IMPRINTS OF CLUSTERING IN MULTIPLICITY FLUCTUATIONS

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INTRODUCTION

One of the key methods for the study of strongly-interacting matter suffering extreme conditions is the measurement of event-by-event fluctuations of experimental observables. The registered fluctuations are sensitive to the proximity of the phase transition between hadronic gas state and the quark-gluon plasma (QGP), and the critical point of strongly interacting matter. Thus, they give us information on the dynamics hidden in the system formed in the collision.

OBJECTIVES

The goal of this work is to investigate the **multiplicity fluctuations of charged particles** observed in high-energy nuclear collisions and relate them to the **size of hadronizing systems** which happen during such processes. We use the **average multiplicities <N>** and variances **Var(N)** of multiplicity distributions of charged particles produced in centrality selected collisions of relativistic heavy-ion nuclei to evaluate the **dynamic variance** Ω and **study its dependence on the size of colliding systems**. We connect the observed system-size dependence of multiplicity fluctuations with the clustering phenomena and the finiteness of the hadronizing sources and the thermal bath [1].

DEFINITIONS

Usually the magnitude of multiplicity fluctuations is quantified by scaled variance of multiplicity distribution:

$$\omega = \frac{Var(N)}{\langle N\rangle}, \quad (1)$$

It is interesting to study the ratio of the variance of multiplicity distribution to the square of the average multiplicity. This quantity as a function of N_{part} shows an intriguing power-law dependence:

$$\frac{Var(N)}{\langle N\rangle^2} \sim N_{part}^{-\alpha} \quad (2)$$

with the exponent $\alpha \simeq 1.25$. This intriguing scaling first observed by the PHENIX Collaboration, also holds for the ALICE data.

MULTIPLICITY FLUCTUATIONS

The experimentally measured average multiplicity and variance of multiplicity distribution are expressed as:

$$\langle N\rangle = p\langle N_{p=1}\rangle, \quad (3)$$

$$Var(N) = p^2 Var(N_{p=1}) + p(1-p)\langle N_{p=1}\rangle. \quad (4)$$

Using Eqs. (3) and (4):

$$\Omega = \frac{Var(N)}{\langle N\rangle^2} - \frac{1}{\langle N\rangle} \quad (5)$$

does not depend on the detector acceptance.This function was connected with parameter k from negative binomial distribution, with non-extensivity parameter q, and with two-particle correlation function $\langle \nu_2\rangle$. This function can also be expressed as:

$$\Omega = 1/k = q - 1 = \langle \nu_2\rangle. \quad (6)$$

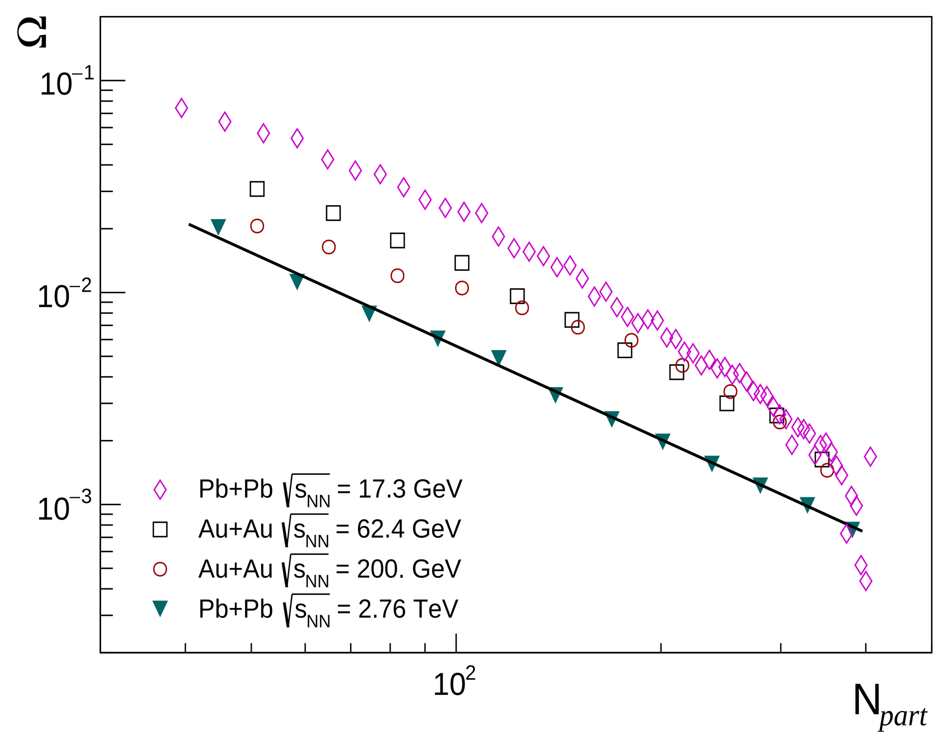

Figure 1: Dependence of Ω on the N_{part}.

We use experimental data on multiplicity distributions of charged particles produced in nuclear collisions obtained by the NA49 experiment [2], PHENIX experiment at BNL RHIC [3] and ALICE experiment at CERN LHC [4] .We first evaluate the values of Ω and its dependence on N_{part}. For the highest energy ($\sqrt{s_{NN}} = 2.76$ TeV) $\Omega \sim N_{part}^{-1.5}$, but for lower energies we observe deviation from the simple power law dependence.

IMPRINTS OF CLUSTERING

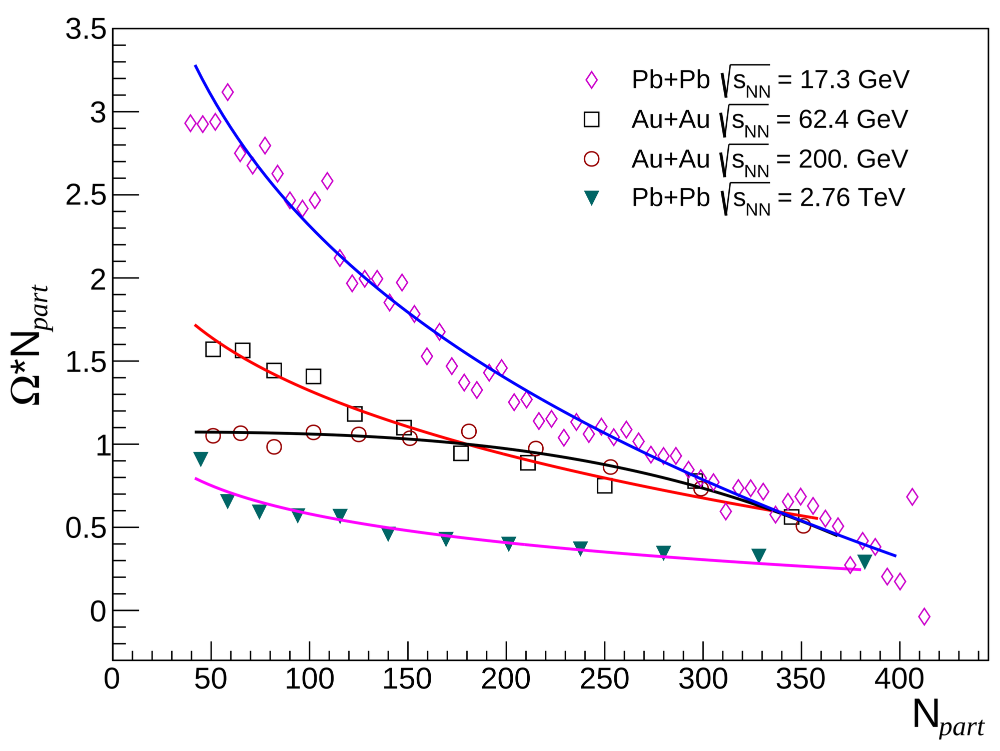

Figure 2: ΩN_{part} as a function of the number of nucleons participating in collisions N_{part}.

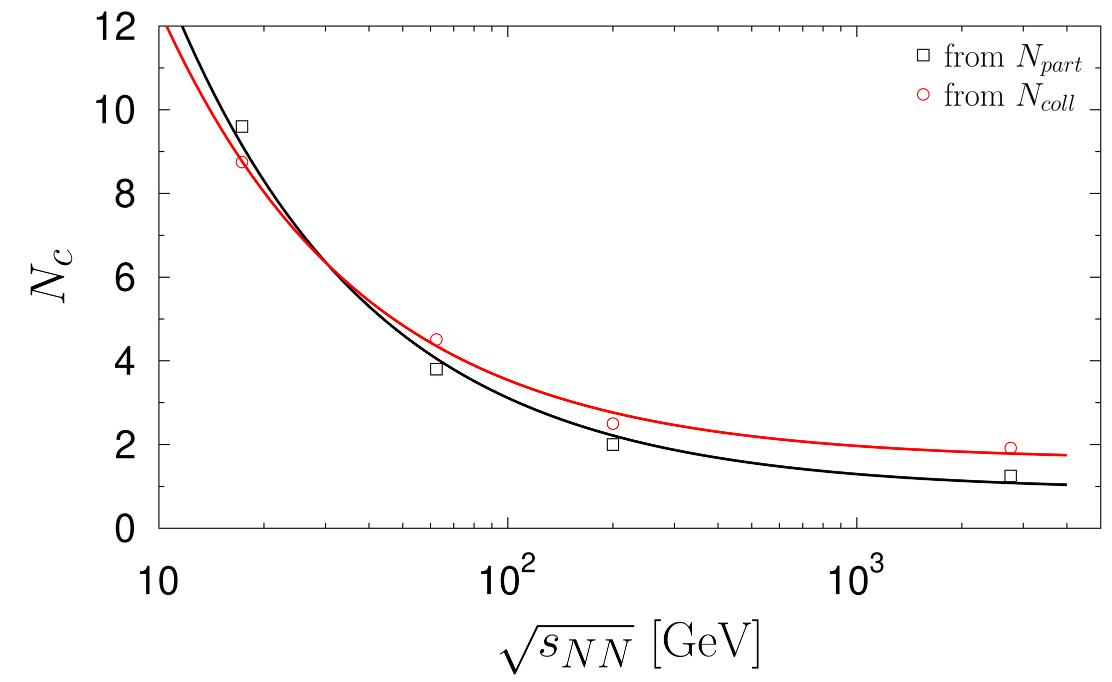

Figure 3: Cluster size, N_c as a function of $\sqrt{s_{NN}}$ evaluated from ΩN_{coll} dependence on number of participants, N_{part} and number of collisions, N_{coll}. The energy dependencies follow: $N_c = 0.9 + 70(\sqrt{s})^{-0.75}$ and $N_c = 1.626 + 60.59(\sqrt{s})^{-0.75}$, respectively.

DEPENDENCE ON NUMBER OF NUCLEON-NUCLEON COLLISIONS

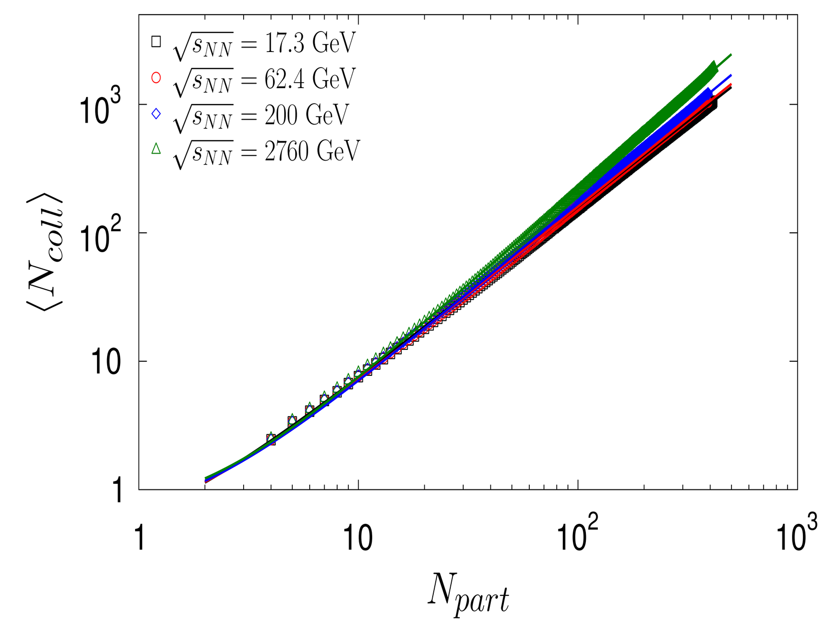

Figure 4: Average number of collisions, $\langle N_{coll}\rangle$ as a function of number of nucleons participating participating in the collisions evaluated from GLISSANDO simulation.

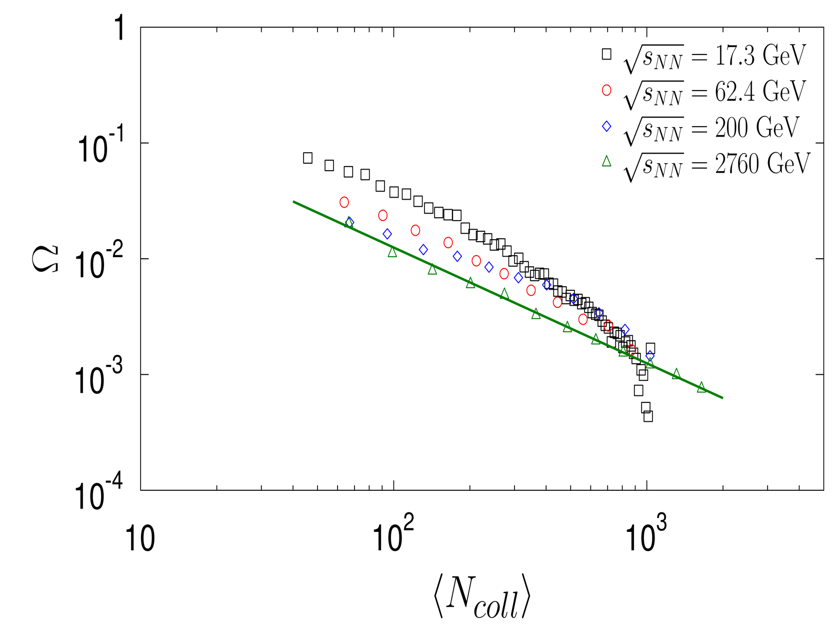

Figure 5: Dependence of $\Omega = Var(N)/\langle N\rangle^2 - 1/\langle N\rangle$ on the average number of collisions, $\langle N_{coll}\rangle$. The line show dependence: $\Omega = 1.25\langle N_{coll}\rangle^{-1.0}$.

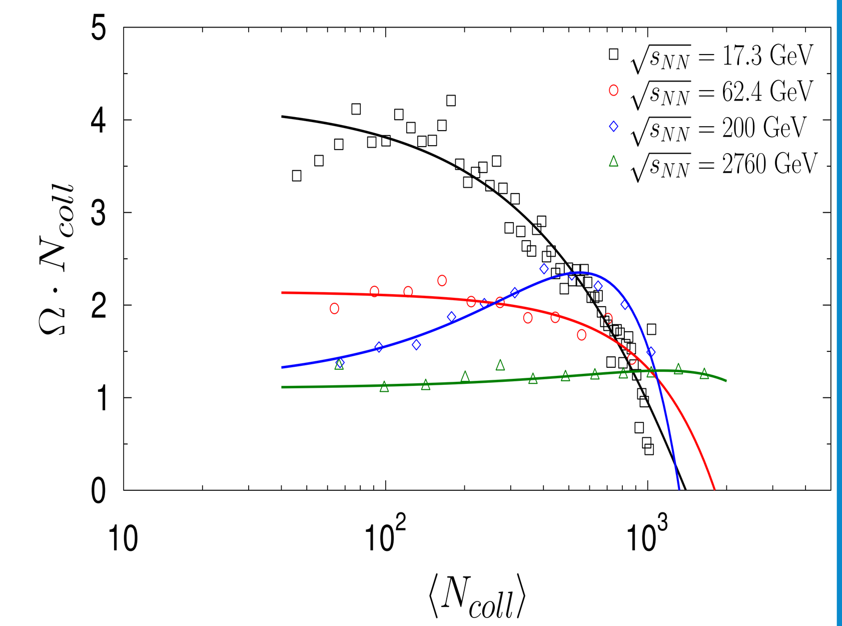

Figure 6: Dependence of ΩN_{coll} on the average number of collisions, $\langle N_{coll}\rangle$.

ONGOING RESEARCH

Up to now, looking for critical point, the multiplicities (of produced pions and Kaons) were analyzed. We propose, additionally, the analyze of energy which is spend for production of produced particles. Investigation of inelasticity in nuclear collisions, in comparison with p+p collision, may provide new additional information.The concept of inelasticity tells us that in the collisions only a fraction of the whole invariant energy is spent for production of new particles while the rest is taken by leading particles to the forward and backward phase-space regions.

ACKNOWLEDGEMENTS

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