Entropy Evaluation in Simulated Pb-Pb Collisions at $\sqrt{s_{NN}}$ = 5.5 TeV

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Introduction

A large quantity of entropy is believed to be produced during the initial stages of relativistic nucleus-nucleus collisions[1,2] and the subsequent expansion is visualized to take place under constant entropy. It is worthmentioning that the linear rise in the multiplicity of produced particles with beam energy is consistent with the idea[3-5] that more than 80% of the specific entropy is produced during the initial stages of the collisions. In this scenario, the observable particle yields during the final stages of the collisions, are envisaged to be closely linked with the entropy production during the compression stage of the colliding nuclear matter. Entropy produced in high energy nuclear collisions shows a scaling behavior [6] and study of entropy production can give more insight into the underlying mechanism of multiparticle production in such collisions.

Entropy of produced particles may be easily calculated using their multiplicity distributions. If in a collision of two relativistic nuclei 'n' particles are produced then entropy, S, can be calculated using the expression:

$$S = -\sum_n P_n \ln P_n \quad (1)$$

where P_n is the probability of production of 'n' particles. A serious attempt has been made[7] to investigate evolution of entropy in multiparticle production in different high energy nuclear collisions. At RHIC(Relativistic Heavy Ion Collider) energy[8], entropy per unit rapidity has been determined for the central collisions at the freezout and with minimal model dependence using two-particle correlations. Interestingly, this is in fine agreement with the prediction of Lattice Gauge theory for thermalized quark-gluon plasma. Also, at LHC(Large Hadron Collider) energy the ALICE(A Large Ion Collider Experiment) Collaboration[9] has exhaustively investigated entropy evolution. Entropy has been observed to increase with projectile energy. Furthermore, the ratio of S to the maximum rapidity in the centre-of-mass frame, Y_m, is observed to exhibit a scaling behavior with $\Delta\eta/Y_m$.

In the present study, entropy, S, has been calculated for the production of all the charged particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5\,\text{TeV}$. Studying Pb-Pb collisions at this energy is the future goal of ALICE at LHC.

Details about the Data

For carrying out the present study a sample of 5000 minimum bias Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5\,\text{TeV}$ have been generated using HIJING Monte Carlo simulation code.

Results and Discussion

For addressing the main issue of entropy evolution, we first plot pseudorapidity(η) distribution of all the charged particles produced in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5\,\text{TeV}$ in Fig. 1. It may be of interest to note that the mean charged particle multiplicity, $\langle N_{ch}\rangle$, is found to be 7264.69±8.86.

Entropy is calculated using Eq. 1 for different η bins. From the available η-space($-8.5<\eta<8.5$) different η intervals, $|\Delta\eta|$=2,3,4,5......,16, are selected; these values are given in Table 1. Fig. 2 shows the variation of S/Y_m with $\Delta\eta/Y_m$. It is observed that S/Y_m first increases rapidly and then the rise becomes slow and finally there seems to be some tendency towards saturation in the value of S/Y_m with increasing $\Delta\eta/Y_m$. This trend, incidentally, agrees with those observed other workers[1-6].

Table 1: Values of entropy, S, for various $\Delta\eta$ intervals in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5\,\text{TeV}$.

$\Delta\eta$	S
2	0.0038±0.0008
3	0.0040±0.0005
4	0.0059±0.0007
5	0.0060±0.0007
6	0.0070±0.0007
7	0.0078±0.0007
8	0.0100±0.0012
9	0.0119±0.0014
10	0.1310±0.0016
11	0.0152±0.0019
12	0.0170±0.0021
13	0.0174±0.0021
14	0.0187±0.0021
15	0.0190±0.0023
16	0.0192±0.0023

Conclusions

Entropy is found to increase with increasing $\Delta\eta$ value. The ratio S/Y_m first increases with $\Delta\eta/Y_m$ and a tendency of saturation with further increase in $\Delta\eta/Y_m$ is discernible as envisaged. These results point towards occurrence of some novel dynamical phenomenon during hadronization of produced nuclear matter under extreme conditions of energy density in relativistic nuclear collisions. Conclusive confirmation regarding scaling of S/Y_m with $\Delta\eta/Y_m$ obviously requires that the analysis be carried out further by increasing the statistics manifolds. We wish to carry out a similar analysis for the experimental data on Pb-Pb collisions at various LHC energies ($\sqrt{s_{NN}} = 2.76\text{TeV},\ 5.5\,\text{TeV}$) and Monte Carlo simulated data generated after taking into account the detector parameters and imposing cuts for the central barrel of the ALICE detector.

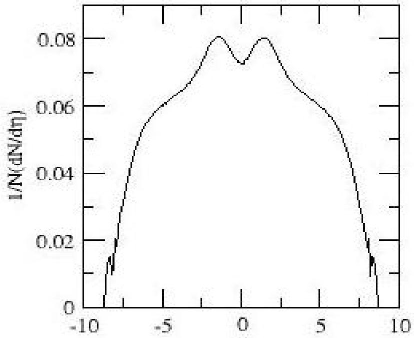

Fig.1 η distribution of all the charged particles produced in HIJING simulated PbPb collisions at center of mass energy of 5.5 TeV/nucleon pair.

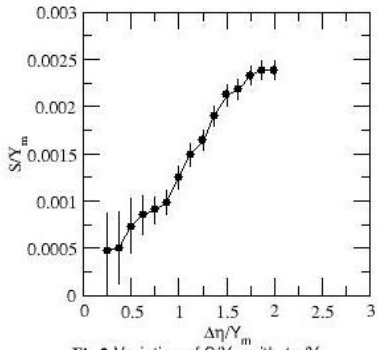

Fig.2 Variation of S/Y_m with $\Delta\eta/Y_m$

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