**Proposal Number:** C12-15-005 **Hall: C**

**Title:** Measurements of the Quasi-Elastic and Elastic Deuteron Tensor Asymmetries

**Contact person:** Elena Long

**Beam time request:**

Days requested for approval: 44.3 days

Tune up included in beam time request: No

**Beam characteristics:**

Energy: 8.8, 6.6, 2.2 GeV

Current: 80 nA

Polarization: No

**Targets:**

Nuclei: UVa/JLab Polarized ND3  
Carbon

Target Cryo Load: < 100 watt

Rastering: Yes (Slow raster)

Polarized: Yes

**Spectrometers:**

HMS Yes

SHMS Yes

Other (BigCal, etc.): No

**Special requirements/requests:**

* Installation of the UVa/JLab Polarized ND3 target.
* Possible custom BCM/BPM hardware for thermal stabilization, long period baseline tracking, and low-noise, linear readout at < 100 nA beam currents.
* Luminosity monitors

**Technical Comments:**

1. The great open question about this proposal is the effectiveness of the RF technique used to enhance the tensor polarization of the ND3 target from about 20% up to 30%. The technique, referred to as “semi-selective saturation” is pretty well understood, and was discussed and explored at great length by Delheij *et al*. for a frozen spin target at TRIUMF[[1]](#footnote-1). It was ultimately abandoned because it the predictions of how much the tensor polarization was enhanced did not match the value extracted from known scattering asymmetries. However, there are significant differences between the technique and analysis of the TRIUMF group and those in the current proposal.

First, the TRIUMF target material was deuterated butanol, not ND3. This probably doesn’t make a huge difference. Second, the TRUIMF target was dynamically polarized, placed into the frozen spin mode, and then the RF was used to burn holes in the deuteron NMR line at specific frequencies chosen to reduce the m=0 spin population, thereby increasing the tensor polarization Pzz. In the current proposal, the DNP and hole burning processes will occur simultaneously. Third, the TRIUMF analysis of the hole burning process assumed complete saturation of the NMR line at the given range of hole burning frequencies. In the current proposal, the saturation is assumed to be complete at some frequencies (at one pedestal portion of the NMR line) and only partial at others (at one of the NMR peaks). From my discussions with one of the co-authors, I understand that the analysis is quite sophisticated. It is not a line shape fit, as some have assumed. Instead, it uses a set of coupled differential rate equations that describe the action of the deuteron spin populations under the simultaneous radiation of microwaves for dynamic polarization and RF for hole burning. The equations are solved numerically using input from ancillary measurements such as the polarization build-up and relaxation times.

One of the problems encountered in the TRIUMF work was spectral diffusion. That is, mutual spin flips among the deuterons altered the NMR line shape in areas that should not have been affected by the RF. The TRIUMF analysis had no way to account for this. This effect may be ameliorated by the continuous pumping of the DNP transitions, and can be possibly be included in the rate equations.

Still, a serious question remains: How unique are the solutions to the rate equations? The collaboration is very upfront in suggesting that measurements of T20 at low Q2 should be used to benchmark the Pzz analysis. They do not state what they will do if the two results do not agree. A suggestion to measure T20 at an alternative location was made at the TAC. This will be a very substantial undertaking. However, we believe there is one “offline” measurement that can be made to partially test the Pzz analysis. If only the smaller of the two pedestals is saturated, the enhancement of Pzz is fairly straightforward to calculate, assuming spectral diffusion is negligible. Moreover, a simple relation exists between the increase in tensor polarization and the corresponding *decrease* in the vector polarization:

Pzz = -3 Pz

The decrease in the vector polarization is easy to measure, as it is simply the decrease in the total area under the entire NMR curve.

1. As recognized by the collaboration, errors from drifts in detector efficiencies, beam position and energy, magnetic fields, luminosity determination and other factors are amplified by the subtraction of polarized and un polarized yields. The efforts and lead time to control systematic errors may need to be comparable to efforts on the target.
2. The experiment plans for nine 2-hour long BCM calibrations, which may be invasive to the other halls.

1. P.P.J Delheij, D.C. Healey, and G.D. Wait, Nucl. Instr. and Meth. A251 458 (1986).  [↑](#footnote-ref-1)