Measurements of open-charm hadron production and total charm cross section in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV by the STAR experiment

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Quark Matter 2022, Poland, Krakow

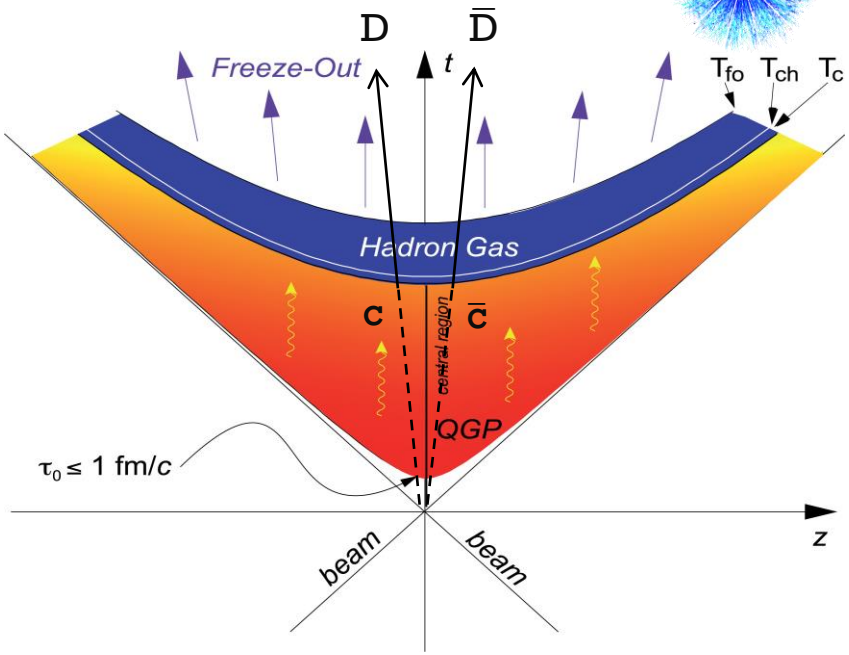
08. 04. 2022

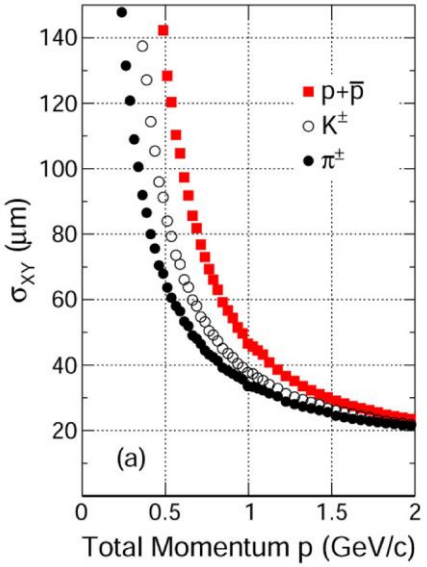
Supported in part by

U.S. DEPARTMENT OF ENERGY | Office of Science

PHYSICS MOTIVATION

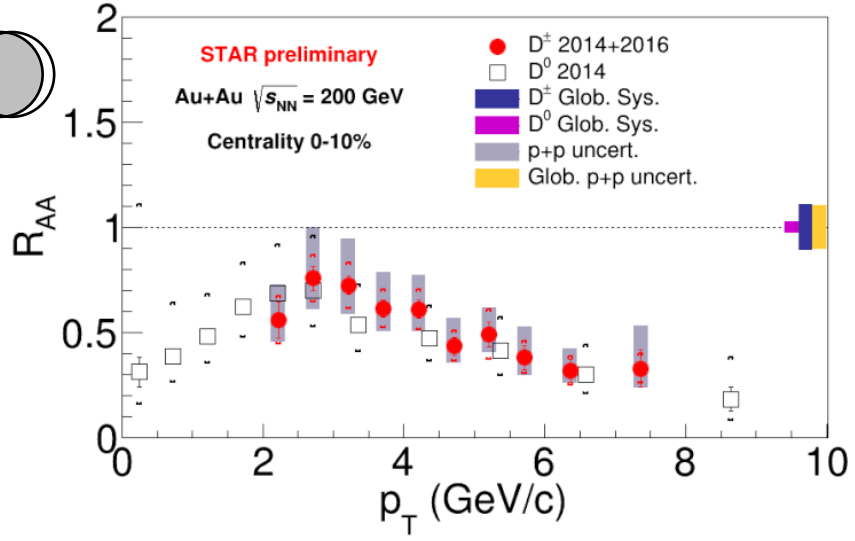
- **Quark-Gluon Plasma** (QGP) is the state of matter where quarks and gluons are no longer trapped inside colorless hadrons
- QGP can be studied using relativistic heavy-ion collisions
- At RHIC energies, **charm quarks** are produced predominantly through hard partonic scatterings at **early stage** of Au+Au collisions
  - They experience **the whole evolution of the medium**
- Charm quark production accessed at STAR via topological reconstruction of hadronic decays of open-charm hadrons
  - Thanks to good pointing resolution of the Heavy Flavor Tracker detector

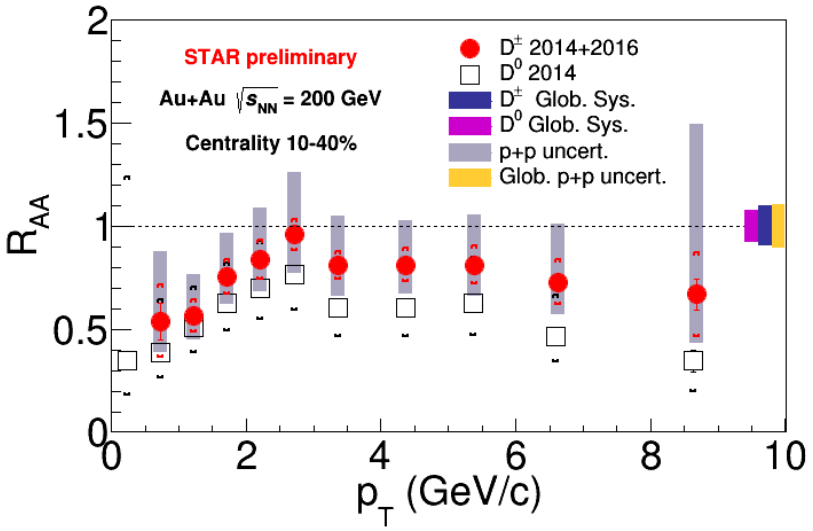


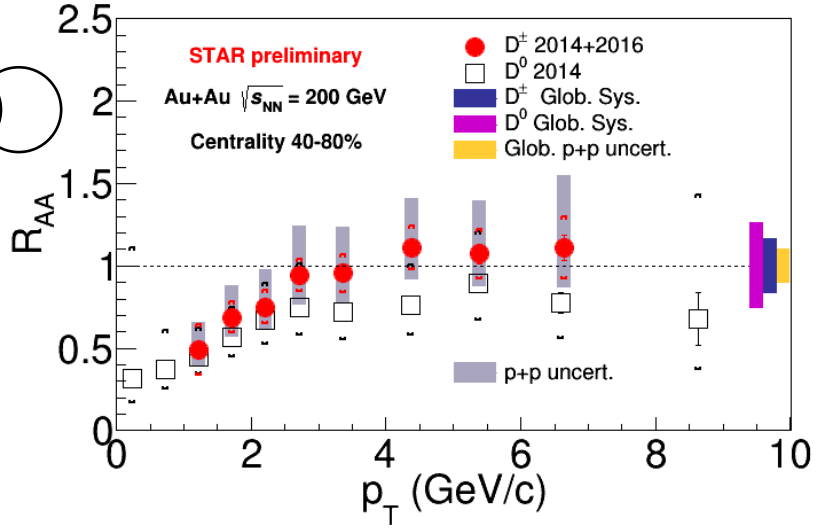


STAR: PRL 118, 212301, (2017)

D^0 AND $D^{\pm}$ NUCLEAR MODIFICATION FACTOR







- Nuclear modification factor:

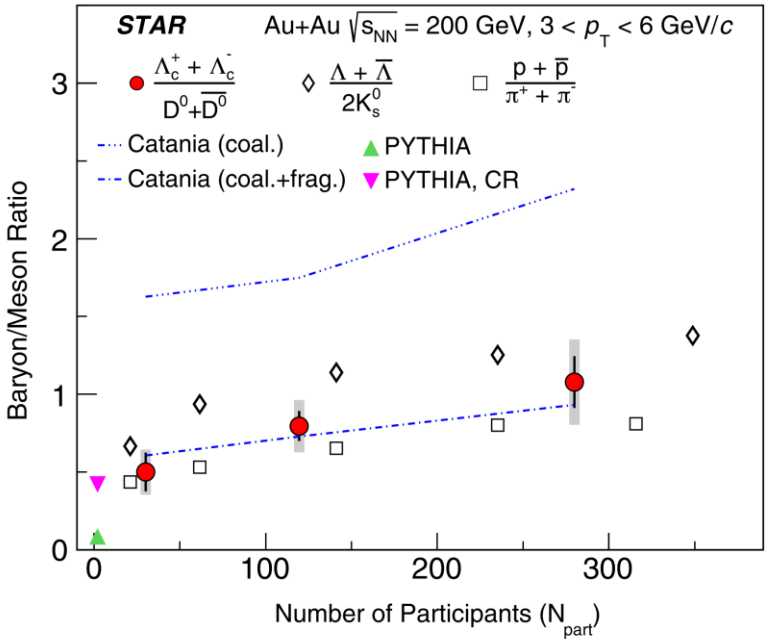
$$R_{AA}(p_T) = \frac{dN^{AA}/dp_T}{\langle N_{coll}\rangle\, dN^{pp}/dp_T}$$

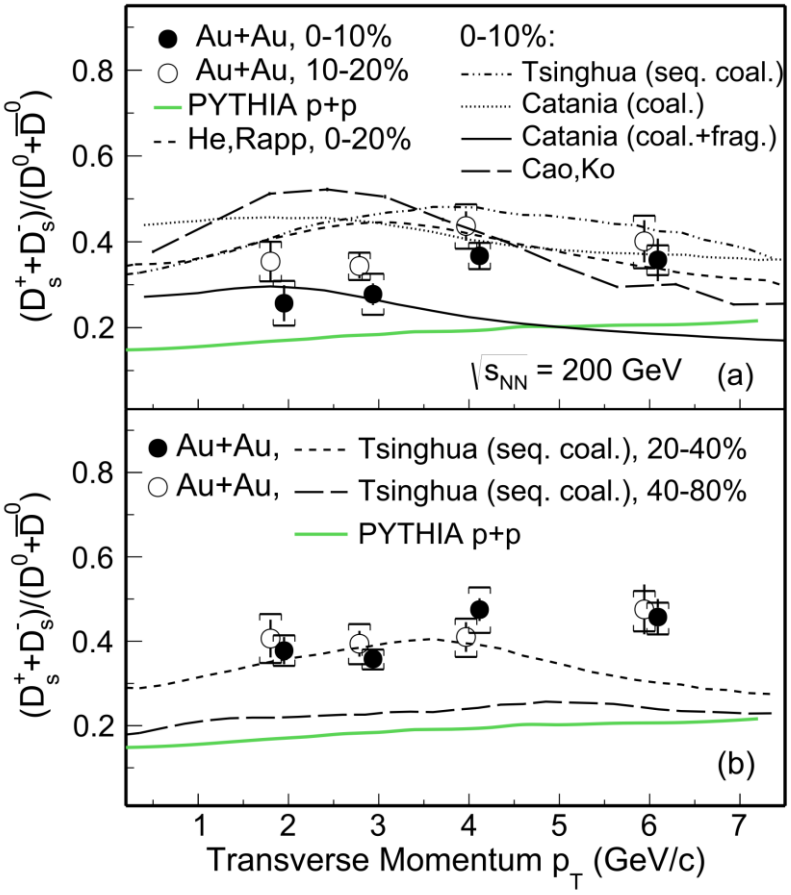
  - Systematic uncertainty of p+p reference plotted separately for $D^{\pm}$ (grey band), for D^0 included in brackets
- High-p_T $D^{\pm}$ and D^0 suppressed in central Au+Au collisions
- Similar level of suppression and centrality dependence for $D^{\pm}$ and D^0
- **Strong interactions between charm quarks and the medium**

p+p reference (STAR): Phys. Rev. D 86, 072013, (2012)
D^0 (STAR): Phys. Rev. C 99, 034908, (2019).

Λ_c/D^0 AND D_s/D^0 YIELD RATIO ENHANCEMENT

- Λ_c/D^0 and D_s/D^0 yield ratios enhanced in Au+Au collisions with respect to PYTHA calculations
- **Enhancement consistent with coalescence hadronization of charm quarks in QGP**





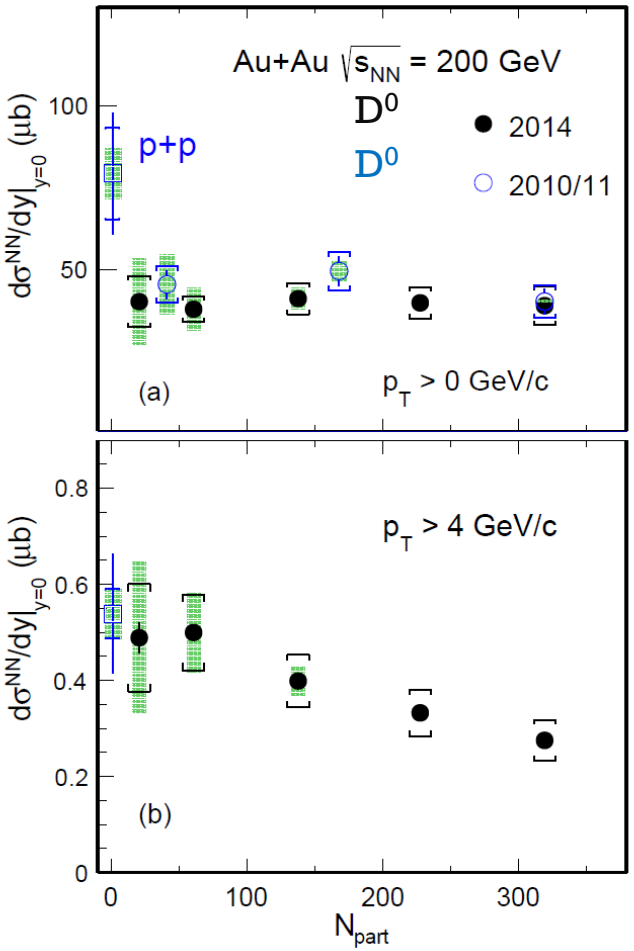
Λ_c (STAR): Phys. Rev. Lett. 124, 172301, (2020)
p/π (STAR): Phys. Rev. Lett. 97, 152301 (2006)
Λ /K (STAR): Phys. Rev. Lett. 108, 072301 (2012)
Catania: Eur. Phys. J. C 78, 348, (2018)

D_s (STAR): Phys. Rev. Lett. 127, 092301 (2021).
Catania: Eur. Phys. J. C 78, 348, (2018).
Tsinghua: arXiv1805.10858, (2018).
He, Rapp, Phys. Rev. Lett. 124, 042301 (2020)
Cao, Ko *et al.*: Phys. Lett. B 807, 135561 (2020).

TOTAL CHARM PRODUCTION CROSS SECTION

- Total charm production **cross section per binary collision** in Au+Au extracted from the measurements of open-charm hadrons
- The Au+Au result is consistent with that measured in p+p collisions within the uncertainties
- **Redistribution of charm quarks among open – charm hadron species in Au+Au collisions compared to p+p collisions**

Coll. system	Hadron	$d\sigma_{NN}/dy$ [μb]
Au+Au at 200 GeV Centrality: 10-40% $0 < p_T < 8$ GeV/c	D^0	$39 \pm 1 \pm 1$
	$D^{\pm}$	$18 \pm 1 \pm 3$
	D_s	$15 \pm 2 \pm 4$
	Λ_c	$40 \pm 6 \pm 27$*
	Total:	**$112 \pm 6 \pm 27$**
p+p at 200 GeV	**Total:**	**$130 \pm 30 \pm 26$**



*The Λ_c cross section is derived using the Λ_c/D^0 yield ratio
$D^{\pm}$ cross section calculated using preliminary invariant yields
Remaining cross sections calculated using published results

D^0 2014 (STAR): Phys. Rev. C 99, 034908, (2019).
D^0 2010/11 (STAR): Phys. Rev. Lett. 113, 142301 (2014), erratum: Phys. Rev. Lett. 121, 229901 (2018).
p+p (STAR): Phys. Rev. D 86 072013, (2012).
D_s (STAR): Phys. Rev. Lett. 127, 092301 (2021).
Λ_c (STAR): Phys. Rev. Lett. 124, 172301, (2020).

Acknowledgement: This research is funded by the project LTT18002 of the Ministry of Education, Youth, and Sport of the Czech Republic