Playing With Focal Ratio #2
by Jim Thompson, P.Eng
Test Report – January 26th, 2012

Objectives:

My objective in this test was to further investigate visually 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 the same deep-sky object as last time for 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 Meade 8" LX-10 SCT telescope, which is native focal length 2000mm (f/10). 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 Optical that cuts everything below Hbeta and above Halpha.

Picture of Meade 8" LX-10 and ED80 on my Orion Atlas mount

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. Ten focal ratios were tested:

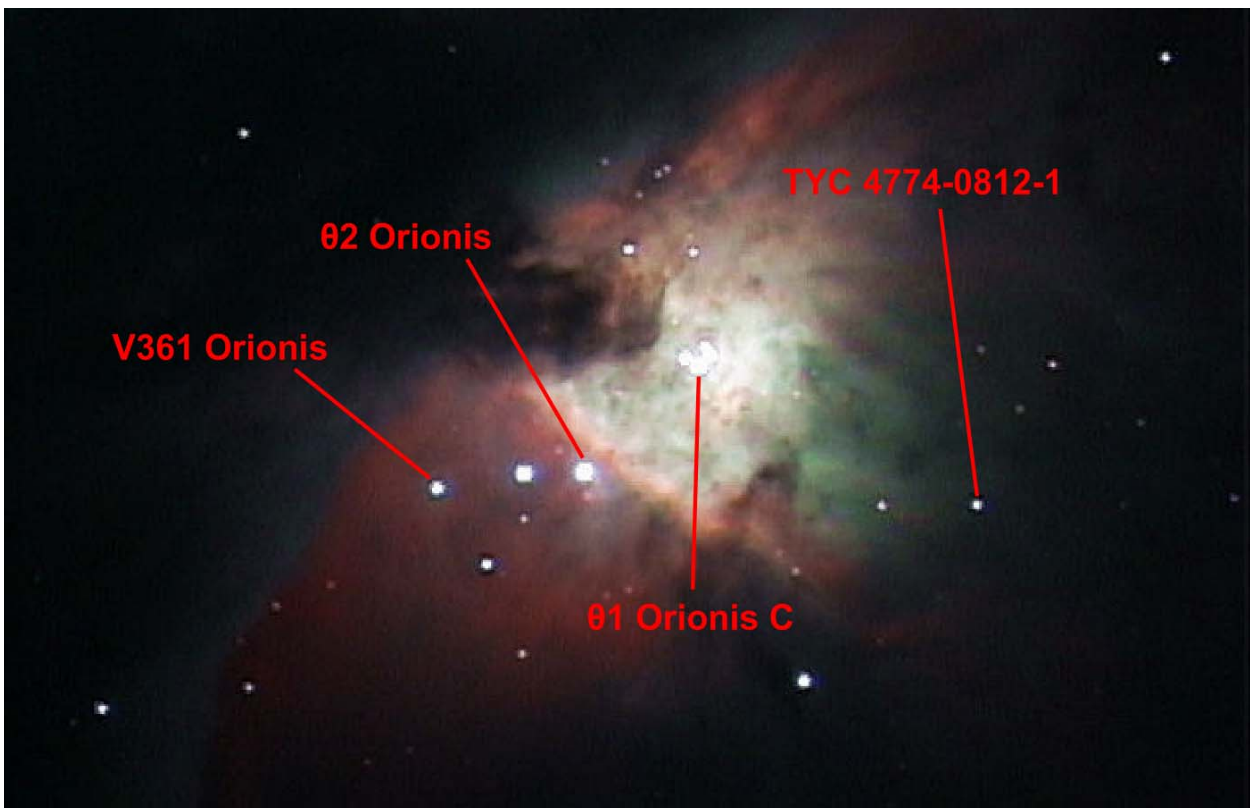
1. native = f/10
2. 2x Barlow (Meade 5000 series 2") ~ f/20
3. larger half of Mallincam Focal Reducer 5 (MFR5) ~ f/7
4. complete MFR5 ~ f/5.0
5. complete MFR5 + 10mm spacer between it and camera ~ f/3.7
6. new Mallincam 2" Focal Reducer ~ f/4.2
7. Meade f/3.3 focal reducer ~ f/3.3
8. Meade f/6.3 focal reducer ~ f/6.3
9. Meade f/6.3 FR + larger half of MFR5 ~ f/3.5
10. Meade f/6.3 FR + whole MFR5 ~ f/2.4

The f/ratios quoted in the above list are my estimates going in. I calculate the actual achieved f/ratio in my results below. The Barlow connected to the Mallincam using the default supplied 'c' mount-to-1.25" adapter plus a "tall" 1.25"-to-2" adapter (10mm taller than normal). The MFR5 connected directly to the Mallincam via its 'c' mount thread. The 2" Mallincam FR connected to the Mallincam via the new 'c' mount 2" adapter. The two Meade brand focal reducers screw directly on the back of the telescope, then the SCT-to-2" adapter screws onto them. When I used both the Meade FR and the MFR5, I had the "tall" 1.25"-to-2" adapter in between. I often use this "tall" adapter to provide more distance between the 1.25" nosepiece on the end of the camera and the 2" filters I put on the end of the adapter.

Results:

Below are the images I collected during my test. They were all recorded over the course of a three hour period from ~8pm to 11pm EST on January 18th, 2012 from my backyard in Ottawa, CANADA. There was no Moon present, the sky was 100% clear, transparency 3/5, and seeing 4/5. The telescope was refocused after changing f/ratios using a Bahtinov mask.

The f/ratio noted in the image legends below are what I calculated from the test images. The measurement was made using the same method as last time, using two stars in M42 that are visible in all the f/ratio shots. I had to use a different pair of stars for the f/20 case since the field of view was so small. I used "theta 1 Orionis C" and "theta 2 Orionis" for the f/20 case, and "V361 Orionis" and "TYC 4774-0812-1" for all the other cases. According to the data in Stellarium and Sky Safari, these star pairs are 152 and 601 arc sec from each other in the sky respectively. 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.



Screen capture from Mallincam of M42 with distance stars marked

Test Config #	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
1	f/10	*128.0* / 441.0	1.00x (ref)	**f/10**	1.3	15' x 11'	2000mm
2	f/20	*254.6*	1.99x	**f/19.9**	0.6	6.4' x 4.8'	3978mm
3	f/7	309.0	0.70x	**f/7.0**	1.9	21' x 16'	1401mm
4	f/5	233.0	0.53x	**f/5.3**	2.6	28' x 21'	1057mm
5	f/3.7	161.2	0.37x	**f/3.7**	3.7	40' x 30'	731mm
6	f/4.2	185.0	0.42x	**f/4.2**	3.2	35' x 26'	839mm
7	f/3.3	106.2	0.24x	**f/2.4**	5.7	60' x 45'	482mm
8	f/6.3	305.0	0.69x	**f/6.9**	2.0	21' x 16'	1383mm
9	f/3.5	200.0	0.45x	**f/4.5**	3.0	32' x 24'	907mm
10	f/2.4	138.1	0.31x	**f/3.1**	4.4	46' x 35'	626mm

***** Dawes (resolution) Limit for 8" aperture scope = 0.6 arc sec

Summary of 8" LX-10 data from test

The focal reducers that were tested the other night on my ED80 appear to perform identically on my 8" SCT. This makes sense considering the fact that the camera-to-FR distance is fixed for all of them (they all screw to the front of the camera). The two Meade focal reducers were quite different than their nominal advertised reduction factor, and inconsistently so. Both Meade FR's were at the same distance to the camera and yet the f/3.3 one provided much more reduction than labeled, and the f/6.3 delivered less reduction. I conclude from this that the variation is not due entirely to my spacing but due to the fact that the optics in the FR aren't actually what Meade says they are. Note that my using the "tall" adapter should in fact make my reduction factors with the Meade FR's both smaller since it adds to the distance between FR and camera.

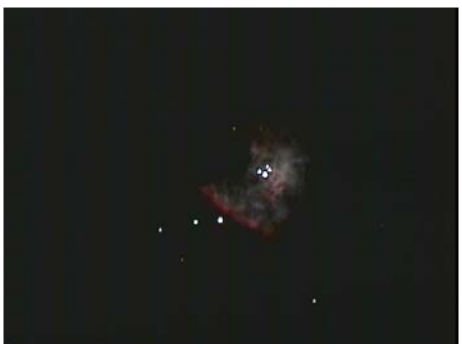
With regards to image quality, in my opinion the image gets sharper as the focal ratio goes down. I imagine this is partly due to the resolution limit of my telescope but also the fact that atmospheric perturbations and tracking errors are less visible at the larger field of view. The images at large f/ratios were quite blurry, especially f/20, but I am not surprised since I was pushing the resolution limit of the scope at that f/ratio. I also think the seeing conditions were in fact much worse than suggested in the ClearDarkSky.com forecast of 4/5. This was later confirmed by the poor quality view I had on other DSO's later in the same night's broadcast. The images were all quite good between f/7 and f/4, but once the focal ratio was below f/4 the image quality started to degrade again due to increased vignetting (darkness around the outside edge) and distorted stars. Of the low focal ratio configurations tried, the MFR5 with a 10mm spacer gave the nicest stars but had vignetting. Interestingly the Meade f/3.3 which had the lowest measured focal ratio had pretty much no vignetting but lots of star distortion. I found out



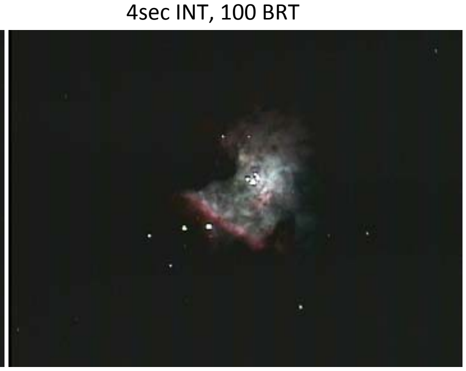
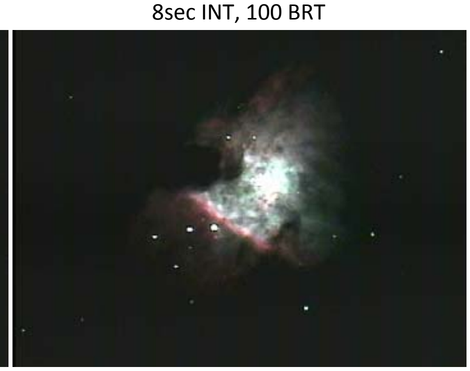
#2 - f/19.9 2sec INT, 100 BRT 4sec INT, 100 BRT 8sec INT, 100 BRT



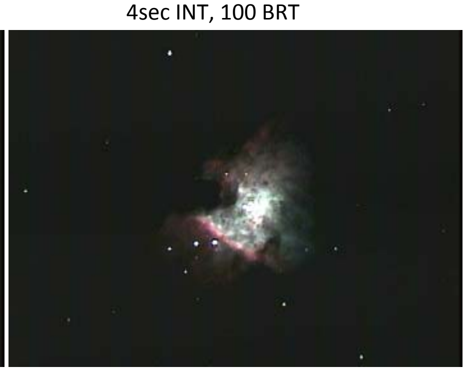
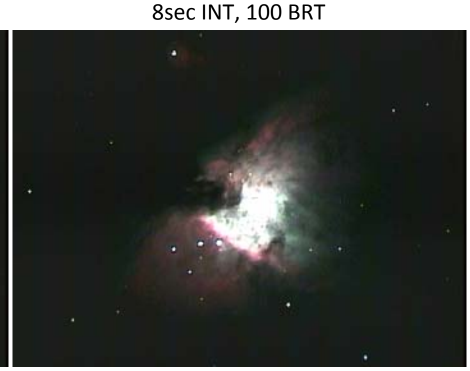
#1 - f/10 2sec INT, 100 BRT 4sec INT, 100 BRT 8sec INT, 100 BRT



#3 - f/7.0 2sec INT, 100 BRT 4sec INT, 100 BRT 8sec INT, 100 BRT

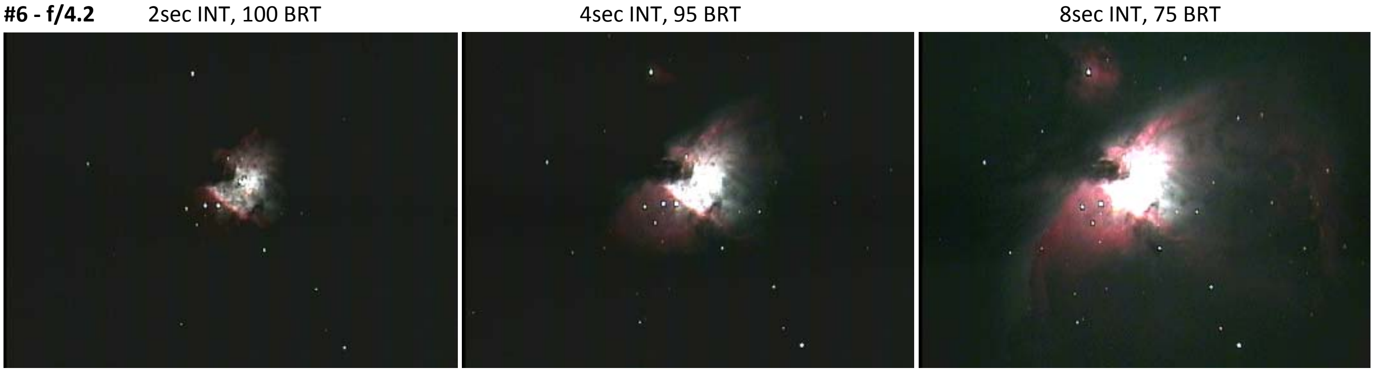
#8 - f/6.9 2sec INT, 100 BRT 4sec INT, 100 BRT 8sec INT, 100 BRT

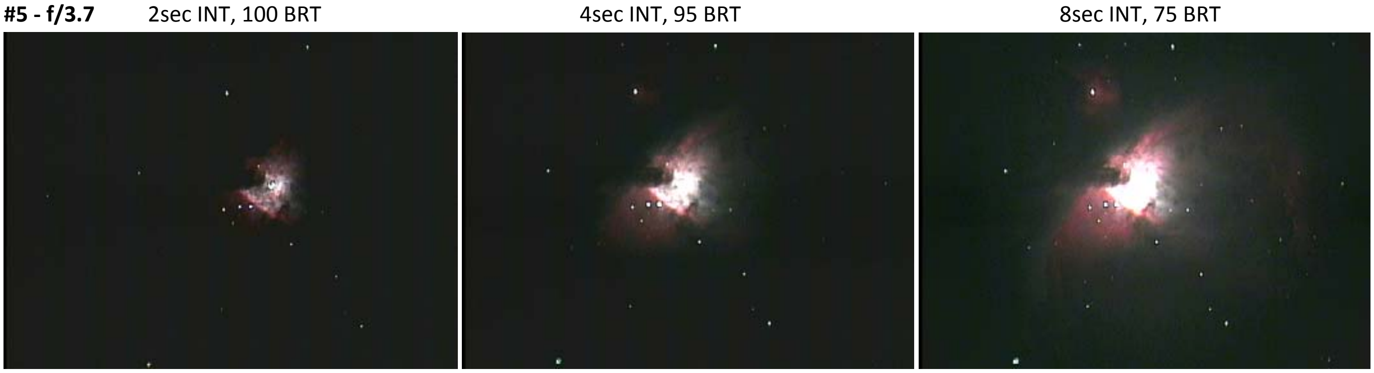
#4 - f/5.3 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT

#9 - f/4.5 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT

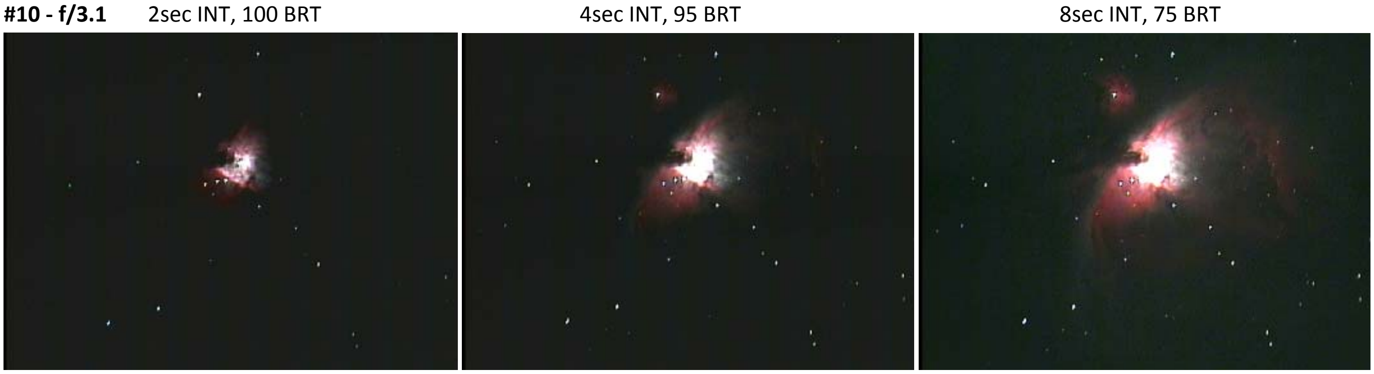
#6 - f/4.2 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT



#5 - f/3.7 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT



#10 - f/3.1 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT



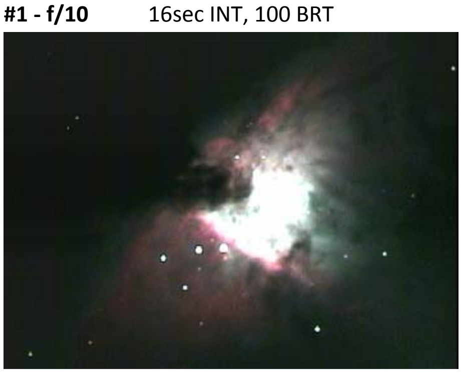
#7 - f/2.4 2sec INT, 100 BRT 4sec INT, 95 BRT 8sec INT, 75 BRT

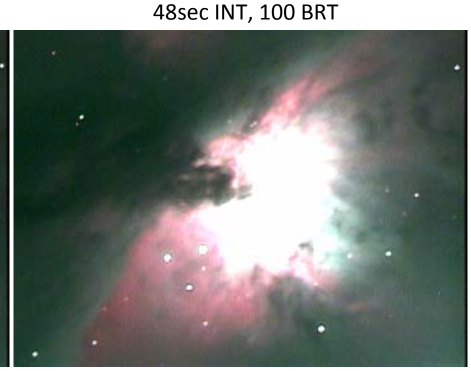


#2 - f/19.9 16sec INT, 100 BRT | 32sec INT, 100 BRT | 48sec INT, 100 BRT

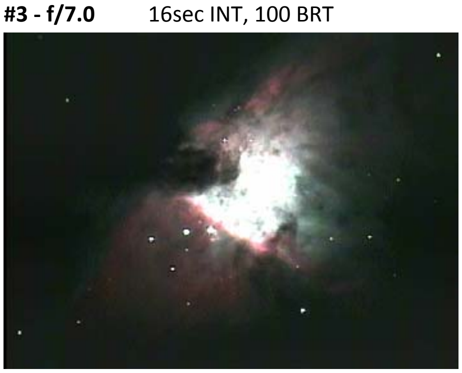


#1 - f/10 16sec INT, 100 BRT | 32sec INT, 100 BRT | 48sec INT, 100 BRT

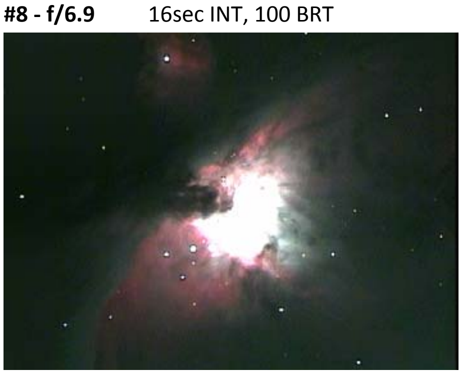


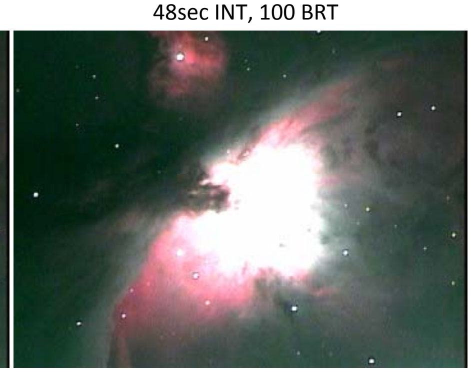


#3 - f/7.0 16sec INT, 100 BRT | 32sec INT, 100 BRT | 48sec INT, 100 BRT



#8 - f/6.9 16sec INT, 100 BRT | 32sec INT, 100 BRT | 48sec INT, 100 BRT





#4 - f/5.3 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT

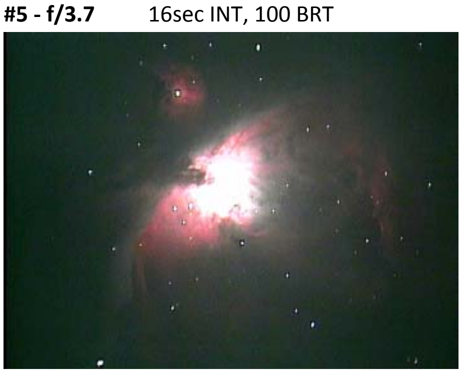
#9 - f/4.5 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT

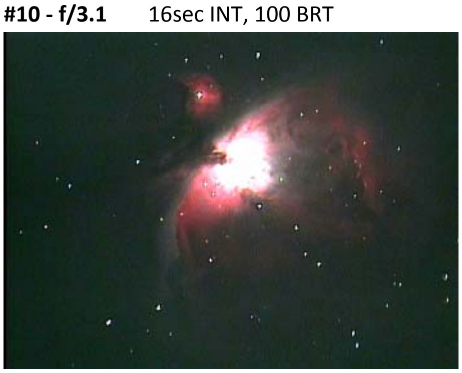
#6 - f/4.2 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT

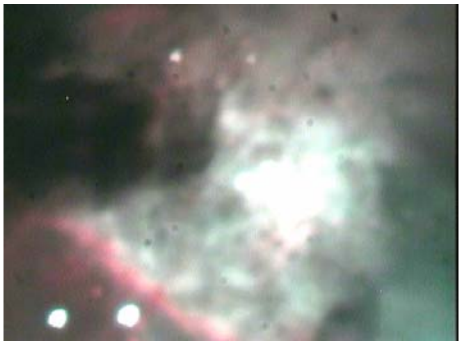
#5 - f/3.7 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT

#10 - f/3.1 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT

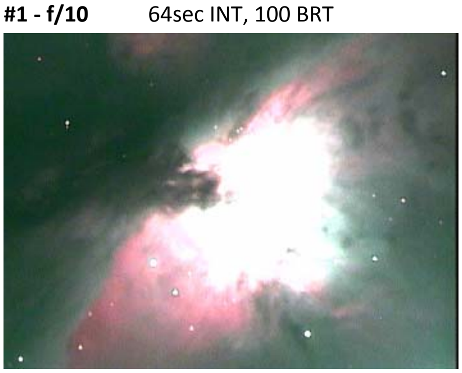
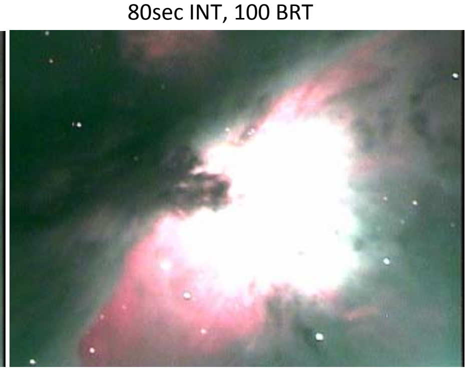
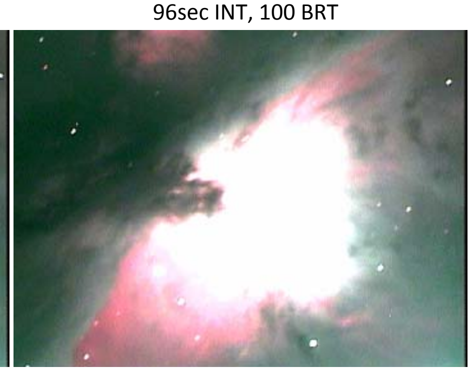
#7 - f/2.4 16sec INT, 100 BRT | 32sec INT, 95 BRT | 48sec INT, 75 BRT



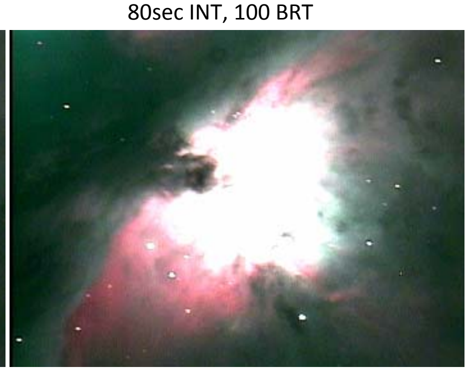
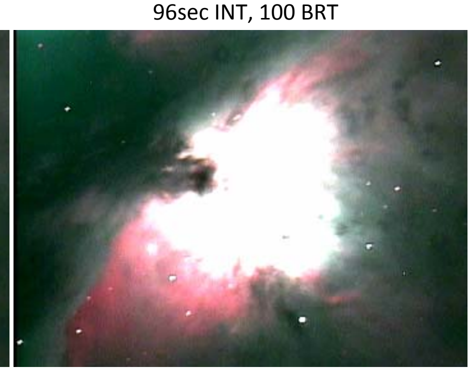
#2 - f/19.9 64sec INT, 100 BRT 80sec INT, 100 BRT 96sec INT, 100 BRT



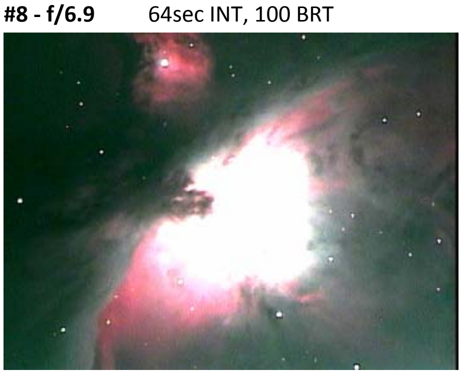
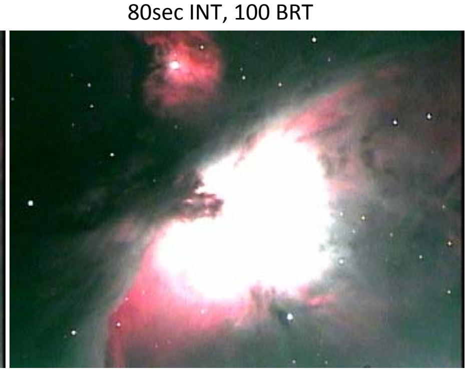
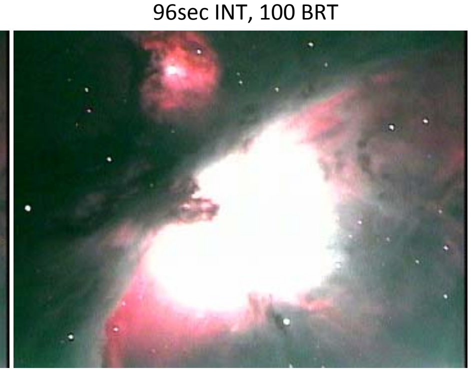
#1 - f/10 64sec INT, 100 BRT 80sec INT, 100 BRT 96sec INT, 100 BRT

#3 - f/7.0 64sec INT, 100 BRT 80sec INT, 100 BRT 96sec INT, 100 BRT

#8 - f/6.9 64sec INT, 100 BRT 80sec INT, 100 BRT 96sec INT, 100 BRT

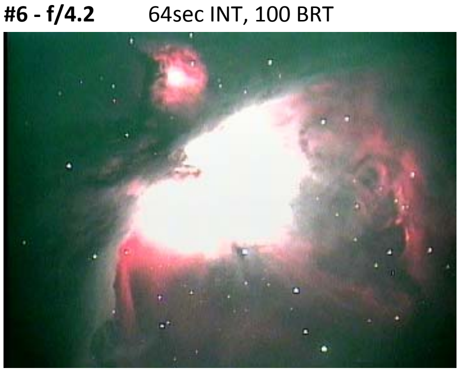
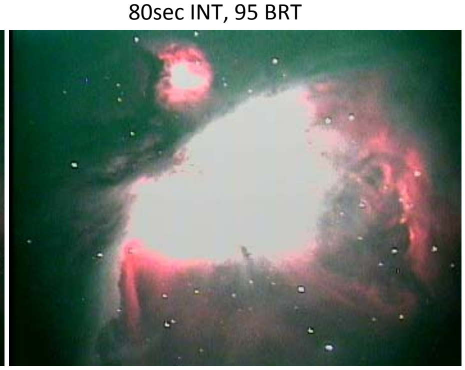
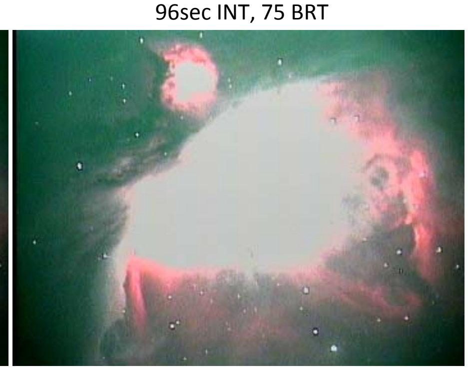
#4 - f/5.3 64sec INT, 100 BRT 80sec INT, 95 BRT 96sec INT, 75 BRT



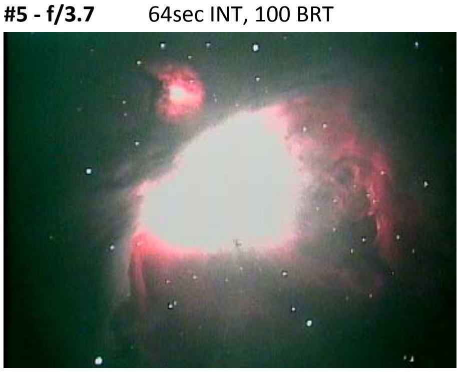
#9 - f/4.5 64sec INT, 100 BRT 80sec INT, 95 BRT 96sec INT, 75 BRT



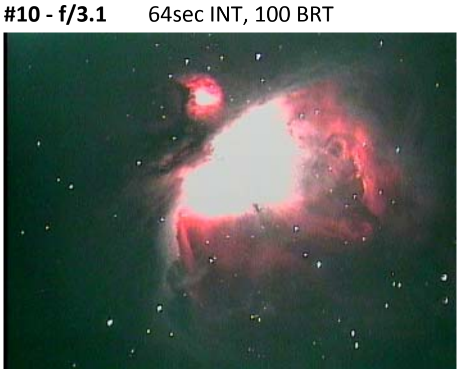
#6 - f/4.2 64sec INT, 100 BRT 80sec INT, 95 BRT 96sec INT, 75 BRT

#5 - f/3.7 64sec INT, 100 BRT 80sec INT, 95 BRT 96sec INT, 75 BRT



#10 - f/3.1 64sec INT, 100 BRT image too saturated above 64sec INT



#7 - f/2.4 64sec INT, 100 BRT 80sec INT, 95 BRT 96sec INT, 75 BRT

later (thanks Mega256!) that this reducer is very sensitive to the distance between it and the camera. I will have to go back some day and try it again with less spacing. I very much like the image with the Meade f/6.3, nice round stars and sharp focus, even when I added half the MFR5. When I combined the Meade f/6.3 with the whole MFR5 there was some star distortion and the image appeared dimmed somewhat; too much glass I guess! I was happy to see that Rock's new 2" FR performed quite well on my SCT compared to on my short 80mm refractor, having only mild star coma and no vignetting.

Although the data on actual achieved focal ratio and field of view with my two telescopes is very useful information to myself and others, I had an ulterior motive for performing these tests. Some of you may remember a discussion on the Mallincam Yahoo Group a couple weeks ago about how f/ratio affects the brightness of the Mallincam image. I stated my belief that if two telescopes have the same f/ratio, then the image brightness will be the same only the field of view is different. Many others disagreed with my position including one most important group member who shall remain nameless, but who's name sounds a lot like "brock". My hope is that this test will prove I am not crazy, or at the very least that I'm pretty good at math type stuff. So I've compared my images from the two telescopes, and guess what…they're not the same brightness. The thing is they're different in the wrong direction, the 8" SCT is dimmer at the same f/ratio than the 80mm refractor. What the?... But then I clued in that these are two different types of telescope, a refractor and a reflector. It makes sense that some of the light is lost in the SCT due to having to pass through the corrector plate and bounce off two mirrors (that have 1990's technology coatings by the way). From my images my SCT has ~2/3 of the efficiency that the refractor has, assuming my original statement that same f/ratio equals same brightness is true. An efficiency of 67% seems believable to me, that's two bounces off 82% reflective mirrors. So not as definitive a result as I was hoping for, but I think I've proved I'm not completely crazy. Haven't I? ☺

ED80 f/4.1, 48sec INT

8" LX10 f/4.2, 48sec INT

8" LX10 f/2.4, 48sec INT

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

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