Filter Comparison For Imaging Broad Spectrum Objects In Light Pollution Areas

Introduction

The primary purpose of imaging with a filter in the city is to litigate light pollution and help suppress the noise so that the signal of the target object becomes easier to identify. This is rather easily achieved for nebula type objects that emit at very specific wavelengths but much more challenging to accomplish for full-spectrum sources such as galaxies and globular clusters. Cutting down on city glare is becoming even more challenging as city lighting transitions from Mercury type lighting that emits at defined wavelengths to LED lighting that generally emits broad spectrum lighting.

Raw files along with processed images can be downloaded here:
http://www.artcentrics.com/02_Astronomy/Studies/FiltersBroadband/Filters_Compare-BroadBand.htm

The purpose of this study is to determine what the best filter (if any) is for imaging broad-band objects (Galaxies, Globular Clusters, Open Clusters ect.) in the big city between the four filters presented here.

Imaging Session Details

- Location: **Chandler, Arizona**
- Bortle Scale: **7**
- Date: **2019.03.10**
- Conditions: **No moon in sky, clear skies**
- Imaging Window: **2:00am – 5:33am**
- Hardware Configuration: **| C-11 | SC Corrector |** *{Filter}* **| QHY128c |**

The Target

- Object: **NGC5907**
- Visual Magnitude: **+10.16**
- Apparent Size: **11.3 x 1.8 arcmin**
- Object Type: **Edge-on Spiral Galaxy**
- Constellation: **Draco**
- Target was selected is in the northern section of sky. Imaging secession was timed so that it was near the meridian when imaging to minimalize atmospheric effects between filters.

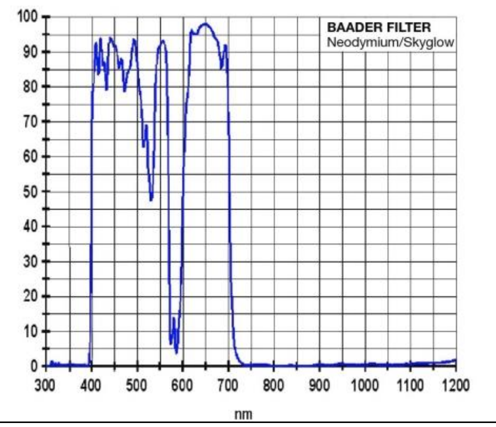
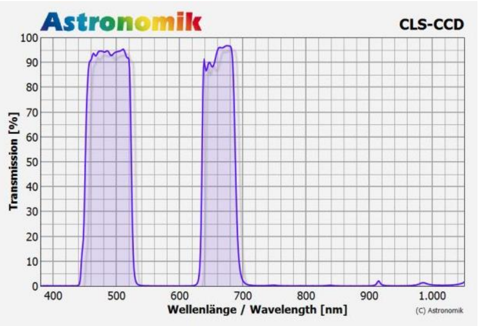
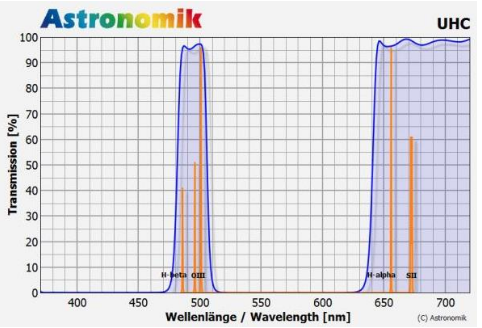
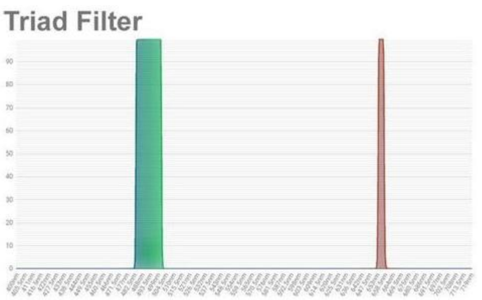
Imaging Process

Take 3 images, 5 minute exposures for a total of 15min integration time with each of the following configuration:

| **C-11** | **Corrector** | {***Identified Filter Below***} | **Camera** |

Filter	Time Range	Altitude Range	Comments
None	01:58 – 02:14	55.0° - 57.0°	
Baader Moon	02:39 – 02:54	59.9° - 61.5°	
OPT Triad	03:19 – 03:35	63.8° - 65.0°	
Astronomik CLS-CCD	04:20 – 04:36	67.0° - 67.1°	
Astronomik CLS-UHC	05:18 – 05:33	65.7° - 64.8°	

The Filters

Filter	Specifications	Chart
Baader Moon and Skyglow Filter	Moon and Light Pollution filter Primary Usage: • Visual: Moon, Planets, Deepsky • Astrophotography: Planets, Moon List Price: **$132.00**	
Astronomik CLS-CCD	• 95% transmission at 486nm (H-beta) • 95% transmission at 496nm (O III) • 95% transmission at 501nm (O III) • 97% transmission at 656nm (H alpha) • 1st Passband 450nm to 520nm • 2nd passband 640nm to 690nm List Price: **$200**	
Astronomik CLS-UHC	• 97% transmission at 486nm (H-beta) • 97% transmission at 496nm (OIII) • 97% transmission at 501nm (OIII) • 97% transmission at 656nm (H alpha) List Price: **$200**	
OPT Triad	• FilterType: **Triband** • Manufacturer OPT • Wavelengths H alpha/**656.3**/3nm • Wavelengths OIII/H beta/ Center **493**/18nm List Price: **$775**	

The Hardware

Hardware	Manufactor and Model	Specifications
Telescope	Celestron C-11	• Type: **Schmidt-Cassegrain** • Aperture: **279.4 mm** (11") • Focal Length: **2,800 mm** (110") • Focal Ratio: **f/10** • Secondary Mirror Obs: 95mm = 12% • Weight: 27.5 lbs
Mount	iOptron CEM60EC	• Type: **Center Balanced Equatorial Mount (CEM)** • Payload: **60lbs** • Controller: **Go2Nova 8407+** • Mount Weight: **27 lbs** • Resolution: **0.06 arc seconds** • GPS: **Internal 32-channel GPS** • Autoguide Port: **ST-4**
Focal Reducer/ Corrector	Starizona SCT Corrector (LF)	• Focal Length: **2,000mm** • Focal Ratio: **f/7.2** • Image Circle: **42mm** • Mechanical Backfocus: **132mm** from top of mounting threads
Camera	QHYCCD QHY128c	• Sensor Type: **Color CMOS** • Read Noise: **1e- to 4e-** • Pixel Size: **5.97 um** • Well Capacity: **74ke-** • Bit Depth: **14 bit** • Dynamic Range: **14 stops** • Sensor: **Sony Exmor IMX1238** • Dark Current: **0.0006e-/p/s @ -15C** • Pixel Scale: **0.581 arcsec/pixel** • Image Size: **58.6 x 39.5 arcmin**

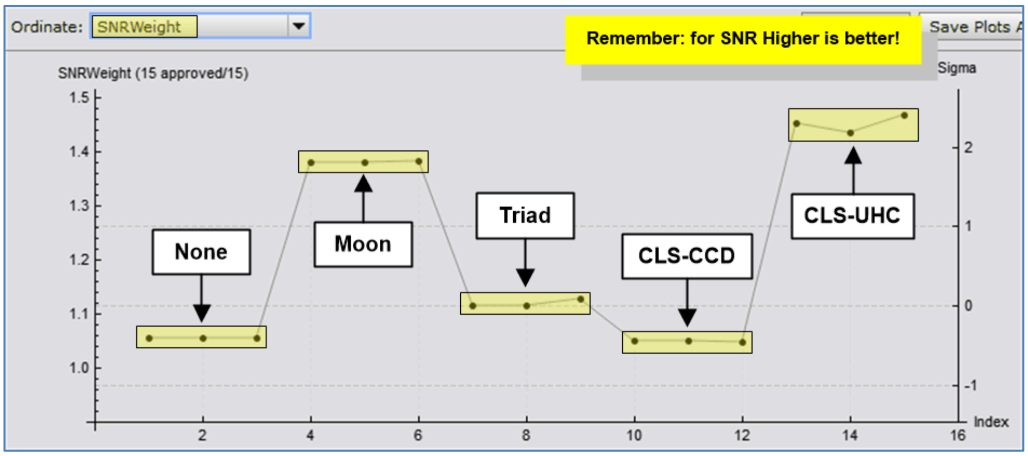
Analysis

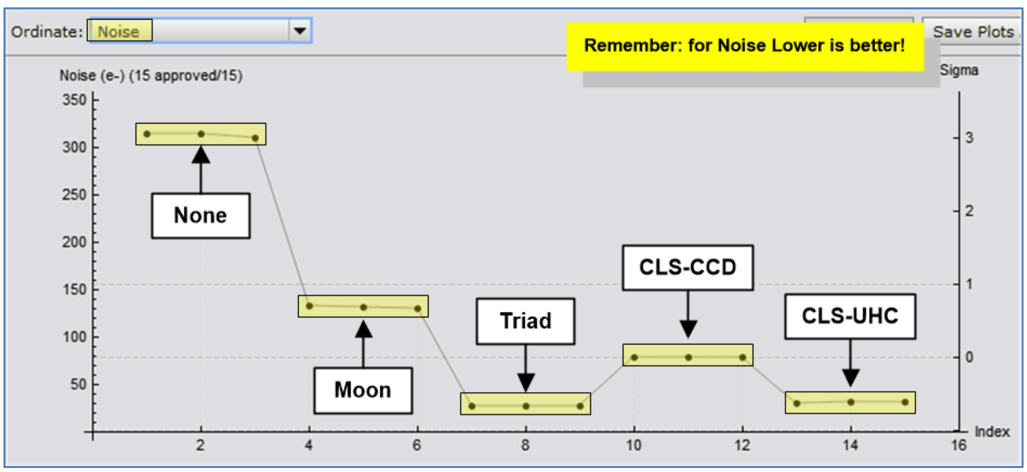
The purpose of utilizing filters when imaging is to eliminate unwanted signal from the image resulting in an increased signal. As a result the Signal to Noise ratio should be improved. As a result when multiple images are stacked together the target object is more prominent than what it would appear without the filter.
Software used for Stacking and image analysis is PixInsight.

Raw Files Statistics

Here we took the each of the tree raw files generated for each configuration and performed analysis on the files utilizing the SubframeSelector tool in PixInsight. As expected the filters appear to have helped raising the SNRWeight value in most instances. While I'm not certain of the equation governing the Signal to Noise Ratio Weight (SNRWeight) in Pixinsight, I think we can determine the relative signal change since the Noise value is readily available.

Index	Filter	SNRWeight (average)	FWHM (avg)	Noise (avg)	*Signal	Comments
1-3	**None**	1.06	7.28	312.8	331.6	
4-6	**Baader Moon**	1.38	6.11	131.3	181.2	Seems to be quite good
7-9	**OPT Triad**	1.12	5.81	26.6	29.8	
10-12	**Astronomik CLS-CCD**	1.05	7.49	78.1	82.0	
13-15	**Astronomik CLS-UHC**	1.45	0.34	31.0	45.0	Seems to be quite good





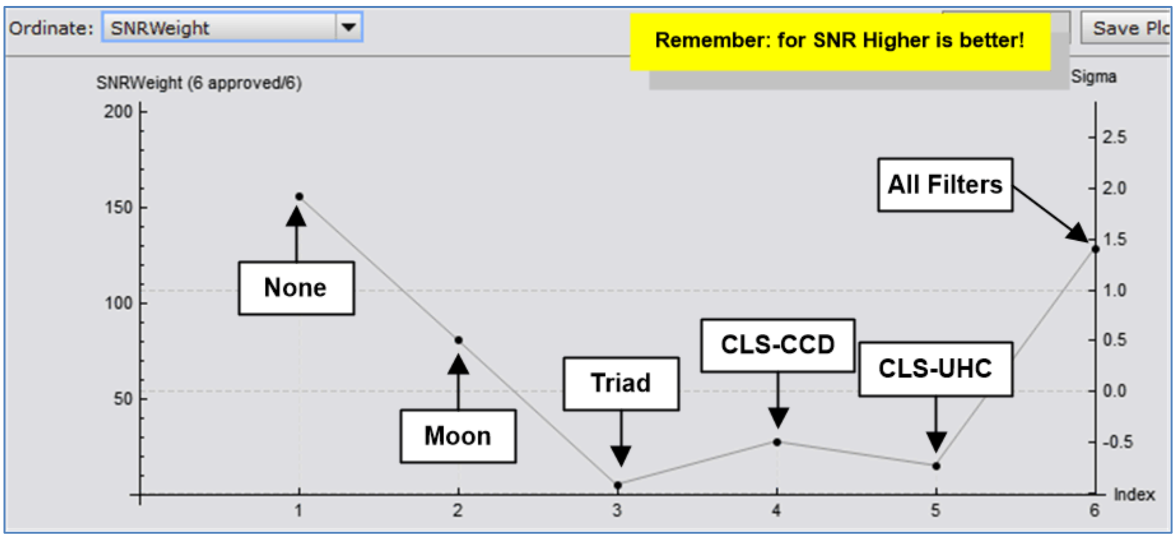
Stacked Files Statistics

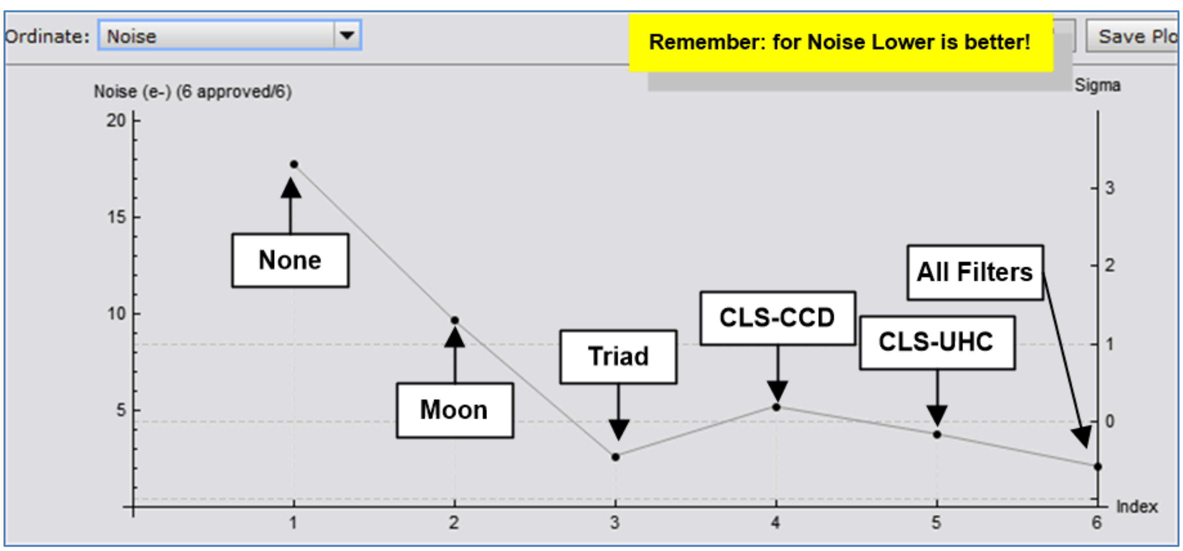
Utilizing PixInsight each of the three raw files were processed using the process flow indicated below. In addition, we also processed the group of filtered files together. All sets of images were processed identically.

Image Press flow:

|Image Calibration | Cosmetic Correction | Debayer | Star Alignment | Image Integration |

Index	Filter	SNRWeight	FWHM	Noise	*Signal	Comments
1	**None**	155.5	7.19	17.72	2,755	
2	**Baader Moon**	81.0	5.77	9.67	783	
3	**OPT Triad**	5.00	5.83	2.62	13.0	
4	**Astronomik CLS-CCD**	27.1	7.39	5.13	138	
5	**Astronomik CLS-UHC**	14.8	6.09	3.73	55.0	
6	All filters Stacked (exclude None)	128.2	6.49	2.06	264	This just for fun, not in consideration





Processed photos

Each of the images were processed identically in PixInsight for the following steps (In order of operation):

| Dynamic Crop | Dynamic Background Extraction | Automatic Background Extraction |
| Background Neutralization | Photometric Color Calibration |
| Multiscale Linear Transform-Luminance | Multiscale Linear Transform-Chrominance |

Images were then duplicated and broken up into two identical sets to have final stretch performed in two differing processes:

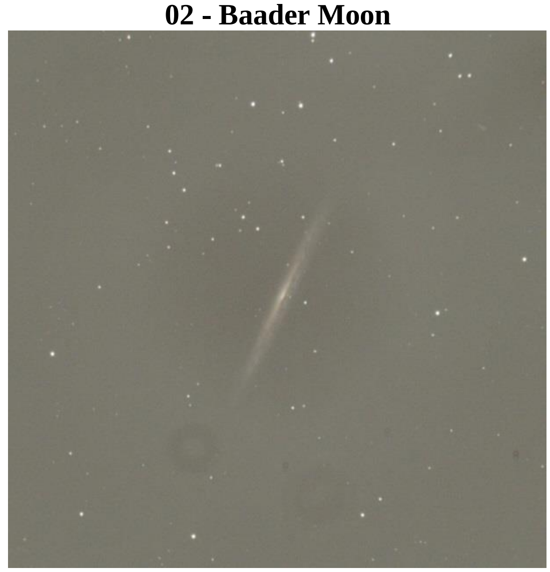
1. **Batch Stretch -** Performed stretch on the "All-Filters Combined" image and then this stretch was applied to the rest of the images so the complete set all received identical stretch.
2. **Custom Stretch** – Stretch each image based on background noise where I tried to drop the background noise to just under detectible amounts for each image.

Final Results are on the following two pages…

Batch Stretch

01 – No Filter

02 - Baader Moon



03 – OPT Triad

04 – Astronmik CLS-CCD

05 – Astronmik CLS-UHC

06 – All Filters Combined

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Individual Stretch

01 – No Filter

02 - Baader Moon

03 – OPT Triad

04 – Astronmik CLS-CCD

05 – Astronmik CLS-UHC

06 – All Filters Combined

Conclusions

Statistical analysis of the Raw files leads us to conclude that the **Baader Moon** and the **Astronomik CLS-UHC** filters provide the best **S**ignal to **N**oise **R**atio. Yet when images have been stacked, the **None** and **Baader Moon** come in as showing the best SNR. This data seems to be in conflict since process used stack the photos was identical for all stack photos.

Inspection of the final stretch images is difficult and subjective. For the images where identically stretch is performed on all images the **Astronmik CLS-CCD** filter seems to be able to provide the best contract between the galaxy and the background. Images with Individual stretch are by nature of the stretching process much more difficult to judge, but to me it seems that the **Astromik CLS-CCD** and **Astronmik CLS-UHC** filter images appear to be the better images (I am not overly confident in this).

We are trying to minimalize noise while keeping as much signal as possible. My final conclusion is that the **Astronmik CLS-CCD** or **UHC** filters may be the best filter for imaging broad spectrum objects such as galaxies and globular clusters in the city measuring in with a Bortle Scale 7 while the **Baader Moon** filter should be considered in Darker sites that measure at Bortle scale 4. Real world examples seem to bare this out.

Some real world imaging examples are provided below:

Whale and Hockey Stick Galaxies

[Massacre Ground Trailhead, AZ](#) (Bortle 4)
Baader Skyglow filter
31 frames @ 5min = 155min integration time

M-106 Galaxy Group

Chandler, AZ (Bortle 7)
Astronomik UHC filter
17 frames @ 5min = 85min integration time

Splinter Galaxy (NGC 5907)

Chandler, AZ (Bortle 7)
Astronomik UHC filter
30 frames @ 5min = 150 min integration time