Intermittent production of particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

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Introduction

The phenomenon of intermittency, first introduced by Bialas and Peschanski [1, 2], helps understand the dynamics of multiparticle production in relativistic nuclear collisions. In high-energy heavy-ion collisions unusually large non-statistical fluctuations have been observed but the understanding of its origin is still unclear. Such fluctuations are considered a manifestation of occurrence of phase transition from normal nuclear matter to the deconfined state of matter, called quark-gluon plasma, predicted by QCD.

Fluctuations depend on the properties of the system and may carry significant information about the intervening medium created in the collisions.

Amongst the various methods proposed to study dynamical fluctuations, the method of scaled factorial moments, suggested by Bialas and Peschanski, is one of the most effective approaches to investigate non-statistical fluctuations in relativistic nuclear collisions.

The power-law increase of scaled factorial moments with decreasing rapidity bin width would indicate existence of intermittent fluctuations in particle spectra[3].

The main objective of the present analysis is to examine intermittency patterns using the simulated data.

The Data

A total of 1000 Pb - Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV were simulated using Monte Carlo model AMPT. Mean multiplicities of charged particles for each events and pseudorapidities of the particles were determined for carrying out the analysis.

Mathematical formalism

Intermittency patterns in multiparticle production can be studied in terms of factorial moments of multiplicity distributions in small rapidity intervals. In order to investigate this behavior, distribution of particles in a pseudorapidity range $\triangle\eta$ is considered. The interval $\triangle\eta$ can be divided into M bins of equal width, $\delta\eta = \triangle\eta/M$. Then, for a data sample containing events of varying multiplicities, the scaled factorial moment of order q is defined [1, 3] as:

$$< F_q >= \frac{1}{N_{evt}} \sum_{N_{evt}} \sum_{m=1}^{M} \frac{k_m(k_m-1)...(k_m-q+1)}{< N >^q} \qquad (1)$$

where $< N >$ is the mean multiplicity in the interval $\triangle\eta$, k_m is the number of charged particles in m^{th} bin in a single event, N_{evt} is the total number of events and q is a positive integer.

It was shown [1] that when only statistical fluctuations are present, $< F_q >$ is independent of $\delta\eta$, provided $\delta\eta$ must not be smaller than a typical range over which inclusive pseudorapidity distribution changes considerably. Moreover, non-statistical fluctuations lead to a power-law behavior of the moments[4–6] of the type:

$$< F_q >= (\triangle\eta/\delta\eta)^{\varphi_q} \qquad (2)$$

This power-law dependence of $< F_q >$ on $\delta\eta$ is referred to as intermittency. The slopes of $\ln < F_q >$ vs $-\ln\delta\eta$ plots, φ_q, represents strength of intermittency. The data were fit-

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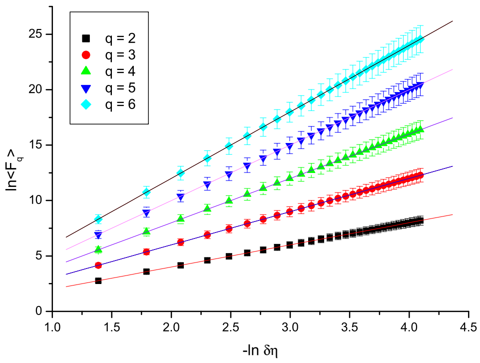

FIG. 1: Variations of $\ln < F_q >$ with $-\ln\,\delta\eta$ for q = 2 - 6. Solid lines represent linear fits to the data.

ted using the following expression[4]:

$$ln < F_q >= A - \varphi_q ln\delta\eta \quad (3)$$

where A is a constant. Eq.3 suggests a linear increase of $\ln < F_q >$ with $-\ln\delta\eta$ for smaller bin widths.

TABLE I: Values of the slopes,φ_q, for various orders of moments.

q	φ_q
2	2.00±0.06
3	3.00±0.09
4	3.99±0.12
5	4.98±0.15
6	5.96±0.18

Results and Discussion

The scaled factorial moments $< F_q >$ for q = 2 - 6 are calculated using Eq.1 for the given data. $\ln < F_q >$ vs $-\ln\delta\eta$ plots are displayed in Fig.1. A linear rise in $\ln < F_q >$ with decreasing pseudorapidity bin width is clearly observed indicating the presence of intermittency.
The values of φ_q for q = 2 - 6 are tabulated in Table I. It can be seen that the value of φ_q increases with increasing q which implies that intermittency effect gets stronger with increasing the order of moments.

Conclusions

The scaled factorial moments linearly increase with decreasing pseudorapidity bin width for all the orders of moments; indicating thereby existence of intermittent behavior.
Further, investigation of intermittency may provide important information regarding mechanism of multiparticle production in relativistic high-energy nuclear collisions.
Finally, it may be stressed that a clear understanding of the origin of intermittency requires study of some similar aspects involving larger sample of events.

References

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