Probing gluon structure with J/ψ photoproduction in isobaric ultra-peripheral collisions at $\sqrt{s_{NN}}$ = 200 GeV with the STAR

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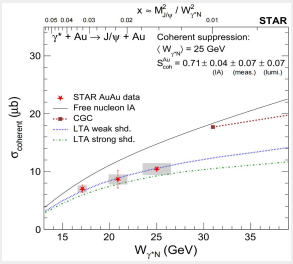
Abstract

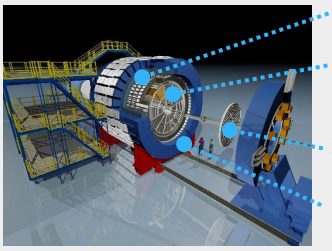
In ultra-peripheral collisions (UPCs), coherent J/ψ photoproduction has been recognized as one of the most sensitive probes of the nuclear gluon distribution. The collision system size in isobaric collisions ($^{96}_{44}Ru + ^{96}_{44}Ru$ and $^{96}_{40}Zr + ^{96}_{40}Zr$) lies between d+Au and Au+Au collisions. Therefore, the measurement of coherent J/ψ photoproduction in isobaric UPCs offers a unique opportunity to study the system size dependence of gluon structure. In this poster, we present the differential cross sections of photoproduced coherent J/ψ as a function of rapidity (y) in isobaric UPCs at $\sqrt{s_{NN}}$ = 200 GeV. These data provide crucial constraints on the system size dependence of the gluon structure function within nuclei in the kinematic range x_{parton}, the momentum fraction carried by the gluon, ~0.015−0.03. The results are compared with STARlight and previous STAR measurements. Physics implications are also discussed.

1. Motivation



- The measurement of the coherent J/ψ cross section in Au+Au collisions provides insight into the gluon structure of heavy nuclei and shows good agreement with the shadowing model[1][2].
- A direct probe of the system-size dependence of the gluon structure can be made using Ru+Ru and Zr+Zr collisions.

2. STAR Detector



Barrel ElectroMagnetic Calorimeter
- Trigger and identify electron/positron

Time Projection Chamber
- Tracking
- Particle identification (dE/dx)

Beam-Beam Counters
- Trigger UPC events

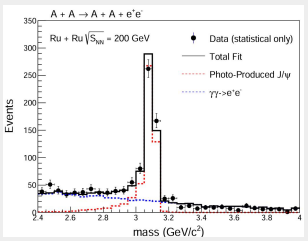
Time Of Flight Detector
- Time of flight
- Particle identification

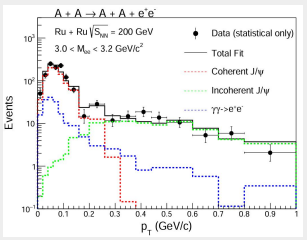
3. Dataset and Analysis Details

- Dataset: Run18 Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV
- Luminosity: 2.6 nb^{-1} for each Ru+Ru and Zr+Zr
- Trigger Requirements for UPC Coherent Events:
  - 2 ≤ TOF multiplicity ≤ 6
  - EMC have back to back high tower hit
  - No signal in BBCs from both sides
- Event Selection:
  - $|V_z| < 100$ cm with UPC trigger requirement
  - BEMC clusters ≤ 6 with UPC trigger requirement
- Track Selection:
  - TPC hits used to reconstruct tracks ≥ 15
  - TPC hits used to calculate dE/dx ≥ 11
  - $|\eta_e| < 1$
- Electron Identification:
  - $\chi^2_{ee} = n\sigma^2_{e1} + n\sigma^2_{e2} < 10$ && $\chi^2_{ee} < \chi^2_{\pi\pi}$, $n\sigma_e = \frac{1}{R_{dE/dx}} log \frac{\langle dE/dx \rangle^{Mea.}}{\langle dE/dx \rangle^{Th.}_e}$

4. Raw Signal

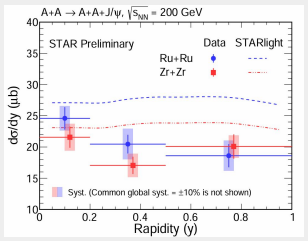
- $J/\psi \rightarrow e^+ + e^-$, Br = 5.92 %.

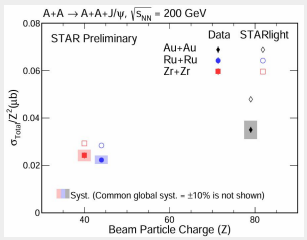




- The uncorrected p_T and mass spectra were reconstructed from the data.
- A combined fit, incorporating coherent J/ψ, incoherent J/ψ (EPA-VMD) and $\gamma\gamma \rightarrow e^+e^-$ (QED calculation) contributions, was applied to the mass and p_T spectra to extract the coherent J/ψ yields[3][4]. The same fitting method is applied separately to three rapidity bins: [0,0.2], [0.2,0.5], and [0.5,1.0].

5. Physics Results





- Left: coherent J/ψ cross section as function of rapidity, fully corrected for efficiency, in ultra-peripheral Ru+Ru and Zr+Zr collisions.
  - The measured data is lower than the STARlight prediction.
- Right: the J/ψ cross section as a function of Z, scaled by 1/Z², for data and STARlight simulation.
  - Photon flux dependence is roughly cancelled by dividing by Z².
  - The measured data is lower than STARlight predictions, indicating shadowing effects in coherent photoproduction of J/ψ in Ru, Zr, and Au.
  - There is no significant system size dependence.

6. Summary

- The coherent J/ψ cross section is lower than predicted by STARlight, but shows a similar trend with rapidity in isobaric UPCs.
- The J/ψ cross section scaled by 1/Z² also shows the data is lower than STARlight, indicating shadowing effects, but there is no significant system size dependence.

7. References

[1] M. I. Abdulhamid et al. (STAR), Phys. Rev. Lett. 133, 052301 (2024)
[2] M. I. Abdulhamid et al. (STAR), Phys. Rev. C. 110, 014911 (2024)
[3] P. Wang et al, Chinese Phys. C. 46074103 (2022)
[4] W. Zha et al, Phys. Lett. B. 800, 135089 (2020)

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