PROCEEDINGS OF SCIENCE

Production of D_s meson in Au+Au collision at $\sqrt{s_{NN}}$ = 200 GeV

Md Nasim (for the STAR Collaboration)*
University of California, Los Angeles
E-mail: mnasim2008@gmail.com

We present the invariant yield and elliptic flow of D_s as a function of transverse momentum in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The nuclear modification factors of D_s are found to be systematically higher than those of K^0_S . The ratio between the yields of strange and non-strange open charm mesons is shown. We find that such a ratio in 0-40% central Au+Au collisions is higher than the fragmentation baseline. Our measurement indicates a substantial enhancement of D_s production in Au+Au collisions with respect to p+p collisions as compared to non-strange D mesons. The elliptic flow of D_s is also measured and compared to that of D^0 as well as model calculations.

Critical Point and Onset of Deconfinement - CPOD2017
7-11 August, 2017
The Wang Center, Stony Brook University, Stony Brook, NY

*Speaker.

PoS(CPOD2017)089

1. Introduction

The primary purpose of relativistic heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) is to create the QCD matter under high temperature and high density - Quark-Gluon Plasma (QGP), and study its properties. Due to their large masses, heavy quarks are produced on a short time scale in hard partonic scatterings during the early stages of the nucleus-nucleus collisions and the probability of thermal production in the QGP phase is expected to be small. Therefore, they are considered a good probe for studying the QGP. Among all the open charm mesons, the charm-strange meson, D_s, is particularly sensitive to the charm quark hadronization in the hot nuclear medium because of its unique valence quark composition. Theoretical calculations predict that the production of D_s can be influenced by the charm-quark recombination with strange quarks whose production is enhanced in the deconfined matter [1]. Like multi-strange hadrons, D_s mesons have smaller hadronic interaction cross-sections compared to the non-strange D mesons and are expected to freeze out early. Therefore, the elliptic flow (v_2) of D_s is considered a better measure of the partonic contribution to the charm hadron v_2 than that of D^0 or $D^{\pm}$. The Heavy Flavor Tracker (HFT) at STAR provides an opportunity for D_s measurements by reconstructing displaced decay vertices.

2. Data set and analysis details

The results presented here are based on an analysis of about 900 million minimum bias events taken during the 2014 Au+Au run at $\sqrt{s_{NN}}$ = 200 GeV. The Time Projection Chamber (TPC) and the Time-of-Flight (TOF) detectors, both with full azimuthal coverage, are used for particle identification in the central rapidity (y) region ($|y| < 1.0$). The HFT detector is used to reconstruct the decay vertices. It is made of three layers, named as PiXeL detector (PXL), Intermediate Silicon Tracker (IST) and Silicon Strip Detector (SSD). A state-of-the-art thin Monolithic Active Pixel Sensors (MAPS) technology has been used in the PXL. There are two layers of the MAPS in the PXL, which are placed at radii of 2.8 and 8 cm from the centre of the beam pipe, respectively. The track pointing resolution of the HFT detector is about 46 μm for 750 MeV/c kaons. We reconstruct D_s through the decay channel, ${D_s}^{\pm} \longrightarrow \phi$ ($\phi \longrightarrow K^+ + K^-$) + $\pi^{\pm}$. Topological and kinematic cuts are applied to reduce the combinatorial background. The wrong-sign method is used to estimate the combinatorial background. A first order polynomial function is then used to describe the residual background and a Gaussian function for the signal peak after subtraction of the combinatorial background, as shown in Fig. 1.

3. Results

The nuclear modification factors (R_{AA}) of D_s, as a function of transverse momentum (p_T), for the 0-10% and 10-40% most central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV are shown in Fig. 2. The cap symbols are the systematic uncertainties and statistical uncertainties are shown by vertical lines. The systematic uncertainties have been evaluated by using different approaches for background subtraction and by varying topological cuts. To obtain the R_{AA}, the charm quark production cross-section measured in p+p collisions by the STAR experiment [2] is used together a fragmentation

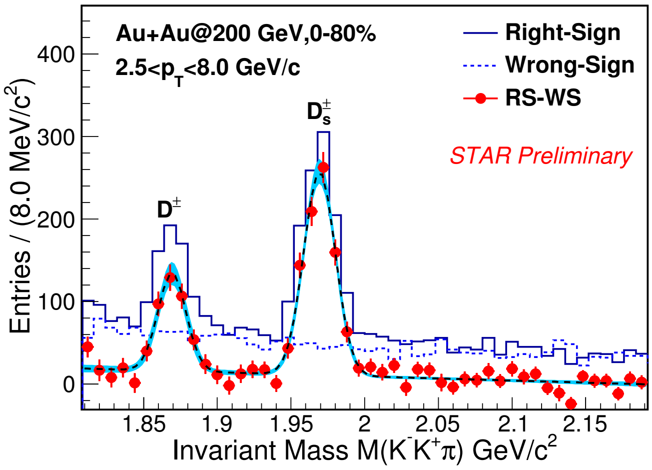

Figure 1: (Color online) The invariant mass distributions of $K^+K^-\pi$ triplets from Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV for 0-80% centrality, $2.5 < p_T < 8.0$ GeV/c.

factor $f_{frag}(c \longrightarrow D_s) = 0.079 \pm 0.004$ [3]. A Levy fit function is used to obtain the D_s yield in p+p collisions at corresponding measured p_T in the Au+Au collisions. Shaded grey bands represent combined statistical and systematic uncertainties from the p+p reference. The R_{AA} of K^0_s are also shown in Fig. 2 for 0-12% Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV [4]. The D_s R_{AA} is found to be systematically higher than those of K^0_S. The R_{AA} of D_s is consistent with unity at low p_T (2.5 <p_T < 4 .0 GeV/c) within large uncertainties. There is an indication of a suppression of high p_T (> 5 GeV/c) D_s w.r.t the p+p reference.

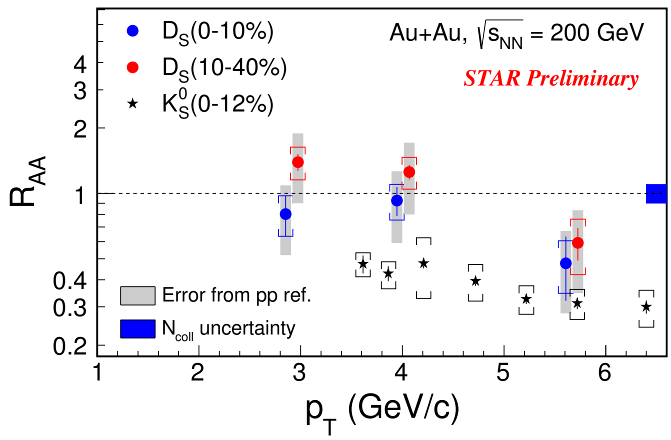

Figure 2: (Color online) The R_{AA} of D_s for 0-10% and 10-40% central Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV. Cap symbols are systematic uncertainties and statistical uncertainties are shown by vertical lines. The R_{AA} of K^0_s are shown as black stars for 0-12% Au+Au collisions.

The ratio of D_s/D^0 yields, as a function of p_T, is shown in Fig. 3. To compare with the D_s/D^0

ratio in p+p collisions, we have used the result from the PYTHIA 6.4 Monte Carlo generator [5], which is shown as a magenta band. The model prediction for Au+Au collisions by the TAMU group is also shown by the red band [1]. A substantial enhancement in the D_s/D^0 ratio in Au+Au collisions w.r.t. the fragmentation baseline (as well as PYTHIA model) is observed. The TAMU model calculation [1] based on charm quark recombination with enhanced strange quarks also under-predicts data. We have also compared our results with the ALICE measurement in Pb+Pb collisions at 5.02 TeV [6], as shown in the right panel of Fig. 3. The STAR and ALICE results are comparable in the overlapping p_T range.

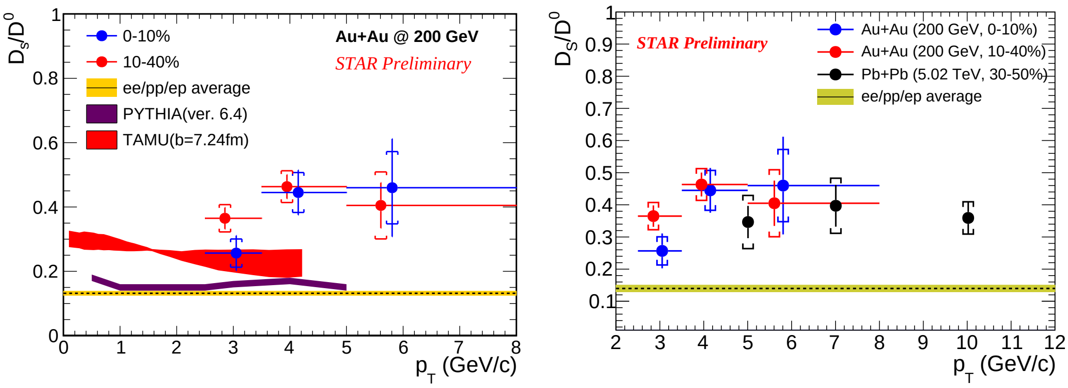

Figure 3: (Color online) The ratio of D_s/D^0 yields as a function of p_T in Au+Au collisions at $\sqrt{s_{NN}}$ =200 GeV. Yellow band corresponds to the fragmentation baseline. The magenta and red bands (left panel) represent the PYTHIA prediction and TAMU model calculation [1], respectively. Results from the ALICE collaboration for Pb+Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV are also shown (right panel). Cap symbols are systematic uncertainties and statistical uncertainties are shown by vertical lines.

The elliptic flow (v_2), a measure of the anisotropy in the momentum space, can be used to probe the dynamics of early stages of heavy-ion collisions [7]. The measured D_s v_2, as a function of p_T, in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV is shown in Fig. 4. These results are obtained by using the event plane method [8, 9]. The left panel of Fig. 4 shows that the D_s v_2 is non-zero and its magnitude is comparable to the D^0 v_2, [9]. However, the statistical uncertainties are still large. The right panel of Fig. 4 shows a comparison of the D_s v_2 with available model predictions [1, 10]. Both the AMPT and TAMU models are in agreement with the data within 1σ confidence intervals. In the AMPT model calculation, partonic interactions generate v_2 and hadronization is done via Dynamic Coalescence Model [10], whereas coupling of the charm quarks to the QGP medium and their subsequent recombination with equilibrated strange quarks give rise to the v_2 of D_s in the TAMU model [1].

4. Summary

In summary, we present the nuclear modification factors of D_s, D_s/D^0 ratio and elliptic flow of D_s as a function of transverse momentum in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the data

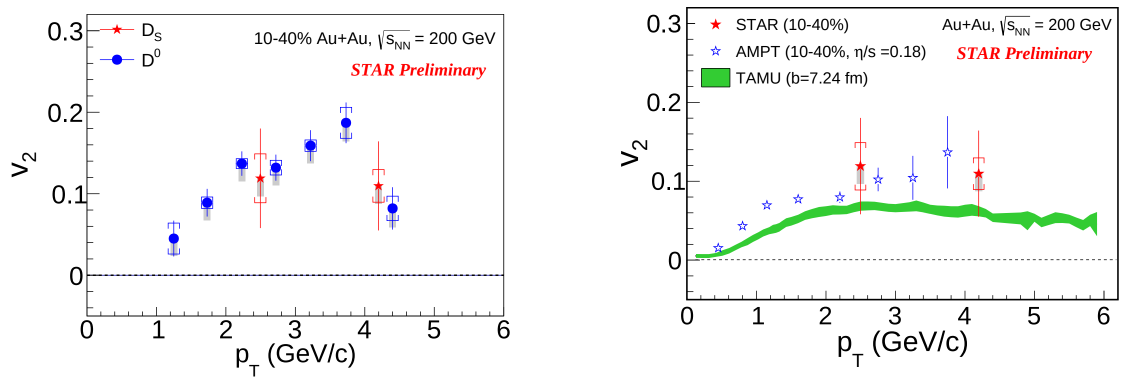

Figure 4: (Color online) D_s v_2 as a function of p_T in 10-40% Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The cap symbols are systematic uncertainties and statistical uncertainties are shown by vertical lines. Grey bands represent non-flow contribution.

collected by the STAR experiment in year 2014. The R_{AA} of D_s in 0-10% and 10-40% Au+Au collisions are consistent with unity at low p_T (2.5 $< p_T <$ 4 .0 GeV/c) with large uncertainties and there is an indication of a suppression of high p_T (> 5 GeV/c) D_s. Production of the light strange K_S^0 meson is found to be more suppressed compared to that of the heavy D_s meson. We have observed a strong enhancement in the D_s/D^0 ratio in Au+Au collisions with respect to that in p+p baseline. This may indicate that coalescence plays an important role for charm quark hadronization in the QGP. The elliptic flow of the D_s meson is measured in Au+Au collisions (10-40%) at $\sqrt{s_{NN}}$ = 200 GeV and is found to be comparable to the D^0 v_2 within large uncertainties.

References

[1] M. He, R.J. Fries and R. Rapp, Phys. Rev. Lett. 110, 112301 (2013).

[2] L. Adamczyk et al. (STAR Collaboration), Phys. Rev. D 86, 72013 (2012).

[3] M. Lisovyi, et. al., EPJ C 76, 397 (2016).

[4] G. Agakishiev et al. (STAR Collaboration), Phys. Rev. Lett. 108, 72302 (2012).

[5] T. Sjostrand, S. Mrenna and P. Skands, JHEP 0605:026 (2006).

[6] A. Barbano (for the ALICE Collaboration), Nucl. Phys. A 967, 612 (2017).

[7] P. F. Kolb et al., Nucl. Phys. A 715, 653c (2003).

[8] A. M. Poskanzer and S. A. Voloshin, Phys. Rev. C 58, 1671 (1998).

[9] L. Adamczyk et al. (STAR Collaboration), Phys. Rev. Lett. 118, 212301 (2017).

[10] R. Esha et al., JPG 44, 045107 (2017).