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Physics

Model Correlators in VHM Region

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ABSTRACT. Correlation characteristics of high energy very high multiplicity interactions are investigated.

Key words: *very high multiplicity, correlation analysis, thermalization.*

1. Introduction

The physics of hadron interactions at low energies deals with a small number of secondaries. An effective method has been created for analysis of such events. It allows to discover many new interesting phenomena of particle physics. Increase of hadron energies and usage of accelerated ions lead to interactions with some hundred and thousand particles in the final state and the old methods of their analysis have become ineffective. Simple prolongation of old methods on the high multiplicity events leads to serious computational difficulties. In the present state of affairs it is very urgent to look for new dynamical characteristics of many-particle state which may describe their collective property.

The momenta distribution, correlators, of course, remain actual for arbitrary inelastic events. But in the papers [1, 2] the ratio of correlators K_3 to K_2 was introduced as an important characteristic of the thermalization of the system of produced particles. In this work we investigate properties of this ratio and a new generator of events was created for this purpose.

2. Correlation analysis

A large base of experimental data is necessary for high-quality statistical analysis of many-particle state. Several event generators are used since the volume of experimental data is constrained and access to these is usually limited. We chose the fast phenomenological events generator for our investigation of $p-p$ inelastic interactions. It was fitted to the experimental data [3].

We study the question of how correlations may influence the momenta distribution of particles. To this end we build a histogram by two methods. In the first case we fill all bins of the histogram with the values of momenta. We denote this method as "correlated approach". In the latter case we open only one bin to except the influence of fullness of bin on the population of data in another bin and fill it. Fig. 1 illustrates the scheme of this numerical experiment. We simulated events of the following type:

$$p+p\to p+p+\underbrace{\pi^0+\ldots+\pi^0}_{10}, \qquad (1)$$

using the generator at energy $\sqrt{s}$ = 11.54GeV. Fig. 2 presents momentum distributions of π° mesons of both approaches. We can see the statistical identity of both approaches.

Correlation function contains important information about the behavior of the system of particles. If we know the function of momenta distribution $\psi(p)$ and binary distribution function $\psi(p_1,p_2)$ (i.e. probability to find two particles with momenta p_1 and p_2 simultaneously) we can define the two-particle correlation function:

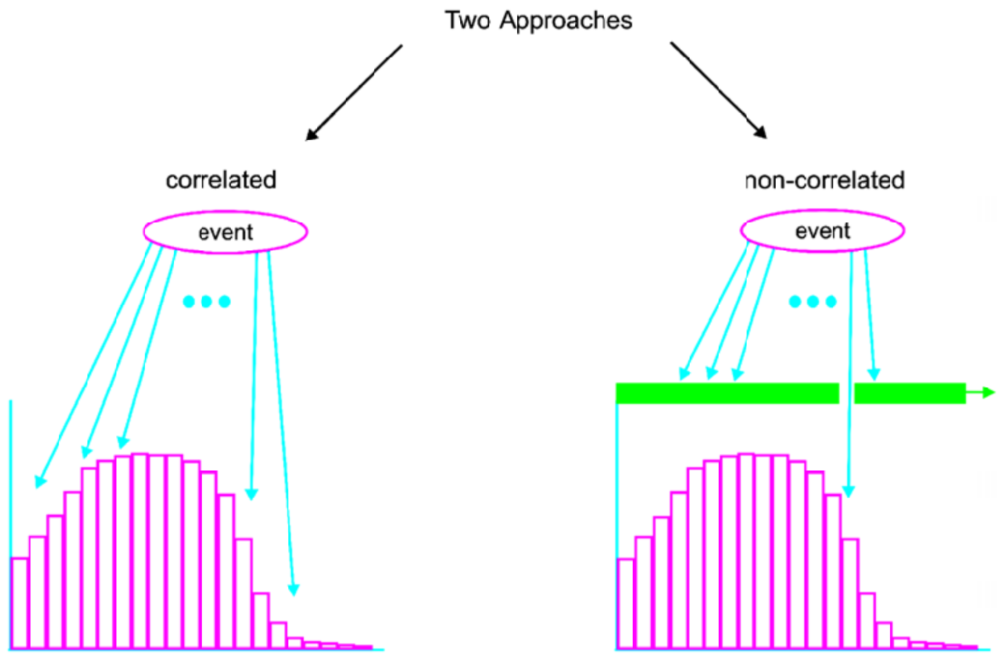

Fig. 1. Scheme of numerical experiment for study of the influence of correlation on the momenta distribution of particles.

$$C_2(p_1,p_2)=\psi(p_1,p_2)-\psi(p_1)\cdot\psi(p_2). \qquad (2)$$

Fig. 3 presents the two-particle correlation function for collision (1), where p_1 and p_2 are momenta of $\pi°$-mesons. The $\pi°$-mesons are strongly correlated in the area where momenta are less than *2GeV/C* as it follows from Fig. 3:

$$C_2(p_1,p_2)\sim 0 \ \text{if}\, p_1>2\text{GeV/C} \ \text{or}\, p_2>2\text{GeV/C}. \qquad (3)$$

3. Parameter of thermalization

Let us consider now the parameter of thermalization [1]. The so-called ratio "K_3 to K_2" is described by the following equalities. If

$$E_1=\frac{1}{n}\sum_{i=1}^{n}p_i\,,$$

$$E_2=\frac{2}{n(n-1)}\sum_{i<j}^{n}p_ip_j\,, \qquad (4)$$

$$E_3=\frac{6}{n(n-1)(n-2)}\sum_{i<j<k}^{n}p_ip_jp_k\,,$$

then K_2 and K_3 have the definitions:

$$K_2=E_2-E_1^2\,, \qquad (5)$$

$$K_3=E_3-3E_1E_2+2E_1^3 \qquad (6)$$

and ratio K_3 to K_2 is:

$$R=K_3/K_2^{3/2}. \qquad (7)$$

Fig. 4 demonstrates the behavior of the ratio K_3 to K_2 as a function of neutral pions multiplicity.

The procedure of calculation of ratio K_3 to K_2 using equations (4)-(7) is inconvenient and needs a long time, particularly, for a very high multiplicity case. Let us in-

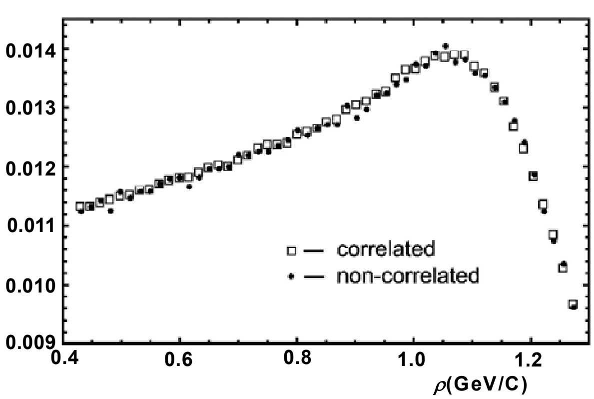

Fig. 2. Momenta distributions of $\pi°$-mesons for correlated and non-correlated approach. The figure presents only part of distribution, because in the full distribution picture for $p \subset 0.\sim 3.66$GeV/C curves are interflowed.

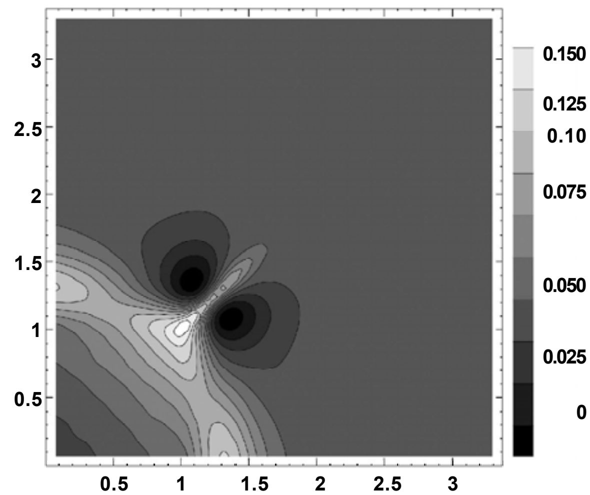

Fig. 3. Two-particle correlation function.

troduce new variable ε_i, which is relatively a deviation from the mean value:

$$p_i = \bar{p}(1+\varepsilon_i), \qquad (8)$$

where $\bar{p} \equiv E_1$ is the mean value. It follows from the definition of ε_i that:

$$\sum_{i=1}^{n} \varepsilon_i = 0\,. \qquad (9)$$

Substituting (8) into (4) we find that:

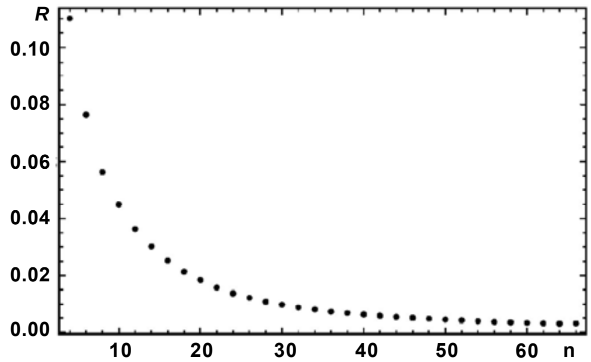

Fig. 4. Ratio K_3 to K_2 as function of multiplicity of neutral pions in the final state.

$$E_2 = \bar{p}^2 - \frac{\bar{p}^2}{n(n-1)} \sum_{i=1}^{n} \varepsilon_1^2\,, \qquad (10)$$

$$E_3 = \bar{p}^3 - \frac{3\bar{p}^3}{n(n-1)} \sum_{i=1}^{n} \varepsilon_1^2 + \frac{2\bar{p}^3}{n(n-1)(n-2)} \sum_{i=1}^{n} \varepsilon_1^3\,. \qquad (11)$$

For K_2 and K_3 we receive the following equalities:

$$K_2 = \frac{\bar{p}^2}{n(n-1)} \sum_{i=1}^{n} \varepsilon_1^2\,, \qquad (12)$$

$$E_3 = \frac{2\bar{p}^3}{n(n-1)(n-2)} \sum_{i=1}^{n} \varepsilon_1^3\,. \qquad (13)$$

As a result, the ratio K_3 to K_2 has the form:

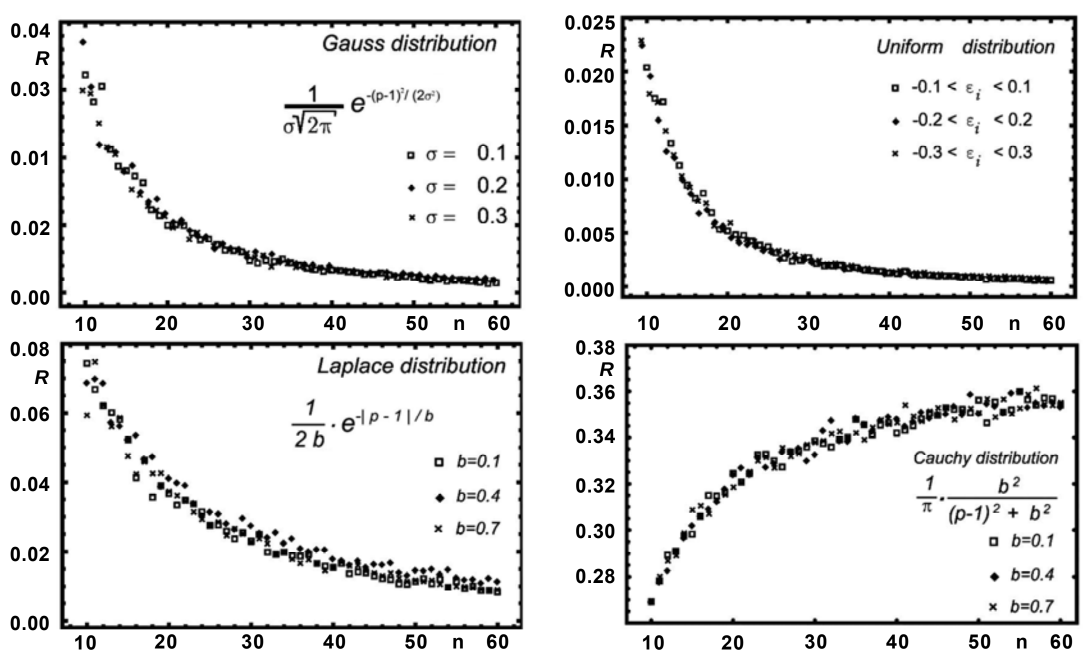

Fig. 5. Ratio K_3 to K_2 for various distributions.

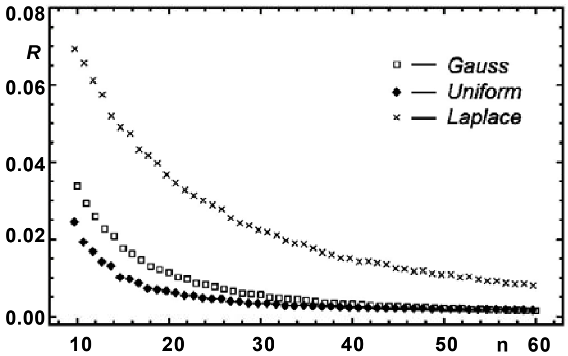

Fig. 6. The ratio K_3 to K_2 for various "elementary" distributions.

$$R = 2\frac{\sqrt{n(n-1)}}{n-2}\cdot\frac{\sum\varepsilon_1^3}{\left[\sum\varepsilon_1^2\right]^{3/2}}. \qquad (14)$$

We test the ratio K_3 to K_2 for different classical distributions with various values of parameters as a function of multiplicity. Fig. 5 presents the result of simulations. We see a weak dependence on the distribution parameters.

4. Conclusion

Our investigations allow us to make the following conclusions.

Correlated and non-correlated approaches are identical, this being a very important fact. We gain the possibility of saving time since non-correlated approach requires several orders greater higher statistics.

The ratio K_3 to K_2 does not depend on its mean value as it follows from the eq.(14). Fig. 5 demonstrates the dependence of ratio K_3 to K_2 from the distribution parameters.

In Fig. 6 we join the example in one picture to demonstrate the strong dependence on the distribution type.

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ფიზიკა

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REFERENCES

1. *J. Manjavidze, A. Sissakian* (2001), Phys. Rep., **346**, 1.
2. *Дж.А. Будагов, Я.А. Руссакович, А.Н. Сиссакян* (2004), Ядерная физика, **67**: 70.
3. *N. Shubitidze*, Event Generator for *pp* Interactions., JINR Preprint E1-2006-178.

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