Measurement of identified particle spectra and tracking the baryon number in $^{16}_{8}O + ^{16}_{8}O$ and $^{197}_{79}Au + ^{197}_{79}Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV

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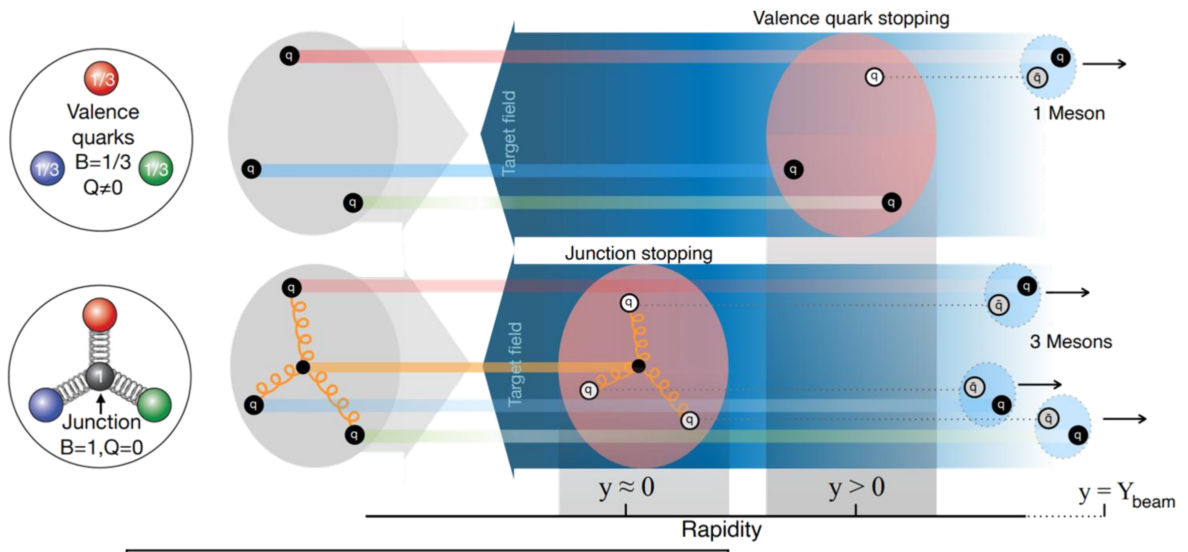
Abstract

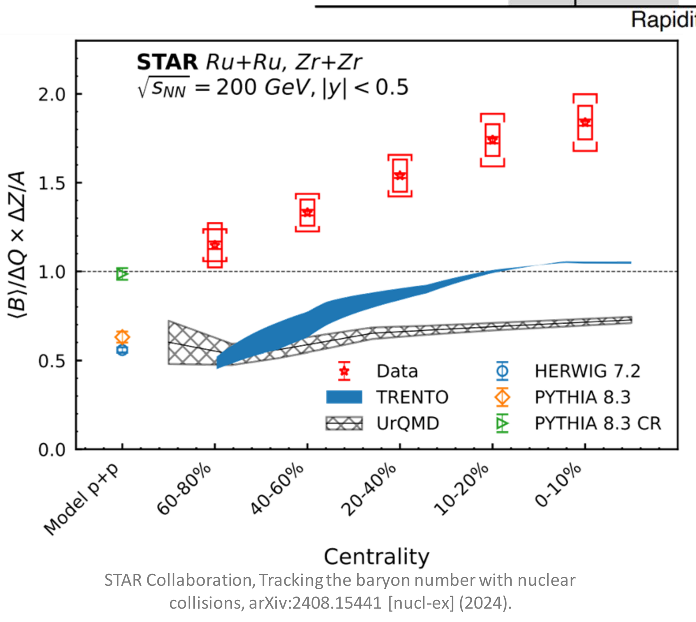
Baryon number is one of the most rigorously tested conserved quantities in physics. In the conventional picture, baryon number is carried by valence quarks. However, this assumption currently lacks experimental evidence. An alternative hypothesis was proposed in the 1970s: baryon number is carried by a Y-shaped structure in the gluon field, known as the baryon junction. Since gluons are much lighter than valence quarks, they have a longer interaction time in high-energy heavy-ion collisions and tend to stop at mid-rapidity; furthermore, gluons are electrically neutral. Therefore, measurements of charge and baryon stopping in heavy-ion collisions can be used to probe the carrier of baryon number. We have obtained the results of this study in isobar collisions. Since the Z/A ratios of the two in isobars are very close, the subsequent plan is to investigate the carrier of baryon number in the set of O+O and Au+Au collisions. To quantify baryon and charge stopping, the yields of identified particles are required. In this presentation, We will present the p_T spectra of charged hadrons (π, K, p) and dN/dy in O+O collisions at mid-rapidity.

Motivation



Owing to the momentum fraction difference between valence quarks and gluons, they have different times to interact in heavy-ion collisions.

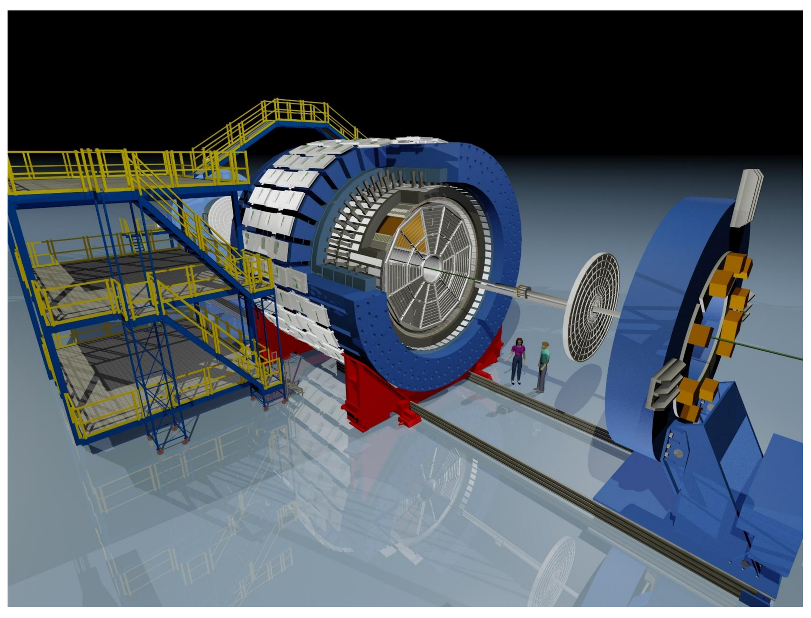
Unlike conventional models, in the baryon junction model, charge and baryon come from valence quarks and gluon fields separately. Thus their stopping reflects the baryon number carrier.



Results in isobar were obtained in previous studies:
If baryon number is carried by quarks:
$\Delta Q = \langle B \rangle \times \Delta Z/A$
If baryon number is carried by junctions:
$\Delta Q < \langle B \rangle \times \Delta Z/A$
The result is :
UrQMD model(carried by quarks):
$\Delta Q > \langle B \rangle \times \Delta Z/A$
Data:
$\Delta Q < \langle B \rangle \times \Delta Z/A$
$\langle B \rangle$: net-baryon, ΔQ: the difference of net-charge

These results show that the conventional baryon number carrier cannot explain the discrepancy between data and model. To study the correlation between Q/B and Z/A, we will further study the baryon number carrier in O+O and Au+Au collisions with larger Z/A differece.

Event and track selection

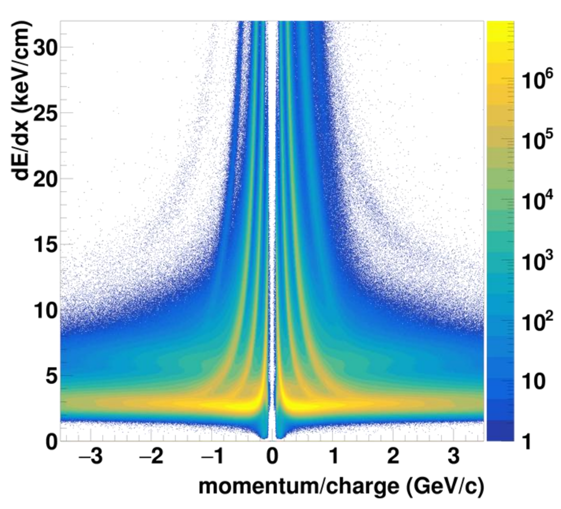
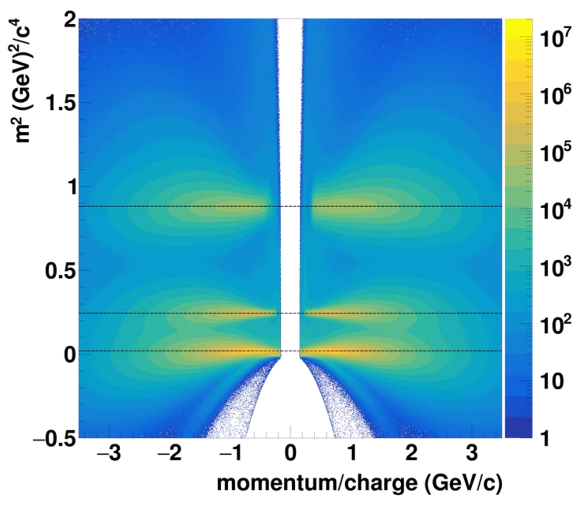


TPC: Tracking, momentum and dE/dx
TOF: Time of flight
Data set: $^{16}_{8}O + ^{16}_{8}O$ @ 200 GeV (taken in 2021)
Event level cut:
- $|V_z| < 30$ cm, $|V_r| < 2$ cm
- TPC-calibrated centrality
- ~234M good events after cuts

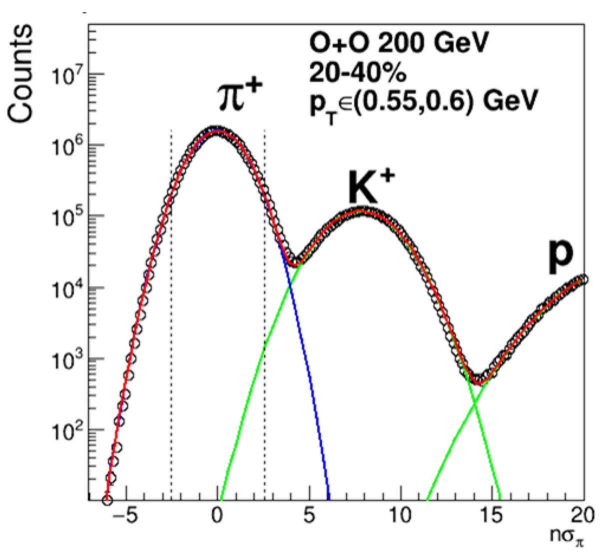
Track quality cuts:
$|\eta| < 1, |y| < 0.5$
- nHitsFit > 15, nHitsFit/nHitsMax > 0.52
- nHitsDedx > 10
- DCA < 3 cm

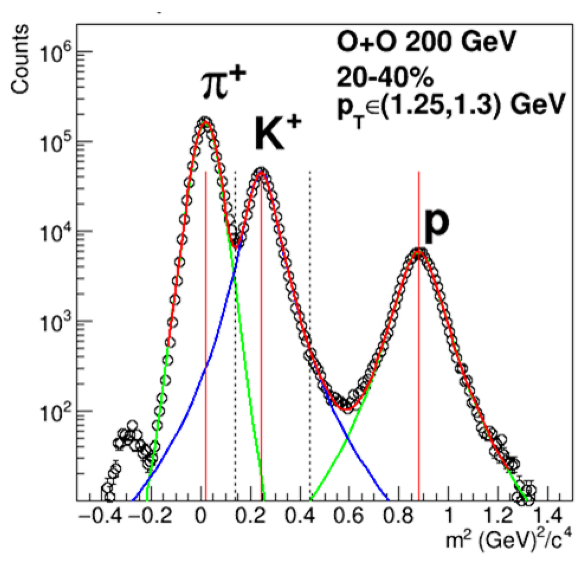
TOF cuts
- Valid TOF hits matched with track
- $|TOFYLocal| < 1.8$ cm

Particle identification

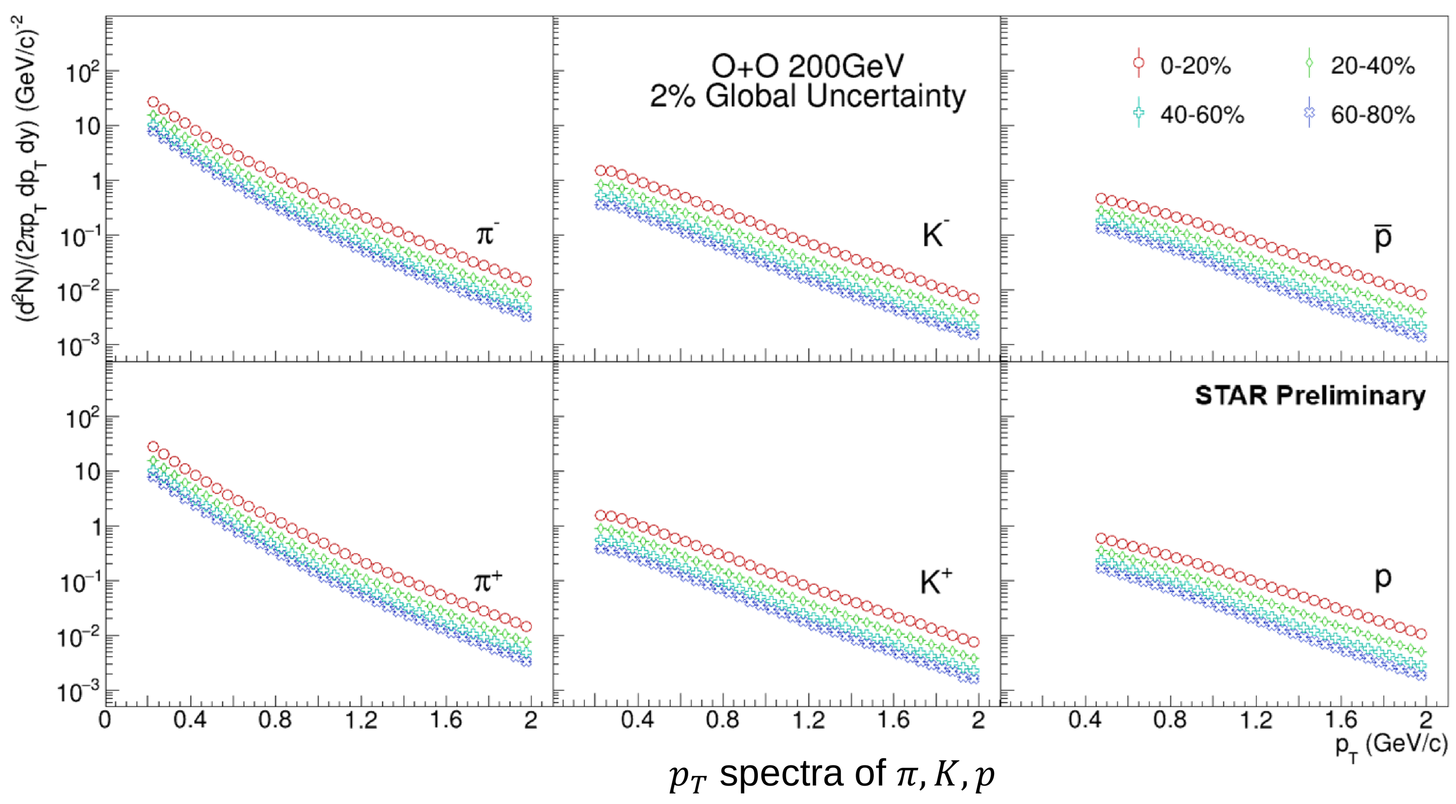
Energy loss and m^2 vs. momentum/charge



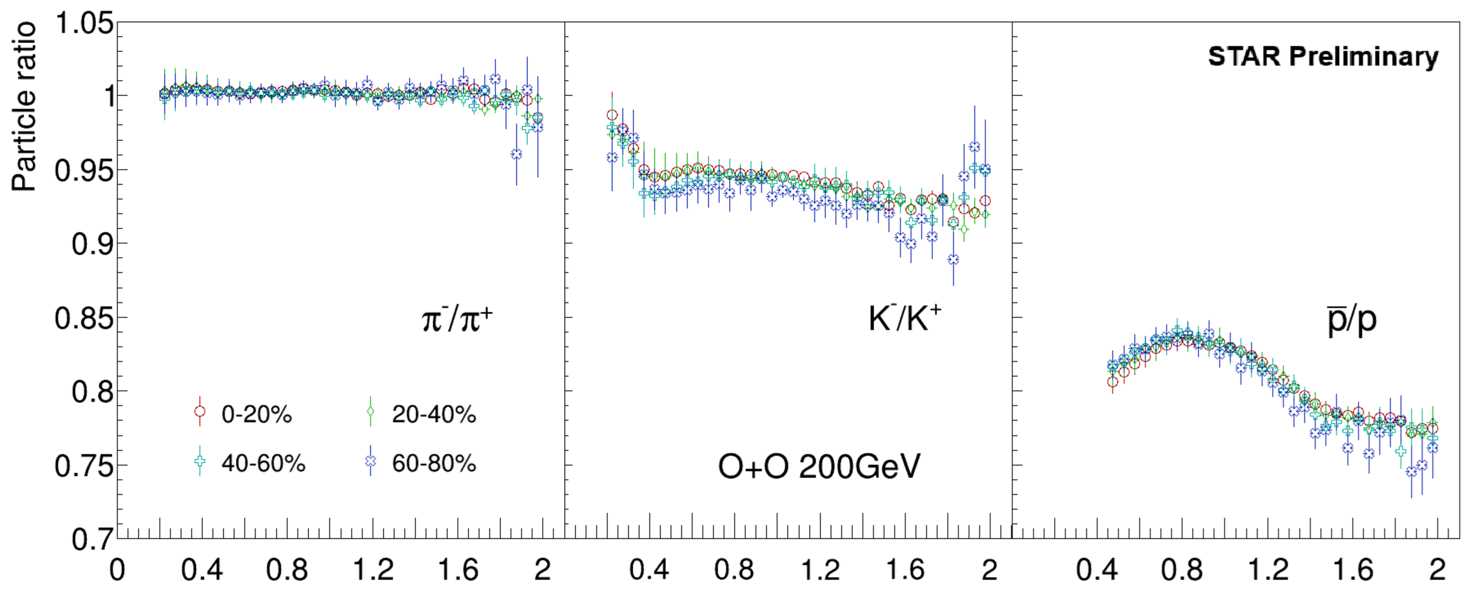


- Raw yield:
  Count inside two dashed lines and subtract the integral of background.
  Low p_T: $n\sigma$ distribution fit with multi-gauss distribution.
  High p_T: m^2 distribution fit with multi-students distribution.
- Corrections:
  Tracking efficiency: from embedding;
  TOF match efficiency: use data driven;
  Knock-out proton: from the fit of DCA distribution.

p_T spectra and dN/dy



p_T spectra of π, K, p

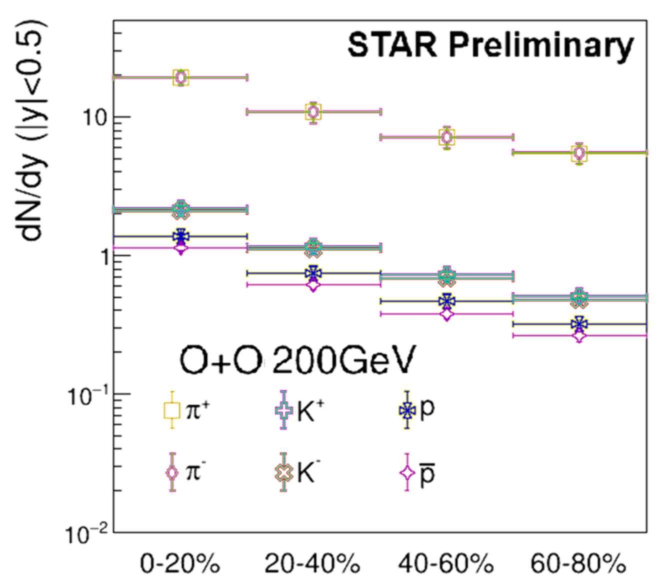


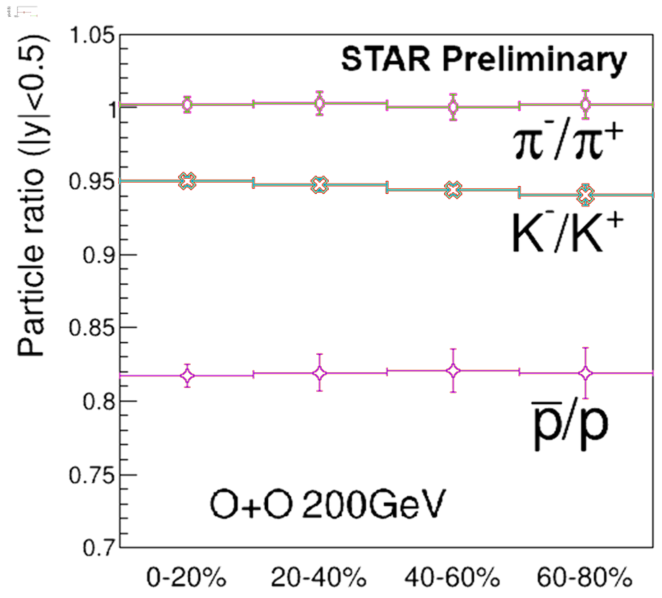
Ratio of p_T spectra

- To obtain the difference of net-charge between two collision system at midrapidity, the particle ratio is required.
- After getting the result in Au+Au collisions, the difference of net-charge will be calculate by the formula:

$$\Delta Q = Q_{OO} - Q_{AuAu} = \sum_{i=\pi,K,p} N_i(R2_i - 1), R2_i = \frac{N_{i^-}^{OO}/N_{i^+}^{OO}}{N_{i^-}^{AuAu}/N_{i^+}^{AuAu}}, N_i = (N_{i^-}^{OO} + N_{i^+}^{OO} + N_{i^-}^{AuAu} + N_{i^+}^{AuAu})/4$$

With this method, the systematic uncertainty of the yield can be canceled by division.

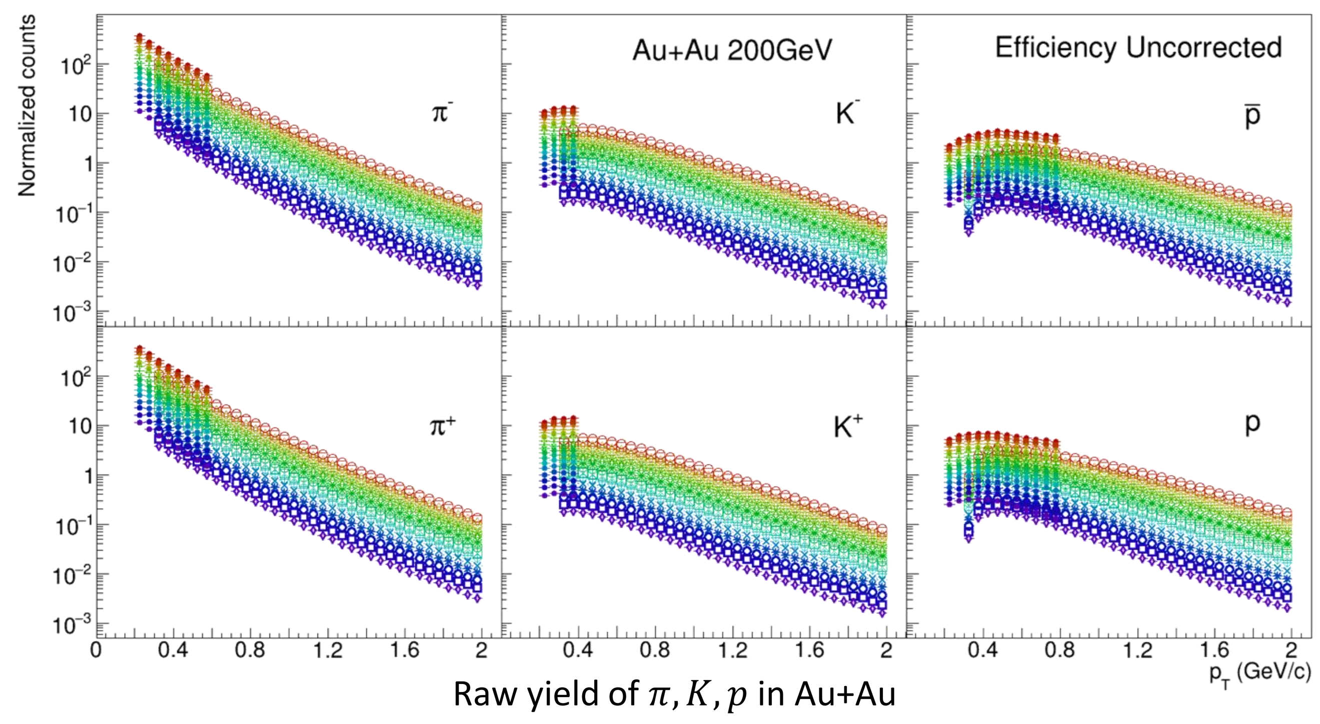




- dN/dy of π, K, p is obtained by integrating the pT spectra.
- The p_T spectra outside the PID range are obtained by Tsallis Blast Wave fitting and extrapolation.
- Exponential function is used to estimate the systematic uncertainty.

Summary and outlook

- To study baryon and charge stopping in systems with larger Z/A difference, PID for O+O and Au+Au collisions is under study.
- p_T spectra obtained in O+O collisions.
- Measurement of Au+Au is in progress. Raw yields are shown on the right.



Raw yield of π, K, p in Au+Au

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