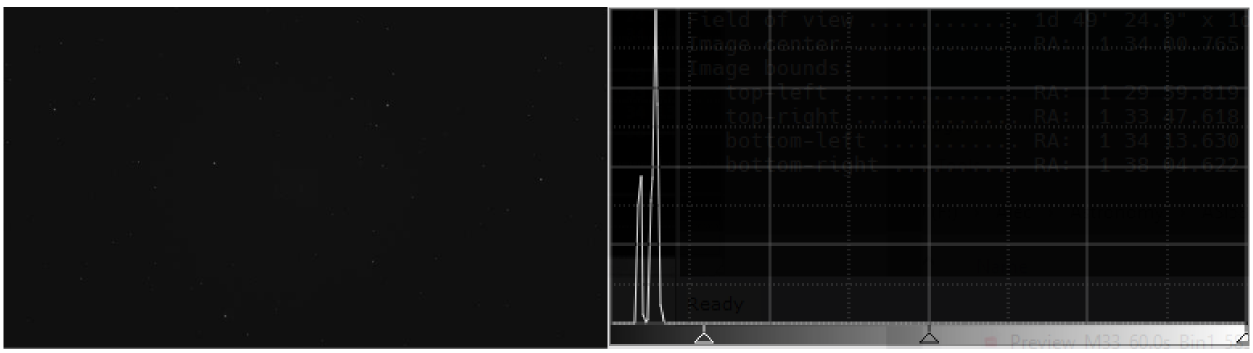
You can get the same result with a shorter exposure time, both reducing the time spent imaging, and reducing the chance that something (clouds, airplanes, satellites, etc.) will taint your image.

Your signal to noise ratio decreases, improving image quality.

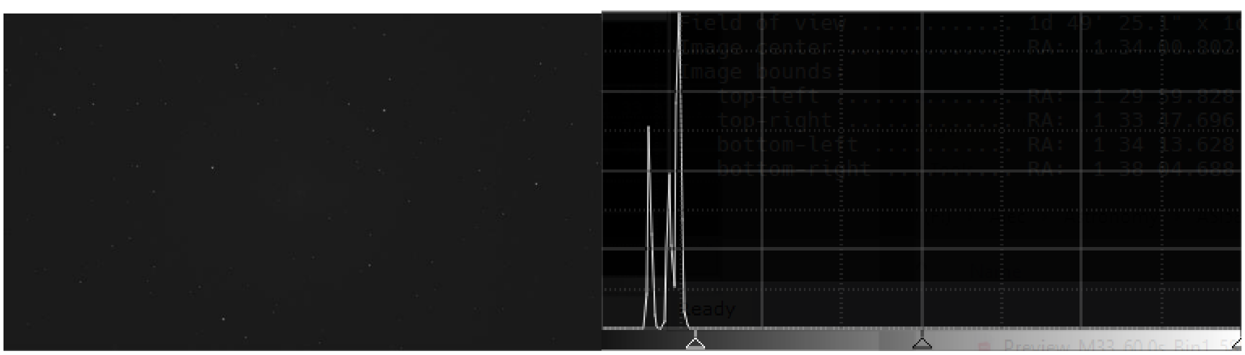
<u>Gain 0, Exposure 300 seconds</u>



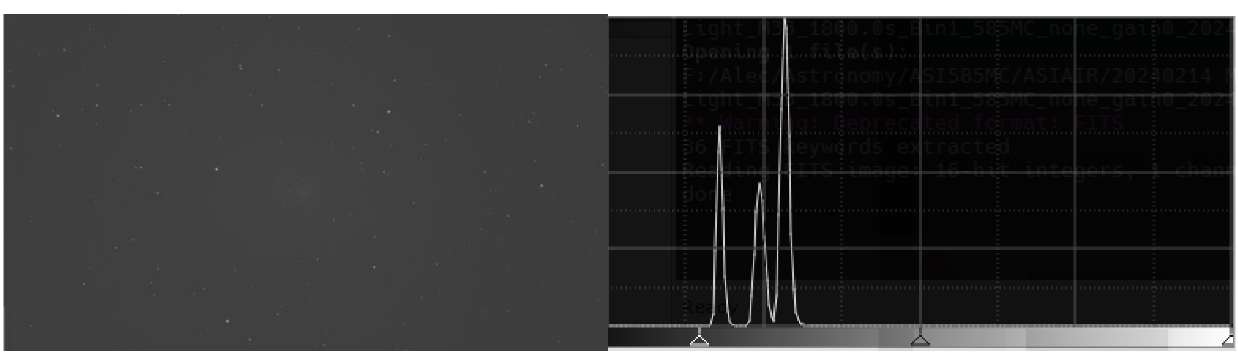
<u>Gain 0, Exposure 600 seconds</u>



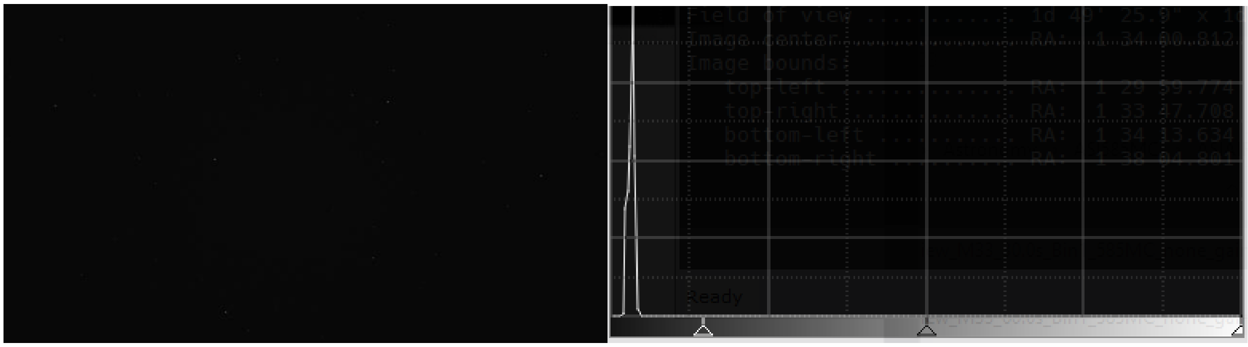
<u>Gain 0, Exposure 1000 seconds</u>



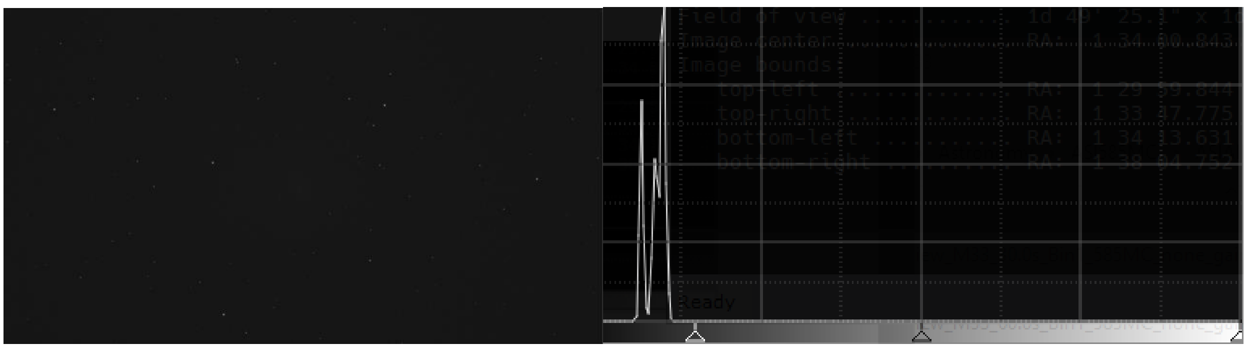
<u>Gain 0, Exposure 1800 seconds</u>



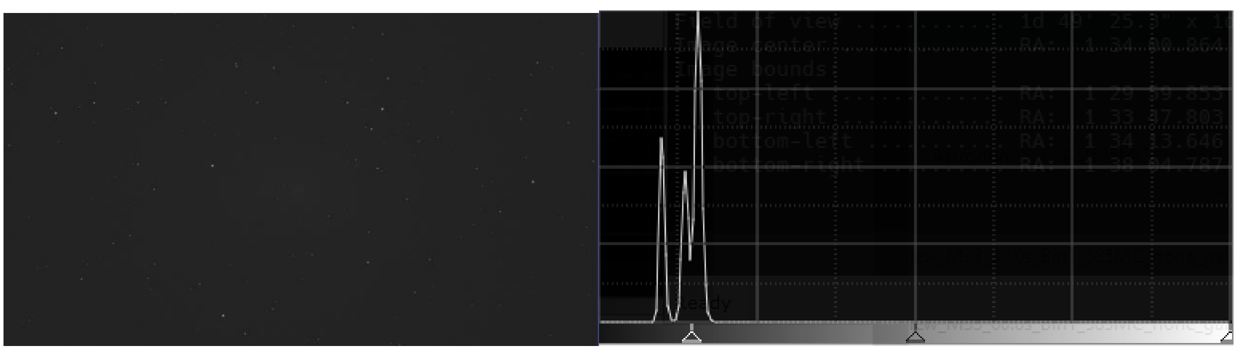
Gain 120, Exposure 60 seconds



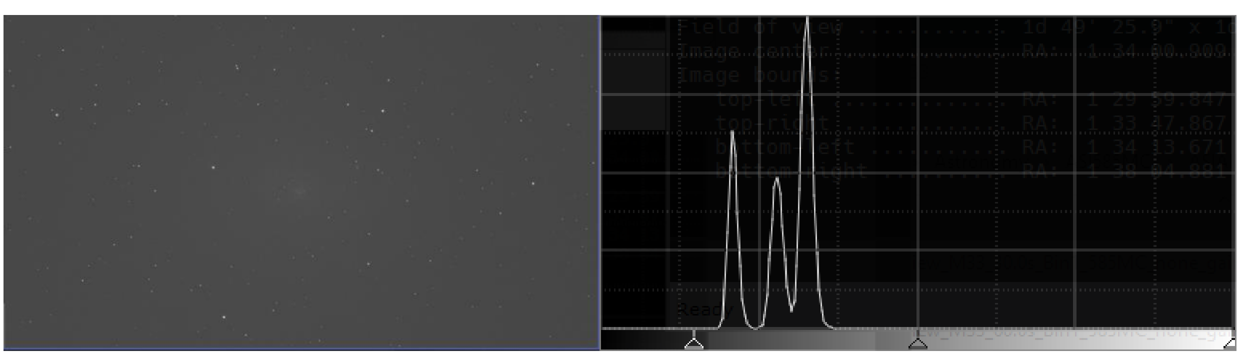
Gain 120, Exposure 180 seconds



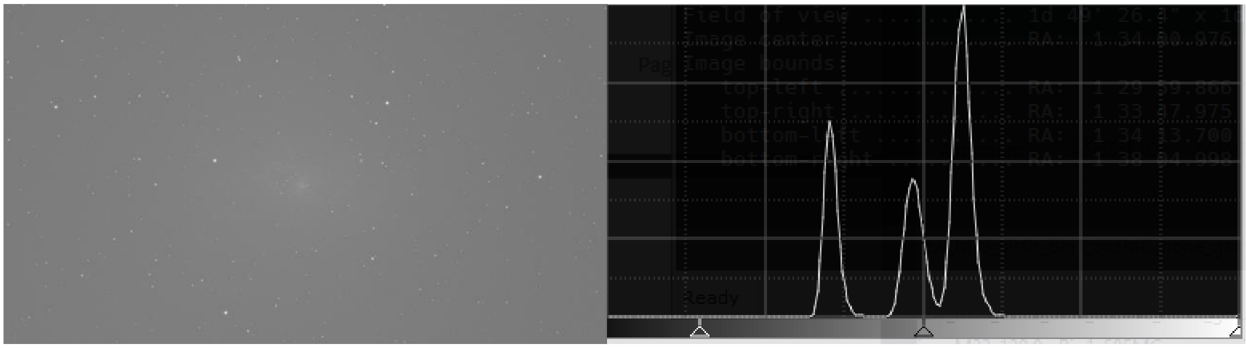
Gain 120, Exposure 300 seconds



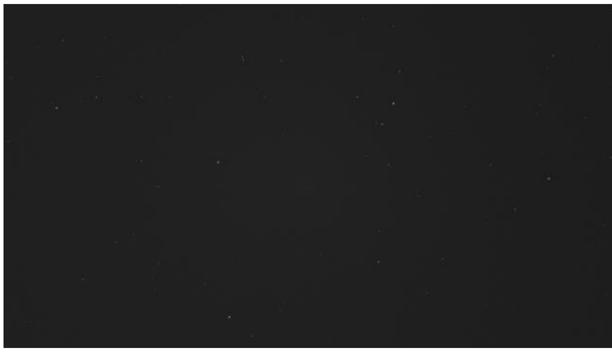
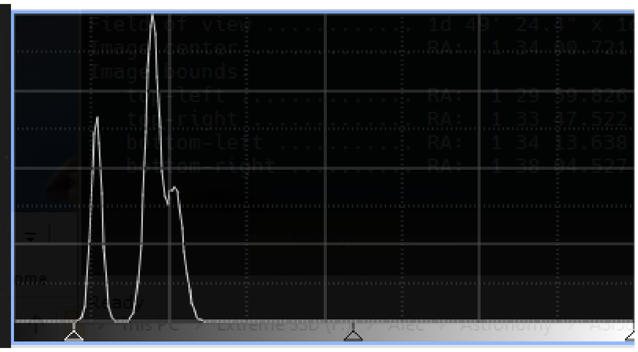
Gain 120, Exposure 600 seconds



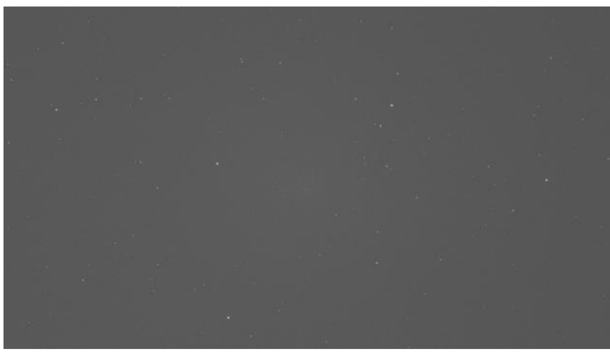
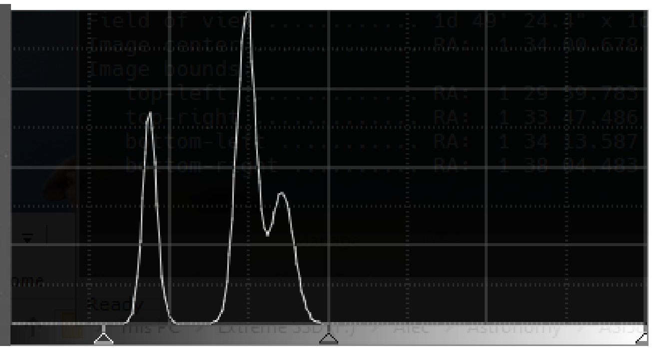
Gain 120, Exposure 1000 seconds



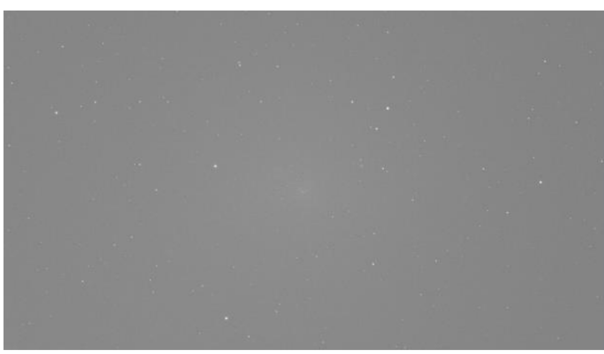
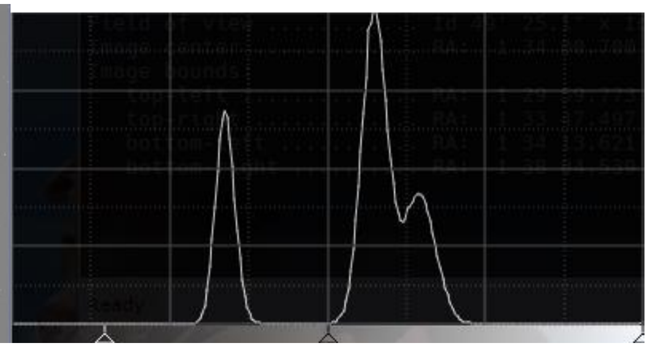
<u>Gain 252, Exposure 30 seconds</u>

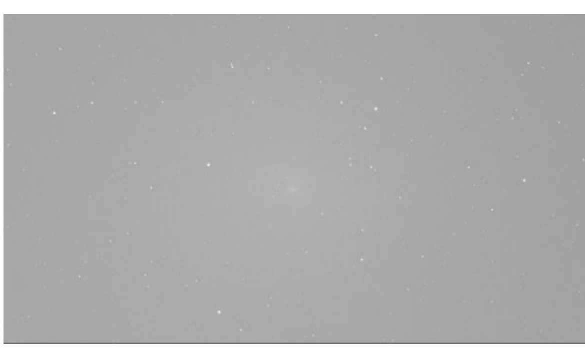
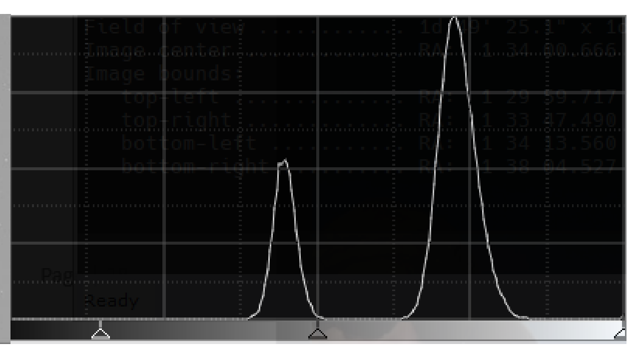
<u>Gain 252, Exposure 60 seconds</u>

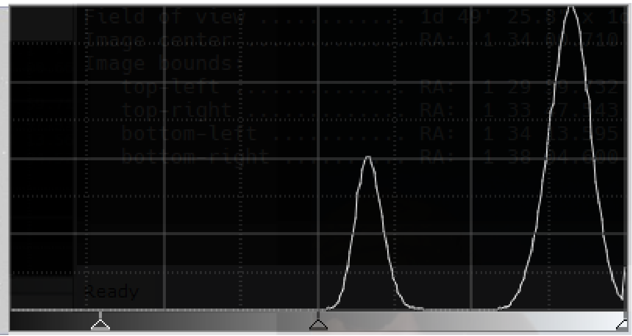
<u>Gain 252, Exposure 120 seconds</u>

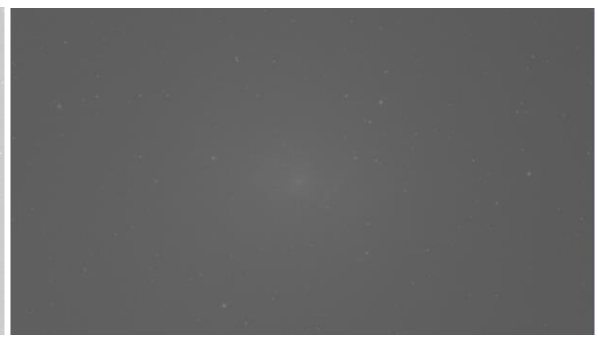
Gain 252, Exposure 180 seconds

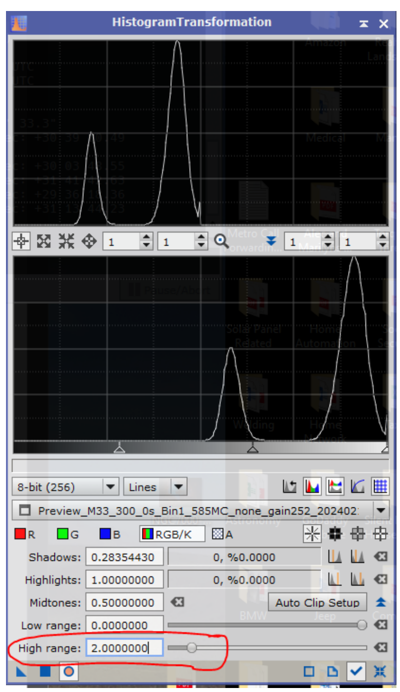



Gain 252, Exposure 300 seconds

Note that, even though this image (gain 252, exposure 300) "appears" completely washed out, you can still "fix" it (except for the missing clipped data) by adjusting the histogram "high limit" value as shown below (left = before, right = adjusted.) However, this does not restore the dynamic range or clipped values.

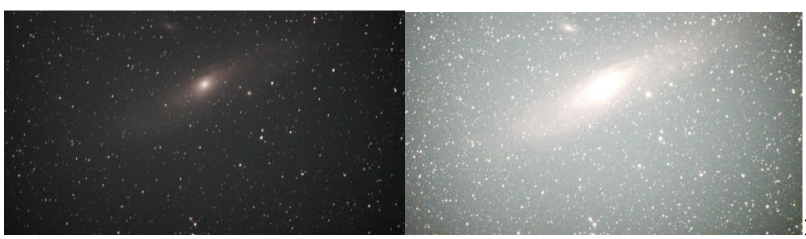


The following pictures (Andromeda Galaxy – magnitude 3.44) illustrate the effect of gain and exposure time on the image. The left column is with gain of zero, and the right column is with gain of 252 (medium.) No filters were used.


5 Sec


60 Sec


120 Sec


180 Sec

Note how these are much clearer than the previous M33 shots, this is because M33 is much dimmer at magnitude 5.72.

Stacking

Normal Image Stacking

Stacking is the process of taking multiple images of the same object over time and then merging them together in order to eliminate the differences. This has the effect of cropping out distractions (shooting star, airplane, light clouds, etc.) and improving the detail of the object.

Below is an example of stacking on the Orion nebula taken through high mixed clouds where I was unable to even see the constellation with my eyes. This set of images show the unstacked progress of the light clouds (haze over image) with a heavy cloud (orange color) approaching from the right side of the image.




And here you can see a stacked image of the nebula taken after the ones above, and over a few minutes before a large denser cloud was going to obscure the nebula from the right of the image.

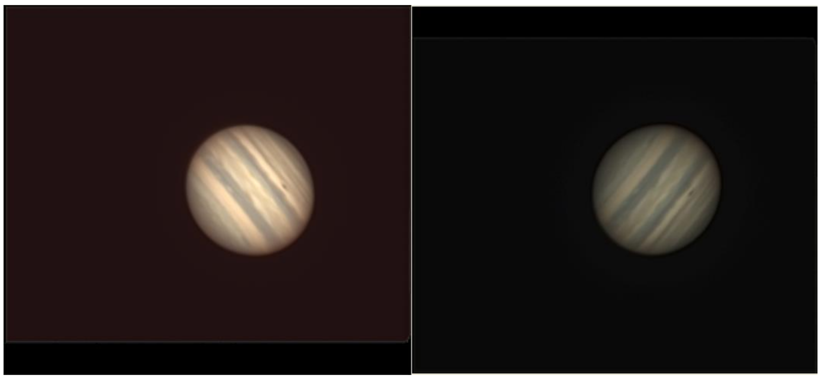
Stacking has dramatically cleaned up the left side of the image (and smudged the right side.)

Lucky Image Stacking

Lucky image stacking is the process of taking hundreds, or thousands, of frames of video and hoping that some of them turn out OK by luck and throwing the others away.

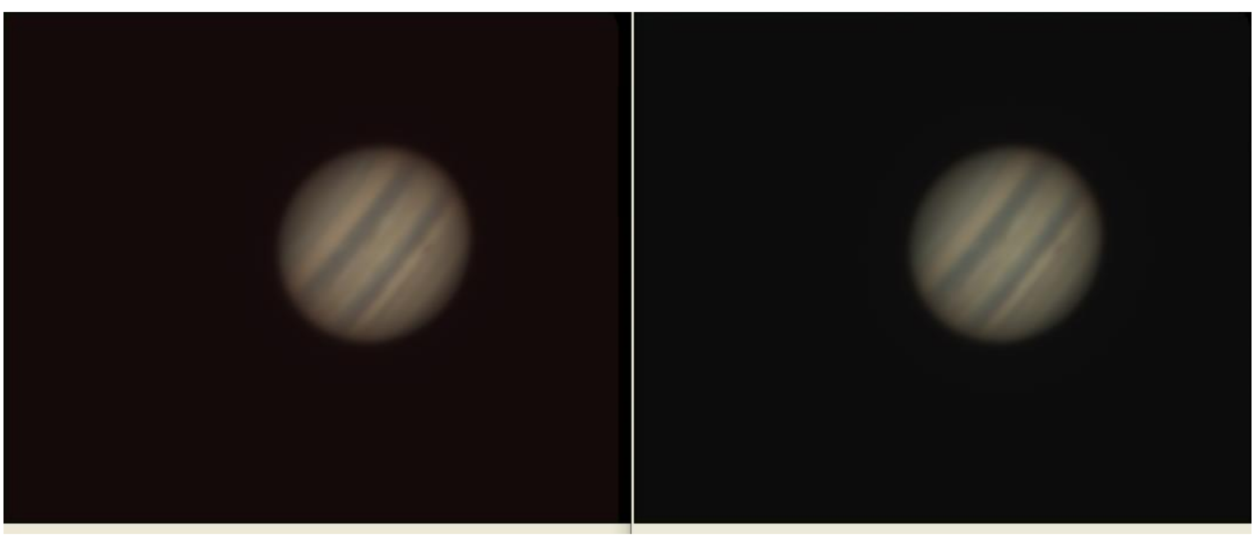
Because a video is just a sequence of frames there is software that can pick them apart and analyze them for the level of quality. [AutoStakkert!] is one such tool and the one I have been using.

Saving as FIT (below left) causes the image to be rotated and flipped for some reason. TIF preserves the original orientation, so prefer to save the stacks as TIF.



If you are used to using WeightedBatchProcess in PixInsight (or some other tool) to stack with calibration frames, you will find that this will not work – because most tools require at least 3 live frames to stack, and AutoStakkert has already stacked all of the frames into a single frame. Therefore, you will need to specify the calibration frames in AutoStakkert see Calibration Frames in AutoStakkert!

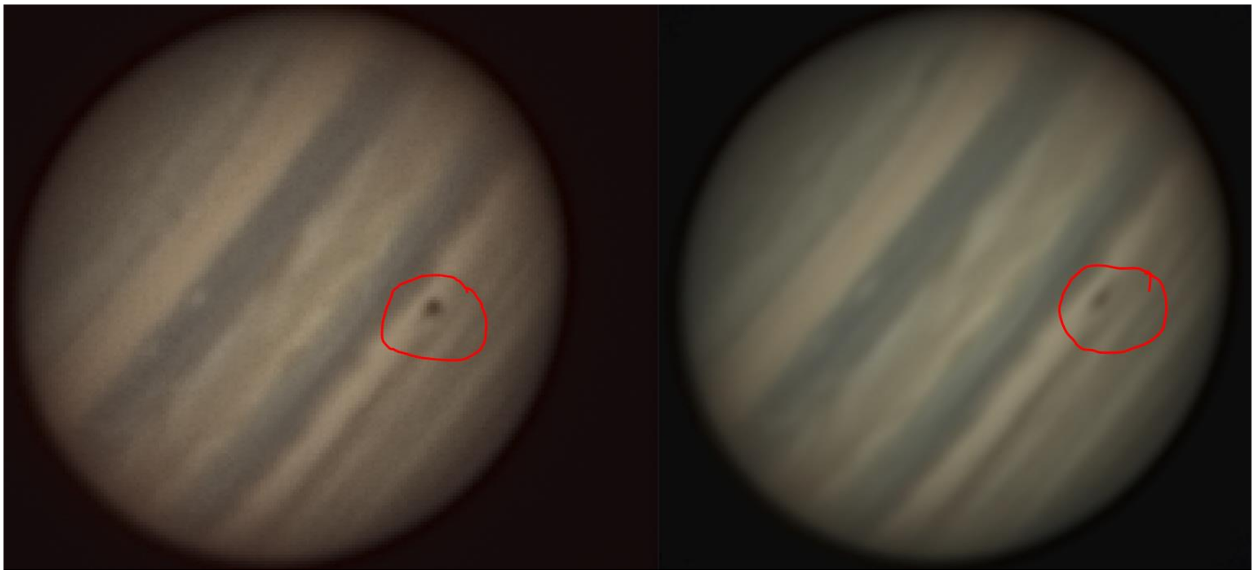
Below is the same lucky image stack of Jupiter without (left) any calibration frames, and with a dark calibration frame (right.) Note how the right image has a much blacker background.



Max Video Duration

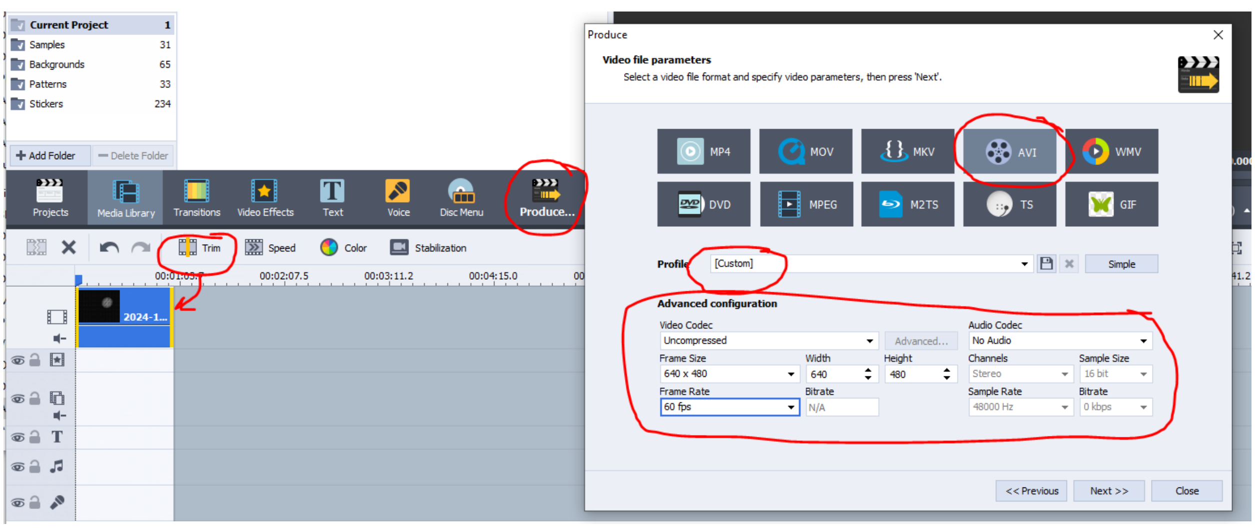
One-shot-color cameras can record full-color still sequences of Jupiter in one go, but there are a number of limitations. For Jupiter, capture times should be kept below 120 seconds (ideally 60 seconds) to avoid motion blur due to the planet's rapid rotation. Other planets will have different requirements.

Below you can see the effects of this problem. On the left is a 1-minute clip stack (the first 1 minute extracted from the 10-minute clip on the right), and on the right is the full 10-minute clip stack.



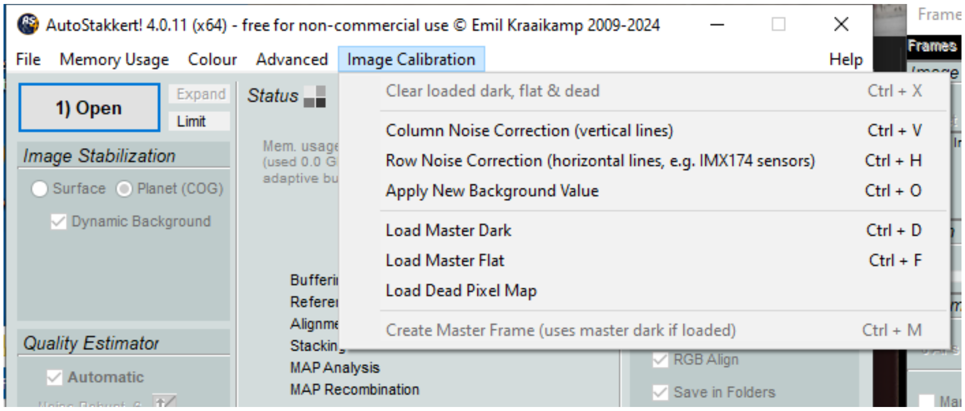
You can see the blur in the right image. It is especially clear in the red circled area that shows a moon. In the left it is nice and round, in the right it is stretched out and smeared. You can see blurring in all the bands as well on the right, and there is much more clear detail on the left.

You can still take long videos – which are easier – on the telescope. You just have to remember to break them up into smaller AVI files (using AVS Video Editor – Trim, or some other such tool) before stacking them.



Calibration Frames in AutoStakkert!

To create the calibration frames:



1. On your telescope setup
   a. Setup your video capture to the same ROI, exposure time, gain, and temperature as your live video.
   b. Setup your calibration conditions (ex: for darks, put the lens cap on in a dark room.)
   c. Record some video – at least 10-20 frames, more (like 100+) is better.
2. On AutoStakkert
   a. Load the video just recorded into AS!4.
   b. Under ‘Image Calibration’, choose ‘Create Master Frame’
      i. Save the file as a TIF file with a name like:
         1. Dark_533MCPro_0C_480P_1ms_gain450.tif
   c. This is your calibration frame

To use the calibration frames:

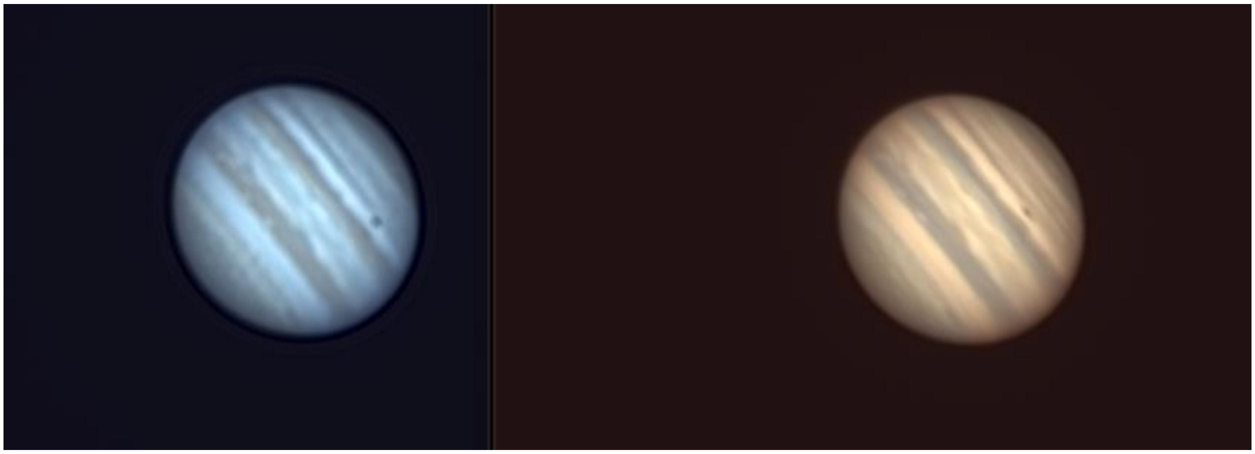
1. On AutoStakkert
   a. Load your live video with ‘Open’
   b. Under ‘Image Calibration’ choose ‘Load Master Dark/Flat/Dead Pixel Map’
      i. Repeat (b) for all calibration frames
   c. Continue processing your live video as normal and stack it. The result will be adjusted by the calibration frames.

It is important to remember that the dark frame video needs to be the same size and ROI as the live video. If you use the "cutout" feature in FC for example, this will not work because the cutout is basically a floating ROI, and there will not be a pixel-to-pixel match in the ROI of a dark video.

Effect of Exposure Time on Stacking

Here is an example of two separate 10-minute image stacks of Jupiter, both taken in good focus, only a few minutes apart. Both were stacked with AS!4 and PixInsight UnsharpMask processing.

gain=148 and exposure=17ms　　　　　　　　gain=364, exposure=1ms



Clearly the image on the right is much better and the reason for this is simple if you think about it.

Each image is taken through earths atmosphere which is a turbulent mass of varying air densities – each one distorting the image in a slightly different way. The longer your exposure time is, the more such distortions will be affecting your image.

Stated another way, if 1 out of 10 shots is clear and your exposure time covers all 10 shots, you are going to get 9 blurry shots ruining your 1 good shot. So, by taking 10 short shots (instead of 1 long shot) you have a MUCH better chance of capturing that 1 good shot.

Things that affect Exposure Time

Barlows

Barlows aren't designed to produce wide, flat fields of focus so adding a Barlow will add curvature to your field of focus – effectively ruining the benefits of an expensive Petzval refractor.

Additionally, your effective f-ratio will be changed by the magnification factor of the Barlow, so a 2X Barlow will make the telescope’s f-ratio increase by a factor of two (and that means a 4X increase in the needed exposures). Lastly, most Barlows change magnification depending upon the Barlow-to-sensor spacing and, in most cases, the greater the spacing the greater the magnification.

F-Ratio

As noted above, exposure time varies by the square of the f-ratio, so doubling the f-ratio will require four times longer exposure times. And likewise halving the f-ratio will cut the exposure time by a factor of four.

Binning

Binning is the process of having the camera "combine" several physical pixels (actual pixels on the camera sensor) into one logical pixel (pixels in the generated image file.) This is a trade-off between resolution and light sensitivity.

The benefit of doing this is to increase the number of photons collected for each logical pixel so that you can view dimmer objects better by reducing exposure time. The effects of binning can be seen in the table below.

Binning Level	Effect on Image Scale	Effect on Exposure Time
1	x1	x1
2	x2	x1/4
3	x3	x1/9
4	x4	x1/16

As can be seen the effect on image scale is linear because each level of binning increases the pixel diameter linearly. The effect on exposure time is inversely proportional the square of the binning because each bin level increases the pixel area by the square of the diameter increase – allowing it to accumulate more light and reduce exposure time.

Binning provides these benefits at the expense of image resolution which is generally a trade-off. However, in the case where your image scale is already smaller than current viewing conditions allow you to see anyway (roughly 1.5" in good to excellent viewing conditions) then you can use binning without any loss in "real" resolution.

Binning also reduces the signal to noise ratio of your image – but ONLY when using a CCD (not CMOS) image sensor. This is because on CCD devices you are combining multiple signals BEFORE the read amplifier – CMOS devices combine the signals AFTER the read amplifier.

The following illustrate the effect of binning on the image. Note all images are at a gain of zero, an exposure time of 300 seconds, and no filters were used.

Bin 1

Bin 2

Bin 3

Bin 4

SCT (Schmidt-Cassegrain) Issues

Focusing is pretty straightforward for most telescopes, however SCT (Schmidt-Cassegrain) telescopes have several additional complications that you need to take into account. These are all due to the fact that the large primary mirror moves as you focus and the mirror can 'stick' and 'flop' around as the telescope is moved (during tracking, etc.)

- Image shift (mirror tilts as it moves)
- Mirror flop (as telescope moves, the mirror tips to the other side)

An excellent review of these issues, and ways to solve them, can be found here: Upgrading the Focuser of Your Schmidt-Cassegrain Telescope

From a point of view of 'focusing' you are better off not using an SCT.

Mirror Clutches & Locks

Some larger SCT have clutches and locks.

The lock, as it sounds, locks the mirror in position and prevents it from moving. This is useful when transporting the telescope to prevent damage, but is very dangerous if you forget to unlock it before focusing because the focusing mechanism could be damaged.

The clutch is a 'gentler' way of stabilizing the mirror. It provides stability by applying light pressure to the edge of the mirror so that minor vibrations will not affect the focus. You can still move the mirror safely, although it will put more strain on the EAF motor so you are better off disengaging the clutch before altering the focus.