CEBAF PROPOSAL COVER SHEET

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A. TITLE:

MEASUREMENT OF PROTON POLARIZATION IN THE $d(\gamma,p)n$ REACTION

B. CONTACT PERSON:

R. GILMAN

ADDRESS, PHONE AND BITNET:

DEPT. OF PHYSICS, RUTGERS UNIVERSITY
POB 849, PISCATAWAY, NJ 08855-0849
BITNET = GILMAN@RUTHEP

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

☐ YES
☒ NO

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

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RESEARCH PROPOSAL
CEBAF

MEASUREMENT OF PROTON POLARIZATION IN THE $d(\gamma,p)n$ REACTION

P. Bosted
AMERICAN UNIVERSITY/SLAC

K. Coulter, S. J. Freedman, D. F. Geesaman,
R. J. Holt (Spokesperson), H. E. Jackson, E. Kinney,
D. Krakauer, D. Potterveld, B. Zeidman
ARGONNE NATIONAL LABORATORY

E. Beise, B. Filippone, R. D. McKeown
CALIFORNIA INSTITUTE OF TECHNOLOGY

J. Napolitano
CEBAF/COLLEGE OF WILLIAM AND MARY

R. Milner
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

R. E. Segel
NORTHWESTERN UNIVERSITY

D. Beatty, R. Gilman (Spokesperson), C. Glashausser
G. Kumbartzki, R. Ransome
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Z.-E. Meziani (Spokesperson)
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UNIVERSITY OF ILLINOIS

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I. ABSTRACT

We propose to measure angular distributions of the proton polarization in the reaction $d(\gamma,p)n$ in the GeV region. This measurement will test the validity of extensions of conventional nuclear-physics theories to the higher energy regime. The results of the experiment will further constrain recent claims of the observation of asymptotic scaling in the $d(\gamma,p)n$ differential cross section above 1.4 GeV photon energy and of possible exotic dibaryon resonances.

II. INTRODUCTION

The $d(\gamma,p)n$ reaction is the simplest test case for nuclear-physics theories. The deuteron is the simplest nucleus, and allows the best separation of nuclear-structure ambiguities from reaction-mechanism ambiguities. As the incident γ energy is raised, new degrees of freedom become important, and may be investigated. Near threshold, it is necessary to consider only the Born term and final-state NN interactions. Meson exchange current effects are important for incident γ energies above a few MeV. The Δ resonance is a dominant part of the cross section for incident γ energies in the range of a couple hundred MeV. At higher energies, one might find evidence for relativistic effects, additional resonances, and substructure of the nucleons.

Cross sections for photodisintegration of the deuteron have been measured[1] up to 1.6 GeV photon energy and can provide important tests of microscopic reaction-mechanism theories in the CEBAF energy regime. A more sensitive test is provided by the measurement of polarization observables. Different reaction mechanisms can interfere to produce large changes in the polarization, but only small changes in differential cross sections. This basic fact has led, for example, to the large number of searches for dibaryons with spin measurements in two-nucleon systems.

We conclude that an exploratory measurement of the outgoing proton polarization in the $d(\gamma,p)n$ reaction is a desirable first-generation CEBAF polarization experiment. It provides a test of the ability of nuclear theories to calculate spin observables in the high energy regime. Since spin measurements are typically more sensitive to interference of reaction mechanisms than differential cross section measurements, it provides a more precise test of theory. It is of fundamental importance to check the validity of theories in the simplest reactions such as $d(\gamma,p)n$ before applying them to more complicated reactions.

III.A. PHYSICS MOTIVATION - MESON-EXCHANGE THEORIES

Current conventional nuclear meson-exchange calculations for photon- or electron-induced reactions have been applied to reactions at incident energies from 0 to over 2 GeV, although few calculations and little data exist for photon energies above 1 GeV. The deuteron photodisintegration has been studied over this entire energy range both experimentally and theoretically, with a number of models. Here we review the data and some of the existing calculations.

The major feature of the total and differential cross sections is a smooth falloff with energy above an incident photon energy of four or five MeV, except for the prominant Δ peak at approximately 275 MeV. There is some conflict between existing data sets in the Δ resonance region, but otherwise the experiments are in generally good agreement. Cross sections at $\theta_{c.m.} \approx 90^o$ are shown in Figure 1.

With an unpolarized target and beam, the outgoing proton may be polarized in the direction perpendicular to the reaction plane, p_n. The polarization is then measured through a second scattering, of the proton in a polarimeter. An excitation function for p_n at $\theta_{c.m.} = 90^o$ is shown in Figure 2. The polarizations are small $(0.0 > p_n > -0.2)$ below 350 MeV, but increase to about -0.6 between 400 and 700 MeV.

Kamae and Fujita,[2] observing the peaking in the 90^o excitation function for p_n, suggested the possible existence of an exotic dibaryon resonance. Conventional calculations (see Figure 2) are not too different from the data up to 400 MeV, then predict a decreasing polarization, from p_n = -0.2 to 0.0, as the photon energy increased above 300 MeV. The addition of a dibaryon component improves the agreement between calculation and data. The calculations with dibaryons were later extended[3] to fit similar features in the excitation functions at other angles. A later analysis of this type[4] for deuteron photodisintegration from 300 - 700 MeV concludes that, while the addition of dibaryon resonances improves the agreement of theory with data, the agreement is still unsatisfactory.

More recent estimates[5] of dibaryon resonances suggest that the structure is too wide – dibaryon widths should be 15 - 100 MeV – and at too low an energy. The structures may instead result from the $\Delta\Delta$ threshold. Although a search for exotic dibaryon resonances is not the primary focus of this proposal, we note that it may be possible to observe dibaryonic effects if the structures in the polarization are least 30 MeV in width and the polarization changes by 0.3 or more. No attempt has been made in the current experimental plan to optimize for the detection of any particular dibaryons which have been speculated to exist, but the experiment will span the mass range from 2.36 to 3.18 GeV.

Laget[6] calculated total and differential cross sections and outgoing proton polarizations for $d(\gamma,p)n$ for incident energies up to 800 MeV. He expanded the reaction amplitude into leading diagrams, including Born terms, excitation of the nucleon into an intermediate Δ, and absorption of the photon on a virtual meson (meson exchange currents), and included NN final-state interactions. He studied the effects of varying the wavefunction, meson ranges, and the strength of the ρ coupling. The cross section in the energy range above pion production threshold was found to be dominated by amplitudes involving the emission of a virtual pion by one nucleon and its absorption by the other. Cross sections at $\theta_{c.m.} = 90^o$ were well reproduced with accepted parameterizations up to E_γ = 600 MeV, but overpredicted above this energy. Angular distributions above E_γ = 100 MeV show qualitative agreement between data and theory. The outgoing proton polarizations were adequately reproduced below 400 MeV, but the calculations tended to decrease toward p_n = 0 above this energy, instead of increasing as indicated by the data. The prediction of the bump in the polarization data could be much improved by adjusting the high-momentum part of the d-state deuteron wave function, but the differential-cross-section data above $E_\gamma = 500$ MeV is then greatly overpredicted.

Leidemann and Arenhovel[7] performed conventional coupled channels calculations and emphasized the importance of their inclusion of dynamical Δ degrees of freedom. They also included Δ components to the deuteron wave function, meson exchange currents, and the $N\Delta$ channel in their final-state interactions. They presented comparisons with NN data up to 1 GeV, and $d(\gamma,p)n$ data and several older calculations for energies up to 500 MeV. The NN phase shifts are generally well described, but problems exist in a few channels. Angular distributions in the Δ resonance region are qualitatively reproduced, but the agreement is difficult to assess since in this region there exist discrepancies between various data sets. For p_n angular distributions from 240 to 500 MeV, problems exist with each calculation, but the full coupled-channels calculations agree with data better than the impulse approximation calculations, especially at the higher energies. Leidemann and Arenhovel also warned of some missing physics, including relativistic effects and coupling of the $NN\pi$ to the NN channel in their final state interactions.

More recently, Lee[8] has performed calculations of $d(\gamma,p)n$ differential cross sections up to 3 GeV incident photon energy. The reaction amplitude results from the absorption of the incoming photon by a nucleon, follwed by a meson exchange to the second nucleon and final state interactions. The necessary channels to be coupled with the struck nucleon include the Δ resonance and the πN and γN channels at the lower energies. At higher energies, more reaction channels are open, and Lee included in addition the D13(1520) and F15(1680) resonances and the $\pi\Delta$ and $\pi\pi N$ systems. Final-state NN interactions and the deuteron wave function are generated from the Paris potential. The reaction model is sufficient to fit the γN total cross section data well up to $E_\gamma =$ 2 GeV, without any of the several other nucleon resonances that exist in this energy region. Thus, all parameters are determined for calculating the $d(\gamma,p)n$ reaction. Lee calculates a 90° excitation function (see Figure 1) in agreement with data near the Δ resonance, and within a factor of two of the experimental cross sections up to 1.6 GeV γ energy. The calculation is consistently large above 1 GeV. It appears that, in this model, it will be difficult to improve the agreement with $d(\gamma,p)n$ cross sections by adjusting parameters without destroying the agreement with the other fitted data. Lee finds that the most significant change in the cross section can be achieved by changing the deuteron wave function at distances shorter than 0.5 fm. Pfeil[9] has, however, argued that the inclusion of the other nucleon resonances in this energy region improves the agreement of theory with data, and that polarization data will be a better test of his calculations.

III.B. PHYSICS MOTIVATION - ASYMPTOTIC SCALING

Recently, it has been suggested[1,10] that dimensional scaling has been observed in the $d(\gamma,p)n$ reaction at photon energies above 1.4 GeV, which might indicate that the reaction is sensitive to the quark substructure of the nucleons. Holt[11] has pointed out that the momentum transfer to the nucleon in this reaction is much greater than that in, e.g., elastic electron scattering at the same incident energy, because of the absorption of the photon. Thus, scaling in the $d(\gamma,p)n$ reaction at such low incident energy might not be such a great surprise. The confirmation of dimensional scaling might indicate that the reaction is more economically understood in terms of the quark degrees of freedom, rather than nucleon and meson degrees of freedom.

The dimensional scaling prediction for the differential cross section for an exclusive reaction is well known.[12] For an exclusive reaction at constant center-of-mass angle and large momentum transfer, one can show that $d\sigma/dt$ scales as $s^{-(n-2)}$, where s and t are the usual Mandelstam variables, and n is the number of fundamental constituents (quarks, leptons, photons) in the initial plus final states of the reaction. Studies in the 1970s showed that this scaling accurately describes, e.g., proton-proton scattering and meson production, and it was accepted as evidence of partons, which are now known as quarks. We note that the scaling implies that angular-distribution shapes become independent of energy.

Figure 1 suggests that the $d(\gamma,p)n$ cross sections exhibit scaling for incident photon energies greater than 1.4 GeV, but this is not conclusive proof that quarks are needed in an explanation. First, the data cover a limited energy and angular range. Second, simple arguments can demonstrate that conventional nuclear theories, under some stringent assumptions, can scale asymptotically as s^{-11}.

The proposed polarization experiment would also provide a sensitive check on the possible scaling behavior. In order to get proton polarization, multiple reaction amplitudes must interfere. In the scaling limit suggested by Brodsky and others, the reaction involves a single hard quark scattering amplitude and results in an unpolarized proton. Sivers[13] has indicated that scaling may be derived from other models with hard and soft quark scatterings, and in these models the polarization may be nonzero, but no calculations have been performed. However, there is nothing in these models to give a rapid energy dependence to the polarization.

IV. SUMMARY OF PROPOSED MEASUREMENTS

We propose to continue earlier investigations into the CEBAF kinematic regime with an exploratory survey of outgoing-proton-polarization angular distributions for incident photon energies from 0.5 to 1.8 GeV. The angles will be $\theta_{c.m.} = 30°$, $60°$, $90°$, $120°$, and $150°$. The lowest energies will overlap with existing data and provide a calibration check for the experiment. The higher energies are not feasible anywhere but CEBAF. The data obtained will provide a test of the capabilities of conventional nuclear physics theories, will help distinguish between extensions of currently existing models, and will provide a constraint on the existence of variofis exotica, such as dibaryons and the onset of dimensional scaling.

V. EXPERIMENTAL TECHNIQUE

The basic experimental technique is straightfoward. Since the $d(\gamma,p)n$ reaction has only two bodies in either the initial or final state, the measurement of one final-state particle completely determines the energy and momentum vector of the other, and the incident photon energy. The latter fact is very important, as it allows the experiment to be run with a large bremsstrahlung photon flux from a radiator in an incident electron beam. The experiment exploits three capabilities of CEBAF. The large duty factor keeps accidental rates low. The high current allows the measurement of polarization for a small cross section. The high energy allows a consistent measurement of the polarization across a large range of incident energies. The experiment is also appropriate for for early running at CEBAF. Only a 1.8-GeV electron beam is required, and the experiment does not require the fully developed design momentum and angular resolution capabilities of the spectrometers, which will probably require much study to be realized.

Except for the addition of a focal plane polarimeter (FPP), the experimental technique and energy range are similar to that of Experiment NE8 at SLAC (in which much of the current collaboration was involved), which measured diffential cross sections for $d(\gamma,p)n$ from 0.8 to 1.8 GeV photon energy. The experimental setup is depicted in Figure 3. The electron beam strikes a radiator, producing a 0° bremsstrahlung photon beam with maximum energy essentially equal to the electron kinetic energy. The target, located downstream of the radiator, is irradiated by both the photons and residual electrons. Thus, radiator-out measurements need to be performed to subtract the electrodisintegration contributions. Full-target and empty-target yields will also be measured so that target-cell background may be subtracted.

The experiment as designed can be run at CEBAF in either Hall A with the HRS hadron arm or Hall C with the SOS spectrometer. We note in advance that we expect similar quality experimental results with either system for the same amount of beam time. Some of the details leading to this conclusion follow.

We expect to use a conventional liquid deuterium target, operating at 20° K. For the time estimates in this proposal, we limit the power loss in the target to be 200 watts, about the same as existing designs at SLAC. Using a target cell of length 10 cm, the limit of the acceptance of either the hadron arm in Hall A or the SOS in Hall C, limits the beam to 60 microamps.

The spectrometer requirements are modest. The angular range to be covered is from 16 to 136 degrees in the lab. Because of the slow variation of the bremsstrahlung photon spectrum and reaction cross sections over a range of about 100 MeV, a 10^{-3} momentum resolution is certainly adequate. The polarizations vary slowly in the center of mass, so angular resolution is not crucial.

Based on our experience at SLAC and various background calculations, we conclude that particle identification is not a problem. The background deuterons and pions from the target are at much lower momentum than the $d(\gamma,p)n$ protons in our measurement range, and will generally be outside the momentum acceptence of the spectrometer. Outgoing momenta for positively charged particles from some reactions on deuterium are shown in Figure 4. The first contamination reaction that appears in the proton spectrum is $d(\gamma,p)n\pi^0$. The endpoint of this reaction and the experimental resolution of the spectrometer and electron beam will restrict the usable portion of the bremsstrahlung spectrum for extraction of $d(\gamma,p)n$ polarizations to the top $\approx$130 MeV.

Deuterons and pions from the aluminum target cell will have momenta up to and above those of the $d(\gamma,p)n$ reaction protons, and rates for these particles will be about equal to the $d(\gamma,p)n$ proton rate, depending on details of the target cell construction and spectrometer acceptance. The background data from SLAC follow estimates from a quasideuteron model. The deuterons and pions can be almost completely removed from our spectra by particle identification cuts. For example, at our highest proposed energy, with a 2-meter flight path, the time-of-flight separation is 1.0 (2.7) ns for $\pi - p$ ($p - d$). With 300 ps resolution, this allows rejection of over 95% of all pions with only a few percent loss for the protons, and rejection of essentially all deuterons. The proton losses are not important, since we are not measuring absolute cross sections. Additional particle identification can be performed with energy loss in scintillators and, for example, an Aerogel Cerenkov detector, but the latter is not required for this experiment.

Protons from the target cell must also be rejected, along with pions and deuterons not removed by particle identification cuts. Some of these particles may be removed by target-position cuts, depending on the target-position resolution. All remaining target-cell background will be removed by the subtraction of empty target background runs. The measurement of momenta above the maximum allowed proton momentum from $d(\gamma,p)n$ provides a check on the background suppression procedures.

In Table 1, we present the momentum of the outgoing protons from the $d(\gamma,p)n$ reaction as a function of the γ energy, and the difference in momentum for protons at the same angle from the $d(\gamma,p)n\pi^0$ reaction. At the higher energies, one spectrometer setting will be sufficient to cover the region from π^0 production through the endpoint of the $d(\gamma,p)n$ reaction and a sufficient region above this to check that the background subtractions give 0 above the maximum gamma energy. At the lowest energies, a second spectrometer setting is required with HRS, but not with SOS.

The major requirement different from the SLAC experiment is a FPP in the spectrometer to measure the proton polarization. There is extensive experience measuring proton polarization with a carbon FPP up to T_p = 800 MeV at Los Alamos. For the present experiment, the detected proton kinetic energy goes up to 870 MeV at the highest beam energy, making the extrapolation uncertainties small. We note that this proposal is an excellent commissioning experiment for a FPP because it does not require optimum performance of other parts of the spectrometer detection or calibration systems.

For $d(\gamma,p)n$ the proton polarization will be normal to the reaction plane. The longitudinal and sideways components, p_l and p_s, are zero. As the proton is transported through the spectrometer, the spin will precess about the magnetic field into the longitudinal direction, with the net precession resulting mostly from the dipole magnets. The precession angle, Ξ, is given by $\Xi = 1.79\omega\gamma$, where 1.79 is the numerical value of $g_p/2$ - 1, ω is the bend angle of the spectrometer, and $\gamma = E/m$ is the Lorentz factor. For the 18° (45°) bend of the SOS (HRS) spectrometer, the proton precession angle in the proposed experiment at $\theta_{c.m.} = 90^o$ ranges from 42 to 62° (104 to 156°).

Thus, the proton polarization in the detector stack will have both normal and longitudinal components. Only the transverse polarization components are measured in the FPP. With $p_s = 0$, the proton scatters in the carbon block of the FPP with an angular distribution shape $I_o(\Theta)[1 + p_n A_c(\Theta)cos(\phi_c)$, where $I_o(\Theta)$ is the unpolarized angular distribution, A_c is the analyzing power of carbon, and ϕ is the azimuthal angle. The useful range in scattering angle Θ is typically 5° to 20°, for which $A_c \approx$ 0.2. At smaller angles, multiple Coulomb scattering creates background problems. At larger angles, the analyzing power and cross sections decrease. The efficiency of the polarimeter is about 1%.

For the proposed experiment, we desire precession angles near 0 or 180°. At $\Xi =$ 90°, the polarization is rotated to be purely longitudinal, and a measurement cannot be made. Thus, the SOS spectrometer is preferred at the lower energies, but the HRS spectrometer is preferred at higher energies. For the planned set of measurements, the two systems are roughly equal.

Commissioning the polarimeter will involve a set of calibration runs to examine the detector alignment and response. Experimental asymmetries from the device can be checked with unpolarized e^-p elastic scattering, which should yield 0 polarization. An excellent calibration reaction is $p(\gamma,p)\pi^0$. For photon energies from 600 to 700 MeV, p_n ranges from about -0.5 to -1.0 for $\theta_{c.m.} = 105\pm15^o$.

The collaboration could either use the planned hadron arm in Hall A (several members of the collaboration are active participants of the Hall A collaboration, working on the FPP), or the SOS spectrometer planned for Hall C (several members of the collaboration are involved in the design of the SOS). In this case, the collaboration would build an FPP for the SOS. The polarimeter required for the SOS is much smaller in size than that for the HRS, with wire chamber active areas only ≈50 cm by 60 cm. Because of the similarities in spectrometer acceptances, count rates in the two spectrometer systems are roughly equal. For protons at these momenta, the bend angle in HRS in Hall A results in precession being more of a problem at the lower momenta, where the count rates are much higher. For SOS, the precession requires higher statistics at the higher energies. In the times requested below, a similar quality experiment could be run with either spectrometer.

VI. TIME ESTIMATES

The cross sections for the $d(\gamma,p)n$ reaction at $\theta_{c.m.} = 90^\circ$ are known. In the following estimates, we simply employ the suggested dimensional-scaling cross sections, which underestimates the cross sections at lower energies. We plan to measure at angles of $\theta_{c.m.} = 30^\circ, 60^\circ, 90^\circ, 120^\circ$, and 150° at all but the highest incident energy. At 1.8 GeV, we will only measure at 90° because of the low cross section. We assume all angles at each energy will require about the same amount of time. We assume the target is 10 cm long (1.7 g/cm^2) and the beam current is 60 μamps, giving a power loss in the target of 2 MeV-cm^2/g * 1.7 g/cm^2 * 60 μamps = 204 watts. The photon flux is calculated for a 6% radiator. The HRS spectrometer is assumed to have a solid angle of 7.8 msr and to be 100% efficient at detecting particles. The resulting count-rate estimates are shown in Table 1. The counts needed in Table 1 assume the polarizations will be determined to ± 0.1, similar to the precision of existing data.

To obtain a time estimate for the experiment, we also assume that electrodisintegration and empty-target background measurements will require about the same amount of time as the photodisintegration measurements, and about 6 hours overhead will be required at each incident beam energy for energy changes, target changes, angle changes, etc. The lowest three energies will require additional time with HRS for a second momentum setting. For the HRS times listed in Table 2, five-point angular distributions are measured at all energies except 1.8 GeV, at which only $\theta_{c.m.} = 90^\circ$ is measured. The total time for data taking and overlapping existing data, as shown in Table 2, is then 492 hours beam time. For the measurement with SOS, the total time requested is the same, but the distribution of time between energies will be different, and the error bars will increase to ± 0.12. We also request 108 additional hours for checkout, calibration, and commissioning time. Additional time without beam may be required for the installation of the FPP and cryogenic target. The total time request is for 600 hours of beam time.

VII. COLLABORATION BACKGROUND AND RESPONSIBILITIES

The collaboration consists of many individuals from several institutions with combined experience in all necessary technical requirements for the experiment. Almost all participants are currently active in either the Hall A or C collaborations at CEBAF. In particular, the Argonne group is involved in the development of the SOS spectrometer for Hall C and the Rutgers group is involved in the development of the focal plane polarimeter for HRS in Hall A. Many of the individuals were involved in the deuteron photodisintegration experiment NE8 at SLAC / NPAS, which was similar to the present experimental design except for the focal plane polarimetry requirement. Several members of the collaboration are experienced in the design, constuction, and use of focal plane polarimeters.

The experiment as currently designed requires only hardware that is already being developed by its participants for this and other experiments as part of the Hall A and

Hall C collaborations, or that is expected to be supplied by CEBAF (e.g., the cryogenic target). An exception is the requirement for a focal plane polarimeter if the experiment is approved for the SOS spectrometer in Hall C. In this case, the collaboration will develop a design for the device and submit a proposal to the funding agencies for funding for the construction of the device.

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IX. TABLE 1

Kinematics and count rate estimates at $\theta_{c.m.} = 90^o$ for the $d(\gamma,p)n$ polarization measurements with the HRS spectrometer in Hall A. The electron beam energy is 50 MeV greater than the listed γ energy. The counts are the average number in each of two 50-MeV energy bins. The column labelled Pp(π^0) indicates the percentage difference between the momenta of protons from the $d(\gamma,p)n$ reaction and those from the $d(\gamma,p)n\pi^0$ reaction at the same lab angle. The rate is the raw count rate in the focal plane. The counts needed are good-polarimeter events needed to get an error of ± 0.1 in the polarization. The time listed is sufficient to get the counts needed in each of two 50-MeV bins.

$d(\gamma,p)n$ kinematics and HRS count rates										
E_γ	s	q_{cm}	θ	Pp	Pp(π^0)	σ_{lab}	rate	$\theta_{precess}$	counts	time
(GeV)	(GeV^2)	(GeV/c)	(deg)	(GeV/c)	%	(nb/sr)	(ct/sec)	(deg)	needed	(hours)
0.55	5.581	0.839	69.0	0.768	-13.9	291.3	2221.5	104.1	84421.	1.06
0.75	6.331	1.007	65.9	0.917	-10.0	114.6	647.0	112.7	33631.	1.44
0.95	7.082	1.156	63.3	1.056	-7.8	47.3	212.0	121.2	18552.	2.43
1.15	7.832	1.292	61.0	1.186	-6.4	20.7	76.9	129.8	12166.	4.39
1.35	8.582	1.418	59.0	1.311	-5.4	9.6	30.4	138.4	8922.	8.14
1.55	9.332	1.535	57.3	1.432	-4.7	4.7	13.0	147.0	7096.	15.19
1.75	10.083	1.645	55.7	1.551	-4.2	2.4	5.9	155.6	6020.	28.38

X. TABLE 2

Time estimate for HRS in Hall A

E_{e^-} (GeV)	Time (hours)
0.6	33
0.8	41
1.0	61
1.2	50
1.4	87
1.6	158
1.8	62
Total	492

XI. FIGURE CAPTIONS

Figure 1: Cross sections for $d(\gamma,p)n$ at $\theta_{c.m.} = 90^o$. The top panel shows raw data. The middle panel shows $S^{11}d\sigma/dt$ to exhibit scaling. In the bottom panel, the reduced nuclear amplitude is plotted. This removes a factor of S^{11} modified by threshold factors. In either case, scaling would cause an energy independent behavior in the plot, as demonstrated by the dashed lines. The solid line is a calculation by Harry Lee.[8] The NE8 data are from Reference 1; other data are from Reference 14.

Figure 2: Outgoing proton polarization measurements in the $d(\gamma,p)n$ reaction at $\theta_{c.m.} = 90^o$. The data is from References 3 and 15. A conventional calculation (solid curve) and conventional + dibaryon calculations (dashed curves) in two different models for the dibaryon are taken from Reference 2. The dotted curves are from Laget[6], and show the sensitivity of his reaction mechanism model to the choice of wave function. The most positive curve was calculated with Reid soft core, the intermediate curve with HM2, and the most negative curve with a phenomenological wave function.

Figure 3: Floor plan showing the experimental setup in either Hall A or Hall C in the present proposal.

Figure 4: Outgoing momenta plotted versus electron/photon incident energy for several reactions. Top solid curve is for $d(\gamma,p)n$. Middle solid curve is for $d(\gamma,p)n$ with γ energy 100 MeV lower than the value on the x-axis. Bottom solid curve is for $d(\gamma,p)n\pi^0$. Dashed curve is for $d(\gamma,\pi^+)nn$ reaction. Dotted curve is for $d(e^-,d)e^-$ reaction. For the top $\approx$130 MeV of the proton spectrum, there are no contaminants in the proton momentum spectrum from other single-step reactions on deuterium.

Figure 1: d(γ,p)n Cross Sections

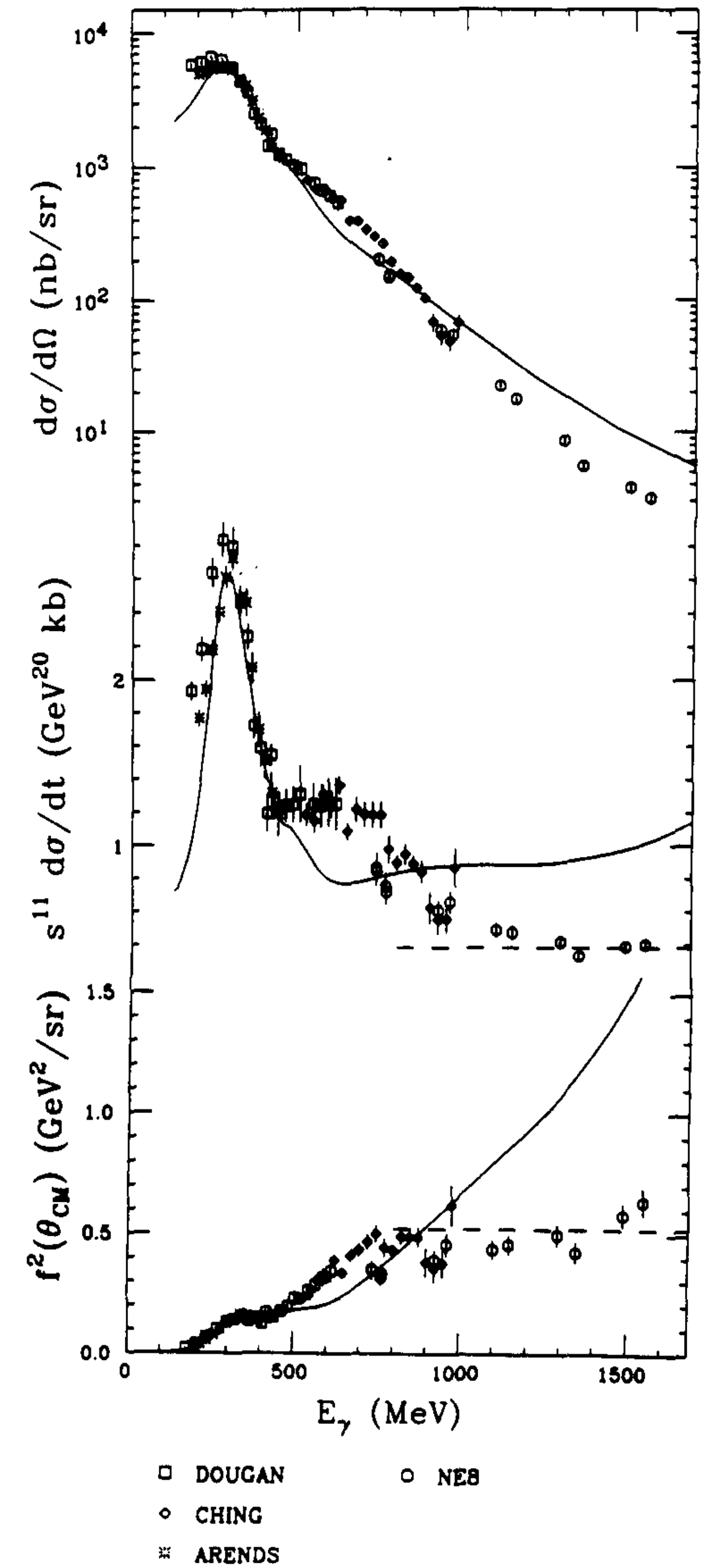

Figure 2: d(γ,p)n Polarization at θ_{cm} = 90°

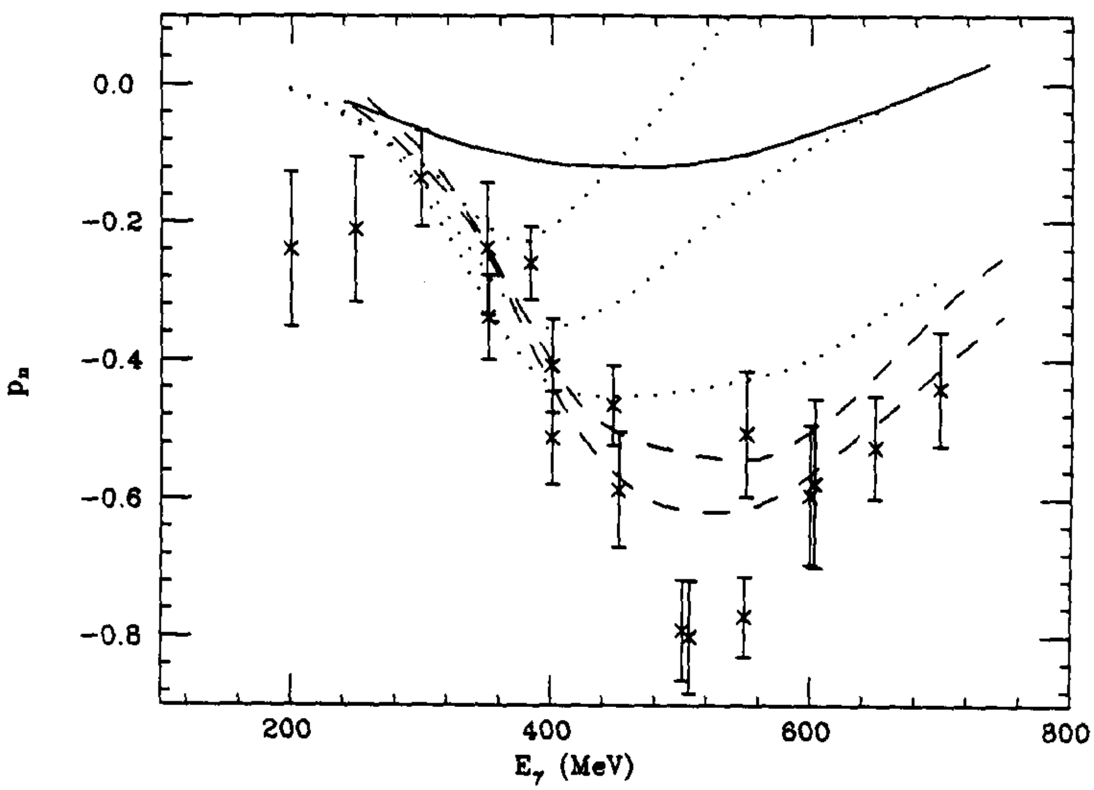

Figure 3: d(γ,p)n Experimental Setup

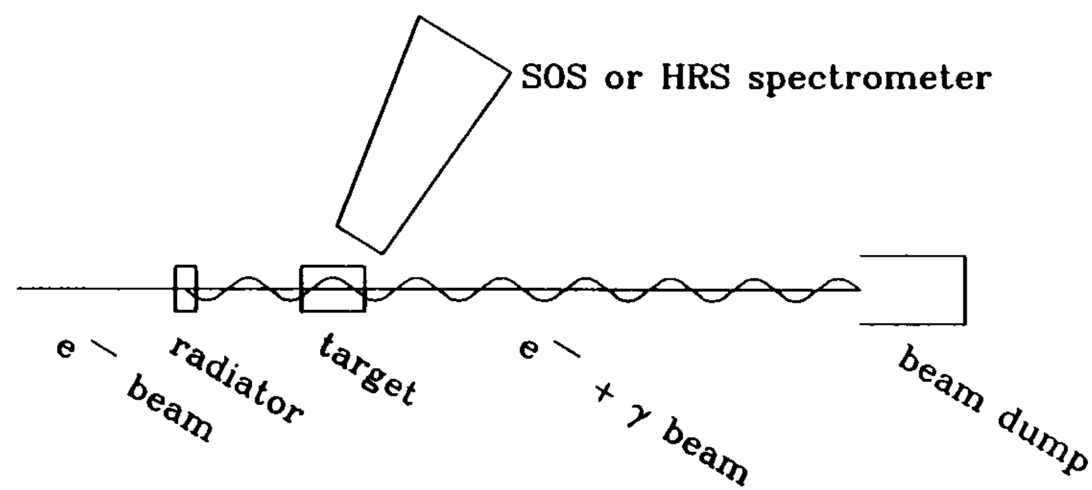

Figure 4: d(γ,p)n Kinematics at θ_{cm} = 90°