Proposal #	PR-99-017	**Hall:** C
Previous #	(PR-93-016)	

Title: Measurement of the Spin-Dependent asymmetry in Quasi elastic Electron Scattering from Polarized Tritium

Contact person: C. Jones (ANL)

Beam time request:

Days requested in proposal:	47 days
Tune up time included in request:	yes

Hall C equipment required:

H.M.S.	normal tune
S.O.S.	normal tune
Targets	polarized Tritium (50 Curies)[1]
Target Raster	yes (1 cm x 1 cm)
Beam Polarimeter	yes

Beam characteristics:

Energies	0.96, 1.5, 1.9 GeV
Polarized Beam	yes (49%)
Current	190 μA[2]

Special requirements/requests:

Optically pumped polarized tritium CalTech

Comments:

1) There are serious safety issues associated with having 50 Curies of tritium in an experimental end station. At this time it us unclear believe that there is any realistic possibility that the Radiation Control group at Jefferson Laboratory will allow a 50Ci tritium source, particularly in a cell with thin windows, to be operated on site. Even Radiation Control group at Jefferson Laboratory were to permit a multi Ci gaseous target, the controls and procedures that they will require will be elaborate, costly, and very time consuming to design and implement.

It has been suggested that a dynamically polarized target using LiH would provide a safer alternative (Don Crabb) target. In this target, the tritium would be in the form of a chemically stable solid. LiH may not be the ideal target material (long relaxation times) and further development is needed (polarization reversal by adiabatic fast passage), but it would greatly reduce the rad con problems that the collaboration could expect to encounter.

2) The collaboration is proposing to use very high beam currents. The beam time request should be adjusted to account for the fact that the nominal currents per hall are more typically ~100 •a. which would allow other halls to also conduct experiments. How does the collaboration propose to keep the windows cool ? One would expect significant depolarization effects at high beam currents. Does the collaboration have any data ? It should be possible to draw some conclusions from experience with ^{3}He targets. The collaboration should also consider using less current and an ~80% polarized beam. It is likely that such capability will be routinely available by the time this experiment can be placed in the experimental scheduling queue.

3) The experiment requests an initial test run with a polarized hydrogen target. They propose to do their development work with hydrogen. One would expect ionization due to the decay of tritium to contribute to the relaxation rate. Again, do they have data or estimates as to how much this will reduce the polarization that can be achieved?

4) A reasonable installation time is likely to be ~2.5 months including the removal of our standard target system and the installation of the polarized target. About 2 months will be required to restore the hall for normal operations after the experiment has been run.

5) The experiment requires the use of the Hall C Moller polarimeter.

6) Has the collaboration assessed the possibility of conducting the measurement using the CLAS?

Jefferson Lab PAC15

Proposal Cover Sheet

This document must be received by close of business Thursday, Dec 17, 1998 at:

Jefferson Lab
User Liaison,
Mail Stop 12B
12000 Jefferson Ave.
Newport News, VA
23606

Experimental Hall: C

Days Requested for Approval: 50

Proposal Title:
Measurement of the Spin-Dependent Asymmetry in Quasielastic Electron Scattering from Polarized Tritium

Proposal Physics Goals

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

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

Contact Person

Name: Cathleen Jones
Institution: Caltech
Address: Kellogg Lab, 106-38
Address: 1200 E. California Blvd.
City, State, ZIP/Country: Pasadena, CA 91125
Phone: (626) 395-4584 Fax: (626) 564-8708
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Jefferson Lab Use On:

Receipt Date: 12/21/98

PR 99-017

By: [signature]

LAB RESOURCES LIST

JLab Proposal No.: 93-016 (For JLab ULO use only.)

Date 12/15/98

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

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

Installation of tritium target
in place of Hall C standard target.

New Support Structures:

Data Acquisition/Reduction

Computing Resources:

New Software:

Major Equipment

Magnets:

Power Supplies:

Targets:

Detectors:

Electronics:

Computer Hardware:

Other:

Other: 1) Acquisition and installation of vent system (TBD) by laboratory and collaboratio to reduce tritium release to allowable limits in the event of a catastrophic accident.

2) Tritium sniffers, as necessary, to monitor target area.

HAZARD IDENTIFICATION CHECKLIST

JLab Proposal No.: 93-016 (For CEBAF User Liaison Office use only.) Date: 12/15/98

Check all items for which there is an anticipated need.

Cryogenics
- ___ beamline magnets
- X analysis magnets
- ___ target

type: standard op.
flow rate: ___
capacity: ___

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

Radioactive/Hazardous Materials
List any radioactive or hazadorous/ toxic materials planned for use:
tritium, ~1 Curie target, up to 50 Curie total inventory in experimental hall

Pressure Vessels
- ___ inside diameter
- ___ operating pressure
- ___ window material
- ___ window thickness

Flammable Gas or Liquids
type: ___
flow rate: ___
capacity: ___

Drift Chambers
type: ___
flow rate: ___
capacity: ___

Other Target Materials
- ___ Beryllium (Be)
- ___ Lithium (Li)
- ___ Mercury (Hg)
- ___ Lead (Pb)
- ___ Tungsten (W)
- ___ Uranium (U)
- ___ Other (list below)

Vacuum Vessels
- ___ inside diameter
- ___ operating pressure
- ___ window material
- ___ window thickness

Radioactive Sources
- ___ permanent installation
- X temporary use

type: tritium
strength: 50 Curie

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

Lasers
type: ___
wattage: ___
class: ___

Installation:
- ___ permanent
- ___ temporary

Use:
- ___ calibration
- ___ alignment

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

tritium

General:
Experiment Class:
- ___ Base Equipment
- X Temp. Mod. to Base Equip.
- ___ Permanent Mod. to Base Equipment
- ___ Major New Apparatus

Other: ___

BEAM REQUIREMENTS LIST

JLab Proposal No.: 93-016 Date: 12/15/98

Hall: C Anticipated Run Date: 2/2000 PAC Approved Days: ______

Spokesperson: Cathleen Jones Hall Liaison: ______
Phone: (626) 395-4584
E-mail: cjones@krl.caltech.edu

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

Condition No.	Beam Energy (MeV)	Mean Beam Current (μA)	Polarization and Other Special Requirements (e.g., time structure)	Target Material (use multiple rows for complex targets — e.g., w/windows)	Material Thickness (mg/cm^2)	Est. Beam-On Time for Cond. No. (hours)
1	1600	100	$P_{beam} \geq 49\%$	hydrogen w/	2.6 mg/cm^2	50
				copper windows	230 mg/cm^2	
2	1600	190	$P_{beam} \geq 49\%$	hydrogen w/	0.9 mg/cm^2	150
				copper windows	230 mg/cm^2	
3	960	190	$P_{beam} \geq 49\%$	tritium w/	2.6 mg/cm^2	120
				copper windows	230 mg/cm^2	
4	1500	190	$P_{beam} \geq 49\%$	tritium w/	2.6 mg/cm^2	240
				copper windows	230 mg/cm^2	
5	1900	190	$P_{beam} \geq 49\%$	tritium w/	2.6 mg/cm^2	570
				copper windows	230 mg/cm^2	

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

PAC15 - UPDATE TO PROPOSAL 93-016

Measurement of the Spin-Dependent Asymmetry in Quasielastic Electron Scattering from Polarized Tritium

D. F. Geesaman, H. E. Jackson, Z.-T. Lu, D. H. Potterveld
Argonne National Laboratory

R. Carr, C. E. Jones (spokesperson), R. D. McKeown
California Institute of Technology

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E. Segbefia, L. Tang
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Massachusetts Institute of Technology

S. Deiterich, R. Gilman, C. Glashausser, X. Jiang, G. Kumbartzki,
R. Ransome, S. Strauch
Rutgers University

R. Ent, A. Lung, D. Mack, J. Mitchell, S. Wood
Thomas Jefferson National Accelerator Facility

T. Averett, M. Finn
College of William and Mary

Abstract

A measurement of the transverse and transverse-longitudinal asymmetries and the unpolarized cross sections in $^3\vec{\mathrm{H}}(\vec{e}, e')$ quasielastic scattering at $Q^2 =$ 0.23, 0.50, and 0.80 $(\mathrm{GeV/c})^2$ is proposed. The experiment uses longitudinally polarized electrons of energy $0.96 - 1.90$ GeV and an optically-pumped spin-exchange polarized tritium target. The target requires only 1 Curie of tritium for a target thickness of $2 \times 10^{17}/\mathrm{cm}^2$. The asymmetry measurement proposed is of sufficient accuracy to serve as a benchmark for theoretical calculations of the spin observables in the three-body system. Furthermore, because the polarization of the tritium nucleus is carried almost entirely by the proton, for which the electromagnetic form factors are relatively well known, these measurements can be used to study medium modification of the electromagnetic form factors.

Update on the Status of the Proposal

We are submitting an update to experiment 93-106, an experiment to measure the spin-dependent asymmetry in quasielastic scattering of polarized electrons from polarized tritium, which was conditionally approved by PAC6. The experiment must be reviewed by PAC15 as part of the jeopardy process in Hall C. This document serves as a formal request that the experiment remain approved.

We ask that PAC15 consider the proposal as originally submitted with regard to the theoretical and experimental details, the kinematics and precision of the measurement, and the beamtime request. In this document, which supplements the original proposal, we review and update the theoretical motivation for the experiment, give an overview of the experiment, discuss the technical progress made since 1993 in developing the polarized tritium target, and update the membership in the collaboration.

Physics Motivation

The original motivation for proposing this experiment was two-fold; 1) we would obtain high precision data on previously unmeasured spin-dependent properties of tritium which, when combined with data of similar precision on ^{3}He and the deuteron, would constrain models of the nucleon-nucleon interaction and the three-body forces in nuclei; and 2) because the nuclear polarization of tritium is mostly carried by the proton, the measurements could be used to study whether the electromagnetic form factors of the proton are modified in the nuclear medium. Both of these motivations stem from the realization that experiments to study the neutron using polarized ^{3}He targets will ultimately be limited by the theoretical uncertainty in extracting free nucleon properties from experiments on a three-body nucleus. To reduce that theoretical uncertainty, it is clear that one should study tritium, the mirror nucleus of ^{3}He, in which the proton plays the analogous role of the neutron in ^{3}He. For this reason, the kinematics of this measurement were chosen to be well-matched to the theoretical input, in a region where the underlying free nucleon degrees of freedom are well known and will not contribute significantly to the theoretical uncertainty.

The theoretical motivation driving a measurement of polarization observables in electron-$^3\vec{\mathrm{H}}$ scattering has only been strengthened since the time of the original proposal. No new measurements on tritium in the kinematic range addressable by the CEBAF machine have been made, yet the theoretical difficulties in simultaneously describing the transverse response function R_T for ^{3}He and ^{3}H persist [1], and the Coulomb sum rule for ^{3}H, as determined by the Bates data on the unpolarized response functions of tritium [2], remains underestimated [3]. It is not anticipated that the Argonne V18 potential will resolve the problem [4]. In 1993, phenomenological models suggesting that the electromagnetic form factors of the nucleon are modified in the nuclear medium, and that the modification could be significant in ^{3}He and ^{3}H at relatively low Q^2, were already available [5, 6, 7, 8, 9]. More recently Lu et al. predicted a modification of G_E^n in ^{3}He by as much as 12% at $Q^2 = 0.5$ (GeV/c)^2 [10]. The issue of medium modification of the electromagnetic form factors is not likely to go away, and it cannot be adequately addressed in experiments using ^{3}He targets. While the measurement we propose here is not the only way to experimentally study whether nucleon properties change in the nuclear medium, which, for example, can be studied using the unpolarized response functions of heavy nuclei, it is the measurement which most directly addresses whether the form factors are modified in ^{3}He. Additionally, tritium has the advantage that it is a light but dense nucleus, so medium modifications may be observed in a nuclear system for which theoretical calculations are more complete and reliable. Finally, determining to high precision the neutron electric form factor remains one of the highest priority goals of the nuclear physics community. For lack of a neutron target, the light elements ^{2}H and ^{3}He are used for these studies since, ostensibly, their nuclear properties are most easily understood. Yet data from MAMI that uses quasielastic scattering from deuterium and polarized ^{3}He targets to determine G_E^n do not get values that are in good agreement for the two targets (see Figure 1 and [11]).

We currently find ourselves in the situation where large and possibly ill-determined corrections for nuclear effects limit our ability of determine G_E^n, and the question of whether the neutron electric form factor is modified in the medium only further clouds the issue without a reasonable hope of being resolved by data on either the deuteron or ^{3}He. Data on tritium would serve to greatly clarify the situation. If the theoretical community cannot develop a theory that explains simultaneously data from thorough, high precision measurements on tritium combined with data of similar precision from unpolarized ^{3}He and the deuteron, it will not be possible to unambiguously extract G_E^n from measurements on polarized ^{3}He. Furthermore, until data is available on tritium, the accuracy of these theoretical models of the three-body system cannot be fully tested.

The reason that tritium has not been studied extensively is that it is a hazardous radioactive isotope, and great care must be taken to avoid its release into the general environment. These difficulties have been overcome by accelerator facilities in the past, and experiments have run with significant inventories of tritium at Los Alamos, Bates and SAL. Independent of the technical difficulties associated with tritium handling, from a physics perspective, our understanding of the three-body system and of the neutron will not be complete without an extensive program of high precision measurements in elastic, quasielastic and deep inelastic electron scattering from tritium. Unquestionably, the beam conditions, i.e. energy range, current, polarization, stability, and beam delivery, at the CEBAF accelerator at Jefferson Lab are the best in the world for these measurements. Because of its direct relevance to the extraction of G_E^n from data on polarized ^{3}He, we feel that the experiment proposed here addresses a timely, even pressing, question within the nuclear physics community.

Overview of the Experiment and Status of the Target

The experimental procedure and run plan for the experiment is essentially unchanged since the original proposal. The experiment would run in Hall C, using the SOS and HMS spectrometers to make simultaneous, independent measurements of the quasielastic asymmetries sensitive to $R_{T'}$ and $R_{TL'}$ at $Q^2 = 0.23$, 0.50, and 0.80 $(\text{GeV/c})^2$. At this time, we still propose to use a thin (~ 1 Curie) tritium target polarized through spin-exchange optical pumping with potassium, although we are currently considering alternatives which could yield more robust, higher density and higher polarization targets. We would polarize the atom and rely on $^3\text{H}-^3\text{H}$ spin-exchange collisions to drive the system to a spin-temperature distribution, polarizing the nucleus [15]. We propose mixing hydrogen and tritium in the target because the two hydrogen isotopes will have the same polarization and elastic electron-proton scattering from the hydrogen will serve as a continuous polarization monitor and normalization for the target thickness.

At the time of the original proposal, one major open question was whether the target could be nuclear polarized through the spin-temperature mechanism. Since that time, several experiments have shown unambiguously that atomic polarized hydrogen reaches spin temperature at densities equal or lower than those proposed for this experiment [12, 13, 14]. This very effectively answers the most critical question concerning the feasibility of the polarized tritium target. In addition, a lot of work has been done to develop and characterize surface coatings that reduce molecular recombination and are resistant to attack by alkalis [16]. Experiments CE66 and CE68 at IUCF, mounted primarily by the groups at UIUC and Argonne in this collaboration, with help from the Caltech and MIT groups, has tested the spin-exchange polarized hydrogen and deuterium internal targets which are the predecessors to the tritium target proposed here. The experience with running the target in an accelerator has been invaluable, and in the last run polarizations of 50% were maintained. Other work specific to the details of extending the internal target technology to a sealed target was done at Argonne by C. Jones and coworkers, including a study to determine how to effectively isolate the discharge to the dissociator region in a two-cell sealed system.

Further work on constructing the tritium target must be done before the experiment can run in Hall C. Because of the size of the project, we will need at least conditional approval to obtain funding to continue development of the tritium target. We intend to do the target development primarily at Caltech, with input from the other groups in the collaboration which are working on polarized hydrogen targets. All prototype work will be done with hydrogen to avoid the safety issues which are necessarily tantamount in working with tritium.

Membership in the Collaboration

The collaboration has been significantly expanded since the original proposal was submitted in 1993. The core group presenting the original proposal was the Medium Energy group at Argonne National Lab, which was at the time developing a polarized hydrogen target for use in Novobirsk. Since 1993, several members of the group have moved to universities. The collaboration now contains several groups with polarized target experience, including Roy Holt and Mike Miller at UIUC, Haiyan Gao at MIT, Y.-T. Lu at Argonne, Todd Averett at William and Mary, and Cathleen Jones at Caltech. The collaboration also includes three strong groups local to JLab, in the Hall C staff, the group at Hampton University and the group at the College of William and Mary. Furthermore, Rutgers University's nuclear physics group has joined the collaboration, bringing substantial knowledge and experience gained in other experiments at JLab, including measurements of the GDH sum rule using a polarized ^{3}He target, and recoil polarimetry experiments using the focal plane polarimeter and ^{16}O and proton targets in Hall A. Among these experiments is a high precision measurement of the electric form factor of the proton. In short, the collaboration for this experiement consists of strong groups familiar with experiments at Jefferson Lab, who have successfully carried out challenging experiments in the past, and who will be able to plan and execute an experimental program using tritium at the lab.

References

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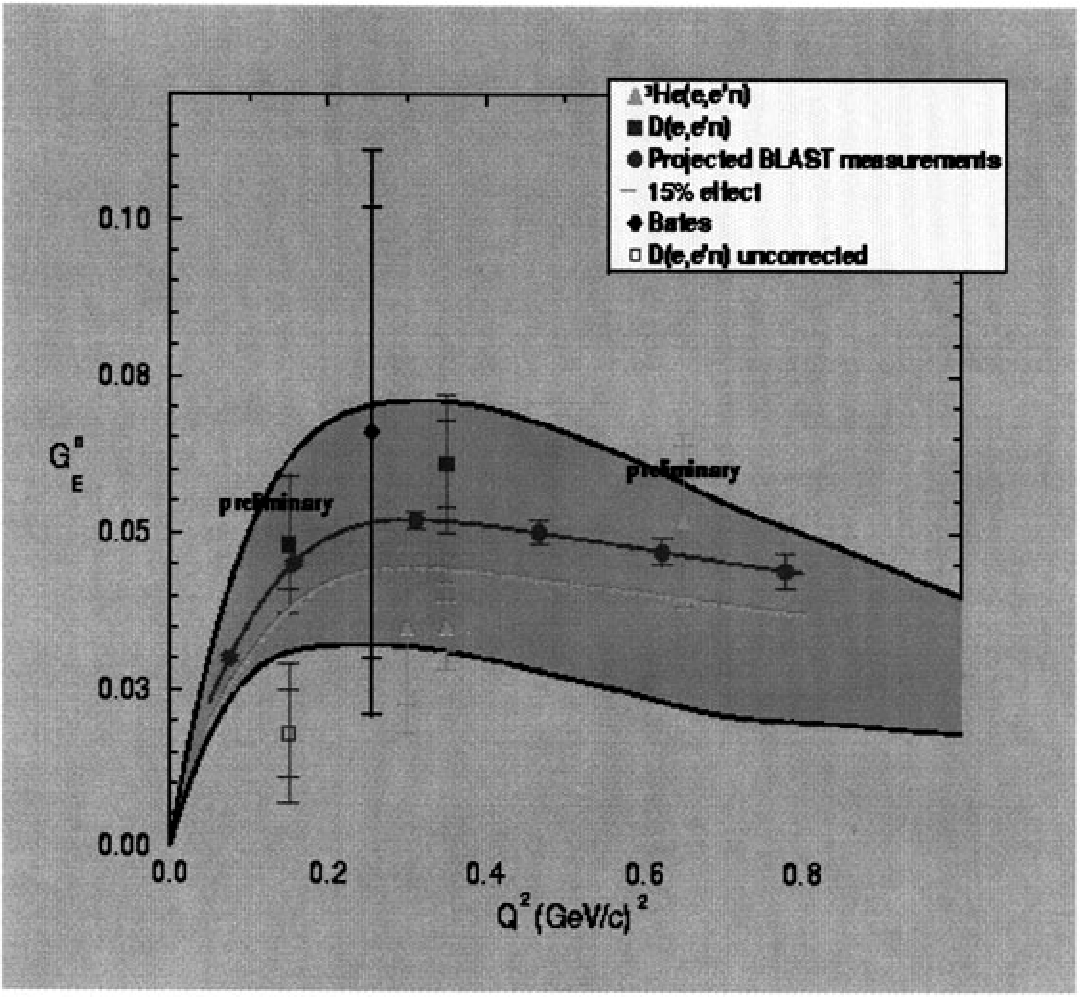

Figure 1: A summary of the more recent measurements of G_E^n. The band represents the uncertainty from the e−d elastic scattering data from Saclay. The data from MAMI on deuterium are the solid squares and on ^{3}He are the solid triangles.