

CRD ECal design and performance

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Outline

Introduction

Geometry construction

Simulation and digitalization

Reconstruction

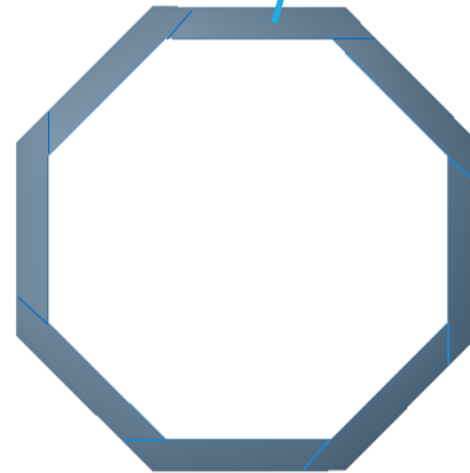
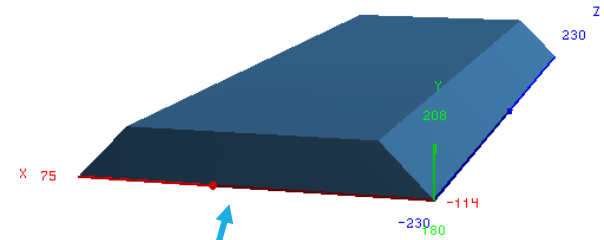
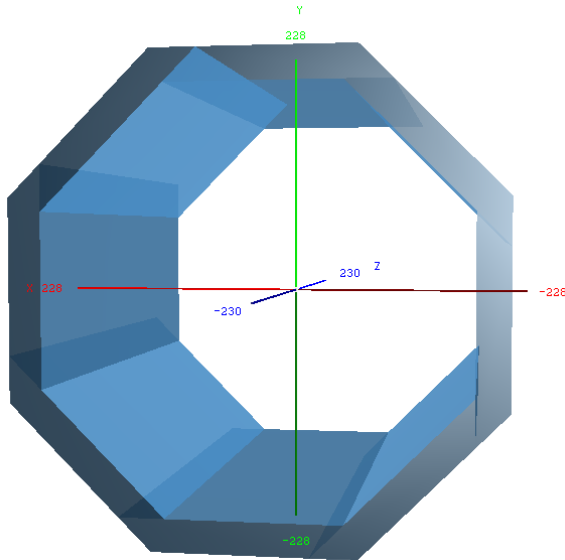
- Single shower reconstruction
- Di-photon events
- π^0 reconstruction with Pandora(not finished)
- $H \rightarrow \gamma\gamma$ events reconstruction with Pandora(not finished)

Summary and Next step

Geometry construction

A full BGO crystal barrel:

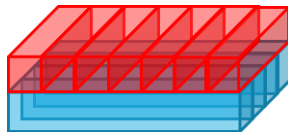
- $R_0 = 1.8m, Z = 4.6m, \text{Height}=28\text{cm}$
- 8 same trapezoidal **modules**.
- Crystal bar: $1\text{cm} \times 1\text{cm} \times \sim 40\text{cm}$.
- Ideal detector without readout, supporting, etc.



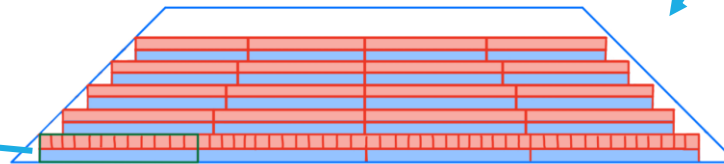
Geometry construction

In each trapezoidal module:

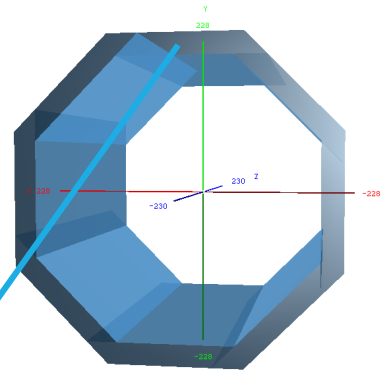
- 28 **layers**, counting 2 layers as a **super-layer**.
- In each super-layer, **layer0** goes horizontal(ϕ -direction), **layer1** goes longitudinal(z-direction).
- Basic unit for reconstruction: $\sim 40\text{cm} * \sim 40\text{cm} * 2\text{cm}$ **block**.
- Each block has $\sim 40(\text{layer0}) + \sim 40(\text{layer1})$ crystal bars.
- 4 blocks in ϕ , 10 blocks in z direction.
- *Left a ~ 2 cm blank at the edge of module.



40cm*40cm*2cm block



A module in x-y plane, with part of bars.



Simulation and digitalization

Construct the geometry in DD4hep.

Simulation could be performed with Geant4 in CEPCSW.

Digitalization for one long crystal bar:

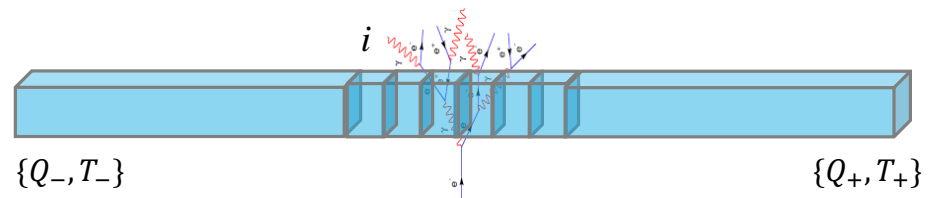
- Readout information: 2-side Q and T.
- Contribution from G4step i :

$$Q_{\pm}^i = E_0 \cdot e^{-\frac{L_{\pm} z_i}{L_{Att}}}, T_{\pm}^i = Gaus(z_{\pm}^i/v, \sigma_T).$$

- For the full bar:

$$Q_{\pm} = \sum_{step} Q_{\pm}^i, T_{\pm} = \min(T_{\pm}^i)$$

- Simplified condition: $L_{Att} = \infty$, so $Q_{\pm} = E_{tot}$.



Hit reconstruction

Digitalized hit reconstruction is based on bar cross-locating.

Truth-level Simulated hit: merge G4steps in $1*1*1 \text{ cm}^3$ cube as a truth hit.

Reconstructed hit:

- Hit position: $(u_{layer0}^i, v_{layer1}^j, \frac{w_{layer0}^i + w_{layer1}^j}{2})$
- Hit energy: Get energy deposition in each u-bar/v-bar
 $E_{bar1} [Nbars], E_{bar2} [Nbars]$.

$$\text{Hit.E} = E_{bar1} \frac{E_{bar2}}{\Sigma E_{bar2}} + E_{bar2} \frac{E_{bar1}}{\Sigma E_{bar1}}$$

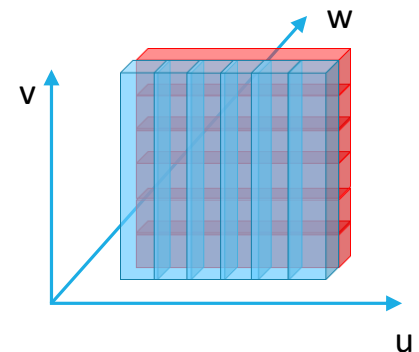
- Position from time:

- $x_T = x_{bar} + \frac{T1-T2}{2} v, \sigma_x = \frac{\sigma_T}{\sqrt{2}} v.$

- If $(|x_T - x_{bar2}| > N\sigma_x)$ remove this hit.

Based on bar position.
Get hit size: $1*1*2 \text{ cm}^3$

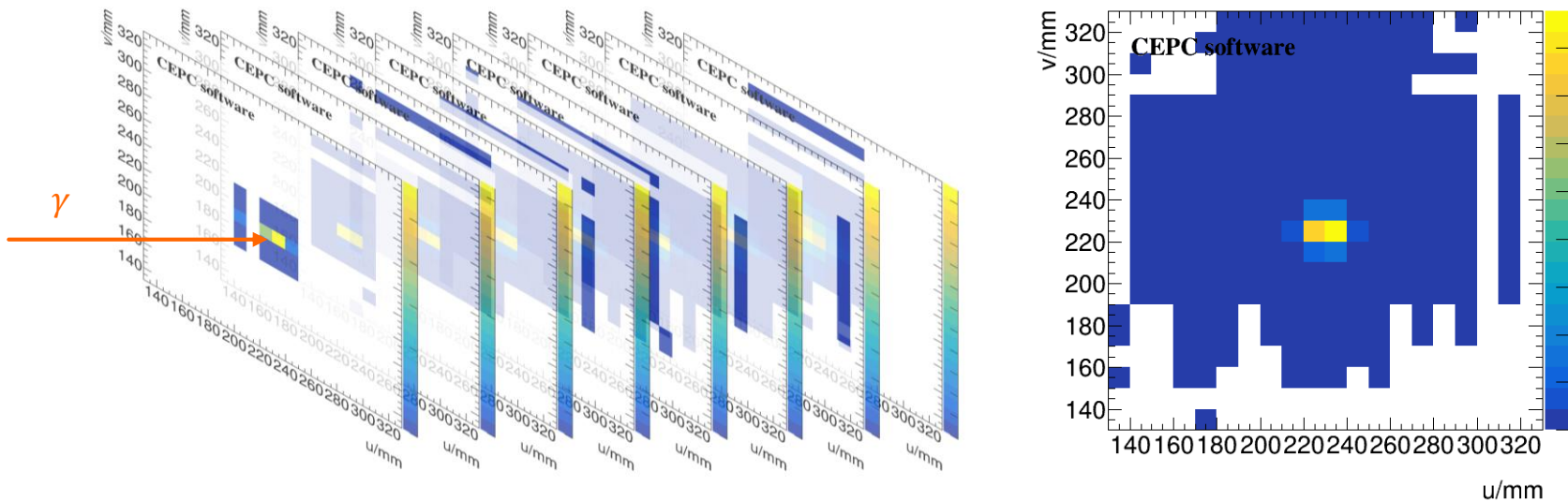
Ghost hit removal.
 $N = \infty \Rightarrow$ No time information



Hit reconstruction single photon

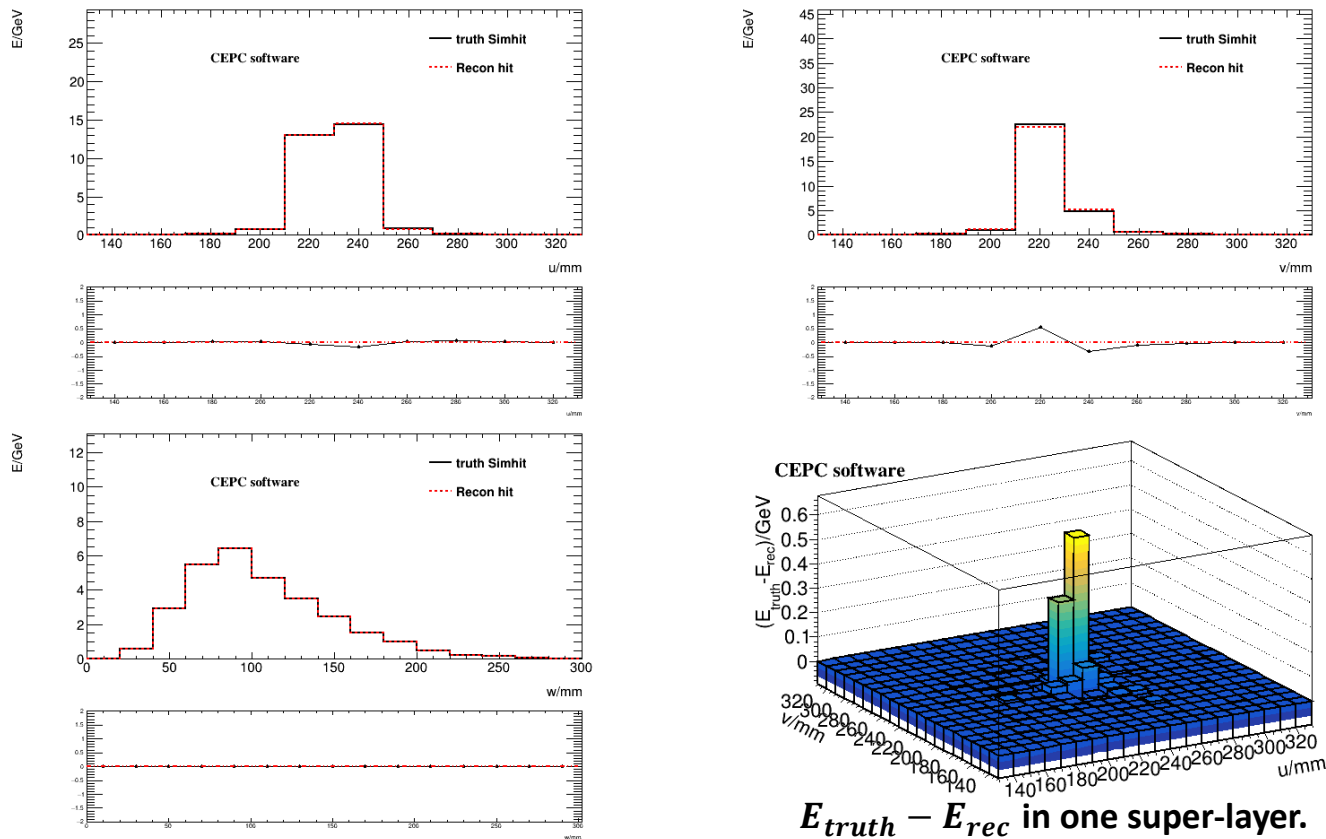
Check performance with 30GeV single photon.

- $L_{Att} = \infty, N = \infty$
- Energy threshold for a crystal bar: 3GeV.
- Vertical shoot at the central of one block in first super-layer.



Hit reconstruction single photon

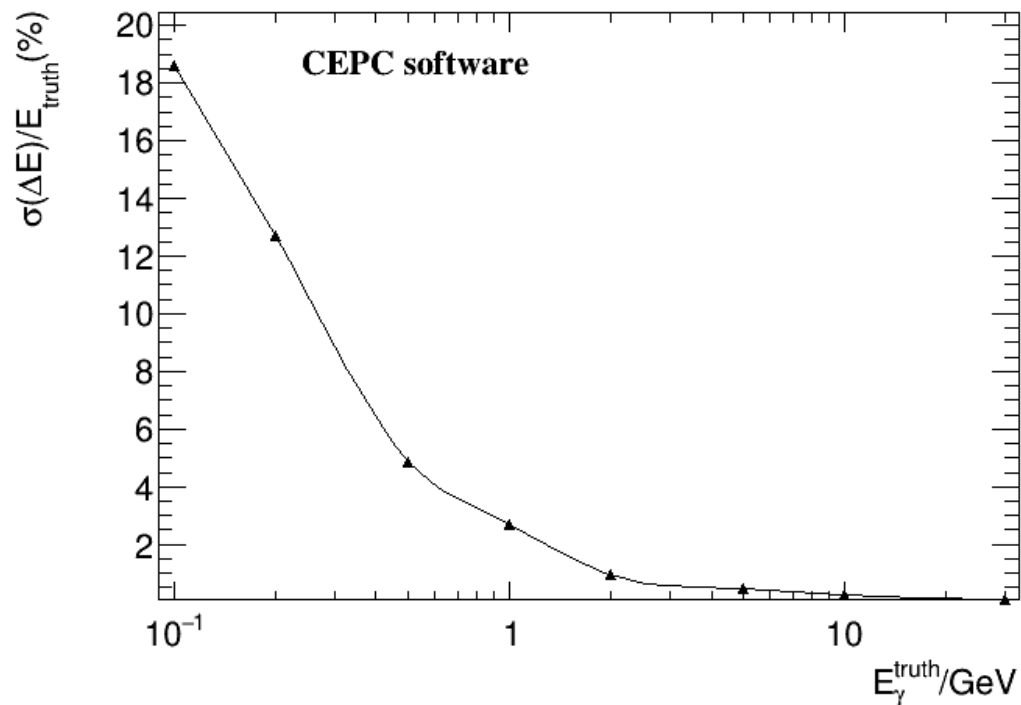
Position and energy comparison for RecHit and truth hit.



Hit reconstruction single photon

Reconstructed energy resolution

~20% for 100MeV photon

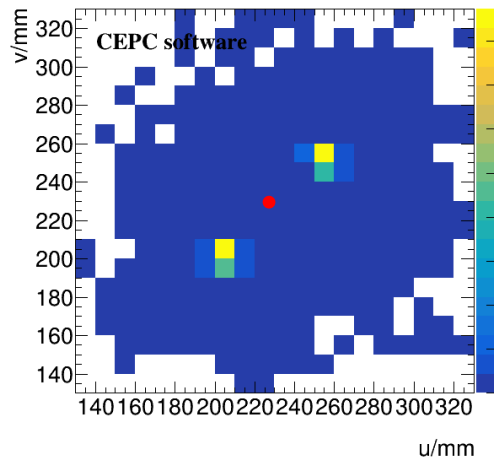


Hit reconstruction di-photon

Diphoton events

- 2 10GeV photon from vertex: (0, 260, 260), (0, 200, 200).
- Vertical shoot at the block.

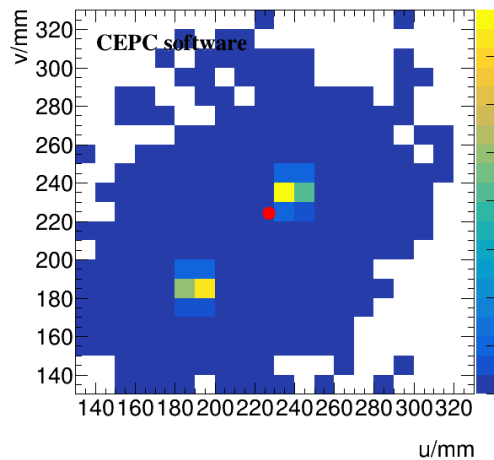
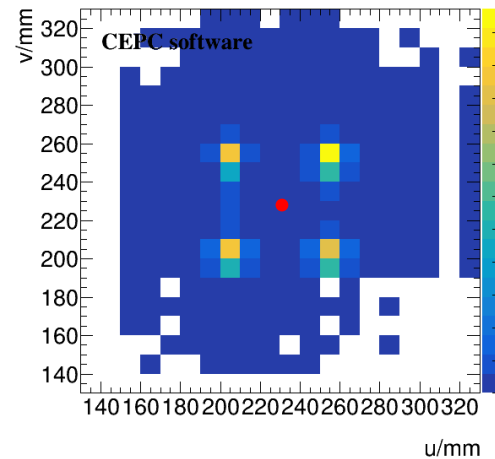
Hit reconstruction di-photon



reconstruction

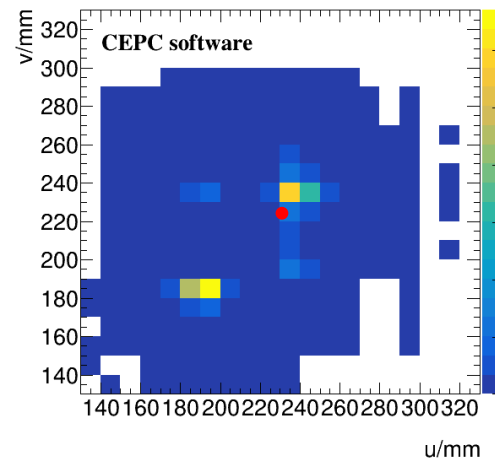
$\gamma_1(200, 200),$
 $\gamma_2(260, 260)$

Block center:
(230, 230)mm



reconstruction

$\gamma_1(180, 180),$
 $\gamma_2(240, 240)$



Hit reconstruction

Pi0: in different energy point(1/2/5/8/10/15/20/30 GeV). Hit map and Nreco in Pandora.

Hit reconstruction

Higgs- \rightarrow yy sample, higgs mass resolution.

backup

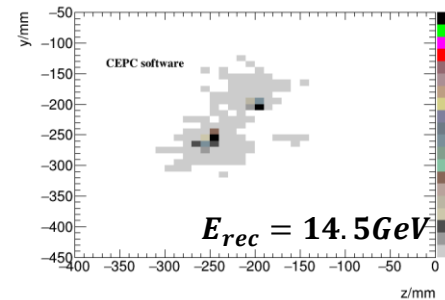
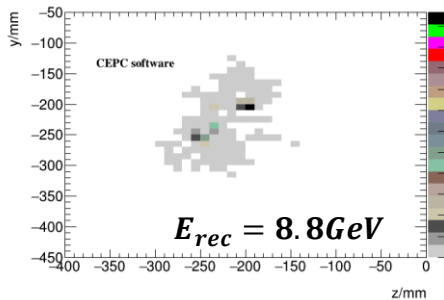
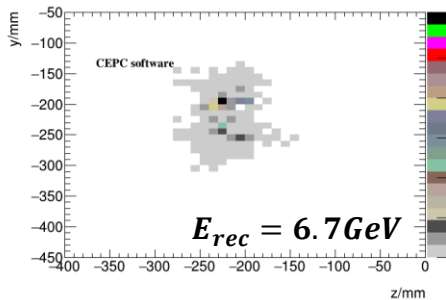
3cm*3cm

4cm*4cm

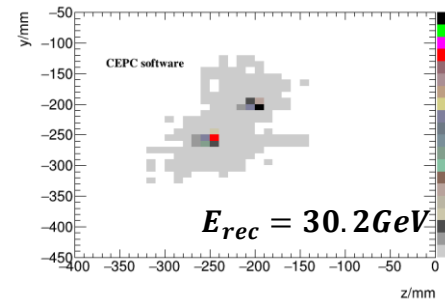
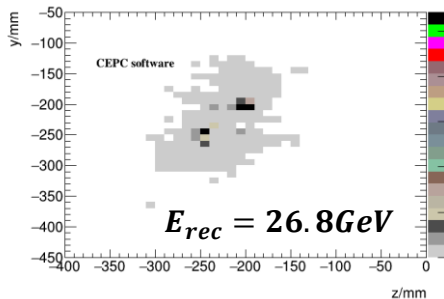
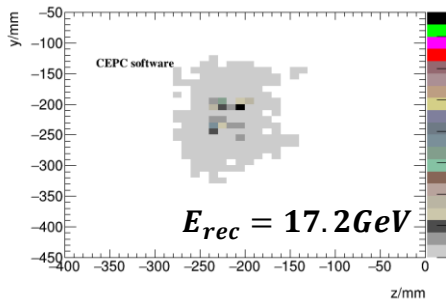
5cm*5cm

$\sigma_T = 100ps$

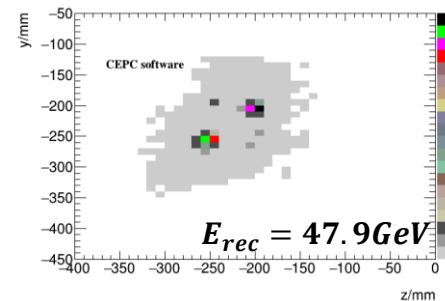
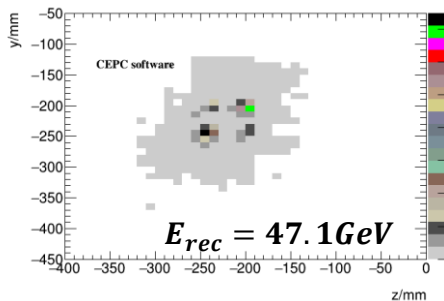
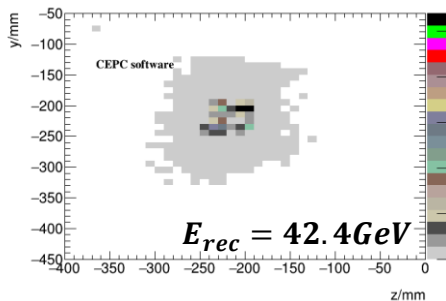
2 σ



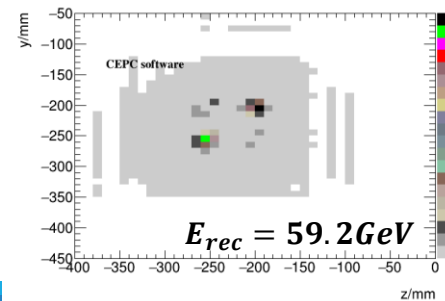
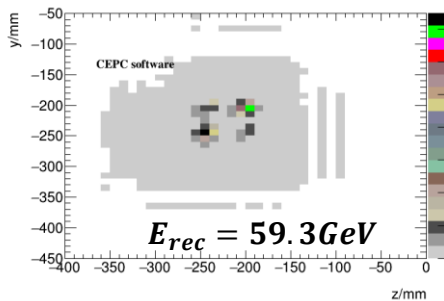
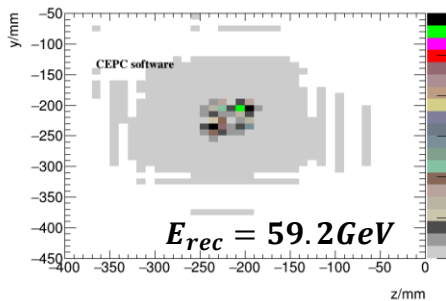
3 σ



5 σ



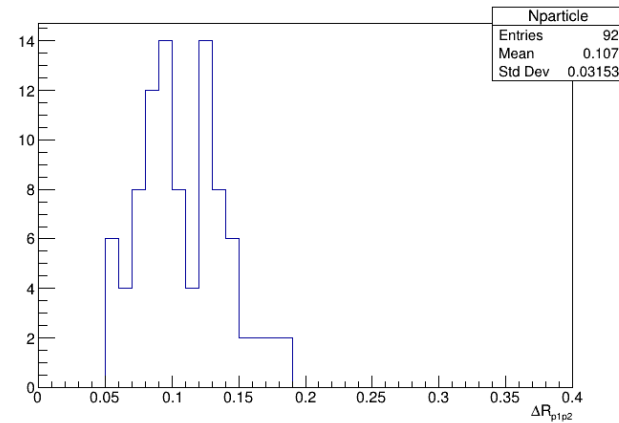
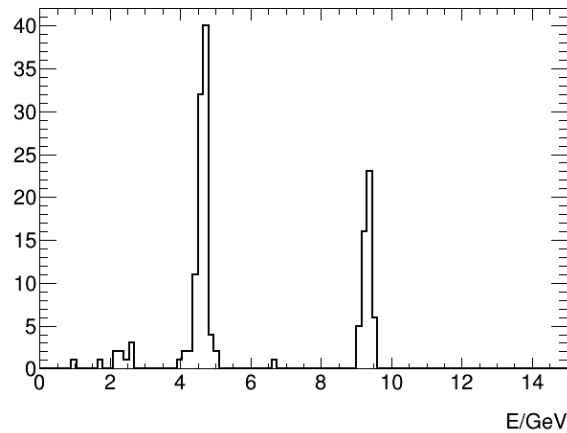
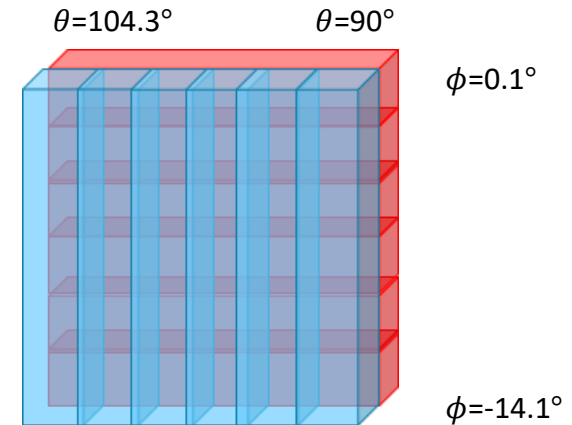
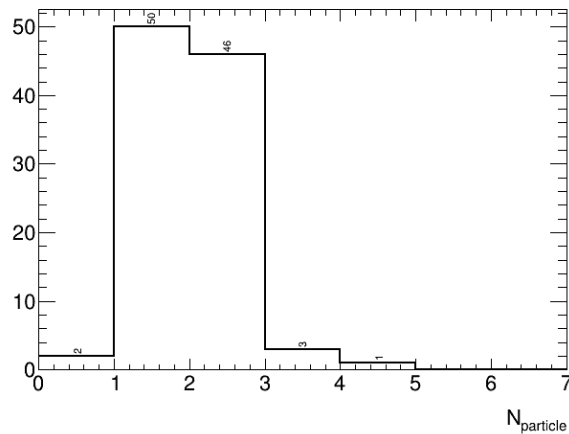
No cut



Q2: ghost hit removal

Reconstruct 100 di-photon events with Pandora

- Energy: 5GeV
- Direction: $\theta \in [91^\circ, 100^\circ], \phi \in [-10^\circ, 0^\circ]$.



ΔR for 2 recPart

$$\Delta R = 0.05 \sim$$

$$\Delta u/v = 6cm$$

Q2: ghost hit removal

Reconstruct 200 π^0 events with Pandora in full detector.

8GeV π^0 , $\theta \in [60, 120]$, $\phi \in [0, 360]$

