Charged Hadrons Elliptic Flow at RHIC Energy 200 GeV

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Introduction

The hadrons, which compose our beautiful universe, may take a state such that quarks and gluons are not confined known as Quark Gluon Plasma (QGP) and quantum chromodynamics (QCD) describes the Quark Gluon Plasma. QCD calculations performed on the lattice (LQCD) predicts that relativistic heavy-ion collisions under extreme conditions of temperature and energy density produces strongly interacting matter i.e. QGP, similar to those prevailing in the first few microseconds after the Big Bang [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 QGP. Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) has been constructed for this purpose. The flexibility of Relativistic Heavy Ion Collider (RHIC) provides different kinds of heavy ion collisions at different different energies for various colliding species [4].

One of the experimental observables that is sensitive to the properties of QGP is the azimuthal distribution of particles in the plane perpendicular to the beam direction. The geometrical overlap region becomes anisotropic during non-central collisions i.e. collisions at non-zero impact parameter. This initial spatial asymmetry is converted into an anisotropic momentum distribution of the produced particles due to multiple collision [5]. The azimuthal anisotropy is characterized by the Fourier coefficients. Second order coefficients represents elliptic flow [6, 7].

In this work we studied dependence of elliptic flow of charged hadrons on collision species Au+Au and Cu+Cu at centre of mass energy 200 GeV. We used AMPT generated data sets and PHENIX (RHIC) experimental data sets for study purpose.

Event Generation

We obtained simulated events using event generator AMPT (A Multiphase Transport Model) with default setting for Au+Au and Cu+Cu at RHIC's top most centre of mass energy 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]. We generated 400K events having parameters identical to experimental situation i.e. pseudorapidity range from -0.35 to 0.35.

Analysis

A commonly used method the azimuthal distributions are expanded in Fourier series where the coefficients of expansion are the measures of different orders of anisotropy [7]. This method is also 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:

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

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

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 variation of elliptic flow parameter v_2 with various centrality percentile for simulated events generated at 200 GeV for Au+Au and Cu+Cu collisions. We calculated the elliptic flow parameter v_2 by above mentioned method for AMPT(default) events for 0-10%, 10-20%, 20-30%, 30-40% and 40-50% centrality bins for low transverse momentum ranging from 0.2-1.0 GeV/c. We compared our simulated data results with results calculated from data sets taken in Run-4 and Run-5 periods by PHENIX at RHIC [10]. Fig.1 shows elliptic flow parameter (v_2) variation with centrality for charged hadrons generated in Au+Au and Cu+Cu collisions at centre of mass energy 200 GeV per nucleon pair for $|\eta| < 0.35$ and $p_t = 0.2$ to 1 GeV/c.

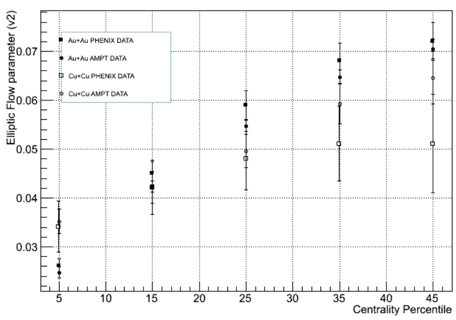

Fig. 1: Variation of v_2 for charged hadrons with centrality generated in Au+Au and Cu+Cu collisions at centre of mass energy 200 GeV per nucleon pair for $|\eta|<0.35$ and $p_t = 0.2\text{-}1$ GeV/c for AMPT & PHENIX data sets

Conclusion

It is clear from the graphs that results from simulated data and from experimental data are approximately same within error limits. As centrality increases flow of particle increases as expected. For higher centrality experimental value differed from simulation value due to decreased number of particles in simulations. This is more in case for Cu+Cu collisions due to small size in comparision to Au+Au. Some of the difference in experimental and simulation results is due to detector effect.

This figure also shows mass dependency on the flow values. Elliptic flow of Au+Au is more than Cu+Cu at 200 GeV. It shows that a heavy ion which is heavier than the other ion shows more flow then a lighter heavy ion.

References

[1] D. Schwarz, Annalen Phys.12:220-270,2003 (2003), arXiv:astro-ph/0303574v3
[2] K. Adcox et al., Nucl. Phys. A 757, 184 (2005).
[3] Quark-GluonPlasma:theoretical foundations, J. Kapusta, B. Muller and J. Rafelski, Elsevier (2003).
[4] Introduction on RHIC at \http://www.bnl.gov/RHIC
[5] J. Y. Ollitrault, Phys. Rev. D 46, 229 (1992)
[6] S. Voloshin and Y. Zhang, Z. Phys. C 70 665 (1996)
[7] A. M. Poskanzer and S. A. Voloshin Phys. Rev. C 58 1671 (1998)
[8] Z.-W.Lin,C.M.Ko, B.-A. Li, B. Zhang and S. Pal. Phys. Rev. C72, 064901(2005), nucl-th/0411110
[9] J. Xu and C. M. Ko, Phys. Rev. C83, 034904 (2011), 1101.2231.
[10] "Systematic Study of Azimuthal Anisotropy for Charged Hadron in Relativistic Nucleus-Nucleus Collisions at RHIC-PHENIX" thesis by M. Shimomura submitted to University of Tsukuba (2009)