Heavy-quark measurement using distance of closest approach analysis

R. Akimoto,[*1,*2] Y. Akiba,[*1] H. Asano,[*1,*3] T. Hachiya,[*1] M. Kurosawa,[*1] M. Shimomura,[*4] and the PHENIX VTX group

Heavy quarks (charm and bottom) can be used as probes to study the interaction between partons and a quark-gluon plasma (QGP). Heavy quarks are created by initial hard scattering, and thus, the changes intheir properties when passing through the QGP can be clearly extracted from their final states.

Separate measurements of modifications for charm and bottom quarks are informative because the dependence of the modification on the quark mass can be evaluated. The separation of charm and bottom quarks can be achieved by the analysis of the distances between the tracks and the beam collision vertex (DCA). The DCA distributions of bottomed hadrons are wider than those of charmed hadrons because the lifetimes of bottomed hadrons are considerably longer than those of charmed hadrons.

In this study, electrons and positrons from heavy-quark decay were measured[a], and the yields of charm and bottom quarks were evaluated by fitting the DCA distribution in the XY plane[b]. We updated the following items from the previous results reported in ref.[1]:

- Optimization of cut parameters for the isolation cut, which is explained in ref.[1].
- Evaluation of contributions of electrons from heavy quarkonia such as J/ψ.
- Evaluation of a systematic error from uncertainties of transverse momentum (p_T) distributions of charm and bottom quarks.

Owing to the optimization, the purity of heavy-quark electrons in inclusive electrons is increased to more than 50% where p_T is larger than 1 GeV/c. The left panel of Fig. 1 shows the S/N ratio, which is defined as the yield of heavy-quark electrons divided by that of the others. The solid and open circles represent the S/N ratios as a function of electron p_T with and without the isolation cut, separately. The contribution from heavy quarkonia was evaluated by using their cross sections[2]. The right panel of Fig. 1 shows the yield fractions of electron components in inclusive electrons. The brown points represent the contributions of heavy-quarkonium decay. The contribution of heavy quarkonia is ~15% in inclusive electrons at $p_T > 3$ GeV/c. The systematic error from the uncertainties of p_T distributions of charm and bottom quarks was evaluated using the distributions obtained from a PYTHIA simulation and FONLL calculation[3] and was found to be ~50% for all p_T ranges.

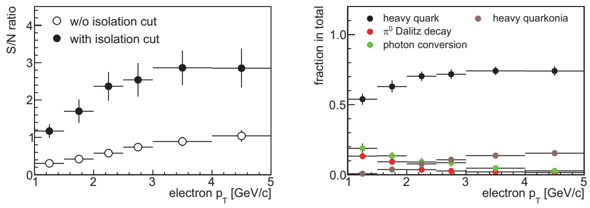

Fig. 1. S/N ratio (left) and yield fractions of electron components in inclusive electrons (right). The black, red, green, and brown points in the right panel represent the fractions of heavy-quark electrons, electrons from π^0 Dalitz decay, electrons from photon conversion, and electrons from decay of heavy quarkonia, respectively.

Figure 2 shows a comparison of the bottom fractions in heavy-quark electrons as a function of electron p_T before and after the updates for p+p collisions with $\sqrt{s} = 200$ GeV. The open and solid circles indicate the fractions before and after the updates, respectively. The result after the updates is consistent with that before the updates. The increase in the systematic error is due to the error from the uncertainties of p_T distributions of charm and bottom quarks.

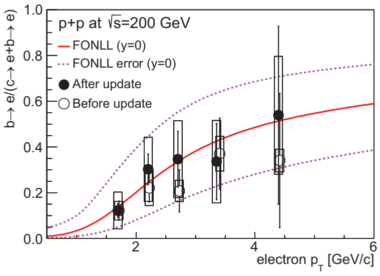

Fig. 2. Bottom fractions in heavy-quark electrons. The open and solid circles indicate the fractions before and after the updates. The bars and squares represent statistical and systematic errors, respectively. The solid line indicates the result of FONLL calculation at rapidity $y = 0$, and the dashed lines indicate the boundaries of the error band for the calculation.[3]

*1 RIKEN Nishina Center
*2 Center for Nuclear Study, Graduate School of Science, University of Tokyo
*3 Kyoto University
*4 Iowa State University

a) Electrons and positrons from heavy-quark decay are called heavy-quark electrons.
b) The XY plane is defined as the plane perpendicular to the beam axis, and the Z direction is defined as the direction along the beam axis.

References
1) R. Akimoto *et al.*: RIKEN Accel. Prog. Rep. **46**, 60 (2012).
2) A. Adare *et al.*: Phys. Rev. D **85**, 092004 (2012).
3) M. Cacciari *et al.*: Phys. Rev. Lett. **95**, 122001 (2005).