



Measurement of the Υ production in heavy-ion collisions at the top RHIC energy with the STAR detector

Gaohan Yang (for the STAR collaboration)

South China Normal University

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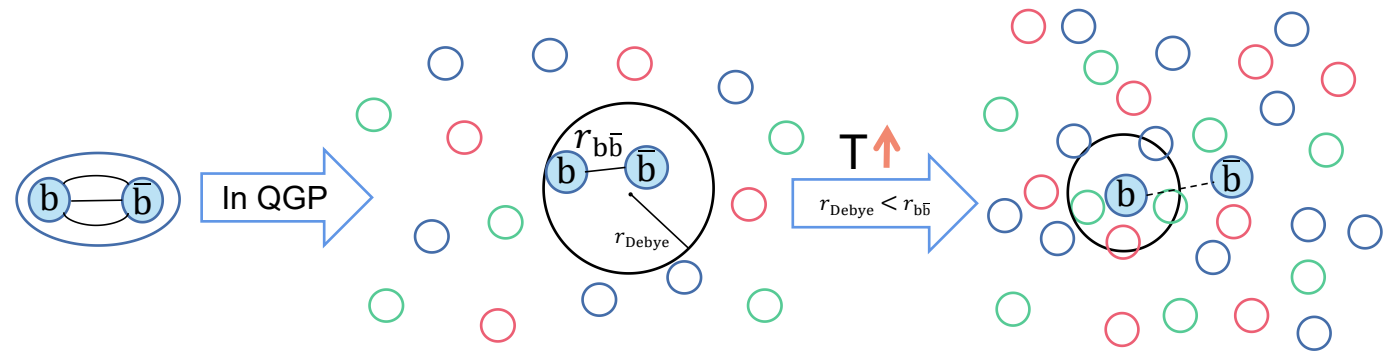
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Outline

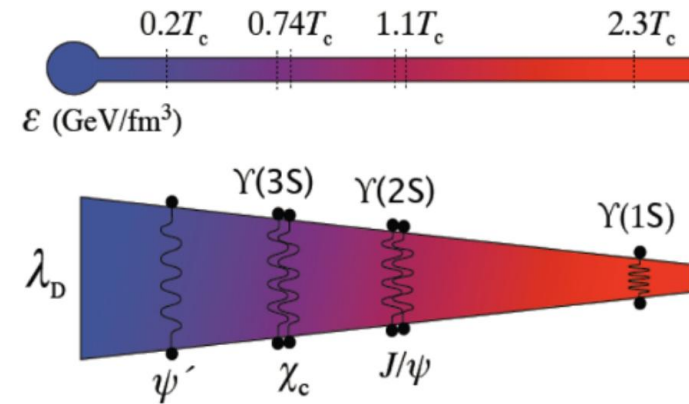
- Physics motivation
- STAR detector
- Υ measurement in Au+Au and isobar (${}_{40}^{96}\text{Zr}+{}_{40}^{96}\text{Zr}$ & ${}_{44}^{96}\text{Ru}+{}_{44}^{96}\text{Ru}$) collisions
- Comparison with LHC results and theoretical calculations
- Summary

Physics motivation

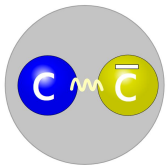
- Heavy quarks produced via initial hard scatterings
 → Imprint the entire evolution history of QGP
- Quarkonium suppression due to the color-screening effect was proposed as a direct evidence of the QGP formation
 T. Matsui, H. Satz, Phys. Lett. B178 (1986) 416
- Compared to charmonia, bottomonia are suggested as cleaner probes



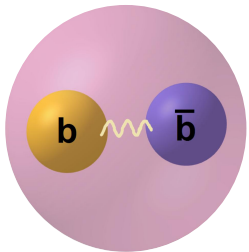
$$r_{q\bar{q}} \sim 1/E_{binding} > r_D \sim 1/T$$



Alexei Bazavov *et al.* arXiv:1904.09951(2018)



- Sizable regeneration

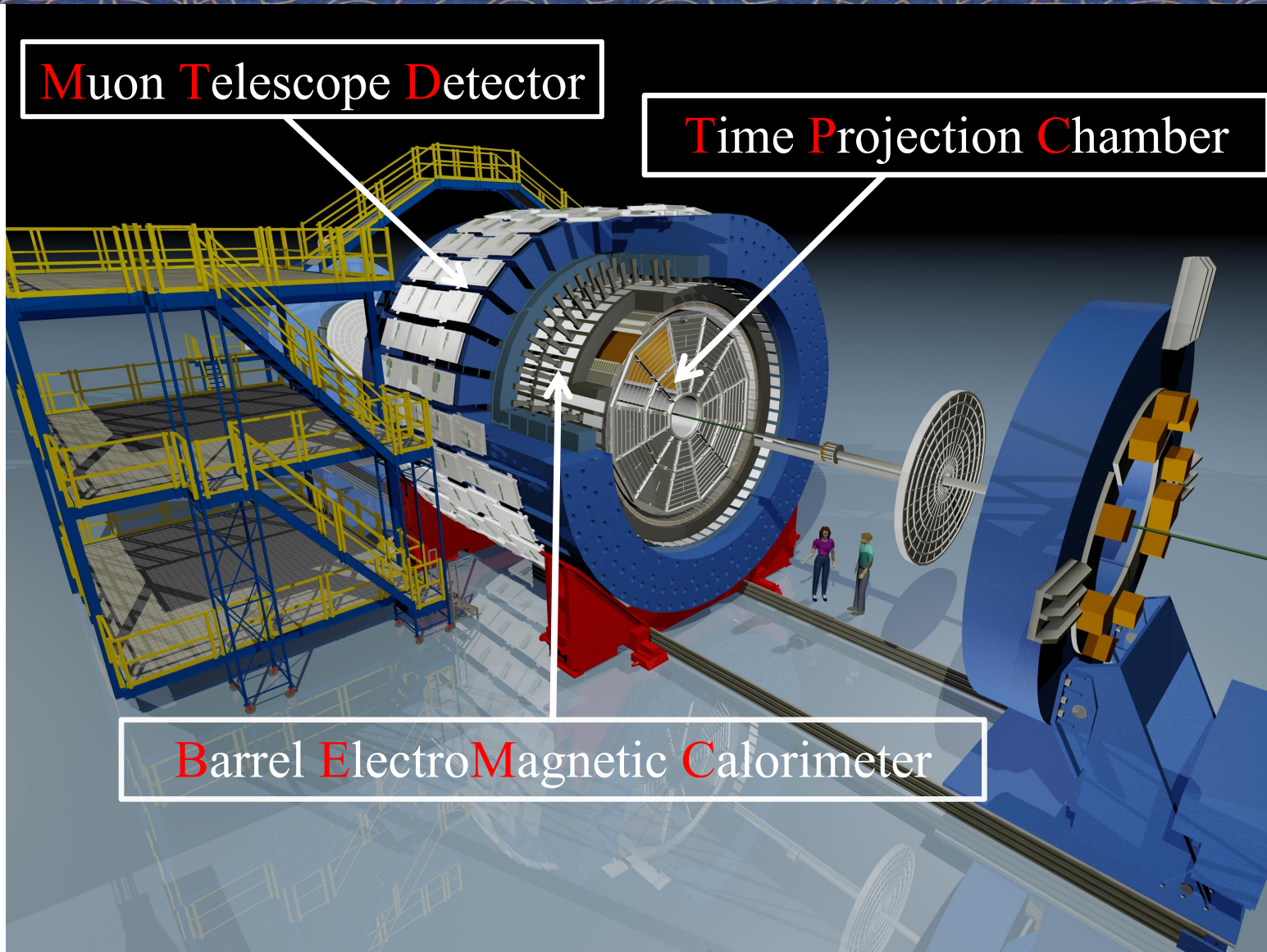


- Negligible regeneration
- Sequential suppression -> "QGP thermometer"

- Cold nuclear matter (CNM)
- Medium-induced energy loss
- Feed-down

Other effects

STAR detector



➤ TPC

- $|\eta| < 1$
- Tracking, momentum and energy loss

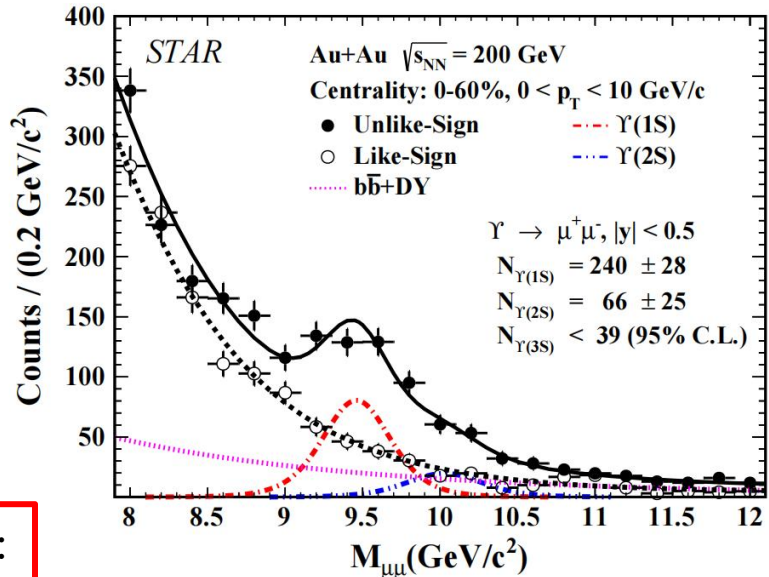
➤ BEMC

- $|\eta| < 1$
- Trigger on electron with $p_T > 3.5$ GeV
- Identify high- p_T electron

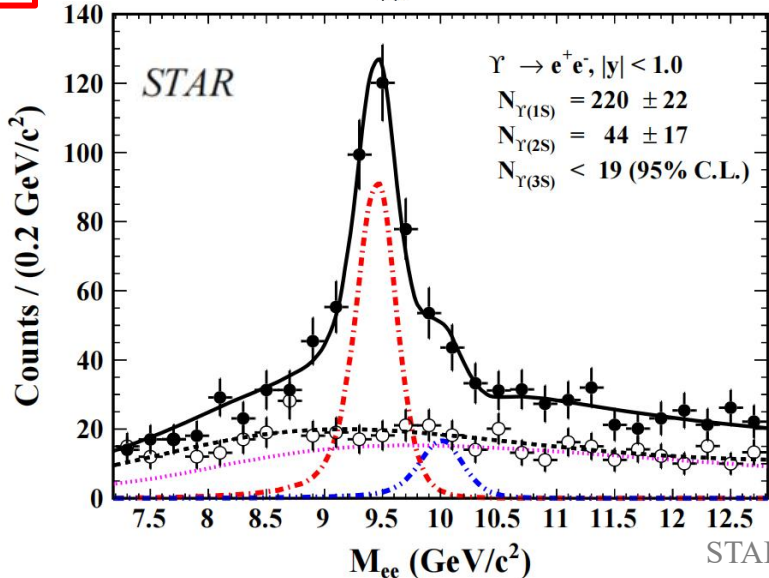
➤ MTD

- $|\eta| < 0.5$
- Trigger on muon with $p_T > 1.2$ GeV
- Identify muon

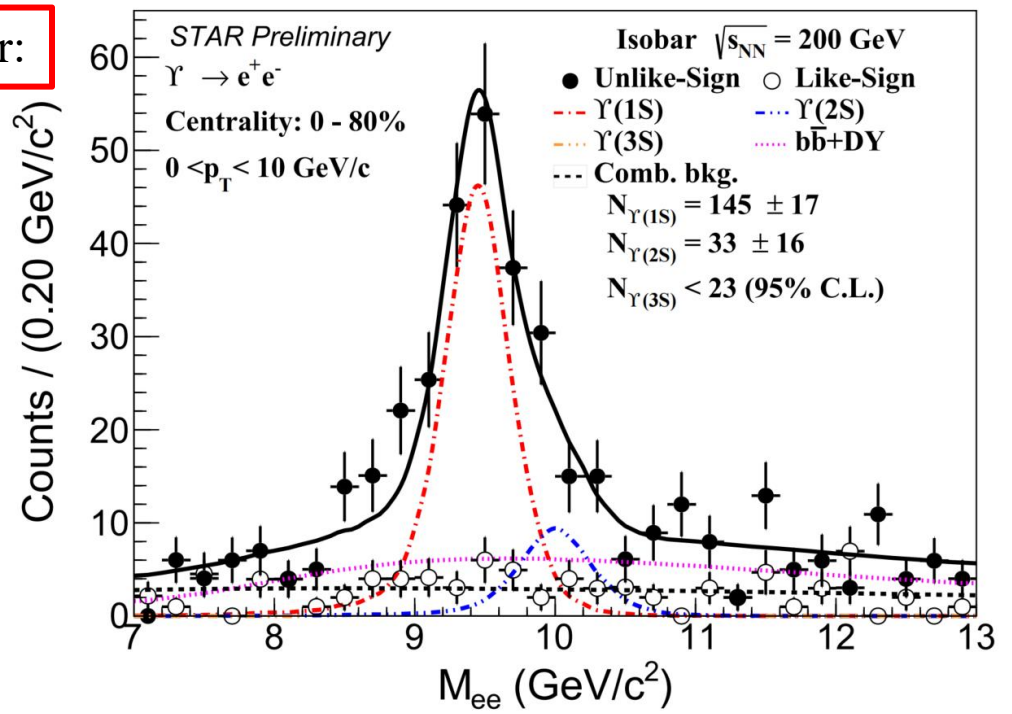
Signal extraction



Au+Au:



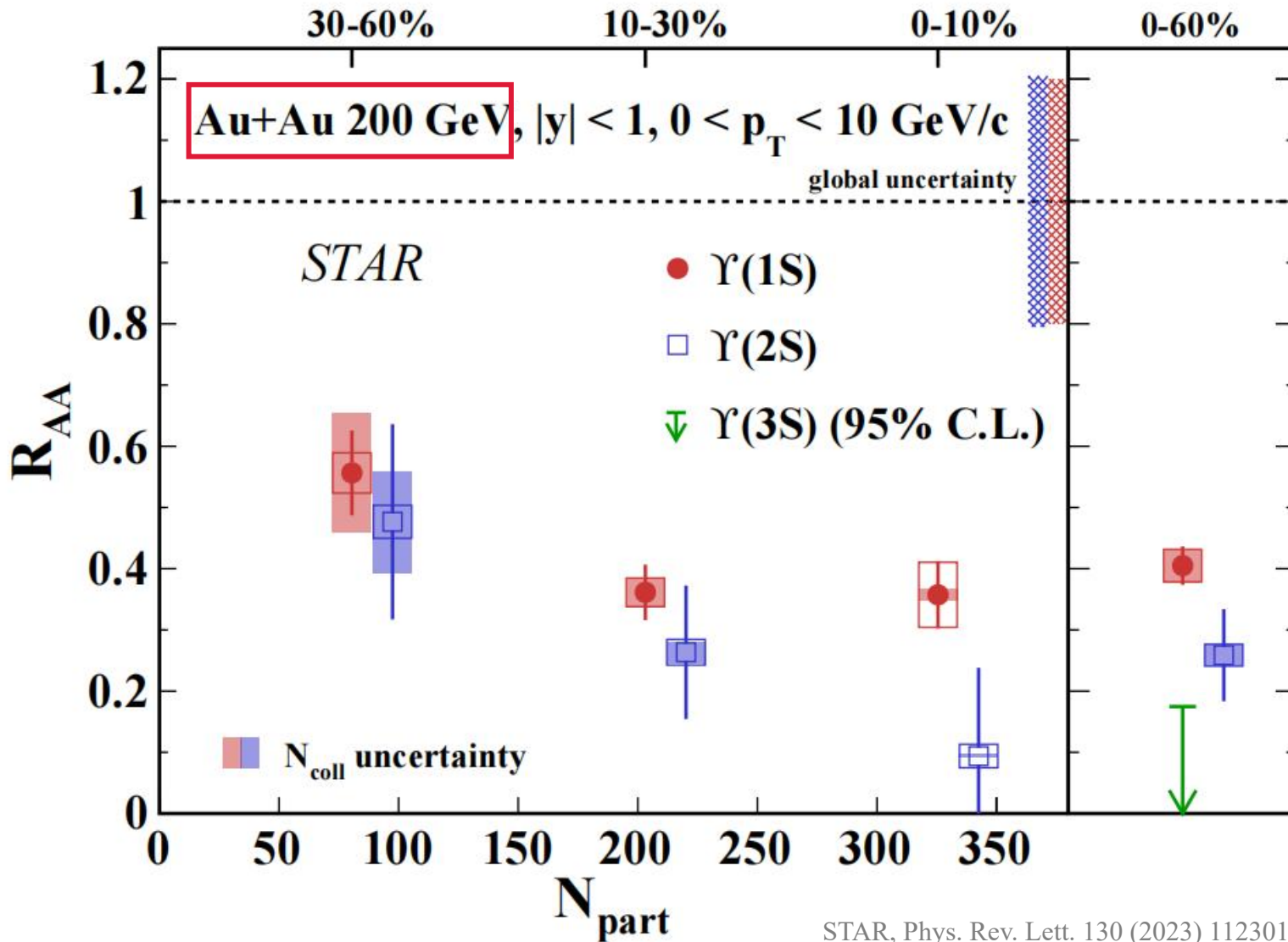
Isobar:



- Unbinned maximum-likelihood simultaneous fit to unlike-sign and like-sign mass distributions
- Template of each Υ state — simulation with detector effects
- Residual background (dotted line) — Correlated $b\bar{b}$ + Drell-Yan background with its shape determined using Pythia 6
- Combinatorial Background (dashed line) — exponential function

STAR, Phys. Rev. Lett. 130 (2023) 112301

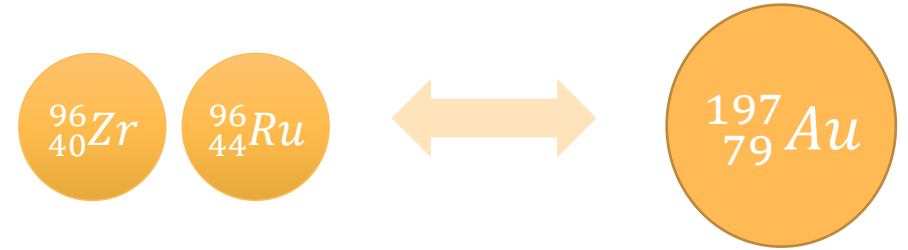
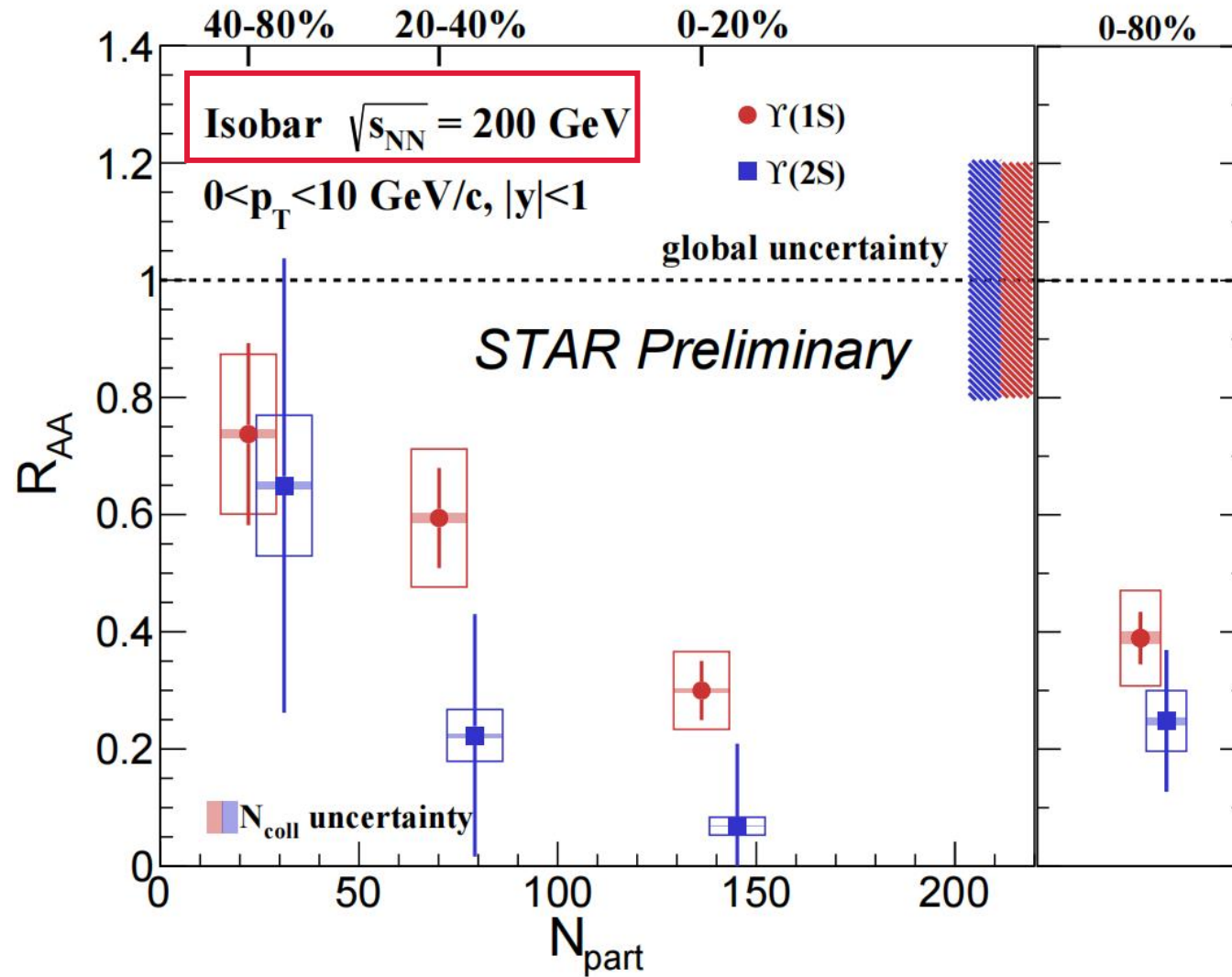
Centrality dependence of R_{AA} in Au+Au collisions



- Significant suppression for different Υ states is observed
- Suppression gradually increase towards central collisions
- Results are consistent with sequential suppression pattern

STAR, Phys. Rev. Lett. 130 (2023) 112301

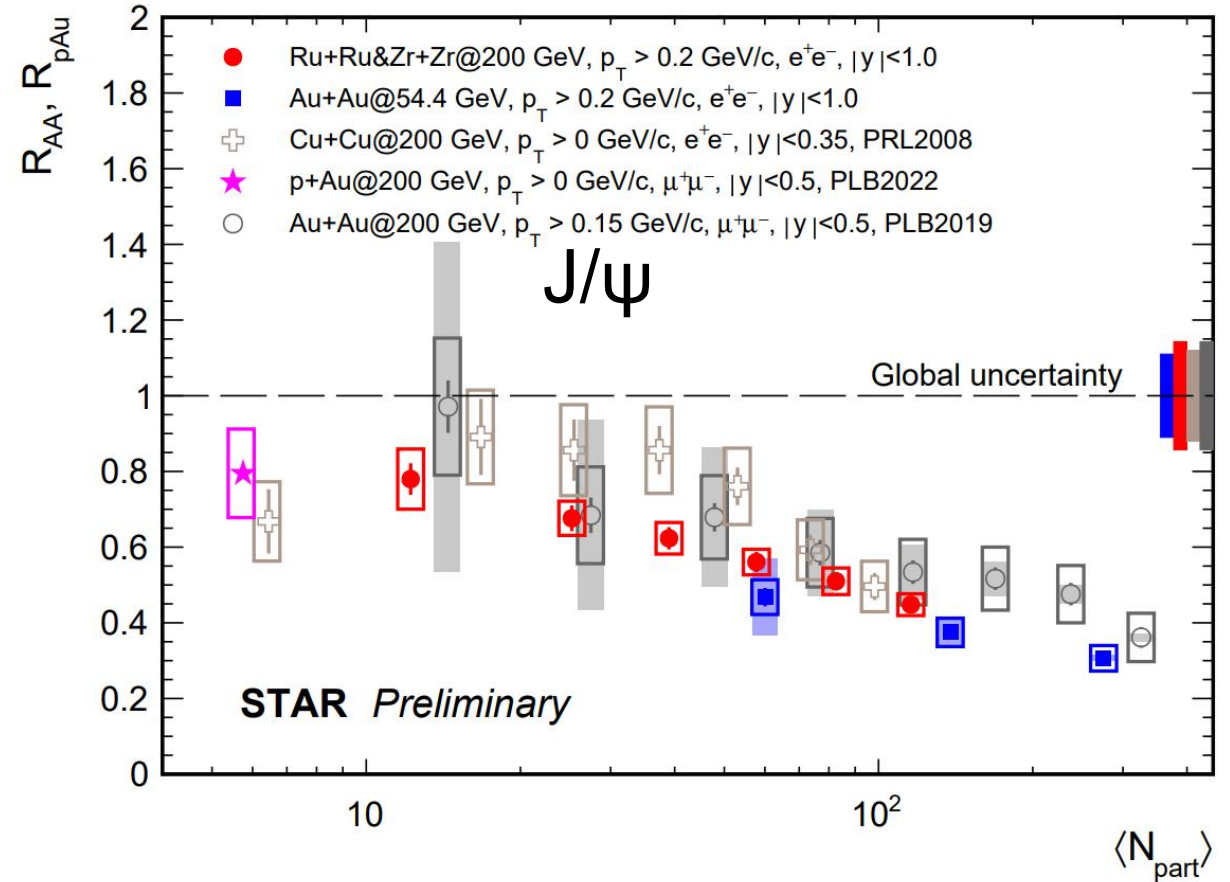
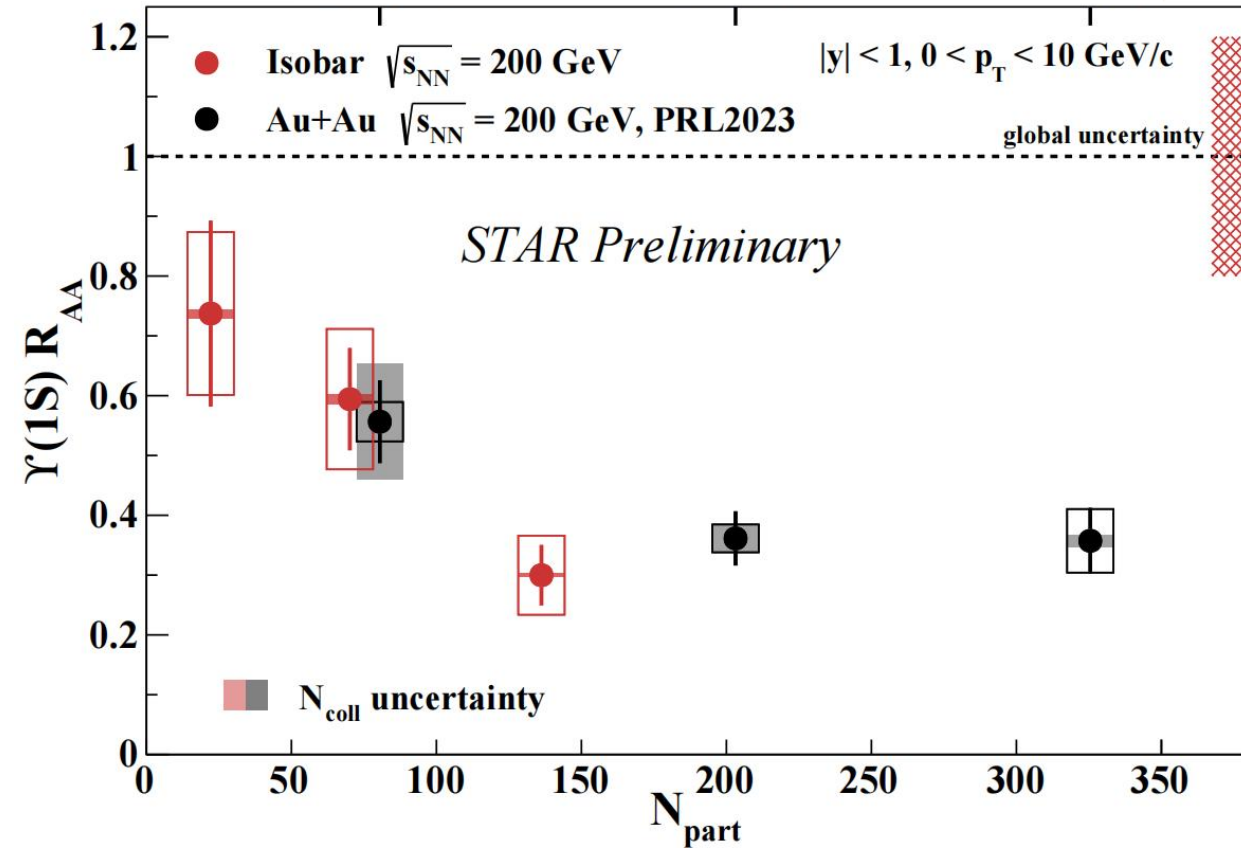
Centrality dependence of R_{AA} in isobar collisions



- Similar behavior observed in isobar collisions as in Au+Au collisions
 - Significant suppression in 0-80% isobar collisions
 - More suppression in central collision
 - Hint of sequential suppression pattern

STAR, Phys. Rev. Lett. 130 (2023) 112301

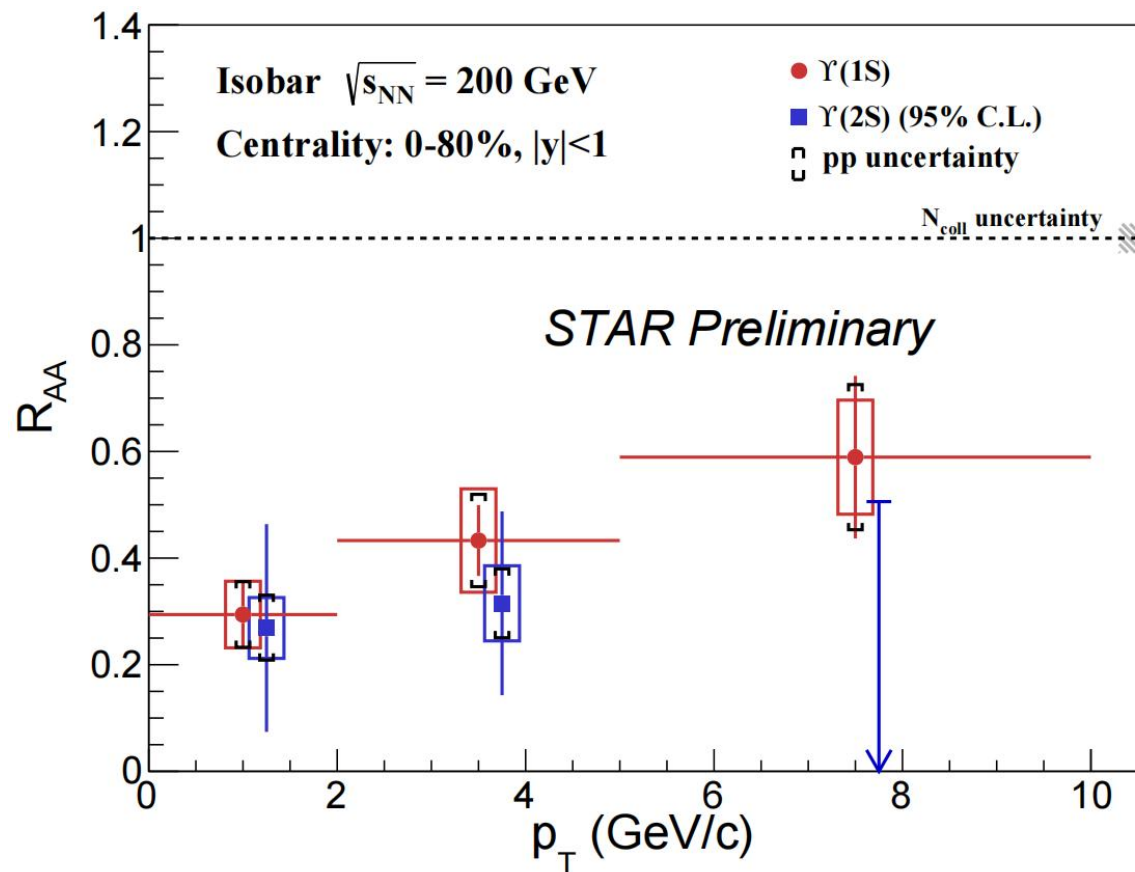
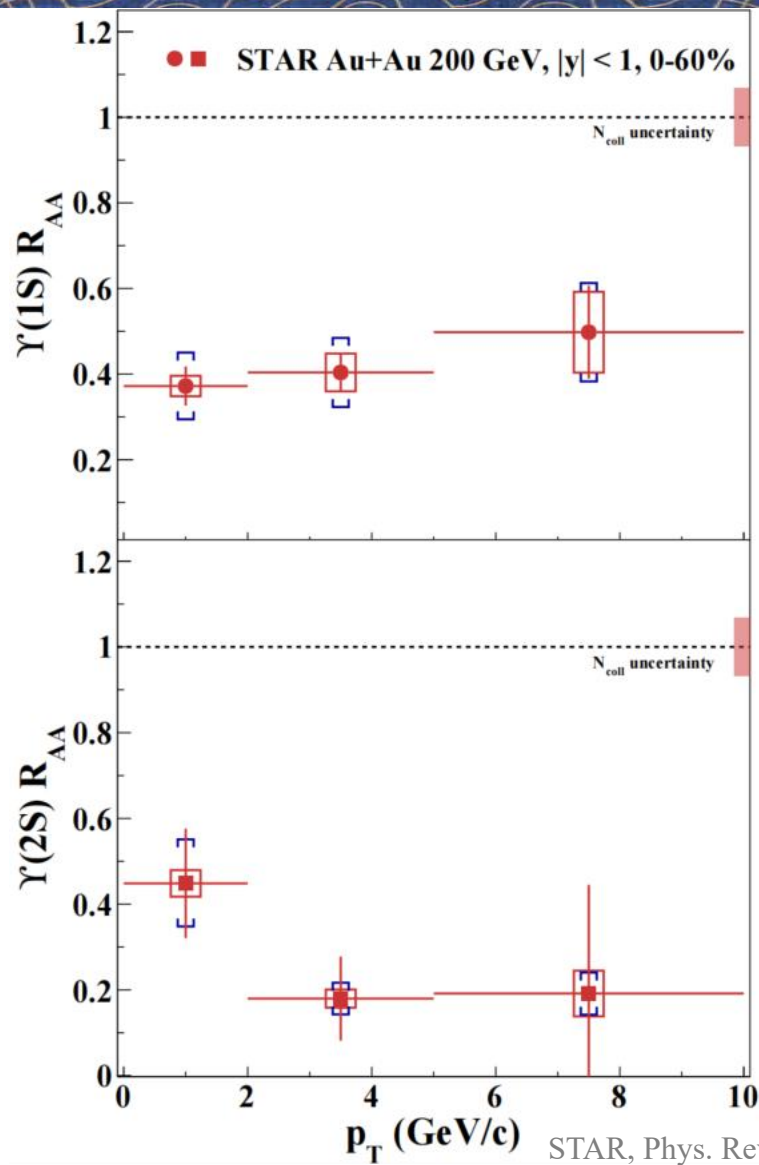
System size dependence of R_{AA} at 200 GeV



STAR, Phys. Rev. Lett. 130 (2023) 112301

No significant collision species dependence of the suppression at similar $\langle N_{part} \rangle$

R_{AA} as a function of p_T



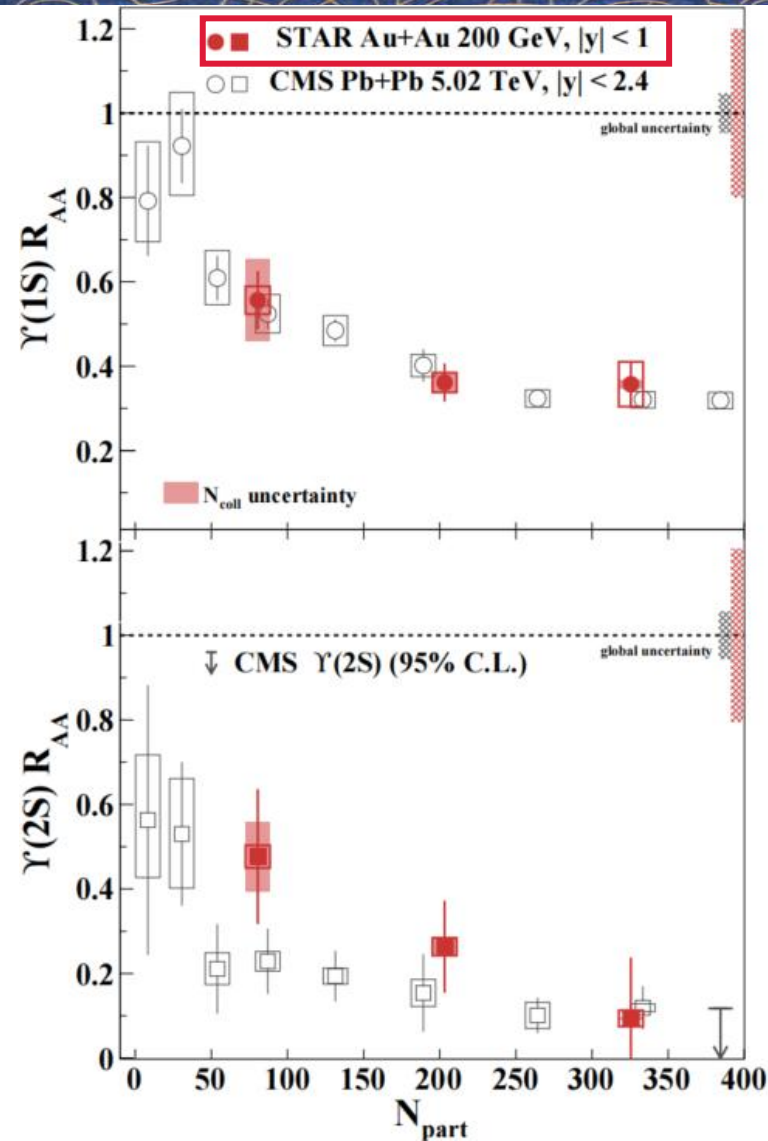
- No significant p_T dependence in Au+Au and isobar collisions
 - Hint of an increasing trend of Y(1S) R_{AA} as a function p_T

STAR, Phys. Rev. Lett. 130 (2023) 112301

Comparison with LHC results

➤ $\Upsilon(1S)$ exhibits a similar magnitude of suppression at RHIC and the LHC

➤ Hint of less suppression for $\Upsilon(2S)$ in peripheral Au+Au collision at RHIC



STAR, Phys. Rev. Lett. 130 (2023) 112301
 CMS, Phys. Lett. B790 (2019) 270–93.

Comparison with models

➤ **OQS+pNRQCD:**

dissociation+regeneration+feed-down

JHEP 05 (2021) 136.
arXiv 2205.10289 (2022).

➤ **Transport model:**

dissociation+regeneration + feed-down
+ CNM

X. Du *et al.* Phys. Rev. C 96 (2017) 054901.

➤ **Coupled Boltzmann equations:** elastic

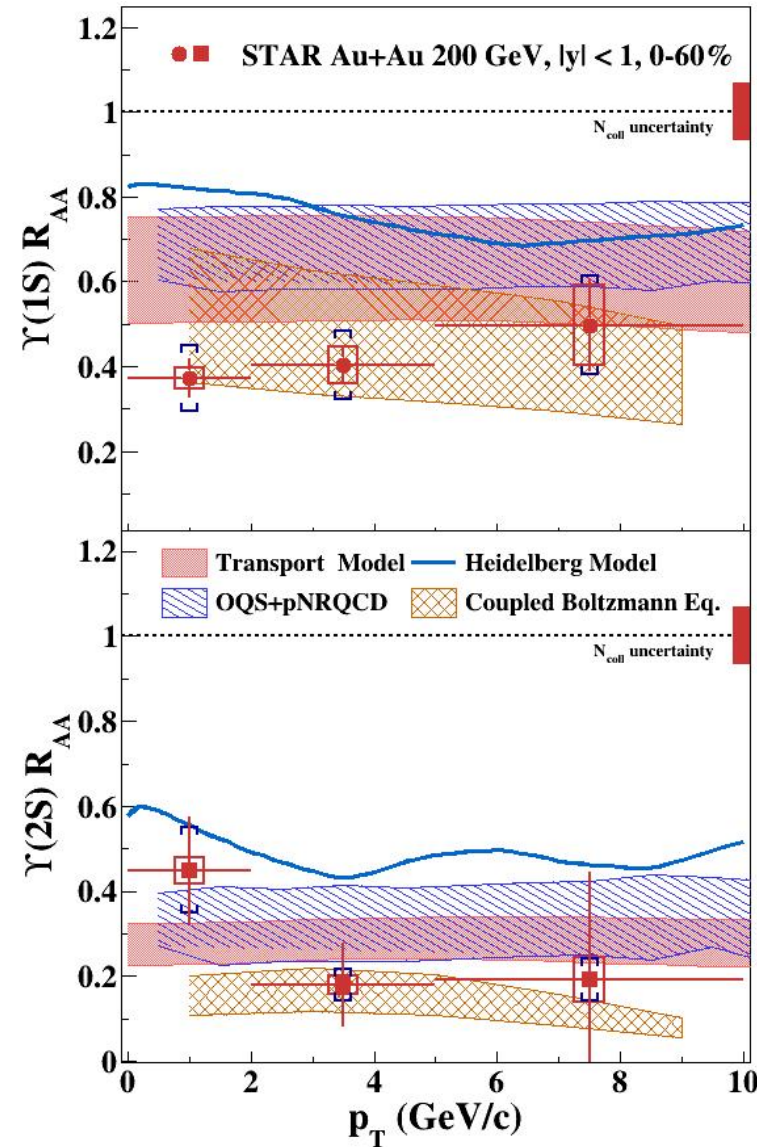
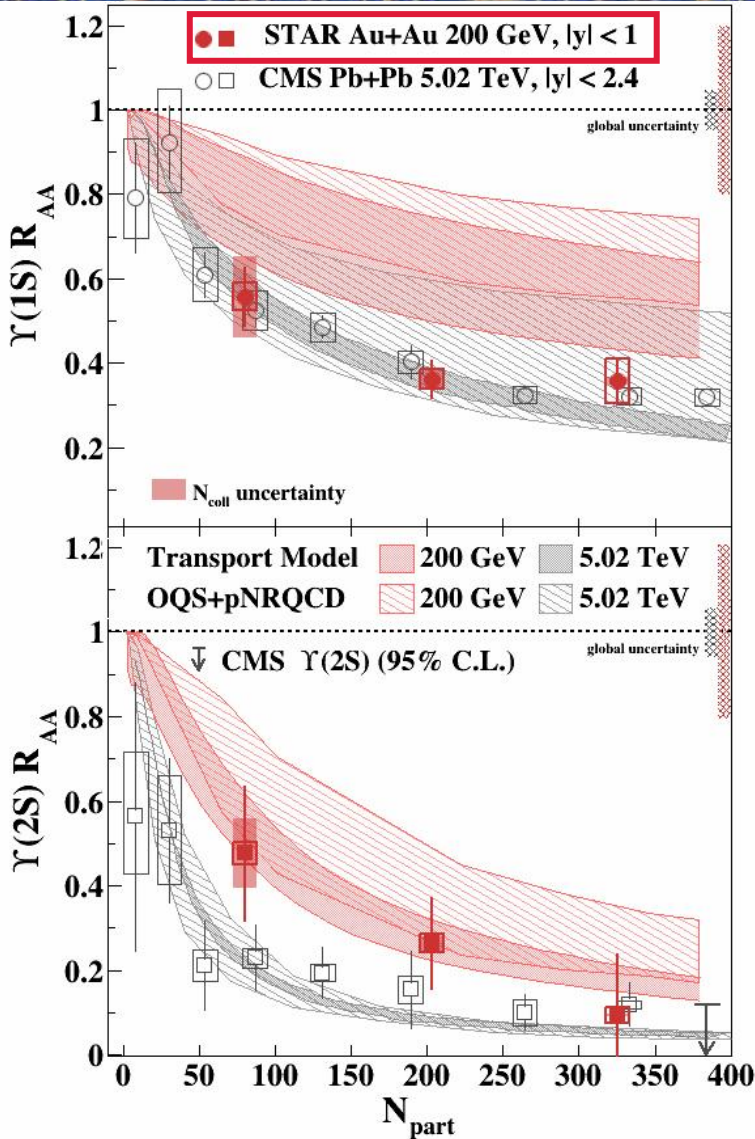
and inelastic scatterings+correlated
regeneration+CNM

X. Yao *et al.* JHEP 01 (2021) 046.

➤ **Heidelberg model:** gluon-induced

dissociation+feed-down.

J. Hoelck *et al.* Phys.Rev. C 95 (2017) 024905



Summary

- Different Υ states are measured separately in Au+Au and isobar collisions at $\sqrt{s_{\text{NN}}} = 200$ GeV
 - Consistent with sequential suppression pattern
 - No significant p_{T} dependence is observed
 - No significant species dependence at the same $\langle N_{\text{part}} \rangle$: suppression driven by system size
- $\Upsilon(1S)$ has a similar magnitude of suppression at RHIC as observed in Pb+Pb collisions at $\sqrt{s_{\text{NN}}} = 5.02$ TeV
- Different model calculations are consistent with data within the uncertainties

Thank you!