CEBAF Program Advisory Committee Eight Cover Sheet

This proposal must be received by close of business on Thursday, April 14, 1994 at:

CEBAF
User Liaison Office, Mail Stop 12 B
12000 Jefferson Avenue
Newport News, VA 23606

Proposal Title

Investigation of the $^3\vec{He}$ wave function using the $^3\vec{He}(\vec{e},e'p)d$ and the $^3\vec{He}(\vec{e},e'p)pn$ Reactions

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Experimental Hall: A
Total Days Requested for Approval: 15
Minimum and Maximum Beam Energies (GeV): 4.0
Minimum and Maximum Beam Currents (μAmps): 15

CEBAF Use Only

Receipt Date: 4/14/94 PR-94-006

By: [illegible]

HAZARD IDENTIFICATION CHECKLIST

CEBAF Experiment: PR-94-0020 Date: June 10, 94

Check all items for which there is an anticipated need—do not check items that are part of the CEBAF standard experiment (HRSE, HRSH, CLAS, HMS, SOS in standard configurations).

Cryogenics ____ beamline magnets ____ analysis magnets ____ target ____ drift chambers ____ other	**Electrical Equipment** ____ cryo/electrical devices ____ capacitor banks ____ high voltage ____ exposed equipment	**Radioactive/Hazardous Materials** List any radioactive or hazadorous/toxic materials planned for use: ____ ____
Pressure Vessels 2 cm inside diameter 12 atm operating pressure glass window material 100 μm window thickness Glass cells must be treated as having potential to burst	**Flammable Gas or Liquids** (incl. target) 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 ____ temporary use type: ____ strength: ____	**Large Mech. Structure/System** ____ lifting devices ____ motion controllers ____ scaffolding or elevated platforms ____ other
Lasers Diode/Ar$^+$ type: Ti-sapphire wattage: 20-40 W class: IV **Installation** ____ permanent X temporary **Use** ____ calibration ____ alignment Polarized target (^{3}He)	**Hazardous Materials** ____ cyanide plating materials ____ scintillation oil (from) ____ PCBs ____ methane ____ TMAE ____ TEA ____ photographic developers ____ other (list below) ____ ____ ____	**Notes:** ____ ____ ____ ____ ____ ____

CEBAF Proposal

Investigation of the ^{3}He wave function using the $^3\vec{\mathrm{He}}(\vec{e},e'p)d$ and the $^3\vec{\mathrm{He}}(\vec{e},e'p)pn$ Reactions

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I. Physics Motivation

The study of few body systems, especially the ^{3}He nucleus, has been of great interest in the last years, since one can now solve the three body system exactly by means of solving the corresponding Faddeev equations. However, due to the different treatment of the nucleon-nucleon isospin dependence and tensor forces most existing calculations show some scatter in their predictions for the triton binding energy. Nearly all calculations underestimate the triton binding energy by about 0.9 MeV (the experimental value is 8.48 MeV). The effect of three-nucleon forces is hardly addressed at all. Since the ^{3}He nucleus consists of two protons and one neutron, where the probability of finding the neutron in a spatial S-part of the wave-function is about 0.87, the nuclear spin of ^{3}He is more or less comletely carried by the neutron (both proton spins add up to zero). This means a polarized ^{3}He nucleus can be envisaged to a good approximation as a polarized neutron. Due to the isospin dependence and tensor force in the nucleon-nucleon interaction, the neutron can also be found in part in the spatially mixed S′-state, at low missing momenta, and in the D-state, at higher missing momenta. The S′ state has both proton spins paired parallel to the spin of the nucleus whereas in the D-state the spins of the nucleons are antiparallel to the orbital momentum L=2 and therefore antiparallel to the ^{3}He spin. Friar*et al.*[1] give an estimate for the S′-state probability of 2.8%. The D-wave contribution is of the order 10%. This shows that ^{3}He is a suitable target to study the electromagnetic form factors of the neutron. On the other hand, in order to extract precise numbers on the neutron, the ^{3}He wave-function has to be knwon to good precision as well, due to the uncertainties described above. Therefore, we propose to perform a measurement which will allow us to study the effects of the S′- and D-states at a Q^2 of 1.0 GeV/c^2. We plan to study the reactions $^3\vec{\mathrm{He}}(\vec{e},e'p)d$ and $^3\vec{\mathrm{He}}(\vec{e},e'p)pn$ in Hall A using both high resolution spectrometers (HRS).

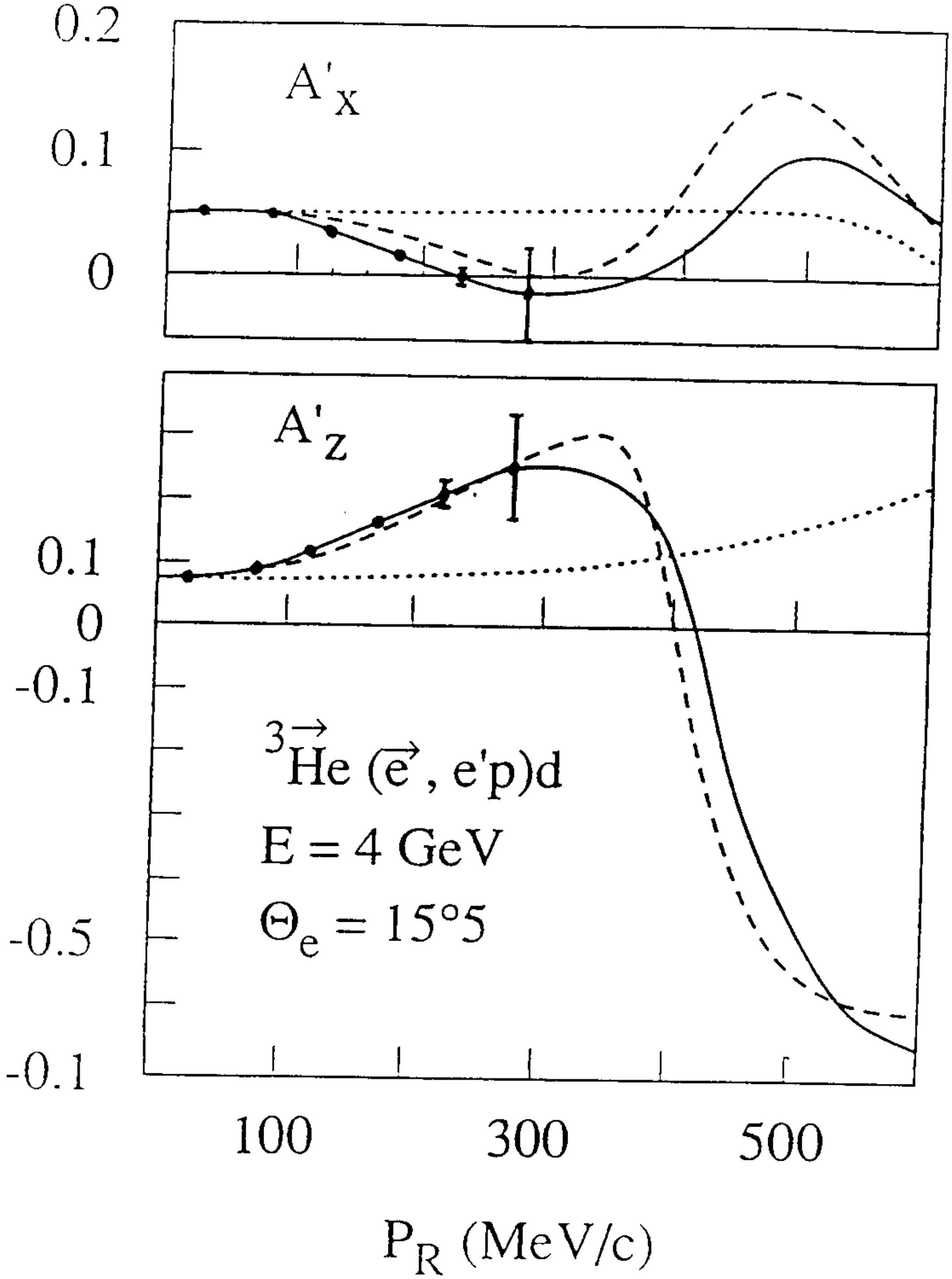
II. Discussion of the Experiment

We plan to investigate the ^{3}He wave-function using the $^3\vec{\mathrm{He}}(\vec{e},e'p)d$ reaction as function of missing momentum p_m at a Q^2 of 1.0 GeV^2/c^2. These measurements serve as a comparison to a calculation by Laget [2]. Simultaneously we will collect high precision data on the $^3\vec{\mathrm{He}}(\vec{e},e'p)pn$ reaction. So far no theoretical calculations are available for the 3-body breakup reaction in the proposed kinematics. However, Laget's calculations at low Q^2 indicate good sensitivity to the ^{3}He wave function in this final state.

In the case of polarized beam and polarized target, the (e, e'N) cross-section can be written in the following way (we follow here the notation of Laget [2]):

$$\frac{d\sigma(h,\vec{S})}{d\Omega_e\ dE_e\ d\Omega_p\ dp_p} = \frac{d\sigma^0}{d\Omega_e\ dE_e\ d\Omega_p\ dp_p} \cdot [1 + \vec{S}\cdot\vec{A^0} + h(A_e + \vec{S}\cdot\vec{A'})] \ , \qquad (1)$$

where h is the helicity of the electron $(+1/-1)$, $\vec{S}$ is the spin of the target, σ^0 is the unpolarized cross-section, $\vec{A^0}$ is the target analyzing power, or target asymmetry, $\vec{A'}$ is the spin correlation parameter, or spin transfer asymmetry. The quantization axis is chosen to be along the direction of the momentum of the virtual photon. Fig.1 shows the results of a calculation by Laget for typical CEBAF kinematics. The upper graph shows the predicted asymmetry in perpendicular kinematics A'_x, i.e. the spin of the target is aligned perpendicular to the q-vector in the scattering plane. The lower graph shows the asymmetry in parallel kinematics A'_z, here is the target spin aligned along the q-vector. In both graphs is the (e,e'p) asymmetry different from zero, even at zero missing momentum, i.e. on top of the quasielastic peak. The figure includes also the projected statistical error bars for our proposed experiment. The errors were achieved with a Monte Carlo code which is a modified version of the EGPN code developed by van den Brand [3]. Here the specifications of both high resolution spectrometers have been used. That means we assumed a horizontal acceptance of ±30 mr and a



0.2
A'$_X$
0.1
0
A'$_Z$
0.1
0
-0.1
$^3\vec{He}$ ($\vec{e}$, e'p)d
E = 4 GeV
Θ_e = 15°5
-0.5
-0.1
100
300
500
P_R (MeV/c)

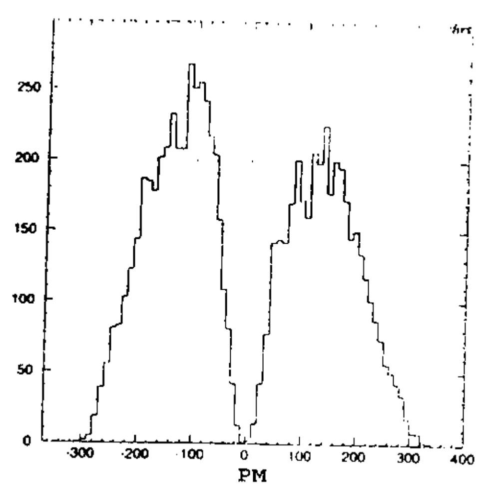
Figure 1

vertical acceptance of ±65 mr. This results in a solid angle of 7.8 msr. The momentum acceptance $\Delta p/p$ is 10 % and the accepted target length 10cm. Since we plan to built a 40 cm long target cell (see section on target), we will be able to accept effectively 38 cm ($= 10\text{cm}/\sin(\vartheta_e)$) at a Q^2 of 1 GeV^2/c^2. The electron scattering angle is in this case 15.5°. So, assuming a ^{3}He density of $2.5\cdot 10^{20}$ atoms/cm^3 and a beam current of 15μA, we will operate at a luminosity of $8.8\cdot 10^{35}/\text{cm}^2/\text{s}$. Table 1 summarizes some experimental parameters.

TABLE 2 *Experimental parameters for a Q^2 value of 1 GeV^2/c^2 at an incident beam energy of 4 GeV. The effective target length was taken to be $10cm/sin(\vartheta_e)$.*

Q^2 [GeV^2/c^2]	ϑ_e [°]	ϑ_q [°]	E′ [GeV]	eff. tgt. length [cm]	tgt. density [cm^{-2}]
1.0	15.5	54.3	3.463	37.4	$9.4\cdot 10^{21}$

All cross-sections were calculated in PWIA with de Forest's CC1 off-shell description [4] and the ^{3}He 2-body breakup momentum distribution was taken from a fit to the data of Jans *et al.* [5]. We used a pointlike target in our calculation. The range in missing momentum we will cover is shown in Fig. 2.



The polarizations should be about 45 % for the target and 80 % for the beam. Here we assumed that a strained GaAs crystal can be used to get high beam polarization. Since these crystals have low quantum efficiencies (SLAC achieved 0.1-0.3 % with polarizations up to 80 %), we assumed a low beam current of 15 μA. The count rates and expected uncertainties for the two different asymmetries are listed in detail in Table 1. All the errors are statistical only.

TABLE 1 *Expected uncertainties for A'_x and A'_z in the $^3\vec{H}e(\vec{e},e'p)d$ reaction. It is assumed that the beam polarization is 0.8 and the target polarization is 0.45.*

p_m [MeV/c]	N(10 days) $\vec{s} \perp \vec{q} (\rightarrow A'_x)$	ΔA	N(2 days) $\vec{s} \parallel \vec{q} (\rightarrow A'_z)$	ΔA
$0 < p_m < 50$	$1.21 \cdot 10^7$	$\pm 7.99 \cdot 10^{-4}$	$2.42 \cdot 10^6$	$\pm 1.79 \cdot 10^{-3}$
$50 < p_m < 100$	$1.63 \cdot 10^7$	$\pm 6.87 \cdot 10^{-4}$	$3.26 \cdot 10^6$	$\pm 1.54 \cdot 10^{-3}$
$100 < p_m < 150$	$3.39 \cdot 10^6$	$\pm 1.51 \cdot 10^{-3}$	$6.84 \cdot 10^5$	$\pm 3.36 \cdot 10^{-3}$
$150 < p_m < 200$	$7.12 \cdot 10^5$	$\pm 3.29 \cdot 10^{-3}$	$1.42 \cdot 10^5$	$\pm 7.37 \cdot 10^{-3}$
$200 < p_m < 250$	$9.66 \cdot 10^4$	$\pm 8.94 \cdot 10^{-3}$	$1.93 \cdot 10^4$	$\pm 2.00 \cdot 10^{-2}$
$250 < p_m < 300$	$5.62 \cdot 10^3$	$\pm 3.71 \cdot 10^{-2}$	$1.12 \cdot 10^3$	$\pm 8.30 \cdot 10^{-2}$

Simultaneously we will collect data for the 3-body breakup reaction. Here we binned the data in 20 MeV bins for the missing energy and 50 MeV/c bins for the missing momentum. The rates above $p_m > 300$ MeV/c will be too small to extract any useful information. The expected rates are listed in Table 2 and Table 3.

The systematic errors will be dominated by the beam - and target polarizations. We will measure the beam polarization with the Moeller polarimeter which will be operational in Hall A and plan to get a relative uncertainty of 5 % or better. The target polarization will be monitored and measured using the NMR technique of adiabatic fast

TABLE 2 *Expected uncertainties for A'_x and A'_z in the $^3\vec{H}e(\vec{e}, e'p)pn$ reaction. It is assumed that the beam polarization is 0.8 and the target polarization is 0.45. This table covers the missing energy range 7.7 MeV < E_m < 20 MeV.*

p_m [MeV/c]	N(10 days) $\vec{s} \perp \vec{q} (\rightarrow A'_x)$	ΔA	N(2 days) $\vec{s} \parallel \vec{q} (\rightarrow A'_z)$	ΔA
$0 < p_m < 50$	$3.24 \cdot 10^6$	$\pm 1.54 \cdot 10^{-3}$	$6.45 \cdot 10^5$	$\pm 3.46 \cdot 10^{-3}$
$50 < p_m < 100$	$7.04 \cdot 10^6$	$\pm 1.05 \cdot 10^{-3}$	$1.41 \cdot 10^6$	$\pm 2.34 \cdot 10^{-3}$
$100 < p_m < 150$	$2.59 \cdot 10^6$	$\pm 1.73 \cdot 10^{-3}$	$5.18 \cdot 10^5$	$\pm 3.86 \cdot 10^{-3}$
$150 < p_m < 200$	$7.56 \cdot 10^5$	$\pm 3.19 \cdot 10^{-3}$	$1.51 \cdot 10^5$	$\pm 7.15 \cdot 10^{-3}$
$200 < p_m < 250$	$1.41 \cdot 10^5$	$\pm 7.40 \cdot 10^{-3}$	$2.82 \cdot 10^4$	$\pm 1.65 \cdot 10^{-2}$
$250 < p_m < 300$	$1.15 \cdot 10^4$	$\pm 2.59 \cdot 10^{-2}$	$2.31 \cdot 10^2$	$\pm 5.78 \cdot 10^{-2}$

TABLE 3 *20 MeV < E_m < 40 MeV. Rest same as Table 3.*

p_m [MeV/c]	N(10 days) $\vec{s} \perp \vec{q} (\rightarrow A'_x)$	A	N(2 days) $\vec{s} \parallel \vec{q} (\rightarrow A'_z)$	A
$0 < p_m < 50$	$8.65 \cdot 10^4$	$\pm 9.44 \cdot 10^{-3}$	$1.73 \cdot 10^4$	$\pm 2.11 \cdot 10^{-2}$
$50 < p_m < 100$	$2.57 \cdot 10^5$	$\pm 5.30 \cdot 10^{-3}$	$5.15 \cdot 10^4$	$\pm 1.22 \cdot 10^{-2}$
$100 < p_m < 150$	$1.93 \cdot 10^5$	$\pm 6.32 \cdot 10^{-3}$	$3.76 \cdot 10^4$	$\pm 1.43 \cdot 10^{-2}$
$150 < p_m < 200$	$1.14 \cdot 10^5$	$\pm 8.23 \cdot 10^{-3}$	$2.28 \cdot 10^4$	$\pm 1.84 \cdot 10^{-2}$
$200 < p_m < 250$	$4.09 \cdot 10^4$	$\pm 1.37 \cdot 10^{-2}$	$8.16 \cdot 10^3$	$\pm 3.08 \cdot 10^{-2}$
$250 < p_m < 300$	$6.24 \cdot 10^3$	$\pm 3.52 \cdot 10^{-2}$	$1.25 \cdot 10^3$	$\pm 7.86 \cdot 10^{-2}$

passage (see specific section on the target) . We assume an uncertainty in the target polarization of 5%. So the total systematic error is about 7 %. Since the target is filled with the "contaminants" $^{85}_{37}$Rb (72.165% of the natural Rb abundance) and $^{87}_{37}$Rb (27.835% natural abundance) as well as $^{14}_{7}$N in the form of molecular nidrogen, "empty target", i.e. without ^{3}He in the target, background studies have to be performed. The Rb density will be of the order $6 \cdot 10^{14}/cm^3$, the nidrogen partial pressure will be about 100 torr or $1.4 \cdot 10^{19} N/cm^3$ at room temperature, and the ^{3}He density will be about $2.5 \cdot 10^{20}/cm^3$. Since we are interested in the two body break-up reaction and the resolution of the spectrometer is about 0.35 MeV in our kinematics, i.e. we can measure the 5.5 MeV two body break-up quite precisely, we should not see directly knocked out protons from N or Rb, since the separation energy for the 1p shell of nidrogen is about 17 MeV [6] and a simple Skyrme Hartree-Fock calculation [7] gives about 10 MeV separation energy for the 2p and 1f shell of rubidium. We certainly will perform careful background studies with "empty" target runs to enable reliable determination of the asymmetries in the 3 body breakup channel.

III. The Polarized ^{3}He Target

The polarized target will be based on the principle of spin exchange between optically pumped alkali-metal vapor and noble-gas nuclei ([8], [9], [10]). The design will be similar in many ways to that used in E-142, an experiment at SLAC to measure the spin dependent structure function of the neutron [11]. A central feature of the target will be sealed glass target cells, which will contain a ^{3}He pressure of about 10 atmospheres. As indicated in Fig. 3, the cells will have two chambers, an upper chamber in which the spin exchange takes place, and a lower chamber, through which the electron beam will pass. In order to maintain the appropriate number density of alkali-metal (which will probably be Rb) the upper chamber will be kept at a temperature of 170–200°C using an oven constructed of the high temperature plastic Torlon. With a density of 2.5×10^{20} atoms/cm^3, and a lower cell length of 40 cm, the target thickness will be 1.0×10^{22}atoms/cm^2.

We describe below in greater detail some features of the target.

Operating Principles

The time evolution of the ^{3}He polarization can be calculated from a simple analysis of spin-exchange and ^{3}He nuclear relaxation rates [12]. Assuming the ^{3}He polarization $P_{^3He} = 0$ at $t = 0$,

$$P_{^3He}(t) = \langle P_{Rb} \rangle \left(\frac{\gamma_{SE}}{\gamma_{SE} + \Gamma_R} \right) \left(1 - e^{-(\gamma_{SE}+\Gamma_R)\,t} \right) \tag{5}$$

where γ_{SE} is the spin-exchange rate per ^{3}He atom between the Rb and ^{3}He, Γ_R is the relaxation rate of the ^{3}He nuclear polarization through all channels other than spin exchange with Rb, and $\langle P_{Rb} \rangle$ is the average polarization of a Rb atom. Likewise, if the optical pumping is turned off at $t = 0$ with $P_{^3He} = P_0$, the ^{3}He nuclear polarization will decay according to

$$P_{^3He}(t) = P_0\, e^{-(\gamma_{SE}+\Gamma_R)\,t} \,. \tag{6}$$

The spin exchange rate γ_{SE} is defined by

$$\gamma_{SE} \equiv \langle \sigma_{SE}\ v \rangle\ [\mathrm{Rb}]_A \tag{7}$$

where, $\langle \sigma_{SE}\ v \rangle = 1.2 \times 10^{-19}$ cm^3/sec is the velocity-averaged spin-exchange cross section for Rb–^{3}He collisions ([12], [13], [14]) and $[\mathrm{Rb}]_A$ is the average Rb number density seen by a ^{3}He atom. Our target will be designed to operate with $1/\gamma_{SE} = 8$ hours.

¿From Eq. (6) it is clear that there are two things we can do to get the best possible ^{3}He polarization — maximize γ_{SE} and minimize Γ_R. But from Eq. (7) it is also clear that maximizing γ_{SE} means increasing the alkali-metal number density, which in turn means more laser power. The number of photons needed per second must compensate for the spin relaxation of Rb spins. In order to achieve $1/\gamma_{SE} = 8$ hours, we will require about 24 Watts of usable laser light at a wavelength of 795 nm. We will say more about the source of laser light below.

The rate at which polarization is lost, which is characterized by Γ_R, will have four principle contributions. An average electron beam current of about 15 μA will result in a depolarization rate of $\Gamma_{\text{beam}} = 1/30$ hours [15]. Judging from experience at SLAC, we can produce target cells with an intrinsic rate of $\Gamma_{\text{cell}} = 1/50$ hours. This has two contributions, relaxation that occurs during collisions of ^{3}He atoms due to dipole-dipole interactions [16], and relaxation that is presumably due largely to the interaction of the ^{3}He atoms with the walls. Finally, relaxation due to magnetic field inhomogeneities can probably be held to about $\Gamma_{\nabla B} = 1/100$ hours [17]. Collectively, under operating conditions, we would thus expect

$$\Gamma_R = \Gamma_{\text{beam}} + \Gamma_{\text{cell}} + \Gamma_{\nabla B} = 1/30\,\text{hours} + 1/50\,\text{hours} + 1/100\,\text{hours} = 1/16\,\text{hours}\,. \quad (8)$$

Thus, according to Eq. 5, the target polarization cannot be expected to exceed

$$P_{\text{max}} = \frac{\gamma_{\text{SE}}}{\gamma_{\text{SE}} + \Gamma} = 0.66\,. \quad (9)$$

Realistically, we will not achieve a Rb polarization of 100% in the pumping chamber, which will reduce the polarization to about 45–50%.

Target Cells

The construction and filling of the target cells must be accomplished with great care if $1/\Gamma_{\text{cell}}$ is to be in excess of 50 hours. We plan to use the "Princeton Prescription" which was developed for use in SLAC E-142. This resulted, among the cells that were tested, in lifetimes that were always better than 30 hours, and in about 60% of the cells, better than 50 hours. The following precautions will be taken:

1. Cells will be constructed from aluminosilicate glass.
2. All tubing will be "resized." This is a process in which the diameter of the tubing is enlarged by roughly a factor of two in order to insure a smooth pristine glass surface that is free of chemical impurities.
3. Cells will be subjected to a long (4–7 day) bake-out at high (> 400°C) temperature on a high vacuum system before filling.

4. Rb will be doubly distilled in such a manner as to avoid introducing any contaminants to the system.
5. The ^{3}He will be purified either by getters or a liquid ^{4}He trap during filling.

The cells will be filled to a high density of ^{3}He by maintaining the cell at a temperature of about 20 K during the filling process. This is necessary so that the *pressure* in the cell is below one atmosphere when the glass tube through which the cell is filled is sealed.

The length of the cell has been chosen to be 40 cm so that the end windows will not be within the acceptance of the Hall A spectrometers. The end windows themselves will be about 100 μ thick. Thinner windows could in principle be used, but this does not appear to be necessary.

The Optics System

As mentioned above, approximately 20–24 Watts of "usable" light at 795 nm will be required. By "usable," we essentially mean light that can be readily absorbed by the Rb. It should be noted that the absorption line of the Rb will have a full width of several hundred GHz at the high pressures of ^{3}He at which we will operate. Furthermore, since we will operate with very high Rb number densities that are optically quite thick, quite a bit of light that is not within the absorption linewidth is still absorbed.

It is our plan to take advantage of new emerging diode laser technology to economically pump the target. Systems are now commercially available in which a single chip produces about 20 watts of light, about half of which is probably usable. Between 2–4 such systems, at a cost of about $25,000 each, should do the job. There is also a group a Lawrence Livermore Laboratory that has offered to build us a single chip that can produce 150 watts. While some studies of the use of diode lasers for spin-exchange optical pumping do exist in the literature [18], actual demonstrations of high polarizations in cells suitable for targets are much more recent [19]. It is our opinion that diode lasers will probably work, but we will perform several tests before freezing this decision.

At SLAC, five titanium-sapphire/argon ion laser systems were used to drive the E-142 polarized ^{3}He target. This option will definitely work, but is much more expensive.

Polarimetry

Polarimetry will be accomplished by two means. During the experiment, polarization will be monitored using the NMR technique of adiabatic fast passage (AFP) [20]. The signals will be calibrated by comparing the ^{3}He NMR signals with those of water. The calibration will be independently verified by studying the frequency shifts that the polarized ^{3}He nuclei cause on the electron paramagnetic resonance (EPR) lines of Rb atoms [23]. This second techniques will be performed in separate target studies, not during the experiment. It will serve solely as a check of our calibration. We plan to determine the polarization of the target to within 5% of itself.

Apparatus Overview

The target will be in air or, perhaps, in a helium bag. This greatly simplifies the design. The main components of the target are shown in Fig. 3.

The "main coils" shown are large Helmholtz coils that will be used to apply a static magnetic field of about 20 Gauss. In addition to establishing the quantization axis for the target, the main coils are important for suppressing relaxation due to magnetic field inhomogeneities, which go like $1/B^2$. At 20 G, inhomogeneities can be as large as about 30 mG/cm while keeping $\Gamma_{\nabla B} < 1/100$hours. By increasing the applied field to about 40 G, and relaxing our requirements on $\Gamma_{\nabla B}$ by about factor of two, inhomogeneities as large as 0.25 G/cm can be tolerated. We are still finalizing our final choice of static field.

The NMR components in the target include a set of RF drive coils, and a separate set of pick-up coils. Not shown in the figure are the NMR electronics, which include an RF power amplifier, a lock-in amplifier, some bridge circuitry, and the capability to sweep the static magnetic field.

The oven shown in Fig. 3 is constructed of Torlon, a high temperature plastic. The oven is heated with forced hot air.

The optics system will either include five Ti;sapphire lasers (only one is shown) or 2-4 laser diode systems. Either way, there will also be several lenses and a quarter wave plate to provide circular polarization.

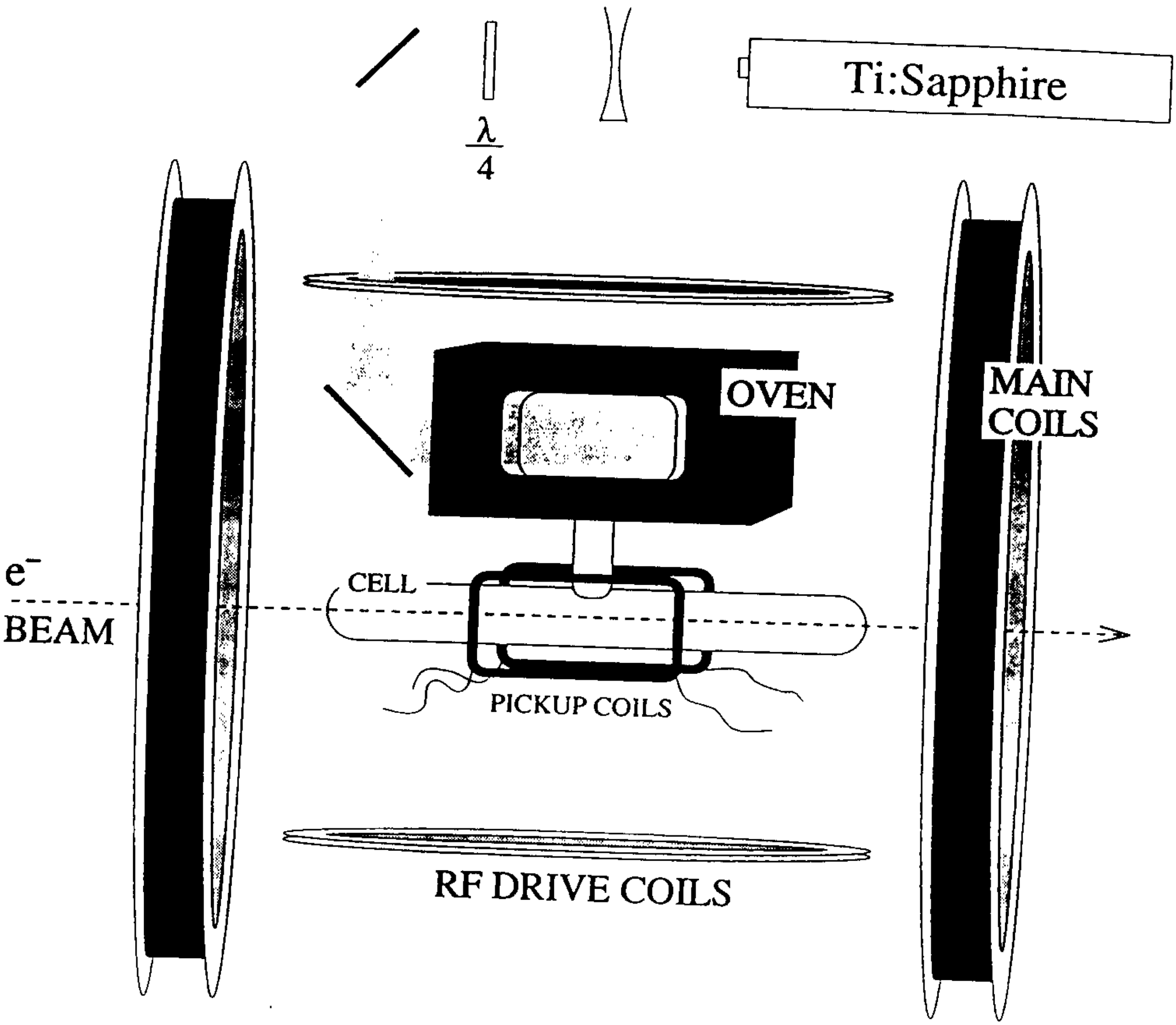

Ti:Sapphire
λ/4
OVEN
MAIN COILS
e⁻ BEAM
CELL
PICKUP COILS
RF DRIVE COILS

Figure 3

IV. Contribution of the Collaboration and Beam Time Request

- Construction and installation of the polarized ^{3}He target. This includes Helmholtz coils for the target guiding field and target polarimeter.

We request from CEBAF:

- Polarized beam of 15μA and a beam polarization of 80% at a beam energy of 4 GeV.
- Support for target installation.
- Beam pipe instrumentation, i.e. beam position and beam current monitors.
- Working polarimeter to measure the beam polarization.

Further we request a total running time of 360 hrs to perform the complete experiment. We will need 300 hrs for the production run, about 24 hrs for beam polarization measurements (about 2 hours per day), 10% of the data taking for background studies, i.e. 30 hrs.

V. References

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