Υ Production and Suppression in Heavy Ion Collisions at STAR

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Anthony Kesich
University of California, Davis
STAR Collaboration

Outline

- Motivation for measuring Upsilons
- The Solenoidal Tracker At RHIC and its triggers
- Υ production cross section in p+p
- Υ production in d+Au
- Υ Nuclear Modification Factor in Au+Au
- Suppression Models
- Conclusions

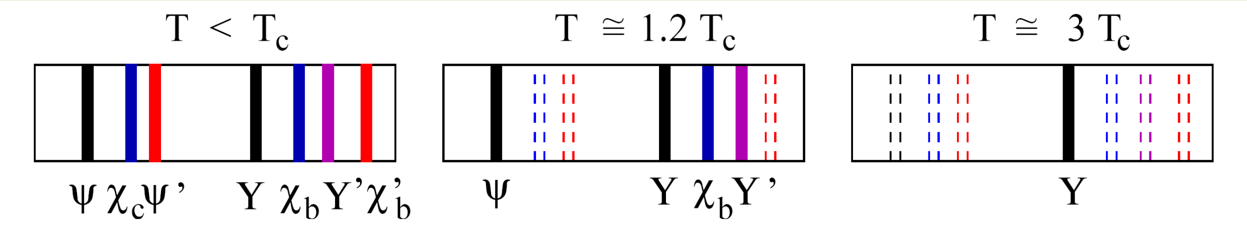
Goal: Quarkonia states in A+A

Charmonia: J/Ψ, Ψ', χ_c Bottomonia: ϒ(1S), ϒ(2S), ϒ(3S), χ_B

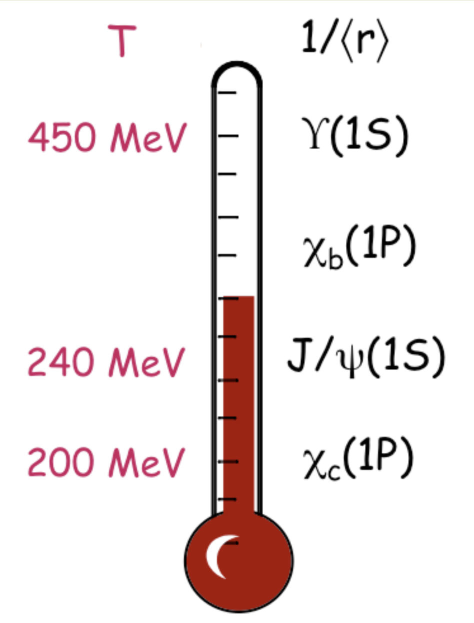
Key Idea: Quarkonia Melt in the plasma

- Color screening of static potential between heavy quarks
- Suppression of states is determined by T_C and their binding energy
- Lattice QCD: Evaluation of spectral functions ⇒ $T_{melting}$
- Originaly proposed by Matsui & Satz (1986)

When do states melt?



H. Satz, *HP06*

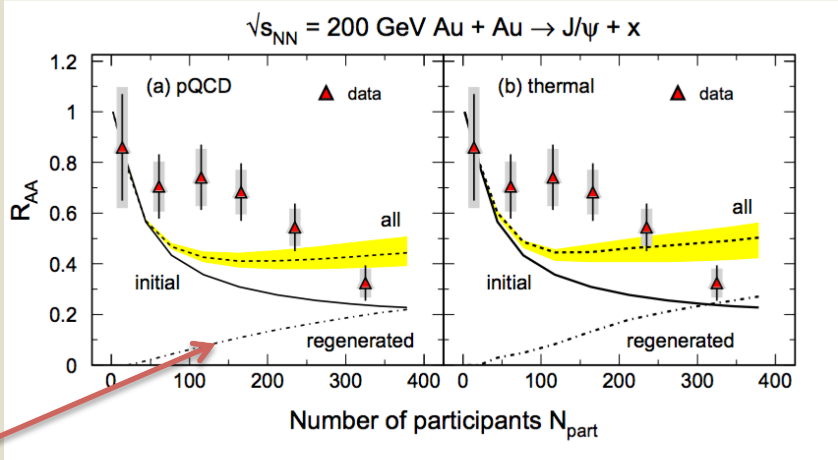


***A.Mocsy**, Summer Quarkonium Workshop, BNL, 2011*

Why do Υ at RHIC instead of J/Ψ?

- A cleaner probe compared to J/Ψ
  - co-mover absorption → negligible
  - recombination → negligible
    - $\sigma_{cc} = \sim 800\ \mu b$
    - $\sigma_{bb=} \sim 2 \mu b$

- Challenge: low rate, rare probe
  - Large acceptance detector
  - Efficient trigger



R. Rapp et al., arXiv:0807.2470 [hep-ph]
Data from: H. Pereira Da Costa [PHENIX Collaboration], Nucl. Phys. A 774 (2006) 747.

Regeneration of J/ψ!

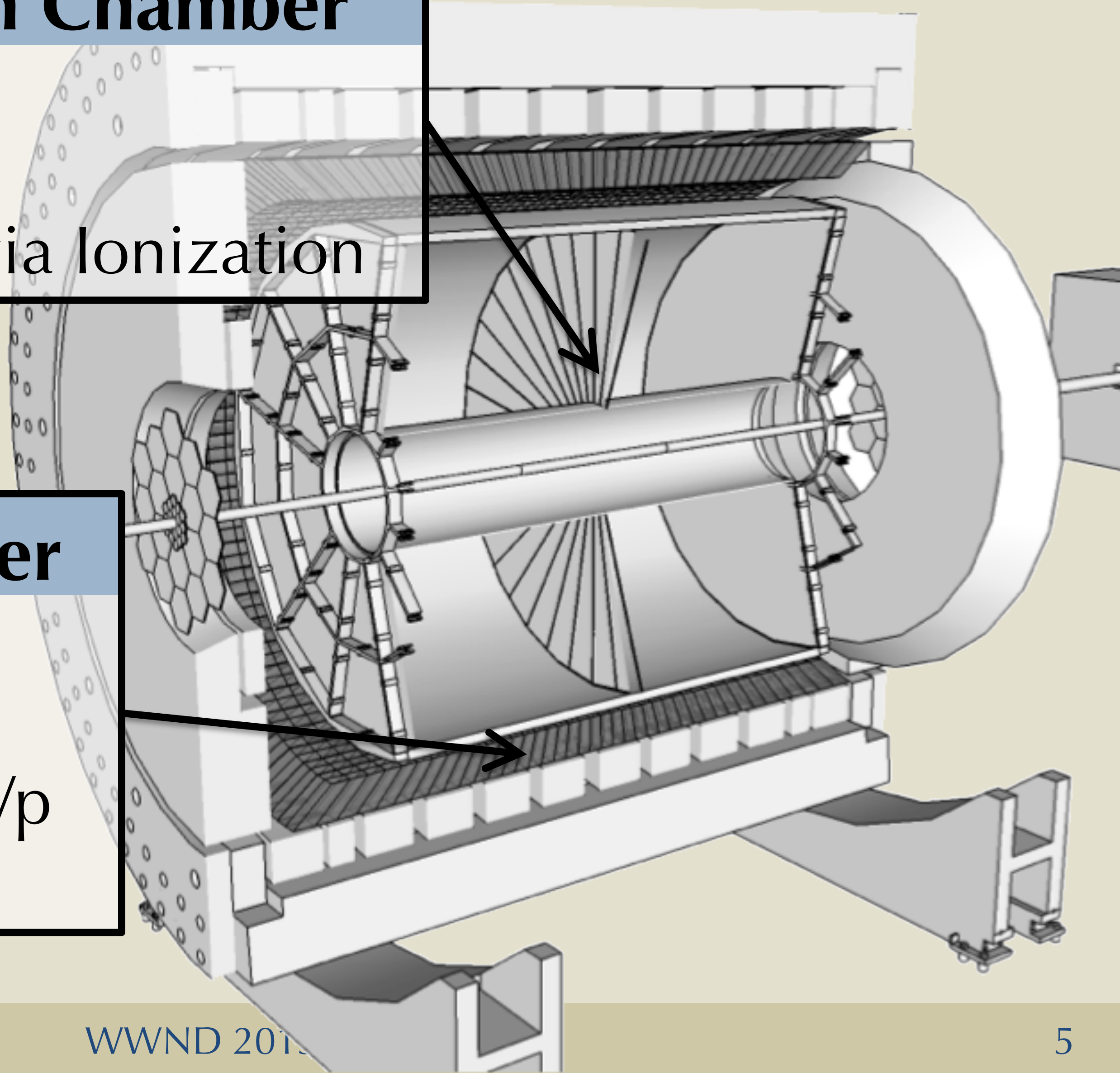
STAR

Time Projection Chamber

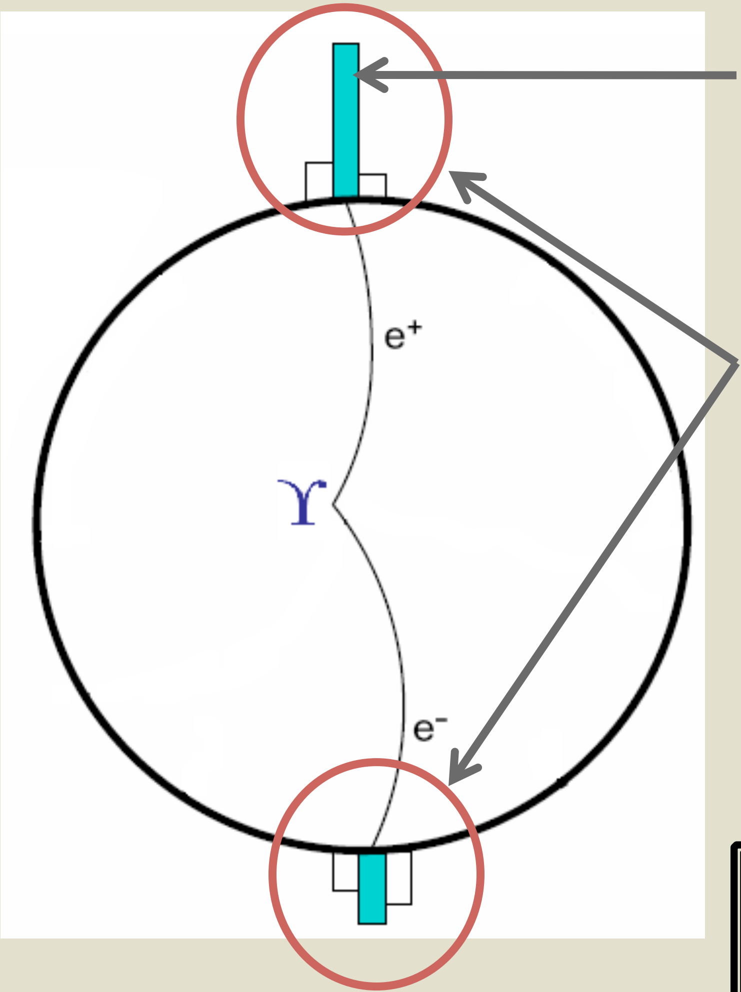
- $|\eta| < 1$
- Full ϕ coverage
- Tracking and EID via Ionization

EM Calorimeter

- $|\eta| < 1$
- Full ϕ coverage
- Electron ID via E/p
- Event Triggering



Triggering on ϒ decays



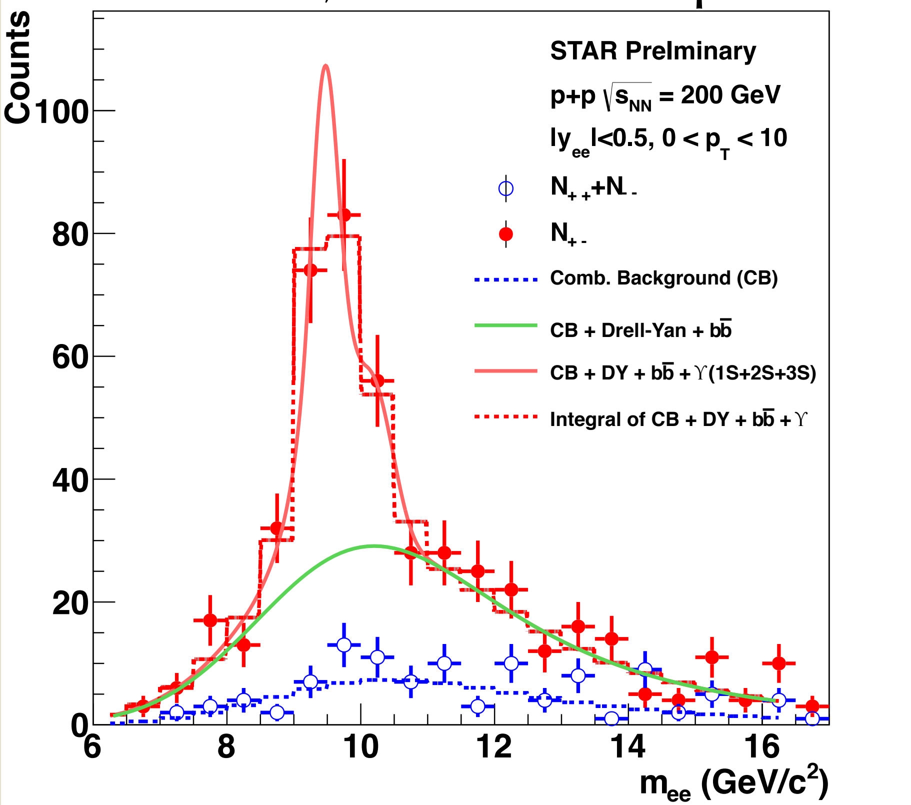
Level 0 Trigger (p+p,d+Au,Au+Au):
- Hardware-based
- Fires on at least one high tower

Level 2 Trigger (p+p,d+Au):
- Software-based
- Calculates:
    - Cluster energies
    - Opening angle
    - Mass

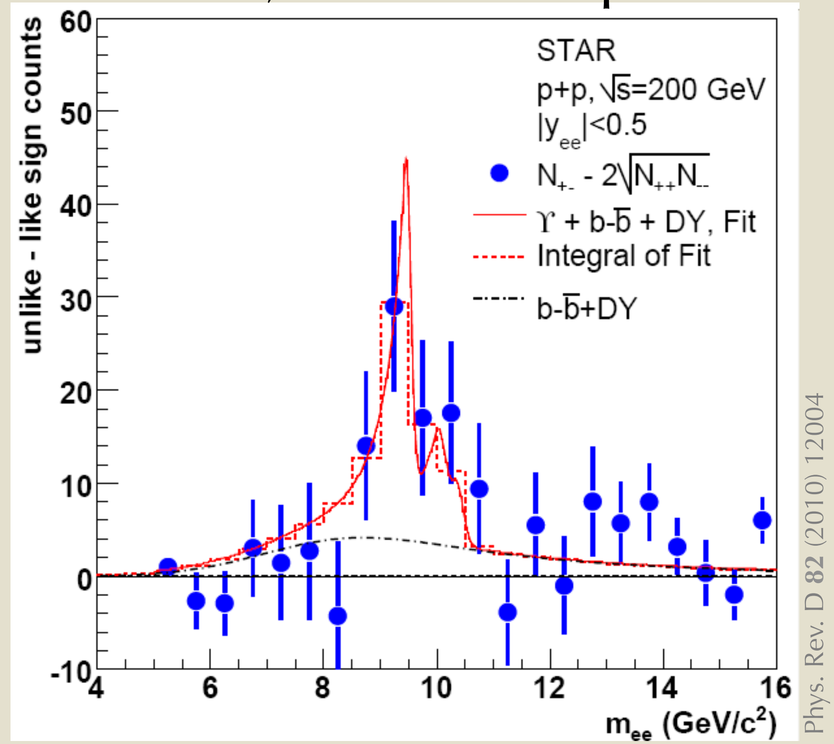
High rejection rate allowed us to sample entire luminosity

Υ in p+p 200 GeV

2009, $\int L\, dt = 19.7\ \mathrm{pb}^{-1}$



2006, $\int L\, dt = 7.9\ \mathrm{pb}^{-1}$



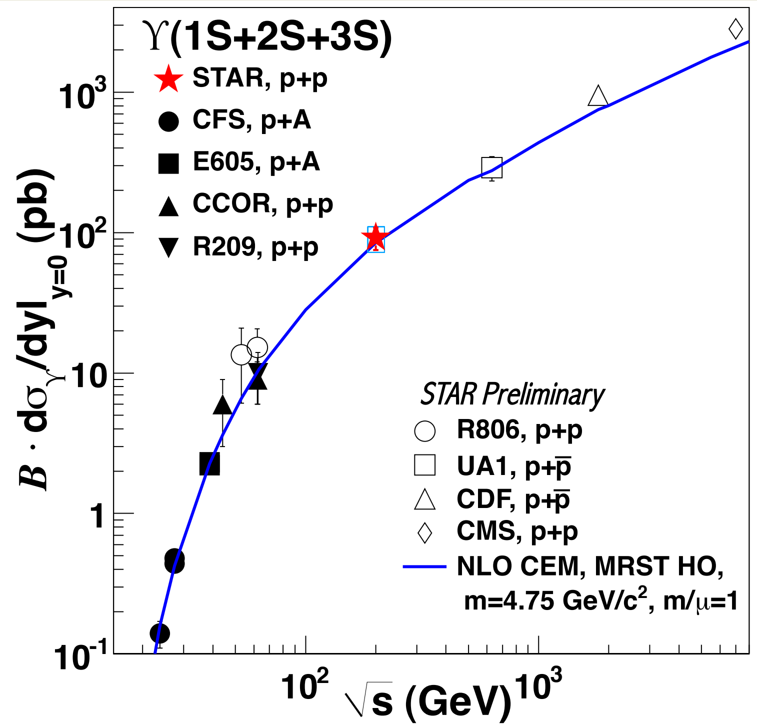
N_{Υ}(total)= 145±26(stat.)

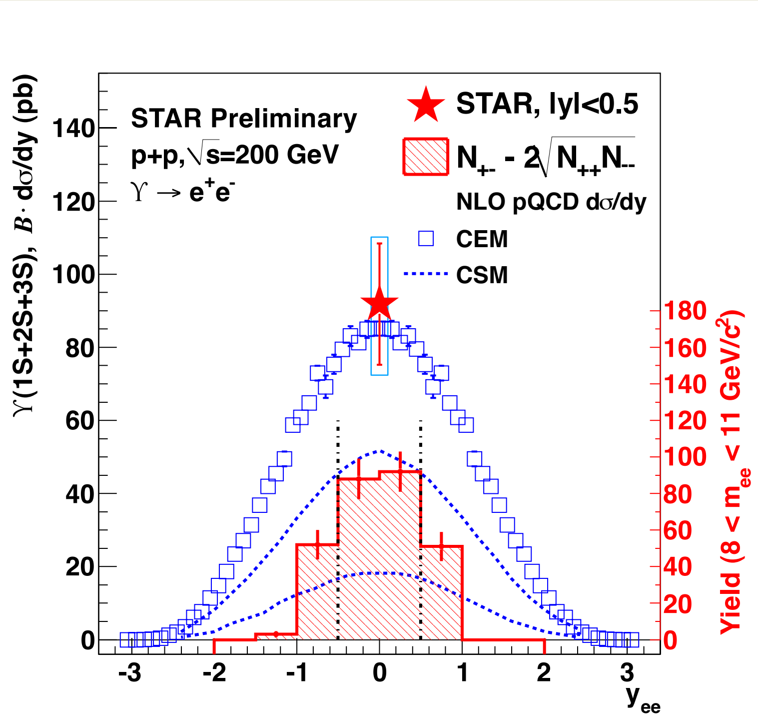
$$\sum_{n=1}^{3} \mathcal{B}(nS) \times \sigma(nS) = 91.8 \pm 16.6 \pm 19\ \mathrm{pb}$$

STAR Preliminary

Statistical error reduced by a factor of 2!

Υ in p+p 200 GeV, Comparisons

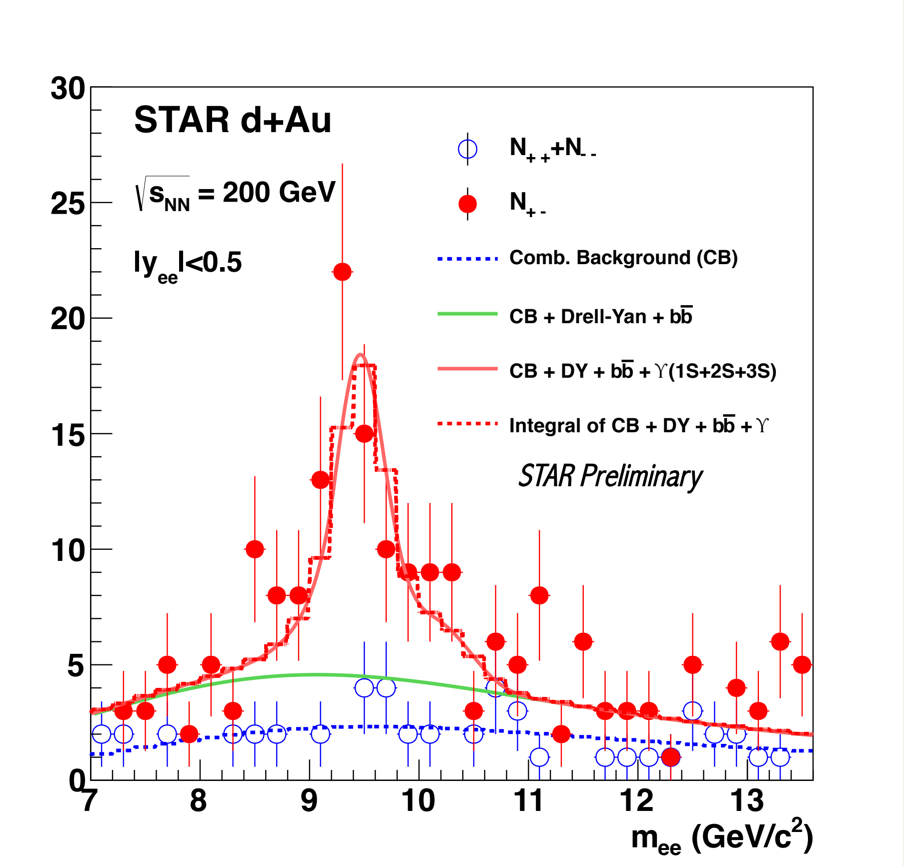


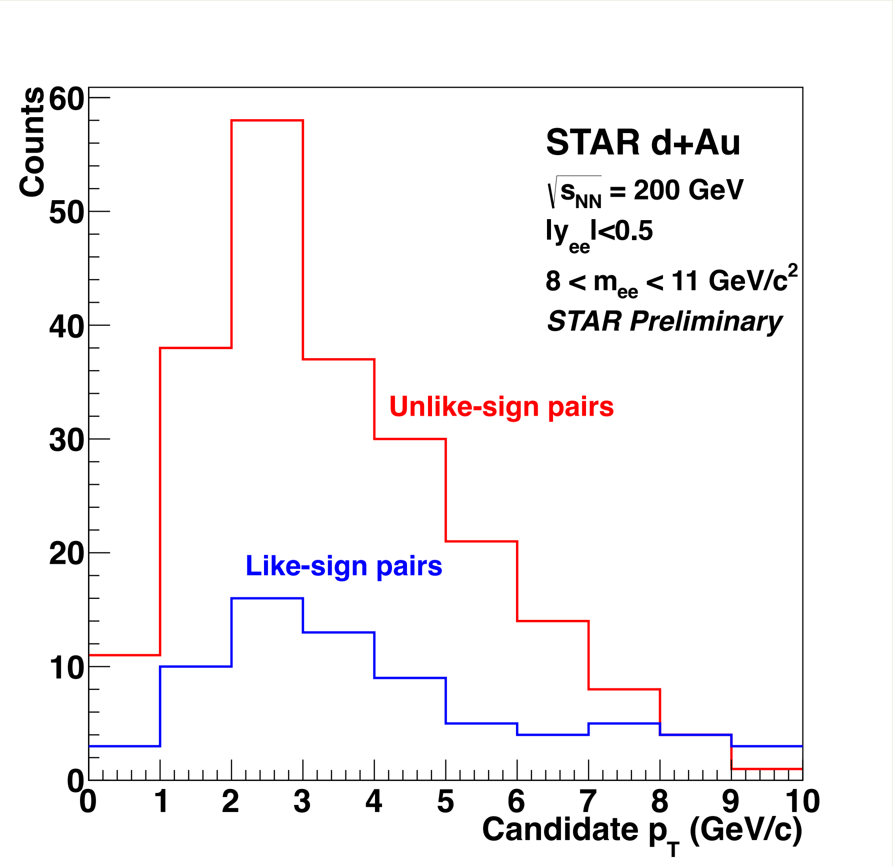


CEM: R. Vogt, Phys. Rep. 462125, 2008
CSM: J.P. Lansberg and S. Brodsky, PRD 81, 051502, 2010

STAR √s=200 GeV p+p Υ+Υ′+Υ″→e^+e^- cross section consistent with pQCD and world data trend

Υ in d+Au 200 GeV





Signal has ~8 σ significance

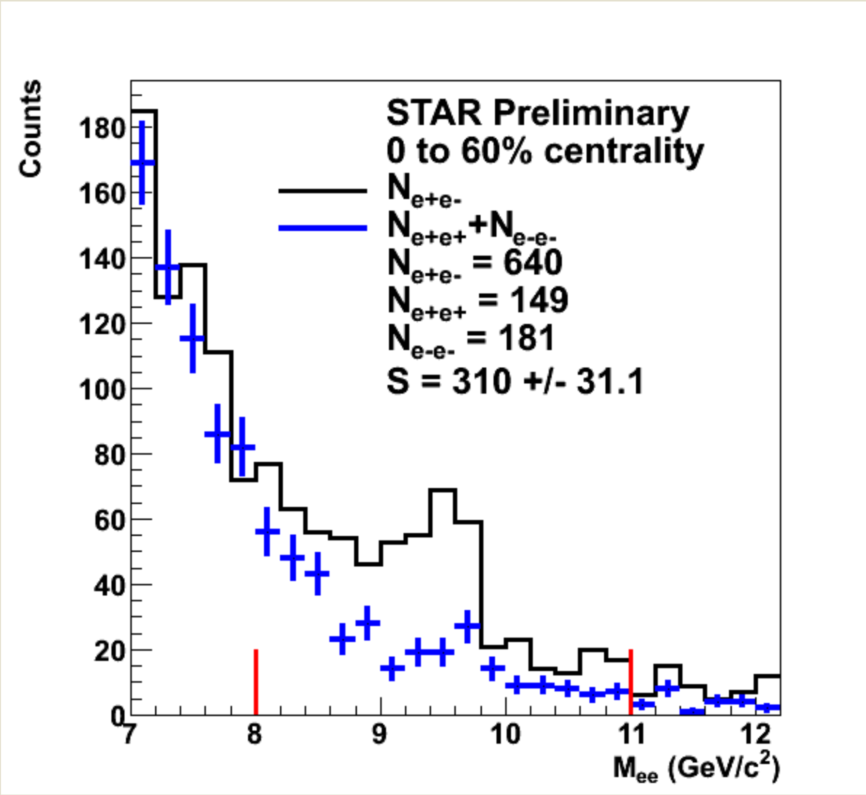
p_T reaches ~8 GeV/c

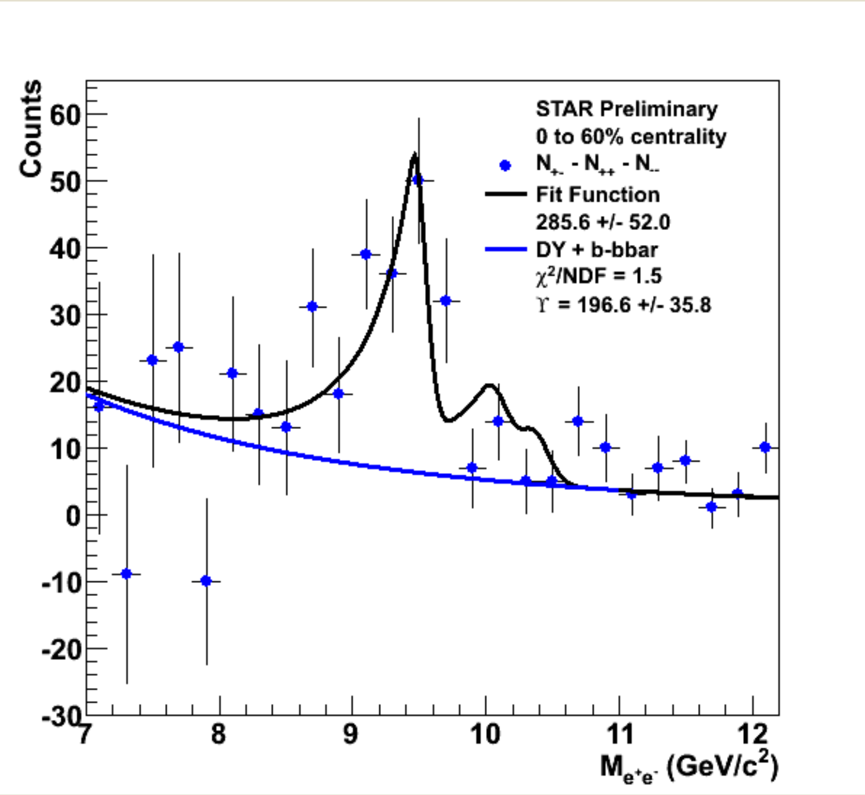
Efficiency/calibrations under study

$\int L\,dt$ = 32.6 nb^{-1}

N_{Υ} = 79 ± 17 (stat.) ± 13 (syst.)

Υ in Au+Au 200 GeV

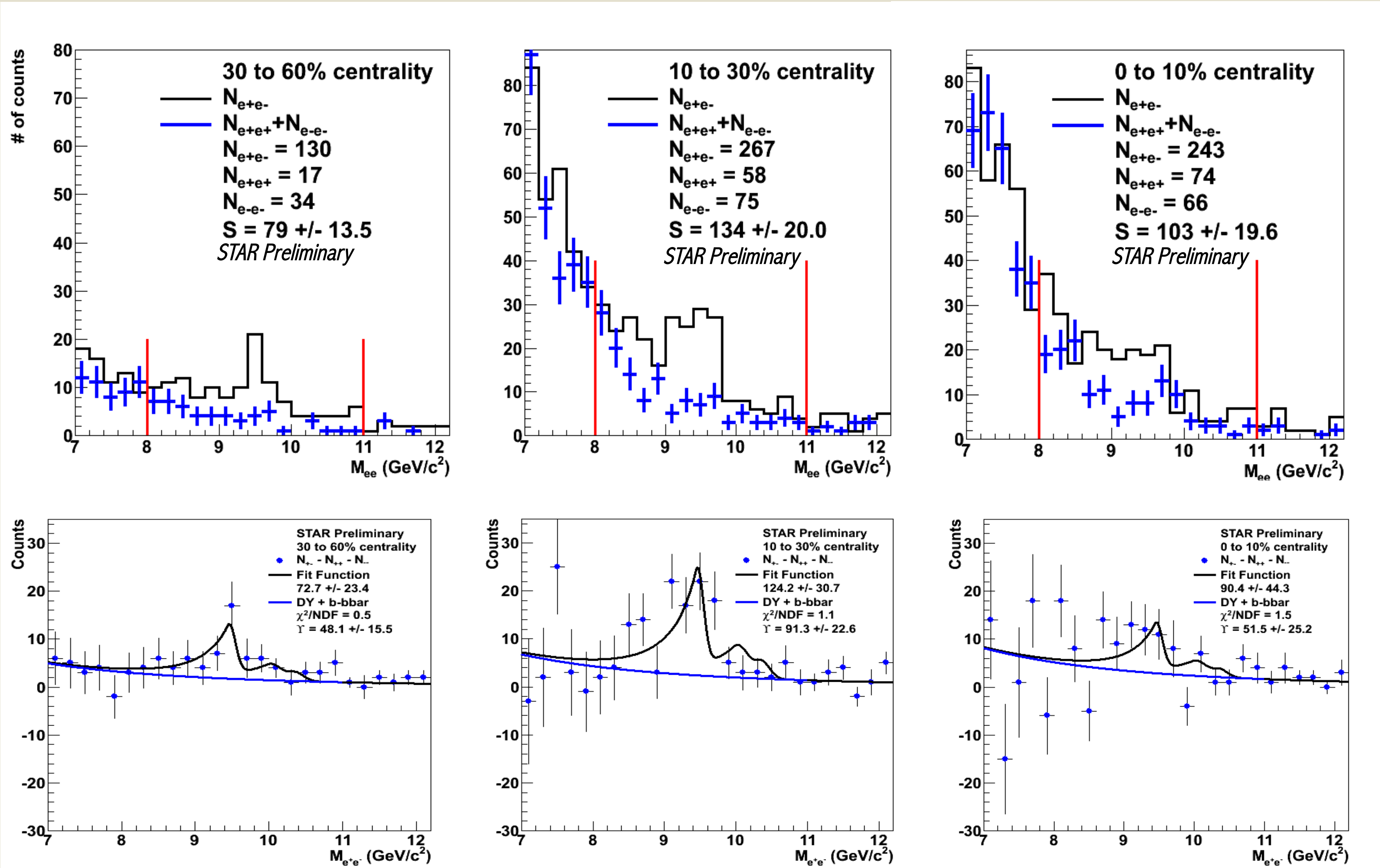




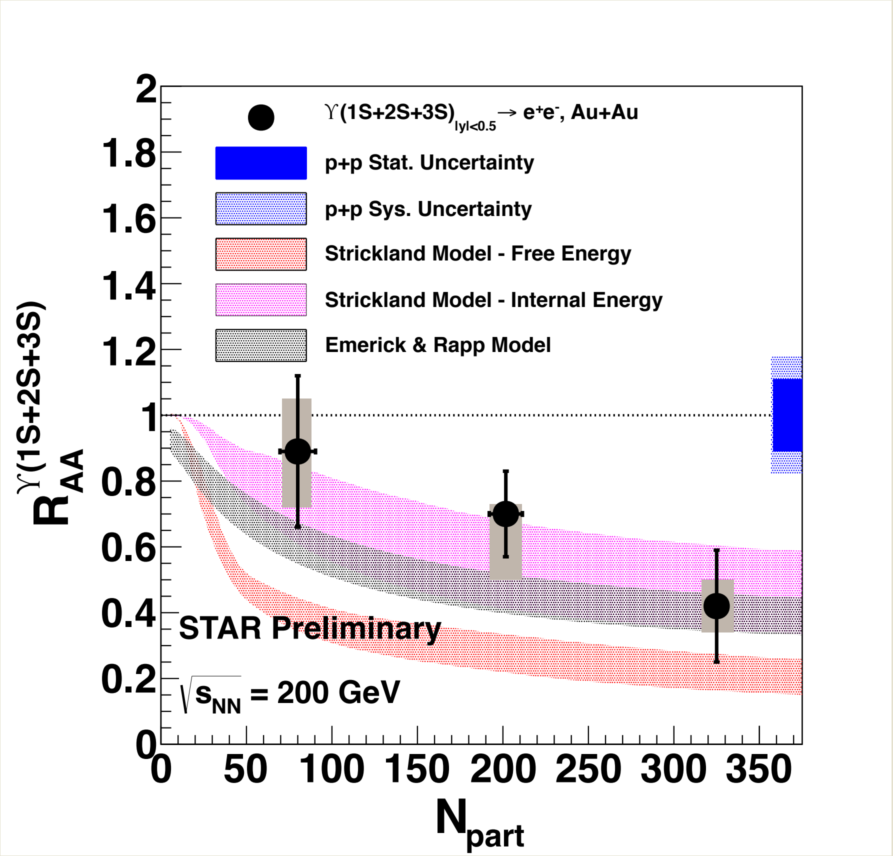
Raw yield of $\Upsilon \rightarrow e^+e^-$ with $|y|<0.5$ = 197 ± 36

$\int L\,dt \approx 1400\ \mu b^{-1}$

Υ in Au+Au 200 GeV, Centrality



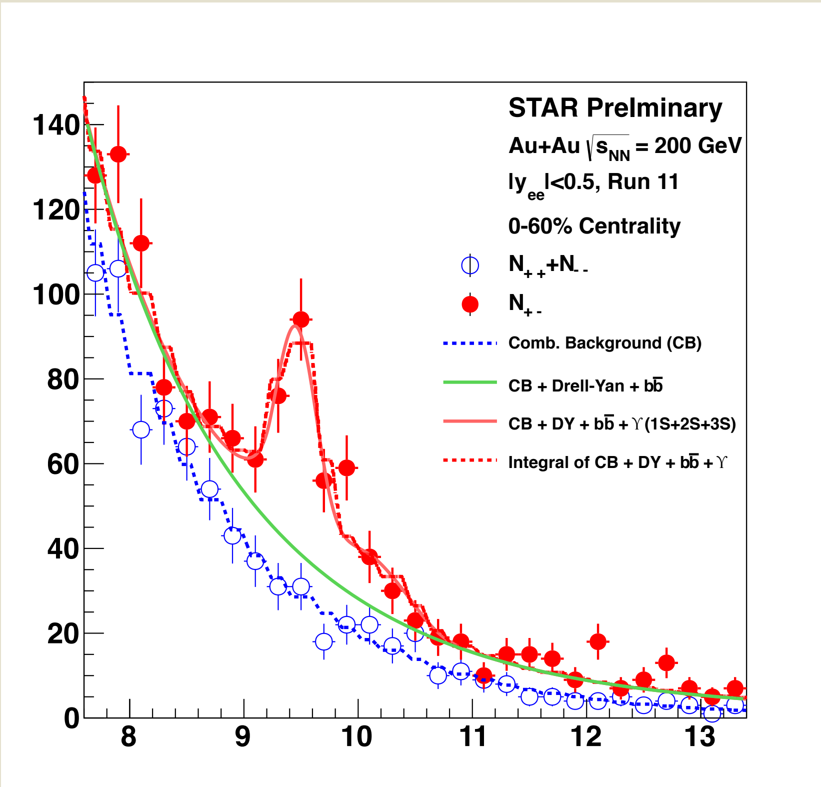
Υ in Au+Au 200 GeV, R_{AA}

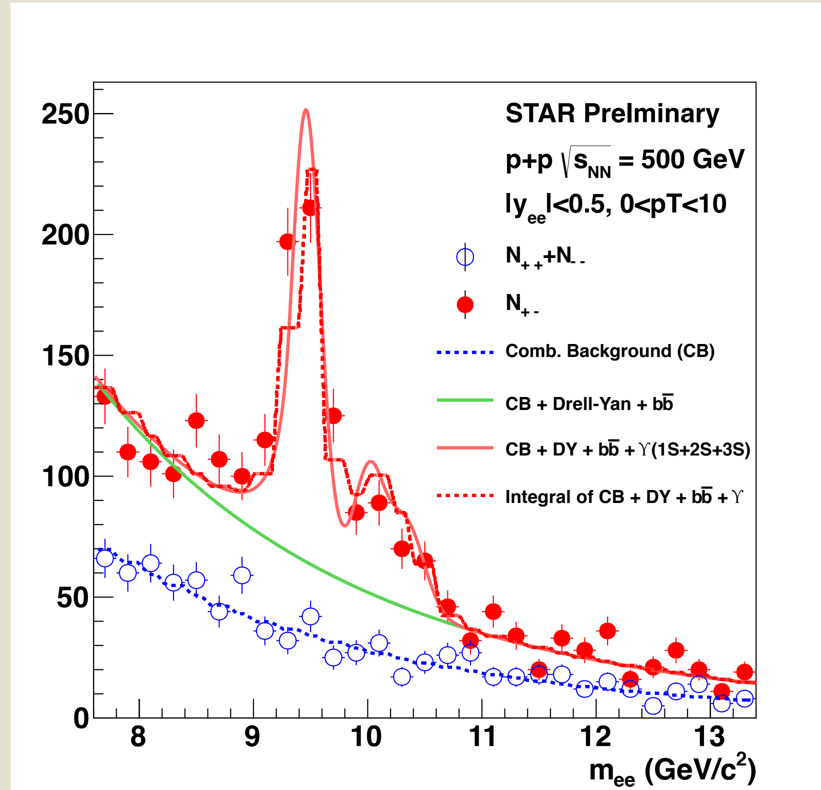


Models from M. Strickland and D. Bazow, arXiv:1112.2761v4
A. Emerick et al., Eur. Phys. J. A48 (2012) 72

- Strickland uses a dynamic model with fireball expansion and feed-down
  - Results are consistent with complete 2S and 3S suppression in this model
  - Model is assumes a T_0 in the range of 428-442 MeV and $1/4\pi < \eta/S < 3/4\pi$
- Emerick & Rapp band covers two scenarios:
  - Binding energy of the Upsilon decreases with T (Weak Binding)
  - Suppression is due to gluo-dissociation of Upsilon (Strong Binding)

Outlook





Au+Au @ 200 GeV, 2011

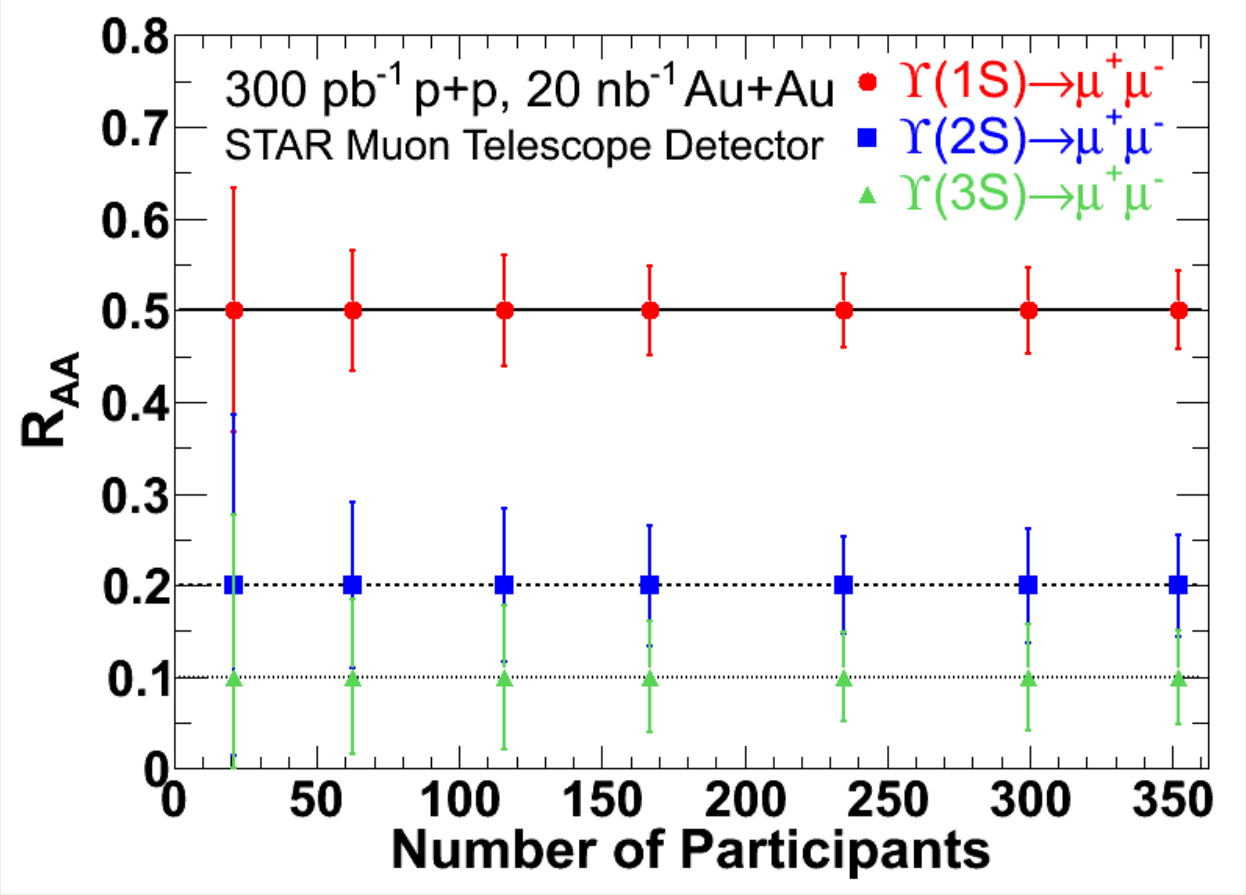
- Same setup as in 2010
- Double the total luminosity
  - Approximately 2.8 nb^{-1}

p+p @ 500 GeV, 2011

- High energy doubles Upsilon cross section
- Excited-to-ground state ratio
- P_T spectrum
- Approximately 22 pb^{-1} of data

Outlook

Statistical Error Projection for Muon Detectors



New muon detectors will open up a second, cleaner channel for Upsilon detection. About 60% of it is currently installed.

Important due to increased material in the detector from new vertexer

Conclusions

- Measured Υ production in p+p, d+Au, and Au+Au collisions at 200 GeV
- Au+Au results consistent with 2S and 3S suppression
- Increased Au+Au statistics from run 11 will further decrease R_{AA} uncertainties
- New muon channel will enhance and compliment our electron measurements

Thank you