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The BATSE SLED: The Problem and The Correction

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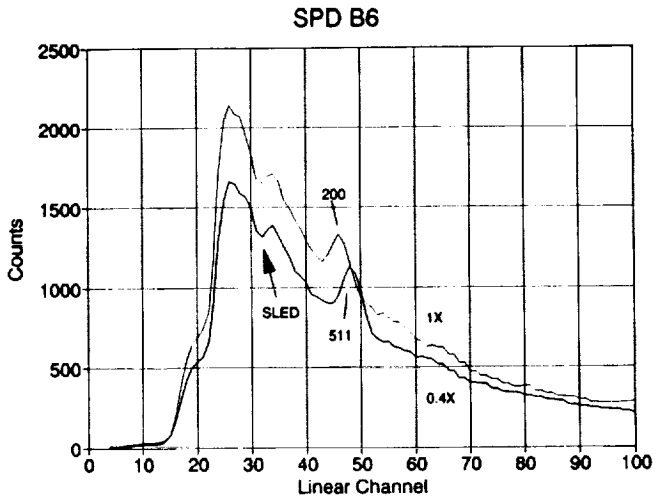

Figure 1. The SLED in the BATSE SPD Spectra.

1. Introduction:

The Burst And Transient Source Experiment (BATSE) has been in space for 4 months and, by anyone's reckoning, is performing better than even the most optimistic pre-flight predictions. That doesn't mean there haven't been some small surprises.

Because of the discreteness of γ-ray energies available to us in pre-flight testing, we could not subject the instrument to the continuous distribution of energies it now sees in space. Therefore, it was not until the beginning of mission operations that a small non-linearity was discovered in the low energy region of the SPD spectra (Band, 1991). The nickname for this depression is the *SLED* (Spectrocopy Low-Energy Depression). Figure 1 presents sample spectra for module 6 at two gains (1X and 0.4X). Note that the position of the sled is gain-independent in channel space.

A further study on a non-flight module discovered the cause lay in the spectroscopy analog electronics. Above a certain energy threshhold, the digital signal from the SPEC-FAST2 discriminator causes, in effect, an extra small amount of charge to be added to the SHER analog input. Figure 2 presents the laboratory measurements of SHER output energy as a function of input energy. The change of slope at the point of the SLED results in narrower bin widths for the channels in that region. The SLED is approximately 5 channels wide. It should be mentioned that below the SLED and for many decades above the SLED (not shown in Figure 2) the response is extremely linear.

The proposed fix was to move the lower straight line up to match the extrapolation of the upper straight line, shown by the dotted line. In effect, this means reassigning channel numbers. All channel edges lower than the SLED are moved a fixed amount to higher channel numbers. Channel edges *in* the SLED are moved a different amount depending on their position. The latter obviously results in narrower channel widths in energy space.

Although the energy at which this effect occurs is lower than the stated design specifications of the BATSE modules, it was felt that we could significantly enlarge the range of our data coverage, if we could fix this depression. Plotting the spectra in energy space provides a guide for fixing the depression. Since the SLED is constant in channel position

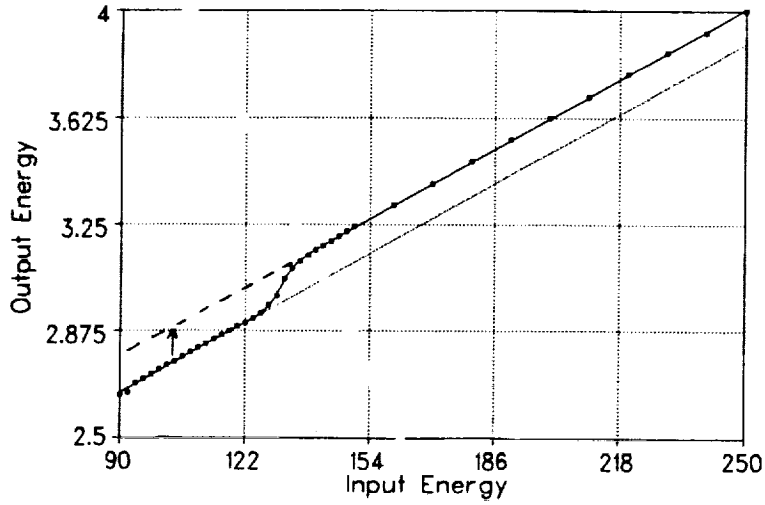

Figure 2. MQT Output vs. Input Energy (both in arbitrary units).

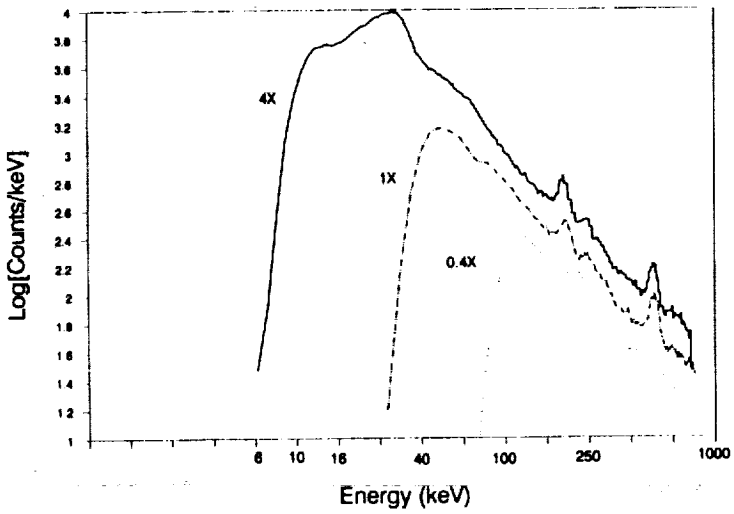

Figure 3. The SLED in Energy Space.

for different gains, it will appear at different energies. This is shown in Figure 3 where the SLED occurs at approximately 15 keV, 60 keV, and 200 keV for gains of 4X, 1X, and 0.4X, respectively.

The background at 60 keV, distorted in the 1X spectrum, is undistorted in the 4X spectrum. Thus the 4X spectrum tells us what the corrected 1X spectrum should look like. In the same way, the 1X and 4X spectra tell us what the 0.4X spectrum should look like at 200 keV. Since there were no spectra that provided a hint as to what the 4X spectrum should look like at 15 keV, we temporarily increased the gain for four in-flight detectors to 5X.

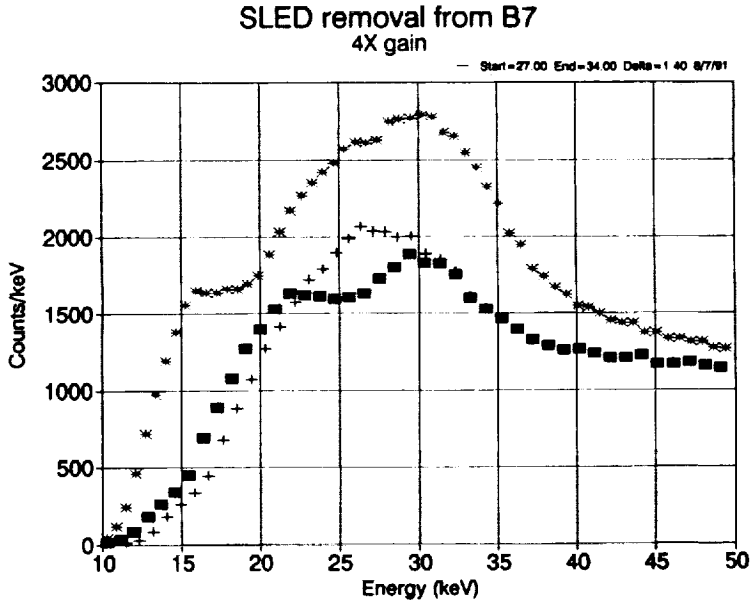

Figure 4. The Corrected Spectrum for SPD 7 at 4X Gain.

2. The Fix

It was determined from Figure 3 that the form of the SLED correction would be a change to the channel number x to $x + \delta$, where

$$\delta = d\left[1 - \frac{1}{1 + e^{-(x-c)/w}}\right],$$

and where d is the maximum value of δ ($\approx$ 1 chan), c is the center of the SLED, and w is the width of the SLED.

Making the correction involved finding the optimum set of SLED parameters for each detector that would fill in the depressions at all three gains to match the expected backgrounds. This was done with an optimization program that was created for spreadsheets on IBM compatibles, *Goal Solutions* by Enfin Software. Figure 4 shows the spectrum of SPD B7 with and without the SLED correction. Note how the channels to the left of the SLED are shifted to the right.

3. Results:

Table 1 presents the results of the analysis for all eight SPD's. Since the position and width of the sled is dependent on the setting of the lower level discriminators (LLD's), the present LLD settings are also included.

The plan since launch has been to keep the LLD's at a constant setting. However, if they are changed, or drift, then the derived SLED parameters must also change. In order to measure the correlation between LLD voltage and SLED parameters, we will soon measure spectra for several different LLD settings. The results of that analysis will be added to Table 1 in the near future.

Table 1. Optimum Parameters for the SLED Correction.

Module number	LLD (Hex Volts)	Center	Width	*d*: Offset
0	24	27.0	1.20	1.20
1	20	32.1	1.54	0.84
2	20	11.0	1.33	1.40
3	1C	17.4	1.36	0.92
4	14	23.7	1.62	0.73
5	1C	25.0	1.33	1.20
6	24	31.9	1.11	0.86
7	2C	30.5	1.56	1.40

4. Acknowledgements

As in previous summers here at MSFC with the BATSE team, I have benefitted greatly from the camaraderie and spirit of the team members. Their willingness to cooperate is unbounded. For that I am very grateful.

I would also like to acknowledge the BATSE representatives at the University of San Diego, Jim Matteson and David Band and those at the Goddard Space Flight Center, Bonnard Teegaren, Brad Schaeffer, and Jay Norris. They have all been aggresive in pursuing this and other BATSE phenomena. Thanks.

Finally, a special thanks to Jerry Fishman for his continued help and support.

5. References:

1) Austin, R. W., 1991, Letter to BATSE Personnel entitled "Spectroscopy HER Data Notch", June 4, 1991. unpublished.

2) Band, D. L., 1991, Fax to Bill Paciesas entitled: "Of Dips and LLD's: Characterization of an Additional Low Energy Non-Linearity in SD Spectra". May, 29, 1991, unpublished.