

# Deep Sky Observing with SharpCap v3+

## The Unofficial Quick Start Guide

DRAFT v0.5

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Astrojedi @ Cloudy Nights



*Figure 1: M16 The Eagle Nebula 15 x 10s exposure (C8@F2, ASI224 & SharpCap Pro v3) from a White LP Zone*

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# Introduction

I wrote this guide to address common issues most new as well as experienced users encounter while using SharpCap for live deep sky observing also colloquially called Electronically Assisted Astronomy (EAA). Topics are driven by questions that come up again and again in online forums such as Cloudy Nights and the content is based on my experience of using SharpCap for live observing and pushing its capabilities to the limit.

This guide is meant to be more practical in approach and is meant to complement the official SharpCap user manual which should be treated as the main reference for all functionality. Also note that I have no affiliation, official or otherwise to either SharpCap or ZWO and this guide has not been reviewed by the author of SharpCap.

The guide also assumes you have aligned your scope & mount, attached the camera and focused it. Those topics are beyond the scope of this quick start guide which is focused on the deep sky observing experience with SharpCap.

Needless to say this draft is incomplete in many respects and may have errors and omissions. I expect to keep updating and evolving the content as time permits.

Ultimately, the content is driven by the users and I am happy to receive feedback, comments and suggestions for new topics. Please feel free to reach out to me on Cloudy Nights.

I hope you enjoy this guide and it increases your enjoyment of this vast and fascinating universe.

Best,

Astrojedi @ Cloudy Nights

# Section 1: Quick Start Steps

## Help! there are too many controls – Making sense of SharpCap’s Menus

SharpCap can be a little intimidating for the new user but it is an incredibly powerful program whose capabilities should not be discounted. The reason for so many controls is that the software started out as a planetary capture program and tries to cater to many different types of imagers.

Over time SharpCap has morphed in to an astrophotography image capture tool and also a live stacking program for deep sky observing. Newer versions have also introduced cutting edge features such as polar alignment tools, plate solving, tools for exposure time and sensor read noise analysis etc.

But to get started with deep sky observing there are only really a few minimum controls that you need to focus on (note the exact layout and controls may vary with the brand of camera you are using. I use the ASI290 and ASI224 but most of these controls should be available for other brand cameras.)

Here is the SharpCap user interface in action while observing live at the scope. These are the basic steps to start observing. We get into details next.

1. Connect the camera
2. Choose camera settings
3. Set exposure time and gain
4. Adj. display histogram for view finding
5. Start Live stacking

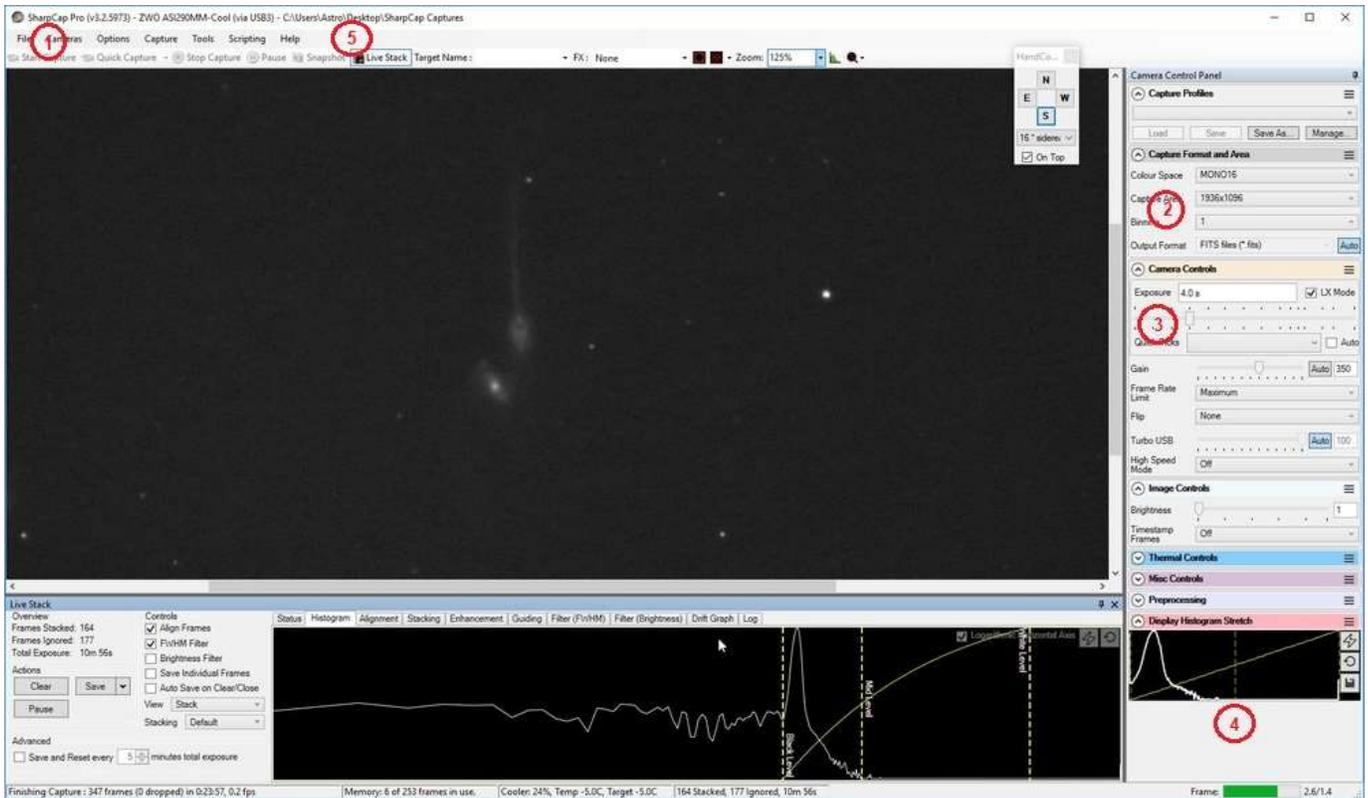


Figure 2 Mice Galaxies Stack with ASI290MM Camera

### **STEP 1: Connect to your camera**

There are 3 primary ways of connecting your camera to SharpCap and each provides different amounts of control.

**1. Native Camera Support:** This is the preferred approach as it provides access to full functionality of the camera manufacturer’s SDK but requires official support by Robin, the developer of SharpCap. Many brands of cameras are now natively supported.

**2. Connect via ASCOM:** ASCOM defines common astronomy standards and standards interfaces to ensure interoperability of hardware and software. This is generally very useful when certain hardware is not supported natively by an astro software but it has ASCOM compatibility. The limitation is that because ASCOM is designed to be compatible with a wide variety of hardware and defines common standards and interfaces it usually does not support vendor specific enhancements and features.

**3. Connect via DirectShow:** Least preferred as the functionality is very limited and I have found it unstable with certain cameras. But can be a fall back if nothing else is working.

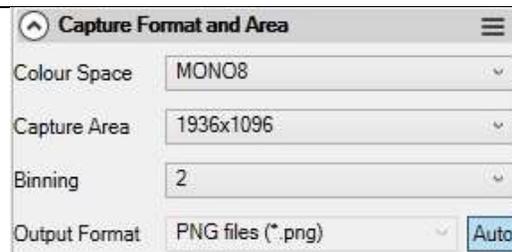
### **STEP 2: Choose the format and binning.**

Almost any setting will work to start with. As you get more particular about your captures you can start to tweak this.

If using the 224 or 290 cameras I would use Mono 8 or Mono 16. Don’t be confused by the word “Mono”. Does not mean that the image you see will be mono. It is just the output of the sensor.

Mono 8 has limited dynamic range – only 8 bits, which means it can display only 256 levels (i.e.  $2^8$ ). So usually works well with very short exposures at high gain. In fact for dimmer objects and very short exposures you will see very little difference between Mono8 and Mono16.

For brighter objects with very bright and dim regions (like the Orion Nebula I would stick to 16 bit, lower gain



and short exposure time). Don't hesitate to experiment and find the right setting.

I generally prefer Mono 16 as ADC and quantization issues are minimized. If you want, just stick with Mono16 for simplicity.

Also if you have a very low read noise high sensitivity CMOS camera like the 224, 294 or 290 you can use x2 software binning to speed up acquisition (I will cover the conceptual background in more detail in future versions of this guide). Make sure HW binning is turned off (please refer to the SharpCap manual: <http://docs.sharpcap.co.uk/2.9/#ZWO Camera Controls>)

### STEP 3: Choose exposure time and gain

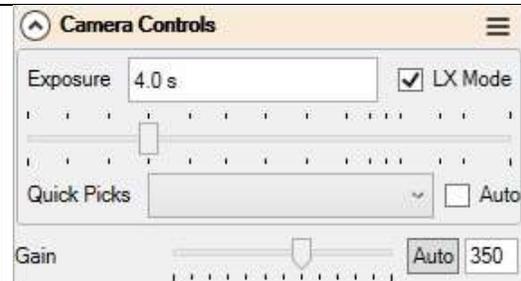
#### View finding:

I usually use 1s exposures at high gain 350-400 and turn up the contrast (see next step) for view finding. This is plenty to find and center even very faint objects with the 224 and 290 sensors (they are very sensitive)

#### Observing and live stacking:

For live stacking and viewing the object with the ASI224 and ASI290 cameras I find that a gain of 300 - 350 with sub exposures times of 4-10s is pretty much sufficient for most objects including the dimmest galaxies. Note that other camera manufacturers may have different numerical scales for the same gain range. I am typically targeting about 30-35 db of gain as it minimizes read noise with these cameras and corresponds to about 300-350 on the ZWO gain scale.

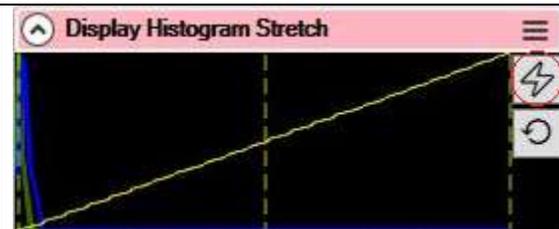
See next section for typical settings for various cameras.



### Step 4: Tweak Display Controls for view finding and centering

In newer versions of SharpCap the best way to make the object visible while view finding and centering is to click on the "auto stretch" button in the Display Histogram Stretch control.

Keep in mind that this stretch will be additive to the stretch in the Live Stacking tab once you start Live Stacking but the contribution does not get saved when you click "Save as viewed" in the Live Stacking tab! This



leads to some confusing behavior and unexpected results.

Hence make sure you “reset” this stretch once you start Live Stacking (see below).

### Step 5: Start Live Stacking

Once your object is centered in the display, click on the “Live Stack” button to start live stacking.

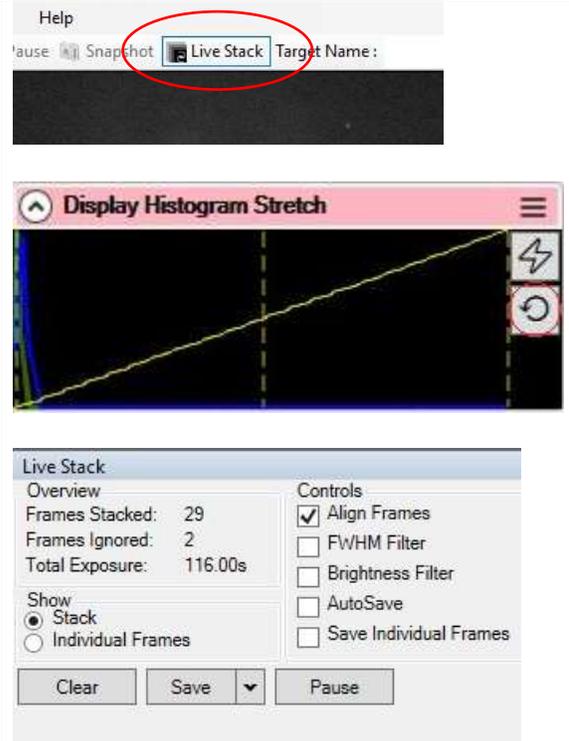
Also, don’t forget to reset the Display Histogram Stretch – click the reset button on the tool. This will ensure you are only using

*Sidebar: Here is where the fun begins. I won’t get into detail here as to why stacking is such a powerful approach as it is out of scope for this guide but briefly: it is a way to capture more photons without doing one incredibly long exposure which puts unreasonably high demands on equipment (mount, camera, scope, focus etc.) – you can easily spend thousands of dollars or more on premium equipment to achieve that or just use stacking. No need for even an EQ mount for observing the faintest objects. A modest goto Alt Az mount is sufficient. I have observed mag 19 gravitationally lensed quasars using a ASI290 Mono and an Evolution C8 from my heavily light polluted white zone backyard with stacking sub exposures as short as 1s.*

When you press the “Live Stack” button a Live Stack panel will pop up at the bottom of the SharpCap interface with a number of tabs. Looks complicated but once I walk you through it (next section), it will feel like second nature.

If you have already observed an object during the session then make sure you press “Clear” to clear the image stack. Sometimes when you press clear SharpCap may show an old image. Ignore that as it is just the contents of the buffer. Once a new exposure comes in the stack will start fresh.

The Pause button will pause stacking but note that the continuous camera readout /exposures will not stop. They just keep on running...



## Step 6: Manipulate the Histogram to produce a pleasing image

The histogram represents all the information in the image. There is usually a hill or bump in the left or middle which typically represents most of the signal from the object.

In new versions of SharpCap there are options to auto adjust the stretch and the color balance and these typically work pretty well.

Typically when you first start stacking the image will look dark and the object may look very dim. You have to “stretch” the image to make the object brighter. This is because the image stack is potentially a 16 to 18 bit image but our monitors are only 8 bit. Hence the object looks dim if you don’t “stretch” the signal for the 8 bit display as typically only the high order bits are used for display.

To auto adjust / auto stretch the histogram click on button (1) – see image below. This should stretch out the image and show faint details. I find that sometimes it over does the stretch. If so, adjust the “White Level” control (4) below. Move it to the right to reduce the stretch.

You may also need to adjust the control (5) below. This manipulates the mid tones and can sometimes really help bring out the faint details without blowing out the brighter parts (highlights as they are called in photography). Push it to the left to stretch the mid tones (curve will “bump up”) and to the right to suppress the mid tones.

You can also adjust the dark levels – control (3) in case the background is too bright. This is useful sometimes to see the object more clearly especially in light pollution. Move it to the right to darken the background.

Lastly, you will most likely need to color balance especially if you are in a heavy LP area. For this click on the auto color balance control (2). If the colors are still wonky, say the image has a green or red cast, then adjust those sliders.

Don’t be afraid to play around with the controls. If you get into a difficult situation you can just click the auto adjust or reset buttons (next to the auto adjust)

That’s basically all there is to it! In the next section I will get into troubleshooting typical issues.

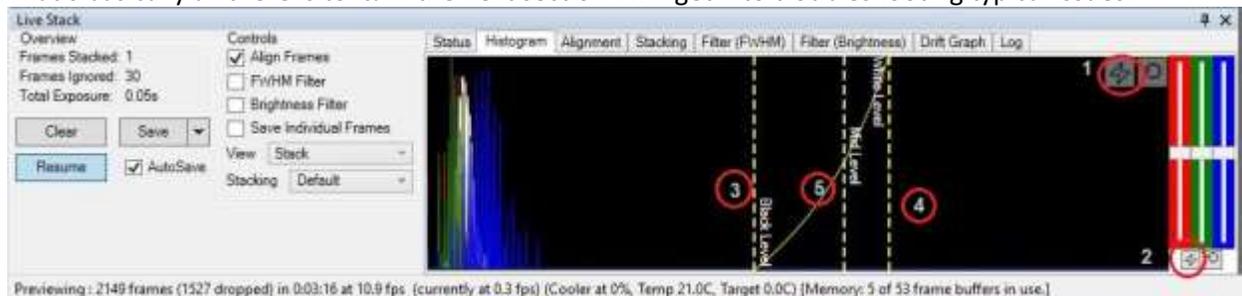


Figure 3 Adjusting the histogram

# Section 2: Troubleshooting Live Stacking

## Addressing common Live Stacking issues

SharpCap’s live stacking algorithm is typically very robust although in newer versions of sharpcap seems slightly less reliable. For example I have used it to observe live at the scope very faint (mag 19) incredibly small lensed quasars requiring <2 arc second resolution with sub exposures less than 1.5s using my ASI290 mono! This is quite incredible considering the very low SNR of each individual frame. But with a few tweaks of the live stacking settings the stacking was incredibly smooth.

In my experience live stacking issues are primarily caused by two reasons:

1. Too few stars in the image for the alignment algorithm to work
2. Too many stars in the image which overwhelms the alignment algorithm.

Lets look at each of these in detail.

### 1. Too few stars in the image

SharpCap, like other astronomical image stacking programs uses stars in the image to calculate alignment of the sub exposures in the stack. If there aren’t sufficient stars it is unable to accurately calculate the transforms required to align the frames.

How to tell if this is the problem: Look at the log tab in the Live Stack section. In the log you will usually see messages like: “Too few stars... unable to align” or “Less than 3 stars found” – a very tell tale sign that SharpCap cannot find enough alignment stars.

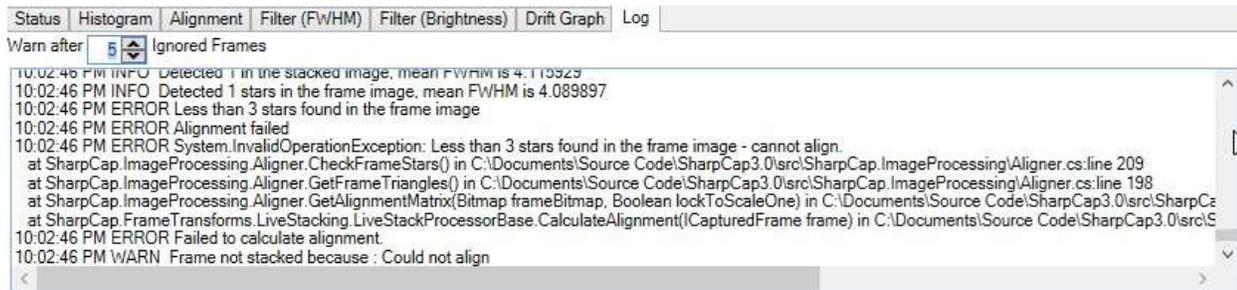


Figure 4 Too Few Stars Error Message in the SharpCap Live Stacking Log

This can happen because of a few reasons:

Usually insufficient SNR is the underlying cause for all of these but due to different factors.

*[Author’s Note: This is likely not a complete list. If there are other scenarios that come up contact me and I can add to this list]*

- a. Firstly, check your mount tracking. Some mounts need a few seconds to settle down after a goto and for the gears to mesh and track smoothly. If the mount is still drifting the stars will be oblong or have trails in which case star detection algorithms will struggle.

- b. You are trying to observe an object (typically a galaxy) in a sparse star field (or rather there aren't enough bright stars with sufficient Signal to Noise ratio "SNR")
- c. You are using very short exposures and potentially low gain due to which again there are not enough stars with the required SNR to align the frames.
- d. You are in a very light polluted area or there are other factors impacting SNR.
- e. Sometimes there may be enough stars but SharpCap is still not able to align – in many instances this is because the SNR is not high enough and the star detection is varying across frames

Steps to take to fix most common issues:

(i) Use a longer exposure time or higher gain

(ii) If for some reason you don't want to change exposure time and gain or when stacking just does not seem to be working you can use these controls to improve SharpCap's stacking performance.

**"Align using"** – I will typically set the align using value to the lowest allowed number possible. This will try to use fewer stars to calculate the alignment transforms.

**"Digital Gain"** – This is the most important setting. I typically try "2x" setting and if that does not work I increase it to "4x". I recommend staying at "2x". Note this gain setting is only used by the stacking algorithm and does not impact the image.

**"Black Threshold"** – This is the black point used by the stacking algorithm. I would try lowering the value to avoid clipping some of the fainter stars in the image.

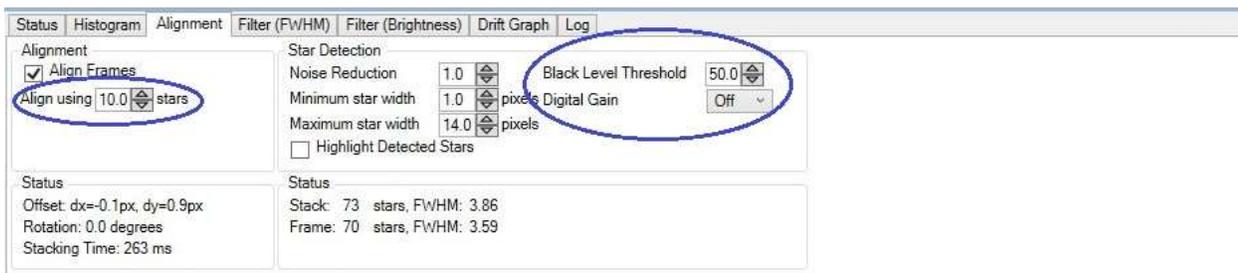


Figure 5 Tweaking SNR for Stacking

## 2. Too many stars in the image

Yes, this can happen if you are in a very busy star field with typically a large FoV. The very high SNR CMOS cameras can produce more stars than the stacking algorithm can handle.

How to tell if this is the problem:

In the alignment tab in the status section check to see how many stars the stacking algorithm has found in the image. If the number is **250** then you are pretty much maxing out on # of stars.

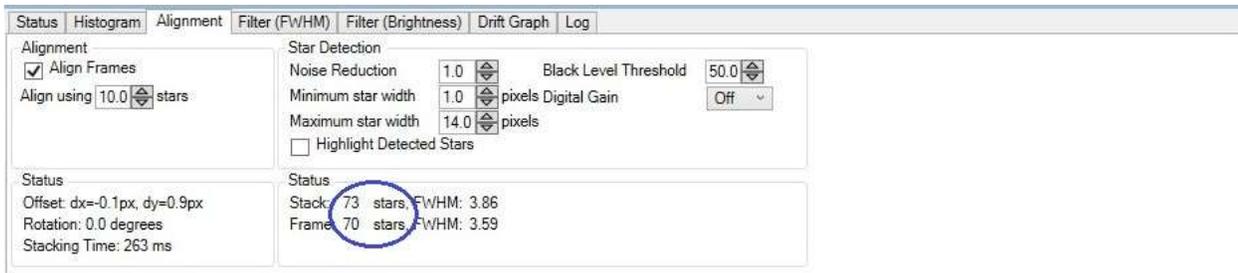


Figure 6 How to tell if there are too many stars in the image

Here are some settings that I have found work:

Try increasing the “Noise Reduction” to 2 or 3. You can also try increasing the minimum star width. These settings will weed out a few stars or potential mishits and generally helps with stacking. But be careful not to overdo these. If you see the star count falling below 30 then stop.

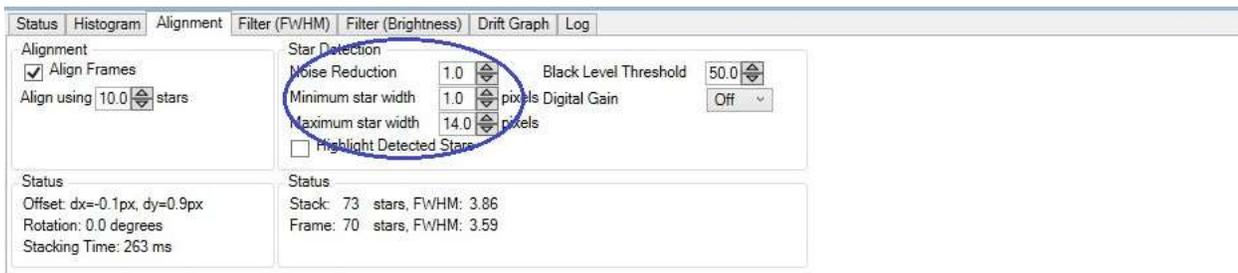


Figure 7 Adjustments for busy star fields

## Section 3: Additional Topics

### Typical exposure settings for different cameras

Based on my experience I have found these settings work best with these cameras:

Camera	View finding	Live Stacking / Observing
ASI224	1 -2s, 350-400 gain, high contrast	10s-15s, 300 – 350 gain, Use histogram for stretching
ASI290 Mono	1s, x2 bin, 350-400 gain, high contrast	1s-10s, 300 – 350 gain, x2 bin, use x1 bin for observing very small objects. Use histogram for stretching
ASI294MC Pro	1s-2s, x2 bin, 350-400 gain, high contrast	10-30s, 350+ gain, x1 or x2 bin depending on resolution required. Use histogram for stretching

### Achieving good Color balance – A step by step guide

Most color cameras will suffer from color balance issues when used in a light polluted or poor transparency environment due to artificial skyglow. But there are also other factors which could also potentially impact color balance including filters used or response of the optics and sensor and the interaction between those factors.

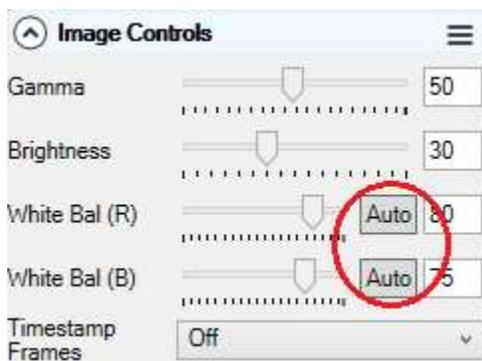
A typical RGB color sensor uses 2 green, one blue and one red pixel to recreate the color image.



When there is significant skyglow the total contribution from the green pixels tends to overwhelm the contribution from the red and blue pixels and throws off the color balance.

#### Auto Color Balance

SharpCap has controls for automatic color balancing. To enable it just click on the auto buttons in the Image Controls section (see image below). Note these settings are for the continuous display image only and will not be saved with a live stacked image. When live stacking you need to use the color balance tool on the live stacking tab (see above).



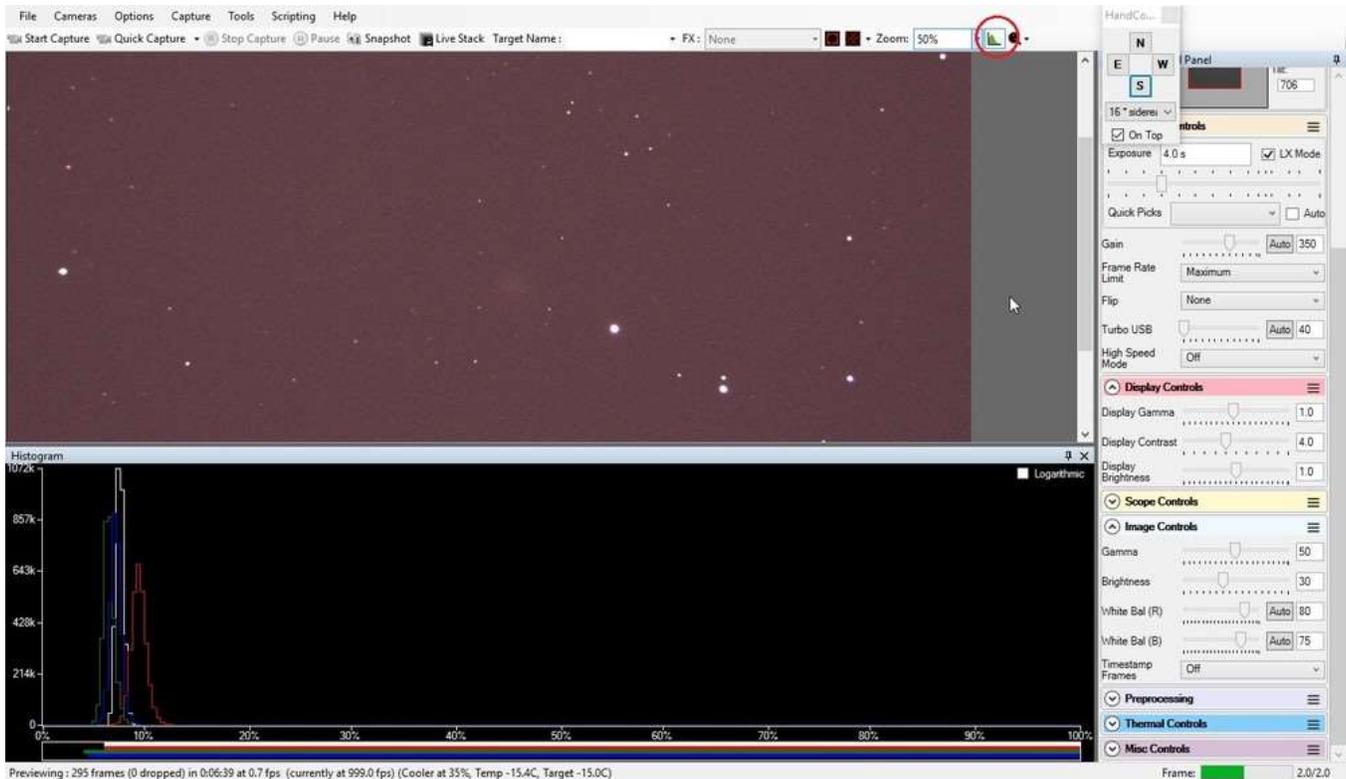
## Manual Color Balance

If automatic color balance is not working for you then you can manually set the color balance by following these steps

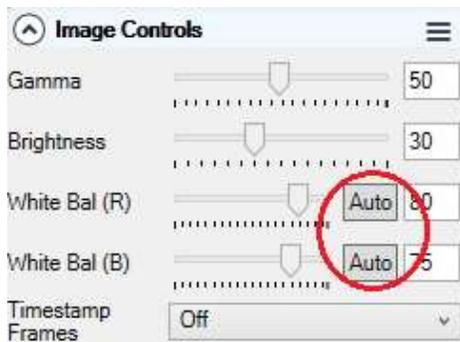
**Step 1.** Once you have centered the object you want to observe, set the desired sub exposure parameters i.e. exposure time, gain and binning. If you have a cooled camera make sure the TEC has been running for a while and the sensor temp has stabilized.

Important: You must do this step before you color balance and start stacking. Changing any of these parameters will change the color balance

**Step 2.** Click on the histogram button – This will display the histogram Tab at the bottom.

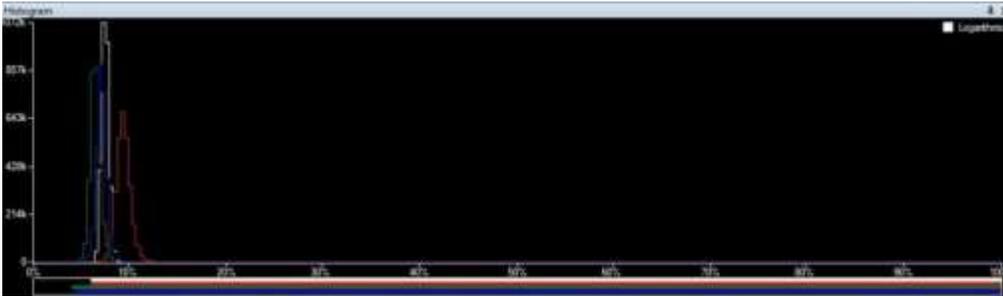


**Step 3.** If color balance is set to “Auto” then click the two “Auto” buttons to enter manual color balance mode

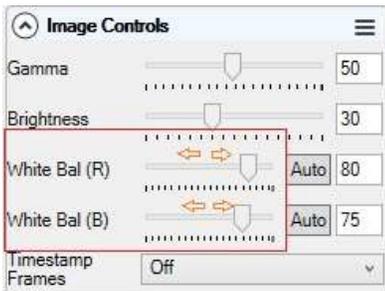


#### Step 4. Adjust Color balance

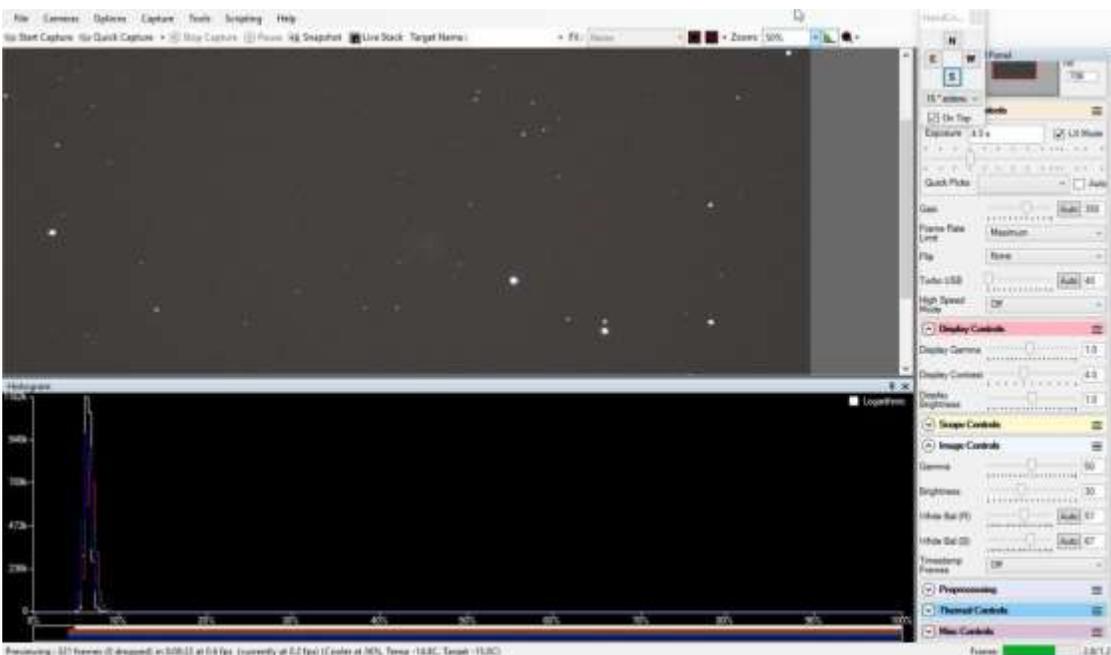
After clicking on the histogram button observe the histogram and the 3 color curves. The goal is to make sure these are completely aligned (but don't kill yourself with precision). The image below shows the unaligned curves before color balancing. Your color histogram curves may look different.



Now adjust the Red and Blue color balance sliders such that all the 3 color curves are aligned.



Here is the result after adjustment. Now you can start stacking. If you still see a color cast repeat these steps.



## Applying dark frame calibration while live stacking

SharpCap makes it very easy to create a master dark frame and a dark library and apply it on the fly. Dark frames primarily try to correct temporal camera/sensor issues that arise in exposures longer than a few seconds like hot / warm pixels and dark current. Different cameras/sensors behave differently in this regard. A full discussion of calibration is out of scope here but there are many good resources available on the Internet.

To create and reuse a dark you need to pay attention to these 4 key settings / variables:

1. Exposure time
2. Gain
3. Color Space (e.g. RAW8, RAW16)
4. ROI (if you have defined a ROI) and Binning (e.g. x1 or x2)
5. Sensor Temperature (Usually available for many cameras in SharCap. ZWO cameras provide this information for both cooled and uncooled cameras.)

Dark frames work best when these variables are closely matched between the dark frames and the light frames (i.e. Settings you are using for observing)

If there is a significant mismatch between the settings at which the dark frames were taken and the settings which you are using for observing then you will likely encounter many different issues from dark pixels to losing dynamic range from over correction of dark current (the image will become too dark and data may start clipping on the low end.

For cameras with amp glow sticking with the same gain setting is also important. So if the dark was taken with a gain of say 300, then it is best to use it with gain of 300 while observing. Otherwise you will under correct or over correct the amp glow.

For uncooled cameras I find the darks are usable as long as the sensor temp is within +/- 3 to 4 deg C.

### Creating the master dark

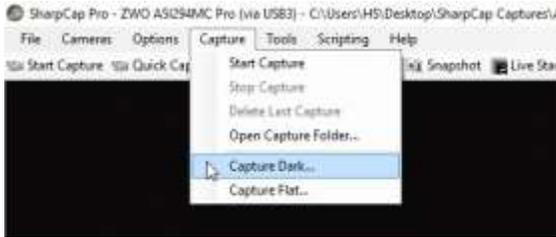
Here are the basic steps to create a master dark calibration frame which you can then apply on the fly. Before you start make sure in SharpCap settings you have selected "FITS" as the preferred file format.



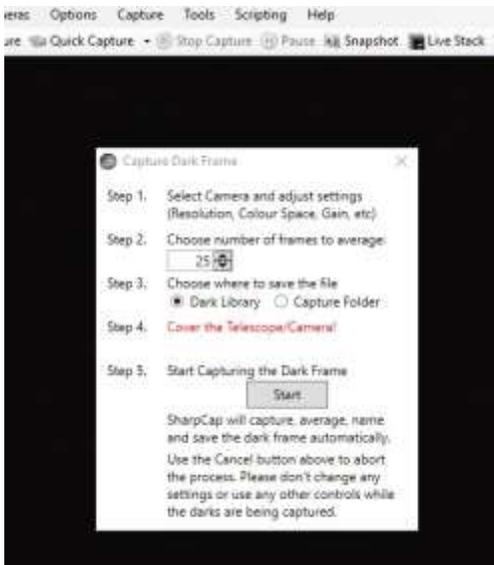
1. Cover the telescope or camera with a cover. Ensure there is no light leakage.
2. Adjusted camera settings to desired exposure time, gain and binning.

3. If using a cooled camera set the temperature and give the TEC a few minutes to reach the desired temperature. For uncooled cameras run the camera for a few minutes which allows the sensor temperature to reach equilibrium between the ambient air and heat generated by sensor electronics.

4. In SharpCap select dark capture > capture dark.



5. I would capture at least 20-25 dark frames to minimize noise from the dark current itself.



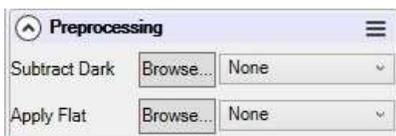
6. Click "Start". SharpCap will automatically take the specified number of dark frames, average them and then save a master dark ready to be applied while stacking.

7. Make a note of where SharCap saved the master dark. I would navigate to the file and put all the key settings in the name. The convention for naming darks I usually follow is:

"ASI224\_Dark\_RAW16\_25x10s\_Gain300\_x1Bin\_ROI2112x2116\_Temp20degC.fit"

### Using the master dark

1. In the "Preprocessing" section click the "Browse" button next to the "Subtract Dark:"



2. Navigate to the master dark saved by SharpCap and select it.

3. Once you do that SharpCap automatically adds the master dark to the drop-down list (i.e. your dark library). Next time you open SharpCap and you want to use that dark you don't need to navigate to it again. You just select it from the drop-down list.



4. If the master dark is not already selected, select it from the drop-down list.

5. That's it. Now SharpCap will apply the dark to every frame coming in from the camera.

## Checking the bit depth of the stack

Stacking subexposures is a very powerful technique to build SNR and dynamic range without resorting to very long single exposures. As you stack more sub-exposures the bit depth builds quite rapidly just as it would in a single long exposure.

SharpCap shows you the current bit depth of the stack in the "Status" tab in the live stacking section. Next time you are stacking take a look here. You will be surprised as to how quickly you build dynamic range with live stacking even if using 8 bit single frames at high gain. Key takeaway is that the bit depth of the camera becomes less important if you are stacking short exposures.

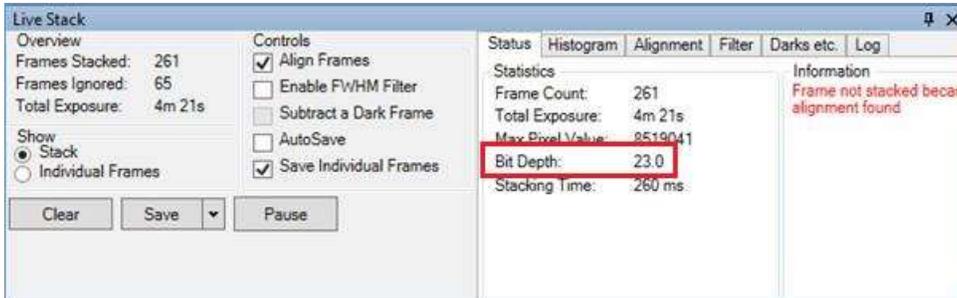


Figure 8: Bit depth of the stack

## Saving Captures

We all like to share our observations and the excitement of seeing a deep sky object appear on the screen. When using live stacking in SharpCap you have the following options for saving the current image stack.

Save as viewed: This option will save the image as a 8 or 16 bit PNG file. This is typically the option you want if you want to share your observations “as viewed” on the screen. Note that the saved image will only include adjustments to the histogram. Any contrast settings will not be saved.

Save as 16bit Stack: This will save the current stacked image as a 16bit FITs file for post processing.

Save as RAW 32bit Stack: This will save the current stacked image as a 32bit FITs file for post processing. Note that not all applications can work with a 32bit depth file.

## Is there any SNR (Signal to Noise ratio – higher is better) benefit from Software Binning?

You will find many heated debates on this on Cloudy Nights and other astro forums. The short answer is yes, there is a significant SNR benefit. You can expect nearly a 2x improvement in SNR with x2 bin especially when you are operating at a high gain / low read noise setting. Note that this discussion is specific to EAA. Different considerations apply to long exposure imaging.

Whether you are using CCDs or CMOS cameras the SNR improvement from binning (software or hardware) comes from the following two factors:

1. Adding the signal and noise of adjacent pixels together – this is the major contributor to higher SNR when software binning the CMOS sensor
2. Keeping read noise constant while you increase SNR (applicable when hardware binning CCDs)

Lets look at (1). When you bin in software the noise will add in quadrature (which is true only if the noise is uncorrelated and random – a fair assumption for newer CMOS cameras).

Lets take a simplistic example. Say you have four adjacent pixels with the following signal and noise for a CMOS sensor operating at high gain and low read noise between 1-2e RMS:

Signal: 5 Noise: 1 SNR: <b>5.0</b>	Signal: 50 Noise: 2 SNR: <b>25.0</b>
Signal: 10 Noise: 2 SNR: <b>5.0</b>	Signal: 16 Noise: 1 SNR: <b>16</b>

So, average SNR is **12.8**

Let software bin these four pixels x2.

Signal = 5+50+10+16 = 81 Total Noise = $\text{Sqrt}(1^2+2^2+2^2+1^2) = 3.2$ Total SNR = 81 / 3.2 = <b>25.3</b>
--

So you have almost doubled the SNR over the four pixels from **12.8 to 25.3 (a 1.97x improvement in SNR)**.

Now lets look at (2). This is mostly applicable to CCDs as they have a common pixel readout and digital conversion path. When you hardware bin pixels in CCDs your read noise stays constant but signal increases much more.

Signal: 5 Noise: 6 SNR: <b>-1</b>	Signal: 50 Noise: 6 SNR: <b>8.3</b>
Signal: 10 Noise: 6 SNR: <b>1.7</b>	Signal: 16 Noise: 6 SNR: <b>2.7</b>

So, average SNR is **~3.0**

First thing you notice off the bat is that SNR is much lower vs. a CMOS camera – this is due to much higher read noise in CCD cameras.

So what happens when you hardware bin the CCD sensor?

Signal = $5+50+10+16 = 81$ Total Noise = 6 Total SNR = $81 / 6 = 13.5$
--

There is almost a 4.5x improvement in SNR using hardware binning! That is great but note that the overall SNR is still lower than the CMOS sensor as the read noise of the CMOS sensor is much lower.

So, does this hold in the real world? Yes it does but things do get more complicated. The above is a highly simplified example. You have to take sensor QE, optical system and sampling / resolution into account for a fair comparison.

If you use a 9 micron pixel CCD at the same F ratio and FL as a 3 micron CMOS sensor then despite higher read noise chances are that the CCD could match or exceed the SNR of the CMOS sensor (assuming equal QE). But if you normalize for sampling i.e. arcseconds / pixel on the same optical system you will likely see a significant SNR gain from using a CMOS sensor. What does this mean? It means you can use smaller apertures with CMOS sensors and still generate high SNR and high resolution images. No need to do EAA with that backbreaking C11 anymore.

### Focusing with SharpCap [ToDo]

TODO

### Using ASCOM drivers [ToDo]

TODO

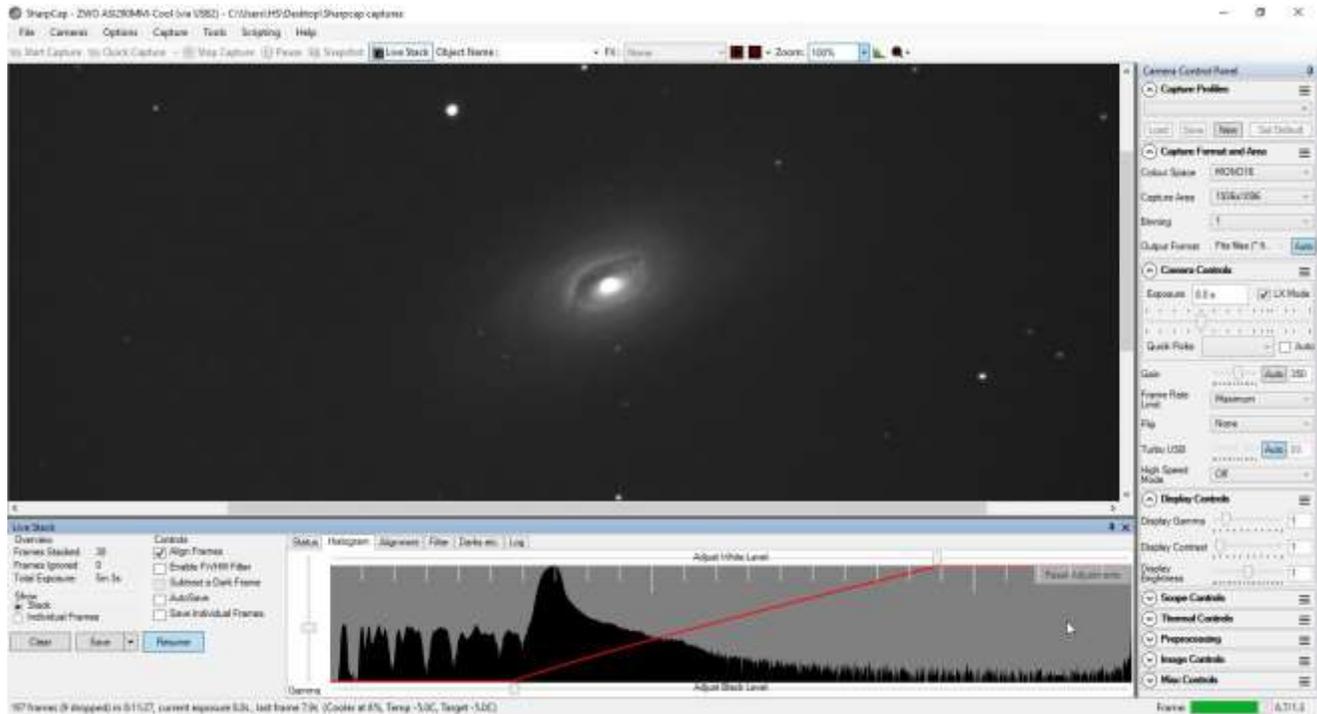
### Using FWHM filter and short exposures for high resolution imaging [ToDo]

TODO

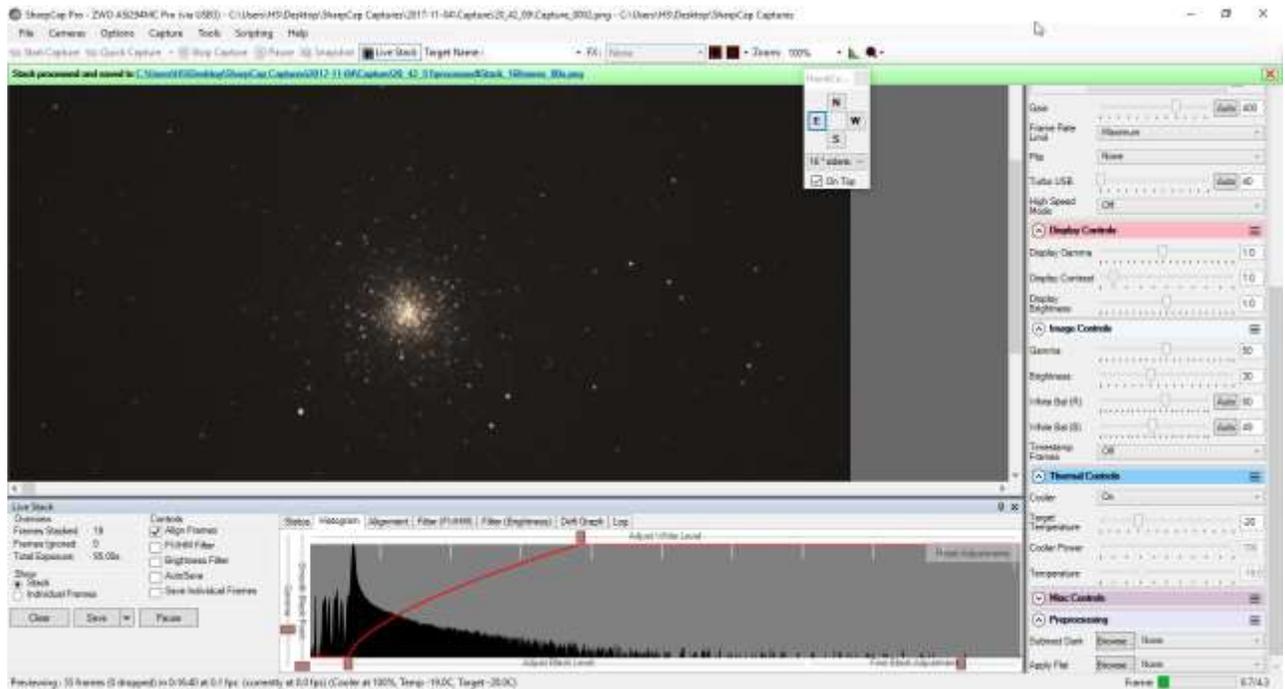
# Section 4: Live stacking examples illustrating histogram settings

These are with a C8 with ASI290 Mono (@F5) and ASI224 Color (@F3.7 and F10) cameras

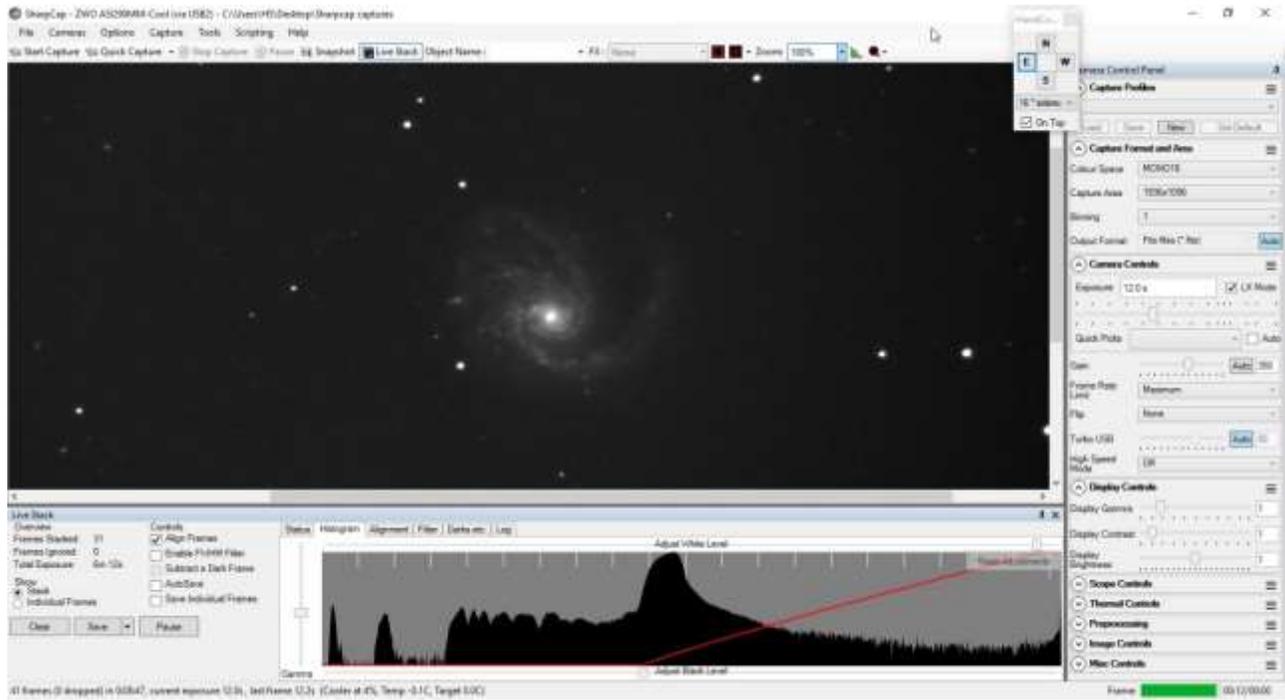
## M64 - A galaxy with a bright core using x1 bin



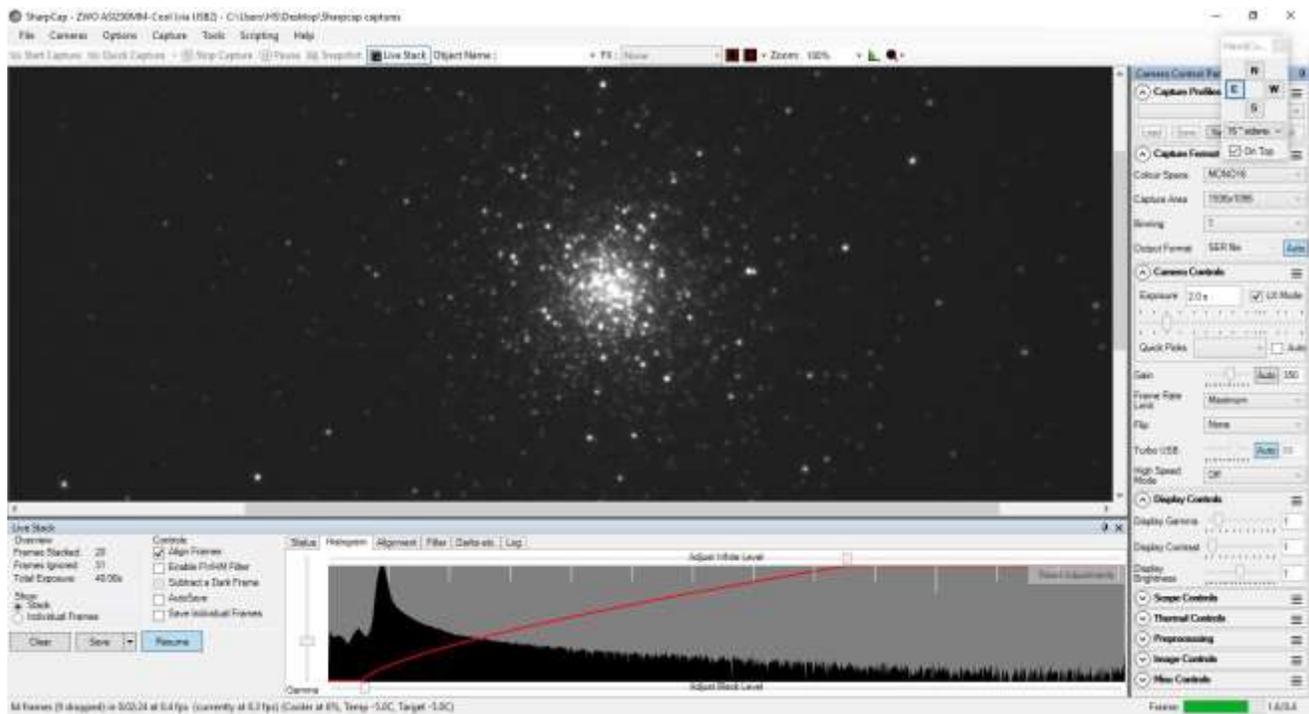
## M2 – A globular cluster using the ASI294MC (C8 @ F6.3)



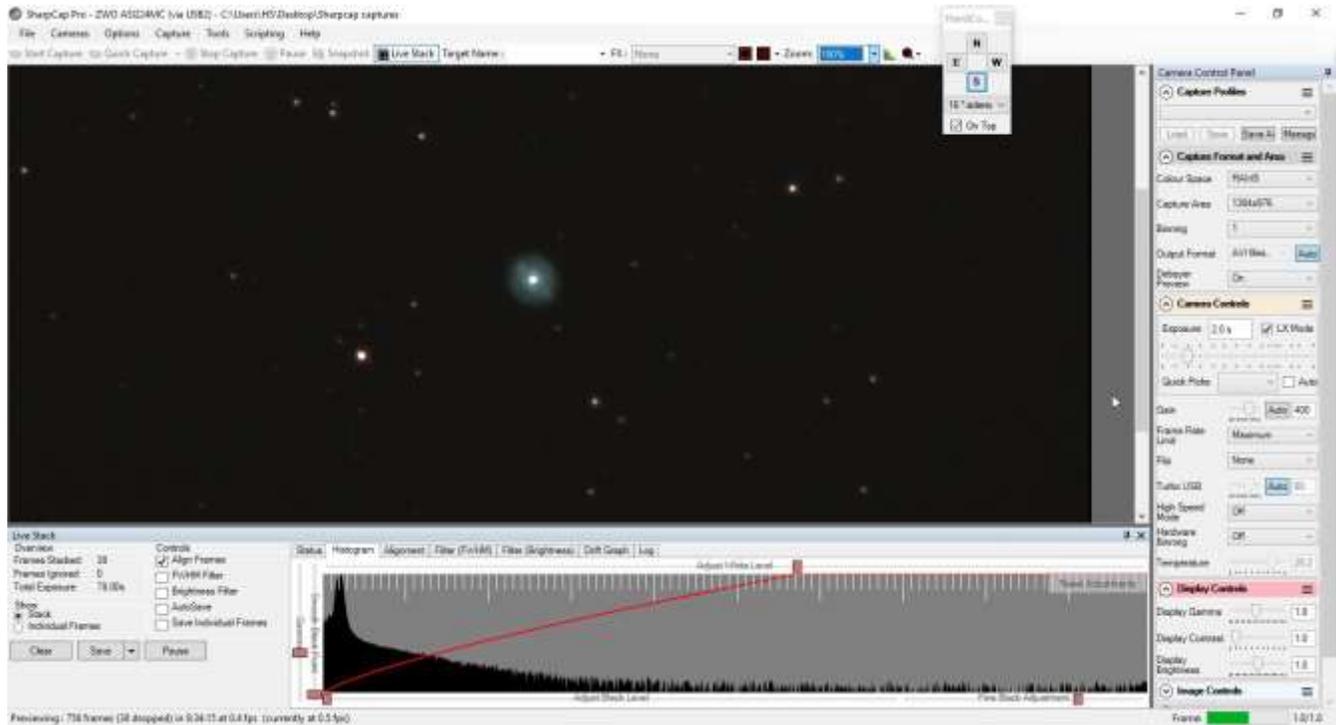
## M99 – A galaxy with faint spiral arms using x1 bin for extra detail



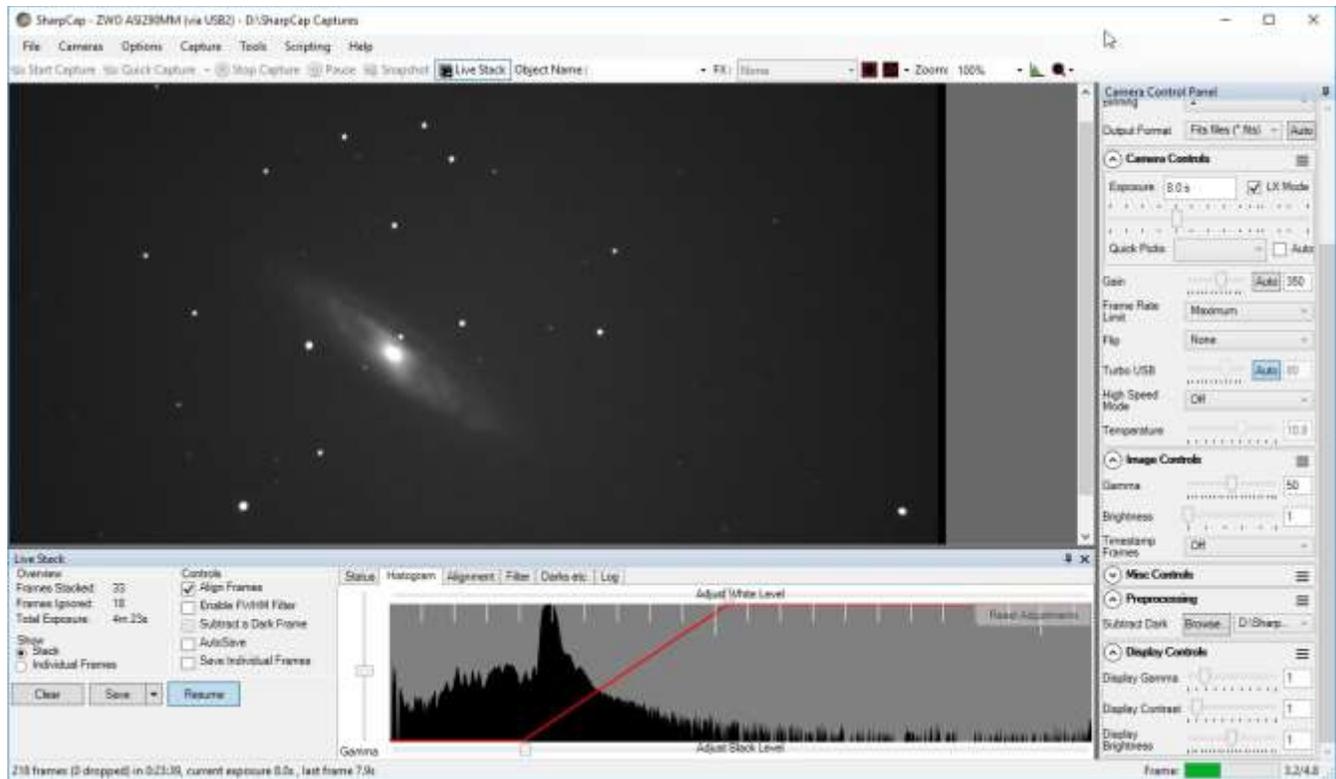
## M3 – A globular Cluster



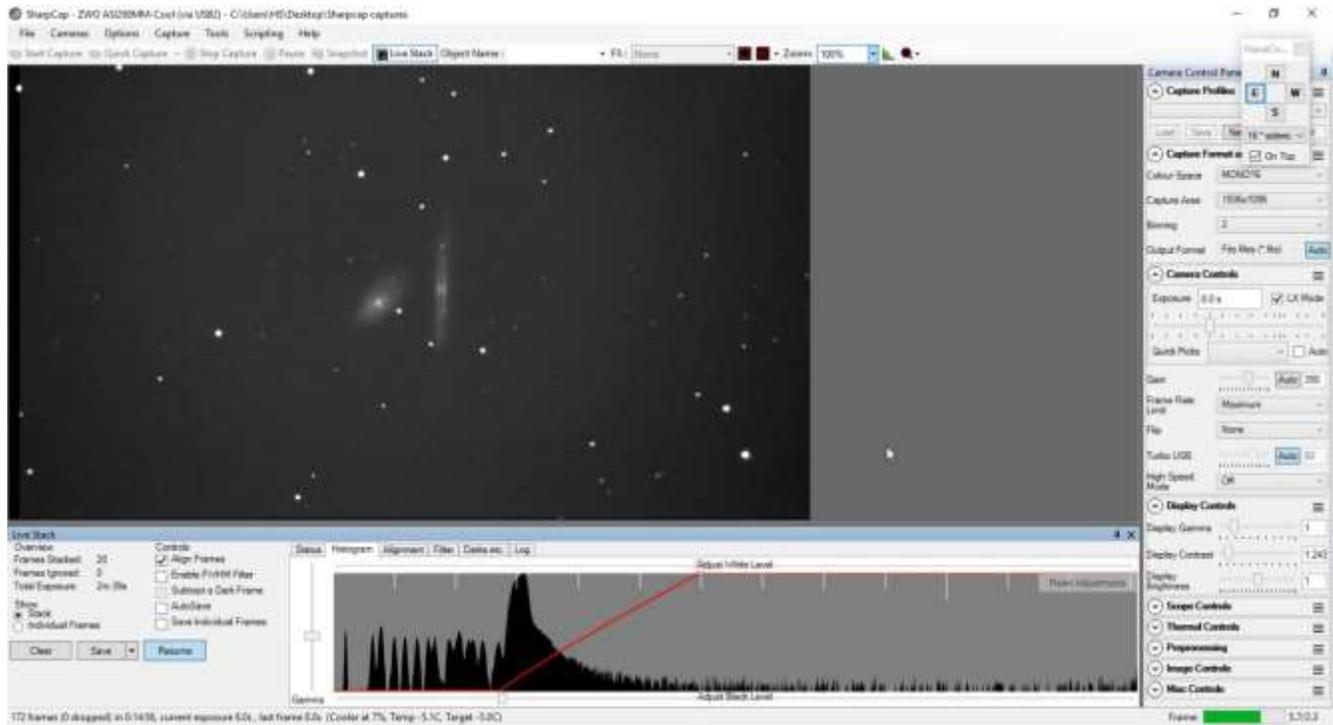
## NGC6826 – Blinking Planetary, A bright Planetary Nebula using short exposures



## M65 – A spiral galaxy with subtle structure x2 bin



**NGC4302 & NGC4298 – Faint interacting galaxies using x2 bin**



**QSO 0957+561 A – Magnitude 17 Twin Quasar using 4s exposures with total exposure time of just 64s!**

