DNP2020

Fall Meeting of the Division of Nuclear Physics of the American Physical Society

Oct. 29 – Nov. 1, 2020 *Now Virtual Meeting!*

~~Hyatt Regency Hotel, New Orleans, LA~~

APS physics

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

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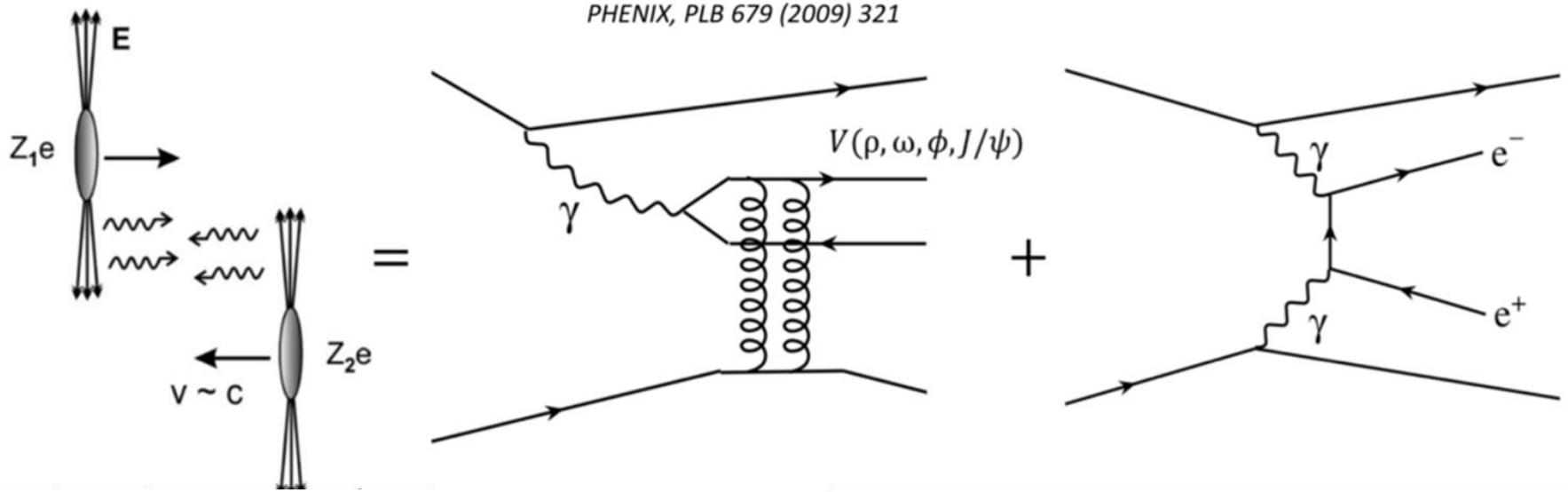
Supported in part by

U.S. DEPARTMENT OF ENERGY | Office of Science

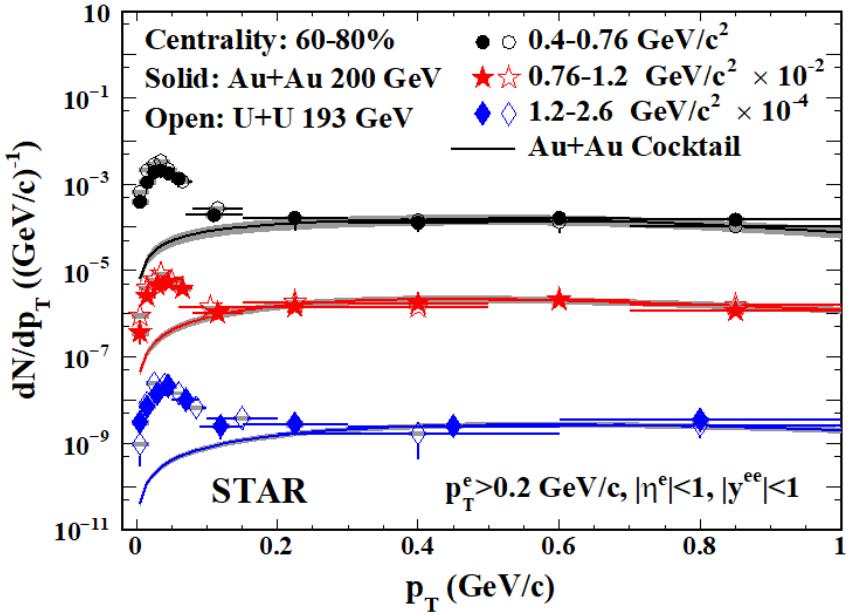
Dileptons from photon interactions

C. A. Bertulani et al., Ann. Rev. Nucl. Part. Sci. 55 (2005) 271
PHENIX, PLB 679 (2009) 321

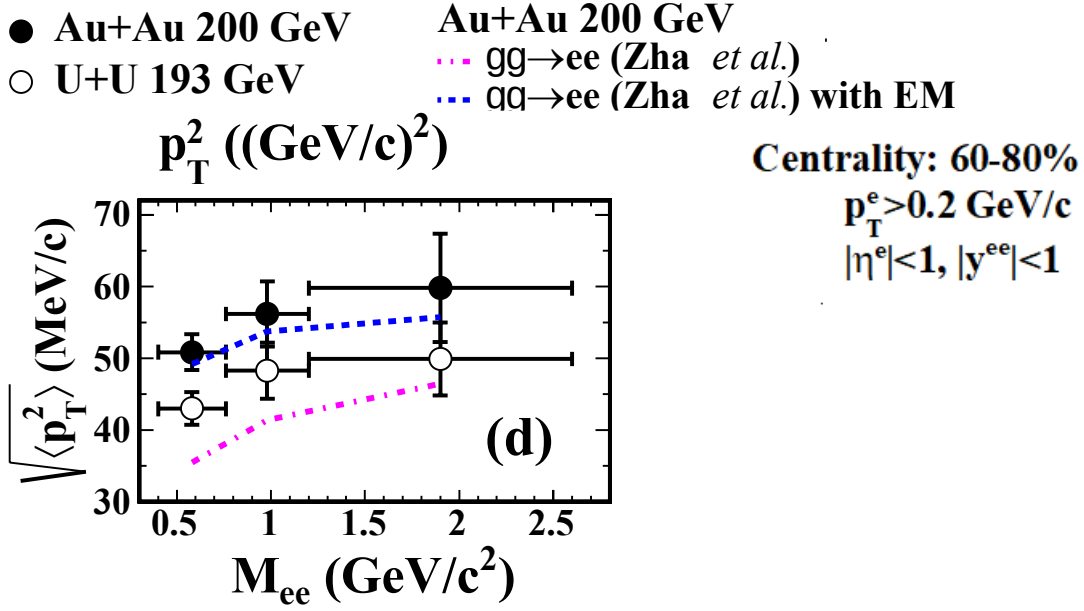


- Large quasi-real photon flux $\propto Z^2$
- Photon interactions
  - photon-photon interaction (dilepton...) $\propto Z^4$
  - photon-nuclear interaction (vector mesons) $\propto Z^2$
    - ✓ Coherent: photon interacts with the whole nucleus
    - ✓ Incoherent: photon interacts with nucleon or parton individually
- Conventionally only studied in ultra-peripheral collisions (b>$2R_A$,UPCs) to keep coherence condition

Photoproduction with nuclear overlap



STAR, Phys. Rev. Lett. 121 (2018) 132301

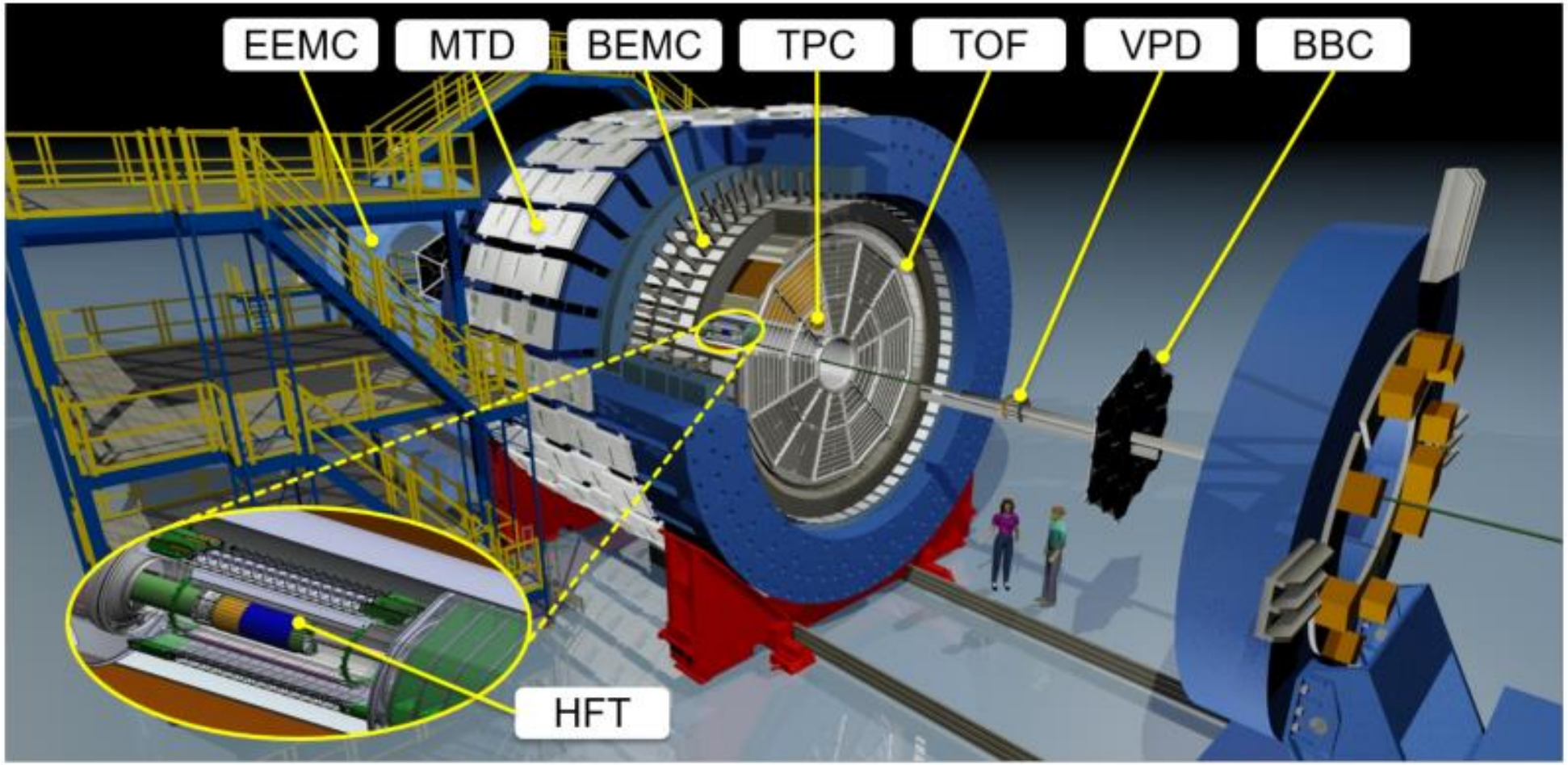


STAR, Phys. Rev. Lett. 121 (2018) 132301

W.M. Zha et al., Phys. Lett. B 800 (2020) 135089

- Excess e^+e^- pair p_T distribution concentrates below $p_T \sim 0.15$ GeV/c.
  - Evidence of photon interactions in hadronic heavy ion collisions.
- The observed p_T^2 broadening is consistent with QED calculations. Possible additional broadening is also proposed as a probe of a trapped magnetic field or of Coulomb scattering in a QGP.
- Low-p_T muon pairs production measurements provide a complementary channel and will help to further improve our understanding of photon-induced processes.

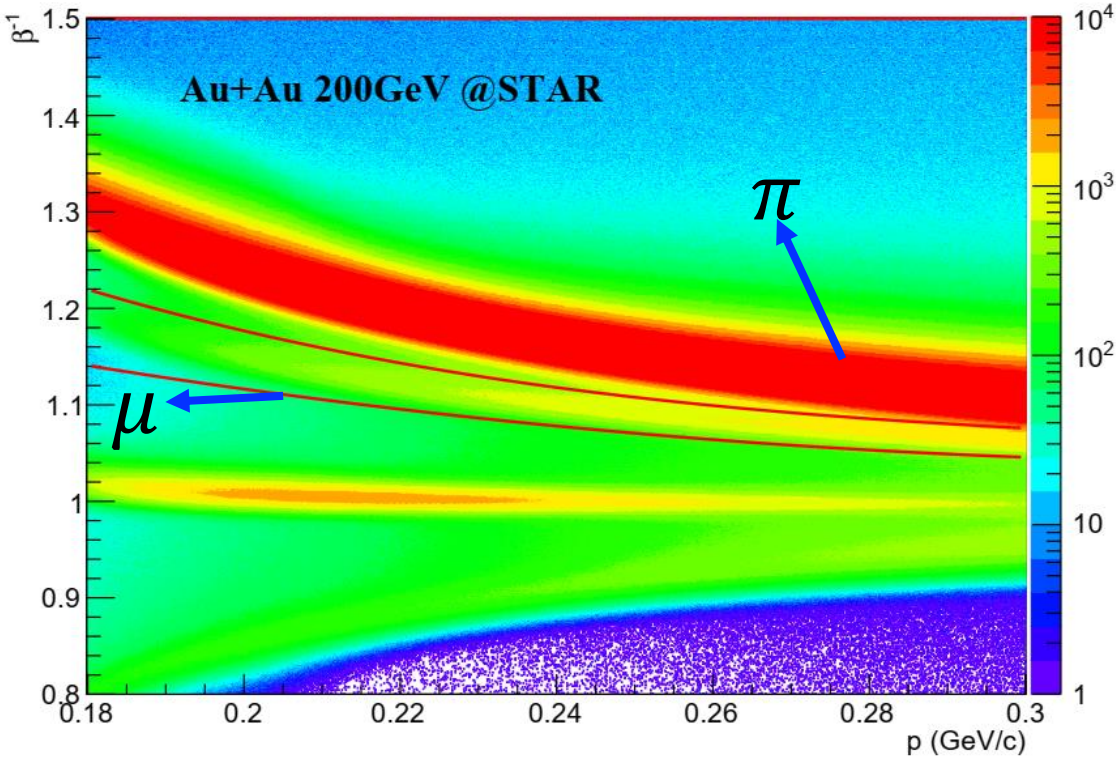
The Solenoidal Tracker At RHIC (STAR)



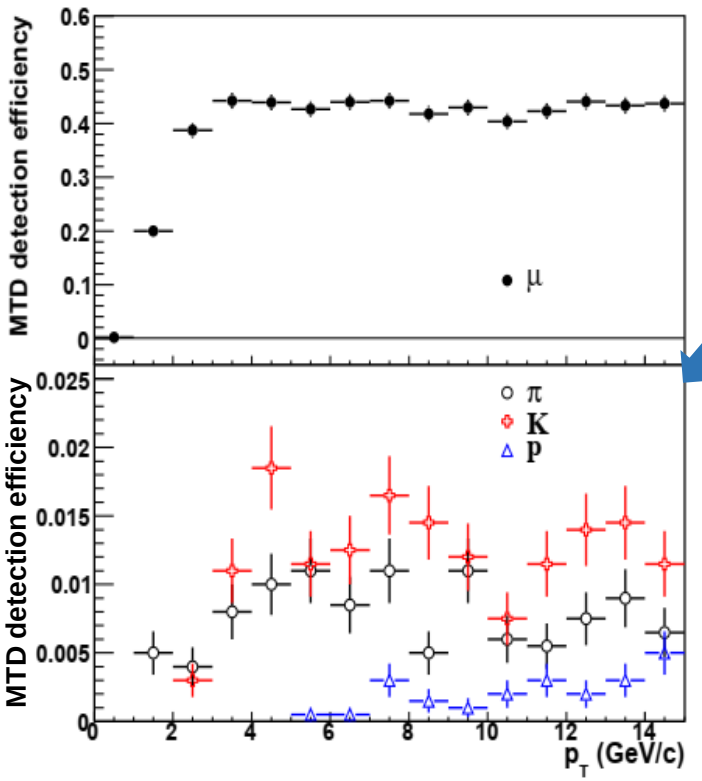
- Time Projection Chamber: tracking, momenta, and PID
- Time of Flight: PID by velocity
- Muon Telescope Detector: trigger on and identify muons

Muon identification

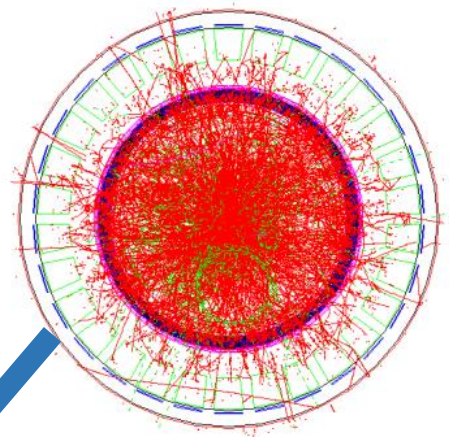
PID@TOF



PID@MTD



STAR, J. Phys. G **36** (2009) 095001

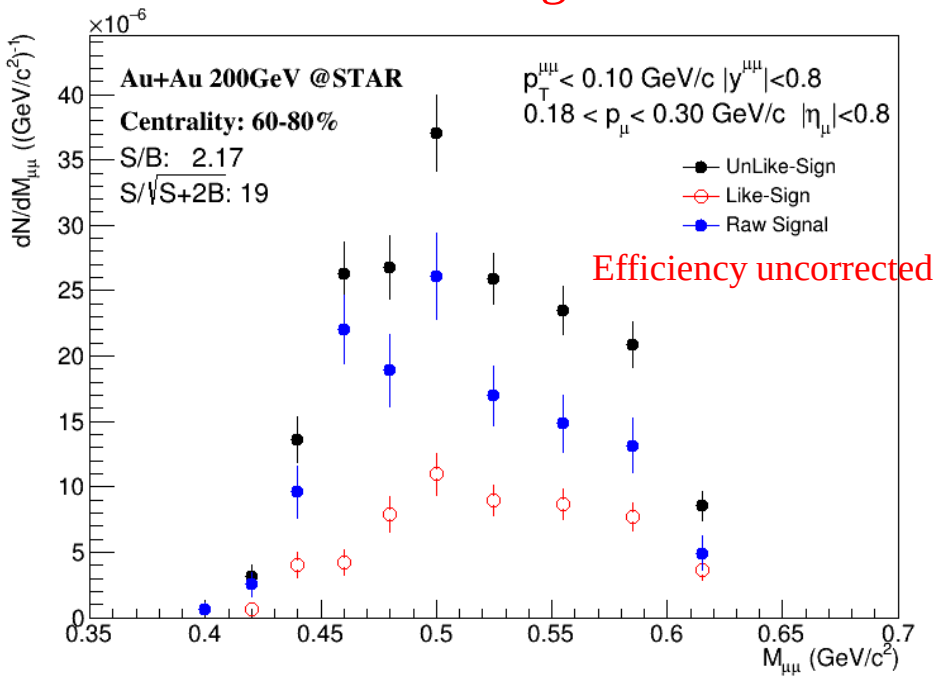


Significantly suppress pion with MTD

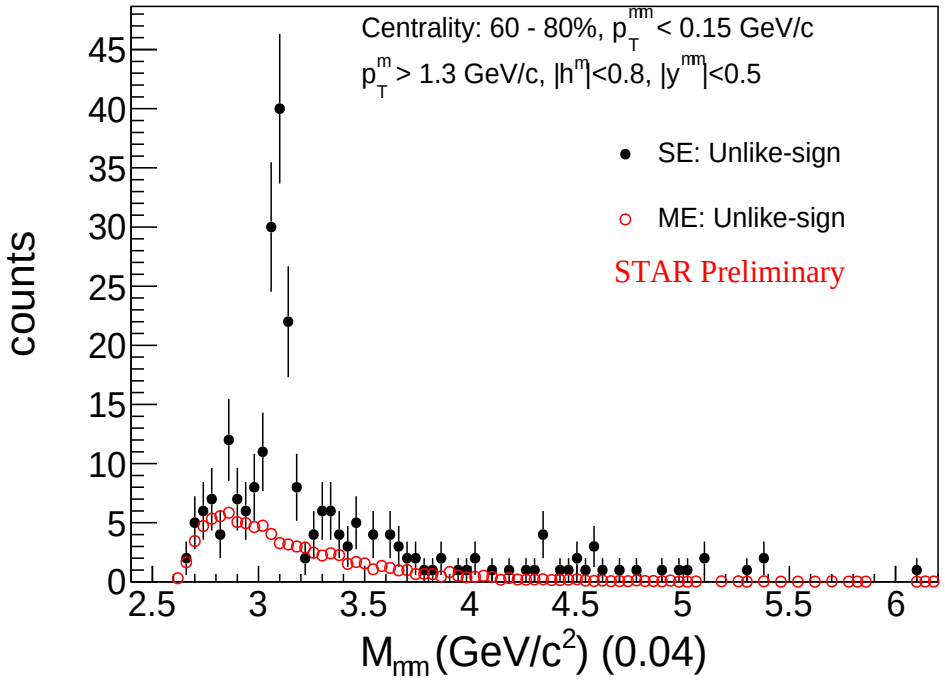
- Muon can be identified at low p_T by using TOF.
- Muon can be identified at high p_T by using MTD.

Invariant mass spectrum

Low mass region

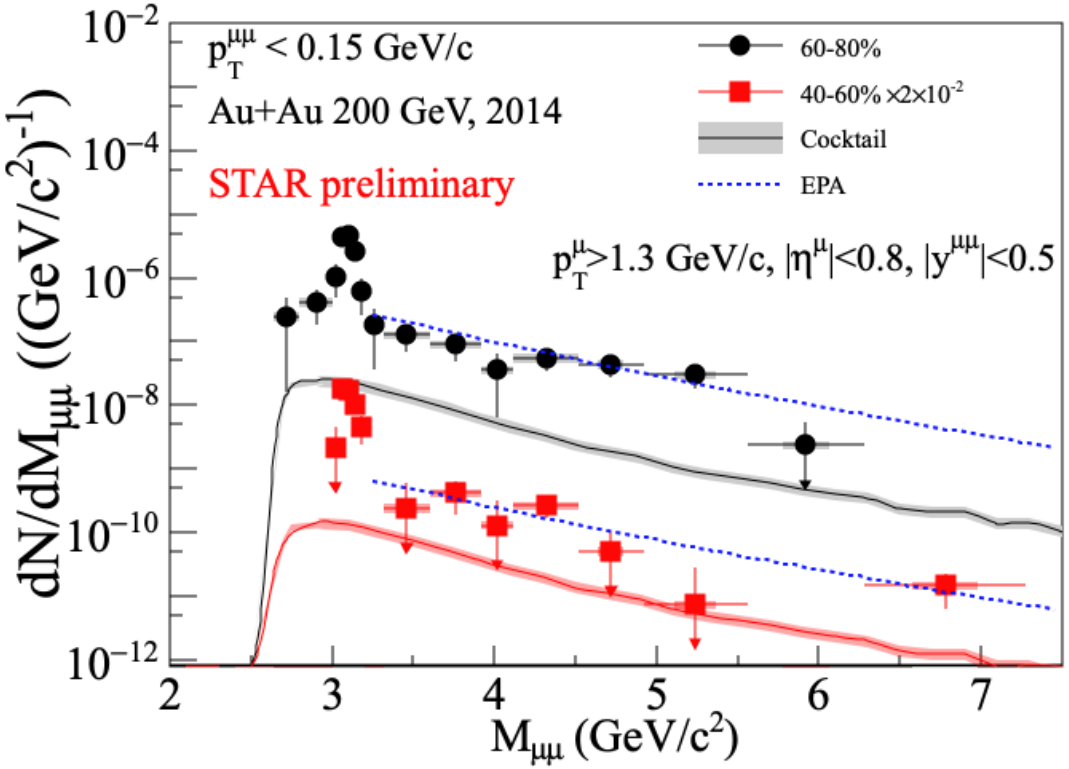


High mass region



- The $\mu^+\mu^-$ invariant mass distribution at very low p_T in peripheral collisions.
  - Low mass region ($0.40 < M_{\mu\mu} < 0.64$ GeV/c^2) using TOF.
  - High mass region ($M_{\mu\mu} > 3.2$ GeV/c^2) using MTD.

Invariant mass spectra in high mass region



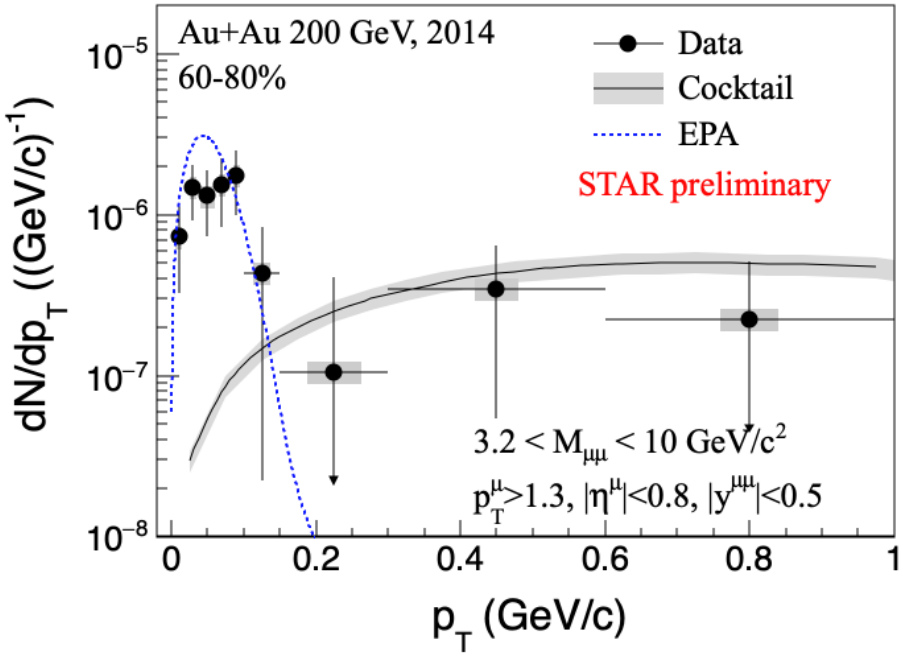
- Significant enhancement with respect to the cocktail in 60-80% centrality collisions.
- Consistent with the theoretical calculation.

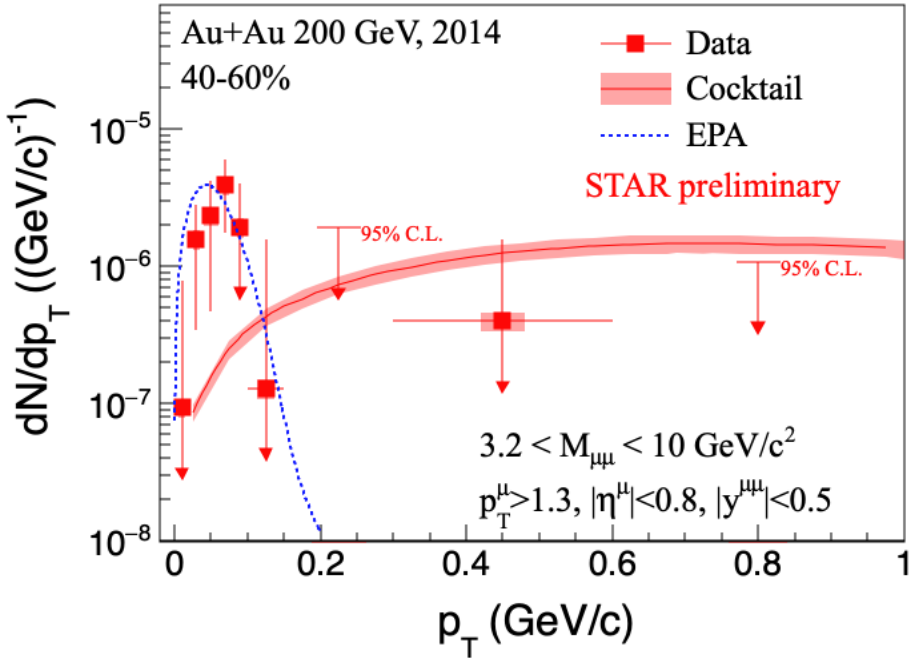
Calculations based on Equivalent Photon Approximation (EPA) method.

- Weizsacker–Williams method to estimate photon flux.
- Use Woods-Saxon charge distribution in nucleus for photon flux estimation.
- Photon is treated as real.
- Consider dilepton production insides nucleus.

W.M. Zha et al., Phys. Lett. B 800 (2020) 135089

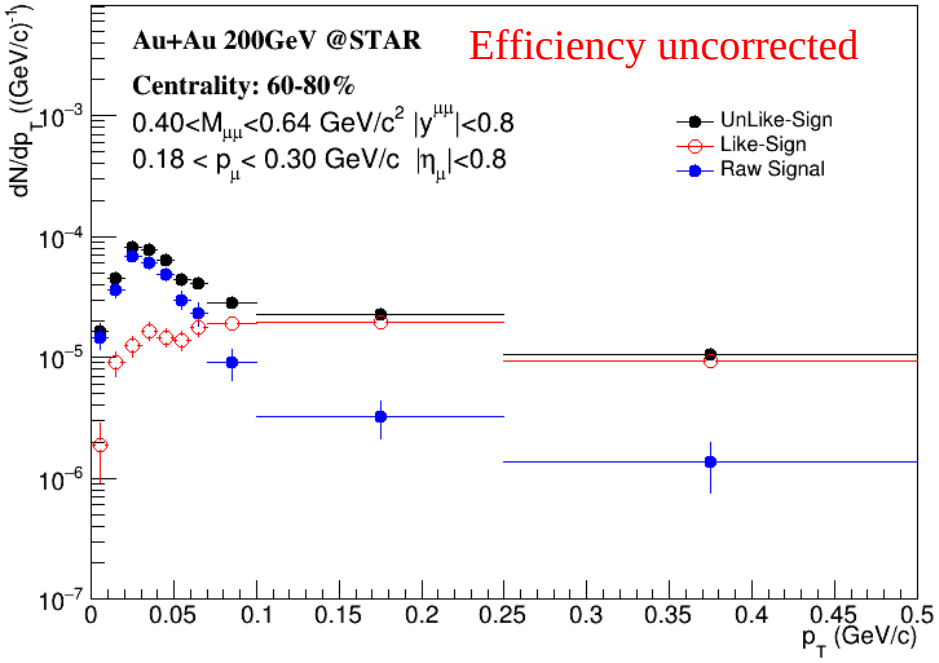
p_T distributions in high mass region

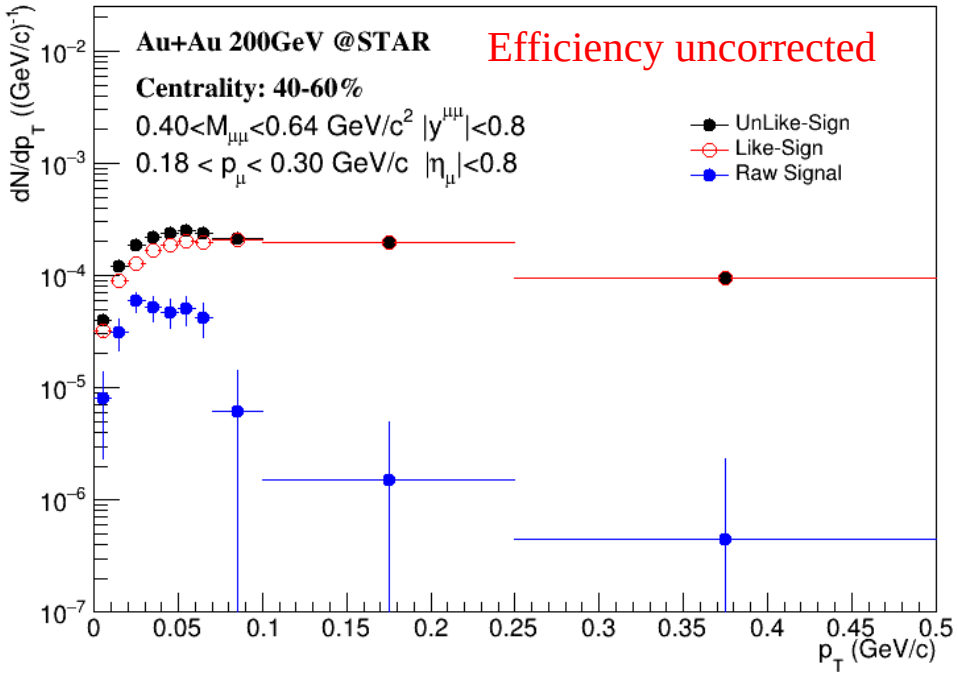




- Excesses concentrate below $p_T \approx 0.15$ GeV/c.
- Data are consistent with hadronic expectation when $p_T > 0.15$ GeV/c.
- Theoretical calculation is compatible with data.

p_T distribution in low mass region





- Excesses concentrate below $p_T \approx 0.15$ GeV/c.
  - Similar shape to e^+e^- and high mass $\mu^+\mu^-$ measurements.
  - Indication of photon interactions in hadronic heavy ion collisions.
  - Efficiency correction and cocktail simulation are ongoing.

Summary

- A significant $\mu^+\mu^-$ enhancement relative to the cocktail is observed at very low p_T in peripheral Au+Au collisions at 200 GeV.

  In high mass Region ($M_{\mu\mu} > 3.2$ GeV/c^2):

  - Excess was entirely observed below $p_T \approx 0.15$ GeV/c.
  - Compatible with the theoretical calculation.

  In low mass Region ($0.40 < M_{\mu\mu} < 0.64$ GeV/c^2):

  - Excess was entirely observed below $p_T \approx 0.15$ GeV/c.
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- Outlook

  - Search for cos4Δϕ angular distribution which is related to vacuum birefringence. ——STAR, arXiv : 1910.12400

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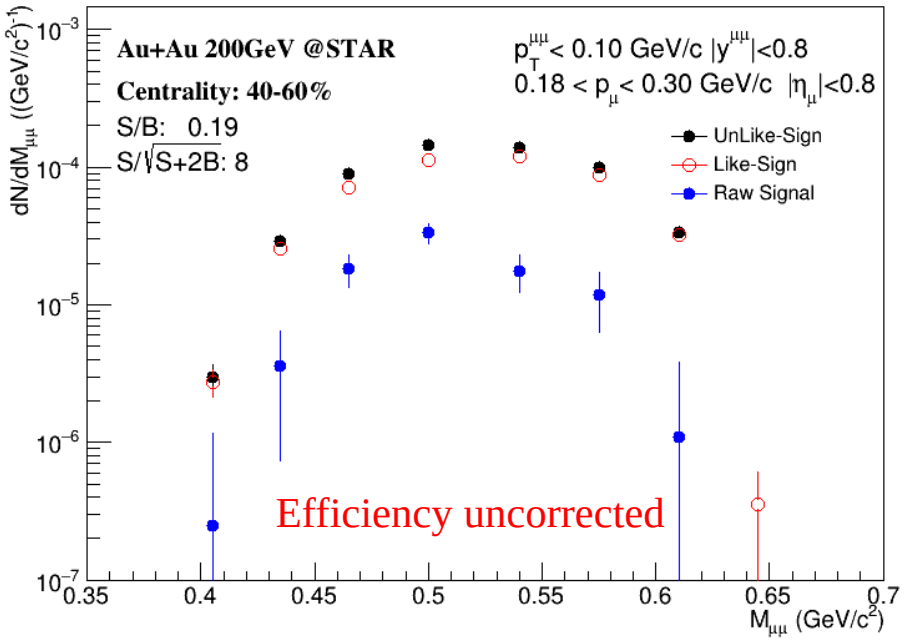
Thank you!

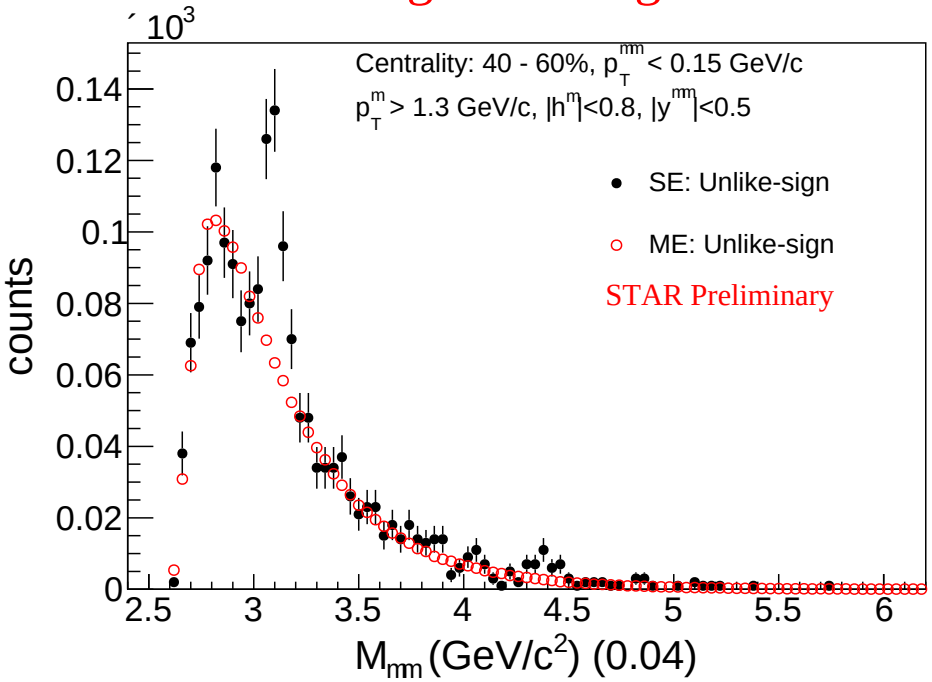
Back up

Invariant mass spectrum (40-60%)

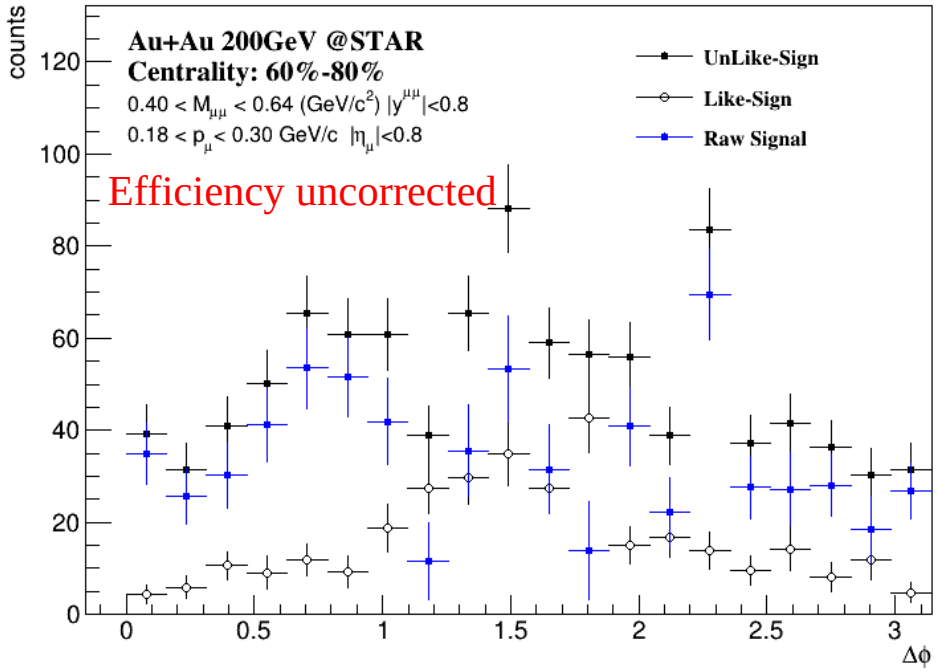
Low mass region



High mass region



Outlook—— $\Delta\phi$ distribution (60-80%)



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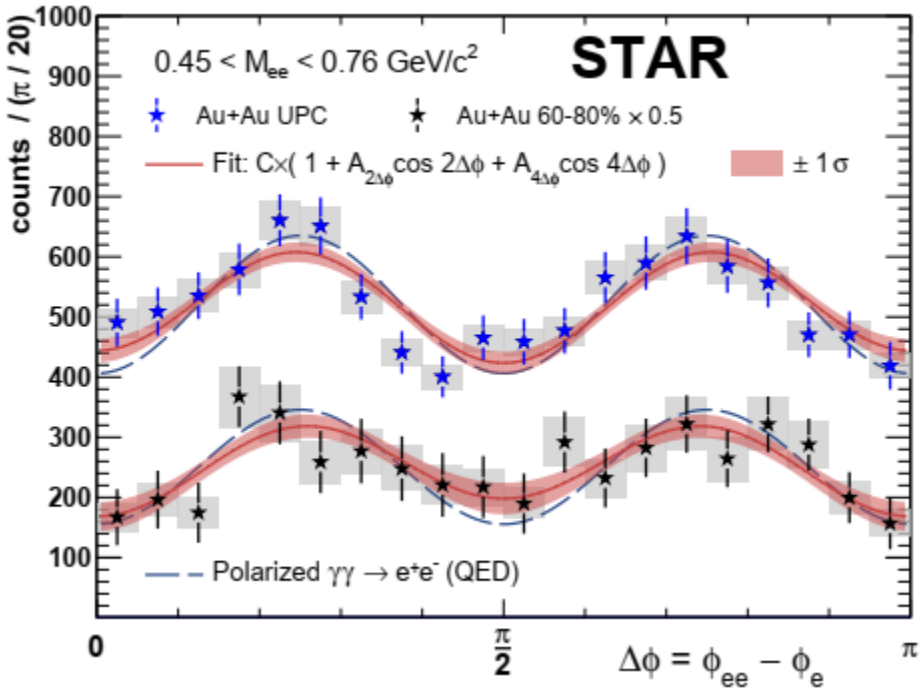

- Theory predicts that the linearly polarized photon-photon collisions will lead to a $cos4\Delta\phi$ angular distribution which can be identified as vacuum birefringence.
- The previous observation of dielectron production is in agreement with theoretical predictions.
- Dimuon channel provides a new channel to study the Breit-Wheeler process.