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

Ota Kukral* for the STAR Collaboration

Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University, Prague

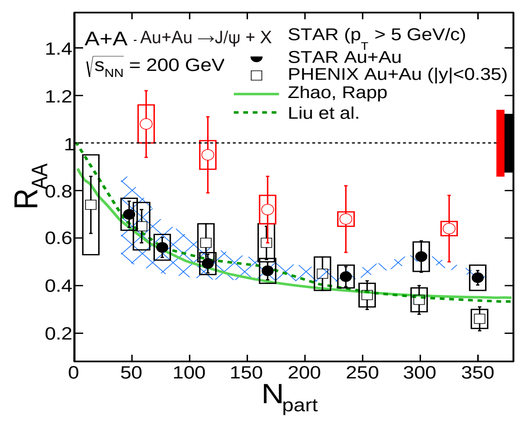
Abstract

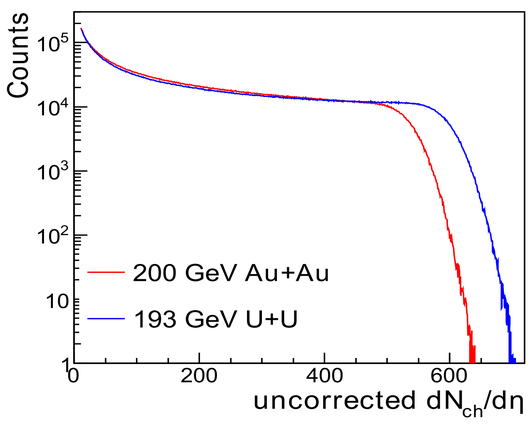
Suppression of quarkonium production in high-energy nuclear collisions relative to proton-proton collisions, due to color screening of the quark-antiquark potential, has been predicted to be a sensitive indicator of the temperature of the created QGP. However, initial state cold nuclear matter effects, 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 quarkonium production in different colliding systems are hence crucial for disentangling relative contributions of these effects. At the STAR experiment we can utilize collisions of uranium nuclei to further study the quarkonia suppression pattern. Since the uranium nuclei are non-spherical and larger than Au nuclei, we are able to reach higher energy densities in the most central U+U collision compared to Au+Au collisions. In this poster, we will present the transverse momentum spectrum ($0 < p_T < 6$ GeV/c) and nuclear modification factor of J/ψ production, reconstructed at midrapidity via di-electron decay channel, in minimum bias 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. However, the interpretation of such medium-induced modification requires a good understanding of J/ψ production mechanisms in p+p collisions and cold nuclear matter effects in d+Au collisions.
Higher achievable energy density in uranium collisions could be used to further study quarkonium production [1].

- **Top picture** [2,3]: R_{AA} dependence on centrality of Au+Au collisions for all p_T and for high p_T only. J/ψ suppression in Au+Au increases with the centrality and decreases toward higher p_T across the measured centrality range. The data are compared to models that include contributions from prompt production and statistical charmonium regeneration [4,5]
- **Bottom picture** [6]: Charged-track multiplicity for Au+Au and U+U collisions. Top values of charged-track multiplicity are higher in U+U collisions, which is caused by higher initial energy density.



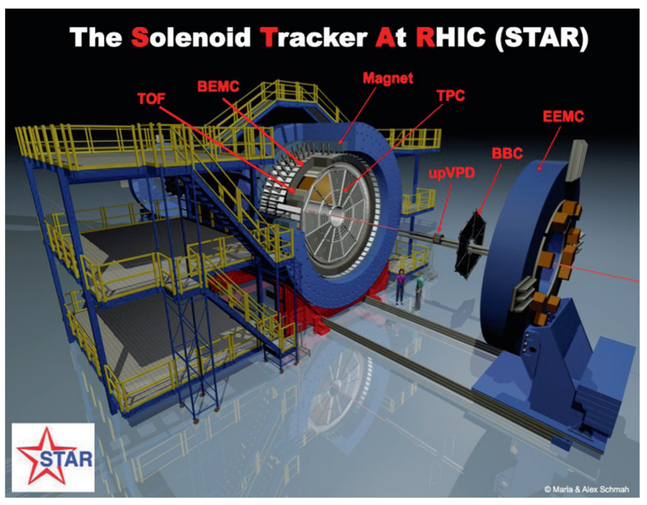


STAR Experiment

The Solenoidal Tracker At RHIC (STAR) 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 $-1.3 < \eta < 1.3$
- Charged particle tracking and momentum reconstruction
- Particle identification via ionization energy loss dE/dx



Time of Flight Detector (TOF)

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

Barrel Electromagnetic Calorimeter (BEMC)

- Tower $\Delta\eta \times \Delta\varphi = 0.05 \times 0.05$
- Electron-hadron separation using p/E at high momentum

Data Analysis

Data used are 377M minimum bias U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV taken in 2012.
Electrons are selected from good quality tracks with $|\eta|<1$ 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

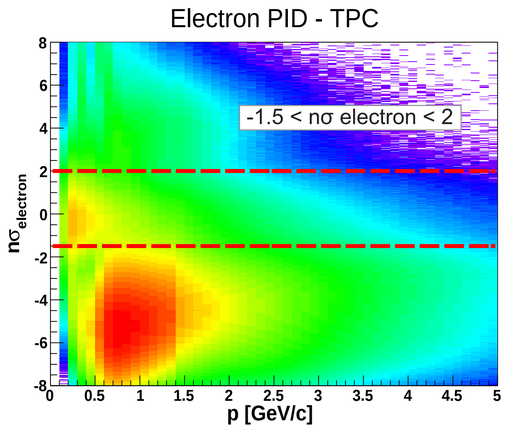
TOF

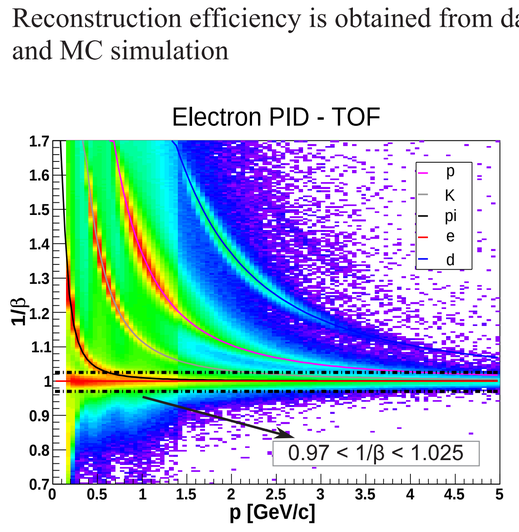
- $0.97 < 1/\beta < 1.025$
- Used: • $p <$ 1.4 GeV/c — strictly required
  • $p >$ 1.4 GeV/c — only if the particle has a TOF signal

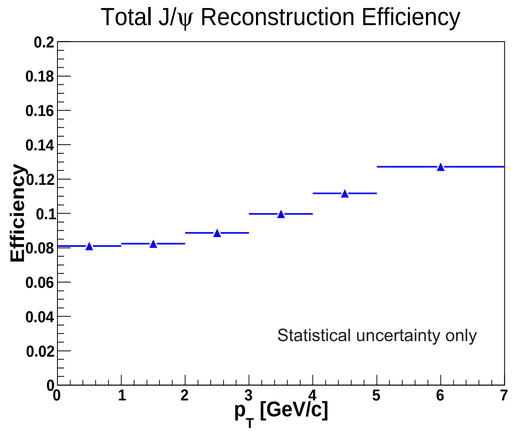
BEMC

- Used only for $p >$ 1.4 GeV/c
- $0.5 <$ pc/E < 2.0

Reconstruction efficiency is obtained from data and MC simulation







Results

- $J/\psi \rightarrow e^+e^-$ 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

$$sg = \frac{S}{\sqrt{S + 2B}}$$

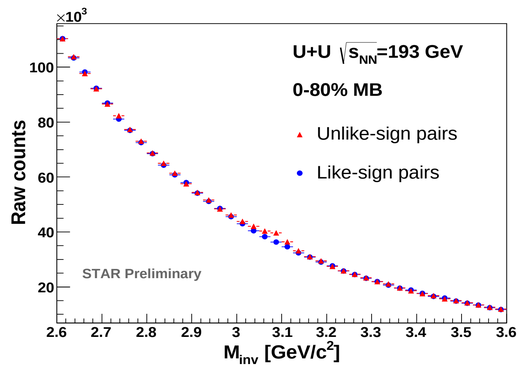
- S = 10900 ± 1300 with significance 11 σ
- Signal divided into 6 p_T bins from 0 to 7 GeV/c
- Nuclear modification factor R_{AA}:

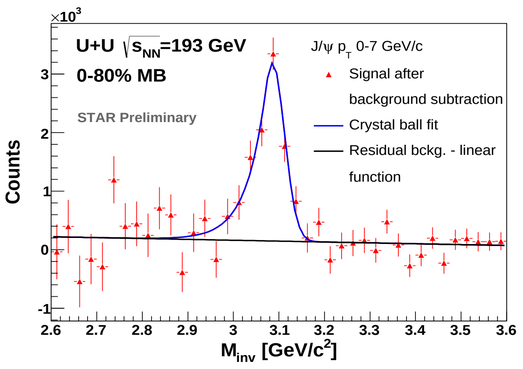
$$R_{AA} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \frac{d^2N_{AA}/dy\,dp_T}{d^2\sigma_{pp}/dy\,dp_T}$$

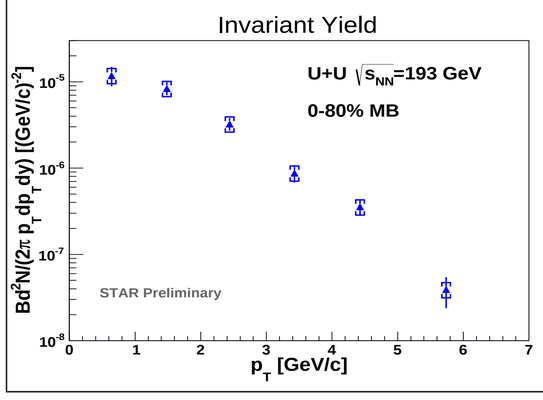
is similar as that in Au+Au collisions

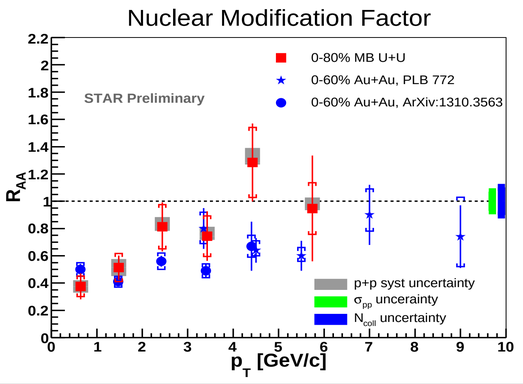
- p+p data from collisions at 200 GeV used as the baseline:

STAR [2]	$p_T > 2$ GeV/c
PHENIX [7]	$p_T < 2$ GeV/c









Conclusions and Perspectives

- J/ψ signal of significance of 11 σ (p_T 0-7 GeV/c) observed in U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV
- First STAR measurement of J/ψ nuclear modification factor in U+U presented
- Nuclear modification factor as a function of p_T is similar as in Au+Au collisions

References

[1] D. Kikola et al., Phys.Rev. C84,054907 (2011)
[2] L. Adamczyk et al. [STAR Collaboration], Phys. Lett. B722, 55-62 (2013)
[3] L. Adamczyk et al. [STAR Collaboration], ArXiv 1310.3563 (2013)
[4] Y. Liu et al., Phys. Lett B678, 72 (2009)
[5] X. Zhao and R. Rapp, Phys. Rev. C82, 064905 (2010)
[6] G. Wang, Nuclear Physics A904–905, 248c-255c (2013)
[7] A.Adare et al. [PHENIX Collaboration], PhysRevD.82, 012001 (2010)

Acknowledgement: This work was supported by the grant of the Grant Agency of Czech Republic n. 13-20841S and by the Grant Agency of the Czech Technical University in Prague, grant No. SGS13/215OHK4/3T/14.

* kukral@rcf.rhic.bnl.gov.
Presented at the Quark Matter 2014, Darmstadt, Germany, 19-24 May, 2014