Proposal: PR12-23-011
Hall: B – PRad Setup
Title: Precision Deuteron Charge Radius Measurement with Elastic Electron-Deuteron Scattering
Contact: D. Dutta
Beam time request: 40 days
Tune up time and target changes: 8.5 days tune up, target changes: H_2, D_2, empty
Configuration changes included: Beam energy change 1.1 GeV to 2.2 GeV
Electron beam energy: 1.1 GeV, 2.2 GeV
Electron beam current/luminosity: 30 nA @ 1.1 GeV, 70 nA @ 2.2 GeV
Electron beam polarization: N/A
Targets: H_2, D_2 gas
Basic instrumentation: HyCal (upgraded), GEM trackers, PRad vacuum chamber, windowless gas-flow target
Non-standard instrumentation? New Si recoil detector
Trigger: HyCal cluster with energy cut
Magnetic field settings: N/A

The proposal aims to perform a measurement of ed elastic scattering cross sections with high precision over a range of Q^2 from $2\text{x}10^{-4}$ to $5\text{x}10^{-2}$ GeV^2. These cross sections will be normalized by those from simultaneously measured Moller scattering to enable minimized systematic uncertainties. The measurement of this cross section ratio vs. Q^2 will enable a precision measurement of the deuteron charge radius and charge form factor with tightly controlled systematics in the extrapolation to $Q^2 = 0$. The experiment will use the PRad vacuum chamber setup augmented with the existing gas-flow target and a new Si-based recoil detector near the target to detect the deuteron recoils to reduce backgrounds. This proposal is a resubmission of PR12-17-009 (PAC45) and PR12-20-006 (PAC48).

Technical Comments:

1. The required beam parameters do not pose any challenge. Such beams have been delivered for various experiments in Hall B. The requested energy of 1.1 GeV requires a non-standard setting for CEBAF.
2. The original HyCal readout was based on NIM and FASTBUS electronics. The old electronics is currently getting replaced by JLab with new VME FADC250 cards and VXS crates.
3. The sensitivity of the experiment requires careful and controlled energy calibrations of the HyCal for each beam energy setting. For such an operation in the past, the calibration was done sending the electron beam to the photon tagger focal plane counters. However, these were removed for 12 GeV operation in Hall B. Re-installation is possible, but this is a non-trivial exercise. Also, the tagger scattering chamber has relatively poor vacuum due to degradation of the chamber window. This affects the beam photon energy resolution. Plans should be communicated of how the energy calibration can be performed without using the tagger, exploiting the new FADC readout and its enhanced capabilities.
4. The proposal plans on including two GEM/µRWELL layers in front of the HyCal. It is assumed/expected that these detectors will be the same as those planned for use with PRad-II. Some current and future experiments at JLab, such as SBS and MOLLER, use the Multi-Purpose Digitizer (MPD) system as a backend for the APV25 ASICs to read out GEMs and future

experiments with the PRad setup are planned to use the MPD-APV system. While the Scalable Readout System from the old PRad GEM readout will no longer be supported, it remains to be decided which fast readout system will become the standard to be used in the future for such detectors at JLab.

5. The planned Si-based recoil detector included in the proposal is a detector that requires significant levels of design and optimization, not to mention potential R&D and a significant cost projection. There is no discussion in the proposal about who is responsible for this system at any level. As it is a critical part of the experimental plans, such discussions must be advanced and developed. The performance and reliability of the silicon detectors at cryogenic temperatures is not clear. It is not clear if the requirements and experimental needs have been discussed with the Hall B CVT group who have significant expertise with design, testing, and operations of such detectors. It is also mentioned/assumed in the proposal that readout electronics (and likely other cabling/components) can use spares from the CLAS12 CVT, although it is not clear if such spares are available. This detector design amounts to significant technical (and cost) risk and needs to be completely fleshed out beyond the brief schematic concept mentioned in the proposal.
6. Another aspect required in the proposal is a new target cell to accommodate the new recoil detector. It is not clear what engineering and design is required for this new component and who is responsible for this work.
7. The proposal mentions the requirement of two additional turbopumps to achieve acceptable target performance. It is assumed that this represents a new procurement, although it is not explicitly stated in the proposal.

Based on notes by the target group the following technical comments needs to get addressed:

The PRad experiment did not require an extremely precise knowledge of the target thickness. Does this experiment? What about the relative density of H2 and D2?

The amount of gas in the beamline outside the target cell was minimized using differential pumping with very large turbomolecular pumps. The speed of these pumps will not be the same for H2 and D2, so the ratio of target gas to background gas will not be the same. Proponents should be aware of this.

Gas pressure in the large downstream chamber was the largest source of background in PRad. This can be significantly reduced using larger pumps with better conductance on the chamber. The proponents could consider a redesign/modification if this chamber will be used for several experiments in a run group.

The proposal calls for a completely new target cell which incorporates 20 silicon strip detectors on the inside. The design for the cell shown in the proposal is not very far advanced. A heat budget for the detector leads should be calculated, but it is probably pretty low. Can they be heat sunk at an intermediate temperature? The extra weight and tension of the readout cables may force us to re-think how the target cell was suspended inside the pumping chamber. Is there space on top of the vacuum chamber for the feedthroughs? The target cell is significantly larger than the existing one: 30x30x7 cm3, vs 7.5x7.5x4 cm3. The existing motion system will not be able to move the target out of the beam. The

proposed redesign and construction of the target is a major effort. What portion will fall upon the JLab Target Group?