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

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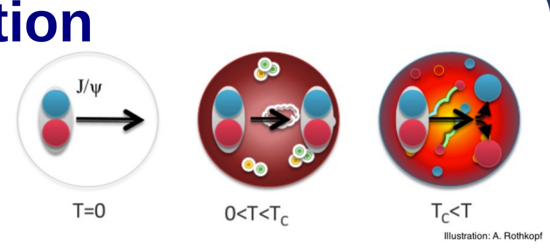
Abstract

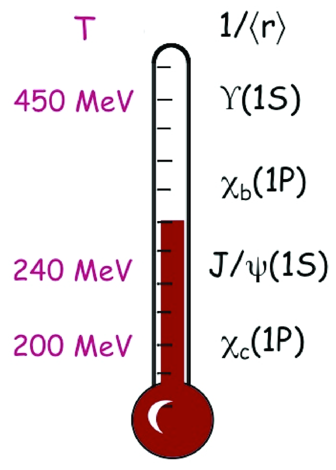
Quarkonia are excellent probes for studying the properties of quark-gluon plasma formed in relativistic heavy-ion collisions at RHIC. In order to fully understand the observed suppression of quarkonium production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, it is essential to understand the cold nuclear matter (CNM) effects on the quarkonium production. Collisions of p+Au at the same energy can be used to study the CNM effects since these effects are expected to be dominant in such systems.

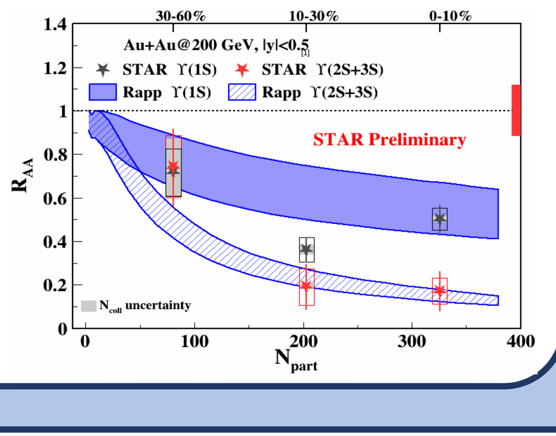
In this poster, we present measurements of inclusive *J/ψ* and *Υ* cross sections in p+p collisions and their modification in p+Au collisions (the nuclear modification factor R_{pAu}) at $\sqrt{s_{NN}}$ = 200 GeV. The results are extracted from data recorded by the STAR experiment in 2015 using the dielectron or dimuon decay channel of the quarkonia.

Motivation



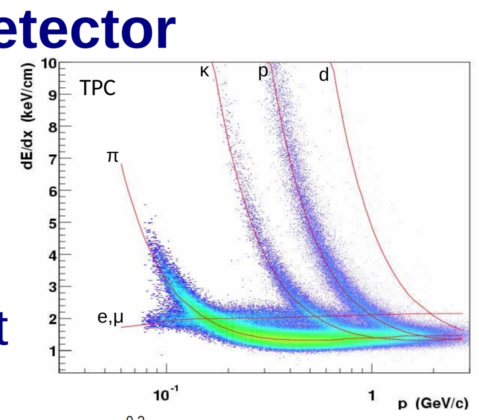
- QGP properties are closely related to the temperature
- Quarkonium production is sensitive to the temperature in heavy-ion collisions
- Different states of quarkonia dissociate at different temperature: sequential melting
- A good understanding of the CNM effects is essential for studying the Hot Nuclear Matter (HNM) effects

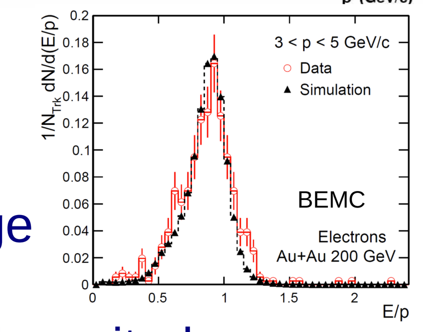


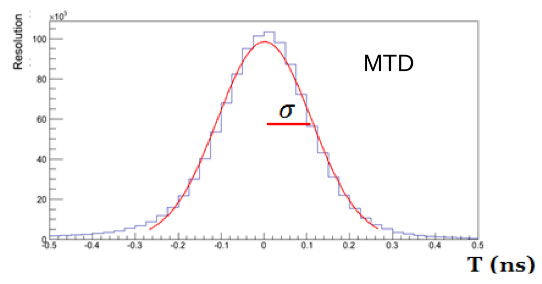


The STAR Detector

- Time Projection Chamber
  - |η|<1; full azimuthal coverage
  - Momentum measurement
  - Electron and muon identification with dE/dx
- Barrel ElectroMagnetic Calorimeter
  - |η|<1; full azimuthal coverage
  - Trigger detector
  - Electron identification with deposited energy
- Muon Telescope Detector
  - |η|<0.5; 45% coverage in φ
  - Muon trigger detector
  - Muon identification







Analysis Method

The cross section is calculated via:

$$\sigma_{\Upsilon,J/\psi} = \frac{\sigma_{MB}}{N^{eqv.}_{MB}\,\epsilon^{goodvtx}_{MB}} \cdot \frac{\epsilon^{BBC}_{MB}\,\epsilon^{goodvtx}_{MB}}{\epsilon^{BBC}_{\Upsilon,J/\psi}\,\epsilon^{goodvtx}_{\Upsilon,J/\psi}} \cdot \frac{N^{raw}_{\Upsilon,J/\psi}}{\epsilon^{Trk}_{\Upsilon,J/\psi}\,\epsilon^{pId}_{\Upsilon,J/\psi}\,\epsilon^{Trig}_{\Upsilon,J/\psi}}$$

- σ_{MB} : minimum-bias (MB) cross section in p+p
- $N^{eqv.}_{MB}$: equivalent number of MB events
- $\epsilon^{goodvtx}_{X}$: good vertex efficiency for X
- ϵ^{BBC}_{X} : beam-beam counter efficiency for X
- $N^{raw}_{\Upsilon,J/\psi}$: raw yield of *Υ* or *J/ψ*
- $\epsilon^{Trk}_{\Upsilon,J/\psi}$, $\epsilon^{pId}_{\Upsilon,J/\psi}$, $\epsilon^{Trig}_{\Upsilon,J/\psi}$: tracking, particle identification, trigger efficiency of *Υ* or *J/ψ*

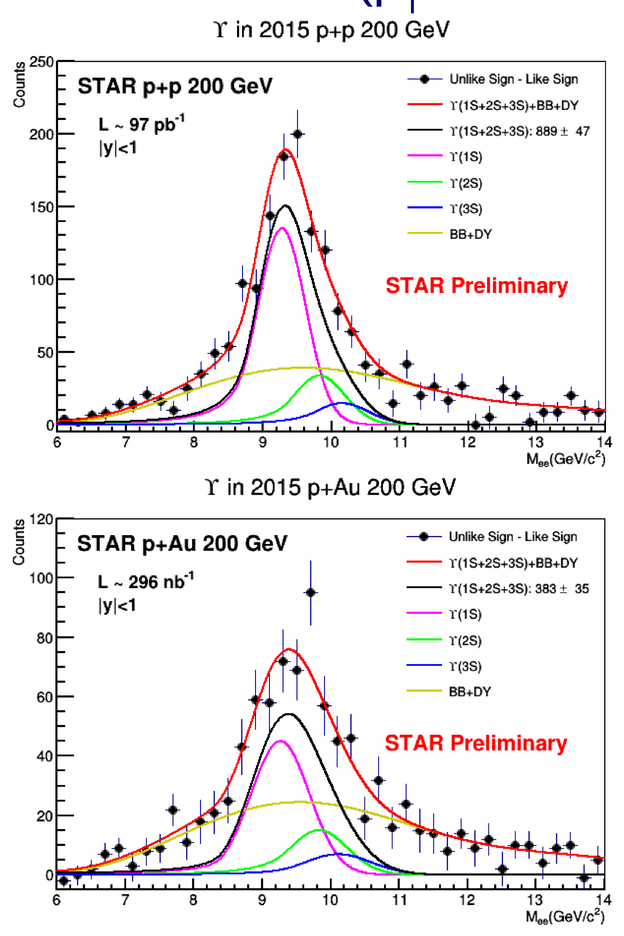
The nuclear modification factor is calculated via:

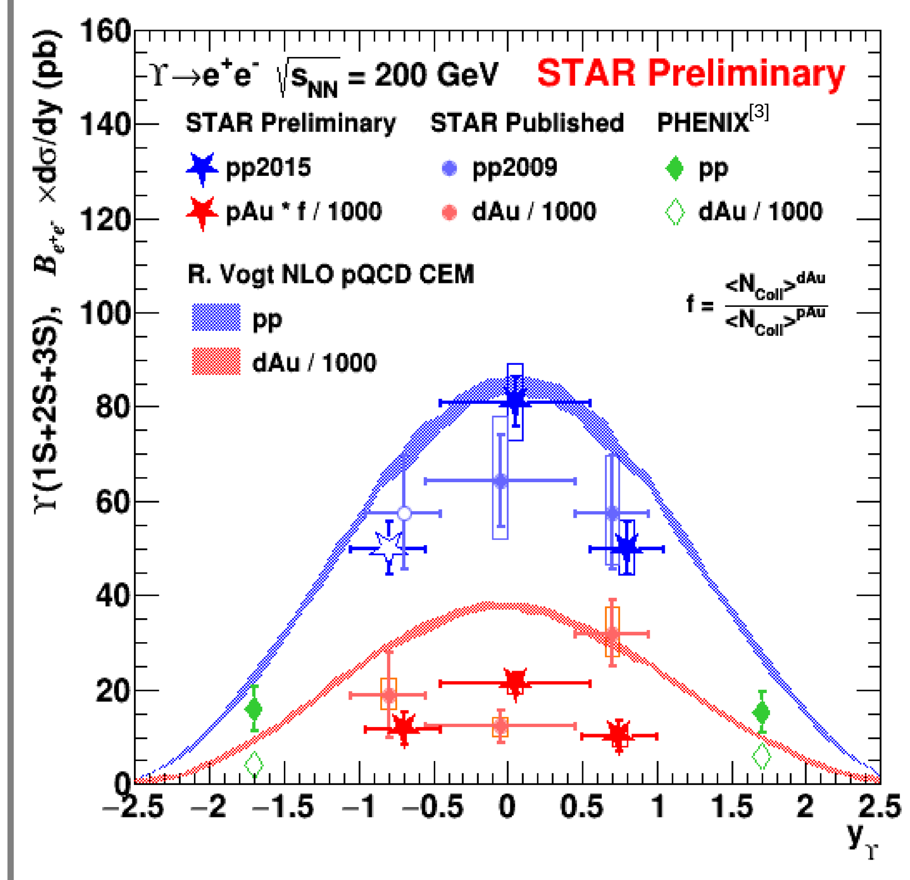
$$R_{pAu} = \frac{Inv.Yield^{\Upsilon,J/\psi}_{pAu}}{\sigma^{\Upsilon,J/\psi}_{pp}} \cdot \frac{\sigma^{inel.}_{pp}}{\langle N^{coll.}_{pAu}\rangle}$$

- $\sigma^{inel.}_{pp}$: inelastic cross section of p+p collisions
- $\langle N^{coll.}_{pAu}\rangle$: average number of binary collisions (p+Au)

Cold Nuclear Matter Effects on *Υ* Production

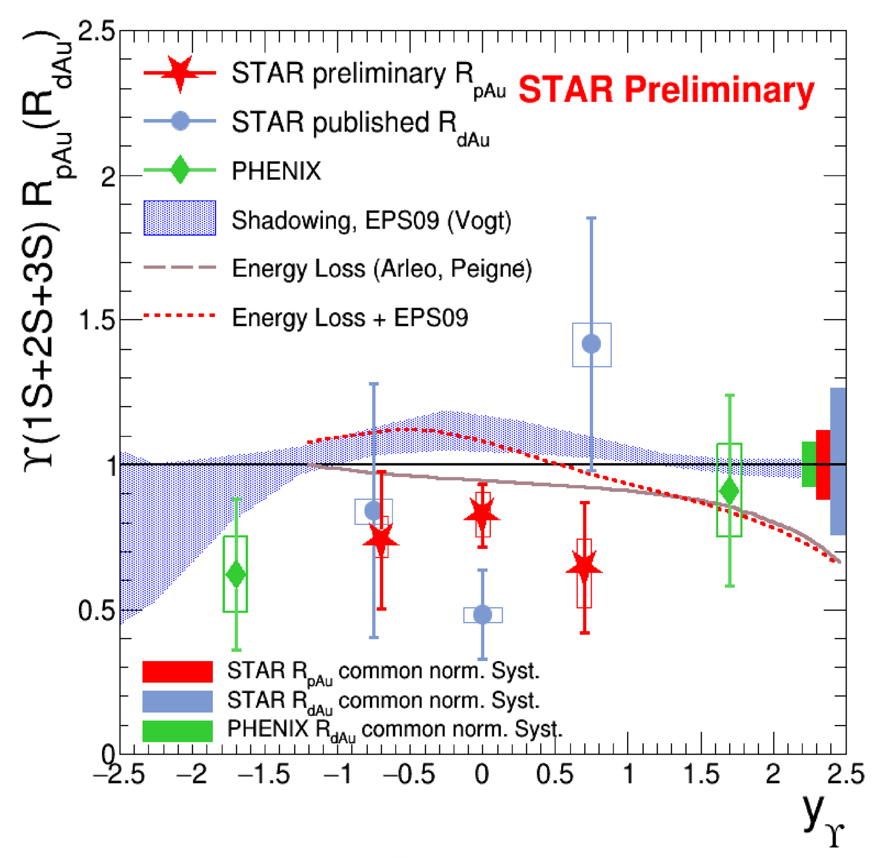
Υ Invariant Mass (p_T < 10 GeV/c)





Cross section vs y_Υ

Cross Section and R_{pAu}

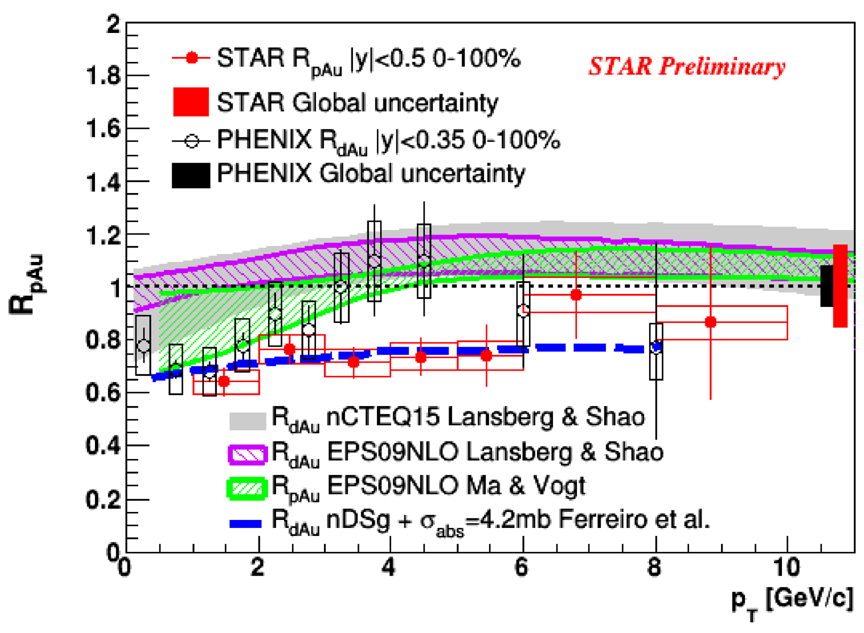


R_{pAu} vs y_Υ

- Data set: STAR 2015 Run (p+p and p+Au)
- NLO pQCD CEM[4] overestimates the width of cross section distribution as a function of rapidity in p+p collisions
- Improved precision in p+Au collisions compared to previous published d+Au result by STAR[2]
- Indication of *Υ* suppression in p+Au collisions beyond that expected from nPDF and/or energy loss effects[5]

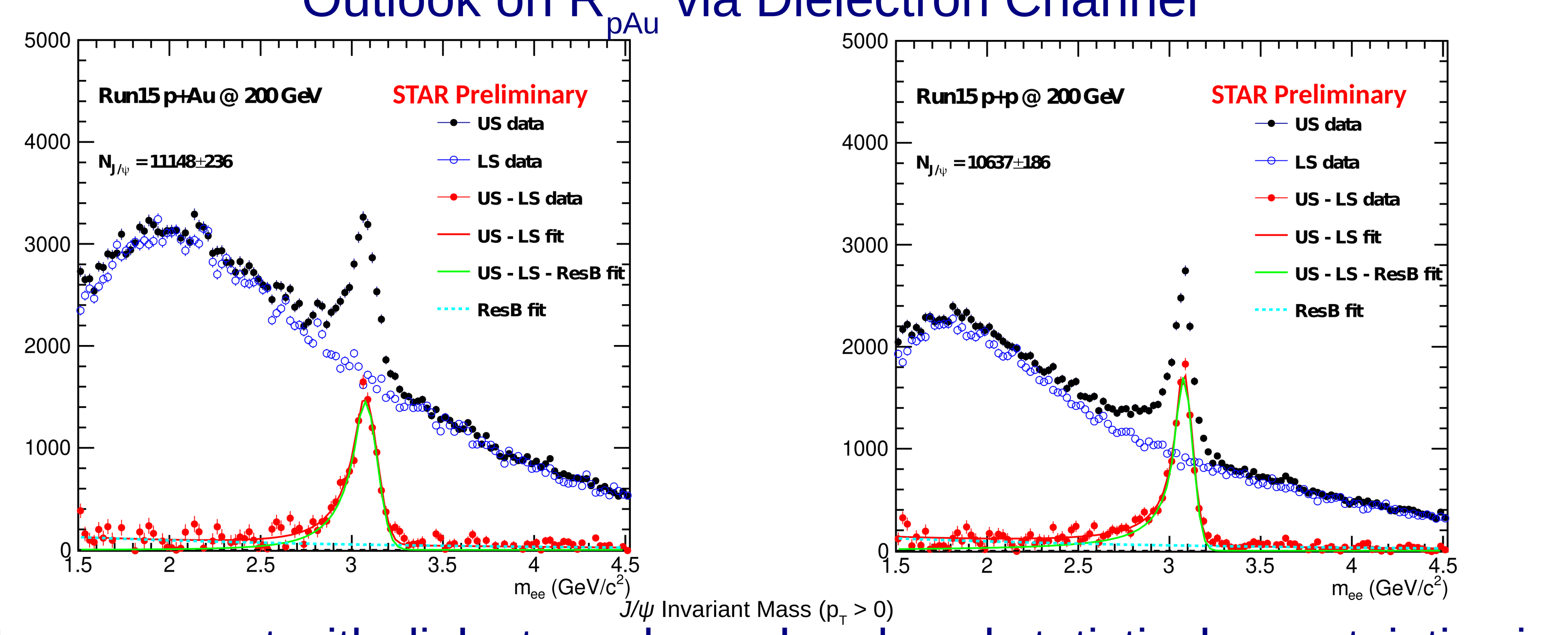
Cold Nuclear Matter Effects on *J/ψ* Production

R_{pAu} via Dimuon Channel



- Data set: STAR 2015 Run (p+p and p+Au)
- The preliminary R_{pAu} result is consistent with the d+Au result published by PHENIX within uncertainty[6]
- Indication of similar CNM effects in p+Au and d+Au collisions
- The model with additional nuclear absorption is favored by STAR data[7]

Outlook on R_{pAu} via Dielectron Channel



- Improvement with dielectron channel: reduced statistical uncertainties in intermediate and high p_T range are expected due to wider acceptance of BEMC compared to MTD

Reference

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