First Measurement of ϒ Suppression

Rosi Reed (UC Davis), *for the STAR Collaboration*

Abstract

Suppression of Quarkonia in heavy ion collisions with respect to proton-proton collisions due to the Debye screening of the potential between the heavy quarks was hypothesized to be a signature of the Quark Gluon Plasma (QGP) [1]. Lattice calculations show that quantifying the suppression of an entire family of Quarkonium mesons can give us a model dependent measurement of the temperature of the hot, dense matter produced in heavy ion collisions. For the ϒ family, calculations indicate that the ϒ(1S) state should not be suppressed at 200 GeV which would give a standard candle that the ϒ(2S) and ϒ(3S) states can be compared to. The suppression of Quarkonia can be quantified by calculating the nuclear modification factor R_{AA}, which is the ratio of the production in Au+Au collisions to the production in p+p scaled by the number of binary collisions. We will present our results for mid-rapidity ϒ(1S+2S+3S) production in p+p and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. These results will be combined into the nuclear modification factor R_{AA}. The centrality dependence of R_{AA} will be shown for the combined ϒ(1S+2S+3S) yield.

Introduction

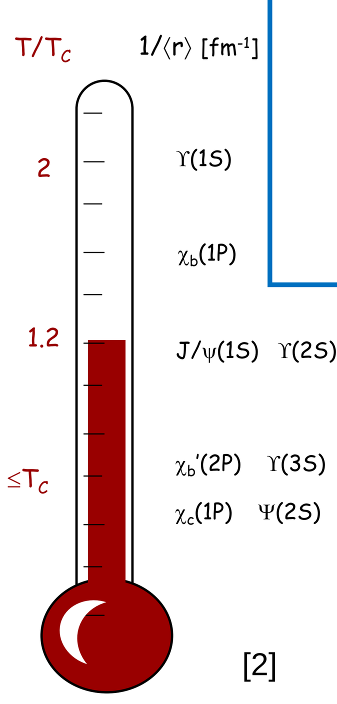
Sequential suppression of Quarkonium mesons acts as a QGP thermometer.

At 200 GeV [3]:

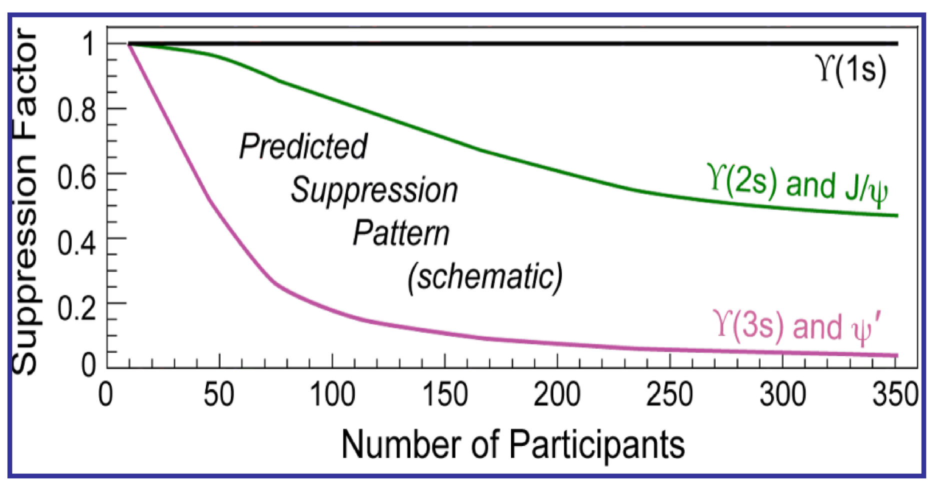
ϒ(3S) should be **completely dissociated**

ϒ(2S) state **may dissociate**

ϒ(1S) state **should survive**



[2]



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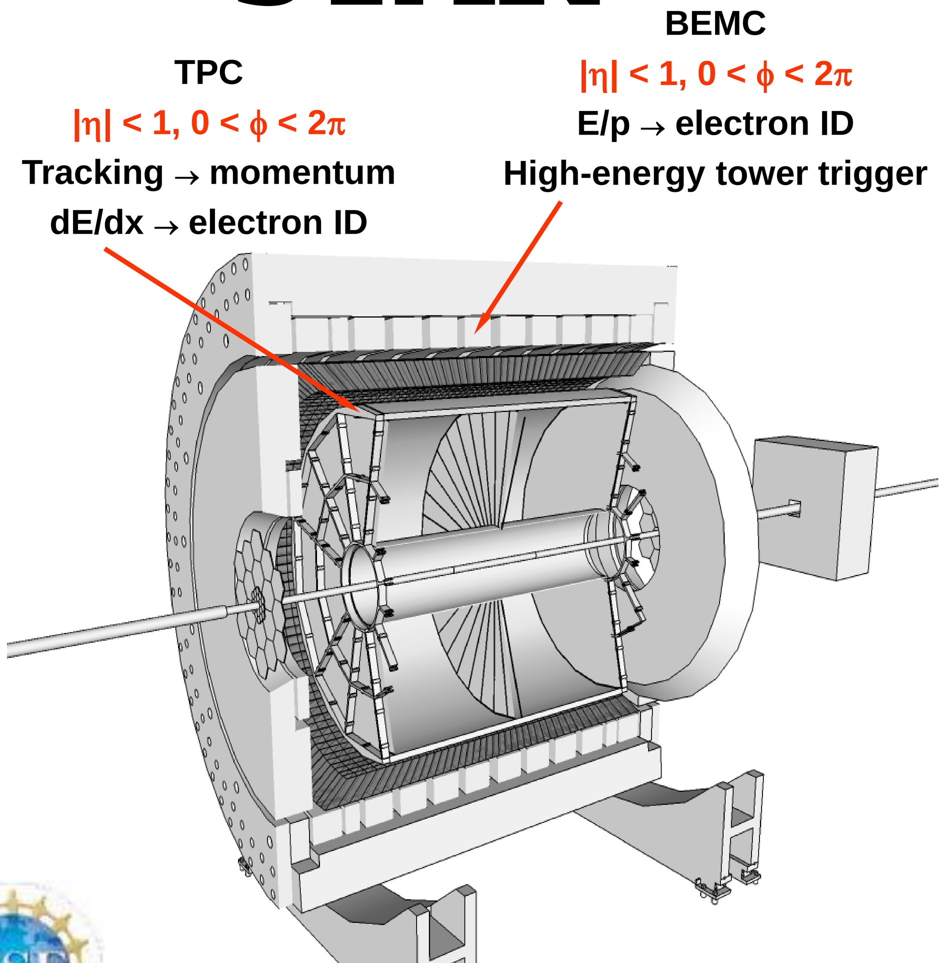
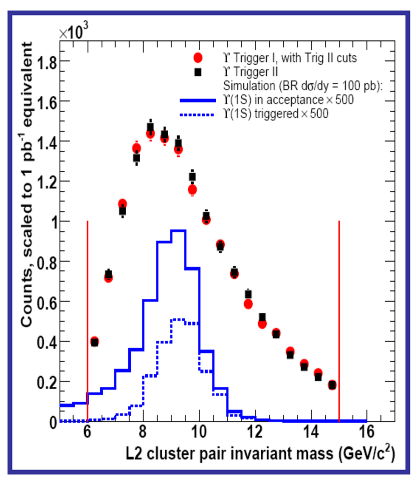
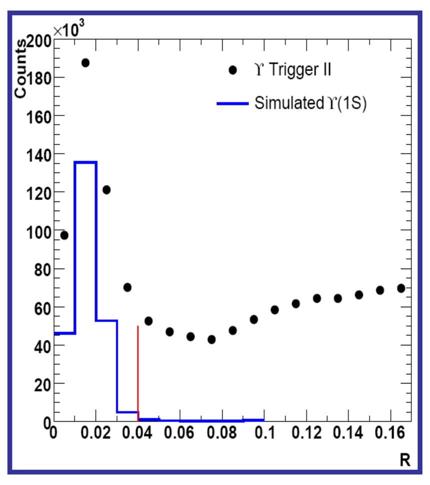


Analysis

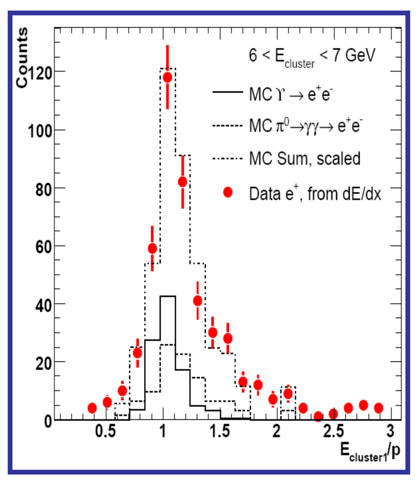
Triggered candidates exceed number of ϒ by a factor of ~700 (p+p)

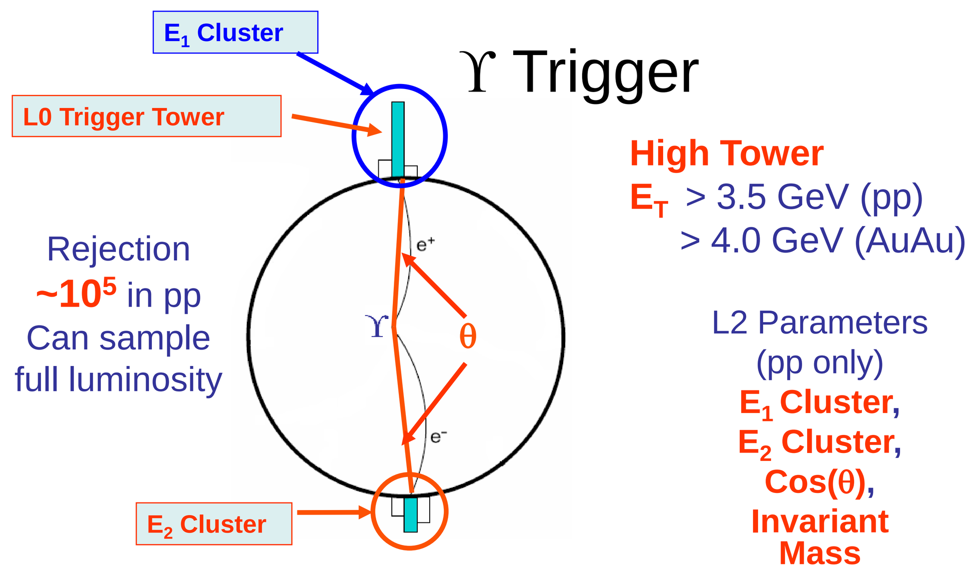


TPC tracks that extrapolate to R=0.04 in η−φ to trigger clusters are "matched"



E/p and dE/dx of matched tracks are used to select e⁺ and e⁻ tracks





Track pairs combined into:

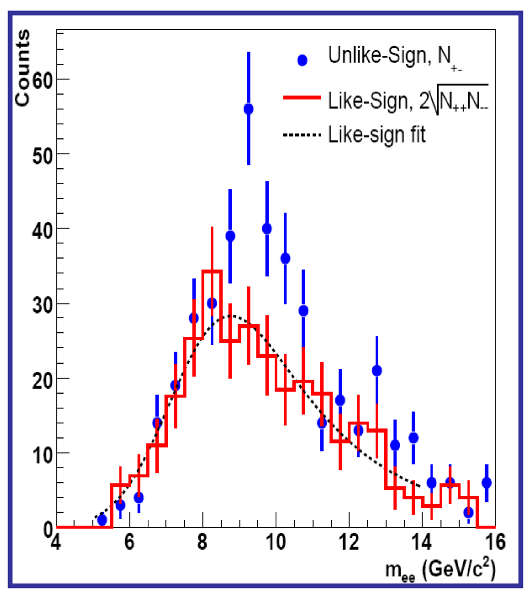
e^+e^- = N_{+-} = Signal + Background

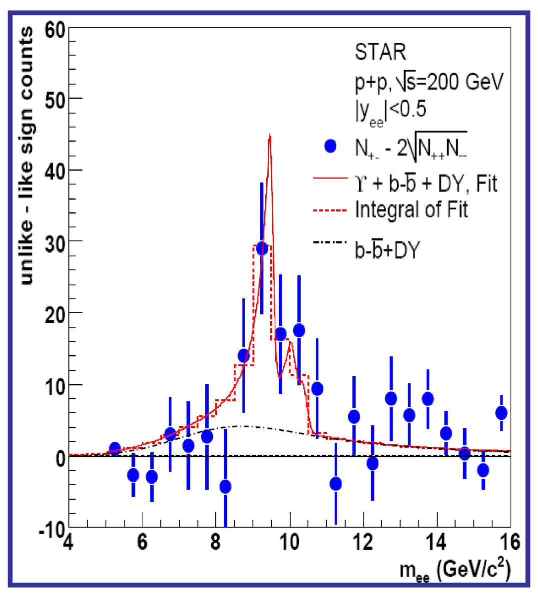
$e^-e^-+e^+e^+$ = $N_{--}+N_{++}$ = Background

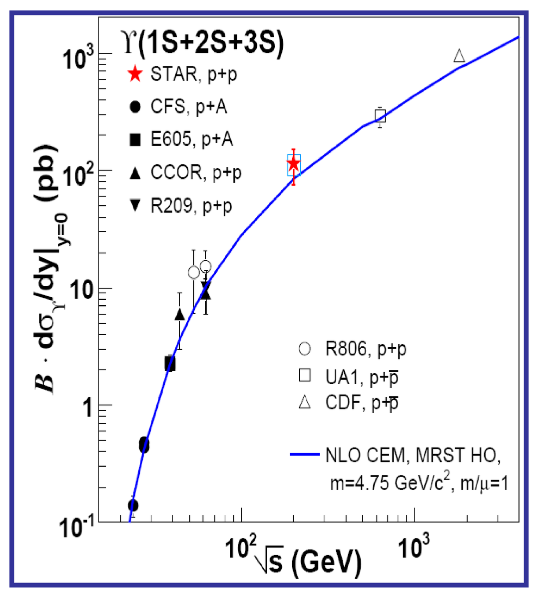
Yield of bb and Drell-Yan determined by fitting S with 3 Crystal Ball functions for the ϒ(1S+2S+3S) states and power law multiplied by an erf functions for Drell-Yan and bb̄

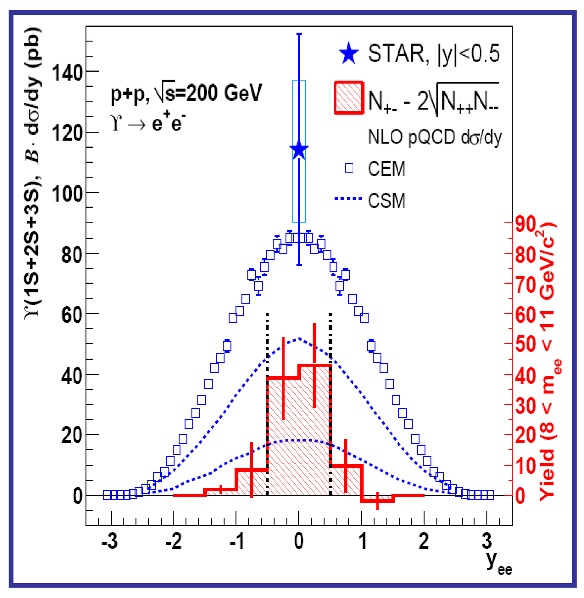
ϒ in p+p 200 GeV

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

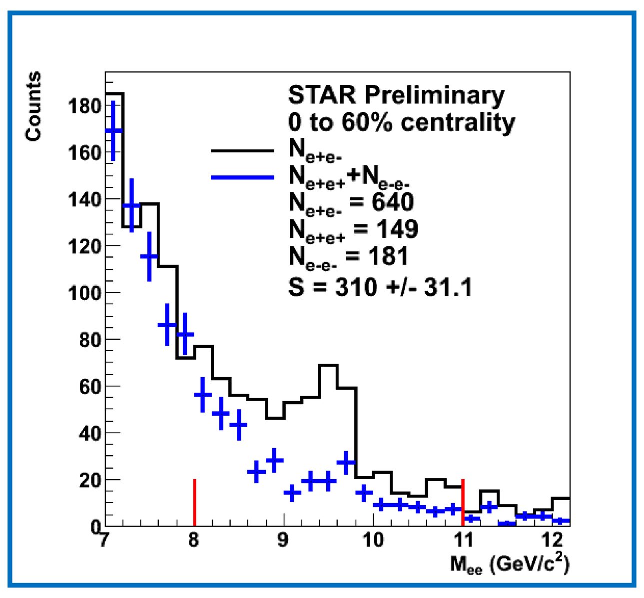


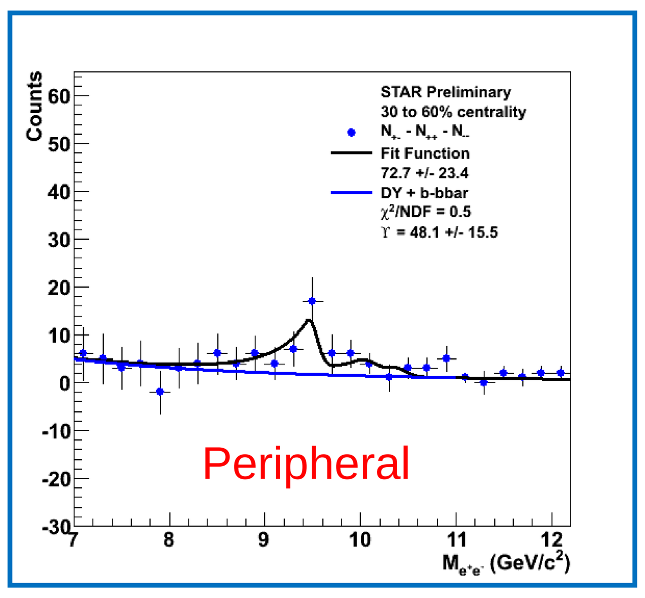


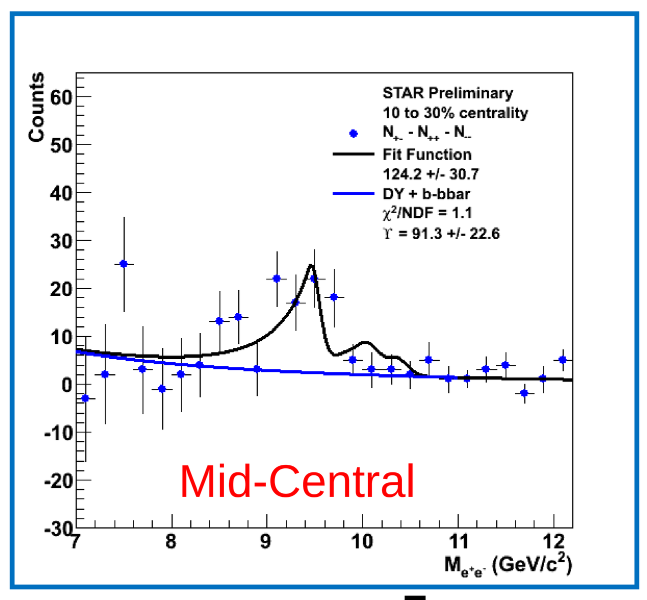


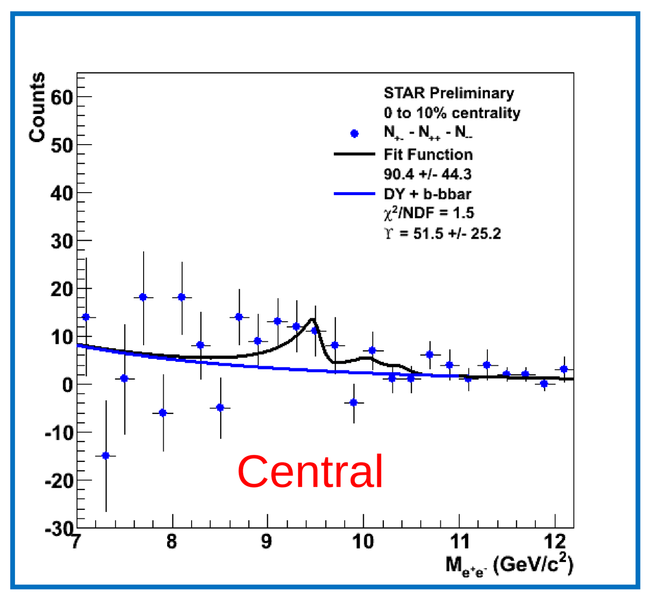


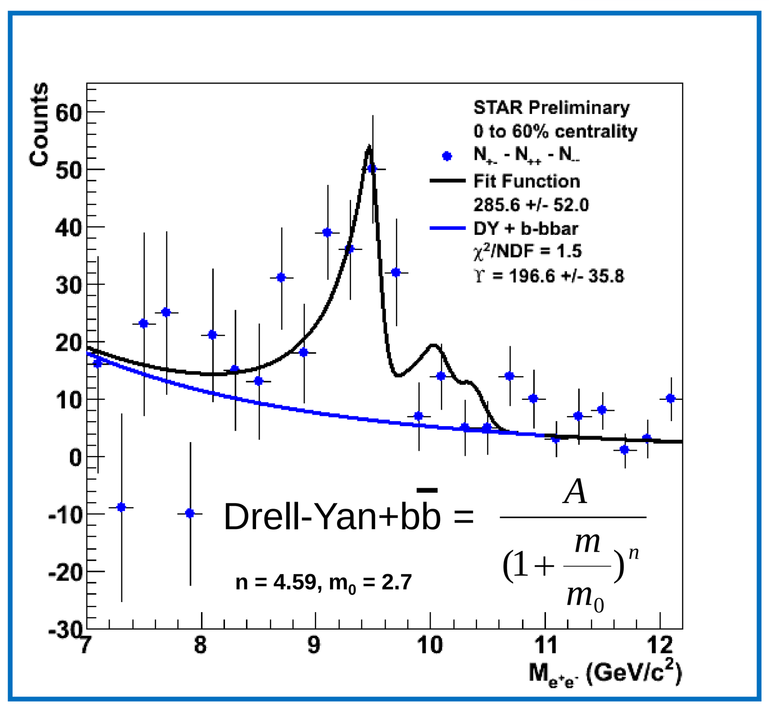
ϒ in Au+Au 200 GeV







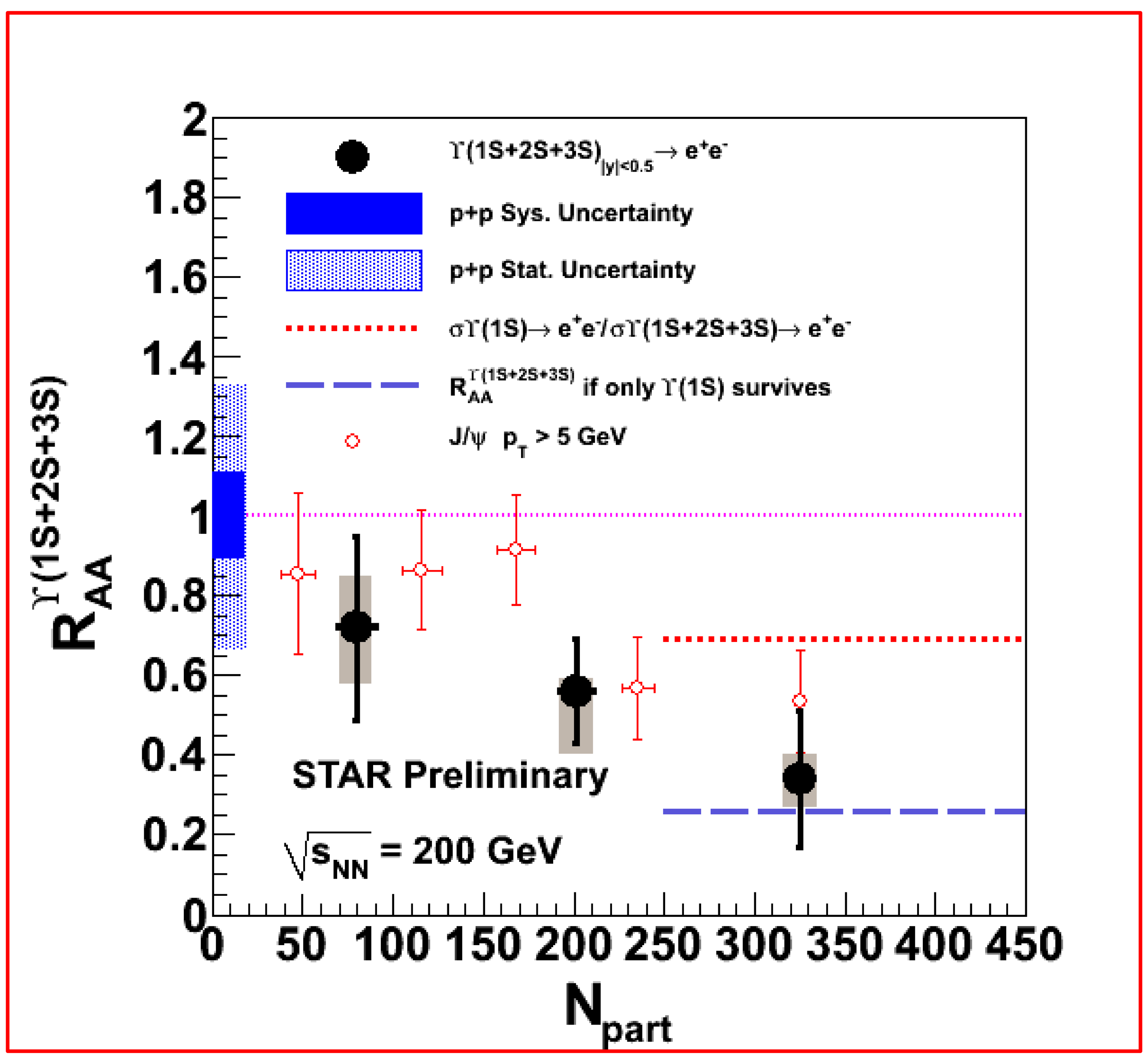




Extracting ϒ requires knowledge of the bb̄ and Drell Yan background. There are large theoretical uncertainties in these yields at 10 GeV. Yield of Drell-Yan and bb was parameterized as $A/(1+m/m_0)^n$ where n=4.69 and m_0 =2.7 from ref [4]. The yield was set by fitting this parameterization with 3 crystal-ball functions representing the ϒ yield.

ϒ= N_{+-} - N_{--} - N_{++} - ∫DY+bb̄ This allows a model independent measurement of the ϒ yield

Ratios and masses of the ϒ(1S+2S+3S) states fixed to their PDG values



Conclusions

- R_{AA} (0-60%)=0.56±0.11(stat)+0.02/-0.14(sys)
- R_{AA} (0-10%)=0.34±0.17(stat)+0.06/-0.07(sys)
- **ϒ(1S+2S+3S) is suppressed in central collisions!** 3σ away from R_{AA} = 1
- 3x the p+p statistics (run 9) + ~2x the Au+Au statistics (run 11) will decrease the uncertainty by more than a factor of 2.

References

[1] T. Matsui, H. Satz, J/psi suppression by quark-gluon plasma formation, Physics Letters B 178 (4) (1986)

[2] A. Mocsy and P.Petreczky, PRL 99, 211602 (2007)

[3] S. Digal, P. Petreczky, H. Satz, Quarkonium feed-down and sequential suppression, Phys. Rev. D 64 (9) (2001) 094015

[4] B. I. e. a. Abelev, cross section in p + p collisions at s = 200 gev, Phys. Rev. D 82 (1) (2010)