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HIGH MULTIPLICITY STUDY*

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The multiparticle production problems are analyzed in the high multiplicity region. Some collective phenomena can be revealed in this region. The results obtained on *Thermalization* project are reported.

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1. Introduction

The multiparticle production is one of important topics of high energy physics. The particular interest in *Thermalization* project is related with hadron and hadron–nucleus interactions with the extremely large number of secondaries (much more than the mean multiplicity) [1]. This region is called the high multiplicity (HM) region. The following collective phenomena have been predicted in it: the Bose–Einstein condensate (BEC) formation [2], ring events (gluon Čerenkov emission) [3], certain grouping of secondaries (clusterization) [4] and also high exit of soft photon emission in comparison with the estimations obtained in quantum electrodynamics [5].

The existing theoretical models and most of Monte-Carlo generators are in disagreement with their estimations on multiplicity behavior predictions in this extreme region. The main trouble in carrying-out these experimental investigations consists in registration of very rare events. *Thermalization* project is aimed at studying the collective behavior of secondaries in proton and proton–nucleus interactions on the U-70 accelerator at IHEP (Protvino): $p + p(A) \rightarrow n_\pi \pi + 2N$.

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The experiment is carried out on SVD-2 (Spectrometer with a Vertex Detector) setup. By now the experimental data on topological cross-sections at U-70 energies are measured up to 18–20 charged particles. In our experiment it is scheduled to advance in HM region. Sec. 2 gives a brief description of the setup. Sec. 3 informs about collective phenomena whose existence or absence is planned to confirm by the obtained and future data.

2. Experimental setup

The SVD-2 setup includes a liquid hydrogen target, a drift tubes tracker, a magnetic spectrometer, a multichannel Čerenkov counter, an electromagnetic calorimeter, and a scintillator hodoscope which generated the trigger signal to register the HM events [1]. The target is a vessel for liquid hydrogen 7 cm thick and 3.5 cm in diameter. A straw tube chamber or drift tracker is supplemented with front end boards with preamplifiers and TDC modules to detect several pulses consequently coming from the anode on each trigger signal. The middle plane dimension is 70×70 cm^2. The total number of channels is about 2400. The found resolution of this detector reaches 250–300 μm and the installation effectiveness is not lower than 99.9%.

The scintillation hodoscope makes a signal which allows one to register events with not lower than the specified multiplicity level. Besides, this hodoscope is so thin that does not distort the angular and momentum resolution of the setup. This equipment gives out an exit signal of a 250 mV voltage for MIP at the 25 mV noise level. The complete signal width is shorter than 20 ns. At present these perfect characteristics are not possible to get in any silicon system except this scintillator hodoscope.

The main element of SVD-2 setup is a vertex detector. It permits to reconstruct the interaction vertex at a high degree of accuracy. The magnetic spectrometer includes 18 proportional chambers. The magnet MC-7A produces the field inside the spectrometer placed 3 m from the target. The electromagnetic calorimeter consists of 1536 full absorption Čerenkov counters. Radiators made from lead glass are connected with PMT-84-3. The accuracy of the γ quantum coordinate reconstruction is equal to ~ 2 mm.

3. Collective phenomena

The main task of *Thermalization* project is related with search and study of collective phenomena. The soft photon excess, the ring events, the Bose–Einstein condensation formation and other phenomena can be considered as the evidence of the collective behavior of secondary particles. The estimations of the soft photon (smaller than 40 MeV) number obtained with quantum electrodynamics are by few times smaller than the data [5]. Van

Hove and Lichard explained this excess in their model [6]. According to it the source of these photons is the "cold spot" emission of quarks and/or gluons at evaporation.

It is known that secondary particles are distributed nonuniformly in the phase space of rapidity and transverse momentum. Preliminary data processing results obtained in 2002 run at SVD (nuclear targets) have shown (Fig. 1) the appearance of ring events (Čerenkov gluon emission) in high multiplicity region [7]. The two-bump structure appears from the projection of the pseudorapidity distribution on the ring diameter. It was observed for away-side jets at RHIC [8]. The peak positions and their altitude defined by the hadronic medium properties (the nuclear index of refraction, parton density, the free path length and the energy losses of Čerenkov gluons).

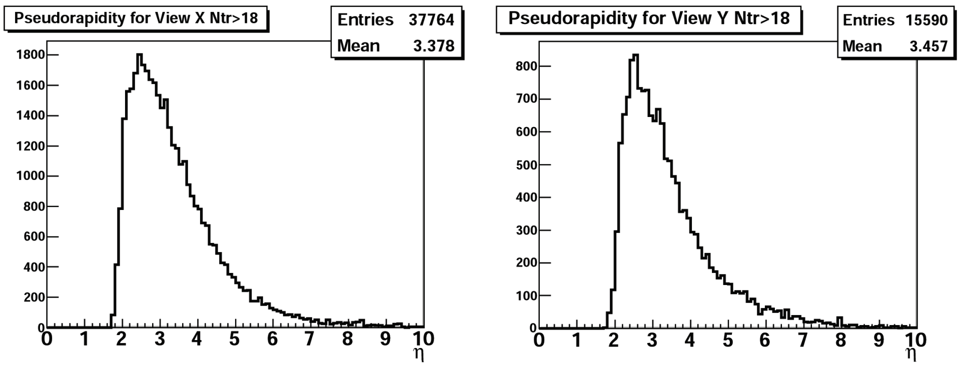

Fig. 1. The pseudorapidity spectra in pPb at $n > 18$.

The pions (charged and neutral) are copiously formed at 70 GeV and are spin-zero bosons. Their momenta are approaching to zero in the HM region. The Bose–Einstein condensation may be formed in this system. The pion number fluctuations will be a prominent signal of approaching the BEC point [2] in the ideal Bose gas model. The chemical potential is increasing at the fixed particle number density with the temperature decreasing and becomes equal to zero at $T = T_{\mathrm{C}}$ known as the BEC temperature $T = T_{\mathrm{C}}$. In this point the pions reach their lowest energy state.

Gorenstein and Begun suggested that the pion system may reach the global thermodynamical equilibrium in the HM region with parameters close to BEC-line. They had studied the scaled variance behaviour ω^0 defined by expression $\omega^0 = \frac{\langle(\Delta N)^2\rangle}{\langle N\rangle}$ and predicted an abrupt and anomalous increase of the scaled variance of fluctuations of neutral and charged pion number in the vicinity of the BEC line [2]. *Thermalization* project can carry out the experimental check of this prediction.

The collective phenomena depend on hadronization and confinement mechanisms, and QCD-vacuum properties. Consequently the experimental discovery of the new collective phenomena and their properties study give information about the multiparticle production mechanism and the evolution of the excited hadron system.

We proposed a gluon dominance model (GDM) for multiparticle production study [9–11]. It is based on the main QCD essentials and phenomenological hadronization scheme. The multiplicity distribution calculations have been carried out in the framework of GDM in lepton and hadron processes. The principal result of this model related with the active behaviour of gluons and the passive behaviour of valent quarks. Our model has confirmed the recombination mechanism of hadronization in hadron and nucleus interactions. The cluster mechanism of multiparticle production indicates the finite number of charged, neutral, and total secondaries produced in pp-collisions at 70 GeV and higher. We are planning to move forward to the HM region and verify these predictions.

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