Azimuthal anisotropy of identified hadrons in Au+Au collisions at E_{lab} = 35 A GeV using the PHSD model

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Introduction

At high temperatures and densities, lattice quantum chromodynamics (lQCD) predicts a transition from normal nuclear matter to a deconfined state of quarks and gluons known as the quark-gluon plasma (QGP) [1]. These conditions can be recreated in the laboratory by colliding heavy-ions at relativistic energies. The primary objective of the heavy-ion collision experiments is to understand the properties of the QGP matter. An important observable for investigating the properties of the matter produced in these collisions is azimuthal anisotropy. It describes the momentum space anisotropy of the produced particles, which is predicted to be produced by the pressure gradient formed during the initial stages of collisions. The resulting anisotropy is defined by the Fourier coefficients according to

$$v_n = \langle \cos[n(\phi - \psi_n)] \rangle, \quad (1)$$

where ϕ is the particle's azimuthal angle, n is the flow harmonic order, and ψ_n is the reaction plane angle. The azimuthal momentum space anisotropy of particle emission relative to the second harmonic reaciton plane is measured by the v_2 known as elliptic flow [2]. The identified hadrons anisotropic flow offers important information on the particle production mechanism. One finding is that when the identified hadrons v_2 is divided by the number of constituent quarks n_q and plotted against $(m_T - m_0)/n_q$, it follows a universal curve. This scaling is known as number of constituent quark (NCQ) scaling. The NCQ scaling of v_2 suggests the formation of partonic medium, where quarks and gluons are the effective degrees of freedom.

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PHSD model

Parton Hadron String Dynamics (PHSD) is a microscopic off-shell transport approach that describes the strongly interacting partonic and hadronic matter in and out-of equilibrium. It provides a dynamical description of the process of hadronization from partonic to hadronic matter. The partonic dynamics are based on the Dynamical Quasiparticle Model, whereas the hadronic part is substantially identical to the conventional Hadron String Dynamics (HSD) approach [3].

Analysis details

We have analyzed ∼20 million minimum bias events for Au+Au collisions at E_{lab} = 35 A GeV from the PHSD model. Measurements are made in the central rapidity region ($|y| < 1.0$) and different centrality intervals, which cover central to peripheral collisions. The elliptic flow (v_2), is estimated with the η-Sub event method with a pseudorapidity gap of $\Delta\eta = 0.1$.

We present transverse momentum (p_T) dependence of v_2 of identified hadrons ($\pi^{\pm}$, $K^{\pm}$ p, and $\bar{p}$) in different centrality classes for Au+Au collisions at E_{lab} = 35 A GeV. We also show the NCQ scaling of the measured v_2 as a function of the transverse kinetic energy ($m_T - m_0$).

Results and discussion

Figure 1 shows the p_T dependence of v_2 for identified hadrons ($\pi^{\pm}$, $K^{\pm}$ p, and $\bar{p}$) for minimum bias (0–80%) Au+Au collisions at E_{lab} = 35 A GeV. The v_2 increases monotonically with p_T for all the hadrons. $v_2(p_T)$ values

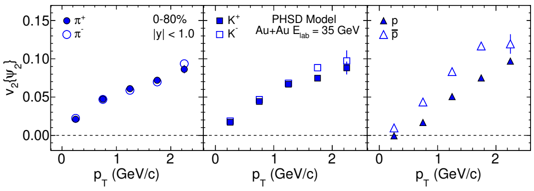

FIG. 1: v_2 vs p_T of identified hadrons for 0–80% Au+Au collisions at E_{lab} = 35 A GeV using the PHSD model.

of pions, kaons and their antiparticles show similar magnitude. We observed a difference in v_2 values between protons and antiprotons, which might be the effect of baryon stopping at low energies.

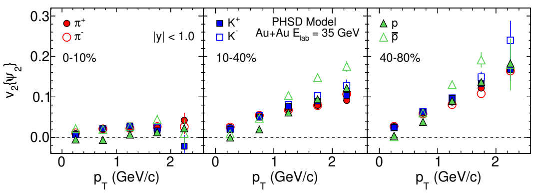

FIG. 2: v_2 vs p_T of identified hadrons ($\pi^{\pm}$, $K^{\pm}$ p, and $\bar{p}$) for 0–10%, 10–40%, and 40–80% central Au+Au collisions at E_{lab} = 35 A GeV using the PHSD model.

Figure 2 shows the centrality dependence of identified hadrons ($\pi^{\pm}$, $K^{\pm}$ p, and $\bar{p}$) $v_2(p_T)$ in Au+Au collisions at E_{lab} = 35 A GeV. We observed a centrality dependence of v_2 of identified hadrons at mid-rapidity. The values of v_2 are lower for central collisions (0–10%) compared to peripheral collisions (40–80%).

Figure 3 shows v_2 scaled by number of constituent quarks (n_q) as a function of $(m_T - m_0)/n_q$ for 0–80% and 10–40% central Au+Au collisions. We observed NCQ scaling of identified hadrons in Au+Au collisions at E_{lab} = 35 A GeV within the statistical uncertanities. v_2 of baryons and mesons when divided by their constituent quarks follow a universal curve. We observed a deviation of NCQ scaling between protons and anti-protons because the NCQ scaling transformation of v_2 does not alter the relative separation between protons and anti-protons at low energies such as Au+Au collisions at E_{lab} = 35 A GeV.

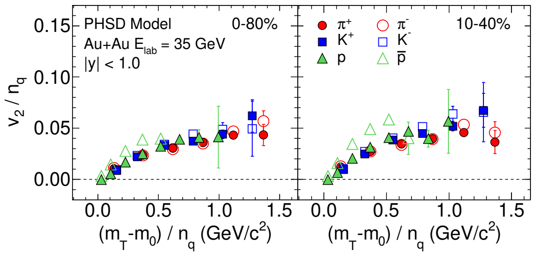

FIG. 3: The Number of Constituent Quark (NCQ) scaled elliptic flow, v_2/n_q versus $(m_T - m_0)/n_q$, for 0–80% (left) and 10–40% (right) central Au+Au collisions for identified hadrons ($\pi^{\pm}$, $K^{\pm}$, p, and $\bar{p}$) at E_{lab} = 35 A GeV using the PHSD model.

Summary

We presented elliptic flow of identified hadrons ($\pi^{\pm}$, $K^{\pm}$ p, and $\bar{p}$) as a function of transverse momnetum at mid-rapidity in Au+Au collisions at E_{lab} = 35 A GeV using the PHSD model. We observed a clear centrality dependence of $v_2(p_T)$. We observed the NCQ scaling of identified hadrons v_2 in these collisions. There is a hint of deviation from the universal scaling particularly for protons which could be due to the baryon stopping at lower energies.

References

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