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CEPC

Incident angle measurement of 100MeV photons

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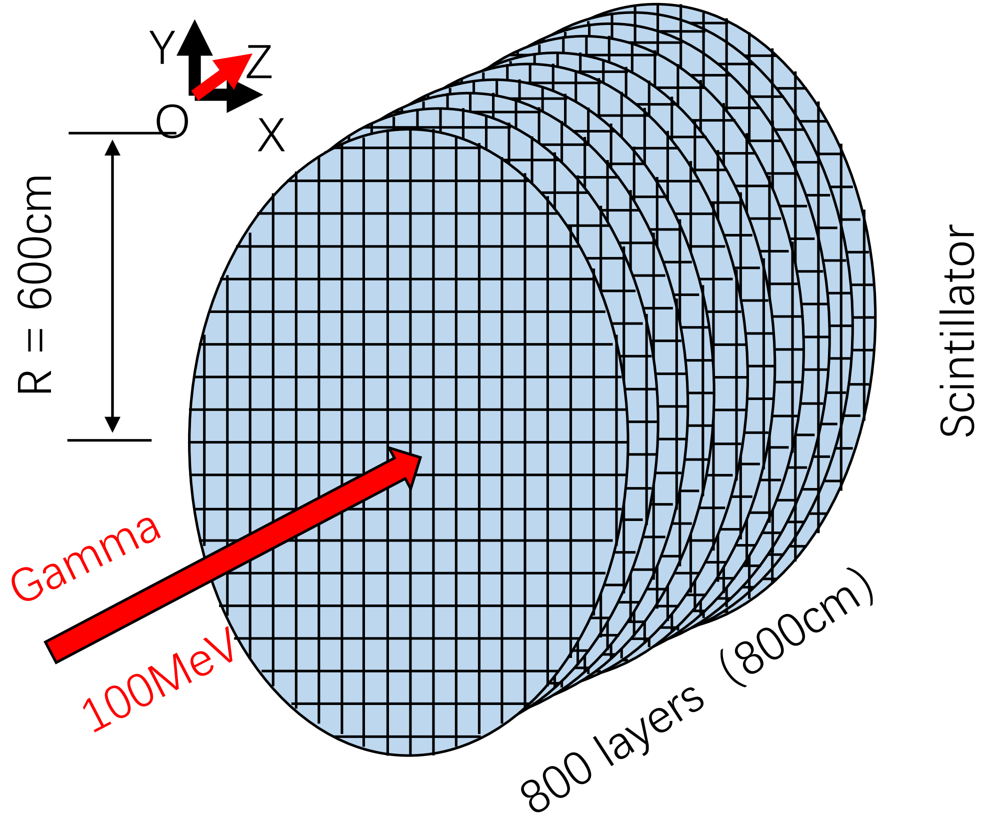
Outline

1. The simulation of gamma ray detector.
2. Gamma shower profile analyses.
3. The angle reconstruction.
4. Compared with Fermi LAT.

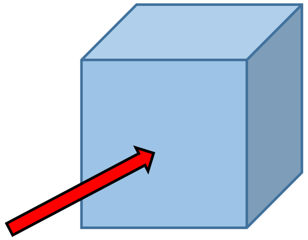
1. The simulation of gamma ray detector.



Gamma ray detector schematic diagram

Motivation:

CEPC as Synchrotron radiation source emission 100MeV gamma ray

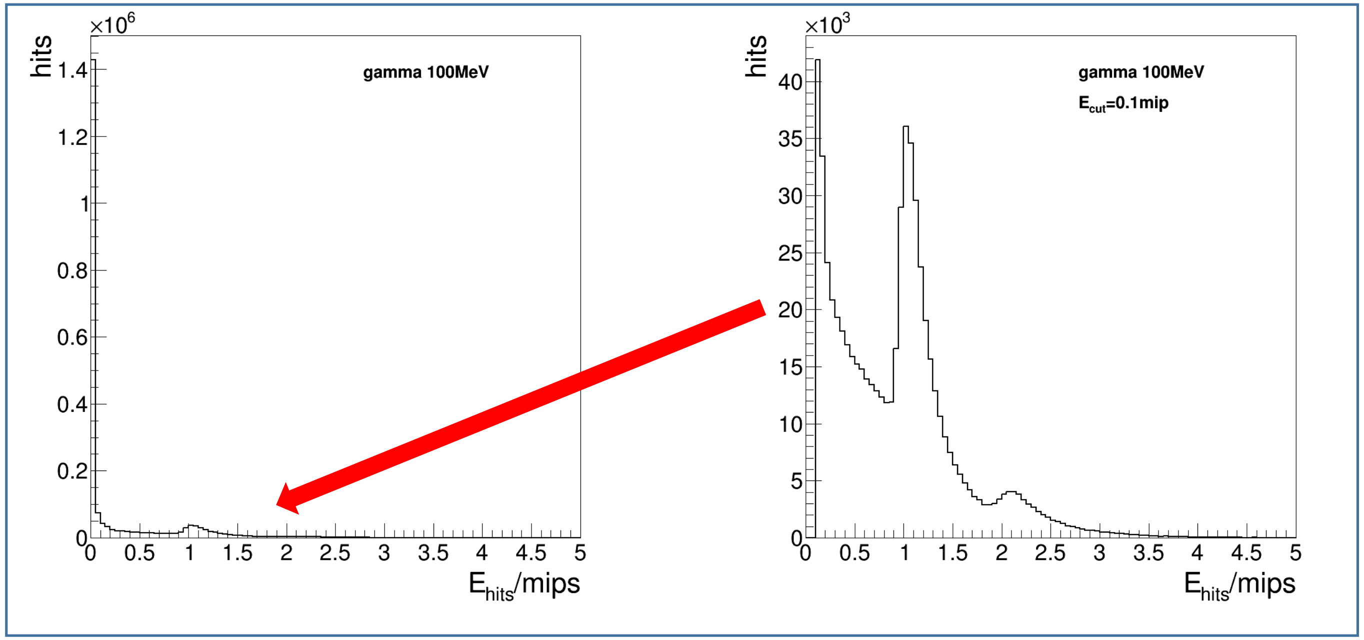


1mip = 1.647MeV

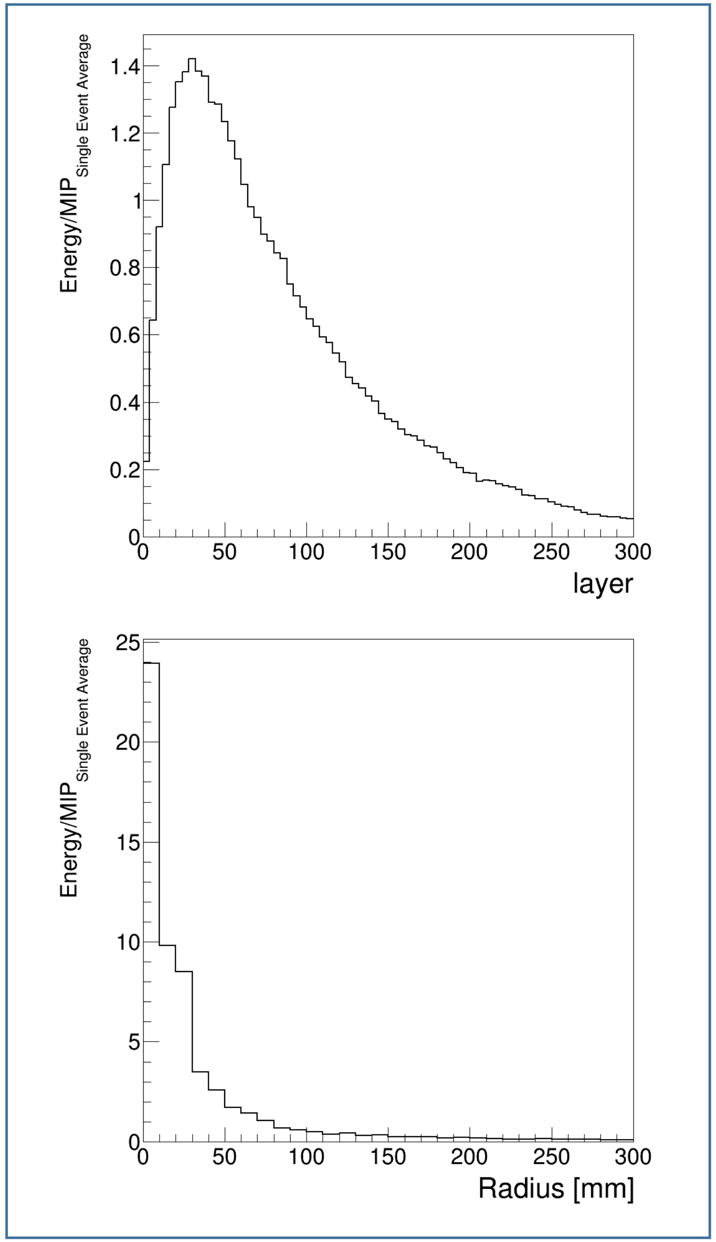
Detector sensitive cell: 10mm*10mm*10mm cube

- Gamma ray is incident perpendicular to the detector surface ,
  - The incident point is the center of the cell.

2. Gamma shower profile analyses .



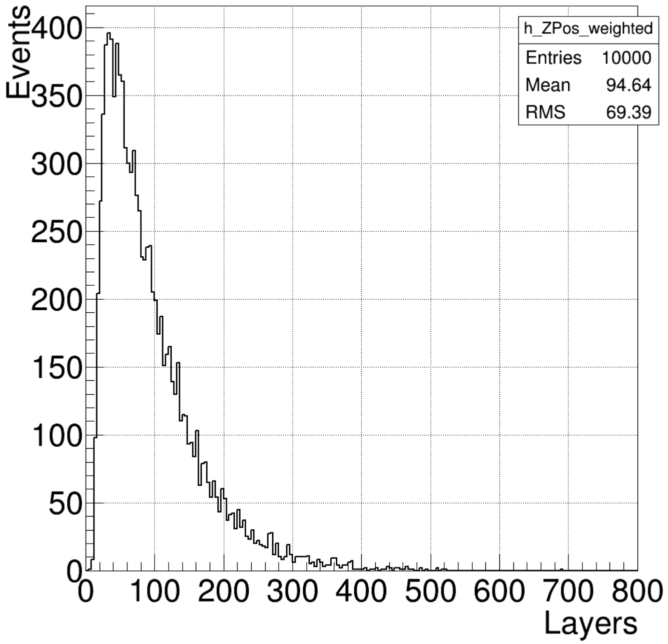
The energy of hits distribution. All hits energy distribution (left), the enlarged figure (right).

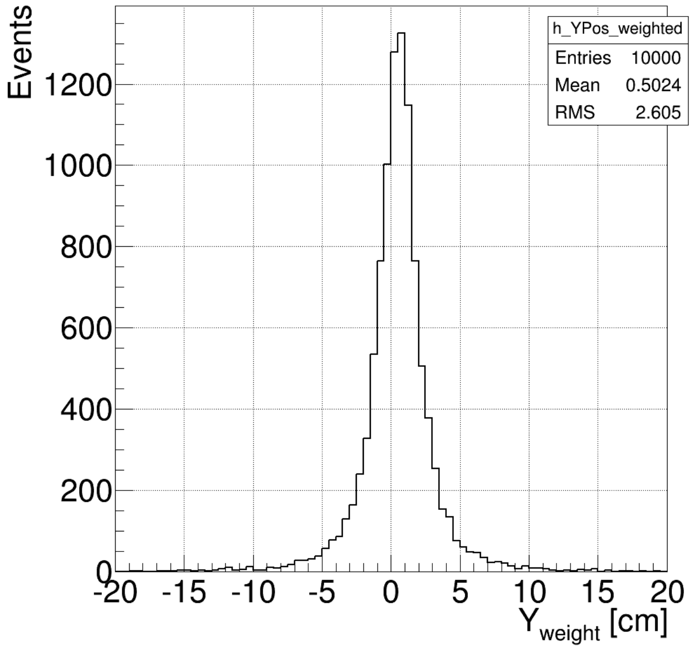


The energy of shower distribution. Longitudinal distribution (upper), transverse distribution (lower).

2. Gamma shower profile analyses .

The incident point is (0.5,0.5)

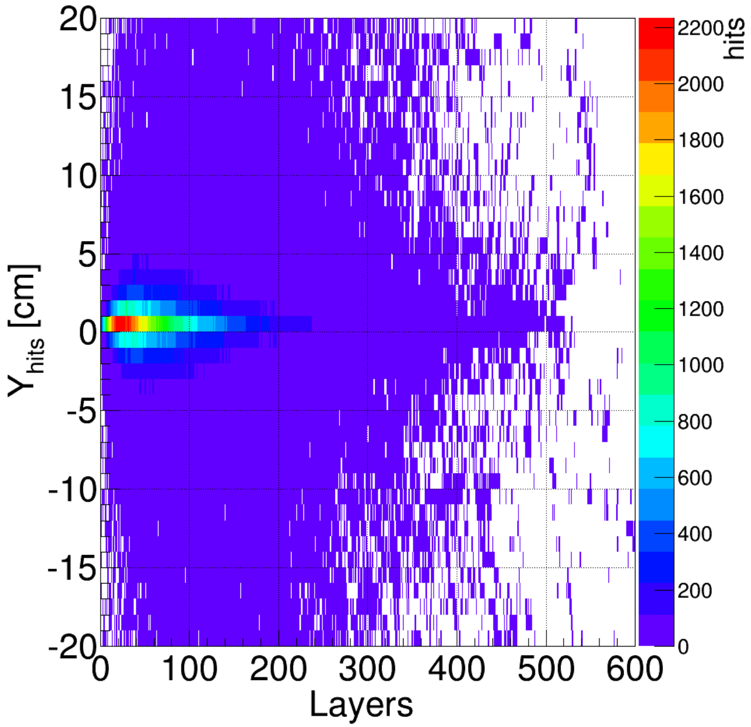




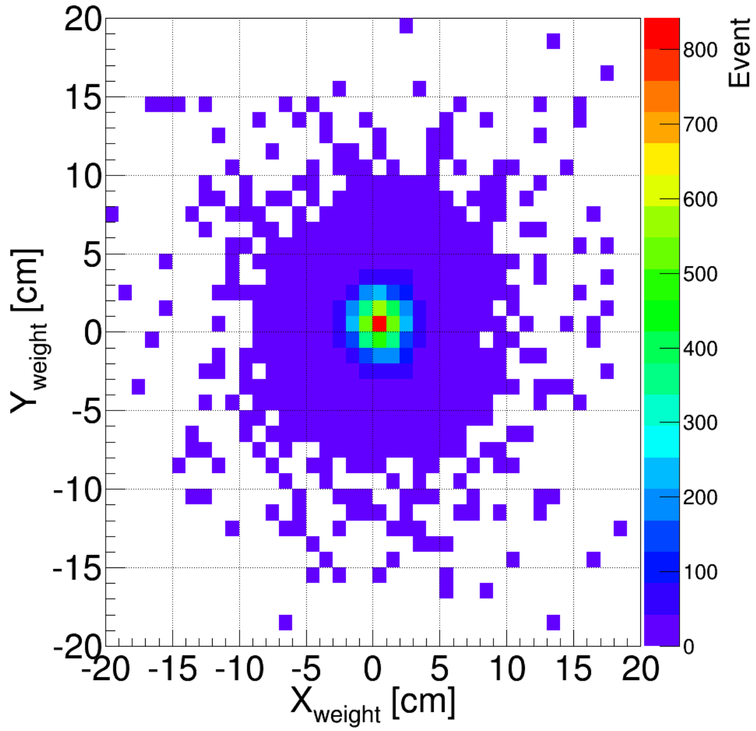
Center of gravity distribution of photon shower position. Distribution in the Z direction (left); Distribution in the Y direction (Right);

- The position center of gravity adopts linear energy weighting method: $X = \frac{\Sigma_i E_i x_i}{\Sigma_i E_i}$, in which E_i and x_i is the energy and position of the i hit, respective.

2. Gamma shower profile analyses .



Hits distribution in YoZ plane.

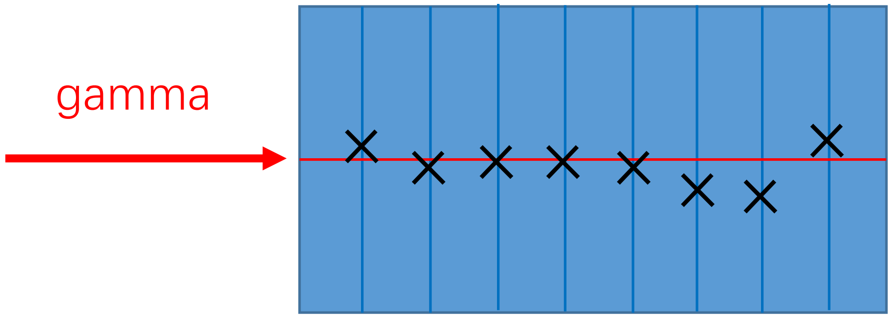


Hits distribution in XoY plane.

- We assume that in the absence of external magnetic field, **The development of a photon's longitudinal shower in ECAL continues along the incident direction**, which reunites with the axis of the shower.

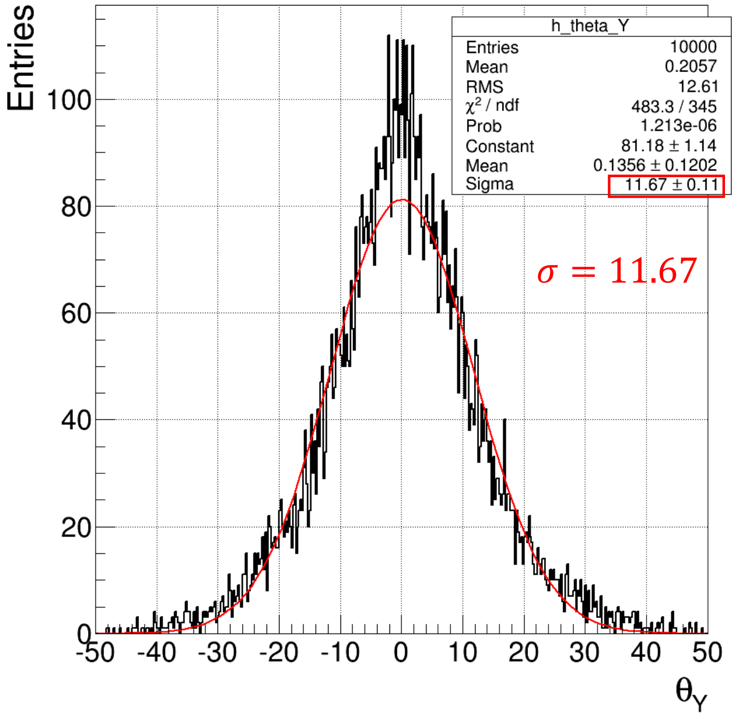
3. The angle reconstruction.

We can fit a straight line through hits information in ECAL, which should be consistent with the direction of photon incident.



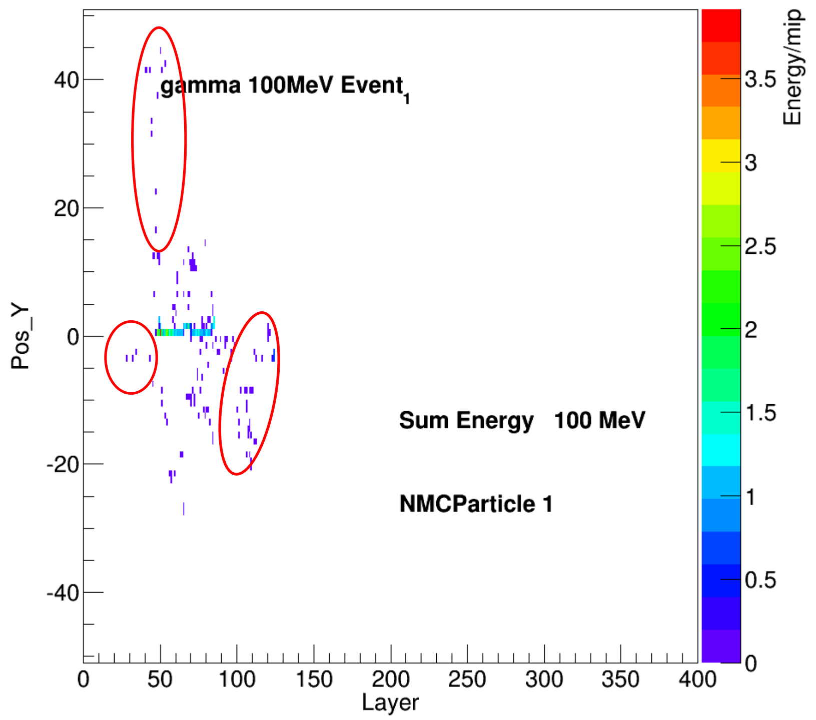
The fit schematic diagram

granularity :10*10*10mm

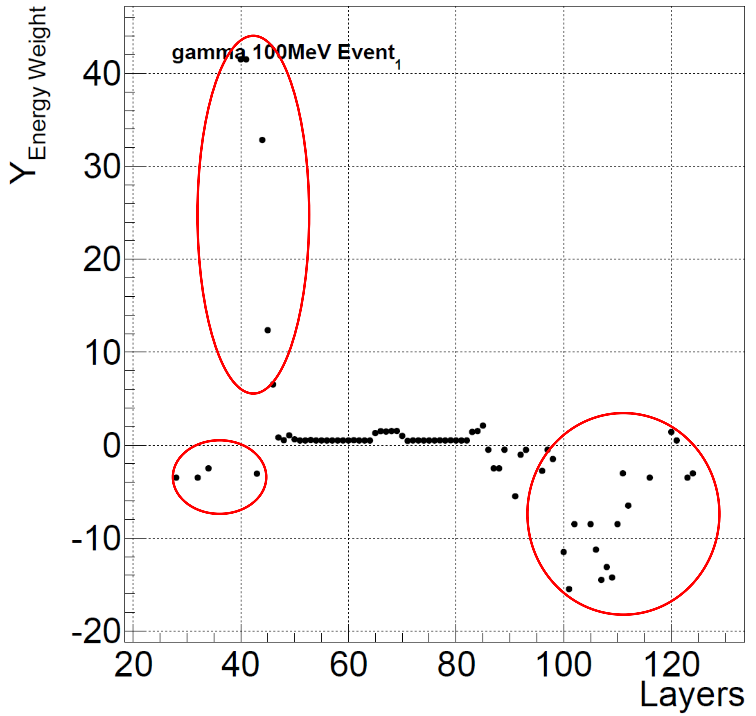


- We get each layer's energy weighted position in ECAL by using $\mathrm{x} = \frac{\Sigma_i x_i \times \mathrm{E}_i^{1.5}}{\Sigma_i E_i^{1.5}}$, fit a straight line to get the incident direction of gamma ray. The Angle between the fitting direction and the true direction is θ。

3.2 Single photon shower profile analyses.



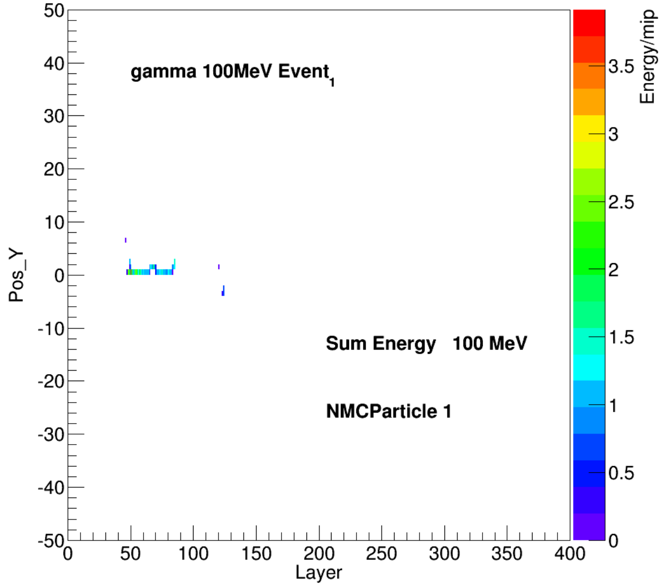
The distribution of single photon hits.

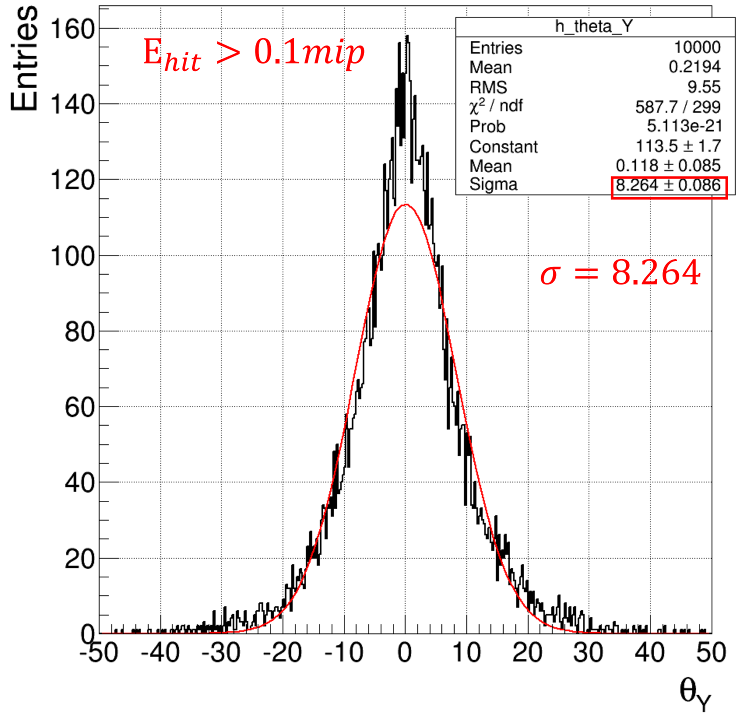


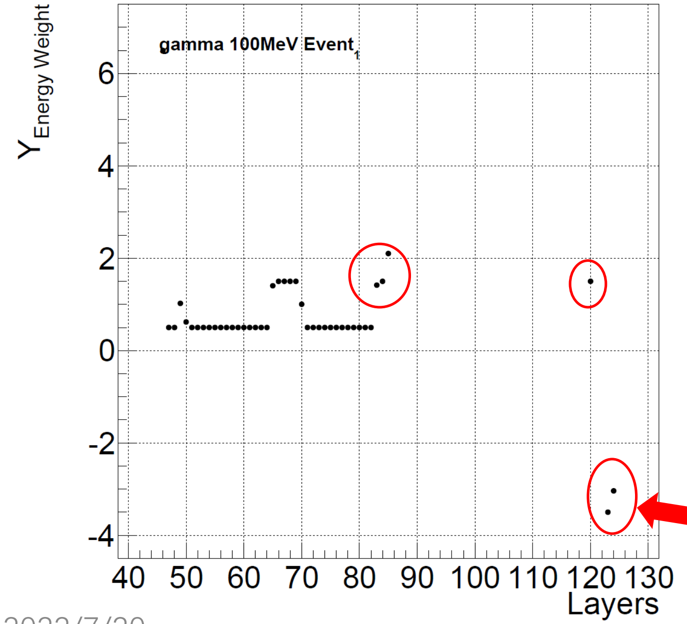
Single photon energy weighted position distribution .

- Since the scattered low-energy hits at the beginning and end of the shower, the fitting result is poor , so the angle resolution obtained is worse.

3.3 algorithm optimization.





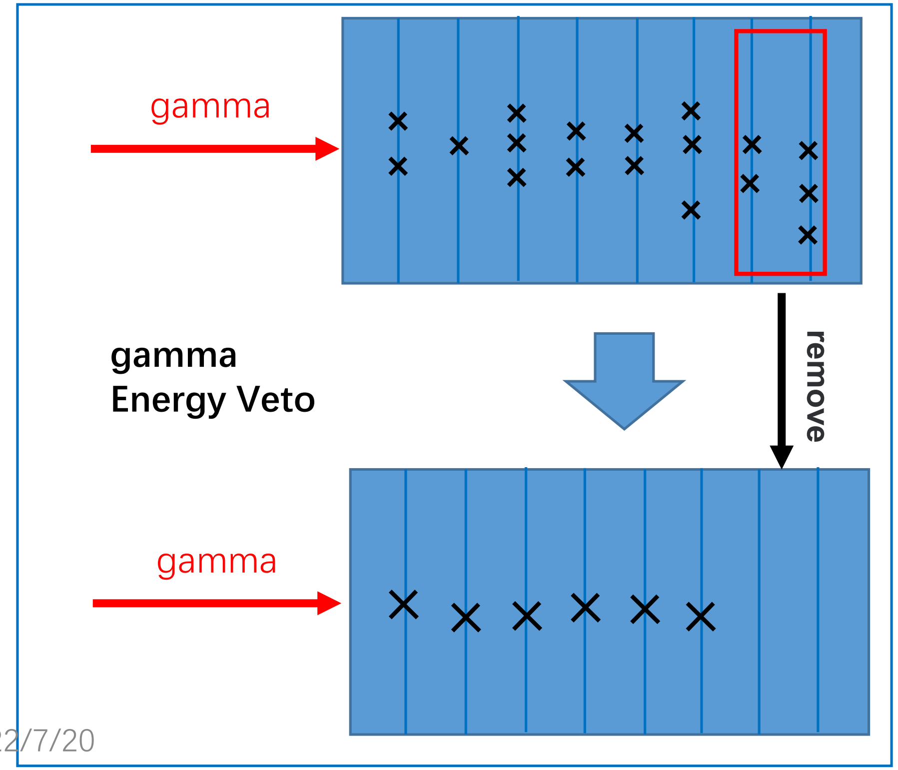


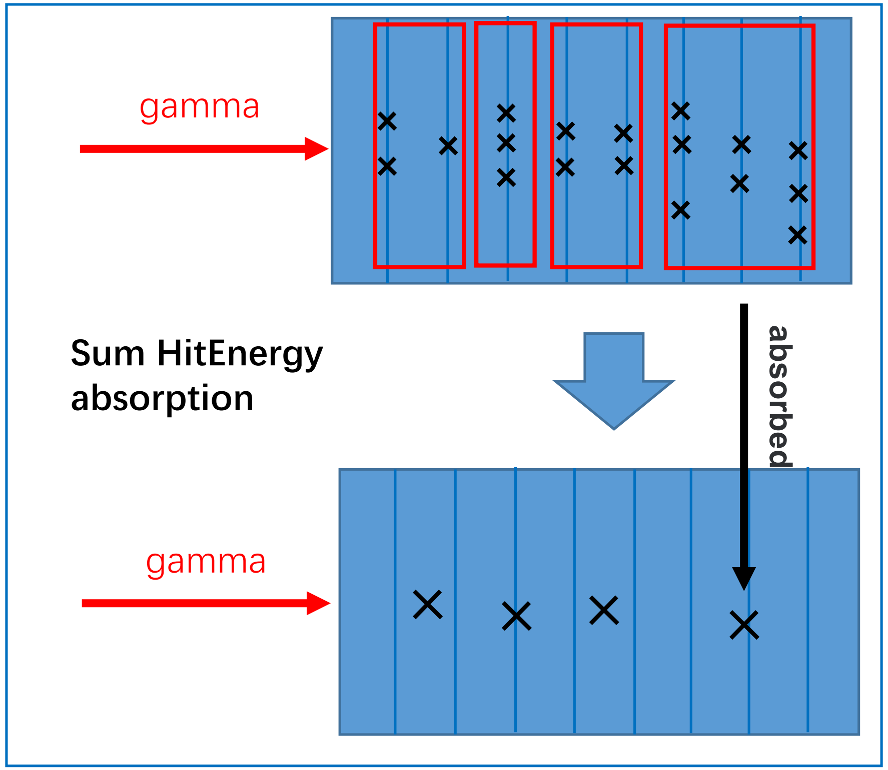
- Add $E_{hit} > 0.1mip$ remove most of the hit with low energy and scattered distribution at the front end and back end of the shower, which effectively improve the fit result. Angle resolution increased from $\sigma = 11.67$ to $\sigma = 8.264$.

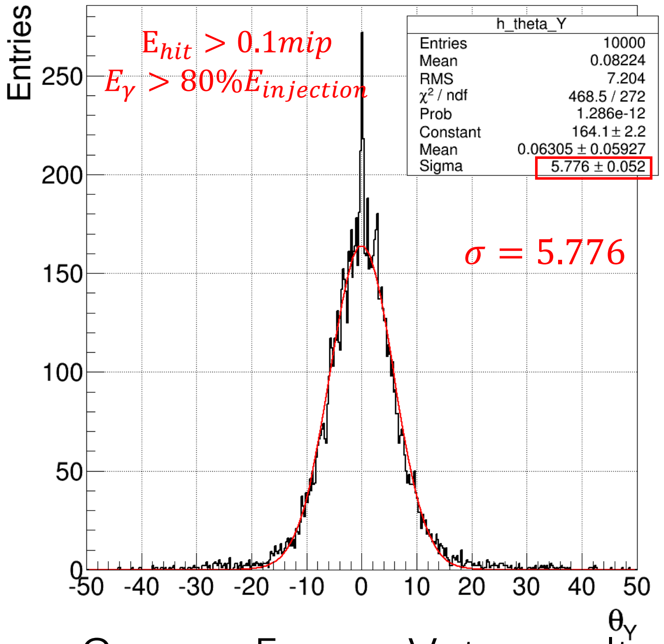
There are still some hits with high energy scattered in the tail.

For the hits scattered in the tail of shower， we consider two methods to remove them.

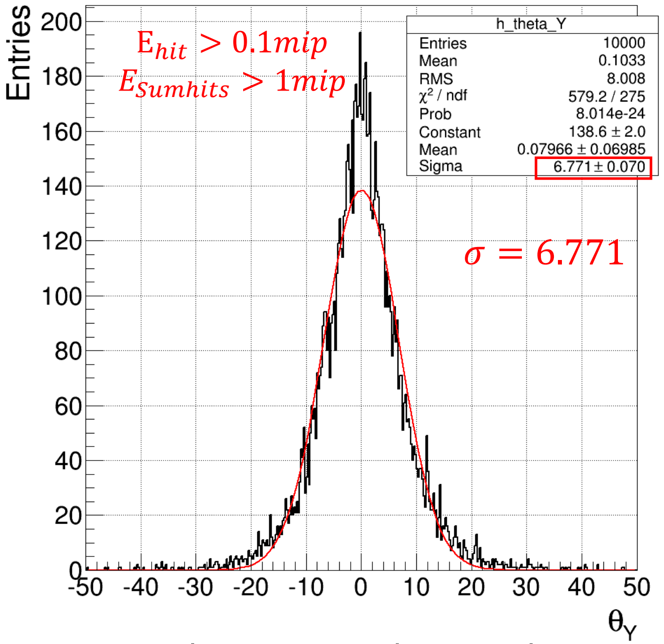
1. **Gamma Energy Veto**: Remove the hit layer with the energy of the incident photon less than 20%, so as to remove the hits scatter at the end of the shower.
2. **Sum HitEnergy absorption**: Add the hit energy layer by layer, when the sum energy of this hits more than 1 mip, take this hits as a whole to get a energy weighted position, then fit the straight line. In this way, the relatively low energy his at the tail of the shower can be "absorbed" .







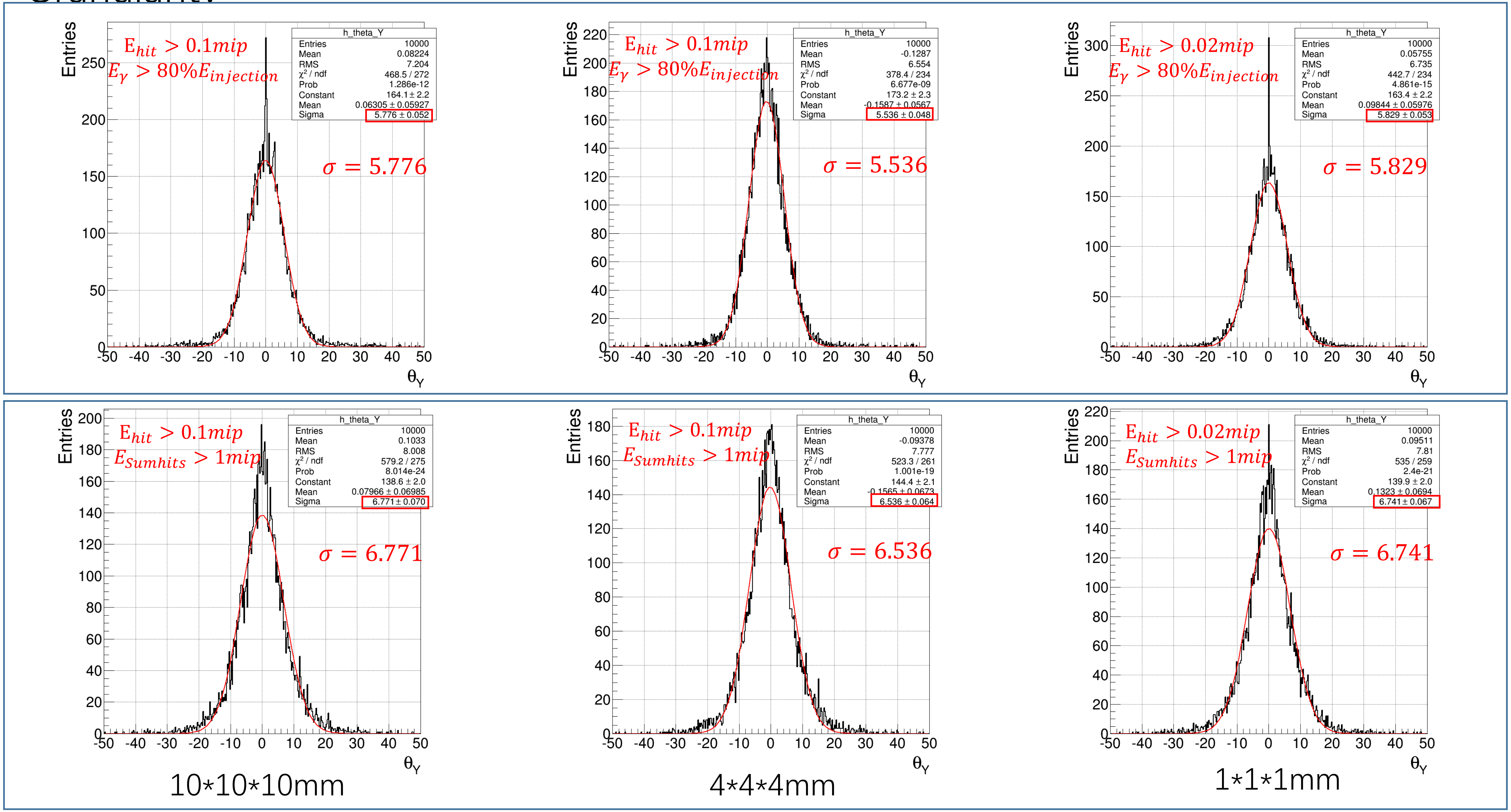
Gamma Energy Veto result



Sum HitEnergy absorption result

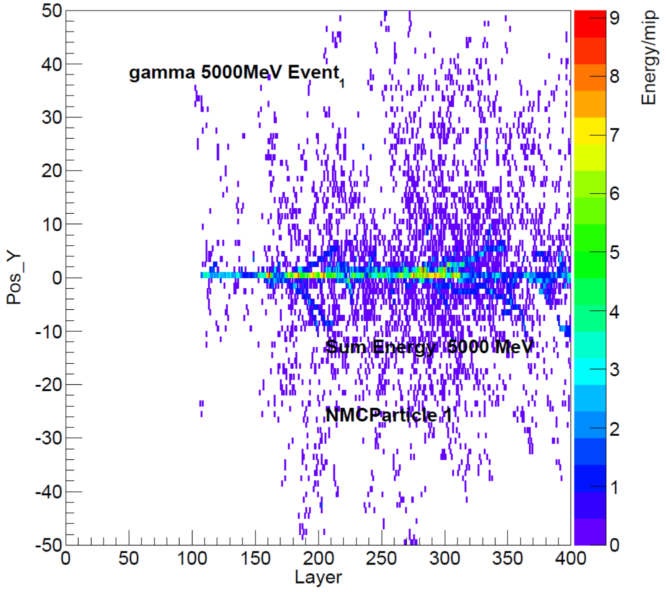
- Both these two methods can improve the fit result, and improve the angle resolution further ($\sigma = 5.776$, $\sigma = 6.771$).

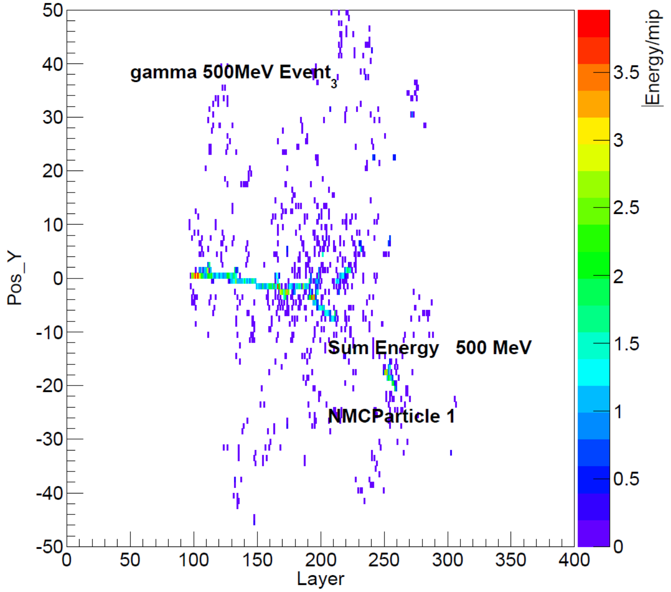
Granularity

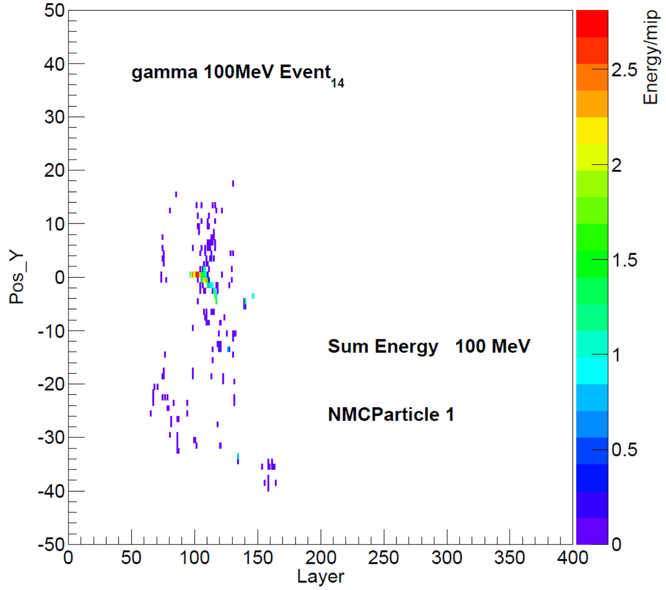


- After increasing the granularity, the Angle resolution does not change significantly!

Influence of energy on the shower profile

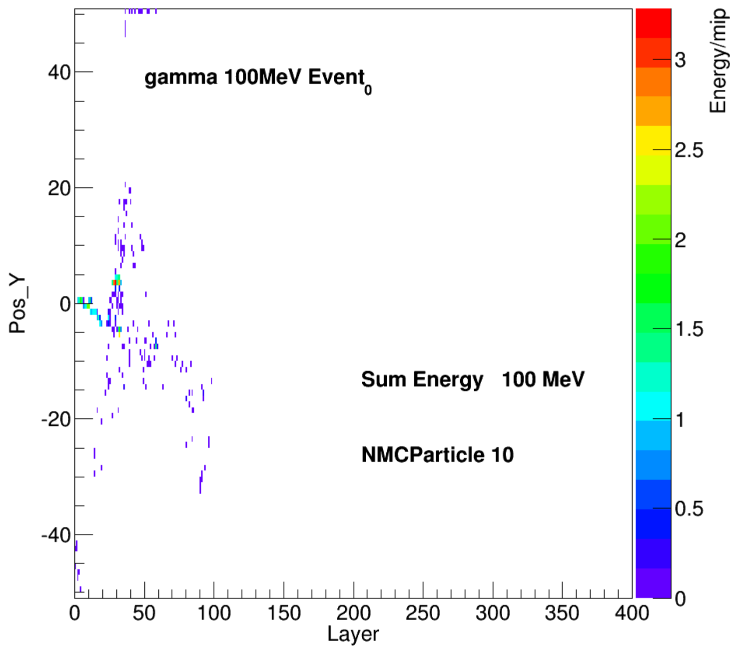




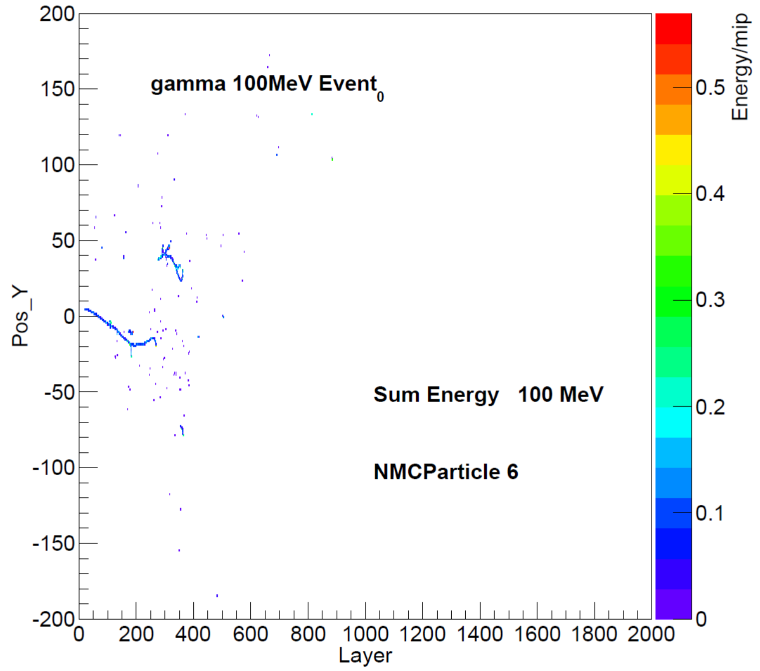


Energy has a great influence on the single photon shower profile. In ECAL, the high-energy photons are concentrated on the axis of the incident direction. With the decrease of energy, the axis direction of the single-photon shower in ECAL gradually deflects with the development of the shower. When the energy is reduced to 100MeV, the axis of single-photon shower is not an ideal straight line, but will be deflected, thus limiting the angle resolution.

Single photon shower profile in different granularity



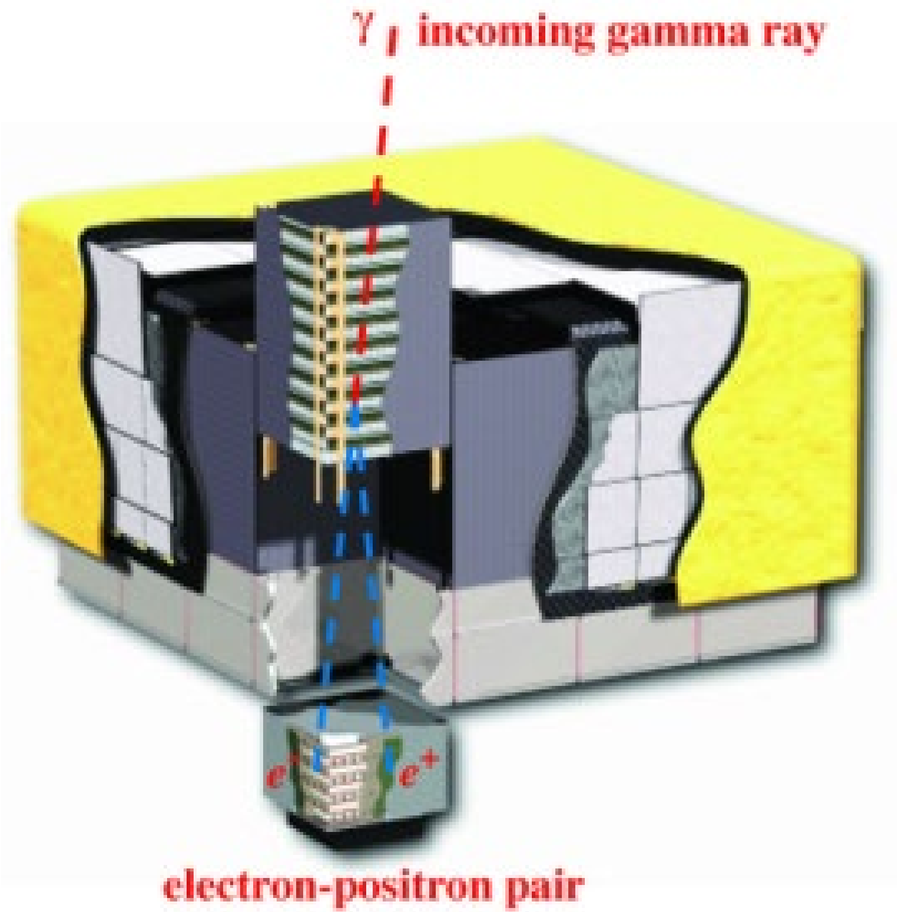
Single photon display in 10*10*10mm



Single photon display in 1*1*1mm

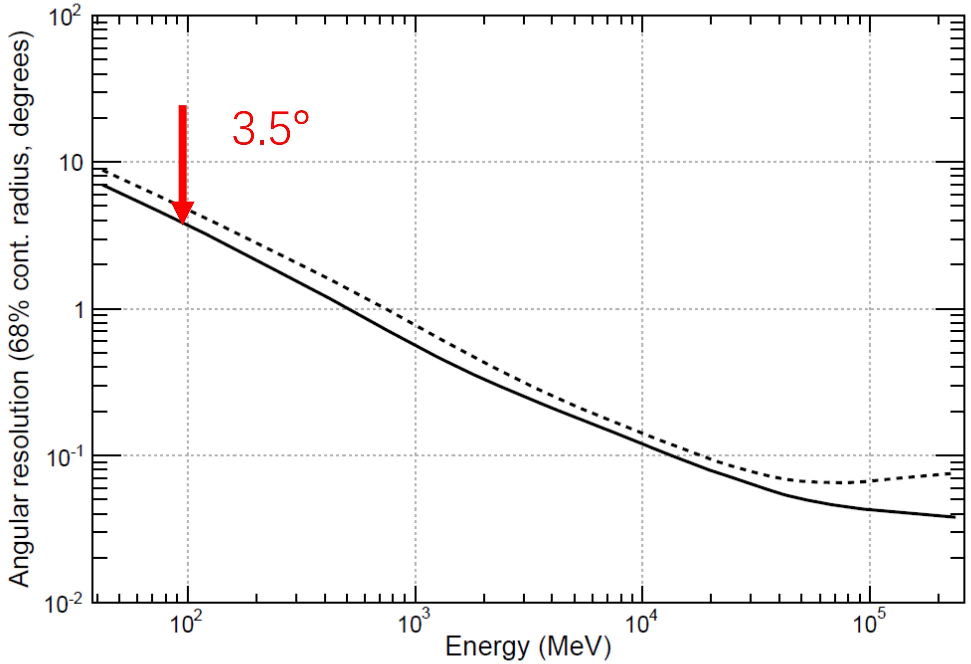
When the energy is reduced to 100MeV, **the energy determines the single photon shower profile and becomes the decisive factor of angle resolution**. This is also the reason why the improvement of granularity does not improve its Angle resolution at low energy scale.

4. Compared with Fermi LAT



Fermi LAT schematic diagram

Our result: $\sigma = 7.819°$



68% containment radius versus energy at normal incidence (solid curve) and at 60° off-axis (dashed curve) for conversions in the thin section of the tracker.

Summary

method	Result（degree）
Simple fit	$\sigma_y = 11.67(\sigma = 16.50)$
Gamma Energy Veto	$\sigma_y = 5.536(\sigma = 7.819)$
Sum HitEnergy absorption	$\sigma_y = 6.536(\sigma = 9.241)$
Fermi LAT	$\sigma = 3.50$

Angle resolution in different methods.

Thank you!

Your comments and suggestions are appreciated.