doi: 10.15407/ujpe62.01.0012

W. BARI,[1] N.A. RATHER[2]

[1] Department of Physics, University of Kashmir
(Srinagar, India – 190 006; e-mail: wbari@kashmiruniversity.ac.in)

[2] Department of Mathematics, University of Kashmir
(Srinagar, India – 190 006)

PACS 25.75-q; 25.75.Ag; 25.75.Gz

SENSITIVITY OF MULTIPLICITY FLUCTUATIONS TO RAPIDITY IN HIGH-ENERGY NUCLEUS-NUCLEUS INTERACTIONS

The multiplicity fluctuations in the relativistic charged particles produced in ^{28}Si-nucleus interactions at two different energies are investigated in terms of a scaled variance. The main binning condition used in the present study is to expand the range of pseudorapidity along both sides of a central rapidity which is obtained from the rapidity distribution of each interaction considered. The dependence of the multiplicity fluctuations on the projectile energy and target size is investigated, and the results are compared with those obtained from the FRITIOF model.

Keywords: multiplicity, scaled variance, fluctuations, correlations.

1. Introduction

The last one and a half decade has observed a great spurt in the study of heavy-ion collisions at relativistic energies. This is attributed to the realization that, in such interactions and under the extreme conditions of energy density and temperature, conditions similar to those which existed within a few microseconds after the Big-Bang could be achieved [1]. It is believed that the intermediate fireball produced in the collision consists of the partonic phase of a deconfined quark-gluon plasma (QGP), which evolves ultimately into the hadronic phase due to the freeze-out [2]. Keeping in view the importance of reaching to such a phase of matter, several heavy-ion collisions programs where initiated at AGS-BNL and CERN-SPS earlier. However, in the last decade, the progress has been tremendous in the field with the advent of Relativistic Heavy Ion Collider (RHIC) at BNL and Large Hadron Collider (LHC) at CERN, wherein a general consensus has been reached at the formation of a strongly interacting QGP [3–6]. The main aim of carrying out heavy-ion collision experiments at RHIC and LHC is to study the nature of the phase transition and understand the QGP in detail. Since the experiments therein result in the production of a large number of particles, the extraction of dynamic variables on the event-by-event basis has become a significant tool for investigating the source. The event-by-event fluctuations in temperature, mean transverse momentum, particle multiplicity, and particle ratios have been found [7–13] of utmost importance in having an idea of the evolution of the various stages of the formation of QGP and its freeze-out to the hadronic phase.

The final distributions of the particles produced in relativistic heavy-ion collisions is very much influenced by the dynamics of the initial process [14]. As such, the multiplicity distributions have an important role to play when it comes to having a first hand information on the multiparticle production mechanism in these collisions. The formation of a QGP and its transition to the hadronic phase is expected to be reflected in terms of large dynamical fluctuations in the multiparticle production [15]. Thus, the study of fluctuations has become an important tool in envisaging the process of phase transition in relativistic nuclear interactions [16]. A great deal of work [17–23] has been carried out in this field over a wide range of energies. Earlier, it has been suggested [24] that the deconfinement should result in the non-monotonous trends in the behavior of multiplicity fluctuations, which could act as an indicator for the observance of the critical point [25]. One of the tools to study the multiplicity fluctuations is the scaled variance which is defined [26] as

$$\omega = \frac{\mathrm{Var}(n)}{\langle n\rangle} = \frac{\langle n^2\rangle - \langle n\rangle^2}{\langle n\rangle}, \qquad (1)$$

where $\mathrm{Var}(n) = \sum_n (n - \langle n\rangle)^2 P(n)$ and $(\langle n\rangle = \sum nP(n)$ are the variance and mean of the multiplicity distribution. It has been suggested [27–29] that an estimate of the scaled variance would be a direct measure of multiplicity fluctuations. The main idea behind these types of studies is that the multiplicity fluctuations are a reflection of particle correlations amongst the particles produced in heavy ion collisions. As such, any correlation amongst the particles would be inferred in terms of a deviation of the multiplicity from the Poissonian one [27]. This is because the independent particle production is represented by a Poisssonian distribution, for which the variance is equal to its mean resulting in ($\omega = 1$). Any positive (negative) deviation would make the distribution broader (narrower) from the Poissonian one. Thus, if the scaled variance is greater than unity, it would be indicative of the presence of a correlation amongst the particles produced. The strength of the corelation can be realized by the amount of deviation of (ω) from 1.

In the present work, results on the scaled variance for the interactions of ^{28}Si nuclei with various targets at two different energies, i.e., $4.5A$ and $14.5A$ GeV/c, are presented. The results have been put on test using the FRITIOF [30] model.

2. Experimental Details

A random sample of 555 interaction events for the collisions of ^{28}Si nuclei with the emulsion at $4.5A$ GeV/c energy has been analyzed. These events pertain to the emulsion stacks exposed to $4.5A$ GeV/c silicon beam from Synchrophasotron at DUBNA. These events correspond to those interactions, for which $n_s \geq 2$, where n_s represents the number of relativistic charged particles produced in an event. The other details of the measurement procedures used and the description of the emulsion stacks can be found elsewhere [31, 32]. For having an idea of the variation in the results with increase in the energy, the results pertaining to these interactions are compared with those pertaining to the interactions of ^{28}Si with various targets in the case of an exposure of emulsion stacks to the $14.5A$ GeV/c silicon beam from AGS at BNL. For the classification of various particles emitted in various interactions considered for the present study, the usual emulsion terminology [33] has been used. The emitted particles are classified in three categories (black, grey, and shower particles), according to the following criteria:

- *Black particles:* (n_b) These are referred to the target fragments with ionization $I > I_0$, where I_0 represents the the minimum ionization of a single charged particle. Black tracks are characterized by velocities $v < 0.3c$ and a range $R < 3$ mm in the nuclear emulsion.
- *Grey particles:* (n_g) These are referred mainly to the recoil protons in addition to few kaons and a small amount of low-energy pions. They fall within the ionization range ($1.4I_0 < I < 9I_0$). Grey particles are characterized by velocity $0.3c < v < 0.7c$ and a range $R > 3$ mm in the nuclear emulsion.
- *Shower particles:* (n_s) Shower particles are the relativistic charged particles produced in the interaction. Most of these particles are charged pions with small amount of fast protons and kaons. The particles have velocities $v > 0.7c$. These particles have largest range amongst all the particles produced in an interaction.

In the present study, we have classified the interactions due to different targets on the basis of the number of heavily ionizing particles (n_h) produced in an interaction. Heavy particles are defined as the sum of black and grey tracks produced in an interaction, i.e., $n_h = n_b + n_g$. The interaction events for which $2 < n_h \leq 7$ are considered to be the interactions resulting from the CNO target of the emulsion, whereas all the interaction events, for which $n_h \geq 8$ are attributed to the interactions due to the AgBr target. The phase space variable, which has been utilized to characterize the relativistic charged particles in the various interactions, is the pseudorapidity variable $\eta = -\ln\tan\frac{\theta}{2}$ with θ representing the emission angle of the particle with respect to the direction of the projectile beam.

3. Results and Discussion

3.1. Mean Multiplicity

One of the fundamental observables to characterize a heavy-ion collision is the multiplicity of a particle produced in the interaction [34]. The multiplicity of each kind of particles is viewed as a diagnostic tool to have an insight of the interaction, from which it results. The results on the mean multiplicity of the various interactions investigated in the present study are exhibited in Table. It is seen that the black and grey particle multiplicities show no significant change, when the projectile energy increases almost three-fold. However, the relativistic charged particle multiplicity does increase significantly with increase in the incident energy. Further, it is observed that the multiplicities of all types of particles are pronouncedly effected by the target size. In fact, there is an evident increase in the multiplicities of the produced particles, when the target size increases.

3.2. Pseudorapidity distributions

In the present study, we have investigated the multiplicity fluctuations for the interactions of ^{28}Si nuclei with various targets in different rapidity window sizes centering about a central rapidity value for each interaction. The central value has been identified from the rapidity distributions shown in Fig. 1 for all the interactions. The central value corresponds to that value of rapidity, for which the number of particles is maximum. A rapidity window ($\Delta\eta$) is afterword defined as a symmetric region of rapidity around both sides of this central value. Although many workers [29] have used asymmetric regions for finalizing $\Delta\eta$, it is a general understanding that even if, as in the present study, we include the region of lower rapidity, this is not going to affect our calculations, because the multiplicity in these regions would automatically go down, thereby not making any difference whether we take a symmetric or asymmetric rapidity region for finalizing the window size.

Mean multiplicities of various particles produced in the interactions of ^{28}Si nuclei with various targets

Energy A GeV/c	Target	$\langle n_b \rangle$	$\langle n_g \rangle$	$\langle n_s \rangle$
4.5	Emulsion	6.74 ± 0.40	3.71 ± 0.41	13.26 ± 0.45
4.5	CNO	2.92 ± 0.10	1.93 ± 0.10	10.82 ± 0.48
4.5	AgBr	15.00 ± 0.81	7.82 ± 0.82	20.54 ± 0.82
14.5	Emulsion	6.95 ± 0.22	4.69 ± 0.21	22.02 ± 0.61
14.5	CNO	3.22 ± 0.11	2.04 ± 0.10	16.75 ± 0.63
14.5	AgBr	10.79 ± 0.24	7.34 ± 0.23	27.07 ± 0.93

3.3. Scaled Variance

In the present case, we have analyzed the data within the interval $-6.0 \leq \eta_c \leq 6.0$ (η_c is the central rapidity value) for all the interactions. The intervals have been varied with a step size of 0.5 on both sides of the central rapidity value so that the rapidity window size, $\Delta\eta$, varies from 1 to 12 in each case. The variation of the scaled variance with the rapidity window for the interactions of ^{28}Si nuclei with an emulsion target at $4.5A$ and $14.5A$ GeV/c are exhibited in Fig. 2. It is observed that the maximum variance occurs within the region of $-2.0 \leq \eta_c \leq 2.0$ i.e., at $\Delta\eta = 4.0$ for both the energies. However, one significant observation is that there is an apparent difference in the amount of fluctuations in the two interactions between the inner region and the outer region, i.e., for the rapidity window sizes $\Delta\eta < 4$ and $\Delta\eta > 4$; the scaled variance for the interactions at two different energies shows a varying behavior. At lower energy, the maximum multiplicity fluctuations are found to pertain to the lower rapidity windows, whereas, at higher energy, the trend is completely opposite. Further, it is worth noting that, after a certain rapidity interval, the scaled variance shows the saturation even if the size of a rapidity window is increased. Such type of behavior is in agreement with what has been observed [29] in many nucleus-nucleus interactions at a wide range of energies.

The experimental findings have been compared with those obtained from analyzing an event sample using the FRITIOF code, which is based on the Lund Monte-Carlo model [30]. This model visualizes the collision between two nuclei as a composition of various constituent nucleon-nucleon collisions. The final multiparticle state is viewed as a result of the creation of the longitudinally excited strings between the nucleons, which ultimately get fragmented to produce the final-state particles. In the present study, a large event sample consisting of about 5000 events pertaining to both the energies has been generated, and the results with the experiemntal findings are compared in Fig. 3. It is quite clear that the FRITIOF model behavior is quite not supporting the experimental find-

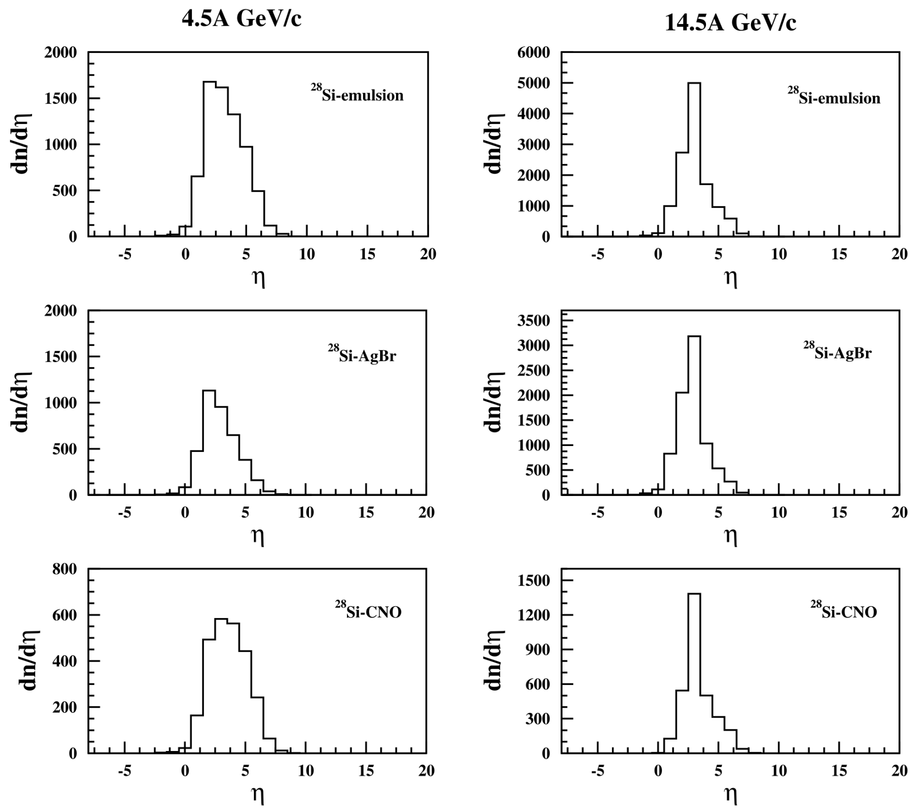

Fig. 1. Rapidity distributions of the interactions of ^{28}Si with various targets at 4.5A and 14.5A GeV/c

ings. However, the trend of the variation is the same in both cases.

In order to investigate the influence of the size of a target on the scaled variance, we present the variations of the parameter in the case of the interactions arising due to CNO and AgBr targets for both the energies considered in Fig. 4. In both cases, we see that the correlation strength has an increasing trend with the rapidity window. However, it is important to note that the scaled variance has higher values in the case of interactions caused by heavier targets at a particular rapidity window. This behavior is observed at both incident energies. Thus, we see an increase of the scaled variance toward the mid-rapidity region. Such type of behavior has been attributed to a strong correlation in the momentum space in the case of Pb–Pb collisions at various energies at CERN SPS.

Figures 5 and 6 exhibit, respectively, the comparisons of the experimental observations with those obtained from the FRITIOF model for interactions due

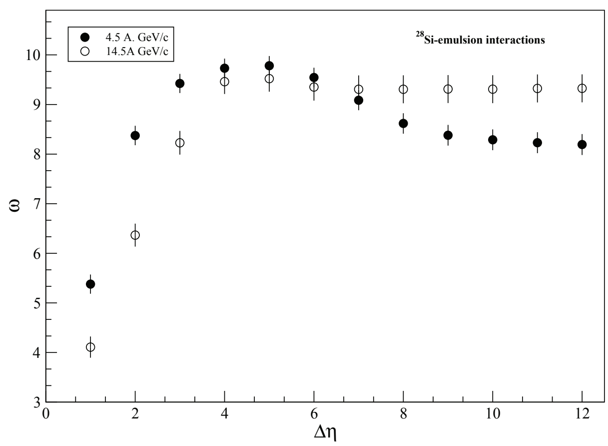

Fig. 2. Variation of the scaled variance with rapidity window for ^{28}Si-emulsion interactions at 4.5A and 14.5A GeV/c

to the CNO and AgBr targets. It is observed that the increasing trend is the same in the case of experiments, as well as the FRITIOF predictions. However, we see that, in the case of the lighter target, i.e., CNO,

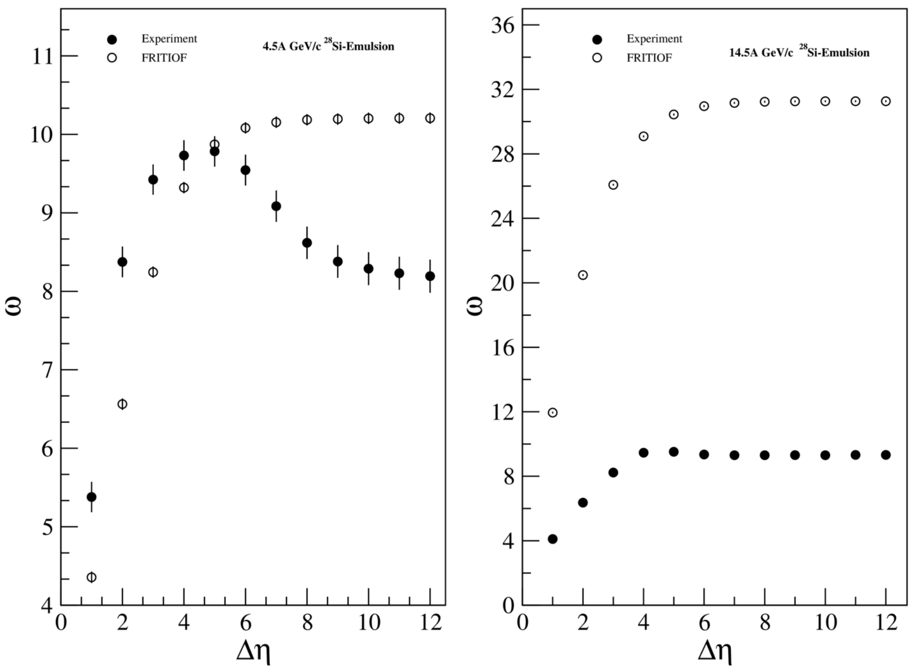

Fig. 3. Variation of the scaled variance with rapidity window for ^{28}Si-emulsion interactions at 4.5A and 14.5A GeV/c for experimental and FRITIOF data

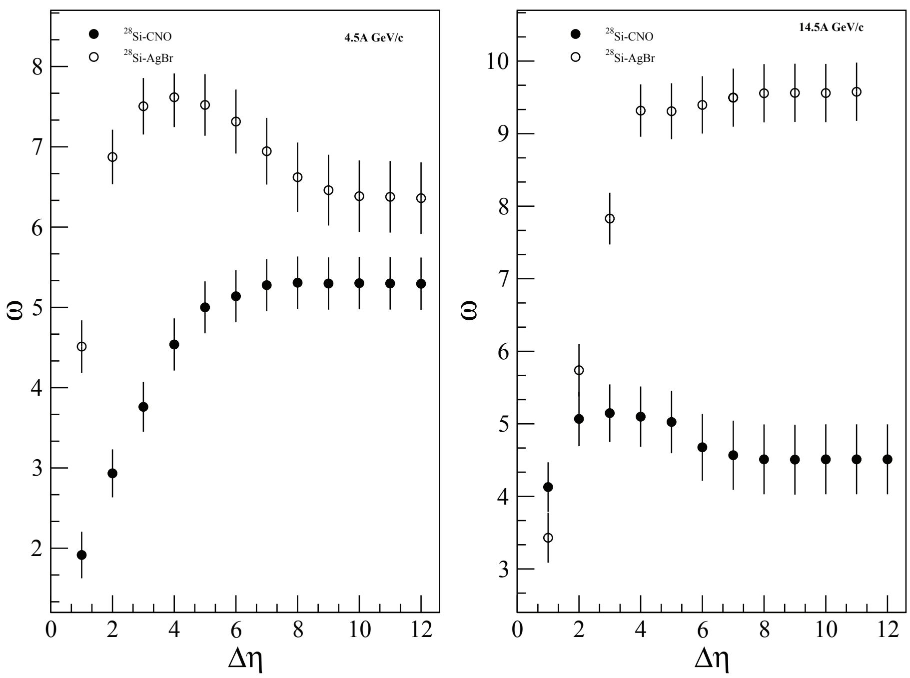

Fig. 4. Variation of the scaled variance with rapidity window for the interactions ^{28}Si with the CNO and AgBr targets at 4.5A and 14.5A GeV/c

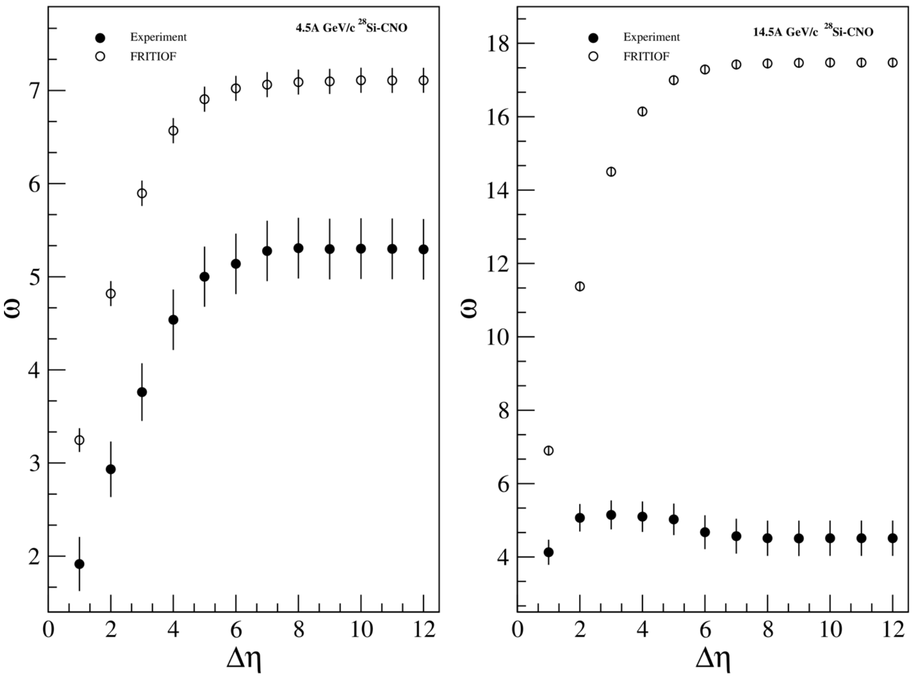

Fig. 5. Variation of the scaled variance with rapidity window for the interactions ^{28}Si with the CNO target at 4.5A and 14.5A GeV/c for experimental and FRITIOF data

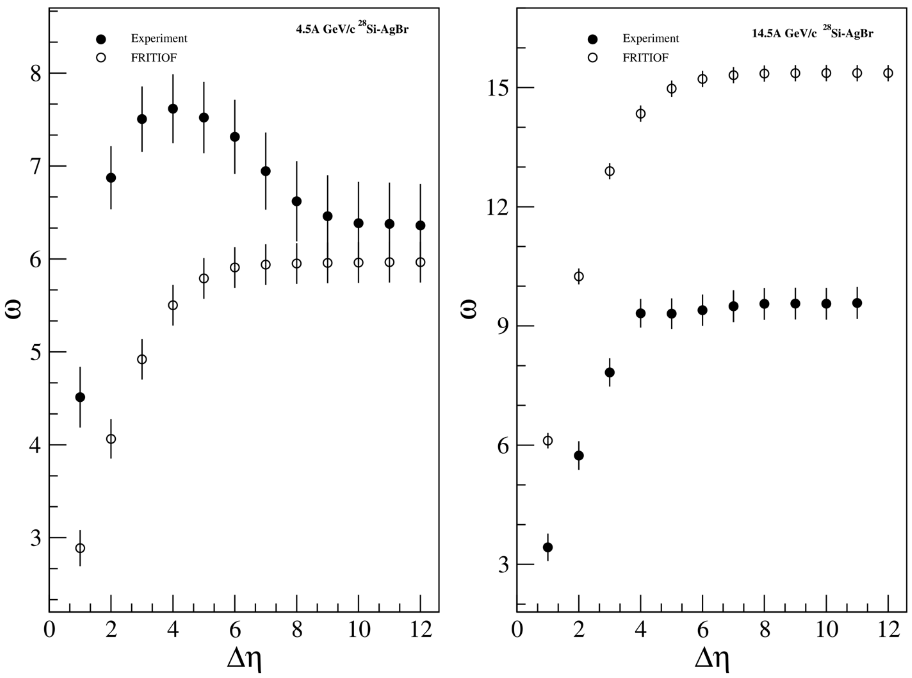

Fig. 6. Variation of the scaled variance with rapidity window for the interactions ^{28}Si with the AgBr target at 4.5A and 14.5A GeV/c for experimental and FRITIOF data

there is a smaller difference between the experimental values and the FRITIOF predictions, whereas, for the interactions due to the heavier target, i.e., AgBr, there is a considerable disagreement between the experiment and the FRITIOF. This kind of behavior has [29] been noticed earlier in the case of ^{16}O-nucleus interactions at $60A$ GeV/c.

4. Conclusions

The present study has been carried out to investigate the nature of correlations amongst the relativistic charged particles produced in the interactions of ^{28}Si nuclei with various targets at two different energies. The correlation was looked into in terms of the scaled variance ω which is considered to be close to unity for uncorrelated particles. For the interactions studied here, it is found that, for all the cases, the scaled variance is far greater than 1, thereby indicating that the multiparticle state produced in these interactions is pronouncedly correlated. We have found that the correlation is stronger in the smaller rapidity range in the case of interactions initiated by a projectile with lower energy. However, for higher energy, the correlation strength is higher at wider rapidity ranges. We also observed that the size of a target does play a role in the formation of a correlated multiparticle final state. The correlation strength is higher for the interactions corresponding to a heavier target. The results are compared with the predictions of the Lund Monte-Carlo model-based FRITIOF code, and we have found that the varying trend of the correlation strength with the rapidity range is well predicted by the FRITIOF model. But, in many interactions, the amount of correlation strength does not match with the experiment.

1. U. Heinz. Towards the little bang standard model. *J. Phys.: Conf. Ser.* **455**, 012044 (2013) [DOI: 10.1088/1742-6596/455/1/012044].
2. Y. Aoki, Z. Fodor, S.D. Katz, K.K. Szabo. The QCD transition temperature: results with physical masses in the continuum limit. *Phys. Lett. B* **643**, 46 (2006) [DOI: 10.1016/j.physletb.2006.10.021]; Y. Aoki, Sz. Borsanyi, S. Durr, Z. Fodor, S.D. Katz, S. Krieg, K.K. Szabo. The QCD transition temperature: results with physical masses in the continuum limit II. *JHEP* **0906**, 088 (2009) [DOI: 10.1088/1126-6708/2009/06/088]; S. Borsányi *et al.* Is there still any T_c mystery in lattice QCD? Results with physical masses in the continuum limit III. *JHEP* **1009**, 73 (2010) [DOI: 10.1007/JHEP09(2010)073].
3. J. Adams *et al.* Experimental and theoretical challenges in the search for the quark–gluon plasma: The STAR Collaboration's critical assessment of the evidence from RHIC collisions. *Nucl. Phys. A* **757**, 102 (2005) [DOI: 10.1016/j.nuclphysa.2005.03.085]; K. Adcox *et al.* Formation of dense partonic matter in relativistic nucleus–nucleus collisions at RHIC: Experimental evaluation by the PHENIX Collaboration. *Nucl. Phys. A* **757**, 184 (2005) [DOI: 10.1016/j.nuclphysa.2005.03.086].
4. K. Aamodt *et al.* [ALICE Collaboration]. Elliptic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV *Phys. Rev. Lett.* **105**, 252302 (2010) DOI: 10.1103/PhysRevLett.105.252302.
5. B.V. Jacak, B. Muller. The exploration of hot nuclear matter. *Science* **337**, 310 (2012) [DOI: 10.1126/science.1215901].
6. R.J. Fries, V. Greco, P. Sorensen. Coalescence models for hadron formation from quark-gluon plasma. *Ann. Rev. Nucl. Part. Sci.* **58**, 177 (2008) [DOI: 10.1146/annurev.nucl.58.110707.171134].
7. L. Stodolsky. Temperature fluctuations in multiparticle production. *Phys. Rev. Lett.* **75**, 1044 (1995) [DOI: 10.1103/PhysRevLett.75.1044].
8. M.A. Stephanov, K. Rajagopal, E.V. Shuryak. Signatures of the tricritical point in QCD. *Phys. Rev. Lett.* **81**, 4816 (1998) [DOI: 10.1103/PhysRevLett.81.4816].
9. E.V. Shuryak. Event-by-event analysis of heavy ion collisions and thermodynamical fluctuations. *Phys. Lett. B* **423**, 9 (1998) [DOI: 10.1016/S0370-2693(98)00127-0].
10. N.R. Sahoo (for the STAR Collaboration). Recent results on event-by-event fluctuations from the RHIC Beam Energy Scan program in the STAR experiment. arXiv:1407.1554 [nucl-ex] [DOI: 10.1088/1742-6596/535/1/012007].
11. G. Wilk, Z. Włodarczyk. Consequences of temperature fluctuations in observables measured in high-energy collisions. *Eur. Phys. Jour. A* **48**, 161 (2012) [DOI: 10.1140/epja/i2012-12161-y].
12. S. Borsanyi *et al.* Fluctuations of conserved charges at finite temperature from lattice QCD. *JHEP* **1201**, 138 (2012) [DOI: 10.1007/JHEP01(2012)138].
13. S. Ejiri, F. Karsch, K. Redlich. Hadronic fluctuations at the QCD phase transition. *Phys. Lett. B* **633**, 275 (2006) [DOI: 10.1016/j.physletb.2005.11.083].
14. S. Gavin, G. Moschelli. Fluctuation probes of early-time correlations in nuclear collisions. *Phys. Rev. C* **85**, 014905 (2012) [DOI: 10.1103/PhysRevC.85.014905].
15. M.I. Adamovich *et al.* Multiplicities and rapidity densities in $200A$ GeV ^{16}O interactions with emulsion nuclei. *Phys. Lett. B* **201**, 397 (1988) [DOI: 10.1016/0370-2693(88)91162-8].
16. L. Van Hove. Hadronization model for quark-gluon plasma in ultra-relativistic collisions. *Z. Phys. C* **27**, 135 (1985) [DOI: 10.1007/BF01642492]; M. Guylassy *et al.* Deflagrations and detonations as a mechanism of hadron bubble growth in supercooled quark-gluon plasmas. *Nucl. Phys. B* **237**, 477 (1984) [DOI: 10.1016/0550-3213(84)90004-X].

17. A. Bialas, R. Peschanski. Moments of rapidity distributions as a measure of short-range fluctuations in high-energy collisions. *Nucl. Phys. B* **273**, 703 (1986) [DOI: 10.1016/0550-3213(86)90386-X]; Intermittency in multiparticle production at high energy. *Nucl. Phys. B* **308**, 857 (1988) [DOI: 10.1016/0550-3213(88)90131-9].
18. R.C. Hwa, M.T. Nazirov. Intermittency in second-order phase transitions. *Phys. Rev. Lett.* **69**, 741 (1992) [DOI: 10.1103/PhysRevLett.69.741].
19. Z. Cao, R. Hwa. In search for signs of chaos in branching processes. *Phys. Rev. Lett.* **75**, 1268 (1995) [DOI: 10.1103/PhysRevLett.75.1268]; Chaotic behavior of particle production in branching processes. *Phys. Rev. D* **53**, 6608 (1996) [DOI: 10.1103/PhysRevD.53.6608]; Fluctuations and entropy indices of QCD parton showers. *Phys. Rev. D* **54**, 6674 (1996) [DOI: 10.1103/PhysRevD.54.6674].
20. R.C. Hwa, C.B. Yang. Local multiplicity fluctuations as a signature of critical hadronization in heavy-ion collisions at TeV energies. *Phys. Rev. C* **85**, 044914 (2012) [DOI: 10.1103/PhysRevC.85.044914].
21. B. Zhang, C.M. Ko, B.A. Li, Z.W. Lin. Multiphase transport model for relativistic nuclear collisions. *Phys. Rev. C* **61**, 067901 (2000) [DOI: 10.1103/PhysRevC.61.067901].
22. Z.-W. Lin, C.M. Ko, B.-A. Li, B. Zhang, S. Pal. Multiphase transport model for relativistic heavy ion collisions. *Phys. Rev. C* **72**, 064901 (2005) [DOI: 10.1103/PhysRevC.72.064901].
23. W. Ochs. Multidimensional intermittency analysis. *Z. Phys. C* **50**, 339 (1991) [DOI: 10.1007/BF01474088].
24. M. Gaździcki, M.I. Gorenstein, S. Mrówczyński. Fluctuations and deconfinement phase transition in nucleus–nucleus collisions. *Phys. Lett. B* **585**, 115 (2004) [DOI: 10.1016/j.physletb.2004.01.077].
25. M.A. Stephanov, K. Rajagopal, E.V. Shuryak. Event-by-event fluctuations in heavy ion collisions and the QCD critical point. *Phys. Rev. D* **60**, 114028 (1999) [DOI: 10.1103/PhysRevD.60.114028].
26. C. Alt *et al.* (NA49 Collaboration). Energy dependence of ϕ meson production in central Pb + Pb collisions at $\sqrt{s_{NN}} = 6$ to 17 GeV. *Phys. Rev. C* **78**, 044907 (2008) [DOI: 10.1103/PhysRevC.78.044907].
27. M. Daugherity *et al.* (STAR Collaboration). *J. Phys. G* **35**, 104090 (2008) [DOI: 10.1088/0954-3899/35/10/104090].
28. C. Alt *et al.* (NA49 Collaboration). Energy dependence of particle ratio fluctuations in central Pb + Pb collisions from $\sqrt{s_{NN}} = 6.3$ to 17.3 GeV. *Phys. Rev. C* **79**, 044910 (2008) [DOI: 10.1103/PhysRevC.79.044910].
29. D. Ghosh *et al.* Rapidity dependence of multiplicity fluctuations and correlations in high-energy nucleus–nucleus interactions. *Pramana J. Phys.* **77**, 297 (2011) [DOI: 10.1007/s12043-011-0131-2].
30. B. Andersson, G. Gustafson, B. Nilsson-Almqvist. A model for low-p_T hadronic reactions with generalizations to hadron-nucleus and nucleus-nucleus collisions. *Nucl. Phys. B* **281**, 289 (1987) [DOI: 10.1016/0550-3213(87)90257-4];
B. Nilsson-Almquist, E. Stenlund. Interactions between hadrons and nuclei: The Lund Monte-Carlo – FRITIOF version 1.6. *Comp. Phys. Comm.* **43**, 387 (1987) [DOI: 10.1016/0010-4655(87)90056-7].
31. A. Shakeel *et al.* Cluster production in 14.5A GeV/c Si-nucleus collisions. *Int. J. Mod. Phys. E* **08**, 121 (1999) [DOI: 10.1142/S0218301399000094].
32. W. Bari *et al.* Intermittency in 4.5A and 14.5A GeV/c ^{28}Si-nucleus interactions. *Int. J. Mod. Phys. E* **11**, 131 (2002) [DOI: 10.1142/S0218301302000740].
33. C.F. Powell, P.H. Fowler, D.H. Perkins. *The Study of Elementary Particles by the Photographic Method* (Pergamon Press, 1959).
34. R.A. Fini (ALICE Collaboration). Multiplicity of charged particles in relativistic heavy-ion interactions. *Nucl. Phys. A* **749**, 325 (2005) [DOI: 10.1016/j.nuclphysa.2004.12.061].
35. B. Lungwitz (NA49 Collaboration). Energy, rapidity and transverse momentum dependence of multiplicity fluctuations in heavy ion collisions at CERN SPS. arXiv:0709.1646v2 [nucl-ex] (2007).

Received 19.12.15

В. Барі, Н.А. Разер

ЧУТЛИВІСТЬ ФЛУКТУАЦІЙ
МНОЖИННОСТІ ДО ШВИДКОСТІ
У ВЗАЄМОДІЇ ЯДЕР ПРИ ВИСОКИХ ЕНЕРГІЯХ

Р е з ю м е

Досліджено флуктуації множинності релятивістських заряджених частинок, народжених у взаємодії ^{28}Si ядер при двох різних енергіях у термінах масштабованої дисперсії. Як основну модельну умову використано розширення діапазону псевдошвидкості в обидва боки від центрального значення швидкості, яке визначається за розподілом швидкості для кожної взаємодії. Вивчено залежності флуктуацій множинності від енергії налітаючого ядра і розміру мішені. Проведено порівняння з результатами моделі кварк-глюонної струни.