Cluster CODIF Calibration Report
Part III

TOF Peak Analysis
Mass Threshold and "Spillover" Determination

Version 2.0

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8/23/00

Revised 12/19/00

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Revision History

12/19/00 During commissioning, it was found that a large peak can be observed in the lowest channel, and during time periods with a high oxygen flux, there is a second peak below the proton peak which seems to be correlated with the O+ flux. It is probably due to ions with a time-of-flight greater than the allowed 200 ns from the long O+ tail. To keep these spurious peaks from being counted with the protons, a threshold below the H+ peak was introduced. This had always been allowed in the on-board software, but had never been set to anything above zero. In addition, the threshold tables used to distinguish between species are slightly different from those originally documented. These changes have been incorporated into this new document. The calibration information for FM5 has not been updated, as it is likely that this unit will not operate.

Introduction

The mass resolution of the CODIF instrument is defined by the resolution in time-of-flight. The width of the peaks in time-of-flight is determined by the spread in energy that results from energy loss in the carbon foil and any noise in the time-of-flight electronics. Because the energy loss is statistical process, ions which enter the foil with one energy come out with a range of energies. The percentage of energy lost is the worst for low-energy ions and heavy ions. The electronic noise is independent of ion energy.

To determine the mass on-board, the on-board processer bins the data using a table that contains 6 threshold values for each energy (127 energy steps), T1 – T6. For each event, the time-of-flight channel (TOF) is compared with the thresholds and the ion is binned according to the following:

If T1 ≤ TOF < T2 Then H+
If T2 ≤ TOF < T3 Then He++
If T3 ≤ TOF < T4 Then He+
If T5 ≤ TOF < T6 Then O+

Note that TOF values between T4 and T5, and values greater than T6 are not assigned to any species. The following will discuss how the thresholds are determined, and how much of each species is contained in each bin. The threshold tables to be used in flight are listed in Appendix 1, tables 6-9.

FM5 TOF resolution

Figure 1 shows the time-of-flight spectra over a range of energies for FM5. This figure is assembled from many data sets using individual species. The H+ He+ and O+ data is from the last FM5 calibration in Oct. 1999. Because no He++ data was taken during this trip, the He++ data is from a 1998 calibration of FM5. The relative heights of the peaks depend on the beam intensity and length of the run, and so have no significance for this analysis.

As discussed above, the width of the peaks is effected by the energy loss and scattering in the carbon foil, and noise in the time-of-flight circuit. Because the loss in the carbon foil is a smaller fraction of the total energy, the peaks should get narrower with energy. This is evident in the O+ peaks, but is not so clear for the lower mass peaks. One reason for this is that there is a significant difference between the locations of the peaks for different positions. This is shown in Figure 2, which shows the H+ peak for the HS and LS data at two energies, 15 keV total and 50 keV total. On the HS side, there is a systematic difference between positions. For example PF 6 aned 7 are consistently high in TOF, and PF 1 and 5 are consistently low. On the LS side is more consistent, with only PF 13 falling slightly lower than the others. The HS peaks are also consistently wider than the LS peaks. This is probably due to slightly higher noise in the HS time-of-flight circuitry.

Because the peaks move closer together with energy, but the width of the low-mass ions does not significantly improve, there are more problems with overlapping peaks, and therefore worse mass resolution, at high energies. The bin with the most overlap with other species is the He++ bin. A quantitative analysis of the spill-over between bins is shown in figure 3. Each panel shows the fraction of a particular species which falls into each bin. There are two points to notice in these figures. First, it is important to get a high percentage of an ion into the correct bin. But second, it is important to keep the spill-over from H+ as low as possible. Because H+ is by far the dominant species, even a small percent of

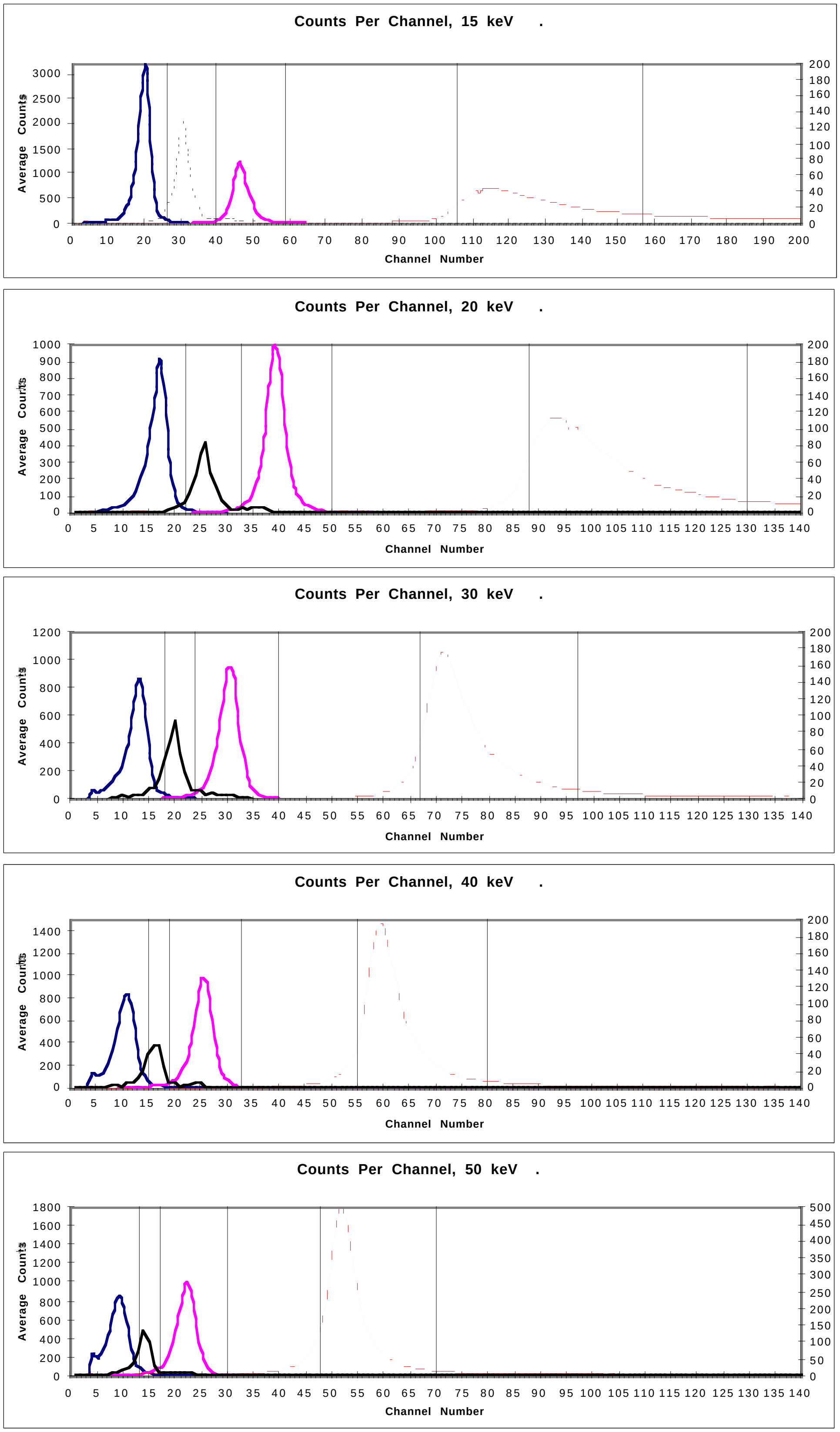

Figure 1. FM5 time-of-flight spectra for the four major species at 4 energies. The spectra are averaged over all positions. The lines show the thresholds used to distinguish species.

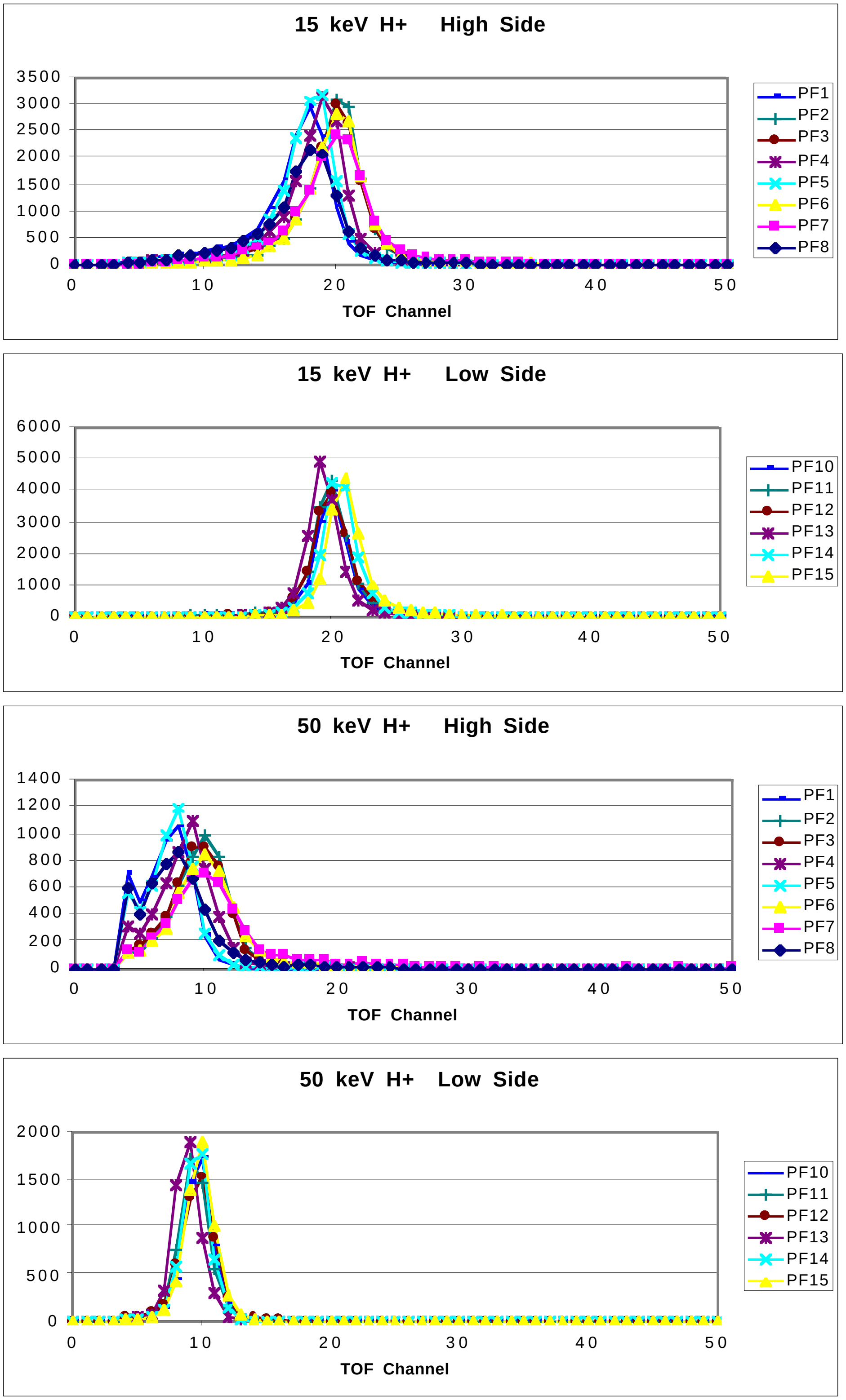

Figure 2. H+ peaks for individual position for the high side and low side at two energies, 15 keV and 50 keV.

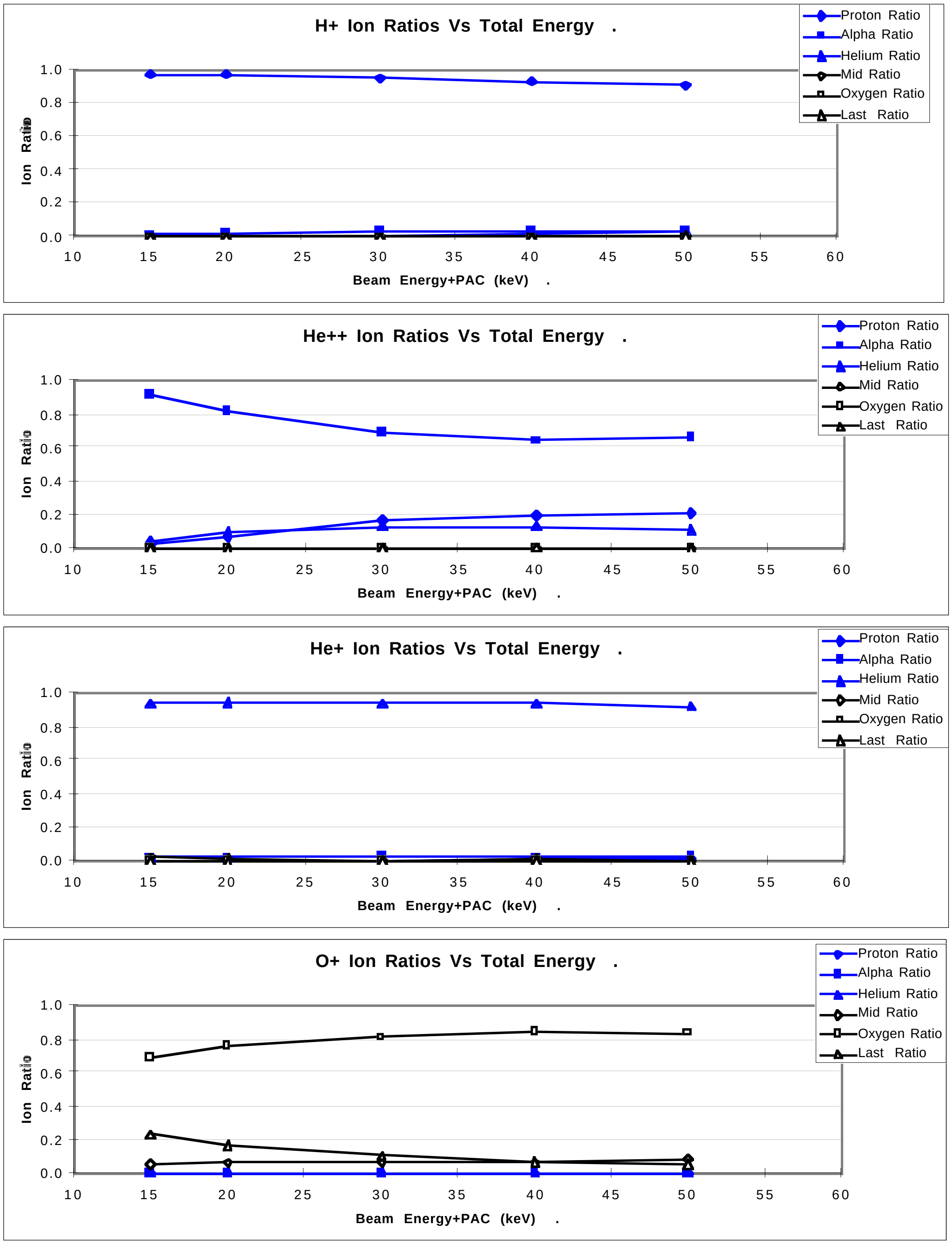

Figure 3. FM5 Fraction of each ion species which is classified into each bin.

spillover from H+ into the He++ bin can effect the He++ measurement. In this case, at the low energy end, H+ has only about 2% spilling over into the He++ bin. At the higher energies this increases to about 4%. For He++, only 65% falls into the bin at high energies. This is because the threshold was set to minimize the H+ in the bin. For O+, the fraction that falls into the O+ bin was kept low at low energies to reduce the background in the bin. At 15 keV, the O+ has a long tail extending to high TOF-channels. The background from accidental coincidences in a bin is proportional to the number of TOF channels in the bin, so there is an advantage to keeping a narrow bin, even if some of the real signal is lost. The numbers which go into the Figure 3 are given in table 1.

Table 1. Spillover between species for FM5.

Species	**Total Ergy**	**Proton Ratio**	**Alpha Ratio**	**Helium Ratio**	**Mid Ratio**	**Oxygen Ratio**	**Last Ratio**
H+	15	0.978	0.018	0.002	0.001	0.001	0.001
H+	20	0.971	0.024	0.002	0.001	0.001	0.001
H+	30	0.948	0.032	0.012	0.003	0.002	0.003
H+	40	0.933	0.033	0.027	0.002	0.002	0.003
H+	50	0.909	0.044	0.035	0.003	0.003	0.006
He++	15	0.027	0.915	0.055	0.004	0.000	0.000
He++	20	0.071	0.824	0.099	0.006	0.000	0.000
He++	30	0.166	0.698	0.133	0.002	0.001	0.000
He++	40	0.205	0.647	0.139	0.001	0.003	0.005
He++	50	0.209	0.660	0.122	0.004	0.003	0.004
He+	15	0.003	0.025	0.940	0.026	0.003	0.003
He+	20	0.003	0.025	0.950	0.018	0.002	0.002
He+	30	0.009	0.031	0.943	0.012	0.002	0.003
He+	40	0.013	0.025	0.942	0.014	0.002	0.004
He+	50	0.020	0.038	0.927	0.010	0.002	0.003
O+	15	0.003	0.000	0.001	0.056	0.698	0.241
O+	20	0.003	0.000	0.001	0.064	0.763	0.169
O+	30	0.003	0.001	0.001	0.071	0.811	0.112
O+	40	0.003	0.001	0.002	0.067	0.850	0.078
O+	50	0.002	0.002	0.003	0.095	0.842	0.056

FM6 TOF resolution

Figure 4 shows the TOF spectra for the four major species for FM6. For FM6, there were no samples taken at 15 keV total, so only peaks for 20-50 keV are shown. While the peak locations and width are very similar to FM5, the quantitative analysis is hampered by the contamination in the beam, for both H+ and He++. The H+ runs show a second peak at about twice the time-of-flight, which is most likely H_2+ at the same energy/charge. Similarly, the He++ also shows a second peak at about twice the time-of-flight. This is most likely He+. This additional peaks in the adjacent species where we are trying to determine the spillover make quantitative analysis difficult. Figure 5 shows the spillover results. The calculated spillover values are most likely worse than the real spillover.

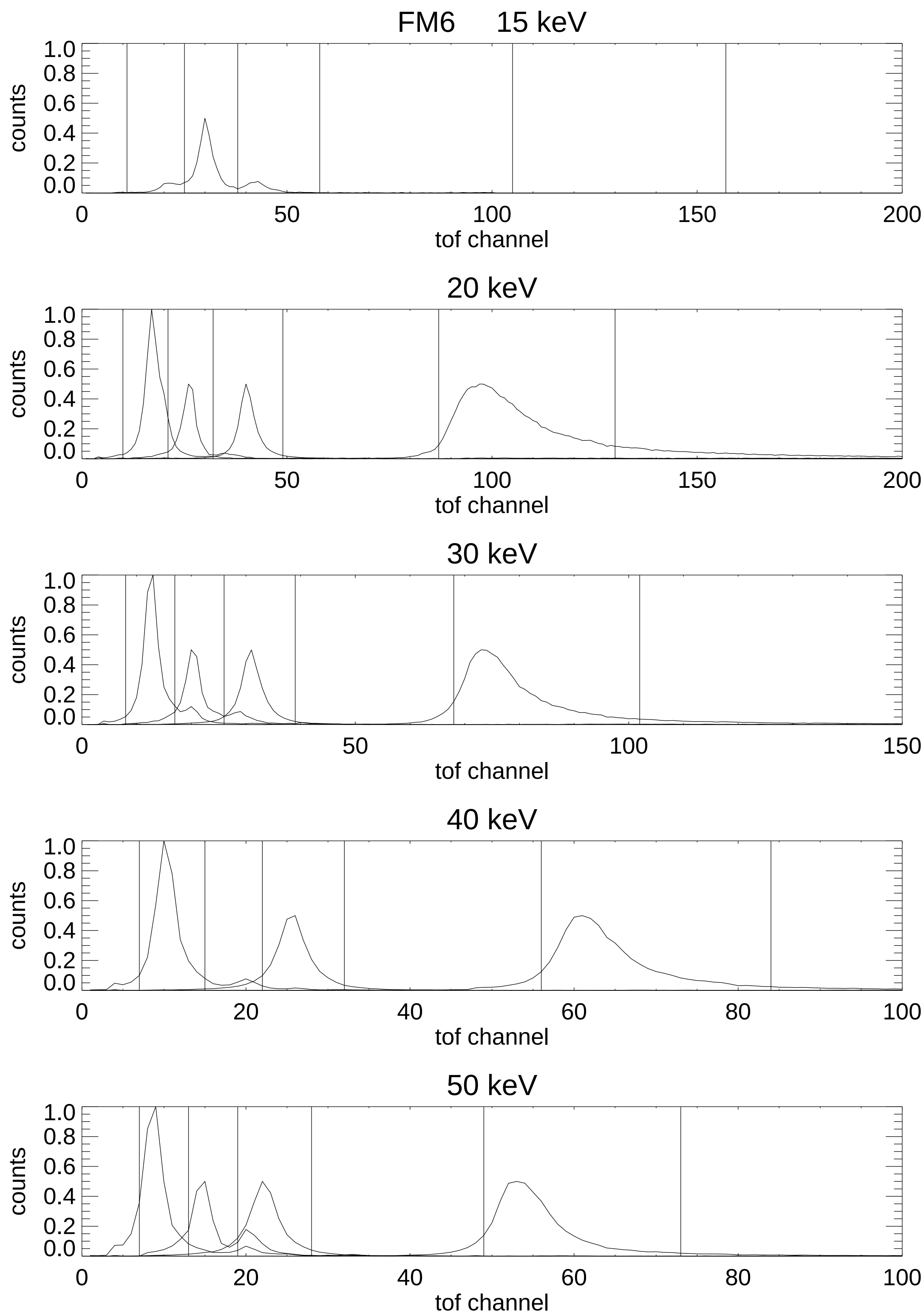

Figure 4. FM6 time-of-flight spectra for the four major species at 4 energies. The spectra are averaged over all positions. The lines show the thresholds used to distinguish species.

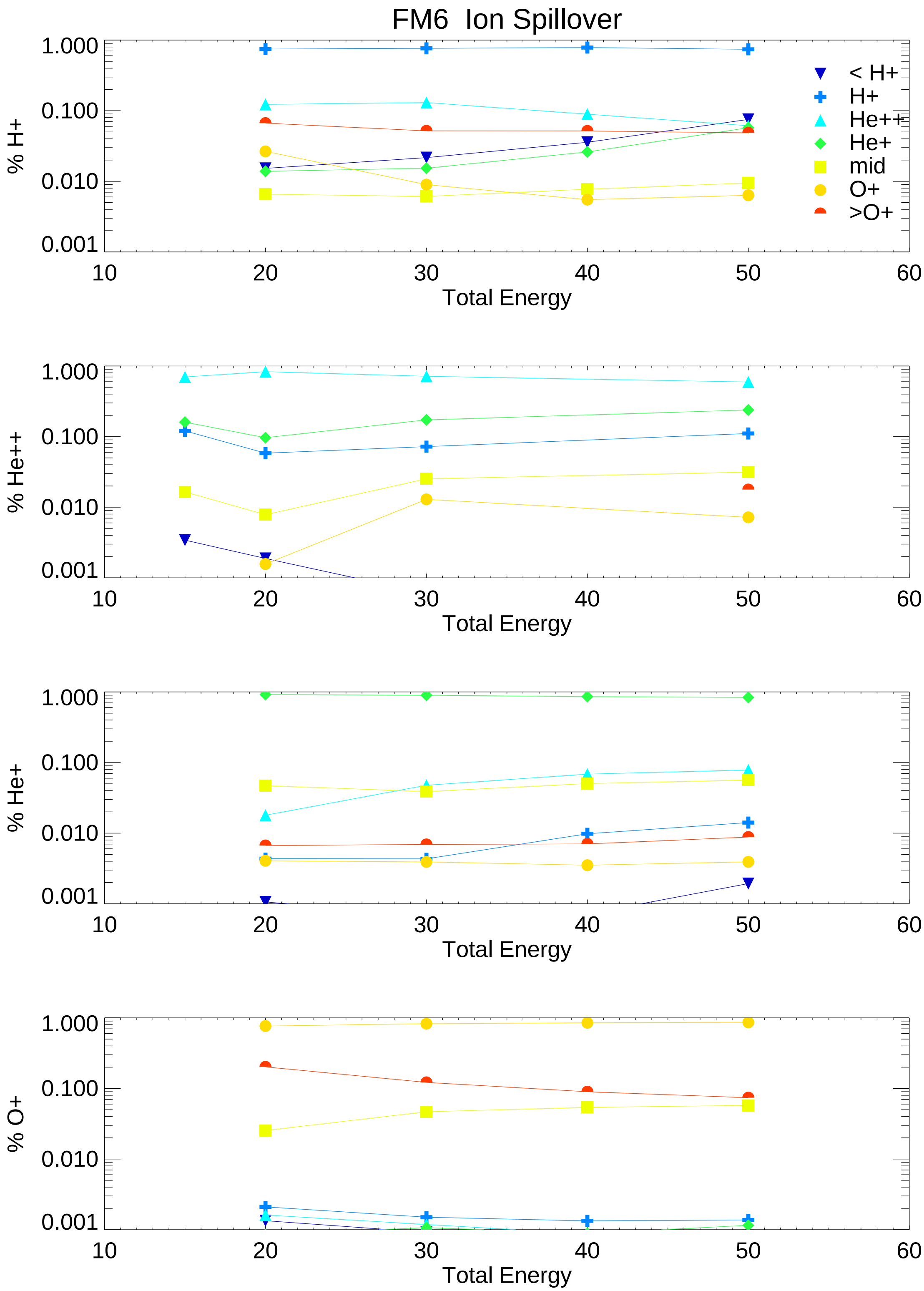

Figure 5. FM6 fraction of each ion species which is classified into each bin. Note that contamination in the beam makes these numbers worse than they really are.

Table 2. Spillover between species for FM6.

Species	**Total Ergy**	**< H+**	**H**	**He++**	**He+**	**Mid**	**O+**	**>O+**
H+	20	0.015	0.748	0.123	0.014	0.007	0.027	0.067
H+	30	0.022	0.765	0.13	0.015	0.006	0.009	0.052
H+	40	0.036	0.784	0.089	0.026	0.008	0.006	0.052
H+	50	0.075	0.741	0.061	0.057	0.009	0.006	0.049
He++	15	0.003	0.121	0.699	0.16	0.017	0	0
He++	20	0.002	0.058	0.834	0.097	0.008	0.002	0
He++	30	0.001	0.072	0.716	0.173	0.025	0.013	0
He++	50	0	0.111	0.594	0.238	0.031	0.007	0.018
He+	20	0.001	0.004	0.018	0.919	0.047	0.004	0.007
He+	30	0.001	0.004	0.048	0.898	0.039	0.004	0.007
He+	40	0.001	0.01	0.069	0.86	0.05	0.004	0.007
He+	50	0.002	0.014	0.079	0.836	0.057	0.004	0.009
O+	20	0.001	0.002	0.002	0.001	0.025	0.766	0.202
O+	30	0.001	0.002	0.001	0.001	0.047	0.827	0.122
O+	40	0.001	0.001	0.001	0.001	0.054	0.852	0.09
O+	50	0.001	0.001	0.001	0.001	0.058	0.864	0.074

FM7 TOF resolution

Figures 6 and 7 show the time-of-flight spectra and the spill-over between bins for FM7. Table 3 shows the data which goes into Figure 6. The results here are very similar to the FM5 results.

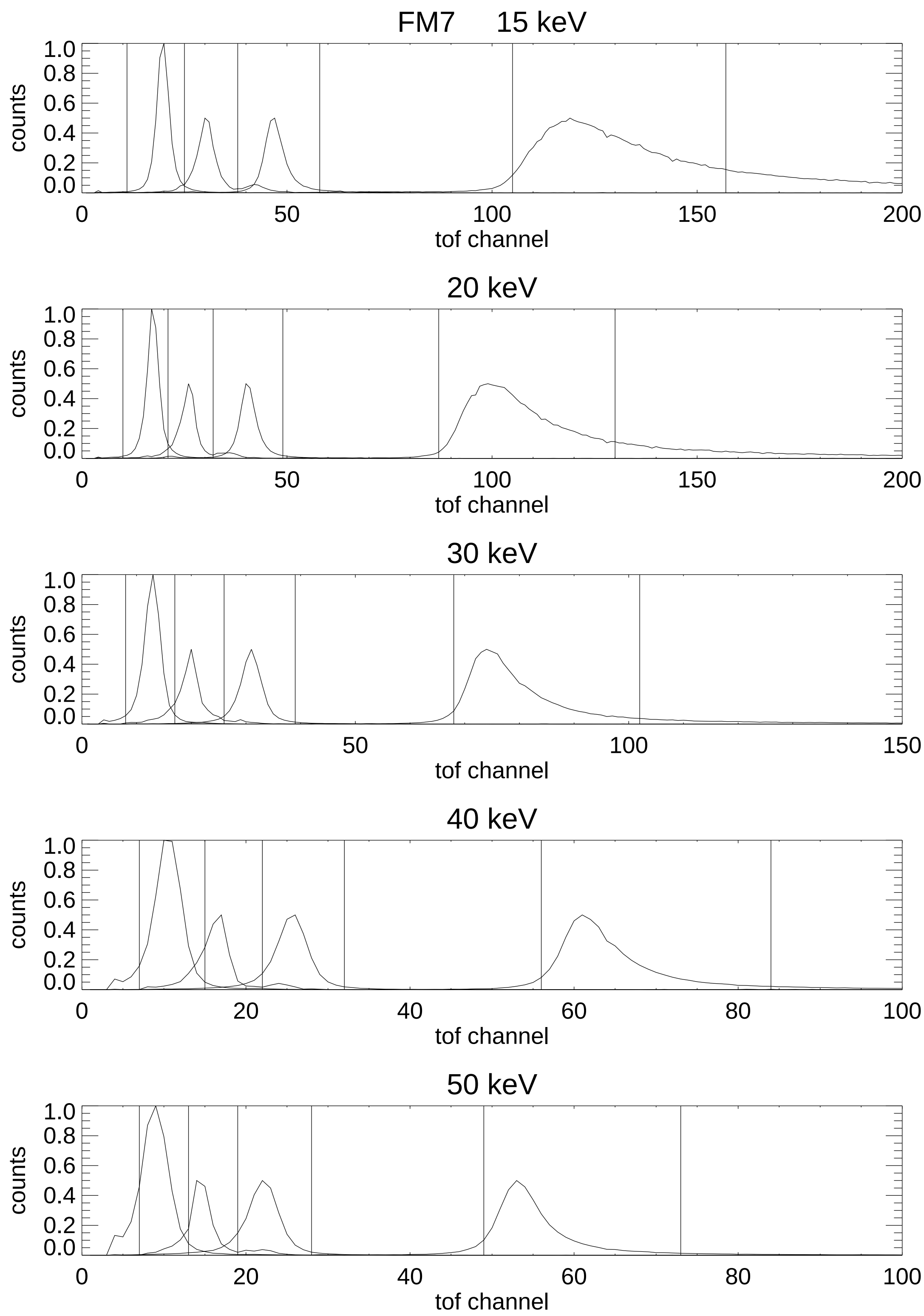

Figure 6. FM7 time-of-flight spectra for the four major species at 4 energies. The spectra are averaged over all positions. The lines show the thresholds used to distinguish species.

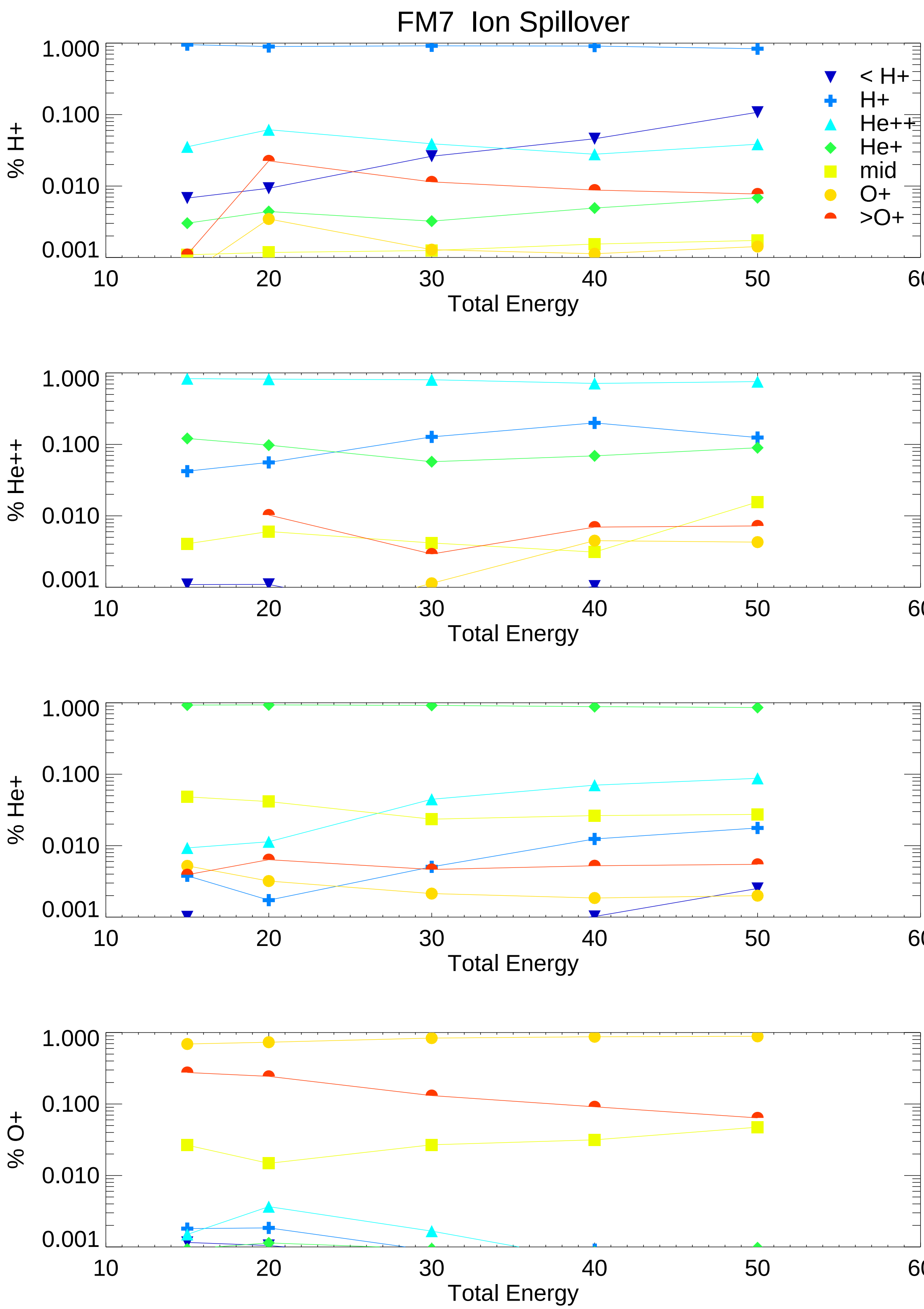

Figure 7. FM7 fraction of each ion species which is classified into each bin.

Table 3. Spillover between species for FM7.

Species	**Total Ergy**	**<H+**	**H+**	**He++**	**He+**	**mid**	**O+**	**>O+**
H+	15	0.007	0.952	0.035	0.003	0.001	0.001	0.001
H+	20	0.009	0.896	0.061	0.004	0.001	0.003	0.022
H+	30	0.026	0.917	0.039	0.003	0.001	0.001	0.011
H+	40	0.046	0.91	0.028	0.005	0.002	0.001	0.009
H+	50	0.108	0.836	0.038	0.007	0.002	0.001	0.008
He++	15	0.001	0.042	0.832	0.121	0.004	0	0
He++	20	0.001	0.056	0.819	0.098	0.006	0	0.01
He++	30	0	0.127	0.802	0.057	0.004	0.001	0.003
He++	40	0.001	0.2	0.714	0.069	0.003	0.004	0.007
He++	50	0	0.125	0.756	0.09	0.016	0.004	0.007
He+	15	0.001	0.004	0.009	0.929	0.048	0.005	0.004
He+	20	0.001	0.002	0.011	0.934	0.041	0.003	0.006
He+	30	0.001	0.005	0.045	0.919	0.024	0.002	0.005
He+	40	0.001	0.012	0.07	0.883	0.026	0.002	0.005
He+	50	0.003	0.018	0.088	0.857	0.027	0.002	0.005
O+	15	0.001	0.002	0.001	0.001	0.027	0.692	0.276
O+	20	0.001	0.002	0.004	0.001	0.015	0.733	0.244
O+	30	0.001	0.001	0.002	0.001	0.027	0.838	0.131
O+	40	0	0.001	0.001	0.001	0.032	0.874	0.091
O+	50	0.001	0.001	0	0.001	0.047	0.886	0.064

FM8 TOF resolution

For FM8, the HS and the LS sides have slightly different time-to-channel number conversions, so that the peak locations are different on the two sides. Figures 8 and 9 show the time-of-flight spectra and the spill-over between bins for the HS side FM8, assuming the same threshold tables as were used for the other models. Figure 9 and 10 show the same information for the LS side. There was no He++ data for the LS side. But since the LS peaks for the other species are in essentially identical locations as the FM5 peaks, we have added the He++ data from FM5 to guide the eye. Note that the standard thresholds work fine on the LS side. On the HS side, however, the thresholds cut severely into the He++ peak, particularly at high energies. The LS side will be used predominantly in the magnetosheath and solar wind, where the distribution is dominated by low energy (~1 keV) solar wind ions. Thus it is most critical to be able to separate H+ and He++ at low energies. Thus the current low-energy thresholds should be maintained. The HS side will be used in the magnetosphere, where the population tends to be higher energy. Thus it would be better to optimize the higher energy data points for the HS side.

In order to be able to separate H+ and He++ on the Low Side (LS) at low energies, and to have good separation on the high side at all energies, a few changes were made to the standard tables. The He++ bin at low energies was narrowed, to decrease the overlap with He+ on the High Side while maintaining good separation on the LS. At high energies, the thresholds were all shifted to lower times-of-flight to give good separation for all species on the HS. The TOF peaks with the new thresholds are shown in figures 12 and 13. Figures 14 and 15 show the new calculations of spillover between species. And the values for the spillover using the new tables are given in tables 4 and 5.

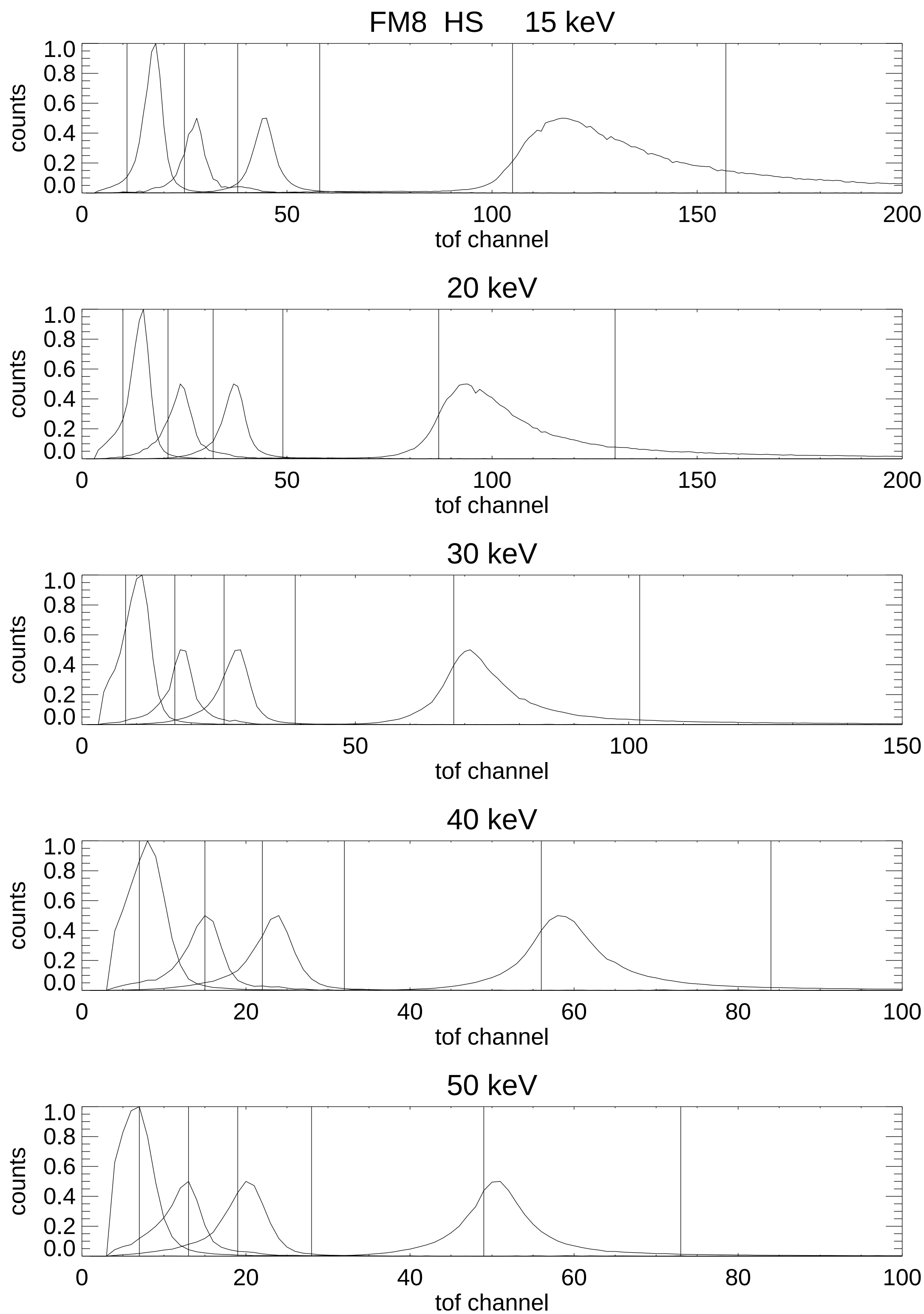

Figure 8. FM8 HS time-of-flight spectra for the four major species at 4 energies. The spectra are averaged over all positions. The lines show the thresholds used to distinguish species.

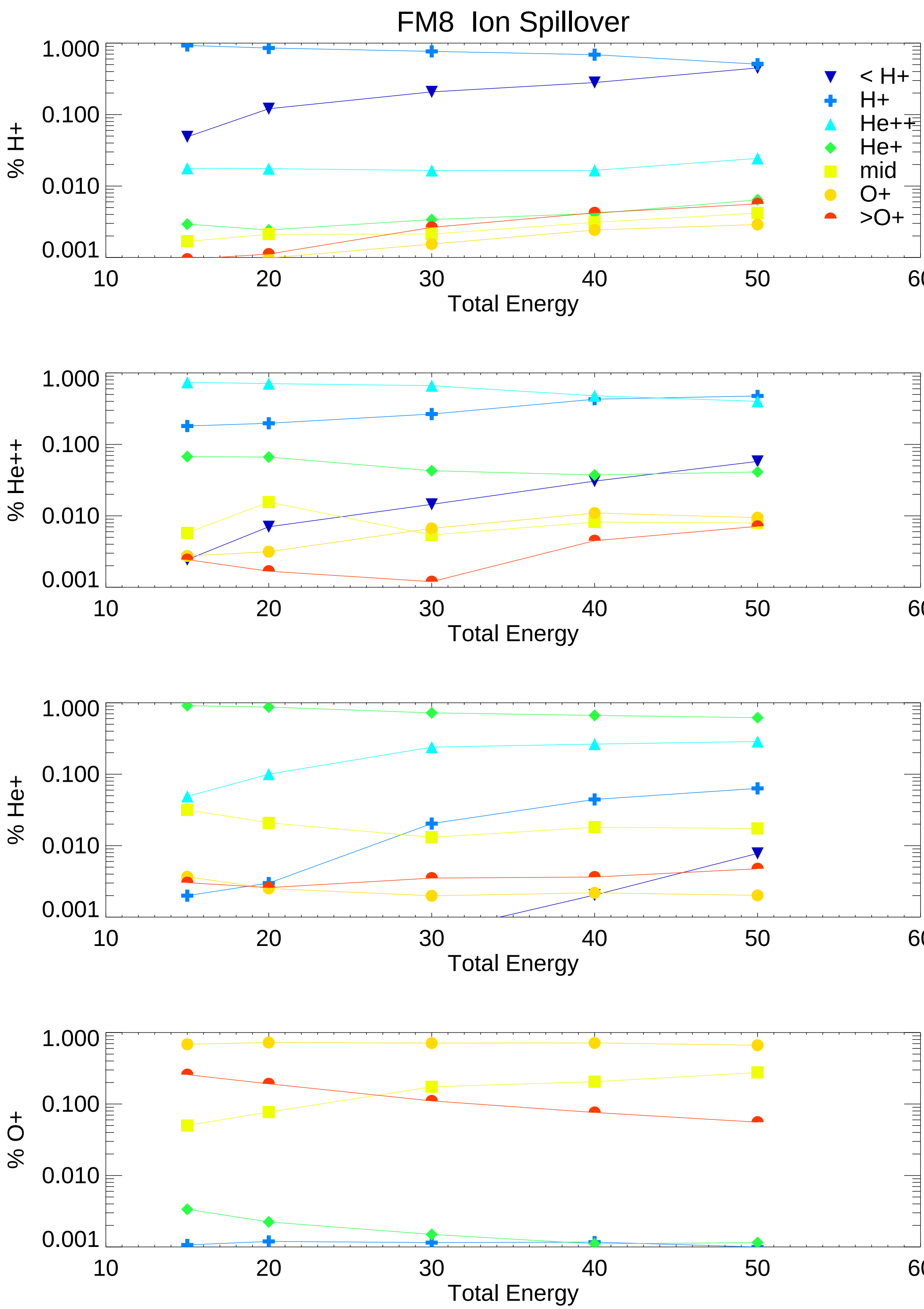

Figure 9. FM8 HS fraction of each ion species which is classified into each bin.

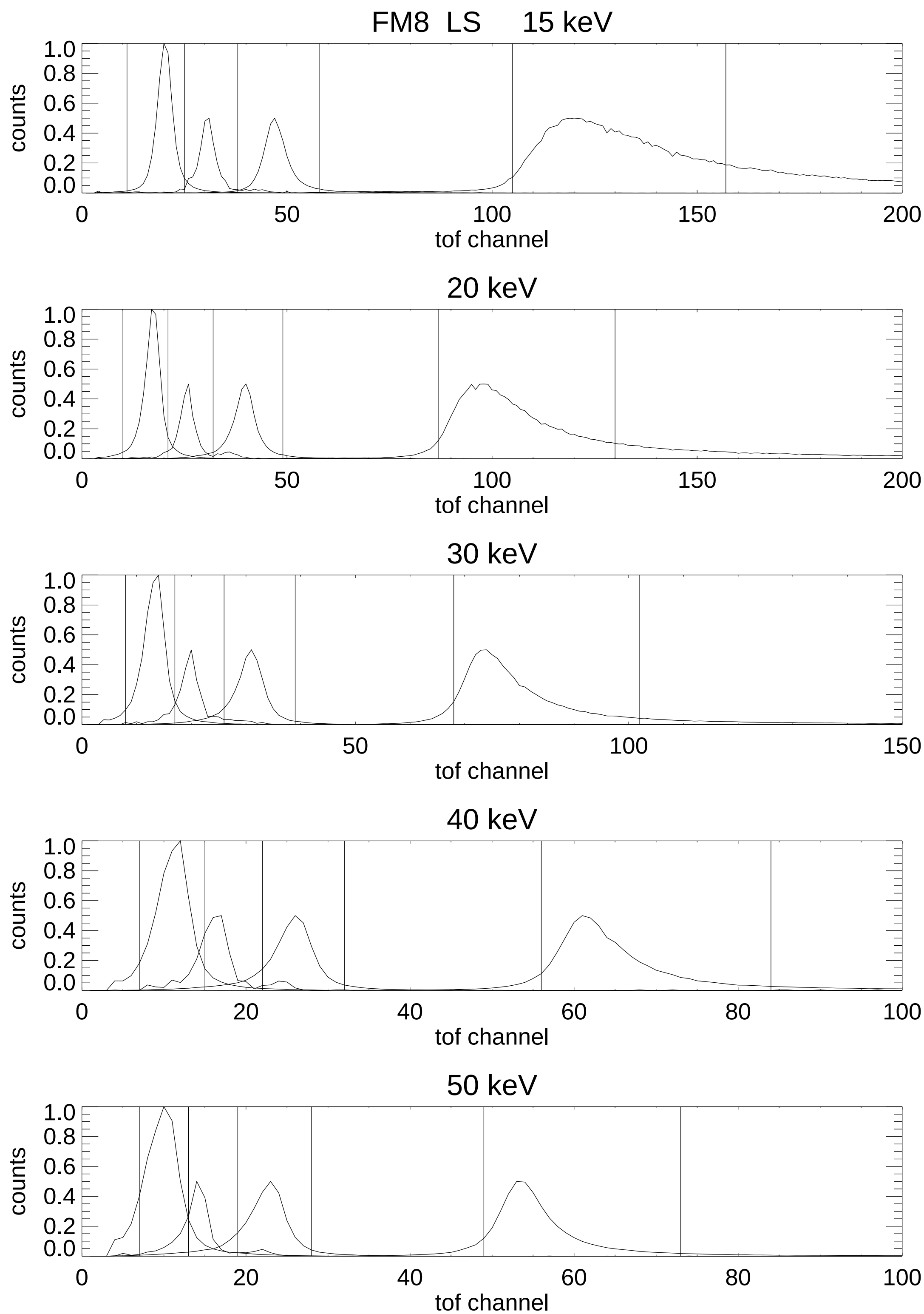

Figure 10. FM8 LS time-of-flight spectra for the four major species at 4 energies. The spectra are averaged over all positions. The lines show the thresholds used to distinguish species. There was no He++ data for the LS, so peaks from FM5 are shown.

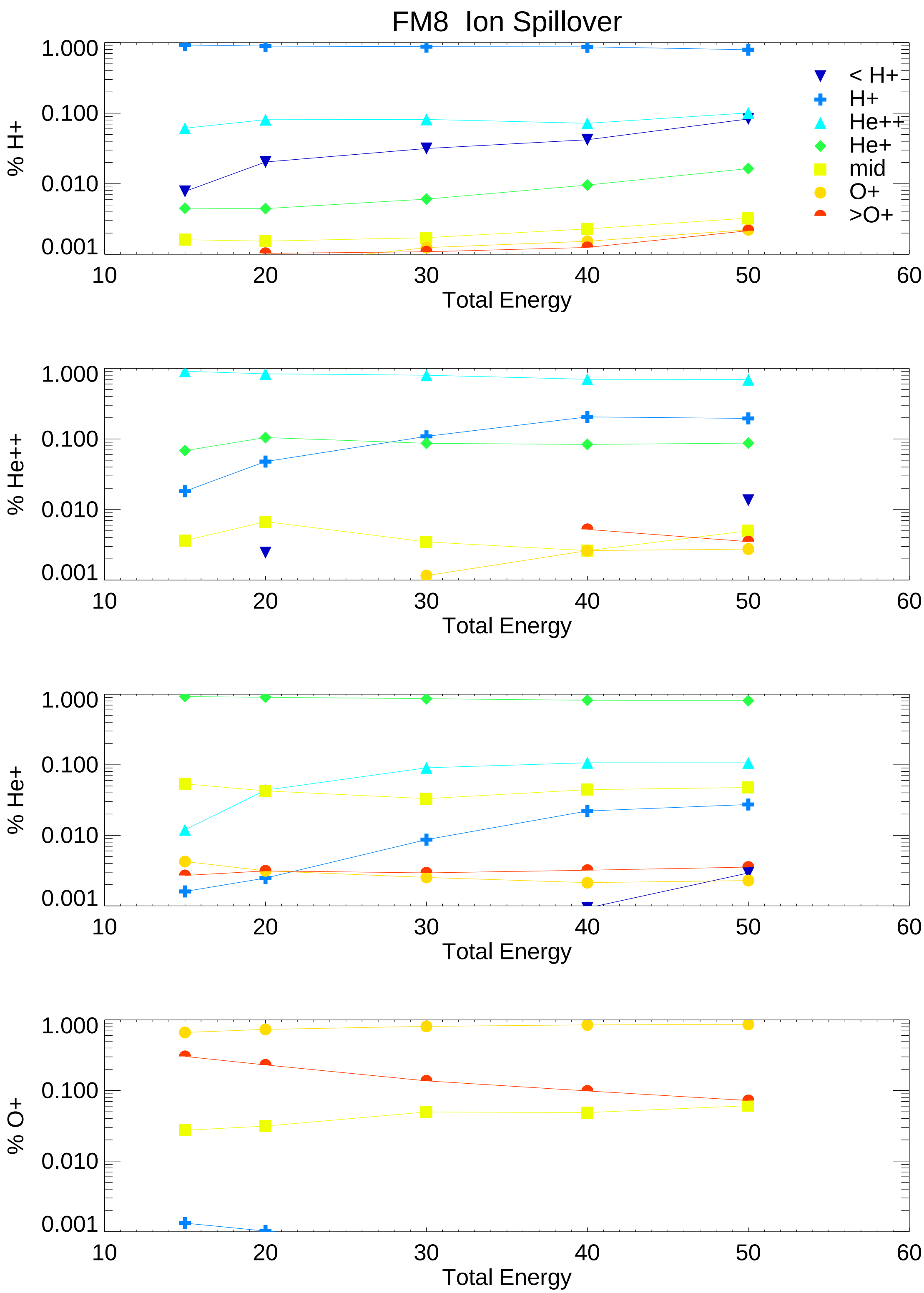

Figure 11. FM8 LS fraction of each ion species which is classified into each bin .

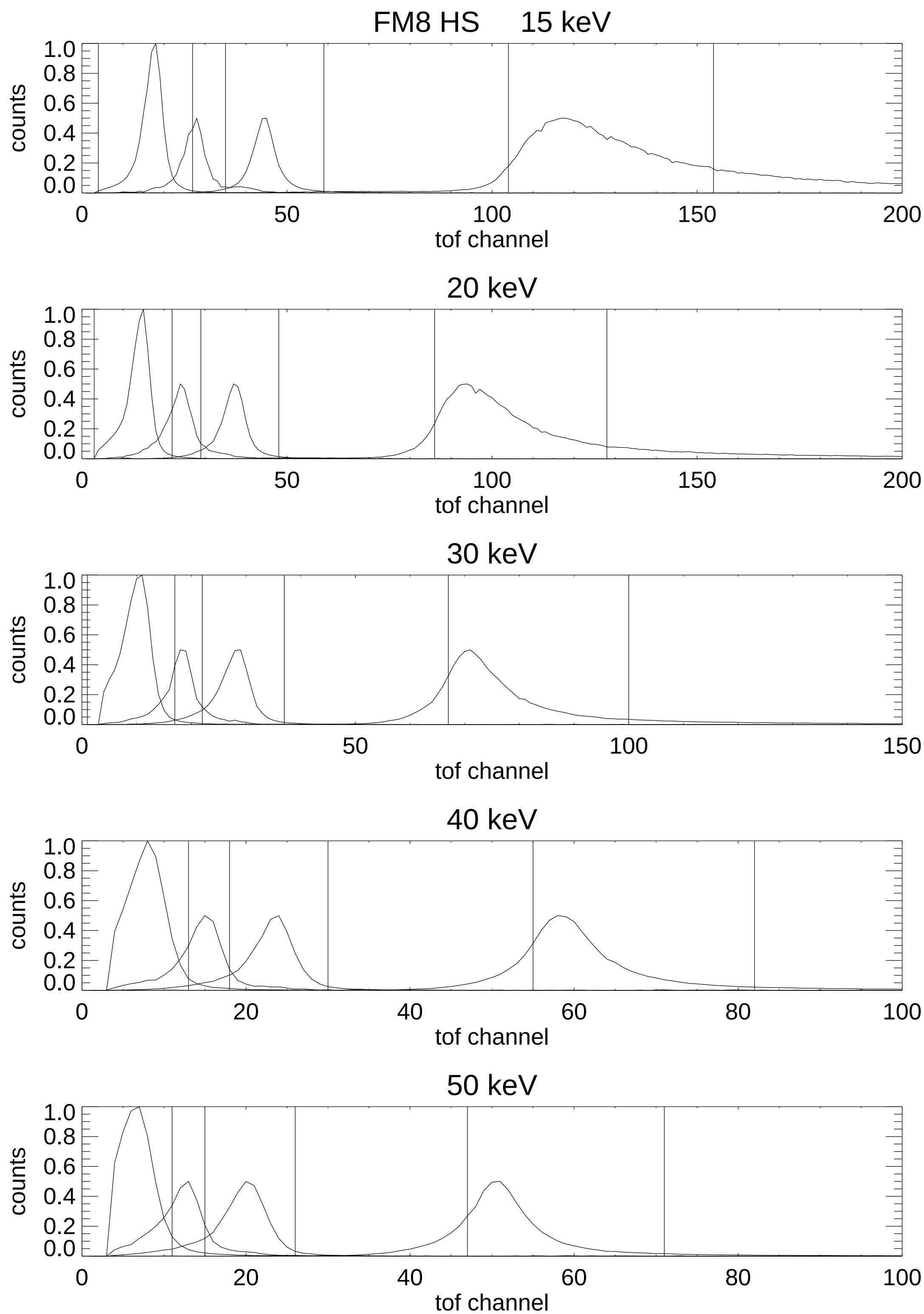

Figure 12. FM8 TOF peaks on the HS, using the new thresholds.

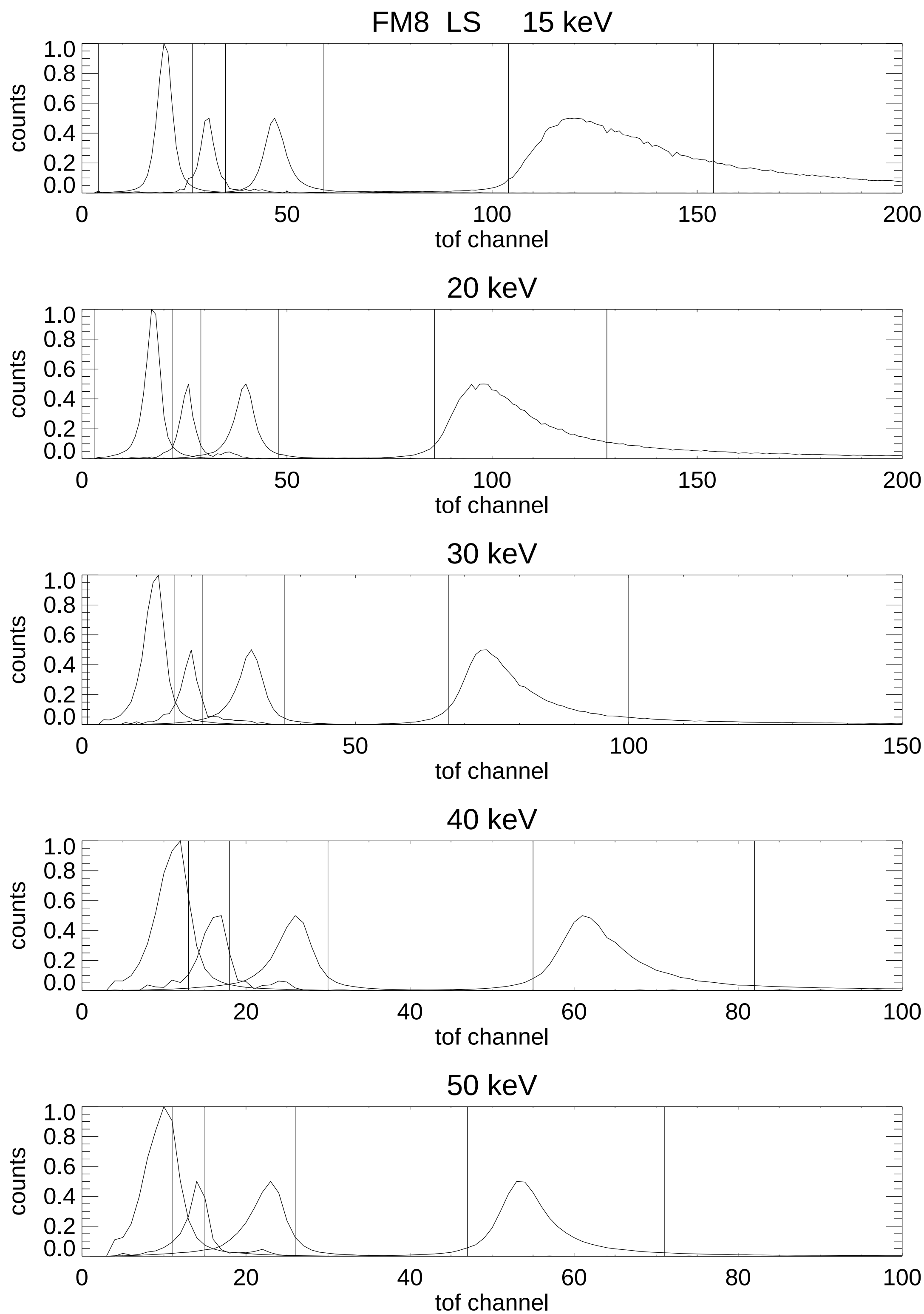

Figure 13. FM8 TOF peaks on the LS, using the new thresholds.

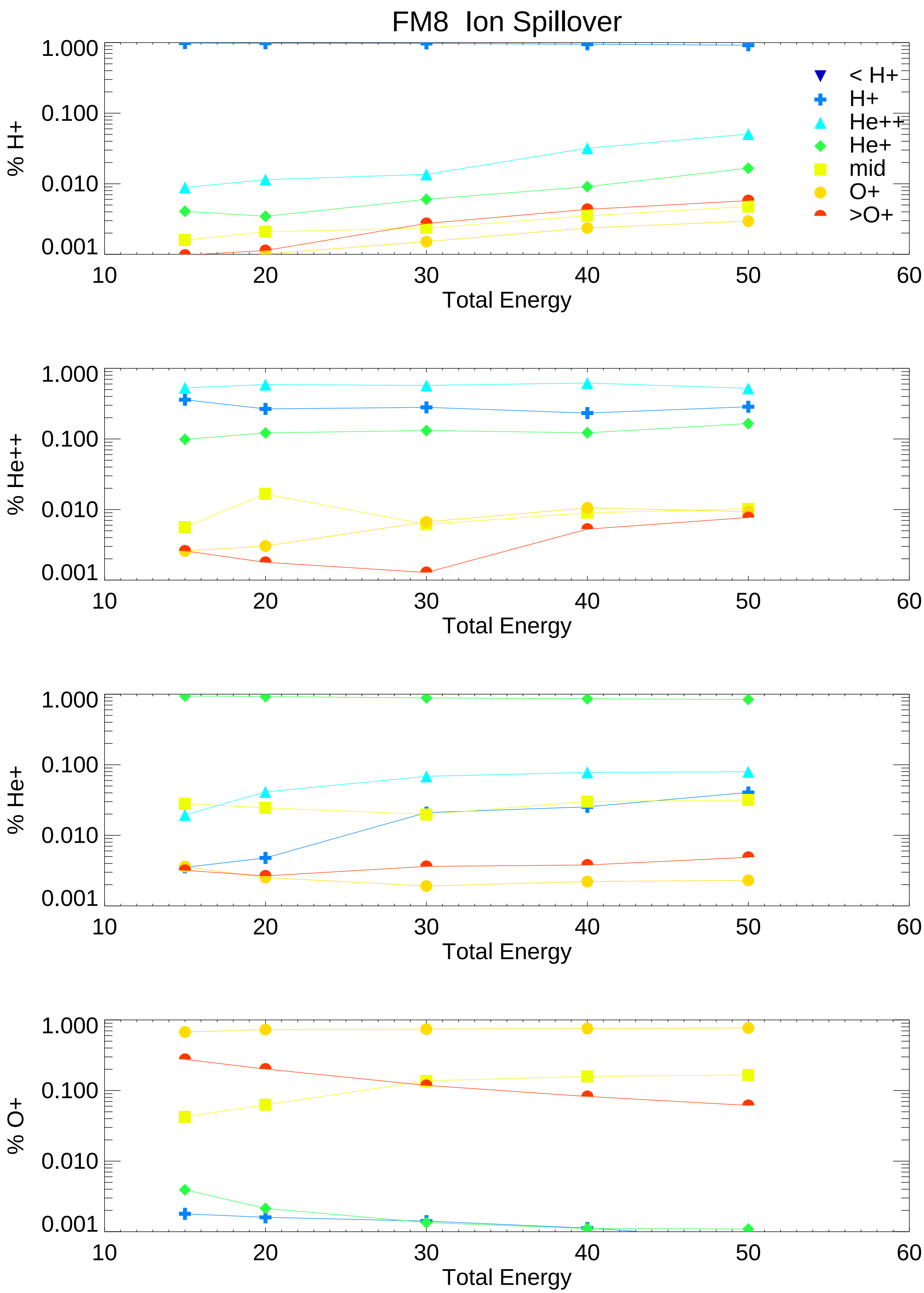

Figure 14. FM8 HS fraction of each ion species which is classified into each bin using the new thresholds.

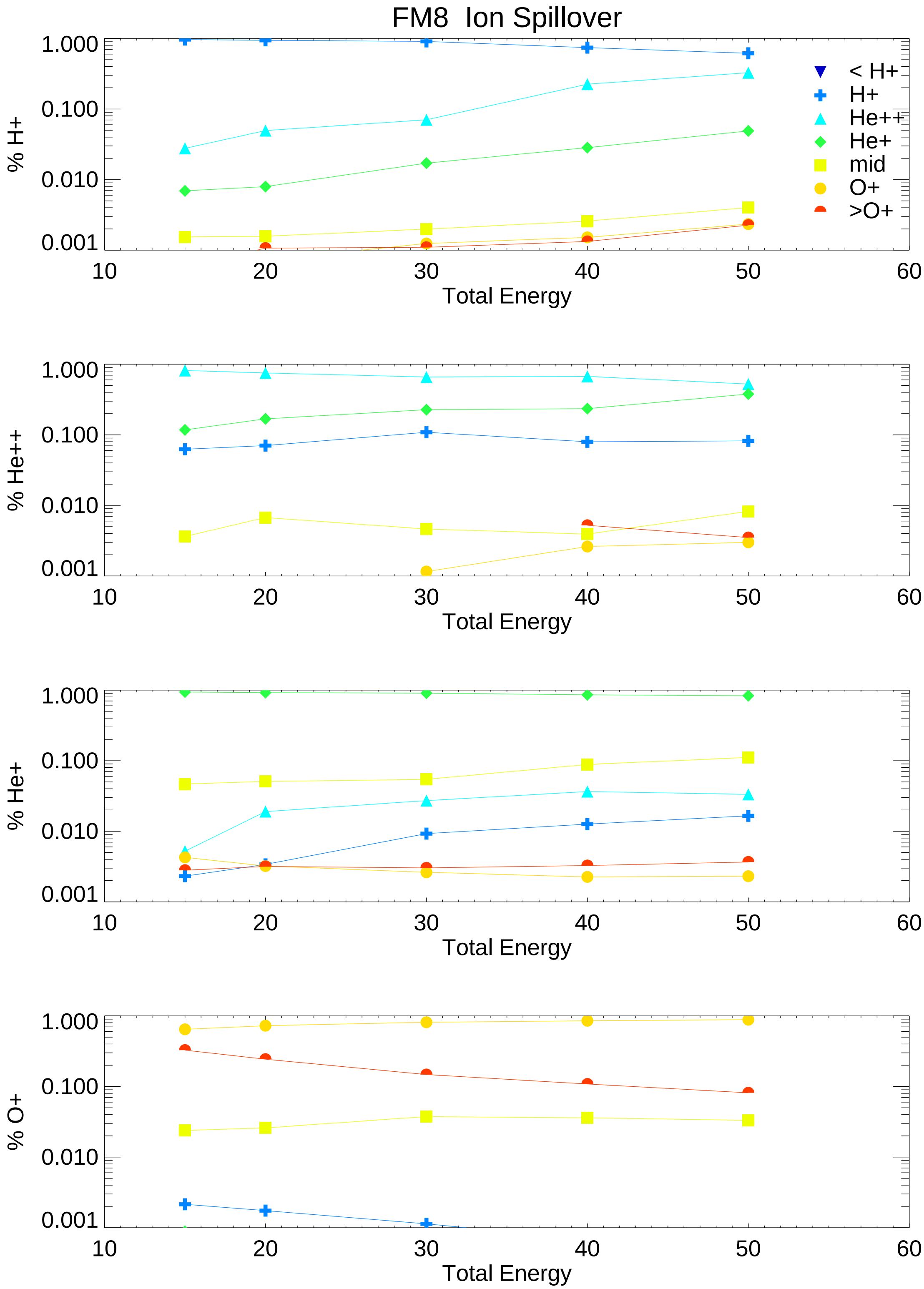

Figure 15. FM8 LS fraction of each ion species which is classified into each bin using the new thresholds.

Table 4. Spillover between species for FM8, HS.

Species	Energy	<H+	H+	He++	He+	mid	O+	>O+
H+	15	0	0.984	0.009	0.004	0.002	0.001	0.001
H+	20	0	0.981	0.011	0.003	0.002	0.001	0.001
H+	30	0	0.974	0.014	0.006	0.002	0.002	0.003
H+	40	0	0.949	0.032	0.009	0.004	0.002	0.004
H+	50	0	0.919	0.051	0.017	0.005	0.003	0.006
He++	15	0	0.36	0.531	0.099	0.006	0.003	0.003
He++	20	0	0.267	0.59	0.122	0.017	0.003	0.002
He++	30	0	0.28	0.574	0.132	0.006	0.007	0.001
He++	40	0	0.232	0.62	0.122	0.009	0.011	0.005
He++	50	0	0.286	0.522	0.165	0.01	0.009	0.008
He+	15	0	0.004	0.019	0.942	0.028	0.004	0.003
He+	20	0	0.005	0.041	0.924	0.025	0.003	0.003
He+	30	0	0.021	0.068	0.885	0.02	0.002	0.004
He+	40	0	0.025	0.078	0.861	0.03	0.002	0.004
He+	50	0	0.041	0.08	0.841	0.032	0.002	0.005
O+	15	0	0.002	0	0.004	0.043	0.675	0.277
O+	20	0	0.002	0	0.002	0.063	0.731	0.202
O+	30	0	0.001	0	0.001	0.137	0.741	0.118
O+	40	0	0.001	0	0.001	0.158	0.756	0.082
O+	50	0	0.001	0.001	0.001	0.166	0.77	0.062

Table 5. Spillover between species for FM8, LS.

Species	Energy	<H+	H+	He++	He+	mid	O+	>O+
H+	15	0	0.963	0.028	0.007	0.002	0.001	0.001
H+	20	0	0.939	0.049	0.008	0.002	0.001	0.001
H+	30	0	0.908	0.07	0.017	0.002	0.001	0.001
H+	40	0	0.741	0.225	0.028	0.003	0.002	0.001
H+	50	0	0.616	0.327	0.049	0.004	0.002	0.002
He++	15	0	0.062	0.816	0.118	0.004	0	0
He++	20	0.001	0.07	0.754	0.169	0.007	0	0
He++	30	0	0.109	0.659	0.227	0.005	0.001	0
He++	40	0	0.08	0.673	0.235	0.004	0.003	0.005
He++	50	0	0.082	0.525	0.378	0.008	0.003	0.004
He+	15	0	0.002	0.005	0.939	0.047	0.004	0.003
He+	20	0	0.003	0.019	0.92	0.051	0.003	0.003
He+	30	0	0.009	0.027	0.904	0.054	0.003	0.003
He+	40	0	0.013	0.036	0.857	0.088	0.002	0.003
He+	50	0	0.017	0.033	0.833	0.111	0.002	0.004
O+	15	0	0.002	0	0.001	0.024	0.646	0.327
O+	20	0	0.002	0	0.001	0.026	0.727	0.244
O+	30	0	0.001	0	0	0.037	0.813	0.148
O+	40	0	0.001	0	0	0.036	0.854	0.108
O+	50	0	0.001	0	0	0.033	0.884	0.081

Appendix 1. Threshold tables for the four flight models.

Table 6. 15 keV PAC threshold table for FM5, FM6, FM7

E-step	Ion Energy	Total E	Min H+	Min He++	Min He+	Max He+	Min O+	Max O+
0	39.15	54.15	7	13	18	27	46	68
1	36.856	51.856	7	13	19	27	48	70
2	34.697	49.697	7	13	19	28	49	73
3	32.664	47.664	7	14	20	29	51	75
4	30.75	45.75	7	14	20	30	52	77
5	28.948	43.948	7	14	21	31	54	79
6	27.252	42.252	7	14	21	31	55	82
7	25.655	40.655	7	15	22	32	56	84
8	24.152	39.152	7	15	22	33	58	86
9	22.737	37.737	8	15	23	34	59	88
10	21.404	36.404	8	16	23	34	61	90
11	20.15	35.15	8	16	24	35	62	92
12	18.97	33.97	8	16	24	36	63	94
13	17.858	32.858	8	16	24	37	65	96
14	16.812	31.812	8	17	25	37	66	98
15	15.827	30.827	8	17	25	38	67	100
16	14.899	29.899	8	17	26	39	68	102
17	14.026	29.026	8	18	26	39	70	104
18	13.204	28.204	8	18	27	40	71	105
19	12.431	27.431	8	18	27	41	72	107
20	11.702	26.702	9	18	27	41	73	109
21	11.017	26.017	9	19	28	42	74	111
22	10.371	25.371	9	19	28	43	75	112
23	9.763	24.763	9	19	29	43	76	114
24	9.191	24.191	9	19	29	44	78	116
25	8.653	23.653	9	19	29	44	79	117
26	8.146	23.146	9	20	30	45	80	119
27	7.669	22.669	9	20	30	45	81	120
28	7.219	22.219	9	20	30	46	82	122
29	6.796	21.796	9	20	31	46	83	123
30	6.398	21.398	9	21	31	47	84	125
31	6.023	21.023	9	21	31	47	84	126
32	5.67	20.67	9	21	32	48	85	128
33	5.338	20.338	9	21	32	48	86	129
34	5.025	20.025	10	21	32	49	87	130
35	4.731	19.731	10	21	33	49	88	132
36	4.454	19.454	10	22	33	50	89	133
37	4.193	19.193	10	22	33	50	90	134
38	3.947	18.947	10	22	33	51	90	135
39	3.716	18.716	10	22	34	51	91	136
40	3.498	18.498	10	22	34	51	92	137
41	3.293	18.293	10	22	34	52	93	139
42	3.1	18.1	10	23	34	52	93	140
43	2.918	17.918	10	23	35	53	94	141
44	2.747	17.747	10	23	35	53	95	142
45	2.586	17.586	10	23	35	53	95	143
46	2.435	17.435	10	23	35	54	96	144
47	2.292	17.292	10	23	35	54	96	144
48	2.158	17.158	10	23	36	54	97	145

49	2.031	17.031	10	24	36	55	98	146
50	1.912	16.912	10	24	36	55	98	147
51	1.8	16.8	10	24	36	55	99	148
52	1.695	16.695	10	24	36	55	99	148
53	1.596	16.596	10	24	37	56	100	149
54	1.502	16.502	10	24	37	56	100	150
55	1.414	16.414	11	24	37	56	100	151
56	1.331	16.331	11	24	37	56	101	151
57	1.253	16.253	11	24	37	57	101	152
58	1.18	16.18	11	24	37	57	102	152
59	1.111	16.111	11	24	37	57	102	153
60	1.046	16.046	11	25	37	57	102	153
61	0.984	15.984	11	25	38	57	103	154
62	0.927	15.927	11	25	38	57	103	154
63	0.872	15.872	11	25	38	58	103	155
64	0.821	15.821	11	25	38	58	103	155
65	0.773	15.773	11	25	38	58	104	155
66	0.728	15.728	11	25	38	58	104	156
67	0.685	15.685	11	25	38	58	104	156
68	0.645	15.645	11	25	38	58	104	156
69	0.607	15.607	11	25	38	58	104	156
70	0.572	15.572	11	25	38	58	104	156
71	0.538	15.538	11	25	38	58	105	157
72	0.507	15.507	11	25	38	58	105	157
73	0.477	15.477	11	25	38	58	105	157
74	0.449	15.449	11	25	38	58	105	157
75	0.423	15.423	11	25	38	58	105	157
76	0.398	15.398	11	25	38	58	105	157
77	0.375	15.375	11	25	38	58	105	157
78	0.353	15.353	11	25	38	58	105	157
79	0.332	15.332	11	25	38	58	105	157
80	0.313	15.313	11	25	38	58	105	157
81	0.294	15.294	11	25	38	58	105	157
82	0.277	15.277	11	25	38	58	105	157
83	0.261	15.261	11	25	38	58	105	157
84	0.245	15.245	11	25	38	58	105	157
85	0.231	15.231	11	25	38	58	105	157
86	0.218	15.218	11	25	38	58	105	157
87	0.205	15.205	11	25	38	58	105	157
88	0.193	15.193	11	25	38	58	105	157
89	0.182	15.182	11	25	38	58	105	157
90	0.171	15.171	11	25	38	58	105	157
91	0.161	15.161	11	25	38	58	105	157
92	0.151	15.151	11	25	38	58	105	157
93	0.143	15.143	11	25	38	58	105	157
94	0.134	15.134	11	25	38	58	105	157
95	0.126	15.126	11	25	38	58	105	157
96	0.119	15.119	11	25	38	58	105	157
97	0.112	15.112	11	25	38	58	105	157
98	0.105	15.105	11	25	38	58	105	157
99	0.099	15.099	11	25	38	58	105	157
100	0.093	15.093	11	25	38	58	105	157
101	0.088	15.088	11	25	38	58	105	157
102	0.083	15.083	11	25	38	58	105	157
103	0.078	15.078	11	25	38	58	105	157

Table 7. 15 keV PAC threshold table for FM8

E-step	Ion Energy	Total E	Min H+	Min He++	Min He+	Max He+	Min O+	Max O+
0	39.15	54.15	0	10	14	24	44	67
1	36.856	51.856	0	11	14	25	46	69
2	34.697	49.697	0	11	15	26	47	71
3	32.664	47.664	0	11	15	27	49	73
4	30.75	45.75	0	12	16	28	50	76
5	28.948	43.948	0	12	17	29	52	78
6	27.252	42.252	0	13	17	29	53	80
7	25.655	40.655	0	13	18	30	55	82
8	24.152	39.152	1	14	18	31	56	84
9	22.737	37.737	1	14	19	32	57	86
10	21.404	36.404	1	14	19	33	59	88
11	20.15	35.15	1	15	20	34	60	90
12	18.97	33.97	1	15	20	34	62	92
13	17.858	32.858	1	16	21	35	63	94
14	16.812	31.812	1	16	21	36	64	96
15	15.827	30.827	1	16	22	37	65	98
16	14.899	29.899	1	17	22	37	67	100
17	14.026	29.026	1	17	22	38	68	102
18	13.204	28.204	1	17	23	39	69	104
19	12.431	27.431	2	18	23	39	70	105
20	11.702	26.702	2	18	24	40	72	107
21	11.017	26.017	2	18	24	41	73	109
22	10.371	25.371	2	19	25	41	74	111
23	9.763	24.763	2	19	25	42	75	112
24	9.191	24.191	2	19	25	43	76	114
25	8.653	23.653	2	20	26	43	77	115
26	8.146	23.146	2	20	26	44	78	117
27	7.669	22.669	2	20	27	45	79	118
28	7.219	22.219	2	20	27	45	80	120
29	6.796	21.796	2	21	27	46	81	121
30	6.398	21.398	2	21	28	46	82	123
31	6.023	21.023	2	21	28	47	83	124
32	5.67	20.67	2	22	28	47	84	126
33	5.338	20.338	3	22	29	48	85	127
34	5.025	20.025	3	22	29	48	86	128
35	4.731	19.731	3	22	29	49	87	129
36	4.454	19.454	3	23	30	49	87	131
37	4.193	19.193	3	23	30	50	88	132
38	3.947	18.947	3	23	30	50	89	133
39	3.716	18.716	3	23	30	51	90	134
40	3.498	18.498	3	23	31	51	91	135
41	3.293	18.293	3	24	31	52	91	136
42	3.1	18.1	3	24	31	52	92	137
43	2.918	17.918	3	24	31	52	93	138
44	2.747	17.747	3	24	32	53	93	139
45	2.586	17.586	3	24	32	53	94	140
46	2.435	17.435	3	25	32	54	95	141
47	2.292	17.292	3	25	32	54	95	142
48	2.158	17.158	3	25	33	54	96	143
49	2.031	17.031	3	25	33	55	96	144
50	1.912	16.912	3	25	33	55	97	145
51	1.8	16.8	3	25	33	55	98	145

52	1.695	16.695	3	26	33	55	98	146
53	1.596	16.596	3	26	34	56	98	147
54	1.502	16.502	4	26	34	56	99	148
55	1.414	16.414	4	26	34	56	99	148
56	1.331	16.331	4	26	34	57	100	149
57	1.253	16.253	4	26	34	57	100	149
58	1.18	16.18	4	26	34	57	101	150
59	1.111	16.111	4	26	34	57	101	150
60	1.046	16.046	4	26	35	57	101	151
61	0.984	15.984	4	27	35	58	102	151
62	0.927	15.927	4	27	35	58	102	152
63	0.872	15.872	4	27	35	58	102	152
64	0.821	15.821	4	27	35	58	102	153
65	0.773	15.773	4	27	35	58	103	153
66	0.728	15.728	4	27	35	58	103	153
67	0.685	15.685	4	27	35	58	103	153
68	0.645	15.645	4	27	35	58	103	154
69	0.607	15.607	4	27	35	59	103	154
70	0.572	15.572	4	27	35	59	103	154
71	0.538	15.538	4	27	35	59	103	154
72	0.507	15.507	4	27	35	59	104	154
73	0.477	15.477	4	27	35	59	104	154
74	0.449	15.449	4	27	35	59	104	154
75	0.423	15.423	4	27	35	59	104	154
76	0.398	15.398	4	27	35	59	104	154
77	0.375	15.375	4	27	35	59	104	154
78	0.353	15.353	4	27	35	59	104	154
79	0.332	15.332	4	27	35	59	104	154
80	0.313	15.313	4	27	35	59	104	154
81	0.294	15.294	4	27	35	59	104	154
82	0.277	15.277	4	27	35	59	104	154
83	0.261	15.261	4	27	35	59	104	154
84	0.245	15.245	4	27	35	59	104	154
85	0.231	15.231	4	27	35	59	104	154
86	0.218	15.218	4	27	35	59	104	154
87	0.205	15.205	4	27	35	59	104	154
88	0.193	15.193	4	27	35	59	104	154
89	0.182	15.182	4	27	35	59	104	154
90	0.171	15.171	4	27	35	59	104	154
91	0.161	15.161	4	27	35	59	104	154
92	0.151	15.151	4	27	35	59	104	154
93	0.143	15.143	4	27	35	59	104	154
94	0.134	15.134	4	27	35	59	104	154
95	0.126	15.126	4	27	35	59	104	154
96	0.119	15.119	4	27	35	59	104	154
97	0.112	15.112	4	27	35	59	104	154
98	0.105	15.105	4	27	35	59	104	154
99	0.099	15.099	4	27	35	59	104	154
100	0.093	15.093	4	27	35	59	104	154
101	0.088	15.088	4	27	35	59	104	154
102	0.083	15.083	4	27	35	59	104	154
103	0.078	15.078	4	27	35	59	104	154
104	0.073	15.073	4	27	35	59	104	154