Simulation Study of Beam Energy Dependence of Elliptic Flow Using AMPT for Au+Au Collisions

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Introduction

The theory of the strong interaction, Quantum Chromodynamics(QCD), has been extremely successful at describing the phenomenology of hadronic physics seen in high energy collisions of elementary particles and deep inelastic scattering. However, other domains may have yet to be discovered, when nuclear matter is subject to extreme conditions of temperature and density, such as those in the cores of neutron stars, or during the first microseconds of the Universe. Relativistic heavy-ion collisions offer a unique opportunity to study the properties of nuclear matter at very high temperatures and energy densities. It is expected that under those conditions a new state of matter may be created, where quarks and gluons are no longer confined inside nucleons and can move and interact within a larger volume, known as Quark-gluon Plasma[1-3]. On the earth, ultra-relativistic heavy ion collisions have been considered to be the only way which can provide the opportunity to create and study the Quark-gluon Plasma. Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) fulfil this purpose. The RHIC provides different kinds of heavy ion collisions at different energies for various colliding species [4].

Analysis of the azimuthal anisotropy resulting from non-central nuclear collisions appears to be one of the most informative observables in studying the nature and properties of matter created in ultra-relativistic heavy ion collisions i.e. Quark-gluon Plasma[5]. The azimuthal anisotropy is usually characterized by the Fourier coefficients [6, 7].

In this work we studied beam energy dependence on variation of elliptic flow of charged hadrons in Au+Au collisions at centre of mass energies 62.4 GeV and 200 GeV. We used AMPT generated data sets for study purpose.

Data Generation

We used event generator AMPT (A Multiphase Transport Model) with default setting to generate events. We generated 400K events having parameters identical to experimental situation i.e. pseudorapidity range from -0.35 to 0.35 for Au+Au at RHIC's centre of mass energies 62.4 GeV and 200 GeV per nucleon pair. AMPT is a hybrid transport model, which models an ultra-relativistic nuclear collision using many tools of Monte Carlo simulations [8,9].

Analysis

The importance of the value of elliptic flow coefficient, v_2, to indicate the extent of thermalisation in ultra-relativistic heavy ion collisions, and the large number of experimental measurements led to the need for a variety of methods to determine the value accurately from experimental data [7,10,11]. In the more commonly used method the azimuthal distributions are expanded in Fourier series where the coefficients of expansion are the measures of different orders of anisotropy. This method is called event plane method. For small values of these coefficients, the first two terms describe an elliptic shape. The first order anisotropy v_1 is called directed flow; it measures the shift of the centroid of the distribution. The second order anisotropy v_2 is called elliptic flow; it measures the difference between the major and minor axes of the elliptic shape of the azimuthal distribution.

one can characterizes this anisotropy in terms of a single-particle probability distribution for each collision event. By writing this distribution as a Fourier series with respect to the azimuthal angle of out-going particles ϕ, one can define flow coefficients v_n and event plane angles Ψ_n:

$$\frac{2\pi}{N}\frac{dN}{d\phi} = 1 + 2\sum_{n=1}^{\infty} v_n \cos n(\phi - \psi_n) \qquad (1)$$

$$v_n e^{in\psi_n} \equiv \left\langle e^{in\phi} \right\rangle \qquad (2)$$

Where the brackets indicate an average over the single particle probability and the event plane angles Ψ_n are chosen such that v_n are the (positive) magnitudes of the complex Fourier coefficients.

Results

We studied beam energy dependence on variation of elliptic flow parameter v_2 with centrality percentile for simulated events generated by AMPT for Au+Au collisions. We calculated the elliptic flow parameter v_2 by for AMPT(default) events for 0-10%, 10-20%, 20-30%, 30-40%, 40-50% and 50-60% centrality bins for low transverse momentum ranging from 0.2 to 1.0 GeV/c. We performed above analysis for two beam energies 62.4 GeV and 200 GeV. Fig.1 shows effect of beam energy on elliptic flow parameter (v_2) variation with centrality for charged hadrons generated in Au+Au collisions at centre of mass energy 62.4 GeV and 200 GeV per nucleon pair for pseudorapidity $|\eta| < 0.35$ and transverse momentum $p_t = 0.2$ to 1 GeV/c.

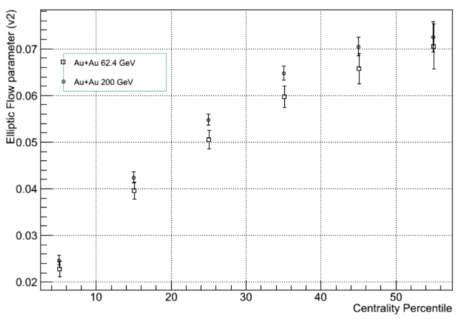

Fig. 1: Variation of v_2 for charged hadrons with centrality generated in Au+Au collisions at centre of mass energy 62.4 GeV and 200 GeV per nucleon pair for $|\eta|<0.35$ and p_t = 0.2-1 GeV/c .

Conclusion

This graph shows beam energy dependency on the flow values. Elliptic flow at 200 GeV is more than at 62.4 GeV. It shows that flow increases on increasing beam energy in all centrality bins.

In future further studies can be done at other energies and for other ion species.

References

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