Excess of J/ψ yield at very low p_T in A+A collisions from STAR

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Abstract

J/ψ suppression in 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. Other mechanisms, such as the cold nuclear matter effects and charm quark recombination, are likely to contribute to the observed modification of J/ψ production in heavy-ion collisions. Recently, a significant excess of J/ψ yield at very low transverse momentum (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, which can not be explained within the scenarios mentioned above. The observed excess may originate from the coherent photoproduction of J/ψ, which would be very challenging for the existing coherent photoproduction models developed for ultra-peripheral collisions. Measurements of J/ψ production at very low p_T in different collision energies, collision systems, and centralities can shed new lights on the origin of the excess .

In this poster, we report on 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 production yields and nuclear modification factors will be presented.

Motivation

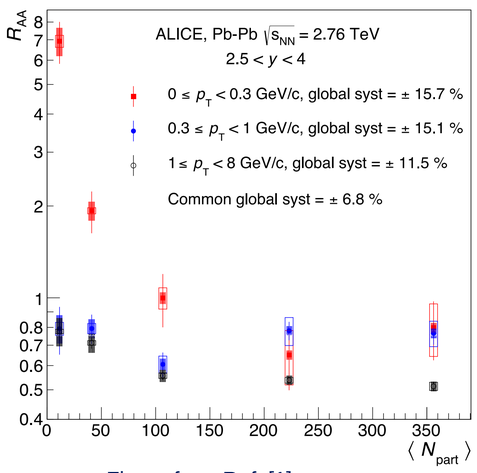
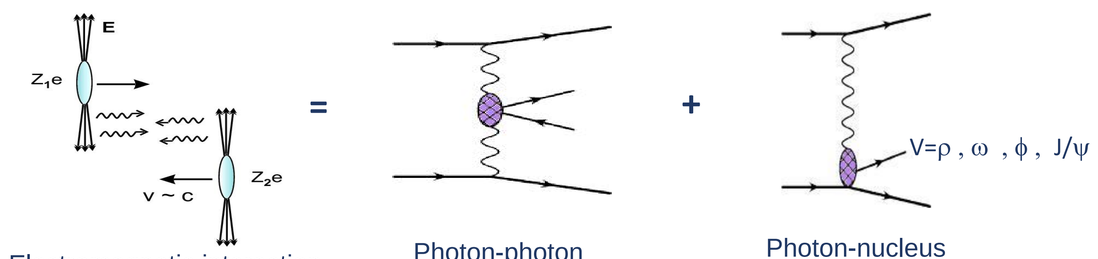


Figure from Ref. [1]

- ✓Significant enhancement of J/ψ yield observed in p_T interval 0 – 0.3 GeV/c for peripheral collisions (50 – 90%) by ALICE.
- ✓Cannot be described by hadronic production modified by the hot medium or cold nuclear matter effects!
- ✓Originate from coherent photon-nucleus interactions?
- ➢Measurements of J/ψ yield at very low p_T in hadronic collisions (U+U and Au+Au) from STAR:
  - ➢Enhancement of J/ψ yield at very low p_T?
  - ➢If so, what are the properties and the origin of the excess?
    - ➢p_T , centrality and system size dependence of the excess; t distribution.

Introduction to photon interactions in A+A collisions



Electromagnetic interaction | Photon-photon interactions | Photon-nucleus interactions

- ✓This large flux of quasi-real photons makes a hadron collider also a photon collider!
- ➢Photon-nucleus interactions:
  - ➢Coherent: emitted photon interacts with the entire target nucleus.
  - ➢Incoherent: emitted photon interacts with nucleon or parton individually.

Details can be found in Ref. [2]

Features of coherent photon-nucleus interactions

- Coherently:
  - ✓Both nuclei remain intact
  - ✓Photon/Pomeron wavelength $\lambda = \frac{h}{p} > R_A$
  - ✓$p_T < h/R_A$ ~30 MeV/c for heavy ions
  - ✓Strong couplings ($Z\alpha_{EM}$ ~ 0.6) → large cross sections
- Interference:
  - ✓Two indistinguishable processes (photon from A_1 or A_2)
  - ✓Vector meson → opposite signs in amplitude
  - ✓Significant destructive interference for p_T << 1/<b>

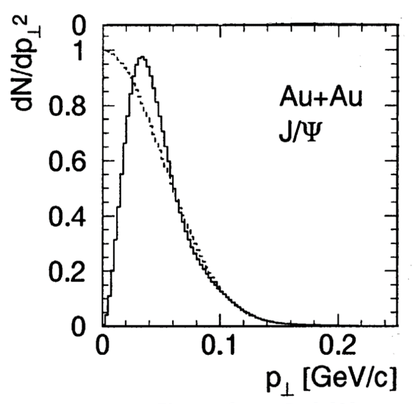
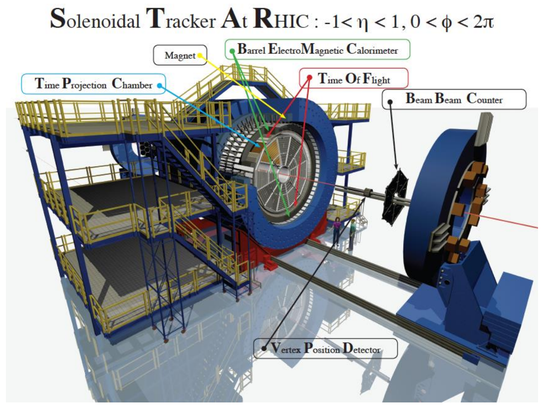


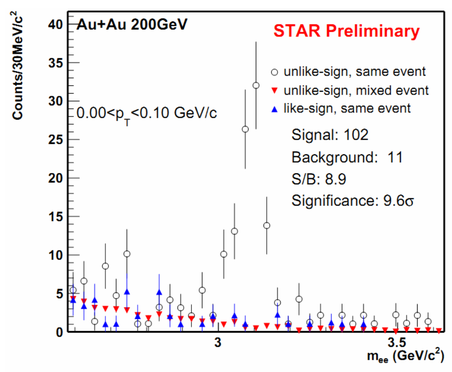
Figure from Ref. [3]

STAR detector

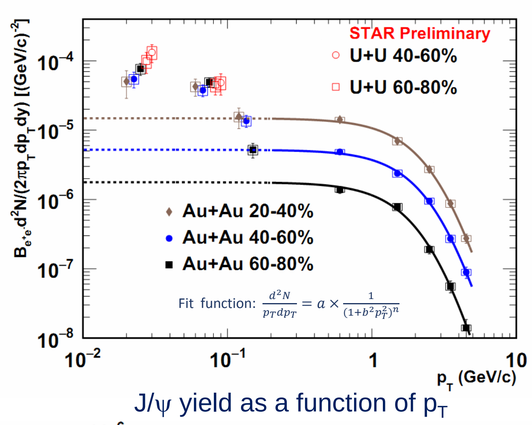


- ➢Large acceptance: |η| < 1, 0 < ϕ < 2π
- ➢Time Projection Chamber (TPC) – tracking, particle identification, momentum
- ➢Time of Flight detector (TOF) – particle identification
- ➢Barrel ElectroMagnetic Calorimeter (BEMC) – electron identification, triggering

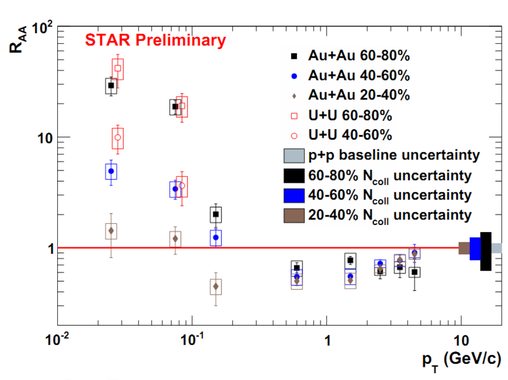
Results Ⅰ --- J/ψ production at very low p_T



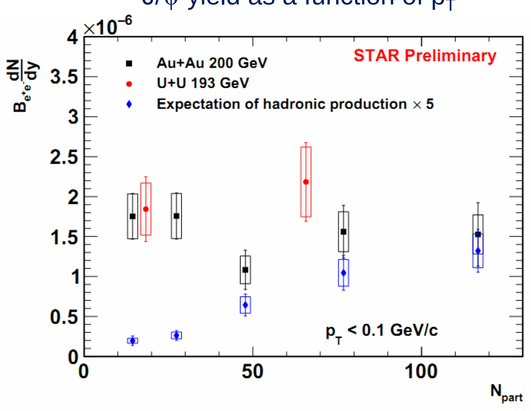
J/ψ signal



J/ψ yield as a function of p_T



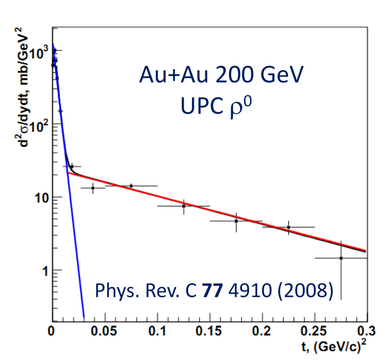
J/ψ R_{AA} as a function of p_T in different centrality bins



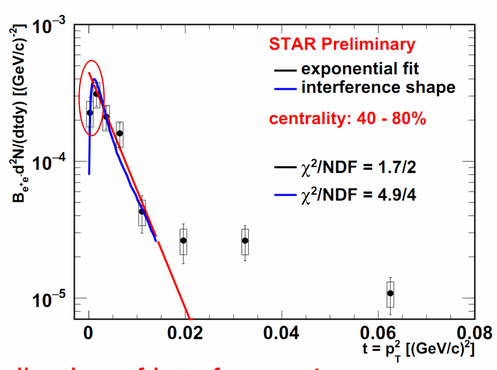
J/ψ yield as a function of centrality

- ✓Excess observed in peripheral collisions (40-80%) for p_T < 0.2 GeV/c!
- ✓No significant centrality dependence in Au+Au collisions (30 – 80%)!

Results Ⅱ --- J/ψ dN/dt distribution at very low p_T



- ☐The slope from the exponential fit reflects the shape of the target.



- ✓Indication of interference!
- ✓Slope parameter (196±31 [GeV/c]$^{-2}$) consistent with the Au nucleus size (199)!

Summary

- ✓Significant excess of J/ψ yield at p_T interval 0 – 0.2 GeV/c is observed for peripheral collisions Au+Au and U+U collisions (40 – 80%).
- ✓The excess shows no significant centrality dependence in Au+Au collisions (30 – 80%) , which is beyond the expectation from the hadronic production.
- ✓The properties of the excess are consistent with the characteristics of coherent photon-nucleus interactions.
  - ✓Similar dN/dt distribution to that in the case of ultra-peripheral collisions.
  - ✓Indication of interference at p_T interval 0 – 0.03 GeV/c.
  - ✓The extracted nuclear form factor slope is consistent with nucleus size.

References

[1] J. Adam *et al.* (ALICE) 2016 *Phys. Rev. Lett.* **116** 222301
[2] A. Bertulani, S. Klein and J. Nystrand 2005 *Ann. Rev. Nucl. Part. Sci.**55** 271*
[3] S. Klein 2000 *Phys. Rev. Lett.* **84** 2330

NSFC National Natural Science Foundation of China

The STAR Collaboration
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