GlueX Document
Written or last updated: June 7, 2007

Understanding the BCAL Energy Deposition per Layer

A Progress Report - Installment III

Alex R. Dzierba

For the beam test the BCAL module was segmented in six layers labeled 1 through 6. The photon beam entered layer 1 and the resulting shower exited layer 6. Three sector contribute to each layer: top, middle and bottom. The beam entered the middle sector. Six PMT's are added for each layer. Each PMT sees a 1.5×1.5 in^2 area.

Re-visiting the Analytical Energy Deposition - Revised Radiation Length: In previous notes I looked at energy deposition in layers and compared that to the epected mean longitudinal profile in an electromagnetic cascade[1]:

$$\frac{dE}{dt} = E_0 b \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)} \tag{1}$$

where t is thickness in radiation lengths, E_0 is the energy of the particle initiating the shower, $b \approx 0.5$, and

$$\frac{a-1}{b} = t_{max} = \ln\left(\frac{E_0}{E_c}\right) + 0.5 \tag{2}$$

with $E_c \approx 800$ MeV/Z_{eff}. From the note by Zisis and others[2] we have $Z_{eff} \approx 73$ for the Pb/SciFi matrix and a radiation length of 1.3 cm. Zisis has recently redone the calculation and now gets 1.43 cm for the radiation length. The energy deposition per layer using equation 1 with the revised radiation length has been re-computed.

Numerical Simulations: Another new development is that Blake Leverington has calculated the fractional energy deposition per layer as a function of beam energy using the full GEANT-based simulation at 90° incidence and 40° incidence.

Comparing Energy Deposition from Analytical Form and Simulations: Figure 1 shows the fractional energy deposition for each layer, as a function of beam energy, using equation 1 (dashed curves) and simulations (points). The solid curves are fits to the points using a second-order polynomial. The left panel is for 90° incidence and the right panel is for 40° incidence.

Comparison with Data: Figure 2 shows the fractional energy deposition for each layer, as a function of beam energy, using equation 1 (dashed curves) and curves derived from the simulations (solid curves). The points are from the beam test data using an inter-layer calibration that is described below. The left panel is for 90° incidence and the right panel is for 40° incidence.

[1] See the *Passage of Charged Particles Through Matter* section of the Particle Data Booklet.
[2] *BCAL Radiation Length Calculations*, GlueX-doc-439.

Inter-Layer Calibration: For the data, the ADC outputs for the six PMT's in a layer were summed and the sum was multiplied by the same calibration constant that was determined by requiring the the geometric mean of the the the sum of the 18 North PMT's and the South PMT's divided by the beam energy yield a distribution whose mean was unity. Using this calibration constant, a HBOOK profile plot of the ratio of calorimeter energy divided by beam energy for each event as a function of beam energy was generated. The data points in Figure 2 are derived from the profiles plots for 90° incidence and 40° incidence with an additional inter-layer re-rescaling and then an overall re-scaling to achieve the best agreement *by-eye* with the 90° incidence simulation curves. The same inter-layer calibration constants were then applied to the 40° incidence data.

For 90° incidence the calibration constants for layers 1 through 6 were 1.0, 0.9, 1.2, 2.0, 2.0 and 2.0 respectively with an overall calibration constant of 0.85. For 40° incidence the overall calibration constant was changed to 0.95.

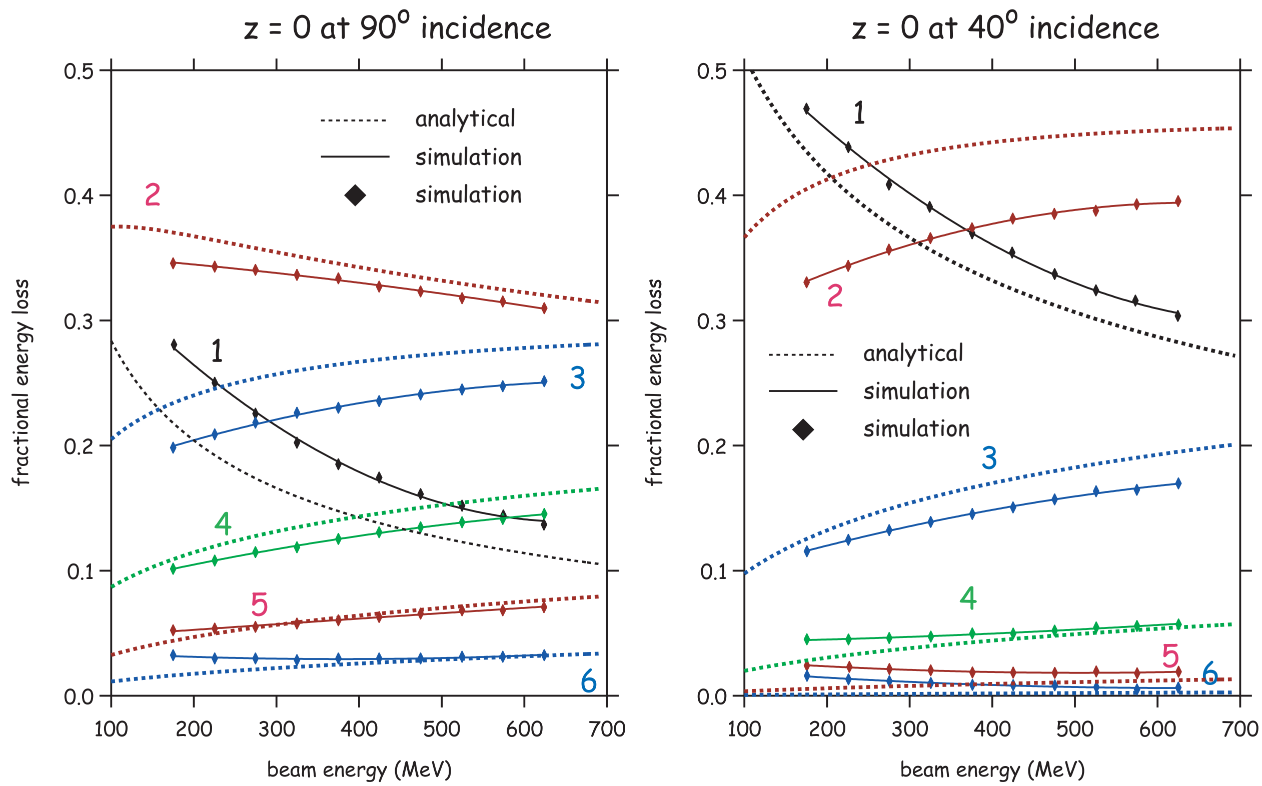

Figure 1: Fractional energy deposition for each layer, as a function of beam energy, using equation 1 (dashed curves) and simulations (points). The solid curves are fits to the points using a second-order polynomial. The left panel is for 90° incidence and the right panel is for 40° incidence.

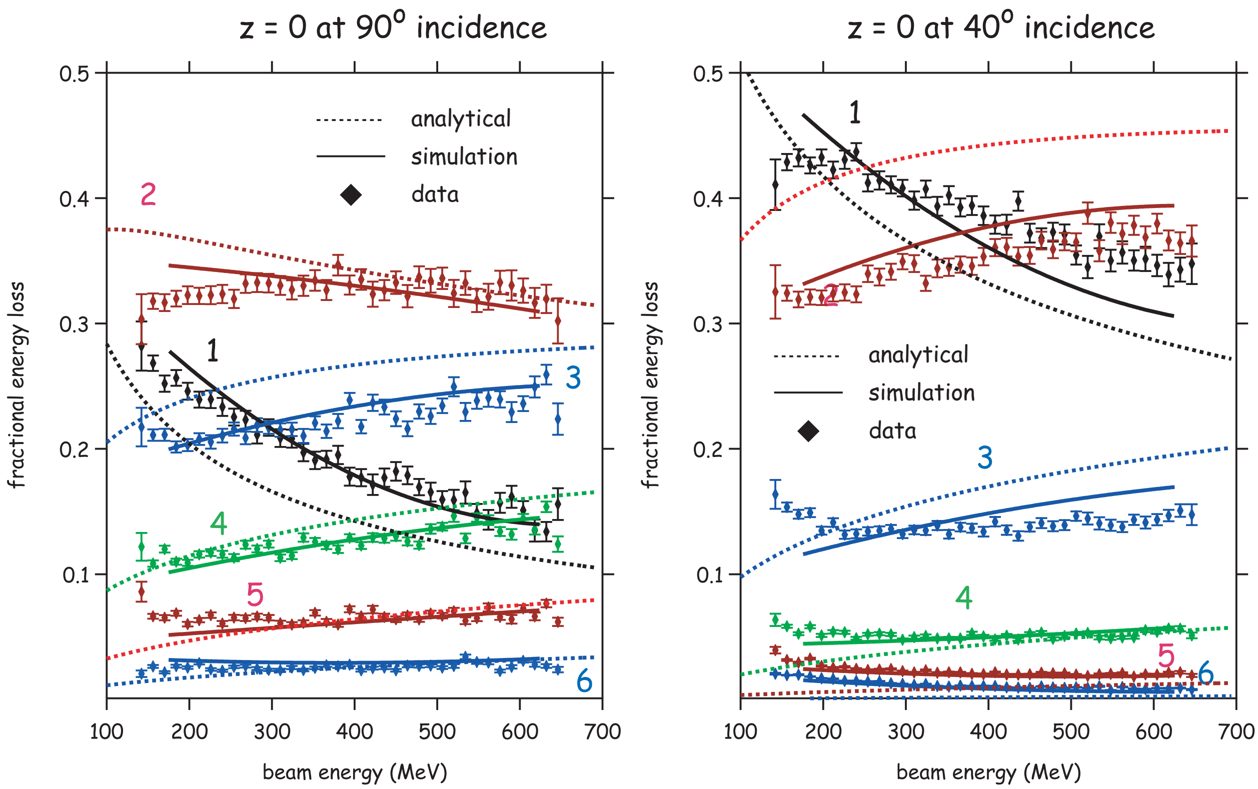

Figure 2: Fractional energy deposition for each layer, as a function of beam energy, using equation 1 (dashed curves) and curves derived from the simulations (solid curves). The points are from the beam test data using an inter-layer calibration that is described in the text. The left panel is for 90° incidence and the right panel is for 40° incidence.