Identified particle production in Xe-Xe collision systems at $\sqrt{s_{NN}}$ = 5.44 TeV using HYDJET++ model

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I. INTRODUCTION

In the past few years or so, RHIC (Relativistic Heavy-Ion Collider) and LHC (Large Hadron Collider) experimental programs have explored anisotropic flow [1] and its associated fluctuations [2, 3] miraculously to a remarkable degree of precision [4]. Anisotropic flow, an important signature of Quark Gluon Plasma (QGP), comes from the initial asymmetries in the geometry of the system produced in any non-central collision. It plays a significant role in the understanding of the collective motion and the bulk properties of the QGP. Our goal is to study the higher fourier harmonics in Xe-Xe collision systems under the monte carlo HYDJET++ model.

Recently, a study was performed on Xe-Xe collisions at $\sqrt{s_{NN}}$=5.44 TeV under the framework of Monte Carlo HYDJET++ model [5], where the results were presented in two different, body-body and tip-tip geometrical configurations. In this paper, we aim to study much higher azimuthal anisotropic fourier harmonics $v_n (n > 3)$ in Xe-Xe collision systems at 5.44 TeV. Further, we will investigate these higher order fourier coefficients with respect to transverse momentum.

II. MODEL FORMALISM

HYDJET++ (HYDrodynamics plus JETs) is a Monte Carlo event generator with the aim of simulating relativistic heavy-ion collisions. The HYDJET++ model works by superimposing the soft hydro type state and the hard state (which results from the multiparton fragmentation) and simulataneously treating both the states independently. It gives an exhaustive approach to the soft hadroproduction (collective flow effects and resonance decays) and also to the hard parton production along with the known medium effects (jet quenching, nuclear shadowing, etc.). The in-depth details of the model and the procedure of simulation can be found in the corresponding articles [6, 7] and the references there within.

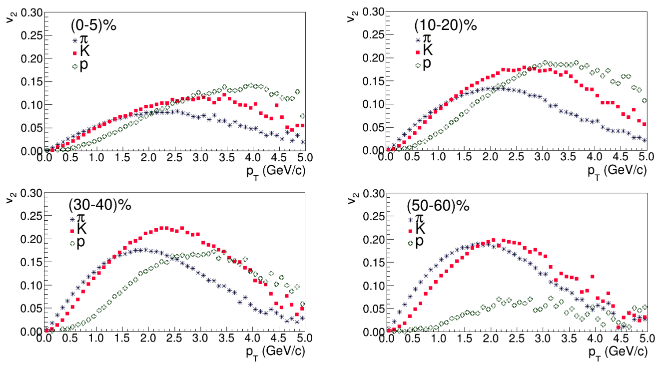

FIG. 1: Transverse momentum dependence of v_2 for identified charged particles in different centrality windows.

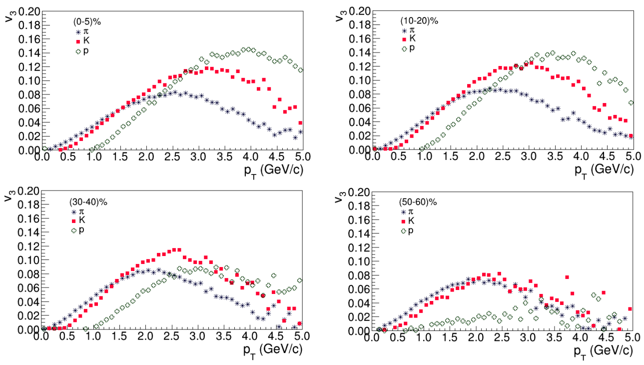

FIG. 2: Transverse momentum dependence of v_3 for identified charged particles in different centrality windows.

The hard state of HYDJET++ event is treated using PYQUEN (PYthia QUENched) model which repairs a jet event which PYTHIA produces by generating binary nucleonic collision vertices according to Glauber model at a certain impact parameter. PYTHIA is an event generator used to simulate hard NN collision with the consideration of only those events whose generated total transverse momentum is higher than p_T^{min}, the remaining having $p_T < p_T^{min}$ are contributed to the soft state. The soft part of HYDJET++ event is the thermal hadronic state generated on the chemical and thermal freezeout hypersurfaces obtaining from a parameterization of relativistic hydrodynamics with preset freezeout conditions. The main assumption of this model is that the hadronic matter created in a nuclear collision reaches a local equilibrium after a short period of time (<1fm/c) and then expands hydrodynamically. HYDJET++ has no evolution stage, as a result, cannot trace for instance, the propagation of energy and density fluctuations of the initial state. So, it only handles the final components of the anisotropic flow.

An important part of our study under the framework of HYDJET++ model is the incorporation of the intrinsic

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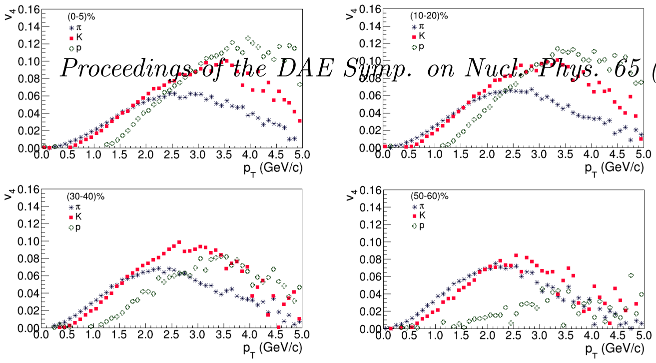

FIG. 3: Transverse momentum dependence of v_4 for identified charged particles in different centrality windows.

deformation in Xe nucleus. This has been already done in [5], where the study was performed in both tip-tip and body-body geometrical configurations making the modified HYDJET++ model work at both RHIC as well as LHC energies. Deformed Woods-Saxon Nuclear density profile function in spherical polar coordinates is expressed as:-

$$\rho(r, z, \theta) = \frac{\rho_0}{1 + \exp\frac{(r - R(1+\beta_2 Y_{20} + \beta_4 Y_{40}))}{a}} \quad (1)$$

where, $\rho_0 = \rho_0^{const}$ + correction, $\rho_0^{const} = \frac{M}{V} = \frac{3A}{4\pi R_A^3} = \frac{3A}{4\pi R_l^3}$,
$R_A = R(1 + \beta_2 Y_{20} + \beta_4 Y_{40})$,
$R_l = R_0(1 + \beta_2 Y_{20} + \beta_4 Y_{40})$,
$R = R_0 A^{1/3}$, where $R_0 = 1.15 fm$,

The correction term is calculated as= $\rho_0^{const} \times (\pi f / R_A)^2$, where f= 0.54fm ,
β_2 =0.162 and β_4 =-0.003
are the deformation parameters,
a=diffuseness parameter= 0.59fm,
$Y_{20} = \sqrt{\frac{5}{16\pi}}(3\cos 2\theta - 1)$, and
$Y_{40} = \frac{3}{16\sqrt{\pi}}(35\cos 4\theta - 30\cos 2\theta + 3)$
are the spherical harmonics. The values of different parameters have been taken from the reference [8].

We have implemented higher fourier harmonics in HYDJET++. Anisotropic flow of identified particles is studied for v_2, v_3 and v_4. Anisotropic flow shows a strong transverse momentum dependence. At a particular centrality, mass ordering is observed. Lower mass particles are produced more at low p_T ($p_T \leq 1.5$), $v_2^{\Pi} > v_2^{K} > v_2^{p}$. However, the order reverses at high p_T ($p_T \geq 1.5$), $v_2^{\Pi} < v_2^{K} < v_2^{p}$. This can be seen in figures 1-3. The reason for this might be the production of high-p_T jets caused by fragmentation mechanism. The fourier harmonics are dependent on centrality of collision as concluded from the figures, $v_2 > v_3 > v_4$. Much higher fourier harmonics ($v_2 > 4$) can be also calculated which is our next target. However, due to lack of experimental evidences, we can only make predictions in this context.

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