Measurements of Near–Threshold Strange Hadron Production at STAR Experiment

Wenyun Bo (*for the STAR Collaboration*)

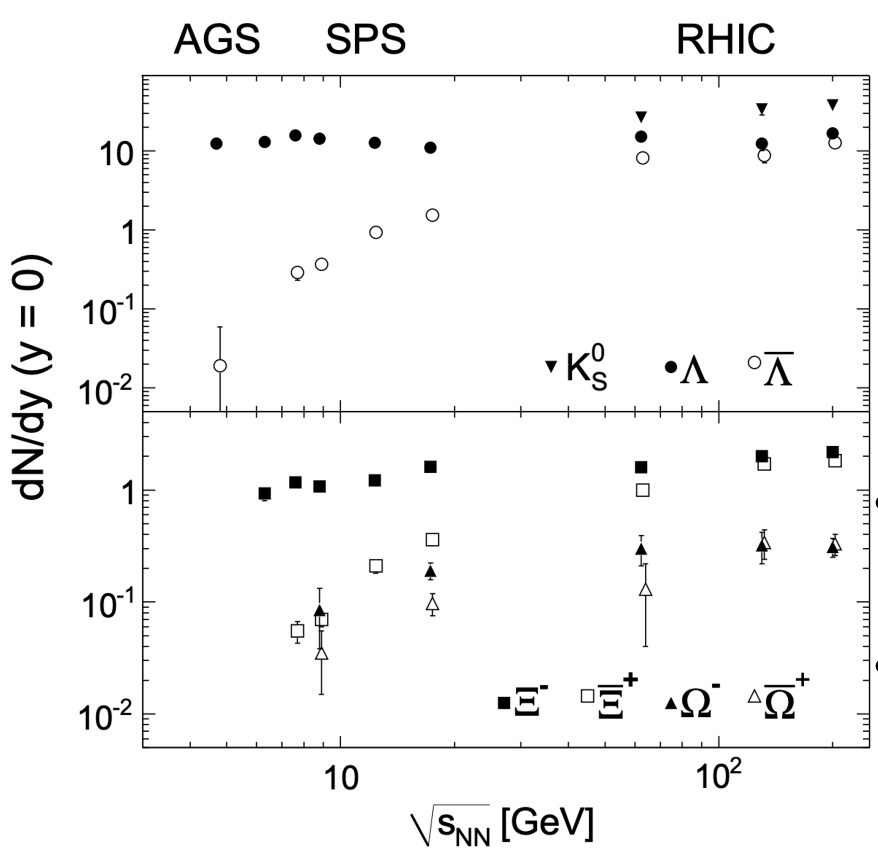
Central China Normal University, bowenyun@mails.ccnu.edu.cn

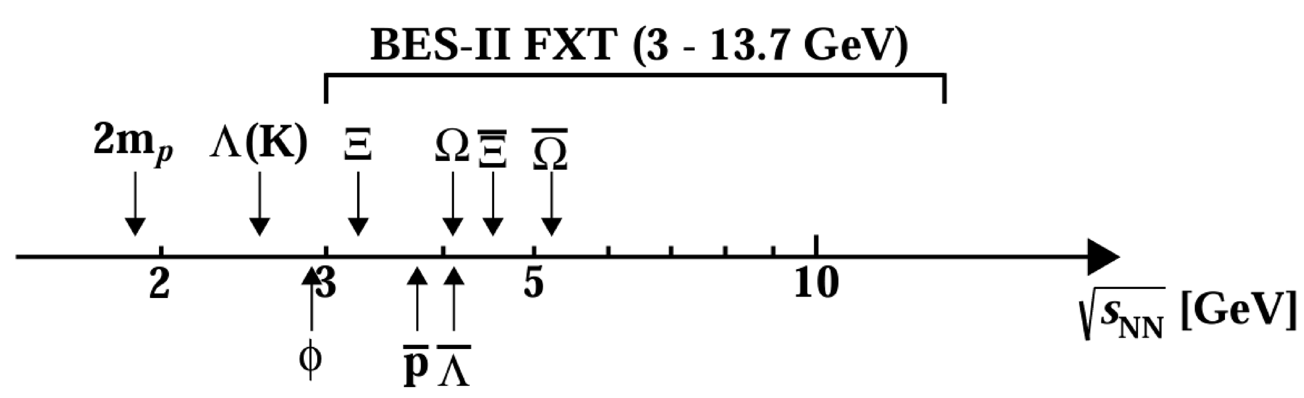
Abstract

Strange hadrons have been suggested as sensitive probes for the medium properties of nuclear matter created in heavy-ion collisions. Dense baryon-rich medium is formed during collisions at center-of-mass energies of a few-GeV. Since strange hadrons are produced near or below the threshold, their phase space distribution and yield ratio may provide strong constraints on the equation of state (EoS) of high baryon density matter.

In this poster, we will present measurements of strange hadron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, 3.9, 4.5, 5.2 and 6.2 GeV with the fixed-target mode from STAR BES-II experiment. The transverse momentum spectra and rapidity densities of $K^{\pm}$, K^0_S, ϕ, Λ, Ξ^- and their yield ratios ϕ/K^-, ϕ/Ξ^-, K^0_S/Λ, Λ/p, Ξ^-/Λ will be presented. We will also explore the centrality dependence of strange hadron yields and the evolution of their kinetic freeze-out temperature T_{Kin} and average radial expansion flow velocity $\langle\beta_T\rangle$ extracted from the Blast-Wave model in the reported energy range, which can give insights on the EoS of the created medium. These results will be compared with those from higher collision energies and the physics implications will be studied by comparing to the thermal and transport model calculations.

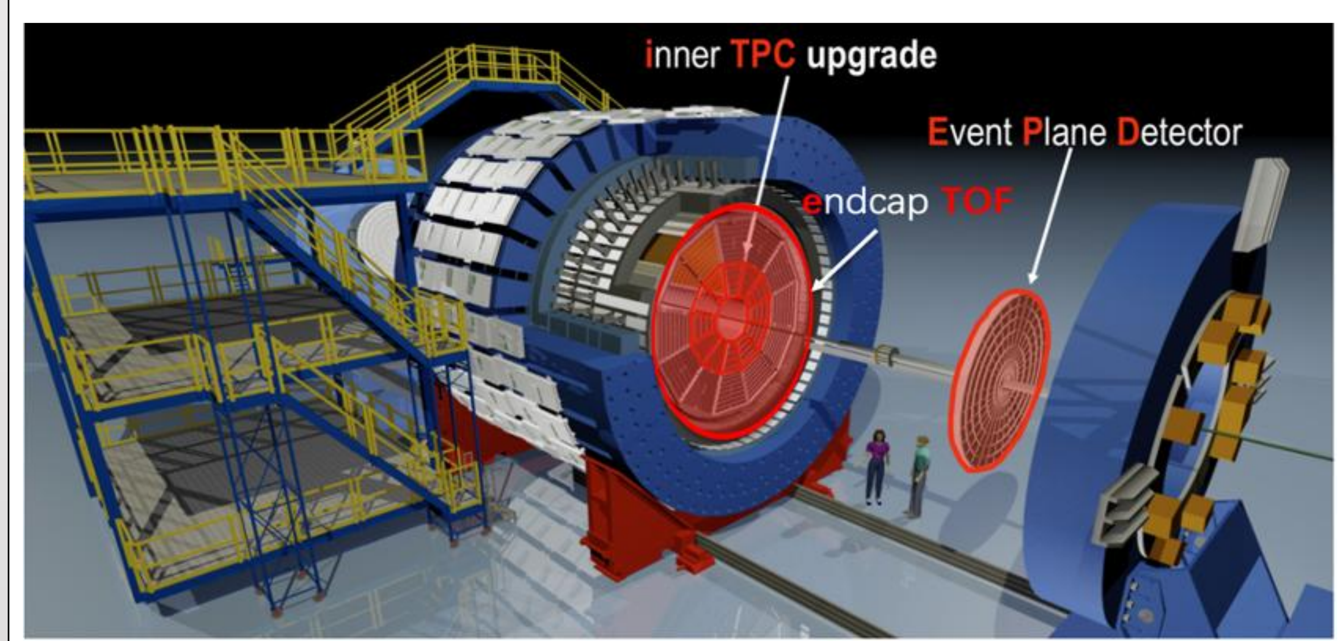
Motivation





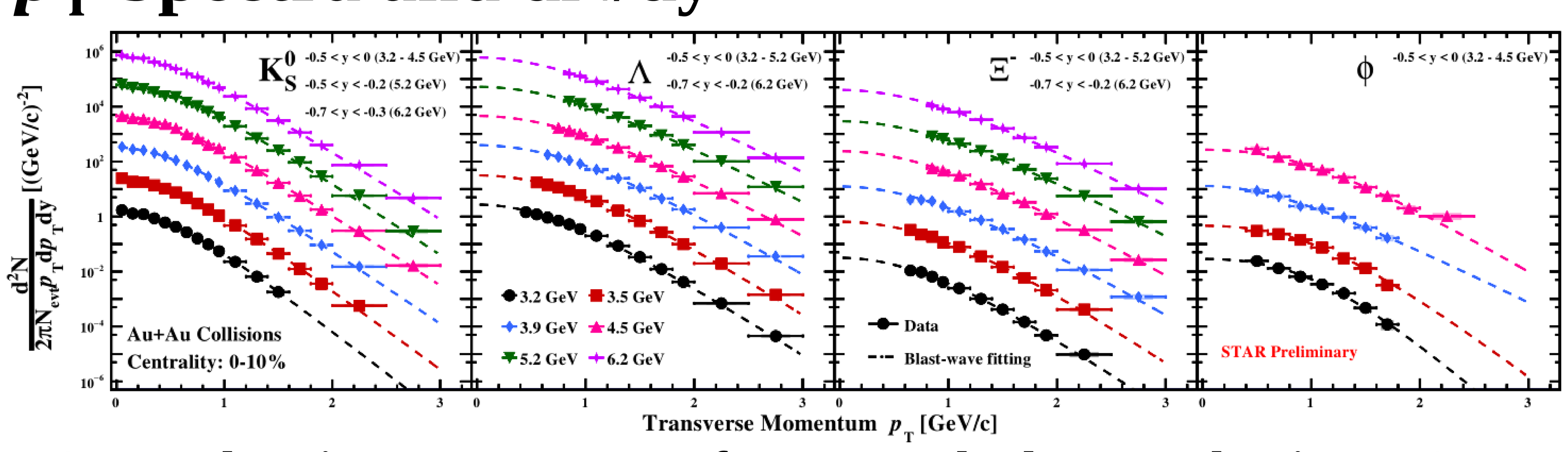
- Strange hadron production at high baryon density is a good probe to study medium properties
- The STAR BES-II FXT experiment provides unique opportunity to study strange hadron production at near or sub-threshold energies

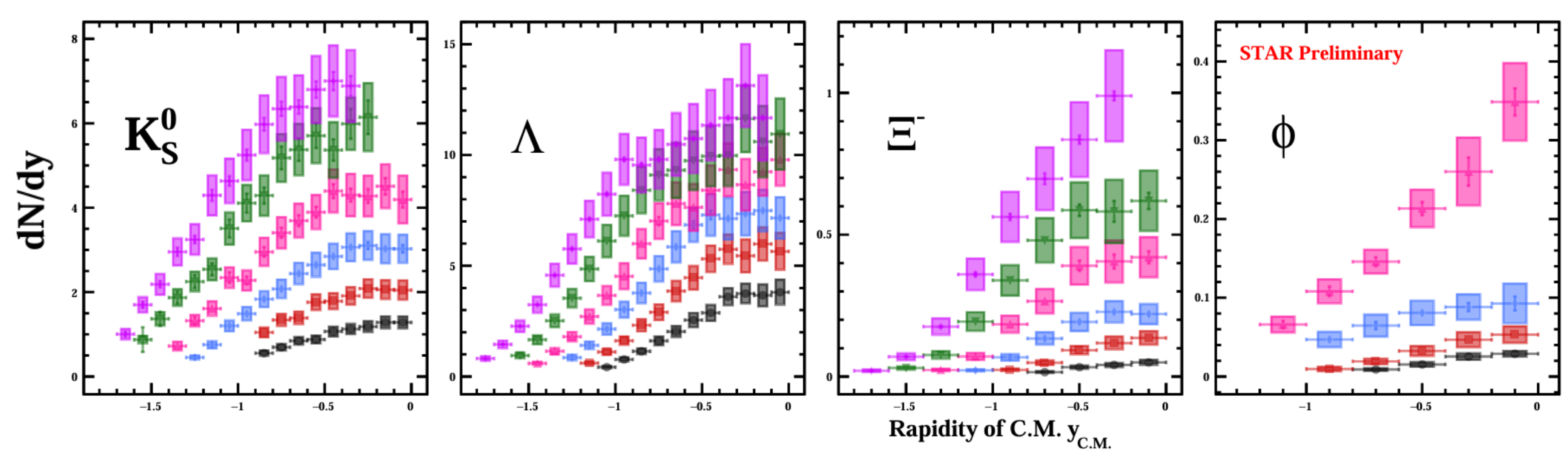
STAR detector



- Detector upgrades
  - ➢Time Projection Chamber (TPC & inner TPC: $-2.4 < \eta < 0$)
  - ➢Time-of-Flight
    Barrel TOF: $-1.45 < \eta < 0$ & end-cap TOF: $-2.15 < \eta < -1.55$

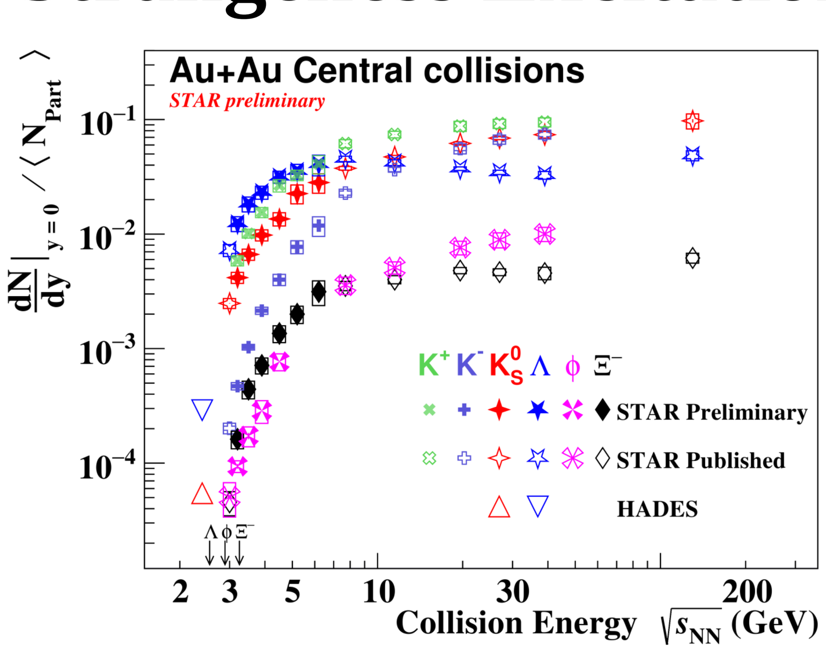
p_T Spectra and dN/dy





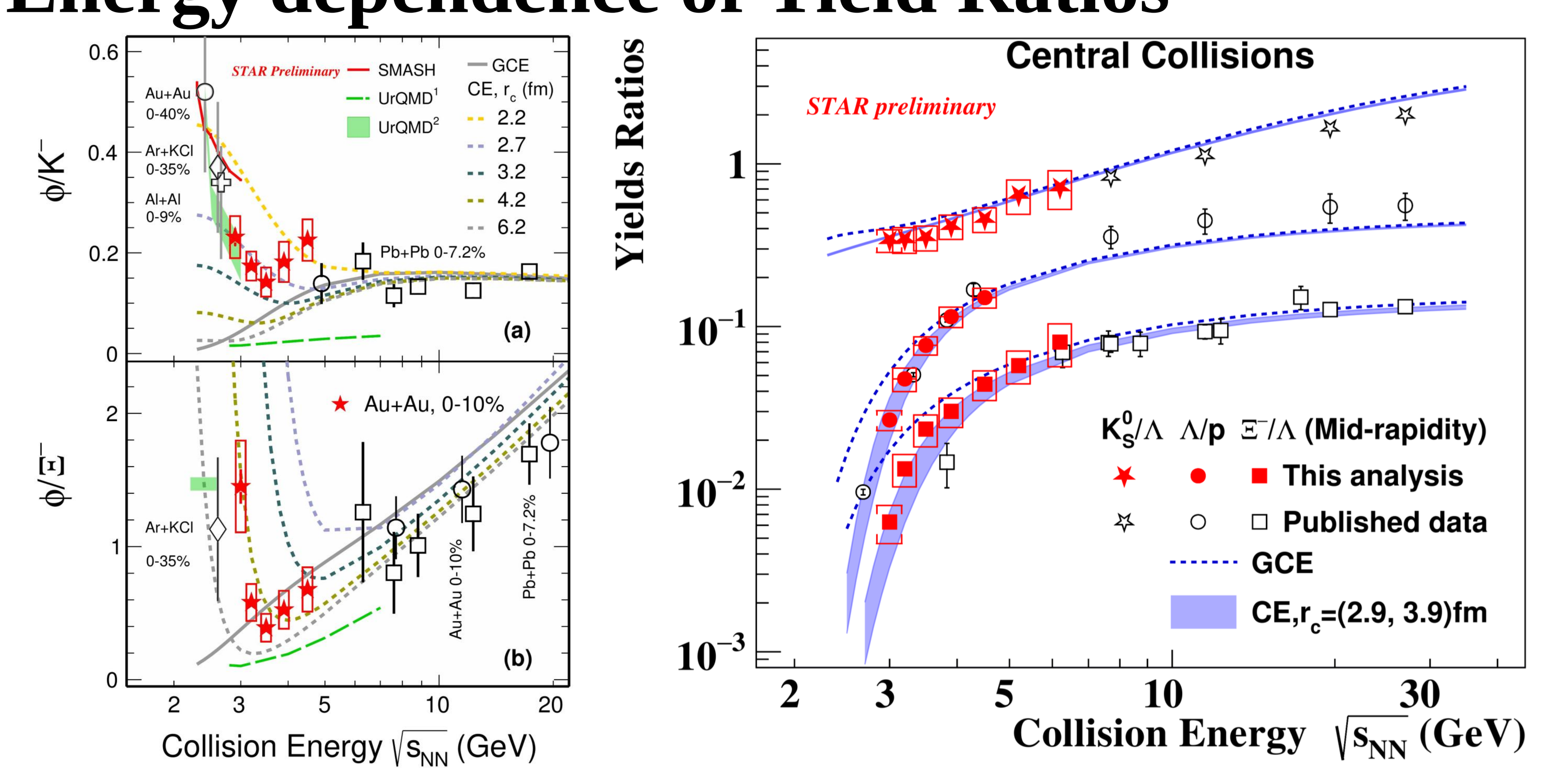
- Comprehensive measurements for strange hadron production at STAR FXT energies

Strangeness Excitation function



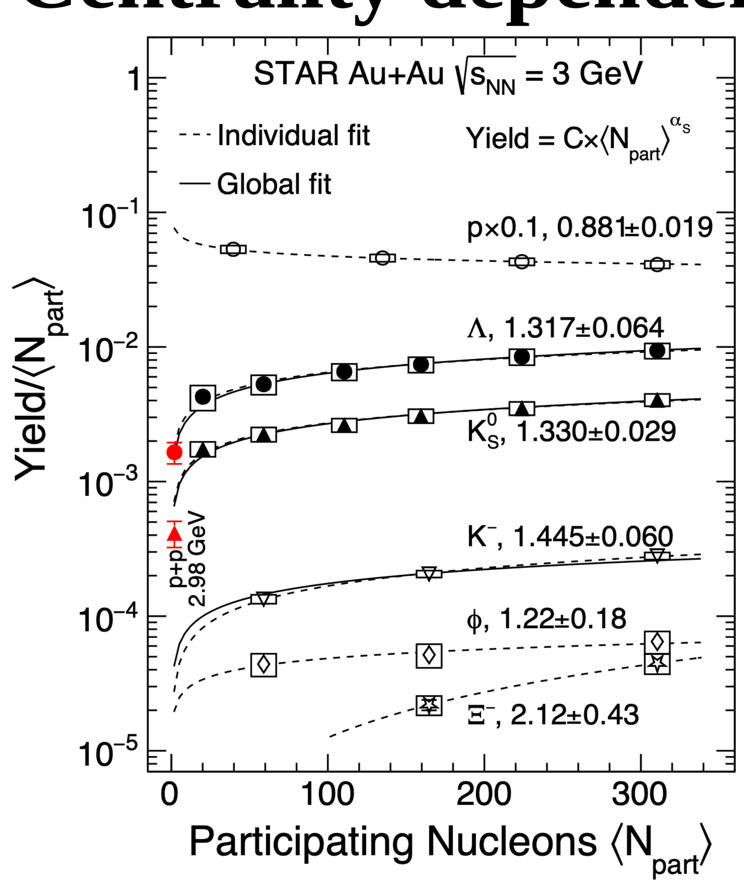
- Mid-rapidity yields increases rapidly at low energy and approximately saturate at high energy
- First measurement of Ξ^- at sub-threshold energies in Au+Au collisions
- Λ yields exceed those of K^0_S below $\sqrt{s_{NN}}$ ~ 8 GeV
  - ➢Due to higher baryon density at low collision energies

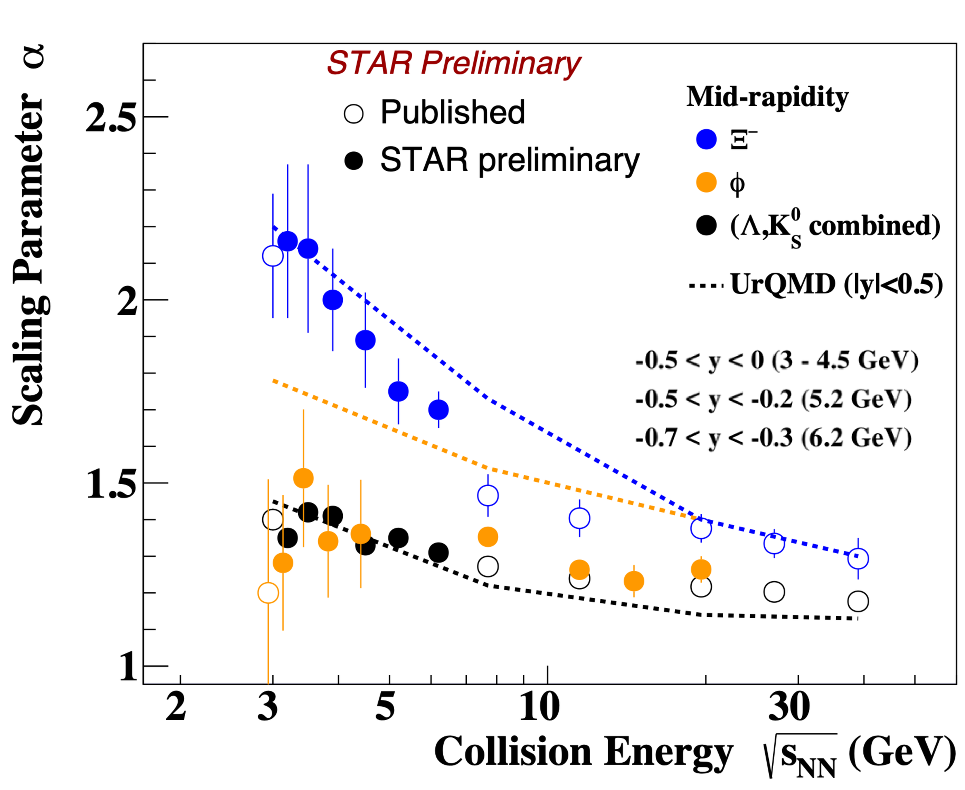
Energy dependence of Yield Ratios



- CE describe yield ratios with $r_c \sim 3-4$ fm, but GCE fails below $\sqrt{s_{NN}}$ ~ 5 GeV
- Local strangeness conservation is important in high baryon density region
- Medium properties may change in high baryon density region

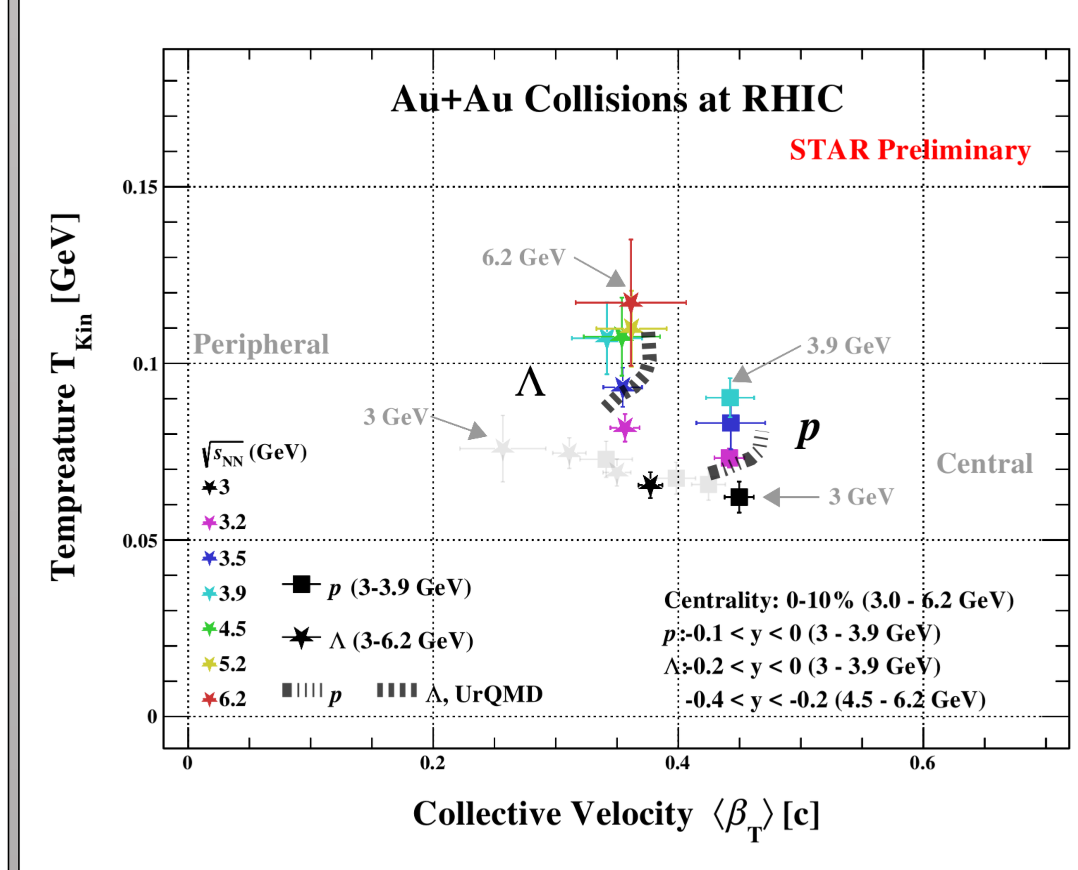
Centrality dependence





- Scaling parameter α decreases with energy
  - ➢$\Lambda(K^0_S)$ and ϕ have similar α, but Ξ^- has significantly larger α below $\sqrt{s_{NN}}$ ~ 7 GeV
    - ☐Likely due to Ξ^- mainly produced via multi-step hadronic interactions
      e.g.: $NN \rightarrow NN^*$ & $N^*N \rightarrow N\Xi KK$, $NN \rightarrow N\Lambda K$ & $\Lambda\Lambda \rightarrow N\Xi$
- Transport model simulations UrQMD
  - ➢Qualitatively reproduces the energy dependence
  - ➢Overestimates α for ϕ meson

Kinetic Freeze-out



- T_{Kin} increases while $\langle\beta_T\rangle$ remains almost constant from $\sqrt{s_{NN}}$ = 3 – 6.2 GeV for Λ
- Different freeze-out parameters between proton and Λ from $\sqrt{s_{NN}}$ = 3 – 3.9 GeV
  - ➢May be due to different production mechanisms
- Hadronic transport model UrQMD qualitatively reproduces the trend at STAR FXT energies

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