Anisotropic flow of strange and multi-strange hadrons in isobar collisions at $\sqrt{s_{\rm NN}} = 200$ GeV

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Introduction

The separation of charged particles in presence of a magnetic field resulting from local parity violation is called the Chiral Magnetic Effect (CME) [1]. Collisions of isobars, $^{96}_{44}$Ru+$^{96}_{44}$Ru and $^{96}_{40}$Zr+$^{96}_{40}$Zr, at $\sqrt{s_{\rm NN}} = 200$ GeV were successfully carried out at RHIC in 2018 to measure the CME [2]. The elliptic flow (v_2) leads to background to the small CME signal. The deformation parameters were observed to differ between the two species and flow measurements are highly sensitive to them. Hence, it is crucial to understand the initial state anisotropies and the properties of the medium formed in these isobar collisions. There have also been recent attempts to probe the nuclear structures via v_2 ratios as well as the v_2-$\langle p_T \rangle$ correlations in isobar collisions [3, 4]. Strange and multi-strange hadrons have a smaller hadronic cross-section compared to the light hadrons, making their elliptic flow a suitable probe for understanding the initial state anisotropies and the particle production in these isobar collisions.

Analysis details

We report strange and multi-strange hadrons v_2 in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{\rm NN}} = 200$ GeV collected by the STAR experiment. Nearly 650M events were analysed for both the isobar collisions. These short-lived particles were reconstructed using the invariant mass technique. ϕ-mesons were reconstructed through their hadronic decay channel: $\phi \rightarrow K^+K^-$. Event mixing technique was used for combinatorial background estimation for ϕ mesons. The weakly decaying neutral strange particles K^0_s and $\Lambda(\bar{\Lambda})$ were identified using their decay (V0) topology through the decay channels: $K^0_s \rightarrow \pi^+ + \pi^-$ and $\Lambda \rightarrow p + \pi^-$, respectively. The multi-strange (anti-)particle $\Xi^-(\bar{\Xi}^+)$ reconstruction involves finding two secondary vertices from various topological selections due to its two-step decay into a pion and a neutral V0 particle (Λ). Rotational background technique was applied to construct the combinatorial background for the weakly decaying particles. The η-sub event plane method with an η gap of 0.1 in the Time Projection Chamber(TPC) was used to calculate the v_2 of these (multi-)strange hadrons.

Results and Discussion

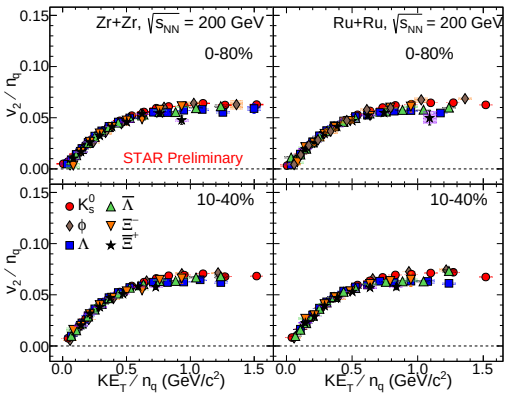

FIG. 1: NCQ-scaled v_2 as a function of scaled transverse kinetic energy for Zr+Zr and Ru+Ru collisions for different centralities at $\sqrt{s_{\rm NN}} = 200$ GeV.

The transverse momentum dependence of

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v_2 was studied for K^0_s, Λ, $\overline{\Lambda}$, ϕ, Ξ^-, and $\overline{\Xi}^+$ at mid-rapidity in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV. To understand the partonic collectivity and the coalescence mechanism of hadronization, we test the number of constituent quark (NCQ) scaling for both the isobar collisions [5]. Figure 1 shows that these (multi-)strange particles and anti-particles seem to follow the NCQ scaling over a wide range of centrality. We have also

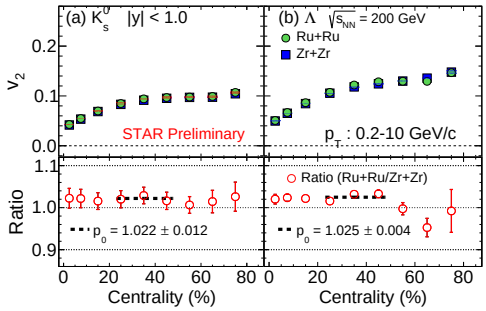

FIG. 2: p_T-integrated v_2 as a function of centrality for K^0_s and Λ in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV. The vertical lines on the ratio include statistical and systematic uncertainties. The dotted lines denote the fitting with a constant.

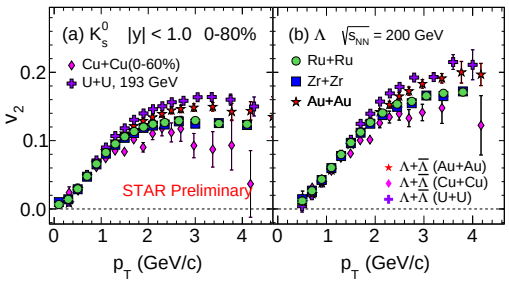

FIG. 3: System size dependence of v_2 of K^0_s and Λ in minimum bias collisions [6–8].

studied the p_T-integrated v_2 as a function of centrality for strange hadrons in Ru+Ru and Zr+Zr collisions along with the corresponding ratios at $\sqrt{s_{\rm NN}}$ = 200 GeV as shown in Fig. 2. The ratios exhibit a deviation from unity by nearly 2% in the mid-central collisions which is consistent with the difference in nuclear structure and shape of the two isobar species [2]. In order to study the system size evolution of v_2, we compare the v_2 of strange hadrons in isobar collisions with $^{63}_{29}$Cu+$^{63}_{29}$Cu, $^{197}_{79}$Au+$^{197}_{79}$Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV, and $^{238}_{92}$U+$^{238}_{92}$U collisions at $\sqrt{s_{\rm NN}}$ = 193 GeV as shown in Fig. 3 [6–8]. We observe larger magnitudes of v_2 at higher p_T for larger nuclei like Au and U, and slightly lower values for Cu+Cu collisions as compared to isobar collisions.

Summary

The elliptic flow of K^0_s, Λ, $\overline{\Lambda}$, ϕ, Ξ^-, and $\overline{\Xi}^+$ in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV was studied which sheds light on the properties of the medium formed in the isobar collisions. We have also observed a system size dependence in the evolution of v_2 for various colliding nuclei. These measurements provide further information on the difference in the deformation and nuclear structure in these isobar nuclei.

Acknowledgments

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