Excess of J/ψ yield at very low transverse momenta in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV and U+U at $\sqrt{s_{NN}} = 193$ GeV with STAR

2017 J. Phys.: Conf. Ser. 779 012039

(http://iopscience.iop.org/1742-6596/779/1/012039)

IOP Conf. Series: Journal of Physics: Conf. Series **779** (2017) 012039 doi:10.1088/1742-6596/779/1/012039

Excess of J/ψ yield at very low transverse momenta in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U at $\sqrt{s_{NN}}$ = 193 GeV with STAR

Wangmei Zha (for the STAR collaboration)

University of Science and Technology of China, Hefei City, Anhui Province, China

wangmei@rcf.rhic.bnl.gov

Abstract. In this article, we report the STAR measurements of J/ψ production at very low transverse momenta (p_T) in hadronic Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV at mid-rapidity. Centrality dependence of J/ψ yields and nuclear modification factors at very low p_T are also presented.

1. Introduction

The Relativistic Heavy Ion Collider (RHIC) is built to search for the Quark-Gluon Plasma (QGP) and to study its properties in laboratory through high energy heavy-ion collisions [1]. J/ψ suppression in "hadronic" heavy-ion collisions, due to color screening of quark and antiquark potential in the deconfined medium, has been proposed as a signature of the QGP formation [2]. Other mechanisms, such as the cold nuclear matter effect [3,4] and charm quark recombination [5], are likely to contribute to the observed modification of J/ψ produced in "hadronic" heavy-ion collisions.

The J/ψ can also be produced via the strong electromagnetic fields generated by heavy ions, e.g. photon-nucleus coherent or incoherent interactions [6], in ultra-relativistic heavy-ion collisions. This has been studied in detail in Ultra-Peripheral Collisions (UPC), where the impact parameter can reach several tens of femtometers and no hadronic interactions occur. Can this electromagnetic process also exist in "hadronic" heavy-ion collisions?

Recently, a significant excess of J/ψ yield at very low transverse momenta (p_T < 0.3 GeV/c) has been observed by the ALICE collaboration in peripheral hadronic Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV at forward-rapidity [7], which cannot be explained within the hadronic J/ψ production modified by the cold and hot medium effects. The excess observed may originate from the coherent photon-nucleus interactions, which would be very challenging for the existing models. Measurements of J/ψ production at very low p_T in different collision energies, collision systems, and collision geometries can shed new light on the origin of the excess.

In this article, we report the STAR measurements of J/ψ production at very low p_T in hadronic Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV at mid-rapidity. Centrality dependence of J/ψ yields and nuclear modification factors at very low p_T are also presented.

2. Experiment and Analysis

The STAR experiment is a large-acceptance multi-purpose detector which covers full azimuth and pseudorapidity of $|\eta| < 1$ [8]. The Au+Au and U+U data were obtained using a minimum-bias trigger which requires coincidence signals in the Vertex Position Detector (VPD) and the Zero Degree Calorimeter (ZDC). In this analysis, the J/ψs are reconstructed through their decay into electron-position pairs, $J/\psi \rightarrow e^+e^-$ (branching ratio Br_{e+e-}=5.97±0.03% [9]). The primary detectors used in this analysis are the Time Projection Chamber (TPC) [10], the Time-of-Flight (TOF) detector [11], and the Barrel Electromagnetic Calorimeter (BEMC) [12]. The electron identification and J/ψ reconstruction techniques are similar to those shown in [13,14].

3. Results

Figure 1 shows the J/ψ invariant yields for Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV as a function of p_T for different centralities at mid-rapidity ($|y| < 1$). The error bars depict the statistical uncertainties. The boxes represent the systematic uncertainties. The solid lines in the figure are the fits using Eq. 1, wherein a, b, and n are free parameters, to data points in the range $p_T > 0.2$ GeV/c. The dashed lines are the extrapolations of the fits. As shown in the figure, the fits describe the data points above 0.2 GeV/c very well, but significantly underestimate the yield bellow 0.1 GeV/c for all three centrality bins.

$$\frac{d^2N}{p_T dp_T} = a \times \frac{1}{(1+b^2p_T^2)^n} \quad (1)$$

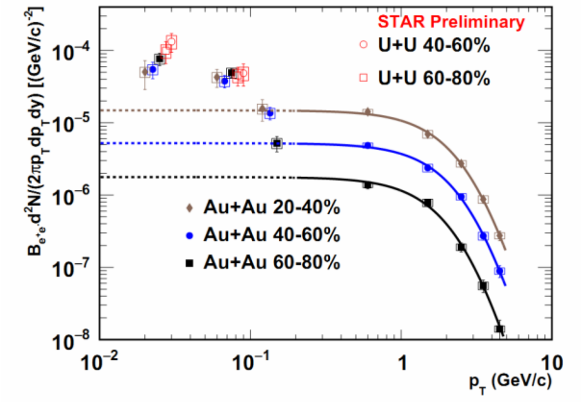

Figure 1. J/ψ invariant yields for Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV as a function of p_T for different centralities at mid-rapidity.

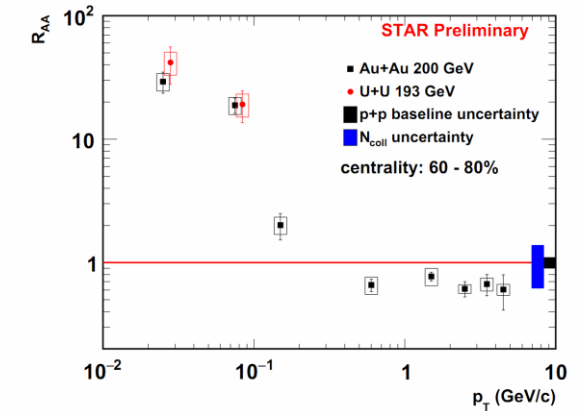

Figure 2. J/ψ R_{AA} as a function of p_T for centrality 60-80%.

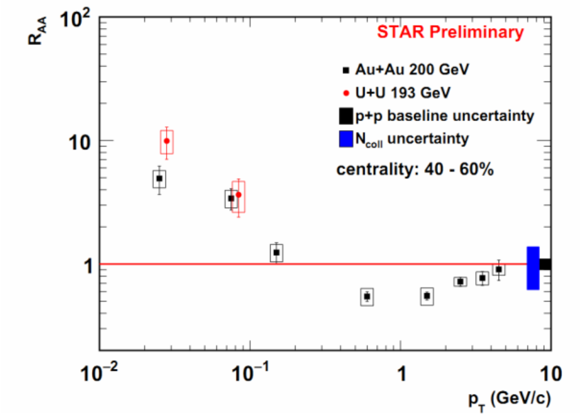

Figure 3. J/ψ R_{AA} as a function of p_T for 40-

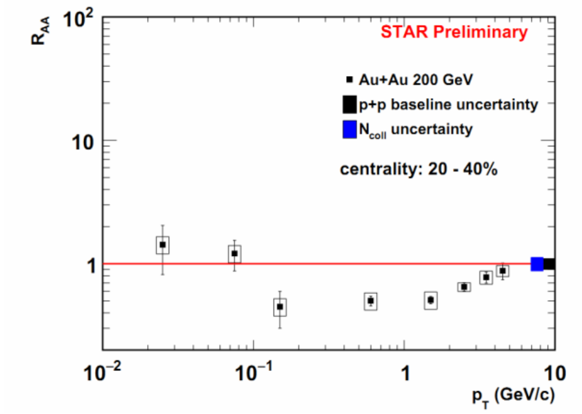

Figure 4. J/ψ R_{AA} as a function of p_T for 20-

60%. 40%.

The J/ψ R_{AA} as a function p_T for centralities 60-80%, 40-60%, and 20-40% are shown in Figures 2, 3, and 4, respectively. The pp baselines used for R_{AA} calculations are derived from [15]. Significant excess of J/ψ yield in the p_T range 0-0.1 GeV/c is observed for peripheral collisions (40-80%). The kinematic range of the enhancement is almost the same as that of coherent photon nucleus interactions, which indicates that the excess may originate from the coherent production.

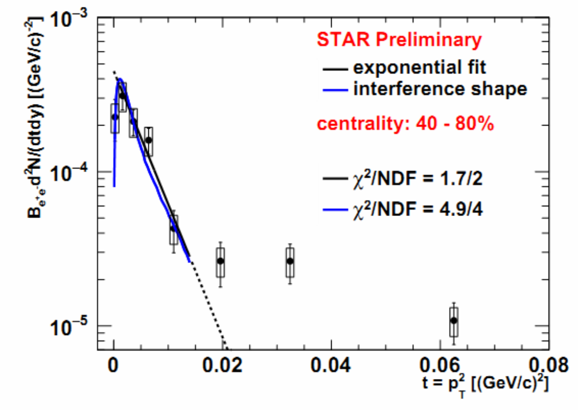

Figure 5. J/ψ invariant yield as a function of the momenta transfer squared t for 40-80% Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

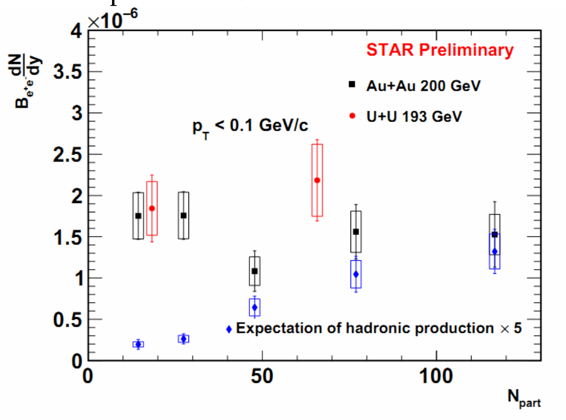

Figure 6. The p_T integrated J/ψ yields (p_T < 0.1 GeV/c) as a function of N_{part} for Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The expectation of hadronic production (scaled by a factor of 5) is also shown for comparison.

Assuming that the coherent photoproduction causes the excess at very low p_T, the J/ψ yield as a function of the momenta transfer squared t ($t \approx p_T^2$) for 40-80% Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV are shown in Figure 5. The structure of the distribution is very similar to that observed in UPC case [16]. An exponential fit has been applied to the distribution in t range 0.002-0.015 (GeV/c)^2. The extracted slope parameter is 196±31 (GeV/c)$^{-2}$, which is consistent with that of Au nucleus (199 [GeV/c]$^{-2}$). As shown in the figure, the first data point is significantly lower than the extrapolation of the exponential fit, which may be an indication of interference. The theoretical calculation with interference for the UPC case [17], shown as the blue curve in Figure 5, can describe the data very well (χ^2/NDF = 4.9/4) for t < 0.015 (GeV/c)$^{-2}$.

Figure 6 shows the p_T integrated J/ψ yields (p_T < 0.1 GeV/c) as a function of N_{part} for 30-80% Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The integrated J/ψ yields show no significant centrality dependence. This is beyond the expectation of hadronic production, which, scaled by a factor of 5, is also plotted for comparison. As depicted in the figure, the contribution of hadronic production is not dominant in the excess range. The integrated J/ψ yields at p_T interval 0-0.1 GeV/c in U+U collisions are similar to those in Au+Au collisions.

4. Summary

In summary, we report the recent STAR measurements of J/ψ production at very low p_T in hadronic Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV and U+U collisions at $\sqrt{s_{NN}} = 193$ GeV at mid-rapidity. Centrality dependence of J/ψ production, nuclear modification factors, and dN/dt distributions at very low p_T are also reported. Significant excess of J/ψ yield at p_T interval 0-0.1 GeV/c is observed for peripheral collisions (40-80%). The excess for 30-80% centrality range shows no significant centrality dependence within uncertainties, which is beyond the expectation from hadronic production. The characteristics of the excess are consistent with the expectation of coherent photon-nucleus interactions.

References

[1] M. Harrison *et al.*, Nucl Instrum Meth A **499**, 235 (2003).
[2] T. Matsui and H. Satz, Phys Lett B **178**, 416 (1986).
[3] E. G. Ferreiro *et al.*, Phys Lett B **680**, 50 (2009).
[4] F. Arleo and S. Peigene, J High Energy Phys **10**, 073 (2014).
[5] L. Grandchamp *et al.*, Phys Rev Lett **92**, 212301 (2004).
[6] C. A. Bertulani *et al.*, Annu Rev Nucl Part S **55**, 271 (2005).
[7] J. Adam (ALICE Collaboration) *et al.*, Phys Rev Lett **116**, 222301 (2016).
[8] K. H. Ackermann *et al.*, Nucl Instrum Meth A **499**, 624 (2003).
[9] K. A. Olive *et al.*, Chinese Phys C **38**, 090001(2014).
[10] M. Anderson *et al.*, Nucl Instrum Meth A **499**, 659 (2003).
[11] W. J. Llope, Nucl Instrum Meth A **661**, S110 (2012).
[12] M. Beddo *et al.*, Nucl Instrum Meth A **499**, 725 (2003).
[13] L. Adamczyk (STAR Collaboration) *et al.*, Phys Rev C **90**, 024906 (2014).
[14] L. Adamczyk (STAR Collaboration) *et al.*, arXiv preprint arXiv:1607.07517 (2016).
[15] W. M. Zha *et al.*, Phys Rev C **93**, 024919 (2016).
[16] B. I. Abelev (STAR Collaboration) *et al.*, Phys Rev C **77**, 034910 (2008).
[17] S. R. Klein and J. Nystrand, Phys Rev Lett **84**, 2330 (2000).