Model 1

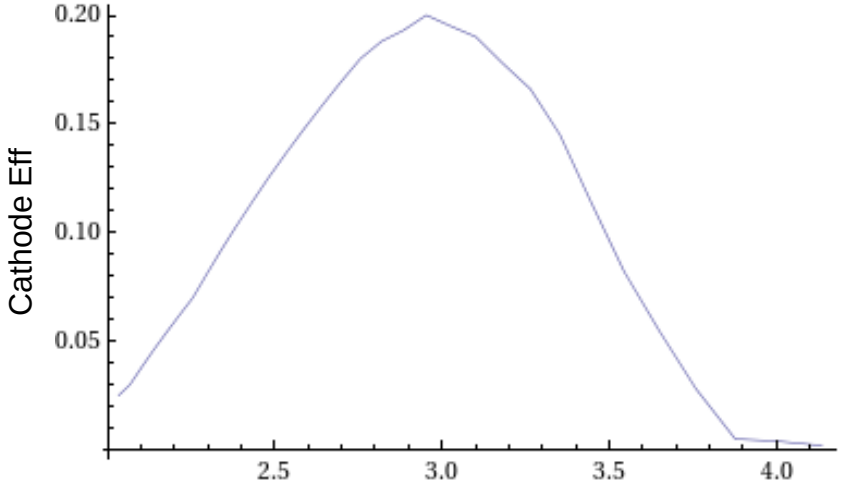
Pb Glass (same as GSTAR)

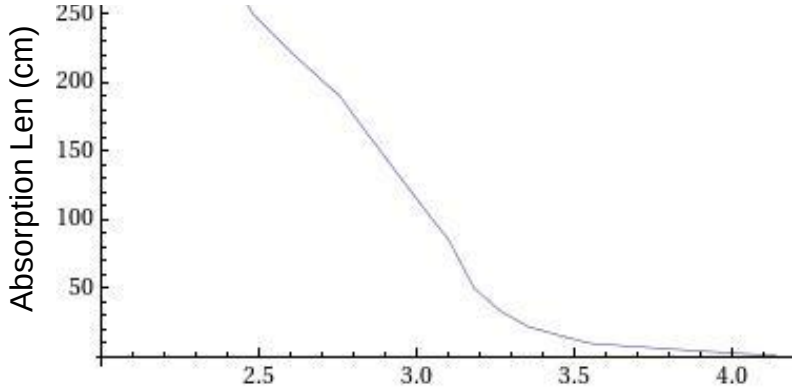
Cerenkov Photon Signal.

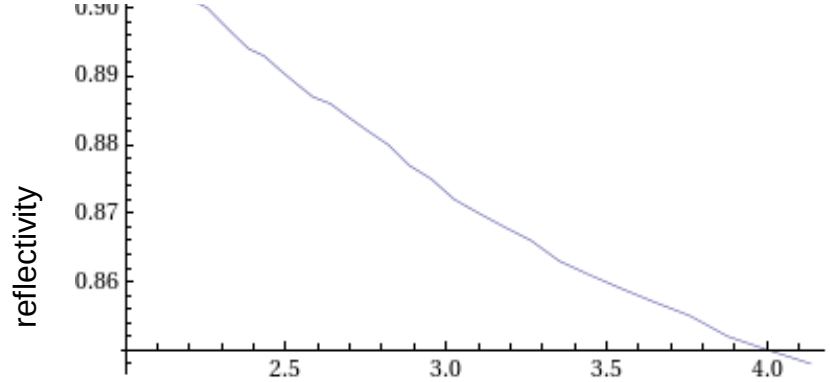
Photo cathode efficiency set by hand.

Reflectivity of surface set by hand.

Photon absorption length of Pb Glass set by hand.



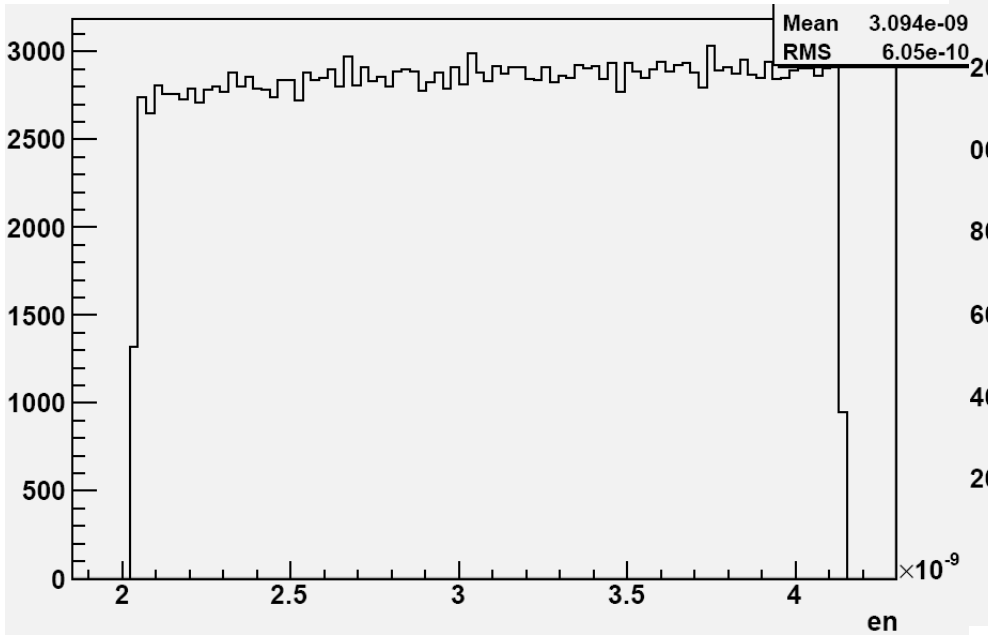




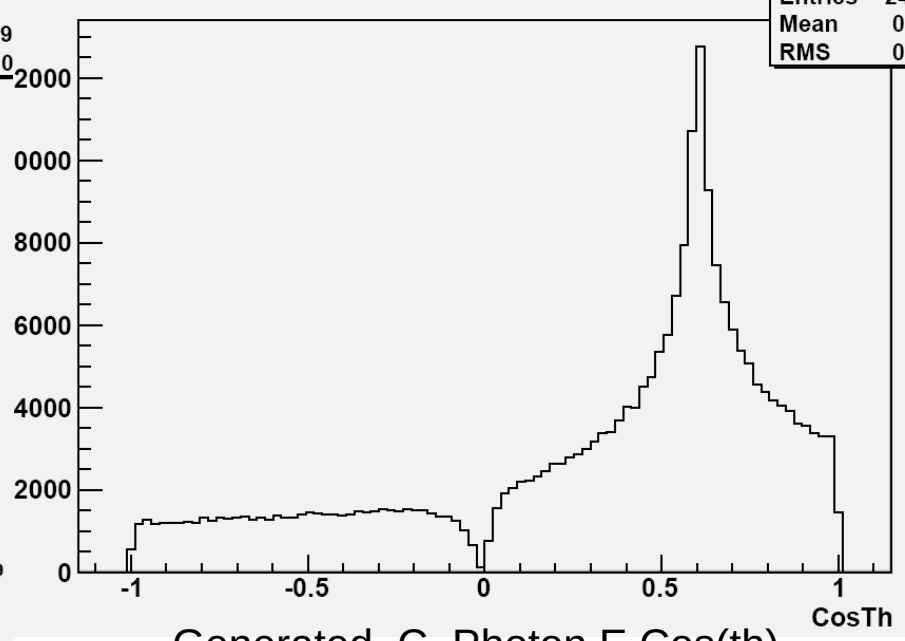
This is a study of a Geant4 based model of a 7x7 Small Cell
FPD type detector.

In the following presentation

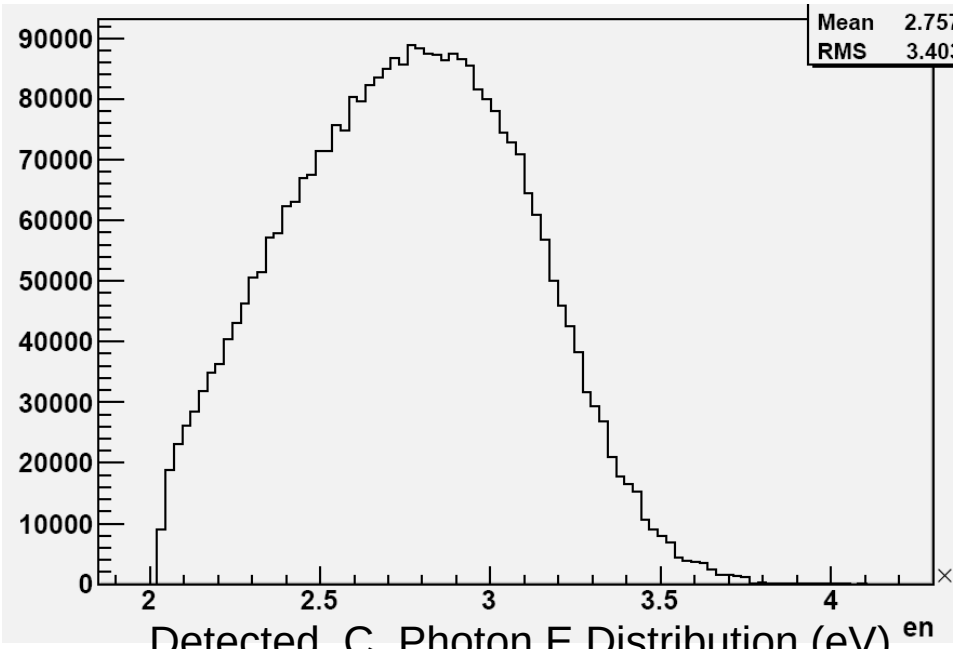
- The signal is modeled both as **energy deposited** in cells and simultaneously as **Number of Cerenkov** produced in the cell and detected at the photo cathode
- Simulation involves a single photon directed in the center of the center cell of a 7x7 array of cells. The cells are arranged with their long axis along the z axis and the photon momentum is in the z direction.
- The detected Cerenkov signal is reduced from the number of produced Cerenkov by three factors
  - Photocathode efficiency as a function of photon energy
  - Absorption length of glass as a function photon energy
  - Reflectivity of Cell surfaces as a function of energy.



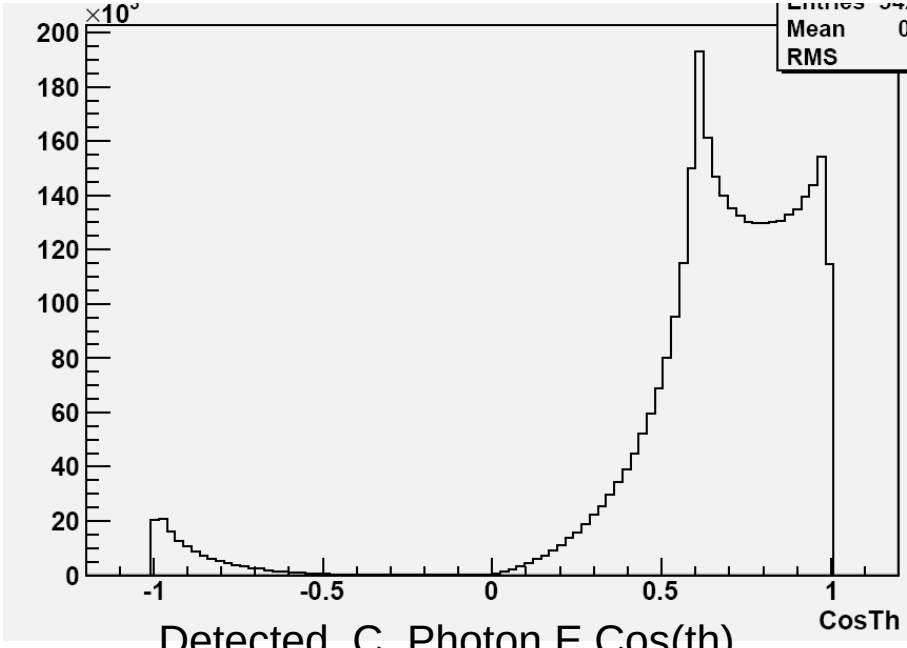
Generated C. Photon E Distribution (eV)



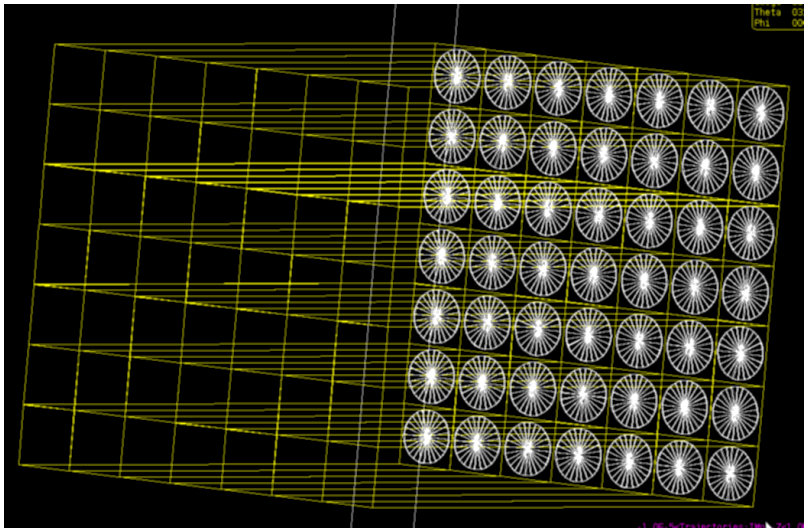
Generated C. Photon E Cos(th)



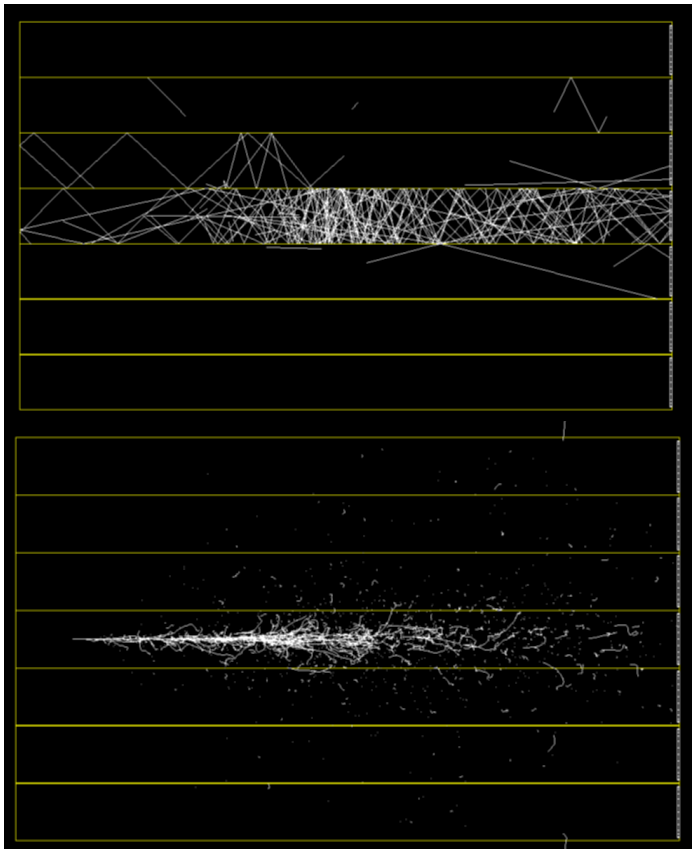
Detected C. Photon E Distribution (eV)



Detected C. Photon E Cos(th)



7x7 FPD like detector with disc shaped photocathode regions near the end of each cell.



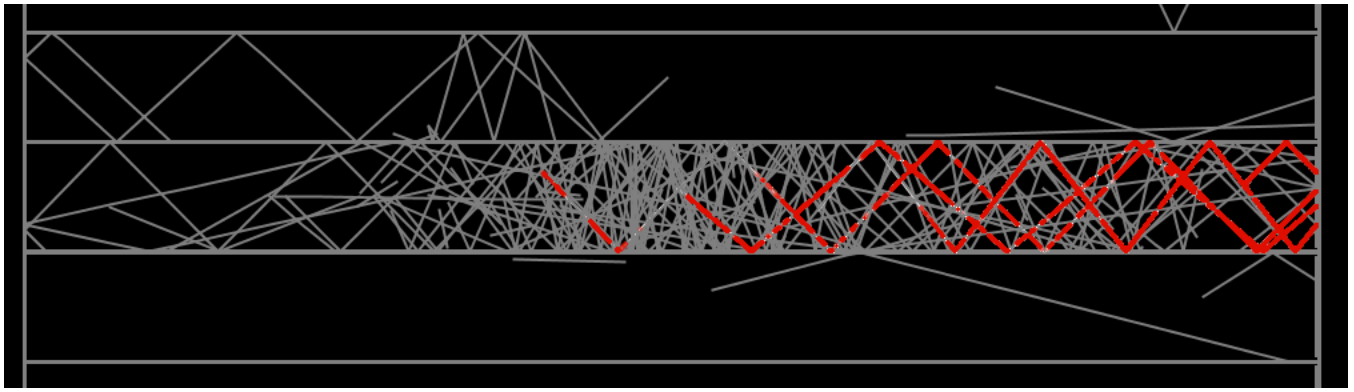
For 10 GeV incident photon.

Full simulation of Cerenkov photons with full absorption, reflection and photo-cathode
efficiency.

Only 1/1000 of the detected Cerenkov photons are shown.

For 10 GeV incident photon.

Full simulation of electrons.



For a 4 GeV incident photon.

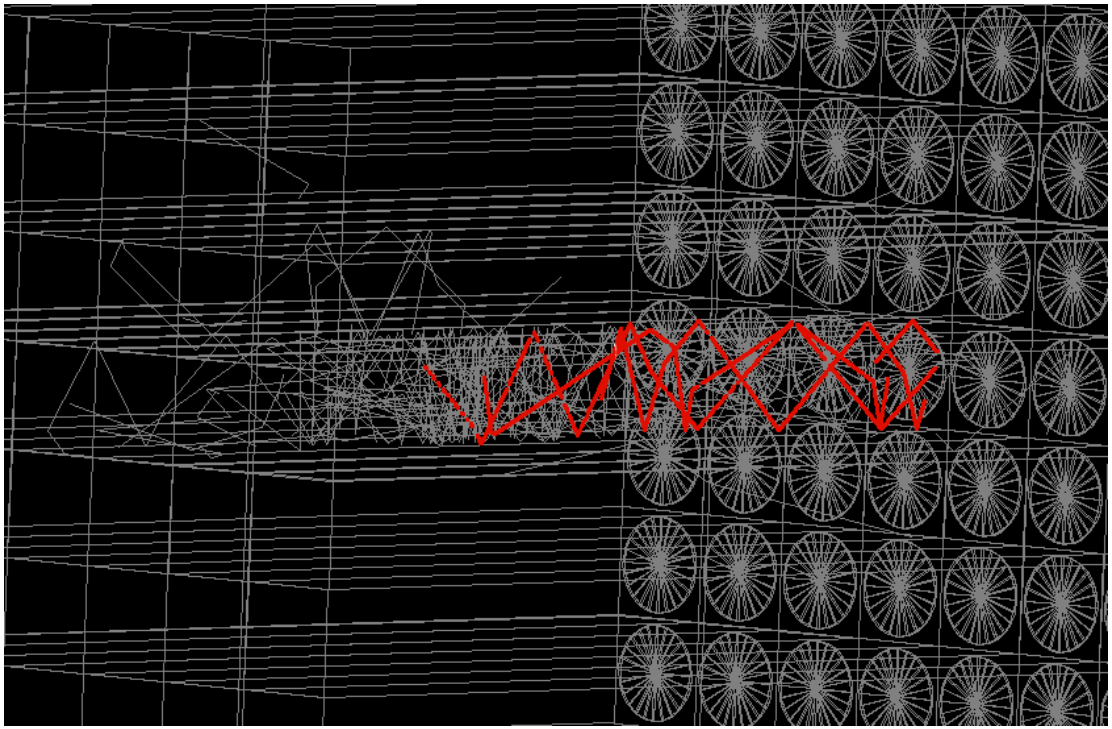
1/1000 of Cerenkov Photons shown.

42461 Cerenkov photons produces
33743 Cerenkov photons come from the central cell (row==3 col==3) (80%).

4246 Generated Photons/GeV
660 Detected Photons per GeV
(~ 1.5%)

1/1000 of all Cerenkov Photons shown.
8 Detected Photons shown in figure.

5 of detected central bin Photons shown in red.

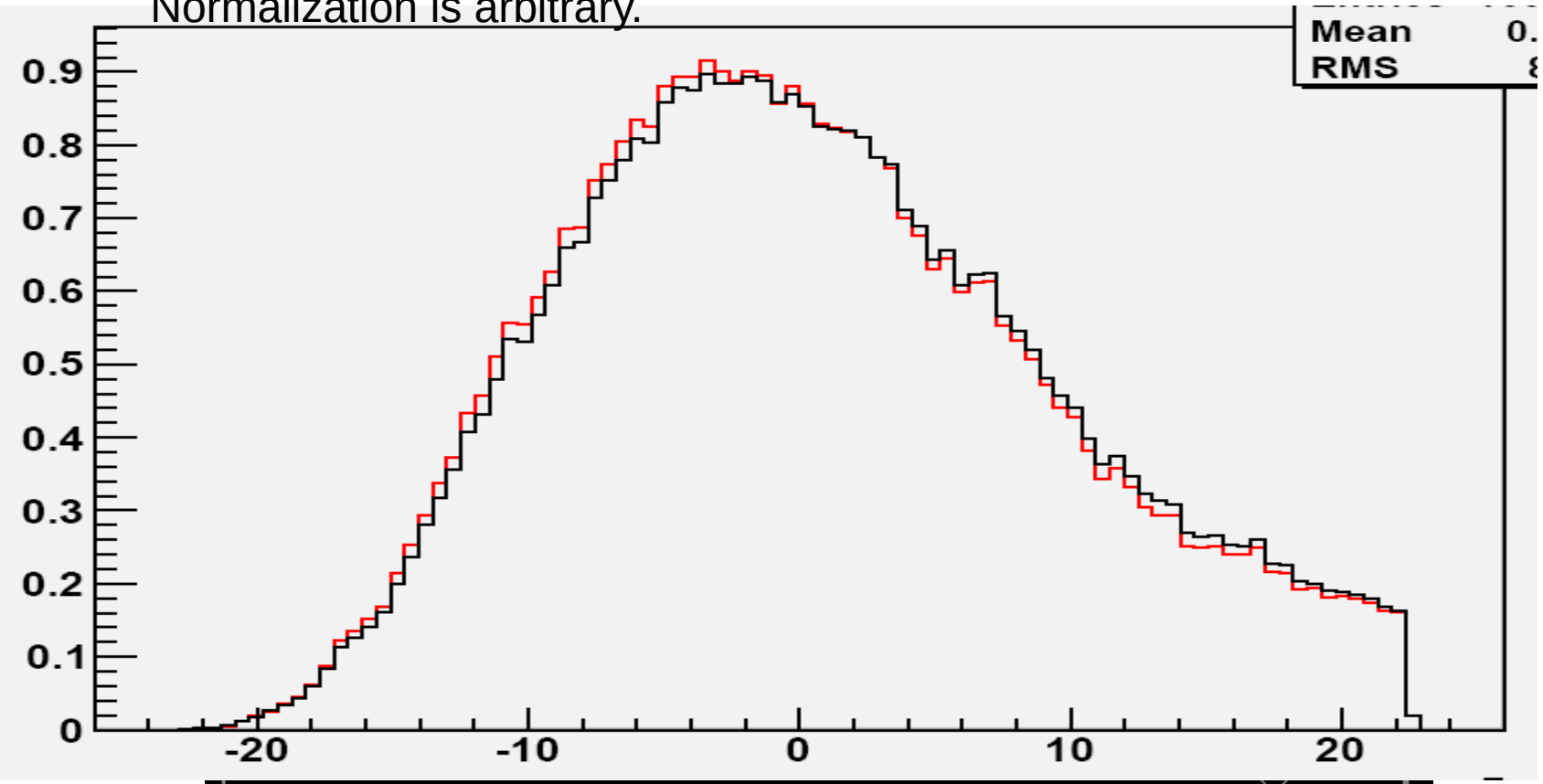


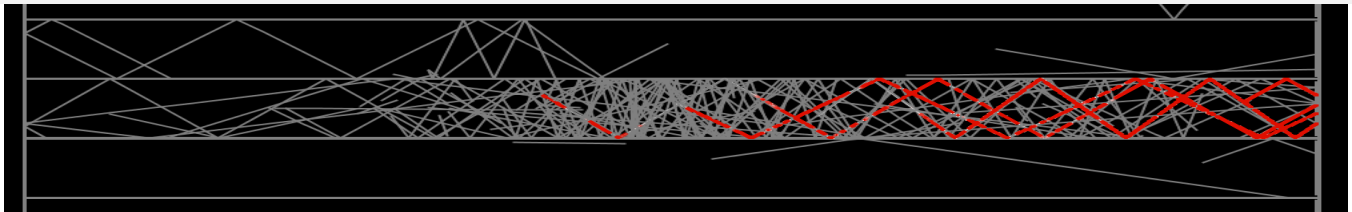
For a 40 GeV incident photon.

The z distribution of the point of generation for Cerenkov photons (red).

The z distribution of energy deposited (black).

Normalization is arbitrary.

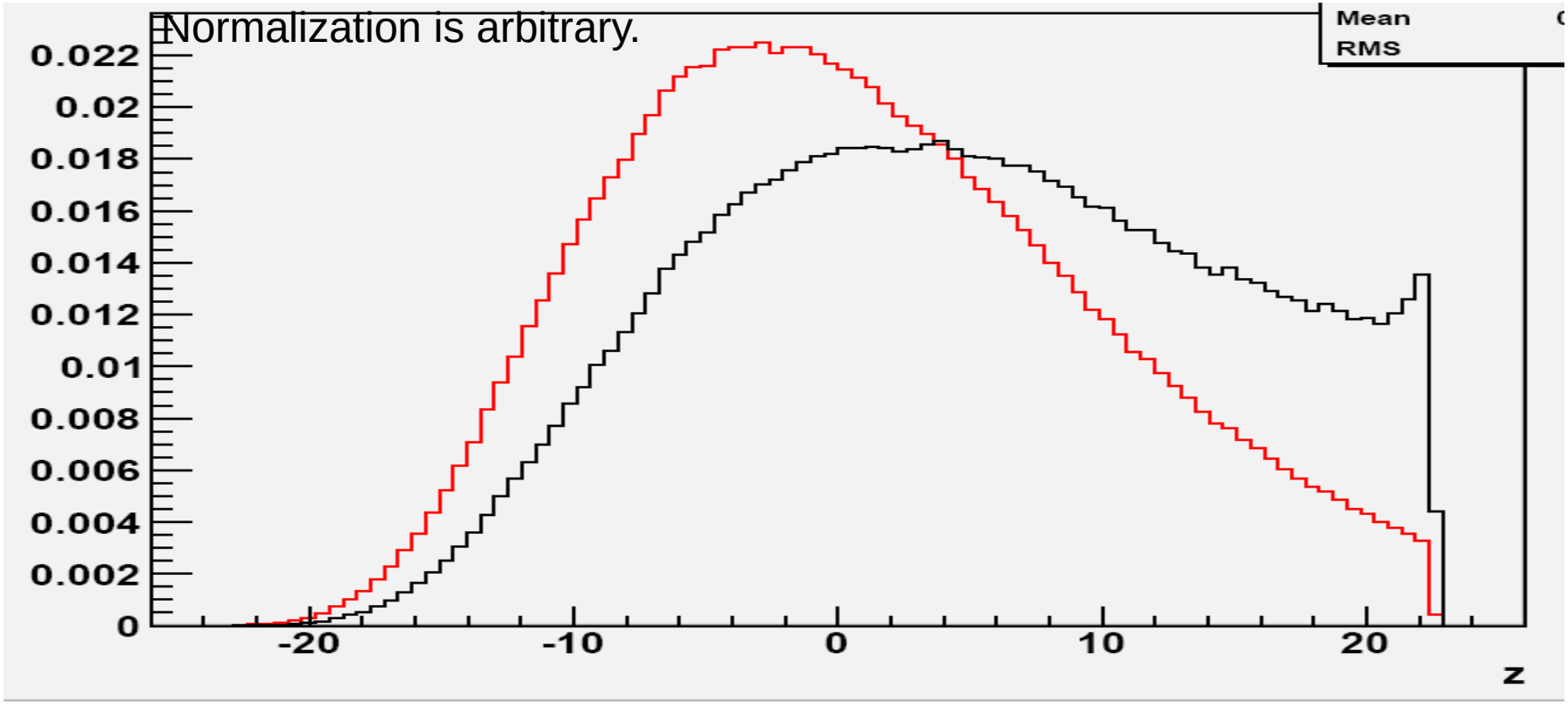


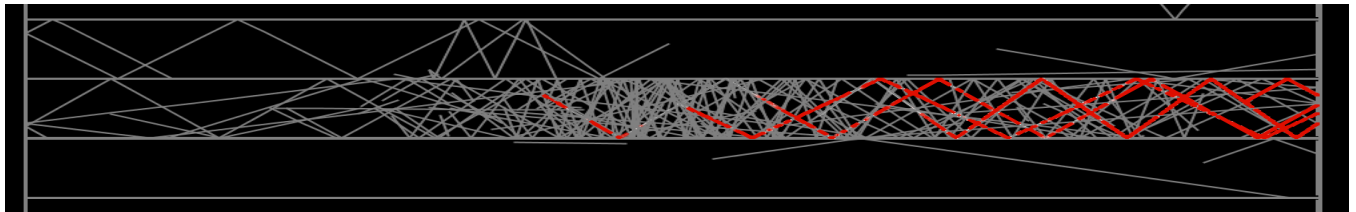


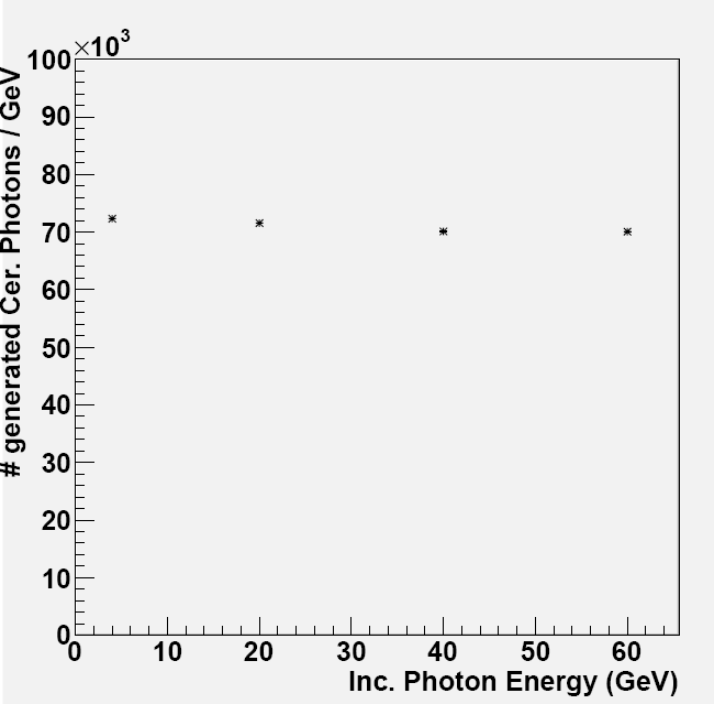
For a 40 GeV incident photon.

The z distribution of the point of generation for Cerenkov photons (red).

The z distribution of the point of generation for detected Cerenkov photons (black).



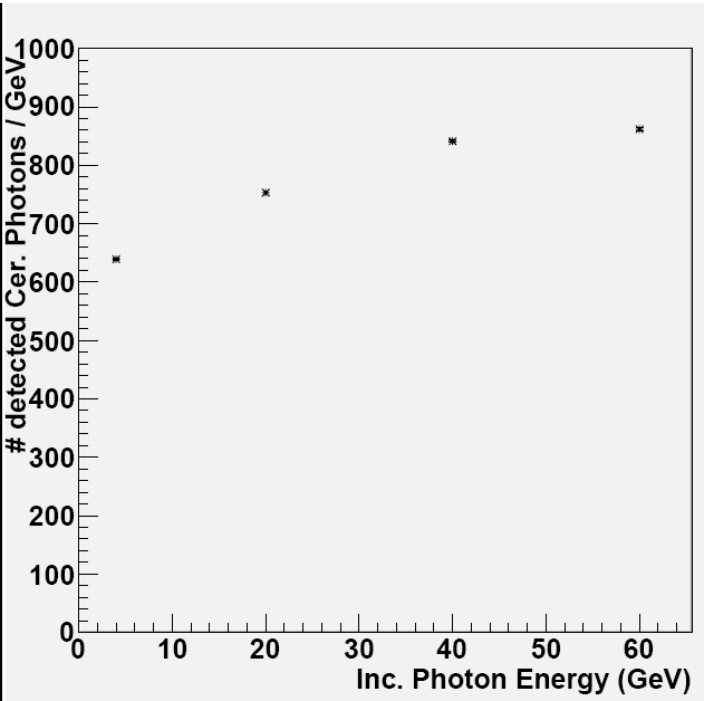




Number of Generated Cerenkov Photons

~ 70000 Photons/GeV

Independent of Photon Energy



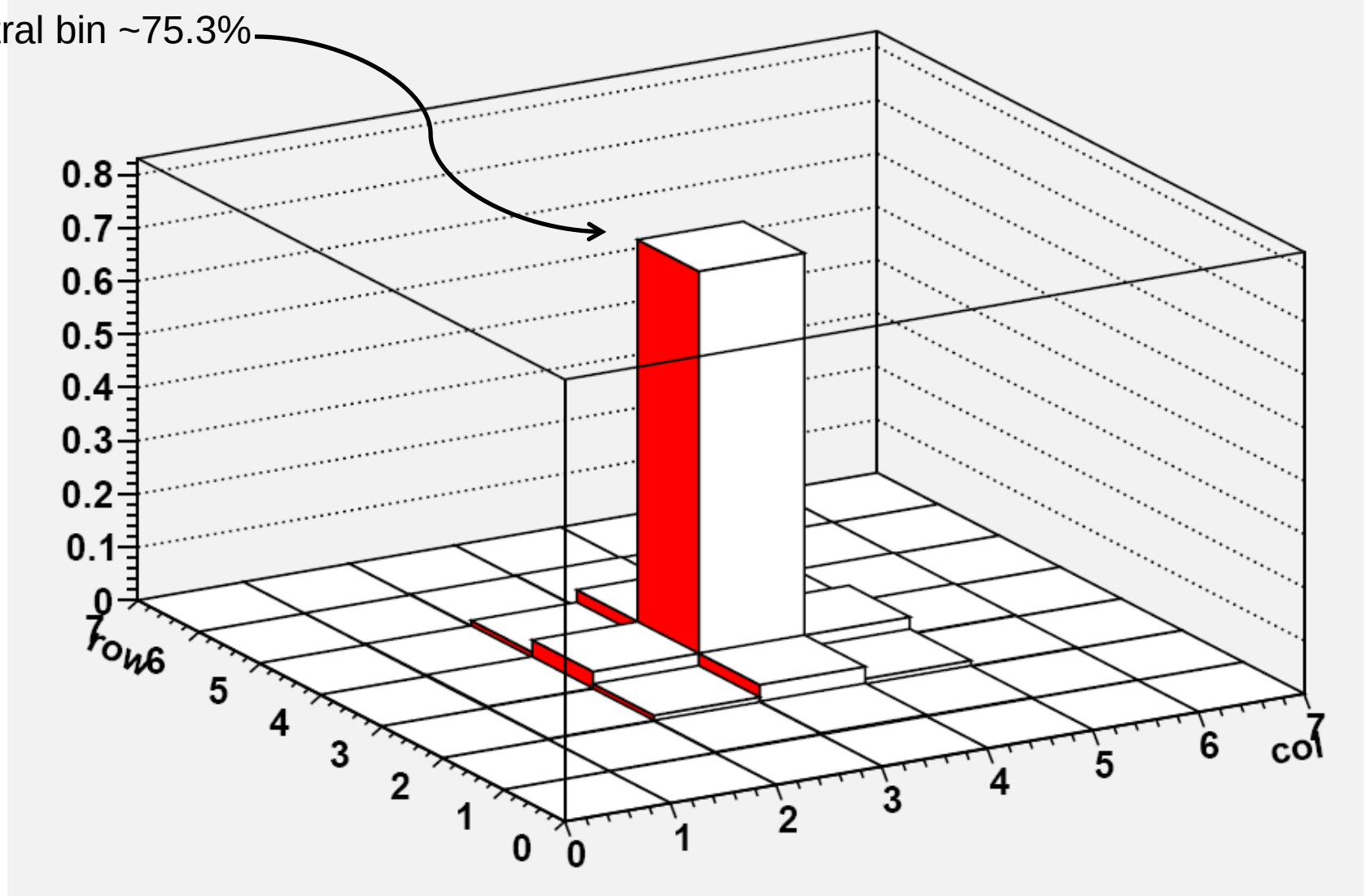
Number of Detected Cerenkov Photons

600 to 800 Photons/GeV

30% CHANGE IN NUMBER
for Energy from 4 to 60 GeV

For 40 GeV incident photon:

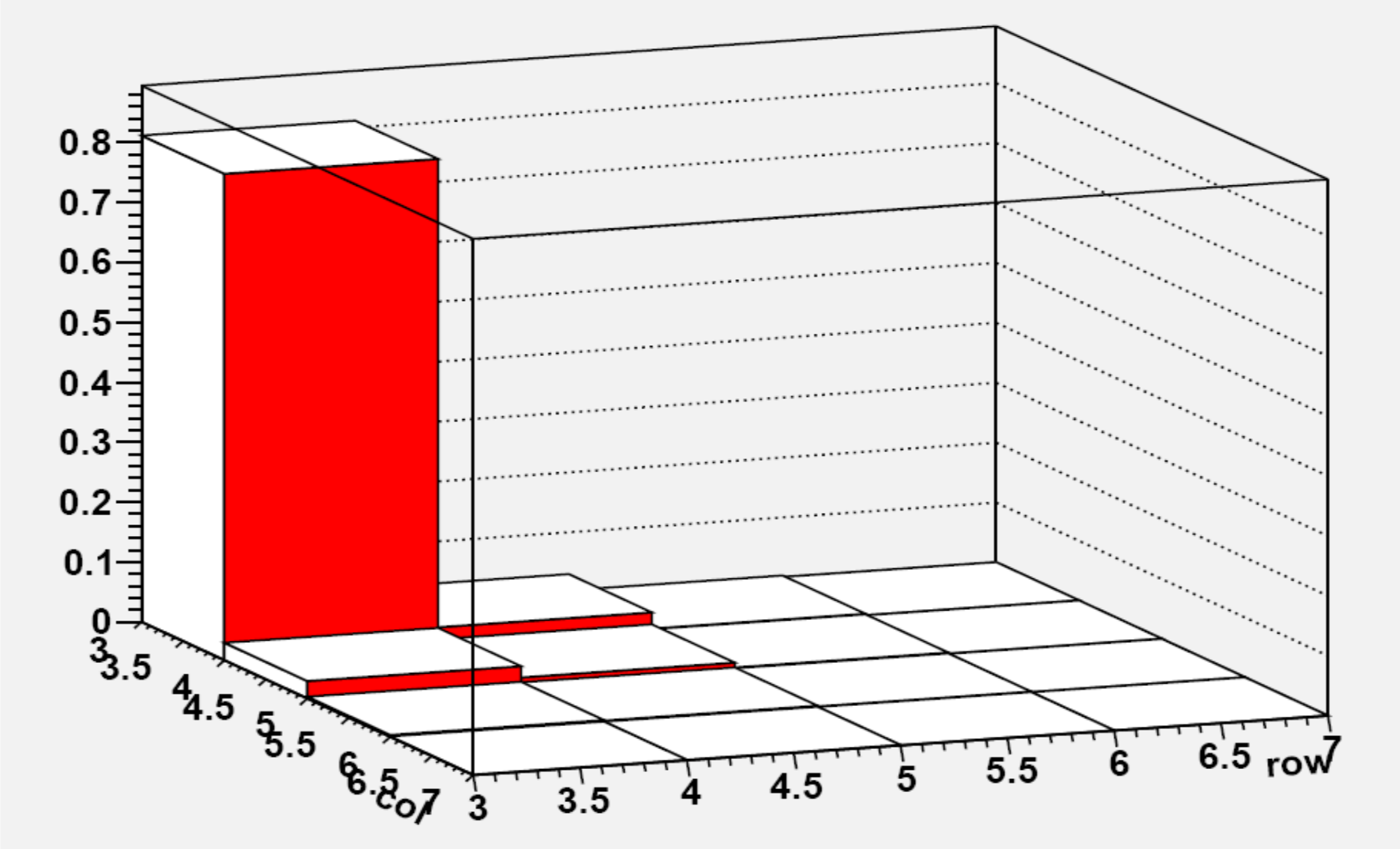
Shower shape for central (normal) photon with measurement **based on energy deposition.**



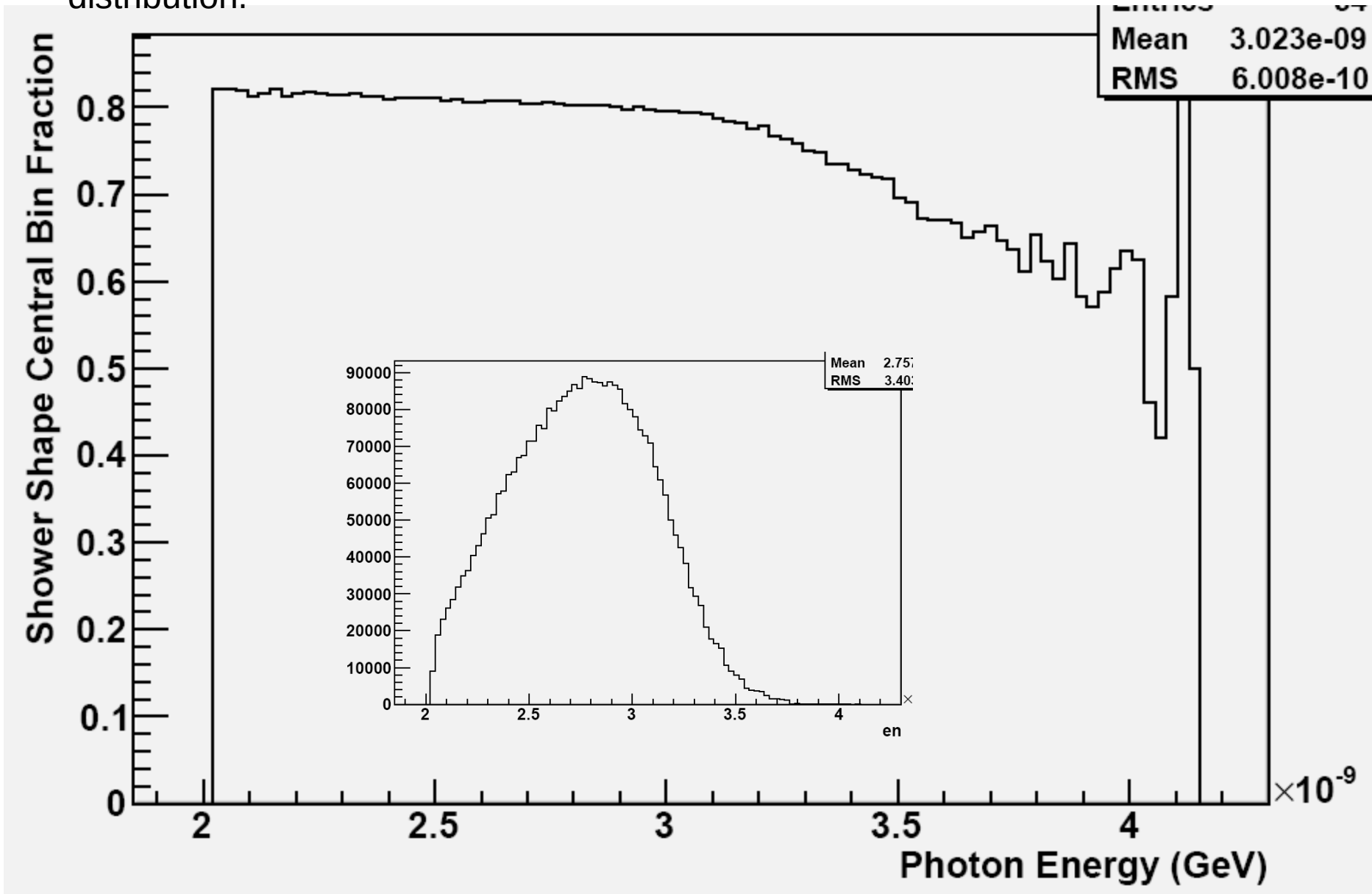
Ephoton = 40 GeV

Shower Shape based on detected Cerenkov Photon count.

Peak fraction = 80.4%



For 40 GeV photons, the fraction of detected Cerenkov photons in the central bin is shown with an inset showing the actual detected energy distribution.



Model 2

Pb Glass (same as GSTAR)

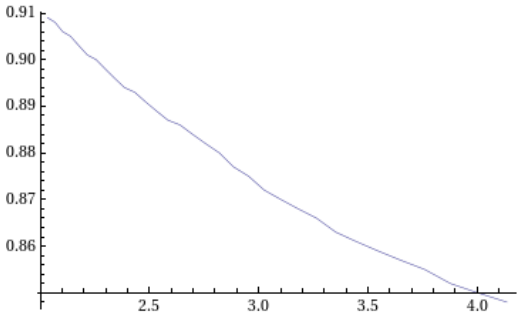
Cerenkov Photon Signal.

Photo cathode efficiency set by hand.

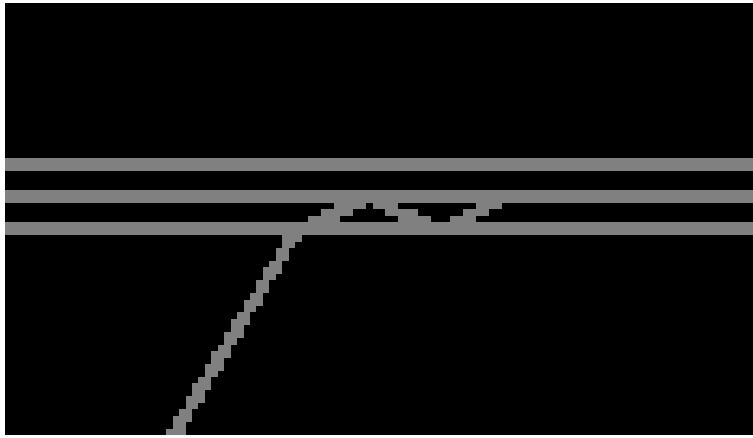
Surface with a air gap backed up by aluminum.

Internal Reflection at glass to air interface.

Reflection from graph at air to aluminum interface (as before)

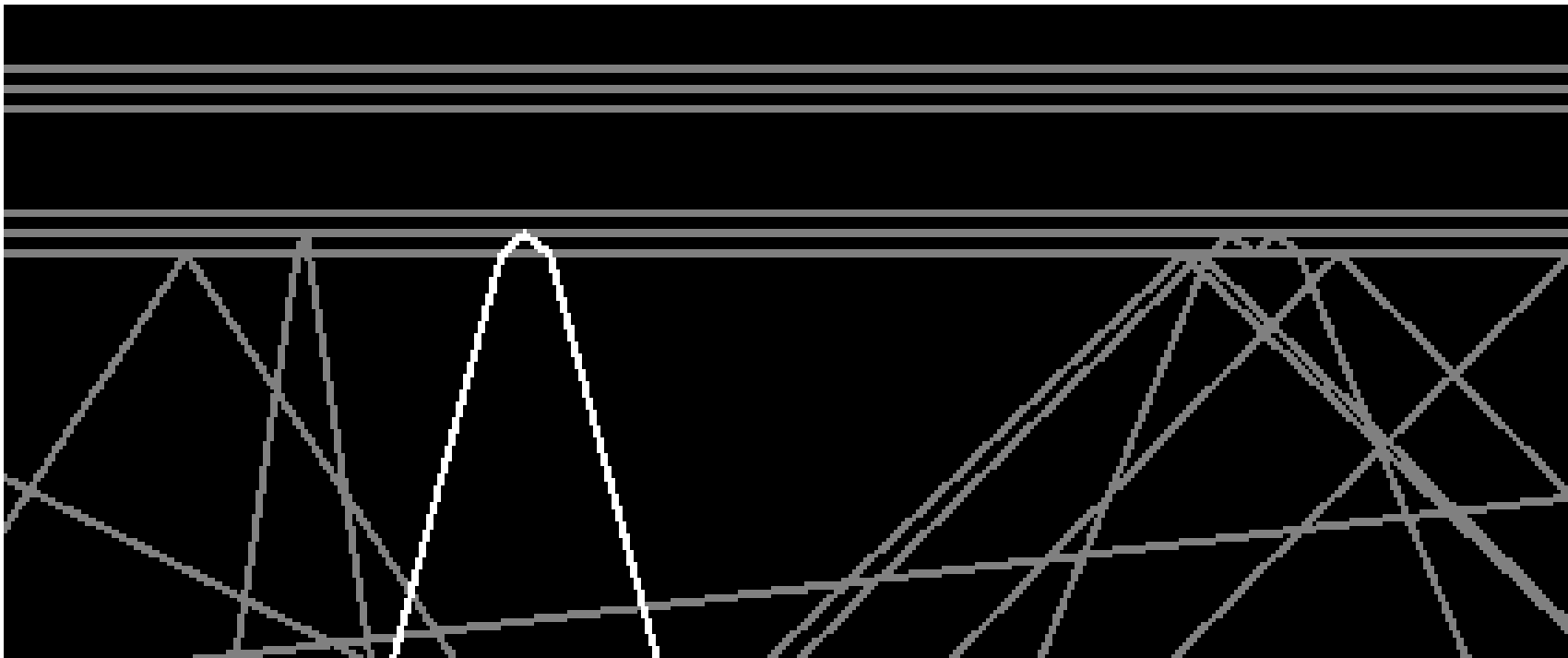


Air-Aluminum Surface Absorption



Air Layer

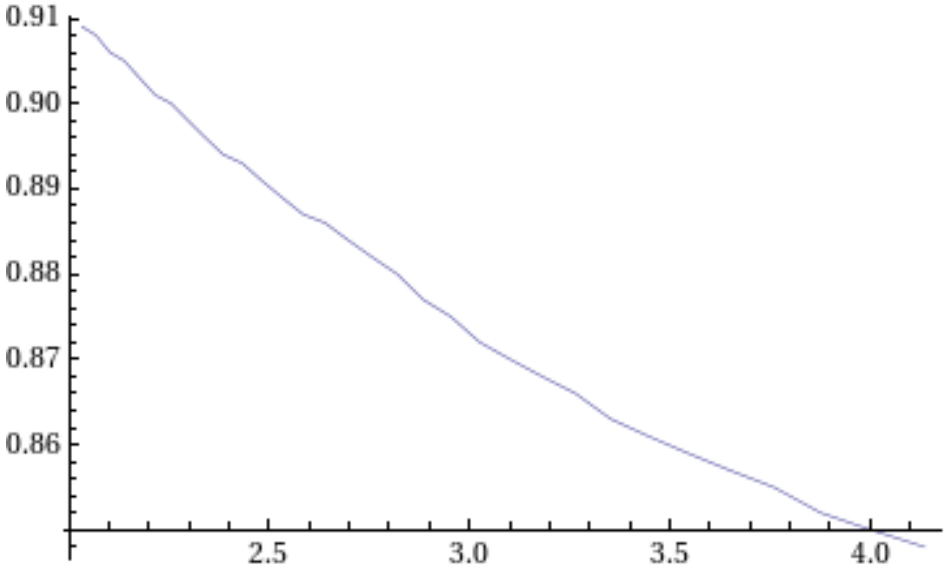
Aluminum Layer



Pb Glass

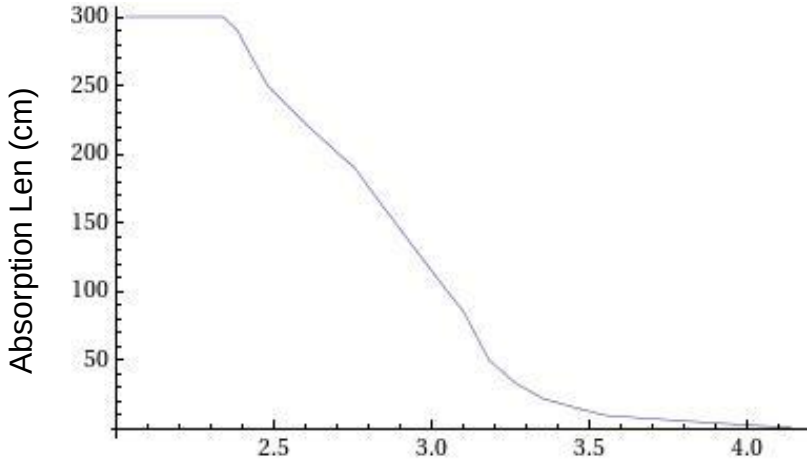
Without P. Cathod Eff.
70,000 PE/Gev

With P.Cathode Eff applied.
For Abs Glass = 4000 cm
For Reflectivity = .999
For Abs Al-Air from graph
@10 GeV
7000 PE/GeV



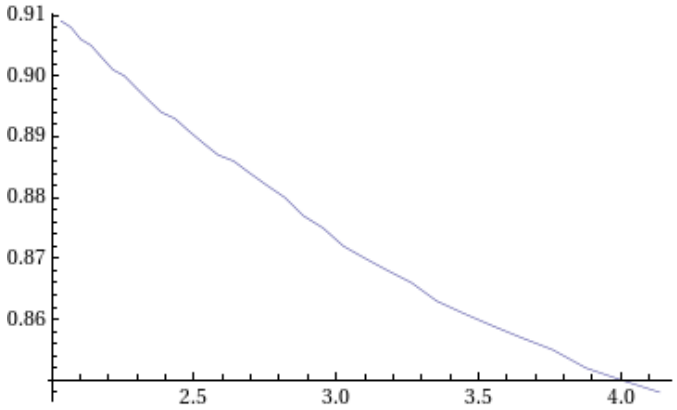
With P.Cathode Eff applied.
For Abs Glass = 4000 cm
For Abs Al-Air from graph
@10 GeV
4900 PE/GeV
% central bin = 83.8 %

For Abs Glass = graph on right
For Abs Al-Air from graph
@10 GeV

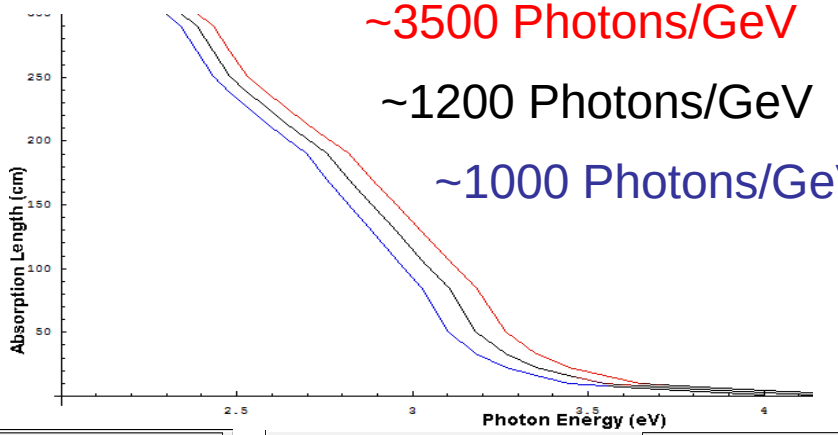


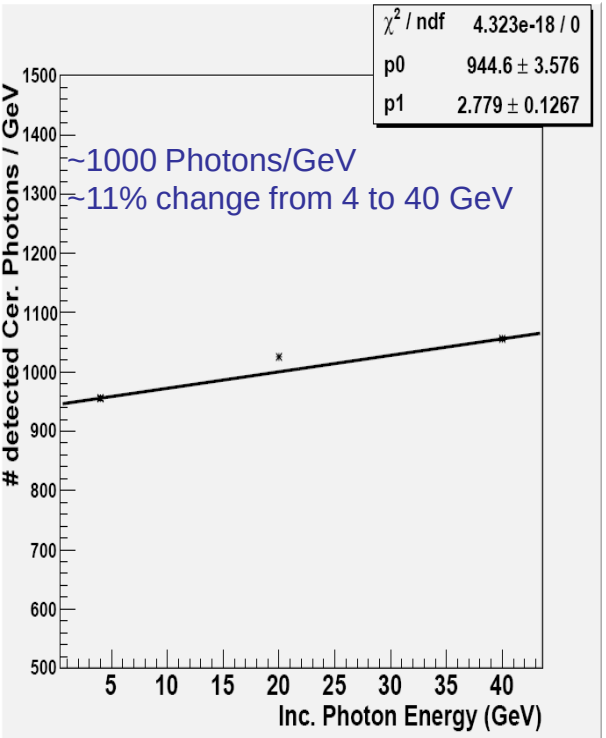
1200 Cer photons / GeV
% central bin = 83. %

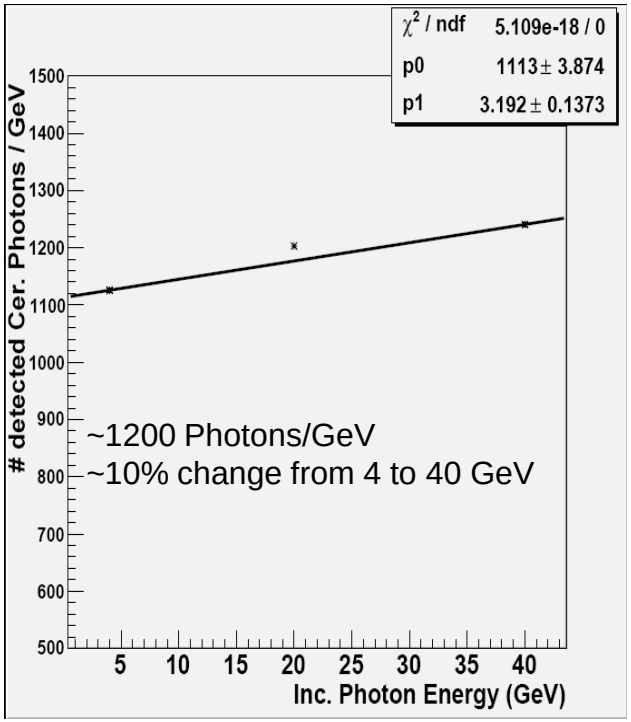
Using PbGl-Air-Aluminum with Air aluminum reflectivity

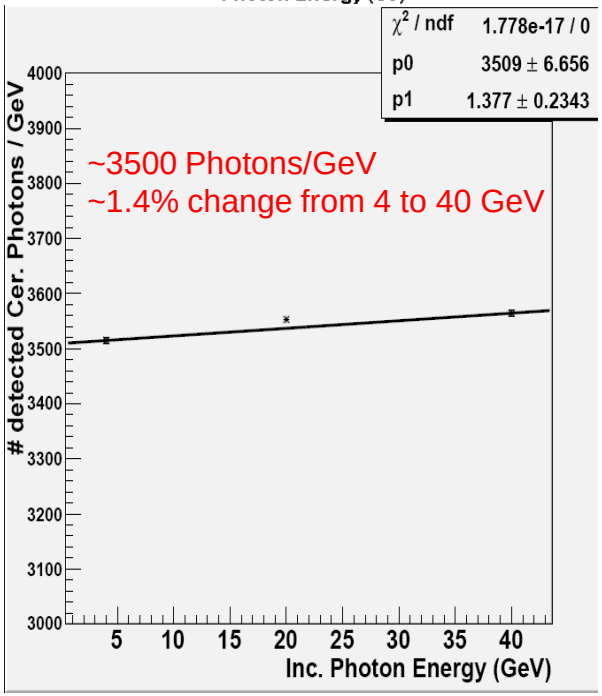


Vary the air-aluminum absorption by shifting in absorption vs energy









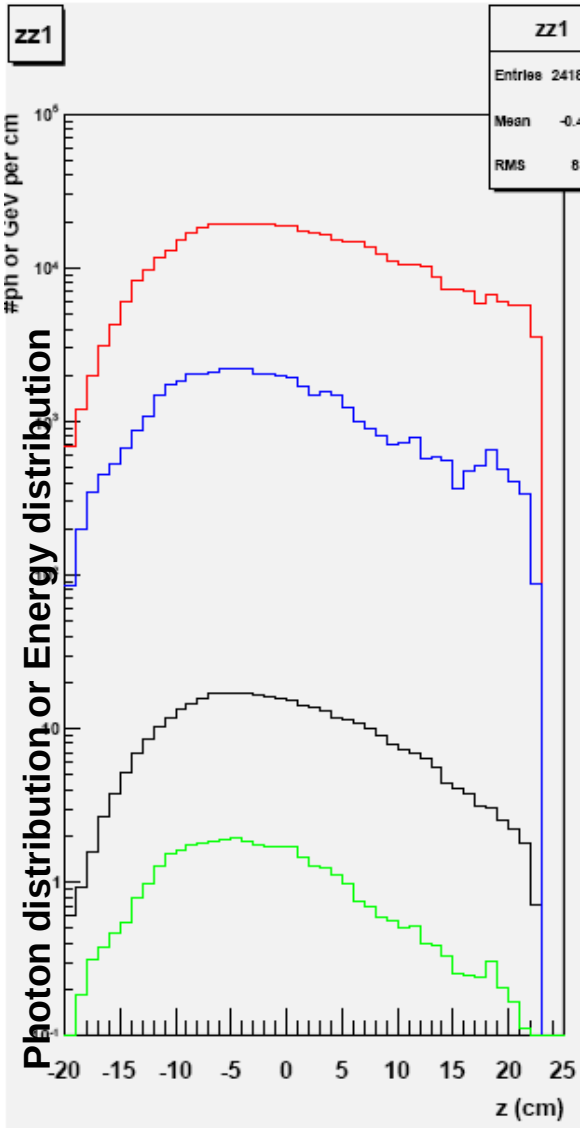
The shower shape is most narrow in the upstream region (center bin>90%)
The shape is most wide in the downstream region (center bin ~ 50%)
The shape is narrower about (central bin 5% to 10% larger) for Cerenkov photons than deposited energy.

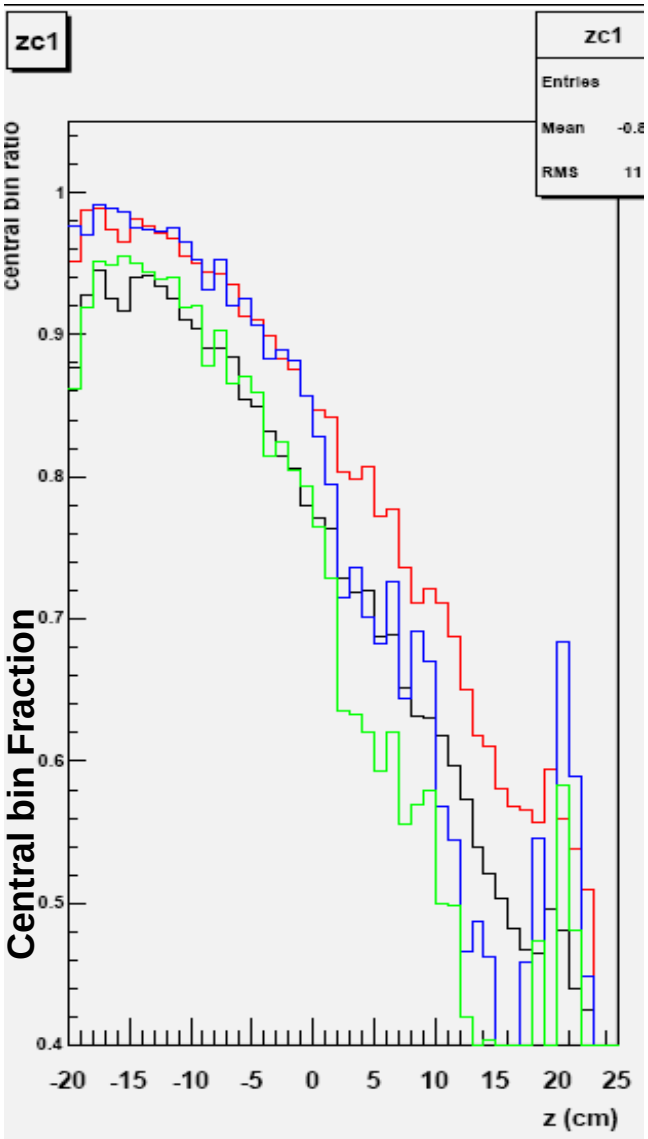
40 GeV (# photons detected)

4 GeV (# photons detected)

40 GeV (energy deposited)

4 GeV (energy deposited)





Summary of Geant4 small cell studies.

- **Two observables**
  - **Width of Shower (% in central bin)**
  - **Gain vs Energy**

•The shower width appears narrower in Run 9 FMS than Run 6 FPD
• The FMS appears to have more energy dependence of the gain than the FPD

• The effect of observing Cerenkov photons would be a narrower shower (~5 to10%) for central bin in comparison to the energy deposition shape.

• Radiation damage will shift the absorption spectrum to lower energy.
  • This would lead to an increase in energy dependence of gain. (as seen in FMS)
  • This would lead to a widening of the shower (in contrast to what is seen in the FMS)

•The extra lead glass in front of small cells may also widen the Run 6 FPD result in comparison the FPD Run 9 result.