Jefferson Lab PAC14

Proposal Cover Sheet

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☒ **New Proposal Title:** Measurement of the polarized electron beam asymmetry on exclusive reactions in nuclei with CLAS

☐ **Update Experiment Number:**

☐ **Letter-of-Intent Title:**

(Choose one)

Proposal Physics Goals

Indicate any experiments that have physics goals similar to those in your proposal.

Multi-hadron (e2) run group

Approved, Conditionally Approved, and/or Deferred Experiment(s) or proposals:

E89-015, E89-017, E89-027, E89-031, E89-032, E89-036

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Measurement of the polarized electron beam asymmetry in exclusive reactions on nuclei with CLAS

The Multihadron Collaboration

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S. Stepanyan, L. Weinstein.

Spokesmen: F.W. Hersman, M. Holtrop

We propose a measurement of the polarized electron beam asymmetry (the fifth response function, R_{LT}') in exclusive reactions on the nuclei of ^{3}He, ^{4}He and ^{12}C. The CLAS detector is an ideal instrument for survey measurements of these asymmetries because of its extensive out of plane capabilities and full angular coverage. The asymmetry A_{LT}' (and the associated response function R_{LT}') is associated with the imaginary part of the longitudinal-transverse interference. Because its symmetry structure is time reversal odd, it vanishes for any direct process and thus provides an unambiguous signature for multi-step processes. As such, it provides information that is uniquely different from that available with the response functions accessible without polarization observables.

A question that is central to the multi-hadron reactions program is to determine the extent to which the virtual photon absorption mechanism that leads to multinuclear emission, sometimes at extreme kinematics, arises from a pre-existing configuration or via final-state rescattering. Measurement of this asymmetry can provide a powerful method for identifying and characterizing the multi-step final-state processes, thereby disentangling the relevant degrees of freedom in exclusive electron scattering on complex nuclei. This measurement is compatible with the already approved time for the cross section survey of the multi-hadron (E2) run group, but will require polarized beam, preferably at high polarization. We also require sufficient beam time to perform measurements of beam polarization with the Møller polarimeter.

Introduction

The approved program to study nuclear multihadron reactions with CLAS is directed at characterizing the virtual photon absorption processes in complex nuclei, and identifying a unifying description of the underlying dynamical degrees of freedom. It was designed from the outset to include the systematic dependencies of these processes in energy transfer, momentum transfer, nuclear species, and final state channel. This proposal requests inclusion of beam polarization among the experimental degrees of freedom, and discusses the benefit of including the electron beam asymmetry to the list of observables.

The polarized electron beam asymmetry is proportional to the longitudinal-transverse interference response function R_{LT}', sometimes referred to as the fifth response function. It is calculated as the imaginary part of the interference between two amplitudes, longitudinal and transverse, and is odd under time reversal. Consequently it vanishes for all direct reactions (and for isolated resonances). It can be non-zero for reactions involving multiple steps, in particular final state interactions and meson exchange currents. As Raskin and Donnelly point out,"…This fifth function is sensitive to the presence of the fundamentally interesting final-state interactions intrinsic to the (e,e'x) process. Thus not only do polarized electrons give us access to new information concerning the nuclear physics underlying the exclusive reaction, but in addition this information is fundamentally different from that which can be obtained in the absence of any polarization."

The CLAS is ideally suited to a comprehensive study of multihadron reactions, including beam asymmetries. The large acceptance is able to simultaneously survey large kinematical regions for multi-particle final states, allowing the many contributing channels of the (e,e'p) cross section to be separated. Its coverage includes out-of-plane detection capability as a natural consequence of its 4-pi configuration. The inclusion of the polarized electron beam asymmetry, which is nonzero only for non-coplanar reactions, in this survey opens up a unique opportunity to address this additional physics. The presence of an asymmetry could provide a signature of multi-step contributions to the reaction process, and serve to calibrate the importance and character of final state interactions.

The polarized beam asymmetry is an experimental quantity relatively insensitive to the accuracy of absolute normalizations. By contrast, determining absolute cross sections for multi-particle reactions, including the efficiency and acceptance of CLAS, requires a fully developed and calibrated software package. Furthermore, a comprehensive understanding of these reactions will emerge only in the context of comparisons with detailed and realistic theories. We believe that incorporating a measurement of the fifth response function into the survey of multihadron reactions on nuclei may expose intriguing features in the data that may be publishable on a shorter time scale than the full cross sections.

In the following section we review the central thrusts of the nuclear multihadron reactions program in CLAS. We identify the connection between the underlying physics mechanisms that are under study, and elaborate on the additional constraints on the physics that beam asymmetry measurements would make possible. In the final section we highlight a few reactions in selected kinematics. We calculate the error bars that could be achieved within the presently approved running time under various assumptions for average beam polarization.

Physics Motivation

High energy electrons reacting with nuclei transfer momentum and energy (and angular momentum) to the nuclear many-body systems. One might naively expect that the observables can be described to a good approximation by folding the nucleon cross section with the initial momenta of bound nucleons (due to Fermi motion) and spreading the final momenta by final state interactions. In some selected kinematics (the quasifree knockout peak or the peak of the Delta-resonance) this is a good approximation. Even in these cases, however, mysteries arise. The dependence of quasifree scattering on scattering angle reveals an anomaly in the ratio of longitudinal to transverse reactions. Further exploration of this phenomenon with electron proton coincidence reactions indicates that there may be a missing energy dependence in the L/T ratio [ref. 1,2]. Also an anomalous enhancement of the R_{LT} structure function has been observed in ^{16}O and ^{12}C [ref. 3,4]. In the resonance region, broadening and flattening of the structures has been observed, which becomes more significant with increasing mass. Because this effect is too strong to be attributed to momentum smearing alone, it indicates the strength of additional resonance damping mechanisms available in the presence of other nucleons.

Reactions have been studied in kinematics selected for their ability to highlight multinucleon effects. Inclusive scattering reveals substantial unexplained strength in the quasielastic dip region. Exclusive reactions reveal correlated two-body knockout, even three- (or more) body correlated knockout is indicated. Unexplained enhancements in deuteron knockout have been observed. Some detailed extractions of response favor interpretations in terms of relativistic effects, while others are more ambiguous.

Searches for non-quasifree effects at higher beam energies reveal an abundance of mysteries. The studies of cumulative particles, backward-going particles observed with vector momenta that could not arise from reactions on single nucleons, find substantial strength for many different particles with high backward momenta [ref. 5,6.] Indeed the scaling behavior extends into kinematical regions requiring the participation of several nucleons.

In all these studies the central question revolves around the correct interpretation of these phenomena. If, in the end, these processes are all successfully described by repeated collisions between known constituents with conventional interactions, we will have made impressive progress on a difficult problem. Most of us believe, however, that the observed discrepancies indicate the presence of a hard scattering, high momentum mechanism that has not yet been fully characterized nor correctly identified. These processes are often identified as nucleon-nucleon short-range correlations (SRC) and the multinucleon photon absorption mechanism. Whether this mechanism is simply the short-range part of the two-nucleon interaction, or whether more exotic configurations (quark delocalization, stable multinucleon clusters) are more appropriate descriptions is not clear. Identifying the most appropriate collective degrees of freedom to characterize this very broad range of many-body phenomena is the goal of this study.

The polarized beam asymmetry is a highly selective observable. Because it is a longitudinal-transverse interference, it vanishes for all combinations of purely transverse reactions. Furthermore, because its symmetry is time-reversal odd (the imaginary part) it vanishes for direct reactions as well as isolated resonances. It offers no information for discriminating between the predominant transverse reaction mechanisms involving pion production and isovector resonance excitation. Consequently, when this observable is non-zero, it reveals the presence of very specific conditions: multi-step reactions involving both longitudinal and transverse amplitudes.

The two nucleon knockout sub-channel of the (e,e'p) cross-section is of particular interest to the study of multi-nucleon reactions, since it creates optimum circumstances to reveal signatures of ground-state correlations. However few measurements of (e,e'pp) or (e,e'pn) exist [ref. 7,8,9,10], and none have used polarization degrees of freedom. The (e,e'pN) cross section is particularly sensitive to short-range correlations (SRC) and meson exchange currents (MEC) [ref. 11] and the addition of polarization degrees of freedom offers good perspectives to study the dynamics of tightly coupled protons and quasi-deuterons in the nuclear medium [ref 12]. Experiments with polarized photon beams on ^{3}He have shown the importance of photo-absorption on two and three nucleons [ref. 13]. Under the kinematical condition that the spectator proton is almost at rest, ref. 12 indicates a remarkable similarity between the $^3\mathrm{He}(\vec{\gamma},\mathrm{pn})\mathrm{p}$ asymmetries with those obtained from $\mathrm{d}(\vec{\gamma},\mathrm{p})\mathrm{n}$.

Interpretations of multi-nucleon processes, whether conventional or exotic, rely on the correct inclusion of initial state interactions (ISI), which are responsible for any participating collective structures, and final state interactions (FSI), which can, in principle, dilute the signatures of these structures. Both ISI and FSI must be considered on equal terms in the theoretical treatment of these reactions. For certain kinematics the MEC contribution almost vanishes and the fifth response function is dominated by FSI, allowing a definitive calibration of the separate roles of the ISI and FSI.

While some of the reaction channels can be interpreted within the theoretical framework available today, we recognize that for other processes the theory may only be qualitative, even at the time the data become available. In each case, however, the unique and unambiguous nature of the information from the fifth response function can help calibrate the contribution of final state interactions. We present those justifications below, many of them extracted from our original approved proposal [E89-031], and verify that high quality, publishable asymmetry data can be achieved.

Studies of ^{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 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 (Faddeev calculation of the ground state), meson exchange currents, and final state rescattering effects [ref.14]. 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 dynamics of the reaction, as well as the importance of final state interaction (FSI) effects.

The cross section alone will be insufficient for determining the extent to which FSI contribute in these kinematics. Measurement of the polarized beam asymmetry will provide a calibration of that piece of the reaction process. The initial state structure of ^{3}He is exactly calculable using modern potentials. Faddeev calculations in the continuum are also able to calculate exact final states, up to increasingly higher outgoing energies. The fifth response function will provide a key observable to compare with the theory in the regime where calculations exist, and extend our understanding of the importance of final state interactions and meson exchange currents into regions where calculations are not applicable.

Studies of ^{4}He

A comparison between ^{3}He and ^{4}He continues to be a central element in the multihadron program. Inclusion of polarized beam measurements enhances the physics opportunities in this comparison. There are a number of motivating arguments:

(1) According to many-body theory, the percentage of closely correlated two-nucleon components in the ground state of ^{4}He is substantially above the corresponding components in either the deuteron or ^{3}He, allowing increased sensitivity to many of those more exotic processes in which we are interested. This correlated two-nucleon component amount is still significantly less than in heavier nuclei.

(2) There is recent data for pion absorption on both ^{3}He and ^{4}He, which indicate substantial complex (N>2) absorption. The variation between the A=3 and 4 systems is not understood. More extensive data on these nuclei, with energies spanning a broader range than the pion data, would help elucidate the mechanisms at play. One example is the 'double-delta' mechanism, by which four nucleons can be ejected in the electromagnetic or pion absorption process. To identify this in particular, data are obviously needed on at least two targets—^{4}He and one heavier nucleus.

(3) Finally, recent inclusive electron scattering *y*-scaling data for ^{3,4}He again indicate unexplained behavior in going from A=3 to A=4. At A=3, the transverse and longitudinal *y*-scaling functions are the same; at A=4 we see the transverse enhancement typical of all heavy nuclei. However, unlike in heavier nuclei, the Coulomb Sum Rule appears to be satisfied in ^{4}He [ref. 15].

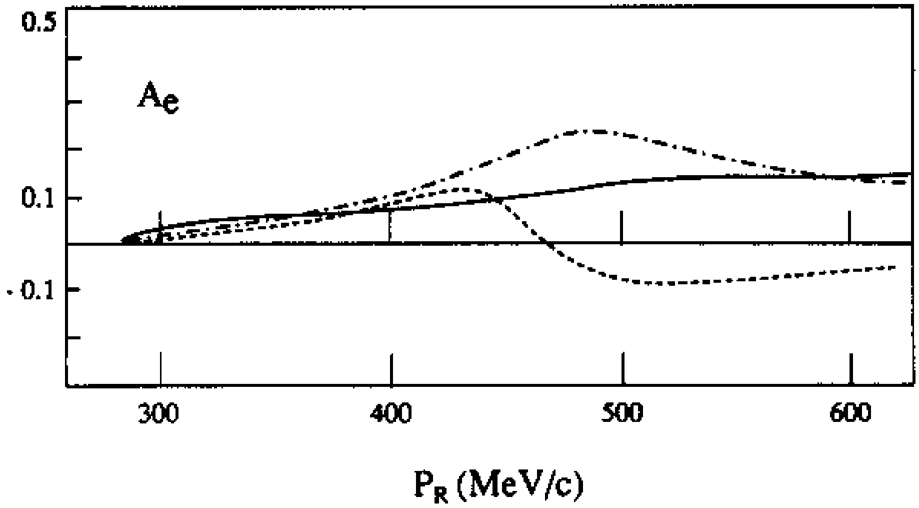

Figure 1. Beam asymmetry for ^{4}He as calculated by J.M. Laget [ref. 16] for E_{beam}= 700 MeV, ω=268 MeV, θ_e=35°. The PWIA contribution vanishes, with nucleon-nucleon rescattering included: dashed curve, meson exchange currents included: dot-dashed curve, three body mechanisms included: solid curve.

Thus, ^{4}He appears to be the transition nucleus between the simpler behavior of the mass 1, 2 and 3 nuclei and the complex, not well understood, behavior of the heavier nuclei. As the reaction mechanism becomes more complex and less calculable, it becomes increasingly important to include observables, like the polarized beam asymmetry, that allow the isolation of separate amplitudes contributing to the overall process.

An example of a calculation of the beam asymmetry by J.M. Laget is given in figure 1 [ref. 16]. The kinematics for this calculation are a beam energy of 700 MeV, electron scattering angle of 35°, and electron energy loss (ω) of 268 MeV, with a 90° out of plane angle. The graph shows how the contributions of meson exchange currents (dot dashed curve) and nucleon-nucleon rescattering (dashed curve) change for varying recoil momenta.

Fifth structure function measurements in medium mass nuclei

Nuclei in the mass range of carbon or oxygen exhibit the full range of many-body behavior detailed in the above discussion. Furthermore, theoretical treatments are generally based on mean-field theory and optical potentials, rather than the ground state and continuum Faddeev treatments used for few-body systems. Nevertheless the many-body dynamics, which depends on the short-range behavior of nucleons in nuclei, is essentially the same.

At lower values of momentum transfer, we make contact with existing data and theory. Using one of the Out-Of-Plane spectrometers at MIT-Bates, Mandeville *et al.* [ref. 17] measured the fifth response function on carbon at Q^2=0.15 GeV/c^2, while more recently Jiang *et al.* [ref. 18] measured the fifth response function at Q^2=0.12 GeV/c^2 and

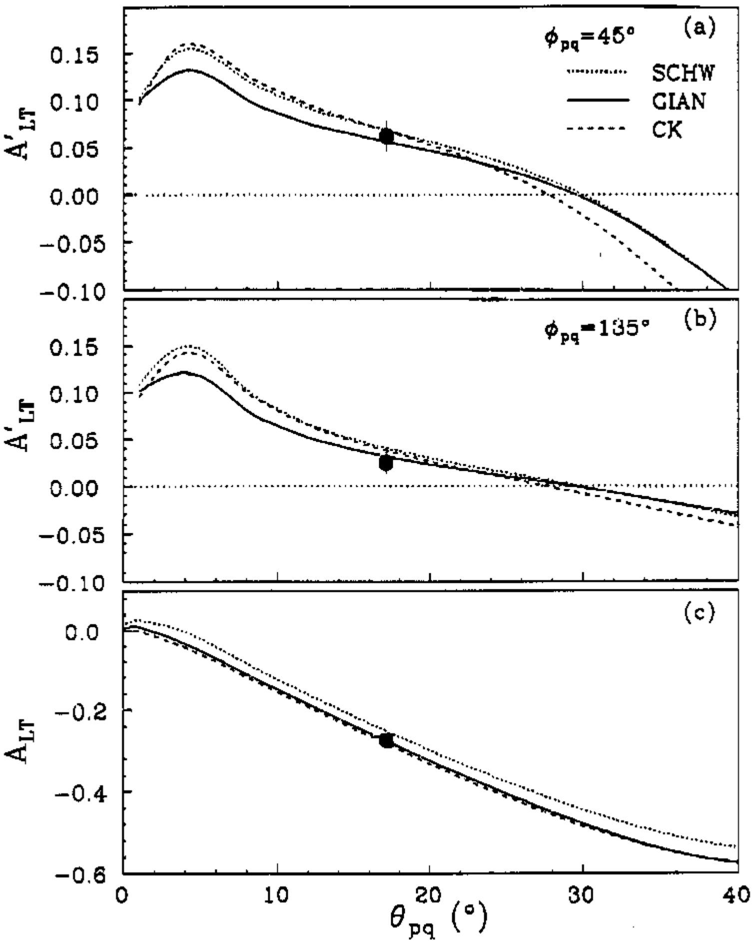

Figure 2 The $R_{LT'}$ and R_{LT} structure functions for Q^2=0.12 GeV^2/c^2 as measured at the Bates laboratory by X. Jiang *et al.* [ref. 18] The different curves indicate different optical potentials.

ω=72 MeV (Figure 2). While the data are in general agreement with calculations using the DWIA code PV5FF [ref. 19] from the Pavia group the kinematical range is too limited to make detailed comparisons. We make use of these calculations below in determining useful bin sizes and goals for statistical uncertainties.

One interesting phenomenon at high momentum is cumulative hadrons, particles emitted from nuclei in the backward direction beyond the kinematical region of projectile-nucleon interactions [ref. 5,6]. This phenomenon was widely studied using hadron, photon and lepton beams. It was established that the interactions of projectiles with multi-nucleon clusters with masses up to six nucleon masses are responsible for the generation of cumulative hadrons. A variety of theoretical models considering such clusters as short-range few-nucleon correlations or multi-quark bags were developed for description of the cumulative hadron production 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. Multiple scattering in the final state could, in principle, reverse the direction of high momentum outgoing particles. The fifth structure function could reveal the extent of final state interactions in cumulative hadron production.

Count rate estimates and experimental uncertainties

We estimate our statistical uncertainties for extracting polarized beam asymmetries using two methods. First we make a choice for the desired error bar and assumptions about the count rate limitations of CLAS and deduce the number of possible bins and the implied bin sizes. We compare the deduced bin size with what one might desire based on the structure of the physics. Secondly we choose a specific reaction, select bin sizes based on the physics, and deduce an error estimate.

Our first estimate is based on the counting rate of CLAS and the extent of the beam time already approved for the multihadron survey measurements. The event rate in CLAS is presently limited to about 1000 events per second, with considerable trigger inefficiency. We assume that when this experiment runs, the good event rate will be 1 kHz. This is less than the design luminosity of 10^{34}. Since three targets will be measured at three energies each, the average beam time per target per energy is 80 hours, yielding 3×10^{8} events. We choose a desired minimum uncertainty of 1% in the physical asymmetry. Since the asymmetry depends on the sine of the azimuthal angle, the number of events required must be doubled, to 20,000. This number must be divided by the square of the beam polarization, requiring 40,000 events for a 1% measurement with 70% beam polarization, and 140,000 events for a 1% measurement with 38% beam polarization. This allows the data set to be divided into either 7500 bins or 2000 bins, depending on beam polarization.

We envision a useful measurement should explore the kinematic acceptance with at least 5 bins in Q^2, 10 bins in omega, 5 bins in missing energy and 10 bins in θ_{pq} (missing momentum), requiring 2500 bins. If the data were distributed uniformly, the experiment could be accomplished in a satisfactory way with or without the high polarization photocathode. Indeed, with the low polarization photocathode, statistics are still adequate for a survey in some kinematics. If, however, we note that much (at least half) of the count rate at low momentum transfer is attributed to quasifree knockout to bound states, and most of the count rate at high momentum transfer is purely transverse, we recognize the impressive gains offered by the high polarization photocathode, and its importance for this experiment.

To examine the experimental requirements in more detail, we examine a particular reaction in the dip region between the quasielastic peak and the delta, one of the most challenging areas to isolate a reaction because of its low cross-section. Starting from the measured cross sections on ^{3}He by Marchand *et al.* [ref. 20], we find that at a missing momentum around 300 MeV/c the five fold cross section for the *ppn* breakup channels (integrated over the missing energy range from 15 MeV to 80 MeV) is 0.22 nb $\mathrm{MeV}^{-1}\mathrm{sr}^{-1}$. To extrapolate this measurement to our kinematics, we extract the spectral function using the formula:

$$\frac{\partial\sigma^5}{\partial\Omega_e\partial\Omega_p\partial E_m} = E_p p_p \sigma_{ep} S(E_m, P_m)$$

where E_p is the final proton energy, p_p is the final proton momentum and σ_{ep} is the off-shell electron proton form factor. The spectral function S only depends on the missing energy and missing momentum. For our kinematics we use a beam energy of 2.2 GeV and a scattering angle θ_e of 15°. For the dip region omega would be around 250 MeV. According to the GSIM Monte Carlo code the scattered electrons with 1.9 GeV/c momentum at 15° scattering angle are still within the acceptance of the CLAS. The same missing momentum of 300 MeV is then achieved at an opening angle θ_{pq}= 27°. The ratio of the kinematic factors and off-shell proton cross section for the new kinematics to those of the original measurement is 0.7. This results in a five fold cross section of 0.15 nb/MeV-sr. Integrating over the dip region gives an omega bin of about 50 MeV, and integrating the electron scattering angle from 15° to 17° (q goes from 600 MeV to 650 MeV) we find a solid angle for the electron of 0.06 sr. The solid angle for the proton is one half of the area between the two circles around the q vector for θ_{pq}=25° to θ_{pq}= 30° (corresponding to a bin in missing momentum from 250 MeV to 300 MeV). This gives a solid angle for the proton of 0.13 sr. The total cross section for this bin is then 0.06 nb. We expect that we can run at a luminosity of $5\bullet10^{33}$ electron-nucleon/cm^2, which has been achieved for a hydrogen target. The ratio of the total electron scattering cross sections from ^{3}He to ^{1}H is about 2 (using the cross sections of Lightbody-O'Connell). We therefore use a scaling factor of 2, which results in a luminosity of $2.5\bullet10^{33}$ electrons-^{3}He/cm^2, and a count rate of 0.15 Hz in our bin, or 13,000 counts/day. At 70% beam polarization this would give an error bar of 1.3% in 2 days running. If 70% polarization is not available, larger bin sizes or less statistics would be necessary, which would reduce the physics information that could be extracted from this measurement.

A similar calculation can be performed for ^{12}C, where we can compare with data from the Bates Laboratory (thesis data for J. Mandeville and M. Holtrop). For quasielastic knockout from the p-shell using a bin size in omega of 50 MeV and integrating the electron scattering angle from 15° to 16°, and with a bin size in missing momentum of about 30 MeV, (11°< θ_{pq}<14°) the expected integrated cross section is about 1.1 nb. For the s-shell, integrating the over the same bin, the cross-section is about 0.56 nb. Note that these bins are considerably smaller than in the previous example. Assuming that the luminosity must be scaled down by a factor of 7 for ^{12}C compared to ^{1}H, we would get a count rate of 0.8 Hz for the p-shell and 0.4 Hz for the s-shell. This results in an error estimate of 0.8% for the p-shell and 1% for the s-shell in one day.

We will investigate the (e,e'pp) sub-channel and other sub-channels of the (e,e'p) reaction by tagging those events that have an additional detected proton or other particle in the CLAS. This will give us a breakdown of the various contributions to the beam asymmetry.

Beam time

Currently the multihadron run group includes approved experiments with a total of 800 hours of beam time. This time will be split among several different beam energies, each with several different nuclei. Although the precise subdivision of the allotted time is not yet fully determined by the run group, an allocation based on determining the essential physics by cross-section measurements alone should have a distribution identical to one that is optimized for beam asymmetry measurements.

The additional overhead involved in running with polarized beam is expected to be small. We estimate that a Møller polarization measurement with adequate statistics will take approximately 15 minutes to complete. If we add the overhead for tuning the beam on the Møller target this becomes approximately 1 hour per measurement. We thus estimate that the total amount of additional time we need for polarization measurements will be around 1 hour per day of running, or 33 hours for the 800 hours of approved beam time.

Summary and Request

A program of experiments on nuclei with CLAS seeks to characterize the virtual photon absorption mechanism associated with multinucleon emission. A central question in these studies is whether the multinucleon emission process can be attributed to initial state configurations in the nuclear wave function, or sequential rescattering due to final state interactions. Measurement of the electron beam polarization asymmetry, the fifth structure function R_{LT}', provides a clear signature of multi-step processes in these reactions. The intrinsically interesting hadronic final state interactions will be more completely characterized. The processes attributable to direct reactions on high-momentum short-range correlations will be more readily distinguished and more accurately interpreted.

The beam time presently approved for a survey of multihadron reactions on ^{3}He, ^{4}He, and ^{12}C is of sufficient duration for extracting high quality data on the polarized electron beam asymmetry. Performing these measurements with the high polarization photocathode will allow data with 1% uncertainty in the physical asymmetry for up to 7500 kinematic bins for each nuclide at each beam energy. In particular, we demonstrated that a 1.4% measurement could even be obtained for kinematics associated with nucleon correlations in ^{3}He in the challenging dip region. We request that the beam time approved for the multihadron reaction survey be scheduled to use the highly polarized beam. We also request additional beam time of 33 hours to cover the necessary measurements of beam polarization with the Møller polarimeter.

References:

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BEAM REQUIREMENTS LIST

JLab Proposal No.: ______________________________ Date: __________________

Hall: ____B_____ Anticipated Run Date: ___________________ PAC Approved Days: _____________

Spokesperson: F.W. Hersman, M. Holtrop__________ Hall Liaison: B . Mecking___________________
Phone: __(617) 862-2019______________
E-mail: _hersman@einstein.sr.unh.edu, maurik.holtrop@unh.edu

List all combinations of anticipated targets and beam conditions required to execute the experiment. (This list will form the primary basis for the Radiation Safety Assesment Document (RSAD) calculations that must be performed for each experiment.)

Condition No.	Beam Energy (MeV)	Mean Beam Current (μA)	Polarization and Other Special Requirements (e.g., time structure)	Target Material (use multiple rows for complex targets — e.g., w/windows)	Material Thickness (mg/cm^2)	Est. Beam-On Time for Cond. No. (hours)
1	-	-	High polarization			

The beam energies, E_{Beam}, available are: $E_{Beam} = N \times E_{Linac}$ where N = 1, 2, 3, 4, or 5. E_{Linac} = 800 MeV, i.e., available E_{Beam} are 800, 1600, 2400, 3200, and 4000 MeV. Other energies should be arranged with the Hall Leader before listing.

LAB RESOURCES LIST

JLab Proposal No.: ____________________ Date ________________

(For JLab ULO use only.)

List below significant resources — both equipment and human — that you are requesting from Jefferson Lab in support of mounting and executing the proposed experiment. Do not include items that will be routinely supplied to all running experiments such as the base equipment for the hall and technical support for routine operation, installation, and maintenance.

Major Installations *(either your equip. or new equip. requested from JLab)*

None

New Support Structures:

Data Acquisition/Reduction

Computing Resources:

Standard Equipment

New Software:

Major Equipment

Magnets:

Power Supplies:

Targets:

Detectors:

Electronics:

Computer Hardware:

Other:

Other:

HAZARD IDENTIFICATION CHECKLIST

JLab Proposal No.: ______________________________ Date: ________________
(For CEBAF User Liaison Office use only.)

Check all items for which there is an anticipated need.

Cryogenics
__X__ beamline magnets
__X __ analysis magnets
__X__ target
type: liquid_
flow rate: _________
capacity: _________

Electrical Equipment
______ cryo/electrical devices
______ capacitor banks
______ high voltage
______ exposed equipment

Radioactive/Hazardous Materials
List any radioactive or hazadorous/ toxic materials planned for use:
____
____
____
____

Pressure Vessels
______ inside diameter
______ operating pressure
______ window material
______ window thickness

Flammable Gas or Liquids
type: _3He/4He._______
flow rate: standard
capacity: standard___________

Drift Chambers
type: Standard _______
flow rate: standard _______
capacity: standard__________

Other Target Materials
___ Beryllium (Be)
__ Lithium (Li)
___ Mercury (Hg)
___ Lead (Pb)
___ Tungsten (W)
___ Uranium (U)
_X Other (list below)
__12C ______
__56Fe_______________

Vacuum Vessels
______ inside diameter
______ operating pressure
______ window material
______ window thickness

Radioactive Sources
_______ permanent installation
_______ temporary use
type: ________________
strength: ________________

Large Mech. Structure/System
______ lifting devices
______ motion controllers
______ scaffolding or
______ elevated platforms

Lasers
type: ________________
wattage: ________________
class: ________________

Installation:
________ permanent
________ temporary

Use:
________ calibration
________ alignment

Hazardous Materials
____ cyanide plating materials
____ scintillation oil (from)
____ PCBs
____ methane
____ TMAE
____ TEA
____ photographic developers
____ other (list below)
____
____

General:

Experiment Class:

_X ___ Base Equipment
______ Temp. Mod. to Base Equip.
______ Permanent Mod. to Base Equipment
______ Major New Apparatus

Other: ___________________
____