Preparatory work toward measurement of the azimuthal anisotropy of heavy quark electrons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

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The azimuthal anisotropy (v_2) of heavy (charm and bottom) quarks is a good probe for the study of the quark gluon plasma (QGP). Perturbative QCD (pQCD) calculations can be applied in the production of heavy quark pairs and fragmentation into heavy quark hadrons. It allows a precise comparison of the measured v_2 of heavy quark hadrons, that of their decay electrons, and theoretical models.

In 2007, v_2 of single electrons from c and b hadron decay was measured, without their separation, in Au+Au collisions,[1)] leading to an unexpected discovery of substantial v_2. The detailed study of v_2 of heavy quarks, *i.e.* measurement of v_2 with c and b hadron separation, has been recognized to be important; however, it is difficult due to their small yields.

A silicon vertex tracker (VTX) consisting of four layers of silicon detectors was installed in the PHENIX experiment in 2011, in order to separate electrons from c and b hadrons by using the distance of closest approach (DCA) method. The tracks of charged particles in the PHENIX central arm are projected backward from the drift chamber (DC) and associated to hits in the VTX. The DCA is calculated for each associated VTX track, to statistically separate electrons from the semileptonic decays of c and b hadrons, based on the correlation between the DCA and the lifetime of the parent hadron. PHENIX collected about 15 billion minimum bias Au+Au events at $\sqrt{s_{NN}} = 200$ GeV in 2014. The new dataset should be large enough to study c and b hadrons with statistical separation.

For the precise v_2 measurement utilizing the DCA method, it is necessary to understand the background (BG) in the DCA distribution, and to precisely determine the reaction plane (RP), which is defined as the plane containing the beam axis and the impact parameter vector between the two colliding nuclei.

The BG is expected to include the mismatched component (due to mismatching of tracks in DC and VTX, especially in high-multiplicity events), hadrons misidentified as electrons, decay electrons from kaons and quarkonia, and photonic electrons. The study of the mismatched component is described in this review. It is estimated with a method called small angle rotation (SAR) using VTX and DC, where each VTX track is rotated by a small angle. The rotated track is no longer connected to the true DC track, and can only be misconnected randomly to resemble the mismatched component. It has been found through simulation studies that this BG contains two subcomponents: mis-reconstruction of fake tracks and mis-connection of real tracks. The simulated DCA distribution is shown in Fig. 1 (left), with the mis-reconstruction due to the random association of hits in red with a broad tail, and the mis-connection in blue with a large central peak. The blue subcomponent shows the possibility that a VTX track accidentally matches with another real DC track after the rotation due to the high-multiplicity environment.

The RP resolution is studied as a function of collision centrality. The RP is mainly measured with two forward detectors in PHENIX, the beam beam counters (BBC), and the forward silicon vertex trackers (FVTX), on both sides of the nominal collision point along the beam axis. The observed v_2 needs to be corrected for the RP resolution.[2)] The RP resolution has been evaluated for the two detectors using the three sub-event method, from the difference of RPs measured with three different detectors,[2)] *i.e.* the north and south side of BBC (or FVTX) and the central arm. The results are shown in Fig. 1 (right), where the larger the parameter is, the better the RP resolution is. The black and red points show the RP resolutions with BBC and FVTX, respectively. The RP resolutions with the two detectors have a similar trend, while that with FVTX is about twice better than that with BBC. The study will be continued with FVTX, which is better suited for the v_2 measurement.

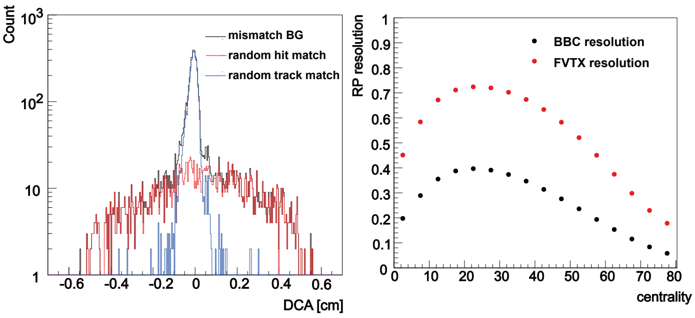

Fig. 1. (Left) Simulated DCA distribution of the mismatched BG component with SAR method. Red histogram shows mis-reconstruction with random hits; blue shows mis-connection of different tracks; black shows the total. (Right) RP resolutions with BBC (black) and FVTX (red).

References
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