Study of $U + U$ collisions at $\sqrt{s_{NN}} = 193$ GeV using HYDJET++

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Introduction

Multi-particle production in relativistic heavy ion collision experiments may provide information about the properties and the dynamical behaviour of QCD matter. Fast and realistic Monte-Carlo (MC) event generators are needed to satisfy the existing experimental data and to predict the particle distributions with various collision control parameters for future experiments. A realistic MC event generator should include hadron production from both soft as well as hard interactions of partons. HYDJET++ is actually that type of fast MC event generator which includes both these physical processes and incorporates most of the dynamical effects during evolution of the QCD medium. The HYDJET++ model incorporates PYTHIA type initial conditions for hard particle production from jet fragmentation and Glauber like initial conditions for soft particle production using thermal processes. In this article, we study the $U + U$ collisions at $\sqrt{s_{NN}} = 193$ GeV in body-body and tip-tip configurations by modifying HYDJET++ model. Further, we study the pseudorapidity density $(dn_{ch}/d\eta)$ distributions, normalized transverse momentum (p_T) distributions and the elliptic flow (v_2) of charged hadrons in body-body and tip-tip configurations of $U+U$ collisions.

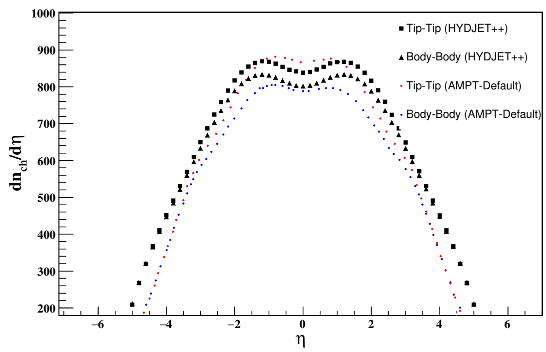

FIG. 1: $dn_{ch}/d\eta$ of charged hadrons produced in $U+U$ collisions with respect to η. AMPT results are taken from Ref. [3].

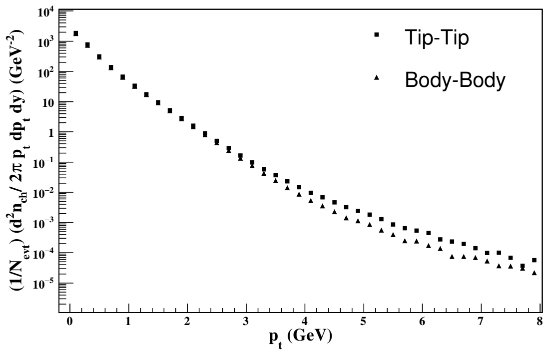

FIG. 2: Normalized p_T distribution of charged hadrons produced in $U+U$ collisions with p_T.

Model description

The hard component in HYDJET++ is generated using PYQUEN partonic energy loss model which creates initial parton spectra according to PYTHIA and jet production vertices at given impact parameter; radiative and collisional energy loss of partons traversing through their defined path in QCD medium. Lund string model provides final hadronization of hard partons and in-medium emitted gluons. The effect of nuclear shadowing on initial parton distribution function is incorporated via Glauber-Gribov theory.

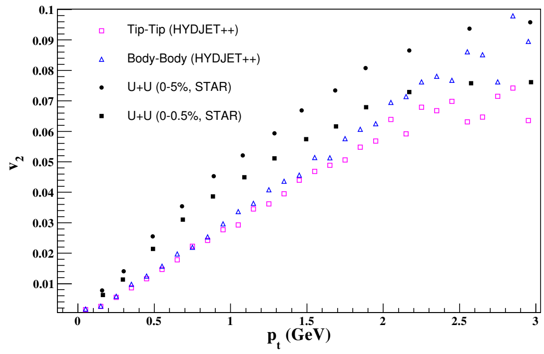

FIG. 3: Elliptic flow as a function of p_T for different initial configurations of $U+U$ collisions at $\sqrt{s_{NN}}$ = 193 GeV. Experimental data are taken from Refs. [4].

The main modification which we have done in the present version of HYDJET++ is, to change the nuclear density profile function. Since HYDJET++ deals in cylindrical coordinates (ρ, z, ψ) instead of polar coordinate system (r, θ, ϕ), one has to transform the deformed wood-saxon nuclear density profile function from polar to cylindrical cordinate system. In polar coordinates the deformed wood-saxon for uranium nucleus is defined as follows:

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

in which $Y_{20} = \sqrt{\frac{5}{16\pi}}(3\cos^2(\theta) - 1)$, $Y_{40} = \frac{3}{16\sqrt{\pi}}(35\cos^4(\theta) - 30\cos^2(\theta) + 3)$ are the spherical harmonics with the deformation parameters β_2=0.28 and β_4=0.093. In the conversion of nuclear density profile from polar to cylindrical, we find a relation $\theta = \tan^{-1}(r/z)$ and $\theta = \tan^{-1}(z/r)$ for tip-tip and body-body configuration of U + U collision, respectively.

The soft part of HYDJET++ is based on the thermal production of hadrons on a single freeze-out hypersurface which depends on the energy, configuration and centrality of the collision. This thermal method provides 4-momentum and spatial positions of hadrons in the rest frame of liquid element. HYDJET++ also includes the two and three body decays of resonances with branching ratios taken from SHARE particle decay table. Further, we use Bjorken's longitudinally boost invariant hydrodynamics to generate 4-velocity of liquid elements and their dynamical evolution with proper time (τ).

Results and Discussion

Fig. 1 shows the variation of $dn_{ch}/d\eta$ with η for most central (0-5%) events in $U+U$ collisions and also shows a comparison with AMPT model [3]. One can see a difference in midrapidity particle density between two configurations in both the models. AMPT results are higher in tip-tip configuration and lower in body-body configuration corresponding to HYDJET++ results. Fig. 2 demonstrates the normalized transverse momentum distribution of charged hadrons in both the configurations. In Fig. 3, we have shown a comparison of the elliptic flow (v_2) for both the configurations along with the experimental results of STAR [4] experiments. We found HYDJET++ results qualitatively matches with the experimental data. The results are obtained for 25000 events and are preliminary in nature which will be more accurate when we increase the statistics.

Acknowledgments

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