Cold Nuclear Matter Effects on J/ψ and ϒ Productions at RHIC with the STAR Experiment

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UIC

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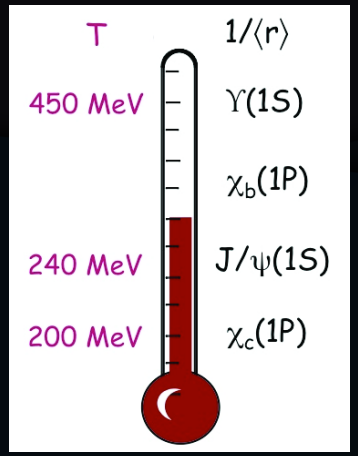
For the STAR Collaboration

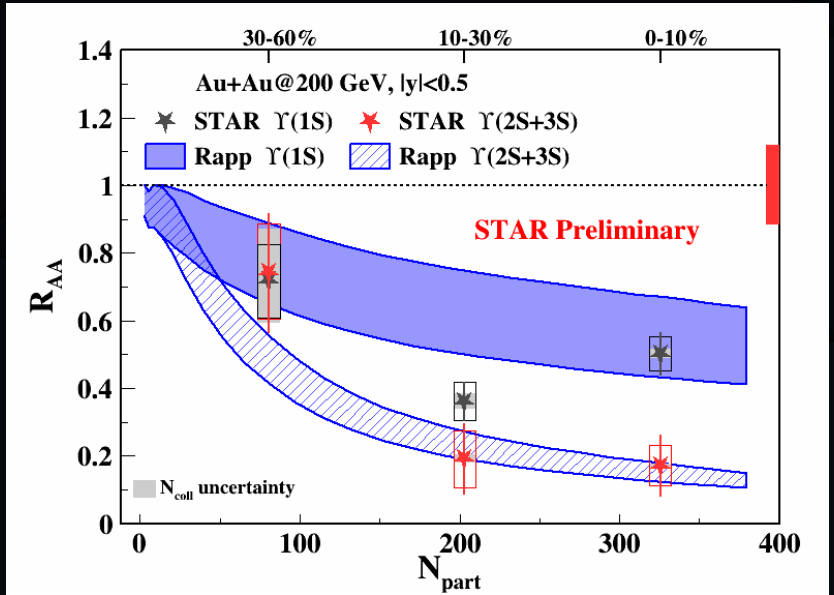
10th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

Contents

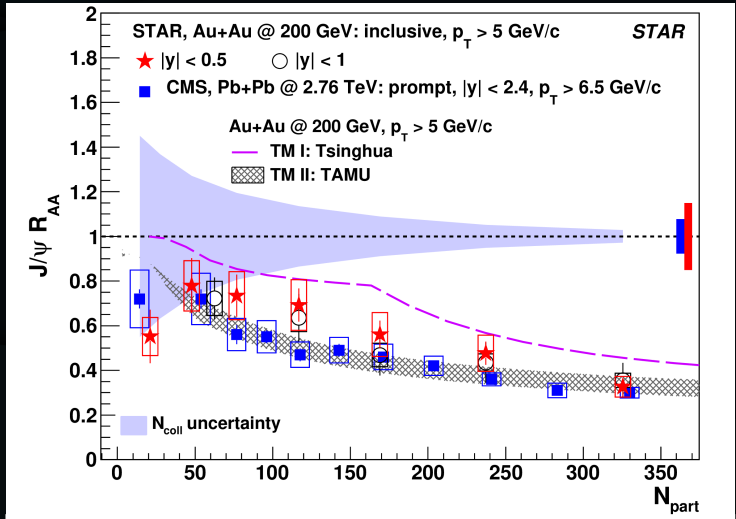
Motivation

- Quarkonia: excellent probes of QGP properties
  - Hot Nuclear Matter Effects





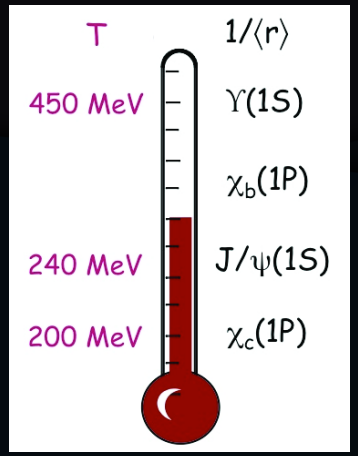
[Rapp: PRC 96 (2017) 054901]

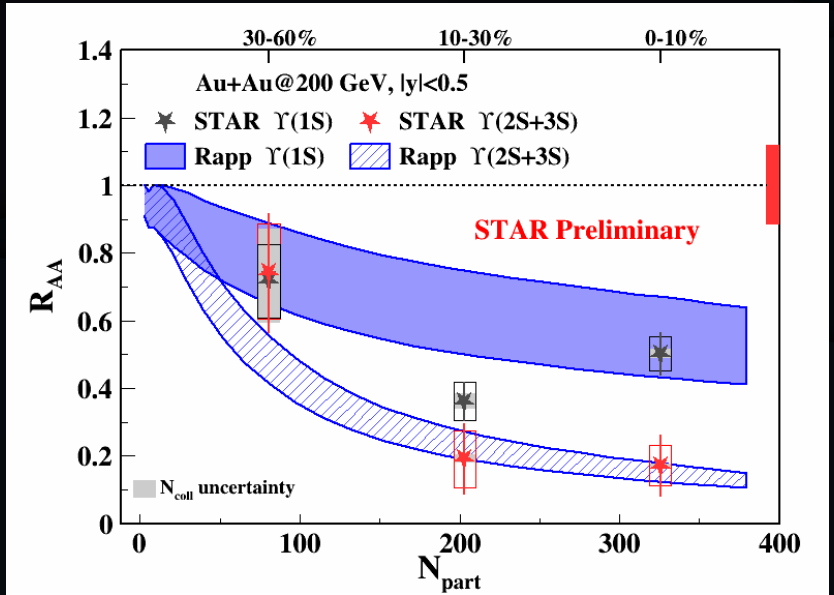


[STAR: PLB 797 (2019) 134917]
[CMS: JHEP 05 (2012) 063]
[Tsinghua at RHIC: PRC 89 (2014) 054911]
[TAMU at RHIC: PRC 82 (2010) 064905]

Motivation

- Quarkonia: excellent probes of QGP properties
  - Hot Nuclear Matter Effects
- Cold Nuclear Matter Effects





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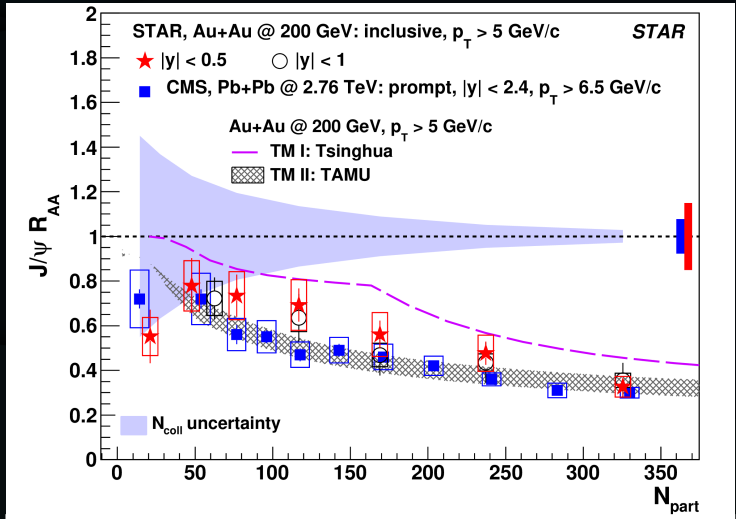

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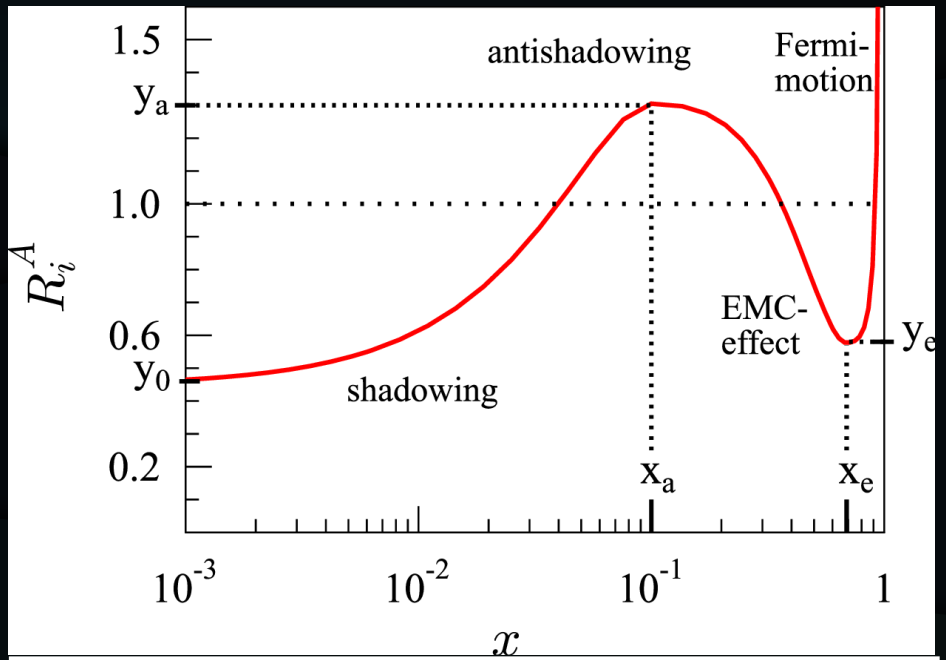
Cold Nuclear Matter Effects

- Modification of PDF (nPDF)
- Nuclear absorption
- Co-mover model
- Energy loss



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

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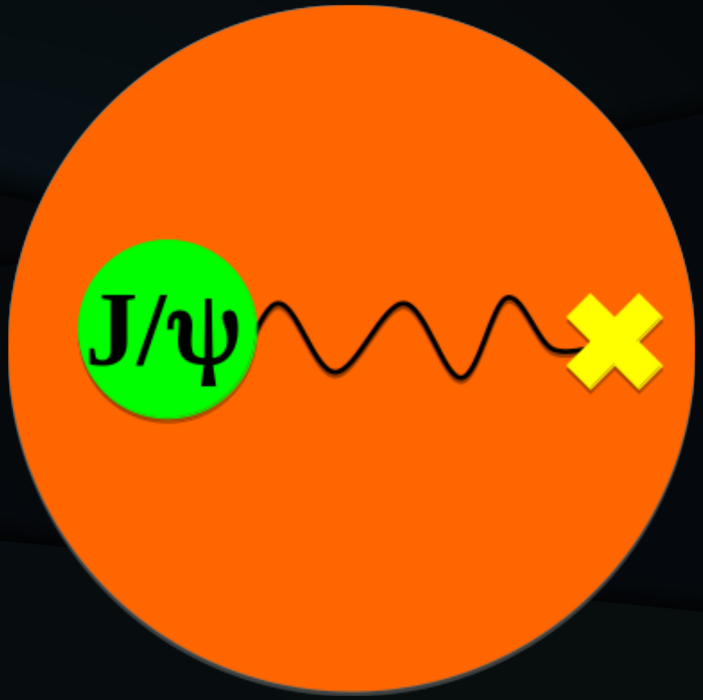

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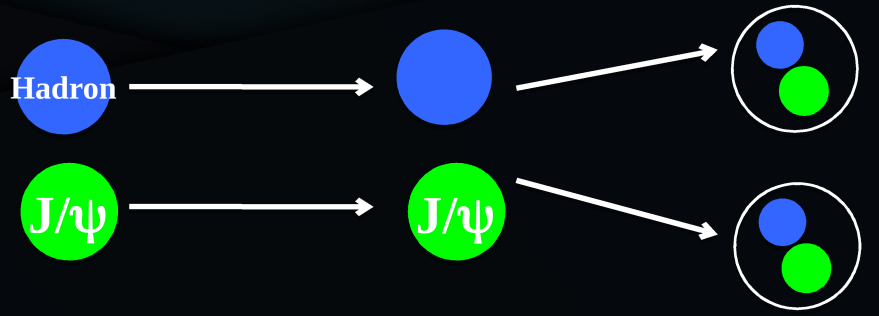

Cold Nuclear Matter Effects

- Modification of PDF (nPDF)
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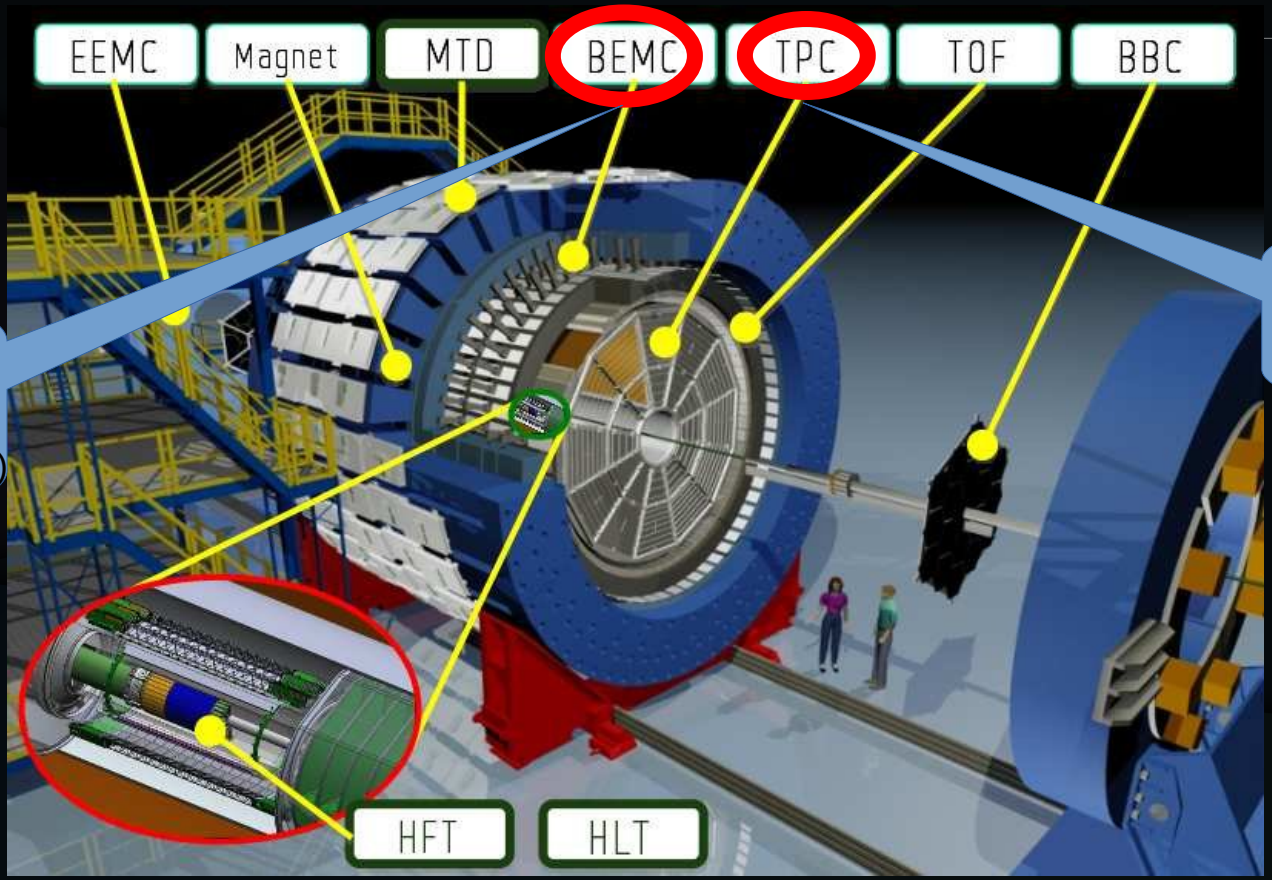
Solenoidal Tracker at RHIC (STAR)

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

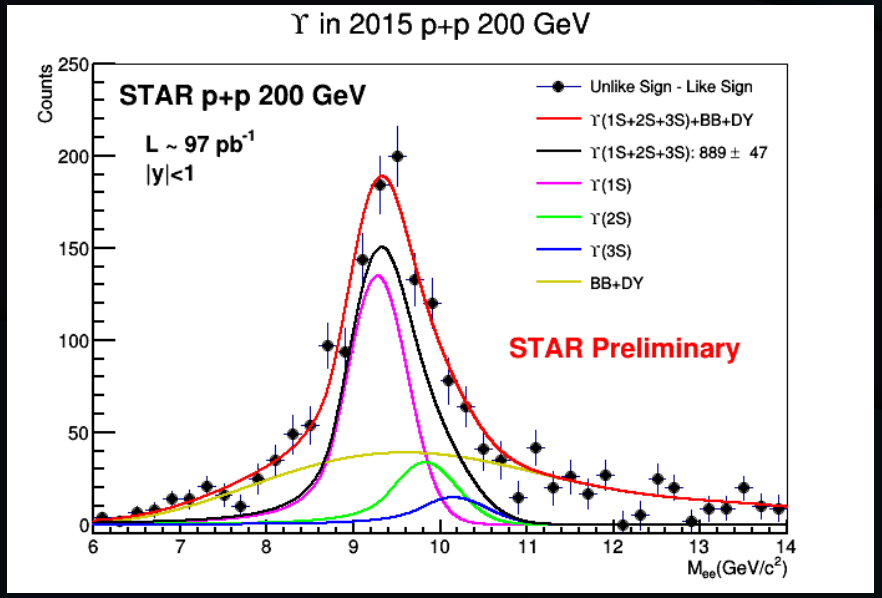


Acceptance:
$|\eta| < 1$; $0 \leq \varphi < 2\pi$
Tracking, dE/dx

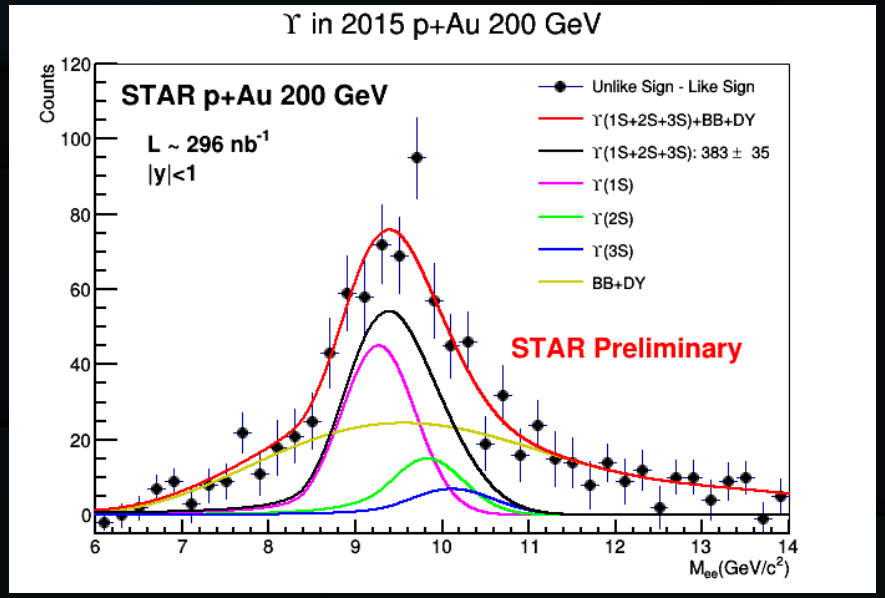
STAR Detector

Υ Signal

STAR 2015, 200 GeV
Decay channel: $\Upsilon \rightarrow e^+ e^-$
Electron trigger threshold ~ 4.3 GeV

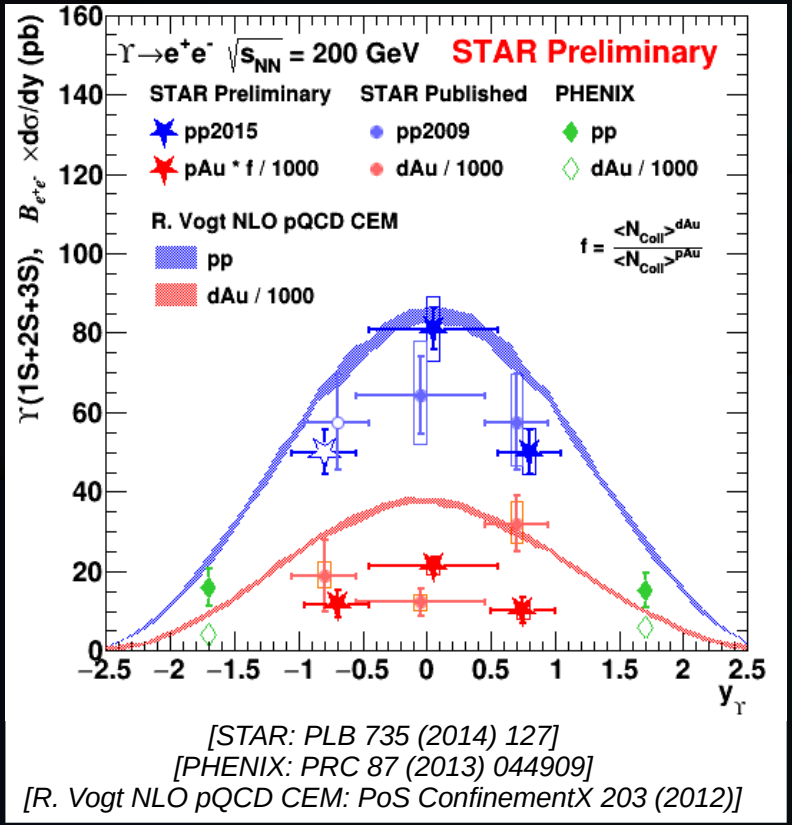


Υ signal extraction in p+p collisions
(integrated over p_T < 10 GeV/c)



Υ signal extraction in p+Au collisions
(integrated over p_T < 10 GeV/c)

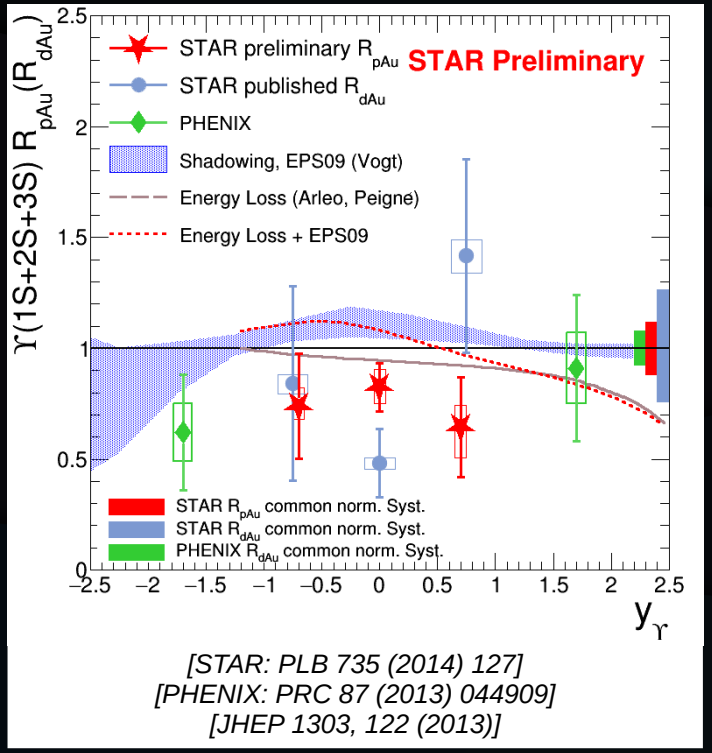
Υ – Cross Section in p+p and p+Au



[STAR: PLB 735 (2014) 127]
[PHENIX: PRC 87 (2013) 044909]
[R. Vogt NLO pQCD CEM: PoS ConfinementX 203 (2012)]

- Cross section measurement:
  - Significantly improved precision over previous d+Au results
  - NLO pQCD CEM overestimates the width of rapidity distribution in p+p
  - Non-negligible cold nuclear matter effects beyond nPDF

R_{pAu} of Υ



[STAR: PLB 735 (2014) 127]
[PHENIX: PRC 87 (2013) 044909]
[JHEP 1303, 122 (2013)]

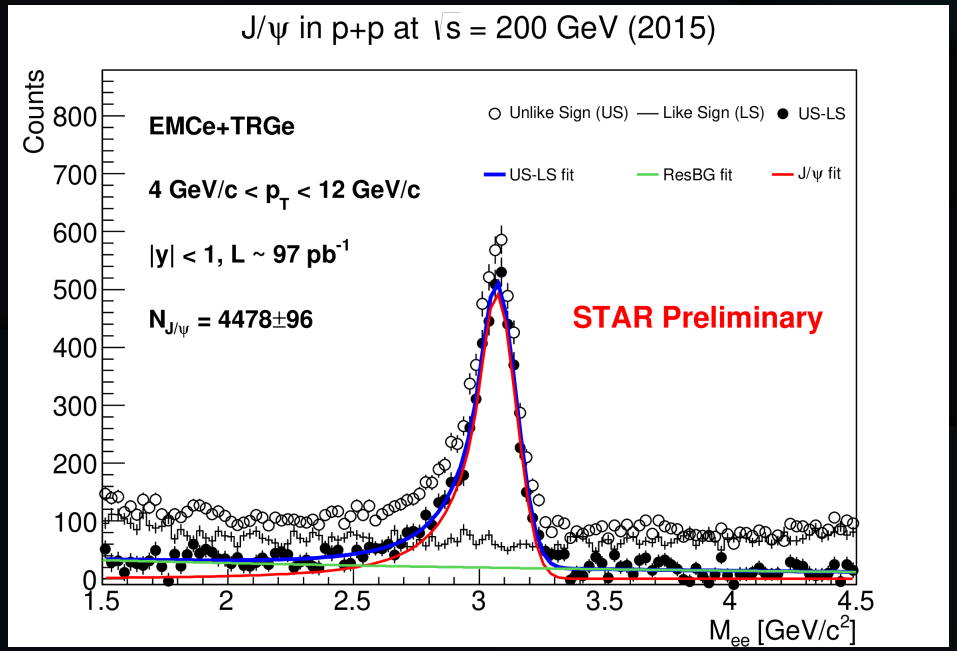
- R_{pAu} calculation:
  - Significantly improved precision over previous d+Au results
  - Indication of more suppression than that from nPDF effects and energy loss in cold nuclear matter

$$\textit{This Analysis}: R_{pAu}(|y|<0.5) = 0.82 \pm 0.10(stat)^{+0.08}_{-0.07}(syst) \pm 0.10(global)$$

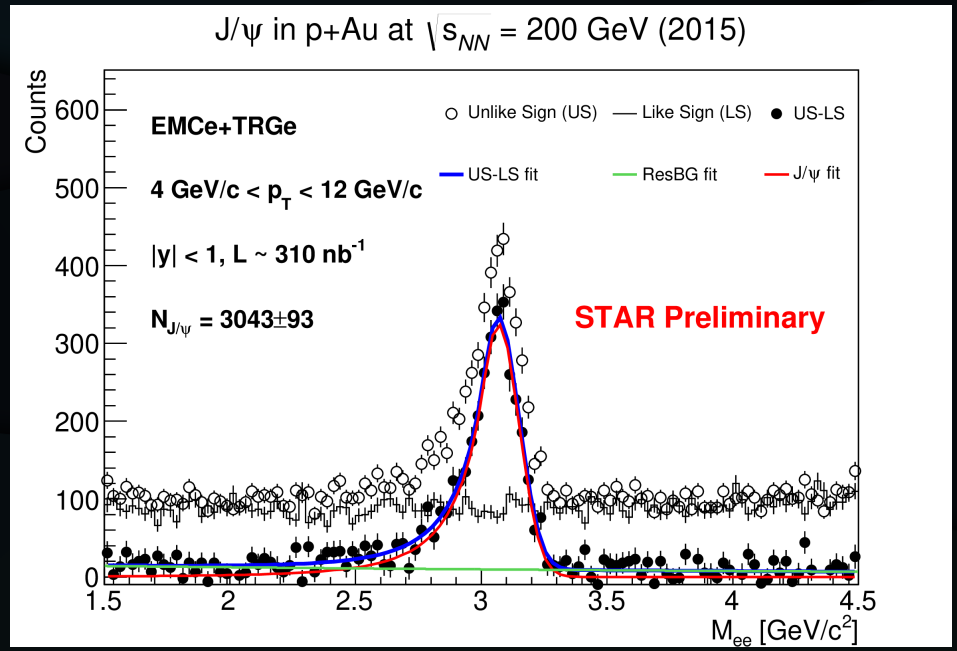
$$\textit{Published}: R_{dAu}(|y|<0.5) = 0.48 \pm 0.15(stat) \pm 0.02(syst)^{+0.13}_{-0.12}(global)$$

J/ψ Signal

STAR 2015, 200 GeV
Decay channel: J/ψ → $e^+ e^-$
Electron trigger threshold ~ 4.3 GeV

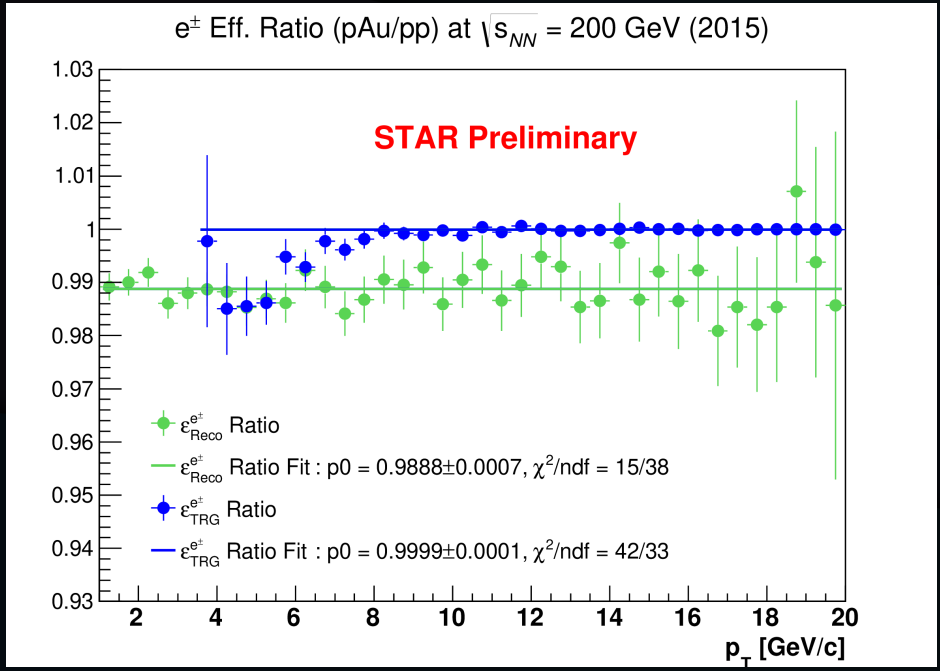


J/ψ signal extraction in p+p collisions



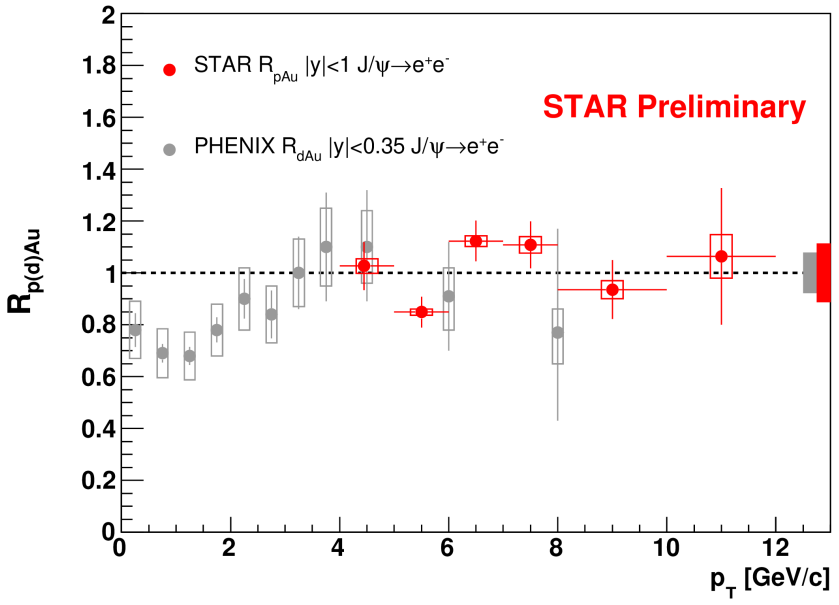
J/ψ signal extraction in p+Au collisions

Efficiency Correction Cancellation in pAu/pp



- pAu/pp ratio in electron tracking and identification efficiency is flat in p_T – small scale factor on pAu/pp yield ratio
- pAu/pp ratio in electron trigger efficiency is flat in higher p_T range, but very small deviation at lower p_T range – assign a global systematic uncertainty

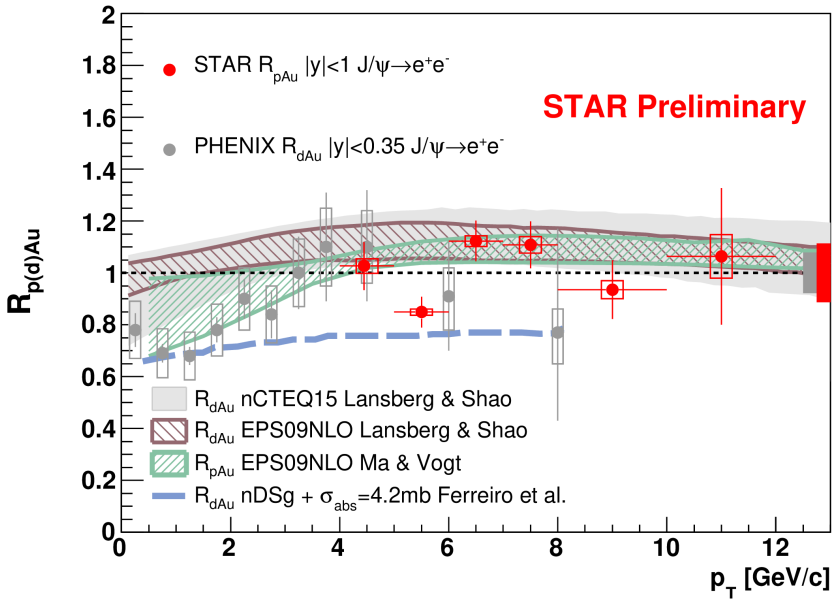
J/ψ R_{pAu} vs R_{dAu}



[PHENIX, PRC 87 (2013) 034904]

- Consistent with result of PHENIX R_{dAu} indicating similar cold nuclear matter effects in p+Au and d+Au collisions
- Significant improvement in uncertainties

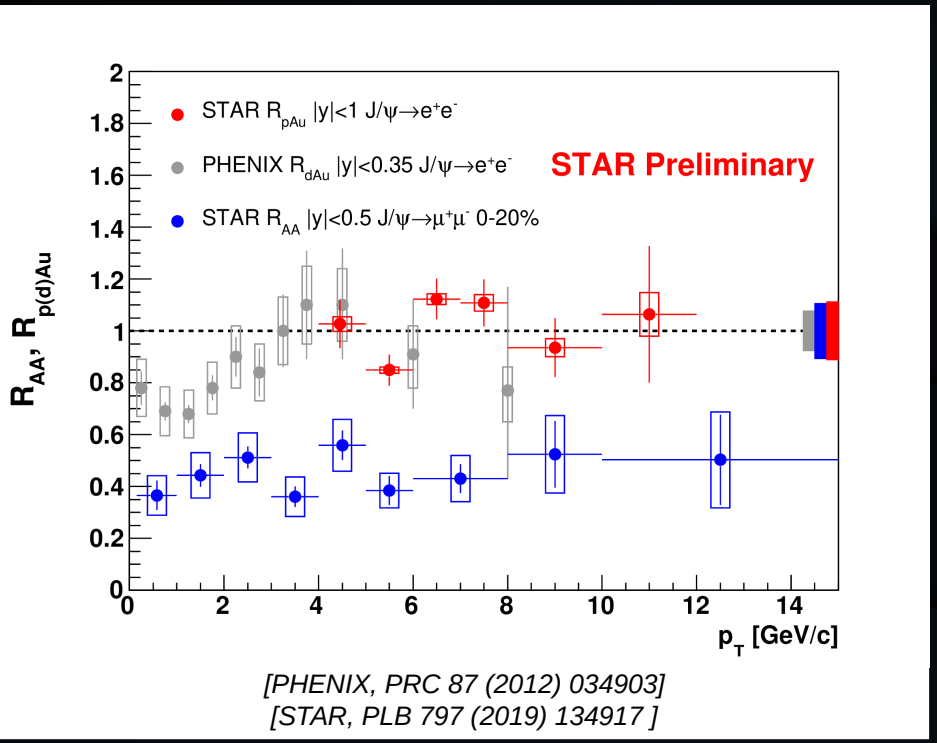
J/ψ R_{pAu} Data vs Models



[PHENIX, PRC 87 (2013) 034904]
[EPS09+NLO, Ma & Vogt, Private Comm.]
[nCTEQ, EPS09+NLO, Lansberg & Shao: Eur.Phys.J. C77 (2017) no.1, 1; Comp. Phys. Comm. 198 (2016) 238-259; Comp. Phys. Comm. 184 (2013) 2562-2570]
[Ferreriro et al., Few Body Syst. 53 (2012) 27]

- Consistent with result of PHENIX R_{dAu} indicating similar cold nuclear matter effects in p+Au and d+Au collisions
- Significant improvement in uncertainties
- R_{pAu} ~ 1 at higher p_T range. Consistent with models taking nPDF into account

J/ψ R_{pAu} vs R_{AuAu}

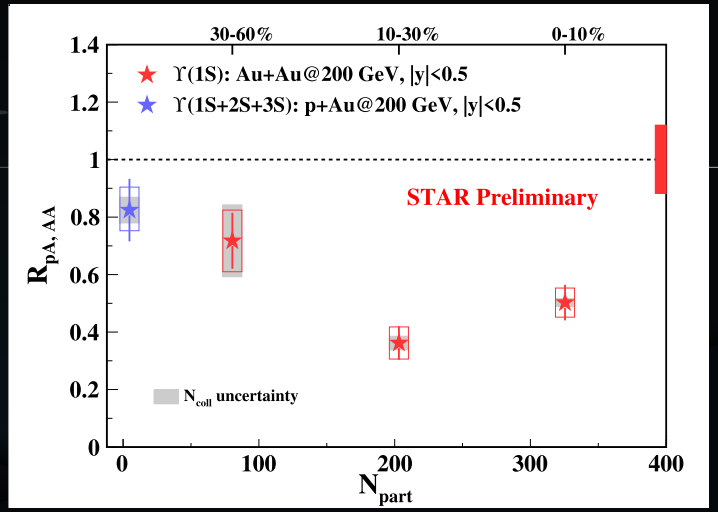


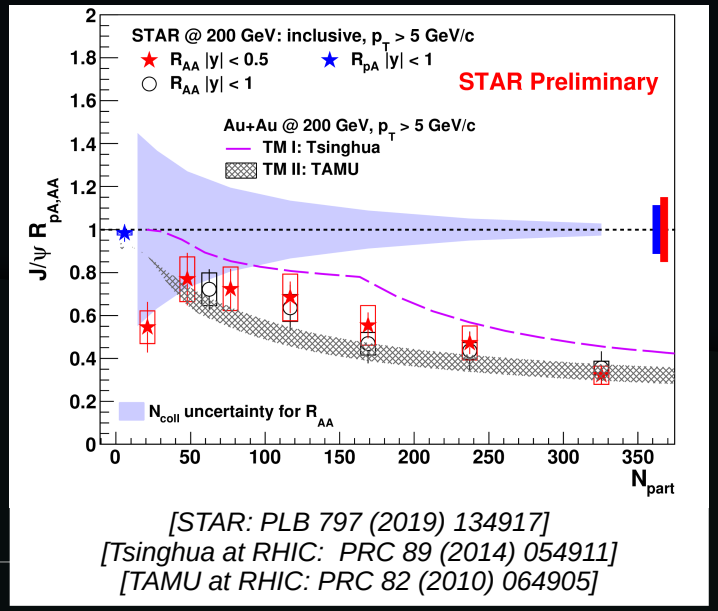
[PHENIX, PRC 87 (2012) 034903]
[STAR, PLB 797 (2019) 134917]

- Suppression in Au+Au collisions in higher p_T range does not have a p_T dependence
- Suppression in Au+Au collisions is dominantly from hot nuclear matter effects

Summary

- Significantly improved precision in R_{pAu} of Υ and J/ψ measurement at 200 GeV
- Υ at $p_T > 0$ GeV/c
  - Indication of suppression in p+Au collisions
  - Non-negligible cold nuclear matter effects beyond nPDF and energy loss
- J/ψ at $p_T > 4$ GeV/c
  - Measured R_{pAu} consistent with models taking nPDF into account
  - Suppression in Au+Au collisions is dominantly from hot nuclear matter effects





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