Strangeness production in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 19.6 GeV from BES-II with the STAR experiment

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Abstract

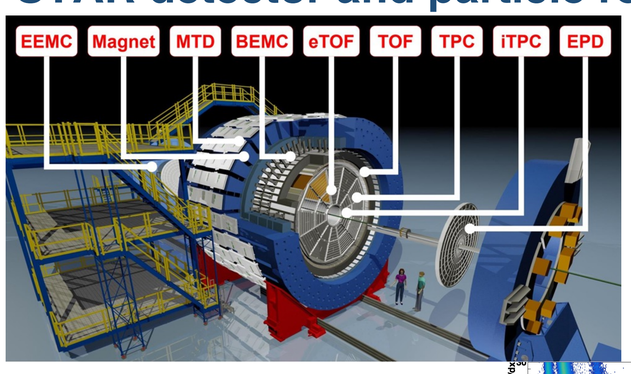
A primary goal of the Beam Energy Scan (BES) program at RHIC is to search for the QCD critical point and the onset of deconfinement. Strangeness production has been suggested as a sensitive probe to the early dynamics of the deconfined matter created in heavy-ion collisions. The rapidity density of (anti-) strange baryons may give insight into the baryon stopping mechanism. Furthermore, the collision energy threshold of QGP production in heavy-ion collisions can be explored by measuring the colliding energy dependence of baryon-to-meson enhancement. In particular, results from BES-I indicate potential changes in the Ω/ϕ ratio at and below 11.5 GeV, which may be indicative of a change in the underlying strange quark dynamics. However, the limited statistics prohibit a strong conclusion.

During the second phase of BES program (BES-II), STAR has accumulated high statistics data in Au+Au collisions, which can help reduce the uncertainties in the strange hadron measurements, in particular for the multi-strange hadrons. In this poster, we will present STAR measurements of strange hadron K_S^0, Λ, Ξ and Ω production in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 9.2, 11.5, 14.6 and 19.6 GeV from BES-II, including transverse-momentum and rapidity spectra, Ω/ϕ ratios and nuclear modification factors. The implications of the collision dynamics are discussed.

Motivation

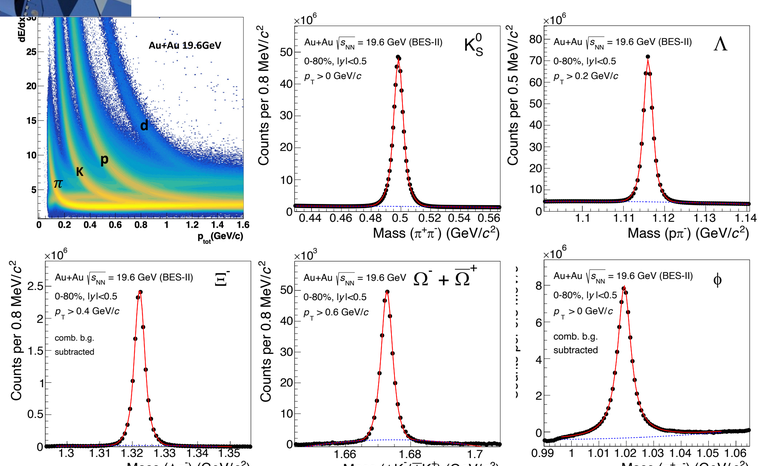
- Rapidity density of strange baryons may give insight into the baryon stopping mechanism.
- Energy dependence of Ω/ϕ ratios explore the collision energy threshold of QGP production in heavy-ion collisions .

STAR detector and particle reconstruction



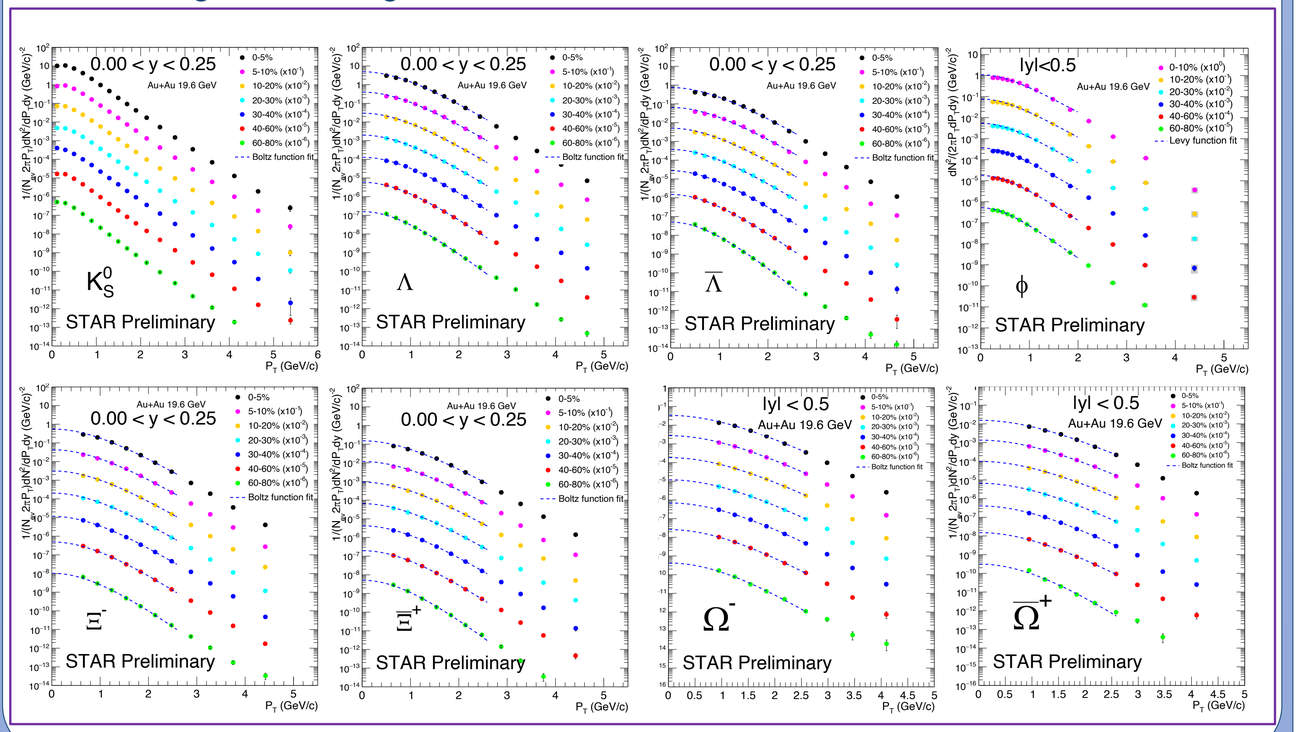
- ✓ Large and uniform acceptance
- ✓ Excellent particle identification
- iTPC (STAR Inner Sector TPC) upgrade compared to BES-I:
  - ✓ Larger rapidity coverage — |η| from 1.0 to 1.5
  - ✓ Better PID — improved dE/dx resolution
  - ✓ Lower p_T limit — from 120 to 60 MeV/c

- Particle identification with dE/dx
- Strange particles are reconstructed via their hadronic decay channel to π, K or p
- Large number of strange particles allow multi-differential measurements



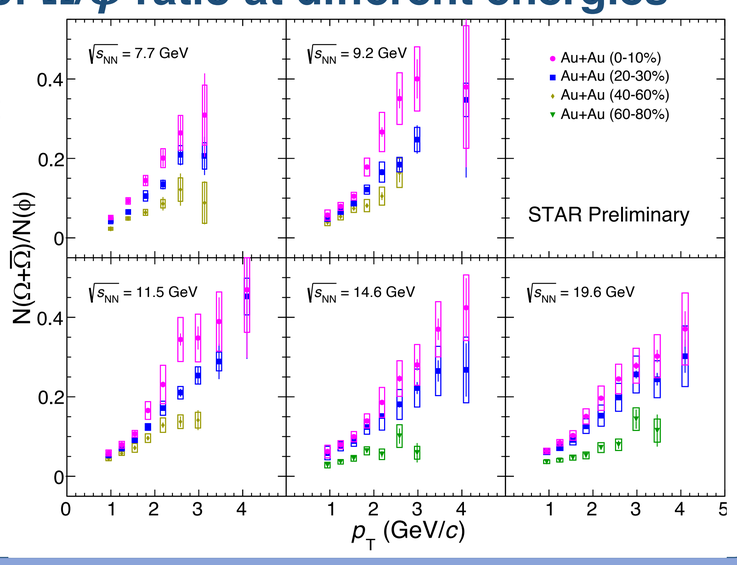
p_T spectra of strange particles in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV

- Low p_T extrapolation: Levy function for ϕ, Boltzmann function for K_S^0, Λ, Ξ and Ω
- Boosted Decision Trees (BDT) is applied to optimize the signal extraction when the background is large.

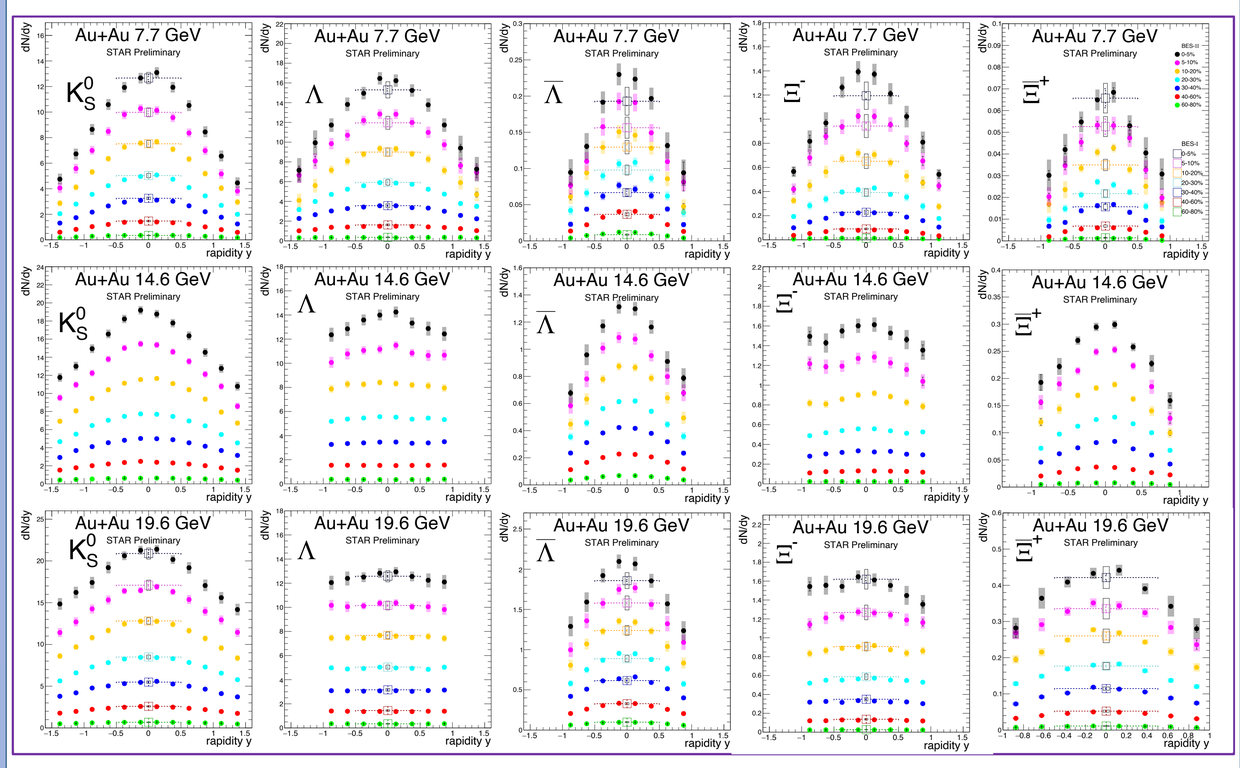


Centrality dependence of Ω/ϕ ratio at different energies

- The Ω/ϕ ratio at intermediate p_T show strong enhancement in central Au+Au collisions compared to peripheral collisions from $\sqrt{s_{NN}}$ = 7.7 to 19.6 GeV.
  - ✓Quark coalescence
  - ✓Cronin effect
  - ✓Radial flow



Rapidity spectra of K_s^0, Λ, Ξ at $\sqrt{s_{NN}}$ = 7.7, 14.6 and 19.6 GeV

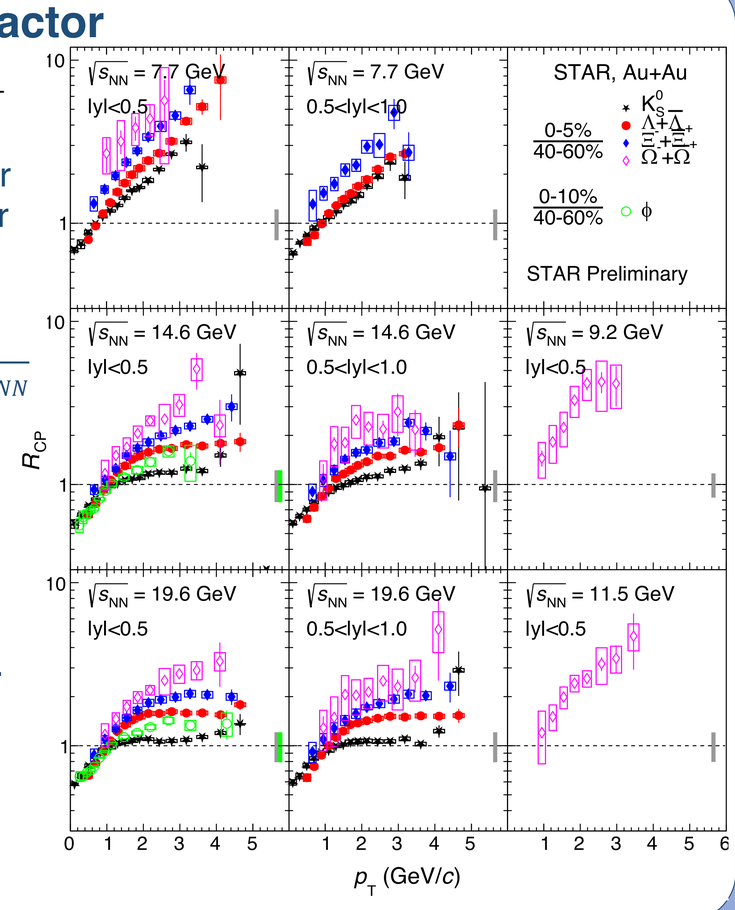


- Rapidity spectra of anti-baryons($\bar{\Lambda}$, $\bar{\Xi}^+$) and mesons(K_S^0) are Gaussian-like distributions.
- Rapidity distribution of baryons(Λ, Ξ^-) are wider than that of anti-baryons ($\bar{\Lambda}$, $\bar{\Xi}^+$).
  - ✓Extra contributions from stopped baryons. *NA49, PRC 78, 034918 (2008)*
- Similar trends from $\sqrt{s_{NN}}$ = 7.7 to 19.6 GeV are observed by NA49.

Nuclear modification factor

$$R_{\mathrm{CP}} = \frac{[(dN/dp_T)/\langle N_{\mathrm{coll}}\rangle]_{\mathrm{central}}}{[(dN/dp_T)/\langle N_{\mathrm{coll}}\rangle]_{\mathrm{peripheral}}}$$

- R_{CP} tends to be flat and larger than unity at $p_T > 2$ GeV/c for energies $\sqrt{s_{NN}} \geq 14.6$ GeV.
- R_{CP} continues to increase beyond $p_T = 2$ GeV/c at $\sqrt{s_{NN}} \leq 11.5$ GeV.
  - ✓ Quark coalescence
  - ✓ Radial flow
  - ✓ Cronin effect
- Stronger enhancement for Ω and Ξ compared to Λ and K_S^0.
- R_{CP} shows minor rapidity dependence.



Summary

- Precise strangeness measurements with extended p_T and rapidity compared to BES-I at $\sqrt{s_{NN}}$ = 7.7 - 19.6 GeV.
- Ω/ϕ enhancement observed in central Au+Au collisions at $\sqrt{s_{NN}}$ ≥ 7.7 GeV.
- Rapidity spectra of anti-baryons($\bar{\Lambda}$, $\bar{\Xi}^+$) and mesons(K_S^0) are Gaussian-like distributions, while the rapidity distribution of baryons(Λ, Ξ^-) are wider than that of anti-baryons.
- R_{CP} shows stronger enhancement for Ω and Ξ compared to Λ and K_S^0.

Outlook

- Strangeness measurements at $\sqrt{s_{NN}}$ = 9.2, 11.5 and 17.3 GeV in BES-II are on-going.

Supported in part by the U.S. DEPARTMENT OF ENERGY Office of Science

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