Low-p_T $\mu^+\mu^-$ pair production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR

Zhen Liu, *for the STAR Collaboration*

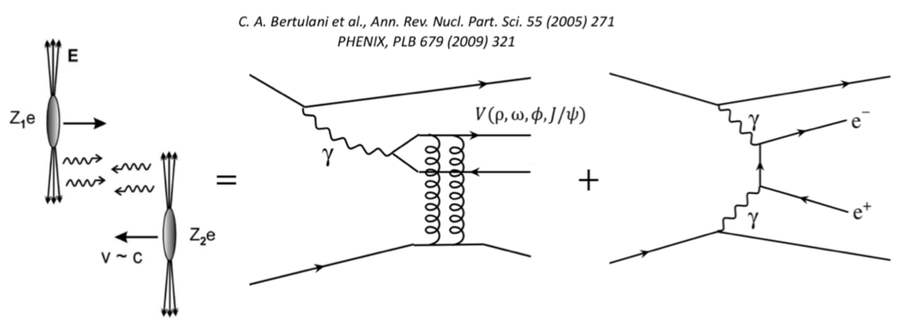
University of Science and Technology of China

State Key Laboratory of Particle Detection and Electronics

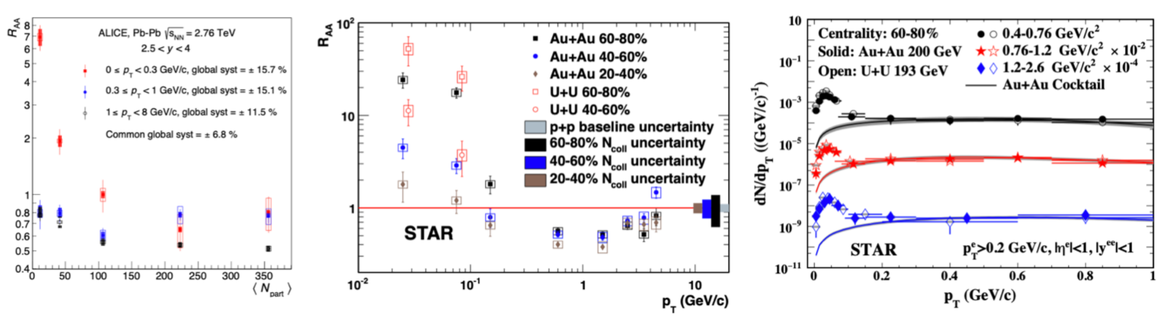
Abstract

In high energy heavy-ion collisions, the strong electromagnetic (EM) fields of the nuclei can produce energetic, high-density photon fluxes, leading to photon-induced interactions. Recently, significant enhancements of e^+e^- pair and J/ψ at very low transverse momentum (p_T) were observed by the STAR collaborations in peripheral hadronic A+A collisions. The excess yields are suggestive of coherent photon-nucleus and photon-photon interactions in violent hadronic heavy-ion collisions, which were conventionally studied only in ultra-peripheral collisions. Measurements with $\mu^+\mu^-$ pairs provide a complementary channel to investigate these phenomena.
In 2014 and 2016, the STAR experiment at RHIC recorded large samples of Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with di-muon triggers utilizing the Muon Telescope Detector. In this poster, we present the uncorrected invariant mass distributions as a function of centrality for inclusive $\mu^+\mu^-$ pair production at $p_T < 0.15$ GeV/c in the mass range large than 2.6 GeV/c^2. The uncorrected p_T distribution of the excess yields for these very low p_T $\mu^+\mu^-$ pairs are also shown.

Motivation



- The strong electromagnetic field, generated by two colliding ions, can be treated as quasi-real photons. The large quasi-real photon flux ($\propto Z^2$) can generate various photon interactions:
  - Photon-nuclear interaction (vector mesons) $\propto Z^2$
  - Photon-photon interaction (dilepton …) $\propto Z^4$
  - Distinctly peaked at low p_T
- Conventionally studied in ultraperipheral collisions (UPCs) -> Can the photon-induced interactions also occur in hadronic heavy-ion collisions, where the nuclei collide and break up?



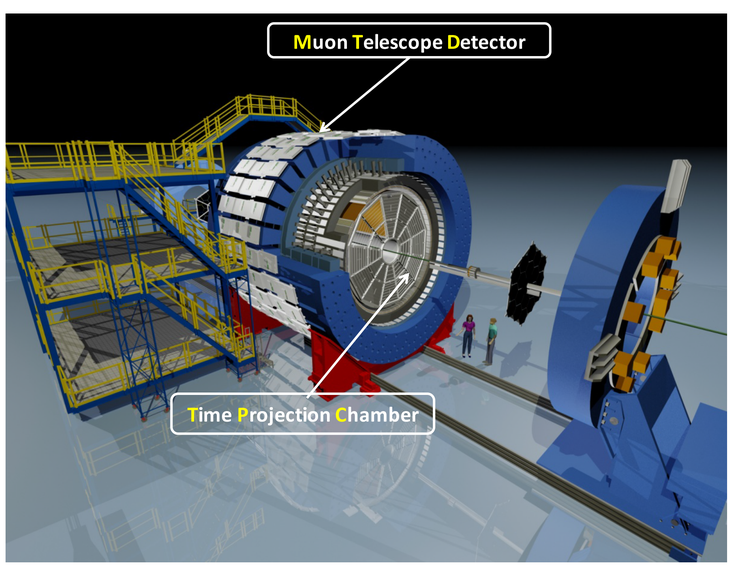
- Left[1] and middle[2]: Significant J/ψ enhancement at low p_T in peripheral collisions have been observed by the ALICE and STAR experiment
  - Cannot be explained by hadronic production accompanied with the cold and hot medium effects
  - Could be qualitatively explained by coherent photonuclear production mechanism[3]
- Right[4]: Excess e^+e^- pair p_T distribution concentrate below $p_T \sim 0.15$ GeV/c measured by the STAR experiment

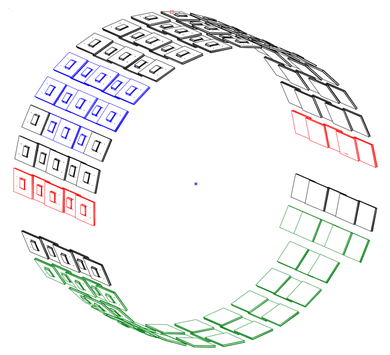
⇨Evidence of photon interactions in hadronic heavy ion collisions

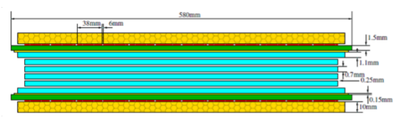
⇨Low-p_T $\mu^+\mu^-$ pairs production measurements provide a complementary channel and will help to further improve our understanding of photon-induced processes

STAR Experiment

- The STAR experiment is a mid-rapidity detector ($|\eta| < 1$) with full azimuthal coverage

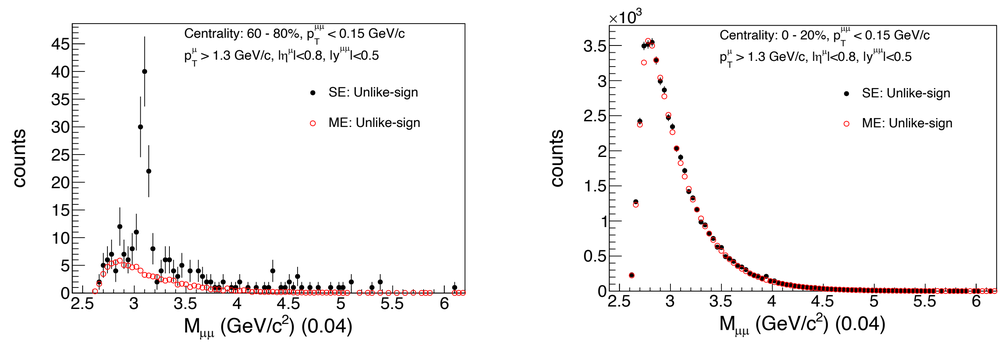






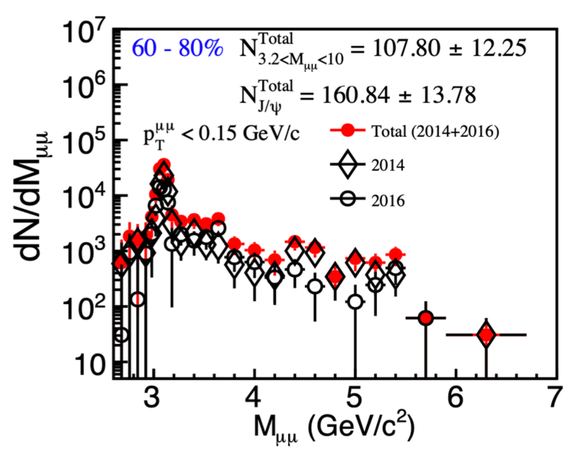
- Top right: A schematic view of the entire Muon Telescope Detector (MTD) system. MTD covers 45% in φ and $|\eta| < 0.5$. It is used to trigger on and identify muons which emit less Bremsstrahlung radiation compared to electrons
- Bottom right: A schematic side-view of the Multi-gap Resistive Plate Chambers with long readout strips (LMRPC) used in the MTD design: time resolution ~100 ps and spatial resolution ~1-2 cm[5]

Signal extraction

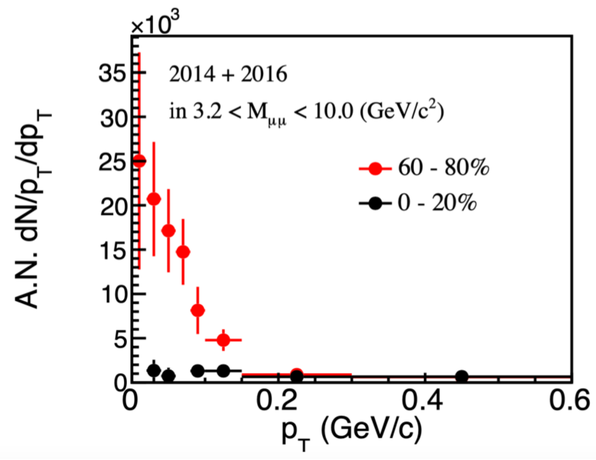


- Examples of the $\mu^+\mu^-$ invariant mass distribution for $p_T < 0.15$ GeV/c in peripheral (left) and central (right) collisions before background subtraction, shown in black points
- The mixed-event technique is used to estimate the combinatorial background, shown in red open circles

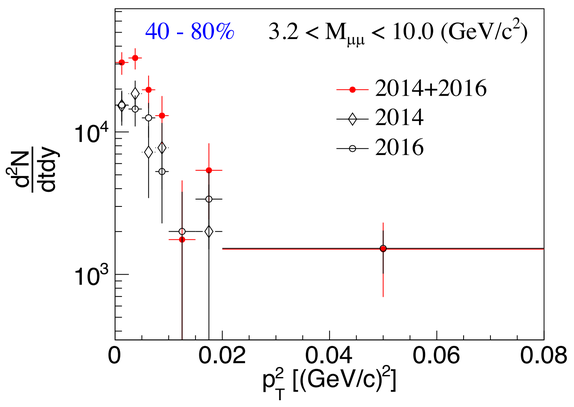
Results

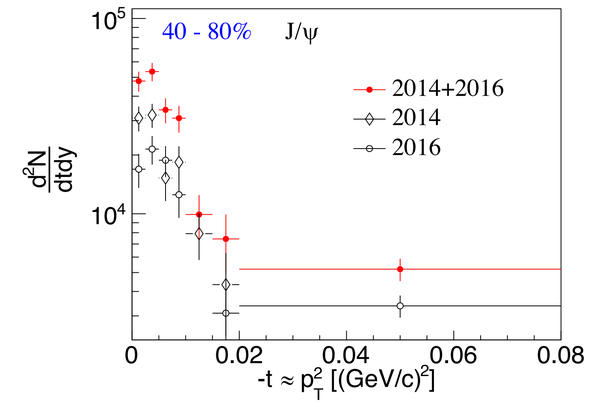


- The uncorrected $\mu^+\mu^-$ pair invariant mass distribution at $p_T < 0.15$ GeV/c in 60-80% centrality interval



- The uncorrected $\mu^+\mu^-$ pair p_T spectra in the mass region $3.2 < M_{\mu\mu} < 10$ GeV/c² in peripheral and central collisions





- The uncorrected $\mu^+\mu^-$ pair yield and J/ψ yield as a function of p_T^2 in 40-80% centrality interval
  - The efficiencies have a very weak t dependence

Conclusions and outlook

- The uncorrected invariant mass and yield distributions as a function of centrality for inclusive $\mu^+\mu^-$ pair production at $p_T < 0.15$ GeV/c in the mass range large than 2.6 GeV/c² are measured
- The uncorrected p_T distribution of the excess yields for $p_T < 0.6$ GeV/c $\mu^+\mu^-$ pairs are also shown
  - Possible signals from photon-induced interactions in the dimuon channel are observed
- Evaluations of the efficiency corrections, systematic uncertainties and the hadronic background contribution are ongoing

References

[1] J. Adam *et al.* (ALICE), *Phys. Rev. Lett.* **116** (2016) 222301
[2] J. Adam *et al.* (STAR), *Phys. Rev. Lett.* **123** (2019)132302
[3] W. M. Zha *et al. Phys. Rev.* **C97** (2018) 004910
[4] J. Adam *et al.* (STAR), *Phys. Rev. Lett.* **121** (2018) 132301
[5] C. Yang *et al. Nucl. Instrum. Meth.* **A762** (2014) 1-6

In part supported by U.S. DEPARTMENT OF ENERGY | Office of Science

The STAR Collaboration
drupal.star.bnl.gov/STAR/presentations

BROOKHAVEN NATIONAL LABORATORY