Correction to the Observed Excess due to the Background Estimation Method

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Abstract

Our method(s) of estimating the background, either the time sloshing or direct integration methods, include the signal events in the estimate of the background. Before estimating a flux from a source this effect must be corrected. The net effect is to increase the flux estimate by 9.7% in the direct integration method with 2-hour integration windows. In this quick memo I document these findings.

Over-estimating the Background

In the time sloshing or direct integration method for estimating the background from a given region of the sky all events are used: even signal events. Therefore the background estimation is systematically high when examining a true source of gamma rays. The effect on the background estimate can be easily calculated in the following manner. I use the *delAngle* distribution from the Monte Carlo as the point spread function of Milagro, see Figure 1 for the *delAngle* distribution. The cuts on the gamma-ray induced events were: *nTop*>60, *nFit*>20, X_2>2.5.

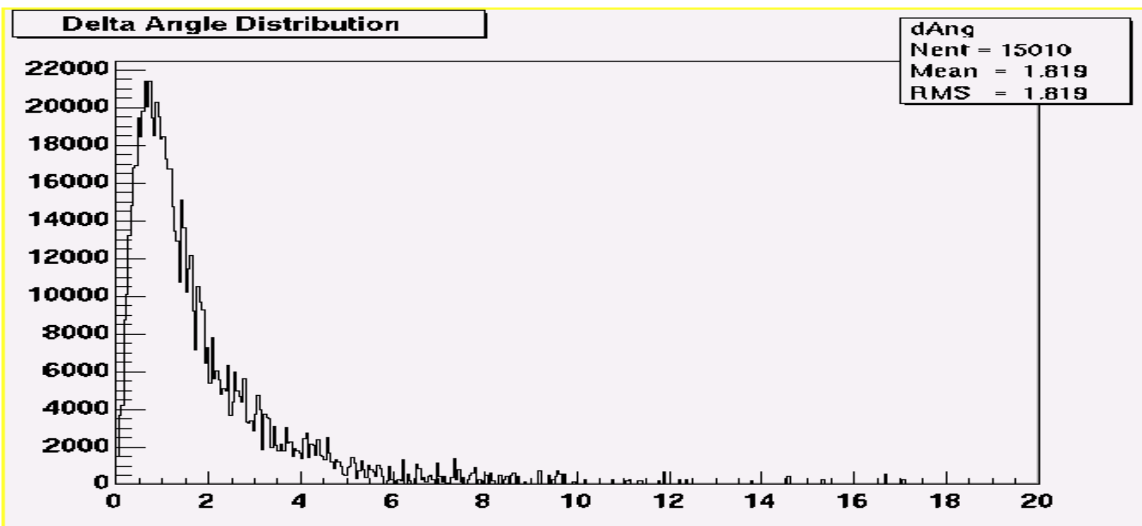

Figure 1. Delta Angle distribution for gamma-ray events in Milagro. X-axis is in degrees. Cuts on the data are: *nTop*>60, *nFit*>20, X_2>2.5.

After drawing randomly from this distribution a random azimuthal angle is assigned to each event. The X and y components of the fake event are found and plotted, see Figure 2. I then find the fraction of events that fall within the band in declination used to estimate the background (±2.1/2 degrees in y) and also the fraction that fall within the reconstructed bin (same requirement in x). It is found that 69% of the events fall within the declination band (and therefore are included in the estimate for the background), while 53% of the events fall within the source bin. It is not enough to correct for the observed excess, one must also account for the total amount of the excess that fell within the declination band used to estimate the background. The final correction to the excess (*nSignal*) is then:

$$nSignal^{true} = nSignal^{observed}\left(1 + \frac{0.69}{0.53}\frac{2.1/\cos(d)}{30}\right)$$

for a 2-hour integration window. The second term on the right-hand side corrects for the relative size of the source bin and the region used to estimate the background (30 degrees is the change in right-ascension in 2 hours). For a source at the declination of the Crab (22 degrees), the above formula leads to:

$$nSignal^{true} = 1.097 nSignal^{observed} .$$

This quantity can either be subtracted from the background estimate or added to the signal estimate. Using Andy's numbers for the Crab excess:

Table 1 Excess from the Crab and affect of correction.

Data Selection	On	Off	Corrected off	Excess	Significance
nTop>60, nFit>20	16,987,703	16,982,067.7	16,981,520.3	6182	1.44
nTop>60, nFit>20, X2>2.5	1,952,917	1,945,798.9	1,945,109	7808	5.4

When Andy reported his numbers at the NYU meeting he had accounted for much of this correction. He included the portion of the signal events that fell in the source bin, but not the events that fell in the declination band but outside of the source bin. With 839 days on source we end up with an estimate of 9.3 events/day from the Crab (that fell within our source bin). If one was to ignore the above effect the result would have been 8.5 events/day from the Crab.

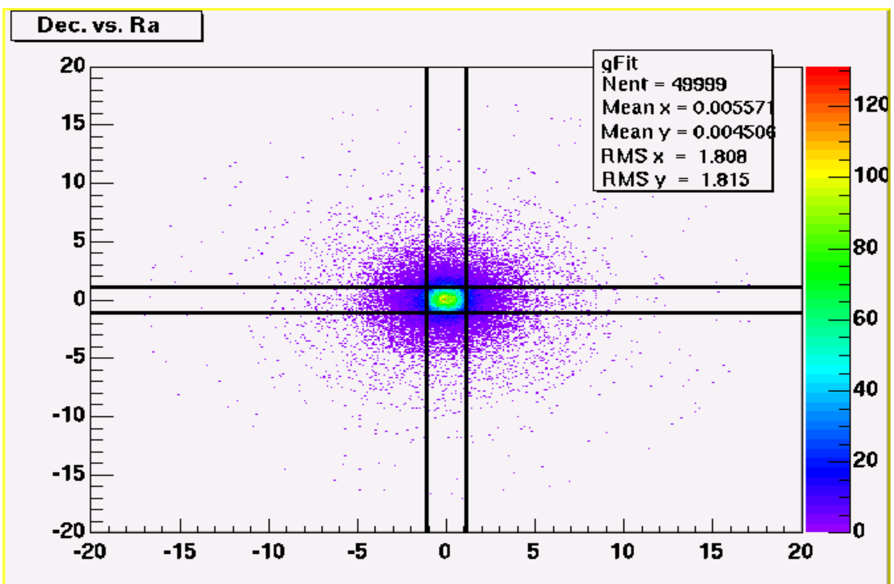

Figure 2. The dots show the angular resolution of Milagro in 2 dimensions. The 2 horizontal lines define the declination band used to estimate the background, 69% of the signal events are reconstructed within this band. The box in the middle is the source bin, 53% of the signal events are reconstructed within this bin.