Charged particle fluctuations using factorial moments at LHC energies

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Introduction

Phase transition and critical point is a subject of great importance in many fields, however in the field of heavy ion collisions, we are still unaware about the nature of the quark-hadron phase transition and vice-versa. Phase transitions (PT) are usually possible only in systems with interactions among its constituents and it is well known that the behavior of the system near a phase transition point shows critical phenomena and exhibit fluctuations due to tension between ordered (collective) and the disordered (thermal) dynamics.

One of the measures to learn about the dynamics of heavy ion collisions is to study scaling properties of multiplicity fluctuations over wide range of bin sizes by studying the spatial patterns in the events. One may look for clustering of produced particles of various sizes. Bialas and Peschanski suggested [1], scaled factorial moments of the multiplicity distributions in smaller and smaller phase space bins to successfully explain the observations of high multiplicity spike in JACEE [2] event. Beauty of scaled factorial moments is that it filter out statistical component. The power law behavior of factorial moments of particle density fluctuations with decreasing rapidity bin width termed as intermittency, was suggested as a signal of QGP formation [3]. The idea of intermittency for the multiparticle production in the high energy collisions gained considerable attention during 1990's to understand the physics of multiparticle production at various energies [4].

As an improvement over the conventional intermittency analysis Hwa and Yang [5] proposed to study the event factorial moments in two dimensional (η, ϕ) phase space instead of conventional scaled factorial moments, to investigate the quark-hadron phase transiton at present accelerator energies. Event factorial moments of multiplicity distributions have been suggested to be measured as means to investigate the local multiplicity fluctuations. High multiplicity events available at present collider energies make it feasible to explore the potential of this methodology to characterize the dynamics of the system created in heavy ion collisions. Thus in [5] it is urged to determine the numerical value of scaling exponent.

Here we analyse charged particle multiplicity distributions in the 2D (η, ϕ) phase space for the events generated using AMPT model at LHC energies and compare the scaling properties for different kinematic cuts.

Methodology

For an e^{th} event, the horizontal factorial moment is defined as

$$F_q^e(M) = \frac{f_q^e(M)}{[f_1^e(M)]^q}, \quad (1)$$

where q is the order of moment ≥ 2 and M is the number of bins. In Eq. (1)

$$f_q^e(M) = \langle n_m(n_m-1).....(n_m-q+1)\rangle_h, \quad (2)$$

Then vertically averaged horizontal factorial moments is,

$$F_q(M) = \langle F_q^e(M)\rangle_v \quad (3)$$

$\langle ....\rangle$ is averaging over whole event sample.
If F_q has power law dependence on M as,

$$F_q(M) \propto M^{\varphi_q}, \quad (4)$$

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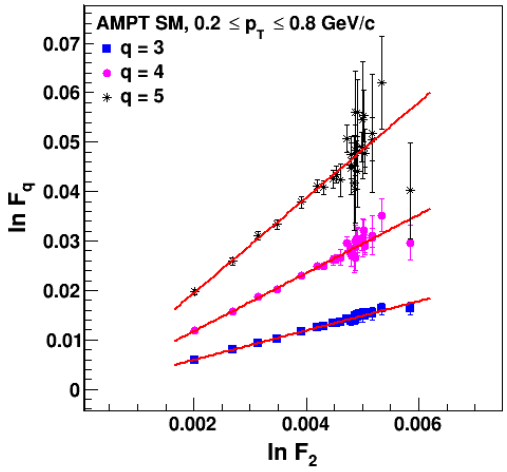

FIG. 1: Dependence of F_q on F_2.

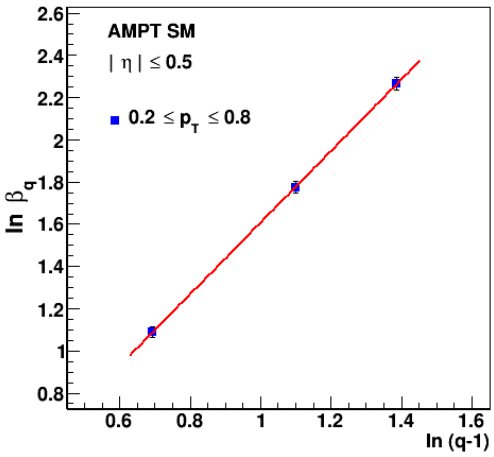

FIG. 2: β_q vs $q-1$ plot to obtain ν.

the phenomenon is referred to as *intermittency* and φ_q is called *intermittency index* for the second order phase transition, F_q satisfies the power-law behavior.

$$F_q \propto F_2^{\beta_q}, \tag{5}$$

where

$$\beta_q = (q-1)^{\nu}, \qquad \nu = 1.304\ . \tag{6}$$

The scaling exponent ν can be used to characterize the scaling properties of multiparticle production.

Observations

F_q moments are calculated in the 2D (η, ϕ) phase space for the kinematic cuts $|\eta| \leq 0.5$ and $0.2 \leq p_T \leq 0.8$ in full azimuth. Dependence of F_q on 2^{nd} order factorial moment F_2 is shown in Fig. 1. Slopes so obtained by the linear fits are plotted against $(q-1)$ to give ν (=1.69 ± 0.06). The results for dependence of scaling exponent on the various kinematic cuts and centrality will be presented.

Summary

Charged particle multiplicity distributions for Pb-Pb collisions using AMPT model at LHC energies, are studied for their local multiplicity fluctuations. Results obtained here for the model can be used to compare with the experimental results to gain as better understanding of physics of multiparticle production in heavy ion collisions at these energies. However results from the experiments at these or lower A-A collisions are not available at present.

Acknowledgments

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