Photon Performance

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Motivation

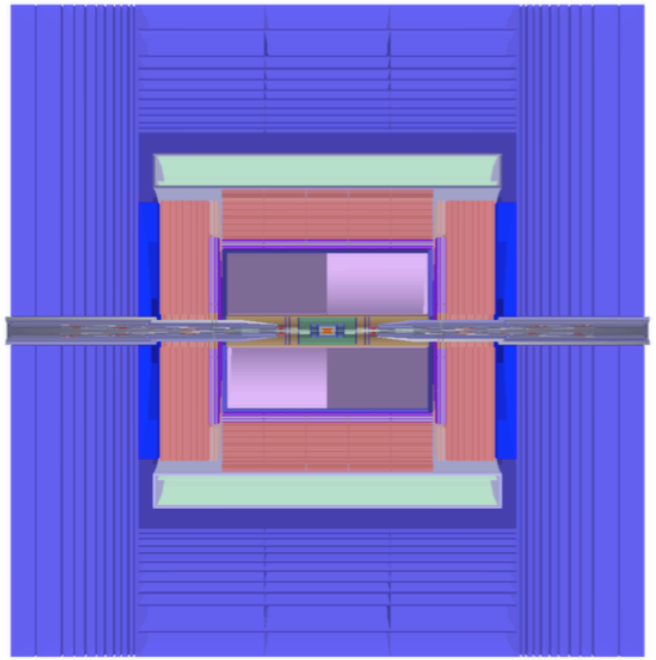
Photons can be produced from ISR, FSR and decays of unstable particles.

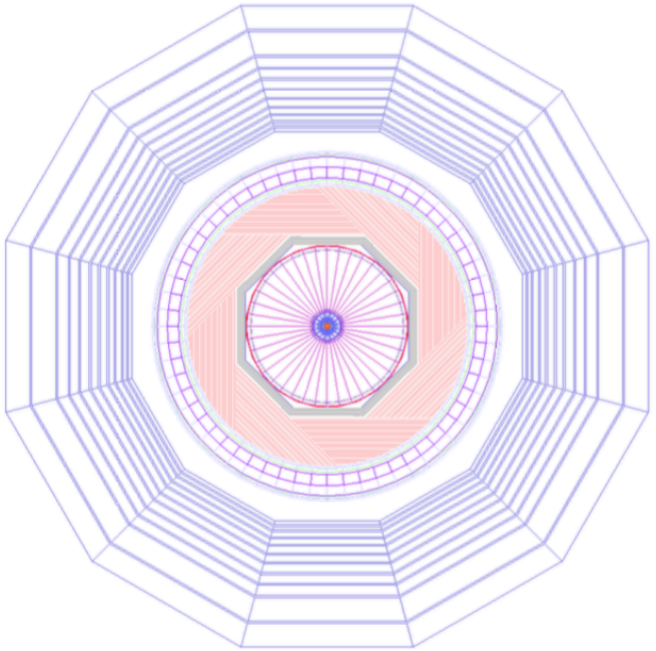
Precise photon measurements are essential:

- jet energy resolution
- measurements of H→$\gamma\gamma$
- studies of radiative process
- the τ identification
- They impact all aspects of the physics at the CEPC

The Baseline Detector Concept

- The Particle Flow Algorithm oriented detector
- In the barrel from inner to outer, the detector is composed of a silicon pixel vertex, a silicon inner tracker(SIT), a TPC, a silicon external tracker(SET) ,an ECAL and a HCAL, a solenoid of 3Tesla and a return yoke with embedded muon detector.
- A dedicated particle flow reconstruction toolkit, Arbor, has been developed.
- More details about detector and reconstruction are in CDR.

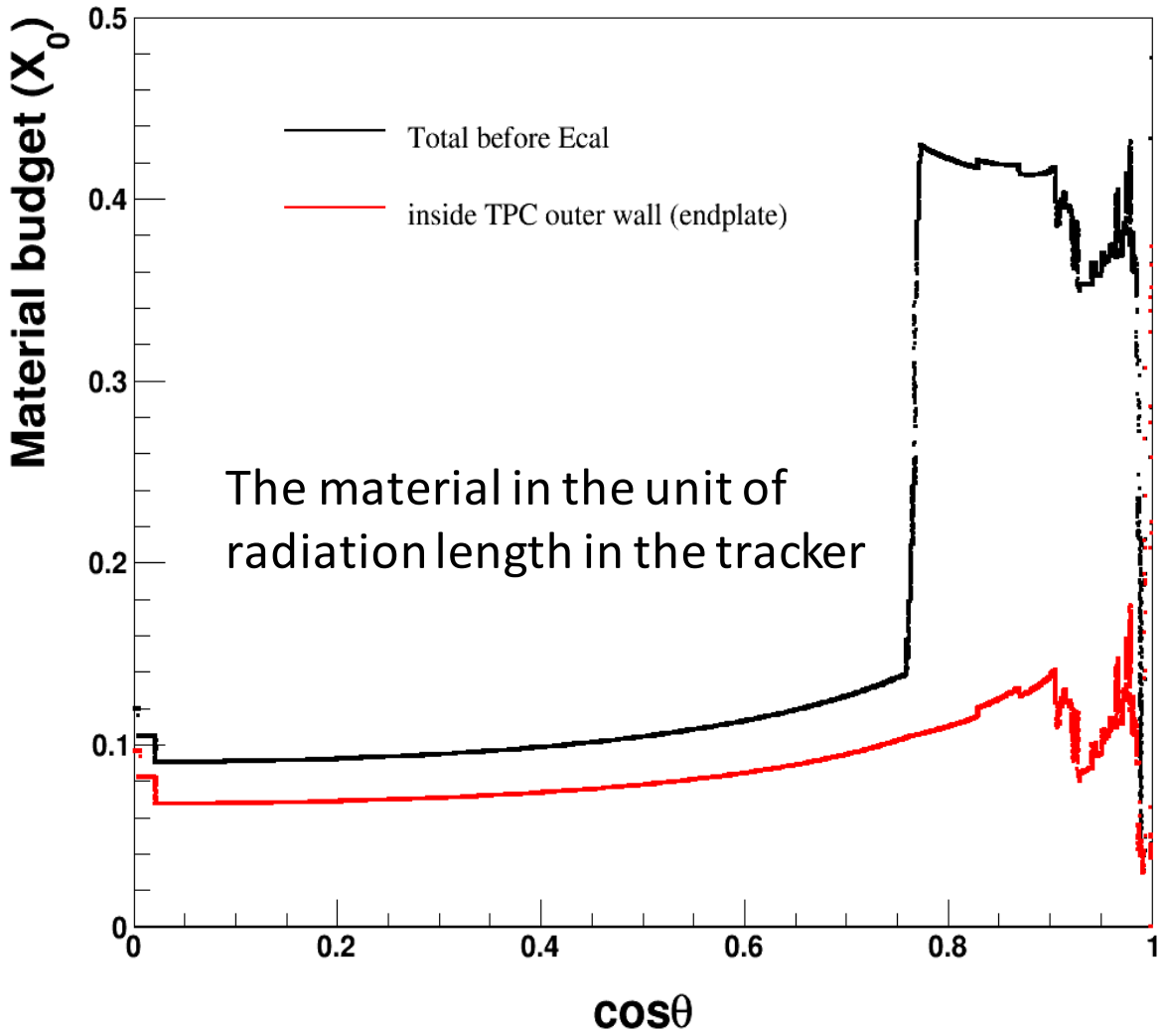


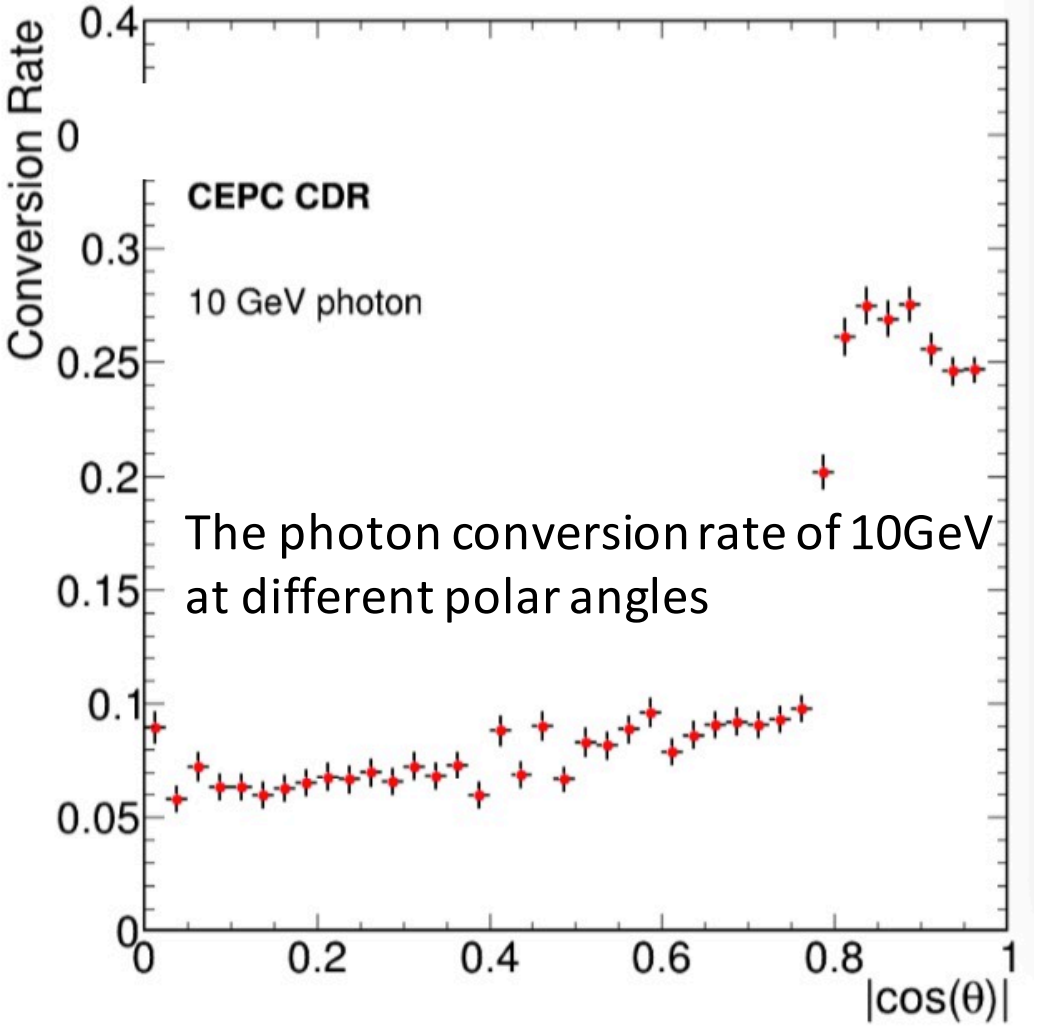


- Content:
- Photon Conversion Rate
- Photon Energy Measurement

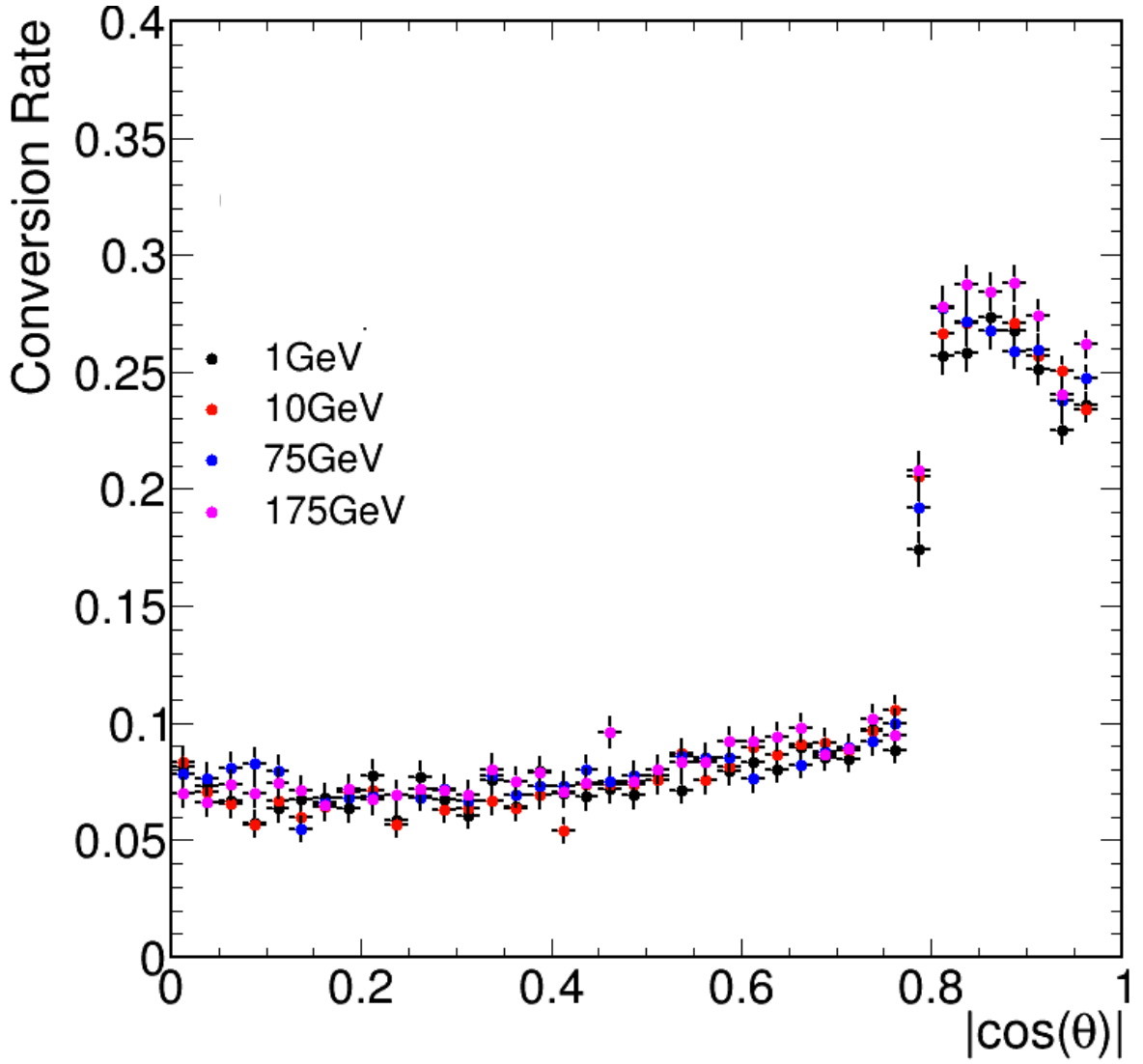
- At hit level before Arbor.
- For photons with energy above 5GeV, Arbor is able to collect more than 99% of the energy deposited in the calorimeter.

Photon Conversion Rate





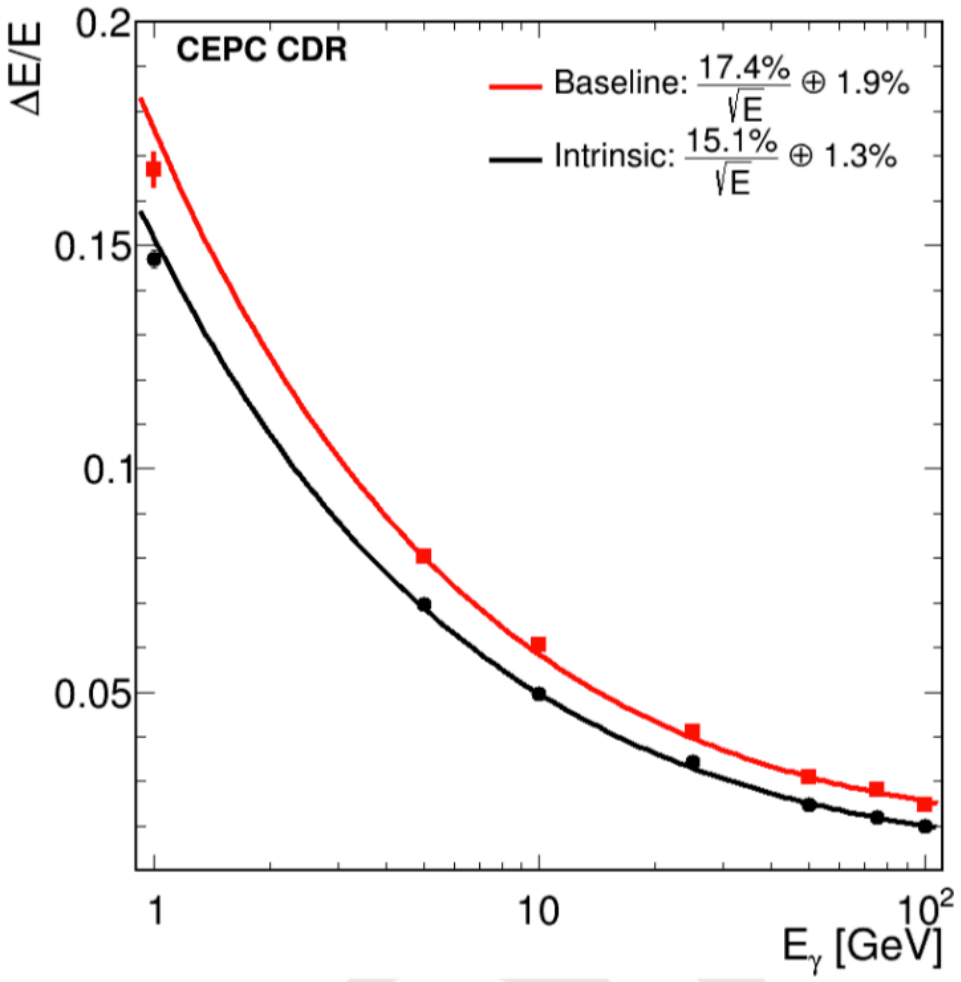
Photon Conversion Rate of Different Energies



Photon Energy Measurements

- PFA reconstruct photons in ECAL
- Photon Energy Resolution and Linearity is used to characterize the performance of ECAL.

Photon Energy Measurements



The photon energy resolution of unconverted photons as function of energy:

Baseline detector

Simplified Geometry

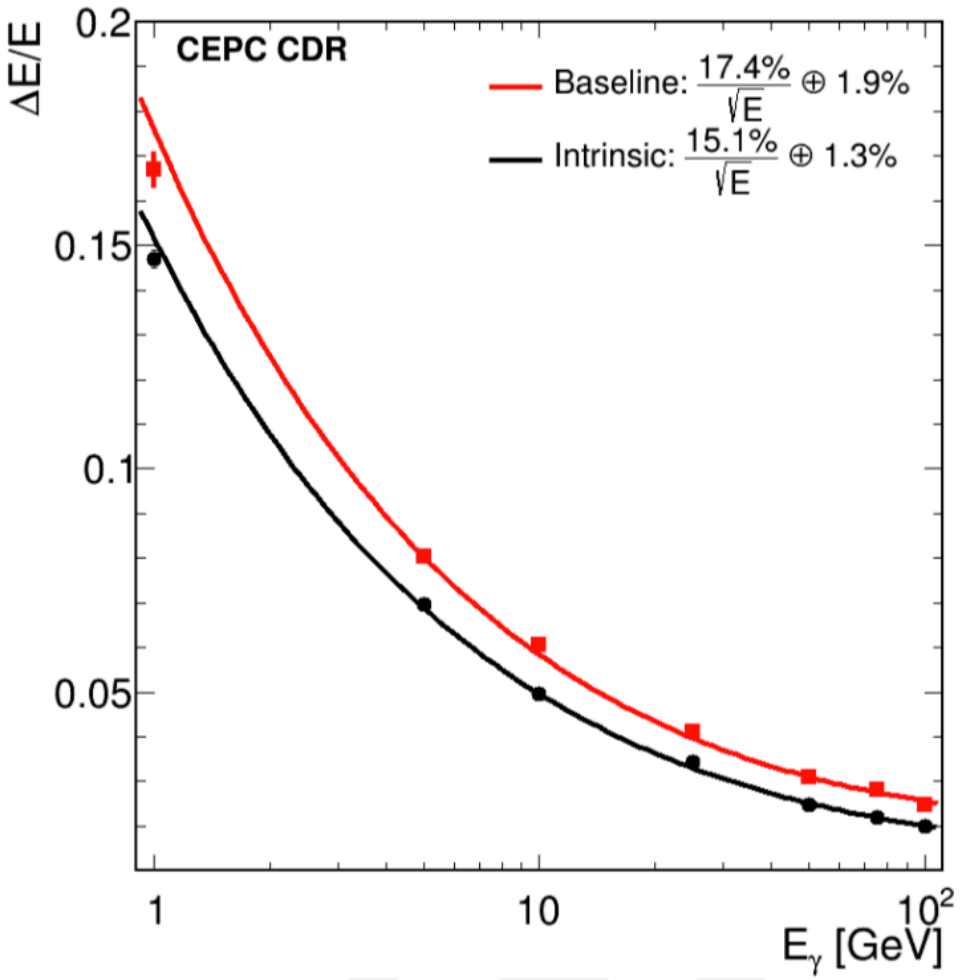
From CDR, Calibration is not taken into account

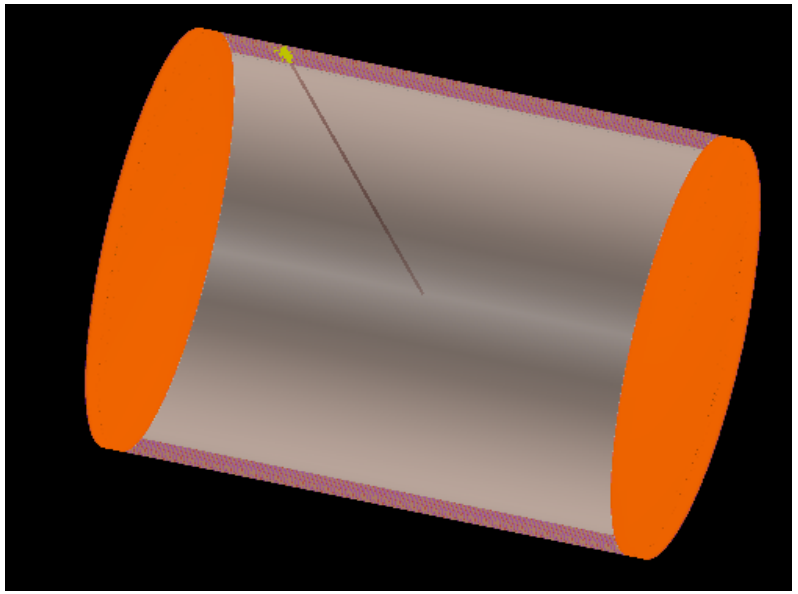
Photon Energy Measurements

The simplified geometry (ECAL):

no material in front

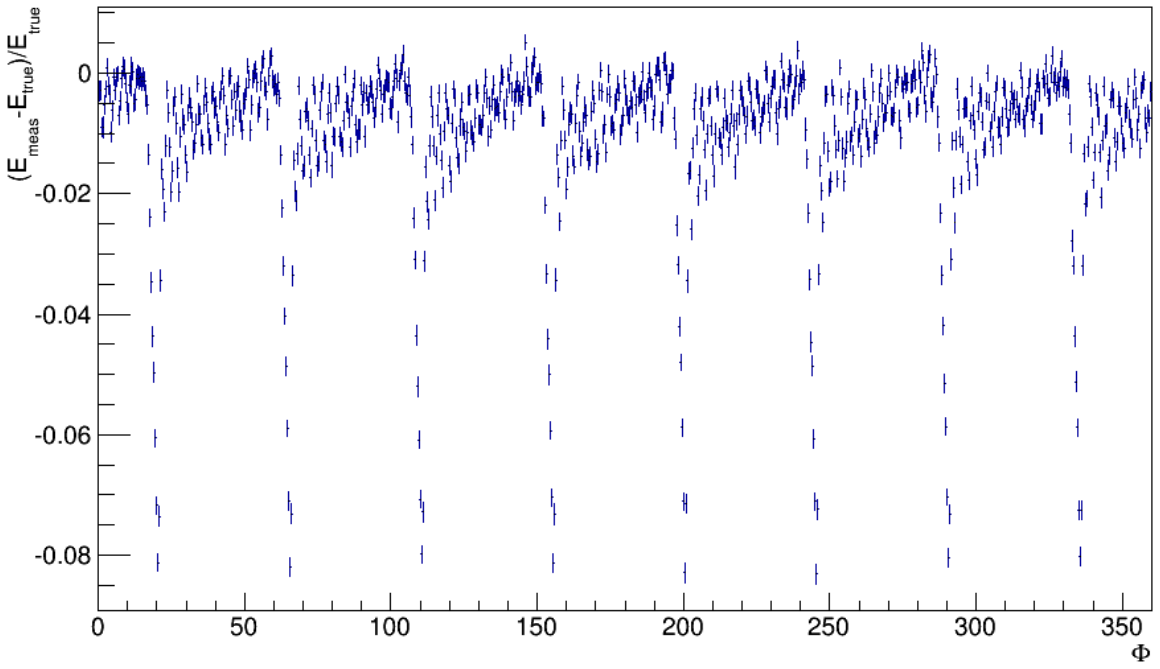
no gaps between two modules.

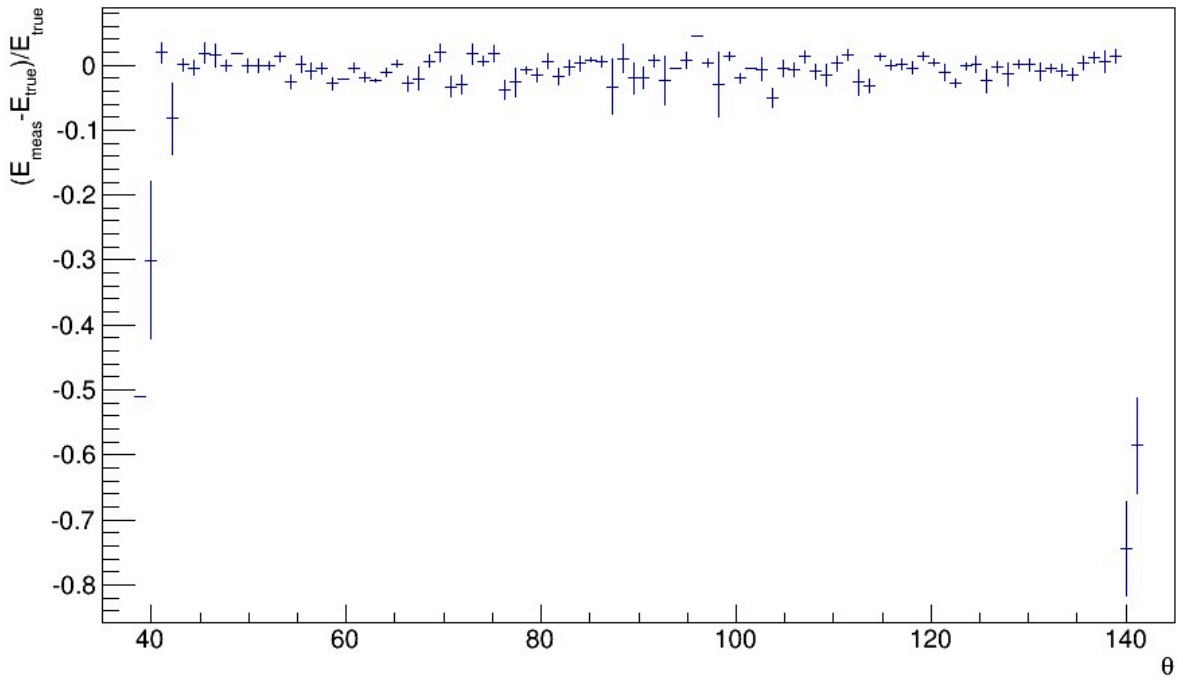




The resolution(Black) is the ideal resolution of the detector.

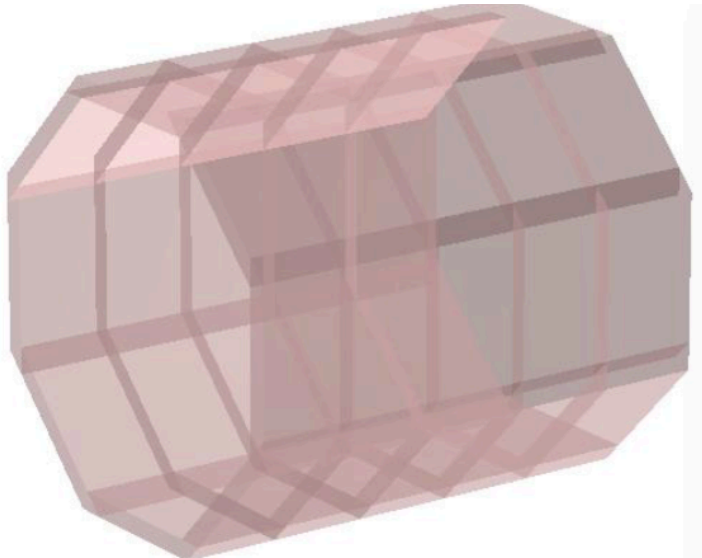
Geometry defects & correction



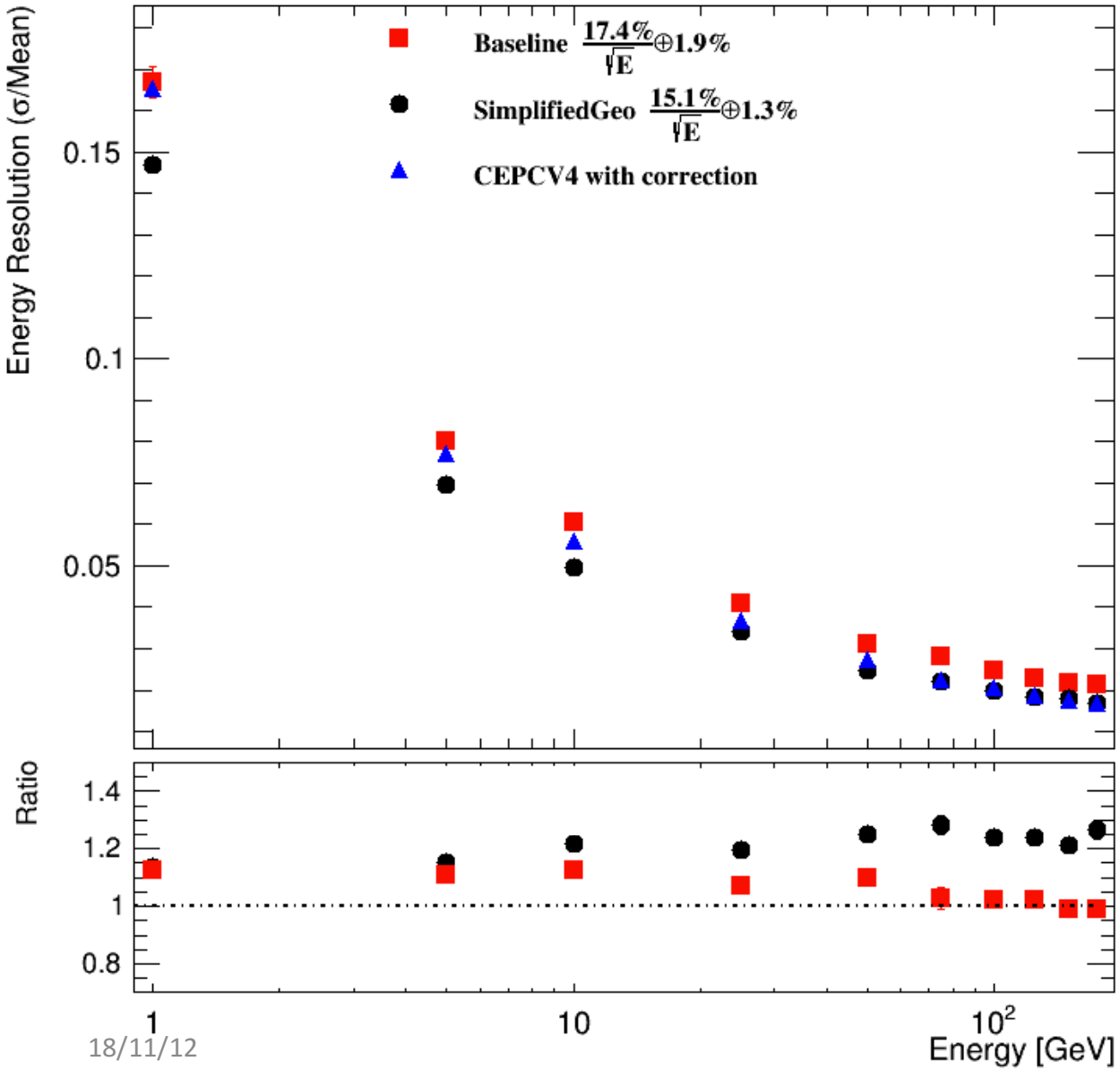


Energy deposited in ECAL depends on the ϕ and θ.
Need corrections (ϕ, θ, E_{true}).

Only Considering the unconverted Photon in the Barrel case at the hit level



Linearity And Resolution after correction

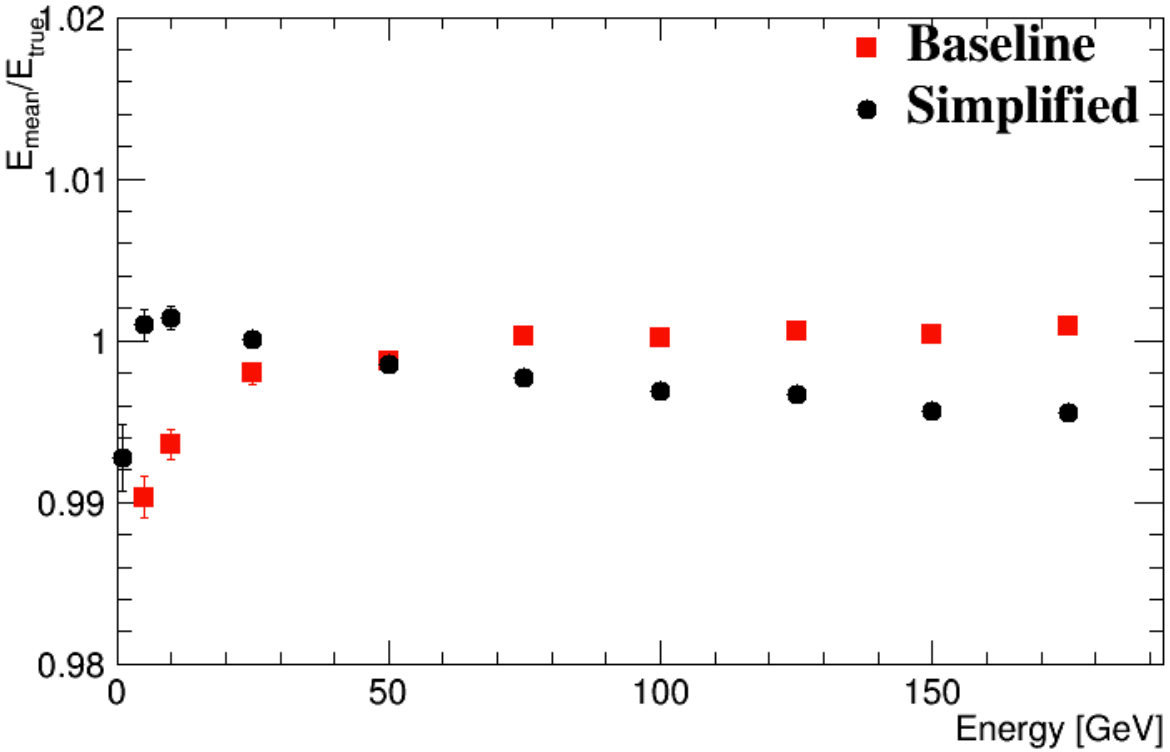


After correction, the resolution is close to the resolution of simplified geometry.

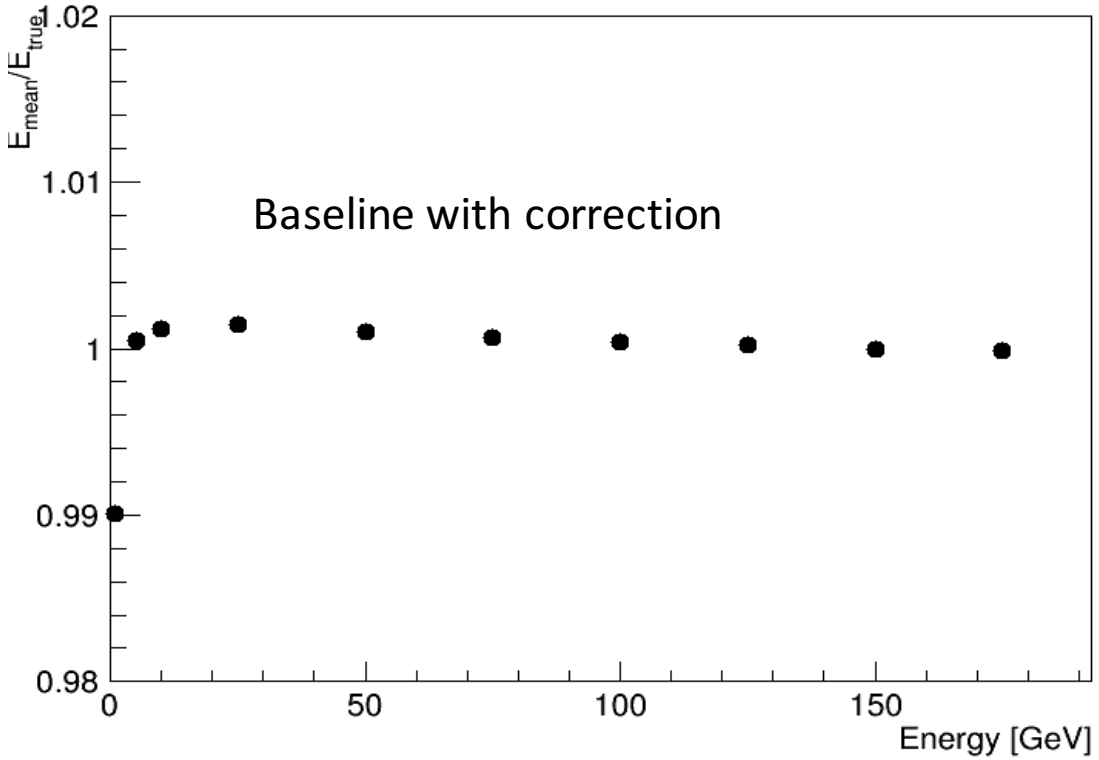
Baseline/Simplified

Baseline after correction/Simplified

Linearity And Resolution after correction



Total region



Barrel

Conclusion:

- Photon conversion rate is proportional to the material budged before ECAL.
- 5-10% of photons convert to e^+e^- in barrel
- About 25% of photons convert to e^+e^- in endcap

- After correction, the photon energy resolution is close to resolution of the simplified geometry.
- Linearity is good.

To do list:

1、Calibration

2、Correction at the Endcap

3、Converted Photon Reconstruction.

For unconverted photons of energies above 5 GeV, the identification efficiency is nearly 100% with more than 99% of their energy reconstructed. But for the the converted photons, 80% are recovered.

4、Photon ID

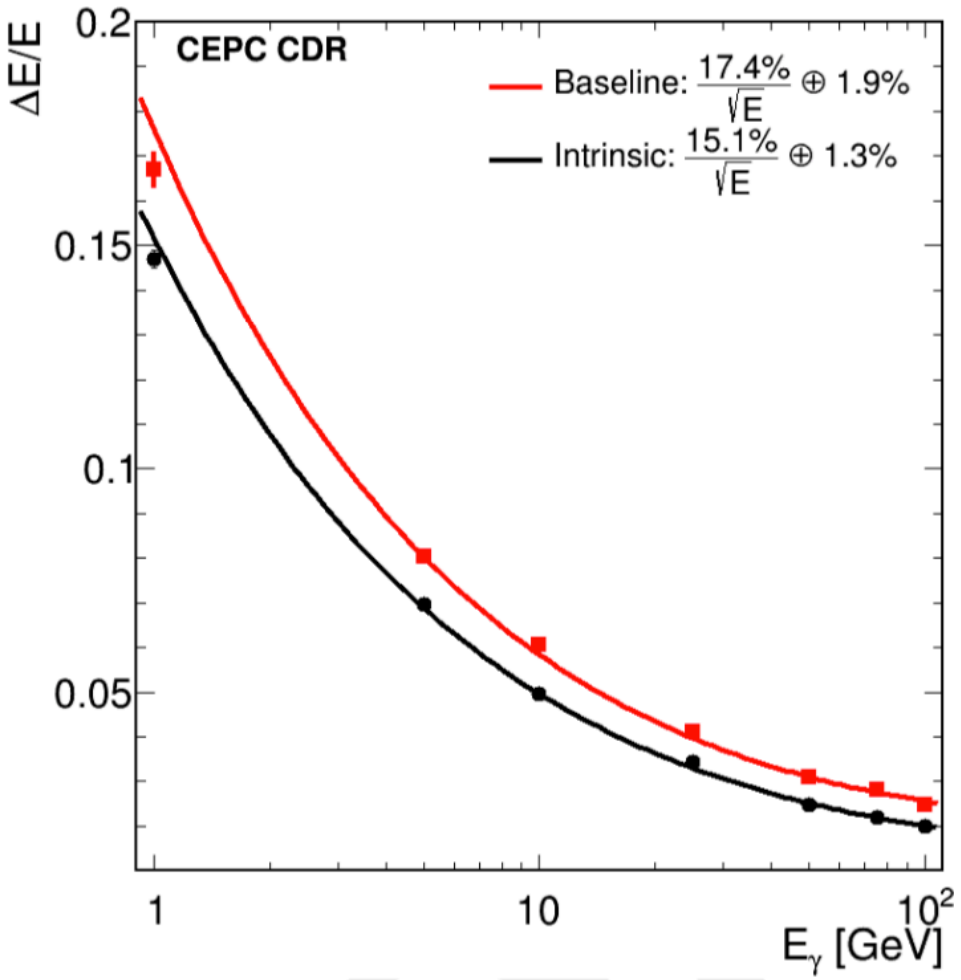
Identifying photons from the pion with high efficiency and purity is essential for the identify the tau-lepton in the different decay modes.

Welcome to join us!

Thank you~~

BackUp

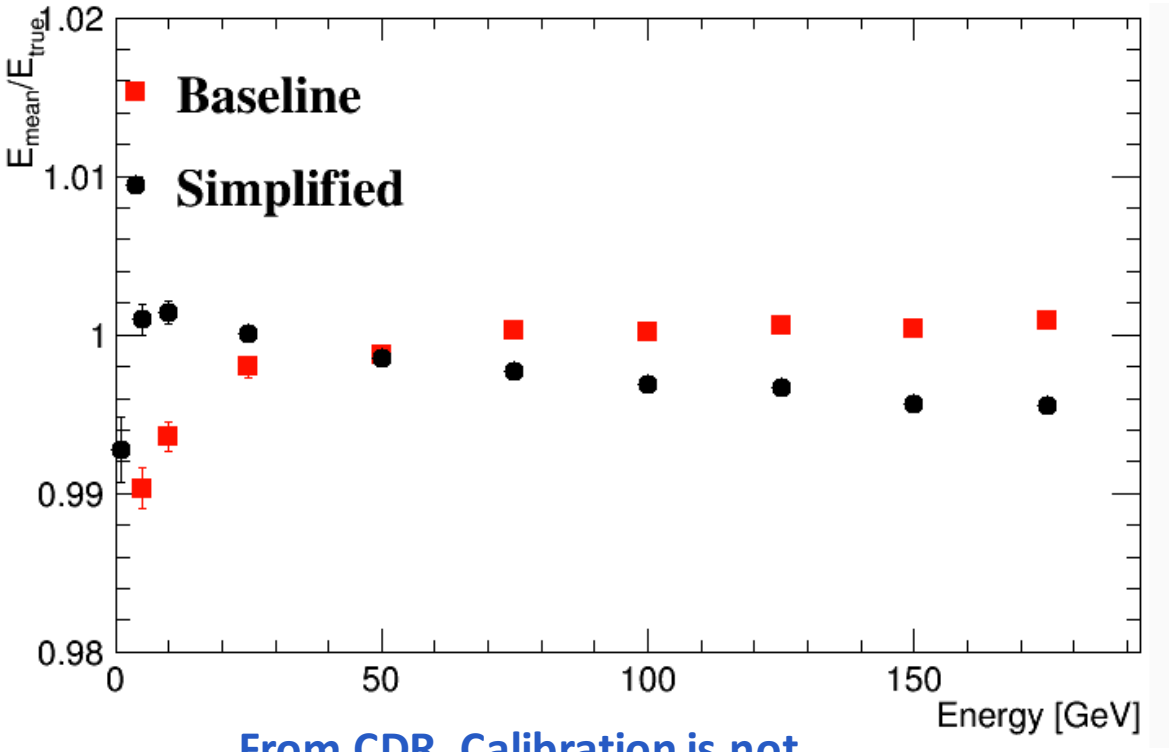
Photon Energy Measurements



The photon energy resolution and linearity of unconverted photons as function of energy:

Baseline detector

Simplified Geometry



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Photon Energy Measurements

The simplified geometry :

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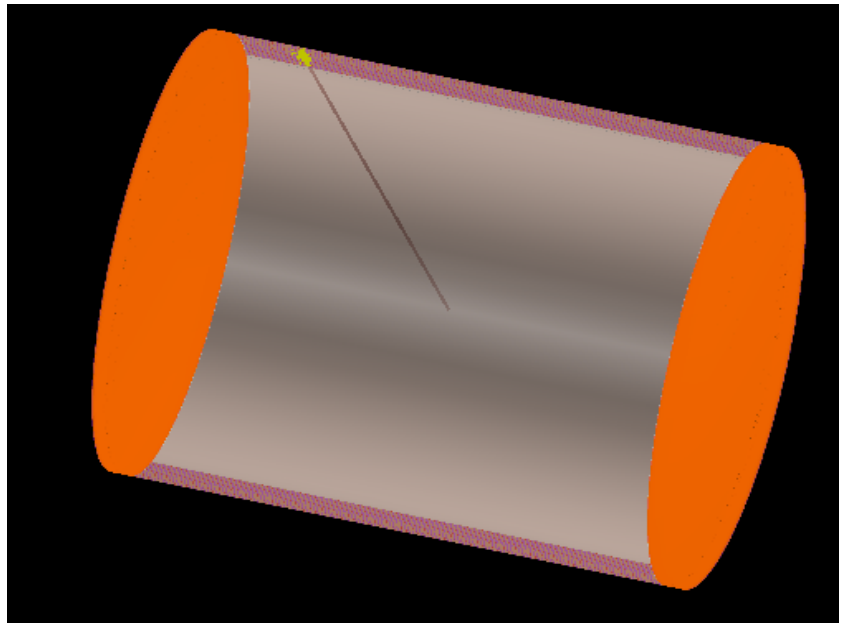
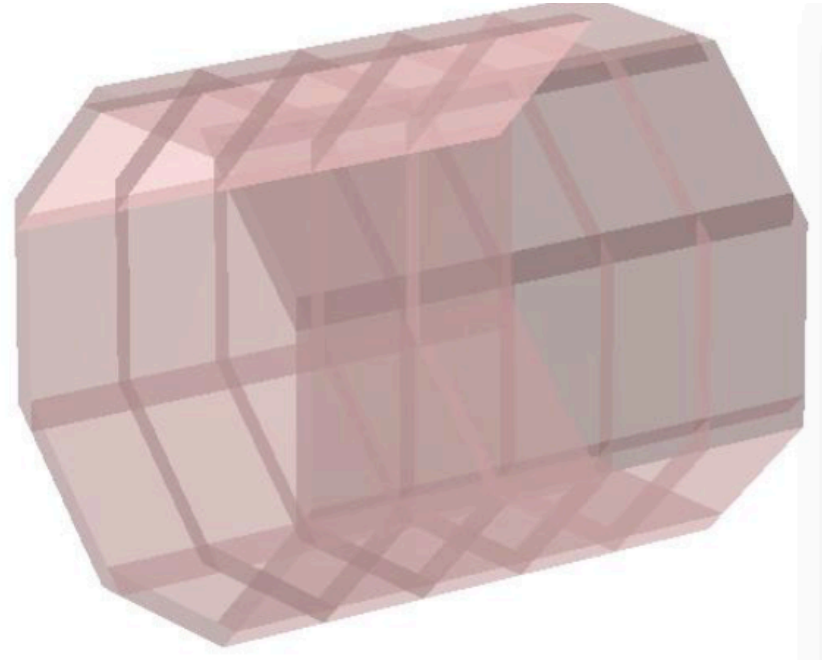
no gaps between two modules.



The Baseline detector (ECAL barrel) :



The resolution(Black) is the ideal resolution of the detector.

Photon reconstruction at the CEPC baseline

- Arbor
- High granularity Calorimeter
- How it looks like
  - Typical # Hit Vs Energy

- Content
  - Photon ID (from Neutral Cluster)
  - Photon Conversion (Intrinsic material effect) & radiation
    - Tag, rate measure & understanding
    - Converted photon finding reconstrcuted
  - Photon Energy Measurement

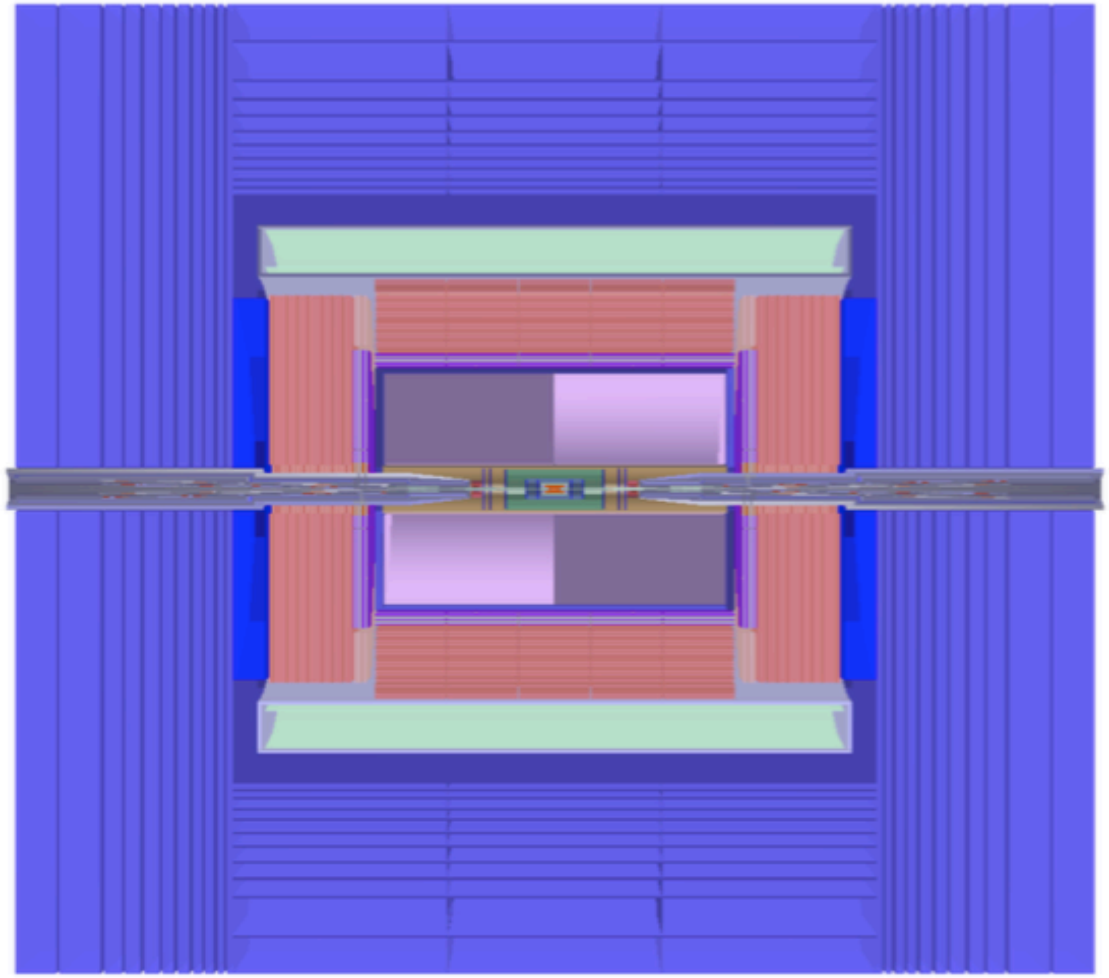
Photon Conversion Rate

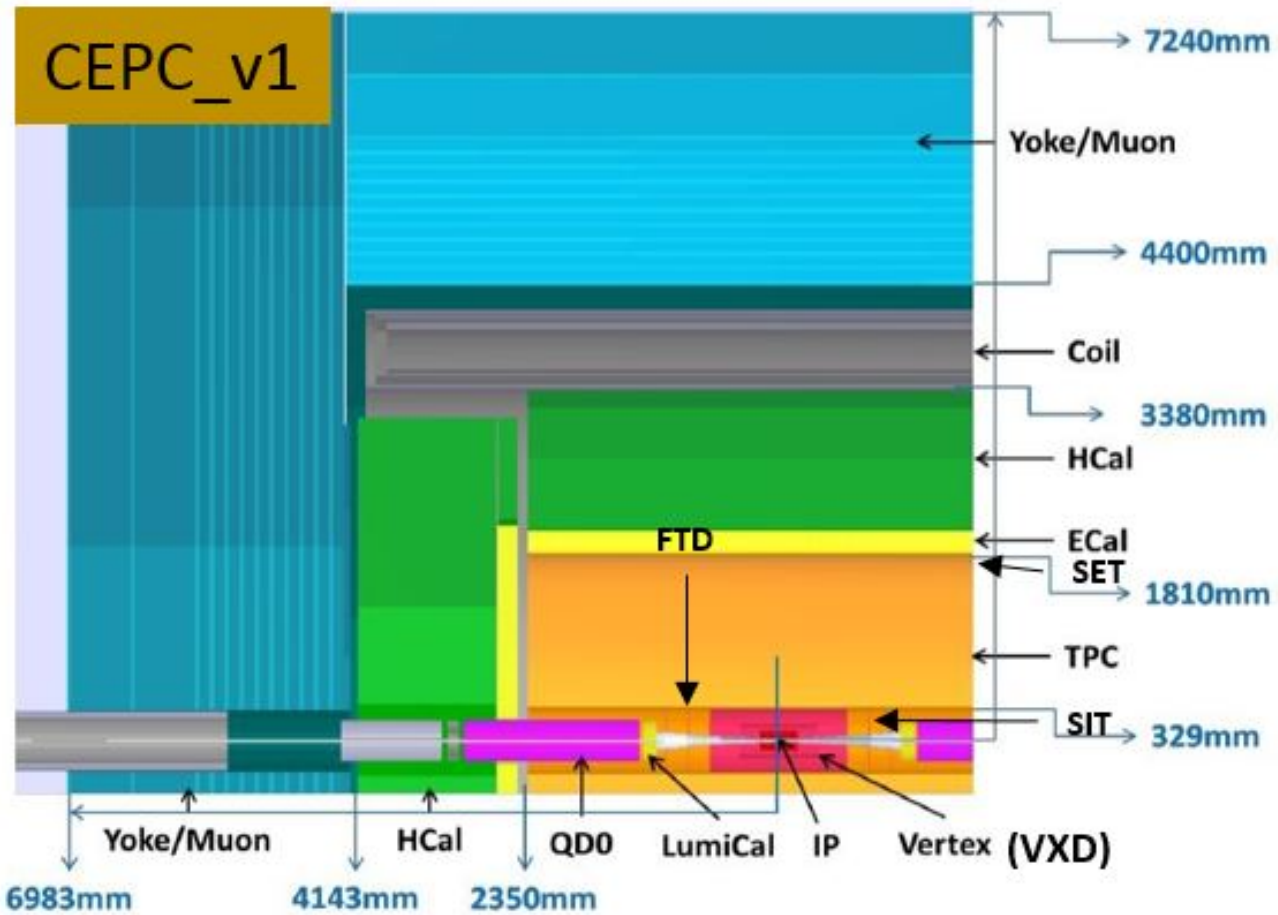
Photons have similar signatures as electrons in the ECAL, but without matching tracks in the tracker.

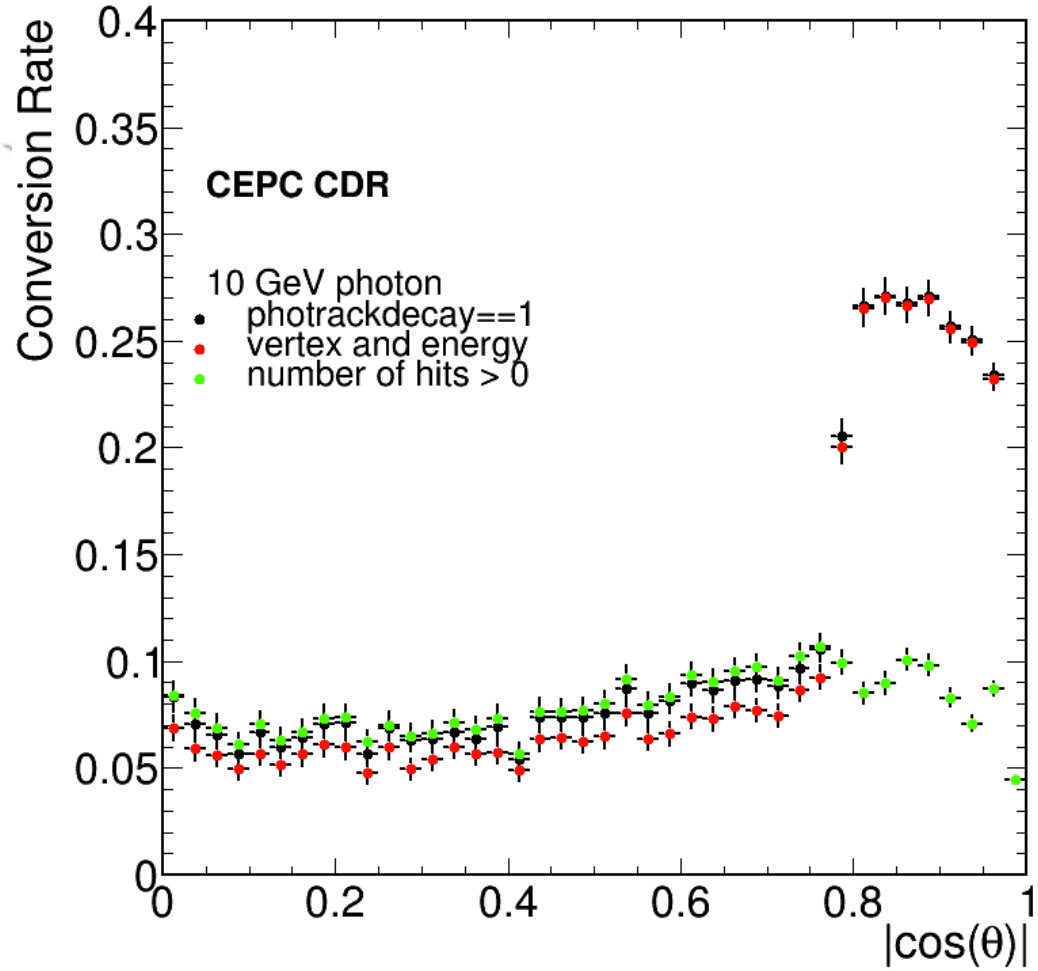
But in front of ECAL, there are some materials. So the photons will convert to e^+e^- pairs through the interaction with the materials.

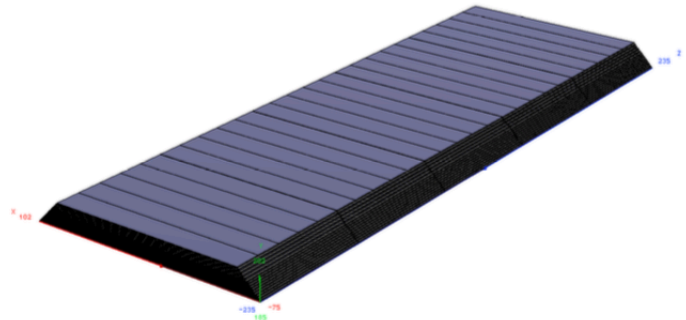
Some of these converted photons will have matched tracks.

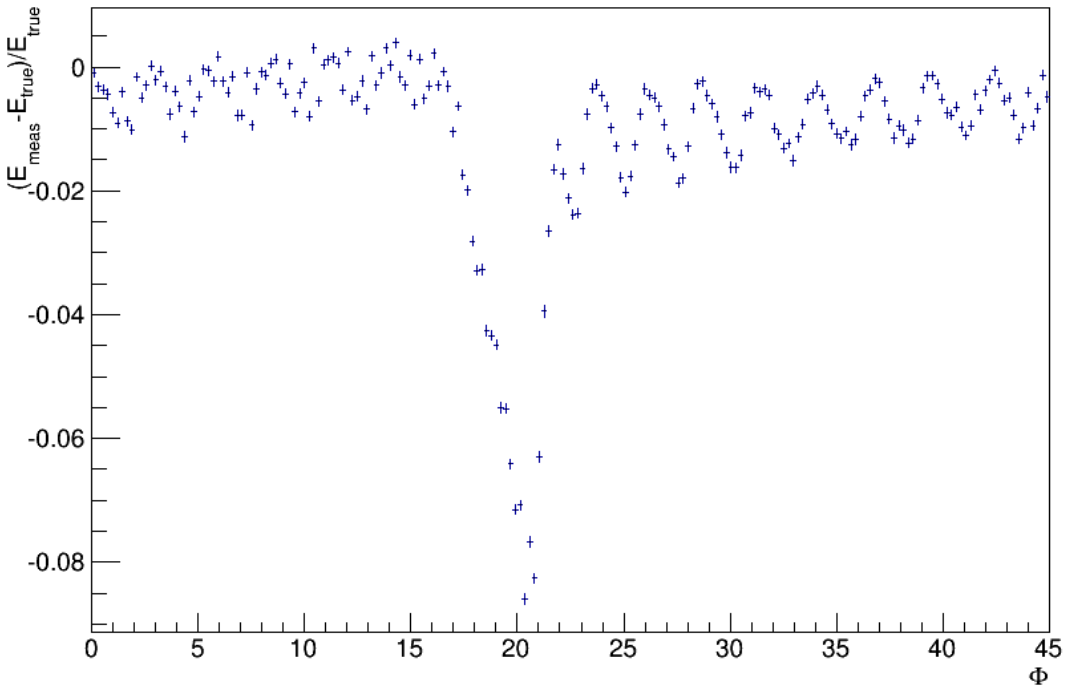
The reconstruct the convert photon is next step.

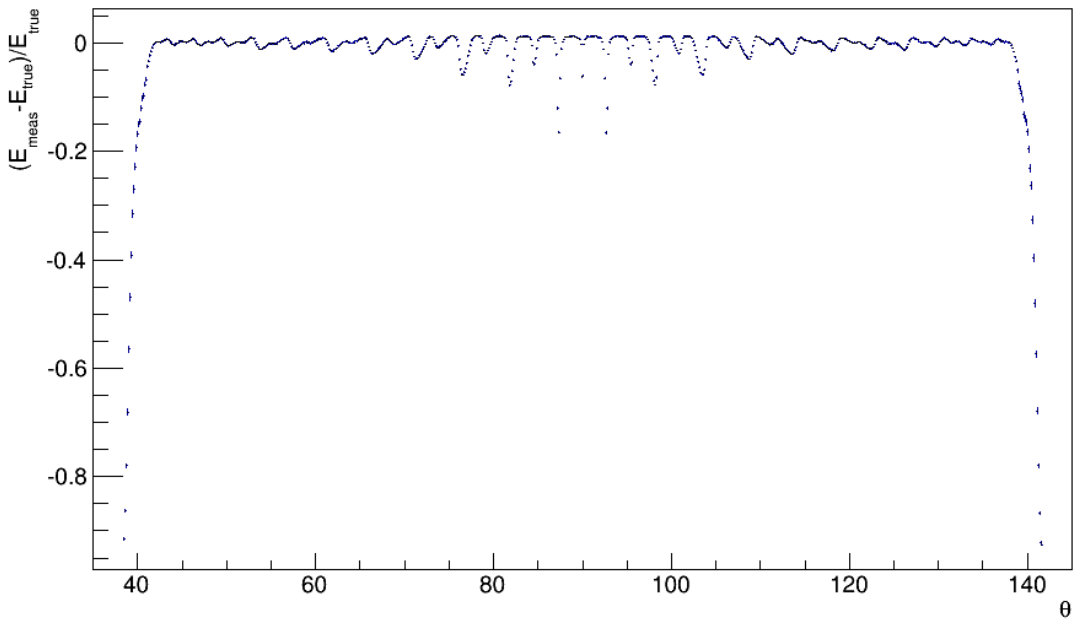



CEPC_v1
7240mm
Yoke/Muon
4400mm
Coil
3380mm
HCal
ECal
FTD
SET
1810mm
TPC
SIT
329mm
Yoke/Muon
HCal
QD0
LumiCal
IP
Vertex
(VXD)
6983mm
4143mm
2350mm

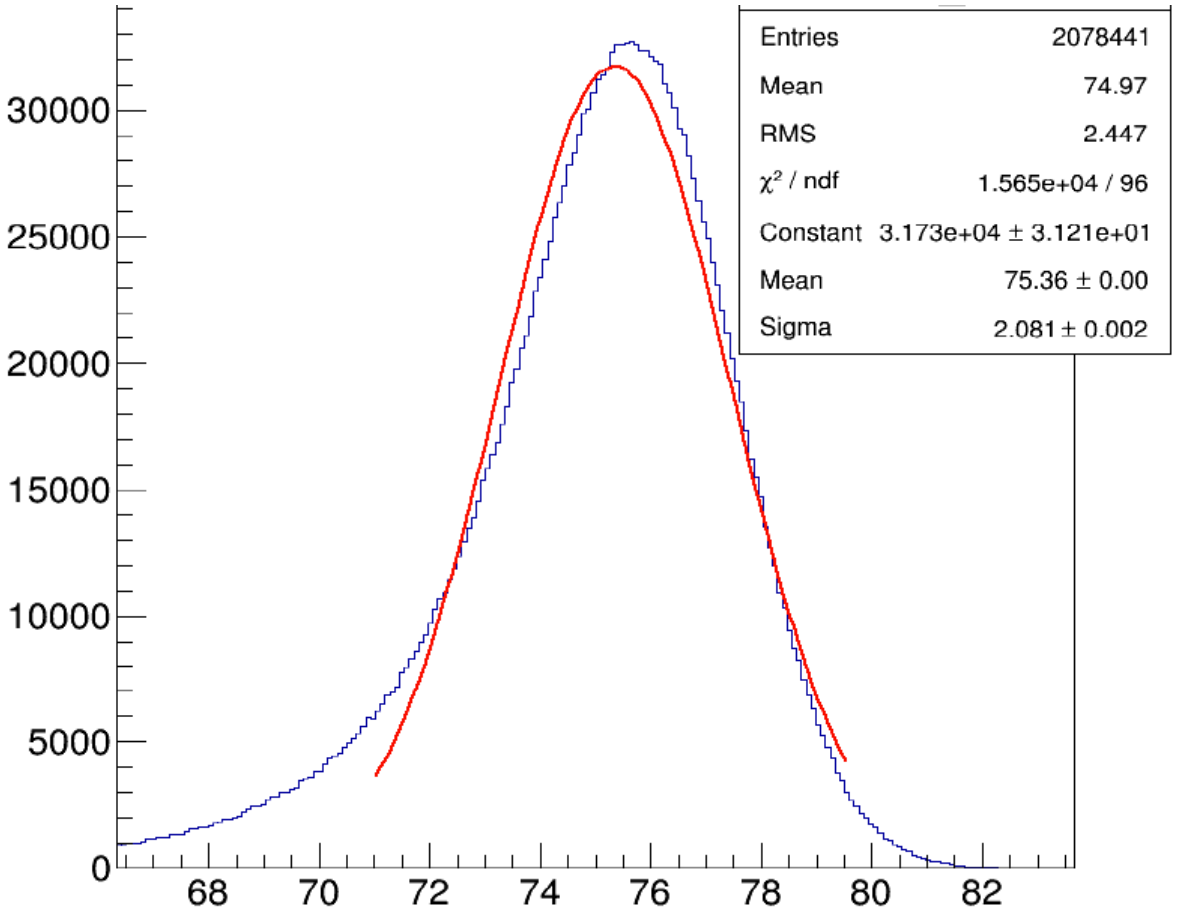

Conversion Rate
CEPC CDR
10 GeV photon
photrackdecay==1
vertex and energy
number of hits > 0
|cos(θ)|
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.2
0.4
0.6
0.8
1



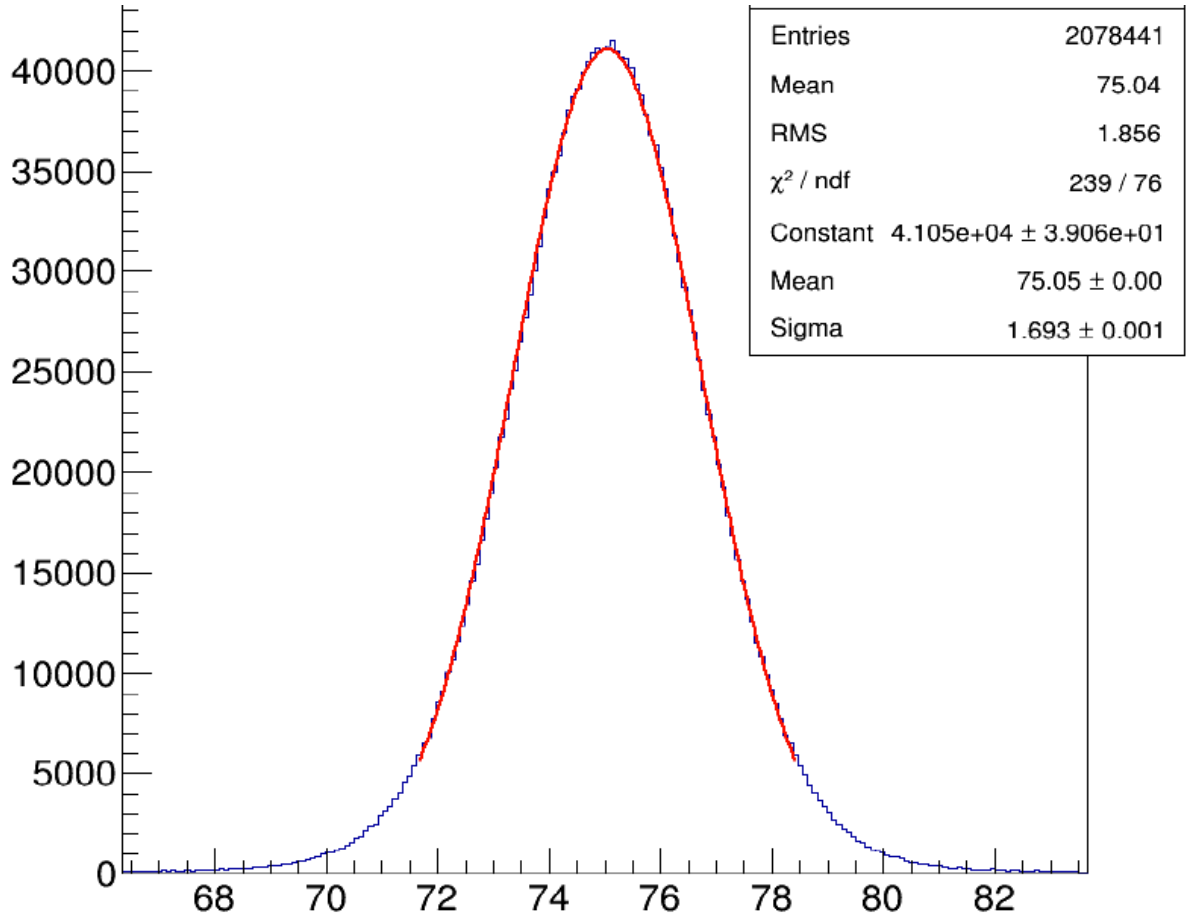

$(E_{meas}-E_{true})/E_{true}$
0
-0.02
-0.04
-0.06
-0.08
0
5
10
15
20
25
30
35
40
45
Φ


$(E_{meas}-E_{true})/E_{true}$
0
-0.2
-0.4
-0.6
-0.8
40
60
80
100
120
140
θ

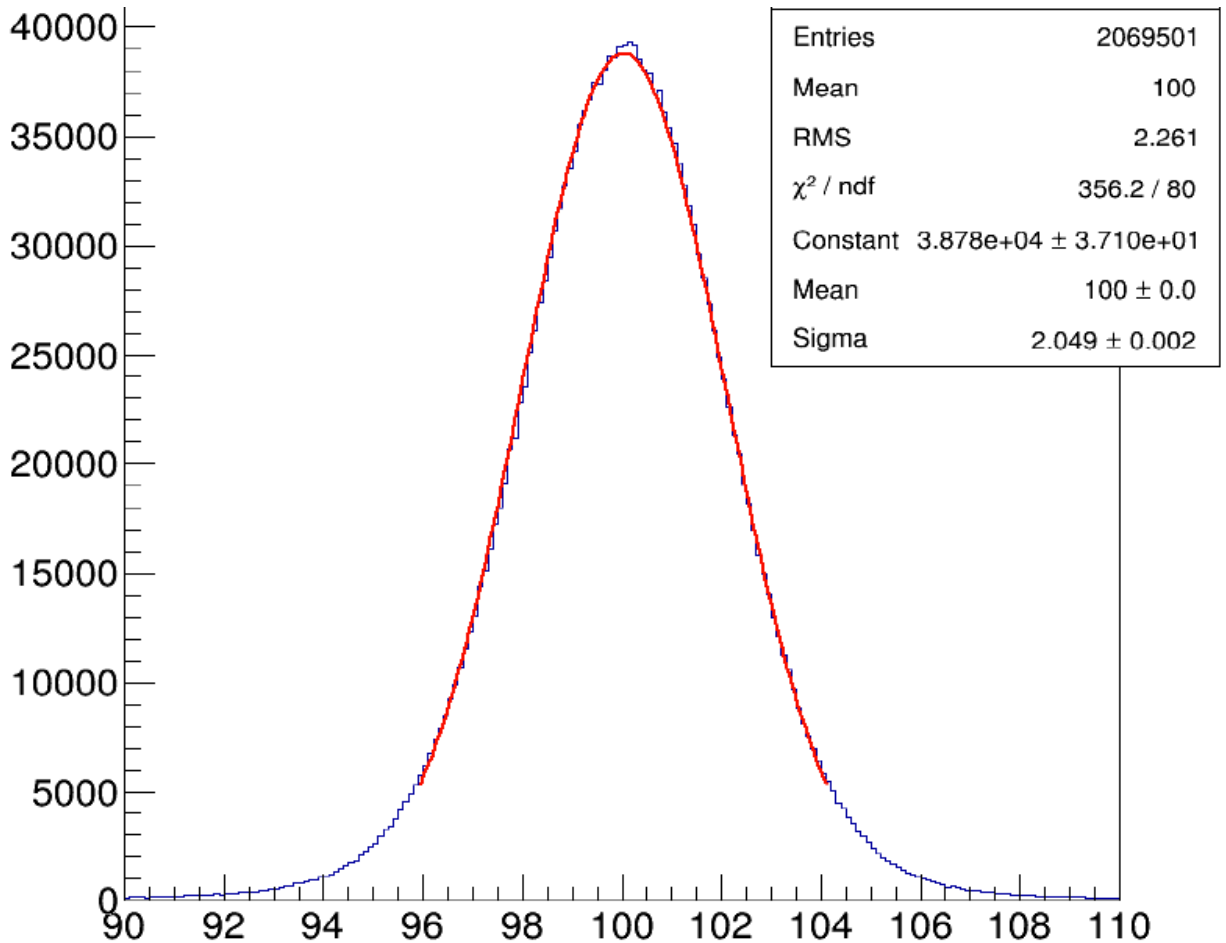
Geometry defects & correction



Before correction



After correction


Entries 2069501
Mean 100
RMS 2.261
χ² / ndf 356.2 / 80
Constant 3.878e+04 ± 3.710e+01
Mean 100 ± 0.0
Sigma 2.049 ± 0.002
40000
35000
30000
25000
20000
15000
10000
5000
0
90
92
94
96
98
100
102
104
106
108
110