Simulation Progress on Crystal Based, Fast Timing ECAL Design

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2018.11.30

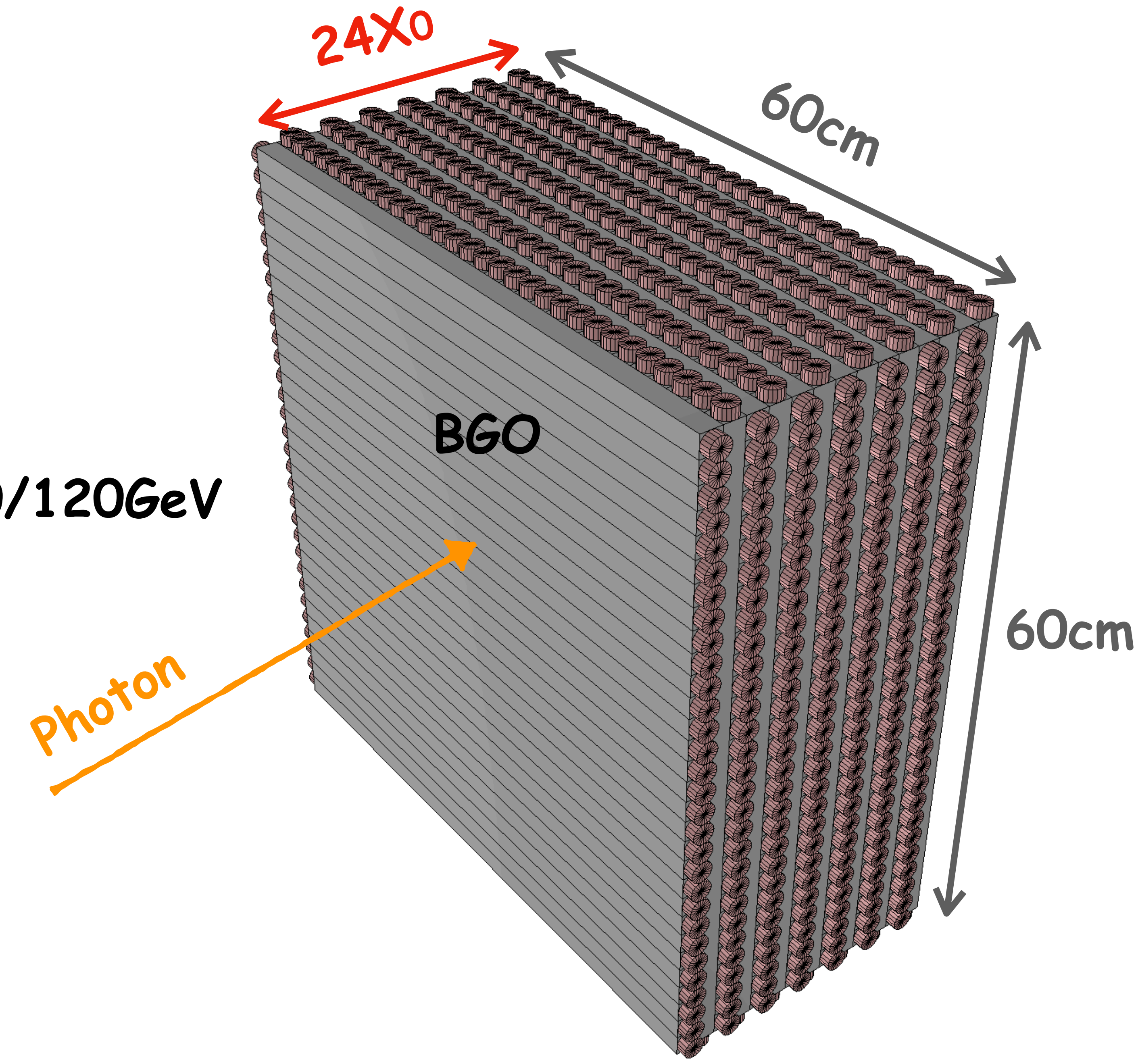
Scan Setup

BGO:

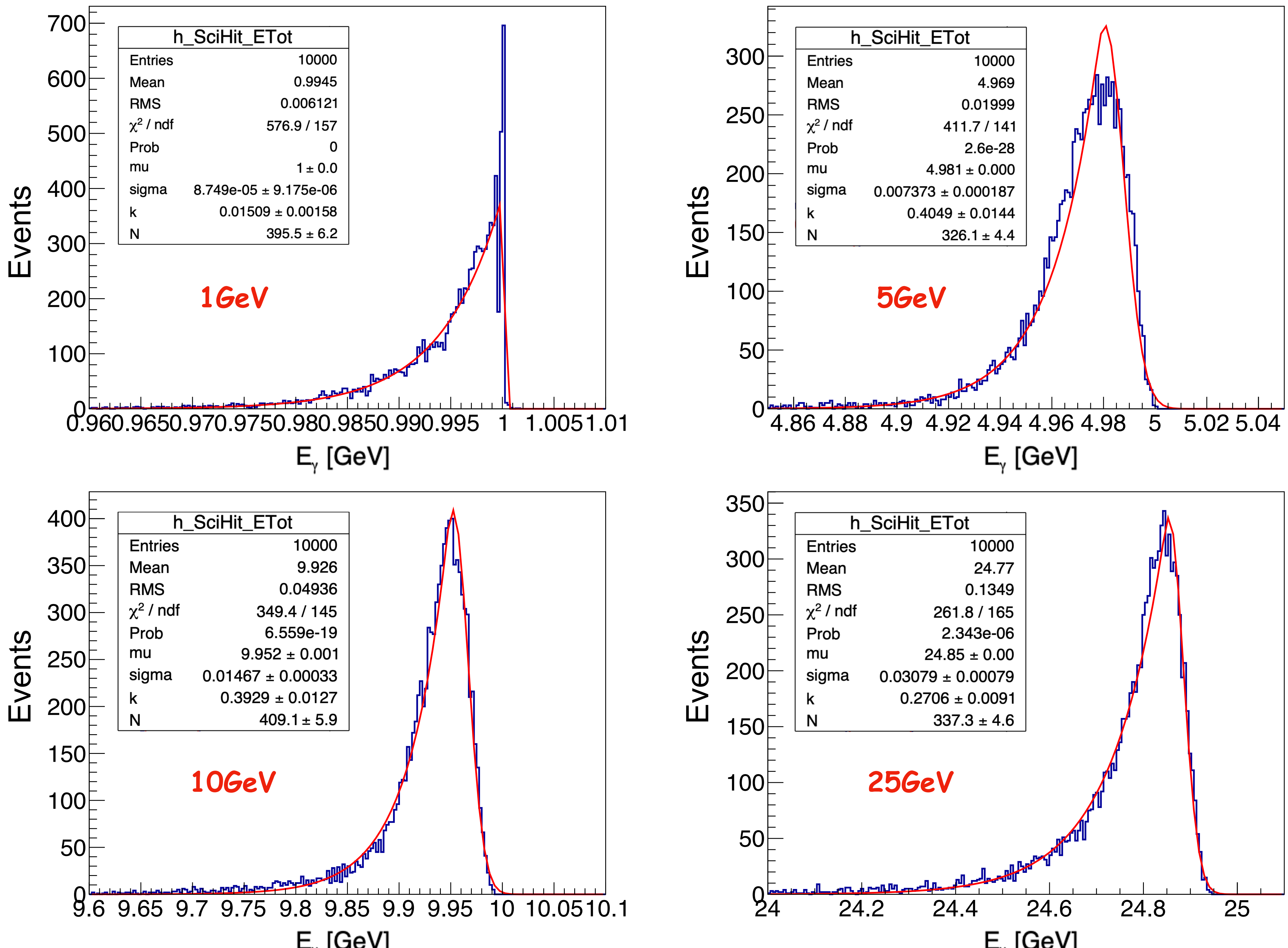
- 1strip: $2x2x60cm^3$
- 14 layers: $24X_0$

Photon:

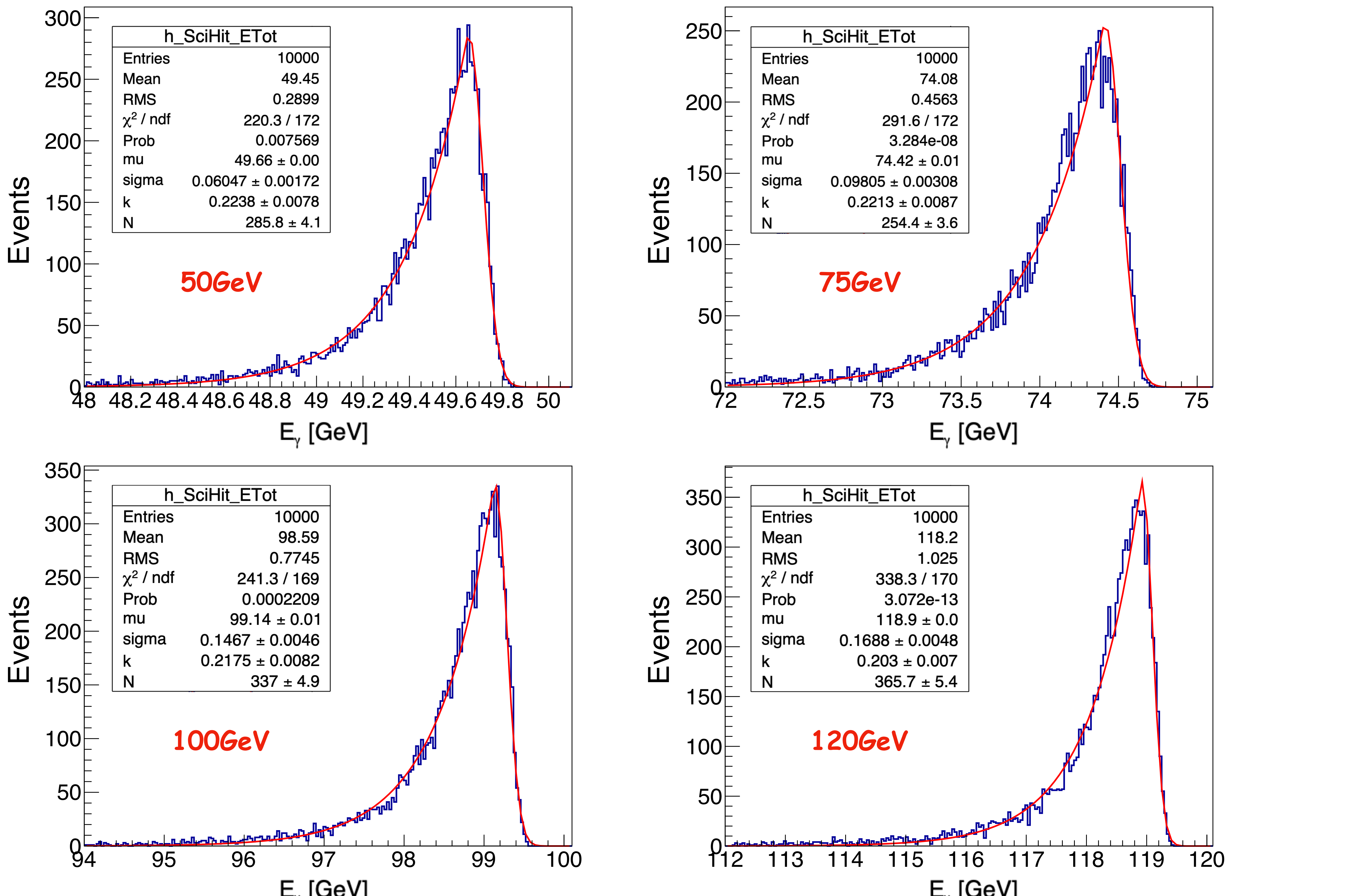
- Position: x=0, y=0
- Direction: (0,0,1)
- Energy: 1/5/10/25/50/75/100/120GeV



Photon Energy Spectrum

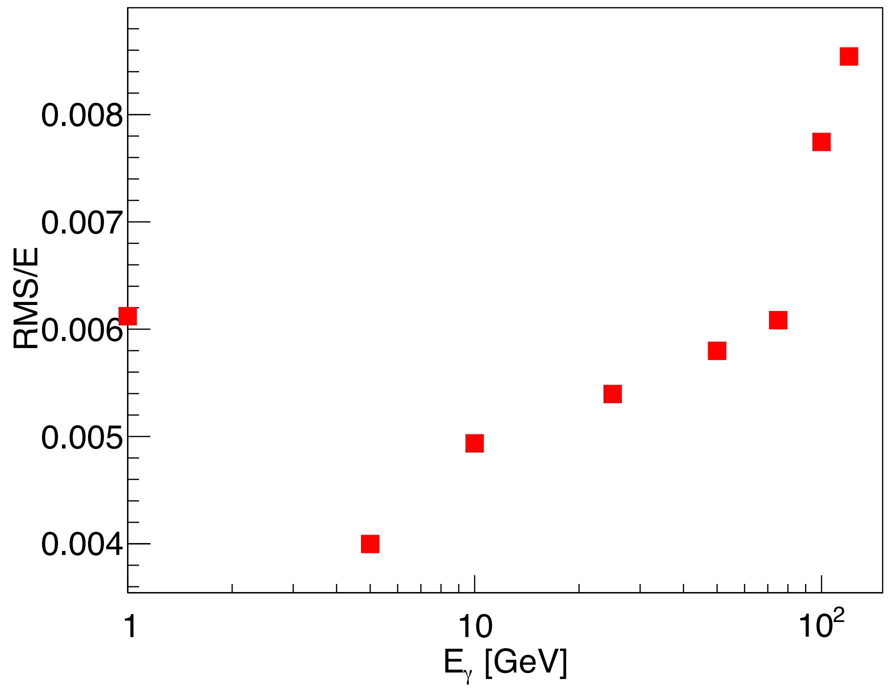


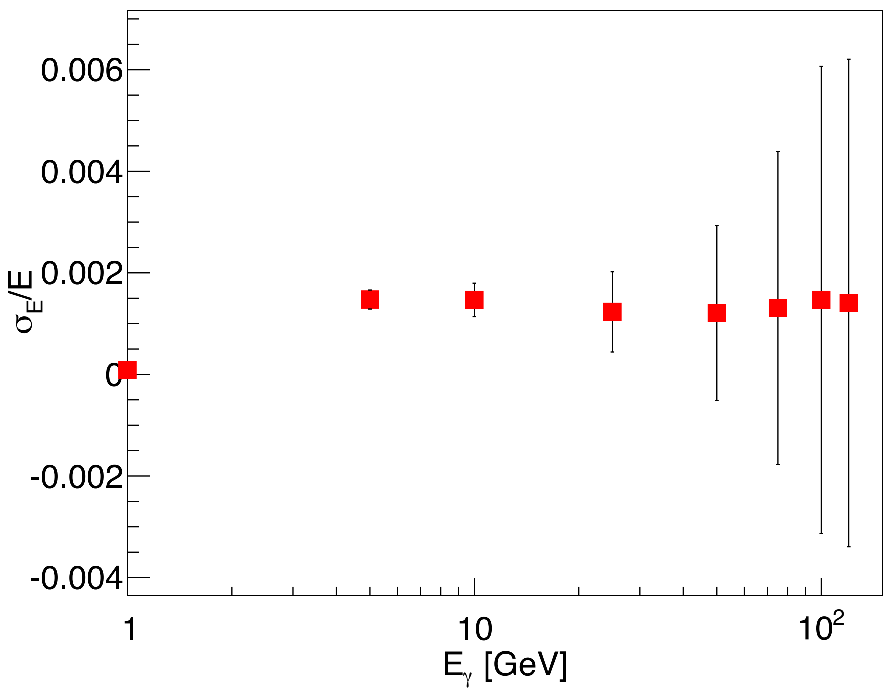
Photon Energy Spectrum

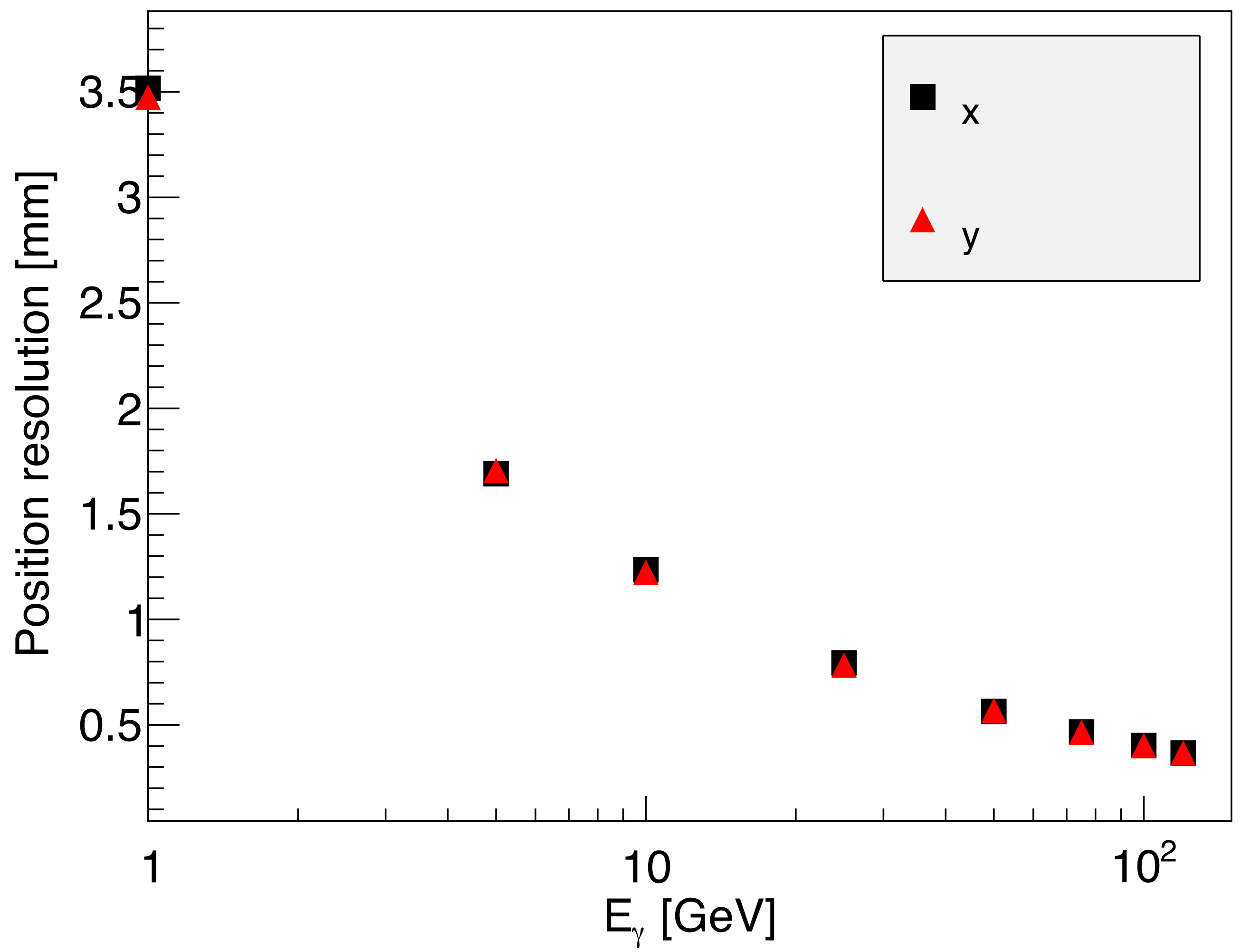


Photon Energy Resolution and Position Resolution

as a function of photon energy







Test on Low Energy Tail

1GeV Photon

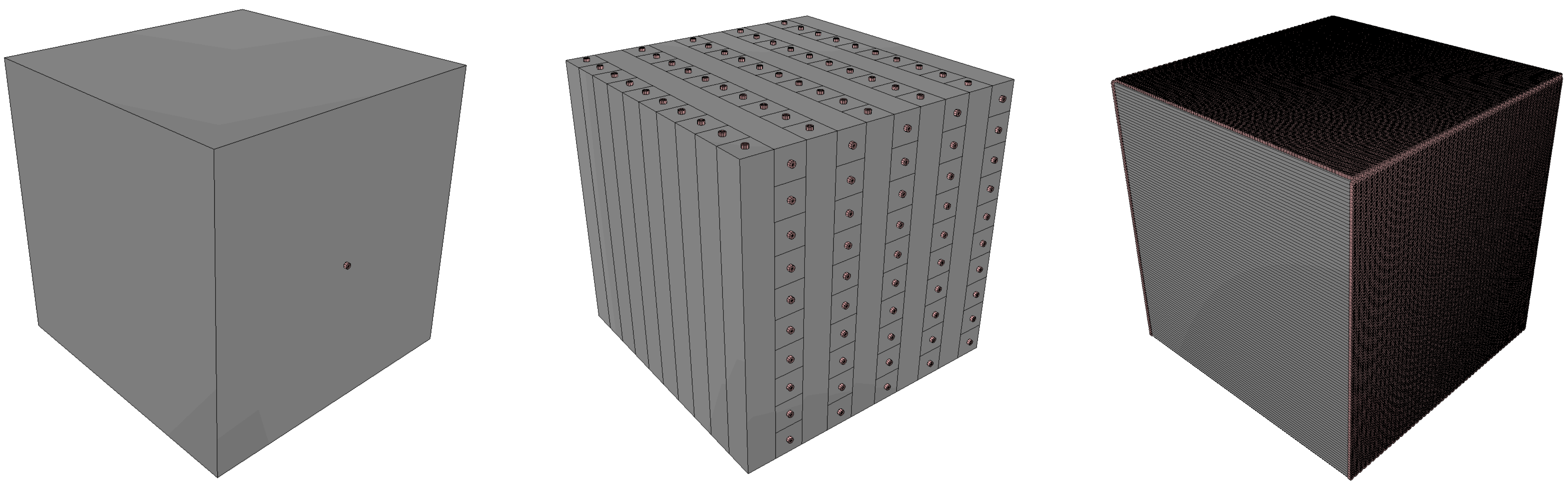
3 different geometries

- $1 \times 1 \times 1 m^3$, 1 layer
- $10 \times 10 \times 100$cm, 10 layers
- $1 \times 1 \times 100$cm, 100 layers

&

3 different incident position

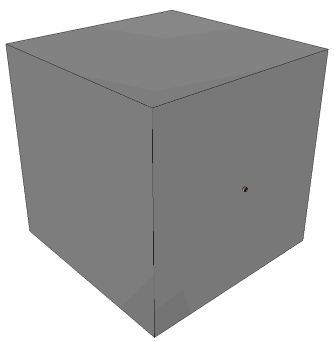
- Outside 50cm
- Surface
- Center

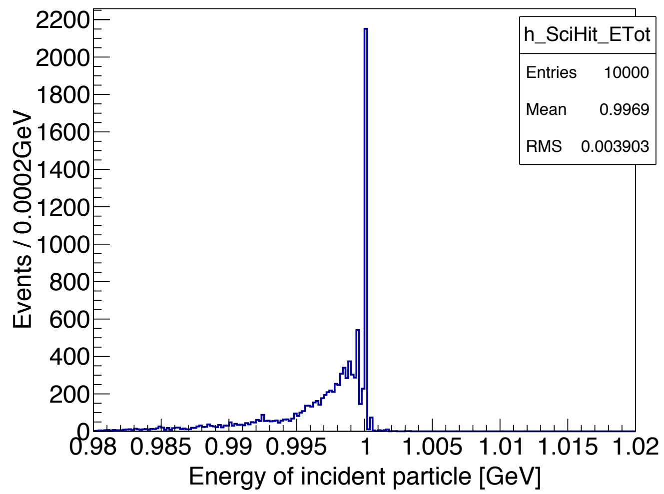


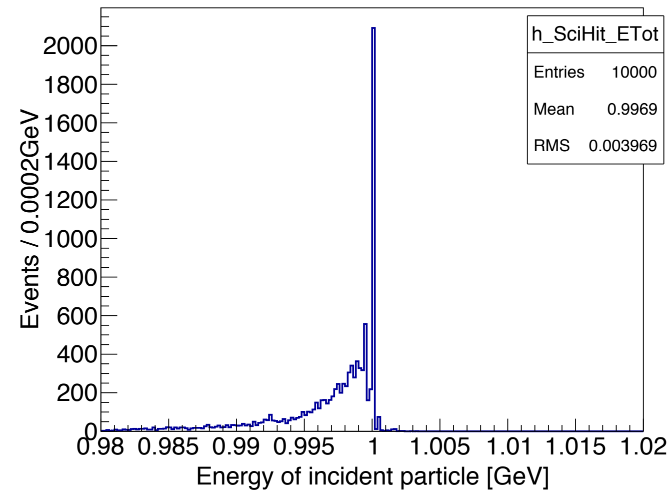
Test on Low Energy Tail

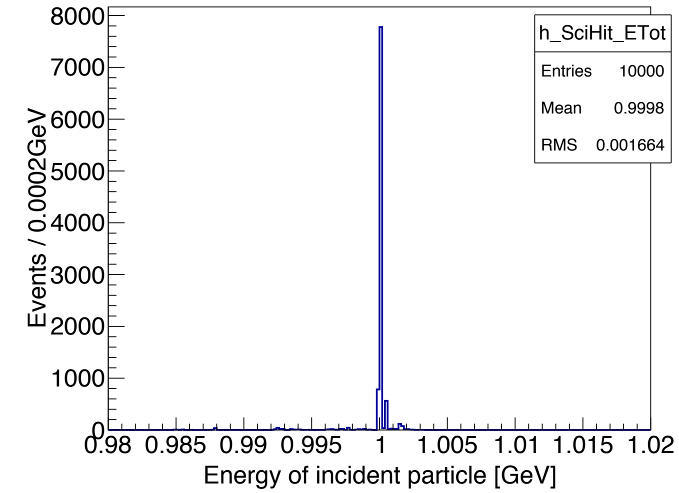
Outside 50cm | Surface | Center

$1x1x1m^3$
1 layer

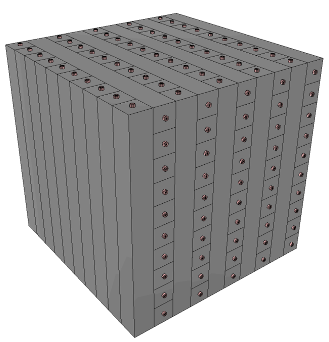


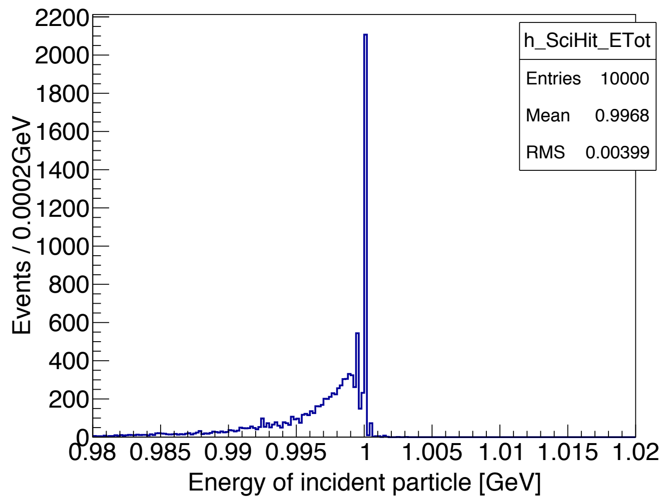


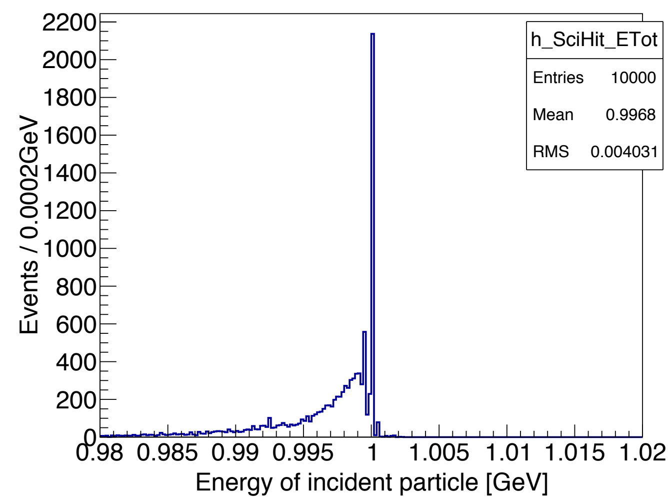


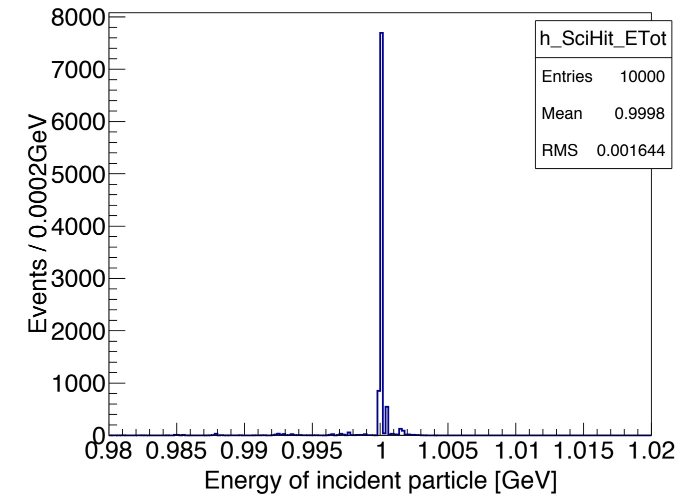


$10x10x100cm^3$
10 layers

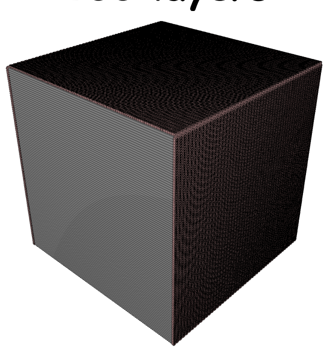


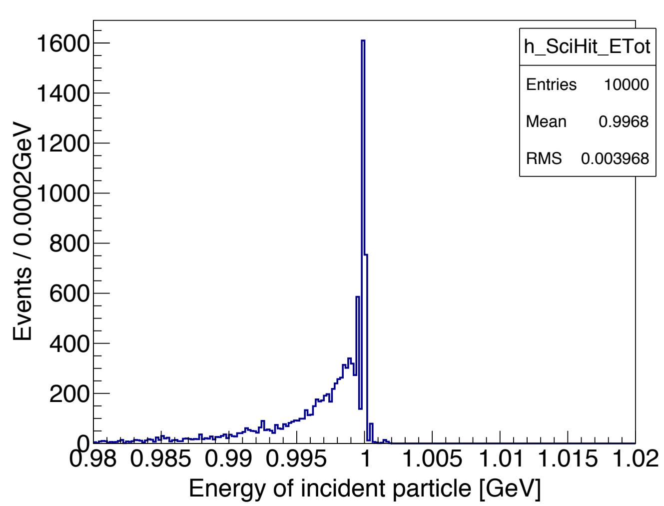


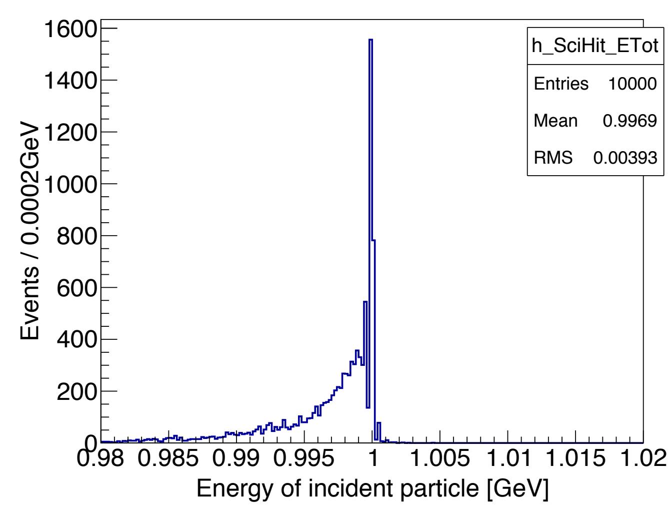


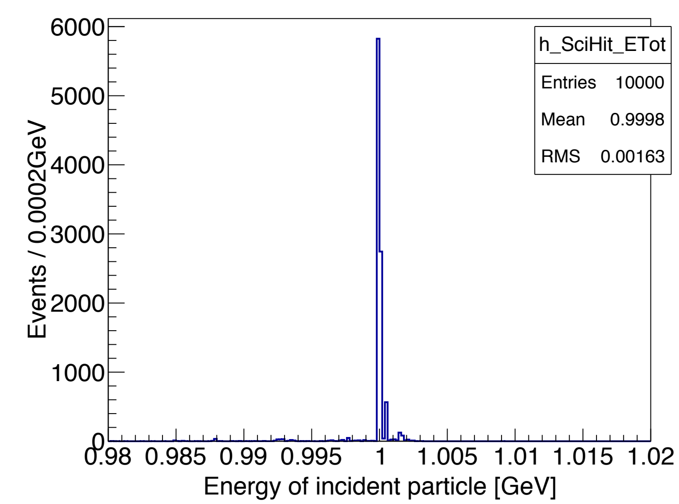


$1x1x100cm^3$
100 layers









Test on Low Energy Tail

1/25/120GeV Electron

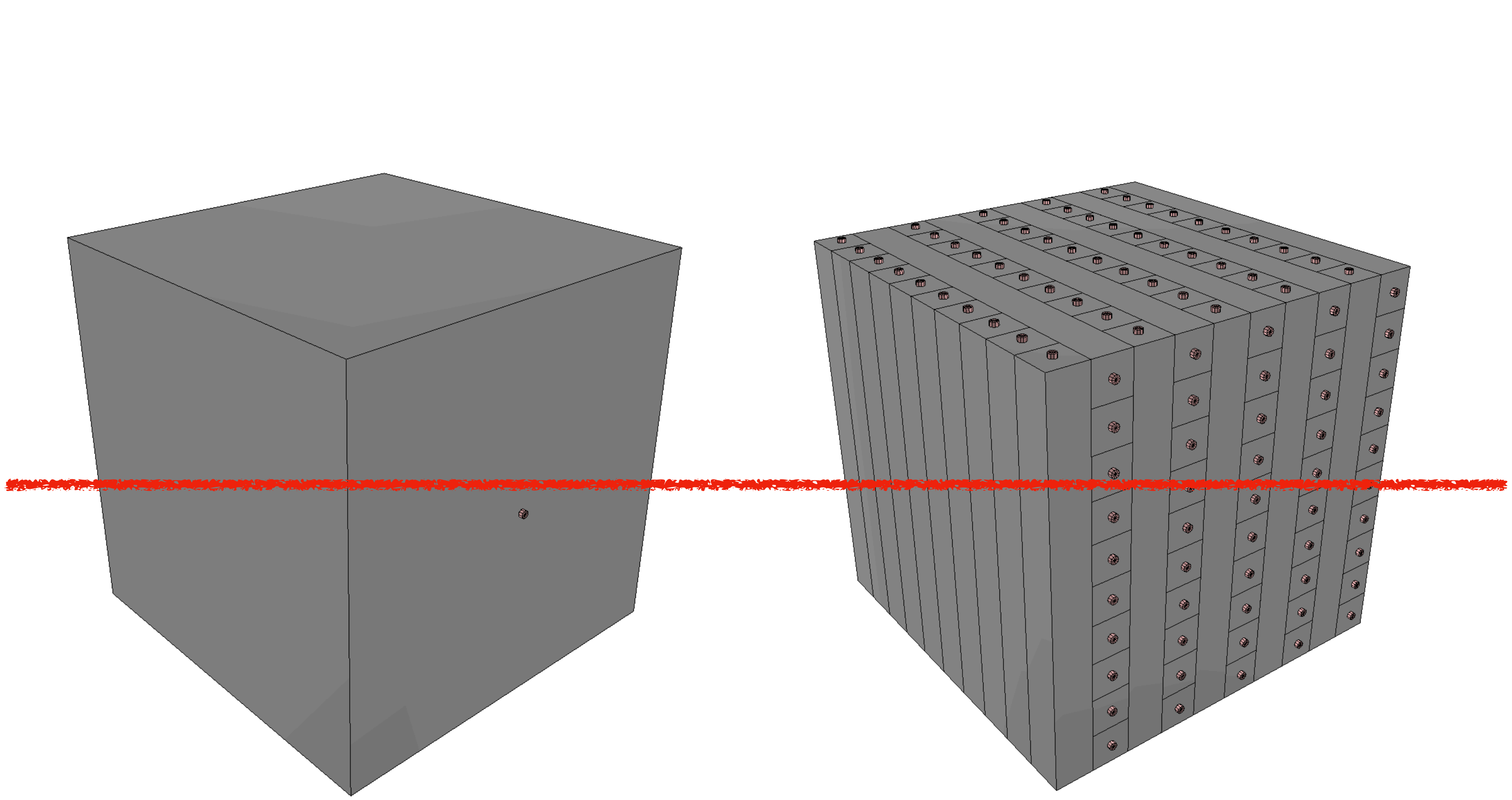
3 different geometries

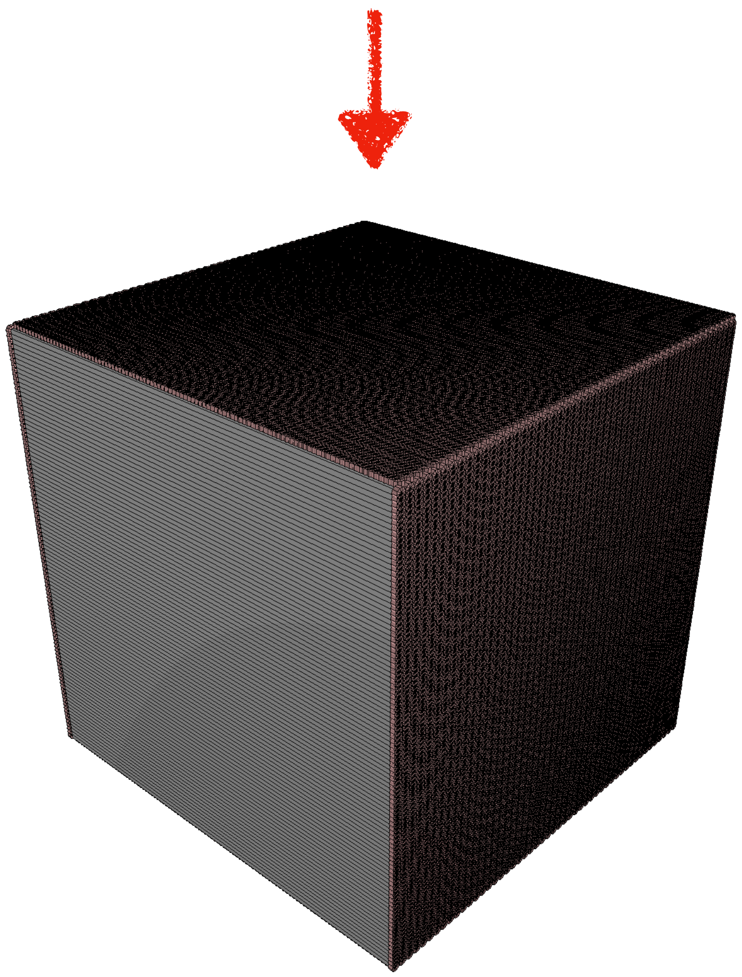
- $1\times1\times1m^3$, 1 layer
- 10x10x100cm, 10 layers
- 1x1x100cm, 100 layers

&

3 different incident position

- Outside 50cm
- Surface
- Center





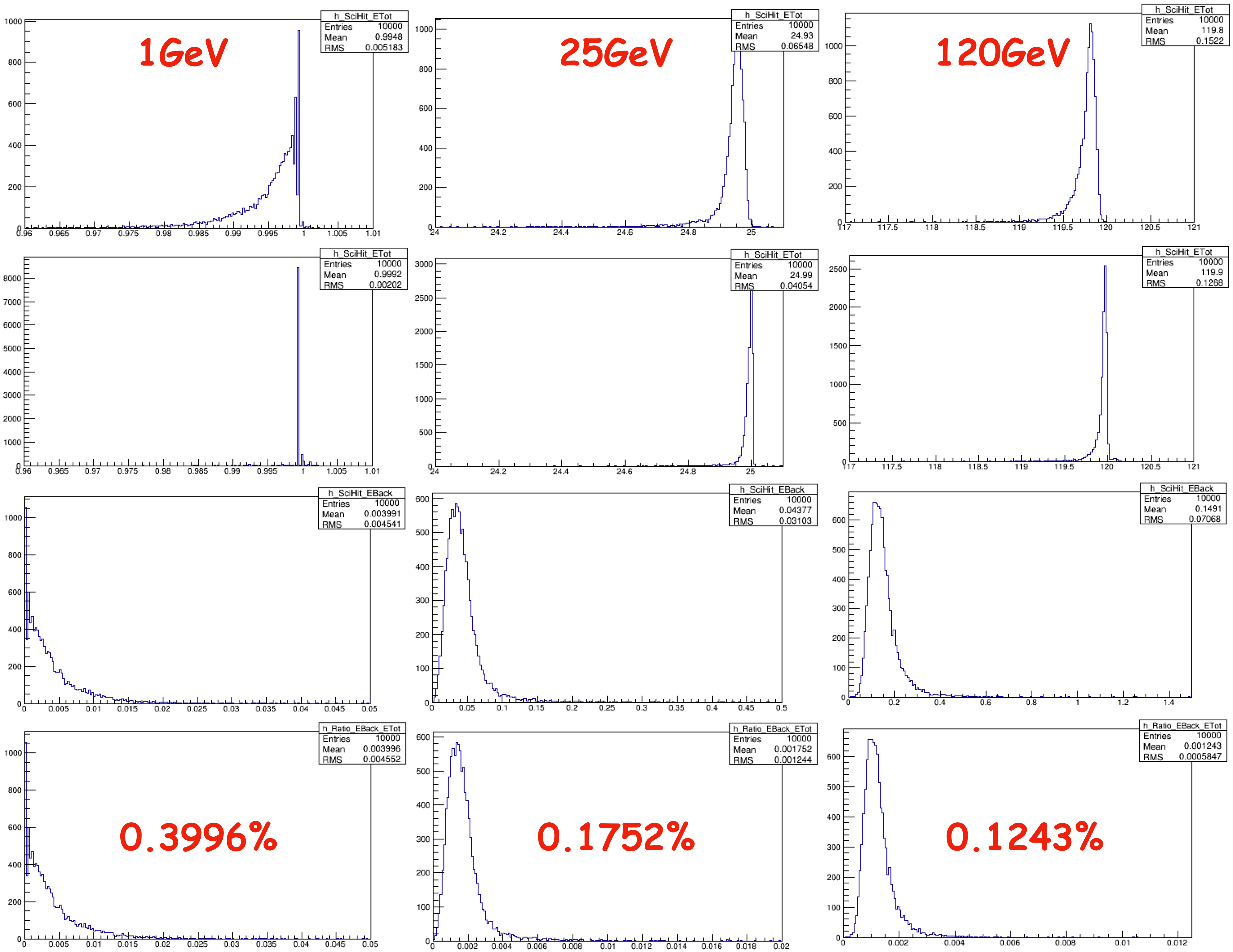
Test on Low Energy Tail

Outside 50cm

Center

Energy of Backscattering

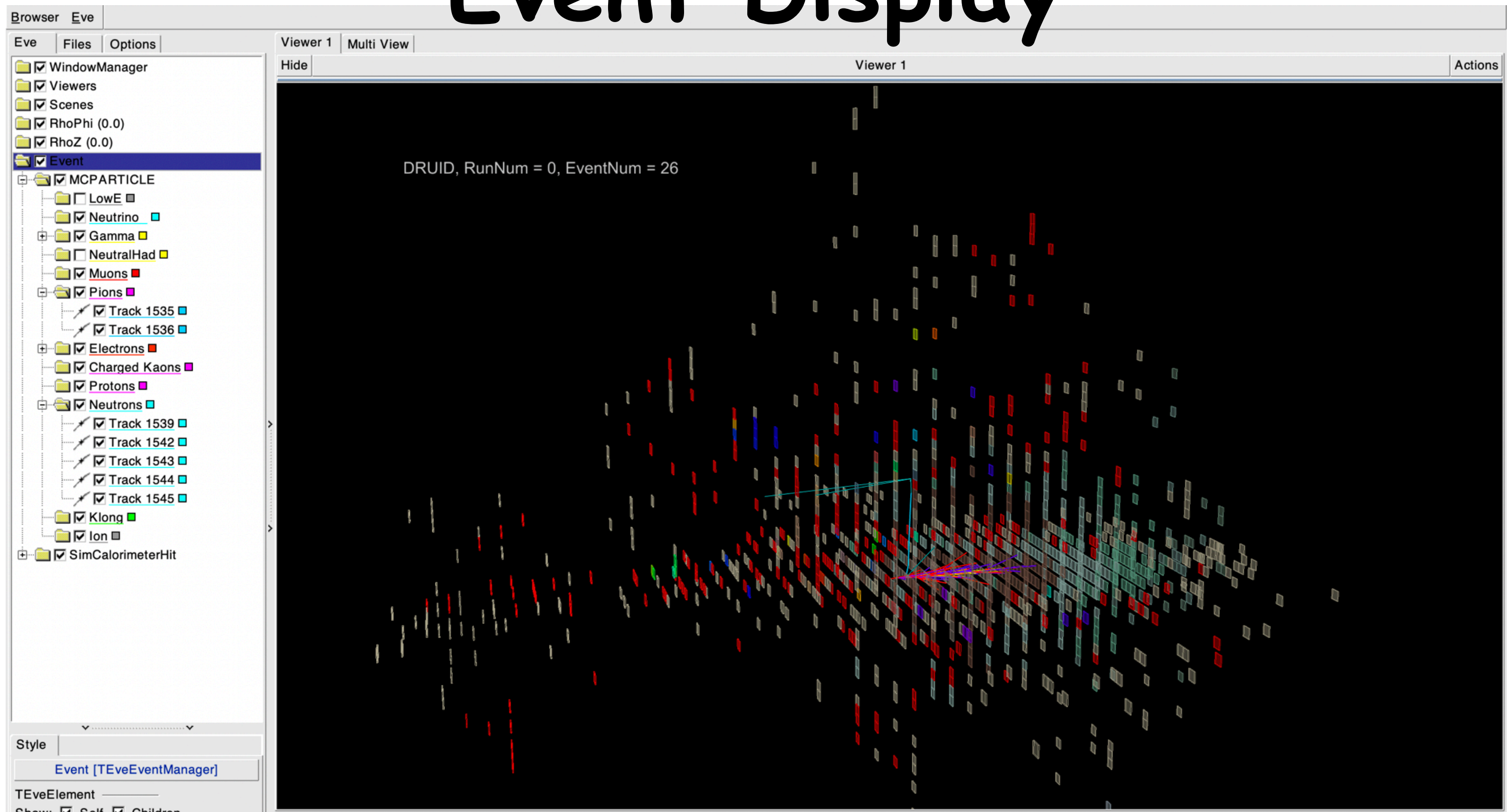
Backscattering/ Total Energy

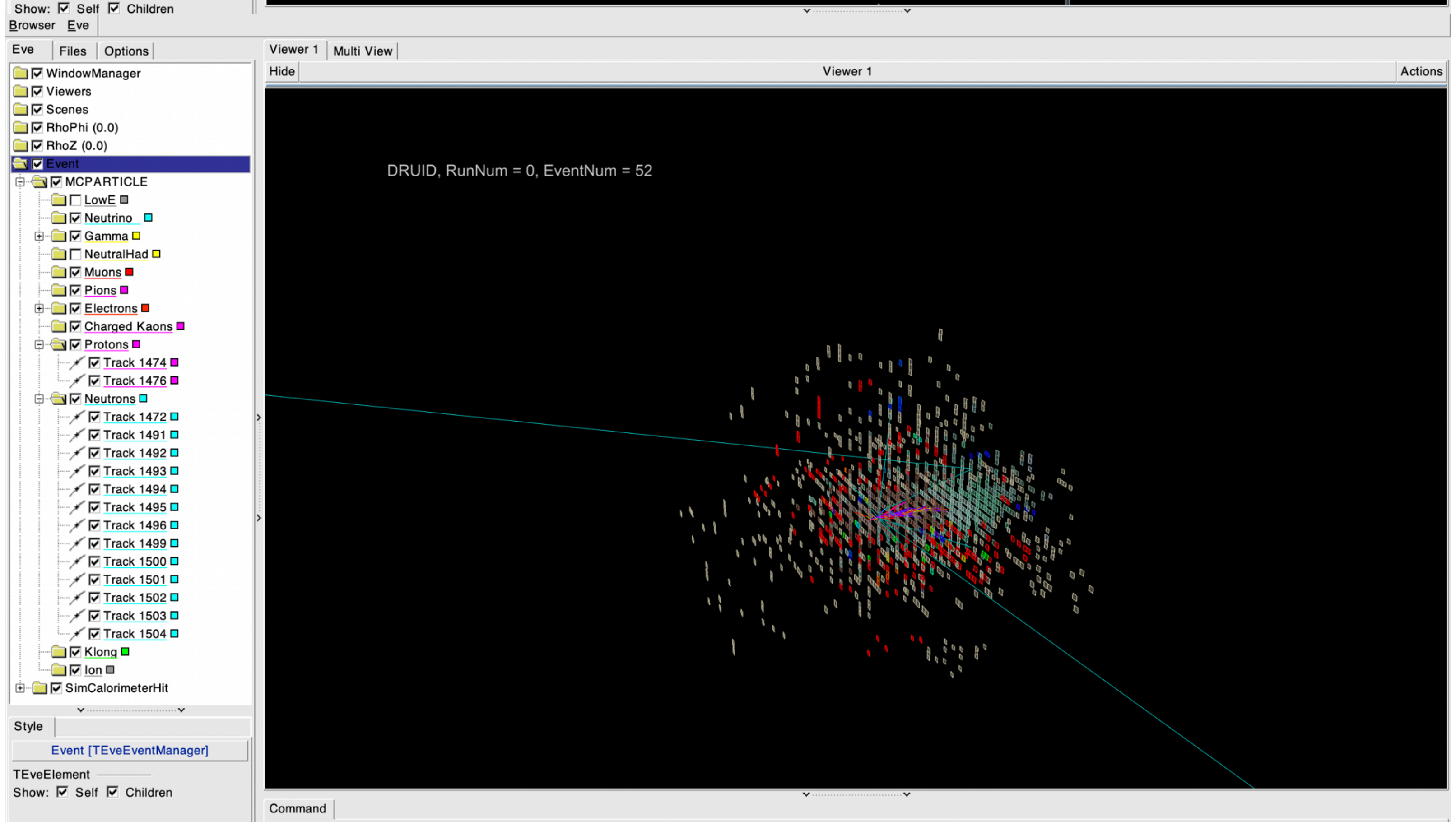


Event Display

$1 \times 1 \times 100 cm^3$
100 layers

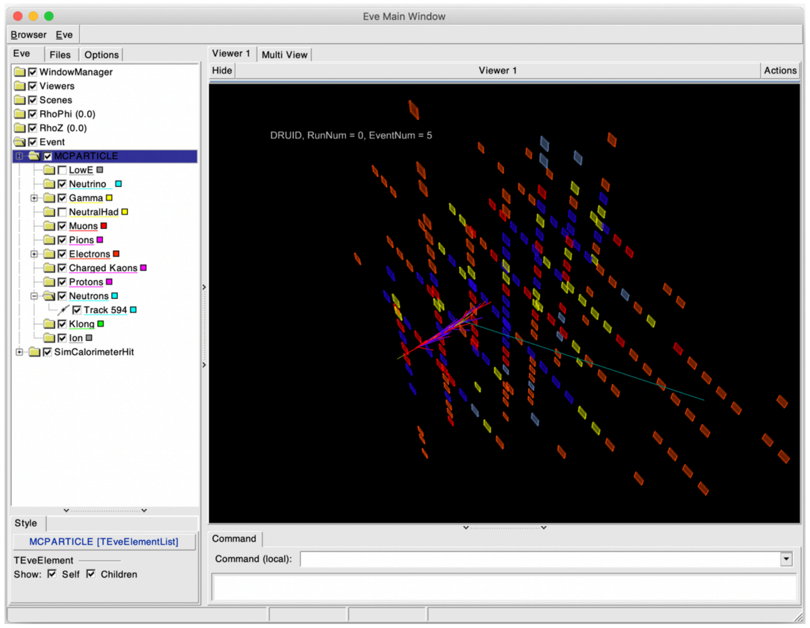
Electron/25GeV



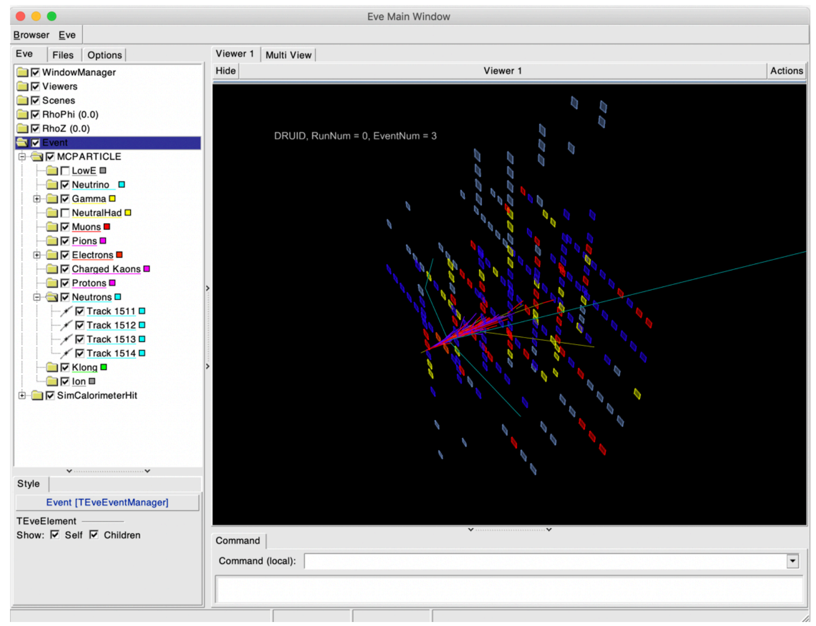


Event Display

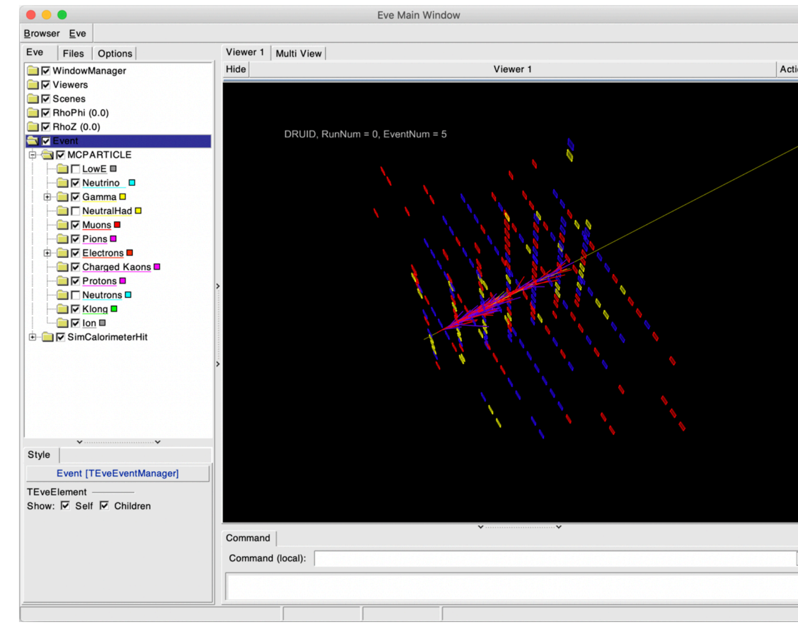
10GeV



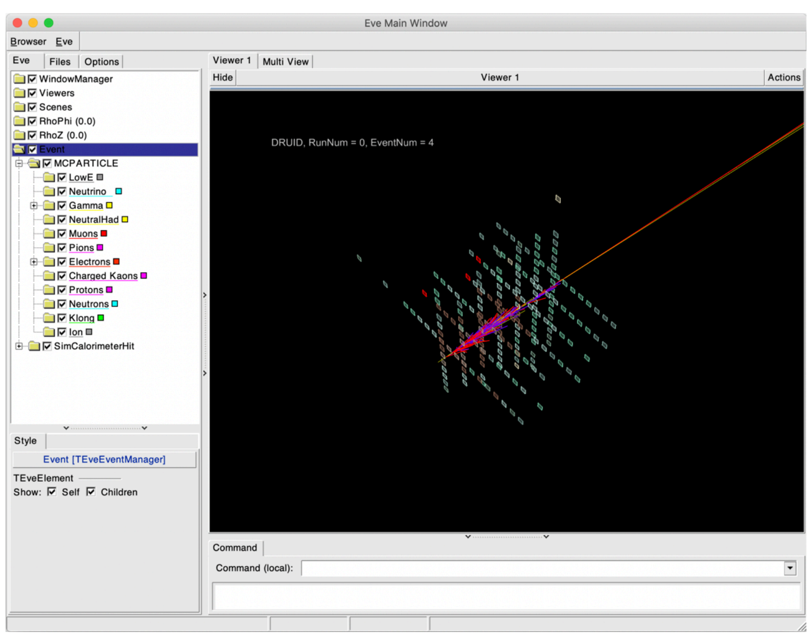
25GeV



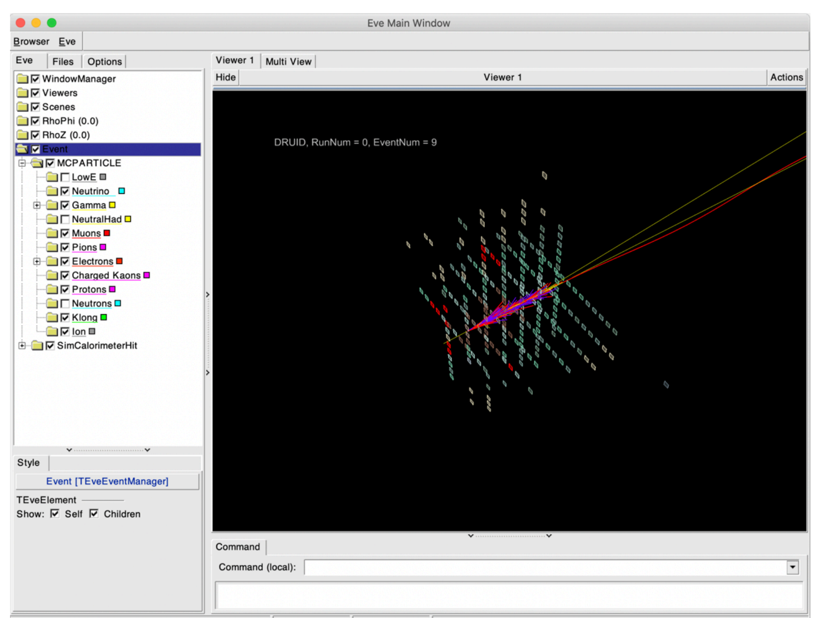
50GeV



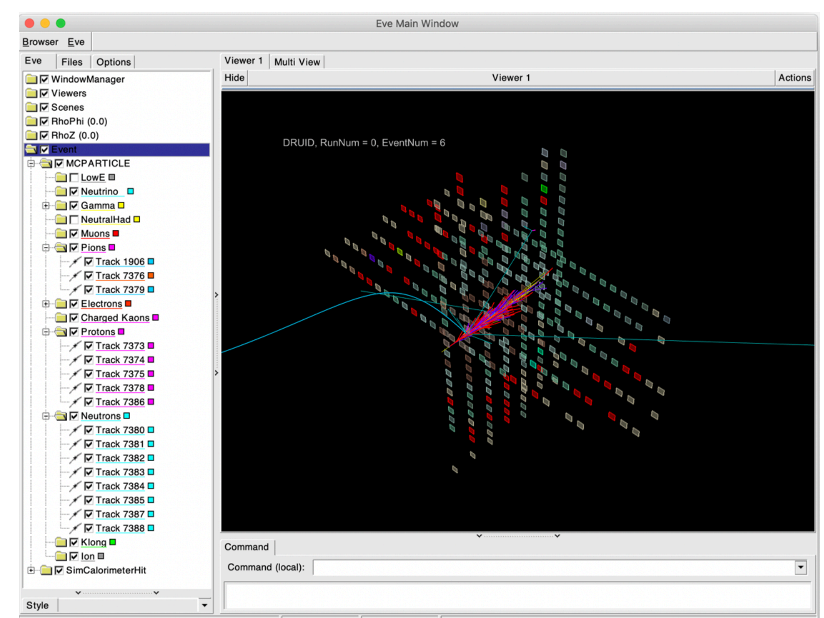
75GeV



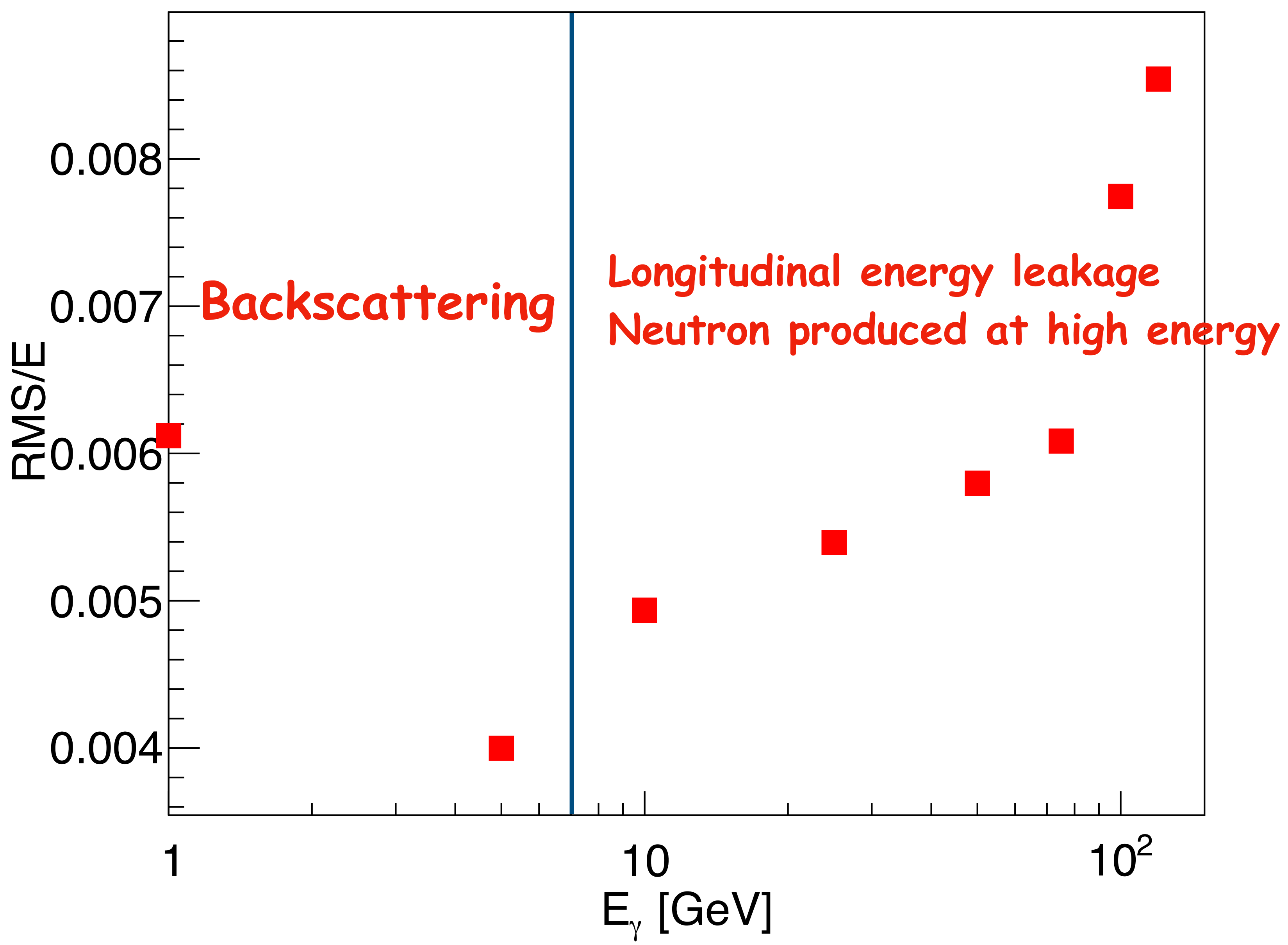
100GeV



120GeV



Photon Energy Resolution



Backup

http://home.fnal.gov/~souvik/GaussExp/GaussExp.pdf

A simple alternative to the Crystal Ball function

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Department of Physics
University of Florida

March 6, 2016

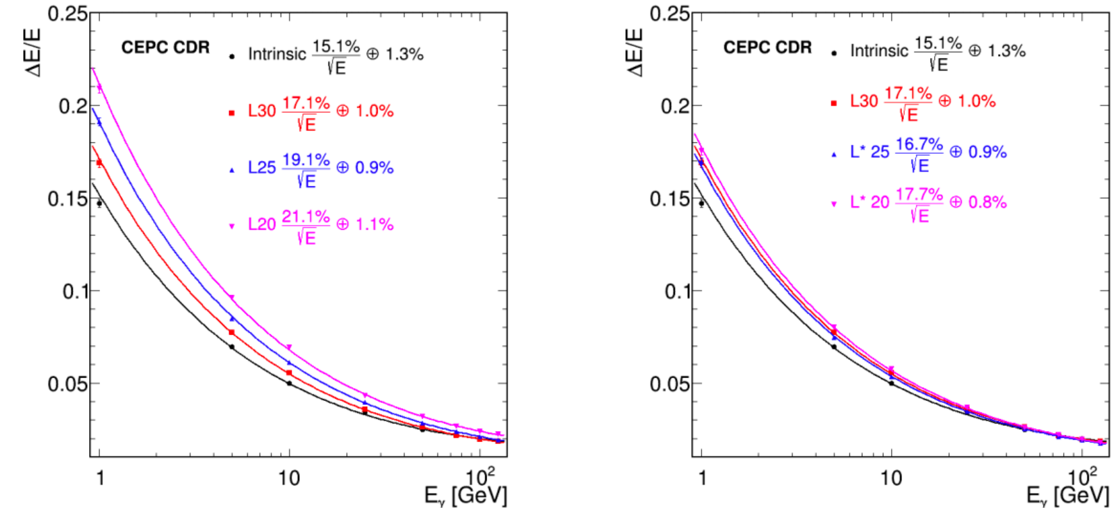
Abstract

We present a simple alternative to the Crystal Ball function that has an exponential tail stitched to a Gaussian core. It has one parameter less than the Crystal Ball function and, where appropriate, offers more stable fits to peaks that continue into exponential tails. The function may also be extended with two exponential tails on each side of the Gaussian, and this has two parameters less than the corresponding double-shouldered Crystal Ball function. This function has been used to model background and signal processes in a recent Higgs pair production search and may be of versatile use in experimental physics and other fields.

$$\begin{aligned} f(x;\alpha,n,\bar{x},\sigma) &= e^{-\frac{1}{2}\left(\frac{x-\bar{x}}{\sigma}\right)^2} \quad \text{for} \quad \frac{x-\bar{x}}{\sigma} > -\alpha \\ &= \left(\frac{n}{|\alpha|}\right)^n e^{-\frac{|\alpha|^2}{2}} \left(\frac{n}{|\alpha|} - |\alpha| - \frac{x-\bar{x}}{\sigma}\right)^{-n} \quad \text{for} \quad \frac{x-\bar{x}}{\sigma} \leq -\alpha \end{aligned} \tag{1}$$

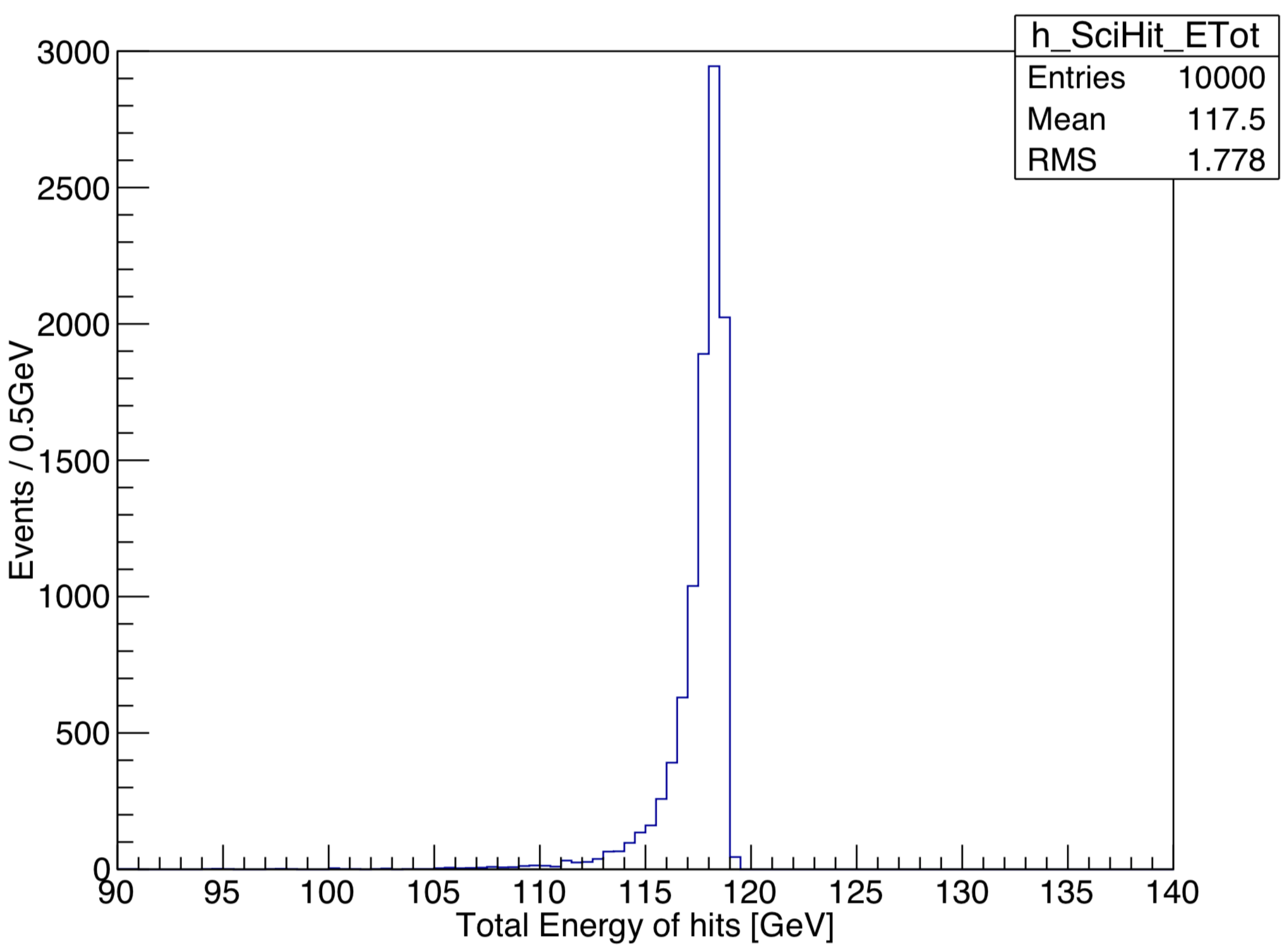
$$\begin{aligned} f(x;\bar{x},\sigma,k) &= e^{-\frac{1}{2}\left(\frac{x-\bar{x}}{\sigma}\right)^2}, \quad \text{for} \quad \frac{x-\bar{x}}{\sigma} \geq -k \\ &= e^{\frac{k^2}{2}+k\left(\frac{x-\bar{x}}{\sigma}\right)}, \quad \text{for} \quad \frac{x-\bar{x}}{\sigma} < -k \end{aligned} \tag{2}$$

```
>>> Event 8, scanning sub-detectors

SciCollection from the Sci sensitive detector has 751 hits.
FPMTCollection from the FPMT sensitive detector has 0 hits.

SpeNt time: 25.82
Particle:       gamma direction: (0,0,1) energy:    119894
Debug:  not Optical
Debug:  not Optical
Debug:  not Optical
Debug:  not Optical
```



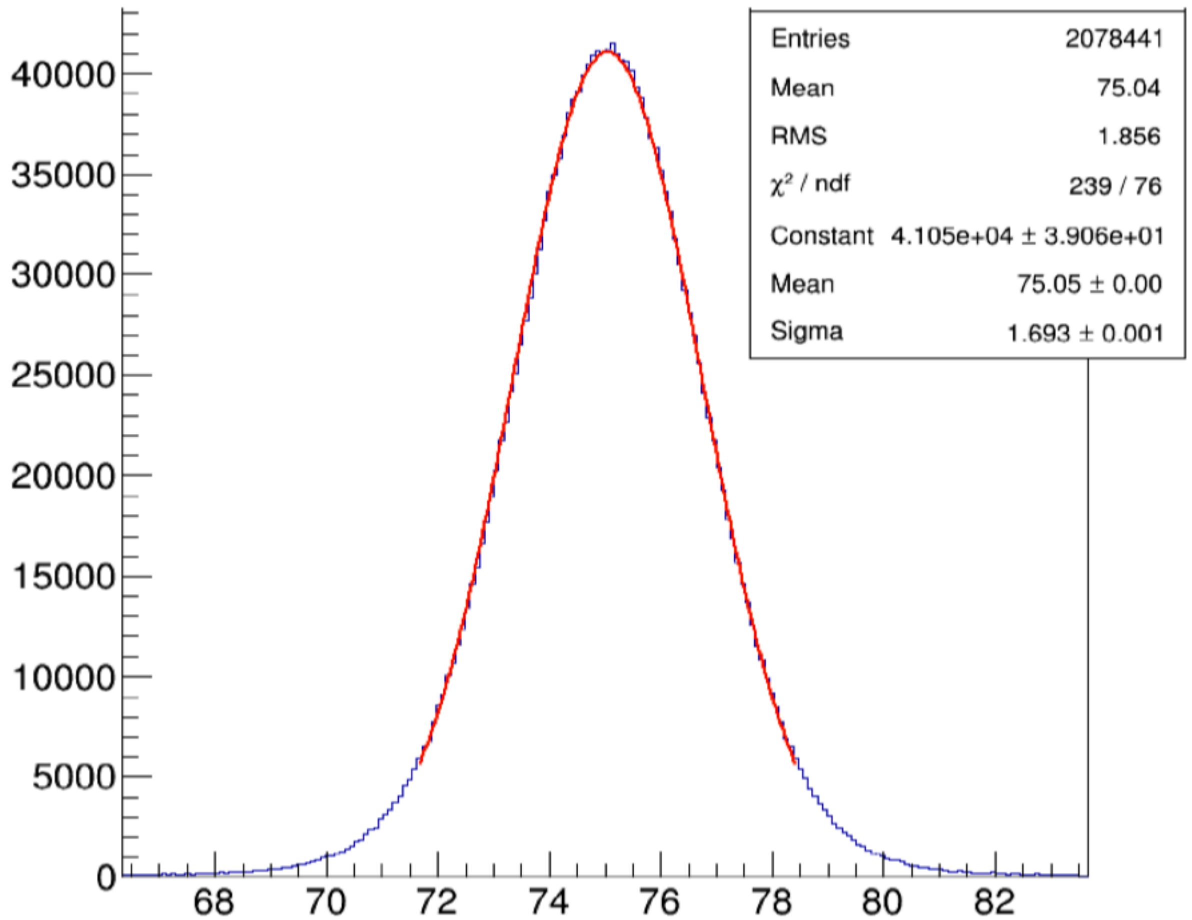
(a) (b)

Figure 5.4: Photon energy resolution of the silicon-tungsten ECAL as a function of photon energy for different numbers of sampling layers of the ECAL: 30 layers (black, red), 25 layers (blue), and 20 layers (magenta). In (a), a silicon sensor thickness of 0.5 mm is used for all cases. In (b), different silicon sensor thicknesses are used: 0.5 mm, 1.0 mm and 1.5 mm for the 30, 25 and 20 layers, respectively. The absorber has a uniform thickness in all layers for the magenta, blue and red curves, while the absorber is 2.1 mm thick for the first 20 layers and 4.2 mm for the last 10 layers of the baseline design for the black curves. Note that the resolutions are obtained for a standalone ECAL without the tracking material in front and dead areas between ECAL modules. Thus the resolutions are labeled as "intrinsic". Photons used in these studies are uniformly distributed over the 4π solid angle.

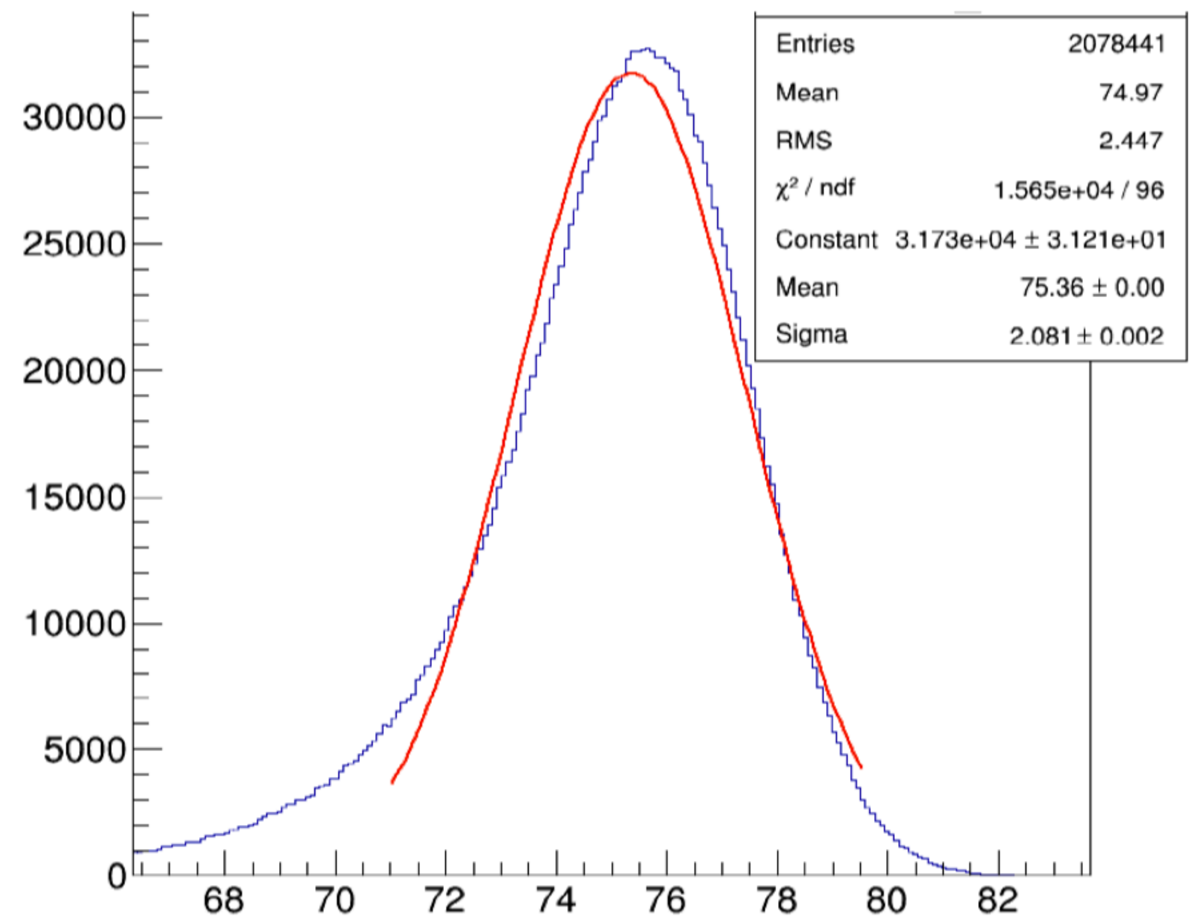


120GeV
CDR:
Intrinsic: 1.89%
L30: 1.56%
New: 1.48%, 0.85%

Ecal

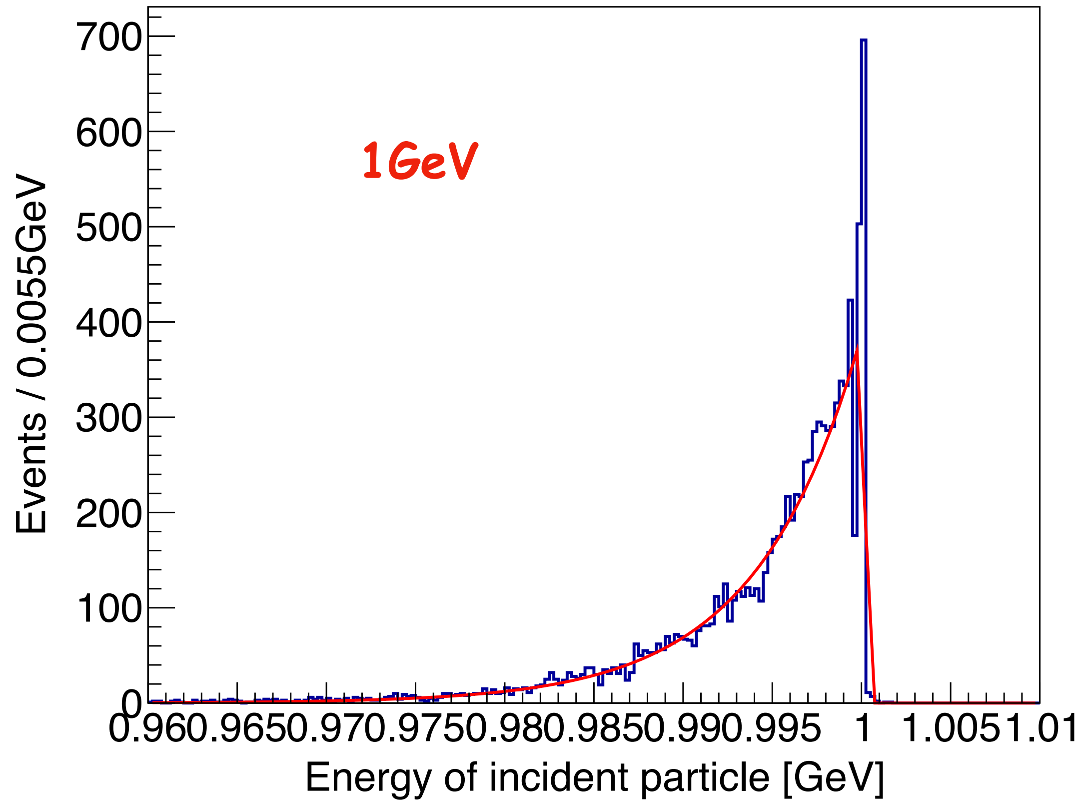


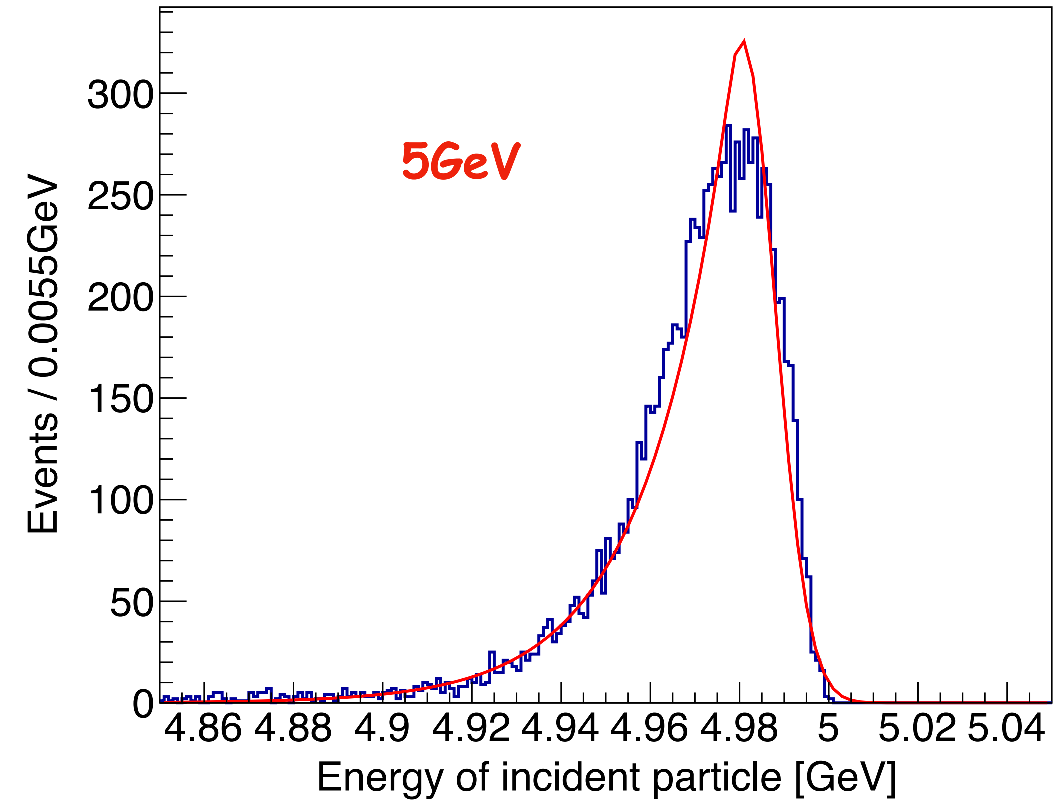
Entries 2078441
Mean 75.04
RMS 1.856
χ² / ndf 239 / 76
Constant 4.105e+04 ± 3.906e+01
Mean 75.05 ± 0.00
Sigma 1.693 ± 0.001

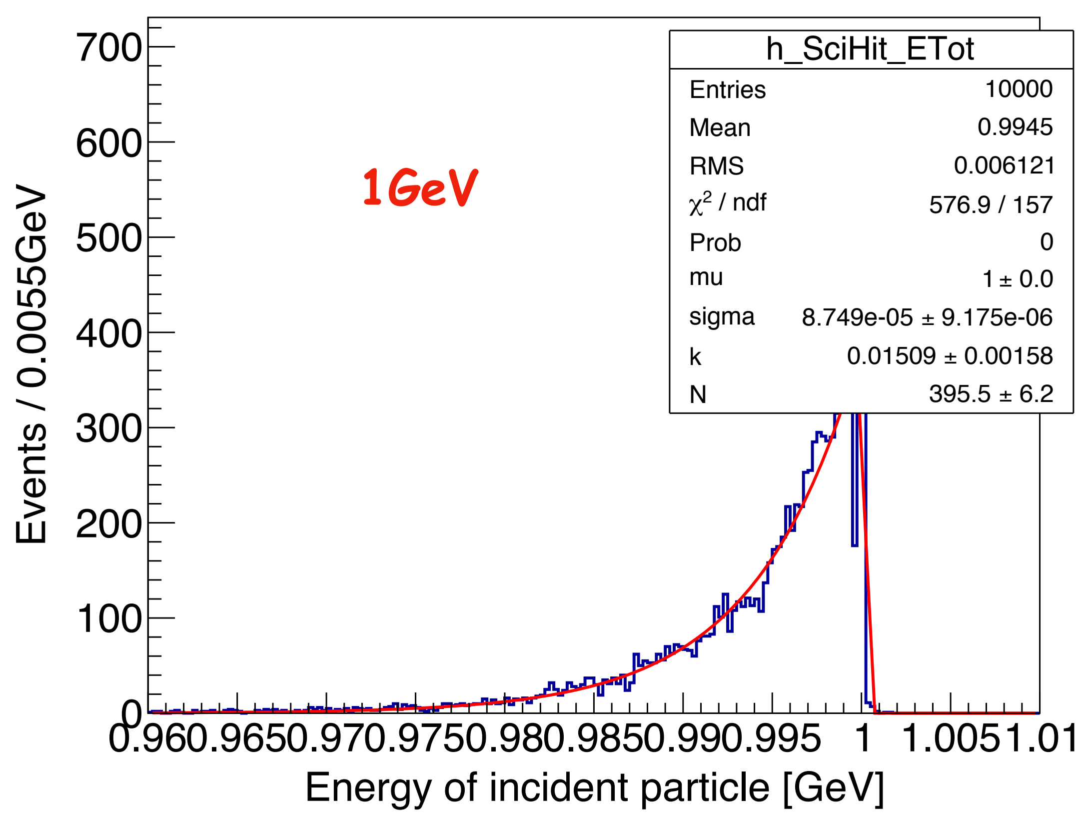


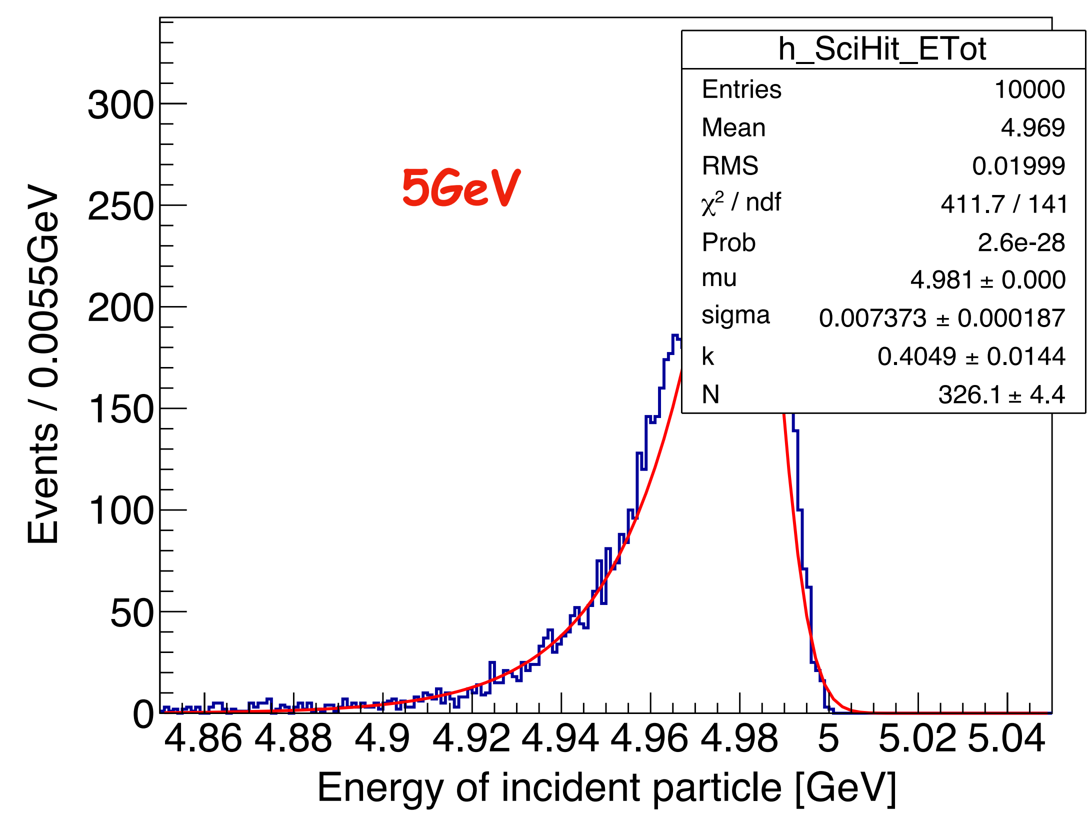
Entries 2078441
Mean 74.97
RMS 2.447
χ² / ndf 1.565e+04 / 96
Constant 3.173e+04 ± 3.121e+01
Mean 75.36 ± 0.00
Sigma 2.081 ± 0.002

Photon Energy Spectrum

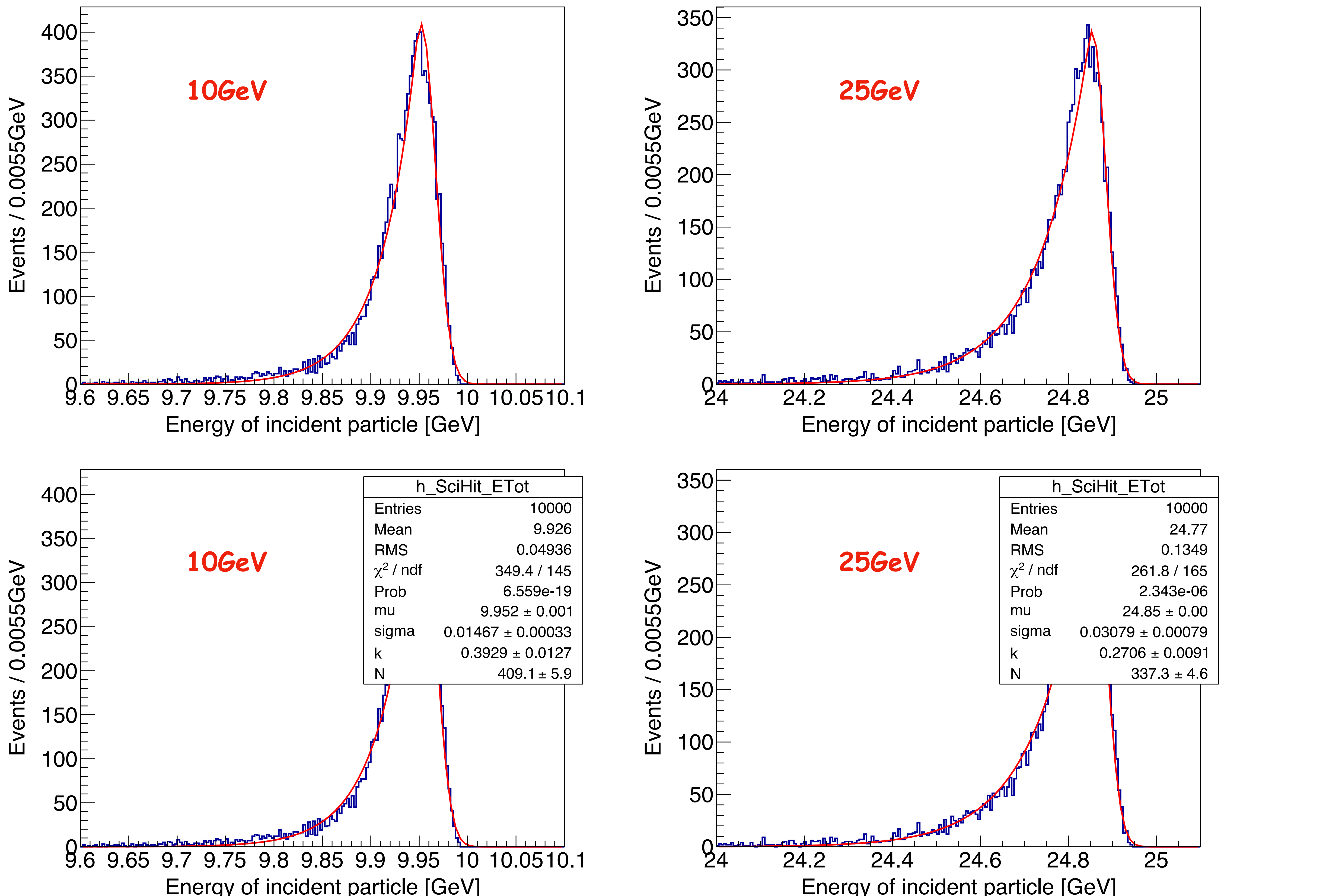




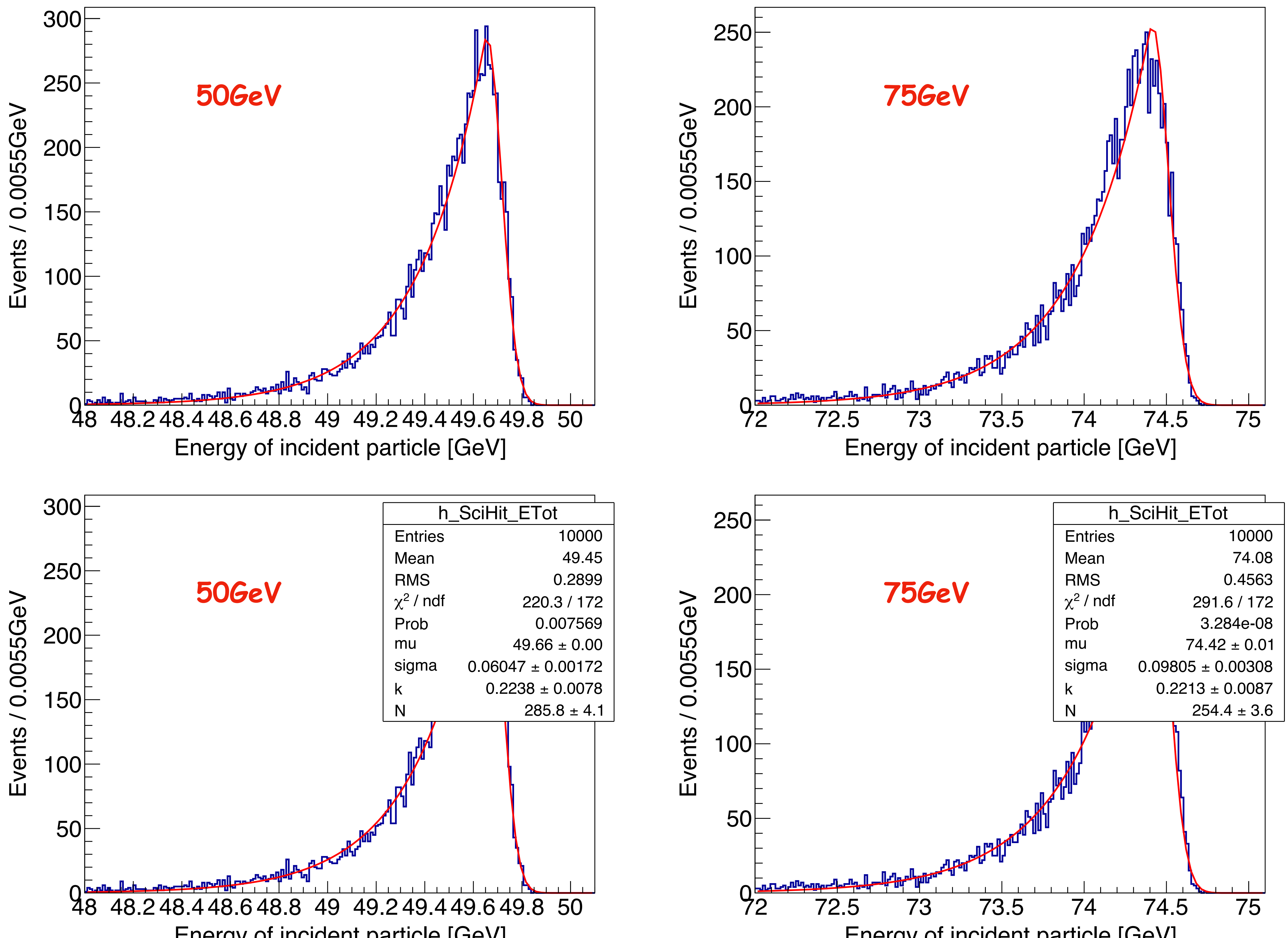




Photon Energy Spectrum



Photon Energy Spectrum



Photon Energy Spectrum