# Z-vertex determination by the sPHENIX INTT detector in $p + p$

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sPHENIX is an experiment that began operations in 2023 at the relativistic heavy-ion collider (RHIC), located at Brookhaven National Laboratory, USA. The goal is to study the properties of the quark-gluon plasma (QGP) and Cold-quantum chronodynamics (QCD). During Run 2024, we took $p + p$ collision data at $\sqrt{s} = 200$ GeV with the sPHENIX detector.

The intermediate silicon tracker (INTT) is a two-layer barrel silicon strip detector that covers full azimuthal angles in the pseudo-rapidity range $|\eta| < 1.1$ for beam collisions of $|z| < 10$ cm. There are two sizes of strips, 78 $\mu$m $\times$ 320 $\mu$m $\times$ 2.0 cm and 1.6 cm. The coverage along the z-coordinate is limited to a range from $-23$ cm to 23 cm, which provides high position resolution in the azimuthal direction. The position resolution in the z-direction is considerably lower than the azimuthal resolution; however, the accuracy of the z-coordinate of collision point (z-vertex) determination can be achieved by optimizing the z-vertex reconstruction method. This study aims to establish a method to determine the z-vertex using INTT, which is essential for various physics analyses utilizing this data.

The z-vertex is calculated for each event in the following procedure. As the first step, each hit on the inner and outer barrel is selected. The pairs are selected for which the angular difference in the x-y plane is less than 0.04 in radian. After selecting, the distance of the closest approach (DCA) between the track by each hit pair and the beam center is calculated. DCAz is defined as the z component of DCA. The DCAz error ranges are determined by considering the width of the sensor of each hit for pairs as shown in Fig. 1(a).

The value of the z-vertex is calculated as the average of DCAz with error ranges that fall within $1\sigma$ of the mean point of the DCAz distribution as shown in Fig. 1(b).

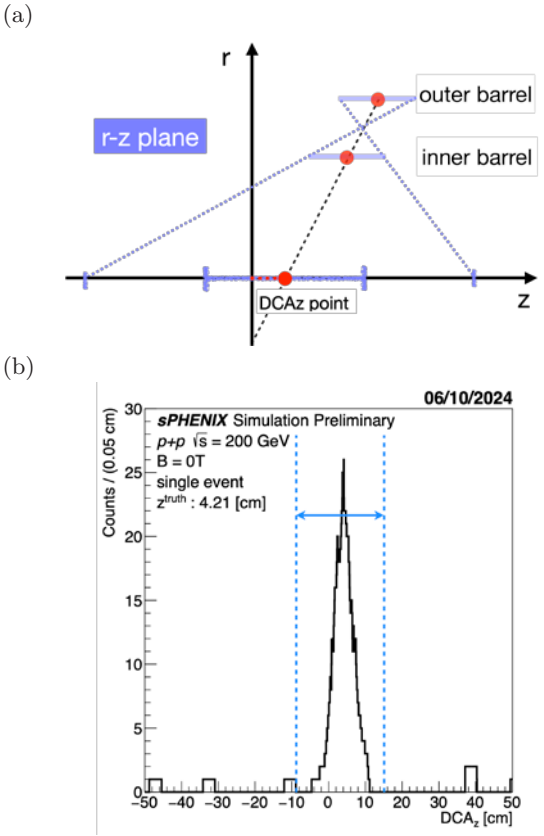


Fig. 1. z-vertex reconstructing method. (a) DCA in r-z plane; (b) DCAz [cm]

Figure 2(a) shows the reconstructed z-vertex distribution in $p + p$ with no magnetic field (B-off). These data were taken by trigger from the MBD when at least one of each has a signal in the PMTs of both north and south MBDs. The result obtained by the INTT with Fig. 2(a) is consistent with the one provided by the MBD. As shown in Fig. 2(a); mean is 1.6 cm and the standard deviation (SD) is 12 cm. The z-vertex distribution measured by MBD is 1.9 cm as the mean and 13 cm as SD, which are consistent with the INTT measurement.

Figure 2(b) is the reconstructed z-vertex distribution in $p + p$ with a magnetic field (B-on) with crossing angles (X-ang) of 0 and 1.5 mrad. The SD is 34.9 cm for 0 mrad and 18.5 cm for 1.5 mrad. In collisions with an X-ang, there is a higher probability of interactions occurring near z = 0, which results in a narrower z-vertex distribution.

We developed the method to determine the z-vertex

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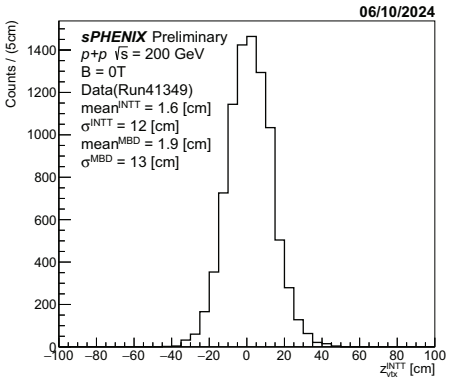
(a)




(b)

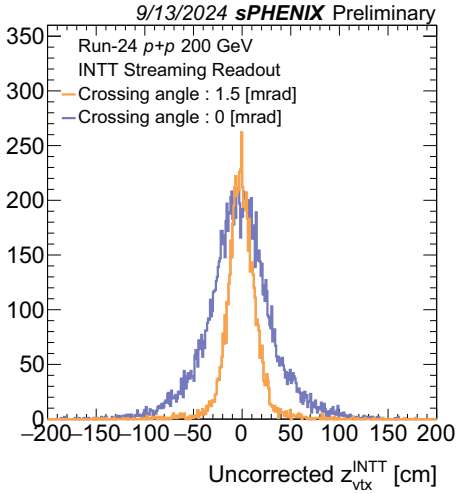



Fig. 2. z-vertex distributions by INTT in p + p. (a) B-field off (b)B-field on,and comparison of two X-ang values

in $p + p$ at sPHENIX. Using this method, we successfully determined the z-vertex for both B-on/B-off, as well as at different X-ang values. The analysis of the reconstruction efficiency (by the size of |z-vertex|) is on-going.