Centrality and transverse momentum dependence of D^0-meson production at mid-rapidity in Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR

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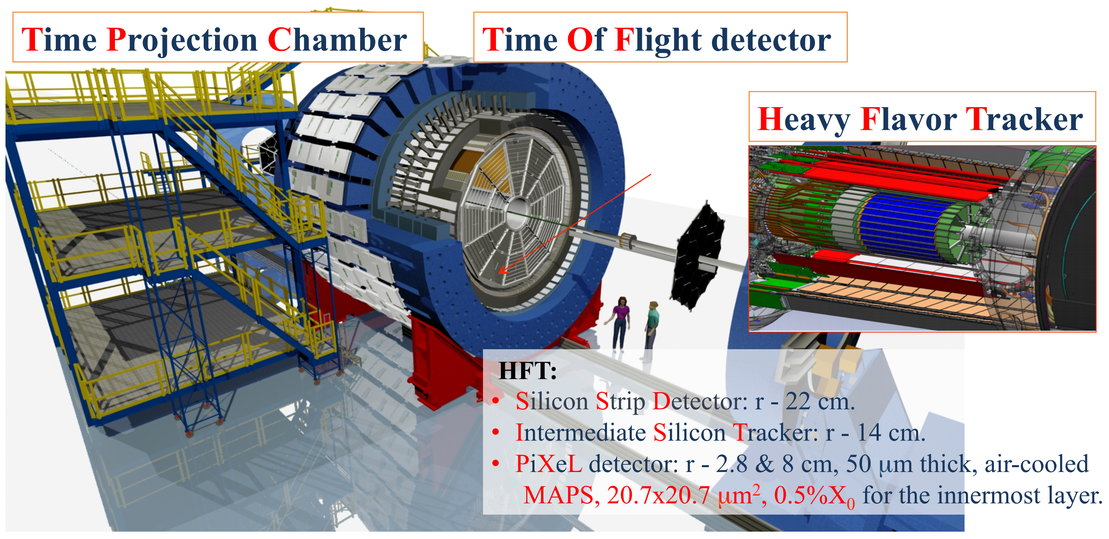
Abstract: Due to their large masses, heavy quarks are considered to be an excellent probe to study the properties of the quark gluon plasma through their interactions with the medium. In this presentation, we report on improved measurements, achieved by using supervised machine learning technique, of D^0-meson transverse momentum (p_T) spectra at mid-rapidity (|y| <1) in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The data were taken in 2014 by the STAR experiment with the Heavy Flavor Tracker, a high resolution silicon vertex detector. D^0 mesons are measured through their hadronic decay channels, $D^0 \rightarrow K^- + \pi^+$, via topological reconstruction of the secondary decay vertices. After being corrected for the detector acceptance, tracking and topological cut efficiencies, invariant yields of D^0 mesons are presented in various centrality intervals covering a wide transverse momentum region ($0 < p_T < 10$ GeV/c). The charmed hadron (D^0) freeze-out properties and radial collectivity are discussed within the Blast-Wave model. Nuclear modification factors of D^0 (R_{CP}, R_{AA}) in various centrality bins are calculated and compared to phenomenological model calculations.

Motivation

- Recent measurements of high-p_T D-meson production at RHIC and LHC show a strong suppression in the nuclear modification factor R_{AA}. The suppression is similar to that of light hadrons at $p_T > 4$ GeV/c.[1,2]
- D mesons also exhibit significant elliptic and triangular flow at RHIC and LHC. The magnitude, when scaled with constituent quark number and plotted as a function of transverse kinetic energy per quark, is similar to those of light and strange flavor hadrons.[3,4]
- Precise measurements of the centrality and transverse momentum dependences of the D-meson spectrum covering a wider kinematic range are presented. They are compared to theoretical calculations, helping to constrain parameters and reduce uncertainties in the models.

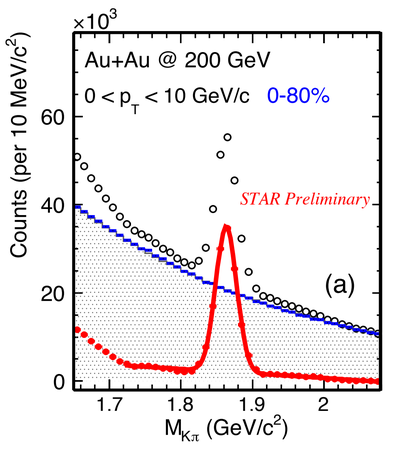
[1] Phys. Rev. Lett. 113 (2014) 142301 [2] JHEP 03 (2016) 081
[3] Phys. Rev. Lett. 118 (2017) 212301 [4] Phys. Rev. C 90 (2014) 034904 [5] Phys. Rev. C94, 014909 (2016)

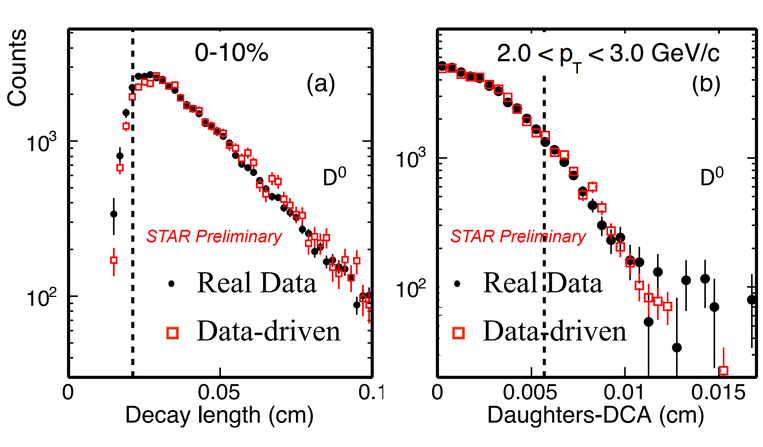
STAR and HFT Performance

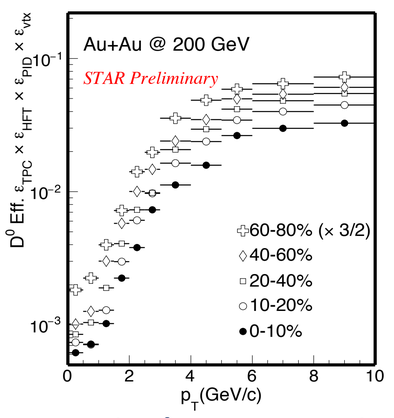


D^0 Reconstruction & Efficiency from Data-driven Simulation

- Topological cuts for the D^0 reconstruction are optomized with TMVA rectangular cuts method.
- Topological variables are well reproduced by data-driven simulation







Ingredients of the data-driven simulator:

- Extract centrality-dependent vertex z distributions from data.
- Extract ratio of HFT tracks matched to TPC tracks from data. [DCA: Distance of the Closest Approach]
- Extract DCA_{XY} - DCA_Z distributions from data.
- Extract TPC tracking efficiency and momentum resolution from embedding.

Validated with full GEANT simulation !

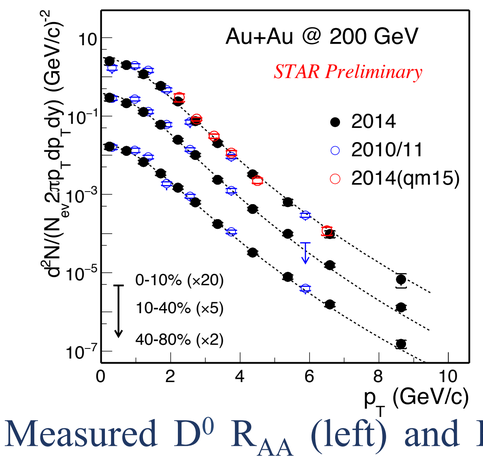
- Total D^0 reconstruction efficiencies containing TPC+PID+HFT+Topo.

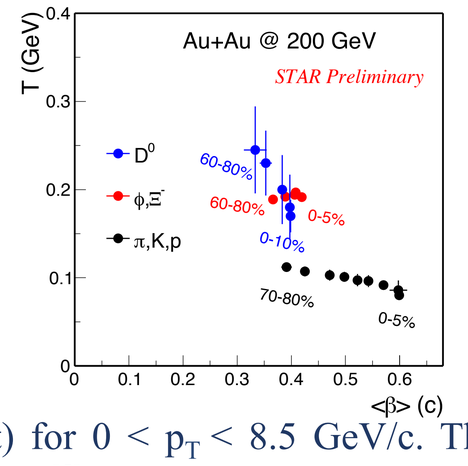
Summary and Conclusions

- We report on the improved measurement of D^0 production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with the STAR HFT detector.
- D^0 invariant yields are presented as a function of p_T in three centralities.
- R_{cp} and R_{AA} are significantly suppressed at high p_T reaffirming the strong energy loss for charm quarks when traversing the hot medium.
- The p_T-integrated D^0 yield is smaller (1.5σ) than that in p+p collisions, indicating that Cold Nuclear Matter (CNM) effect or charm quark coalescence may play a role.
- $\overline{D}^0/D^0$ ratio is above 1 in central and semi-central collisions. We expect $\overline{\Lambda}_c^-/\Lambda_c^+$ to be smaller than 1 and total c and anti-c quarks are conserved.

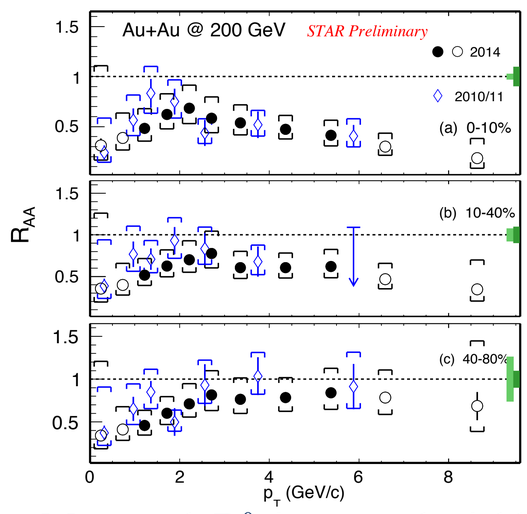
Results

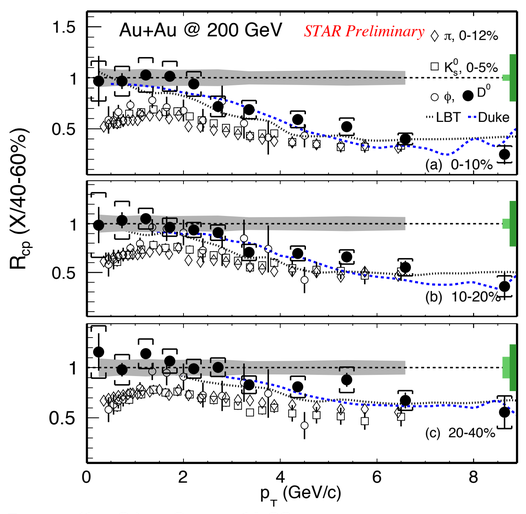
- Measured D^0 transverse momentum spectra (left) for different centralities using 2014 data. Right panel shows the Blast Wave fit parameters.



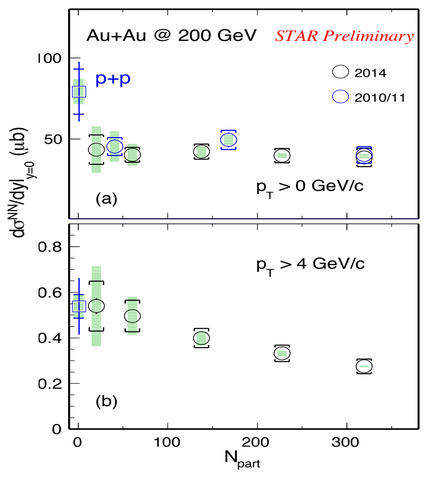


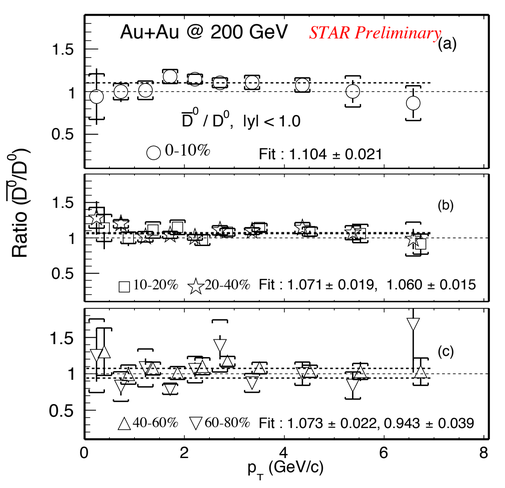
- Measured D^0 R_{AA} (left) and R_{cp} (right) for $0 < p_T < 8.5$ GeV/c. The results are compared to model calculations.[5]





- Measured D^0 integrated yield vs. N_{part} (left) for different ranges of transverse momentum and $D^0/\overline{D}^0$ ratio vs p_T (right) for different centralities.





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