UITF monthly status report

June 3, 2021 (Poelker, McCaughan)

Brief summary:

We finished an additional HDIce run on March 13, 2021 – the so-called run4, or run2b as described by Team HDIce because it represented a follow-up measurement to the official run2 using an unpolarized target. After concluding the HDIce measurements, and with LHe still available for UITF, we pursued optics studies of the booster cryomodule. Booster optics studies ended April 8, 2021, necessitated by the CMTF program to test C100-10 (i.e., LHe was redirected from UITF to CMTF). The booster is presently at 100 K using only liquid nitrogen through the shield line – no significant vacuum activity was observed during the temperature transition from 2 to 100 K. Since then, we have been in UITF SAD-mode, and focused on building a new beamline for waste water irradiation studies, an LDRD project headed by PI Gigi Ciovati. In parallel, the Gun Group has been repairing the photogun and modifying the photocathode activation chamber to accommodate a collaborative effort with Cornell University to enhance photocathode lifetime using a thin Sb coating applied to the photocathode surface.

Important information for others (i.e., read this):

We anticipate our next MeV beam opportunity starting August 2021, in support of LDRD waste water irradiation studies and continued booster optics studies, lasting through Fall 2021. The exact start date of resumed MeV ops at UITF depends on UITF SAD work progress, and the return of LHe to UITF following CMTF tests with C75-01.

We still plan to install the booster at CEBAF during the next SAD, starting January 2022. To get a jump on this activity, we have asked SRF to consider removing the booster from UITF before the end of this calendar year. This would mean the near term UITF program stops by ~ November 2021, and would likely remain OFF in terms of generating MeV beam for ~ 8 months, which includes time focused on commissioning the booster at CEBAF and installation of a traditional ¼ CM at UITF, which will require support from SRF and Engineering.

We request "particulate-free" vacuum work performed by SRF and Engineering, in terms of disconnecting and installation of the booster and ¼ CM from existing beamlines, i.e., the Gun Group does not plan to perform the connections/disconnections to the beamline

HDice and the elevated beamline:

- Run 4 (aka run 2b) was approved by Physics and the SAD Taskforce in February. Team HDice loaded an unpolarized target on Feb 26, 2021 and received beam at various currents and with varied duty factor, from March 3 through March 13. Goal of run4: measure NMR signals from a short-T_1 HD target that rapidly reaches an equilibrium polarization determined by the field and temperature, and use these measurements to deduce the HD temperature under different beam conditions and duty factors. Per Dr. Sandorfi, run4 was successful and graduate students Tom O'Connell and Kevin Wei obtained sufficient data to flesh-out their PhD theses.
- Unfortunately, based on the cumulative series of HDIce tests at UITF, we learned the HD targets quickly depolarize with electron beam, even at sub nA level. As a result, the HDice program was officially terminated.

- Significant portions of the elevated beamline used for HDIce have since been removed and repurposed on a new beamline for waste water irradiation, an LDRD project that expects beam in August of 2021.
- The rooftiles were removed to pull the HDIce pump cart (dilution refrigerator) which is now stored on the labyrinth rooftop, to protect it from radiation related to other UITF tests.

Booster optics studies:

- Following HDIce run4, we continued booster optics studies, in anticipation of installation of the booster at CEBAF injector and the completion of the "Injector Full-Energy Upgrade".
- Yan Wang measured the deflection of the beam caused by the booster operating at CEBAF conditions, 6.3 MeV/c beam momentum. He also measured the x/y coupling inside the booster, a phenomenon that poses problems for beta-matching at the CEBAF injector using the ¼ CM. Time must be devoted at CEBAF start-up to quantify these same parameters, to see if the booster design represents an improvement over the ¼ CM.
- Harp scans were performed using the optics tool qsUtility, which can "back propagate" the beam envelope upstream of the harp. Four out of five harps are functional at UITF, and some of the harp swipes "worked", providing emittance values and some inkling of the upstream beam envelope, but more work is needed to envision the UITF beam envelope along the full length of the accelerator, and to decouple the beam size contribution associated with energy spread
- Graduate student Xi Li used the many viewers at UITF to compare beam size to predictions made using particle tracking code GPT. Care must be taken to avoid saturating the viewer – with this caveat, results are encouraging and point to improvements that can be made to the model (incorporating accurate values for laser spot size and optical pulsewidth at photocathode), and the efficacy of using viewers to evaluate the injector beam envelope, to pinpoint errors in magnet field maps or improper solenoid/quad settings.
- There's still a long way to go at UITF to improve our optics model. In addition, there is no time-of-flight system at UITF to help set the phases of laser, chopper, buncher and the 2 and 7 cell cavities of booster. Besides deflection and x/y coupling, we must measure beam energy spread and bunchlength as function of booster rf settings (crest versus off-crest running). This work will restart once LHe is restored to UITF following tests of C75-1 at CMTF, date to be determined

Opportunistic uses of UITF:

- With the booster at 2K, we provided opportunities to Engineering staff to trouble-shoot code related to LLRF 3.0 and to test a BCM receiver at low current that could form the basis for a PSS BCM system. In addition, new trim rack bulk supplies destined for CEBAF were evaluated.

Water Irradiation Beamline:

- The new water irradiation beamline is complete. Only the thin titanium foil window needs to be added at the end of the line, where the water samples will be located.
- A fast valve must be added near the exit of the booster CM, downstream of the differential pump station used to vacuum-isolate the booster CM from the beamline. And we will rework this section of beamline to permit lead-brick shielding around an insertable faraday cup, in a manner similar to that used at CEBAF for FCup2, per RadCon's request.

- G. Ciovati expects beam during August, to irradiate six water samples that will be evaluated by HRSD staff. This timeline seems realistic but the photogun must be made operational and it would be good to add additional concrete shielding

Other Maintenance Activities:

- The photogun suffers significant field emission that could not be processed out with krypton. In fact, aggressive krypton processing (i.e., at voltage > 225 kV, cable rating) likely punctured the R28 ceramic insulator. The Gun Group is replacing the punctured black R28 insulator and shed electrode with white R28 insulator and niobium tee-shaped electrode which has successfully operated at 200 kV in the past.
- Photogun now undergoing bakeout at 200 ^{o}C to remove the silicone grease contamination that happened when insulator was punctured. Another bakeout will be required – together with the activation chamber - to install the Nb electrode
- Activation chamber: antimony source added in place of lithium source used by Max Herbert summer 2019.
- Price for additional concrete, to enable operation at high current with RadCon blessing, > 70k$, more than twice initial estimate. Waiting to discuss with Mike S. the path forward.
- Waiting for Stangenes steering magnets (ordered 9/10/2020) and YAG screens ordered (7/19/2021). YAG screens to be installed opportunistically when we vent regions with old and worn-out chromox view screens.

Administrative:

- Mike McCaughan replaces Poelker as the work coordinator/facility manager
- Mike McCaughan replaces Poelker as Safety Warden
- Per OSPs, UITF beam authorization rescinded until all credited controls are verified in-place. Until then, the photogun HV power supply and high power RF are locked-out

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