Rescaling X2 for data collected between November 9,2002 and May 14,2003
by Andy Smith

Subsequent to the Fall 2002 repairs there was an effort to rapidly calibrate the Milagro detector and to quickly place new (better) calibrations on-line. On November 9, 2002, new calibrations were placed on-line. These calibrations included much better uniformity in both timing and pulse amplitude than the calibrations that they replaced. Furthermore, they corrected the known bogus calibrations of numerous PMTs that had either been swapped out, experienced calibration drift or were never properly calibrated to begin with. The new calibrations did have one bad feature however, they were created with a poor filter wheel calibration that lead to a “scale shift” in the PE calibrations. This “scale shift”has the effect of raising the efficiency of an X2>2.5 cut from ~10% for proper calibrations to ~23% for the new calibrations. Users making this cut would retain much more background than optimal. In this short memo, I describe a function I have written that corrects the parameters in the reconstructed data collected between Nov 9,2002 and May 14, 2003 when the scale shifted calibrations were on-line.

The scale shift between the faulty calibrations and the true values is not a simple scale shift. In a simple scale shift, the calibration for a given (TOT,IPMT) might be underestimated by some fraction. The scale shift in this case is slightly more complex. The mistake made was a mis-calibration of the neutral density filter wheel. The mistake was consistent with a small (few percent) error made at each step of the wheel. The problem compounded because is that the errors multiply as the wheel is turned to higher transparency. So, 15 3% errors can combine to yield an error greater than 50%!

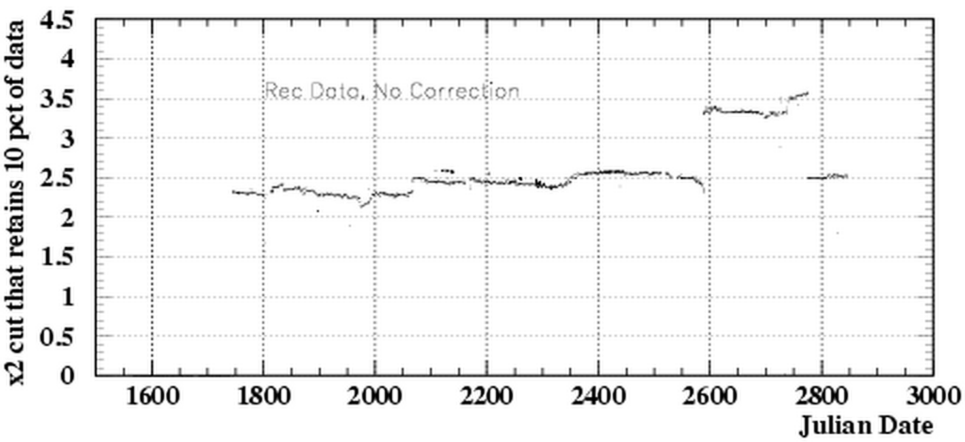
Fixing the problem from the point of view of gamma/hadron separation (read X2) involves understanding the effect of the rescaling on the 2 parameters on which X2 depends, the maximum muon hit amplitude and the number of muon layer hits greater than 2 PEs. It turns out that the nature of the scale shift makes the correction easy. Because the amplitude of the shift scales with the pulse amplitude, the shift on 2 PE hits is negligible. So the number of muon layer hits greater than 2 PEs does not change with the calibration scale shift. The opposite is true about the maximum muon layer hit. The maximum muon layer hit amplitude is in general large and therefore in general is shifted by a large amount. The scale shift that appropriately fixes the maximum muon layer hit is simply a fractional amplitude shift proportional to the log of the amplitude.

A routine called rescalePEs() was created apply the appropriate shift to the maximum muon layer hit parameter in the reconstructed data. The function knows to only apply the correction to data reconstructed during the time when the shifted calibrations were on-line. This function rescales the maximum muon layer hit parameter so that the derived value of X2 is rescaled so that cutting on X2 yields the same background efficiency for all epochs.

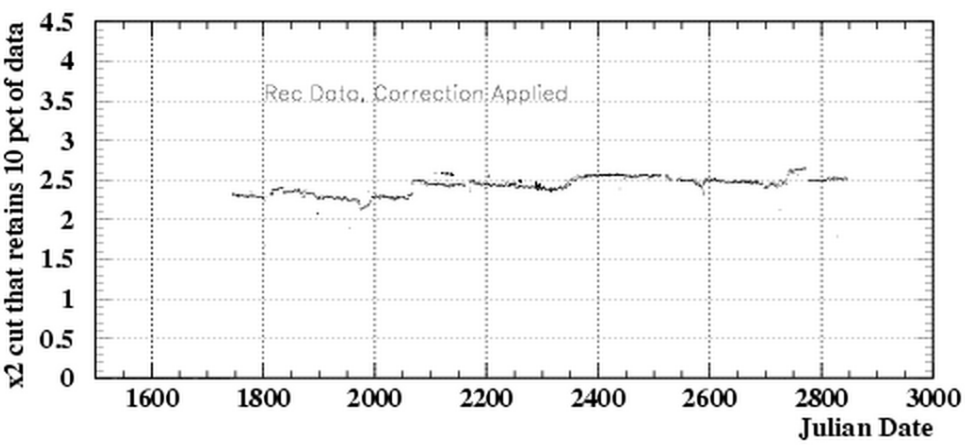
Figure 1 is a plot showing the value of the X2 cut that preserves 10% of the background with Nfit>=20 from the reconstructed data. The data collected with the scale shifted calibrations is easily seen between JD=2696 and 2775. In the corrected data, the distinction disappears. Woo Hoo.

Figure 2 is a plot comparing calibrations derived in the Spring of 2003 that include the correct PE scale to the rescaled calibrations with an incorrect PE scale. Plotted is the "correct" X2 value for 2 cuts: X2(correct)>2.5 and X2(rescaled)>2.5. The cuts have nearly identical efficiency. The rescaled cut provides an efficiency of 85% for preserving events with X2(correct)>2.5. Events lost have X2 values just above 2.5 and the added events have have X2 values just below 2.5. The difference between the correct calibration and the rescaled calibration is minimal.

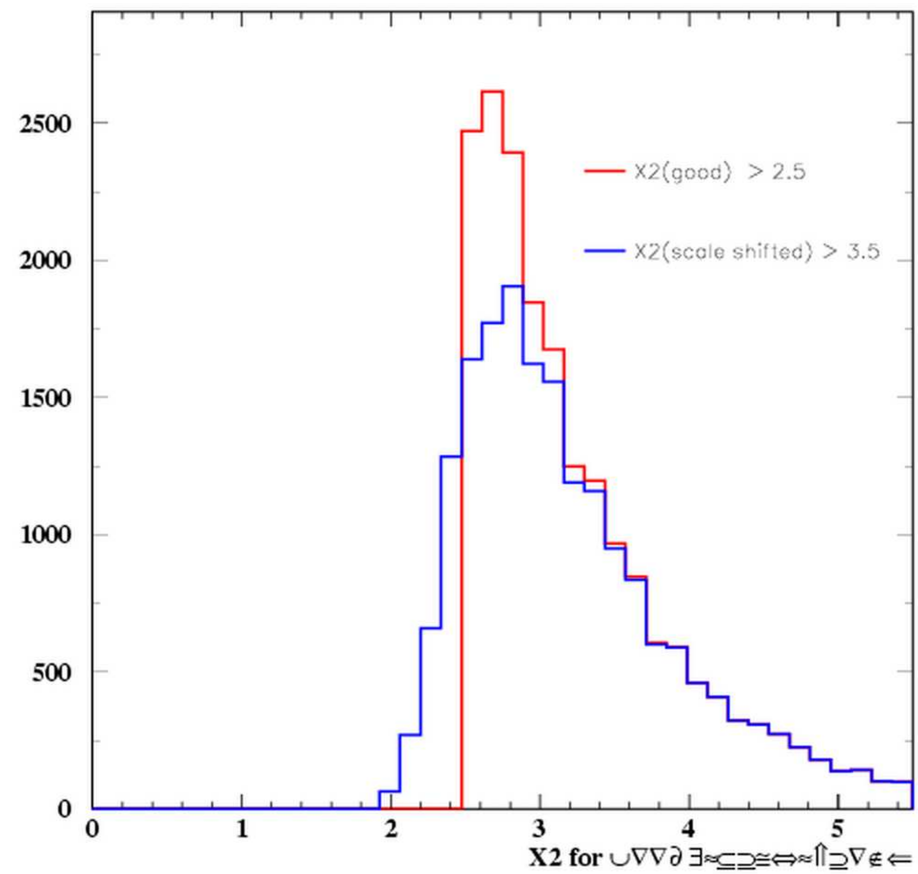
This correction should be used for all data analysis done on data collected on-line during the period when these calibrations were used. Applying the correction removes the effect of the scale shift on the X2 parameter used in gamma/hadron separation.



x2 cut that retains 10 pct of data
Rec Data, No Correction
Julian Date



x2 cut that retains 10 pct of data
Rec Data, Correction Applied
Julian Date


2500
2000
1500
1000
500
0
0
1
2
3
4
5
X2(good) > 2.5
X2(scale shifted) > 3.5
X2 for ∪∇∇∂ ∃≈⊆⊇≅⇔≈⇑⊇∇∉⇐