Production of D± Mesons in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV Measured by the STAR Experiment

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EJC2018 école Joliot-Curie school

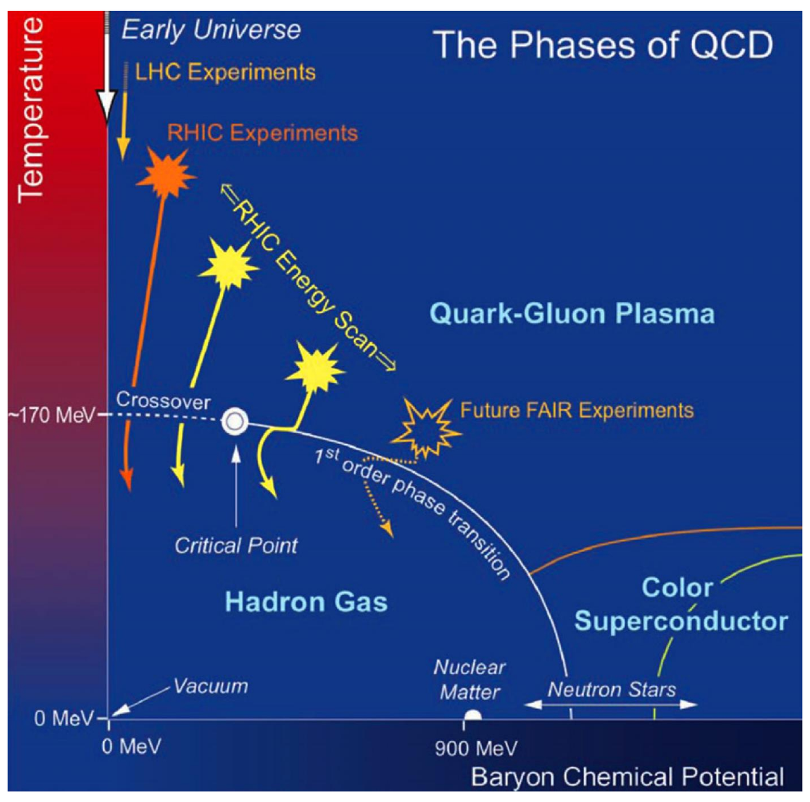
Abstract

Charm quarks are primarily produced at early stages of ultra-relativistic heavy ion collisions and can be used to probe the properties of the quark-gluon plasma (QGP) created in these collisions. Final-state open charm mesons are usually used experimentally to study the charm quark interaction with the medium. For example, suppression of D-meson production in heavy-ion collisions is sensitive to the energy loss of charm quarks in the QGP. In this poster, the production of D± mesons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV measured by the STAR experiment using data taken in 2016 is presented. The secondary decay vertices of D± mesons through the hadronic decay channel, $D^{\pm} \to K^{\mp}\pi^{\pm}\pi^{\pm}$, are reconstructed topologically utilizing the STAR Heavy Flavor Tracker. The nuclear modification factor of D± meson is presented as a function of transverse momentum in 0-10% central collisions.

Physics Motivation

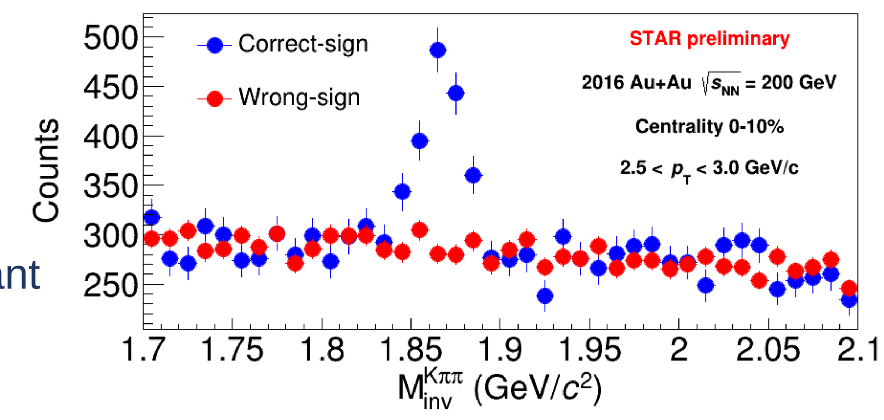
- Heavy-ion collisions are used to explore the phase diagram of the nuclear matter.
- Charm quarks are created dominantly at early stages of a A+A collision, before ignition of the QGP fireball.
- Charm quarks pass through the volume of the QGP where they loose energy.
- The energy loss can be quantified by using the **nuclear modification factor:**

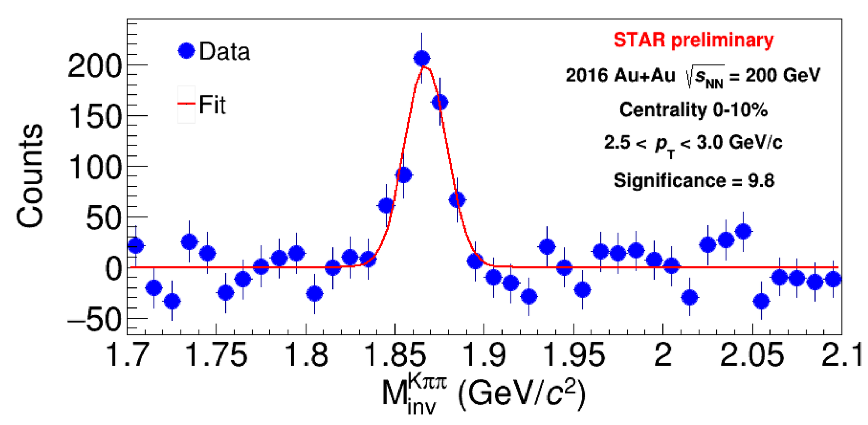
$$R_{AA}(p_T) = \frac{dN^{AA}/dp_T}{\langle N_{coll}\rangle \, dN^{pp}/dp_T}$$



Raw Yield Extraction

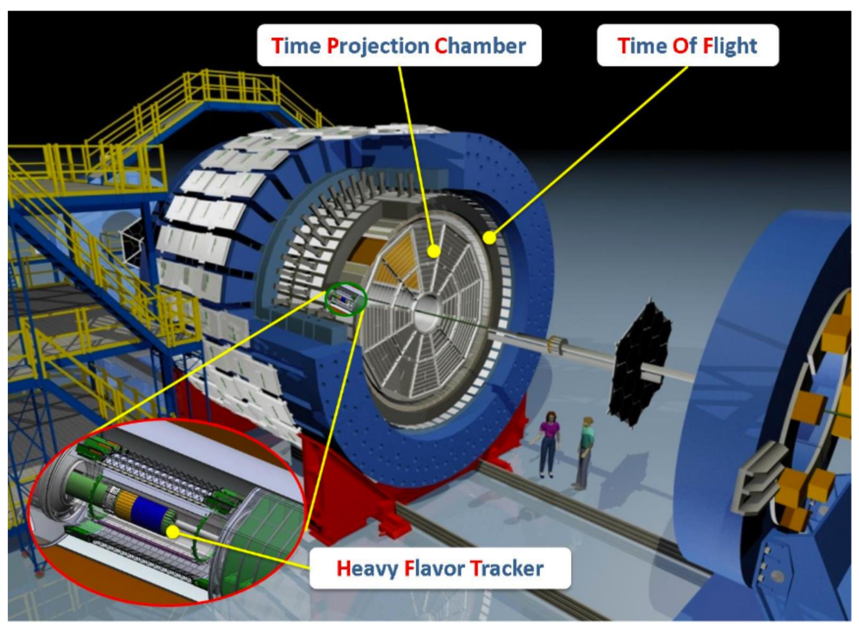
- D± is measured through the hadronic decay channel: $D^{\pm} \to K^{\mp}\pi^{\pm}\pi^{\pm}$.
- D± signal is extracted from Kππ invariant mass $M_{inv}^{K\pi\pi}$ spectrum.
- Background: wrong-sign spectrum scaled using regions outside the D± mass peak.
- The raw yield Y_{raw} is calculated by the bin-counting method in ±3σ region.

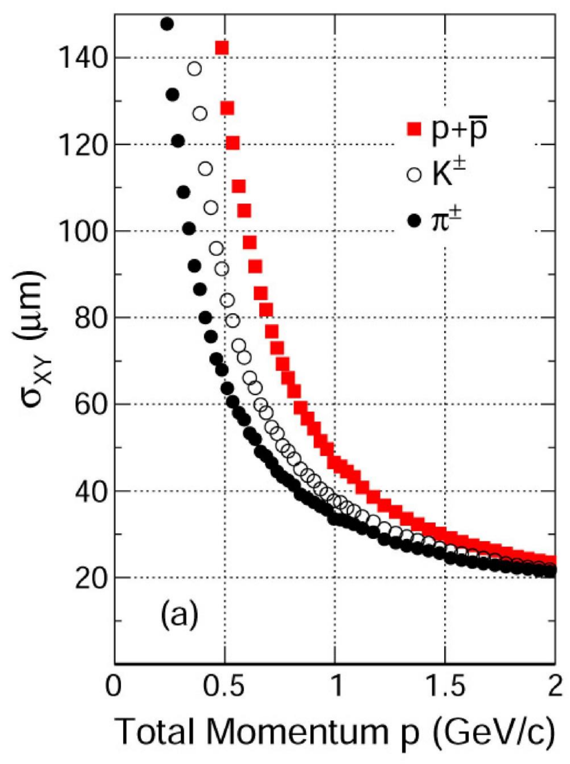




STAR Detector

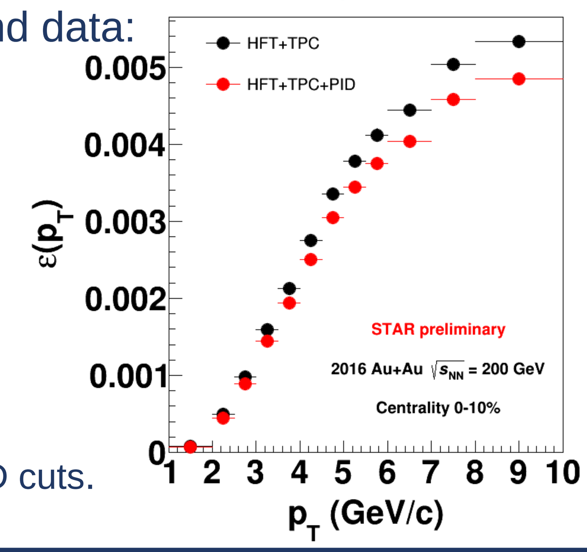
- STAR is an experiment designed primarily to study properties of strongly-interacting matter and proton spin structure.
- **Time Projection Chamber** (TPC) and **Time Of Flight** (TOF)
  - Particle momentum (TPC) and identification (TPC and TOF)
- **Heavy Flavor Tracker** (HFT) is a 4-layer silicon detector used for precise topological reconstruction of heavy-flavor hadrons, such as D± [1].
  - Pixel detectors – 2 layers, Strip detectors – 2 layers





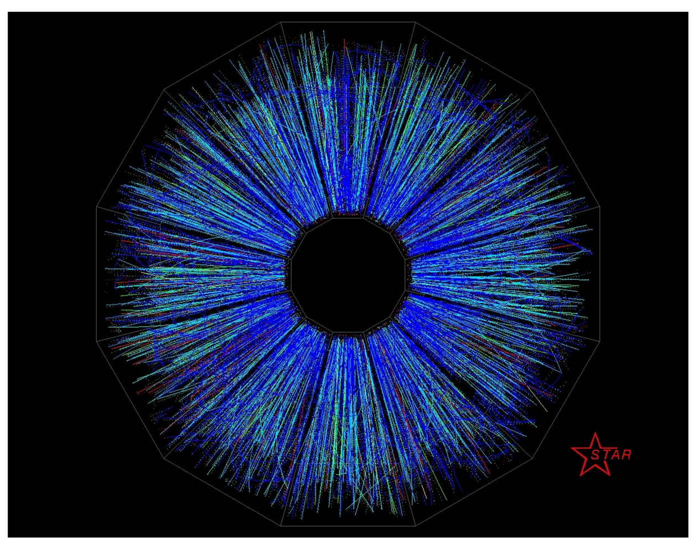
Detector Efficiency and Acceptance

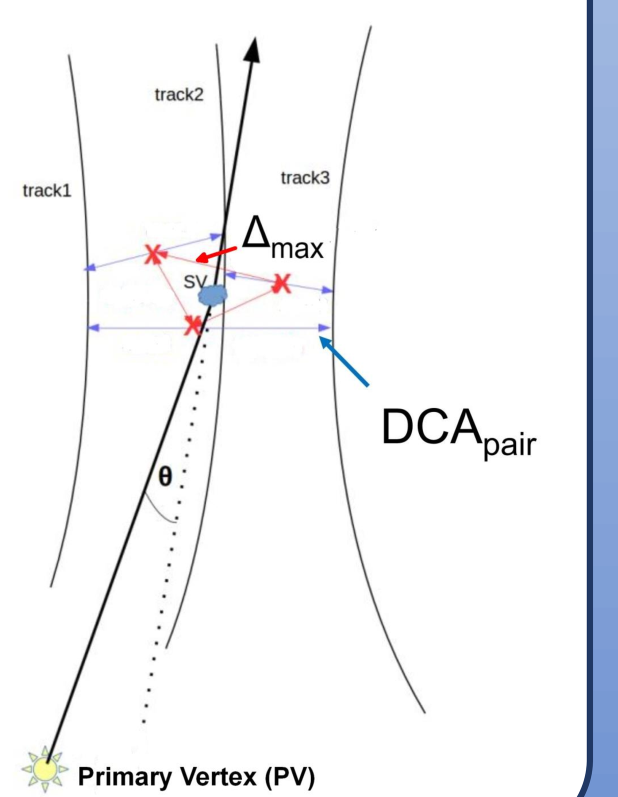
- **HFT+TPC efficiency** determined by **data-driven fast-simulator** with inputs from data and TPC embedding.
  - D± decays are generated by PYTHIA [2].
    - EvtGen [3] will be used for the 3-body decay.
  - Detector efficiency and resolution effects are applied to the D±-decayed daughters according to inputs from embedding and data:
    - TPC momentum resolution (embedding)
    - TPC tracking efficiency (embedding)
    - HFT matching efficiency (data)
    - DCA resolution (data)
    - Primary vertex position along the beam axis (data)
  - Efficiency $\varepsilon(p_T)$ is obtained from fraction of simulated D± passing the analysis cuts.
- **PID efficiency** of TPC and TOF
  - Enriched K sample at low p_T from data using strict TOF PID cuts.
  - Pure π sample obtained by reconstruction of K_S^0.

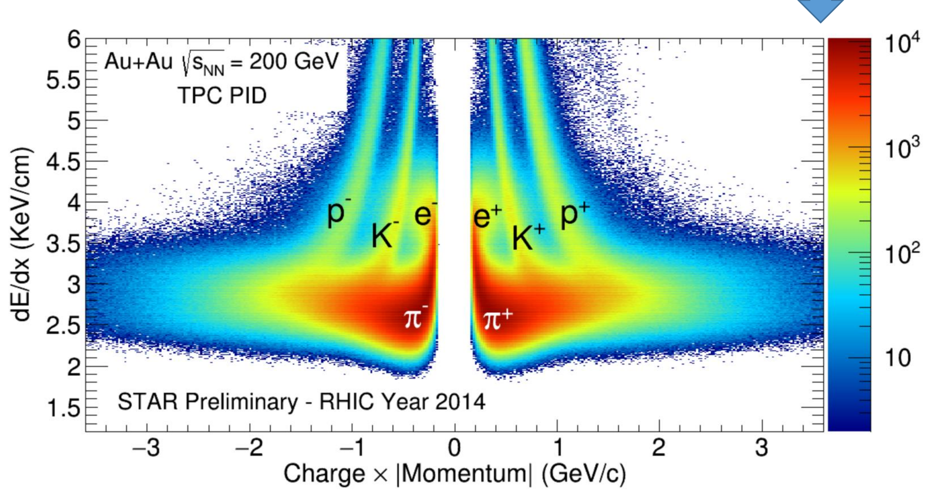


Event and Track Selection

- STAR 2016 Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
- Event selection cuts
  - $|v_z|$ < 6 cm – position of primary vertex along the beam axis
- Track cuts
  - p_T > 300 MeV/c – suppresses combinatorial background from low p_T particles
  - Pseudorapidity $|\eta|$< 1 – detector acceptance
  - Full coverage in azimuthal angle φ.
  - Number of hits in TPC > 20 – good track quality
- Topological cuts
  - Constrain topology of the secondary vertex
    - Decay length, distance among daughter tracks, pointing angle, distance of closest approach to the primary vertex of daughter tracks
  - Suppress combinatorial background
- Particle identification (PID)
  - TPC – energy loss of charged particles in the TPC gas
  - TOF – velocity of the charged particles





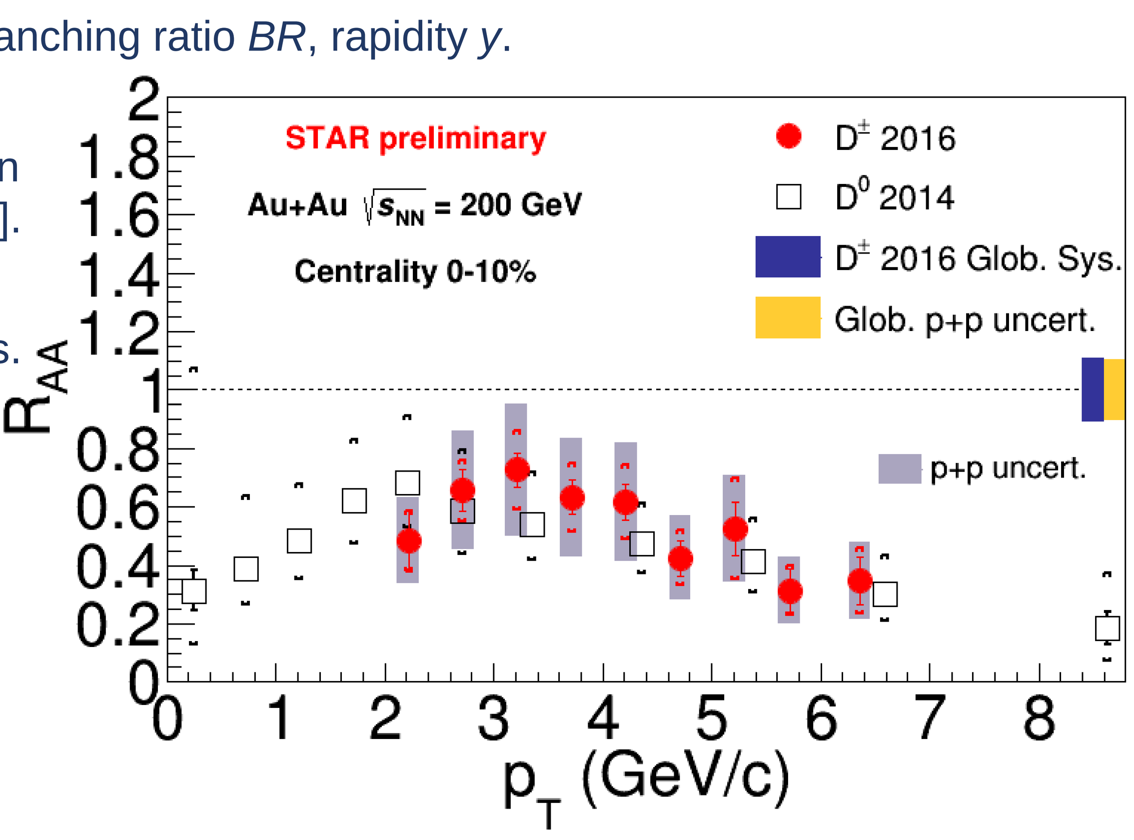


D± Nuclear Modification Factor

- Invariant yield is calculated according to:

$$\frac{d^2N}{2\,\pi\,p_T\;dp_T dy} = \frac{Y_{raw}}{2\,\pi\,N_{evt}\,BR\,p_T \Delta p_T \Delta y\;\varepsilon(p_T)}$$

- Number of events N_{evt}, branching ratio BR, rapidity y.
- Reference: combined D⁰ and D* measurement in 200 GeV p+p collisions [4].
- D± and D⁰ suppressed in central Au+Au collisions.
- D± suppression comparable to that of D⁰.
- Other centralities are currently being studied.



Conclusion

- D± has been measured in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV by STAR using data taken in 2016.
- A significant suppression of the high-p_T D± production is observed in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and is comparable to that of D⁰.
- These high precision measurements can provide stringent constraints on model calculations.

References

[1] Adamczyk L., *et al.* (STAR) 2017 Phys. Rev. Lett. **118** 212301
[2] PYTHIA: http://home.thep.lu.se/~torbjorn/Pythia.html
[3] EvtGen: https://evtgen.hepforge.org
[4] Adamczyk L., *et al.* (STAR) 2012 Phys. Rev. D **86** 072013

This poster is supported by grant Inter-Excellence of the Ministry of Education, Youth and Sports of the Czech Republic.

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research, Development and Education

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The STAR Collaboration
drupal.star.bnl.gov/STAR/presentations

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