Elliptic flow of charged hadrons in Au+Au collisions using the PHSD model

B. Waseem[1],* B. Towseef[1], V. Bairathi[2], M. Farooq[1], S. Kabana[2], and S. Ahmad[1]
[1] *Department of Physics, University of Kashmir, Srinagar - 190006, India and*
[2] *Instituto de Alta Investigación, Universidad de Tarapacá, Arica 1000000, Chile*

Introduction

The purpose of heavy-ion physics is to investigate nuclear matter under extreme conditions of temperatures and densities, which result in the formation of a new state of matter known as the quark-gluon plasma (QGP). This state of matter is known to be existed in the few microseconds following the Big Bang. Several high-energy experiments such as the Large Hadron Collider (LHC) and the Relativistic Heavy Ion Collider (RHIC) collide heavy-ions (Pb+Pb, Au+Au etc.) at high energies, which creates an incredibly hot but nearly net-baryon free medium. A fixed target experiment at the Facility for Anti-Proton and Ion Research (FAIR) called Compressed Baryonic Matter (CBM) aims to investigate the characteristics of highly interacting matter in the high net-baryon density.

Elliptic flow, a measure of azimuthal anisotropy in momentum space, is defined as the 2^{nd}-order coefficient of the Fourier expansion of azimuthal angle of produced particles in heavy-ion collisions. Hydrodynamics explains the appearance of large elliptic flow (v_2) produced in non-central collisions at low transverse momentum. The study of v_2 as a function of several variables, such as collision centrality, transverse momentum (p_T) and pseudo-rapidity (η), is found to be important because it is sensitive to the initial conditions, thermalization and transport coefficients of the medium produced in relativistic heavy-ion collisions.

In this work, the Parton Hadron String Dynamics (PHSD) [1] transport model has been used to study the charged hadron elliptic flow. The PHSD model includes both partonic and hadronic interactions within its framework, which is described by the microscopic off-shell transport method in both equilibrium and out-of-equilibrium states.

Analysis details

We have simulated 30 million Au+Au collision events from the PHSD model at energy, E_{lab} = 35 A GeV. We have calculated inclusive charged hadron v_2 at mid-rapidity for different centrality classes in Au+Au collisions at E_{lab} = 35 A GeV. We used η-sub event plane method to measure integrated and differential v_2. In this flow analysis method, the

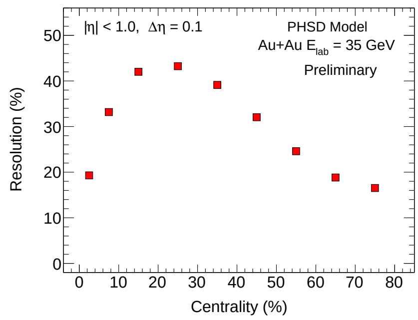

FIG. 1: Event plane angle resolution as a function of centrality calculated from η-sub event method with a η-gap of 0.1 in Au+Au collisions at E_{lab} = 35 A GeV.

azimuthal angle distribution of the particles created in a nucleus-nucleus collision can be expressed as a Fourier series [2]:

$$\frac{dN}{d(\varphi - \Psi_n)} \propto 1 + 2\sum_{n=1}^{\infty} v_n \cos\left[n\left(\varphi - \Psi_n\right)\right], \quad (1)$$

*Electronic address: W.Bhat@gsi.de

where ϕ represents azimuthal angle of produced particles. The elliptic flow v_2 is measured with respect to the estimated event plane angle Ψ_2 and corrected for the resolution as $v_2 = \langle \cos(2(\phi - \Psi_2)) \rangle / R$, where $R = \sqrt{\langle \cos(2(\Psi_2^A - \Psi_2^B)) \rangle}$. To minimize non-flow correlations, we used η-gap of 0.1 between the positive and negative η-sub events. Figure 1 represents the event plane angle resolution as a function of centrality in Au+Au collisions using the PHSD model at $E_{lab} = 35$ A GeV. The resolution increases from central to mid-central collisions due to increase in v_2 magnitude, then decreases from mid-central to peripheral collisions because of low multiplicity.

Results

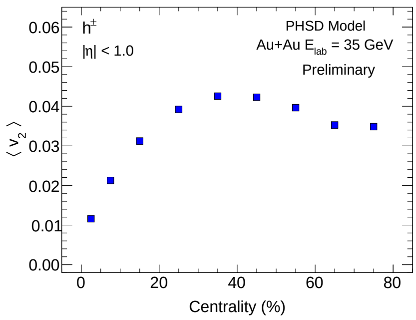

FIG. 2: Average v_2 of charged hadrons as a function of centrality at mid-rapidity in Au+Au collisions at $E_{lab} = 35$ A GeV.

In Fig. 2, we show the $\langle v_2 \rangle$ as a function of centrality in Au+Au collisions for charged hadrons at $E_{lab} = 35$ A GeV using the PHSD model. We observed v_2 increases till 40% centrality and then decreases. Figure 3 represents p_T dependence of charged hadron v_2 for 0-80%, 0-10%, 10-40% and 40-80% centralities. We observed v_2 increases monotonically with p_T. We also observed more $v_2(p_T)$ in peripheral collisions (40-80%) compared to the central collisions (0-10%). Figure 4 shows the v_2 as a function of η for 0-80%, 0-10%, 10-40% and 40-80% centralities. We observed $v_2(\eta)$ remains almost constant with η for all the centralities in Au+Au collisions at $E_{lab} = 35$ A GeV.

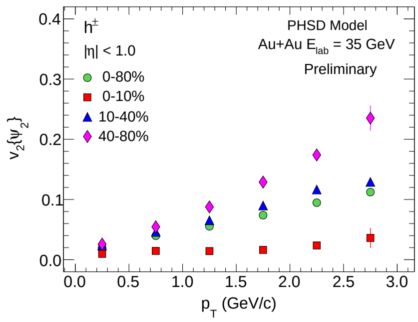

FIG. 3: Charged hadron v_2 as a function of p_T for different centralities in Au+Au collisions at E_{lab} = 35 A GeV.

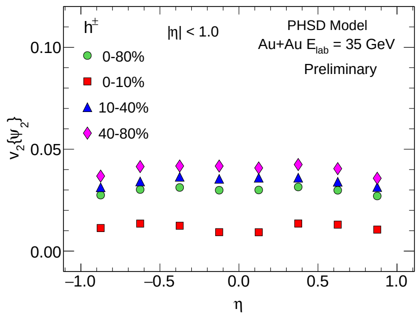

FIG. 4: Charged hadron v_2 as a function of η for different centralities in Au+Au collisions at E_{lab} = 35 A GeV.

Summary

Results on elliptic flow v_2 for charged hadrons from Au+Au collisions at $E_{lab} = 35$ A GeV using PHSD model were presented. The v_2 increases with centrality with maximum around 40% centrality and then decreases. We also observed v_2 increases monotonically from lower to higher p_T for all the centralities. Centrality dependence of v_2 is observed in Au+Au collisions at $E_{lab} = 35$ A GeV.

References

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