Luminosity Detector Study
Energy Measurement and Calorimeter Calibration

Progress Report :

1. Investigation of major mechanism for energy loss in $PbWO_4$ calorimeter.
2. Calibrating each $PbWO_4$ Modules of calorimeter.
    a. Closure Test is perform with another simulation set.

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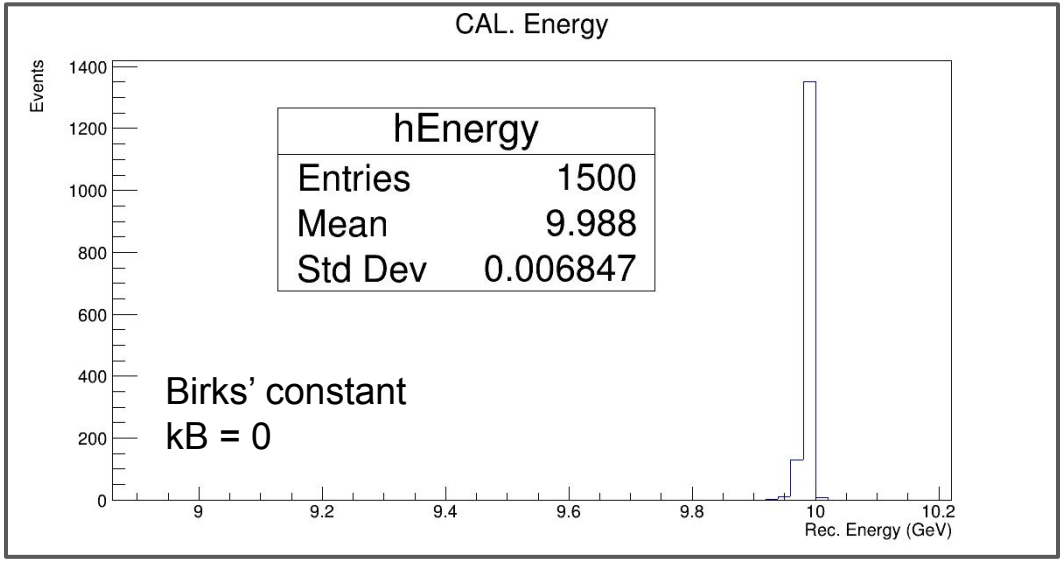
Birk's Law :

$$\frac{dL}{dr} = \frac{S\frac{dE}{dr}}{1 + kB\frac{dE}{dr}},$$

- L is Light Yield (the number of photons generated per unit energy deposited by a particle slowing down in the scintillating medium.)
- dE/dr : The specific energy loss of the particle per path length
- S : Scintillation efficiency.
- k*B : Birk's Constant (k : Quenching Factor & B is the local density of ionized molecules at a point along the particle's path to the specific energy loss).
  - 0.126 mm/MeV Polystyrene
  - 0.033 mm/MeV $PbWO_4$
  - As it increases, the light yield for a given energy deposition decreases.

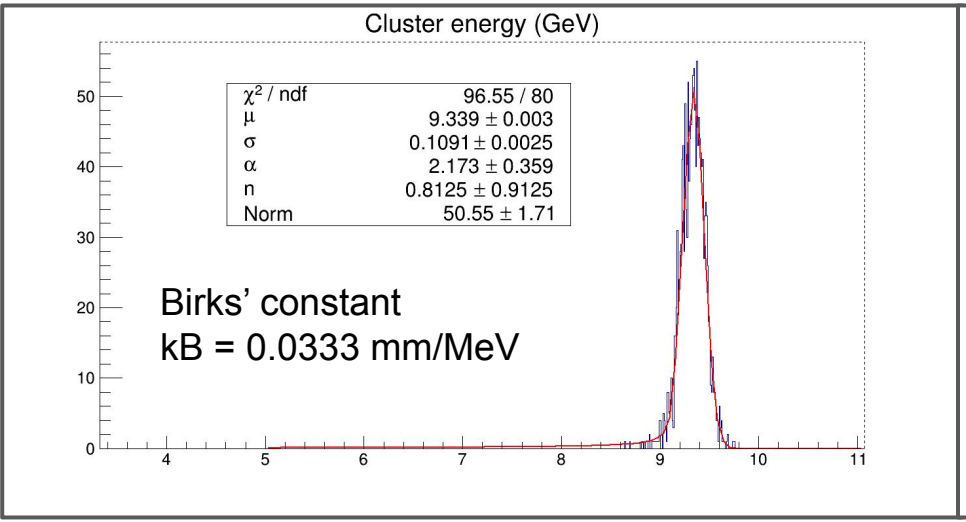
Finite Size of Calorimeter :



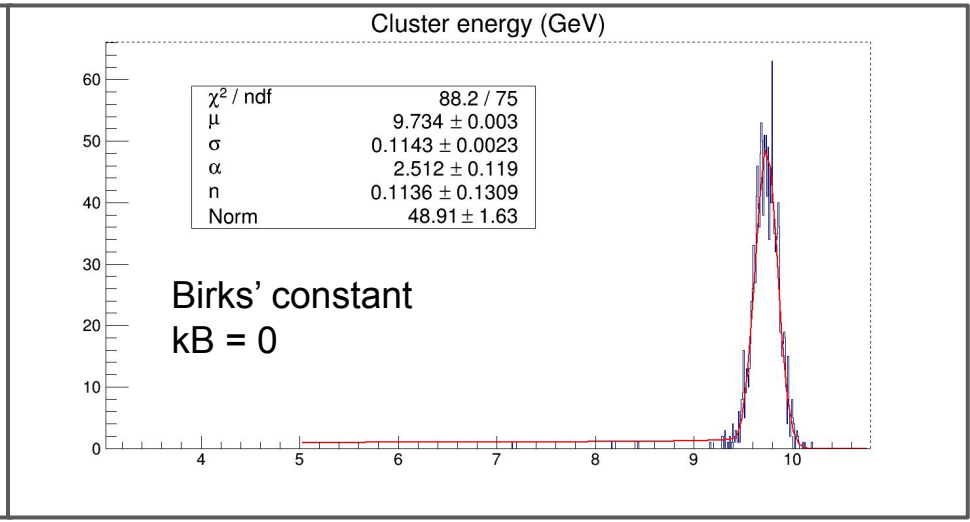
- **Oversized Calorimeter: 2m*2m*2m**
- 10 GeV single e- fired from the center of the CAL

Almost all deposited energy is recovered. Thus, about 3% was lost due to leakage.
The rest of the missing energy (0.1%) could be in nonionizing energy deposits (i.e. thermal vibrations)

Finite Scintillation due to ionization saturation (Birks Law):



Mean rec Energy = 9.339 GeV



Mean rec Energy = 9.734 GeV

- 10 GeV single e-
- Calorimeter Size 0.2m x 0.2m x 0.2m
- PbWO4 Modules = 10x10 (0.02*0.02*0.2) m^3
- No Spacing between Modules

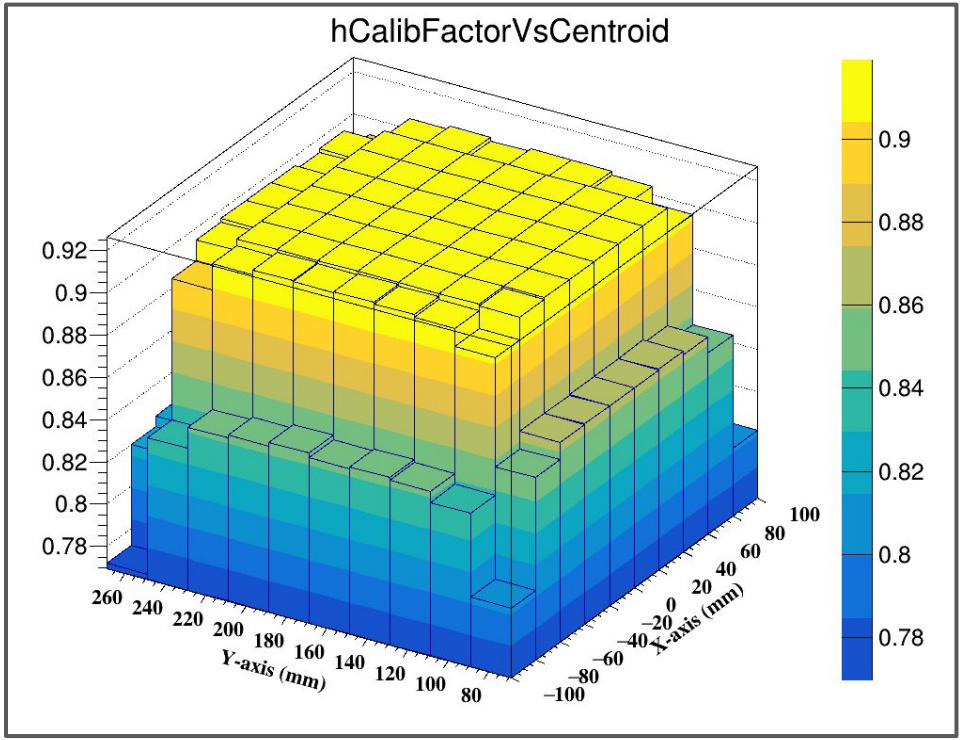
~4% of expected energy not visible due to Birks' Law.

Calibration Matrix of Lumi Spectrometer EM Calorimeter :

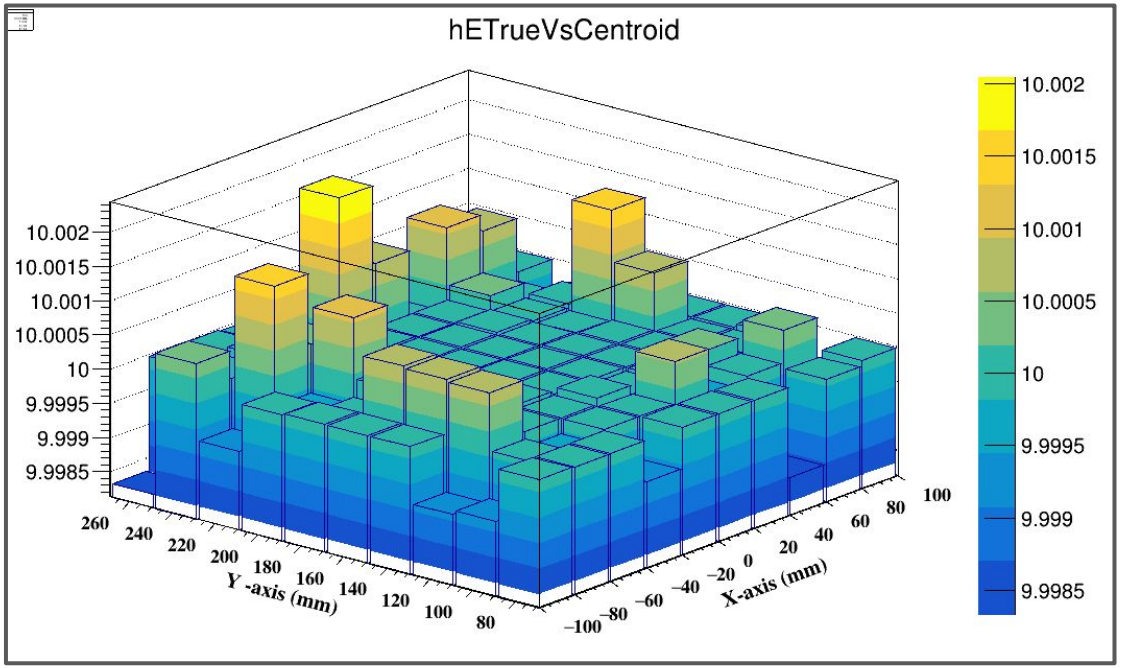
Due to the finite size of the CAL and finite amount of scintillation light, the raw Energy will be lower than the true generated value

Calibration Factor = E_cluster / E_gen

- Calorimeter Size 0.2*0.2*0.2 m^3
- PbWO4 Module = 10x10 (0.02*0.02*0.2) m^3
- No Spacing between Modules
- E_gen = 10 GeV, single e- @ each Module
- Calibration Factor is plotted against cluster centroid.



Closure Test



- Calibration matrix constructed previously is used to correct CAL Energies in an another simulation.
- ETrue = E_cluster / Calibration_factor, is plotted wrt cluster centroid.
- ETrue is within 2 MeV of E_gen (10 GeV).

Next Steps :

- To investigate energy resolution as a function of energy