Strange hadron production in Au+Au collisions at RHIC Beam Energy Scan

Yingjie Zhou, for the STAR Collaboration

Central China Normal University

Strangeness production has been suggested as a sensitive probe into the early-time dynamics of the nuclear matter created in heavy-ion collisions, especially at high baryon density.

This poster will report on the measurements of strange hadron production in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV. The results include the transverse mass spectra, particle ratios, and their centrality dependence of strange hadrons ($K^-$, $K^0_S$, $\phi$, $\Lambda$, $\Xi^-$). These new results will be compared with those from higher collision energies and discussed within the framework of thermal and transport model calculations.
Introduction

- Au+Au collisions @ 3GeV, where are we on this phase diagram? What are the properties of the medium?
- What is the strangeness production mechanism, especially at high baryon density region?
- We focus on strange particles: $K^-$, $K_S^0$, $\phi$, $\Lambda$, $\Xi^-$

- Decay channels: $\Lambda \rightarrow p\pi^-$, $K_S^0 \rightarrow \pi^+\pi^-$
- KF Particle package is used to improve the significance
- The combinatorial background is reconstructed by the rotation method
- Low $p_T$ extrapolation: Blast-Wave function
  - Levy, $m_T$-exponential functions to estimate systematic uncertainty
**Strangeness production vs $\langle N_{\text{Part}} \rangle$**

- Same dependence on the number of participating nucleons:
  \[
  \text{Strangeness yield (} K^-, K^0, \phi, \Lambda) \propto \langle N_{\text{part}} \rangle^\alpha, \quad \alpha = 1.42 \pm 0.04
  \]

- Universal centrality dependence of strangeness production, not for proton
- $\Xi^-$ seems to deviate from the scaling trend
  - Possibly because it is produced below NN-thresholds

---

**STAR Preliminary**

Yingjie Zhou
Strangeness production vs $\sqrt{s_{NN}}$

- The lower production yield of $K^0_S$, $\Lambda$, $\Xi^-$ at 3 GeV: local strangeness conservation may be required
- $\Xi^-$ produced below NN-thresholds
- Following the world trend


Thermal model calculations give:

\[ \frac{N(\Lambda)}{N(K^0_S)} \propto \exp\left(\frac{\mu_B(1-\sigma_\Sigma)}{T}\right) \]

$\sigma_\Sigma = \mu_\Sigma/\mu_B$

Baryon chemical potential driven?

- At high energies, the ratios increase verse $p_T$ and peak at about 3 GeV/c and then fall for higher $p_T$
- At low energies, the ratio increases much faster than at higher energies

Data compilation: C. Blume Prog.Part.Nucl.Phys. 66 (2011) 834-879

• The lower production yield of $K^0_S$, $\Lambda$, $\Xi^-$ at 3 GeV: local strangeness conservation may be required
• $\Xi^-$ produced below NN-thresholds
• Following the world trend
At low energies, strangeness production is rare, local strangeness conservation may be required - CE calculations with different \( r_c \) are needed to describe \( \phi/K^- \) and \( \phi/\Xi^- \), respectively - GCE underpredicts the data at 3 GeV

Default UrQMD failed to describe the measurement data at low energies

Transport models with high-mass resonance decay to \( \phi \) and \( \Xi^- \) can reasonably describe data at low energies

**Summary and outlook**

- Strangeness production in Au+Au 3 GeV collisions - \( \phi/K^- \), \( \phi/\Xi^- \) and \( \Lambda/K_S^0 \) show a strong effect of canonical suppression

- Precise measurements of \( \phi/K^- \) and \( \phi/\Xi^- \) on the centrality dependence, \( \Lambda/K_S^0 \) on the \( p_T \), \( y \) dependence from the STAR BES-II, to constrain the model calculations

- iTPC+cTOF extend the low \( p_T \) reach to reduce systematic uncertainties

- 2B 3GeV-run will reduce the statistical uncertainty by a factor of 3

---

Data compilation: arXiv: 2108.00924