Vertex reconstruction by the sPHENIX INTT in field-off data

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sPHENIX, a new collider experiment at the Relativistic Heavy Ion Collider in Brookhaven National Laboratory, has completed its construction and started to take data with Au + Au collisions in May 2023. The Intermediate Silicon Tracker (INTT) of sPHENIX is a two-layer barrel strip tracker located between the MAPS Vertex Tracker (MVTX) and the Time Projection Chamber (TPC).[1] The INTT plays a unique role in the sPHENIX tracking system. Two spatial points offered by INTT bridge the tracks of MVTX and TPC, and enhance the tracking resolution. In addition, the single-bunch-crossing timing resolution, 106 ns, enables INTT to associate the reconstructed tracks with the corresponding bunch crossings. The widths and lengths of the INTT silicon strips are 78 μm and 16 or 20 mm, respectively, which give INTT a good spatial resolution in the polar angle, while the resolution along the z direction is relatively poor. Even though INTT is not designed to measure the collision vertex position, the investigation has been performed since it could potentially provide a valuable reference to calibrate the vertex position on the z axis (z_{vtx}) measured by the Minimum Bias Detector (MBD) of sPHENIX.

After the reconstruction of collision vertex in the x-y plane, all pairs made of one inner cluster and one outer cluster are checked. Cluster pairs with $\Delta\phi$ and distance of the closest approach smaller than 0.6 degrees and 1 mm, respectively, are kept as proto-tracklets. Since a particle can interact at any position within a strip, the probability distribution of the z_{vtx} location given by one proto-tracklet is a trapezoidal shape, as demonstrated in Fig. 1. By stacking the trapezoidal shapes formed by all the proto-tracklets in one event, a Gaussian-like distribution is obtained as shown in Fig. 1. The stacked distribution is fitted using seven Gaussian functions with different fit ranges for each,

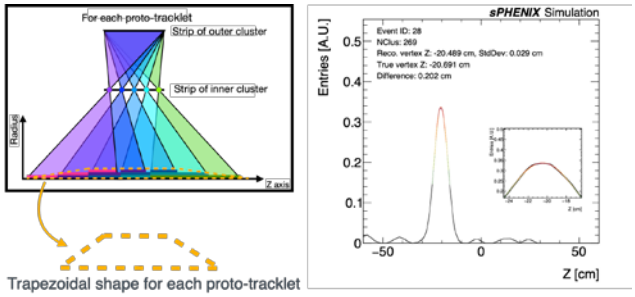

Fig. 1. (Left) The probability distribution of the z_{vtx} location formed by one proto-tracklet. (Right) The stack of the trapezoidal shapes formed by the proto-tracklets in one event.

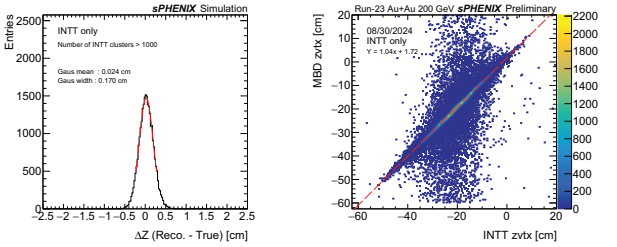

Fig. 2. (Left) The resolution of the z_{vtx} reconstructed by INTT in high multiplicity events. (Right) Correlation between the z-vertices reconstructed by INTT and MBD.

and the z_{vtx} is determined by the average of the fit Gaussian means.

The resolution of this approach with INTT was evaluated in simulation, as shown in Fig. 2. In the events with the number of clusters greater than 1000, the resolution can be up to 1.7 mm. It is 10 times smaller than the intrinsic strip length of INTT, which is satisfactory. The algorithm was also applied to the field-off Au + Au collision data with z_{vtx} shifted by 20 cm, and compared with the z_{vtx} reconstructed by MBD, as shown in Fig. 2. The slope of a linear fit to the correlation is consistent with unity, indicating a good agreement between two independent measurements.

Reference

1) The sPHENIX Collaboration, sPHENIX Technical Design Report (2019).

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