Simulation of Dual-Readout Calorimetery

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PST Program

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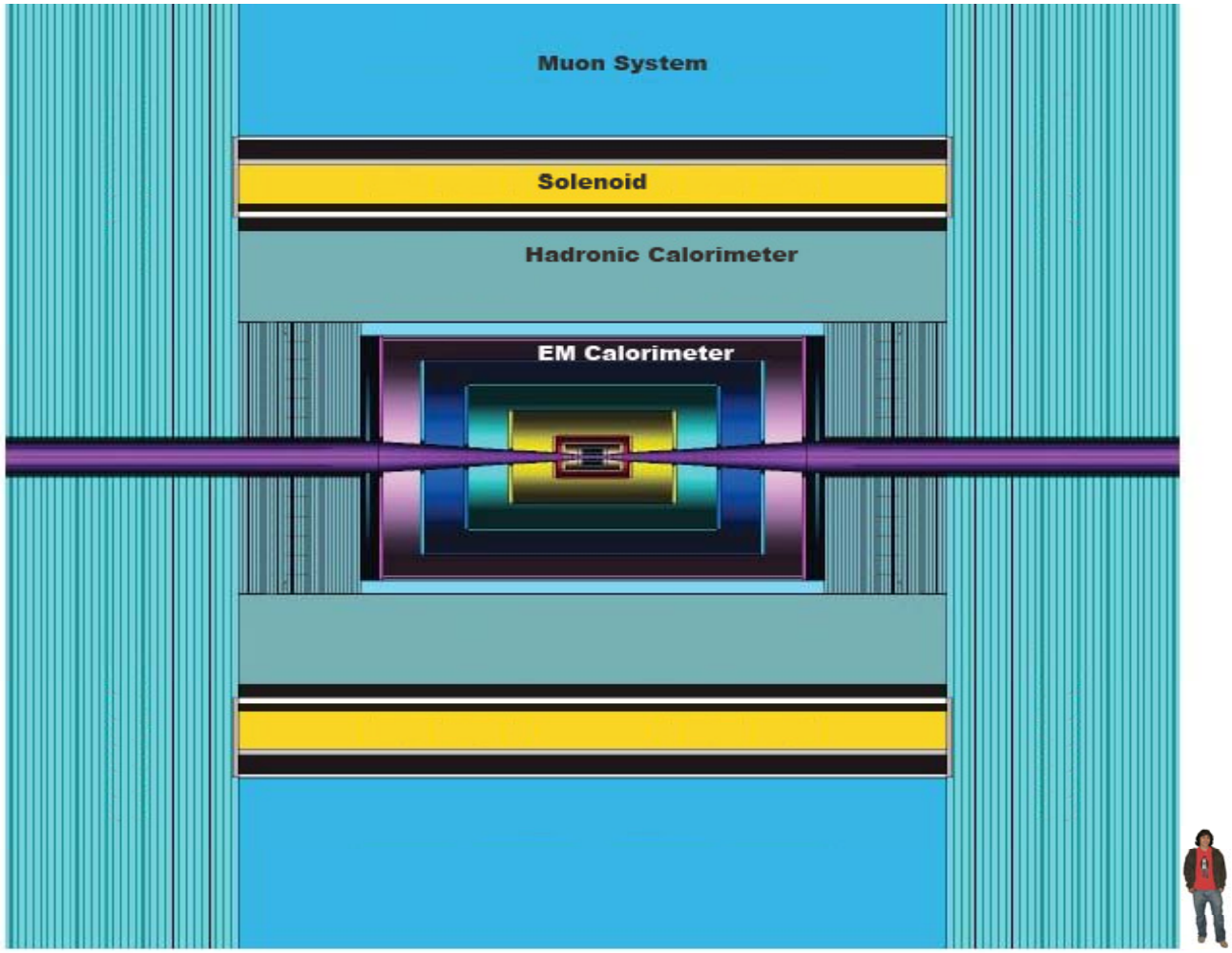
Outline

- Software and Implementation
- Detector Geometry
- Optical and Material Properties
- Energy Corrections for Single Particle Events
- Changes to be Made

Goal

The goal is to simulate a total absorption calorimeter with high energy resolution. The detector is based on the previously defined SiD detector. The calorimeter portion was changed to match our detector design. This type of calorimeter could potentially be used as a detector for the International Linear Collider (ILC) or for upgrades to the Large Hadron Collider (LHC).

SiD Detector



Dual-Readout Calorimetry

Dual-readout calorimetry takes advantage of two distinct physical processes to obtain data: scintillation and Cerenkov radiation.

The two can be distinguished by their arrival times at the photo-detectors.

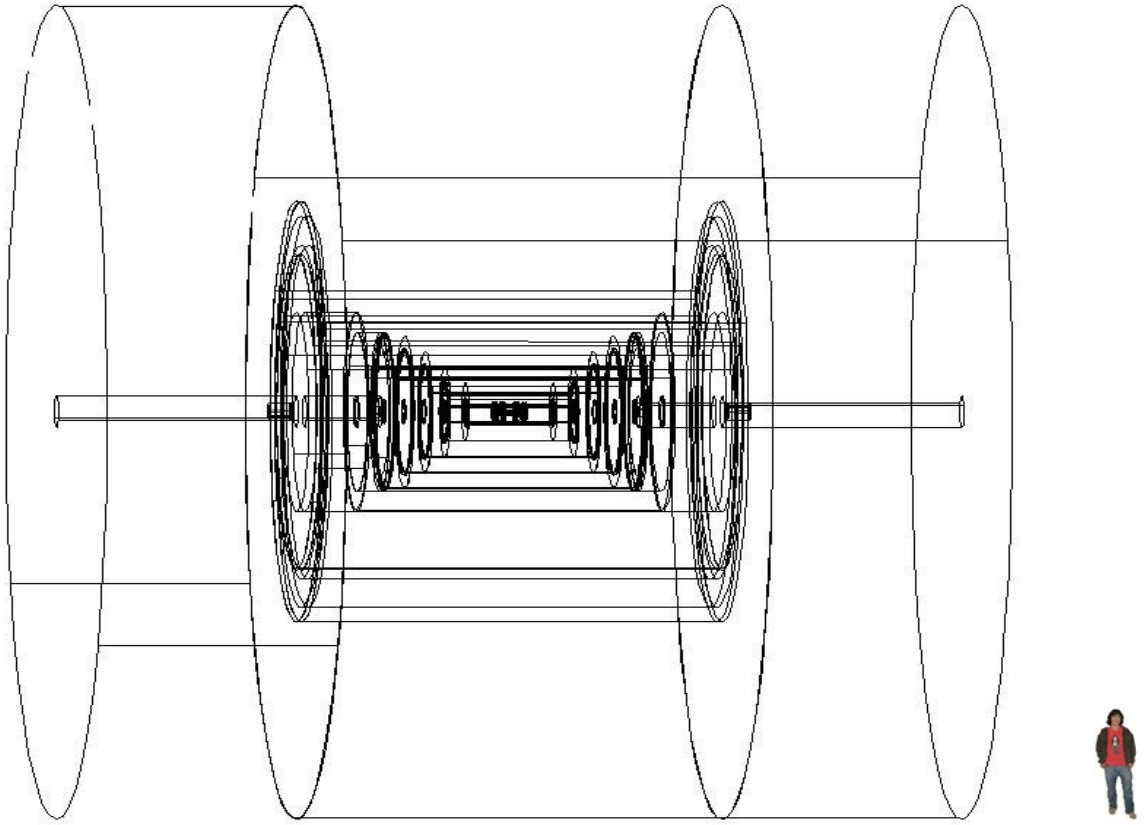
Setup

- The simulations are run using SLIC.
- Using GEANT 4 version 9-01 patch 01
- Using org.lcsim framework in JAS3 for analysis

Geometry

- Geometry is defined using xml (Extensible Markup Language) files, later converted to lcdd (Linear Collider Detector Description) files using GeomConverter
- Starting with a pre-existing xml file, the geometry was changed to match specifications from Adam Para.

Detector Geometry



Geometry

- EM Barrel
  - 6 layers, 5 cm thick
  - 5 x 5 cm segmentation
- EM Endcap
  - 6 disks, 5 cm thick
  - 5 x 5 cm segmentation
- Hadronic Barrel
  - 9 layers, 10 cm thick
  - 10 x 10 cm segmentation
- Hadronic Endcap
  - 7 disks, 9.5 cm thick
  - 10 x 10 cm segmentation

Optical Materials

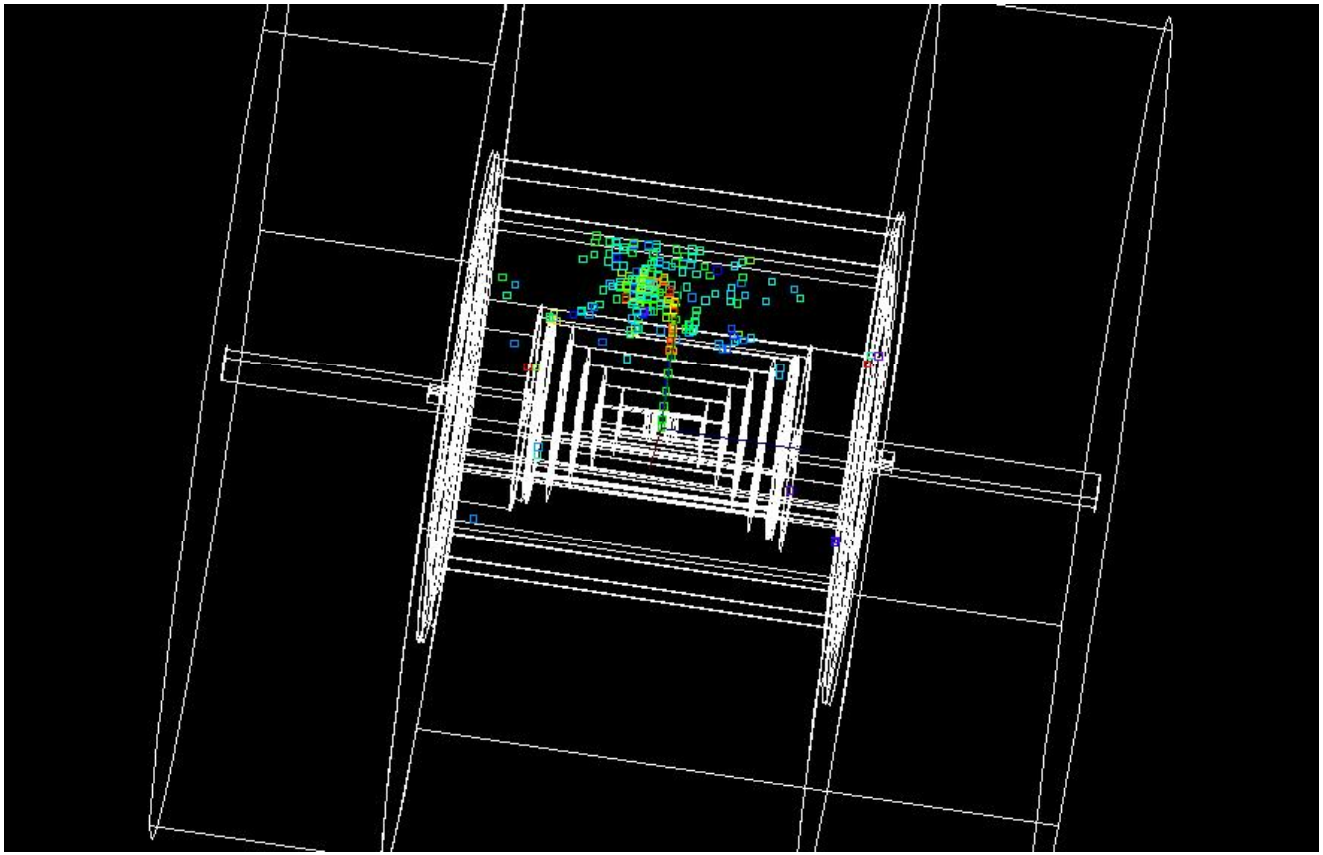
	BGO	PbWO4	Tungsten
Density (g/cm3)	7.1	8.3	17.2
Radiation Length (cm)	1.12	0.9	0.4
Interaction Length (cm)	22.7	20.7	10.3
Total Radiation Lengths	107	134	303
Total Interaction Lengths	5.3	5.8	11.7
Index of Refraction	2.15	2.16	n/a

Optical Properties

- Originally, all optical processes were turned off, and the sensitive material was Tungsten.
- Optical properties were added, BGO crystal properties were defined, Cerenkov process was turned on.

Simulations

- Simulations of 300 single particle events with the following particles:
  - 2 GeV π^-
  - 5 GeV π^-
  - 10 GeV π^-
  - 2 GeV e-
  - 5 GeV e-
  - 10 GeV e-



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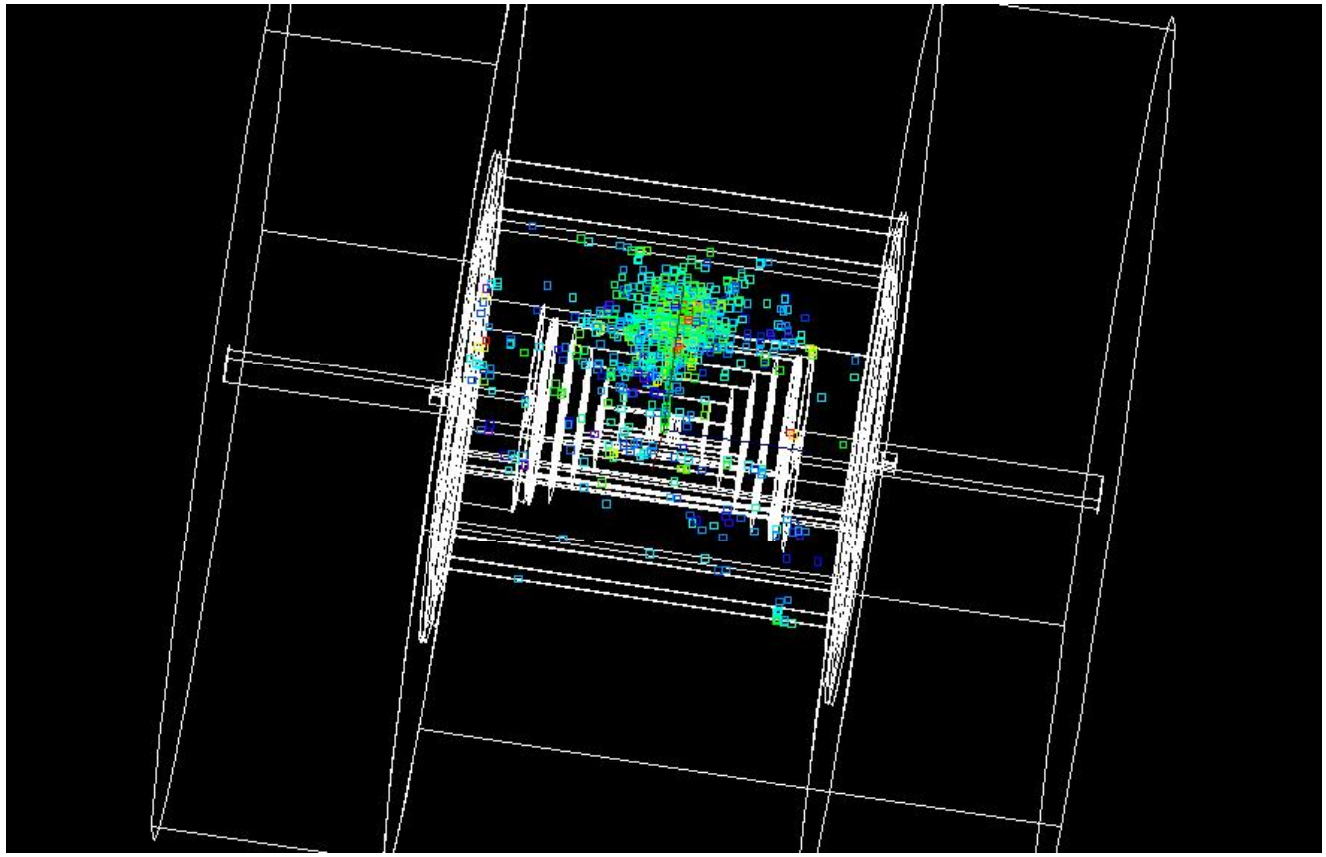

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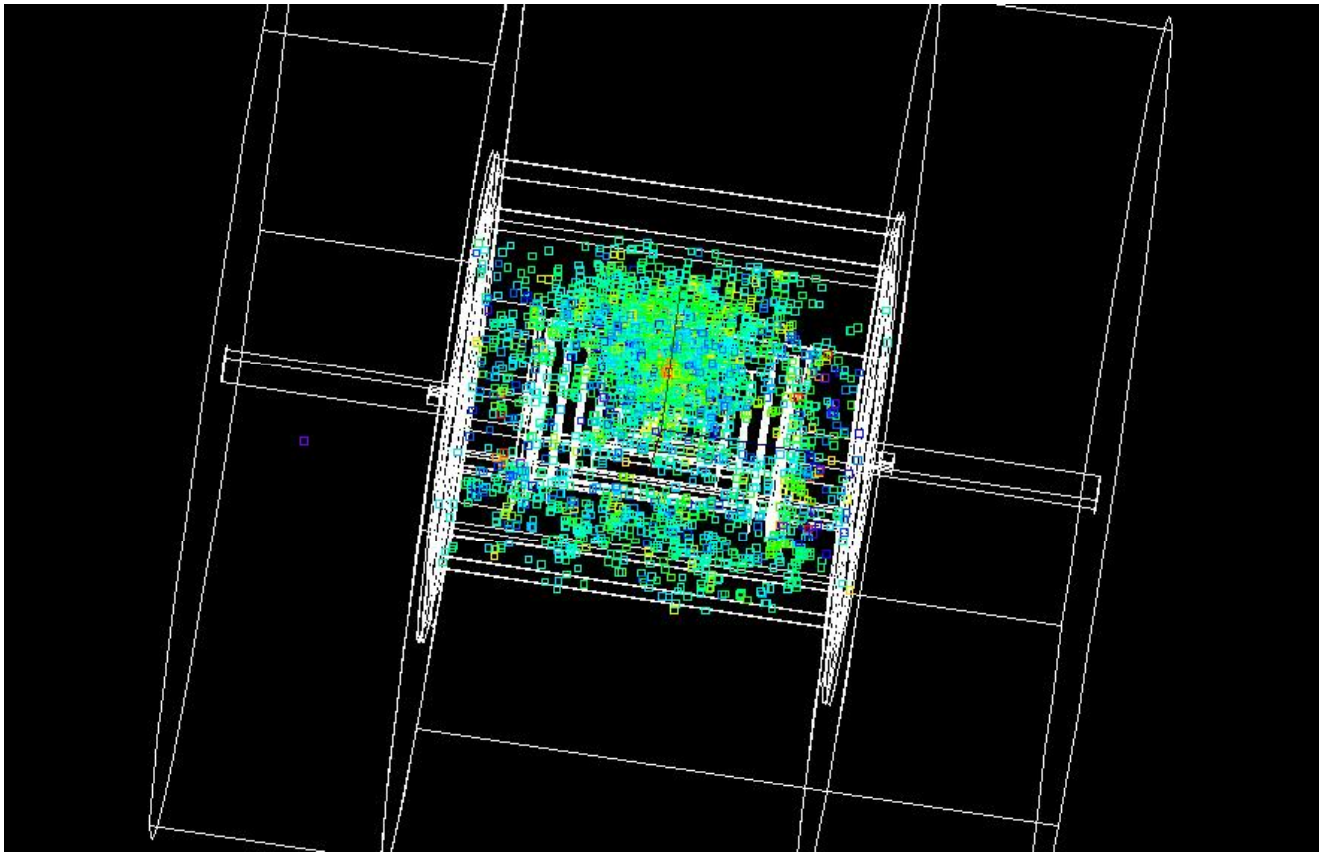

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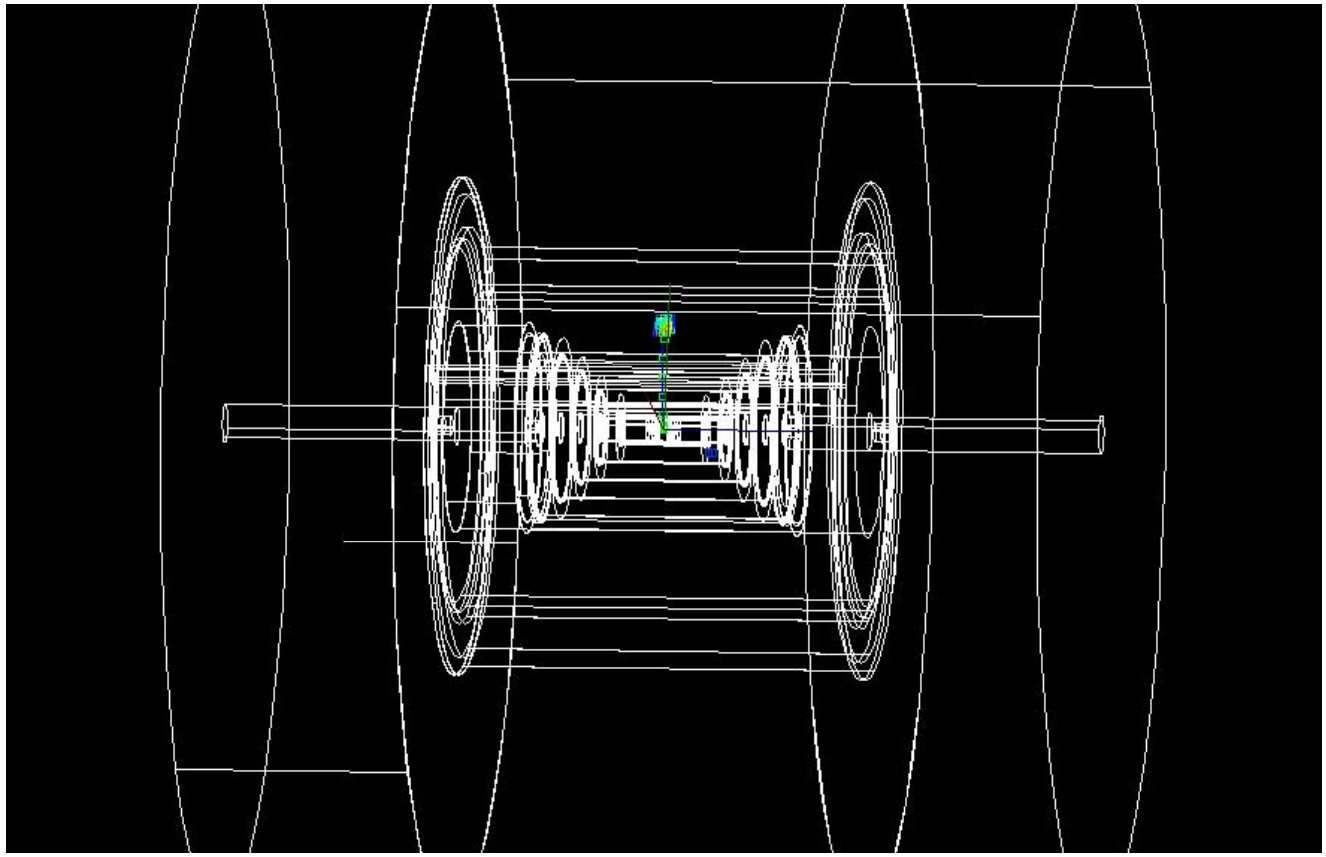

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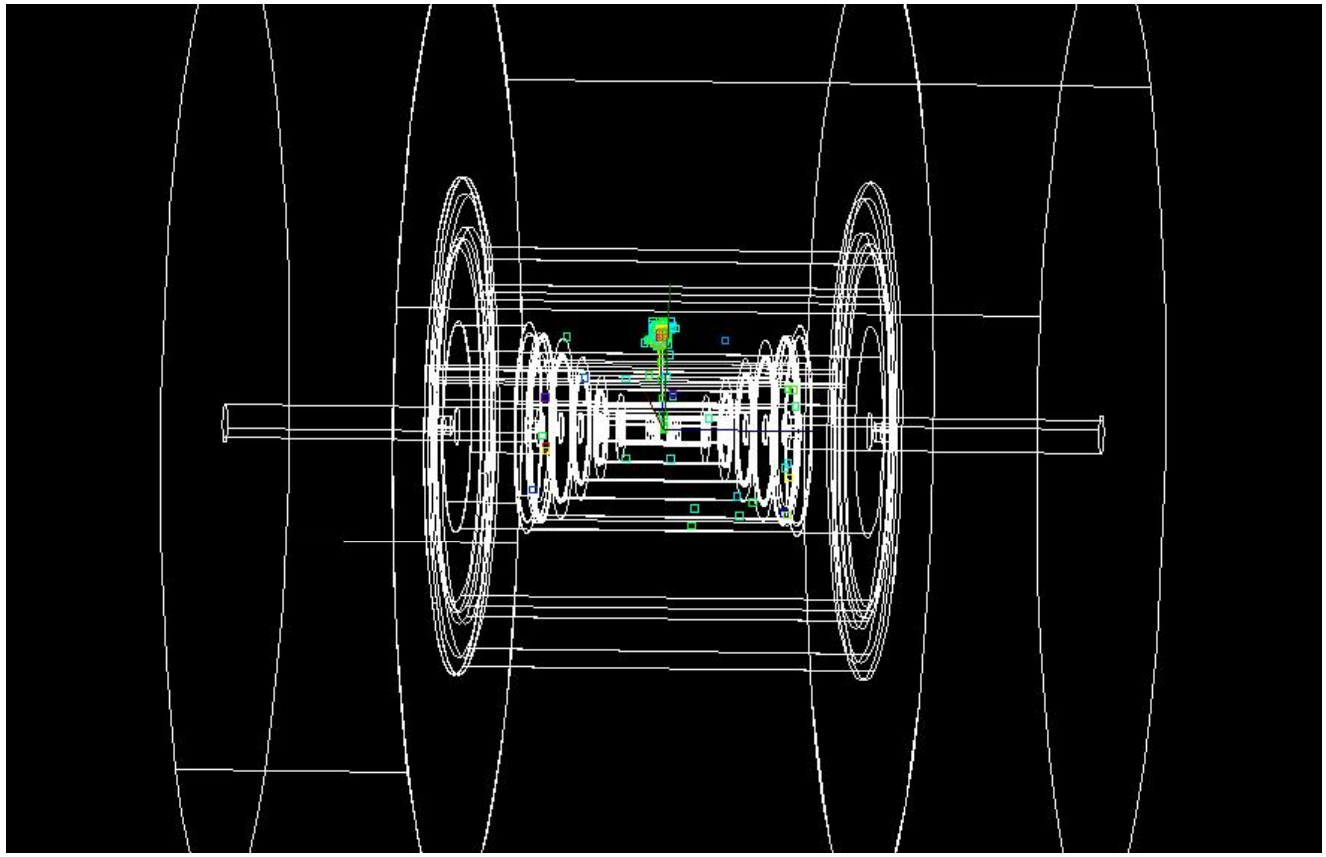

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  - 2 GeV e-
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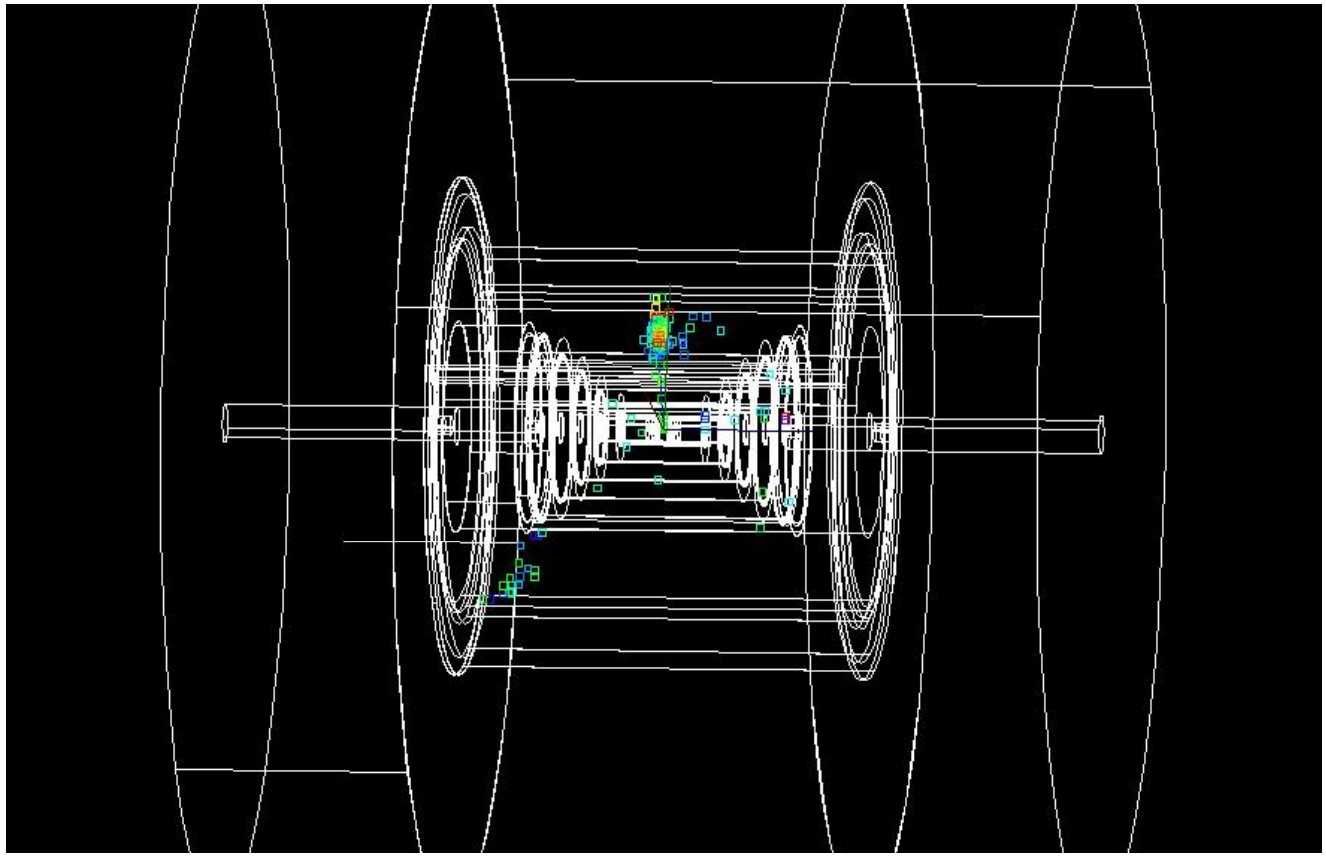
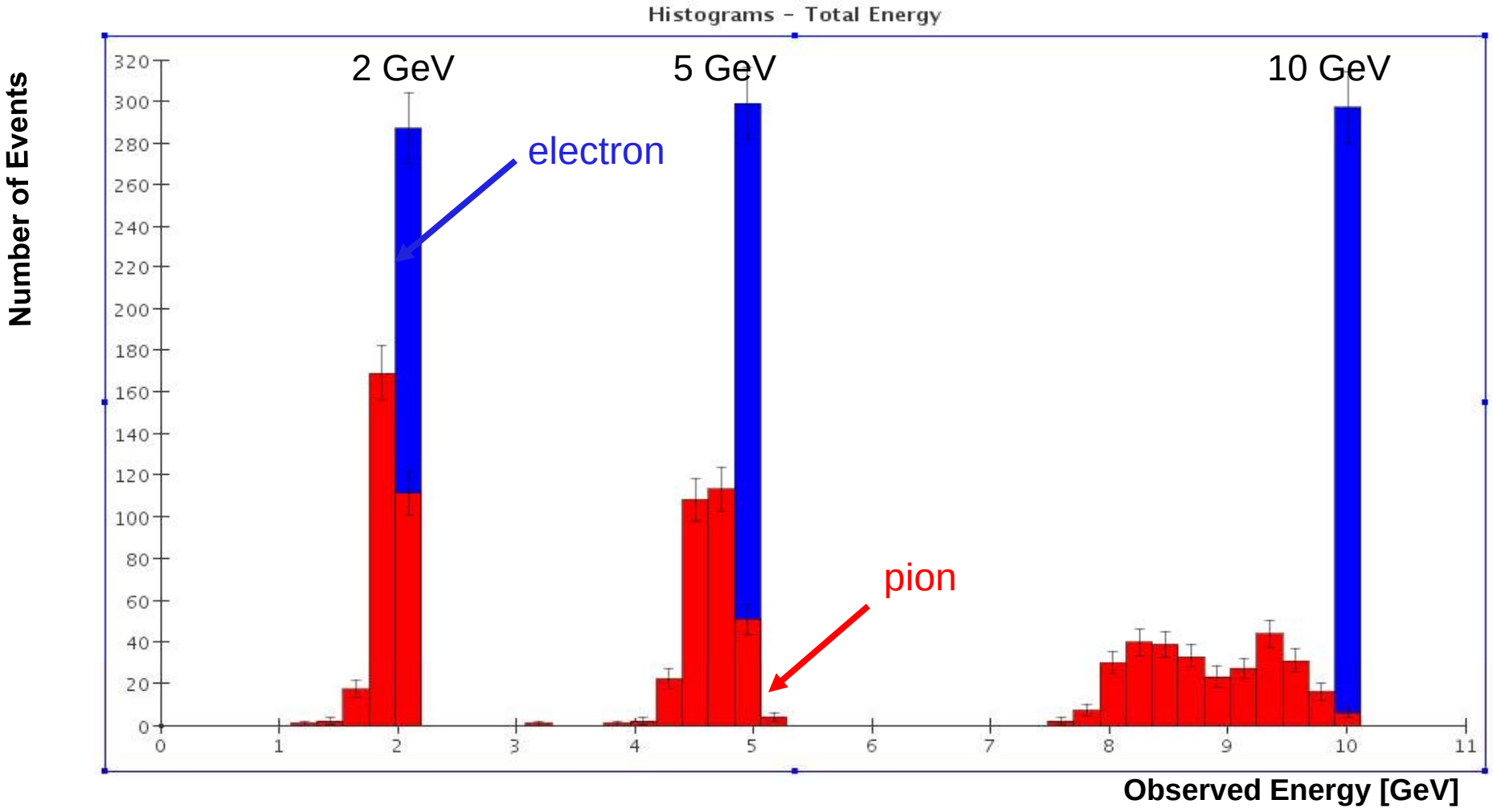
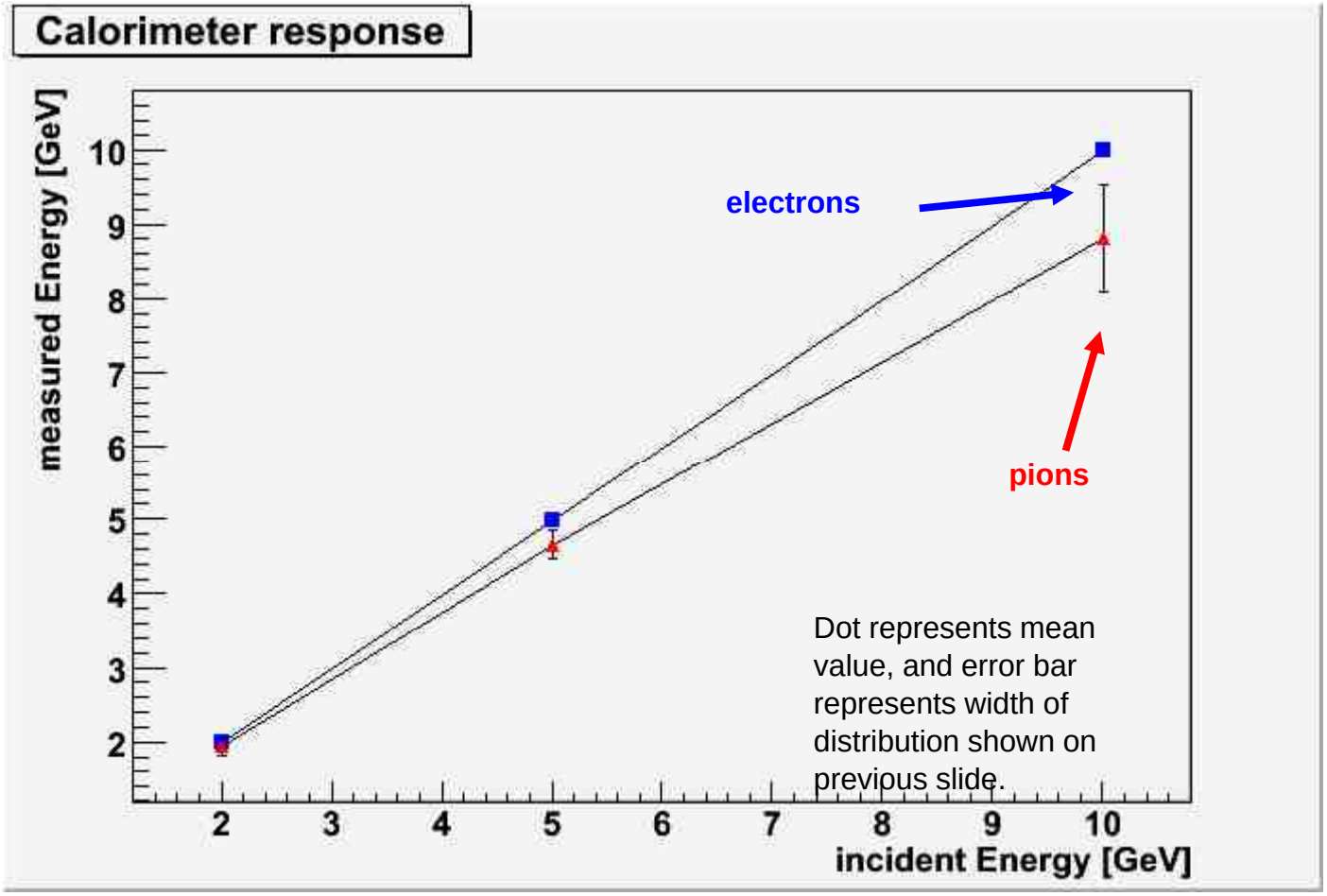


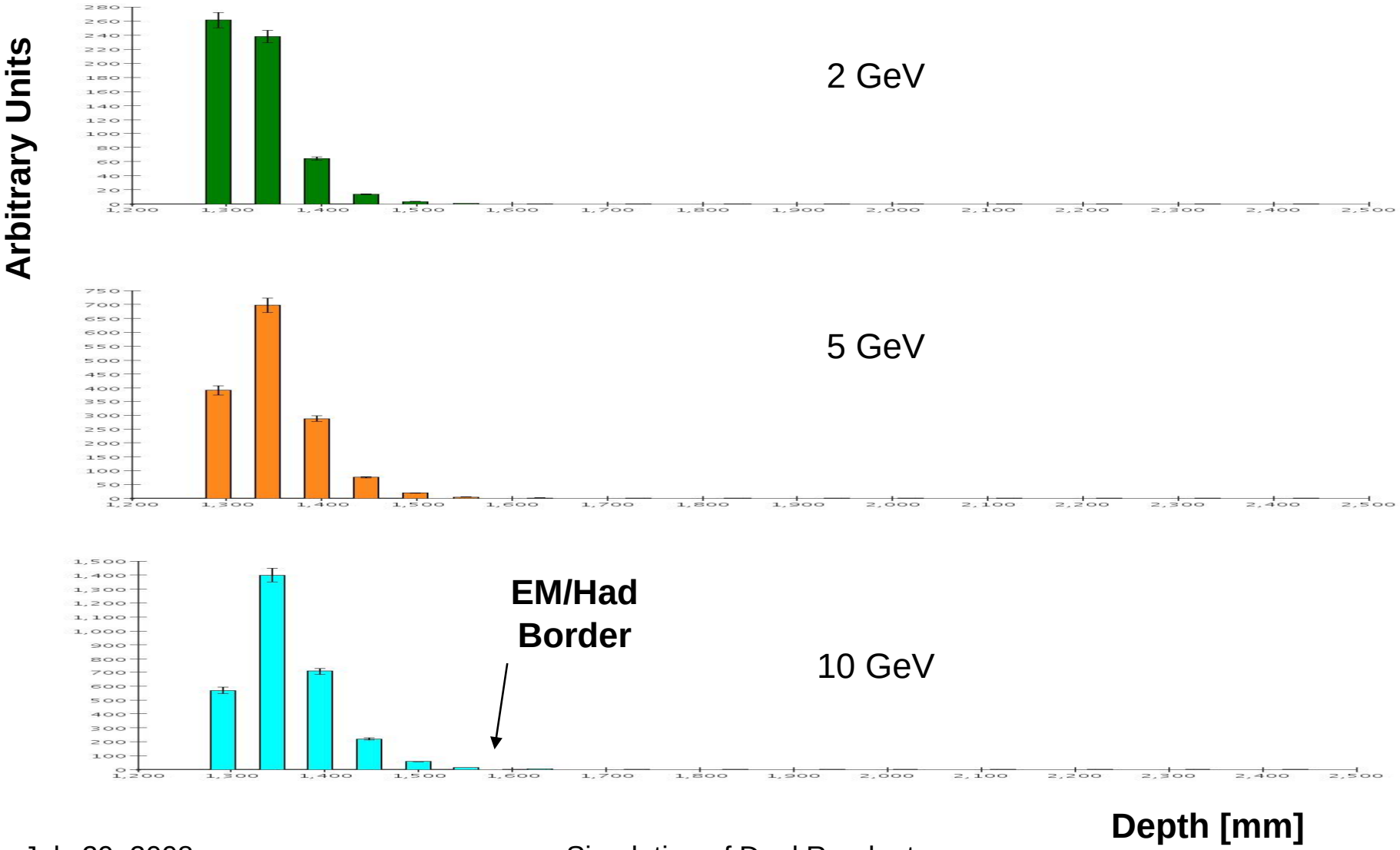
Energy Response to e^- and π^-



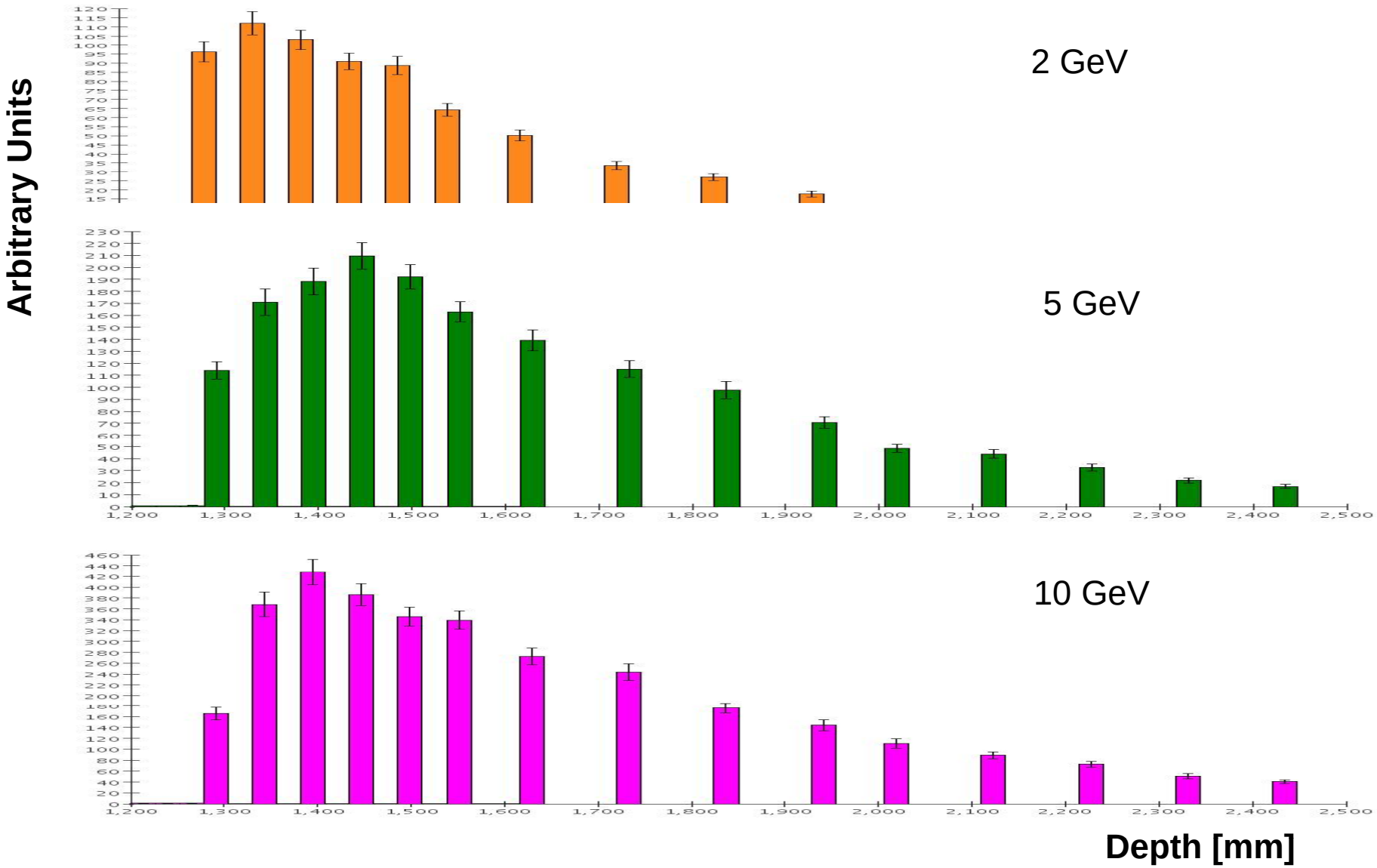
Energy Resolution



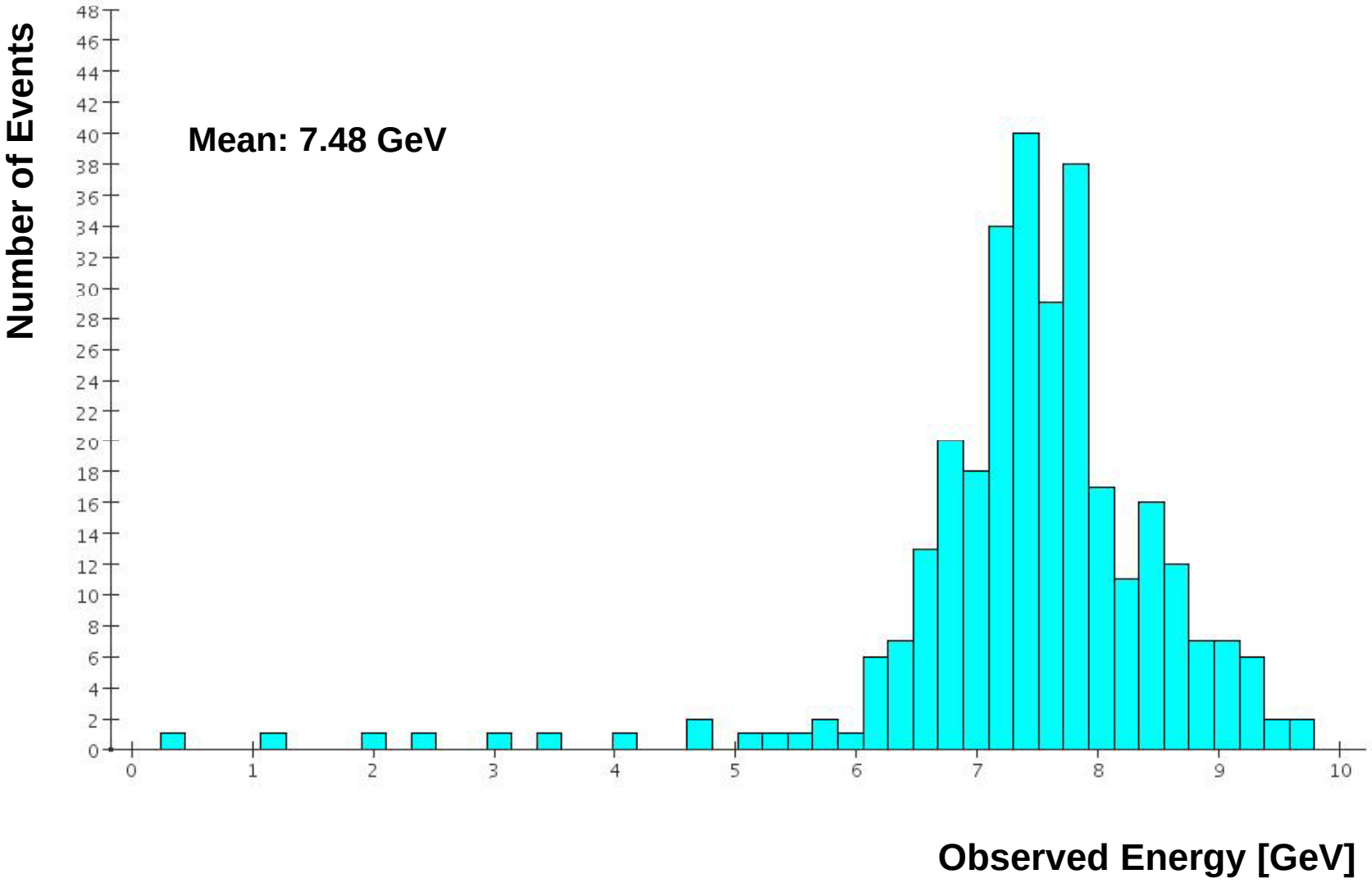
Depth of Energy Deposits (e^-)



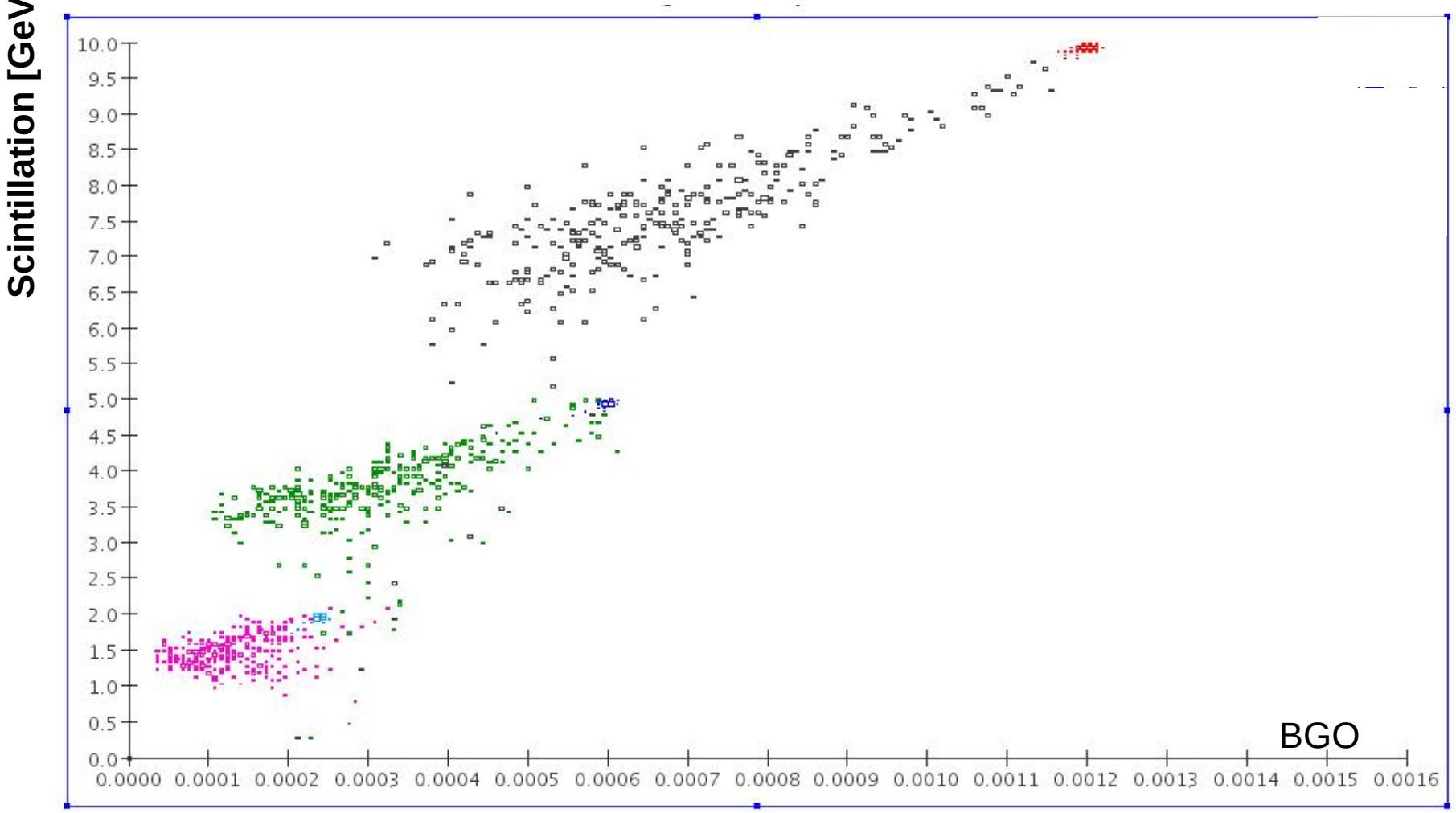
Depth of Energy Deposits (π^-)



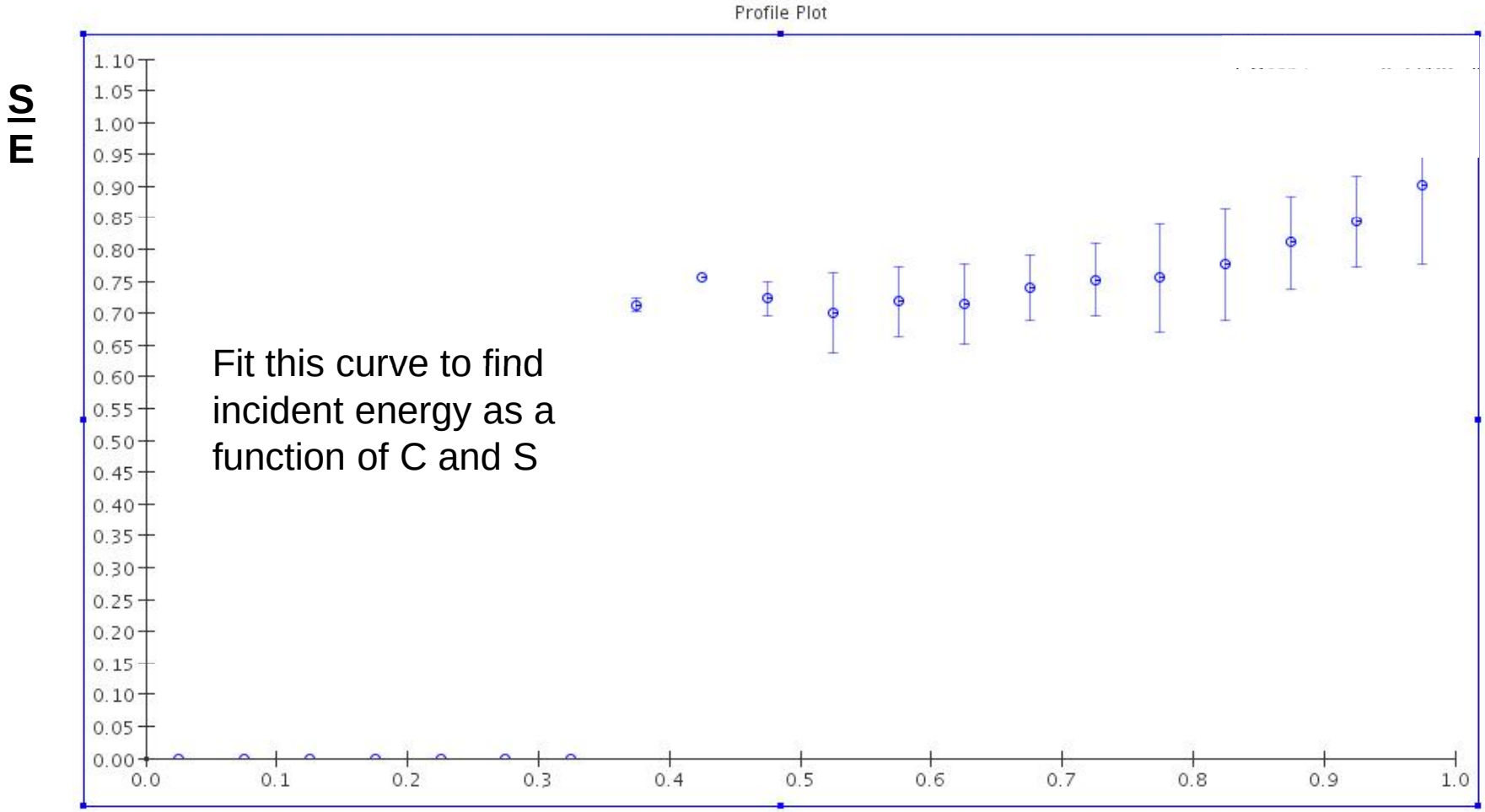
10 GeV π^- Energy



Readout Correlation



Energy Correction



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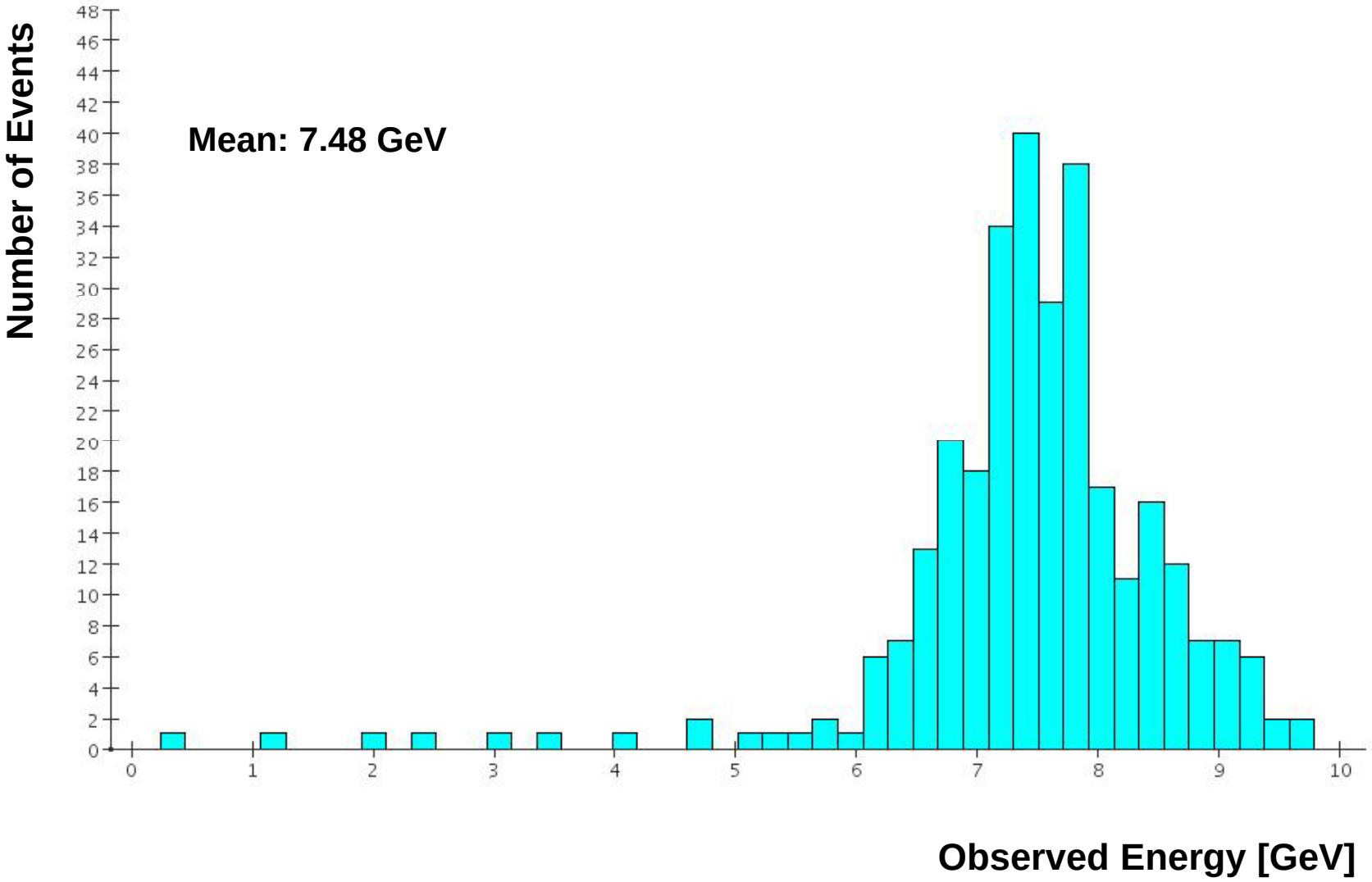
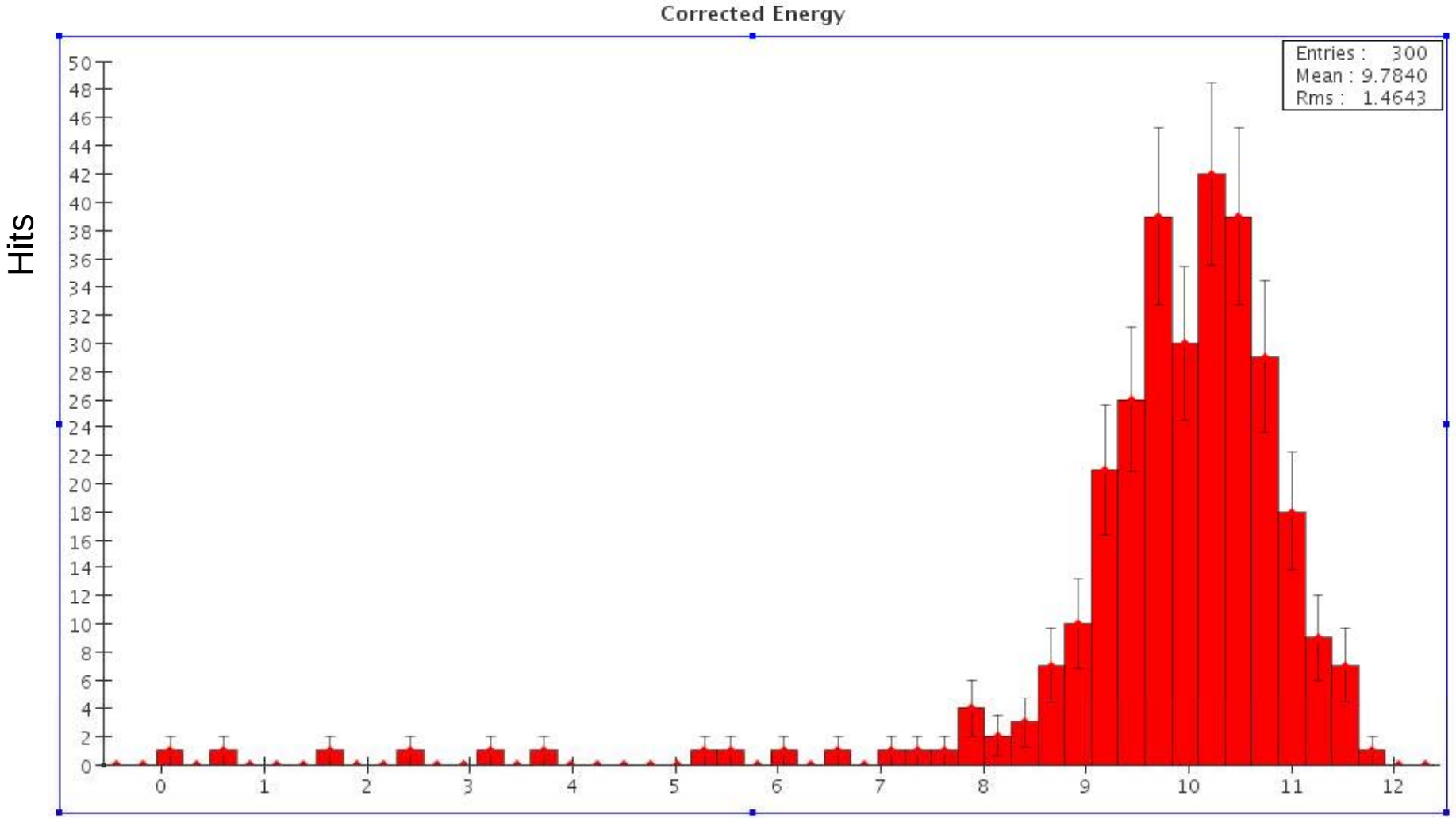


Corrected Energy



Future Changes

- Implement algorithms to reconstruct showers and jets.
- Test the calorimeter using a benchmark physics process such as $Z \rightarrow q \bar{q}$

Thanks to My Advisors

- Norman Graf (SLAC)
- Jeremy McCormick (SLAC)
- Adam Para (Fermilab)
- Hans Wenzel (Fermilab)