ZDC-h simulation

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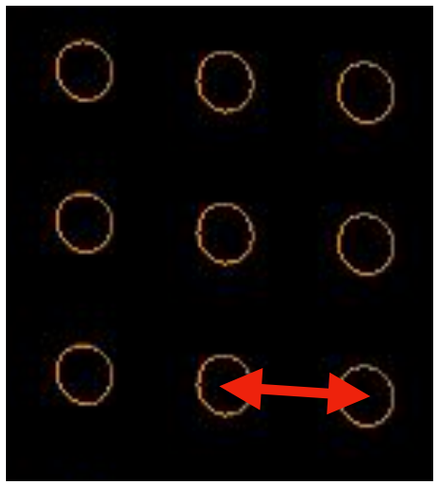
Geometry

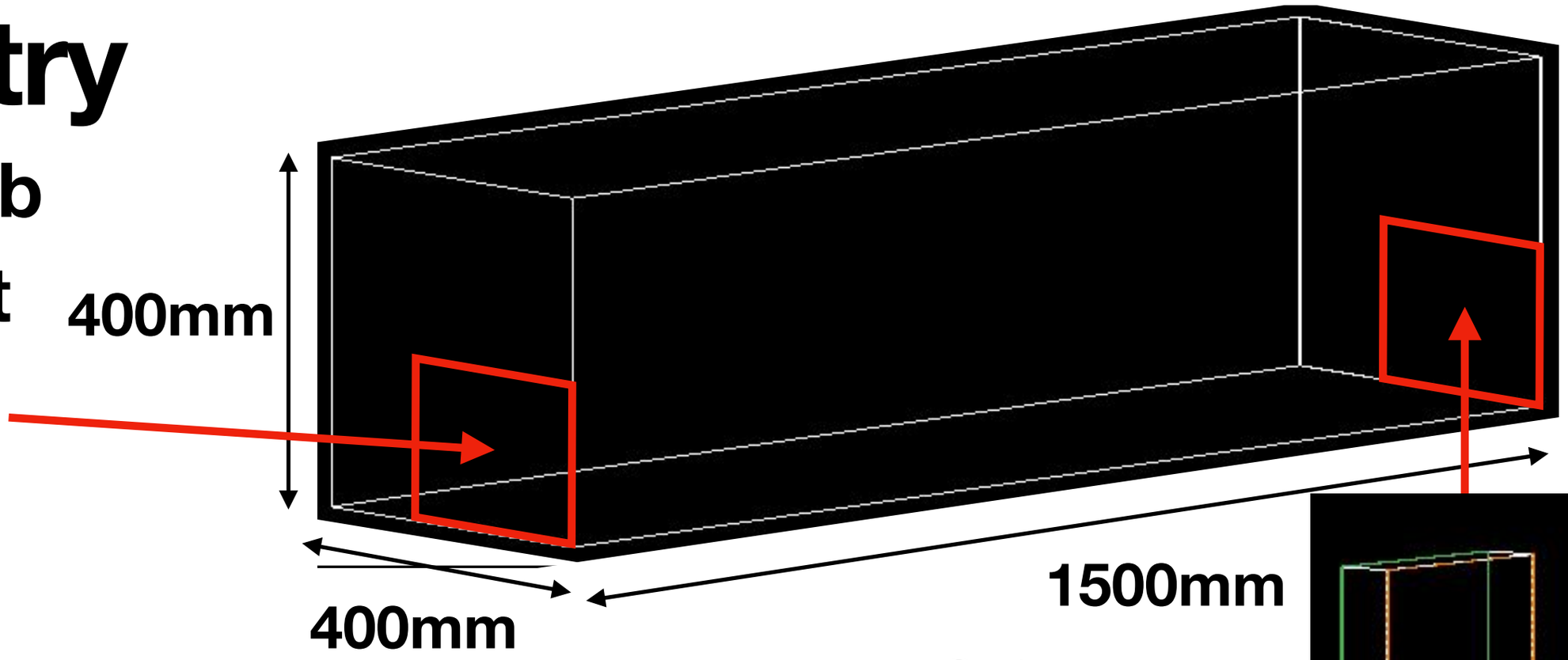
Material : Pb

Fiber : scint



Fiber to fiber 2.5mm

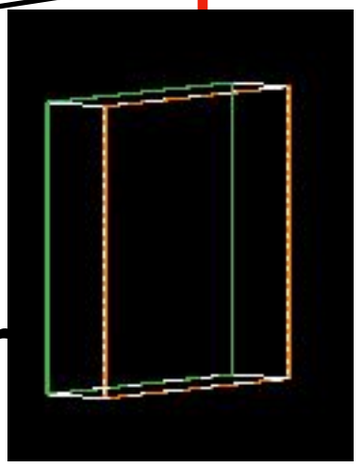
Num of fiber 160 x 160

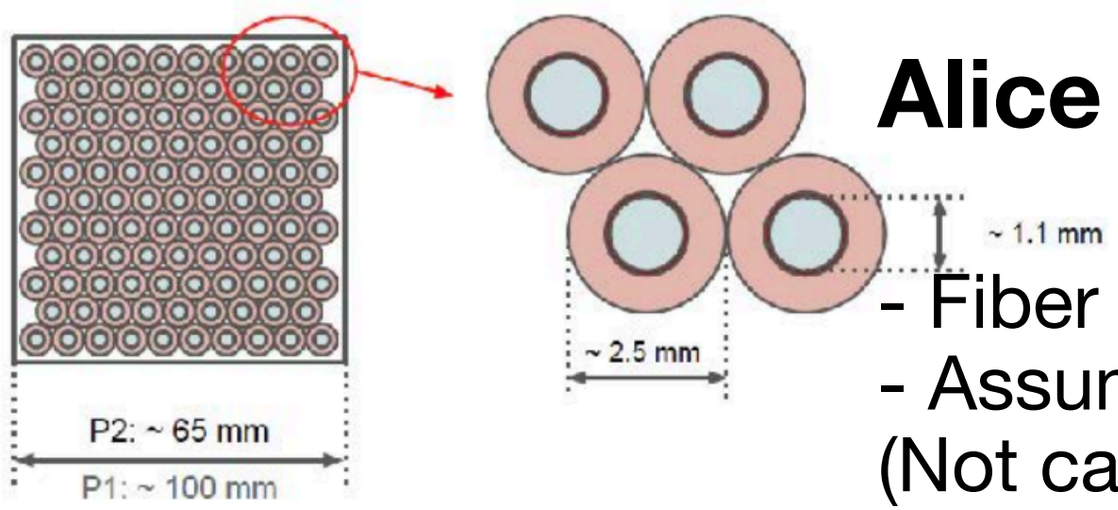


SiPM+

Filter for scintillator

One SiPM by one fiber



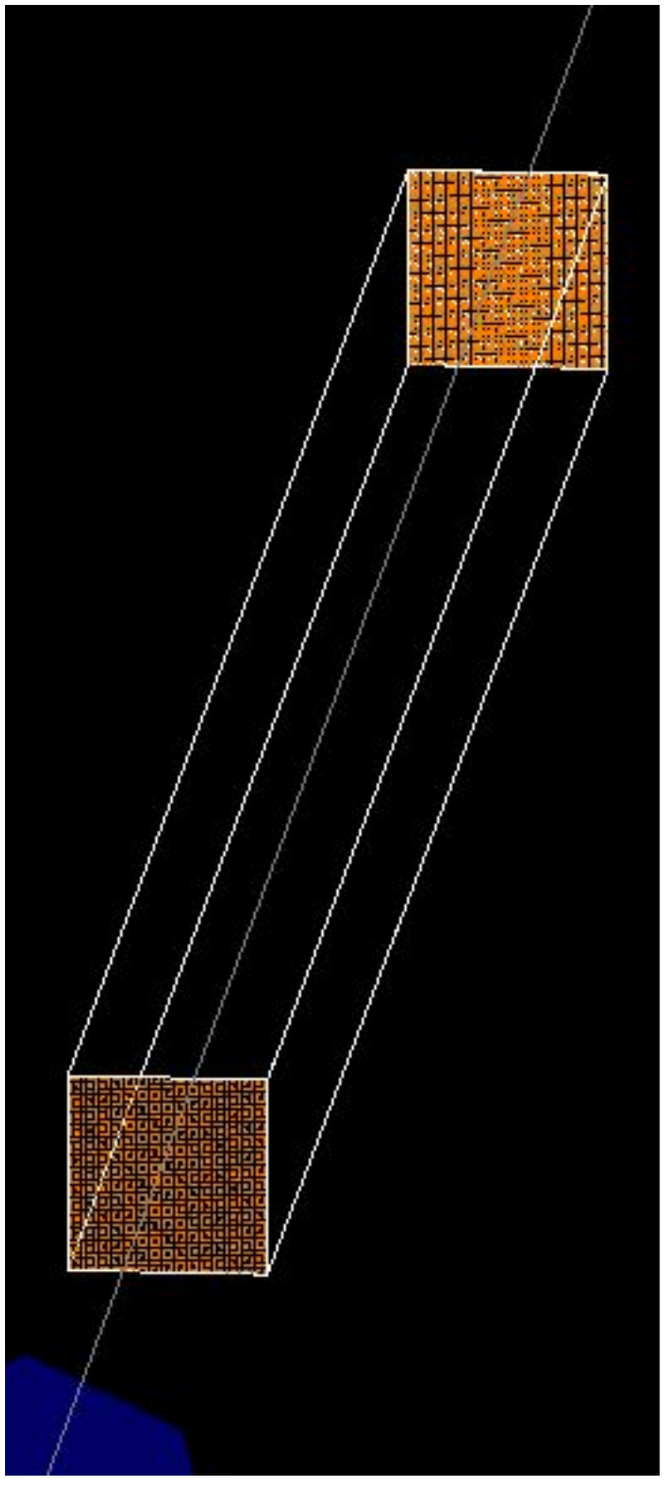


Alice FoCal-H

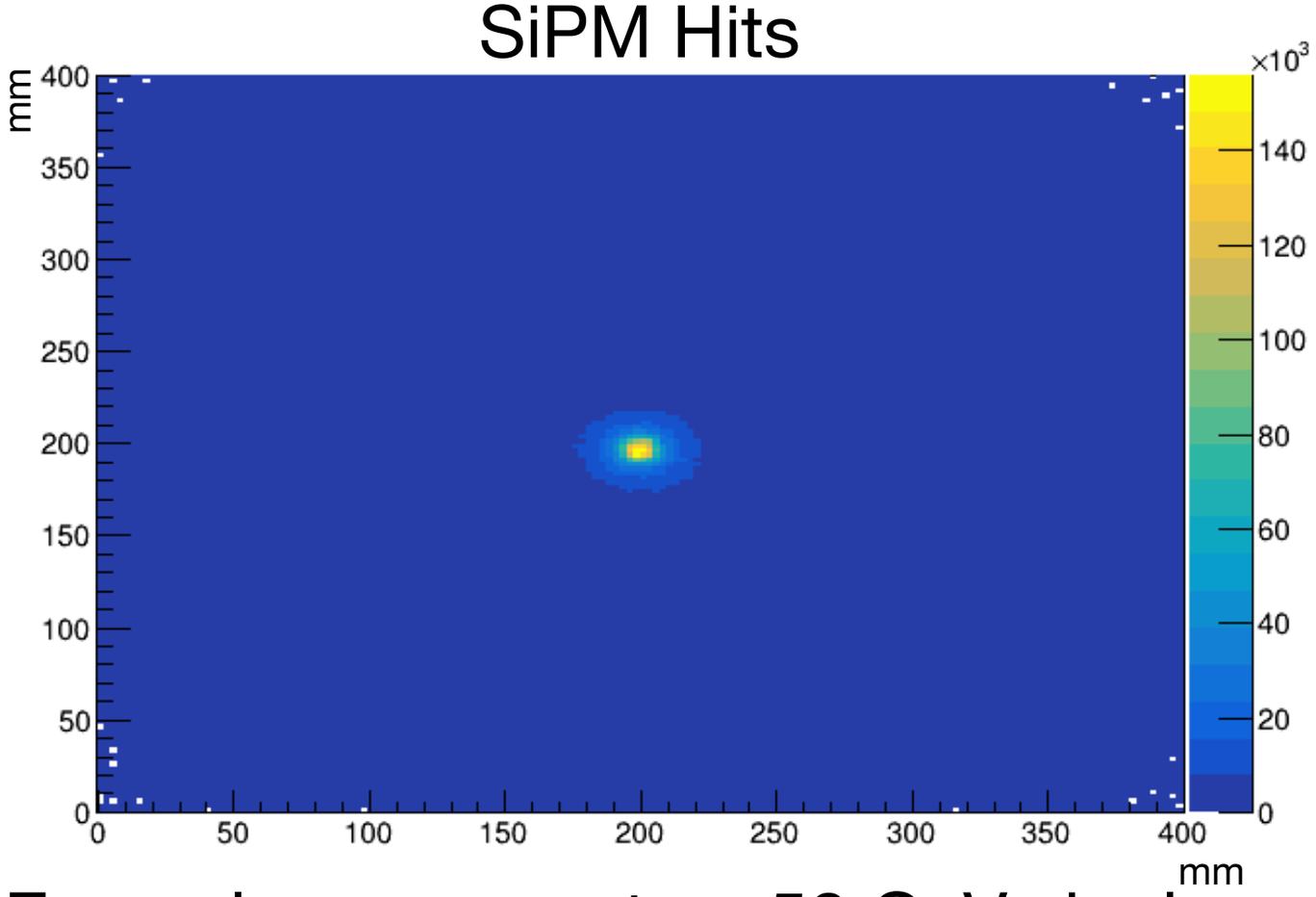
Alice Focal-h as the reference

- Fiber size and spacing
- Assumed Pb fills the rest space between fibers (Not capillary structure)
- All fibers are scintillating fibers

Neutron Beam



Ex) 80 x 80 x 1500 module particle: geantino

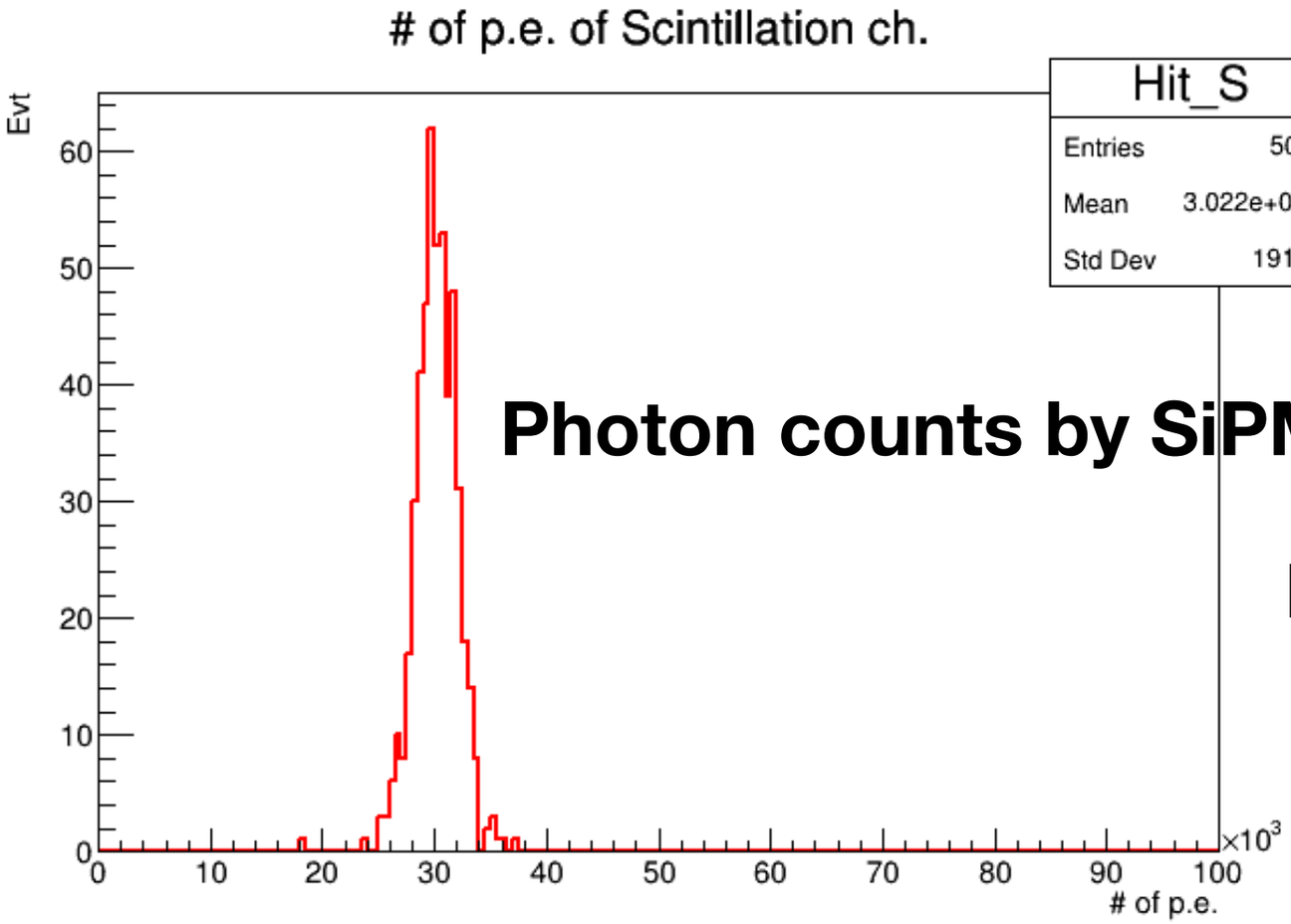


Example response to a 50 GeV single neutron

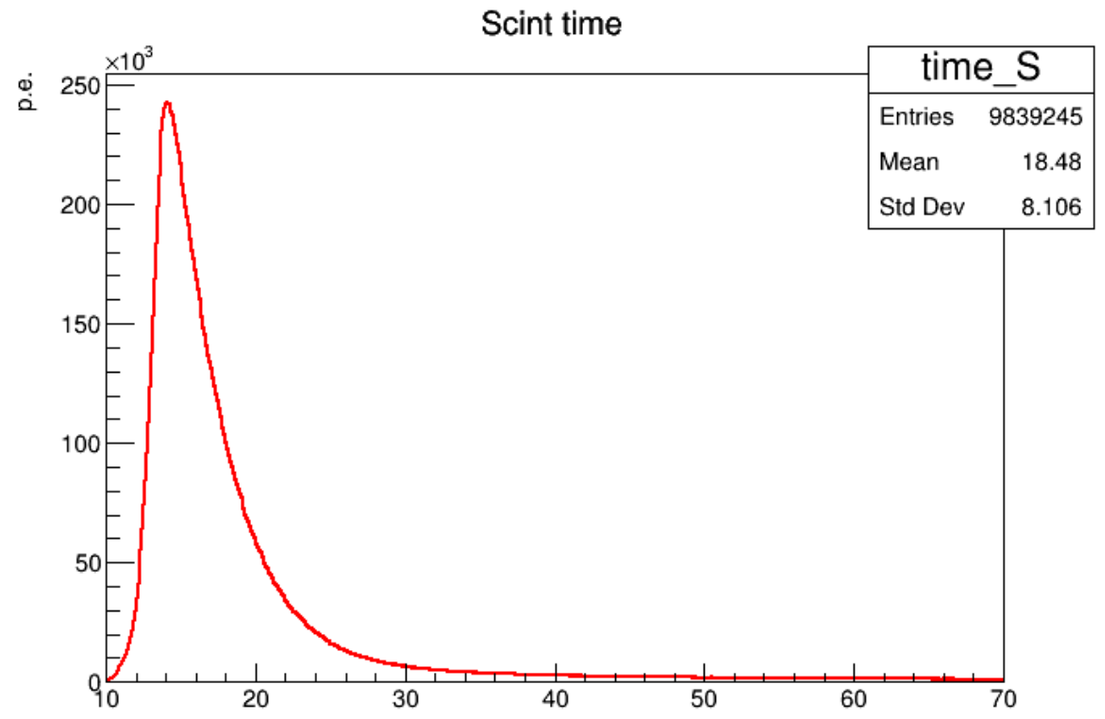
We tried 50 GeV neutron beam

- Normal angle: 4m rad (= EIC forward aperture angle)
- Caveat: no ZDC-e ahead in this study yet

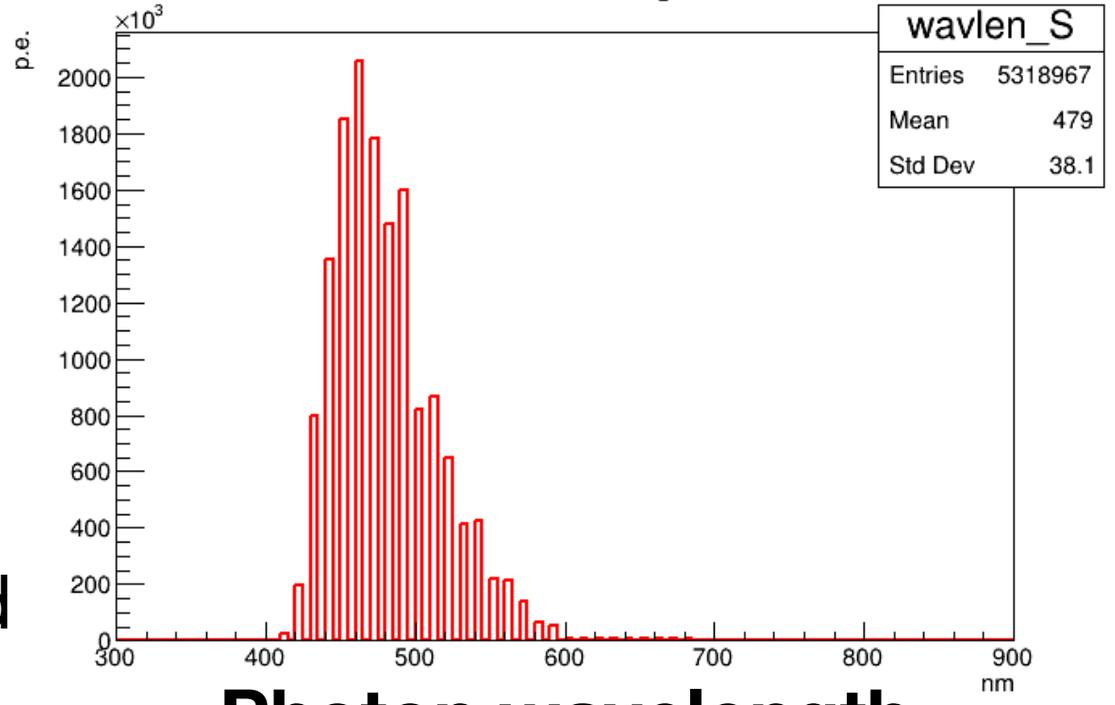
500 MC events



Photon counts by SiPM



Photon's arrival time to reach SiPM



Photon wavelength

Response to 50 GeV neutron

- ΔE/E = 6.3% = 44% / sqrt(E)
- Caveat 1: No ZDC-e ahead
- Caveat 2: We assumed SiPM attached to every fiber, thus resolution is overestimated

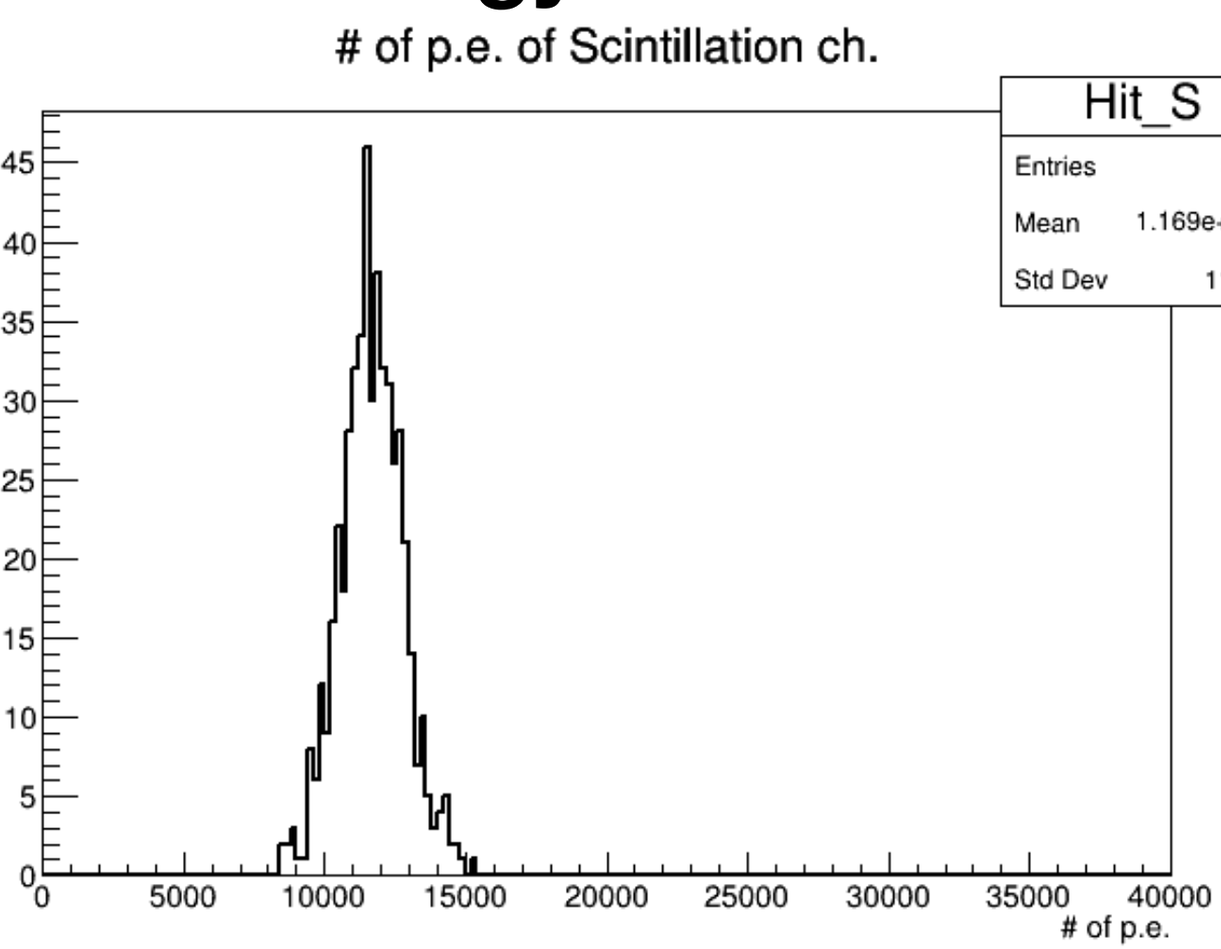
Calibration Based on 20 GeV neutron

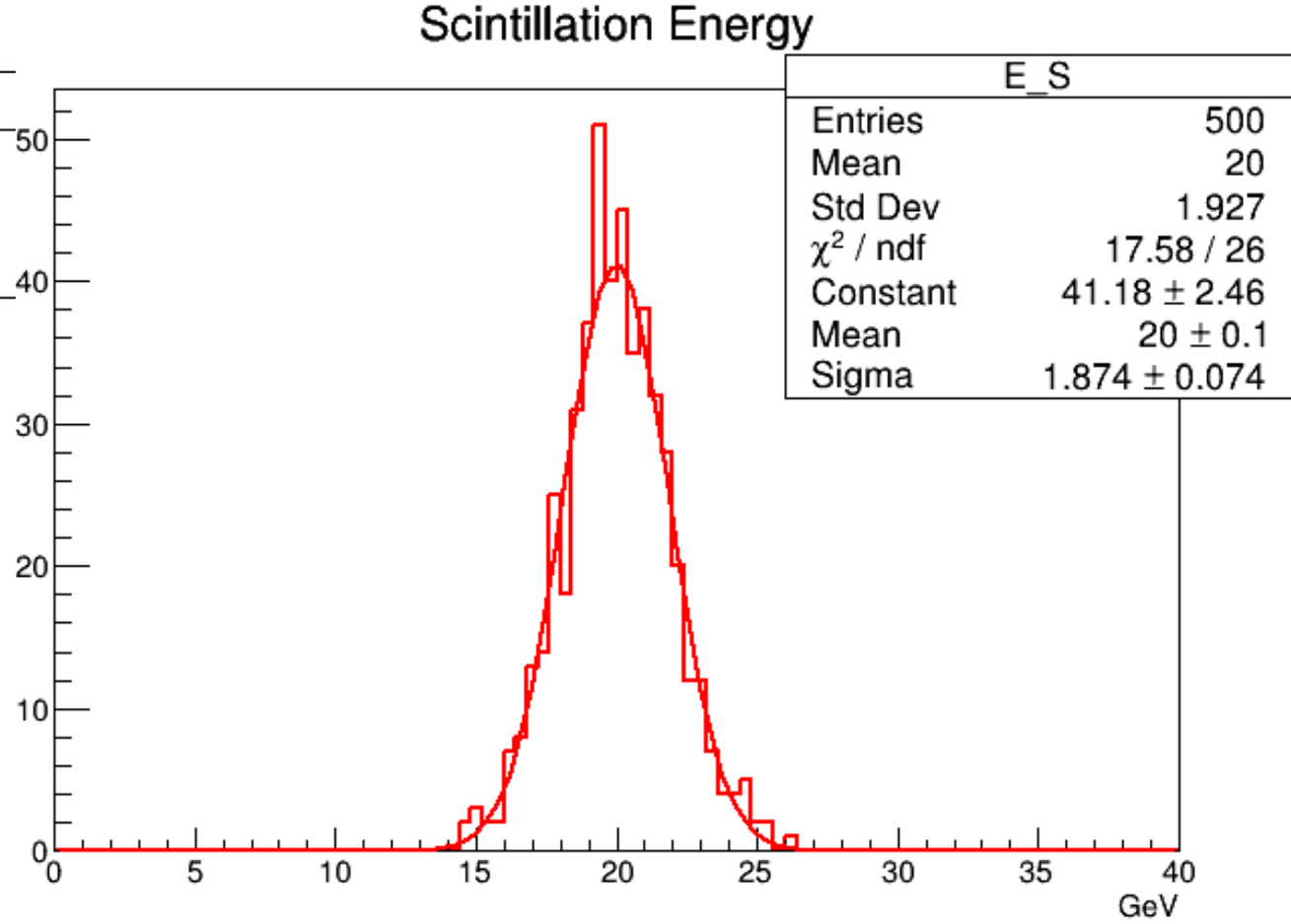
- Energy is propotional to the number of photo-electrons
- Simulation is used to obtain in the scale factors

# of photon = 11690

Energy = 20GeV

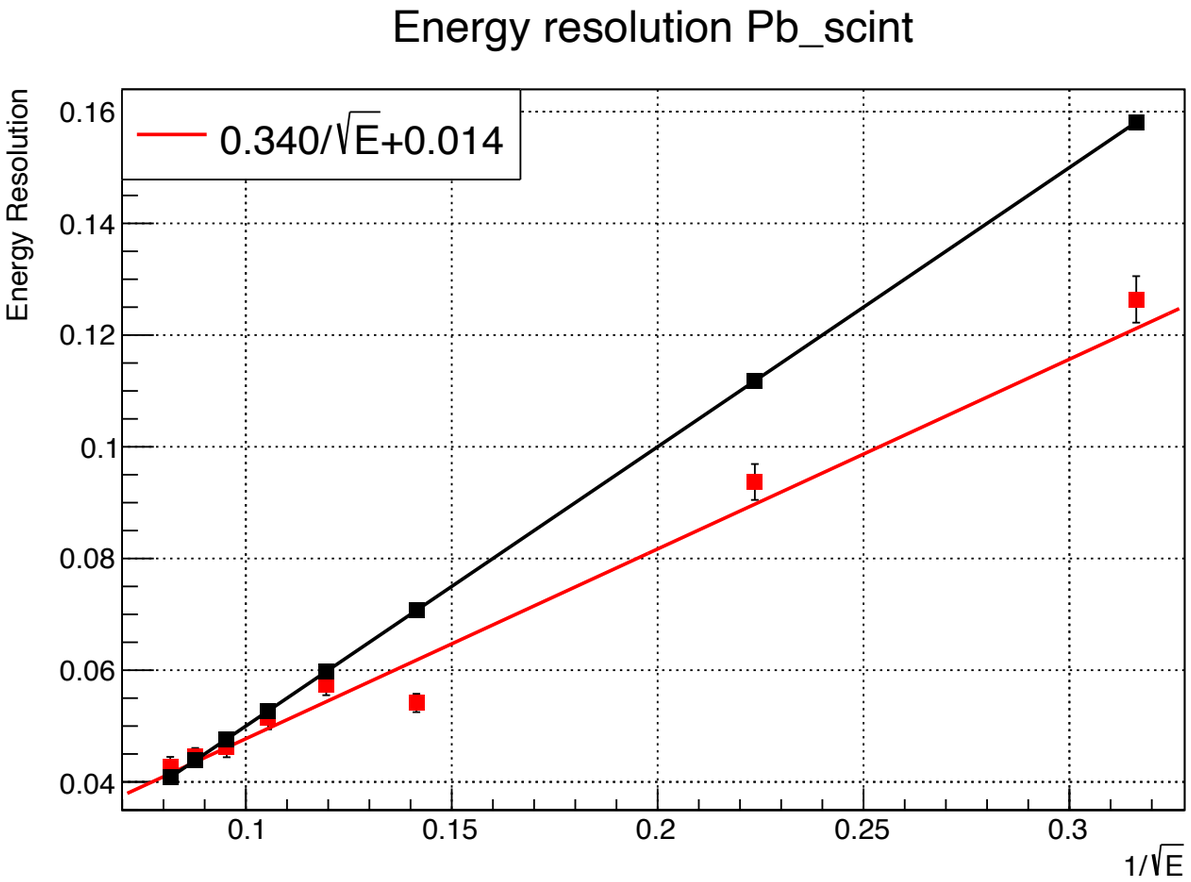
Scale factor = 20/11690

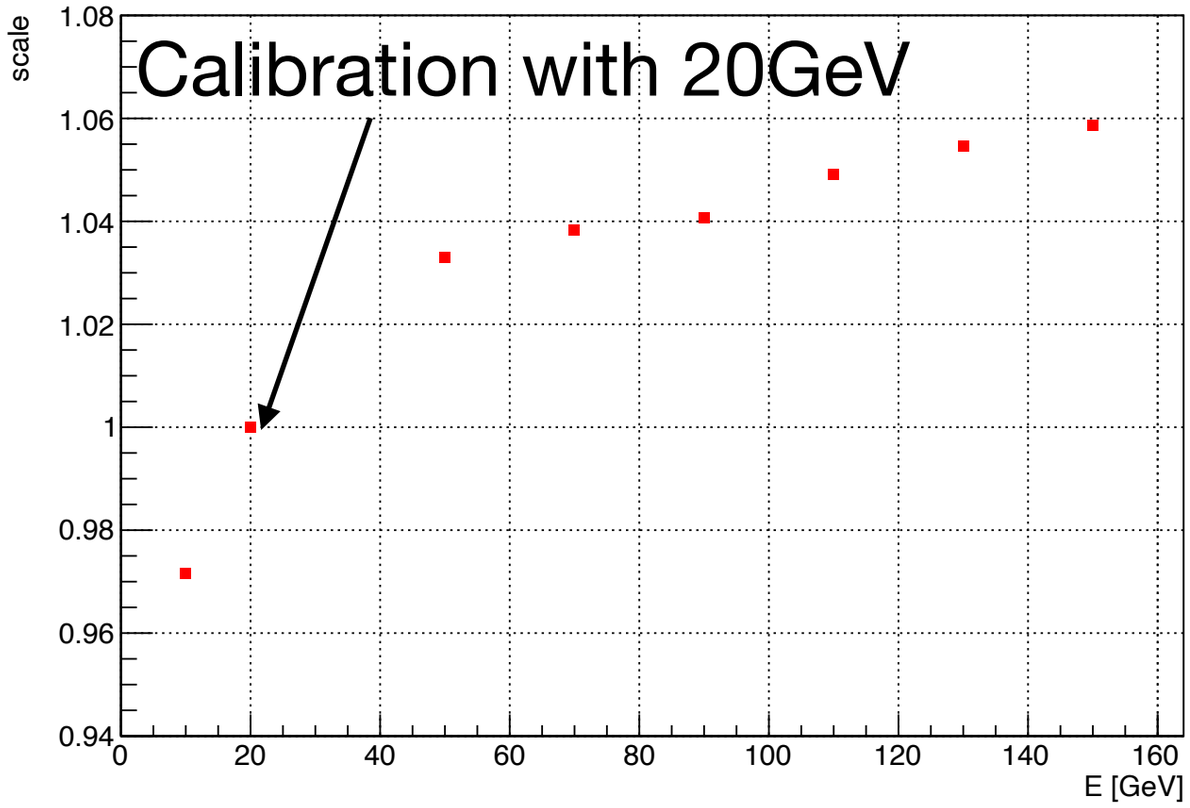




Energy Scale and Resolution

Simulated 8 different neutron energy
10, 20, 50, 70, 90, 110, 130, 150 GeV





Yellow report number = $\dfrac{50\,\%}{\sqrt{E}}$

$\dfrac{50\,\%}{\sqrt{150GeV}} = 4.08$ 4.28% (MC)

$\dfrac{50\,\%}{\sqrt{10GeV}} = 15.8$ 12.6% (MC)

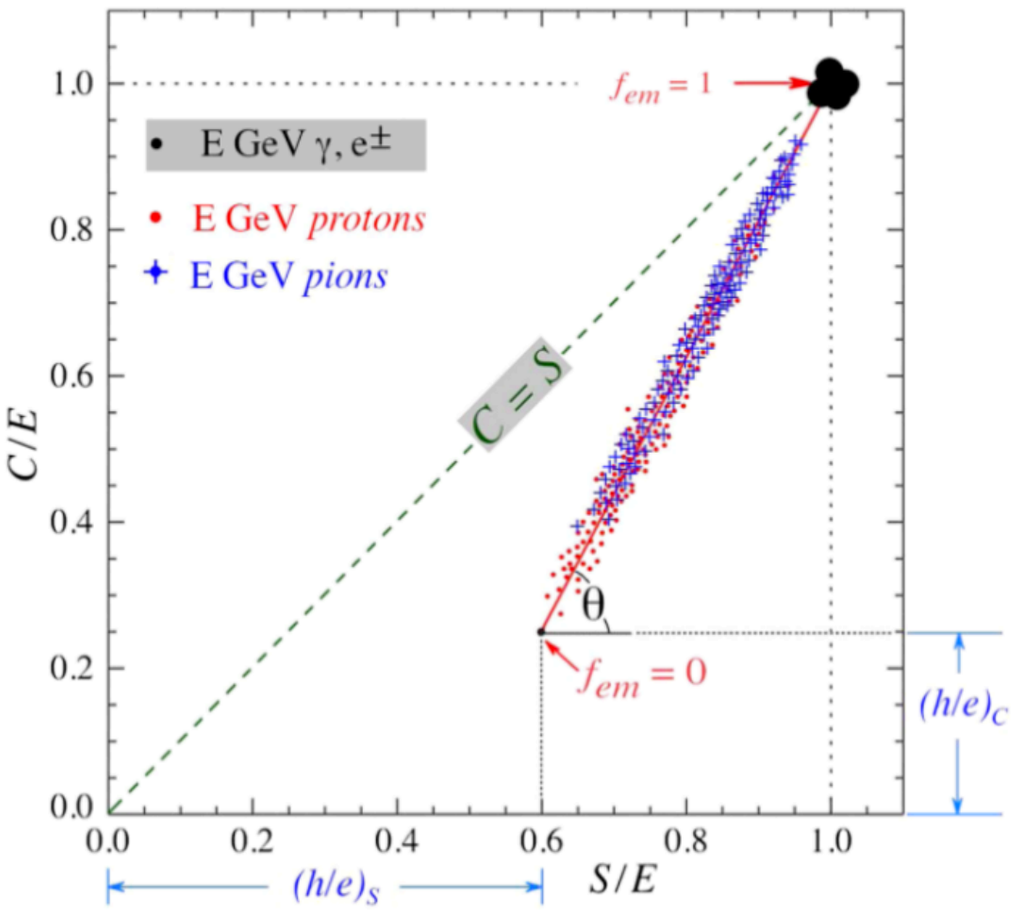
Dual-readout calorimeter

Fiber - scintillating : cherenkov

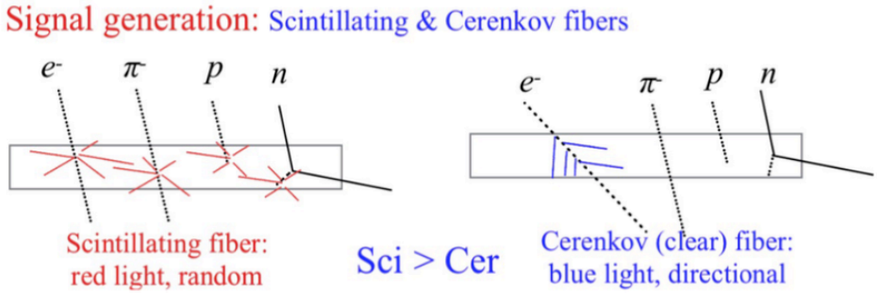
50 : 50

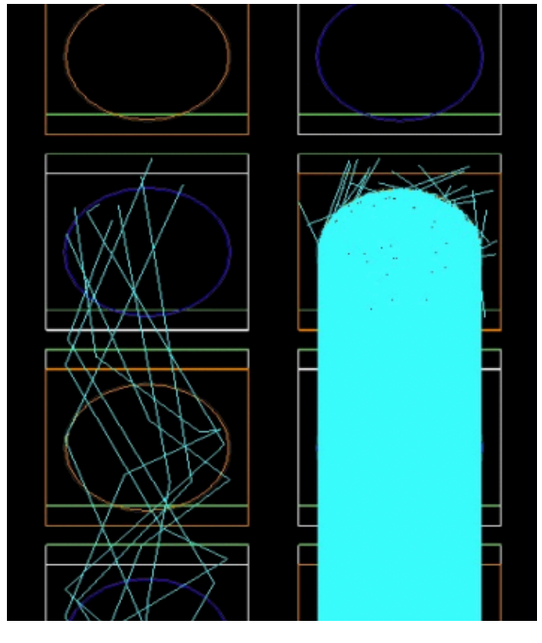
The major difficulty of measuring energy of hadronic showers comes from the fluctuation of EM fraction of a shower, f_em

f_em can be measured by implementing two different Channels with different h/e response in a calorimeter



Energy measured from scintillation channel vs Čerenkov channel for EM particle, π & p





$$S = E[f_{em} + (\frac{h}{e})_S (1 - f_{em})],$$

$$C = E[f_{em} + (\frac{h}{e})_C (1 - f_{em})]$$

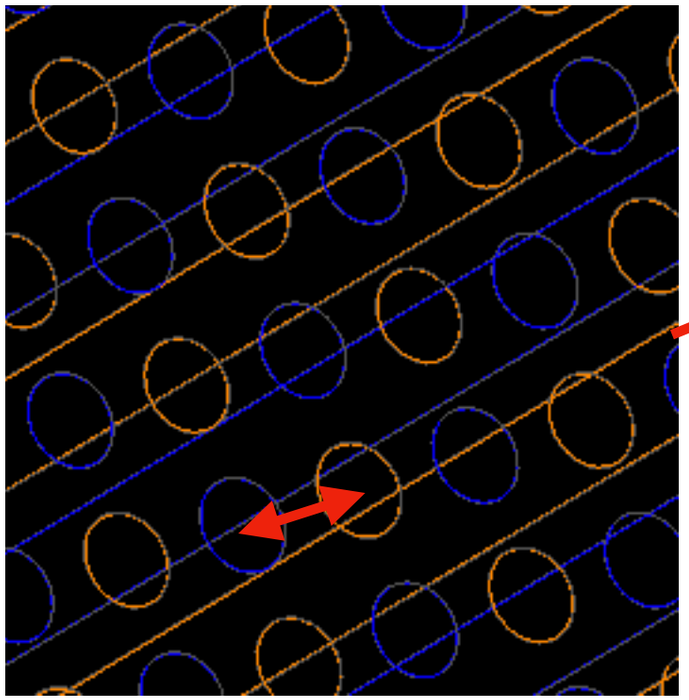
$$f_{em} = \frac{(h/e)_C - (C/S)(h/e)_S}{(C/S)[1-(h/e)_S] - [1-(h/e)_C]}$$

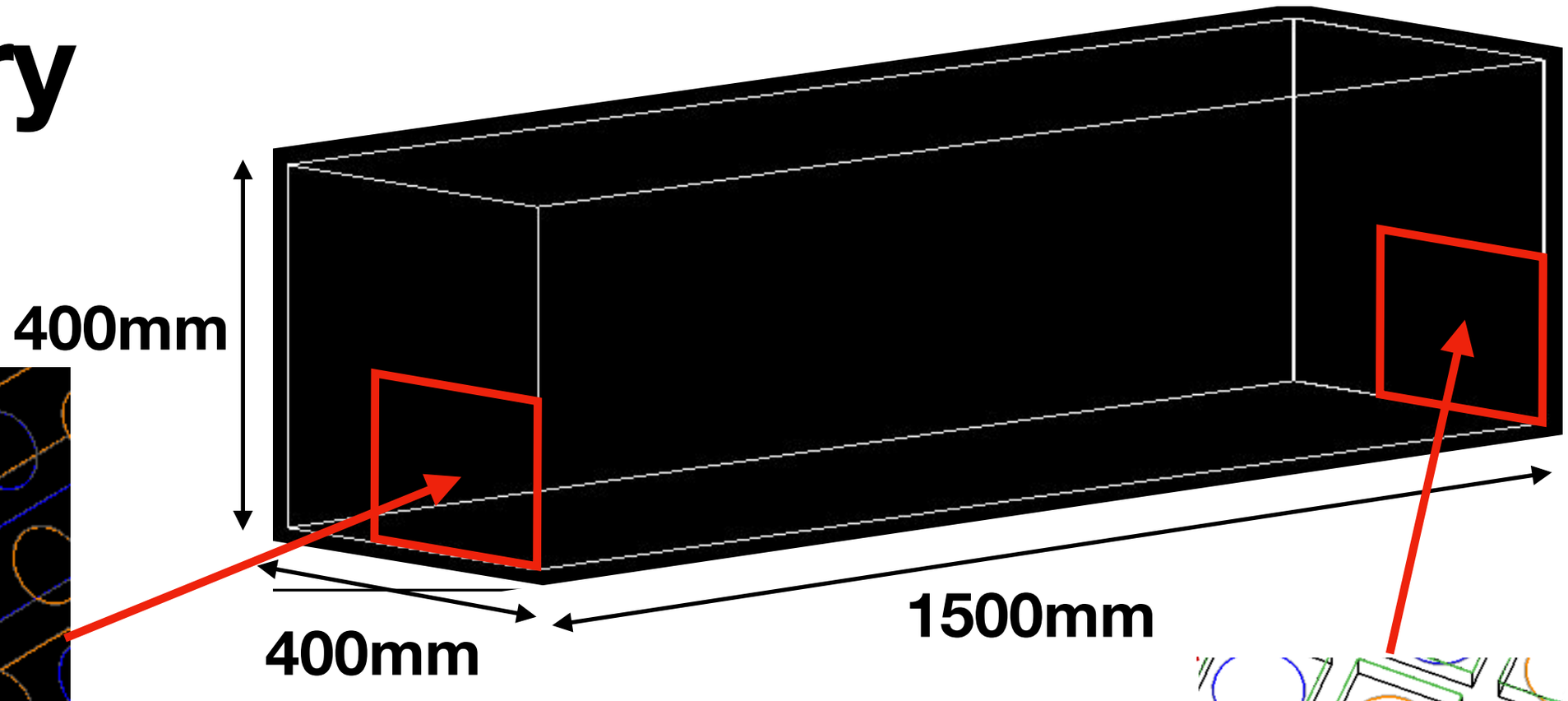
$$\cot\theta = \frac{1-(h/e)_S}{1-(h/e)_C} \equiv \chi,$$

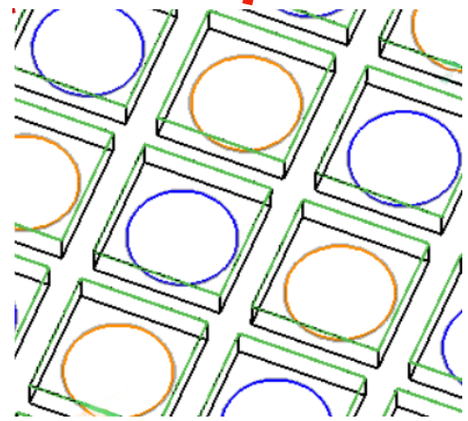
$$E = \frac{S - \chi C}{1 - \chi}$$

Geometry

Material : Pb







SiPM+
Filter for scintillator
& no Filter for Cherenkov

Fiber to fiber 2.5mm
Num of fiber 160 x 160

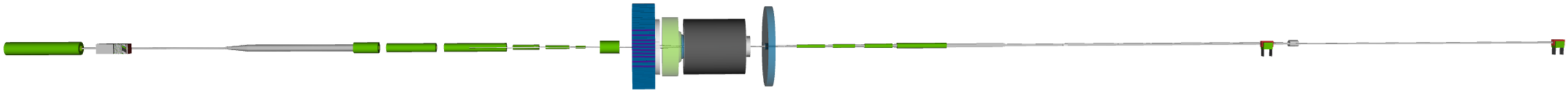
Fiber - scintillating : cherenkov
50 : 50

(No yet result)

EPIC-software

1.Setting up Environment ✔

2.Geometry (I’m working on it)

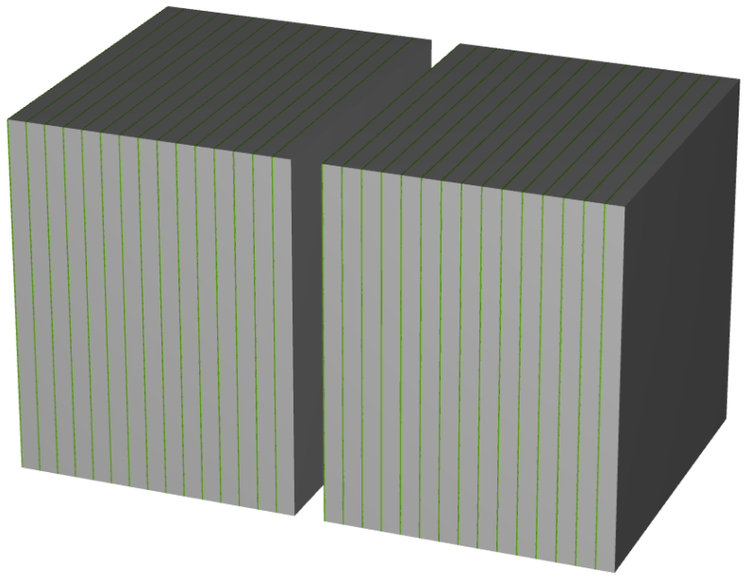


3.Readout & Geant4 simulation

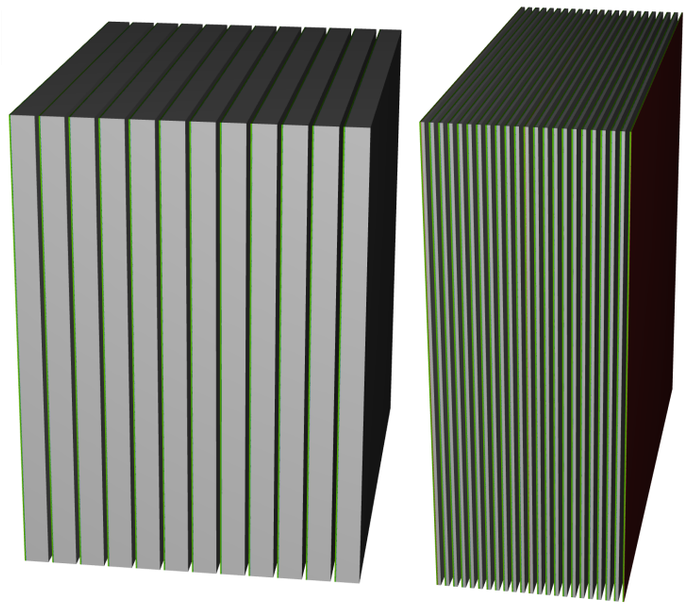
EPIC-software

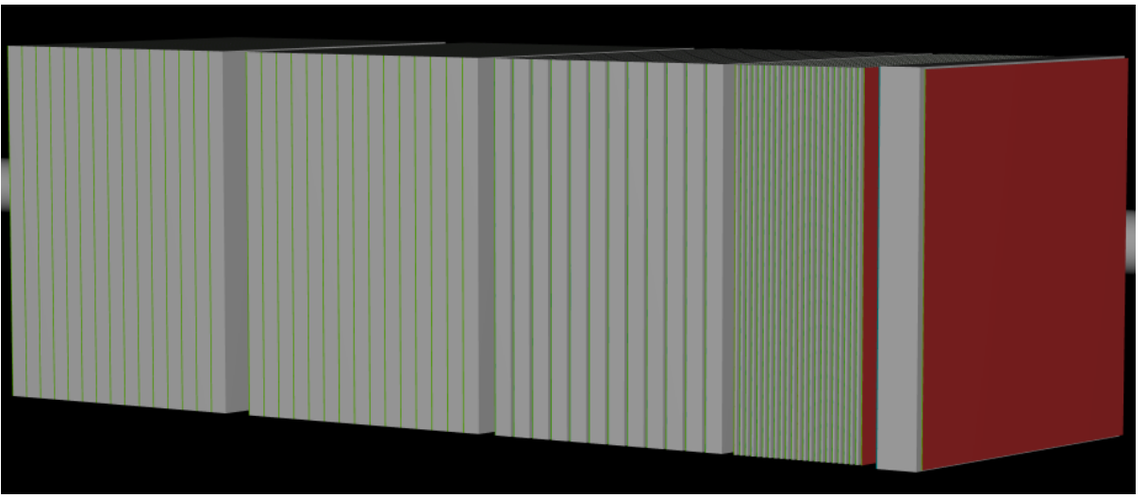
Geometry

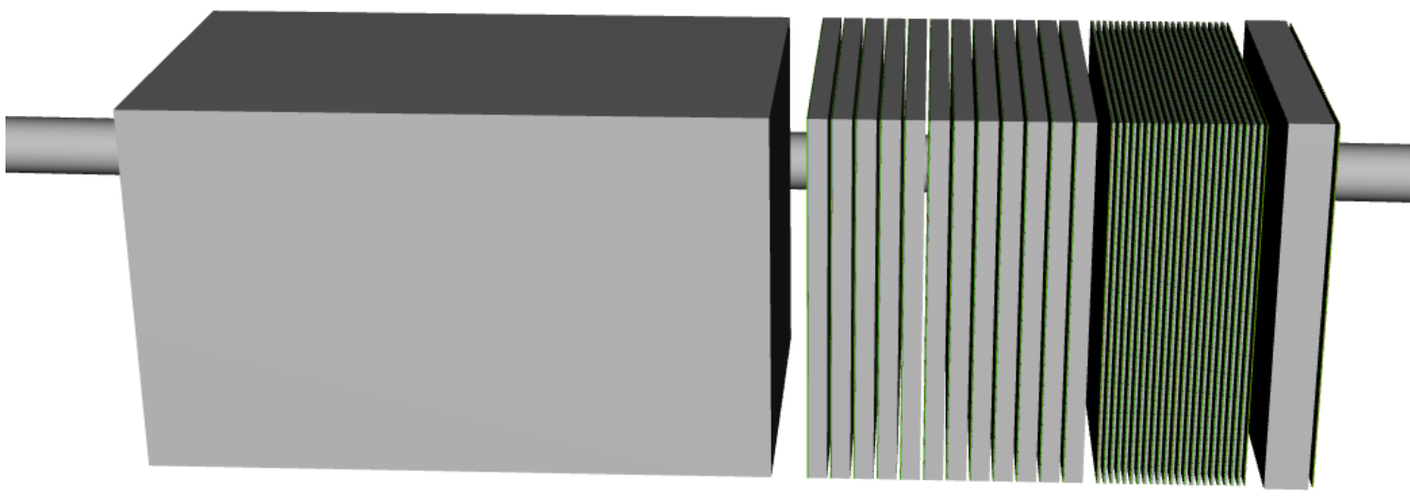
Hcal



Ecal







Replace

Full Geometry

Summary and Plan

- We will use **10 - 150 GeV neutrons** in the MC

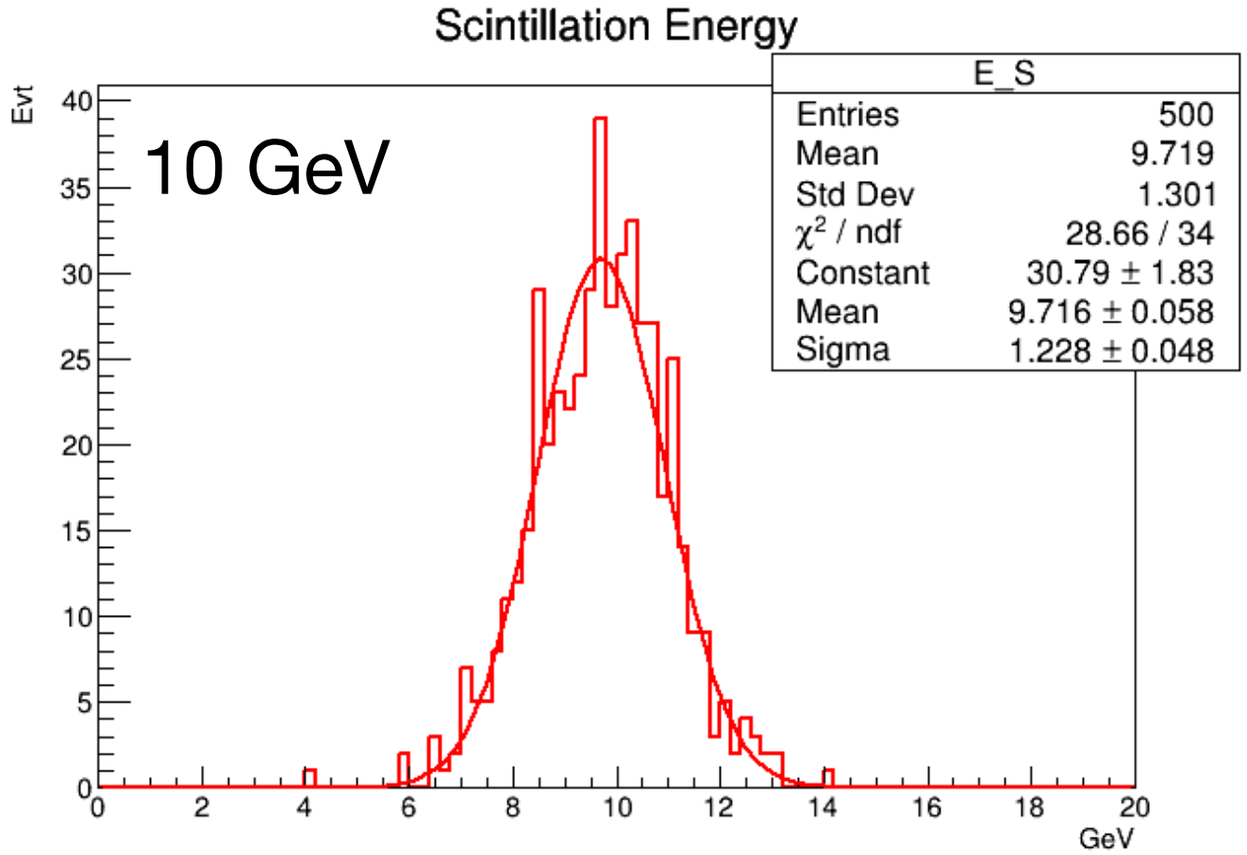
- Other material options will be studied
- ****Cu, and other?**

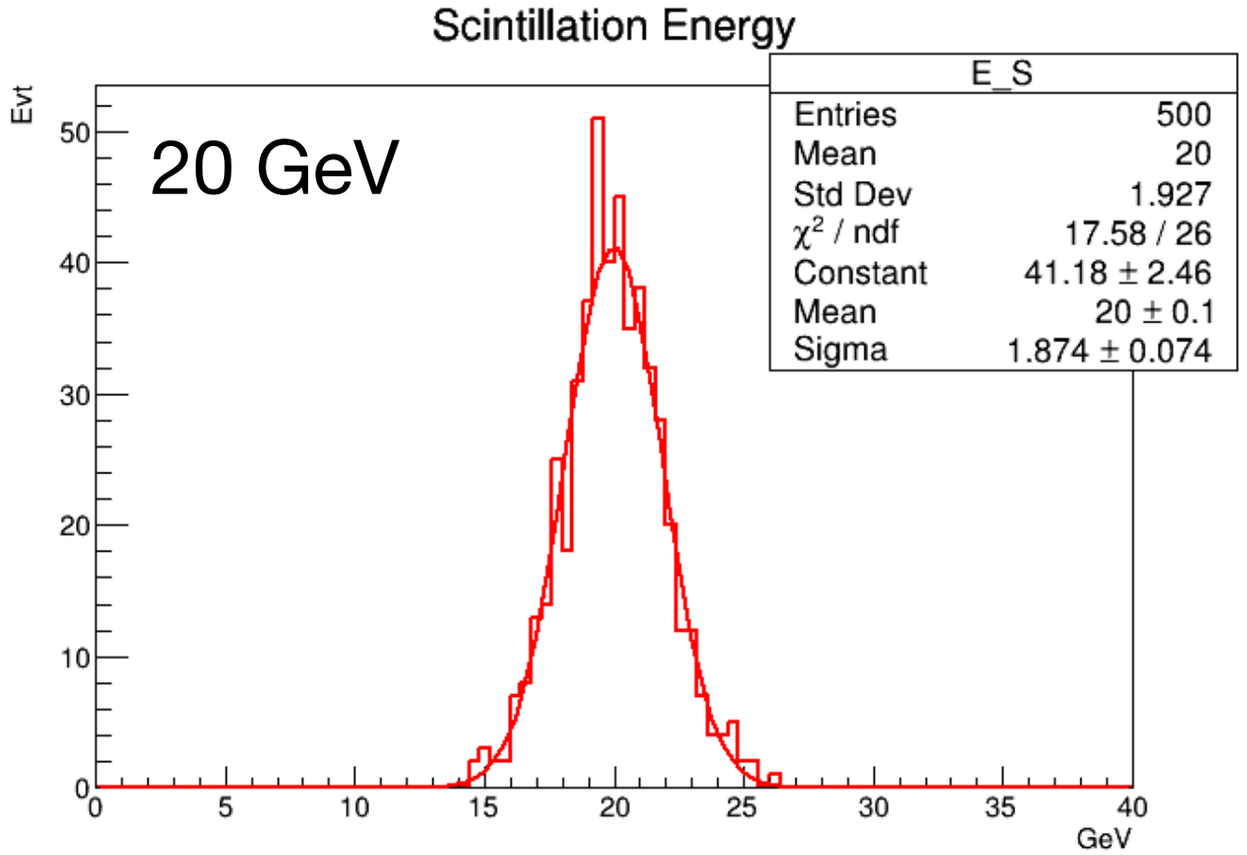
- Other fiber options will be studied
  - Scintillating 100% ✔
  - Cherenkov 100%
  - Scint ch : Cheren ch 50% : 50% dual-readout (I'm working on it)

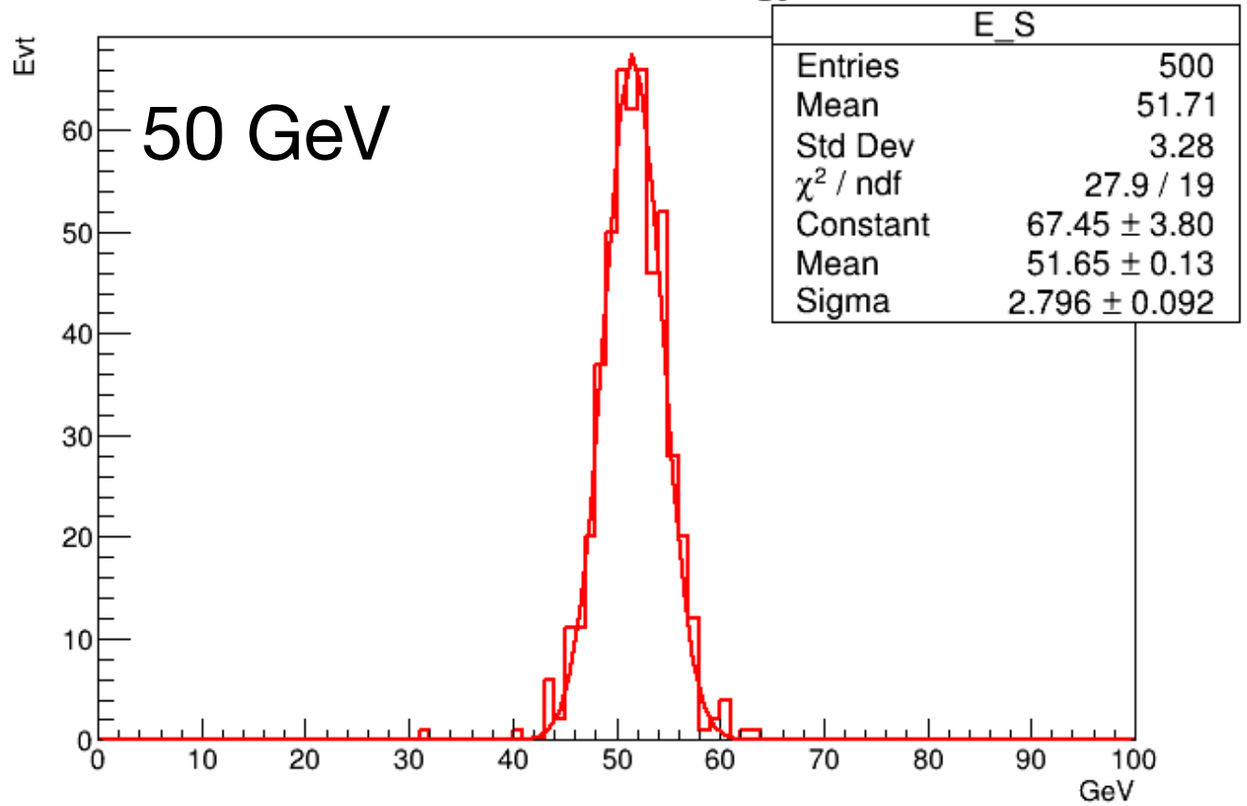
- Will add ZDC-e component ahead ZDC-h in the simulation

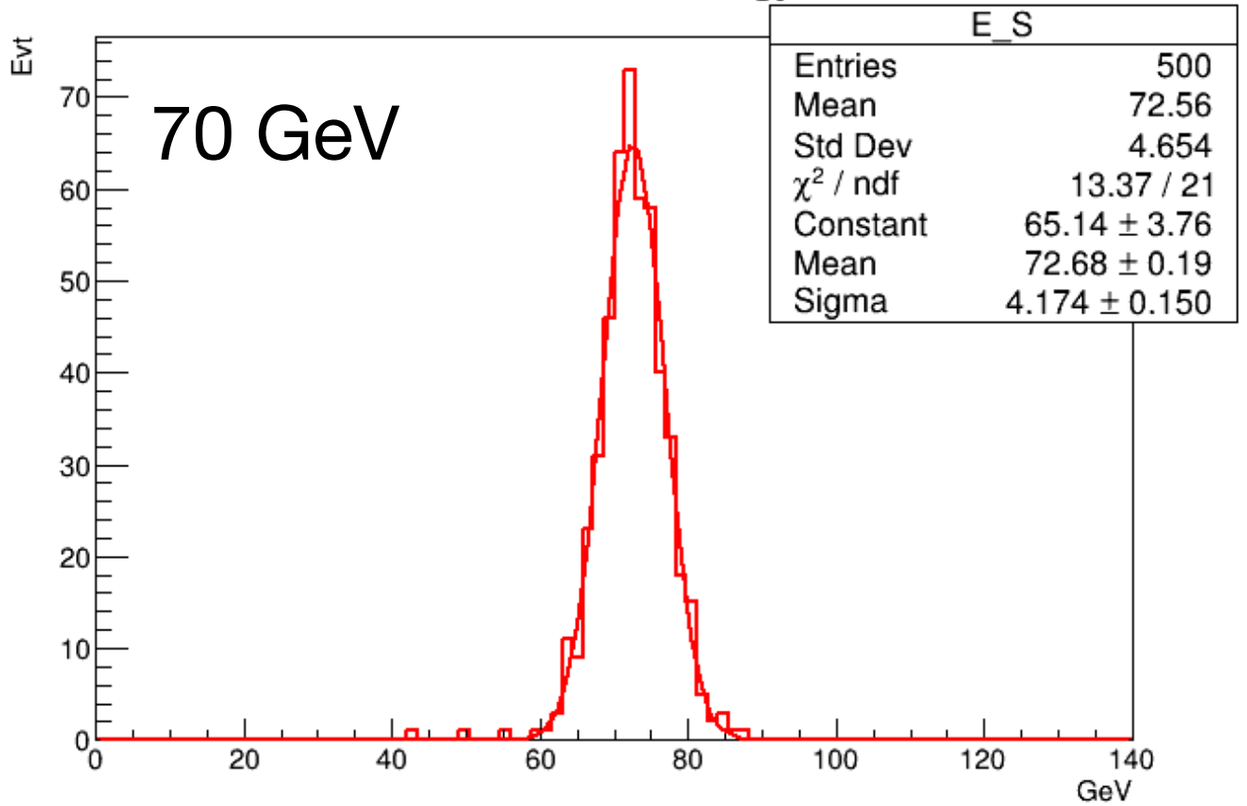
- Migration to ePIC simulation tool?
  - This is a bit tricky business because it's not easy to deploy the full photon simulation in the fiber to another platform
  - Rather, it will be easy to stage the ZDC-e material in our simulation framework as the place holder, for realistic shower development

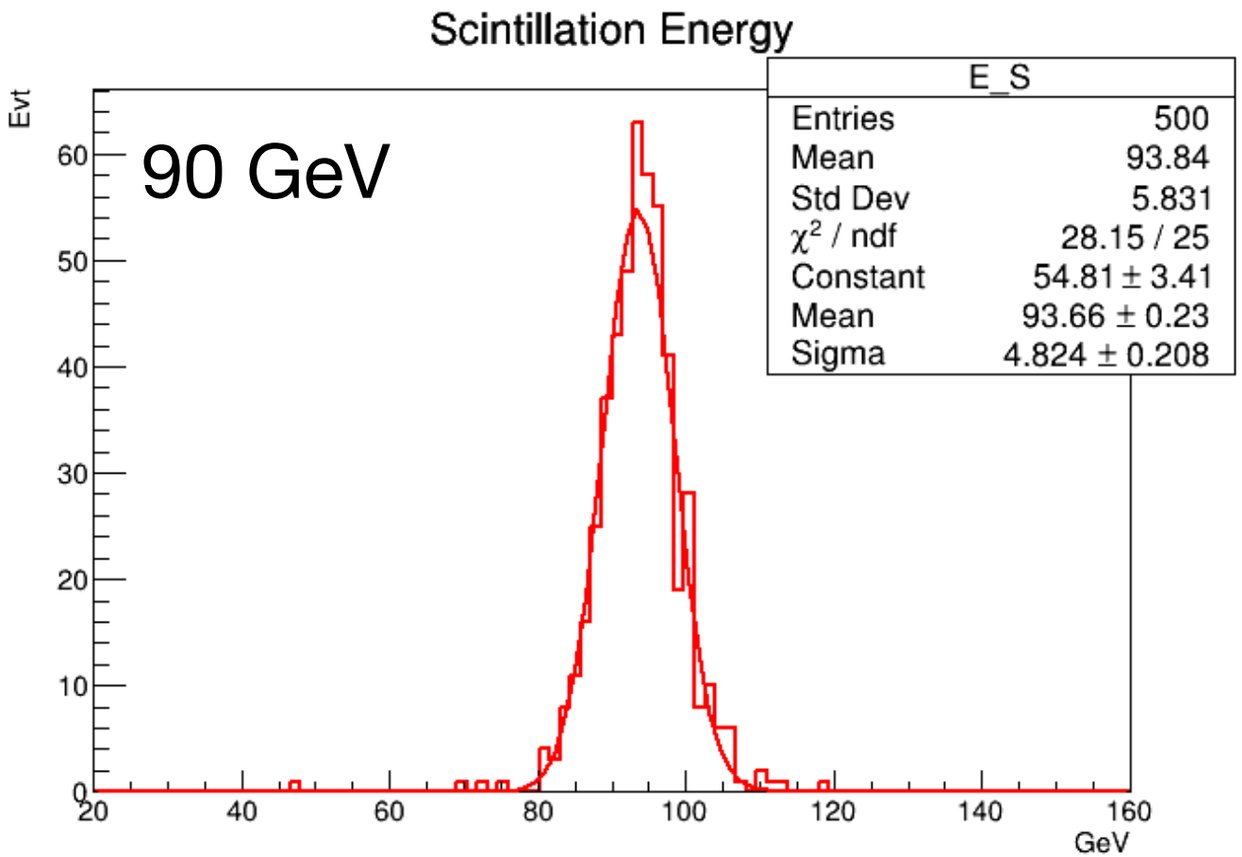
Back ups

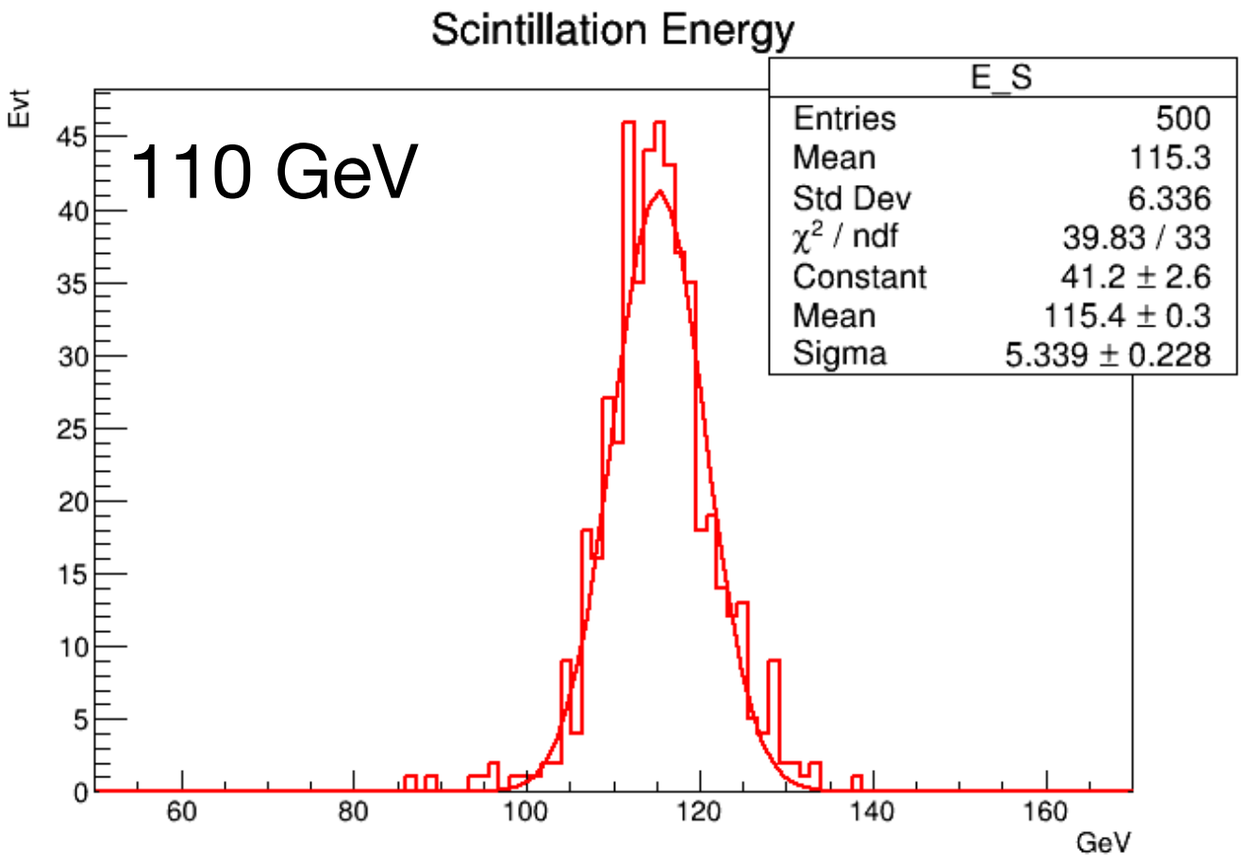

Scintillation Energy
10 GeV
E_S
Entries 500
Mean 9.719
Std Dev 1.301
χ² / ndf 28.66 / 34
Constant 30.79 ± 1.83
Mean 9.716 ± 0.058
Sigma 1.228 ± 0.048
Evt
GeV

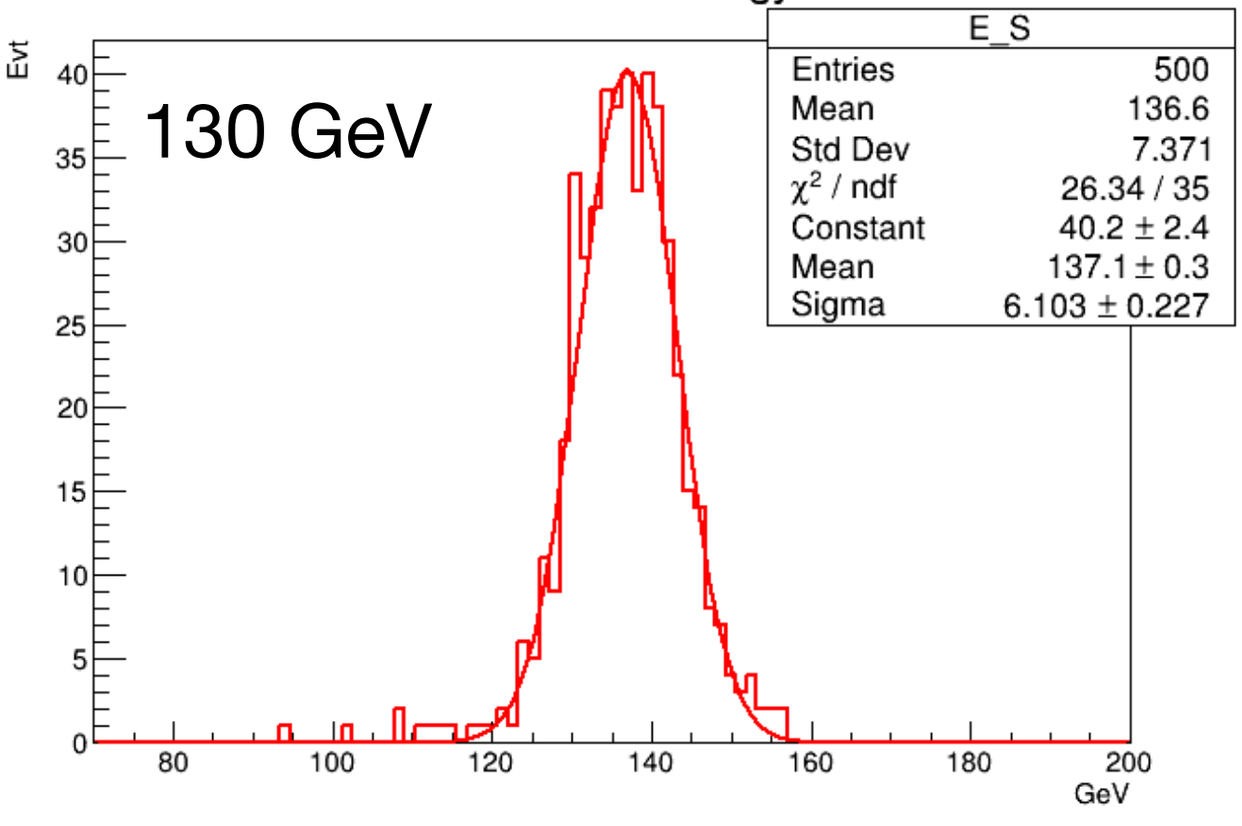

Scintillation Energy
20 GeV
E_S
Entries 500
Mean 20
Std Dev 1.927
χ² / ndf 17.58 / 26
Constant 41.18 ± 2.46
Mean 20 ± 0.1
Sigma 1.874 ± 0.074
Evt
GeV

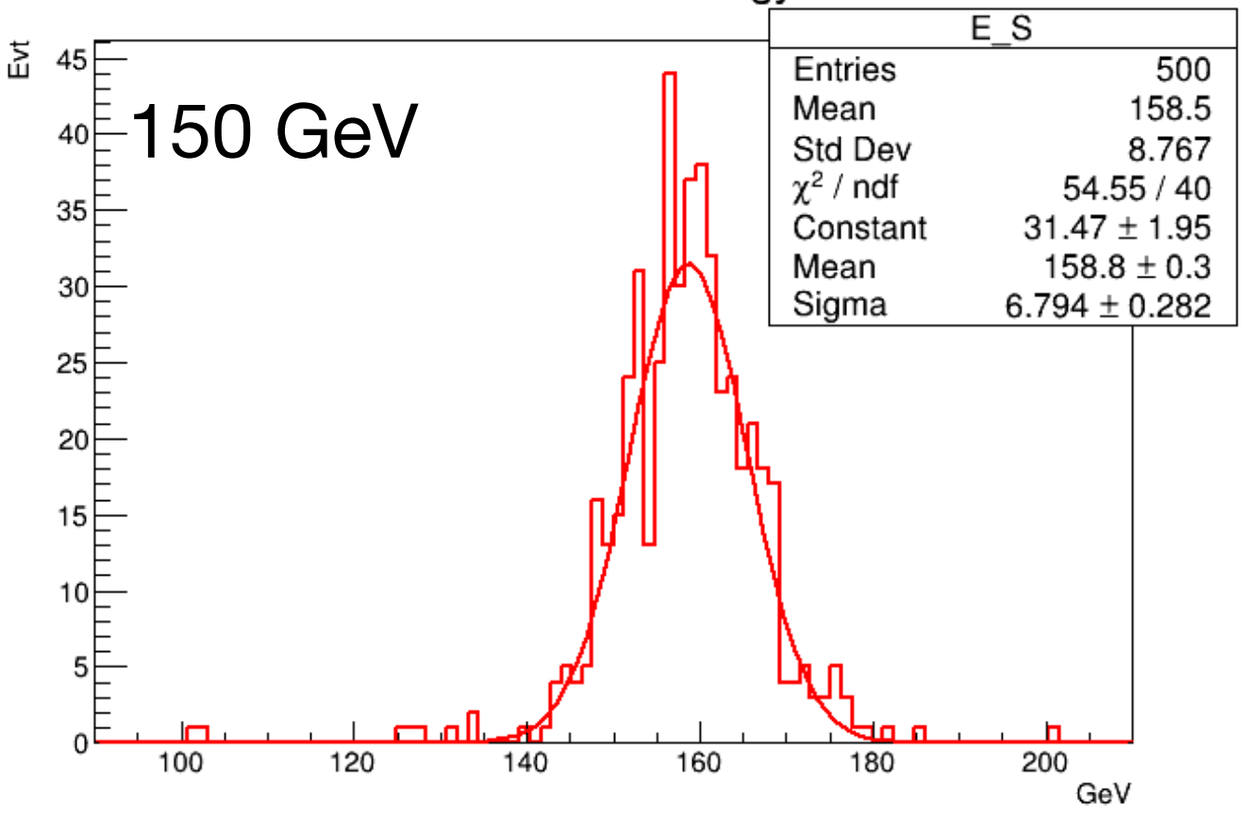

Scintillation Energy
50 GeV
E_S
Entries 500
Mean 51.71
Std Dev 3.28
χ² / ndf 27.9 / 19
Constant 67.45 ± 3.80
Mean 51.65 ± 0.13
Sigma 2.796 ± 0.092
Evt
GeV


Scintillation Energy
70 GeV
E_S
Entries 500
Mean 72.56
Std Dev 4.654
χ² / ndf 13.37 / 21
Constant 65.14 ± 3.76
Mean 72.68 ± 0.19
Sigma 4.174 ± 0.150
Evt
GeV


Scintillation Energy
90 GeV
E_S
Entries 500
Mean 93.84
Std Dev 5.831
χ² / ndf 28.15 / 25
Constant 54.81 ± 3.41
Mean 93.66 ± 0.23
Sigma 4.824 ± 0.208
Evt
GeV


Scintillation Energy
110 GeV
E_S
Entries 500
Mean 115.3
Std Dev 6.336
χ² / ndf 39.83 / 33
Constant 41.2 ± 2.6
Mean 115.4 ± 0.3
Sigma 5.339 ± 0.228
Evt
GeV


Scintillation Energy
130 GeV
E_S
Entries 500
Mean 136.6
Std Dev 7.371
χ² / ndf 26.34 / 35
Constant 40.2 ± 2.4
Mean 137.1 ± 0.3
Sigma 6.103 ± 0.227
Evt
GeV


Scintillation Energy
150 GeV
E_S
Entries 500
Mean 158.5
Std Dev 8.767
χ² / ndf 54.55 / 40
Constant 31.47 ± 1.95
Mean 158.8 ± 0.3
Sigma 6.794 ± 0.282
Evt
GeV