Study of the elliptic flow and their energy dependence over pseudorapidity range at FAIR energies.

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Introduction

The major goal of high energy heavy ion collision experiments is to create extremely hot and dense matter with partons as its fundamental components called the Quark Gluon Plasma (QGP). The various observables have been studied, both in experiments, and in model calculations, so as to unravel the properties of the dense hot matter created in the collisions. Of particular interest is the elliptic flow which is considered as one of the most important signatures of the formation of QGP as it is sensitive to the very early stage of the collision [1, 2]. It has its origin in the initial spatial asymmetry of the system, which is then transformed into the momentum anisotropy of the particles. In this work we have studied the transverse momentum dependence of elliptic flow v2 at 25 A GeV by the AMPT model with the default and the string melting versions and then the energy dependence of elliptic flow with the pseudorapidity is studied.

Elliptic flow

The second coefficient of the Fourier expansion of the azimuthal distribution of the emitted particles (v2) is the elliptic flow [3]. This type of flow is strongest for non central collisions around central rapidities. It is observed by the pressure gradients, due to the geometric anisotropy of the initial overlapping region. We have observed the elliptic flow of identified hadrons with both versions of the AMPT model where we have observed the mass ordering effect in both the versions. This mass ordering is caused by the presence of radial flow which boosts particles to higher momenta [4]. The momentum gain is larger for heavier particles resulting in a flattening of the transverse momentum spectra of heavy particles. This, in its turn, results in a decrease of v_2 at low P_T and a shift towards higher P_T of the linear rise of v_2 (P_T). The effect of the phase transition is more pronounced in the heavier protons because they are more influenced by the collective velocity which is sensitive to the equation of state. At intermediate P_T particle production by coalescence or recombination [5] predicts that v_2 depends on the quark content of the particle. We cannot go beyond $P_T \approx 2$ GeV/c as the simulated data suffer from large fluctuations.

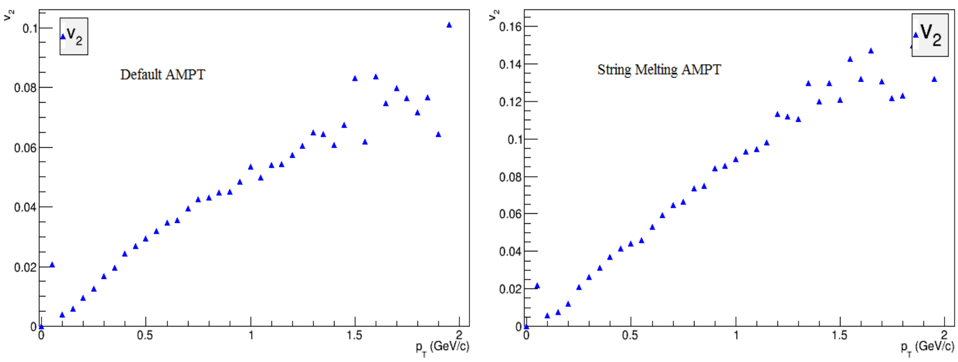

Fig 1: Elliptic flow v_2 as a function of P_T at 25 A GeV FAIR energies from the AMPT model with both the versions for non central Au + Au collisions with the impact parameter b = 5-9fm.

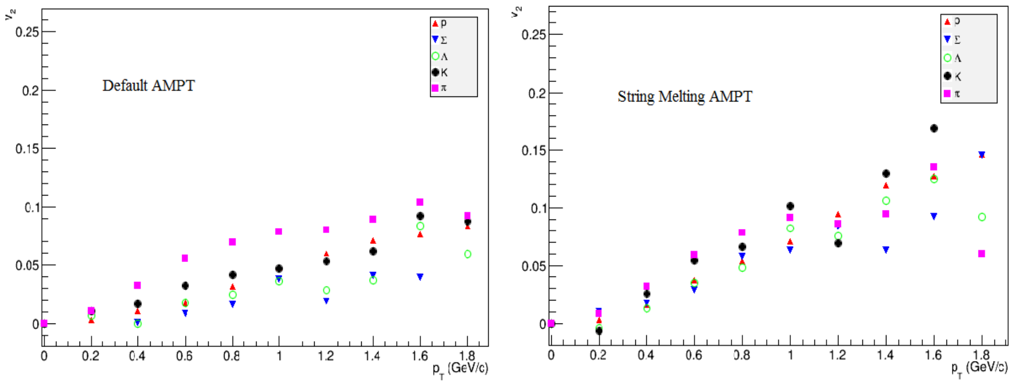

Fig 2: Elliptic flow v_2 as a function of P_T for identified hadrons at 25 A GeV FAIR energies from the AMPT model with both versions for non central Au + Au collisions with the impact parameter b = 5-9fm.

Energy dependence of elliptic flow over Pseudorapidity.

The collective flow of the produced particles by their azimuthal anisotropy is considered to be one of the most important probes of the dynamics of heavy ion collisions. The elliptic flow signal (v_2) at midrapidity is significant and consistent with expectations from hydrodynamic models at low P_T [6]. It has been interpretd as evidence for the production of a highly thermalized state, and perhaps for partonic matter. At high P_T, the observed shape of elliptic flow [7] is consistent with the calculations included in quark coalescence and jet quenching [8]. Interestingly, the decrease of elliptic flow (v_2) with the increasing pseudorapidity (η) [9] has been less amenable to understanding.

It is interesting to observe the extent to which the shape of the distributions of elliptic flow change with the energy in the reference frame of one of the incoming nuclei.

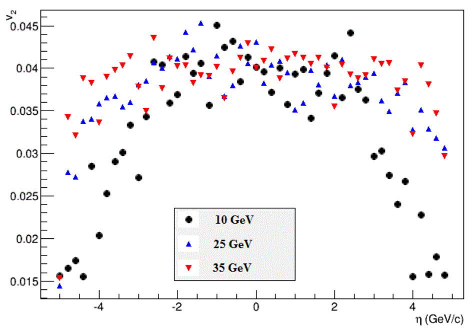

Fig 4: Elliptic flow as a function of pseudorapiduty at different FAIR energies of 10 A GeV, 25 A GeV, and 35 A GeV from the string melting version of the AMPT model.

All three energies in Figure 4 show a non-boost invariant, roughly triangular shape peaking at midrapidity. Moreover, one can see a steep rise in flow at low η and decrease at high η, which is very significant. Also at the lower energies the flow seems to level off (and may even rise) at high | η |.

This might be due to pronounced directed flow in these regions at the lower energies or an effect due to the presence of participant nucleons. At higher energies, the participants are pushed further out in | η | and the directed flow is smaller.

Summary

In summary the results have shown that there is a clear mass ordering effect in the elliptic flow and the energy independence of elliptic flow over pseudorapidity η throught out the region. It is difficult to reconcile this fact with the common assumption that the particle production at midrapidity differs from that in the fragmentation region, particularly at the higher energies.

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