INTT detection efficiency

Takahiro Kikuchi 2025/08/21

About my analysis

- Aim: INTT detection efficiency study in active area
- Goal: Calculate the detection efficiency with INTT inner layer, requiring INTT Outer and MVTX 3 layers clusters in Silicon seeding tracks.

- For that purpose, currently I'm working on Monte Carlo data to understand the relationship of detection efficiency and geometry.

Preliminary request

- I have some plots that I'd like to get the preliminary.
- I'll show those plots in the presentation, and end of that.

- I'm going to send the analysis note later.

MVTX…?

- ~~My analysis basically require MVTX hits.~~
- ~~Currently I'm asking Anne (Publication Board Chair) whether I need approval from MVTX group.~~
- ~~But actually, requiring MVTX hits can replaced by vertex cut.~~
- ~~In this presentation, I'm going to talk based on with-MVTX results.~~
- ~~I'll explain the difference in the end of the presentation.~~
- **Anne said that I don't need to get approval from the other subsystem group!**

What Anne said

- Getting preliminary after circulation of analysis note will be done quickly.
- I don’t need to get approval from another subsystem group, but please tell her about other detectors what I used.

- After circulation of analysis note, send her the reminder with plots which I want to get preliminary.

Simulation data

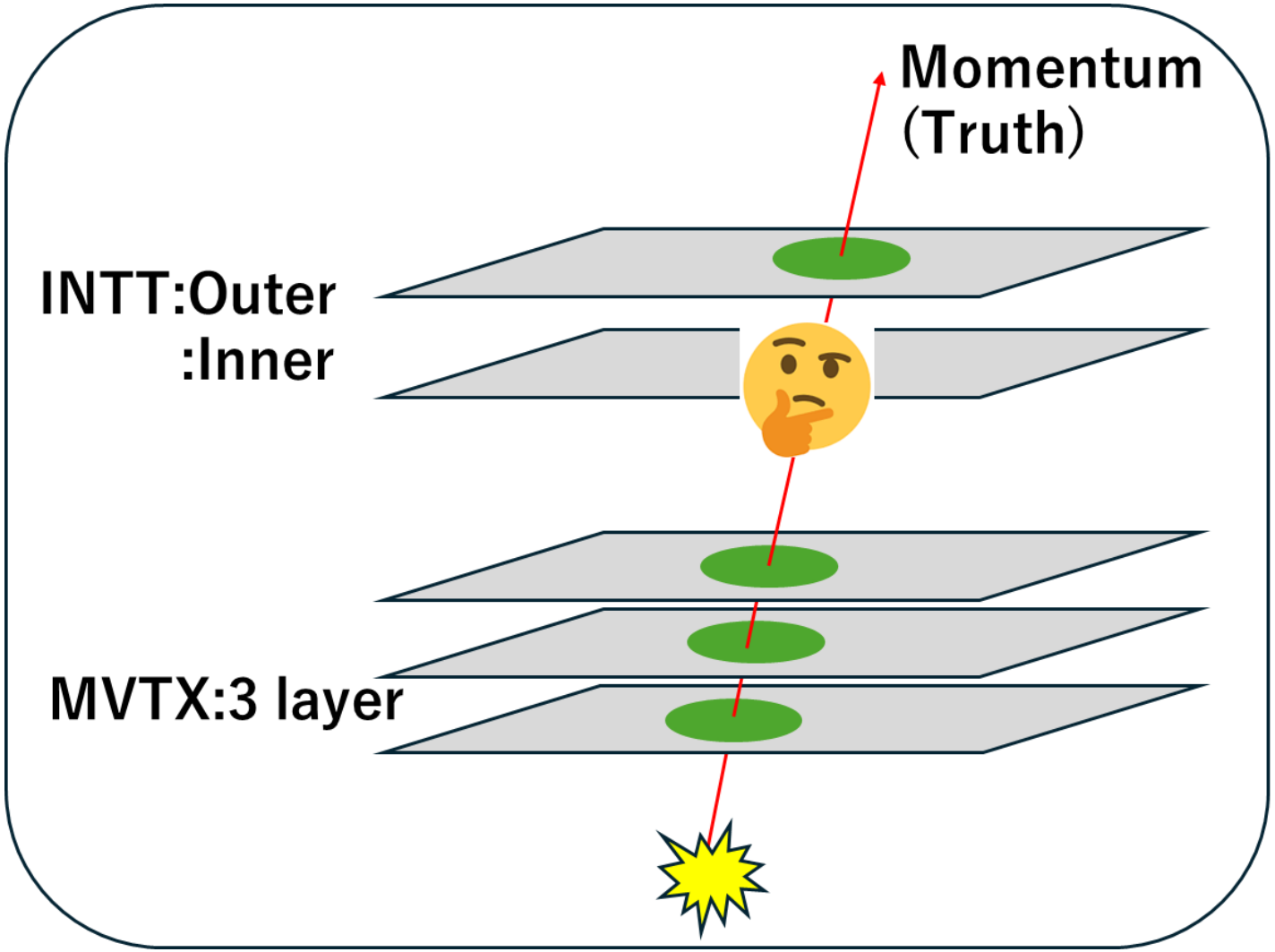
- MDC2
  - Run21 : p-p collision, no crossing angle, **with 1.4 T**
  - Run26 : Au-Au collision, vertex is based on the real data, **off-field**, **real CDB is applied**
- Each run has about 1% random dead channel
- Using INTT Survey Geometry (not ideal)

G4Hit and G4TruthAssoc

- G4Hits, G4Truth and G4TruthAssoc is core of this analysis.
- They have these information
  - Particle’s vertex and momentum there
  - Particle’s type, like proton, pion…
  - The correspondence of each hits and particles.

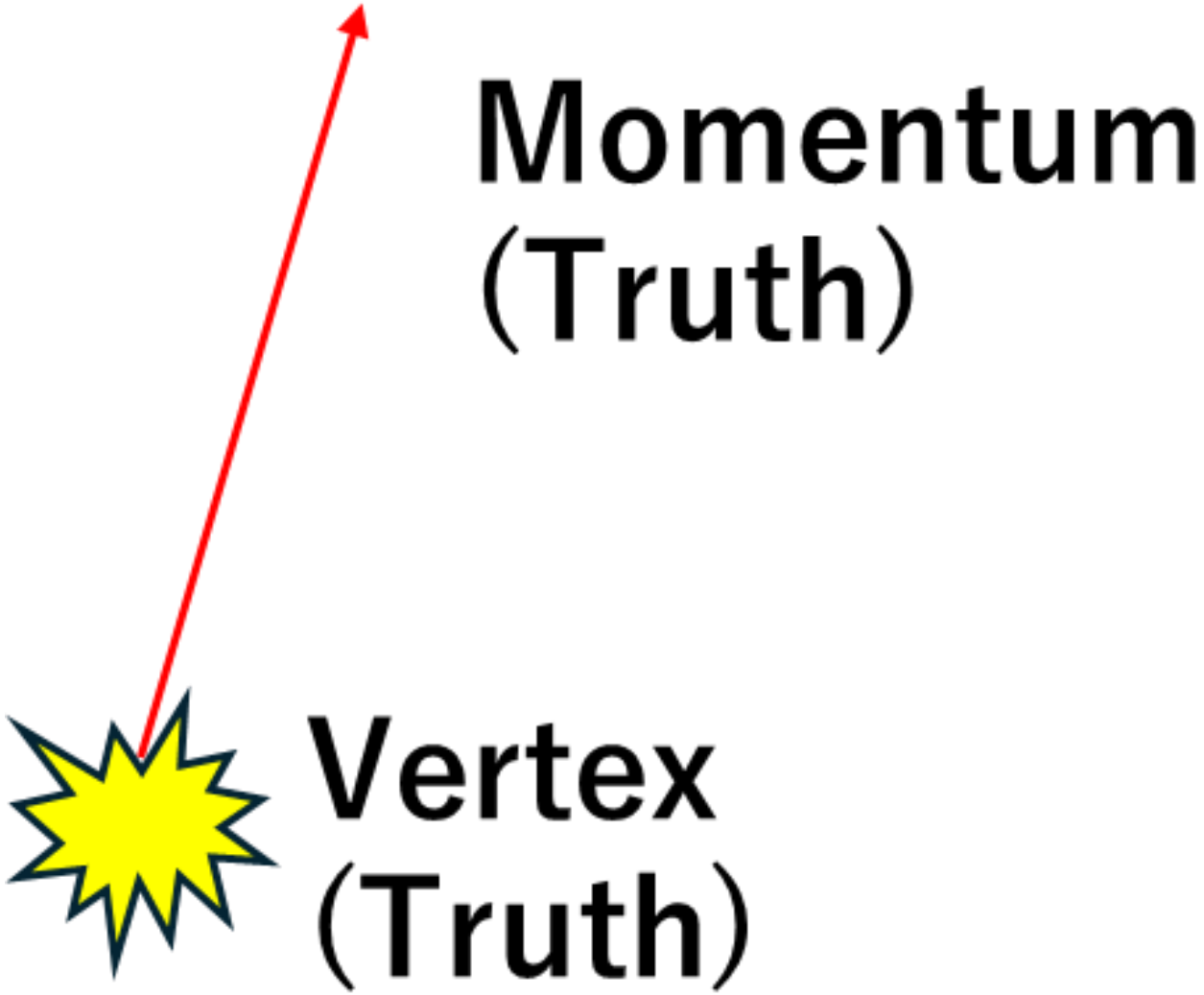
Requiring MVTX 3 layers and INTT Outer

- To make sure particles passed the INTT Inner layer, I require MVTX 3 layers and INTT Outer cluster.



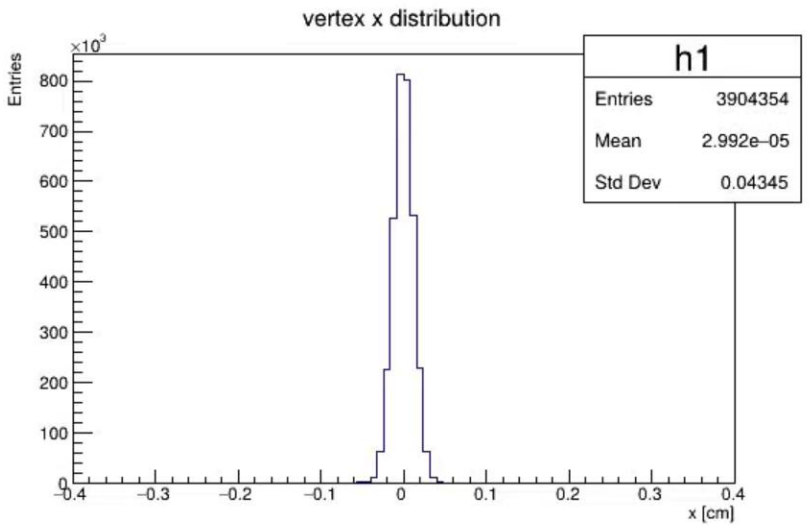
Assuming tracks from G4Truth info

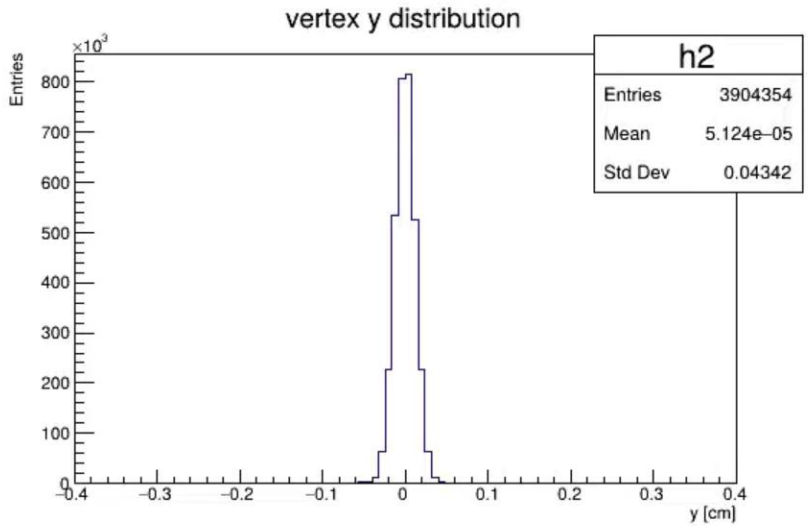
- Instead of tracking algorithm, I assumed tracks with those G4Truth info.
- For off-field, I draw a **line** from vertex.
- For on-field, I draw a **helix** from vertex.

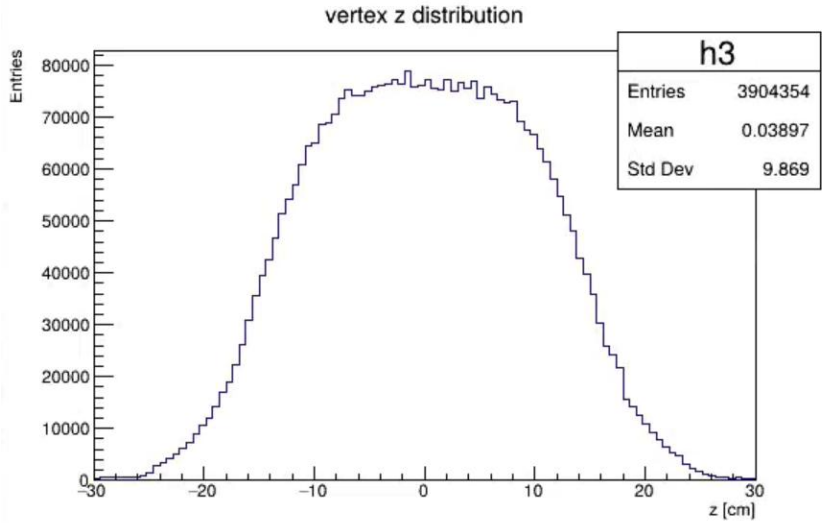


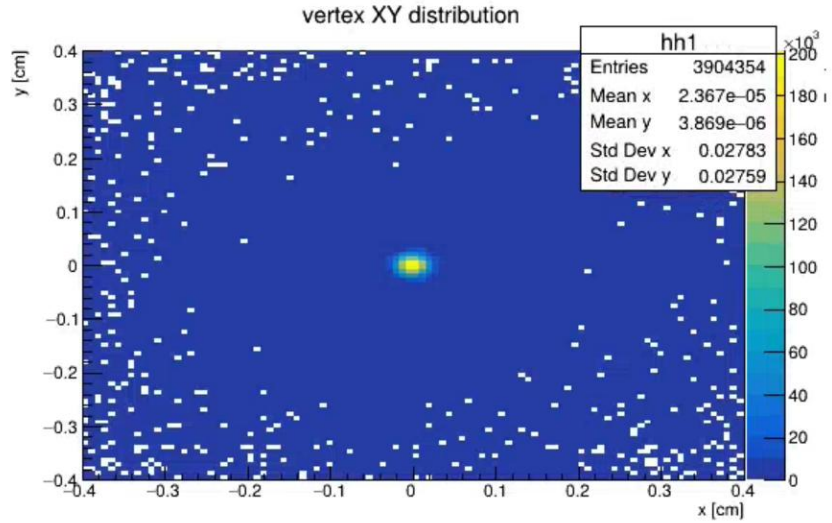
Tracks selection p-p

- Tracks are filtered by vertex(x, y, z)
- For vertex(x, y), I set range between -3 σ to 3 σ
- For vertex(z), I set the range as between -10 to 10 cm.
- -10 to 10 cm corresponds to the trigger configure.









Tracks selection Au-Au

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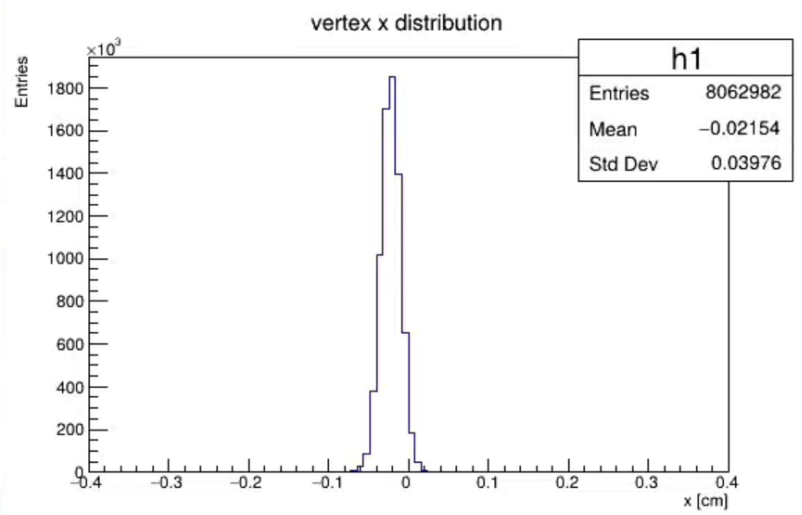
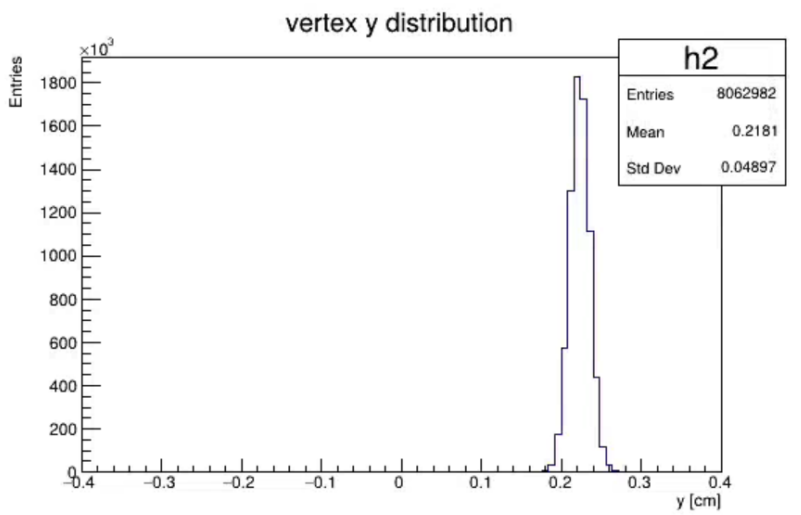
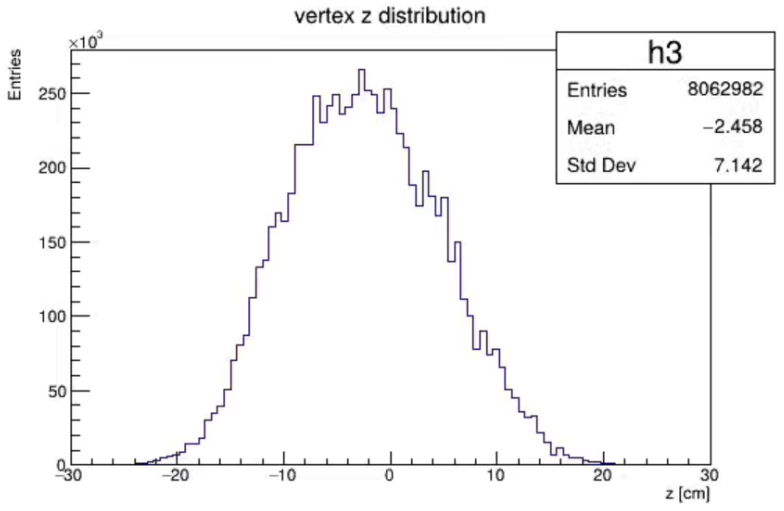
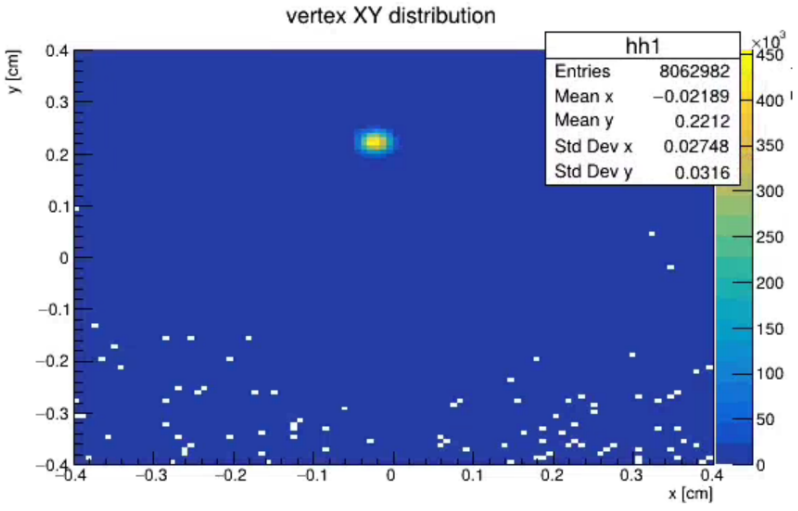
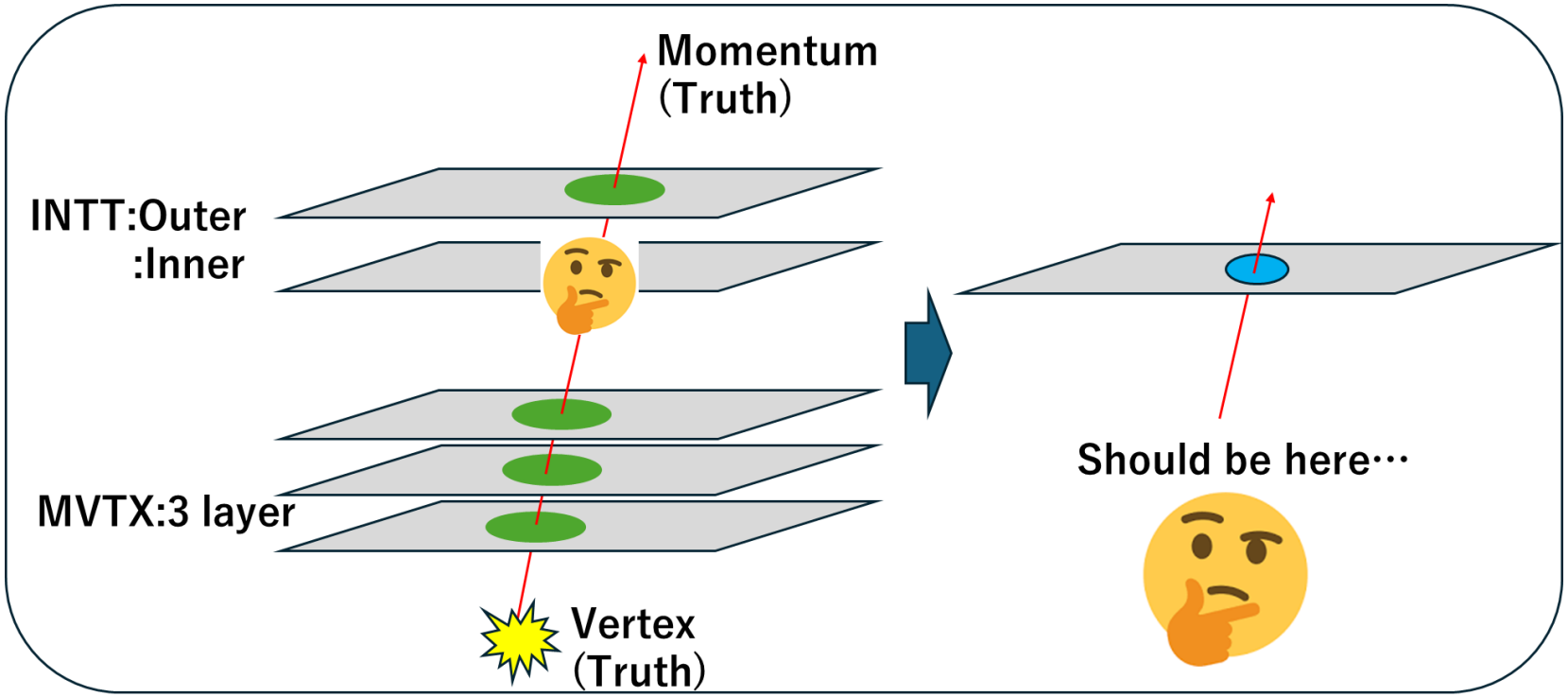










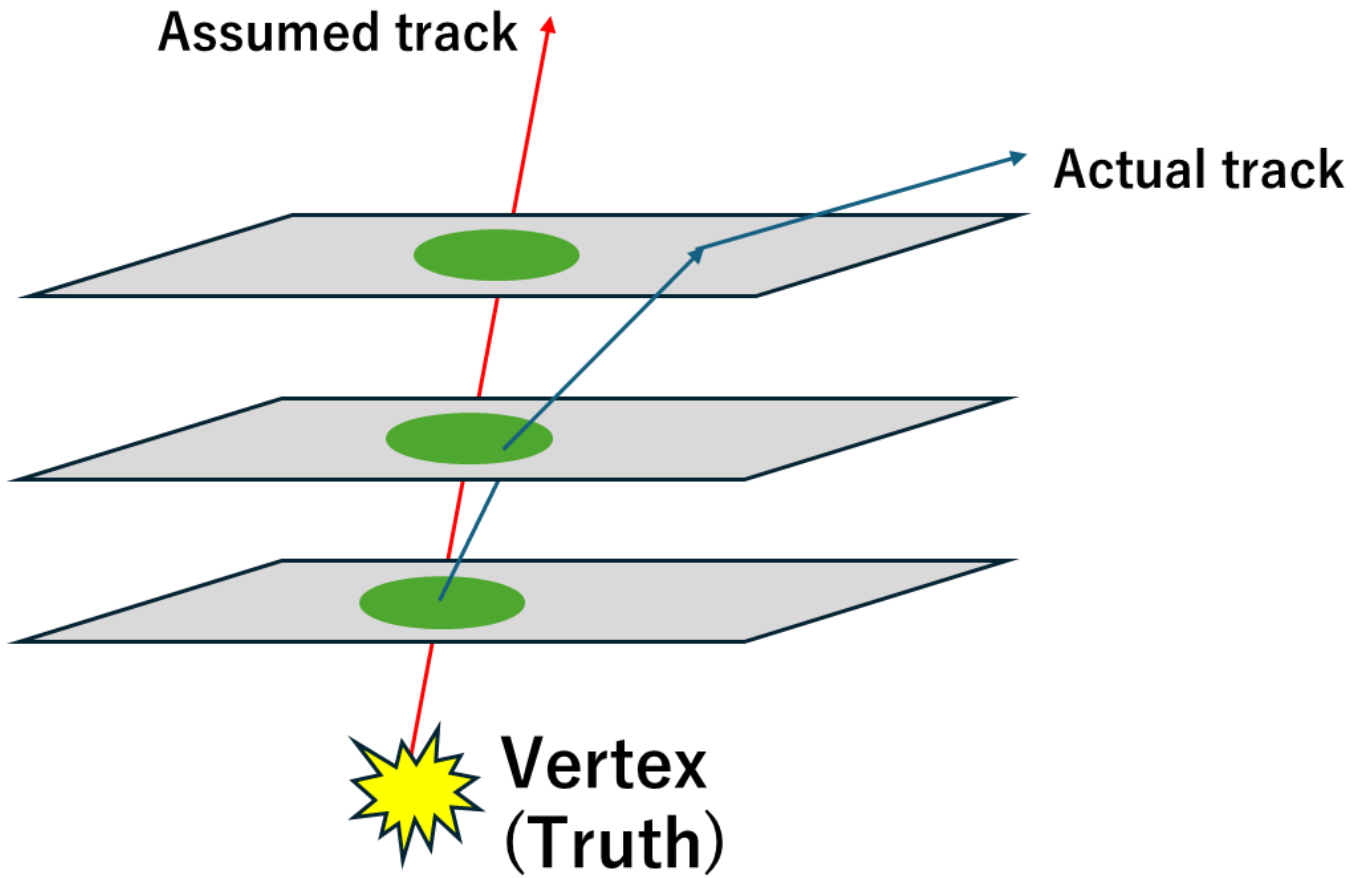
The crossing point of assumed tracks and ladders

- What I want to know is “Where those tracks should have passed on the ladders?”
- With assumed tracks and ladder geometry from ActsPlaneSurface, I calculated all crossing points of them.

Effect of scattering

- Some particles could be scattered when they hits layers.
- To extract these tracks, I used INTT outer cluster position.

- Since the fundamental request for tracks is having INTT Outer cluster, so it is possible to compare the true position and calculated position.

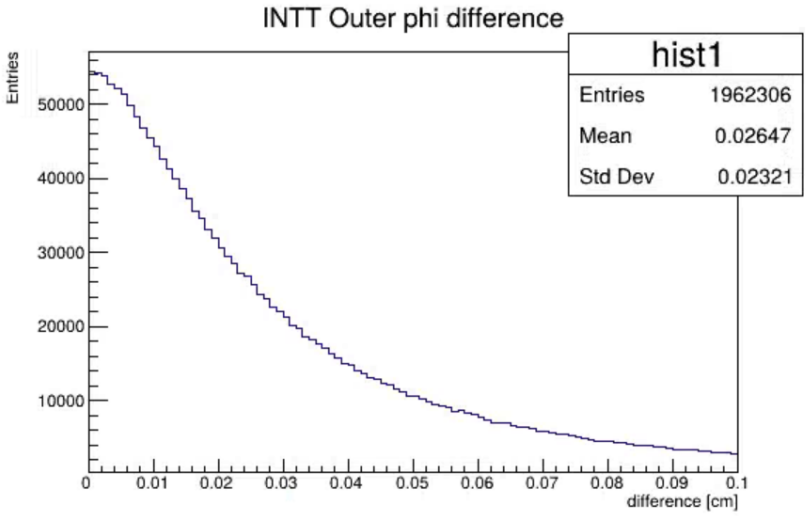


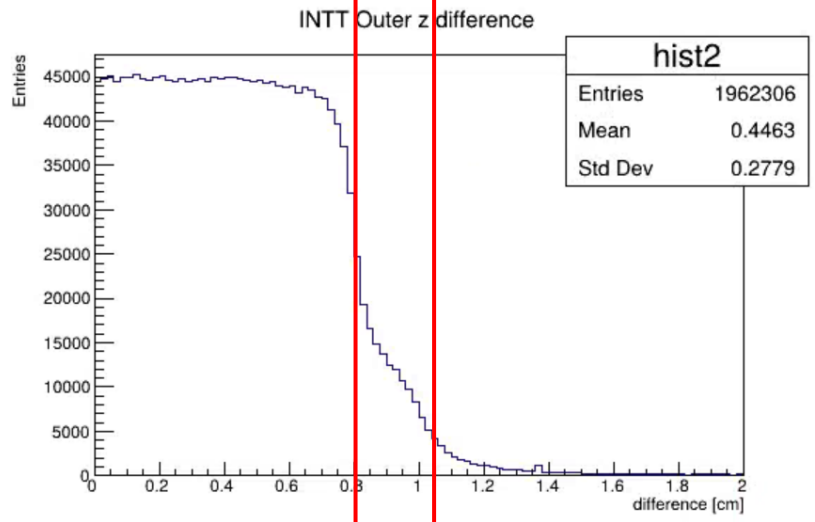
Differences from truth cluster position
INTT Outer/Inner (p-p)

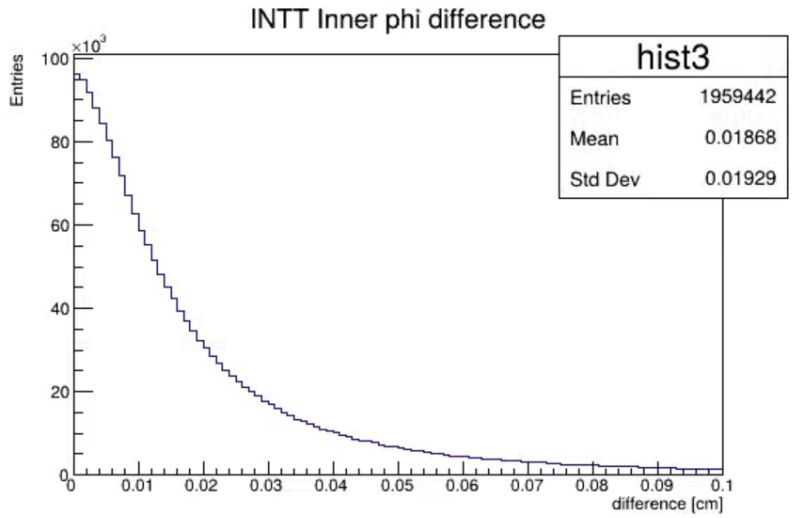
- These plots shows
- “|(INTT Outer calculated position)-(Actually recorded cluster position)|”

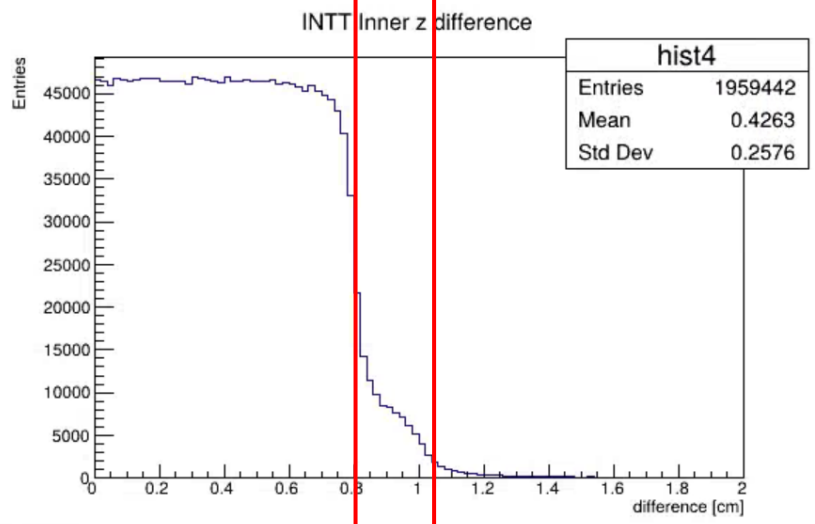
Type A/0.8cm

Type B/1.0cm









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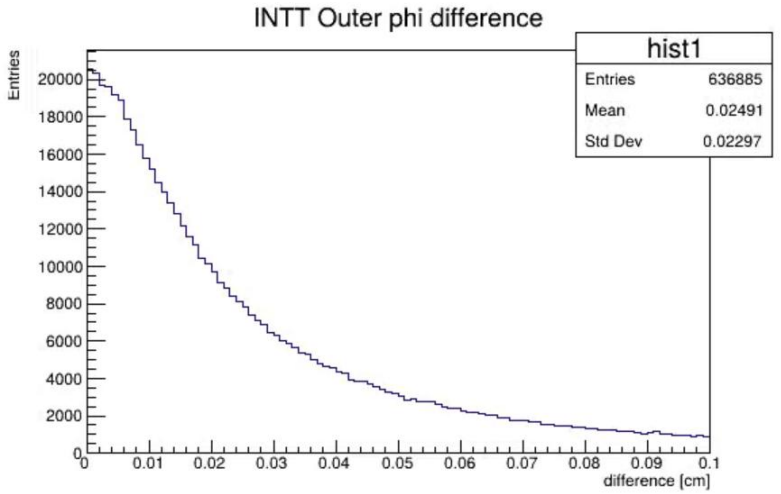
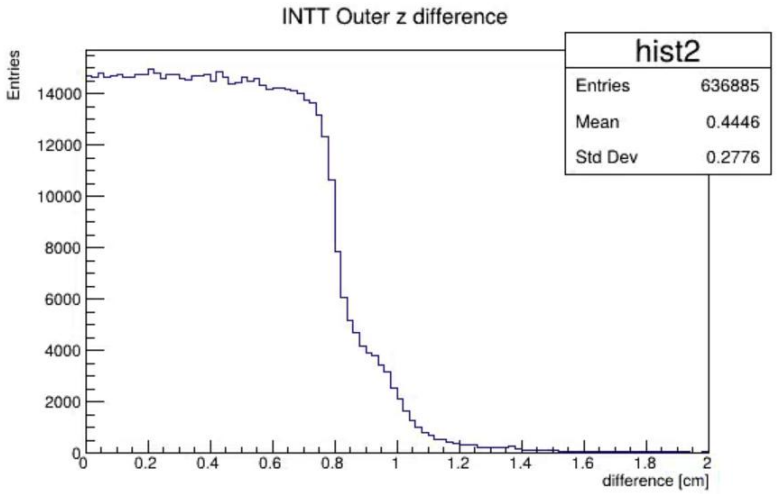
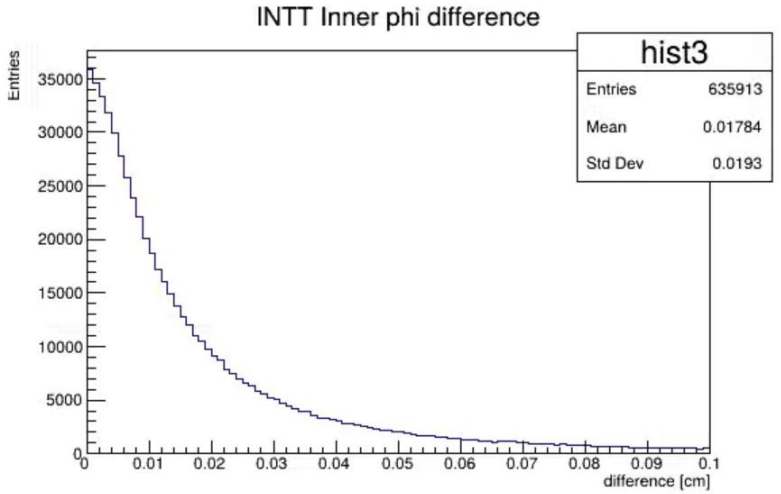
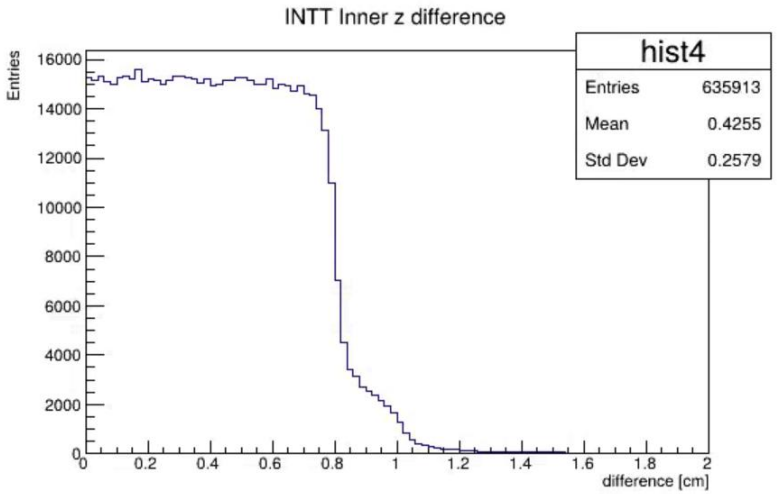


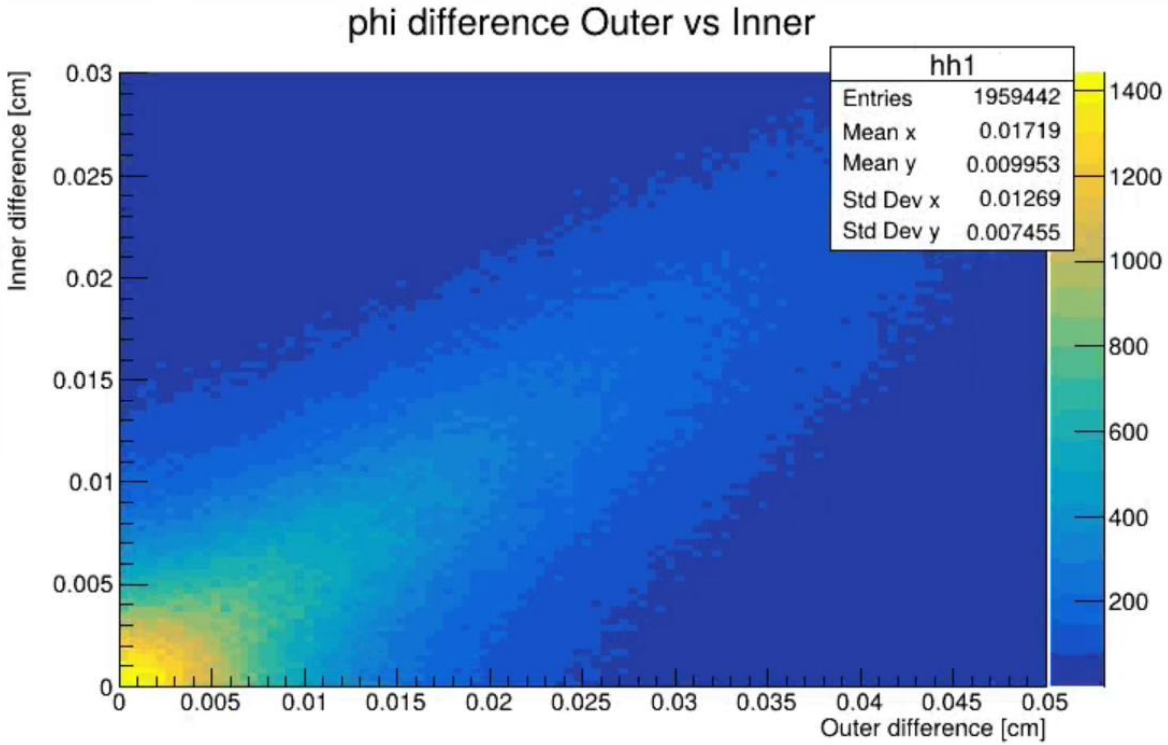


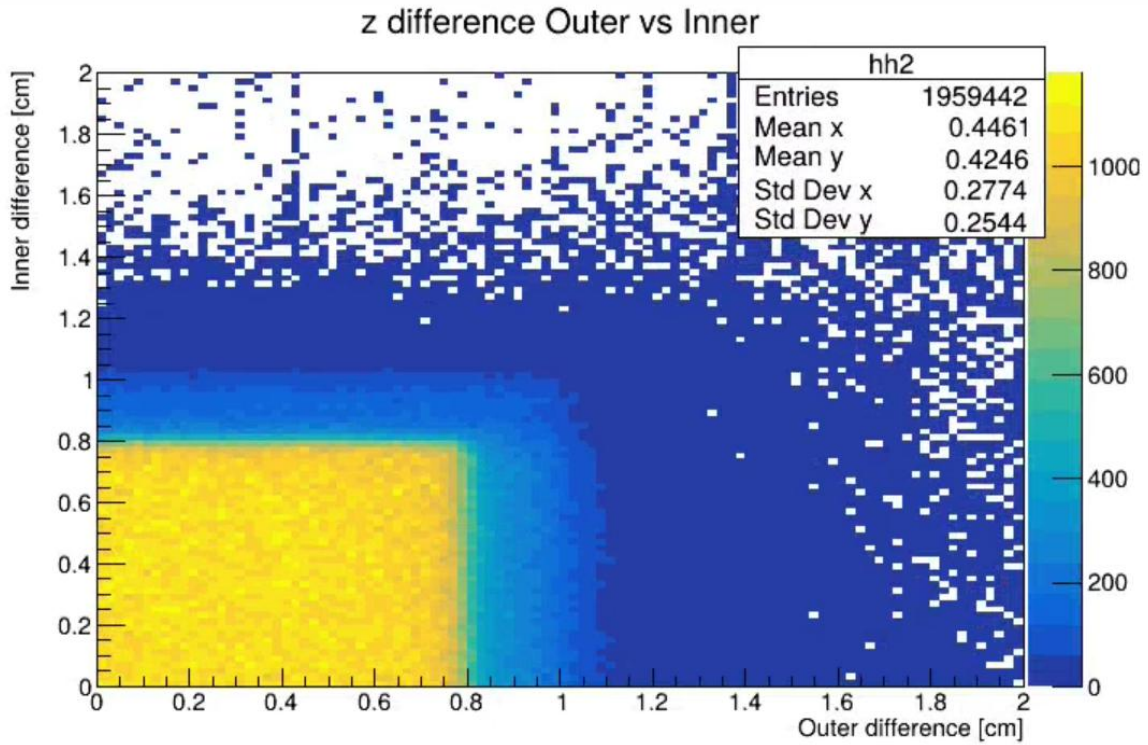




Differences from truth cluster position
INTT Outer VS Inner (p-p)

- These plots shows the relationship of difference between the Inner and Outer.
- Clearly it can be seen that tracks which have big difference in Inner layer tend to have more bigger difference in Outer layer.





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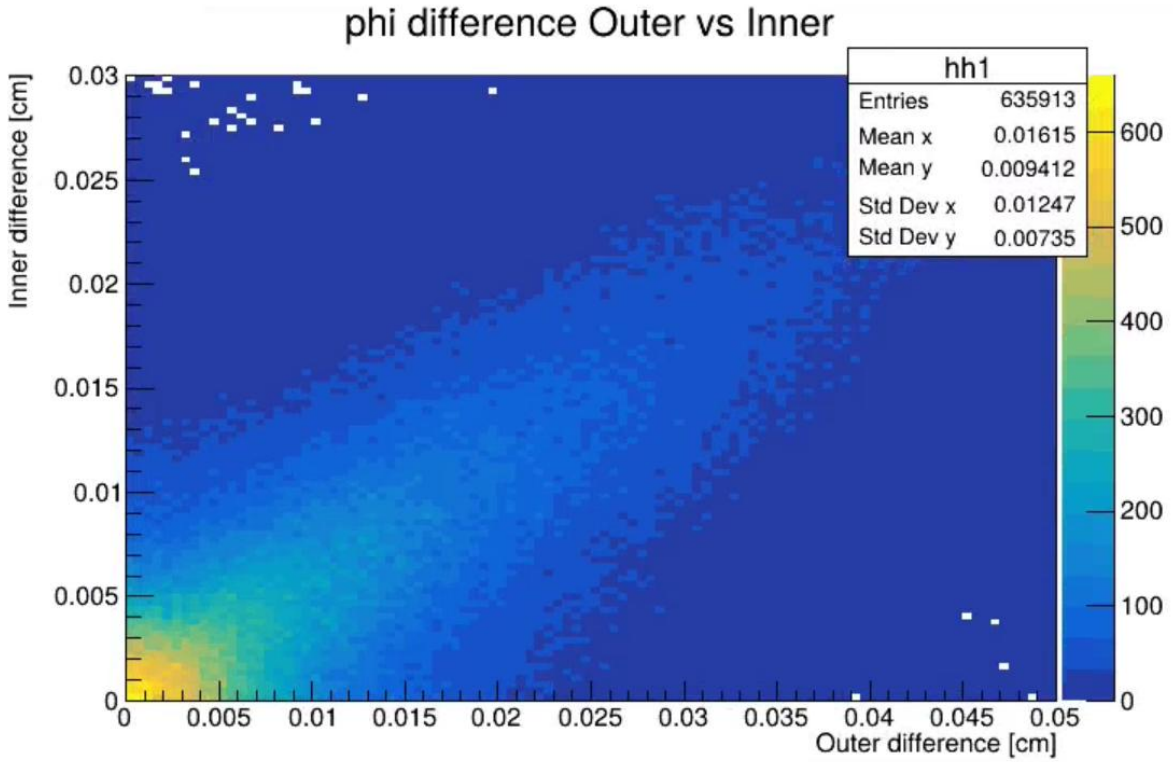
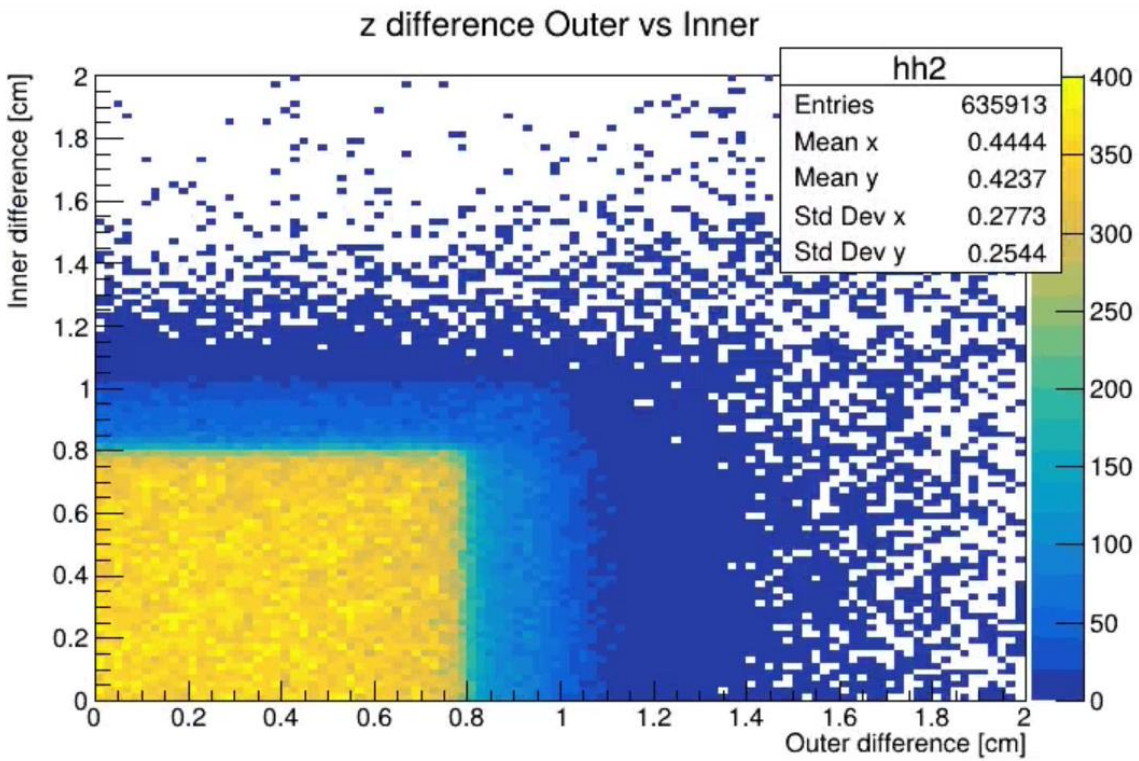
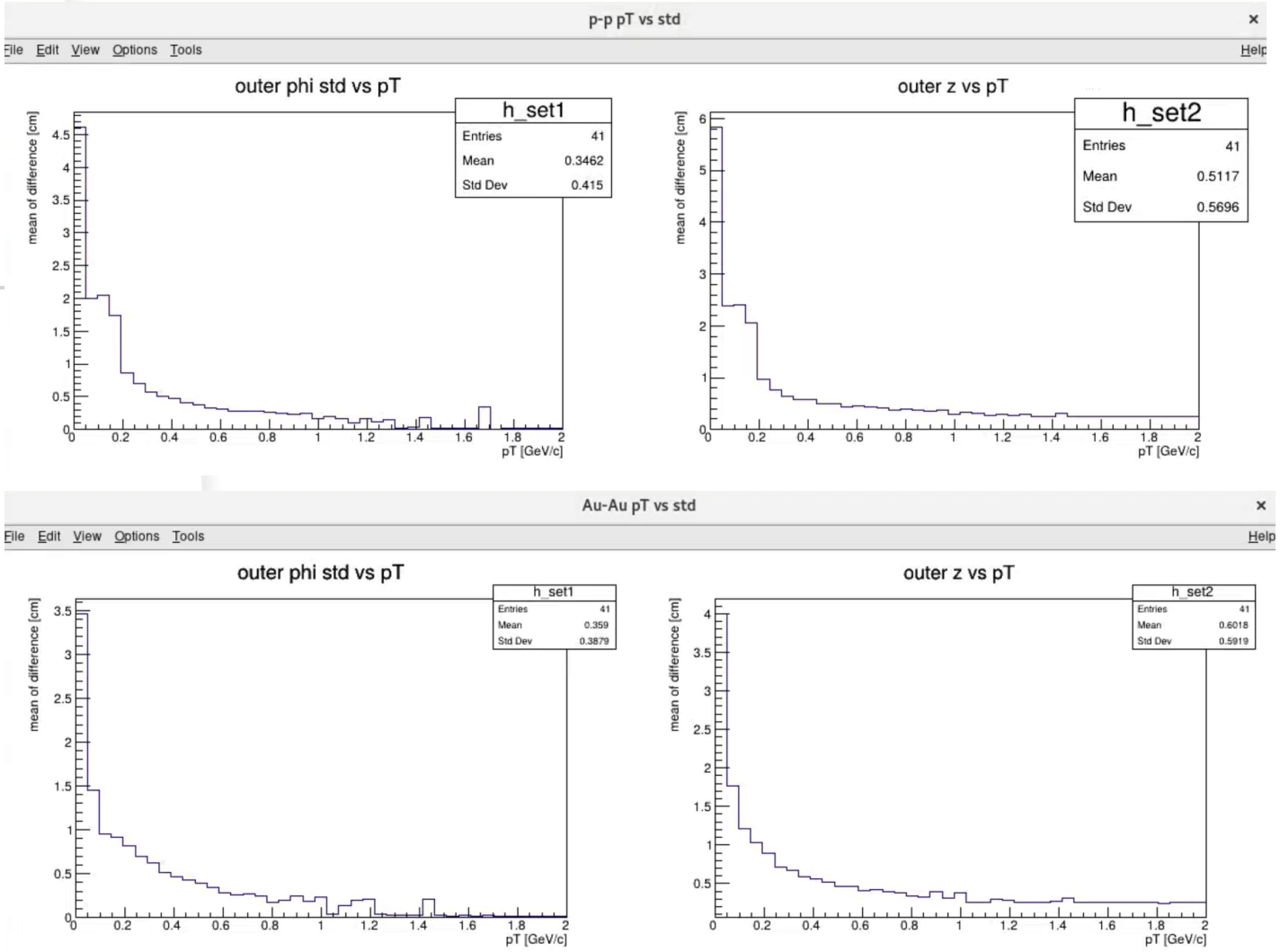




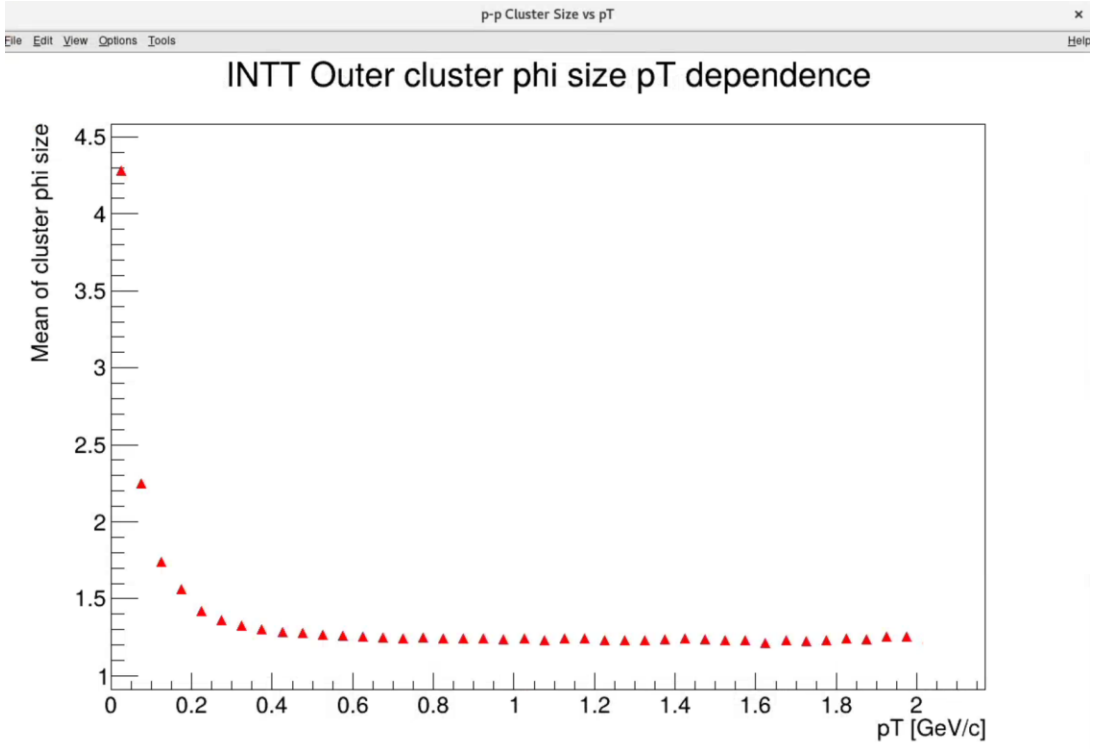
pT dependence?
(p-p)(Au-Au)

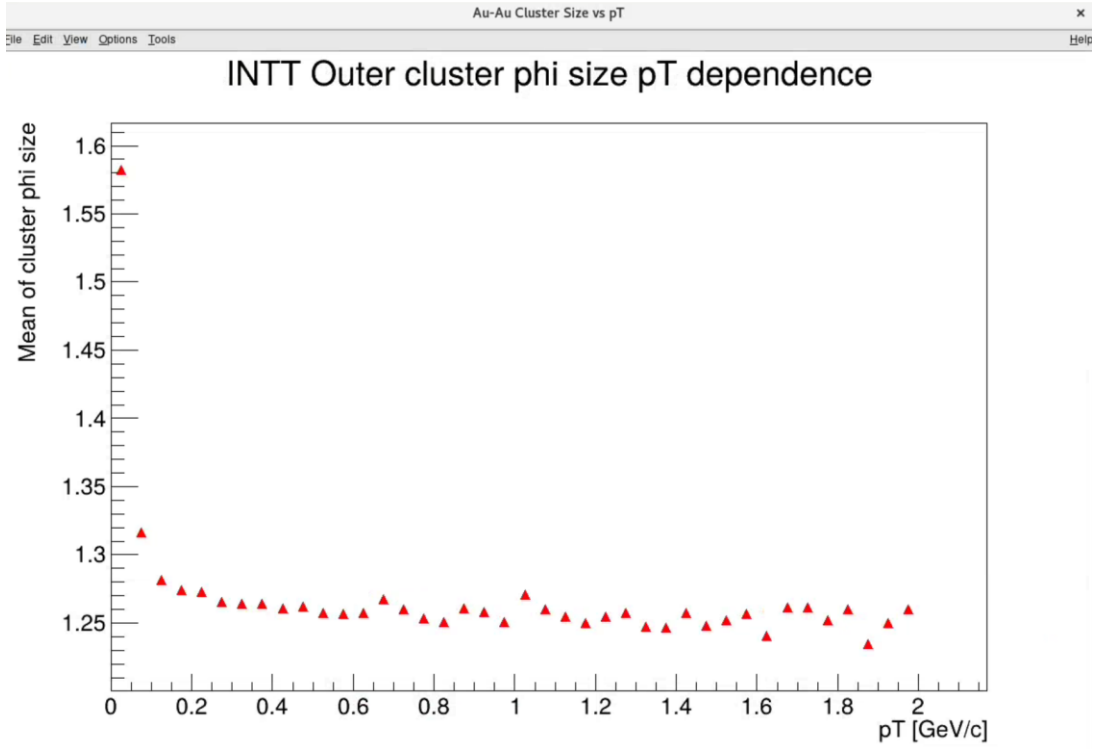
- pT dependence of INTT Outer's difference
- You can see that small pT tend to have large difference.



What caused it?

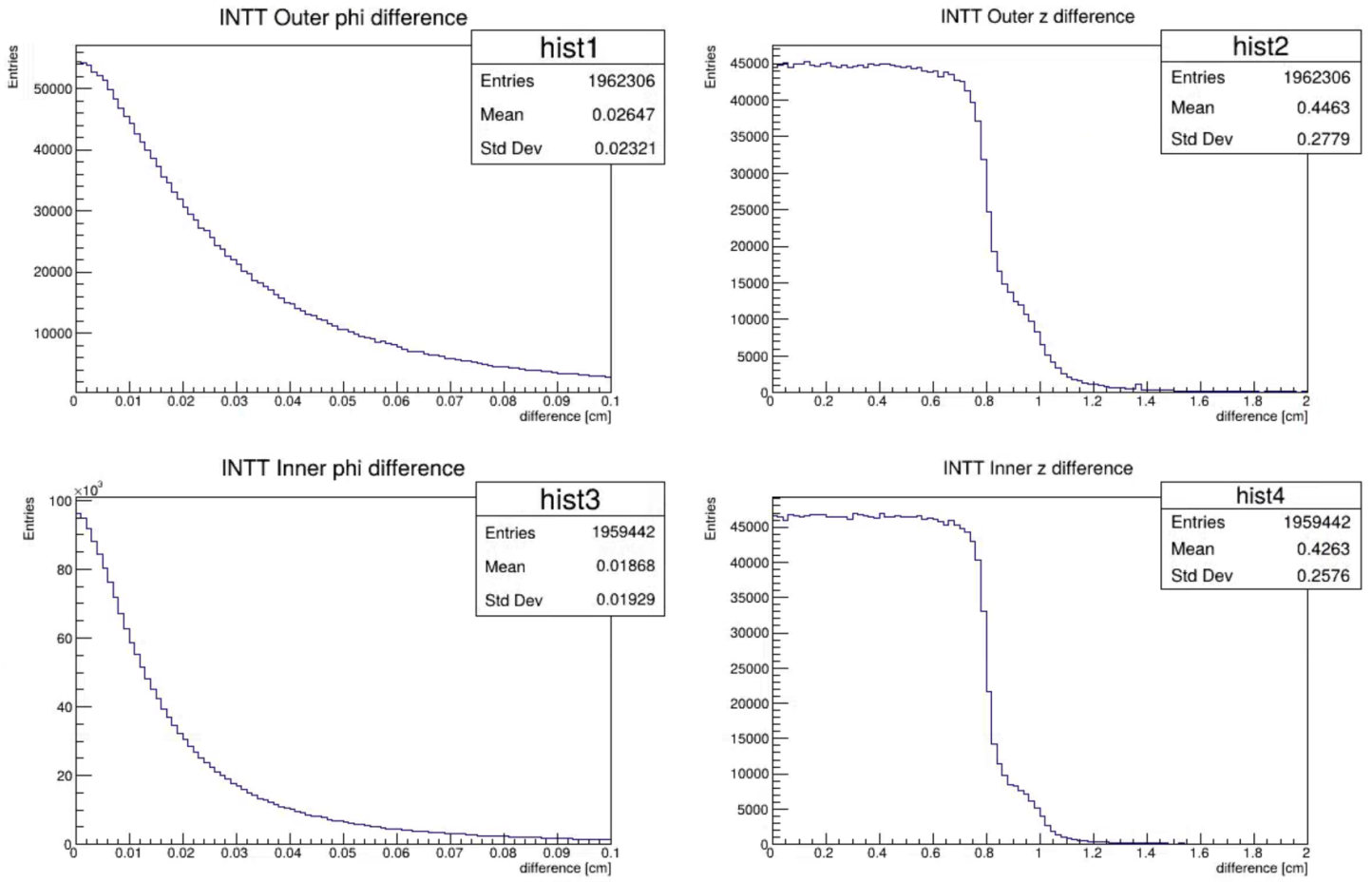
- Here's the pT dependence of mean cluster phi size.
- Especially under 0.2 pT have big cluster size and that seems to correspond to the pT dependence of difference.

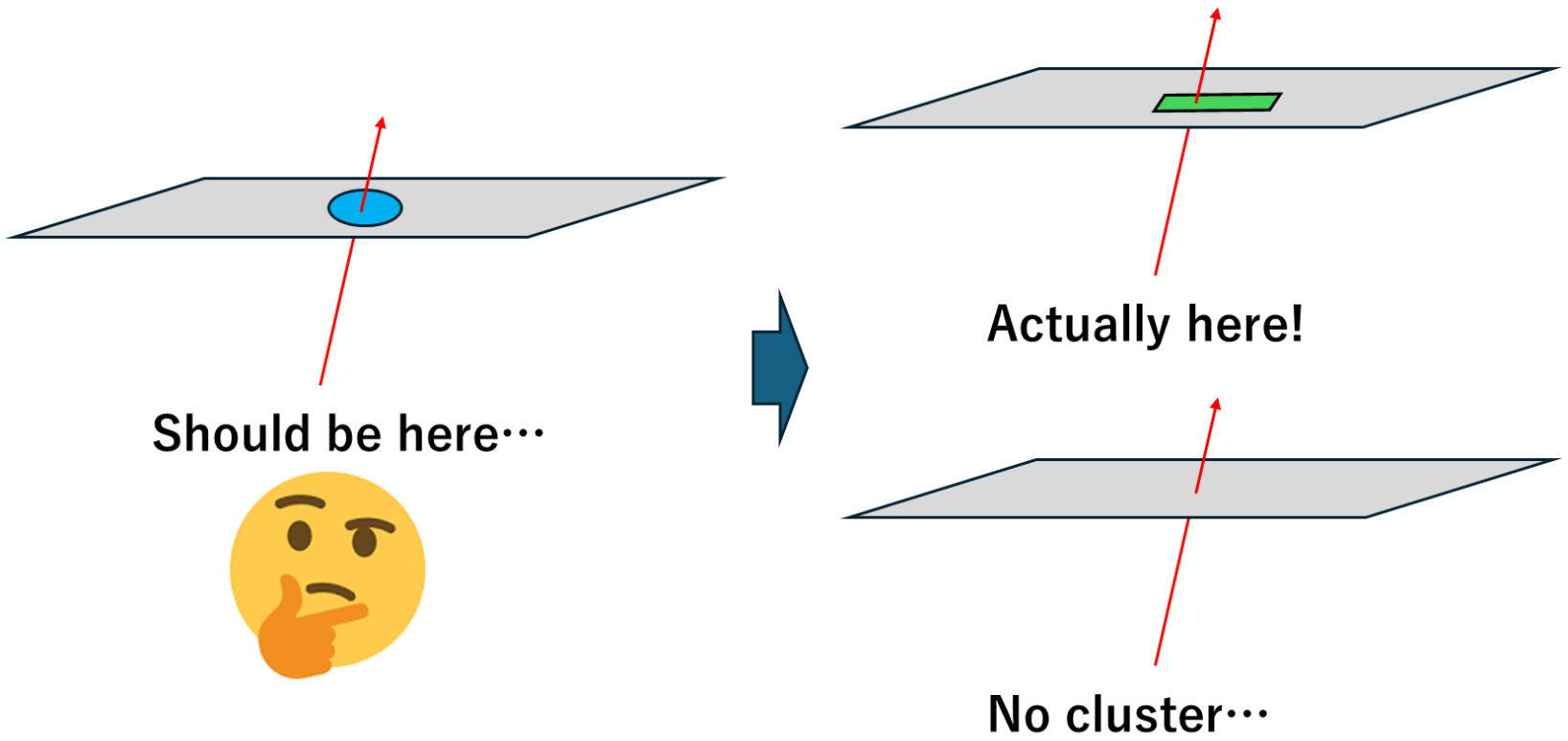




More tracks selection

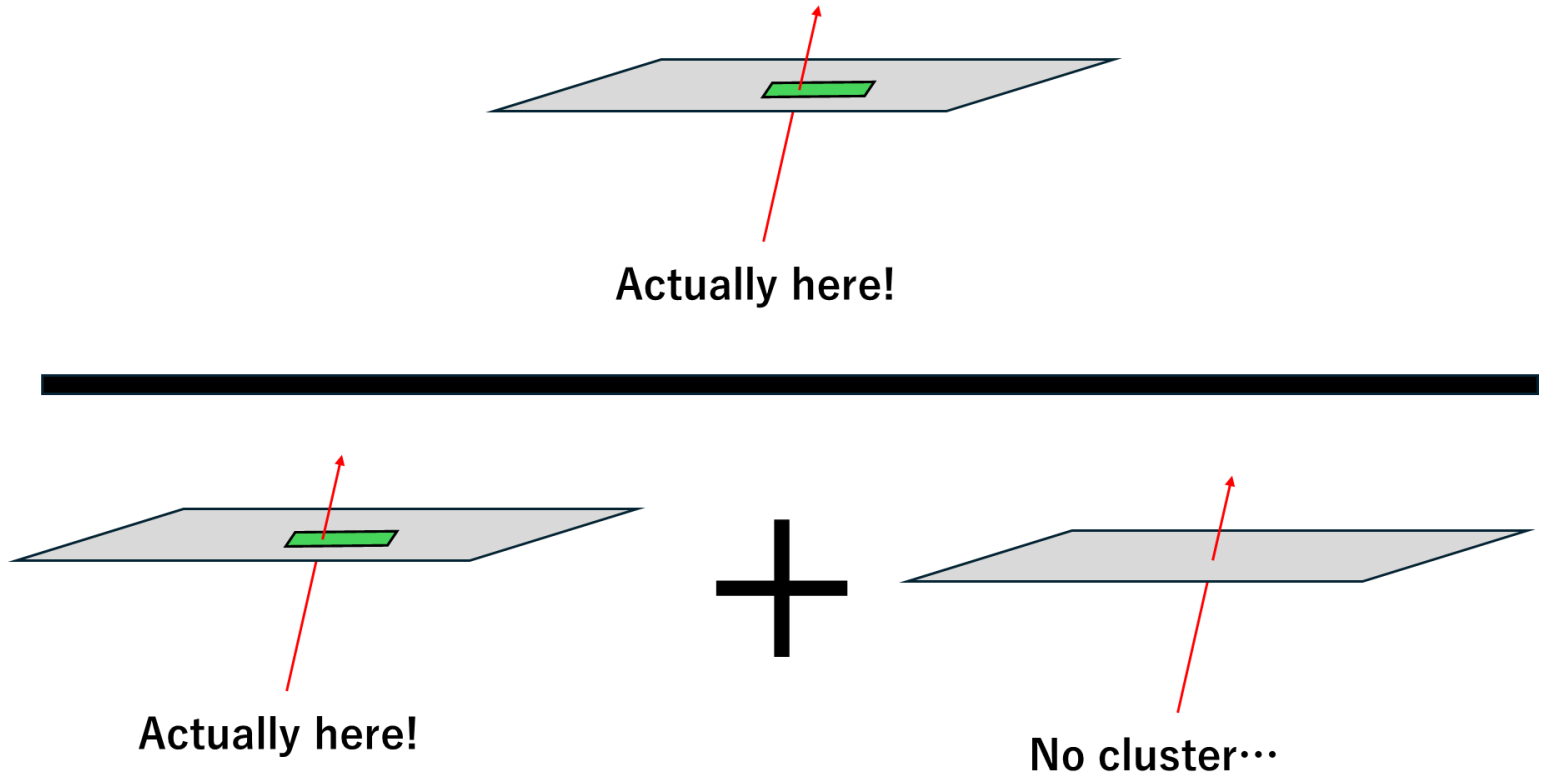
- In addition to the vertex cut, the value of difference in Outer layer is also taken.
- 1 sigma of the standard deviation





How to estimate the efficiency

- INTT chip don't have good resolution for z-direction.
- That is not preferable to see especially z-dependence of INTT detection efficiency.
- So, I decided to use only calculated position, not recorded cluster position.

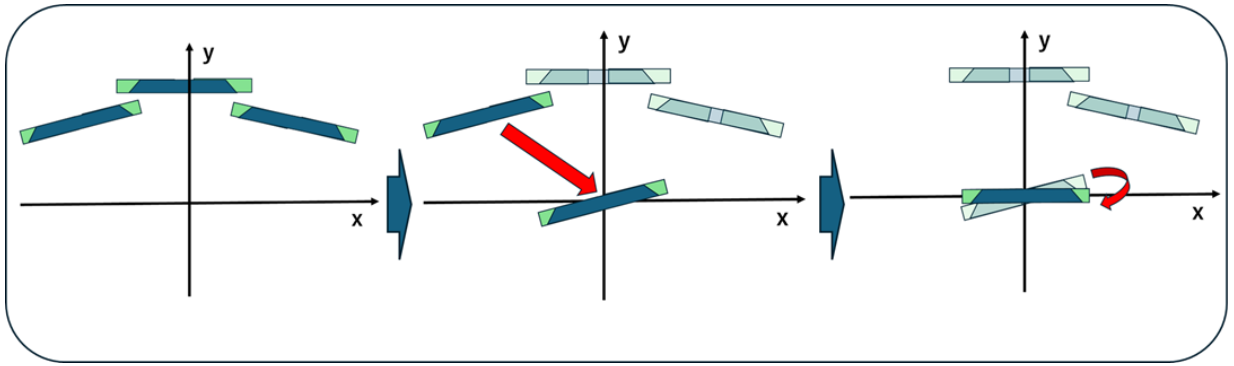


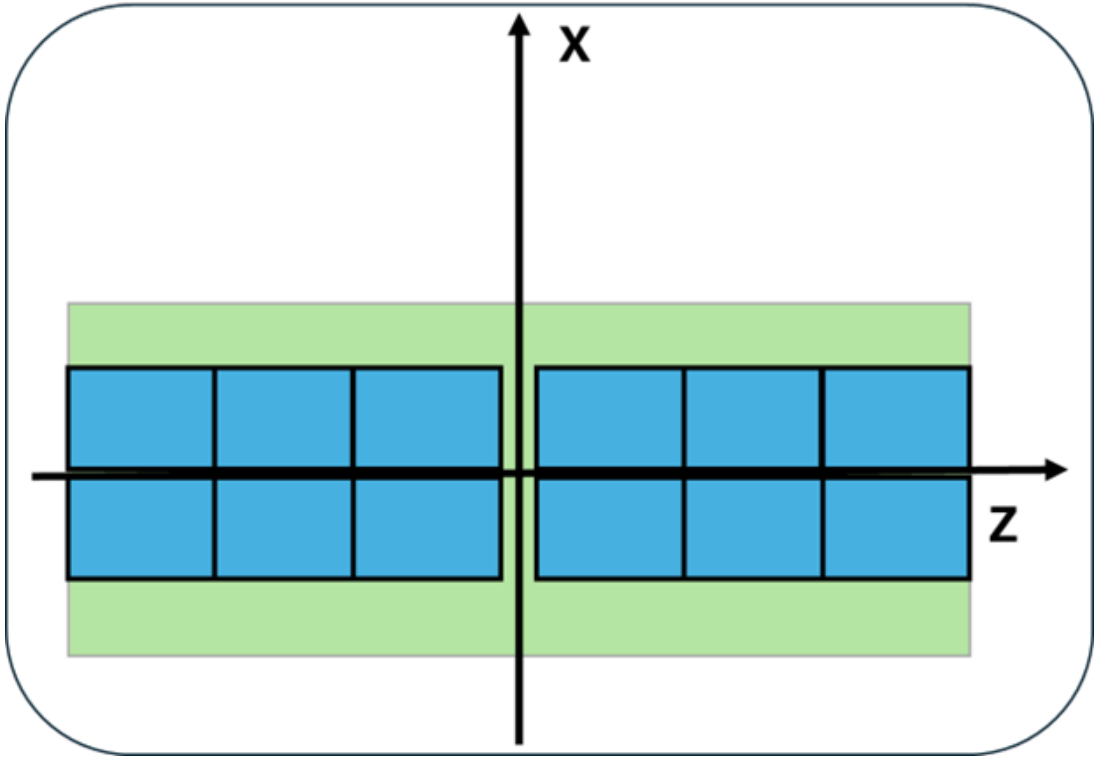
Calculated position

- The detection efficiency in specific segment is defined as
- $\frac{a}{c}$

Calculated position: On the ladder

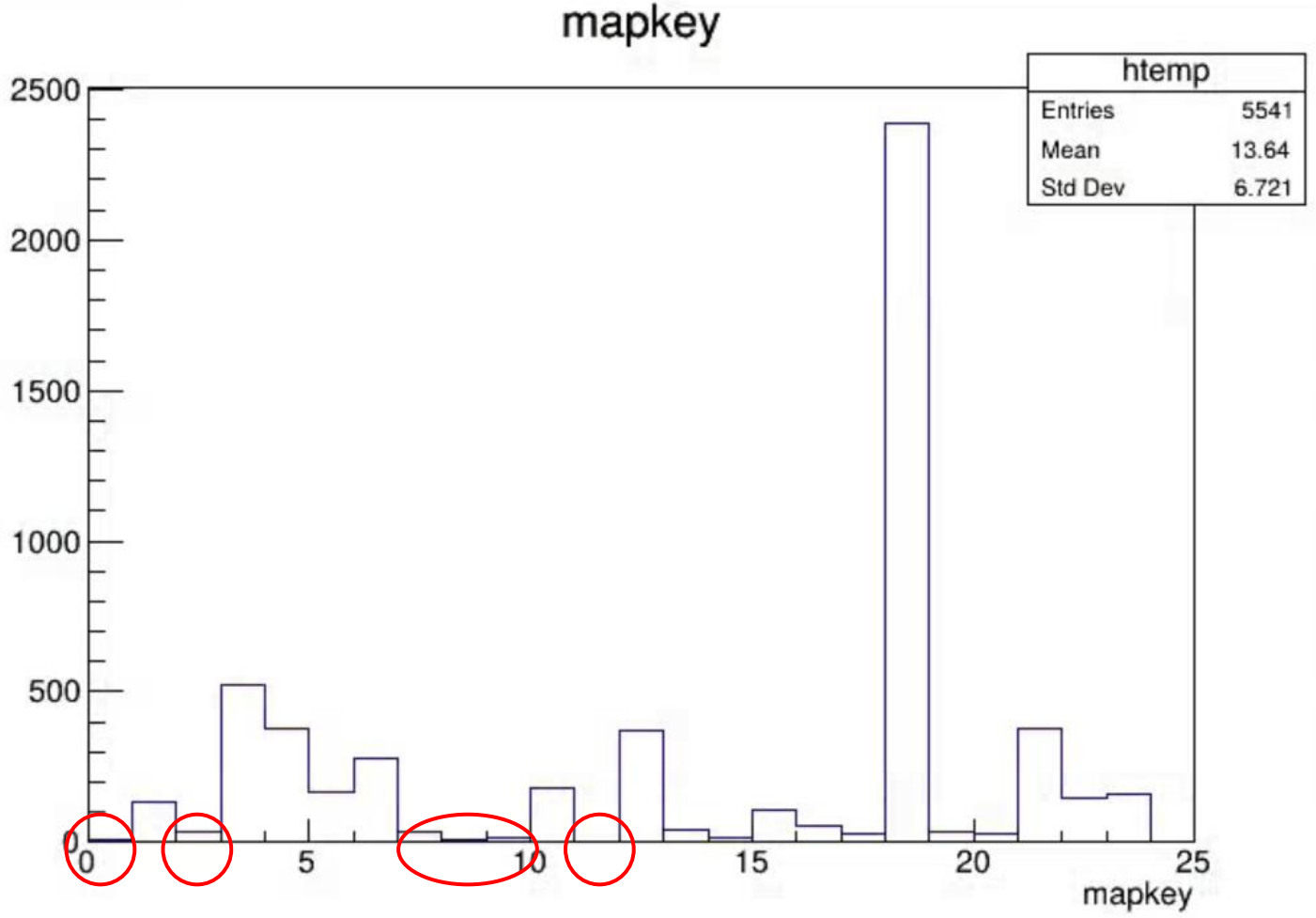
- To overdraw all ladders, I transformed the coordination global to local.
- (ref: CylinderGeomInttHelper…)





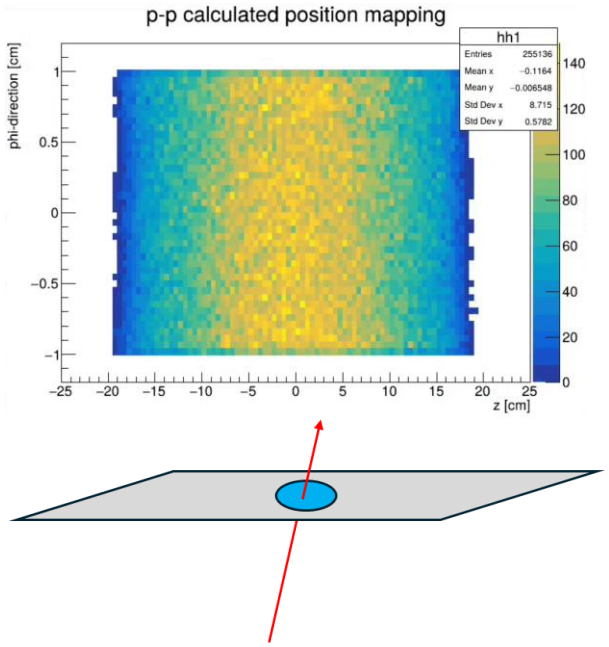
CDB in Run26

- Run26 (AuAu off-field) has CDB deadmap.
- To avoid the effect of dead chip, I selected 6 ladders to calculate the efficiency and compare with pp data.
- 0,2,7,8,9,11



Crossing points mapping on the ladder (p-p)

- These plots shows the crossing points on the ladder



Should be here…

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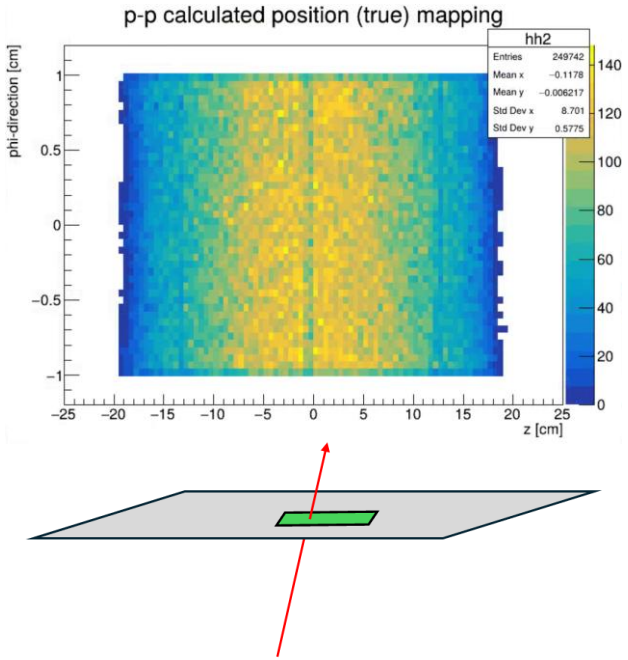
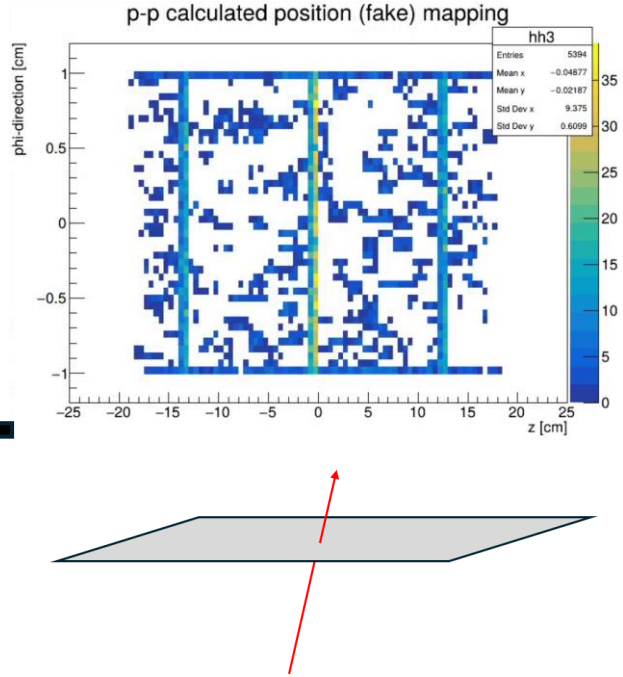


Actually here!

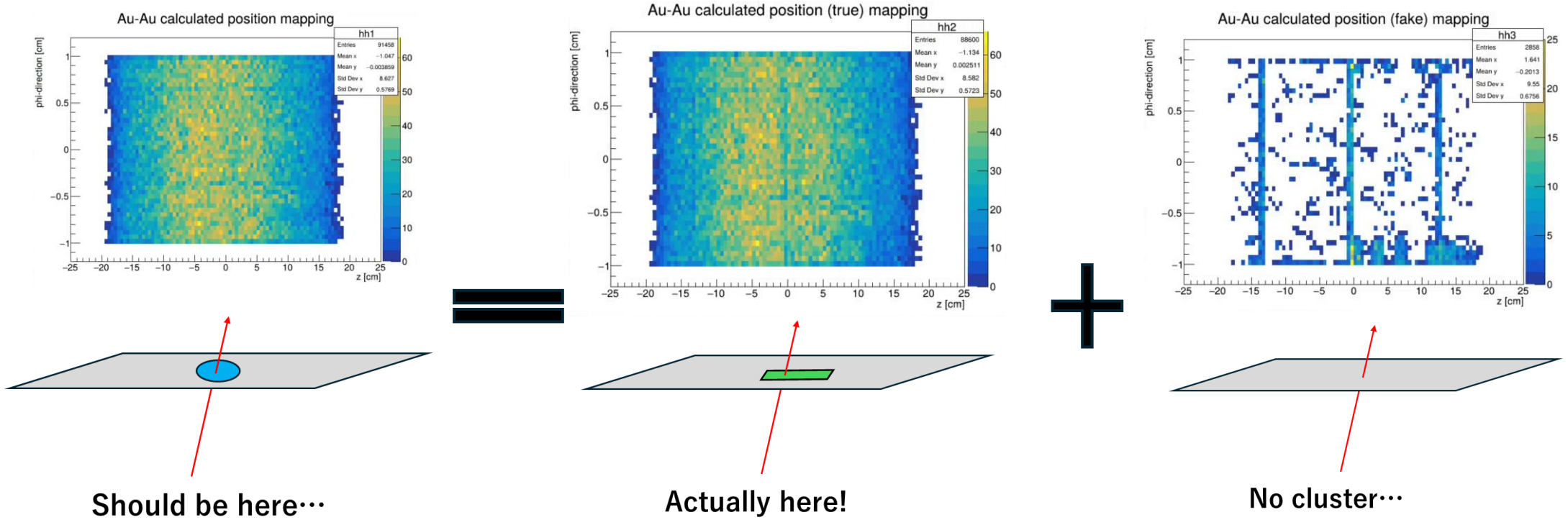
+

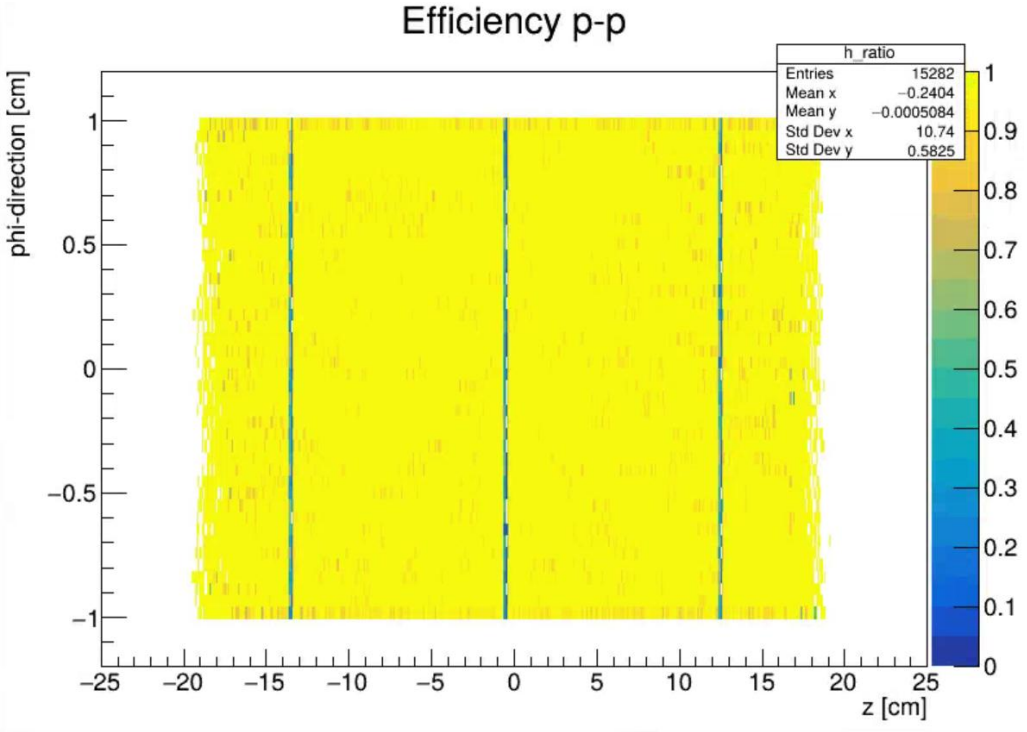


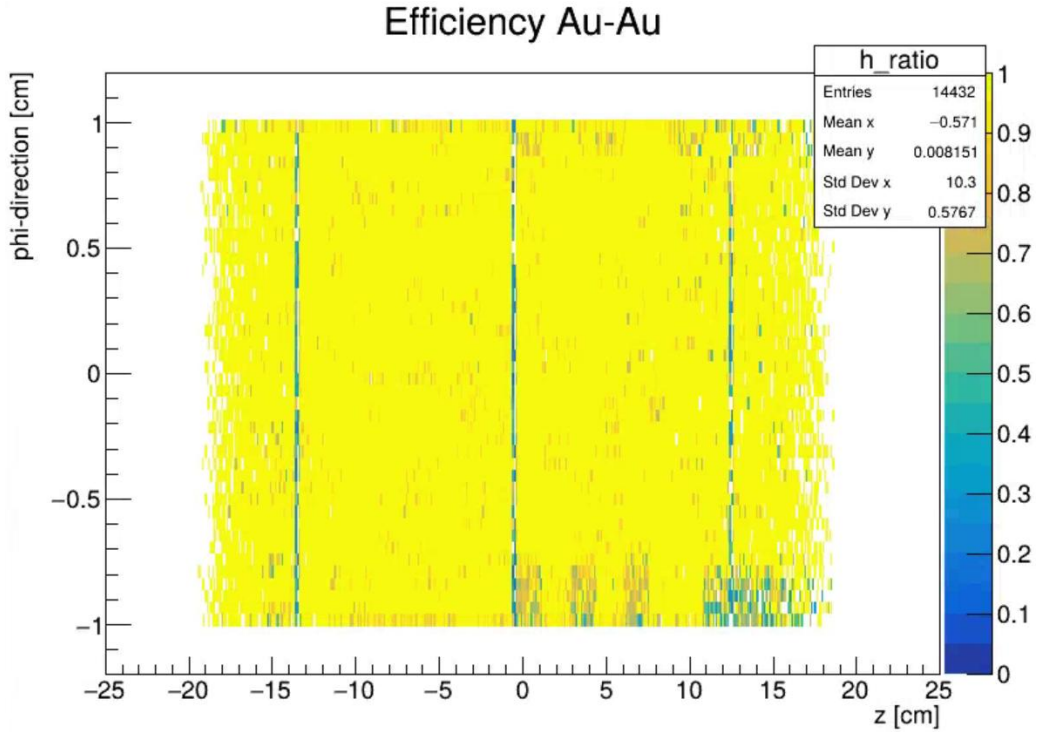
No cluster…

Crossing points mapping on the ladder (Au-Au)

- These plots shows the crossing points on the ladder

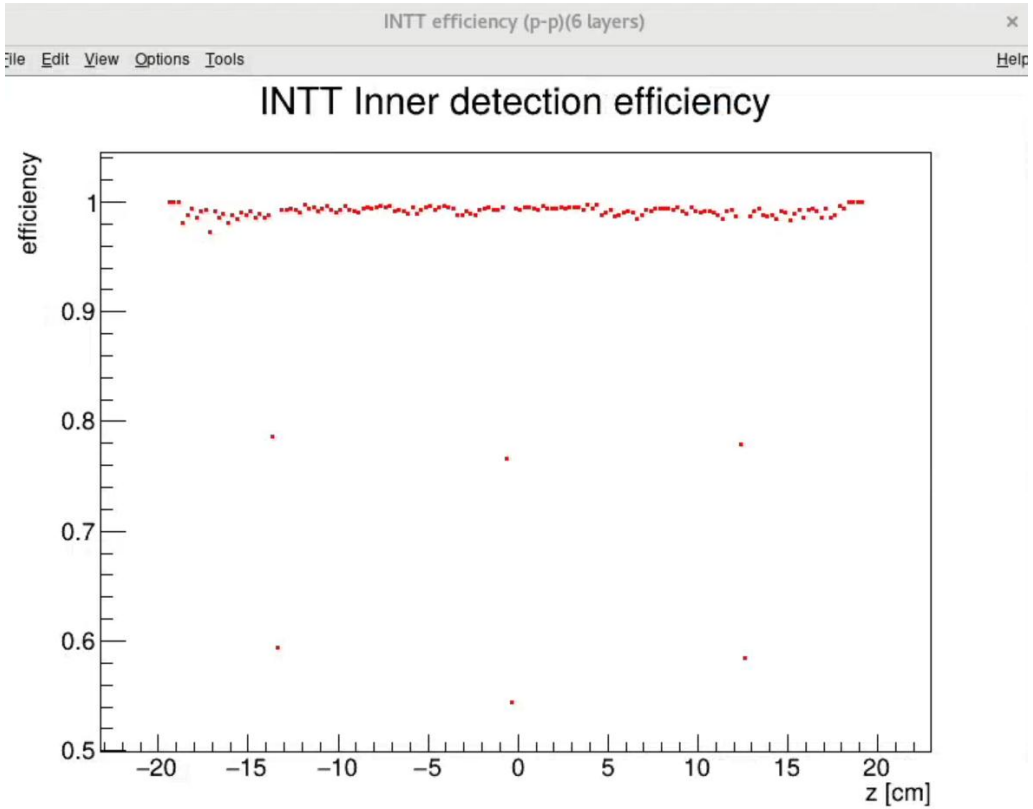


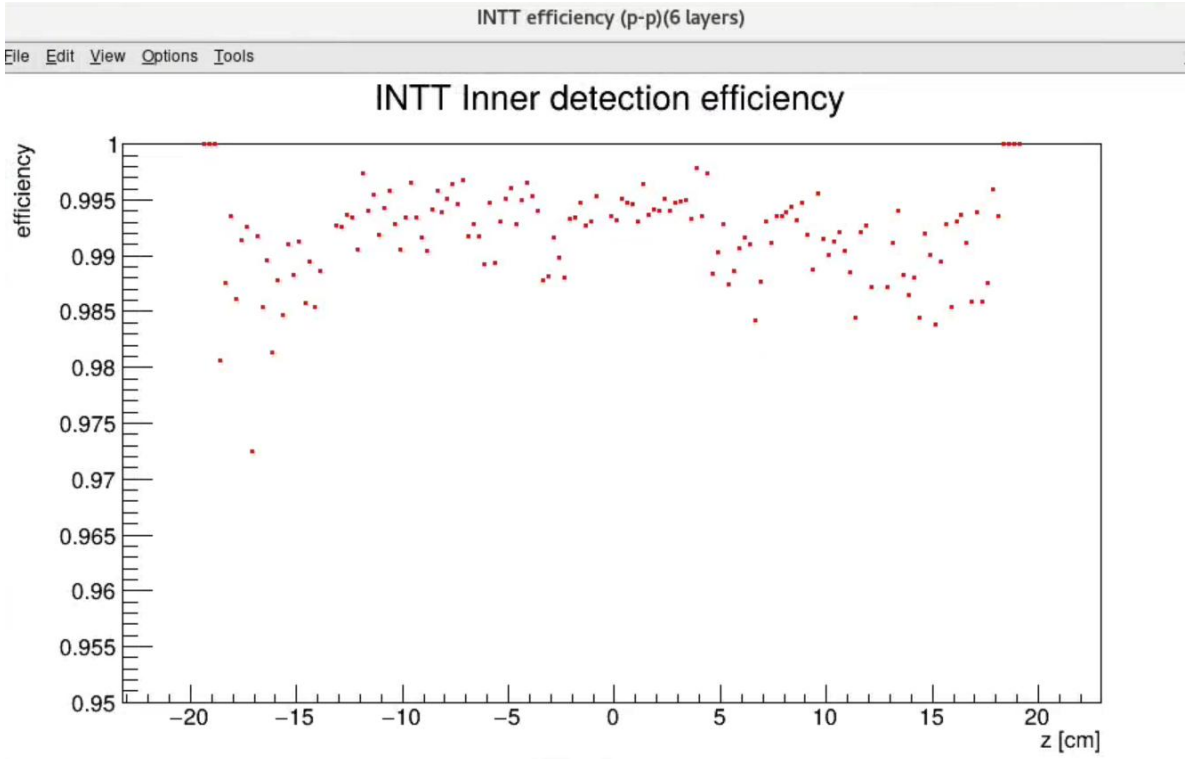




Detection efficiency in 2D plots

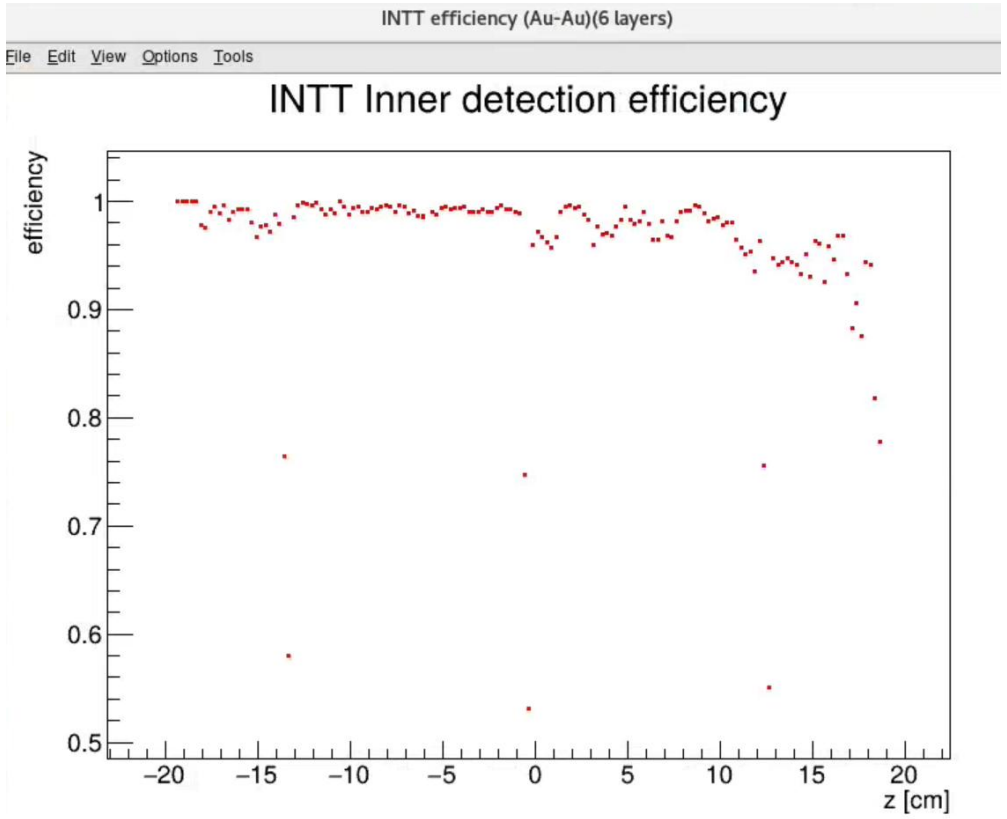
- Right side, you can see the effect of CDB masking.
- The blue lines correspond to the dead area

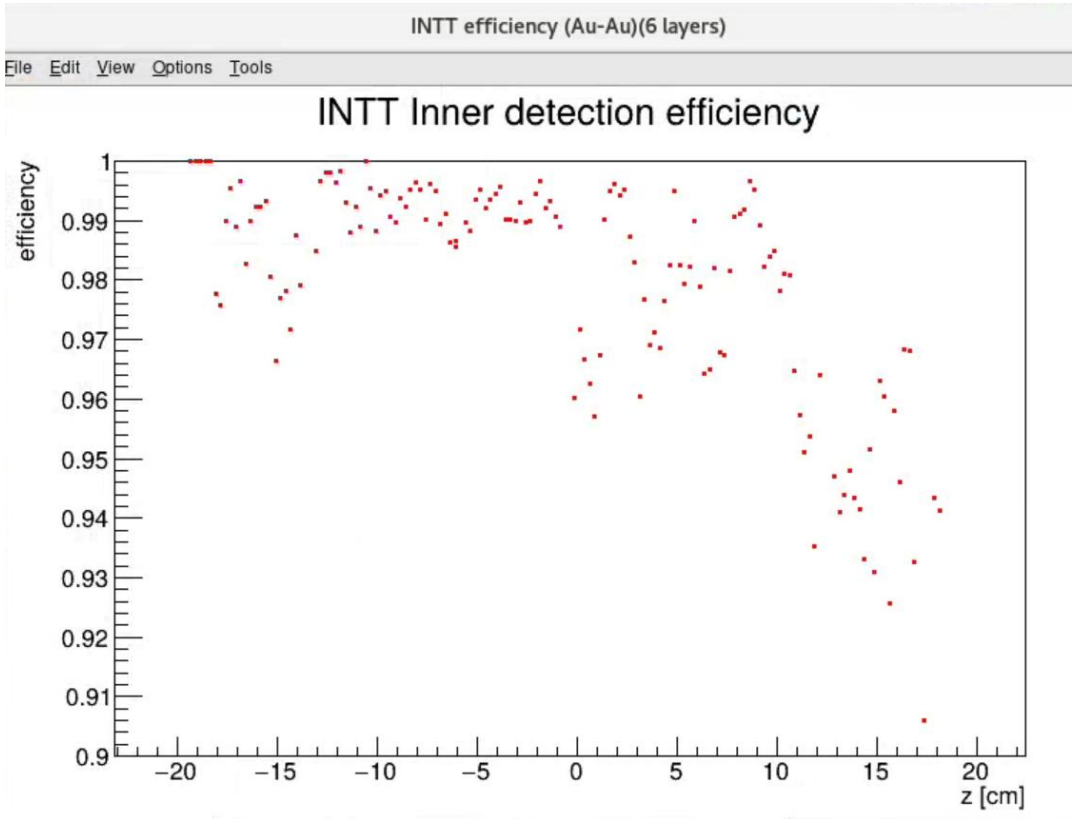




Efficiency: Results (p-p)(z-dependence)

Here is a plot of detection efficiency VS z-position(cm)



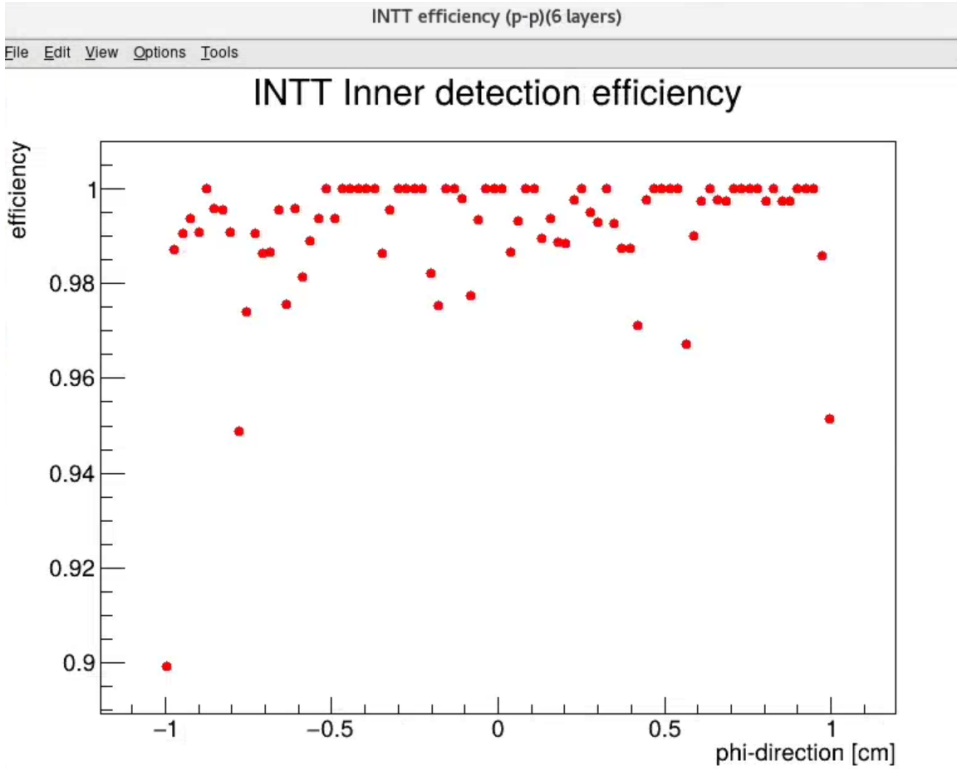


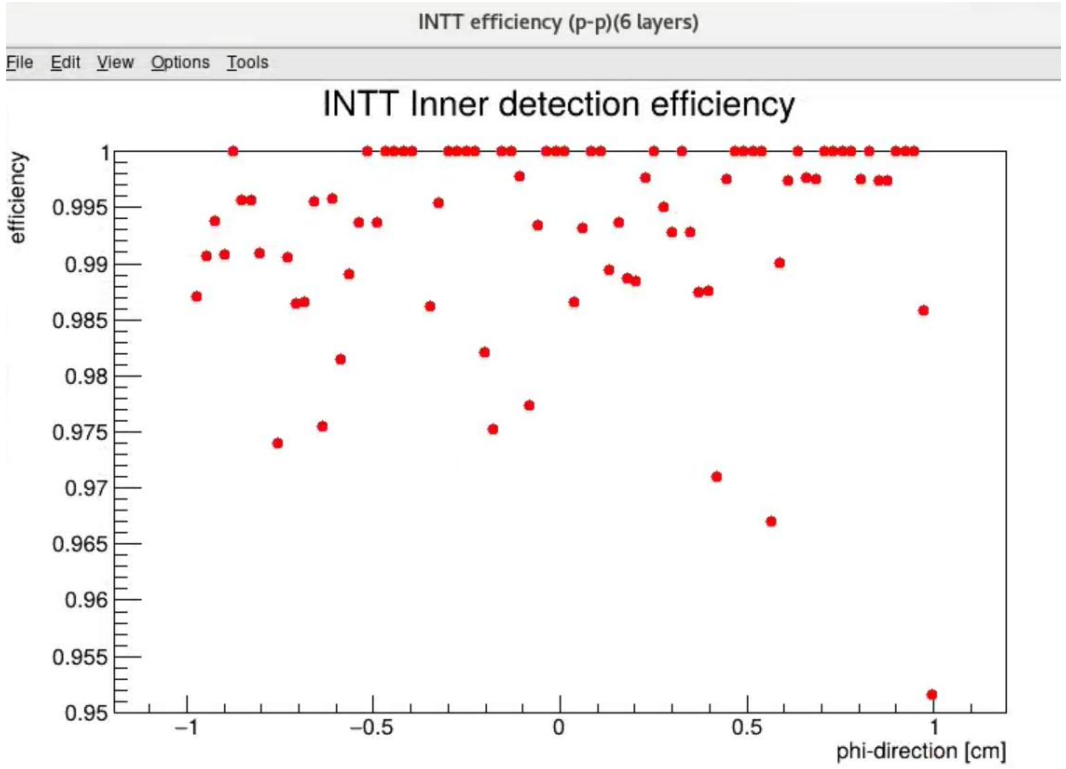
Efficiency: Results (Au-Au)(z-dependence)

Here is a plot of detection efficiency VS z-position(cm)

Efficiency: Results (phi-direction-dependence) (p-p)

- Only Type A area
- Since CDB usually has dead channels in the same chip, from the phi-derection dependence you can see the 100% efficiency in some part.





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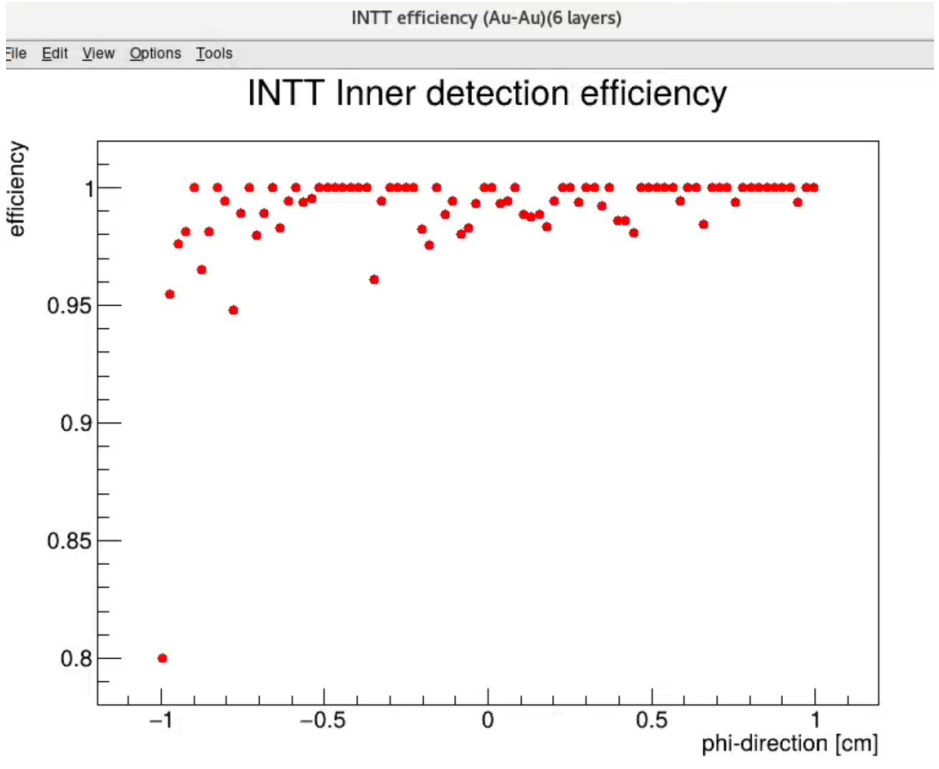
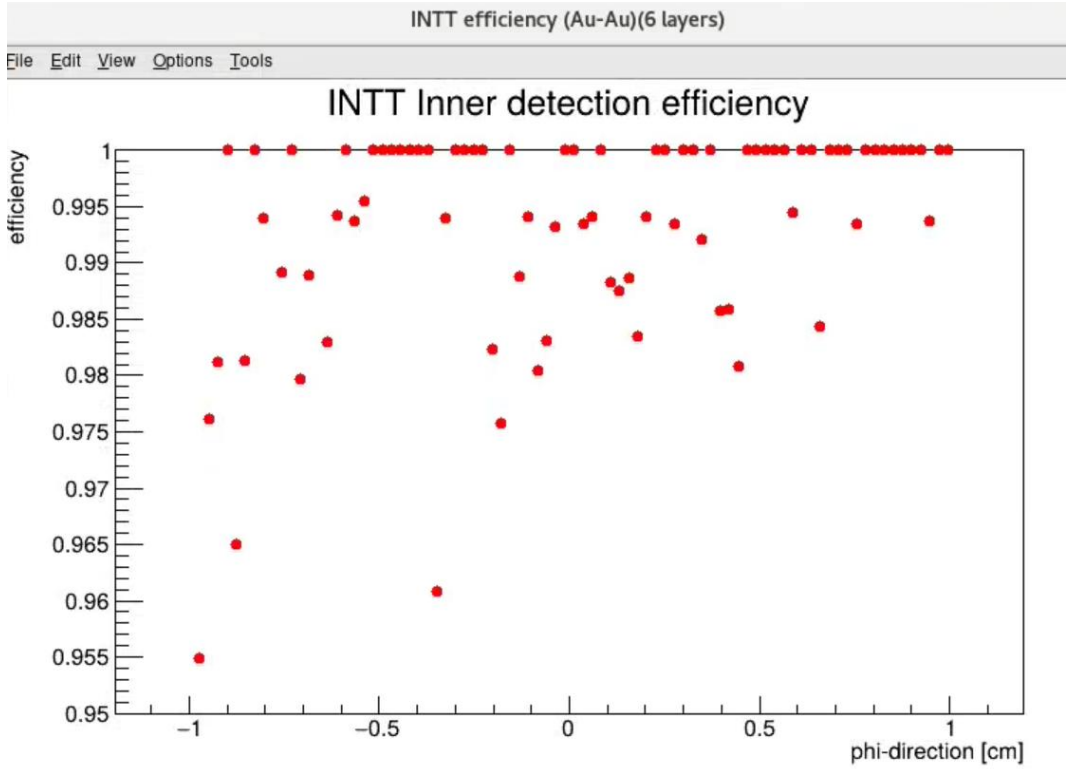
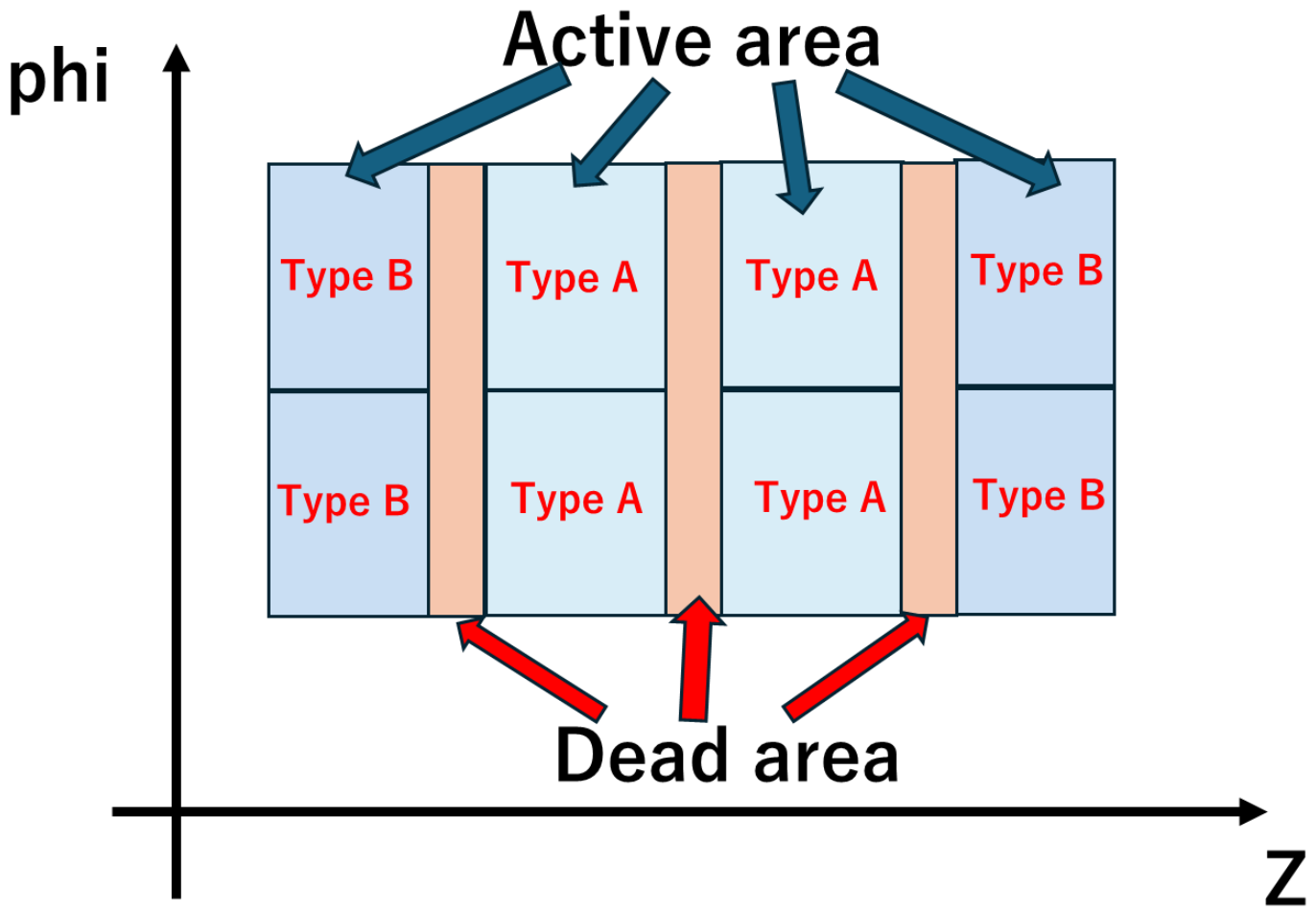




Categorization with the geometry on the ladder

- On the ladder, the calculated position can be categorized in 2 section.



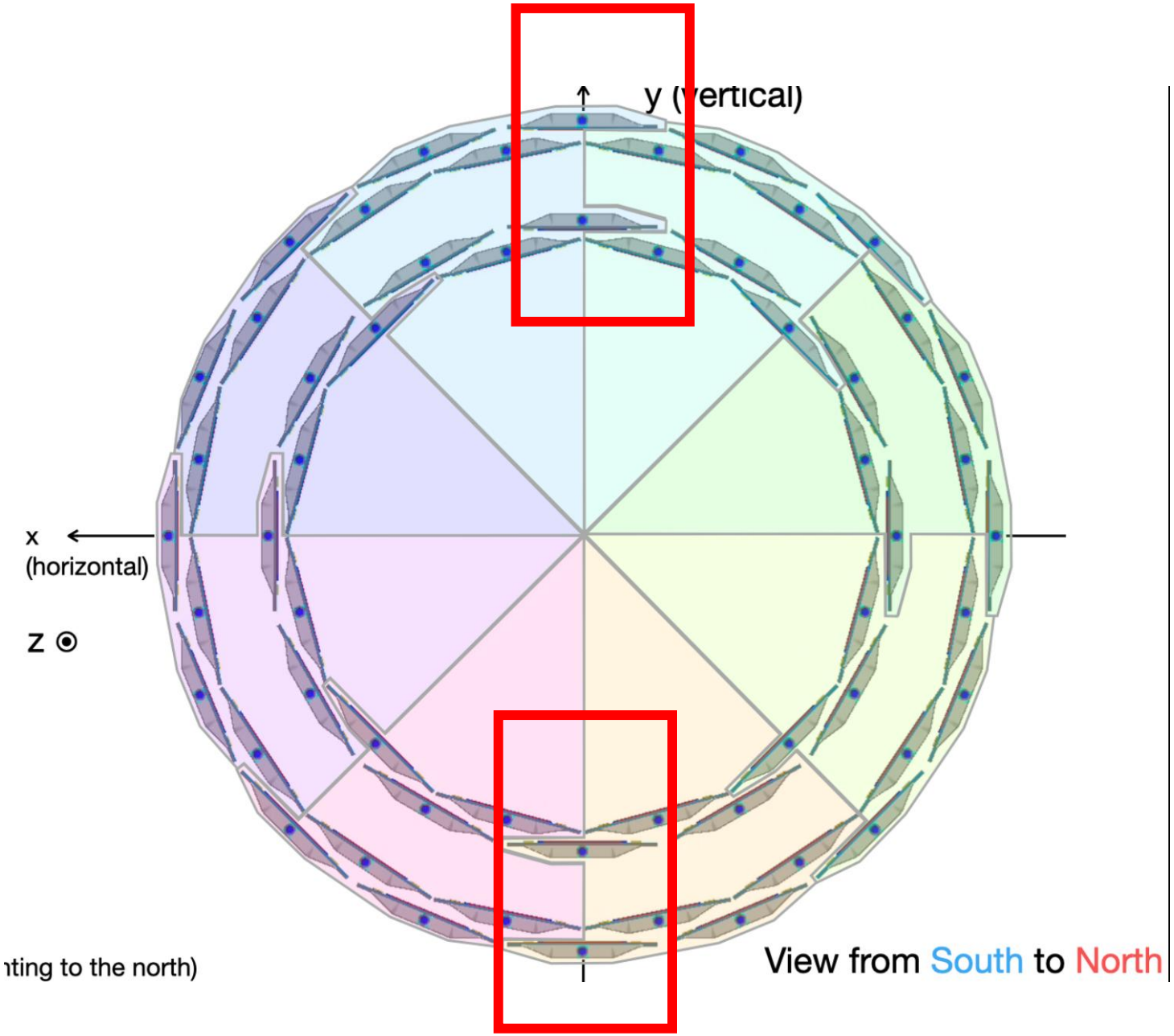
Categorization: Results/total tracks

- Counted points are divided by total tracks
- p-p
  - In active area (6 ladders): 0.2 %
  - Between Type A/B dead area (6 ladders): 0.31 %
  - Passing through (all): 1.89 %
- Au-Au
  - In active area (6 ladders): 0.44 %
  - Between Type A/B dead area (6 ladders): 0.32 %
  - Passing through (all): 1.46 %

- 1 % random dead channels were applied.
  - (p-p) 0.2 $\times 4 = 0.8$ %
  - (Au-Au)0.44 $\times 4 = 1.76$ %

Passing through between the ladders

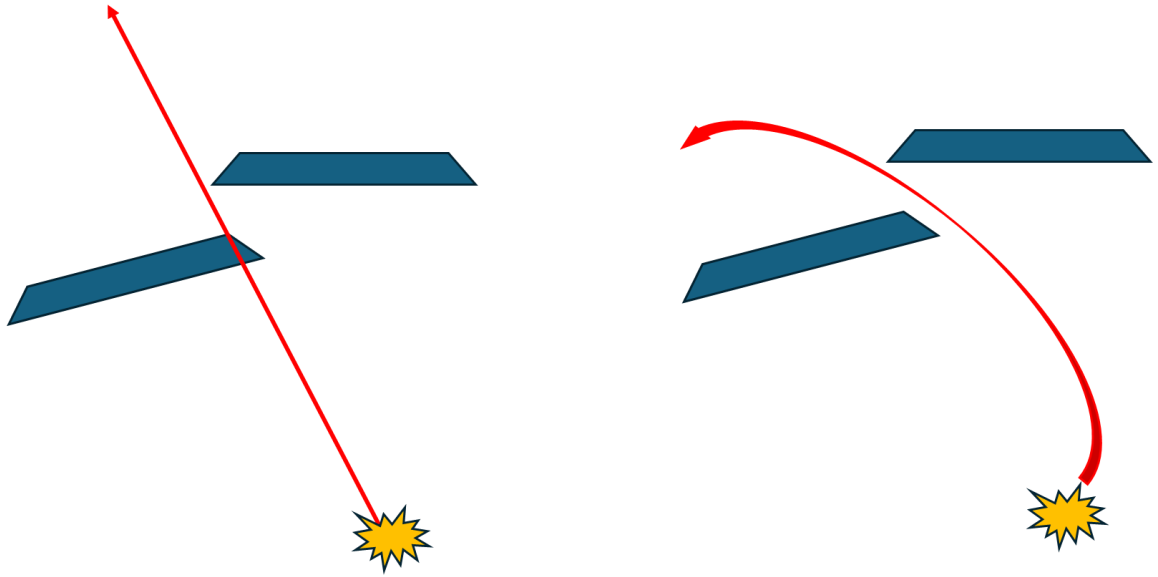
- Between the right barrel and left barrel, there are some gaps which cover about 0.7 % of azimuthal angle.



pT dependence for each categories

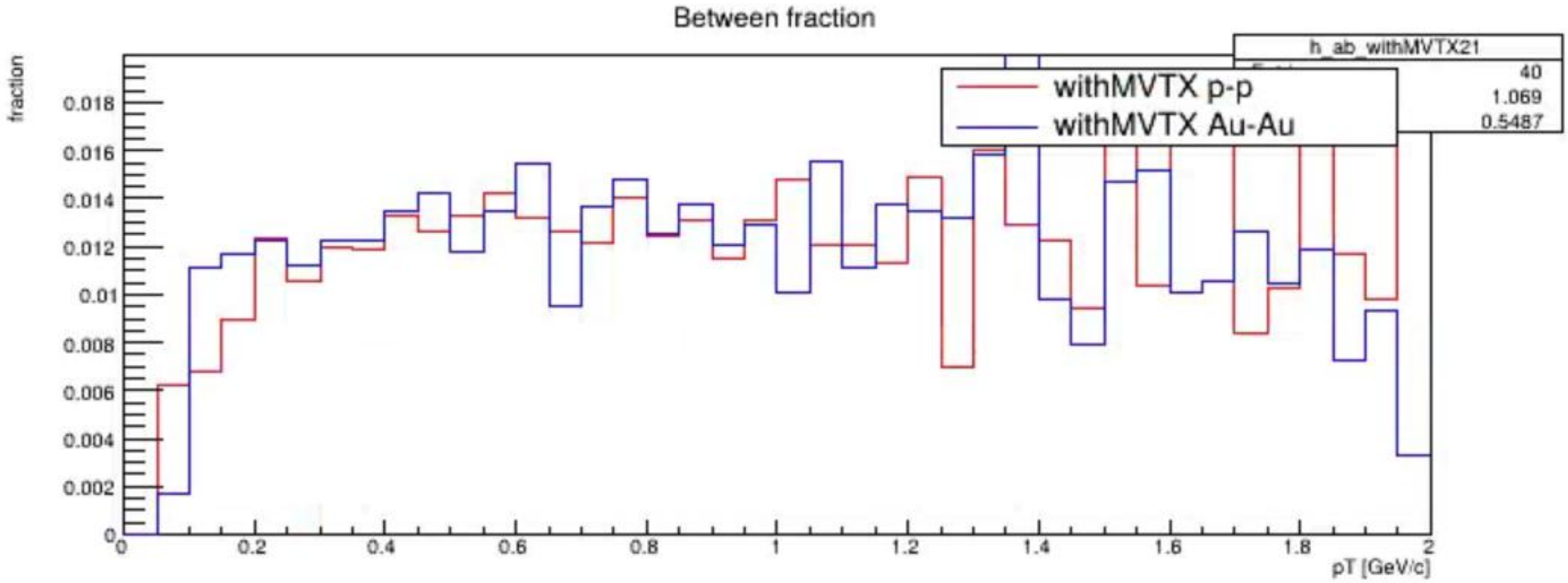
- Some inefficiency, like dead area and passing through tracks can have pT dependence.
- And these effects are expected to be same between the on-field and off field in high pT.

- Especially passing through, low pT particles should have more chance in on-field



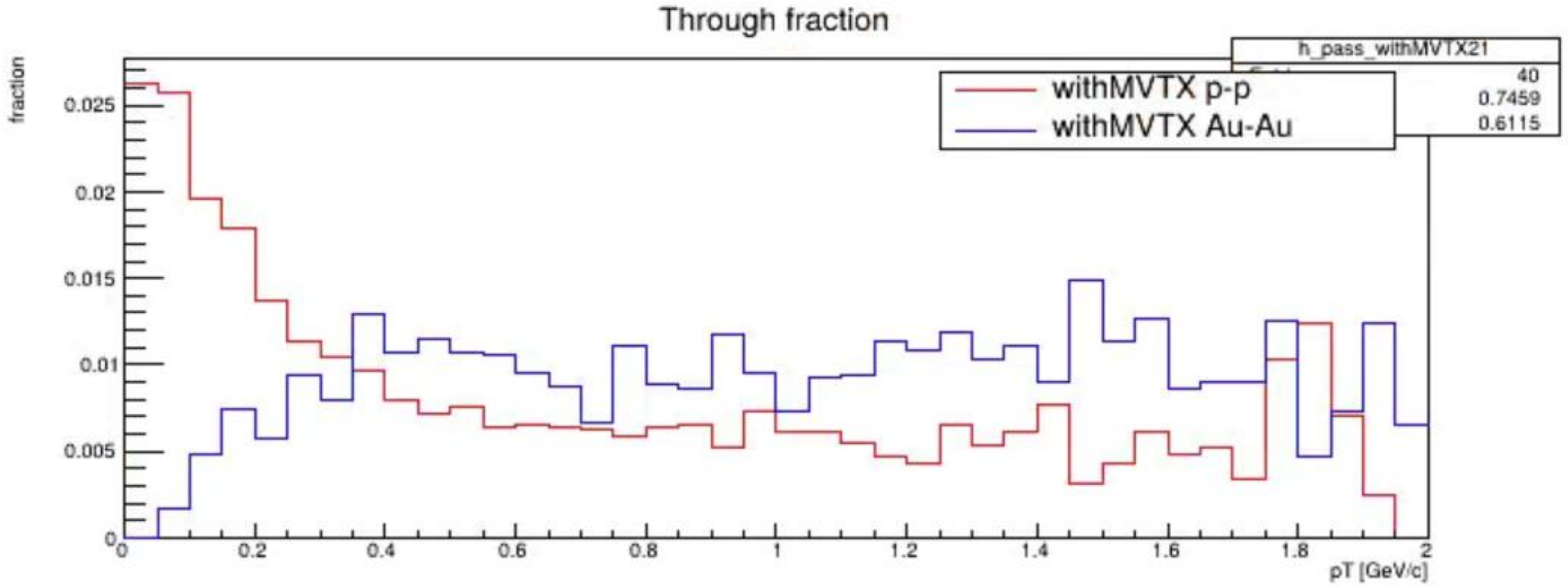
pT dependence: Type A/B dead area

- Both p-p and Au-Au data shows same tendency.
- Low pT has low Type A/B dead area hit.
- I think this is just caused by the bad resolution in pT



pT dependence: Passing through tracks

- P-p(on-field) and Au-Au(off-field) shows opposite effect.
- With magnet, low pT shows high passing through ratio.
- Without magnet, low pT shows low passing through ratio.



Is pT cut needed?

- Some status shows the pT dependence.
- But the most important thing is that low pT tracks have more bigger cluster size.
- That makes it difficult to search the cluster when doing tracking and also make resolution worse.

- At least, in Monte Carlo, pT<0.2~0.4 cut is recommended.

Conclusion

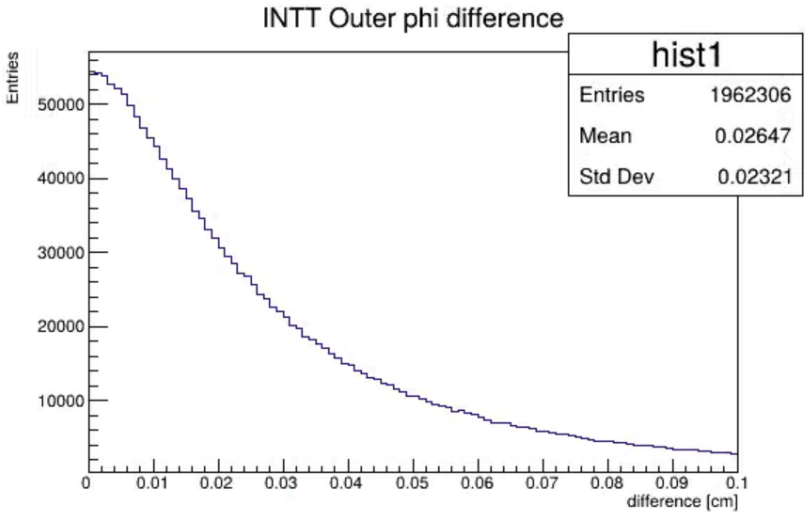
- INTT detection efficiency on active area can be explained by dead area, dead channel, passing through tracks.
- INTT detection efficiency should be calculated with Type A.
  - In simulation, that gives almost 99-100 % efficiency.
- It may be better to cut low pT tracks
  - Low pT (in this, pT<0.2~0.4) can have bigger cluster size, worse resolution, more passing through tracks(on-field).
  - Will make it difficult to search the cluster when doing tracking.

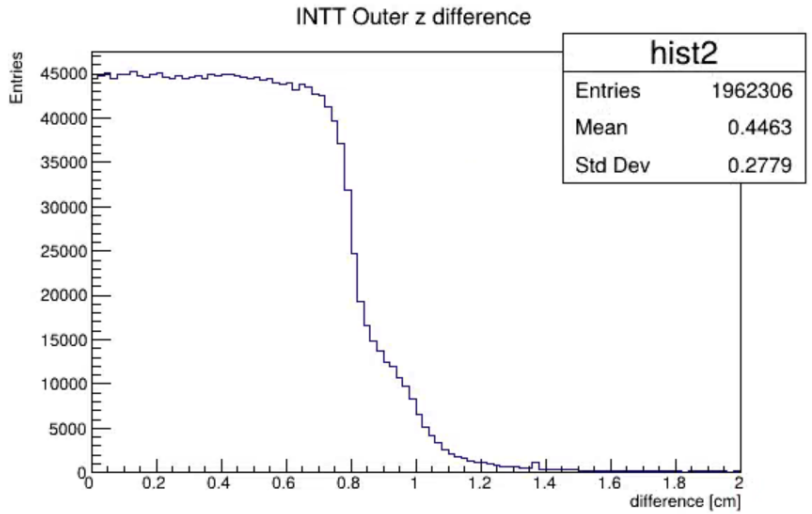
Preliminary request plots

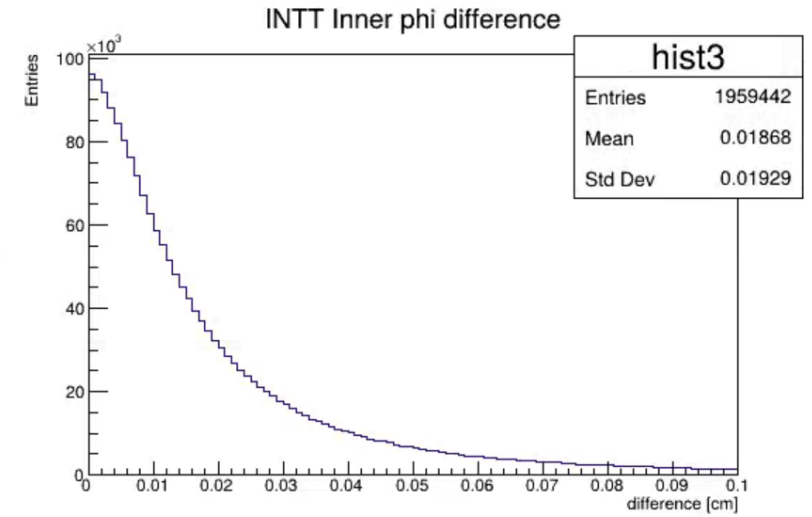
- Difference from truth
- Mapping
- pT vs cluster phi size
- Efficiency
- pT dependence: passing through, Type A/B, dead channel

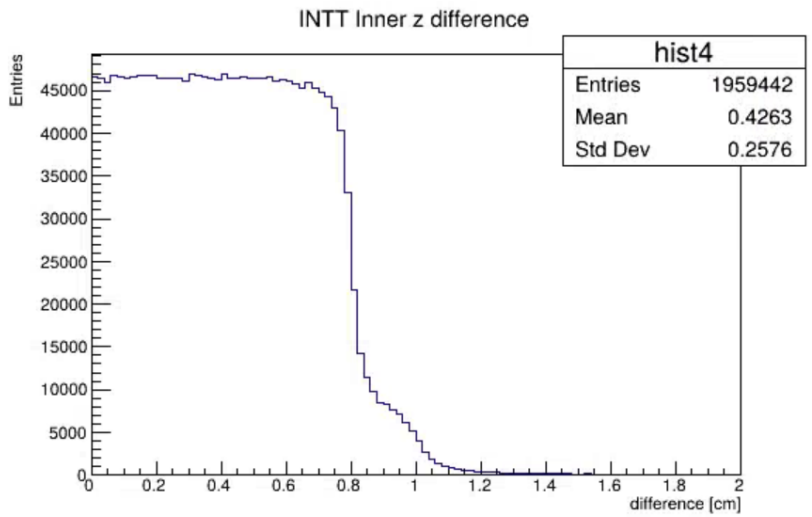
Differences from truth cluster position
INTT Outer/Inner (p-p)

- These plots shows
- “|(INTT Outer calculated position)-(Actually recorded cluster position)|”



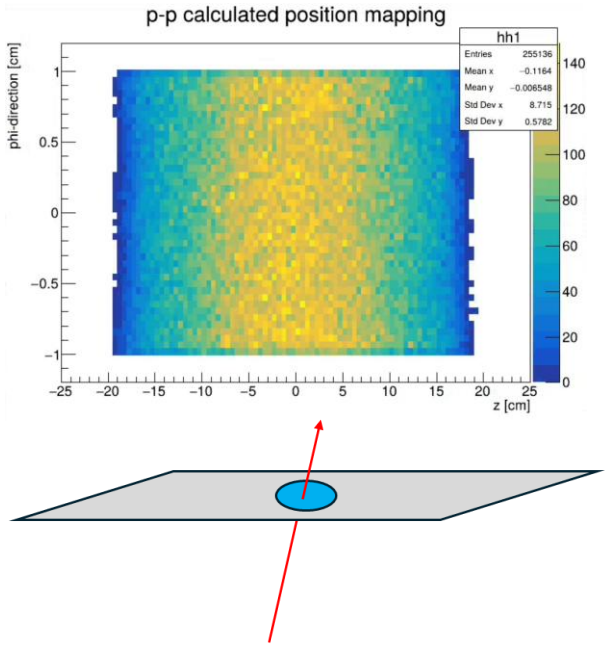






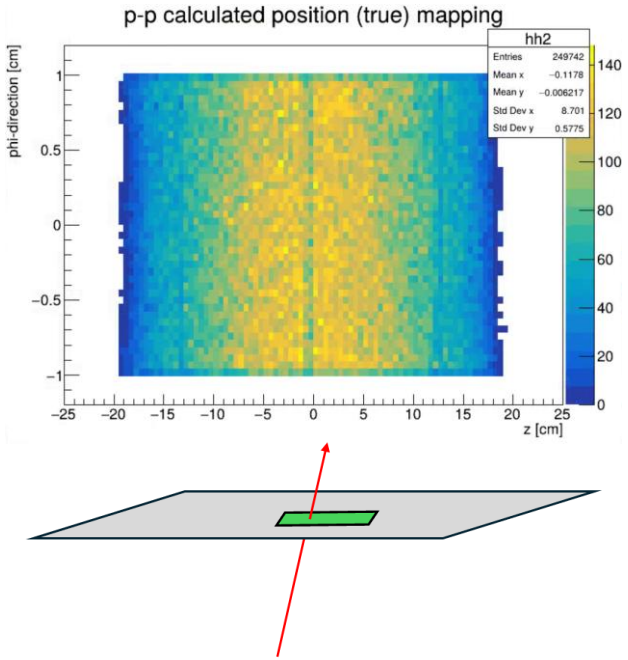
Crossing points mapping on the ladder (p-p)

- These plots shows the crossing points on the ladder



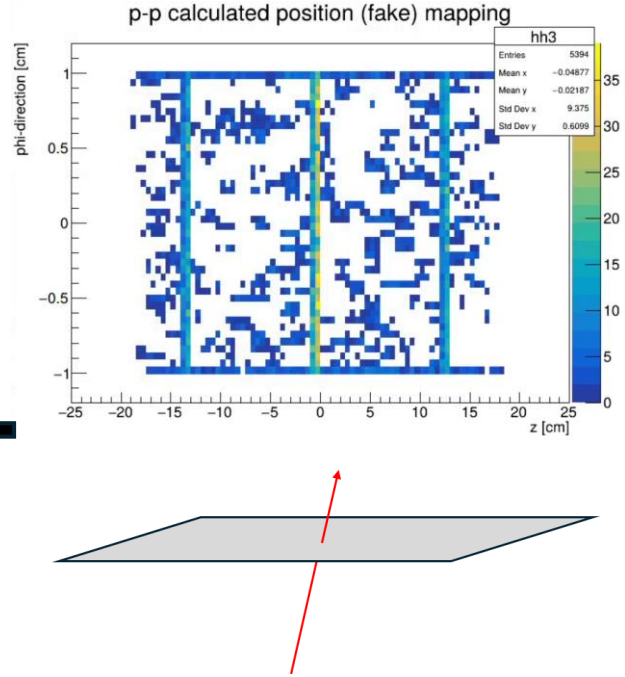
Should be here…

=



Actually here!

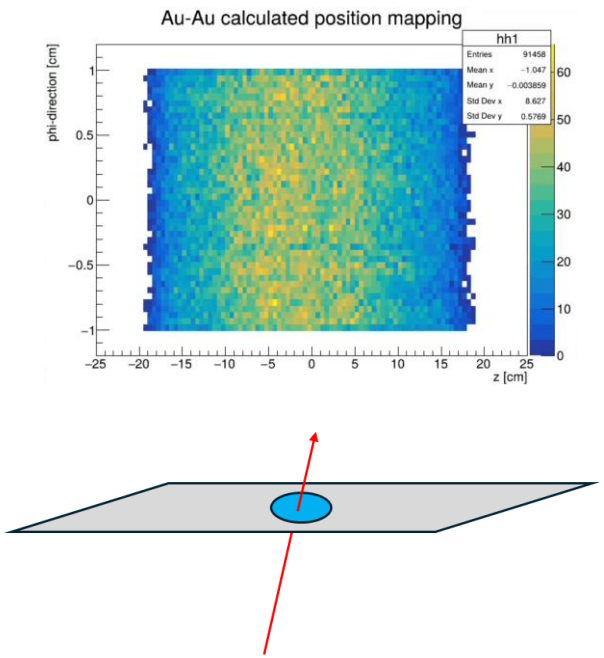
+



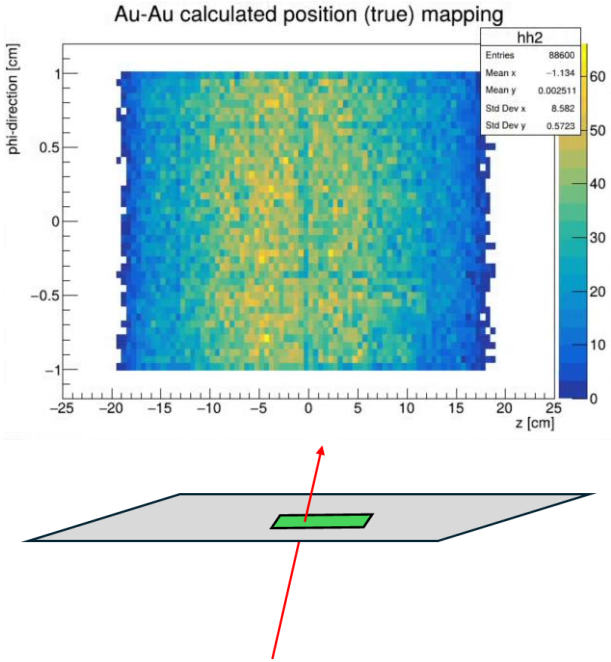
No cluster…

Crossing points mapping on the ladder (Au-Au)

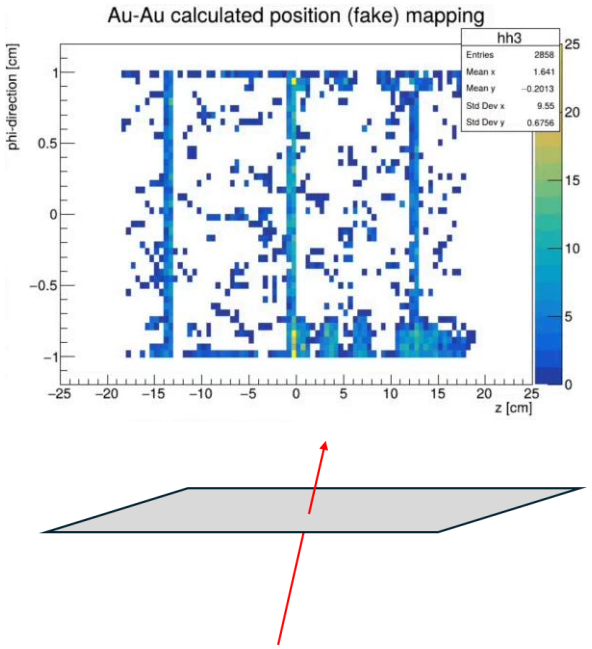
- These plots shows the crossing points on the ladder



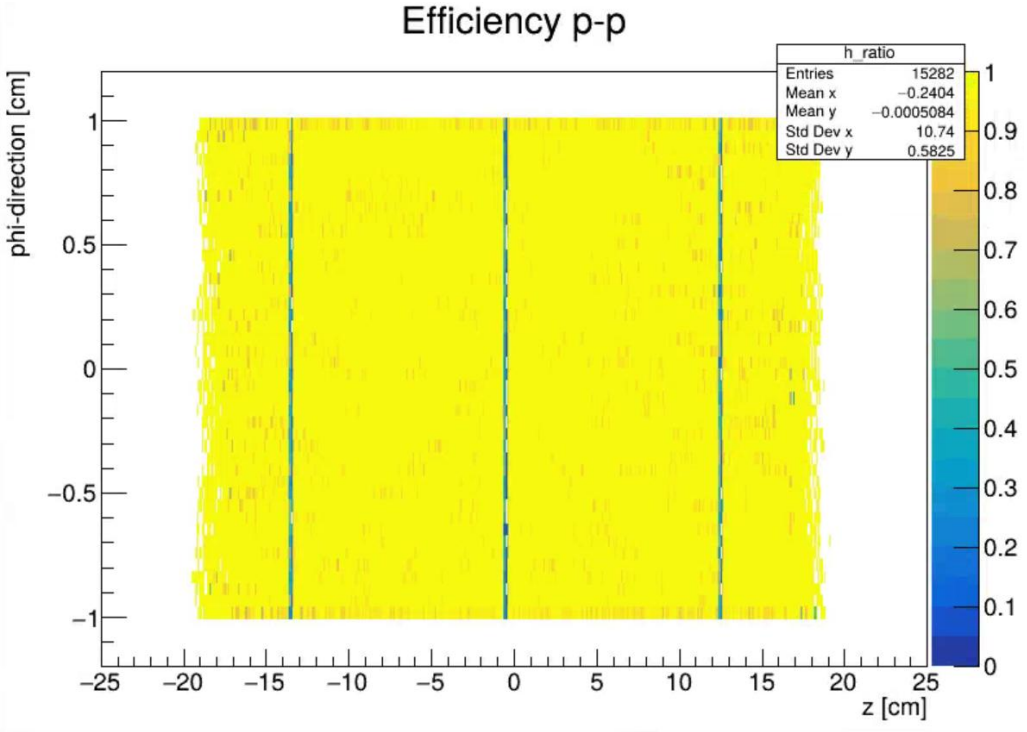
Should be here…

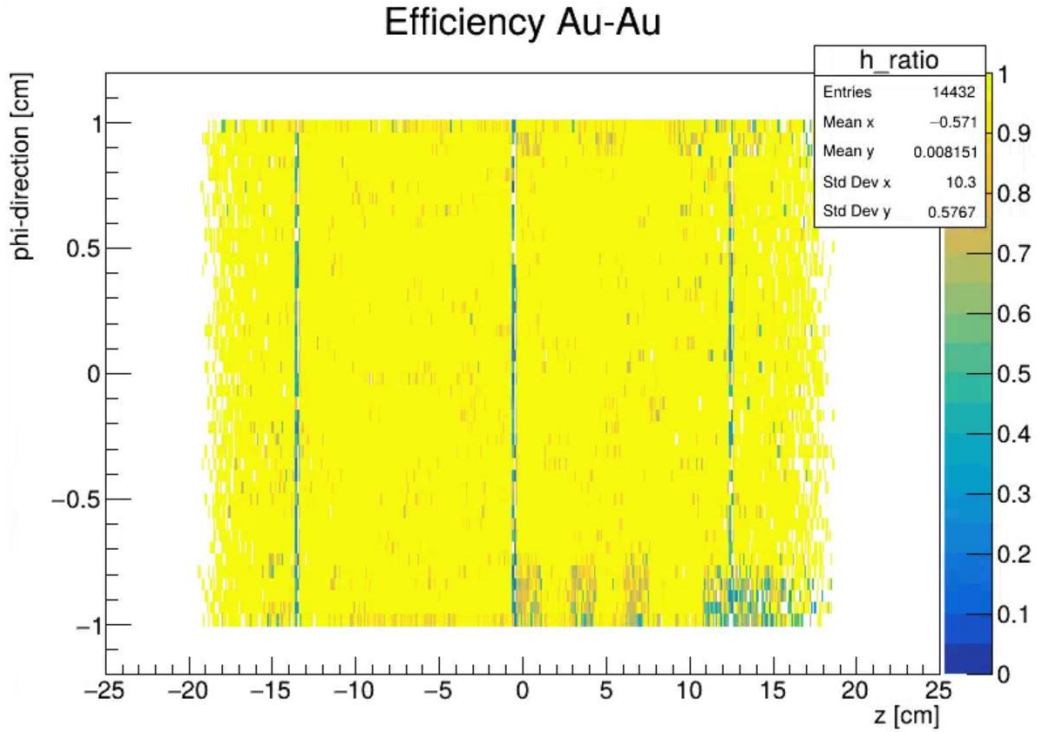


Actually here!



No cluster…



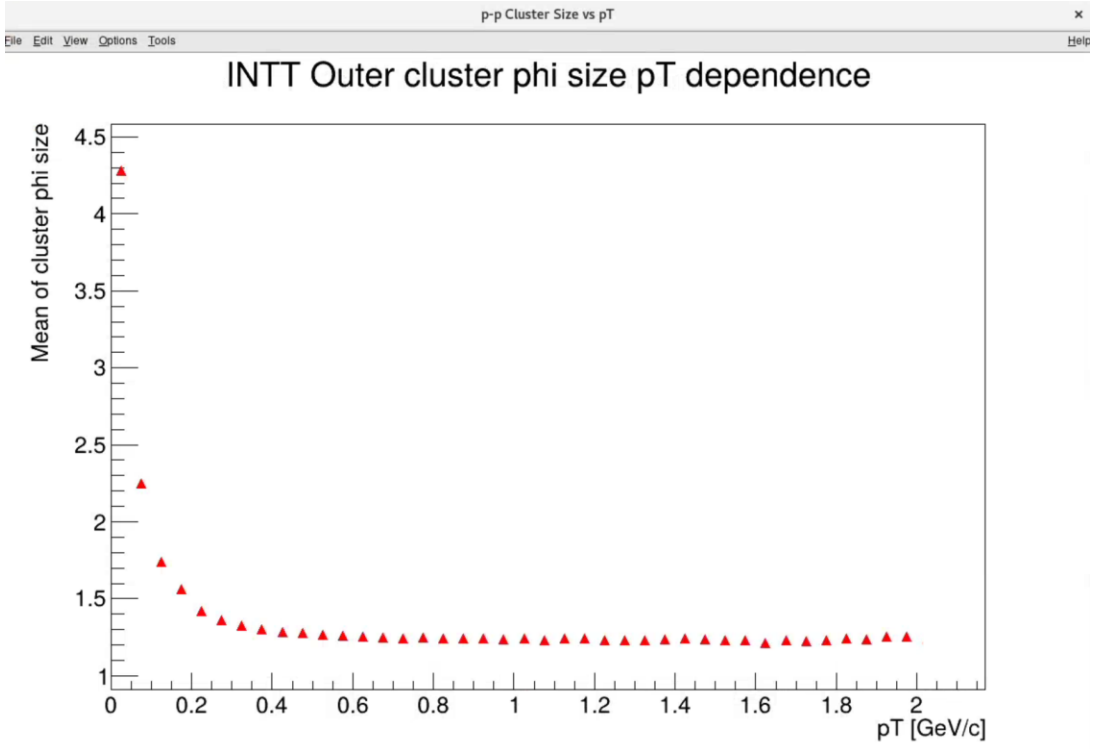


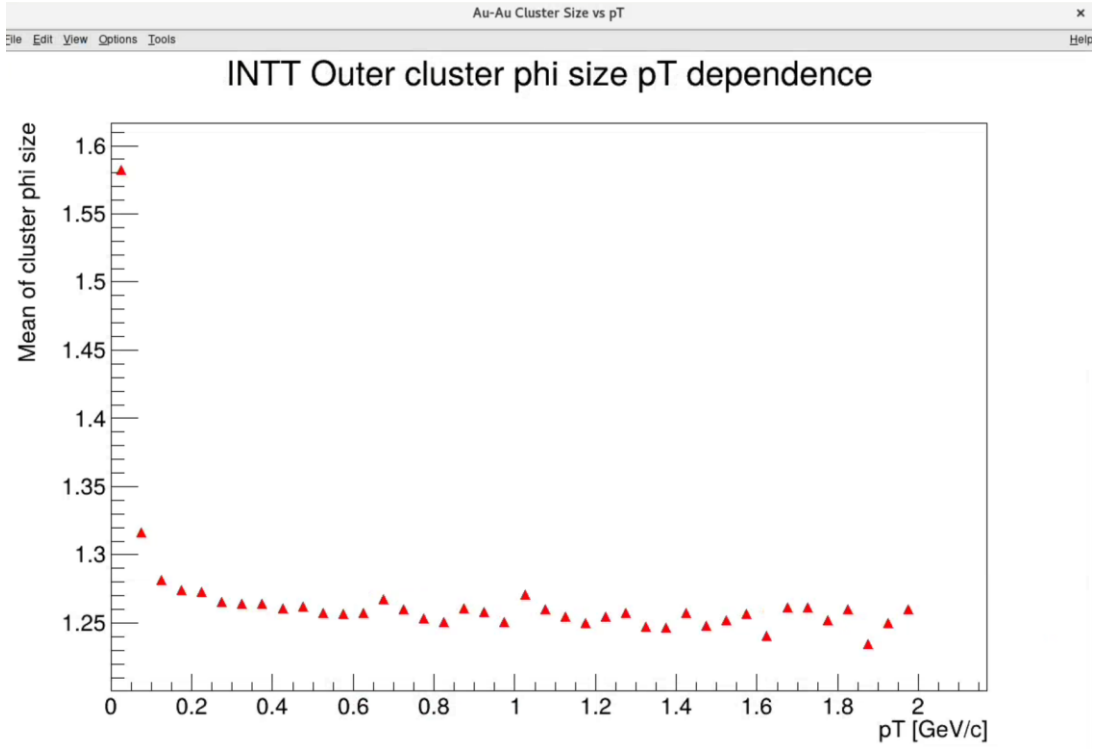
Detection efficiency in 2D plots

- Right side, you can see the effect of CDB masking.
- The blue lines correspond to the dead area

What caused it?

- Here's the pT dependence of mean cluster phi size.
- Especially under 0.2 pT have big cluster size and that seems to correspond to the pT dependence of difference.





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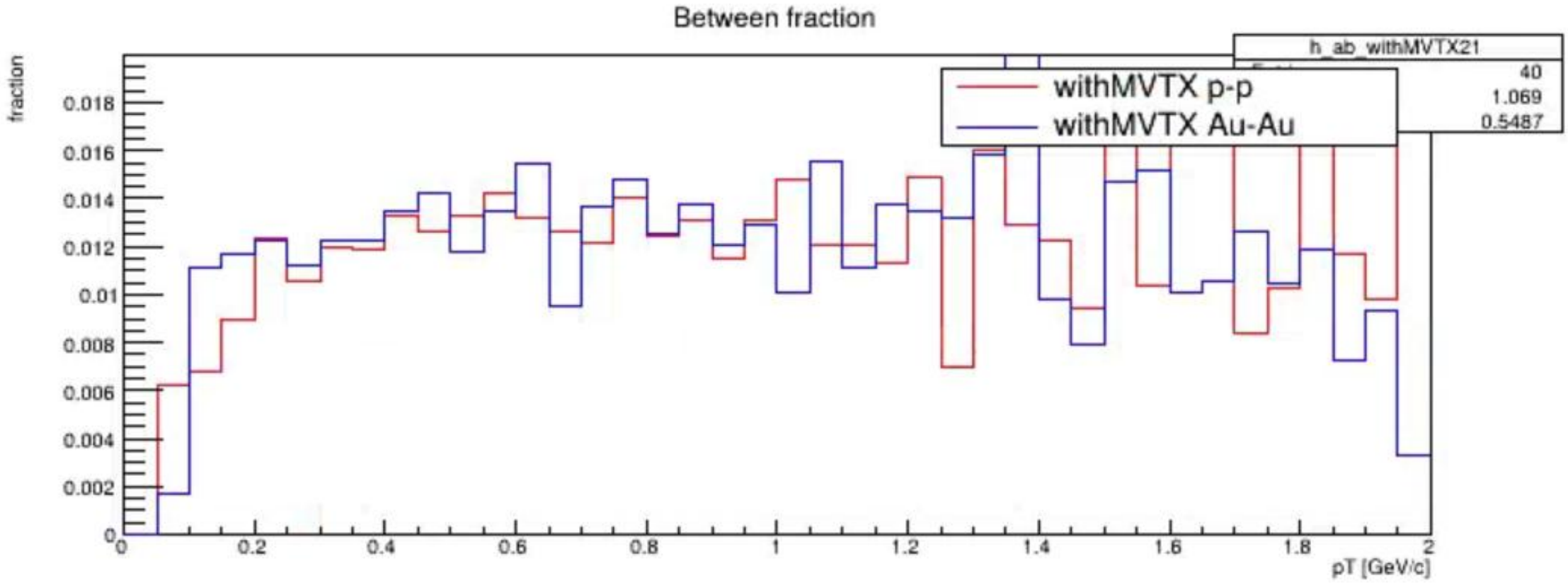

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