Variation of elliptic flow with centrality using UrQMD model in Au+Au and Pb+Pb collision at 200 $AGeV$

N. Subba[1], M. Ghimiray[1], A.N Tawfik[2,3], and P.K Haldar[1]*
[1] *Department of Physics, Cooch Behar Panchanan Barma University, Panchanan Nagar, Vivekananda Street Cooch Behar 736101, West Bengal, India*
[2] *Future University in Egypt (FUE), End of 90th Str., New Cairo, 11835, Egypt and*
[3] *Egyptian Center for Theoretical Physics (ECTP), Juhayna Square of 26th–July–Corridor, Giza, 12588, Egypt*

Introduction

The heavy-ion Physics community's significant goal is to characterize the hot and dense QGP (Quark-Gluon Plasma) matter formed during the heavy-ion collisions experiment. The QGP fireball formed in such experiments collectively expands in the direction perpendicular to the beam axis and is termed as the transverse flow. Flow in relativistic heavy-ion collisions signifies the variation of energy, momentum, and the number of particles produced in the system with direction. One significant discovery of the Relativistic Heavy Ion Collider (RHIC) is the detection of the colossal amount of azimuthal anisotropy in the hadron transverse momentum (p_T) distribution in a non-central collision, termed as the elliptic flow [1]. There are three types of flow: symmetric radial flow, asymmetric direct, and elliptic flow. The elliptic flow provides information on how the flows are distributed unequally in different expected directions on viewing along the beam line. In our study, a microscopic transport model UrQMD 3.4 [2, 3] is used. The elliptic flow $v_2(p_T)$ is characterized as the second harmonic coefficient in the fourier expansion of the azimuthal distribution [4]. The coefficients of such expansion can be calculated as,

$$v_n = \langle cos[n(\phi - \psi_n)]\rangle \quad (1)$$

where v_1 and v_2 corresponds to the direct and the elliptic flow. The angular brackets represent an average over all the particles, summed over all the events. The angle ϕ denotes the azimuthal angle, and ψ_n is the reaction plane angle. In the UrQMD model, ψ_n is fixed at zero degrees. In this paper, we propose to study the variation of elliptic flow with different centrality bin selections.

*Electronic address: `prabirkrhaldar@gmail.com`

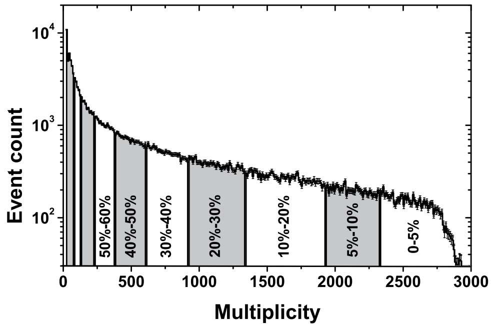

FIG. 1: Particle distribution at collision energy 200AGeV generated from UrQMD simulation represented in centrality percentile.

Results and Discussions

This paper considers two different collision system: Au-Au and Pb-Pb collisions at an energy of 200 AGeV. The properties of such a collision system are studied by classifying the collisions in different centrality bins, which are theoretically characterised by the impact parameter 'b'. Then the centrality is distinguished using the factor $\pi b^2/\pi(2R_A^2)$, R_A being the nuclear radius [5]. The selection and the use of different centrality bins in this paper are shown in Fig.1.

With the centrality selections as above we plot the variation of v_2 with p_T in different centrality bins in Fig.2. We select pions, kaons and protons because the flow of pions

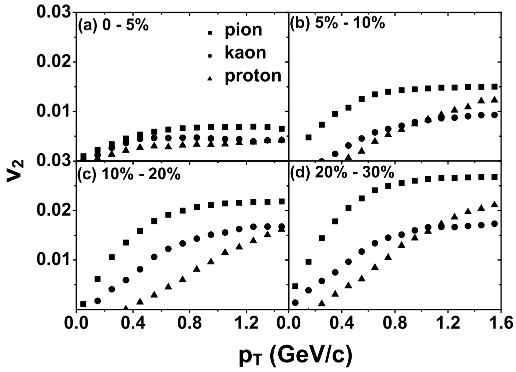

FIG. 2: Elliptic flow $v_2(p_T)$ for pions, kaons, and protons in 200 AGeV Au+Au collisions at different centrality bin.

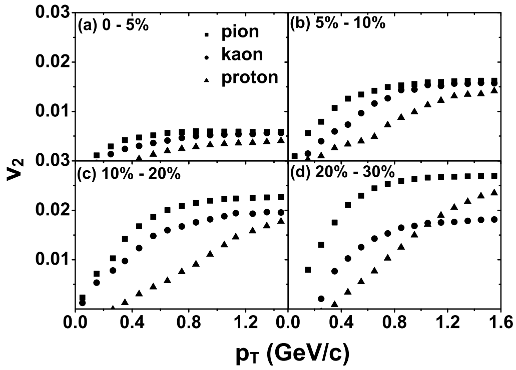

FIG. 3: Elliptic flow $v_2(p_T)$ for pions, kaons, and protons in 200 AGeV Pb+Pb collisions at different centrality bin.

and kaons signalise different properties of the produced particles during the heavy-ion collisions, whereas the flow of protons describe the behavior of nuclear matter.

From Fig.2 and Fig.3 it can be concluded that there is an increase in v_2 values with p_T irrespective of their centrality bin selection. The larger the particle's momentum, the faster it gets away from the collision zone. Moreover, these particles with higher energy carry information about the earliest stage of the collision, where the asymmetry produced in the phase space is highly prominent. Also, the figure depicts an exact mass ordering between baryons and mesons. Evidently, these figures outline the centrality dependence of elliptic flow v_2. Fig.4 illustrates the dependency of v_2 with centrality bin selection.

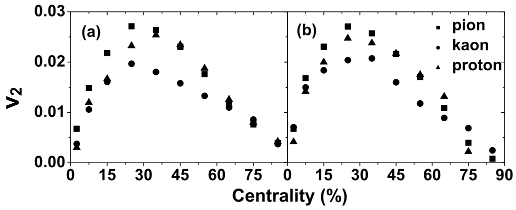

FIG. 4: Centrality dependence of the elliptic flow for pion, kaon and proton at 200 AGeV for (a) Au+Au and (b) Pb+Pb collisions.

Fig.4 shows negligible elliptic flow in the case of 0% centrality and increases up to a maximum value at around the mid-central region and decreases towards higher centrality. The former indicates that the particles are released isotropically from the central collision region, and the anisotropicity increases with the increase in centrality, resulting in higher values of v_2. The latter shows the dependency of v_2 with the particle density, which is maximum in the case of the central collisions and decreases towards peripheral collisions. Hence, elliptic flow is much more pronounced in the mid-central region, i.e., semi-peripheral collisions observed at mid-rapidities, and is almost negligible in central and peripheral collisions.

References

[1] P.F Kolb et al., *Physics Letters B* **500(3)** 232-240, 2001.

[2] H.Petersen et al., *Physical Review C* **74** 064908 2006.

[3] S.Bhattacharjee et al., *Int.J.Mod.Phys.E*, 2022.

[4] S.A. Voloshin et al., *Zeitschrift für Physik C Particles and Fields* **70(4)** 665–671, 1996.

[5] R.Snellings *New Journal of Physics* **13(5)** 055008, 2011.