Elliptic flow of light nuclei in Au+Au collisions at STAR

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Introduction

The production mechanism of light nuclei in heavy-ion collisions is not well understood. The thermal model suggests that these light nuclei are produced near the chemical freeze-out (CFO) surface along with other hadrons [1]. However, the low binding energies of light-nuclei make it unlikely that they will be able to sustain the high temperature at CFO. The coalescence model, on the other hand, suggests that light nuclei might be formed by the final-state coalescence of nucleons at the later stages of evolution of the system [2–6]. We study the elliptic flow (v_2) of d, t, and ^{3}He in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV to understand the production mechanism of light nuclei.

Analysis Details

The data presented here were collected in the second phase of the Beam Energy Scan (BES-II) program by the STAR Experiment at RHIC. Light nuclei are identified using the Time Projection Chamber (TPC) and the Time of Flight (TOF) detectors. TPC uses the specific ionisation energy loss (dE/dx) in a large volume of gas to identify the tracks of light nuclei. Mass-square (m^2) from TOF is used to increase the purity of the signal by putting an appropriate restriction on its value. Elliptic flow is the second order Fourier coefficient of the azimuthal distribution of the produced particles with respect to the reaction plane of the collisions. The reaction plane angle cannot be measured directly in an experimental setup. Therefore, we estimate it by the second order event plane angle (Ψ_2) using the TPC. To avoid self-correlations in v_2 measurements of light nuclei we have used the η-subevent plane method described in Ref. [7].

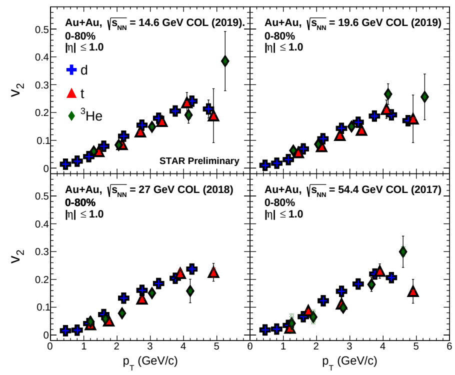

FIG. 1: v_2 of light nuclei as a function of p_T in minimum bias Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV. Vertical lines and shaded region at each marker show statistical and systematic uncertainties, repetitively.

Results

Figure 1 shows v_2 as a function of transverse momentum p_T for d, t, and ^3He in minimum bias Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV. We observe a monotonic increase of v_2 with p_T for the studied collision energies.

Centrality dependence of v_2 of d in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6, 27, and 54.4 GeV is shown in Fig. 2. It is observed that v_2 of d in peripheral collisions (30-80%) is consistently higher than central collisions (0-30%). This trend is observed due to larger initial spatial anisotropy in more peripheral collisions compared to that in central collisions.

Figure 3 shows the comparison of light nuclei v_2/A as a function of p_T/A (where A is the mass number of the nuclei) with proton v_2/A (where A = 1). The aim of this study is to test

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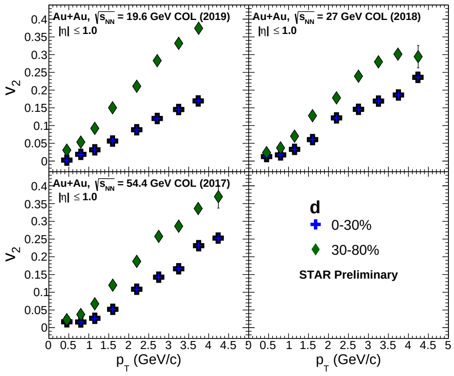

FIG. 2: $v_2(p_T)$ of d in 0%-30% and 30%-80% central Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6, 27, and 54.4 GeV. Vertical lines and shaded area at each marker represent statistical and systematic uncertainties, respectively.

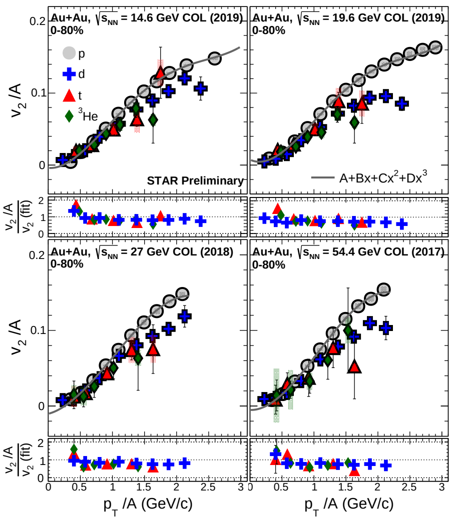

FIG. 3: Mass number scaled v_2 of light nuclei as a function of p_T/A in minimum bias Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV. Proton v_2 has been fitted with a third-order polynomial. The bottom panel in each plot shows the ratio between the v_2/A of light nuclei and the fit to proton v_2. Vertical lines and shaded area at each marker represent statistical and systematic uncertainties, respectively.

the prediction of the coalescence model. The model suggests that if a light nuclei cluster is made up of n number of nucleons, that are very close to each other in phase-space, the v_2 of the cluster will be n-times larger than the v_2 of the individual nucleons [8, 9]. We observed that light nuclei v_2 follow the mass number scaling within 20-30%.

Summary

In summary, we have studied the v_2 of light nuclei (d, t, and ^{3}He) in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6, 19.6, 27, and 54.4 GeV. We observe a monotonic rise in v_2 of light nuclei with p_T. A consistently higher value of v_2 of d in peripheral collisions compared to central ones is also observed in the measured p_T range. We also observed that the light nuclei v_2 follow the mass number scaling within 20-30%.

Acknowledgments

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