Study of mass ordering of v_2^{hadron} from hadronic interactions in AMPT in p-Pb collisions at LHC energy

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Introduction

The results obtained from relativistic heavy ion programme in RHIC and LHC have provided strong evidences of the formation of the Quark-Gluon plasma at such ultra-relativistic energies. A large azimuthal anisotropy in the momentum space (described by second order fourier coefficient (v_2)) has been regarded as one of the most definitive and strong indication of such collective behaviour and argued to be a consequence of collective expansion of the system that starts with an initial azimuthal anisotropy in the coordinate space. The two-particle and multi-particle correlation measurements in p-Pb [1, 2] and d-Au [3] collisions at the LHC and RHIC energies, respectively, have shown unexpected collective behaviours qualitatively indicating towards collective dynamics in small collision systems where small size in the overlap geometry may not be suitable for hydrodynamical treatment that demands an early thermalization.

Microscopic transport models (e.g. AMPT) are shown to have generated similar effects in small collision systems through in-coherent parton scattering with nominal scattering cross-section [4]. The system evolving in the transport models are relatively less dense [5] compared to the evolution of the system near hydro limit, where large number of collisions among the constituents generate the pressure gradient and the hydro like collectivity. In [5] it has been shown that the anisotropic escape mechanism of partons is the dominant source of flow (v_2) generation in AMPT. Recent studies [6] also suggest that the mass-splitting of v_2^{hadron} in AMPT is not of hydrodynamical origin rather, it is generated beacause of the combined effect of coalescence dynamics and the hadronic rescattering [6].

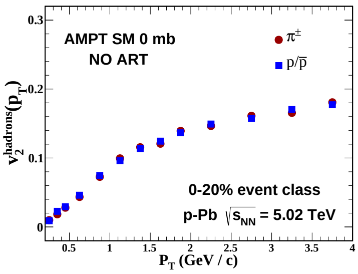

FIG. 1: (colour online) $v_2(p_T)$ of $\pi^{\pm}$ *and* $p/\bar{p}$ in 0-20% multiplicity class of p-Pb collisions at 5.02 TeV without partonic and hadronic scattering.

Here we have shown that in the string melting version of AMPT, the mass-ordering of v_2^{hadron}, once regarded as a characteristic signature of hydrodynamics, can be generated from the hadronic scattering alone without requiring any contribution from the interactions at the partonic phase.

A Multiphase Transport Model

In the string melting (SM) version of the AMPT model which is used in the present study, minijet partons and soft strings produced from HIJING model are converted into quark and antiquarks. Then, their evolution in time and space is modeled by the ZPC parton casade model with scattering cross section

$$\sigma_p \simeq 9\pi\alpha_s^2/2\mu^2 \quad (1)$$

The notations have their usual meanings. Eventually the quarks and anti-quarks are converted to hadrons using a spatial coalescence model. The subsequent evolution in the

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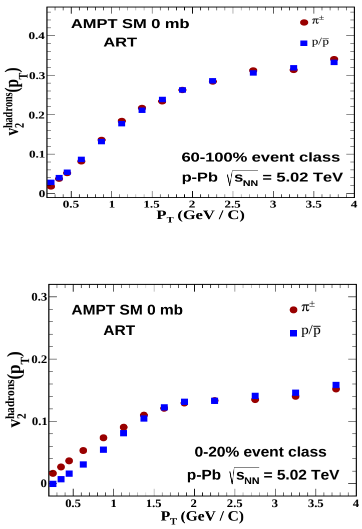

FIG. 2: (colour online) $v_2(p_T)$ of $\pi^{\pm}$ *and* $p/\bar{p}$ in 60-100% (**top**) and, 0-20%(**bottom**) multiplicity classes of p-Pb collisions at 5.02 TeV with hadronic scattering on.

hadronic stage is modelled by A Relativistic Transport (ART) model. The detailed description of the AMPT model can be found in [5].
For this study, we have used the string melting version of AMPT with partonic scattering cross-section of 0 mb (switching off parton cascade) and with hadronic cascade on and off.

v_2 extraction

The anisotropy in the azimuthal distribution has been calculated using 2-particle Q-Cumulant method [8] as a function of p_t. To suppress non-flow contributions a pseudo-rapidity (η) gap is introduced between the particles. In this process, each event is divided into two sub-events with a minimum separation of 0.4 unit in η.

Results and Discussion

The entire sample is analyzed by dividing into four multiplicity classes based on the total amount of charged particles produced (with p_T >0.05 GeV/c) within $2.8 < \eta < 5.1$. This corresponds to the acceptance range of the ALICE VZERO-A detector in the Pb going direction for p-Pb collisions and used for the multiplicity class determination by the ALICE collaboration [7]. The $v_2^{hadron}(p_T)$ calculated from SM version of AMPT without partonic and hadronic interactions is shown in Fig 1. It shows that without partonic and hadronic interactions, the dynamics of coalescence alone can not generate the mass ordering of v_2. To study the effect of hadronic scattering, we repeat the analysis with hadronic scattering (ART) only. In the lowest multiplicity (60-100%) class, no mass splitting of v_2 is observed as shown in Fig 2(**top**). But, in the highest multiplicity class (0-20%), as shown in Fig 2(**bottom**), a clear mass splitting is observed at lower p_T - indicating that with the increase in hadronic density contribution from hadronic interactions towards mass splitting increases significantly, which may play a major role in case of heavy ions. This measurement is in agreement with the observations made in [8] using URQMD model. Our study suggests that mass ordering of v_2 can be generated from hadronic scattering alone, without requiring contributions from the partonic phase. Therefore, mass splitting of v_2 is not uniquely associated with the hydrodynamical evolution of the partonic phase (QGP), produced in high energy collisions.

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