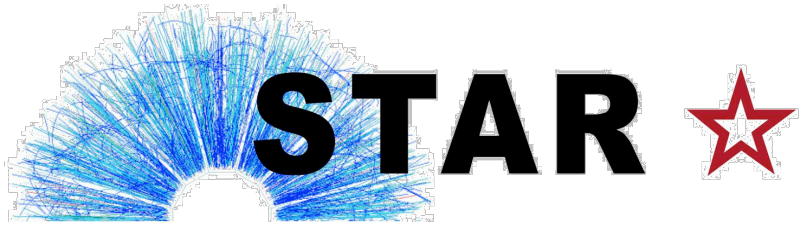


Υ measurements in p+p, p+Au and Au+Au collisions from the STAR experiment

Zaochen Ye for the STAR Collaboration

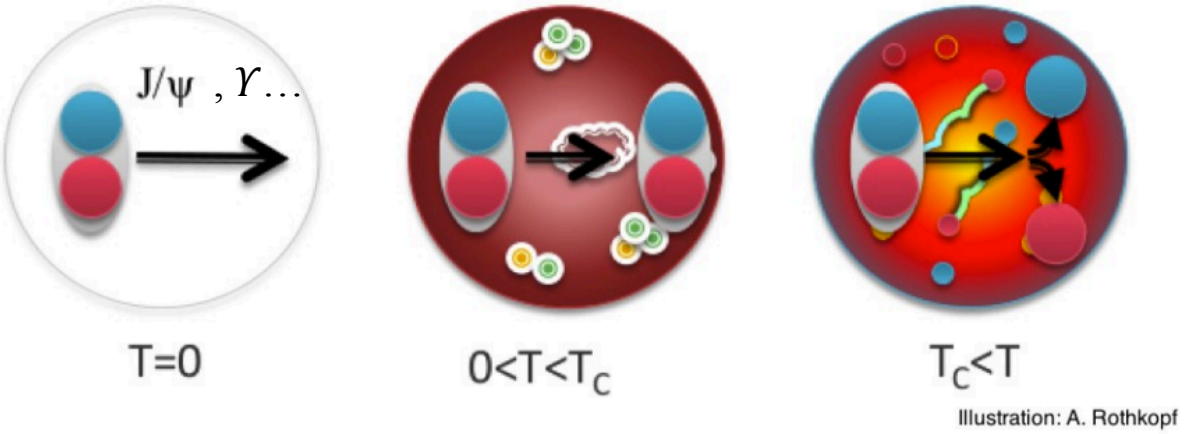
University of Illinois at Chicago

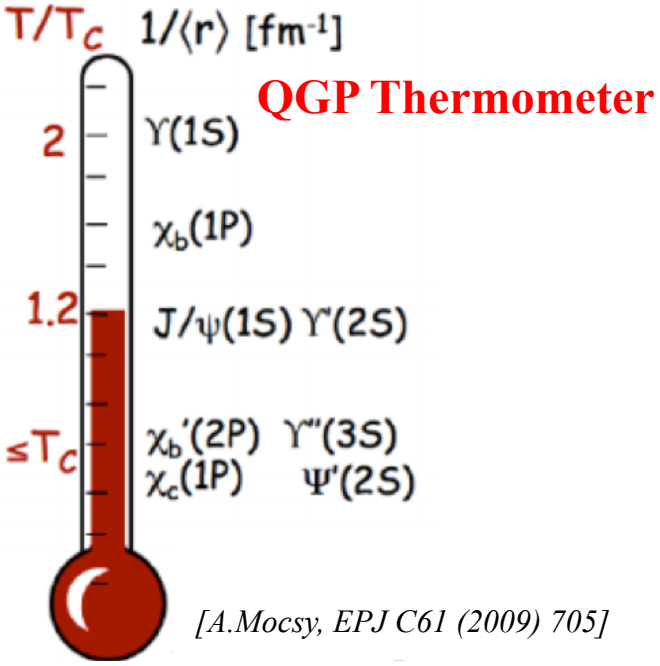
U.S. DEPARTMENT OF ENERGY | Office of Science

Outline

- **Quarkonium as a probe of QGP**
- **STAR experiment**
- **New Υ measurements at STAR in different systems:**
  - **p+p 200 and 500 GeV**
  - **p+Au 200 GeV**
  - **Au+Au 200 GeV**
- **Comparison with LHC results and model calculations**
- **Summary and outlook**

Quarkonia as a thermometer for QGP





Quarkonia melt in QGP due to color screening effect

--------- *T.Matsui and H. Satz (1986)*

Bottomonia, compared to charmonia at RHIC:

- Regeneration is negligible

  [A. Emerick, X. Zhao & R. Rapp EPJ A48 (2012) 72]

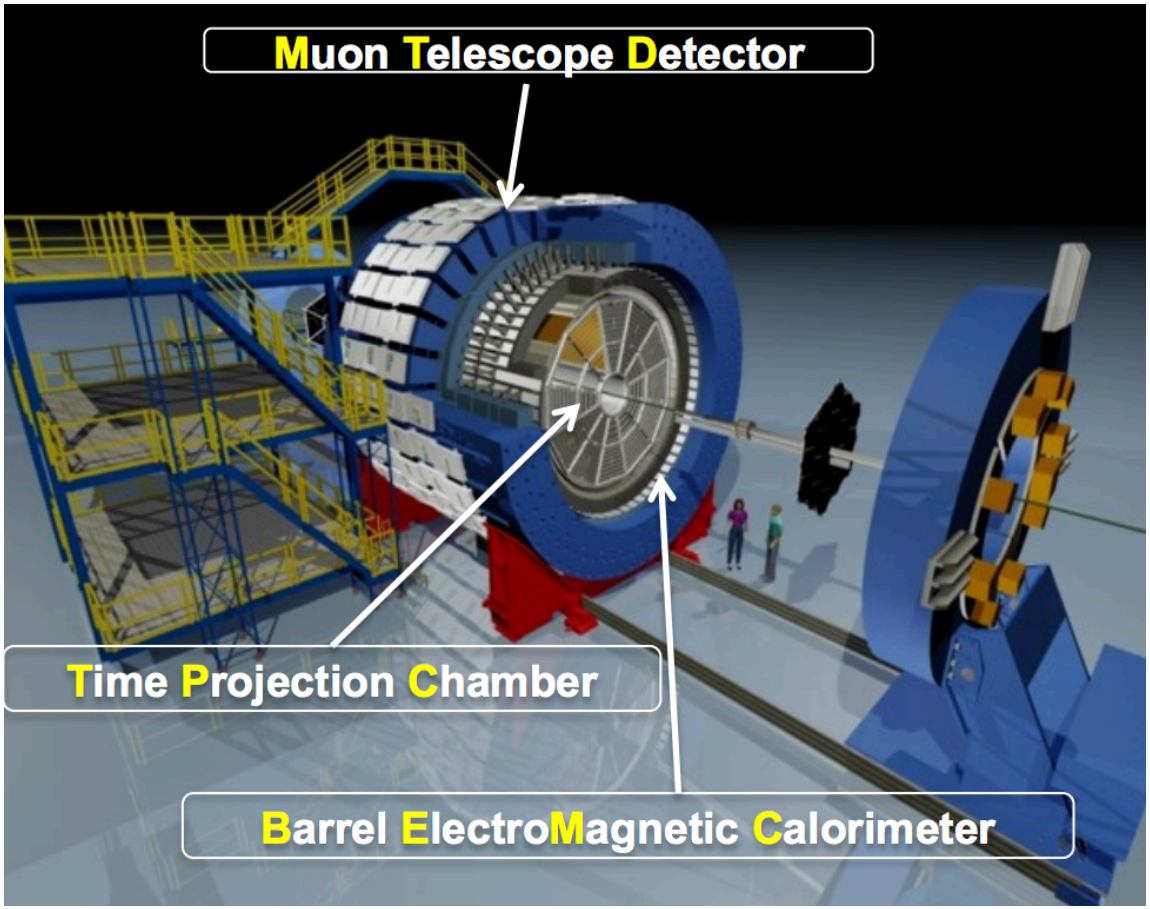
- Co-mover absorption is negligible

  [Lin & Ko, PLB 503 (2001) 104]

→ a cleaner probe

The Solenoidal Tracker At RHIC (STAR)

- Mid-rapidity detector: $|\eta| < 1$, $0 < \varphi < 2\pi$



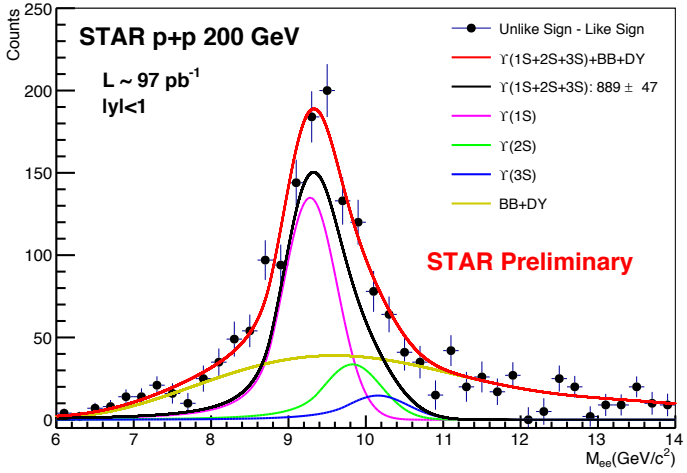
- **TPC**
  - Tracking, momentum
  - dE/dx
- **BEMC**

  Trigger on and identify electrons
  - p/E
- **MTD** ($|\eta|<0.5$, φ~45%)

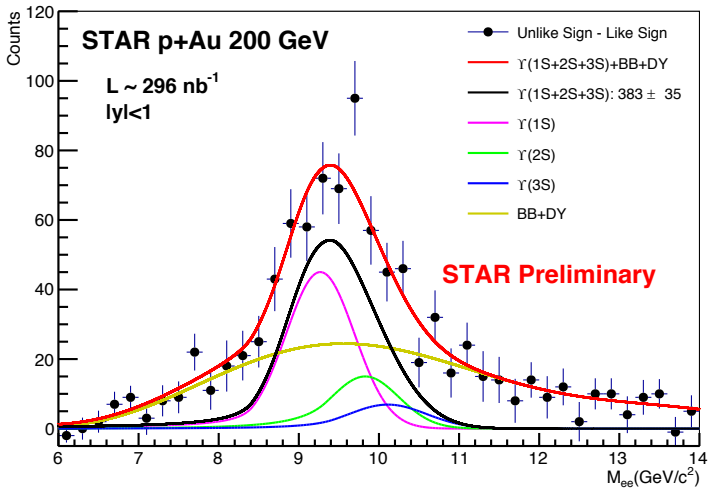
  Trigger on and identify muons
  - **Precise timing (~100 ps)**
  - Spatial resolution (~1 cm)
  - Dimuon trigger for quarkonia
  - **Less Bremsstrahlung**

Υ signals in p+p and p+Au collisions

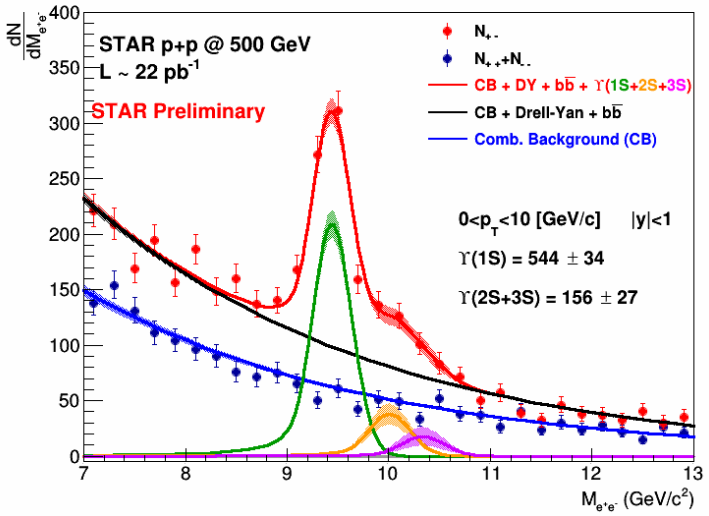
Υ signal in 2015 p+p 200 GeV



Υ signal in 2015 p+Au 200 GeV



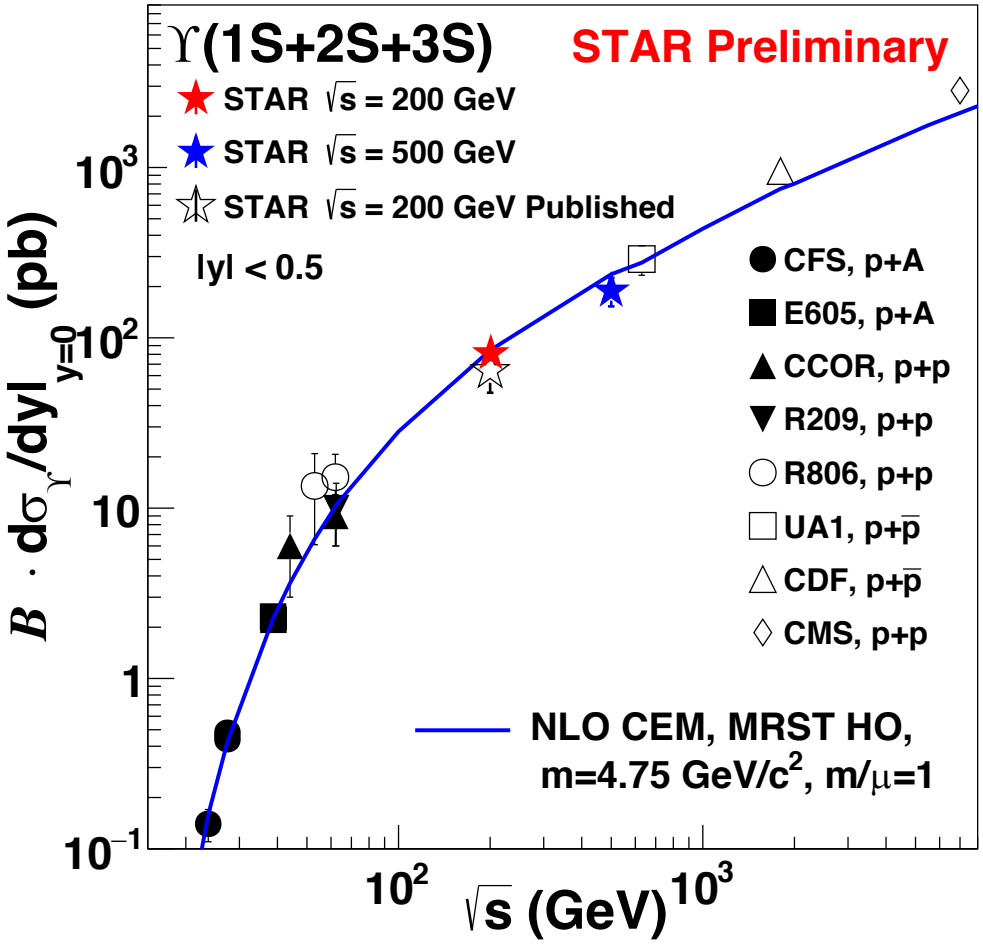
Υ signal in 2011 p+p 500 GeV



Datasets (dielectron):

- 2011 p+p 500 GeV (~20 pb^{-1})
- 2015 p+p 200 GeV (~100 pb^{-1})
- 2015 p+Au 200 GeV (~300 nb^{-1})

Υ in p+p collisions at 200 and 500 GeV



- STAR published (|y|<0.5)
  - 2009 p+p 200 GeV:
    $\mathbf{64 \pm 10(stat) \pm 14(syst)}$ pb

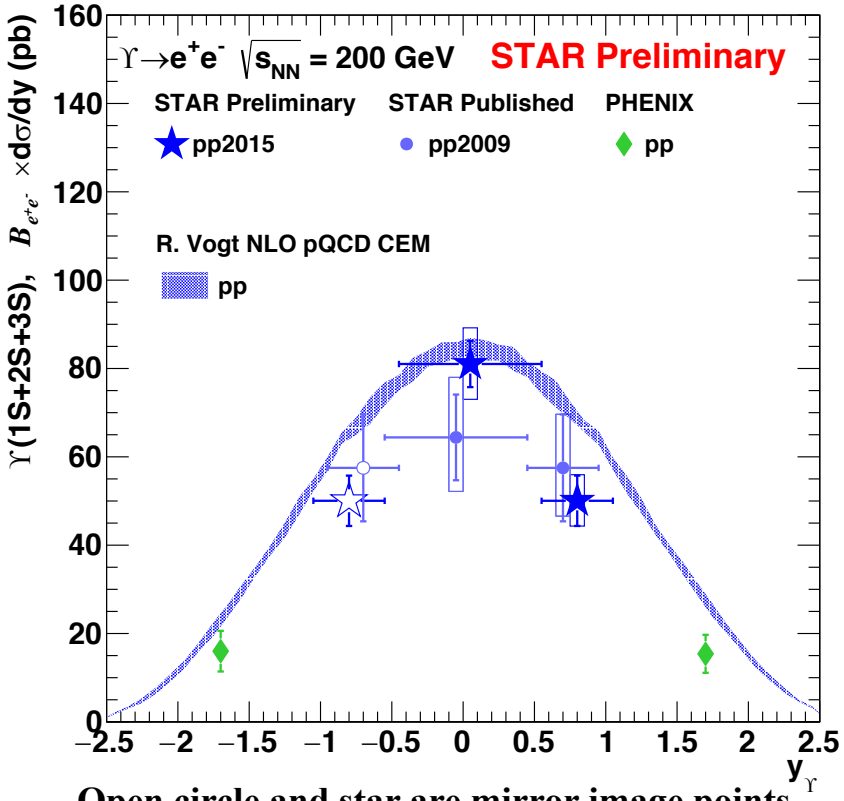
    STAR: PLB 735 (2014) 127

- New results (|y|<0.5)
  - 2015 p+p 200 GeV:
    $\mathbf{81 \pm 5(stat) \pm 8(syst)}$ pb
  - 2011 p+p 500 GeV:
    $\mathbf{186 \pm 14(stat) \pm 33(syst)}$ pb

New measurements in p+p collisions at 200 and 500 GeV

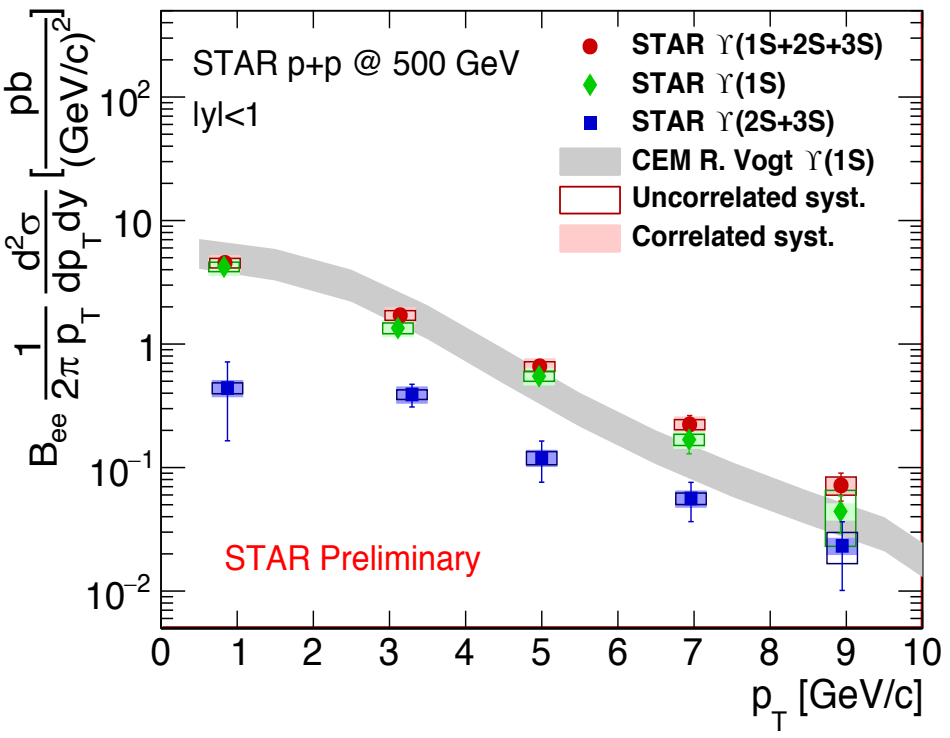
- **Follow world-wide data trend predicted by CEM**
- **Much improved p+p reference for p+Au and Au+Au studies**

Υ in p+p collisions at 200 and 500 GeV



Open circle and star are mirror image points

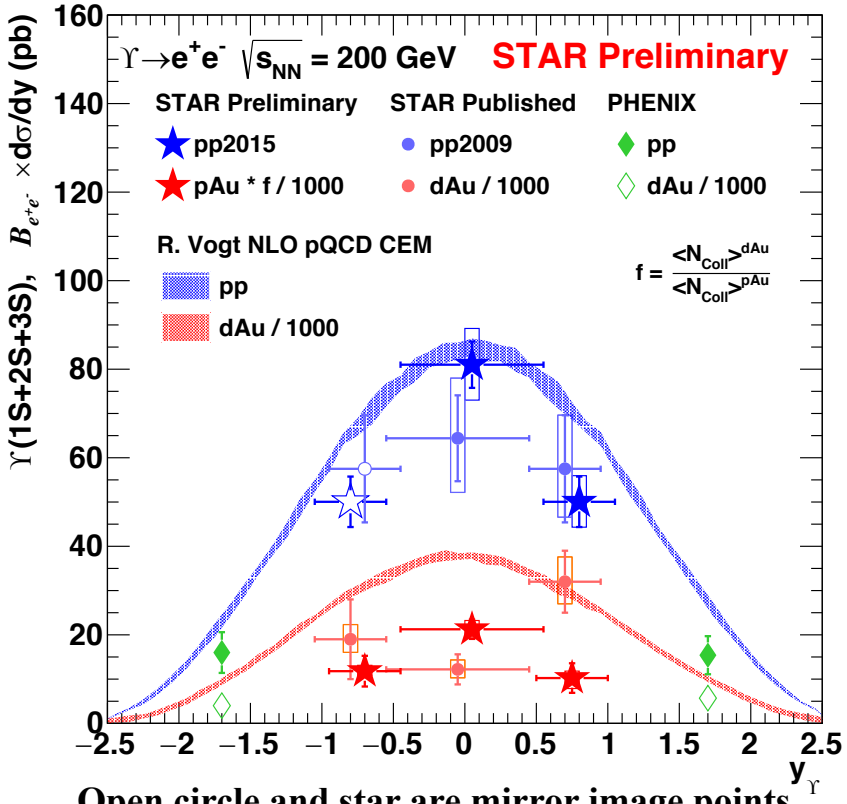
[STAR: PLB 735 (2014) 127]
[PHENIX: PRC 87 (2013) 044909]



[R. Vogt, PRC 92 (2015) 034909]

- **p+p 200 GeV: narrower rapidity distribution than NLO CEM calculation**
- **p+p 500 GeV: Υ(1S) p_T spectrum consistent with NLO CEM calculation**

Υ in p+p and p+Au collisions at 200 GeV



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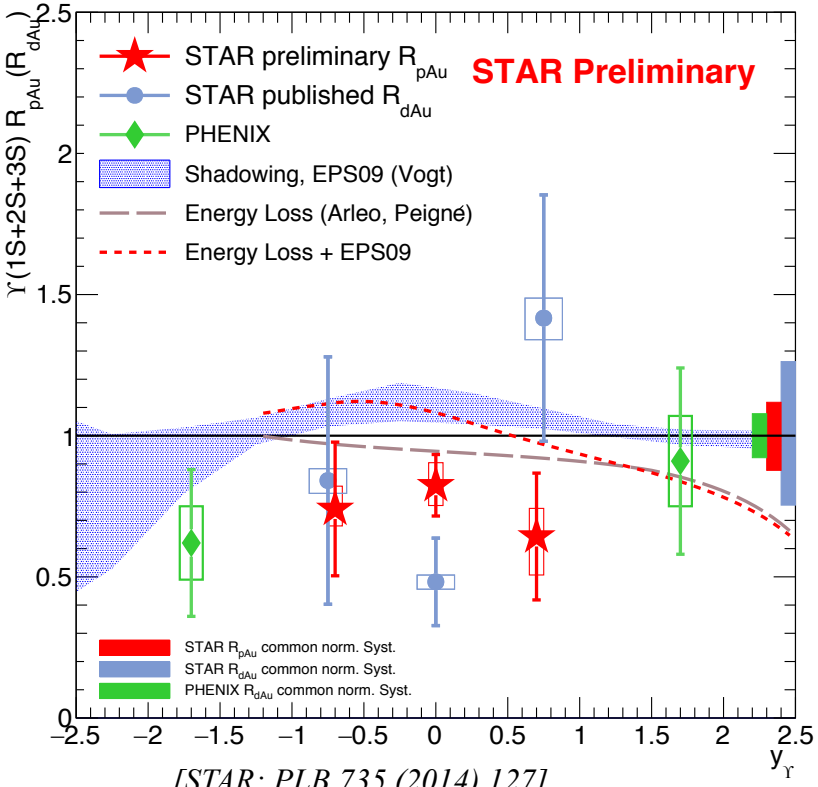
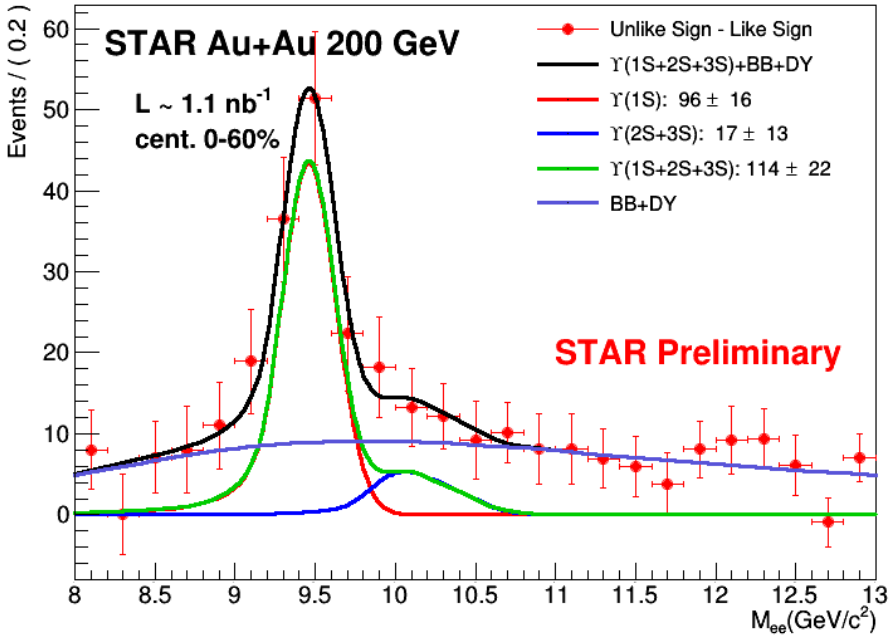


[STAR: PLB 735 (2014) 127]
[PHENIX: PRC 87 (2013) 044909]

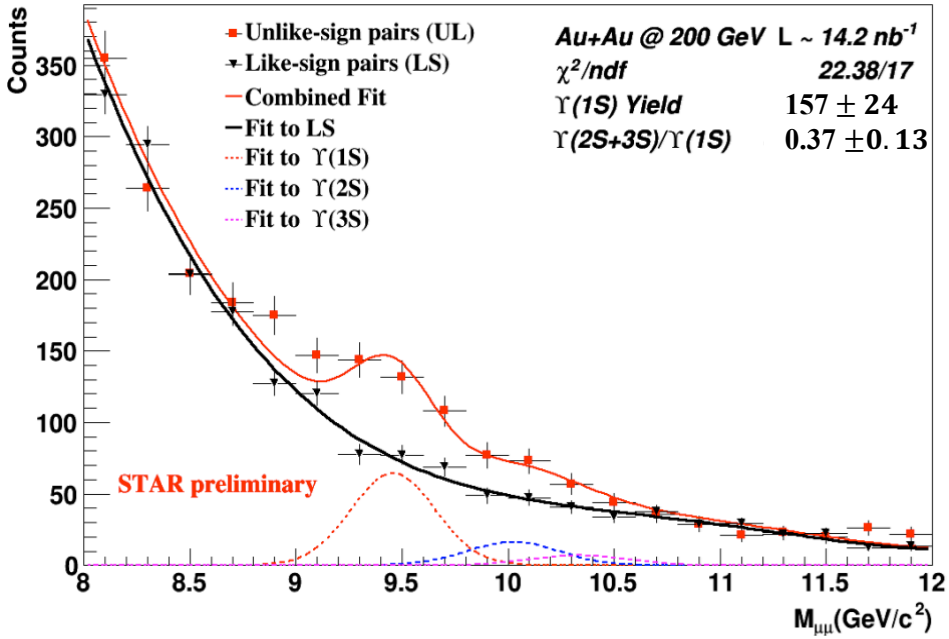
- **Indication of Υ(1S+2S+3S) suppression in p+Au collisions:**
  - **R_{pAu} (|y|<0.5): $0.82 \pm 0.10\ (stat)\ ^{-0.07}_{+0.08}\ (syst) \pm 0.10\ (global)$**
- **The new R_{pAu} has a much better precision than the published R_{dAu}**
  - **R_{dAu} (|y|<0.5): $0.48 \pm 0.15\ (stat) \pm 0.02\ (syst)\ ^{-0.12}_{+0.13}$ (global)**

Υ signals in Au+Au collisions

$\Upsilon \rightarrow e^+e^-$ in 2011 Au+Au



$\Upsilon \rightarrow \mu^+\mu^-$ in 2014 Au+Au

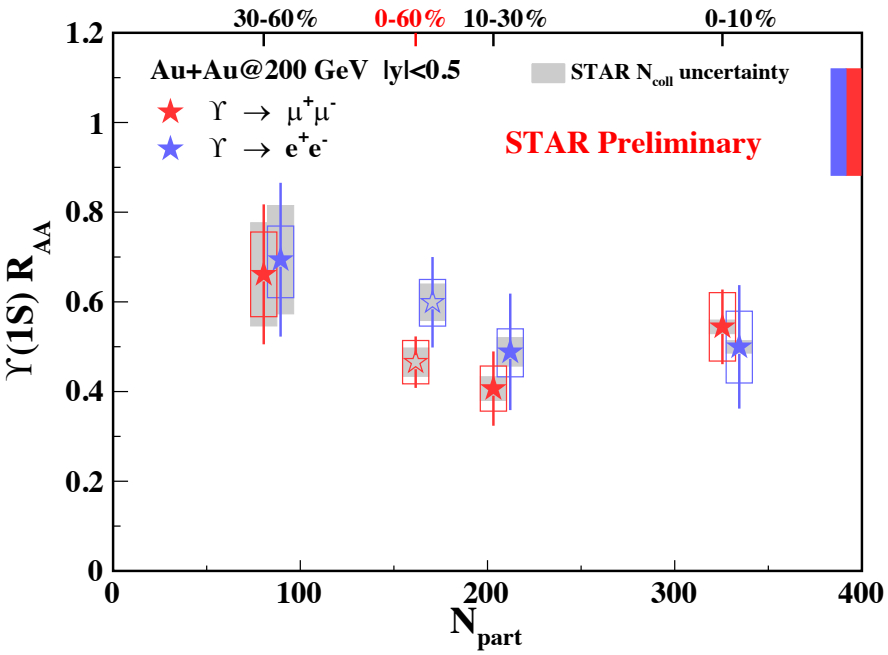


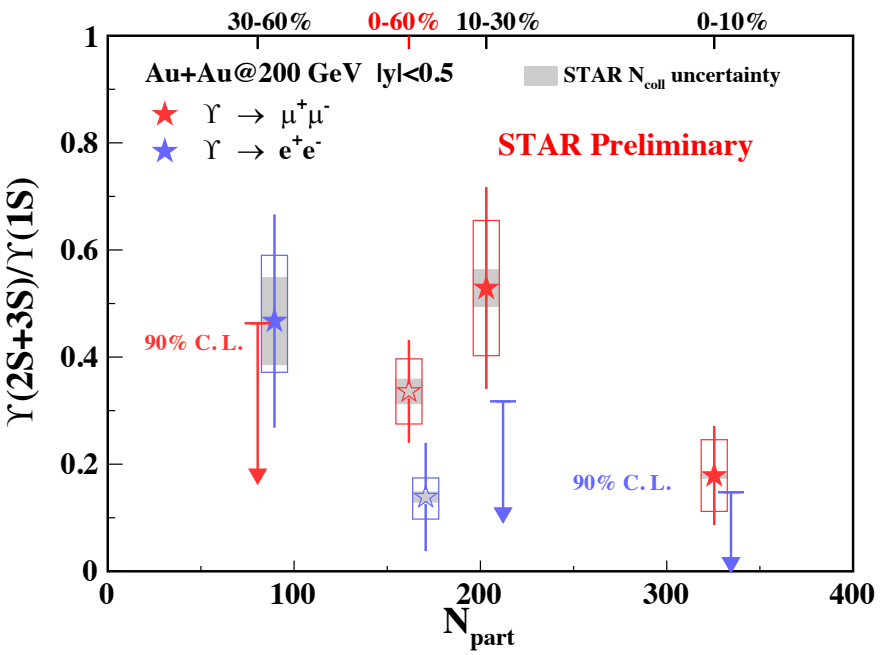
Details in Xinjie Huang's poster: board-D09

Datasets:

- 2011 Au+Au (dielectron) (~1.1 nb^{-1})
- 2014 Au+Au (dimuon) (~14 nb^{-1})

Results from dielectron and dimuon channels

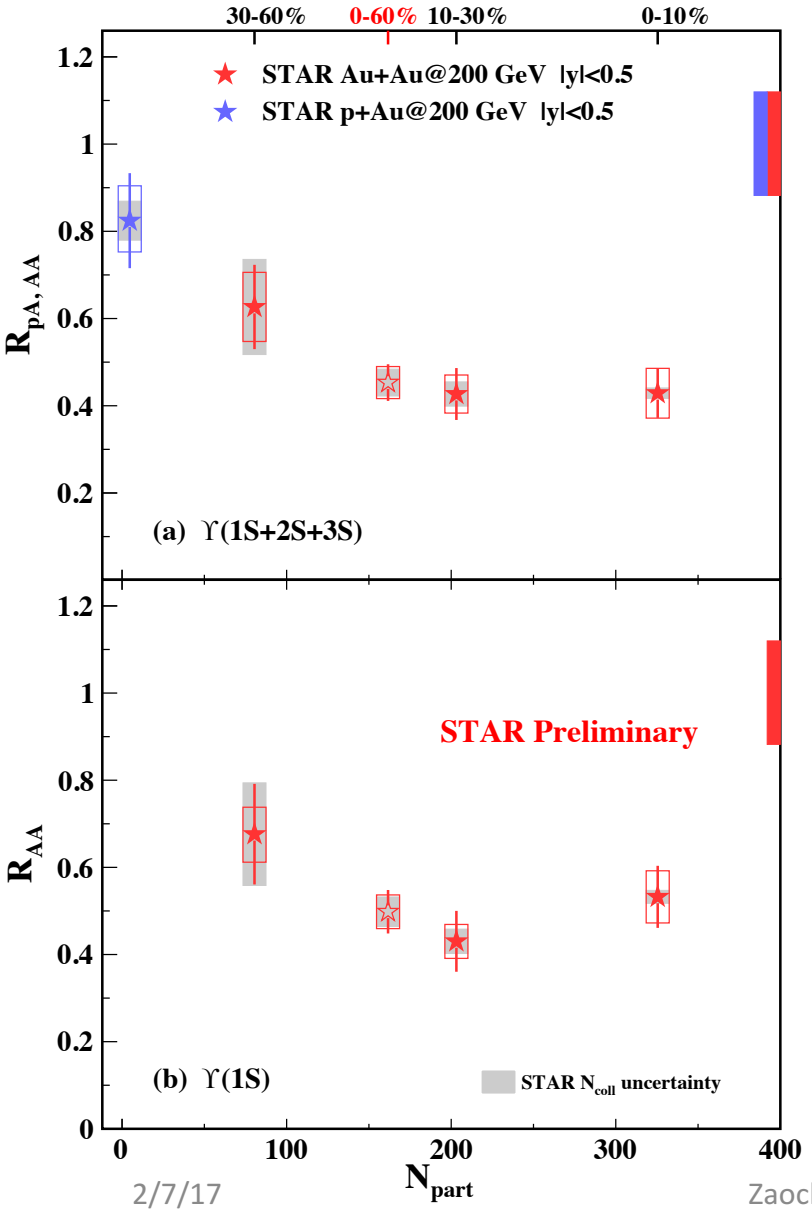




- **Consistent between the dielectron and dimuon channels**

→ Combination

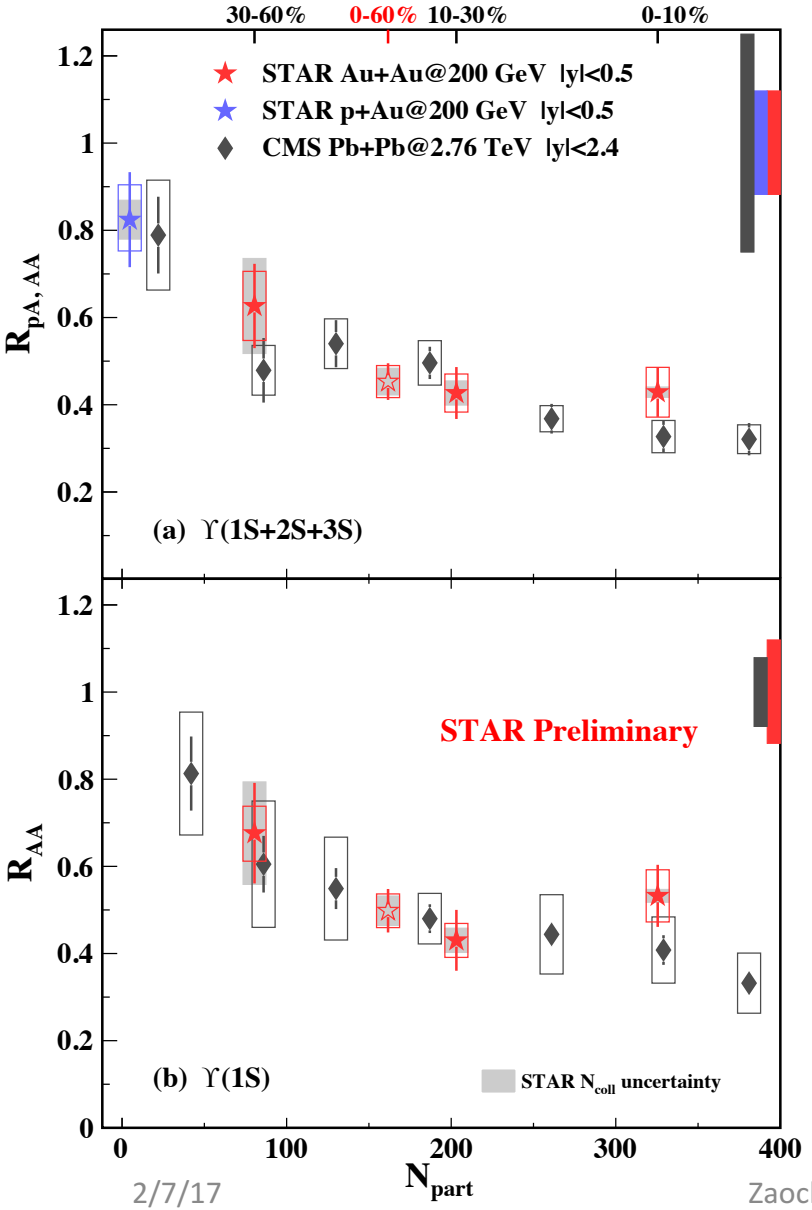
Υ suppression in Au+Au collisions – STAR combined



Υ(1S+2S+3S) and Υ(1S):

- Indication of more suppression towards more central collisions

Υ suppression in Au+Au collisions – STAR vs. CMS

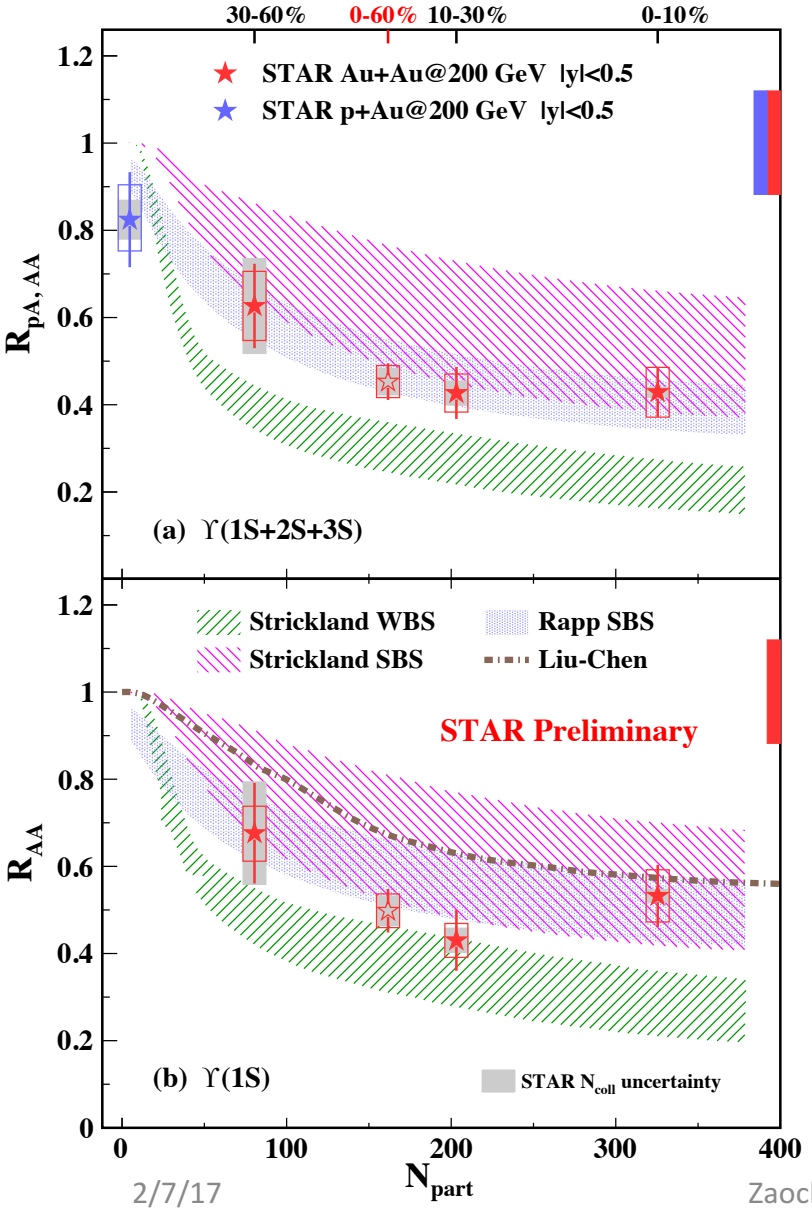


Υ(1S+2S+3S) and Υ(1S):

- Indication of more suppression towards more central collisions
- Similar suppression at RHIC and LHC

[CMS: arXiv:1611.01510]
[CMS: PRL 109 (2012) 222301]

Υ suppression in Au+Au collisions – STAR vs. model



Υ(1S+2S+3S) and Υ(1S):

- **Indication of more suppression towards more central collisions**
- **Similar suppression at RHIC and LHC**
- **Data favor the Strongly Binding Scenario (SBS) model**

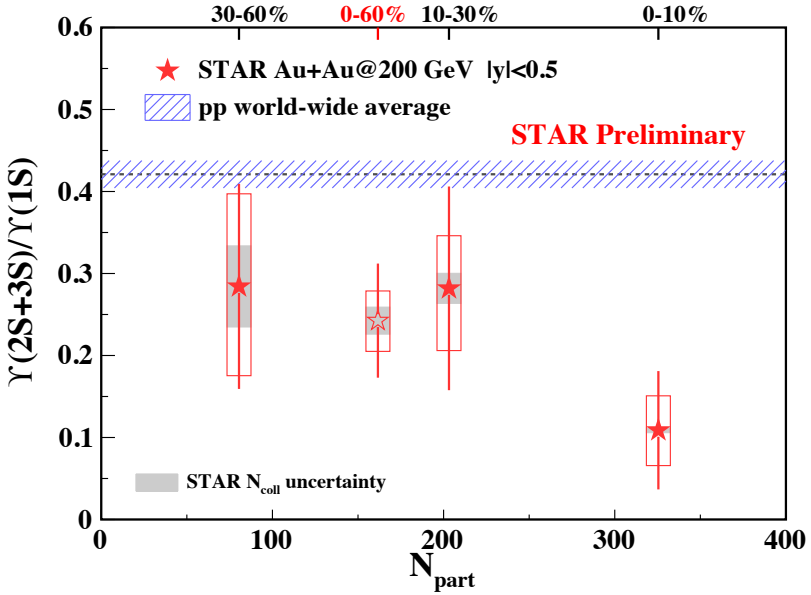
Models without CNM effects:

- **Strickland, Bazov:** *[NPA 879 (2012) 25]*
  - Hydro-dynamically expanding fire ball
  - Feed down included
  - **WBS** : free energy as heavy quark potential
  - **SBS** : internal energy as heavy quark potential
- **Liu, Chen, Xu, Zhuang** *[PLB 697 (2011) 32]*
  - Feed down included
  - Only excited states could dissociate

Model with CNM effects:

- **Emerick, Zhao, Rapp SBS model:** *[EPJ A48 (2012) 72]*
  - Modified nPDFs
  - Absorption cross−section: $\sigma_{(abs)}$ ~ 0-3 mb

Υ(2S+3S) in Au+Au collisions - Ratio

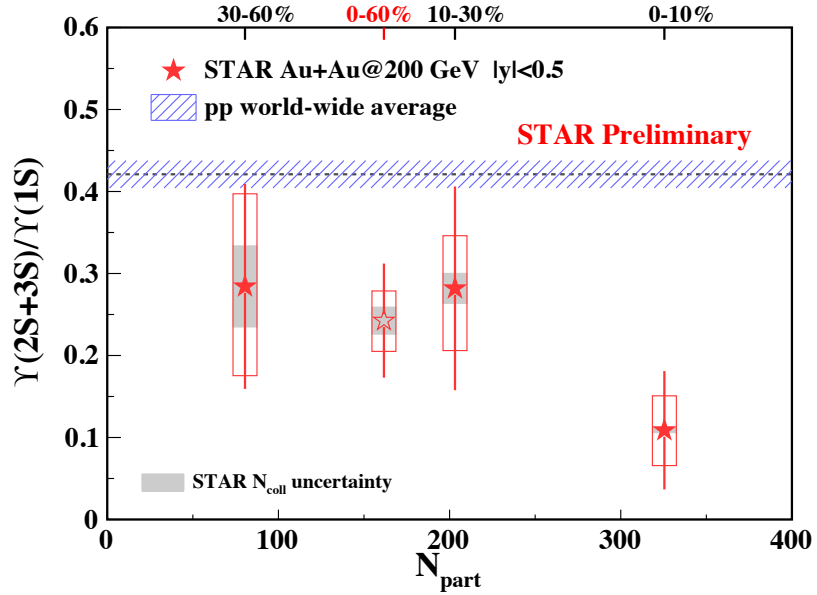


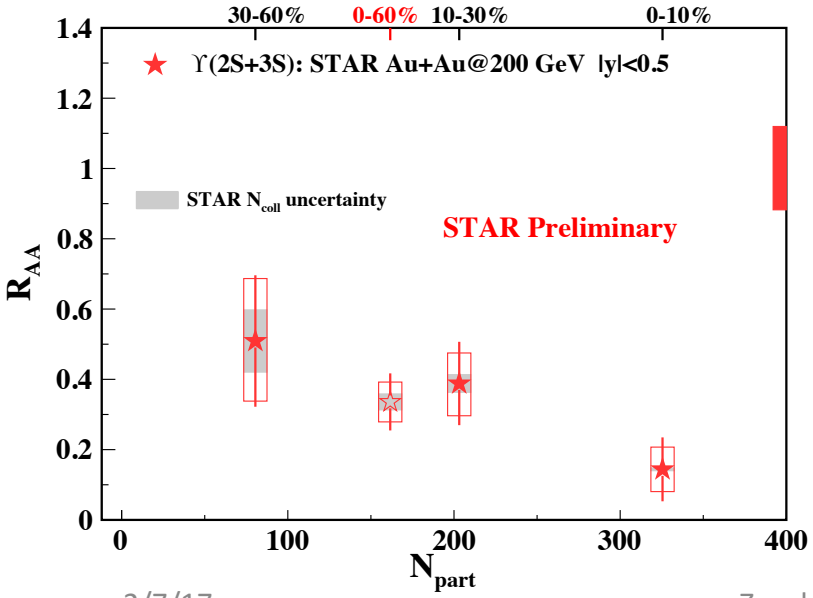
World-wide p+p: [W. Zha, et. al, PRC 88 (2013) 067901]

Υ(2S+3S)/Υ(1S):

- Υ(2S+3S) has stronger suppression than Υ(1S) in the 0-10% central collisions

Υ(2S+3S) in Au+Au collisions - R_{AA}





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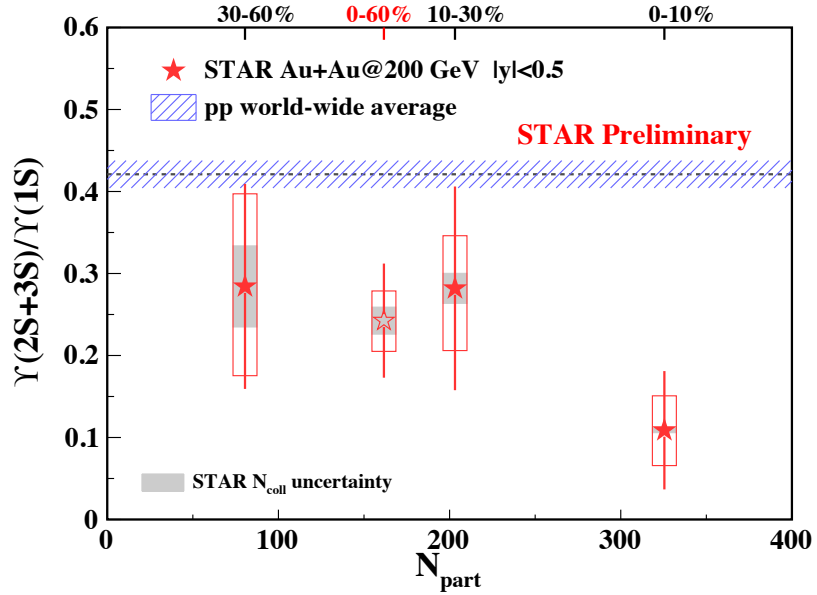
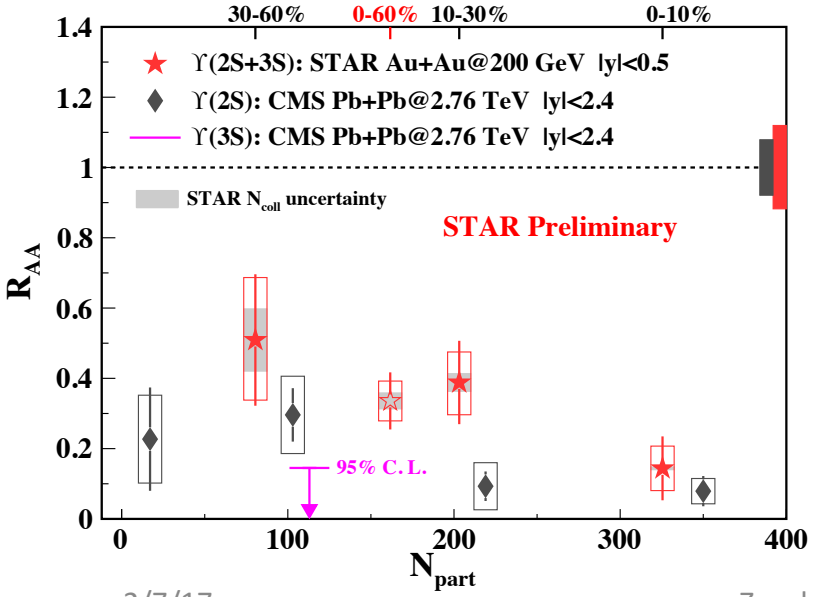
Υ(2S+3S) STAR:

- **Indication of stronger suppression towards more central collisions**

Υ(2S+3S) in Au+Au collisions - STAR vs. CMS





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Υ(2S+3S) STAR:

- Indication of stronger suppression towards more central collisions

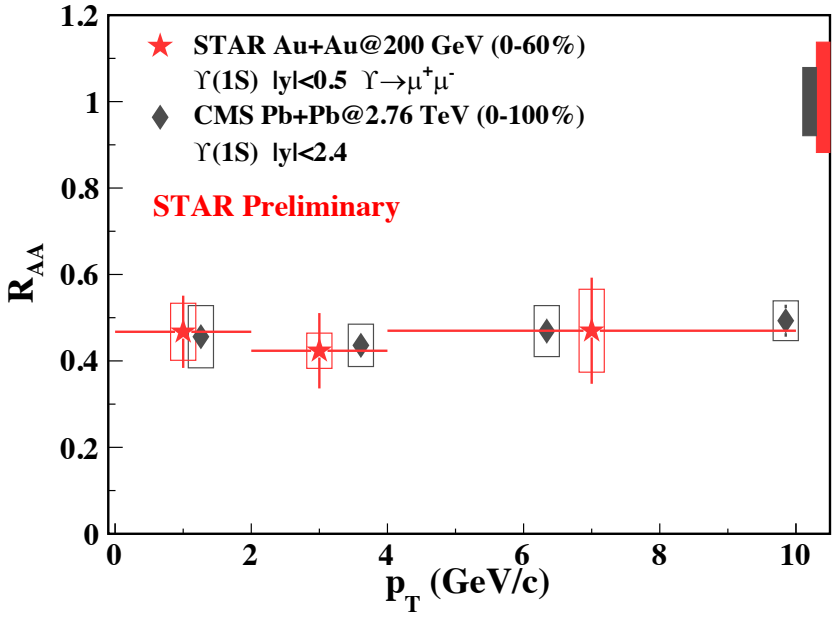
Υ(2S+3S) STAR vs. CMS:

- Hint of less suppression at RHIC than at LHC

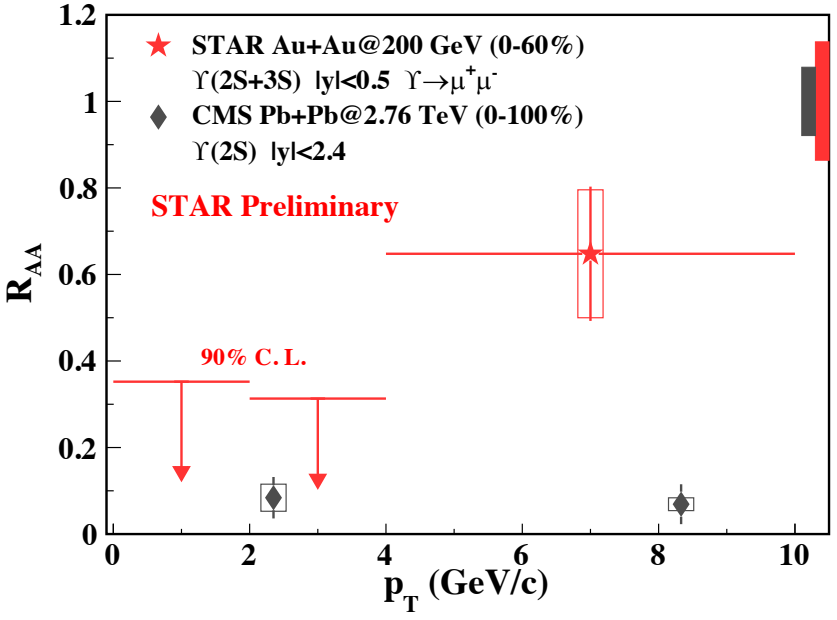
[CMS: arXiv:1611.01510]

Υ suppression vs. p_T via $\Upsilon \to \mu^+\mu^-$

Υ(1S)



Υ(2S+3S)



[CMS: arXiv:1611.01510]

Υ(1S) STAR:

- **Consistent with CMS measurement**

Υ(2S+3S) STAR:

- **Hint of less suppression towards high p_T at RHIC than at LHC**

Summary and outlook

- **p+p collisions:**
  - NLO CEM calculations describe total and p_T-differential cross-section but seem to over-estimate the width of the rapidity distribution

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  - Indication of Υ suppression → **CNM effects**

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- **Au+Au collisions:**
  - Υ(1S):
    - Similar suppression as LHC
    - Support **SBS** model calculations
  - Υ(2S+3S):
    - More suppressed than Υ(1S) in central collisions → **Sequential Melting**
    - Hint of less suppression at RHIC than at LHC

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- **Outlook**
  - **Two times Au+Au data on disk for both dielectron and dimuon channels**

THANK YOU !!!