Strange hadron production in small system using the STAR Detector

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Introduction

The primary goal of high-energy heavy-ion (A–A) collisions is to create a system of deconfined quarks and gluons known as quark–gluon plasma (QGP) and to study its properties. Asymmetric collision systems like proton-nucleus (p–A) and deuteron-nucleus (d–A) can be considered as control experiments where the formation of an extended QGP phase is not expected. These collision systems are used for baseline measurements to study the possible effects of cold nuclear matter and disentangle them from hot dense matter effects present in collisions of heavy-ions. The process of generating hadrons can be affected by various factors, including alterations in parton distribution functions within nuclei, the possiblity of parton saturation, multiple scatterings, and radial flow. It is anticipated that these effects may vary with the rapidity of the produced particles.

Strangeness enhancement in heavy ion collisions with respect to pp collisions has been suggested as al signature of quark-gluon plasma (QGP) formation. But creation of QGP in small systems is still under intense debate. Study of nuclear effects can be done using various ways like nuclear modification factor and rapidity asymmetry. Nuclear modification factor is defined as the ratio of the yield of particle in heavy-ion collisions to its yield in proton-proton collisions, scaled by the number of binary nucleon-nucleon inelastic collisions.

$$R_{\mathrm{dAu}}(p_T) = \frac{d^2N_{dAu}/dydp_T}{\langle N_{bin}\rangle/\sigma_{pp}{}^{inel.}\, d^2\sigma_{pp}/dydp_T}$$

where $\langle N_{bin}\rangle$ is the average number of binary nucleon-nucleon collisions per event, $\langle N_{bin}\rangle/\sigma_{pp}{}^{inel.}$ is the nuclear overlap function T_{dAu}.

Comparative study of particle production in forward and backward rapidity regions is done using rapidity asymmtery (Y_{Asym}). Y_{Asym} is defined as

$$Y_{\mathrm{Asym}}(p_T) = \frac{Y_B(p_T)}{Y_F(p_T)}$$

where Y_B and Y_F are backward and forward particle yields, respectively. Y_{Asym} may provide unique information to help determine the relative contributions of various physics processes affecting particle production, such as multiple scattering, nuclear shadowing, recombination of thermal partons, and parton saturation.

Analysis Details

A successful run of d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV was carried out in 2016 at RHIC. Total of approximately 100 million good events have been selected for the reconstruction of K^0_s, $\Lambda(\bar{\Lambda})$. These are weakly decaying particles. They travel certain distance then decay into daughter particles ($K^0_S \rightarrow \pi^+ + \pi^-$ and $\Lambda(\bar{\Lambda}) \rightarrow$ p($\bar{\text{p}}$) + $\pi^-(\pi^+)$). Identification of daughter particles (π, K and p) is done via measuring $\langle dE/dx\rangle$ using Time Projection Chamber (TPC). The K^0_s, $\Lambda(\bar{\Lambda})$ signals are extracted by reconstructing the invariant mass of the decay daughter pairs. The decay topology can be used to suppress the combinatorial background. We have used double Gaussian and second order polynomial function to decribe the signal and background. Raw yield is determined by using the bin counting method under the mass window of M_0 $\pm 3\sigma$, where M_0 is mass of K^0_S (or Λ) and σ is the fitted width. Raw yield for each p_T interval is corrected for branching ratio, acceptence and efficiency. Weak decay feed

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down correction from Ξ is applied to Λ. The measurements of transverse momentum spectra at different rapidities for identified strange hadrons: K_s^0, Λ and $\bar{\Lambda}$ are presented. The integrated yield (dN/dy) and mean transverse momentum (p_T) are calculated for different rapidities.

Results and Discussions

In Fig. 1, dN/dy scaled by the average number of nucleon participants ($\langle N_{part}\rangle$) for K_s^0, Λ and $\bar{\Lambda}$ as function of $\langle N_{part}\rangle$ is shown for d+Au collisions. The yields of strange particles fill the gap between pp collisions and peripheral Au+Au and Cu+Cu collisions. The yields of K_s^0, Λ and $\bar{\Lambda}$ in d+Au collisions lie in trend with peripheral Cu+Cu and Au+Au collisions and are consistent with strangeness enhancement.

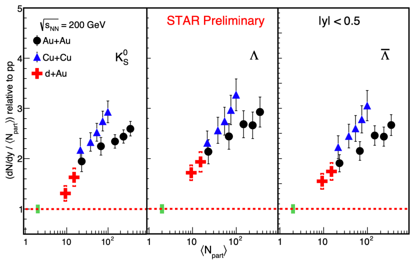

FIG. 1: (dN/dy / $\langle N_{part}\rangle$) relative to pp as a function of $\langle N_{part}\rangle$ for (K_s^0, Λ and $\bar{\Lambda}$) in d+Au collisions $\sqrt{s_{NN}}$ = 200 GeV collisions at |y| < 0.5.

In Fig. 2, nuclear modification factors for K_s^0 and Λ at mid rapidity (|y| < 0.5) for d+Au collisions are shown. Cronin-like enhancement is observed at intermediate $p_{\rm T}$ for K_s^0 and Λ. R_{dAu} for K_s^0 is consistent with charged kaons and enhancement observed is stronger for baryons as compared to mesons.

We have measured the transverse momentum dependence of Y_{Asym} for K_s^0 and Λ in two rapidity intervals ($0 < |y| < 0.4, 0.4 < |y| < 0.8$) in d+Au collision at $\sqrt{s_{NN}}$ = 200 GeV. $Y_{\rm Asym}$ values deviate from unity at low $p_{\rm T}$ (< 3 GeV/c), suggesting the presence of a rapidity dependence in the nuclear effects. $Y_{\rm Asym}$ is consistent with unity at high $p_{\rm T}$, providing a hint that nuclear effects become weaker at

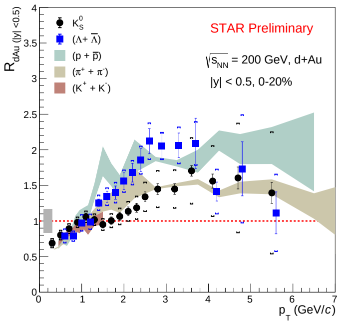

FIG. 2: Nuclear modification factor for strange particles (K_s^0 and Λ) in d+Au collisions $\sqrt{s_{NN}}$ = 200 GeV collisions at |y| < 0.5.

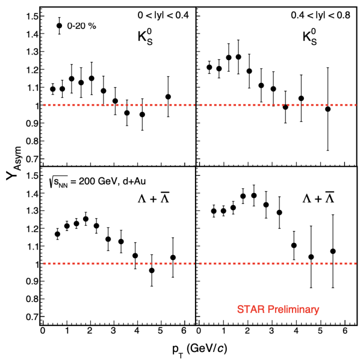

FIG. 3: Rapidity asymmtery for strange particles (K_s^0 and Λ) in d+Au collisions $\sqrt{s_{NN}}$ = 200 GeV collisions.

high $p_{\rm T}$ as shown in Fig. 3. $Y_{\rm Asym}$ is more prominent for larger rapidity interval and it is larger for Λ as compared to that for K_s^0.

Acknowledgments

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References

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