Improvement in the track reconstruction efficiency with VTX in the PHENIX experiment

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Heavy quarks (charm and bottom quarks) with large masses ($M_c \approx 1$ GeV/c^2 and $M_b \approx 4$ GeV/c^2) are a good probe to study the quark gluon plasma (QGP). They are mainly produced by hard scattering in heavy-ion collisions and interact with soft partons in the QGP. The momentum and angular distributions of heavy quarks reveal the properties of the QGP.

For the measurement of heavy quarks, the Silicon Vertex Tracker (VTX) consisting of four layers of silicon detectors was installed in the PHENIX experiment. It reconstructs charged particle trajectories and their distances of closest approach (DCAs) to the primary collision vertex precisely. Since the DCA is related to the lifetime and mass of the particle, we can statistically separate electrons from semileptonic decays of the charm and bottom quarks using the DCA.

In 2014, PHENIX collected about 15 billion minimum bias Au+Au events. We measure the centrality dependence of the nuclear modification factors[1)] and the azimuthal anisotropies of the charm and bottom quarks over a wide range of values of p_T.

The track reconstruction is important for this measurement. The method of track reconstruction with VTX is as follows. First, a line from the primary vertex to a hit point on the 1st VTX layer is defined as a basic track. Then, it is propagated to the 2nd layer. If a hit point on the 2nd layer is found within certain windows in both the ϕ and z directions, called the DPHI and DZ windows, from the propagated track, the track is refitted, including the new hit. The same steps are repeated for 3rd and/or 4th layer.

The window sizes of the 2nd, 3rd and 4th layers are named DPHI0/DZ0, DPHI1/DZ1, and DPHI2/DZ2, respectively. They are changed with the multiplicity because the track density is different.

Precise determination of the primary vertex is necessary to measure the DCA precisely. However, the measurement is difficult in low multiplicity events. Furthermore, the original window sizes used in the peripheral Au+Au collisions were too tight, and a significant fraction of the track was lost. I have optimized the DPHI/DZ window sizes for low multiplicity events to improve the efficiency of track reconstruction, keeping the number of fake tracks as small as possible. Here, the fake track rate is estimated by a simulation.

In low multiplicity events (50–100% centrality), DZ0 is no longer used for the new track reconstruction. DZ1 and 2 are 1.5 times larger than the original window sizes for low multiplicity events, while the sizes for

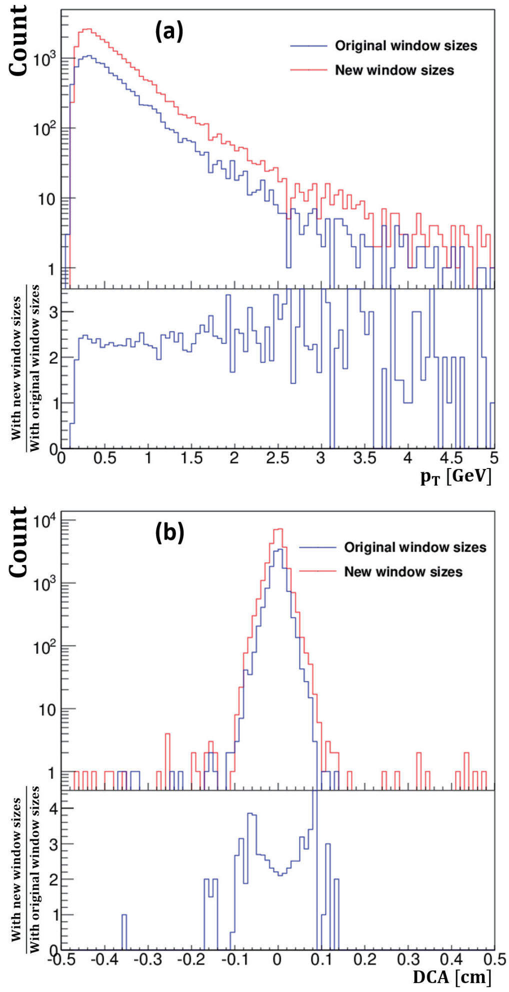

Fig. 1. (a) p_T and (b) DCA distributions in low multiplicity events with the original and new window sizes. Blue and red lines are with the original and new window sizes, respectively.

DPHI are decreased by a factor of 10. This is because an increase in only the window sizes of DZ, especially DZ0, is more effective for improving the efficiency without increasing the number of fake tracks.

The number of tracks in low multiplicity events is increased by a factor of 2.5 using the new window sizes over the p_T range and around the DCA peak (Fig. 1). In addition, the DCA tail part around $|0.1|$ cm is increased only by a factor of four. The fake track rate increases only by a small amount. Therefore, we will apply the new window sizes for the reconstruction of the VTX data.

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Reference

1) K. Nagashima et al.: In this report.