Understanding the BigBite Shower Calibration

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During any scattering experiment with electromagnetic calorimeters, it is vital to be able to accurately detect the particle energy deposited in the calorimeter. In order to do this the electromagnetic calorimeters need to be calibrated. During E06014 we had two electromagnetic calorimeters, the pre-shower and shower detectors. In order to clearly understand how the calibration procedure works, the variables that are saved to the ROOT file need to be defined first. In the ROOT file each calorimeter has several variables associated with determining its energy. For simplicity in the following examples, the pre-shower variables will be listed. The first most basic variable is the raw value of the calorimeter ADC, in the ROOT file this is called BB.ts.ps.a[BlockNumber], where BlockNumber is the ADC for a particular block in the calorimeter. The next variable of importance to the energy in the calorimeter is the variable BB.ts.ps.a_p[BlockNumber], which is the raw ADC minus the pedestal. The final variable that will be considered here is the energy in the calorimeter, BB.ts.ps.e. This is the energy deposited in the calorimeter, more on this later.

Now that the ROOT variables are defined, the rough calibration procedure can be discussed. The rough calibration is done at the time of the experiment. Cosmic ray energy is measured in the calorimeters, and the peaks in the ADCs are aligned to a common channel. In the shower detector the cosmic energy peaks are aligned to channel 120, and in the pre-shower the ADC peak is aligned to channel 240. The pre-shower is set to a higher channel to avoid loss of signal,because there is less signal compared to the shower. The value of these ADCs get written into the ROOT variables BB.ts.ps.a[] and BB.ts.ps.a_p[].

The aligned ADCs from the cosmic rays, now need to be converted from ADC channels to MeV energy. This is done by using a script that matching the total energy in the calorimeters to the reconstructed momentum, by minimizing the χ^2 difference between the total energy and the momentum. The first thing the script needs is the raw pedestal subtracted ADC values (BB.ts.ps.a_p[]). Next it forms a pre-shower energy, called pshe, by adding the BB.ts.ps.a_p[] that corresponds to a cluster,(6 blocks in the pre-shower and 9 blocks in the shower), and a shower energy, called she by adding BB.ts.sh.a_p[]. Since the pre-shower ADCs are aligned at twice the ADC value, when adding the shower energy and pre-shower energy, we must divide the pre-shower ADCs by 2. So when the script forms the total energy, it uses pshe/2 + she. The script then proceeds to minimize the difference of the energy and momentum i.e.

(pshe/2+she)-momentum, or more precisely:

$$\chi^2 = \left[\sum_{i=1}^{N}\left(p^i - \left(\sum_{j=0}^{M}{}_{ps}C_j^{ps}\frac{A_j^{i,ps}}{2} + \sum_{j=0}^{M}{}_{sh}C^{sh}A_j^{i,sh}\right)\right)\right]^2$$

Where A_j is the pedestal subtracted ADC and ps if for pre-shower with sh being for the shower. M is the number of blocks in the cluster and N is the total number of events. By taking the derivative of χ^2 with respect to C and setting it to zero, a set of linear equations can be obtained and solved. Solving these equations produces a C factor for each ADC in the pre-shower and shower. So for example if we take the ith block in the pre-shower, then this script produced a pre-shower corrected ADC of

$$C_i\frac{(BB.ts.ps.a\_p[i])}{2}$$

. These coefficients (C_i), from the script then get put into a database file that is read into the analyzer during a ROOT file replay. The analyzer then produces corrected ADCs which are defined as

$$BB.ts.ps.a\_c[i] = C_i(BB.ts.ps.a\_p[i])$$

and it is this energy that goes into the BB.ts.ps.e variable. The thing to notice here is that the coefficient is being applied to the raw pedestal subtracted ADC value, which for the pre-shower is twice as large as the shower. So if BB.ts.ps.e is plotted, it will be twice the actual pre-shower energy. This is why a factor of 0.5 needs to be applied when plotting the pre-shower energy. A simple fix to this would be to simply create a new coefficient for the pre-shower ADCs $K_i = \frac{C_i}{2}$, where C_i is the coefficient produced from the script for the ith block of the pre-shower.