On Multifractality in 60A and 200A GeV/c ^{16}O-AgBr Collisions

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Introduction

Non-statistical fluctuatios in the pseudorapidity windows of decreasing bin width in multiparticle data at relativistic energies has attracted great deal of attention of high-energy physicists in the last three decades due to possibility of resolving information about the dynamics of particles produced in these collisions. Existence of dynamical fluctuations in high-energy collisions may be investigated in terms of intermittency. The idea which motivated Bialas and Peschanski [1-2] to sudy intermittency, originated from the observation of rapidity fluctuations in an unusually high multiplicity cosmic ray event commonly known as JACEE [3] event. The concept of self-similarity as speculated by Bialas and Peschanski in these collisions is closely related to the fractal theory which is natural consequence of the cascading mechanism prevailing in the multiparticle production processess. The power law behaviour of scaled factorial moments indeed implies the existence of some kind of fractal pattern [2] in the dynamics of particles produced in their final state of reaction. In order to investigate the cascading mechanism [3] of multiparticle production in the frame work of multifractal technique, a formalism has been developed by R. C. Hwa [2] for a systematic study of the fractal properties of produced particle in nuclear collisions. The explanation of cascading as self-similar process in analogy with geometrical objects such as fractals has been allowed by scaling law.

Although many attempts have been made to study the fractal properties using μp, pp and e^+e^-. data [4-5] using the method of multifractal moments, G_q, however, AA collisions are least studied using this method. In the present paper, an attempt is made to investigate various interesting features of multifractality in ^{16}O-AgBr collisions at 60A and 200A GeV. The general theory of multfractals proposed by R. C. Hwa [2] allows us to estimate mass exponent, Tq, generalised dimension, Dq and multfractal spectral function, $f(\alpha_q)$ for different order of moments, q. These parameters serve as the measure of the multifractal structure in the considered data sets.

Experimental Details

The data analyzed in the present paper were collected from two emulsion stacks exposed to Oxygen beams at 60A and 200A GeV at CERN, SPS(EMU01Collaboration). Two data samples of 391 and 212 interctions of ^{16}O with AgBr at 60A and 200A GeV respectively having $N_s \geq 10$ were used for analysis using standard emulsion criteria [6]. In the present analysis psuedorapidity range $\Delta\eta$=2.0 (1.6-3.6 for 60A and 2.1-4.1 for 200A GeV) have been used.

Results and Discussion

The variations of ln<Gq> as a function of -ln$\delta\eta$ are plotted in Fig 1. The data have been fitted using method of least squares for only few initial points, because of saturation effect. It may be noted from the figure that moments with negative q values saturates as $\delta\eta$ decreases whereas for positive q values, it shows linearity over wide range of $\delta\eta$. This saturation could be due to decrease in number of particle as bin size is reduced. The linear rise of the moments with decraseing bin size of pseudorapidity shows a power law behaviour in the experimental data which is an indication of the self-similarity in the production mechanism of investigated reactions.

. Generalized dimensions, Dq, have been calculated and plotted as a function of q in Fig. 2. for both data sets. At both energies Dq decreases with increasing q, which shows the multifractal

behavoiur in the multiparticle production. It may also be mentioned that for positive q values Dq increaes with increasing beam energy for same projectile, whereas for negative q values it seems to be independent of the beam energy.

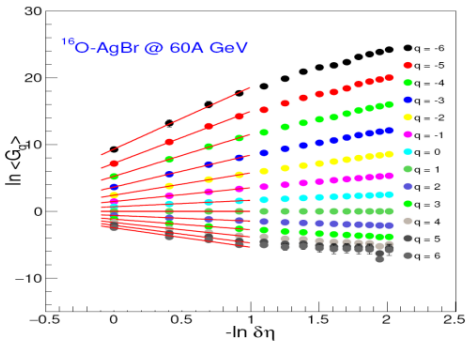

Fig. 1(a) ln<G_q> as a function of -lnδη

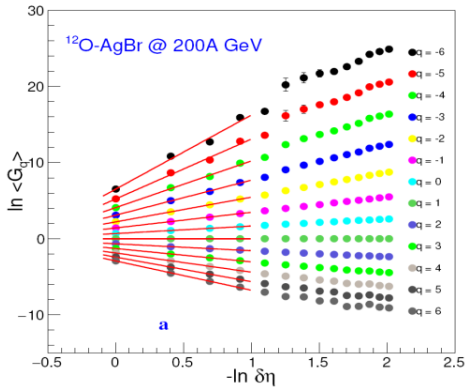

Fig. 1(b) ln<G_q> as a function of -lnδη

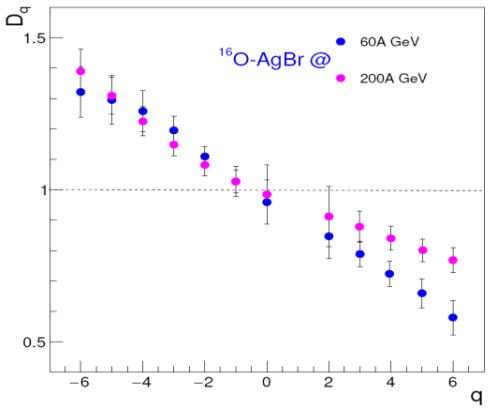

Fig. 2 D_q versus q plots for 60A and 200A GeV.

The multifractal spectrum, $f(\alpha_q)$, are calculated and exhibited in Fig.3..It is represented by continuous concave downward curve with maximum at q=0, $f(\alpha_q)$=Dq=1 and the dotted line represent a common tangent at an angle 45^0. These observations are in agreement with those reported earlier [7-8]

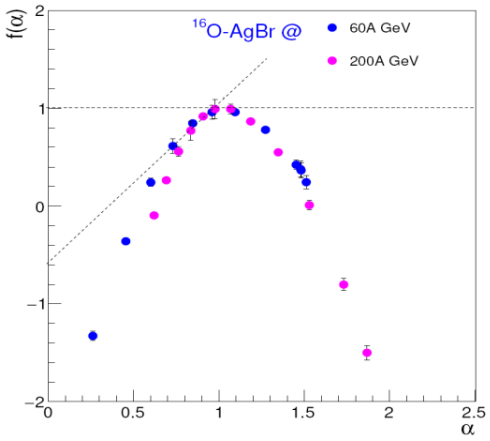

Fig. 3 $f(\alpha_q)$ versus q plots for 60A and 200A GeV.

Conclusions

The present study leads to draw the following important conclusions.

(i) The increasing trends of mass exponents, T_q with the order of the moments, q exhibits the power law behaviour in the considered data sets.

(ii) Multifractal dimension, Dq, decreases with increasing order of the moments, q, indicating thereby the presence of multifractality in the multiparticle productiom process in ^{16}O-AgBr collisions at 60A and 200A GeV energies.

(iii) The multifractal spectral function is found to be continuous and concave downward for both the data sets which indicates the presence of dynamical fluctuations in their pseudorapidity space.

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