System size dependence of collective flow at FAIR energy

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The upcoming Compressed Baryonic Matter (CBM) experiment [1] to be conducted at the Facility for Anti-proton and Ion Research (FAIR), is devoted to provide a suitable database of QCD matter at high baryochemical potential and low/moderate temperature. Anisotropic flow, a typical collective behavior of the produced particles, is an appropriate observable to study such exotic matter expected to be formed in high-energy heavy-ion collisions [2]. The harmonic flow co-efficients (v_n) are obtained from the Fourier expansion of the azimuthal distribution of the produced particles. It is suggested [3] that, taking the event by event fluctuations in initial geometry of the colliding system into account, the azimuthal distribution of final state particles can be expressed as

$$\frac{dN}{d\phi} \propto \left[1 + 2\sum_{n=1}^{\infty} v_n \cos\{n(\phi - \psi_n)\}\right]$$

where ϕ is the momentum azimuthal angle of each particle, and ψ_n is the azimuthal angle of the reaction plane associated with the $n-th$ harmonic, which in the center of mass system of the participating nucleons is given by,

$$\psi_n = \frac{1}{n}\left[\arctan\frac{\langle r^2 \sin(n\varphi)\rangle}{\langle r^2 \cos(n\varphi)\rangle} + \pi\right]$$

where (r, φ) denote the position co-ordinates of the participating nucleons in a plane polar system. We quantify the initial geometric deformation of the overlapping region of two colliding nuclei as,

$$\varepsilon_n = \frac{\sqrt{\langle r^2 \cos(n\varphi)\rangle^2 + \langle r^2 \sin(n\varphi)\rangle^2}}{\langle r^2\rangle}$$

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The anisotropic flow parameter v_n, after considering the initial fluctuations reduces to,

$$v_n = \langle\cos[n(\phi - \psi_n)]\rangle$$

of which the $2nd$ (elliptic flow parameter v_2) and $3rd$ (triangular flow parameter v_3) harmonic co-efficients are of special interest in this investigation. In order to study the system size dependence of flow parameters we have used the string melting version of a multi phase transport (AMPT) model [4] to simulate symmetric heavy-ion collisions like Au + Au, Ni + Ni, and Si + Si at a typical CBM energy of $E_{lab} = 30A$ GeV. Some results of our analysis are described below.

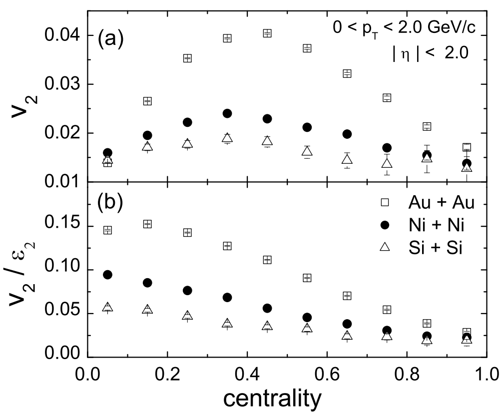

FIG. 1: (a) v_2 and (b) eccentricity (ε_2) scaled v_2 as a function of centrality for different colliding systems at $E_{lab} = 30A$ GeV.

In Fig. 1(a) we present the centrality dependence of v_2 of charged hadrons for systems under consideration, where 0.0 corresponds to most central, and 1.0 corresponds to most peripheral collisions. These distributions have slightly right sided inverted bell shape. This nature however, is significantly flattened as the system size goes down from Au+Au to Si+Si. In all cases, the v_2 values are very small in most central and in most peripheral collisions. The smallness in the v_2 values in central collisions can be attributed to the symmetry of the overlapping zone of the colliding nuclei, and that in peripheral collisions, although highly asymmetric, results in a too low number of participating nucleons that can generate a pressure gradient. In all systems the maximum of v_2 is observed near 35−45% centrality. The magnitude of the maximum is ordered according to the system size, that is, a smaller system results in less flow. In Fig. 1(b) we show the centrality dependence of the elliptic flow after it is scaled by the eccentricity (ε_2). For all colliding systems it is observed that the v_2/ε_2 ratio monotonically decreases with increasing centrality, which is consistetnt with the low density limit of hydrodynamical calculation [5]. In Fig.2 we depict the transverse

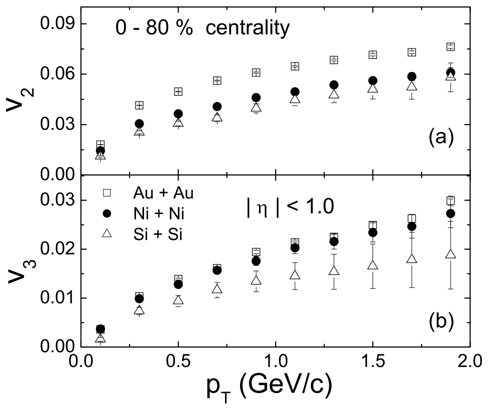

FIG. 2: p_T dependence of (a) v_2 and (b) v_3 for different colliding systems at $E_{lab} = 30A$ GeV.

momentum (p_T) dependence of v_2 and v_3 of charged hadrons. Once again we find a system size ordering, that is, at a particular p_T interval v_2 is higher for a larger colliding system, and v_2 monotonically increases with p_T attaining almost a saturation near $p_T = 2.0$ GeV/c. The v_3 parameter, though always considerably lower valued than v_2, follows a similar trend with increasing p_T as that of v_2. In this context it should be noted that v_2 results from both initial geometric asymmetry and initial fluctuations, whereas v_3 results only from the initial fluctuations. The pseudorapidity (η)

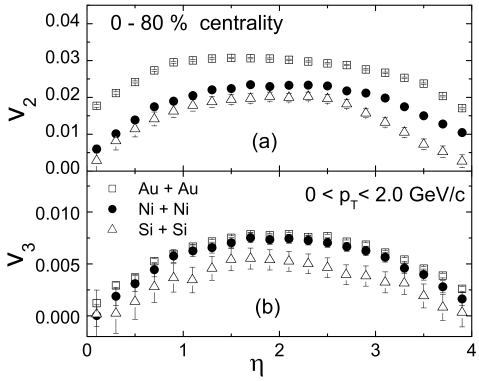

FIG. 3: η dependence of (a) v_2 and (b) v_3 for different colliding systems at $E_{lab} = 30A$ GeV.

dependence of the flow parameters are plotted in Fig. 3, which shows the usual almost symmetric distribution(s) for all three colliding systems, as observed in a previous analysis [6]. Regarding the system size dependence one can draw similar conclusions as that of Fig. 2. To conclude, we observe that the results obtained from this preliminary simulation study on the system size dependence of anisotropic flow behave according to the expectation. In future we intend to perform a more involved analysis on these issues, which may yield some interesting results.

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