SEARCH FOR INTERMITTENCY IN CENTRAL Au + Au COLLISIONS AT INTERMEDIATE ENERGIES*,**

K. Wiśniewski[a], B. Sikora[a], K. Siwek-Wilczyńska[a]

AND

M. Kirejczyk[a,b]

FOR THE FOPI COLLABORATION

[a]Inst. of Experimental Physics, Warsaw University, Poland
[b]Gesellschaft für Schwerionenforschung, Darmstadt, Germany

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Fluctuations in distributions of nuclear fragments produced in central Au + Au collisions at labolatory energies of $150A$ and $400A$ MeV were analyzed by means of normalized scaled factorial moments. No variation of the moments with bin width was found for charge distributions. An intermittency signal was found for distributions of fragments in azimuthal angle. A similar analysis performed for events simulated with the IQMD model did not show any intermittency.

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The method of scaled moments was oryginally proposed by Białas and Peschansky [1, 2] to study fluctuations in distributions of particles in phase space in events of large multiplicity. It is argued [3] that large nonstatistical event to event fluctuations in these distributions can be related to correlations between particles. To separate these fluctuations from purely statistical ones [1], and to properly take into account the inclusive shape of one-particle distributions [4] one has to study the **normalized scaled factorial moments** (NSFMs).

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To calculate the value of the normalized scaled factorial moment of i-th rank $\langle F_i^{\delta X}\rangle$ for distributions of particles in an one dimensional subspace ΔX, with certain bin width δX, for a given set of events, one has to compute the quantity :

$$\langle F_i^{\delta X}\rangle = \left\langle \frac{\sum_{m=1}^{M} k_m(k_m-1)\ldots(k_m-i+1)}{N^i} \right\rangle_{\rm ev} \left(\frac{\sum_{m=1}^{M}\left(k_m^{\rm inc}\right)^i}{\left(N^{\rm inc}\right)^i} \right)^{-1} . \qquad (1)$$

$\langle\ \rangle_{\rm ev}$ denotes averaging over the set of events, $M = \Delta X/\delta X$ is the number of bins, N — the total number of particles in an event, k_m — the number of particles in the m-th bin in this event, $N^{\rm inc}$ and $k_m^{\rm inc}$ — the analogous quantities for inclusive distributions (*i.e.* distributions summed over the set of events).

It was shown [5] that if the fluctuations in distributions of particles in the subspace ΔX are strictly poissonian, the values of the moments $\langle F_i^{\delta X}\rangle$ are independent of the bin width δX and equal to unity. On the contrary, if nonstatistical fluctuations are present in these distributions, the values of $\langle F_i^{\delta Z}\rangle$ are larger than 1 and depend on the bin width δX. If there were no other reason for the fluctuations for being enhanced, one could conclude that the correlations between particles are responsible for such an efect. In the context of NSFMs, **intermittency** occures when the values of $\langle F_i^{\delta X}\rangle$ calculated as a function of δX obey a power law, *i.e.*:

$$\langle F_i^{\delta X}\rangle \propto (\delta X)^{-\alpha_i}, \qquad (2)$$

where α_i is the intermittency exponent of i-th rank.

We analyzed distributions of nuclear fragments produced in collisions of Au nuclei at labolatory energies of $150A$ and $400A$MeV. The data were collected with the FOPI-Phase I detector at GSI/Darmstadt [6].

Since the mixing of events of different characteristics can produce trivial fluctuations in distributions of fragments the analysis was restricted to central collisions, which were selected by means of centrality criteria: high multiplicity of fragments (PM5) and large transversal to longitudinal energy ratio (ERAT5) [7]. In this way a few thousand of events with mean multiplicities about 40 and 60 for $150A$ and $400A$ MeV data respectively were filtered out.

Following the idea of Płoszajczak and Tucholski [8, 9] we calculated the values of the moments $\langle F_i^{\delta Z}\rangle$ for charge distributions of fragments — Fig. 1.

No dependence of the moments $\langle F_i^{\delta Z}\rangle$ of all ranks on δZ is evident for the $400A$ MeV data. The values of $\langle F_i^{\delta Z}\rangle$ are smaller than 1, most probably

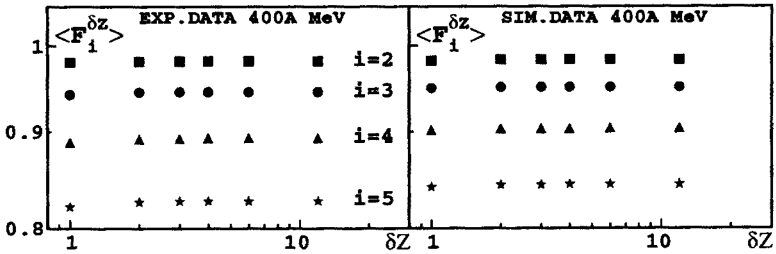

Fig. 1. The values of the moments $\langle F_i^{\delta Z}\rangle$ of ranks $i = 2, 3, 4, 5$ as a function of δZ for experimental (left) and simulated (right) data at energy 400A MeV.

due to charge conservation in a collision. The same observations are valid for distributions obtained from events simulated with the IQMD model [10] and processed with GEANT simulation of the detector response. A similar result was also found for the data at 150A MeV. The conclusion is that the fluctuations in charge distributions both in experimental and IQMD simulated data do not exceed the poissonian limit. Hence no correlations between charges of fragments show up in these data.

A similar analysis was performed for distribution of particles as a function of the azimuthal angle — ϕ. It was restricted, however, only to protons detected by the Forward Wall [6] because of better resolution in ϕ ($\Delta\phi_{\rm exp} \simeq 2°$), but no substantial difference was found when the analysis included also other fragments. Figure 2 shows the dependence of $\langle F_i^{\delta\phi}\rangle$ values on $\delta\phi$ for 400A MeV data. It suggests the presence of correlations between protons in phase space.

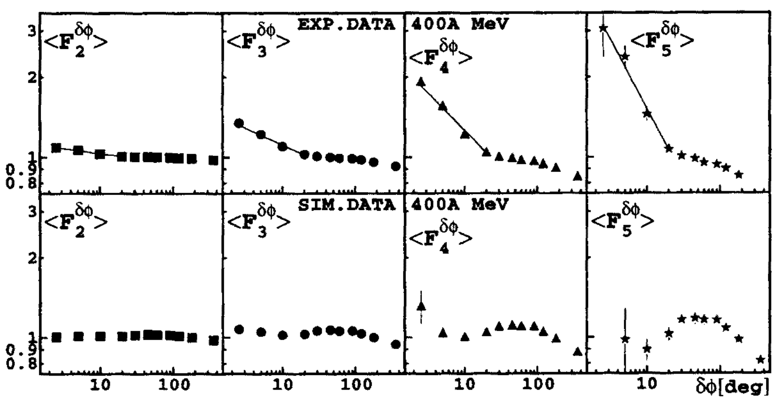

Fig. 2. The values of the moments $\langle F_i^{\delta\phi}\rangle$ of ranks $i = 2, 3, 4, 5$ for experimental (top) and simulated (bottom) data at energy 400A MeV.

A power dependence of the moments on $\delta\phi$, *i.e.* intermittency was identified in a limited range of angles ($2.5° \leq \delta\phi \leq 20°$) in experimental data shown as straight line fits on the log scale plots (formula 2) on figure 2. Evidently this can not be reproduced by the IQMD model. A similar result was obtained for collisions at 150A MeV. Figure 3 shows the values of anomalous fractal dimensions, defined as $d_i = \alpha_i/(i-1)$, extracted from the fits of figure 2.

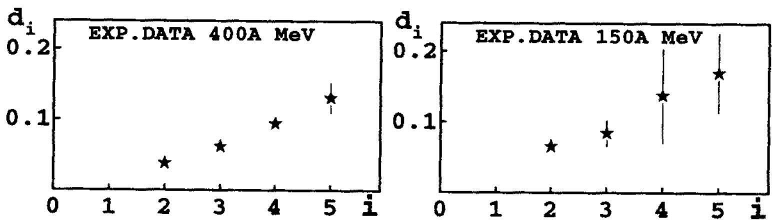

Fig. 3. The values of d_i as a function of rank i for experimental data at energy 400A MeV (left) and 150A MeV (right).

It was found by Białas and Peschansky [2], that such a linear dependence of d_i on the rank i appears for certain cascading processes (*e.g.* α-model). Thus this result may speak in favour of a cascading mechanism of the fragment formation following the studied collisions.

Płoszajczak and Tucholski [8, 9] reported on finding intermittency for charge distributions of fragments produced in Au + emulsion reactions at energy $\sim$ 1A GeV. Such an efect can be also seen in our analysis when selecting the events by means of criteria proposed by these authors (number of fragments with charge $Z \geq 3$ greater than 2). However we believe that this is due to the mixing of events characterized by different shape of the inclusive charge distributions. Thus the efect disappears on applying the selection criterion PM5 $\wedge$ ERAT5.

On the other hand, the intermittency signal found in this work for distributions of particles in ϕ is partly due to the apparatus effect — double counting of single particles scattered to neighbouring strips of the Forward Wall. According to the present stage of our studies on this effect, it can not, however, be responsible for the whole intermittency signal that was observed.

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