

SXT Calibration Note 29 Preliminary Calibration of SXT Flight X-ray Filters

From: Loren w. Acton
Date: 25 January 1992
Refs: a. Solar-A/SXT Filter Wheel Assembly Shop Order # SXT-2SO128.
b. SXT Cal Note 5 (SXT8G004), The SXT x-ray Neutral-density Filters.

A. Flight Analysis Filters

According to my laboratory records and the referenced shop order the following filters were assembled into the SXT filter wheel for flight:

Table 1

<u>Wheel Position</u>	<u>Filter Code</u>	<u>Filter Type</u>	<u>Serial Number</u>
B2	Al.1	Thin aluminum	3569
B3	AlMg	Composite	3231C
B4	Be119	Thick beryllium	3-88
B5	Al12	Thick aluminum	3151C
B6	Mg3	Magnesium	03370A-2
A6	NuDen	Steel mesh	2-90B

B. Laboratory Calibration Data

All filters were calibrated by x-ray transmission on the LPARL high and/or low-energy x-ray monochromators. The high energy machine utilizes a Bragg crystal to render the beam monochromatic and was used for wavelengths of 13.3 Å (Cu-L) and below. The low energy machine utilizes a grating monochromator and was used for 13.3 Å and above. Beam intensity was monitored by a calibrated proportional counter.

The results of the laboratory calibrations of the flight filters listed in Table 1 are presented in Table 2.

Please note: The calibration values of Table 2 are preliminary. The final values will take account of the laboratory calibration of the proportional counter beam monitors which may be slightly different from the assumed detection efficiency used for the analysis reported here.

Also please note that the double entrance filter data given in this report represent the "as flown" average of the 12 filters. This is somewhat different, especially between the oxygen and carbon absorption edges, from the data presently included in the the SXT analysis data base.

Table 2
Calibration Data, SXT Flight Filters

17-SEP-1990 13:28:43.63
Updated 9/19/90
From: SAG::LEMEN
To: ACTON
Subj: Flight Analysis Filters

Wavelength Å	Transmission	(1 sigma)	Designation	In FW 2/22/91
13.34	0.7869	0.0067	Cu La <3569; Al1400; Al/Si>	Flight
21.64	0.6911	0.0064	Cr La <3569; Al1400; Al/Si>	Flight
23.62	0.6691	0.0047	O Ka <3569; Al1400; Al/Si>	Flight
24.78	0.6301	0.0055	Cr LI <3569; Al1400; Al/Si>	Flight
27.42	0.5899	0.0057	Ti La <3569; Al1400; Al/Si>	Flight
31.36	0.5216	0.0053	Ti LI <3569; Al1400; Al/Si>	Flight
44.7	0.2819	0.0021	C Ka <3569; Al1400; Al/Si>	Flight
67.67	0.0876	0.0006	B Ka <3569; Al1400; Al/Si>	Flight
4.16	0.7386	0.0052	Ag La <3231C; Composite; Al/Mg/Mn/C	Flight
5.41	0.6562	0.0042	Mo La <3231C; Composite; Al/Mg/Mn/C	Flight
8.34	0.6046	0.0028	Al Ka <3231C; Composite; Al/Mg/Mn/C	Flight
13.34	0.4691	0.0033	Cu La <3231C; Composite; Al/Mg/Mn/C	Flight
13.34	0.4778	0.0012	Cu La <3231C; Composite; Al/Mg/Mn/C	Flight
21.64	0.3597	0.0032	Cr La <3231C; Composite; Al/Mg/Mn/C	Flight
23.62	0.3274	0.0026	O Ka <3231C; Composite; Al/Mg/Mn/C	Flight
24.78	0.2954	0.0026	Cr LI <3231C; Composite; Al/Mg/Mn/C	Flight
27.42	0.2206	0.0017	Ti La <3231C; Composite; Al/Mg/Mn/C	Flight
31.36	0.1366	0.0014	Ti LI <3231C; Composite; Al/Mg/Mn/C	Flight
44.7	0.0174	0.0001	C Ka <3231C; Composite; Al/Mg/Mn/C	Flight
4.16	0.6414	0.0044	Ag La <Be3-88; Be 100 micron>	Flight
5.41	0.3692	0.003	Mo La <Be3-88; Be 100 micron>	Flight
8.34	0.0265	0.0002	Al Ka <Be3-88; Be 100 micron>	Flight
4.16	0.0656	0.001	Ag La <3151C; Al 12 um; Al/Si>	Flight
5.41	0.005	0.0001	Mo La <3151C; Al 12 um; Al/Si>	Flight
8.34	0.2388	0.0016	Al Ka <3151C; Al 12 um; Al/Si>	Flight
13.34	0.0083	0.0001	Cu La <3151C; Al 12 um; Al/Si>	Flight
13.34	0.0089	0.0001	Cu La <3151C; Al 12 um; Al/Si>	Flight
13.34	0.4431	0.0032	Cu La <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
21.64	0.0887	0.0008	Cr La <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
23.62	0.0617	0.0006	O Ka <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
24.78	0.0453	0.0004	Cr LI <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
27.42	0.0234	0.0003	Ti La <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
31.36	0.0076	0.0001	Ti LI <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
5.41	0.4319	0.003	Mo La <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
8.34	0.111	0.001	Al Ka <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
13.34	0.4503	0.0037	Cu La <3370A-2; Mg 3um; Ti/Mg/Ti>	Flight
13.34	0.0805	0.0008	Cu La <; ND Mesh 10%; 2-90B>	Flight

C. X-ray Transmission of Analysis Filters

The parameters describing the analysis filters were derived by using a least-squares technique to minimize the error between the laboratory transmission data and a model of each filter. The mass absorption coefficients of Henke (smoothed) were used in this analysis. The densities assumed and the resulting filters parameters are given in Table 3.

Table 3

"Best fit" parameters to SXT FM filters.

<u>Material</u>	<u>Density</u> (gm/cm ³)				
Magnesium	1.741				
Manganese	7.43				
Silicon	2.33				
Titanium	4.45				
Aluminum	2.699				
Beryllium	1.845				
Carbon	2.22				
Lexan (C16H14O3)	1.2				
Al oxide (Al2O3)	3.965				
Ti Dioxide (TiO2)	4.26				

<u>Double Entrance</u>	<u>Al 1265 Å</u>	<u>Al/Mg/Mn</u>	<u>Mg 2.5 μm</u>	<u>Al 11.6 μm</u>	<u>Be 119 μm</u>
4150 Å Lexan	1265 Å Al	2930 Å Al	240 Å Ti	11.594 μm Al	119 μm Be
1350 Å Ti	12.65 Å Si	29.30 Å Si	2.520 μm Mg	0.116 μm Si	
1500 Å Al	27 Å Al2O3	2070 Å Mg	70 Å TiO2	110 Å Al2O3	
15 Å Si	83.6% mesh	562 Å Mn	78% mesh	83% mesh	
500 Å Al2O3		190 Å C			
		83% mesh			

The transmission of the SXT analysis filters at any wavelength may be calculated from the parameters of Table 3 and the elemental mass absorption coefficients of Henke. As long as the same densities and mass absorption coefficients are used for this calculation as were used for fitting the laboratory data the result is fairly independent of possible systematic errors in either the densities or the mass absorption coefficients. The resulting filter transmissions are presented in Table 4 for a range of wavelengths. Sharp transitions at the atomic absorption edges have been assumed in this calculation.

The laboratory calibration data and filter transmissions are illustrated in Figure 1 for the analysis filters and Figure 2 for the entrance filter..

Table 4

2/27/91 SXT flight filters using calibrated thicknesses, composition and mesh transmission.
 1/25/92 Replaced old Entrance filter data with least square "bet fit" model

Wavelength Å	Double Entrance Filter	Al 1265 Å +mesh	Al/Mg/Mn +mesh	Mg 2.5 μm +mesh	Al 11.6 μm +mesh	Be 119 μm no mesh
	4150 Å Lexan	1265 Å Al	2930 Å Al	240 Å Ti	11.594 μm Al	119 μm Be
	1350 Å Ti	12.65 Å Si	29.30 Å Si	2.520 μm Mg	0.116 μm Si	
	1500 Å Al	27 Å Al ₂ O ₃	2070 Å Mg	70 Å TiO ₂	110 Å Al ₂ O ₃	
	15 Å Si	83.6% mesh	562 Å Mn	78% mesh	83% mesh	
	500 Å Al ₂ O ₃		190 Å C			
			83% mesh			
72.2070	4.25E-03	6.11E-02	7.32E-05	2.20E-13	5.76E-103	
70.4430	5.60E-03	7.05E-02	1.16E-04	7.74E-13	2.24E-97	
67.6380	8.53E-03	8.77E-02	2.37E-04	5.63E-12	7.56E-89	
65.9500	1.00E-02	9.39E-02	3.15E-04	1.84E-11	3.34E-86	
65.9470	1.00E-02	9.39E-02	3.15E-04	1.84E-11	3.34E-86	
64.3720	1.17E-02	1.00E-01	4.15E-04	5.51E-11	1.34E-83	
63.2550	1.32E-02	1.06E-01	5.08E-04	1.19E-10	1.34E-81	
61.9900	1.50E-02	1.12E-01	6.38E-04	2.84E-10	2.38E-79	
58.4260	2.15E-02	1.31E-01	1.20E-03	3.12E-09	4.12E-73	
55.5960	2.88E-02	1.52E-01	2.03E-03	1.98E-08	1.62E-67	
52.9830	3.75E-02	1.72E-01	3.25E-03	1.04E-07	1.66E-62	
50.6060	4.73E-02	1.93E-01	4.94E-03	4.49E-07	4.44E-58	
50.6040	4.73E-02	1.93E-01	4.94E-03	4.49E-07	4.44E-58	
48.6200	6.23E-02	2.21E-01	7.75E-03	1.47E-06	8.19E-53	
46.7850	7.94E-02	2.49E-01	1.15E-02	4.26E-06	3.32E-48	
44.7580	1.02E-01	2.81E-01	1.75E-02	1.32E-05	2.10E-43	
43.6810	1.15E-01	2.97E-01	2.13E-02	2.37E-05	3.42E-41	
43.6800	1.77E-02	2.97E-01	1.72E-02	2.37E-05	3.42E-41	
42.1700	2.32E-02	3.26E-01	2.36E-02	5.27E-05	1.21E-37	
40.7830	2.95E-02	3.53E-01	3.10E-02	1.07E-04	1.47E-34	
39.7750	3.49E-02	3.72E-01	3.75E-02	1.77E-04	2.01E-32	
38.5030	4.44E-02	3.94E-01	4.64E-02	3.26E-04	3.20E-30	
36.4650	6.40E-02	4.29E-01	6.44E-02	8.34E-04	7.08E-27	
34.4390	8.98E-02	4.65E-01	8.73E-02	2.00E-03	9.05E-24	
32.6260	1.19E-01	4.97E-01	1.13E-01	4.18E-03	3.58E-21	
31.5950	1.38E-01	5.15E-01	1.29E-01	6.22E-03	9.02E-20	
31.3640	1.43E-01	5.18E-01	1.33E-01	6.79E-03	1.70E-19	
30.9960	1.49E-01	5.24E-01	1.39E-01	7.78E-03	4.64E-19	
30.9950	1.49E-01	5.24E-01	1.39E-01	7.78E-03	4.64E-19	
29.5190	1.85E-01	5.53E-01	1.70E-01	1.32E-02	5.99E-17	
28.1770	2.21E-01	5.79E-01	2.01E-01	2.07E-02	3.66E-15	
27.4170	2.44E-01	5.93E-01	2.21E-01	2.64E-02	3.30E-14	
27.2850	2.47E-01	5.95E-01	2.24E-01	2.76E-02	4.40E-14	
27.2840	5.34E-02	5.95E-01	2.24E-01	2.01E-02	4.40E-14	
26.3790	6.51E-02	6.12E-01	2.48E-01	2.69E-02	5.26E-13	
25.5630	7.73E-02	6.27E-01	2.71E-01	3.47E-02	4.42E-12	
24.7960	9.03E-02	6.40E-01	2.94E-01	4.36E-02	2.98E-11	
24.2481	1.01E-01	6.49E-01	3.11E-01	5.10E-02	1.10E-10	
24.2480	1.01E-01	6.49E-01	3.11E-01	5.10E-02	1.12E-10	
23.6200	1.15E-01	6.60E-01	3.30E-01	6.09E-02	4.74E-10	
23.3177	1.23E-01	6.65E-01	3.40E-01	6.62E-02	9.53E-10	
23.3176	8.27E-02	6.58E-01	3.40E-01	6.46E-02	9.13E-10	
21.9910	1.13E-01	6.80E-01	3.84E-01	9.15E-02	1.58E-08	

21.9900	9.70E-02	6.80E-01	3.84E-01	8.87E-02	1.58E-08	
20.7330	1.28E-01	6.99E-01	4.25E-01	1.20E-01	1.70E-07	
19.4510	1.71E-01	7.20E-01	4.73E-01	1.60E-01	2.23E-06	
19.3721	1.74E-01	7.21E-01	4.75E-01	1.63E-01	2.54E-06	
19.3720	1.74E-01	7.21E-01	2.67E-01	1.63E-01	2.54E-06	
18.3190	2.19E-01	7.37E-01	2.86E-01	2.02E-01	1.65E-05	
17.5860	2.48E-01	7.46E-01	2.97E-01	2.31E-01	4.70E-05	
17.5261	2.51E-01	7.47E-01	2.99E-01	2.34E-01	5.06E-05	
17.5260	2.51E-01	7.47E-01	2.99E-01	2.34E-01	5.06E-05	
15.9730	3.33E-01	7.66E-01	3.47E-01	3.04E-01	4.33E-04	
15.9151	3.36E-01	7.66E-01	3.49E-01	3.07E-01	4.61E-04	
15.9150	3.36E-01	7.66E-01	3.49E-01	3.07E-01	4.61E-04	
14.5600	4.19E-01	7.81E-01	4.13E-01	3.74E-01	2.33E-03	
14.5250	4.21E-01	7.81E-01	4.15E-01	3.76E-01	2.41E-03	
14.5240	4.21E-01	7.81E-01	4.15E-01	3.76E-01	2.41E-03	
13.3350	4.98E-01	7.92E-01	4.73E-01	4.37E-01	8.30E-03	
13.2880	5.00E-01	7.93E-01	4.74E-01	4.39E-01	8.63E-03	7.35E-08
13.2870	5.00E-01	7.93E-01	4.74E-01	4.39E-01	8.63E-03	7.38E-08
12.2550	5.70E-01	8.01E-01	5.25E-01	4.92E-01	2.15E-02	2.56E-06
12.1320	5.78E-01	8.02E-01	5.31E-01	4.98E-01	2.35E-02	3.76E-06
12.1310	5.78E-01	8.02E-01	5.31E-01	4.98E-01	2.35E-02	3.77E-06
11.9100	5.93E-01	8.03E-01	5.42E-01	5.09E-01	2.78E-02	7.41E-06
10.4360	6.90E-01	8.13E-01	6.12E-01	5.78E-01	7.86E-02	3.70E-04
9.8899	7.24E-01	8.16E-01	6.36E-01	6.02E-01	1.09E-01	1.23E-03
9.5121	7.43E-01	8.18E-01	6.49E-01	6.17E-01	1.28E-01	2.63E-03
9.5120	7.43E-01	8.18E-01	5.31E-01	5.39E-02	1.28E-01	2.63E-03
8.3393	8.14E-01	8.24E-01	6.04E-01	1.14E-01	2.31E-01	1.92E-02
7.9479	8.31E-01	8.25E-01	6.25E-01	1.42E-01	2.60E-01	3.33E-02
7.9479	6.96E-01	7.31E-01	4.75E-01	1.42E-01	4.89E-06	3.33E-02
7.1253	7.52E-01	7.47E-01	5.31E-01	2.15E-01	3.43E-05	8.93E-02
6.7384	7.76E-01	7.56E-01	5.60E-01	2.55E-01	1.03E-04	1.32E-01
6.7380	7.75E-01	7.56E-01	5.58E-01	2.55E-01	9.50E-05	1.32E-01
6.0703	8.27E-01	7.75E-01	6.16E-01	3.33E-01	8.91E-04	2.33E-01
5.7242	8.50E-01	7.83E-01	6.42E-01	3.77E-01	2.30E-03	2.99E-01
5.584	8.59E-01	7.86E-01	6.53E-01	3.94E-01	3.31E-03	3.27E-01
5.4064	8.70E-01	7.90E-01	6.66E-01	4.17E-01	5.24E-03	3.65E-01
4.7277	9.07E-01	8.04E-01	7.12E-01	5.04E-01	2.39E-02	5.19E-01
4.1544	9.34E-01	8.13E-01	7.45E-01	5.74E-01	6.76E-02	6.49E-01
3.8709	9.43E-01	8.16E-01	7.57E-01	6.06E-01	9.54E-02	7.09E-01
3.8709	9.43E-01	8.16E-01	7.57E-01	6.06E-01	9.54E-02	7.09E-01
3.3583	9.63E-01	8.23E-01	7.82E-01	6.59E-01	2.06E-01	8.05E-01
2.7759	9.78E-01	8.28E-01	8.01E-01	7.07E-01	3.68E-01	8.90E-01
2.7485	9.79E-01	8.29E-01	8.02E-01	7.09E-01	3.76E-01	8.93E-01
2.5035	9.84E-01	8.30E-01	8.09E-01	7.26E-01	4.53E-01	9.20E-01

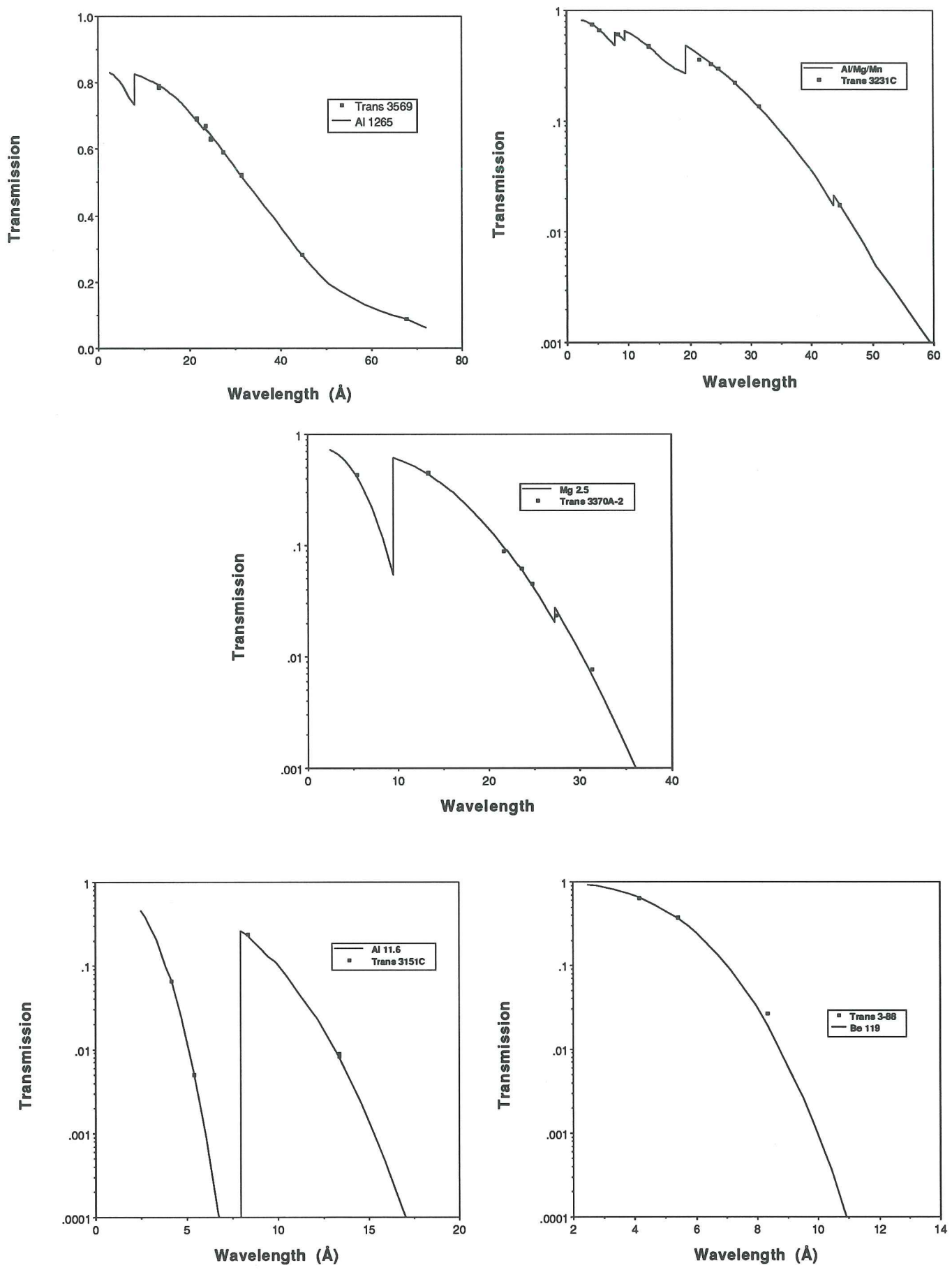


Figure 1 SXT Analysis Filters

Data from "D ENT FILTER CAL WORK"
1/25/92, LWA

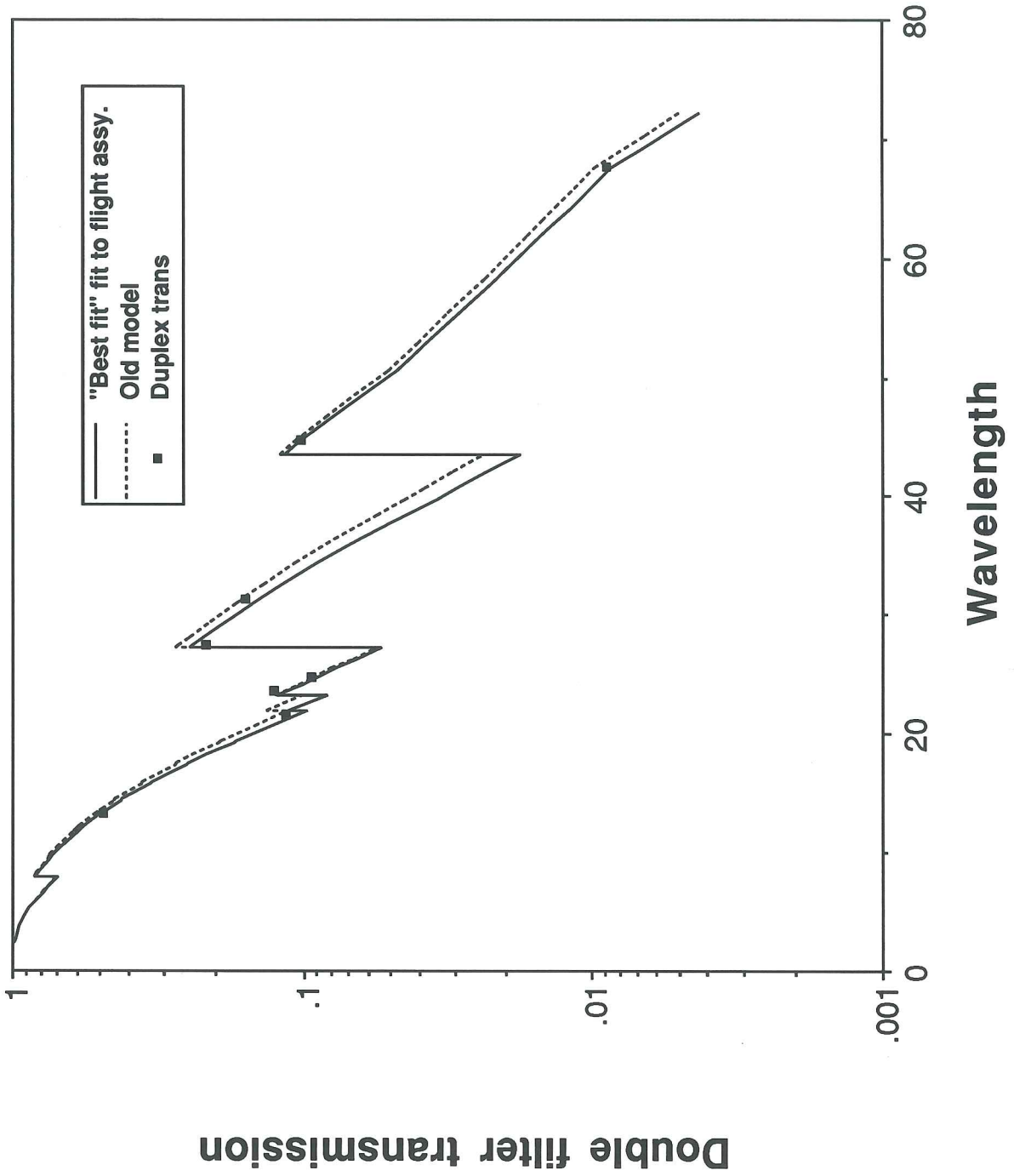


Figure 2 SXT Entrance Filters

D. Filter Uniformity

The following informal report from Hugh Hudson indicates that the analysis filters are quite uniform, except for thick Be filter 2-90, These results are further discussed in reference b.

From: CASS01::HSHCME "Hugh Hudson @ CASS" 23-SEP-1990 17:35:10.96
To: SAG::LEMEN,SAG::HUDSON
CC: HSHCME
Subj: scan results

Jim, the following is some information on application of the F test to the scan data from the analysis filters. As you will recall, the F test is a simple means of comparing an observed distribution with an expected one, assuming both are normal but maybe with different moments. In our case the transmissions at different positions on the filter are compared with those expected from counting statistics. Any non-conformance would be due either to filter non-uniformity or else to uncontrolled systematic errors of measurement.

The table below summarizes the results, which could contribute to the selection of the flight filters. They are not all consistent with unmeasurably small non-uniformity at the level of these 1% measurements. "Good" means that the filter passed the F test at the 99% level. The final column of the table will give an estimated upper limit for the filter non-uniformity estimated over the filter area subtended by a point source. It should be noted that this is just an upper limit based upon partial sampling, and the measurements themselves are consistent with smaller values.

Filter	N	F value	Result
3370A (Mg 3u)	7	1.61	Good
3370B (Mg 3u)	7	1.87	Good
3231B (comp)	9	2.25	Good
3231A (comp)	7	2.33	Good
3471 (Al 1400)	7	N.A.	Good!
3569 (Al 1400)	7	1.07	Good!
2999 (Al 1400)	7	N.A.	Good!
3-88 (Be)	1	1.02	Good!
2-90 (Be)	9	9.6	Bad

Acknowledgements

The SXT project owes a vote of thanks to Luxel Corp. for manufacturing some excellent filters for the telescope and to Jim Lemen, Hugh Hudson, Mons Morrison and Lawrence Shing for their hard work under trying circumstances to complete the laboratory calibration. Much of the filter design work was done or checked by Bill Brown who was also responsible for technical monitoring of the Luxel contract.