Commissioning of the Intermediate Silicon Tracker at sPHENIX

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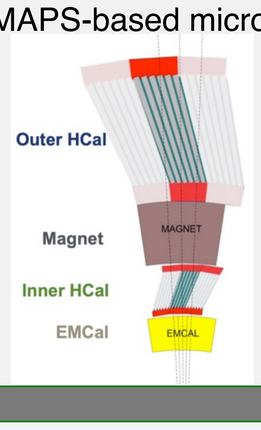
Abstract

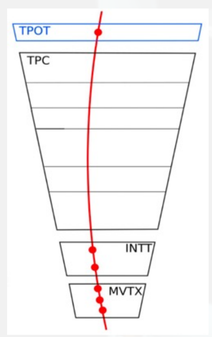
The sPHENIX experiment represents a novel detector system at the Relativistic Heavy Ion Collider at BNL. Its main goal is to advance our understanding of Quark Gluon Plasma and Cold-QCD by studying jet and heavy-flavor observables with a high-precision tracking system.
The sPHENIX tracking system comprises the MVTX, TPC, TPOT, and Intermediate Silicon Tracker (INTT). This poster aims to introduce INTT, a crucial component of the sPHENIX's tracking system, especially for pile-up separation. Since the launch of sPHENIX in May 2023, starting with AuAu collisions, this poster will present significant results obtained from that time onward.

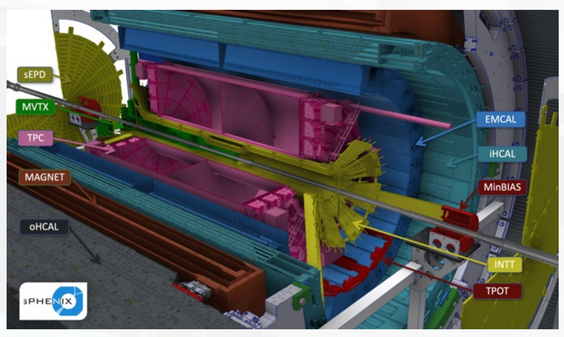
The sPHENIX detector consists of both calorimeters and tracking detectors.

The tracking system comprises four subdetectors:

- TPC Outer Tracker (TPOT)
- Time Projection Chamber (TPC) 30 $< r <$ 78 cm
- Intermediate Silicon Tracker (INTT) 7 $< r <$ 12 cm
- MAPS-based micro-Vertex Detector (MVTX) 2.3 $< r <$ 3.9 cm



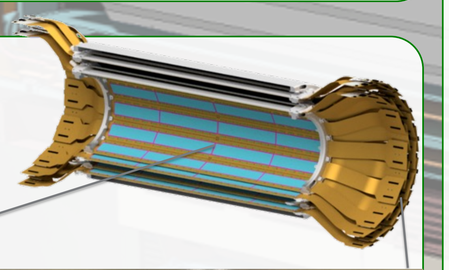


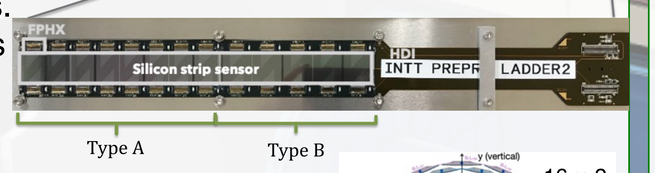


The INTT detector

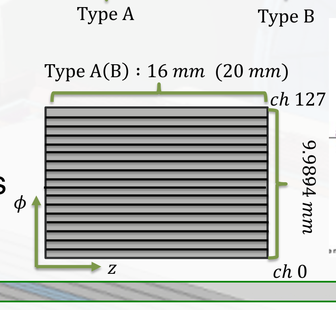
A group of 56 silicon ladders assembled in two layers in a barrel configuration.
- Each ladder has 26 readout FPHX chips
- Each silicon chip has 128 channels.

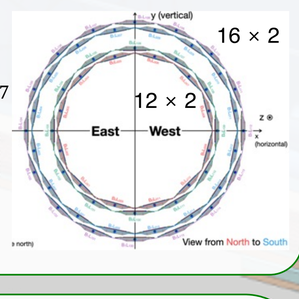
resulting in a total of ~370k channels





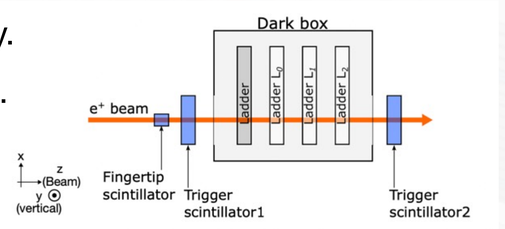
- Fine strip width : 78 μm in ϕ
  For high spatial resolution
- Thin sensors 320 μm (~0.34% X_0)
  For less multiple scattering
- Timing resolution less than 106 ns
  For pile-up separation





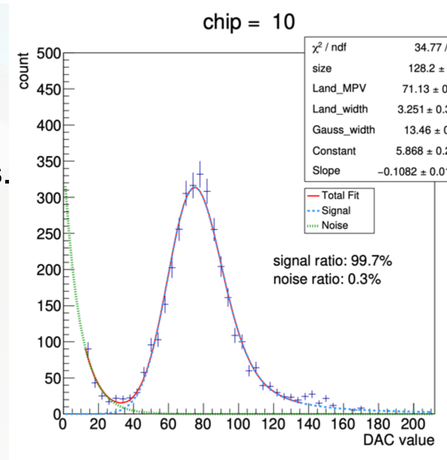
Test beam experiment in 2021

- 1 GeV positron beam at Tohoku University.
- 3 INTT ladders, L0, L1, and L2 were used.
- Two plastic scintillators were installed upstream or downstream of the dark box.



1) Signal noise(S/N) ratio

- DAC values are assigned one ADC value, which is related to the energy loss of a charged particle path through Silicon chips.
- Sum of a Landau-Gaussian convolution function and an exponential function was used for fitting.
- MIP was dominated in the region larger than DAC 40, S/N ratio was evaluated in the MIP dominant region.

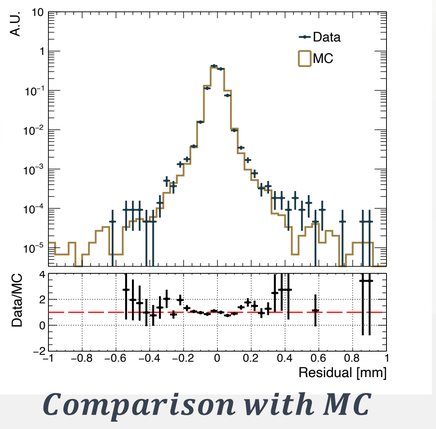


$Signal : 99.7\%\ noise : 0.3\%$

2) Detection efficiency

- The clusters within $\pm 0.234\ mm\ (\pm 3\ strips)$ from the interpolated point were considered as the hits made by the beam.
- Detection efficiency of L1 was defined as

$$\frac{N(L0 \cap L1 \cap L2)}{N(L0 \cap L2)} \times 100\% = \mathbf{99.33 \pm 0.04\ (stat) \pm 0.06\ (sys)}\ \%$$

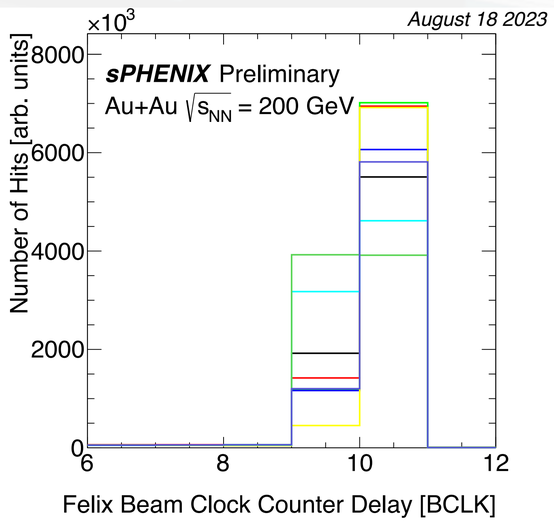


Comparison with MC

Hit rate as function of delay

Hit rate with various value of the delay of FELIX, which is read-out system of INTT indicates collision correlated hits are well aligned in same BCLK timing window. Different color indicates different FELIX servers.

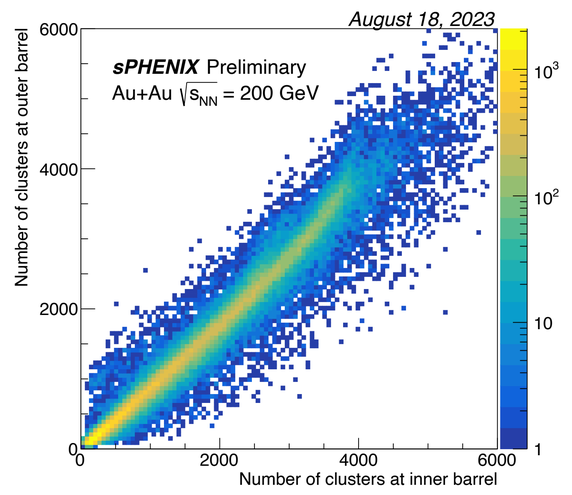
Evidence of Time-in



Correlation between the Inner and the Outer Ladders

A multiplicity of the inner barrel correlates to that of the outer. If a particle passes through the inner barrel, it also goes through the outer barrel.

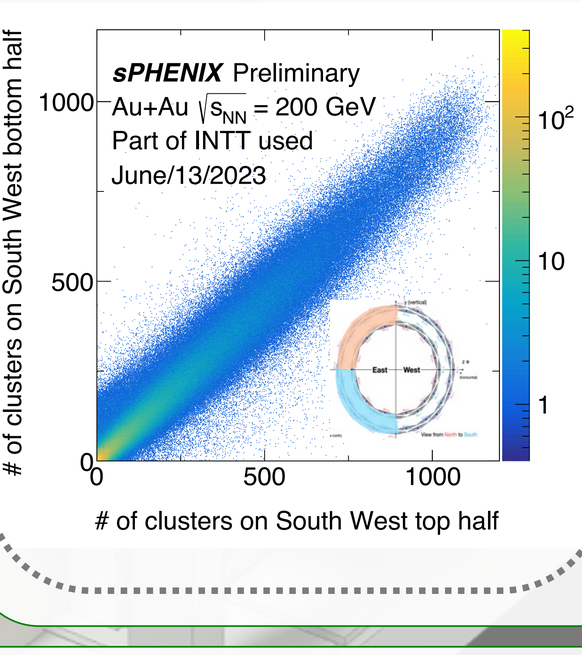
Evidence of collision data



Correlation between Two FELIX servers

Timing synchronization among FELIX servers is crucial for the best timing resolution. By selecting events with the same beam clock count, the plot shows the multiplicity correlation between different FELIX servers.

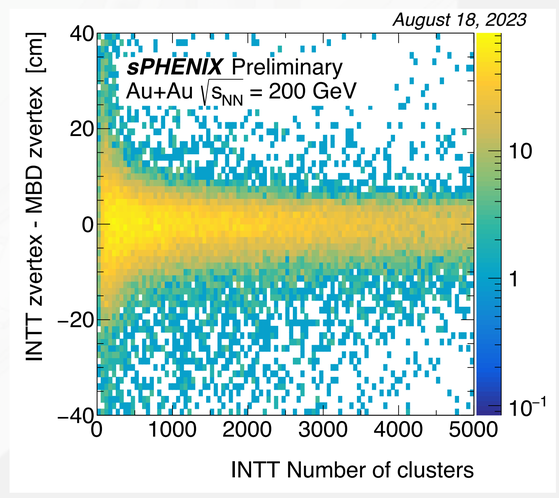
Evidence of Event Synchronization



Z-vertex distribution correlation between INTT and Minimum Bias Detector (MBD)

This run was taken with MBD, the plot indicates data come from the physics collision and synchronize the data between different detectors successfully.

First correlation between different read-out system



Conclusion

The INTT is a crucial component for pile-up separation in the sPHENIX experiment. It has been operating effectively since the AuAu collisions last year, and we are now exploring pp collisions. The INTT is in excellent condition, as indicated by various results!

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