Azimuthal anisotropy of transverse rapidity at CBM energy in the AMPT model

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The Compressed Baryonic Matter (CBM) [1] experiment at the Facility for Antiproton and Ion Research (FAIR) is being designed to explore the nuclear (partonic) matter at high baryon density. One important phenomenon that needs to be examined in the CBM experiment is the collective flow [2] of final state particles that is reflected from anisotropy of distributions in azimuthal plane. It can be used as a signature of the formation of the quark-gluon plasma (QGP) state. The flow parameters (v_n) are measured from the Fourier decomposition of the azimuthal angle distribution of the particle density given by,

$$\frac{dN}{d\phi} \propto 1 + \sum_{n=1}^{\infty} 2\, v_n(N)\, \cos(n\phi)$$

However, it is to be remembered that the initial geometrical anisotropy of the overlapping region in noncentral collisions may lead to an anisotropy not only in the particle number density but also in the kinetic radial expansion. The transvese rapidity

$$y_T = \ln\left(\frac{m_T + p_T}{m_0}\right)$$

of a particle in the final state is a good approximation of its y_T value at the kinetic freeze out. Here m_0 is the particle rest mass, p_T is its transeverse momentum and $m_T = \sqrt{m_0^2 + p_T^2}$ is the corresponding transverse mass. The total transverse rapidity $\langle Y_T(\phi_m)\rangle$ in the m-th azimuthal bin is introduced as,

$$\langle Y_T(\phi_m)\rangle = \frac{1}{N_{ev}} \sum_{j=1}^{N_{ev}} \sum_{i=1}^{N_m} y_{T,i}(\phi_m)$$

where $y_{T,i}(\phi_m)$ is the transverse rapidity of the i-th particle, N_m is the total number of particles in the m-th bin, N_{ev} is the number of events under consideration and $\langle\ \rangle$ denotes an averaging over events. An azimuthal distribution of $\langle Y_T(\phi_m)\rangle$ contains information from both multiplicity and radial expansion [3]. On the other hand due to an averaging over particle number in the mean transverse rapidity

$$\langle\langle y_T(\phi_m)\rangle\rangle = \frac{1}{N_{ev}} \sum_{j=1}^{N_{ev}} \left(\frac{1}{N_m} \sum_{i=1}^{N_m} y_{T,i}(\phi_m)\right)$$

multiplicity influences are small and its distribution counts only radial expansion. In this paper we present a preliminary study on the azimuthal angle distributions of $\langle Y_T(\phi_m)\rangle$, $\langle\langle y_T(\phi_m)\rangle\rangle$ and $dN/d\phi$ by using a sample of 0.3 million Au-Au events at $E_{lab} = 30$A GeV generated by the AMPT (string melting) model [4], and compare them with the results of Au-Au collision at $\sqrt{s_{NN}} = 200$ GeV [5]. In Fig. 1 we present all three distributions over $0 - 80\%$ centrality covering the full rapidity range. In spite of a huge difference in

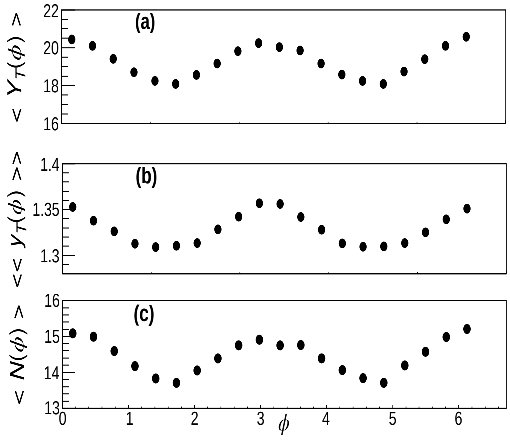

FIG. 1: Azimuthal distribution of (a) transverse rapidity, (b) mean transverse rapidity, and (c) multiplicity in Au-Au collisions at $E_{lab} = 30$A GeV generated by AMPT (string melting).

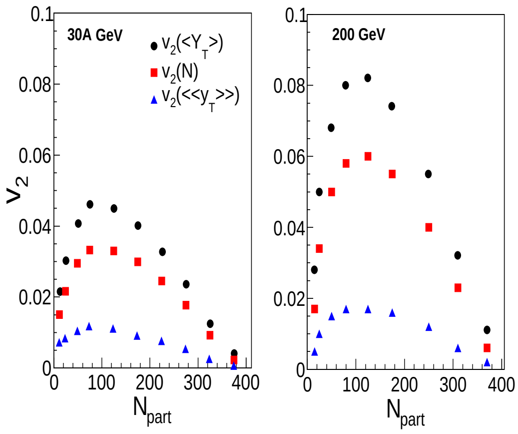

FIG. 2: Centrality dependence of elliptic flow parameter of azimuthal distributions.

collision energies it is found that the distributions look almost similar and anisotropies are present in the azimuthal distributions of total and mean transverse rapidities as it is also in the multiplicity. It is possible to expand the distributions in Fourier series as

$$\frac{d\langle Y_T\rangle}{d\phi} \approx v_0\left(\langle Y_T\rangle\right)\left[1+2v_2\left(\langle Y_T\rangle\right)\cos(2\phi)\right] \text{ and}$$

$$\frac{d\langle\langle y_T\rangle\rangle}{d\phi} \approx v_0\left(\langle\langle y_T\rangle\rangle\right)\left[1{+}2\,v_2\left(\langle\langle y_T\rangle\rangle\right)\cos(2\phi)\right]$$

where only the leading ($n = 0$ and $n = 2$) terms are retained. It is well known that v_0 corresponds to an isotropic part while anisotropy is quantified by the second Fourier coefficient v_2. In Fig. 2 we compare the centrality dependence of the anisotropy v_2 of the distributions. At both energies the centrality dependences are of similar nature and at each centrality $v_2(N)$ is larger than $v_2(\langle\langle y_T\rangle\rangle)$. Higher the collision energy more is the aanisotropy. The anisotropy parameter of the total transverse rapidity $v_2(\langle Y_T\rangle)$ is largest among all as it contains the total anisotropy originating both from particle number and mean transverse rapidity. In Fig. 3 we study the azimuthal distribution of the mean transverse rapidity at three different centralities, $0-5\%$, $30-40\%$ and $60-70\%$ for 30A GeV and compare them with the respective data at 200 GeV. In mid-central

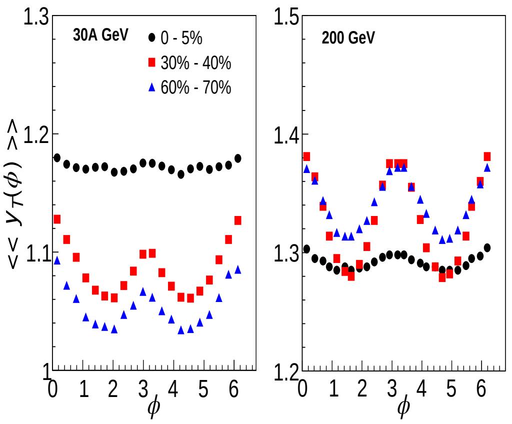

FIG. 3: Azimuthal distribution of mean transverse rapidity at different centralities.

and peripheral collisions the mean transverse rapidity are anisotropic, while for central collisions it becomes approximately isotropic and almost constant at both energies. This is in accordance to our expectation that anisotropy is more prominent in non-central collisions, be it a multiplicity distribution or transverse rapidity distribution. It is interesting to note that at 200 GeV the isotropy parameter v_0 for central collisions is lowest, but at 30A GeV it is highest in the most central collisions. More subtle issues to probe the evolution dynamics of the matter prevailing the collision region need to be further examined.

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