Cluster CODIF Calibration Report
Part II

Geometric Factor, Energy and Angle Response

Lynn M Kistler

7/6/00

Table of Contents

Table of Figures

Table of Tables

Introduction

The total energy and angle response, and the final geometric factor of the CODIF sensor are measured by integrating the response of the instrument over the full range of energies and angles. These measurements were done with the instrument in full flight configuration, including the grids at the front aperture. A separate calibration of the electrostatic analyzer alone, without grids and without the time-of-flight section has been performed, and is reported in a separate document. These tests with the full instrument do not include as large a sample as the tests with the ESA alone - in general only one or two measurements were made on each side of the instrument. In the conclusions, the results from the full system test will be compared with the results from the ESA for each model.

Determining the Geometric Factor

Determining the energy and angle response of the sensor and the geometric factor are all done with the same type of measurement. An azimuthal (theta) angle is chosen. This is generally the center of one of the pixels, but some off-center measurements were taken. The input beam is held at a constant energy and flux level, and then the voltage on the electrostatic analyzer and the polar (alpha) angle of the instrument are stepped through the full range of values through which particles are accepted into the instrument. The result is a matrix in angle and voltage space. The response to a constant beam as a function of voltage is equivalent to the response for a constant voltage and stepping through a range of incoming beam energies.

With this data set, the geometric factor is determined in the following way:

For a flux of **j** (cts/(cm2-s-ster-keV/e)) at the instrument entrance, and a count rate of **N** (cts/s) measured in the instrument, the geometric factor, **G** is defined as
G = N/j, with units (cm2 - ster - keV)

The effective incoming "omni-direction flux" j is

j = (dN/ dt)*1/(dE dA dΩ)

where
dN/ dt is the incoming beam rate in ct/s, recorded from the CEM beam monitor
dE is the energy step size, **dE = κ * d(ESA)** with units (KeV),
κ = analyzer constant = 7.5
d(ESA) = ESA step size volts (usually between 2 and 10 volts)
dA is the beam monitor area, **dA**=0.1 cm^2
dΩ is the solid angle step size, **dΩ** =22.5 degrees θ * 1 degree α = 0.006854 radians

The count rate N (cnts/s), is the total counts entering the instrument. To get N, we use the start rate (SF) is summed over all the ESA/Alpha steps, and divide it by the start efficiency (SFR/SR). As noted in Part I of the calibration document, measuring the start efficiency has some difficulties because of threshold problems on the SR rate. Uncertainties in this value therefore lead directly into uncertainties in the geometric factor. Other contributors to the uncertainty in this value are the constancy of the beam, any uncertainty in the beam monitor measurement, and the background over these long (~5 hour) runs. Background counts were subtracted from all files. To determine the background rate, we used a set of steps at the beginning and the end of each run when no beam particles were entering the instrument. Therefore,

N = ∑ (SF-bkgnd) / (SFR/SR) with units of cnts/s.

Since the geometric factor depends on the incoming energy, an energy independent factor, **g**, can be found by dividing **G** by the energy **E** (keV) of the incoming beam.

g = G/E with units (cm^2-ster)

Determining the Energy and Angle Response

Using the same data set, the energy and angle response, and the analyzer constant, k, are determined by summing the ESA V vs angle matrix in voltage and in angle. The angle and energy response curves are fit to gaussions. From the fits, we derive the peak, and width of the distributions.

FM5 results

Table 1 summarizes the full matrix files which were collected for FM5.

Table 1. Summary of ESA-Alpha scans for FM5.

File	Position (pixel)	Beam Species	Beam Intensity (Hz)	Beam Energy
F5B_19991019_155645a	3, center	He+	990	5 keV
F5B_19991019_155645b	3, edge	He+	990	5 keV
F5B_19991020_154554	14	O+	24270	5 keV

HS response

Figure 1 shows a line plot of the SF rate for the two ESA-Alpha scans on the high side. The counts are normalized by both beam rate and start efficiency, so that the only factor which should account for differences is the geometric factor. The scans start at an alpha of –7 degrees, and then step through the full range of ESA voltages before moving tp the next angle in 1 degree increments. Thus the 13 peaks seen in Figure 1 correspond to ESA scans at 13 different alpha angles, from –7 to +6). Figure 2 shows the same data, but only including the center peaks at alpha= -1, 0, and 1. Note that the two data sets show quite different structure in the peaks. The structure in each of the peaks is a result of the beam moving over the grids which support the carbon foil in the time-of-flgiht section of the instrument. Since ions enter over the full range of energies and angles simultaneously, this enters into the flux calculation as part of the overall geometric factor.The structure in each of the peaks is a result of the beam moving over the grids which support the carbon foil in the time-of-flgiht section of the instrument. Since ions enter over the full range of energies and angles simultaneously, this enters into the flux calculation as part of the overall geometric factor.

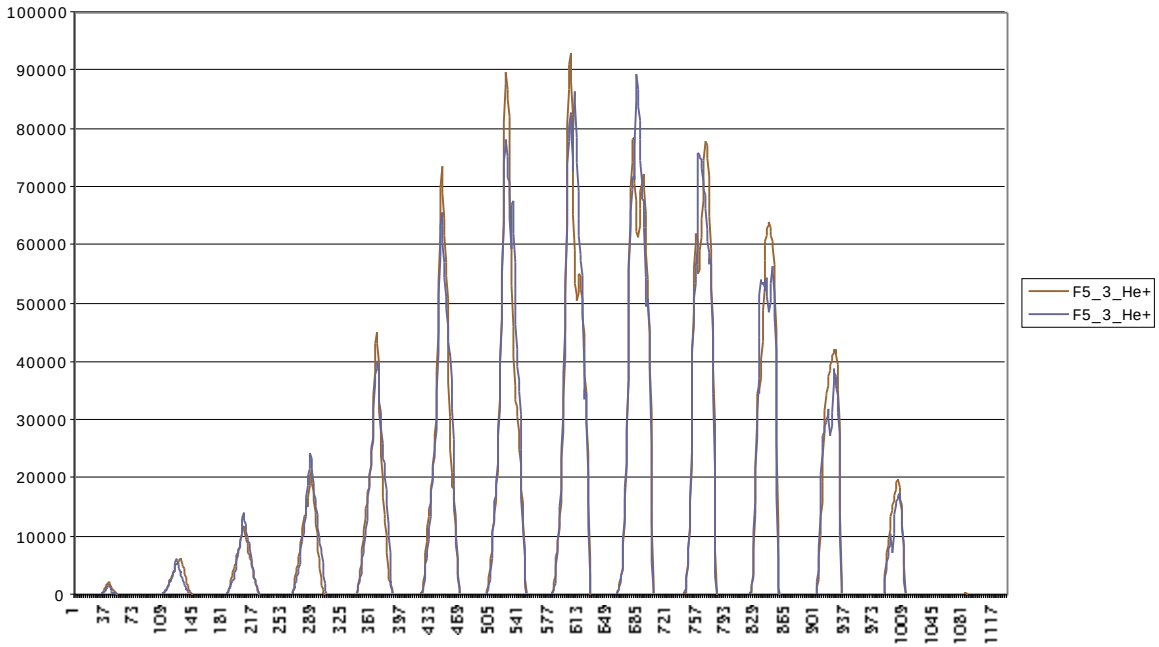

Figure 1.Full ESA Alpha scans for FM5 on the high side.

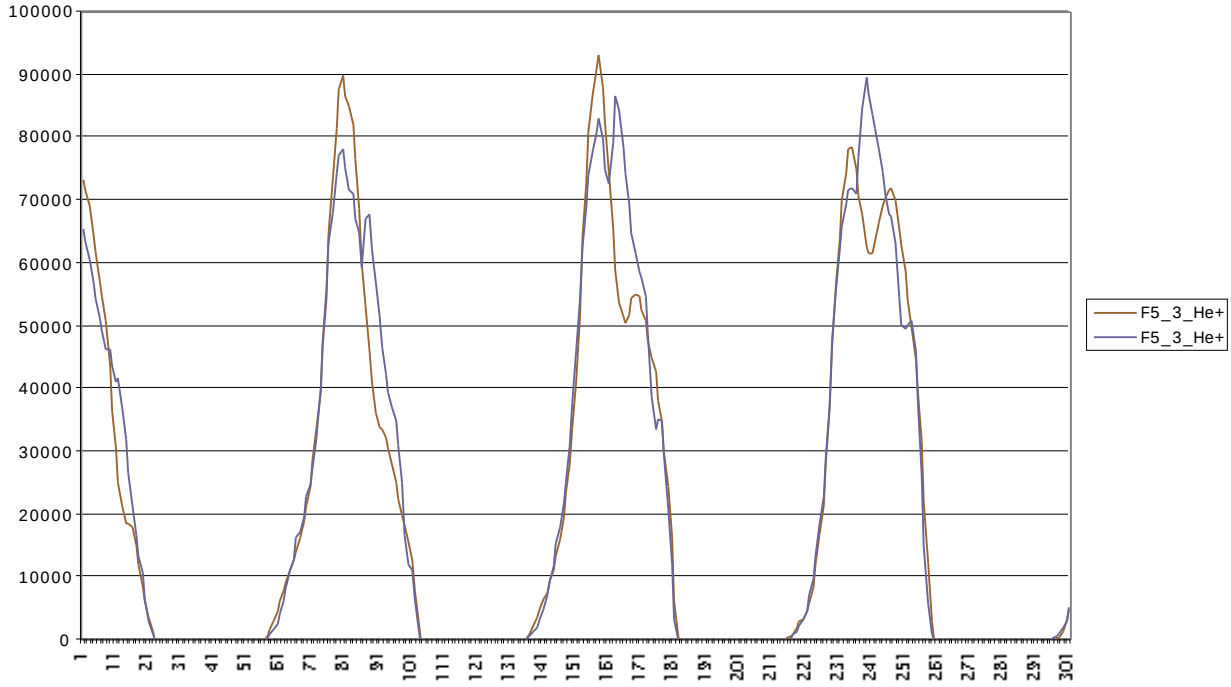

Figure 2. ESA scans for alpha values –1, 0, and 1 for the same files as figure 1.

Figures 3 and 4 show the integrated energy and angle response for F5B_19991019_155645a (pixel 3, center) and figures 5 and 6 show the energy and angle response for F5B_19991019_155645b (pixel 3, edge). Finally, the results of the gaussian fits to the curves, and the total geometric factor are given in tables 2 and 3.

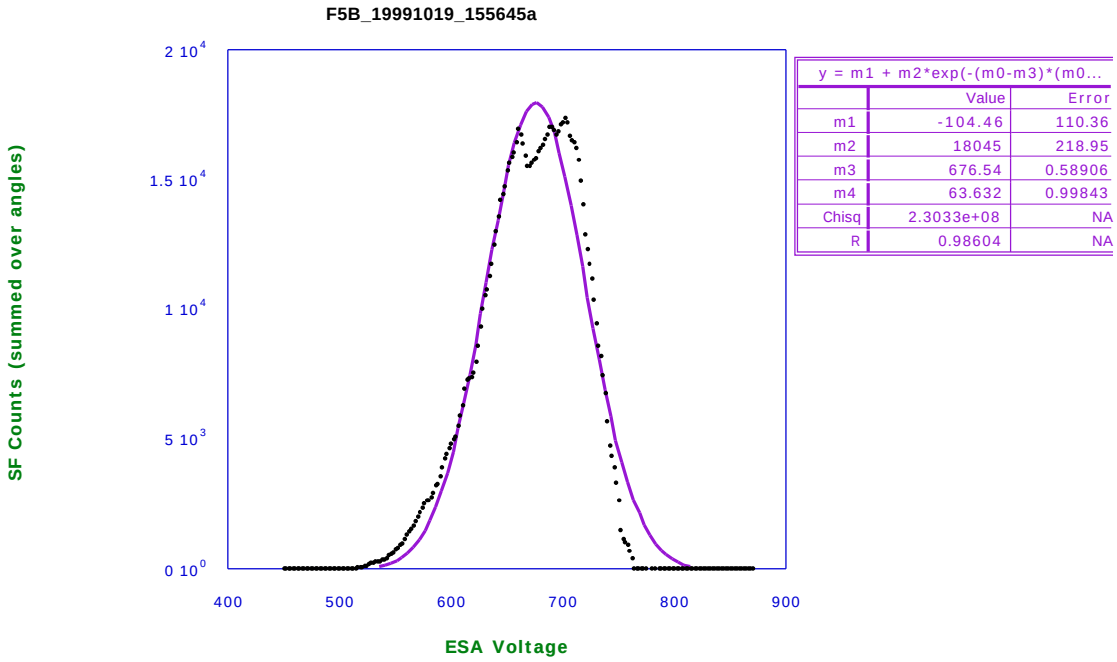

Figure 3. Integrated ESA response FM5, pixel 3, 5 keV He+ beam.

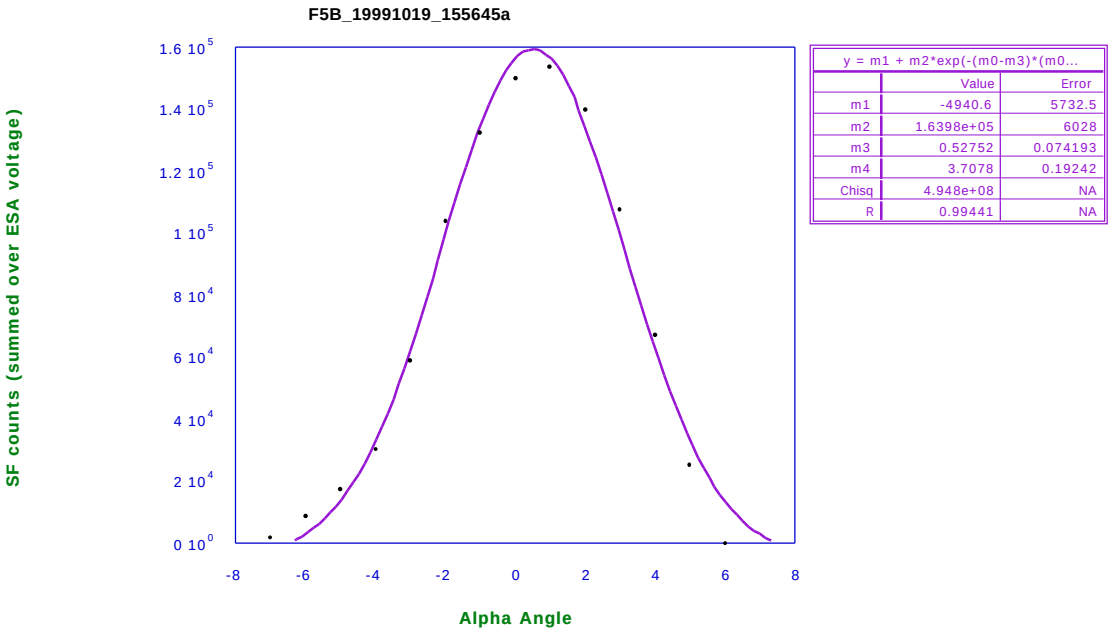

Figure 4. Integrated Alpha response for FM5, pixel 3, 5 keV He+ beam.

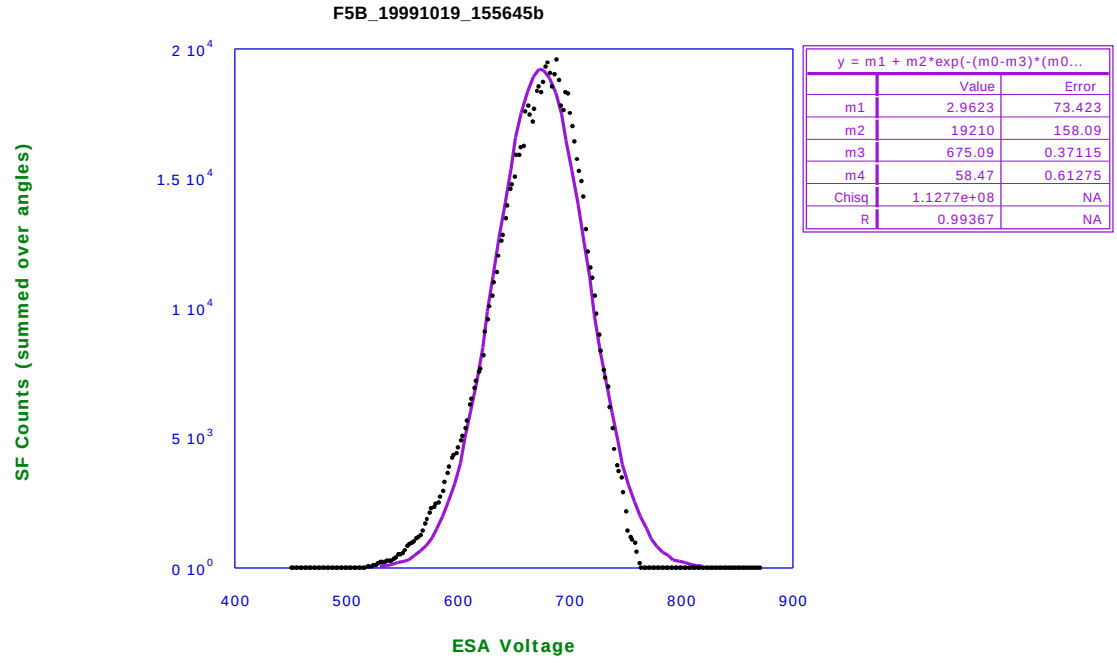

Figure 5. Integrated ESA response FM5, pixel 3, edge, 5 keV He+ beam.

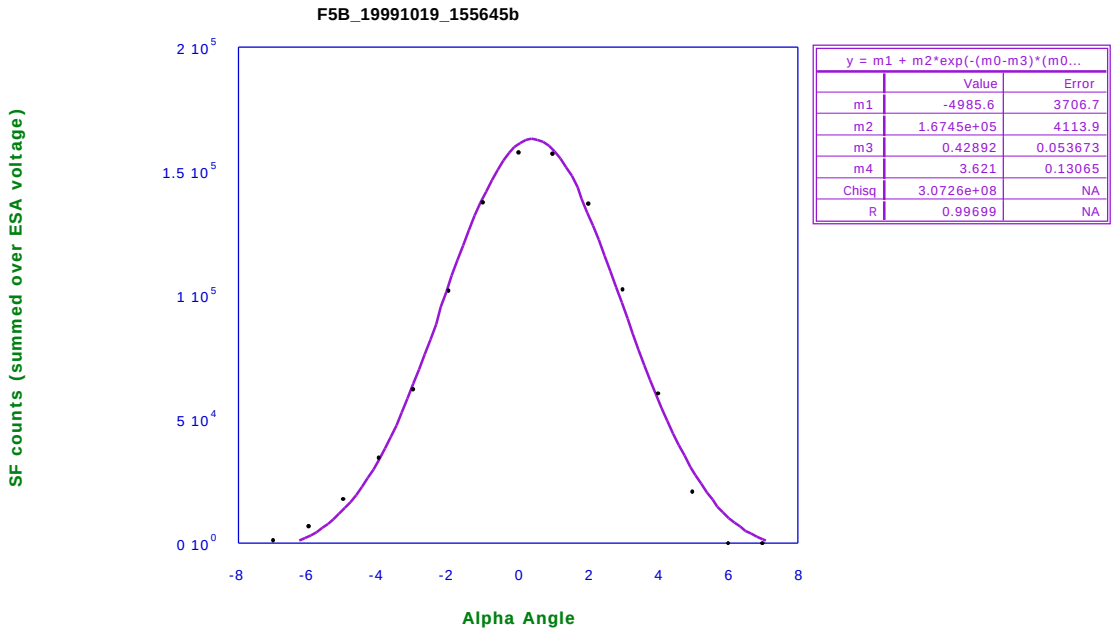

Figure 6. Integrated angle response for FM5, pixel 3, edge, 5 keV He+ beam.

Table 2. Summary of the FM5 HS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F5B_19991019_155645a	5 He+	676.54	105.95	0.157	0.132	7.391	2.58E-03
F5B_19991019_155645b	5 He+	675.09	97.36	0.144	0.123	7.406	2.59E-03
Average		675.82	101.66	0.150	0.128	7.398	2.59E-03

Table 3. Summary of FM5 angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F5B_19991019_155645a	5	0.53	6.174
F5B_19991019_155645b	5	0.43	6.029
Average		0.48	6.102

LS response

Figure 7 shows a line plot of the SF rate for the one ESA-Alpha scan on the high side. Figure 8. Shows a zoomed version of the plot, centered on alpha = 0. Again, the structure in the peaks can be seen. The integrated ESA and Alpha responses are shown in figures 9 and 10. Finally tables 4 and 5 give the fit values and geometric factor for this side of the instrument.

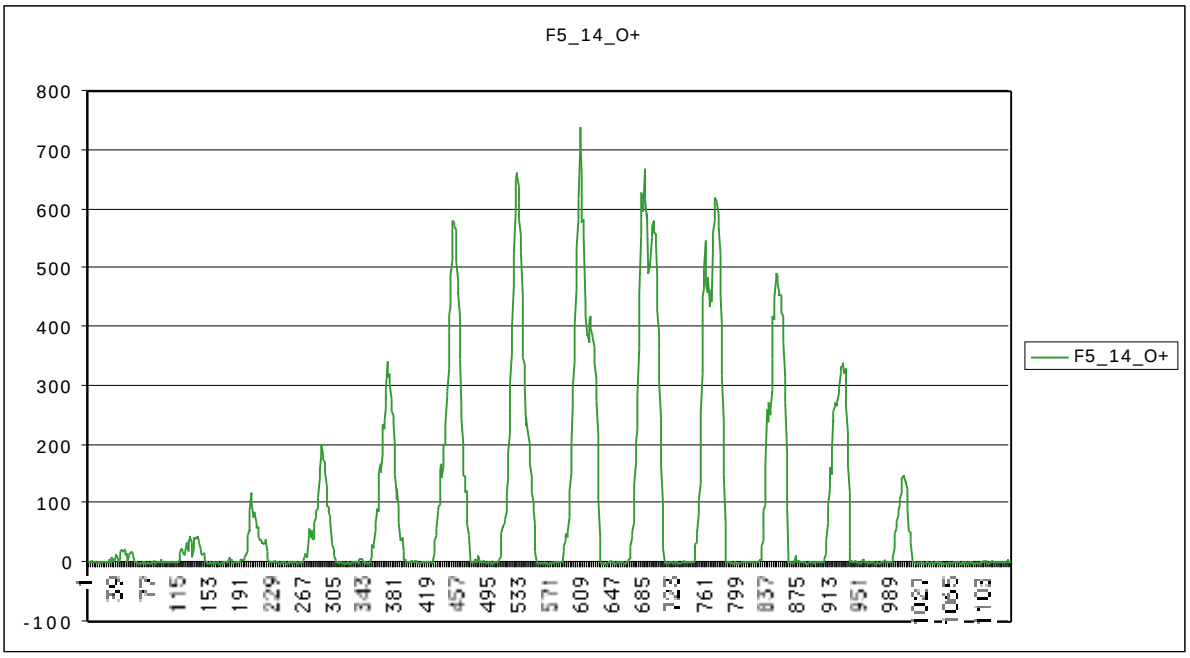

Figure 7. Full scan on LS side (PF 14)

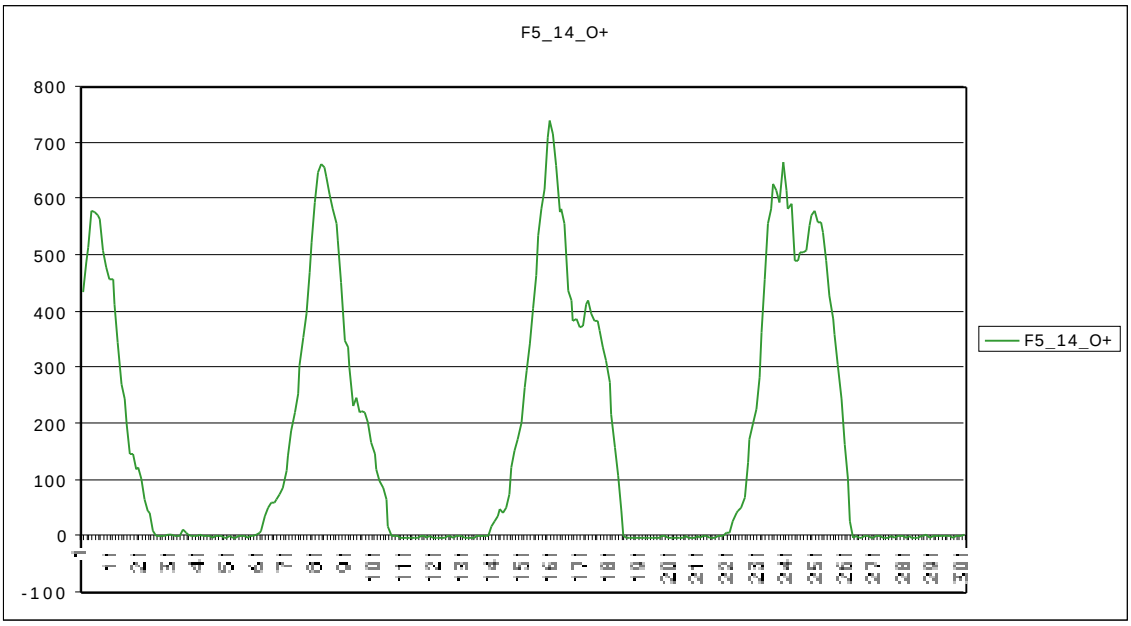

Figure 8. ESA scans for alphas –1, 0, and 1.

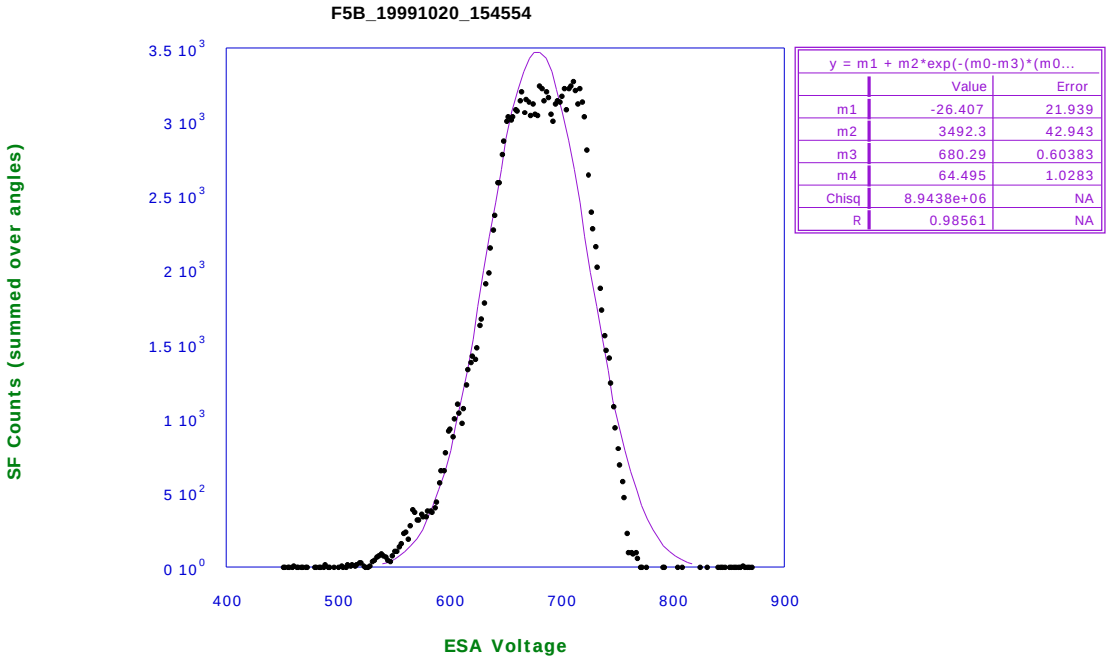

Figure 9. ESA response for F5B_19991020_154554, pixel 14 on LS side.

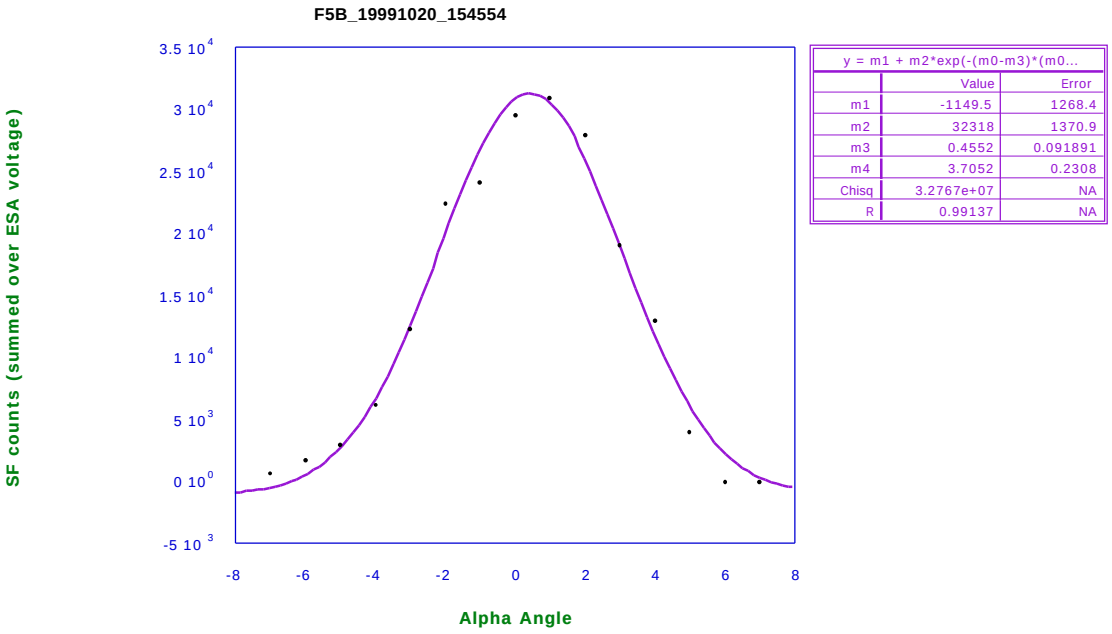

Figure 10. Alpha response for F5B_19991020_154554, pixel 14 on LS side.

Table 4. Summary of the FM5 LS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F5B_19991019_154554	5 He+	680.29	107.39	0.158	0.133	7.350	2.05E-05
Average				0.158	0.133	7.350	2.05E-05

Table 5. Summary of FM5 LS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F5B_19991019_154554	5	0.463	6.170
Average		0.463	6.170

FM6 results

Table 6 summarizes the full matrix files which were collected for FM6. In this case, only one scan was done on each side.

Table 6. Summary of ESA-Alpha scans for FM6.

File	Position (pixel)	Beam Species	Beam Intensity (Hz)	Beam Energy
F6B_19981115_143436	6, center	He+	8143	5 keV
F6B_19981116_124347	11, center	H+	12668	5 keV

HS Response

Figure 11 shows a line plot of the SF rate for the ESA-Alpha scan on the high side.

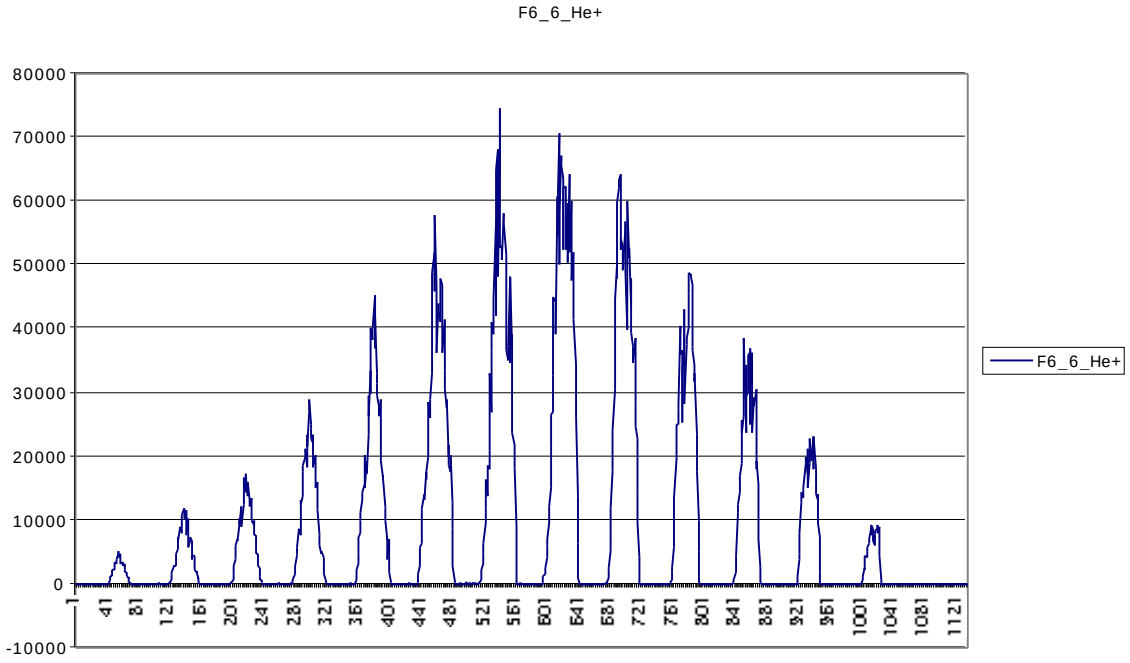

Figure 11. Full SF counts from F6B, 19981115_143436, an esa-alpha scan on FP6

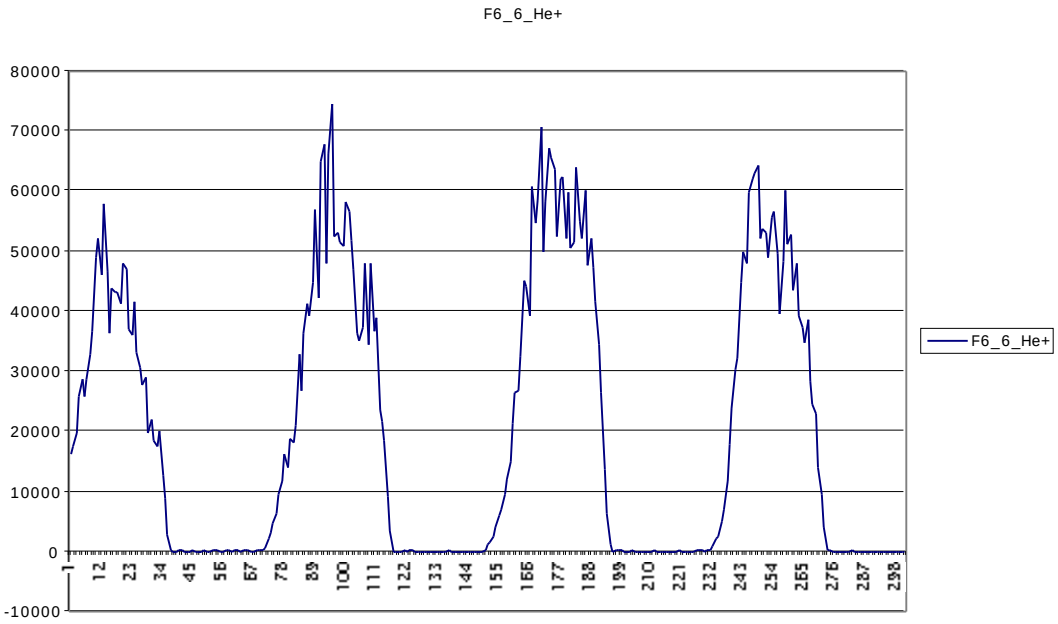

Figure 12. ESA scans on alpha = -2, -1., 0 and 1.

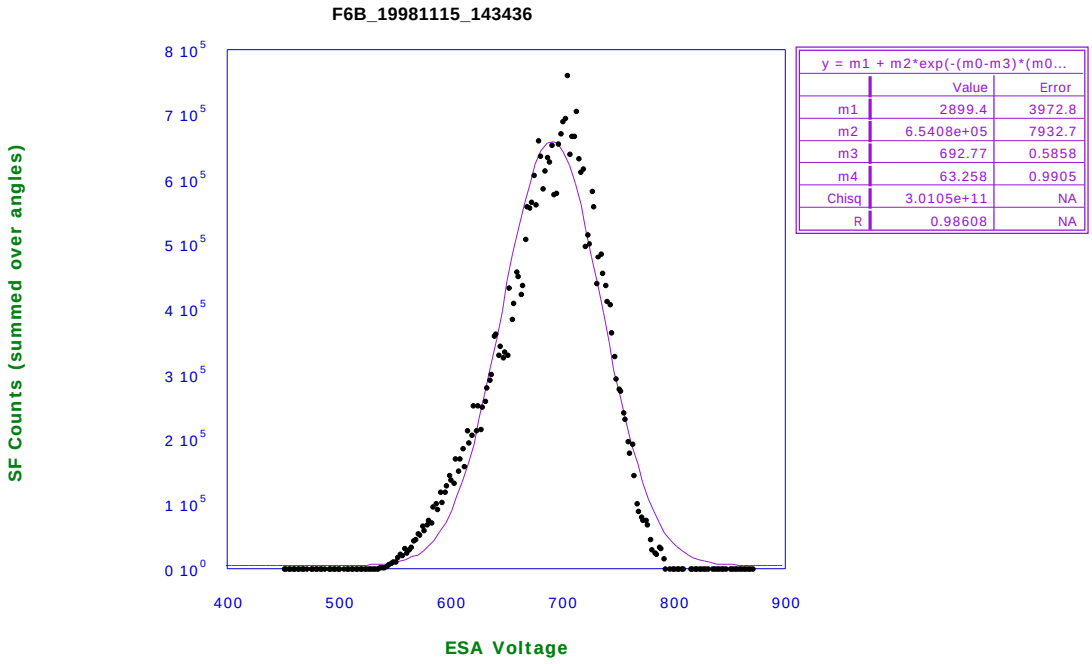

Figure 13. Averaged ESA response for F6B_19981115_143436.

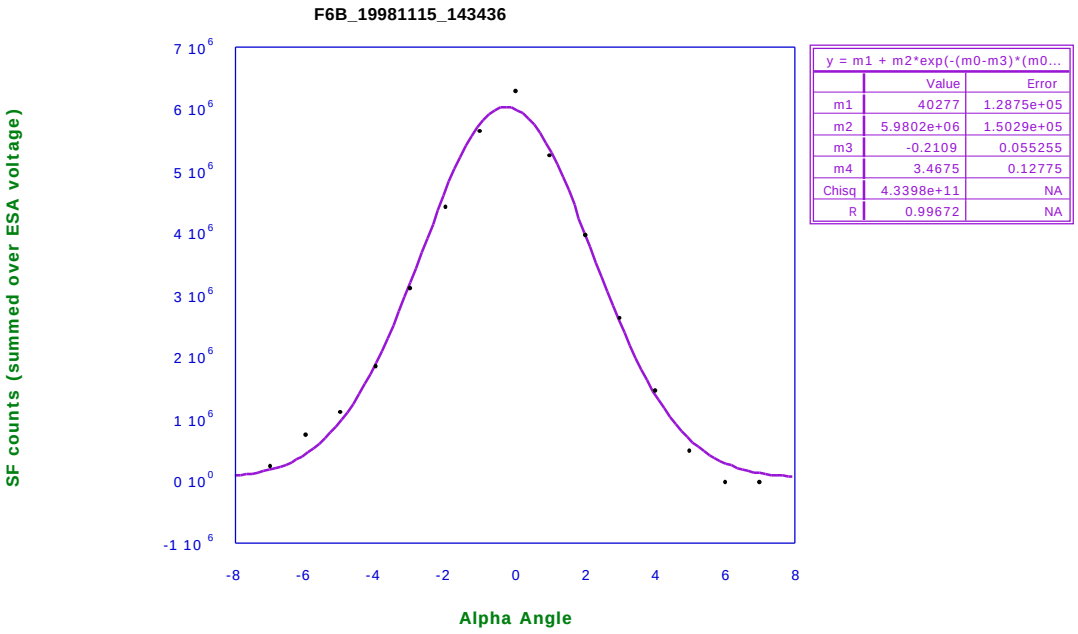

Figure 13. Averaged angle response for F6B_19981115_143436.

Table 7. Summary of the FM6 HS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F6B_19981115_143436	5 He+	692.77	105.33	0.152	0.129	7.217	2.45E-03
Average		692.77	105.33	0.152	0.129	7.217	2.45E-03

Table 8. Summary of FM6 HS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F6B_19981115_143436	5 He+	-0.21	5.774
Average		-0.21	5.774

LS Response

Figure 14 shows a line plot of the SF rate for the ESA-Alpha scan on the high side. As can be seen, the background during this run was high and variable. This therefore adds a large uncertainty to the geometric factor and energy and angular response calcuations.

Unfortunately, this is the only LS ESA-Alpha scan for FM6, so the difference between the HS and LS sides will have to be checked in flight.

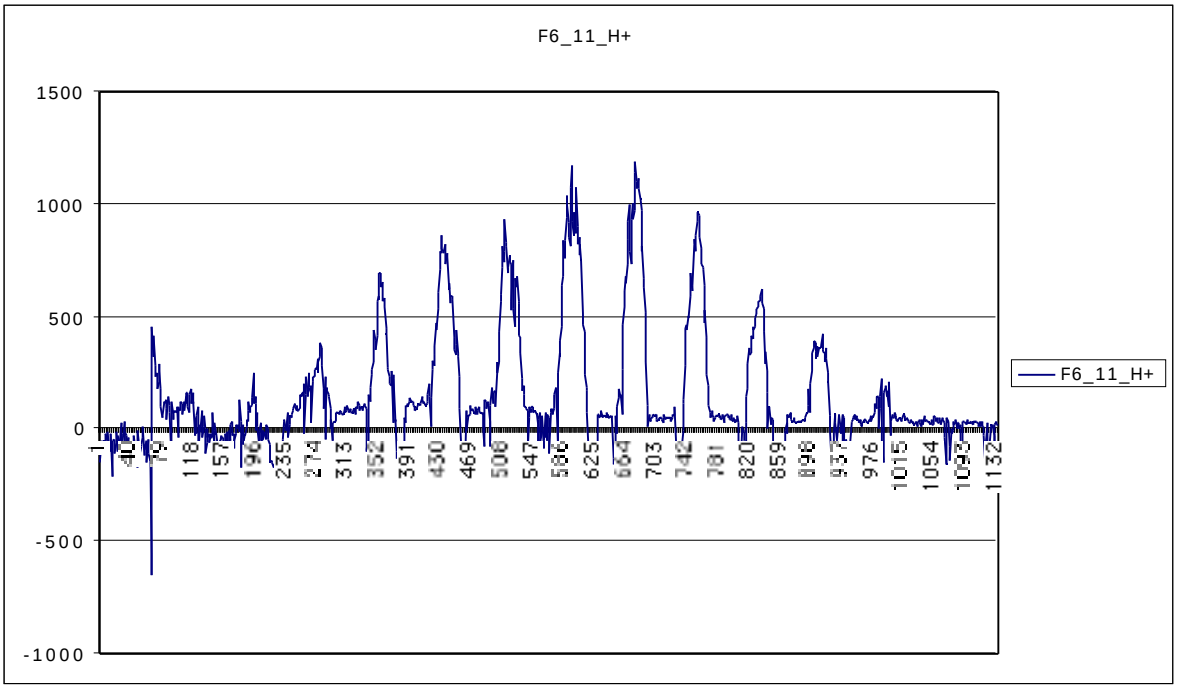

Figure 14. Averaged angle response for F6B_19981115_143436.

FM7 results

Table 9 summarizes the full matrix files which were collected for FM7. In this case there were three scans taken in the same position on each side, with different beam species and intensities. This gives us a good test of the uncertainties.

Table 9. Summary of ESA-Alpha scans for FM7.

File	Position (pixel)	Beam Species	Beam Intensity (Hz)	Beam Energy
F7B_19990303_163059	6, center	He+	5872	5 keV
F7B_19990304_160227	6, center	H+	5243	5 keV
F7B_19990307_083501	6, center	O+	9487	5 keV
F7B_19990303_122138	14, center	He+	95672	5 keV
F7B_19990305_160702	14, center	H+	6117	5 keV
F7B_19990306_180449	14, center	O+	26514	5 keV

HS Response

Figure 15 shows a line plot of the SF rate for the ESA-Alpha scans on the high side. Again, the curves have been normilized using our best knowledge of the start efficiency and the beam rate. Figure 16 shows just the ESA scans at alpha = -1, 0, and 1. It is clear in Figure 16 that the shapes of the curves are identical. The He+ and H+ curves are also almost identical in magnitude. The O+ curve is slightly lower. The geometric factor in all cases is the same, so this implies that either our start efficiency or the beam rate is not well known. One possibility is that the beam monitor response is slightly different for O+ than for H+ and He+.

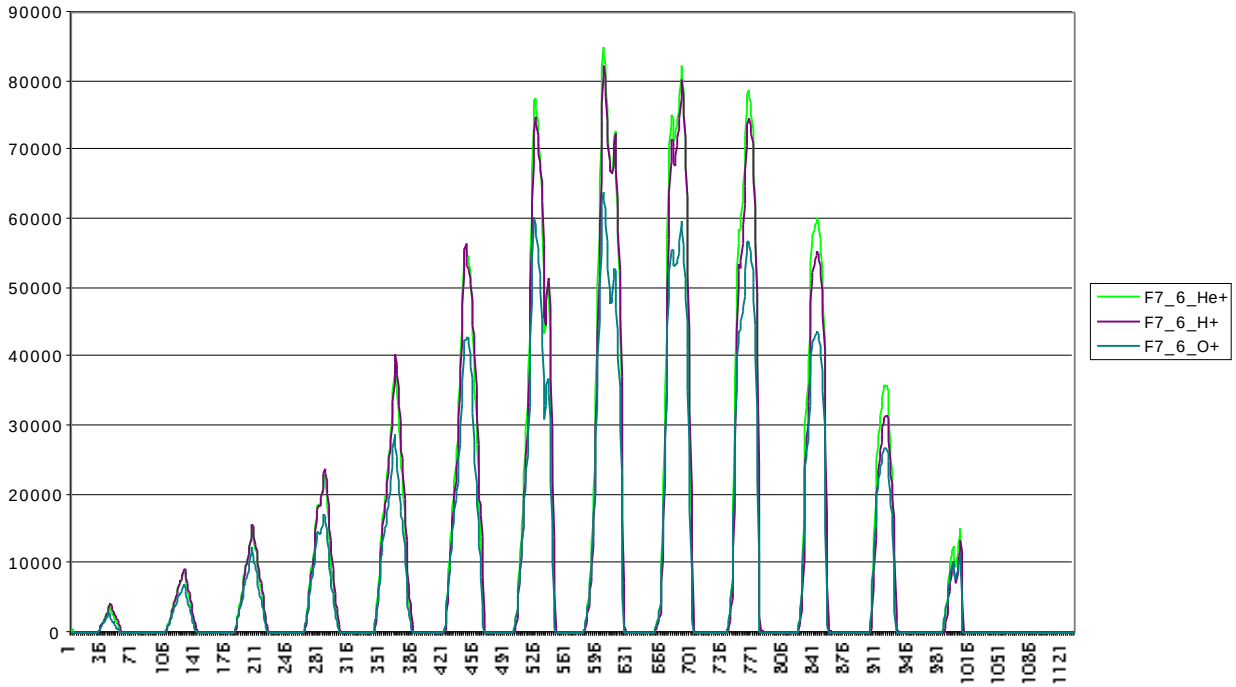

Figure 15 .Full ESA Alpha scans for FM7 on the high side.

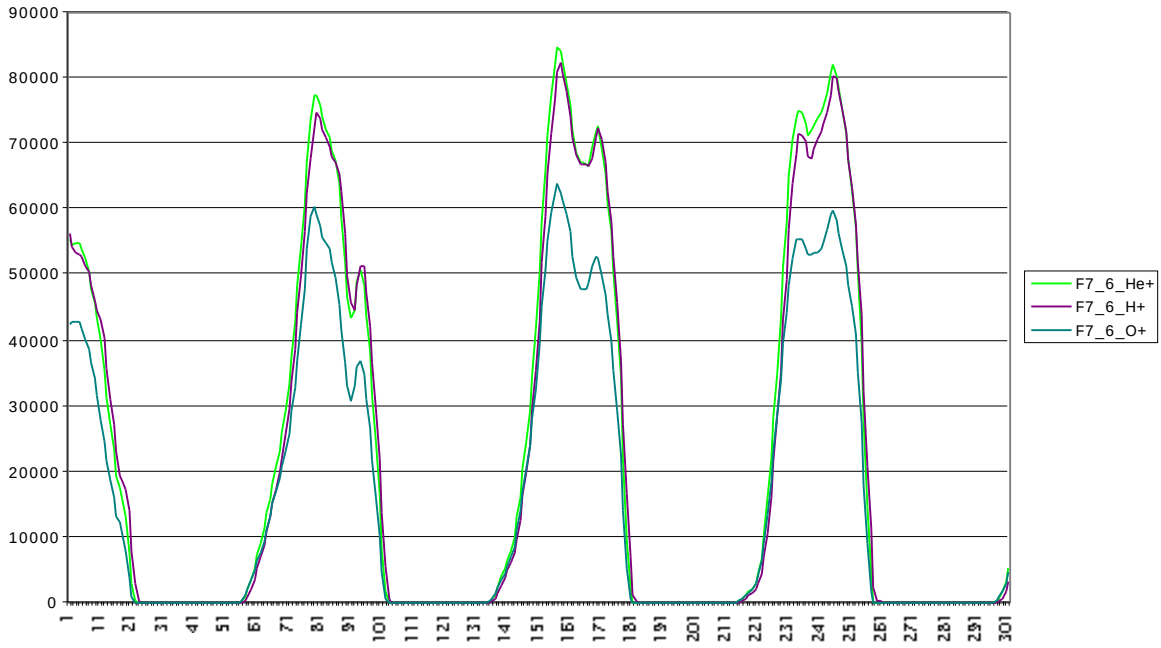

Figure 16 . ESA Alpha scans at alphas = -1, 0, and 1 for FM7 on the high side.

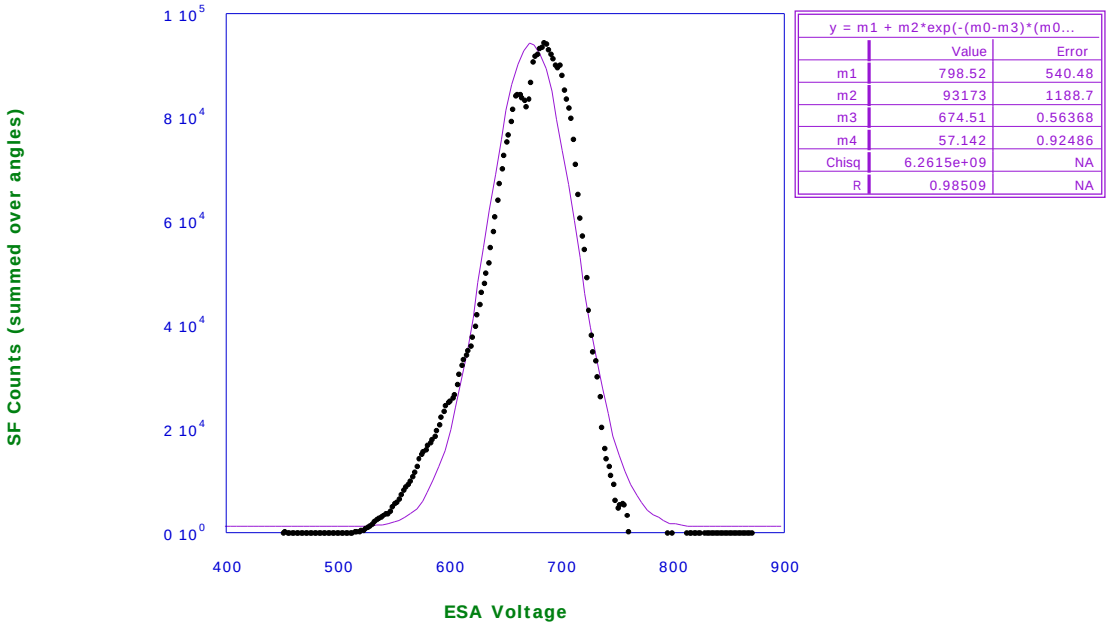

Figure 17. ESA response for F7B_19990304_163059

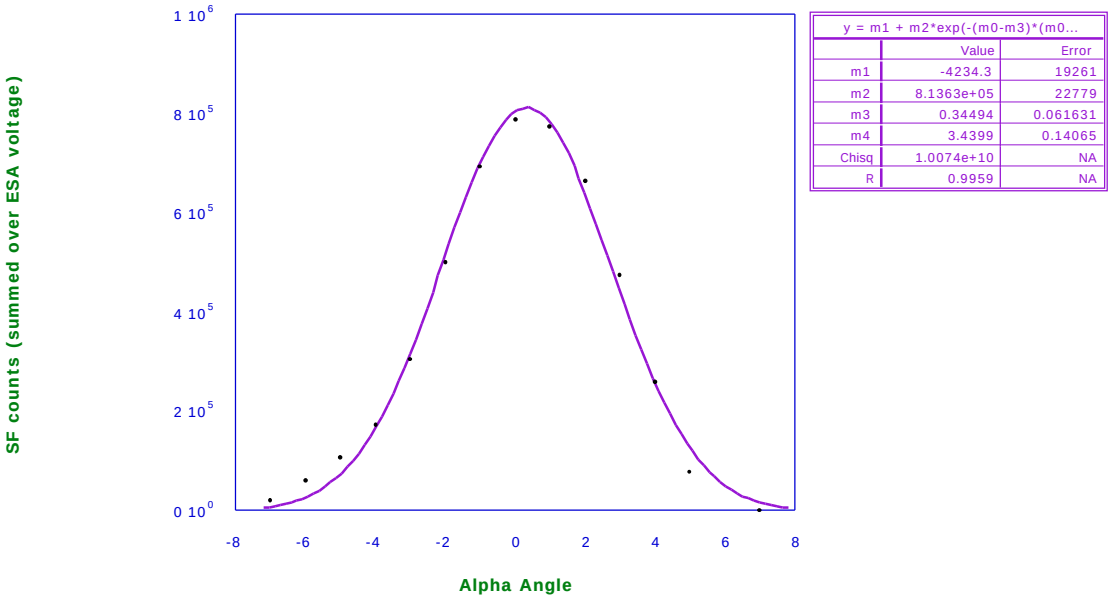

Figure 18. Alpha response for F7B_19990304_163059

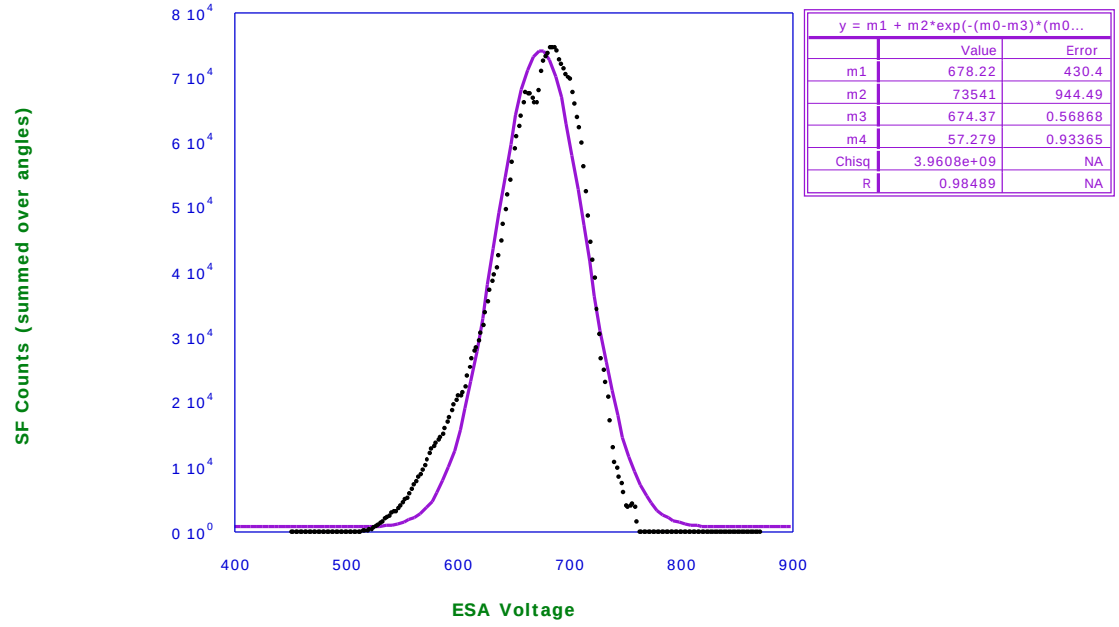

Figure 19. ESA response for F7B_19990304_160227

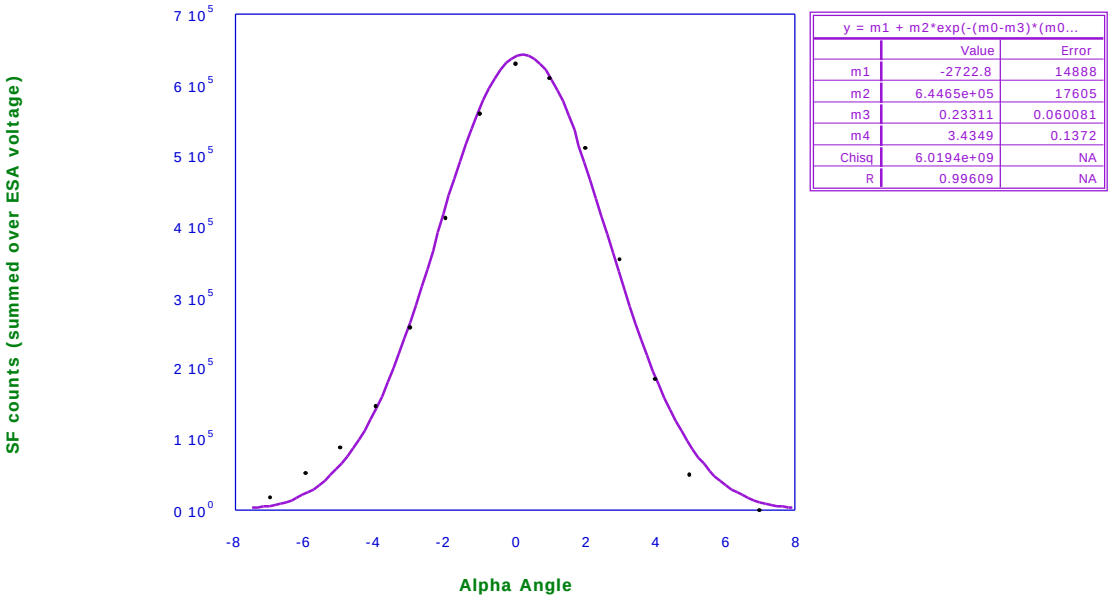

Figure 20. Alpha response for F7B_19990304_160227.

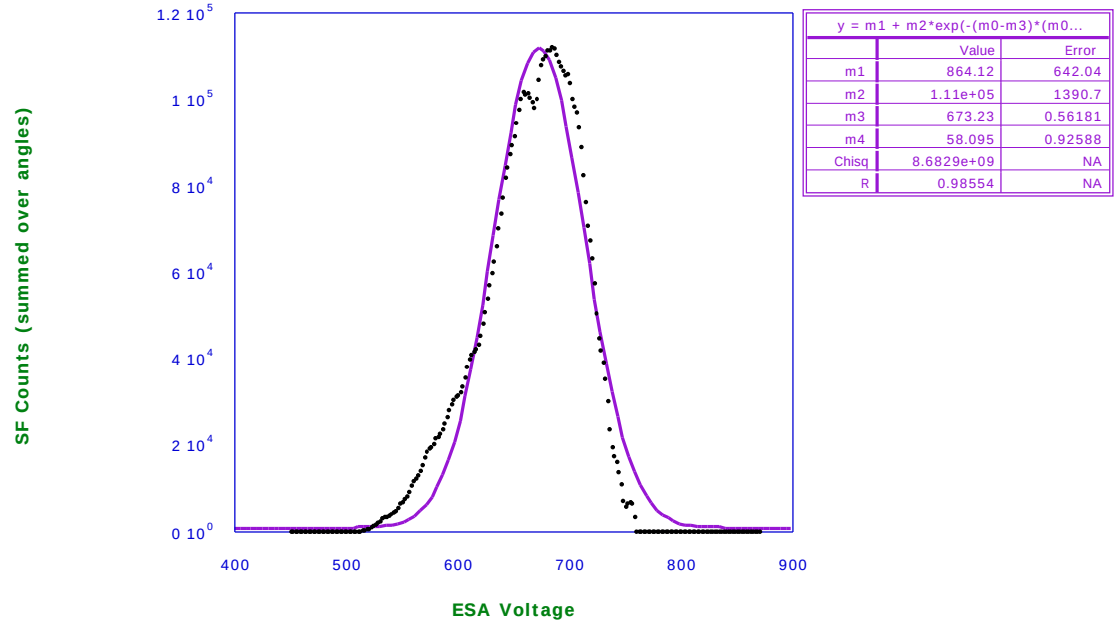

Figure 21. ESA response for F7B_19990307_083501.

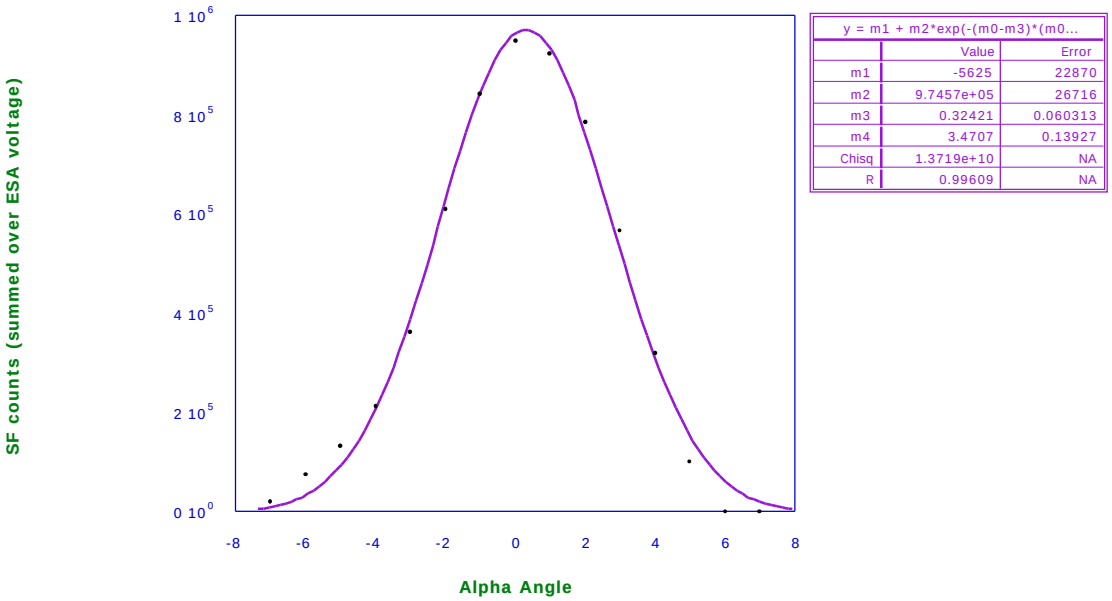

Figure 22. ALPHA response for F7B_19990307_083501.

Table 10. Summary of the FM7 HS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F7B_19990303_163059	5 He+	674.51	95.15	0.141	0.121	7.413	2.63E-03
F7B_19990304_160227	5 H+	674.37	95.38	0.141	0.121	7.414	2.53E-03
F7B_19990307_083501	5 O+	673.23	96.73	0.144	0.123	7.427	1.97E-03
Average		674.04	95.75	0.142	0.122	7.418	2.38E-03

Table 11. Summary of FM7 HS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F7B_19990303_163059	5 He+	0.34	5.728
F7B_19990304_160227	5 H+	0.23	5.719
F7B_19990307_083501	5 O+	0.32	5.779
Average		0.30	5.742

LS Response

Figure 23 shows a line plot of the SF rate for the ESA-Alpha scans on the high side, and Figure 24 shows the same data for just the center angles. The same phenomenon that was evident in the HS data is clear: the He+ and H+ give very consistent results, but the O+ values are slightly lower. Again, this indictates that the beam monitor is responding slightly differently to O+.

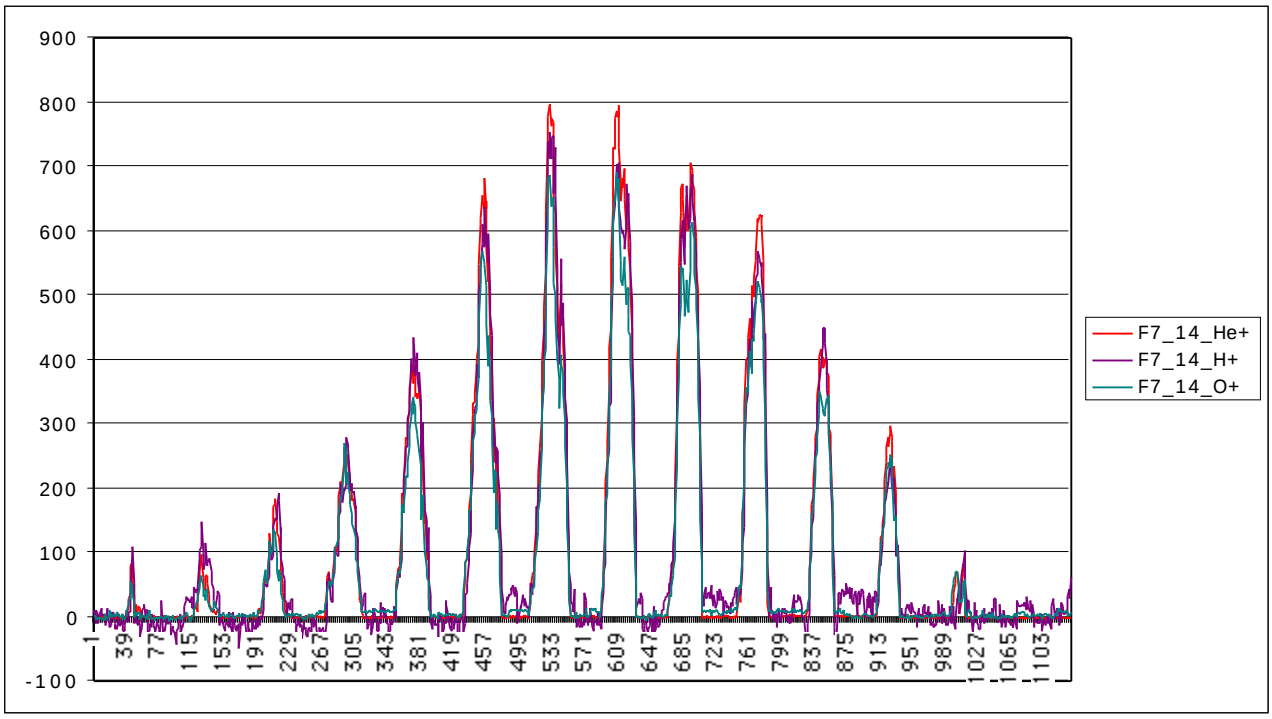

Figure 23. Full ESA-Alpha scans for FM7, LS

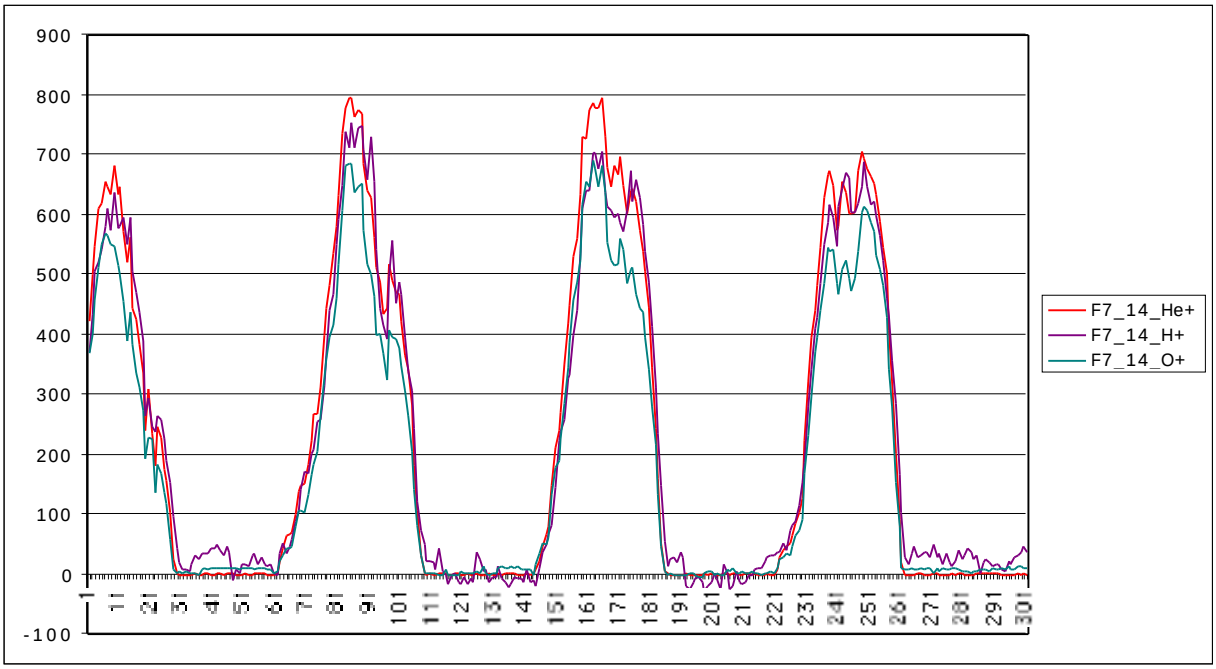

Figure 24. ESA scans for alpha = -2 (partial), -1, 0 and 1 (enlarged from Figure 23).

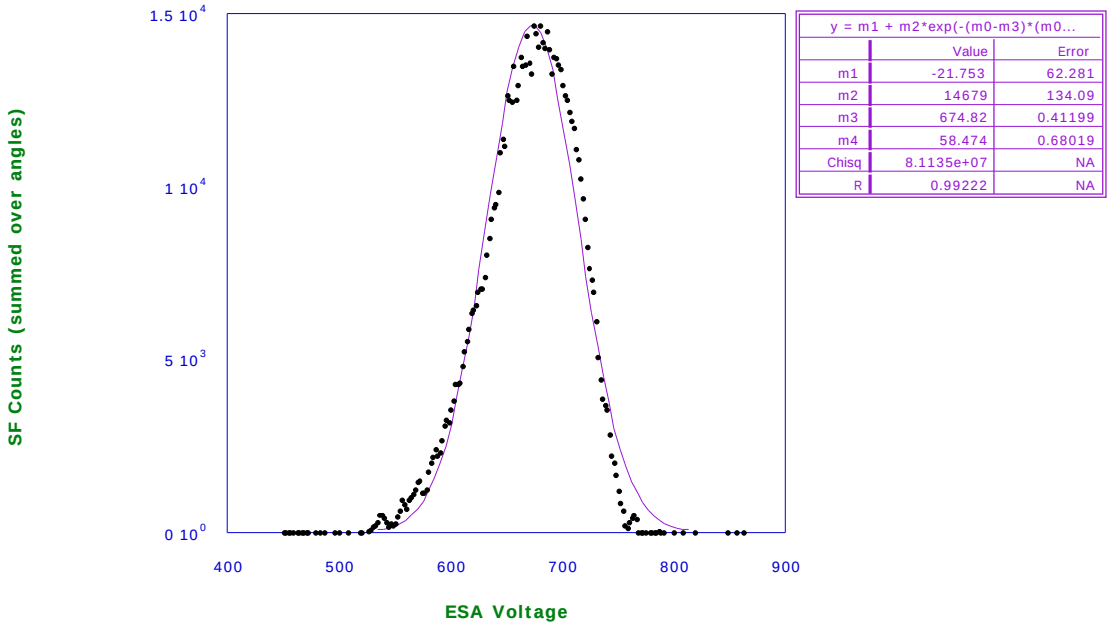

Figure 25. ESA response of F7B_19990303_122138.

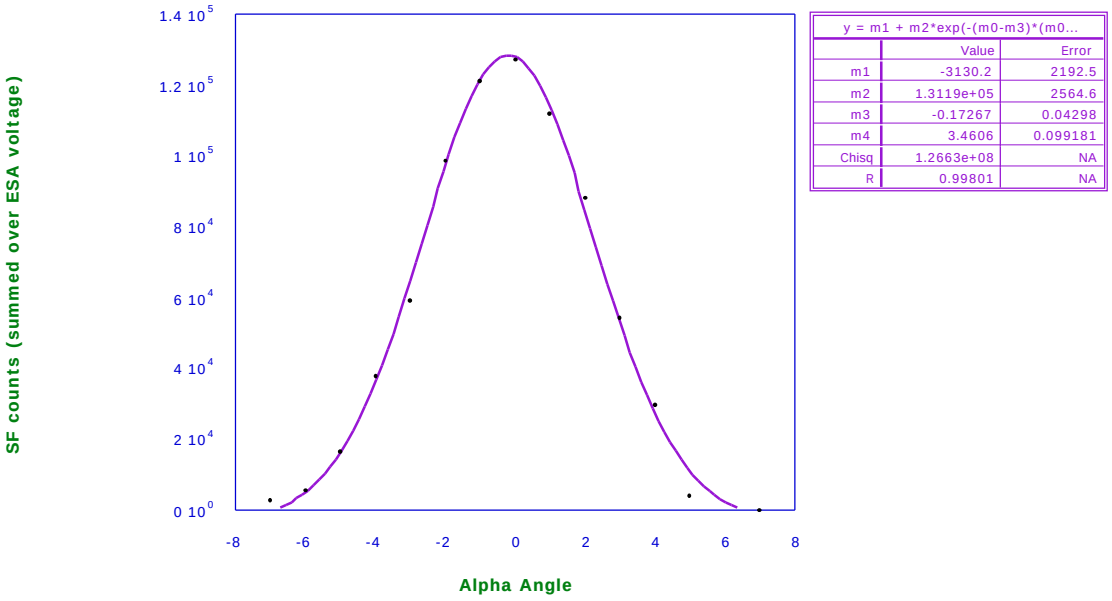

Figure 26. Alpha response of F7B_19990303_122138.

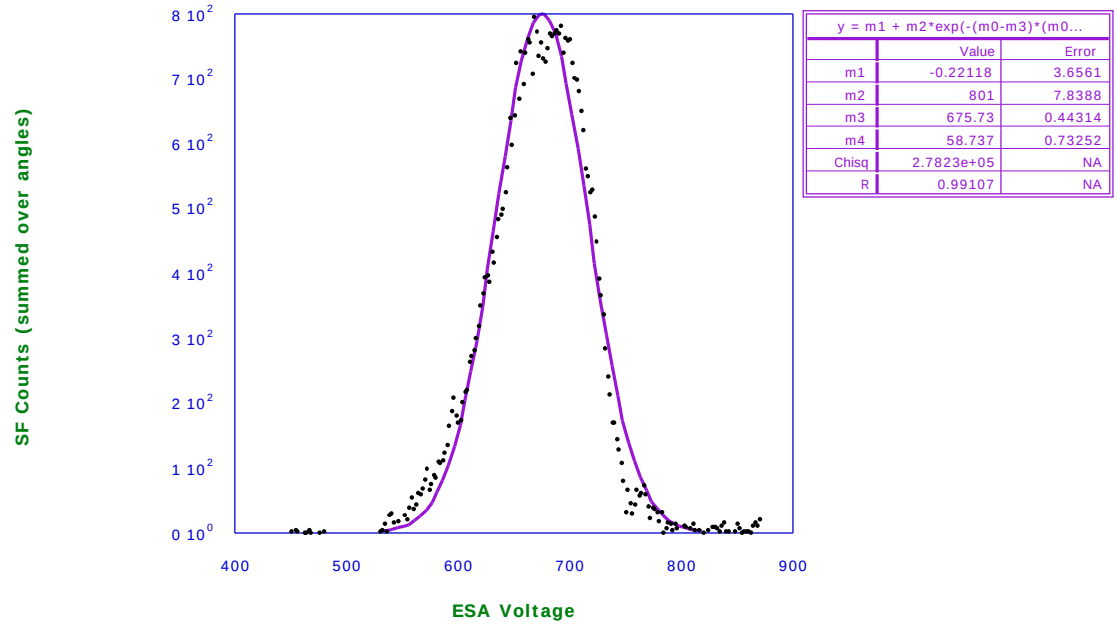

Figure 27. ESA response of F7B_19990305_160702

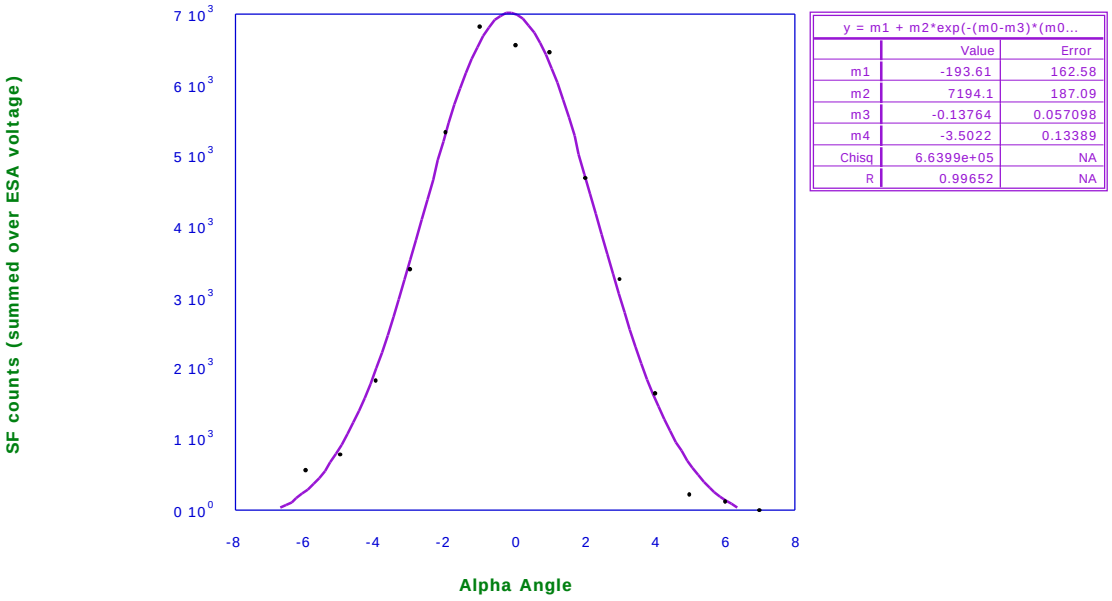

Figure 28. Alpha response of F7B_19990305_160702

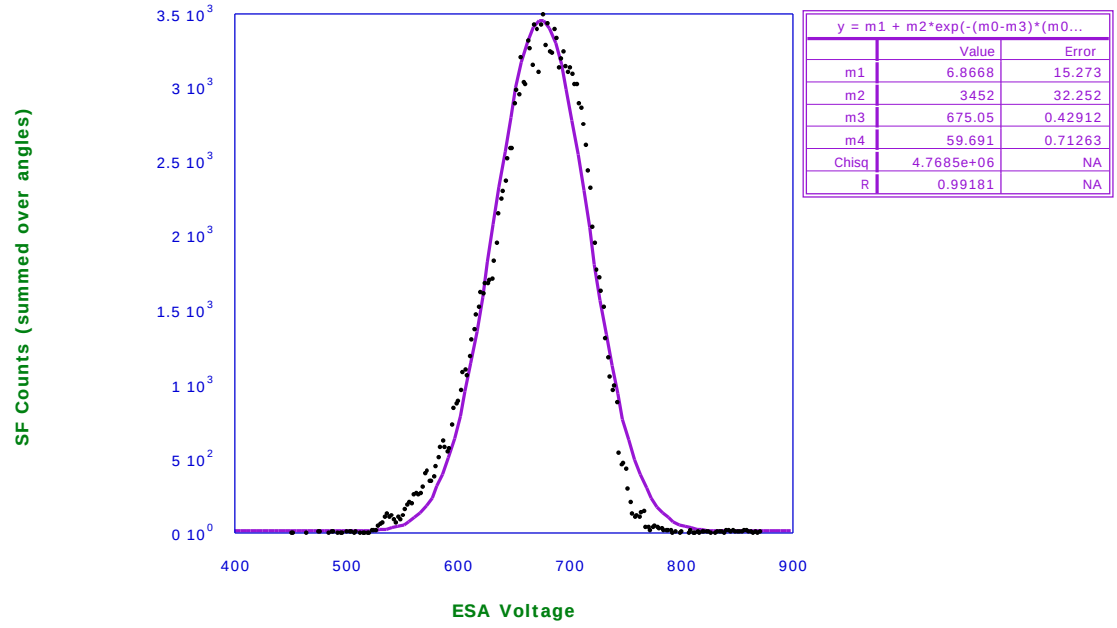

Figure 29. ESA response of F7B_19990306_180449.

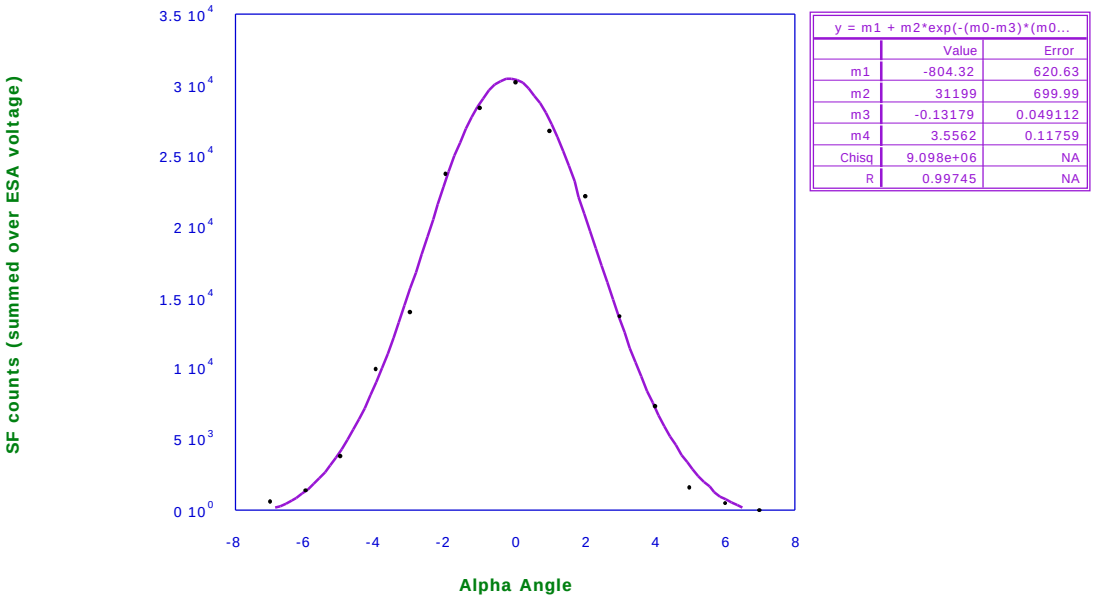

Figure 30. Alpha response of F7B_19990306_180449.

Table 12. Summary of the FM7 LS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F7B_19990303_122138*	5 He+	674.82	97.37	0.144	0.123	7.409	2.39E-05
F7B_19990305_160702*	5 H+	675.73	97.80	0.145	0.124	7.399	2.33E-05
F7B_19990306_180449*	5 O+	675.05	99.39	0.147	0.126	7.407	2.04E-05
Average		675.20	98.19	0.145	0.124	7.405	2.25E-05

Table 13. Summary of FM7 LS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F7B_19990303_122138*	14 He+	-0.17	3.46
F7B_19990305_160702*	14 H+	-0.14	3.50
F7B_19990306_180449*	14 O+	-0.13	3.56
Average		-0.15	3.51

FM8 results

Table 14 summarizes the full matrix files which were collected for FM8. In this case there were three successful scans on the HS side, and 2 on the LS side.

Table 14. Summary of ESA-Alpha scans for FM7.

File	Position (pixel)	Beam Species	Beam Intensity (Hz)	Beam Energy
F8B_19990618_152105a	2, center	He+	13685	5 keV
F8B_19990618_152105b	2, edge	He+	13685	5 keV
F8B_19990620_183451	2, center	H+	10002	5 keV
F8B_19990619_160809a	10, center	He+	232033	5 keV
F8B_19990619_160809b	10, edge	He+	232033	5 keV

HS Response

Figure 31 shows a line plot of the SF rate for the ESA-Alpha scans on the high side. Again, the curves have been normilized using our best knowledge of the start efficiency and the beam rate. Figure 32 shows just the ESA scans at alpha = -1, 0, and 1.

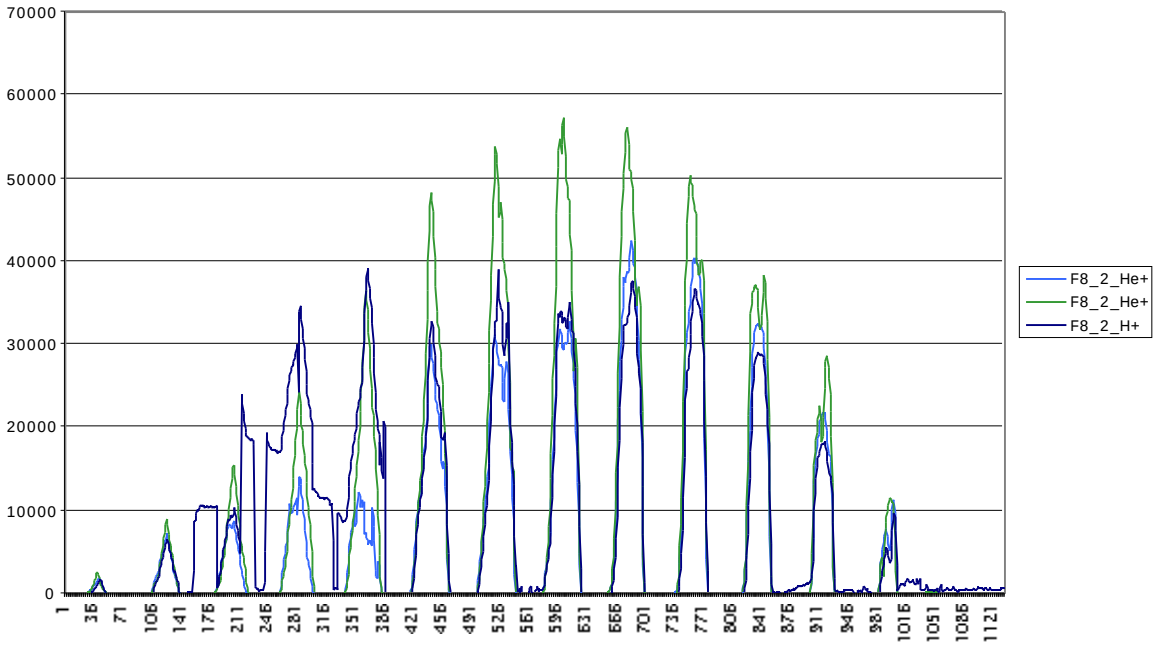

Figure 31. Full ESA-Alpha plots for HS side of FM8.

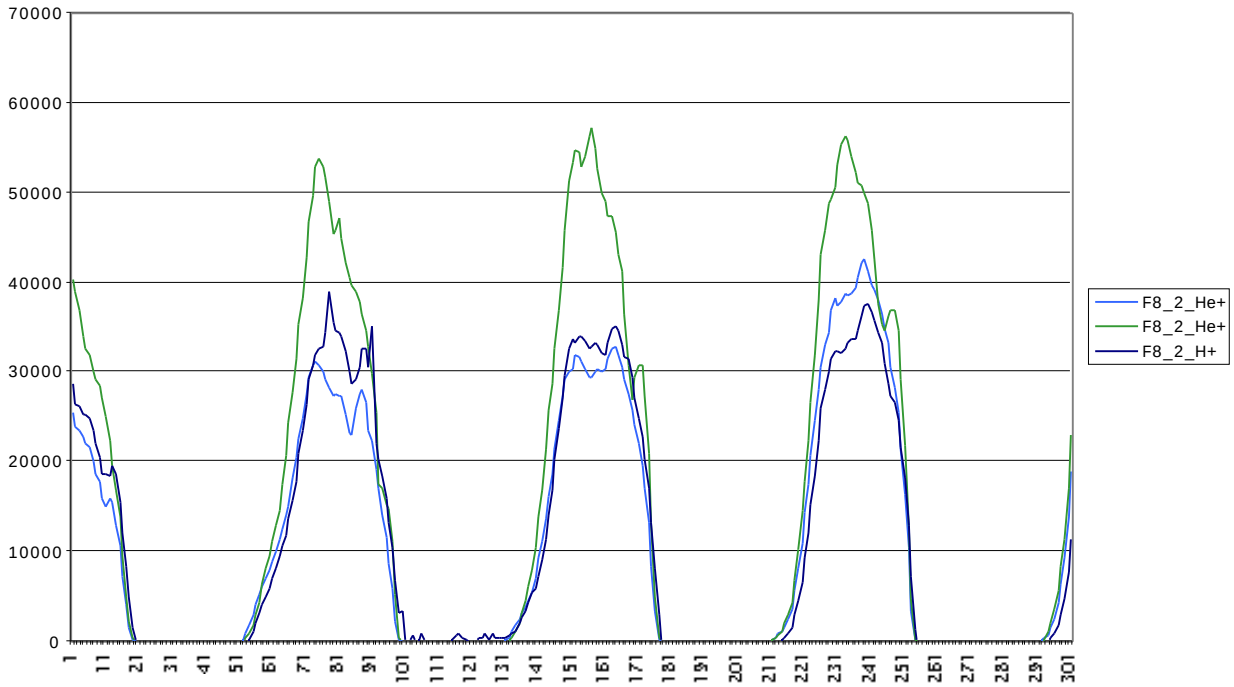

Figure 32. ESA scans for the center alpha angles of FM8.

It can be seen from figure 31 that file F8B_19990620_183451 had some problems at around alpha = -4. For this reason it cannot be used much for further analysis. However, it is included so that it can be compared with the measurements from F8B_19990618_152105a at the same position. Figure 32 shows that there is a significant difference between the two scans taken at the center and the edge of pixel 2, but that the two scans taken at the center of pixel 2 agree very well. The implication is that the blockage at this point is significant. This will naturally result in different geometric factors for the two scans. In the summary, we will discuss the implications of these results.

Figure 33 shows the ESA response for file F8B_19990618_152105a.

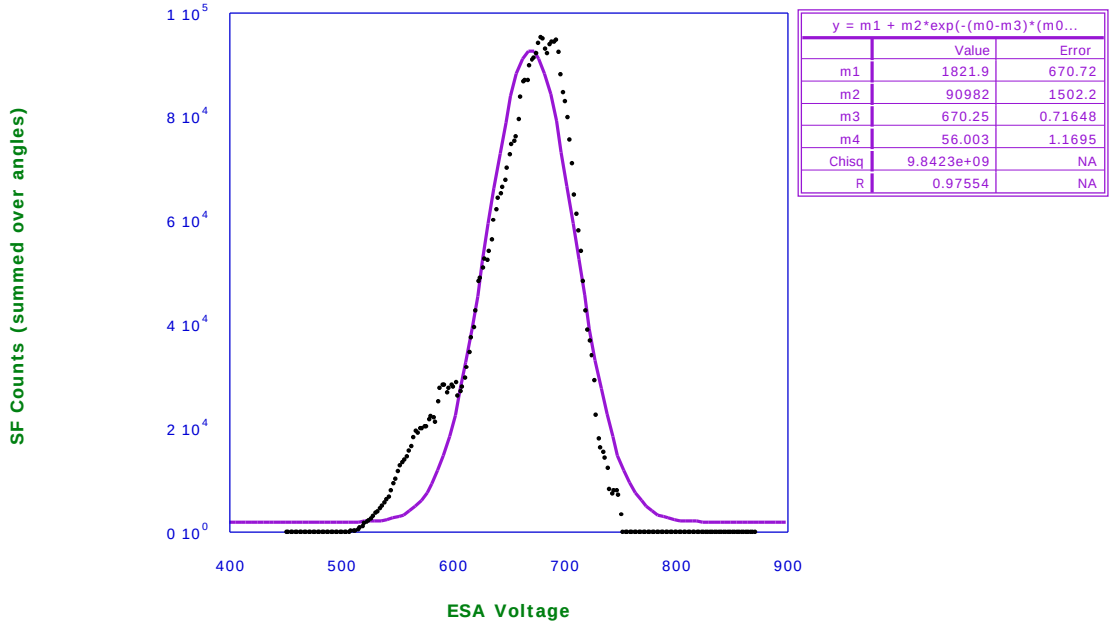

Figure 33. ESA response for F8B_19990618_152105a. (pixel 2, center).

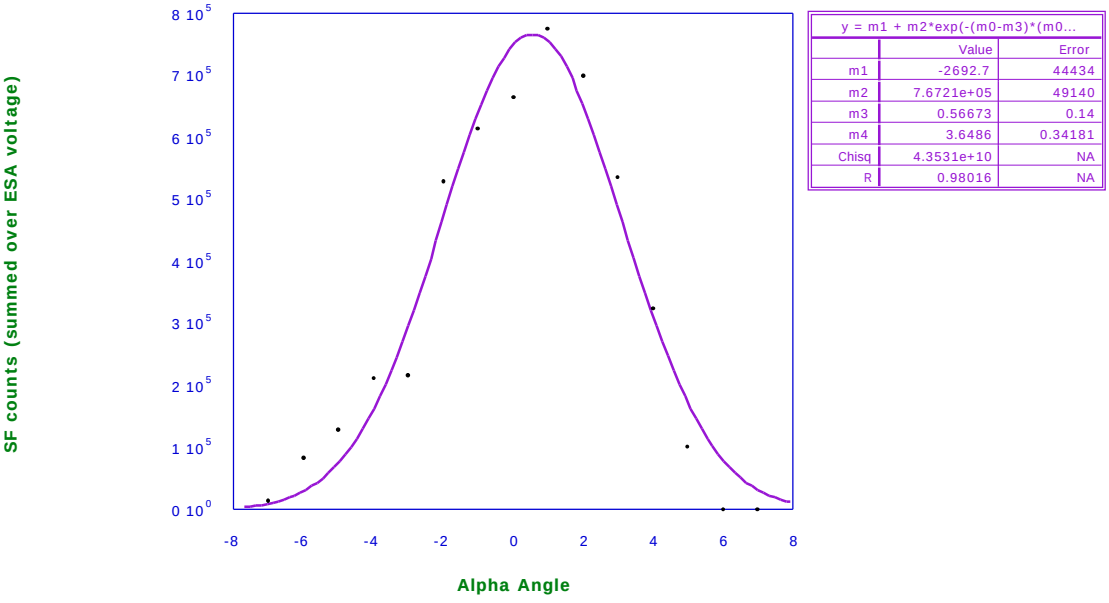

Figure 34. Alpha response for F8B_19990618_152105a. (pixel 2, center).

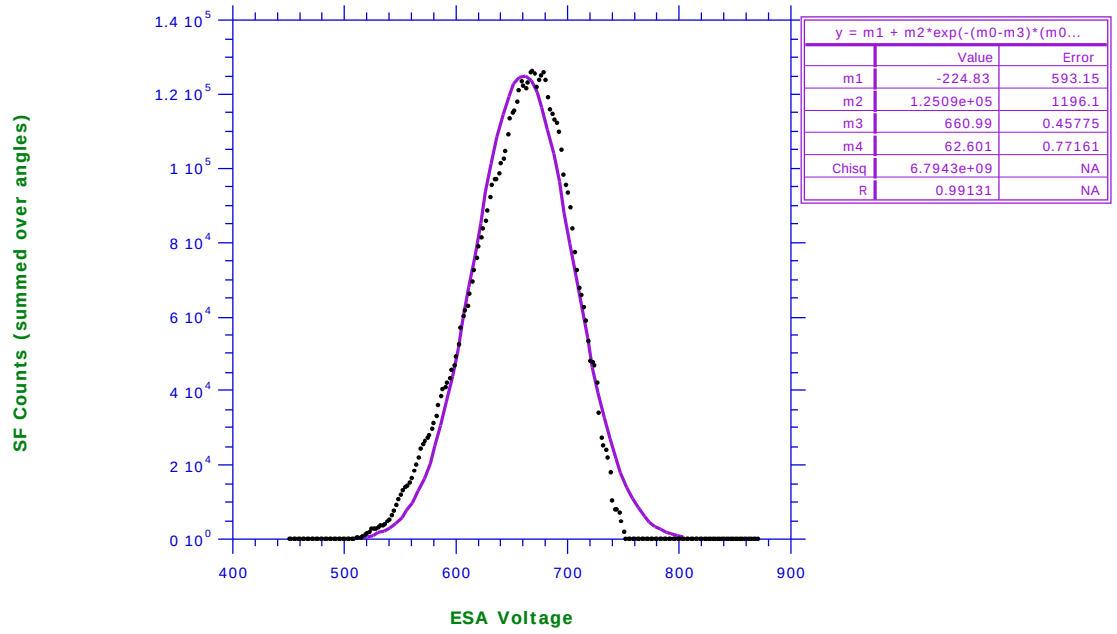

Figure 35. ESA response for F8B_19990618_152105b. (pixel 2, edge).

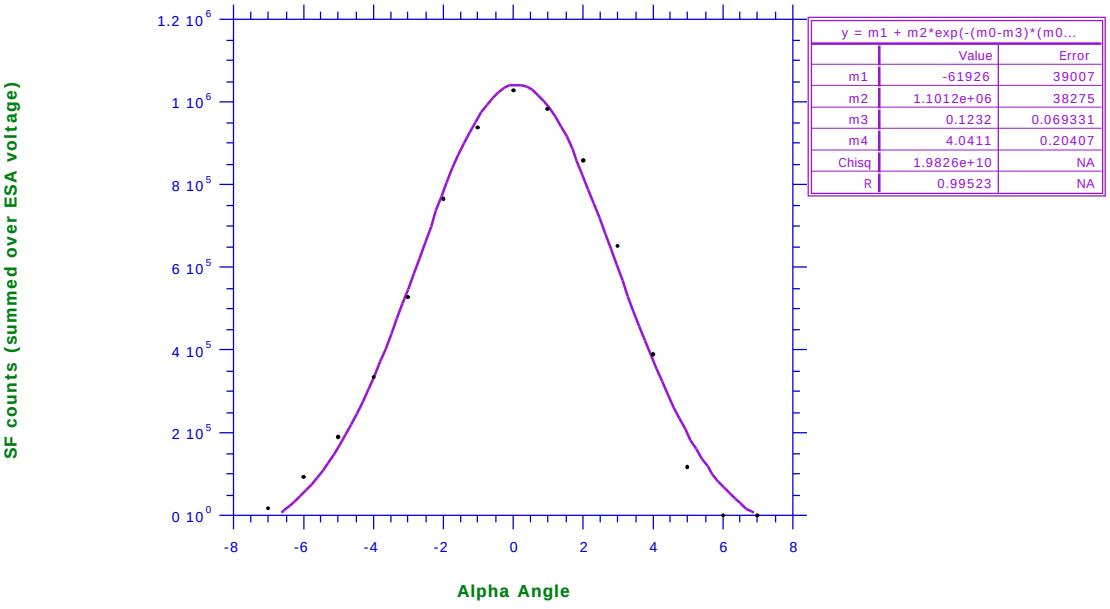

Figure 35. Alpha response for F8B_19990618_152105b. (pixel 2, edge).

Table 15. Summary of the FM8 HS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F8B_19990618_152105a	5 keV He+	670.25	93.25	0.139	0.120	7.460	1.53E-03
F8B_19990618_152105b	5 keV He+	660.99	104.24	0.158	0.133	7.564	2.16E-03
average		665.62	98.74	0.148	0.126	7.512	1.85E-03

Table 16. Summary of FM8 HS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F8B_19990618_152105a	5 keV He+	0.57	3.65
F8B_19990618_152105b	5 keV He+	0.12	4.04
Average		0.34	3.84

LS Response

Figure 36 shows a line plot of the SF rate for the ESA-Alpha scans on the low side, and Figure 37 shows the same data for just the center angles.

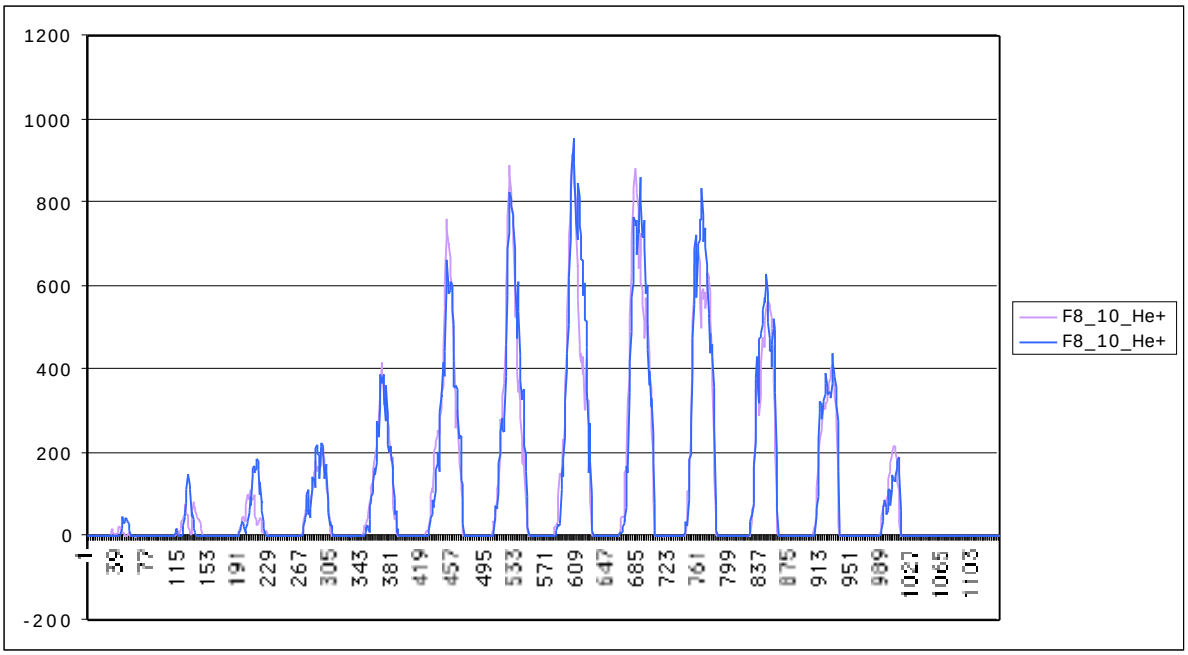

Figure 36. SF rate for the ESA-Alpha scans on the LS on FM8.

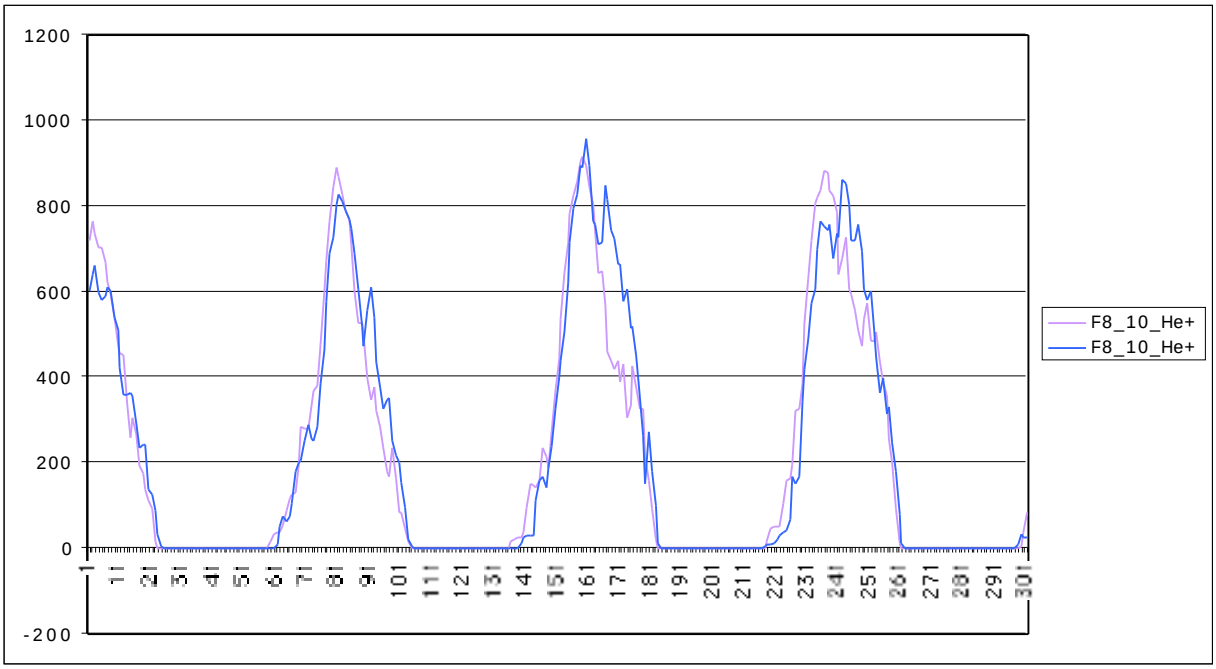

Figure 37. SF rate for the ESA-Alpha scans on the LS on FM8 for the center alpha angles.

Again we have two scans at different positions on the same pixel. In this case, although the two show different structures, the amount of blockage for the two positions is about the same.

Figures 38 and 39 show the energy and angle response for the center position, while Figure 40 and 41 show the response for the edge position.

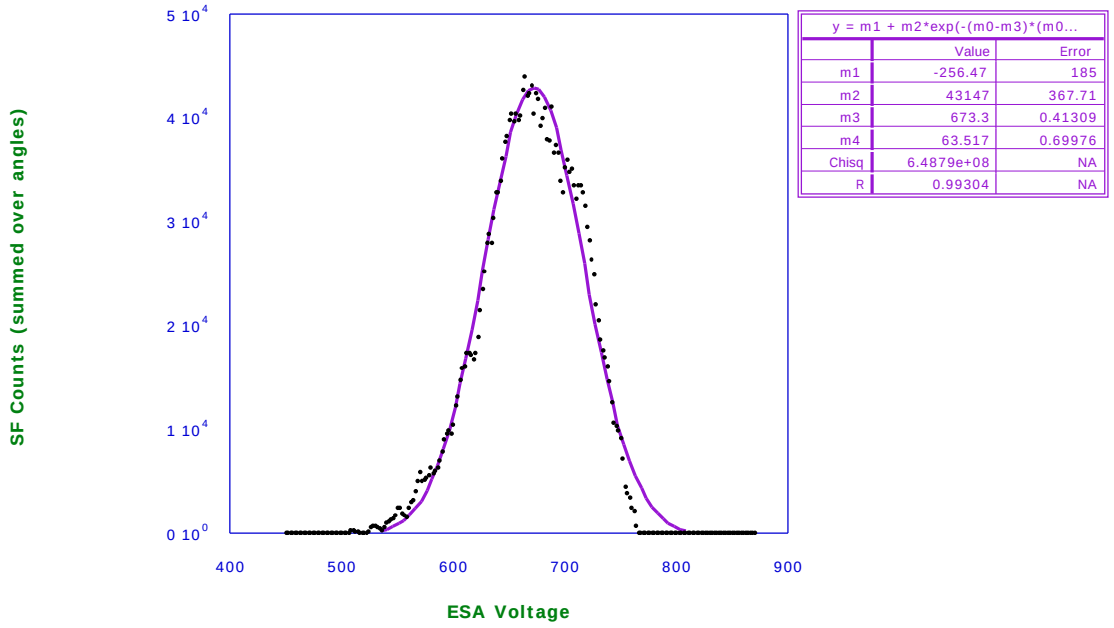

Figure 39. ESA response for F8B_19990619_160809a

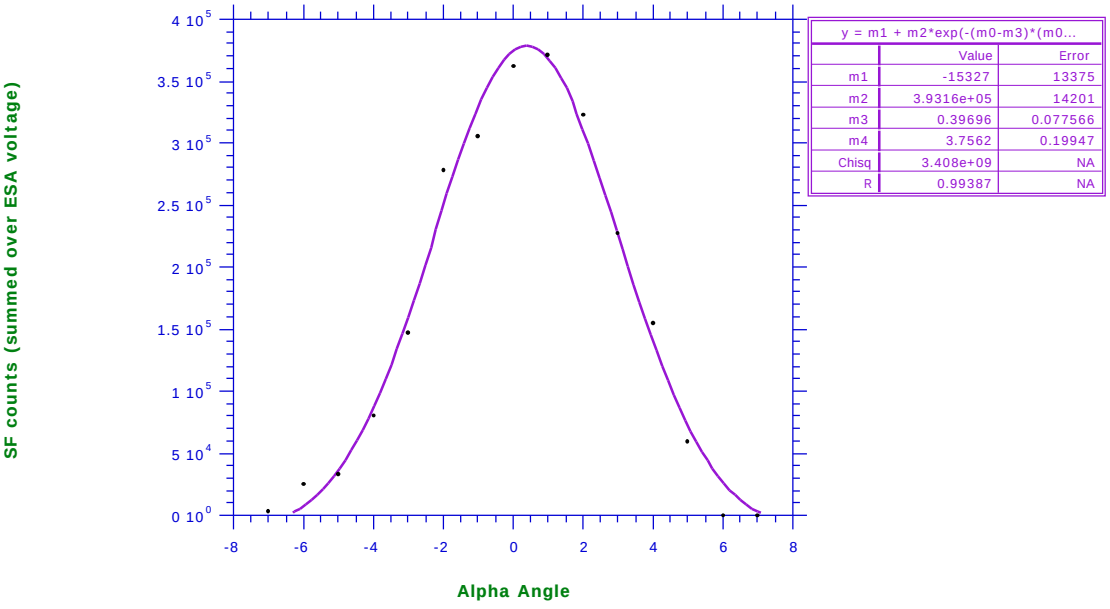

Figure 39. Alpha response for F8B_19990619_160809a

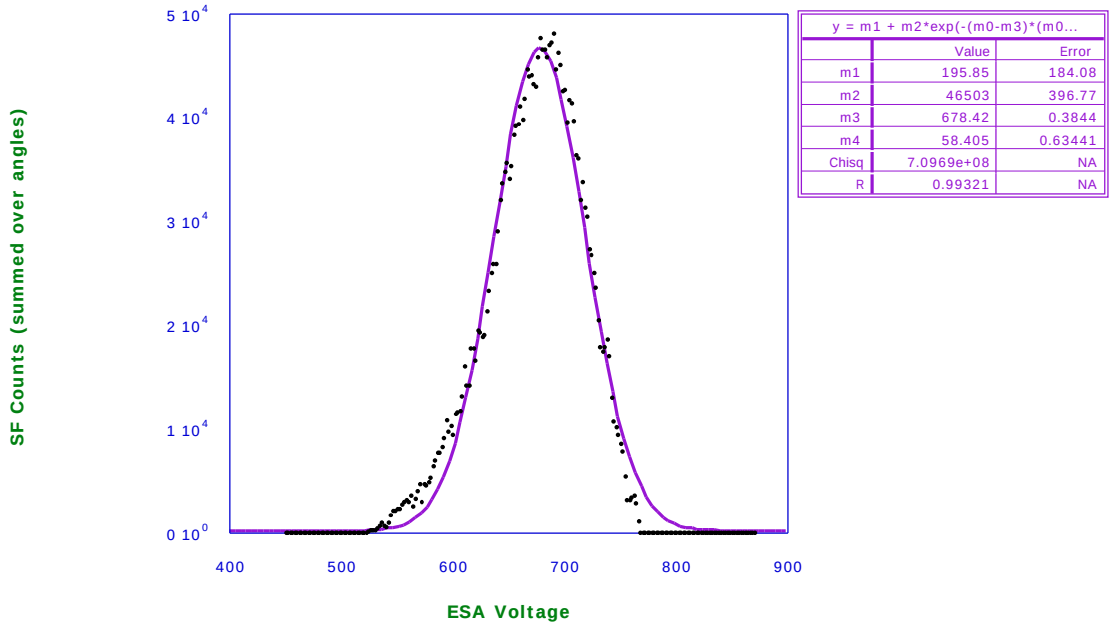

Figure 40. ESA response for F8B_19990619_160809b.

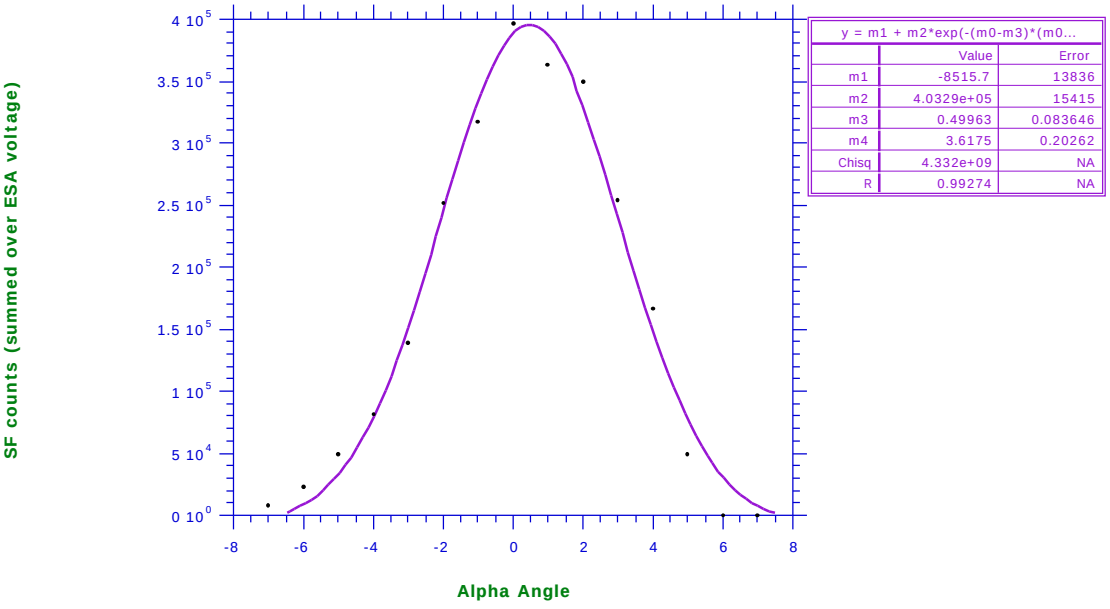

Figure 41. Alpha response of F8B_19990619_160809b – edge of pixel 10.

Table 17. Summary of the FM8 LS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
F8B_19990619_160809a	5 keV He+	673.30	105.76	0.157	0.132	7.426	2.57E-05
F8B_19990619_160809b	5 keV He+	678.42	97.25	0.143	0.123	7.370	2.65E-05
Average		675.86	101.51	0.150	0.128	7.398	2.61E-05

Table 18. Summary of FM8 LS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
F8B_19990619_160809a	5 keV He+	0.40	3.76
F8B_19990619_160809b	5 keV He+	0.50	3.62
Average		0.45	3.69

Phoenix results

Table 19 summarizes the full matrix files which were collected for the flight spare, Phoenix, unit. For the Phoenix unit there were a variety of runs, in both position and species, which allow us to test the factors which effect the geometry factor.

Table 19. Summary of ESA-Alpha scans for Phoenix.

File	Position (pixel)	Beam Species	Beam Intensity (Hz)	Beam Energy
FPB_19990612_123005a	2, center	He+	12562	5 keV
FPB_19990612_123005b	2, edge	He+	12562	5 keV
FPB_19990614_174003	2, center	H+	7975	5 keV
FPB_19990616_113338	6, center	O+	8466	5 keV
FPB_19990611_152330a	10, center	He+	221632	5 keV
FPB_19990611_152330b	10, edge	He+	221632	5 keV
FPB_19990615_182423	13, center	O+	23655	5 keV

HS Response

Figures 42 and 43 show the line plots of the SF for the ESA-Alpha scans on the HS side for the Phoenix unit, normalized by stop efficiency and beam intensity.

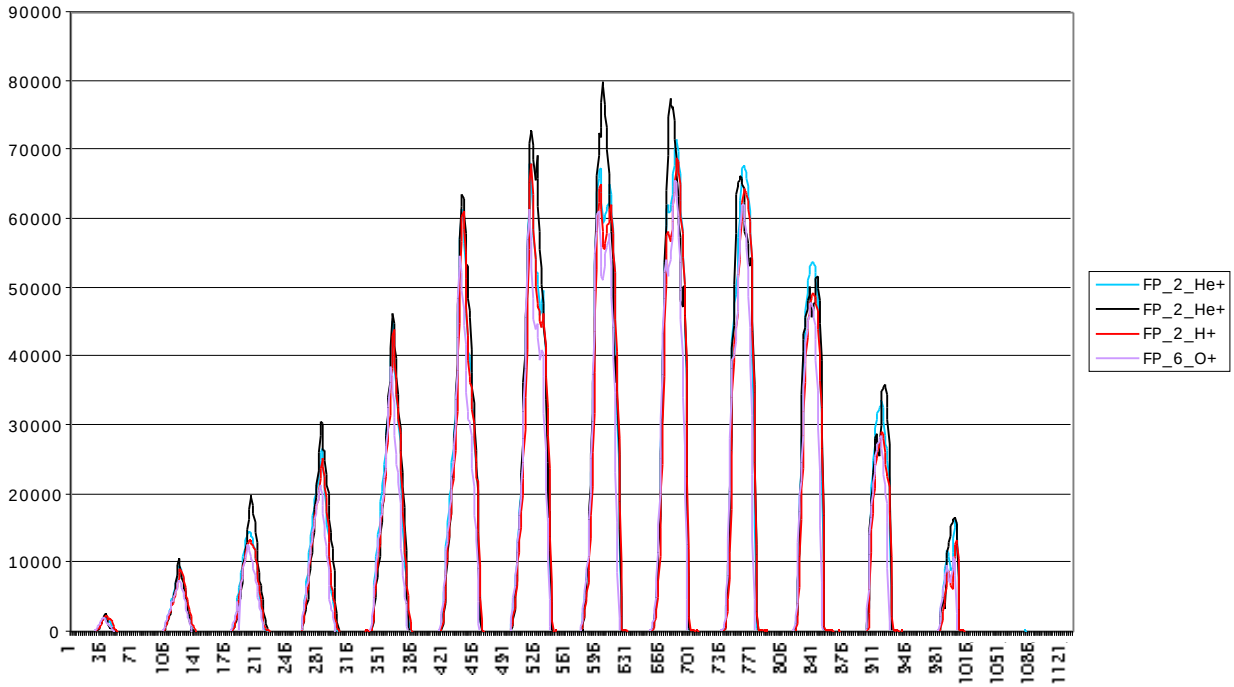

Figure 42. SF values for ESA-Alpha scans on the HS side of the Phoenix unit.

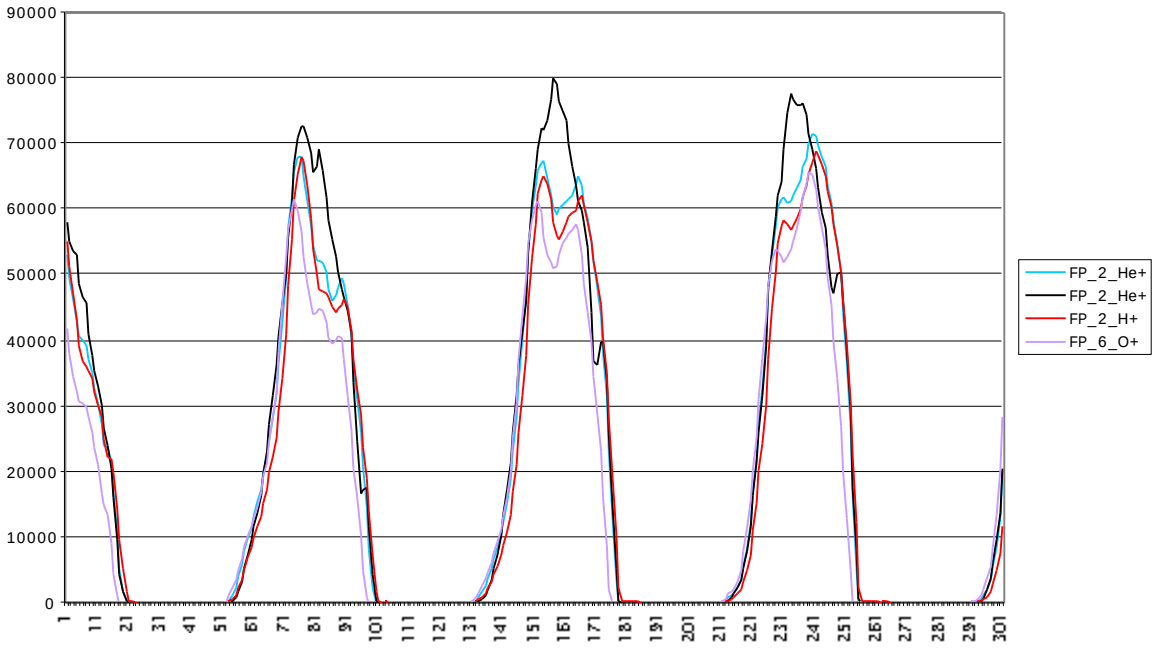

Figure 43. SF values at the center alpha values, from the ESA-Alpha scans.

The results are consistent with those observed in other units: The two scans with He+ on pixel 2 show different structure. The scan with H+ in the center of PF2 shows a very similar profile, both in structure and magnitude to the scan in the same position with He+. The scan with O+ shows a slightly lower intensity than the scans with the other species, while the structure is very similar to the pixel 2 center results. This implies that the difference is not due to blockage, and may again be due to a different response of the beam monitor to heavy ions.

Following are the curves showing the energy and angle responses for each scan.

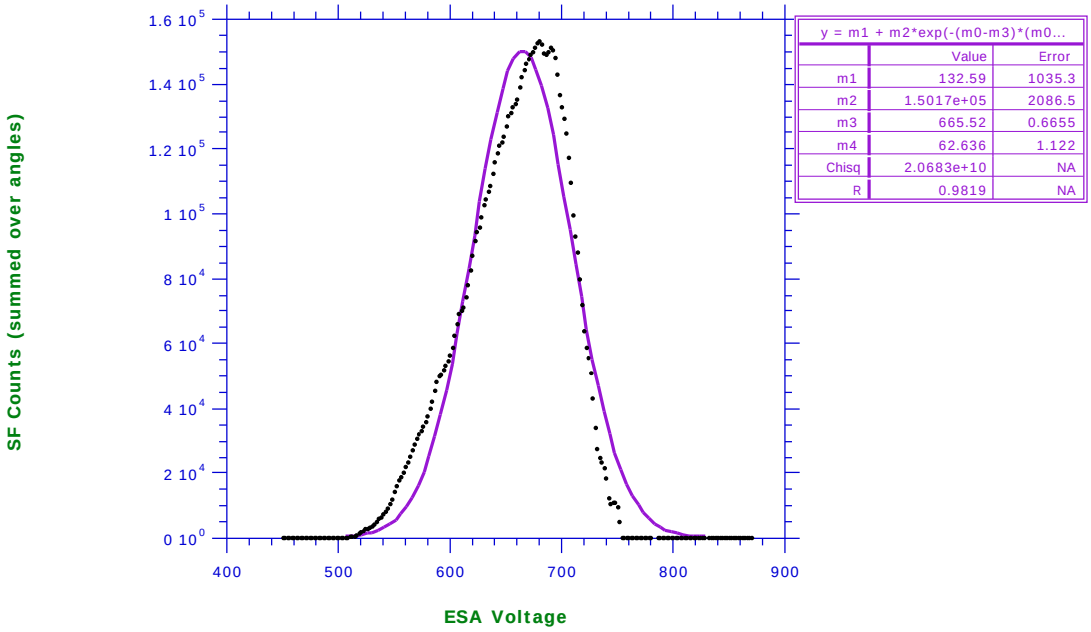

Figure 44. ESA .response for FPB_19990612_123005a.

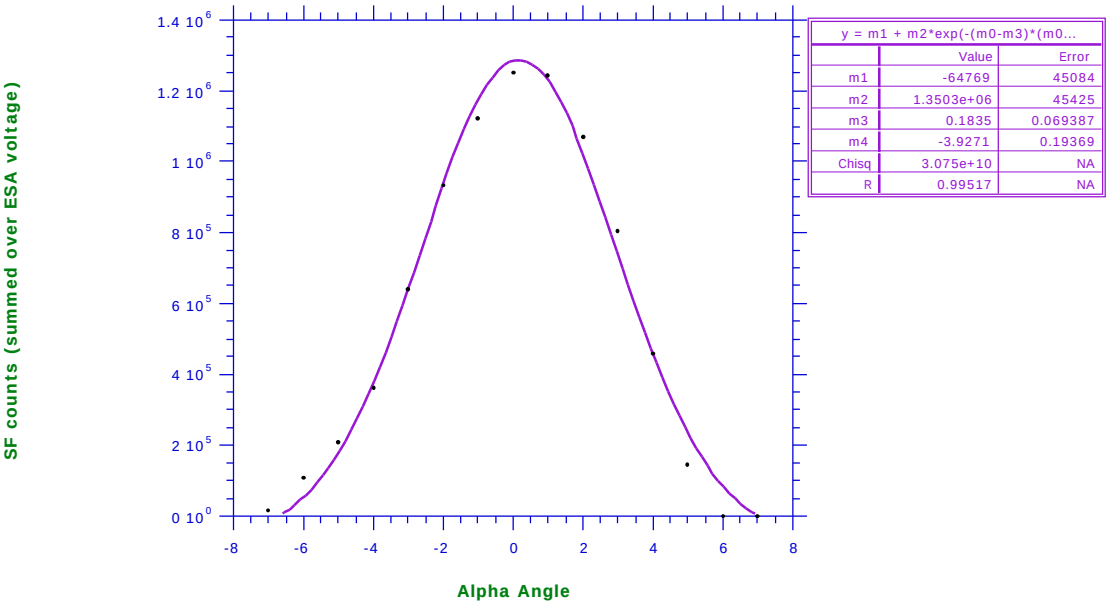

Figure 44. Alpha .response for FPB_19990612_123005a.

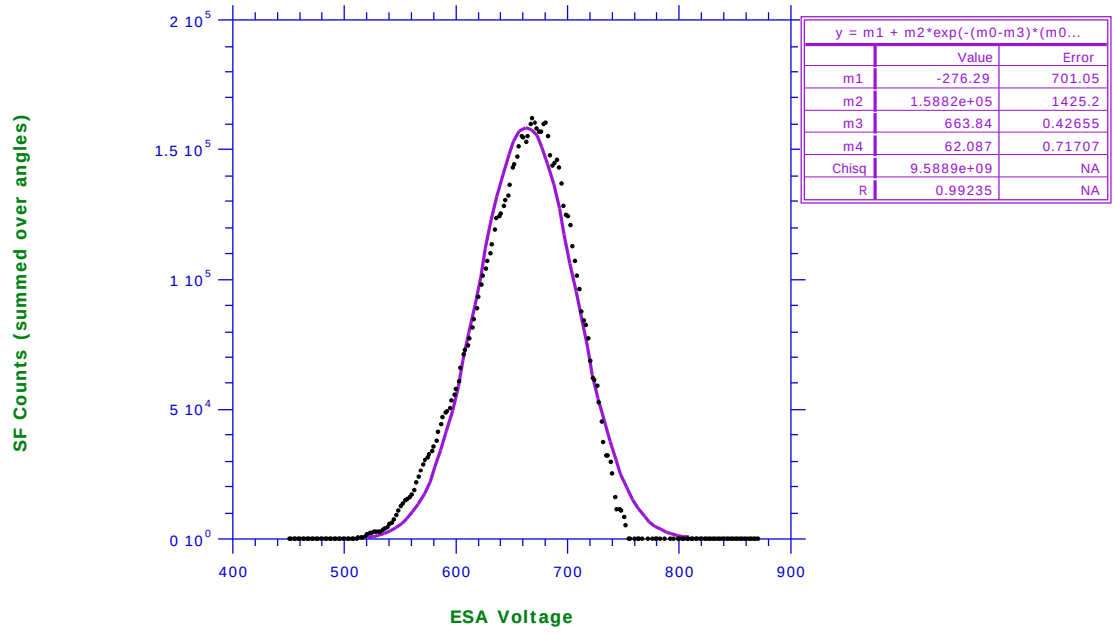

Figure 45. ESA .response for FPB_19990612_123005b

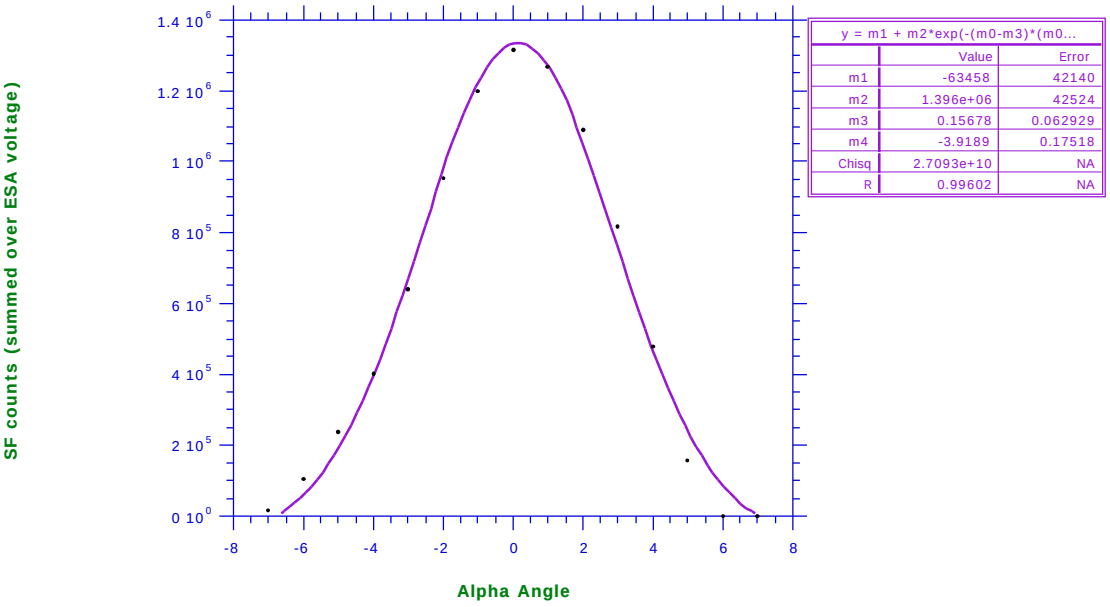

Figure 46. Alpha .response for FPB_19990612_123005b

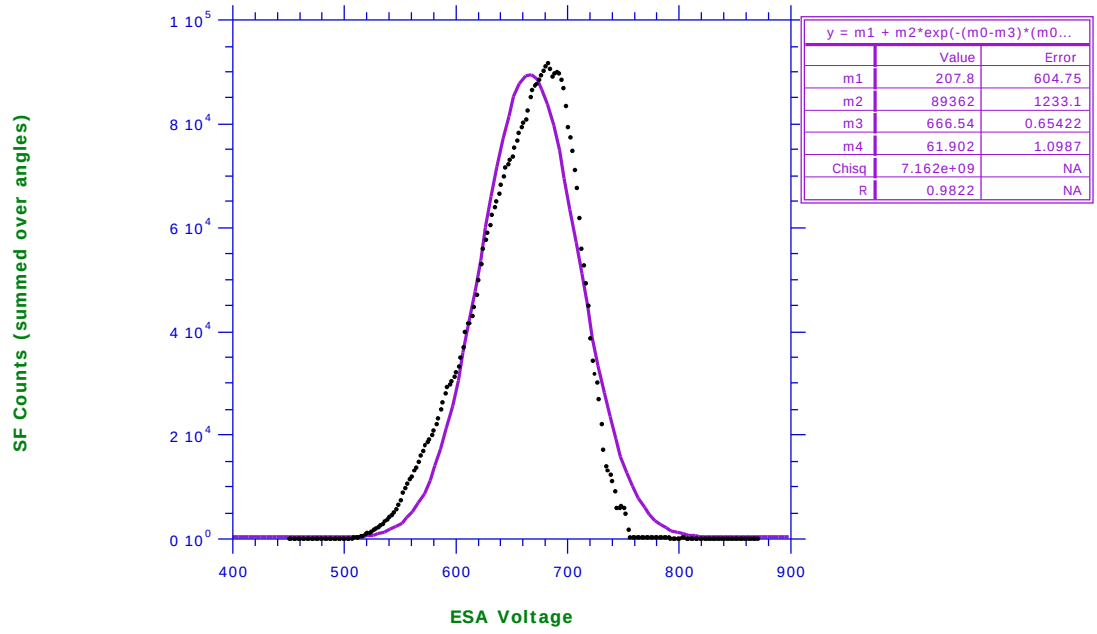

Figure 47. ESA response for FPB_19990614_174003

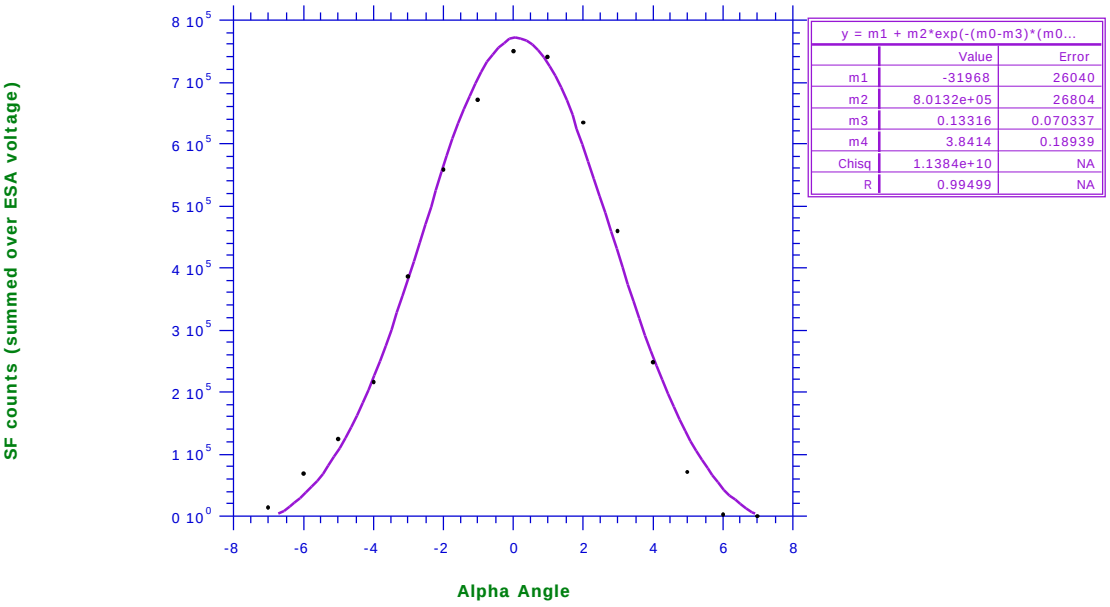

Figure 48. Alpha response for FPB_19990614_174003.

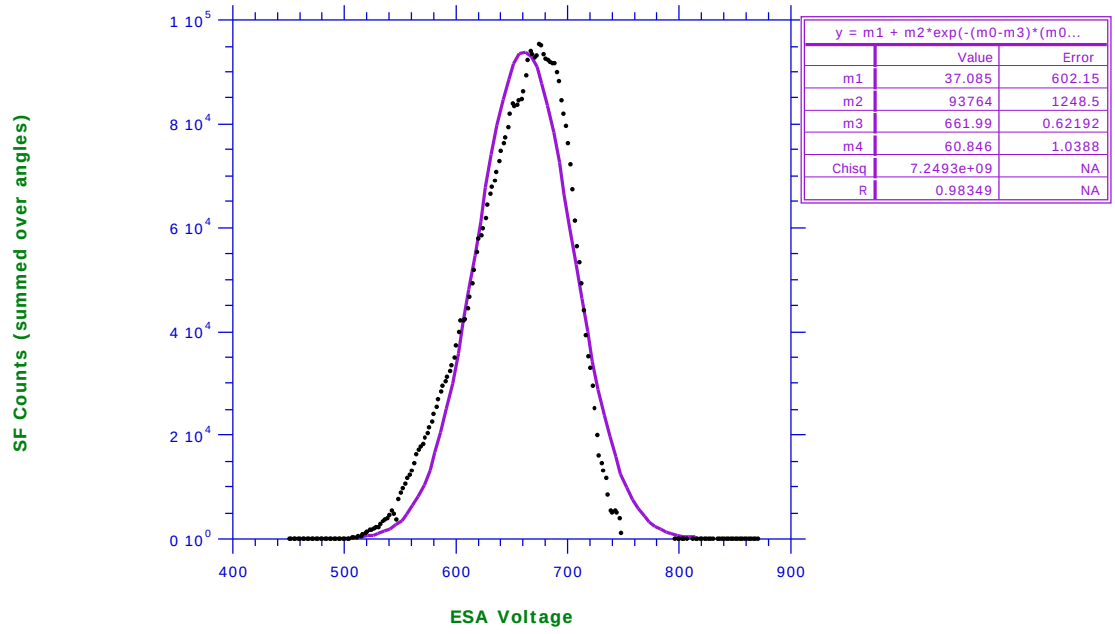

Figure 49. ESA response for FPB_19990616_113338

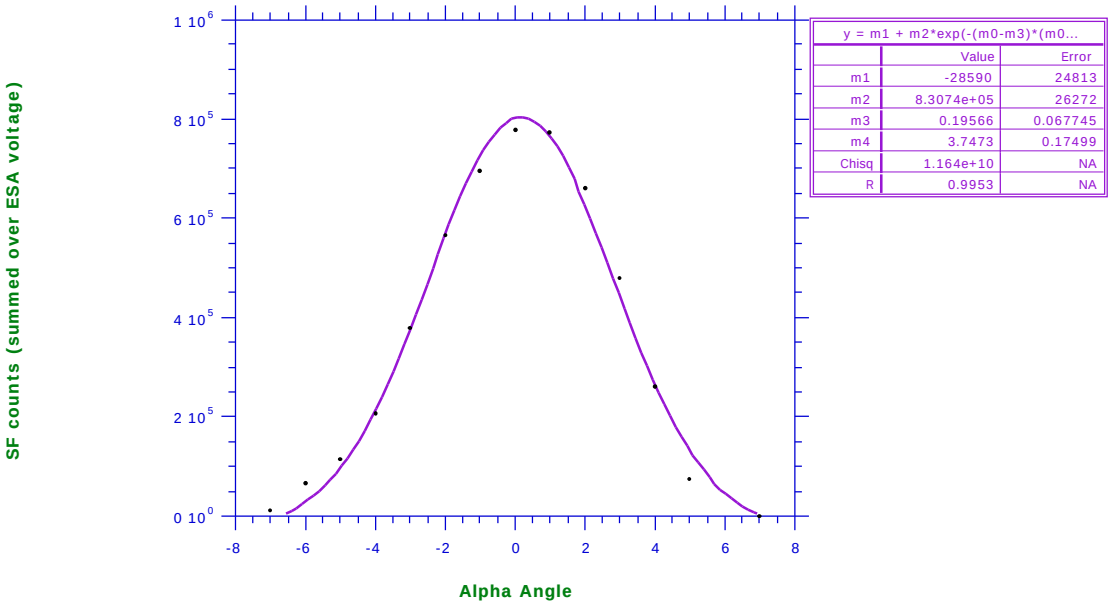

Figure 50. Alpha response for FPB_19990616_113338

Table 20. Summary of the FM8 LS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
FPB_19990612_123005a	2 He+	665.52	104.30	0.157	0.132	7.513	2.49E-03
FPB_19990612_123005b	2 He+	663.84	103.38	0.156	0.131	7.532	2.58E-03
FPB_19990614_174003	2 H+	666.54	103.07	0.155	0.131	7.501	2.32E-03
FPB_19990616_113338	6 O+	661.99	101.32	0.153	0.130	7.553	2.05E-03
Average		664.47	103.02	0.155	0.131	7.525	2.36E-03

Table 21. Summary of FM8 LS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
FPB_19990612_123005a	2 He+	0.18	3.93
FPB_19990612_123005b	2 He+	0.16	3.92
FPB_19990614_174003	2 H+	0.13	3.84
FPB_19990616_113338	6 O+	0.20	3.75
Average		0.17	3.86

LS Response

Figures 51 and 52 show the line plots of the SF for the ESA-Alpha scans on the HS side for the Phoenix unit, normalized by stop efficiency and beam intensity.

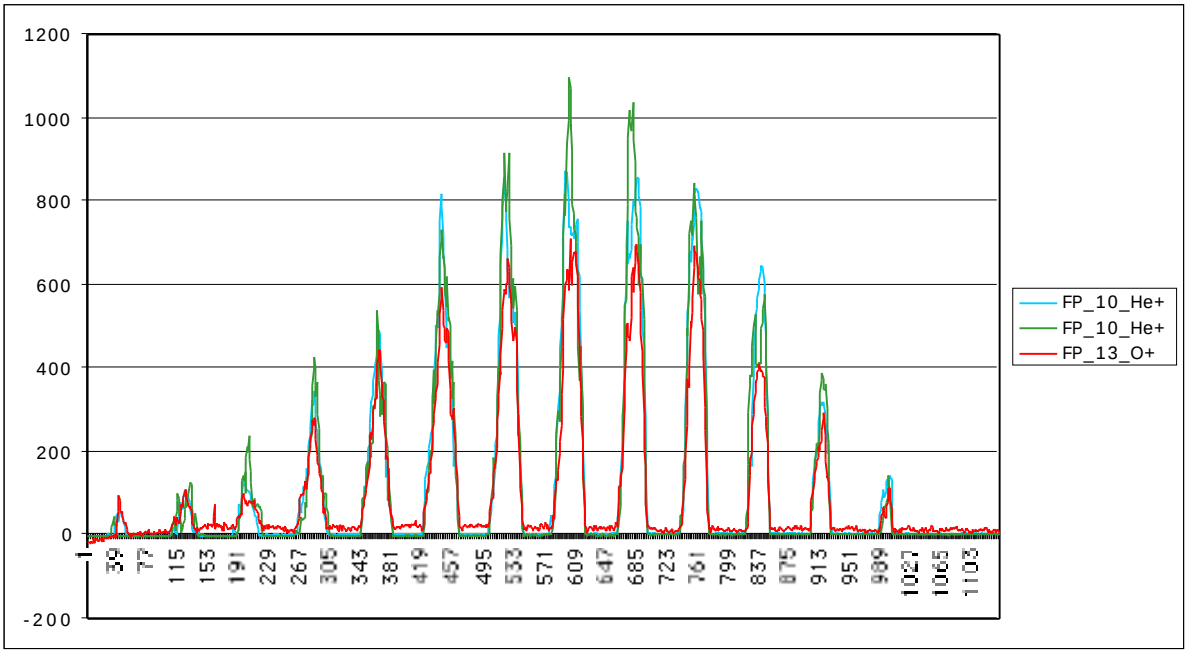

Figure 51. ESA-Alpha scans on LS side for Phoenix

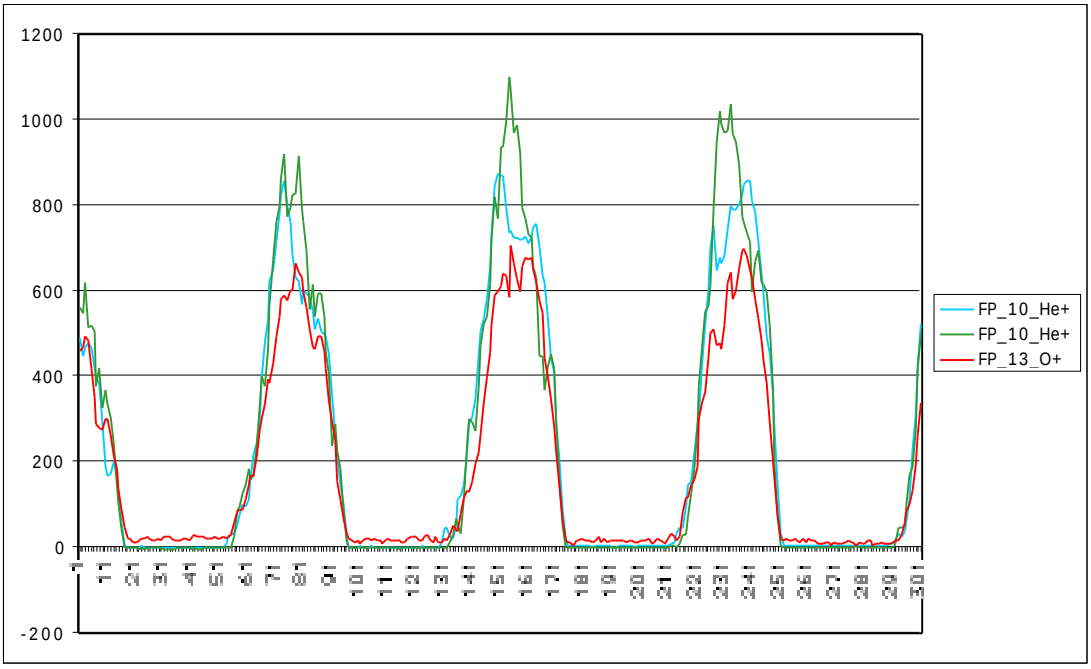

Figure 52. Center angles of ESA-alpha scan for LS side for Phoenix.

As on the high side, the two positions on pixel 10 show quite different structure. The O+ scan on pixel 13 shows similar structure to the center of pixel 10, but a reduced count rate. The integrated responses for these files are shown in figures 53-58.

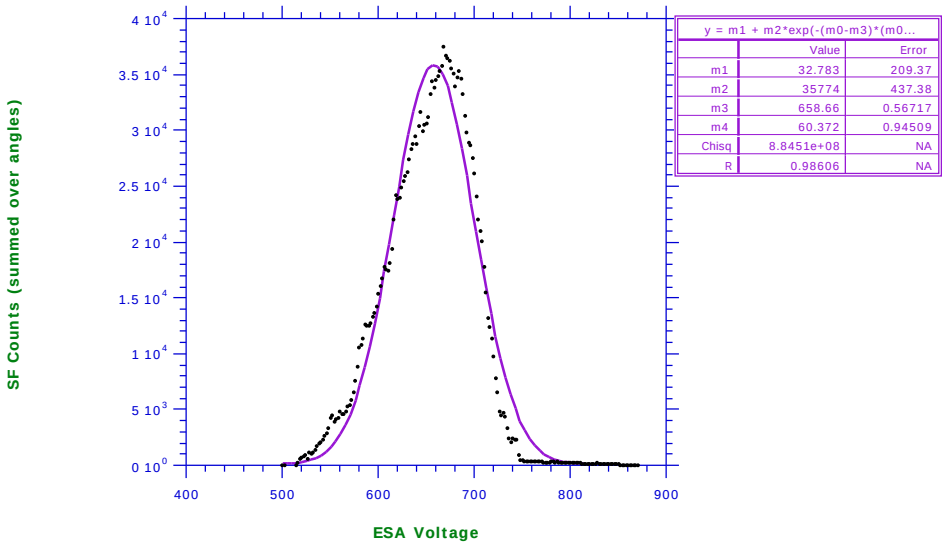

Figure 53. ESA response for FPB_19990611_152330a.

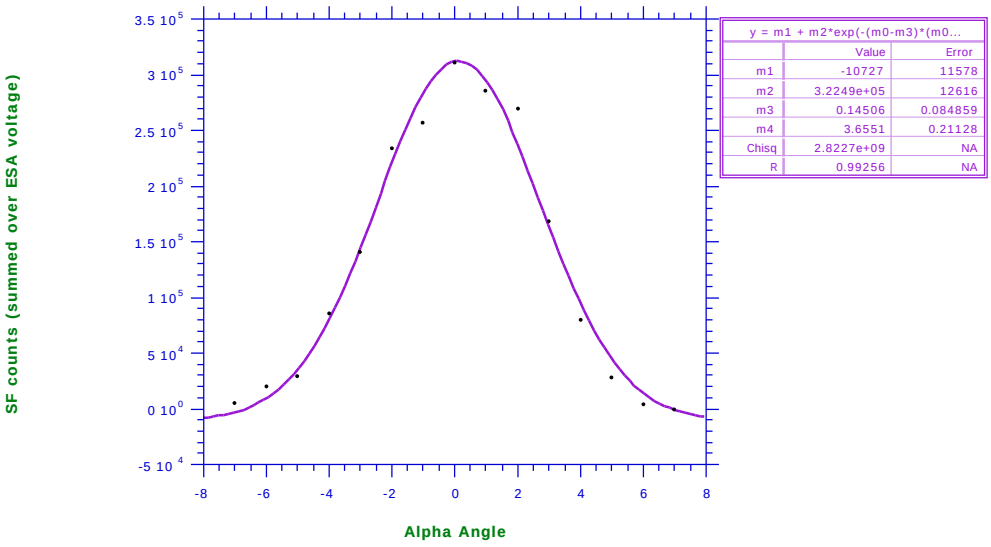

Figure 54. Alphas response to FPB_19990611_152330a

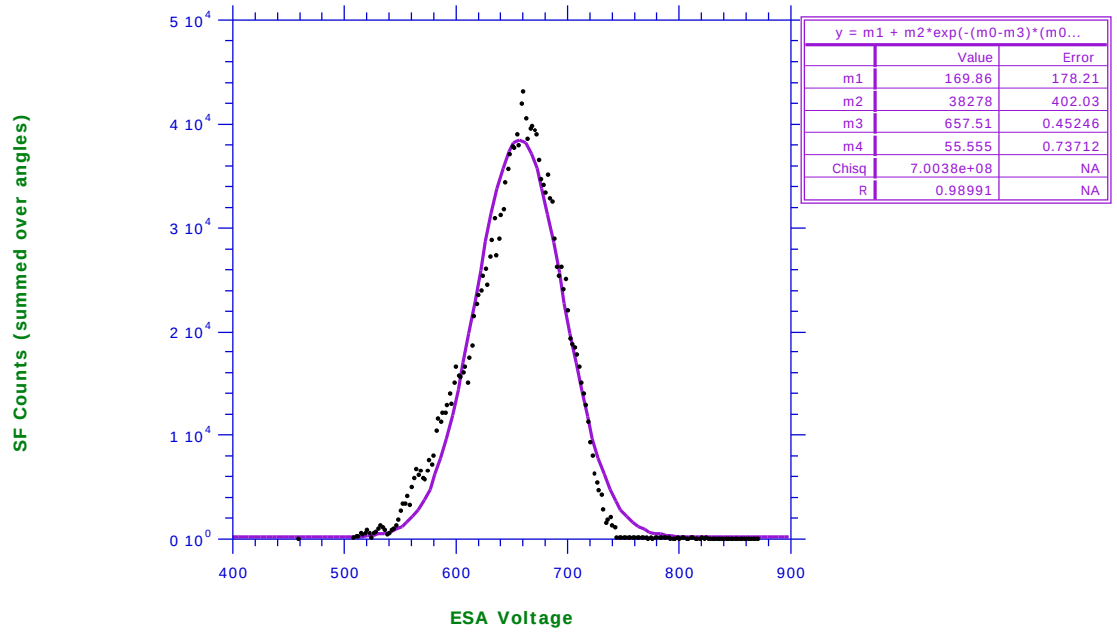

Figure 55. ESA response to FPB_19990611_152330b

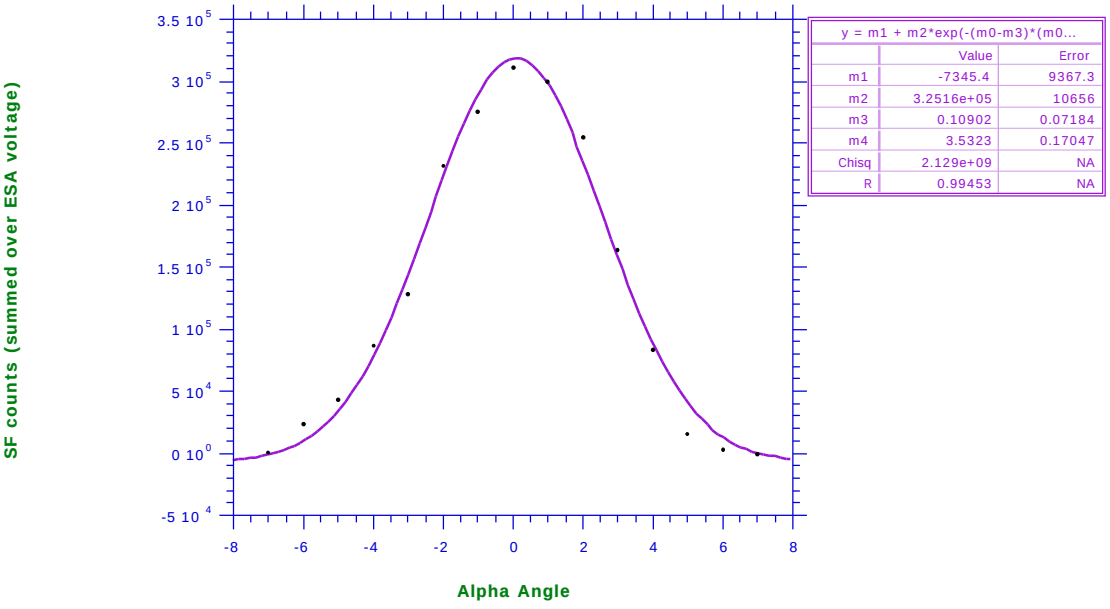

Figure 56. Alpha response to FPB_19990611_152330b

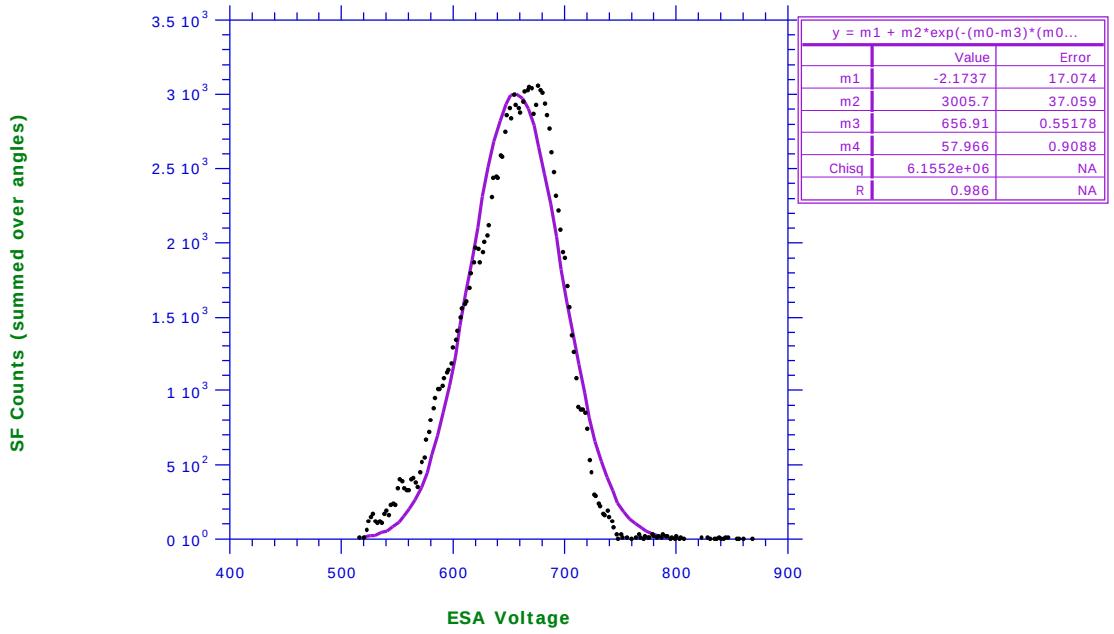

Figure 57. ESA response to FPB_19990615_182423.

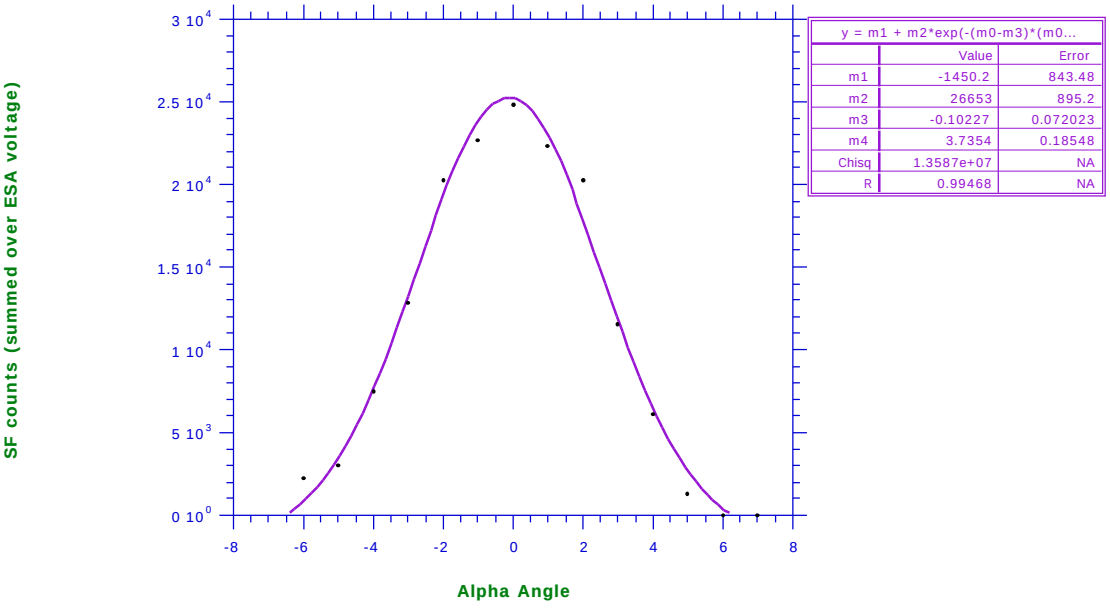

Figure 58. Alpha response to FPB_19990615_182423.

Table 22. Summary of the Phoenix LS energy response values and geometric factor. The analyzer constant, K, is the ratio of the Peak Voltage to the Beam energy.

File	Beam (keV)	Peak (V)	FWHM (V)	DV/V	DE/E	K	gf
FPB_19990611_152330a	10 He+	658.66	100.53	0.153	0.129	7.591	2.74E-05
FPB_19990611_152330b	10 He+	657.51	92.51	0.141	0.121	7.604	2.74E-05
FPB_19990615_182423	13 O+	656.91	96.52	0.147	0.125	7.611	2.05E-05
Average		657.69	96.52	0.147	0.125	7.602	2.51E-05

Table 23. Summary of Phoenix LS angle response.

File	Beam (keV)	Peak (deg)	FWHM (deg)
FPB_19990611_152330a	10 He+	0.15	3.66
FPB_19990611_152330b	10 He+	0.11	3.53
FPB_19990615_182423	13 O+	-0.10	3.74
Average		0.05	3.64

Summary

Table 24 summarizes the geometric factor from all the measurements. From the individual measurements, we have shown that the calculated geometric factor varies with amount of blockage from the carbon foil grid at a particular theta position. The measurements are made with the ion beam at one theta-position. A broad parallel beam, like the calibration source, is focused to a narrow beam in the instrument. This beam can be small relative to the size of the structure of the grid that supports the carbon foil, and so the structure of the grid can be seen in the measurements. The calculated geometric factor for a particular data set depends on how much of the beam hit the grid structure in the particular theta location. In flight, ions are coming in over a full range of the theta angles so the grid structure is averaged out. To get a good measurement for the geometric factor, we have averaged over all the measurements taken on all models and positions, and assumed that we had a good sampling of different areas of the grid.

The other difference that was noticed is that O+ systematically gave a lower geometric factor than H+ or He+. This was especially evident in cases where the measurements were taken at the same location with the three different species, so that the blockage factor is the same in all cases. Two possible explanations are that there is a systematic error in the start efficiency, or that the beam monitor gives systematically different values for different species. Although there may be errors in the start efficiency, the efficiency is determined separately for each unit, and so it is not clear why there should be a systematic error in it. The experts on the Bern calibration system have stated that the efficiencies for all the species at this energy (5 keV) should be about 1. So at this point, the reason for the difference is not understood.

The last two rows of table 24 shows the average geometric factor both with and without the O+ measurements. For an initial flight value, we recommend using the values without the O+ contribution, and then refining the overall geometric factor based on comparisons with HIA and pressure balance arguments. Because of the many factors that contribute to differences in these values, this data set is not large enough to determine small differences between the models. From the measurements we have made here, we think that the geometric factors are quite close for the different models, and the measured differences are a result of different amounts of blockage from the grid.

Tables 25-27 summarize the ESA and Alpha response, compared with the results of the ESA calibration alone. The ESA calibration was performed without the grids at the front entrance. This, and the additional structure added by the time-of-flight section, are the main differences that effect the results. In each case, there is a systematic difference between the two measurements. The analyzer constant is 1.5% higher, the energy width is 7% lower and the angular width is 6% higher with the full instrument, compared to the ESA alone.

Table 24. Summary of the geometric factor for the CODIF sensor.

Model	Position	Species	HS gf	LS gf
FM5	3, center	He+	2.58E-03	
FM5	3, edge	He+	2.59E-03	
FM5	14, center	O+		2.05E-05
FM6	6, center	He+	2.45E-03	
FM7	6, center	He+	2.63E-03	
FM7	6, center	H+	2.53E-03	
FM7	6, center	O+	1.97E-03	
FM7	14, center	He+		2.39E-05
FM7	14, center	H+		2.33E-05
FM7	14, center	O+		2.04E-05
FM8	2, center	He+	1.53E-03	
FM8	2, edge	He+	2.16E-03	
FM8	10, center	He+		2.57E-05
FM8	10, edge	He+		2.65E-05
FP	2, center	He+	2.49E-03	
FP	2, edge	He+	2.58E-03	
FP	2, center	H+	2.32E-03	
FP	6, center	O+	2.05E-03	
FP	10, center	He+		2.74E-05
FP	10, edge	He+		2.74E-05
FP	13, center	O+		2.05E-05
Average		All	2.32E-03	2.40E-05
Average		**No O+**	**2.39E-03**	**2.57E-05**

Table 25. Summary of the analyzer constant, compared with values from the ESA-only calibration.

Model	K (full)	K (ESA only)	Kfull/Kesa
FM5	7.382	7.282	1.014
FM6	7.217	7.093	1.013
FM7	7.412	7.326	1.012
FM8	7.455	7.307	1.020
Phoenix	7.566		

Table 26. Summary of energy response, compared with the ESA-only calibration

Model	dV/V FWHM	dV/V (1-dV/V) dE/E (full) FWHM	dE/E (ESA only)	full/ESA
FM5	0.153	0.130	0.136	0.961
FM6	0.152	0.129	0.141	0.918
FM7	0.144	0.123	0.137	0.899
FM8	0.149	0.127	0.136	0.931
Phoenix	0.163	0.137		

Table 27. Summary of angular response, compared with ESA-only calibration

Model	dA (full) FWHM	dA (ESA only) FWHM	full/ESA
FM5	6.124	5.489	1.113
FM6	5.774	5.610	1.016
FM7	5.790	5.622	1.015
FM8	6.271	5.521	1.114
Phoenix	6.136		