Intermittency Phenomenon for Simulated Central Nuclear Reactions of (Pb + AgBr) Collisions at 158A GeV

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Introduction

The remarkably large non-statistical particle density fluctuations in small phase space region have fascinated a big role in the relativistic heavy-ion collisions to comprehend the mechanism of multiparticle production. Various workers in the field of theory and experiment have proposed different methods to identify the existence of non-statistical fluctuations. Bialas and Peschanski [1] were the first to introduce a perfect method known as scaled factorial moments (SFMs) to study the non-statistical fluctuations in the relativistic nuclear collisions. In such nuclear collisions, the power law behavior of SFMs is known as intermittency phenomenon.

Quantum chromodynamics (QCD) predicts the existence of a new phase of strongly interacting systems i.e. quark-gluon plasma (QGP) at high energy density or temperature [2]. Relativistic heavy ion collisions have provided the opportunity to search for the signal of QGP in the laboratory. Large fluctuations of particle production are expected in the transition from QGP to hadron phase [3]. Experimental data on particle fluctuations in a small space domains have been presented for different collisions at different energies [4-5]. In the present paper we have studied non-statistical fluctuations of relativistic shower particles produced in the collisions of ^{208}Pb + AgBr at 158 A GeV for central reactions.

First we have generated the data of ^{208}Pb + Em collisions at 158 A GeV with the help of UrQMD simulation program and these events were 700. A total number of 75 events were selected with the number of relativistic shower particles Ns > 350 in such collisions. These events belong to the collisions of lead nuclei with the heavy emulsion targets Ag and Br [6]. The events with the number of Ns > 700, 1000, i.e. collisions with increasing number of secondary charged particles or degree of centrality have been also analyzed. Some valuable details in about the experiment and the mathematical description related to the present statistical analysis has been given in our recent publications [7].

Mathematical Analysis

Bialas and Peschanski [1] suggested that a linear dependence of (SFMs), F_q, with the order of moments, q on the bin width $\delta\eta$ in η phase space for the study of non-statistical in addition to dynamical fluctuations. The intermittent behaviour should lead to a power law dependence $F_q \propto (\Delta\eta/\delta\eta)^{\alpha_q}$[1,5,7]. In the present work, the horizontal method of (SFMs) has been used. The standard horizontal factorial moment $F_q^{e(H)}$ for eth events is defined such as:

$$F_q^{e(H)} = M^{q-1} \sum_{m=1}^{M} \frac{F(n_{me};q)}{\{N_e^H\}^q} \qquad (1)$$

where, M is the number of equal bins of size $\delta\eta$ into which the pseudo-rapidity interval $\Delta\eta$ has been divided, n_{me} is the number of relativistic shower particles in the mth bin.

The vertical averaging of $F_q^{e(H)}$ gives the full form; $F^H(q) = \frac{1}{E} \sum_{e=1}^{E} F_e^{(H)}(q)$ (2)

where "E" is the total number of events.

Results and Discussions

A power law behaviour has been observed between the values of $ln < F_q(\eta) >$ and ln M_η for the relativistic shower particles with Ns > 350 in such collisions at energy at 158 A GeV and it is depicted in Fig. 1. From this figure it is evident that the values of $ln < F_q(\eta) >$ for the interactions due to Pb+AgBr at energy 158A

GeV are found relatively higher as compared to simulated events (FRITIOF) at same energy, where for the events from Mc-RAND data show approximate independent behaviour. The linear rise in the values of $ln < F_q(\eta) >$ with ln M_η in Fig. 1, indicates power law dependence of $< F_q >$ on the number of bins M, which clearly suggests that an intermittent behaviour is being observed in such collisions.

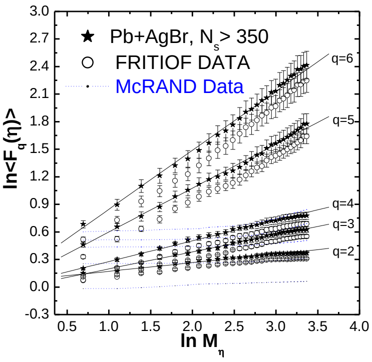

Fig. 1 The dependence of ln<$F_q(\eta)$> on ln M_η for Pb+AgBr collisions at 158A GeV with $N_s > 350$.

The values of intermittency index, α_q, have been determined with the slope values of graph plotted between ln<$F_q(\eta)$> and ln M_η for Pb+AgBr collisions at 158A GeV with $N_s > 350$, 700 and 1000and also depicted in Fig. 2.

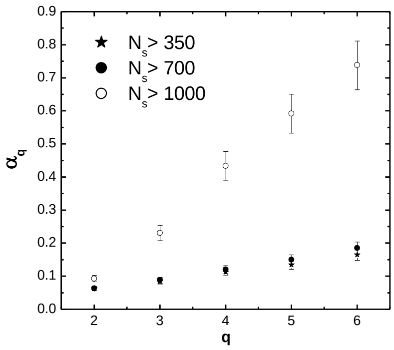

Fig. 2 Variation of α_q on order of moment, q for the collisions of Pb+AgBr at 158A GeV with $N_s > 350$, 700 and 1000.

With the knowledge of intermittency index, α_q, the possibility of detecting a non-thermal phase transition can be obtained by relation: $\lambda_q = (\alpha_q+1)/q$, where q is the order of SFMs (q = 2-6). And this dependence has been shown in Fig. 3 for the collisions of Pb+AgBr collisions at 158A GeV, Si+AgBr collisions at 14.6A GeV and S+AgBr collisions at 200A GeV with $N_s > 350$.

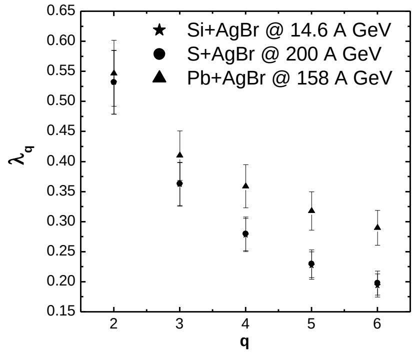

Fig. 3 Variation of λ_q as a function of q for Pb+AgBr, Si+AgBr and S+AgBr collisions at various energies.

It has been observed [1,5,7] that if the dynamics of intermittency is due to self-similar cascading, then there is a possibility of observing a non-thermal phase transition, which is believed to occur during the relativistic heavy ion collisions. The variation of λ_q as a function of q for all data sets has been shown in Fig. 3. From the figure it may be noted that no clear-cut minimum value of λ_q for certain value of q has been observed in the present experimental work as it is reported by other workers. However, a weak intermittency effect has been found in above collisions. To get more unambiguous evidence, the analysis should be done upto q = 8 with large statistics at high energies and with different projectiles.

References

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