CEBAF PROPOSAL COVER SHEET

This Proposal must be mailed to:

CEBAF
Scientific Director's Office
12000 Jefferson Avenue
Newport News, VA 23606

and received on or before 1 October 1991.

A. TITLE:

UPDATE ON MULTIHADRONS

B. CONTACT PERSON:

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C. IS THIS PROPOSAL BASED ON A PREVIOUSLY SUBMITTED PROPOSAL OR LETT OF INTENT?

[X] YES [ ] NO

IF YES, TITLE OF PREVIOUSLY SUBMITTED PROPOSAL OR LETTER OF INTENT

SIX 89 PROPOSALS ON MULTIHADRON
PR-89-015, 017, 027, 031, 032, + 036

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(CEBAF USE ONLY) PR 89-015, 017, 027, 031, 032 + 036 (Conditional)

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Update on CEBAF Proposals
PR-89-015, -017, -027, -031, -032, and -036

ABSTRACT

In this update, we present a unified run plan for proposals PR-89-015, -017, -027, -031, -032, and -036. Through four group meetings and a CEBAF sponsored workshop, we have isolated in our proposals the crucial questions to be addressed with the first CLAS studies of multihadron emission from nuclei, and circumscribed our program to examine those issues. We have coordinated our beam energies, targets, and trigger, but maintain various approaches to interpreting the physics that will be contained in the common data set. We focus our discussion on the need for an energy dependent study of four nuclides, even at the earliest stages of the CEBAF program. Finally we verify that high quality, publishable data can be achieved at the selected energies and targets, within our 800 hour beam time request.

1. Introduction

In this update, we present a unified run plan for proposals PR-89-015, -017, -027, -031, -032, and -036. These proposals were heard at PAC4b, and received a status of "conditional approval". The statements that followed indicated that "The overlap of proposals... 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."

Through four meetings of the CLAS Nuclear Multihadron Reactions Working Group, the proposal spokesmen and collaborators have discussed the physics issues to be explored. At the spring 1991 CEBAF sponsored Workshop on Multihadron Emissions in A(e,e$'$X) Experiments Using the CLAS, we had the opportunity to exchange ideas with theoreticians working in the field. Through these meetings we have identified the crucial elements of an initial CLAS program studying multihadron emission from nuclei.

Any program of study directed at characterizing the unique photon absorption processes available in complex nuclei, and identifying a unifying description of the underlying dynamical degrees of freedom must include, from the outset, the systematic dependences of these processes in energy transfer, momentum transfer, nuclear species, and final state channel. The CLAS is ideally suited to such a comprehensive program of study. Our combined proposal for the initial program, therefore, retains a "first look" over an extensive kinematical regime. Similarly, we retain a request to study these processes in a selected sample of nuclei, which, although scaled down from the original proposals, goes beyond the "present feeling" of the 1989 PAC, "that the initial measurements should be limited to ^{3}He and one heavy nucleus, ^{3}He having priority." Our request follows our recognition that interpretation of existing data, from inclusive quasielastic electron scattering to the EMC effect, has only been possible through comparing responses from different nuclides.

We request 800 hours of beam time at three different energies, with 22% of the request for 0.8 GeV, 36% at 2.0 GeV, and 42% at 4.0 GeV. We plan to study four targets, ^{3}He, ^{4}He, ^{12}C, and ^{56}Fe, with over one third of the beam time for each ^{3}He and ^{12}C. The detailed plan is presented in the table below. We are confident that the proposed program represents something close to an optimal balance between the merits of a more comprehensive study, and the desirability for high statistics on non-dominant reaction channels.

2.1 Studies of ^{3}He

Our largest beam time request. 300 hours, is for ^{3}He. ^{3}He is the simplest nucleus for studying (virtual) photon absorption on two or more nucleons with the kinematically complete ^{3}He(e,e$'$NN) reactions. Measuring both the p-p and p-n final state channels will determine provide information on the importance of absorption on T=0, J=1 (deuteron), and T=1, J=0 nucleon pairs. Calculations are already available which include initial state correlations (Fadeev calculation of the ground state), meson exchange currents, and final state rescattering effects. In these calculations, the longitudinal cross section leading to two high momentum protons in the final state is dominated by initial state short range correlations. Coupling to charged meson exchange currents and other reaction processes occur largely in the p-n system.

Three body forces are expected to enhance the cross section at kinematics where the final state momentum is shared approximately equally among three nucleons. One such configuration, usually referred to as the star configuration, occurs when the nucleons are ejected at equal momentum with 120° between them in their center of momentum system. The dependence of the cross section in the vicinity of such a configuration, will help illuminate the dynamic of the reaction, as well as the importance of final state interaction (FSI) effects.

The main objectives of the multi-nucleon knockout program can be achieved with data taking at beam energies of 0.8, 2.0 and 4.0 GeV. At 2.0 GeV incident energy the data will span a range in Q^2 from 0.3 GeV^2/c^2 to approximately 1 GeV^2/c^2, and a range in W from the quasielastic peak to 1.7 GeV. An extensive first examination of even relatively rare breakup modes, for example the "star" configuration, can be made with the proposed 100 hours of data taking on ^{3}He. Data taken at 0.8 GeV will be useful for low Q^2 studies, and for comparisons with data taken at Bates, Mainz and NIKHEF. Combined with high energy running at 2.0 GeV, the low energy data will provide an unparalleled opportunity to perform Rosenbluth L/T separations on data with multihadron final states. The prospects for doing a useful separation near W=1 GeV and Q^{22}=0.4 GeV^2/c^2 are encouraging. Data taken at 4.0 GeV will provide a first look at multihadron physics in a previously untouched kinematic regime. Mapping out the entire beam energy dependence of the multihadron knockout process will help give us a complete picture of that process and will be crucial for planning the next phase of multihadron studies.

The cospokesmen of all proposals will use and analyze the ^{3}He data. In particular the proponents of proposals PR-89-015, -027, and -031 are committed to measuring the N-N final state distributions and extracting the out-of-plane response functions. Members of these groups are already studying systematic effects in L/T separations, and will take responsibility for minimizing these effects in the designing and commissioning of the CLAS. Rosenbluth separations of the longitudinal and transverse responses will be

2.3 Studies in the Delta region

Multihadron knockout data from CLAS could lead to an understanding of how the structure difference between the nucleon and the Δ influences their interactions with nuclei (i.e. Δ-nucleus versus nucleon-nucleus potentials). Related objectives are to quantify any possible medium modifications of the Δ and to search for higher order reaction mechanisms such as NΔ goes to $\Delta\Delta$.

The original run plan of proposal 89-017 was guided by features of the Δ electroproduction cross sections seen in inclusive electron scattering data, primarily a systematic shift of the apparent Δ peak centroid as Q^2 is increased from 0.1 to 0.5 (GeV/c)^2. This shift is observed for all nuclei with A > 2 (see figure 1 of proposal 89-017). Two departures from the general trend are observed in the Δ position versus Q^2 plot. These are for ^{3}He at high Q^2 and for Fe at Q^2 near 0.1 (GeV/c)^2. Present inclusive data indicate that for ^{3}He the Δ peak position is intermediate between that for the deuteron and that for ^{4}He. For iron the Δ position is well below (1175 MeV) the free nucleon value.

Proposal 89-015 was at least partly guided by semi-exclusive data for two different kinematics in a ^{12}C(e,e$'$p) experiment. The missing energy spectra clearly show the contribution of multinucleon absorption processes in the region above the one-body knockout and pion production threshold. However, the data cannot distinguish two- and many-body processes from each other and furthermore cannot eliminate the possibility that the many-nucleon knockout strength may extend to the pion production region. Separation of the contributing channels in the quasielastic, dip, and delta regions would help isolate the pion production process and study its ω and q dependence.

The CLAS detector is sufficiently flexible that the desired Q^2 range can be covered with a judicious choice of magnet field strength and polarity. It is expected that the lowest Q^2 data will require reversed polarity while the medium Q^2 data will be taken with 2.0 GeV beam but reduced magnetic field in the CLAS. Data from ^{3}He and ^{4}He at 0.8 and 2.0 GeV will address the differences observed in the inclusive data. The anomalous low Q^2 iron position can be investigated during the proposed 10 hours at 0.8 GeV. Iron data with 2.0 GeV beam will provide a high A comparison with the carbon data. The proponents of proposals 89-015 and 89-017 are committed to a separation of the various reaction channels. In particular, 89-017 will isolate specifically the Q^2 dependence of the excitation energy and strength of the resonant contribution, while 89-015 plans to perform a more general decomposition.

process. Within the framework of most of these models, cumulative hadrons are produced as a result of heavy cluster fragmentation or its heating up to the temperature of the order of a pion mass.

The main disadvantage of hadron-nucleus reactions is the multiple interactions of the projectile in the nucleus. Much better conditions should be achieved for electron-nucleus scattering at $Q^2 \geq 1$ GeV^2 and $\nu = E - E' > A^{1/3}$ GeV. In this case for each e-A interaction only one heavy cluster should be involved in the process of cumulative hadron production. High transferred energy is also required for the excitation of exotic components of these clusters, such as multi-quark configurations or Δ-admixture. Correlations of hadrons emitted from the same heavy cluster can be measured. These data should allow to estimate spatial extensions, mass distribution, and density of the clusters, and to distinguish between the models of cumulative particle production.

The most informative data, at least at the first stage of this investigation, can be obtained at the beam energy of 4 GeV using a carbon target. On the one hand, the carbon nucleus is large enough to supply clusters with their mass distribution close to that of infinite nuclear matter. On the other hand it is small enough to achieve the condition $\nu > A^{1/3}$ GeV at $E = 4$ GeV. In order to measure the spatial extensions of the secondary hadron source, the like-particle correlations at small relative momenta should be measured. So the events of C(e,e$'$ppX) and C(e,e$'\pi\pi$X) reactions will be analyzed.

The analysis of 5 GeV electron-oxygen events detected by ARGUS allow us to estimate that about of $3 \cdot 10^7$ events of C(e,e$'$X) reaction should be recorded by CLAS to achieve a statistical accuracy of 5–10% for determining the pion source radius. The statistical accuracy for the proton source radius is expected to be about 3 times better. Such accuracies are required to study the variation of the hadron source radius versus the emission angle and the cluster mass. MC simulations show that about 60 ev/sec of the C(e,e$'$X) reaction at $Q^2 \geq 1$ GeV^2 and $\nu \geq 2$ GeV will be recorded using the CLAS inclusive trigger at 4 GeV beam energy and a luminosity of 10^{33} nucleus$\cdot$cm$^{-2}\cdot$sec^{-1}. Such a luminosity is expected to be the maximum for CLAS operation, due to background conditions. The total rate of C(e,e$'$X) triggers is estimated to be 150 sec^{-1} which seems to be well within the capability for CLAS. So during 150 hours run the required number of events will be accumulated. The analysis of this data sample should allow to measure the inclusive spectrum of the $\Delta(1232)$ at the range of $\alpha = (E - p_L)/m_N \leq 2$ with a good statistical accuracy.

The ^{4}He nucleus is uniquely suited for studying the short-range correlations in nuclei and exotic (non-nucleonic) components of the nucleus wave function because on one hand the probability of these components per nucleon is already rather large, only 1.5 times smaller than in heavy nuclei, though on the other hand, secondary interaction effects are much smaller than in heavier nuclei. Therefore one should try to perform a detailed study of scattering off ^{4}He at as large momentum and energy transfer as possible. For

3. Appendix: Proposal Titles, Spokesmen and Collaborating Institutions

PR-89-015 *Study of Coincidence Reactions in the Dip and Delta-Resonance Regions* H. Baghaei, spokesperson University of Massachusetts

PR-89-017 *Electroexcitation of the* $\Delta(1232)$ *in Nuclei* R. M. Sealock, spokesperson CEBAF, Florida State University, University of Pittsburgh, James Madison University, University of Virginia, Rennsselaer Polytechnic Institute

PR-89-027 *Coincidence Reaction Studies with the LAS* W. Bertozzi, W. Boeglin, L. Weinstein, spokespersons California Institute of Technology CEBAF, The College of William and Mary, University of Maryland, Massachusetts Institute of Technology, University of Virginia,

PR-89-031 *Study of Multinucleon Knockout with CLAS* F. W. Hersman, J. Lightbody, R. A. Miskimen, spokespersons CEBAF, University of Massachusetts, National Institute of Standards and Technology, University of New Hampshire

PR-89-032 *Study of Local Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS Detector* G. A. Leksin, spokesperson Institute of Experimental and Theoretical Physics, Moscow, Kharkov Institute of Technology

PR-89-036 *Study of Short-Range Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS Detector* K. Sh. Egiyan, spokesman Yerevan Physics Institute, Leningrad Institute of Nuclear Physics, Kharkov Institute of Physics and Technology