Transverse momentum spectra and Nuclear Modification factor in Xe-Xe collisions at 5.44 TeV under HYDJET++ framework

Saraswati Pandey[1], B. K. Singh[1]

[1]Department of Physics, Institute of Science Banaras Hindu University, Varanasi-221005, UP, India

Email: saraswati.pandey13@bhu.ac.in

ICHEP 2022 BOLOGNA

Abstract

Transverse momentum (p_T) spectra of charged hadrons at mid-pseudorapidity in deformed Xe-Xe collisions at 5.44 TeV under Monte Carlo HYDJET++ model (HYDrodynamics plus JETs) framework is reported. $0.15<p_T<50$ GeV/c and $|\eta|<0.8$ kinematic ranges are considered. The nuclear modification factor in Xe-Xe collisions is calculated for most central, semi-central, semi peripheral, and most peripheral collision centralities. Transverse momentum spectra and nuclear modification factor R AA show strong p_T, pseudorapidity density, and centrality dependence. Average transverse momentum $\langle p_T \rangle$ as a function of collision centrality is presented. The results have been compared with ALICE experimental data.

Physics Motivation

- The idea of colliding heavy ions at high relativistic energies comes from the motto to understand the properties of quantum chromodynamics(QCD), the theory of Strong Interactions at high temperatures and baryo-chemical potentials.
- The collision of two nuclei results into a system of deconfined quarks and gluons at very high temperatures and baryon densities called as Quark Gluon Plasma (QGP).
- Till recent times, spherical Au, Pb,etc. nuclei have been collided to study QGP. Recently, interests have shifted towards nuclei having some intrinsic deformation like Uranium, Xenon, etc.
- By colliding Xenon, the gap of final state multiplicity between large Pb ion systems and small p+p and p+Pb systems is bridged.
- In deformed collisions, charged particle multiplicity density in the transverse phase space is expected to be higher than the spherical nucleus collisions.
- Assuming energy loss of parton being linearly or quadratically related to only path length through QGP indicate an average reduction in energy loss of 17% or 31% respectively, in head-on Xe-Xe collisions compared to Pb-Pb collisions.

HYDJET++ Model Framework

The simulation model chosen for study must have the following features:-

- ➔can handle collision systems at both RHIC and LHC energies.
- ➔such model works well for spherical, deformed, symmetic and asymmetric collision systems.
- ➔models should be successful in producing experimental results both quantitatively as well as qualitatively.

HYDJET++ (HYDrodynamics plus JETs) Model

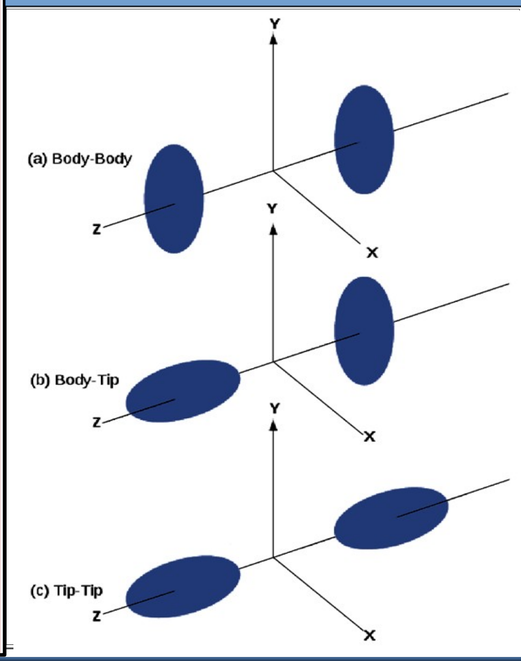
Soft part

- FASTMC statistical model in which particles are produced on thermal or chemical freeze-out hypersurfaces.
- A scenario with different chemical and thermal freeze-outs is implemented ($T_{ch} \geq T_{th}$).
- In between these two freeze-outs, the system is expected to expand hydrodynamically, followed by cooling and then the hadrons stream freely as thermal freeze-out temperature is reached.

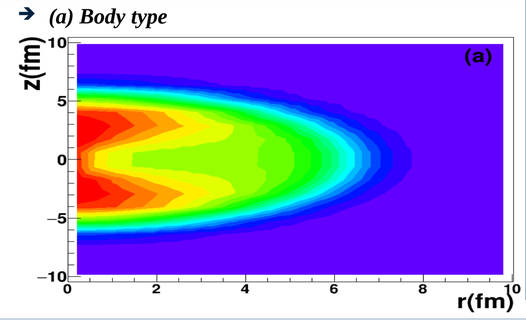
Hard part

- It incorporates PYQUEN model in which a jet actually produced by PYTHIA is modified.
- Event-by-event simulation procedure in PYQUEN.
- PYTHIA is used here for simulation of NN collisions, including only those events whose generated total transverse momentum is greater than p_T^{min} value.

Deformed Xenon geometrical configurations



➔ *(a) Body type*



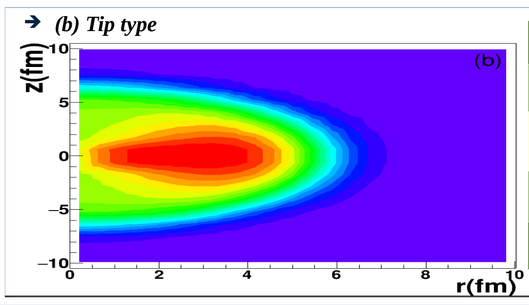
- The deformed Woods-Saxon nuclear density profile function for xenon nucleus in cylindrical polar coordinates is expressed as:-

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

where,

- $R=R_0A^{1/3}$, $R_0 = 1.15$ fm,
- β_2 and β_4 are the deformation parameters,
- Y_{20} and Y_{40} are the spherical harmonics.

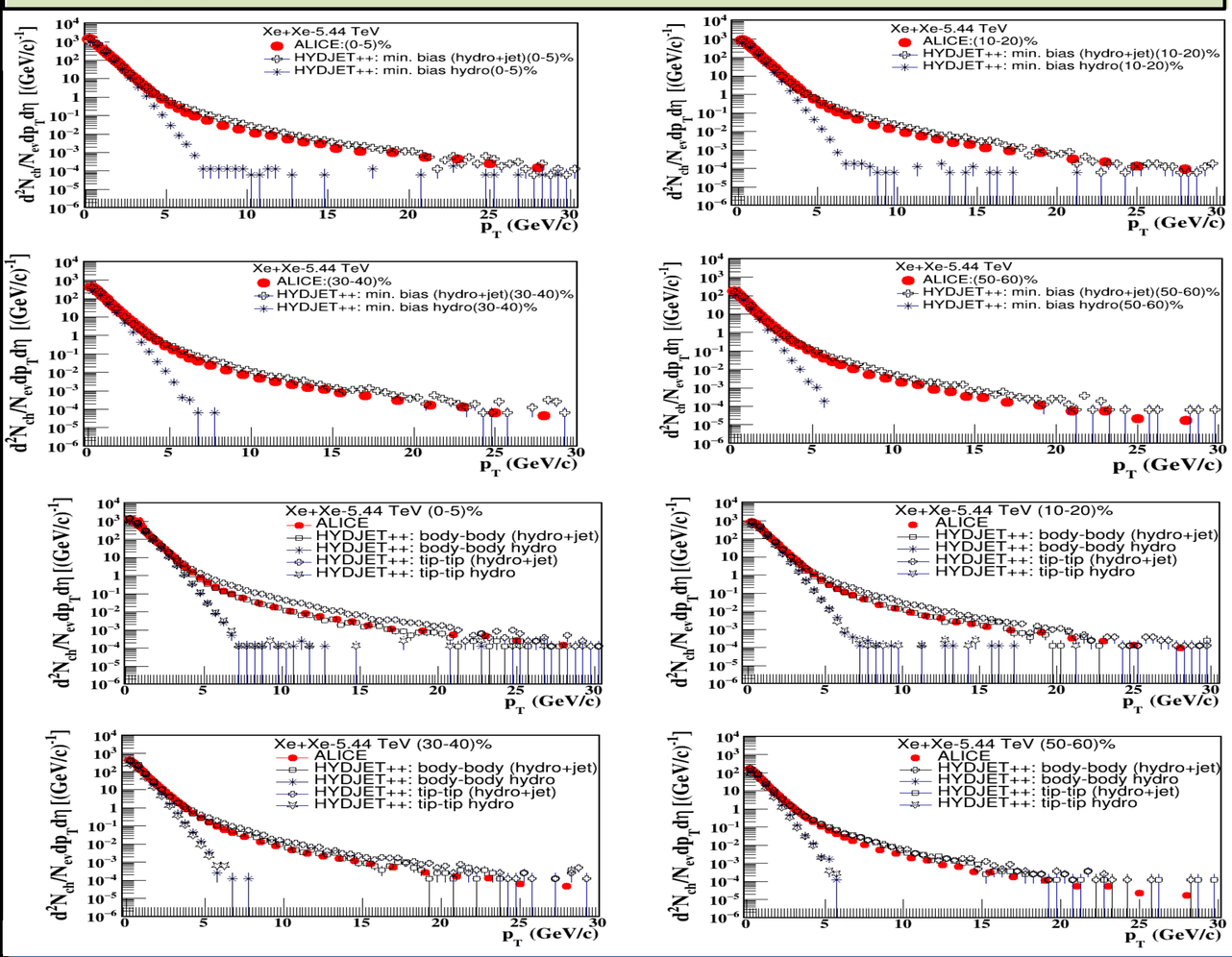
➔ *(b) Tip type*

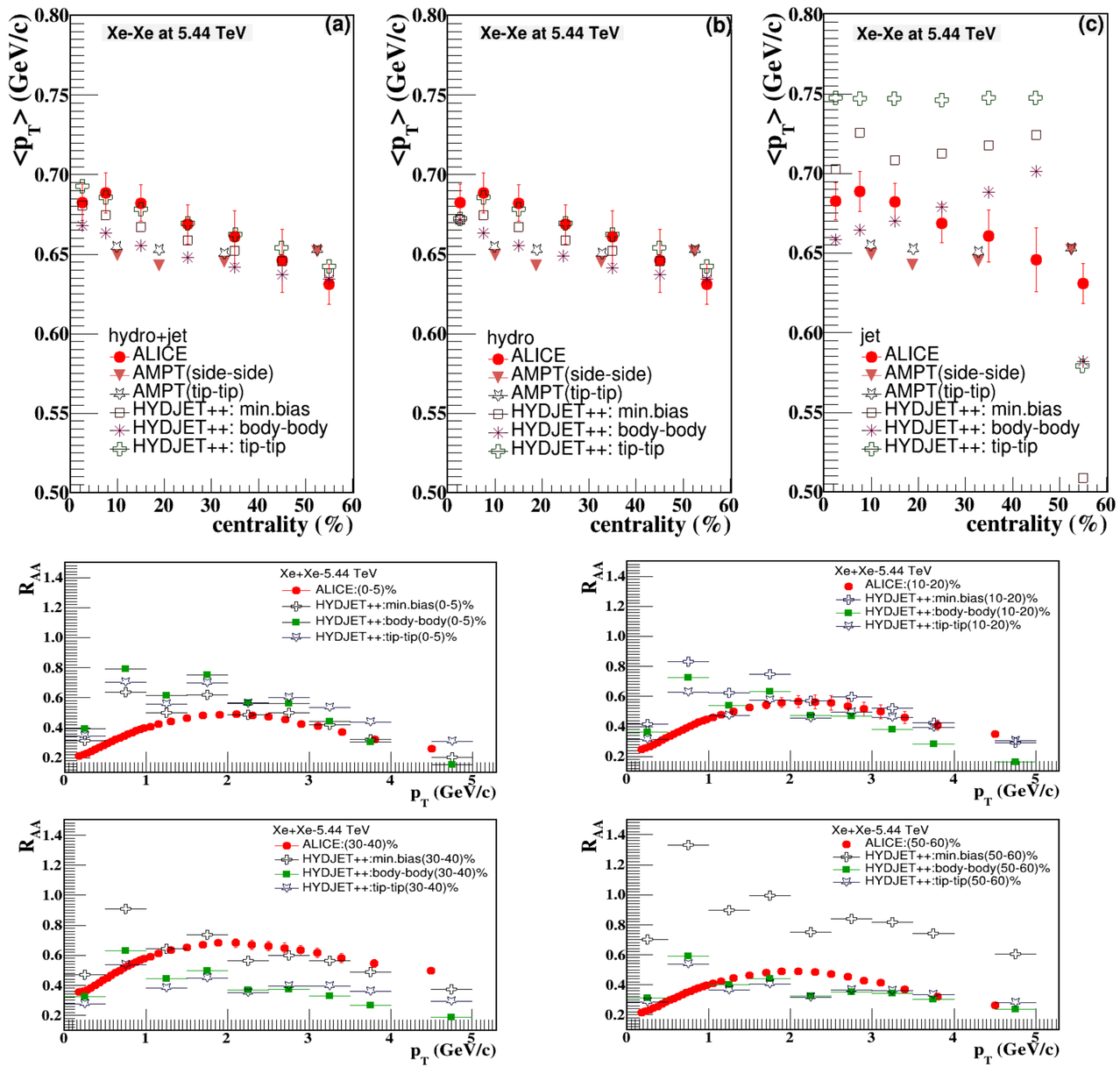


Parameters	Value
A	129
β_2	0.162
β_4	-0.003
a	0.59

Results and Discussion

- ✓Results for 10k events of Xe-Xe collisions at 5.44 TeV.
- ✓From most central (0-5)% collisions to most peripheral collisions (50-60)% of the system.
- ✓Effect of deformation.
- ✓Role of Jets to total p_T distribution.
- ✓Nuclear Modification factor through R_{AA}.
- ✓Centrality dependence of observables.





Conclusions

- ➔Minimum bias transverse momentum distribution of charged hadrons show suitable match with ALICE experimental yield from low to high p_T region.
- ➔Transverse momentum decreases as we move from most-central to most-peripheral collisions.
- ➔Yield for tip-tip collisions (higher fireball temperature) is higher than body-body collisions (relatively smaller fireball temperature).
- ➔The difference between body-body and tip-tip geometrical configurations arises only when hard parton scatterings are involved otherwise yield is same for them.
- ➔Average transverse momentum show strong dependence on collision centrality with and without jet part.
- ➔Average p_T for only jet part is somewhat centrality independent. This behaviour is well agreed with results from AMPT model in string-melting version.
- ➔Minimum bias R_{AA} of charged hadrons shows a suitable match with ALICE experiment, tip-tip R_{AA} being higher than body-body R_{AA} .
- ➔R_{AA} increases almost 2.2 times for body-body collisions while 1.7 times for tip-tip collisions as we move from most-central to most-peripheral class of collisions, showing a peak at around 2.0 GeV/c.

Acknowledgement

BKS sincerely acknowledges financial support from the Institutions of Eminence (IoE) BHU grant number-6031. SP acknowledges the financial support obtained from UGC under research fellowship scheme during the work.

References

[1] I. Lokhtin, L. Malinina, S. Petrushanko, A. Snigirev, I. Arsene, and K. Tywoniuk, Computer Physics Communications 180, 779 (2009), ISSN 0010-4655.

[2] S. Acharya, F.-. Acosta, D. Adamov, J. Adolfsson, M. Aggarwal, G. Aglieri Rinella, M. Agnello, N. Agrawal, Z. Ahammed, S. Ahn, et al., Physics Letters B 788, 166 (2019), ISSN 0370-2693.

[3] S. Pandey, S. K. Tiwari, and B. K. Singh, Phys. Rev. C 103, 014903 (2021), URL https://link.aps.org/doi/10.1103/PhysRevC.103.014903.