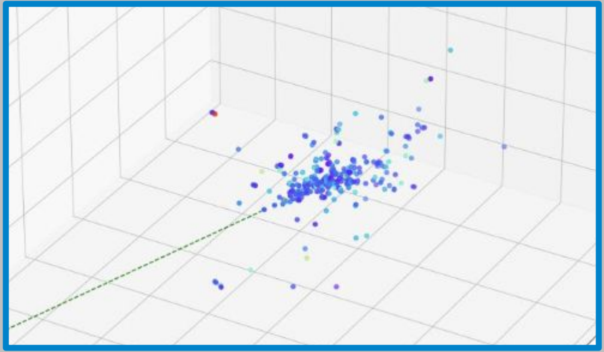
EIC Calorimetry WG Meeting

Calorimetry Benchmarks



ANL EIC Calorimetry Team
W. Armstrong, S. Joosten, J. Kim, J. Metcalfe, Z.E. Meziani, C. Peng, M. Scott, M. Żurek

U.S. DEPARTMENT OF ENERGY
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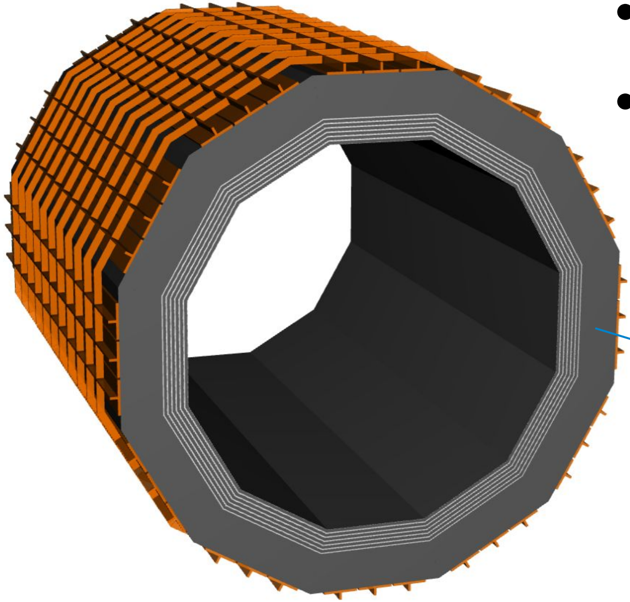
08/09/2021

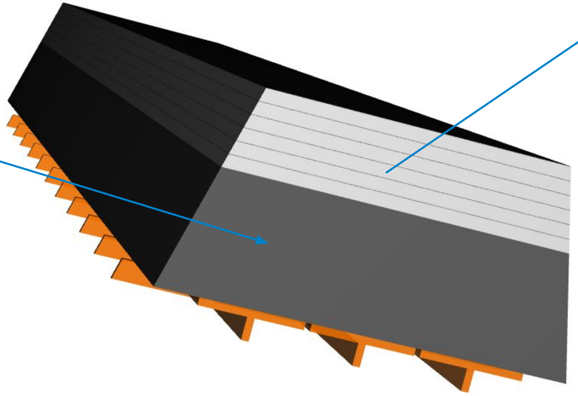
energy resolution studies

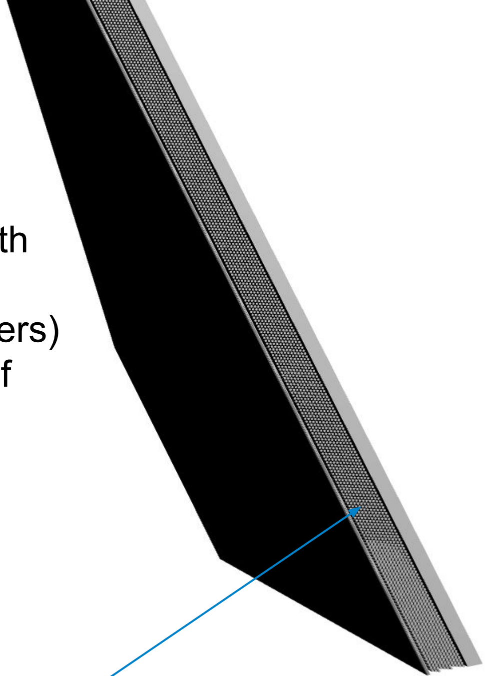
Maria Zurek

ScFi Calorimeter

- 6 imaging layers separated with 13*1.22 mm = 15.86 mm wide layers of ScFi (13 layers of fibers)
- 15*13*1.22 mm = 237.9 mm of ScFi calo in the back
- 1 mm diameter fibers in Pb



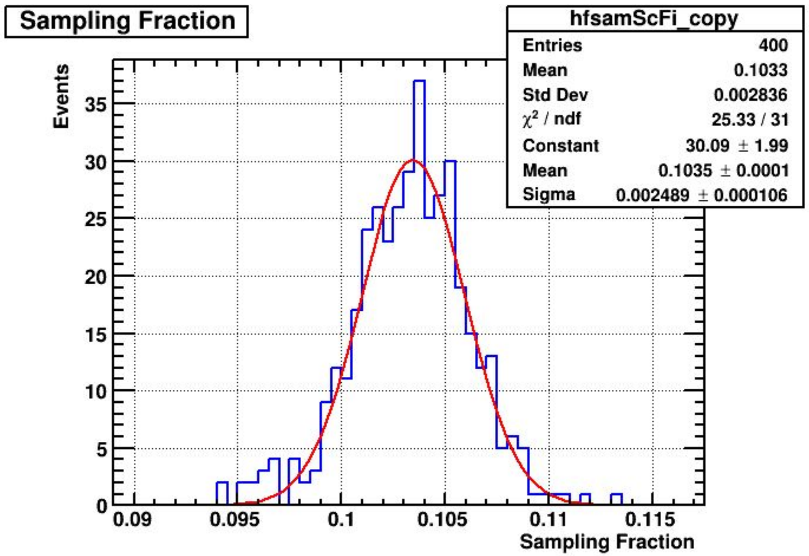




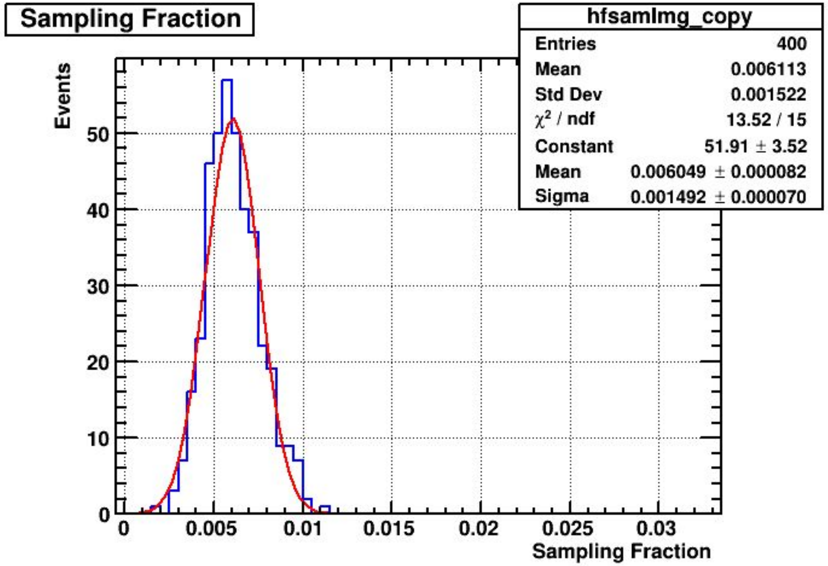
Energy losses in ScFi and Img layers

5 GeV electrons

ScFi Layers



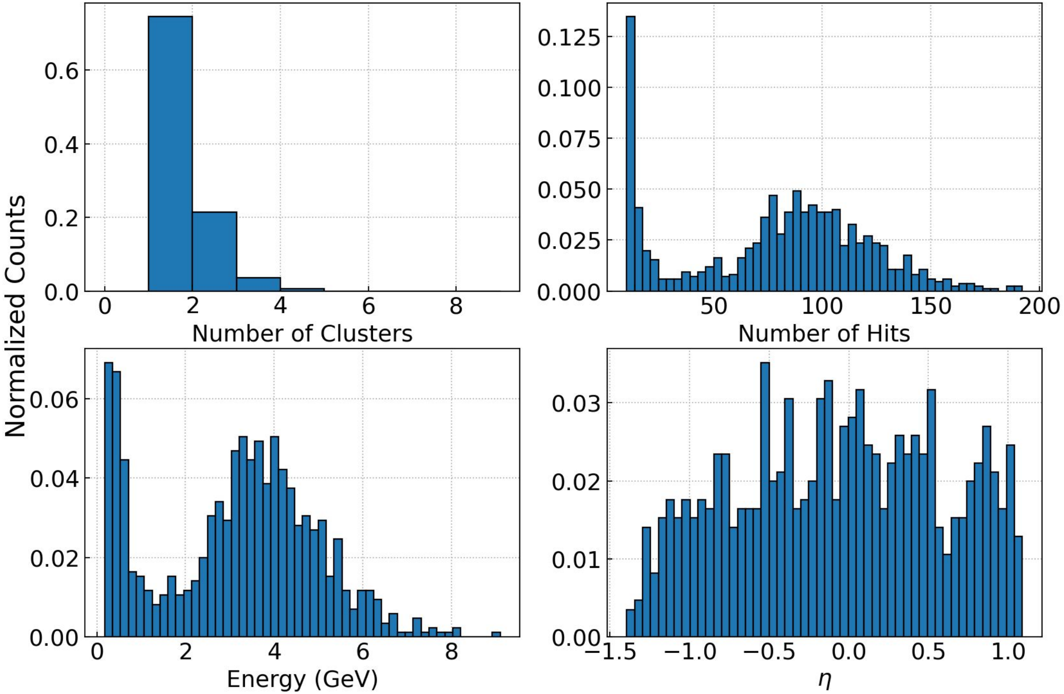
Img Layers



These numbers used as 1st order calibration constant

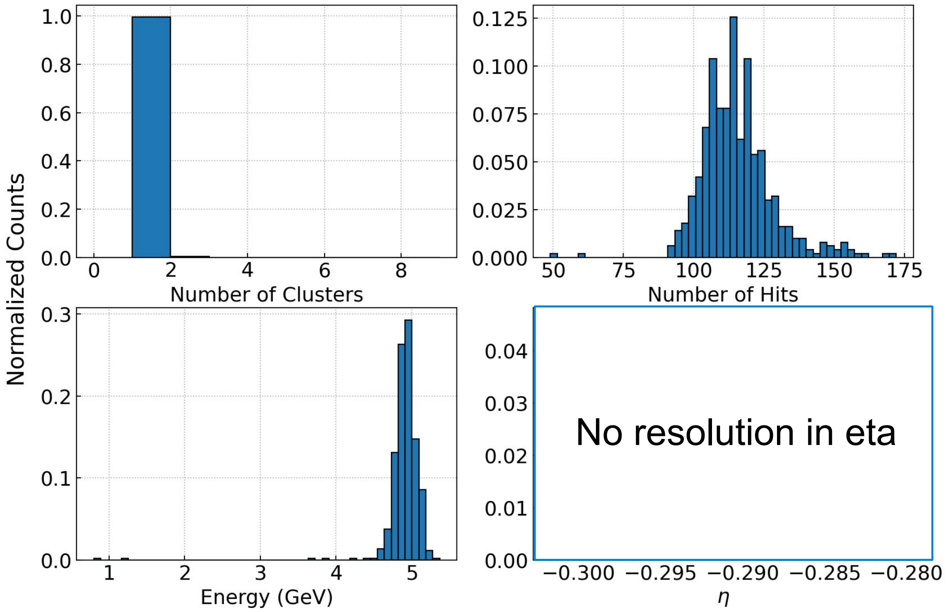
3D Clustering for imaging layers

- 5 GeV electrons, generated flat in theta 60-120 deg.
- Calibration correction based on Geant4 sampling fraction for 5 GeV electrons ~ 0.6%.



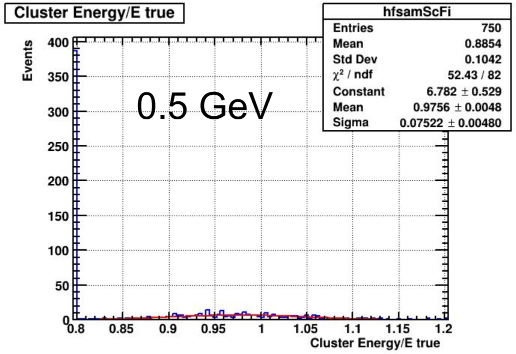
2D Island Clustering for ScFi layers

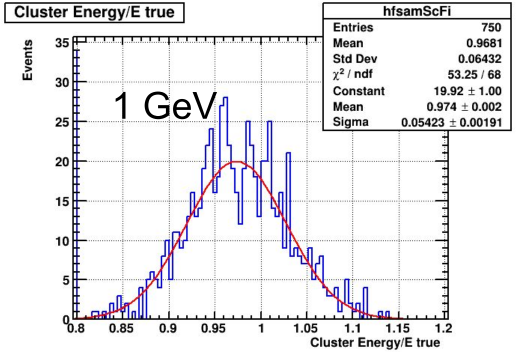
- 5 GeV electrons, generated flat in theta 60-120 deg.
- Calibration correction based on Geant4 sampling fraction for 5 GeV electrons ~ 10.4%.

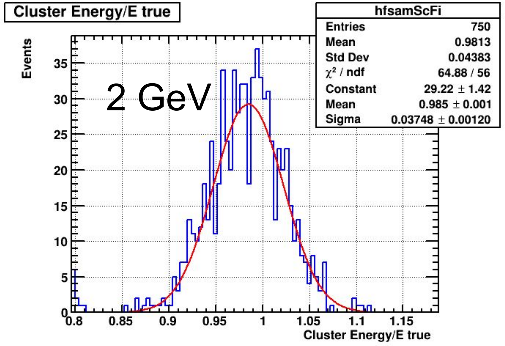


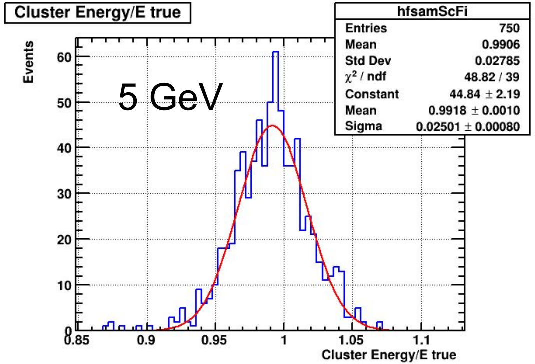
Energy resolution scan for ScFi layers

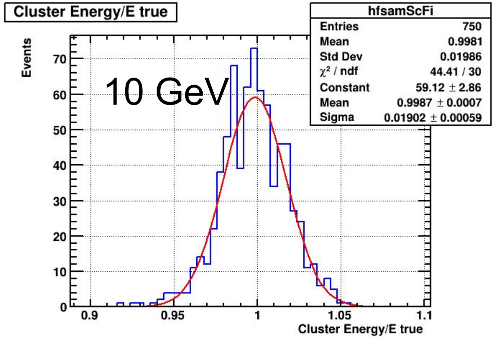
photons







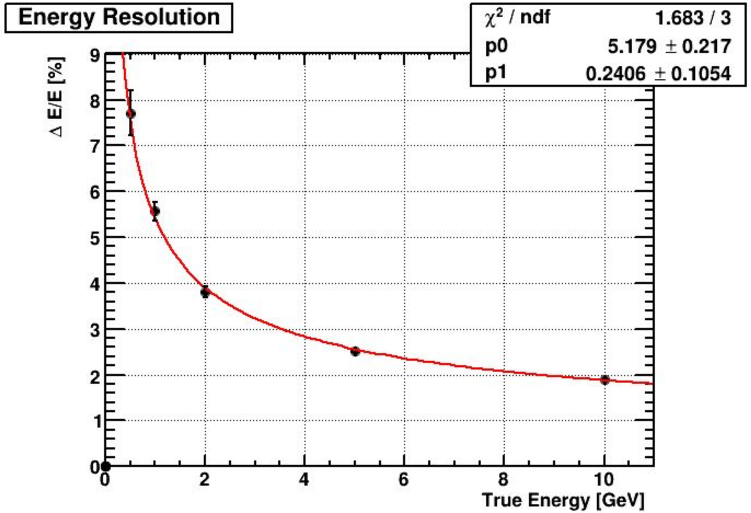




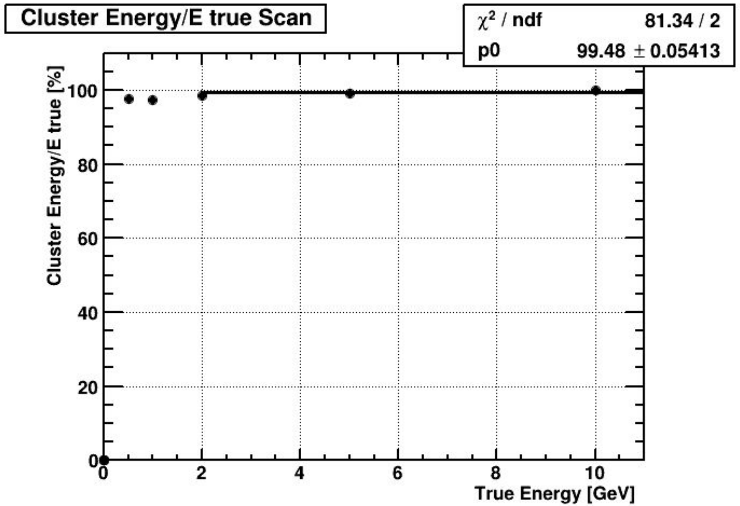

```
scfi_barrel_daq = dict(
        dynamicRangeADC=50.*MeV,
        capacityADC=32768,
        pedestalMean=400,
        pedestalSigma=10)
```

Energy resolution scan for ScFi layers

photons



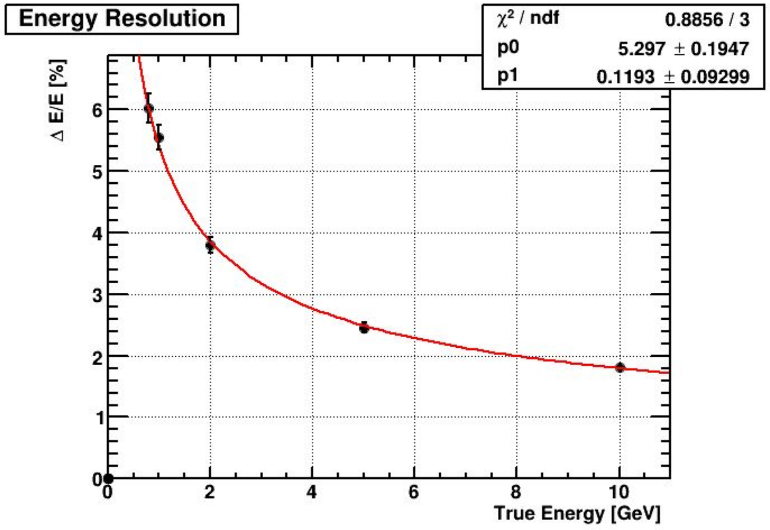
Energy resolution



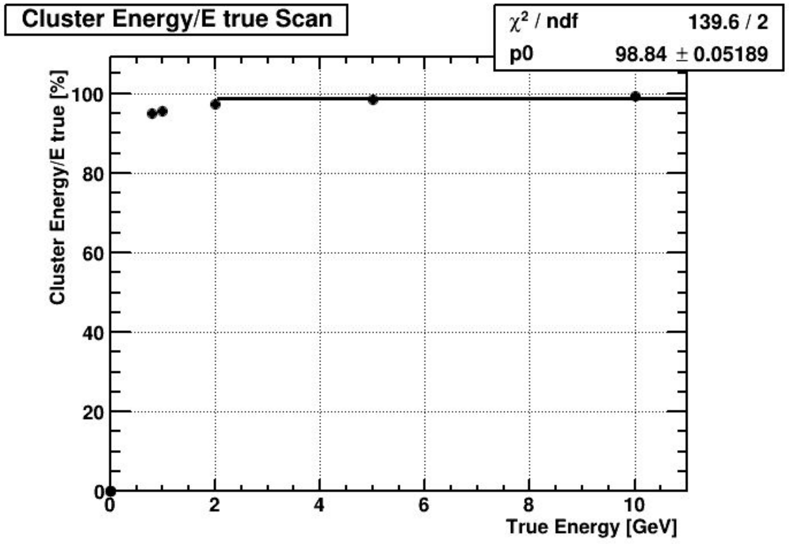
Peak position scan

Energy resolution scan for ScFi layers

electrons



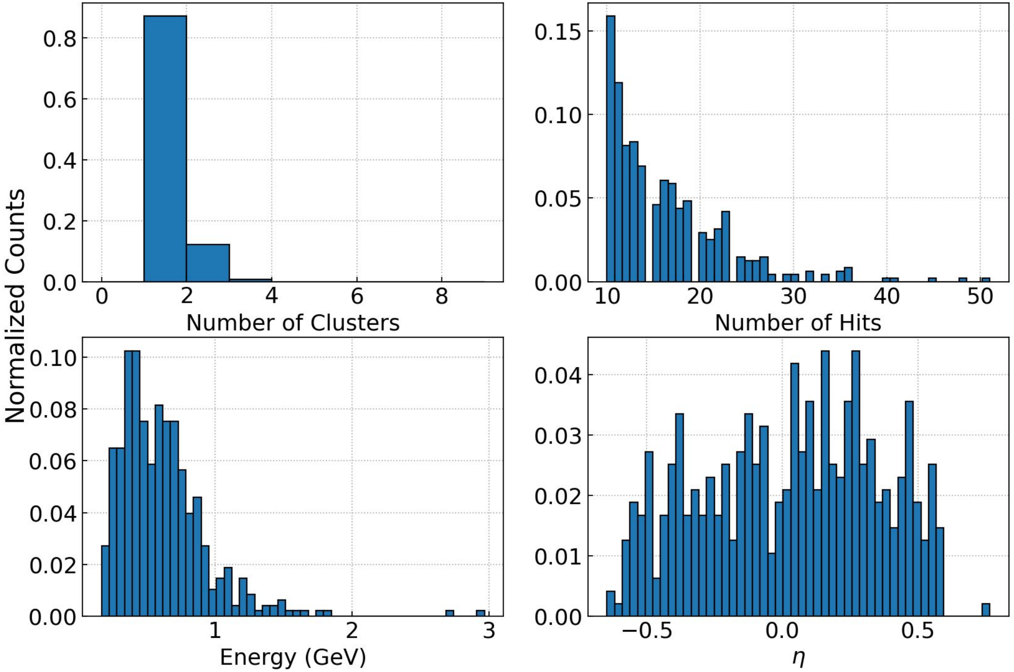
Energy resolution



Peak position scan

Imaging layer clusters

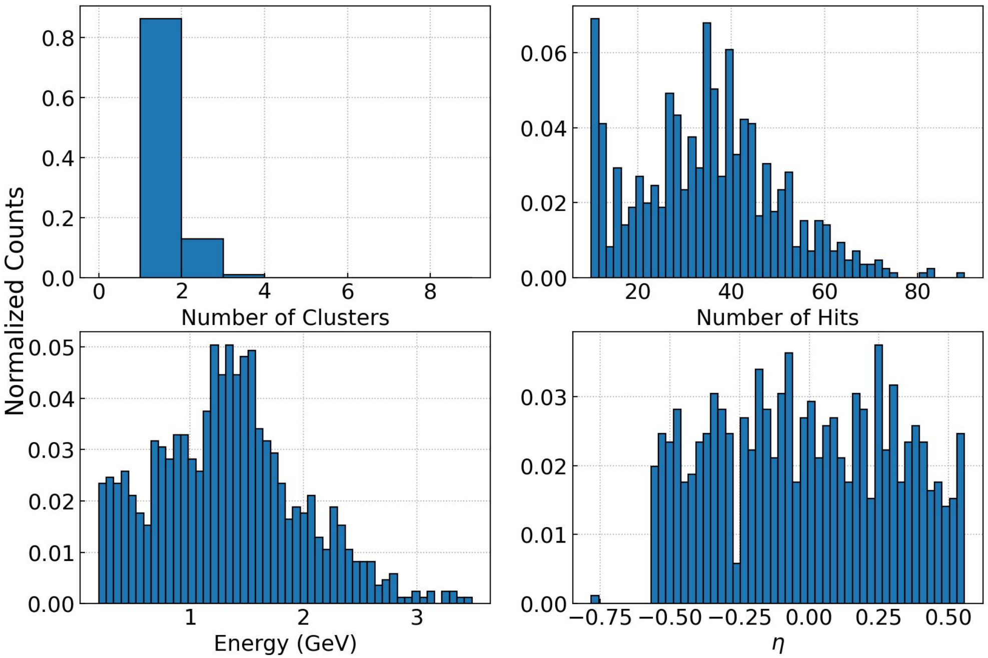
electrons, 1 GeV




```
imcaldaq = dict(
        dynamicRangeADC=3*MeV,
        capacityADC=32767,
        pedestalMean=400,
        pedestalSigma=50)    #
50/32767*3 MeV ~ 5 keV
```

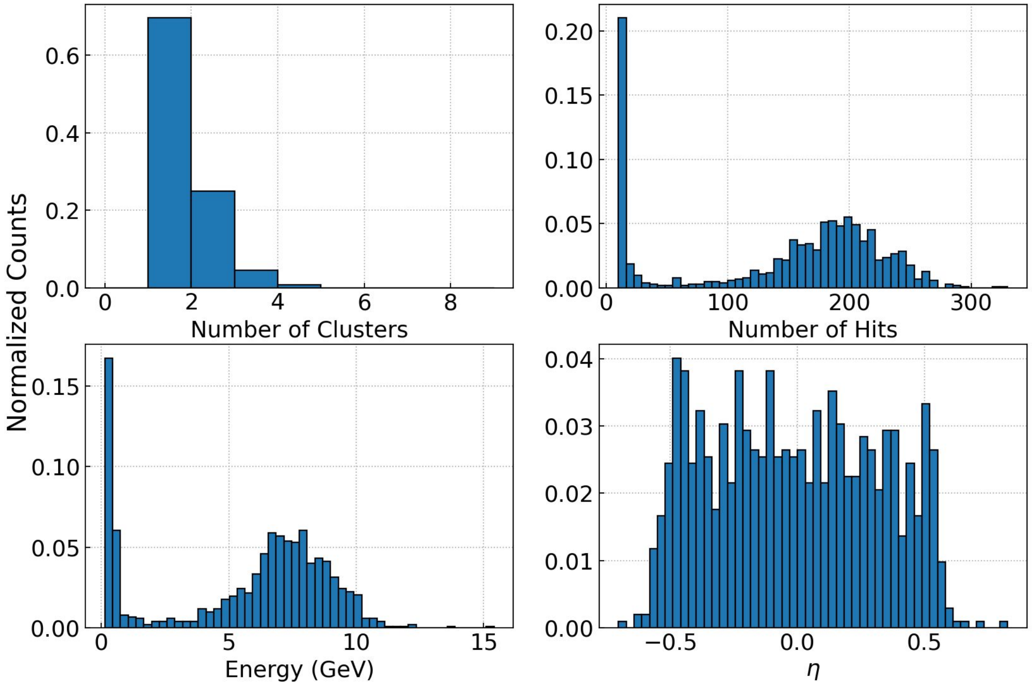
Imaging layer clusters

electrons, 2 GeV



Imaging layer clusters

electrons, 10 GeV



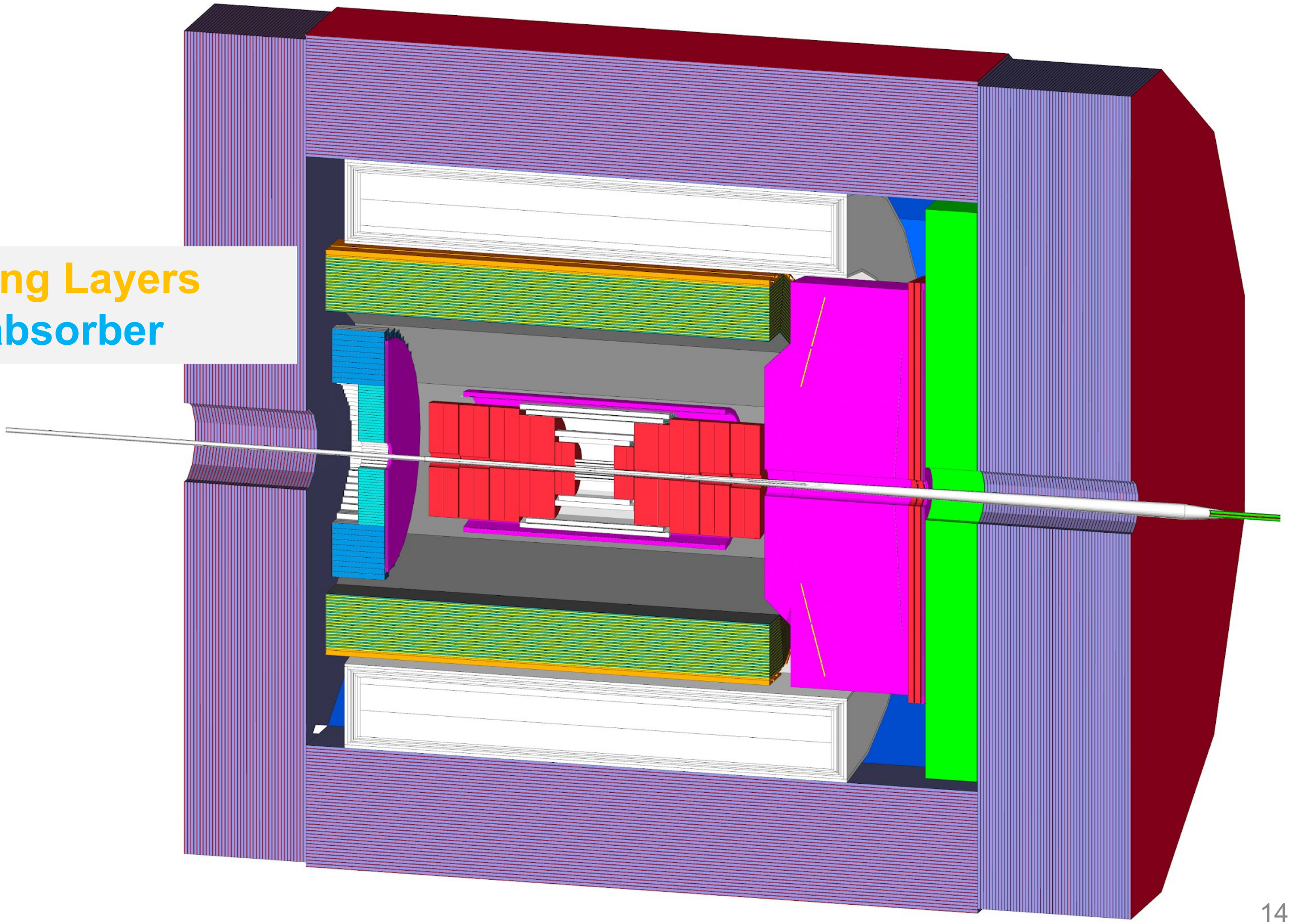

```
imcaldaq = dict(
        dynamicRangeADC=3*MeV,
        capacityADC=32767,
        pedestalMean=400,
        pedestalSigma=50)
# 50/32767*3 MeV ~ 5 keV
```

pion-electron separation studies

Chao Peng
Marshall Scott

20 Imaging Layers

~1.0 X_0 absorber layers

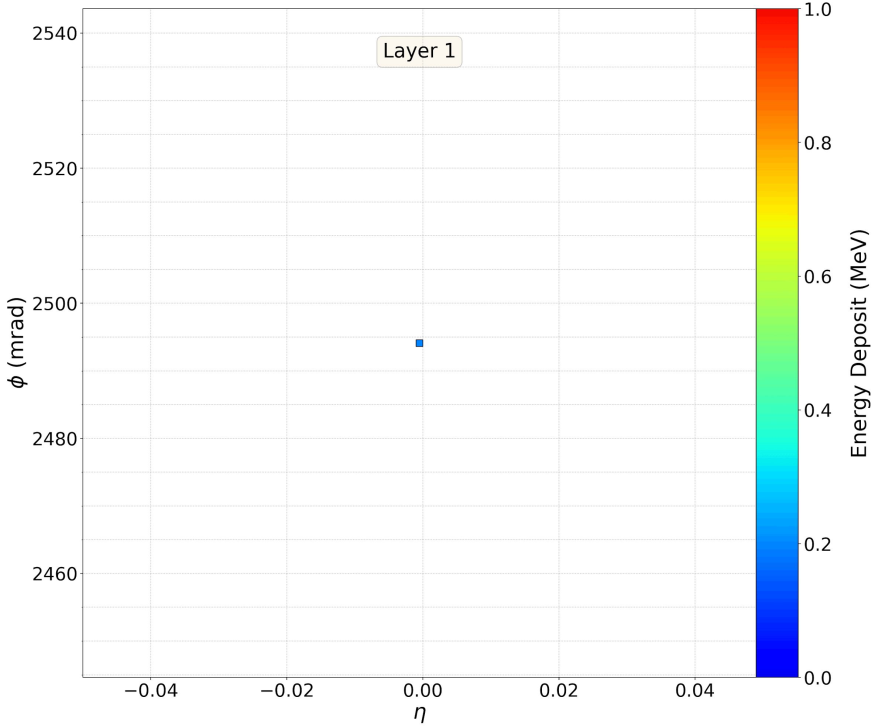


ML Classification

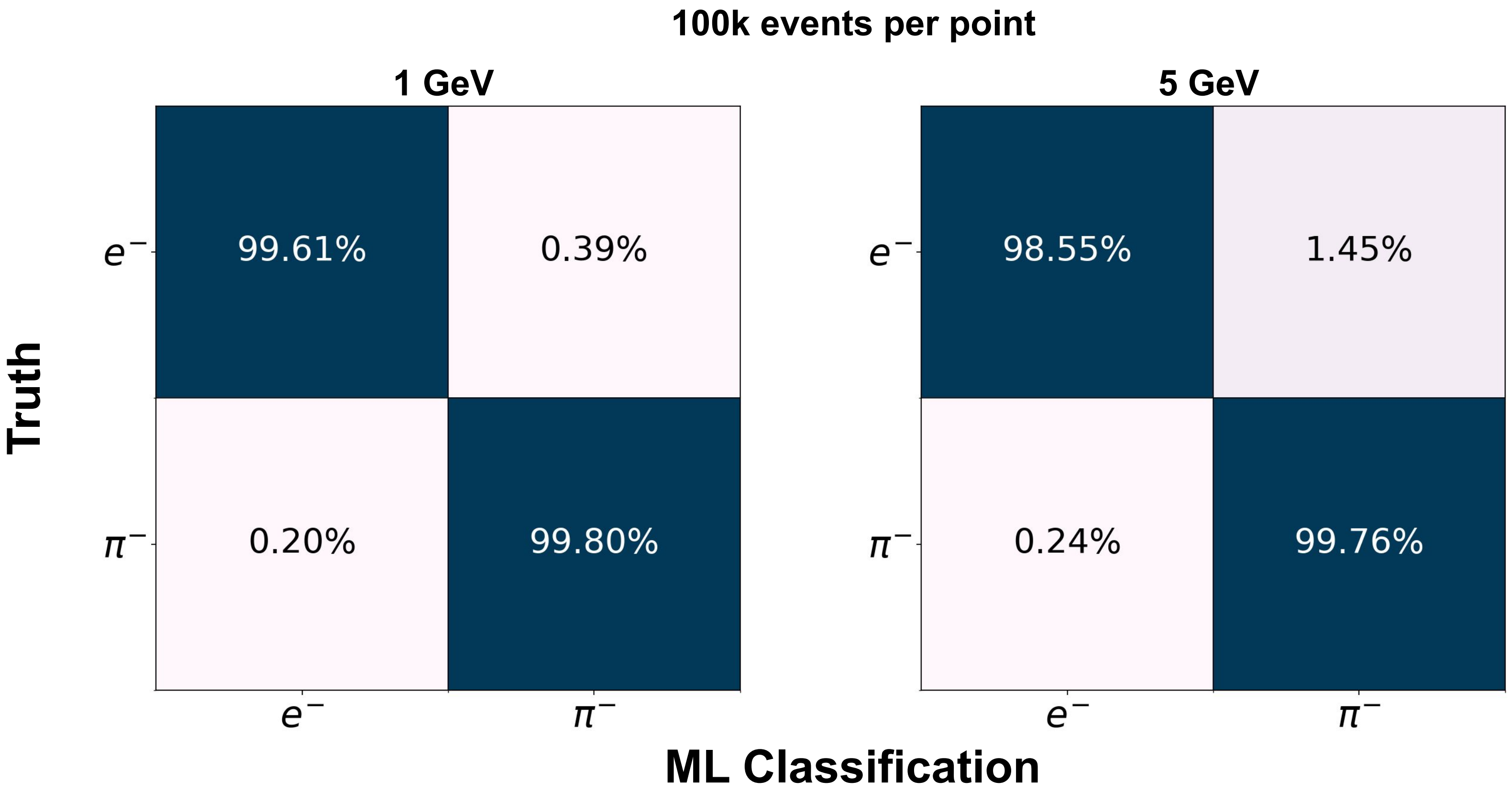
Data Shape: 20 × 20 × 3

Layers Hits Features (E, η, ϕ)

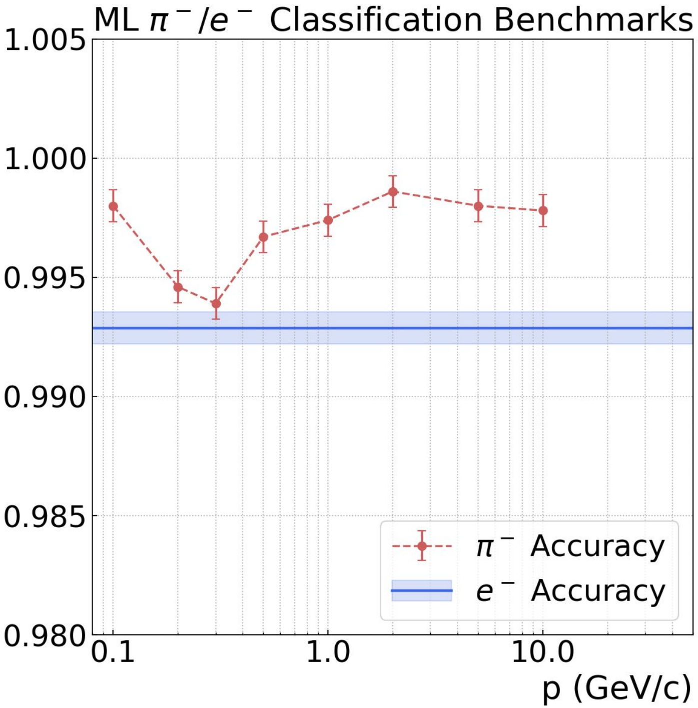
- Grid size for hits is $[\eta: 0.001, \phi: 0.001\ \mathrm{rad}]$
- Raw hits within the same grid is merged (energy sum)
- Sorted by energy
  - Drop lowest energies ones if there were more than 20 hits
- Feature values normalized to [0, 1]
- Padded with zero
  - Fill $(0, 0, 0)$ if less than 20 hits



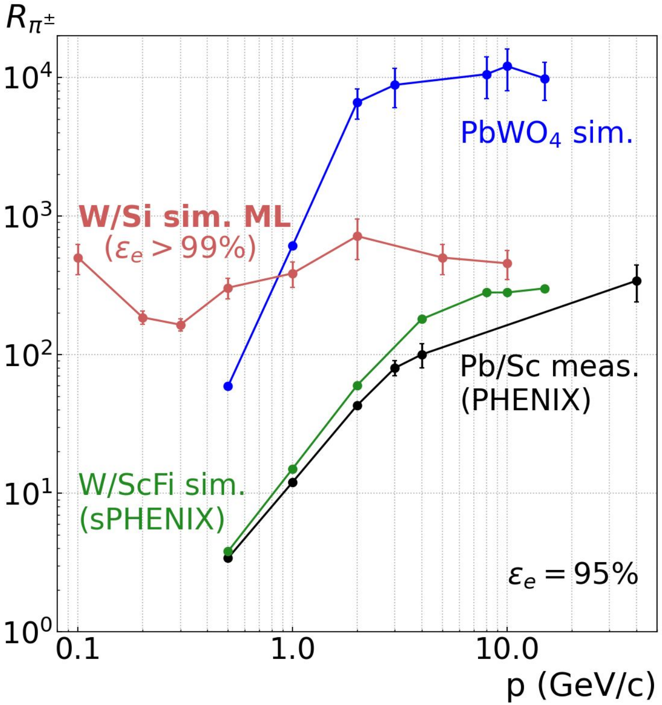
ML Results


100k events per point
1 GeV
5 GeV
Truth
ML Classification
e^-
π^-
99.61%
0.39%
0.20%
99.80%
98.55%
1.45%
0.24%
99.76%

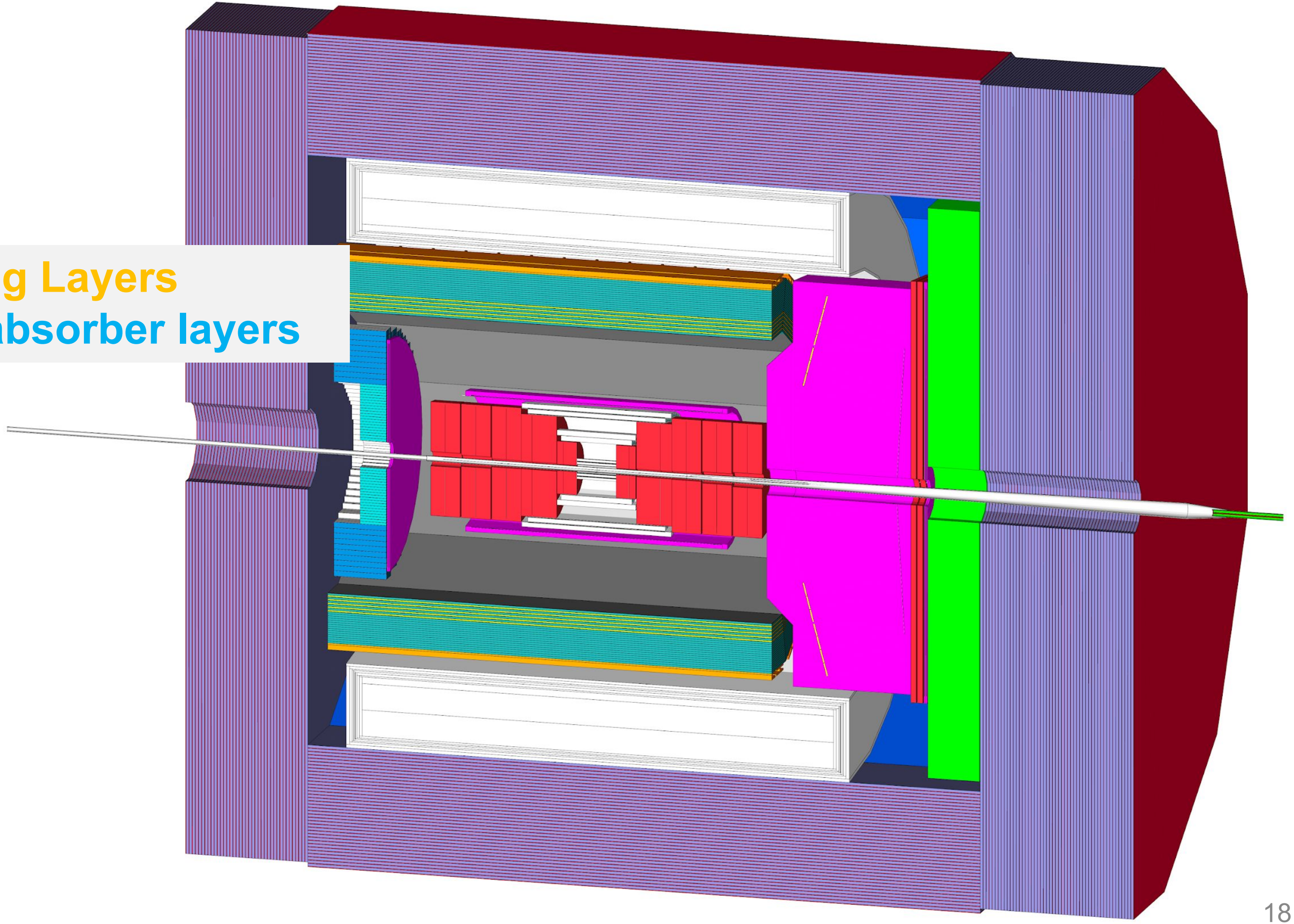
ML Results



ML π^-/e^- Classification Benchmarks
1.005
1.000
0.995
0.990
0.985
0.980
0.1
1.0
10.0
p (GeV/c)
π^- Accuracy
e^- Accuracy



$R_{\pi^\pm}$
10^4
10^3
10^2
10^1
10^0
0.1
1.0
10.0
p (GeV/c)
$PbWO_4$ sim.
W/Si sim. ML
($\varepsilon_e > 99\%$)
Pb/Sc meas.
(PHENIX)
W/ScFi sim.
(sPHENIX)
$\varepsilon_e = 95\%$

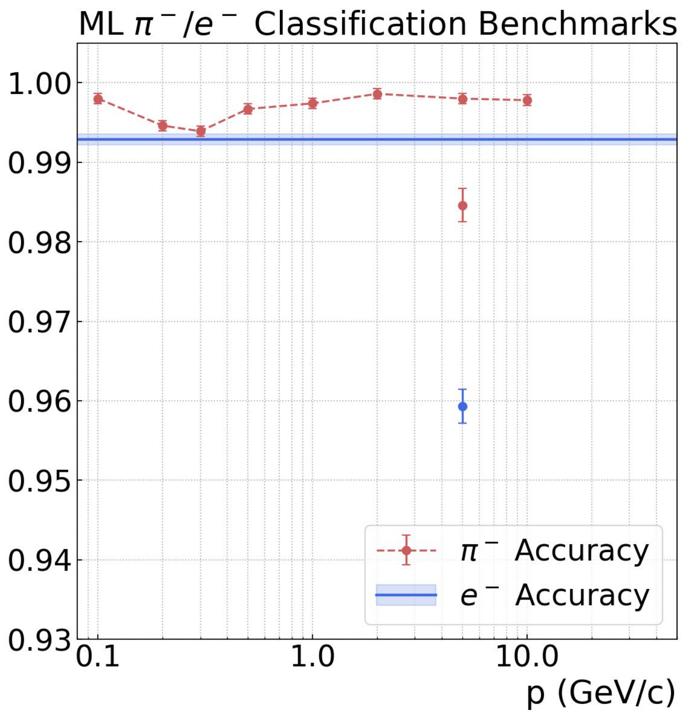


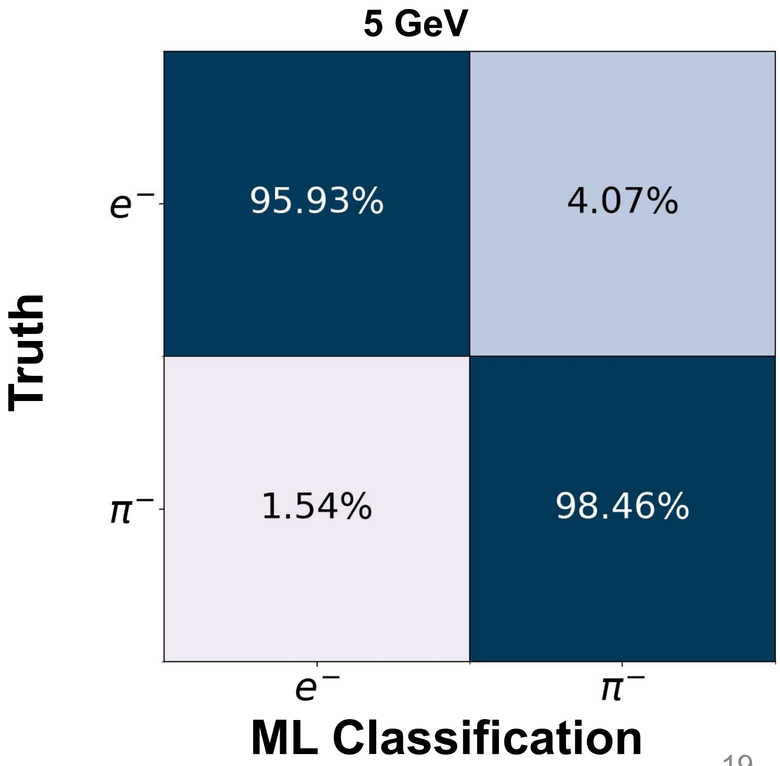
6 Imaging Layers

~1.0 X_0 absorber layers

ML Results

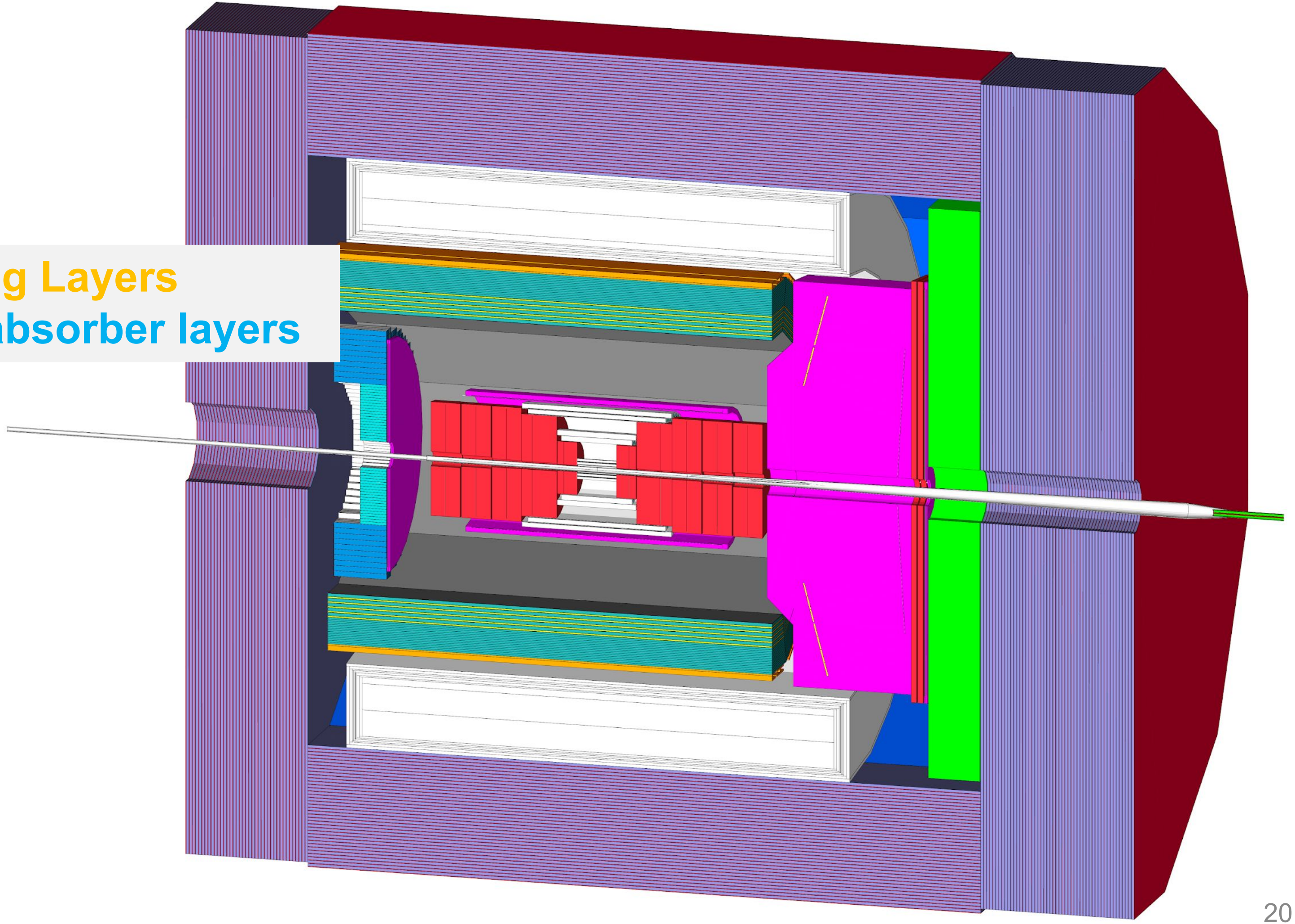
10k events per point





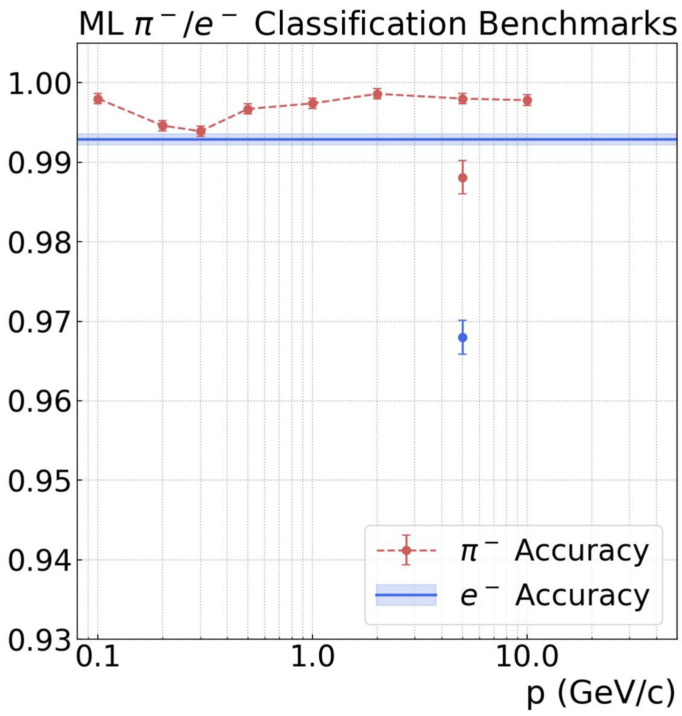
6 Imaging Layers

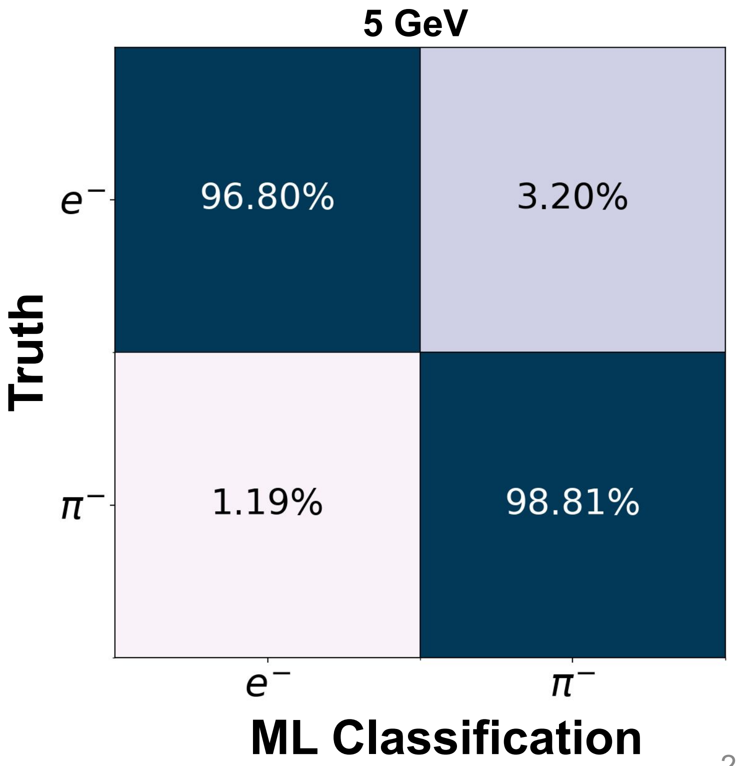
~1.5 X_0 absorber layers



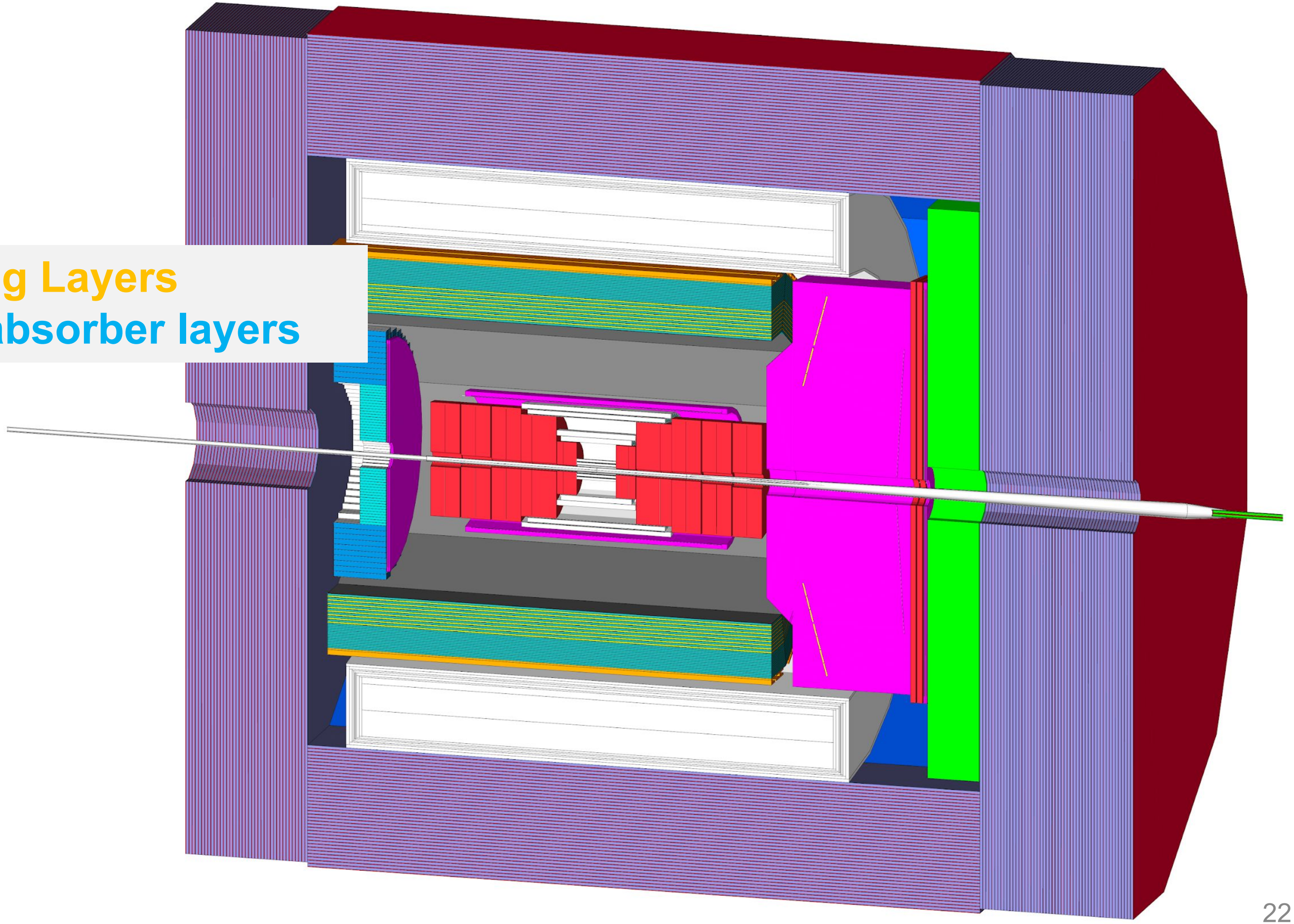
ML Results

10k events per point



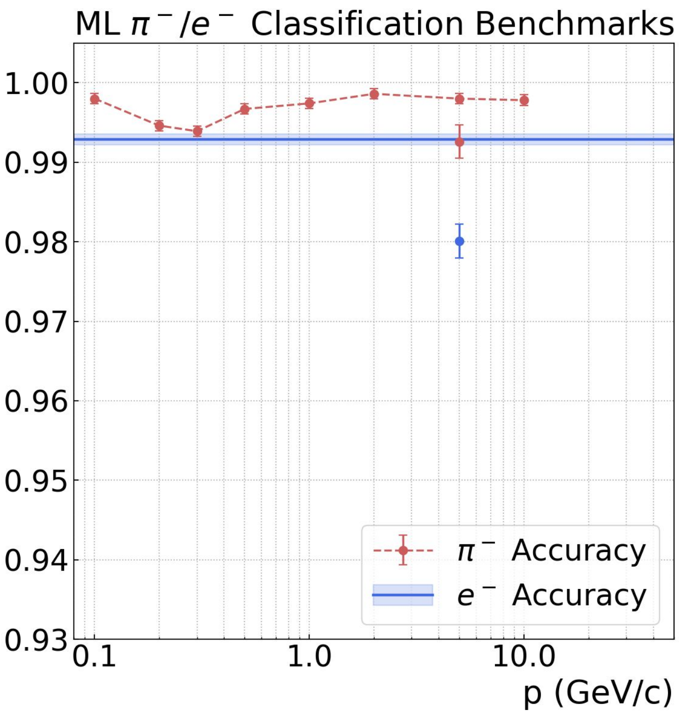


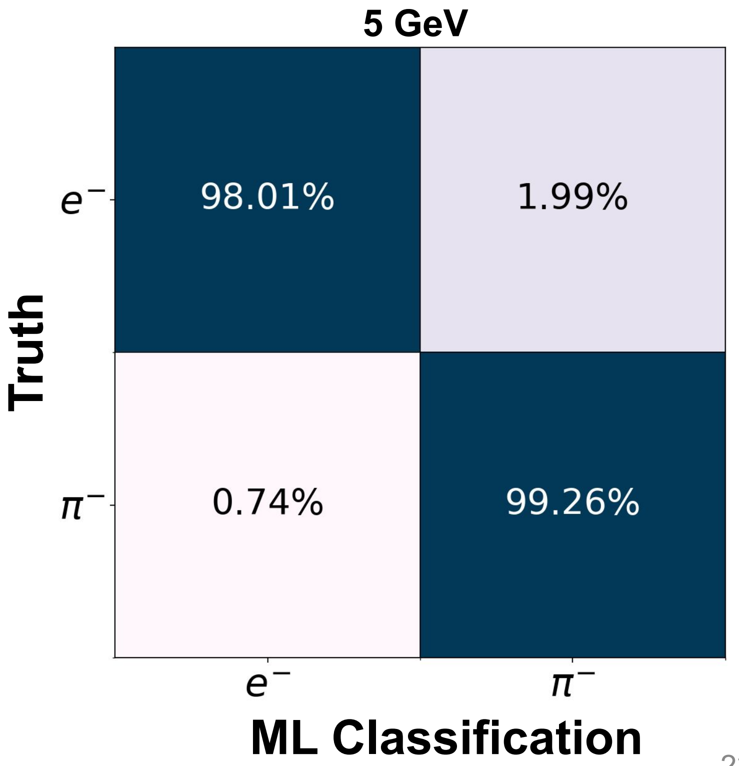
9 Imaging Layers
~1.0 X_0 absorber layers



ML Results

10k events per point





Doing

- Cut pions by E/p, only train ML classification for the events that are difficult to be identified
- Add ScFi information into the data
  - No eta information, but phi, E are there
- Test 9 layers with 1.5 X_0
- More data points

Marshall works on e/pi separation based on E/p

spatial resolution studies

Jihee Kim

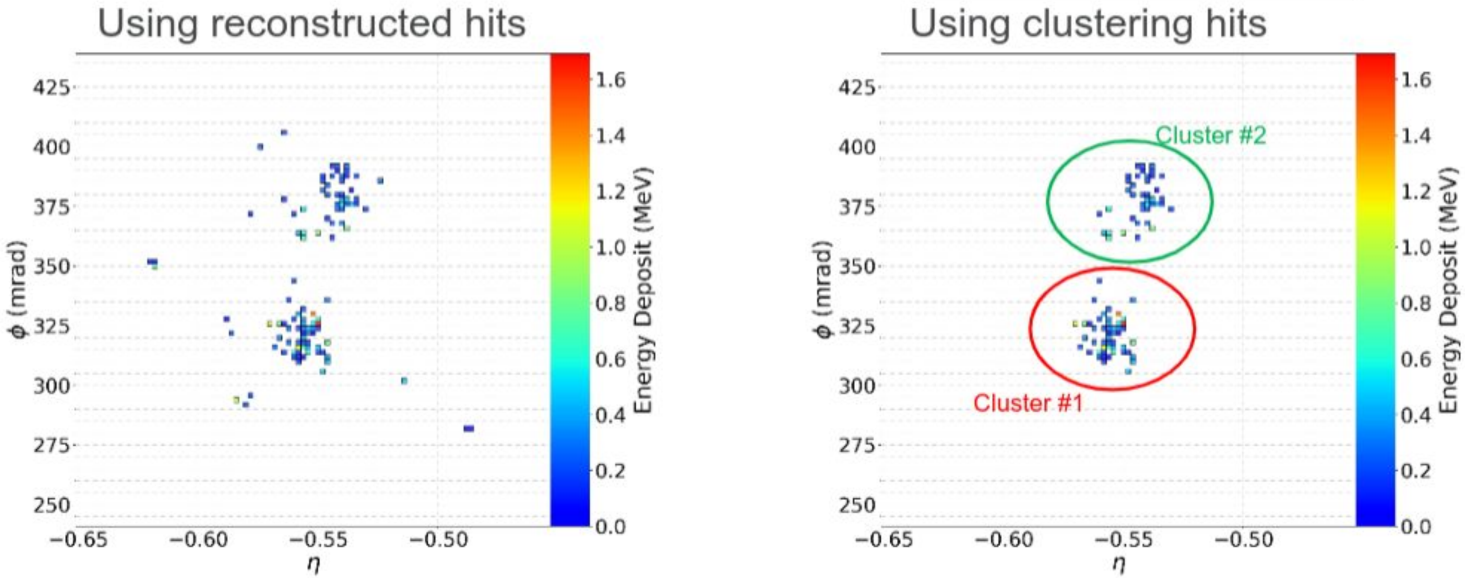
Using only imaging layers

EVENT DISPLAY

5 GeV $\pi^0 \to \gamma\gamma$ events with 2 clusters

$E_{cluster\ \#1}$ = 3.23 GeV
$E_{cluster\ \#2}$ = 1.94 GeV
Total E_{rec} = 5.17 GeV

$E_{cluster\ \#1} / E_{cluster\ \#2}$ = 1.67

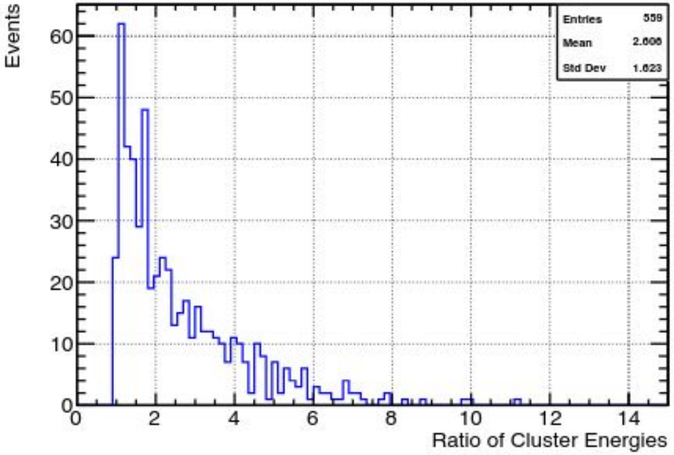


Using only imaging layers

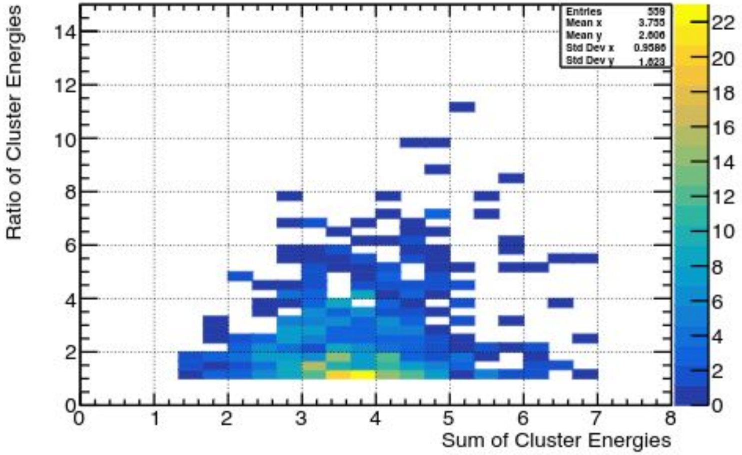
ENERGY DISTRIBUTION

5 GeV $\pi^0 \rightarrow \gamma\gamma$ events with 2 clusters

Ratio of cluster energies ($E_{cl\#1}/E_{cl\#2}$)

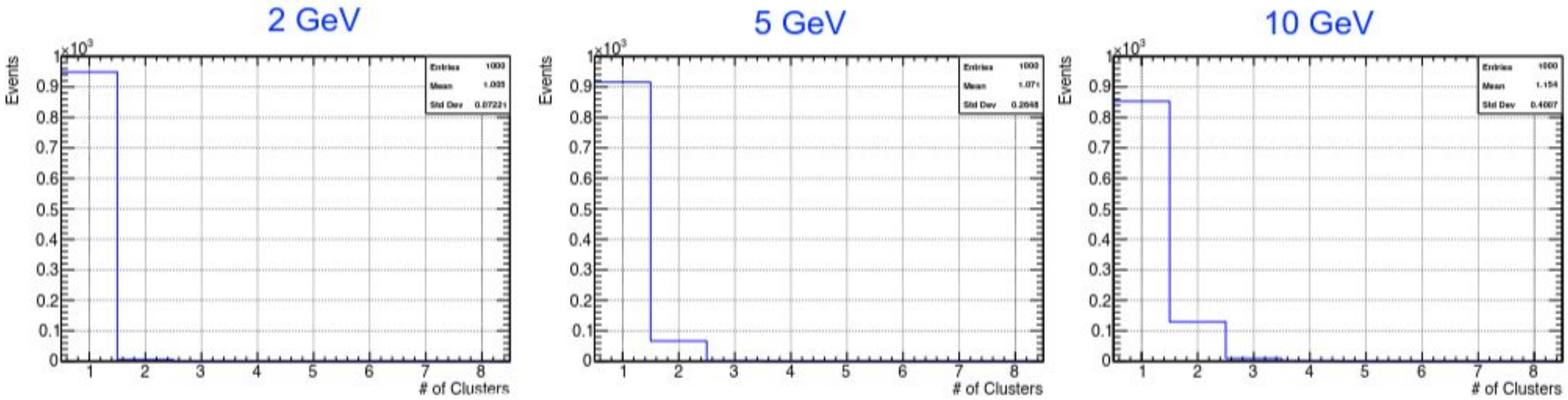


($E_{cl\#1}/E_{cl\#2}$) vs $\sum E_{cluster}$

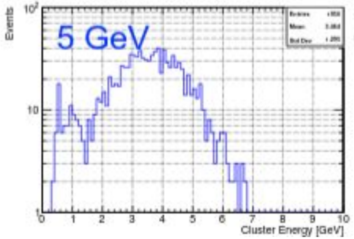


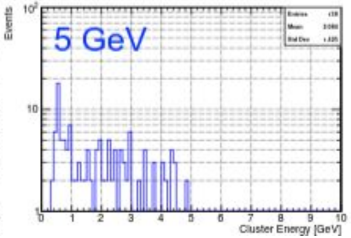
NUMBER OF CLUSTERS

One Photon(γ)



All Cluster energy





Cluster energy
When events have
more than one cluster

Backup

ScFi Calorimeter - Option 2

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  <D value="11.25" unit="g / cm3"/>
  <fraction n="0.954" ref="W"/>
  <fraction n="0.040" ref="Ni"/>
  <fraction n="0.006" ref="Fe"/>
</material>
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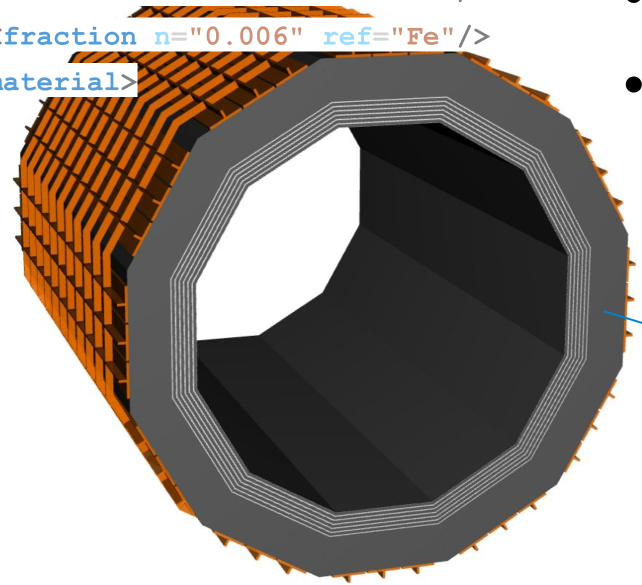

- 6 imaging layers separated with 13*1 mm wide layers of ScFi (13 layers of fibers)
- 15*13*1 mm of ScFi calo in the back
- 0.46 mm diameter fibers in W powder