Playing With Focal Ratio
by Jim Thompson, P.Eng
Test Report – January 16th, 2012

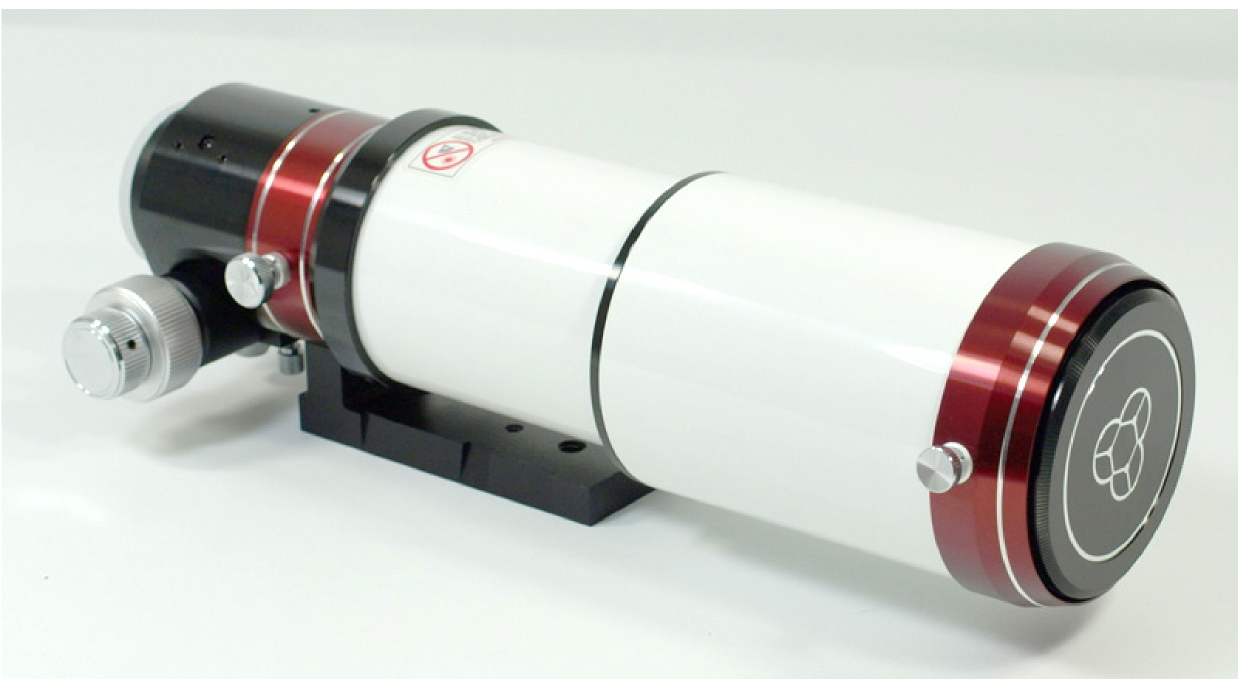
Objectives:

My objective in last night's test was to visually compare how changing the focal ratio of a telescope impacts the following:

1. effective Field Of View (FOV);
2. resolution;
3. relative brightness; and
4. image quality.

Methodology:

I used a single deep-sky object as my target: M42 The Orion Nebula. This is a relatively large object with a very large dynamic range and lots of detail in the nebulosity to resolve. I used my Maxvision brand ED80 telescope, which is native focal length 480mm (f/6). The scope was mounted to my Orion Atlas mount, and remotely controlled through my laptop from inside the house. A stack of two filters was used to combat light pollution: an Astronomik UHC plus a custom UV/IR cut filter I had made by Omega Filters that cuts everything below Hbeta and above Halpha.



Picture of my Maxvision ED80 (same Chinese factory as Meade ED80)

I used my Mallincam Xtreme to capture all image data. The camera and capture device were running with the following settings:

- AGC 4
- gamma 1
- APC vert & horz 2
- white balance ATW
- contrast 80 (full)
- brightness (BRT) varied from 100 to 0 to keep background dark
- hue 62
- saturation 35
- sharpness 1
- DVE off
- TEC set to "on", 10 sec dew prevention, 4 sensitivity

Images were collected for a range of Integration times (INT) from 2sec up to 96sec. Five focal ratios were tested:

1. native = f/6
2. 2x Barlow (Meade #126 shorty) ~ f/12
3. larger half of Mallincam Focal Reducer 5 (MFR5) ~ f/3
4. complete MFR5 ~ f/2.4
5. new Mallincam 2" Focal Reducer ~ f/2.1

The f/ratios quoted in the above list are my estimates going in. I calculate the actual achieved f/ratio in my results below, and they are quite different. The Barlow connected to the Mallincam using the default supplied 'c'-mount to 1.25" adapter. The MFR5 connected directly to the Mallincam via its 'c'-mount thread. The 2" Mallincam FR connected to the Mallincam via a standard telescope 1.25" to 2" adapter plus the 'c'-mount to 1.25" adapter. I tried using the Mallincam 'c'-mount to 2" adapter, but the overall length of the adapter did not allow me to achieve focus on my refractor. The adapter and 2" FR focused fine on my SCT.

Results:

Below are the images I collected during my test. They were all recorded over the course of a two hour period from ~9pm to 11pm EST on January 15th, 2012 from my backyard in Ottawa, CANADA. There was no Moon present, the sky was 100% clear, transparency 4/5, and seeing 3/5. The telescope was refocused after changing f/ratios using a Bahtinov mask. The f/ratio noted in the image legend is what I calculated from the images as is discussed later.

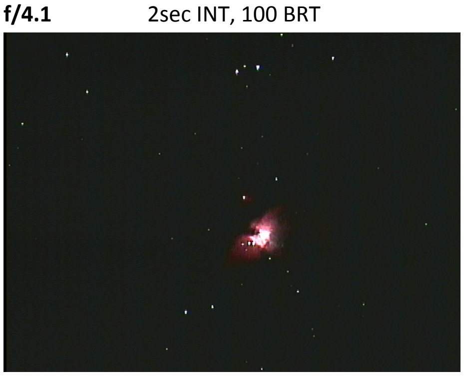
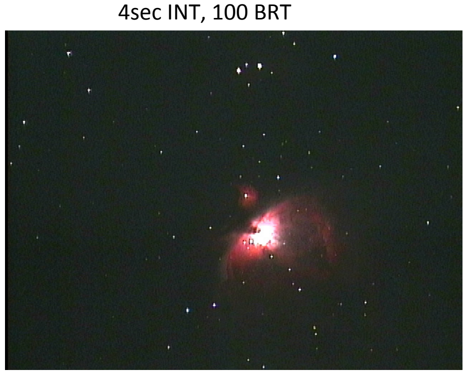
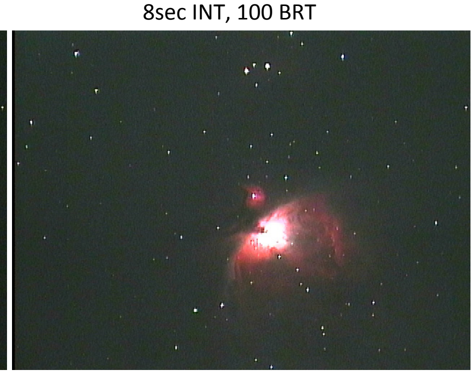
f/13.6 2sec INT, 100 BRT — 4sec INT, 100 BRT — 8sec INT, 100 BRT

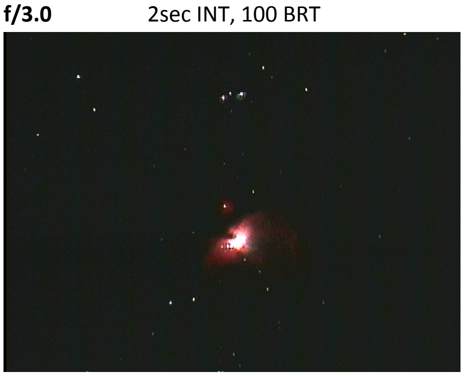
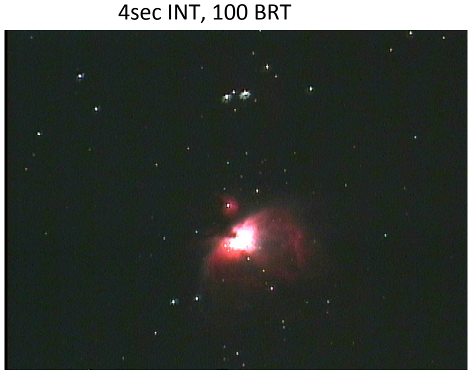
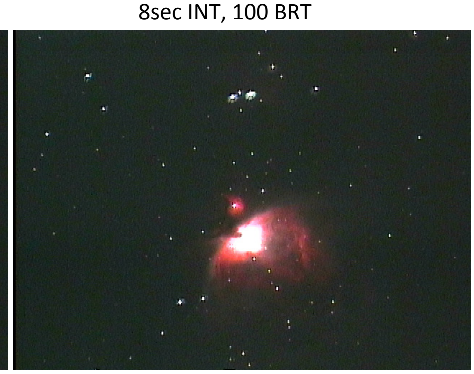
f/6 2sec INT, 100 BRT — 4sec INT, 100 BRT — 8sec INT, 100 BRT

f/4.1 2sec INT, 100 BRT — 4sec INT, 100 BRT — 8sec INT, 100 BRT

f/3.0 2sec INT, 100 BRT — 4sec INT, 100 BRT — 8sec INT, 100 BRT

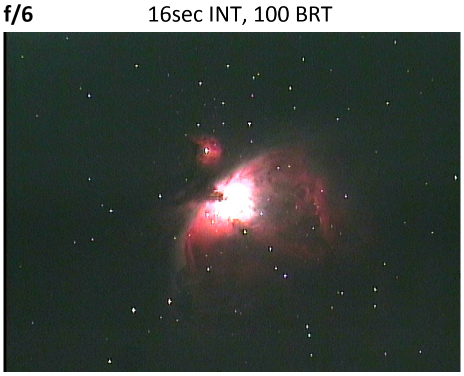
f/2.6 2sec INT, 100 BRT — 4sec INT, 95 BRT — 8sec INT, 75 BRT

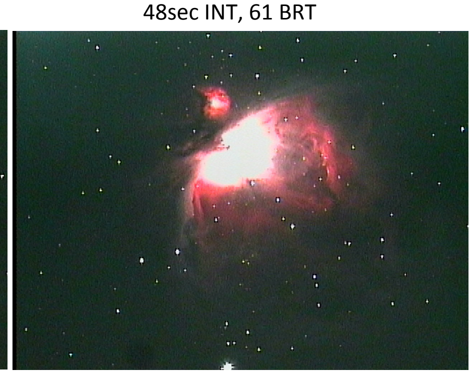


f/13.6 16sec INT, 100 BRT | 32sec INT, 100 BRT | 48sec INT, 100 BRT

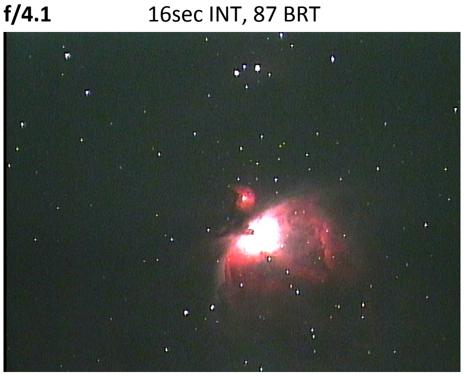
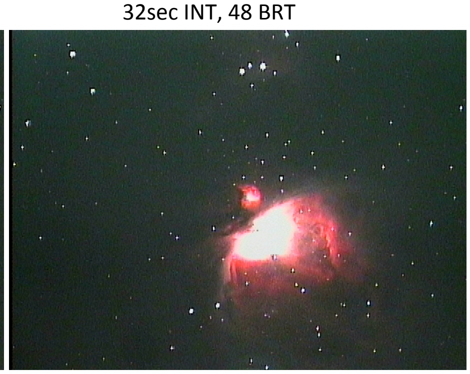
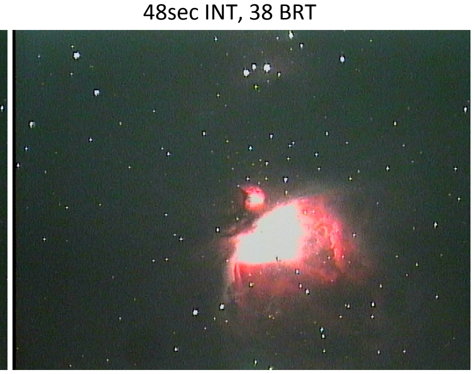


f/6 16sec INT, 100 BRT | 32sec INT, 83 BRT | 48sec INT, 61 BRT

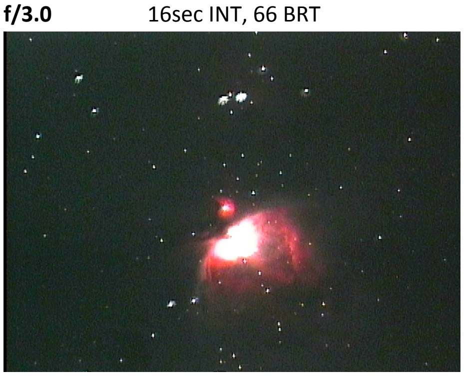
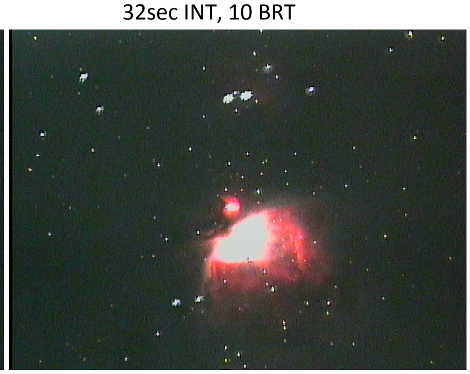




f/4.1 16sec INT, 87 BRT | 32sec INT, 48 BRT | 48sec INT, 38 BRT

f/3.0 16sec INT, 66 BRT | 32sec INT, 10 BRT | 38sec INT, 0 BRT

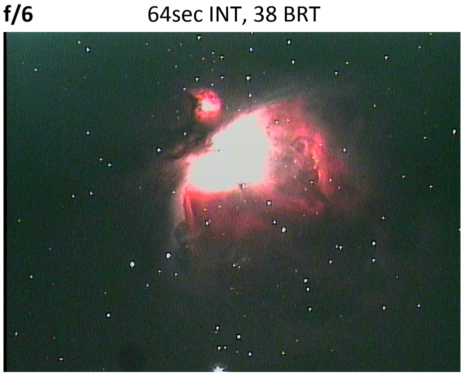
f/2.6 16sec INT, 34 BRT | 24sec INT, 0 BRT | Too saturated above 24 sec

f/13.6 64sec INT, 100 BRT | 80sec INT, 90 BRT | 96sec INT, 75 BRT

f/6 64sec INT, 38 BRT | 80sec INT, 16 BRT | 96sec INT, 3 BRT



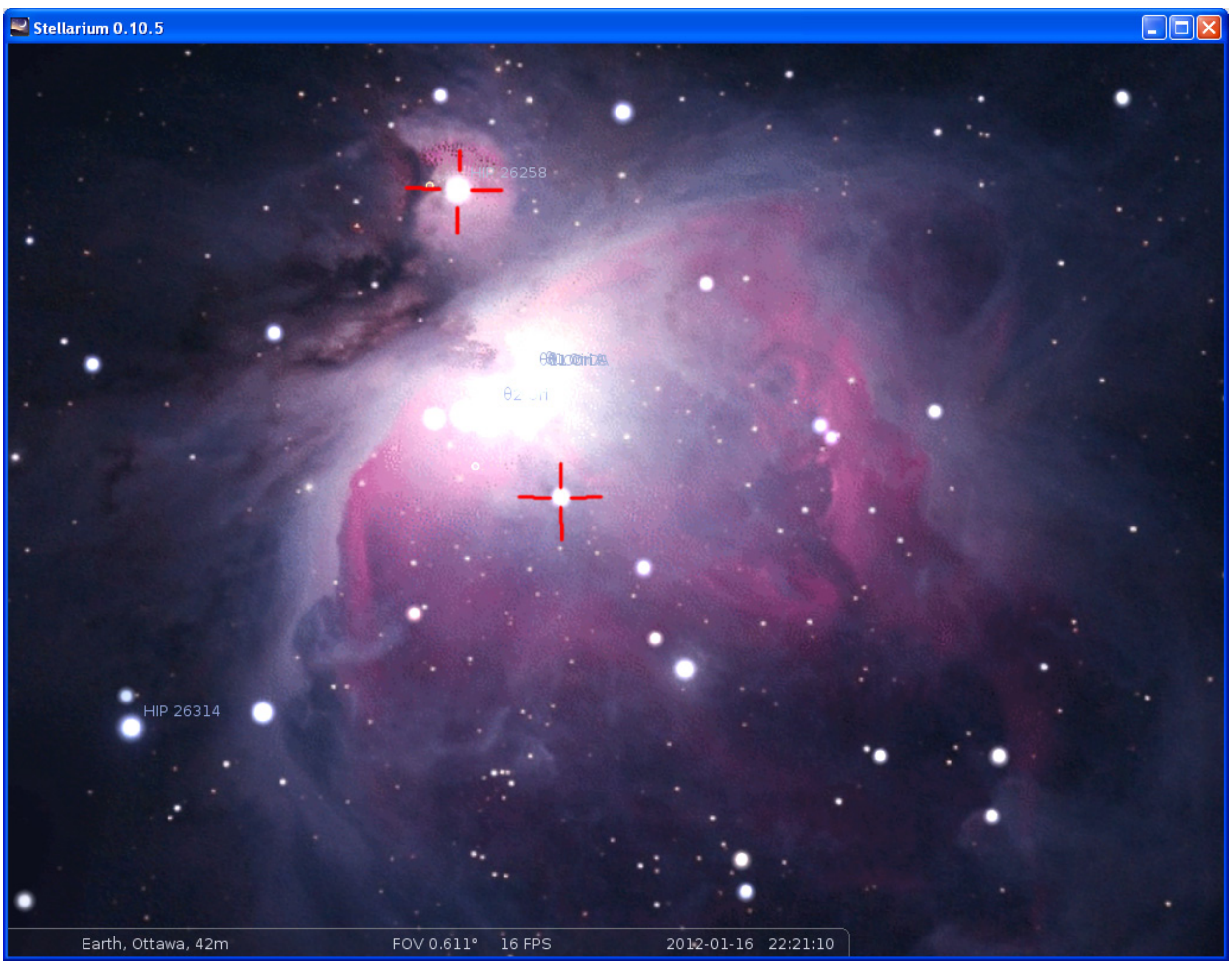
f/4.1 56sec INT, 0 BRT | Too saturated above 56sec

f/3.0 Too saturated above 38sec

f/2.6 Too saturated above 24sec

What surprised me the most about my test was how quickly the image became overly saturated as the focal ratio decreased. It was advantageous to be able to use shorter INT to get the same image exposure, however the light pollution and object brightness ultimately set the final image contrast that was achievable. To really take advantage of the shorter INT times that faster f/ratios provide, at least under my light polluted skies, I need to use a narrower light pollution filter.

Another thing I discovered is that my initial estimates of focal ratio for each focal reducer were wrong. I used two particular stars that were visible in all the images, HIP26258 (bright central star in M43) and 'LP' Orionis (lower marked star in image below), to measure the actual FOV and thus focal length and f/ratio. According to the data in Stellarium, these two stars are 805 arc sec from each other in the sky. Using this information and the distance in pixels from the images, I was able to figure everything out. The results of this calculation are summarized in the table below. I also re-confirmed the effective focal length of my Mallincam Xtreme to be 4.7mm, assuming a camera FOV of 80° x 60°.



Screen capture from Stellarium of M42 with distance stars marked

My Initial F/ratio Guess	Star Distance in Pixels	Measured Reduction Factor	**Actual Measured F/ratio**	Resolution ArcSec per Pixel	Effective FOV in ArcMin	Effective Focal Length
f/12	412.7	2.26x	**f/13.6**	2.0	21’ x 16’	1084mm
f/6	182.6	1.0x (ref)	**f/6**	4.4	47’ x 35’	480mm
f/3	125.0	0.68x	**f/4.1**	6.4	68’ x 51’	326mm
f/2.4	92.5	0.51x	**f/3.0**	8.7	93’ x 70’	245mm
f/2.1	79.9	0.44x	**f/2.6**	10.1	108’ x 81’	211mm

Summary of ED80 data from test

Other Observations:

I found that using my Bahtinov mask to focus became progressively harder to do as my focal ratio decreased. The 3-spike pattern from the mask got smaller and smaller in size as the telescope FOV increased, making it eventually impossible to see. I wonder if this was due to the fact that the Bahtinov mask I was using is optimized for my telescope’s native focal length and not the much shorter effective focal length I had while using the focal reducers.

I also found that tracking errors greatly diminished as the focal ratio decreased. The errors are still there of course, they simply become less noticeable as the angular resolution of the image gets courser. My mount went from starting to struggle with 96sec INT at f/13.6, to doing 96sec without too much trouble at f/6, to absolutely no tracking glitches at all for f/ratios below f/4. This has been one big reason I like observing using wide FOV’s since I don’t presently use guiding with my mount.

All the images taken with the Meade #126 2x shorty Barlow were slightly blurry. I checked the focus a couple times but it did not improve. I’m guessing this is due to a combination of the seeing conditions, the quality of the Barlow, and the limiting resolution of a 80mm aperture telescope.

This was the first night I have had an opportunity to try my new custom UV/IR cut filter, I call it the Blue & Deep Red Blocker (BDRB). I was very happy with the performance of this filter combined with my UHC. The contrast was better than with the UHC alone, and the details in the O-III areas were much more visible.

I originally set up for the night using my new iOptron Cube Pro ALT-AZ mount, however the mount did not want to work at all in the -20°C weather. I had to quickly setup my Orion Atlas at the last minute. The Atlas worked flawlessly all night, even in the cold temperatures.

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

top-jimmy@rogers.com