Intermittency analysis of generated charged particles in central Pb-Pb collisions using EPOS3 model

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Introduction

One of the primary goals in investigating the collisions of heavy nuclei at relativistic energies is to understand the nature of phase-transition from hadronic matter to quark-gluon plasma and vice versa. The collision experiments give us an opportunity to test the predictions of QCD and also to comprehend other processes involved. A system in the state of QGP is expected to undergo quark-hadron phase transition with the expanding and cooling. Although, a number of signals have been proposed, but still a little is known.

The multiplicity fluctuations of hadrons produced in heavy-ion collisions can indicate a phase transition of QGP and hence, study of fluctuations can be used as a signal. The reason is that the fluctuations are substantial near the critical point for statistical systems. A lot of effort has been made in studying large-density fluctuations in hadronic and heavy-ion collisions, which might give us an insight into the phase-transition.

One of the most suitable methods to identify the existence of non-statistical fluctuations is the Normalized Factorial Moments(NFMs) [1]. This method has a scaling nature with diminishing phase-space domains, known as Intermittency, which is mainly an arrangement with the short-range correlations among the particles produced in the heavy ion collisions at high energies. Intermittency may be due to the self-similarity in the random cascading of elementary processes or it may be because of the self-similarity in nuclear collisions by the second-order phase transition from QGP to the hadronic state.

In the present work, intermittency in two dimensional phase-space of kinemetical variable pseudorapidity (η) and azimuthal angle (ϕ) of the events generated using EPOS3 [2] model for Pb-Pb collisons at $\sqrt{s_{NN}}$=2.76 TeV will be presented.

Methodology

The normalised factorial moments, F_q of order q, in its vertical form are defined as [1]:

$$F_q(M) = \langle \frac{1}{M} \sum_{m=1}^{M} \frac{f_q^{ev}(M)}{\langle N \rangle^q} \rangle \quad (1)$$

$\langle \ldots \rangle$ is for averaging over all events (N_{events}) with,

$$f_q^{ev}(M) = n_m(n_m - 1).....(n_m - q + 1) \quad (2)$$

where n_m is the number of charged particles in the m^{th} bin (m=1,2,3,...,M) and $\langle N \rangle$ is the mean multiplicity of hadrons in the pseudorapidity interval $\Delta\eta$ ($=\eta_{\max} - \eta_{\min}$), which in-turn is divided into M bins of equal width, $\delta\eta = \frac{\Delta\eta}{M}$.

It has been proved [1] that in case of statistical fluctuations, for a smooth pseudorapidity distribution, $\langle F_q \rangle$ is primarily independent of the bin width $\delta\eta$ in the limit $\delta\eta \longrightarrow 0$. In the limit of small bin size and when the fluctuations are dynamical in nature, the following proportionality holds:

$$\langle F_q \rangle \propto (M)^{\varphi_q}; \delta\eta \longrightarrow 0 \quad (3)$$

This power law behaviour is known as intermittency and φ_q, intermittency exponent measures the strength of fluctuations.

It is observed [5] that for the second-order phase transition, the power law behaviour is:

$$F_q \propto F_2^{\beta_q} \quad (4)$$

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where

$$\beta_q = (q-1)^\nu, \nu = 1.304 \quad (5)$$

ν (the scaling exponent) is significant in a way that it can be used to characterize scaling properties of multiparticle production. It is also independent of the details of the system,i.e., it is universal.

After observing the power law and self-similarity, the analysis in terms of fractal parameters [3] is crucial. The strength of intermittency effect is related to generalized dimensions by :

$$D_q = 1 - \frac{\varphi_q}{(q-1)} \quad (6)$$

$$or\ D_q = 1 - d_q, d_q = \frac{\varphi_q}{q-1} \quad (7)$$

where d_q are the anamolous fractal dimensions of fractals and multifractals in terms of intermittency exponents, φ_q

Although, data has been interpreted in terms of anamolous dimensions, the relationship between intermittency and fractality or multifractality is still vague. *Bialas* and *Hwa* [4] suggested that if a second-order phase transition takes place from QGP to a hadron phase in the thermodynamic equilibrium, then the produced particles will show intermittency with d_q independent of q.

Observations

EPOS3 events are studied for the intermittency and the dependence of power-law slopes will be investiged. Variation of the Anomalous fractal dimensions (d_q), Generalised fractal dimensions (D_q) and their variations with q will also be presented.

Summary

Charged particle multiplicity distributions for Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV using EPOS3 model are studied for their local multiplicity fluctuations. ν the scaling index value obtained for the model is the characteristic of the generator.

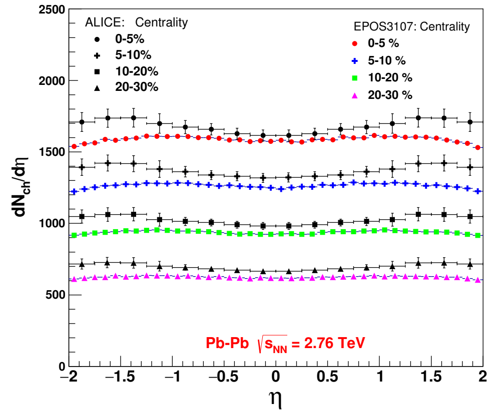

FIG. 1: Pseudorapidity distribution of the EPOS3 event sample compared with ATLAS data for Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76 TeV$.

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References

[1] A. Bialas and R. Peschanski, Nucl. Phys. B **273**, 703 (1986); B **308**, 867 (1988).
[2] T. Pierog, I. Karpenko, J.M. Katzy, E. Yatsenko, and K. Werner, Phys. Rev. C 92 (2015) 034906
[3] P Lipa and Buschbeck, Phys. Lett. B **223**,465 (1989);
[4] A. Bialas and R.C. Hwa, Phys. Lett. B **253**,436 (1991);
[5] R.C. Hwa and M.T. Nazirov, Phys. Rev. Lett. **69**,741 (1992);