

# Sequential Upsilon suppression in Au+Au Collisions

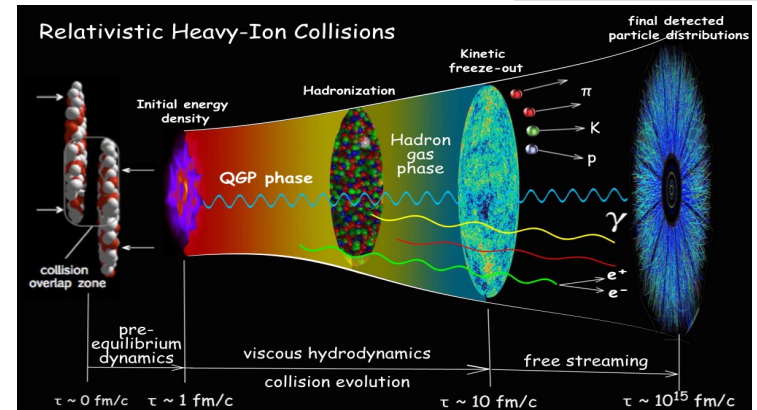
Rongrong Ma

09/09/2022

# QGP and Upsilon

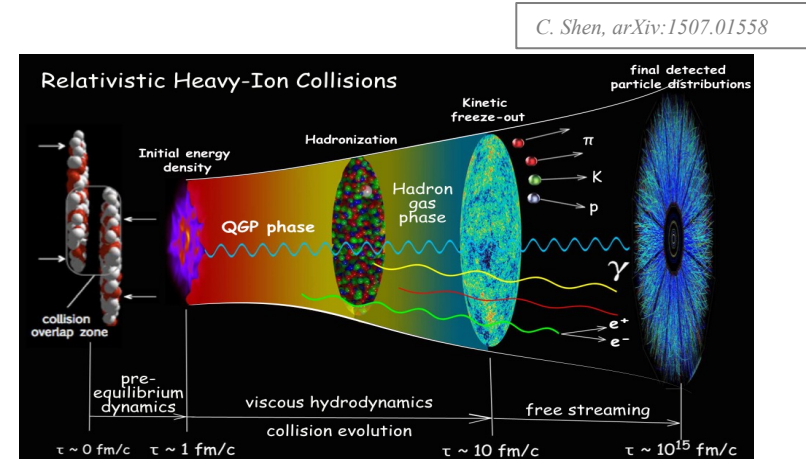
- ✓ Quark gluon plasma (QGP): a state of matter consisting of **deconfined quarks and gluons**
  - Believed to have existed momentarily after the Big Bang
  - Formed in heavy-ion collision

C. Shen, arXiv:1507.01558

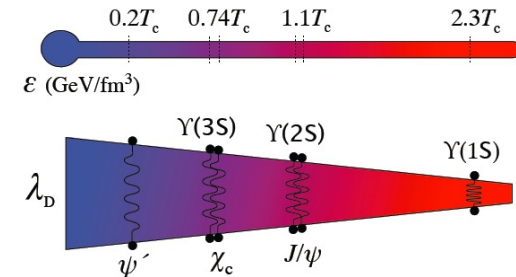
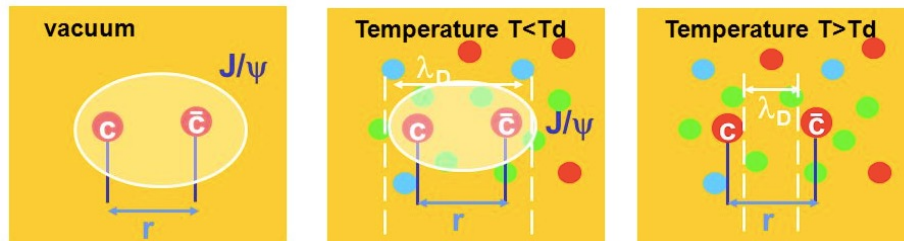


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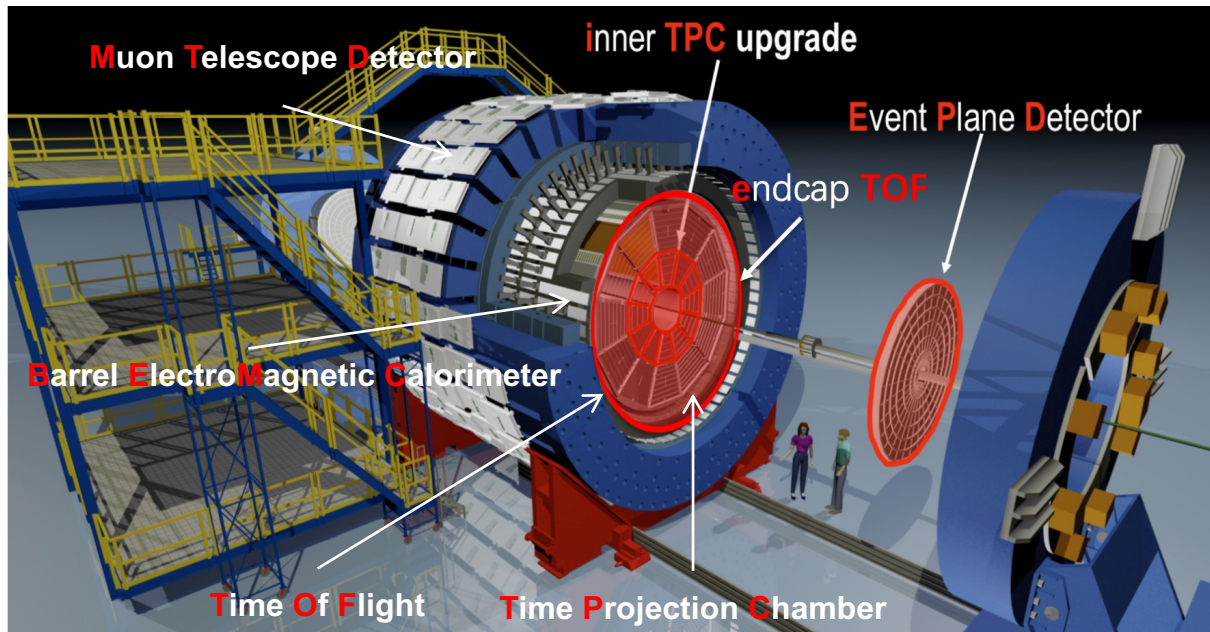
- ✓ Why Upsilon ( $b\bar{b}$ )?
  - Quarkonia expected to dissociate in the QGP  $\rightarrow$  yield suppression
  - Three  $\Upsilon$  states dissociate at different temperatures  $\rightarrow$  probe temperature profile





# STAR Experiment

- ✓ Au+Au collisions @ 200 GeV
- ✓  $\Upsilon$  is reconstructed through both the dimuon and dielectron channels



- ✓ **TPC**
  - Particle momentum, charge
  - Energy loss for PID
- ✓ **BEMC**
  - Trigger on and identify high- $p_T$  electrons
- ✓ **MTD**
  - Dimuon trigger
  - Identify muons above  $\sim 1.2$  GeV/c



# $\Upsilon$ $R_{AA}$ vs. centrality

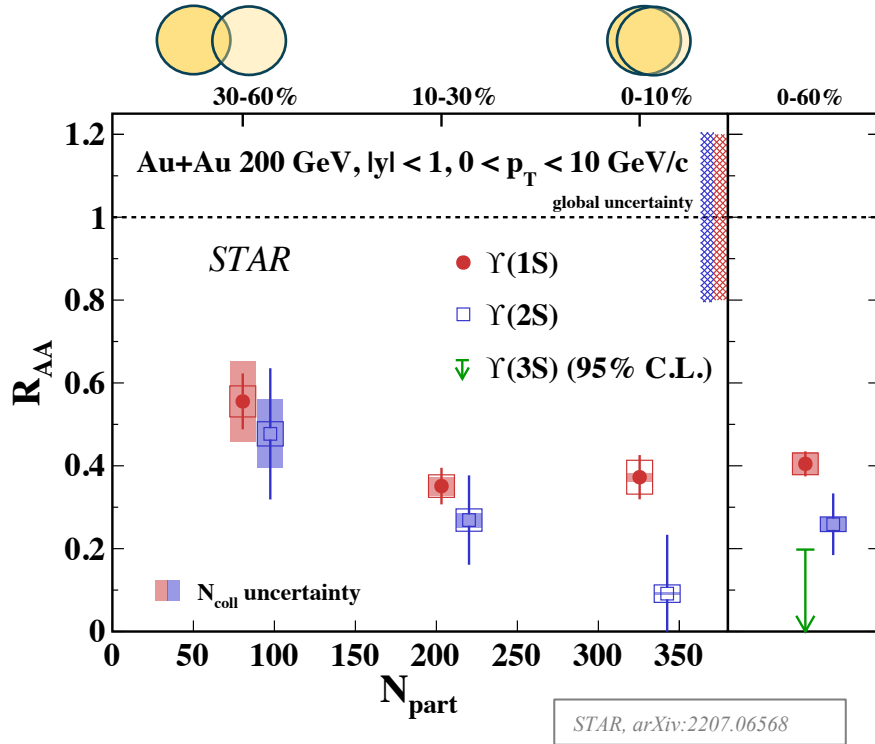
$$R_{AA} = \frac{1}{\langle N_{\text{coll}} \rangle} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$

- $R_{AA} = 1$ : no medium effect
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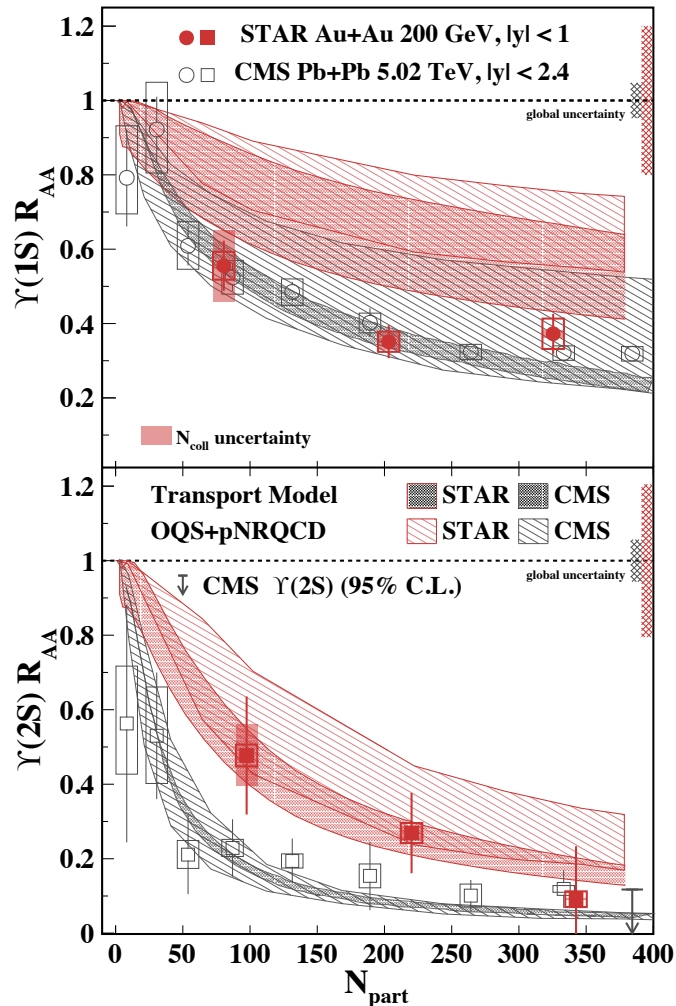
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- ✓ All three  $\Upsilon$  states are suppressed
- ✓ Hint of increasing suppression from peripheral to central collisions
- ✓ **First observation of sequential  $\Upsilon$  suppression at RHIC**
  - Upper limit for  $\Upsilon(3S)$  in 0-60%
  - $> 3\sigma$  difference between  $\Upsilon(1S)$  and  $\Upsilon(3S)$

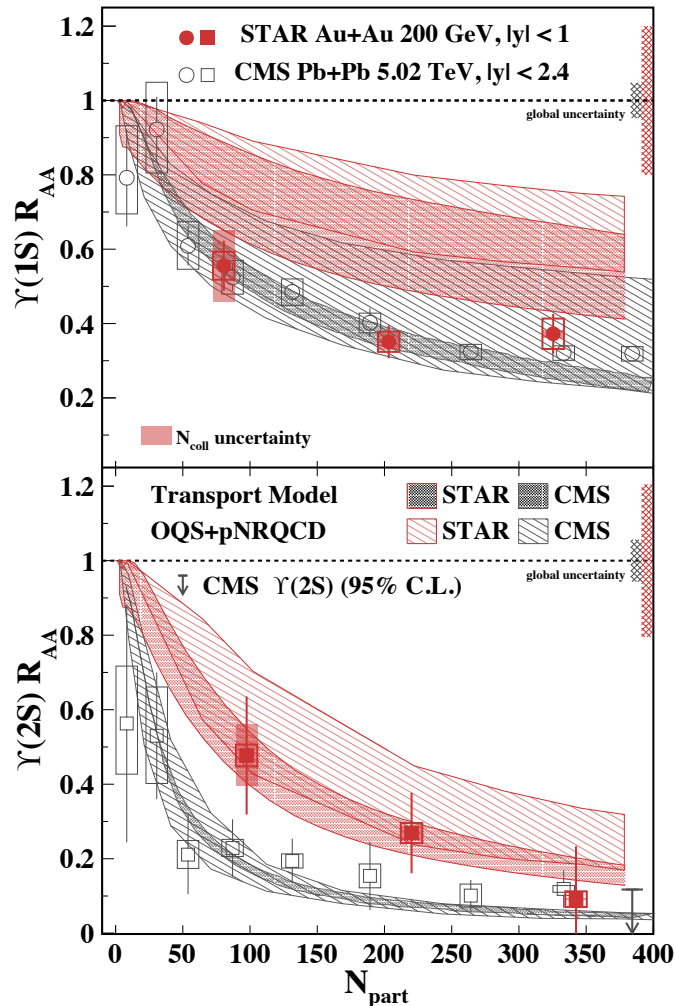
# $\Upsilon R_{AA}$ : RHIC vs. LHC



✓  $\Upsilon(1S)$ : similar level of suppression at RHIC and LHC

- Mostly due to strong suppression of excited states that feeddown to  $\Upsilon(1S)$  and cold nuclear matter effects
- Primordial  $\Upsilon(1S)$  might not significantly suppressed

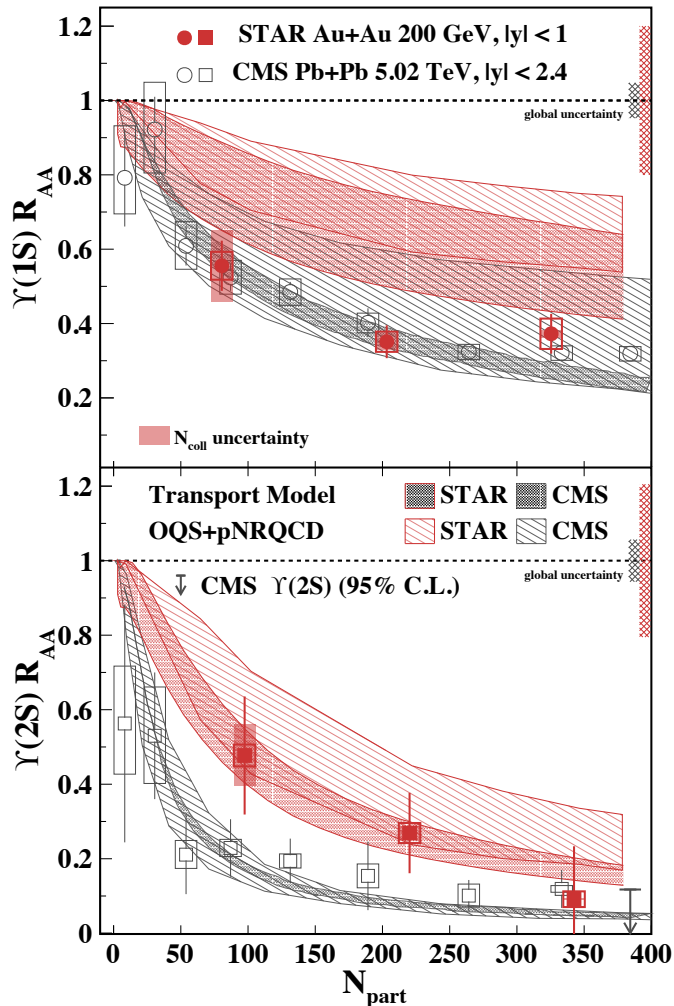
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- ✓ Model calculations:
  - $\Upsilon(1S)$ : larger separation between RHIC and LHC
  - $\Upsilon(2S)$ : tend to undershoot data at the LHC



# Summary

- ✓ First measurement of three  $\Upsilon$  states separately in 200 GeV Au+Au collisions at RHIC
  
- ✓ Sequential suppression is observed
  - $R_{AA}$ :  $\Upsilon(1S) > \Upsilon(2S) > \Upsilon(3S)$
  - The QGP produced at RHIC with temperature high enough to strongly suppress excited states
  
- ✓ Model calculations can qualitatively describe data
  - Seem to predict larger difference between RHIC and LHC than observed in data
  
- ✓ Look forward to 2023+25 data
  - A factor of 17 (1.5) increase in statistics for dielectron (dimuon) channel

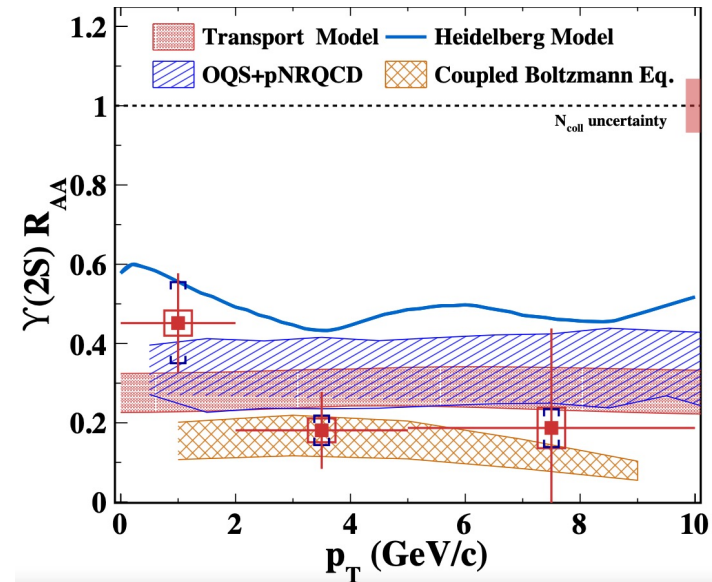
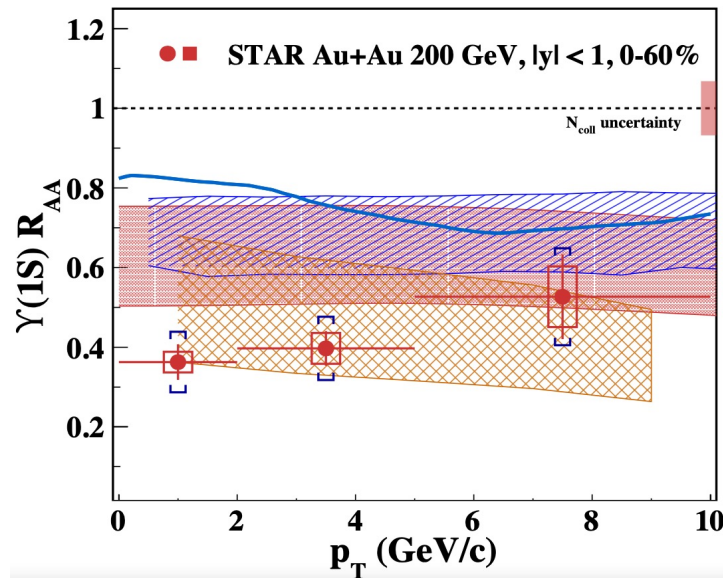


# Backup



# $\Upsilon R_{AA}$ vs. $p_T$

STAR, arXiv:2207.06568  
 Transport Model: PRC 96 (2017) 054901  
 OQS+pNRQCD: 2205.10289  
 Coupled Boltzmann Eq: JHEP 01 (2021) 046  
 Heidelberg Model: PRC 95 (2017) 024905



- ✓ No significant  $p_T$  dependence seen
- ✓ Model calculations can qualitatively describe data