SHORT DISTANCE STRUCTURE OF NUCLEI - MINING THE WEALTH OF EXISTING JEFFERSON LAB DATA

A proposal for 2011 – 2014 submitted to the
U.S. Department of Energy, Office of Nuclear Physics
Program Manager: Dr. Brad Tippens

by

L.B. Weinstein (PI), S.E. Kuhn (co-PI), M. Amarian, S. Stepanyan, W. Van Orden
Old Dominion University, Norfolk VA 23529

Eli Piasetzky
Tel-Aviv University, Tel Aviv, Israel

Keith Griffioen
College of William and Mary, Williamsburg VA

Mark Strikman (co-PI)
Pennsylvania State University

Misak Sargsian (co-PI), Werner Boeglin
Florida International University, Miami

David Ireland, I.J. Douglas McGregor, Dan Protopopescu
University of Glasgow, Scotland, UK

Dan Watts, Derek Glazier
University of Edinburgh, Scotland, UK

Sabine Jeschonnek
Ohio State University

Maurik Holtrop
University of New Hampshire

Shalev Gilad, Vincent Sulkosky
Massachusetts Institute of Technology, Boston

Gerard Gilfoyle
University of Richmond, Richmond (VA)

Rakhsha Nasseripour
George Washington University, Washington (DC)

Contact and Coordinator: Dr. L.B. Weinstein, Department of Physics, Old Dominion University, 4600 Elkhorn Ave, Norfolk VA 23529-0116. Phone: (757) 683-5803; email: weinstein@odu.edu

January 7, 2011

1 Project Objectives

The short-distance structure of nuclei is one of the most important though elusive subjects of experimental nuclear physics. Recent experiments, performed mostly at Jefferson Lab, for the first time gave direct evidence of short-range correlations (SRC) in nuclei, measured their probabilities, showed that *pn*- are far more important than *pp*-correlations, observed significant evidence for modification of bound nucleon structure, and reported the first evidence of color transparency at few-GeV energies. To make further progress, we need a more systematic study, covering a wide range of kinematics and different nuclei.

Since its commissioning over ten years ago, the CEBAF Large Acceptance Spectrometer (CLAS) [1] at Jefferson Lab (JLab) has accumulated an immense data set of electron (and photon) scattering from nuclear targets (see Table 1). These data sets have been collected for specific approved experiments, which have published their results. However, due to the use of a wide open inclusive trigger, the same data sets can be analyzed for additional channels of interest, or for additional kinematic regions not covered by previous analyses. Therefore, these data should allow us to address important physics questions that are now coming to the forefront of scientific interest.

Run period	Beam type	Beam energy GeV	Targets	Comments
E2a	e^-	2.2, 4.4	^{3}He, ^{4}He, ^{12}C, ^{56}Fe	Torus at 2250 A, trigger ECxCC Torus at 2250, trigger EC (high threshold)
E2b	e^-	0.98, 4.47 4.7	^{56}Fe ^{3}He	Torus at 2250 A, trigger EC (CC)
E6	e^-	5.77	^{2}H	Torus at 2250 A and -2250 A (10%)
EG1a	e^-	2.5, 4.2	NH_3, ND_3, ^{12}C	Torus at 1930A/2250/1500/-2250/-1500
EG1b	e^-	1.6 to 5.7	NH_3, ND_3, ^{12}C	Torus at 1930A/2250/1500/-2250/-1500
E5	e^-	4.23, 2.56	^{2}H+^{1}H	Dual liquid target
EG2	e^-	4.7, 4.02, 5.01	^{2}H,Al,^{56}Fe,^{12}C, Ni,^{208}Pb	Some runs with deuterium target alone
E1e	e^-	2.04	^{2}H	
EG3	γ	<5.76	^{2}H	Torus at -1930 A
E8 (BoNuS)	e^-	1.1, 2.2, 4.3, 5.4	^{2}H (^{1}H, ^{4}He)	Slow recoil detector (RTPC); low luminosity; future dedicated ^{4}He run (EG6)

Table 1: CLAS nuclear dataset

Over the ten years that CLAS has been acquiring data, the software tools to reconstruct, correct, cut, and analyze the data have evolved. Our judgement is that the existing CLAS data will need to be re-analyzed, using a consistent set of up-to-date reconstruction software and up-to-date cuts and corrections. In addition, new software could possibly allow us to access new kinematic regions such as lower-momentum recoil nucleons.

The objective of the initiative described in this proposal is two-fold. We aim to greatly increase our understanding of hard scattering (QCD) effects in nuclei and to do so by putting in place an organizational framework to support a significant and sustained analysis effort.

The analysis effort will take place in three phases. In the first phase, the most promising physics analysis channels will be identified using existing data summary tapes.

In the second phase, the various raw CLAS data sets will be consistently reanalyzed ("cooked") with up-to-date reconstruction software and placed in a common, user friendly, format, together with the necessary cuts and corrections. These data sets will then be made available for physics analysis.

In the third phase, we will combine the results from *all* different data sets (beam energies, targets and running conditions) to extract systematic trends and arrive at a comprehensive picture of hard scattering (QCD) effects in nuclear systems. These effects include (but are not limited to) short range correlations, the deuteron at high nucleon momentum, non-nucleonic degrees of freedom, color coherent effects, and the dynamics of the nucleon-baryon resonance interaction.

Contents

1 Project Objectives **i**

2 Project Description **1**
2.1 Introduction 1
2.2 Study of Short Range Correlations (SRC) 2
2.2.1 Scientific background 2
2.2.2 More detailed study of 2N-SRC 8
2.2.3 Study of the deuteron system 8
2.2.4 A search for non-nucleonic decays of the SRC via Δ-isobar production 11
2.2.5 A search for 3N SRC 13
2.3 Study of nuclear transparency (FSI) 13
2.3.1 Scientific background 13
2.4 Time Frame 16
2.5 Organization 18

3 Personnel **18**
3.1 Old Dominion University 18
3.2 Tel Aviv University 19
3.3 College of William and Mary 20
3.4 Pennsylvania State University 20
3.5 Florida International University 20
3.6 Universities of Glasgow and Edinburgh 20
3.7 Ohio State University 21
3.8 University of New Hampshire 21
3.9 Massachusetts Institute of Technology 21
3.10 University of Richmond 21

Appendices
1 Biographical Sketches . . . . .
2 Current and Pending Support . . . . .
3 Bibliography and References Cited . . . . .
4 Facilities and Other Resources . . . . .
6 Letters of Intent . . . . .

2 Project Description

2.1 Introduction

During the last few years, significant progress has been made at Jefferson Lab (JLab) in the studies of the microscopic structure of nuclei in general and in short-range correlations (SRC) in nuclei and dynamics of interactions with nuclei at large momentum transfer in particular.

- $A(e,e')$ experiments at $x > 1$ confirmed the existence of the universal structure of two and three nucleon short-range correlations(SRC) in nuclei and measured the strength of those correlations for a variety of nuclei [2, 3].
- A$(e,e'pN)$ studies of the knockout of a fast proton from an SRC followed by ejection of its correlated partner have confirmed the theoretical expectation of the dominance of pn over pp correlations at low SRC total momentum [4, 5, 6, 7, 8].
- Three body electrodisintegration measurements, ^{3}He$(e,e'pp)n$, measured the relative and total momenta of pp and pn correlated pairs by knocking out the third nucleon and observing the spectator correlated pair [9]. They confirmed the dominance of tensor correlations at intermediate pair relative momenta by measuring the pp to pn ratio as a function of pair total momentum [10, 11].
- Studies of the G_E/G_M ratio for the scattering off a bound nucleon found possible indications of a difference between the bound and free nucleon wave functions [12]. This finding complements results of studies of the EMC effect (which now include the lightest nuclei) which also indicate the manifestation of some non-nucleonic degrees of freedom in nuclei.
- Detailed studies of D$(e,e'p)n$ in Halls A [13] and B [14, 15] and of D$(e,e'p)X$ in Hall B [16] have yielded new data on the interplay of high-momentum components in the nuclear wave function and final state interactions between the nucleons and (in the latter case) the final state "debris" after an inelastic reaction.
- Comparisons of Short Range Correlation scale factors and the magnitude of the EMC effect for different nuclei indicate that the two are strikingly and linearly correlated [17]. This correlation implies that both SRC and the EMC effect are caused by the same underlying physics.

High precision studies of interactions with nuclei also revealed deviations from the Glauber-type dynamics of the interaction of particles in hard large Q^2 processes. In particular the $A(e,e'\pi)$ experiment found a change of the transparency consistent with the predictions of the color transparency models [18]. Corresponding data on the production of ρ-mesons [19] should be available shortly.

These very successful experiments should be followed up by both new experiments at JLab and elsewhere and by exploiting the rich data already collected by the CLAS at a range of beam energies and targets. This proposal will explore several ways of probing microscopic nuclear dynamics and color transparency phenomena using this already-collected data.

This low cost approach will speed up developments in the field, allowing discovery of novel nuclear phenomena, and giving interested groups the flexibility to explore phenomena not currently anticipated. It will also help in optimizing experiments which will be performed at JLab after the 12 GeV upgrade.

Below we will outline the physics topics we want to study and the proposed mode of operation of the study.

2.2 Study of Short Range Correlations (SRC)

2.2.1 Scientific background

Studying two body correlations in nuclei was one of the five 'key programs' described in the Scientific Justification of the 1985 Pre-Conceptual Design Review (PCDR) for CEBAF. Short Range Correlated nucleon pairs in nuclei are those where the nucleon centers are separated by less than approximately 1.2 femtometer (fm). In momentum space, an SRC pair is characterized by a large relative momentum ($p_{rel} = |\vec{p}_1 - \vec{p}_2|/2 \geq 250$ MeV/c) and a small center-of-mass (cm) momentum ($p_{cm} = |\vec{p}_1 + \vec{p}_2|$), where large and small are relative to k_F, the Fermi momentum. Studies of (SRCs) in nuclei are important for understanding the short-distance and large-momentum properties of the nuclear ground-state wave function. The separation distances and associated local densities in SRCs are expected to be comparable to those in the cores of neutron stars. SRCs therefore also have far-reaching implications for modeling and understanding cold dense nuclear matter and neutron stars. As we will discuss below, SRC are also a unique way to study the short range nucleon-nucleon interaction. In particular, the study of SRC pairs in nuclei opens a way to study the short-range tensor force and the even shorter range repulsive core.

The study of SRCs in nuclei is almost as old as the study of the shell model. SRCs enter as a key element of Bethe-Bruckner theory, for the early review see [20]. From the very first days it was clear that the picture of independent particles in a mean field needs corrections due to both long-range and short-range correlations between the nucleons. However, for many years, identifying and studying SRCs presented a formidable challenge to both theory and experiment. Experimental studies of the microscopic structure of SRCs were very much restricted due to the difficulty in resolving SRCs when only moderate momentum-transfer kinematics were available, using low and medium energy probes.

Recently, several high-energy, large-momentum-transfer measurements, along with companion theoretical studies, have made tremendous progress in identifying SRC pairs in nuclei and understanding their dynamics.

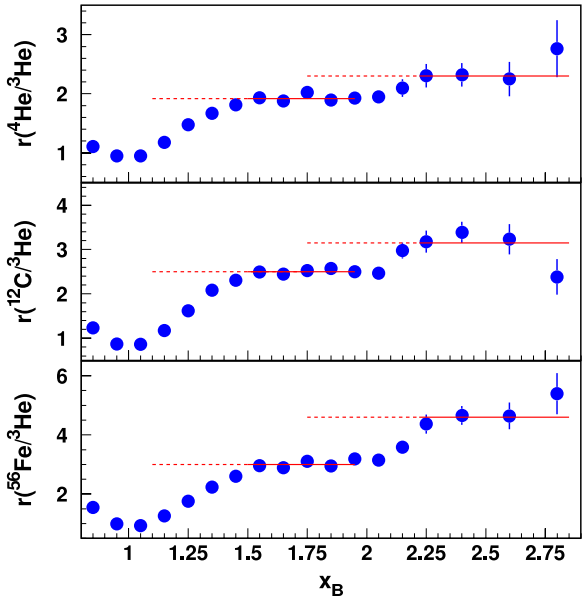

Figure 1: Cross-section ratios of ^{4}He, ^{12}C, and ^{56}Fe to ^{3}He, normalized by the relative nuclear masses, as a function of Bjorken x (x_B). The horizontal lines indicate the two scaling levels associated with two and three nucleon correlations.

We will start with the high momentum transfer, $Q^2 > 1.4$ (GeV/c)^2, and $x_B > 1$ inclusive data from the Hall B Large Acceptance Spectrometer (CLAS) at Jefferson Lab [2, 3]. The measurement was performed to check the predicted universality of short-range correlations by measuring the ratio of the inclusive cross sections for heavy to light nuclei at sufficiently large Q^2 and x_B, where scattering off slow nucleons in the nucleus does not contribute. The main advantage of the discussed process is that the long range final state interactions should cancel due to closure, while the local final state interaction in the SRCs is universal and cancels in the ratios [21, 22]. The predicted signal for dominance of the correlations is the scaling of the ratios, a weak dependence on x_B and Q^2 for $1.5 < x_B < 2$, which is clearly observed in the data. Continuing this line of reasoning would suggest that a second scaling region should be observed for $x_B > 2$ due to three nucleon correlations. Indeed, a second scaling region seems to be present, although the statistics are limited. These results (Figure 1) reflect the dominance of few-nucleon correlations in the high momentum component of the nucleus. Scaling behavior in inclusive (e, e') measurements [21, 2, 3] indicates that such correlations involve about 20% of the nucleons in ^{12}C and about 25% in heavy nuclei. The contribution of three-nucleon SRC at these kinematical conditions is about an order of magnitude smaller than that of two-nucleon SRC.

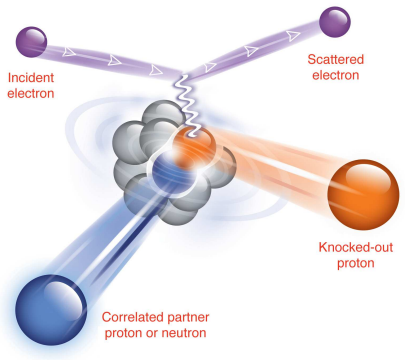

Figure 2: Illustration showing the $A(e, e'pN)$ reaction. The incident electron couples to the proton in a nucleon-nucleon pair via a virtual photon. In the final state, the scattered electron and knocked-out proton are detected along with the correlated nucleon that is ejected from the nucleus. For the BNL measurement the incident and scattered electron should be replaced by a proton and the detected correlated nucleon was only a neutron.

While the inclusive data clearly suggest strong local correlations, it required exclusive data to confirm that the inclusive scaling is due to short-range correlations and to measure directly the fraction of nucleon pair types involved. Experimentally, a high-momentum, small de-Broglie wavelength probe can knock a proton out of a nucleus, leaving the residual nucleus nearly unaffected. If, on the other hand, the proton being struck is part of an SRC pair, the high relative momentum in the pair will cause the correlated nucleon to recoil and be ejected with high-momentum almost equal in size and opposite in direction to the initial momentum of the struck proton [22]. Figure 2 illustrates the measurements with a high energy electron beam at JLab [4, 5]. Similar measurements preceded the JLab measurement using high-momentum proton probes at Brookhaven National Laboratory (BNL) [6, 7, 8].

The triple coincidence $^{12}\mathrm{C}(p, ppn)$ measurement at beam momenta between 6 and 9 GeV/c at Brookhaven National Laboratory [6, 7, 8] identified np SRC pairs and demonstrated that $92^{+8}_{-18}\%$ of the protons in ^{12}C with 'initial' momenta above 275 MeV/c are partners in np SRC pairs [8]. The JLab experiment shows that nearly all nucleons in ^{12}C with momentum in the range 300 to 600 MeV/c have a correlated nucleon partner with roughly equal and opposite momentum [4, 5]. It was also found, by comparing neutron-proton (np) to proton-proton (pp) yields, that most SRCs are np SRCs [8, 5]. The np SRC pairs in ^{12}C outnumber the pp pairs by a factor of 18$\pm$5 [5]. Considering isospin symmetry only, one would expect the number of nn SRC pairs in ^{12}C to be equal to the number of pp SRC pairs. Note that these measurements were performed at relatively small pair cm

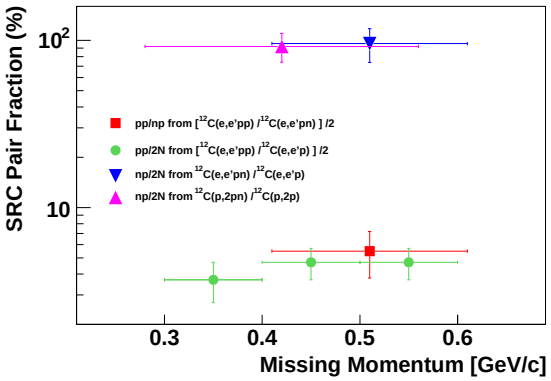

Figure 3: The ratio of SRC pairs as determined from exclusive high momentum transfer measurements [8, 5].

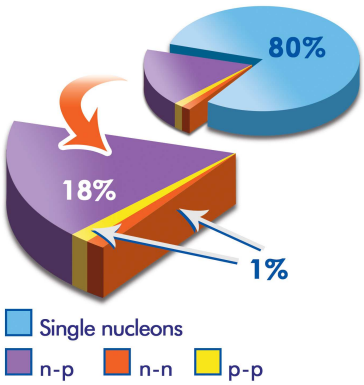

Figure 4: The average fraction of nucleons in the various ground state configurations of ^{12}C.

momentum.

It is of interest to convert these measured ratios to various SRC pair fractions, which we define as the ratios of np or pp correlations to the total $2N$ SRC in ^{12}C. Figures 3 and 4 display various SRC-pair fractions for ^{12}C, based on the BNL and JLab data. The BNL $^{12}\mathrm{C}(p,ppn)/^{12}\mathrm{C}(p,pp)$ ratio [8] and the JLab $^{12}\mathrm{C}(e,e'pn)/^{12}\mathrm{C}(e,e'p)$ ratio [5] yield consistent results for np SRCs. The JLab $^{12}\mathrm{C}(e,e'pp)/^{12}\mathrm{C}(e,e'p)$ ratio measurement [4] determines the number of pp SRC, and the JLab $^{12}\mathrm{C}(e,e'pp)/^{12}\mathrm{C}(e,e'pn)$ ratio measurement determines the pp/np SRC pair fraction [5]. To obtain a comprehensive picture of the structure of ^{12}C, we can combine the results in Fig. 3 with inclusive $^{12}\mathrm{C}(e,e')$ measurements from JLab Hall B [3], which showed that 20±5% of the nucleons in ^{12}C are members of SRC pairs. Fig. 4 shows pictorially that (80±5)% of ^{12}C nucleons are low-momentum independent or long-range correlated nucleons, (18±5)% are np SRC pairs, and both pp and nn SRCs are (1±0.3)%.

The small ratio of pp to np pairs observed by the EVA/BNL and E01-015 experiments was explained by three theoretical groups [23, 24, 25]. At relative momenta of $300 < p_{rel} < 500$ MeV/c and small cm momenta, there is a strong minimum in the pp momentum distribution. This minimum is filled in by tensor forces in the np momentum distribution. This clearly shows that the measured pp-SRC/np-SRC ratio is the result of the NN tensor force.

It is important to emphasize here that the kinematics of the BNL and JLab experiments are very different. In the BNL experiment, the struck nucleon has initial momentum along the beam and $-t \sim 5$ GeV^2, while in the JLab experiment the struck nucleon has initial momentum opposite the beam and the transferred momentum is $Q^2 = 2$ GeV^2. Still the SRC decay model [8] describes both data sets well.

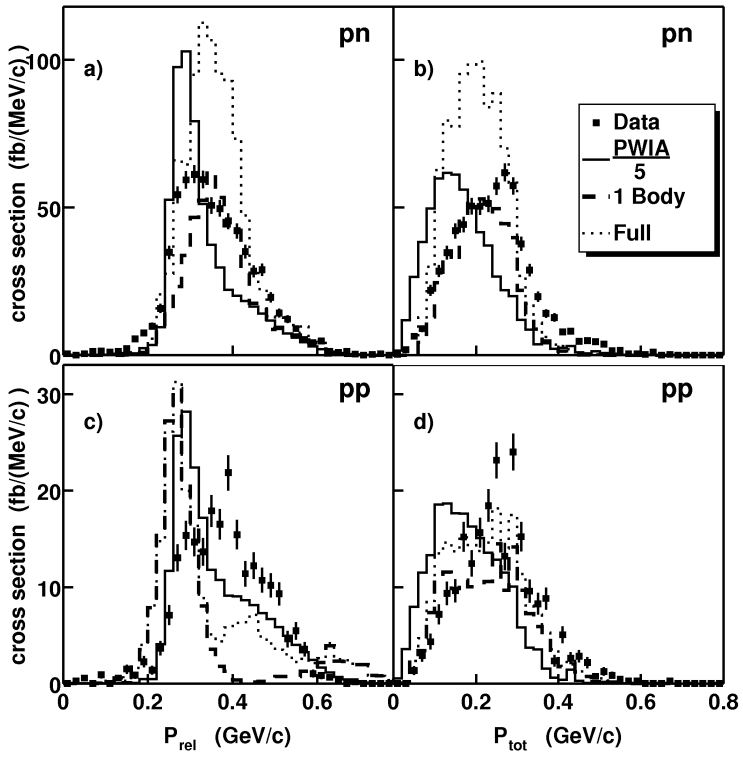

Figure 5: (a) Lab frame cross section vs pn pair relative momentum. Points show the data, solid histogram shows the PWIA calculation of Sargsian times $\frac{1}{5}$, dashed histogram shows Laget's one-body calculation and the dotted histogram shows Laget's full calculation (see [9] and references therein); (b) same for total momentum; (c),(d) same for pp pairs.

CLAS has also measured the distorted relative and total correlated pair momentum distributions in ^{3}He$(e,e'pp)n$ at an incident electron energy of 2.2 GeV, by choosing kinematics where the virtual photon is absorbed on one nucleon (the leading nucleon) and the spectator correlated pair decays [9]. When all three detected nucleons have large momenta ($p_N > 250$ MeV/c), there are peaks in the lab-frame Dalitz plot where the leading nucleon has most of the transferred energy, ω, and the two other nucleons each have less than 20% of ω. The effect of rescattering of the leading nucleon was reduced by requiring that its momentum perpendicular to the momentum transfer, $\vec{q}$, be less than 300 MeV/c. In this case, the two other nucleons a) are predominantly back-to-back, b) have little cm momentum parallel to $\vec{q}$, and c) are relatively isotropic. This indicates that they are spectators to the reaction. The resulting relative and total momentum distributions can be seen in

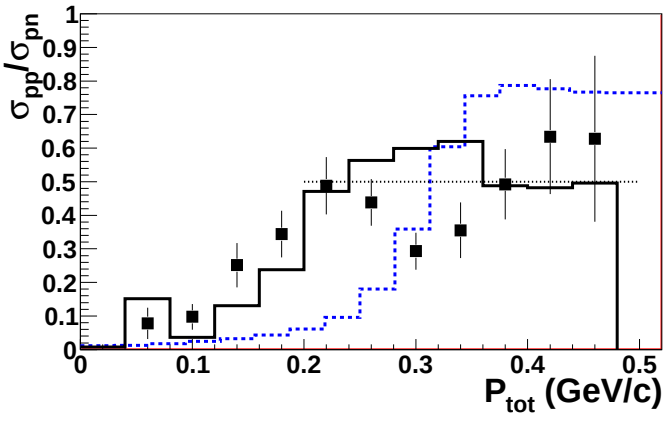

Figure 6: Ratio of *pp* to *pn* spectator pair cross sections as a function of pair total (cm) momentum, integrated over $0.3 < p_{rel} < 0.5$ GeV/c. The points show the data [10, 11], the solid histogram shows the ratio of the Golak one-body calculation and the blue dashed histogram shows the ratio of the Golak bound state momentum distributions [26]. The dotted line at 0.5 shows the simple-minded pair counting result. The data and the one-body calculation have been multiplied by 1.5 to approximately account for the ratio of the average electron-proton and electron-neutron elementary cross sections.

Fig. 5. Note that the one-body calculation (which includes direct knockout of the leading nucleon plus the continuum reinteraction of the spectator pair) describes the data well (except for the *pp* relative momentum). Note also that the continuum reinteraction of the pair drastically decreases the cross section from the PWIA result, primarily by supressing the *s* wave contribution.

The experiment was recently repeated at an incident energy of 4.7 GeV [10, 11]. This increased the average momentum transfer from $Q^2 \approx 0.8$ GeV^2 at $E_{beam} = 2.2$ GeV to $Q^2 \approx 1.5$ GeV^2 at $E_{Beam} = 4.7$ GeV. The momentum distributions are very similar at the higher momentum transfer, although the cross sections are smaller by a factor of about five.

Because the CLAS measurement covered a large range in both relative and cm (total) pair momenta, it also measured the dependence of the *pp* to *pn* pair ratio on the pair cm momentum (see Fig. 6). Note that the ratio is very small at low pair cm momentum, consistent with the results mentioned above, and increases to the pair counting limit at large cm momentum. This result is not consistent with the simple ratio of bound state momentum distributions but it is well described by the results of a calculation by Golak *et al.* which includes direct knockout of the leading nucleon plus the continuum interaction of the spectator pair [26]. This is another indication of the importance of tensor correla-

tions. At low cm momentum, the pp pair has a minimum at $p_{rel} \approx 400$ MeV/c while the corresponding minimum for the np pair is filled in by tensor forces. As the cm momentum increases, the pp pair minimum is predicted to fill in, also due to tensor forces.

The following section lists a few research avenues that could yield new information on SRC using already accumulated data. Analysis of this data should provide information complementary to the published and planned measurements.

2.2.2 More detailed study of 2N-SRC

The large set of available data allow also to improve our knowledge of 2N-SRC by looking for $(e, e'p)$ events in coincidence with a recoil high momentum proton or neutron. The exclusive measurement of Hall A [4, 5] can be extended to:

1. Check the A dependence.

   Study correlations in the scattering off other nuclei than ^{12}C. The correlations should be a universal phenomena except for rescattering and absorption effects for heavier nuclei.

2. Check the Q^2 dependence.

   If the process is $(e, e'p)N$ due to the decay of an SRC after removal of a proton, then it should have the same Q^2 dependence as $(e, e'p)$. This is an important check that we understand the recoil particle production mechanism.

3. Study the dependence on isospin.

   Study in more detail the isospin ratio np-SRC / pp-SRC as a function of the c.m. momentum of the pair and compare to the calculations of double momentum distributions [23, 25]. This can be done using the large acceptance of CLAS.

4. Compare real to virtual photon induced breakup of the SRC pair. For example, look at the process in nuclei of $\gamma + n \to \pi^- p$ at large angles in association with backward proton production.

2.2.3 Study of the deuteron system

The deuteron is the simplest possible system to study SRC, and it has the double advantage that the initial wave function is calculable and that measuring a single nucleon in the final state of D$(e, e'p)$X completely determines the kinematics of the reaction. The previously observed scaling of the ratios for inclusive (e, e') scattering at $x > 1$ [2, 3] indicates that the properties of 2N SRC in nuclei (which are predominantly $I = 0$) are similar to the SRC in the deuteron. Hence these correlations could be studied using scattering off the deuteron. The only drawback is the much smaller likelihood of SRC in deuterium (maybe 2-4%) compared to heavier nuclei.

While extensive data sets on (both polarized and unpolarized) deuterium targets have been taken with CLAS, only a few analyses of these data exist so far that looked for nuclear effects (as opposed to extracting neutron form factors, structure functions and resonance excitation). The most salient published results (for the purposes of this proposal) come from the e6 run period (5.7 GeV electron beam on a liquid deuterium target):

- The reaction $\mathrm{D}(e,e'p)n$ was studied [14] to compare the measured recoil neutron distribution with various models, including a simple PWIA spectator model where the momentum distribution would be given by the wave function of the deuteron in momentum space. It was found that this approximation is rather good for recoil momenta below 100 MeV/c, while final state interactions (FSI) play an important role at higher momenta.

- The same data were analyzed [16] to extract the momentum, angle, final state and Q^2 dependence of the cross section in the reaction $\mathrm{D}(e,e'p)X$ where the proton was detected in "spectator kinematics", i.e., with a relatively small momentum and at large angle relative to the momentum transfer vector $\mathbf{q}$. Consistent with the discussion above, FSI were found to be important at higher proton momenta and for angles forward of about 100 degrees relative to $\mathbf{q}$. This is visible in Fig. 7, which shows the distribution of (spectator) protons in angle (relative to $\mathbf{q}$) for various final state masses and proton momenta. While the spectator picture (together with on-shell neutron structure functions) describes the data reasonably well for lower momenta, there is an increasing trend of a strong enhancement in the forward direction (and suppression at far backward angles) as p_s and W^* (the final state mass) increase. Using the spectator mechanism, a new experiment [27] with CLAS attempts to extract free neutron structure functions by "tagging" electron scattering from a "nearly on-shell" neutron in deuterium with a low-momentum, backwards moving proton, using a novel TPC-type recoil detector.

Examples of possible future studies, using the deuteron data accumulated with CLAS, include:

1. Increasing the kinematic range in (spectator) proton momentum and Q^2 for the reaction $\mathrm{D}(e,e'p)\mathrm{X}$, to pin down the region where the spectator picture is approximately valid and to look for possible modifications of the structure functions of a neutron that is part of a SRC. (This may be linked to the JLab observation of a possible difference between the bound and free nucleon form factors [12].) We need a more detailed study of final state interactions as a function of final state particles, momenta, and Q^2. This is important both as a correction to the spectator picture and in its own right, with connections to studies of CT (see below) and hadronization.

2. To disentangle the effects of SRCs from other nuclear effects, we need a complete understanding of all the components of the hadronic model (final-state interactions

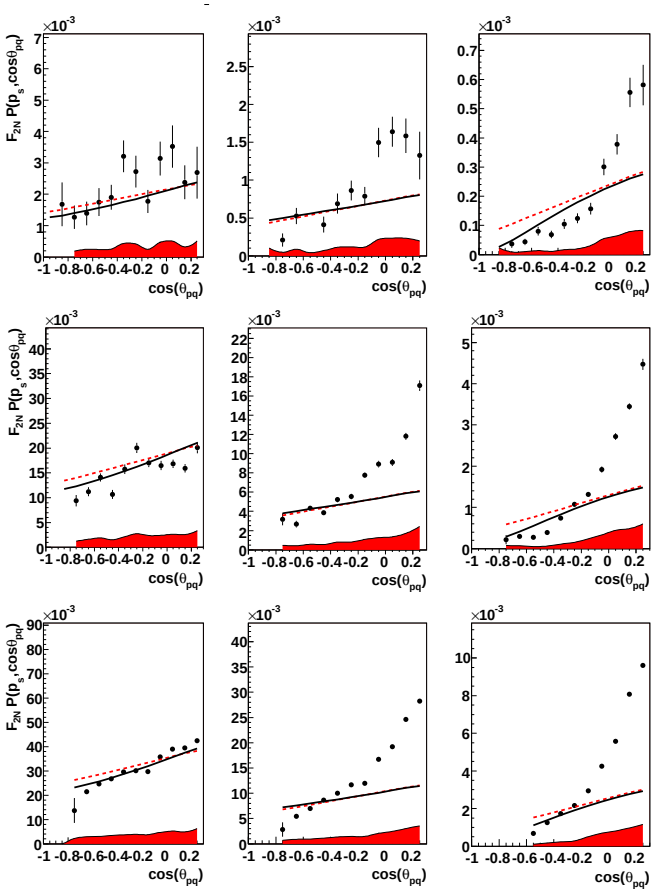

Figure 7: Results for the normalized cross section (equivalent to the product $F_{2n} \times |\psi(\vec{p}_s)|^2$ in the spectator picture) for the reaction D$(e, e'p_s)$X. Each row is for a different mass W^* of the unobserved final state X, namely $W^* = 0.94$ GeV (quasi-elastic scattering) in the first row, $W^* = 1.5$ GeV in the second and $W^* = 2$ GeV in the third. The three columns are for three different proton momentum ranges, with average momenta of $p_s = 0.3$, 0.39 and 0.56 GeV/c, respectively. All data (filled circles with statistical error bars) are for one Q^2 bin with average Q^2 of 1.8 (GeV/c)^2. The two lines come from a simple PWIA spectator model using a light-cone wave function (solid line) or a non-relativistic WF (dashed line), while the shaded band at the bottom indicates the systematic error.

(FSI), relativistic corrections (RC), meson-exchange currents (MEC), and isobar configurations(IC)). We propose to extract the so-called fifth structure function of the deuteron σ'_{LT} in the GeV region using the $D(\vec{e}, e'p)n$ reaction to test the hadronic model of nuclei. The deuteron is an essential laboratory for testing our knowledge of

the pn interaction and σ'_{LT} is particularly sensitive to FSI. The fifth-structure function vanishes for in-plane measurements so out-of-plane detection is a necessity and the CLAS detector is an ideal device for making such measurements.

To extract the fifth structure function consider the cross section for the $D(\vec{e}, e'p)n$ reaction (polarized beam and unpolarized target).

$$\frac{d\sigma 5}{d\nu d\Omega_e d\Omega_{pq}} = \sigma_L + \sigma_T + \sigma_{TT}\cos\phi_{pq} + \sigma_{LT}\cos 2\phi_{pq} + h\sigma'_{LT}\sin\phi_{pq} \qquad (1)$$

The σ_i are the different components of the cross section and $h = \pm 1$ is the beam helicity. The angle ϕ_{pq} is the angle between the plane defined by the incoming and outgoing electron 3-momenta and the plane defined by the ejected proton and neutron. The structure functions are measured by forming asymmetries. We define the asymmetry $A'_{LT} = \sigma'_{LT}/(\sigma_L + \sigma_T)$ which can be extracted in a model independent way using the $\sin\phi_{pq}$-weighted moments as a function of the missing momentum p_m ($\vec{p}_m = \vec{q} - \vec{p}_p$ where $\vec{q}$ is the 3-momentum transfer and $\vec{p}_p$ is the measured proton momentum). Analysis of this asymmetry for quasielastic kinematics from the E5 data set is nearly complete and we propose here to extend that work to higher energy transfer [28]. We expect from earlier measurements at lower Q^2 that the mixture of different effects (FSI versus RC versus EC versus MEC) will change as we move to higher energy transfer [29]. The goal here is to use all of these measurements to disentangle the different effects and develop a more complete hadronic model of the deuteron.

3. In addition to single spin asymmetries, we can also learn more about the spin structure of SRC in the deuteron by using existing double polarization data for polarized electron scattering off the polarized deuteron [30]. In particular the reaction $\mathrm{D}(e, e'p)n$ can be use to learn more about the importance of the tensor force and the spin-dependence of FSI.

4. Finally, we can look for more complicated possible final states in electroproduction on the deuteron; e.g., we can search for $\Delta\Delta$ admixtures in the deuteron wave function by studying the reaction $\mathrm{D}(e, e'\Delta)\Delta$ (see below).

2.2.4 A search for non-nucleonic decays of the SRC via Δ-isobar production

The SRC are local high density spots. Quark distributions of nucleons in this case strongly overlap making transition to non-nucleonic configurations more likely. If there are some conditions in the nucleus where nucleons do not behave as a system of nucleons, then these high density droplets seem to be the ideal places to look for these cases. This is in line with the experimental observation of the increase of the EMC effect (which unambiguously requires presence of non-nucleonic degrees of freedom in nuclei) with atomic number, and

evidence of increase of deviations from G_E/G_M ratio from the free value with increase of momentum [12].

A signature for a non-nucleonic component in the SRC will be its decay with a relatively high probability (as compared to the NN channel of the decay of SRC) to a final state with non-nucleons like ΔN and/or $\Delta\Delta$.

1. Search for backward emitted $\Delta^{++}(\pi^+, p), \Delta^+(\pi^0, p), \Delta^0(\pi^-, p)$, and $\Delta^-(\pi^-, n)$

   We propose to look for Δ electroproduction at backward angles (relative to $\vec{q}$) at both $x > 1$ and $x < 1$, possibly even in coincidence with the forward protons/neutrons from the decay of forward angle Δs. Based on the inclusive data on electron - air interactions at $E_e = 5$ GeV obtained at DESY using the ARGUS detector (published only as a DESY preprint [31]), one can expect that the production rates of fast backward Δ^{++} or Δ^0 should be about 5% of the fast backward proton rate for the same light-cone fractions of nucleon and Δ.

   Measuring the x and Q^2 dependence of the reaction in addition to the momentum and angle dependence of the forward particles should allow us to separate the contribution of the decays from the contribution of background multistep processes.

   It would also be interesting to look for production of fast backward hyperons such as Λ (which was observed in pion-nucleus interactions) and investigate the origin of such processes (for example they may originate from the γ^* scattering off fast backward nucleons such as $\gamma^* N \to K\Lambda$).

2. Search for forward Δ^{++} production at $x > 1$

   In this kinematics (Δ^{++} carrying most of the virtual photon momentum) we plan to look for knockout of isobars from the SRC in the nucleus wave function. Since the momentum distribution of Δ's is broader than that of nucleons, we expect this process to be enhanced for $x \geq 1.3$ where the virtual photon is absorbed by a fast moving baryonic constituent of the nucleus. At the same time we will explore the $x \sim 1$ kinematics where production of the Δ^{++} from two step processes like $\gamma^* + p \to \Delta^+$ followed by $\Delta^+ + p \to \Delta^{++} + n$ is enhanced in order to understand the contribution of these two step processes. To ensure the condition of knock out kinematics with the final Δ moving fast relative to the rest of the nucleus we will impose the condition $Q^2 \geq 1.5\text{GeV}^2$.

3. Delta production on nuclei

   We propose to look at the properties of the $\Delta^0(1232)$ generated from a quasi-free neutron in a ^{3}He target [32]. This work is complementary to previous CLAS analyses using the free proton target, and will allow the study of the Δ resonance region in a different isospin channel. We would look at angular distributions of the decay products from the reaction $^3\text{He}(e, e'p\pi)2p$ (mainly the $p\pi^-$ channel). Information on the

'shape' of the Δ^0 can be extracted by measuring the dominant magnetic dipole (M1) and the interference from the electric quadrupole (E2) and Coulomb quadrupole (C2). We plan to investigate the Q^2 range of $0.1 - 0.4$ $(GeV/c)^2$. Theoretical comparisons will be made with MAID predictions.

The analysis will complete work already begun, and will use existing E-89-017 data acquired with CLAS during the $e2b$ run period, in June 2002, with a ^{3}He cryogenic target and a beam energy of 0.982 GeV. The study will be extended to the higher energy data to provide a greater Q^2 range.

2.2.5 A search for 3N SRC

The scaling of the (e, e') ratios for $x > 2$ [3] and analysis of the data on fast backward nucleon production [22] suggest that, in addition to 2N SRC, higher order correlations should be present (though with a much smaller probability on the order of 10% of 2N SRC). The current uncertainties in the study of SRC in nuclei allow a small fraction of the $(e, e'p)$ events to be associated with multi-nucleon SRC. 3N-SRC are probably the most populated multi-nucleon SRC. We propose to look for 3N-SRC by identifying events with two high energy recoil nucleons. This can be done inclusively and also in coincidence with the scattered electron. In particular, if the two backward nucleons are produced in processes where the electron scatters off a forward moving nucleon, then a "Doppler" type shift in the scattered electron distribution is expected to smaller x.

We will also perform an analysis to investigate the 3-body effects in the $^3He(e, e'p)n$ reaction within the energy transfer range of $0.1 - 0.5$ GeV and $q = 0.35 - 0.80$ GeV/c.

This analysis of 3-body effects [33] would give a unique and comprehensive measurement of ^{3}He electrodisintegration with an electron beam energy of ≈ 1 GeV. With this beam energy we can make a comparison with the newest generation of Faddeev calculations that are valid at low energy transfers, and also provide tests of the Laget model in previously untested kinematic regimes.

2.3 Study of nuclear transparency (FSI)

2.3.1 Scientific background

A well known QED phenomena is the suppression of small dipole interactions due to the internal screening of charges. For particle physics this was demonstrated experimentally by measuring the reduced energy deposited from a e^+e^- pair in the vicinity of their creation point in a π^0 decay, known as the King-Perkins-Chudakov effect. The first reported measurement in 1955 used cosmic rays and emulsions [34]. A modern version, measuring the same phenomenon, was reported this year by a group from CERN that measured the energy deposited by a e^+e^- pair produced by high energy photons as a function of the distance from the production point [35].

QCD leads to a similar prediction of suppression of the strong interaction of small size singlet wave packets. The applicability of this prediction to describing hadron interaction that pass through a nuclear medium is a question that needs to be addressed by experiments. Nuclear transparency is defined as the ratio of the cross section per nucleon in the nucleus to that from a free nucleon. If in the elementary process hadrons are produced in a compressed configuration and next travel some distance through nuclei in a compressed configuration (due to a sufficiently large Lorentz factor) then the CT prediction is that there will be a larger nuclear transparency than if these hadrons were not compressed. An example of such elementary process is production of a leading meson by a longitudinally polarized virtual photon: $\gamma_L^* + N \to "meson" + baryon$ for which the factorization theorem is proved [36]. Measurements of nuclear transparency therefore allow us to study both microscopic dynamics of the hard processes and the space-time evolution of small color singlet wave packages. Since CT is a necessary condition for factorization of exclusive hard processes it is important to verify its validity and the conditions under which it plays a role in hadronic physics.

For the nuclear transparency to show an effect due to CT, there are three conditions that need to be fulfilled. These are the questions that need to be answered by measurements:

1. Is the strong interaction of small neutral (colorless) objects suppressed?
2. Can we produce/find hadrons in small configurations (known as Point Like Configurations - PLC)?
3. Can we freeze the PLC long enough to observe the suppression of its interaction?

If the answers to all of the above questions are positive, then we can expect CT to be relevant. If CT is relevant it opens more questions that can be addressed by measurements:

5. Where is the onset of CT?
6. How does it depend on the process?
7. What is the time/space structure of the transition from the PLC to a 'normal' hadron?

At JLab energies, the requirement of *coherence*, namely that the wave packet does not expand to a normal size while traveling the distance $r_{NN} \sim 2$ fm between two nearby nucleons, is given by the condition

$$l_{coh} \approx 0.4 \div 0.8\text{fm} \cdot p_h/\text{GeV} \gg r_{NN} \tag{2}$$

It implies that effects should be rather small, but could be amplified if special kinematic conditions are chosen where r_{NN} is smaller.

A large number of experiments have been carried out over the last few decades that can determine nuclear transparency. A word of caution: the nuclear transparency is affected

by other phenomena that can mimic a CT signature. None of these measurements exclude CT, but the question is to what level they provide evidence of CT.

The best evidence for CT comes from studies with very high energy probes where the freezing condition is well satisfied even for heavy nuclei. Fermilab experiment E791 measured the coherent diffractive dissociation of 500 GeV/c pions into di-jets [37]. This measurement shows a platinum to carbon cross section ratio which is consistent with CT predictions and is very different from the $A^{2/3}$ expected for typical soft pion-nucleus diffractive interactions ($\sigma \sim A^{\alpha}$, $\alpha = 1.6 \pm 0.1$). That cross section ratio is also supported by a measurement of the longitudinal and transverse distributions of the di-jets that are also in good agreement with the prediction of the CT theory [38]. Further indications for the relevance of CT to describe the interactions of high energy mesons with nuclei can be obtained from the J/ψ photoproduction measurements at SLAC and Fermilab, as well as the exclusive vector meson production (ep→epVM) at HERA [39, 40, 41].

We only mention, but do not discuss, a wide range of coherent and non coherent ρ^0 production measurements done at Fermilab/E665, HERMES/DESY since in these experiments either accuracy of the measurements was not high enough or the production of the hadrons in the final state was not excluded. It is also worth mentioning that for meson production at small enough x, the nuclear transparency also changes due to the increase of essential longitudinal distances with decreasing x. This leads to nuclear transparency being a complicated function of both the transverse size (CT ?) and of x (for fixed Q^2) (see ref [42, 43] and references quoted in them).

We will conclude the discussion of the meson sector by mentioning a new measurement of pion nuclear transparency done at JLab using the $A(e, e'\pi)$ reaction at a momentum transfer (Q^2) range of 1-5 (GeV/c)^2 [18]. The measurements of the Q^2 and A dependence show deviations from traditional Glauber calculations and better agreement is obtained with prediction of the CT models which include space-time evolution of the wave package with coherence length given by Eq.2 [44, 45] with $l_{coh} \approx 0.6$ fm $\cdot p_h$/GeV. If the agreement between the data and the calculations with CT is really due to CT the onset of CT is at a relatively low Q^2 of a few (GeV/c)^2.

The situation in the baryon sector is much less clear. The onset of CT should be at higher Q^2 for baryons than for mesons. There are also no high energy measurements for baryons. The measurements at lower energies are sparse and not conclusive. The $(e, e'p)$ measurements from Bates, SLAC, and JLab at $Q^2 \leq 8$ (GeV/c)^2 are consistent with little or no Q^2 dependence [46, 47, 48, 49, 50].

On the other hand, $(p, 2p)$ data from BNL show a very strong Q^2 dependence [51]. The nuclear transparency is consistent with a Glauber approximation at $Q^2 \sim$5 (GeV/c)^2, increases to a maximum at $Q^2 \sim 8$ (GeV/c)^2, and than decreases at $Q^2 \sim$10 (GeV/c)^2. It is not clear whether this Q^2 dependence is a result of CT, CT plus something else, or no CT. In the $(p, 2p)$ case we have 3 nucleons that may be sensitive to CT effects and therefore the sensitivity should be larger than for the $(e, e'p)$ reaction. This extra sensitivity could explain the fact that the $(p, 2p)$ transparency increases up to $Q^2 \sim$8 (GeV/c)^2 but the

$(e, e'p)$ transparency does not. See the reviews of different approaches to the explanation of the energy dependence of nuclear transparency in $(p, 2p)$ reactions in [52, 53].

New data from Hall C mentioned above seem to indicate color transparency effects even at JLab energies [18]. At JLab energies a careful study of nuclear transparency may lead to observation of effects that can be related to chiral transparency, *i.e.:* suppression of the pion cloud and its interaction with the nuclear medium at and close to the point that a hadron is being produced in a hard reaction. We will discuss below some options that can be studied using the proposed data mining with the available CLAS data.

1. Study on the deuteron at transverse kinematics

   We propose to look for the $ed \to e'pn$ and the $ed \to e'p\Delta^0$ reaction in the transverse kinematics that is dominated by rescattering. The Δ^0 should be produced in the final state by pion exchange. The onset of chiral transparency should suppress this production and can be studied by comparing the ratio of $(ed \to e'pn)/(ed \to e'p\Delta^0)$ as a function of Q^2.

2. Resonance vs. non-resonance production

   We propose to study the virtual photon production of leading mesons, for example $\pi^+\pi^-$ and ρ-mesons on nuclei and compare the A dependence of these two channels. The expectation is that due to the small formation time at JLab energies, absorption effects in the nonresonance channel will be significantly larger since the resonance (the ρ-meson) interacts with the medium with about the same cross section as a pion and has a larger transparency than two independent pions. The interplay between the radius of the nucleus to be crossed and the effective formation length might be revealed by a study of the A and Q^2 dependence of the relative production of these two channels. We would like to compare the effective $\rho - N$ cross section to $2\sigma_{\pi N}$. We will also investigate some other channels like $\pi^+\pi^-\pi^0$ where the effect should be amplified.

   If the difference in A-dependence is significant, then it should be possible to use it in the program of resonance searches both with CLAS and in future experiments in Hall D.

3. S_{11} production

   The same idea could be used for the production of baryon resonances. Namely, we suggest to study the nuclear transparency of the S_{11} produced in a hard process as a function of A and Q^2 to map its transparency in the nuclear medium and to compare it to the transparency of a nucleon.

2.4 Time Frame

We plan to analyze the data in several distinct stages:

1. Exploration

   We will start by using existing data summary files to explore many of the reaction channels mentioned above to estimate the available statistics and identify interesting signals in the data. This will let us identify the most promising analysis projects. This effort will be spearheaded by present members of the data mining collaboration and the new postdoc to be hired under this proposal. Several graduate students would also be involved. This would take about six to 12 months.

2. Re-cooking of (selected) data sets

   In the next stage, we will repeat the low-level analysis (dubbed "cooking") of the data for the promising analysis projects with the most up-to-date analysis software in order to

   - maximize the available statistics
   - maximize the kinematic coverage
   - standardize the cuts and corrections

   Where necessary, we will develop new analysis tools, for example to extend particle reconstruction and tracking to lower momenta. Standardizing the cuts and corrections will allow us to combine data sets from different run groups much more easily.

   This development work will be led by the new experimental data mining postdoc, under the guidance of the data mining collaboration. This should take about one year. The actual "cooking" will be done with help from students and postdocs at the home institutions of the members of this initiative.

   The result of this analysis stage will be Data Summary Files, together with a standardized set of cuts and corrections that can easily be used for physics analysis.

   Starting during this phase, the theoretical data mining postdoc will model the processes discussed in the project in order to guide the experimental effort. This modeling will include both analysis of competing effects to determine the sensitivity of different experimental signals to the physics of interest (e.g., determining how best to measure NN correlations without the obscuring effects of final state interactions) as well as preparing physics event generators for Monte Carlo analysis of the data.

3. Physics Analysis

   In this final stage, we will use the Data Summary Files to analyze the most promising physics channels. This final analysis step will be done by the members of this initiative at their home institutions, with help from postdocs and students.

   Once we have identified the most promising channels and data sets of interest, we will develop and submit proposals to the CLAS collaboration for the detailed analyses

envisioned. Once approved, these will be CLAS Approved Analyses (CAA). We will follow the standard CLAS procedures to get any new analyses and papers based on them approved by the CLAS Nuclear Physics Physics Working group and the collaboration as a whole.

The results of this stage (publications and conference talks) will become available towards the end of the proposed 3-year duration of the present grant proposal.

2.5 Organization

The overall effort will be supervised by a "steering committee" consisting of the Principal Investigators and some senior members of the data mining collaboration. This committee will guide the analysis efforts, directing them toward the most promising channels. It will decide about allocation of resources and will prioritize tasks for the postdocs we are requesting in this proposal. The committee will meet regularly in person or using phone conferencing.

The entire collaboration will meet once or twice each year at Jefferson Lab. These meetings will be open to all interested parties, and will be supported by the travel funds requested here. The steering committee will organize these meetings, with support by Jefferson Lab conference staff.

The technical administration of the grant funds (if this proposal is successful) will be done by Old Dominion University (for the graduate student, the first post doc, and most travel funds) and Pennsylvania State University and Florida International University (for the remaining funds, in particular the theory post doc). To simplify the review of the present proposal, all funding requests are presented by Old Dominion University at this time.

3 Personnel

Table 2 shows the effort (as % FTE of overall research effort) that each PI and senior personnel anticipate spending on the program proposed here, assuming it is funded. Please see also the list of Current and Pending Support (Appendix 2). In the following, we list each of the institutions that are part of this proposal and the nature of their commitments to the overall research effort.

3.1 Old Dominion University

The major participants from ODU are Profs. Weinstein, Kuhn, Amarian, van Orden and Stepanyan. (Dr. Stepanyan is a Jefferson Lab senior staff member who has an appointment as "Jefferson Lab Professor" at Old Dominion, with full faculty privileges). In addition, Dr. Gavalian (who is a research assistant professor in our group) has expressed his willingness to work on this program. We have already one graduate student (Michael Major) who will

Name	Institution	Anticipated Effort
L.B. Weinstein	Old Dominion Univ.	20%
S.E. Kuhn	Old Dominion Univ.	30%
M. Amarian	Old Dominion Univ.	10%
M. Strikman	Pennsylvania State Univ.	25%
M. Sargsian	Florida International Univ.	20%
E. Piasetzky	Tel Aviv Univ.	60%
M. Holtrop	Univ. of New Hampshire	5%
D. Ireland	Univ. of Glasgow	10%
D. Protopopescu	Univ. of Glasgow	30%
D. MacGregor	Univ. of Glasgow	10%
D. Watts	Univ. of Edinburgh	10%
D. Glazier	Univ. of Edinburgh	10%
R. Nasseripour	George Washington Univ.	15%

Table 2: Anticipated Research Effort in % FTE

be analyzing polarized deuterium data for his thesis and will take on one more graduate student to work on analysis topics connected to this program.

Our main interest and expertise is in the area of short-range correlations, studied through direct observation of spectator nucleons or nucleon pairs in D$(e, e'p)$X and ^{3}He$(e, e'pp)$n. We have already published first results on these reactions from previous analyses [9, 16] and are well poised to expand this analysis to the complete existing data set. We are also studying (both experimentally and theoretically) polarization observables in deuteron break-up D$(e, e'p)$n. Finally, one of us (M. Amarian) has initiated a program of DVCS on nuclei both at HERMES and with CLAS [54] and will explore this aspect within the frame of the proposed research program.

3.2 Tel Aviv University

The Tel Aviv group includes Prof. E. Piasetzky, a major participant in this project, as well as a postdoc, Dr. R. Shneor, and two four graduate students, Or Chen Hen and, Igor Korover., Natanel Bubis, and Isreal Yaron. This group is supported by a dedicated grant from the Israel Science Foundation and has its focus on studies of short range correlations (SRC) in nuclei [4, 5, 6, 7, 8]. We plan in the coming years to contribute to the analysis of available data from Hall A and Hall B (as part of this data mining proposal) in parallel to preparing and performing a new SRC experiment [55] in Hall A . At Tel Aviv University we also have Prof. L. Frankfurt, a world leading theory expert in this field, with whom we

plan to consult extensively.

3.3 College of William and Mary

The senior member from this group is Prof. Keith Griffioen, who has extensive experience running and analyzing experiments with CLAS. The group will also include one or more graduate students. The main interest will be using deuteron data to study short-range correlations and color transparency.

3.4 Pennsylvania State University

This group is led by Prof. Mark Strikman who has worked extensively on the connection of nuclear and particle physics. Therefore, his group is uniquely poised to provide theoretical support for this initiative. The group has one post doc (M. Alvioli), who is working on calculations of short-range correlations in nuclei and the applications of the generalized eikonal approximation to the calculation of various processes with light nuclei. Both topics are directly related to the main aims of the data mining program. Further studies of M. Alvioli will involve investigation of the dynamics related to the three nucleon correlations which is one of the principal elements of the planned data mining.

3.5 Florida International University

Senior members from this group are Profs. Werner Boeglin and Misak Sargsian. Graduate students Harry Khanal, Carlos Granados and undergraduate students Ricardo Leante, Shana Berry will also take part in this effort. The group will analyze deuteron electrodisintegration data and exclusive electroproduction of resonances in $d(e, e'R)N$ reactions. Dr. Sargsian will support the whole data mining initiative by providing Physics event generators and universal Monte Carlo programs for studies of triple coincidence experiments, and theoretical guidance on FSI and tagged structure functions.

3.6 Universities of Glasgow and Edinburgh

The personnel from Glasgow who are supporting this project are: Dave Ireland (10%), Dan Protopopescu (30%) and Douglas MacGregor (10%). Additional interest and support from Edinburgh will be provided by Daniel Watts (10%) and Derek Glazier (10%).

D. Protopopescu will coordinate the groups overall analysis effort and will be in charge of data skimming, cuts and corrections, simulations, cross-section extraction and comparisons with theoretical models, as well as collecting the inputs of the other team members. He will contribute to the writing of the GAS software framework. He has already set up and will administer the documentation and communication tools for this project [56]. D. Ireland will work on Δ^0 electroproduction in ^{3}He and D. Watts on 3-Nucleon force effects. D. Glazier will provide help in running simulations, and will be in charge of the Fadeeev

calculations for comparison with the 3-Nucleon Forces results. D. MacGregor will provide Glagow input in the short-range correlations studies. He will assist D. Protopopescu and D. Ireland with the data analyses, normalization issues, and physics interpretation.

3.7 Ohio State University

The major participant from OSU is Sabine Jeschonnek, who has recently performed a fully relativistic calculation of the D(e,e'p)n reaction in the impulse approximation together with W. VanOrden [57]. Their most recent calculations have been performed for both vector- and tensor-polarized deuteron targets [58], employing the Gross equation to describe the deuteron ground state, and using the SAID parametrization of the full pn scattering amplitude to describe the final state interactions (FSIs).

As contribution to this proposed activity, Dr. Jeschonnek will provide calculations and theoretical guidance for analyses of the D(e,e'p)n reaction. Calculations will be performed for unpolarized and polarized targets, and for polarized ejectiles. In the future, isobar states and meson exchange currents will be included in these calculations. She will work on a faster version of a Monte Carlo code that can be used to for acceptance simulation of CLAS.

3.8 University of New Hampshire

Our group, consisting of Prof. Maurik Holtrop and postdoc Sarah Phillips, will contribute to the data mining efforts by being strongly involved in the creation of a common analysis system. Such a system will be needed to make sure that all the data can be analyzed by all members of the data mining initiative. We will also be working on the analysis of several physics topics of interest, which include the study of Short Range Correlations and Nuclear Transparencies, Final State Interactions and the onset of Color Transparency. The UNH group has good access to excellent undergraduate students, who we hope to involve in the data analysis. We also have access to a large (208 CPUs with a lot of storage) computer cluster on which we can perform simulations and other compute intensive tasks, also as a service to other data mining collaborators.

3.9 Massachusetts Institute of Technology

The senior members from MIT are Dr. Shalev Gilad and Dr. Vincent Sulkosky. They are interested in continuing their program of investigating the properties of few-body nuclei, including short range correlations, within the context of this proposal.

3.10 University of Richmond

The University of Richmond group consists of one senior faculty member (Dr. G.P.Gilfoyle) and 1-4 undergraduates doing research full-time during the summer and part-time during

the academic year. The group is already focused on the analysis of the deuteron data to extract the so-called fifth structure function (beam helicity-dependent) in quasielastic kinematics and this work is nearly complete. We are proposing to extend that analysis to higher energy transfer. The undergraduate student now working on the quasielastic data would begin working on the high-energy-transfer data in the summer of 2010. At the same time we will also have 1-2 undergraduates to begin the search for Δ-isobar production off the deuteron (see Section 2.2.4). They will begin that search using the E5 data set which is the same one used in the fifth-structure function analysis so they should make rapid progress.

3.11 George Washington University

The active member of this group is Dr. Rakhsha Nasseripour who has been strongly involved in data analysis from CLAS experiments. This group is interested in studying few-body forces as well as SRC and isobar configurations in nuclei. They will perform data analysis on data with ^{3}He and ^{4}He as well as deuterium targets within the context of this proposal.

Appendix 1. Biographical Sketches

Biographical Sketch for Dr. Lawrence Weinstein

(a) **Education and Training**

Yale University, New Haven, CT	Physics	B.S. 1981, cum laude
MIT, Cambridge, MA	Nuclear Physics	Ph.D. 1988
MIT, Lab for Nuclear Science	Sponsored Research Staff	1988-1991

(b) **Research and Professional Experience**

Old Dominion University	University Professor	2007-
Old Dominion University	Professor of Physics	2003-
Old Dominion University	Assc. Prof. of Physics	1998-1993
Old Dominion University	Asst. Prof. of Physics	1992-1998
MIT, Laboratory for Nuclear Science	Research Scientist	1991-1992

(c) **Honors and Awards**

Virginia Outstanding Faculty Award	2009
ODU College of Sciences, Faculty Excellence Award	2005
Fellow, American Physics Society	2004

(d) **Publications**

L. M. Qin, B. A. Raue, G. E. Dodge, C. E. Hyde-Wright, A. Klein, S. E. Kuhn, T. D. Pyron, K. G. Vansyoc, L. B. Weinstein, J. Yun, M. D. Mestayer: "Prototype studies and design considerations for the CLAS Region 2 drift chambers", Nucl. Instr. Meth. **A411**, nos. 2,3, pp. 265–274 (August 1998).

M.M. Sargsian, J. Arrington, W. Bertozzi, W. Boeglin, C. Carlson, D. Day, L. Frankfurt, K. Egiyan, R. Ent, S. Gilad, K. Griffioen, D.W. Higinbotham, S. Kuhn, W. Melnitchouk, G.A. Miller, E. Piasetzky, S. Stepanyan, M. Strikman, and L. Weinstein: "Hadrons in the Nuclear Medium", J. Phys. G.: Nucl. Part. Phys. **29**, R1 (March 2003).

B.A. Mecking et al. (CLAS collaboration, see Ref. [1]): "The CEBAF Large Acceptance Spectrometer (CLAS)", Nucl. Instr. Meth A **503**, 513 (May 2003).

K.Sh. Egiyan, et al (The CLAS Collaboration see Ref. [2]), "Observation of Nuclear Scaling in the A(e,e′) Reaction at x_B >1", Phys Rev C **68**, 014313 (2003)

R.A. Niyazov, et al. (the CLAS Collaboration see Ref. [9]), "Two-Nucleon Momentum Distributions Measured in ^{3}He(e,e'pp)n", Phys Rev Lett **92,** 052303 (2004).

A.V. Klimenko, et al., (the CLAS collaboration see Ref. [15]), "Electron Scattering From High-Momentum Neutrons in Deuterium", Phys Rev C **73**, 035212 (2006).

K. Sh. Egiyan, et al. (the CLAS Collaboration see Ref. [3]), "Measurement of 2- and 3-Nucleon Short Range Correlation Probabilities in Nuclei", Phys Rev Lett **96**, 082501 (2006)

R. Shneor, et al. (the Hall A Collaboration see Ref. [4]), ``Investigation of Proton-Proton Short-Range Correlations via the ^{12}C(e,e'pp) Reaction'', Phys Rev Lett **99**, 072501 (2007).

K. Sh. Egiyan et al (the CLAS Collaboration see Ref. [13]), "Study of Exclusive d(e,e'p)n Reaction Mechanism at High Q^2", Phys Rev Lett **98**, 262502 (2007).

R. Subedi, et al. [see Ref. [5]), ``Probing Cold Dense Nuclear Matter'', Science **320**, 1476 (2008).

(e) **Synergistic Activities**

L. Weinstein and J. Adam, "Guesstimation, Solving the World's Problems on the Back of a Cocktail Napkin", Princeton University Press, Princeton, NJ, 2008. Fourth Printing, 2009. Gave talks on Guesstimation to high schools, social clubs, the general public, physics departments, and scientific conferences.

Editor, Fermi Questions column, The Physics Teacher, 2007-present.

Involved several undergraduate students in research, including data analysis, detector development, and testing. Supervised three undergraduate senior thesis projects.

Supervised six high school students in their senior mentorship projects. Projects included data analysis, magnet design and construction, etc.

Organized Virginia Children's Festival booths, physics demo shows and pumpkin drops. Delivered many physics presentations to thousands of middle and high school students.

(f) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list.
(ii) Graduate advisor (both thesis and postdoctoral): Prof. William Bertozzi, MIT.
(iii) Graduate students advised: Dr. Rustam Niyazov (Passport Systems), Dr. Hovhannes Baghdasaryan (U Virginia), Megh Niroula, and Dasuni Kalhari. Postdoctoral fellows advised: Dr. Wendy Hinton (Norfolk State U), Dr. Rikki Roche (no affil), Dr. J. Lachniet (Arete Associates)

Biographical Sketch for Dr. Sebastian Kuhn [*)]

(a) **Education and Training**

University of Bonn, Germany	Nuclear Physics	Diploma (M.S.) 1982
University of Bonn, Germany	Nuclear Physics	Dr. rer. nat (Ph.D.) 1986
Lawrence Berkeley Lab, USA	Nuclear Physics	NATO fellow 1986-1988

(b) **Research and Professional Experience**

Old Dominion University	Eminent Scholar	2007 -
Old Dominion University	Professor of Physics	2003 -
Old Dominion University	Assoc. Prof. of Physics	1997 - 2003
Old Dominion University	Asst. Prof. of Physics	1992 - 1997
Stanford University	Acting Asst. Prof.	1988-1992

(c) **Publications**

S.E. Kuhn, W.J. Cummings, G.E. Dodge, S.S. Hanna, B.H. King, Y.M. Shin, J.G. Congleton, R. Helmer, R.B. Schubank, N.R. Stevenson, U. Wienands, Y.K. Lee, G.R. Mason, B.E. King, K.S. Chung, J.M. Lee, D.P. Rosenzweig: "Multi-Nucleon Effects in Muon Capture on ^{3}He at High Energy Transfer", Phys. Rev. C **50** No. 4, pp. 1771–1786 (October 1994).

M.D. Mestayer, D. Carman, B. Asavabiphop, F.J. Barbosa, P. Bonneau, S.B. Christo, G.E. Dodge, T. Dooling, W.S. Duncan, S.A. Dytman, R. Feuerbach, G.P. Gilfoyle, V. Gyurjyan, K.H. Hicks, R.S. Hicks, C.E. Hyde-Wright, G. Jacobs, A. Klein, F.J. Klein, M.V. Kossov, S.E. Kuhn, R.A. Magahiz, R.W. Major, C. Martin, T. McGuckin, J. McNabb, R.A. Miskimen, J.A. Mueller, B.B. Niczyporuk, J. O'Meara, L.M. Qin, B.A. Raue, J. Robb, F. Roudot, R.A. Schumacher , D.J. Tedeschi, R.A. Thompson, D. Tilles, W. Tuzel, K. VanSyoc, M.F. Vineyard, L.B. Weinstein, G.R. Wilkin, A. Yegneswaran, J. Yun: "The CLAS Drift Chamber System", Nucl. Instr. Meth. **A449**, pp. 81–111 (11 July 2000).

M.M. Sargsian, J. Arrington, W. Bertozzi, W. Boeglin, C. Carlson, D. Day, L. Frankfurt, K. Egiyan, R. Ent, S. Gilad, K. Griffioen, D.W. Higinbotham, S. Kuhn, W. Melnitchouk, G.A. Miller, E. Piasetzky, S. Stepanyan, M. Strikman, and L. Weinstein: “Hadrons in the Nuclear Medium”, J. Phys. G.: Nucl. Part. Phys. **29**, R1 (March 2003).

J. Yun, S.E. Kuhn, G.E. Dodge, T.A. Forest, M. Taiuti, et al. (CLAS collaboration, see Ref. [28]): “Measurement of Inclusive Spin Structure Functions of the Deuteron with CLAS”, Phys. Rev. C **67**, 055204 (13 pages) (May 2003).

B.A. Mecking et al. (CLAS collaboration, see Ref. [1]): “The CEBAF Large Acceptance Spectrometer (CLAS)”, Nucl. Instr. Meth A **503**, 513 (May 2003).

M. Osipenko, S. Simula, W. Melnitchouk, P. Bosted, V. Burkert, E. Christy, K. Griffioen, C. Keppel, S. Kuhn, and G. Ricco:” Global analysis of data on the proton structure function g_1 and the extraction of its moments”, Phys Rev. D **71**, 054007 (March 2005).

A. V. Klimenko, S. E. Kuhn, C. Butuceanu, K. S. Egiyan, K. A. Griffioen, et al. (CLAS collaboration, see Ref. [15]): “Electron scattering from high-momentum neutrons in deuterium”, Phys. Rev. C **73**, 035212 (March 2006).

[*)] Fellow of the APS, 2007

K. S. Egiyan, et al. (CLAS collaboration, see Ref. [13]): "Experimental Study of Exclusive ^{2}H(e,e'p)n Reaction Mechanisms at High Q^2", Phys. Rev. Lett. **98**, p. 262502 (27 June 2007).

A. Deur, P. Bosted, V. Burkert, D. Crabb, V. Dharmawardane, G. E. Dodge, T. A. Forest, K. A. Griffioen, S. E. Kuhn, R. Minehart, and Y. Prok: "Experimental Study of Isovector Spin Sum Rules", Phys. Rev. D **78**, 032001 (August 2008).

S.E. Kuhn, J.-P. Chen and E. Leader: "Spin structure of the nucleon – status and recent results", Prog. Part. Nucl. Phys. **63**, 1-50 (July 2009).

(d) **Synergistic Activities**

Involved several undergraduate students in my research, including detector development and testing. Supervised Senior Thesis project of undergraduate ODU student Peter Bradshaw.

Worked with a high school teacher as part of the 1999 RECET program to upgrade the Undergraduate Physics Labs at Old Dominion.

Led an 8-week research project for a high school student in the framework of the NASA Sharp Plus Program, involving a cosmic ray telescope. Involved several other high school students in my research (including 6 African-Americans).

Participated in science fairs, open houses, children's festivals, and other outreach activities; lectured to high school classes; wrote articles popularizing research for general circulation newspapers.

(e) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list. Main collaborators over past 4 years: Harut Avakian, Peter Bosted, Volker Burkert, Jian-Ping Chen, Alexandre Deur, Howard Fenker (Jefferson Lab), E. Christy and Thia Keppel (Hampton Univ.), Elliot Leader (Imperial College, London), Keith Griffioen (College of William and Mary), Ralph Minehart (Univ. of Virginia), Claudio Ciofi degli Atti (Univ. of Perugia, Italy).

(ii) Graduate Advisor: Prof. Frank Hinterberger, University of Bonn. Post-graduate advisor: Prof. Henry Weller, Duke University

(iii) Graduate Students advised: Dr. Frank Wesselmann; Dr. Junho Yun; Dr. Alexei Klimenko, Dr. V. Dharmawardane, Nevzat Guler, Svjatoslav Tkachenko, Jixie Zhang, Krishna Adhikari. Postdocs advised: Dr. Brian Raue (Florida International Univ.); Dr. Tony Forest (Idaho State Univ.)

Biographical Sketch for Dr. Moskov Amaryan

(a) **Education and Training**

Armenian Pedagogical Institute ,Armenia	Physics	Diploma (M.S.) 1972
Yerevan Physics Institue ,Armenia	Nuclear Physics	Ph.D. 1993

(b) **Research and Professional Experience**

Old Dominion University	Associate Professor	2004 -
DESY, Hamburg, Germany	HERMES Analysis Coordinator	2001-2004
NIKHEF, Amsterdam, Holland	Visiting Scientist	2000 - 2001
INFN, Rome University, Italy	Primo Ricercatore	1997 - 2001
Yerevan Physics Institute	Group Leader	1994-1997
Yerevan Physics Institute	Staff Scientist	1974-1994

(c) **Publications**

M.Dugger et al., (CLAS Collaboration, see Ref.[1-3]): "pi+ photoproduction on the proton for photon energies from 0.725 to 2.875-GeV". Phys. Rev. C79: 065206, 2009.

M.Amarian, D.Diakonov and M.V.Polyakov: "Exotic Theta+ Baryon from interference". Phys. Rev. D 78, 074003, 2008.

A.Airapetian et al.,(HERMES Collaboration, see Ref.[41]): "Quark helicity distributions in the nucleon for up, down, and strange quarks from semi-inclusive deep-inelastic scattering". Phys. Rev. D71: 012003, 2005.

A.Airapetian et al., (HERMES Collaboration, see Ref.[41]): "Single-spin asymmetries in semi-inclusive deep-inelastic scattering on a transversely polarized hydrogen target". Phys. Rev. Lett. 94 : 012002, 2005.

O.Gayou et al., (Hall A Collaboration, see Ref.[11]): "Measurements of the elastic electromagnetic form-factor ratio mu(p) G(Ep) / G(Mp) via polarization transfer". Phys. Rev. C64:038202, 2001.

A.Airapetian et al., (HERMES Collaboration, see Ref.[41]): Measurement of the beam spin azimuthal asymmetry associated with deeply virtual Compton scattering". Phys. Rev.Lett. 87: 182001, 2001.

A.Airapetian et al., (HERMES Collaboration, see Ref.[41]): " Observation of a single spin azimuthal asymmetry in semiinclusive pion electro production". Phys. Rev. Lett. 84: 4047-4051, 2000.

A.Airapetian et al., (HERMES Collaboration, see Ref.[41]): "Measurement of the spin asymmetry in the photoproduction of pairs of high p(T) hadrons at HERMES". Phys. Rev. Lett. 84: 2584-2588, 2000.

M. Amarian, L. Auerbach, T. Averett, J. Berthot, P. Bertin, W. Bertozzi, T. Black, E. Brash, D. Brown, E. Burtin, J. Calarco, G. Cates, Z. Chai, J.-P. Chen, Seonho Choi, E. Chudakov, E. Cisbani, C. W. de Jager, A. Deur,, R. DiSalvo, S. Dieterich, P. Djawotho, J. M. Finn, K.

Fissum, H. Fonvieille, S. Frullani, H. Gao, J. Gao, F. Garibaldi, A. Gasparian, S. Gilad, R. Gilman, A. Glamazdin, C. Glashausser, E. Goldberg, J. Gomez, V. Gorbenko, J.-O. Hansen, B. Hersman, R. Holmes, G. M. Huber, E. Hughes, B. Humensky, S. Incerti, M. Iodice, S. Jensen, X. Jiang, C. Jones, G. Jones, M. Jones, C. Jutier, A. Ketikyan, I. Kominis, W. Korsch, K. Kramer, K. Kumar, G. Kumbartzki, M. Kuss, E. Lakuriqi, G. Laveissiere, J. Lerose, M. Liang, N. Liyanage, G. Lolos, S. Malov, J. Marroncle, K. McCormick, R. Mckeown, Z.-E. Meziani, R. Michaels, J. Mitchell, Z. Papandreou, T. Pavlin, G. G. Petratos, D. Pripstein, D. Prout, R. Ransome, Y. Roblin, D. Rowntree, M. Rvachev, F. Sabatie, A. Saha, K. Slifer, P. Souder, T. Saito, S. Strauch, R. Suleiman, K. Takahashi, S. Teijiro, L. Todor, H. Tsubota, H. Ueno, G. Urciuoli, R. Van der Meer, P. Vernin, H. Voskanian, B. Wojtsekhowski, F. Xiong, W. Xu, J.-C Yang, B. Zhang, and P. A. Żołnierczuk (Jefferson Lab E94010 Collaboration): "Measurement of the generalized forward spin polarizabilities of the neutron". Phys. Rev. Lett. 93 : 152301, 2004.

(d) **Synergistic Activities**

Involved several undergraduate students in my research.
Supervised Senior Thesis project of undergraduate ODU students Benjamin Tokarz and Brian Wieland.

Participated in science fairs, open houses, children's festivals, and other outreach activities.

(e) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list. Main collaborators over past 4 years: Larry Weinstein (ODU), M.Polyakov (University of Bochum, Germany), Reinhard Schumacher (Carnegie Mellon University), Volker Burkert, Stepan Stepanyan (Jefferson Lab), Patricia Rossi (INFN, Frascati, Italy).

(ii) Graduate Students advised: Heghine Seraydaryan, Michael Kunkel.

Biographical sketch for Dr. Stepan Stepanyan

Education

Ph.D. in Physics 1996, Yerevan Physics Institute, Yerevan, Armenia.
M.S., 1979, Experimental high energy nuclear and particle physics, Yerevan State University, Yerevan, Armenia

Research and Professional Experience

Staff scientist,Thomas Jefferson National Accelerator Facility, 2003 -
Research assistant professor, Old Dominion University, 2001 - 2003
Research assistant professor, Christopher Newport University, 2000 - 2001
Visiting scientist, Thomas Jefferson National Accelerator Facility, 1997 - 1999
Staff scientist, Yerevan Physics Institute, Yerevan, Armenia, 1982 - 1997
Junior researcher, Yerevan Physics Institute, Yerevan, Armenia, 1979 - 1982

Publications

F. X. Girod *et al.* [CLAS Collaboration], 'Deeply Virtual Compton Scattering Beam-Spin Asymmetries," Phys. Rev. Lett. **100**, 162002 (2008)

T. Mibe *et al.* [CLAS Collaboration], "First measurement of coherent ϕ-meson photoproduction on deuteron at low energies," Phys. Rev. C **76**, 052202 (2007)

B. McKinnon *et al.* [CLAS Collaboration], Phys. Rev. Lett. **96**, 212001 (2006)

S. Stepanyan, S. Boyarinov, H. Egiyan, L. Guo, D. Dale, M. Gabrielyan, L. Gan, A. Gasparian, A. Glamazdin, B. Mecking, I. Nakagawa, A. Teymurazyan and M.H. Wood, "Energy calibration of the JLab bremsstrahlung tagging system," Nucl. Instrum. Meth. A **572**, 654 (2007)

K. Hicks, V. Burkert, A. E. Kudryavtsev, I. I. Strakovsky and S. Stepanyan, "Comment on the evidence for a pentaquark and kinematic reflections," Phys. Rev. D **71**, 098501 (2005)

S. Stepanyan *et al.* [CLAS Collaboration], "Observation of an exotic S = +1 baryon in exclusive photoproduction from the deuteron," Phys. Rev. Lett. **91**, 252001 (2003)

S. Stepanyan *et al.* [CLAS Collaboration], "First observation of exclusive

deeply virtual Compton scattering in polarized electron beam asymmetry measurements," Phys. Rev. Lett. **87**, 182002 (2001)

I. G. Aznauryan and S.G. Stepanyan, "P33(1232) resonance contribution to the amplitudes M1+3/2,E1+3/2,S1+3/2 from an analysis of the p(e,e$\breve{2}$032p)$\breve{0}$3c00 data at Q2=2.8, 3.2, and 4 (GeV/c)2 within the dispersion relation approach," Phys. Rev. **D59**, 054009 (1999)

M. Amarian, G. Asryan, K. Beard, W. Brooks, V.Burkert, T.Carstens, A.Coleman, R. Demirchyan, Yu. Efremenko, H. Egiyan, K. Egiyan, H. Funsten, V. Gavrilov, K. Gioanetti, R.M. Marshall, B. Mecking, H. Mkrtchan, R.C. Minehart, M. Ohandjanyan, Yu. Sharabian, L.C. Smith, S. Stepanyan, W.A. Stephens, T.Y. Tung, C. Zorn, "The CLAS forward electromagnetic calorimeter," Nucl. Instrum. Meth. A **460**, 239 (2001).

Other Activities

Detector Development: (a) Radial time projection chamber based on GEM technology for detection of low energy alpha-particles, (b) scintillation hodoscope based on silicon photo multipliers for electron detection, (c) PbO_4W crystal calorimeter with APD readout for detection of electrons and photons at small angles.

Graduate Advised: Dr. Gagik Gavalyan, Dr. Bryan M^{c}Kinnon, Rafael Paremuzyan

Undergraduate Advised (SULI/JLAB program): Jeffrey Eldred, Ofelya Nersesyan, Erik Skau, Rafael Paremuzyan, Nikolay Balasanyan, Kristin Whitlow

Biographical Sketch for Dr. J. Wallace Van Orden[*)]

(a) **Education and Training**

Utah State University	Physics	B.S. 1973
Stanford Univerity	Physics	M.S. 1975
Stanford University	Nuclear Physics	Ph.D. 1978

(b) **Research and Professional Experience**

Old Dominion University	Eminent Scholar	2003 -
Old Dominion University	Professor of Physics	1998 –
Old Dominion University	Associate Professor	1990-1998
Jefferson Lab (CEBAF)	Staff Scientist	1988-
Jefferson Lab (CEBAF)	Visiting Scientist	1987 - 1988
University of Maryland	Asst. Prof. of Physics	1981 - 1988
University of Maryland	Postdoc.	1978-1981

(c) **Publications**

J. W.Van Orden and S. Jeschonnek, "Energy-weighted sum rules, y-scaling and duality," Eur. Phys. J. A **17**, 391 (2003).

J. W. Van Orden and S. Jeschonnek, "Modeling quark-hadron duality for relativistic, confined fermions," Phys. Rev. D **69,** 054006 (2004).

J. Adam, Jr. and J. W. Van Orden, "A comprehensive treatment of electromagnetic interactions and the three-body spectator equations," Phys. Rev. C **71**, 034003 (2005).

S. Jeschonnek and J. W. Van Orden, "Modeling quark-hadron duality in polarization observables," Phys. Rev. D **71**, 054019 (2005).

J. W. Van Orden, Sabine Jeschonnek, and John Tjon, "Scaling of Dirac Fermions and the WKB approximation", Phys. Rev. D **72**, 054020 (2005).

J. W. Van Orden, "Conserved electromagnetic currents in a relativistic optical model," Phys. Rev. C **74**, 345007 (2006).

S. Jeschonnek and J. W. Van Orden, "A new calculation for D(e,e'p)n at GeV energies," Phys. Rev. C **78**, 014007 (2008)

.

S. Jeschonnek and J. W. Van Orden, "Target Polarization for ^{2}H(e,e'p)n at GeV energies," to be published in Phys. Rev. C.

(d) **Synergistic Activities**

(e) **Collaborators and other Affiliations**

[*)] Fellow of the APS, 2003

(i) All collaborators are listed as authors in the publication list. Main collaborator over past 4 years: Sabine Jeschonnek (Ohio State University, Lima),
(ii) Graduate Advisor: Prof. T. W. Donnelly, MIT, Post-graduate advisors: S. J. Wallace and M. Banerjee, University of Maryland

Biographical Sketch

Eli Piasetzky

Professional Preparation

Tel Aviv University	Physics	B.Sc.	1974
Tel Aviv University	Physics	M.Sc.	1978
Tel Aviv University	Physics	Ph.D	1981
Tel Aviv University	Archeology	B.A.	1999

Appointments

Tel Aviv University	Institute for Nuclear Physics Director	2007 -
Tel Aviv University	The wolfson chair in experimental physics	2006-
Tel Aviv University	Nuclear Phyics dep. Chair	2000 - 2002
Tel Aviv University	Nuclear Phyics dep. Chair	1996 – 1998
Tel Aviv University	Professor	1992 –
Brokhaven Nat. Lab.	Visiting Physicist	1992
Tel Aviv University	Nuclear Phyics dep. Chair	1989 – 1991
Tel Aviv University	Assoc. Professor	1987 – 1992
Tel Aviv University	Senior Lecturer	1984 – 1987
Los Alamos Nat. Lab.	Staff Member	1982 – 1984
Los Alamos Nat. Lab.	Post-doctorate	1981 – 1982

Publications

Publications closely related to proposed project

1. *n-p Short-Range Correlations from (p, 2p + n) Measurements*, A. Tang, J. W. Watson, J. Aclander, J. Alster, G. Asryan, Y. Averichev, D. Baxton, V. Baturin, N. Bukhtoyarova, A. Carroll, S. Gushue, S. Heppelmann, A. Leksanov, Y. Makdisi, A. Malki, E. Minina, 1. Navon, H. Nicholson, A. Ogawa, Yu. Panebratsev, E. Piasetzky, A. Schetkovsky, S. Shimanskiy, and D. Zhalov, Phys. Rev. Lett **90**, 042301 (2003).

2. *Evidence for the Strong Dominance of Proton-Neutron Correlations in Nuclei,* E. Piasetzky, M. Sargsian, L. Frankfurt, M. Strikman and J. W. Watson, Phys. Rev. Lett. **97**, 162504 (2006).

3. *Investigation of Proton-Proton Short-Range Correlations via the 12C(e,e'pp) Reaction,* R. Shneor, P. Monaghan, R. Subedi, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, P. Bertin, W. Bertozzi, W. Boeglin, J. P. Chen, Seonho Choi, E. Chudakov, E. Cisbani, B. Craver, C. W. de Jager, R. J. Feuerbach, S. Frullani, F. Garibaldi, O. Gayou, S. Gilad, R. Gilman, O. Glamazdin, J. Gomez, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim,1 R. Igarashi, E. Jans, X. Jiang, Y. Jiang, L. Kaufman, A. Kelleher, A. Kolarkar, E. Kuchina, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, S. Nanda, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, B. Reitz, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, N. Thompson, P. E. Ulmer, G. M. Urciuoli, E. Voutier, K. Wang, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, H. Yao, X. Zheng, and L. Zhu,Phys. Rev. Lett., **99**, 072501 (2007)

4. *Probing Cold Dense Nuclear Matter,* R. Subedi, R. Shneor, P. Monaghan, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, W. Boeglin, J.-P. Chen, Seonho Choi, E. Cisbani, B. Craver, S. Frullani, F. Garibaldi, S. Gilad, R. Gilman, O. Glamazdin, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, C. W. de Jager, E. Jans, X. Jiang, L. J. Kaufman, A. Kelleher, A. Kolarkar, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, G. M. Urciuoli, E. Voutier, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, X.-C. Zheng, L. Zhu, Science, **320,** 1476 (2008).

Other significant publications

1. *Energy Dependence of Nuclear Transparency in C(p,2p) Scattering*, A. Leksanov, J. Alster, C. Asryan, Y. Averichev, D. Barton, V. Baturin, N. Bukhtoyaxova, A. Carroll, S. Heppelmann, T. Kawabata, Y. Makdisi, E. Minina, I. Navon, A. Malki, H. Nicholson, A. Ogawa, Yu. Panebratsev, E. Piesetzky, A. Schetkovsky, S. Shimanskiy, A. Tang, J. W. Watson, H. Yoshida, and D. Zhalov, Phys. Rev. Lett. **87**, 312301 (2001).

2. *Nuclear transparency in 90° C. M. quasielastic A (p,2p) reactions*, J. Aclander, J. Alster, G. Asryan, Y. Averiche, D. S. Barton, V. Baturin, N. Buktoyarova, G. Bunce, A. S. Carroll, N. Christensen, H. Courant, S. Durrant, C. Fang, K. Gabriel, S. Cushue, K. J. Heller, S. Heppelmann, I. Kosonovsky, A. Leksanov, Y. 1. Makdisi, A. Malki, I. Mardor, Y. Mardor, M. L. Marshak, D. Martel, E. Minina, E. Minor, 1. Navon, H. Nicholson, A. Ogawa, Y. Panebratsev, E. Piasetzky, T. Roser, J. J. Russell, A. Schetkovsky, S. Shimanskiy, M. A. Shupe, S. Sutton, M. Tanaka, A. Tang, 1. Tsetkov, J. Watson, C. White, J-Y. Wu, and D. Zhalov, Phys. Rev. C **70**, 015208 (2004).

3. *Proton Electromagnetic Form Factor at low* Q^2 , G. A. Miller, E. Piasetzky, G. Ron, Phys. Rev. Lett. 101 082002 (2008).

4. *The proton elastic form factor ratio GE/GM at low momentum transfer*, R. Guy et al., Phys. Rev. Lett. 99 202002 (2007).

Synergistic Activities

(1) Member of the organizing committee and the International Advisory Committee for International Conferences (PANIC08, and others in Israel, Europe, and USA. ; (2) Proposal reviewer for the ISF and BSF.; (3) Principal Investigator on two ISF and one BSF proposals.

Collaborators & Other Affiliations

Collaborators

J. Watson (Kent State), W. Bertozzi (MIT), R. Gilman (Rutgers), L. Frankfurt (Tel Aviv), S. Gilad (MIT), D. Higinbotham (JLab), M. Sargsian (Florida Int. U), M. Strikman (Penn State), S. Wood (JLab)

Thesis Advisor and Postgraduate-Scholar Sponsor

Graduate Students: I. Pomerantz, A. Malki, Or ChenHen, Igor korover , N. Bubis, I. Yaron (School of Physics
all at Tel Aviv University).
Postdoctoral Fellows sponsored: R. Shneor (Tel Aviv University).

Keith A. Griffioen

(i) Professional Preparation

Calvin College, Grand Rapids, MI	Physics & Math	B.A. 1979
Stanford University, Stanford, CA	Nuclear Physics	PhD 1984
Stanford U. and Lawrence Berkeley Labs	Research Associate; Nuclear Physics	1984-1985
Rijksuniversiteit Utrecht, The Netherlands	Research Associate; Nuclear Physics	1985-1987

(ii) Appointments

2005-present	Chair, Dept. of Physics, The College of William & Mary, Williamsburg, VA
2001-present	Professor, The College of William & Mary, Williamsburg, VA
1994-2001	Associate Professor, The College of William & Mary, Williamsburg, VA
1988-1993	Assistant Professor, University of Pennsylvania, Philadelphia, PA

(iii) Publications

Related to Current Proposal

BoNuS: Development and Use of a Radial TPC using Cylindrical GEMs, H. Fenker, N. Baillie, P. Bradshaw, S. Bueltmann, V. Burkert, M. Christy, G. Dodge, D. Dutta, R. Ent, J. Evans, R. Fersch, K. Giovanetti, K. Griffioen, M. Ispiryan, C. Jayalath, N. Kalantarians, C. Keppel, S. Kuhn, G. Niculescu, I. Niculescu, S. Tkachenko, V. Tvaskis, J. Zhang, Nucl. Instr. Meth. A **592**, 273 (2008).

Experimental study of exclusive $H_2(e,e'p)n$ reaction mechanisms at high Q^2, K.S. Egiyan *et al.* (the CLAS Collaboration, Ref. [13]), Phys. Rev. Lett. **98**, 262502 (2007).

Electron scattering from high-momentum neutrons in deuterium, A.V. Klimenko *et al.* (the CLAS Collaboration, Ref. [15]), Phys. Rev. C **73**, 035212 (2006).

Measurement of 2- and 3-Nucleon Short Range Correlation Probabilities in Nuclei, K.S. Egiyan *et al.* (the CLAS Collaboration, Ref. [3]), Phys. Rev. Lett. **96**, 082501 (2006).

Hadrons in the Nuclear Medium, M.M. Sargsian, J. Arrington, W. Bertozzi, W. Boeglin, C.E. Carlson, D.B. Day, L.L. Frankfurt, K. Egiyan, R. Ent, S. Gilad, K.A. Griffioen, D.W. Higinbotham, S. Kuhn, W. Melnitchouk, G.A. Miller, E. Paisetzky, S. Stepanyan, M.I. Strikman and L.B. Weinstein, J. Phys. **G29**, R1 (2003).

Other Significant Publications

Nuclear decay following deep-inelastic scattering of 470 GeV muons, M.R. Adams, *et al.* (the E665 Collaboration at FNAL), Phys. Rev. Lett. **74**, 5198 (1995); *erratum* **80**, 2020 (1998).

Observation of nuclear scaling in the $A(e,e')$ reaction at $x_{Bj} > 1$, K.S. Egiyan, *et al.* (the CLAS Collaboration, Ref. [2]), Phys. Rev. C **68**, 014313 (2003).

Double hadron leptoproduction in the nuclear medium, A. Airapetian *et al.* (HERMES Collaboration), Phys. Rev. Lett. **96**, 162301 (2006).

Proton structure corrections to electronic and muonic hydrogen hyperfine splitting, C.E. Carlson, V. Nazaryan and K.A. Griffioen, Phys. Rev. A **78**, 022517 (2008).

Moments of the Spin Structure Functions g_1^p and g_1^d for $0.05 < Q^2 < 3.0$ GeV^2, Y. Prok *et al.* (CLAS Collaboration), Phys. Lett. B **672**, 12 (2009).

(iv) Synergistic Activities

- Advising 1–2 undergraduate majors per year in year-long senior projects related to the physics of Jefferson Lab; the latest ones involved analyzing 2-pion single-spin asymmetries from CLAS and fitting the world's data on photo- and electroproduction of the J/ψ.
- Participating yearly in the career day for gifted middle and high school students at W&M, with talks about cosmology, subatomic physics, and careers in physics.

(v) Collaborators and Other Affiliations

(a) Collaborators and Co-Editors: Author lists for nuclear/particle physics collaborations often number over 100 researchers and are much too long for a two-page biographical sketch, therefore web links are provided.

- SLAC E155x (see http://www.slac.stanford.edu/spires/find/hep/wwwauthors?key=4909437)
- JLab G0 (see http://www.slac.stanford.edu/spires/find/hep/wwwauthors?key=7181647)
- HERMES (see http://www.slac.stanford.edu/spires/find/hep/wwwauthors?key=6393209)
- JLab CLAS (see http://www.slac.stanford.edu/spires/find/hep/wwwauthors?key=7036426)

(b) Graduate and Postdoctoral Advisors:

- Graduate Advisors: Mason Yearian (Stanford, emeritus); Karl VanBibber (Stanford, LLNL).
- Postdoctoral Advisors: Karl VanBibber (Stanford, LLNL); Rene Kamermans (Utrecht).

(c) Thesis Advisor/Postgraduate Scholar Sponsor:

- Arijit Banerjee (PhD UPenn, 1995), Fidelity Investments, Boston;
- Paul Raines (PhD UPenn, 1996), Massachusetts General Hospital, Boston;
- Paul King (PhD W&M, 2000), Ohio University;
- Hovanes Egiyan (PhD W&M, 2001), University of New Hampshire;
- Cornel Butuceanu, (PhD W&M, 2005) Hampton University Proton Therapy Institute;
- Rob Fersch, (PhD W&M, 2008); University of Kentucky;
- Nathan Baillie, (PhD W&M, 2009) Hampton University Proton Therapy Institute;
- Sucheta Jawalkar, (PhD student, W&M);
- Julie Roche (W&M post-doctoral fellow), Ohio University;
- Klaus Grimm (W&M post-doctoral fellow), Louisiana Tech.
- Bo Zhao (W&M post-doctoral fellow).

Biographical Sketch of Mark Strikman

strikman@phys.psu.edu (814) 865-7382 (phone) (814) 865-3604 (fax)

(a) **Education and Training**

Leningrad University	Theoretical Physics	M.S. 1972
Leningrad Institute of Nuclear Physics	Theoretical Physics	Ph.D. 1978
Leningrad Institute of Nuclear Physics	Theoretical Physics	Professor Habilitation, 1988

(b) **Research and Professional Experience**

2006	Visiting Professor, INT, University of Washington
2005	Visiting Professor, KEK, Tsukuba, Japan
1997 - 1998	Visiting Professor, DESY, Hamburg, Germany
1995	Visiting Professor, INT, University of Washington
1995 -	Professor, Penn State University
1992 - 1995	Associate Professor, Penn State University
1991 - 1992	Visiting Professor, Penn State University
1991	Visiting Professor, INT, University of Washington
1990 - 1991	Visiting Professor, University of Illinois at Urbana-Champaign
1990 - 1991	Leading Member, Leningrad Institute of Nuclear Physics
1986 - 1990	Senior Member, Leningrad Institute of Nuclear Physics
1975 - 1986	Research Associate, Leningrad Institute of Nuclear Physics
1972 - 1975	Postgraduate, Leningrad Institute of Nuclear Physics

Honors

Fellow of the American Physical Society (1997)
Alexander von Humboldt award for senior scientists of the Humboldt foundation (Germany) 1999 & 2008.

(c) **Publications**

1. L.L. Frankfurt and M.I. Strikman, HIGH-ENERGY PHENOMENA, SHORT RANGE NUCLEAR STRUCTURE AND QCD. Phys. Rep. 76 (1981) 215-347.

2. L.L. Frankfurt and M.I. Strikman, HARD NUCLEAR PROCESSES AND MICROSCOPIC NUCLEAR STRUCTURE. Phys. Rep. 160 (1988) 235-427.

3. L.L. Frankfurt and M.I. Strikman, SHORT RANGE CORRELATIONS IN NUCLEI AS SEEN IN HARD NUCLEAR REACTIONS AND LIGHT-CONE DYNAMICS, in "Modern topics in electron scattering", B. Frois and I. Sick, eds., World Scientific (1991) 645-694.

4. D.B.Day, L.Frankfurt, M.Sargsyan and M.Strikman, EVIDENCE FOR SHORT RANGE CORRELATIONS FROM HIGH Q^2 (e, e') REACTIONS, Preprint INPP-92, Phys. Rev. C48 (1993) 2451-2461.

5. L. L. Frankfurt, M. M. Sargsian and M. I. Strikman, "Feynman graphs and generalized eikonal approach to high energy knock-out processes," Phys. Rev. C **56**, 1124 (1997).

6. M. M. Sargsian, T. V. Abrahamyan, M. I. Strikman and L. L. Frankfurt, "Exclusive electrodisintegration of ^{3}He at high Q^2. I. Generalized eikonal approximation", Phys. Rev. C**71**, 044614 (2005).

7. M. M. Sargsian, T. V. Abrahamyan, M. I. Strikman and L. L. Frankfurt, "Exclusive electrodisintegration of ^{3}He at high Q^2. II: Decay function formalism," Phys. Rev. C **71**, 044615 (2005).

8. M.Sargsian, J. Arrington, W. Bertozzi, W. Boeglin, C. Carlson, D. Day, L. Frankfurt, K. Egiyan, R. Ent, S. Gilad, K. Griffioen, D.W. Higinbotham, S. Kuhn, W. Melnitchouk, G.A. Miller, E. Piasetzky, S. Stepanyan, M. Strikman, and L. Weinstein: "Hadrons in the nuclear medium,"
J. Phys. G **29**, R1 (2003).

9. A. Larson, G. A. Miller and M. Strikman, "Pionic color transparency," Phys. Rev. C **74**, 018201 (2006).

10. L. Frankfurt, M. Sargsian and M. Strikman, "Recent observation of short range nucleon correlations in nuclei and their implications for the structure of nuclei and neutron stars," Int. J. Mod. Phys. A **23**, 2991 (2008).

(d) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list. Main collaborators over past 4 years: C.Ciofi degli Atti (Perugia University) , L.Frankfurt (TAU), V.Guzey (TJNAF), S.Kumano (KEK), G.A.Miller (University of Washington), T.Rogers (Amsterdam University), M.Sargsian (Florida International), R.Vogt (LNL), C.Weiss (TJNAF), S.White (BNL).

(ii) Graduate adviser Dr. Leonid Frankfurt (Leningrad Nuclear Physics Institute)

(iii) Graduate Students advised: T.Rogers (Amsterdam University), V.Guzey (TJNAF)

Name: Misak Sargsian
Position Title: Associate Professor
Organization: Florida International University

Education:

1983 - M.S. Theoretical Physics, Yerevan State University, Armenia
1993 - Ph.D.Theoretical Physics, Yerevan Physics Institute, Armenia

Professional Experience:

September 2005	Associate Professor Department of Physics Florida International University, Miami
May 1999 - August 2005	Assistant Professor Department of Physics Florida International University, Miami
May 1998 - April 1999	Research Associate Department of Physics University of Washington, Seattle
March 1997 - April 1998	Alexander von Humboldt Research Fellow Department of Physics Technical University of Muenchen, Germany
May 1993 - February 1997	Postdoctoral Research Associate Department of Nuclear Physics School of Physics and Astronomy Tel Aviv University, Israel
February 1988 - April 1993	Research Associate Laboratory of Photo-Nuclear Studies Yerevan Physics Institute, Armenia

Fellowship: Alexander von Humboldt Fellowship, 1997
Membership: Program Committee of APS, Division of Nuclear Physics, 2007-2009

Publications most closely related to the proposed project:

1 M. M. Sargsian and C. Granados, "Hard Break-Up of Two-Nucleons from the 3He Nucleus," Phys. Rev. C **80**, 014612 (2009).

2 L.L. Frankfurt, M.M. Sargsian, M.I. Strikman, "Recent Progress in Studies of Short Range Correlation in Nuclei and their Implication for Nuclear, Particle Physics and Astrophysics", Int. J. Mod. Phys. A **23**, 2991 (2008).

3 E. Piasetzky, M. Sargsian, L. Frankfurt, M. Strikman and J. W. Watson, "Evidence for the Strong Dominance of Proton-Neutron Correlations in Nuclei," Phys. Rev. Lett. **97**, 162504 (2006).

4 M. Sargsian and M. Strikman, "Model independent method for determination of the DIS structure of free neutron," Phys. Lett. B **639**, 223 (2006)

5 T. C. Rogers, M. M. Sargsian and M. I. Strikman, "Coherent vector meson photo-production from deuterium at intermediate energies," Phys. Rev. C **73**, 045202 (2006)

6 K. S. Egiyan N.B. Dashyan, M.M. Sargsian, M.I. Strikman, L.B. Weinsten *et al.*, "Measurement of 2- and 3-Nucleon Short Range Correlation Probabilities in Nuclei," Phys. Rev. Lett. **96**, 082501 (2006).

7 M.M. Sargsian, T.A. Abrahamyam, L.L. Frankfurt, M.I. Strikman, "Exclusive Electrodisintegration of $^3\boldsymbol{He}$ at High $\boldsymbol{Q2}$:II. Decay Function Formalism", Phys. Rev. **C 71**, 044615 (2005)

8 M.M. Sargsian, T.A. Abrahamyam, L.L. Frankfurt, M.I. Strikman, "Exclusive Electrodisintegration of $^3\boldsymbol{He}$ at High Q^2:I. Generalized Eikonal Approximation", Phys. Rev. **C 71** 044614 (2005)

9 M.M. Sargsian, "Polarization Observables in Hard Rescattering Mechanism of Deuteron Photodisintegration", Phys. Lett. **B587** 41-51 (2004).

10 S. Brodsky, L. Frankfurt, R. Gilman, J. Hiller, G. Miller, E. Piasetzky, M. Sargsian, M. Strikman, *Hard Photodisintegration of a Proton Pair in* ^3He, Phys. Lett. B **578**, 69 (2004).

Collaborators and other Affiliations:

(i) All collaborators are listed as authors in the publication list. Main collaborators over past four years: Leonid Frankfurt (Tel Aviv University) and Mark Strikman (The Pennsylvania State University).

(ii) Graduate Advisors: Leonid Frankfurt (Tel Aviv University) and Kim Egiyan (Yerevan Physics Institute).

(iii) Graduate Students advised: Tigran Abrahamyan and Carlos Granados.

Biographical sketch for Dr. Werner U. Boeglin

(a) Education and Training:

Ph.D.	Universität Basel, Switzerland, 1986
	Dissertation Advisor: I.Sick, Universität Basel, Switzerland
Diploma	Universität Basel, Switzerland, 1980

(b) Research and Proffesional Experience:

2008-	**Professor**, Physics Department, Florida International
2000-2008	**Associate Professor**, Physics Department, Florida International University
1995-2000	**Assistant Professor**, Physics Department, Florida International University
1990-95	**Hochschulassistent**, Universität Mainz, Germany
1988-90	**Research Scientist**, Massachusetts Insitute of Technology
1986-88	**Research Associate**, Massachusetts Insitute of Technology
	Postdoctoral Advisor: W. Bertozzi, Massachusetts Institute of Technology
1981-86	**Teaching Assistant**,Universität Basel, Switzerland

Professional Activities:

Member, American Physical Society (1987)
Member, Jefferson Lab Users Group
Member, GlueX Collaboration Board

(c) Publications:

1. The f_{LT} Response Function of D(e,e'p)n at $Q^2 = 0.33(GeV/c)^2$
W.U. Boeglin, H. Arenhvel, K.I. Blomqvist, R. Bhm, M. Distler, R. Edelhoff, I. Ewald, R. Florizone, J. Friedrich, R. Geiges, J. Jourdan, M. Kahrau, M. Korn, H. Kramer, K.W. Krygier, V. Kunde, M. Kuss, A. Liesenfeld, K. Merle, R. Neuhausen, E.A.J.M. Offermann, Th. Pospischil, M. Potokar, A.W. Richter, A. Rokavec, G. Rosner, P. Sauer, I. Sick, S. Sirca S. Schardt, A. Serdarevic, B. Vodenik, A. Wagner, Th. Walcher, S. Wolf **Phys. Rev C78** 054001 (2008). (24 pts)

2. Quark-Hadron Duality in Neutron (^{3}He) Spin Structure
P. Solvignon, N. Liyanage, J.-P. Chen, Seonho Choi, K. Aniol, T. Averett, W. Boeglin, A. Camsonne, G. D. Cates, G. Chang, E. Chudakov, B. Craver, F. Cusanno, A. Deur, D. Dutta, R. Ent, R. Feuerbach, S. Frullani, H. Gao, F. Garibaldi, R. Gilman, C. Glashausser, V. Gorbenko, O. Hansen, D. W. Higinbotham, H. Ibrahim, X. Jiang, M. Jones, A. Kelleher, J. Kelly, C. Keppel, W. Kim, W. Korsch, K. Kramer, G. Kumbartzki, J. J. LeRose, R. Lindgren, B. Ma, D. J. Margaziotis, P. Markowitz, K. McCormick, Z.-E. Meziani, R. Michaels, B. Moffit, P. Monaghan, C. Munoz Camacho, K. Paschke, B. Reitz, A. Saha, R. Sheyor, J. Singh, K. Slifer, V. Sulkosky, A. Tobias, G. M. Urciuoli, K. Wang, K. Wijesooriya, B. Wojtsekhowski, S. Woo, J.-C. Yang, X. Zheng, L. Zhu **Phys.Rev.Lett. 101** 182502 (2008). (8 pts)

3. Probing Cold Dense Nuclear Matter
R. Subedi, R. Shneor, P. Monaghan, B.D.Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, W. Bertozzi, W. Boeglin, J.-P.Chen, Seonho Choi, E. Cisbani, B. Craver, S. Frullani, F. Garibaldi, S. Gilad, R. Gilman, O. Glamazdin, J.-O.Hansen, D.W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, C.W. de Jager, E. Jans, X. Jiang, L. Kaufman, A. Kelleher, A. Kolarkar, G. Kumbartzki, J.J. LeRose, R. Lindgren, N. Liyanage, D.J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, C.F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. irca, K. Slifer, P. Solvignon, V. Sulkosky, G. Urciuoli, E. Voutier, J.W. Watson, L.B. Weinstein, B. Wojtsekhowski, S. Wood, X.-C. Zheng, L. Zhu **Science 320** 1476 (2008).

4. Transverse momentum dependence of semi-inclusive pion production
H. Mkrtchyan, P.E. Bosted, G.S. Adams, A. Ahmidouch, T. Angelescu, J. Arrington, R. Asaturyan, O.K. Baker, N. Benmouna, C. Bertoncini, H.P. Blok, W.U. Boeglin, H. Breuer, M.E. Christy, S.H.

Connell, Y. Cui, M.M. Dalton, S. Danagoulian, D. Day, T. Dodario, J.A. Dunne, D. Dutta, N. El Khayari, R. Ent, H.C. Fenker, V.V. Frolov, L. Gan, D. Gaskell, K. Hafidi, W. Hinton, R.J. Holt, T. Horn, G.M. Huber, E. Hungerford, X. Jiang, M. Jones, K. Joo, N. Kalantarians, J.J. Kelly, C.E. Keppel, V. Kubarovsky, Y. Li, Y. Liang, S. Malace, P. Markowitz, E. McGrath, P. McKee, D.G. Meekins, B. Moziak, T. Navasardyan, G. Niculescu, I. Niculescu, A.K. Opper, T. Ostapenko, P.E. Reimer, J. Reinhold, J. Roche, S.E. Rock, E. Schulte, E. Segbefia, C. Smith, G.R. Smith, P. Stoler, V. Tadevosyan, L. Tang, h, M. Ungaro, A. Uzzle, S. Vidakovic, A. Villano, W.F. Vulcan, M. Wang, G. Warren, F. Wesselmann, B. Wojtsekhowski, S.A. Wood, C. Xu, L. Yuan, X. Zheng and H. Zhu **Phys.Lett. B665** 20 (2008).

5. Measurement of Nuclear Transparency for the A$(e, e\prime\pi^+)$ Reaction
B. Clasie, X. Qian, J. Arrington, R. Asaturyan, F. Benmokhtar, W. Boeglin, P. Bosted, A. Bruell, M. E. Christy, E. Chudakov, W. Cosyn, M. M. Dalton, A. Daniel, D. Day, D. Dutta, L. El Fassi, R. Ent, H. C. Fenker, J. Ferrer, N. Fomin, H. Gao, K. Garrow, D. Gaskell, C. Gray, T. Horn, G. M. Huber, M. K. Jones, N. Kalantarians, C. E. Keppel, K. Kramer, A. Larson, Y. Li, Y. Liang, A. F. Lung, S. Malace, P. Markowitz, A. Matsumura, D. G. Meekins, T. Mertens, G. A. Miller, T. Miyoshi, H. Mkrtchyan, R. Monson, T. Navasardyan, G. Niculescu, I. Niculescu, Y. Okayasu, A. K. Opper, C. Perdrisat, V. Punjabi, A. W. Rauf, V. M. Rodriquez, D. Rohe, J. Ryckebusch, J. Seely, E. Segbefia, G. R. Smith, M. Strikman, M. Sumihama, V. Tadevosyan, L. Tang, V. Tvaskis, A. Villano, W. F. Vulcan, F. R. Wesselmann, S. A. Wood, L. Yuan, and X. C. Zheng **Phys.Rev.Lett 99** 242502 (2007).

(d) Synergistic Activities
Involved several undergraduate students in my research, including detector development, testing software development and modeling.

(e) Collaborators and other Affiliations:

i. Member of the Hall A and the GlueX collaborations.

ii. Main collaborators for the last four years: Misak Sargsian (Florida International University (FIU)), Mark Jones(JLAB), Elton Smith(JLAB), Beni Zihlmann(JLAB), Doug Higinbotham(JLAB), Ole Hansen(JLAB), Sabine Jeschonnek(Ohio State University), Joerg Reinhold (FlU), Pete Markowitz(FIU), Mark Strikman (Penn State)

iii. Graduate Advisor: Prof. I.Sick, University of Basel, Switzerland, Post-graduate advisor: Prof. Bill Bertozzi, MIT

iv. Graduate Students advised: Marius Coman, Luminita Coma, Chen Xi Lu. Postdocs advised: Dr. Heinz Anklin (Switzerland), Dr. Seema Dhamija (FIU)

Biographical Sketch for Dr. David G. Ireland

Address: Department of Physics and Astronomy,
University of Glasgow, G12 8QQ, Scotland, UK
WWW: http://nuclear.gla.ac.uk/infoWrapper.php?surname=Ireland

Education and Training

1988-1991: University of Edinburgh, UK, **Ph.D. (1991)**
1984-1988: University of Edinburgh, UK, **B.Sc. (1988)**

Research and Professional Experience

2004-present: Senior Lecturer, University of Glasgow, UK
1994-2004: Lecturer, University of Glasgow, UK
1993-1994: Research Associate, University of Glasgow, UK
1991-1993: Royal Society Postdoctoral Fellow (at NIKHEF-K, Amsterdam, Netherlands)

Chartered Physicist, Member of the Institute of Physics

Selected Publications

- Electroproduction of kaons from the proton in a Regge-plus-resonance approach *T. Corthals, T. Van Cauteren, P. Van Craeyveld, J. Ryckebusch, D.G. Ireland* Phys.Lett.B656:186-192,2007, arXiv:0704.3691
- Regge-plus-resonance treatment of the $p(\gamma, K^+)\Sigma^0$ and $(\gamma, K^+)\Sigma^+$ reactions at forward kaon angles *T. Corthals, T. Van Cauteren, J. Ryckebusch, D.G. Ireland* Phys.Rev.C75:045204,2007, nucl-th/0612085
- Polarization Transfer in the ^{4}He$(\vec{e}, e'\vec{p})^3$H Reaction up to Q^2 = 2.6 (GeV/c)^2 *with S. Strauch, et al. (Jefferson Lab Hall A Collaboration, see Ref.[11])* Phys. Rev. Lett. 91 (2003) 052301
- Measurement of Two- and Three-Nucleon Short-Range Correlation Probabilities in Nuclei *with K.S. Egiyan, et al. (CLAS Collaboration, see Ref.[3])* Phys. Rev. Lett. 96 (2006) 082501
- Experimental study of exclusive 2H(e,e' p)n reaction mechanisms at high Q2 *with K.S. Egiyan, et al. (CLAS Collaboration, see Ref.[13])* nucl-ex/0701013 Phys. Rev. Lett. 98 (2007) 261502
- A Genetic Algorithm Analysis of N* Resonance in $p(\gamma, K^+)\Lambda$ Reactions *Ireland, DG; Janssen, S; Ryckebusch, J* Nucl. Phys. A 740 (2004) 147-167, nucl-th/0312103
- Extraction of N* information from the limited $p(\gamma, K^+)\Lambda$ data set *Janssen, S; Ireland, DG; Ryckebusch, J* Phys. Lett. B 562 (2003) 51, nucl-th/0302047
- Using a genetic algorithm to investigate two-nucleon knockout reactions *D.G. Ireland* J. Phys. G-Nucl. Part. Phys. 26 (2000) 157 - 166

- Interpretation of two-nucleon photoemission data *Ireland, DG; MacGregor, IJD; Ryckebusch, J* Phys. Rev. C 59 (1999) 3297 - 3303

For a complete list please visit:
http://nuclear.gla.ac.uk/results.php?searchfield=lastname&searchterm=Ireland

Other Activities

- Chair of UK Institute of Physics Nuclear Physics Group
- Member of UK's Science and Technology Facilities Council (STFC) Nuclear Physics Grants Panel

Potential Conflicts of Interest

Collaborators and Affiliations

- Member of CLAS collaboration (Jefferson Lab)
- Member of PANDA collaboration (FAIR)
- Published with J. Ryckebusch et al, Nuclear Theory Group, University of Gent, Belgium
- Prof. Gerard van der Steenhoven (Universiteit Twente, Netherlands; postdoctoral collaborator)

Graduate and Postdoctoral Advisers

- Prof. Alan Shotter (University of Edinburgh; Thesis adviser)
- Prof. Derek Branford (University of Edinburgh; Thesis adviser)

Biographical Sketch for Dr. I J Douglas MacGregor

(a) **Education and Training**

University of Glasgow, UK	Maths & Natural Philosophy	B.Sc. (1st class)	1978
University of Glasgow, UK	Nuclear Physics	Ph.D.	1982
Chartered Physicist		C.Phys.	1986
Fellow Institute of Physics,UK		F.Inst.P.	1995

(b) **Research and Professional Experience**

University of Glasgow, UK	Reader	2002-
University of Glasgow, UK	Senior Lecturer	1994-2002
University of Glasgow, UK	Lecturer	1984-1994
University of Manchester,UK	Research Associate	1982-1983

(c) **Publications**

I J D MacGregor and R Kaiser (Eds): " Hadron Physics", Proc. 58th Scottish Summer School in Physics, Scottish Graduate Series, vol 58, 2006, Taylor & Francis CRC Press, ISBN 1584887052, pp496.

DG Middleton, JRM. Annand, M Ases Antelo, C Ayerbe, P Barneo, P Bartsch, D Baumann, J Bermuth, J Bernauer, HP Blok, D Bosnar, R Böhm, M Ding, MO Distler, J Friedrich, J García Llongo, DI Glazier, J Golak, W Glökle, P Grabmayr, S Grözinger, T Hehl, J Heim, WHA Hesselink, E Jans, H Kamada, J Jover Mañas, M Kohl, L Lapikás, IJD MacGregor, I Martin, JC McGeorge, H Merkel, P Merle, K Monstad, F Moschini, U Müller, A Nogga, R Pérez Benito, T Posposchil, M Potokar, G Rosner, M Seimetz, R Skibinski, H de Vries, T Walcher, DP Watts, M Weinriefer, M Weiss, H Witala, B Zihlmann: "Investigation of the Exclusive ^{3}He(e, e'pn)p Reaction", Phys. Rev.Lett. 103 (2009) 152501:1-5.

DP Watts, JRM Annand, R Beck, D Branford, DI Glazier, P Grabmayr, K Livingston, IJD MacGregor, JC McGeorge, RO Owens: "The dependence of the ^{12}C(γ_{pol},pd) reaction on photon linear polarization", Phys. Lett. B 647 (2007) 88-93.

DG Middleton, JRM Annand, C Barbieri, P Barneo, P Bartsch, D Baumann, J Bermuth, D Bosnar, HP Blok, R Böhm, M Ding, MO Distler, D Elsner, J Friedrich, C Giusti, DI Glazier, P Grabmayr, S Grözinger, T Hehl, J Heim, WHA Hesselink, E Jans, F Klein, M Kohl, L Lapikas, IJD MacGregor, I Martin, JC McGeorge, H Merkel, P Merle, F Moschini, U Müller, T Posposchil, G Rosner, H Schmieden, M Seimetz, A Süle, H de Vries, T Walcher, DP Watts, M Weis, B Zihlmann: "First measurement s of the ^{16}O(e, e'pn)^{14}N reaction", Eur. Phys. J. A 29 (2006) 261-270.

DP Watts, J Ahrens, JRM Annand, R Beck, D Branford, P Grabmayr, T Hehl, JD Kellie, IJD MacGregor, JC McGeorge, RO Owens: "Three-nucleon mechanisms in photoreactions", Phys. Lett. B 553 (2003) 25-30.

IJD MacGregor: "Photoinduced Two-Nucleon Emission in near Super-Parallel Kinematics", Proc. 6th Int. Workshop on Electromagnetically Induced 2-Hadron Emission, Pavia, 2003, (Ed. C Giusti et al.), http://www.pv.infn.it/~2hconf/CDpavia/

D Branford, JF Arneil, JA MacKenzie, K Föhl, J Ahrens, JRM Annand, R Beck, S Franczuk, P Grabmayr, SJHall, PD Harty, T Hehl, JD Kellie, M Liang, IJD MacGregor, JC McGeorge, A Natter, S Oberkirsch, ROOwens, CJY Powrie, M

Sauer, DP Watts and S Wunderlich; "Investigation of Δ medium effects using the ^{4}He(γ,π$^+$ n)^{3}H and ^{4}He(γ,π$^+$ p)nnn reactions", Phys. Rev. C 66 (2002) 015208:1-10.

CJY Powrie, JC McGeorge, IJD MacGregor, J Ahrens, JRM Annand, JF Arneil, R Beck, D Branford, S Franczuk, DI Glazier, P Grabmayr, SJ Hall, T Hehl, PD Harty, DG Ireland, JD Kellie, K Livingston, FA Natter, S Oberkirsch, RO Owens, J Ryckebusch, M Sauer, A Settle, DP Watts: "Polarised Photon Measurements of the ^{12}C(γ_{pol},pp) and (γ_{pol},pn) Reactions for E_γ=160-350 MeV", Phys. Rev. C 64 (2001) 034602:1-9

B Krusche, J Ahrens, R Beck, IJD MacGregor, JC McGeorge, V Metag and H Ströher: "In-medium properties of the D_{13}(1520) nucleon resonance", Phys. Rev. Lett. 86 (2001) 4764-4767

DP Watts, IJD MacGregor, J Ahrens, JRM Annand, R Beck, D Branford, P Grabmayr, SJ Hall, PD Harty, T Hehl, JD Kellie, T Lamparter, M Liang, JA MacKenzie, S McAllister, JC McGeorge, RO Owens, M Sauer, R Schneider, GJ Wagner,TT-H Yau: "The ^{12}C(γ,NN) reaction studied over a wide kinematic range", Phys. Rev. C 62 (2000) 014616:1-15.

(d) **Synergistic Activities**

1. Membership of relevant learned societies: European Physical Society, Nuclear Physics Board (2007-); Scientific Secretary (2009-); UK Institute of Physics, Nuclear & Particle Physics Division Board (1986-1993, 2001-); Honorary Secretary (2005-2009); Chair (2009-); Nuclear Physics Group Board (1989-1994, 2000-2005); Chair (2001-2005); UK West of Scotland Physics Education Group Board (1984-1990)
2. Organisation of relevant conferences: 2004 58th Scottish Summer School in Physics, Hadron Physics Conference, St Andrews, UK; 2009 European Physical Society, European Nuclear Physics Conference, Bochum, Germany (Hadron physics contribution selection committee); 2011 Institute of Physics, Nuclear and Particle Physics Division Conference, Glasgow, UK
3. Membership of Steering Committee: Mainz A2 Crystal Ball collaboration

(e) **Senior Collaborators, last 48 months**

J Ahrens[1], JO Adler[2], C Barbieri[3], R Beck[4], HP Blok[5], A Braghieri[6], D Branford[7], W J Briscoe[8], H de Vries[5], MO Distler[1], J Friedrich[1], C Giusti[6], P Grabmayr[9], KHansen[2], WHA Hesselink[5], D Hornidge[10], E Jans[5], R Kaiser[16], VL Kashevarov[11], F Klein[4], B Krusche[12], L Lapikás[5], DM Manley[13], V Metag[14], BMK Nefkens[15], M Ostrick[1], RO Owens[16], P Pedroni[6], SN Prakhov[15], JW Price[15], G Rosner[16], B Schoch[4], B Schroder[2], DI Sober[15], A Starostin[15], I Supek[17], A Thomas[1], T Walcher[1], DP Watts[7]

Affiliation: [1]M ainz, [2]Lund, [3]GSI, [4]Bonn, [5]NIKHEF/Amsterdam, [6]Pavia, [7]Edinburgh, [8]George Washington, [9]Tuebingen, [10]Saskatoon, [11]Lebedev, [12]Basel, [13]Kent State, [14]Giessen, [15]UCLA, [16]Glasgow, [17]Zagreb

(f) **Graduate Students & Postdoctoral Associates, last 5 years (current affiliation Glasgow unless specified)**

Graduate Students: Dr DG Middleton (Tuebingen), S Waddell, K Monstad, J Robinson, D Howdle, J Mancell.

Postdoctoral Associates: Dr JRM Annand, Dr K Livingston, Dr JC McGeorge Dr D Protopopescu, Dr D Hamilton, Dr DI Glazier (Edinburgh).

Biographical Sketch for Dr. Dan Protopopescu

Address: Department of Physics and Astronomy,
University of Glasgow, G12 8QQ, Scotland, UK, Tel: +44 141 330-5531
WWW: http://nuclear.gla.ac.uk/infoWrapper.php?surname=Protopopescu

Education and Training

1998-2002: University of New Hampshire, NH, USA, **Ph.D. (2002)**
1996-1997: University of Bucharest, Romania, **M.Sc. (1997)**
1990-1996: University of Bucharest, **B.Sc. (1996)**

Research and Professional Experience

2007- : Chair of Slow Controls Group for PANDA@FAIR
2007- : Member of CLAS12@Jlab, USA
2005- : Head of Grid Computing for PANDA@FAIR
2005- : Member of the Hall D collaboration at Jlab
2005-2006: Participated in HERMES@DESY, Germany
2004- : Member of PANDA@FAIR (GSI), Germany
2004- : Member of the Hall A collaboration at Jlab
2003-2005: Member of A2/GDH collaboration at MAMI, Germany
2002- : Research position at University of Glasgow, UK
1999- : Member of CLAS@Jlab
1996-1998: Research position in FLNP@JINR, Russia

Selected Publications

- Helicity dependence of the total inclusive cross section on the deuteron, *J. Ahrens, S. Altieri, J.R.M. Annand, H.-J. Arends, R. Beck, M.A. Blackston, A. Braghieri, N. dHose, H. Dutz, E. Heid, O. Jahn, F. Klein, R. Kondratiev, M. Lang, V. Lisin, M. Martinez Fabregate, J.C. McGeorge, W. Meyer, A. Panzeri, P. Pedroni, T. Pinelli, D. Protopopescu, G. Reichertz, Ch. Rohlof, G. Rosner, T. Rostomyan, D. Ryckbosch, M. Schwamb, G. Tamas, A. Thomas, H.R. Weller (MAMI A2 and GDH Collaborations)*, Physics Letters B, Vol. 672, p328-33 (2009)
- Reply to 'Comment on "A Bayesian analysis of pentaquark signals from CLAS data"', *D.G. Ireland and D. Protopopescu*, Phys. Rev. Lett. 101, 029102 (2008)
- Experimental Study of Exclusive $^2H(e,e'p)n$ Reaction Mechanisms at High Q^2, *K.S. Egiyan, et al. (CLAS Collaboration, see ref. [13])*, Phys. Rev. Lett. 98, 262502 (2007)
- Electron scattering from high-momentum neutrons in deuterium, *A. Klimenko, et al. (CLAS Collaboration, see ref. [15])*, Phys. Rev. C 73, 035212 (2006)

- Measurement of Two- and Three-Nucleon Short-Range Correlation Probabilities in Nuclei, *K.S. Egiyan, et al. (CLAS Collaboration, see ref. [3])*, Phys. Rev. Lett. 96, 082501 (2006)
- Two-Nucleon Momentum Distributions Measured in $^3He(e,e'pp)n$, *R. Niyazov, et al. (CLAS Collaboration, see ref. [9])*, Phys. Rev. Lett. 92, 052303 (2004).
- Observation of Nuclear Scaling in the $A(e,e')$ Reaction at $x_B > 1$, *K.S. Egiyan, et al. (CLAS Collaboration, see ref. [2])*, Phys. Rev. C68 (2003) 014313

For a complete list (total 85 from 1996) please visit:
http://nuclear.gla.ac.uk/results.php?searchfield=lastname&searchterm=Protopopescu

Other Activities

Member of the PANDA Computing Committee
Member of the CLAS Service Work Committee
Hall B Shifts Schedule administrator

Organisation of conferences and workshops: PANDA DCS Roundtable 2008; Biannual PANDA Grid Workshops since 2005; SUSSP58 and the Hadron-Physics I3 Topical Workshop in St Andrews, UK, 2004; GlueX Collaboration Meeting, Glasgow, 2003, IOP Nuclear Physics Conference 2003.

Collaborators and Affiliations

All the collaborations listed in the 'Research' section above. Graduate Advisor: V. K. Ignatovich (JINR), Postgraduate Advisor: Bill Hersman (UNH).

Biographical Sketch for Dr. Dan Watts

Address: School of Physics and Astronomy,
University of Edinburgh, Scotland, UK
WWW: http://www2.ph.ed.ac.uk/nuclear/photo/

Education and Training

Ph.D., A survey of photo-reactions on ^{12}C, University of Glasgow (1997).
B.Sc (Hons) Physics, University of Newcastle Upon Tyne (1993).

Research and Professional Experience

Oct '05 - Present University of Edinburgh, SUPA lectureship, Nuclear and plasma physics theme
Oct.'03 - Oct.'08 University of Edinburgh, UK Engineering and Physical Sciences Research Council Advanced Research Fellowship.
Oct.'01-Sep.'03 University of Glasgow - RA2 Research Assistant in the Department of Physics and Astronomy.
Oct.'97-Sep.'01 University of Glasgow - RA1 Research Assistant in the Department of Physics and Astronomy.

Member of the Programme Advisory Committee (Nuclear physics), Max-Laboratory, Lund, Sweden *'08 - present*
Member of the Nuclear Physics Group of the UK Institute of Physics *'08-present*
Member of the Crystal Ball steering committee, MAMI microtron, Germany *'06-present*
UK Engineering and Physical Sciences Research Council Peer Review Panel *'03 - '07*

Selected Publications

- **"The Edinburgh Ge6 Array: An array of stacked HpGe detectors for observing medium energy pions and protons in tagged photon experiments"**
  D. Branford, K. Fohl, N. Harrington, D. Watts, E. Roche and T. Jude
  Nucl. Instrum. Meth. A **602**, 511 (2009)
- **"Beam-Helicity Asymmetries in Double Pion Photoproduction off the Proton"**
  D. Krambrich *et al.* [Crystal Ball at MAMI Collaboration and TAPS Collaboration and A2 Colla]
  Phys. Rev. Lett. **103**, 052002 (2009) [arXiv:0907.0358 [nucl-ex]]

- **"A measurement of the differential cross section for the reaction $\gamma n \rightarrow \pi^- p$ from deuterium"**
  W. Chen *et al.*
  Phys. Rev. Lett. **103**, 012301 (2009) [arXiv:0903.1260 [nucl-ex]]
- **"Investigation of the Exclusive ^{3}He(e,e'pn)p Reaction"**
  D. G. Middleton *et al.*
  arXiv:0903.1215 [nucl-ex]
- **"Light Vector Mesons in the Nuclear Medium"**
  M. H. Wood *et al.* [CLAS Collaboration]
  Phys. Rev. C **78**, 015201 (2008) [arXiv:0803.0492 [nucl-ex]]
- **"Incoherent pion photoproduction on ^{12}C"**
  C. M. Tarbert *et al.* [The Crystal Ball Collaboration and A2 Collaboration]
  Phys. Rev. Lett. **100**, 132301 (2008) [arXiv:0711.1839 [nucl-ex]]
- **"Experimental study of the halo nucleus He-6 using the Li-6(gamma, pi+)He-6 reaction"**
  N. P. Harrington *et al.*
  Phys. Rev. C **75**, 044311 (2007)
- **"$First measurements of the ^16O(e,e'pn)^14N reaction$"**
  D. G. Middleton *et al.*
  arXiv:nucl-ex/0701053 (Submitted to Eur.Phys.J.A29:261-270,2006)
- **"Dependence of the ^{12}C($\vec{\gamma}$,pd) reaction on photon linear polarisation"**
  D. P. Watts *et al.*
  Phys. Lett. B **647**, 88 (2007) [arXiv:nucl-ex/0506018]
- **"Three-nucleon mechanisms in photoreactions"**
  D. P. Watts *et al.*
  Phys. Lett. B **553**, 25 (2003) [arXiv:nucl-ex/0212010]

Collaborators and Affiliations

Graduate Advisor: B. Peart Newcastle, Postgraduate Advisor: R.O. Owens D. MacGregor (Glasgow), I am a member of the Crystal Ball and the CLAS collaborations.

Sabine Jeschonnek

Professional Preparation:

Institution	*Major*	*Degree*	*Date*
Universität Bonn (Germany)	Physics	Dipl.-Phys.	1993
Universität Bonn (Germany)	Physics	Dr. rer. nat.	1996

Appointments:

Position	*Institution*	*Dates*
Associate Professor	The Ohio State University (Lima)	2006–present
Assistant Professor	The Ohio State University (Lima)	2001–2006
Postdoctoral Fellow	Jefferson Lab	1998–2001
Feodor Lynen Fellow of the Alexander von Humboldt Foundation	MIT	1997–1998
Research Associate	Research Center Jülich (Germany)	1996

Relevant Publications:

1. "Target Polarization for $^2\vec{H}(e,e'p)n$ at GeV energies," S. Jeschonnek and J. W. Van Orden, arXiv:0907.3712 [nucl-th], PRC, in print.

2. "A Precise Measurement of the Neutron Magnetic Form Factor GMn in the Few-GeV2 Region," J. Lachniet, ..., S. Jeschonnek, ... *et al.* [CLAS Collaboration, see *e.g.* Ref. [1]], Phys. Rev. Lett. **102**, 192001 (2009) [arXiv:0811.1716 [nucl-ex]].

3. "A new calculation for D(e,e'p)n at GeV energies," S. Jeschonnek and J. W. Van Orden, Phys. Rev. C **78**, 014007 (2008).

4. "Faddeev and Glauber Calculations at Intermediate Energies in a Model for n+d Scattering," C. Elster, T. Lin, W. Gloeckle and S. Jeschonnek, Phys. Rev. C **78**, 034002 (2008) arXiv:0805.2010 [nucl-th].

Other Publications

1. "Scaling of Dirac fermions and the WKB approximation," J. W. Van Orden, S. Jeschonnek and J. Tjon, Phys. Rev. D **72**, 054020, (2005) [arXiv:hep-ph/0507254].

2. "Modeling quark-hadron duality in polarization observables," S. Jeschonnek and J. W. Van Orden, Phys. Rev. D **71**, 054019, (2005) [arXiv:hep-ph/0501194].

3. "Modeling quark hadron duality for relativistic, confined fermions," S. Jeschonnek and J. W. Van Orden, Phys. Rev. D **69**, 054006, (2004) [arXiv:hep-ph/0310298].

4. "Covariant description of inelastic electron deuteron scattering: Predictions of the relativistic impulse approximation," J. Adam, F. Gross, S. Jeschonnek, P. Ulmer, and J. W. Van Orden, Phys. Rev. C **66**, 044003 (2002) [arXiv:nucl-th/0204068].

Synergistic Activities

1. Service to the Physics Community: Chair of the Gordon Research Conference on Photonuclear Reactions 2008, Vice Chair in 2006. Member-at-Large (2004 - 2007), Ohio Section of the APS; Member-at-Large (2005 - 2008), APS Topical Group on Few Body Systems; Theory Director (2002 - 2004), Jefferson Lab User Group Board of Directors.

2. Outreach to under-represented groups: founded the "Women in Science & Engineering Group" at OSU-Lima, which meets once per quarter for networking.

3. Service to the general public: Organized the visit of Dr. Pervez Hoodbhoy (Quaid-i-Azam University, Islamabad, Pakistan), who gave presentations on "Loose Pakistani Nukes - An Imagined Danger?" and on "Science and Islam" in Lima and Columbus.

4. Worked with five OSU-Lima undergraduates (twelve over the last eight years) on small research projects.

5. Introduced new, interactive teaching methods on the Lima Campus.

6. Active participant in the planning and analysis of experiments. Co-author of three proposals for experiments at Jefferson Lab.

Collaborators J. Adam Jr (Resz, Czech Republic), T.W. Donnelly (MIT), C. Elster (Ohio U), R. J. Furnstahl (Ohio State), W. Gloeckle (Ruhr U Bochum), N. Isgur (Jefferson Lab, deceased), T. Lin (Ohio U), W. Melnitchouk (Jefferson Lab), R. Perry (Ohio State), J. Tjon (Utrecht, The Netherlands), J.W. Van Orden (Jefferson Lab & Old Dominion University), F. Gross (Jefferson Lab & College of William & Mary), P. Ulmer (Old Dominion University)

Graduate and Postdoctoral Advisors J. Speth (FZ Jülich), S. Krewald (FZ Jülich), N.N. Nikolaev (FZ Jülich), T.W. Donnelly (MIT), N. Isgur (Jefferson Lab, deceased)

Thesis Advisor and Postgraduate-Scholar Sponsor (last 5 years): Sunethra Ramanan (former graduate student), Scott Bogner, Joaqin Drut (post-docs)

Biographical Sketch for Dr. Maurik Holtrop

(a) **Education and Training**

University of New Hampshire	Physics	BS 1987
Massachussetts Institute of Technology	Nuclear Physics	Ph.D. 1995

(b) **Research and Professional Experience**

University of New Hampshire	Assoc. Prof. of Physics	2002 - 2008
University of New Hampshire	Asst. Prof. of Physics	2002 - 2008
University of New Hampshire	Asst. Research Prof.	2000 - 2002
University of New Hampshire	Research Scientist	1996 - 2000

(c) **Publications**

G. Gavalian, V.D. Burkert, L. Elouadrhiri, M. Holtrop, S. Stepanyan, D. Abrahamyan, G. Adams, M.J. Amaryan, P. Ambrozewicz, M. Anghinolfi, B. Asavapibhop, G. Asryan, H. Avakian, H. Bagdasaryan, N. Baillie, J.P. Ball, N.A. Baltzell, S. Barrow, V. Batourine, M. Battaglieri, K. Beard, I. Bedlinskiy, M. Bektasoglu, M. Bellis, N. Benmouna, B.L. Berman, A.S. Biselli, B.E. Bonner, S. Bouchigny, S. Boiarinov, R. Bradford, D. Branford, W.J. Briscoe, W.K. Brooks, S. Bultmann, C. Butuceanu, J.R. Calarco, S.L. Careccia, D.S. Carman, B. Carnahan, S. Chen, P.L. Cole, A. Coleman, P. Collins, P. Coltharp, D. Cords, P. Corvisiero, D. Crabb, H. Crannell, V. Crede, J.P. Cummings, N. Dashyan, R. De Masi, R. De Vita, E. De Sanctis, P.V. Degtyarenko, H. Denizli, L. Dennis, A. Deur, K.V. Dharmawardane, K.S. Dhuga, R. Dickson, C. Djalali, G.E. Dodge, J. Donnelly, D. Doughty, P. Dragovitsch, M. Dugger, S. Dytman, O.P. Dzyubak, H. Egiyan, K.S. Egiyan, L. El Fassi, A. Empl, P. Eugenio, R. Fatemi, G. Fedotov, G. Feldman, R.J. Feuerbach, T.A. Forest, H. Funsten, M. Garcon, G.P. Gilfoyle, K.L. Giovanetti, F.X. Girod, J.T. Goetz, E. Golovatch, A. Gonenc, R.W. Gothe, K.A. Griffioen, M. Guidal, M. Guillo, N. Guler, L. Guo, V. Gyurjyan, C. Hadjidakis, K. Hafidi, H. Hakobyan, R.S. Hakobyan, J. Hardie, N. Hassall, D. Heddle, F.W. Hersman, K. Hicks, I. Hleiqawi, J. Hu, M. Huertas, C.E. Hyde, Y. Ilieva, D.G. Ireland, B.S. Ishkhanov, E.L. Isupov, M.M. Ito, D. Jenkins, H.S. Jo, K. Joo, H.G. Juengst, N. Kalantarians, J.D. Kellie, M. Khandaker, K.Y. Kim, K. Kim, W. Kim, A. Klein, F.J. Klein, M. Klusman, M. Kossov, L.H. Kramer, V. Kubarovsky, J. Kuhn, S.E. Kuhn, S.V. Kuleshov, M. Kuznetsov, J. Lachniet, J.M. Laget, J. Langheinrich, D. Lawrence, A.C.S. Lima, K. Livingston, H.Y. Lu, K. Lukashin, M. MacCormick, J.J. Manak, N. Markov, S. McAleer, B. McKinnon, J.W.C. McNabb, B.A. Mecking, M.D. Mestayer, C.A. Meyer, T. Mibe, K. Mikhailov, R. Minehart, M. Mirazita, R. Miskimen, V. Mokeev, K. Moriya, S.A. Morrow, M. Moteabbed, J. Mueller, G.S. Mutchler, P. Nadel-Turonski, J. Napolitano, R. Nasseripour, S. Niccolai, G. Niculescu, I. Niculescu, B.B. Niczyporuk, M.R. Niroula, R.A. Niyazov, M. Nozar, G.V. O'Rielly, M. Osipenko, A.I. Ostrovidov, K. Park, E. Pasyuk, C. Paterson, S.A. Philips, J. Pierce, N. Pivnyuk, D. Pocanic, O. Pogorelko, E. Polli, I. Popa, S. Pozdniakov, B.M. Preedom, J.W. Price, Y. Prok, D. Protopopescu, L.M. Qin, B.A. Raue, G. Riccardi, G. Ricco, M. Ripani, B.G. Ritchie,

F. Ronchetti, G. Rosner, P. Rossi, D. Rowntree, P.D. Rubin, F. Sabati, J. Salamanca, C. Salgado, J.P. Santoro, V. Sapunenko, R.A. Schumacher, V.S. Serov, Y.G. Sharabian, J. Shaw, N.V. Shvedunov, A.V. Skabelin, E.S. Smith, L.C. Smith, D.I. Sober, D. Sokhan, A. Stavinsky, S.S. Stepanyan, B.E. Stokes, P. Stoler, I.I. Strakovsky, S. Strauch, R. Suleiman, M. Taiuti, S. Taylor, D.J. Tedeschi, U. Thoma, Â§ R. Thompson, A. Tkabladze, S. Tkachenko, C. Tur, M. Ungaro, M.F. Vineyard, A.V. Vlassov, D.P. Watts, L.B. Weinstein, D.P. Weygand, M. Williams, E. Wolin, M.H. Wood, A. Yegneswaran, J. Yun, M. Yurov, L. Zana, J. Zhang, B. Zhao, and Z.W. Zhao [CLAS Collaboration] "Beam Spin Asymmetries in DVCS with CLAS at 4 .8 GeV" arXiv:0812.2950 [hep-ex] JLAB-PHY-08-930(2008)

M. Holtrop [CLAS Collaboration] "Investigating the onset of color transparency with CLAS" JLAB-PHY-07-747(2007) Prepared for 15th International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2007), Munich, Germany, 16-20 Apr 2007

B.A. Mecking et al. (CLAS collaboration, see Ref. [1]): "The CEBAF Large Acceptance Spectrometer (CLAS)", Nucl. Instr. Meth A **503**, 513 (May 2003).

K.Sh. Egiyan et al. (CLAS collaboration, see Ref. [3]): "Measurement of Two- and Three-Nucleon Short-Range Correlation Probabilities in Nuclei", Phys. Rev. Lett. **96**, 082501 (2006).

K.Sh. Egiyan et al. (CLAS collaboration, see Ref. [13]): "Experimental Study of Exclusive 2H(e,e'p)n Reaction Mechanisms at High Q^{2}", Phys. Rev. Lett. **98**, 262502 (2007).

(d) **Synergistic Activities**

Involved several undergraduate students in my research, including detector development and testing. Supervised Senior Thesis project of undergraduate UNH students Will Morrison, Sam Meehan, Kyle Snively.

(e) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list. Main collaborators over past 4 years: Kawtar Hafidi, Will Brooks, Brahim Mustapha, Lamiaa el Fassi, Elton Smith, Stepan Stepanyan.
(ii) Graduate Advisor: Prof. Bill Bertozzi, Massachussetts Institute of Technology. Post-graduate advisor: Prof. Bill Hersman, University of New Hampsire
(iii) Graduate Students advised: Dr. Dan Protopopescu, Dr. Gagik Gavalian.
Current Graduate Students: Lorenzo Zana. Current Postdocs: Dr. Hovanes Egiyan; Dr. Sarah Phillips

Biographical Sketch

SHALEV GILAD

Professional Preparation

Stanford University	Physics	B.Sc.	1971
University of California, Berkeley	Physics	M.Sc.	1972
Tel Aviv University	Physics	Ph.D.	1978
Massachusetts Institute of Technology	Nuclear Physics	postdoc	1982-5

Appointments

MIT	Principal Research Scientist	1994 – present
MIT	Research Scientist	1990 – 1994
Cubital, Ltd.	Chief Scientist	1988 – 1990
Indigo, Ltd.	Senior Physicist	1986 – 1988
Scitex Corp.	Senior Physicist	1985 – 1986
Israeli Aircraft Industries	Senior Physicist	1979 – 1982

Publications

Publications closely related to proposed project

1. *Measurement of the ^{3}He(e,e'p)pn Reaction at High Missing Energies and Momenta*, F. Benmokhtar, K. A. Aniol, W. Bertozzi, W. U. Boeglin, F. Butaro, J. R. Calarco, J. –P. Chen, E. Cisbani, A. Cochran, S. Dietrich, P. Djawotho, W. Duran, M. B. Epstein, J. M. Finn, K. G. Fissum, A. Frahi-Amroun, S. Frullani, C. Furget, F. Garibaldi, O. Gayou, S. Gilad, R. Gilman, C. Glashausser, O. Hansen, D. W. Higinbotham, A. Hotta, B. Hu, M. Iodice, R. Iommi, C. W. de Jager, X. Jiang, M. K. Jones, J. J. Kelly, S. Kox, M. Kuss, J. –M. Laget, J. J. LeRose, R. A. Lindgren, N. Liyanage, R. W. Lourie, S. Malov, D. J. Margaziotis, P. Markowitz, F. Merchez, R. Michaels, J. Mitchell, J. Mougey, E. Penel, C. F. Perdrisat, A. V. Punjabi, G. Quéméner, R. D. Ransome, R. Roché, M. Rvachev, J. –S. Real, F. J. Sabatie, A. Saha, S. Strauch, R. Suleiman, T. Tamae, J. A. Templon, R. Tieulent, H. Uono, P. E. Ulmer, G. M. Urciuoli, S. van Verst, E. Voutier, K. Wijesooriya, B. Wojtsekhowski, Phys. Rev. Lett. **94**, 082305 (2005); http://prola.aps.org/abstract/PRL/v94/i8/e082305

2. *Investigation of Proton-Proton Short-Range Correlations via the ^{12}C(e,e'pp) Reaction,* R. Shneor, P. Monaghan, R. Subedi, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, P. Bertin, W. Bertozzi, W. Boeglin, J. P. Chen, Seonho Choi, E. Chudakov, E. Cisbani, B. Craver, C. W. de Jager, R. J. Feuerbach, S. Frullani, F. Garibaldi, O. Gayou, S. Gilad, R. Gilman, O. Glamazdin, J. Gomez, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim,1 R. Igarashi, E. Jans, X. Jiang, Y. Jiang, L. Kaufman, A. Kelleher, A. Kolarkar, E. Kuchina, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, S. Nanda, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, B. Reitz, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, N. Thompson, P. E. Ulmer, G. M. Urciuoli, E. Voutier, K. Wang, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, H. Yao, X. Zheng, and L. Zhu,Phys. Rev. Lett., **99**, 072501 (2007);

http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=PRLTAO00009900 0007072501000001&idtype=cvips&gifs=yes

3. *Probing Cold Dense Nuclear Matter,* R. Subedi, R. Shneor, P. Monaghan, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, W. Boeglin, J.-P. Chen, Seonho Choi, E. Cisbani, B. Craver, S. Frullani, F. Garibaldi, S. Gilad, R. Gilman, O. Glamazdin, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, C. W. de Jager, E. Jans, X. Jiang, L. J. Kaufman, A. Kelleher, A. Kolarkar, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, G. M. Urciuoli, E. Voutier, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, X.-C. Zheng, L. Zhu, Science, **320,** 1476 (2008); http://www.sciencemag.org/cgi/search?src=hw&site_area=sci&fulltext=cold+dense+nuclear+matter&search_submit.x=0&search_submit.y=0&search_submit=go

Other significant publications

1. *Recoil Polarization Measurements for Neutral Pion Electroproduction at* $Q^2 = 1$ $(GeV/c)^2$ *Near the Delta Resonance*, J. J. Kelly, O. Gayou, R. E. Roché, Z. Chai, M. K. Jones, A. J. Sarty, S. Frullani, K. Aniol, E. J. Beise, F. Benmokhtar, W. Bertozzi, W. U. Boeglin, T. Botto, E. J. Brash, H. Breuer, E. Brown, E. Burtin, J. R. Calarco, C. Cavata, C. C. Chang, N. S. Chant, J.-P. Chen, M. Coman, D. Crovelli, R. De Leo, S. Dieterich, S. Escoffier, K. S. Fissum, V. Garde, F. Garibaldi, S. Georgakopoulos, S. Gilad, R. Gilman, C. Glashausser, J.-O. Hansen, D. W. Higinbotham, A. Hotta, G. M. Huber, H. Ibrahim, M. Iodice, C. W. de Jager, X. Jiang, A. Klimenko, S. Kozlov, G. Kumbartzki, M. Kuss, L. Lagamba, G. Laveissière, J. J. LeRose, R. A. Lindgren, N. Liyanage, G. J. Lolos, R. W. Lourie, D. J. Margaziotis, F. Marie, P. Markowitz, S. McAleer, D. Meekins, R. Michaels, B. D. Milbrath, J. Mitchell, J. Nappa, D. Neyret, C. F. Perdrisat, M. Potokar, V. A. Punjabi, T. Pussieux, R. D. Ransome, P. G. Roos, M. Rvachev, A. Saha, S. Širca, R. Suleiman, S. Strauch, J. A. Templon, L. Todor, P. E. Ulmer, G. M. Urciuoli, L. B. Weinstein, K. Wijesooriya, B. Wojtsekhowski,, X. Zheng, and L. Zhu, Phys. Rev. **C75**, 025201 (2007); http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=PRVCAN00007500 0002025201000001&idtype=cvips&gifs=yes

Synergistic Activities

(1) Referee of Phys. Rev. and Phys. Lett. manuscripts; (2) Co-principal Investigator on three Israel-US BSF proposals.

Collaborators & Other Affiliations

Collaborators

W. Bertozzi (MIT), J.–P. Chen (JLab) L. R. Gilman (Rutgers U), D. Higinbotham (JLab), E. Piasetzky (Tel Aviv), M. Sargsian (Florida Int. U), M. Strikman (Penn State), J. Watson (Kent)

Graduate and Postdoctoral Advisors

Ph.D.: J. Alster (Tel Aviv U); Postdoctoral: R. Redwine (MIT)

Thesis Advisor and Postgraduate-Scholar Sponsor

Graduate Students: A. Puckett, X.-H Zhan, J. Huang, N. Muangma, K. Pan (MIT) career total 12; Postdoctoral Fellows sponsored: V. Sulkovsky, B. Moffit, N. Sparveris (career total 15)

Biographical Sketch

VINCENT A. SULKOSKY

Professional Preparation

Saint Vincent College	Physics	B.A.	May 1998
College of William and Mary	Physics	M.S.	Dec. 2000
College of William and Mary	Nuclear Physics	Ph.D.	Aug. 2007
Jefferson Laboratory	Nuclear Physics	postdoc	Apr. 2007-09
Massachusetts Institute of Technology	Nuclear Physics	postdoc	Jun. 2009-present

Publications

Publications closely related to proposed project

1. *Probing Cold Dense Nuclear Matter,* R. Subedi, R. Shneor, P. Monaghan, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, W. Boeglin, J.-P. Chen, Seonho Choi, E. Cisbani, B. Craver, S. Frullani, F. Garibaldi, S. Gilad, R. Gilman, O. Glamazdin, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, C. W. de Jager, E. Jans, X. Jiang, L. J. Kaufman, A. Kelleher, A. Kolarkar, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, G. M. Urciuoli, E. Voutier, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, X.-C. Zheng, L. Zhu, Science, **320,** 1476 (2008), http://dx.doi.org/10.1126/science.1156675.

2. *Investigation of Proton-Proton Short-Range Correlations via the 12C(e,e'pp) Reaction,* R. Shneor, P. Monaghan, R. Subedi, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, P. Bertin, W. Bertozzi, W. Boeglin, J. P. Chen, Seonho Choi, E. Chudakov, E. Cisbani, B. Craver, C. W. de Jager, R. J. Feuerbach, S. Frullani, F. Garibaldi, O. Gayou, S. Gilad, R. Gilman, O. Glamazdin, J. Gomez, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim,1 R. Igarashi, E. Jans, X. Jiang, Y. Jiang, L. Kaufman, A. Kelleher, A. Kolarkar, E. Kuchina, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, S. Nanda, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, B. Reitz, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Širca, K. Slifer, P. Solvignon, V. Sulkosky, N. Thompson, P. E. Ulmer, G. M. Urciuoli, E. Voutier, K. Wang, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, H. Yao, X. Zheng, and L. Zhu, Phys. Rev. Lett. **99**, 072501 (2007), http://dx.doi.org/10.1103/PhysRevLett.99.072501.

Other significant publications

1. *Measuring the Neutron and He-3 Spin Structure at Low Q^2*, V. Sulkosky, Proc. of 16th Int. Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2008), Apr. 2008. http://dx.doi.org/10.3360/dis.2008.211.

2. *Quark-Hadron Duality in Neutron (He-3) Spin Structure*, P. Solvignon, N. Liyanage, J.-P. Chen, Seonho Choi, K. Aniol, T. Averett, W. Boeglin, A. Camsonne, G. D. Cates, C. C. Chang, E. Chudakov, B. Craver, F. Cusanno, A. Deur, D. Dutta, R. Ent, R. Feuerbach, S. Frullani, H. Gao, F. Garibaldi, R. Gilman, C. Glashausser, V. Gorbenko, O. Hansen, D. W. Higinbotham, H. Ibrahim, X. Jiang, M. Jones, A. Kelleher, J. Kelly, C. Keppel, W. Kim, W. Korsch, K. Kramer, G. Kumbartzki, J. J. LeRose, R. Lindgren, B. Ma, D. J. Margaziotis, P. Markowitz, K. McCormick, Z.-E. Meziani, R. Michaels, B. Moffit, P. Monaghan, C. Munoz Camacho, K. Paschke, B. Reitz, A. Saha, R. Sheyor, J. Singh, K. Slifer, V. Sulkosky, A. Tobias, G. M. Urciuoli, K. Wang, K. Wijesooriya, B. Wojtsekhowski, S. Woo, J.-C. Yang, X. Zheng, and L. Zhu, Phys. Rev. Lett. **101**, 182502 (2008), http://dx.doi.org/10.1103/PhysRevLett.101.182502.

3. *Precision Measurement of the Neutron Spin Asymmetries and Spin-dependent Structure Functions in the Valence Quark Region,* X. Zheng, K. Aniol, D. S. Armstrong, T. D. Averett, W. Bertozzi1, S. Binet, E. Burtin1, E. Busato, C. Butuceanu, J. Calarco, A. Camsonne, G. D. Cates, Z. Chai1, J.-P. Chen, Seonho Choi, E. Chudakov, F. Cusanno, R. De Leo, A. Deur, S. Dieterich, D. Dutta, J. M. Finn, S. Frullani, H. Gao, J. Gao, F. Garibaldi, S. Gilad, R. Gilman, J. Gomez, J.-O. Hansen, D. W. Higinbotham, W. Hinton, T. Horn, C. W. de Jager, X. Jiang, L. Kaufman, J. Kelly, W. Korsch, K. Kramer, J. LeRose, D. Lhuillier, N. Liyanage, D. J. Margaziotis, F. Marie, P. Markowitz, K. McCormick, Z.-E. Meziani, R. Michaels, B. Moffit, S. Nanda, D. Neyret, S. K. Phillips, A. Powell, T. Pussieux, B. Reitz, J. Roche, R. Roché, M. Roedelbronn, G. Ron, M. Rvachev, A. Saha, N. Savvinov, J. Singh, S. Širca, K. Slifer, P. Solvignon, P. Souder, D. J. Steiner, S. Strauch, V. Sulkosky, A. Tobias, G. Urciuoli, A. Vacheret, B. Wojtsekhowski, H. Xiang, Y. Xiao, F. Xiong, B. Zhang, L. Zhu, X. Zhu, and P. A. Zonierczuk, Phys. Rev. C 70, 065207 (2004), http://dx.doi.org/10.1103/PhysRevC.70.065207.

Synergistic Activities

(1) Co-Mentor/Mentor of two DOE summer and two New Horizons Governor's School for Science and Technology high school students; (2) Spokesperson of Jefferson Lab nuclear physics experiment E08-005; (3) Analysis coordinator of Jefferson Lab experiment E06-010/E06-011 (Transversity); (4) Jefferson Lab Graduate Student Association Officer 2004-07.

Collaborators & Other Affiliations

Collaborators

B. D. Anderson (Kent State), J. Annand (Glasgow), J. Arrington (ANL), T. Averett (W&M), W. Bertozzi (M.I.T.), G. D. Cates (UVa), J.-P. Chen (JLab), S. Choi (Seoul), A. Deur (JLab), H. Gao (Duke), F. Garibaldi (INFN), S. Gilad (M.I.T.), R. Gilman (Rutgers), J.-O. Hansen (JLab), T. K. Holmstrom (Longwood), C. W. de Jager (JLab), X. Jiang (LANL), J. J. LeRose (JLab), R. Lindgren (UVa), N. Liyanage (UVa), P. Markowitz (FIU), Z.-E. Meziani (Temple), R. Michales (JLab), B. Moffit (JLab), B. E. Norum (UVa), J.-C. Peng (UIUC), E. Piasetzky (Tel Aviv), M. Potokar (Slovenia), G. Ron (Tel Aviv), A. Saha (JLab), B. Sawatzky (JLab), A. Shahinyan (JLab), P. Solvignon (ANL), S. Širca (Slovenia), K. Slifer (UNH), R. Shneor (Tel Aviv), R.Subedi (UVa), J.Watson (Kent State), B.Wojsekhowski (JLab), and X.Zheng (UVa)

Graduate and Postdoctoral Advisors

Ph.D.: T. D. Averett (W&M); Postdoctoral: C. W. de Jager (JLab) 2007-09, W. Bertozzi (M.I.T.) 2009-present

Co-Mentor/Mentor

Undergraduate Students: Nate Justis (BYU) and Ronald Pandolfi (Randolph-Macon)
High School Students: Richard Zhang and Hai Zhang (both at New Horizons Governor's School)

Dr. Gerard P. Gilfoyle

Professional Preparation:

Franklin and Marshall College, Physics, A.B., 1979.

University of Pennsylvania, Experimental nuclear physics, Ph..D., 1985.

SUNY, Stony Brook, Postdoctoral Fellow, Experimental Heavy-Ion Physics, 1985-1987.

Appointments:

2009-2010 - Scientific Consultant, Jefferson Laboratory.

2008-present - Clarence E. Denoon Professor of Science.

2006-present - Chair, Nuclear Physics Working Group of the CLAS Collaboration.

2004-present - Professor of Physics, University of Richmond.

2002-2003 - Scientific Consultant, Jefferson Laboratory.

2000-2006 - Chair, Department of Physics, University of Richmond.

1999-2000 - AAAS Defense Policy Fellow.

1994-1995 - Scientific Consultant, Jefferson Laboratory.

1993-2004 - Associate Professor of Physics, University of Richmond.

Summer, 1988 - Visiting Research Professor, University of Pennsylvania.

1987-1993 - Assistant Professor, University of Richmond.

Awards and Honors:

2009-2010 - National Science Foundation Major Research Instrumentation Program ($162,000).

1990-present - US Department of Energy ($1,560,000).

2004 - Who's Who Among America's Teachers.

2003 - University of Richmond Distinguished Educator Award.

2001-2002 - National Science Foundation Major Research Instrumentation Program ($175,000).

1999-2000 - AAAS Defense Policy Fellow ($53,000).

1995-1997 - National Science Foundation, ILI Program ($14,986).

1992-1995 - National Science Foundation, ILI Program ($49,813).

1989-1991 - Research Corporation($26,000).

Selected Publications Related to the Proposed Research:

See References 1,2,3,13 for a list of members of the CLAS Collaboration.

1. J.Lachniet, A.Afanasev, H.Arenhoevel, W.K.Brooks, G.P.Gilfoyle, S.Jeschonnek, B.Quinn, M.F.Vineyard *et al.* (the CLAS Collaboration), 'A Precise Measurement of the Neutron Magnetic Form Factor G_M^n in the Few-GeV^2 Region', Phys. Rev. Lett. **102**, 192001 (2009).

2. G.P.Gilfoyle, 'Review of QCD Processes in Nuclear matter at Jefferson Lab', Proc. of XVI Int. Workshop on Deep-Inelastic Scattering and Related Topics, London, England, April 2008.

3. G.P. Gilfoyle, *et al.*, (the CLAS Collaboration), 'Measuring form Factors and Structure Functions with CLAS', Proceedings of the Third High-Energy Physics International Conference (HEP-MAD07), SLAC eConf C0709107, 2008.

4. G.P. Gilfoyle, et al., (the CLAS Collaboration), "A Precise Measurement of the Neutron Mag-

netic Form Factor GMn in the Few-GeV2 Region", Exclusive Reactions at High Momentum Transfer, World Scientific, 2008.

5. K.Sh. Egiyan, G.A. Asryan, N.B. Dashyan, N.G. Gevorgyan, J.-M. Laget, K. Griffioen, S. Kuhn, *et al.* (The CLAS Collaboration), 'Study of Exclusive d(e,e'p)n Reaction Mechanism at High Q2', Phys. Rev. Lett. **98**, 262502 (2007).

6. K. Egiyan *et al.* (The CLAS Collaboration), 'Measurement of 2- and 3-nucleon short range correlation probabilities in nuclei,' Phys. Rev. Lett. **96**, 082501 (2006).

7. D. Protopopescu, *et al.* (The CLAS Collaboration), 'Survey of A'_{LT} asymmetries in semi-exclusive electron scattering on ^{4}He and ^{12}C,' Nuclear Physics, **A748**, 357 (2005).

8. B. Mecking *et al.*, (The CLAS Collaboration), 'The CEBAF Large Acceptance Spectrometer,' Nucl. Instr. and Meth., **503**/3, 513 (2003).

9. K. Joo, *et al.* (The CLAS Collaboration), 'Measurement of Polarized Structure Function σ'_{LT}) for $p(\vec{e}, e'p)\pi 0$ from single $\pi 0$ electroproduction in the Delta resonance region,' Physical Review C, Rapid Communications, **68**, 032201 (2003).

Synergistic Activities:

(1) Gilfoyle served in government (1999-2000) as a scientific consultant on weapons of mass destruction for the US Department of Defense. His work included a publication on new ways to secure special nuclear materials in Russia. (2) His teaching has been illuminated by this work. He added computational methods to upper-level courses and computer-based data acquisition and analysis to introductory physics (with teaching grants from NSF). (3) He has recruited women and African-American students to nuclear physics. A former female student is now a staff scientist at the Jet Propulsion Lab in California and over the last four years three women and two African-American men have worked in his laboratory. One female graduate (Greenholt) is combining nuclear physics and public policy.

List of Recent Collaborators:

See the website `https://clasweb.jlab.org/membership/phonebook.php` or References 1,2,3,13 for a list of CLAS collaborators. Below we list additional ones.

E. Bunn	University of Richmond	J.W. Van Orden	Old Dominion University
D. F. Geesaman	Argonne National Lab	R. J. Holt	Argonne National Lab
S. Jeschonnek	Ohio State University	H. Arenhoevel	Mainz
P. Kroll	Universität Wuppertal	B. Mustapha	Argonne National Lab

Graduate and Postdoctoral Advisors

Graduate Advisor - Dr. H..T. Fortune, University of Pennsylvania.

Postdoctoral Advisor - Dr. R.W. McGrath, SUNY, Stony Brook.

Thesis Advisor and Post-Graduate Advisor

None. The University of Richmond is a primarily undergraduate institution.

lefill

Biographical Sketch for Dr. Rakhsha Nasseripour

(a) **Education and Training**

Florida International University	Particle Physics	Ph. D. degree 2004
Florida International University	Particle Physics	M. Sc. degree 2001
Amir Kabir University of Technology, Tehran	Nuclear Physics	B. Sc. degree 1990

(b) **Research and Professional Experience**

George Washington University	Postdoc. Research Scientist	2007-
University of South Carolina	Postdoc. Fellow	2005-2007
Nuclear Research Center, Tehran	Radionuclide QC	1990-1998

(c) **Publications**

R. Nasseripour and B. L. Berman: "Coherent Photoproduction of π^+ on ^{3}He", submitted to the Phys. Rev. C. (Nov. 2010), arXiv: 1011.0073v1[nucl-ex] (Oct. 2010).

M. Wood, R. Nasseripour, M. Paolone, D. Weygand, and C. Djalali: "Absorption of the ω and φ Mesons in Nuclei", Phys. Rev. Lett. 105, 112301 (2010).

R. Nasseripour, N. Benmouna, B. L. Berman, Y. Ilieva, J. -M. Laget: "Photodisintegration of ^{4}He into p+t", Phys. Rev. C 80, 044603 (2009).

M. H. Wood, C. Djalali, R. Nasseripour and D. Weygand: " Medium Modifications Of Light Vector Mesons In Photoproduction Reactions At Jlab, Int. J. Mod. Phys. A 24, 309 (2009).

R. Nasseripour, C. Djalali, M. Wood and D. Weygand: " Medium modification of the light vector mesons in nuclei", AIP Conf. Proc. 1056, 223 (2008).

C. Djalali, M. Wood, R. Nasseripour and D. Weygand: "Vector meson modification in nuclear matter at CLAS", Mod. Phys. Lett. A 23, 2417 (2008).

C. Djalali, M. H. Wood, R. Nasseripour and D. P. Weygand: " Medium modifications of light vector mesons in photoproduction reactions at JLab", J. Phys. G 35, 104035 (2008)

R. Nasseripour, B. A. Raue, D. S. Carman, and P. Ambrozewicz: "Polarized Structure function $\sigma_{LT'}$ for ^{1}H($\vec{}$e, e′K$^+$)Λ in the nucleon resonance region", Phys. Rev. C 77, 065208 (2008).

M. Wood, R. Nasseripour, C. Djalali, D. Weygand: " Light Vector Mesons in the Nuclear Medium", Phys. Rev. C 78, 015201 (2008).

R. Nasseripour, M. Wood, D. Weygand, and C. Djalali: " Search for In-medium Modification of the ρ Meson", Phys. Rev. Lett.99, 262302 (2007).

(d) **Collaborators and other Affiliations**

(i) All collaborators are listed as authors in the publication list. Main collaborators over past 6 years: M. Wood, D. Weygand, C. Djalali, B. Berman, Y. Ilieva, J-M. Laget, L. Tiator, U. Mosel, D. Carman, B. Raue, and M. Paolone.

(ii) Graduate Advisor: Prof. B. Raue, Florida International University.

Appendix 2. Current and Pending Support

Current and Pending Support - Old Dominion University Group

A Current Support

1	Source of Support:	Department of Energy
	Project Title:	From Quarks to Nuclei
	Investigators:	M. Amarian, S. Bültmann, G.E. Dodge, C.E. Hyde, S.E. Kuhn (PI), and L.B. Weinstein
	Amount Awarded:	$2,000,000
	Period Covered:	March 15, 2008 – March 14, 2011
	Effort:	80% of research time (M. Amarian, S. Kuhn, L. Weinstein)
	Location:	Old Dominion University
2	Source of Support:	National Science Foundation
	Project Title:	Collaborative Research: MRI-Consortium for the Development and Construction of a Longitudinally Polarized Proton and Deuteron Target for CLAS12 at Jefferson Lab (MRI-R2)
	Investigators:	S. Bültmann (PI), S.E. Kuhn
	Amount Awarded:	$420,723
	Period Covered:	April 1, 2010 – March 31, 2014
	Effort:	20% of research time (S. Kuhn)
	Location:	Old Dominion University

B Pending Support

1	Source of Support:	Department of Energy
	Project Title:	SHORT DISTANCE STRUCTURE OF NUCLEI - MINING THE WEALTH OF EXISTING JEFFERSON LAB DATA
	Investigators:	M. Amarian, S.E. Kuhn, and L.B. Weinstein (PI)
	Amount Requested:	$793,424
	Period Covered:	March 1, 2011 – February 28, 2014
	Effort:	20% of research time (M. Amarian, S. Kuhn, L. Weinstein)
	Location:	Old Dominion University
2	Source of Support:	Department of Energy
	Project Title:	From Quarks to Nuclei
	Investigators:	M. Amarian, S. Bültmann, G.E. Dodge, C.E. Hyde, S.E. Kuhn (PI), and L.B. Weinstein
	Amount Requested:	$3,260,000
	Period Covered:	March 15, 2011 – March 14, 2014
	Effort:	80% of research time (M. Amarian, S. Kuhn, L. Weinstein)
	Location:	Old Dominion University
3	Source of Support:	National Science Foundation
	Project Title:	Spin-Dependent Elastic and Diffractive Proton-Proton Scattering at RHIC
	Investigators:	S. Bültmann (PI), S.E. Kuhn
	Amount Requested:	$349,547
	Period Covered:	April 1, 2011 – March 31, 2014
	Effort:	10% of research time (S. Kuhn)
	Location:	Old Dominion University

Current and Pending Support - Pennsylvania State University Group

A Current Support

1	Source of Support:	Department of Energy
	Project Title:	Theoretical studies in high-energy nuclear physics
	Investigator:	M. Strikman
	Amount Awarded:	$461,000
	Period Covered:	January 1, 2008 - December 31, 2010
	Effort:	100 % of research for the first two years and 80% for the third year.
	Location:	Pennsylvania State University
2	Source of Support:	United States - Israel Binational Science Foundation
	Project Title:	Linear and Nonlinear Color Coherent Phenomena at Colliders
	Investigators:	Leonid Frankfurt, Mark Strikman
	Amount Awarded:	$72,000
	Period Covered:	October 1, 2009 to September 30, 2013
	Effort:	20 % of research.
	Location:	Pennsylvania State University

B Pending Support

1	Source of Support:	Department of Energy
	Project Title:	SHORT DISTANCE STRUCTURE OF NUCLEI - MINING THE WEALTH OF EXISTING JEFFERSON LAB DATA
	Investigator:	M. Strikman
	Amount Requested:	$774,793
	Period Covered:	January 1, 2010 – December 31, 2013
	Effort:	20% of research time)
	Location:	Pennsylvania State University

Current and Pending Support - Florida International University Group

A Current Support

1	Source of Support:	Department of Energy
	Project Title:	Theoretical Studies of High-Energy Electro-Nuclear Processes
	Investigator:	M. Sargsian (PI)
	Amount Awarded:	$193,000
	Period Covered:	April 15, 2007 – April 14, 2010
	Effort:	67% of research time (M. Sargsian)
	Location:	Florida International University

B Pending Support

1	Source of Support:	Department of Energy
	Project Title:	SHORT DISTANCE STRUCTURE OF NUCLEI - MINING THE WEALTH OF EXISTING JEFFERSON LAB DATA
	Investigators:	W. Boeglin and M. Sargsian (co-PI)
	Amount Requested:	$774,793
	Period Covered:	March 1, 2010 – February 28, 2013
	Effort:	15% of research time (W. Boeglin, M.Sargsian)
	Location:	Florida International University
2	Source of Support:	Department of Energy (submitted on 10/13/2009)
	Project Title:	Theoretical Studies of High-Energy Electro-Nuclear Processes
	Investigator:	M. Sargsian (PI)
	Amount Requested:	$276,000
	Period Covered:	April 15, 2010 – April 14 , 2013
	Effort:	67% of research time (M. Sargsian)
	Location:	Florida International University

Appendix 3. Bibliography and References Cited

References

[1] B. A. Mecking, G. Adams, S. Ahmad, E. Anciant, M. Anghinolfi, B. Asavapibhop, G. Asryan, G. Audit, T. Auger, H. Avakian, J. P. Ball, F. J. Barbosa, S. Barrow, M. Battaglieri, K. Beard, l, B. L. Berman, N. Bianchi, S. Boiarinov, P. Bonneau, W. J. Briscoe, W. K. Brooks, V. D. Burkert, D. S. Carman, T. Carstens, C. Cetina, S. B. Christo, P. L. Cole, a, A. Coleman, 1, J. Connelly, 2, D. Cords, P. Corvisiero, D. Crabb, H. Crannell, R. C. Cuevas, P. V. Degtyarenko, L. Dennis, E. DeSanctis, R. DeVita, J. Distelbrink, G. E. Dodge, W. Dodge, G. Doolittle, D. Doughty, a, M. Dug-ger, W. S. Duncan, S. Dytman, H. Egiyan, K. S. Egiyan, L. Elouadrhiri, R. J. Feuer-bach, J. Ficenec, V. Frolov, H. Funsten, G. P. Gilfoyle, K. L. Giovanetti, E. Golo-vatch, J. Gram, M. Guidal, V. Gyurjyan, D. Heddle, P. Hemler, F. W. Hersman, K. Hicks, R. S. Hicks, M. Holtrop, C. E. Hyde-Wright, D. Insley, M. M. Ito, G. Jacobs, D. Jenkins, K. Joo, D. Joyce, D. Kashy, M. Khandaker, W. Kima, A. Klein, F. J. Klein, M. Klusman, M. Kossov, L. Kramer, V. Koubarovski, S. E. Kuhn, A. Lake, D. Lawrence, A. Longhi, K. Lukashin, J. Lachniet, R. A. Magahiz, W. Major, J. J. Ma-nak, C. Marchand, C. Martin, S. K. Matthews, M. McMullen, J. W. C. McNabb, M. D. Mestayer, R. Minehart, M. Mirazita, R. Miskimen, V. Muccifora, J. Mueller, L. Y. Murphy, G. S. Mutchler, J. Napolitano, I. Niculescu, B. B. Niczyporuk, M. Nozar, J. T. O'Brien, A. K. Opper, J. E. O'Meara, E. Pasyuk, S. A. Philips, E. Polli, J. W. Price, b, S. Pozdniakov, L. M. Qin, B. A. Raue, G. Riccardi, G. Ricco, C. Riggs, M. Ripani, B. G. Ritchie, J. Robb, F. Ronchetti, P. Rossi, F. Roudot, C. Salgado, V. Sapunenko, R. A. Schumacher, V. S. Serova, Y. G. Sharabian, E. S. Smith, L. C. Smith, T. Smith, D. I. Sober, A. Stavinskya, S. Stepanyan, P. Stoler, M. Taiuti, W. M. Taylor, S. Tay-lora, D. J. Tedeschia, U. Thoma, R. Thompson, D. Tilles, L. Todor, T. Y. Tung, W. Tuzel, M. F. Vineyard, A. V. Vlassov, L. B. Weinstein, R. E. Welsh, D. P. Weygand, G. R. Wilkin, M. Witkowski, E. Wolin, A. Yegneswaran, P. Yergin, and J. Yun: "The CEBAF Large Acceptance Spectrometer (CLAS)", Nucl. Instr. Meth. **A 503**, 513-553 (11 May 2003).

[2] K. S. Egiyan,N. Dashyan, M. Sargsian, S. Stepanyan. L.B. Weinstein, G. Adams, P. Ambrozewicz, E. Anciant, M. Anghinolfi, B. Asavapibhop, G. Asryan, G. Audit, T. Auger, H. Avakian, H. Bagdasaryan, J.P. Ball, S. Barrow, M. Battaglieri, K. Beard, I. Bedlinski, M. Bektasoglu, M. Bellis, N. Benmouna, B.L. Berman, N. Bianchi, A.S. Biselli, S. Boiarinov, B.E. Bonner, S. Bouchigny, R. Bradford, D. Branford, W.J. Briscoe, W.K. Brooks, V.D. Burkert, C. Butuceanu, J.R. Calarco, D.S. Carman, B. Carnahan, C. Cetina, L. Ciciani, P.L. Cole, A. Coleman, D. Cords, P. Corvisiero, D. Crabb, H. Crannell, J.P. Cummings, E. DeSanctis, R. DeVita, P.V. Degtyarenko, R. Demirchyan, H. Denizli, L. Dennis, K.V. Dharmawardane, K.S. Dhuga, C. Djalali,

G.E. Dodge, D. Doughty, P. Dragovitsch, M. Dugger, S. Dytman, O.P. Dzyubak, M. Eckhause, H. Egiyan, L. Elouadrhiri, A. Empl, P. Eugenio, R. Fatemi, R.J. Feuerbach, J. Ficenec, T.A. Forest, H. Funsten, M. Gai, G. Gavalian, S. Gilad, G.P. Gilfoyle, K.L. Giovanetti, P. Girard, C.I. O. Gordon, K. Griffioen, M. Guidal, M. Guillo, L. Guo, V. Gyurjyan, C. Hadjidakis, R.S. Hakobyan, J. Hardie, D. Heddle, P. Heimberg, F.W. Hersman, K. Hicks, R.S. Hicks, M. Holtrop, J. Hu, C.E. Hyde-Wright, Y. Ilieva, M.M. Ito, D. Jenkins, K. Joo, J.H. Kelley, M. Khandaker, D.H. Kim, K.Y. Kim, K. Kim, M.S. Kim, W. Kim, A. Klein, F.J. Klein, A. Klimenko, M. Klusman, M. Kossov, L.H. Kramer, Y. Kuang, S.E. Kuhn, J. Kuhn, J. Lachniet, J.M. Laget, D. Lawrence, Ji Li, K. Lukashin, J.J. Manak, C. Marchand, L.C. Maximon, S. McAleer, J. McCarthy, J.W. C. McNabb, B.A. Mecking, S. Mehrabyan, J.J. Melone, M.D. Mestayer, C.A. Meyer, K. Mikhailov, R. Minehart, M. Mirazita, R. Miskimen, L. Morand, S.A. Morrow, M.U. Mozer, V. Muccifora, J. Mueller, L.Y. Murphy, G.S. Mutchler, J. Napolitano, R. Nasseripour, S.O. Nelson, S. Niccolai, G. Niculescu, I. Niculescu, B.B. Niczyporuk, R.A. Niyazov, M. Nozar, G.V. O'Rielly, A.K. Opper, M. Osipenko, K. Park, E. Pasyuk, G. Peterson, S.A. Philips, N. Pivnyuk, D. Pocanic, O. Pogorelko, E. Polli, S. Pozdniakov, B.M. Preedom, J.W. Price, Y. Prok, D. Protopopescu, L.M. Qin, B.A. Raue, G. Riccardi, G. Ricco, M. Ripani, B.G. Ritchie, F. Ronchetti, P. Rossi, D. Rowntree, P.D. Rubin, F. Sabatie, K. Sabourov, C. Salgado, J.P. Santoro, V. Sapunenko, R.A. Schumacher, V.S. Serov, A. Shafi, Y.G. Sharabian, J. Shaw, S. Simionatto, A.V. Skabelin, E.S. Smith, L.C. Smith, D.I. Sober, M. Spraker, A. Stavinsky, P. Stoler, I. Strakovsky, S. Strauch, M. Strikman, M. Taiuti, S. Taylor, D.J. Tedeschi, U. Thoma, R. Thompson, L. Todor, C. Tur, M. Ungaro, M.F. Vineyard, A.V. Vlassov, K. Wang, A. Weisberg, H. Weller, D.P. Weygand, C.S. Whisnant, E. Wolin, M.H. Wood, L. Yanik, A. Yegneswaran, J. Yun, B. Zhang, J. Zhao, Z. Zhou [The CLAS collaboration]: "Observation of nuclear scaling in the A(e,e) reaction at $x_B > 1$", Phys. Rev. **C68**, 014313 (2003).

[3] K. S. Egiyan, N. B. Dashyan, M. M. Sargsian, M. I. Strikman, L. B. Weinstein, G. Adams, P. Ambrozewicz, M. Anghinolfi, B. Asavapibhop, G. Asryan, H. Avakian, H. Baghdasaryan, N. Baillie, J. P. Ball, N. A. Baltzell, V. Batourine, M. Battaglieri, I. Bedlinskiy, M. Bektasoglu, M. Bellis, N. Benmouna, A. S. Biselli, B. E. Bonner, S. Bouchigny, S. Boiarinov, R. Bradford, D. Branford, W. K. Brooks, S. Bltmann, V. D. Burkert, C. Bultuceanu, J. R. Calarco, S. L. Careccia, D. S. Carman, B. Carnahan, S. Chen, P. L. Cole, P. Coltharp, P. Corvisiero, D. Crabb, H. Crannell, J. P. Cummings, E. De Sanctis, R. DeVita, P. V. Degtyarenko, H. Denizli, L. Dennis, K. V. Dharmawardane, C. Djalali, G. E. Dodge, J. Donnelly, D. Doughty, P. Dragovitsch, M. Dugger, S. Dytman, O. P. Dzyubak, H. Egiyan, L. Elouadrhiri, A. Empl, P. Eugenio, R. Fatemi, G. Fedotov, R. J. Feuerbach, T. A. Forest, H. Funsten, G. Gavalian, N. G. Gevorgyan, G. P. Gilfoyle, K. L. Giovanetti, F. X. Girod, J. T. Goetz, E. Golovatch, R. W. Gothe, K. A. Griffioen, M. Guidal, M. Guillo, N. Guler, L. Guo, V. Gyurjyan, C. Hadjidakis,

J. Hardie, F. W. Hersman, K. Hicks, I. Hleiqawi, M. Holtrop, J. Hu, M. Huertas, C. E. Hyde-Wright, Y. Ilieva, D. G. Ireland, B. S. Ishkhanov, M. M. Ito, D. Jenkins, H. S. Jo, K. Joo, H. G. Juengst, J. D. Kellie, M. Khandaker, K. Y. Kim, K. Kim, W. Kim, A. Klein, F. J. Klein, A. Klimenko, M. Klusman, L. H. Kramer, V. Kubarovsky, J. Kuhn, S. E. Kuhn, S. Kuleshov, J. Lachniet, J. M. Laget, J. Langheinrich, D. Lawrence, T. Lee, K. Livingston, L. C. Maximon, S. McAleer, B. McKinnon, J. W. C. McNabb, B. A. Mecking, M. D. Mestayer, C. A. Meyer, T. Mibe, K. Mikhailov, R. Minehart, M. Mirazita, R. Miskimen, V. Mokeev, S. A. Morrow, J. Mueller, G. S. Mutchler, P. Nadel-Turonski, J. Napolitano, R. Nasseripour, S. Niccolai, G. Niculescu, I. Niculescu, B. B. Niczyporuk, R. A. Niyazov, G. V. O'Rielly, M. Osipenko, A. I. Ostrovidov, K. Park, E. Pasyuk, C. Peterson, J. Pierce, N. Pivnyuk, D. Pocanic, O. Pogorelko, E. Polli, S. Pozdniakov, B. M. Preedom, J. W. Price, Y. Prok, D. Protopopescu, L. M. Qin, B. A. Raue, G. Riccardi, G. Ricco, M. Ripani, B. G. Ritchie, F. Ronchetti, G. Rosner, P. Rossi, D. Rowntree, P. D. Rubin, F. Sabati, C. Salgado, J. P. Santoro, V. Sapunenko, R. A. Schumacher, V. S. Serov, Y. G. Sharabian, J. Shaw, E. S. Smith, L. C. Smith, D. I. Sober, A. Stavinsky, S. Stepanyan, B. E. Stokes, P. Stoler, S. Strauch, R. Suleiman, M. Taiuti, S. Taylor, D. J. Tedeschi, R. Thompson, A. Tkabladze, S. Tkachenko, L. Todor, C. Tur, M. Ungaro, M. F. Vineyard, A. V. Vlassov, D. P. Weygand, M. Williams, E. Wolin, M. H. Wood, A. Yegneswaran, J. Yun, L. Zana, and J. Zhang [The CLAS collaboration]: "Measurement of Two- and Three-Nucleon Short-Range Correlation Probabilities in Nuclei", Phys. Rev. Lett. **96**, 082501 (2006).

[4] R. Shneor, P. Monaghan, R. Subedi, B. D.,erson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, P. Bertin, W. Bertozzi, W. Boeglin, J. P. Chen, Seonho Choi, E. Chudakov, E. Cisbani, B. Craver, C. W. de Jager, R. J. Feuerbach, S. Frullani, F. Garibaldi, O. Gayou, S. Gilad, R. Gilman, O. Glamazdin, J. Gomez, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, E. Jans, X. Jiang, Y. Jiang, L. Kaufman, A. Kelleher, A. Kolarkar, E. Kuchina, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, S. Nanda, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, B. Reitz, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Sirca, K. Slifer, P. Solvignon, V. Sulkosky, N. Thompson, P. E. Ulmer, G. M. Urciuoli, E. Voutier, K. Wang, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, H. Yao, X. Zheng, and L. Zhu [Jefferson Lab Hall A Collaboration]: "Investigation of Proton-Proton Short-Range Correlations via the ^{12}C$(e, e'pp)$ Reaction", Phys. Rev. Lett. **99**, 072501 (2007).

[5] R. Subedi, R. Shneor, P. Monaghan, B. D. Anderson, K. Aniol, J. Annand, J. Arrington, H. Benaoum, F. Benmokhtar, W. Boeglin, J.-P. Chen, Seonho Choi, E. Cisbani, B. Craver, S. Frullani, F. Garibaldi, S. Gilad, R. Gilman, O. Glamazdin, J.-O. Hansen, D. W. Higinbotham, T. Holmstrom, H. Ibrahim, R. Igarashi, C. W. de Jager, E. Jans,

X. Jiang, L. J. Kaufman, A. Kelleher, A. Kolarkar, G. Kumbartzki, J. J. LeRose, R. Lindgren, N. Liyanage, D. J. Margaziotis, P. Markowitz, S. Marrone, M. Mazouz, D. Meekins, R. Michaels, B. Moffit, C. F. Perdrisat, E. Piasetzky, M. Potokar, V. Punjabi, Y. Qiang, J. Reinhold, G. Ron, G. Rosner, A. Saha, B. Sawatzky, A. Shahinyan, S. Sirca, K. Slifer, P. Solvignon, V. Sulkosky, G. M. Urciuoli, E. Voutier, J. W. Watson, L. B. Weinstein, B. Wojtsekhowski, S. Wood, X.-C. Zheng, and L. Zhu, "Probing Cold Dense Nuclear Matter", Science **320**, 1475 (2008).

[6] J. Aclander, J. Alster, D. Barton, G. Bunce, A. Carroll, N. Christensen, H. Courant, S. Durrant, S. Gushue, S. Heppelmann, E. Kosonovsky, I. Mardor, Y. Mardor, M. Marshak, Y. Makdisi, E.D. Minor, I. Navon, H. Nicholson, E. Piasetzky, T. Roser, J. Russell, M. Sargsian, C.S. Sutton, M. Tanaka, C. White and J-Y. Wu, "The large momentum transfer reaction ^{12}C$(p, 2p+n)$ as a new method for measuring short range NN correlations in nuclei", Phys. Lett. **B453**, 211 (1999).

[7] A. Tang, J. W. Watson, J. Aclander, J. Alster, G. Asryan, Y. Averichev, D. Barton, V. Baturin, N. Bukhtoyarova, A. Carroll, S. Gushue, S. Heppelmann, A. Leksanov, Y. Makdisi, A. Malki, E. Minina, I. Navon, H. Nicholson, A. Ogawa, Yu. Panebratsev, E. Piasetzky, A. Schetkovsky, S. Shimanskiy, and D. Zhalov, "$n - p$ Short-Range Correlations from $(p, 2p + n)$ Measurements", Phys. Rev. Lett. **90**, 042301 (2003).

[8] E. Piasetzky, M. Sargsian, L. Frankfurt, M. Strikman, and J. W. Watson, "Evidence for Strong Dominance of Proton-Neutron Correlations in Nuclei", Phys. Rev. Lett. **97**, 162504 (2006).

[9] R. Niyazov, L. B. Weinstein, G. Adams, P. Ambrozewicz, E. Anciant, M. Anghinolfi, B. Asavapibhop, G. Asryan, G. Audit, T. Auger, H. Avakian, H. Bagdasaryan, J. P. Ball, S. Barrow, M. Battaglieri, K. Beard, M. Bektasoglu, M. Bellis, N. Benmouna, B. L. Berman, N. Bianchi, A. S. Biselli, S. Boiarinov, B. E. Bonner, S. Bouchigny, R. Bradford, D. Branford, W. K. Brooks, V. D. Burkert, C. Butuceanu, J. R. Calarco, D. S. Carman, B. Carnahan, C. Cetina, S. Chen, L. Ciciani, P. L. Cole, A. Coleman, D. Cords, P. Corvisiero, D. Crabb, H. Crannell, J. P. Cummings, E. De Sanctis, N. Dashyan, R. DeVita, P. V. Degtyarenko, H. Denizli, L. Dennis, K. V. Dharmawardane, K. S. Dhuga, C. Djalali, G. E. Dodge, D. Doughty, P. Dragovitsch, M. Dugger, S. Dytman, O. P. Dzyubak, M. Eckhause, H. Egiyan, K. S. Egiyan, L. Elouadrhiri, A. Empl, P. Eugenio, R. Fatemi, R. J. Feuerbach, J. Ficenec, T. A. Forest, H. Funsten, G. Gavalian, G. P. Gilfoyle, K. L. Giovanetti, P. Girard, C. I. O. Gordon, R. W. Gothe, K. Griffioen, M. Guidal, M. Guillo, L. Guo, V. Gyurjyan, C. Hadjidakis, R. S. Hakobyan, J. Hardie, D. Heddle, F. W. Hersman, K. Hicks, M. Holtrop, J. Hu, C. E. Hyde-Wright, Y. Ilieva, W. Ingram, M. M. Ito, D. Jenkins, K. Joo, H. G. Juengst, J. H. Kelley, J. Kellie, M. Khandaker, D. H. Kim, K. Y. Kim, K. Kim, M. S. Kim, W. Kim, A. Klein, F. J. Klein, A. V. Klimenko, M. Klusman, M. Kossov, L. H.

Kramer, Y. Kuang, S. E. Kuhn, J. Kuhn, J. Lachniet, J. M. Laget, J. Langheinrich, D. Lawrence, Ji Li, K. Livingston, K. Lukashin, J. J. Manak, C. Marchand, S. McAleer, S. McLauchlan, J. W. C. McNabb, B. A. Mecking, S. Mehrabyan, J. J. Melone, M. D. Mestayer, C. A. Meyer, K. Mikhailov, M. Mirazita, R. Miskimen, L. Morand, S. A. Morrow, V. Muccifora, J. Mueller, G. S. Mutchler, J. Napolitano, R. Nasseripour, S. O. Nelson, S. Niccolai, G. Niculescu, I. Niculescu, B. B. Niczyporuk, M. Nozar, G. V. O'Rielly, M. Osipenko, K. Park, E. Pasyuk, G. Peterson, S. A. Philips, N. Pivnyuk, D. Pocanic, O. Pogorelko, E. Polli, S. Pozdniakov, B. M. Preedom, J. W. Price, Y. Prok, D. Protopopescu, L. M. Qin, B. A. Raue, G. Riccardi, G. Ricco, M. Ripani, B. G. Ritchie, F. Ronchetti, P. Rossi, D. Rowntree, P. D. Rubin, F. Sabati, K. Sabourov, C. Salgado, J. P. Santoro, V. Sapunenko, R. A. Schumacher, V. S. Serov, A. Shafi, Y. G. Sharabian, J. Shaw, S. Simionatto, A. V. Skabelin, E. S. Smith, L. C. Smith, D. I. Sober, M. Spraker, A. Stavinsky, S. Stepanyan, P. Stoler, I. I. Strakovsky, S. Strauch, M. Taiuti, S. Taylor, D. J. Tedeschi, U. Thoma, R. Thompson, L. Todor, C. Tur, M. Ungaro, M. F. Vineyard, A. V. Vlassov, K. Wang, H. Weller, D. P. Weygand, C. S. Whisnant, E. Wolin, M. H. Wood, A. Yegneswaran, J. Yun, and B. Zhang [The CLAS collaboration]: "Two-Nucleon Momentum Distributions Measured in ^{3}He$(e, e'pp)$n", Phys. Rev. Lett. **92**, 052303 (2004).

[10] H. Baghdasaryan, Ph.D. Thesis, "Measurements of Correlated Pair Momentum Distributions in ^{3}He$(e, e'pp)n$ with CLAS", Old Dominion University (2007).

[11] Baghdasaryan, H. and Weinstein, L. B. and Laget, J. M. and Adhikari, K. P. and Aghasyan, M. and Amarian, M. and Anghinolfi, M. and Avakian, H. and Ball, J. and Battaglieri, M. and Bedlinskiy, I. and Bennett, R. P. and Berman, B. L. and Biselli, A. S. and Bookwalter, C. and Briscoe, W. J. and Brooks, W. K. and Bültmann, S. and Burkert, V. D. and Carman, D. S. and Crede, V. and D'Angelo, A. and Daniel, A. and Dashyan, N. and De Vita, R. and De Sanctis, E. and Deur, A. and Dey, B. and Dickson, R. and Djalali, C. and Dodge, G. E. and Doughty, D. and Dupre, R. and Egiyan, H. and El Alaoui, A. and El Fassi, L. and Eugenio, P. and Fegan, S. and Gabrielyan, M. Y. and Gilfoyle, G. P. and Giovanetti, K. L. and Gohn, W. and Gothe, R. W. and Griffioen, K. A. and Guidal, M. and Guo, L. and Gyurjyan, V. and Hakobyan, H. and Hanretty, C. and Hyde, C. E. and Hicks, K. and Holtrop, M. and Ilieva, Y. and Ireland, D. G. and Joo, K. and Keller, D. and Khandaker, M. and Khetarpal, P. and Kim, A. and Kim, W. and Klein, A. and Klein, F. J. and Konczykowski, P. and Kubarovsky, V. and Kuhn, S. E. and Kuleshov, S. V. and Kuznetsov, V. and Kvaltine, N. D. and Livingston, K. and Lu, H. Y. and MacGregor, I. J. D. and Markov, N. and Mayer, M. and McAndrew, J. and McKinnon, B. and Meyer, C. A. and Mikhailov, K. and Mokeev, V. and Moreno, B. and Moriya, K. and Morrison, B. and Moutarde, H. and Munevar, E. and Nadel-Turonski, P. and Nepali, C. and Niccolai, S. and Niculescu, G. and Niculescu, I. and Osipenko, M. and Ostrovidov, A. I. and Paremuzyan, R. and Park, K. and Park, S. and Pasyuk, E. and

Pereira, S. Anefalos and Pisano, S. and Pogorelko, O. and Pozdniakov, S. and Price, J. W. and Procureur, S. and Protopopescu, D. and Ricco, G. and Ripani, M. and Rosner, G. and Rossi, P. and Sabatié, F. and Salgado, C. and Schumacher, R. A. and Seraydaryan, H. and Smith, G. D. and Sober, D. I. and Sokhan, D. and Stepanyan, S. S. and Stepanyan, S. and Stoler, P. and Strauch, S. and Taiuti, M. and Tang, W. and Taylor, C. E. and Tedeschi, D. J. and Ungaro, M. and Vineyard, M. F. and Voutier, E. and Watts, D. P. and Weygand, D. P. and Wood, M. H. and Zhao, B. and Zhao, Z. W. (the CLAS Collaboration), "Tensor Correlations Measured in $^3He(e,e^{'}pp)n$", Phys. Rev. Lett **105** (2010), p. 222501.

[12] S. Strauch, S. Dieterich, K. A. Aniol, J. R. M. Annand, O. K. Baker,, W. Bertozzi, M. Boswell, E. J. Brash, Z. Chai, J.-P. Chen, M. E. Christy, E. Chudakov, A. Cochran, R. De Leo, R. Ent, M. B. Epstein, J. M. Finn, K. G. Fissum, T. A. Forest, S. Frullani, F. Garibaldi, A. Gasparian, O. Gayou,, S. Gilad, R. Gilman,, C. Glashausser, J. Gomez, V. Gorbenko, P. L. J. Gueye, J. O. Hansen, D. W. Higinbotham, B. Hu, C. E. Hyde-Wright, D. G. Ireland, C. Jackson, C. W. de Jager, X. Jiang, C. Jones, M. K. Jones, J. D. Kellie, J. J. Kelly, C. E. Keppel, G. Kumbartzki, M. Kuss, J. J. LeRose, K. Livingston, N. Liyanage, S. Malov, D. J. Margaziotis, D. Meekins, R. Michaels, J. H. Mitchell, S. K. Nanda, J. Nappa, C. F. Perdrisat, V. A. Punjabi, R. D. Ransome, R. Roch, G. Rosner, M. Rvachev, F. Sabatie, A. Saha, A. Sarty, J. M. Udias, P. E. Ulmer, G. M. Urciuoli, J. F. J. van den Brand, J. R. Vignote, D. P. Watts, L. B. Weinstein, K. Wijesooriya, and B. Wojtsekhowski [The Jefferson Lab E93-049 Collaboration], "Polarization Transfer in the ^{4}He$(e \rightarrow ,e'p \rightarrow)^3$H Reaction up to $Q^2 = 2.6$ (GeV/c)^2", Phys. Rev. Lett. 91 (2003), p. 052301; S. Malace, M. Paolone, S. Strauch and the Jefferson Lab Hall A Collaboration, "Medium Modifications from ^{4}He$(e \rightarrow ,e'p \rightarrow)^3$H", arXiv: 0807.2252 [nucl-ex].

[13] Jefferson Lab Experiment E01-020, spokespersons W. Boeglin, M. Jones, A. Klein, P. Ulmer, J. Mitchell, E. Voutier (2001).

[14] K.Sh. Egiyan, G. Asryan, N. Gevorgyan, K. A. Griffioen, J. M. Laget, S. E. Kuhn, G. Adams, M. J. Amaryan, P. Ambrozewicz, M. Anghinolfi, G. Audit, H. Avakian, H. Bagdasaryan, N. Baillie, J. P. Ball, N. A. Baltzell, S. Barrow, V. Batourine, M. Battaglieri, I. Bedlinskiy, M. Bektasoglu, M. Bellis, N. Benmouna, B. L. Berman, A. S. Biselli, L. Blaszczyk, S. Bouchigny, S. Boiarinov, R. Bradford, D. Branford, W. J. Briscoe, W. K. Brooks, S. Bltmann, V. D. Burkert, C. Butuceanu, J. R. Calarco, S. L. Careccia, D. S. Carman, A. Cazes, S. Chen, P. L. Cole, P. Collins, P. Coltharp, D. Cords, P. Corvisiero, D. Crabb, V. Crede, J. P. Cummings, N. Dashyan, R. De Masi, R. De Vita, E. De Sanctis, P. V. Degtyarenko, H. Denizli, L. Dennis, A. Deur, K. V. Dharmawardane, R. Dickson, C. Djalali, G. E. Dodge, J. Donnelly, D. Doughty, M. Dugger, S. Dytman, O. P. Dzyubak, H. Egiyan, L. El Fassi, L. Elouadrhiri, P. Eugenio, R. Fatemi, G. Fedotov, G. Feldman, R. J. Feuerbach, R. Fersch, M. Garon,

G. Gavalian, G. P. Gilfoyle, K. L. Giovanetti, F. X. Girod, J. T. Goetz, A. Gonenc, C. I. O. Gordon, R. W. Gothe, M. Guidal, M. Guillo, N. Guler, L. Guo, V. Gyurjyan, C. Hadjidakis, K. Hafidi, H. Hakobyan, R. S. Hakobyan, C. Hanretty, J. Hardie, F. W. Hersman, K. Hicks, I. Hleiqawi, M. Holtrop, C. E. Hyde-Wright, Y. Ilieva, D. G. Ireland, B. S. Ishkhanov, E. L. Isupov, M. M. Ito, D. Jenkins, H. S. Jo, K. Joo, H. G. Juengst, N. Kalantarians, J. D. Kellie, M. Khandaker, W. Kim, A. Klein, F. J. Klein, A. V. Klimenko, M. Kossov, Z. Krahn, L. H. Kramer, V. Kubarovsky, J. Kuhn, S. V. Kuleshov, J. Lachniet, J. Langheinrich, D. Lawrence, Ji Li, K. Livingston, H. Y. Lu, M. MacCormick, C. Marchand, N. Markov, P. Mattione, S. McAleer, B. McKinnon, J. W. C. McNabb, B. A. Mecking, S. Mehrabyan, J. J. Melone, M. D. Mestayer, C. A. Meyer, T. Mibe, K. Mikhailov, R. Minehart, M. Mirazita, R. Miskimen, V. Mokeev, K. Moriya, S. A. Morrow, M. Moteabbed, J. Mueller, E. Munevar, G. S. Mutchler, P. Nadel-Turonski, R. Nasseripour, S. Niccolai, G. Niculescu, I. Niculescu, B. B. Niczyporuk, M. R. Niroula, R. A. Niyazov, M. Nozar, G. V. O'Rielly, M. Osipenko, A. I. Ostrovidov, K. Park, E. Pasyuk, C. Paterson, S. Anefalos Pereira, J. Pierce, N. Pivnyuk, D. Pocanic, O. Pogorelko, S. Pozdniakov, B. M. Preedom, J. W. Price, Y. Prok, D. Protopopescu, B. A. Raue, G. Riccardi, G. Ricco, M. Ripani, B. G. Ritchie, F. Ronchetti, G. Rosner, P. Rossi, F. Sabati, J. Salamanca, C. Salgado, J. P. Santoro, V. Sapunenko, R. A. Schumacher, V. S. Serov, Y. G. Sharabian, N. V. Shvedunov, A. V. Skabelin, E. S. Smith, L. C. Smith, D. I. Sober, D. Sokhan, A. Stavinsky, S. S. Stepanyan, S. Stepanyan, B. E. Stokes, P. Stoler, S. Strauch, M. Taiuti, D. J. Tedeschi, U. Thoma, A. Tkabladze, S. Tkachenko, L. Todor, C. Tur, M. Ungaro, M. F. Vineyard, A. V. Vlassov, D. P. Watts, L. B. Weinstein, D. P. Weygand, M. Williams, E. Wolin, M. H. Wood, A. Yegneswaran, L. Zana, J. Zhang, B. Zhao, and Z. W. Zhao [The CLAS collaboration]: "Experimental Study of Exclusive ^{2}H(e,ep)n Reaction Mechanisms at High Q^2", Phys. Rev. Lett. **98**, 262502 (2007).

[15] Jefferson Lab Experiment E94-017, spokespersons W. Brooks, M. Vineyard (1994).

[16] A. Klimenko, S. E. Kuhn, C. Butuceanu, K. S. Egiyan, K. A. Griffioen, G. Adams, P. Ambrozewicz, M. Anghinolfi, G. Asryan, H. Avakian, H. Bagdasaryan, N. Baillie, J. P. Ball, N. A. Baltzell, S. Barrow, V. Batourine, M. Battaglieri, I. Bedlinskiy, M. Bektasoglu, M. Bellis, N. Benmouna, A. S. Biselli, S. Bouchigny, S. Boiarinov, R. Bradford, D. Branford, W. K. Brooks, S. Bltmann, V. D. Burkert, J. R. Calarco, S. L. Careccia, D. S. Carman, A. Cazes, S. Chen, P. L. Cole, P. Coltharp, D. Cords, P. Corvisiero, D. Crabb, J. P. Cummings, N. B. Dashyan, R. DeVita, E. De Sanctis, P. V. Degtyarenko, H. Denizli, L. Dennis, K. V. Dharmawardane, C. Djalali, G. E. Dodge, J. Donnelly, D. Doughty, M. Dugger, S. Dytman, O. P. Dzyubak, H. Egiyan, L. Elouadrhiri, P. Eugenio, R. Fatemi, G. Fedotov, R. G. Fersch, R. J. Feuerbach, H. Funsten, M. Garon, G. Gavalian, G. P. Gilfoyle, K. L. Giovanetti, F. X. Girod, J. T. Goetz, A. Gonenc, C. I. O. Gordon, R. W. Gothe, M. Guidal, M. Guillo, N. Guler, L. Guo, V. Gyurjyan, C. Hadjidakis, R. S. Hakobyan, J. Hardie, F. W. Hersman, K.

Hicks, I. Hleiqawi, M. Holtrop, C. E. Hyde-Wright, Y. Ilieva, D. G. Ireland, B. S. Ishkhanov, M. M. Ito, D. Jenkins, H. S. Jo, K. Joo, H. G. Juengst, J. D. Kellie, M. Khandaker, W. Kim, A. Klein, F. J. Klein, M. Kossov, L. H. Kramer, V. Kubarovsky, J. Kuhn, S. V. Kuleshov, J. Lachniet, J. M. Laget, J. Langheinrich, D. Lawrence, Ji Li, K. Livingston, S. McAleer, B. McKinnon, J. W. C. McNabb, B. A. Mecking, S. Mehrabyan, J. J. Melone, M. D. Mestayer, C. A. Meyer, T. Mibe, K. Mikhailov, R. Minehart, M. Mirazita, R. Miskimen, V. Mokeev, L. Morand, S. A. Morrow, J. Mueller, G. S. Mutchler, P. Nadel-Turonski, J. Napolitano, R. Nasseripour, S. Niccolai, G. Niculescu, I. Niculescu, B. B. Niczyporuk, R. A. Niyazov, M. Nozar, G. V. O'Rielly, M. Osipenko, A. I. Ostrovidov, K. Park, E. Pasyuk, C. Paterson, J. Pierce, N. Pivnyuk, D. Pocanic, O. Pogorelko, S. Pozdniakov, B. M. Preedom, J. W. Price, Y. Prok, D. Protopopescu, B. A. Raue, G. Riccardi, G. Ricco, M. Ripani, B. G. Ritchie, F. Ronchetti, G. Rosner, P. Rossi, F. Sabati, C. Salgado, J. P. Santoro, V. Sapunenko, R. A. Schumacher, V. S. Serov, Y. G. Sharabian, A. V. Skabelin, E. S. Smith, L. C. Smith, D. I. Sober, A. Stavinsky, S. S. Stepanyan, S. Stepanyan, B. E. Stokes, P. Stoler, S. Strauch, M. Taiuti, D. J. Tedeschi, U. Thoma, A. Tkabladze, S. Tkachenko, L. Todor, C. Tur, M. Ungaro, M. F. Vineyard, A. V. Vlassov, L. B. Weinstein, D. P. Weygand, M. Williams, E. Wolin, M. H. Wood, A. Yegneswaran, L. Zana, J. Zhang, and B. Zhao [The CLAS collaboration]: "Electron scattering from high-momentum neutrons in deuterium", Phys. Rev. C **73**, 035212 (2006). (nucl-ex/0510032)

[17] L.B. Weinstein, E. Piasetzky, D.W. Higinbotham, J. Gomez, O. Hen, R. Shneor, "Short Range Correlations and the EMC Effect", submitted to Phys. Rev. Lett.; arXiv:1009.5666v2 [hep-ph].

[18] B. Clasie, X. Qian, J. Arrington, R. Asaturyan, F. Benmokhtar, W. Boeglin, P. Bosted, A. Bruell, M. E. Christy, E. Chudakov, W. Cosyn, M. M. Dalton, A. Daniel, D. Day, D. Dutta, L. El Fassi, R. Ent, H. C. Fenker, J. Ferrer, N. Fomin, H. Gao, K. Garrow, D. Gaskell, C. Gray, T. Horn, G. M. Huber, M. K. Jones, N. Kalantarians, C. E. Keppel, K. Kramer, A. Larson, Y. Li, Y. Liang, A. F. Lung, S. Malace, P. Markowitz, A. Matsumura, D. G. Meekins, T. Mertens, G. A. Miller, T. Miyoshi, H. Mkrtchyan, R. Monson, T. Navasardyan, G. Niculescu, I. Niculescu, Y. Okayasu, A. K. Opper, C. Perdrisat, V. Punjabi, A. W. Rauf, V. M. Rodriquez, D. Rohe, J. Ryckebusch, J. Seely, E. Segbefia, G. R. Smith, M. Strikman, M. Sumihama, V. Tadevosyan, L. Tang, V. Tvaskis, A. Villano, W. F. Vulcan, F. R. Wesselmann, S. A. Wood, L. Yuan and X. C. Zheng, "Measurement of Nuclear Transparency for the $A(e, e'\pi^+)$ Reaction", Phys. Rev. Lett. **99**, 242502 (2007).

[19] Jefferson Lab Experiment E02-110, "Q^2 Dependence of Nuclear Transparency for Incoherent ρ^0 Electroproduction", spokespersons: K. Hafidi, M. Holtrop, B. Mustapha.

[20] H. A. Bethe, "Theory of nuclear matter," Ann. Rev. Nucl. Part. Sci. **21**, 93 (1971).

[21] L. L. Frankfurt, M. I. Strikman, D. B. Day, M. Sargsian, "Evidence for short-range correlations from high Q^2 (e, e') reactions", Phys. Rev. **C48**, 2451 (1993).

[22] L. L. Frankfurt, M. I. Strikman, "High-energy phenomena, short-range nuclear structure and QCD", Phys. Rept. **76**, 215 (1981).

[23] R. Schiavilla, R. B. Wiringa, S. C. Pieper, J. Carlson, "Tensor Forces and the Ground-State Structure of Nuclei", Phys. Rev. Lett. **98**, 132501 (2007).

[24] M. M. Sargsian, T. V. Abrahamyan, M. I. Strikman, L. L. Frankfurt, "Exclusive electrodisintegration of ^{3}He at high Q^2. II. Decay function formalism", Phys. Rev. **C71**, 044615 (2005).

[25] M. Alvioli, C. Ciofi degli Atti and H. Morita, "Proton-Neutron and Proton-Proton Correlations in Medium-Weight Nuclei and the Role of the Tensor Force", Phys. Rev. Lett. **100**, 162503 (2008).

[26] J. Golak, H. Kamada, H. Witala, W. Glockle, and S. Ishikawa, "Electron induced *pd* and *ppn* breakup of ^{3}He with full inclusion of final-state interactions", Phys. Rev. C **51**, 1638 (1995).

[27] Jefferson Lab Experiment E03-012 "BoNuS", S.E. Kuhn, H. Fenker, C. Keppel, and W. Melnitchouk, co-spokespersons (2003).

[28] G.P. Gilfoyle *et al.* (the CLAS Collaboration), "Measuring the Fifth Structure Function in $D(e, e'p)n$", poster presented at the Gordon Conference on Photonuclear Reactions in Tilton, New Hampshire, August 15, 2008

[29] Z.-L. Zhou et al. Relativistic effects and two-body currents in $^2\mathrm{H}(\vec{e}, e'p)n$ using out-of-plane detection. *Phys. Rev. Lett.*, 87(17):172301, Oct 2001.

[30] J. Yun, S.E. Kuhn, G.E. Dodge, T.A. Forest, M. Taiuti, G.S. Adams, M.J. Amaryan, E. Anciant, M. Anghinolfi, D.S. Armstrong, B. Asavapibhop, G. Asryan, G. Audit, T. Auger, H. Avakian, S. Barrow, M. Battaglieri, K. Beard, M. Bektasoglu, B.L. Berman, W. Bertozzi, N. Bianchi, A.S. Biselli, S. Boiarinov, B.E. Bonner, P. Bosted, S. Bouchigny, D. Branford, W.J. Briscoe, W.K. Brooks, S. Bueltmann, V.D. Burkert, J.R. Calarco, G.P. Capitani, D.S. Carman, B. Carnahan, C. Cetina, L. Ciciani, R. Clark, P.L. Cole, A. Coleman, J. Connelly, D. Cords, P. Corvisiero, D. Crabb, H. Crannell, J. Cummings, E. De Sanctis, R. De Vita, P.V. Degtyarenko, R.A. Demirchyan, H. Denizli, L.C. Dennis, A. Deppman, K.V. Dharmawardane, K.S. Dhuga, C. Djalali, J. Domingo, D. Doughty, P. Dragovitsch, M. Dugger, S. Dytman, M. Eckhause, Y.V. Efremenko, H. Egiyan, K.S. Egiyan, L. Elouadrhiri, A. Empl, L. Farhi, R. Fatemi, R.J. Feuerbach, J. Ficenec, K. Fissum, A. Freyberger, V. Frolov, H. Funsten, S.J. Gaff, M. Gai, G. Gavalian, V.B. Gavrilov, S. Gilad, G.P. Gilfoyle, K.L. Giovanetti,

P. Girard, E. Golovatch, K.A. Griffoen, M. Guidal, M. Guillo, V. Gyurjyan, D. Hancock, J. Hardie, D. Heddle, P. Heimberg, J. Heisenberg, F.W. Hersman, K. Hicks, R.S. Hicks, M. Holtrop, J. Hu, C.E. Hyde-Wright, M.M. Ito, D. Jenkins, K. Joo, J.H. Kelley, M. Khandaker, K.Y. Kim, D.H. Kim, K. Kim, W. Kim, A. Klein, F.J. Klein, M. Klusman, M. Kossov, L.H. Kramer, Y. Kuang, J.M. Laget, D. Lawrence, G.A. Leksin, A. Longhi, K. Loukachine, M. Lucas, R.W. Major, J.J. Manak, C. Marchand, S.K. Matthews, L.C. Maximon, S. McAleer, J.W.C. McNabb, J. McCarthy, B.A. Mecking, M.D. Mestayer, C.A. Meyer, R. Minehart, M. Mirazita, R. Miskimen, V. Mokeev, V. Muccifora, J. Mueller, L.Y. Murphy, G.S. Mutchler, J. Napolitano, S.O. Nelson, G. Niculescu, B. Niczyporuk, R.A. Niyazov, J.T. O'Brien, G.V. O'Rielly, M.S. Ohandjanyan, A. Opper, M. Ossipenko, K. Park, Y. Patois, G.A. Peterson, S. Philips, N. Pivnyuk, D. Pocanic, O. Pogorelko, E. Polli, B.M. Preedom, J.W. Price, L.M. Qin, B.A. Raue, A.R. Reolon, G. Riccardi, G. Ricco, M. Ripani, B.G. Ritchie, S. Rock, F. Ronchetti, P. Rossi, D. Rowntree, P.D. Rubin, K. Sabourov, C.W. Salgado, M. Sanzone, V. Sapunenko, M. Sargsyan, R.A. Schumacher, V.S. Serov, A. Shafi, Y.G. Sharabian, J. Shaw, S.M. Shuvalov, S. Simionatto, A. Skabelin, E.S. Smith, L.C. Smith, T. Smith, D.I. Sober, L. Sorrell, M. Spraker, S. Stepanyan, P. Stoler, I.I. Strakovsky, S. Taylor, D. Tedeschi, R. Thompson, L. Todor, T.Y. Tung, M.F. Vineyard, A. Vlassov, K. Wang, L.B. Weinstein, A. Weisberg, H. Weller, R. Welsh, D.P. Weygand, S. Whisnant, M. Witkowski, E. Wolin, L. Yanik, A. Yegneswaran, B. Zhang, J. Zhao, and Z. Zhou [The CLAS collaboration]: "Measurement of Inclusive Spin Structure Functions of the Deuteron with CLAS", Phys. Rev. C **67**, 055204 (13 pages) (May 2003).

[31] P. V. Degtyarenko, Yu. V. Efremenko, V. B. Gavrilov and G. A. Leksin, "Production of Cumulative Delta(1232) in eA Interactions at 5 GeV", Preprint ITEP-90-12 (1990).

[32] J. Donnelly, D. Protopopescu and D.G. Ireland, *Multipole analysis of* $\Delta(1232)$ *in* ^3He, CLAS-ANALYSIS 2006-101, 2006.

[33] D. Protopopescu, D. Watts and D.G. Ireland, *CAA proposal on study of three-body forces in* $^3He(e,e'p)n$ *reactions*, CLAS CAA, 2005.

[34] Perkins, Philos. Mag. **46**, 1146 (1955).

[35] T. Virkus, H. D. Thomsen, E. Uggerhoj, U. I. Uggerhoj, S. Ballestrero, P. Sona, A. Mangiarotti, T. J. Ketel, A. Dizdar, S. Kartal, and C. Pagliarone, "Direct Measurement of the Chudakov Effect" Phys. Rev. Lett. **100**, 164802 (2008).

[36] J.C. Collins, L. Frankfurt, M. Strikman, "Factorization for hard exclusive electroproduction of mesons in QCD", Phys. Rev. D **56**, 2982 (1997).

[37] E. M. Aitala, S. Amato, J. C. Anjos, J. A. Appel, D. Ashery, S. Banerjee, I. Bediaga, G. Blaylock, S. B. Bracker, P. R. Burchat, R. A. Burnstein, T. Carter, H. S.

Carvalho, N. K. Copty, L. M. Cremaldi, C. Darling, K. Denisenko, S. Devmal, A. Fernandez, G. F. Fox, P. Gagnon, S. Gerzon, C. Gobel, K. Gounder, A. M. Halling, G. Herrera, G. Hurvits, C. James, P. A. Kasper, S. Kwan, D. C. Langs, J. Leslie, J. Lichtenstadt, B. Lundberg, S. MayTal-Beck, B. Meadows, J. R. T. de Mello Neto, D. Mihalcea, R. H. Milburn, J. M. de Miranda, A. Napier, A. Nguyen, A. B. d'Oliveira,, K. O'Shaughnessy, K. C. Peng, L. P. Perera, M. V. Purohit, B. Quinn, S. Radeztsky, A. Rafatian, N. W. Reay, J. J. Reidy, A. C. dos Reis, H. A. Rubin, D. A. Sanders, A. K. S. Santha, A. F. S. Santoro, A. J. Schwartz, M. Sheaff, R. A. Sidwell, A. J. Slaughter, M. D. Sokoloff, J. Solano, N. R. Stanton, R. J. Stefanski, K. Stenson, D. J. Summers, S. Takach, K. Thorne, A. K. Tripathi, S. Watanabe, R. Weiss-Babai, J. Wiener, N. Witchey, E. Wolin, S. M. Yang, D. Yi, S. Yoshida, R. Zaliznyak, and C. Zhang [Fermilab E791 Collaboration], "Observation of Color-Transparency in Diffractive Dissociation of Pions", Phys. Rev. Lett. **86**, 4773 (2001); also "Direct Measurement of the Pion Valence-Quark Momentum Distribution, the Pion Light-Cone Wave Function Squared", **86**,4768 (2001).

[38] L. Frankfurt, G. A. Miller and M. Strikman, "Coherent nuclear diffractive production of mini - jets: Illuminating color transparency," Phys. Lett. B **304** (1993) 1.

[39] R. L. Anderson, W. W. Ash, D. B. Gustavson, T. Reichelt , D. M. Ritson, D. J. Sherden, C. K. Sinclair, U. Camerini, J. G. Learned, R. Prepost, and D. E. Wiser, "Measurement of the A Dependence of J/Ψ Photoproduction", Phys. Rev. Lett. **38** (1977) 263.

[40] M. D. Sokoloff, J. C. Anjos, J. A. Appel, S. B. Bracker, T. E. Browder, L. M. Cremaldi, J. R. Elliott, C. O. Escobar, P. Estabrooks, M. C. Gibney, G. F. Hartner, P. E. Karchin, B. R. Kumar, M. J. Losty, G. J. Luste, P. M. Mantsch, J. F. Martin, S. McHugh, S. R. Menary, R. J. Morrison, T. Nash, P. Ong, J. Pinfold, M. V. Purohit, J. R. Raab, A. F. S. Santoro, J. S. Sidhu, K. Sliwa, M. H. G. Souza, W. J. Spalding, M. E. Streetman, A. B. Stundzia, and M. S. Witherell, "Experimental Study of the A Dependence of J/Ψ Photoproduction", Phys. Rev. Lett. **57** (1986) 3003.

[41] ZEUS Collaboration , M. Derrick, D. Krakauer, S. Magill, D. Mikunas, B. Musgrave, J. Repond, R. Stanek, R. L. Talaga, H. Zhang, R. Ayad, G. Bari, M. Basile, L. Bellagamba, D. Boscherini, A. Bruni, G. Bruni, P. Bruni, G. Cara Romeo, G. Castellini, M. Chiarini, L. Cifarelli, F. Cindolo, A. Contin, M. Corradi, I. Gialas, P. Giusti, G. Iacobucci, G. Laurenti, G. Levi, A. Margotti, T. Massam, R. Nania, C. Nemoz, F. Palmonari, A. Polini, G. Sartorelli, R. Timellini, Y. Zamora Garcia1, A. Zichichi, A. Bargende, J. Crittenden, K. Desch, B. Diekmann, T. Doeker, M. Eckert, L. Feld, A. Frey, M. Geerts, M. Grothe, H. Hartmann, K. Heinloth, E. Hilger, H. -P. Jakob, U. F. Katz, S. M. Mari, S. Mengel, J. Mollen, E. Paul, M. Pfeiffer, Ch. Rembser, D. Schramm, J. Stamm, R. Wedemeyer, S. Campbell-Robson, A. Cassidy, N. Dyce, B.

Foster, S. George, R. Gilmore, G. P. Heath, H. F. Heath, T. J. Llewellyn, C. J. S. Morgado, D. J. P. Norman, J. A. O'Mara, R. J. Tapper, S. S. Wilson, R. Yoshida, R. R. Rau, M. Arneodo, M. Capua, A. Garfagnini, L. Iannotti, M. Schioppa, G. Susinno, A. Bernstein, A. Caldwell, N. Cartiglia, J. A. Parsons, S. Ritz, F. Sciulli, P. B. Straub, L. Wai, S. Yang, Q. Zhu, P. Borzemski, J. Chwastowski, A. Eskreys, K. Piotrzkowski, M. Zachara, L. Zawiejski, L. Adamczyk, B. Bednarek, K. JeleImage , D. Kisielewska, T. Kowalski, E. Rulikowska-ZarImage bska, L. Suszycki, J. ZajImage c, A. KotaImage ski, M. PrzybycieImage , L. A. T. Bauerdick, U. Behrens, H. Beier, J. K. Bienlein, C. Coldewey, O. Deppe, K. Desler, G. Drews, M. FlasiImage ski, D. J. Gilkinson, C. Glasman, P. Gttlicher, J. Grose-Knetter, B. Gutjahr, T. Haas, W. Hain, D. Hasell, H. Heling, Y. Iga, K. Johnson, P. Joos, M. Kasemann, R. Klanner, W. Koch, L. Kopke, U. Kotz, H. Kowalski, J. Labs, A. Ladage, B. Lohr, M. Lowe, D. Loke, J. Mainusch, O. MaImage czak, T. Monteiro, J. S. T. Ng, S. Nickel, D. Notz, K. Ohrenberg, M. Roco, M. Rohde, J. Roldn, U. Schneekloth, W. Schulz, F. Selonke, E. Stiliaris, B. Surrow, T. Vo, D. Westphal, G. Wolf, C. Youngman, W. Zeuner, J. F. Zhou, H. J. Grabosch, A. Kharchilava, A. Leich, M. C. K. Mattingly, A. Meyer, S. Schlenstedt, N. Wulff, G. Barbagli, P. Pelfer, G. Anzivino, G. Maccarrone, S. De Pasquale, L. Votano, A. Bamberger, S. Eisenhardt, A. Freidhof, S. Soldner-Rembold, J. Schroeder, T. Trefzger, N. H. Brook, P. J. Bussey, A. T. Doyle, J. I. Fleck, D. H. Saxon, M. L. Utley, A. S. Wilson, A. Dannemann, U. Holm, D. Horstmann, T. Neumann, R. Sinkus, K. Wick, E. Badura, B. D. Burow, L. Hagge, E. Lohrmann, J. Milewski, M. Nakahata, N. Pavel, G. Poelz, W. Schott, F. Zetsche, T. C. Bacon, N. Bruemmer, I. Butterworth, E. Gallo, V. L. Harris, B. Y. H. Hung, K. R. Long, D. B. Miller, P. P. O. Morawitz, A. Prinias, J. K. Sedgbeer, A. F. Whitfield, U. Mallik, E. McCliment, M. Z. Wang, S. M. Wang, J. T. Wu, P. Cloth, D. Filges, S. H. An, S. M. Hong, S. W. Nam, S. K. Park, M. H. Suh, S. H. Yon, R. Imlay, S. Kartik, H. -J. Kim, R. R. McNeil, W. Metcalf, V. K. Nadendla, F. Barreiro, G. Cases, J. P. Fernandez, R. Graciani, J. M. Hernandez, L. Hervas, L. Labarga, M. Martinez, J. del Peso, J. Puga, J. Terron, J. F. de Trocniz, G. R. Smith, F. Corriveau, D. S. Hanna, J. Hartmann, L. W. Hung, J. N. Lim, C. G. Matthews, P. M. Patel, L. E. Sinclair, D. G. Stairs, M. St.Laurent, R. Ullmann, G. Zacek, V. Bashkirov, B. A. Dolgoshein, A. Stifutkin, G. L. Bashindzhagyan, P. F. Ermolov, L. K. Gladilin, Yu. A. Golubkov, V. D. Kobrin, I. A. Korzhavina, V. A. Kurzhavina, V. A. Kuzmin, O. Yu. Lukina, A. S. Proskuryakov, A. A. Savin, L. M. Shcheglova, A. N. Solomin, N. P. Zotov, M. Botje, F. Chlebana, A. Dake, J. Engelen, M. de Kamps, P. Kooijman, A. Kruse, H. Tiecke, W. Verkerke, M. Veeswijk, L. Wiggers, E. de Wolf, R. van Woudenberg, D. Acosta, B. Bylsma, L. S. Durkin, K. Honscheid, C. Li, T. Y. Ling, K. W. McLean, W. N. Murray, I. H. Park, T. A. Romanowski, R. Seidlein, D. S. Bailey, A. Byrne, R. J. Cashmore, A. M. Cooper-Sarkar, R. C. E. Devenish, N. Harnew, M. Lancaster, L. Lindemann, J. D. McFall, C. Nath, V. A. Noyes, A. Quadt, J. R. Tickner, H. Uijterwaal, R. Walczak, D. S. Waters, F. F. Wilson, T. Yip, G. Abbiendi, A. Bertolin, R. Brugnera, R. Carlin, F. Dal Corso, M.

De Giorgi, U. Dosselli, S. Limentani, M. Morandin, M. Posocco, L. Stanco, R. Stroili, C. Voci, J. Bulmahn, J. M. Butterworth, R. G. Feild, B. Y. Oh, J. J. Whitmore, G. D'Agostini, G. Marini, A. Nigro, E. Tassi, J. C. Hart, N. A. McCubbin, K. Prytz, T. P. Shah, T. L. Short, E. Barberis, T. Dubbs, C. Heusch, M. Van Hook, W. Lockman, J. T. Rahn, H. F. -W. Sadrozinski, A. Seiden, D. C. Williams, J. Biltzinger, R. J. Seifert, O. Schwarzer, A. H. Walenta, G. Zech, H. Abramowicz, G. Briskin, S. Dagan, A. Levy, T. Hasegawa, M. Hazumi, T. Ishii, M. Kuze, S. Mine, Y. Nagasawa, M. Nakao, I. Suzuki, K. Tokushuku, S. Yamada, Y. Yamazaki, M. Chiba, R. Hamatsu, T. Hirose, K. Homma, S. Kitamura, Y. Nakamitsu, K. Yamauchi, R. Cirio, M. Costa, M. I. Ferrero, L. Lamberti, S. Maselli, C. Peroni, R. Sacchi, A. Solano, A. Staiano, M. Dardo, D. C. Bailey, D. Bandyopadhyay, F. Benard, M. Brkic, D. M. Gingrich, G. F. Hartner, K. K. Joo, G. M. Levman, J. F. Martin, R. S. Orr, S. Polenz, C. R. Sampson, R. J. Teuscher, C. D. Catterall, T. W. Jones, P. B. Kaziewicz, J. B. Lane, R. L. Saunders, J. Shulman, K. Blankenship, B. Lu, L. W. Mo, W. Bogusz, K. CharchuImage a, J. Ciborowski, J. Gajewski, G. Grzelak, M. Kasprzak, M. KrzyImage anowski, K. Muchorowski, R. J. Nowak, J. M. Pawlak, T. Tymieniecka, A. K. Wroblewski, J. A. Zakrzewski, A. F. Image arnecki, M. Adamus, Y. Eisenberg, U. Karshon, D. Revel, D. Zer-Zion, I. Ali, W. F. Badgett, B. Behrens, S. Dasu, C. Fordham, C. Foudas, A. Goussiou, R. J. Loveless, D. D. Reeder, S. Silverstein, W. H. Smith, A. Vaiciulis, M. Wodarczyk, T. Tsurugai and S. Bhadra, M. L. Cardy, C. -P. Fagerstroem, W. R. Frisken, K. M. Furutani, M. Khakzad and W. B. Schmidke, "Exclusive ρ^0 production in deep inelastic electron-proton scattering at HERA", Phys. Lett. B **356**, 601 (1995); and "Measurement of the cross section for the reaction $\gamma p \to J/\Psi p$ with the ZEUS detector at HERA", Phys. Lett. B **350**, 120 (1995). and T. Ahmed, S. Aid, V.,reev, B.,rieu, R. -D. Appuhn, M. Arpagaus, A. Babaev, J. Baehr, J. Bn, P. Baranov, E. Barrelet, W. Bartel, M. Barth, U. Bassler, H. P. Beck, H. -J. Behrend, A. Belousov, Ch. Berger, H. Bergstein, G. Bernardi, R. Bernet, G. Bertrand-Coremans, M. Besancon, R. Beyer, P. Biddulph, J. C. Bizot, V. Blodel, K. Borras, F. Botterweck, V. Borrdry, A. Braemer, F. Brasse, W. Braunschweig, V. Brisson, D. Bruncko, C. Brune, R. Buchholz, L. Bungener, J. Burger, F. W. Busser, A. Buniatian, S. Burke, G. Buschhorn, A. J. Campbell, T. Carli, F. Charles, D. Clarke, A. B. Clegg, M. Colombo, J. G. Contreras, J. A. Coughlan, A. Courau, Ch. Coutures, G. Cozzika, L. Criegee, D. G. Cussans, J. Cvach, S. Dagoret, J. B. Dainton, M. Danilov, W. D. Dau, K. Daum, M. David, E. Deffur, B. Delcourt, L. Del Buono, A. De Roeck, E. A. De Wolf, P. Di Nezza, C. Dollfus, J. D. Dowell, H. B. Dreis, J. Duboc, D. Dullmann, O. Dunger, H. Duhm, J. Ebert, T. R. Ebert, G. Eckerlin, V. Efremenko, S. Egli, H. Ehrlichmann, S. Eichenberger, R. Eichler, F. Eisele, E. Eisenhandler, R. J. Ellison, E. Elsen, M. Erdmann, W. Erdmann, E. Evrard, L. Favart, A. Fedotov, D. Feeken, R. Felst, J. Feltesse, J. Ferencei, F. Ferrarotto, K. Flamm, M. Fleischer, M. Flieser, G. Flugge, A. Fomenko, B. Fominykh, M. Forbush, J. Formnek, J. M. Foster, G. Franke, E. Fretwurst, E. Gabathuler, K. Gabathuler, K. Gamerdinger, J. Garvey, J. Gayler,

M. Gebauer, A. Gellrich, H. Genzel, R. Gerhards, U. Goerlach, L. Goerlich, N. Gogitidze, M. Goldberg, D. Goldner, B. Gonzalez-Pineiro, A. M. Goodall, I. Gorelov, P. Goritchev, C. Grab, H. GrAssler, R. GrAssler, T. Greenshaw, G. Grindhammer, A. Gruber, C. Grubber, J. Haack, D. Haidt, L. Hajduk, O. Hamon, M. Hampel, E. M. Hanlon, M. Hapke, W. J. Haynes, J. Heatherington, V. Hedberg, G. Heinzelmann, R. C. W. Henderson, H. Henschel, R. Herma, I. Herynek, M. F. Hess, W. Hildesheim, P. Hill, K. H. Hiller, C. D. Hilton, J. Hladk, K. C. Hoeger, M. Hoppner, R. Horisberger, Ph. Huet, H. Hufnagel, M. Ibbotson, H. Itterbeck, M. -A. Jabiol, A. Jacholkowska, C. Jacobsson, M. Jaffre, J. Janoth, T. Jansen, L. Jonsson, K. Johannsen, D. P. Johnson, L. Johnson, H. Jung, P. I. P. Kalmus, D. Kant, R. Kaschowitz, P. Kasselmann, U. Kathage, H. H. Kaufmann, S. Kazarian, I. R. Kenyon, S. Kermiche, C. Keuker, C. Kiesling, M. Klein, C. Kleinwort, G. Knies, W. Ko, T. Kohler, H. Kolanoski, F. Kole, S. D. Kolya, V. Korbel, M. Korn, P. Kostka, S. K. Kotelnikov, M. W. Krasny, H. Krehbiel, D. Krucker, U. Kruger, U. Kruner-Marquis, J. P. Kubenka, H. Kuster, T. Kurlen, T. Kurca, J. Kurzhofer, B. Kuznik, D. Lacour, F. Lamarche, R. Lander, M. P. J. Landon, W. Lange, P. Lanius, J. -F. Laporte, A. Lebedev, C. Leverenz, S. Levonian, Ch. Ley, A. Lindner, G. Lindstrom, F. Linsel, J. Lipinski, B. List, P. Loch, H. Lohmander, G. C. Lopez, D. Luke, N. Magnussen, E. Malinovski, S. Mani, R. Maracek, P. Marage, J. Marks, R. Marshall, J. Martens, R. Martin, H. -U. Martyn, J. Martyniak, S. Masson, T. Mavroidis, S. J. Maxfield, S. J. McMahon, A. Mehta, K. Meier, D. Mercer, T. Merz, C. A. Meyer, H. Meyer, J. Meyer, S. Mikocki, D. Milstead, F. Moreau, J. V. Morris, G. Muller, K. Muller, P. Murn, R. Nahnhauer, B. Naroska, Th. Naumann, P. R. Newman, D. Newton, D. Neyret, H. K. Nguyen, F. Niebergall, C. Niebuhr, R. Nisius, G. Nowak, G. W. Noyes, M. Nyberg-Werther, H. Oberlack, U. Obrock, J. E. Olsson, E. Panaro, A. Panitch, C. Pascaud, G. D. Patel, E. Peppel, E. Perez, J. P. Phillips, Ch. Pichler, D. Pitzl, G. Pope, S. Prell, R. Prosi, G. Rdel, F. Raupach, P. Reimer, S. Reinshagen, P. Ribarics, V. Riech, J. Riedlberger, S. Riess, M. Rietz, S. M. Robertson, R. Robmann, H. E. Roloff, R. Roosen, K. Rosenbauer, A. Rostovtsev, F. Rouse, C. Royon, K. Ruter, S. Rusakov, K. Rybicki, R. Rylko, N. Sahlmann, E. Sanchez, D. P. C. Sankey, M. Savitsky, P. Schacht, S. Schiek, P. Schleper, W. von Schlippe, C. Schmidt, D. Schmidt, G. Schmidt, A. Schoning, V. Schroder, E. Schuhmann, B. Schwab, A. Schwind, U. Seehausen, F. Sefkow, M. Seidel, R. Sell, A. Semenov, V. Shekelyan, I. Sheviakov, H. Shooshtari, L. N. Shtarkov, G. Siegmon, U. Siewert, Y. Sirois, I. O. Skillicorn, P. Smirnov, J. R. Smith, Y. Soloviev, H. Spitzer, R. Starosta, M. Steenbock, P. Steffen, R. Steinberg, B. Stella, K. Stephens, J. Stier, J. Stiewe, U. Stosslein, J. Strachota, U. Straumann, W. Struczinski, J. P. Sutton, S. Tapprogge, R. E. Taylor, V. Tchernyshov, C. Thiebaux, G. Thompson, I. Tichomirov, P. Truol, J. Turnau, J. Tutas, P. Uelkes, A. Usik, S. Valkr, A. Valkrova, C. Valle, P. Van Esch, P. Van Mechelen, A. Vartapetian, Y. Vazdik, M. Vecko, P. Verrecchia, G. Villet, K. Wacker, A. Wagener, M. Wagener, I. W. Walker, A. Walther, G. Weber, M. Weber, D. Wegener, A. Wegner, H. P. Wellisch, L. R. West, S. Willard, M. Winde,

G. -G. Winter, A. E. Wright, E. Wunsch, N. Wulff, T. P. Yiou, J. Zacek, D. Zarbock, Z. Zhang, M. Zimmer, W. Zimmermann, F. Zomer and K. Zuber [H1 Collaboration], "Photoproduction of J/Ψ mesons at HERA", Phys. Lett. B **338**, 507(1994).

[42] B. Z. Kopeliovich, J. Nemchik, A. Schafer and A. V. Tarasov, "Color transparency versus quantum coherence in electroproduction of vector mesons off nuclei", Phys. Rev. C **65**, 035201 (2002).

[43] A. Airapetian, N. Akopov, Z. Akopov, M. Amarian, V. V. Ammosov, A. Andrus, E. C. Aschenauer, W. Augustyniak, R. Avakian, A. Avetissian, E. Avetissian, P. Bailey, V. Baturin, C. Baumgarten, M. Beckmann, S. Belostotski, S. Bernreuther, N. Bianchi, H. P. Blok, H. Bttcher, A. Borissov, M. Bouwhuis, J. Brack, A. Brll, I. Brunn, G. P. Capitani, H. C. Chiang, G. Ciullo, M. Contalbrigo, G. R. Court, P. F. Dalpiaz, R. De Leo, L. De Nardo, E. De Sanctis, E. Devitsin, P. Di Nezza, M. Dren, M. Ehrenfried, A. Elalaoui-Moulay, G. Elbakian, F. Ellinghaus, U. Elschenbroich, J. Ely, R. Fabbri, A. Fantoni, A. Fechtchenko, L. Felawka, B. Fox, J. Franz, S. Frullani, Y. Grber, G. Gapienko, V. Gapienko, F. Garibaldi, E. Garutti, D. Gaskell, G. Gavrilov, V. Gharibyan, G. Graw, O. Grebeniouk, L. G. Greeniaus, W. Haeberli, K. Hafidi, M. Hartig, D. Hasch, D. Heesbeen, M. Henoch, R. Hertenberger, W. H. A. Hesselink, A. Hillenbrand, Y. Holler, B. Hommez, G. Iarygin, A. Izotov, H. E. Jackson, A. Jgoun, R. Kaiser, E. Kinney, A. Kisselev, K. Knigsmann, H. Kolster, M. Kopytin, V. Korotkov, V. Kozlov, B. Krauss, V. G. Krivokhijine, L. Lagamba, L. Lapiks, A. Laziev, P. Lenisa, P. Liebing, T. Lindemann, W. Lorenzon, N. C. R. Makins, H. Marukyan, F. Masoli, F. Menden, V. Mexner, N. Meyners, O. Mikloukho, C. A. Miller, Y. Miyachi, V. Muccifora, A. Nagaitsev, E. Nappi, Y. Naryshkin, A. Nass, K. Negodaeva, W.-D. Nowak, K. Oganessyan, H. Ohsuga, G. Orlandi, S. Podiatchev, S. Potashov, D. H. Potterveld, M. Raithel, D. Reggiani, P. Reimer, A. Reischl, A. R. Reolon, K. Rith, G. Rosner, A. Rostomyan, D. Ryckbosch, I. Sanjiev, I. Savin, C. Scarlett, A. Schfer, C. Schill, G. Schnell, K. P. Schler, A. Schwind, J. Seibert, B. Seitz, R. Shanidze, T.-A. Shibata, V. Shutov, M. C. Simani, K. Sinram, M. Stancari, M. Statera, E. Steffens, J. J. M. Steijger, J. Stewart, U. Stsslein, H. Tanaka, S. Taroian, B. Tchuiko, A. Terkulov, S. Tessarin, E. Thomas, A. Tkabladze, A. Trzcinski, M. Tytgat, G. M. Urciuoli, P. van der Nat, G. van der Steenhoven, R. van de Vyver, M. C. Vetterli, V. Vikhrov, M. G. Vincter, J. Visser, M. Vogt, J. Volmer, C. Weiskopf, J. Wendland, J. Wilbert, T. Wise, S. Yen, S. Yoneyama, B. Zihlmann, H. Zohrabian, and P. Zupranski [The HERMES Collaboration], "Q^2 Dependence of Nuclear Transparency for Exclusive ρ^0 Production", Phys. Rev. Lett. **90**, 052501 (2003).

[44] A. Larson, G. A. Miller and M. Strikman, "Pionic color transparency," Phys. Rev. C **74**, 018201 (2006) [arXiv:nucl-th/0604022].

[45] W. Cosyn, M. C. Martinez, J. Ryckebusch and B. Van Overmeire, "Nuclear transparencies from photoinduced pion production," Phys. Rev. C **74**, 062201 (2006) [arXiv:nucl-th/0701029].

[46] G. Garino, Saber, M., Segel, R. E. Geesaman, D. F. Gilman, R., Green, M. C. Holt, R. J. Schiffer, J. P. Zeidman, B., Beise, E. J. Dodson, G. W. Høibråten, S., Pham, L. D. Redwine, R. P. Sapp, W. W. Williamson, C. F. Wood, S. A. Chant, N. S. Roos, P. G. Silk, J. D. Deady, and M. Maruyama, X. K., "Proton propagation in nuclei studied in the $(e, e'p)$ reaction", Phys. Rev. C **45**, 780 (1992).

[47] T. G. O'Neill, W. Lorenzon, P. Anthony, R. G. Arnold, J. Arrington, E. J. Beise, J. E. Belz, P. E. Bosted, H. -J. Bulten, M. S. Chapman, K. P. Coulter, F. Dietrich, R. Ent, M. Epstein, B. W. Filippone, H. Gao, R. A. Gearhart, D. F. Geesaman, J. -O. Hansen, R. J. Holt, H. E. Jackson, C. E. Jones, C. E. Keppel, E. R. Kinney, S. Kuhn, K. Lee, A. Lung, N. C. R. Makins, D. J. Margaziotis, R. D. McKeown, R. G. Milner, B. Mueller, J. Napolitano, J. Nelson, V. Papavassiliou, G. G. Petratos, D. H. Potterveld, S. E. Rock, M. Spengos, Z. M. Szalata, L. H. Tao, K. van Bibber, J. F. J. van den Brand, J. L. White and B. Zeidman, "A-dependence of nuclear transparency in quasielastic $A(e, e'p)$ at high Q^2", Phys. Lett. B **351**, 87 (1995).

[48] N. C. R. Makins, R. Ent, M. S. Chapman, J.-O. Hansen, K. Lee, R. G. Milner, J. Nelson, R. G. Arnold, P. E. Bosted, C. E. Keppel, A. Lung, S. E. Rock, M. Spengos, Z. M. Szalata, L. H. Tao, J. L. White, K. P. Coulter, D. F. Geesaman, R. J. Holt, H. E. Jackson, V. Papavassiliou, D. H. Potterveld, B. Zeidman, J. Arrington, E. J. Beise, E. Belz, B. W. Filippone, H. Gao, W. Lorenzon, B. Mueller, R. D. McKeown, T. G. ONeill, M. Epstein D. J. Margaziotis, J. Napolitano, E. Kinney, P. L. Anthony, K. van Bibber, F. S. Dietrich, R. A. Gearhart G. G. Petratos, S. E. Kuhn, J. F. J. van den Br, H.-J. Bulten, and C. E. Jones, "Momentum transfer dependence of nuclear transparency from the quasielastic ^{12}C$(e, e'p)$ reaction", Phys. Rev. Lett. **72**, 1986 (1994).

[49] K. Garrow, D. McKee, A. Ahmidouch, C. S. Armstrong, J. Arrington, R. Asaturyan, S. Avery, O. K. Baker, D. H. Beck, H. P. Blok, C. W. Bochna, W. Boeglin, P. Bosted *, M. Bouwhuis, H. Breuer, D. S. Brown, A. Bruell, R. D. Carlini, N. S. Chant, A. Cochran, L. Cole, S. Danagoulian, D. B. Day, J. Dunne, D. Dutta, R. Ent, H. C. Fenker, B. Fox, L. Gan, D. Gaskell, A. Gasparian, H. Gao, D. F. Geesaman, R. Gilman, P. L. J. Guye, M. Harvey, R. J. Holt , X. Jiang, C. E. Keppel, E. Kinney, Y. Liang, W. Lorenzon, A. Lung, D. J. Mack, P. Markowitz, J. W. Martin, K. McIlhany, D. Meekins , M. A. Miller, R. G. Milner, J. H. Mitchell, H. Mkrtchyan, B. A. Mueller, A. Nathan, G. Niculescu, I. Niculescu, T. G. ONeill, V. Papavassiliou, S. Pate, R. B. Piercey, D. Potterveld, R. D. Ransome, J. Reinhold, E. Rollinde, P. Roos, A. J. Sarty , R. Sawafta, E. C. Schulte, E. Segbefia, C. Smith, S. Stepanyan, S. Strauch, V.

Tadevosyan, L. Tang, R. Tieulent, A. Uzzle, W. F. Vulcan, S. A. Wood, F. Xiong, L. Yuan, M. Zeier, B. Zihlmann, and V. Ziskin, "Nuclear transparency from quasielastic $A(e, e'p)$ reactions up to $Q^2 = 8.1$ (GeV/c)^2", Phys. Rev. C **66**, 044613 (2002).

[50] D. Abbott, A. Ahmidouch, Ts. A. Amatuni, C. Armstrong, J. Arrington, K. A. Assamagan, K. Bailey, O. K. Baker, S. Barrow, K. Beard, D. Beatty, S. Beedoe, E. Beise, E. Belz, C. Bochna, H. Breuer, E. E. W. Bruins, R. Carlini, J. Cha, N. Chant, C. Cothran, W. J. Cummings, S. Danagoulian, D. Day, D. DeSchepper, J.-E. Ducret, F. Duncan, J. Dunne, D. Dutta, T. Eden, R. Ent, H. T. Fortune, V. Frolov, D. F. Geesaman, H. Gao, R. Gilman, P. Guye, J. O. Hansen, W. Hinton, R. J. Holt, C. Jackson, H. E. Jackson, C. E. Jones, S. Kaufman, J. J. Kelly, C. Keppel, M. Khandaker, W. Kim, E. Kinney, A. Klein, D. Koltenuk, L. Kramer, W. Lorenzon, K. McFarlane, D. J. Mack, R. Madey, P. Markowitz, J. Martin, A. Mateos, D. Meekins, M. A. Miller, R. Milner, J. Mitchell, R. Mohring, H. Mkrtchyan, A. M. Nathan, G. Niculescu, I. Niculescu, T. G. O'Neill, D. Potterveld, J. W. Price, J. Reinhold, C. Salgado, J. P. Schiffer, R. E. Segel, P. Stoler, R. Suleiman, V. Tadevosyan, L. Tang, B. Terburg, D. van Westrum, Pat Welch, C. Williamson, S. Wood, C. Yan, Jae-Choon Yang, J. Yu, B. Zeidman, W. Zhao, and B. Zihlmann, "Quasifree $(e, e'p)$ Reactions and Proton Propagation in Nuclei", Phys. Rev. Lett. **80**, 5072 (1998).

[51] J. Aclander, J. Alster, G. Asryan, Y. Averiche, D. S. Barton, V. Baturin , N. Buktoyarova , G. Bunce, A. S. Carroll , N. Christensen , H. Courant, S. Durrant, G. Fang, K. Gabriel, S. Gushue, K. J. Heller, S. Heppelmann, I. Kosonovsky, A. Leksanov, Y. I. Makdisi, A. Malki, I. Mardor, Y. Mardor, M. L. Marshak, D. Martel, E. Minina, E. Minor, I. Navon, H. Nicholson, A. Ogawa, Y. Panebratsev, E. Piasetzky, T. Roser, J. J. Russell, A. Schetkovsky , S. Shimanskiy, M. A. Shupe , S. Sutton, M. Tanaka, A. Tang, I. Tsetkov, J. Watson, C. White, J-Y. Wu, and D. Zhalov [EVA Collaboration], "Nuclear transparency in $90^o_{\rm c.m.}$ quasielastic $A(p, 2p)$ reactions", Phys. Rev. C **70**, 015208 (2004) .

[52] P. Jain, B. Pire and J. P. Ralston, "Quantum Color Transparency and Nuclear Filtering," Phys. Rept. **271** (1996) 67.

[53] G. A. Miller, "Colour transparency," *In *Close, Frank (ed.) et al.: Electromagnetic interactions and hadronic structure* 457-494*

[54] M.J. Amarian, H. Juengst, F. Sabatie, and L. Elouadhriri, "Deeply Virtual Compton Scattering on the Deuteron with CLAS at 6 GeV", Proposal 06-015 to the Jefferson Lab PAC 29 (January 2006); deferred.

[55] S. Gilad, D. Higinbotham, B. Moffit, E. Piasetzky, J. W. Watson, (spokespersons), Jefferson Lab Experiment E07-006, (2007).

[56] D. Protopopescu, *Nuclear Data Mining wiki* and *mailing list*, http://clasweb.jlab.org/wiki/index.php/Nuclear_Data_Mining

[57] S. Jeschonnek and J. W. Van Orden, "A new calculation for D$(e, e'p)n$ at GeV energies," Phys. Rev. C **78**, 014007 (2008).

[58] S. Jeschonnek and J. W. Van Orden, "Target Polarization for $^2\vec{H}(e, e'p)n$ at GeV energies," arXiv:0907.3712 [nucl-th].

Appendix 4. Facilities and Other Resources

The ODU group has recently moved into a new, state-of-the art laboratory space including various computational resources (including a computer farm). The University supports the group with a 1/2 FTE computer support person, a 1/2 FTE technician, secretarial staff and graduate student funding.

The William and Mary nuclear and particle physics group maintains an active set of laboratories for the construction and testing of detector systems for use in experiments at Fermilab, JLab, and other facilities as well as multi-node computer farms for Monte Carlo simulations. The department maintains a fully equipped and staffed machine shop with CNC machining and in-house design capability. W&M has fast internet access to Jefferson Lab, which facilitates data transfers and provides good access to JLab computer resources from campus. W&M will also all provide the administrative support required for the activities outlined in this proposal.

The FIU group will provide adequate storage and computing resources for data analysis and Monte-Carlo simulations. Presently our group has a 48×2.4GHz computer cluster which could be used for data simulations.

The Glasgow/Edinburgh group will be able to use their group's computer cluster at Glasgow ($>$ 200 CPU cores) and possibly the Grid for the higher level analyses of stage 3 (acceptance calculations, comparison with theory). They should also be able to make use of funds from their rolling grant to attend collaboration meetings and other analysis meetings in connection with this initiative.

The UNH group hase access to a large (208 CPUs with a lot of storage) computer cluster on which we can perform simulations and other compute intensive tasks, also as a service to other data mining collaborators.

The nuclear and particle physics laboratory at Richmond holds a 15-node, 30-CPU computing cluster with 2 TByte of storage installed in a laboratory in the Richmond Physics Department with a 5-ton, 60,000-BTU air conditioner, an upgraded electrical panel, and backup power. The system is for the exclusive use of the nuclear physics group. An NSF MRI grant has been awarded to Gilfoyle and a colleague at Richmond to obtain a new 15-node, 120-core, computing cluster. This system will be in place by summer, 2010. The cluster will be supported and maintained by our group and the Richmond information services staff. It will be available to the members of the data-mining collaboration. The University of Richmond has routinely supported 1-2 summer stipends for undergraduates in nuclear and particle physics over the last five years. We expect this support to continue.

Because of the importance of this initiative, Jefferson Lab has agreed to support the proposed effort by offering the following resources (see attached letters):

- Space and office equipment to host the first postdoc to be hired under this proposal
- Computer Center support for data retrieval and retrieval as well as general computing

- Conference staff help in organizing and running the meetings (once or twice a year) of the data mining collaboration at Jefferson Lab
- Allowing one staff member (Dr. Stepan Stepanyan, who is also a senior member of the collaboration in his position as Old Dominon University faculty) to spend up to 50% of his effort on this program
- Sharing the cost for one graduate student working on this program (to be located at ODU).

Appendix 6. Letters of Intent

Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Volker Burkert, Hall B Group Leader, Tel: 757 269 7540, *FAX: 757 269 5800, burkert@jlab.org*

October 29, 2009

To Whom It May Concern:

As leader of Hall B within Jefferson Lab's Physics Division, I am fully supportive of the proposed initiative to extract new results for QCD Nuclear Physics from existing data sets. CLAS has measured electron scattering from a large range of nuclear targets over a large range in incident energies. These data have already provided important new insights on short-range correlations and on the dynamics of hadron formation in nuclei. Since these experiments typically used inclusive, (e,e'), triggers, the same data sets can be re-analyzed for additional physics topics. By combining the data from all of these different data sets, we expect to greatly extend our knowledge of such topics as short-range correlations non-nucleonic degrees of freedom in the nucleus, modifications of bound nucleon structure and color transparency effects.
Because of the importance of this initiative for maximizing the output of physics from data already collected at Jefferson Lab, I am willing to support it in the following ways:

- Providing space and office equipment to host the postdoc to be hired for the software development and reanalysis effort proposed here

- Obtaining support from the Computer Center for data retrieval, storage and general computing

- Obtaining Jefferson Lab conference staff help with organizing meetings of the collaborators at Jefferson Lab, including meeting rooms and meeting support

- Allowing up to 50% of the time of a staff member (S. Stepanyan) to be allocated to work on this initiative

- Agreeing to share costs with one of the collaborating institutions (Old Dominion) for support of one graduate student.

Volker Burkert

Volker D. Burkert

Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Hugh E. Montgomery
Laboratory Director and Jefferson Science Associates President

June 17, 2009
Phone: (757) 269-7552
e-mail: mont@jlab.org

To whom it may concern

Dear Sir or Madame,

I am writing to express my support for a CLAS (Jefferson Lab) data mining initiative to extract new results for QCD Nuclear Physics from existing data sets (as spelled out in the white paper "Analyzing CLAS/Hall B Data to Extract New Results on QCD Nuclear Physics: An Initiative to Maximize the Return on Already Collected Data"). This is a welcome initiative with the potential to augment the output of physics from data "already in the can".

As you are well aware, CLAS has measured electron scattering from a large range of nuclear targets over a broad range of incident energies. These data have already provided important new insights on short-range correlations and on the dynamics of hadron formation in nuclei. Since these experiments typically used inclusive, (e,e'), triggers, the same data sets can be re-analyzed for additional physics topics. By combining the data from all of these different data sets, we expect to greatly extend our knowledge of such topics as short range correlations, non-nucleonic degrees of freedom in the nucleus, modifications of bound nucleon structure, and color transparency effects.

This effort will need new personnel to reanalyze the existing huge data set using up-to-date reconstruction software and to provide sufficient theoretical support to extract important results. Hall B has a well developed procedure for allowing data access to people who were not part of the original data taking team. Therefore, the group of people who can benefit from this analysis is large, and many non-CLAS collaborators have already expressed interest.

To summarize, the proposed effort is cost effective and well worthwhile. I fully support this valuable initiative and the request of additional funding for its implementation.

Sincerely,

Hugh E. Montgomery
Laboratory Director