Recent Heavy Flavor Results from the STAR Experiment

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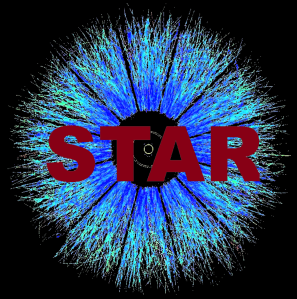

UIC

QM QUARK MATTER KRAKÓW 2022

29TH INTERNATIONAL
CONFERENCE ON ULTRARELATIVISTIC
NUCLEUS - NUCLEUS COLLISIONS
APRIL 4-10, 2022
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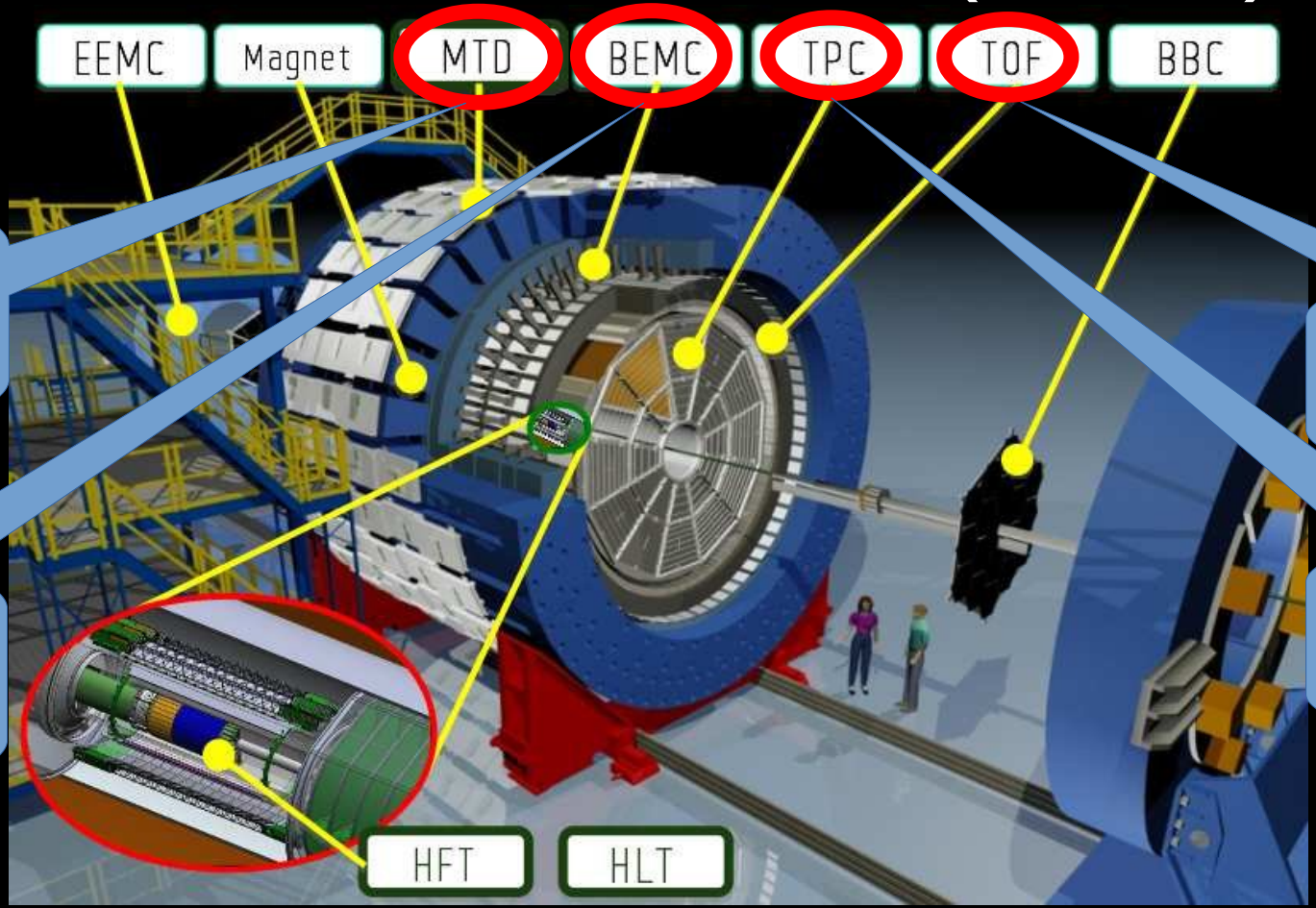
University of Illinois at Chicago
For the STAR Collaboration

Content

- Solenoidal Tracker at RHIC
- Nuclear matter effects on quarkonia
  - J/ψ R_{AA} in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV
  - J/ψ R_{AA} in isobar (${}^{96}_{44}Ru + {}^{96}_{44}Ru$ and ${}^{96}_{40}Zr + {}^{96}_{40}Zr$) collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - J/ψ R_{pAu} at $\sqrt{s_{NN}}$ = 200 GeV
- Open heavy flavor production
  - Λ_c, D_s, $D^{\pm}$ and D^0 production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - Total charm production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

Solenoidal Tracker at RHIC (STAR)



Acceptance:
$|\eta| < 0.5$; ~45% in φ
$\mu^{\pm}$ trigger
$\mu^{\pm}$ identification

Acceptance:
$|\eta| < 1$; $0 \le \varphi < 2\pi$
$e^{\pm}$ trigger
$e^{\pm}$ identification (E/p)

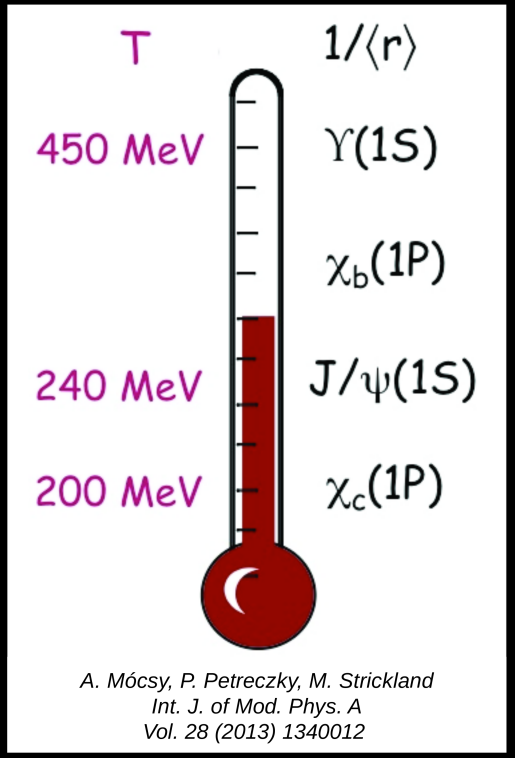
Acceptance:
$|\eta| < 1$; $0 \le \varphi < 2\pi$
$e^{\pm}$ identification (1/β)

Acceptance:
$|\eta| < 1$; $0 \le \varphi < 2\pi$
Tracking, dE/dx

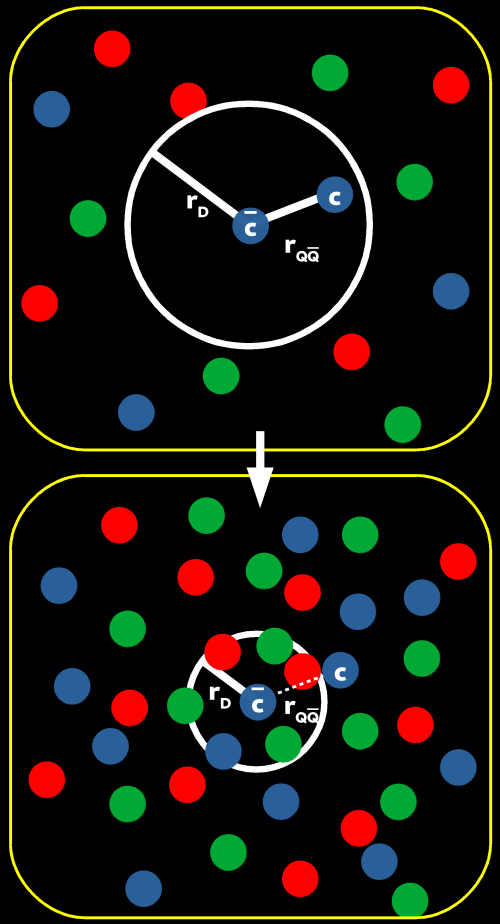
Nuclear Matter Effects on Quarkonia

Hot Nuclear Matter (HNM) Effects

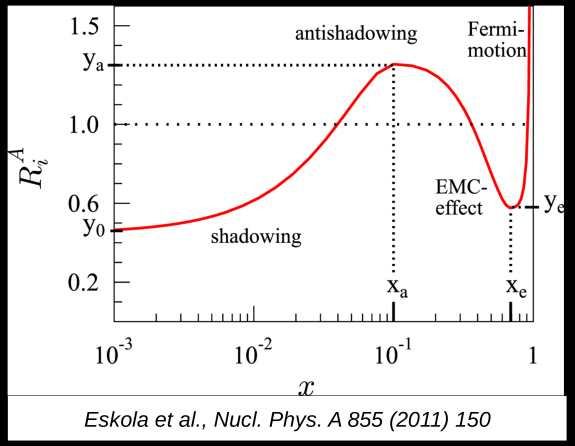
- Color screening
- Regeneration



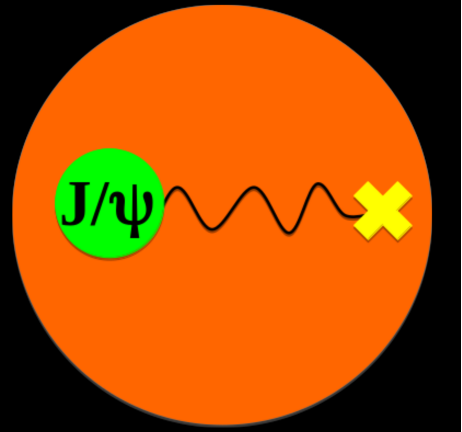
A. Mócsy, P. Petreczky, M. Strickland
Int. J. of Mod. Phys. A
Vol. 28 (2013) 1340012

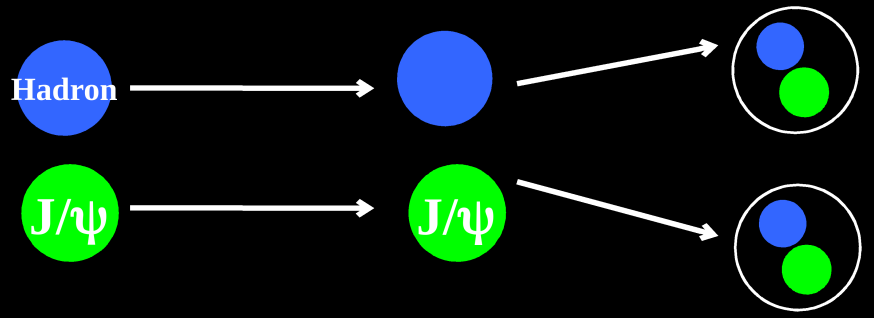


Cold Nuclear Matter (CNM) Effects



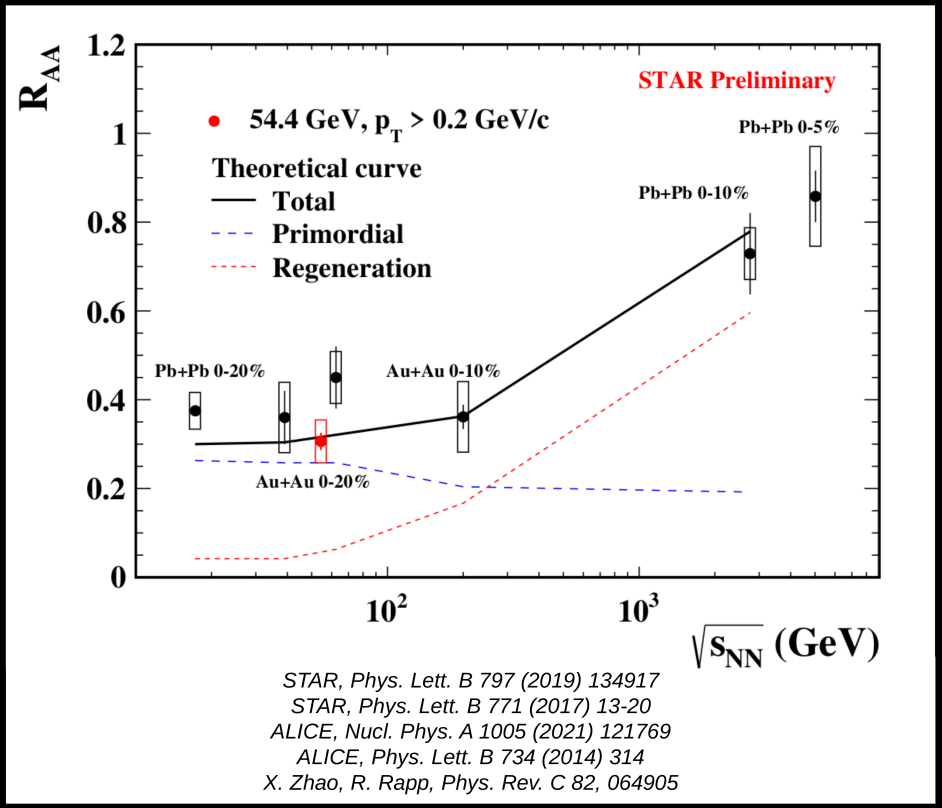
Eskola et al., Nucl. Phys. A 855 (2011) 150





- Modification of PDF
- Parton saturation
- Nuclear absorption
- Co-mover absorption
- (...)

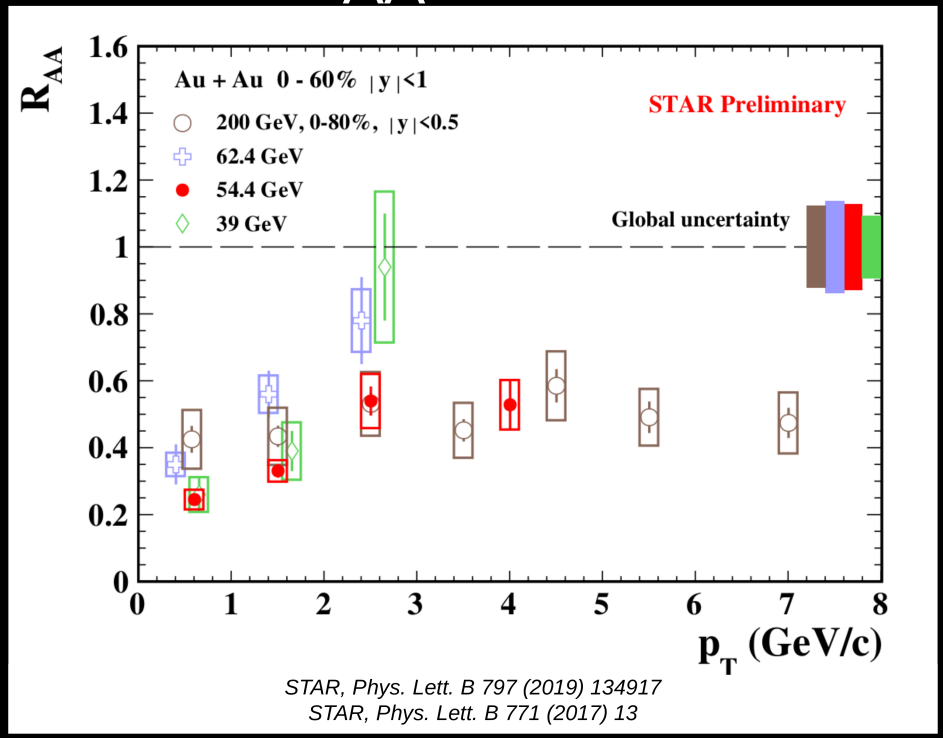
Energy Dependence of J/ψ R_{AA}



STAR, Phys. Lett. B 797 (2019) 134917
STAR, Phys. Lett. B 771 (2017) 13-20
ALICE, Nucl. Phys. A 1005 (2021) 121769
ALICE, Phys. Lett. B 734 (2014) 314
X. Zhao, R. Rapp, Phys. Rev. C 82, 064905

Data are consistent with a transport model including primordial and regeneration contributions

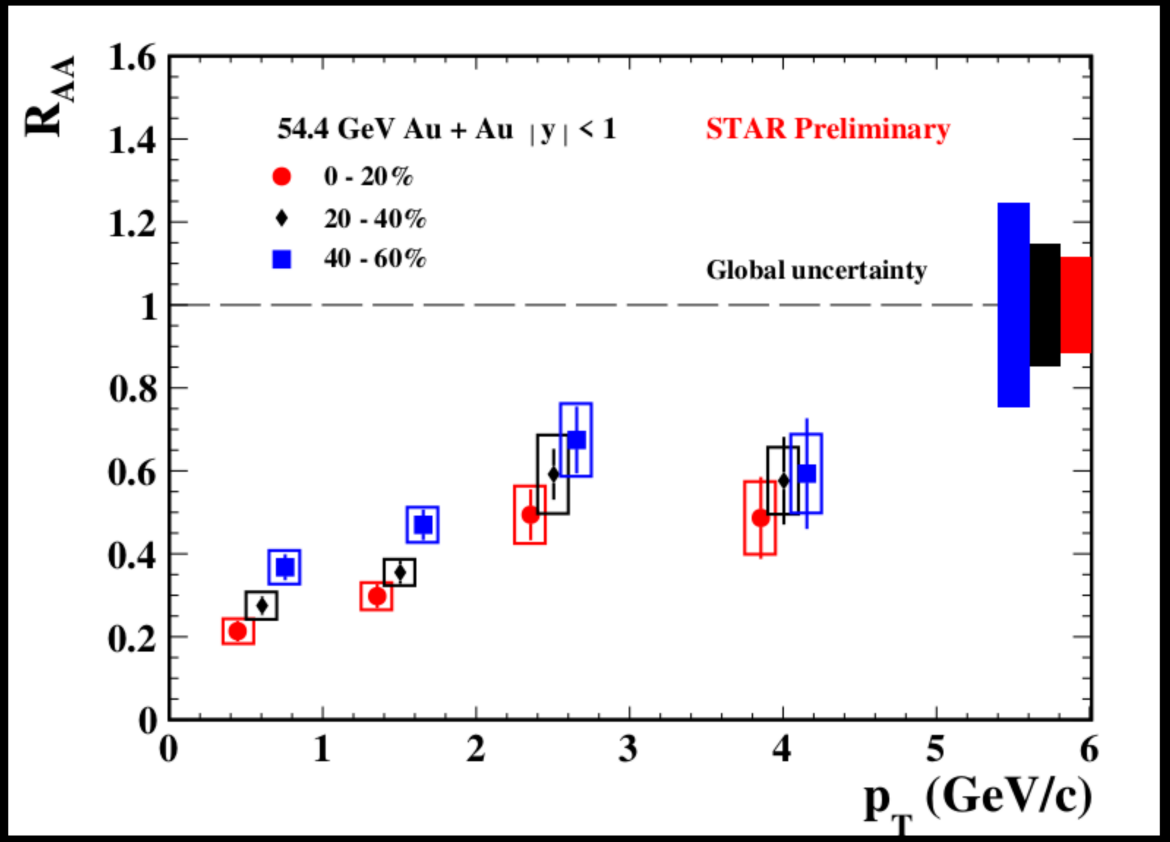
*Model calculation is in 0-20% centrality



STAR, Phys. Lett. B 797 (2019) 134917
STAR, Phys. Lett. B 771 (2017) 13

- R_{AA} increases with p_T at $\sqrt{s_{NN}}$ = 39, 54.4 and 62.4 GeV (but not 200 GeV) below 3 GeV/c
  - Could be due to more regeneration contribution at low p_T at 200 GeV
- $\sqrt{s_{NN}}$ = 54.4 GeV: improved precision

J/ψ R_{AA} at $\sqrt{s_{NN}}$ = 54.4 GeV

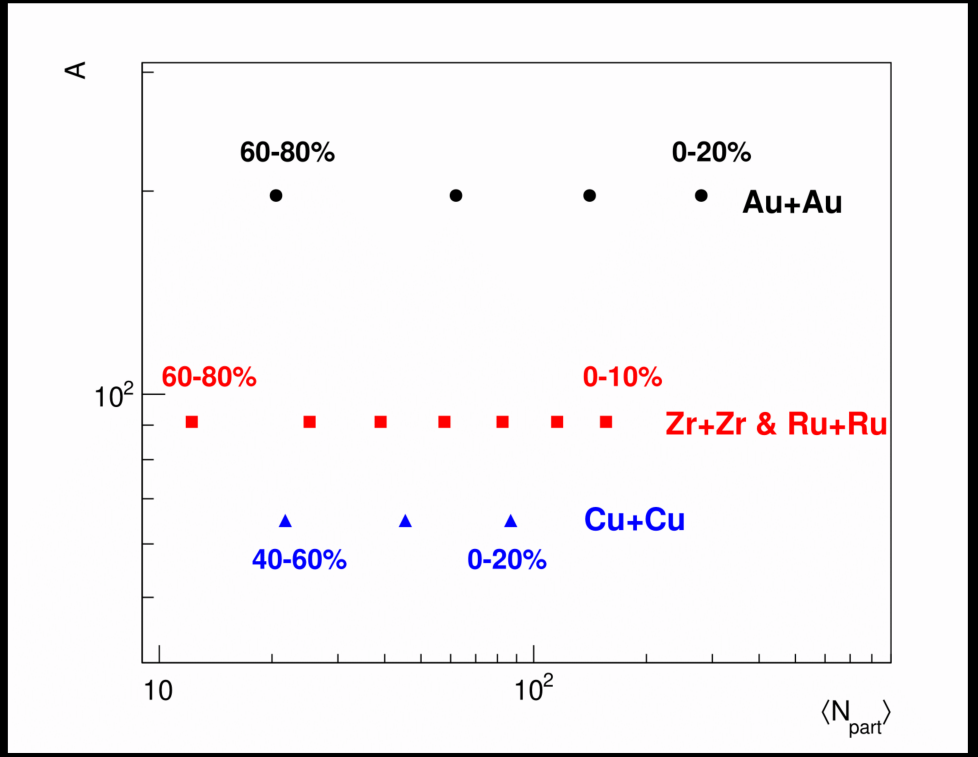


- Suppression observed across centrality
- Larger suppression in more central collisions as they are more impacted by the HNM effects

Isobar Collisions at $\sqrt{s_{NN}}$ = 200 GeV

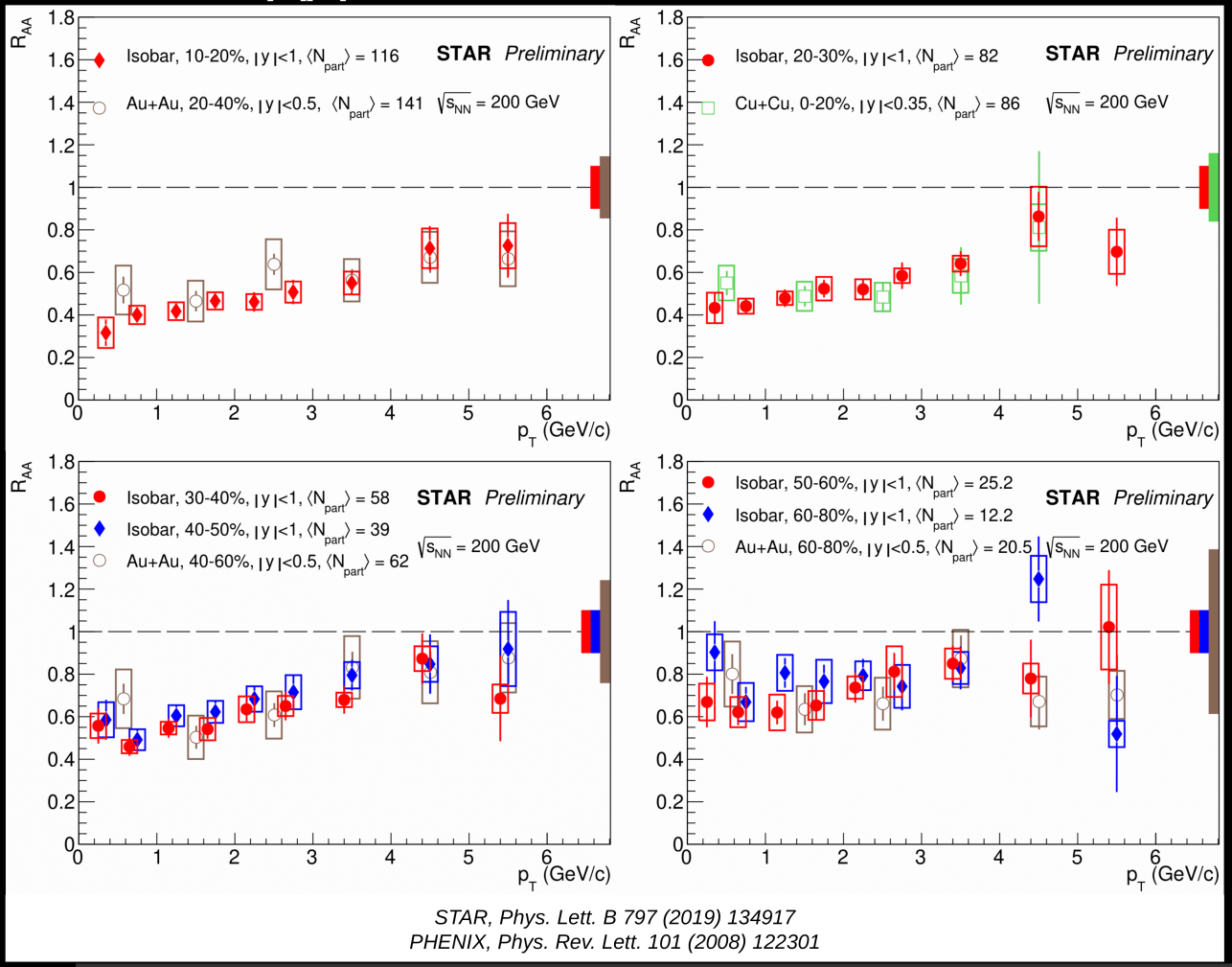
- $^{96}_{44}Ru+^{96}_{44}Ru$, $^{96}_{40}Zr+^{96}_{40}Zr$

  $(^{197}_{79}Au+^{197}_{79}Au)(\ ^{63}_{29}Cu+^{63}_{29}Cu\ )$
- Isobar collisions are smaller (larger) collision systems compared to Au+Au (Cu+Cu); this allows us to study the dependence of HNM effects on medium size and geometry
- Good data quality: around 4 billion minimum bias events



Yan Wang, Apr 8, 2022
Poster Session 3 T11_2

J/ψ R_{AA} in Isobar Collisions

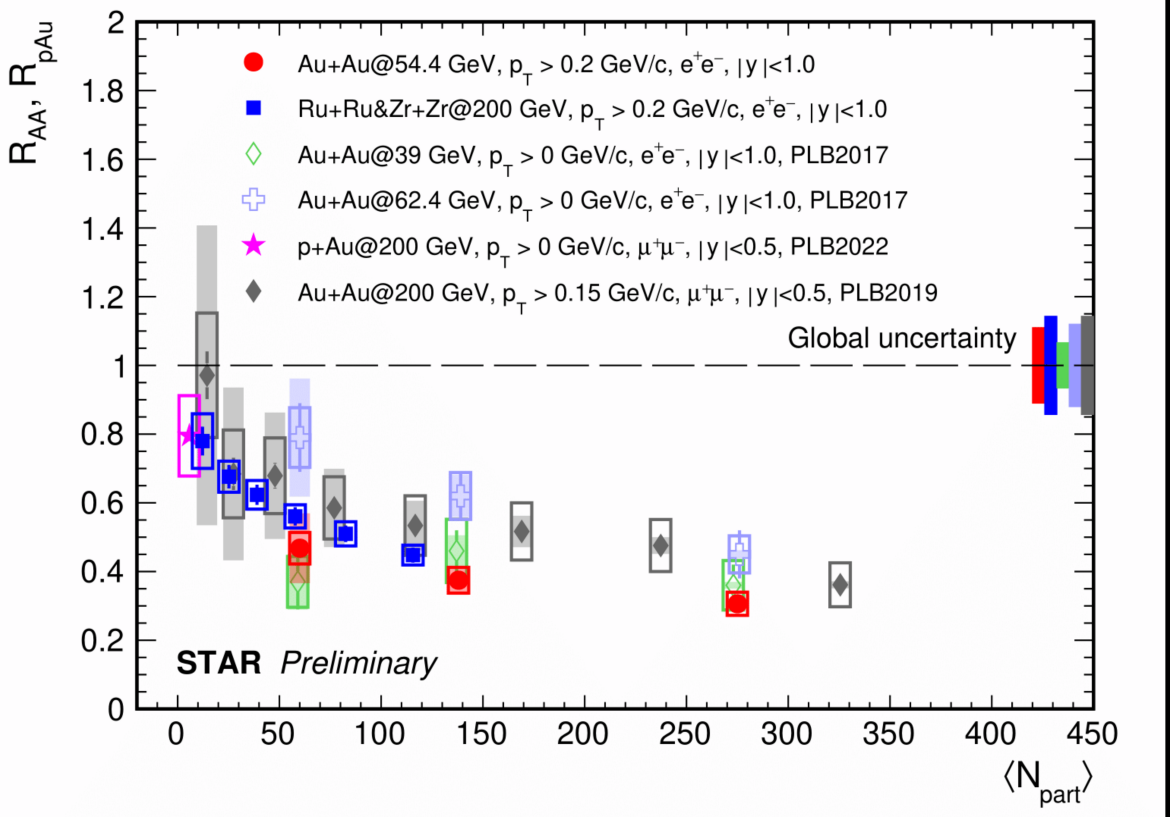


STAR, Phys. Lett. B 797 (2019) 134917
PHENIX, Phys. Rev. Lett. 101 (2008) 122301

- R_{AA} vs p_T is consistent with results in Cu+Cu and Au+Au collisions with similar $\langle N_{par} \rangle$ at the same collision energy
- No significant collision system dependence at the same $\langle N_{part} \rangle$

Yan Wang, Apr 8, 2022
Poster Session 3 T11_2

J/ψ R_{AA} vs $\langle N_{part} \rangle$

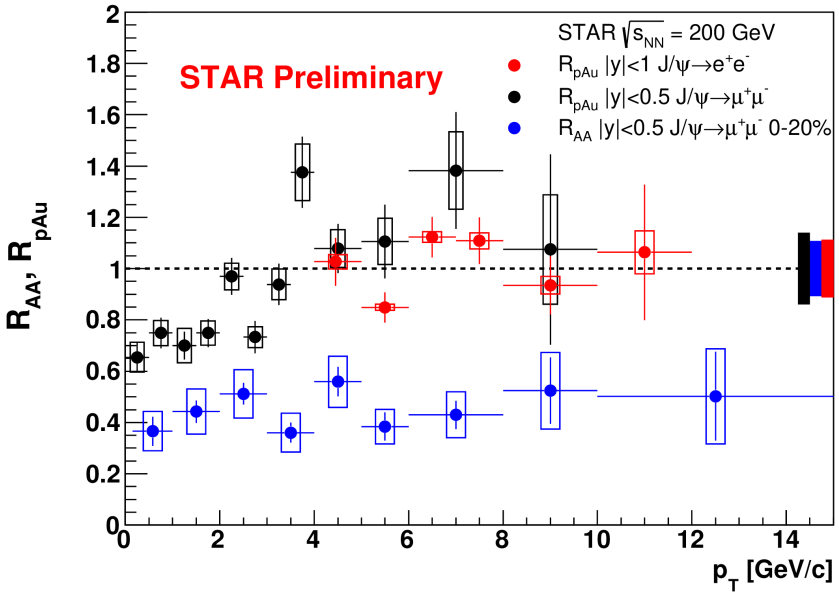


STAR, Phys. Lett. B 825 (2022) 136865
STAR, Phys. Lett. B 797 (2019) 134917
STAR, Phys. Lett. B 771 (2017) 13

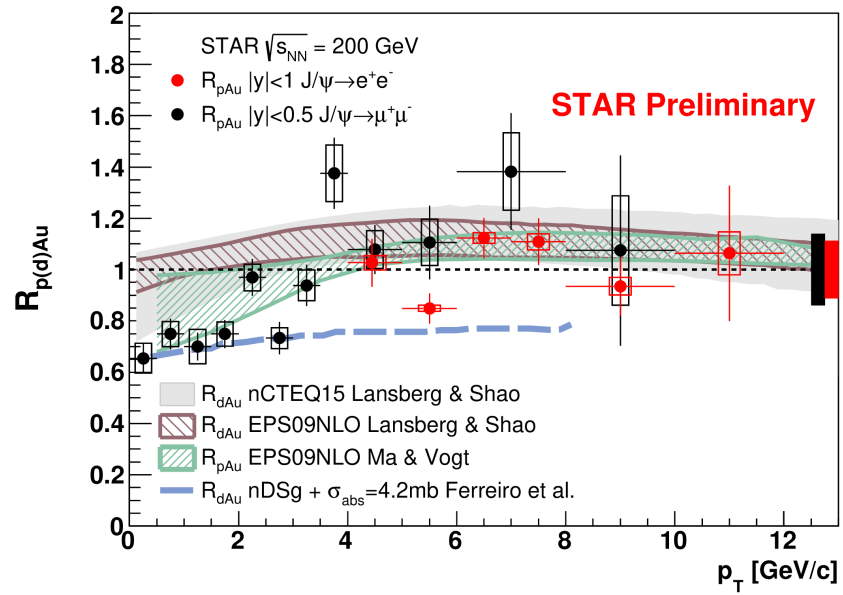
- R_{AA} decreases with $\langle N_{part} \rangle$ at RHIC energy
- No significant energy and species dependence of R_{AA}

Yan Wang, Apr 8, 2022
Poster Session 3 T11_2

J/ψ R_{pAu} at $\sqrt{s_{NN}}$ = 200 GeV



STAR, Phys. Lett. B 825 (2022) 136865
STAR, Phys. Lett. B 797 (2019) 134917



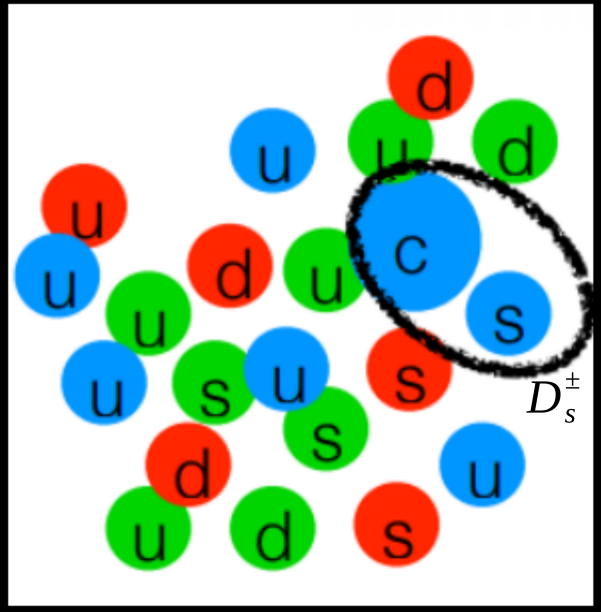
STAR, Phys. Lett. B 825 (2022) 136865
Ma & Vogt, EPS09+NLO, Private Comm.
Lansberg & Shao, nCTEQ15, EPS09+NLO, Eur.Phys.J. C77 (2017) no.1, 1
Ferreiro et al., nDSg+σ_{abs}, Few Body Syst. 53 (2012) 27

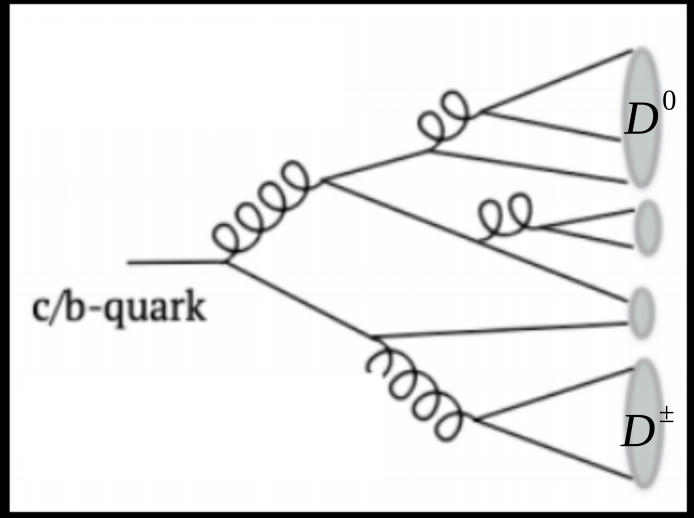
- R_{pAu} < 1 at low p_T
- R_{pAu} is consistent with unity at mid to high p_T
- The suppression in Au + Au collisions at mid to high p_T is dominated by HNM effects

R_{pAu} result is consistent with model calculations taking nPDF into account, but at high p_T disfavor the one with additional nuclear absorption

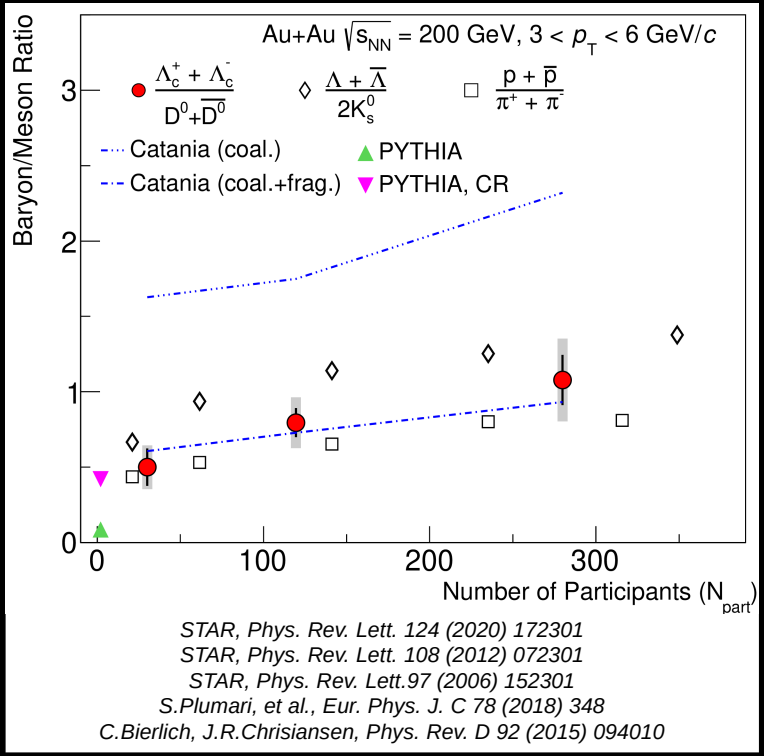
Hadronization of Heavy Flavor Quarks

- Coalescence
  - Dominant at low p_T
- Fragmentation
  - Dominant at higher p_T

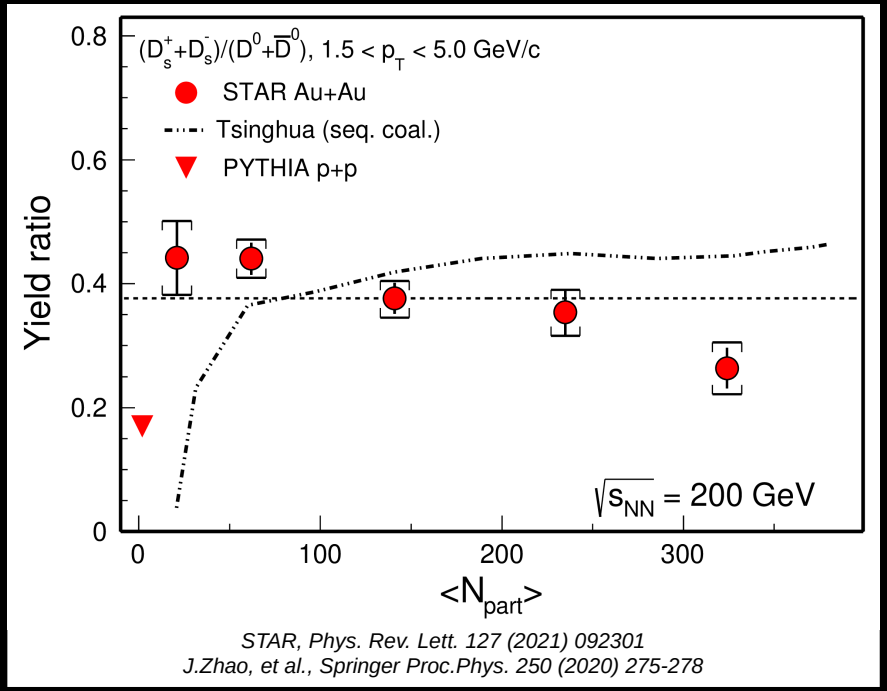




Open Heavy Flavor Production in 200 GeV Au+Au Collisions



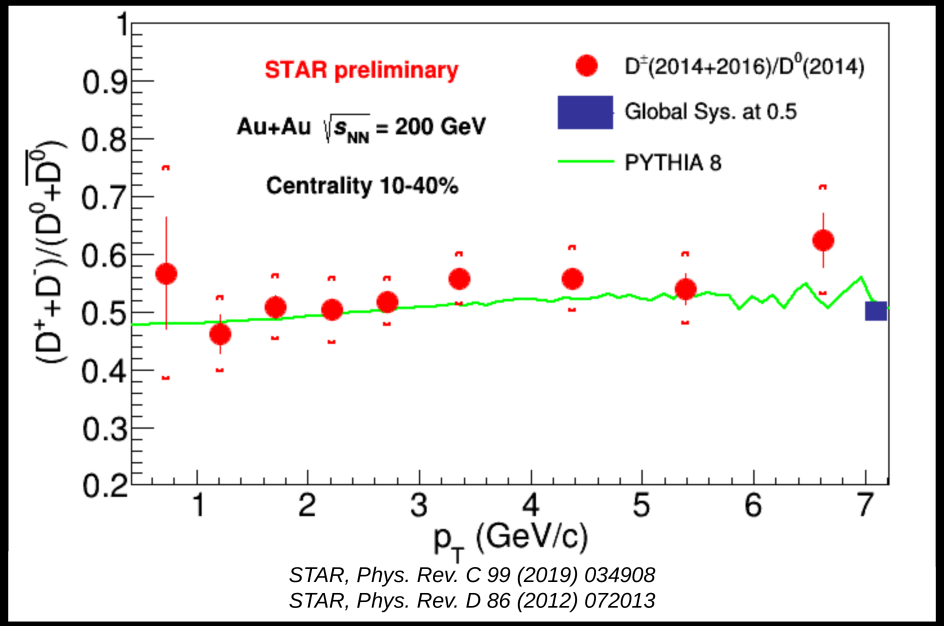
STAR, Phys. Rev. Lett. 124 (2020) 172301
STAR, Phys. Rev. Lett. 108 (2012) 072301
STAR, Phys. Rev. Lett.97 (2006) 152301
S.Plumari, et al., Eur. Phys. J. C 78 (2018) 348
C.Bierlich, J.R.Chrisiansen, Phys. Rev. D 92 (2015) 094010



STAR, Phys. Rev. Lett. 127 (2021) 092301
J.Zhao, et al., Springer Proc.Phys. 250 (2020) 275-278

- Enhancements compared to PYTHIA for both Λ_c and D_s
- Λ_c and D_s significantly contribute to the total charm production
- Coalescence plays an important role in hadronization

Open Heavy Flavor Production in 200 GeV Au+Au Collisions



STAR, Phys. Rev. C 99 (2019) 034908
STAR, Phys. Rev. D 86 (2012) 072013

Similar level of suppression is observed for $D^{\pm}$ and D^0

Jan Vaněk, Apr 8, 2022
Poster Session 3 T11_3

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

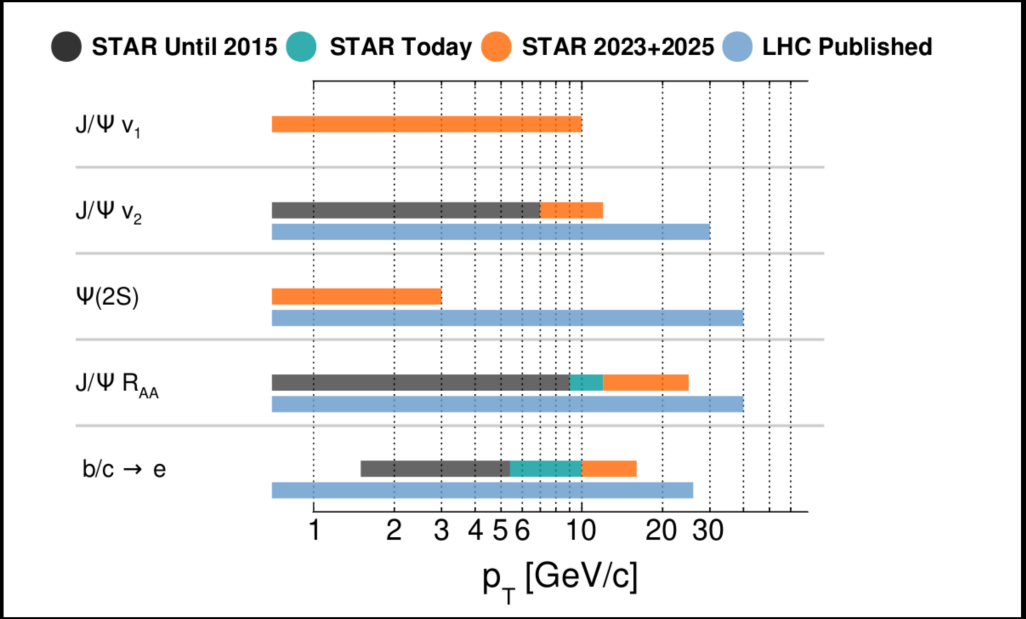
D^0 [1] STAR, Phys. Rev. C 99 (2019) 034908
D_s [2] STAR, Phys. Rev. Lett. 127 (2021) 092301
Λ_c [3]STAR, Phys. Rev. Lett. 124 (2020) 172301
p+p [4] STAR, Phys. Rev. D 86 (2012) 072013

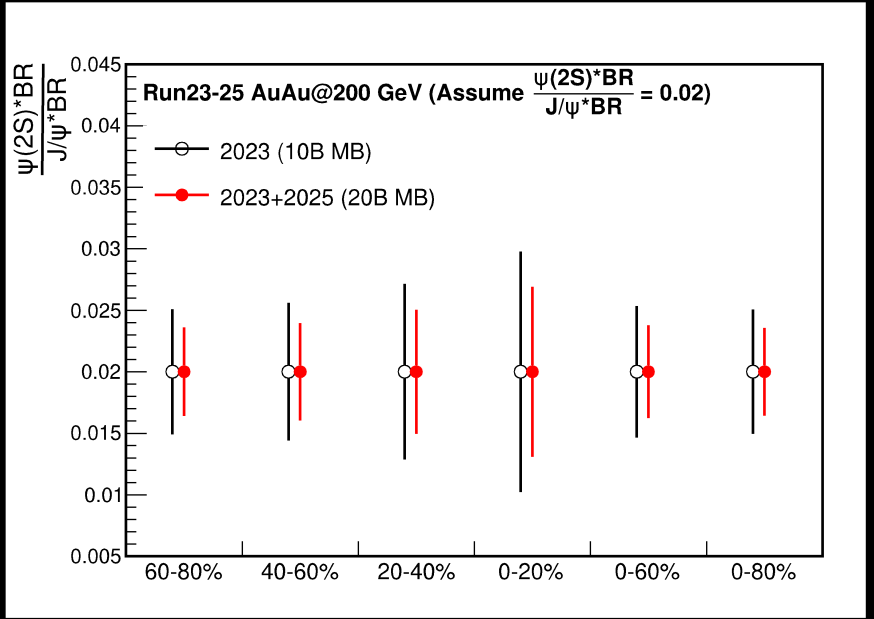
*$D^{\pm}$ calculated from preliminary invariant yields
**Cross section of Λ_c is calculated based on Λ_c/D^0 yield ratio

Summary

- J/ψ R_{AA} measured at $\sqrt{s_{NN}}$ = 54.4 GeV in Au+Au collisions and at $\sqrt{s_{NN}}$ = 200 GeV in isobar collisions
  - No significant energy and species dependence at the same $\langle N_{part} \rangle$ between $\sqrt{s_{NN}}$ = 39 and 200 GeV
  - Suppression seems to be driven by system size $\langle N_{part} \rangle$
- J/ψ R_{pAu} at $\sqrt{s_{NN}}$ = 200 GeV
  - Suppressed at low p_T; consistent with unity at mid to high p_T
  - R_{AA} suppression at mid to high p_T is dominated by HNM effects
- Open heavy flavor production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - Coalescence plays an important role in hadronization
  - Total charm production cross section per binary nucleon-nucleon collision in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV is consistent with that in p+p collisions with a hint of suppression

Look Ahead: 2023 – 2025





- Extend the kinematic reach of J/ψ v_2, J/ψ R_{AA} and b/c → e measurement
- Allow new measurements on J/ψ v_1 and ψ(2S)

Thank you for your attention!

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