INTT tracking with p+p simulation

Tracklet efficiency based on clusters

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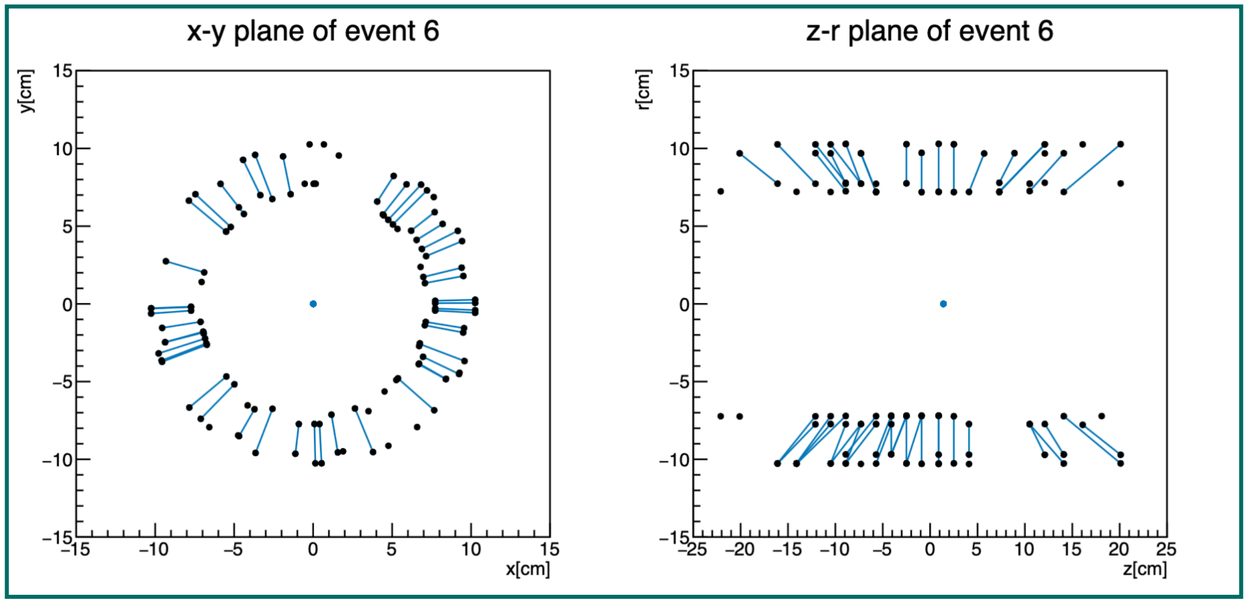
Abstract

【How many clusters can be reconstructed to tracklets?】

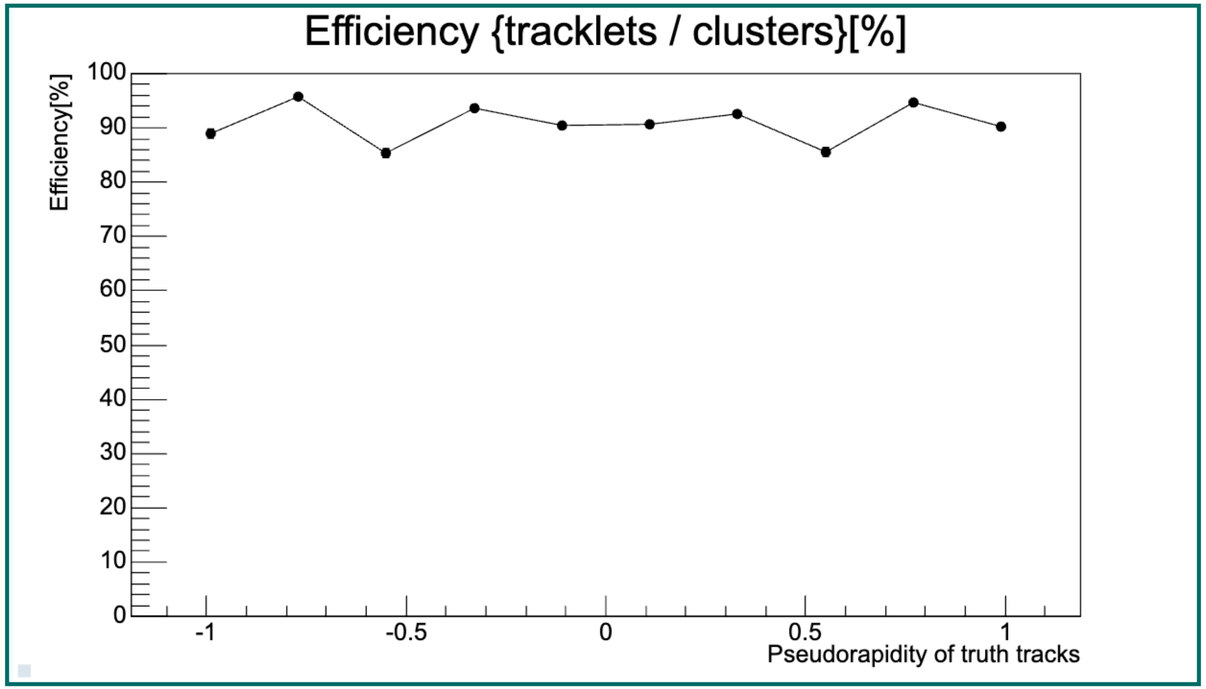
- The tracklet efficiency, which is the ratio of tracklets to clusters, is evaluated.
- This efficiency ϵ is calculated as below.

$$\epsilon = \frac{N_{\text{tracklets}}}{N_{\text{clusters}}}$$



The tracklet efficiency

- The tracklet efficiency, which is the ratio of tracklets to clusters, as a function of pseudorapidity is calculated.
- In this evaluation, only clusters in the inner barrel are used.



error : $\sqrt{np(1-p)}$

- The average tracklet efficiency : 90.7 ± 0.2%
- This is consistent to the event display.

Summary

【Evaluation of my tracking algorithm】

- The tracklet efficiency, which is the ratio of tracklets to clusters, as a function of pseudorapidity is evaluated.

➡ This efficiency is 90.7 ± 0.2%.

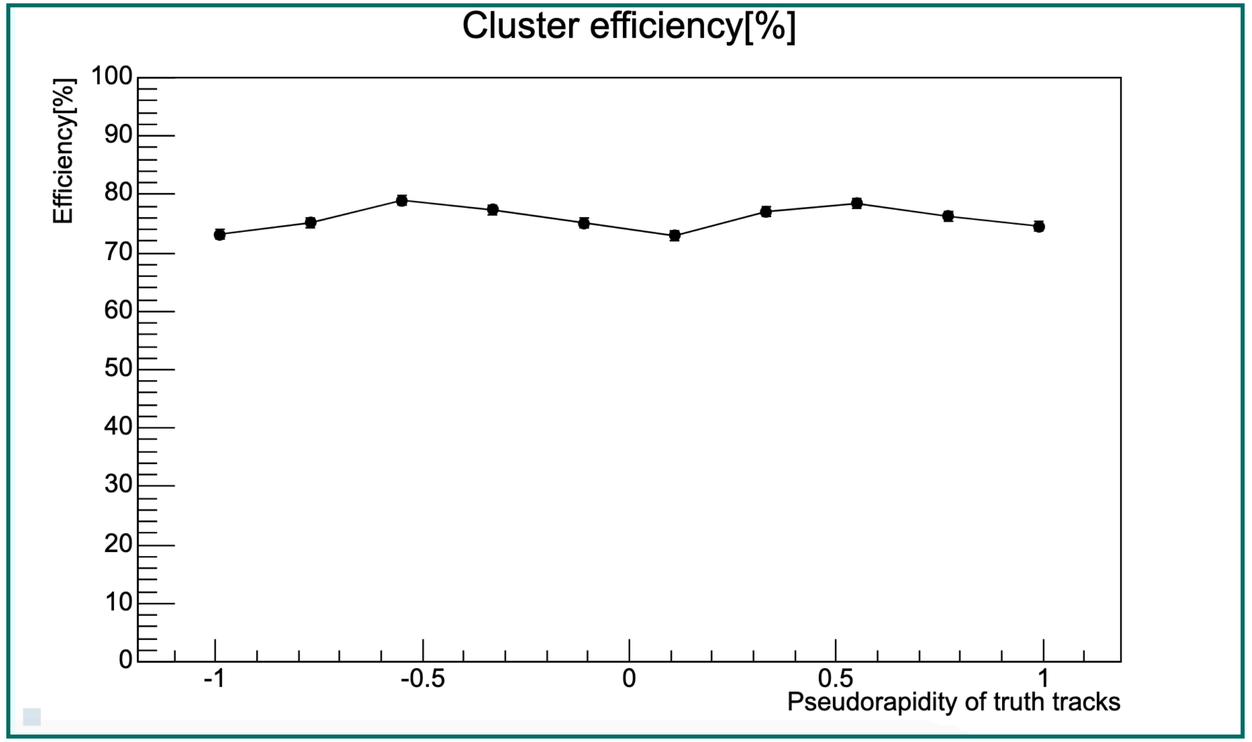
BACK UP

Cluster efficiency

- The efficiency of the clusters in the inner barrel as a function of the truth eta is calculated using truth vertex.

The cuts to the truth tracks

- final status, $\eta \leqq 2.0$, $p \geqq 50$MeV
- The truth tracks which don't have charge (γ, n, K^0, π^0) aren't used.
- The truth tracks which don't pass through the outer barrel aren't used.



error : $\sqrt{np(1-p)}$

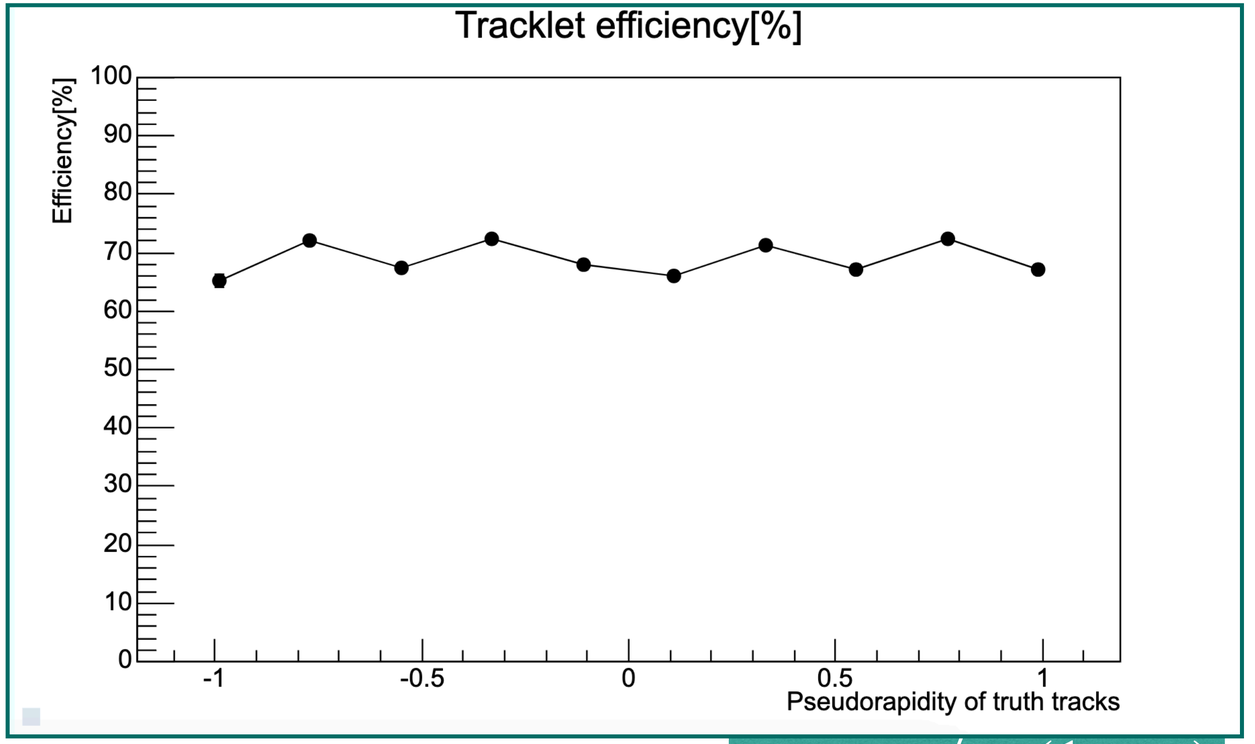
- The average cluster efficiency : 75.9 ± 0.3%

Tracklet efficiency

- The tracklet efficiency as a function of the truth eta is calculated.

The cuts to the truth tracks

- final status, $\eta \leqq 2.0$, $p \geqq 50$MeV
- The truth tracks which don't have charge (γ, n, K^0, π^0) aren't used.
- The truth tracks which don't pass through the outer barrel aren't used.



error : $\sqrt{np(1-p)}$

- The average cluster efficiency : 68.9 ± 0.3%

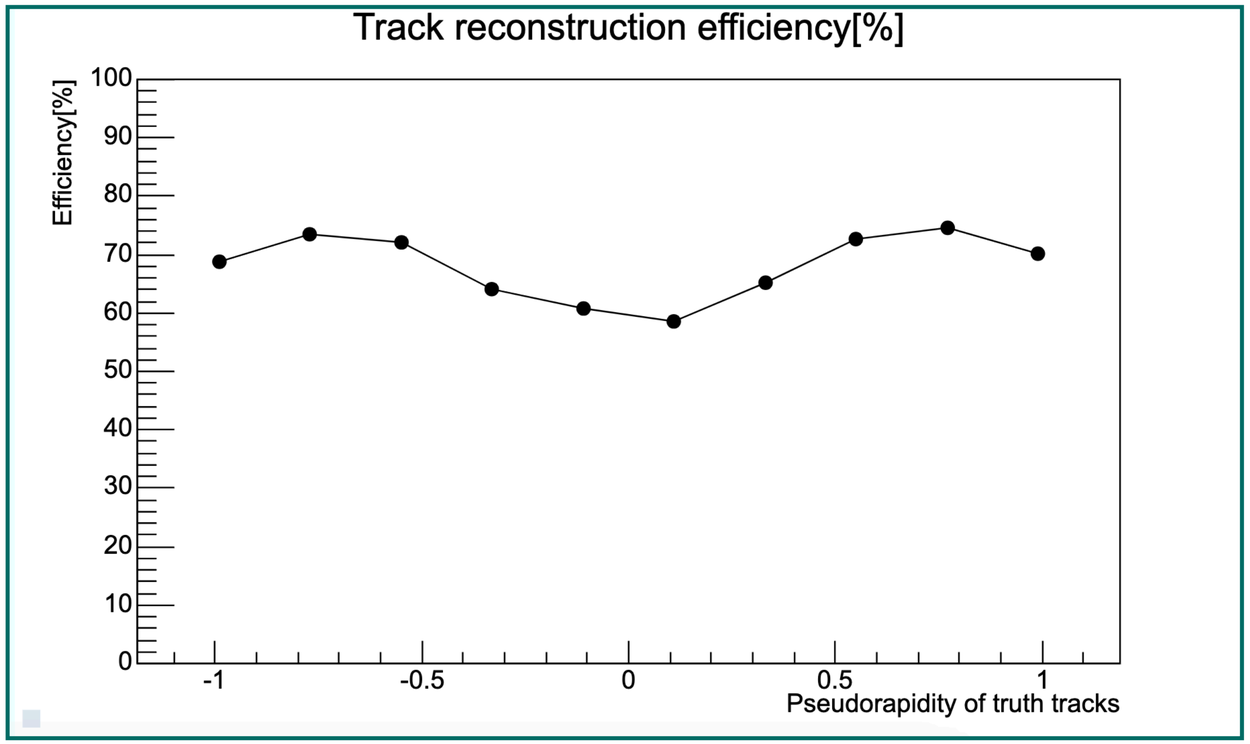
Track reconstruction efficiency

- The track reconstruction efficiency as a function of the truth eta is recalculated.

error : $\sqrt{np(1-p)}$

The cuts to the truth tracks

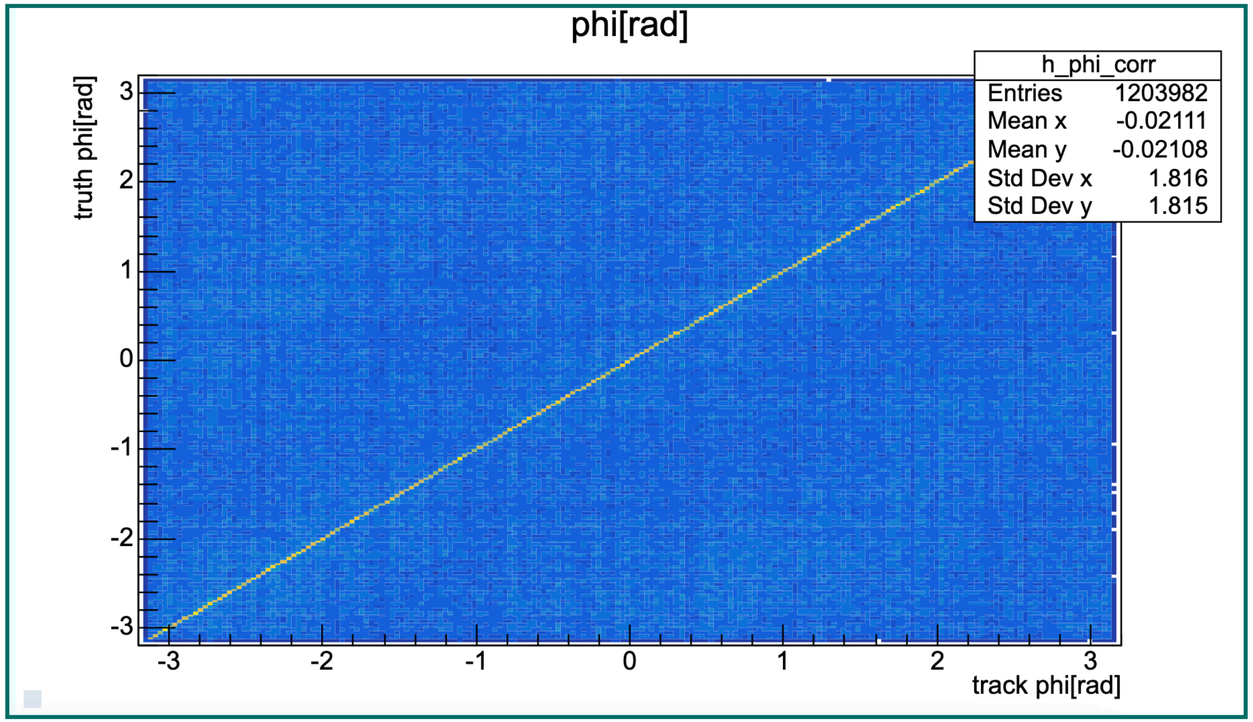
- final status, $\eta \leqq 2.0$, $p \geqq 50$MeV
- The truth tracks which don't have charge (γ, n, K^0, π^0) aren't used.
- The truth tracks which don't pass through the outer barrel aren't used.

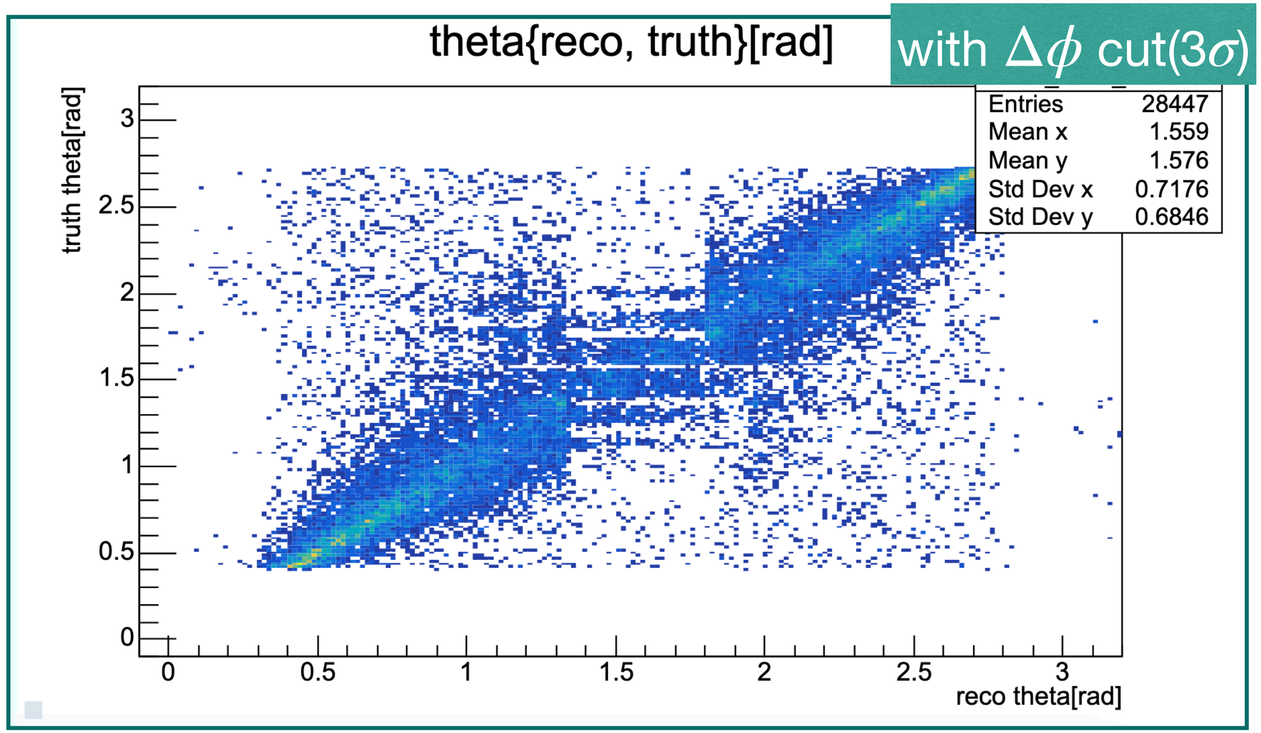


- The average reconstructed track efficiency : 67.8 ± 0.3%
- It seems to depend on truth pseudorapidity.

The angles of the reconstructed tracks

- The angles of the reconstructed tracks are recalculated. And The correlation b/w the reconstructed tracks and the truth tracks is checked.

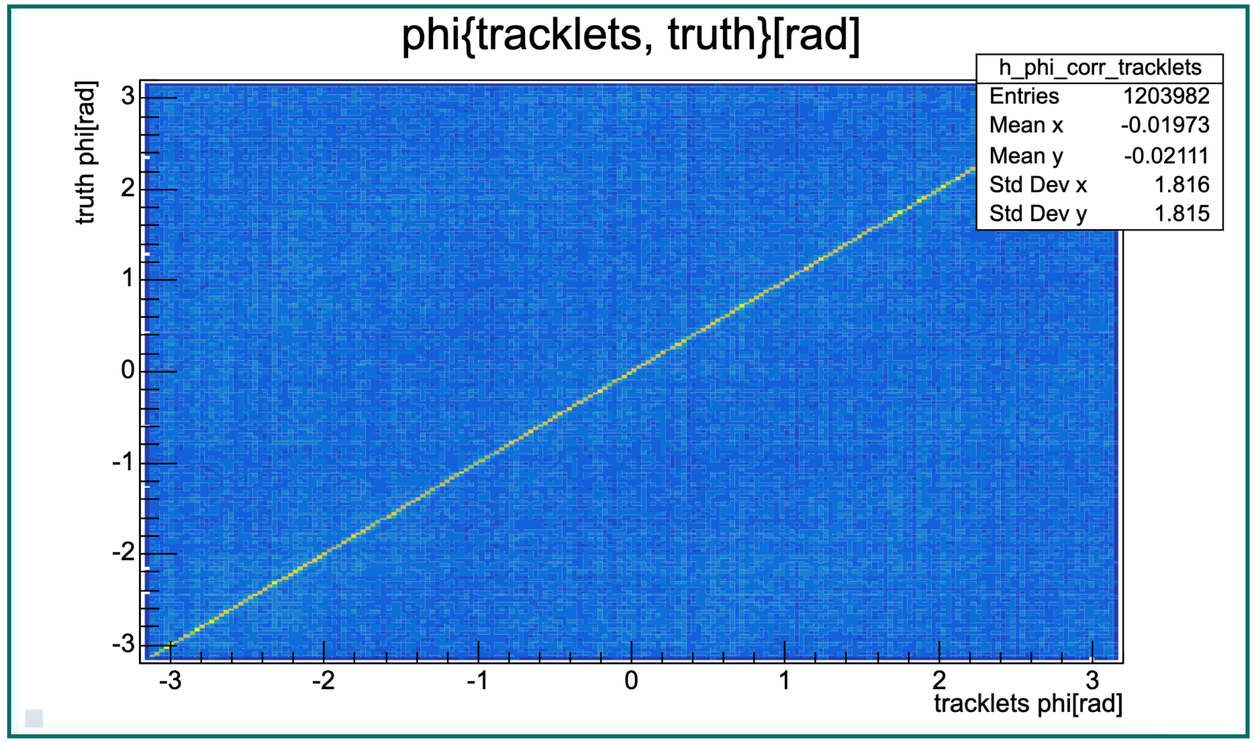


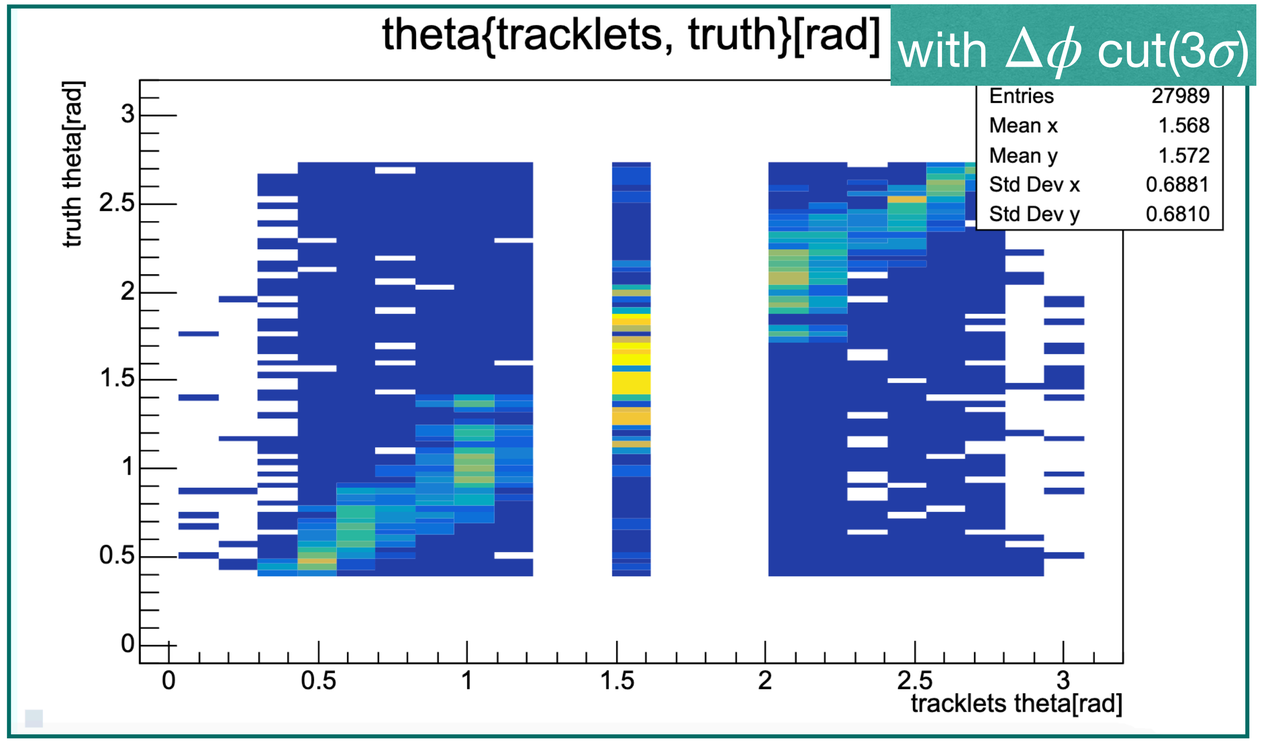


- These two have correlation.
- But theta distribution has correlation which isn't expected.

The angles of the tracklets

- The angles of the tracklets are recalculated. And The correlation b/w the tracklets and the truth tracks is checked.

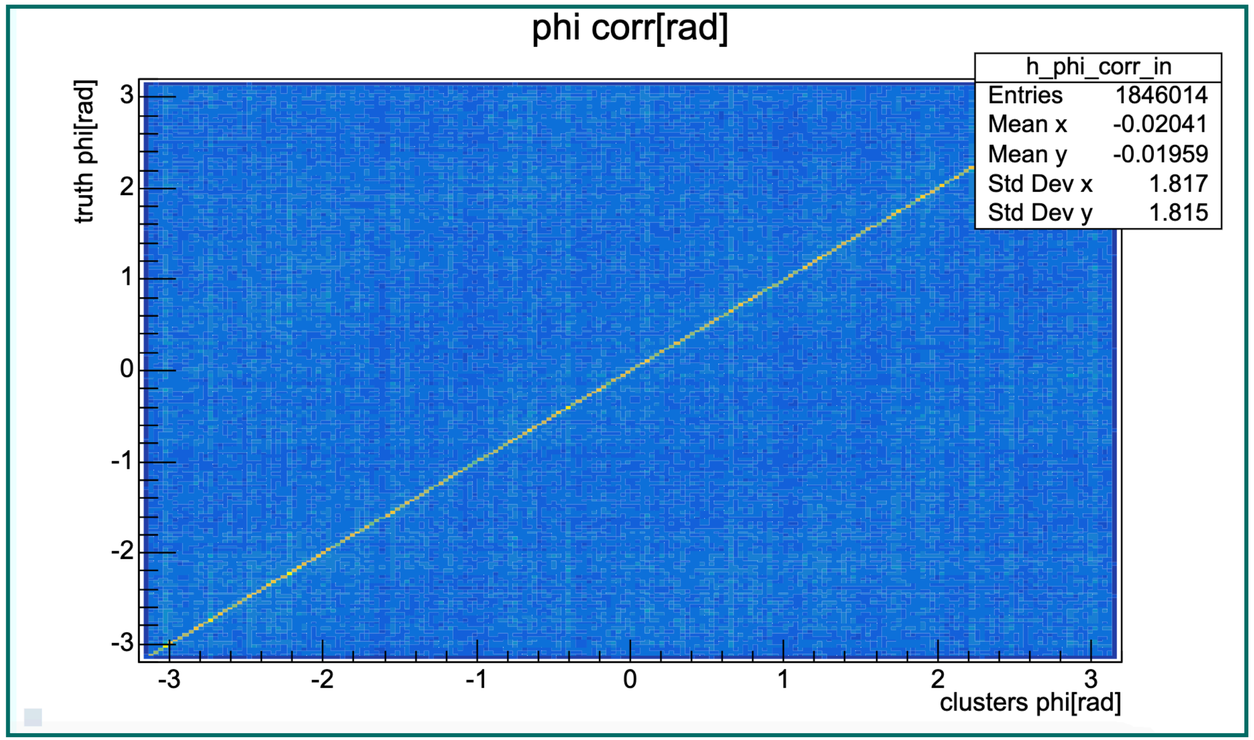


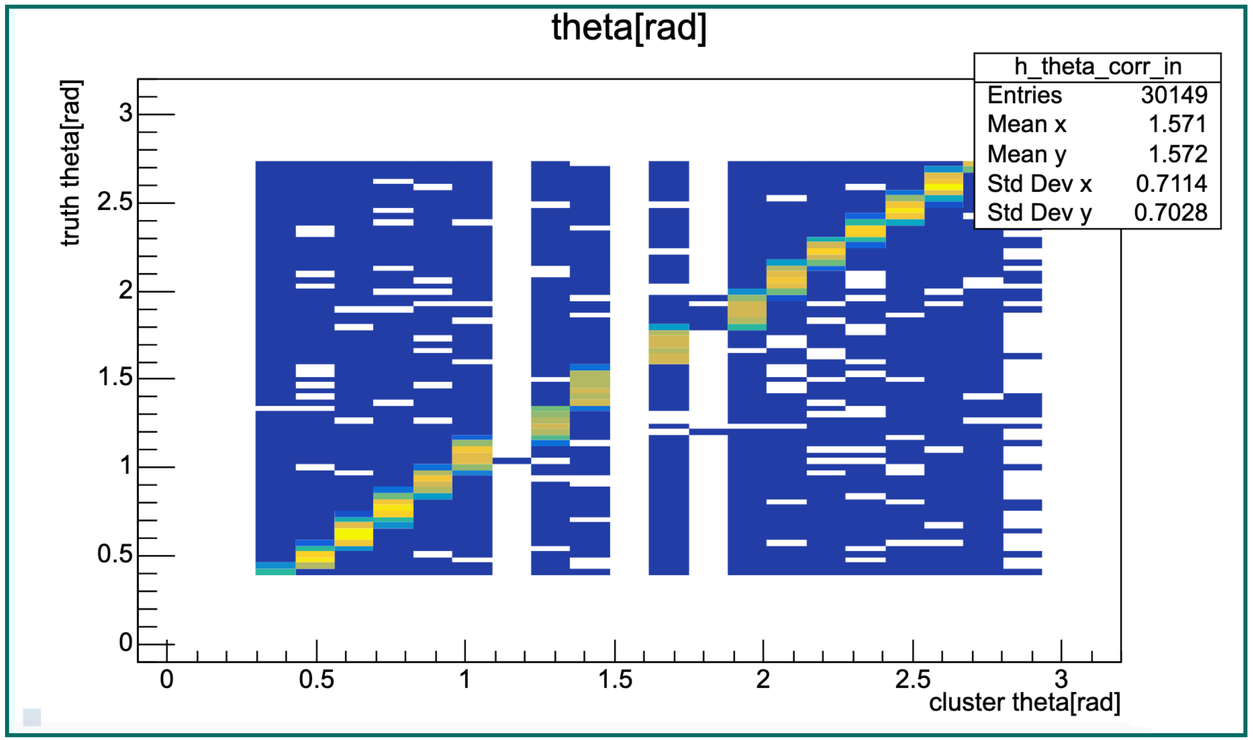


- These two have good correlation.

The angles of the clusters

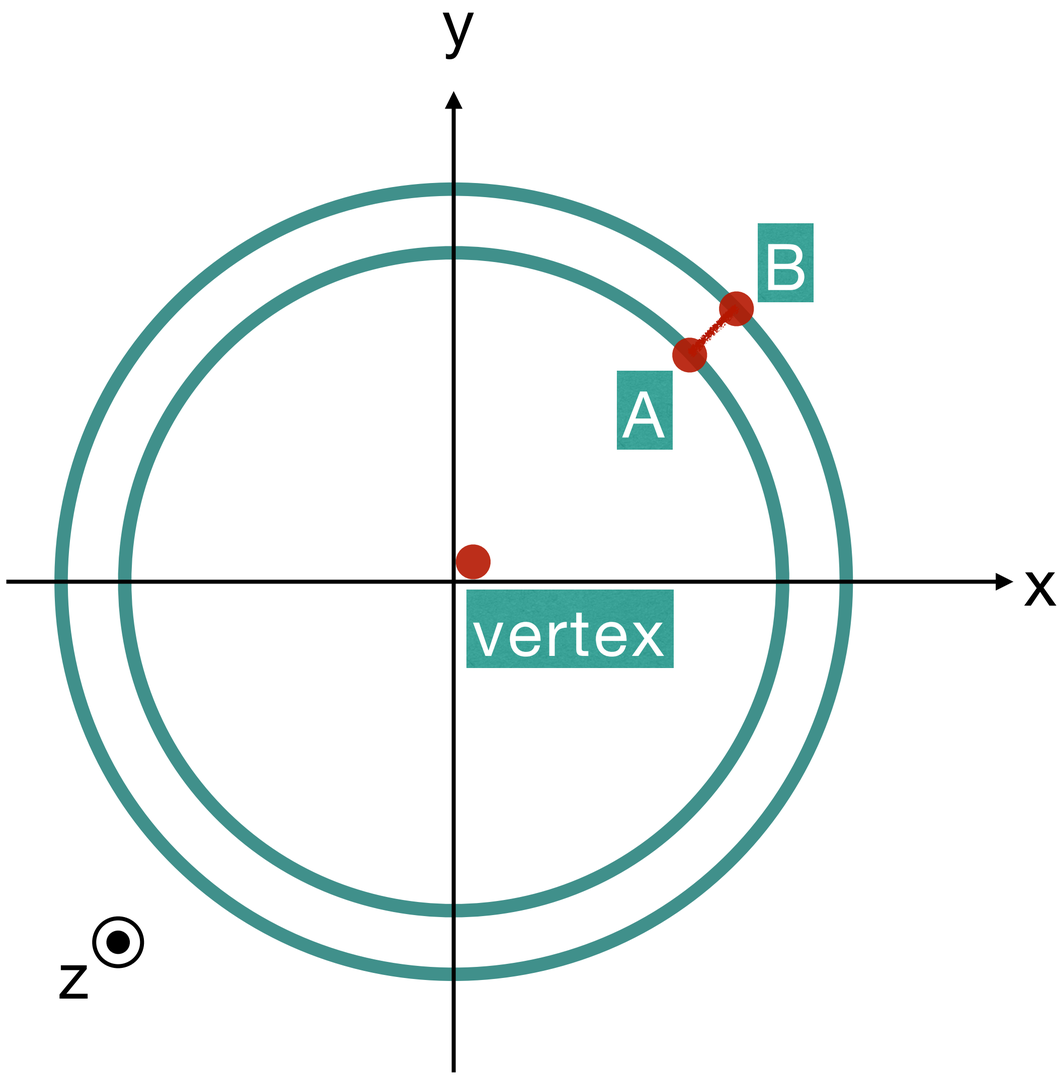
- The angles of the clusters are recalculated. And The correlation b/w the clusters and the truth tracks is checked.





- <u>These two have good correlation.</u>

Tracking method

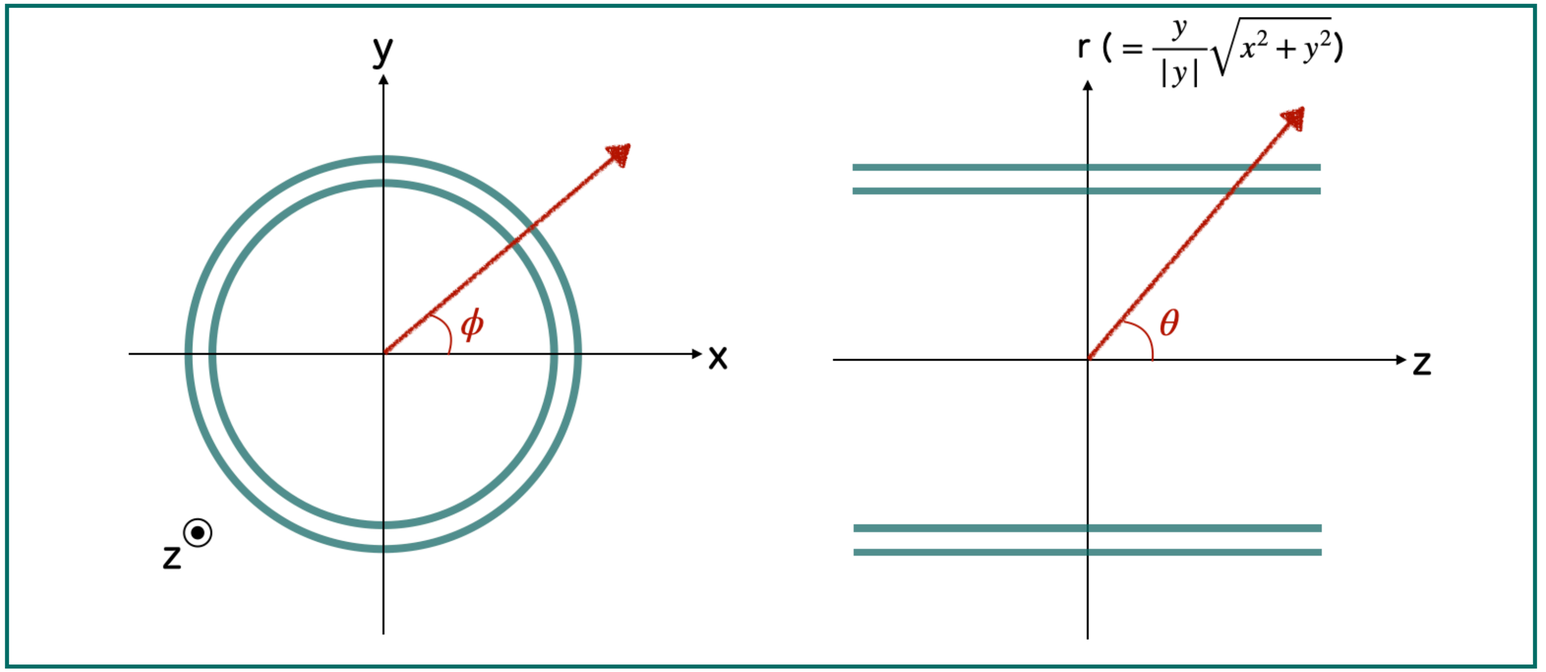


1. Select a cluster in the inner barrel A and a cluster in the outer barrel B.
2. Connect them with a line (tracklet).
3. Determine the vertex using tracklets.
4. Connect the three points (A, B, vertex) by the least-squares method (track).

<Setting of the simulation>
PYTHIA + GEANT4 (1K events)
p + p collision, $\sqrt{s} = 200\mathrm{GeV}$, no magnetic field.
z-vertex of the truth tracks = 0.

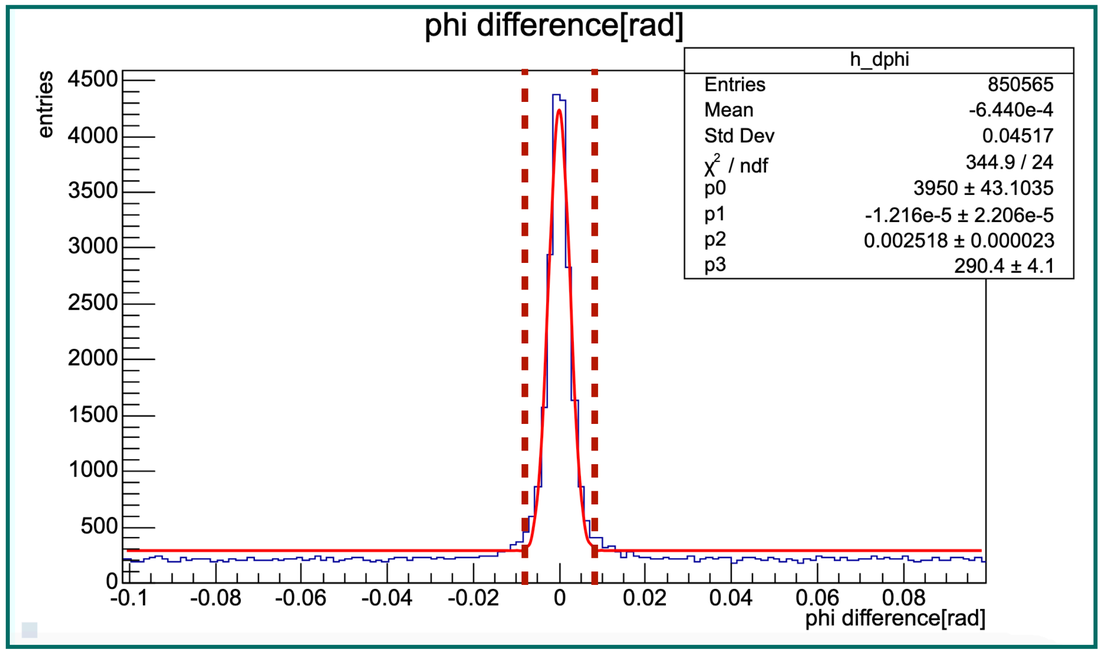
How to evaluate my tracking algorithm

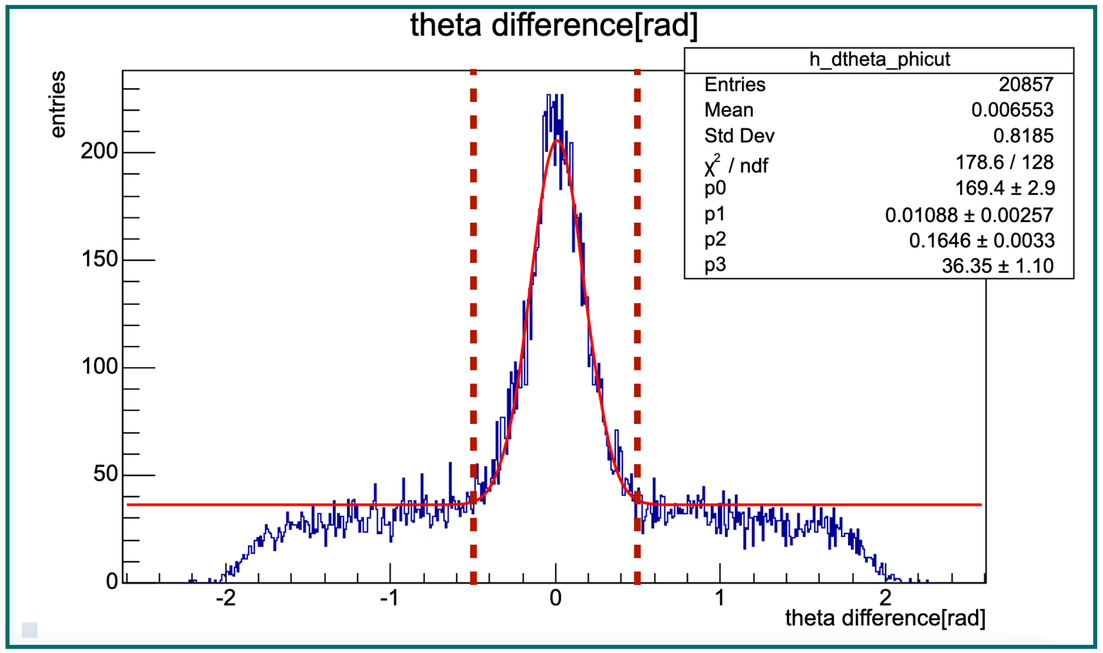
- The efficiency is defined as the ratio of the combination of the truth track and reconstructed track in the window of the angular difference (between one angle of reconstructed track and all truth tracks) distribution.



How to set the windows

- Setting of the window
  - $\Delta\phi$ and $\Delta\theta$ (with $\Delta\phi$ cut) distribution are fitted by the Gaussian distribution.
  - The window is defined as within the 3σ of these distributions.





How to evaluate the efficiency?

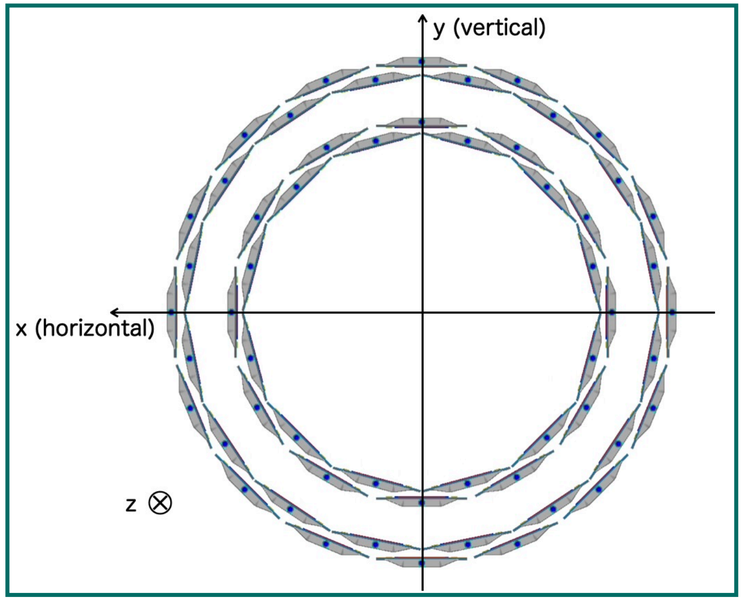
【How many clusters can be reconstructed to tracklets?】

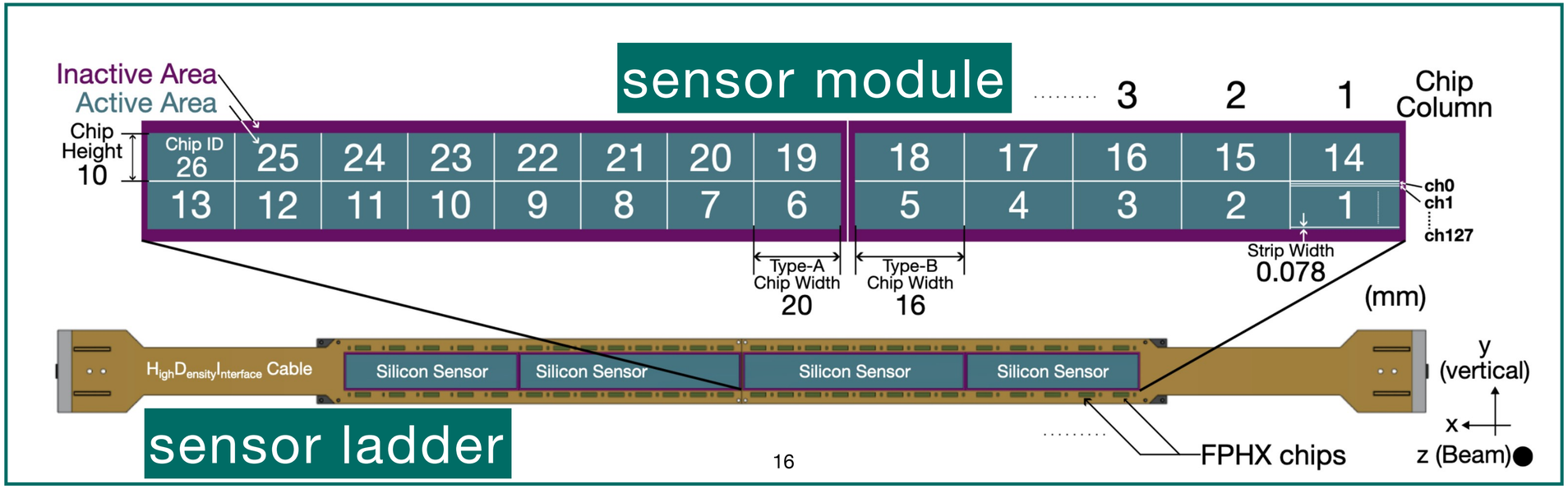
- The tracklet efficiency, which is the ratio of tracklets to clusters, as a function of pseudorapidity is evaluated.
- This efficiency ϵ is calculated as below.

$$\epsilon = \frac{N_{\text{tracklets}}}{N_{\text{clusters}}}$$

INTT silicon sensor

- INTT has 56 sensor ladders.
- One sensor ladder has two silicon sensor modules.
- One silicon sensor module has 26 silicon sensors (Type-A × 16, Type-B × 10).
- One silicon sensor has 128 strips of 78 μm × 16 mm (Type-A) or 20 mm (Type-B) × 320 μm.



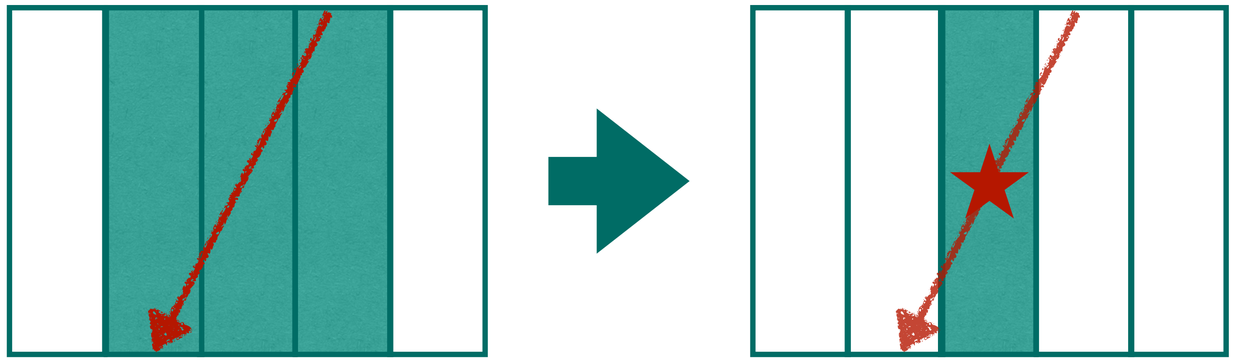


Clustering

When charged particles enter the sensor at an angle, they may pass across multiple sensors. The hits which are made by one track is combined into one cluster.

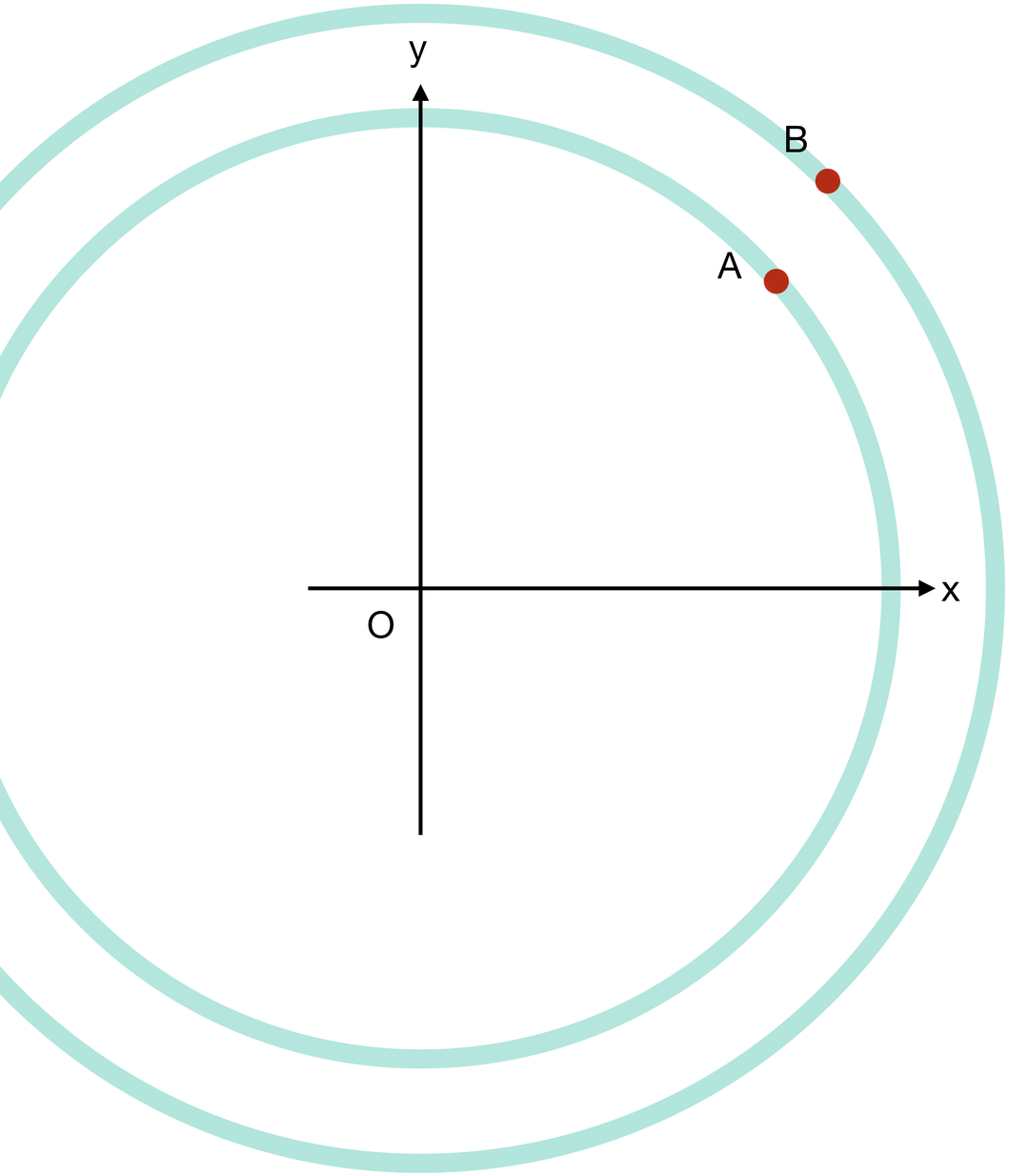
→The cluster position is weighted by the ADC value (the loss energy).

$$\text{cluster\_position} = \frac{\sum (\text{ADC}_i \times \text{hit\_position}_i)}{\sum \text{ADC}_i}$$



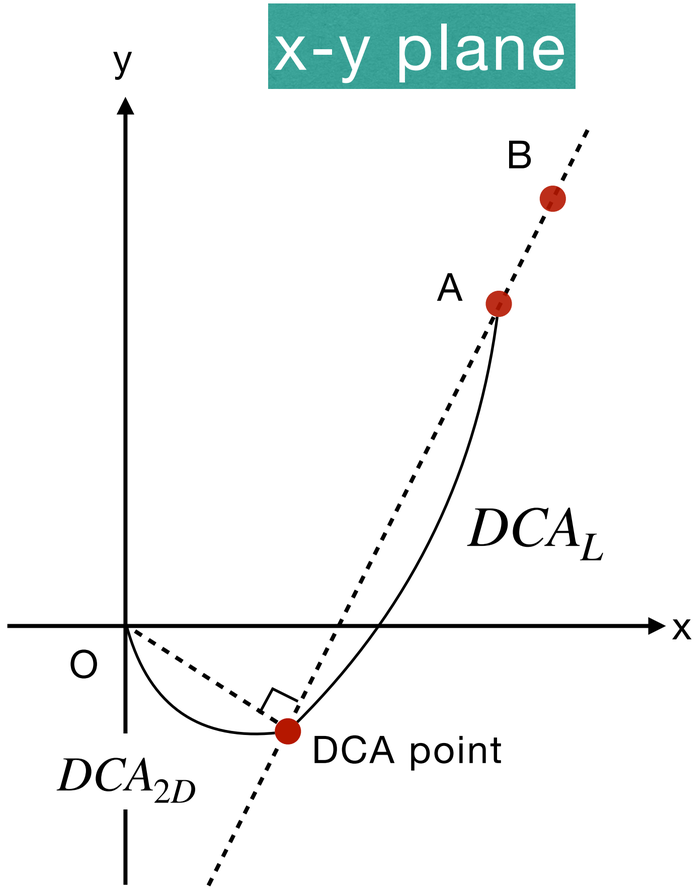
3hits　　1cluster

How to get the vertex 1



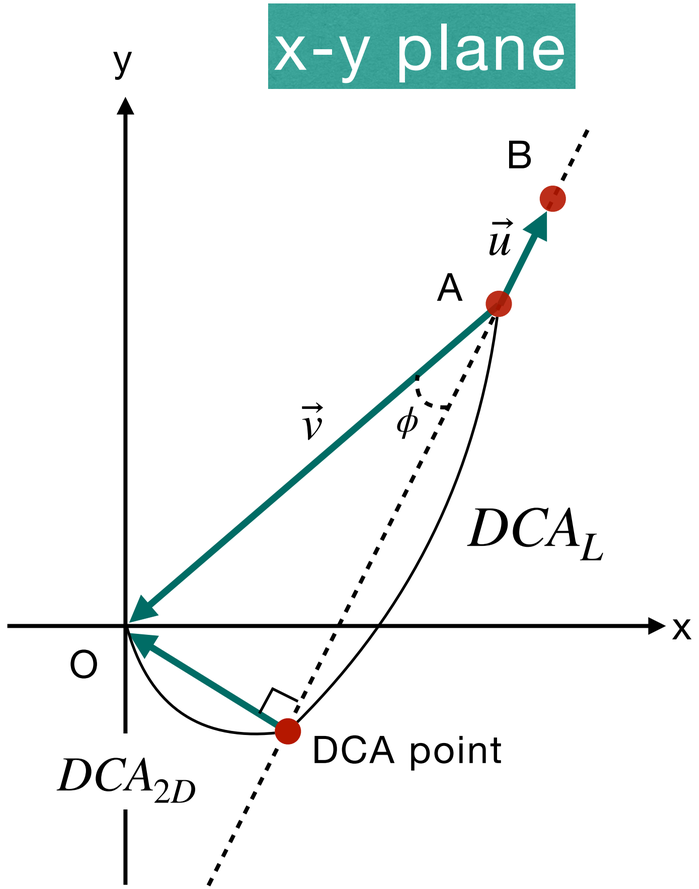
- To find the vertex, the distance of closest approach (DCA) between each tracklet and origin is calculated.

How to get the vertex 2



- To find the vertex, the distance of closest approach (DCA) between each tracklet and origin is calculated.
- DCA_{2D} and DCA_L are calculated.

How to get the vertex 3



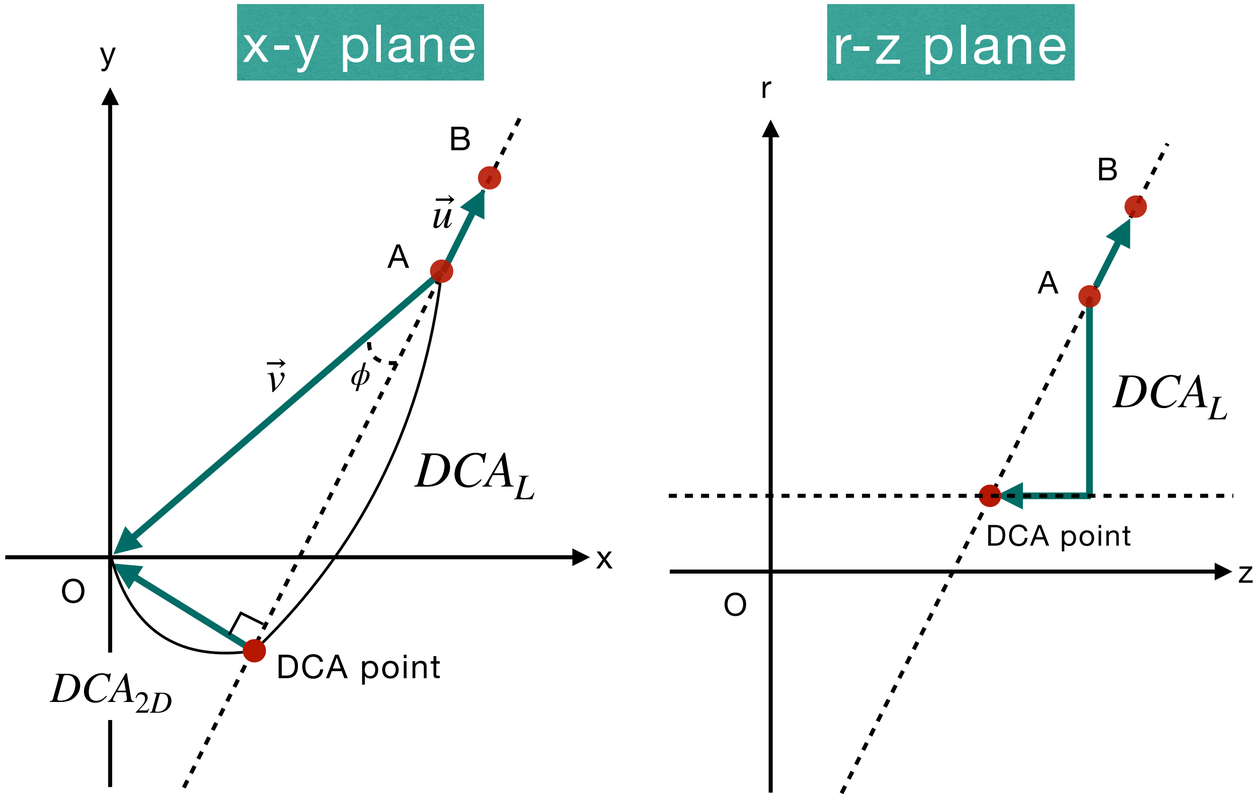
- To find the vertex, the distance of closest approach (DCA) between each tracklet and origin is calculated.
- DCA_{2D} and DCA_L are calculated.

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

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

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

How to get the vertex 4



- To find the vertex, the distance of closest approach (DCA) between each tracklet and origin is calculated.
- DCA_{2D} and DCA_L are calculated.

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

- Using DCA_L, the DCA position of the tracklet is calculated.

$$DCA_X = DCA_L \times \vec{u}_x + A_x$$
$$DCA_Y = DCA_L \times \vec{u}_y + A_y$$
$$DCA_Z = DCA_L \times \vec{u}_z + A_z$$

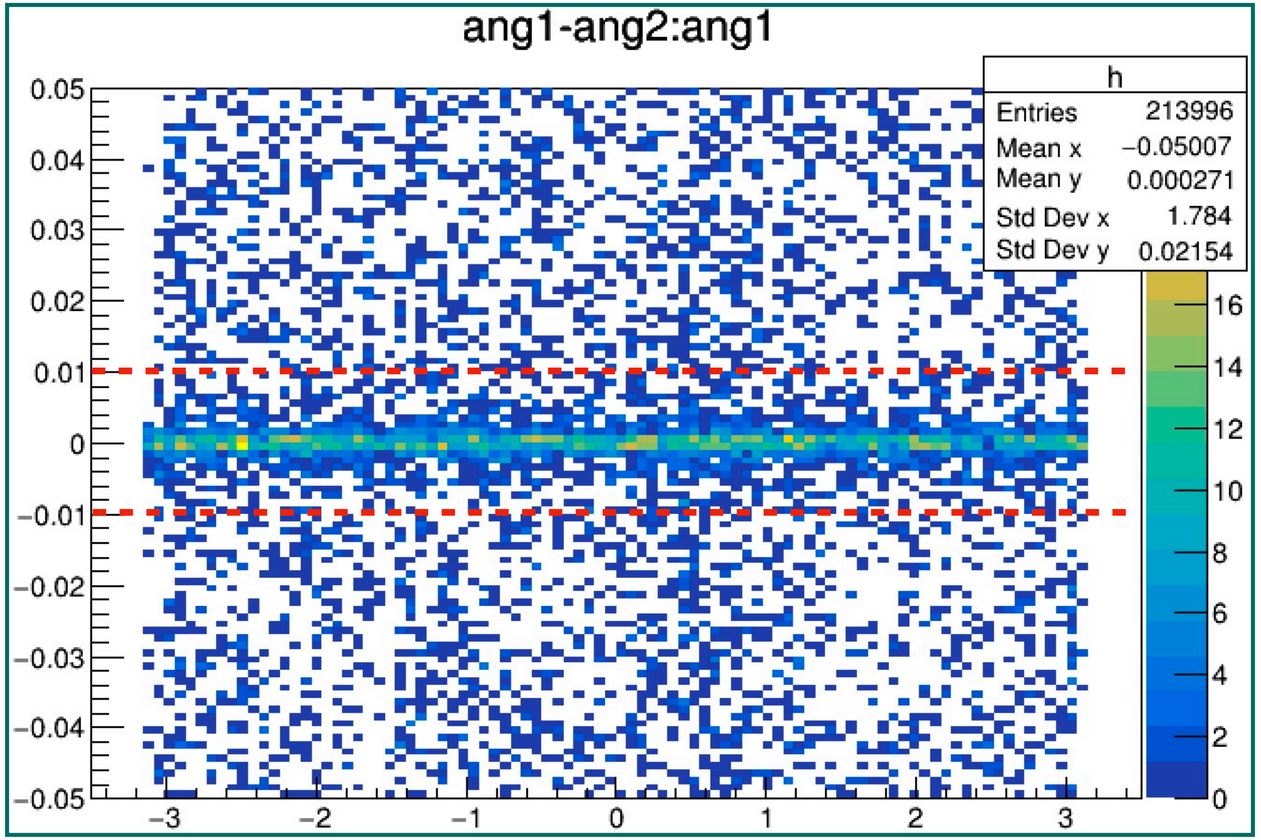
- <u>The vertex is the average of the DCA.</u>

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

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

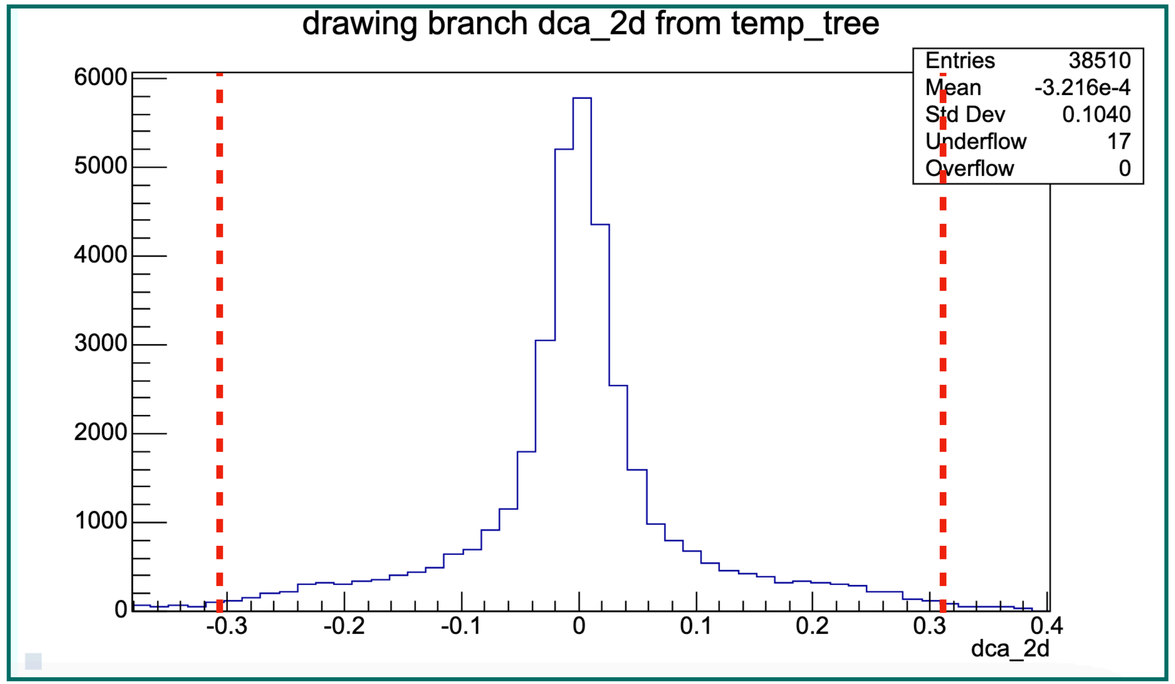
The cuts in making the tracklets

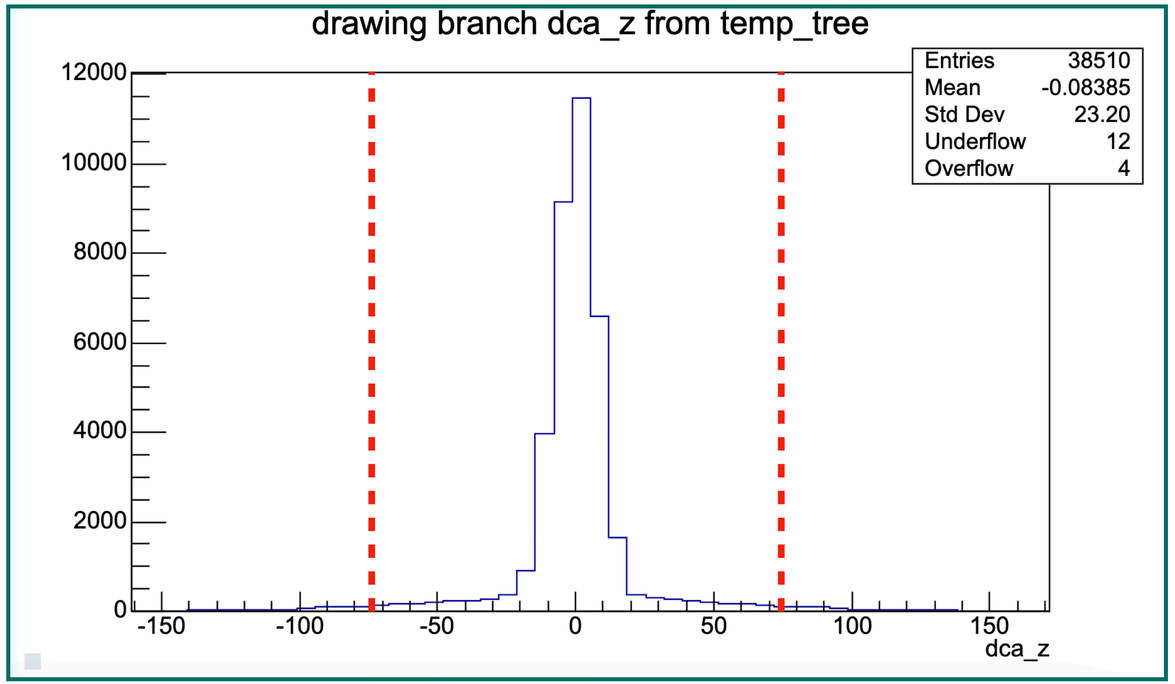
- The tracklets whose $d\phi = \phi_{innner} - \phi_{outer} < 0.01$ aren't used.



The cut to the tracklets

- The tracklets whose the DCA_{2D} and DCA_z (the distance of closest approach between the tracklets and vertex) are within 3σ from the means are used.
- If the tracklets share a cluster, the one whose DCA_{2D} is smaller is used.





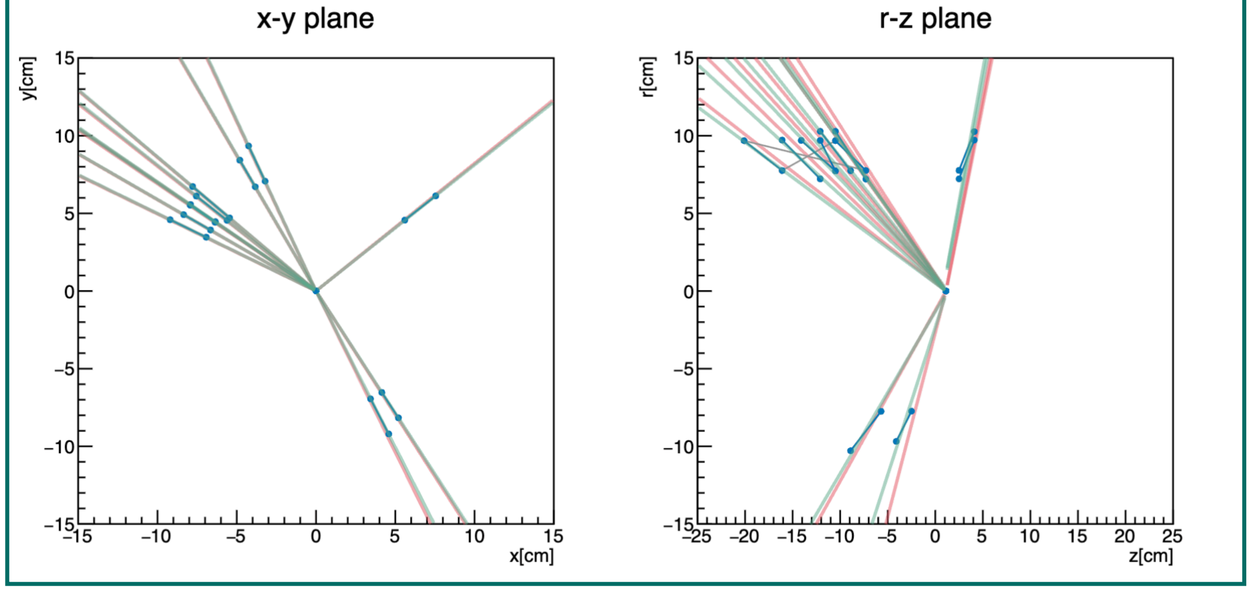
Comparison to the truth tracks

Green : reconstructed tracks

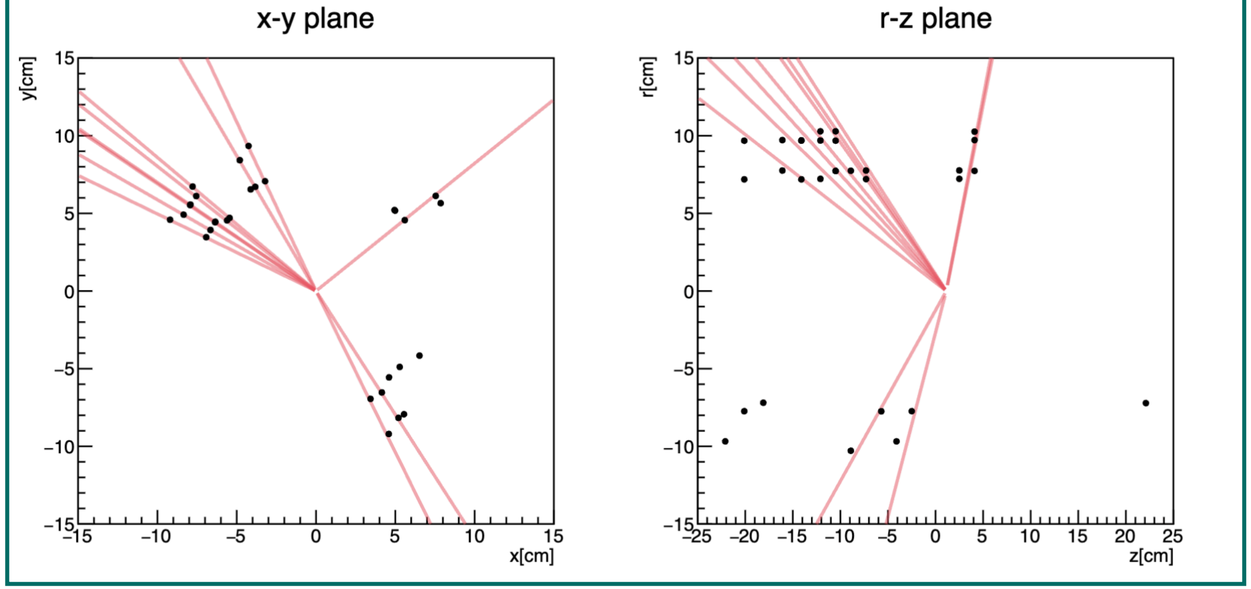
Red : truth tracks

Black : clusters

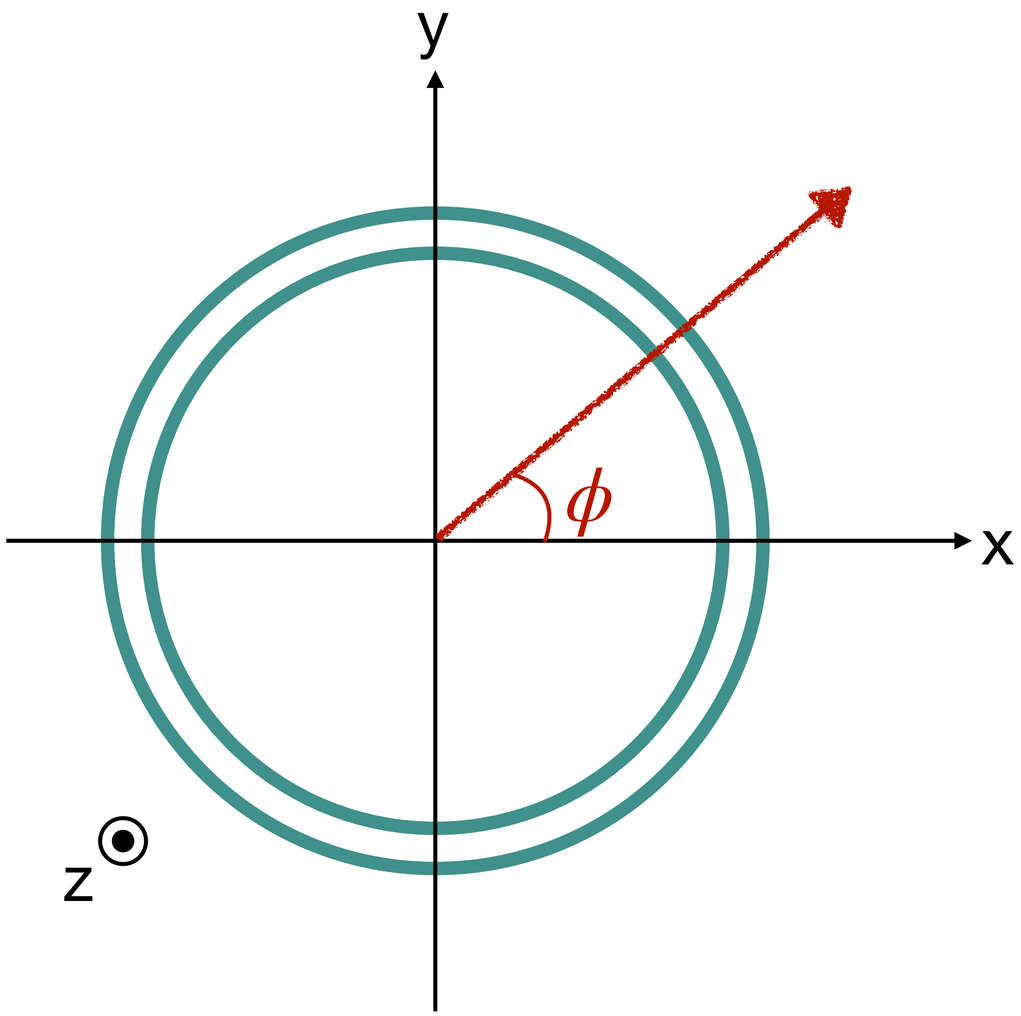
The reconstructed & truth tracks

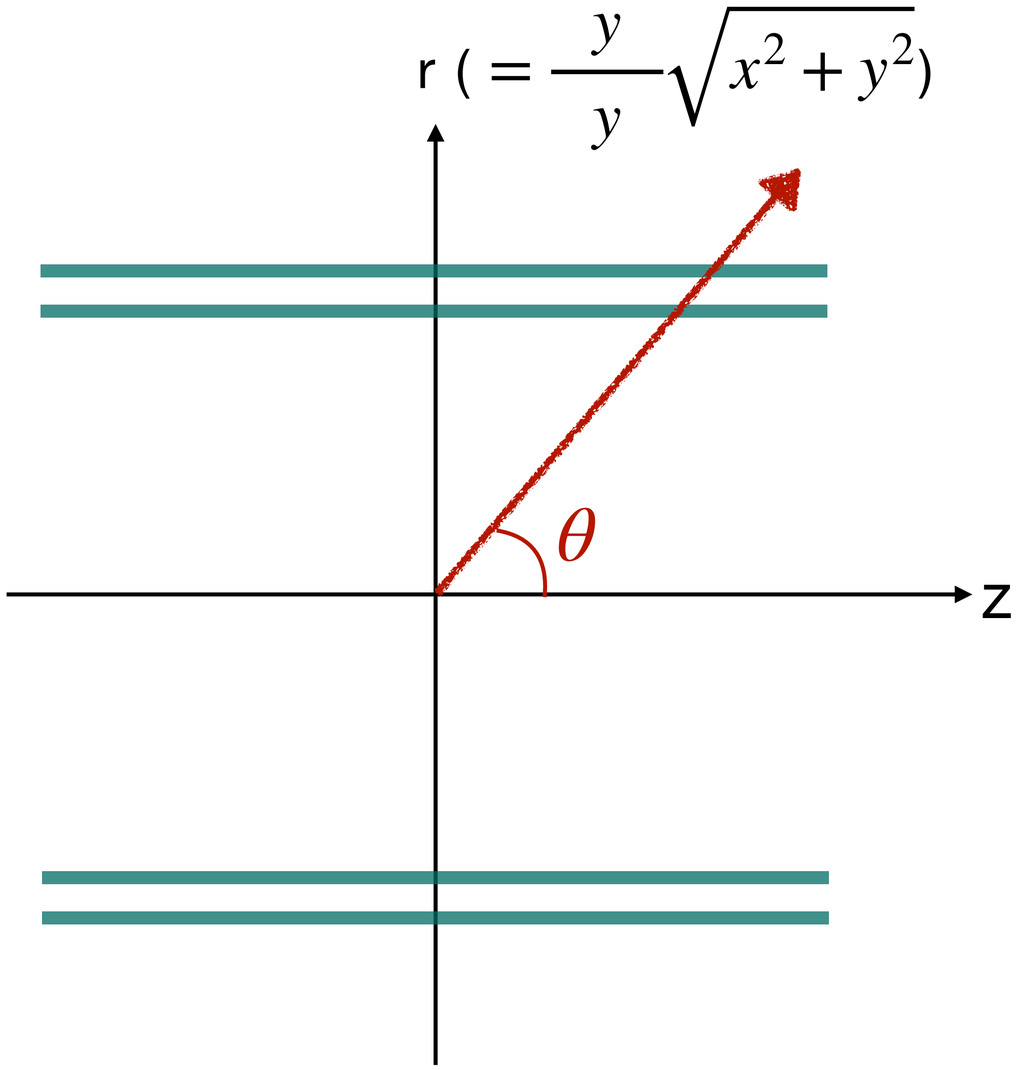


The clusters & truth tracks



The definition of the angles

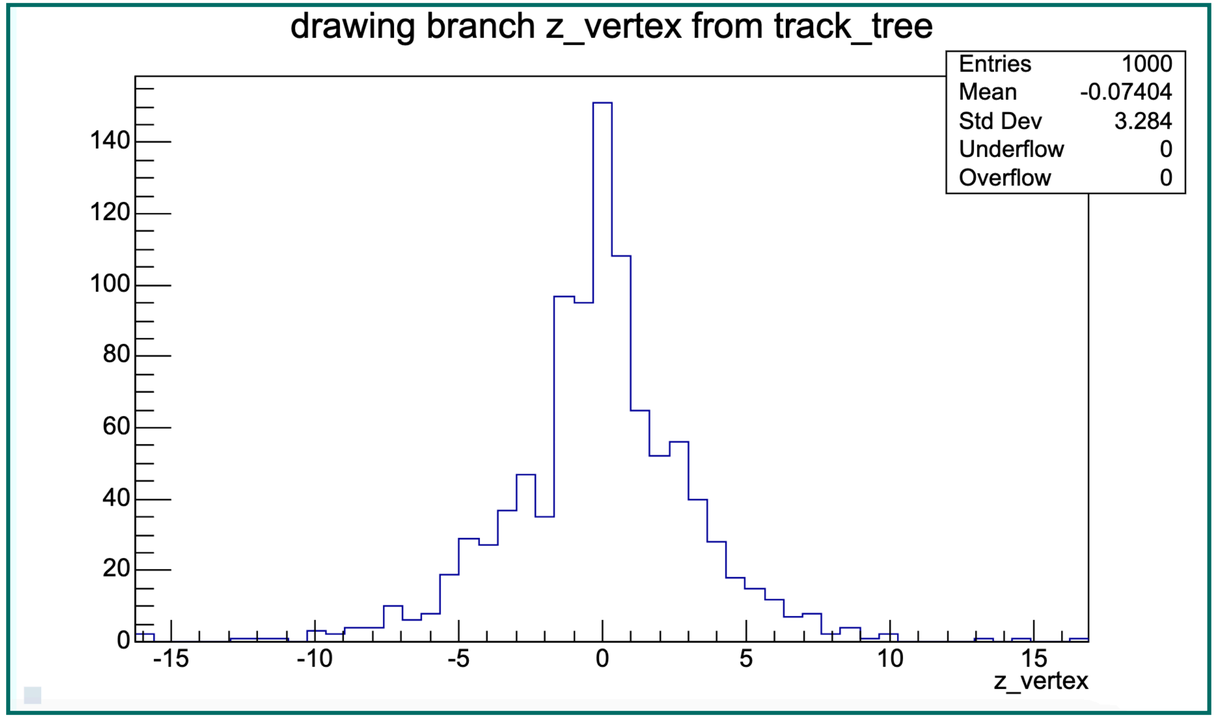




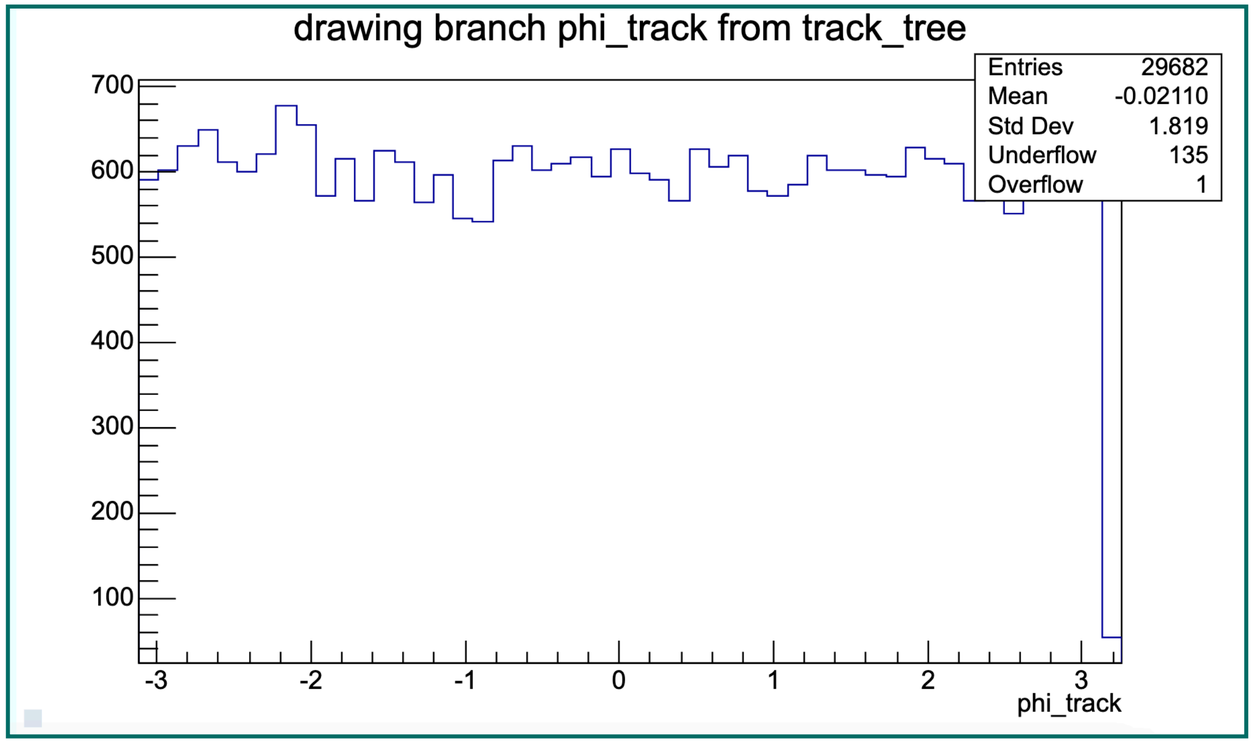
The reconstructed vertex

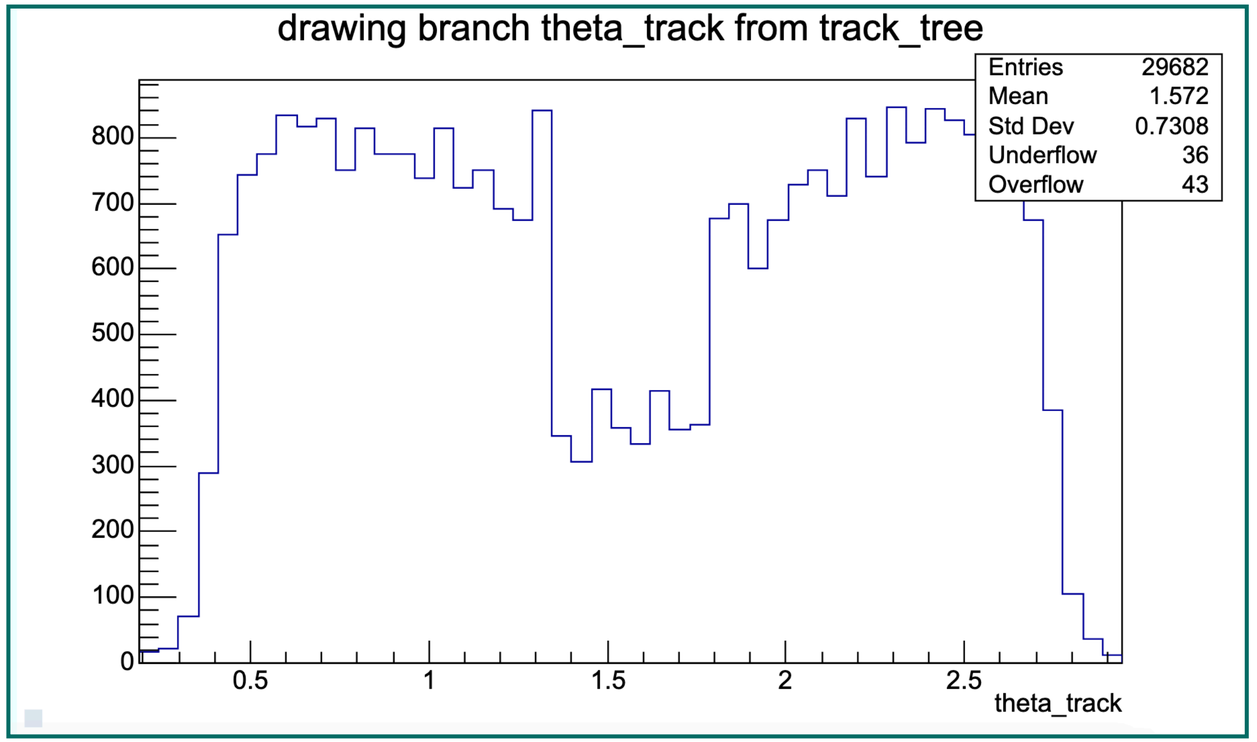
- x,y vertex are same in the all events.
  - x_vertex : 0.0004279
  - y_vertex : -0.000564

- z vertex is same in one event.
  - z_vertex : right plot

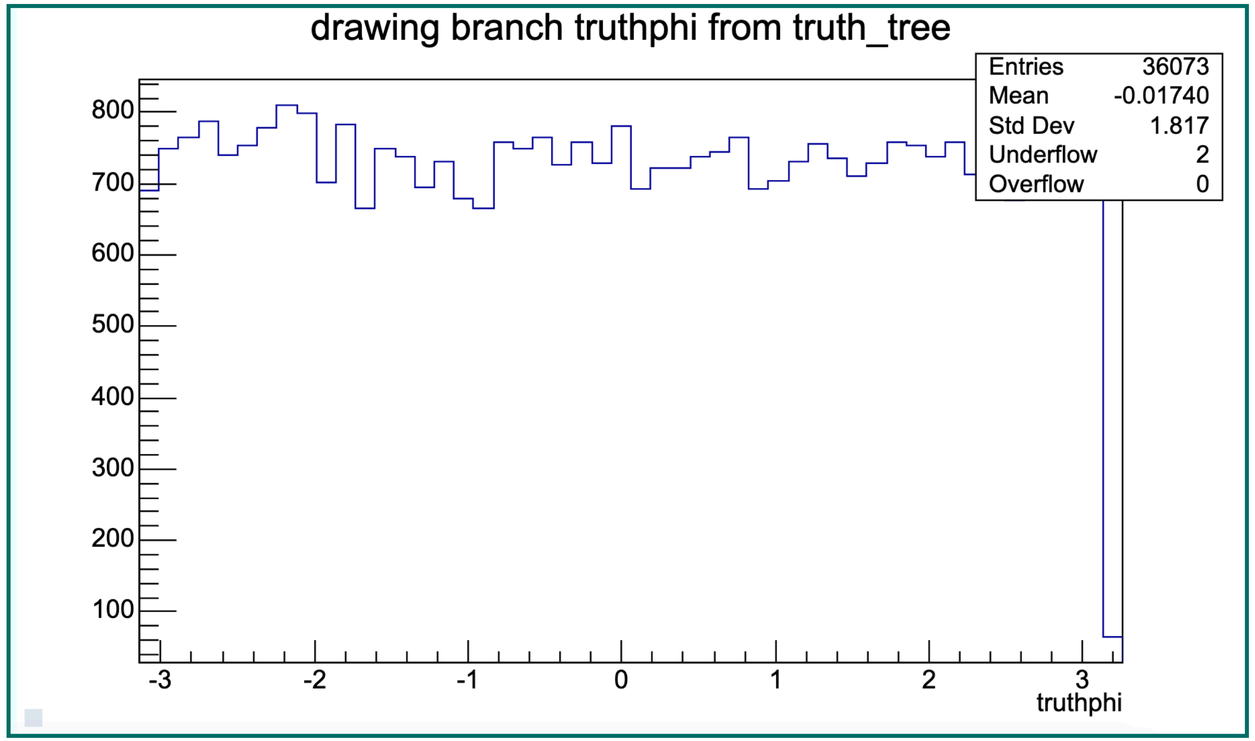


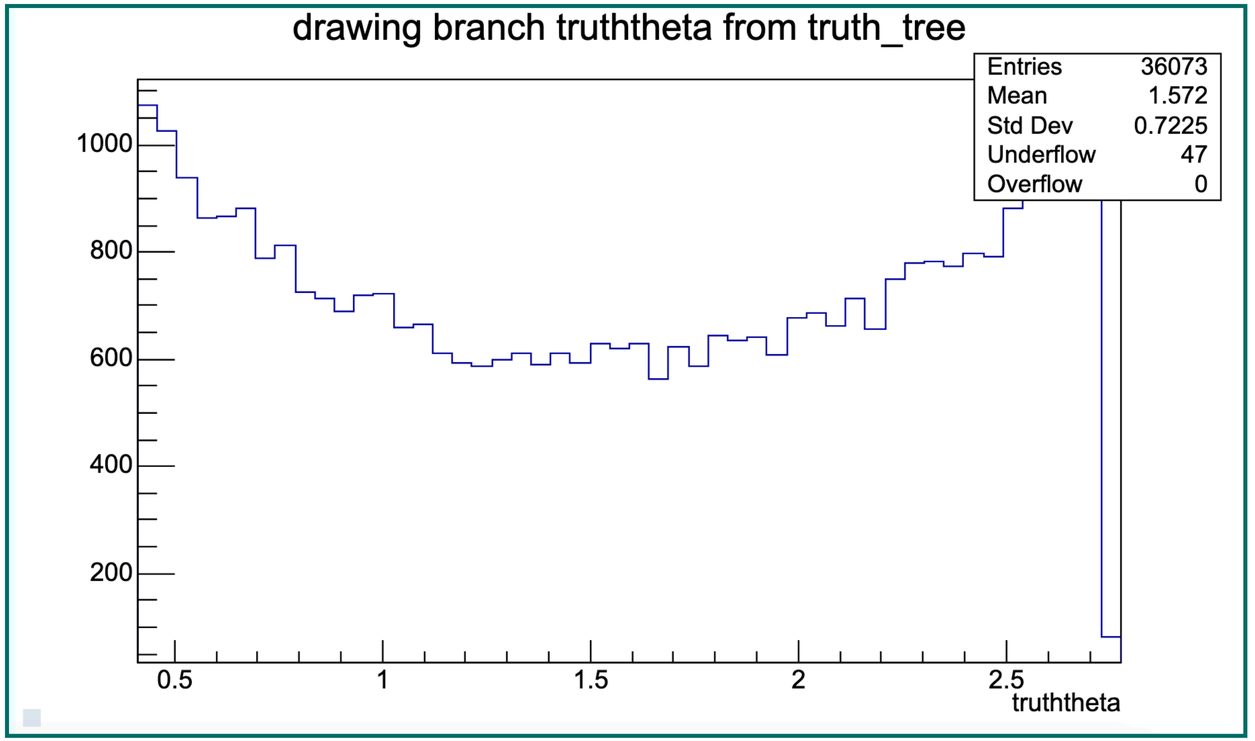
The angles of the reconstructed tracks



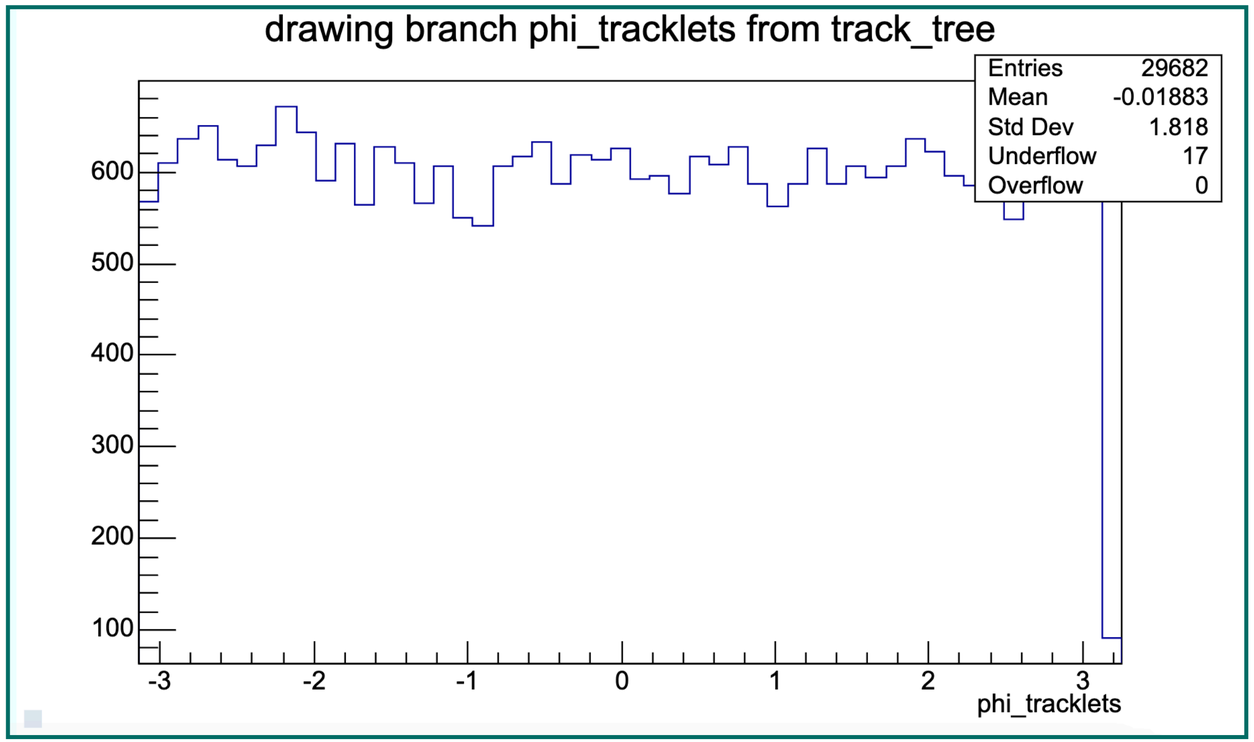


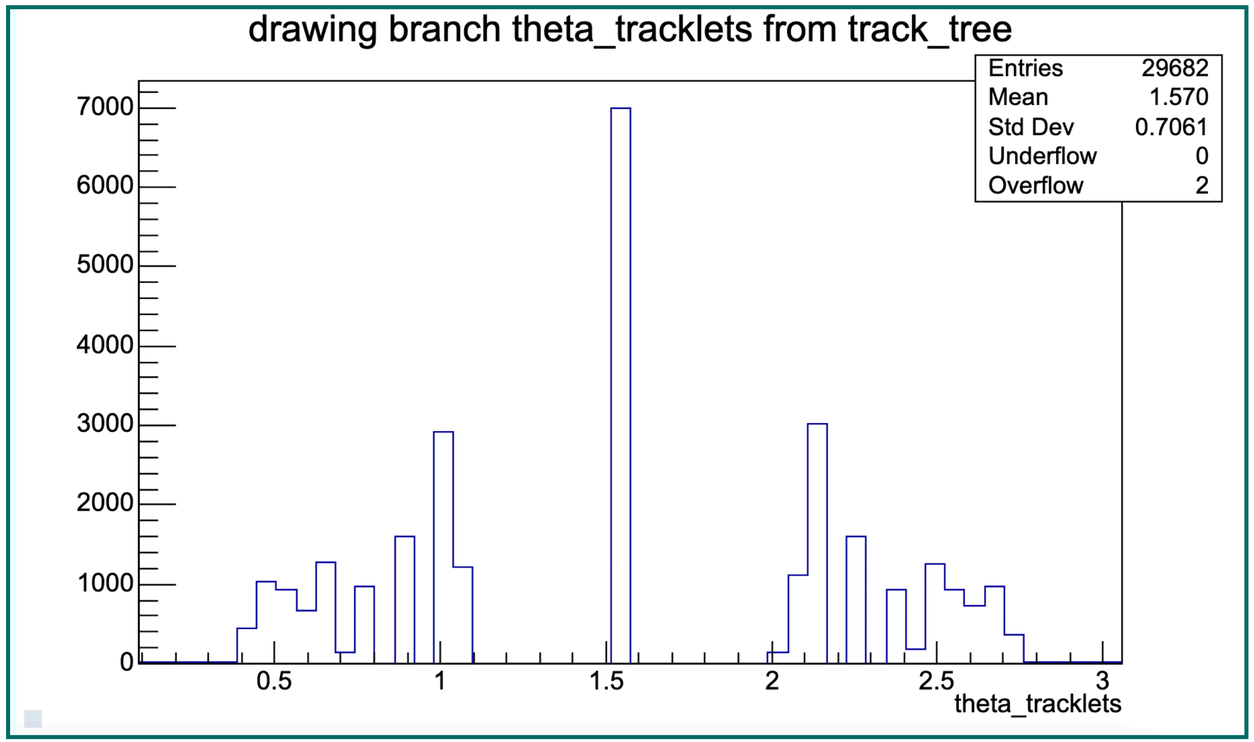
The angles of the truth tracks



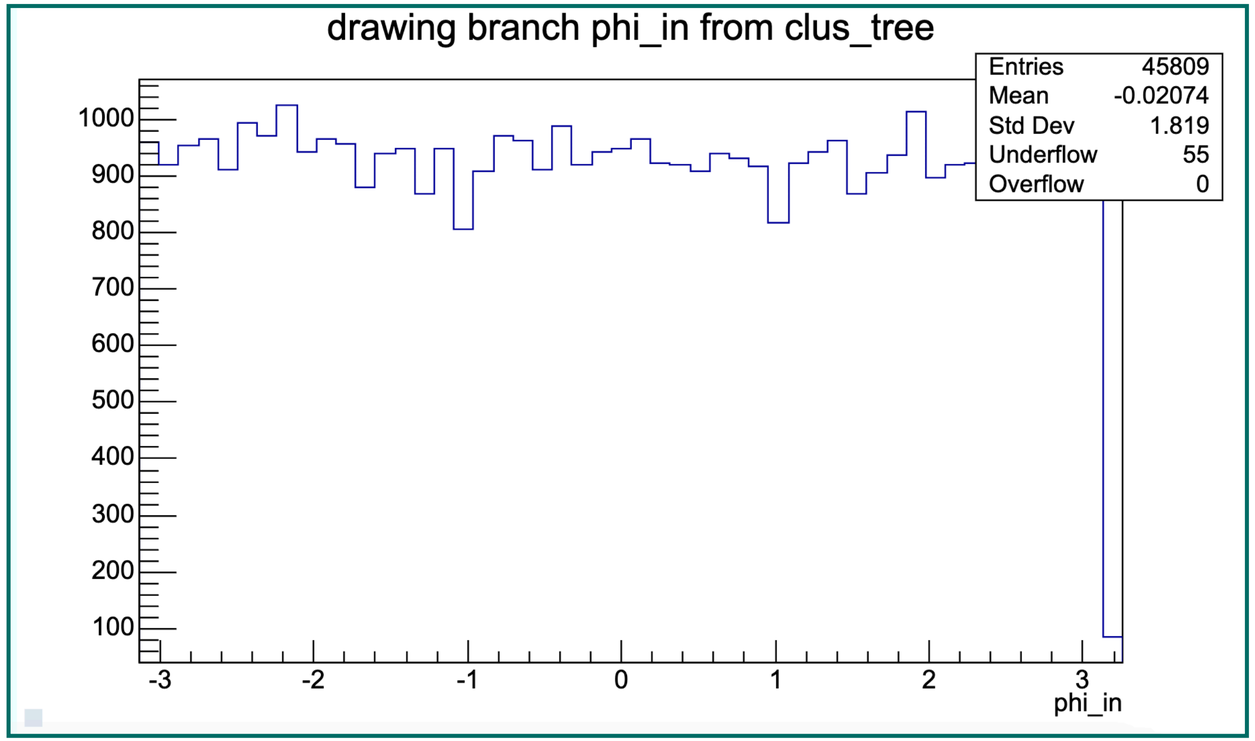


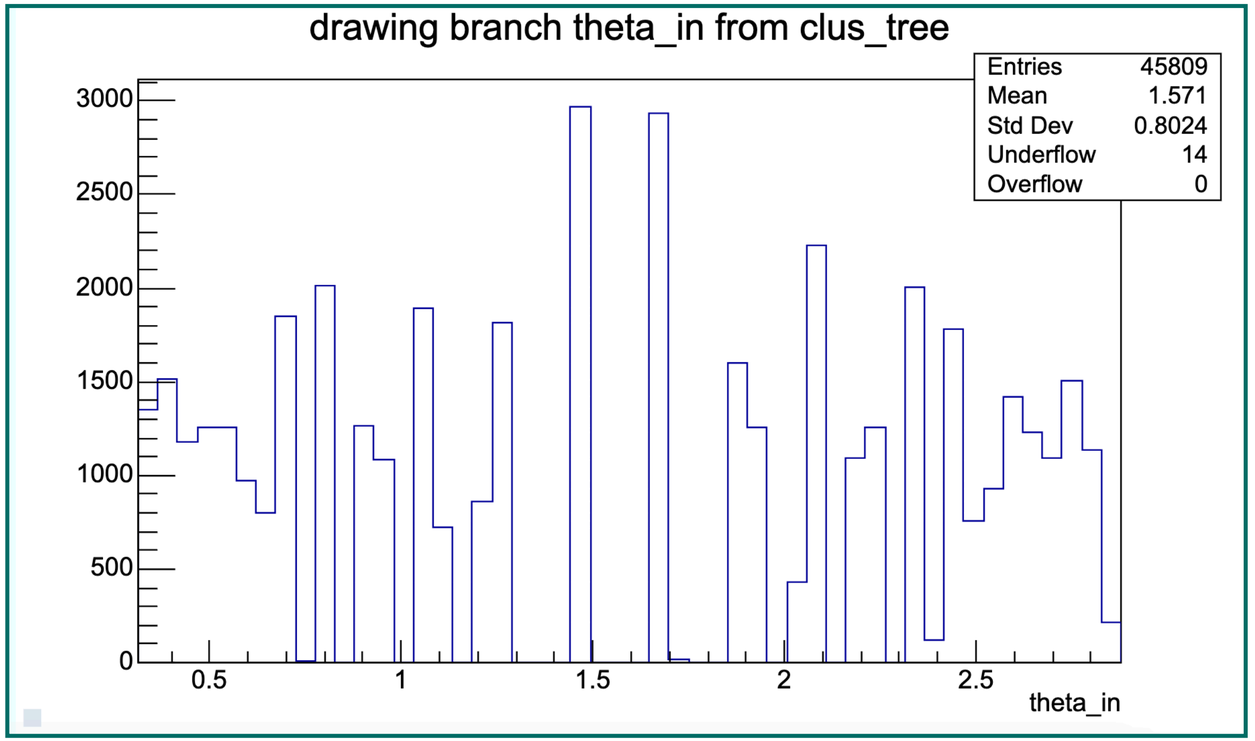
The angles of the tracklets





The angles of the clusters in the inner barrel





Setting of the simulation

```
! Beam settings
Beams:idA = 2212   ! first beam, p = 2212, pbar = -2212
Beams:idB = 2212   ! second beam, p = 2212, pbar = -2212
Beams:eCM = 200.   ! CM energy of collision

! Settings related to output in init(), next() and stat()
Init:showChangedSettings = on
#Next:numberCount = 0          ! print message every n events
Next:numberShowInfo = 1            ! print event information n times
#Next:numberShowProcess = 1         ! print process record n times
#Next:numberShowEvent = 1          ! print event record n times

! PDF
# PDF:useLHAPDF = on
# PDF:LHAPDFset = CT10.LHgrid
PDF:pSet = 7 ! CTEQ6L, NLO alpha_s(M_Z) = 0.1180.

! Process
#HardQCD:hardccbar = on
# HardQCD:hardbbbar = on
HardQCD:all = on
# Charmonium:all = on
# Bottomonium:all = on
# SoftQCD:nonDiffractive = on
! Cuts
PhaseSpace:pTHatMin = 10.0
```

```
 -------  PYTHIA Process Initialization
 ------------------------
 |                                                    |
 | We collide p+ with p+ at a CM energy of 2.000e+02 GeV
|
 |                                                    |
 |----------------------------------------------------------------|
 |                                          |         |
 | Subprocess                               |    Code |   Estimated |
 |                                          |     max (mb) |
 |                                          |         |
 |----------------------------------------------------------------|
 |                                          |         |
 | g g -> g g                               |  111 |   6.989e-03 |
 | g g -> q qbar (uds)                      |  112 |   1.747e-04 |
 | q g -> q g                               |  113 |   1.768e-02 |
 | q q(bar)' -> q q(bar)'                   |  114 |   7.543e-03 |
 | q qbar -> g g                            |  115 |   7.036e-05 |
 | q qbar -> q' qbar' (uds)                 |  116 |   4.246e-05 |
 | g g -> c cbar                            |  121 |   5.485e-05 |
 | q qbar -> c cbar                         |  122 |   1.368e-05 |
 | g g -> b bbar                            |  123 |   3.171e-05 |
 | q qbar -> b bbar                         |  124 |   1.019e-05 |
 |                                                    |
 -------  End PYTHIA Process Initialization
 ----------------------
```