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STUDY OF PROPERTIES OF DENSE FLUCTUATIONS OF NUCLEAR MATTER USING HIGH-ENERGY DEEP-INELASTIC eA SCATTERING.

Proposal for European Electron Facility

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STUDY OF PROPERTIES OF DENSE FLUCTUATIONS OF NUCLEAR MATTER USING HIGH-ENERGY DEEP-INELASTIC eA SCATTERING: Preprint ITEP 93-24/

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The experimental program for studying the local few-nucleon clusters in nuclei based on hA and eA interaction data is suggested. The best experimental conditions for these studies, which could be achieved at European Electron Facility, are discussed. Trigger condition and estimation of necessary working time, having in mind Large acceptance detector are presented.

Fig. - 10. ref - 46

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1 Cumulative particle physics - QCD in nuclear matter.

Inelastic interactions of a high-energy projectile with close groups of nucleons in a nucleus have been discovered at ITEP more than twenty years ago [1], when fixed nuclear targets were irradiated with proton beam from ITEP 10 GeV machine and fast proton (with momentum up to 1 Gev/c) emission backward in the laboratory frame was studied. In the antilaboratory frame such a particles exceed the single nucleon momentum level. These particles are considered as a result of process in which few initial nucleon momentum cumulated into secondary hadron, and have been called "cumulative"[2]. Now this term is commonly used for particles emitted beyond the projectile - free nucleon kinematics, and sometimes also for all fast ($T_{kin} \gg \epsilon$, where ϵ - binding energy of nucleus) secondary particles in nuclear fragmentation region. The features of cumulative particle production in hadron-nucleus interactions have been investigated in details [3] by large groups of physicists mainly at ITEP (Moscow) and JINR (Dubna).

According to modern models the cumulative products appear as a result of interaction of projectile with a dense fluctuation of nuclear matter (flucton) termed in the literature either as a short-range nucleon correlation [4] or more likely multiquark bag [5].

Now we have a lot of experimental data on cumulative particle production, mainly in hadron-nucleus collisions. These data could not be explained as a whole in terms of traditional nuclear physics. Some of the most striking and unexpected results illustrates this statement.

Fig.1 shows the cumulative particle spectra in $p(10GeV)Ta \rightarrow h(120^{\circ} lab. fr.)X$ reaction [6] as a function of minimum target mass α (in nucleon mass units). Inclusive spectra are described in terms of invariant cross section defined as follows

$$f = E \cdot \frac{d^3\sigma}{d^3\vec{p}} \tag{1}$$

One can see from the figure, that experimental data extended up to $\alpha > 3$ and it is impossible to speak about a small correction on traditional nuclear physics picture due to Fermi-motion to explain this result.

The inclusive cross section fall exponentially with increasing of α and the slope parameter $\approx m_{\mu}$. This is the typical value for high energy particle physics and $\gg \epsilon$ which is typical for low energy nuclear physics. It means, that cumulative particle production can be considered as the processes with large momentum transfer. The characteristic scale of the size for this process $\leq r_A$, where r_A is the nucleon size.

When the cumulative particle spectra for different polar angle have been compared the $p_\perp$ dependence of inclusive cross section turn out to be faint, so that $\langle p_\perp \rangle > 1GeV$ for $\alpha \gg 1$.

Fig.2 shows the A - dependence of slope-parameter of inclusive spectra in terms of divergence of the value of this parameter for separate target from the value of this parameter been averaged for all targets [7]. One can see that this divergence is less then 2 % , for $A > 10$. This value much smaller than the difference between nucleus in binding energy and mean Fermi - momentum. It means, that this slope is the characteristic of nuclear matter (or, more correctly, its dense fluctuation) in contrast to Fermi-momentum and binding energy which is the characteristic of a nucleus.

Fig.3 shows the n/p ratio for cumulative nucleons production in $\pi^{\pm}(5GeV)Pb \rightarrow N(120^{\circ} lab.fr.)X$ reaction as a function of cumulative neutrons and protons kinetic energy T [8]. One can see that this ratio (which is symmetrised with respect to the initial particle charge) differ from N/Z ratio (which is ≈ 1.52 for Pb) and ≈ 1. This is only one example of contradiction between cumulative particle production results and some of its trivial interpretations (such as rescattering or fragmentation models).

The similar effect one can see in Fig.1: $\pi^+/\pi^- \approx 1$ for Ta nucleus ($N/Z \approx 1.48$). It is interesting to remember that the ratio of d/u quarks is smaller then N/Z and not so far from 1: in heavy nucleus $d/u \approx 1.15$.

The α dependence are similar for different secondaries (see Fig.1). It also may be considered as indirect argument for quark level of process of cumulative particle production.

According to hypothesis of A.M.Baldin and coworkers (see, for example, [9]) the α dependence of spectra of different cumulative particles is closely connected with quark-parton nuclear structure function. In this case the ratio of inclusive cross sections of different secondaries one can attribute to hadronization process.

One more detail can be seen in Fig.1: the ratio $K^+/\pi^+ \approx 1$ at fixed α . High level of this ratio is only one of many facts, which support the analogy between a cumulative particle production source and QGP [10] . It is clear, that in the case of cumulative particle production one can say about a small droplets of baryon-rich plasma only.

Undoubtedly that the experimental study of the cumulative particle production provides an information which, in principle, can not be obtained in hydrogen target experiments. As well some questions may concern the fundamental problems of QCD:

- the measurements of flucton size (as a function of the number of valence quarks) would give an information for the solution of confinement problems
- hadronization in the nuclear matter differs from the vacuum one so the produc-

tion features of different cumulative particles at different conditions would modify and/or even discriminate some models of hadronization

- large energy deposition in local and dense flucton would lead to formation of exotic state of nuclear matter, for example droplets of baryon-rich QCD plasma [10].

We propose to use the new Europian Electron Facility to investigate the properties of flucton and mechanism of cumulative particle production, because of some principal advantage of this facility are very important to achieve the success in this part of nuclear physics.

2 Scenario of cumulative particle production in hA interaction and its modification for lepton-nucleus interaction.

To understand the principal advantage of new electron accelerator in studying of cumulative process one should compare the scenario of cumulative particle production in hadron-nuclear and lepton-nuclear collision [11].

Fig. 4(a). hA interaction. The incident hadron is considered as a quark-gluon jet which successively interacts in the nuclear matter both with separate nucleons and with any kind of fluctons. These fluctons may be short-range few-nucleon clusters or multi quark bags (MQB) with radii of about $1fm$. The hadronization of high energy quark-gluon jet occurs outside the nucleus. The products of fragmentation of excited flucton are hadronized in nuclear matter (and this is one of the most intrigue question) into different particles ($p, n, \pi, K, \Lambda, \bar{p}$...) including cumulative ones.

A lot of experimental data support this scenario for hA interaction. The most direct confirmation of space-time picture of this process was obtained in correlation measurements for two hadrons at small relative momentum [12]. A part of the data on cumulative particle correlation at small relative momentum q [13] is shown in Fig.5(a,b,c). The q -dependence of correlation function

$$R = \frac{\sigma_{in} \cdot \frac{d^6\sigma}{d^3p_1 d^3p_2}}{\frac{d^3\sigma}{d^3p_1} \cdot \frac{d^3\sigma}{d^3p_2}} \qquad (2)$$

is shown in Fig.5a for pair of cumulative protons in $p(7.5GeV/c)A(C, Pb) \rightarrow ppX$ reactions. The curves in this figure are the results of calculations for different size of the interaction region r [12] .

One can see, that experimental data are in accordance with theoretical calculations. The size of the interaction region for heavy nucleus is greater then for light one (the smaller points at small q the larger r).

Fig.5b shows the dependencies of correlation function R on the transverse and longitudinal components of q . One can see the difference between these two dependencies

which was interpreted [13] as the difference between transverse and longitudinal size of the interaction region: $r_{\parallel} > r_{perp}$. Both the large value of parallel component of the size and the A-dependence of the average size (Fig.5a) are in accordance with the scenario of hA interaction.

The scenario of hadroproduction of cumulative particles supports by inclusive data also.

For example the space-time picture of this interaction is in a good agreement with A-dependence of the inclusive cross section [14]. The A-dependence of cumulative particle yield in hadron-nucleus interaction has the volume nature; that is the result of the increasing of the length of the interaction region with increasing of A.

At the initial momentum higher than several GeV/c the slope parameter of cumulative particle spectra does not depend on the energy [3, 11]. Also it does not depend on the type of incident particle and this feature is valid not only for incident hadrons but also for photons [15, 16], and neutrinos [17].

Experimental points in Fig.6 show the value of normalized invariant cross section ρ ($\rho = \frac{f}{\sigma_{in}}$) as a function of energy of incident p [18, 11]. It's known that the higher atomic weight the stronger energy dependence of yield is observed. The experimental data allow to say that the yield of cumulative particles become energy independent at $E > E_A$. According to the discussed scenario one can introduce a concept of specific energy loss of beam hadron in nuclear matter. Its estimation on the base of initial energy dependence data is $E \approx 1 - 2GeV$ per unit of path length (fm) . The direct calculation of the sum of the energies of all secondary particles emitted in the nucleus fragmentation region gives just the same value of specific energy loss.

The longitudinal size of reaction region and the value of normalized cross section ρ increase with the initial energy if $E < E_A$ (see Fig.5c). Two sets of points in this figures corresponds to interactions $pPb \to pp$ for initial momentum 3 GeV/c and 7.5 GeV/c. One can see that the size of the interaction region increases with increasing of the initial momentum as well as with increasing of A.

Number of fluctons may be also estimated by means of azimuthal correlations of secondary hadrons. Azimuthal correlations are due to the momentum conservation law and their intensity decreases with multiplicity of secondaries n [19] or (in our scenario) with the number of fluctons. The characteristic of azimuthal correlations β is defined:

$$\beta = 2 \cdot \frac{\int_{\frac{\pi}{2}}^{\pi} \sigma \, d\phi - \int_{0}^{\frac{\pi}{2}} \sigma \, d\phi}{\int_{\frac{\pi}{2}}^{\pi} \sigma \, d\phi + \int_{0}^{\frac{\pi}{2}} \sigma \, d\phi} \sim n^{-1} \qquad (3)$$

We suppose, that multiplicity is proportional to the number of fluctons and to normalized inclusive cross section ρ also. Therefore the value of β^{-1} would depend on E (or ν and Q^2) as well as the value of ρ. In practice, r and β dependencies on E and A in hA interactions are closely connected (see Fig. 7) [13, 20].

The scenario of cumulative particle production process in high energy photon interaction with nucleus at small Q^2 is shown in Fig. 4(b). This scenario is very similar

to the scenario of hadron-nucleus interactions (see Fig. 4(a)). Such a photon dissociates into $q\bar{q}$ -pair for a period of time which is considerably longer than time necessary to pass through a nucleus [21]. Therefore the $q\bar{q}$ -pair is the object interacting with the nucleus. The experimental evidence for this scenario not so numerous as for hA interaction [15, 16], but this scenario could be verified experimentally using the existing machine and properties of this interaction should be similar to that of high energy hadron-nucleus interaction.

The modification of properties of cumulative particle production process with the transition from the region of low Q^2 ($Q^2 < 0.1GeV^2$) to that of high Q^2 ($Q^2 > 1GeV^2$) is worthy of especial investigation. The scenario of the process of cumulative particle production in eA-interaction with high Q^2 is shown in Fig. 4(c,d). In this case a virtual photon is absorbed by a quark in the vicinity of the point of its emission by the electron.

The schemes shown in Fig. 4(c,d) correspond to the different hadron jet energy $\nu = E - E'$. In the case of low energy ν (Fig.4(c)) not only the primary e-flucton interaction may serve as a source of cumulative (and other secondary) particles. Additional secondary nuclear "star" would be produced by recoil quark if its hadronization will occur in the matter (see for instance [22]). This kind of scenario is similar to for νA one and could be studied in detail at CEBAF [23] because of high intensity and full duty cycle is needed for this experiments.

For sufficiently high value of energy ($\nu \geq 10GeV$ for intermediate nucleus) the hadronization of knocked quark should occur outside of the nucleus [22, 24] (Fig.4d). Therefore the products of its hadronization would not take part in the generation of cumulative (and noncumulative) particles. In this case the cumulative particles should be produced only as a result of the hadronization of the spectator quarks of that flucton in which the virtual photon have been absorbed.

It's obviously that only this scheme of e-nucleus interaction at the limit high ν and Q^2 gives the possibility to investigate the intrinsic features of one separate flucton. The main advantages of this case are follows:

a).One can control the energy and momentum transfer to flucton. This is important even for single cumulative particle spectra and in particularly for correlation measurements [25]. It is important, that one can control the size of the interaction region which depends on Q^2 and ν.

b).The background of particles from different fluctons which is undesirable in studying of short living secondaries (for example Δ or ρ) and also for correlation measurements (to measure the size of the flucton, for example) is smaller then in hadron nucleus interaction.

3 Features of cumulative particle source

One of the most important characteristics of the flucton is its size and mean lifetime. The direct way to measure this parameter is to study the correlation between

secondaries at small relative momentum (see Fig.5). But in the case of hadron - nucleus interaction we study the distance between fluctons rather then the size of single flucton (see scenario at Fig.4a). One can only estimate the upper limit of the size of the flucton $r_f \leq r_f^*$. From the existing experimental data one can conclude that the size of flucton $r_f' < 2fm$ [13].

To estimate the mean life-time of the flucton one should compare the two component of the measuring size: in the reaction plane and out of plane. Now we have only qualitative conclusion that these two component of the size has the same order of value [13]. It means that $c \cdot \tau \leq r_f$. The size and mean life-time of the flucton both are the characteristics of flucton which could be measured at EEF (see scenario at Fig.4d) with a good accuracy (up to the method's accuracy $\approx 0.2fm$), which is important for estimation of the energy density in the interaction volume.

One of the simplest but very important characteristic of the flucton - the slope parameter for inclusive spectra. This parameter have been measured in hadron - nucleus collision for various secondaries (Fig.1). As it was mentioned above this parameter is independent on initial energy while this energy exceed one or two GeV. Due to this reason one can regards the intranuclear interactions with fluctons as quasi-independent collisions.

The small initial energy dependence of the slope parameter is the reason for very simple procedure in data analysis: one can consider the present data as the data at infinite initial energy without regard for mass correction [6]. But the fenomenon of scaling in few GeV hadron - nucleus collision can be due to the small mean energy loss ($\approx 1GeV$) in hadron - flucton interaction.

In the case of deep inelastic electron - nucleus interaction one should has in mind two possible variants: the first variant - the slope parameter is independent on ν at high Q^2 , another one - the increasing of this parameter with increasing ν. The difference between these variants may be crucial for the problem of transverse momentum dependence for the cumulative particle production process because of this dependence is a small effect in comparison with α dependence of the cross sections.

The other characteristic of the flucton is its quark composition. It may be obtained from the ratios of cross sections of different secondaries at the same kinematical conditions (see also Fig.3 and the first section of this proposal). For example the increasing of the ratio of cross section of $\frac{K}{\pi}$ is important signature of QGP. For cumulative particle production the strong yield of strange particle is known from a number of experiments [26]. But the procedure of fixing of the cinematical conditions depends on initial energy. So, this conditions one can fixed more correctly only for lepton-nucleus collisions at high Q^2 region (see scenario at Fig.4d).

Some of the important ratios involves the unstable particle: $\frac{\rho}{\pi}, \frac{\Delta}{N}$. The last ratio was measured in [27] and is about few percents. This ratio may be used for choice of the model of cumulative particle production because of large difference between quark [28] and nucleon [29] models predictions. To determine this ratio one should takes into account the background of particles from different fluctons when invariant

mass distribution been analyzed. This background will be smaller in lepton - nucleus collision at large Q^2 and ν and such kind of ratios could be determined more accurate.

Some of the interesting ratios involves the particle which may be produced only at high energy transferred to flucton. At high ν and Q^2 one can study the production of cumulative $\bar{p}$ and charm particles.

Study of the charmed particle production in deep-inelastic reactions can give a unicue information on the intrinsic charm component of a nucleon and nuclei. Cumulative charm particles production is extremely interesting phenomenon. Its experimental investigation allows to study a mechanism for formation of the heavy-quark component in nuclei and can give an important insight into the problem of the heavy-quark interaction with nuclear matter in the extremal conditions. It is possible to expect a relative increase of charmed particle production in cumulative processes in the way as it is observed for strange particles.

The next characteristic of the flucton is the momentum distribution of its constituents. One can hope to obtain some data about this distribution from azimuthal correlations of cumulative particles.

One can see from this section that our knowledge of all properties of the flucton may be improved radically using the EEF.

4 Nuclear structure function for $X > 1$

As it was mantioned above according to hypothesis of A.M.Baldin and coworkers [9] the α dependence of spectra of different cumulative particles is closely connected with quark-parton nuclear structure function. But the nuclear structure function could be measured directly in deep inelastic eA scattering. It is interesting to compare the structure function which is obtained from direct measurements and from cumulative particle production and to verify the Baldin's hypothesis.

In [5] the transition from structure function and cumulative particle spectra is at the hadronization stage. The combined analysis of data on nuclear structure functions and cross sections of cumulative particle production will allow to investigate the hadronization process in the nuclear matter.

The detailed measuring of A-dependence of the structure functions will allow to estimate the contributions of clusters with different masses in different nuclei. The comparison with the data at lower Q^2 [30] will allow to investigate the transition from quasi elastic to deep inelastic regime at $x > 1$.

The measuring of the structure function at $x > 1$ give the information about the presence of the high momentum quark in nuclear matter but such inclusive measurements could not provide the full information about the properties of fluctuation which is the source of this quark. The investigation of cumulative particle production (in particularly correlation measurements) gives in principle more detailed information but in this case the order of cumulativity (x) is the characteristics of flucton and of the hadronization stage.

So, the coincidence measurements between "cumulative" lepton and secondary hadrons (see also the proposal of A.Houdard et.al. for EEF [31]) could be used to obtain the additional independent information on structure of the flucton in such interesting configuration. For example very interesting data are the ratios of the cross sections of different secondaries (see section "Features...").

The only data available at $x > 1$ and $Q^2 > 10(GeV/c)^2$ are the preliminary results of BCDMS [32] which are shown in the Fig.8. At the $x < 0.8$ there are detailed data of EMC [33] and SLAC [34]. At $Q^2 < 3(GeV/c)^2$ there are data of D.Day [30], obtained at SLAC, but in this case the inclusive scattering cross section is basically determined by the quasi elastic scattering on the bound nucleons. This process is characterized by the additional Q^2 -dependence of the elastic nucleon form factor $F_{el} \approx (m^2 - Q^2)^{-2}$ - and its contribution will be negligible at $Q^2 > 10(GeV/c)^2$.

In order to estimate possible deep inelastic scattering cross sections at $x > 1$, we use the F_2 approximation at low x and $Q^2 \approx 10(GeV/c)^2$ in the form [35]:

$$F_2(x) = x^{0.85} \cdot (1-x)^{3.3} + 1.1 \cdot (1-x)^6 \qquad (4)$$

Then we can suppose that for the some x_o the nuclear structure function at $x > x_o$ has an exponential tail $F \approx \exp \frac{-x}{x^*}$. We approximate the Q^2 -dependence of the structure function [35] as follows:

$$F_2(x,Q^2) = F_2(x,10) \cdot exp(ln\frac{Q^2}{10} \cdot (0.15 - 0.7x)) \qquad (5)$$

From the description of the BCDMS data we obtained the values of $x_o = 0.57$ and $x^* = 0.07$. Points in the Fig.8 shows how measured values at $10 < Q^2 < 15(GeV/c)^2$ will look in the case of 4π detector and luminosity $10^{36} cm^{-2} sec^{-1} nucleon^{-1}$ for 100 hours run.

It is possible, that this estimation (see Fig.8) is rather conservative. Due to the Baldin's hypothesis [9], the slope of cumulative pion spectra is connected with the slope of the nuclear structure function at large x by simple relationship. We may expect from the known experimental data on cumulative pion production [6] the value of $x^* \approx 0.14$ at $x > 1.2$.

Some theoretical estimations also shown in Fig.8. Solid curves in this figure represent the results of calculations when effects of Fermi-motion, separation energy and NN-correlations in nuclei were taken into account [36, 37]. Dashed lines represent possible contribution of six-quark bags in this region [38, 39].

The theoretical estimates of the 6q-bag structure function performed by J.Vary [39] gives essentially more weak x -dependence of $F_2(x^* \approx 0.16)$ at $x > 1.2$.

Dotted line represents our calculation of $F_2(x)$. By the calculation of the nuclear structure function $F_2(x)$ it is suggested that some multiquark configurations exist in the nucleus [1]. The probabilities of such configurations were calculated in the framework of usual statistic theory [5, 40]. The function $F_2(x)$ according to [5] was

represented in the following form:

$$F_2(x) = \sum k = 1 w_k f_{2,k}(x) \qquad (6)$$

where w_k is the probability of the existence of k-"nucleon" cluster in a nucleus, here "nucleon" means the three-quark colorless cluster [5].

The function $f_{2,k}(x)$ has the form analogous to the form of the destribution of quarks on the ends of $q - \bar{q}$ string $q_k(x)$ [5, 41], i.e.,

$$f_{2,k}(x) = C_k \sqrt{x}(k - x)^{2(1-\bar{\alpha}_B(0))(k-1)+2(k-1)d_1+b_N(Q^2)} \qquad (7)$$

where $b_N(Q^2)$ is the function taking into account the Q^2-evolution of the usual nucleon structure function. At same $Q_0^2 = 3 - 5(Gev/c)^2$ $b_N(Q_0^2) = b_N^{(0)} + d_1$, where $b_N^{(0)}$ is the value calculated in the framework of the quark-gluon strings model [42], d_1 is the some parameter which is choosen in order to get $b_N(Q_0^2) = 3 - 3.5$ [43]; $\bar{\alpha}_B(0)$ is the average intercept of the baryon trajectory, according to [5] $\alpha_B(0) = -0.05 - -0.1$.

5 Measurements which are proposed for EEF

As a result we can propose experimental program with the goals of studying

-the fundamental characteristic of nuclei - their structure function

-the cumulative particle production and hadronization mechanism

-the properties of flucton.

We suggest to measure

1) Deep-inelastic eA scattering cross section in reactions: $eA \to e'X$ for three or four nucleus (from light to heavy; C, Ti, Pb for example) at $x = \frac{Q^2}{2\nu}$ from ≈ 0.5 up to $\approx 1.5 - 2$ (as high as possible) in the region of high $Q^2 \geq 5 - 10(GeV/c)^2$.

The angular range for secondary electrons in this experiments is $3° - 30°$ (see Fig.9); the momentum accuracy needed 1 - 2 percents.

2) Semiinclusive cross section of cumulative particle production in reaction $eA \to e'hX$ for the same set of nucleus and $Q^2 > 1(GeV/c)^2$ region for wide ν range (from few GeV up to $\omega \sim$ initial energy).

Minimal electron scattering angle depends upon the range of ν and Q^2 . For $Q^2 = 1(GeV/c)^2$ (deep - inelastic region) and $\nu > 5GeV$ minimal electron production angle will be $\approx 2°$ in lab. for $E_o = 30GeV$ and $\approx 4°$ in lab. for $E_o = 15GeV$. Maximal electron scattering angle will not exceed 30° in lab.

The secondary hadrons ($p, \pi^\pm, K^\pm, n, \Lambda, \pi^\circ, \Lambda_c, \bar{p}$, etc.) would be measured in wide angular ($3° < \theta < 170°$ in lab.frame) and for kinetic energy from $\approx 30MeV$ up to the statistical limit which depends on polar angle and of the order of 1GeV. The angular and momentum accuracy in this case are not crucial and should be only batter then the typical value of slope parameter of the inclusive spectrum: $\delta\bar{p} \approx 10 - 20MeV/c$ (1-2 percents).

3) Correlations between cumulative particles in the reaction $eA \to e'h_1h_2X$ at high $Q^2 > 1(GeV/c)^2$ region.

We propose to pay the particularly attention for correlation measurements at small relative momentum of secondaries to study the space-time characteristics of the interaction and in the case of single flucton interaction regime space-time characteristics of flucton.

To obtain the information on the size and shape of the flucton one would obtained the relative momentum $\vec{q}$ and its component distribution for secondary pions (kaons) or(and) nucleons in the region $\vec{q} \leq 0.2GeV/c$. For illustration the relative momentum distributions of secondary protons and pions is shown in Fig.10(a,b). This is the data from eA interaction at initial energy 5GeV (ARGUS, [16]) and model calculation [44] for this interactions. Such distribution do not change radically in the case of EEF experiment. One can see from this figure that only a small part of distribution is in the region $\vec{q} < 0.2GeV/c$.

The relative momentum accuracy which needed for this experiment is about 10-15 MeV/c ($\ll \frac{\hbar}{r}$). For this measurements a good efficiency for small relative momentum (up to $\approx 10 - 15MeV/c$) needed.

Another kind of proposed correlation measurements - so called azimuthal correlations. These measurements need the absence of secondary particles correlation in trigger.

4) Semiinclusive cross section of particle production in reaction $eA \to e'hX$ for $X > 1$ and $Q^2 > 1(GeV/c)^2$ region for electron.

Small cross section of the proposed reactions and many particles final state will require the high luminosity, full duty cycle and large acceptance detector. The demands on Q^2 and ν lead to the beam energy not less than 15 GeV.

6 Detector, counting rate, and triggers.

We consider our proposal as a part of physical program for the Large Acceptance Detector, for variant MEMUS for example (see the report of G.Fournier et al. at Mainz Workshop [45]). This detector provide a possibility of operation at L up to $10^{36}sm^{-2}sec-1$ per nucleon.

The main experimental problem for registration of deep inelastic electron scattering in large acceptance detector is the small $\frac{e}{\pi}$ ratio in the region of small energy and large angle of secondaries. High $\frac{e}{\pi}$ rejection value have been obtained for PEGASYS conditions (see [46]), in this case $\frac{e}{\pi}$ rejection of ≈ 1000 .

To investigate the properties of source of cumulative particles, i.e. the features of particle production from nuclear fragmentation region the trigger conditions in the form of different ν and $Q^2 > 1(GeV/c)^2$ are very suitable.

Table 1 illustrated the statistic level for $E_0 = 15GeV$, $L = 10^{36}sm^{-2}sec^{-1}nucleon^{-1}$ and t = 10 hours in the form of Q^2, ν (in GeV and $(GeV/c)^2$) plot.

	$1 < Q^2$	$2 < Q^2$	$4 < Q^2$	$8 < Q^2$	$16 < Q^2$
$1 < \nu < 2$	$3.7 \cdot 10^7$	$7.0 \cdot 10^6$	$6.0 \cdot 10^3$		
$2 < \nu < 3$	$4.0 \cdot 10^8$	$5.0 \cdot 10^7$	$1.0 \cdot 10^5$		
$3 < \nu < 4$	$3.5 \cdot 10^8$	$8.2 \cdot 10^7$	$2.0 \cdot 10^6$	$2.0 \cdot 10^2$	
$4 < \nu < 5$	$3.1 \cdot 10^8$	$8.8 \cdot 10^7$	$8.0 \cdot 10^6$	$4.0 \cdot 10^3$	
$5 < \nu < 6$	$2.5 \cdot 10^8$	$8.0 \cdot 10^7$	$1.0 \cdot 10^7$	$4.0 \cdot 10^4$	
$6 < \nu < 7$	$2.1 \cdot 10^8$	$7.0 \cdot 10^7$	$1.0 \cdot 10^7$	$2.0 \cdot 10^5$	3
$7 < \nu < 8$	$1.7 \cdot 10^8$	$6.0 \cdot 10^7$	$1.1 \cdot 10^7$	$6.0 \cdot 10^5$	4
$8 < \nu < 9$	$1.5 \cdot 10^8$	$5.0 \cdot 10^7$	$1.1 \cdot 10^7$	$1.0 \cdot 10^6$	$2.0 \cdot 10^2$
$9 < \nu < 10$	$1.3 \cdot 10^8$	$4.9 \cdot 10^7$	$1.1 \cdot 10^7$	$1.0 \cdot 10^6$	$9.0 \cdot 10^2$
$10 < \nu < 11$	$1.2 \cdot 10^8$	$4.8 \cdot 10^7$	$1.2 \cdot 10^7$	$2.0 \cdot 10^6$	$3.0 \cdot 10^3$
$11 < \nu < 12$	$1.0 \cdot 10^8$	$4.7 \cdot 10^7$	$1.2 \cdot 10^7$	$2.0 \cdot 10^6$	$8.0 \cdot 10^3$
$12 < \nu < 13$	$1.0 \cdot 10^8$	$4.5 \cdot 10^7$	$1.2 \cdot 10^7$	$2.0 \cdot 10^6$	$2.0 \cdot 10^4$
$13 < \nu < 14$	$0.9 \cdot 10^8$	$4.3 \cdot 10^7$	$1.2 \cdot 10^7$	$2.0 \cdot 10^6$	$4.0 \cdot 10^4$
$14 < \nu < 15$	$0.8 \cdot 10^8$	$4.0 \cdot 10^7$	$1.2 \cdot 10^7$	$3.0 \cdot 10^6$	$7.0 \cdot 10^4$

The probability of registration of one cumulative particle in deep inelastic eA interaction is about 0.1. To obtain statistical level of inclusive and correlation data comparable with hadron-nuclear interaction one needs of the order of 100 hours run for each of three targets.

For correlation measurements (in particularly narrow correlations) spatial resolution for two close tracks (of the order of 5 mm) are needed.

Table 2 illustrated the statistic level for $E_0 = 15GeV, L = 10^{36} sm^{-2} sec^{-1} nucl^{-1}$ and t = 100 hours in the form of Q^2, x plot. The polar angle of e' is $3^0 < \theta < 60^0$, $\nu_{min} = 2GeV$.

	$5 < Q^2 < 10$	$10 < Q^2 < 15$	$15 < Q^2 < 20$	$20 < Q^2 < 25$
$0.2 < X < 0.3$	$2.3 \cdot 10^8$			
$0.3 < X < 0.4$	$2.4 \cdot 10^8$	$1.7 \cdot 10^6$		
$0.4 < X < 0.6$	$2.2 \cdot 10^8$	$3.4 \cdot 10^7$	$1.6 \cdot 10^5$	
$0.6 < X < 0.8$	$2.6 \cdot 10^7$	$5.8 \cdot 10^6$	$1.2 \cdot 10^6$	$7.1 \cdot 10^2$
$0.8 < X < 1.0$	$1.3 \cdot 10^6$	$2.8 \cdot 10^5$	$1.0 \cdot 10^5$	$2.0 \cdot 10^4$
$1.0 < X < 1.2$	$6.8 \cdot 10^4$	$1.4 \cdot 10^4$	$4.8 \cdot 10^3$	$2.3 \cdot 10^3$
$1.2 < X < 1.4$	$3.6 \cdot 10^3$	$6.8 \cdot 10^2$	$2.3 \cdot 10^2$	$1.0 \cdot 10^2$
$1.4 < X < 1.6$	$1.5 \cdot 10^2$	$3.4 \cdot 10$	$1.1 \cdot 10$	4.9
$1.6 < X < 1.8$	5.6	1.8	0.6	0.2

The statistical limit (for 100 hours run) is $x \approx 1.6 - 1.8$.

The simplest variant of the trigger is electron at large Q^2, ν . One can see from the Table 1,2 that the number of events depends strongly on the Q^2 and not very strongly on ν . For $Q^2 > 1(GeV/c)^2$ and $2 < \nu < 12GeV(E = 15GeV)$ the number of events is about $\approx 6 \cdot 10^4 sec^{-1}$ for 100

To reduce the counting rate one can suppress the $Q^2 < 5(GeV/c)^2$ region by factor ≈ 100 .

7 Conclusion

Thus, the main purpose of the discussed experiments is to investigate the characteristic features of local fluctuations of dense nuclear matter. Such a flucton - the source of cumulative particles - termed in the literature either as a short-range nucleon correlation or a multi quark bag. In this case high-energy deep-inelastic eA scattering gives new and unique possibilities.

Experimental program for 4π detector consists of several main points.

1. The regime of maximal nuclear transparency should be used, where the only source of cumulative particles is the primary e-flucton interaction.

Then we must confirm that only one local source of secondaries exists. This condition is very crucial.

2. If such a source exists the wide experimental program would be developed to investigate features and nature of flucton. It's possible:

to measure the size and the density of flucton;

to measure the energy density in this process

to measure the composition of flucton and momentum distribution of constituents.

3. To measure the structure function at $x > 1$ that gives the direct way to confirm the existence of such a fluctuation. This point consists from two subsections

the information about the presence of the high momentum quark in nucleus.

the coincidence measurements between "cumulative" lepton and secondary hadrons.

Operation time needed for this program $\approx 300 - 400$ hours for luminosity level up to $10^{36} sm^{-2} sec^{-1}$ per nucleon and acceptance $\approx 4\pi$.

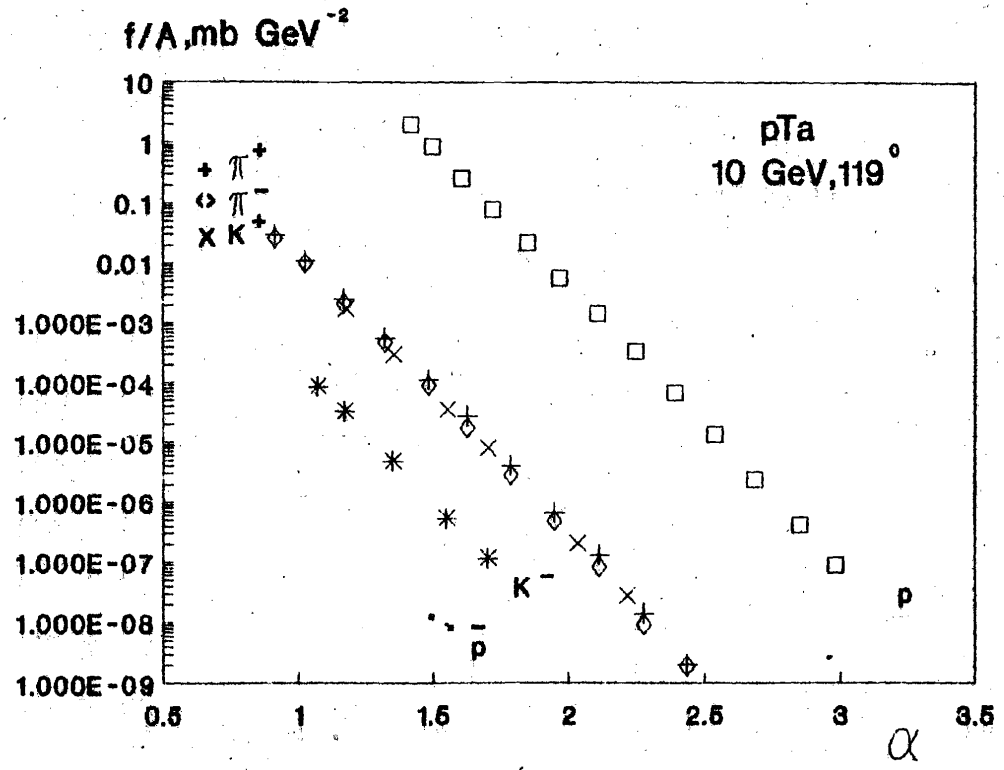

Figure 1.
Inclusive cross-sections of hadron production at the angle of 119° at 10 GeV pTa interaction[6] versus the variable α (see text).
□ - protons, + - π^+, ◇ - π^-, × - K^+, * - K^-, * - $\bar{p}$.

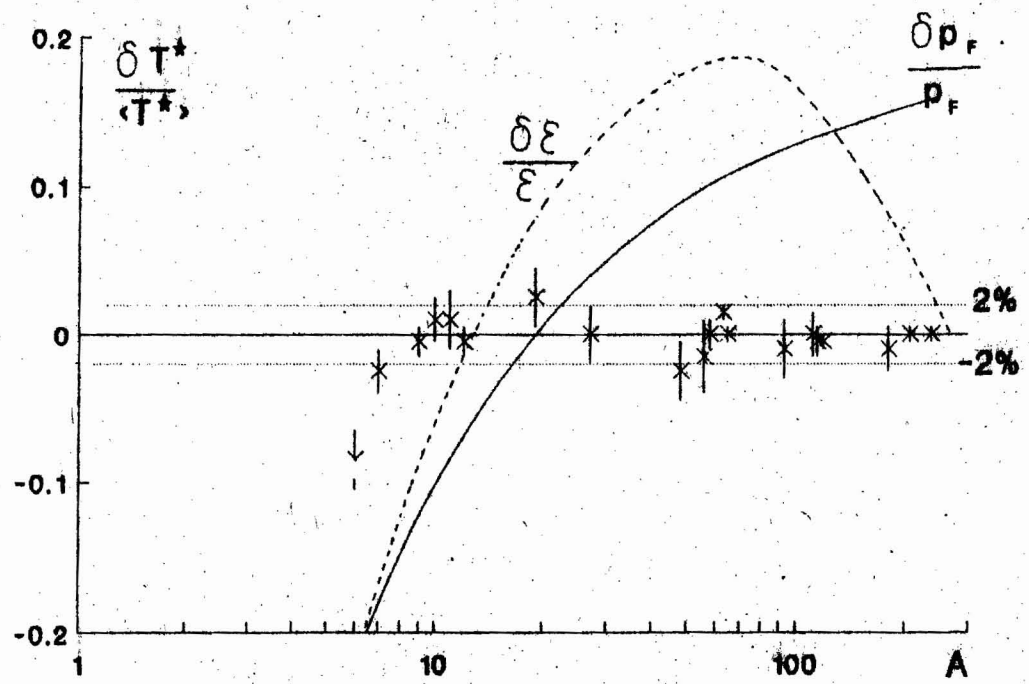

Figure 2.
The A-dependence of the slope parameter of the inclusive spectra of cumulative protons in terms of divergence of the value of this parameter for separate target from the value of this parameter been averaged for all targets[7] (o).
The solid line represent the divergence in Fermi-momentum and the dashed line - in binding energy.

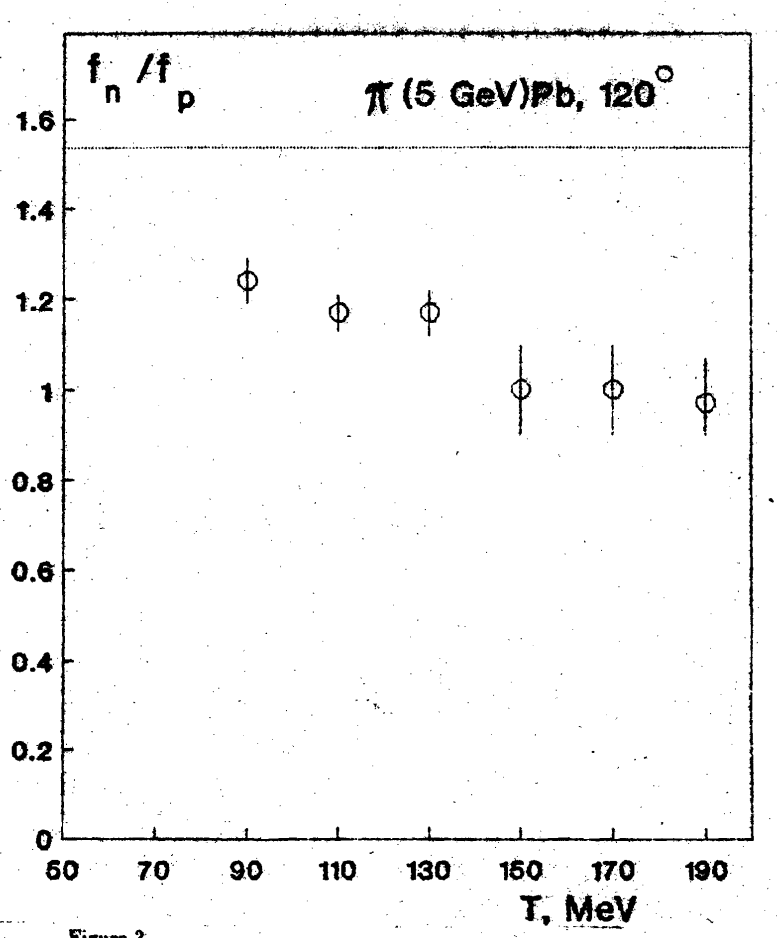

Figure 3.
The ratio of yields of cumulative neutrons and protons as a function of its kinetic energy [8] . Experimental data for $\pi^{\pm}(5GeV)Pb$ interactions are symmetrized with respect to the initial particle charge. The dashed line represent the $\frac{N}{Z}$ ratio for Pb.

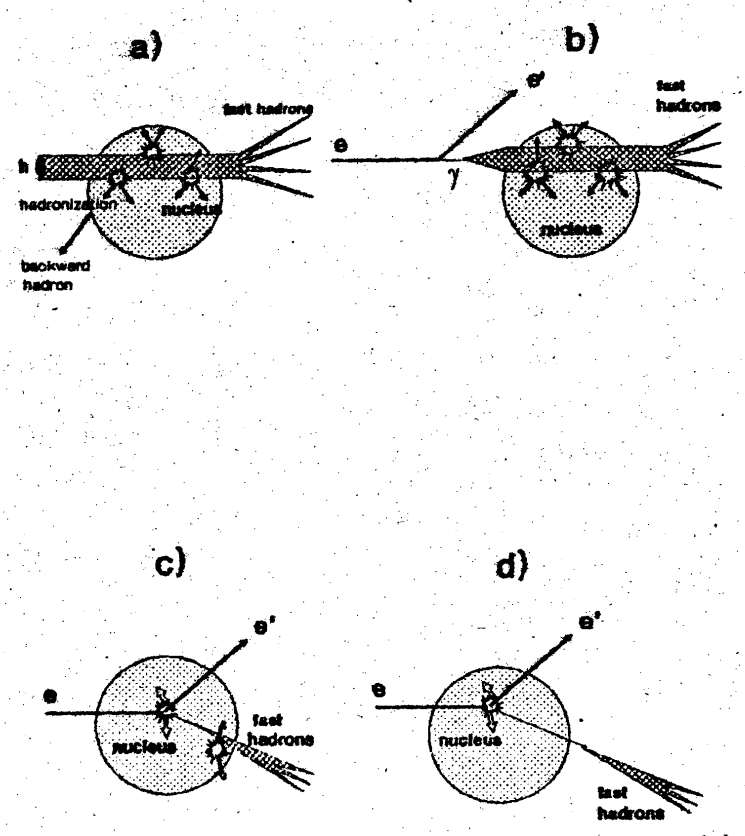

Figure 4.
The scenario of cumulative particle production.
a). hA interaction.
b). eA interaction at small Q^2 region.
c). eA interaction at high Q^2 and small ν .
d). eA interaction at high Q^2 and high ν .

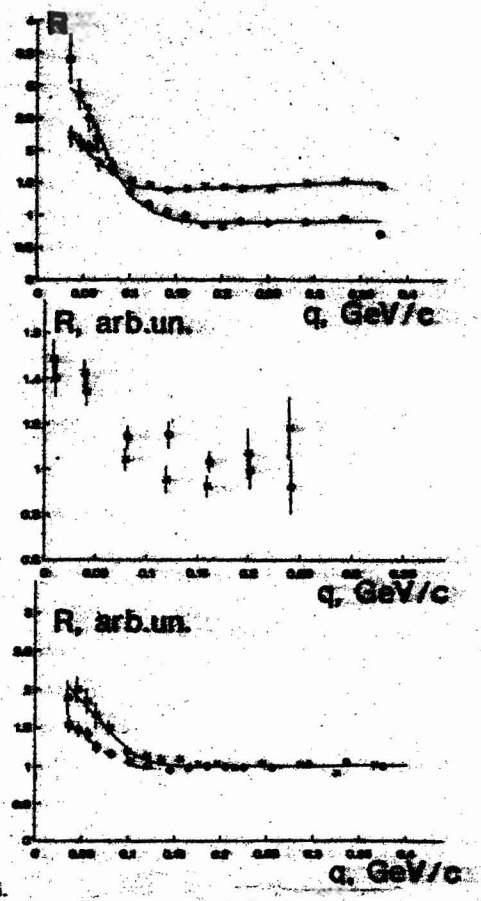

Figure 5.
Experimental data [13] on the correlations between cumulative protons at small relative momentum.
a). The q dependence of correlation function of cumulative protons at $pA(C, Pb)$ interactions. Initial momentum 7.5 GeV/c, polar angle of secondaries $\approx 90°$ in lab.frame. o - pC, • - pPb. The curves are the results of calculations in accordance with [12] which take into account the interference and final state interaction.
b). The $q_{\parallel}$ - •, and $q_{\perp}$ - o dependencies of correlation function in the p(7.5 GeV/c)Pb interaction. The complementary component of relative momentum $< 0.04 GeV/c$.
c). The q dependence of correlation function of cumulative protons at pPb interactions.
o - initial momentum 3 Gev/c, • - 7.5 GeV/c. The curves are the results of calculations in accordance with [12].

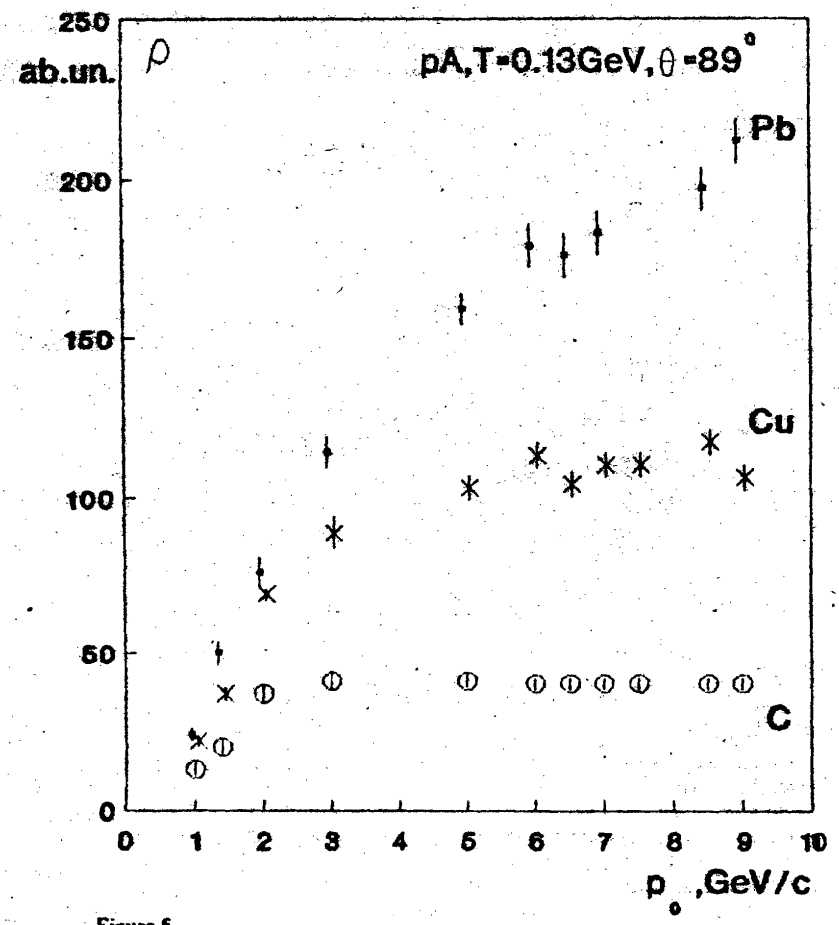

Figure 6.
The normalized inclusive cross sections of cumulative protons productions in pA interactions as a function of initial energy [18].
o - C, × - Cu, • - Pb.

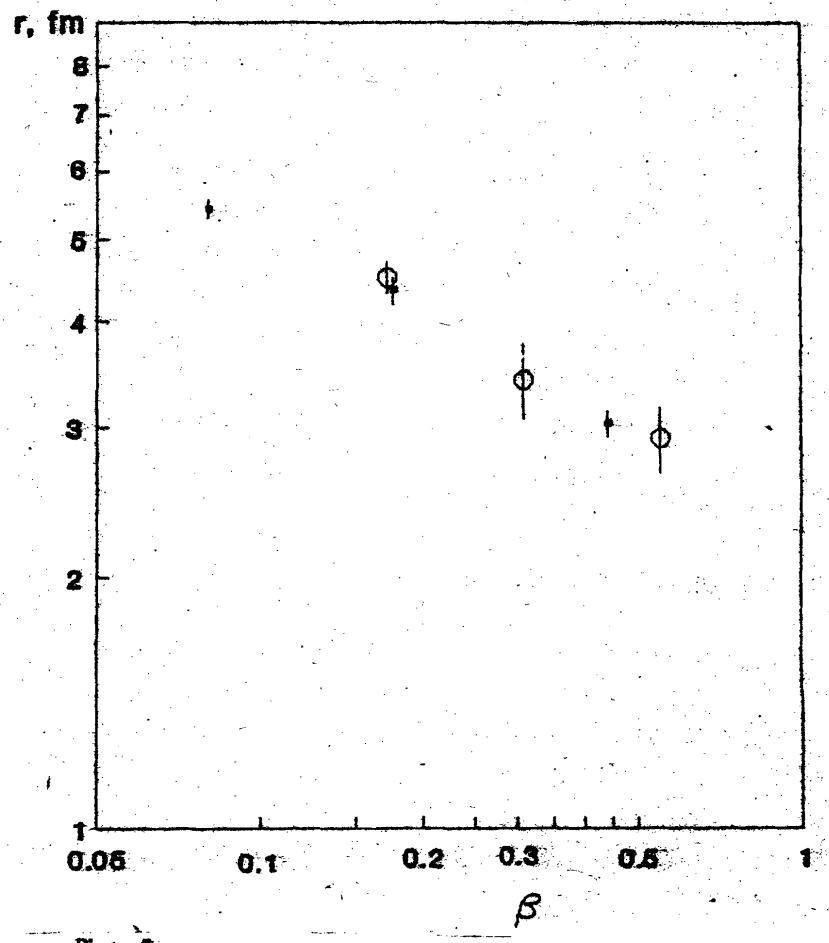

Figure 7.
The correlation between parameter of azimuthal asymmetry for cumulative protons β [20] and the size of the interaction region r [13] in pA interactions at 3 GeV/c (o) and 7.5 GeV/c (•).

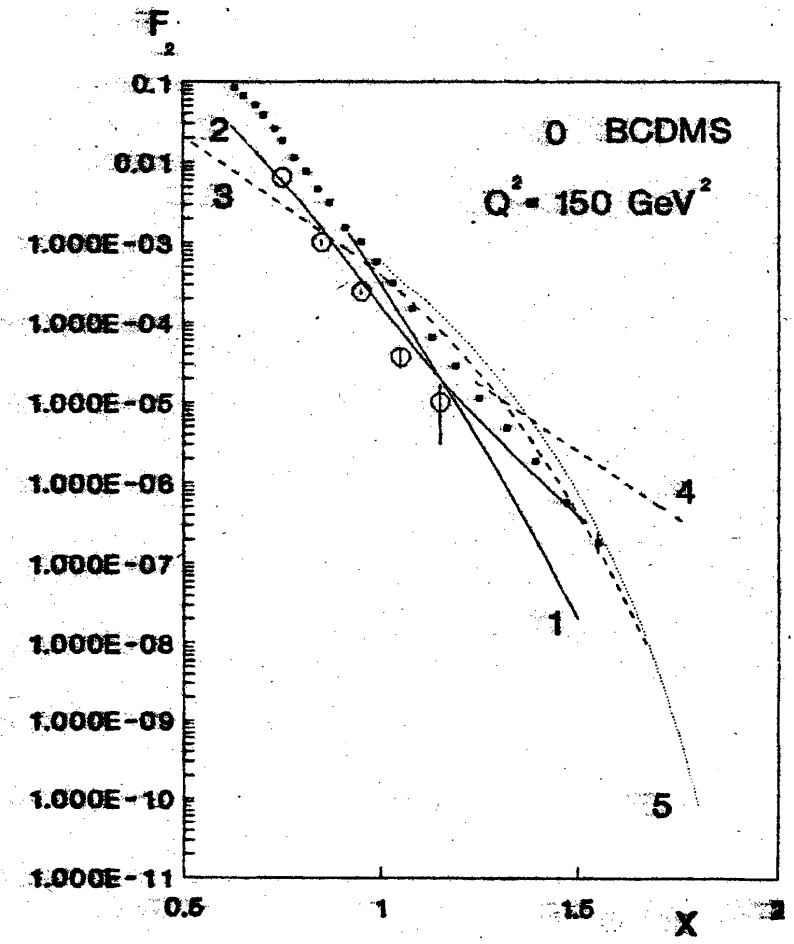

Figure 8.
Predicted dependence F_2 on x.
Solid curves: 1- for He [36] ; 2- for C [37] , $Q^2 > 10(GeV/c)^2$;
Fermi-motion, separation energy and close NN-correlations are taken into account.
Dashed curves: 3- structure function for 6-q bag [38] (normalized on 20 per cents of its admixture). $Q^2 > 10(GeV/c)^2$; 4- 6-q bag [39] at $Q^2 \approx 6 \pm 8(GeV/c)^2$ for D.
Dotted curve (5) - our calculation was described in the text. *Points - estimated 100 hours run statistics for the EEF proposed experiment.*

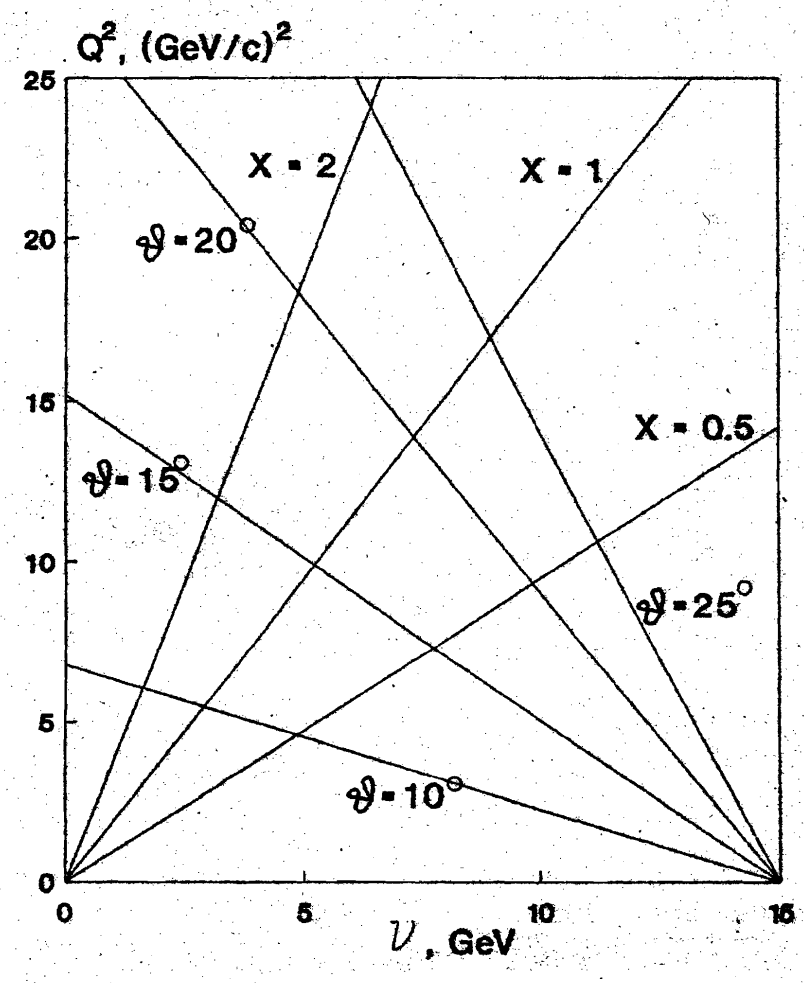

Figure 9. $Q^2(\nu)$ plot for 15 GeV initial energy.

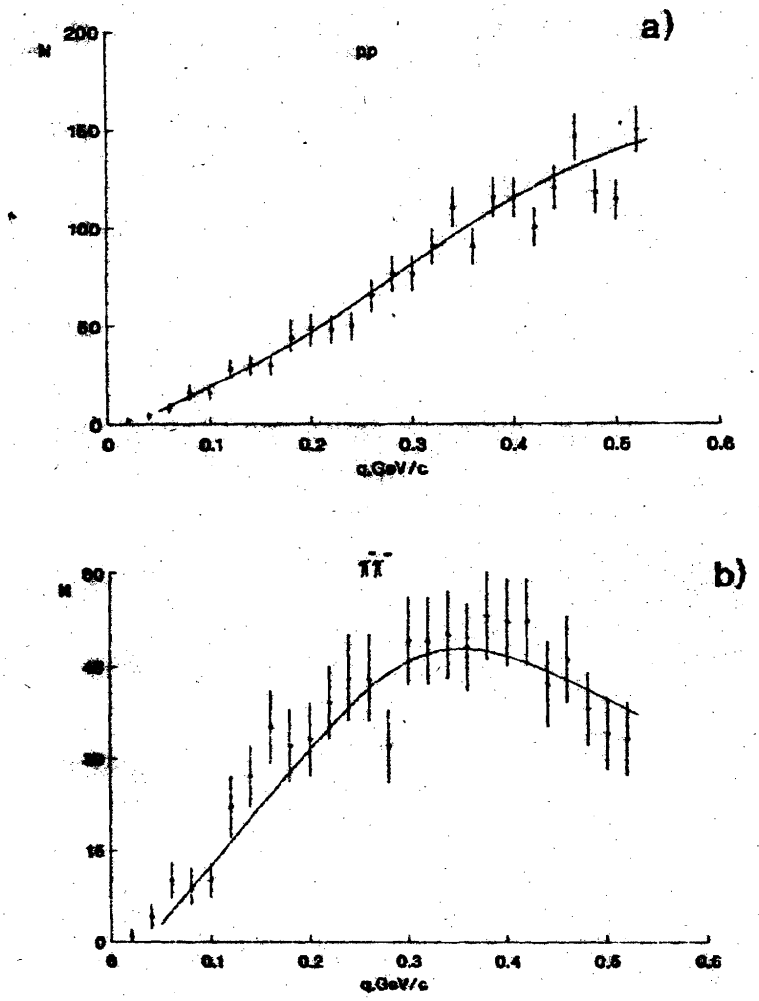

Figure 10.
The typical relative momentum distributions for cumulative protons (a) and pions (b). Data from ARGUS [16] and model [44] estimations (dashed line).

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