Dimuon production at low transverse momentum in peripheral Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR

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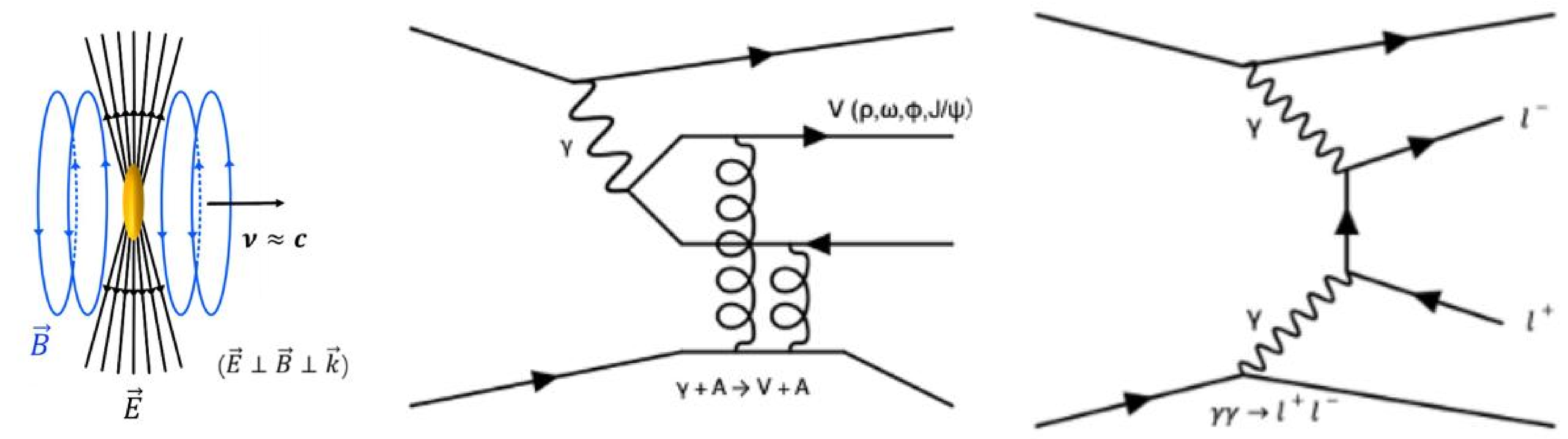
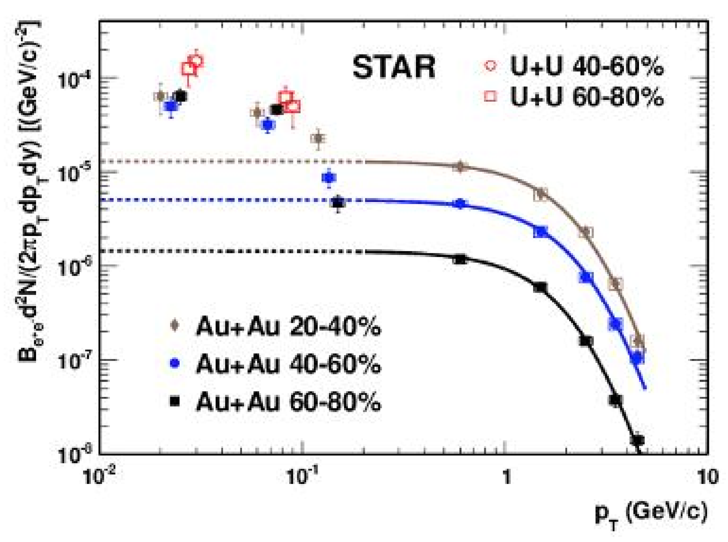
I. Introduction

- In heavy-ion collisions, boosted nuclei generate intense electromagnetic fields.
- The strong electromagnetic fields can be treated as quasi-real photons in Weizsacker-Williams equivalent photon approximation (EPA)[1,2]. $n \propto \vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B} \approx |\vec{E}|^2 \approx |\vec{B}|^2$
- Large quasi-real photon flux $\propto Z^2$.

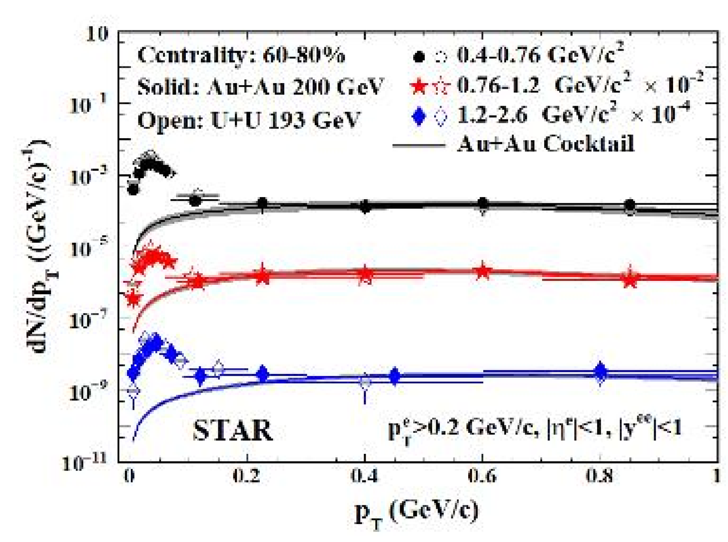


- In photon-induced interactions, the generated vector mesons or dileptons are distinctly peaked at very low transverse momentum (p_T < 0.2 GeV/c). Such interactions are traditionally studied in ultra-peripheral collisions (UPC) with impact parameters larger than twice the nuclear radius, where no hadronic interactions occur.
  - ✓ Evidence of photon interactions in hadronic heavy ion collisions also seen[3,4].
- Measurements from dimuon channel complement the previous results from dielectron channel.

$J/\psi \to e^+e^-$ [3]



e^+e^- pairs [4]



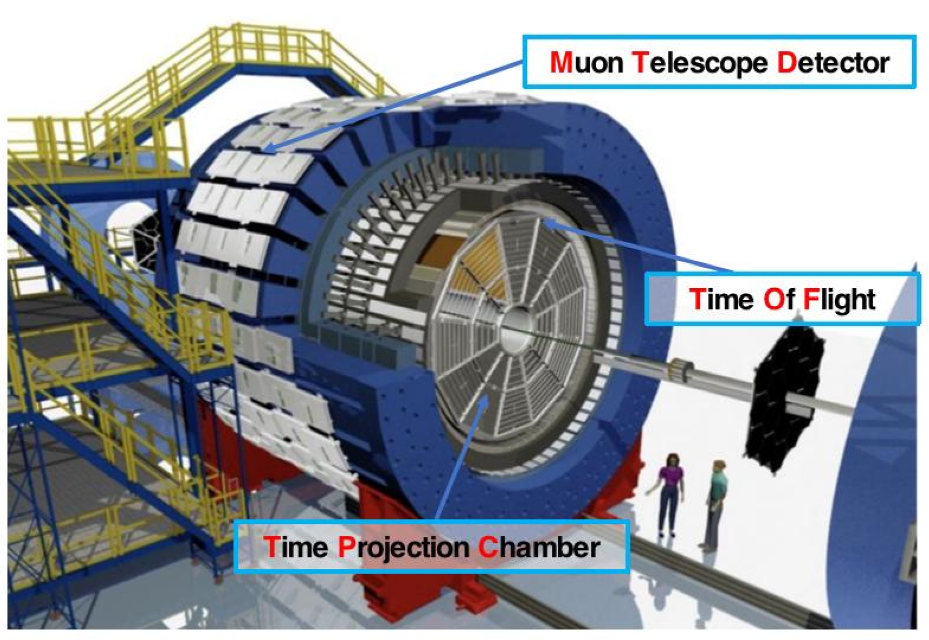
II. Muon identification at STAR

STAR: Solenodial Tracker At RHIC

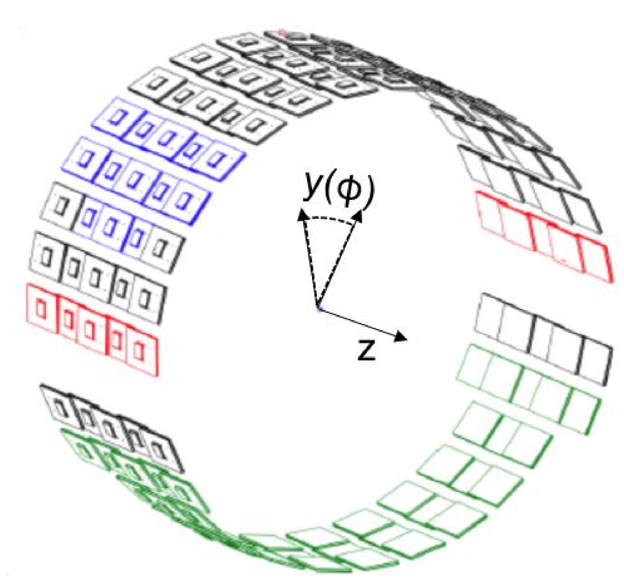
TPC :
- Particle identification using dE/dx.

MTD system:
- Triggering on and identifying muon.

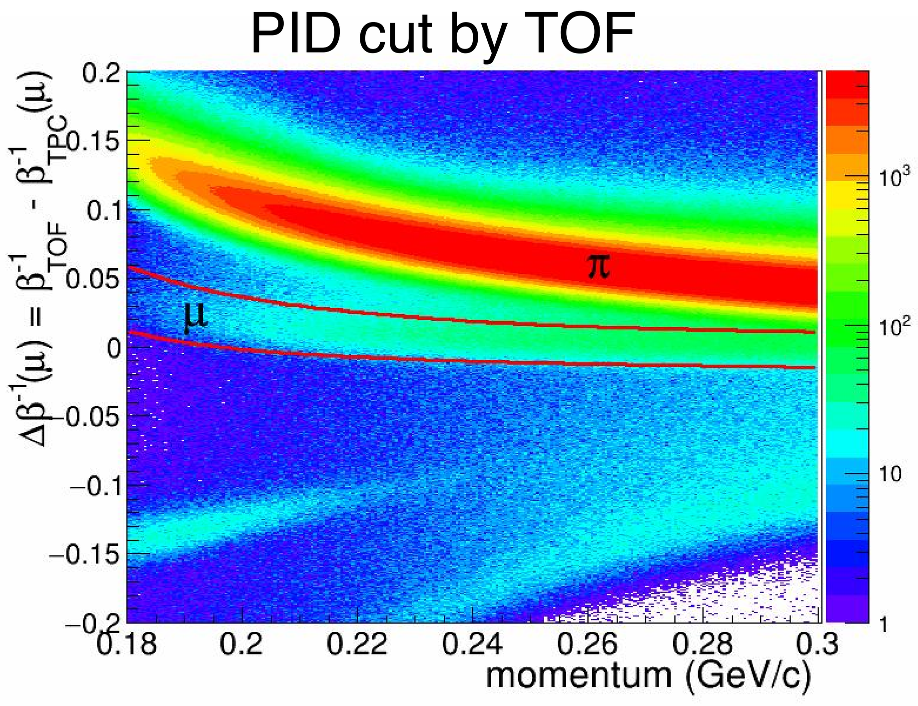
TOF:
- Muon identification at low p_T.



MTD system



PID cut by TOF



III. J/ψ measurements

- Dimuon measurement in J/ψ mass region : MTD+TPC

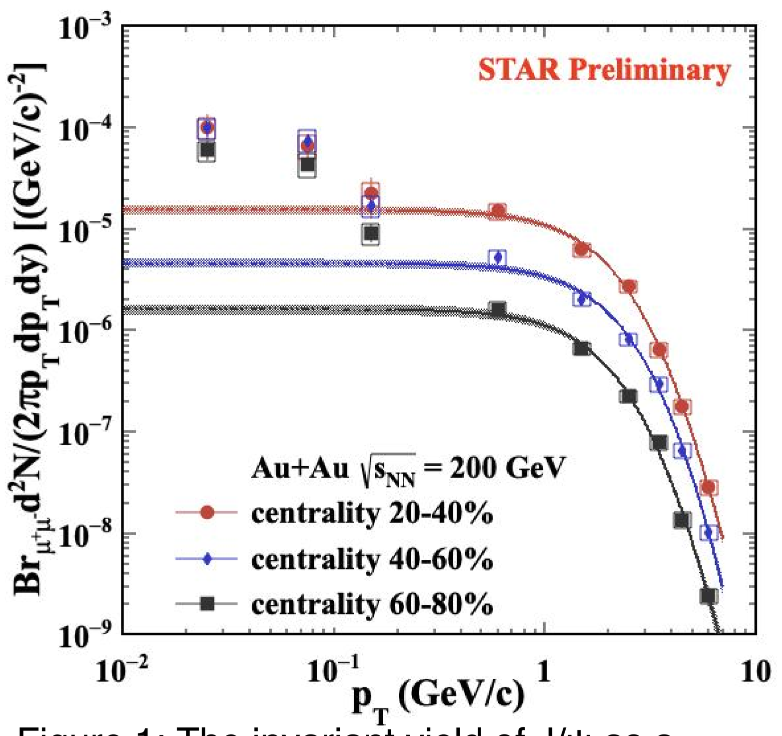


Figure 1: The invariant yield of J/ψ as a function of p_T in different centralities.

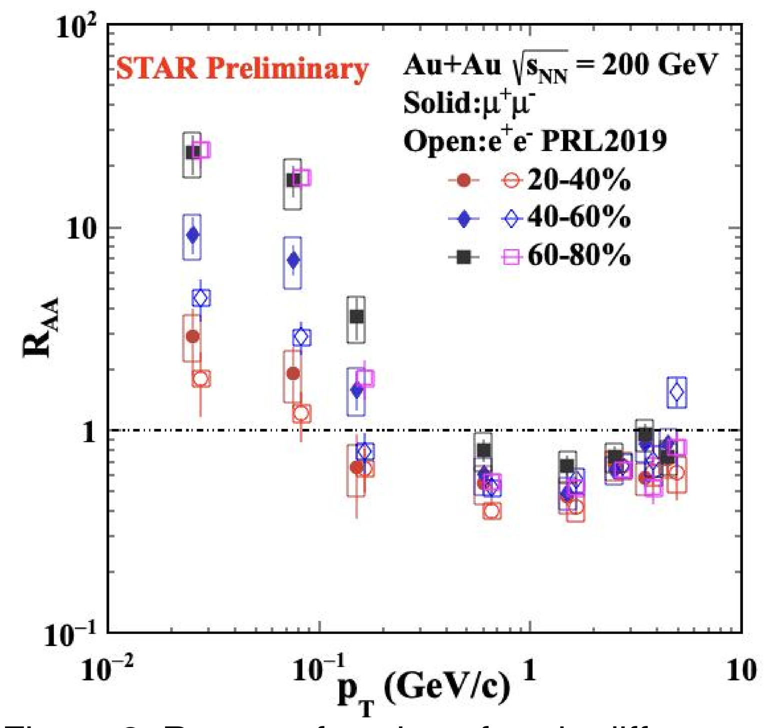


Figure 2: R_{AA} as a function of p_T in different centralities.

- A large enhancement of the J/ψ yield at low p_T in peripheral collisions relative to the p+p collisions.

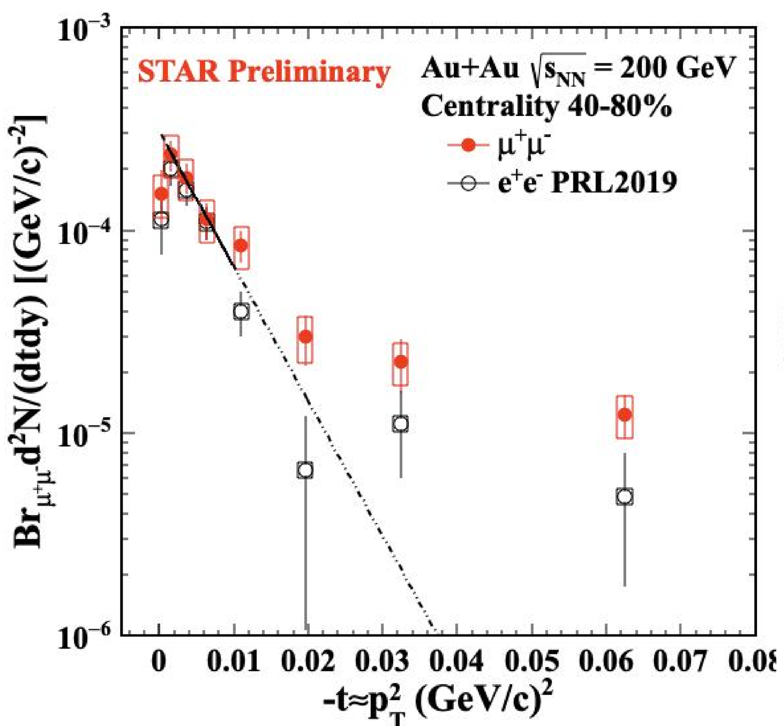


Figure 3: The J/ψ yield as a function of p_T^2 for the 40-80% centrality class.

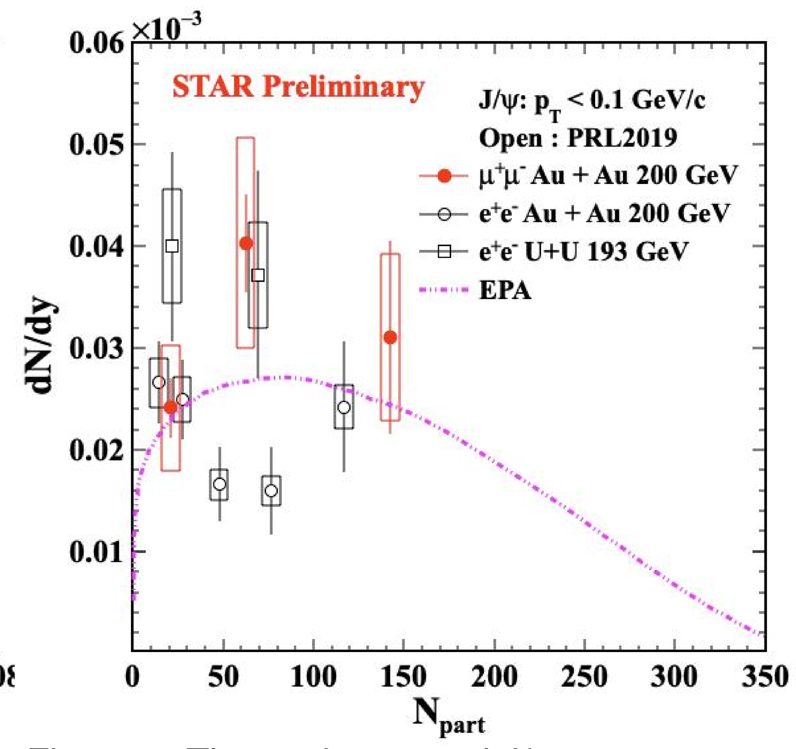


Figure 4: The p_T-integrated J/ψ excess yield (p_T < 0.1 GeV/c) as a function of N_{part}.

- An exponential fit is applied to the -t distribution, and the slope parameter is 153 ± 55 $(GeV/c)^{-2}$, consistent with that expected for an Au nucleus [199 $(GeV/c)^{-2}$] within uncertainties.
- Excess yield consistent with EPA calculations[5].

IV. μ+μ- continuum measurements

- Dimuon measurement in low mass region : TPC+TOF

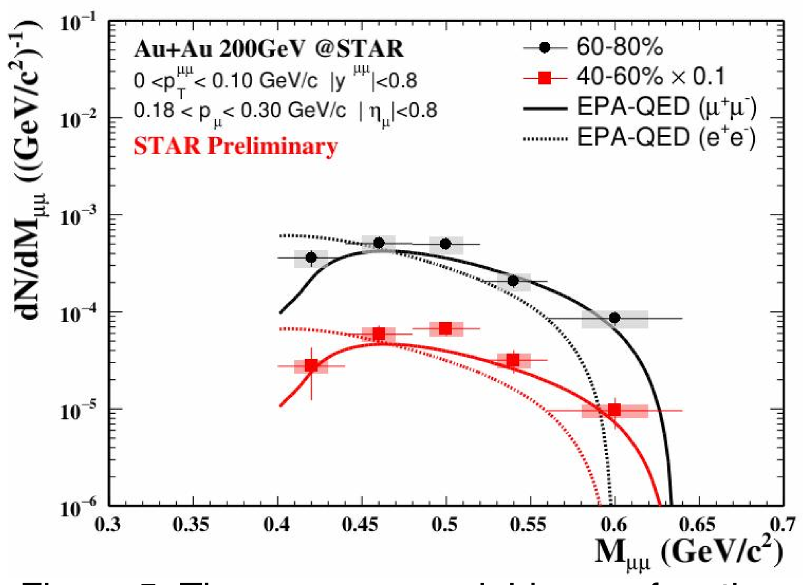


Figure 5: The μ+μ- excess yields as a function of invariant mass in peripheral collisions.

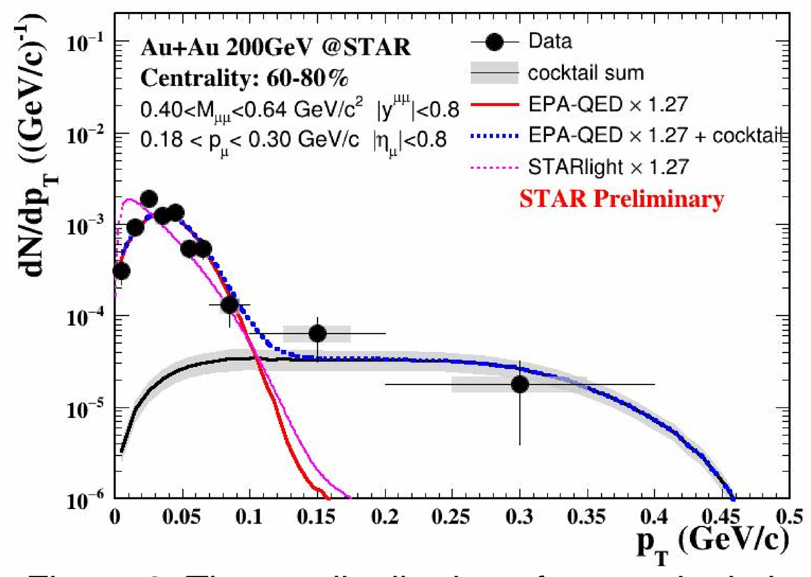


Figure 6: The p_T distribution of μ+μ- pairs in low mass region in 60-80% centrality.

- Excess dimuon yield concentrates below p_T≈0.15 GeV/c. The hadronic cocktail can describe the data for p_T > 0.15 GeV/c.
- The EPA-QED [6] calculations are consistent with the data, while the STARlight calculations [7] can not describe the data.

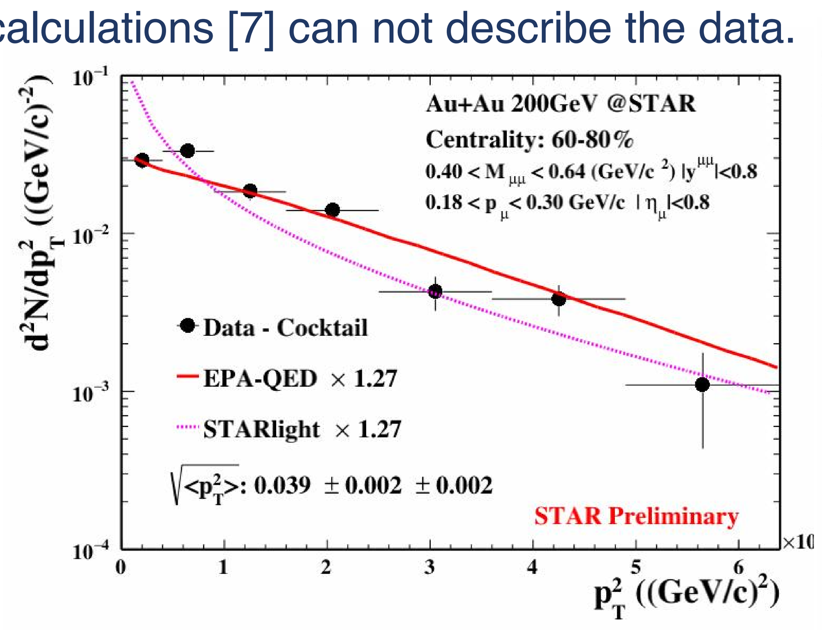


Figure 7: The p_T^2 distibution of excess yield in 60-80% centrality.

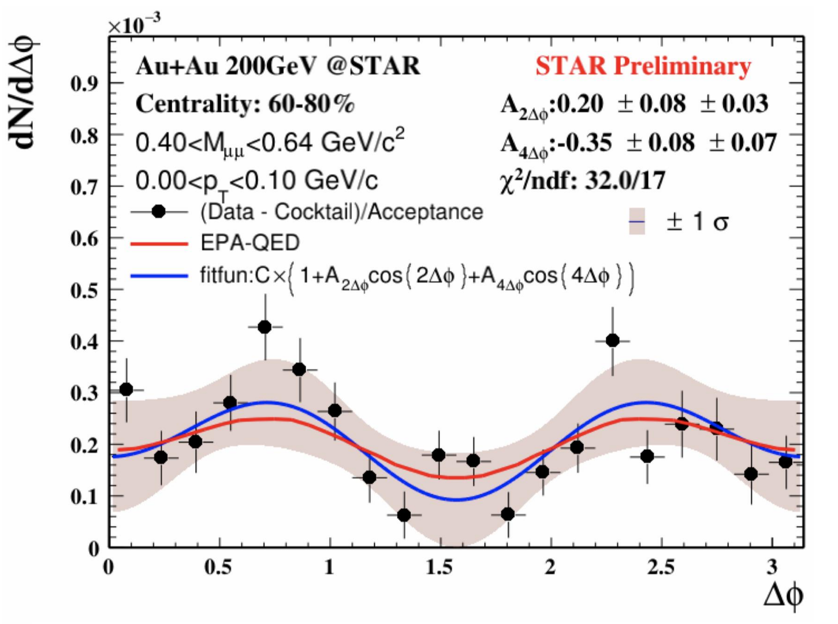


Figure 8: The Δφ distibution in 60-80% centrality. $\Delta\varphi = \varphi_{\vec{\mu^+}+\vec{\mu^-}} - \varphi_{\vec{\mu^+}-\vec{\mu^-}}$

- The $\sqrt{\langle p_T^2\rangle}$ is consistent with the EPA-QED calculation.
- Indication of the 4th-order azimuthal angular modulation of μ+μ- pairs.
- Hint of 2nd-order azimuthal angular modulation.

V. Summary

- First measurement of dimuon production in low and high mass regions at very low p_T in peripheral Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.
- Significant J/ψ and μ+μ- enhancements are observed.
- The EPA calculations can describe data, indicating the enhancements at very low p_T originate from photon-induced interactions.
- Can be used to map the strength and spatial distribution of the initial EM field.

References

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