Proposal Number: PR12-18-005 **Hall: C**

Title: Time-like Compton Scattering off a transversely polarized photon

Contact person: mboer@jlab.org

Beam time request:

Days requested for approval:	16 calendar days + 35 PAC days
Time needed including energy changes:	no explicit energy changes
Tune up included in beam time request:	5 PAC days

Beam characteristics:

Energy:	“11” GeV
Current:	2.5 μA
Polarization:	Yes (85% or higher)
Radiator:	Yes (bremsstrahlung photon beam)

Targets:

Nuclei:	NH3
Rastering:	Yes
Polarized:	Yes (proton)

Spectrometers:

HMS	No
SHMS	No
Other	Two NPS-ish calorimeters

Special requirements/requests:

- Top and bottom calorimeters
- (Presumably) Install a beam pipe with close to 6 degrees aperture to minimize background.
- Mount the so-called Top and Bottom calorimeters downstream of the target
- Mount the plastic scintillator hodoscope
- Install a (possibly customized) version of the Compact Photon Source
- Install the polarized proton target which will be oriented 100% transversely

Comments:

1. The niche of this experiment is to carry out a TCS measurement with high figure of merit with sufficient sensitivity to test the universality of certain GPD's. To avoid backgrounds from meson decays such as ρ and ρ'→e+e-, the invariant mass M(e+e-) is selected in the range 2-3 GeV/c2. The latter requirement contributes to small cross sections.

2. The use of an untagged Bremsstrahlung beam means the experiment must detect all particles in the final state (the e+, e-, and recoil proton) in order to reject inelastic backgrounds. They plan to do this with a cut on co-planarity or missing transverse momentum.

Technical Concerns:

1. Proton hodoscope rate - The rates in the plastic scintillator hodoscopes in Figure 25 are O(100) MHz, or on average one hit every 10 ns. This is at least one order of magnitude larger than is feasible with scintillating hodoscopes. The text in Section 3.6, discussions with the proponents, and Figure 23 suggest the main background is from low energy photons from Compton scattering on electrons which convert in the scintillator. A proton detector technology is needed which is either faster, thinner, or both.

2. Trigger rate – The trigger rate (using a high level trigger with fairly well calibrated detectors and a missing momentum algorithm) should be estimated. The *total* rate in the proton detector is O(1000) MHz. In a tight, 10 nsec coincidence timing window, the occupancy in the proton detector would be O(10). Most of these background hits will fail the missing transverse momentum cut, but they will contribute a random coincidence background which dilutes the signal.

3. Improving Signal/Background – Hardening the Bremsstrahlung photon beam would in principle improve S/B by increasing the ratio of useful high energy photons to useless, background-producing low energy photons. It *might* be possible to achieve this with a Be or Li plug located inside the magnetic field of the Compton Photon Source (CPS). In this scenario, either the radiator thickness or the beam current would be slightly increased to compensate for loss of high energy photons. Both the CPS and the downstream beamline should eventually be added to the GEANT background simulation.

4. Low acceptance at larger –t - This proposal would benefit immensely from a new transverse polarized target with a larger exit aperture. Many of the protons of interest are near 30 degrees but are (mostly) stopped in the present target by thick metal structures beyond ~21 degrees. Being able to detect protons at larger angles (higher –t) than the existing target may also allow the experiment to improve the figure of merit while avoiding the extremely high background rates at small angles (low –t).

5. A second NPS-style calorimeter may be challenging to fund. If that is the case, the experimenters could consider whether the lead tungstate calorimeter blocks of 2cmx2cm transverse dimensions could be replaced with existing lead glass blocks of 4cmx4cm transverse size (possibly at a larger distance from the target).

6. The proponents need to include the impact of the ~27% target dilution on their projections.

7. Target comments:

   This proposal will put a heat load equivalent of 100 nA of real photons on NH3.

   The experimental design calls for a slow rotation and up-down motion of the target, not the beam. The rotational speed is expected to be "faster than 1 Hz", meaning the beam will only spend "no more than a few hundred milliseconds on each set of target bead." This is about two orders of magnitude longer than the fast-rastered beam that has been used with previous NH3 targets in Halls A and C. Will this lead to localized excessive heating and polarization loss? Probably not, because the polarization of the NH3 will respond much more slowly than the temperature.

   Assuming a 2 mm beam spot on the target, the heat flux on a typical 2 mm bead is high, about 1000 W/m^2. Because a single bead has extremely low specific heat at these temperatures, a bead will reach an equilibrium temperature of about 2.5 K in about 50 microseconds. This estimate is based solely on the thermal-boundary resistance between the solid NH3 and superfluid helium and does not take into account the poorly understood boiling heat transfer properties of superfluid helium at 1 K. However, even if the bead warms significantly above 2.5 K, it can only lose polarization at a rate determined by the spin-lattice relaxation time T_1. This varies rapidly with temperature: more than an hour at 1K, approximately 30 minutes at 1.4, and probably about 10 seconds at 4 K.Even at 4 K the loss of polarization due to direct beam heating should be negligible.

   There will be a loss of polarization due to a warming of the helium bath, with the polarization roughly proportional to 1/T. This should be measurable with the NMR coil. This has been observed in previous high-current experiments in Hall C, where the coil is embedded in the target sample cell. The proposed rotating cell will require an external NMR coil, and it should be designed to provide a spatially uniform measurement of the target polarization.

   The number of days required for annealing and TE calibrations is underestimated, probably by a factor of 4.

   Will there be one or two rotating cups on a stick? What is the expected reliability?

   Up/down target motion will fatigue the bellows on the target insert. At 1 Hz, there will be approximately 2.5 million cycles over the 30-day experiment. Typical stainless steel bellows are rated for less than one million. This may not be too great a concern as the stroke from the top of a NH3 cell to its bottom is only 2.5 cm.