WHY THE VERY HIGH MULTIPLICITY EVENTS ARE RARE

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The possibility to suppress the nonperturbative effects choosing the vary high multiplicity final state is discussed. The theoretical uncertainties and the experimental observable consequence of this choice are discussed.

1. The topic of present report is to show the reason *why the experiments with Very High Multiplicity (VHM) final state of hadrons may be important.* Actually, we imply here that the investigations in VHM region may give the information which is not attainable in other experiments.

One of the reasons of necessity to examine the VHM processes is connected with following fundamental question:

$\star$ *Why the VHM events are so rear*?

In other words, we offer look into the question: why the mean multiplicity in the hadron processes is so small ($\sim \ln^2 s$) in comparison with the multiplicity threshold value ($\sim \sqrt{s}/m_\pi$).

Present paper is based on the described in [1] idea that the very hot cup of tea cooling in the very cold room is the analogy of VHM process. Intuitively we know that in this case the cooling process should proceed quickly.

In field-theoretical terms the "fastness" of process means that the decay of virtual coloured partons on secondaries should prevail over its dispersion from interaction zone. This becomes possible if and only if the parton virtuality is high enough: if the "virtuality" of constituent is $|q|^2$ then the life time of such object $\sim 1/|q|^{\ 2}$. But this means that the process should be hard.

In addition, the produced particle in VHM kinematics have the low energies. Last one singles out VHM processes from other hard processes (i.e., from hadron production in the e^+e^--annihilation process, or DIS processes, etc.).

Fig.1 defines the range of VHM domain. But it should be stressed that, in definite sense, this determination is conditional and depends on the model.

Yet, we will assume that the multiperipheral kinematics governs the dynamics in the range **A**. The range **B** assumes that the particle momentum is

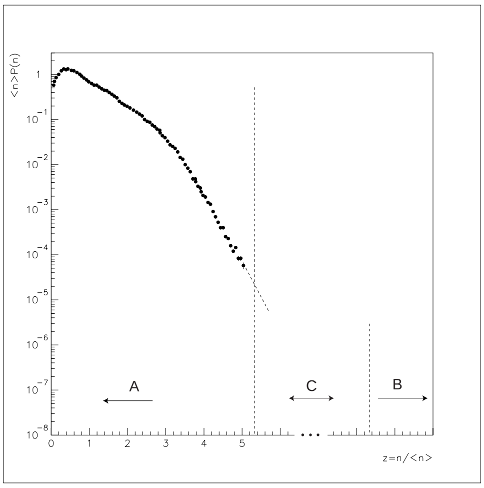

Figure 1. Multiplicity distribution. Points are E735 (Tevatron) data. **C** is the VHM region.

less then its mass and for this reason the dynamics did not play any role in it. We will assume that $n << n_{max} = \sqrt{s}/m_\pi$. So, we would interested in the range **C**, where the "trivial" multiperipheral picture do not work, but the dynamics is still important.

2. The standard point of view on hadron dynamics based on the fact that it is "soft", the diffraction radii increase with energy and the mean transverse momentum of secondaries is approximately constant. This picture is described, actually postulating, by, so called, *soft Pomeron* model [3].

This soft processes may be approximated by the very spatial class of ("ladder") Feynman diagrams of perturbative quantum chromodynamics (pQCD). This is so called "*BFKL Pomeron*" approach [4]. Both model absorb the condition that the dynamics of main multiple production processes is restricted. In the *soft Pomeron* case this constrains are the "hidden conservation laws" as the consequence of underlying non-Abelian gauge symmetry. The LLA ideology is used in the *BFKL Pomeron* case.

The constrains restrict production dynamics and the mean multiplicity in that way constraint processes must be small, i.e. $n << n_{max}$ should be important.

So, this constrains should be suppress to have the VHM final state. Notice also that the long-range constrains suppression assume change of mechanism of particles production in the VHM region **C**. Discussed scenario would realized if (i) the hard processes may prevail over the soft ones and if (ii) the hard processes may lead to the "fast" production.

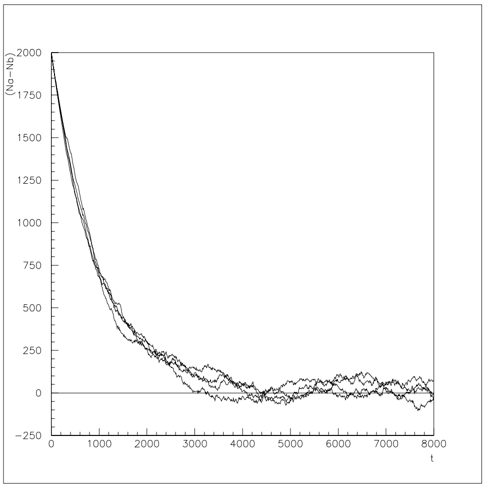

Figure 2. Particles production in the Markovian process

Formal prove contains following steps [1,5]. So, it can be shown that if the "final-state" interaction are excluded then the soft processes may provide only following asymptotics: $\sigma_n^s < O(e^{-n})$. On other hand, the hard process gives following asymptotic estimation: $\sigma_n^h = O(e^{-n})$. Therefore, one always may find such energy $\sqrt{s}$ and multiplicity n that $\sigma_n^h >> \sigma_n^s$ for $n << \sqrt{s}/m_\pi$. This proves (i).

The qualitative argument in favor of (ii) follows from the Eurenfest-Kac model [6] of the irreversibility phenomenon. It shows that if initial state is far from final one then the system goes to equilibrium *as fast is possible*, see absence of fluctuations on the early stage of the process on Fig.2.

The formal prove of supposition (ii) uses the KNO-scaling form of the particles number distribution in the pQCD jets [7].

3. We know well that it is necessary to have definite proportional to the particle energy ε "formation length" for particle production in the hadron-ion collision. For this reason the mean multiplicity in the hadron-ion collision is comparatively small, it is proportional to the radii of ion.

To have the VHM final state one should have enormous reproduction. So, the VHM final state may produced in hadron-ion collisions if the "formation length" is always smaller than the ion radii. In this case all nucleon work in the process of particles production. So, the VHM states production is the "volume effect": the measurable should dependent on the whole number of the ion constituents. The detailed investigation of the VHM states in the ion-ion collision is intensively performed.

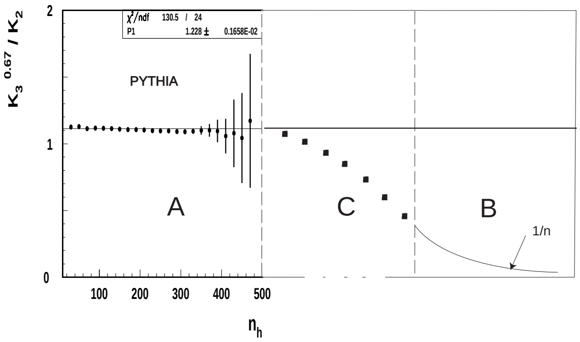

Figure 3. Ratio $R(n,s) = |K_3|^{2/3} \,/\, |K_2|$ vs. multiplicity. PYTHIA prediction in **A**.

It was shown that the VHM processes should be hard. Then, one can say that such process is freely evolves. It is the important observation since allows to conclude that the final state reach in this case *the equilibrium condition* [1,8].

Observed hadron system contains definite number of constrains, but not enough to suppress the particle production completely. This conclusion follows from existence of large multiplicity fluctuations, see Fig.1. But in the domain **A** the constrains are important and mean multiplicity is small in comparison with n_{max}. We investigate this conclusion theoretically and the result is following: in the region **B** the system without fail is equilibrium.

We found the experimentally measurable characteristic, which measures the "equilibrium phenomena". For instance, absence of energy correlations mean the thermal equilibrium. We would like to underline that the condition $R = |K_3|^{2/3}/|K_2| < 1$ is the necessary and sufficient condition of thermalization. The quantity K_l is the l-particle central energy correlator, $l = 2, 3, ...$

Fig.3 shows the Monte Carlo simulation of the ration $R(n,s)$ for domain **A** using PYTHIA generator of events. Absence of thermalization in the domain **A** is natural since PYTHIA resembles the Regge model. At the same time, it is simple to show that in the region **B** the system without fail should reach the thermal equilibrium: $R \sim 1/n$ in this domain.

We can conclude that VHM processes

(i) allows to investigate the hadron dynamics beyond standard (multiperipheral) kinematics,

(ii) are hard and the influence of the hidden constrains do not play the important role,

(iii) can not be described using ordinary LLA ideology [10],

(iv) allows to reach the thermal equilibrium,

We would like to add at the very end that, as follows from above conclusion, the VHM processes are the source of *dense*, *cold* and *equilibrium* locally coloured state (plasma).

Acknowledgments

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