Document Title: Effects of Varying Detector Thresholds on the PSF

Document ID: COM-RP-UNH-DRG-056

Issue No. : 1

Issue Date: 25-January-1999

Prepared by: Mark McConnell

Authorized by:

Approved by:

Introduction

Since the time of the GRO launch, the D2 module thresholds on COMPTEL have slowly been moving upwards (in energy). There had been previous indications that these threshold changes were now becoming sufficient so as to impact the low energy PSFs (E < 1 MeV). Here we report on an investigation of this issue using tools available within the SIM subsystem of COMPASS to simulate the impact of these threshold changes.

Threshold Determinations

In order to determine the in-flight threshold values, we used COMPASS task IFCTHR, which fits a Gaussian to the threshold region of each individual module. The threshold fits provided by IFCTHR can be used directly in SIM via the ISS dataset. (The ISS dataset contains several pieces of information that are used to convert the raw simulated data to the 'smoothed', or more realistic, simulated data.)

The detector thresholds were determined at approximately six month intervals, starting with 01-Jul-1991. The latest datapoint (which corresponded to the data that was then available at UNH) was 01-Jul-1997.

The threshold values (in keV) are all listed in Tables 1, 2 and 3.

TABLE 1 – Thresholds for All D1 Modules

TJD	D1-1	D1-2	D1-3	D1-4	D1-5	D1-6	D1-7
8438	45.78	51.17	45.51	41.53	48.71	46.87	48.46
8622	46.90	51.94	46.11	N/A	49.99	49.61	49.92
8804	47.98	52.81	45.95	43.05	49.15	50.65	48.89
8988	48.85	52.91	45.86	43.99	49.51	50.10	50.08
9169	47.71	53.66	47.36	43.69	49.98	50.81	50.57
9353	48.87	53.14	47.08	44.10	49.47	50.85	50.19
9534	48.35	53.89	47.00	43.62	49.25	50.37	50.11
9718	47.70	54.02	47.62	43.48	50.22	51.09	49.92
9899	47.99	54.45	47.55	43.65	49.52	51.17	49.10
10083	48.23	54.39	48.10	43.40	50.29	51.25	49.38
10265	48.42	54.66	47.96	43.49	50.23	51.46	49.18
10449	49.16	54.59	48.54	43.58	49.91	51.61	49.81
10630	48.90	54.20	48.33	43.58	50.29	52.11	49.61

TABLE 2 – Thresholds for Modules D2-1 thru D2-7

TJD	D2-1	D2-2	D2-3	D2-4	D2-5	D2-6	D2-7
8438	618.48	637.76	652.51	587.59	602.17	572.14	585.86
8622	613.73	679.80	693.39	601.73	633.38	592.10	572.24
8804	604.08	N/A	742.07	613.28	668.73	618.96	580.73
8988	539.93	773.04†	677.23	562.39	624.91	568.78	526.87
9169	541.23	808.62†	703.12	576.29	641.85	581.78	532.82
9353	N/A	797.23†	691.03	569.71	638.58	578.67	524.07
9534	N/A	813.43†	701.94	582.78	651.21	591.51	528.37
9718	N/A	827.71†	718.35	587.50	661.45	598.36	522.78
9899	N/A	842.89†	723.09	597.47	672.37	609.18	522.04
10083	N/A	857.50†	730.44	613.23	680.97	620.51	527.86
10265	N/A	859.71†	726.06	621.91	685.22	626.62	525.90
10449	N/A	862.23†	729.88	628.02	691.12	630.73	527.16
10630	N/A	866.17†	726.89	631.99	693.34	633.55	523.23

†Module includes failed PMT.

TABLE 3 – Thresholds for Modules D2-8 thru D2-14

TJD	D2-8	D2-9	D2-10	D2-11	D2-12	D2-13	D2-14
8438	582.12	604.76	579.76	617.48	595.78	586.93	N/A
8622	589.13	608.75	602.49	637.78	584.26	605.37	N/A
8804	593.79	601.10	625.63	725.26†	572.91	700.08†	711.33†
8988	539.88	537.98	569.95	675.21†	517.95	636.82†	673.80†
9169	542.95	541.14	586.97	682.78†	515.52	645.48†	695.00†
9353	539.95	534.73	579.36	678.05†	509.69	636.67†	691.13†
9534	544.37	537.05	589.89	691.62†	511.87	649.74†	705.72†
9718	543.41	536.02	595.50	693.79†	506.77	656.19†	710.73†
9899	546.74	536.66	605.63	706.85†	506.30	673.37†	720.43†
10083	553.74	533.57	615.00	717.15†	504.22	676.54†	724.79†
10265	554.23	534.26	617.79	721.80†	502.48	682.02†	726.91†
10449	555.69	533.12	620.86	726.97†	499.79	685.61†	730.81†
10630	553.00	532.75	626.13	729.76†	504.09	696.37†	728.00†

†Module includes failed PMT.

PSF Generation

Once the ISS datasets were established (based on the IFCTHR output), the next step was to generate simulated PSFs for each epoch in the study. In each case, four PSFs were generated – one for each of the four standard COMPTEL energy intervals (0.75–1.0 MeV, 1.0–3.0 MeV, 3.0–10.0 MeV and 10.0–30.0 MeV).

For each epoch, task SIMFIN was used (along with the corresponding ISS file) to generate the simulated EVP file that was subsequently used in SIMPSF to generate the PSFs. Input to SIMFIN was based on an available set of simulated data for an E^{-2} power-law spectrum.

The impact of missing (or dead) PMTs is not completely modeled in the present analysis. The dead PMT regions are excluded from the threshold determinations (via the FPM dataset in task IFCTHR), but the dead PMT regions are not considered in generating the simulated PSFs. Instead, the thresholds determined in IFCTHR are applied to the entire module in generating the simulated PSFs.

Analysis

The comparison of the resulting PSFs can be done in a variety of ways. One way is to use those PSFs in the analysis of some bright celestial source, such as the Crab, and then to compare the reproduced flux values. Another way would be to use the SIM data to calculate an effective area corresponding to each instrument configuration (combination of module on/off status and module thresholds). This approach would be complicated by variations of the module on/off status (especially early in the mission). Perhaps the simplest means of comparing the results is to compare the IAQ data, for example, in terms of integrated area (normalization). This approach is insensitive to changes n the module on/off status and may, in fact, be the best means of guaging the impact of detector thresholds on the PSF.

Here, we make two comparisons – one using the effective area as derived from SIM data and one using the normalization of the IAQ data. The results are shown on the following pages. The effective area data reflect not only the loss of D2 signal, but also the changing on/off module status and the change in instrument configuration (D2 thresholds and D2 calibration window change) that took place in September, 1992 (TJD 8892). The IAQ normalization is immune to the effects of varying on/off module status, but it does reflect both the loss of signal in D2 and the instrument configuration change in September, 1992. (Note the *increase* in the 0.75-1.0 MeV IAQ normalization between TJD 8804 and 8988 due to change of instrument configuration.)

TABLE 4 – PSF Data for 0.75–1.0 MeV

TJD	Date	IAQ	FAQ	Effective Area (cm^2)	IAQ Norm
8438	01-Jul-1991	UNH-IAQ-58266	UNH-FAQ-58033	16.69 ± 0.05	2.294×10^{-2}
8622	01-Jan-1992	UNH-IAQ-58273	UNH-FAQ-58040	13.88 ± 0.05	2.250×10^{-2}
8804	01-Jul-1992	UNH-IAQ-58278	UNH-FAQ-58045	14.65 ± 0.04	2.064×10^{-2}
8988	01-Jan-1993	UNH-IAQ-58282	UNH-FAQ-58049	16.63 ± 0.04	2.134×10^{-2}
9169	01-Jul-1993	UNH-IAQ-58286	UNH-FAQ-58053	16.05 ± 0.04	2.064×10^{-2}
9353	01-Jan-1994	UNH-IAQ-58290	UNH-FAQ-58057	14.97 ± 0.04	2.063×10^{-2}
9534	01-Jul-1994	UNH-IAQ-58294	UNH-FAQ-58061	14.59 ± 0.04	2.018×10^{-2}
9718	01-Jan-1995	UNH-IAQ-58298	UNH-FAQ-58065	14.30 ± 0.04	1.987×10^{-2}
9899	01-Jul-1995	UNH-IAQ-58302	UNH-FAQ-58069	13.85 ± 0.04	1.933×10^{-2}
10083	01-Jan-1996	UNH-IAQ-58307	UNH-FAQ-58074	13.64 ± 0.04	1.889×10^{-2}
10265	01-Jul-1996	UNH-IAQ-58311	UNH-FAQ-58078	13.51 ± 0.04	1.880×10^{-2}
10449	01-Jan-1997	UNH-IAQ-58315	UNH-FAQ-58082	13.37 ± 0.04	1.851×10^{-2}
10630	01-Jul-1997	UNH-IAQ-58319	UNH-FAQ-58086	13.27 ± 0.04	1.848×10^{-2}

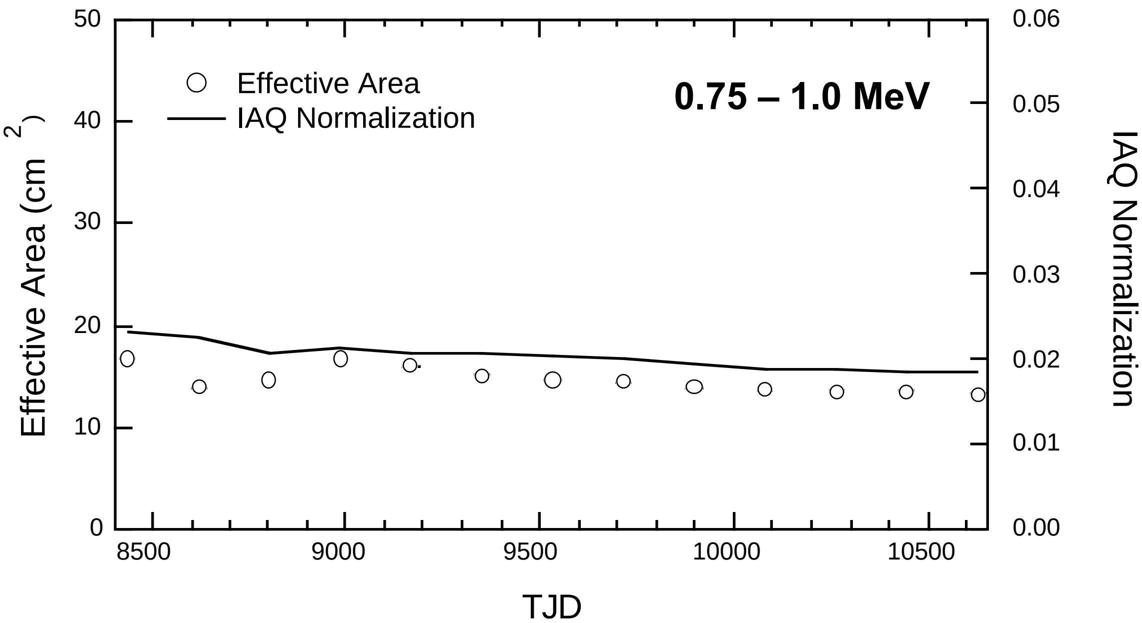

FIGURE 1 – Effective area and IAQ normalization for 0.75-1.0 MeV energy range.

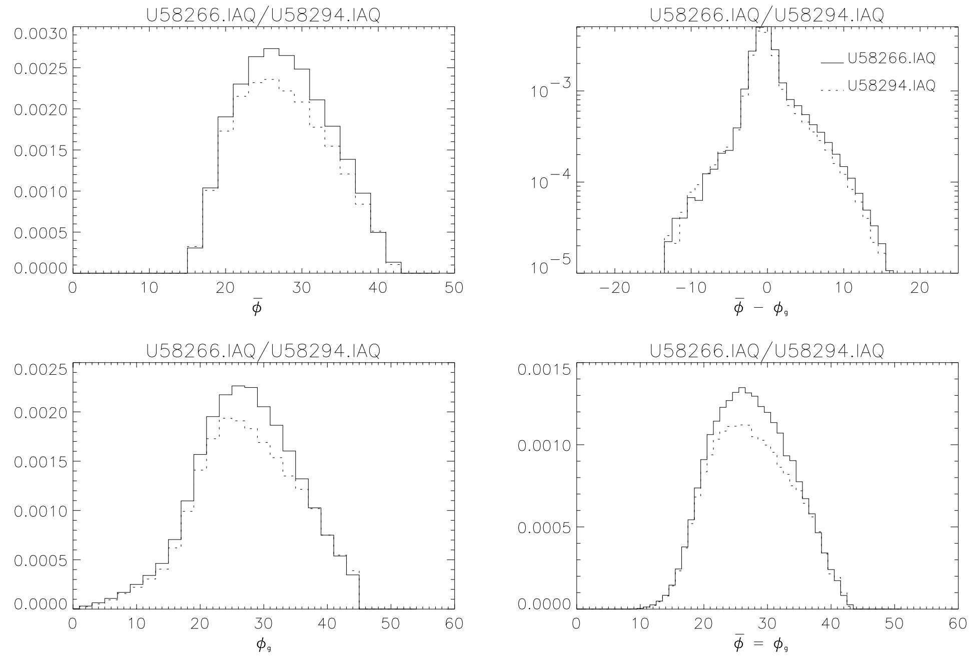

FIGURE 2 – Comparison of IAQs for TJD 8438 (IAQ-58266) and TJD 9534 (IAQ-58294). These dates correspond to 01-Jul-1991 and 01-Jul-1994, respectively.

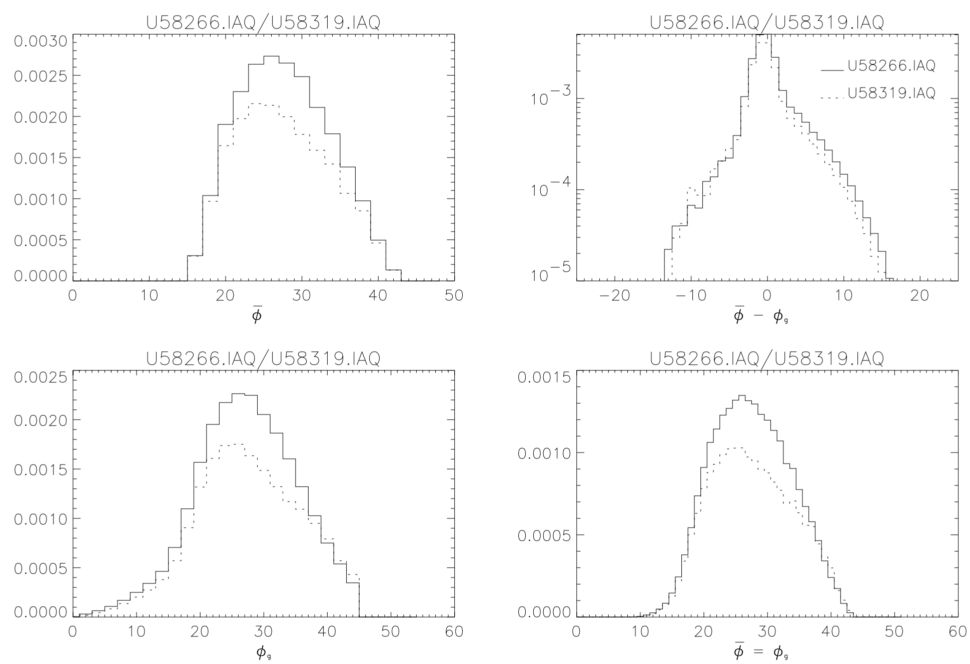

FIGURE 3 – Comparison of IAQs for TJD 8438 (IAQ-58266) and TJD 10630 (IAQ-58319). These dates correspond to 01-Jul-1991 and 01-Jul-1997, respectively.

TABLE 5 – PSF Data for 1.0–3.0 MeV

TJD	Date	IAQ	FAQ	Effective Area (cm^2)	IAQ Norm
8438	01-Jul-1991	UNH-IAQ-58269	UNH-FAQ-58036	33.42 ± 0.05	4.296×10^{-2}
8622	01-Jan-1992	UNH-IAQ-58274	UNH-FAQ-58041	28.60 ± 0.04	4.290×10^{-2}
8804	01-Jul-1992	UNH-IAQ-58279	UNH-FAQ-58046	33.36 ± 0.05	4.263×10^{-2}
8988	01-Jan-1993	UNH-IAQ-58283	UNH-FAQ-58050	35.91 ± 0.05	4.285×10^{-2}
9169	01-Jul-1993	UNH-IAQ-58287	UNH-FAQ-58054	35.80 ± 0.05	4.256×10^{-2}
9353	01-Jan-1994	UNH-IAQ-58291	UNH-FAQ-58058	33.51 ± 0.05	4.251×10^{-2}
9534	01-Jul-1994	UNH-IAQ-58295	UNH-FAQ-58062	33.45 ± 0.05	4.262×10^{-2}
9718	01-Jan-1995	UNH-IAQ-58299	UNH-FAQ-58066	33.39 ± 0.05	4.246×10^{-2}
9899	01-Jul-1995	UNH-IAQ-58303	UNH-FAQ-58070	33.32 ± 0.04	4.230×10^{-2}
10083	01-Jan-1996	UNH-IAQ-58308	UNH-FAQ-58075	33.22 ± 0.04	4.229×10^{-2}
10265	01-Jul-1996	UNH-IAQ-58312	UNH-FAQ-58079	33.25 ± 0.04	4.223×10^{-2}
10449	01-Jan-1997	UNH-IAQ-58316	UNH-FAQ-58083	33.20 ± 0.04	4.216×10^{-2}
10630	01-Jul-1997	UNH-IAQ-58320	UNH-FAQ-58087	33.19 ± 0.04	4.201×10^{-2}

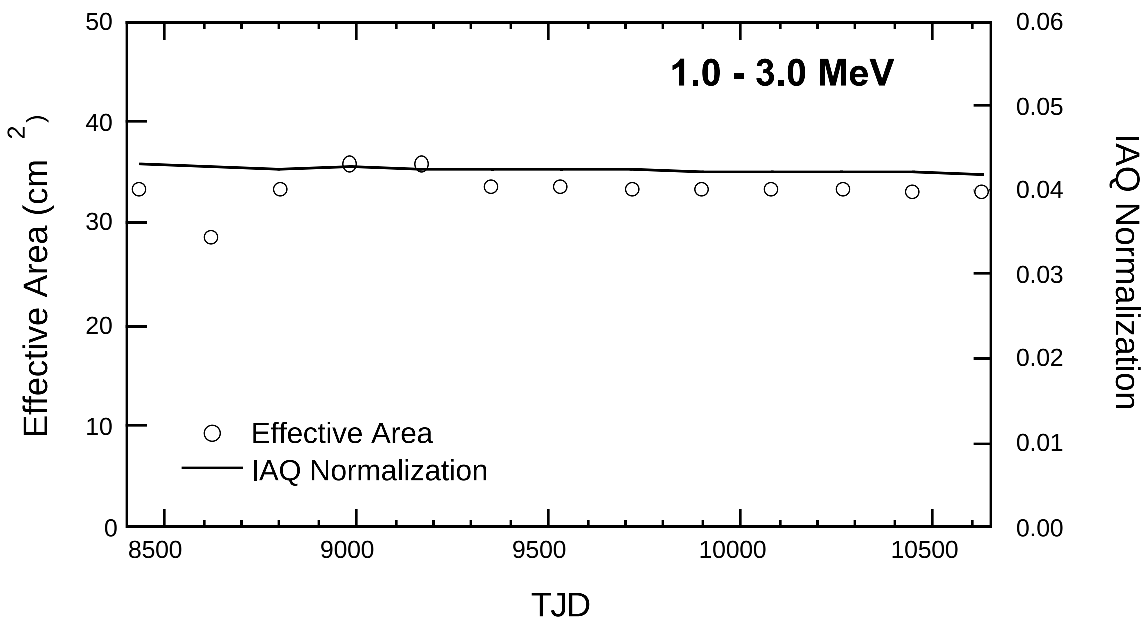

FIGURE 4 – Effective area and IAQ normalization for 1.0-3.0 MeV energy range.

TABLE 6 – PSF Data for 3.0–10.0 MeV

TJD	Date	IAQ	FAQ	Effective Area (cm^2)	IAQ Norm
8438	01-Jul-1991	UNH-IAQ-58270	UNH-FAQ-58037	35.01 ± 0.08	3.329×10^{-2}
8622	01-Jan-1992	UNH-IAQ-58275	UNH-FAQ-58042	29.78 ± 0.07	3.323×10^{-2}
8804	01-Jul-1992	UNH-IAQ-58280	UNH-FAQ-58047	35.50 ± 0.08	3.342×10^{-2}
8988	01-Jan-1993	UNH-IAQ-58284	UNH-FAQ-58051	38.01 ± 0.08	3.359×10^{-2}
9169	01-Jul-1993	UNH-IAQ-58288	UNH-FAQ-58055	38.01 ± 0.08	3.344×10^{-2}
9353	01-Jan-1994	UNH-IAQ-58292	UNH-FAQ-58059	35.97 ± 0.08	3.349×10^{-2}
9534	01-Jul-1994	UNH-IAQ-58296	UNH-FAQ-58063	35.96 ± 0.08	3.325×10^{-2}
9718	01-Jan-1995	UNH-IAQ-58300	UNH-FAQ-58067	35.97 ± 0.08	3.341×10^{-2}
9899	01-Jul-1995	UNH-IAQ-58304	UNH-FAQ-58071	35.96 ± 0.08	3.318×10^{-2}
10083	01-Jan-1996	UNH-IAQ-58309	UNH-FAQ-58076	35.99 ± 0.08	3.348×10^{-2}
10265	01-Jul-1996	UNH-IAQ-58313	UNH-FAQ-58080	35.95 ± 0.08	3.336×10^{-2}
10449	01-Jan-1997	UNH-IAQ-58317	UNH-FAQ-58804	35.96 ± 0.08	3.332×10^{-2}
10630	01-Jul-1997	UNH-IAQ-58321	UNH-FAQ-58088	35.94 ± 0.08	3.343×10^{-2}

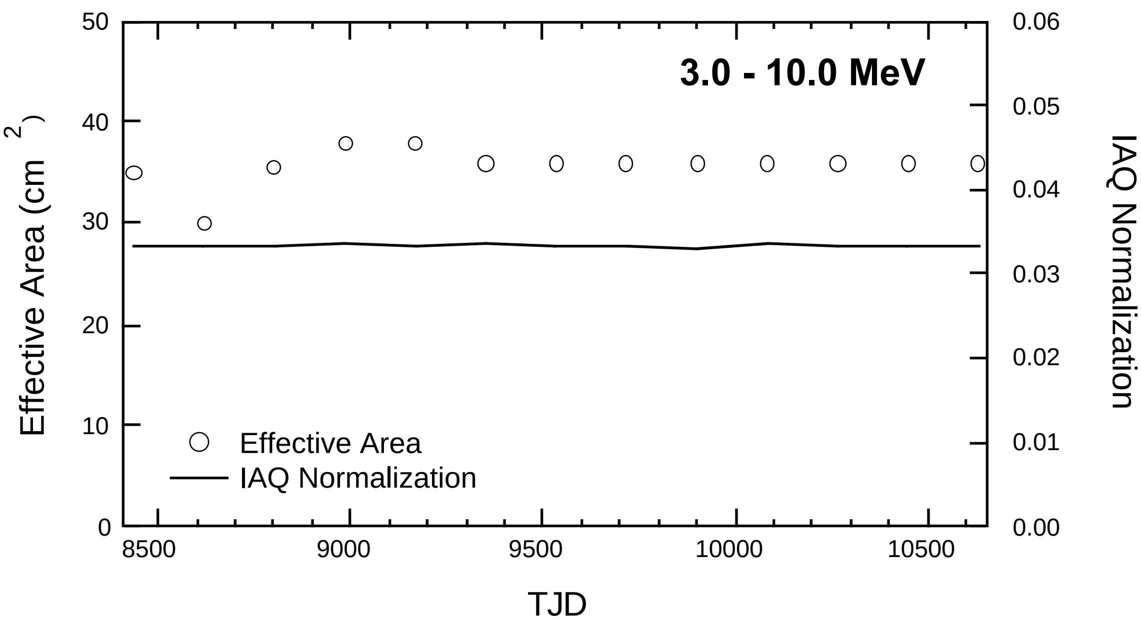

FIGURE 5 – Effective area and IAQ normalization for 3.0-10.0 MeV energy range.

TABLE 7 – PSF Data for 10.0–30.0 MeV

TJD	Date	IAQ	FAQ	Effective Area (cm^2)	IAQ Norm
8438	01-Jul-1991	UNH-IAQ-58271	UNH-FAQ-58038	24.83 ± 0.12	1.763×10^{-2}
8622	01-Jan-1992	UNH-IAQ-58276	UNH-FAQ-58043	20.86 ± 0.11	1.780×10^{-2}
8804	01-Jul-1992	UNH-IAQ-58281	UNH-FAQ-58048	24.89 ± 0.12	1.779×10^{-2}
8988	01-Jan-1993	UNH-IAQ-58285	UNH-FAQ-58052	26.94 ± 0.13	1.786×10^{-2}
9169	01-Jul-1993	UNH-IAQ-58289	UNH-FAQ-58056	26.88 ± 0.13	1.759×10^{-2}
9353	01-Jan-1994	UNH-IAQ-58293	UNH-FAQ-58060	25.69 ± 0.12	1.771×10^{-2}
9534	01-Jul-1994	UNH-IAQ-58297	UNH-FAQ-58064	25.85 ± 0.13	1.784×10^{-2}
9718	01-Jan-1995	UNH-IAQ-58301	UNH-FAQ-58068	25.83 ± 0.13	1.776×10^{-2}
9899	01-Jul-1995	UNH-IAQ-58305	UNH-FAQ-58072	25.88 ± 0.13	1.786×10^{-2}
10083	01-Jan-1996	UNH-IAQ-58310	UNH-FAQ-58077	25.82 ± 0.13	1.770×10^{-2}
10265	01-Jul-1996	UNH-IAQ-58314	UNH-FAQ-58081	25.85 ± 0.13	1.783×10^{-2}
10449	01-Jan-1997	UNH-IAQ-58318	UNH-FAQ-58085	25.87 ± 0.13	1.792×10^{-2}
10630	01-Jul-1997	UNH-IAQ-58322	UNH-FAQ-58089	25.88 ± 0.13	1.779×10^{-2}

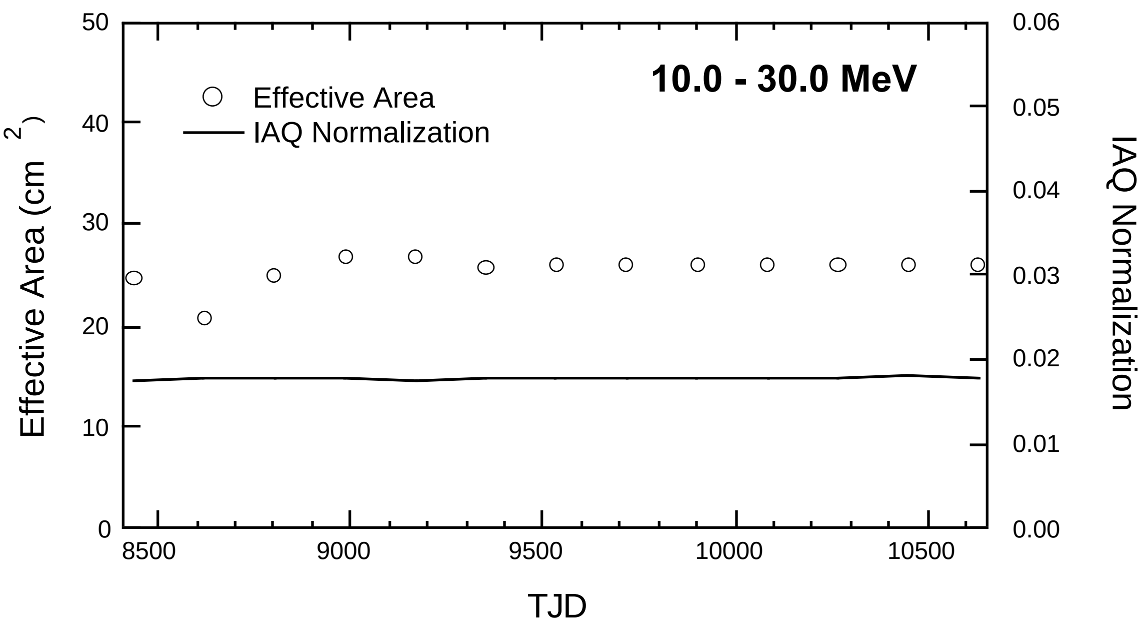

FIGURE 6 – Effective area and IAQ normalization for 10.0-30.0 MeV energy range.

Results

The results we present here indicate that at energies above 1 MeV, the varying D2 detector thresholds have no significant impact on the PSF. At energies below 1 MeV, however, the results indicate a significant variation in the PSF, with the IAQ normalization down by about 20% after six years on orbit. This suggests that flux values derived for energies below 1 MeV may be underestimated by up to 25-30% for data now being collected by COMPTEL.

TABLE 8 – Relative IAQ Normalization Factors

TJD	Date	0.75-1.0 MeV	1-3 MeV	3-10 MeV	10-30 MeV
8438	01-Jul-1991	1.00	1.00	1.00	1.00
8622	01-Jan-1992	0.98	1.00	1.00	1.01
8804	01-Jul-1992	0.90	0.99	1.00	1.01
8988	01-Jan-1993	0.93	1.00	1.01	1.01
9169	01-Jul-1993	0.90	0.99	1.00	1.00
9353	01-Jan-1994	0.90	0.99	1.01	1.00
9534	01-Jul-1994	0.88	0.99	1.00	1.01
9718	01-Jan-1995	0.87	0.99	1.00	1.01
9899	01-Jul-1995	0.84	0.98	1.00	1.00
10083	01-Jan-1996	0.82	0.98	1.01	1.00
10265	01-Jul-1996	0.82	0.98	1.00	1.01
10449	01-Jan-1997	0.81	0.98	1.00	1.02
10630	01-Jul-1997	0.81	0.98	1.00	1.01