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J/ ψ production in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment

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Outline



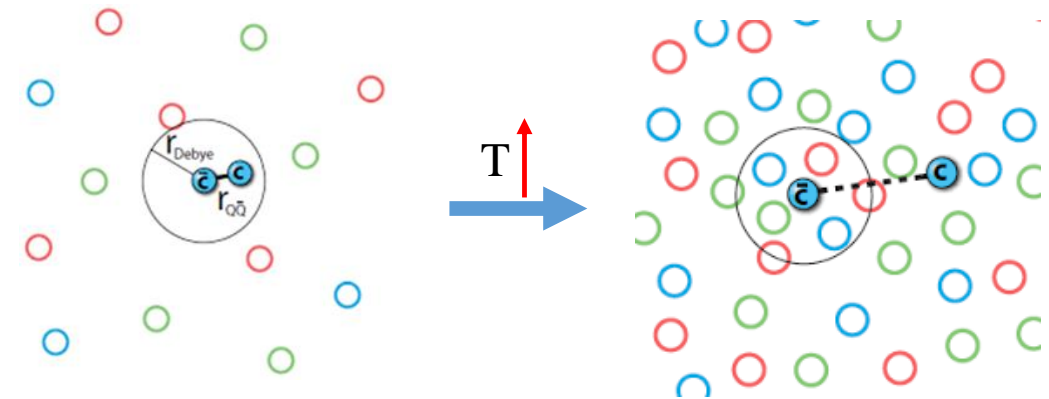
- Introduction
- J/ψ R_{AA} measurement
- J/ψ elliptic flow measurement
- Summary

Introduction

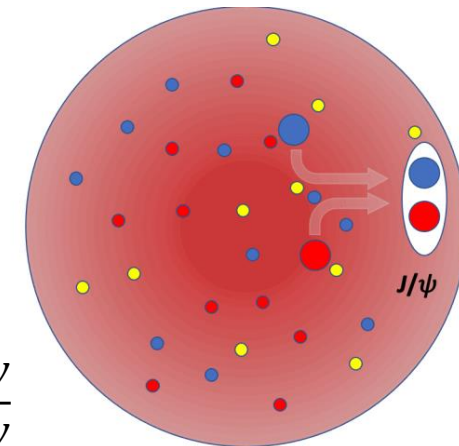
- Heavy quarks produced via hard scattering, experience the whole medium evolution
- J/ψ is considered a unique probe of the Quark-Gluon Plasma (QGP)
- Hot medium effects
 - Dissociation
 - Regeneration
 - Feed-down contribution
- Cold nuclear matter effects (e.g. nPDF, coherent energy loss, nuclear absorption)
- Other final state effects (e.g. comovers)
- Two key observables:
 - Nuclear modification factor (R_{AA})
 - Elliptic flow (v_2)

$$R_{AA} = \frac{1}{\langle N_{coll} \rangle} \times \frac{d^2 N_{AA}/dp_T dy}{d^2 N_{pp}/dp_T dy}$$

$$v_2 = \langle \cos[2(\phi - \Psi_{rp})] \rangle$$

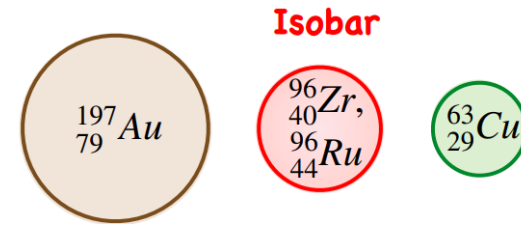
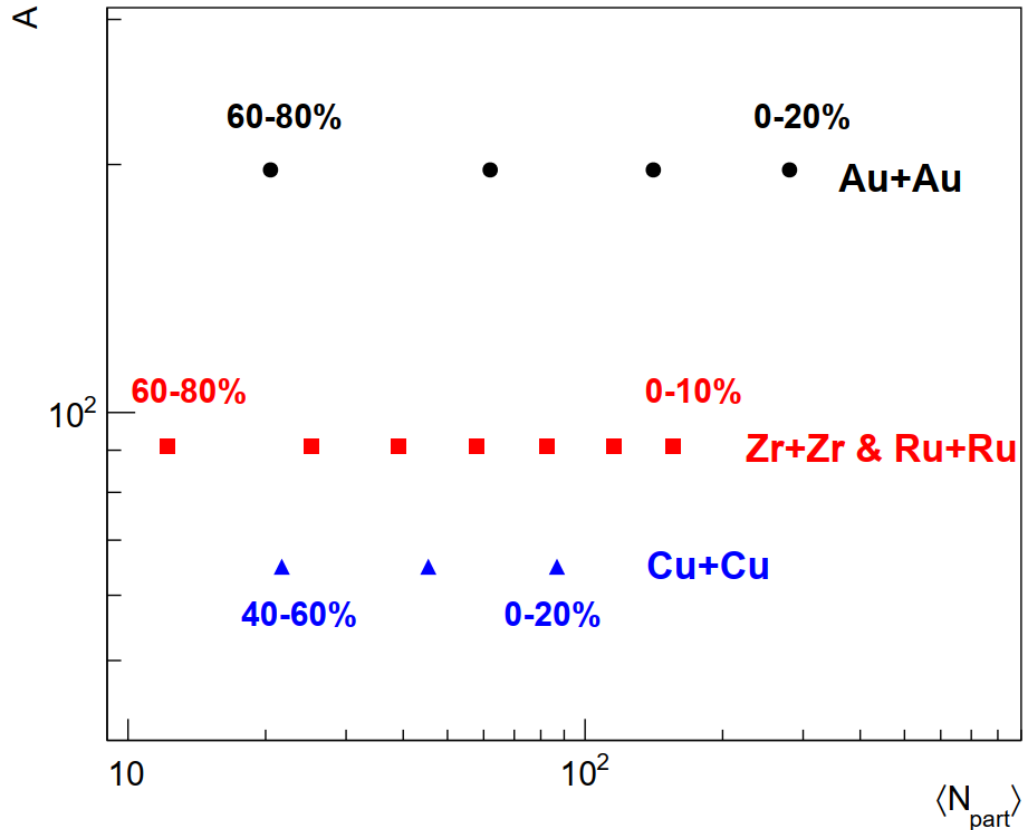


color screening



regeneration

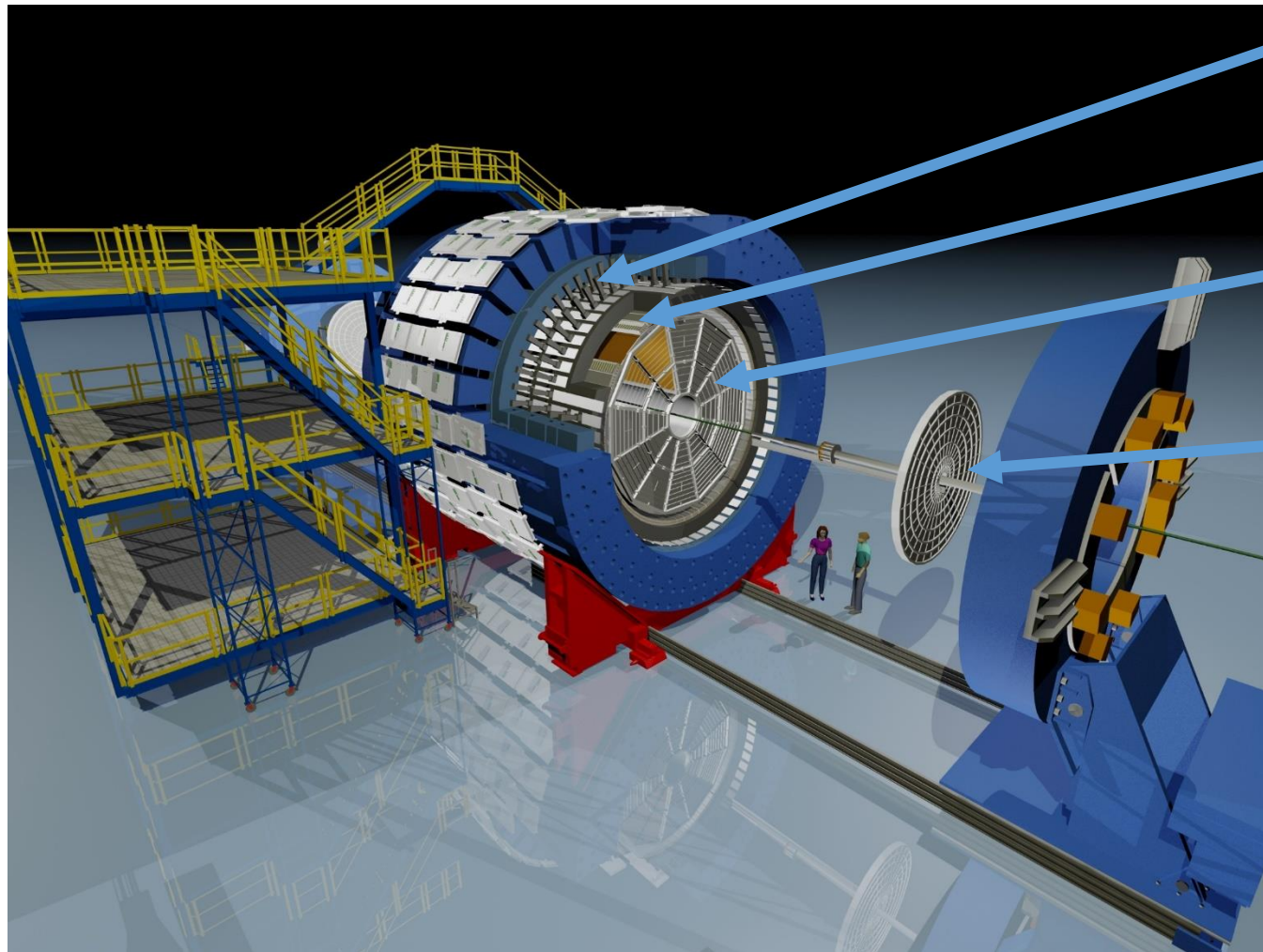
Isobar collisions



- A moderate size collision system
 - All these effects are expected to show strong dependence on collision system size
 - Unique opportunity to study the system size dependence

- Large isobar sample
 - **~4B good minimum bias** $^{92}_{44}\text{Ru} + ^{92}_{44}\text{Ru}$ and $^{92}_{40}\text{Zr} + ^{92}_{40}\text{Zr}$ events
 - Unique opportunity to measure the spectra and v_2 with good precision

The Solenoidal Tracker At RHIC

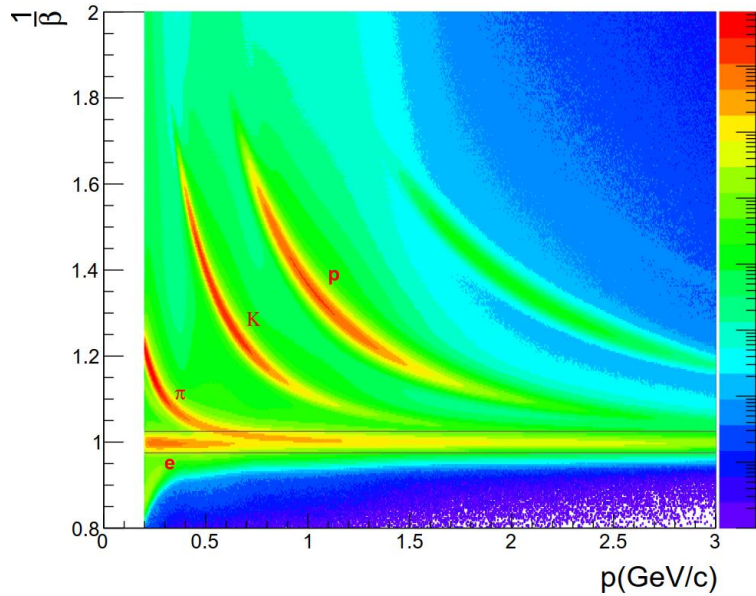


- ✓ **BEMC**: Identification of high- p_T electrons
- ✓ **TOF**: Time of flight, particle identification
- ✓ **TPC**: Tracking, momentum and energy loss
- ✓ **EPD**: Event-plane reconstruction

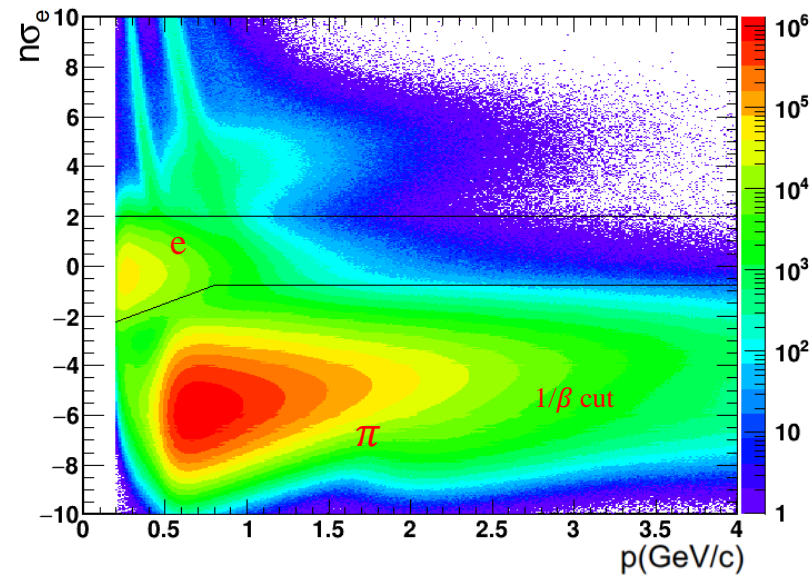
Electron identification



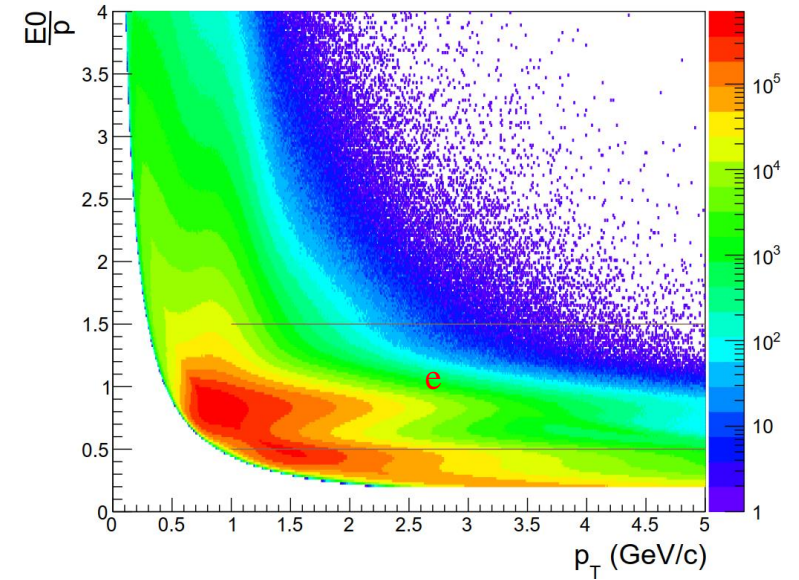
TOF PID



TPC PID after TOF cut



BEMC PID after TPC cuts



➤ TPC, TOF, and BEMC used to identify electron

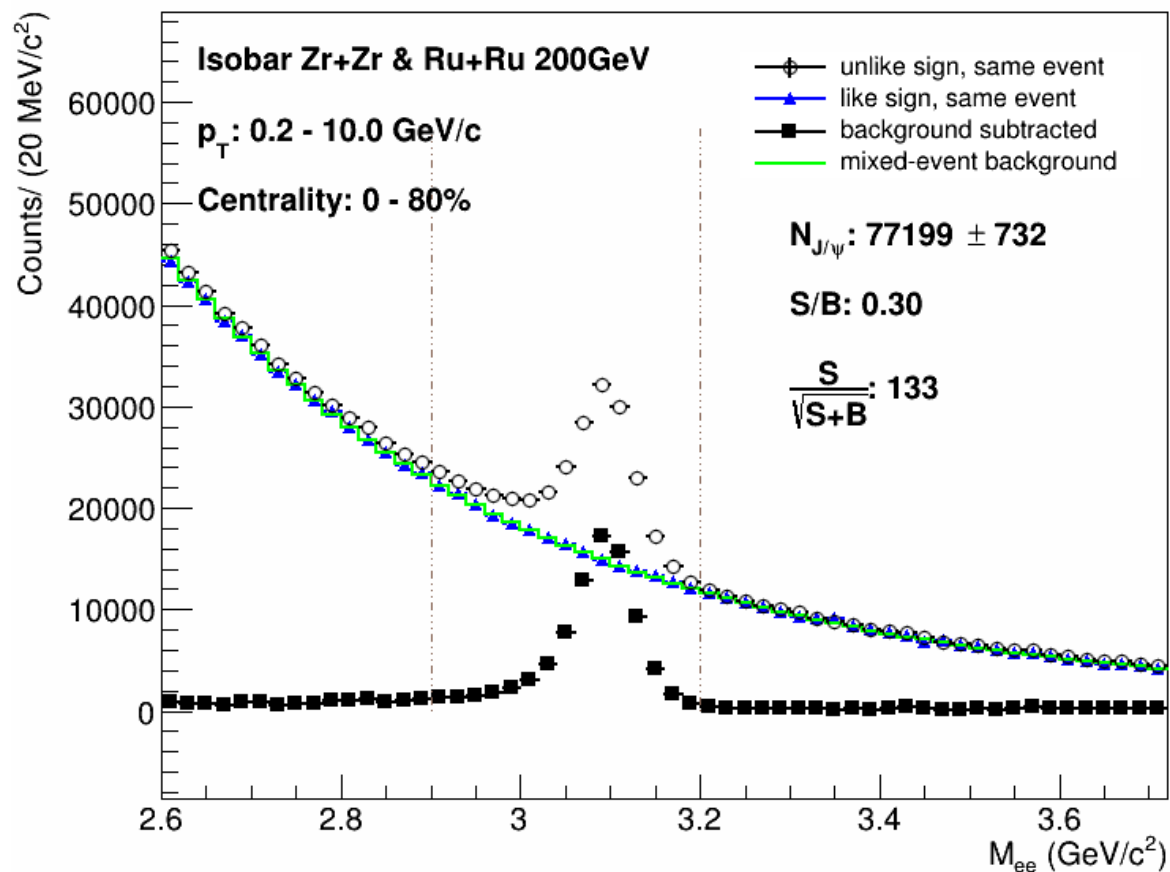


• TPC: $n\sigma_e$

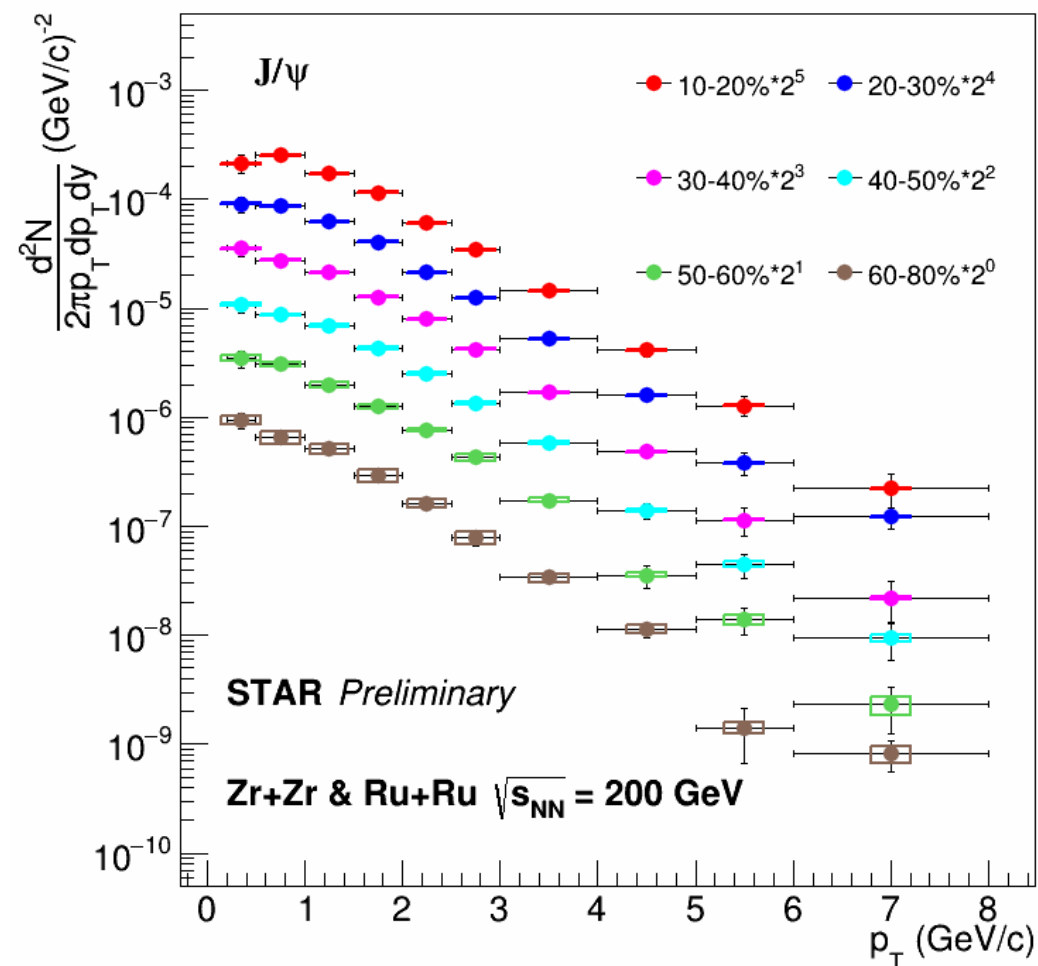
• TOF: $\frac{1}{\beta}$

• BEMC: $\frac{E_0}{p}$

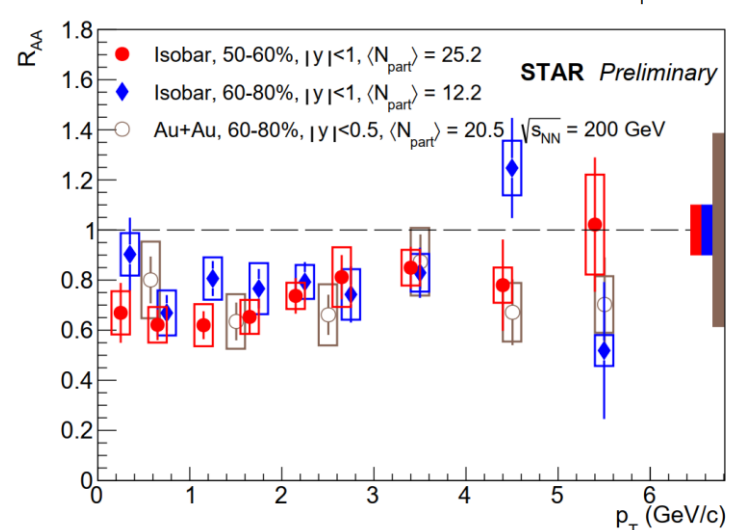
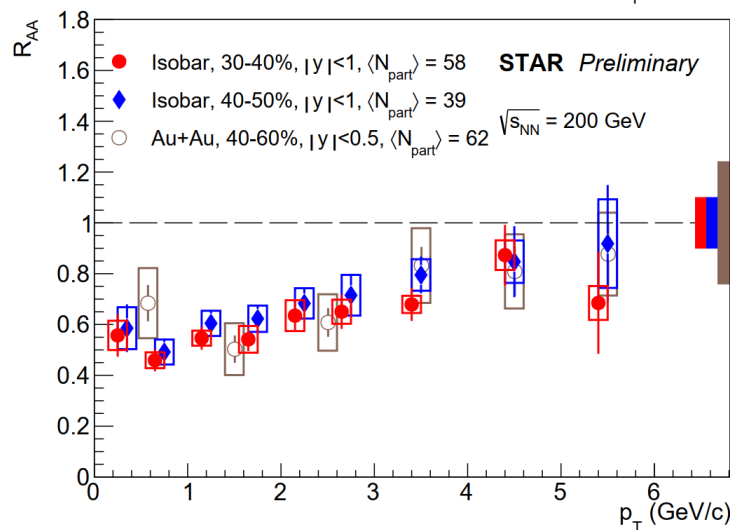
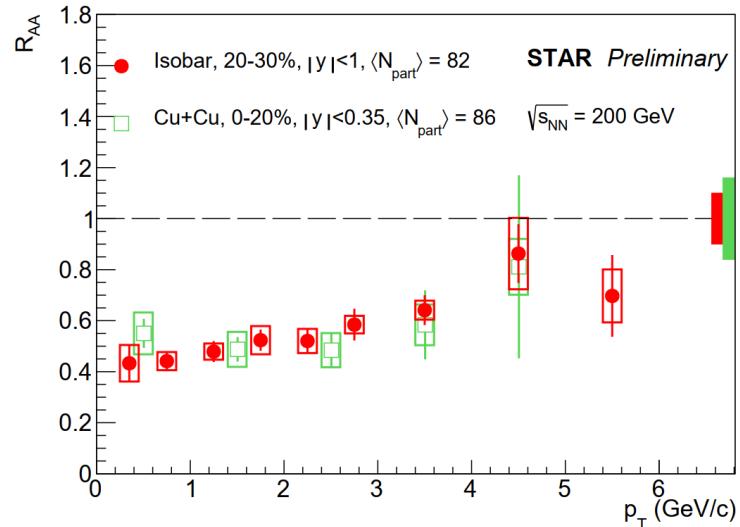
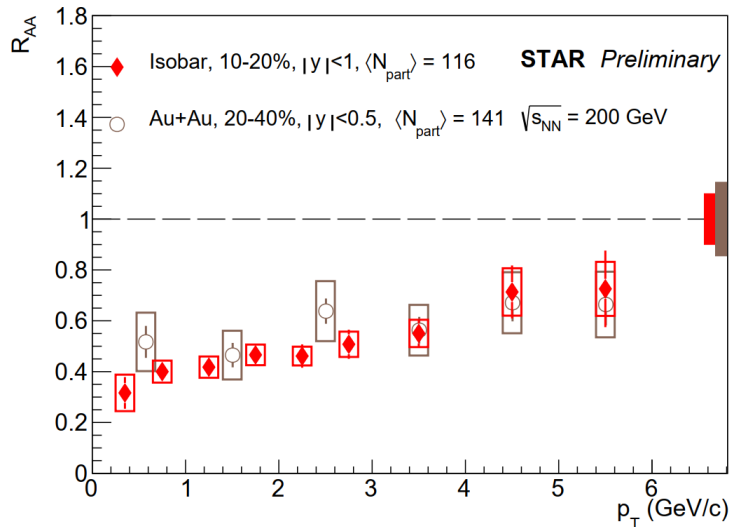
J/ψ spectra



Excellent J/ψ signal



Nuclear modification factors

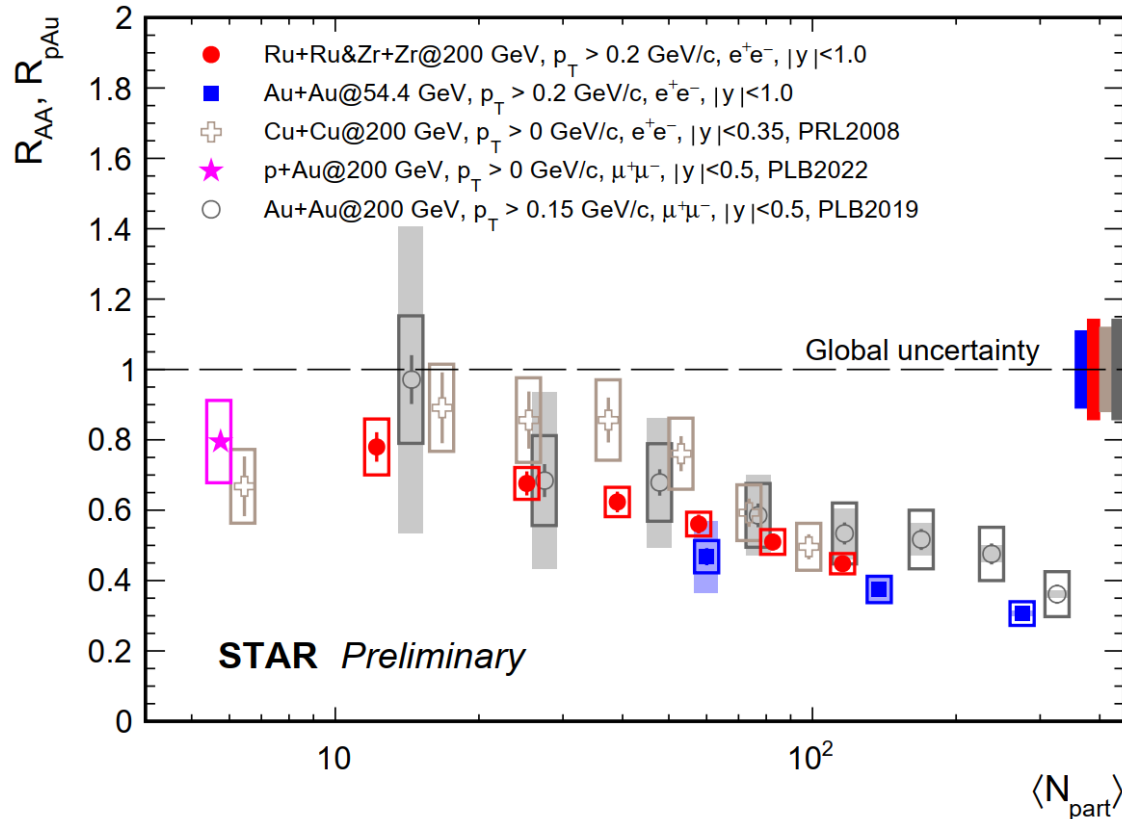


Au+Au: STAR, PLB 797, 134917, 2019

Cu+Cu: PHENIX, PRL101, 122301, 2008

- R_{AA} as a function of p_T measured in 6 centralities of isobaric collisions
- High-precision J/ψ measurement at RHIC
- Significant suppression observed in central and mid-central collisions
- Consistent with Au+Au and Cu+Cu results for similar system size ($\langle N_{part} \rangle$)

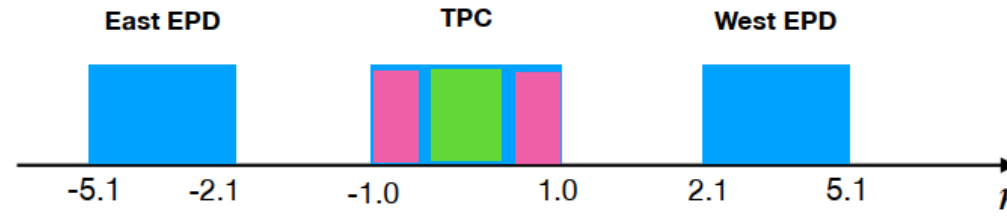
Nuclear modification factors



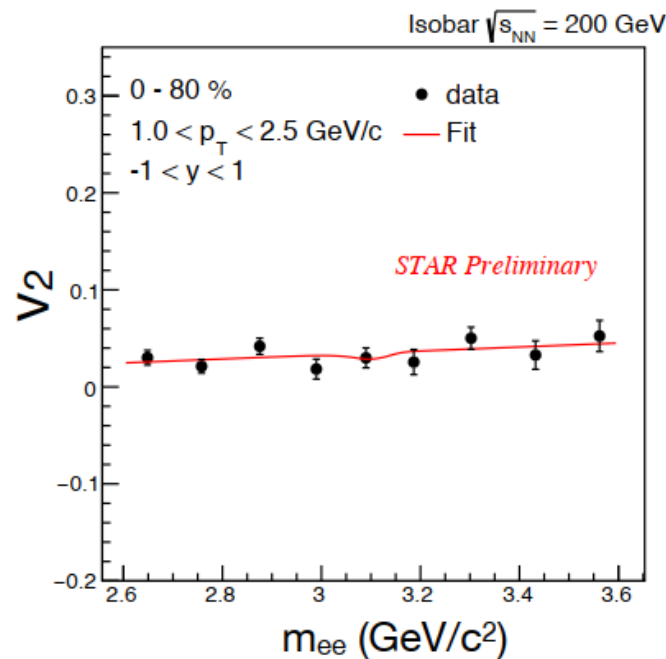
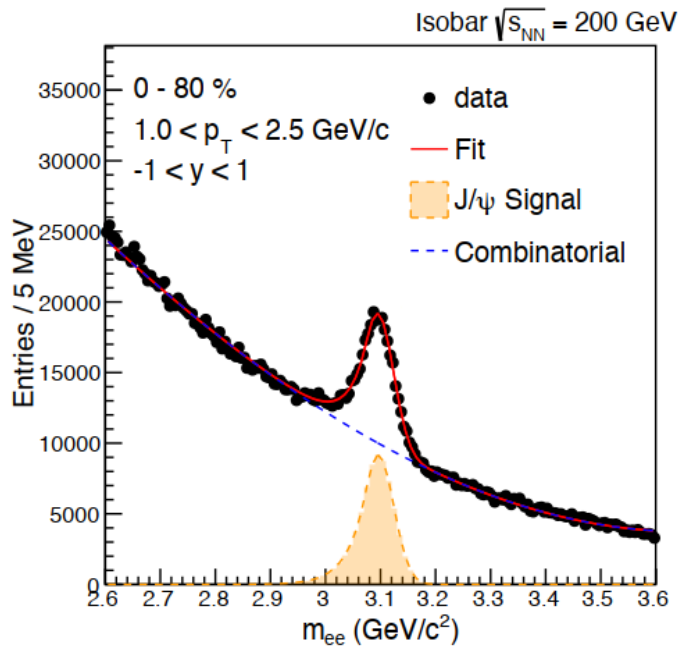
- A decreasing trend with increasing $\langle N_{part} \rangle$ is observed
- Significant suppression observed at large $\langle N_{part} \rangle$ due to dissociation
- No significant collision system and energy dependence at RHIC energies

v_2 extraction for MB events

Scalar-Product (SP) method:
(MB trigger)



Large η gap between J/ψ and EPD \rightarrow reduced non-flow contribution to final results



- Crystal-ball function for J/ψ mass distribution
- 3rd order polynomial for background mass distribution
- Background v_2 : $a + b * mass$

$$v_2^{S+B}(m_{inv}) = f(m_{inv})v_2^S + [1 - f(m_{inv})] v_2^B$$

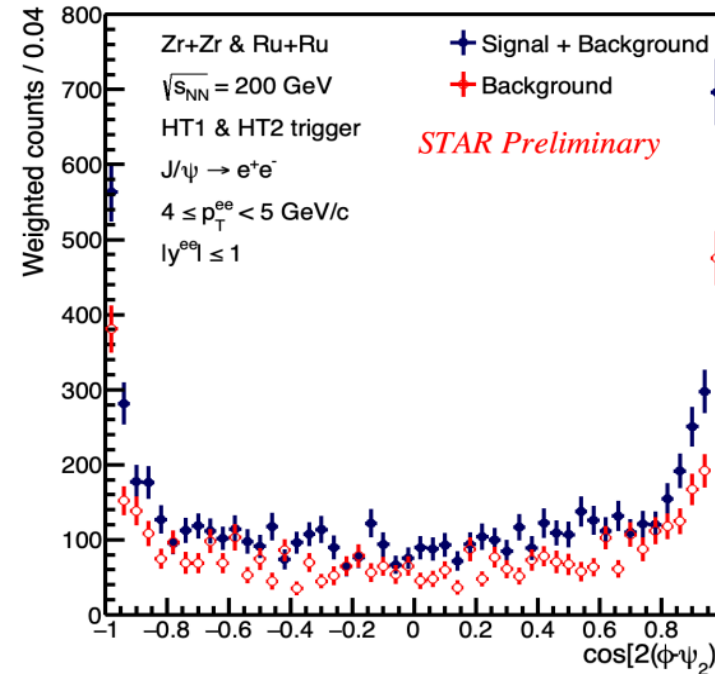
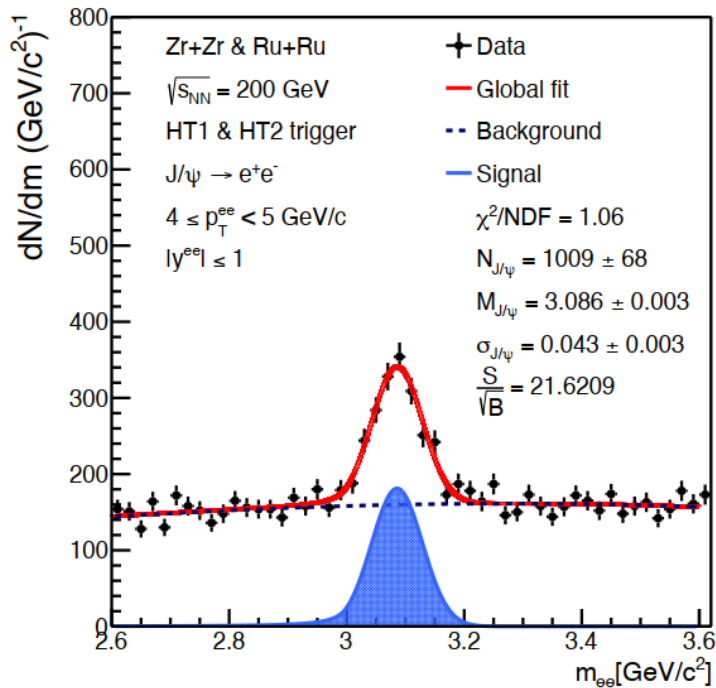
$$f(m_{inv}) = \frac{S(m_{inv})}{S(m_{inv}) + B(m_{inv})}$$

v_2 extraction for BEMC-triggered events

TPC Event-Plane (EP) method:
(HT trigger)

$$E \frac{d^3N}{d^3p} = \frac{1}{2\pi} \frac{d^2N}{p_T dp_T dy} \left(1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\phi - \Psi_n)] \right)$$

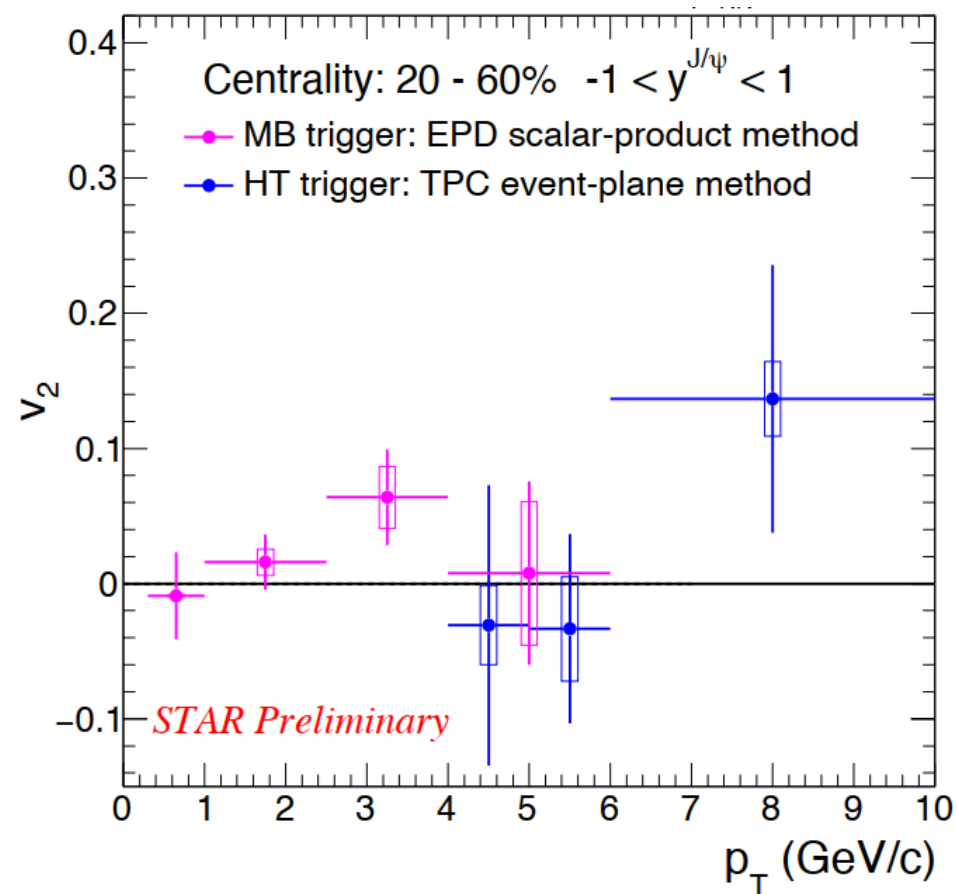
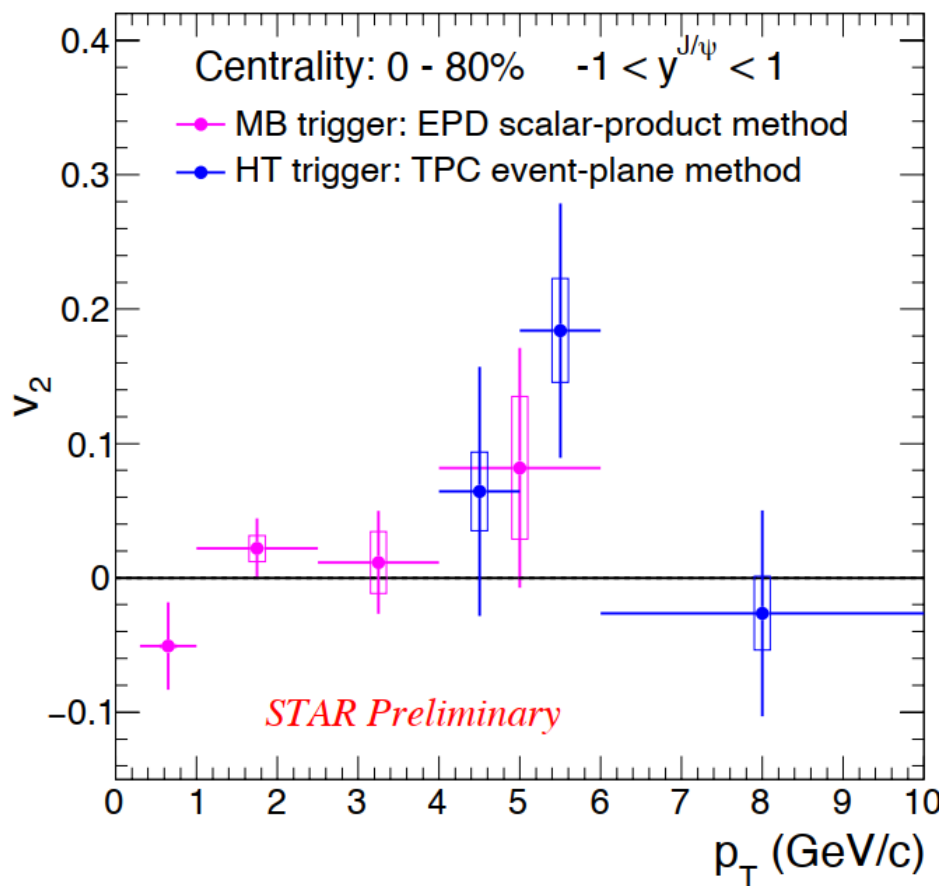
TPC second-order event plane to estimate the reaction plane



$$v_2^{obs} = \frac{\sum_i \cos[2(\phi - \Psi_2)]_{S+B,i} - \sum_j \cos[2(\phi - \Psi_2)]_{B,j}}{N_{J/\psi}}$$

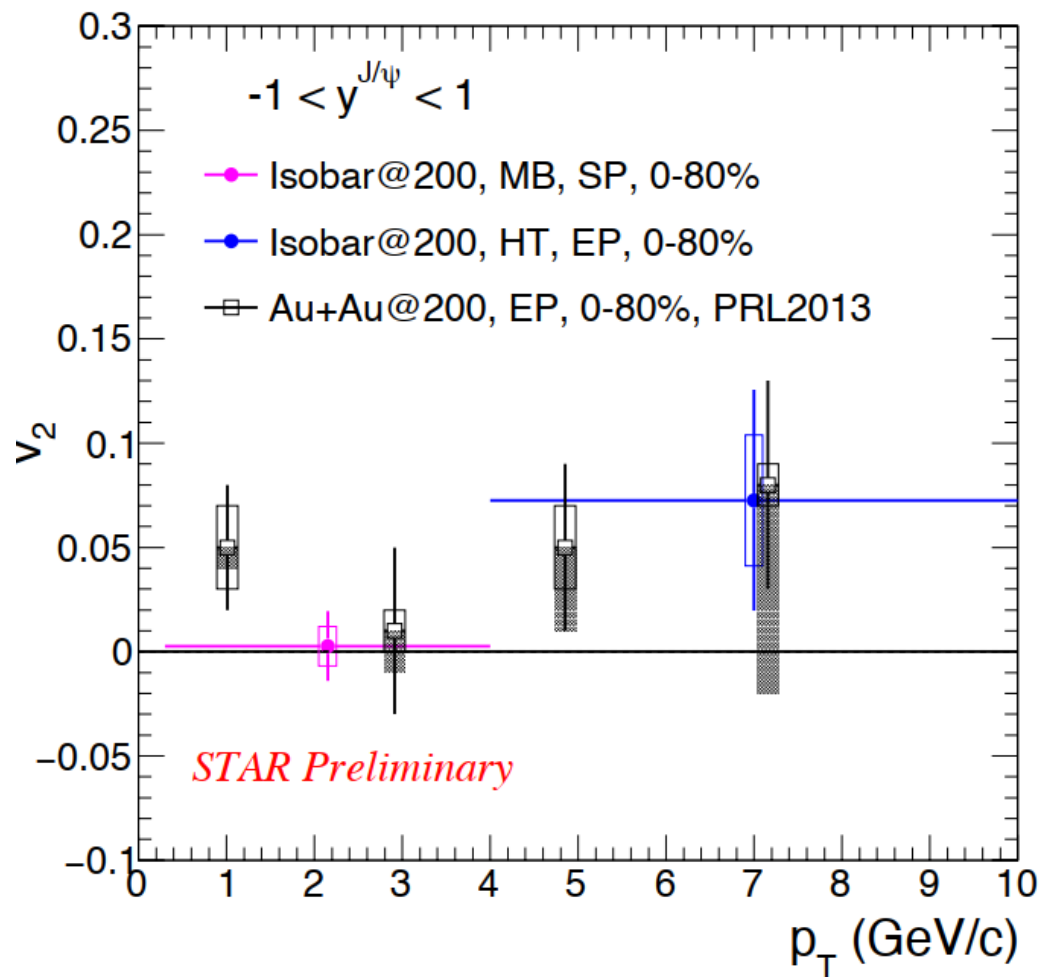
$$v_2 = \frac{v_2^{obs}}{\langle \cos[2(\Psi_2 - \Psi_r)] \rangle}$$

J/ ψ elliptic flow



- No significant J/ ψ v_2 is observed with the current statistics
- No significant p_T dependence is seen for J/ ψ v_2

J/ψ elliptic flow



- More precise v_2 results at low p_T range (< 4 GeV/c) in isobar data than previous Au+Au results
- $v_2 = 0.003 \pm 0.017(stat.) \pm 0.010(sys.)$
- Indication of little regeneration effect and/or small charm quark flow

Summary



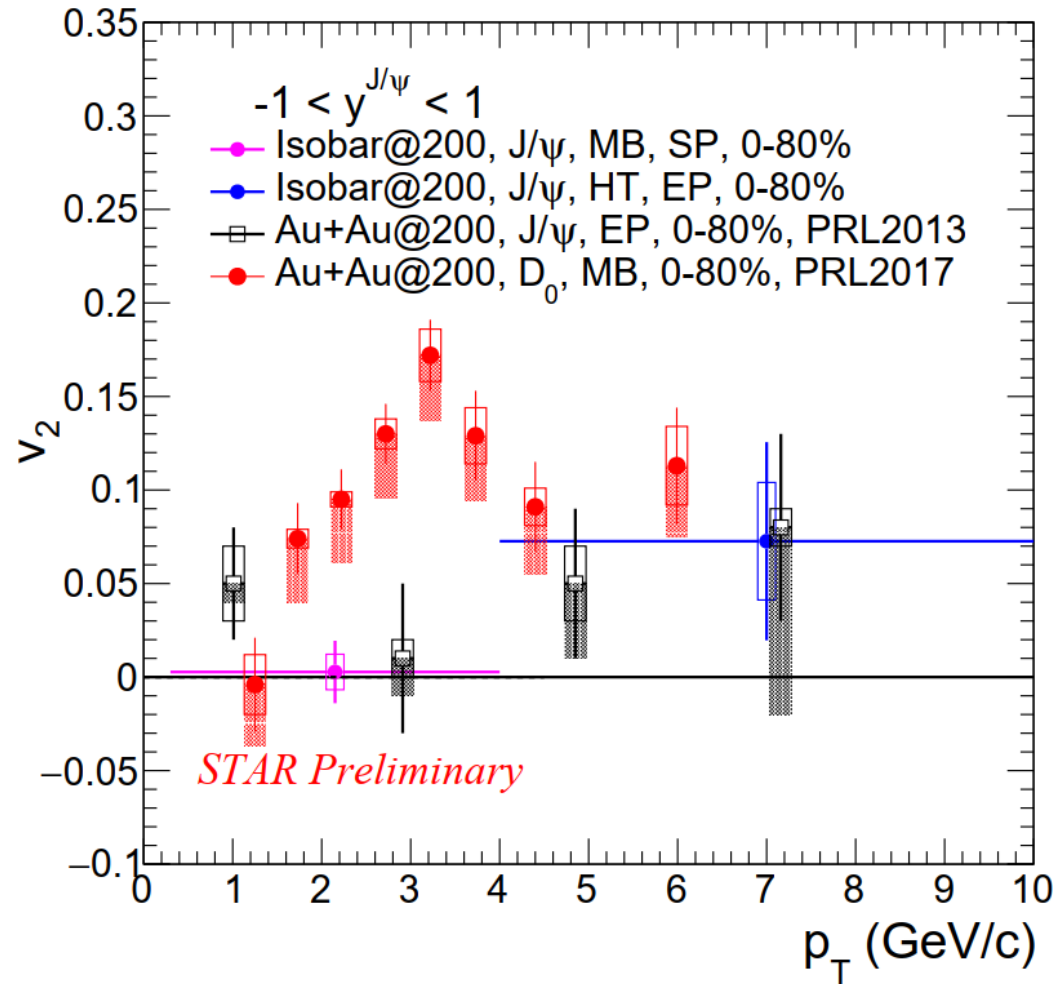
- J/ψ R_{AA} and v_2 are measured in isobaric collisions with great precision
 - Significant suppression of J/ψ in isobaric collisions at $\sqrt{s_{NN}} = 200$ GeV has been observed
 - No significant energy and size dependence of J/ψ R_{AA} at RHIC at similar $\langle N_{part} \rangle$
 - v_2 is consistent with zero

- Indicate strong dissociation effect in central isobaric collisions

Thank you!

Back up

D_0 elliptic flow



Acknowledgments



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