D± meson production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by the STAR experiment

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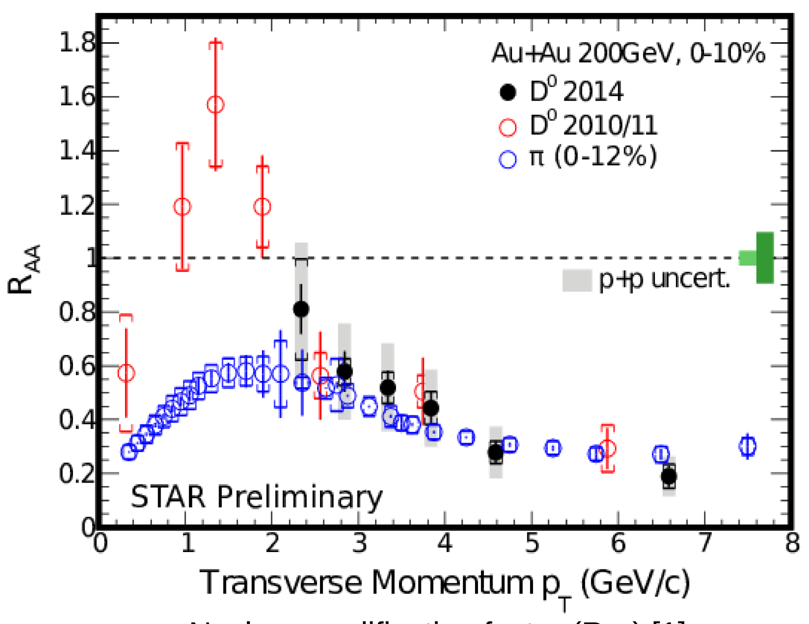
Abstract

Charm quarks are mainly created in hard processes at the beginning of heavy-ion collisions and can be used as a tool to study properties of the Quark-Gluon Plasma (QGP). The modification to D-meson production in heavy-ion collisions is sensitive to the energy loss of charm quarks in the QGP. The Heavy Flavor Tracker was installed at the STAR experiment in 2014 and enables the topological reconstruction of the decay vertices for open charm mesons. It significantly improves precision on charm meson measurements. Besides the measurement of D^0, $D^\pm$ provides an additional handle and cross-check to study the interaction between charm quarks and the medium. In this poster, we present measurements of $D^\pm$ production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. $D^\pm$ mesons are reconstructed topologically via the hadronic decay channel $D^\pm \to K^\mp\pi^\pm\pi^\pm$ from the data collected in 2014 with the Heavy Flavor Tracker. The invariant yield of $D^\pm$ mesons in the transverse momentum range of $2 < p_T < 10$ GeV/c is extracted for 0-10% most central Au+Au collisions, and is found to be consistent with the D^0 yield.

Motivation

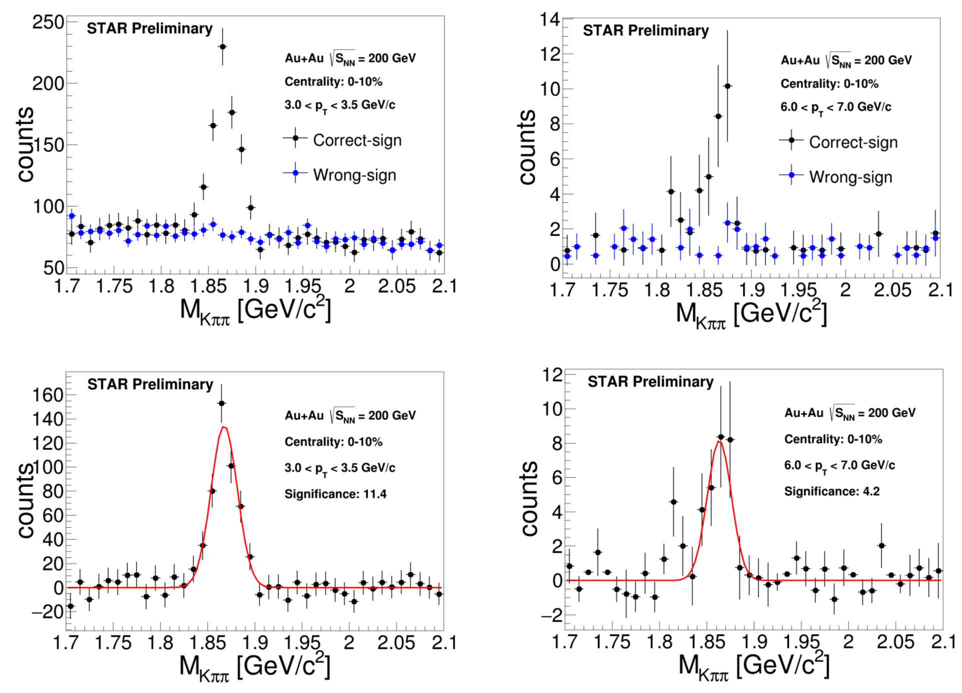
- Heavy quarks are mostly created in the initial phase of heavy-ion collisions. Therefore they experience the entire evolution of the system and are a good probe to study the properties of the Quark-Gluon Plasma (QGP).
- The strong suppression of high-p_T D^0 meson yields indicates large energy loss of charm quarks in the QGP.
- Besides the D^0 meson, $D^\pm$ provides an independent handle to study the charm quark interaction with the medium.



Nuclear modification factor (R_{AA}) [1].

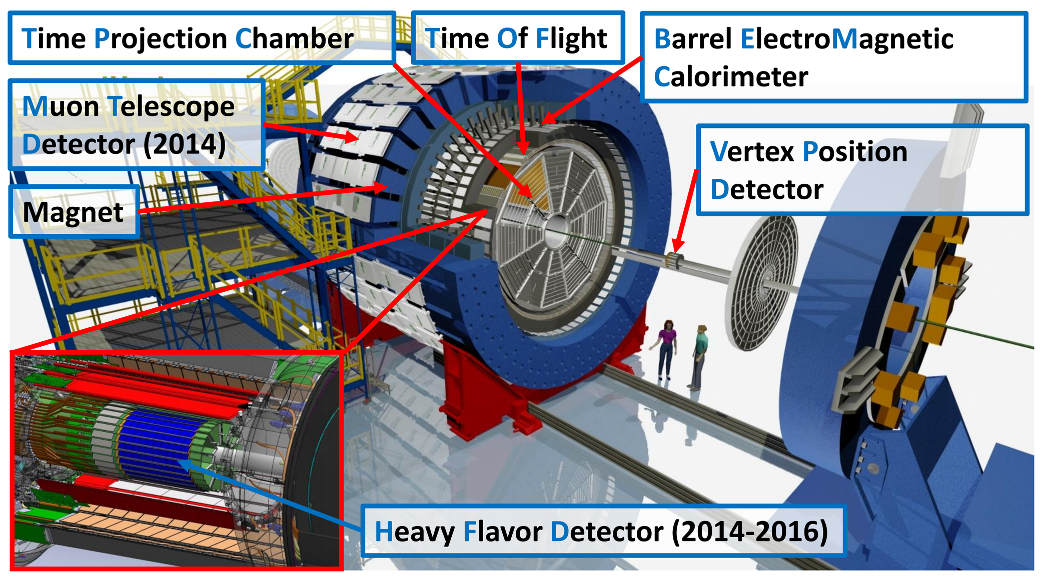
D± raw yields

- The Hadronic decay channel $D^\pm \to K^\mp\pi^\pm\pi^\pm$ is used.
- Background is estimated via the wrong-sign method: 2 correct-signal (D^+, D^-) and 6 wrong-signal (background) combinations.
- $D^\pm$ raw yields and significance are calculated using the bin-counting method in the 0-10% central Au+Au collisions for $2 < p_T < 10$ GeV/c.
- Significance: $\frac{signal}{\sqrt{signal+background}}$

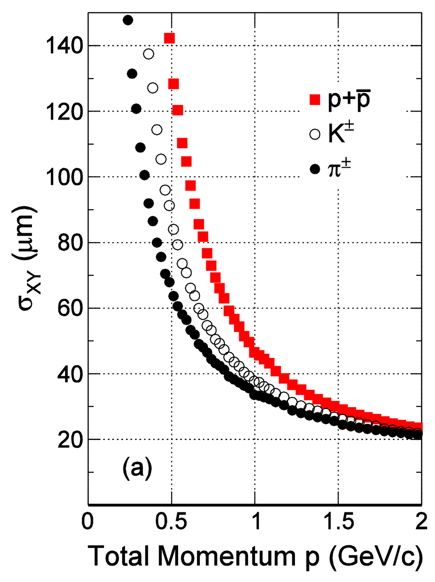


STAR detector

- The Solenoidal Tracker at RHIC (STAR) was designed to investigate the strongly interacting matter. It covers full azimuth at mid-rapidity (|η| < 1) with 0.5 T of solenoidal magnetic field.
- Main sub-detectors used in this analysis are:
  1. Time Projection Chamber (TPC): main tracking device, particle identification via specific energy loss dE/dx, momentum reconstruction.
  2. Time Of Flight (TOF): low p_T particle identification via velocity 1/β.
  3. Heavy Flavor Tracker (HFT) [2]: new inner tracking system composed of three silicon detectors – the PIXEL made of two Monolithic Active Pixel Sensors layers, Intermediate Silicon Tracker (IST) and Silicon Strip Detector (SSD).



STAR detector with main mid-rapidity detectors.

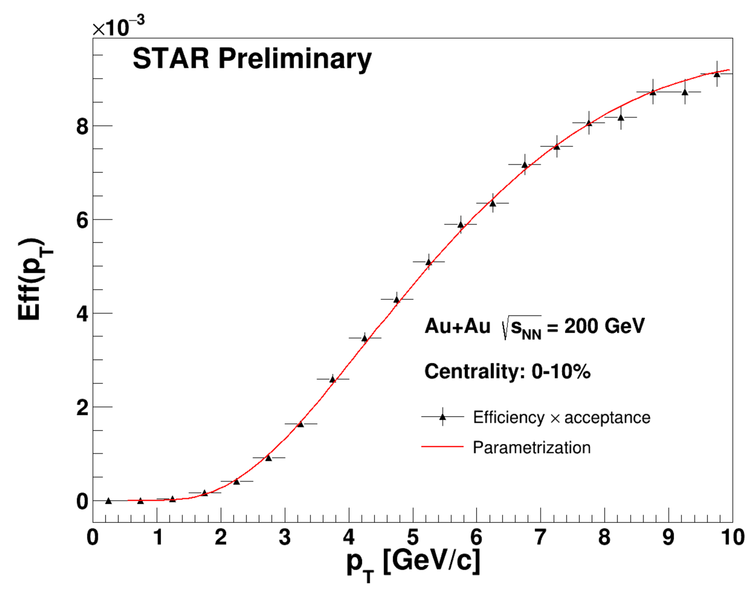


HFT resolution [3].

Acceptance and reconstruction efficiency

- Data-driven fast simulator has been developed using
  1. centrality-dependent V_z distributions from data
  2. ratio of HFT matched tracks to TPC tracks from data
  3. TPC efficiency and momentum resolution from embedding

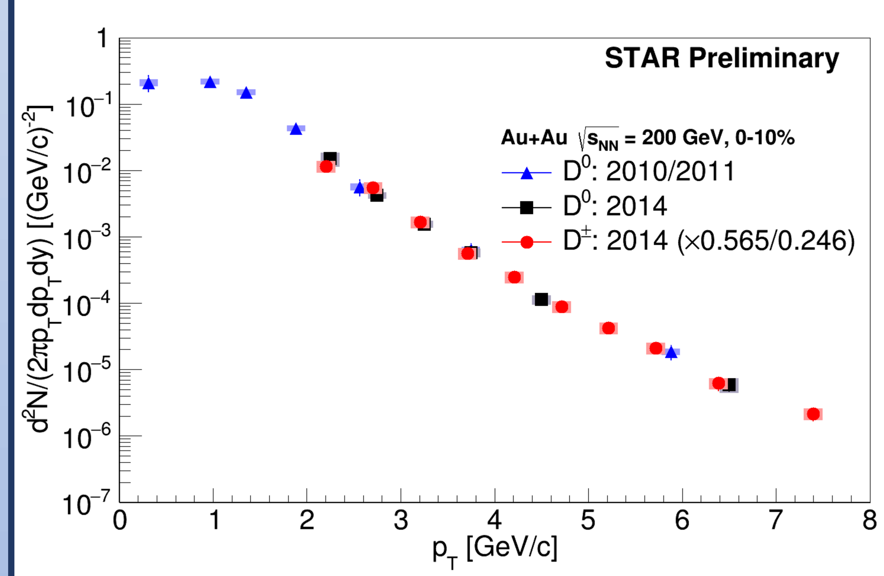
and validated with full GEANT simulation.

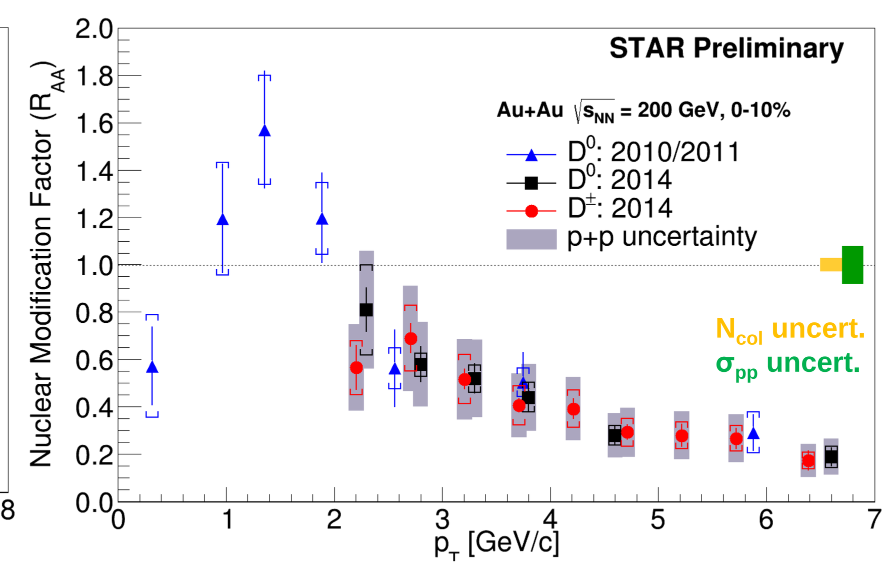


Results

- The $D^\pm$ raw yield is corrected using the following formula:
  - $\frac{d^2N}{dp_T dy}\frac{1}{2\pi p_T} = \frac{Yield_{uncorrected}}{2\cdot\pi\cdot N_{charge}\cdot N_{events}\cdot BR\cdot p_T\cdot \Delta p_T\cdot \Delta y\cdot Eff(p_T)}$

  where $N_{charge} = 2$, N_{events} number of events, BR = (9.13±0.19)%, Δp_T bin width, Δy rapidity width, $Eff(p_T)$ detector acceptance x efficiency.
- Systematic uncertainties are estimated by varying cuts on daughter p_T, daughter DCA, DCA_{pair}, Δ_{max}, TPC fit points, changing histogram binning and testing fit stability.
- The D^0 spectrum in p+p collisions measured using 2009 data is used as the baseline.

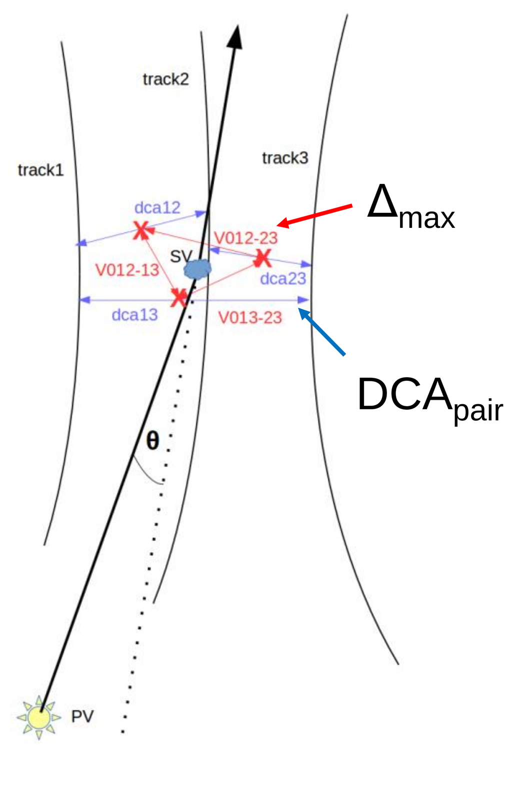




- The invariant yield of $D^\pm$ mesons with $2 < p_T < 8$ GeV/c in 0-10% central Au+Au collisions is consistent with that of D^0 mesons within uncertainties. The nuclear modification factor (R_{AA}) for $D^\pm$ also exhibits strong suppression at high p_T, indicating substantial energy loss of charm quarks in the medium.

D± reconstruction

- About 900 million minimum-bias Au+Au events at $\sqrt{s_{NN}}$ = 200 GeV recorded in year 2014 are used for this analysis.
- **Event selection cuts:**
  - Vertex position $|V_z| < 6$ cm
  - Vertex correlation $|V_z(VPD)-V_z| < 3$ cm.
- **Track selection cuts:**
  - Hits in the two PIXEL and one IST layers are required.
  - At least 20 space points in the TPC for track reconstruction.
  - Pseudo-rapidity: |η| < 1.
- **Topological cuts:**
  - Daughter DCA to primary vertex: $DCA_\pi > 100$ μm, $DCA_K > 80$ μm.
  - Pointing angle of reconstructed vertex to primary vertex: cos(θ) > 0.998.
  - $D^\pm$ decay length between 30 μm and 2000 μm (PDG cτ = 311.8 μm).
  - DCA between daughter pairs: $DCA_{pair} < 80$ μm.
  - Longest edge of the triangle formed by reconstructed daughter pair vertices must fulfil $\Delta_{max} < 200$ μm.
- **Particle identification:**
  - Daughter $p_T > 500$ MeV/c.
  - TPC: $|n\sigma_\pi| < 3.0$ for pions and $|n\sigma_K| < 2.0$ for kaons.
  - TOF: $|1/\beta-1/\beta_\pi| < 0.03$ for pions and $|1/\beta-1/\beta_K| < 0.03$ for kaons. TOF information is used when available, otherwise only TPC is used.



$D^\pm$ three body decay, DCA_{pair} (blue lines), Δ_{max} (red lines).

Conclusion

- The $D^\pm$ invariant yield spectrum in 0-10% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV is measured via the hadronic decay channel $D^\pm \to K^\mp\pi^\pm\pi^\pm$ for the p_T range of 2-8 GeV/c.
- The $D^\pm$ and D^0 yields are consistent, both indicating strong energy losses of charm quarks in the medium.

References

[1] G. Xie, for the STAR Collaboration, Nuclear Physics A, Volume 956, Pages 473-476
[2] J. Schambach, for the STAR Collaboration, Physics Procedia, Volume 66, 2015, Pages 514-519
[3] L. Adamczyk, for the STAR Collaboration, arXiv:1701.06060 [nucl-ex]

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