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Multifractality in relativistic charged particles produced at SPS energies

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ABSTRACT

The multifractal analysis of relativistic shower particles produced in ^{32}S–emulsion interactions at 200 AGeV has been investigated using the method of modified multifractal moments, G_q, in pseudo-rapidity space. The anomalous fractal dimension, d_q, and generalized fractal dimensions, D_q, are determined for the present data for different order of moment. The experimental data reflects multifractal geometry in a multipion production process. The downward concave shape of the multifractal spectral function, $f(\alpha_q)$, gives an evidence for self-similar cascade mechanism. The multifractal specific heat has also been evaluated for the present data using the generalized fractal dimensions, D_q. We compared our experimental results with those obtained from simulated events of the Lund Monte Carlo Code FRITIOF and uncorrelated Monte Carlo events, (MC-RAND) generated randomly in pseudo-rapidity space based on the assumption of independent emission of particles. The experimental data on multifractality has been found to exhibit a remarkable proximity to the analogous data obtained from the FRITIOF code and the uncorrelated Monte Carlo events.

1. Introduction

Fractal geometry is nowadays widely used in many branches of physics [1]. In multiparticle dynamic methods introduced originally for description of fractal properties of stochastic systems [2] are extensively used. There are phenomenological hints for intermittent behaviour in the emission pattern of charged secondaries emitted from high energy nuclear collisions. It was Carruthers and Ming [3] who, possibly for the first time, investigated the fractal dimension in hadronic multiparticle production. Later Dremin [4] suggested the study of correlation dimension. Lipa and Buschbeck [5] considered other generalized dimensions. Hwa [6] then pointed out that in none of the above mentioned investigations formalism could be developed for a systematic study of the fractal properties that can provide an effective means of describing a highly non-uniform rapidity distribution of produced particles. He then identified a new set of moment, called generalized moment, G_q, to study the multifractality and self-similarity in multiparticle production. However, if the multiplicity is low, the G_q-moments are found to be dominated by statistical fluctuations. In order to suppress the statistical contribution, a modified form of G_q-moments in terms of the step function was suggested by Hwa and Pan [6,7], which can act as a filter for the low multiplicity events [6–9]. Hwa also discussed the general properties of the spectrum of scaling indices and indicated how it can provide an effective means of describing a highly non-uniform rapidity distribution.

The properties of a multiply excited hadron can be explained by observing the multiplicity of particles and their distributions in variable phase space. We made an attempt to investigate some observations on multifractality of the multiplicity distributions of relativistic shower particles produced due to the interactions caused by 200 AGeV

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