PROCEEDINGS OF SCIENCE

Measurement of D$^{\pm}$ meson production in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 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 very early stages of such collisions and subsequently experience the whole evolution of the system. At STAR experiment, charm quark production can be accessed by direct topological reconstruction of open-charm hadrons thanks to an excellent track pointing resolution provided by the Heavy Flavor Tracker. In these proceedings, we present a measurement of D$^{\pm}$ meson production in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV by STAR using data collected in 2014 and 2016. Supervised machine-learning techniques were used to optimize the signal significance of the D$^{\pm}$ three body decay D$^{\pm} \rightarrow$ K$^{\mp}\pi^{\pm}\pi^{\pm}$ reconstruction. The D$^{\pm}$ invariant spectra were then obtained in 0-10%, 10-40%, and 40-80% central Au+Au collisions. The measured nuclear modification factor $R_{\rm AA}$ as a function of transverse momentum ($p_{\rm T}$) reveals a significant suppression of high-$p_{\rm T}$ D$^{\pm}$ mesons in central and mid-central Au+Au collisions with respect to p+p collisions. The $({\rm D}^{+}+{\rm D}^{-})/({\rm D}^{0}+\overline{{\rm D}^{0}})$ yield ratio has also been extracted and compared to that from PYTHIA 8 calculations.

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1. Physics motivation

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 properties of a hot and dense medium called the Quark-Gluon Plasma (QPG) created in heavy-ion collisions. The charm quarks are an excellent probe of the QGP as they are produced at very early stages of the 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 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 the open-charm hadrons.

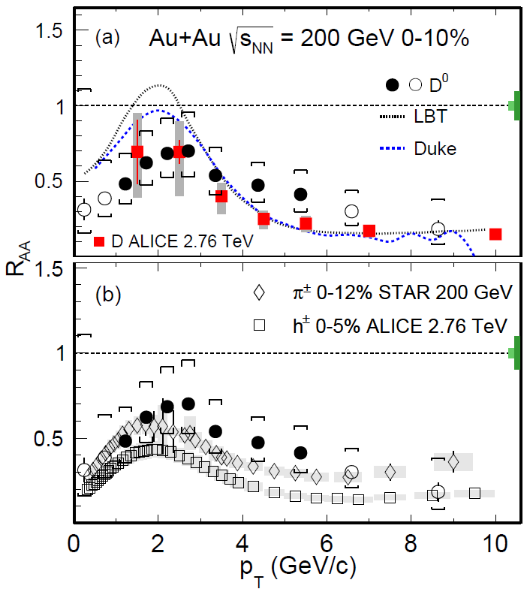

Figure 1: Nuclear modification factor of D^0 mesons measured by STAR in 0-10% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV [2]. The data are compared to STAR measurement of charged pions in Au+Au collisions at the same energy [3] and also to LBT and Duke model calculations [4, 5] . ALICE measurements of D mesons and charged hadrons are shown for comparison as well [6, 7].

Result from one of the first open-charm hadron measurements with the HFT by STAR is presented in Fig. 1 which shows the nuclear modification factor (R_{AA}) of D^0 mesons as a function of transverse momentum (p_T) for 0-10% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. High-p_T D^0 mesons are significantly suppressed in Au+Au collisions with respect to p+p collisions. The suppression is comparable to that of charged pions measured by STAR in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The D^0 data are reasonably well reproduced by models incorporating both collisional and radiative energy losses, and collective flow [4, 5].

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 only utilizing the precise track reconstruction with 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 total open-charm cross section.

2. Results

The invariant spectra 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. 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 invariant spectra are used to calculate the nuclear modification factor (R_{AA}) and the $(D^+ + D^-)/(D^0 + \overline{D^0})$ yield ratio.

The R_{AA} of $D^{\pm}$ mesons as a function of p_T is shown in Fig. 2 for 0-10%, 40-80%, and 40-80% 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 of $D^{\pm}$ and D^0 mesons is comparable and the larger suppression for more central Au+Au collisions suggests stronger interactions of the charm quarks with the QGP compared to peripheral collisions.

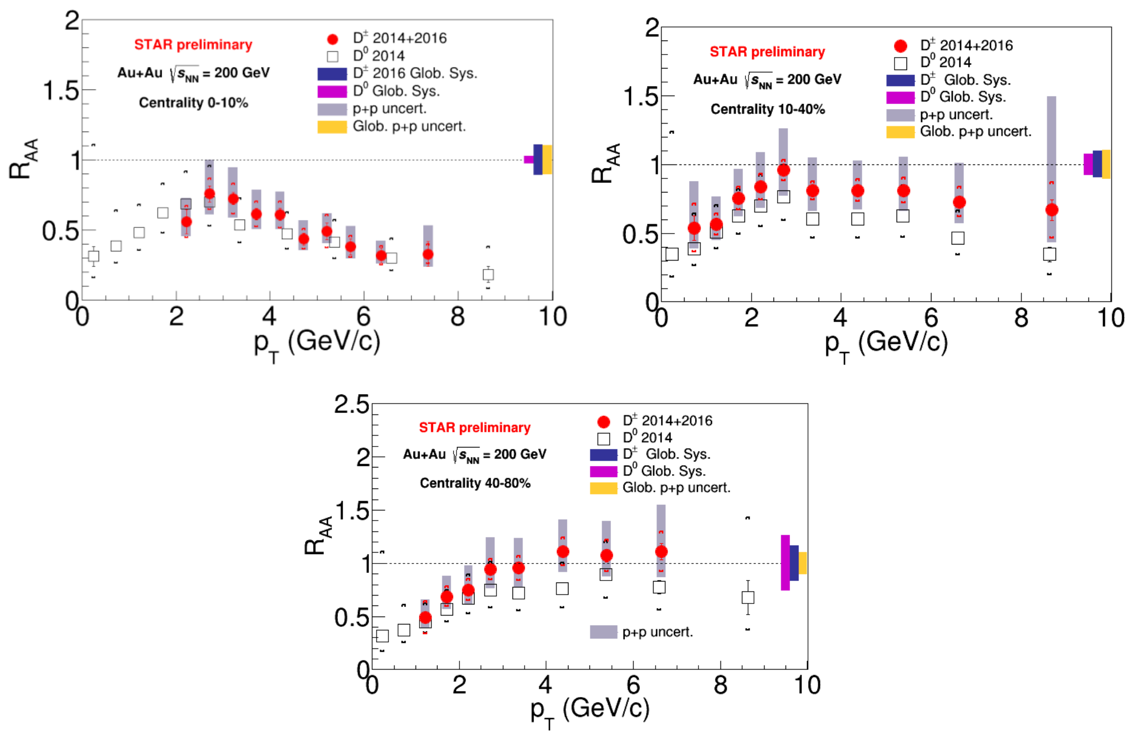

Figure 2: R_{AA} of D^0 [2] and $D^{\pm}$ mesons as a function of p_T measured by STAR in 0-10%, 10-40%, and 40-80% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

The $(D^+ + D^-)/(D^0 + \overline{D^0})$ yield ratio is shown in Fig. 3 for 0-10%, 10-40%, and 40-80% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The data are in agreement with PYTHIA 8 calculation 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 which means that the ratio has no or very week centrality dependence.

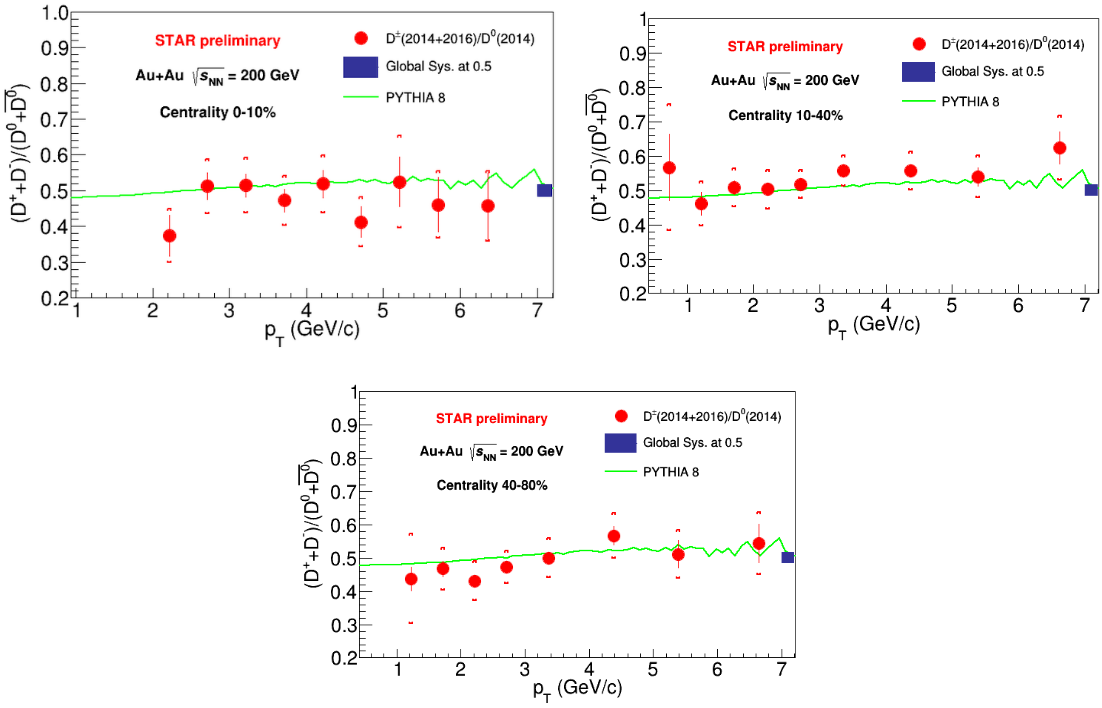

Figure 3: $(D^{+} + D^{-})/(D^{0} + \overline{D^{0}})$ yield ratio measured as a function of p_{T} by STAR in 0-10%, 10-40%, and 40-80% central Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV. The data are compared to PYTHIA 8 theoretical calculation.

3. Summary

The STAR experiment has extensively studied 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 spectra of $D^{\pm}$ mesons have been measured for three centrality classes (0-10%, 10-40%, and 40-80%) of Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 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 similar level of suppression as 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 PYTHIA 8 calculation which means that no modification of the ratio is observed in Au+Au collisions with respect to the p+p collisions. In the near future, the $D^{\pm}$ measurement will help to constrain the total open-charm cross section in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV.

Acknowledgments

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