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

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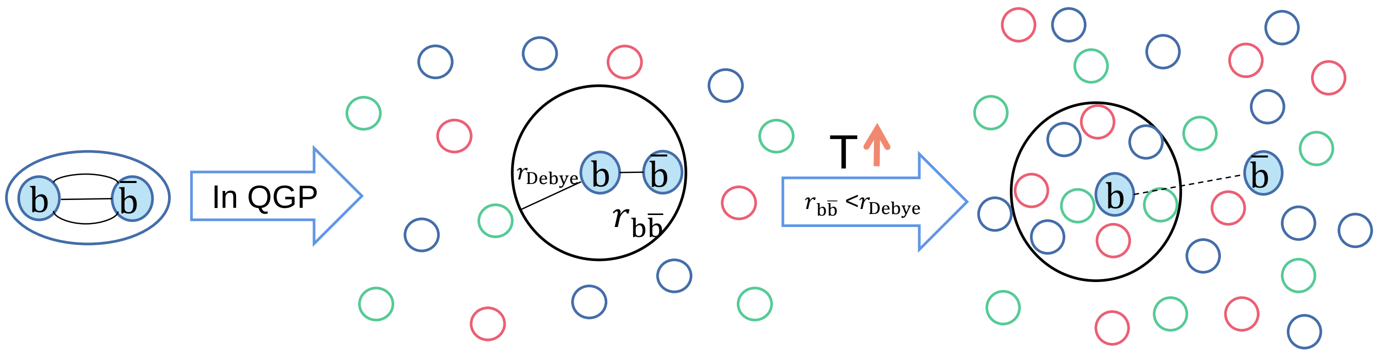
Outline

- Physics motivation
- STAR detector
- ϒ measurement in AuAu collisions
  - Comparison with LHC result and theoretical calculations
- ϒ nuclear modification factors in isobar collisions
- Summary

Physics motivation

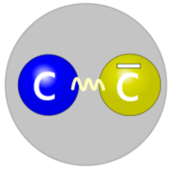
- Heavy quarks produced via initial hard scatterings
  ➡ Imprint the entire evolution history of QGP.



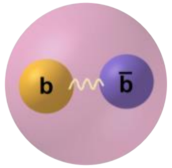
- Quarkonium suppression due to the color-screening effect was proposed as a direct evidence of the QGP formation.

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

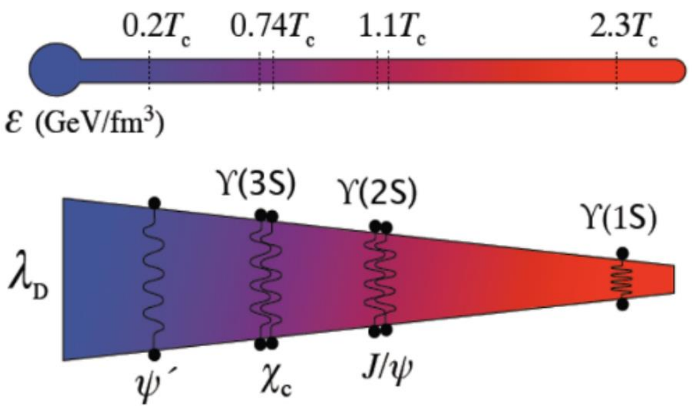
- Compared to charmonia, bottomonia are cleaner probes.



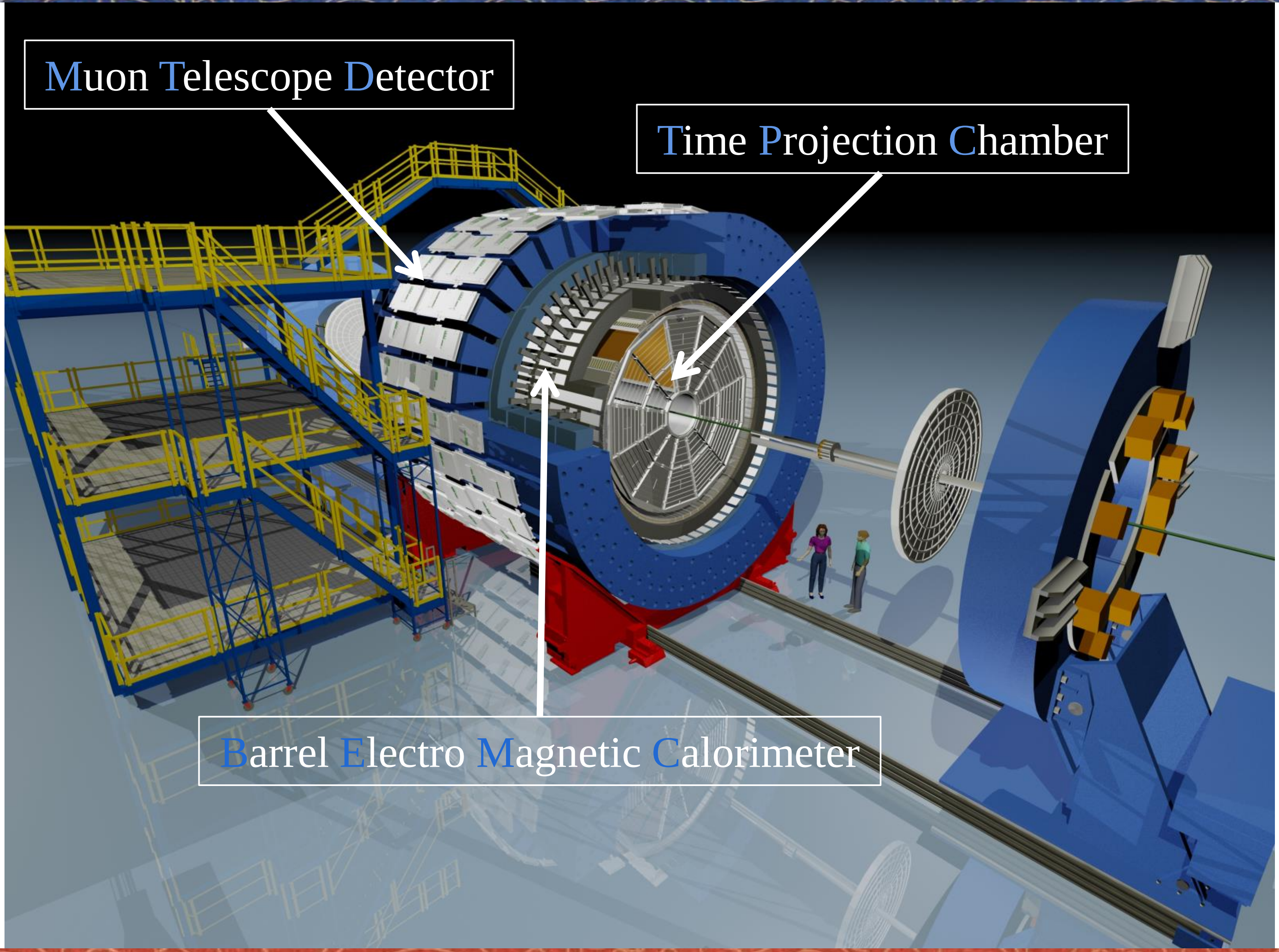
- Large production cross section
- Hot medium effects
- Cold nuclear matter effects



- Small production cross section
- Cold nuclear matter effects

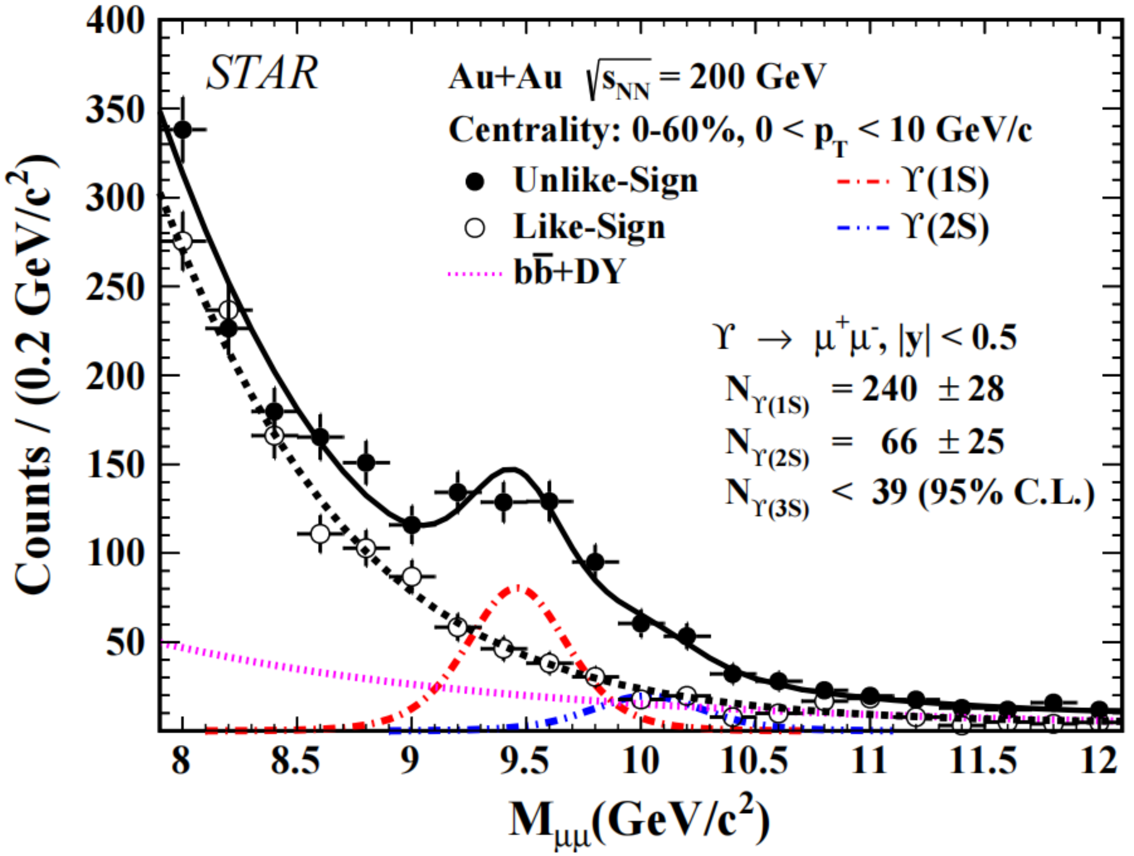


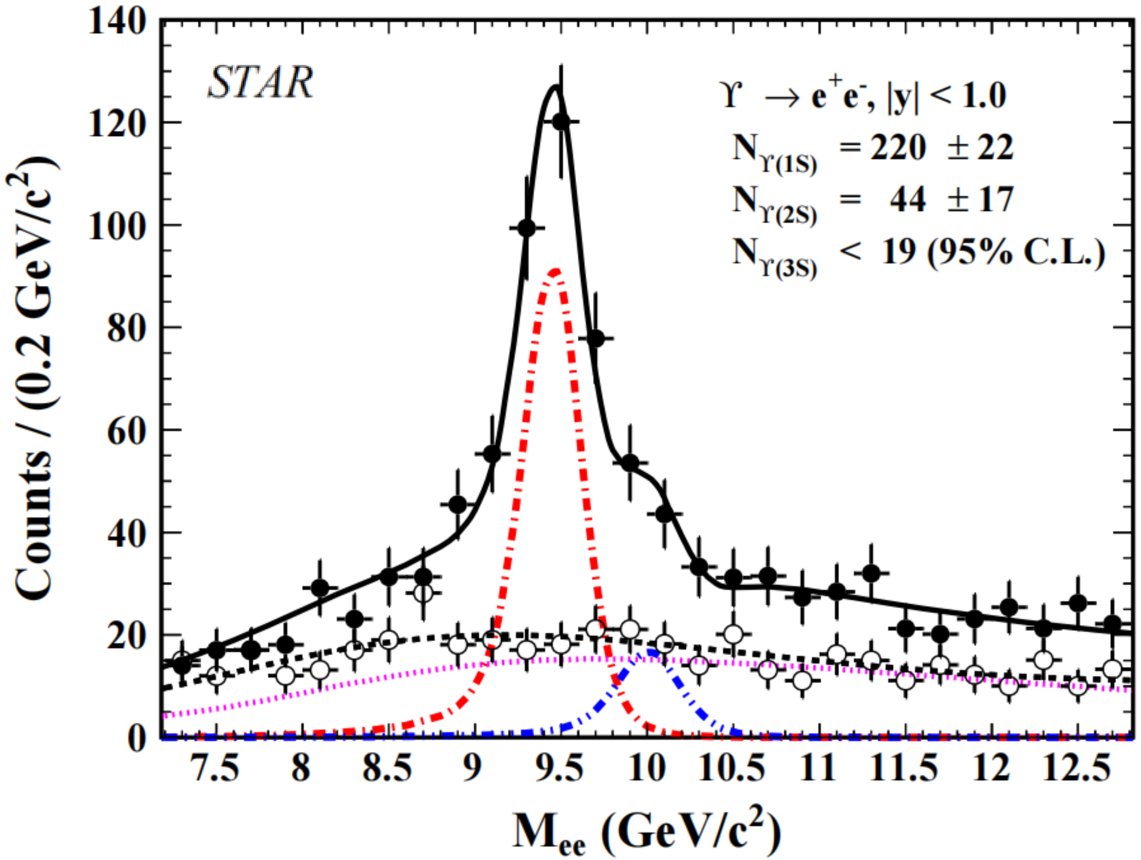
STAR detector



- TPC
  - |η|<1
  - Tracking, momentum and energy loss
- BEMC
  - |η|<1
  - Trigger and identify high-p_T electron
- MTD
  - |η|<0.5
  - Trigger and identify muon

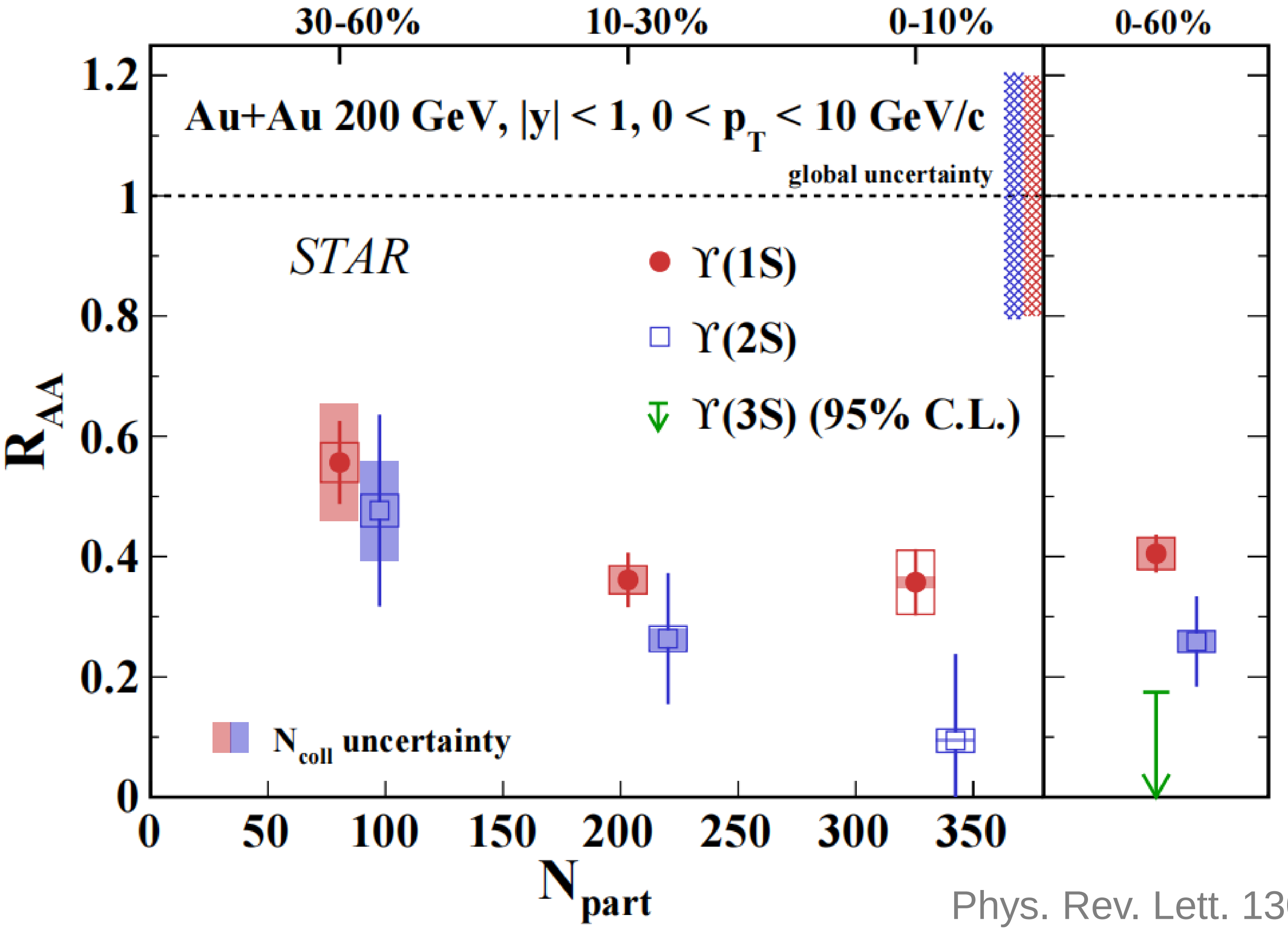
Signal extraction in Au+Au collisions





- Unbinned maximum-likelihood simultaneous fit to unlike-sign and like-sign mass distributions
- Template of each ϒ state - embedding sample
- Residual background (dotted line) - Correlated bbar + Drell-Yan background (dotted line) - Pythia 6
- Combinatorial Background (dashed line) fitting by exponential function

R_{AA} of Au+Au collisions



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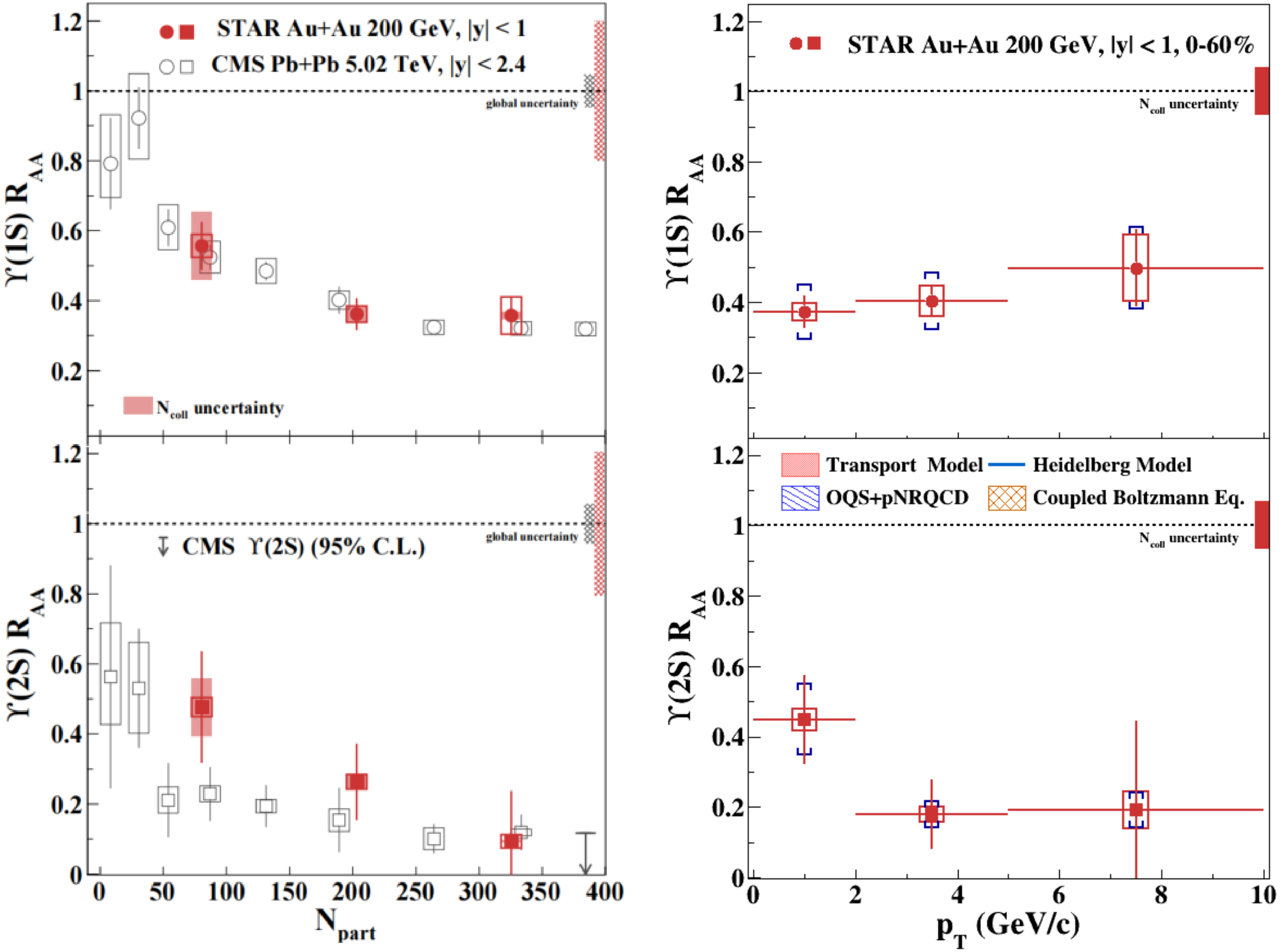
- Significant suppression for different ϒ states is observed
- Suppression gradually increase towards central collisions
- The results are consistent with sequential suppression pattern

Comparison with LHC results

- ϒ(1S) exhibits a similar magnitude of suppression at the LHC and RHIC collision energies

- Hint of less suppression of ϒ(2S)

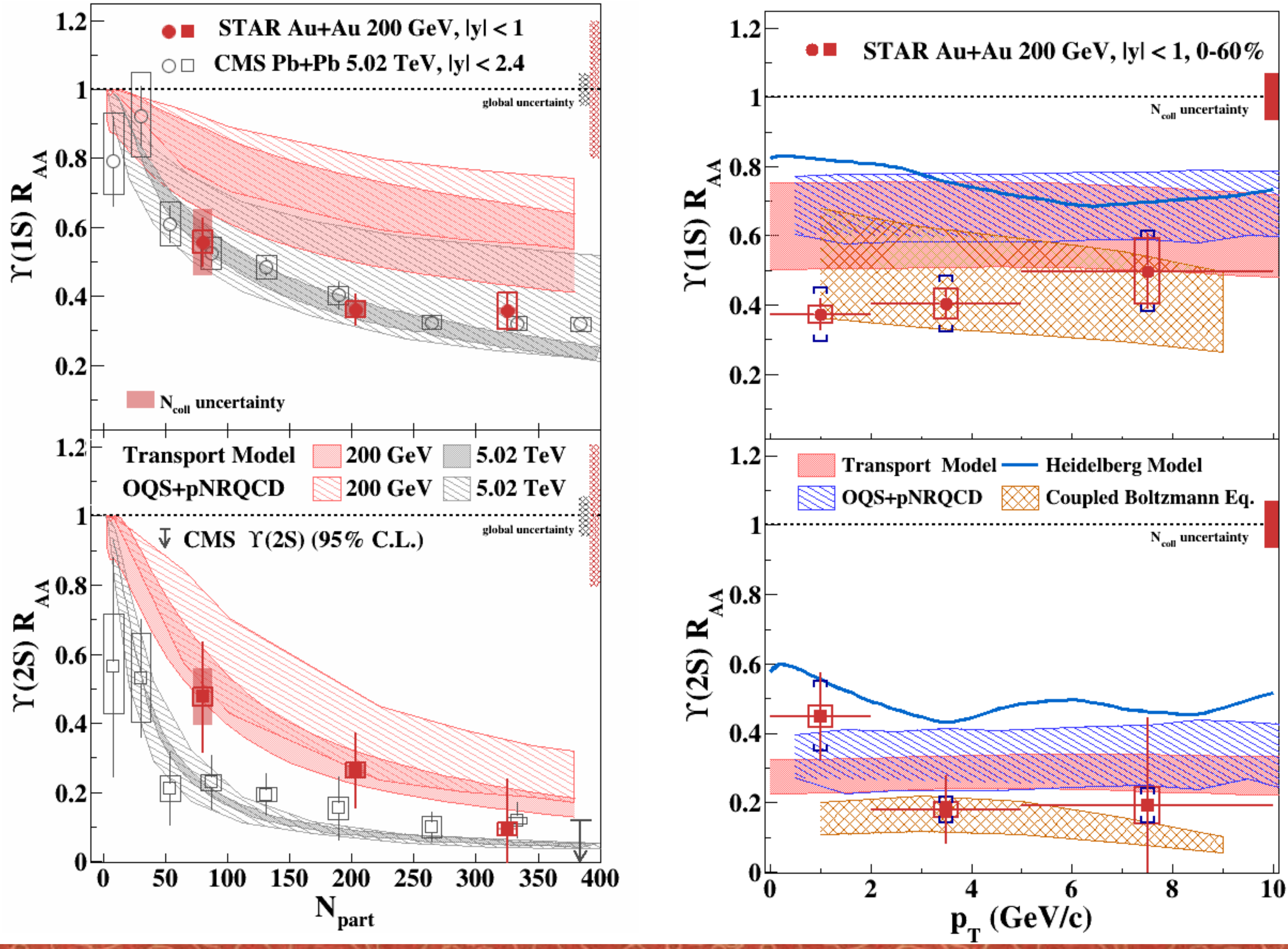
- No significant p_T dependence is observed



Comparison with models

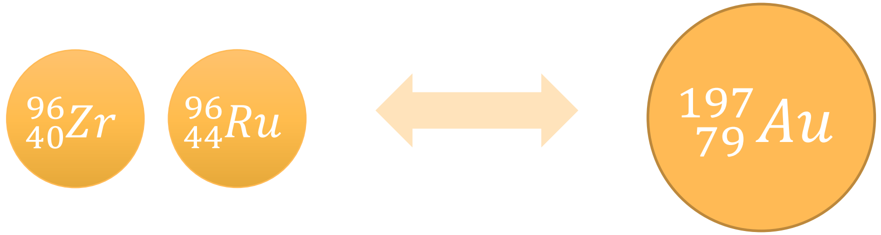
For both Υ(1S) and Υ(2S), model calculations are consistent with data within the uncertainties, except the Heidelberg Model that overshoots the data. Coupled Boltzmann equations contains CNM effects as well.

- **OQS+pNRQCD**: regeneration+feed-down
- **Transport model**: dissociation+regeneration + feed-down + CNM
- **Coupled Boltzmann equations:** dissociation+regeneration+elastic and inelastic scatterings.
- **Heidelberg model**: gluon-induced dissociation+feed-down.

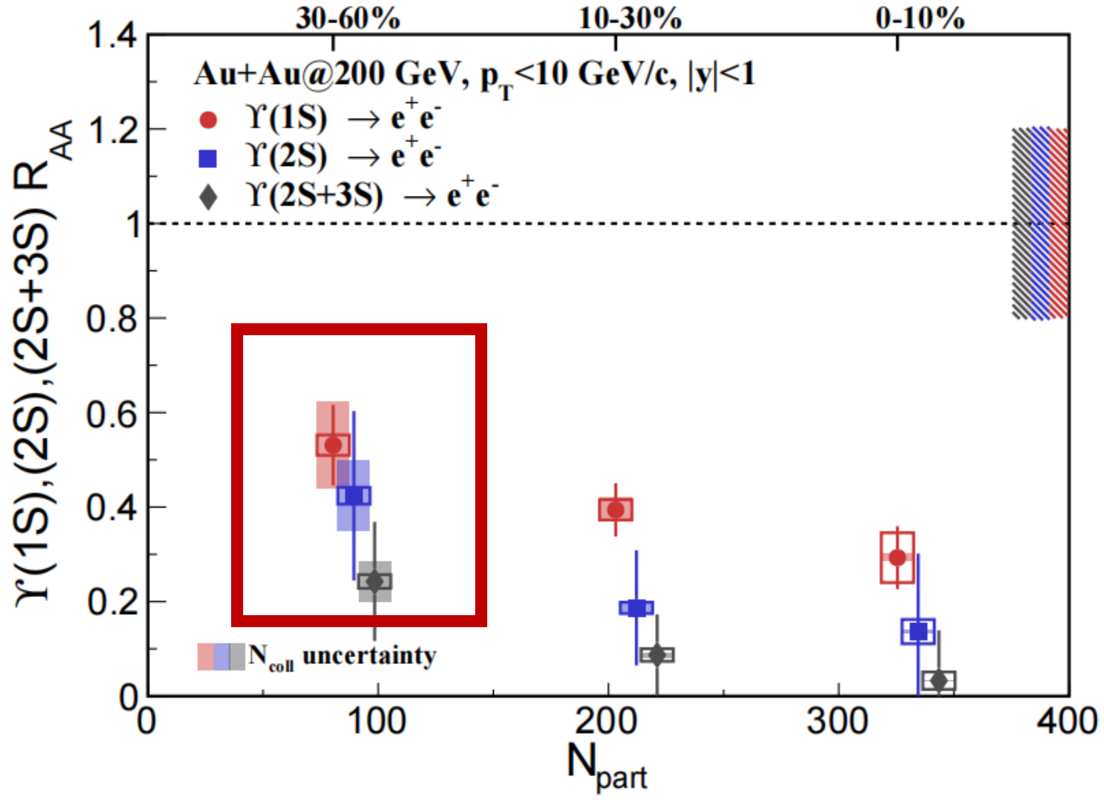


ϒ measurement in isobar collision

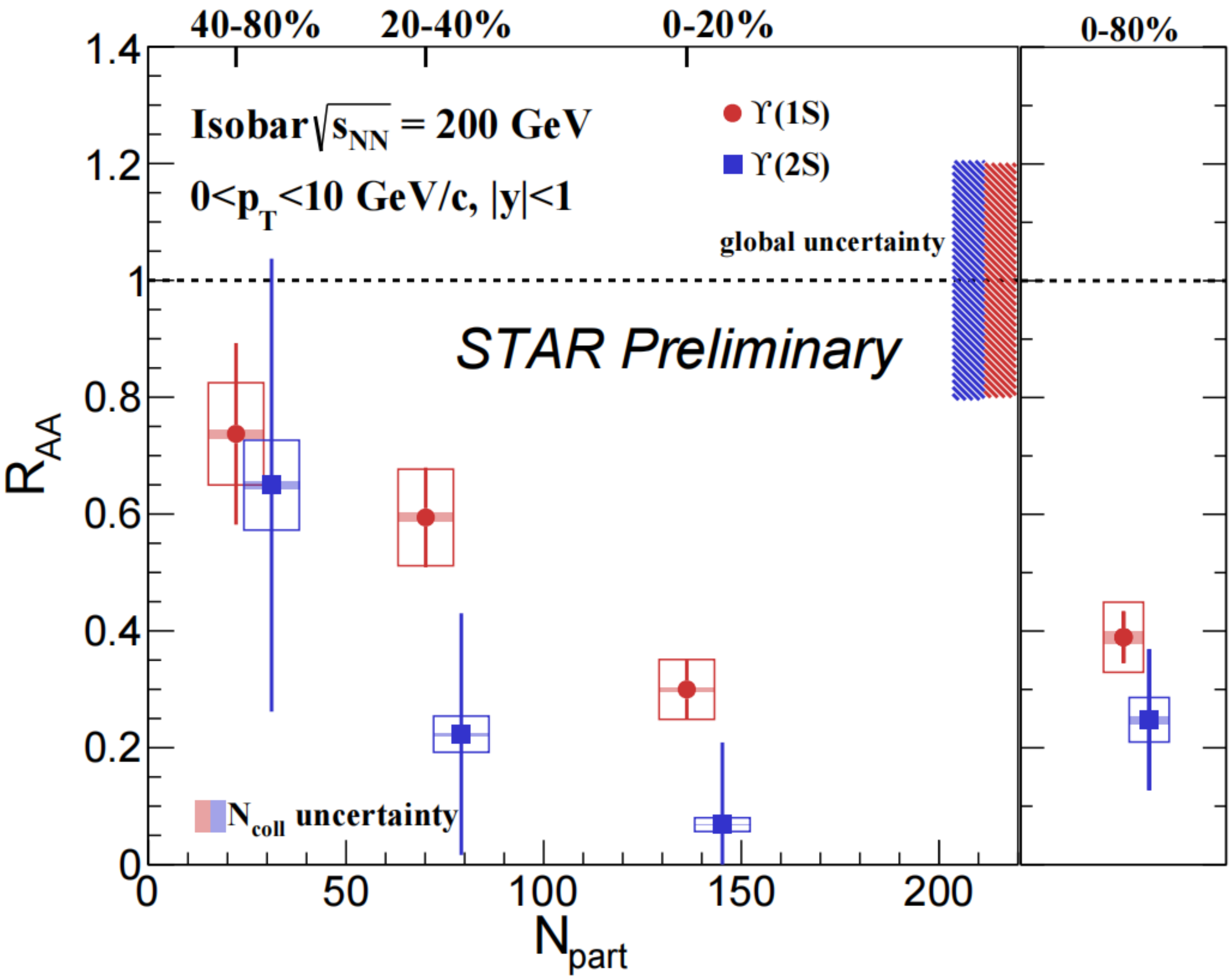
Compare to Au+Au, isobar ($^{96}_{40}Zr$+$^{96}_{40}Zr$ & $^{96}_{44}Ru$+$^{96}_{44}Ru$) systems are relatively small



	Au+Au	Ru+Ru	Zr+Zr
Centrality	30-60%	0-80%	0-80%
<N_{coll}>	132.9	116.2	111.9

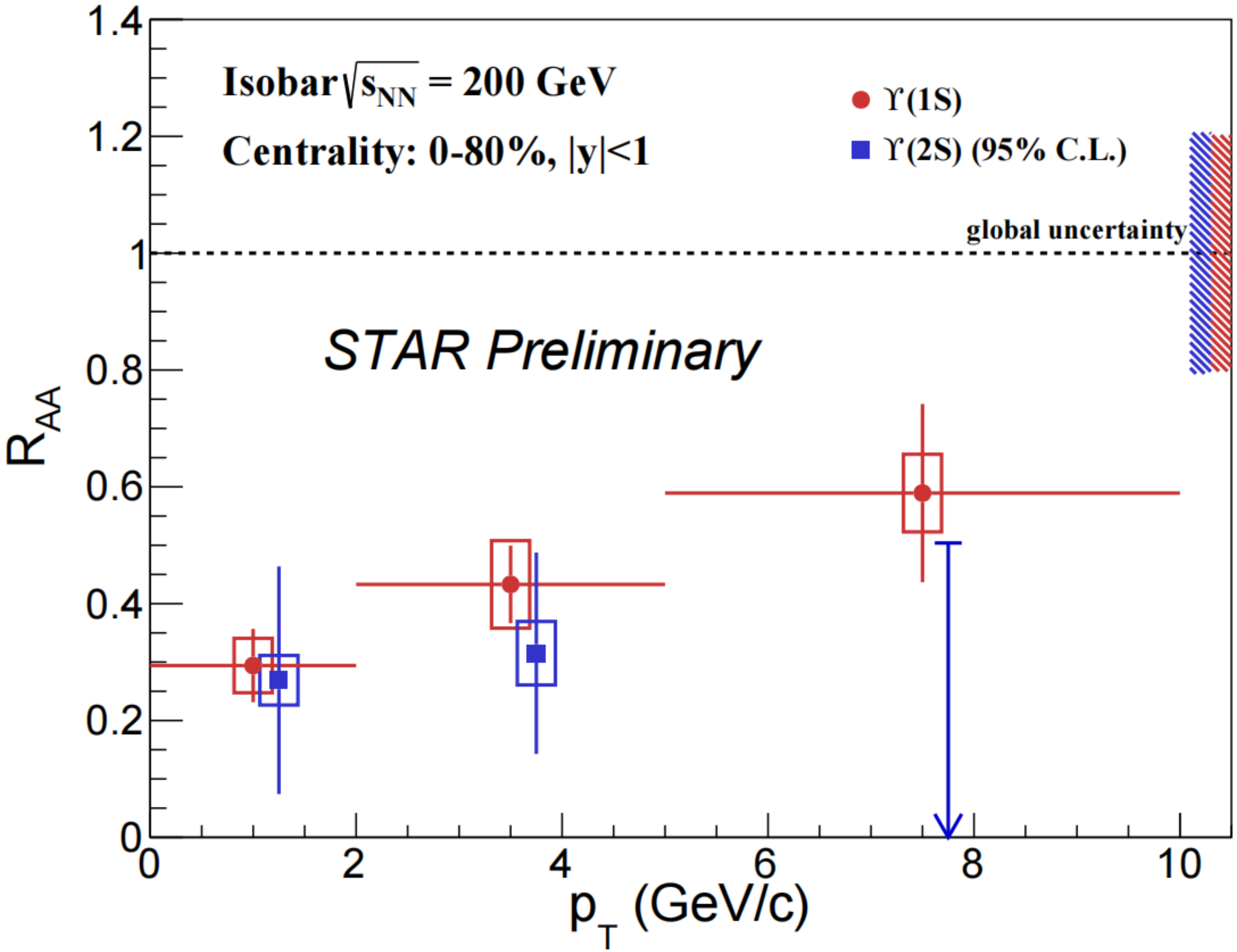


R_{AA} of isobar collisions as a function of centrality



- Significant suppression in 0-80% centrality observed
- Suppression gradually increase towards central collisions
- Hint of sequential suppression pattern

R_{AA} of isobar collisions as a function of p_T



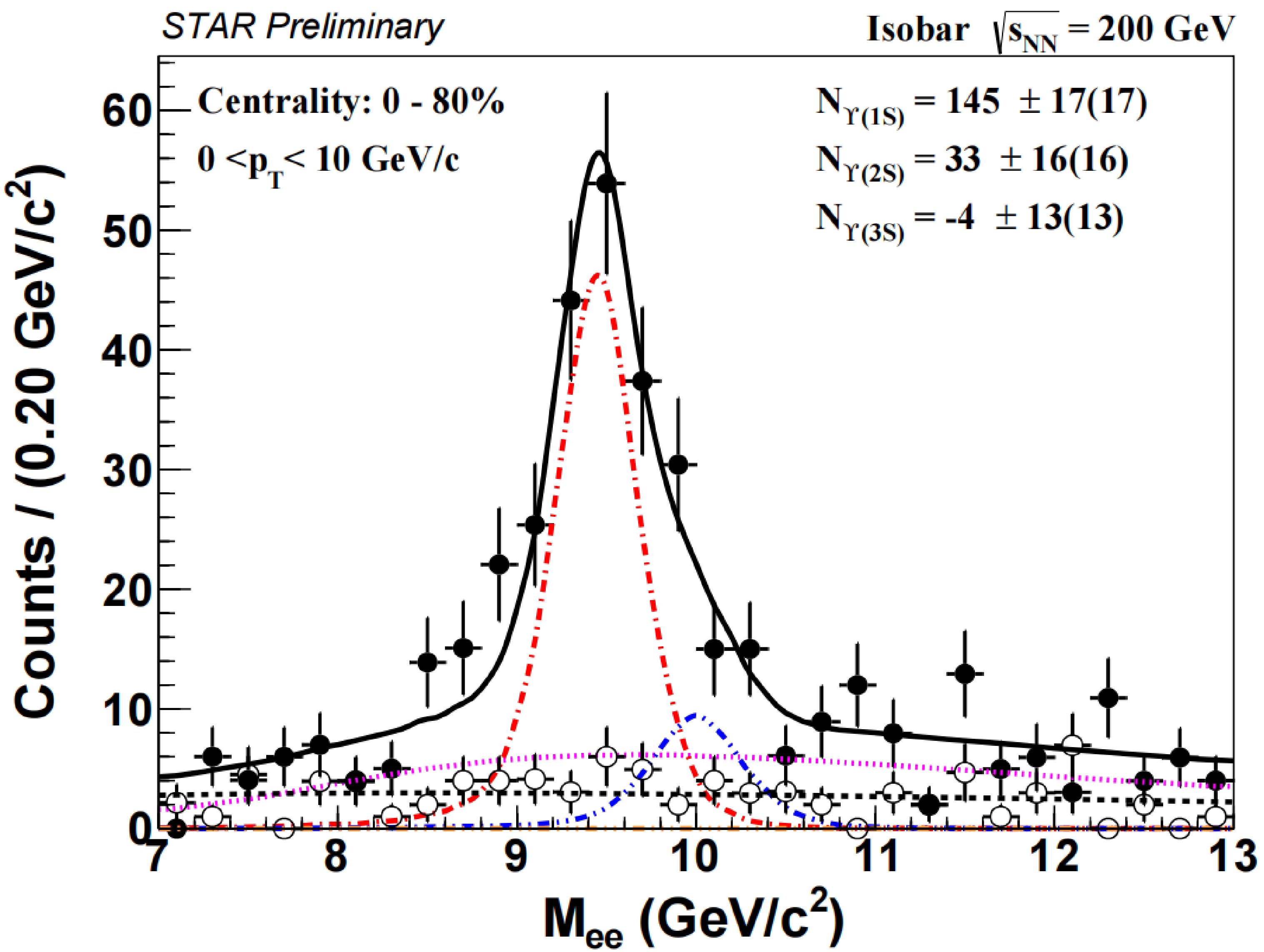
No significant p_T dependence

Summary

- Sequential suppression pattern is measured separately in Au+Au and isobar collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV
  - Υ(1S) has a similar magnitude of suppression as observed in LHC Pb+Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV
  - No significant species dependence at the same <N_part>, suppression driven by system size (<N_part>)
- No signficant p_{T} dependence is observed
- Different model calculations consistent(Coupled Boltzmann eq is also consistent) with data within the uncertainties

Back Up

Signal extraction in isobar collisions



Analyzed bin	$\Upsilon(1S)$	$\Upsilon(2S)$
0-80%	146.4 ±16.6	32.8 ±16.0
40-80%	37.1 ± 7.8	11.5 ± 6.9
20-40%	84.6 ± 12.2	11.2 ± 10.4
0-20%	73.7 ± 12.4	5.9 ± 12.2
0-2 GeV / c	46.0 ± 9.8	12.9 ± 9.4
2-5 GeV / c	75.2 ± 11.5	20.6 ± 11.2
5-10 GeV / c	25.6 ± 6.6	8.7(95% C. L)

- Unbinned maximum-likelihood simultaneous fit to unlike-sign and like-sign mass distribution.
- Template of each ϒ stats - embedding sample
- Residual background (dotted line) - pythia
- Combinatorial Background (dashed line) fitting by exponential function