Medium Size Sensor Focal Reducer Testing - Follow-up

by Jim Thompson, P.Eng

Test Report – May 31st, 2016

Introduction:

This report is a follow-up to the larger batch of testing performed about a month ago. This report summarizes testing with the Meade f/6.3 SCT focal reducer and a series of spacers with the hopes of getting closer to the optimum reduction factor for the camera in question.

Objectives:

The objective of this test is to observe the quality of image produced by each FR as tested in various possible configurations, and to evaluate the reduction factor that results. The objective is to produce as low a focal ratio as possible with a minimum of image defects.

Methodology:

This testing was performed outdoors in my backyard in central Ottawa, Canada. I used a 10" Ritchey-Chretien telescope (f/8) on an Orion Atlas EQ/G mount to observe a single deepsky object, M13 the great globular cluster in the constellation Hercules. A variety of extension tubes and focuser spacer rings had to be used to achieve focus with the various FR configurations. The camera used was the Mallincam SkyRaider DS2.3+ . This camera was used due to its medium sized sensor (IMX302LQJ, 13.4mm diagonal) and HD resolution. The camera was used with its accompanying MallinSky software, with single frames of 5 to 10sec exposure collected for the analysis. In all cases an LP filter was used, placed in the optical train in such a way that it added to the sensor-FR spacing. In all cases the scope was re-focused on nearby Mars after FR configuration changes using a Bahtinov mask.

The FR configurations tested were based on a single basic optical elements (see Figure 1):

- Meade f/6.3 SCT (made in Japan)

This FR was combined with a number of different length 2" extensions, all of which are made by Blue Fireball and purchased from AgenaAstro.com. The focal reducer configurations tested were all attached directly to the camera's T-thread via a T-to-2" nosepiece (35mm long). The Meade focal reducer which has an SCT thread was connected to the camera via a 2"-to-SCT adapter which was also approximately 5mm long. In between the nosepiece and 2"-to-SCT adapter was added the filter and different 2" extensions.

Meade f/6.3 SCT (Made in Japan)

Figure 1 Optical Element Used In Testing

Data was gathered by capturing an image of the star pattern for each FR configuration, including an image taken with no FR for reference. These captures were then later used to determine reduction factor and to quantitatively assess coma and vignetting in the image. All image analysis was performed using a basic image editing software tool. Also recorded during the testing was the distance from the back of the telescope to the front face of the camera, referred to in this report as the "focus distance". Data was gathered over the course of a single evening, May 30th, 2016.

Results:

The images captured for each FR configuration can be found at the end of this report in Appendix A. An example image is shown below in Figure 2, that of the telescope at its native f-ratio (no focal reducer). The reference length used in all the images to determine reduction factor is shown in the figure. Another sample image is provided in Figure 3, that of M11 taken after the testing using the final FR configuration tested (f/3.87). This image is of a richer star field and shows better the quality of the image, ie. relative lack of aberrations. Note that in Figure 3 there is a bit of gradient from center to edge; this is not vignetting it is an artifact resulting from the dark frame I was using at the time the image was captured, ie. the dark frame did not exactly align with my current gain/exposure/temperature. From what I could tell there was no appreciable vignetting observed during my testing.

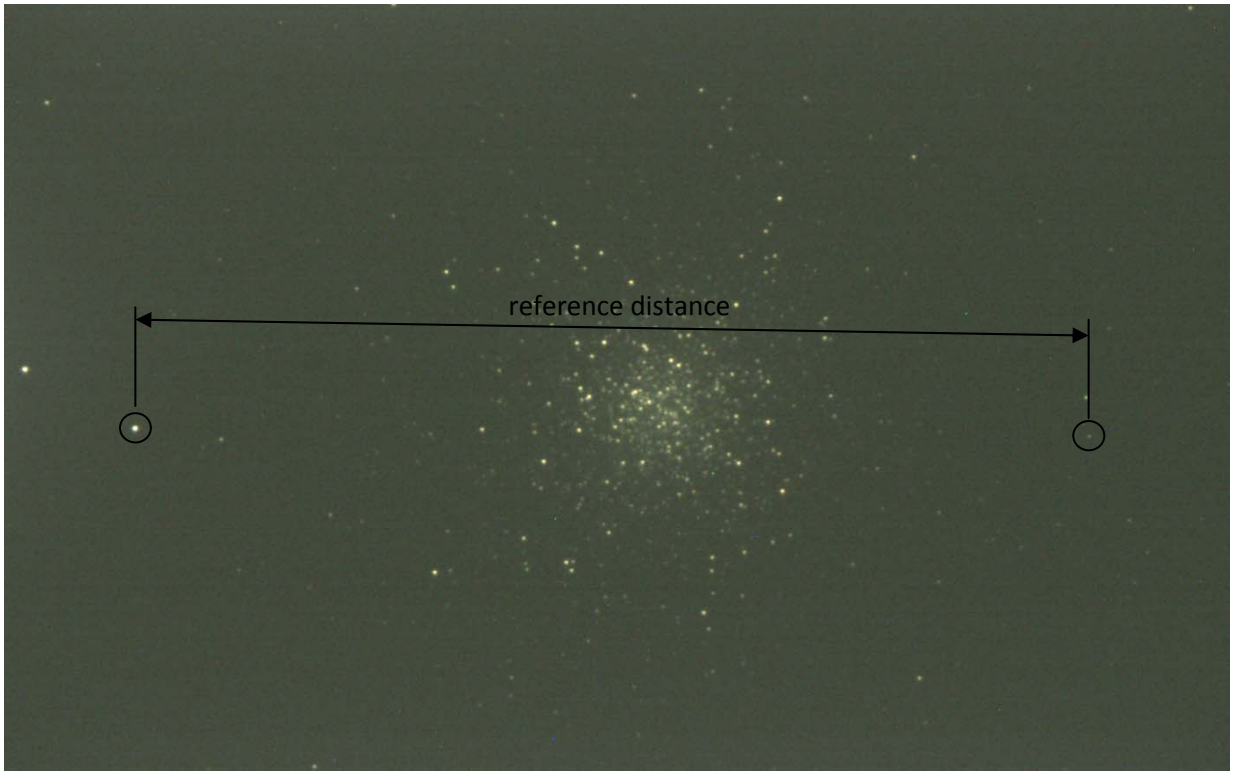

Figure 2 M13 Through VRC10 at Native f/8 (no FR)

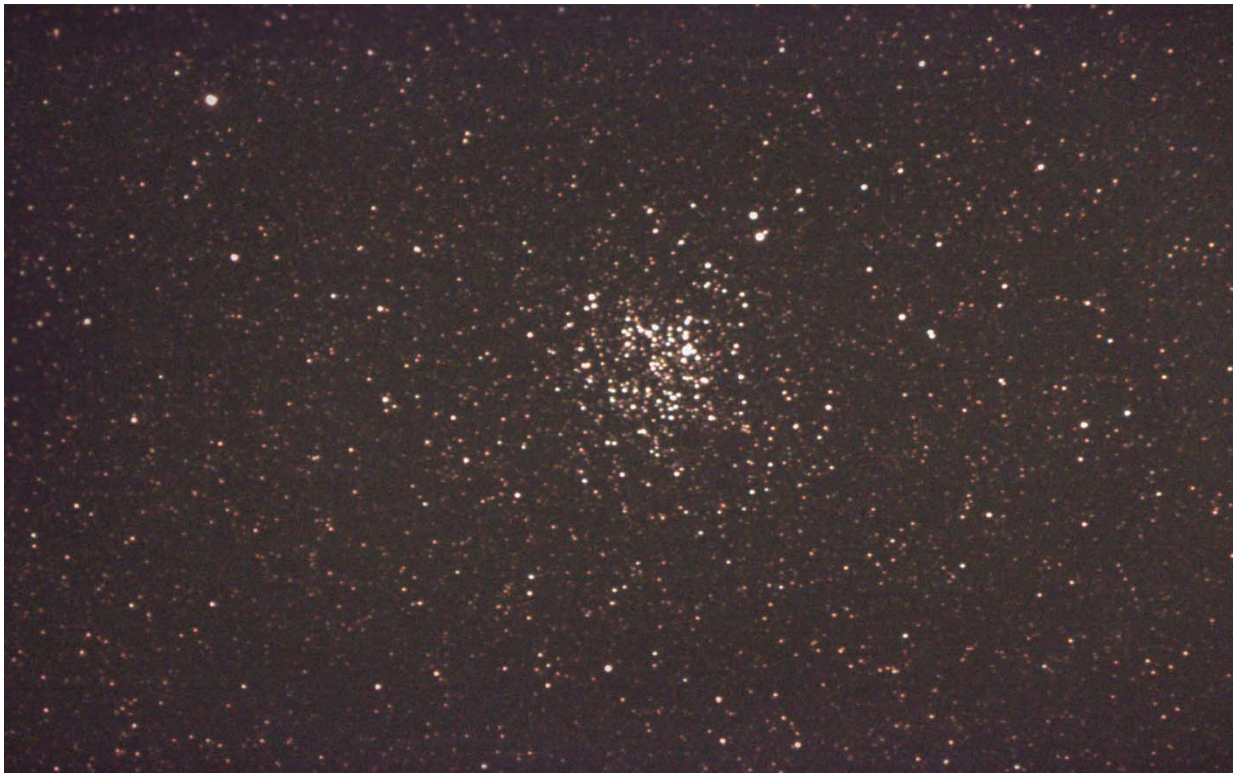

Figure 3 M11 Through VRC10 w/ FR Config #6 (f/3.87)

The focal reduction factor that resulted from each FR configuration has been summarized in Table 1 below. Included in the table is a measurement of the percentage of the frame by area that was observed to be coma free and vignetting free, which in this case was 100% for all the configurations tested. Out of curiosity I plotted this new data against data I collected back in 2013 (see Figure 4). At that time I limited my testing of the Meade f/6.3 FR to spacings that resulted in moderate reduction ratios which could be achieved with the FR entirely outside of the telescope focuser. My more recent testing routinely makes use of the fact that I can unscrew the 2"-to-3" adapter from my VRC10's focuser and install the SCT focal reducer on the inside of the focuser drawtube, providing more in-focus. I have also included some of my other data from the testing earlier in 2016. All data plotted was collected using the same telescope, the VRC10. Note that in Figure 4 the FR-to-CCD distance is measured from the middle of the FR lens element, or in the case of a multiple lens FR from the middle of the lens stack.

test point	date	config	reduction factor	fratio	focal length	% coma free	% vign. free	focus dist. (mm)	relative clear FOV
1	30-May-16	native scope (VRC10 no FR)	1.000	8.00	2000	100	100	121	1.51
2		35mm+filter (5mm)+5mm+Meade0.63x	0.662	5.30	1324	100	100	91	2.28
3		35mm+filter (5mm)+5mm+1/4"+Meade0.63x	0.601	4.81	1201	100	100	70	2.52
4		35mm+filter (5mm)+5mm+3/4"+Meade0.63x	0.571	4.57	1142	100	100	58	2.65
5		35mm+filter (5mm)+5mm+1"+Meade0.63x	0.542	4.33	1083	100	100	44	2.79
6		35mm+filter (5mm)+5mm+1.3"+Meade0.63x	0.484	3.87	967	100	100	8	3.13

Table 1 FR Testing Result Summary

Conclusions:

1. The Meade f/6.3 SCT focal reducer performed better than expected. I was anticipating aberrations to be visible starting at a reduction factor of around 0.58x based on my previous testing. Instead I was able to reduce as far as my in-focus allowed, 0.48x, and still have an aberration free scene.
2. If the Meade f/6.3 SCT focal reducer could be repackaged to fit within a 2" casing instead of the SCT threaded casing, it would be much more versatile. To get the lowest f-ratios the FR needs to insert into the focuser draw tube to give as much in-focus as possible.

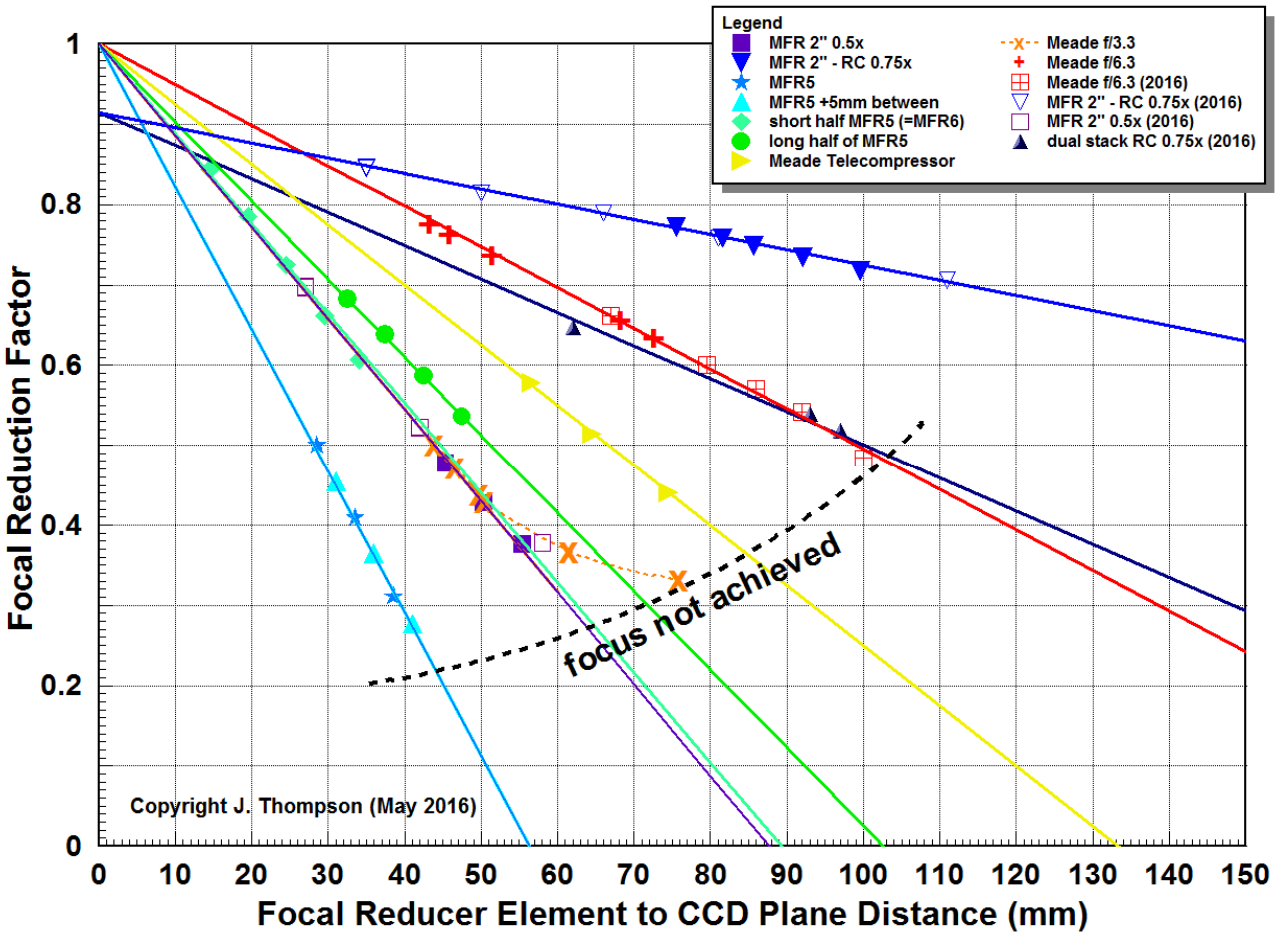

Figure 4 Focal Reduction Factor vs. FR-to-CCD Plane Distance

3. I have no idea how Antares and Celestron brand versions of the f/6.3 SCT FR perform compared to the "Made in Japan" Meade version I used in my testing.

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

Best Regards,

Jim Thompson
Abbey Road Observatory

top-jimmy@rogers.com

Appendix A - Images Captured During Testing

#1-native

#2-35mm+filter+5mm+M063x

#3-35mm+filter+5mm+13mm+M063x

#4-35mm+filter+5mm+19mm+M063x

#5-35mm+filter+5mm+25mm+M063x

#6-35mm+filter+5mm+33mm+M063x