Measurement of D^0 in $p+p$ collisions at $\sqrt{s} = 200$ GeV using the Silicon Vertex Tracker at RHIC-PHENIX

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Measurements of the D^0 meson (and its charge conjugate) via the hadronic channel $D^0 \rightarrow K^- + \pi^+$ ($\bar{D}^0 \rightarrow K^+ + \pi^-$) in $p+p$ collisions provide important information. First, the total cross section of charm production can be obtained and compared with perturbative Quantum Chromodynamics (pQCD) calculations. Second, it provides the baseline measurement of charm production in order to understand the properties of the hot and dense QCD medium, created by heavy ion collisions, by comparing D^0 production in $p+p$ and Au+Au collisions.

Direct reconstruction of the D^0 meson is challenging because of its short decay lengths, $c\tau = 122.9\mu m$, and a very large combinatorial background. However, the Silicon Vertex Tracker (VTX),[1),2)] installed into the PHENIX experiment during the 2011 run, can separate the primary vertex and the $D^0 \rightarrow K^- + \pi^+$ decay vertex with high resolution. This can substantially eliminate the combinatorial background.

The strategy to extract D^0 production yield is based on an invariant mass analysis of all the possible pairs of two oppositely charged tracks. The invariant mass, $M_{K\pi}$, is defined as follows.

$$M_{K\pi} = \sqrt{(E_+ + E_-)^2 - (\vec{p}_+ + \vec{p}_-)^2} \tag{1}$$

$$E_\pm = \sqrt{m_\pm^2 + \vec{p}_\pm^{\,2}} \tag{2}$$

In the above equations, the subscript + or − indicates the charge of the track. We assigned the mass, $(m_+, m_-) = (m_K, m_\pi)$ or (m_π, m_K).

In the absence of any ion pair selection, the signal to combinatorial background ratio would be too small to extract the D^0 signal in the invariant mass distribution. It is, therefore, mandatory to select tracks on the basis of kinematical and geometrical considerations.

One of the quantities that is useful for track selection is the distance of the closest approach (DCA) of the reconstructed track to the primary vertex in the plane transverse to the beam direction. DCA of the daughter track, K^- or π^+, of the D^0 meson is larger than that of primary track, which comes from the primary vertex. Therefore, we can reject those primary tracks used in the invariant mass analysis by applying a DCA cut.

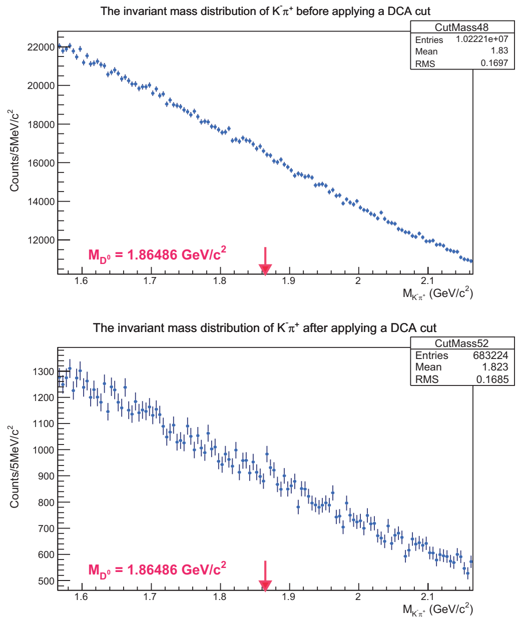

Fig. 1. The invariant mass distribution of $K^-\pi^+$ before and after applying a DCA cut

The intermediate result is shown in Fig. 1, which indicates the invariant mass distribution of $K^-\pi^+$ before and after applying a DCA cut. There is a hint of a small peak at the D^0 mass region in the mass spectrum with the DCA cut (the lower panel). However, there still remains a substantial combinatorial background. Therefore, it is necessary to further reduce the combinatorial background without sacrificing too many D^0 signals, and it is expected to be solved by selecting tracks in accordance with the D^0 decay kinematics using the VTX. We have been developing an analysis code that selects the decay kinematics of D^0 appropriately, leaving room for improving of the signal to background ratio.

References

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