INTT hit detection efficiency (IS)

2025/08/28 Takahiro Kikuchi

Abstract of my poster

- My G4 simulation study is focusing on “preparing the answer sheet for silicon seeding”.
- Basically, what I did with G4 truth value can be replaced by SvtxTrack value.

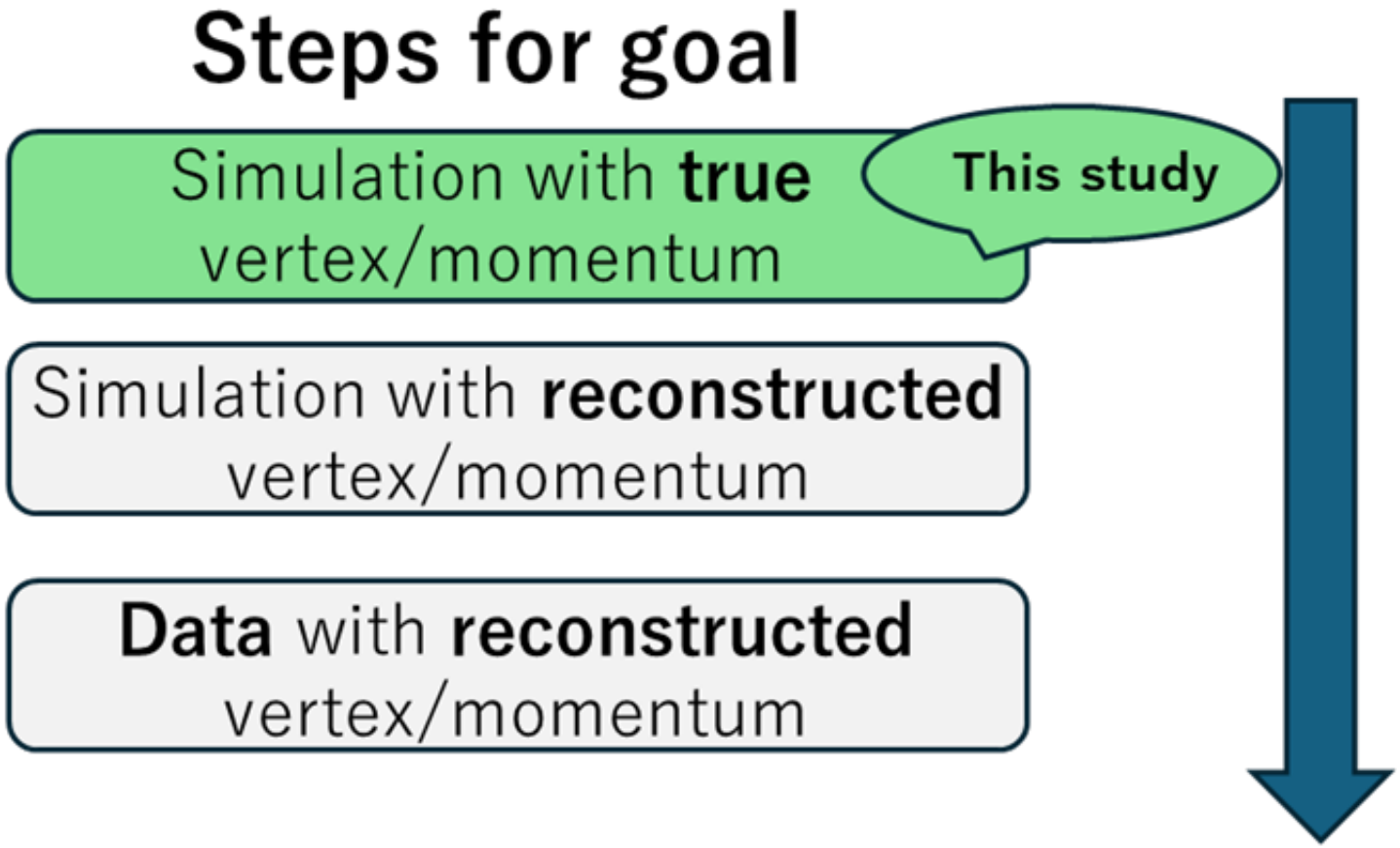


Figure 5: Analysis flowchart

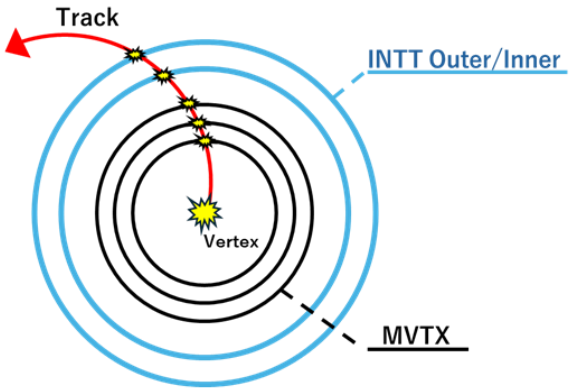


Figure 6: Tracking with INTT and MVTX

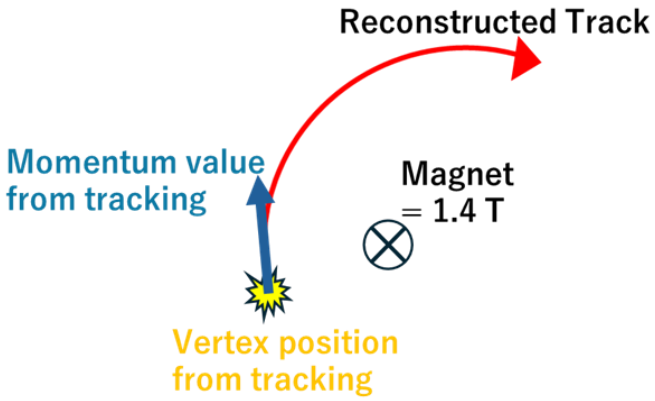


Figure 7: Draw reconstructed track

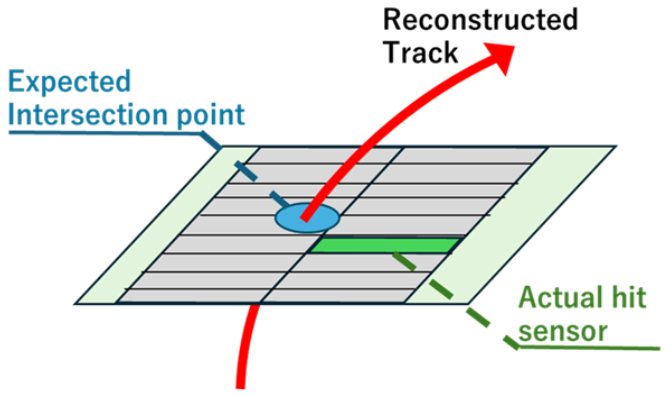


Figure 8: Intersection point on the ladder

How to

- To estimate the detection efficiency, drawing the track and calculate the intersection point is needed to evaluate the dead area.
- With silicon seeding, that can be done with vertex/momentum value from svtxtrack.

Compatibility

- G4Truth value also have vertex/momentum true value.
- But those value don't promise that particles didn't scatter and go somewhere else.
- That's why I calculate the residual between the true and calculated INTT Outer cluster position.
  - I don't want to touch MVTX data in this step so only INTT Outer

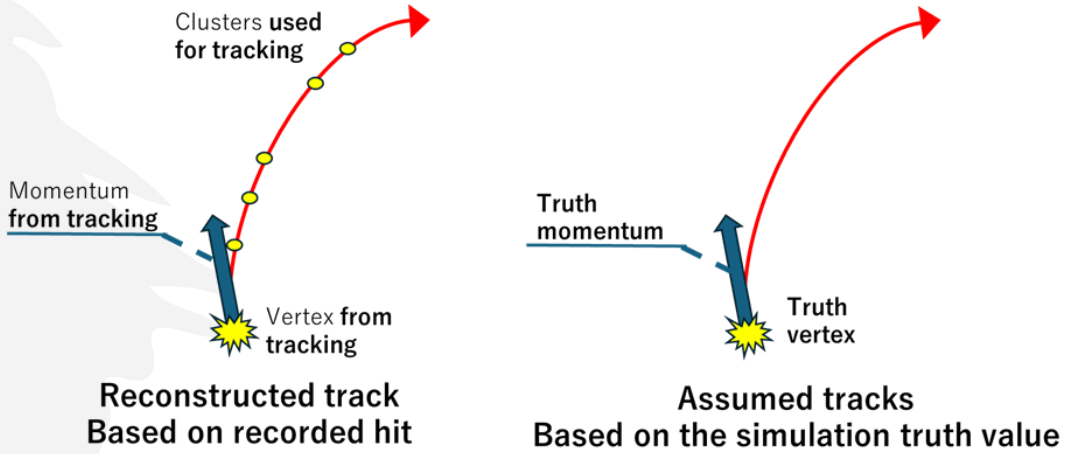


Figure 9: Compatibility of track vertex/momentum

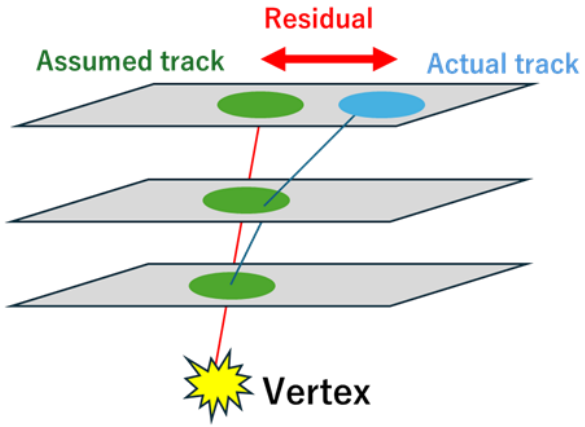


Figure 12: Residual from scattering

Goal

- The goal of this study with G4Truth is guarantee everything looks reasonable with the way drawing track from vertex/momentum.
  - Geometry acceptance
  - Efficiency on the active area

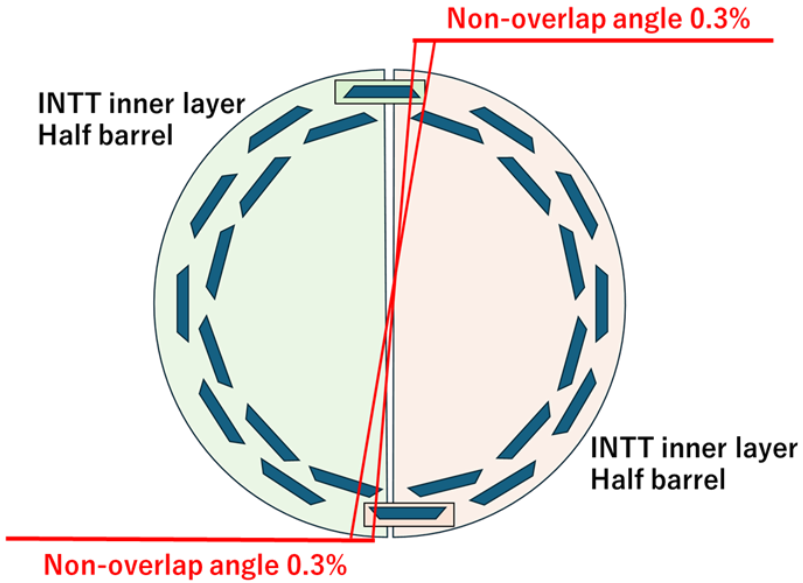


Figure 3: INTT inner barrel geometry

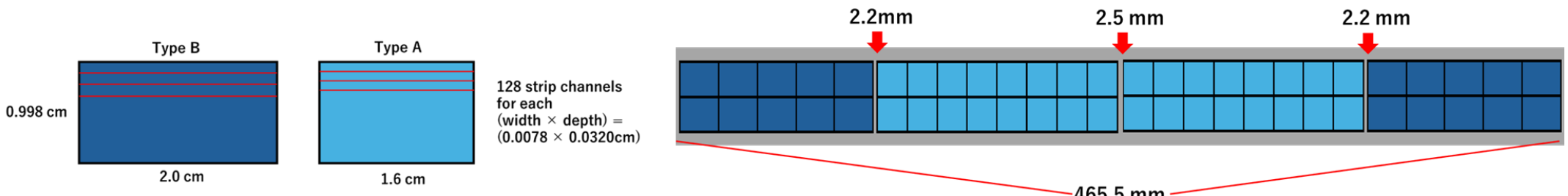


Figure 4: INTT ladder geometry

Preliminary

- Calculated intersection position
- Have hits
- Don’t have hits

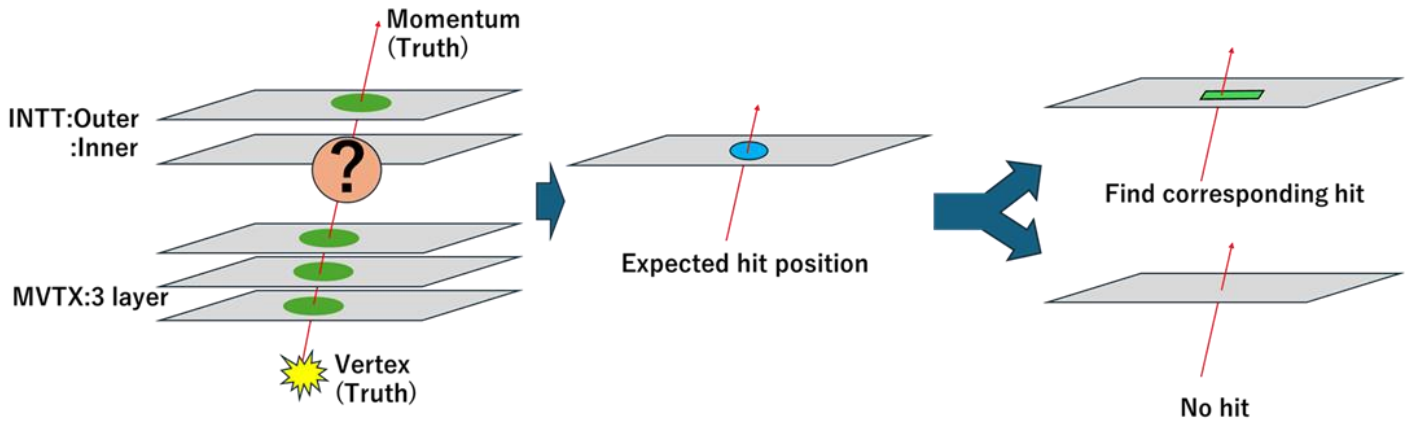


Figure 10: Search hits near the intersection point

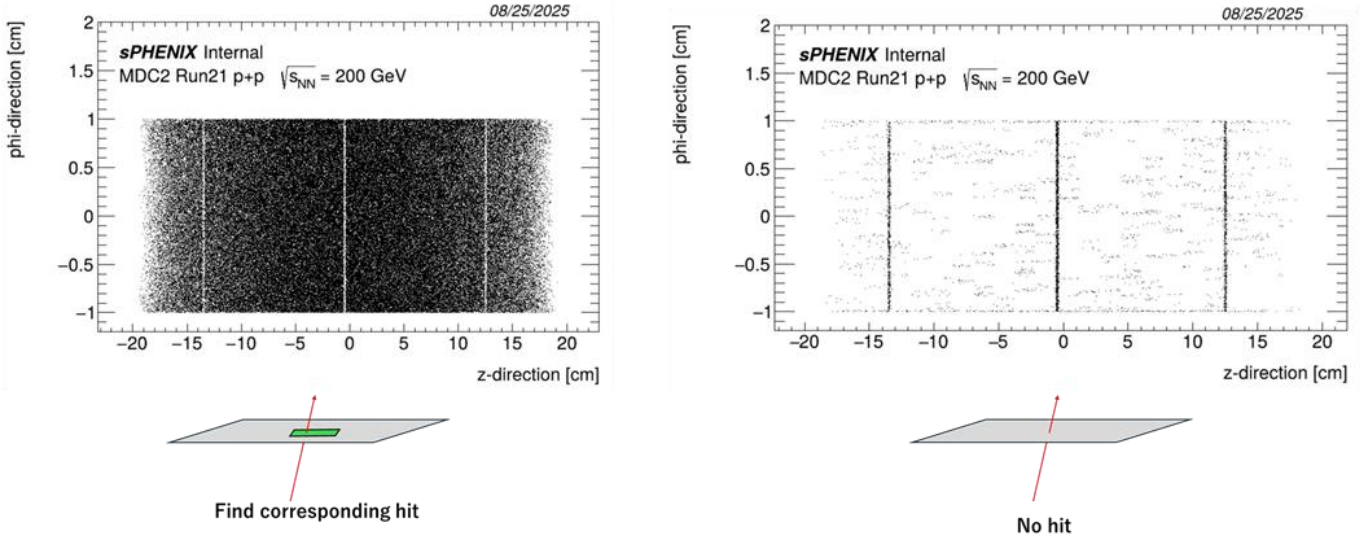


Figure 11:Intersection point with/without actual hit

Preliminary

- Residual in INTT Outer layer
- Phi/z

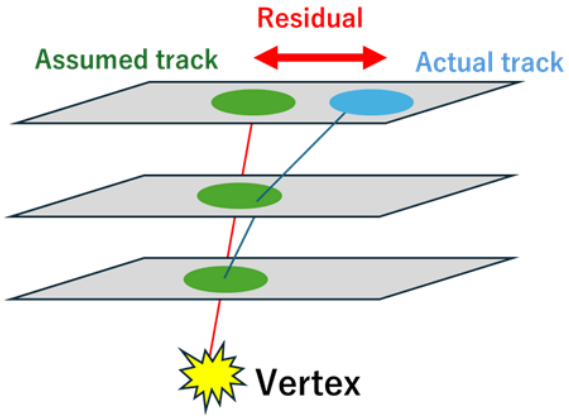


Figure 12: Residual from scattering

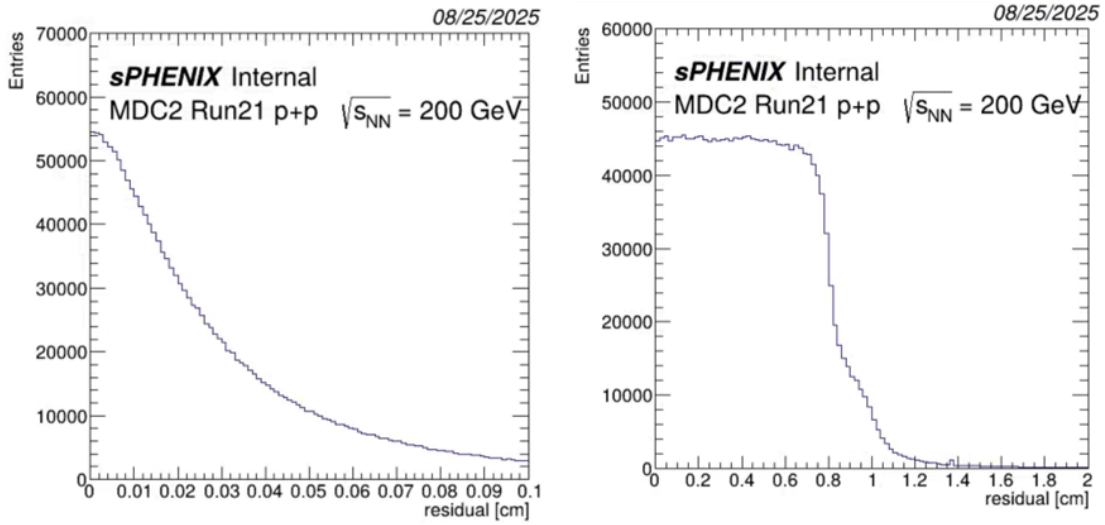


Figure 13: Residual distribution (Left: phi/Right: z)

Preliminary

- Geometry effect
- Left: Calculated intersection points which has corresponding hits in inner layer.
- Right: Passing through track ratio with pT dependence

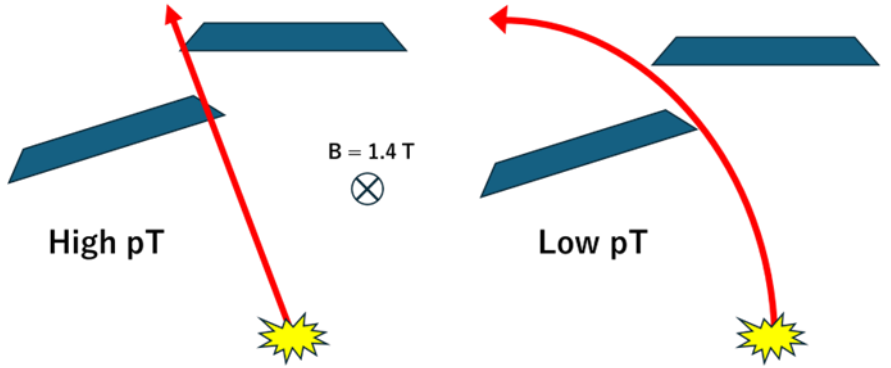


Figure 14: Passing through between the ladders

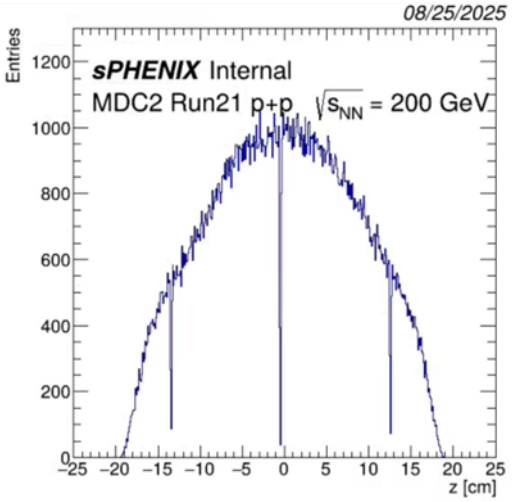


Figure 15: Ladder geometry effect

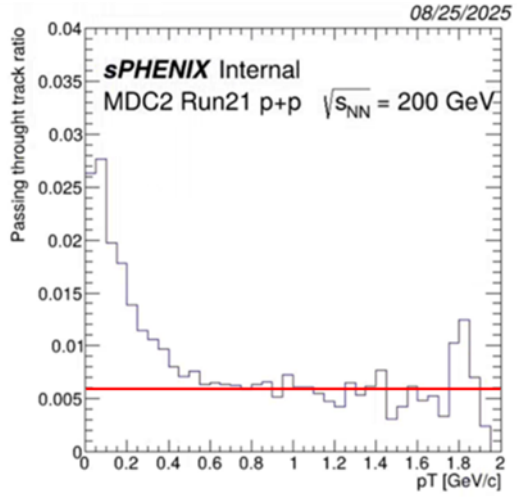


Figure 16: Barrel geometry effect

Preliminary

- Hit detection efficiency on the ladder
- (That contains type A/B dead area)

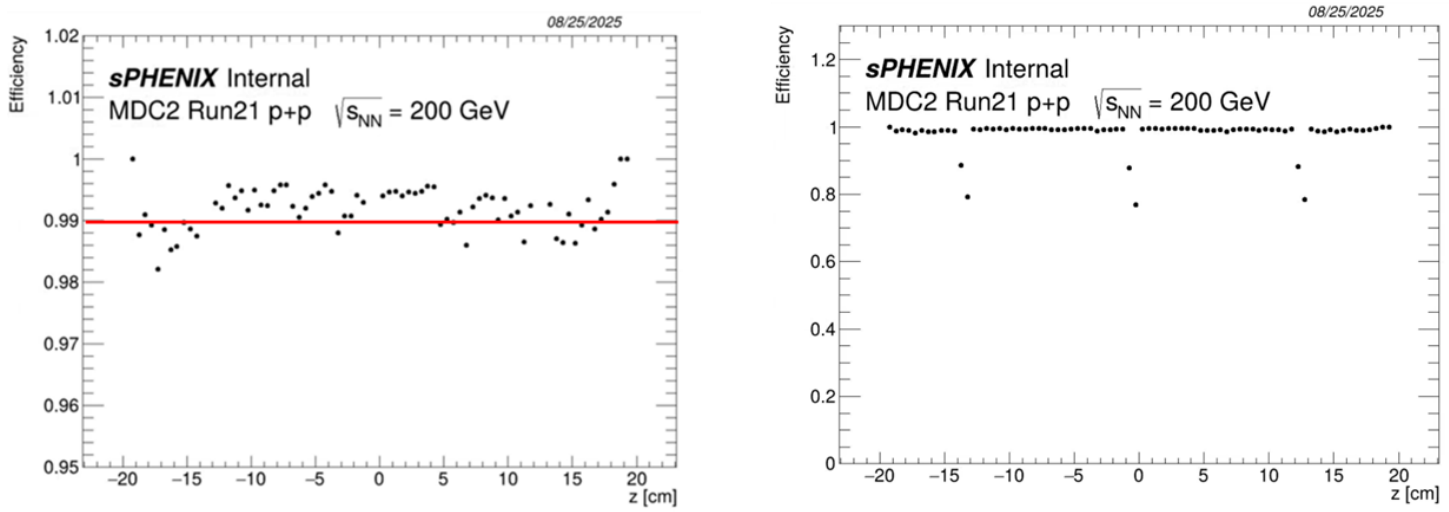


Figure 17: Hit detection efficiency on the ladder (z-dependence)
Left plot: Zoomed to 0.9-1 of right plot

INTT hit detection efficiency study with Monte Carlo simulation

INITIAL STAGES 2025

Takahiro Kikuchi, Rikkyo university, for the sPHENIX Collaboration

Abstract

INTT is one of the detector of the tracking system of sPHENIX. As a key performance of INTT, the detection efficiency and its geometrical acceptance is studied. For this study, a Monte-Carlo simulation was used which implements realistic geometries of INTT and another tracking detector MVTX. The dead-area evaluated with simulated tracks showed consistent result with expected one based on the implemented geometries of the detectors in MC. Confirmed nearly 100% detection efficiency for the active area in MC. The study is ready to move on to introduce reconstructed hit clusters into the algorithm, an important step towards the application to real data.

sPHENIX experiment and INTT detector

sPHENIX experiment is a high energy accelerator physics with p-p and Au-Au collision in =200 GeV
For each collision, the purpose of p-p collision is study of the spin structure of proton.
The purpose of Au-Au collision is the study of Quark Gluon Plasma (QGP).

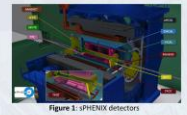


Figure 1: sPHENIX detectors

Figure 2: INTT silicon sensor

INTermediate Tracker(INTT) is a silicon strip sensor having two layers which covers full azimuthal angle and pseudorapidity η<|1.1|. INTT is good at timing resolution and with MVTX/TPC, they take on a role of tracking.

INTT geometry

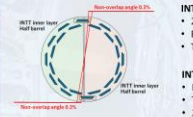


Figure 3: INTT inner barrel geometry

INTT Inner layer geometry
- 24 ladders covering the r=7.5 cm circle.
- Be composed of two left/right barrel which has 12 ladders
- There are about 2.2 degree gap between the barrels.
  - Corresponds to 0.6 % of azimuthal angle.

INTT ladder geometry
- Be composed of 26 chips which have 128 strip channels
- Two types of chip were used to normalize the ----.
- 2.2 mm gap between the Type A/B chip assemblies.
- 2.5 mm gap between the Type A chip assemblies.

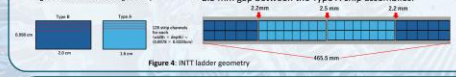


Figure 4: INTT ladder geometry

INTT Inner layer hit detection efficiency

Goal of this study: Measure the INTT hit detection efficiency on the active sensor area in inner layer.

Methods:
- Correct tracks which have clusters inner/outer of the target layer.
  - Inner: MVTX 3 layers / Outer: INTT Outer layer
- Draw the track based on the original the true vertex/momentum.
- Calculate the expected intersection point of the track in the target layer, then search for clusters near by.
- Evaluate hit detection efficiency
  - Some inefficiency factor has geometry dependence.

Steps for goal

Figure 5: Analysis flowchart

Figure 6: Tracking with INTT and MVTX

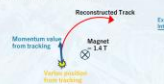


Figure 7: Draw reconstructed track

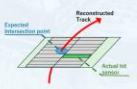


Figure 8: Intersection point on the ladder

Figure 9: Compatibility of track vertex/momentum

For the next step of the simulation study:
- The true vertex/momentum values are to be replaced by reconstructed ones as the next step.
- This is one step forward to move on to the efficiency study of real data.

Simulation study

Simulation data configuration
- Particles: Proton-Proton
- Center-mass energy: 200 GeV
- Event generation: pythia8
- Magnet: 1.4 T
- Masking: 1% random dead channels
- Crossing angle: 0 mrad

Intersection point calculation: Figure 10
- Ladders are approximated to a plane equation.
- Calculated points are divided in two
  - Tracks which have actual corresponding cluster.
  - Tracks which don't have actual corresponding cluster.

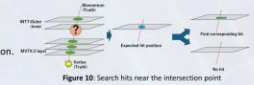


Figure 10: Search hits near the intersection point

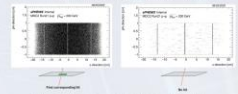


Figure 11:Intersection point with/without actual hit

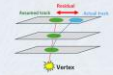


Figure 12: Residual from scattering

Tracks selection: Figure 12
- Vertex cut
  - x, y : ±0.14 cm (3σ)
  - z: ±10 cm (Physics trigger config.)
- Scattering cut
  - Based on the residual between the true cluster and calculated intersection point in INTT Outer
  - Require under 0.023 cm (1σ)

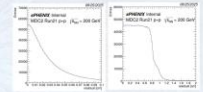


Figure 13: Residual distribution (Left: phi/Right: z)

Results: Geometry acceptance effect

Ladder geometry: Figure 14
- Gaps around ±13cm, 0 cm
  - Corresponding to the dead area between the Type A/B chip assemblies.

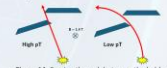
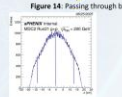


Figure 14: Passing through between the ladders

Layer geometry: Figure 15
- Lower pT particles have more tendency to passing through between the ladders.
- Over 0.5 pT, passing through particle ratio converges into 0.7% (Red line in figure 15).



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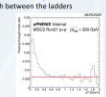

Figure 16: Barrel geometry effect

Results: Hit detection efficiency on the active area

Hit detection efficiency: Figure 16
- Most part on the active area, the hit detection efficiency is over 99%.
- Red line shows the line of active channel ratio (99%).
- The reason of that value is over 99% is because of cluster size.
  - The mean value of hit channel by one particle is 1.3.

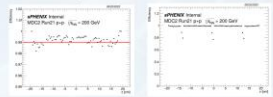

Figure 17: Hit detection efficiency on the ladder (z-dependence)
Left plot: Zoomed to 0.9-1 of right plot

Summary

This study shows that the method with calculating the intersection point with true momentum/vertex value can produce almost ideal result. For the next step, I'm going to reproduce these results with tracking algorithm.

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