

Production of D^\pm mesons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment

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Charm quarks are an excellent probe of the quark-gluon plasma created in heavy-ion collisions as they are produced at a very early stage of such collisions and subsequently experience the whole evolution of the system. With the STAR experiment, charm quark production can be measured by direct topological reconstruction of open-charm hadrons thanks to the exceptional spatial resolution of the Heavy Flavor Tracker detector. In these proceedings, we present a measurement of D^\pm meson production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV by the STAR experiment using data collected in 2014 and 2016. Supervised machine-learning techniques were used to maximize signal significance in raw yield extraction from the three-body hadronic decay channel $D^\pm \rightarrow K^\mp \pi^\pm \pi^\pm$. The D^\pm invariant spectra were measured in 0-10%, 10-40%, and 40-80% Au+Au collisions. The measured transverse-momentum (p_T) differential nuclear modification factor $R_{AA}(p_T)$ reveals a significant suppression of high- p_T D^\pm mesons in central (0-10%) Au+Au collisions with respect to p+p collisions. The $(D^+ + D^-)/(D^0 + \bar{D}^0)$ yield ratio has also been extracted and compared to that from PYTHIA calculations.

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STAR is a versatile experiment which studies a variety of physics phenomena observed in high energy p+p and heavy-ion collisions. One of the main goals of the STAR experiment is to study the properties of a hot and dense medium called the Quark-Gluon Plasma (QGP) created in heavy-ion collisions. The charm and bottom quarks are an excellent probe of the QGP as they are produced in the very early stage of heavy-ion collisions which means that they experience the whole evolution of the system. One way to access information about the charm quark production in heavy-ion collisions is through the reconstruction of open-charm hadrons. From year 2014 to 2016, STAR was equipped with the Heavy Flavor Tracker (HFT) [1] which allowed direct topological reconstruction of decays of open-charm hadrons.

In these proceedings, we present recent results from measurement of D^\pm mesons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. One key difference between the D^\pm and D^0 measurements is that D^0 mesons are reconstructed in two-body hadronic decay channel ($D^0 \rightarrow K^- \pi^+$, and its charge conjugate), but D^\pm mesons are accessed through three-body hadronic decay ($D^\pm \rightarrow K^\mp \pi^\pm \pi^\pm$). This is possible thanks to excellent track pointing resolution provided by the HFT. The measurement of D^\pm mesons serves as an independent check for the open-charm suppression and will also play an important role in measuring the total charm cross section in heavy-ion collisions.

The invariant yields of D^\pm mesons as a function of transverse momentum (p_T) have been measured in three centrality classes (0-10%, 10-40%, and 40-80%) of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The methods for signal reconstruction and reconstruction efficiency correction are analogous to those used for D^0 and described in detail in Ref. [2]. The p_T spectra are used to calculate the nuclear modification factor (R_{AA}) and the $(D^+ + D^-)/(D^0 + \bar{D}^0)$ yield ratio.

The R_{AA} of D^\pm mesons as a function of p_T is shown in Fig. 1 for 0-10% and 10-40% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The R_{AA} of D^0 mesons is plotted for comparison [2]. As expected, the level of suppression for D^\pm and D^0 mesons is comparable. The suppression is observed to be larger for 0-10% central than for 10-40% central Au+Au collisions which is likely caused by different size of the QGP bulk in the two collision centrality classes.

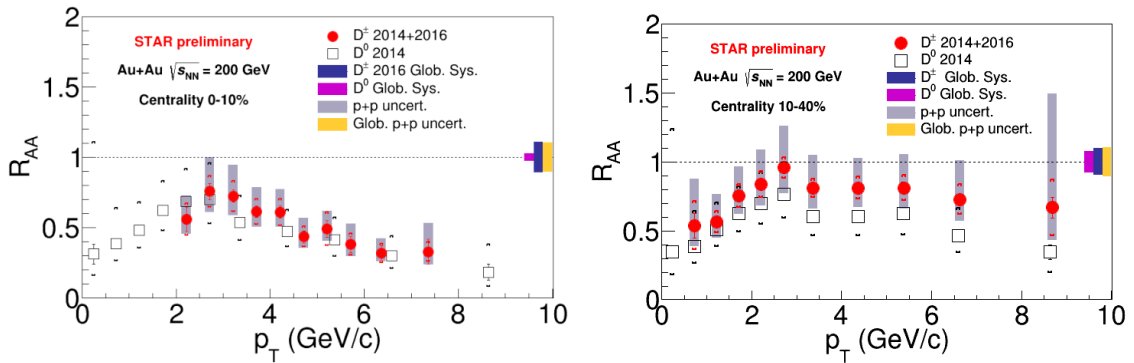


Figure 1: R_{AA} of D^0 [2] and D^\pm mesons as a function of p_T measured in 0-10% (left) and 10-40% (right) central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

The $(D^+ + D^-)/(D^0 + \bar{D}^0)$ yield ratios are shown in Fig. 2 for 0-10% and 10-40% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The data are in agreement with PYTHIA 8 calculations which suggests that no modification of the ratio is observed in Au+Au collisions with respect to

p+p collisions. The agreement is observed in all studied centrality classes indicating that the ratio has no or very weak centrality dependence.

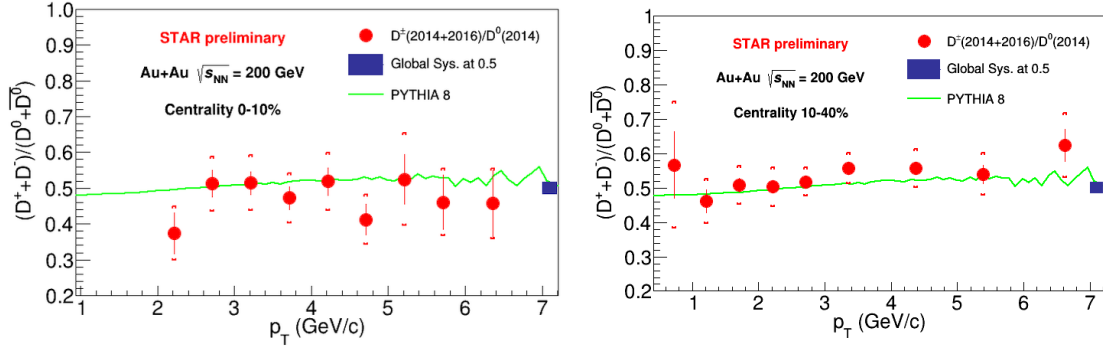


Figure 2: $(D^+ + D^-)/(D^0 + \overline{D}^0)$ yield ratio measured as a function of p_T by STAR in 0-10% and 10-40% central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. Data are compared to PYTHIA 8 calculation.

Summary

The STAR experiment has extensively studied the production of open-charm hadrons in heavy-ion collisions utilizing the HFT which allows direct topological reconstruction of hadronic decays of these hadrons. The invariant yields of D^\pm mesons have been measured for three centrality classes (0-10%, 10-40%, and 40-80%) of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV and were subsequently used to calculate the R_{AA} and $(D^+ + D^-)/(D^0 + \overline{D}^0)$ yield ratio. The R_{AA} of D^\pm mesons reveals a significant suppression at high p_T , similar to that observed for D^0 mesons, which suggests that charm quarks strongly interact with the QGP. The $(D^+ + D^-)/(D^0 + \overline{D}^0)$ yield ratio is consistent with a PYTHIA 8 model calculation indicating that no modification of the ratio is observed in Au+Au collisions with respect to the p+p collisions. The D^\pm measurement will help to constrain the total charm quark cross section in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

Acknowledgments

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References

- [1] Giacomo, C., et al., *The STAR MAPS-based PiXeL detector*, *Nucl. Instrum. Methods. Phys. Res. A* **907**, 60-80, (2018).
- [2] Adam, J., et al. [STAR Collaboration], *Centrality and transverse momentum dependence of D^0 -meson production at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV*, *Phys. Rev. C* **99**, 034908, (2019).