Scaling Characteristics of multiplicity fluctuations in the Relativistic Heavy Ion Collisions

INTRODUCTION:
Why the study of heavy ion collisions is so important??
1. It has been proposed that colliding heavy nuclei at relativistic energies can lead to the understanding of the ultimate constituents of matter.
2. The primary aim of such collisions is to study the dynamics of hottest and densest form of matter created at extremely high energies.
3. Transition from hadronic phase to QGP phase.
4. To reach the conditions explaining the phase transition at extremely high energies.
5. At low temperatures quarks and gluons are bounded by a strong force into a colorless objects- Hadrons.
6. Matter at high temperature and/or density becomes simple: weakly interacting gas of quarks.
7. Thus one may be able to reach to the fundamental constituents of matter i.e; quarks.

THE EXPERIMENTAL DETAILS:
The experimental data is obtained from the EMU-01 collaboration at SPS CERN. In each of the interaction, the charged secondaries were recorded which include the shower particles, target recoiled proton, target evaporated fragment and projectile ete.

The mean multiplicities of the various types of charged secondaries that have been produced in these interactions are:

<table>
<thead>
<tr>
<th>Interaction type</th>
<th>Experimental</th>
<th>AMPT</th>
<th>UrQMD</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5A GeV/c 16O-AgBr</td>
<td>18.05±0.22</td>
<td>16.14±0.25</td>
<td>17.79±0.22</td>
<td>Ref. [1]</td>
</tr>
<tr>
<td>6A GeV/c 16O-AgBr</td>
<td>73.22±0.15</td>
<td>52.88±0.91</td>
<td>41.86±0.65</td>
<td>Present work</td>
</tr>
<tr>
<td>200A GeV/c 16O-AgBr</td>
<td>126.73±0.61</td>
<td>109.98±0.98</td>
<td>65.87±1.02</td>
<td>Present work</td>
</tr>
</tbody>
</table>

THEORETICAL MODEL:
The General characteristics of these tracks are as under:

- **Black tracks**: (n_1)
  - Range ≤ 3mm
  - Velocity, β ≤ 0.3
  - Low energy protons, Deuterons, tritium, Helium

- **Grey Tracks**: (n_2)
  - Range ≥ 3mm
  - Velocity, 0.3 ≤ β ≤ 0.7
  - Knockout protons from target and a low percentage of pions

- **Shower Tracks**: (n_3)
  - Long range particles (relativistic)
  - Velocity, β ≥ 0.7
  - Mostly pions with some kaons and protons

Mathematical Formalism:
Bialas and Peschanski proposed a method of Normalised Factorial Moments (NFM) to corroborate that the fluctuations are dynamical. Let a phase space (M) is partitioned into m bins and let n_m be the multiplicity in each bin.

\[ F_i = M^{i-1} \frac{\sum_n (n_m - \bar{n})(n_m + q - 1)}{N(N-1)...(N-q+1)} \]

Using
\[ \delta \eta = \Delta n / M \]

\[ \ln F_i = c + \phi \ln M \]

REFERENCES: