INTT hit detection efficiency study with Monte Carlo simulation

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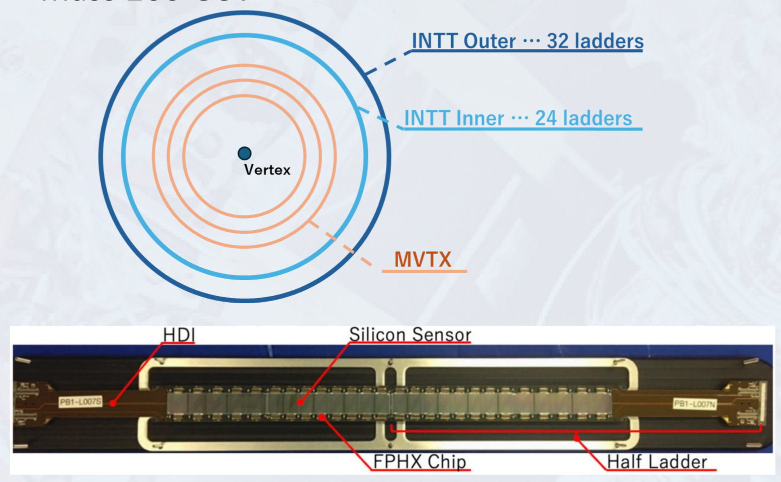
Takahiro Kikuchi, Rikkyo university, for the sPHENIX Collaboration

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 center of mass 200 GeV



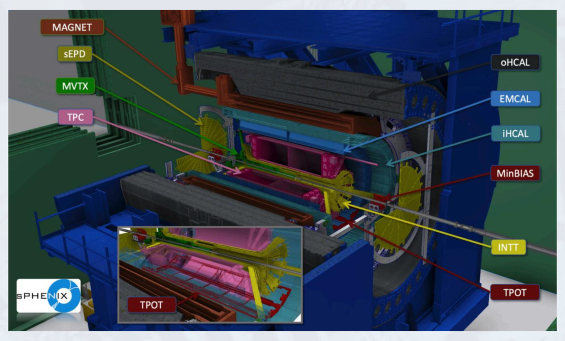


Figure 1: sPHENIX detectors

INTermediate silicon 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

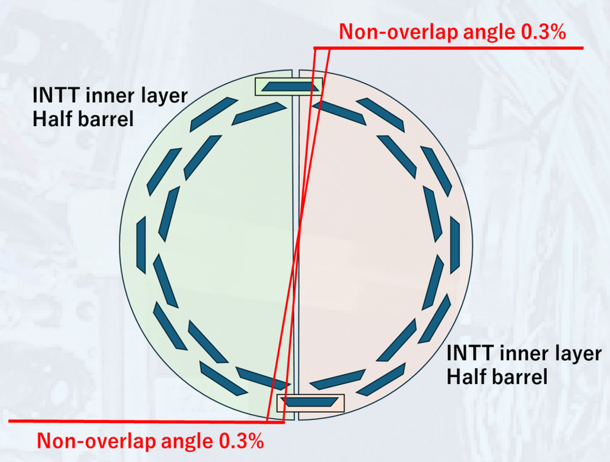


Figure 3: INTT inner barrel geometry

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 0.7 % of azimuthal angle.

INTT ladder geometry

- Be composed of 26 chips which have 128 strip channels
- 2.2 mm gap between the Type A/B chip assemblies.
- 2.5 mm gap between the Type A chip assemblies.

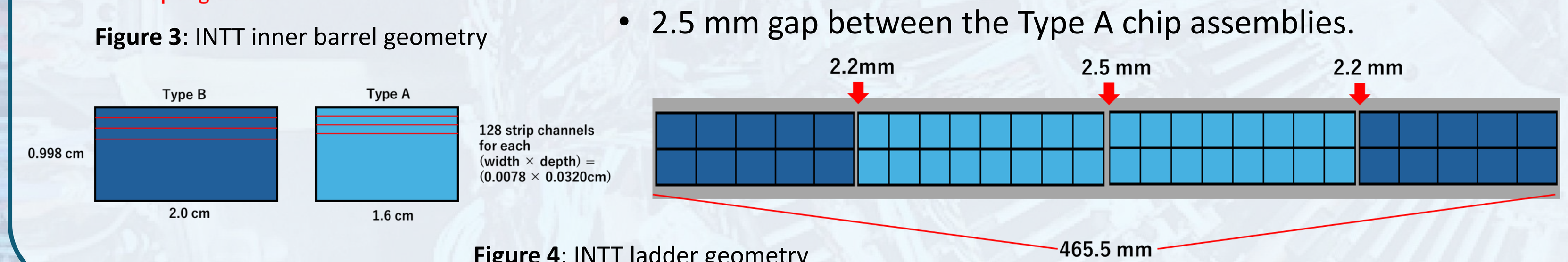


Figure 4: INTT ladder geometry

INTT Inner layer hit detection efficiency

Goal of this study: Measure the INTT hit detection efficiency on the active sensor area in inner layer. Make sure geometry acceptance can be seen as expected

Methods:

- Correct tracks which have clusters inner/outer of the target layer.
  - Inner: MVTX 3 layers / Outer: INTT Outer layer
- Draw the helix 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.

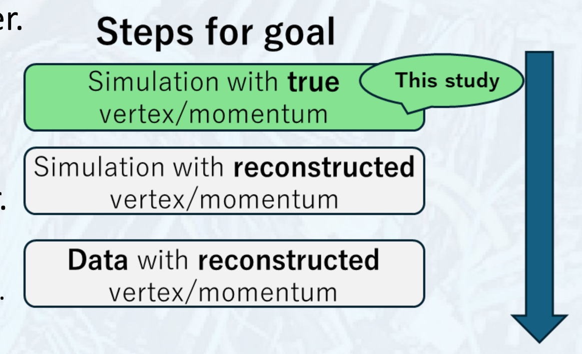


Figure 5: Analysis flowchart

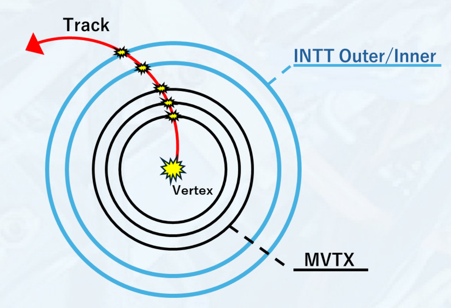


Figure 6: Tracking with INTT and MVTX

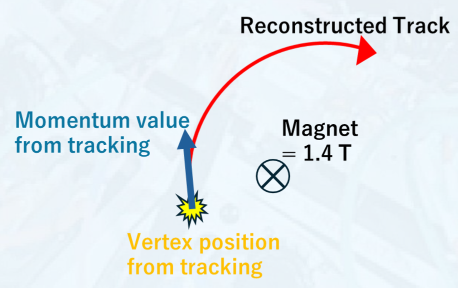


Figure 7: Draw reconstructed track

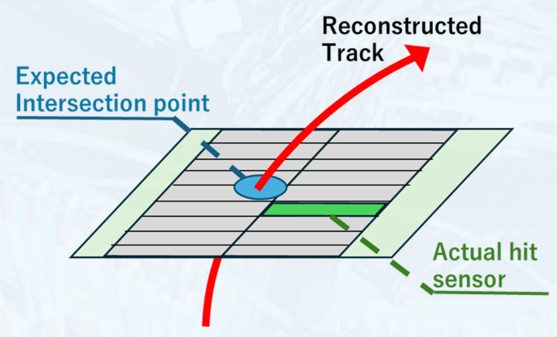


Figure 8: Intersection point on the ladder

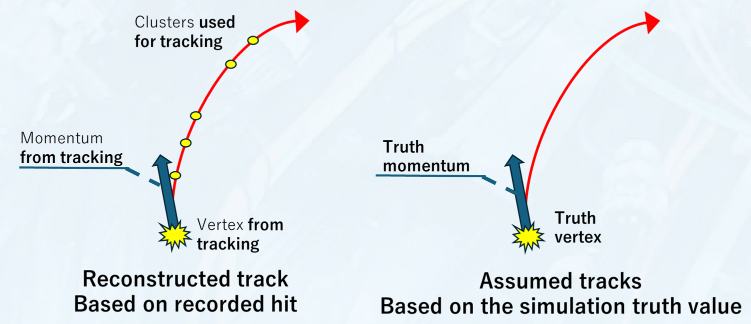


Figure 9: Compatibility of track vertex/momentum

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 of mass energy: 200 GeV
- Event generation: pythia8
- Magnet: 1.4 T
- Masking: 1% random dead channels
- Crossing angle: 0 mrad

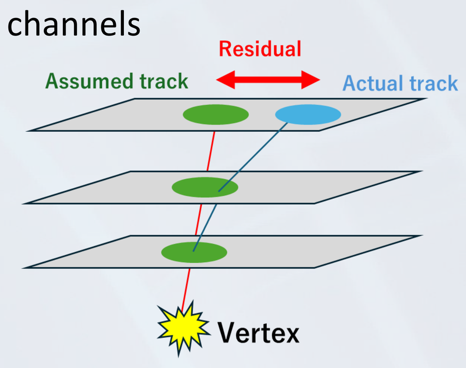


Figure 10: Residual from scattering

Tracks selection: Figure 11

- 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)

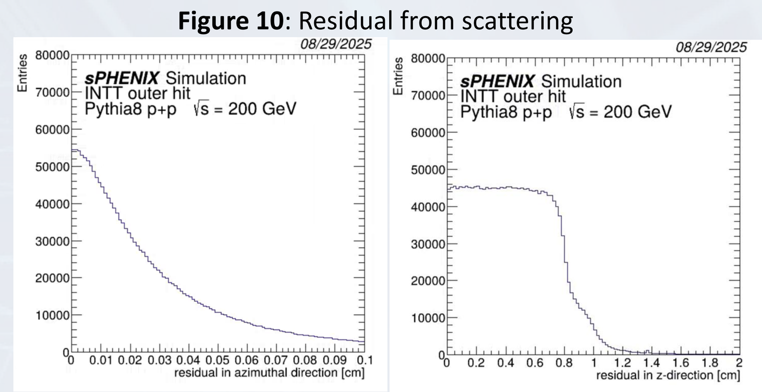


Figure 11: Residual distribution (Left: phi/Right: z)

Intersection point calculation: Figure 13

- 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.

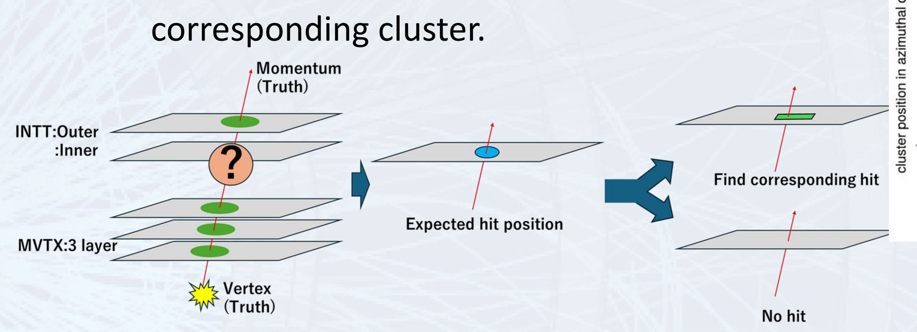


Figure 12: Search hits near the intersection point

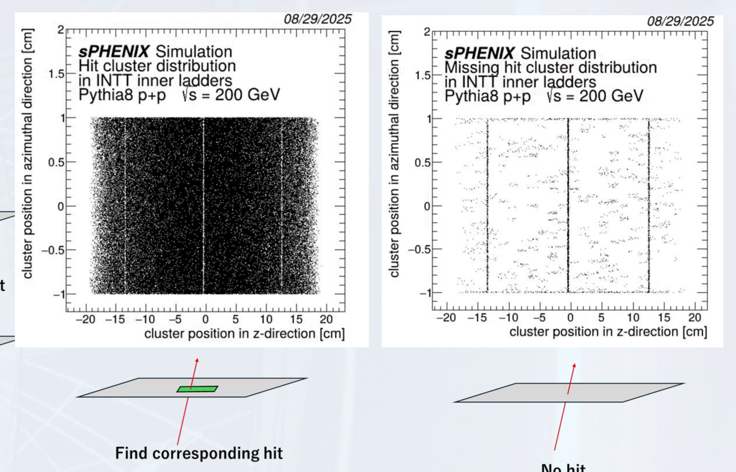


Figure 13: Intersection point with/without actual hit

Results: Geometry acceptance effect

Ladder geometry: Figure 15

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

Layer geometry: Figure 16

- 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).

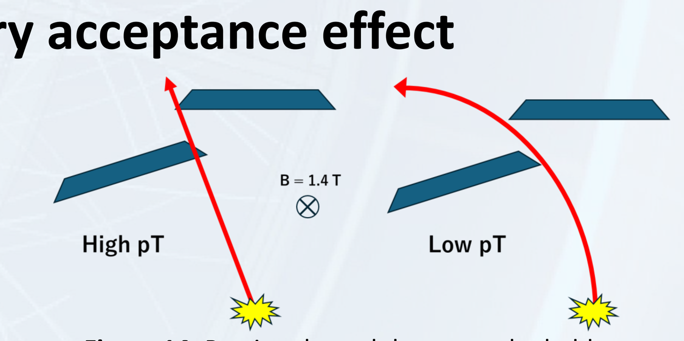


Figure 14: Passing through between the ladders

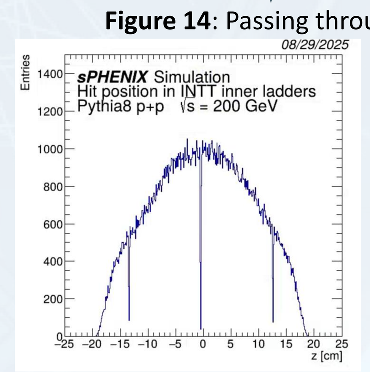


Figure 15: Ladder geometry effect

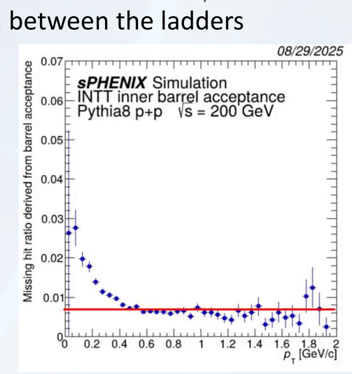


Figure 16: Barrel geometry effect

Results: Hit detection efficiency on the active area

Hit detection efficiency: Figure 17

- 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.

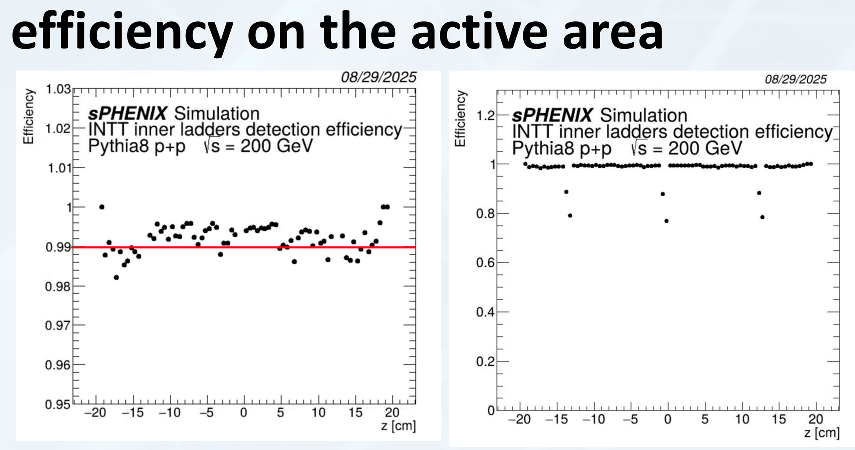


Figure 17: Hit detection efficiency on the ladder (z-dependence)
Left plot: Zoomed to 0.9-1 of right plot

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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