Improvement of the DCA resolution for PHENIX

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The PHENIX experiment accumulated data from the Relativistic Heavy Ion Collider at Brookhaven National Laboratory from 2001 to 2016 to study quark-gluon plasma and the spin structure of the nucleon.

The measurement of the distance of closest approach (DCA), which is the minimum distance from a beam collision point to the trajectory of a reconstructed particle, significantly suppress the background to heavy-flavor production measurements in a single electron channel. The vertex tracker (VTX)[1,2] consists of two layers with silicon pixel sensors and two layers with silicon strip sensors. The VTX in each of the west and east arms measures the trajectory, and the beam-beam counter determines the Z-coordinate of the beam collision point. DCA is calculated event by event using this information.

In 2016, PHENIX measured Au-Au collisions at the collision energy $\sqrt{s_{NN}} = 200$ GeV. One of the tasks needed to start the data summary tape production of the data is the alignment of the VTX detector. In the alignment process, we found strong linear correlations between DCA in the transverse direction with respect to the beam-axis and the residual in track fitting in the direction $s = r\Delta\phi$ (Fig. 1), where r is the distance from the beam axis and $\Delta\phi$ is the relative azimuth angle between hits and track projections on the VTX plane. The abscissa and ordinate axes represent the residual in the s direction and the transverse DCA, respectively. Only clusters with a transverse momentum p_T between 1.5 GeV$/c$ and 2.0 GeV$/c$ are shown in Fig. 1. Green points show average values over the DCA of a residual bin. A linear fitting shown with the red line estimates the correlation.

The correlation strength depends on p_T, the arm, and the VTX layer. The correlations can be used to correct the DCA value and to improve the DCA resolution. The corrected DCA distribution is narrower than the raw distribution (Fig. 2). The dark and light blue histograms represent the raw and corrected DCA distributions, respectively. Fittings with a Gaussian function to the raw DCA (red) and the corrected DCA (orange) yield DCA resolutions.

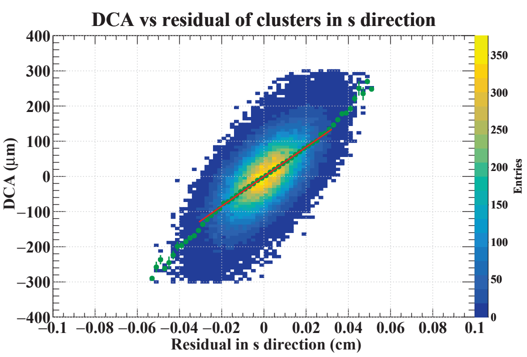

Fig. 1. Correlation between DCA and the cluster residual in the s direction in the innermost layer of the west arm with the selection $1.5 < p_T < 2.0$ GeV$/c$.

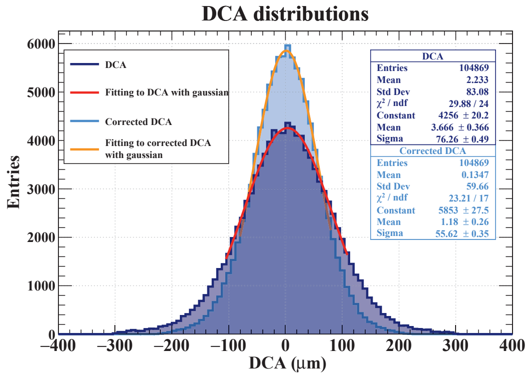

Fig. 2. DCA (dark black) and corrected DCA (light blue) distributions taken by the west arm with the selection $1.5 < p_T < 2.0$ GeV$/c$.

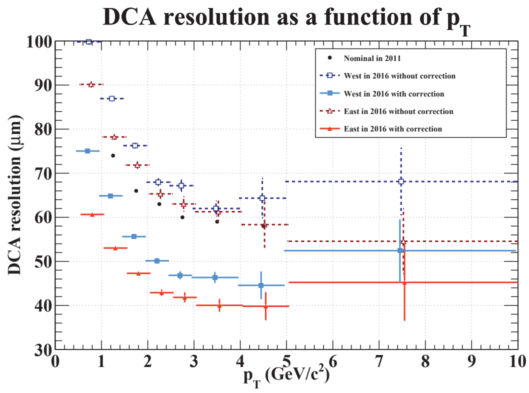

Fig. 3. DCA resolutions as a function of p_T. Points except black ones are slightly shifted for visibility.

Figure 3 shows DCA resolution as a function of p_T. The dark and light blue graphs are the raw and corrected DCA resolutions in the west arm, respectively, while the graphs in dark and light red are those in the east arm. The black points indicate the nominal DCA resolution for a run in 2011.[2] By applying all corrections, the resolution is improved by 15% to 35%.

In 2016, VTX was operated without one strip layer in the west arm owing to a beam accident in 2015. Under those severe conditions, a DCA resolution less than 50 μm was achieved in $p_T > 2.0$ GeV$/c$, while it was approximately 60 μm in 2011.[2]

This method may reduce background in the heavy flavor measurements because it is valid for data from other PHENIX runs, in principle.

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References
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