Production of $\mathrm{D}_s^{\pm}$ mesons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV by STAR

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Outline

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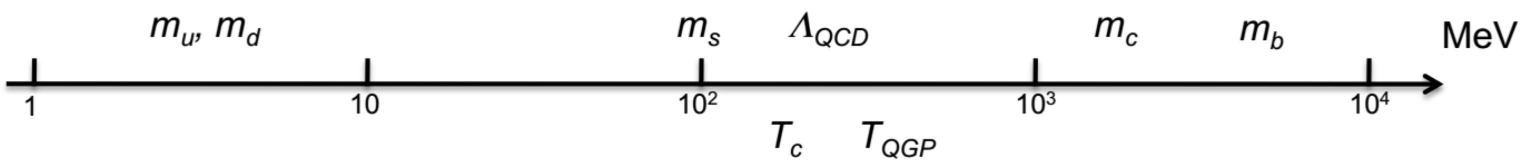
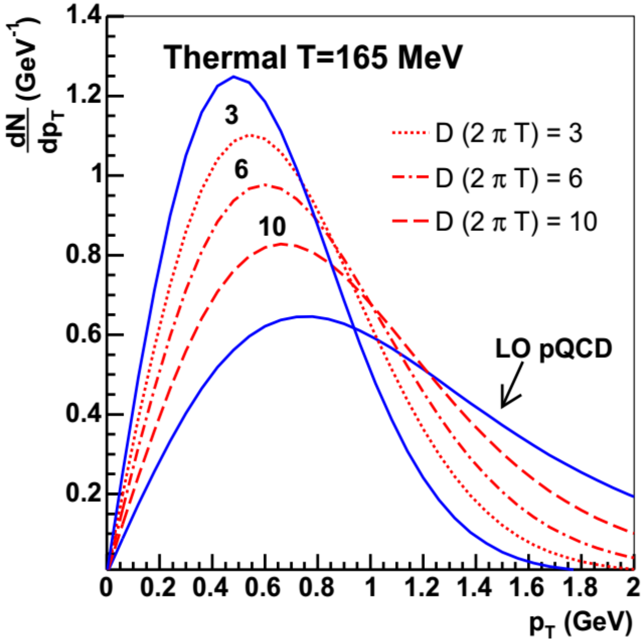
- Experiment setup
- Results
  - $D_s^{\pm}$ signal extraction
  - $D_s^{\pm}$ p_T spectrum
  - $D_s^{\pm}/D^0$ ratio
- Summary

Heavy quarks



$M_{c,b} >> T_{QGP}$: predominately created from initial hard scatterings, relaxation time is comparable with life of QGP.



$$D = \frac{T}{M\eta_D} = \frac{2T^2}{\kappa} \, .$$

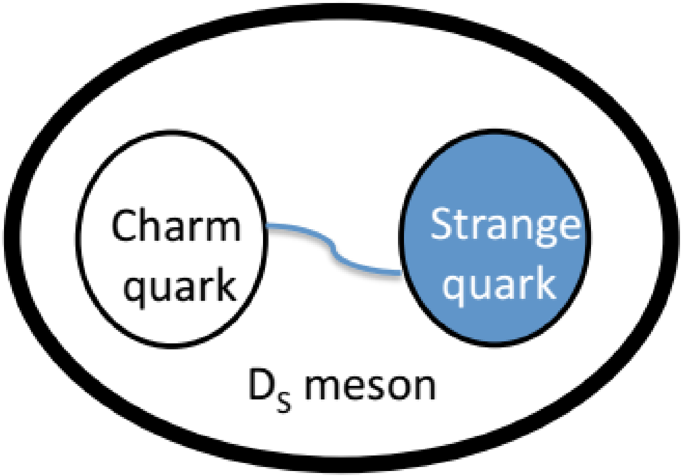
Diffusion constant D: constrain the η_D and κ in QGP evolution, investigate the interaction of HQ and QGP.

Influence the p_T spectrum of heavy quarks and heavy hadrons.

Experimental measurements: constrain model tuning and investigate properties of QGP.

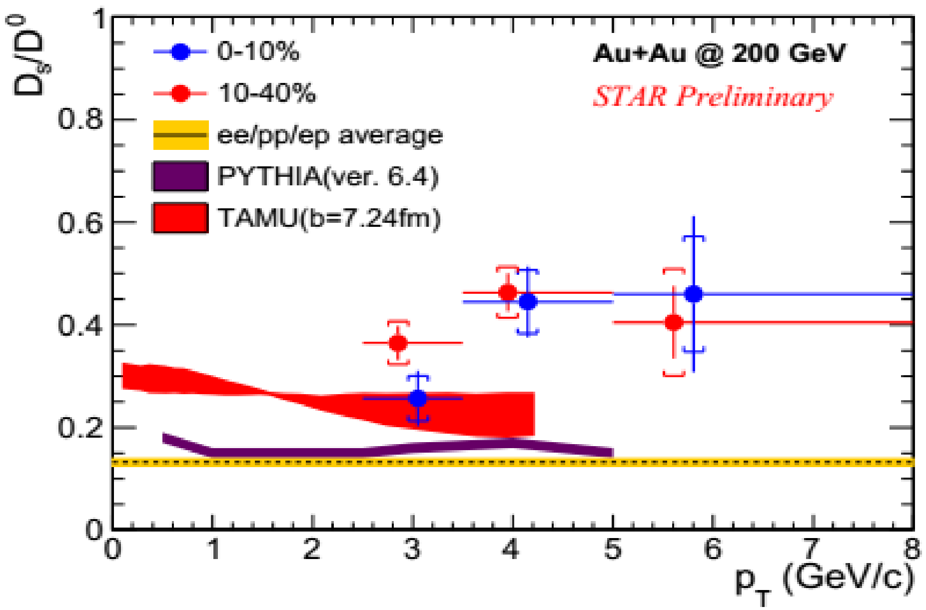
Moore G D, Teaney D. Physical Review C, 2005, 71(6): 064904.

Why study $D_s^{\pm}$?



- D_s meson: one charm quark and one strange quark.
- Excellent probes for the properties of Quark-Gluon Plasma (QGP).
- Coalescence hadronization: charm quark recombination with strange quark.

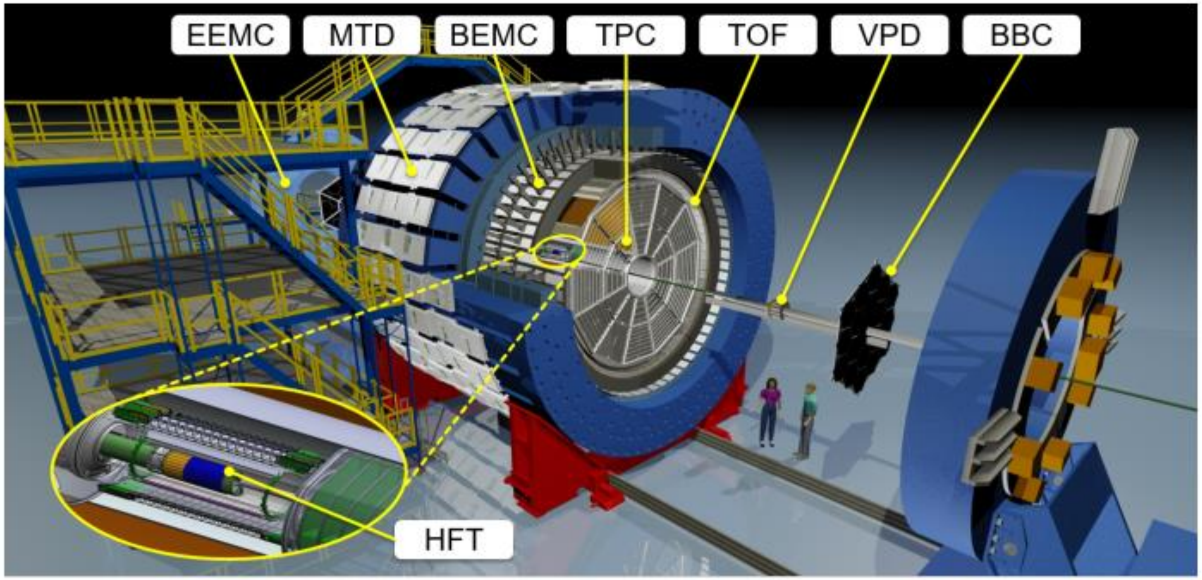
Why study $D_s^{\pm}$?



- Charm quark coalescence hadronization + strangeness enhancement --> $D_s^{\pm}/D^0$ ratio exists an enhancement relative to PYTHIA.

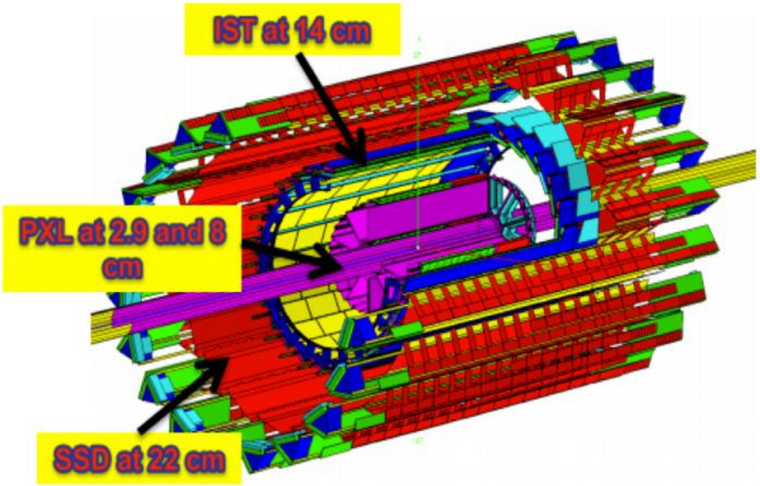
Phys.Rev.Lett.113(2014) 142301

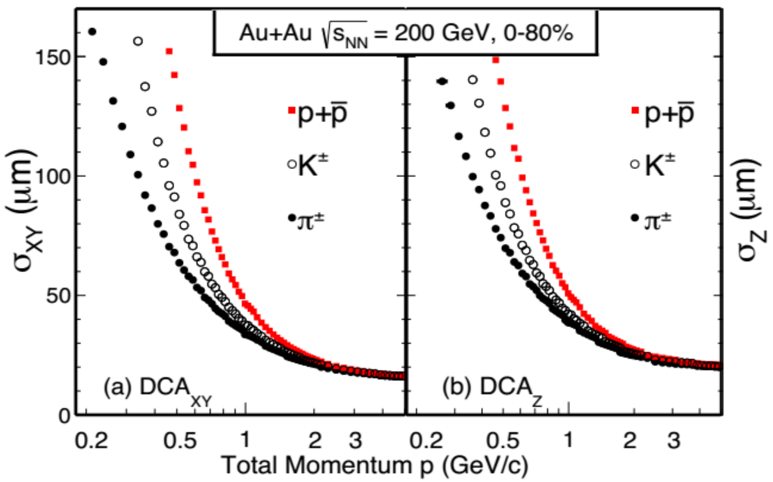
Experiment setup



- TPC + HFT: reconstruct the track of charge particles ($\pi^{\pm}, \mathrm{K}^{\pm}$), the decay vertex is reconstructed accurately.
- TPC + TOF: identify charge particles.

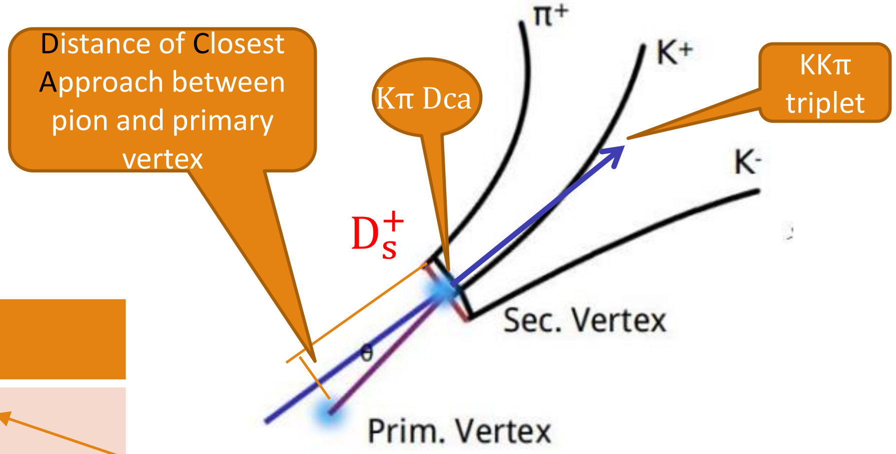
Heavy Flavor Tracker





- Heavy Flavor Tracker (HFT, 2014-2016): four-layer silicon detectors, two layer PXL, one layer IST and one layer SSD.
- Excellent resolution of Distance of Closest Approach (DCA).

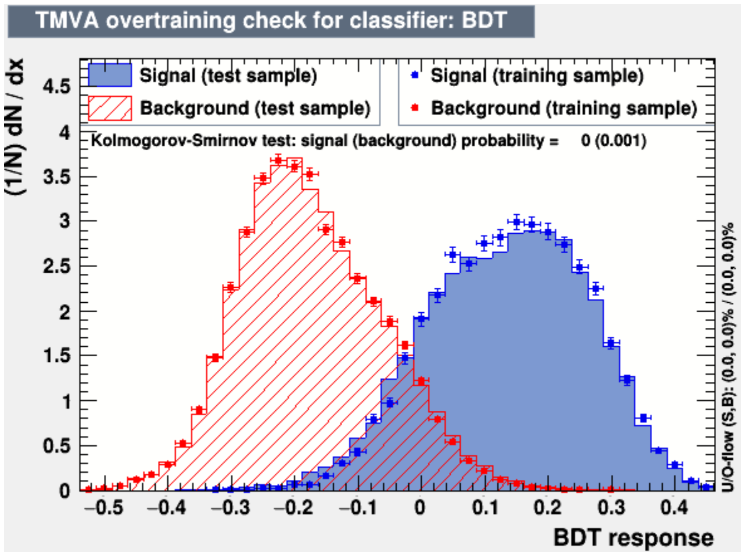
How to measure $D_s^{\pm}$?



$D_s^{\pm}$	
Quark constituent	$c\bar{s}$ ($\bar{c}s$)
Branching ratio	2.27 %
$c\tau$	150 μm
Rest mass	1967 MeV/c^2

$$D_s^{\pm} \rightarrow \phi + \pi^{\pm} \rightarrow K^+ + K^- + \pi^{\pm}$$
$$c\tau(\phi) = 4.65 \times 10^{-8} \mu m$$

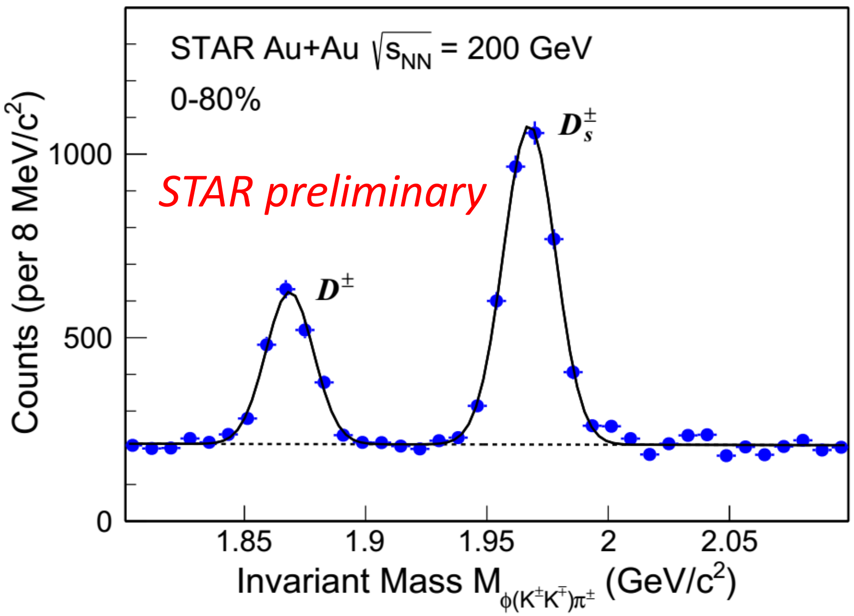
TMVA-BDT training



- D_s signal sample (PYTHIA + data-driven simulation) + Background sample (Wrong-Sign) -> BDT training.
- Overtraining test ($1.5 < p_T < 2.5$ GeV/c, 0-10%) and no overtraining.

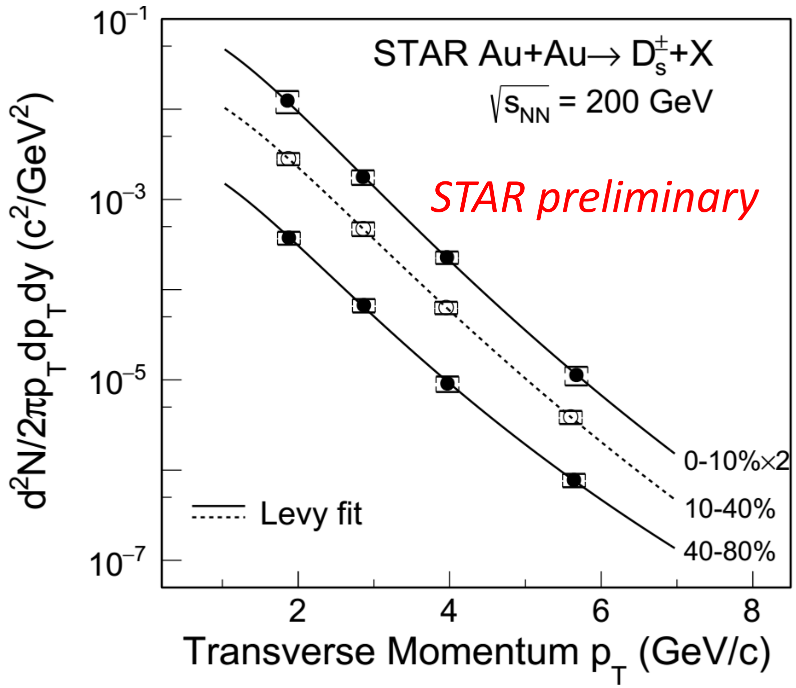
Initial topological variable cuts for BDT tuning
$1.5 < p_T^{D_s} < 8$ GeV/c, Centrality: 0-80%, $1.92 < \mathrm{Mass}_{D_s} < 2.01$ GeV/c², $\lvert y_{D_s} \rvert < 1$
DCADaughters < 0.01, Decay Length > 0.012, $0.98 < \cos\theta < 1$, $\lvert \mathrm{Mass}_{K^+K^-} - \mathrm{Mass}_{\phi} \rvert < 0.008$ GeV/c²
Min (p_T^{Kaon1}, p_T^{Kaon2}) > 0.5 GeV/c, p_T^{Pion} > 0.6 GeV/c, DCA between D_s and PV
Min (DCAKaon1, DCAKaon2) > 0.006 cm , DCAPion > 0.006 cm

Invariant mass distribution



- 2014+2016 data
- Improved signal number and significance.

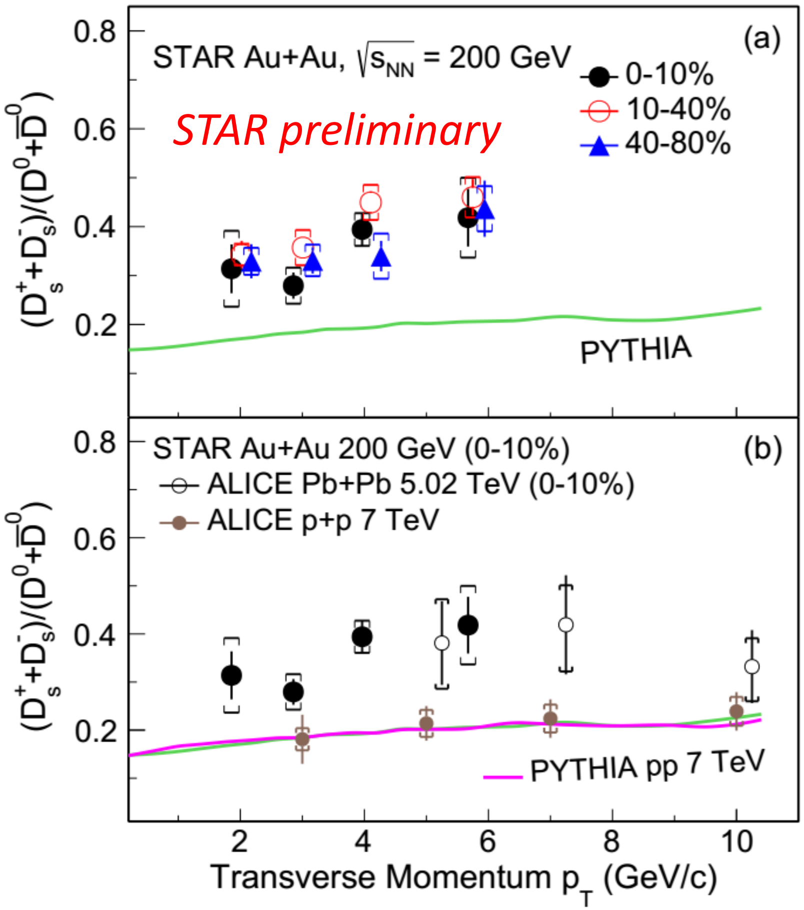
Merged spectrum from run14+run16



Statistical error as a weight is used to merge spectrum from 2014 and 2016.

Accurate measurements on D_s p_T spectrum in different centrality.

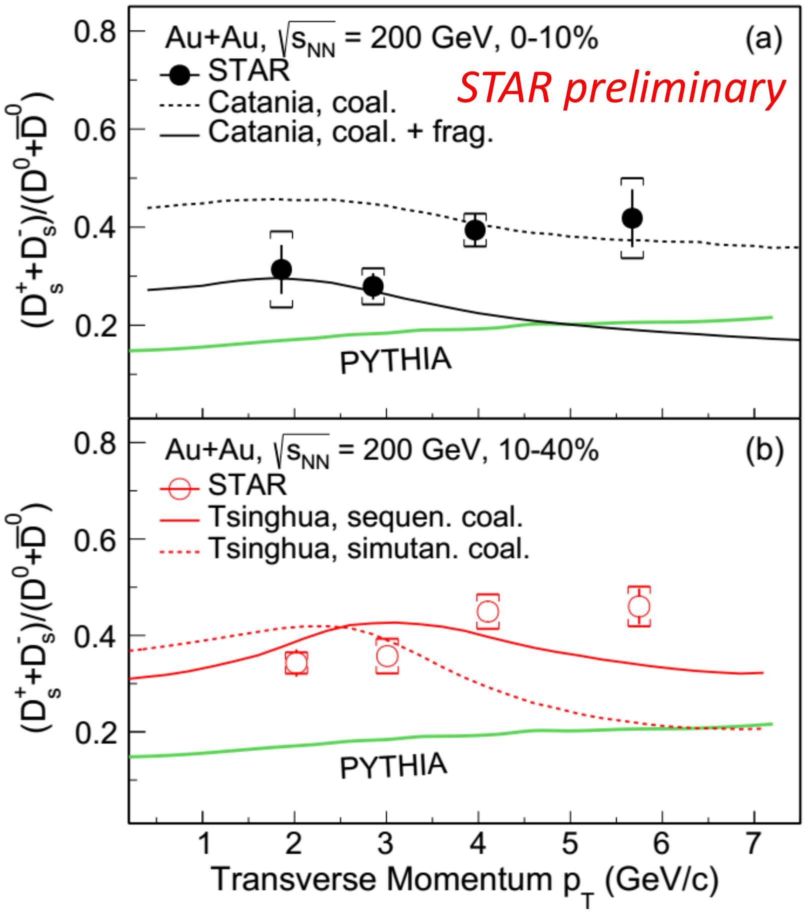
$D_s^{\pm}/D^0$ ratio



- $D_s^{\pm}/D^0$ ratio: larger enhancement (~1.5-2 times) relative to PYTHIA, no clear centrality dependence.
- Consistent well with ALICE measurements.
- Strangeness enhancement + coalescence hadronization mechanism.

Journal of High Energy Physics, 2018, 2018(10): 174
The European Physical Journal C, 2017, 77(8): 550

$D_s^{\pm}/D^0$ ratio



The European Physical Journal C, 2018, 78: 1-13

- Coal. + frag. : consistent well for $1.5 < p_T < 4$ GeV/c,
  Coal. : consistent well for $4 < p_T < 8$ GeV/c.
- Seq. coal. : a little higher than our measurement for $1.5 < p_T < 4$ GeV/c, lower than that for $4 < p_T < 8$ GeV/c.
- Strangeness enhancement + coalescence hadronization play an important role for charm quark hadronization.

arXiv preprint arXiv:1805.10858, 2018

Summary

- $D_s^{\pm}$ measurements in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV enabled by the HFT.

- $D_s^{\pm}/D^0$ enhancement with respect to PYTHIA:

  -Strangeness enhancement + coalescence hadronization play an important role for charm quark hadronization.