PRIMEX-NOTE 016

Optimization of GEANT Tracking Cutoff Parameters for $PbWO_4$ and $Lead - Glass$

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September 4, 2003

1 Introduction

The PrimEx experiment is scheduled to take production data over a period of appoximately one and a half months continuous beam time. This places great importance on having effective and accurate online monitoring of the data to ensure high data quality as it comes in. Since beam data for the full sized HYCAL will not exist prior to the commissioning run, we must make use of simulated data to develop online monitoring and analysis software. This makes it imperative that the simulated data represent the detector response accurately.

One of the key physical properites of the detectors in HYCAL is the *Moliere Radius* R_M. The value of R_M is related to the transverse development of a shower created by an energetic particle in a material. R_M is defined as the radius of a tube, whose axis is aligned with the direction of an incident particle, for which 90shower is contained in a given material [1]. This property is often used to determine the optimal transverse dimensions of the detectors in a segmented calorimeter.

The transverse shower development has a significant impact on the position reconstructed from a segmented calorimeter. This becomes significant for simulated data since the effective R_M varies strongly with the cutoff values. The cutoff values are used by GEANT to determine when a particle will no longer be tracked and it's energy simply added to the current detector. GEANT has several cutoff values, but only two, the photon and electron/positron cutoffs are important here. Previous Monte Carlo studies have indicated there are different optimal tracking cutoffs for $PbWO_4$ and lead-glass detectors [2].

This short Monte Carlo study was done to determine the optimal cutoff energies for $PbWO_4$ and lead-glass as will be used in the construction of HYCAL. Values of the cutoffs will be determined by what corresponds to the R_M values found in the literature [?]. A version of the primsim simulation code was modified for this study to replace the HYCAL detector with one $PbWO_4$

crystal and one lead-glass detector. Both detectors had the same geometry as shown in figure 1. Two sets of simulated data were produced. One in which energetic photons were thrown into the center of the $PbWO_4$ and the other into the lead-glass. The analysis results of these two sections are given in sections 2 and 3 respectively.

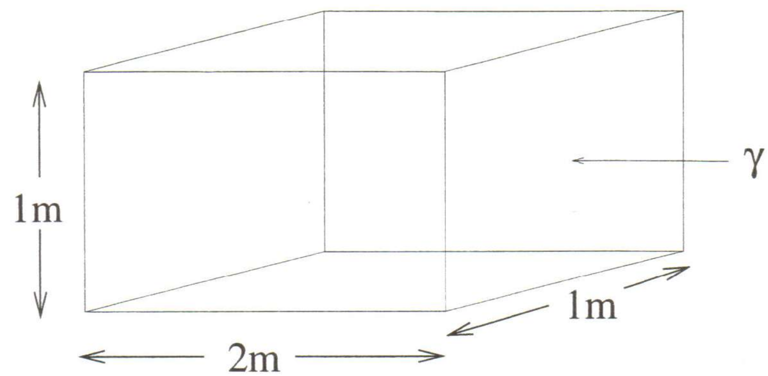

Figure 1: For the purposes of this study, $PbWO_4$ and lead-glass detectors were defined as blocks of dimension $1x1x2m^3$. The incident photon momentum was along the $2m$ dimension.

For both sets of data, the incident photons were sampled evenly between 0.5 and 5.5GeV as shown in figure 2.

2 Lead-Glass Analysis

Figure 3 shows the energy distribution as a function of transverse distance from the beamline for 10,000 simulated showers developed in a large lead-glass block. This shows one example of the distribution for a specific cutoff energy. A set of 10,000 events was produced for 17 different values of the cutoff energy.

The value of R_M was determined by finding the point on the x-axis for which the integral fraction was 90%. Figure 4 shows the calculated R_M values plotted against the tracking cutoff value in MeV. The data were separated into 5 equal bins in incident photon energy between 0.5GeV and 5.5GeV. The plot indicates that R_M has virtually no dependance on the incident photon energy.

Figure 5 shows a linear fit to the R_M values for the lead-glass simulated data. The fit was done over a narrow range so that it covered the nominal value of R_M, 3.6cm.

The fit to the data in figure 5 yields a relation between R_M and the cutoff value which is shown in equation 1.

$$R_M = 2.46 - 0.746 \times cutoff \tag{1}$$

where R_M is returned in cm and cutoff is in MeV.

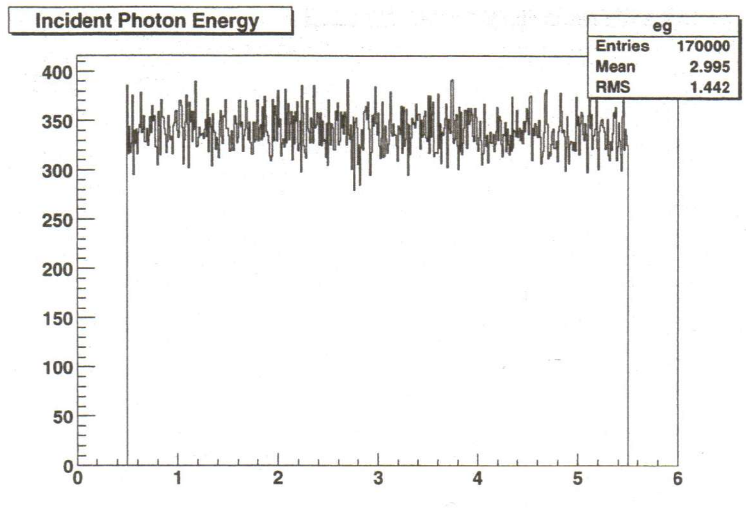

Figure 2: Incident photon energy distribution in GeV. Photon energies were randomly sampled evenly from 0.5 to 5.5 GeV.

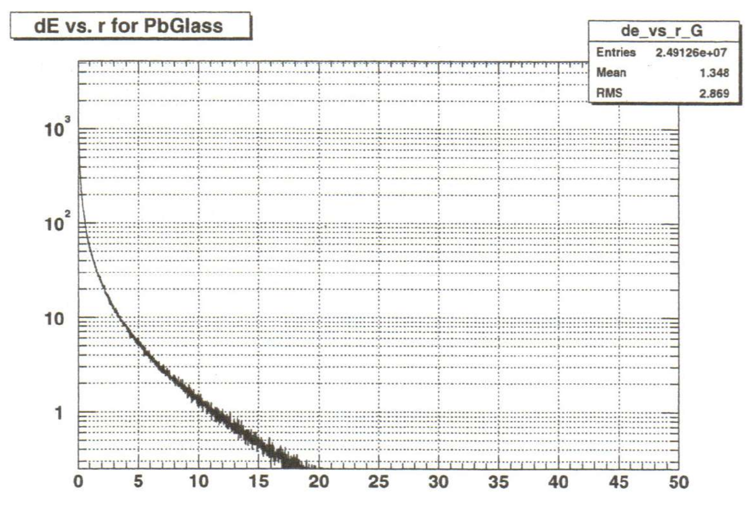

Figure 3: Energy deposition in lead-glass as a function of distance from photon "beamline". Each entry in this histogram was weighted by the energy lost during the current step during tracking (DESTEP).

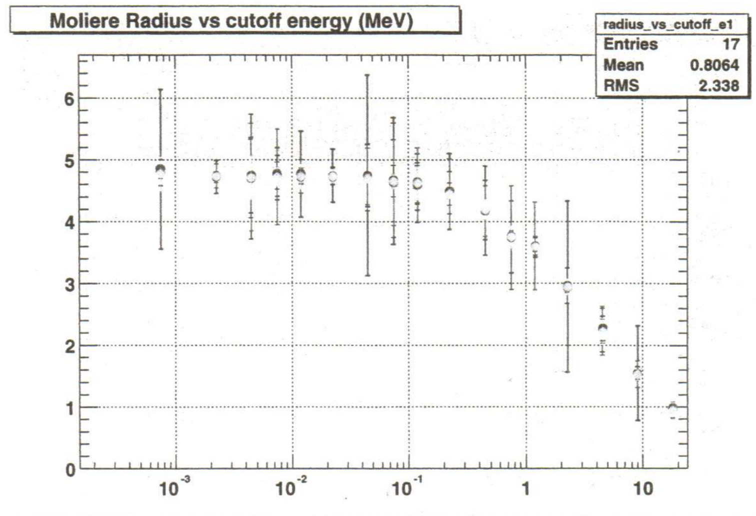

Figure 4: The Moliere radius as a function of electron and photon cutoff parameters in GEANT for lead-glass. This plot shows R_M calculated for 5 separate energy bins. The points all line up on one another quite well indicating negligible energy dependance for R_M.

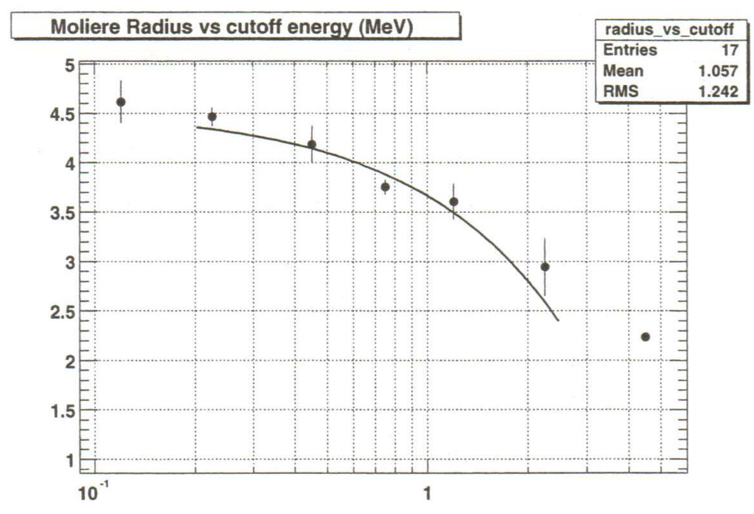

Figure 5: A linear fit to the data in figure 4 for all incident photon energies. The fit was done over a narrow range near the known Moliere radius for lead-glass.

3 $PbWO_4$ Analysis

The analysis of the $PbWO_4$ data was carried out in a similar fashion to the that of the lead-glass. Figure 6 shows the radial depence of the shower in $PbWO_4$ for a particular cutoff energy. Figure 7 shows the calculated R_M values vs. cutoff energy for $PbWO_4$. As for the lead-glass, there is apparently no dependance of R_M on the incident photon energy.

Figure 8 shows a fit to the subset of data near the known value of R_M for $PbWO_4$, 2.0. The fit values give the relation in equation 2.

$$R_M = 4.53 - 0.097 \times cutoff \tag{2}$$

where R_M is returned in cm and cutoff is in MeV.

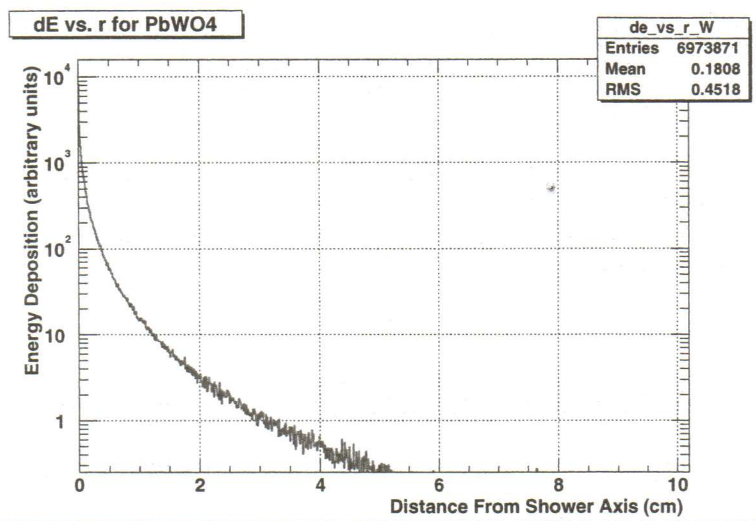

Figure 6: Energy deposition in $PbWO_4$ as a function of distance from photon "beamline". Each entry in this histogram was weighted by the energy lost during the current step during tracking (DESTEP).

4 Conclusion

Two sets of simulated data were produced to deterimine the appropriate setting for the electron and photon energy cutoff parameters in GEANT such that the know values of the Moliere Radius are returned.

For the lead glass,this is approximately 1.1MeV. For the $PbWO_4$, this is approximately 630keV.

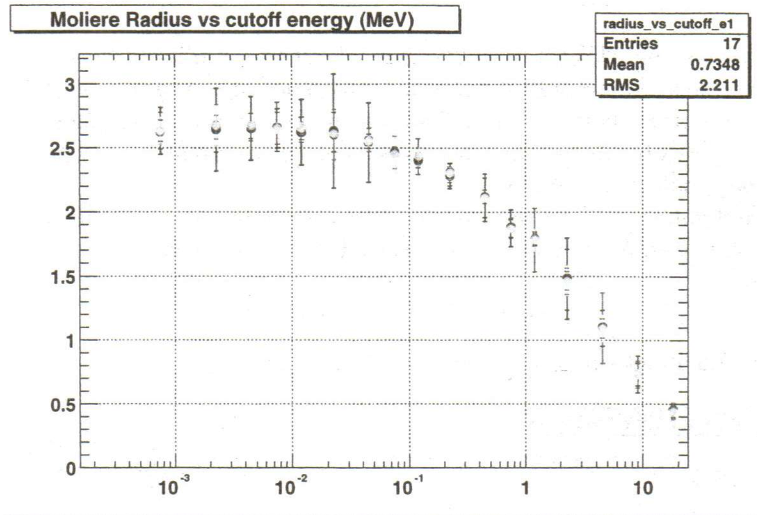

Figure 7: The Moliere radius as a function of electron and photon cutoff parameters in GEANT for $PbWO_4$. This plot shows R_M calculated for 5 separate energy bins. The points all line up on one another quite well indicating negligible energy dependance for R_M.

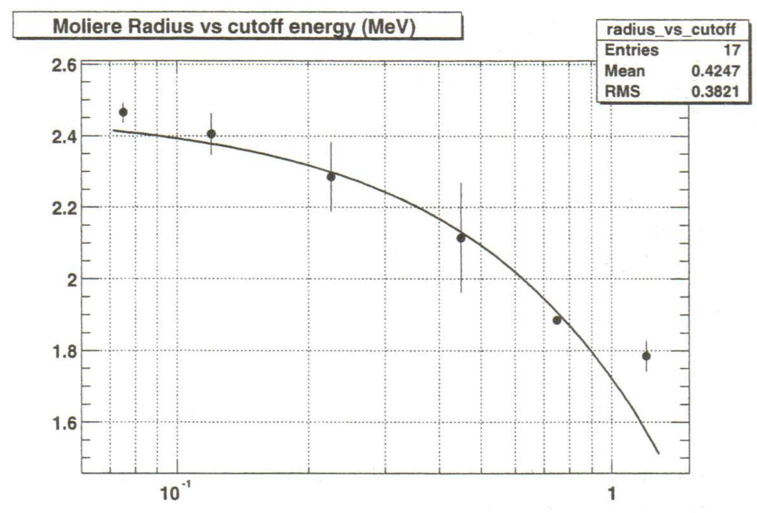

Figure 8: A linear fit to the data in figure 7 for all incident photon energies. The fit was done over a narrow range near the known Moliere radius for $PbWO_4$.

References

[1] Particle Data Group, Phys. Rev. D 66(2002) 203

[2] Tong Uk-Lee, private communication.