



Initial electromagnetic field dependence of photon-induced production in isobaric collisions at STAR

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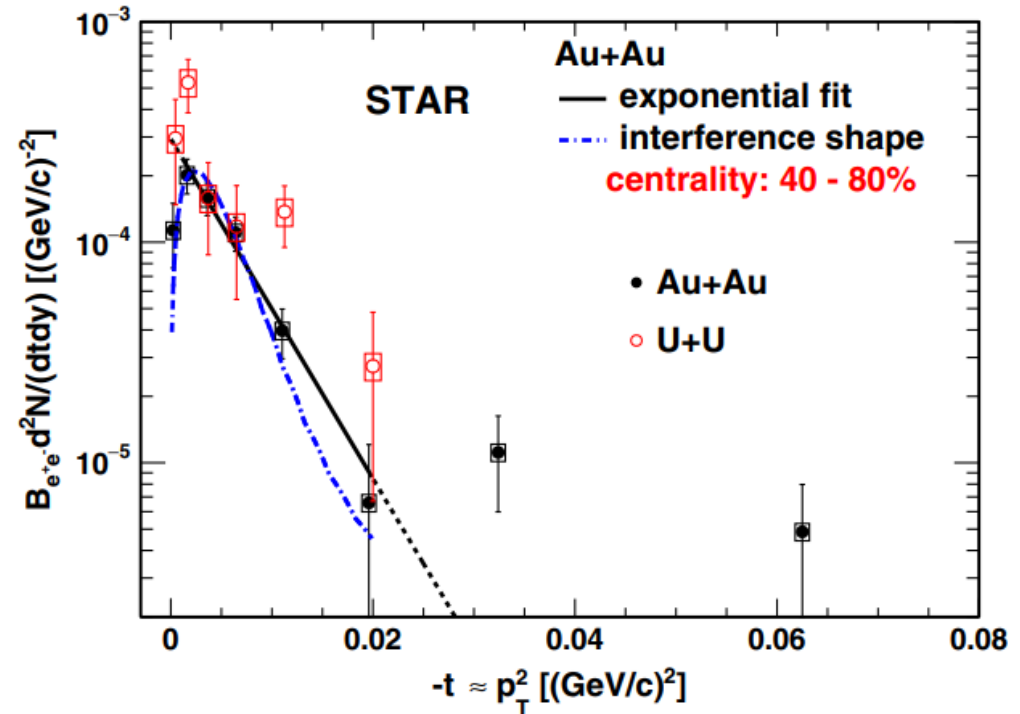
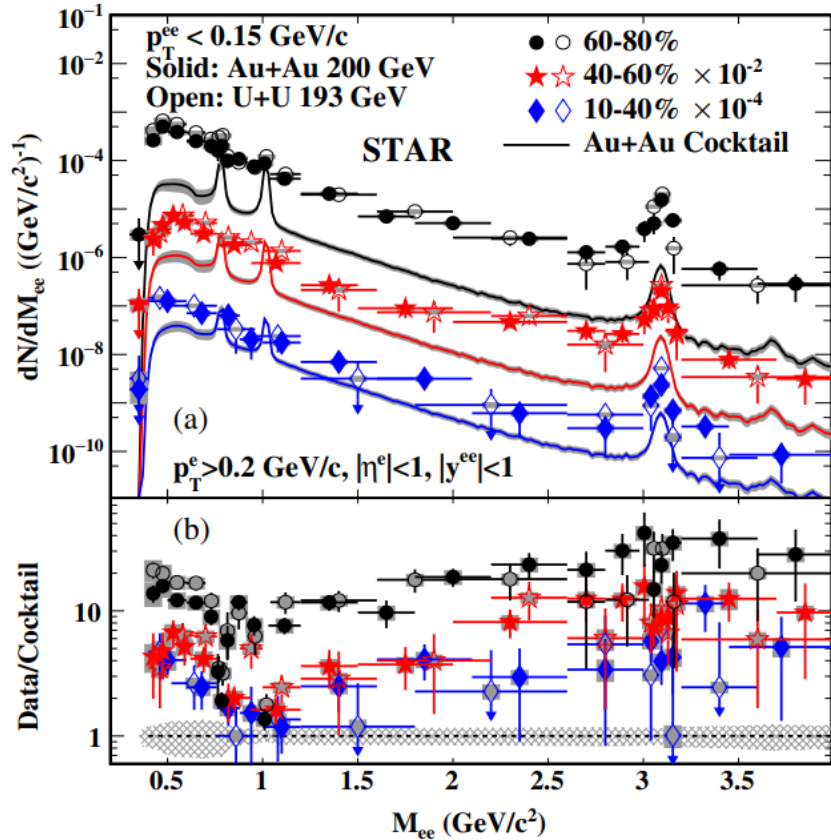




- Motivation and STAR Experiment
- e^+e^- Pair Production in Ru+Ru and Zr+Zr Collisions at $\sqrt{s_{NN}} = 200$ GeV at Very Low p_T
- J/ψ Production in Ru+Ru and Zr+Zr Collisions at $\sqrt{s_{NN}} = 200$ GeV at Very Low p_T
- Angular Distribution of e^+e^- in Isobaric Collisions
- Summary

Photon-induced Production in Peripheral Collisions

- Photon-induced interactions could explain the observed enhancements of J/ψ and e^+e^- production at very low p_T



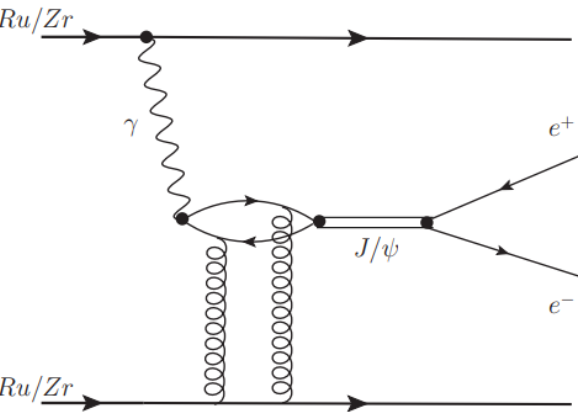
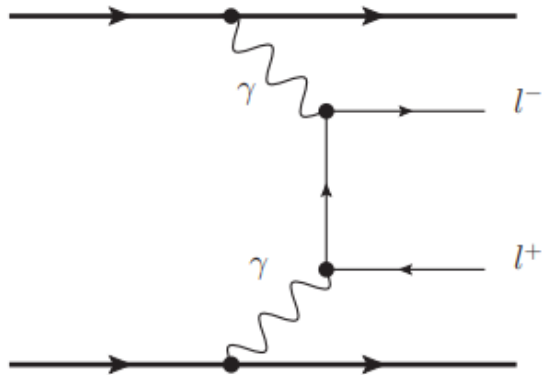
- The photon-induced production is sensitive to initial EM field:
 - Charge (Z) of the colliding nuclei
 - Collision system

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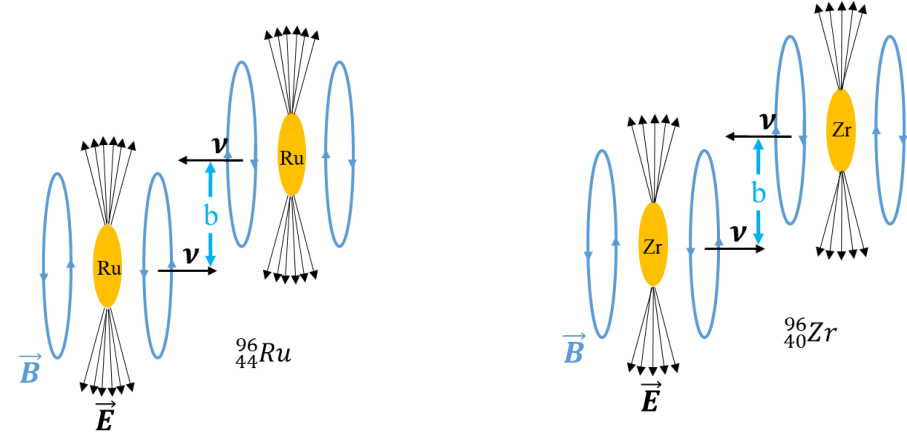
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Photon-induced Production in Peripheral Collisions

□ The isobaric collisions provide a unique opportunity to test the electromagnetic field dependence



- Charge (Z)
- Collision energy
- Impact parameter
- ...



□ Comparison between Ru+Ru and Zr+Zr:

➤ Charge (Z)

□ Comparison between Au+Au/U+U and Isobaric collisions:

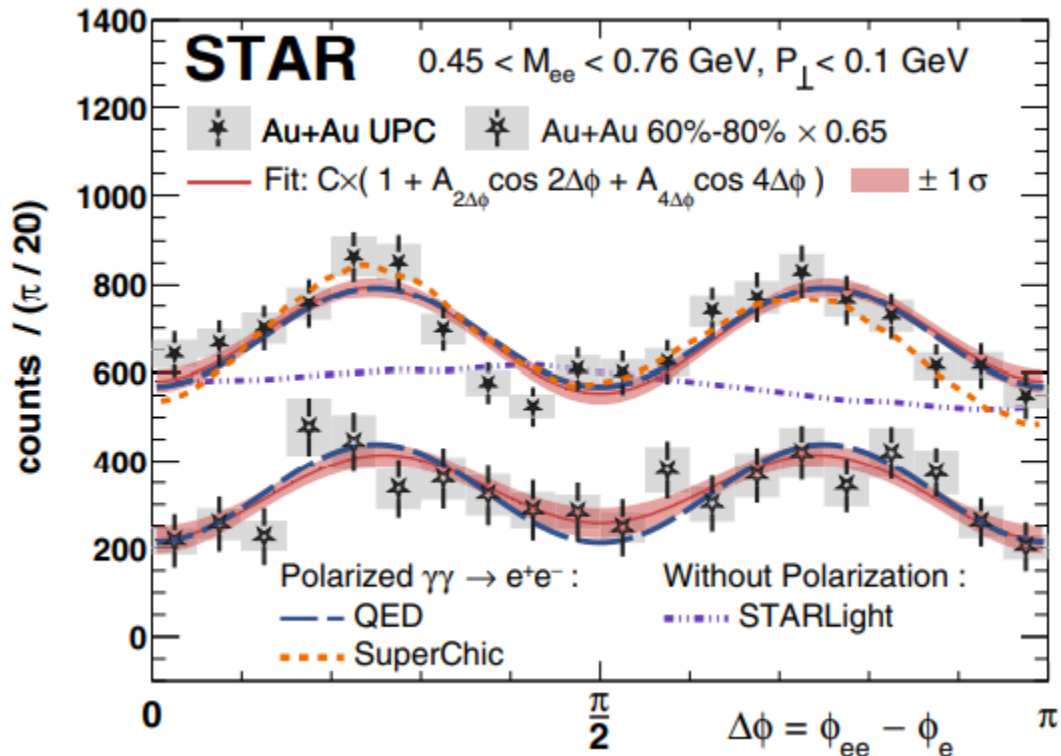
➤ Charge (Z)

➤ Impact parameter

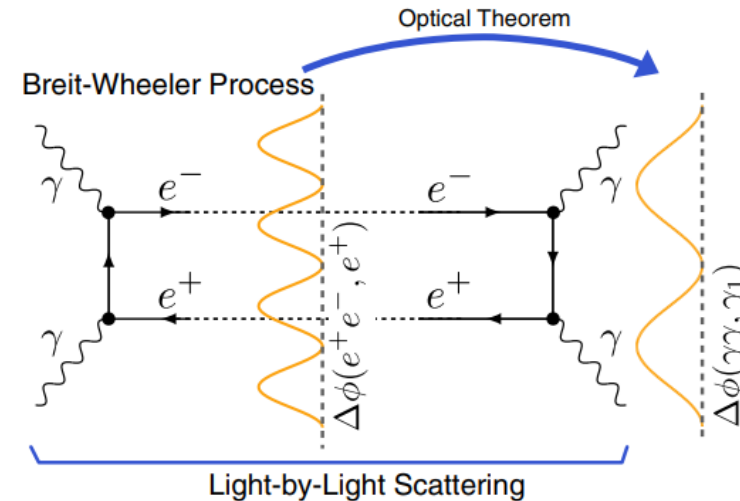
➤ ...

Photon-induced Production in Peripheral Collisions

- The Breit-Wheeler process has been investigated in peripheral and ultraperipheral Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV through $\gamma + \gamma \rightarrow e^+e^-$ process

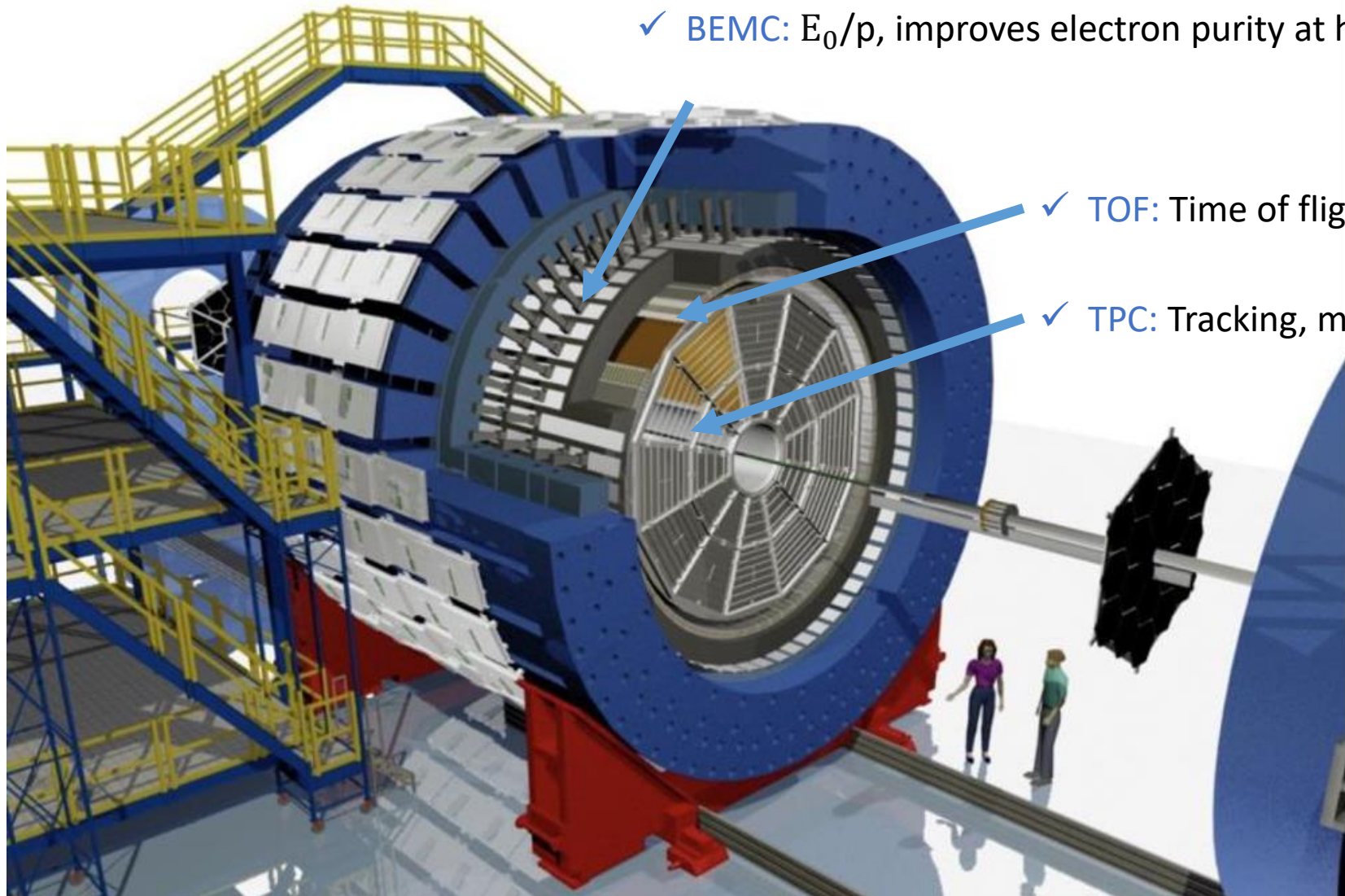


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- The fourth-order angular modulation, $\cos(4\Delta\phi)$, measured in isobaric collisions
- Investigate collision system dependence of $\cos(4\Delta\phi)$

The Solenoid Tracker At RHIC

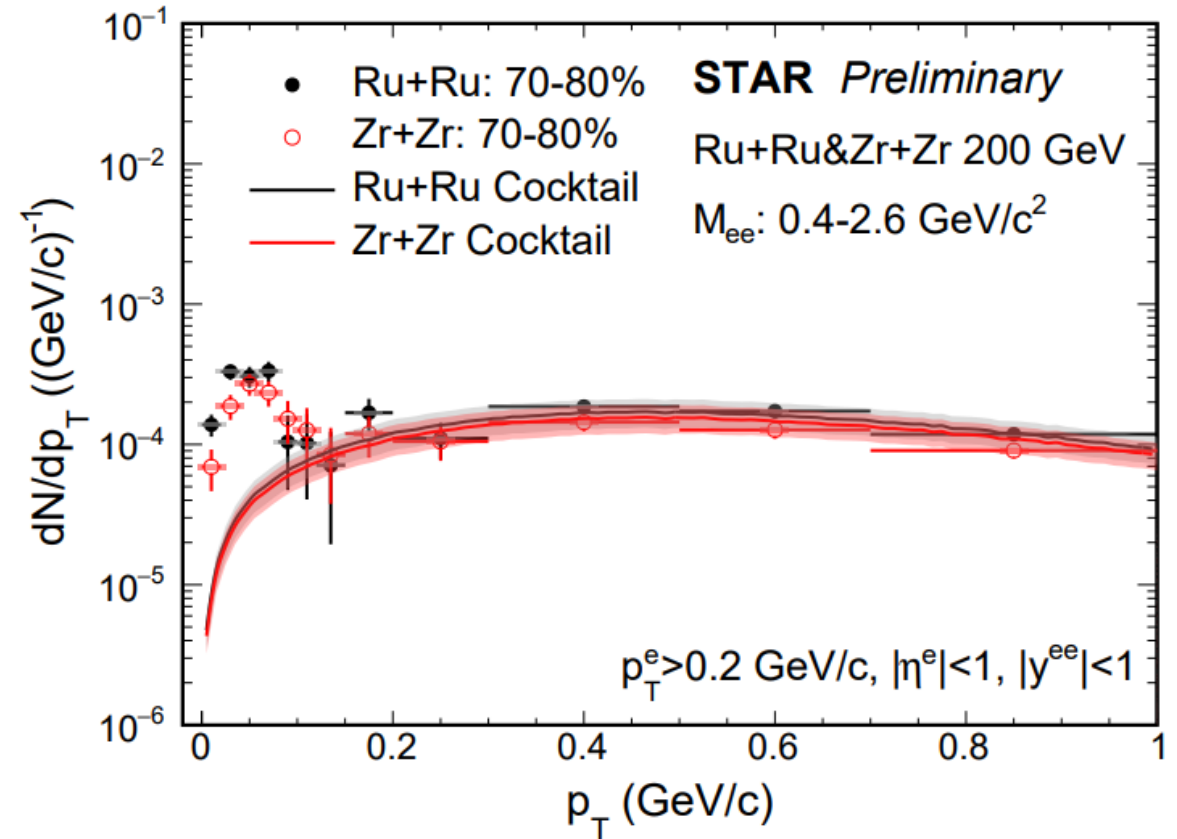
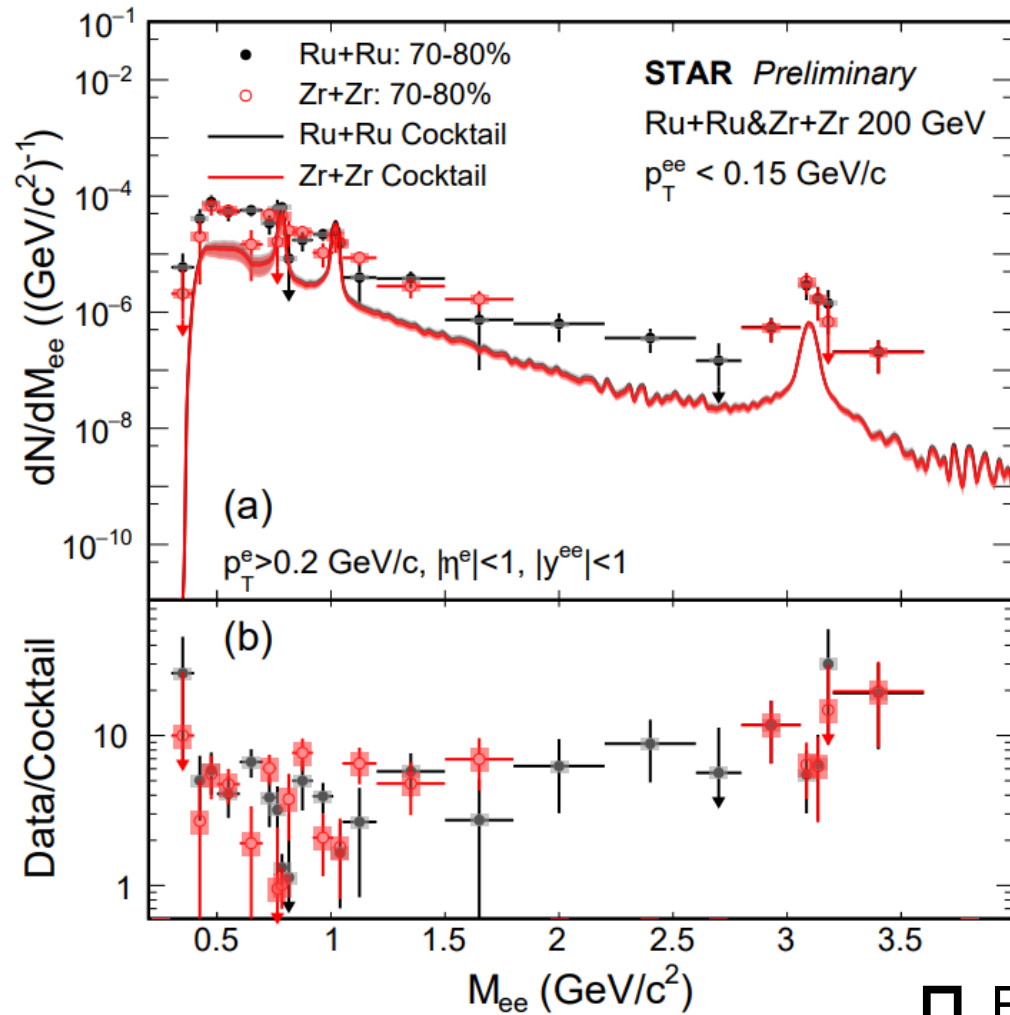


✓ BEMC: E_0/p , improves electron purity at high p_T

✓ TOF: Time of flight, particle identification

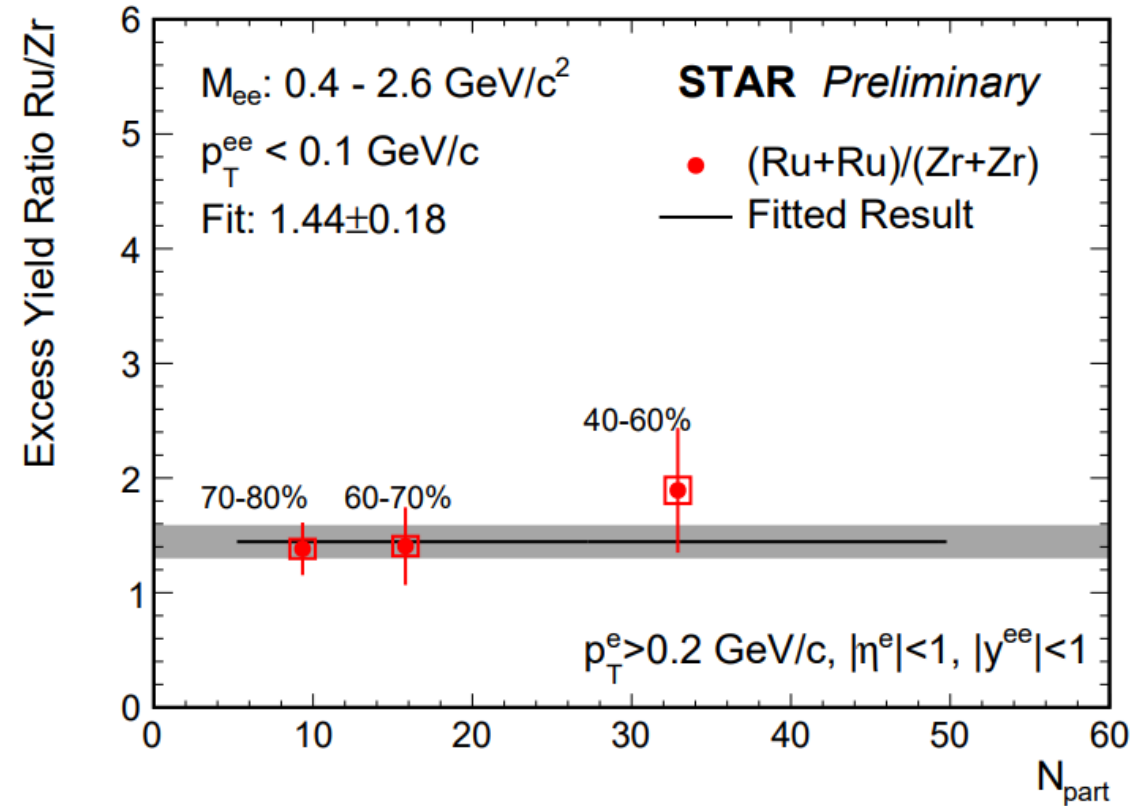
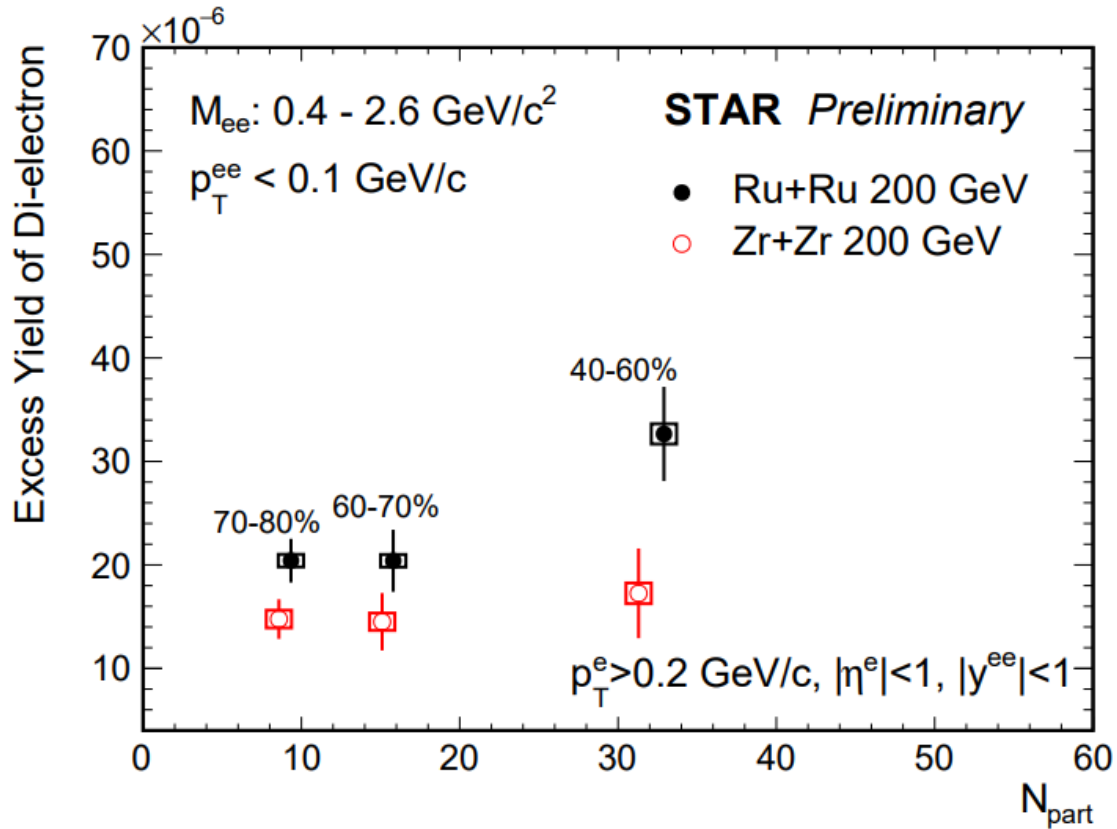
✓ TPC: Tracking, momentum and energy loss

Invariant Mass and Transverse Momentum Distributions of e^+e^-



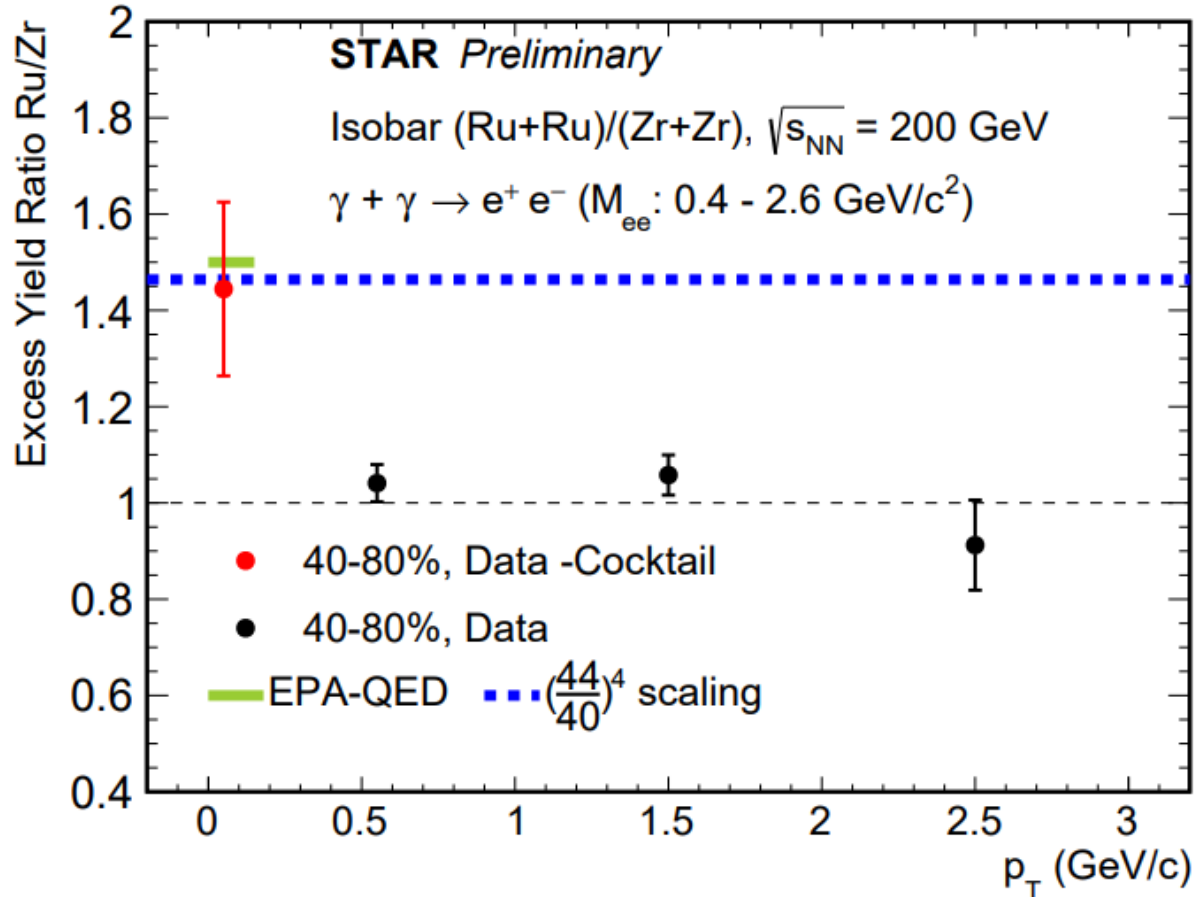
□ Excesses above hadronic production are observed at low- p_T

Centrality Dependence of Excess Yield



- The low- p_T ($p_T < 0.1 \text{ GeV}/c$) e^+e^- excess and the ratio of excess are shown as function of N_{part}
- The excess yields in Ru+Ru collisions are systematically higher than in Zr+Zr collisions
- A constant function is used to fit the ratio and is about 2.4σ higher than unity

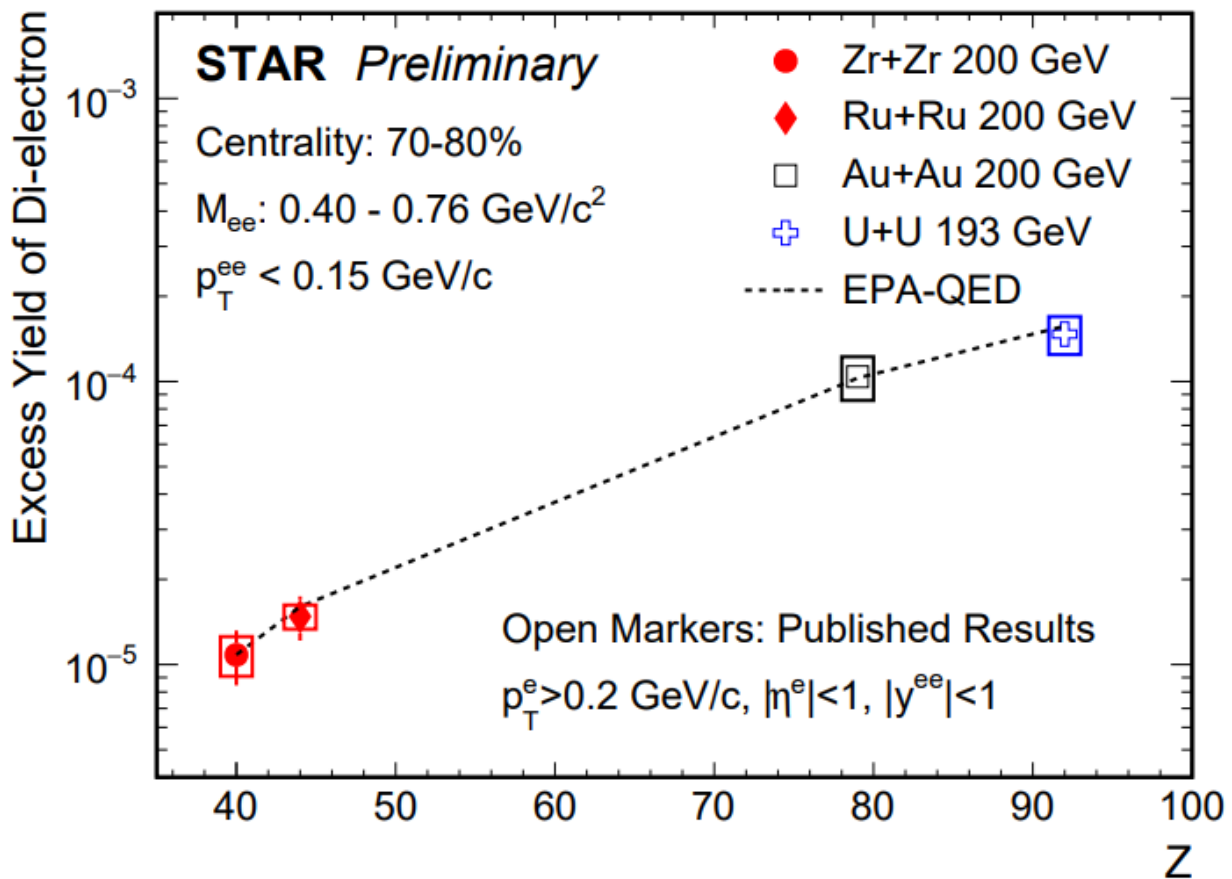
Excess Yield Ratio Between Isobaric Collisions



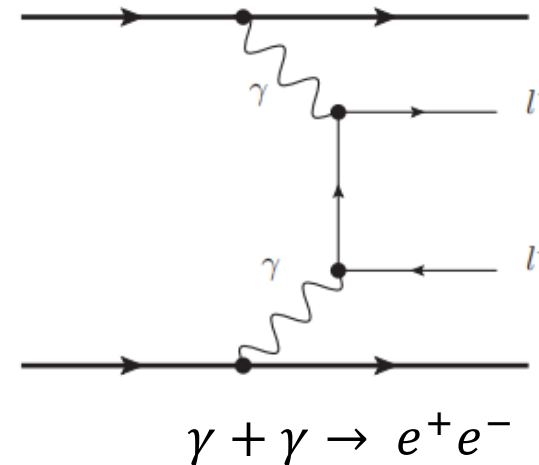
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- With cocktail subtracted, the yields at low- p_T are mainly from photon-induced production while the hadronic contributions dominate in intermediate p_T range
- The ratio of excess e^+e^- yield at low- p_T (< 0.1 GeV/c) in the 40-80% centrality is consistent with EPA-QED calculation and Z^4 scaling
- The initial EM fields seem to be different

Charge Dependence of Excess Yield

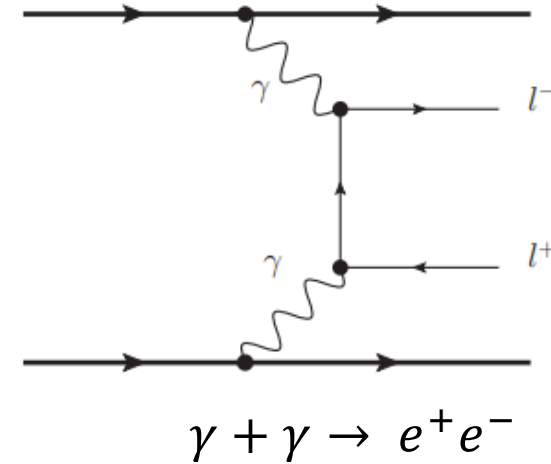
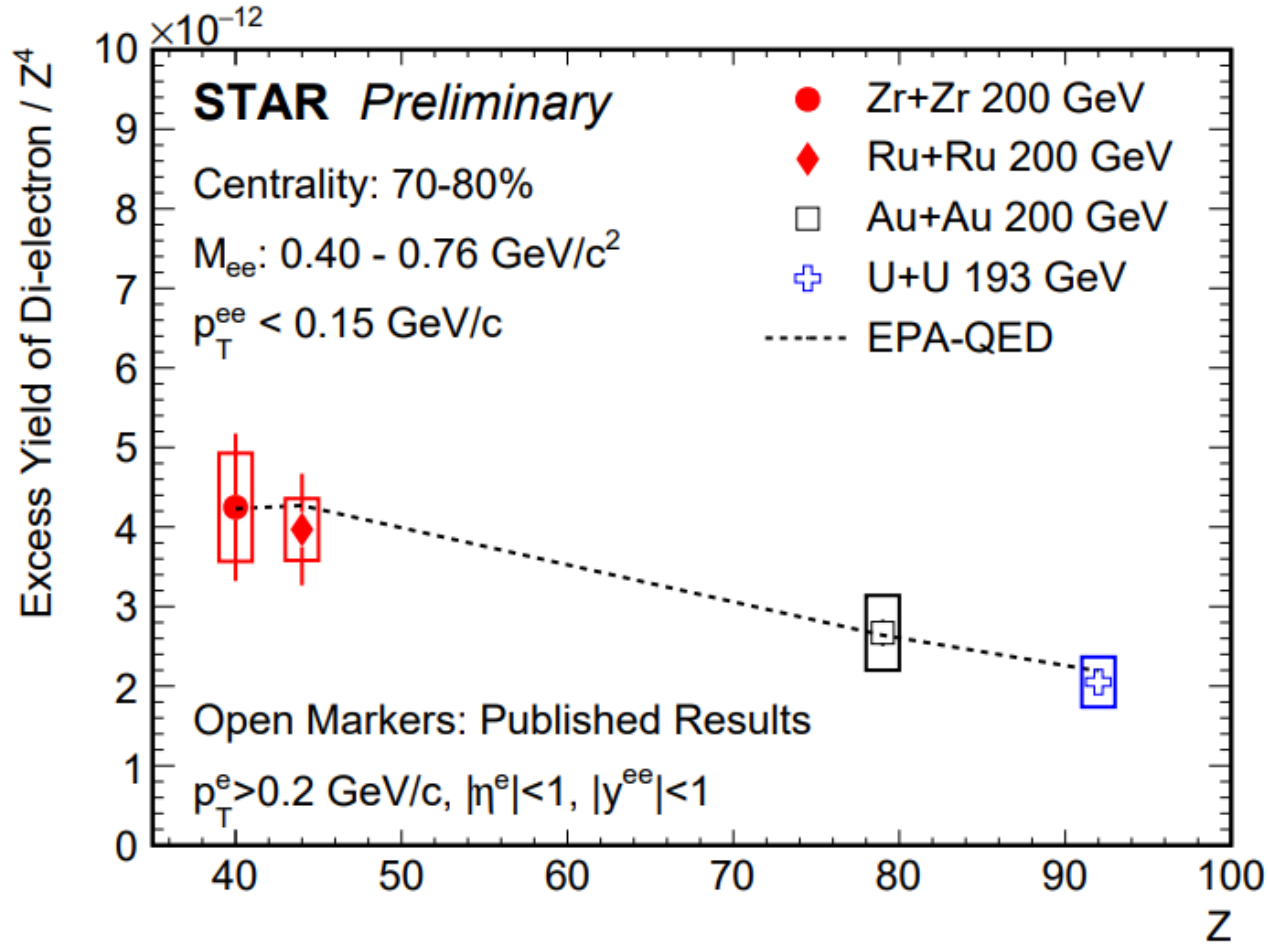


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- The charge dependence of the integrated excess yield in the mass region of 0.4-0.76 GeV/c² at low-p_T (<0.15 GeV/c) in 70-80% centrality
- The excess yields in isobaric collisions are significantly smaller compared to those in Au+Au and U+U collisions, which is an interplay of the differences in charge, impact parameter and form factor

Charge Dependence of Scaled Excess Yield

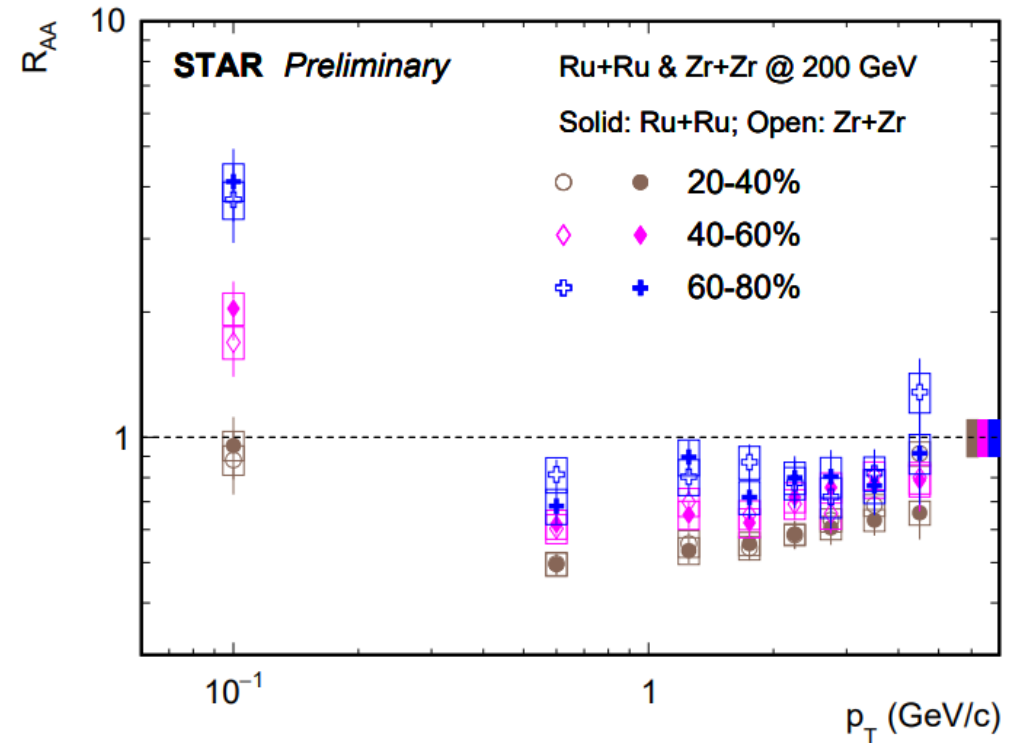
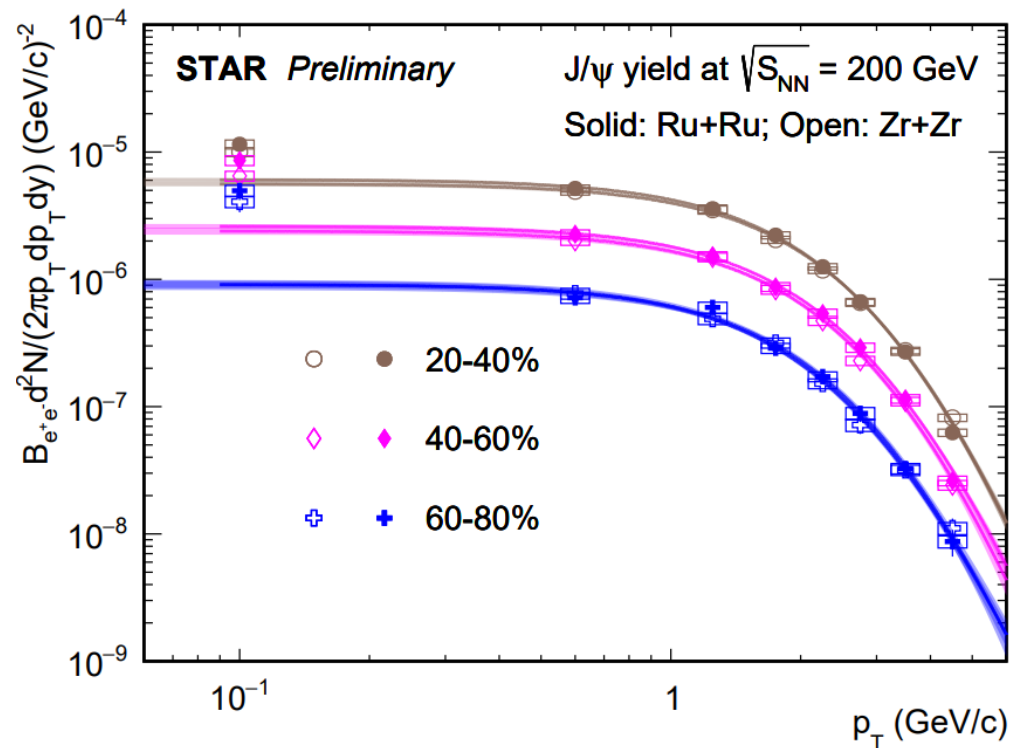


- Z^4 scaled yield shows clear collision system dependence, likely originating from impact parameter dependence
- Decreasing trend described the EPA-QED calculation

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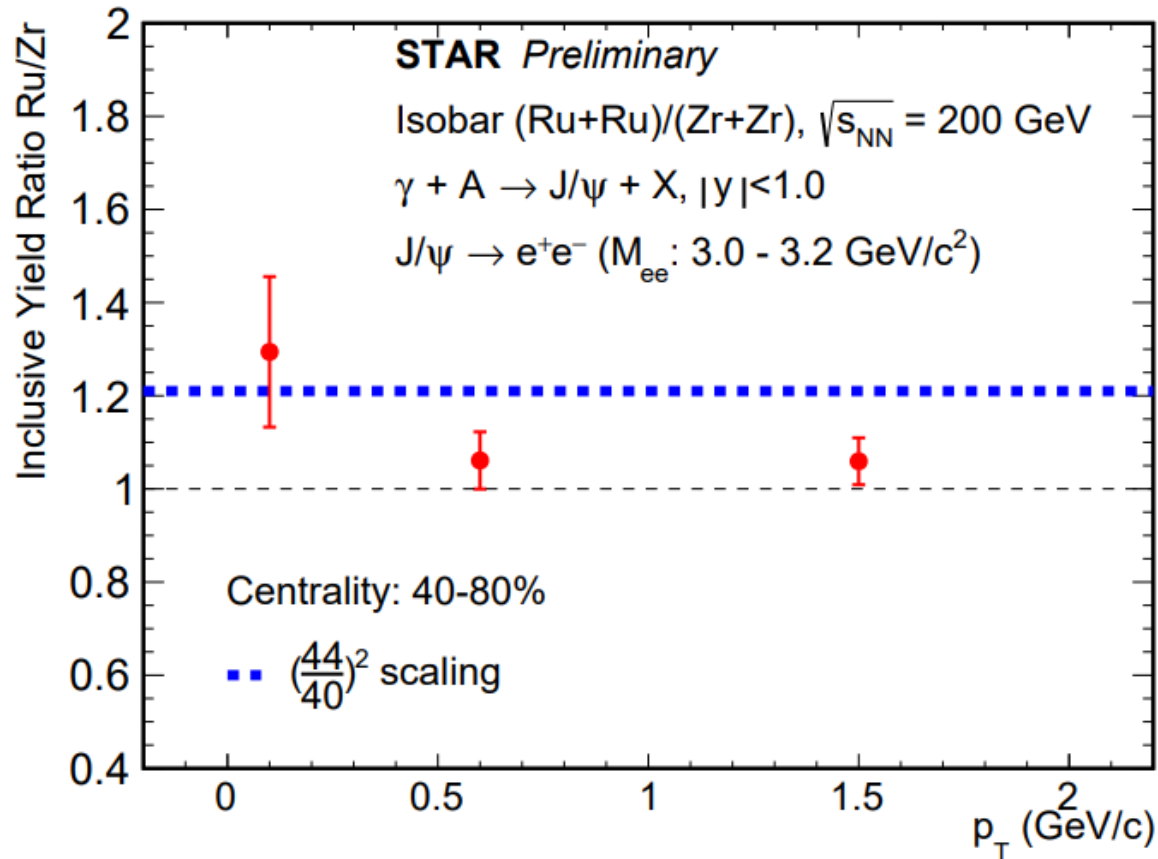
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Invariant Yield and Nuclear Modification Factor of J/ψ



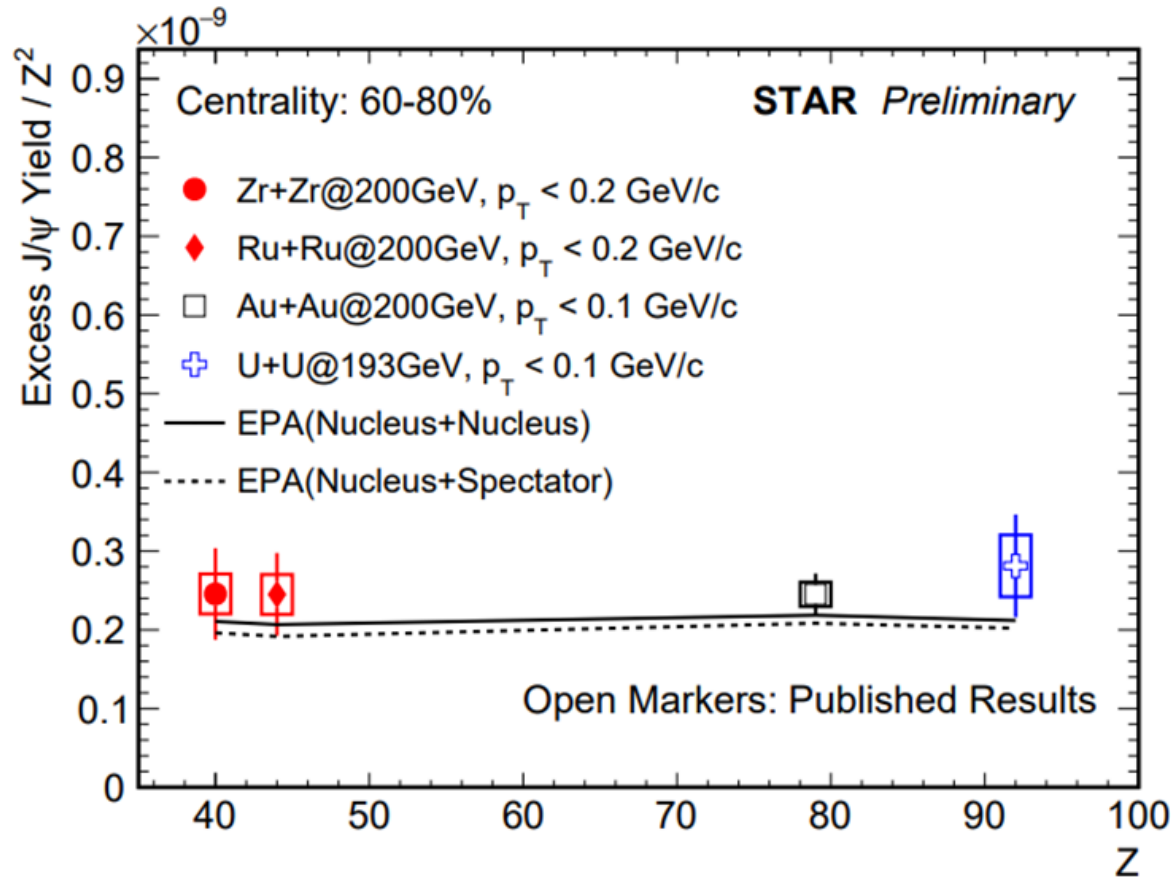
- ❑ The yield spectra are fitted by the Tsallis function at p_T larger than 0.2 GeV/c, and extrapolated to low- p_T range
- ❑ The data are well described by the fitted curves above 0.2 GeV/c, but show significant enhancements at low- p_T range
- ❑ The R_{AA} is significantly higher than unity at low- p_T range

Ratio of J/ψ Yields Between Isobaric Collisions

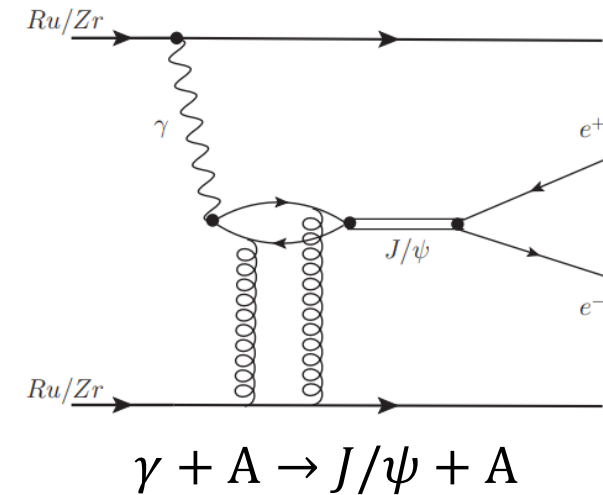


- The collision system dependence (${}^{96}_{44}\text{Ru}+{}^{96}_{44}\text{Ru}$ and ${}^{96}_{40}\text{Zr}+{}^{96}_{40}\text{Zr}$) of yield is shown as function of p_T
 - Inclusive J/ψ production follows Z^2 scaling at very low p_T
 - $\sim 1.7\sigma$ deviation from unity at $p_T < 0.2$ GeV/c
 - Hint of different initial EM fields

Collision System Dependence Between Iso-bar and Au+Au / U+U

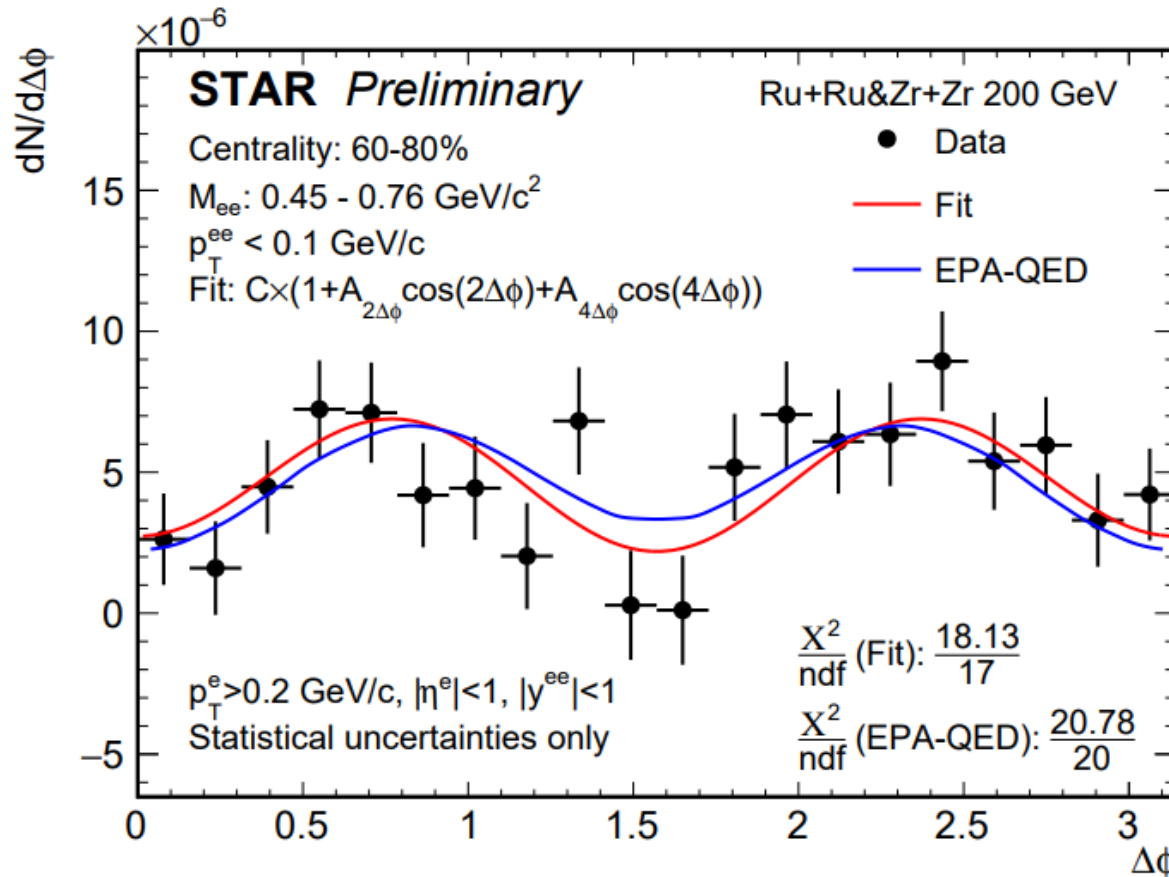


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 W. Zha et al. Phys. Rev. C 97, 044910 (2018)



- Scale J/ψ excess yields at very low p_T with Z^2
- The photo-nuclear production of J/ψ seems to be independent of collision species at a given centrality
- Effects of form factor and impact parameter seem to balance each other

cos(4Δφ) Modulation in Isobaric Collisions



	$ A_{4\Delta\phi} $ (%)	$ A_{2\Delta\phi} $ (%)
Isobar(60-80%)	$47 \pm 13(\text{stat})$	$6 \pm 12(\text{stat})$
Au+Au(60-80%)	27 ± 6	6 ± 6

- ❑ Clear cos(4Δφ) signal ($\sim 3.6\sigma$) in isobaric collisions: $|A_{4\Delta\phi}| = 0.47 \pm 0.13(\text{stat}) \pm 0.05(\text{sys})$
 - $|A_{4\Delta\phi}|$ predicted by QED-EPA is 0.40
- ❑ No significant difference between isobaric and Au+Au collisions



- ❑ Enhancements of J/ψ and e^+e^- production at very low p_T have been observed in peripheral isobaric collisions

- ❑ The collision species dependence of photon-induced production have been measured at STAR
 - The initial EM field seems to be different in peripheral Ru+Ru and Zr+Zr collisions
 - After taking out the charge difference, the excess yield of J/ψ is mostly independent of collision system, while e^+e^- shows an impact parameter dependence

- ❑ The $\cos(4\Delta\phi)$ signal is prominent ($\sim 3.6\sigma$) in isobaric collisions and no significant difference is observed between isobaric and Au+Au collisions