J/ψ production in U+U collisions at 193 GeV in the STAR experiment

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Abstract

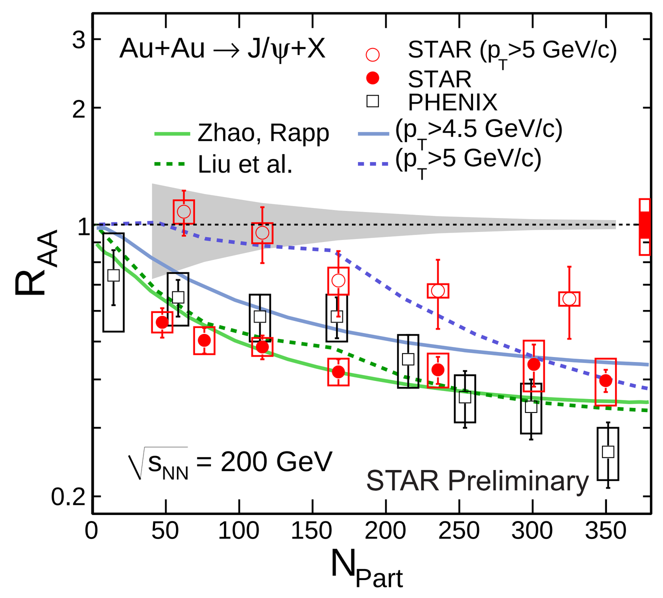
Extensive studies of properties of quark-gluon plasma (QGP), the partonic matter created in heavy ion collisions, have been conducted at RHIC for over a decade. Suppression of quarkonia production in high energy nuclear collisions relative to proton-proton collisions, due to Debye screening of the quark-antiquark potential, has been predicted to be a sensitive indicator of the temperature of the created QGP. However, initial-state nuclear effects on the parton distributions (shadowing), production via recombination of quark-antiquark pairs in the QGP and dissociation in hadronic phase could also alter the expected suppression picture. Systematic measurements of the quarkonia production for different colliding systems are required to understand the quarkonium interactions with the partonic medium, and then the QGP properties. To further study the pattern of quarkonia suppression we can utilize the collisions of non-spherical nuclei such as uranium.
In this poster, we present the analysis status on J/ψ production, reconstructed at midrapidity via di-electron decay channel, in U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV in the STAR experiment.

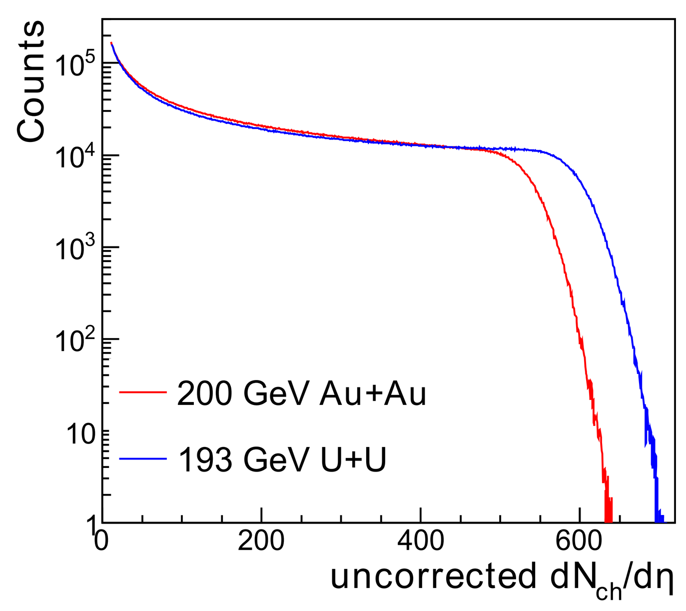
Motivation

Measurements of J/ψ in-medium dissociation in heavy ion collisions are expected to provide an estimate of the initial temperature of the system. The interpretation of medium induced modification requires a good understanding of its production mechanisms in p+p collisions and cold nuclear matter effects in d+Au collisions.
In STAR, J/ψ was measured in p+p, d+Au, Au+Au [1] and Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV and Au+Au collisions at $\sqrt{s_{NN}}$ = 39 GeV and 62 GeV.

- **Top picture** [2]: R_{AA} dependence on centrality of a collision for all p_T and for high p_T only. J/ψ suppression in Au+Au increases with a centrality and decreases toward higher p_T across the centrality range. The data are compared to models that include contributions from prompt production and statistical charm quark regeneration [3,4]
- **Bottom picture** [5]: Charged tracks multiplicity for Au+Au and U+U collisions. Top values of charged tracks multiplicity are higher in U+U collisions, which is caused by higher initial energy density (due to prolate shape of uranium nucleus).

Higher achievable energy density in uranium collisions could be used to further study quarkonia production [6].





STAR Experiment

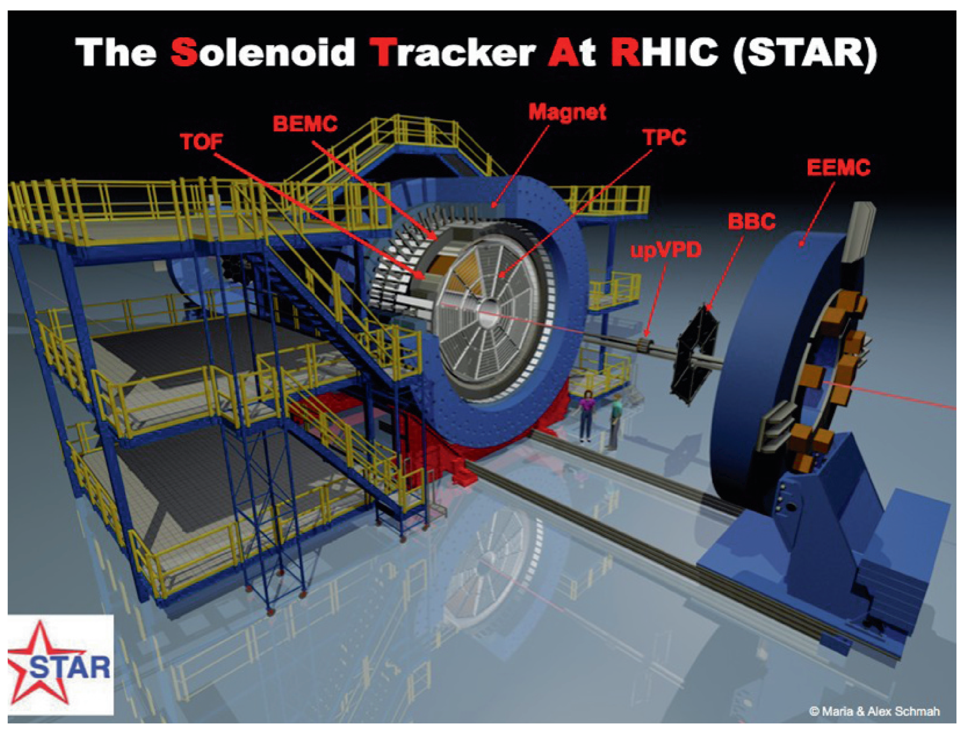
The Solenoidal Tracker At RHIC is a multi-purpose detector exceling at tracking and identification of charged particles at mid-rapidity in the high multiplicity environment of heavy ion collisions. The main subsystems used in this analysis are:

Time Projection Chamber (TPC)

- Full 2π azimuthal coverage
- Pseudorapidity -1.3 < η < 1.3
- Charged particle tracking and momentum reconstruction
- Particle identification via specific ionization energy loss dE/dx

Time of Flight (TOF)

- Timing resolution <100 ps
- Particle identification via 1/β
- Together with TPC provides a good separation of electrons from heavier hadrons up to about 1.5 GeV/c



Barrel Electromagnetic Calorimeter (BEMC)

- Tower Δη×Δϕ = 0.05×0.05
- Electron-hadron separation using p/E at high momentum

Data Analysis

Data used are 377M minimum bias uranium collisions at $\sqrt{s_{NN}}$ = 193 GeV taken in 2012.
Electrons are selected from good trajectories using TPC, TOF and BEMC:

TPC

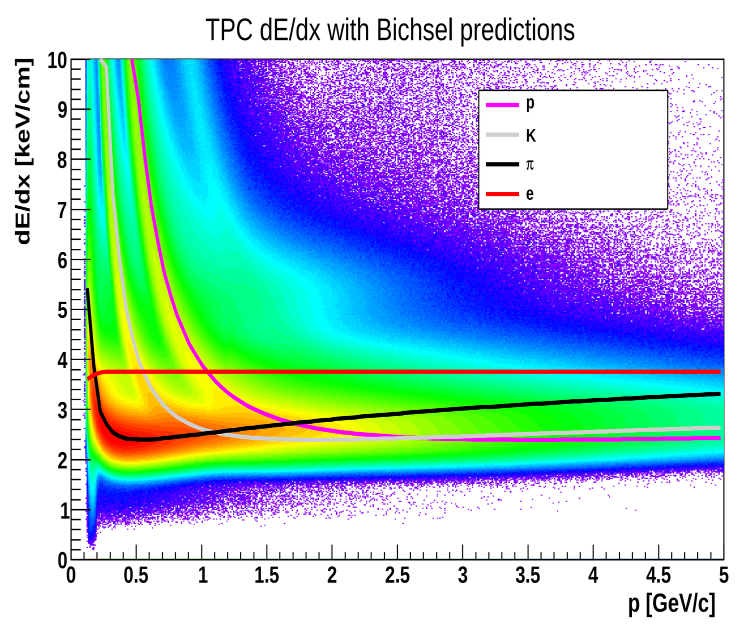
- nσ - distance from the expected mean value of the energy loss expressed as number of standard deviations
- -1.5 < nσ electron < 2
- |nσ pion| > 2.5

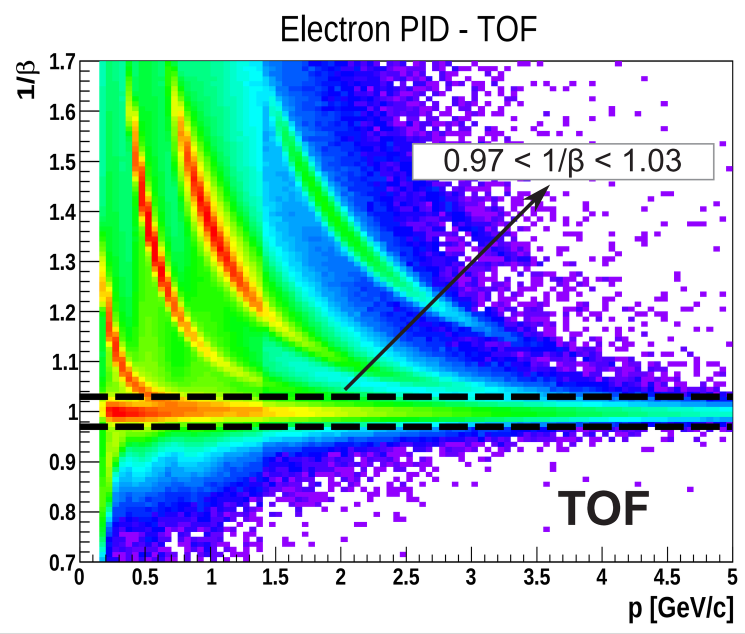
TOF

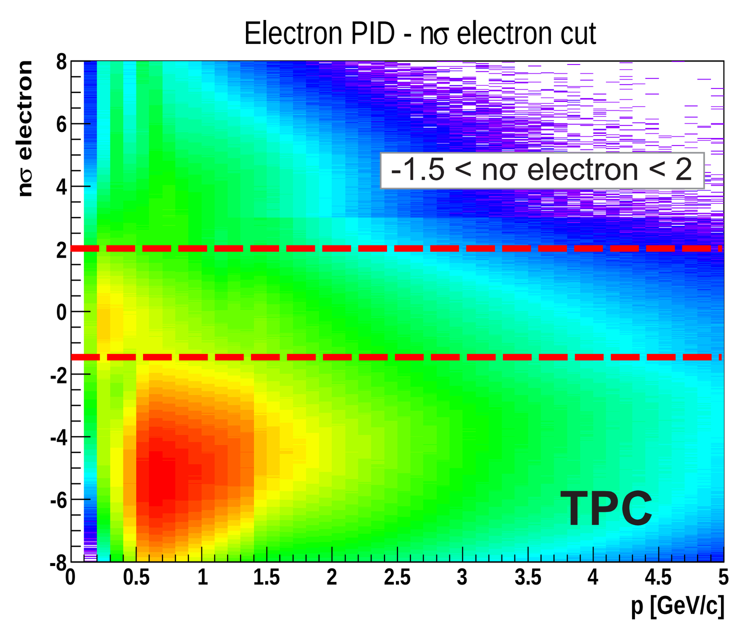
- 0.97 < 1/β < 1.03
- Used: • p < 1.4 GeV/c — strictly required
  • p > 1.4 GeV/c — only if the particle has a TOF signal

BEMC

- Used only for p > 1.4 GeV/c
- 0.3 < p/E < 1.5

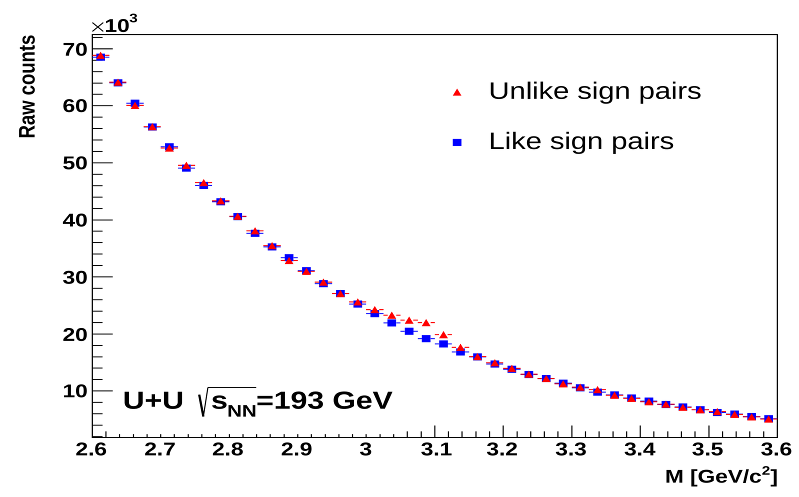


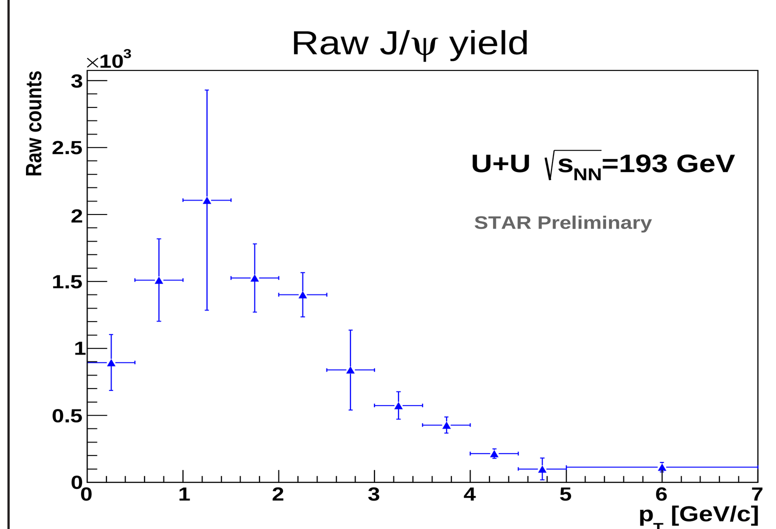


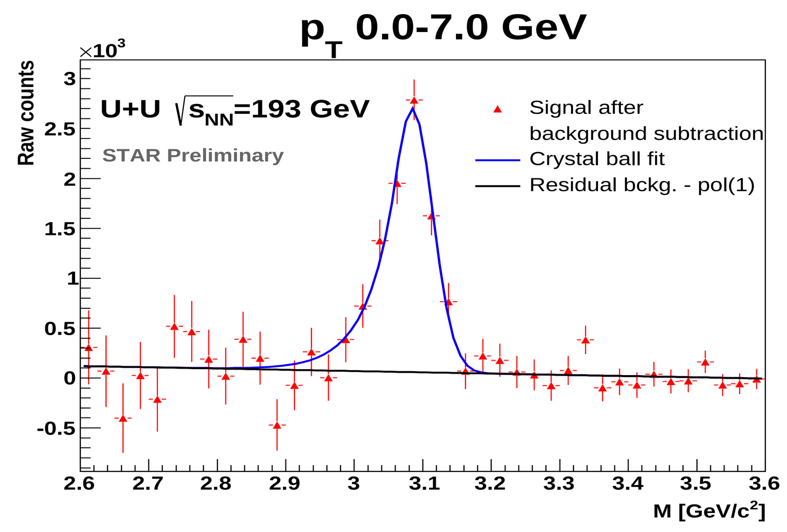


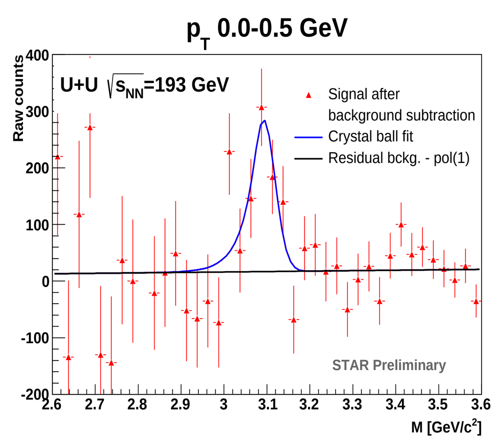
Results

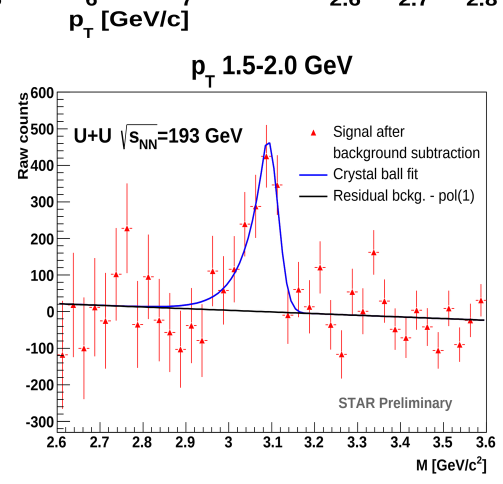
- J/ψ → e^+e^- channel used for the analysis (branching ratio 5.9%)
- Combinatorial background reconstruction: Like-sign method (e^+e^+ + e^-e^- pairs)
- Signal significance calculated in mass region (2.9 - 3.2) GeV/c² as $sg = \frac{S}{\sqrt{S+2B}}$
- S = 9440 ± 640 with significance 12.9 σ
- Signal divided into 11 p_T bins from 0 to 7 GeV/c with significance from 3.0 to 6.5 σ

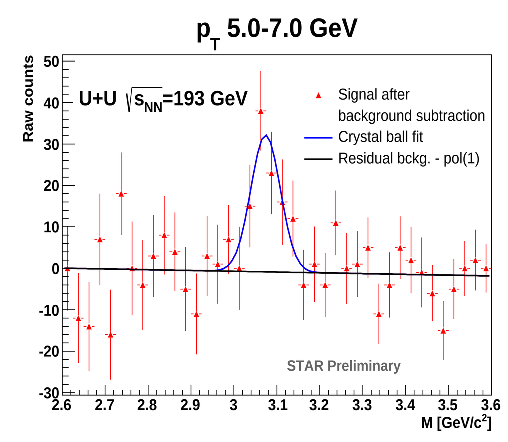












Conclusions and Perspectives

- J/ψ signal of significance of 12.9 σ observed
- Signal was divided into several p_T bins
- Studies of efficiency corrections and detectors effects are currently underway

References

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Acknowledgements

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