Anisotropic flow of strange and multi-strange hadrons in isobar collisions at $\sqrt{s_{NN}}$ = 200 GeV

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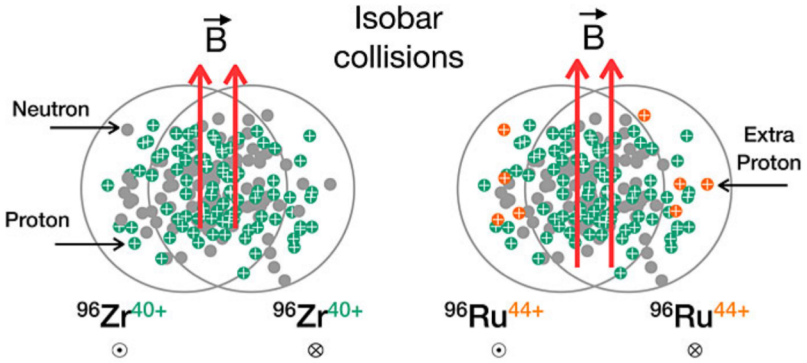
https://drupal.star.bnl.gov/STAR/presentations

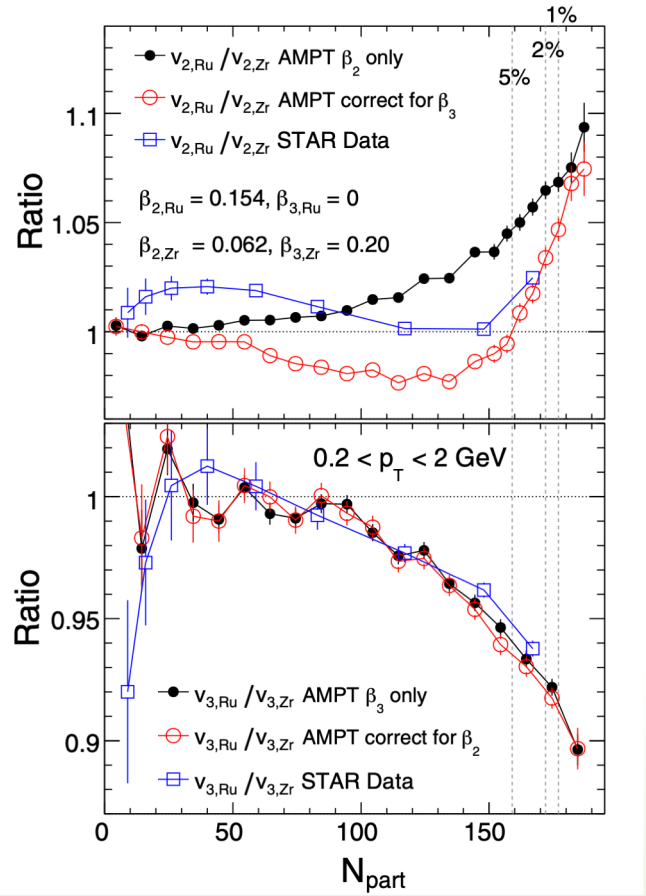
Motivation



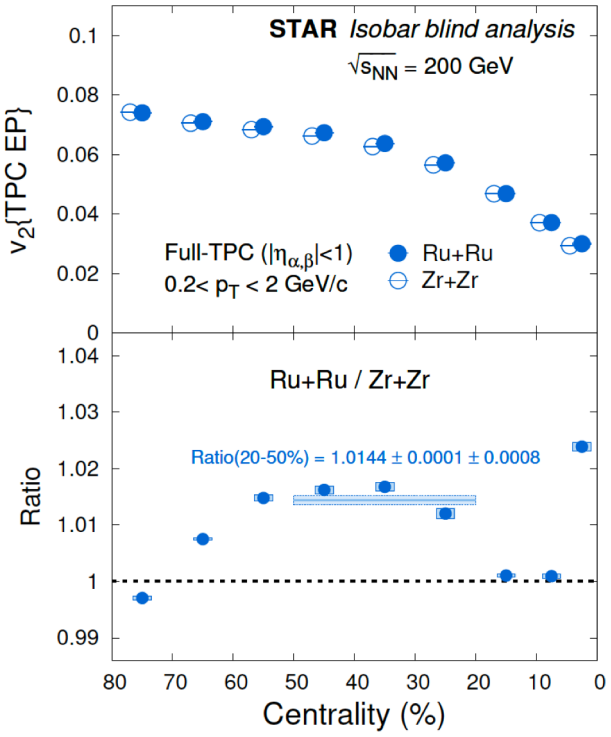
- Characterizing the nuclear density and deformation using elliptic flow
- v_2 of strange and multi-strange hadrons gives direct information on initial state anisotropies

For identified hadrons, check if: $\frac{(v_2)_{Ru+Ru}}{(v_2)_{Zr+Zr}} \stackrel{?}{=} 1$

- System size dependence $^{238}_{92}U$, $^{197}_{79}Au$, $^{96}_{44}Ru$, $^{96}_{40}Zr$, $^{63}_{29}Cu$

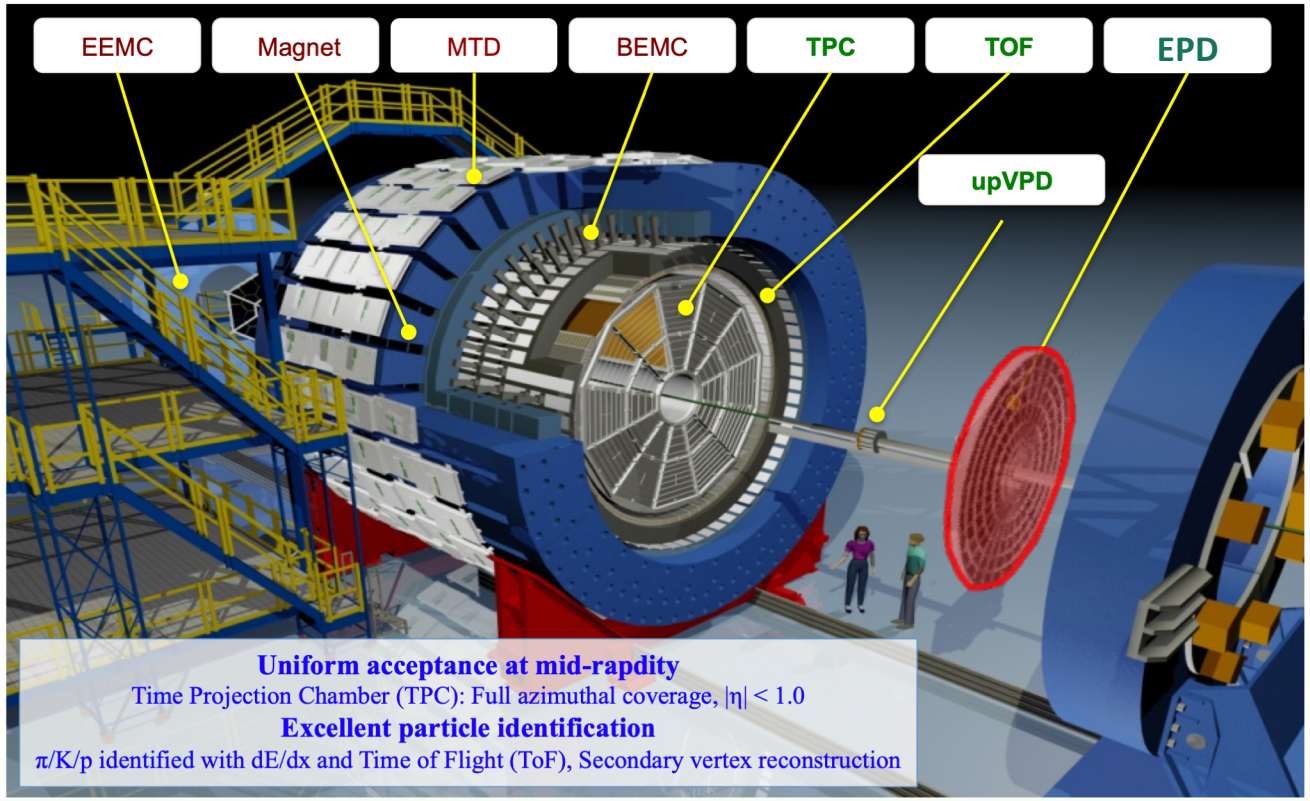


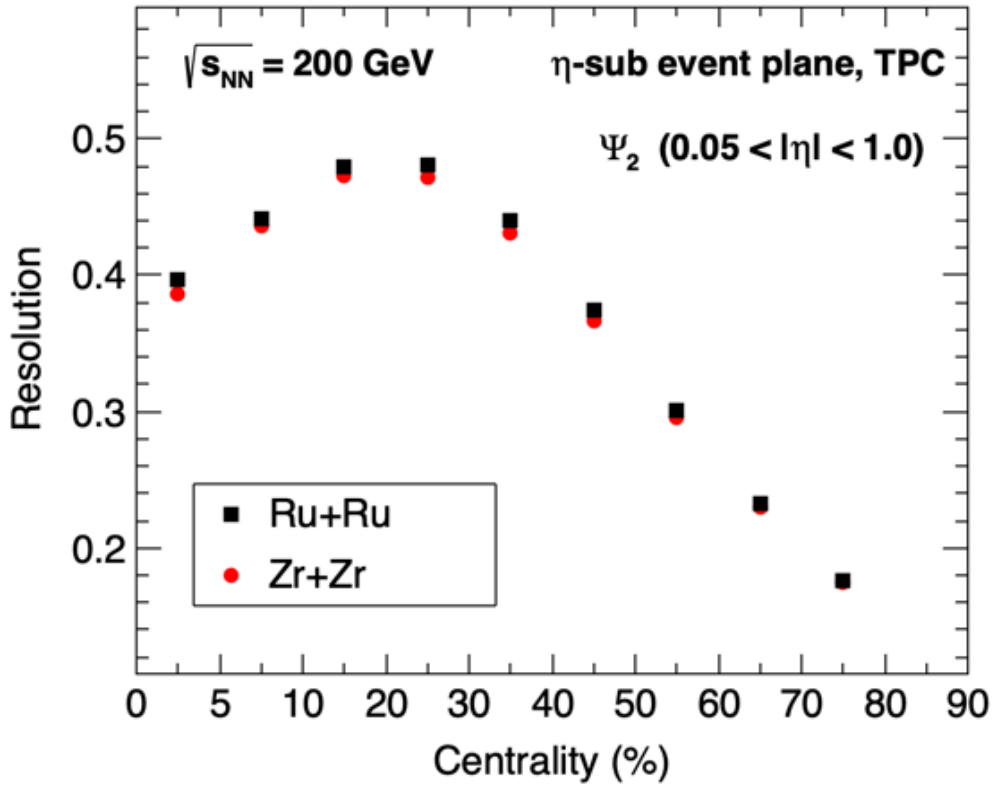
C. Zhang and J. Jia,
Phys. Rev. Lett. 128, 022301 (2022)



M. S. Abdallah et al. (STAR Collaboration),
Phys. Rev. C 105, 14901 (2022)

Methodology





Dataset: Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV (2018)

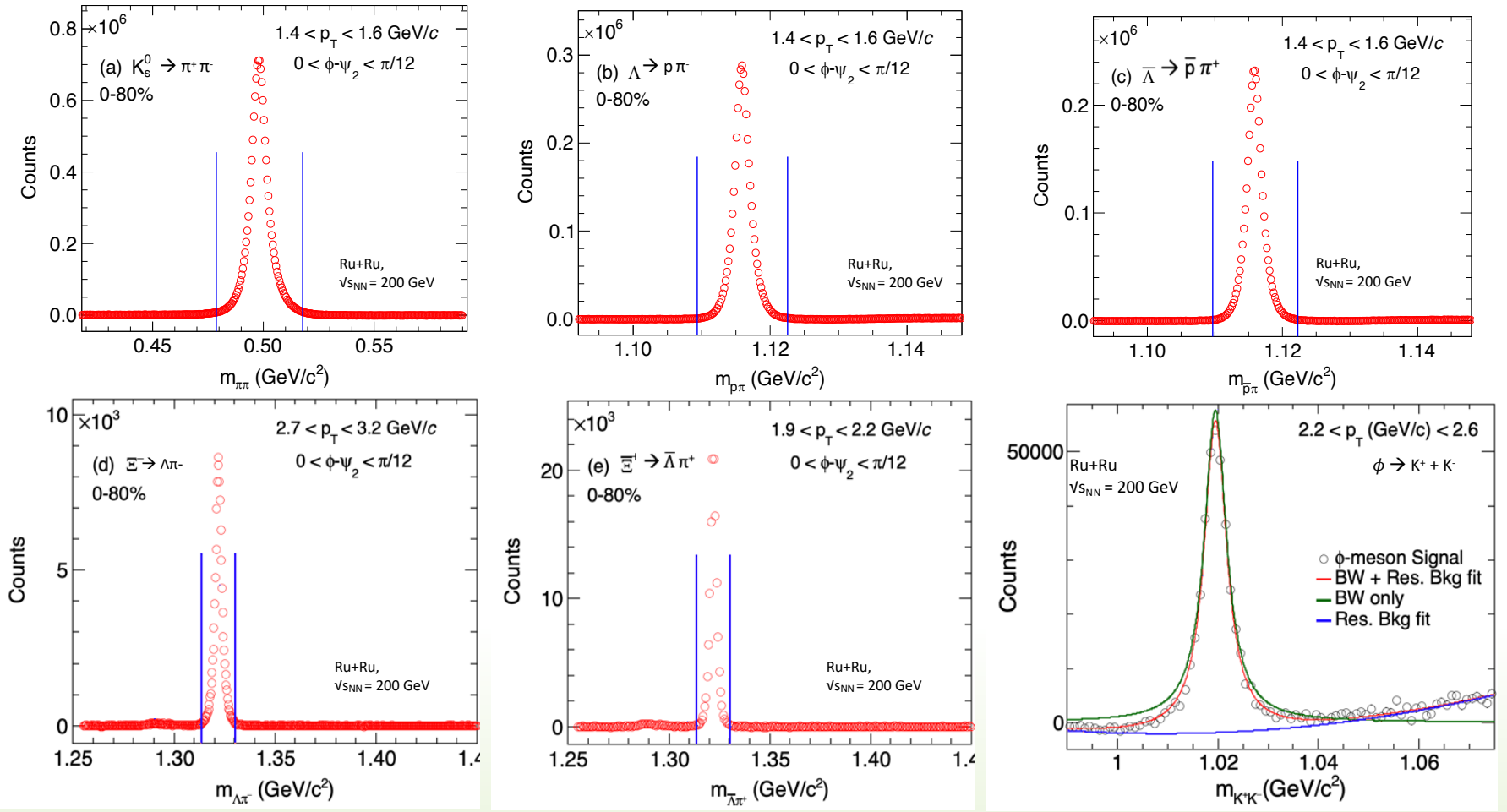
- Systematic uncertainty sources: Event and track selections, Topological selection, Functional fitting for yield extraction

$$\Psi_2 = \left[\tan^{-1}\left(\frac{\sum_i w_i \sin(2\phi_i)}{\sum_i w_i \cos(2\phi_i)}\right)\right]/2$$

$$R = \sqrt{\langle \cos 2(\Psi_2{}^a - \Psi_2{}^b)\rangle}$$

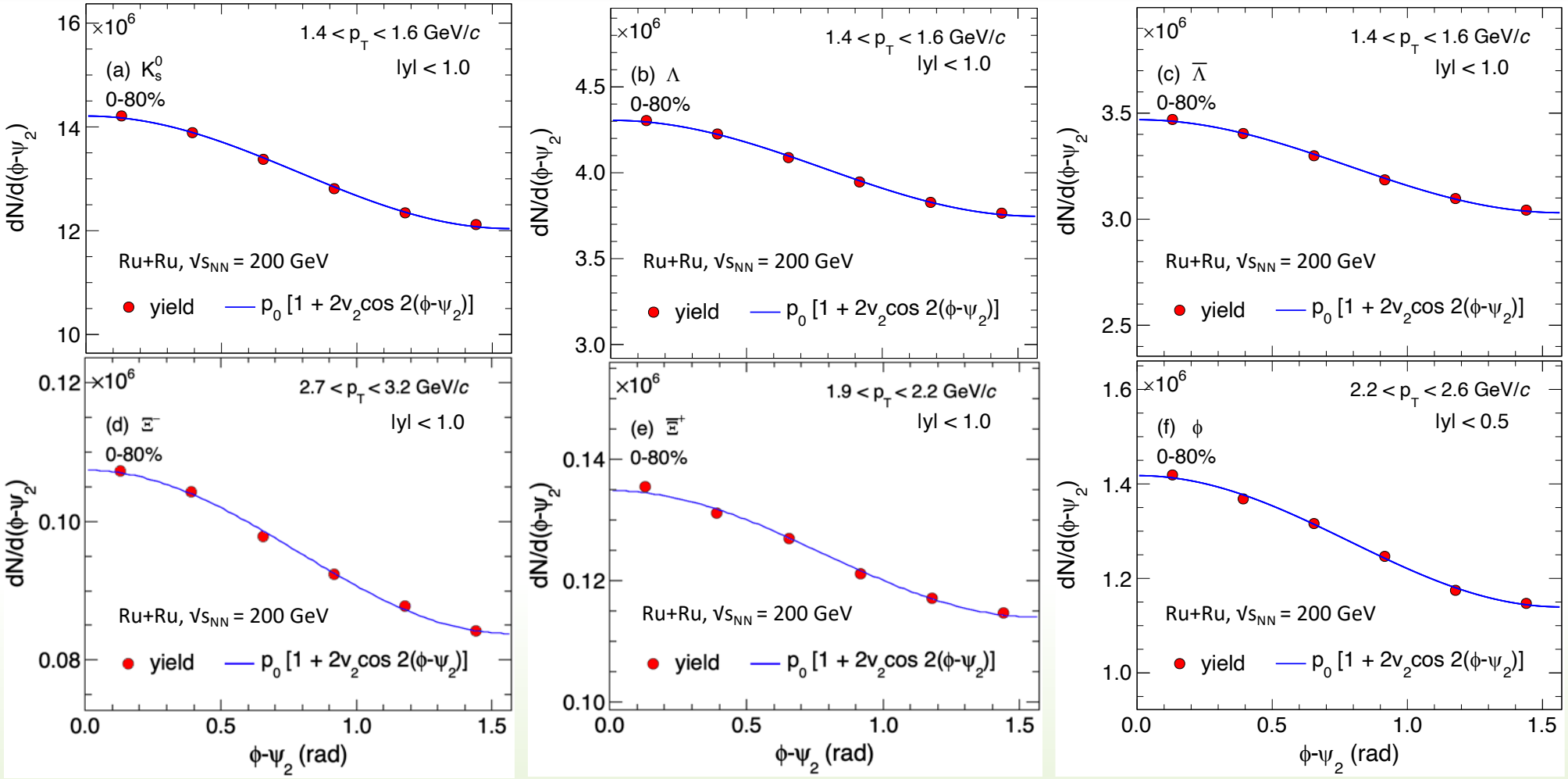
A. M. Poskanzer & S. A. Voloshin, Phys. Rev. C 58, 1671 (1998)

Particle reconstruction



- Reconstructed using invariant mass method; topological cuts using Helix method for K_s^0, Λ, and Ξ
- Background reconstruction using event-mixing method for ϕ-mesons and rotational method for K_s^0, Λ, and Ξ

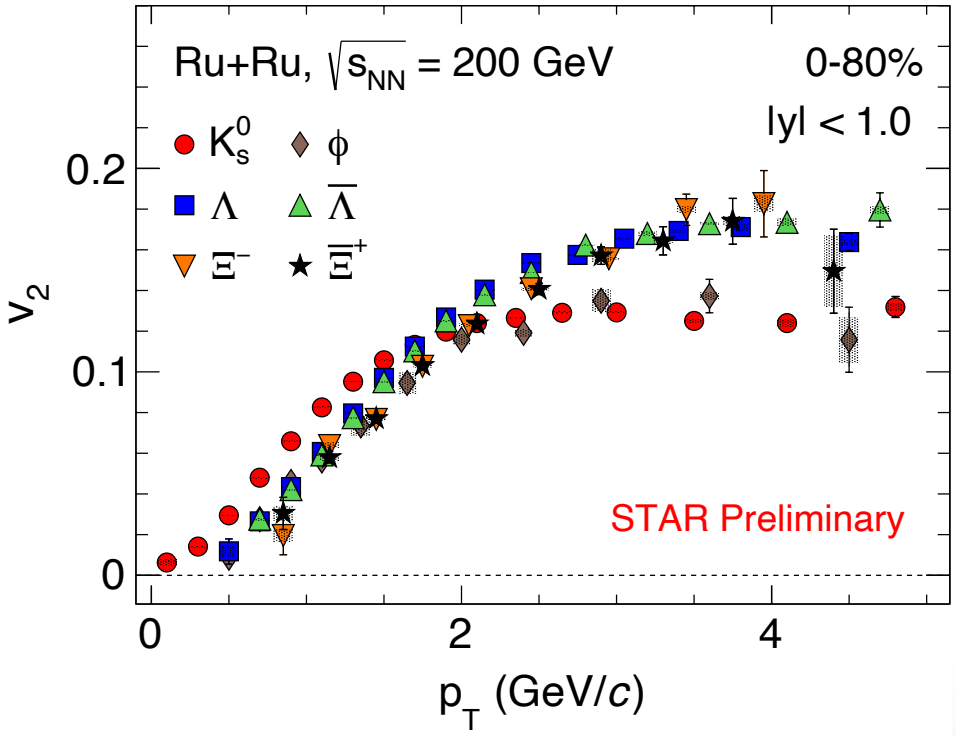
Flow analysis method

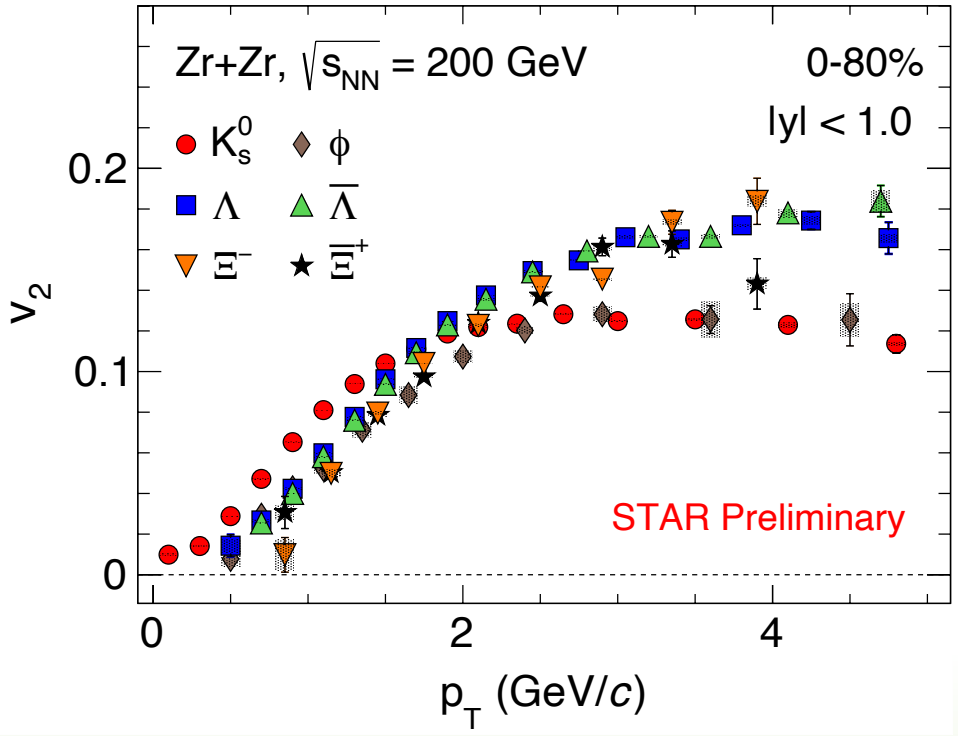


Event plane method:

- Particle raw-yields as a function of ϕ - Ψ_2 are fitted with a Fourier fit function for different p_T ranges

Results: Elliptic flow

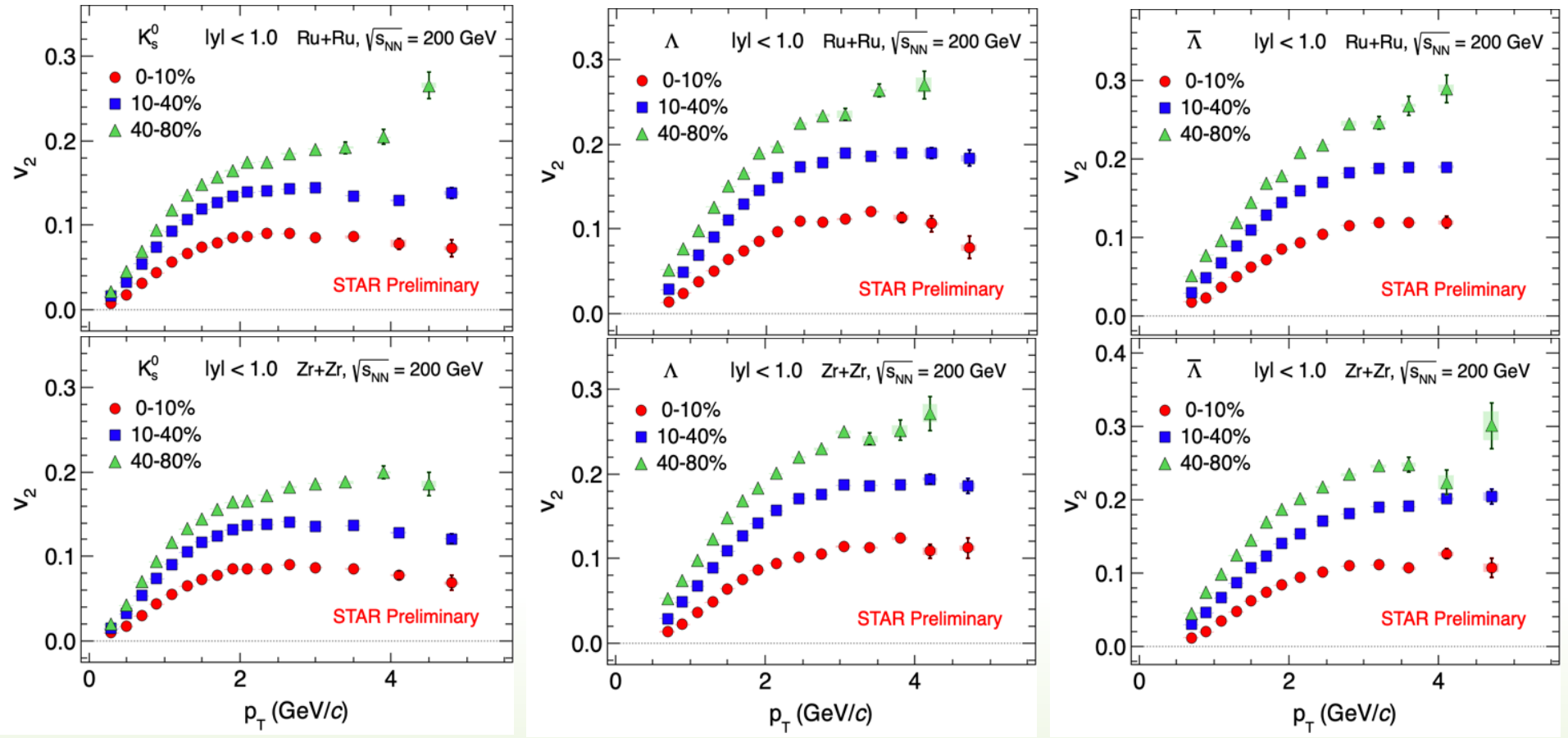




**Vertical bars indicate statistical error and shaded boxes denote systematic errors*

- v_2 values have similar p_T dependence in minimum bias Ru+Ru and Zr+Zr collisions
- v_2 shows a mass ordering at low p_T in isobar collisions
- Baryon-meson splitting at intermediate p_T region (> 2 GeV/c)

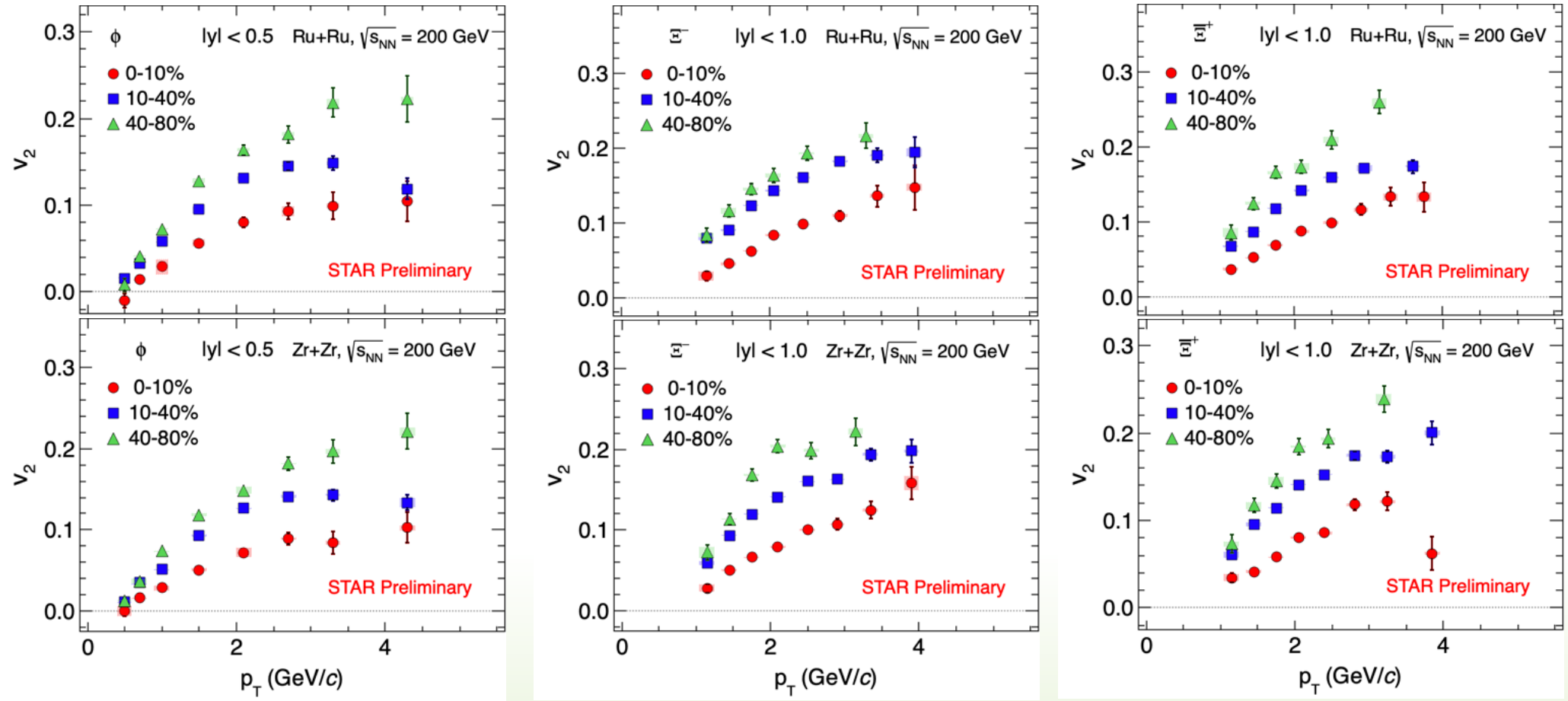
Centrality dependence of $v_2(p_T)$



**Vertical bars indicate statistical error and shaded boxes denote systematic errors*

- Strong centrality dependence is observed for v_2 of K_s^0, Λ, and $\bar{\Lambda}$
- v_2 (p_T) increases from central to peripheral collisions

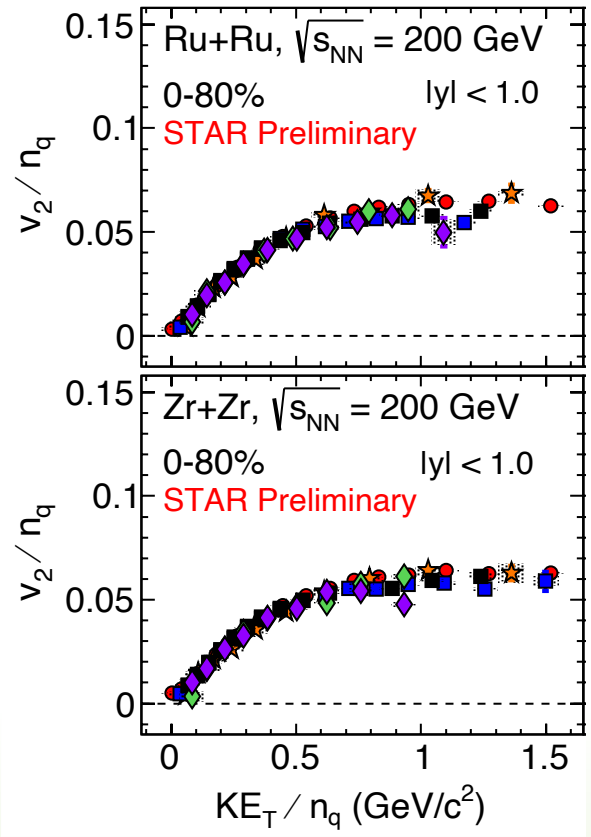
Centrality dependence of $v_2(p_T)$

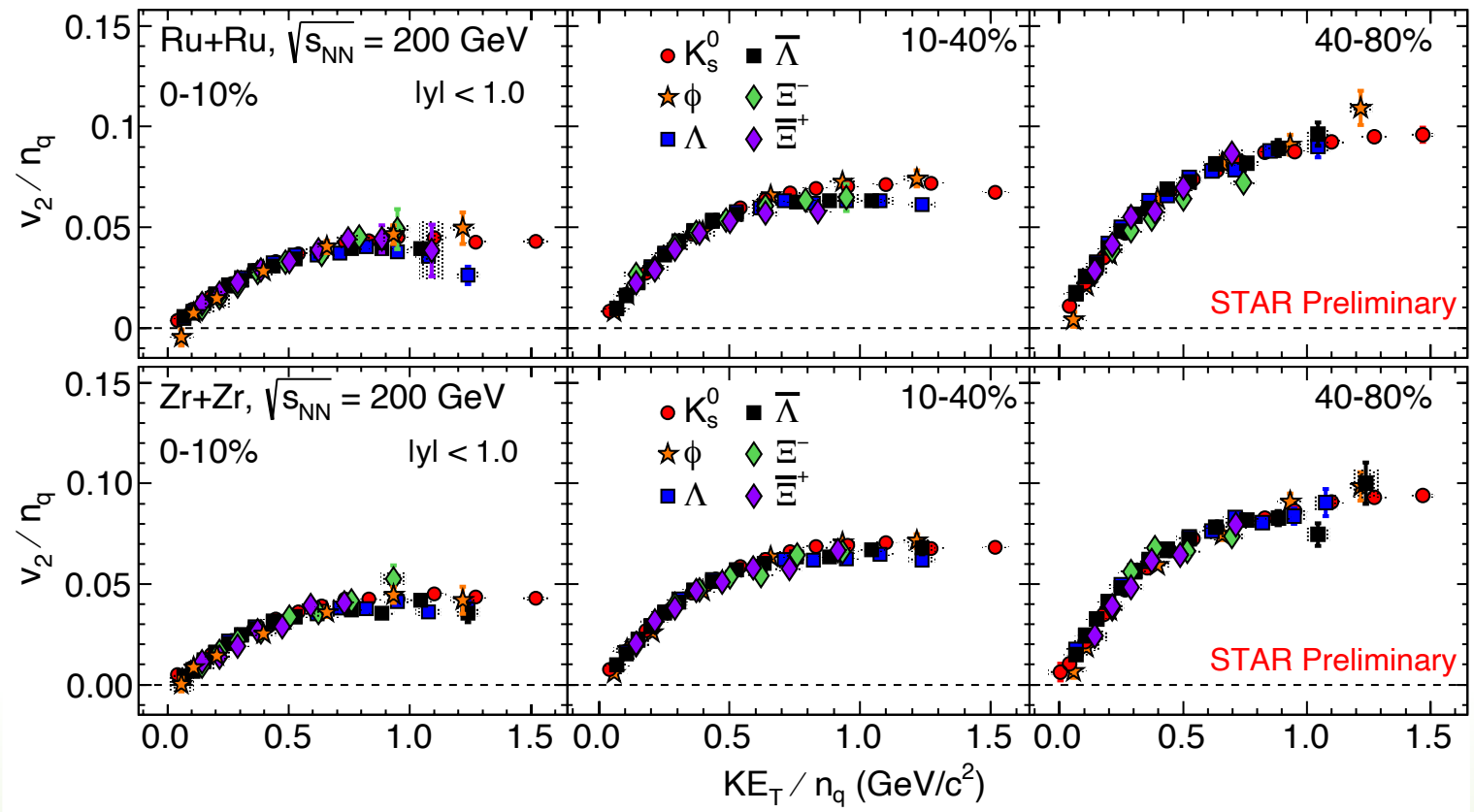


**Vertical bars indicate statistical error and shaded boxes denote systematic errors*

- Strong centrality dependence is observed for v_2 of ϕ, Ξ^-, and $\bar{\Xi}^+$
- v_2 (p_T) increases from central to peripheral collisions

NCQ scaling





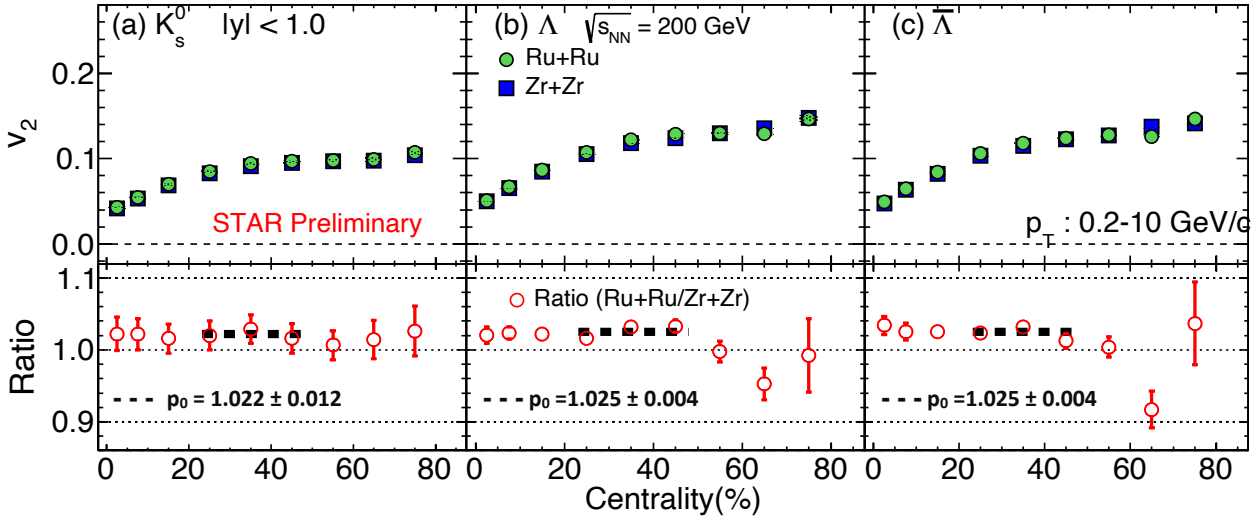
Transverse kinetic energy (KE_T) = $m_T - m_0$

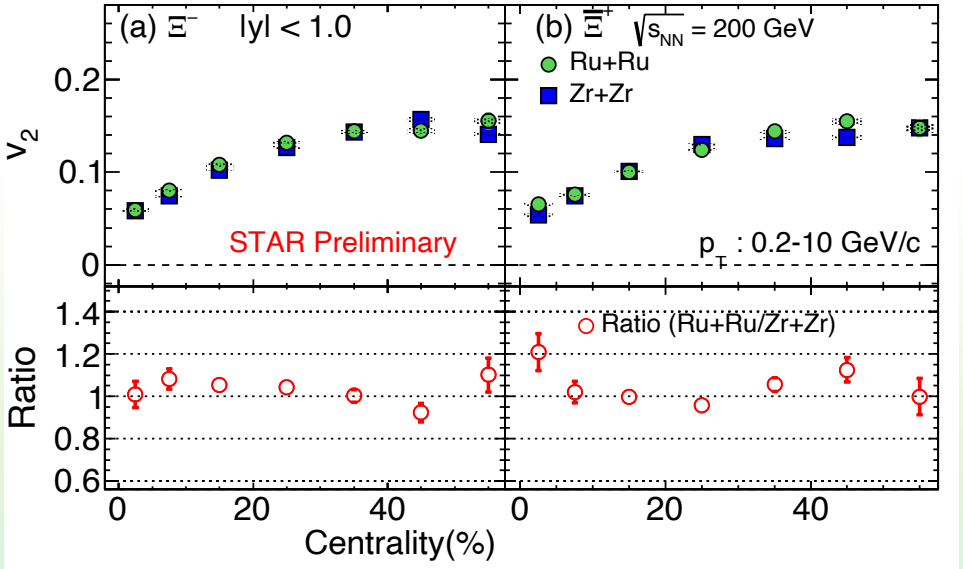
- NCQ scaling holds good for (multi-)strange hadrons within 10% uncertainties

→ Indicative of the quark coalescence mechanism in the system

**Vertical bars indicate statistical error and shaded boxes denote systematic errors*

v_2 vs centrality

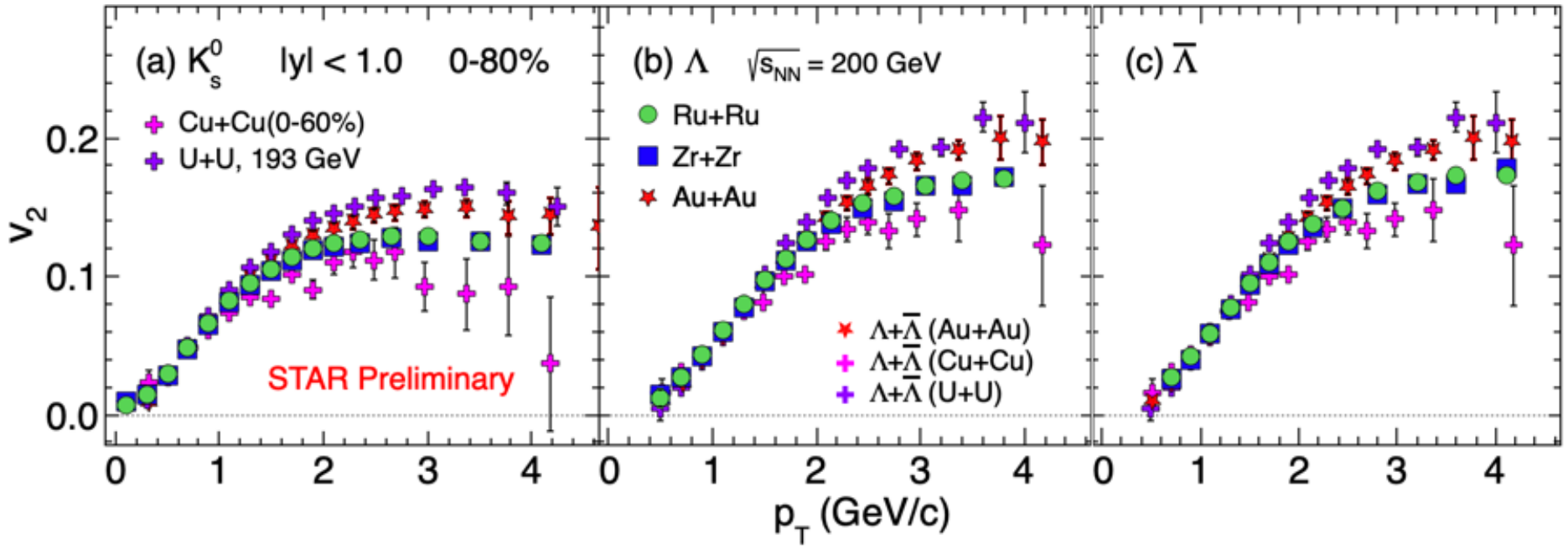




- p_T-integrated elliptic flow increases from central to peripheral collisions
- Ratios of v_2 for K_s^0, Λ and $\bar{\Lambda}$ seem to deviate from unity by ~2% at central and mid-central collisions
  - → May indicate nuclear shape and structure difference between the two isobars

**No tracking efficiency correction since the effect would be largely cancelled*
**Error in the ratio includes statistical and systematic uncertainties*

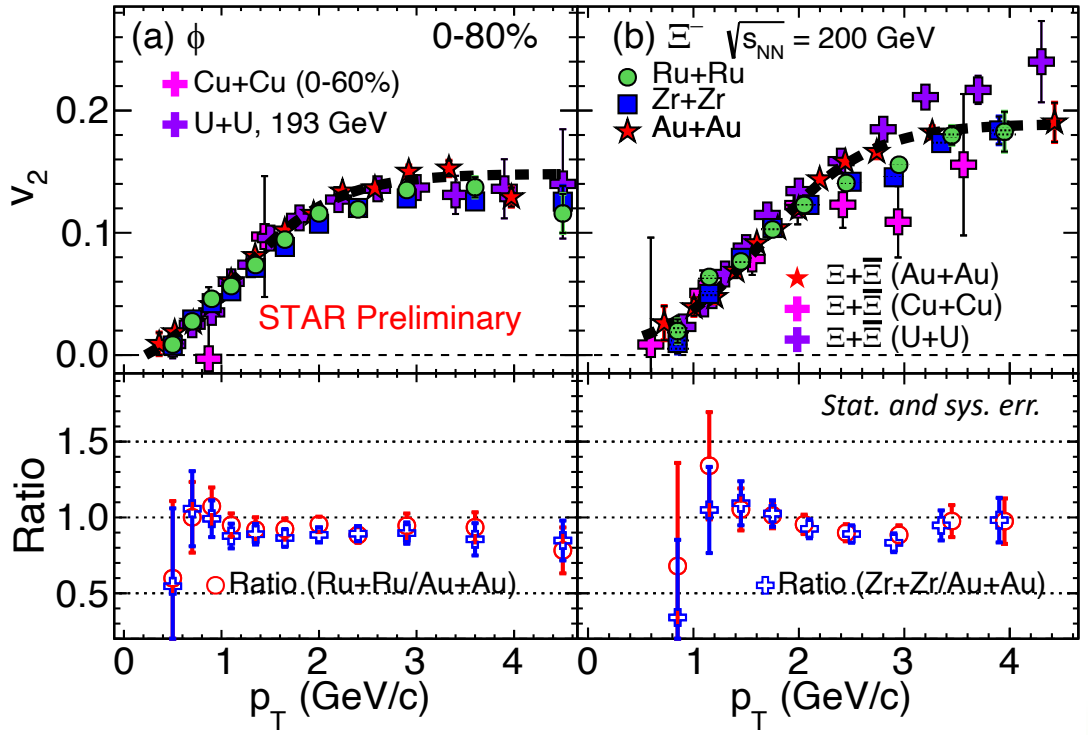
System size dependence (strange)



- v_2 of K_s^0, Λ, and $\bar{\Lambda}$ in isobar collisions is smaller than in ^{197}Au+^{197}Au and ^{238}U+^{238}U collisions at higher p_T
- v_2 in isobar collisions is larger as compared to ^{63}Cu+^{63}Cu collisions at higher p_T

B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C 77, 054901 (2008)
B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C 81, 044902 (2010)
M. S. Abdallah et al. (STAR Collaboration), Phys. Rev. C 103, 064907 (2021)

System size dependence (multi-strange)



Fitting function :

$$f_{v_2}(n) = \frac{an}{1 + e^{-(p_T/n-b)/c}} - dn$$

n: number of quarks; a, b, c, d: free parameters

- v_2 of ϕ is similar in the measured p_T range for different collision systems
- v_2 of Ξ is lower than $^{238}U+^{238}U$ collisions at higher p_T

B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C 77, 054901 (2008)
B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C 81, 044902 (2010)
L. Adamczyk et al. (STAR Collaboration), Phys. Rev. Lett. 116, 062301 (2016)

Summary

- Elliptic flow of K_s^0, Λ, $\overline{\Lambda}$, ϕ, and Ξ has been measured for Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV
- Strong centrality dependence of v_2 for all particles
- NCQ scaling holds good for (multi-)strange hadrons within 10% uncertainties in all centralities for the isobar collisions
- Elliptic flow ratio between Ru+Ru over Zr+Zr seems to show a deviation of nearly 2% in central and mid-central collisions

  → Maybe related to nuclear shape and structure difference between the two isobars
- v_2 of strange hadrons in isobar collisions
  - At high p_T : Smaller compared to Au+Au and U+U collisions, and larger compared to Cu+Cu collisions
  - At low p_T : Similar for all collision systems studied

Thank you for your attention!