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## Introduction

In preparation for the upcoming solar maximum, we have started to investigate a new solar mode for COMPTEL, based, in part, on what we learned from observations of the major solar flares in 1991. Our goal has been to define a mode for COMPTEL that would be entered whenever the Sun is within the COMPTEL FoV (within 60° of the COMPTEL z-axis). COMPTEL would be left in this mode as long as the Sun was within this extended FoV. (Recall that we have successfully imaged gamma-ray bursts up to 60° off-axis, the most recent such case being GRB 990123.) Note that this is a very different approach to the original concept of solar flare observations by COMPTEL, in which a BATSE trigger would be used to place COMPTEL into a temporary solar mode. Past experience demonstrated several difficulties with this approach. For example, the inherent delay in getting into solar mode (up to 2 minutes) meant that COMPTEL was not fully into its solar mode configuration until well into the flare event. Additionally, background for solar flare analysis typically comes from time periods 15 orbits before and after the flare. Such data is generally not available when operating in a triggered configuration. (Recall that, for the major flares of June 1991 COMPTEL was placed into a continuous solar mode, thus providing very useful background data.) A continuous solar mode is therefore a very desirable goal, especially with the upcoming solar maximum and the growing emphasis of CGRO on solar science.

At the same time, we would like not to interrupt the continuous sequence of consistent non-solar science data. For example, collecting additional data to be used for galactic diffuse studies. We have therefore been considering continuous solar modes in which the impact on the instrument response is kept to a minimum. We have found that minimizing the impact on the instrument response at energies above 1 MeV is not too difficult. For energies below 1 MeV, there will be some impact on the instrument response, but the low-energy response has been slowly changing since launch due to the varying thresholds on the individual detector modules. So an impact on the low-energy response ($E < 1$ MeV) may not be as serious. Our philosphy has therefore been to develop a continuous solar mode that: 1) maximizes solar science; 2) has minimal impact on the instrument response at energies above 1 MeV; and 3) accepts an impact on the instrument response at energies below 1 MeV.

Motivated by the CGRO schedule (in which the Sun entered our FoV starting 2-Feb-1999), we defined a first-order solar mode that was implemented for a full day on 01-Jan-1999 (TJD 11179). The results from this first test (the *strawman solar mode*) have been reported in COM-RP-DRG-UNH-055 (“Solar Mode Test Results – Processed Data”). Beginning with VP 805.5 on TJD 11211, COMPTEL was placed into a new solar mode, with slight modifications from the strawman solar mode. Here we present some of the results based on the new solar configuration (SOLAR80, where the ‘80’ refers to the MODEWRD given to this operating mode in the COMPTEL data stream).

An important point to make here is that the previous comparisons which we made between the strawman solar mode and the standard normal mode were based on comparisons with the standard COMPTEL response, which, in turn, were based on the *pre-flight* threshold values. Although such comparisons may be important for long-term studies, the important comparison to be made at this point in time is with the NORMAL mode which currently exists (with *current* NORMAL mode thresholds). Only in this way can we accurately assess the impact of the solar mode on non-solar science. *In the comparisons we report here, we use the response based on recent threshold determinations.*

## The SOLAR80 Mode

Our first tests with a new solar mode took place on TJD 11179 (01-Jan-1999). Results from this preliminary solar mode (the *strawman solar mode*) were presented in COM-RP-UNH-DRG-055 (“Solar Mode Test Results – Processed Data”). The SOLAR80 mode is based on the strawman solar mode, but with some small iterative changes.

First, the *sliding time window* was raised from 26 to 52. This places the high end of the 40 ns TOF hardware window at channel 255 to pick up all possible neutrons. The low end of the ToF hardware window is near (perhaps just below) channel 100. This was the same setting used before for the old solar neutron mode.

The *main veto threshold values* have been raised from level 5 to level 3 to avoid soft X-ray pileup that was evident in earlier solar flare events. (G. Lichti says it is ok to run at higher threshold values.)

Table 1 lists those changes relevant to the gamma-1 data stream. The TOF window has been reduced to the minimum width to reject accidentals. The PSD window has been reduced to reject pulse pile-up events in D1 that leads to invalid PSD values for high fluxes (evident in the 1991 solar flare data). The D1 threshold has been raised to lower the D1 count rates. The goal here was to raise the D1 thresholds to ~70-80 keV, so as to closely match the standard DRG data selections (D1 = 70 keV to 20 MeV). This was not achieved in the strawman mode, where the D1 thresholds ended up near 100 keV. Adjustments for the SOLAR80 mode achieved the desired D1 thresholds. In addition to the D1 threshold adjustments, the only other change in SOLAR80 with respect to the strawman mode was to modify the ToF window. The ToF adjustments include both a change in the width (from 40 to 35 channels) and to shift the lower edge of the ToF window from channel 110 to channel 105.

**Table 1 – Changes to Gamma-1 Data Stream**

| Parameter | Normal Mode | Strawman Solar Mode | SOLAR80 Mode |
|---|---|---|---|
| | | | |
| D1 Lower Threshold (hardware) | all at level 6 | all at level 2 | all set at level 3 |
| D1 Lower Threshold (DE) | channel 20 | channel 32 | channel 26 |
| D2 Lower Threshold (DE) | channel 55 | channel 55 | channel 55 |
| ToF Window | 95 – 150 | 110 – 150 | 105 – 140 |
| PSD Window | 0 – 255 | 50 – 120 | 50 – 120 |

Table 2 lists those changes relevant to the gamma-2 data stream. The idea here was to define a mode in which, once the impulsive phase photons decayed away, the on-board event selections would accept the delayed neutron events into the gamma-2 datastream.

| Table 2 – Changes to Gamma-2 Data Stream | | | |
|---|---|---|---|
| **Parameter** | **Standard Normal Mode** | **Strawman Solar Mode** | **SOLAR80 Mode** |
| | | | |
| D1 Lower Threshold (hardware) | all at level 6 | all at level 2 | all set at level 3 |
| D1 Lower Threshold (DE) | channel 5 | channel 32 | channel 26 |
| D2 Lower Threshold (DE) | channel 5 | channel 55 | channel 55 |
| ToF Window | 0 – 255 | 110 – 255 | 105 – 255 |
| PSD Window | 0 – 255 | 50 – 255 | 50 – 255 |

## NORMAL Mode Data – TJD 11201 (23-Jan-1999)

This day was used as a baseline for comparison with the SOLAR80 data to determine the impact of the mode changes. This particular day was chosen because it was a recent set of data that (along with the data for the two surroundings days) was already available at UNH. The following is a list of the critical datasets for this day:

MPE-FBY-25706
MPE-HKD-27254
MPE-OAD-28391
MPE-ISD-25703
MPE-EVP-47168
UNH-BTH-1351
UNH-ISS-1128
MPE-TIM-22588 (NORMAL mode TIM)

The individual module thresholds were determined using COMPASS task IFCTHR. The specific threshold energies are as follows (as given by output from UNH-IFCTH2-300).

| | *Position* (keV) | *Error* (keV) | *FWHM* (keV) | *Error* (keV) |
|---|---|---|---|---|
| Module D1- 1 | 49.15 | 0.260 | 15.63 | 0.358 |
| Module D1- 2 | 54.88 | 0.183 | 13.76 | 0.253 |
| Module D1- 3 | 48.17 | 0.253 | 13.45 | 0.349 |
| Module D1- 4 | 44.15 | 0.211 | 13.85 | 0.288 |
| Module D1- 5 | 50.18 | 0.193 | 13.30 | 0.263 |
| Module D1- 6 | 52.53 | 0.254 | 14.21 | 0.343 |
| Module D1- 7 | 49.59 | 0.192 | 14.51 | 0.254 |
| Module D2- 2 | 874.16 | 3.563 | 123.75 | 4.953 |
| Module D2- 3 | 723.60 | 1.193 | 90.05 | 1.511 |
| Module D2- 4 | 660.24 | 1.457 | 76.77 | 2.025 |
| Module D2- 5 | 702.68 | 1.421 | 94.31 | 1.971 |
| Module D2- 6 | 651.26 | 1.668 | 80.95 | 2.388 |
| Module D2- 7 | 522.19 | 0.994 | 76.74 | 1.351 |
| Module D2- 8 | 560.43 | 0.587 | 45.20 | 0.822 |
| Module D2- 9 | 532.93 | 0.338 | 40.49 | 0.478 |
| Module D2-10 | 639.73 | 1.213 | 77.64 | 1.702 |
| Module D2-11 | 742.37 | 0.725 | 110.51 | 3.806 |
| Module D2-12 | 505.66 | 0.314 | 56.47 | 0.425 |
| Module D2-13 | 698.84 | 1.807 | 82.77 | 2.558 |
| Module D2-14 | 733.43 | 2.275 | 103.86 | 3.170 |

## SOLAR80 Mode Data – TJD 11212 (03-Feb-1999)

This day was the first full day that COMPTEL was operated in the SOLAR80 mode. The data were received at UNH direct from PACOR and processed at UNH. The following is a list of the critical datasets for this day:

UNH-FBY-4316
UNH-HKD-4100
UNH-OAD-4265
UNH-ISD-4320
UNH-EVP-17828
UNH-BTH-1349
UNH-ISS-1127
UNH-TIM-4942 (SOLAR mode TIM)

The individual module thresholds were determined using COMPASS task IFCTHR. The specific threshold energies are as follows (as given by output from UNH-IFCTH2-298).

| | *Position (keV)* | *Error (keV)* | *FWHM (keV)* | *Error (keV)* |
|---|---|---|---|---|
| Module D1- 1 | 73.49 | 0.488 | 17.09 | 0.660 |
| Module D1- 2 | 79.62 | 0.368 | 12.92 | 0.499 |
| Module D1- 3 | 73.41 | 0.408 | 15.43 | 0.553 |
| Module D1- 4 | 66.55 | 0.422 | 13.56 | 0.584 |
| Module D1- 5 | 72.87 | 0.312 | 14.29 | 0.409 |
| Module D1- 6 | 76.48 | 0.418 | 14.75 | 0.563 |
| Module D1- 7 | 72.02 | 0.455 | 13.75 | 0.622 |
| Module D2- 2 | 870.48 | 3.708 | 136.04 | 5.129 |
| Module D2- 3 | 734.13 | 1.485 | 106.03 | 1.792 |
| Module D2- 4 | 660.68 | 1.659 | 87.85 | 2.346 |
| Module D2- 5 | 701.96 | 2.139 | 96.50 | 2.942 |
| Module D2- 6 | 648.45 | 1.916 | 95.52 | 2.712 |
| Module D2- 7 | 516.87 | 1.121 | 69.55 | 1.503 |
| Module D2- 8 | 559.32 | 0.548 | 43.03 | 0.781 |
| Module D2- 9 | 529.79 | 0.292 | 41.22 | 0.414 |
| Module D2-10 | 640.61 | 1.313 | 90.05 | 1.799 |
| Module D2-11 | 748.41 | 2.919 | 107.37 | 3.964 |
| Module D2-12 | 508.03 | 0.335 | 56.96 | 0.454 |
| Module D2-13 | 696.75 | 2.227 | 74.63 | 3.067 |
| Module D2-14 | 743.26 | 2.120 | 127.54 | 2.890 |

## Impact on $E^{-2}$ Power-Law Point-Spread-Functions ($\theta$ = 10°)

In order to determine the impact on the PSF, task IFCTHR was used to determine the threshold parameters for a recent NORMAL mode day (TJD 11201, 23-Jan-1999) and for one day furing the SOLAR80 mode operations (TJD 11212, 03-Feb-1999). For TJD 11201, file UNH-BTH-1351 was used to create UNH-ISS-1128. For TJD 11212, file UNH-BTH-1349 was used to create UNH-ISS-1127. These ISS files were used as input to SIMFIN to generate a set of simulated EVP data using these modified thresholds. Simulated PSFs were then generated using SIMPSF. The following table shows the baseline (NORMAL mode) PSFs, based on the threshold data for TJD 11201 and the SOLAR80 mode PSFs, based on the threshold data for TJD 11212.

***$E^{-2}$ Power-Law at 10° Zenith Angle***

| Energy Range (MeV) | Baseline PSF | IAQ norm | Solar80 Mode PSF | IAQ norm |
|---|---|---|---|---|
| 0.75 – 1.0 MeV | UNH-IAQ-58356 | 1.773 ( 10-2 | UNH-IAQ-58329 | 1.714 ( 10-2 |
| 1.0 – 3.0 MeV | UNH-IAQ-58357 | 4.195 ( 10-2 | UNH-IAQ-58330 | 4.178 ( 10-2 |
| 3.0 – 10.0 MeV | UNH-IAQ-58358 | 3.336 ( 10-2 | UNH-IAQ-58331 | 3.334 ( 10-2 |
| 10.0 – 30.0 MeV | UNH-IAQ-58359 | 1.788 ( 10-2 | UNH-IAQ-58332 | 1.767 ( 10-2 |

Comparisons between the baseline (NORMAL mode) PSFs and SOLAR80 mode PSFs can be made from the IAQ normalizations in the above table (simply summing over all elements in the IAQ array) and from the figures on the following pages.

Comparison of these PSFs reveals that the most significant differences is in the 0.75–1.0 MeV energy range, where the SOLAR80 mode results in a 3% reduction in the IAQ normalization. In the 1.0–3.0 MeV energy range, the reduction in IAQ normalization is less than 0.5%. Differences above 3.0 MeV are insignificant.

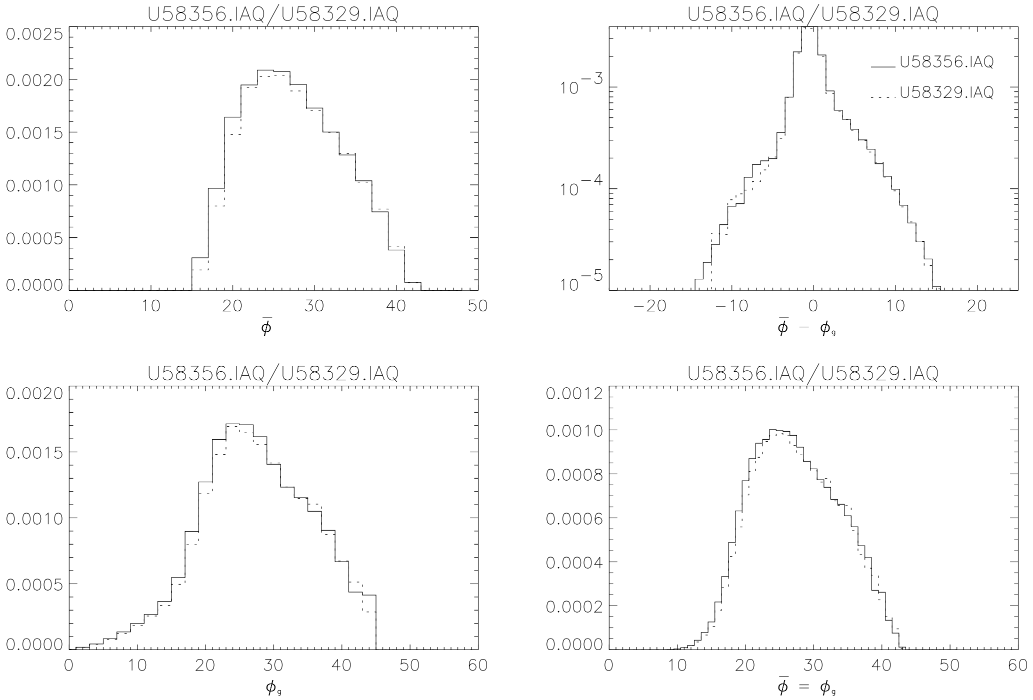

Figure 1: PSF comparison an E-2 power-law at 10° zenith for 0.75-1.0 MeV.

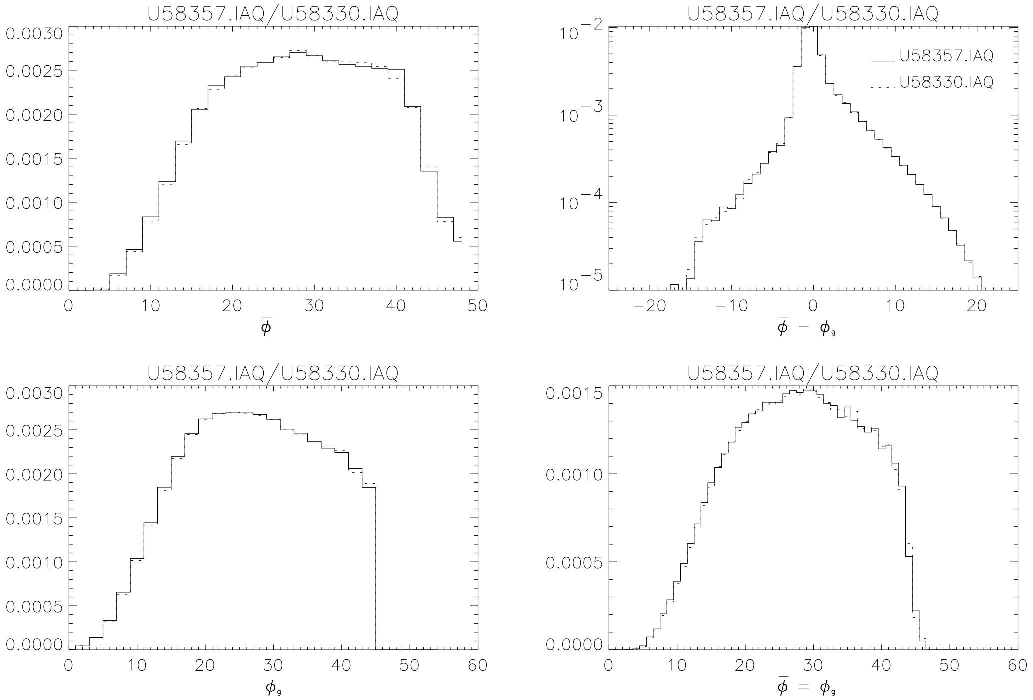

Figure 2: PSF comparison for an E-2 power-law at 10° zenith for 1.0-3.0 MeV.

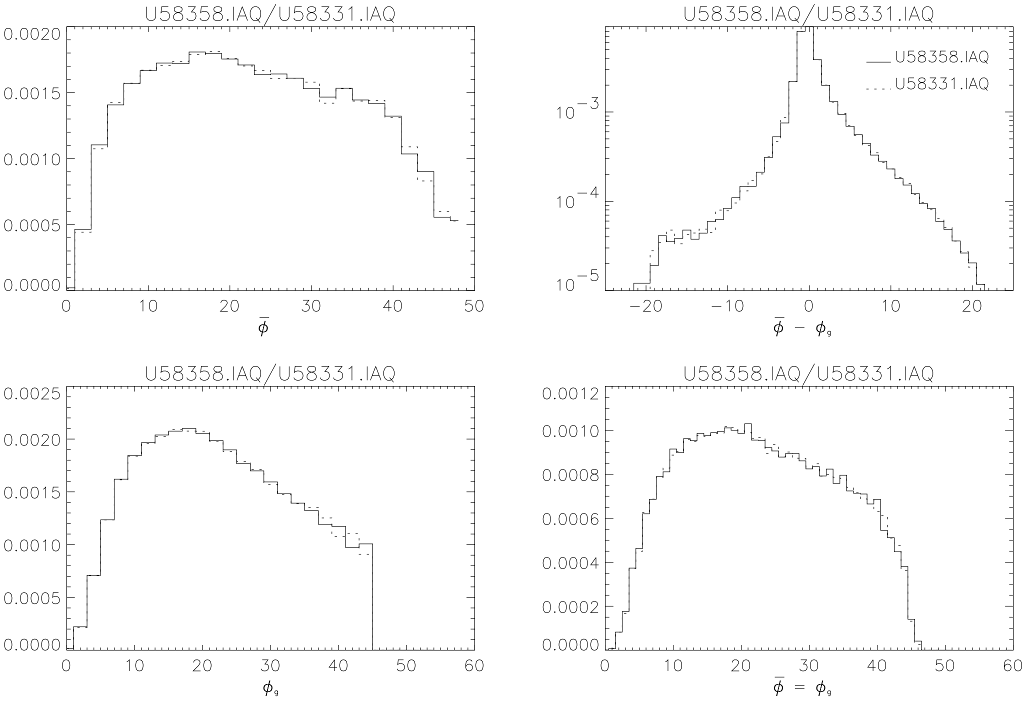

Figure 3: PSF comparison for an $E^{-2}$ power-law at 10° zenith for 3.0-10.0 MeV.

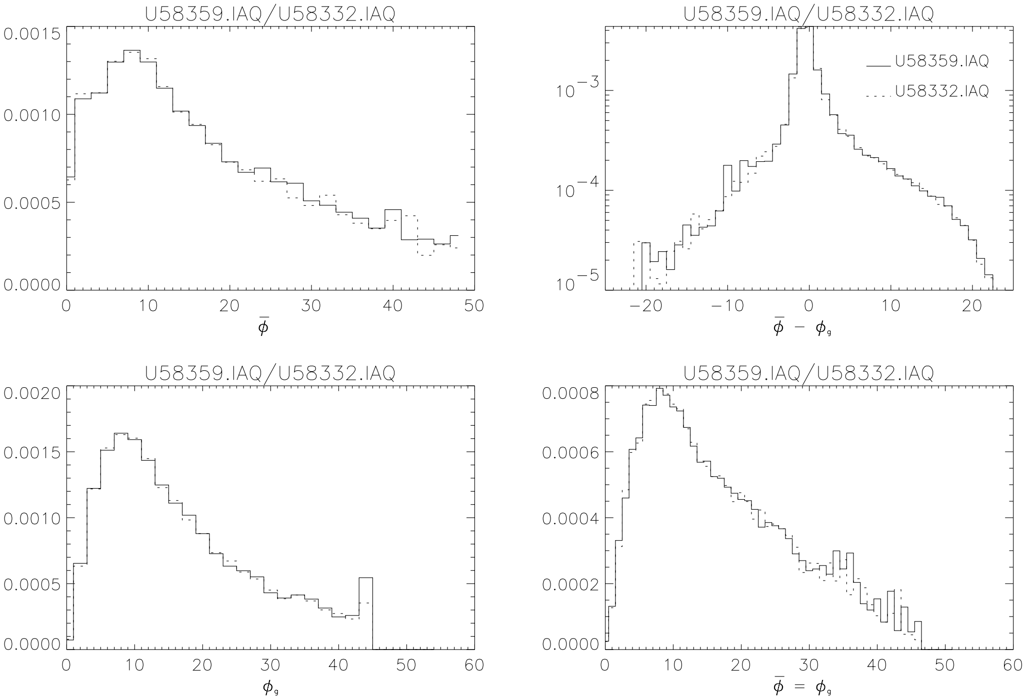

Figure 4: PSF comparison for an $E^{-2}$ power-law at 10° zenith for 10.0-30.0 MeV.

## Impact on $E^{-2}$ Power-Law Point-Spread-Functions ($\theta$ = 30°)

In order to determine the impact on the PSF, task IFCTHR was used to determine the threshold parameters for a recent NORMAL mode day (TJD 11201, 23-Jan-1999) and for one day furing the SOLAR80 mode operations (TJD 11212, 03-Feb-1999). For TJD 11201, file UNH-BTH-1351 was used to create UNH-ISS-1128. For TJD 11212, file UNH-BTH-1349 was used to create UNH-ISS-1127. These ISS files were used as input to SIMFIN to generate a set of simulated EVP data using these modified thresholds. Simulated PSFs were then generated using SIMPSF. The following table shows the baseline (NORMAL mode) PSFs, based on the threshold data for TJD 11201 and the SOLAR80 mode PSFs, based on the threshold data for TJD 11212.

***$E^{-2}$ Power-Law at 30° Zenith Angle***

| Energy Range (MeV) | Baseline PSF | IAQ norm | Solar80 Mode PSF | IAQ norm |
|---|---|---|---|---|
| 0.75 – 1.0 MeV | UNH-IAQ-58360 | $1.600 \times 10^{-2}$ | UNH-IAQ-58342 | $1.546 \times 10^{-2}$ |
| 1.0 – 3.0 MeV | UNH-IAQ-58361 | $4.379 \times 10^{-2}$ | UNH-IAQ-58343 | $4.358 \times 10^{-2}$ |
| 3.0 – 10.0 MeV | UNH-IAQ-58362 | $3.611 \times 10^{-2}$ | UNH-IAQ-58344 | $3.610 \times 10^{-2}$ |
| 10.0 – 30.0 MeV | UNH-IAQ-58363 | $2.078 \times 10^{-2}$ | UNH-IAQ-58345 | $2.078 \times 10^{-2}$ |

Comparisons between the baseline (NORMAL mode) PSFs and SOLAR80 mode PSFs can be made from the IAQ normalizations in the above table (simply summing over all elements in the IAQ array) and from the figures on the following pages.

Comparison of these PSFs reveals that the most significant differences is in the 0.75–1.0 MeV energy range, where the SOLAR80 mode results in a ~3% reduction in the IAQ normalization. In the 1.0–3.0 MeV energy range, the reduction in IAQ normalization is less than 0.5%. Differences above 3.0 MeV are insignificant.

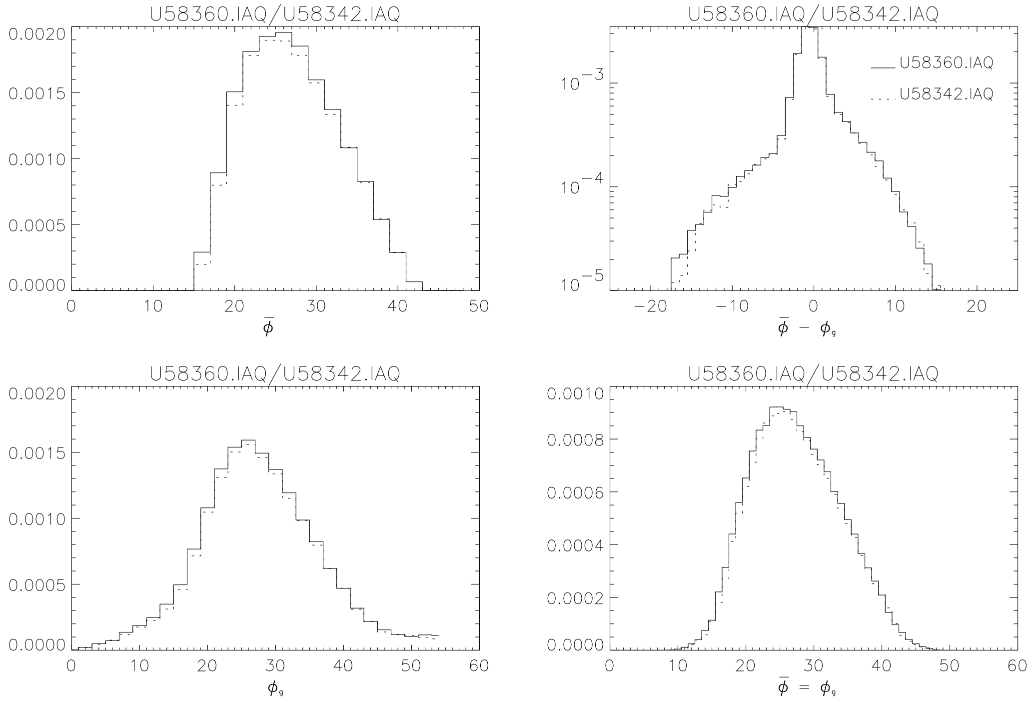

Figure 5: PSF comparison for an $E^{-2}$ power-law at 30° zenith for 0.75-1.0 MeV.

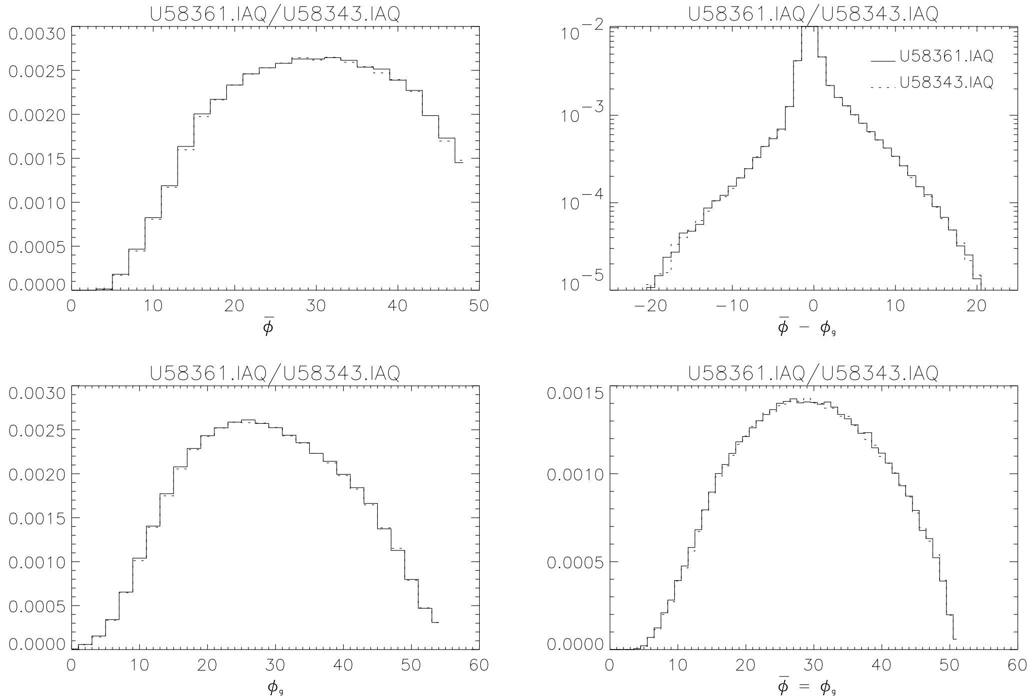

Figure 6: PSF comparison for an $E^{-2}$ power-law at 30° zenith for 1.0-3.0 MeV.

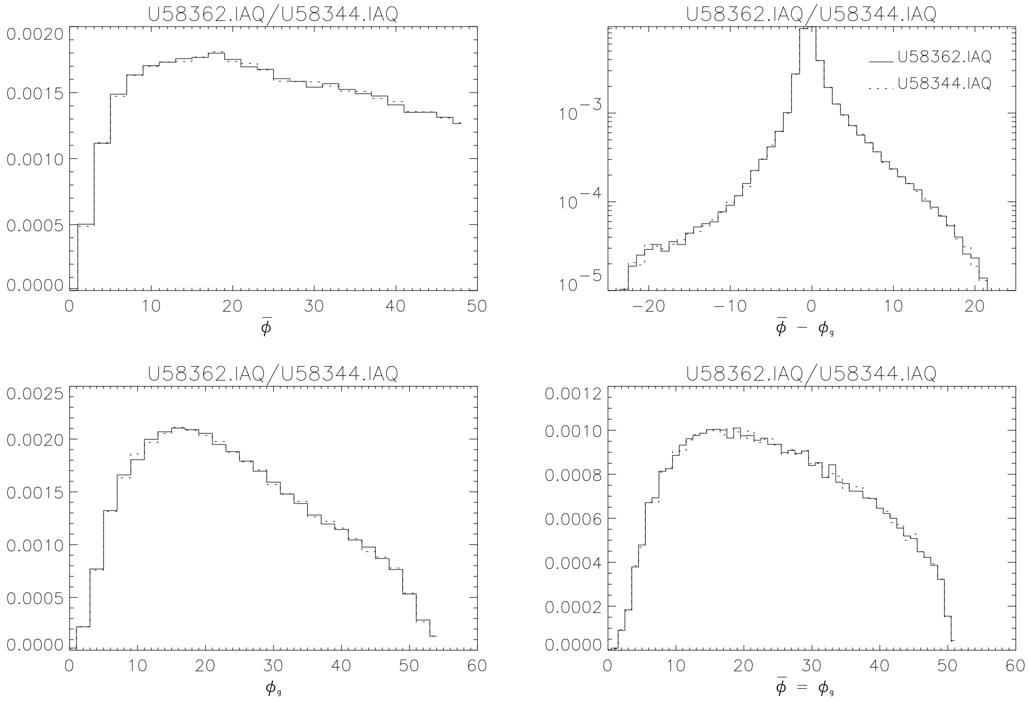

Figure 7: PSF comparison for an $E^{-2}$ power-law at 30° zenith for 3.0-10.0 MeV.

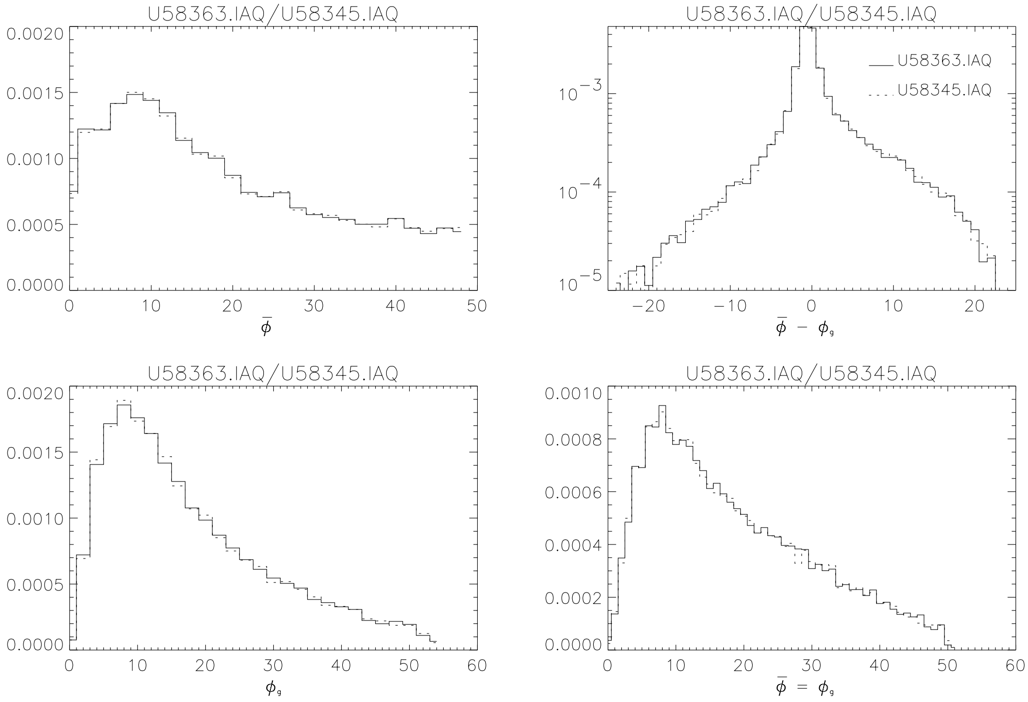

Figure 8: PSF comparison for an $E^{-2}$ power-law at 30° zenith for 10.0-30.0 MeV.

## Impact on Monoenergetic Point-Spread-Functions ($\theta$ = 10°)

In order to determine the impact on the PSF, task IFCTHR was used to determine the threshold parameters for a recent NORMAL mode day (TJD 11201, 23-Jan-1999) and for one day furing the SOLAR80 mode operations (TJD 11212, 03-Feb-1999). For TJD 11201, file UNH-BTH-1351 was used to create UNH-ISS-1128. For TJD 11212, file UNH-BTH-1349 was used to create UNH-ISS-1127. These ISS files were used as input to SIMFIN to generate a set of simulated EVP data using these modified thresholds. Simulated PSFs were then generated using SIMPSF. The following table shows the baseline (NORMAL mode) PSFs, based on the threshold data for TJD 11201 and the SOLAR80 mode PSFs, based on the threshold data for TJD 11212.

***Monoenergetic Lines at 10° Zenith Angle***

| Line Energy (MeV) | Baseline PSF | IAQ norm | Solar80 Mode PSF | IAQ norm |
|---|---|---|---|---|
| 0.847 MeV | UNH-IAQ-58371 | $1.179 \times 10^{-2}$ | UNH-IAQ-58367 | $1.156 \times 10^{-2}$ |
| 1.238 MeV | UNH-IAQ-58372 | $3.198 \times 10^{-2}$ | UNH-IAQ-58368 | $3.162 \times 10^{-2}$ |
| 1.809 MeV | UNH-IAQ-58373 | $3.079 \times 10^{-2}$ | UNH-IAQ-58369 | $3.069 \times 10^{-2}$ |
| 2.223 MeV | UNH-IAQ-58374 | $2.820 \times 10^{-2}$ | UNH-IAQ-58370 | $2.820 \times 10^{-2}$ |

Comparisons between the baseline (NORMAL mode) PSFs and SOLAR80 mode PSFs can be made from the IAQ normalizations in the above table (simply summing over all elements in the IAQ array) and from the figures on the following pages.

Comparison of these PSFs reveals that the most significant differences are, as expected, at the lower energies. At 847 keV, the SOLAR80 mode results in a ~1.5% reduction in the IAQ normalization. At 1.238 MeV, the reduction in IAQ normalization is ~1.1%. At 1.809 MeV, the reduction in IAQ normalization is ~0.3%. Differences above 2.0 MeV are insignificant.

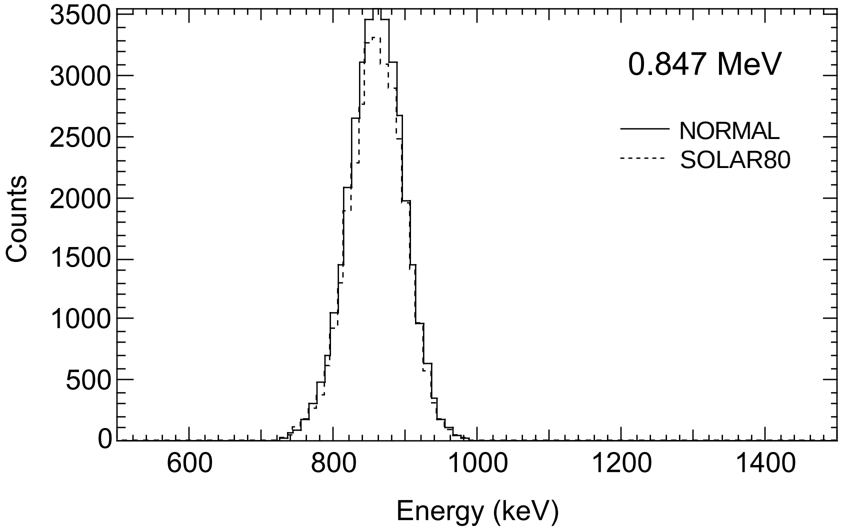

Figure 9: Comparison of energy spectra at 847 keV.

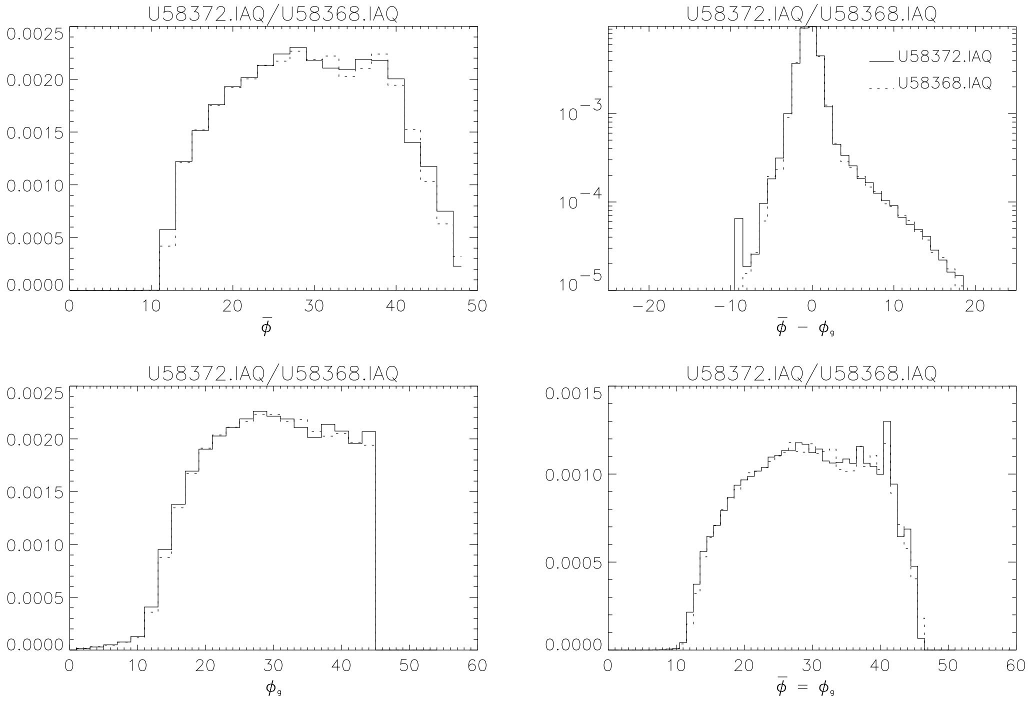

Figure 10: PSF comparison at 847 keV.

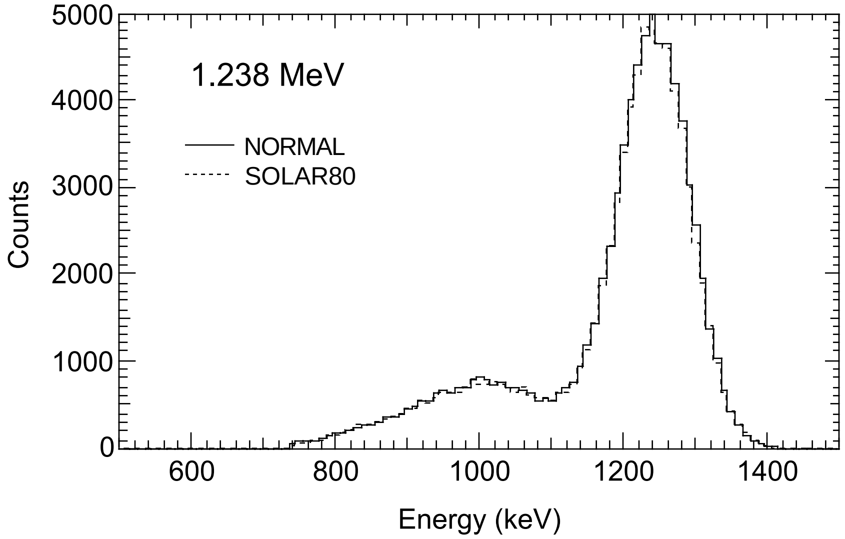

Figure 11: Comparison of energy spectra at 1.238 MeV.

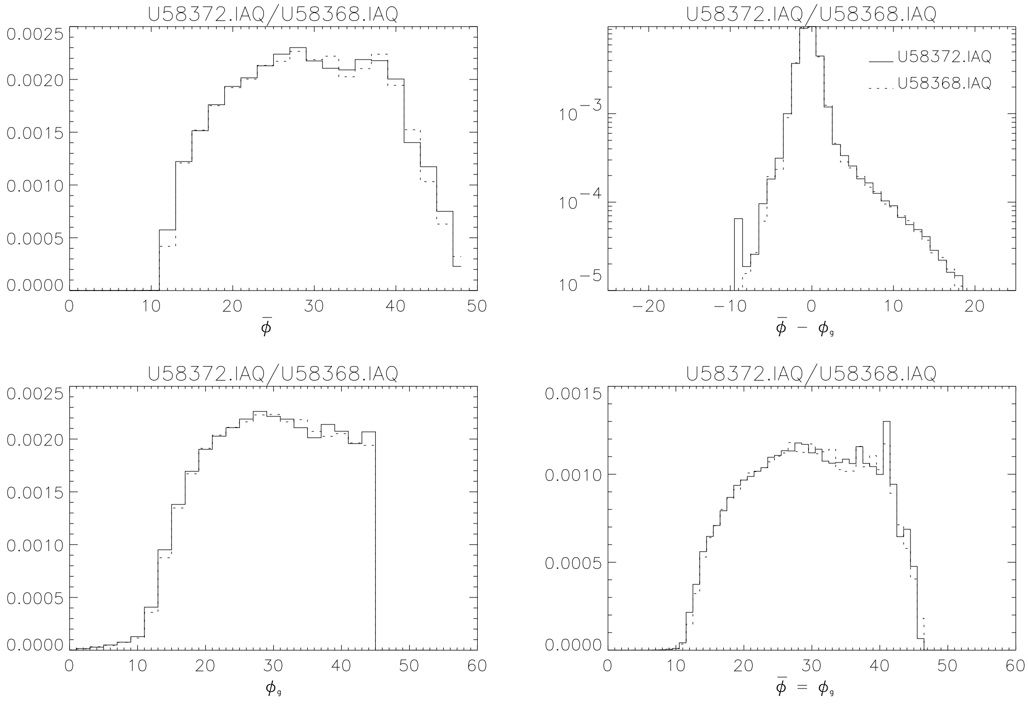

Figure 12: PSF comparison at 1.238 MeV.

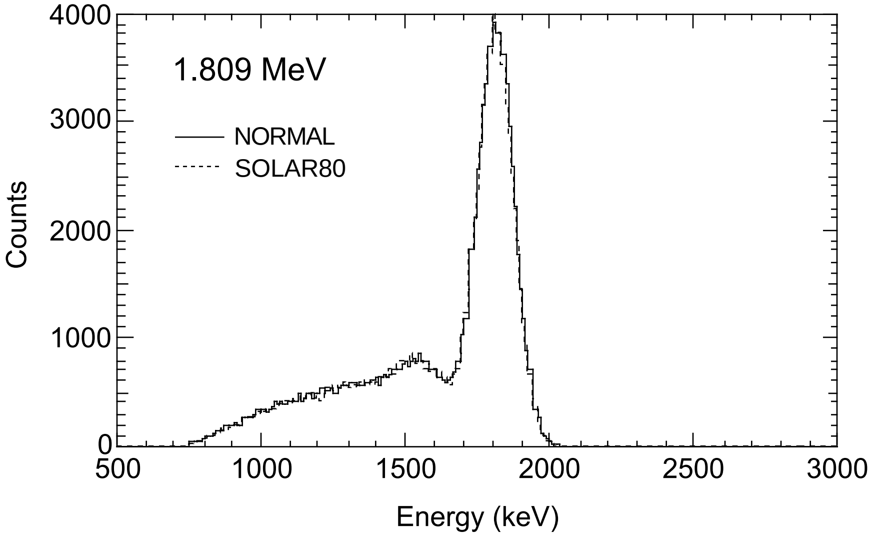

Figure 13: Comparison of energy spectra at 1.809 MeV.

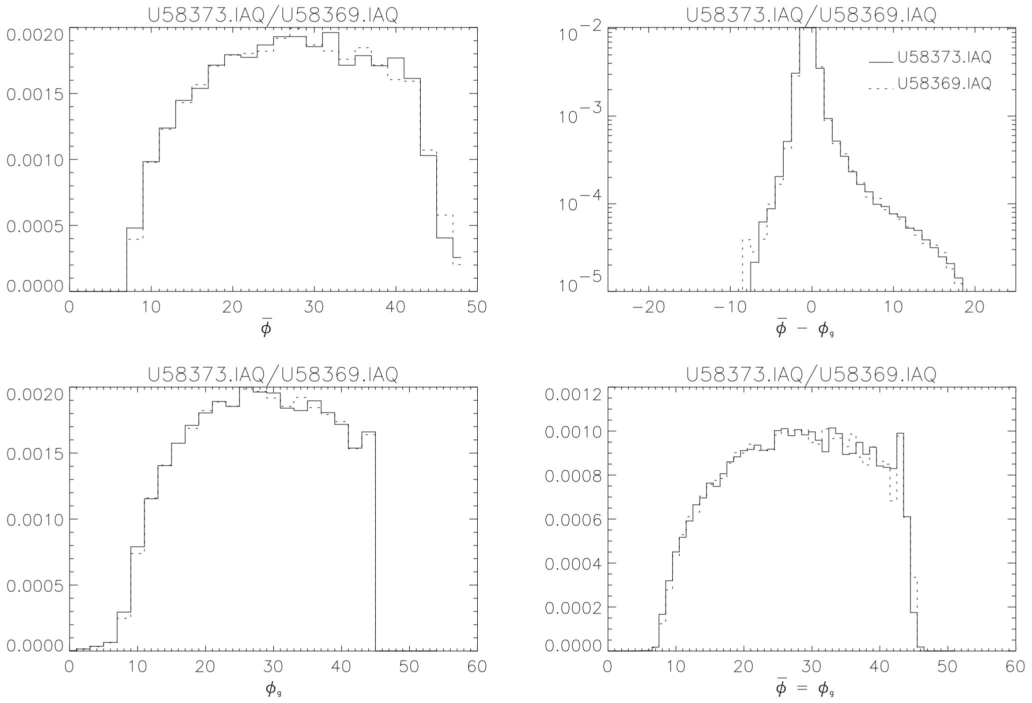

Figure 14: PSF comparison at 1.809 MeV.

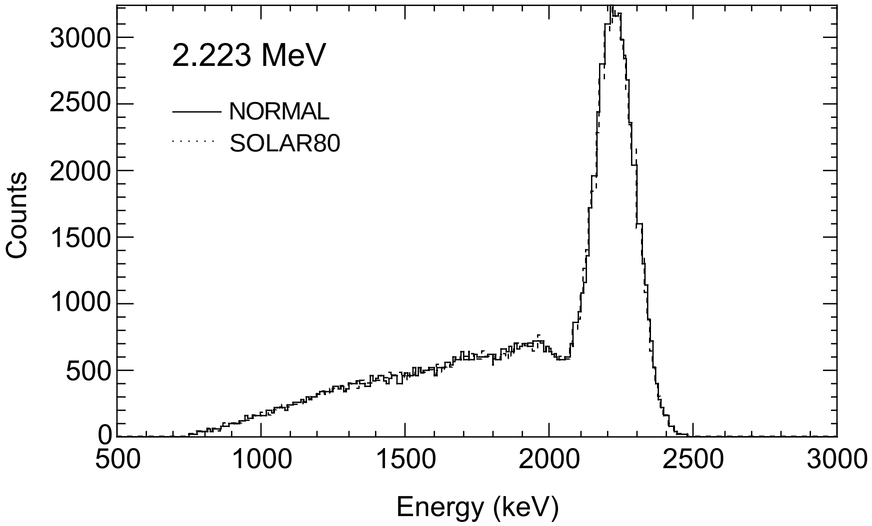

Figure 15: Comparison of energy spectra at 2.223 MeV.

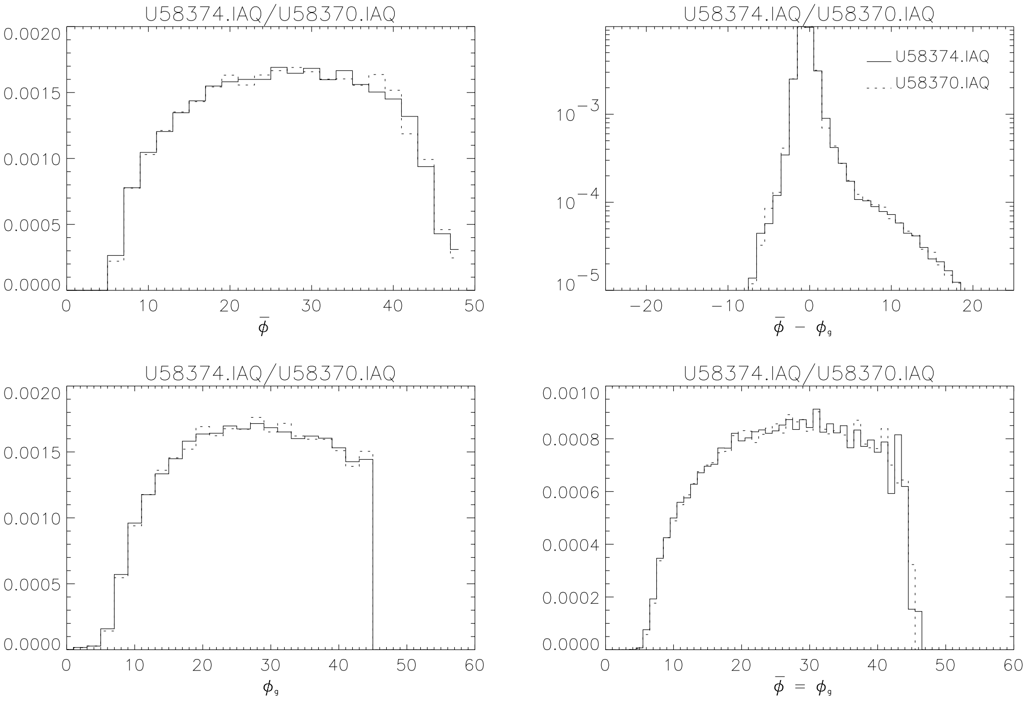

Figure 16: PSF comparison at 2.223 MeV.

## Impact on Distribution of Events in D1 Modules

One one of the concerns expressed at the Feb, 1999 COMPTEL team meeting was the impact of the newly-defined ToF windows on the distribution of events within the seven D1 modules. The concern here is that the tighter ToF windows may impact some modules differently than others due to the intrinsic ToF variations of selected minitelescopes.

We have used DDMCHK to determine the total number of counts in each module for both TJD 11201 (NORMAL mode) and TJD 11212 (SOLAR80 mode). In each case, we used a TIM dataset that selected only those times when the spacecraft earth horizon angle (EHORA) was greater than 0°. The event selections also included the following:

D1E = 70 keV – 20 MeV
D2E = 650 keV – 30 MeV
ToF = 115 – 130
PSD = 40 - 90

Figures 17 and 18 show plots of the D1 counts for both the 1 –5 MeV energy range (Figure 17) and for the 0 – 30 MeV energy range (Figure 18). For the 1 – 5 MeV energy range the average counts per module was 11867 ± 924 on TJD 11201 and 11,834 ± 462 on TJD 11212. For the 1 – 30 MeV energy range, the average counts per module was 14782 ± 1166 on TJD 11201 and 14427 ± 568 on TJD 11212. The relative counts ratios are shown in Figure 19 (1-5 MeV) and Figure 20 (0-30 MeV). Most the variation (about 10%) occurs in D1-3 and D1-6.

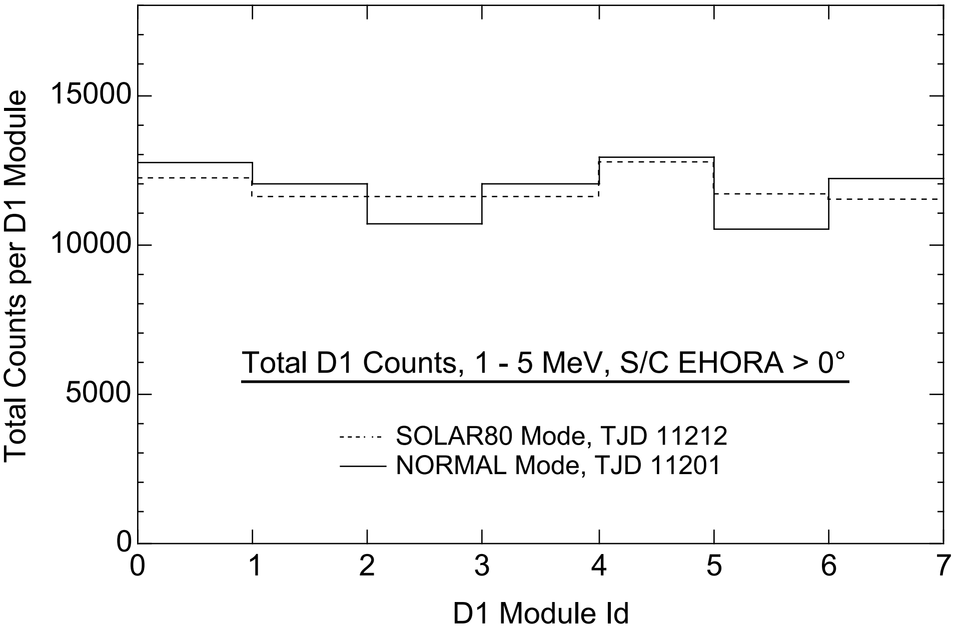

Figure 17: Total counts per D1 module, 1-5 MeV.

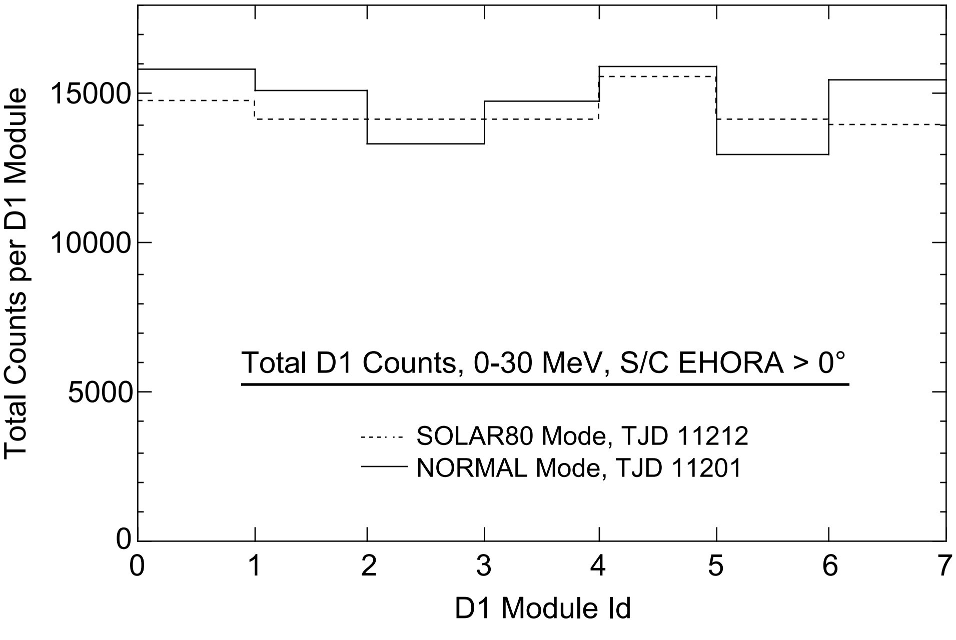

Figure 18: Total counts per D1 module, 0-30 MeV.

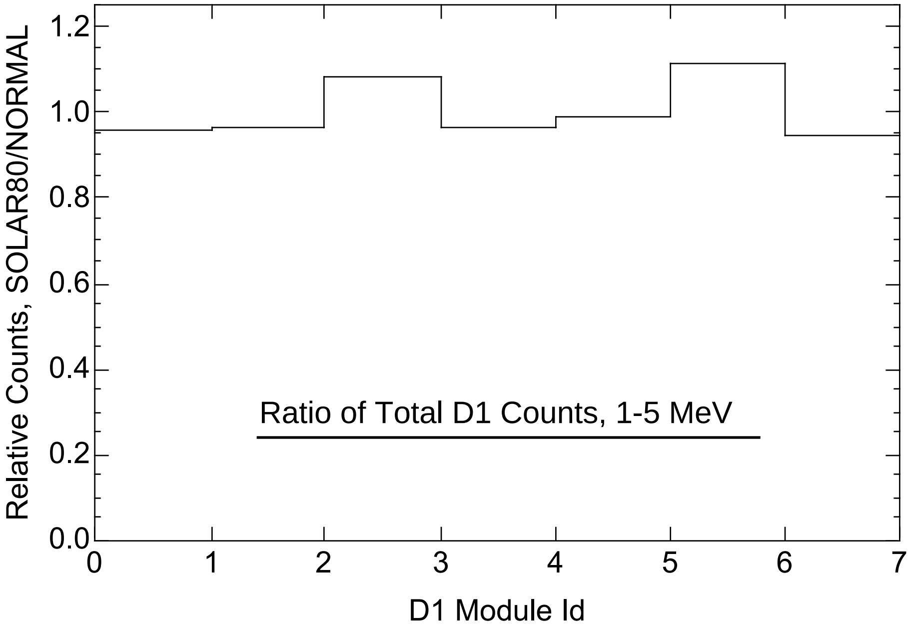

Figure 19: Ratio of total counts per D1 module, 1-5 MeV.

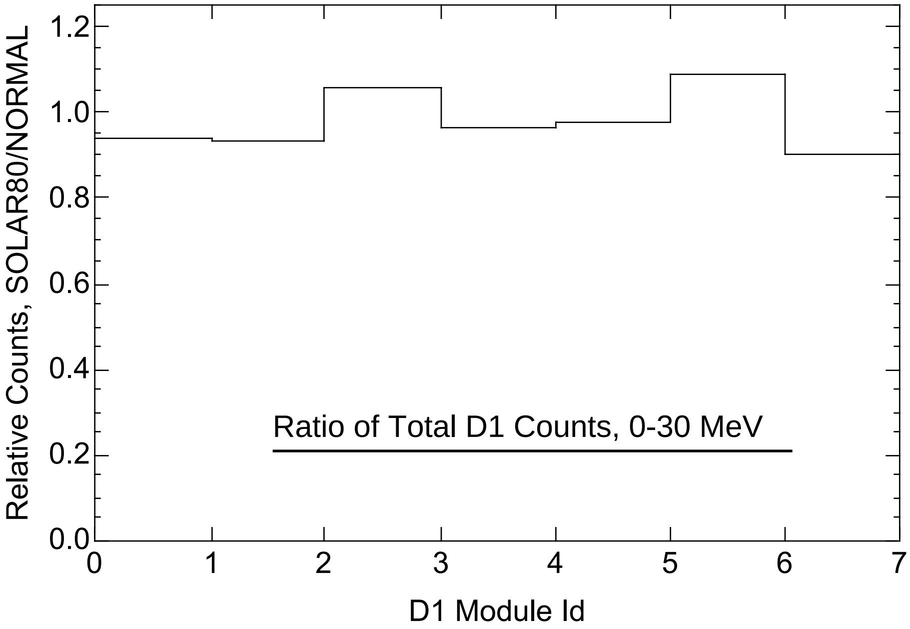

Figure 20: Ratio of total counts per D1 module, 0-30 MeV.

## Summary

A previous comparison of the strawman solar mode with the normal mode (COM-RP-DRG-UNH-055) was not an appropraite comparison, since the normal mode used in that case was that defined for the beginning of the CGRO mission. Here we have repeated that comparison, this time comparing the latest SOLAR80 observing mode with the latest NORMAL mode. In general, the comparisons show only a small impact on the instrument response, at most only a few percent at the lowest energies. The relative counts per D1 module show some variation, the implication of which is not clear.