Antlia ALP-T Filter Comparison Test (Rev 1)

by Jim Thompson, P.Eng
Test Report – June 7th, 2022

Revisions in blue text

Introduction:
With the success of multi-narrowband filters over the past couple of years, there seems to be an ongoing interest from manufacturers to produce the "ultimate filter"; a sort of filter arms race if you will. Take for example the latest addition to the growing list of available multi-narrowband filters: the Antlia ALP-T. This filter is designed to have two 5nm wide pass bands, one centered on O-III (500.7nm) and the other on Hα (656.3nm). The transmission performance marketed by Antlia for this brand new filter is shown in Figure 1.

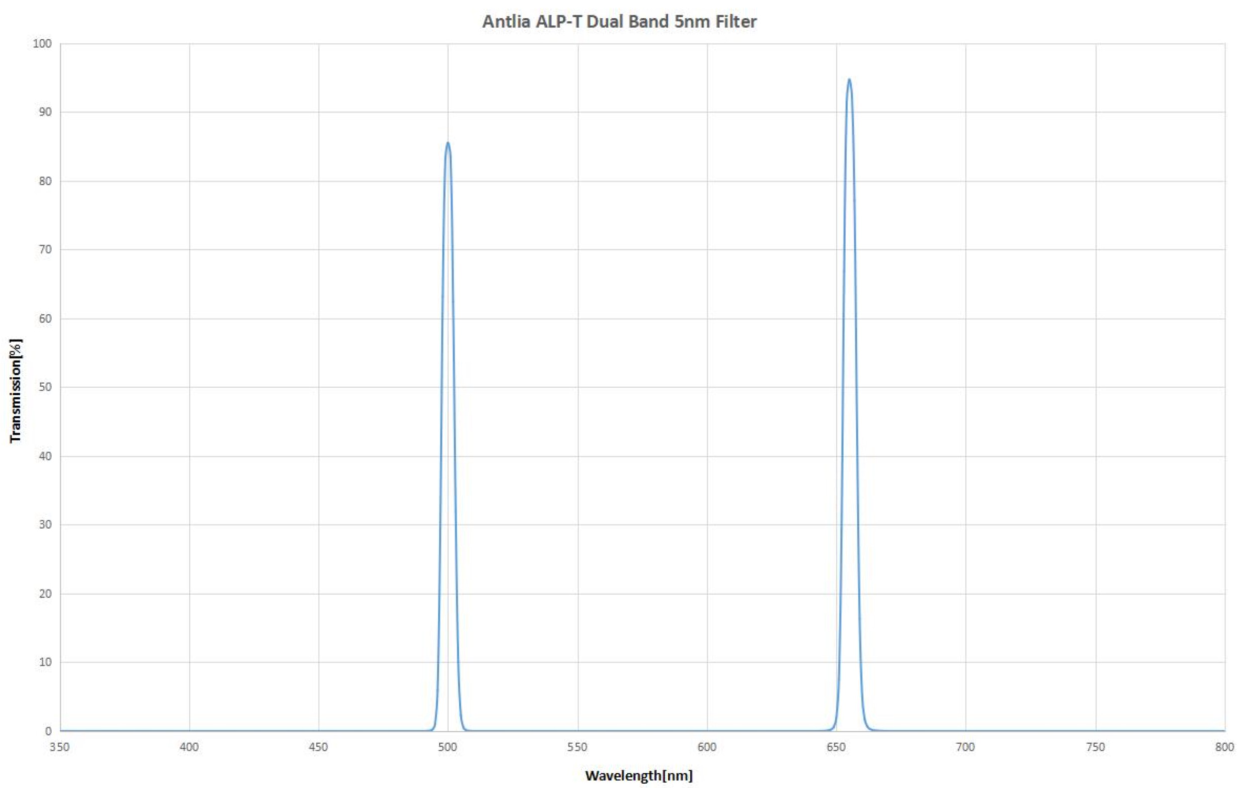


Figure 1 Manufacturer Published Spectrum for ALP-T Filter

Based on all of my previous filter testing and analysis, narrower pass bands should mean better contrast. That said, Antlia is a fairly new company on the astronomical filter market, so the question in my mind is: does the ALP-T deliver the performance that Antlia says it does? That is the question I have set out to answer in this test report.

Objective:
The objective of this test report is to evaluate the performance of the ALP-T filter, and to compare it with other multi-narrowband filters already on the market. The list of filters considered in this test report is as follows:

- Baader Planetarium UV/IR Cut (for reference in imaging)
- IDAS NB-1 – 34nm/22nm wide bands, $199USD
- IDAS NBZ – 12nm/12nm wide bands, $299USD
- Optolong L-eXtreme – 7nm/7nm wide bands, $309USD
- Antlia ALP-T – 5nm/5nm wide bands, $380USD
- Radian Triad Ultra – 5nm/4nm/4nm/4nm wide bands, $1075USD

I have procured a sample of all the filters in this list. If theory is born out in the test results, there should be an observable improvement in deepsky object contrast as I move down the list of filters since they have progressively narrower pass bands. You will note that there is also an increase in filter cost as the pass bands get narrower. Whether or not the increase in performance is worth the increase in cost is yet to be determined. For example: is the performance of the Triad Ultra three times better than the L-eXtreme? … we shall see. Filter performance is evaluated during this test based on the increase in contrast between the observed object and the background, which is a measurable quantity. It was evaluated quantitatively using the measured filter spectra combined with the spectra of several common deepsky objects, and qualitatively by visually comparing images captured using each filter and a one shot colour (OSC) camera.

Method:
Testing consisted of data collection in the following manner:

- Spectral transmissivity data, from near-UV to near-IR, measured using an Ocean Optics USB4000 spectrometer; and
- Image data, collected using a ZWO ASI-533MC Pro OSC camera, and a William Optics FLT98 triplet apochromatic refractor with f-ratio f/6.3.

The spectrometer data was collected in my basement workshop with the USB4000 and a broad spectrum light source. Filter spectrums were measured for a range of filter angles relative to the light path, from 0° (perpendicular) to 20° off-axis. The spectrometer was recently upgraded, replacing the entrance slit and diffraction grating, to give a wavelength resolution of 0.5nm.

The image data was collected from my backyard in central Ottawa, Canada where the naked eye limiting magnitude (NELM) due to light pollution is +2.9 on average, which translates to Bortle 9+. I switched filter configurations using a ZWO 2" filter drawer. Each time I changed filters I refocused on a conveniently located bright star using a Bahtinov mask. Images with the various filters under test were collected in a two hour period on January 21st, 2022. Two common Winter deepsky targets were used for all the images: the Orion Nebula (M42) with the neighbouring Running Man Nebula (NGC1977), and the Flame Nebula (NGC2024) with nearby Horsehead Nebula (B33). These objects were selected because they were well placed in the southern sky for the duration of the image captures. These two deepsky targets are a good proxy for many different types of objects, presenting a variety of emissions (i.e. O-III, H-alpha, reflection nebula, & dark nebula). The waning gibbous Moon was present at the time of the image captures, but was 80 to 90° to the East of Orion during my testing.

Results – Spectrum Measurements:

Using the test method mentioned above the spectral transmissivity for each filter was measured for a range of filter angles relative to the light path. Figure 2 presents a plot of the resulting spectral transmissivity data for the case of the filter perpendicular to the light path. The O-IIIb pass bands for all the filters tested appear to be well centered on the desired wavelength of 500.7nm. The Hα pass band for the Triad Ultra is well centered on the desired wavelength of 656.3nm. For the NB1, NBZ and ALP-T their bands are shifted slightly up in wavelength, which is advantageous when the filter is used on fast optics. This shift is by design for the NB1 and NBZ filter, but I don't know if the same is true for the ALP-T. The L-eXtreme's Hα pass band is shifted slightly down in wavelength, making it more sensitive to fast optics. Also noted from the measured spectrum data for the Triad Ultra filter was that its S-II pass band is well centered in wavelength, and its Hβ pass band is shifted significantly down in wavelength (not good).

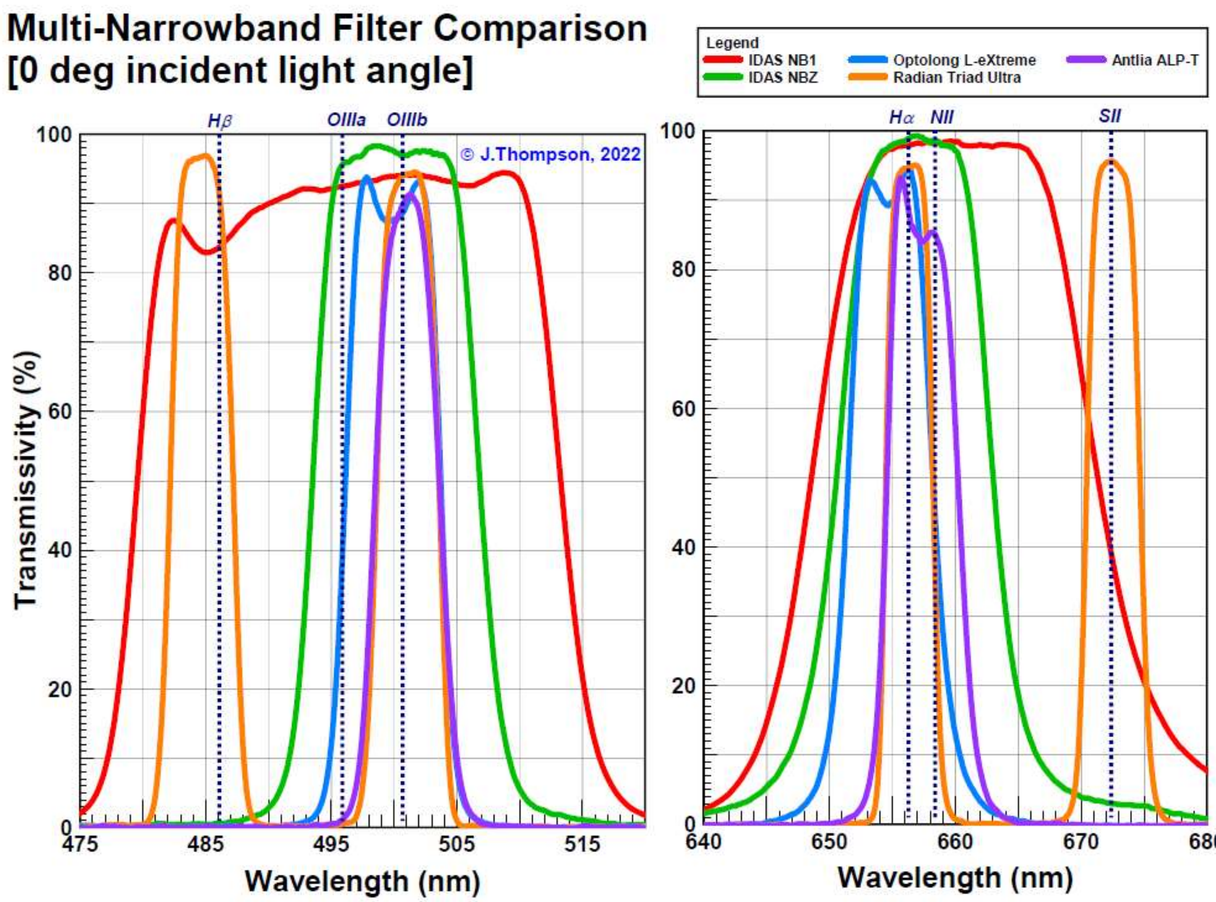


Figure 2 Measured Spectral Response of Tested Filters – Filter Perpendicular to Light Path

The impact of angle on each filter's transmission for some important nebula emission wavelengths is shown in Figure 3. As expected, filters with wide pass bands were less sensitive to angle than filters with narrow pass bands, with the most sensitive filter to angle being the Radian Triad Ultra. As mentioned earlier, my sample of the Antlia ALP-T has a small shift of its Hα pass band which gives it a slight advantage over the L-eXtreme and Triad Ultra in that band. The L-eXtreme has a dual peak response in its O-III pass band, giving it the advantage over the ALP-T and Triad Ultra in that band. The NBZ in comparison has superior transmissivity versus angle to all the filters (but the NB-1) in both bands.

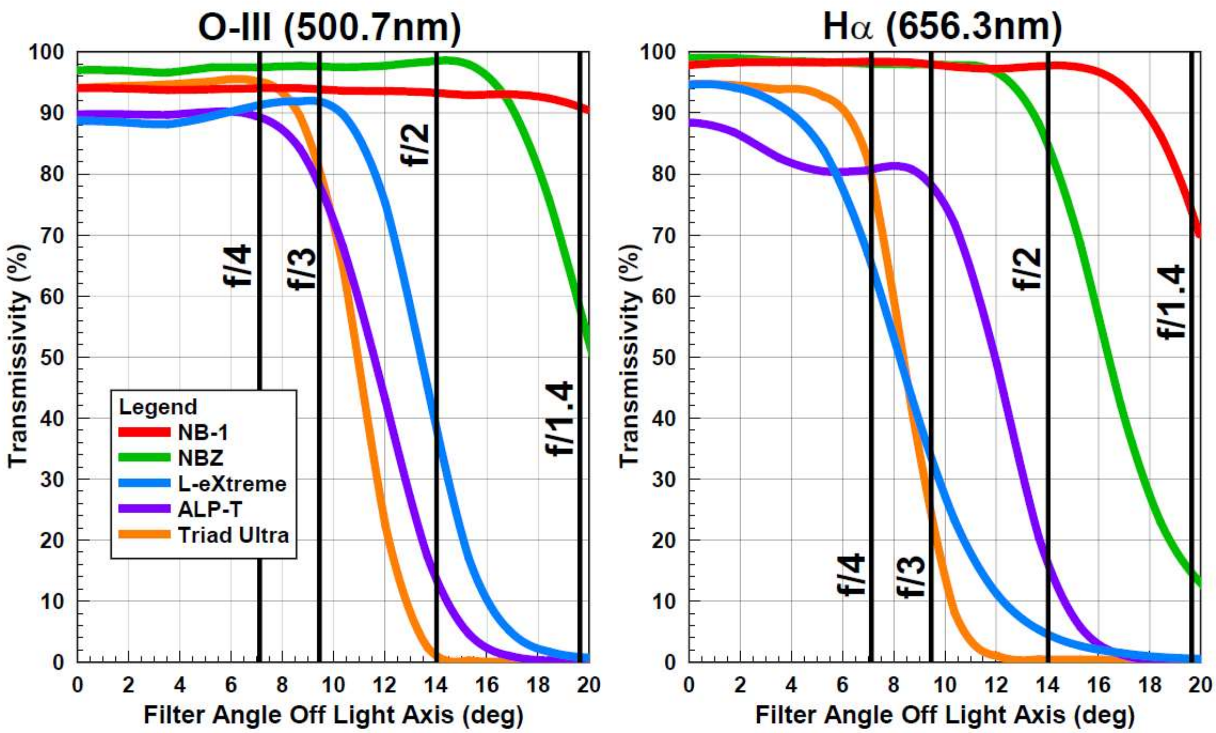


Figure 3 Measured Impact of Angle on Filter Response

Figure 3 also has black vertical lines corresponding to different optics f-ratios. These lines are positioned at the angle values corresponding to light coming from the outer edge of the scope's aperture for the noted f-ratio. The net performance of a filter on any particular speed of optics is an area weighted average of the filter's performance, for light angles from perpendicular out to the angle at the outer edge of the aperture. Using the measured filter spectra at each angle I have calculated a net filter spectrum for a selection of telescope f-ratios. The area averaging process is illustrated in Figure 4. Essentially the aperture of the scope is divided into rings defined by the angles at which I have measured filter data. The percentage each ring is of the total primary optical area is the weighting applied to that particular spectrum in the average. Figures 5 through 8 present the resulting net spectra for the different speeds of telescope. The shift in filter response between that shown in Figure 2 and for the f/6.3 telescope (Figure 5) is almost zero, but is very significant for the f/2 scope (Figure 8). The effects of filter band shift are worse on the Hyperstar scope due to the large central obstruction which results in a larger percentage of the light having to pass through the filter at an angle.

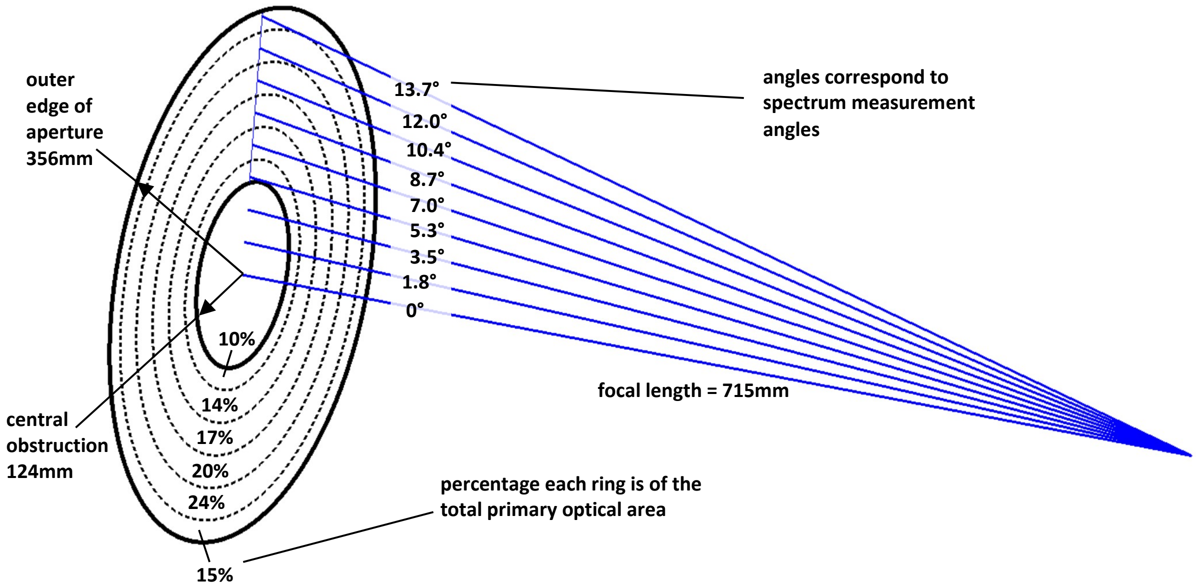


Figure 4 Illustration of Area Weighted Average Filter Response Calculation – C14 Hyperstar

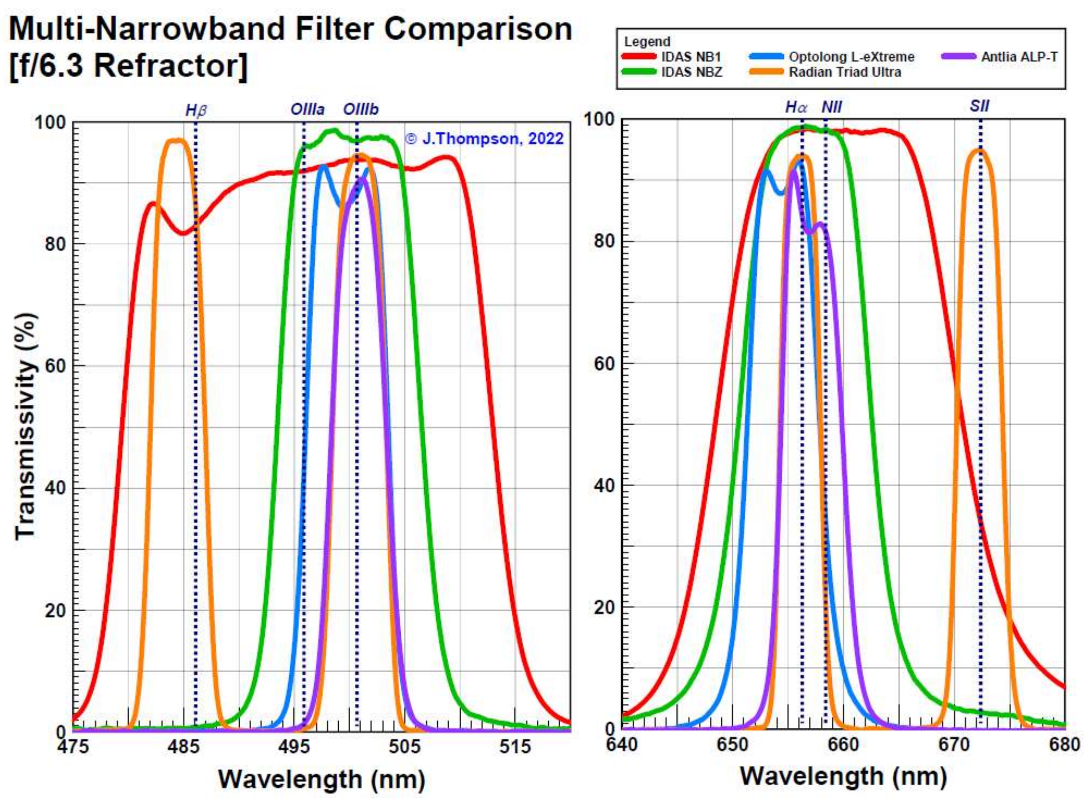


Figure 5 Net Spectral Response of Tested Filters – f/6.3 Refractor Area Weighted Average

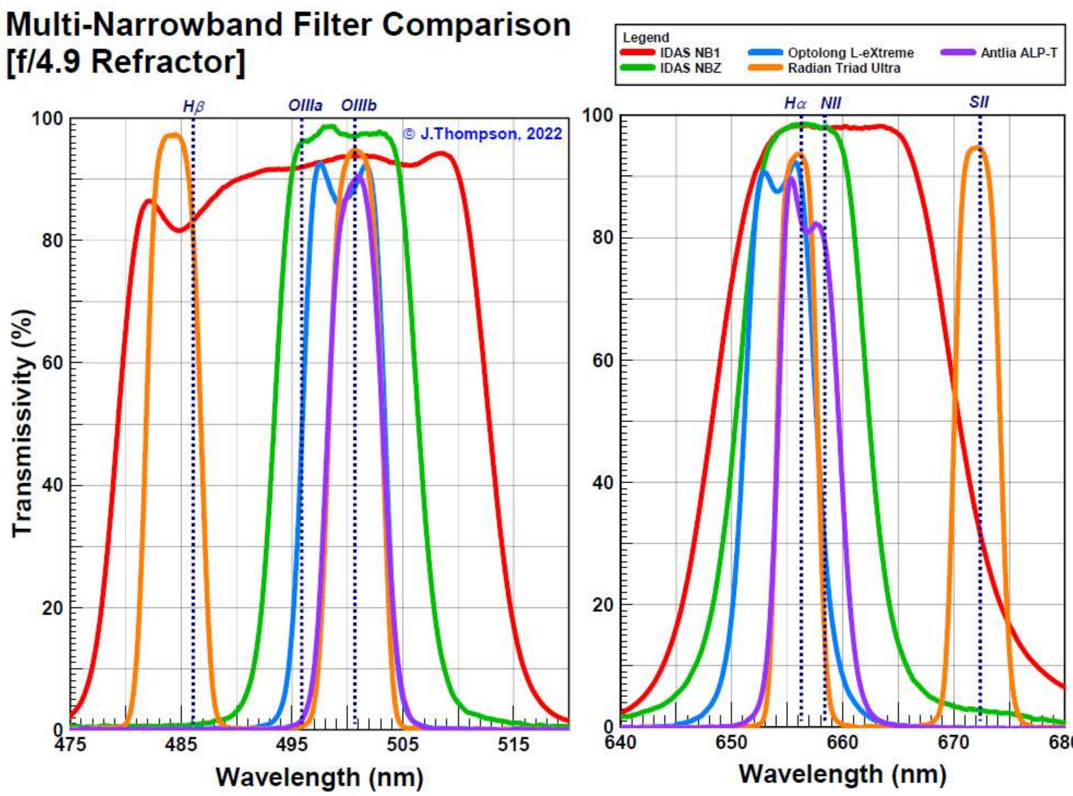


Figure 6 Net Spectral Response of Tested Filters – f/4.9 Refractor Area Weighted Average

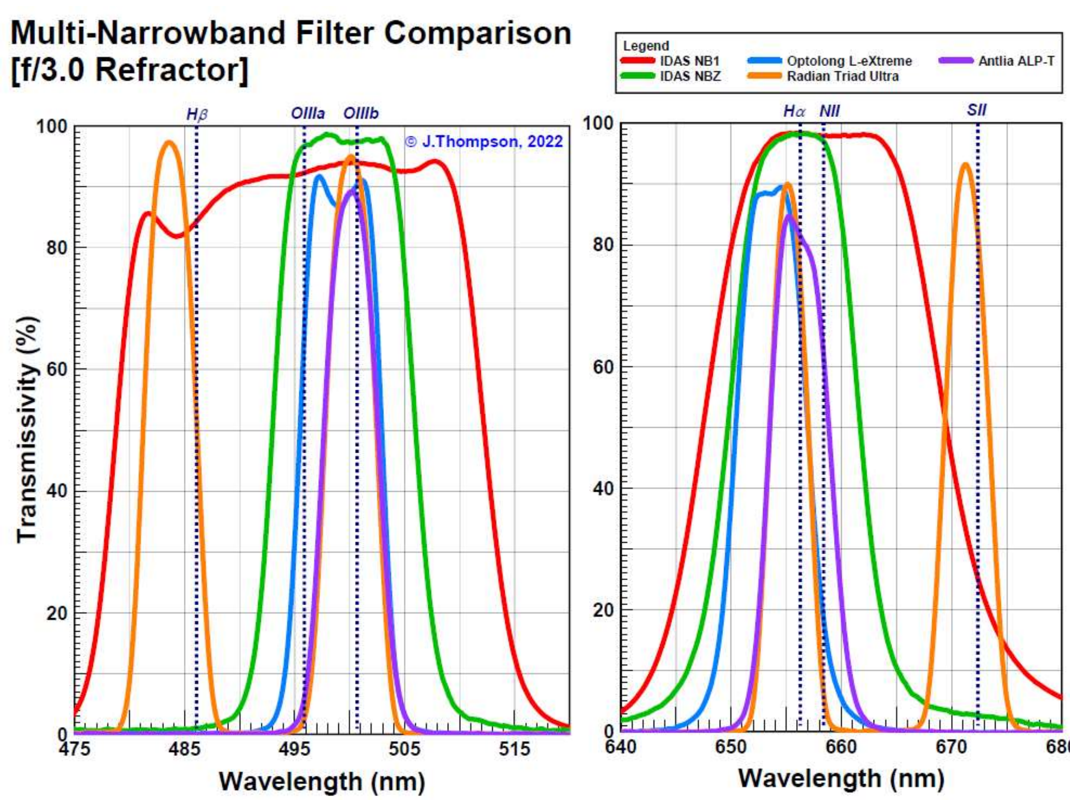


Figure 7 Net Spectral Response of Tested Filters – f/3.0 Refractor Area Weighted Average

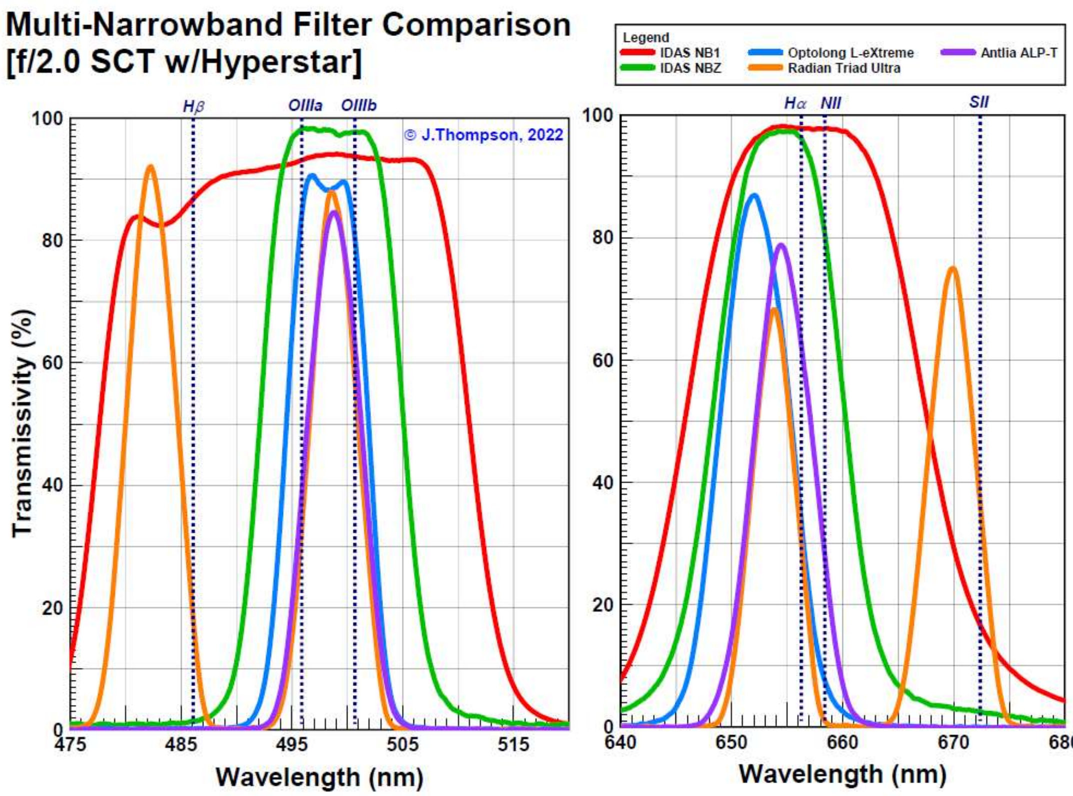


Figure 8 Net Spectral Response of Tested Filters – f/2 C14 w/Hyperstar Area Weighted Average

With the net filter spectra in hand, it is possible to extract overall performance related statistics for each filter, such as transmission values at key wavelengths of interest and pass band widths. These filter statistics are provided in Table 1, including a calculated value for percent Luminous Transmissivity (%LT), a single number that describes generally how much light is getting through the filter. The calculated value of %LT depends on the spectral response of the detector, which in this case is assumed to be a modern back illuminated colour CMOS sensor. I have included transmission and FWHM band width measurements in the table for a range of telescope f-ratios, from f/∞ (perfectly parallel & perpendicular light) down to f/2.

For each filter I have also included in Table 1 what the manufacturers' marketing material states for peak transmission and band width. The two IDAS brand filters had measured filter characteristics that matched their marketing data quite well, in fact exceeding peak transmission values in most instances. The Optolong L-eXtreme filter also had measured characteristics that closely matched its marketing material, but a little bit on the low side of the quoted O-III peak transmission rates. From what I have read online, my sample of this filter is pretty good, with others showing larger deviations from the marketed filter specification. The O-III band of the ALP-T filter measured to be well over its marketed values, but the Hα band was measured to be low on transmission by between 2 and 8% depending on the optics speed. The Radian Ultra was measured to have transmission rates exceeding the marketed performance in all of its bands except O-III, for which it is was 3% below the marketed value. The FWHM for the O-III band is also a little off from the marketed value, measuring at 4.7 to 4.8nm when it supposed to be

4.0nm. The Radian Ultra otherwise has measured characteristics closely matching its marketed specifications.

Filter	Scope Optics	%LT*	Hbeta/O-III Pass Band				Halpha Pass Band			
			FWHM	Hbeta (486.1)	O-IIIA (495.9)	O-IIIB (500.7)	FWHM	Halpha (656.3)	N-II (658.4)	S-II (672.4)
NB-1	*manuf.*	-	-	*86%*	*92%*	*93%*	-	*98%*	*98%*	*35%*
	f/∞	11.8%	33.5nm	83.7%	92.5%	94.0%	22.4nm	97.8%	98.1%	39.4%
	f/6.3**	11.7%	33.3nm	83.0%	92.0%	93.8%	22.0nm	98.2%	98.1%	34.2%
	f/4.9**	11.7%	33.3nm	83.2%	92.0%	93.8%	21.9nm	98.2%	98.0%	31.8%
	f/3.0**	11.7%	33.3nm	84.4%	92.3%	93.9%	21.7nm	98.3%	97.9%	25.4%
	f/2***	11.6%	33.2nm	86.8%	93.7%	93.7%	21.5nm	97.8%	97.8%	16.8%
NBZ	*manuf.*	-	*12nm*	*0%*	*80%*	*96%*	*12nm*	*96%*	*96%*	*3%*
	f/∞	6.2%	13.1nm	0.7%	95.6%	97.0%	12.2nm	98.9%	98.4%	3.0%
	f/6.3	6.2%	12.9nm	0.8%	95.8%	96.8%	11.9nm	98.7%	98.2%	2.7%
	f/4.9	6.2%	12.8nm	0.9%	96.1%	97.0%	11.9nm	98.5%	98.0%	2.7%
	f/3.0	6.2%	12.8nm	1.0%	96.7%	97.4%	11.9nm	98.2%	96.9%	2.6%
	f/2	6.2%	12.8nm	1.5%	98.2%	97.7%	12.0nm	96.2%	80.5%	2.4%
L-eXtreme	*manuf.*	-	*7nm*	*0%*	-	*>90%*	*7nm*	*>90%*	-	*0%*
	f/∞	3.0%	7.5nm	0%	38.7%	88.7%	6.6nm	94.6%	44.2%	0%
	f/6.3	3.0%	7.4nm	0%	42.0%	88.3%	6.5nm	91.8%	33.9%	0%
	f/4.9	3.0%	7.4nm	0.1%	47.0%	88.8%	6.5nm	88.6%	29.3%	0%
	f/3.0	3.2%	7.4nm	0.1%	65.5%	90.4%	6.7nm	68.3%	18.4%	0%
	f/2	3.2%	7.6nm	0.1%	84.0%	80.2%	6.9nm	33.4%	7.6%	0%
ALP-T	*manuf.*	-	*5nm*	*0%*	-	*82%*	*5nm*	*90%*	-	*0%*
	f/∞	2.7%	5.1nm	0%	1.1%	89.8%	5.5nm	88.4%	85.0%	0%
	f/6.3	2.6%	4.9nm	0%	1.3%	89.7%	5.4nm	83.9%	81.4%	0%
	f/4.9	2.6%	4.9nm	0%	1.6%	89.9%	5.5nm	82.5%	79.0%	0%
	f/3.0	2.4%	5.0nm	0%	5.8%	88.0%	5.6nm	81.4%	61.6%	0%
	f/2	2.2%	5.3nm	0%	38.3%	62.5%	5.9nm	62.3%	28.0%	0%
Triad Ultra	*manuf.*	-	*5/4nm*	*79%*	-	*97%*	*4/4nm*	*87%*	-	*90%*
	f/∞	4.3%	4.8/4.8nm	90.3%	0.5%	94.1%	3.5/4.1nm	94.7%	35.9%	95.6%
	f/6.3	4.0%	4.8/4.7nm	84.7%	0.5%	94.6%	3.5/4.0nm	94.0%	20.3%	94.8%
	f/4.9	3.9%	4.7/4.7nm	79.1%	0.6%	94.8%	3.5/4.0nm	93.5%	14.4%	94.5%
	f/3.0	3.3%	4.7/4.6nm	49.6%	2.6%	93.2%	3.5/4.0nm	74.1%	6.1%	81.7%
	f/2	2.6%	4.8/4.7nm	17.1%	32.7%	57.0%	4.3/4.7nm	30.0%	1.0%	36.6%

* calculated assuming spectral QE curve for IMX174C with no UV/IR blocking filter; ** refractor; *** C14 w/Hyperstar

Table 1 Measured Filter Performance Summary

Knowing the measured spectral response of the sample filters also allowed me to predict the theoretical relative performance of each filter on different kinds of deepsky object, under different sky conditions. To do this I used the method I developed back in 2012 which uses the spectral response of the filter and sensor combined with the spectral emission from the deepsky object and background sky to estimate the apparent luminance observed. To help visualize the results of this analysis I have plotted the predicted % increase in contrast for each filter versus the filter's %LT. Figure 9 shows the resulting plot corresponding to filter performance when using a colour CMOS camera under heavily light polluted skies complete with local LED street lights (i.e. my backyard). Note that these are theoretical predictions of the increase in visible contrast between the object and the background. The absolute values of my predictions may not reflect what a user will experience with their own setup, but the predicted relative performance of one filter to another should be representative. In general the desired performance for a filter is high contrast increase with high %LT, so the higher and more to the right a filter's performance is in the plot the better. Each filter's performance is plotted as a short line to show how the performance is predicted to change depending on the f-ratio of the telescope you are using the filter with. Slow f-ratio optics are at the right-most end of the line, f/3 is roughly in the middle of the line, and f/2 is at the left-most end of the line. I have plotted predicted filter performance on three different types of deepsky object: bright O-III rich nebulae (eg. M27) along the top of the graph, dim Hα rich nebulae (eg. NGC7000) across the middle of the graph, and reflection nebulae (eg. M45) along the bottom of the graph.

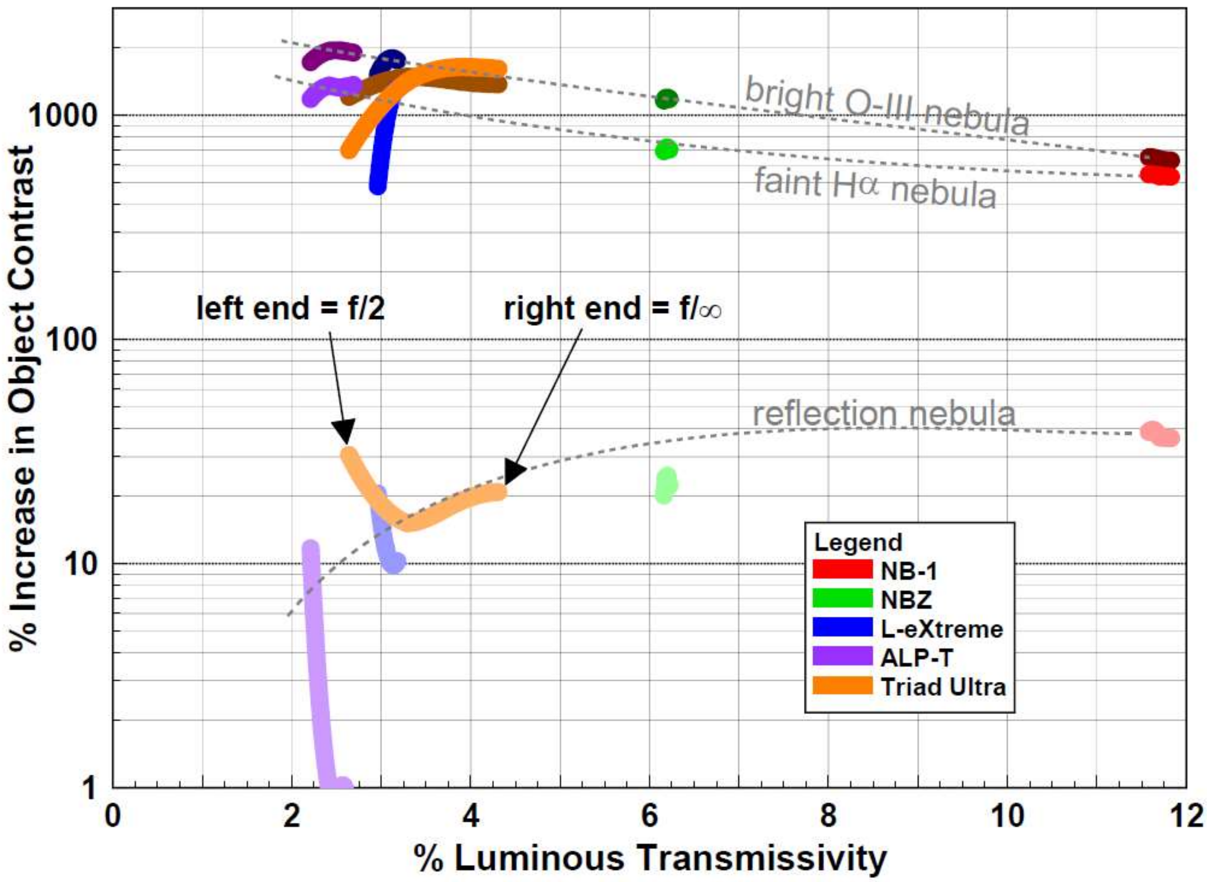


Figure 9 Predicted Filter Performance: Back Illuminated Colour CMOS, LP w/LED (NELM+2.9)

As expected, the predictions suggest that the narrower the filter's pass band (and thus lower %LT), the larger the contrast increase on emission-type nebulae. The NB-1 and NBZ filters are predicted to deliver a consistent increase in contrast, one that does not change significantly down to an f-ratio of f/2. This is consistent with the measured angle sensitivity data presented in Figure 3. The L-eXtreme and ALP-T filters are predicted to deliver a higher increase in contrast than the two IDAS filters, but they are also more sensitive to f-ratio. The L-eXtreme is predicted to be especially sensitive to f-ratio on Hα rich objects. The Triad Ultra filter is predicted to be much more sensitive to f-ratio than any of the other filters tested. It is predicted to deliver the highest contrast increase on Hα objects out of all the filters tested, presumably because it has both Hα and Hβ pass bands. It is also predicted to deliver lesser performance on O-III rich objects, worse than the ALP-T and L-eXtreme, and only marginally better than the NBZ. Thus the net performance of the Triad Ultra is predicted to be not significantly different from the L-eXtreme, a filter that costs less than a 1/3 as much. On emission nebulae it would seem that the ALP-T has a slight edge in object contrast over the other filters tested. On reflection nebulae, the filter letting in the most blue light is predicted to give the best performance: the IDAS NB-1. The Triad Ultra is predicted to give comparable performance on reflection nebulae but only when used at f/2, an undesirable optics speed to use the filter at for emission nebulae.

Another thing to note from Figure 9 is the trade-off between contrast increase and exposure time. For example the ALP-T filter is predicted to provide a contrast increase 3x that of the NB-1 (1905% vs. 629%), but at the cost of 4.4x the exposure (%LT of 2.69 vs. 11.83).

Results - Imaging:

As described above in the Method section, image data was captured with each filter using the same OSC camera, with all images collected on the same night within a two hour time window. The camera colour channel gains were adjusted at the start of the imaging session to give a white balanced image with UV/IR cut filter on, and then left fixed for the duration of the data collection with each of the other filters. Data was collected by generating a live stack in Sharpcap of five minutes total duration, which was then saved as a 16bit FITS file. Camera settings were fixed for all images, as defined below:

- FLT98: 350gain (58%), bin 2x2, WB(R) 75%, WB(B) 75%, TEC -10°C

The exposure time per frame was adjusted for each filter in order to achieve an image of generally the same level of overall exposure as the UV/IR cut filter reference image. This was determined qualitatively by observing the extent of image saturation around the core of M42. I did not use any calibration frames during my data collection, so no dark or flat frames have been applied. There was also no histogram adjustment made to the live stacks within Sharpcap; black point and white point were left at their default positions, and the gamma slider was positioned in the middle.

Using the histograms from my raw captured images, combined with the sub-exposure times, I pulled out the impact of each filter on relative exposure for each colour channel. The results are summarized in Table 2. The table also includes the %LT value calculated from the measured spectra for comparison. This information can be used to help astrophotographers determine how each filter will impact their exposure time relative to just a UV/IR cut filter.

For the visual comparison of the images I approached the task from two different directions. First I separated each colour channel out for comparison to each other. In this way the performance of the filter on different nebula emission wavelengths can be evaluated individually. I used AstroImageJ to save each image’s colour channel as a 16-bit TIFF, and then used an image editor to apply the same amount of histogram stretching to each colour channel image. The resulting images are presented in Figures 10 to 12 for M42, and Figure 13 for just the red channel from the Flame Nebula.

Filter	Sub-Exposure Time [s]	Measured Exposure (Relative To UV/IR Cut Filter)				%LT @f/6.3
		R	G	B	L	
UV/IR Cut	3.5	100%	100%	100%	100%	-
NB-1	12	8.1%	14.4%	12.8%	12.7%	11.7%
NBZ	17	4.8%	6.7%	5.5%	6.0%	6.0%
L-eXtreme	25	2.5%	3.6%	3.1%	3.2%	3.2%
ALP-T	25	1.7%	2.4%	1.9%	2.1%	2.5%
Triad Ultra	20	2.1%	3.5%	3.6%	3.2%	4.1%

Table 2 Measured Relative Exposure By Colour Channel

The second approach to visually comparing the images was to work with the full colour images. I first aligned the colour channel histograms for each image in Fitswork v4.47, a free FITS editing software. This was done by adjusting the black point on each colour channel's histogram until the histogram peaks were all aligned with each other. I then applied the same amount of luminance channel histogram stretching to each image. The resulting images are presented in Figures 14 and 15.

Although many images have been assembled for comparison in this test report, the results are all pretty consistent. The trend in contrast improvement predicted by my spectral analysis was reflected in the images that were recorded. There were a few other interesting observations I made from the collected images:

- Many of the filters tested showed halos around bright stars, especially around the bright star Alnitak in Flame Nebula images. The halo is quite prominent with the NB-1, L-eXtreme, and Triad Ultra filters, but is more subdued with the NBZ filter. The halo is all but gone when using the UV/IR cut and ALP-T filters. I am not sure but I think the halo is due to a reflection between the filter and the camera sensor window. It may be that my choice for the position of the filters relative to the camera has played a role. For my testing the filter drawer was positioned as close to the camera as possible. Placing it further away from the camera may reduce the visibility of halos.
- Although the contrast improvement in the images is quite evident going from the UV/IR cut to NB-1, and NB-1 to NBZ, the same is not true for the other filters. The step improvement that can be observed in my images between the four filters with the narrowest pass bands (i.e. NBZ, L-eXtreme, ALP-T, and Triad Ultra) is small. It can be perceived that the ALP-T shows more detail than the L-eXtreme, and the L-eXtreme more detail than the NBZ, but the differences are subtle. Perhaps the differences would be more evident if I used a longer total exposure time.
- My predictions of contrast improvement (Figure 9) suggest that there isn't a significant difference in performance between the L-eXtreme and the Triad Ultra; the Triad Ultra is a little better on Hα but a little worse on O-III. This prediction was in my opinion born out by my image data; the contrast and detail observed in

the images collected using these two filters on average was not significantly different.

- The colour saturation in the images captured using the Triad Ultra was less than that produced using the NBZ, L-eXtreme, or ALP-T filters. This may be a result of the Triad Ultra’s pass band at Hβ letting in more light pollution from the blue part of the spectrum, for example from LED street lights. That would explain why the Triad Ultra images have a similar colour saturation to those captured using the NB-1 filter, which also lets in more blue light than the other filters.

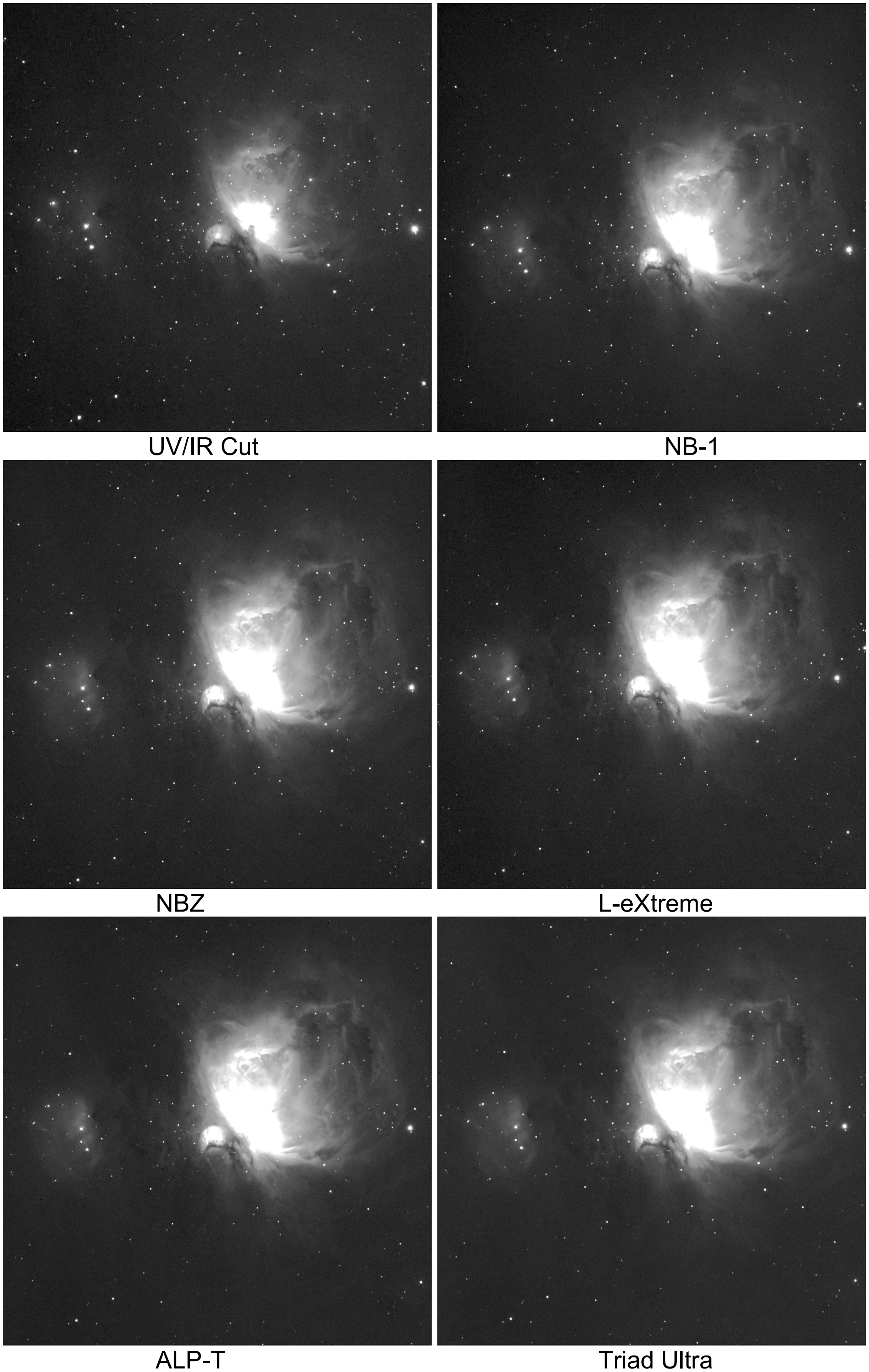


Figure 10 Image Comparison: M42, f/6.3, Red Channel

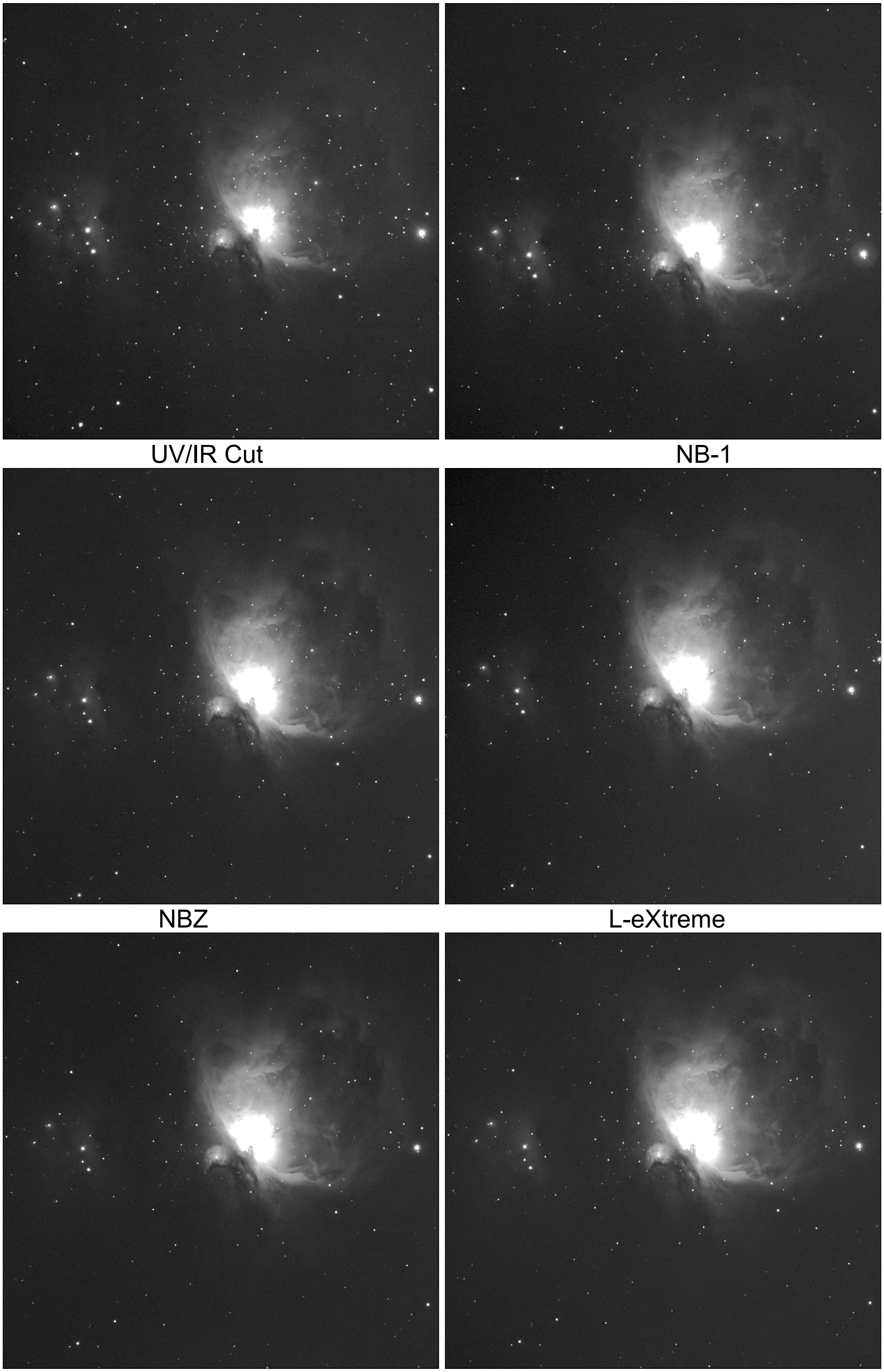
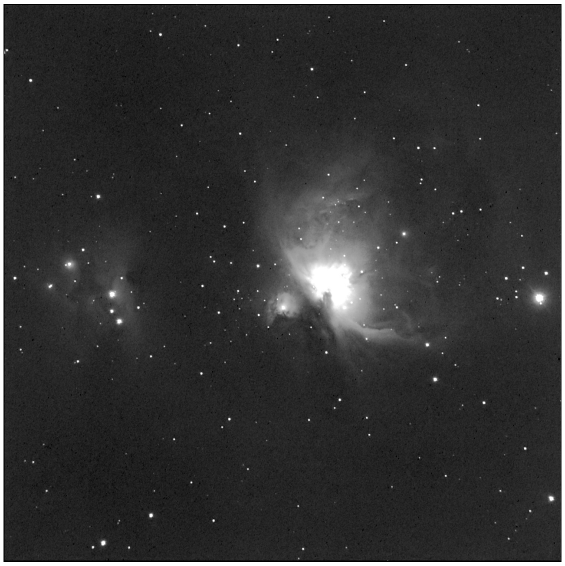
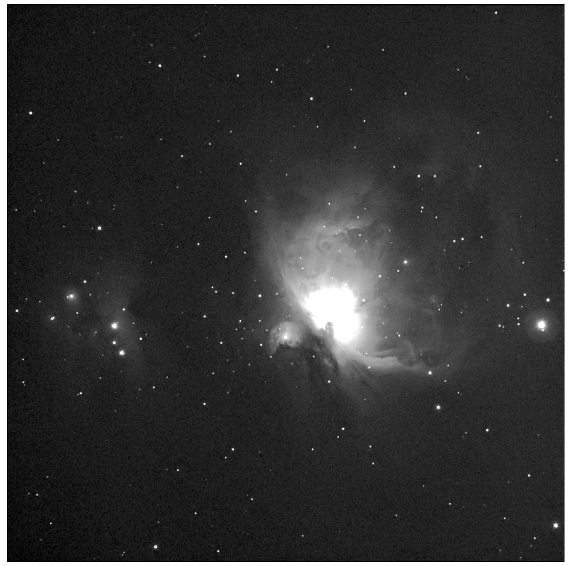


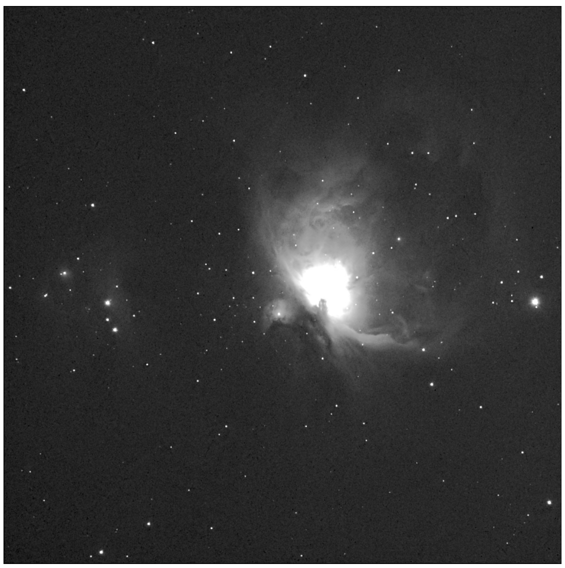
Figure 11 Image Comparison: M42, f/6.3, Green Channel



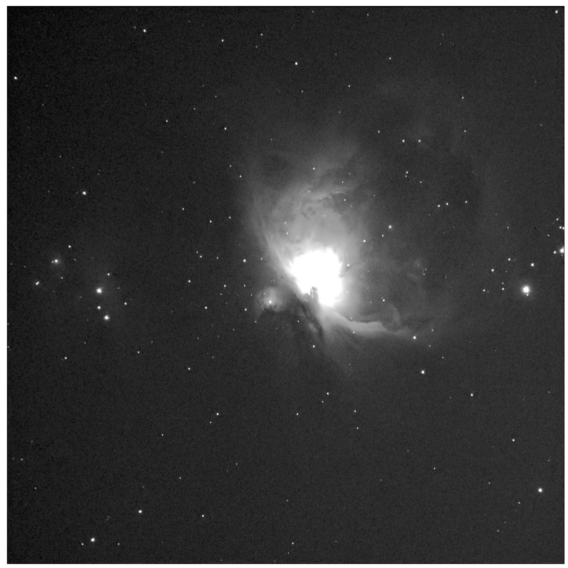
UV/IR Cut



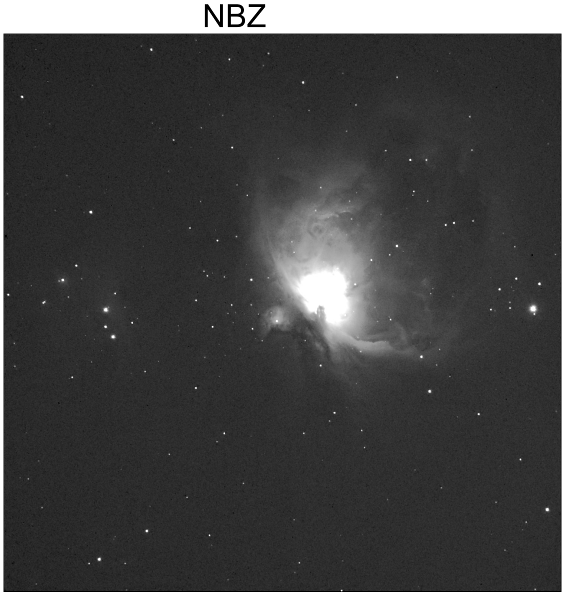
NB-1



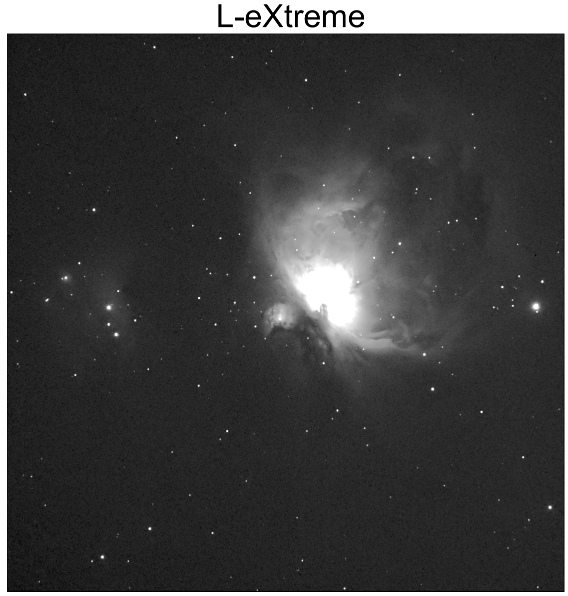
NBZ



L-eXtreme



ALP-T



Triad Ultra

Figure 12 Image Comparison: M42, f/6.3, Blue Channel

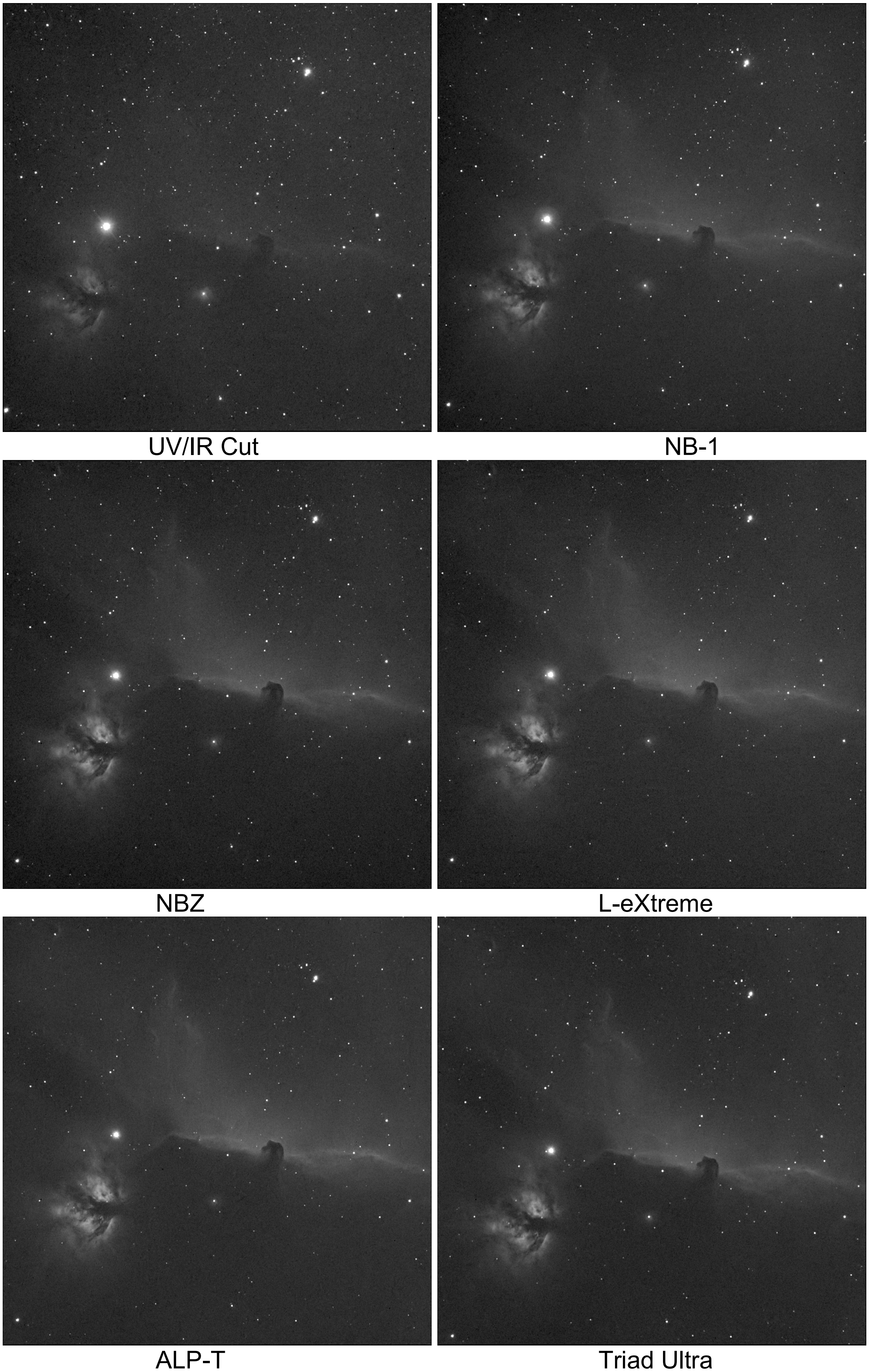


Figure 13 Image Comparison: Flame, f/6.3, Red Channel

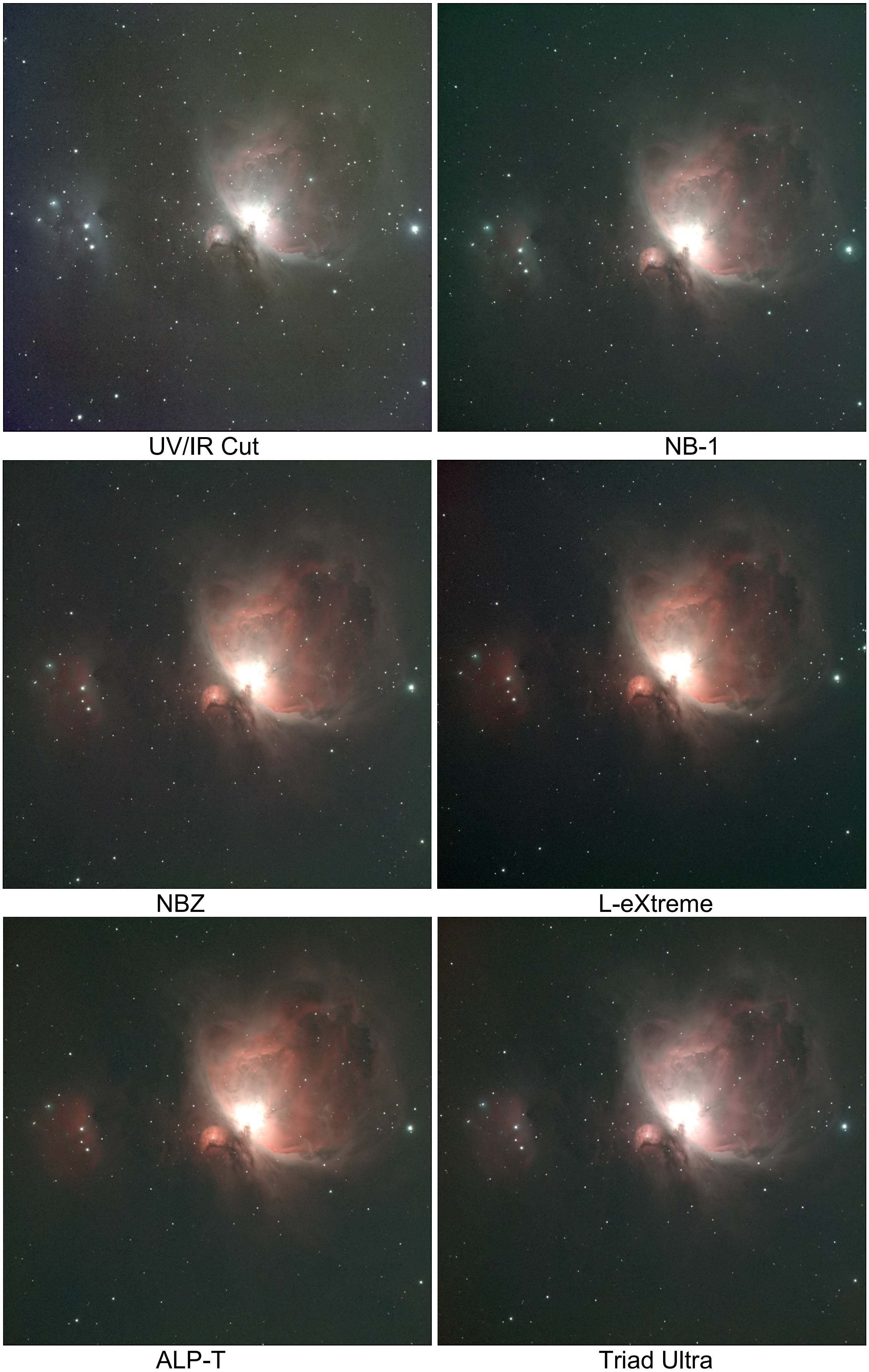


Figure 14 Image Comparison: M42, f/6.3, Full Colour

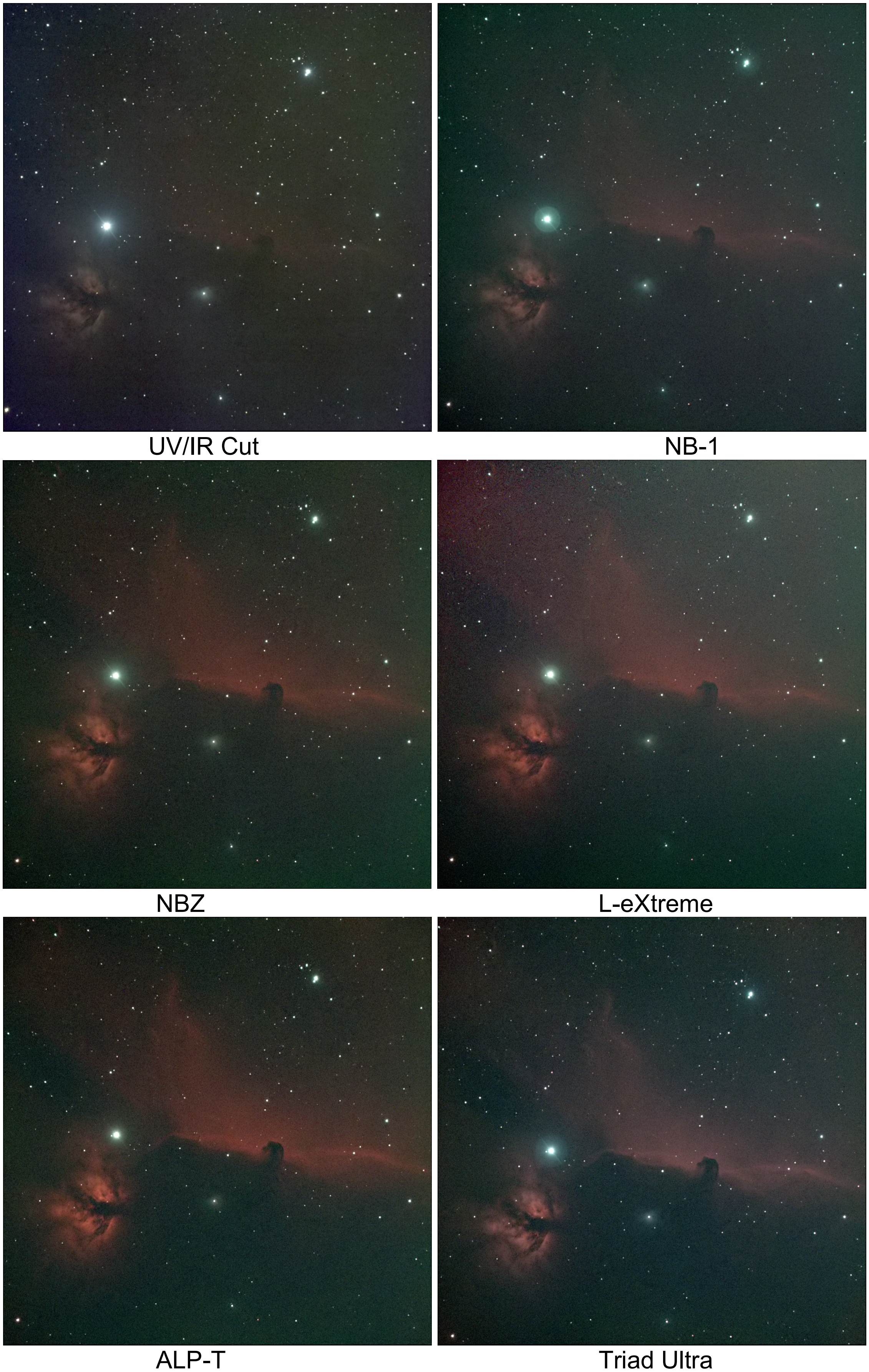


Figure 15 Image Comparison: Flame, f/6.3, Full Colour

Conclusions:
Based on the results of the testing described above, I have made the following conclusions:

1. Although my sample of the Antlia ALP-T filter has transmission rates in the Hα band below the manufacturer's spec, the filter still demonstrated that it has the highest overall performance (i.e. best increase in emission nebula contrast) of the filters tested.
2. Based on my measured spectrum data, the ALP-T filter should provide good performance on optics down to around f/3. At f/2 the reduction in filter performance is significant.
3. Based on my measured spectrum data, and captured image data, there is not a significant difference in the performance of the Optolong L-eXtreme versus the Radian Triad Ultra. I am unable to find a justification for the difference in price between these two filters.

If you have any questions, please feel free to contact me.

Cheers!

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