Study of Flow in Asymmetric Heavy-Ion Collisions

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Introduction

Azimuthal anisotropy is a key tool to study the strongly interacting medium produced in relativistic heavy ion collisions. This observable is sensitive to the equation of state of the system formed in the heavy-ion collisions. Recently, it has been proposed at the Relativistic Heavy Ion Collider, to carry out a program of asymmetric heavy-ion collisions. Among other physics possibilities, it is believed to provide insight on the initial conditions through study of event-by-event fluctuation in the measure of the azimuthal anisotropy. Knowing the initial condition is vital for any theoretical calculations in relativistic heavy-ion collisions. The strength of anisotropic flow is measured from the corresponding Fourier coefficient in the Fourier expansion of the azimuthal distribution function, given as,

$$\frac{dN}{d\phi} \propto 1 + \sum_n 2v_n \cos[n(\phi - \psi_n)]$$

where ψ_n is the participant plane angle defined as,

$$\psi_n = \frac{tan^{-1}(<r^2 \sin(n\phi_{part})>,<r^2 \cos(n\phi_{part})>) + \pi}{n}$$

where r and ϕ_{part} is the polar co-ordinate of the participant nucleons.
The second Fourier coefficient (v_2) is the measure of elliptic flow and third Fourier coefficient (v_3) is the measure of triangular flow and they are expressed as,

$$v_2 = < \cos(2(\phi - \psi_2)) >$$

$$v_3 = < \cos(3(\phi - \psi_3)) >$$

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where <> sign indicates average value. In this work we have studied the elliptic and triangular flow for the asymmetric heavy-ion collisions (Au+Cu, Au+Ag and Au+Si) at $\sqrt{s_{NN}}$ = 200 GeV using A Multi Phase Transport model (AMPT) and compared the corresponding results to those from Au+Au collisions at the same energy.
We define participant eccentricity ϵ_2 and participant triangularity ϵ_3 as,

$$\epsilon_2 = \frac{\sqrt{(<r^2\cos(2\phi_{part})>^2 + <r^2\sin(2\phi_{part})>^2)}}{<r^2>}$$

$$\epsilon_3 = \frac{\sqrt{(<r^2\cos(3\phi_{part})>^2 + <r^2\sin(3\phi_{part})>^2)}}{<r^2>}$$

Analysis and Results

Fig. 1 shows the participant eccentricity for heavy-ion collisions. The eccentricity decreases with decrease in colliding ion size for the same number of participating nucleons (N_{part}). The difference for the ϵ_3 (as shown in Fig. 2) are smaller.

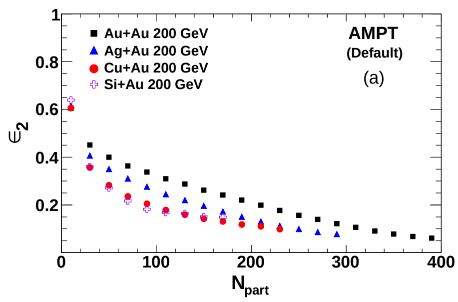

FIG. 1: Distribution of eccentricity ϵ_2.

Fig. 3 shows the event-by-event fluctuation in the participant eccentricity. Although the fluctuation in participant triangularity is independent of colliding ion size (Fig. 4), those of participant eccentricity shows a clear ion size dependence for the same N_{part} for mid-central collisions.

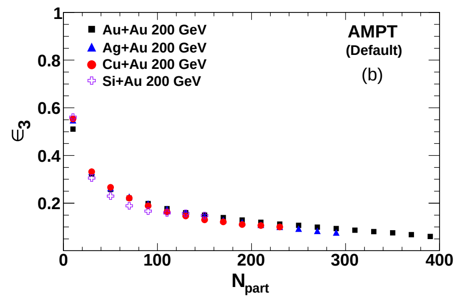

FIG. 2: Distribution of triangularity ϵ_3.

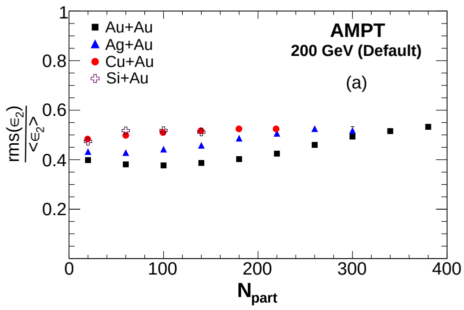

FIG. 3: Fluctuation in eccentricity ϵ_2.

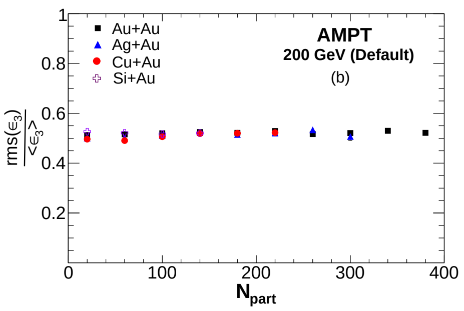

FIG. 4: Fluctuation in triangularity ϵ_3.

Fig. 5 shows the elliptic flow (v_2) and Fig. 6 triangular flow (v_3) as a function of transverse momentum (p_T). The ion size dependence is consistent with the expectation of $v_2 \propto \epsilon_2$ and $v_3 \propto \epsilon_3$. We have also studied the dependence of these flow coefficients with respect to various other quantities like number of participant nucleons and eccentricity the details of which will be discussed.

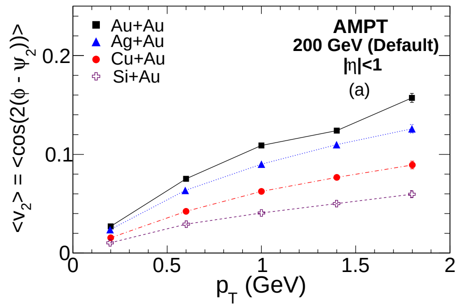

FIG. 5: Average elliptic flow v_2 as a function of transverse momentum p_T.

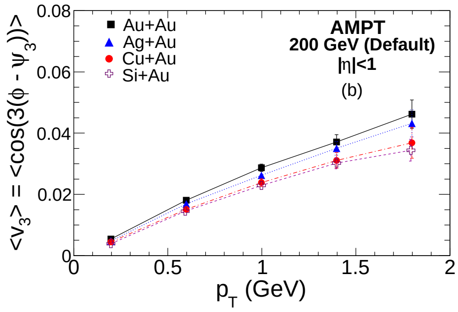

FIG. 6: Average triangular flow v_3 as a function of transverse momentum p_T.

Conclusion

1. Participant eccentricity (ϵ_2) and triangularity (ϵ_3) varies with colliding ion size for the same N_{part}.
2. There is event by event fluctuations in ϵ_2 and ϵ_3.
3. v_2 and v_3 depends on the ion size and are in general proportional to ϵ_2 and ϵ_3 respectively.

Acknowledgments

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