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A. TITLE: Study of Local Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS Detector

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C. THIS PROPOSAL IS BASED ON A PREVIOUSLY SUBMITTED LETTER OF INTENT

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D. ATTACH A SEPARATE PAGE LISTING ALL COLLABORATION MEMBERS AND THEIR INSTITUTIONS

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Study of Local Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS Detector

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REACTIONS:

A(e,e'p)X	A(γ,p)X
A(e,e'pp)X	A(γ,pp)X
A(e,e'd)X	A(γ,d)X
A(e,e'π)X	A(γ,π)X
A(e,e'$\pi\pi$)X	A(γ,$\pi\pi$)X
A(e,e'Δ)X	
A(e,e'n)X	

NUCLEI: He, C, Al, Cu, Pb

KINEMATICAL REGIONS:

e' or photon: E-E' from 0 to 3.5 GeV,
Q^2 from 0 to 4 GeV^2

secondary
hadrons: lab. polar angles from 10 to 150(135) degrees.

momenta:

protons	-	from 400 to 1500 MeV/c
pions	-	from 100 to 1200 MeV/c
deuterons	-	from 600 to 2000 MeV/c
neutrons	-	from 400 to 1000 MeV/c

Abstract: We propose a series of experiments using the CLAS detector to study local properties of nuclear matter. CLAS features good spatial and momentum resolution as well as good identification of secondary particles. Use of this detector provides a unique opportunity to investigate the nature of local intranuclear interactions. Backward particle production, or, in general, production of secondary particles in kinematical regions, which are forbidden for the reactions on free nucleons, is characteristic for such processes.

1. GOALS OF THE EXPERIMENT

The goals of the proposed experiment are the following:

1) Study the space time picture of backward hadron production in deep inelastic electron-nucleus reactions by means of like-particle correlations with small relative momenta. Measurement of A, Q^2 and ν dependence.

2) To test the conjecture that in the case of deep-inelastic eA-interactions ($Q^2 > 1$ GeV^2, $\nu > 2$ GeV) with light nuclei ($A < 20$) all secondary hadrons emitted backward are generated in only one local interaction inside the nucleus.

3) To investigate the nature of these local interactions (short-range few-nucleon correlations, virtual multiquark bags and generation of droplets of quark-gluon plasma).

4) To study the properties (spatial extension, density, structure functions and formfactors) of these objects, and how these properties depend on their baryon charge.

The study of these questions encompasses only the study of the properties of nuclear matter, but is also closely connected to the most pressing problems of modern QCD such as hadronization, confinement and generation of quark-gluon plasma.

2. INTRODUCTION

Inelastic interactions of incident protons with clusters of nucleons in nuclei were observed in the middle 1960's [1]. In these experiments protons with momenta up to 1 GeV/c were observed emitted backward in the laboratory frame. Such protons cannot be produced in the interactions with separate quasi-free nucleons. Since the early 1970's, processes with hadrons emitted backward from different nuclei were widely investigated using hadron, photon

[2] and neutrino [3] beams. The results are reviewed [4-8]. At Yerevan, an experiment has recently been started to study backward production of protons in A(e,e'p)X reaction at 2 GeV incident energy.

The total scope of experimental data and various attempts at their interpretation [5,8] indicate that fast hadrons emitted backward off nuclei are produced in the interactions with close multinucleon clusters inside the nuclei. Support for this interpretation comes from the phenomenon of nuclear scaling [4,6]. The inclusive spectra of hadrons emitted backward at fixed angles may be parameterized as

$$f = \frac{E d\sigma}{d^3p} = C \cdot \exp(-T/T_0) \qquad (1)$$

Nuclear scaling means that the slopes of the spectra do not depend on:

- the atomic weight of the target nucleus (at $A > 10$);
- the type of incident particle (hadrons, electrons, photons and neutrinos);
- the beam energy (at $E_o > 1\text{-}5$ GeV).

It should be noted here that the interaction with clusters produces not only backward emitted hadrons. One also observes a noticeable contribution to the total inelastic cross-section, from nearly 50% in hC to more than 90% in hPb interactions. One might expect that the situation in γA and eA interactions is similar.

The most suitable way to study properties of clusters inside nuclei is to investigate reactions where only one such cluster is involved. Due to multiple interaction within the nucleus hadron beams cannot be used for this purpose. There is experimental evidence that in this case the production of backward particles is the result of successive intranuclear interactions of the incident hadron. Up to now the space-time picture of photo-nucleus and lepton-nucleus reactions at different Q^2 and ν has not been studied. However, at sufficiently high Q^2 and ν the interaction should involve only one cluster. Under these conditions the properties of heavy intranuclear clusters may be investigated most clearly.

There are different approaches and models concerning the nature of local interactions with multinucleon clusters [5,8-11]. One of the most elaborate models is the model of few-nucleon short-range correlations [5]. This model may be tested by measuring differential cross-sections of exclusive reactions where two or three nucleons are detected in A(e,e') scattering. The study of exclusive reactions with Δ-isobar production allows the study of the role of non-nucleon degrees of freedom in few-nucleon clusters.

An alternative point of view is to consider heavy clusters as multiquark bags. In the framework of this model the virtual photon with high Q^2 and ν is absorbed by one quark in the bag. As is shown in fig.1 the spectra of different kind of hadrons (p, π, K) emitted backward in hA-interactions [12] become similar to each other when plotted as functions of the light cone variable $\alpha = (E - P_1)/m$ (E is the energy and P_1 is the longitudinal momentum of secondary hadron; m is the nucleon mass). This observation is called "superscaling". It indicates that the interaction at quark-level is the common origin of the processes.

It is also seen in fig.1 that the cross-sections of K^+ and π emission are almost the same in the hadron interaction with heavy nuclei. It should be noted that the enhanced yield of strange particles was expected [13] for quark-gluon plasma (QGP) generation. All data on backward particle production in high energy hadron-nucleus reaction are in accord with the assumption of QGP-droplets generation.

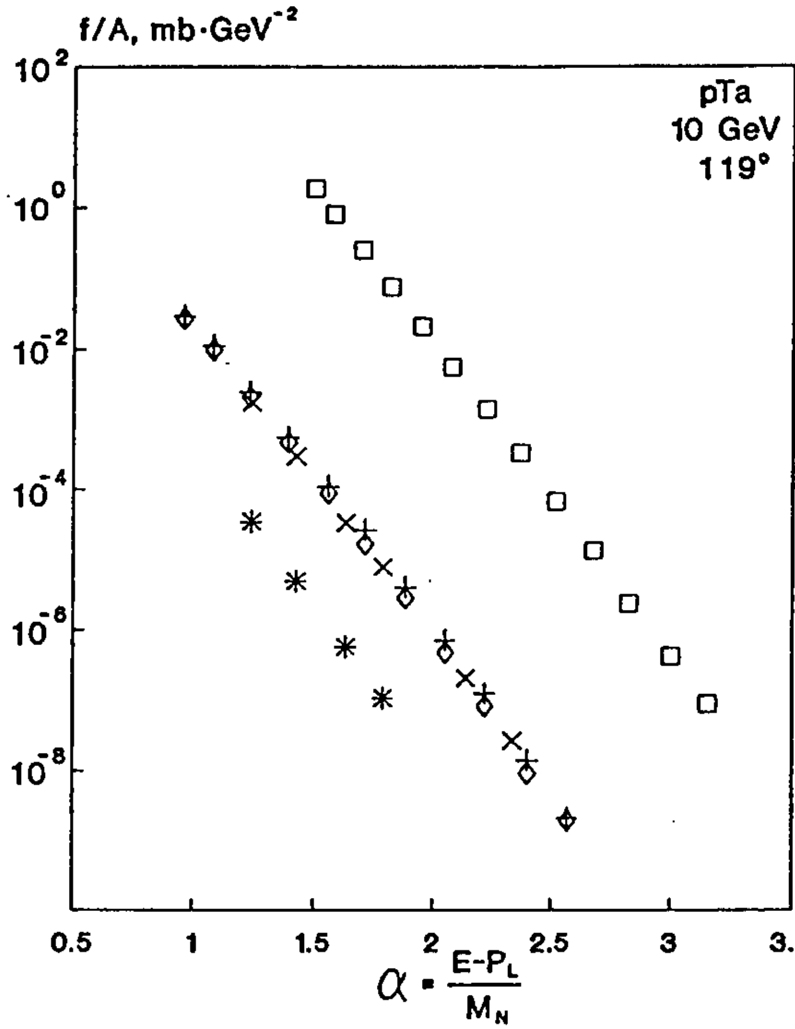

Figure 1. Inclusive cross-sections of hadron production at the angle of 119° at 10 GeV pTa interactions [12] versus the light cone variable α (protons - (□), π^+ - (+), π^- - (◊), K^+ - (×), K^- - (✳)).

3. PHYSICAL MOTIVATION

There are two approaches to investigate the properties of dense multinucleon clusters. The first one is to study different channels of electron-cluster interaction with backward baryon emission in an exclusive way, i.e. measuring all secondary particles . The Yerevan Physics Institute proposal is directed to the realization of this possibility. Another way is to perform inclusive measurements to study correlations in multiple particle production from one small source. The present proposal takes this approach.

3.1 Study of Space-Time Characteristics of Hadron Emission Region

Measurement of correlations of like-hadrons with small relative momenta allows the study of space-time characteristics of the particle emission region [14,15]. It is also possible to separately estimate the longitudinal and transverse sizes of this region by measuring the correlations as functions of longitudinal and transverse components of relative momentum [14,16,17]. The data obtained up to now [16,18,19] can be interpreted such that the shape of the region of the backward hadron emission in high energy hadron-nucleus reaction is a tube elongated in the direction of the incident particle momentum. Measurement of the production of secondary deuterons and more complex fragments also allows study of the space-time picture of the process [20,21].

All data obtained up to now for backward hadron production in high energy hadron-nucleus interactions are in agreement with the following scenario for the interaction process (see fig.2). The incident hadron is considered as a quark-gluon jet interacting successively in the nuclear matter with separate quasi-free nucleons and with any kind of fluctons. These fluctons may be short-range

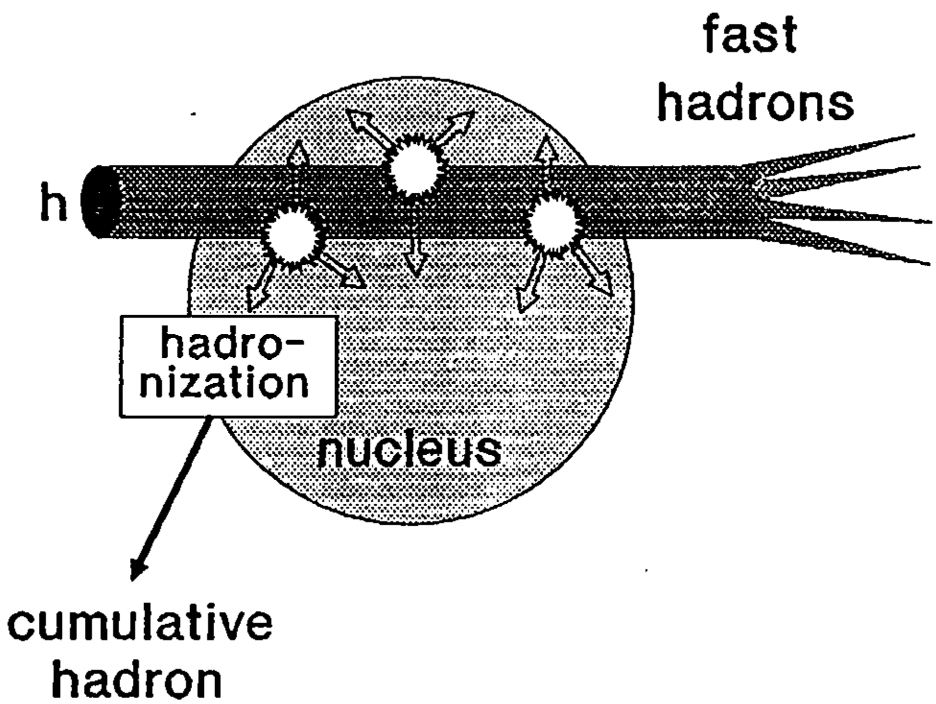

Figure 2. Scenario of backward hadron production in hA-interactions.

few-nucleon clusters or multiquark bags. The hadronization of the high energy quark-gluon jet occurs outside the nucleus. Fragmentation products of the excited fluctons are hadronized in nuclear matter into different hadrons (p, π, K, $\bar{p}$, ...) including backward emitted particles.
The high energy photon-nucleus interaction scenario is shown in the fig.3. It is expected to be similar to the scenario of hadron-nucleus interaction. High energy photons dissociate into $q\bar{q}$ pair for a period of time which is considerably longer than the time required to pass through a nucleus [22]. Therefore the $q\bar{q}$ pair is the object interacting with the nucleus and the properties of this interaction should be similar to that of high energy hA-interactions. Of course, this scenario and the region of its validity should be verified experimentally. The data obtained for 5 GeV electron-oxygen scattering at low Q^2 [23] show that the size of the emission region for pions and protons is the same as in high energy hadron-carbon interaction.

The modification of properties of the hadron production process with the transition from the low Q^2 ($Q^2 < 0.1$ GeV^2) region to high Q^2 ($Q^2 > 1$ GeV^2) is of great interest. The space-time picture of deep inelastic lepton scattering on nuclei is discussed in [24]. The scenario of backward particle production in high Q^2 eA-interactions is shown in fig.4. In this case electromagnetic interaction becomes point-like (in the nuclear scale). For sufficiently high value of ν = E-E' the hadronization of a knocked out quark should occur outside the nucleus [25]. Therefore its hadronization products would not take part in the generation of backward emitted hadrons. In this case the backward emitted hadrons should be produced only as a result of the virtual photon interaction with a heavy cluster. Tests of the validity of this scenario at high Q^2 ($Q^2 > 1$ GeV^2) and ν ($\nu > 1 \div 2$ GeV in the case of carbon target) is a first and necessary stage of the proposed experiment.

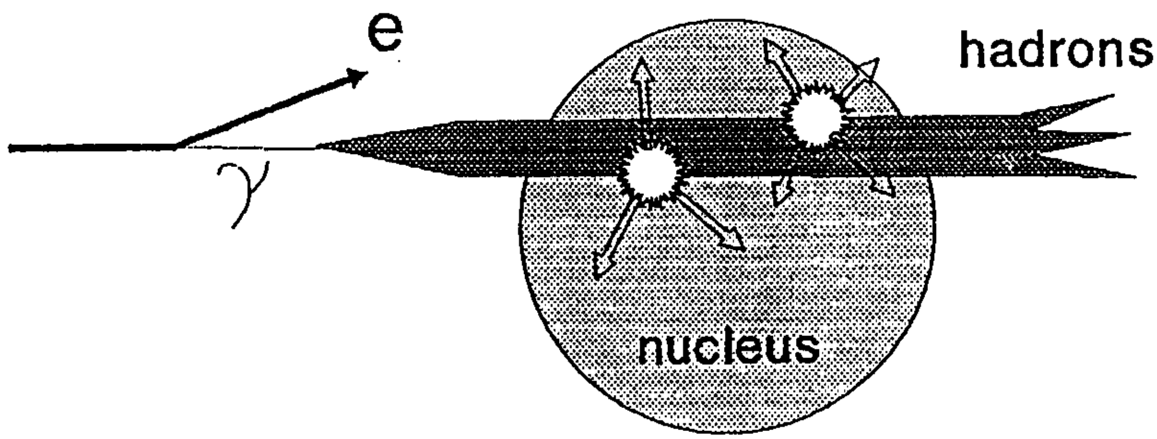

Figure 3. Scenario of backward hadron production in high energy photon-nucleus interactions.

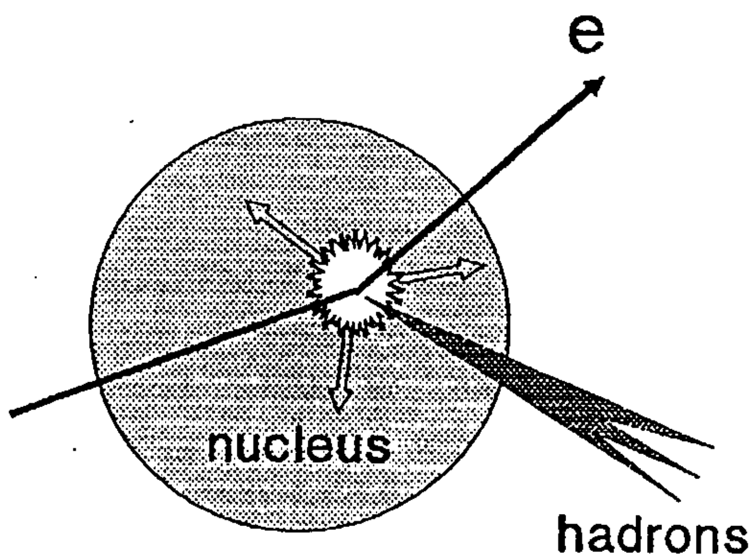

Figure 4. Scenario of backward hadron production in high Q^2 eA-interactions.

Direct measurement of the size and the shape of the source of hadrons with energies higher than 50 MeV in the nucleus fragmentation region using the method of like-particle correlations at small relative momenta provides an opportunity to verify the assumption that only one local intranuclear interaction takes place. Comparison of pion emission and proton emission allows testing of this method. Measurement of the heavy cluster size as a function of its estimated baryon charge allows the evaluation of its baryon density.

3.2 Study of Backward Hadron Production in A(e,e'h)X Reactions

Up to now there are no data on backward inclusive production of hadrons in A(e,e'h)X reactions. The interest in such measurements is emphasized by the fact that corresponding spectra in hadron-nucleus interactions highlighted many qualitatively new effects, and lead to the development of models for their generation and to the different notions about the nature of the clusters. It is obvious that the A(e,e')X data at fixed Q^2 and ν would allow us to distinguish between these models and to better understand nature of the cluster.

For example, it is important to measure inclusive spectra for various secondary particles in the region $a > 2$ at different Q^2 and ν, and to compare them with the corresponding data obtained in hA interactions. In addition, ratios of yields for different secondary particles such as π/p, n/p, K/π, may also give us valuable information.

One can obtain further information from the measurement of double-inclusive secondary particle cross-sections (secondary particle correlations). In distinction to the like-particle correlations at low relative momenta used to determine the space-time characteristics of the interacting region, correlations at large relative momenta yield information about the dynamics of the interaction process with heavy cluster. The correlations are also sensitive to the number of constituent particles in the cluster [26].

When registering pairs of secondary particles in the large solid angle provided by CLAS, it is natural to try to measure the production cross-sections of baryon and meson resonances, especially in the regions kinematically forbidden for the reactions on a free nucleon. Such data will allow clarification of questions related to non-nucleonic degrees of freedom in the clusters and to investigate the process of hadronization. There is a special interest in observing ϕ meson. Anomalously large production cross-sections could be an additional evidence of the presence of quark-gluon plasma, or an increased strange quark sea inside the nuclei.

4. EXPERIMENT.

The CEBAF Large Acceptance Spectrometer is particularly suited for these experiments. All of them require detection of the scattered electron e' with $Q^2 \geq 1$ GeV^2. Some experiments require measurements at $Q^2 \leq 1$ GeV^2 and with tagged photons. All experiments require a trigger on the scattered electron. Several experiments require a trigger on one (in some cases two) charged particles emitted in backward hemisphere, often within a set momentum range. Measurements on a C target seem to be most informative because C is heavy enough to observe clusters in eC interactions. Compared with heavier nuclei, C has: (a) a low number of clusters in the nucleus and better possibility to isolate one of them and (b) a better possibility of hadronization to occur outside the nucleus.

Comparative and not so detailed experiments on other nuclei (He, Al, Cu, Pb) are also needed: to study changes in the space-time picture of the interaction and to test our propositions.

4.1.1 Measurement of the mean size of the interaction region in eC interactions

The two-particle correlation function for the reaction aA $\to$ 1 + 2 + X may be defined as follows:

$$R_2^{12}(q,p) \equiv R_2^{12}(p_1,p_2) = \frac{\sigma_{in} \cdot d\sigma_{12}/(dp_1^3 \cdot dp_2^3)}{(d\sigma_1/dp_1^3) \cdot (d\sigma_2/dp_2^3)} \qquad (2)$$

Here p_1 and p_2 are the momenta of the particles 1 and 2; $q=p_1-p_2$, $p=(p_1+p_2)/2$; $d\sigma_{12}/(dp_1^3 \cdot dp_2^3)$ is the double differential inclusive cross-section; $(d\sigma_1/dp_1^3)$ and $(d\sigma_2/dp_2^3)$ are inclusive production cross-sections for particles 1 and 2 in the reactions aA $\to$ 1 + X and aA $\to$ 2 + X; σ_{in} is is the total inelastic cross-section for the reaction aA $\to$ X. This definition is experimentally convenient. One-particle detector efficiency corrections to the function $R_2(q)$ defined in this way are insufficient to a first approximation. However these corrections, which are identical in the numerator and the denominator of (2), are cancelled and only the detector efficiency for close tracks should be taken into consideration. The q - dependence of the correlation function may be sensitive to space-time characteristics of the source emitting particles 1 and 2 [14,15].

The two-proton or two-pion correlation function R_2^{pp} or $R_2^{\pi\pi}$ may be determined as the ratio of two distributions on the relative momentum q of the particles in the pair: the numerator is the q distribution for pairs of particles in eA events and the denominator is the same distribution for pairs composed of particles taken from different events.

Figures 5 and 6 show $R_2^{pp}(q)$ and $R_2^{\pi\pi}(q)$ obtained as a result of analysis of approximately 50,000 inelastic e ^{16}O interactions (beam-gas interactions registered by the ARGUS detector at the e^+e^- storage ring DORIS-II at

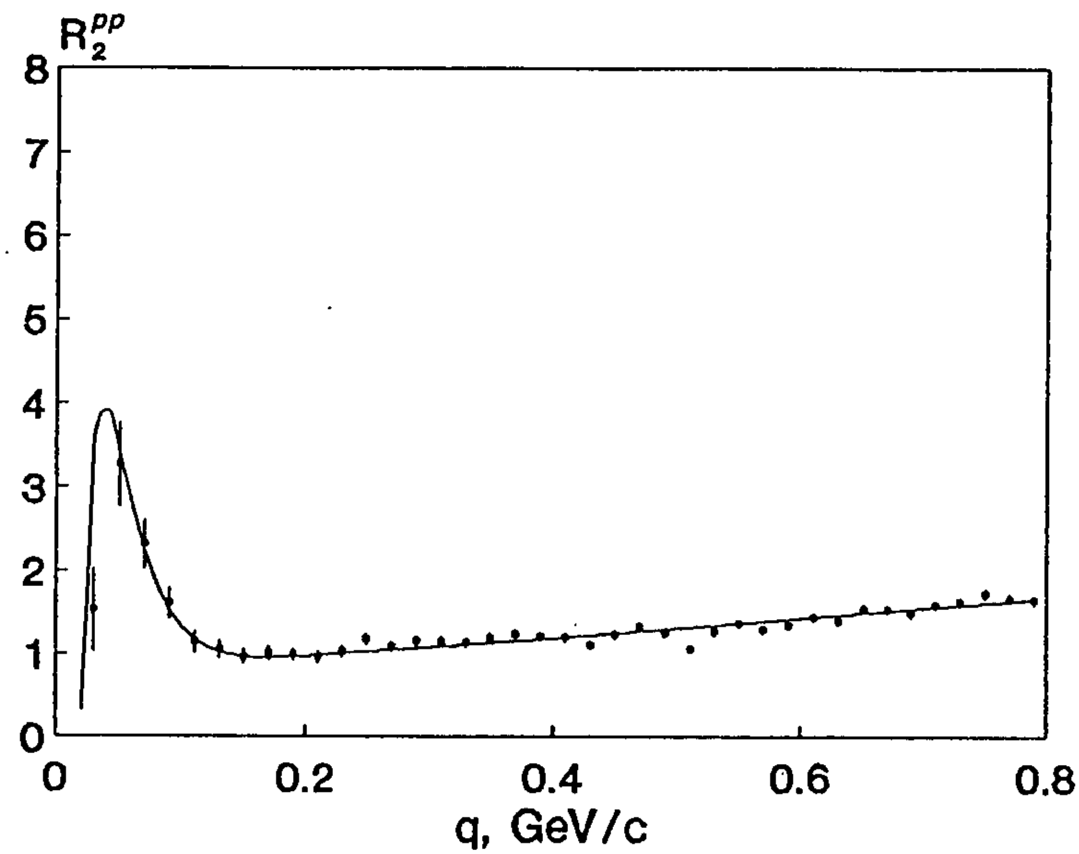

Figure 5. R_2^{pp}. as a function of q. The solid line is the result of calculations performed under assumption of spherically symmetric gaussian proton source with rms radius $r = 2.89$ fm.

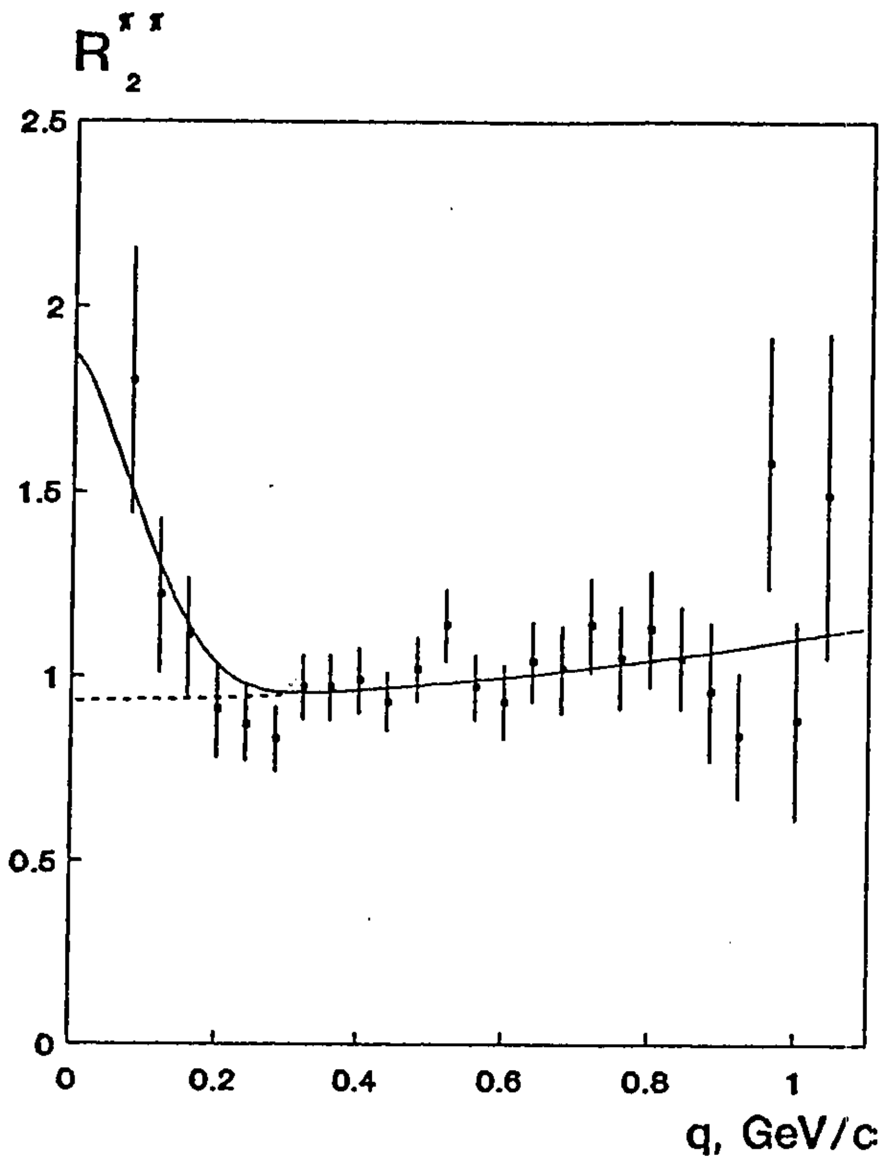

Figure 6. $R_2^{\pi\pi}$ as a function of q. The solid line is the result of fitting of the data. The difference between the solid and dashed lines shows the effect of like-pion interference.

DESY)[23]. The main cuts on the data were: (a) presence of a secondary proton and (b) three or more charged particles in the final state. Secondary electrons in the reaction A(e,e')X in ARGUS detector were not detected because the cross-section decreases sharply with Q^2 ($d\sigma/dQ^2 \sim Q^{-4}$) and $Q^2_{min} \simeq 1$ GeV^2 in ARGUS. Therefore the data sample consisted mainly of events with low $Q^2 << 1$ GeV^2.

The effect of low relative momenta correlations is clearly seen in figures (5,6). The enhancement of $R_2^{\pi\pi}(q)$ at low q is attributed to like-meson interference, while the more complex behaviour of $R_2^{pp}(q)$ is due to the combined effects of interference, strong attractive short-range interactions and Coulomb repulsion in the final state. Mean source radii were estimated using the ARGUS data. Analysis of the proton pair data yielded a rms source radius of $r^{pp} =$ 2.89 ± 0.13 fm, and the pion pair data gave $r^{\pi\pi} = 2.53 \pm 0.54$ fm. Although the proton pair source radius is reasonably determined, an equally good measurement of the pion pair source radius requires 10 to 100 times better statistics.

This work may be performed using CLAS detector with a simple inclusive trigger on scattered electron. In this case the number of events analogous to the ARGUS e ^{16}O events may be estimated to be 1 to 2% of the total number of events. Assuming a trigger rate to be 100 triggers/sec we can obtain comparable statistics in approximately 10 hours of operation.

4.1.2 Measurement of the mean size of the interaction region in different intervals of Q^2 and ν for different A

To confirm various aspects of supporting reaction models, it is necessary to measure the space-time characteristics of the interaction region as a function of Q^2, ν and target A. As the eA cross-section strongly falls with growing Q^2, a special trigger should be applied to cut off processes with low Q^2. The rate of events in the different regions of Q^2 and ν in e(4 GeV)C interactions were estimated using a modified version of CELEG [27], with a luminosity = 10^{33} $cm^{-2}\cdot sec^{-1}$ (see table 1). A rough approximation was made that the cross-section of the processes of interaction with clusters is of the order of 50% in comparison to the total inelastic cross-section. One may see in the table that the rates are quite high even in the regions of high Q^2. Acquired data can be sufficiently (up to the factor ≃20) enhanced with cluster interaction events if we require the detection of backward emitted particle as a trigger condition. Another way to separate such interactions from interactions with quasifree nucleons is using some sort of multiplicity trigger (require two or more particles in the final state).

Table 1.
Rates of events in different intervals of Q^2 and ν (events/sec).
Luminosity = 10^{33} $cm^{-2}\cdot sec^{-1}$. eC interactions at 4 GeV.

		ν interval,GeV			
		0 - 1	1 - 2	2 - 3	3 - 3.6
Q^2 interval, GeV^2	0.1 - 1.0	3200	770	360	150
	1.0 - 2.0	20	108	96	40
	2.0 - 4.0	-	17	48	30

4.1.3 Measuring longitudinal and transversal dimensions of the interacting region

The existence of a non-symmetrical source of secondary particles will result in the observed difference of the correlation functions $R_2(q_l)$ and $R_2(q_t)$, where q_l is the longitudinal and q_t is transverse component of q vector. By measuring $R_2(q_l)$ and $R_2(q_t)$ as a function of angle, one can determine both the direction and degree of elongation of the interaction region.

Fig. 7 shows the $R_2^{pp}(q_l, \text{or } q_t)$, functions measured in 7.5 GeV/c p + Pb interactions at ITEP [18]. Secondary protons were detected in the region of 80 to 100 degrees in the laboratory frame. The difference between the two functions is clearly seen. The longitudinal size of the emitting source is estimated to be from 2 to 4 times greater than the transverse size.

Such experiments require statistics x100 better than that necessary for the measurement of the mean pair source radii. As a result, both high luminosity and a sophisticated trigger on the presence of one or two secondary particles emitted in backward hemisphere of the proper momentum are required. It is extremely interesting to observe the asymmetry of the interaction region for eA interactions with large momentum |Q| transferred to nucleus. For example, using a Pb target, one expects the direction of elongation of the interaction region to coincide with the direction of Q.

4.1.4 Angular dependence of the coalescence coefficient in deuteron production

Figure 8 shows the angular dependence of coalescence coefficient κ_2:

$$\kappa_2 = \frac{\rho_d^c(T_d)}{\rho_{pn}(T_p/2, T_n/2)} \qquad (3),$$

where $\rho_d^c(T)$ is the normalized inclusive cross-section for deuteron production and $\rho_{pn}(T/2,T/2)$ is the normalized cross-section for the double-inclusive reaction h + A $\rightarrow$ p + n + X when both proton and neutron are emitted with equal energies at the same angle as the deuteron [21].

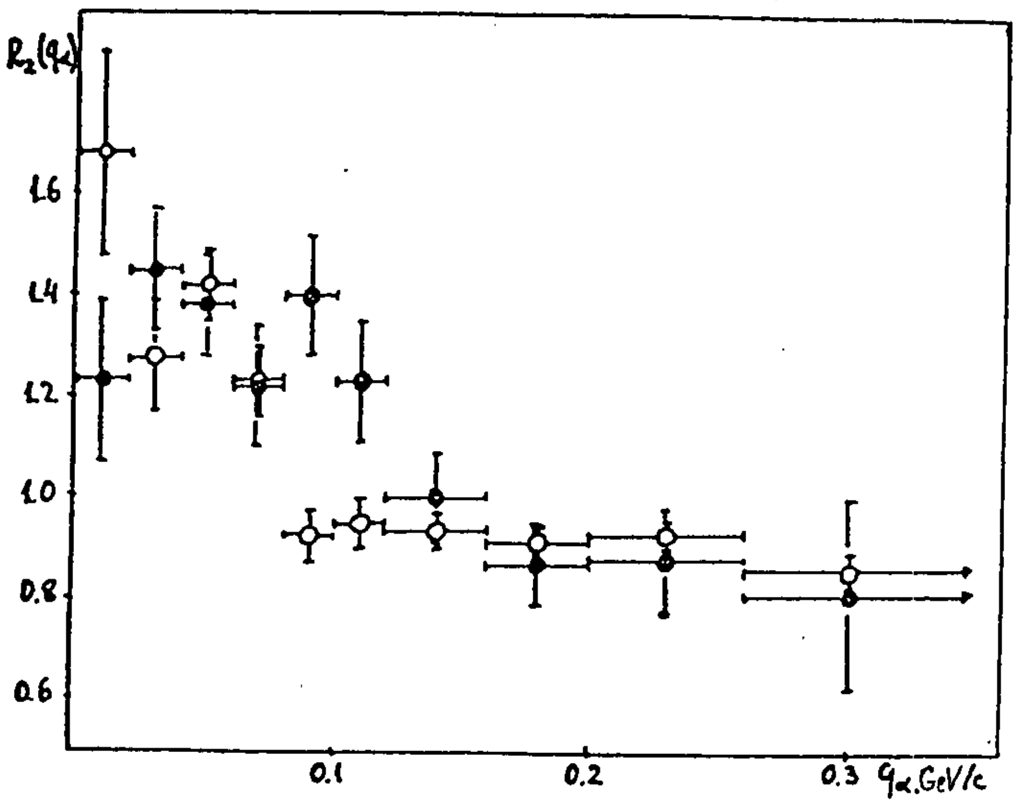

Figure 7. $R_2^{PP}(q_l)$ - filled circles; $R_2^{PP}(q_t)$ - open circles. pPb interactions at 7.5 GeV/c [18].

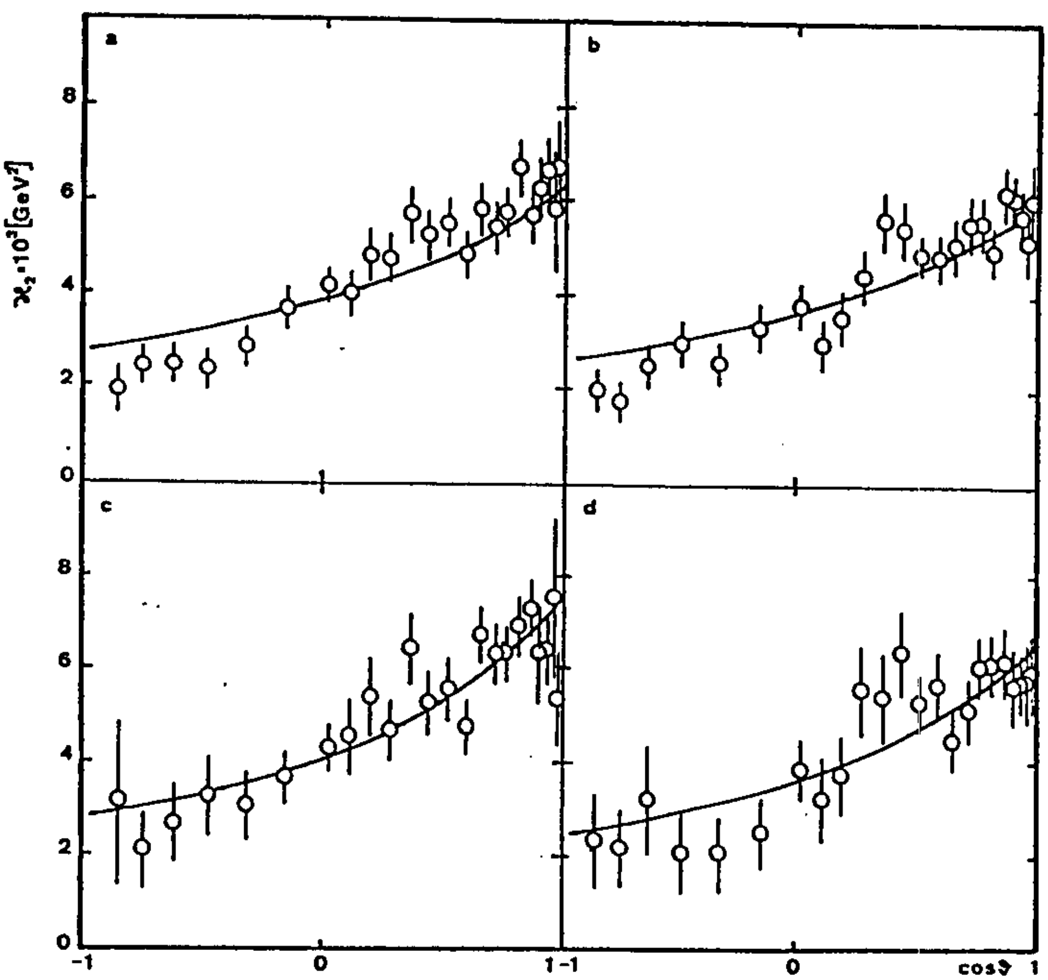

Figure 8. The coalescence coefficient as a function of cosθ for 150 MeV (a,b) and 230 MeV (c,d) deuterons emitted from Pb and U nuclei in 7.5 GeV/c pA (a,c) and 5 GeV/c π^-A (b,d) interactions (the results for Pb and U targets have been averaged)

The angular dependence is sensitive to the space-time picture of the interaction. Analysis of the angular dependence suggests that secondary nucleons are successively emitted through local interactions of the incident hadron in the nucleus. A similar effect may be expected in electron-nucleus interactions if there is a hadron jet interacting in the nucleus. At low Q^2 this jet is related to the hadron component of the virtual photon. In the region of high Q^2 this jet may be related to a knocked out quark. Alternatively, if the incident electron interacts with only one multiquark bag, the coalescence coefficient would not depend on angle.

Measurement of the angular dependence of the coalescence coefficient κ_2 should be made using both light and heavy nuclei (C and Pb) in all accessible regions of Q^2 and ν. Approximately 10,000 deuterons in the momentum region of 0.4 to 1.0 GeV/c and at angles between 30 and 135 degrees are required to provide meaningful statistics for these measurements. Based on the mean multiplicity of deuterons that has been measured for ARGUS $e^{16}O$ events [23], one would need to collect roughly 250,000 events similar to those of the "ARGUS" data.

4.1.5 Angular and momentum dependences of the source size

The size of the interaction region should vary as a function of the mean angle of observation. This dependence is closely connected to the coalescence coefficient angular dependence. $R_2(q)$ functions analogous to those shown on the figs. 5 and 6 should be observed for secondary particles emitted at several different angular intervals.

Figure 9 illustrates the dependence of the nucleon emission region size on the mean momentum of the nucleons [18,28]. The decrease of the size may be understood as a decrease of the process duration time at the transition from nucleon production via evaporation processes to the production of nucleons via local intranuclear interaction processes. A study of similar effects in eA interactions would provide important measurements necessary in the study of short range nuclear properties.

4.1.6 Source size dependence on baryon content of the cluster

The baryon charge of a cluster or multi-quark bag may be estimated in two ways. First, one may consider the number of baryons in the final state. In the case of interactions with a single cluster, the baryon multiplicity is closely tied to the cluster baryon charge. Figure 10 shows the experimental proton multiplicity distribution for eA events detected by ARGUS. Measurements using CLAS should be first carried out on light nucleus and in the region of large Q^2 and ν, such that the interaction with a single cluster may be isolated.

An alternative method to determine the mass of multiquark bags is to measure the sum of the light cone variables α of all secondary particles in an event. In this case the pair source size measurements should be carried out in the several intervals of $\Sigma\alpha$.

4.2 Inclusive measurements

4.2.1 Multiplicity distributions for single cluster events

The multiplicity distribution shown in the figure 10 is dependent upon two distributions: first, the number of sources of protons, or clusters in the inelastic hadron-nucleus interactions, and secondly, the number of protons

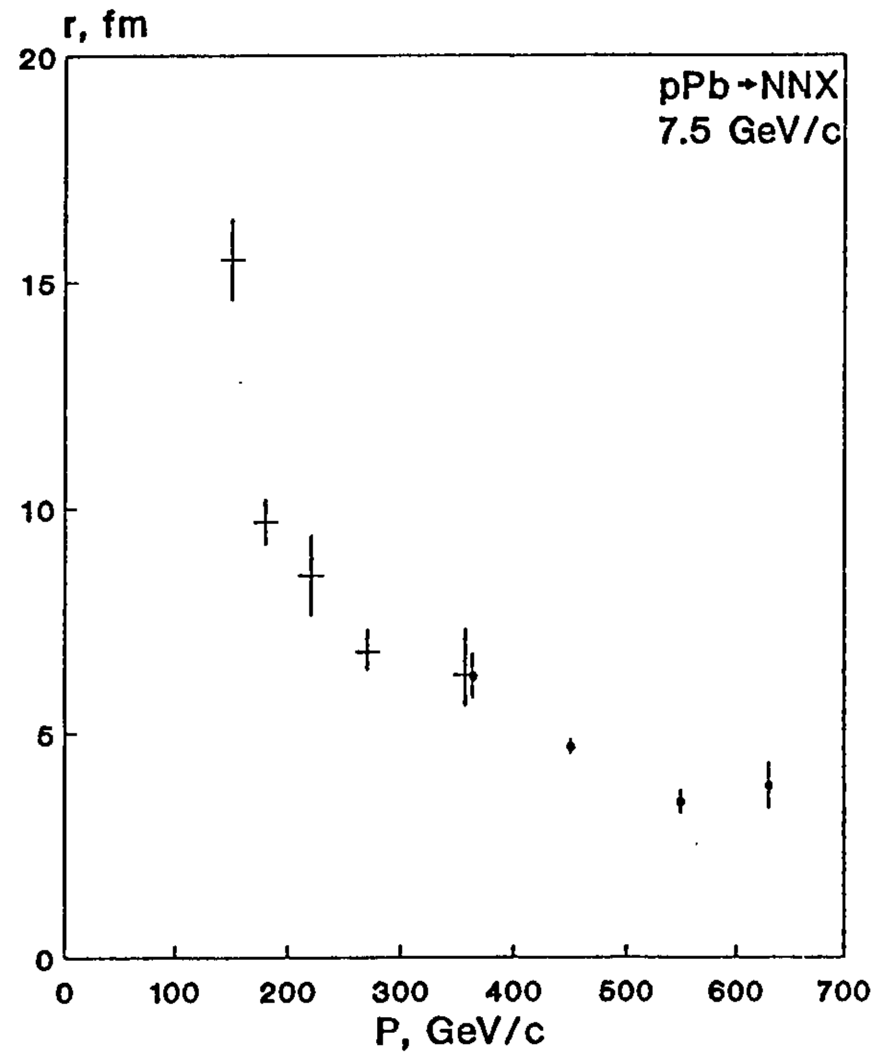

Figure 9. Root mean square radii of the nucleon emission region as a function of mean momentum of the nucleon in the pair.
+ - in reaction pPb → n+n+X [28] at E_o = 7.5 GeV/c;
• - in reaction pPb → p+p+X [18] at E_o = 7.5 GeV/c;

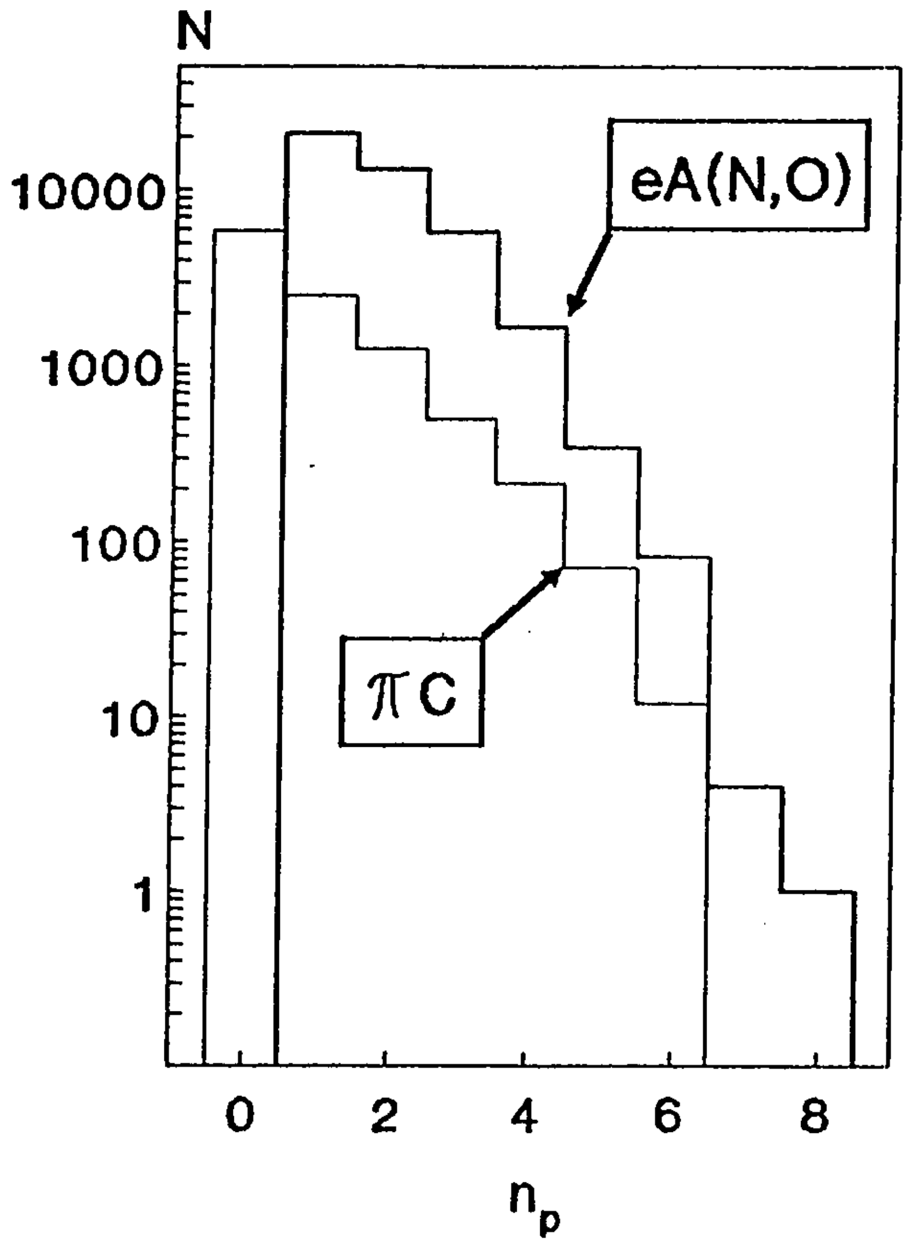

Figure 10. Proton multiplicity distribution in ARGUS $e^{16}O$ events (thick line) and in πC interactions [29] (thin line).

emitted by single cluster. For electron-nucleus interactions at high Q^2 and ν, it may be possible to isolate events in which only one cluster is produced (at CEBAF energies it might be possible with a light target nucleus). Multiplicity distributions of different secondary particles emitted by the cluster would then be measured.

4.2.2 Angular distributions

Figure 11, derived from 5 GeV incident energy $e^{16}O$ ARGUS data, shows the angular distributions of protons and pions with momenta between 0.5 and 1.2 GeV/c and between 0.2 and 0.9 GeV/c respectively. The polar angle θ was determined with respect to the direction of incident electron. Such angular distributions in e(He,C,Al,Cu,Pb) interactions should be measured to check the predicted universality of angular dependencies as well as to look for possible manifestations of energy and momentum transfer to the target nucleus as a whole.

4.2.3 Inclusive spectra

Figure 12 shows the measured proton inclusive cross-section (normalized to the total inelastic cross-section) as a function of the light cone variable α (ARGUS data, 50000 events). It is necessary to obtain inclusive data in a wider α range such that the spectra of different secondary particles including p, π^+, π^-, K^+, K^-, could be compared (see fig. 1).

4.2.4 Production of Δ-resonances

Figure 13 shows the ratio of the M_{eff} distribution of $p\pi^+$ pairs in real $e^{16}O$ events (ARGUS data) to the M_{eff} distribution of pairs of p and π^+ taken from different $e^{16}O$ events (mixed pairs). The ratio is similar to the R_2 correlation function (2). The bump in the distribution may be related to the production of Δ-isobars in inelastic $e^{16}O$ interactions and has been fit using the standard mass and width of the Δ^{++} resonance (see the solid curve on the figure). It is very important to measure the spectra of produced resonances. In the fig. 12 the measured α-dependence of the normalized Δ-production cross-section is shown in addition to the proton spectrum. The Δ^{++} production cross-section is $\simeq$20 times smaller than the proton cross-section. Future measurements of Δ production in the region of α = 1 to 3 must be made with statistics roughly a factor of 100 to 1000 better than the current measurements. It is also very interesting to measure Δ production in single cluster interaction events.

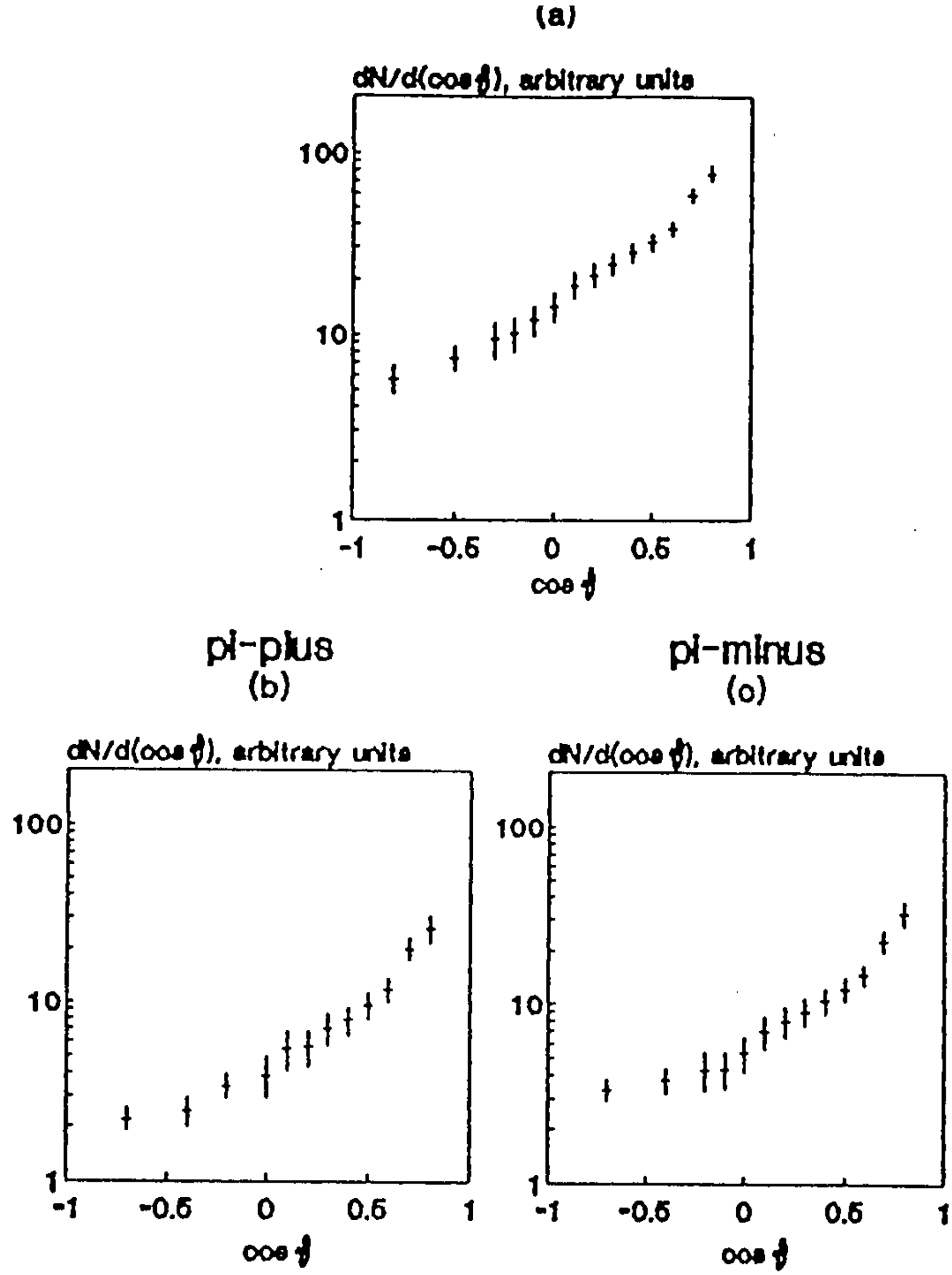

Figure 11. Angular distributions for protons and pions emitted in $e^{16}O$ interactions at $E_o = 5$ GeV.

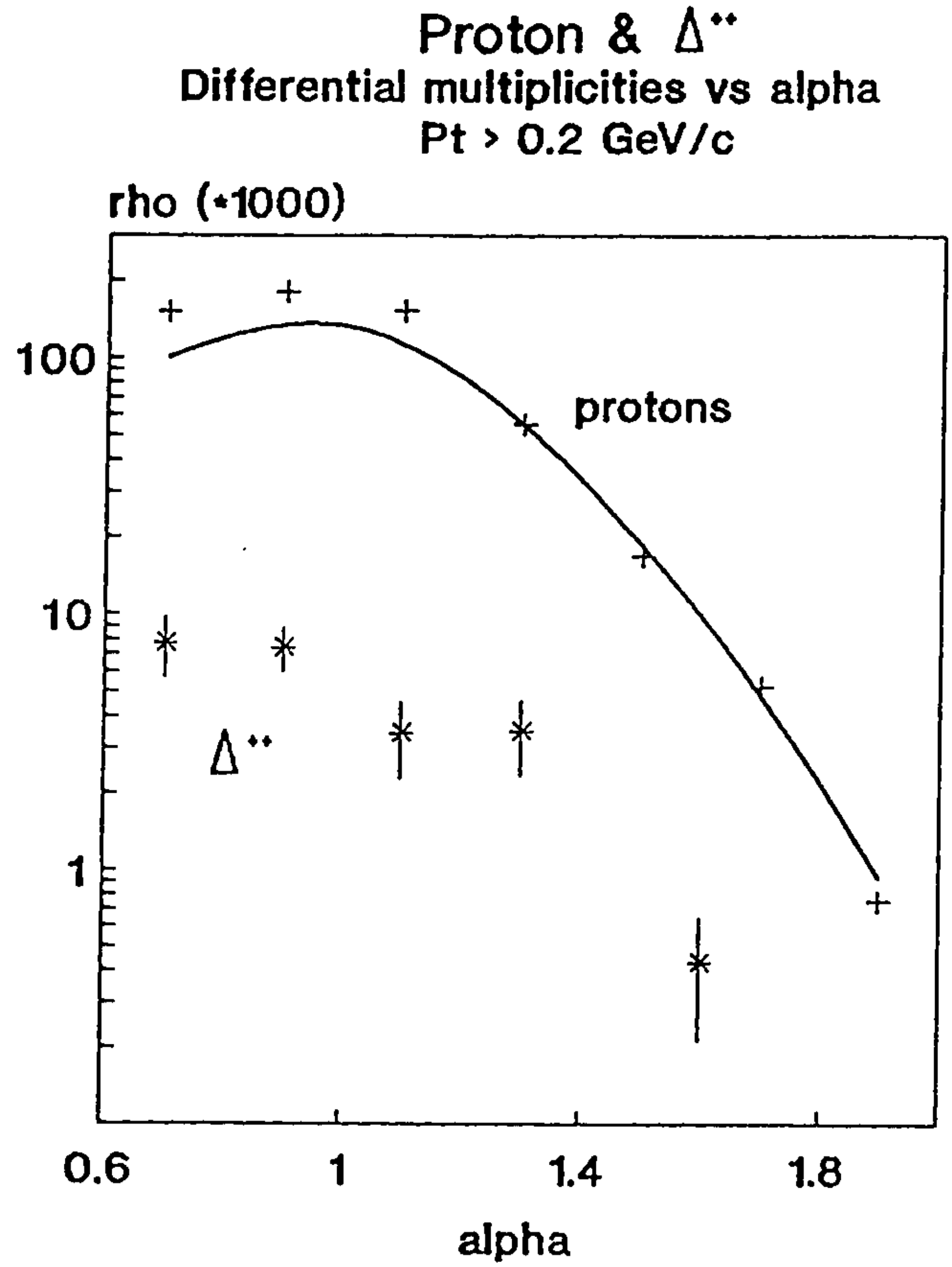

Figure 12. Differential multiplicity ρ (inclusive invariant cross-section normalized to the total inelastic cross-section) for protons and Δ^{++} produced in 5 GeV incident energy $e^{16}O$ interactions.

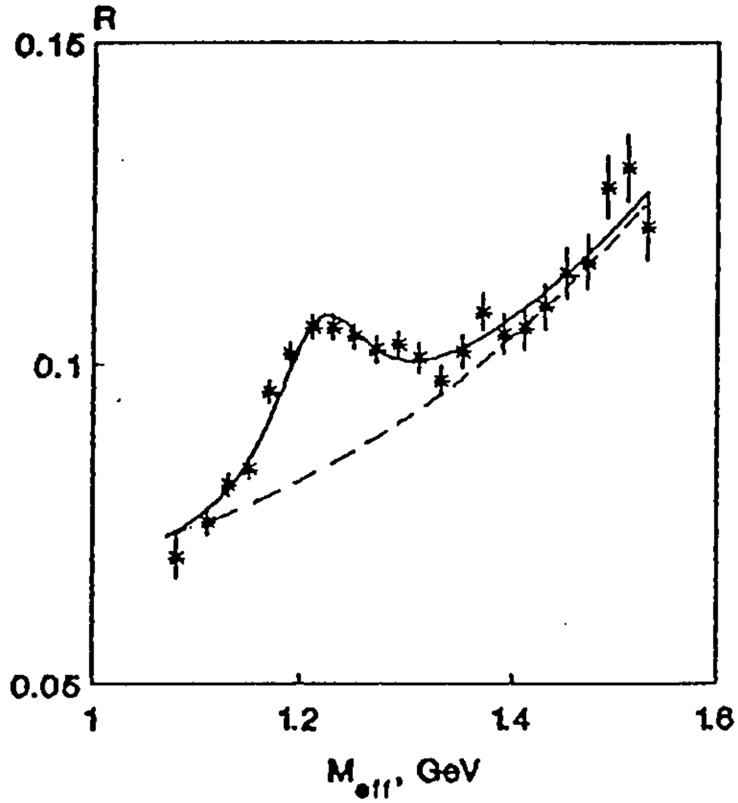

Figure 13. The ratio of the M_{eff} distribution of $p\pi^+$ pairs in real $e^{16}O$ events (ARGUS data) to the M_{eff} distribution of pairs of p and π^+ taken from different $e^{16}O$ events (mixed pairs).

R E F E R E N C E S:

1. Bayukov Yu.D. et al.,- Izvestiya Akad. Nauk, Fizika, 1966, v.30, p.521
2. Alanakyan K.V. et al.,- Sov.J.Nucl.Phys., 1977, v.26, p.539
3. Efremenko V.I. et al.,- Phys.Rev.D, 1980, v.22, p.2591
4. Leksin G.A. - Proc. of XVIII Int. Conf. on High Energy Phys., Tbilisi, 1976, v.1, p.A6-3
5. Frankfurt L.L. and Strikman M.I. - Phys.Rep, 1981, v.76, p.215
6. Leksin G.A. - Proc. of 6th Int. Conf. on High Energy Nucl. Phys., Balatonfured, Hungary, 1983, p.165
7. Gavrilov V.B. and Leksin G.A. - Deep Inelastic Nuclear Reactions and Some Aspects of Quantum Chromodynamics - Preprint ITEP-128, 1989
8. Frankfurt L.L. and Strikman M.I. - Phys.Rep, 1988, v.160, p.235
9. Efremov A.V. - Part. and Nucl., Dubna, 1982, v.13, p.613
10. Baldin A.M. - Nucl. Phys., 1985, v.A434, p.695
11. Gavrilov V.B. and Leksin G.A. - Preprint ITEP-95, 1987
12. Boyarinov S.V. et al.,- Sov.J.Nucl.Phys., 1987, v.46, p.871
13. P.Koch, B.Muller, J.Rafelski - Phys.Rep., 1986, v.142, p.167
14. Kopylov G.I and Podgoretskii - Sov.J.Nucl.Phys., 1971, v.15, p.219; Kopylov G.I and Podgoretskii - Sov.J.Nucl.Phys., 1973, v.18, p.336
15. Koonin S.E. - Phys.Lett, 1977, v.70B, p.43
16. Vlassov A.V. et al.,- Sov.J.Nucl.Phys., 1982, v.36, p.536
17. CERN AA data, Phys., Lett., 1988
18. Bayukov Yu.D. et al., - Preprint ITEP-2, 1988
19. Gavrilov V.B. et al., - Preprint ITEP-72, 1988
20. Mekjian A.Z. - Phys.Rev.C 1978, v.17, p.1051; Nucl.Phys., 1978, v.A312, p.491
21. Gavrilov V.B. et al.,- Z.Phys.A, 1986, v.324, p.75

22. Gribov V.N. - Sov.Phys ZhETF, 1969, v.57, p.709; Brodsky S. and Pumplin J. - Phys.Rev., 1969, v.182, p.1974
23. Degtyarenko P.V. et al.,- Inelastic Electron-Nucleus Interactions at 5 GeV Detected by ARGUS - Preprint ITEP-62, 1989, (Submitted to Z.Phys.)
24. Nikolaev N.N. and Zakharov V.I. - Phys.Lett., 1975, v.55B, p.397
25. Kancheli O.V. - Pis'ma v ZhETF, 1973, v.18, p.465
26. Bayukov Yu.D. et al., - Preprint ITEP-99, 1986.
27. Joyce D. - CELEG 1.0, CEBAF Large Acceptance Spectrometer Event Generator User's Manual, CEBAF, 1988
28. Bayukov Yu.D. et al., - Phys.Lett., 1987, v.189, p.291.
29. Angelov N. et al. - Yad.Fiz., 1979, v.30, p.400.

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Proposal Number: PR-89-032

Proposal Title: Study of Local Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS

Spokespersons/Contact Persons: V. Gavrilov, G. Leskin

Proposal Status at CEBAF:

Conditional approval. The overlap of proposals PR-89-015, -017, -027, -031, -032, and -036 is high but not complete. The proponents should attempt to coordinate beam energies, targets, and data acquisition, so that the six experiments can run simultaneously. The present feeling of the PAC is that the initial measurements should be limited to ^{3}He and one heavy nucleus, ^{3}He having priority, and that the optimal beam energies and kinematics are close to those in PR-89-031.

Dirk Walecka

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