Test baryon junction in isobaric collisions of Ru+Ru and Zr+Zr at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV with the STAR experiment

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Motivation

- Theory proposed that baryon number (B) could be carried by a non-perturbative Y-shaped topology, called the baryon junction, while charges (Q) are carried by quarks.

D. Kharzeev, Phys. Lett. B 378, 238–246 (1996)

- One can compare the relative change in net-charge numbers in Ru+Ru and Zr+Zr collisions to test the baryon junction hypothesis.
  - If baryon number carried by junctions (easier to stop): $\Delta Q < B * \Delta \mathrm{Z/A}$
- Charge stopping difference can be precisely measured using double ratios.
  - Double ratio of pions:

$$R2_\pi = (N^{\mathrm{Ru}}_{\pi^+}/N^{\mathrm{Ru}}_{\pi^-})/(N^{\mathrm{Zr}}_{\pi^+}/N^{\mathrm{Zr}}_{\pi^-})$$
$$\simeq 1 + (N^{\mathrm{Ru}}_{\pi^+}/N^{\mathrm{Ru}}_{\pi^-}) - (N^{\mathrm{Zr}}_{\pi^+}/N^{\mathrm{Zr}}_{\pi^-}),$$

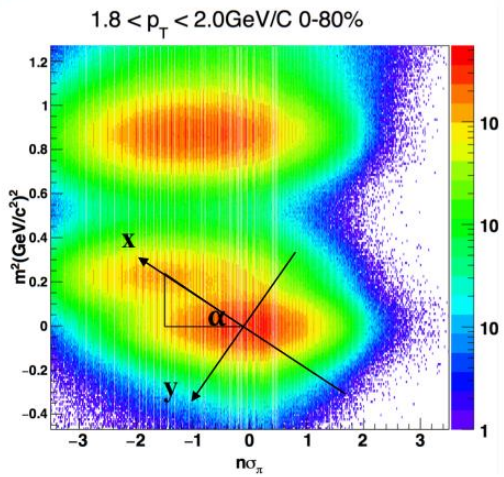
  - The charge difference at midrapidity of two isobar systems:

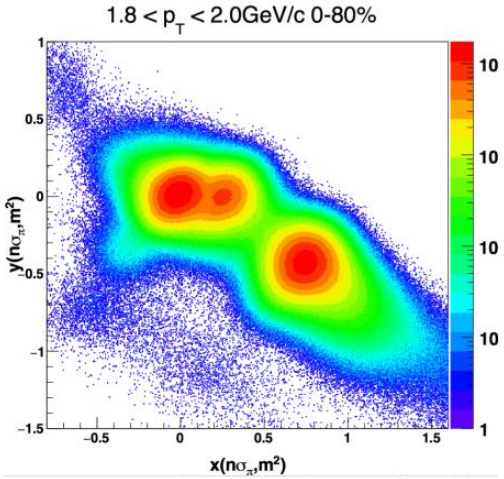
$$\Delta Q = N_\pi[(R2_\pi - 1) + \frac{N_K}{N_\pi}(R2_K - 1) + \frac{N_p}{N_\pi}(R2_p - 1)]$$

J. D. Brandenburg, N. Lewis, P. Tribedy, and Z. Xu, (2022), 2205.05685

Particle identification

- Particle identification at high momentum region is challenging when using dE/dx or m^2 alone.
- PID capability could be improved if TPC and TOF information are combined.





$$f_{scale} = \sigma(n\sigma_\pi)/\sigma(m^2(\pi))$$
$$x' = (n\sigma_\pi - \mu(n\sigma_\pi))/f_{scale}$$
$$y' = m^2 - \mu(m^2(\pi))$$

Rotation angle:

$$\alpha = tan^{-1}\left[\frac{\mu(m^2(K)) - \mu(m^2(\pi))}{\mu(n\sigma_K) - \mu(n\sigma_\pi)}\right]$$

Rotation :

$$\begin{pmatrix} x(n\sigma_\pi, m^2) \\ y(n\sigma_\pi, m^2) \end{pmatrix} = \begin{pmatrix} cos(\alpha) & -sin(\alpha) \\ sin(\alpha) & cos(\alpha) \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix}$$

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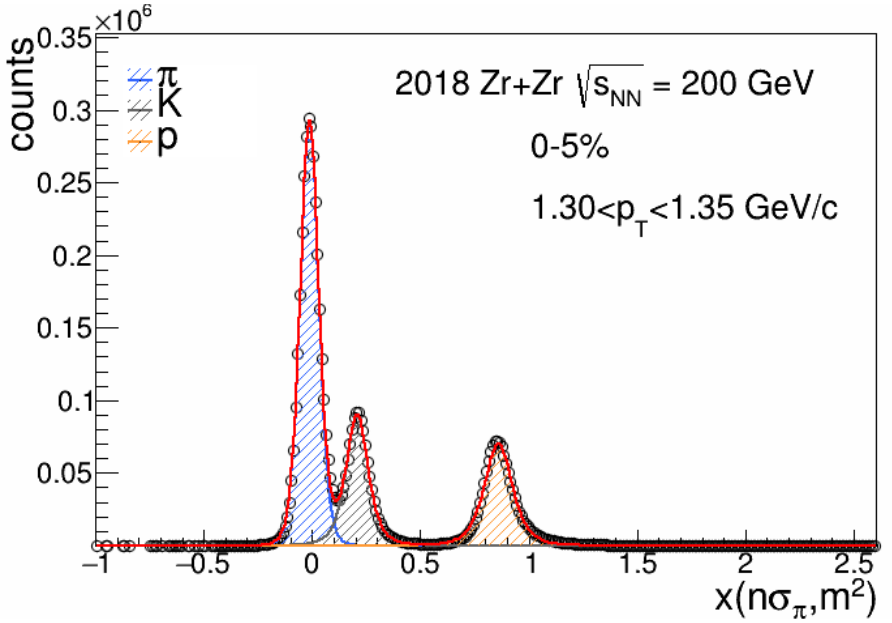
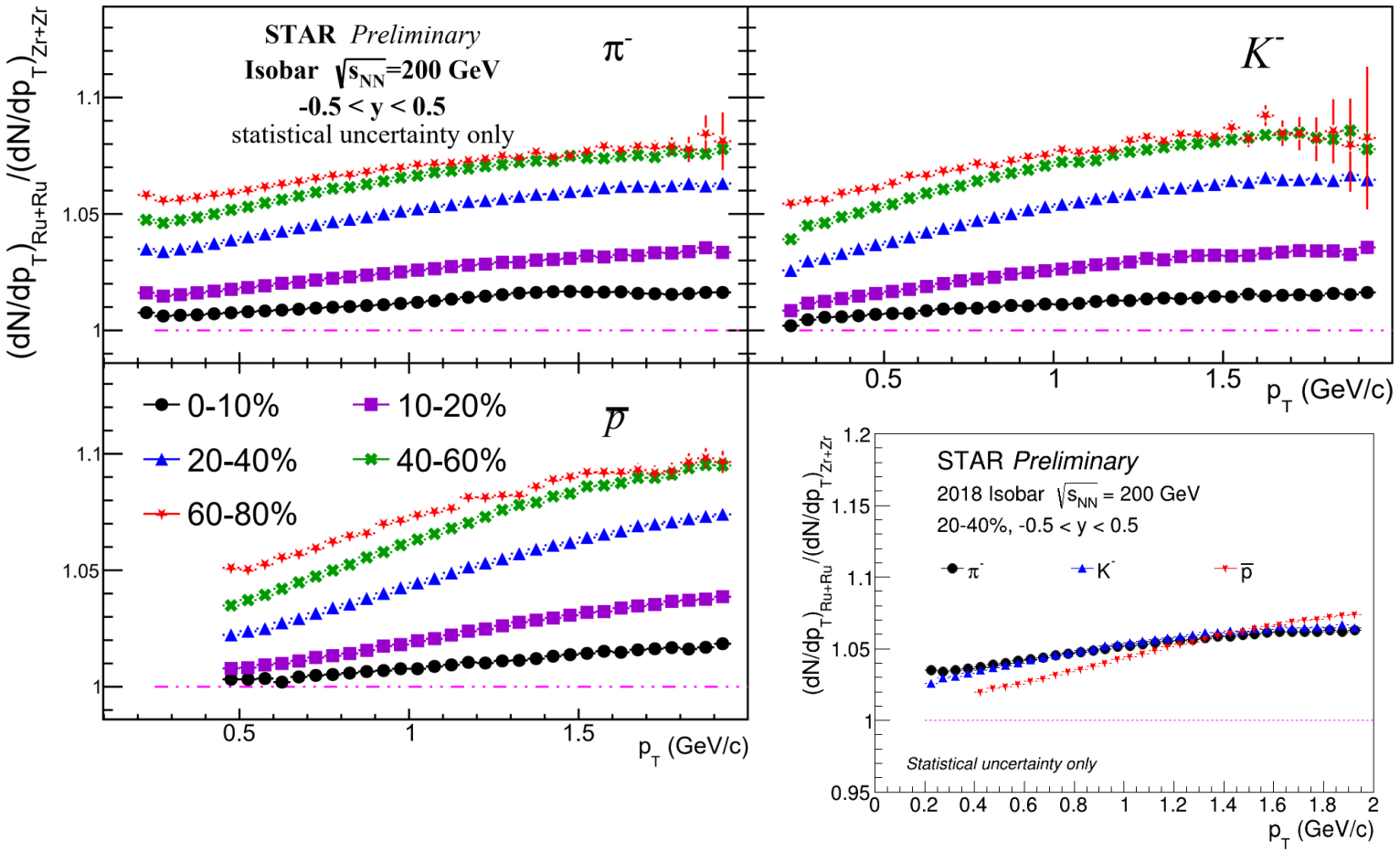
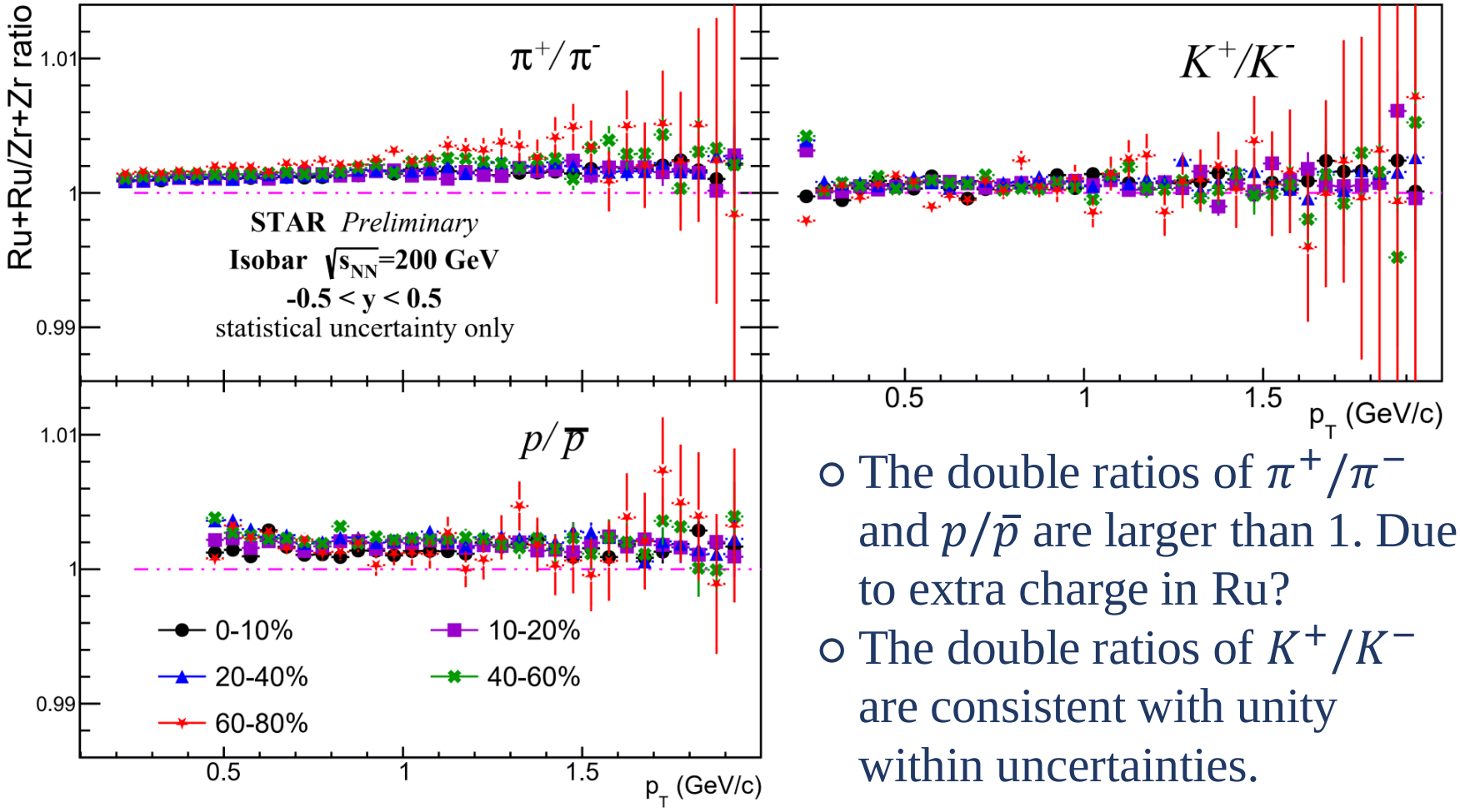


Particle ratios between Ru+Ru and Zr+Zr collisions



- More particle production in Ru+Ru than Zr+Zr at same centrality.
- Similar centrality dependence for each particle species.
- For a given centrality, the particle ratio increases more rapidly with increasing particle mass, which could be driven by different radial flows in the two collision systems.

Double ratios between Ru+Ru and Zr+Zr collisions



- The double ratios of π^+/π^- and $p/\bar{p}$ are larger than 1. Due to extra charge in Ru?
- The double ratios of K^+/K^- are consistent with unity within uncertainties.

Outlook:

- Measure net-baryon number in isobar collisions for testing baryon junction hypothesis.