Determination algorithm of z_vertex

Poster at RHIC&AGS meeting and plots to approved

Mahiro Ikemoto @ NWU

Presenting a Poster at the RHIC&AGS Meeting!🔥

- I will attend the General meeting on 6/7(Fri) to get approval for the plots.
- I have written analysis note for z_vertex determination algorithm, I send it to the meaning list yesterday.
  You can find my analysis note from the link below.
  https://sphenix-invenio.sdcc.bnl.gov/communities/sphenixcommunity/requests/2a27e268-b2bc-4d8e-8213-f048029ef859
- 3 plots will be approved.

The content of my poster 🔥🔥

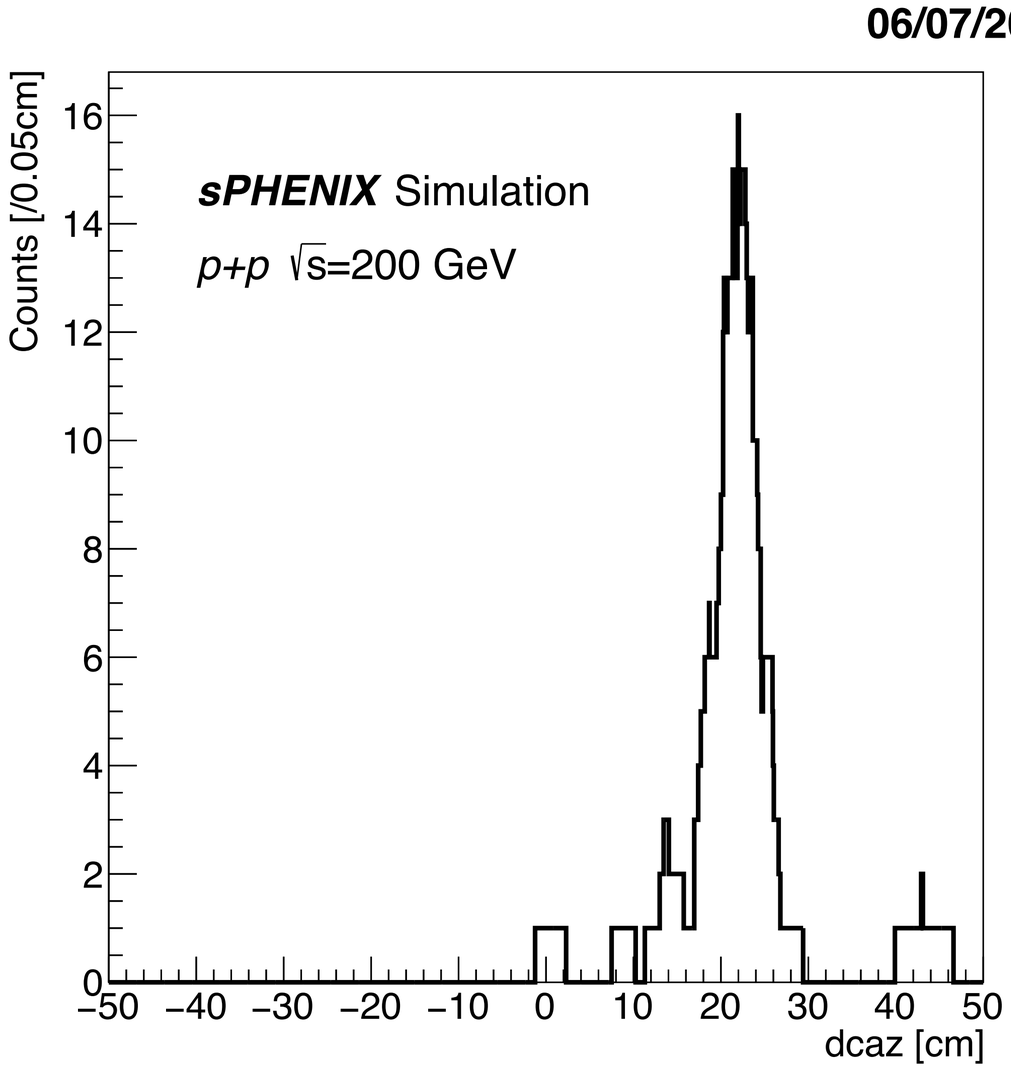
- Z_vertex determination methods with simulation data.
  - DCAz distribution for a single event.
  - The difference between the reconstructed z_vertex and truth z_vertex.

Used data：simulation data, p+p collision, no magnetic field(Pythia (8.307)),10K events

- Z_vertex determination with data taken in 2024.

Used data：Run 41349, p+p collision, no magnetic field

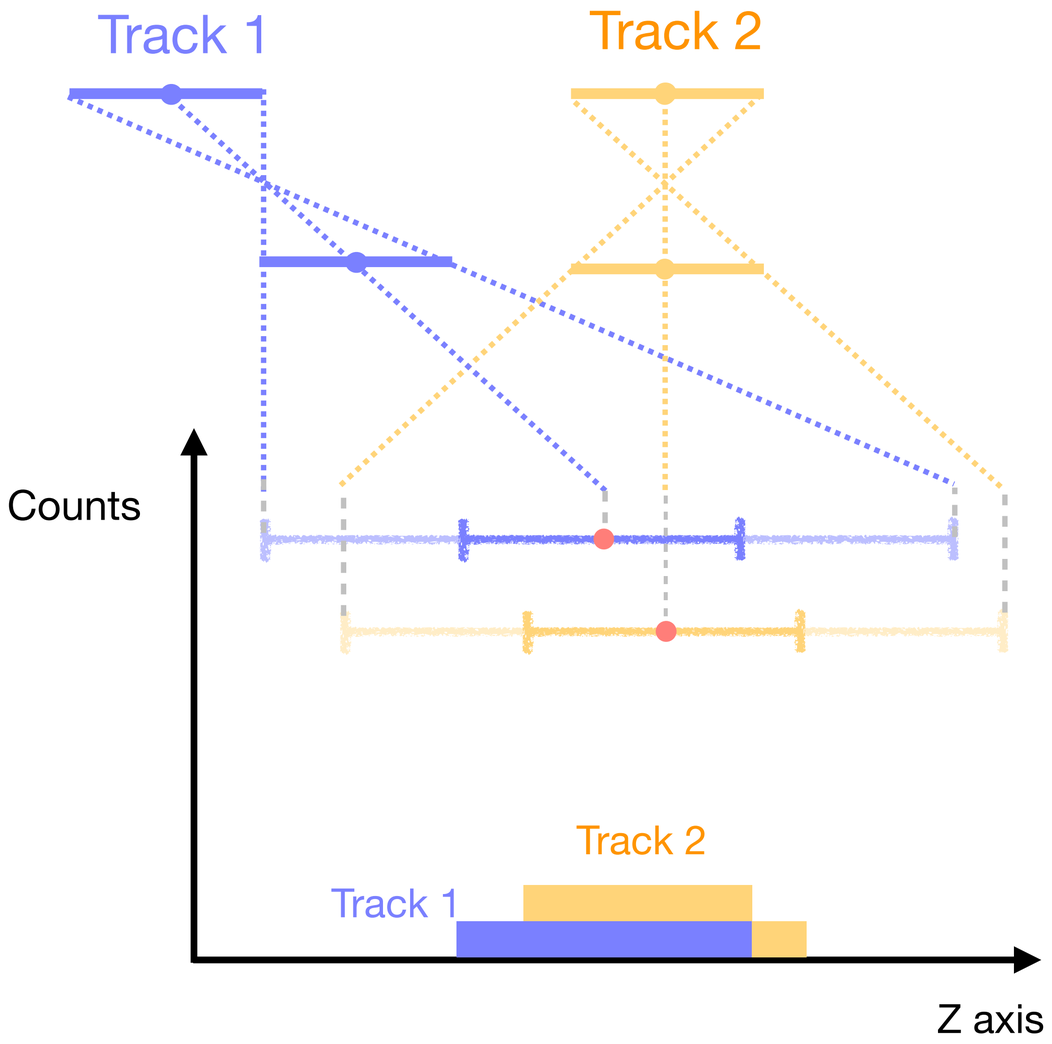
Plot 1 : DCAz distribution for a single event



- In this distribution, the DCAz ("Distance of Closest Approach" of the track to the Beam Center) points have the error ranges.
- This ranges is considered to be the ranges of the possible zvtx.
- About the error ranges are explained on the next page.

Plot 1 : DCAz distribution for a single event

from Cheng-Wei's method



1. The strip size is taken as the error of the clusters.
2. DCAz range is determined by the connecting line of the two strip sizes.
3. The position resolution width of the defined range(DCAz range $/\sqrt{12}$) is the error in the DCAz points.

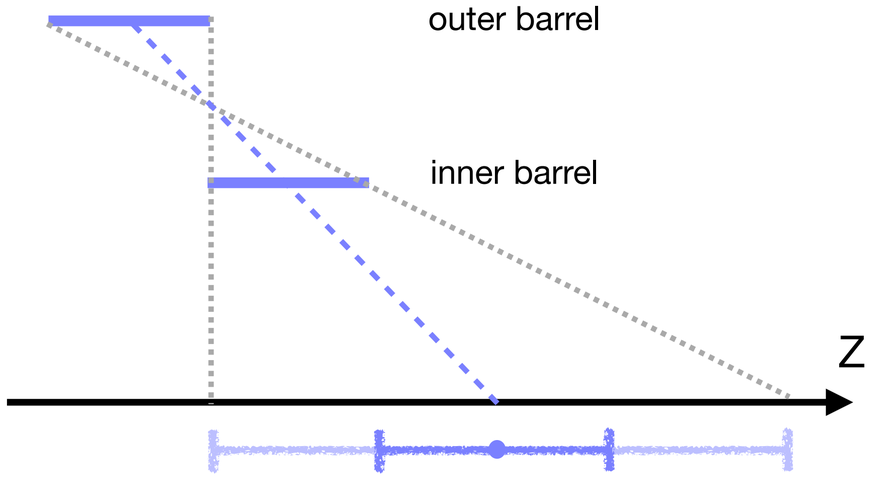
I will explain why the position resolution width is DCAz range $/\sqrt{12}$.

Plot 1 : DCAz distribution for a single event

When a single charged particle pass a sensor of width w, the incident positions are uniformly distributed.

Assuming the leftest position of the sensor to be Z_0, the existence probability density P can be expressed

$$P = \frac{1}{w}$$



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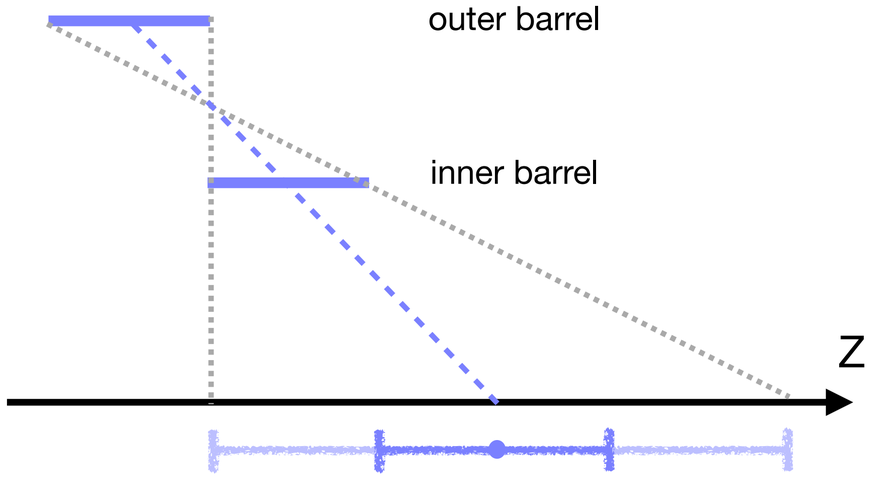
The expected value E of the incident position and position resolution σ are

$$E = \int_{Z_0}^{Z_0+w} PZ\,dw = Z_0 + \frac{1}{2}w$$

$$\sigma^2 = \int_{Z_0}^{Z_0+w} P \times (Z-E)^2\,dw = \frac{w^2}{12}$$



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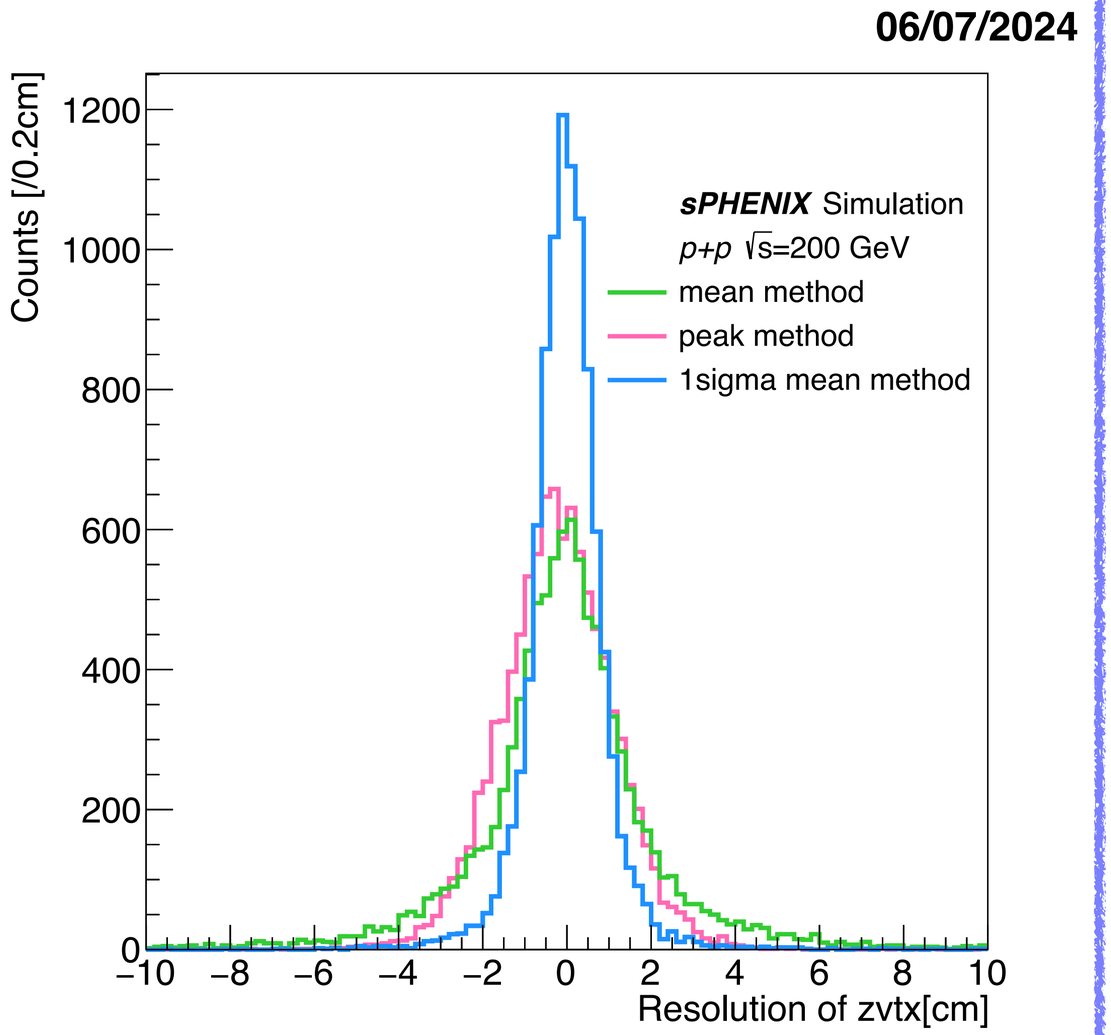
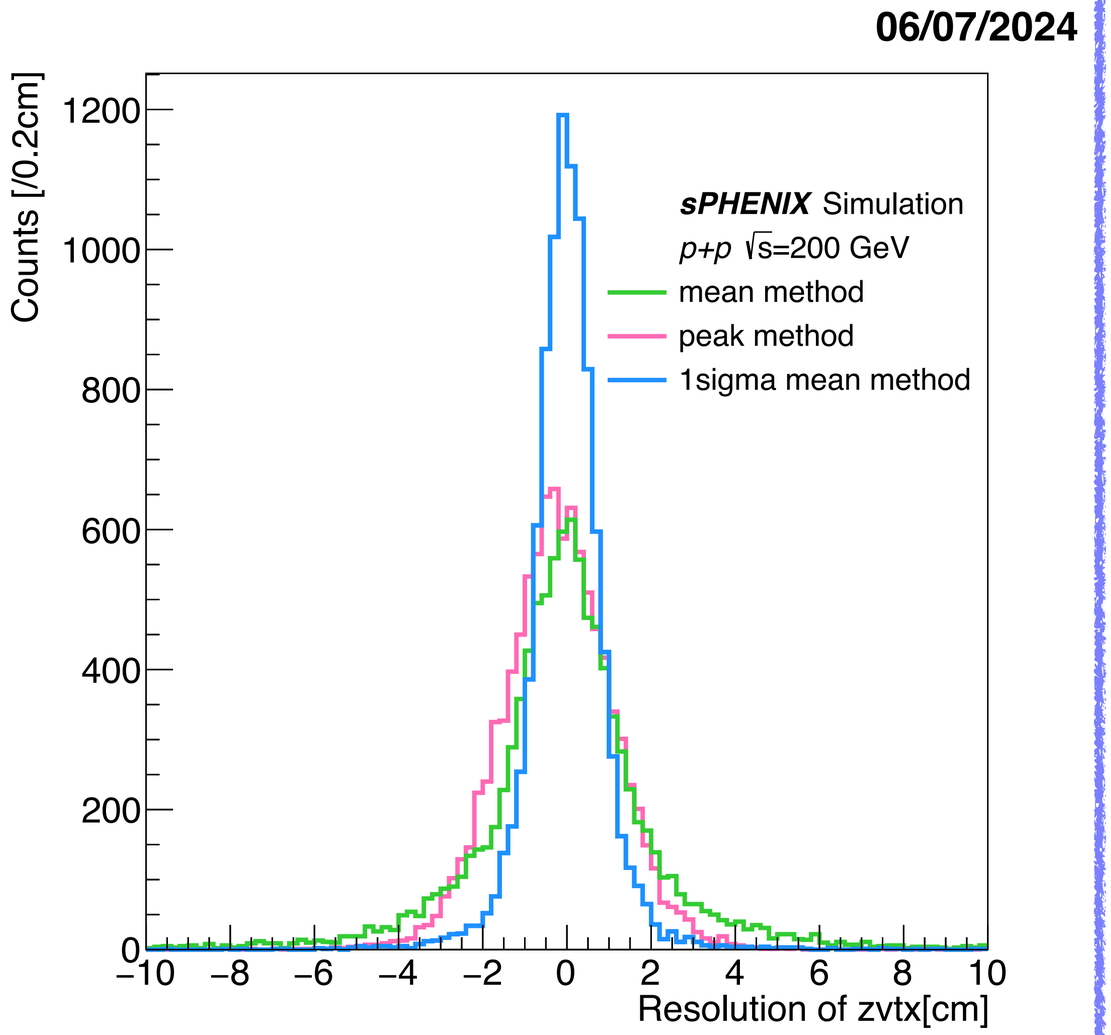
$$\sigma = \frac{w}{\sqrt{12}}$$

Plot 2 : The difference between the reconstructed z vertex and MC truth



- The z_vertex calculated by three different methods are drawn for a comparison.

Plot 2 : The difference between the reconstructed z vertex and MC truth



Mean method

To calculate the mean value of DCAz distribution, which is the z_vertex.

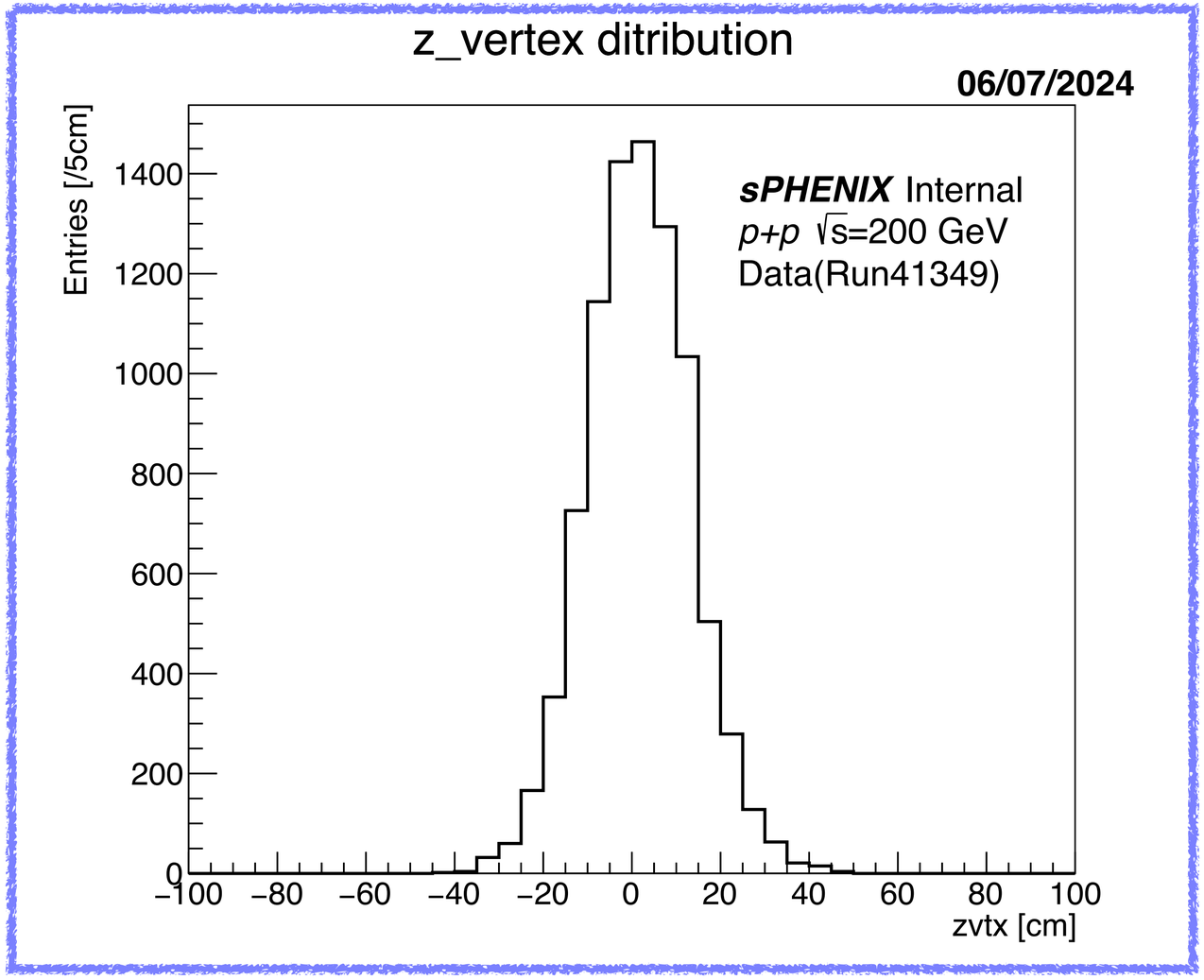
Peak method

To find the peak point of DCAz distribution.

1σ mean method

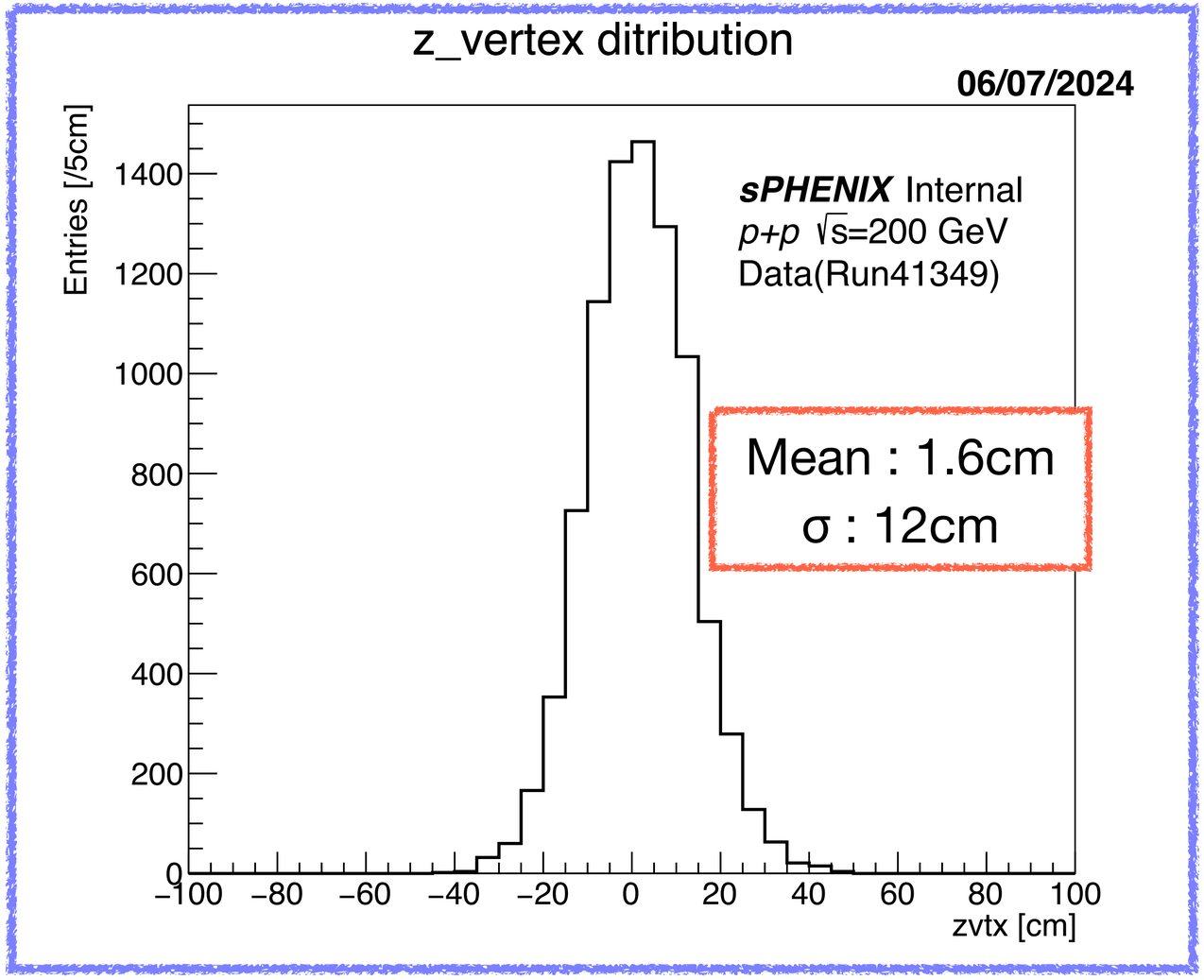
To calculate the mean value using only data within 1σ from the average point of DCAz distribution.

Plot 3 : Reconstructed z_vertex distribution

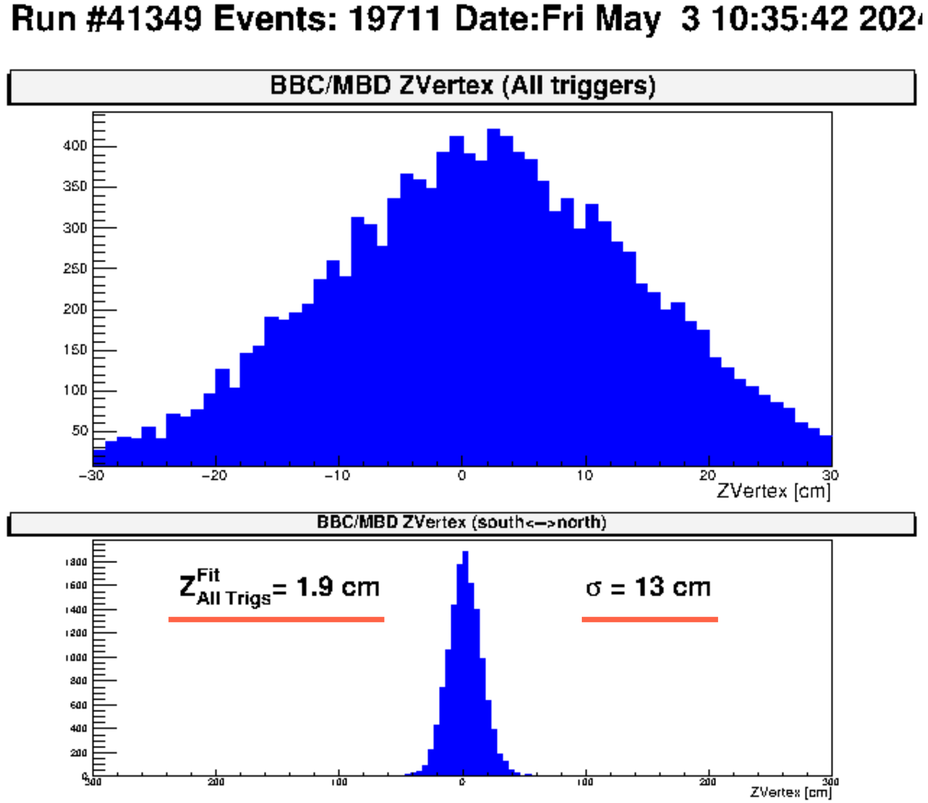


- It shows the reconstructed z_vertex distribution by using real data.

Plot 3 : Reconstructed z_vertex distribution



- Reconstructed z_vertex distribution provided by MBD detector⬇



Consistent!!!

Summary

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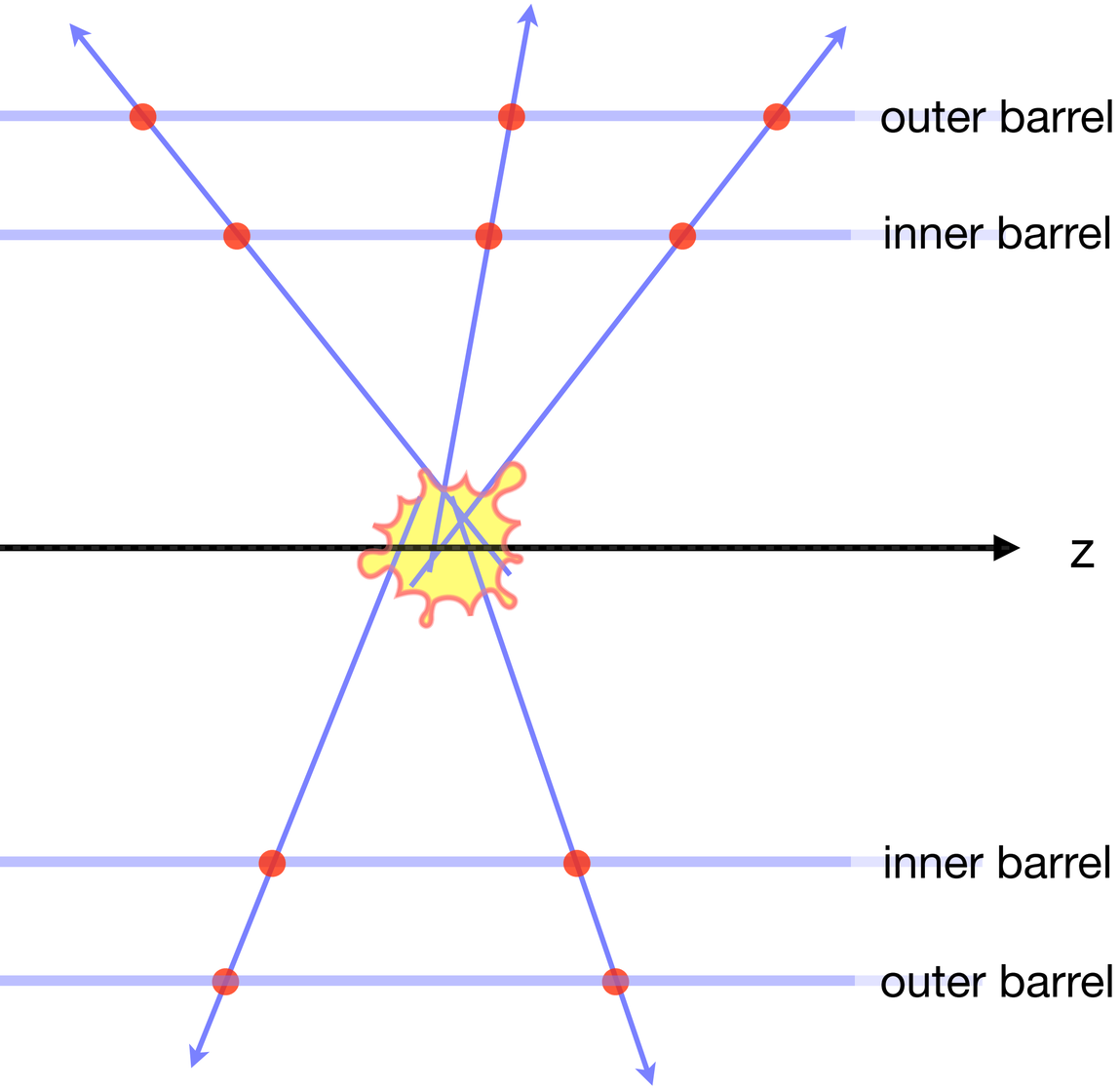
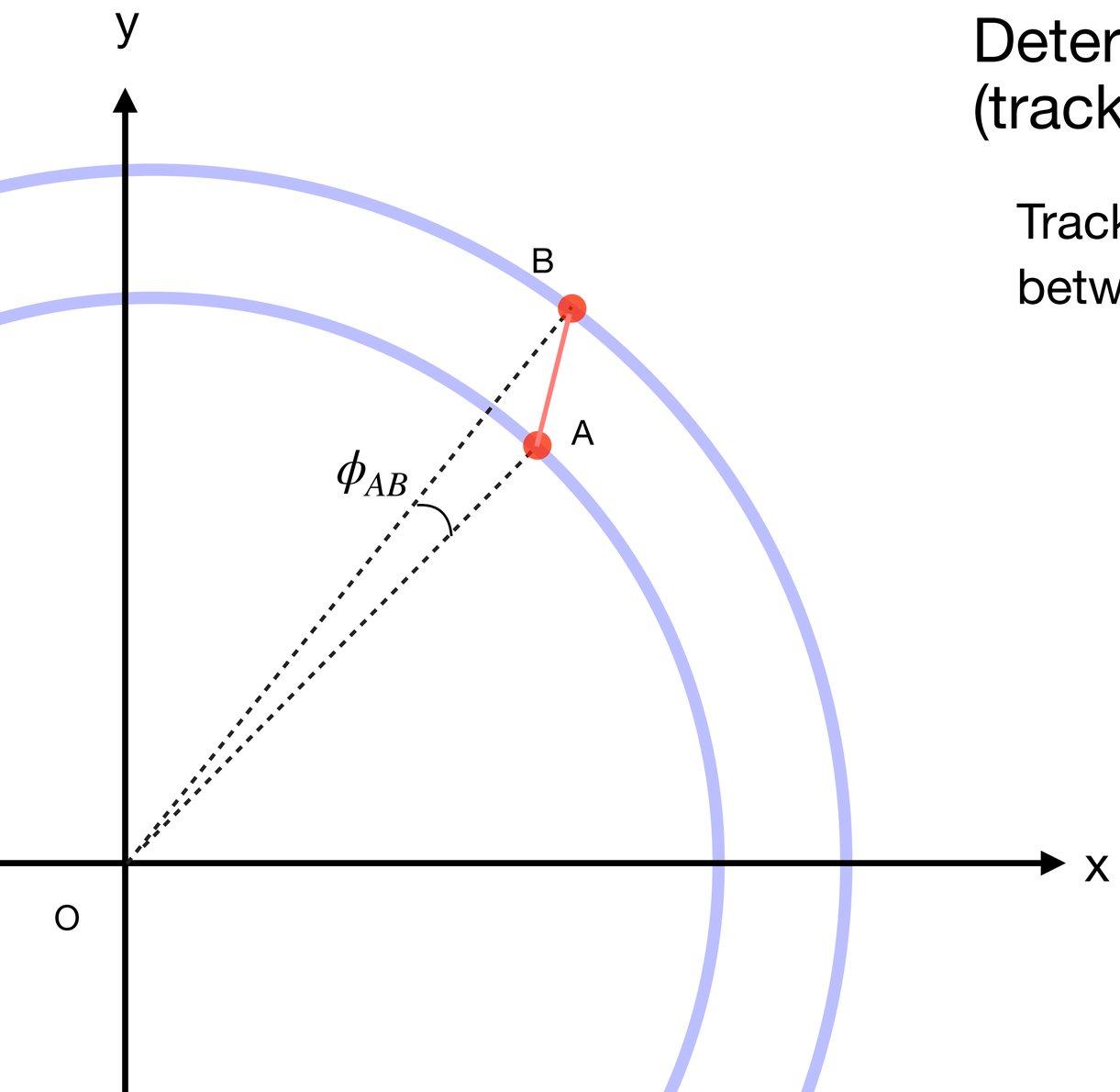
Back Up

Reconstruction of collision point



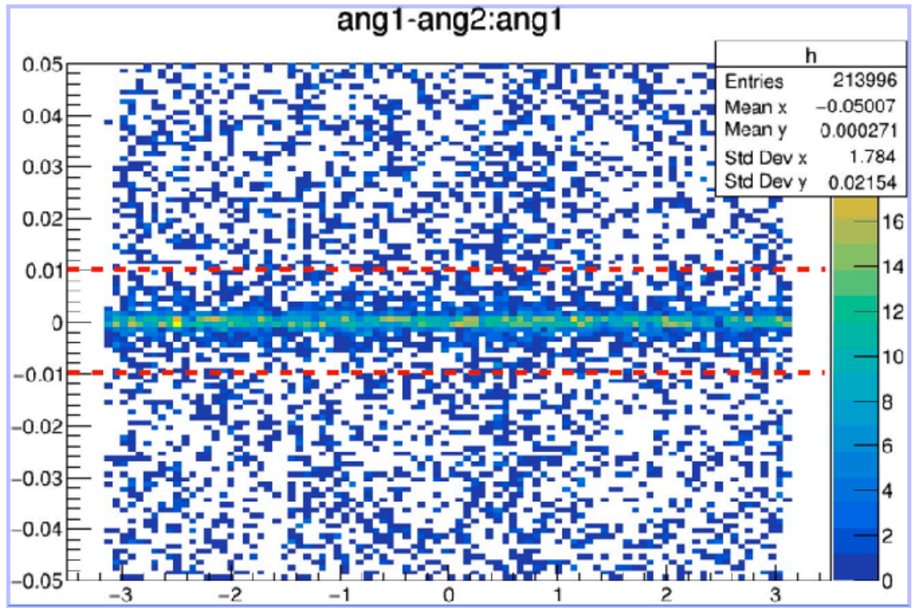
1. Clustering.
2. Select each cluster on the inner barrel and outer barrel.
3. Connect them with a line.
   Calculate the distance of closest approach(DCAz) to line of x=0,y=0 and DCAz point.
4. Determine the z_vertex.

Tracklet



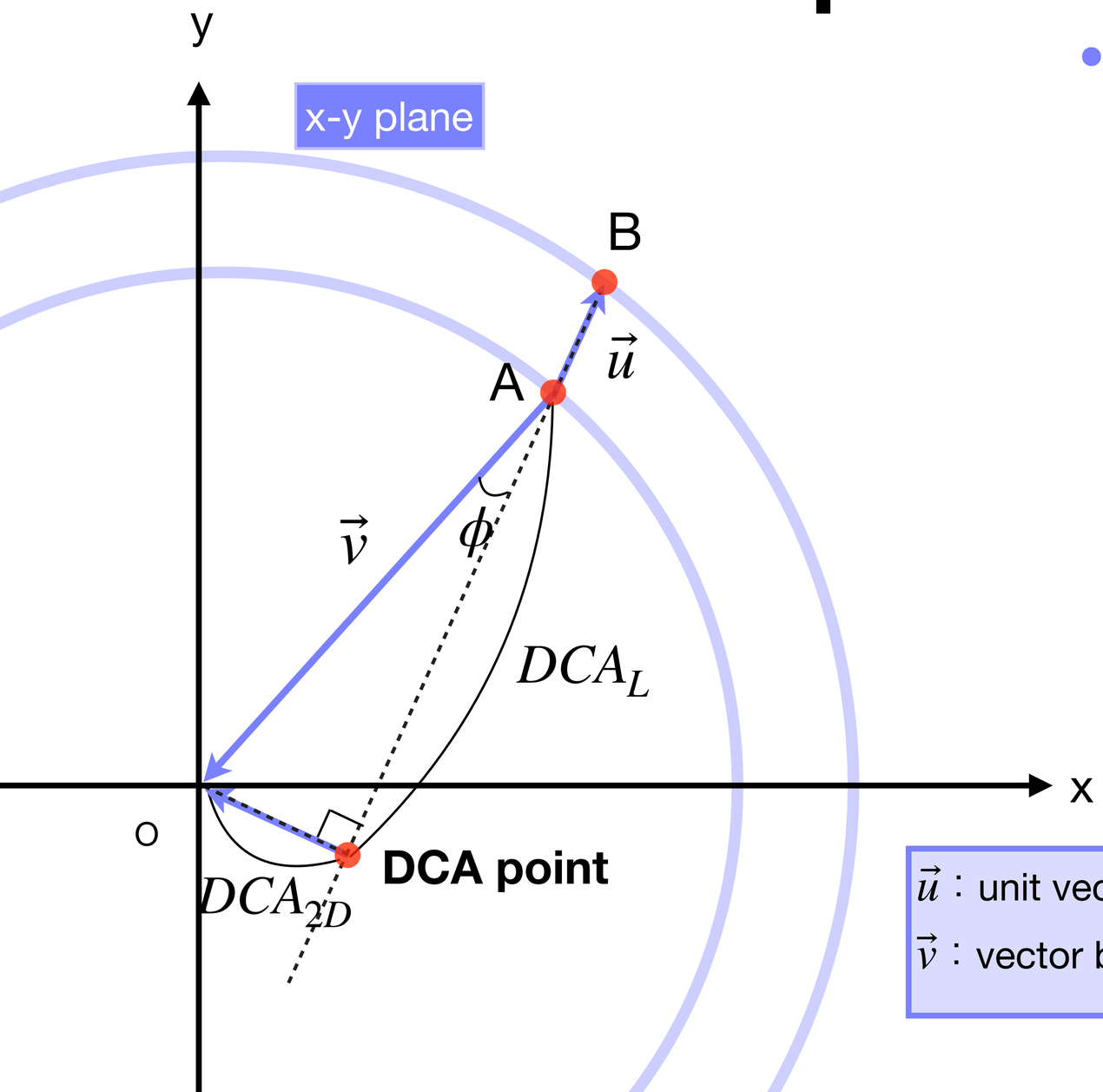
Determine the pair of Cluster A and Cluster B (tracklet) on the x-y plane.

Tracklets are selected for which the angular difference between cluster A and B $|\Delta\phi_{AB}| < 0.01$ [rad].



horizontal axis : angular of cluster A
vertical axis : angular difference between cluster A and cluster B

Calculate DCAz point



- Calculate the distance of closest approach between A and the origin.

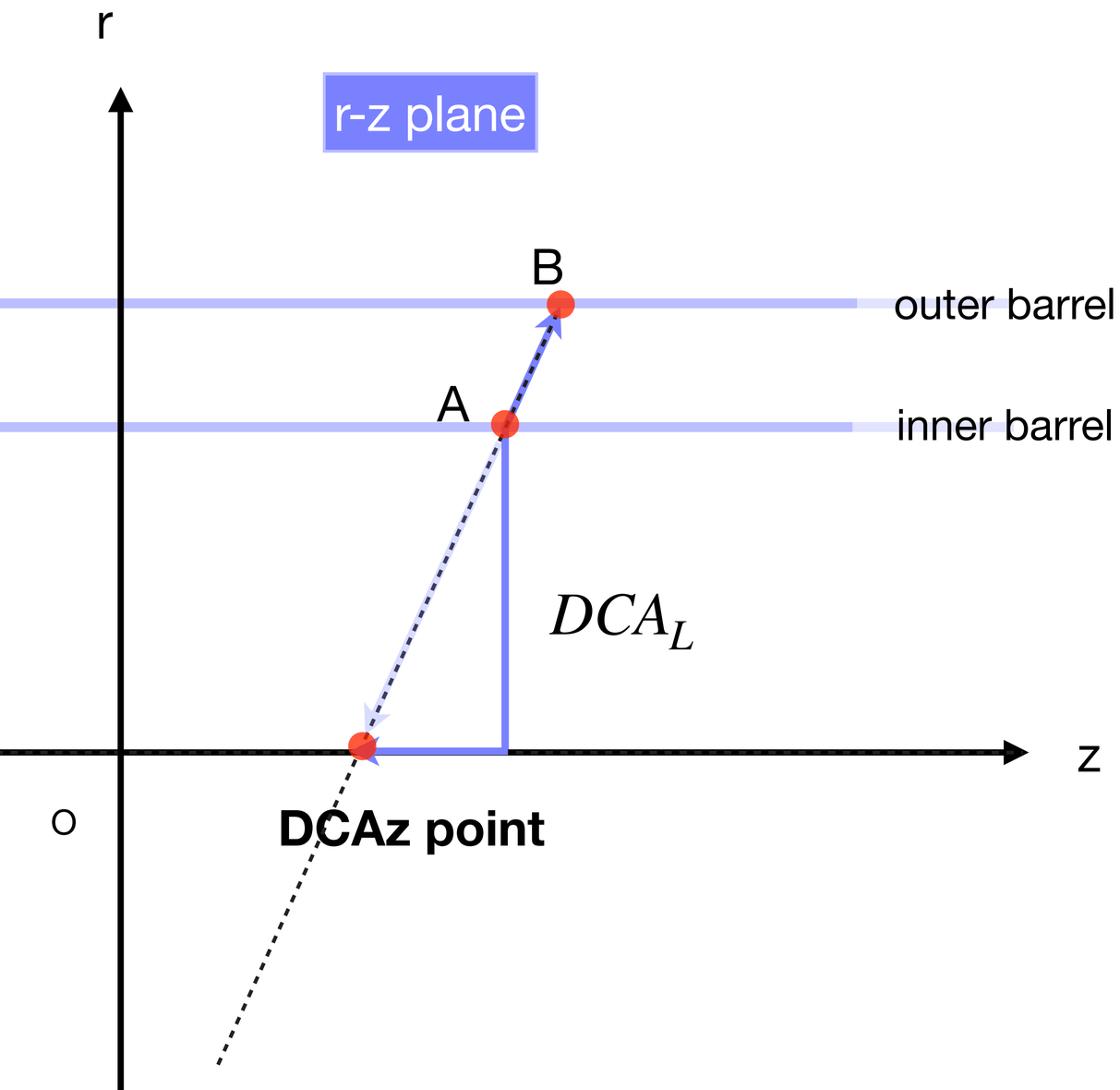
  Calculate the distance between DCA point and A (DCA_L),
  the distance between DCA point and origin(DCA_{2D}).

$$DCA_L = \vec{v} \cdot \vec{u} = \vec{v} \cdot \cos\phi$$
$$DCA_{2D} = \vec{v} \times \vec{u} = \vec{v} \cdot \sin\phi$$

$\vec{u}$: unit vector between point A and B

$\vec{v}$: vector between point A and O

DCAz座標の求め方



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- Calculate DCAz point to use DCA_L.

$$DCA_Z = DCA_L \times \vec{u}_Z + A_Z$$

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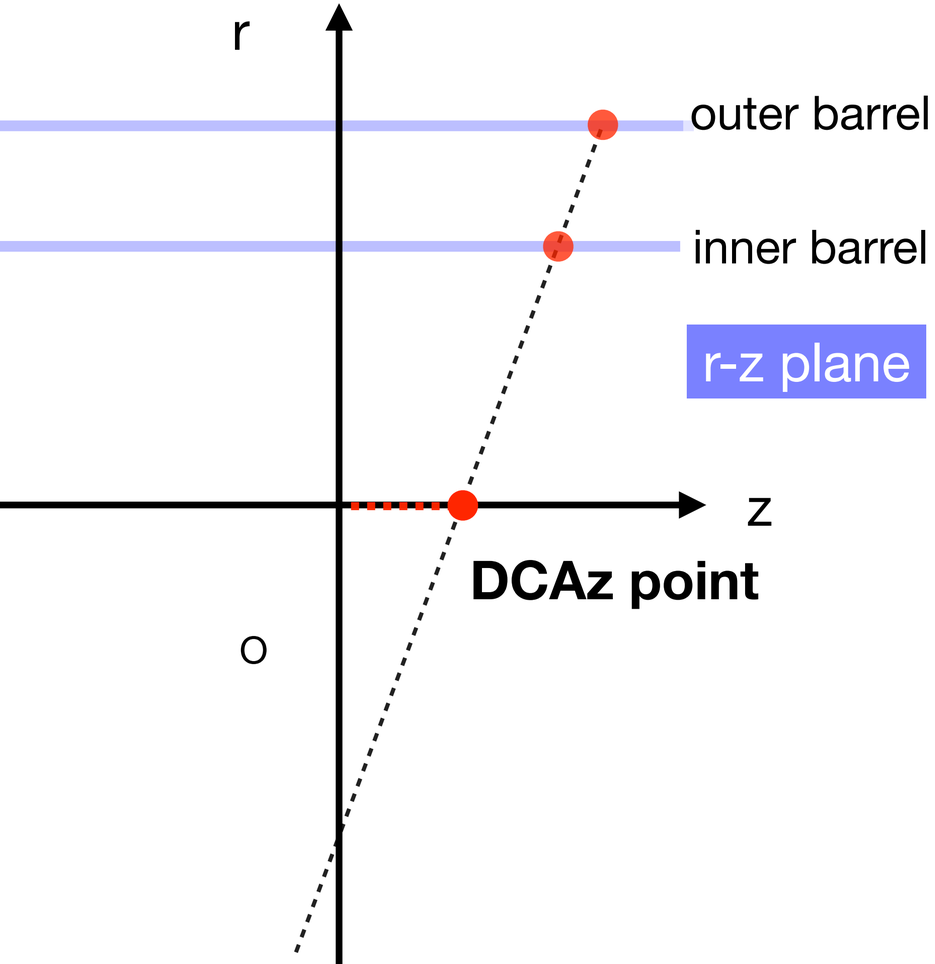

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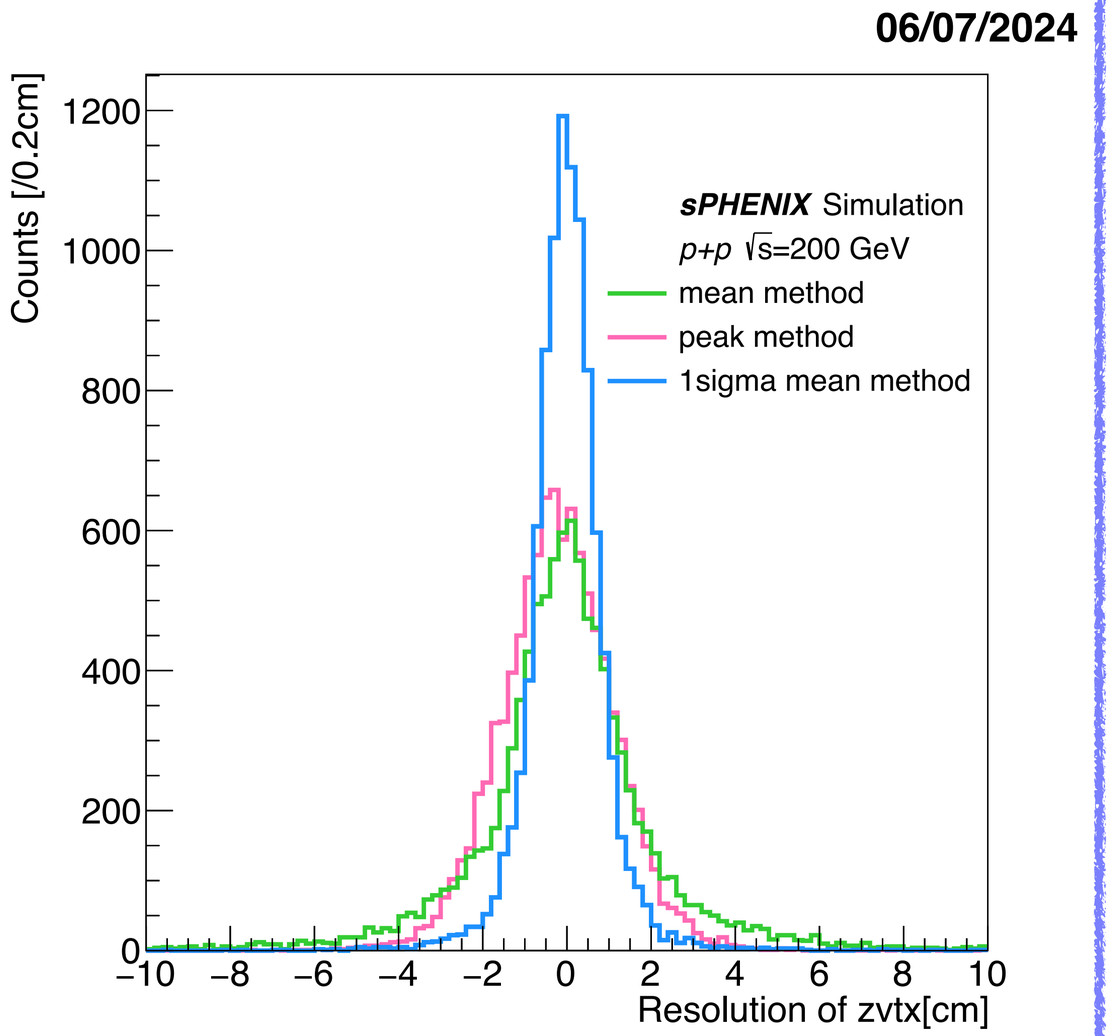

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  To calculate the mean value of DCAz distribution, which is the z_vertex.

- Peak method

  To find the peak point of DCAz distribution.

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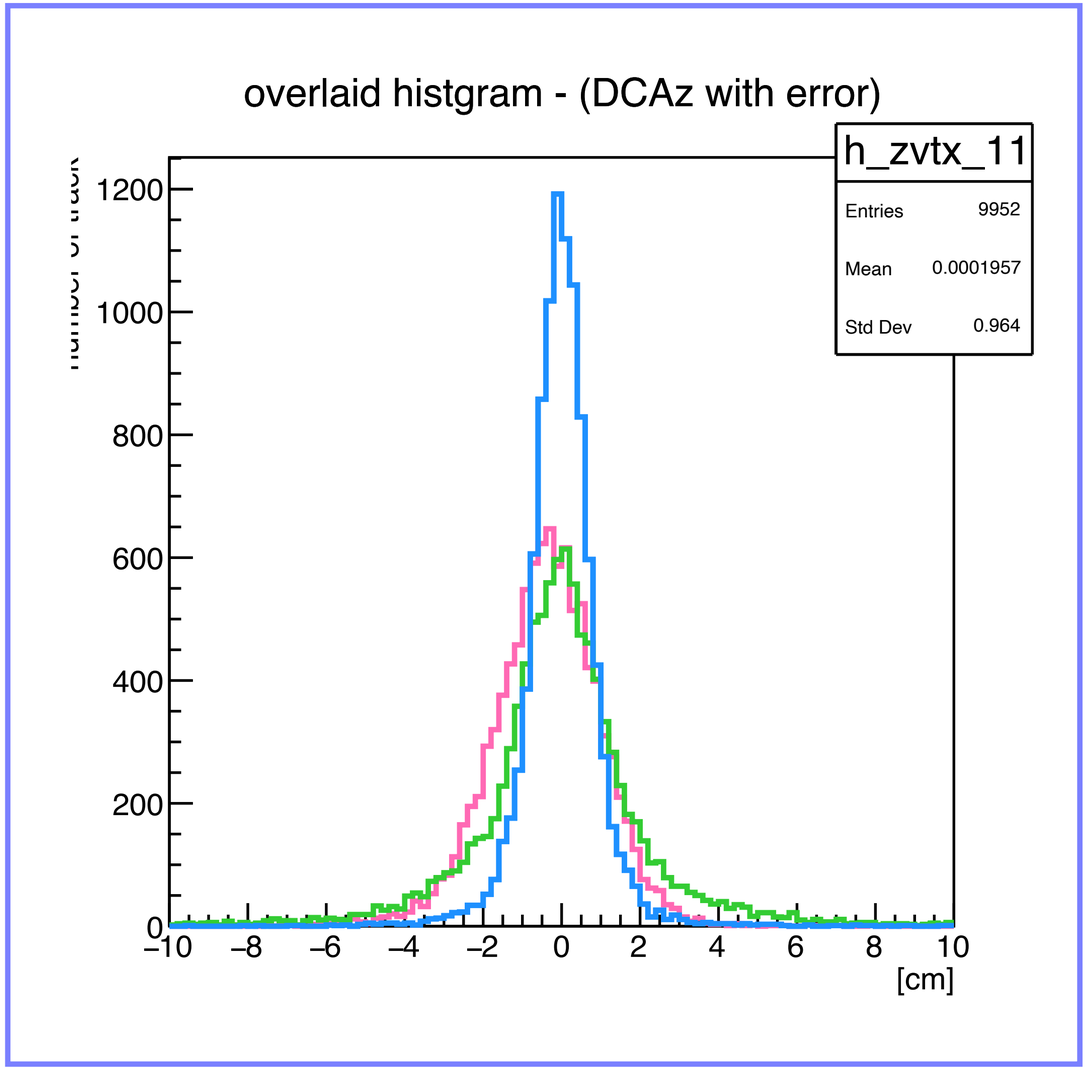
Comparing the z_vertex plot and resolution(use the DCAz plot with error)



	Std[cm]
mean method	2.119
peak method	1.423
1sigma mean method	0.964

Histogram obtained by 1sigma mean method is the longest and thinnest.Also resolution is the highest.

⇒**1sigma mean method has the most accurate results.**