

Experimental Readiness Review Close Out Report

On

UITF Wastewater Irradiation Experiment

2/15/2021

Review Committee:

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Charge to the Committee:

The review committee is requested to review the integration of the various components based on the material prepared and presented. In addition to making comments and recommendations on this broad view, the committee should address the following charge questions:

- What is the present status of the UITF, and is it conducive both in facility and schedule to the operation of this experiment? (Specifically, with respect to shielding, SRF, and cryogenics...)
- Does the material presented herein provide sufficient information to evaluate the safe execution of the planned experiment?
- What are the goals of the experiment, and what defines success?
- Is the run plan sufficiently detailed for safe and effective operation?
- Are the roles and responsibilities of the JLab staff, specifically Accelerator and Engineering divisions, clearly defined for this beam run?
- Will all work be documented and planned out within the framework of Jefferson Lab's work planning and applicable safety documentation?
- Will this beam run be documented, planned, and executed in accordance with the UITF Operations Directives (UOD)?
- Will the target and associated diagnostics be ready to receive an electron beam of the scale described?
- Is the materials handling plan appropriate, and does it adhere to both ALARA principles and JLAB environmental expectations?
- What is the status of the COO, ESAD, and OSPs documents, and are the specific procedures and documentation in place and adequate to operate the experiment safely and efficiently?
- Have lessons learned from earlier UITF experiments been sufficiently addressed and applied to the execution of this experiment?
- Are special emergency response guidelines needed for this beam run? If so, are the plans to train laboratory staff on these new guidelines adequate?

A presentation of the essential conclusions of the review is requested at a closeout following the review. The committee is asked to deliver a written report within two weeks of completion of the review.

Reference Information:

ERR Presentations: <https://indico.jlab.org/event/431/>

Definition of Results Terminology:

- FINDINGS: Facts and figures collected by a reviewer to satisfy the objectives of the charge elements
- COMMENTS: Inferences drawn by the reviewers from the review materials and presentations
- RECOMMENDATIONS: Courses of action suggested by the reviewers in line with the objectives of the charge
- NOTABLE ITEMS – areas which demonstrate a preferred process or activity or method
- OFIs – Opportunities for Improvement

Executive Summary:

Overall, the preparation for the review was complete and informative. Based on the information presented, there was only one area of concern (construction) which the committee feels needs to be addressed “Pre-Start”. All aspects in regards to installation of experiment equipment and supplemental radiation shielding have yet to be carried out. The path forward to accomplish the required tasks needs to be developed and an Engineering Change Order needs to be issued to get the process rolling for Engineering support.

There are no obvious show stoppers regarding the progress towards the irradiation of HRSD water samples. However, there are beamline updates to be completed and competing resources with the CEBAF Scheduled Accelerator Down (SAD). The team believes these issues should be resolved in time for the irradiation run. However, no schedule for the work was presented at the time of the review and with the Lab in the midst of a SAD with resource limiting conditions due to COVID-19 controls, it remains a concern for the experiment.

Readiness Review of Charge Elements:

In assessing the readiness of the target system, shielding system, and UITF beamline to take beam, there remain some final activities which are anticipated to be completed prior to the run. The main issues are:

1. Radiation shielding needs to be upgraded to support the experiment’s requirements,
2. The waist height straight ahead section needs to incorporate the planned experiment beamline elements,

3. PSS BCM needs to be added and calibrated for experiment use,
4. Develop a commissioning and run plan with all the stakeholders,
5. Need a beam termination point when not delivering beam on target,
6. Define the roles, responsibilities and workload for remaining tasks as well as experiment task expectations,
7. Submit an Engineering Change Request to enlist Engineering assistance with engineering tasks.

While none of these items appear to be a show stopper towards preparing for the irradiation of HRSD samples, we have highlighted specific items that are recommended as being completed pre-start; identified with a **Δ**.

1) *What is the present status of the UITF, and is it conducive both in facility and schedule to the operation of this experiment? (Specifically, with respect to shielding, SRF, and cryogenics...)*

The ERR committee considers this charge element as NOT MET. The committee expects the experiment can be run safely once shielding and certain beamline components are in place.

FINDINGS:

1. UITF is set up to provide <25 nA @ 9.7 MeV/c. The delivery of <25nA current is the Radiation Control Group's maximum limit and is based on the Radiation Shielding in place at the time of the review. The 9.7 MeV/c energy is based on UITF capability with the single superconducting booster in its current state.
2. Operational beam parameters for the experiment run: 8 MeV/c, 100 nA un-polarized (0.8 W beam power), with a ~50 mm beam diameter (3s) at the exit window.
3. There is a window between March and June where installation of experiment components is planned in the waist height straight ahead section of the UITF.
4. There is a window between July and August where CTF cryo capacity can be used to cool the UITF superconducting booster during the planned experiment run. The CMTF will not be in use during this proposed time, and cryo capacity can be switched from CMTF to UITF needs.

COMMENTS:

1. To meet the requirements for the 100nA average beam current at 8.0 MeV/c the existing radiation shielding is not sufficient. This deficiency has been anticipated by UITF/Experiment/RadCon and plans have been made with FM&L to address these issues before the start of the experiment.
2. The superconducting booster, in its current state, is adequate to deliver the required energy of 8.0MeV/c.
3. The existing polarized gun at the UITF should be capable of delivering an average of 100nA of un-polarized current with a few minor adjustments.

4. The exit window, as designed, meets with JLab pressure safety program requirements. The inclusion of the fast valve and conductance limitation to protect the SRF booster module is a good practice.

RECOMMENDATIONS:

1. **Δ** Existing radiation shielding needs to be upgraded to support the experiment's requirements for delivering an average of 100nA average current at 8.0 MeV/c.
2. If a fast valve and conductance limitation is to be installed to mitigate using a vacuum window to protect the SRF booster module as planned, this will need to be installed before the experiment is conducted.
3. **Δ** The straight ahead section of the beamline, which is to be used during this experiment run, needs modification to incorporate the planned experiment beamline elements.
4. **Δ** A PSS BCM should be added with sufficient accuracy and bandwidth to measure the beam intensity within 2 seconds.

2) Does the material presented herein provide sufficient information to evaluate the safe execution of the planned experiment?

The ERR committee considers this charge element MET. The information was sufficient for safe execution of the planned experiment. Some comments and suggested recommendations were included.

FINDINGS:

1. HRSD Sample Water is not expected to have more than 0.1 ppm concentration of 1,4-dioxane.
2. HRSD Sample Water is not expected to have activated components after irradiation.
3. There is no significant risk for residual pathogens in the "filtered secondary effluent" water matrix.

COMMENTS:

1. Since the water samples from HRSD are basically black box containers, it was uncertain if the provided water samples run the risk of becoming activated by elements within the treated water or may already contain activated elements from medical waste.
2. In terms of safety to personnel, the ERR committee believes that potential safety issues will be addressed based on the plan.
3. The machine protection systems were described and the ERR committee believes that the measures that were described are adequate.

RECOMMENDATIONS:

1. Consider taking Radiation measurements of the water samples before and after the run. E.g. Before dispensing/shipping/disposing to ensure JLab radiation protocols are being adhered to.

2. Evaluate if the planned fast valve interlock vacuum gauge may not operate properly within close proximity to the exit window.

3) *What are the goals of the experiment, and what defines success?*

The ERR committee considers this charge element MET.

FINDINGS:

1. JLab personnel will pick up 4 bottles, 0.5 L each, from HRSD facility:
 - a. 1 bottle with low concentration (10 microg/L) 1,4-dioxane in UPW
 - b. 1 bottle with high concentration (100 microg/L) 1,4-dioxane in UPW
 - c. 1 bottle with low concentration (10 microg/L) 1,4-dioxane in secondary effluent wastewater
 - d. 1 bottle with high concentration (100 microg/L) 1,4-dioxane in secondary effluent wastewater
2. Five sample holders, 75 mL each, will be filled with the content from one of the bottles
3. The water in each of the five sample holders will be irradiated with e-beam at different doses in the range 1-20 kGy. This will be done in a single "beam run"
4. The content of each sample holder will be transferred to 40 mL VOA vials provided by HRSD.
5. Steps 2-4 will be repeated for each bottle, resulting in 20 vials to be analyzed by HRSD.
6. The LDRD project must accomplish goals before the end of FY21.

COMMENTS:

1. Success of the experiment, from JLab's perspective, will be measured by irradiation of each of the samples for the prescribed amount of time using 100nA average beam current at 8.0 MeV/c.
2. Success of the experiment, from HRSD's perspective, will be evidence of the removal of 1,4-dioxane from the samples as a function of dose.
3. Success of experiment, from LDRD side, continued collaboration between JLab and HRSD after LDRD is complete.
4. Success of the experiment, from student's perspective, paper(s) written and student receives PhD.

RECOMMENDATIONS:

1. None.

4) *Is the run plan sufficiently detailed for safe and effective operation?*

The ERR committee considers this charge element NOT MET. There needs to be a document which explains the commissioning and run plan of the irradiation experiment.

FINDINGS:

1. There is an understanding of what the experiment run will require (as far as sample types and beam delivery/sample) to irradiate the samples.
2. There are five (5) sample holders, but no empty or separate target to run beam to when setting up or tuning the beam without irradiating a sample.

COMMENTS:

1. While there are documents on setting up the front end of the machine, the experiment plan is not yet detailed enough to define the safe and effective operation downstream of the modified beamline.
2. Using the YAG viewer to determine beam size may prove difficult with such a diffuse beam (in viewer limited mode).
3. There does not appear to be a plan to validate initial beam size at the target or to validate beam integrity should there be an issue with the UITF causing a beam trip (mismatched magnet, solenoid issue, beam drift over time, etc.)

RECOMMENDATIONS:

1. **Δ** Develop a commissioning and run plan with all the stakeholders which describes all steps required to setup the optics for the new beamline, validate radiation shielding, commission the beamline and expectations for experimental run to each sample including steps to empty sample for transport, clean and refill each sample container.
2. Investigate the use of an x-ray sensitive material at the YAG location to define beam profile during beam delivery.
3. Review beam diagnostics on the target ladder to “see” and understand beam interactions and target location with respect to beam.
4. **Δ** UITF should provide a beam dump/termination to measure that the beam reaches the desired end point, independent of target.

5) Are the roles and responsibilities of the JLab staff, specifically Accelerator and Engineering divisions, clearly defined for this beam run?

The ERR committee considers this charge element Partially MET.

FINDINGS:

1. There is an understanding of what the experiment run will require (as far as hours of beam delivery/sample) to irradiate the samples.
2. Man-hours required for beam delivery during each of the 4 runs of 5 samples is understood.
3. Man-hours for changing the UITF configuration for the experiment was not presented.
4. Staffing limitations due to COVID within the Control Room and UITF User facility are defined by Lab COVID protocols.

COMMENTS:

1. From previous experimental runs with HDIce, as well as UOD staffing expectations, the expectations of staffing requirements for beam delivery are understood.
2. Staffing of the UITF for the experiment run may require additional support should delays occur.
3. Staffing needed to change out UITF components to support the experiment are not fully understood and may be hampered by CEBAF (Schedule Accelerator Down - SAD) needs.

RECOMMENDATIONS:

1. **Δ** Define the roles, responsibilities and workload for changing the beamline components and shielding (Engineering, Injector, Facilities, RadCon, etc.) required for the experiment as well as for running the machine (Injector and Operations staffing) to achieve goals of experiment.
2. **Δ** A change request to Engineering Division will be needed to assist with the UITF engineering needs.

6) Will all work be documented and planned out within the framework of Jefferson Lab's work planning and applicable safety documentation?

The ERR committee considers this charge element MET.

FINDINGS:

1. None.

COMMENTS:

1. It appears that all work for the experiment will be documented and planned per Jefferson Lab's work planning and control processes as well as applicable safety processes.

RECOMMENDATIONS:

1. None.

7) Will this beam run be documented, planned, and executed in accordance with the UITF Operations Directives (UOD)?

The ERR committee considers this charge element MET. The ERR Committee believes that all tasks will be documents, planned and executed as per the UOD. Those tasks which fall outside the UOD will be covered in the run plan or separate work planning documentation.

FINDINGS:

1. None.

COMMENTS:

1. The ERR Committee believes that all tasks will be documents, planned and executed as per the UOD.
2. Those tasks which fall outside the UOD will be covered in the run plan or separate work planning documentation.

RECOMMENDATIONS:

1. Document the location of the all beamline changes and define within the UED.

8) Will the target and associated diagnostics be ready to receive an electron beam of the scale described?

The ERR committee considers this charge element Partially MET. The sample cells have been designed and target windows have been analyzed for beam interactions. There are other experiment diagnostics which need to be considered for an effective run.

FINDINGS:

1. There are five (5) target cells for water samples.

COMMENTS:

1. There is a question regarding the ability to validate the size and location of beam on target.
2. If additional diagnostics are not needed, the experiment already has everything at hand and planned for installation.
3. If the experiment or UITF Management decides to add a termination point for tuning the beam, then the plan will have to be revised. Due to the remaining time between now and beam delivery in July – August, there should be enough time to add a termination point which is not a sample given that the low beam power does not place stringent requirements on such a system.
4. It was unclear if there was an “out” determination on the target ladder for when the target is out of center or in motion to prevent inadvertent beam delivery.
5. 100 nA at a 50 mm diameter is about >1000x more diffuse than typical beam spot. Expect it will be difficult to manage when solenoid is on; using the YAG might be marginal.
6. Loss of electron beam in air is not understood and may need further calculation. (i.e. Gamma and e- distribution will be somewhat different.)

RECOMMENDATIONS:

1. UITF should consider adding mu-metal to the long throw between steering coils.

2. UITF should consider a more functional approach to correctors and bpm's for controlling beam on target, (e.g.: sol-cor-cor-bpm-bpm-tgt; especially helpful to define position/angle in front of target, reproducibly.)
3. UITF needs to add a target motion FSD to prevent inadvertent beam delivery to a target in motion or misaligned.
4. UITF needs to demonstrate the low level baseline of PSS BCM receiver before it can be used for the experiment.
5. UITF needs to consider using an x-ray screen with viewer for position at target
6. UITF needs to consider relocating the gauge on the top of the last cross to prevent radiation damage. Contact Jim Kortze for recommendation. If moved, the response time of the fast valve may need to be reevaluated.

9) *Is the materials handling plan appropriate, and does it adhere to both ALARA principals and JLAB environmental expectations?*

The ERR committee considers this charge element MET.

FINDINGS:

1. Water solution is non-toxic, but must not be ingested.
2. There is no significant risk for residual pathogens in the "filtered secondary effluent" water matrix.
3. Handlers of the sample water from HRSD must wear nitrile gloves and eye protection.
4. Transfer of the water samples from the HRSD containers to the sample holders and from the sample holders to the VOA vials will be done on an absorbent surface.
5. Any leftover water from the sample holders can be disposed in a conventional sanitary drain.

COMMENTS:

1. None.

RECOMMENDATIONS:

1. To aid with actual experimental run efficiency and experiment procedure development, suggest performing a trial sample exchange at the target location with all shielding and experiment equipment in place.
2. As a best practice and to prevent cross-contamination of samples within the target cells, recommend cleaning each target cell after the water sample has been removed.
3. Contact JLab Environmental Program Manager (Scott Conley) to verify that the sample disposal in conventional sanitary drain is consistent with existing NEPA documentation.

10) *What is the status of the COO, ESAD, and OSPs documents, and are the specific procedures and documentation in place and adequate to operate the experiment safely and efficiently?*

The ERR committee considers this charge element MET.

FINDINGS:

1. The COO and ESAD for the experiment were released but not finalized for the review.

COMMENTS:

1. The COO and ESAD appeared to be complete.
2. COO and ESAD experiment number is blank, and should be UE-21-001.
3. While there were no special needs above those defined within the UITS Operations Directives (UOD) the ERG was not presented at the time of the review.

RECOMMENDATIONS:

1. Recommend developing an ERG for the experiment to complete the experiment package. The ERG should explain the hazards as found for the experiment within the UITS and the expectations for personnel if those hazards are found during the experiment.
2. Finalize and have the COO and ESAD documents signed by the ADSO.

11) Have lessons learned from earlier UITS experiments been sufficiently addressed and applied to the execution of this experiment?

The ERR committee considers this charge element MET.

FINDINGS:

1. None.

COMMENTS:

1. The simulations show a large energy spread (75 keV at 8MeV) about 1%. Based on CEBAF experience and Alicia Hoffler's General Particle Tracer (GPT) simulations for UITS expect energy spread closer to 0.1%.
2. Solenoid is a highly dispersive element, so beam sizes might be smaller than expected. Consult with Alicia or Reza for input on E and dE.

RECOMMENDATIONS:

1. Cross-compare and confirm the Energy Spread calculations with Injector Scientist's calculations

12) Are special emergency response guidelines needed for this beam run? If so, are the plans to train laboratory staff on these new guidelines adequate?

The ERR committee considers this charge element MET. There are no special emergency response guidelines outside of UITF protocols and Jefferson Lab training required at UITF.

FINDINGS:

1. No changes to the Emergency Response Guidelines from UITF and HDIce run.

COMMENTS:

1. None

RECOMMENDATIONS:

1. See recommendation above for ERG development.

Notable Items:

1. The placement of the valve at 5m location which will be opened during beam operations only and closed at any other time to protect the beamline components is a good practice.

Opportunities for Improvement:

- a. None