Measurements of Υ Production and Nuclear Modification Factor at STAR

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STAR Collaboration

Outline

- Motivation for measuring Upsilons
- The Solenoidal Tracker At RHIC and its triggers
- Υ production cross section in p+p
  - New 2009 results!
- Υ production in d+Au
- Υ Nuclear Modification Factor in Au+Au
  - Updated with 2009 statistics!
- Conclusions

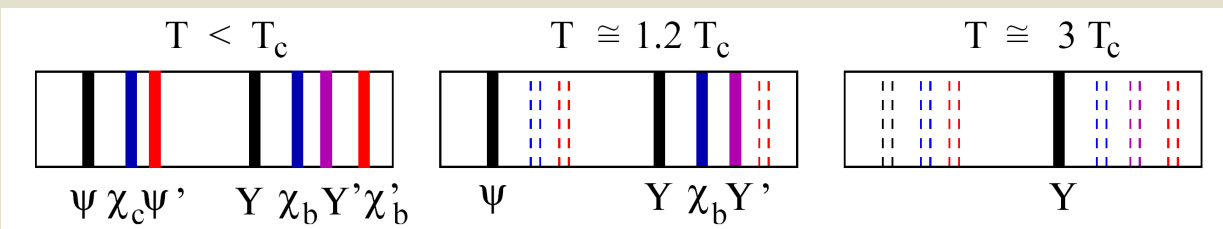
Goal: Quarkonia states in A+A

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

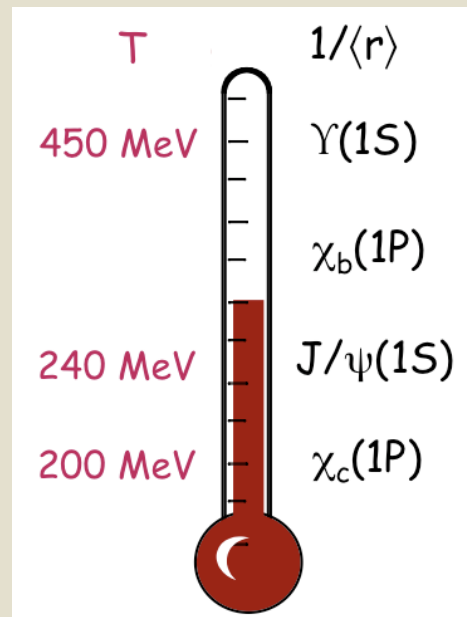
<u>Key Idea:</u> Quarkonia Melt in the plasma

- 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 $\Rightarrow T_{melting}$

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
    - σ_{cc} = ~800 μb, $\sigma_{bb=}$ ~ 2μb

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

- Expectation:
  - Υ(1S) no melting
  - Υ(2S) likely to melt
  - Υ(3S) melts

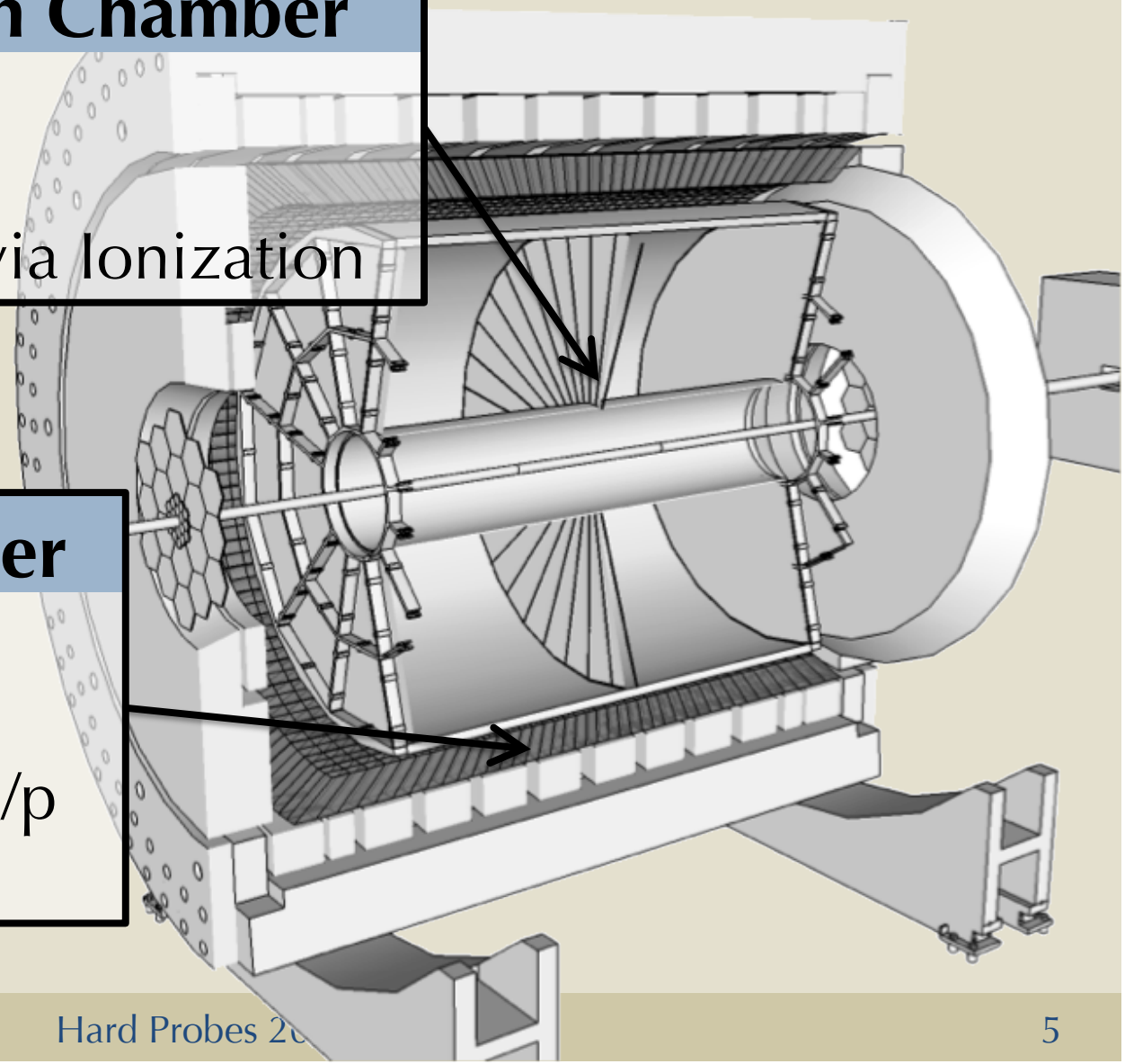
STAR

Time Projection Chamber

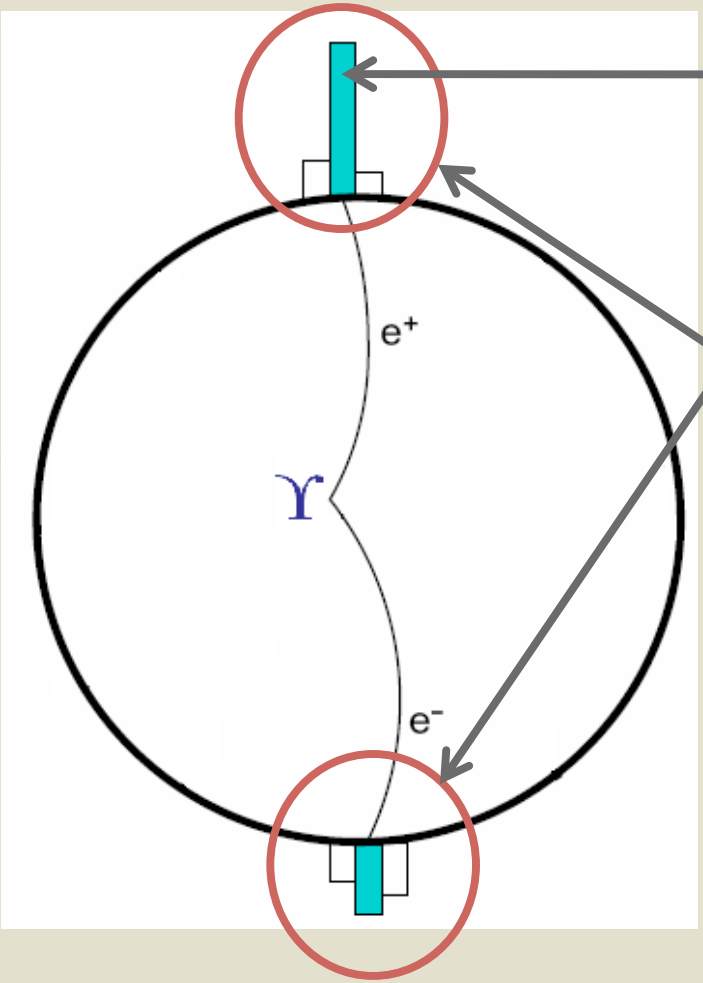
- $|\eta| < 1$
- Full ϕ coverage
- Tracking and EID via Ionization

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

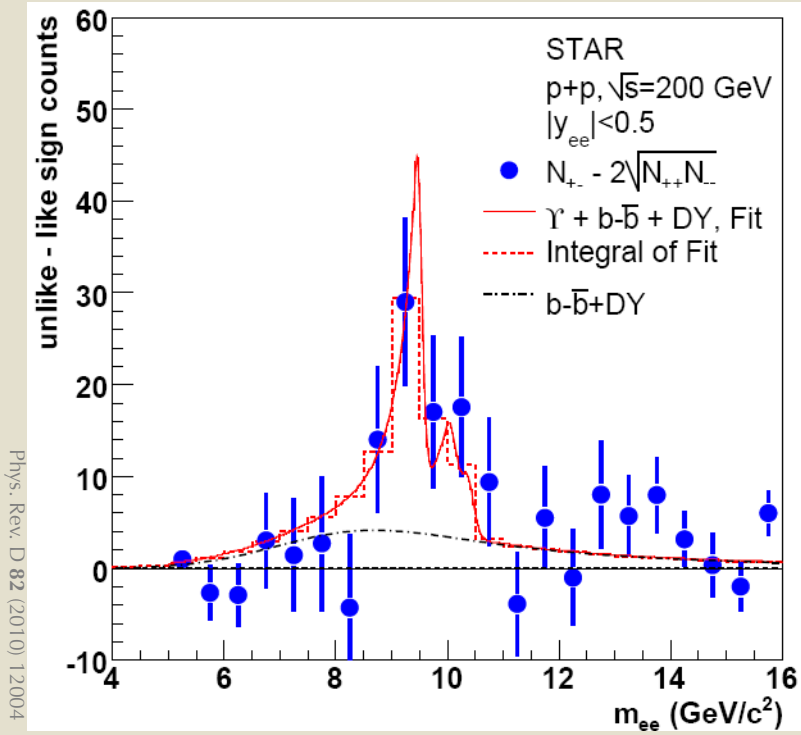
Level 2 Trigger (p+p,d+Au):

- Software-based
- Calculates:
  - Cluster energies
  - Opening angle
  - Mass

High rejection rate allowed us to sample entire luminosity

ϒ in p+p 200 GeV

2006



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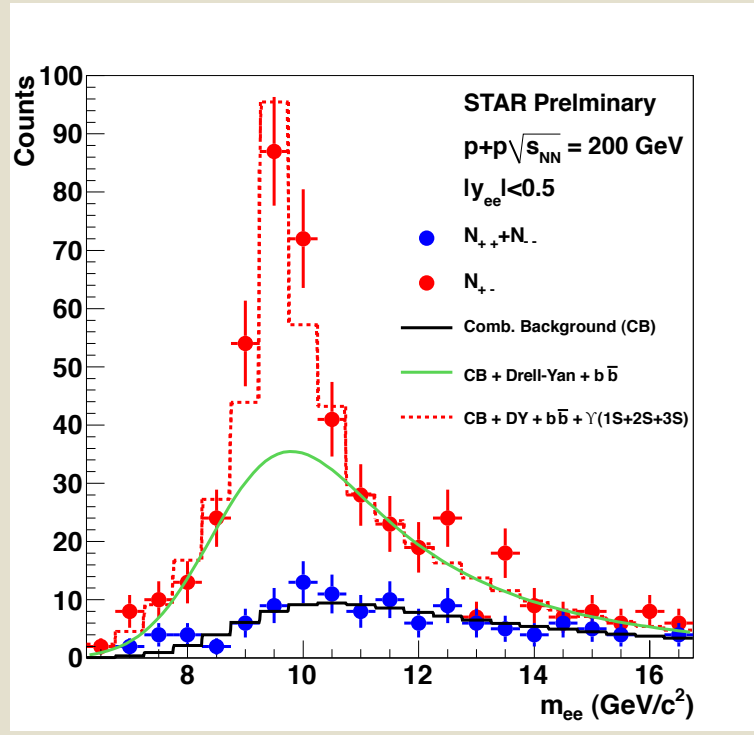
$\int L\,dt = 7.9 \pm 0.6\ \mathrm{pb}^{-1}$
$N_\Upsilon(\mathrm{total}) = 67 \pm 22(\mathrm{stat.})$

$$\sum_{n=1}^{3} \mathcal{B}(n\mathrm{S}) \times \sigma(n\mathrm{S}) = 114 \pm 38^{+23}_{-24}\ \mathrm{pb}$$

2009

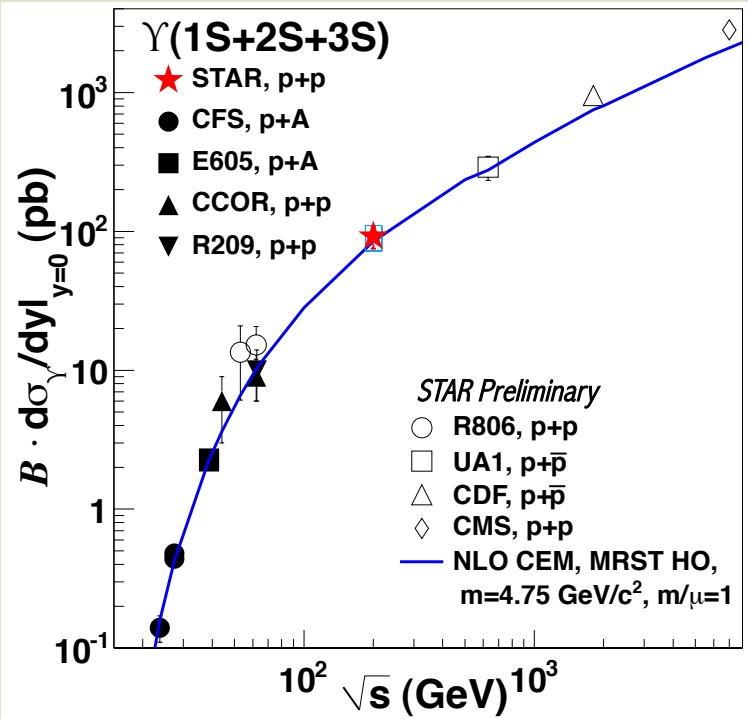


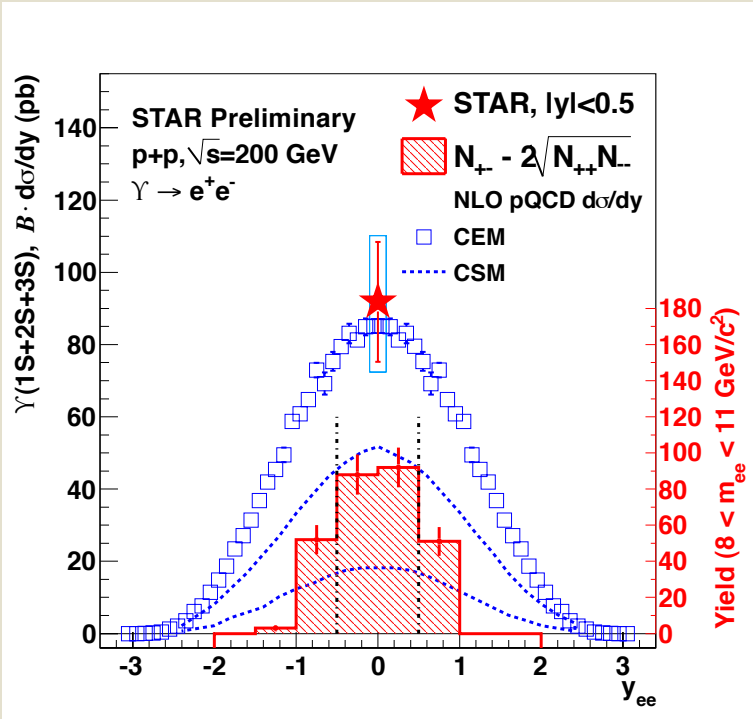
$\int L\,dt = 19.7\ \mathrm{pb}^{-1}$
$N_\Upsilon(\mathrm{total}) = 145 \pm 26(\mathrm{stat.})$

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

STAR Preliminary

ϒ in p+p 200 GeV, Comparisons

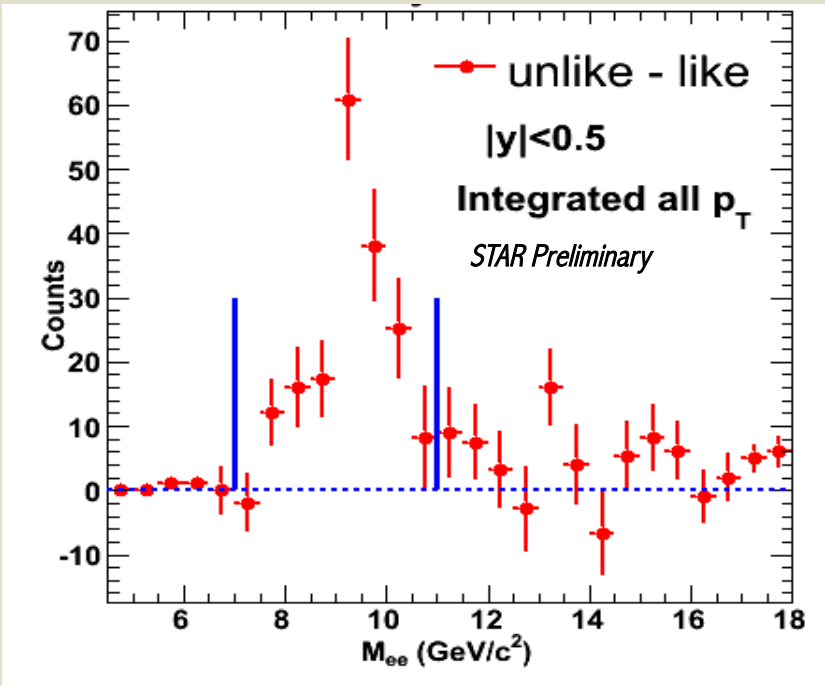


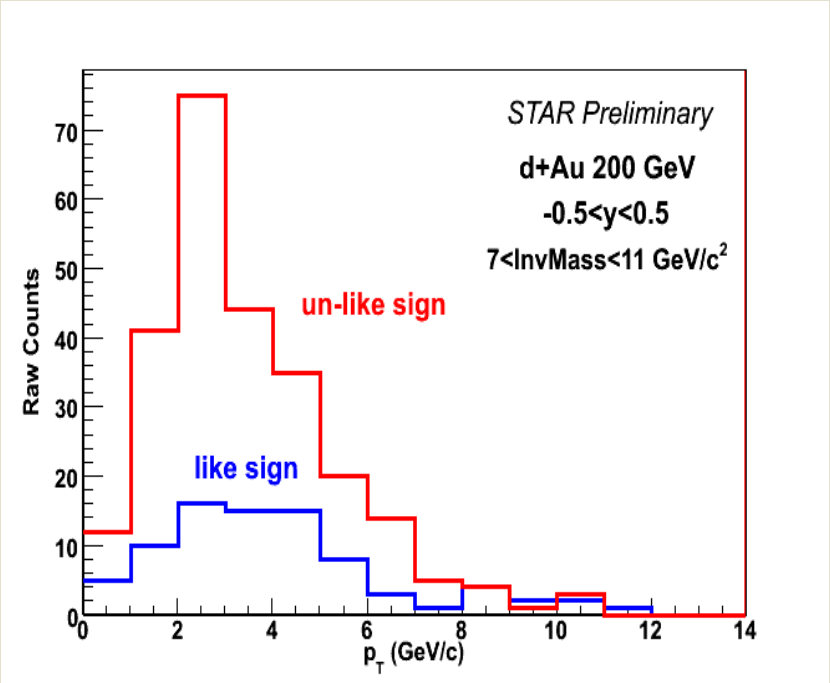


CEM: R. Vogt, Phys. Rep. 462125, 2008
CSM: J.P. Lansberg and S. Brodsky, PRD 81, 051502, 2010

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

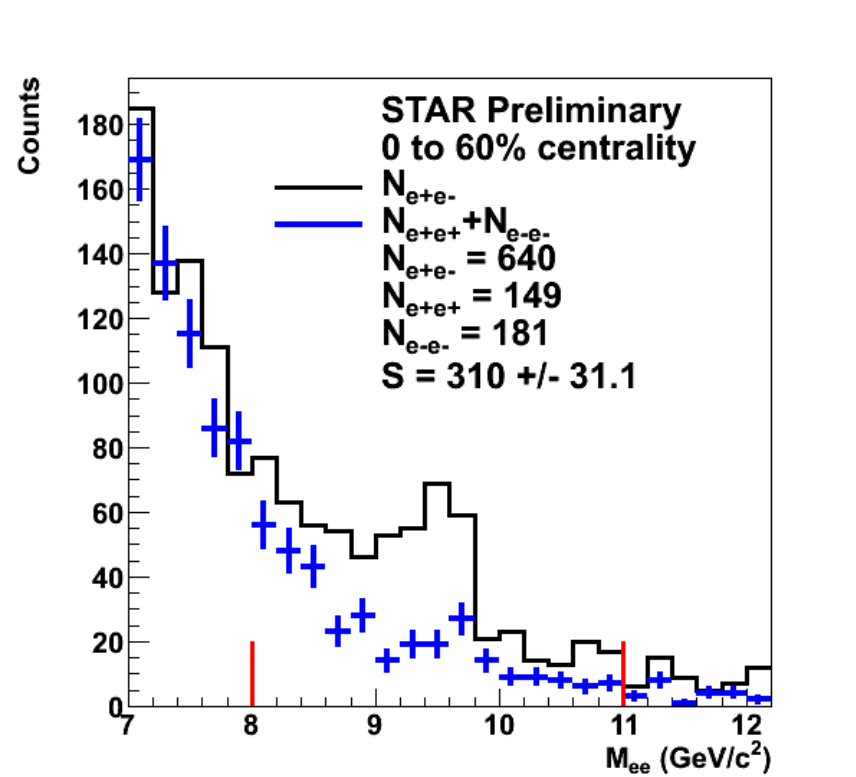
p_T reaches ~ 5 GeV/c

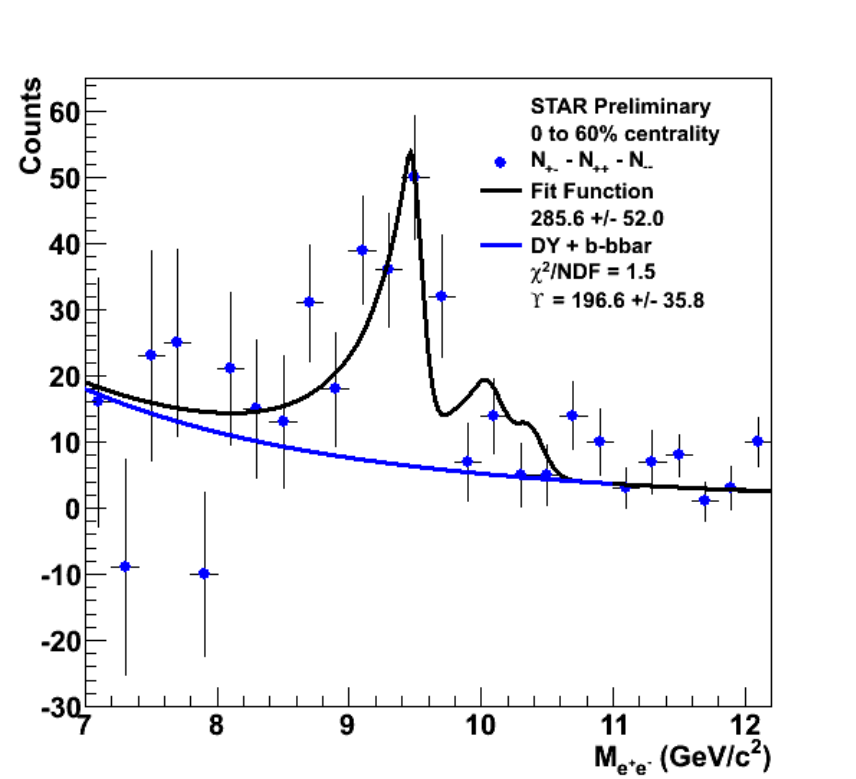
$\int L\,dt = 32.6\ nb^{-1}$

$N_{\Upsilon+DY+bb}$(total)= 172 ± 20(stat.)

$$\sum_{n=1}^{3} \mathcal{B}(n\mathrm{S}) \times \sigma(n\mathrm{S}) + \sigma(DY + b\bar{b}) = 35 \pm 4 \pm 5\ \mathrm{nb}$$

ϒ in Au+Au 200 GeV

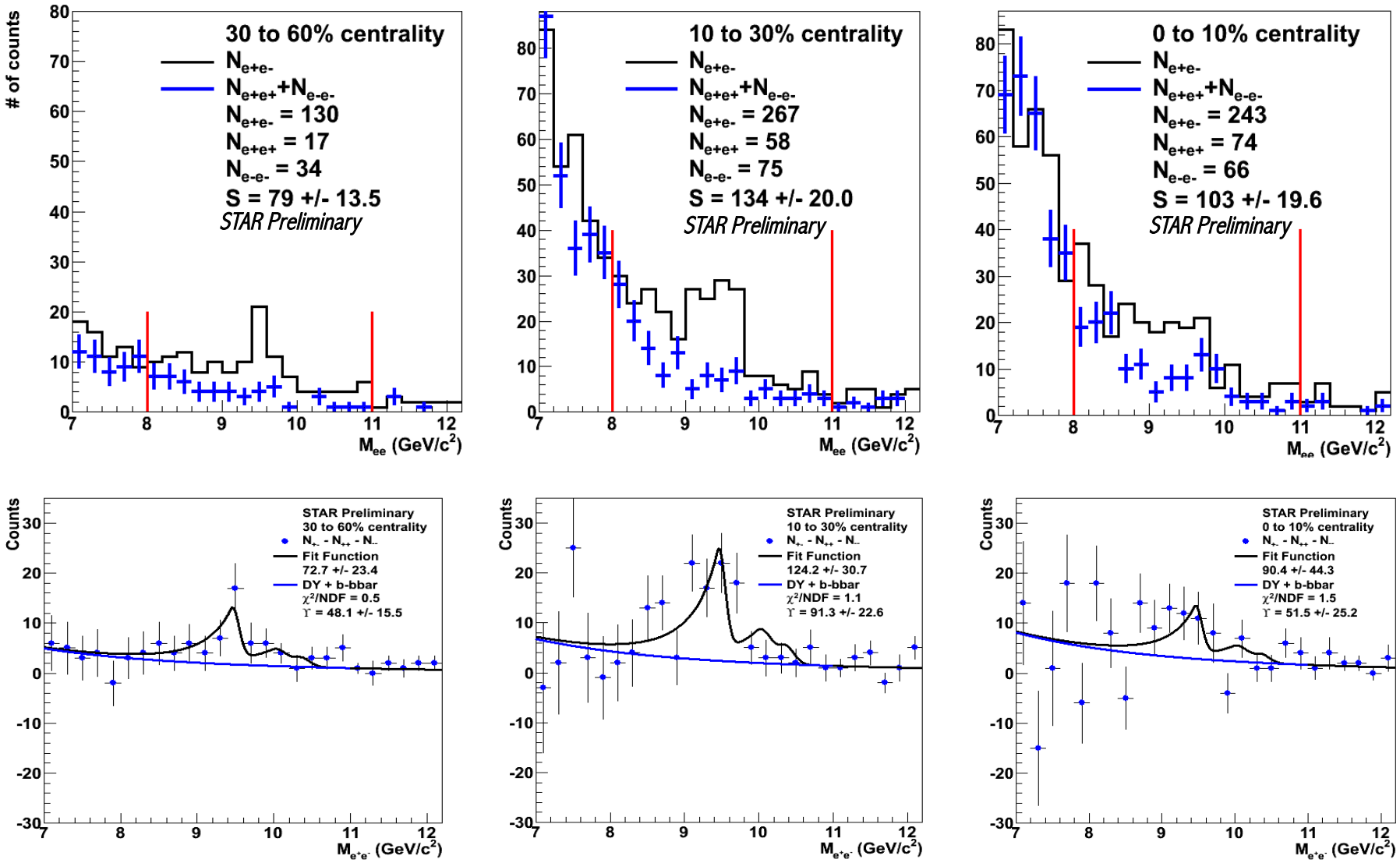




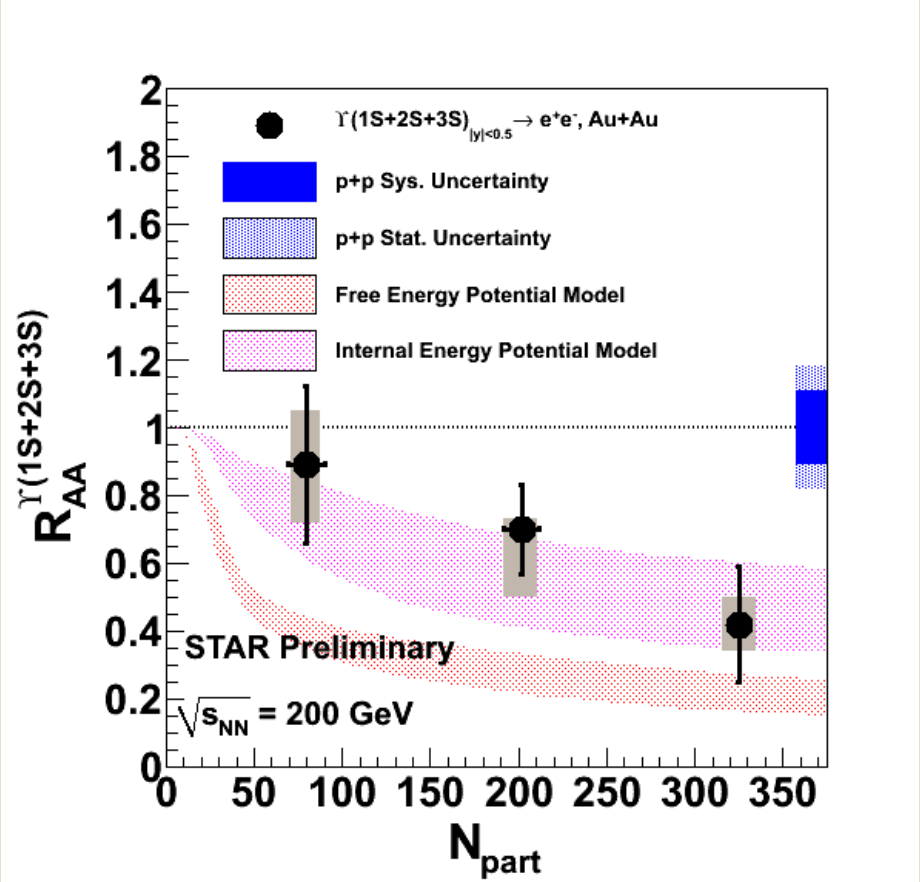
Raw yield of $\Upsilon \rightarrow e^+e^-$ with $|y|<0.5 = 197 \pm 36$

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

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

- Dynamic model with fireball expansion and quarkonium feed-down
- Results are consistent with 2S and 3S suppression in this model
- Calculation included variation of initial η/S and T_0
  - Data indicates a T_0 in the range of 428-442 MeV and $1/4\pi < \eta/S < 3/4\pi$

Conclusions

- Measured Υ production in p+p, d+Au, and Au+Au collisions at 200 GeV
- Final d+Au results coming soon
- Au+Au results consistent with 2S and 3S suppression
- Increased Au+Au statistics from run 11 will further decrease R_{AA} uncertainties
- Enhanced pp signal from 2009 will allow us to extend our measurement to $|y|<1.0$

Thank you