Participants: M. Battaglieri, J. Gomez (partially), C. Keith, W. Oren, A. Seryi, P. Rossi, A. Sandorfi

On February 10 2021, M. Battaglieri, J. Gomez (partially), C. Keith, W. Oren, A. Seryi, P. Rossi, A. Sandorfy had a BlueJeans meeting to discuss the request made by A. Sandorfi for another short HD-Ice calibration run to be performed at the UITF at beginning of March (Run 2b).
Andy Sandorfi gave a presentation during and after which (in the executive session) a lengthy discussion was held to understand the need and the goal of the run. Also, the impact on the work the SFR group is committed to, i.e. CEBAF cryomodules refurbishment, was briefly discussed during the meeting. Additional information was collected by J. Gomez afterwards.

Three runs, 2a, 3a and 3b, were performed on solid samples of hydrogen deuteride (HD) using the UITF electron beam. These followed an initial commissioning run for the UITF (Run 0) and an optics run on a thin copper target (Run 1). An additional fourth run (Run 2b) with an HD target has been requested to measure the HD sample temperature under the same pulsed-beam conditions of Run 3b. It is believed these measurements will help understand how the depolarization of HD depends on accumulated electron dose and sample temperature.

The HD target used in Run 2a was not a highly polarized sample in the so-called frozen spin state. Instead, it had a short spin-lattice relaxation time T1 of a few seconds, and its polarization was determined by its temperature and field inside the In-Beam Cryostat, about 1% proton polarization at 1 T and 0.1 K. Because the polarization tracked rapidly with the temperature, its NMR signal was used to determine the average sample temperature under CW beam currents up to 0.5 nA. On the other hand, Runs 3a and 3b were performed with frozen spin samples. These had been polarized at very low temperatures and high magnetic fields to a value of 30% and subsequently aged to increase T1 to thousands of hours. Their NMR signal did not give a direct indication of the sample's temperature. However, upon irradiation by the UITF beam, their relaxation times decreased and the targets lost polarization over a time scale of tens of hours. It was observed that the rate of depolarization depended both on the beam current (presumably due to beam heating) and the total accumulated charge (attributed to the creation and build-up of paramagnetic species within the sample).

This is exactly the behavior observed in more traditional solid polarized target materials such as ammonia and butanol, where depolarization due to paramagnetic impurities is well understood and explained by theory. However, HD is a quantum solid with a large zero-point motion, and additional depolarization mechanisms may exist. A precise map of T1 as a function of temperature, field, and accumulated dose could help understand the behavior of HDice in an electron beam, reveal possible nonconventional depolarization mechanisms, and guide additional R&D. As explained below, the HDice team is requesting an additional run at the UITF that will help complete this map by measuring the temperatures encountered in Run 3b.

Because a CW beam was used in Run 3a, the temperature of the sample during those irradiations could be estimated from the results of Run 2a. However, portions of Run 3b were made using pulsed beam with duty factors of 1/3 and 2/3. It may not be possible to assign accurate sample temperatures to these measurements because the cycle time of the pulses

was too similar to the estimated thermal response time of the HD sample, of order 10 ms. Therefore, HDice wishes to complement Run 2a using a short T1 sample and measure the sample temperature under the same pulsed beam conditions as Run 3b. These temperatures will be combined with T1 measurements from Run 3b and added to those taken with CW beam.

Concerning the impact this test could have on other ongoing/planned activities at the lab:

a) Matt Poelker seems to indicate that the test will not impact the UITF work. Rather, it could benefit him.
b) Engineer and Accelerator resources seem to be dominated by manpower needed to remove and re-install the roof blocks and service to the machine, mainly from the DC group. From the information collected, we think that those groups can absorb the work if done this/next month.

In conclusion: Run 2b is expected to provide a better understanding, even if not full, of the depolarization mechanism and consequently provide a better conclusion to the R&D effort carried by the HDIce group at JLab into the use of these targets with charged particle beams. Moreover, the data collected during the test would benefit the theses of two PhD students. Since the execution of the test seems to require a modest contribution from other groups and due to the major investment the lab has already committed to the HD-Ice project, we recommend the execution of this test although it is understood it will not change the final conclusion regarding the suitability of the target for the approved experimental program in Hall B requiring a transversally polarized target.