Plots for RHIC/AGS User's Meeting

INTT tracking

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2024.06.04 INTT MT

Abstract

Development of a tracking algorithm using INTT

- I’m going to give a poster presentation about INTT tracking at RHIC/AGS User’s Meeting and request approval of my plots at General Meeting on this Friday.
- My analysis note was uploaded here
  - https://sphenix-invenio.sdcc.bnl.gov/me/requests/592c12ff-01a8-4ee5-bd5b-6d4d3796892f

- INTT tracking was reported in more detail in previous INTT meeting(May 15).
  - https://indico.bnl.gov/event/23383/

The contents of my poster

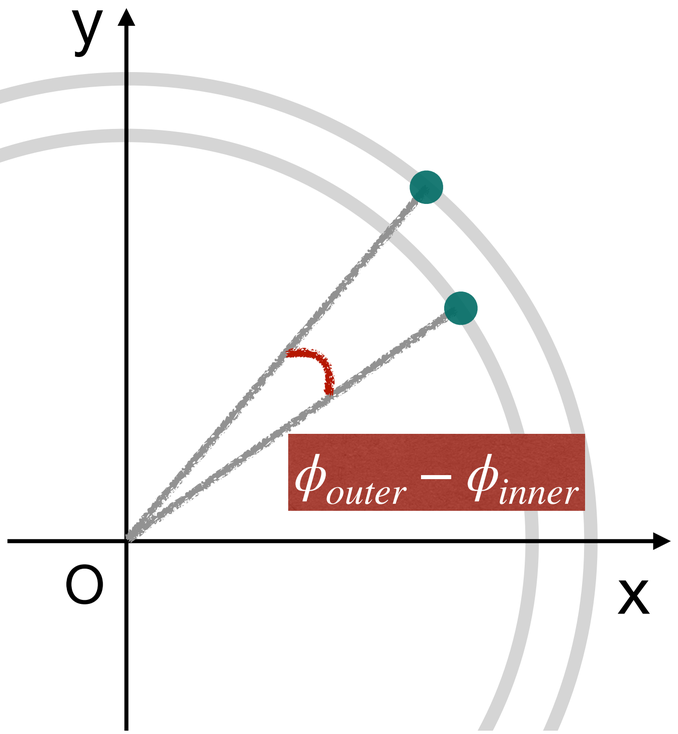
- Tracking method with(without) magnetic field data
  - Angular differences btw the inner and the outer layer clusters
- Quality of the algorithm with the simulation
  - Tracking efficiency
  - pT resolution
- Results with data taken in 2024
  - event display with magnetic field data
  - pT

- I will show plots to be approved in this slides.

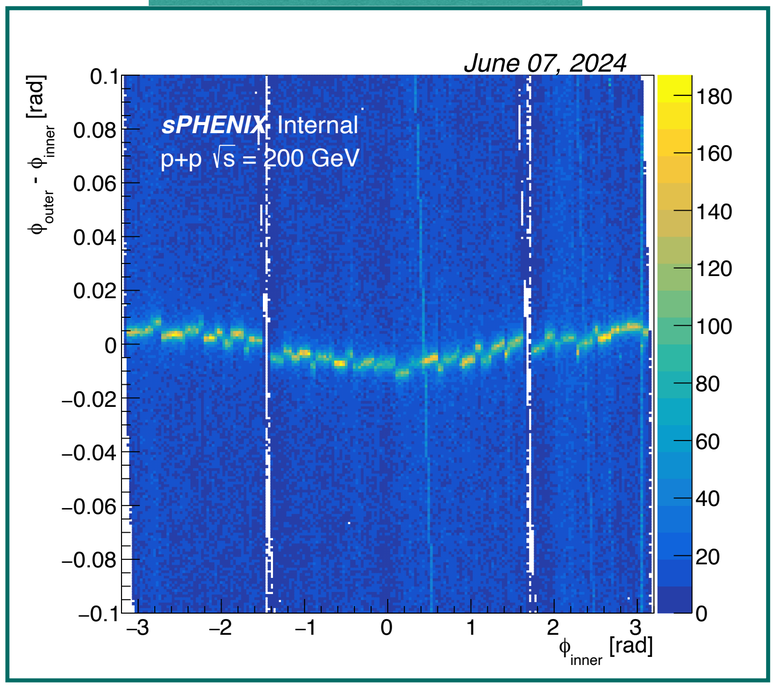
Plot1, 2 : $\phi_{\mathrm{outer}} - \phi_{\mathrm{inner}}$

Used data : 40741 without B-field

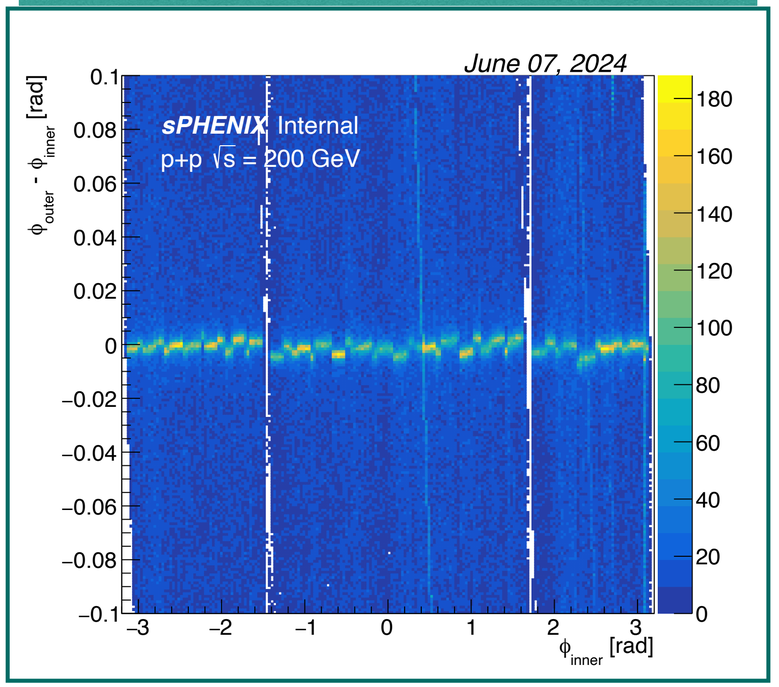
- Left(Right) plot shows angular differences btw the inner and the outer layer clusters from the origin of the coordinate (optimized collision point) in the x-y plane.



from (0, 0)cm



from (-0.019, 0.198)cm

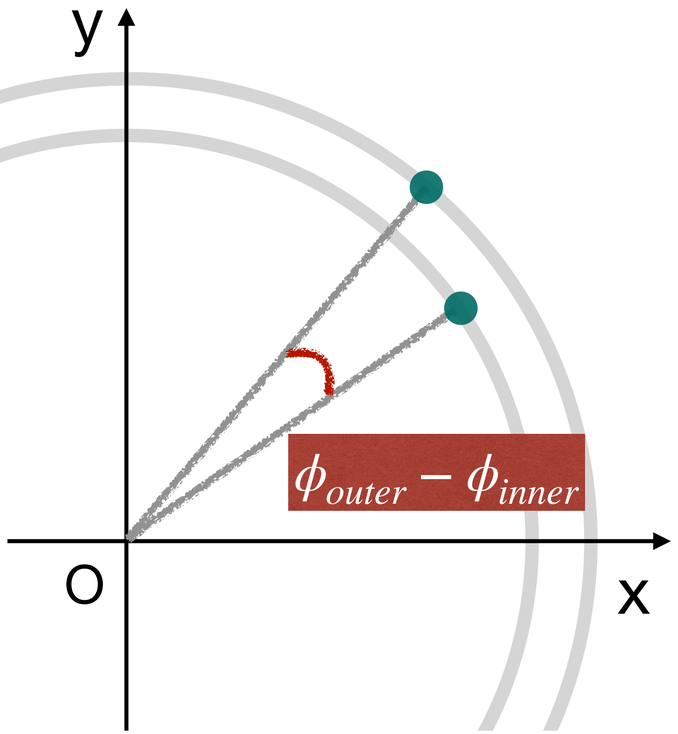


- These distribution has good correlations.
- Using the optimized collision vertex, the shape becomes straight.

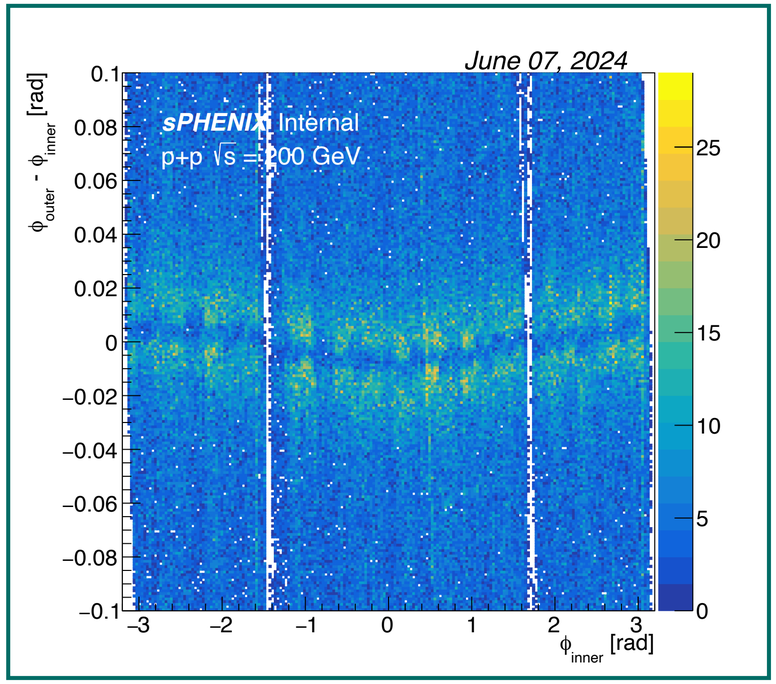
Plot3, 4 : $\phi_{\text{outer}} - \phi_{\text{inner}}$

Used data : 41981 with B-field

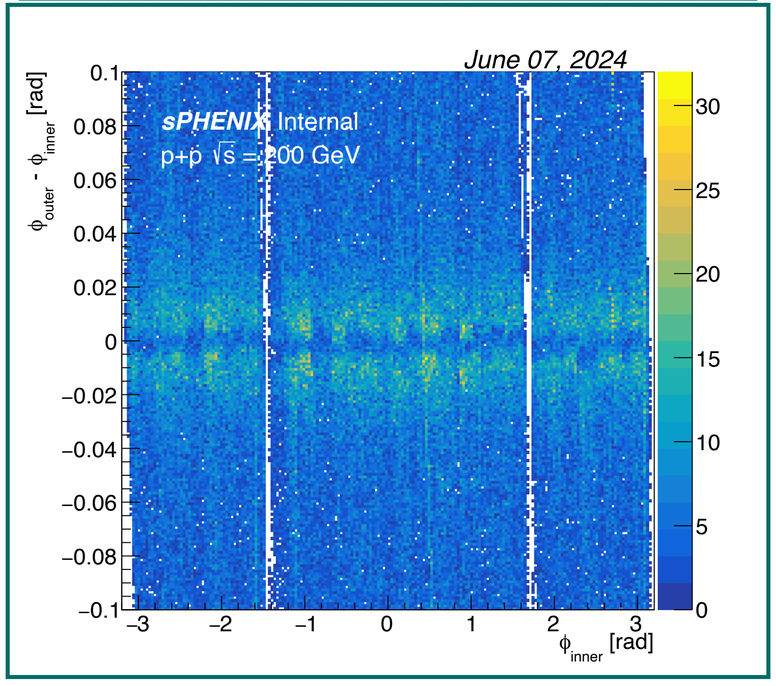
- Left(Right) plot shows angular differences btw the inner and the outer layer clusters from the origin of the coordinate (optimized beam center) in the x-y plane.



from (0, 0)cm



from (-0.019, 0.198)cm

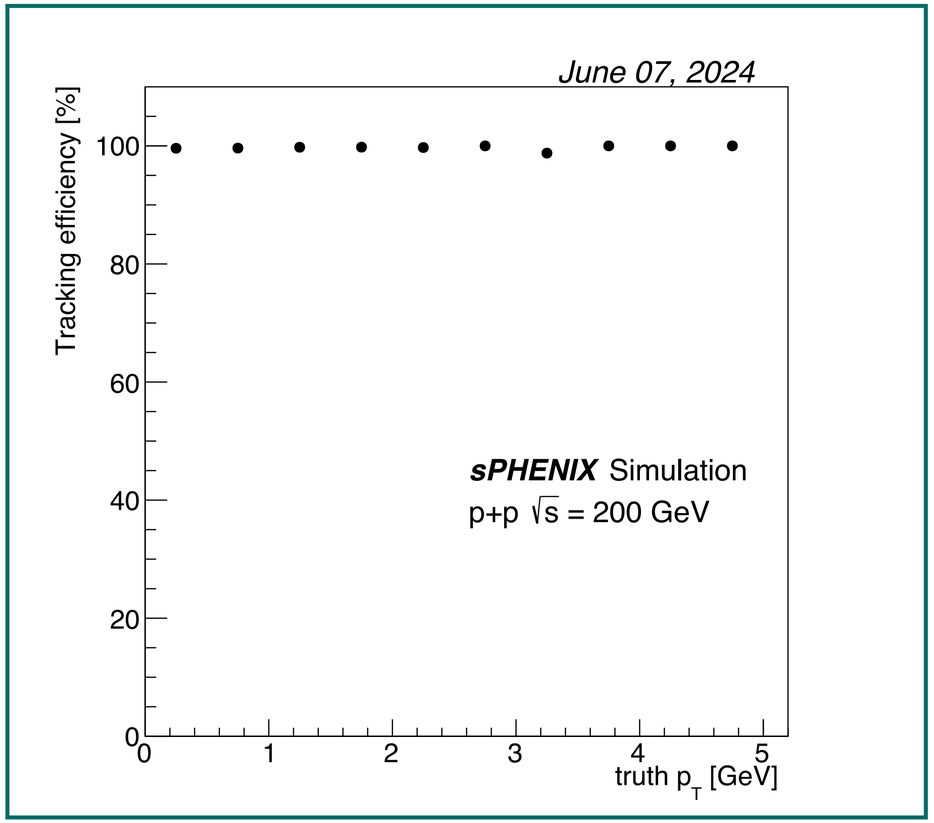


- A good correlation can be seen.
- Using the optimized collision vertex, the shape becomes straight.

Plot5 : Tracking efficiency

Used data : MC without B-field

- proton-proton collisions at $\sqrt{s}$ = 200GeV were simulated.



- The tracking efficiency as a function of pT is evaluated.
- The tracking efficiency is :

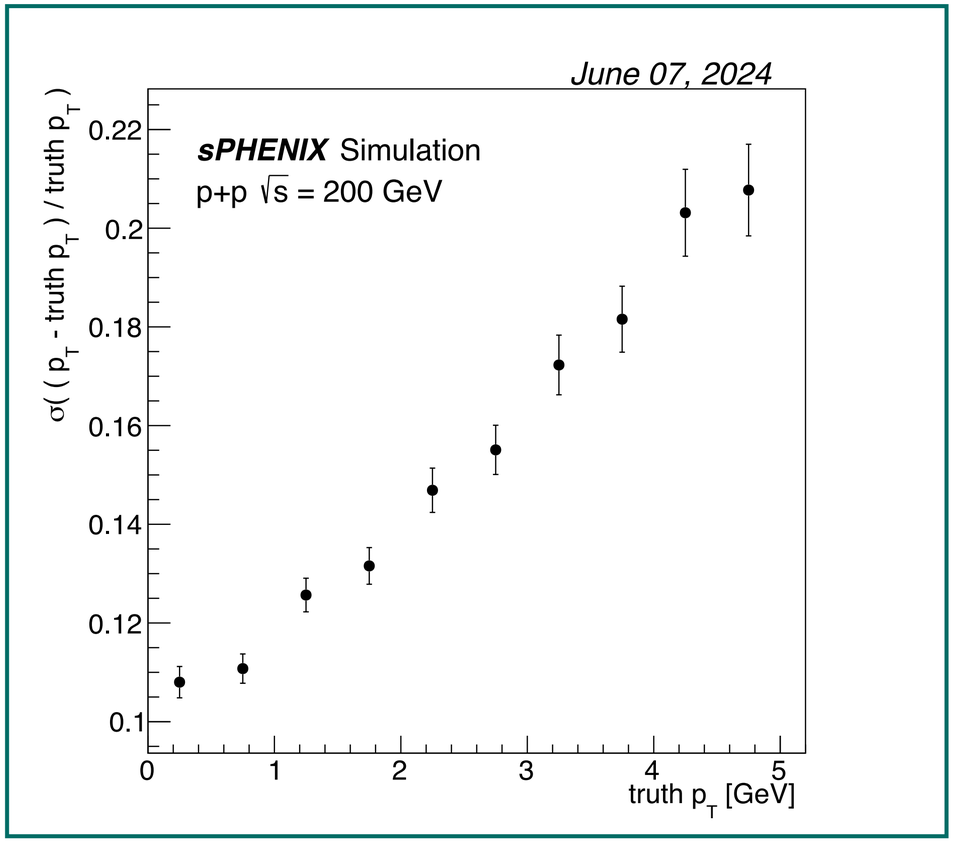
$$\frac{N_{\text{tracks}}}{N_{\text{cluster pairs}}}$$

- The entire average appears to be 99.6 ± 0.3%.

Plot6 : pT resolution

Used data : MC with B-field

- Single particles (μ^-) were injected from the origin of coordinate to INTT.

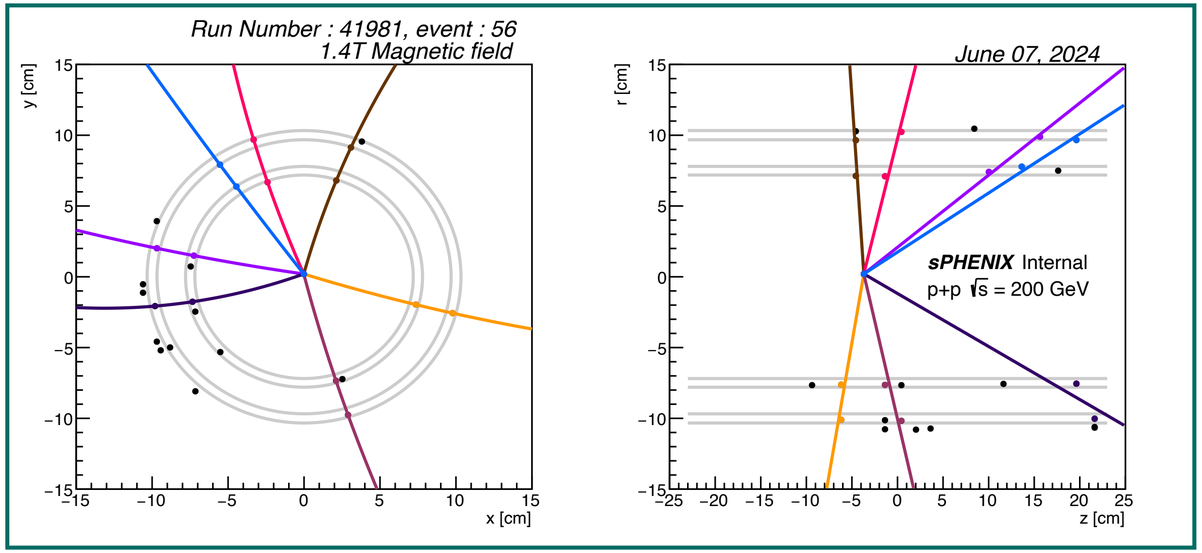


- pT resolution as a function of truth pT is evaluated.

- pT resolution is evaluated as below :
  - pT difference between the reconstructed and truth track is calculated and it is divided by truth pT.
  - This difference is fitted with Gaussian distribution to obtain its sigma as a resolution.

Plot7 : Event display

Used data : 41981 with B-field

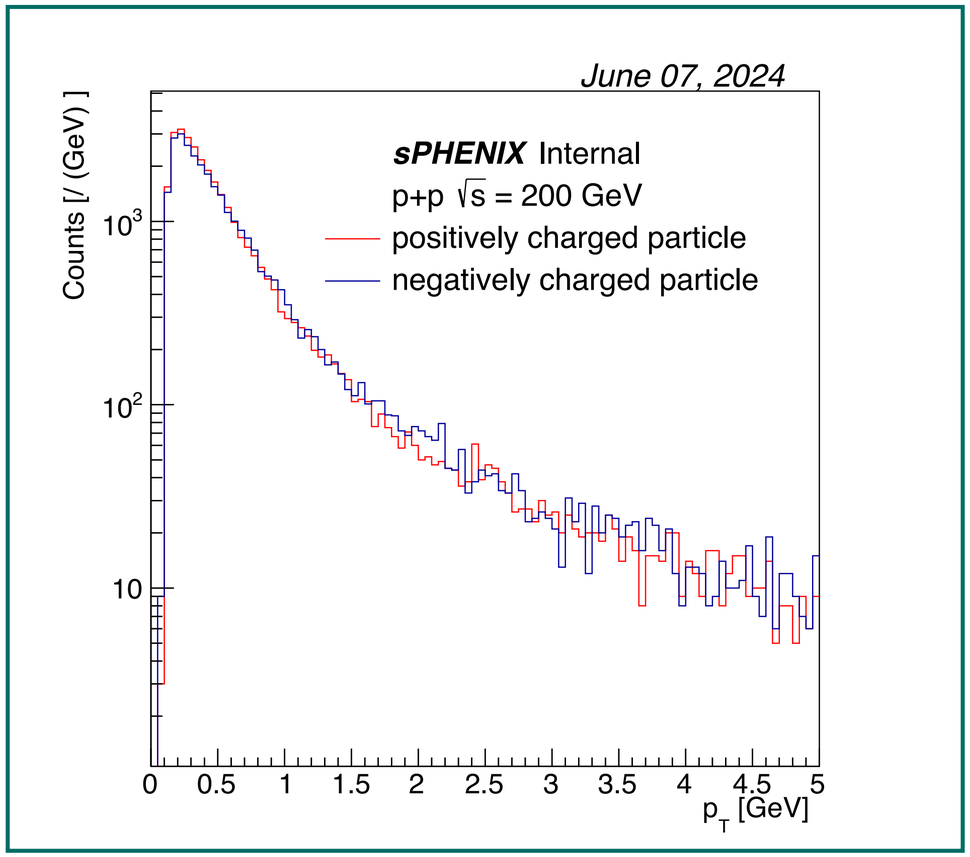


- This is event display of tracking in the x-y and the r($= \sqrt{x^2 + y^2}$)-z planes.
- This plot used data with magnetic field taken in 2024.

- Colored lines : reconstructed tracks
- Colored points : associated cluster pairs
- Black points : clusters

Plot8 : pT

Used data : 41981 with B-field



- pT is obtained with data with magnetic field.

Red : positively charged particles

Blue : negatively charged particles

- We could confirm that the number difference of positively and negatively charged particles are at the level of 1.9%.

Summary

Development of a tracking algorithm using INTT

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- My analysis note was uploaded here
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BACK UP

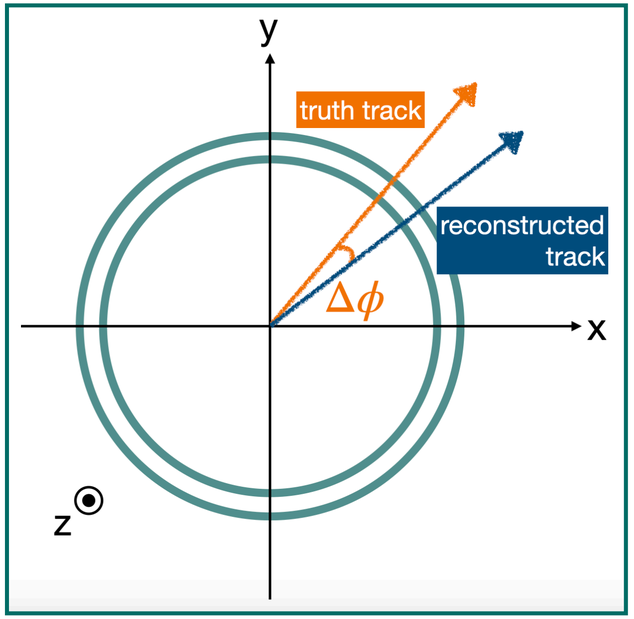
How to evaluate the tracking algorithm

Tracking efficiency is calculated as below.

$$\text{effi.} = \frac{N_{\text{tracks}}}{N_{\text{cluster\_pairs}}}$$

<How to count N_{tracks} and N_{clusters}>

1. Make $\Delta\phi$ b/w the truth track and the closest track(cluster) distribution.
2. Fit the distribution by Gaussian distribution.
3. Define a window as within 3σ of the distribution.
4. Count the tracks in the window.



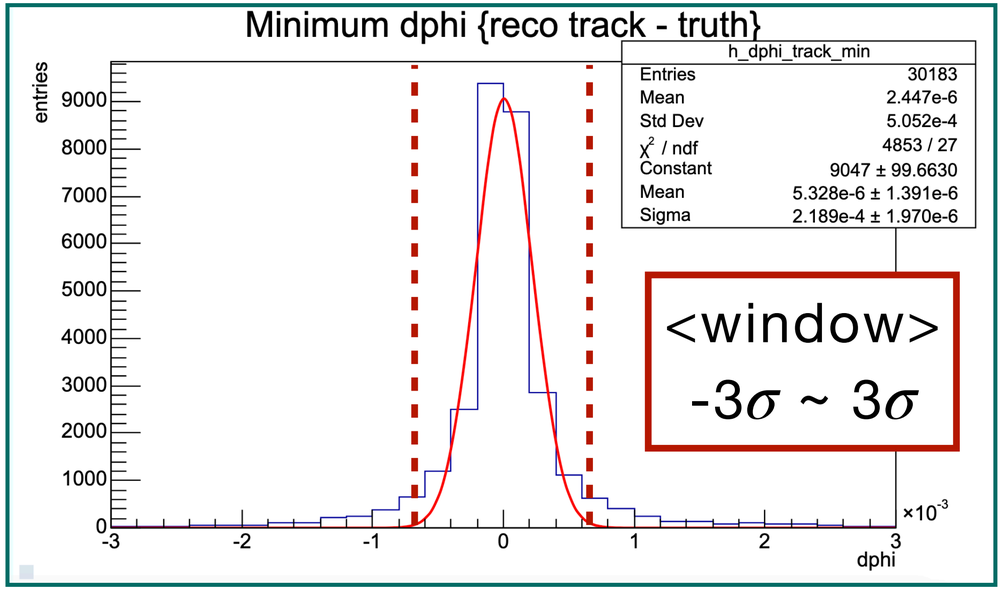


Table of content & used data

Development of a tracking algorithm using INTT

- Tracking method with B-off and B-on data.
- Event display of tracking.
- Reconstructed pT and pz of MC and data.

Used data

【MC】(p+p/200GeV)

- PYTHIA8 + GEANT4
- B-on / B-off
- vertex : Gaussian distribution
  - mean : (x, y, z) = (0, 0, 0)
  - width : (x, y, z) = $(10^{-4}, 10^{-4}, 10^{-4})$

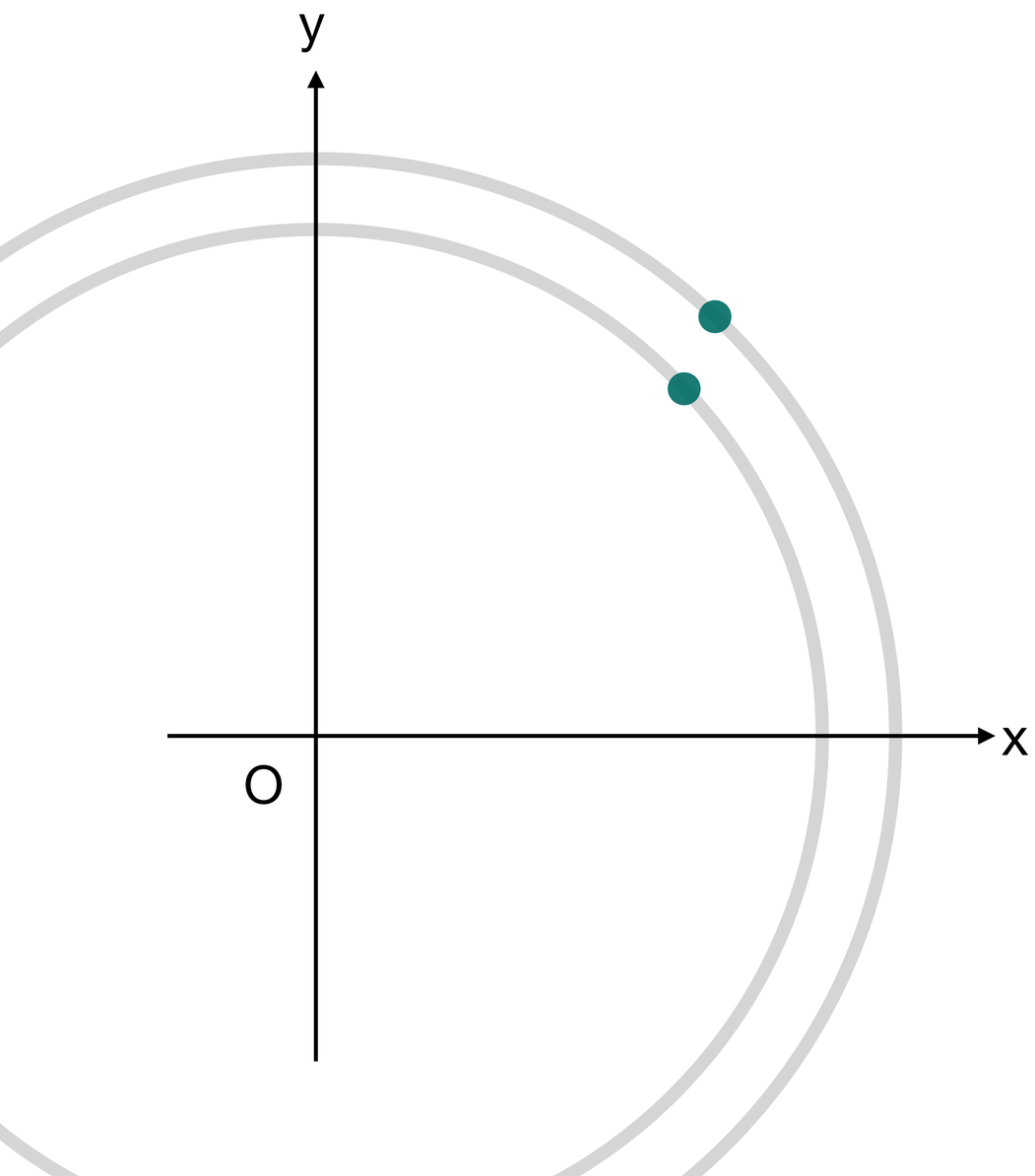
【run 40741】

- 2024/04/28
- 10K events
- DAC0 = 30
- B-off

【run 41981】

- 2024/05/10
- 10K events
- B-on (B = 1.4T)

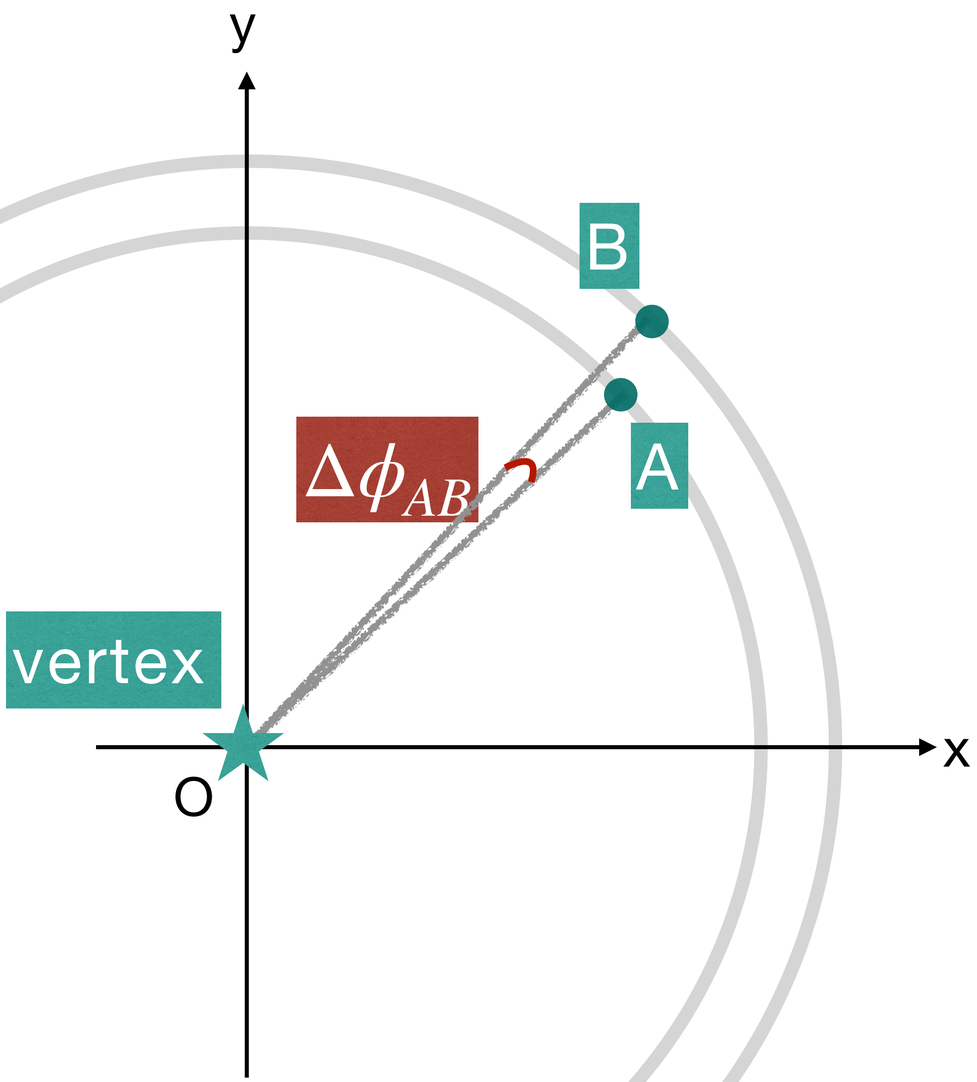
How to reconstruct a track (B-off) (1/4)



1. Reconstruct a “tracklet”.

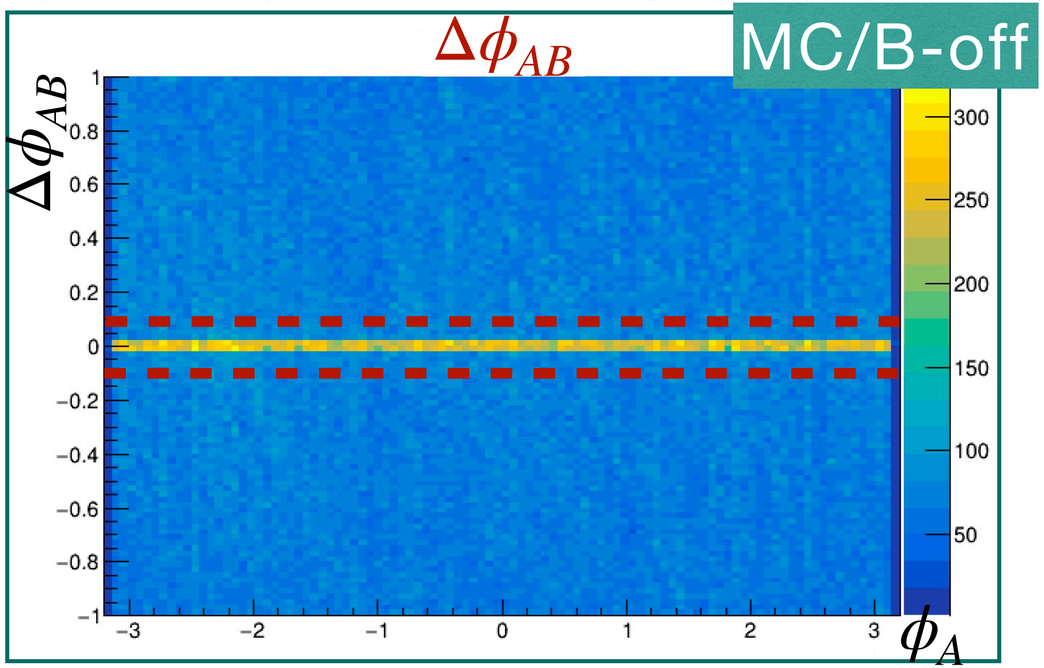
2. Optimize the tracks.

How to reconstruct a track (B-off) (2/4)



1. Reconstruct a “tracklet”.
   - Make a pair of inner cluster A and outer cluster B.

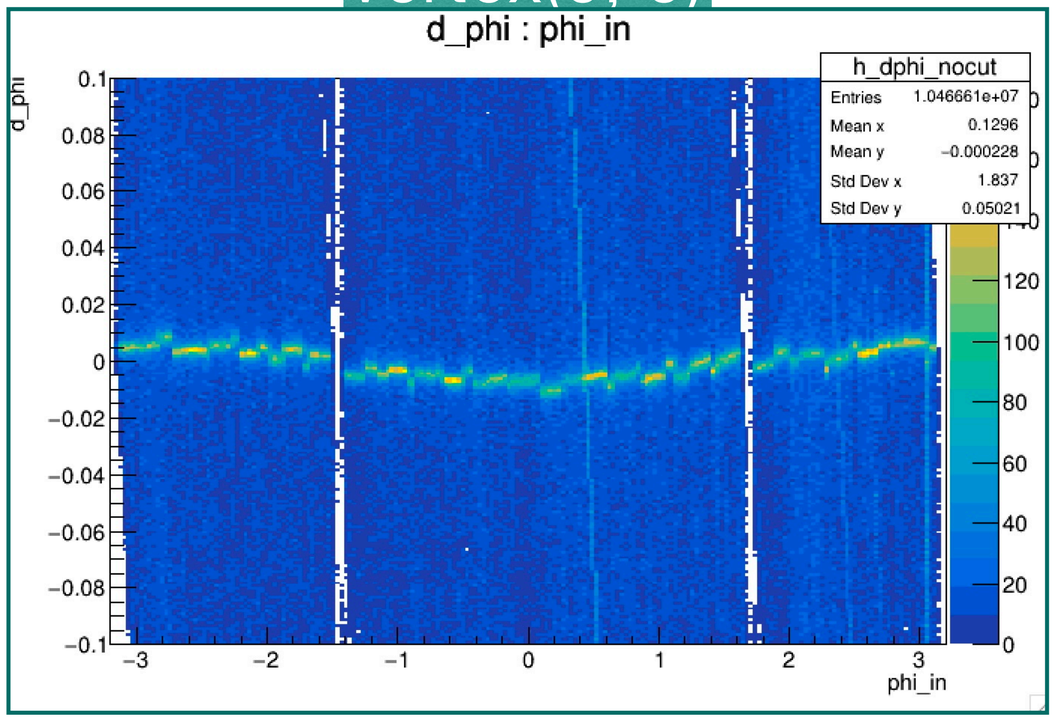
Requirement：the angular difference from vertex between clusters is $|\Delta\phi_{AB}| < 0.1$.



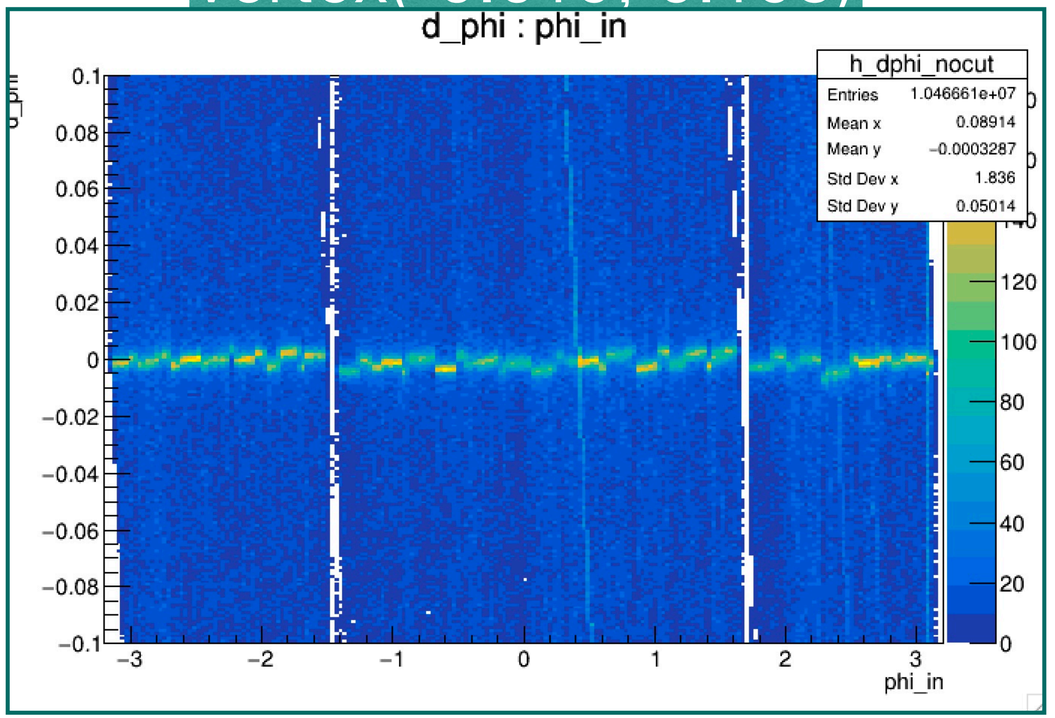
Used vertex value (run 40741/B-off)

- The vertex used in this analysis is (x, y) = (-0.019, 0.198).
  - The plot below shows angular difference btw inner cluster and outer cluster in x-y plane.

vertex(0, 0)

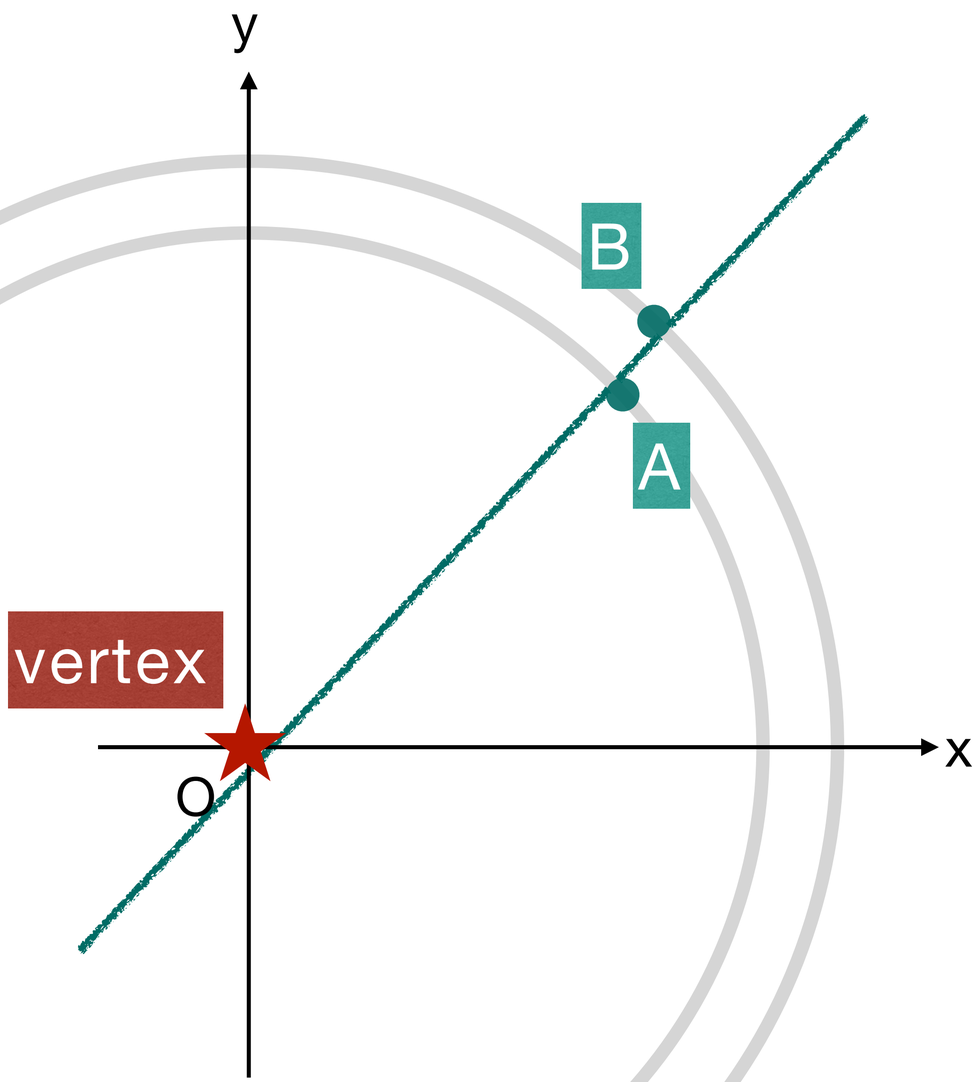


vertex(-0.019, 0.198)



- The vertex(-0.019, 0.198) should be used with B-off data.
- The range of d_phi cut($|\Delta\phi_{AB}| < 0.1$) works for B-off data as well.

How to reconstruct a track (B-off) (3/4)



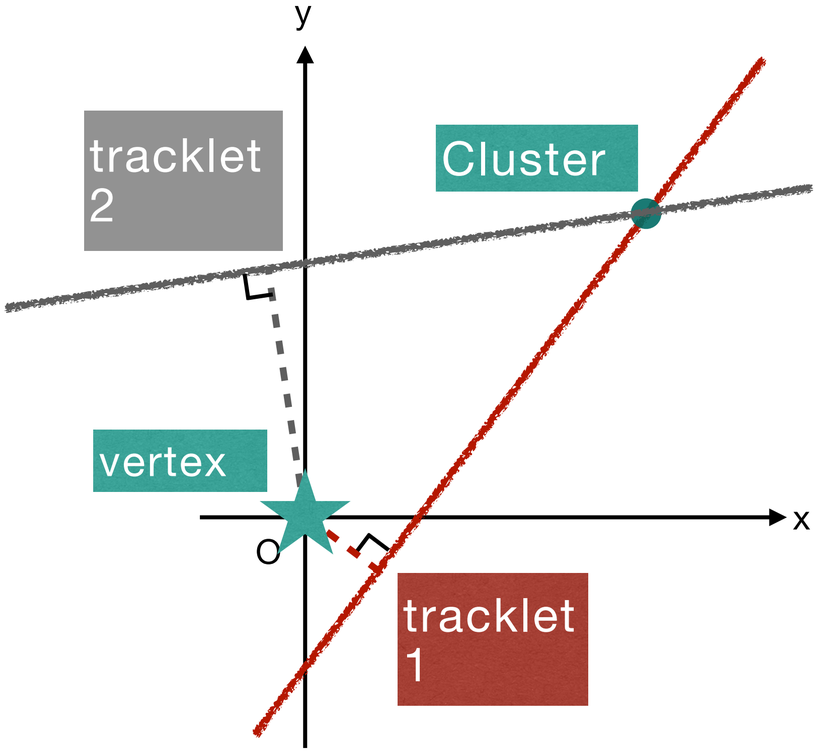
2. Optimize the tracks.

- Fit the tracklet and reconstructed vertex with a linear function using the least-square method.

Exclude the background

When multiple tracklets share one cluster

- Select the tracklet which is the closest to the vertex in x-y plane.

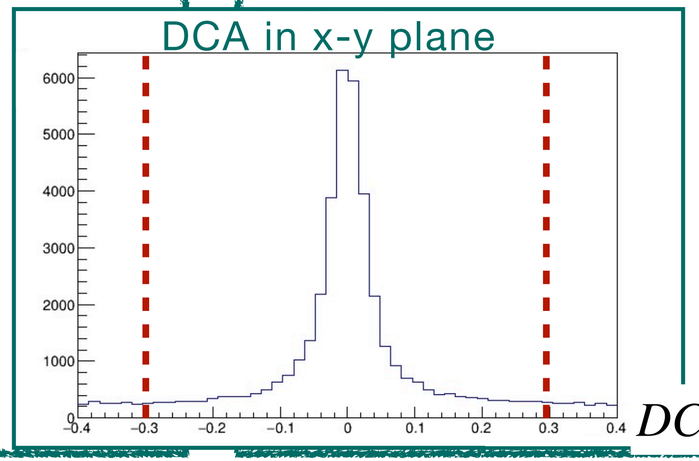


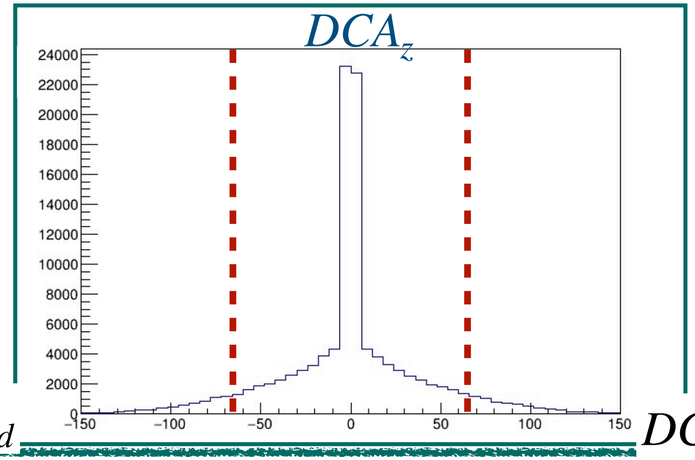
When tracklet is far from the vertex

- Exclude tracklet whose DCA in x-y plane, DCAz is far from the vertex.

<window>

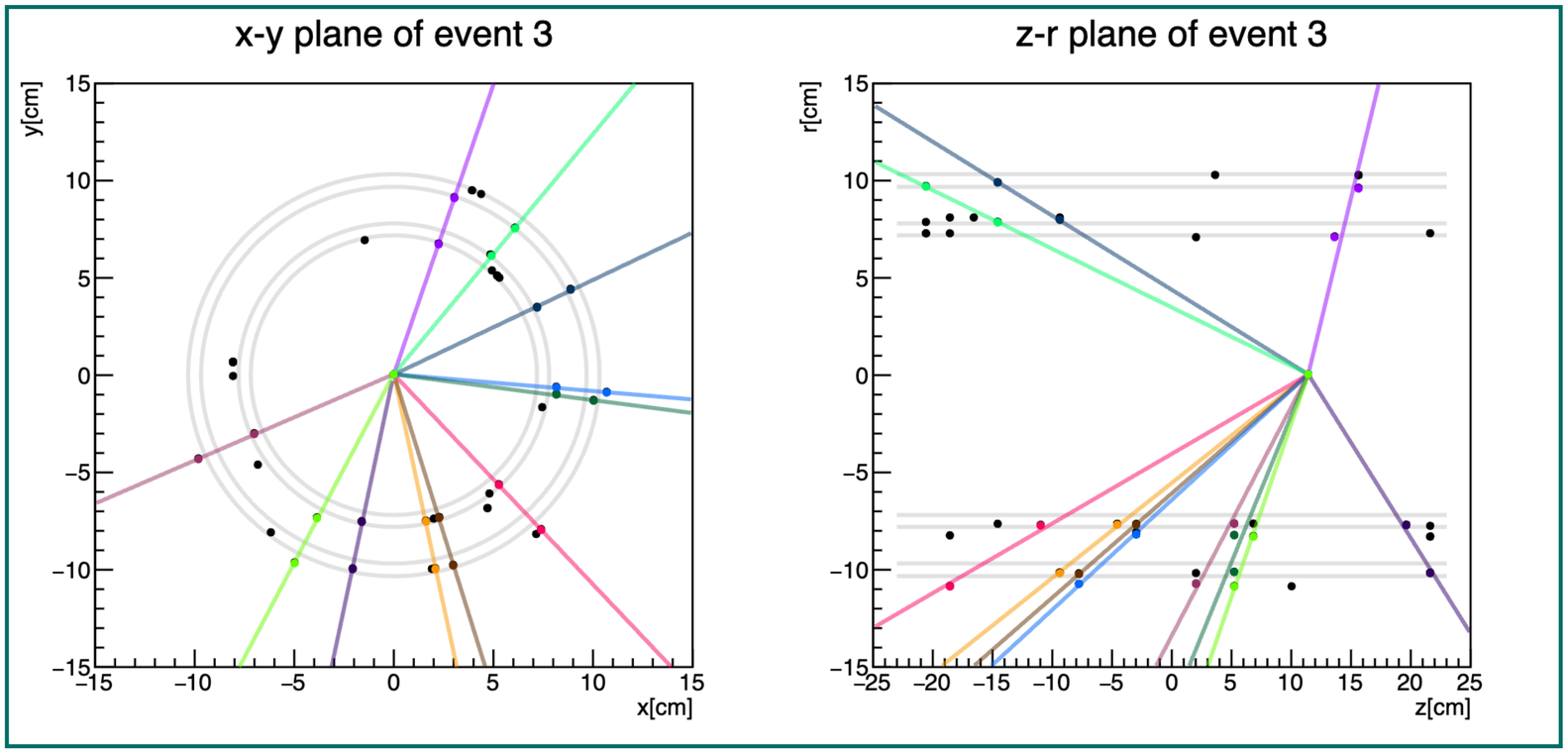
$-3\sigma \sim 3\sigma$



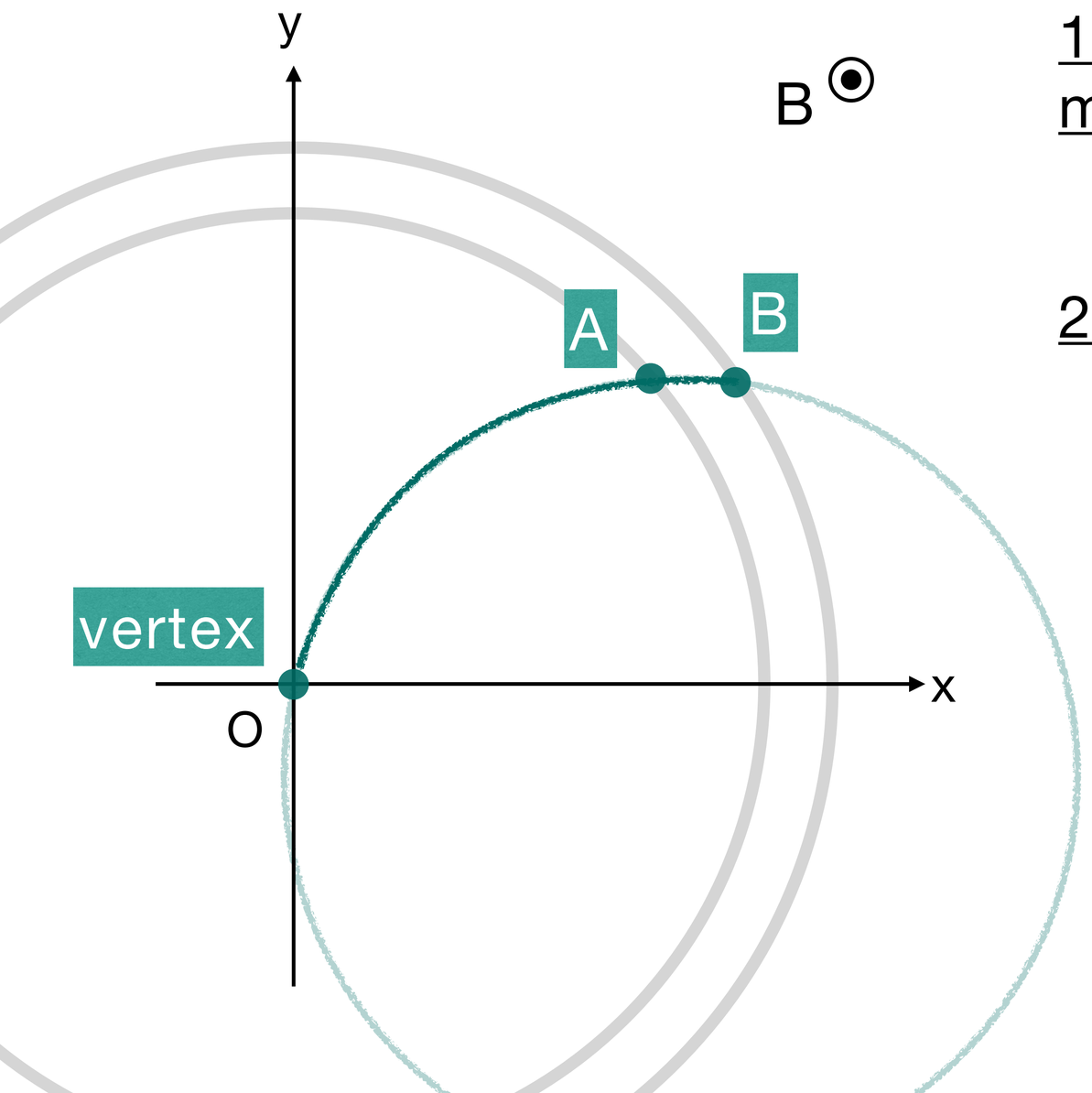


Reconstructed tracks (run40741/B-off)

- The tracks were reconstructed successfully using data(run40741/B-off).
- This result is reported in the Shift Change Meeting(April 29)🙂.



How to reconstruct a track (B-on)



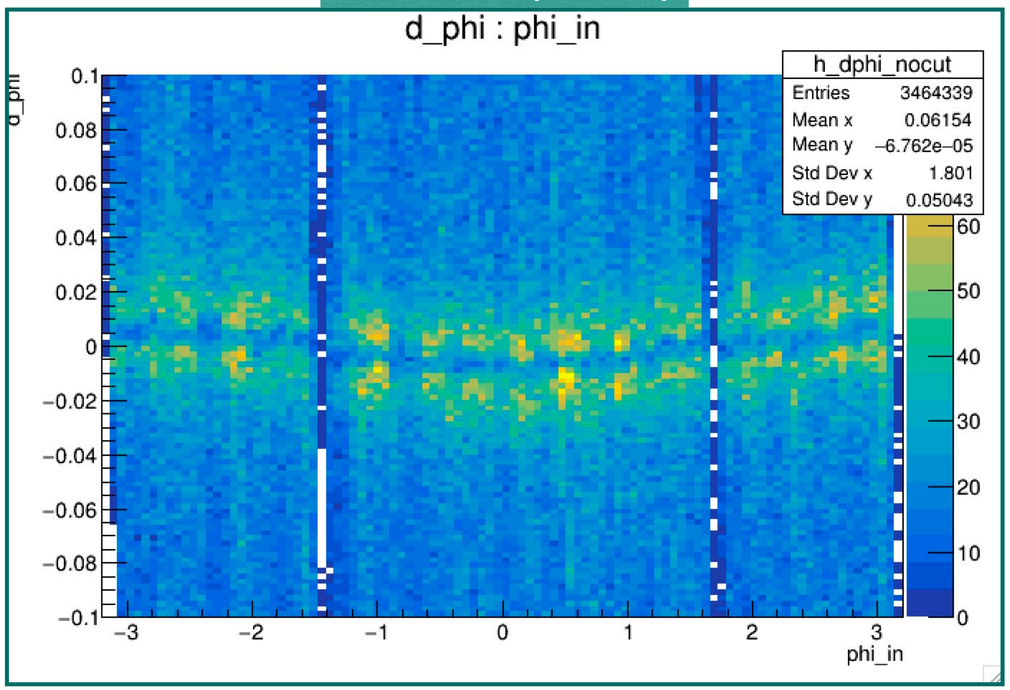
1. Reconstruct a “tracklet” in the same method as B-off data.
   The vertex is the same as B-off is used.

2. Optimize the tracks.
   Connect the tracklet and reconstructed vertex with a circle.

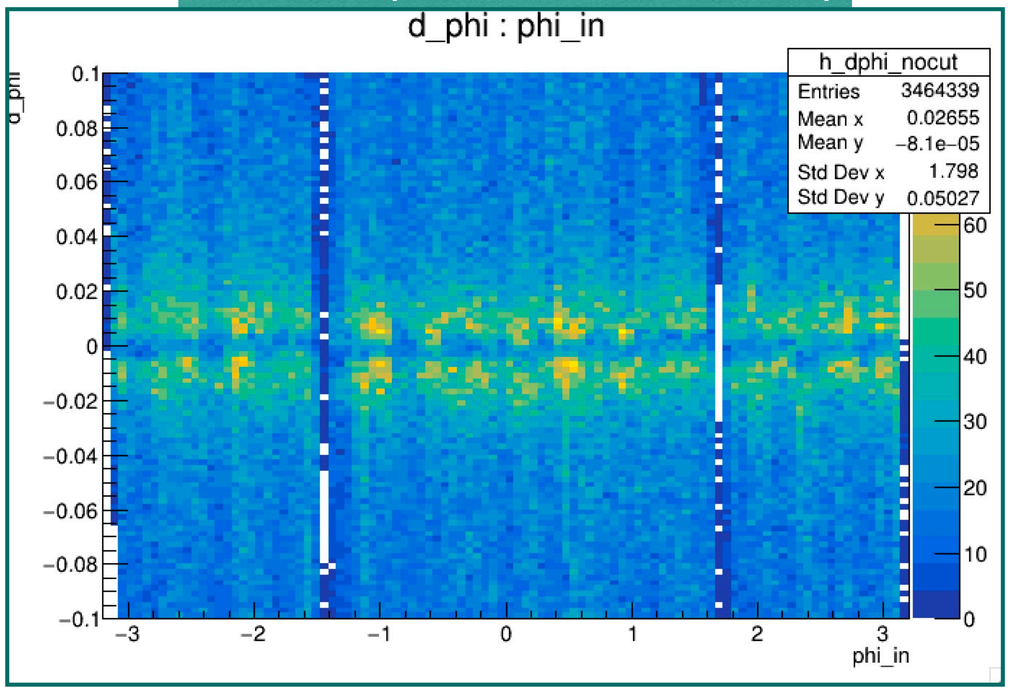
Used vertex value (run 41981/B-on)

- The vertex used in this analysis is (x, y) = (-0.019, 0.198).
  - The plot below shows angular difference btw inner cluster and outer cluster in x-y plane.

vertex(0, 0)



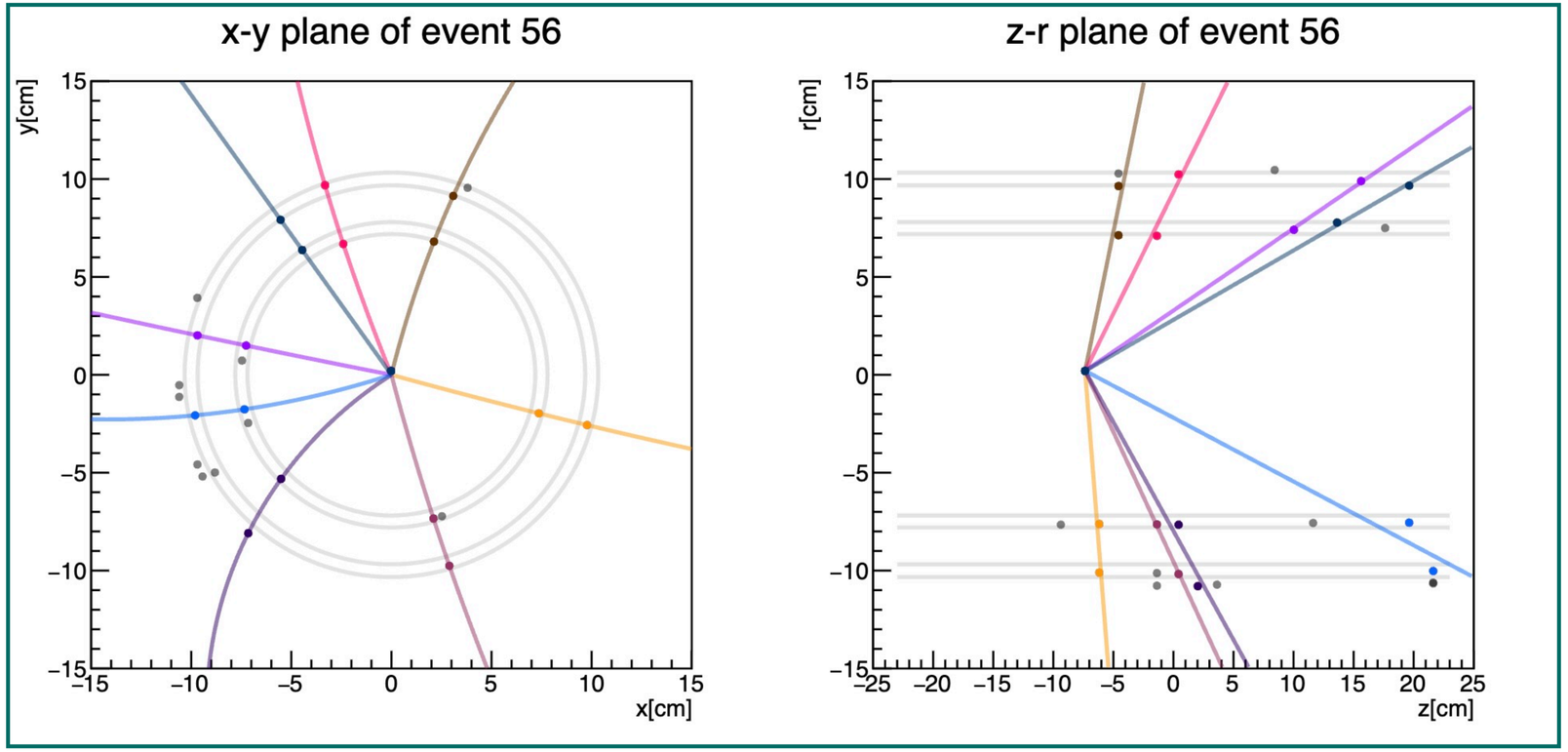
vertex(-0.019, 0.198)



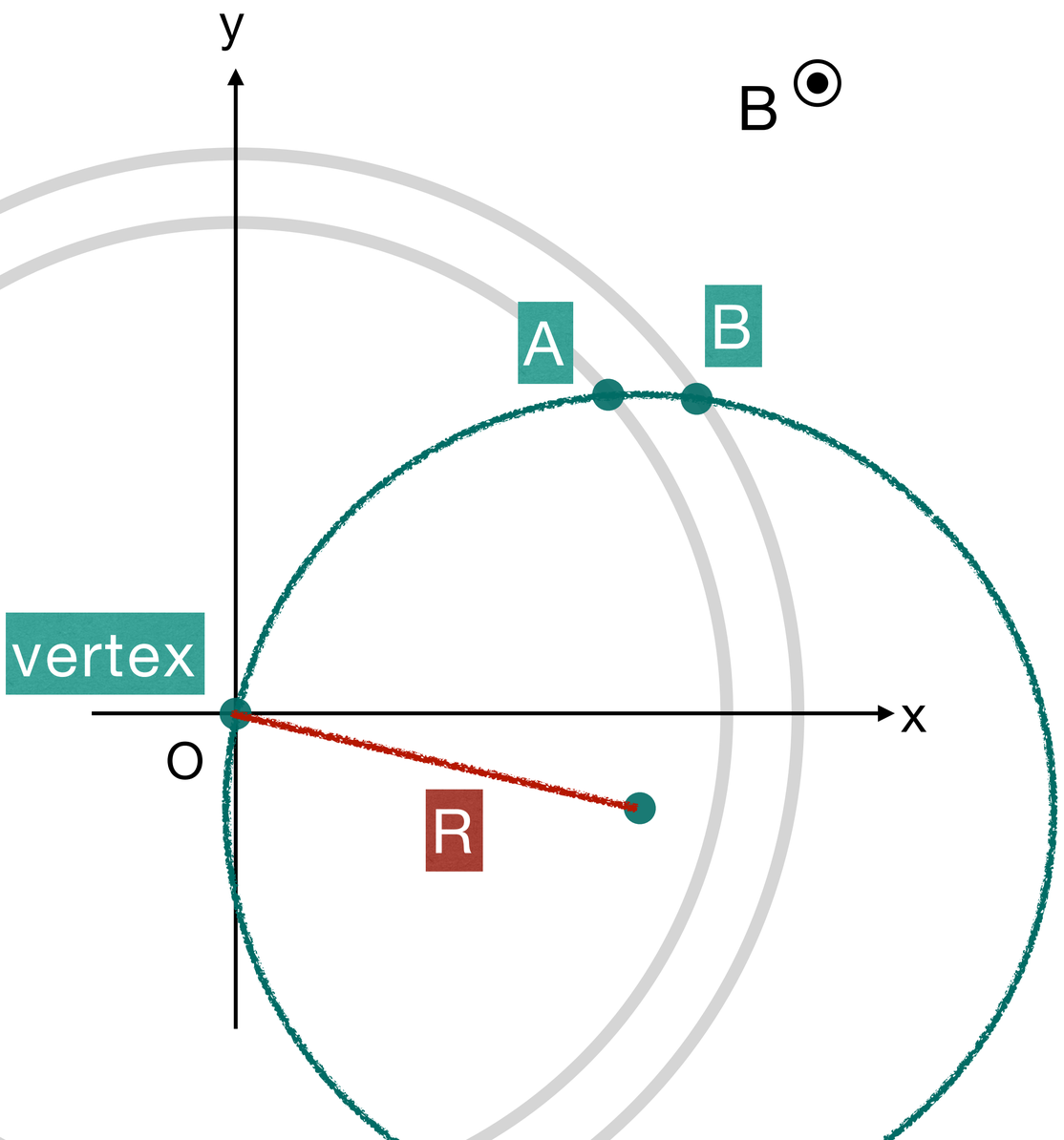
- The vertex(-0.019, 0.198) should be used with B-on data as well.
- The range of d_phi cut works for B-off data.

Reconstructed tracks(run41981/B-on)

- The tracks were reconstructed successfully using data(run40741/B-on).
- This result is reported in the Shift Change Meeting(May 13)🙂.



How to calculate pT



1. Reconstruct a track curvature with B-on data.
2. Calculate the Radius of curvature (R).
3. Calculate p_T from the equation for circular motion.

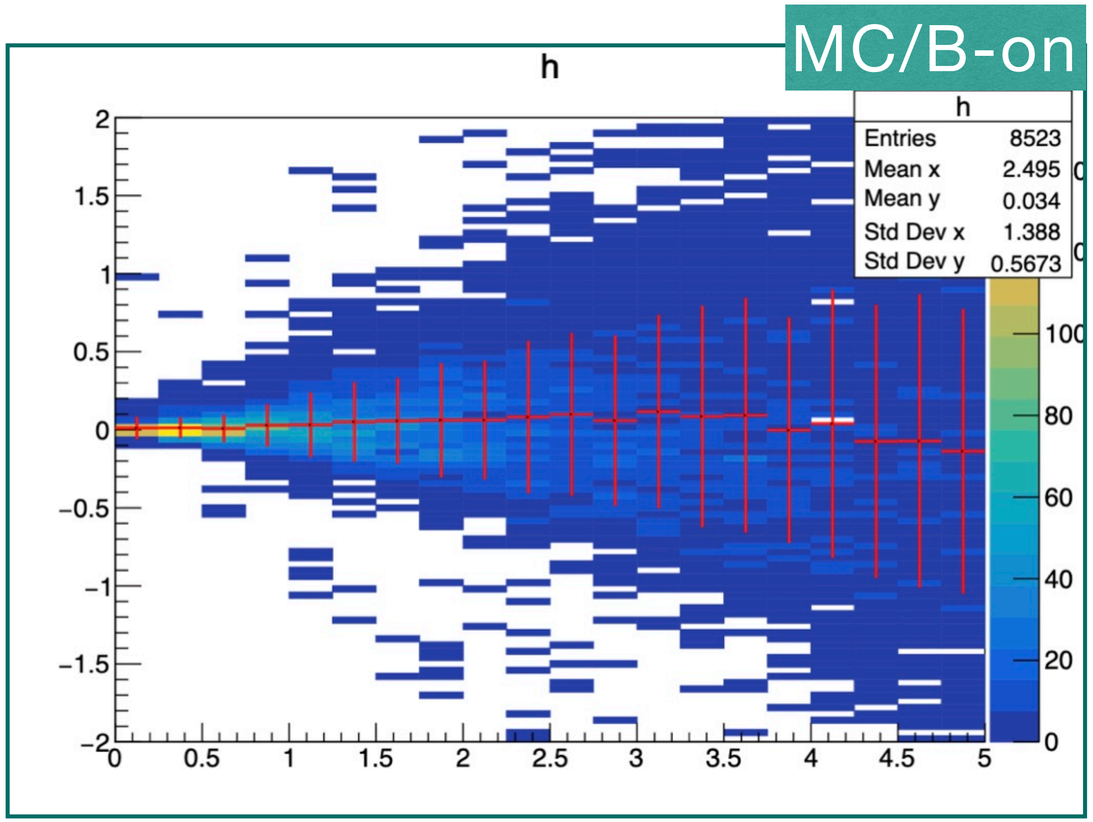
$$m\frac{v_T^2}{R} = ev_TB$$

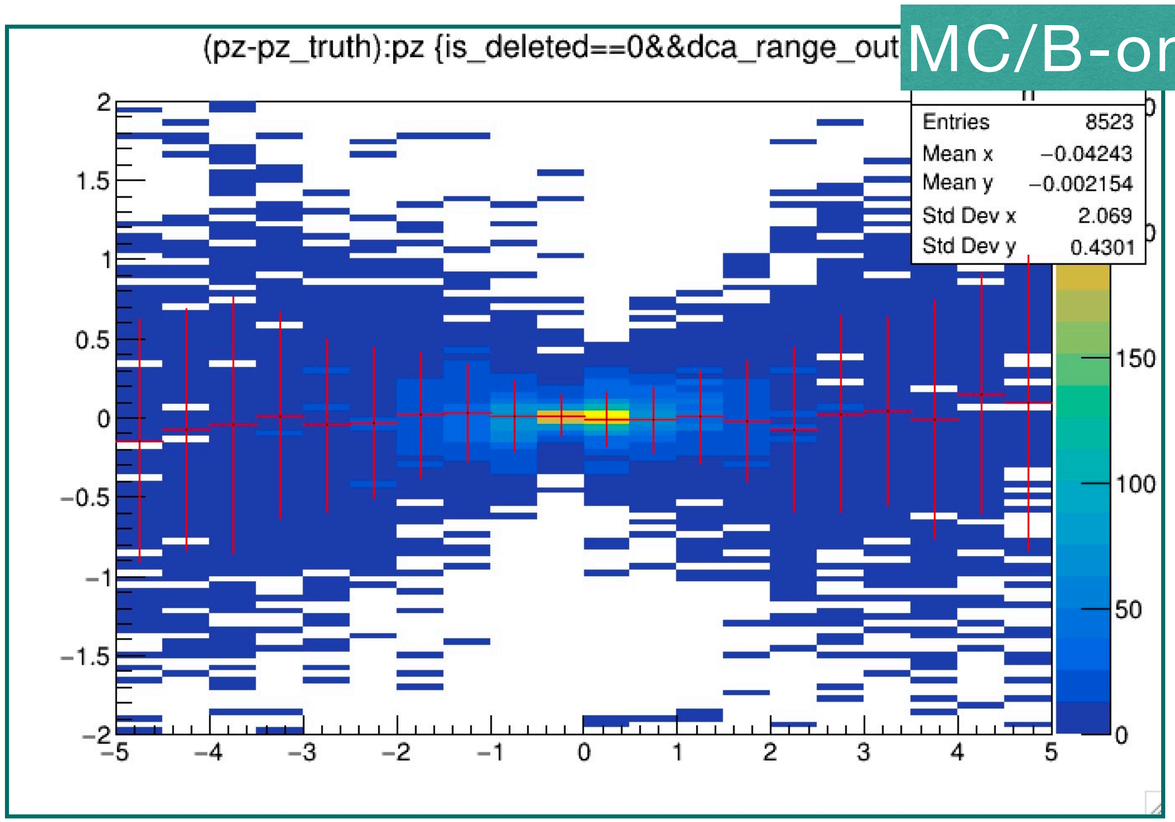
$$p_T = 0.3BR \quad [\mathrm{GeV/c}]$$

- B = 1.4T is used in this analysis.

Reconstructed pT, pz (MC/B-on)

- Left(Right) plot : pT(pz) difference btw reconstructed pT(pz) and simulated pT(pz) as a function of simulated pT(pz).
  - Red line represents the mean value and StdDev of pT(pz) difference.

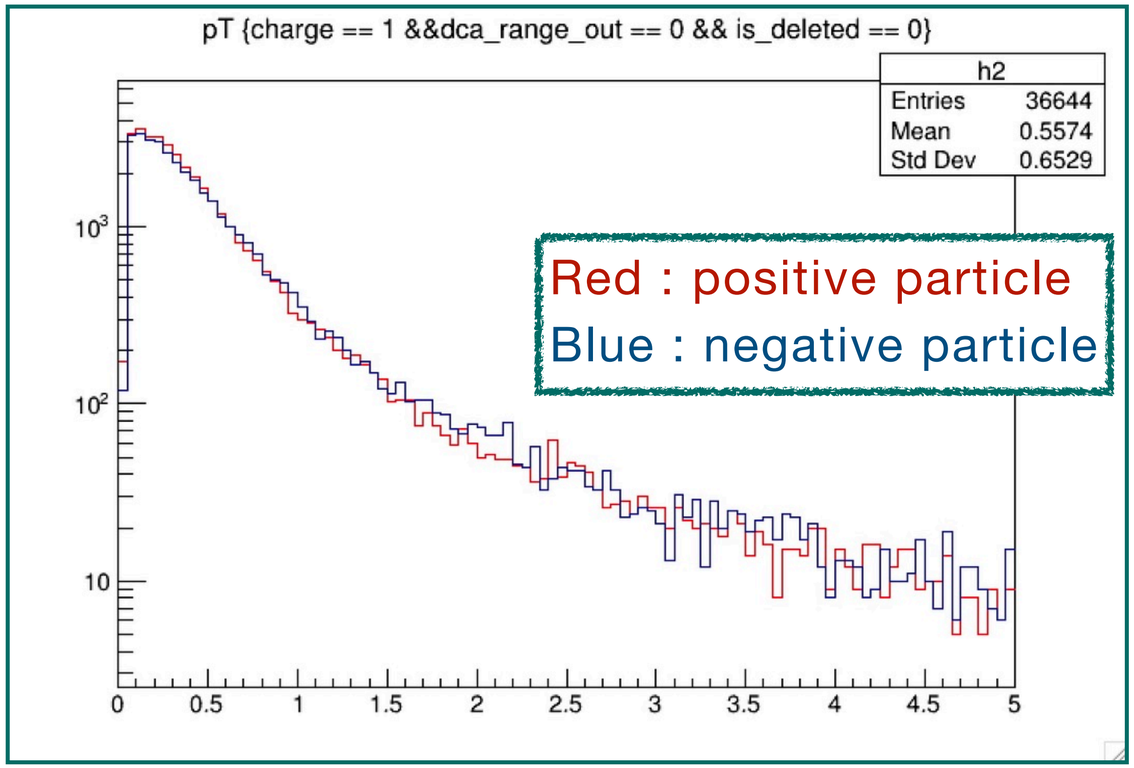


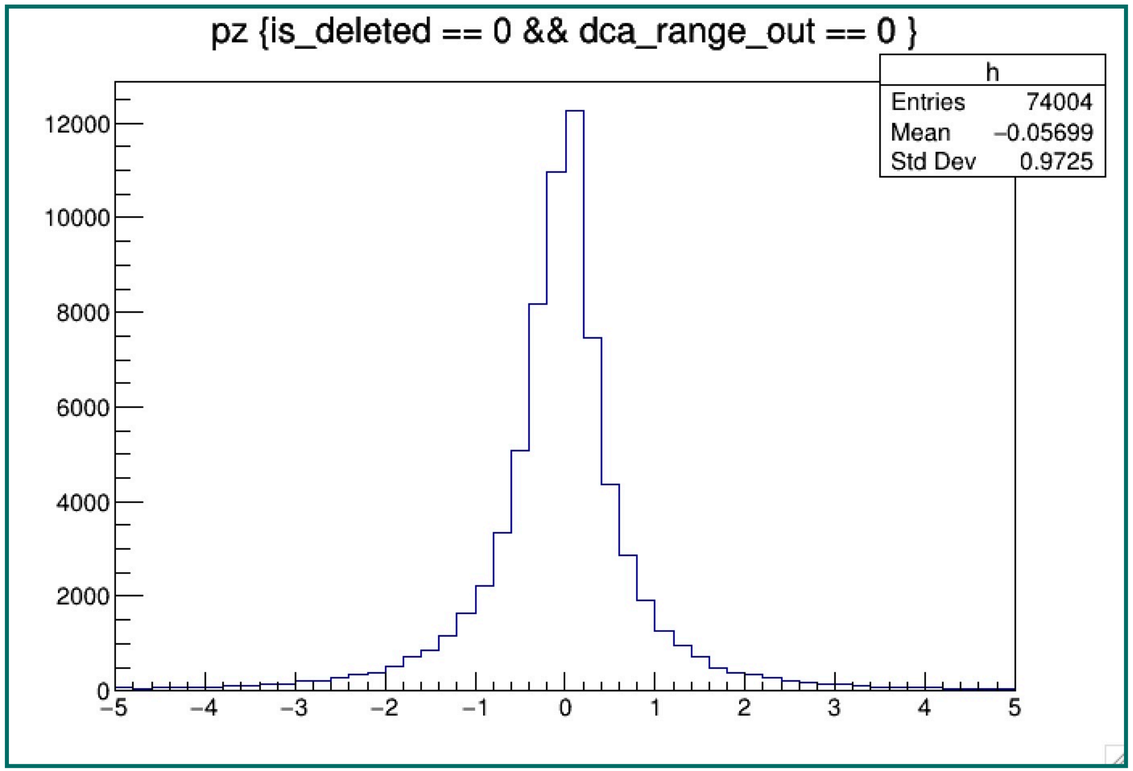


- pT resolution is 20% and pz resolution is 2% in 5GeV.

Reconstructed pT with run 41981(B-on)

- pT and pz are reconstructed with B-on data (run41981).
  - The left plot shows pT and the right plot shows pz.





- pT and pz are reconstructed successfully with data.
- The # of positive particles is as same as the # of negative particles as the level of few%.

Summary & Next step

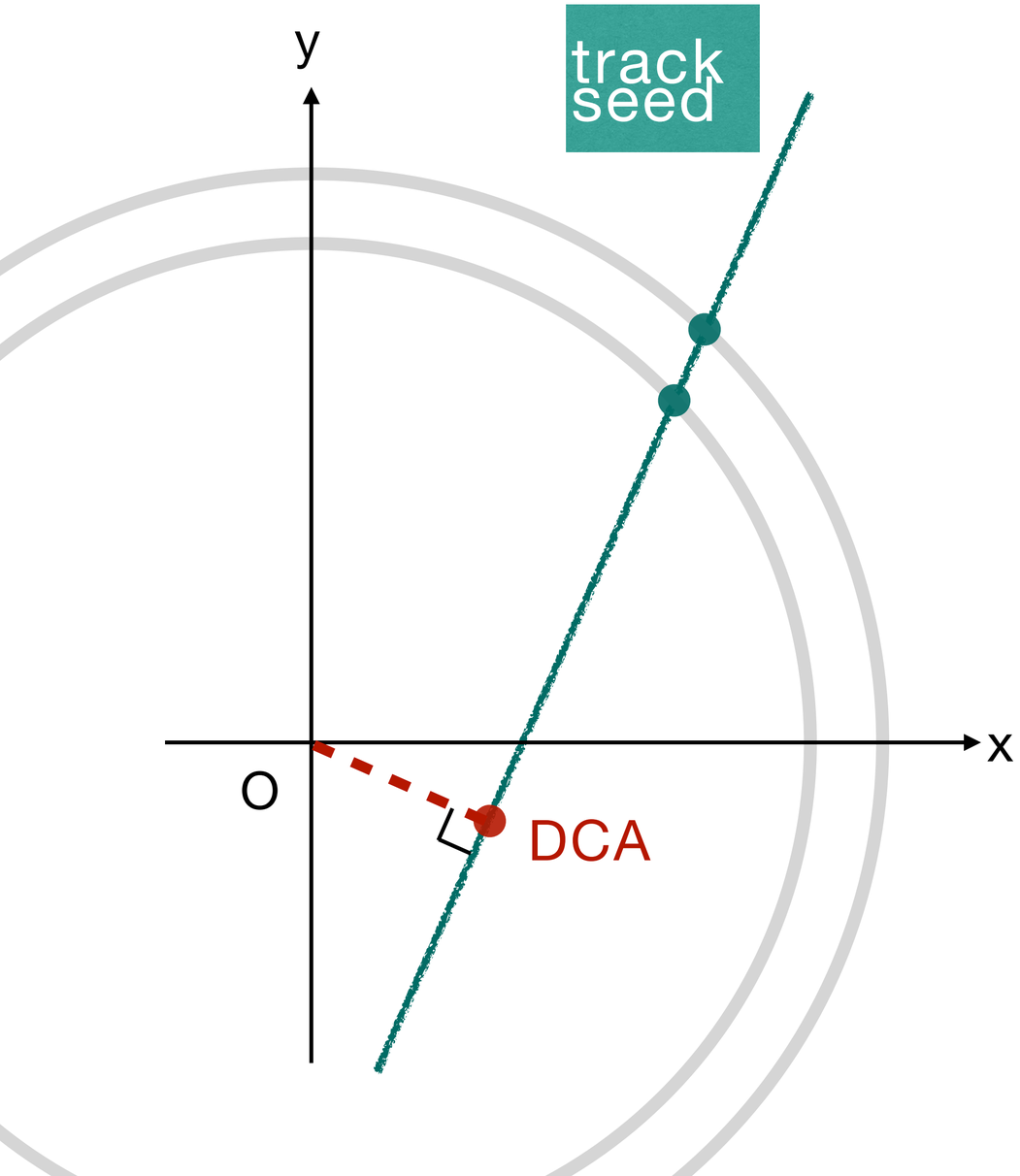
Summary : Development of a tracking algorithm using INTT

- Tracks are reconstructed with B-off and B-on data successfully.
- Obtained pT and pz with MC and data.
  - (MC)pT resolution is 20% and pz resolution is 2% in 5GeV.
  - The result with data should be compared with MC.
  - The # of positive particles is as same as the # of negative particles as the level of few%.

Next step

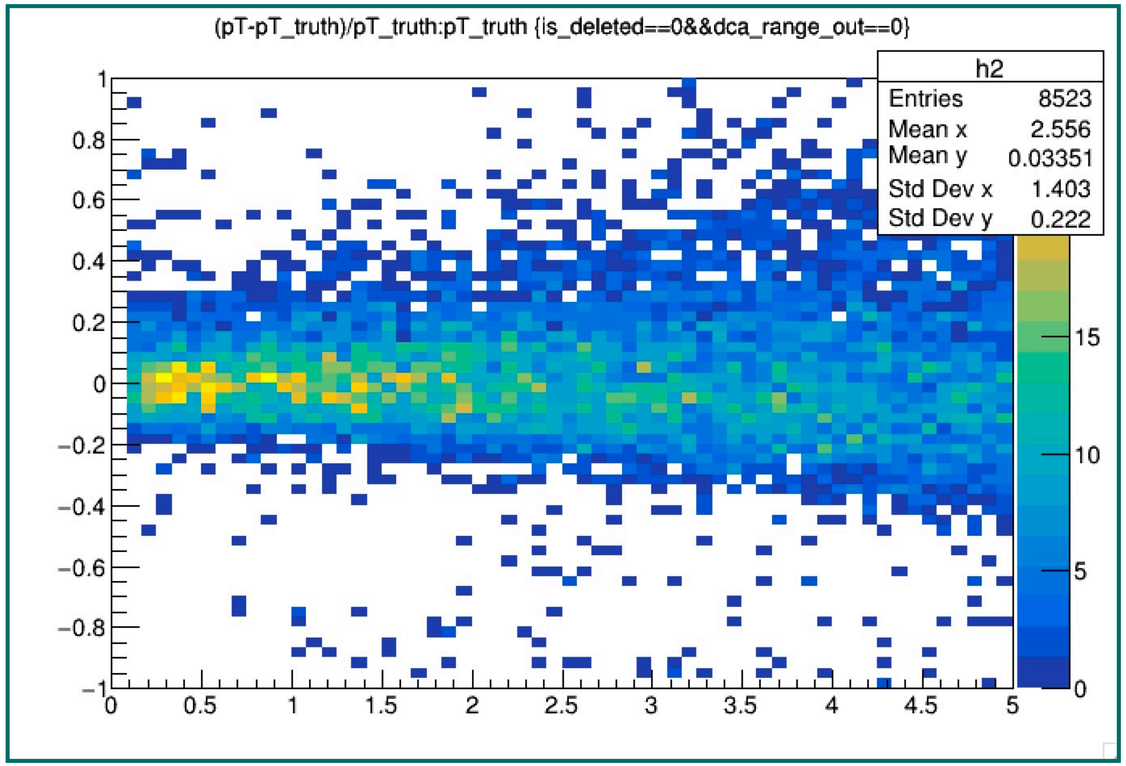
- Associate INTT tracks with EMCal tracks

How to reconstruct a track (3/4)



2. Reconstruct a vertex using multiple track seeds.

- Calculate the closest point to the origin (DCA point) on the track seed.
- Define the vertex position as the mean of DCA position.


(pT-pT_truth)/pT_truth:pT_truth {is_deleted==0&&dca_range_out==0}
h2
Entries 8523
Mean x 2.556
Mean y 0.03351
Std Dev x 1.403
Std Dev y 0.222
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
15
10
5
0