Differential elliptic flow of charged hadrons at FAIR SIS100

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Introduction

In relativistic heavy ion collision, elliptic flow (v_2) of identified hadrons has been studied intensively to look for thermalization of the produced medium. For non-central collisions, the azimuthal anisotropy of the transverse momentum (p_T) distribution is believed to be sensitive to the early evolution of the fireball. The second fourier coefficient of this anisotropy is the elliptic flow (v_2) defined as,

$$v_2 =< \cos[2(\phi - \Psi)] >= \left\langle \frac{{P_x}^2 - {P_y}^2}{P_T^2} \right\rangle$$

where, ϕ & Ψ denote azimuthal angle of the particle & reaction plane angle respectively. Elliptic flow is sensitive to the rescattering of the constituents of the fireball, that converts the initial spatial anisotropy into the momentum anisotropy. In the present article, we have estimated differential elliptic flow ($v_2(p_T)$) of charged hadrons for the mid-central ($b = 5-9$ fm) Au-Au collisions at 10 A GeV beam energy, in the midrapidity region (-1 $\leqslant y_{c.m.} \leqslant$ 1). These results will be useful as soon as we have data from FAIR SIS-100 accelerator [1]. Simulations are carried out employing different variants of the UrQMD [2][3] model namely the pure transport (cascade) mode and hybrid mode [4]. In the hybrid mode, transport calculations are coupled with the ideal hydrodynamical evolution. Within the hydrodynamic scenario, two different equation of states (EoS) viz. hadron resonance gas and chiral + deconfinement EoS have been employed separately to mimic hadronic and partonic scenarios respectively.

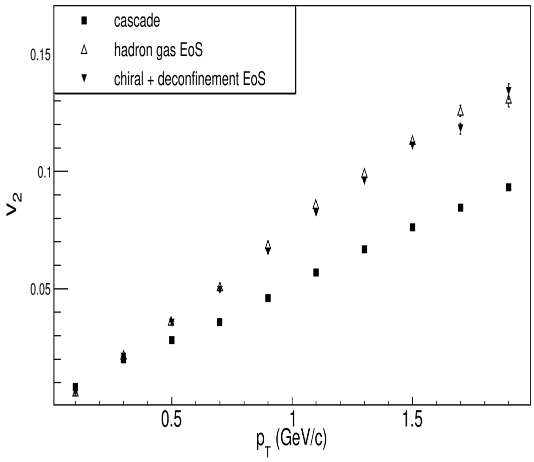

FIG. 1: *Differential elliptic flow $v_2(p_T)$ of charged hadrons using UrQMD model in cascade mode & hadro mode using hadron gas and chiral + deconfinement EoS.*

Results & Discussion

For all the three cases studied here, we have observed the approximately linear rise in elliptic flow v_2 with p_T. However the magnitude of v_2 is sensitive to the underlying evolution dynamics. v_2 is increased by 10% in hydrodynamic scenario compared to the pure transport scenario. However the difference in v_2 is much smaller for two different EOS. When we look at identified v_2, at low p_T (p_T < 1 GeV/c), the particles exhibit mass ordering in all the three cases as expected from the hydrodynamical calculations [5]. However the de-

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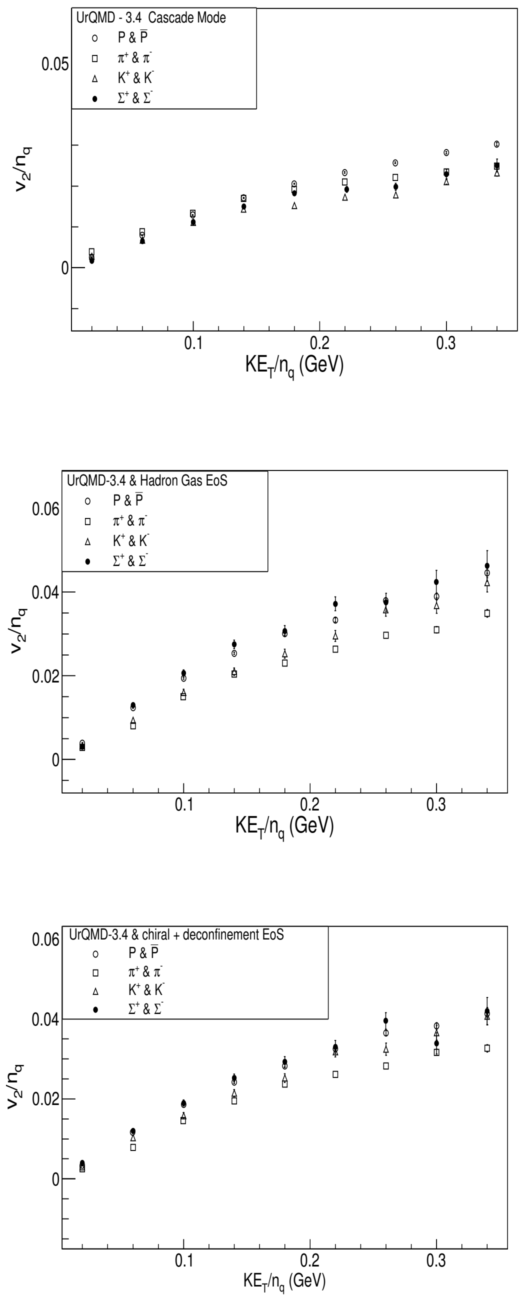

FIG. 2: *NCQ scaling of v_2 with KE_T using UrQMD model in cascade mode (top panel) and hybrid mode using hadron gas (intermediate panel) and chiral + deconfinement EoS (bottom panel).*

gree of ordering is sensitive to the underlying collision dynamics. In the cascade mode, protons and pions show mass ordering up to $p_T <$ 1 GeV/c and inverse mass ordering for $p_T > 1$ GeV/c. Also in hybrid mode with hadron gas equation of state, we have seen that mesons (pions and kaons) show mass ordering up to $p_T < 1$ GeV/c and inverse mass ordering for $p_T > 1$ GeV/c. But if we compare the chiral + deconfinement EoS and hadron gas EoS then the former one mimics an equilibrated partonic medium and it does not show any inverse mass ordering at $p_T > 1$ GeV/c.

Next we have studied the effect of constituent quark number scaling (NCQ) of v_2 with respect to the scaled transverse kinetic energy ($KE_T = m_T$ - m). KE_T is considered as a very important scaling variable because it takes care of the relativistic effects, which are important for the lighter particles and also the pressure gradient which generates v_2 is related to the kinetic energy of particles. In Fig.2, we have shown the variation of v_2/n_q with KE_T/n_q, where n_q denotes numer of constituent hadrons. It is quite evident that v_2 shows good scaling with KE_T/n_q at low p_T range in all three scenarios and thus makes this observable insensitive to the onset of partonic collectivity. Such a scaling behavior is a natural outcome of the mass ordering, in a boosted thermal model. The results obtained here are in line with the previous observations performed at FAIR SIS-300 energies [6].

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