Chapter 25

HRMA Ring Focus Shutter Test

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25.1 Introduction

The HRMA ring focus shutter test was designed to measure the HRMA shutter positions. During the HRMA calibration in early January 1997, it was found that the throughput of the HRMA top and bottom quadrants were unequal. For shell 6 it differed by as much as 10%. An early suggestion was that the shutters behind the HRMA were not positioned properly. For example, if the North or/and South shutters were blocking part of the bottom quadrant, the throughput asymmetry would occur. Also, if one shutter were blocking a slice of neighboring shell, the asymmetry could happen.

The quadrant shutter assembly, mounted behind the H shells, contained four shutters for each mirror. The shutters were named according to their positions: T(op), B(ottom), N(orth) and S(outh). Each shutter blade is 92 degrees wide to ensure complete blocking when all four shutters are closed.

25.2 Measurements

The ring focus shutter tests were made with the HSI at the ring focus position (65.2 mm defocus) and with either T & B shutters or N & S shutters open for one shell only. The eight shutter test images were taken on 15 Jan 1997 with the C-K EIPS source, immediately following the ring focus test (with run ID 108944), which had all 16 shutters open. Image 108944 had an integration time of 1800 sec. The shutter tests had integration times ranging from 200 to 600 sec; Table 25.1 lists these eight shutter tests.

25.3 Data Analysis

Figures 25.1–25.8 show the eight shutter test images as listed in Table 25.1. The image orientations are looking towards the HSI from the HRMA, i.e. the top, left, bottom, and right of each image corresponds to the Top, North, Bottom, and South at the XRCF. The mean radii of the rings from the four shells are 3.88 mm, 3.10 mm, 2.73 mm, and 2.05 mm, respectively.

Table 25.1: HRMA Ring Focus Shutter Test Data
Date: 15 Jan 1997 Source: C-Kα Defocus: 65.2 mm

Run ID	TRW ID	Shell	Shutters open	Defocus	Integration
108945	D-IXH-RF-17.001	1	T + B	65.2 mm	200 sec
108946	D-IXH-RF-17.002	1	N + S	65.2 mm	200 sec
108947	D-IXH-RF-17.003	3	T + B	65.2 mm	200 sec
108948	D-IXH-RF-17.004	3	N + S	65.2 mm	300 sec
108949	D-IXH-RF-17.005	4	T + B	65.2 mm	360 sec
108951	D-IXH-RF-17.006	4	N + S	65.2 mm	360 sec
108953	D-IXH-RF-17.007	6	T + B	65.2 mm	600 sec
108954	D-IXH-RF-17.008	6	N + S	65.2 mm	600 sec

To analyze the data, each image pair was combined to make a full ring. Figures 25.9–25.12 show the four combined full rings.[1] Each ring was sliced into 360 sectors with 1 degree per sector. The intensity of each sector (counts/second/sector) was then measured using the IRAF/imcnts package and plotted as a function of azimuthal angle.

25.4 Results

Figures 25.13–25.16 illustrate the results of the ring focus shutter test for the four shells. There are five panels in each figure:

1. The top panel shows the HSI intensity of the corresponding ring from run 108944 (C-Kα source, 1800 sec exposure time), which was taken with all the shutters open. The intensity variation is due to the quantum efficiency of the HSI which depends on the incident angle of the X-ray. There are intensity dips at 30 degree multiples. These are due to the supporting struts blocking the rays.

2. The second panel is the HSI intensity from the shutter tests. In addition to the intensity dips at 30 degree multiples, there are dips at $\pm$45 and $\pm$135 degrees. These are due to the shutter overlaps: each shutter is designed to be 92 degrees wide, so each open quadrant should be 88 degrees wide. The figures show that those dips are 2-3 degrees wide as expected. And their positions are within 1-2 degrees from the expected values.

3. The third panel is the ratio of the above two panels. The dips at $\pm$45 and $\pm$135 degrees are still there as expected. There are also spikes (both positive and negative) at 30 degree multiples. Because the HSI was moved between these tests, the gaps were not aligned exactly.

4. The fourth panel is the third panel with the spikes and dips removed. It looks pretty flat.

5. The fifth panel shows the data from the fourth panel binned into 15 degree bins and fitted to a straight line. The straight line is the average ratio over the entire ring. The straight line fits these data very well.

[1] In Figure 25.9, a quasi-elliptical scattering pattern, clocked about 7 degrees clockwise, appears above and below the shell 1 ring. In Figure 25.11, there is a very faint ring outside the shell 4 ring. There is also a faint scattering pattern on the north side of the ring 3 (Figure 25.10). These were probably caused by the reflections from the mirror ends, which, for the last a few millimeters, have a slightly different tangent from the designed surface.

These figures answer the question of whether the shutters were mounted and positioned properly. As we can see, the ratios of the ring focus test and the shutter tests are nearly constant (other than the spikes and dips) with values between 2.89 and 2.99. The magnitude of these ratios is due to the source intensity difference between the run 108944 and the shutter test runs). These results tell us that the shutters were not blocking anything other than their assigned areas. If there were any unwanted blocking in the azimuthal direction, there would have been dips wider than 2-3 degrees at the ±45 and ±135 degree locations. If there were any unwanted blocking in the radial direction, the intensity ratio in that quadrant would have systematically dropped below the overall average ratio.

25.5 Conclusion

The conclusion is: based on the HSI ring focus shutter test, all the shutters were mounted properly. They only block rays in their assigned area when closed. The HRMA shutters do not block on-axis rays beyond design expectations. (Note, however, the design requirements did allow the shutters to vignette off-axis rays, as discussed in Chapter 15). The HRMA throughput asymmetry was not due to shutter vignetting. (Later, the throughput asymmetry was attributed to the decenters between the P shells and the H shells. See Chapter 30 of this report.)

HRMA Ring Focus Shutter Test Images

Source: C-Kα, Defocus: 65.2 mm

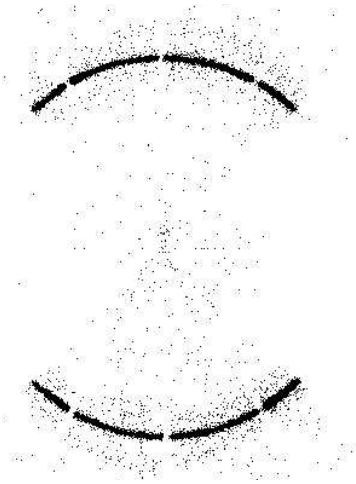

Figure 25.1: D-IXH-RF-17.001, 108945, Shell 1 TB, 200 sec.

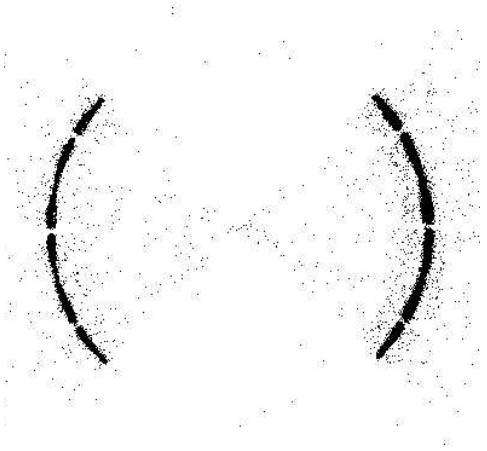

Figure 25.2: D-IXH-RF-17.002, 108946, Shell 1 NS, 200 sec.

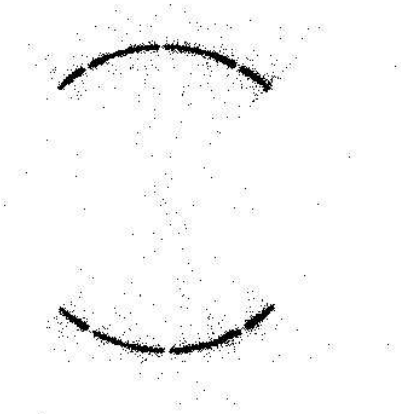

Figure 25.3: D-IXH-RF-17.003, 108947, Shell 3 TB, 200 sec.

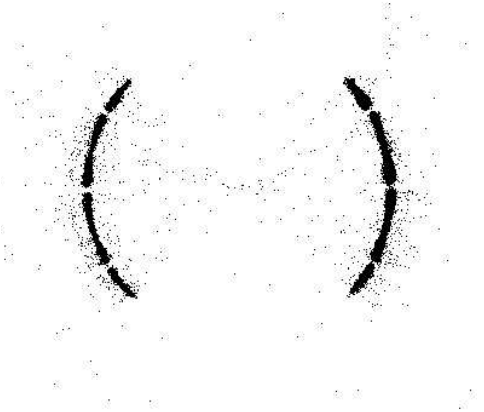

Figure 25.4: D-IXH-RF-17.004, 108948, Shell 3 NS, 300 sec.

HRMA Ring Focus Shutter Test Images
Source: C-Kα, Defocus: 65.2 mm

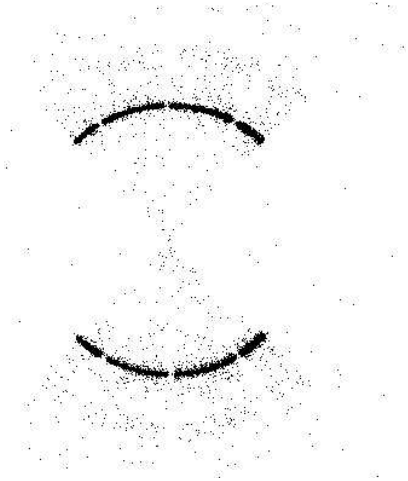

Figure 25.5: D-IXH-RF-17.005, 108949, Shell 4 TB, 360 sec.

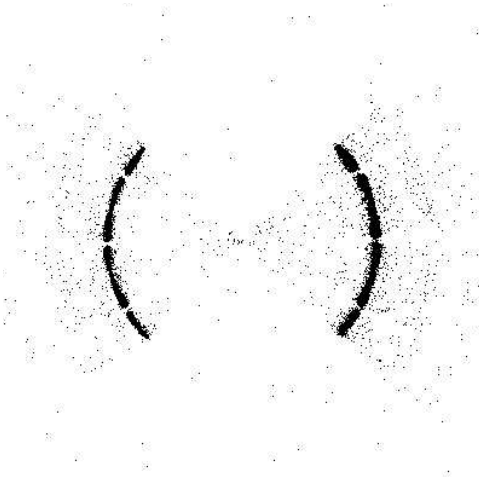

Figure 25.6: D-IXH-RF-17.006, 108951, Shell 4 NS, 360 sec.

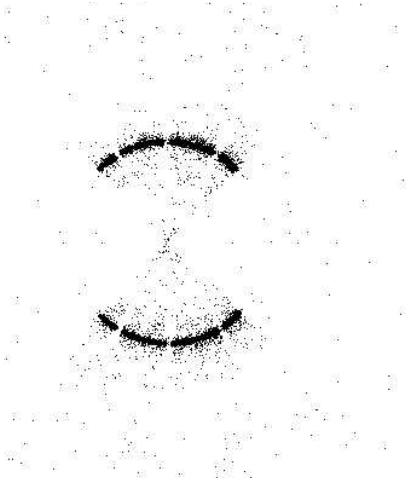

Figure 25.7: D-IXH-RF-17.007, 108953, Shell 6 TB, 600 sec.

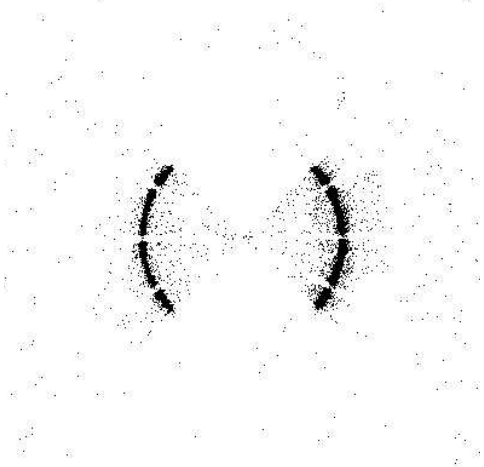

Figure 25.8: D-IXH-RF-17.008, 108954, Shell 6 NS, 600 sec.

HRMA Ring Focus Shutter Test Combined Images
Source: C-Kα, Defocus: 65.2 mm

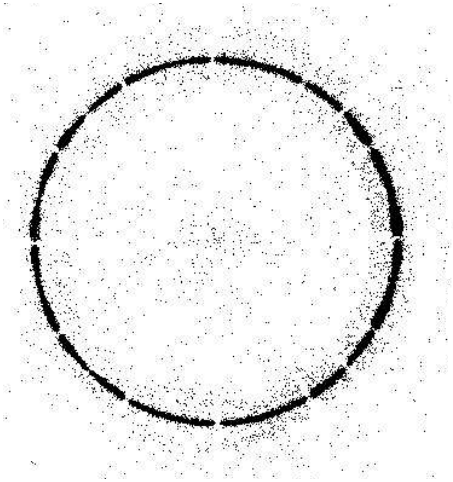

Figure 25.9: 108945 & 108946, Shell 1, 200 + 200 sec.

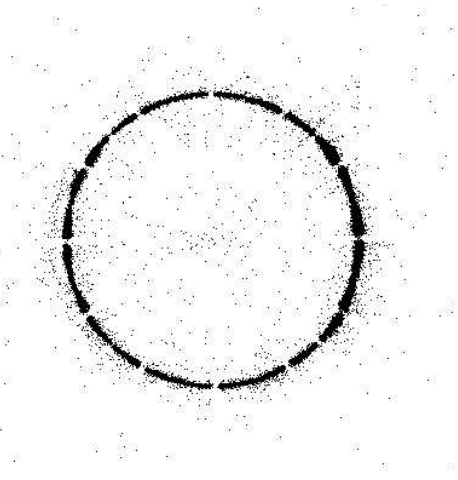

Figure 25.10: 108947 & 108948, Shell 3, 200 + 300 sec.

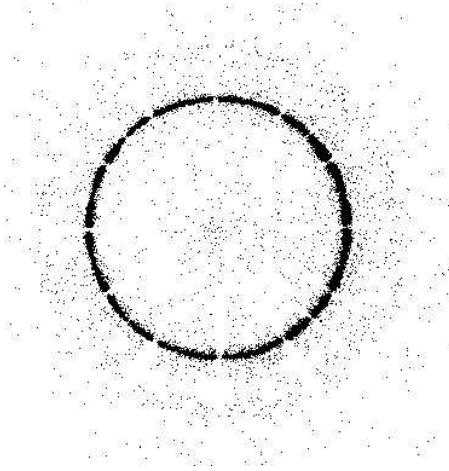

Figure 25.11: 108949 & 108951, Shell 4, 360 + 360 sec.

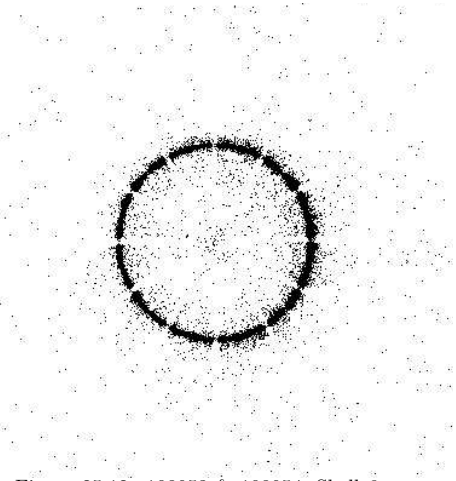

Figure 25.12: 108953 & 108954, Shell 6, 600 + 600 sec.

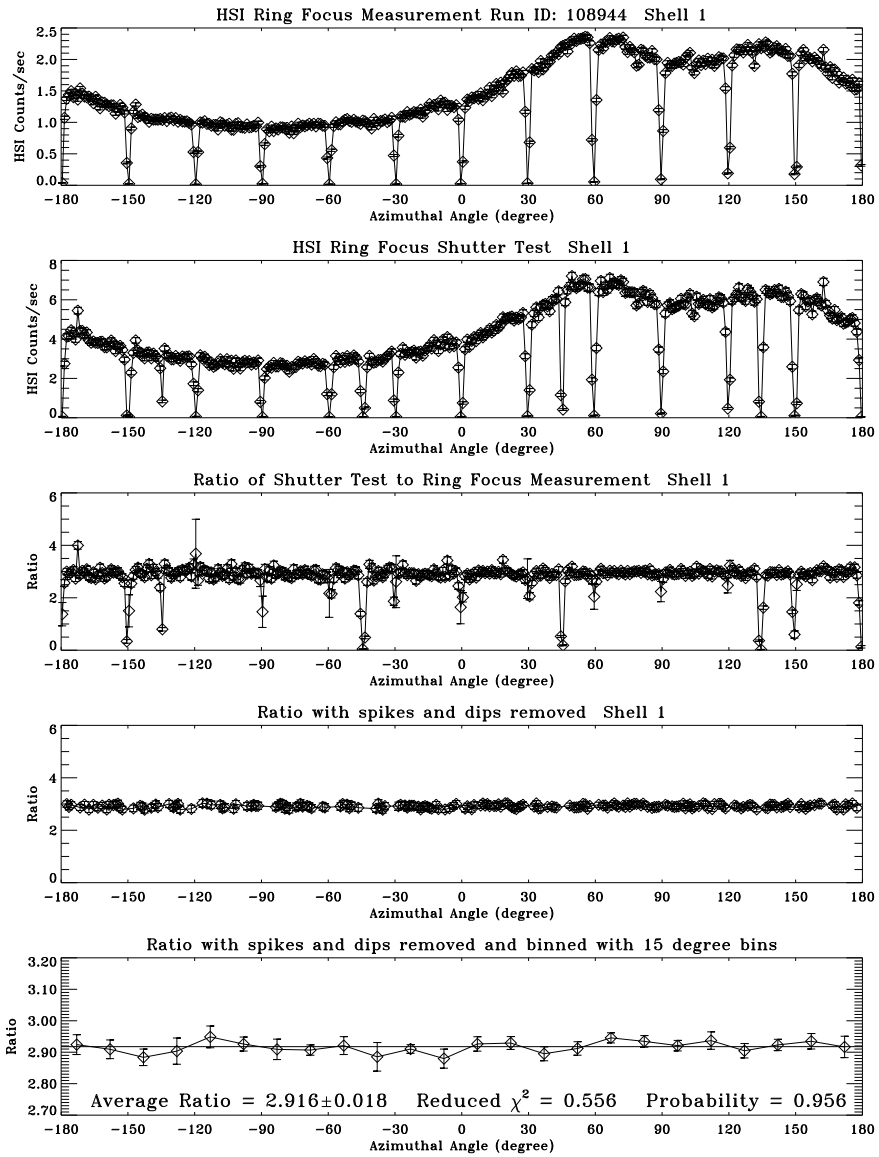

Figure 25.13: The HRMA ring focus shutter test results. Shell 1

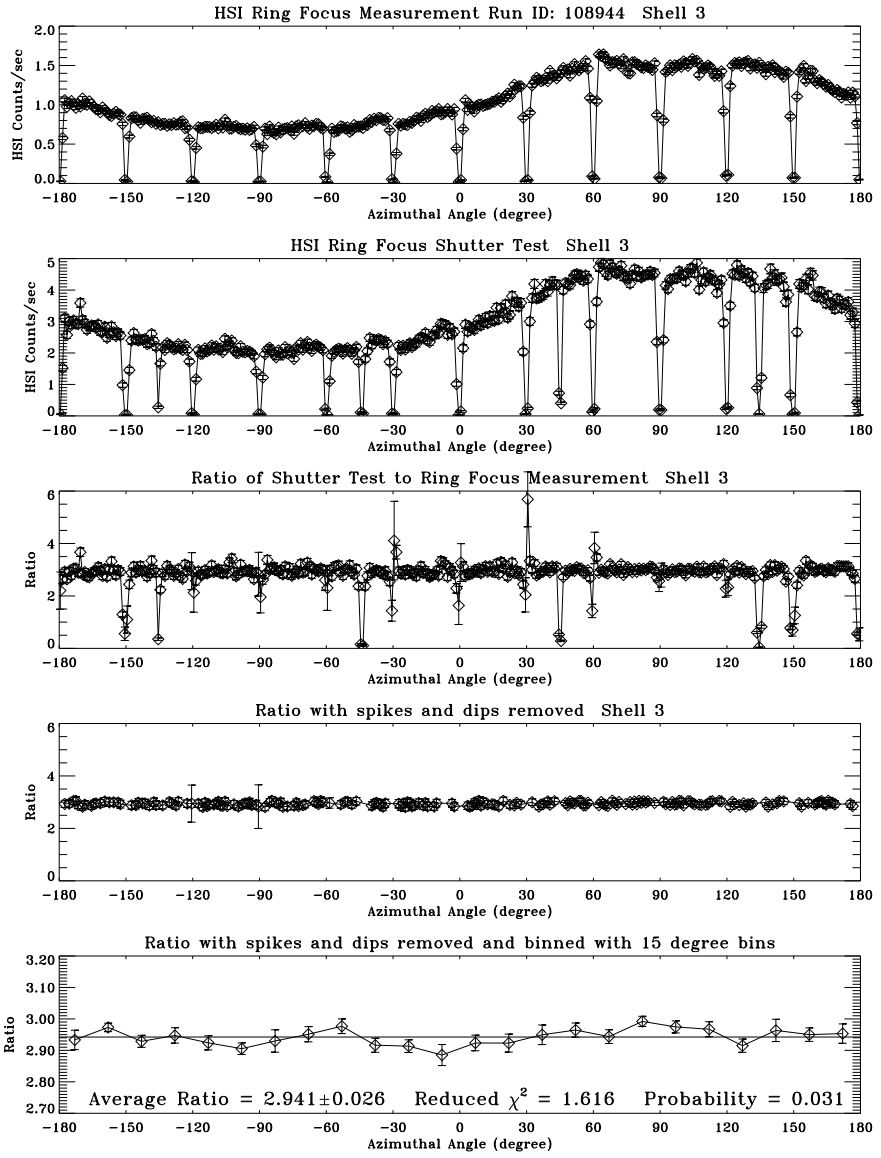

Figure 25.14: The HRMA ring focus shutter results. Shell 3

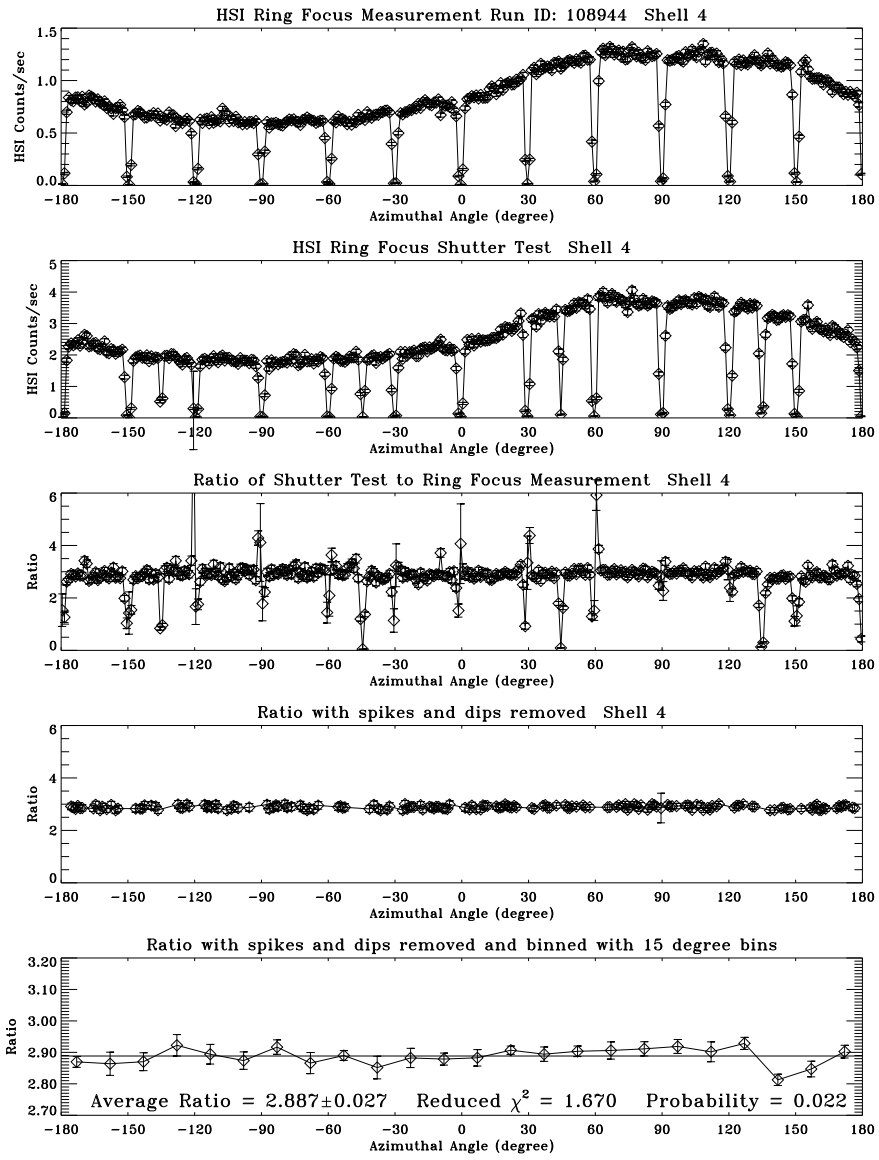

Figure 25.15: The HRMA ring focus shutter results. Shell 4

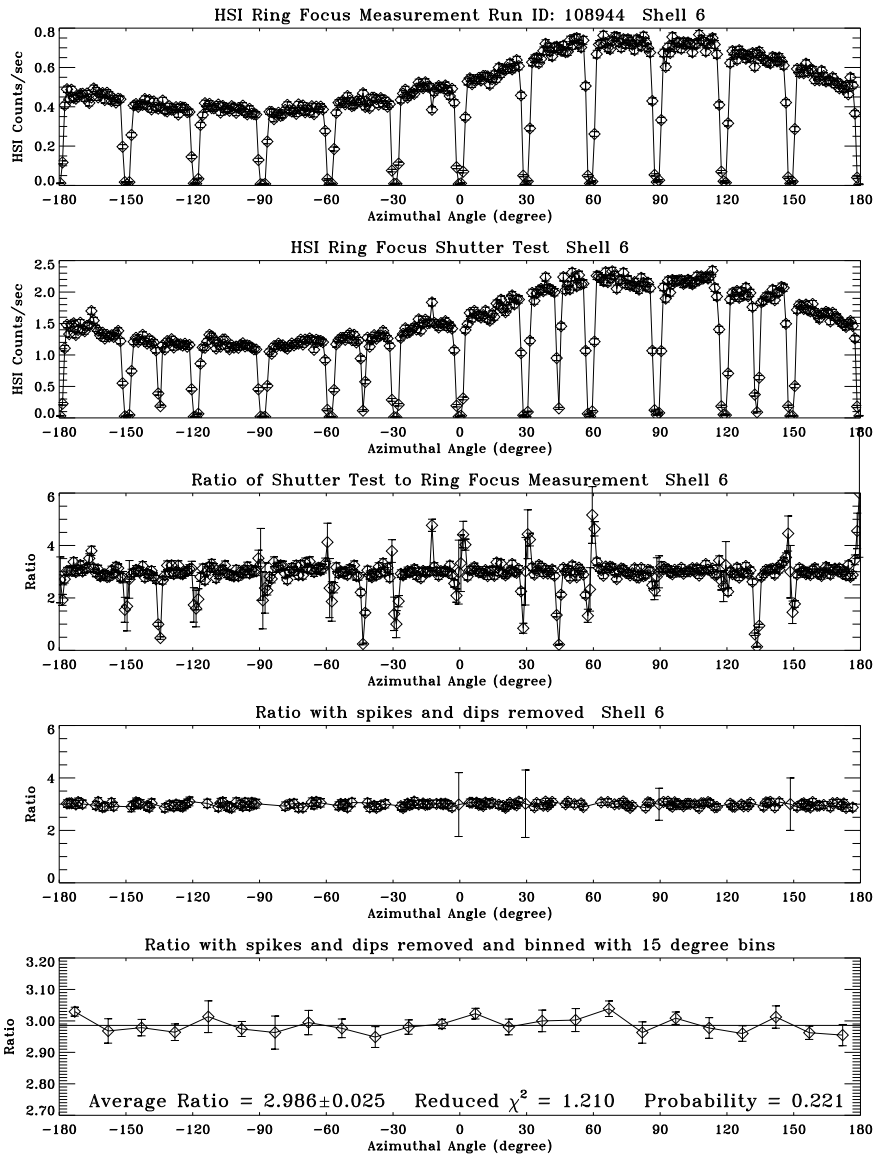

Figure 25.16: The HRMA ring focus shutter results. Shell 6