ES&H DIVISION
RADIATION CONTROL DEPARTMENT

Radiological Safety Analysis Document

Hall D Fall 2021 Run

E12-19-003 (SRC/CT)

Liaison: L. Pentchev

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RCD-RSAD-09.01.2021-HD

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Thomas

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Thomas Jefferson National Accelerator Facility

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SRC/CT

(E12-19-003)

RCD-RSAD-09.01.2021-HD

Approval

Keith Welch (Sep 2, 2021 08:07 EDT)

Sep 2, 2021

Keith Welch, Manager
Radiation Control Department

Date

Preparer/ Reviewer

Pavel Degtiarenko (Sep 2, 2021 09:28 EDT)

Sep 2, 2021

Pavel Degtiarenko, Radiation Physicist
Radiation Control Department

Date

Preparer/ Reviewer

Lorenzo Zana (Sep 2, 2021 11:19 EDT)

Sep 2, 2021

Lorenzo Zana, Radiation Physicist
Radiation Control Department

Date

Preparer/ Reviewer

Lubomir Pentchev (Sep 2, 2021 12:01 EDT)

Sep 2, 2021

Lubomir Pentchev, Staff Scientist
Hall D

Date

Contents

This Radiological Safety Analysis Document (RSAD) identifies the general conditions and controls with regard to production, movement, or import of radioactive materials.

1 DESCRIPTION

The fall Hall D SRC/CT experiment (E12-19-003) is scheduled to run from 10-20-2021 to 12-15-2021, a total running time of 55 days. E12-19-003 will utilize up to 12 GeV electron beam; maximum beam current at 300 nA (less than 10 hours); and, regular beam current of 140 nA.

This experiment's run conditions are different than the previous PRIMEX-eta experiment and more similar to the default GlueX configuration. Conditions for this run include:

- the solenoid in Hall D will be turned on
- the vacuum pipe downstream of the FCAL will be installed similar to that of GlueX
- the diamond radiators will be used for data production runs
- targets
  - liquid helium 30 cm (3.9% X0)
  - liquid deuterium 30 cm (4.1% X0)
  - carbon 1.52 cm (7.9 % X0)
  - copper 0.12 cm (8.5% X0)

Table 1. Hall D fall 2021 run plan

Radiator	Current (nA)	Total Time (days)	Comment*
3.9 x10^{-4} X_0 Diamond	< 150	10	30 cm liquid helium target
3.9 x10^{-4} X_0 Diamond	< 150	8	30 cm liquid deuterium target
3.9 x10^{-4} X_0 Diamond	< 150	20	1.52 cm carbon target
3.9 x10^{-4} X_0 Diamond	< 150	10	0.12 cm copper target
3.9 x10^{-4} X_0 Diamond	< 150	1	empty liquid helium target
0.2x10^{-4} X_0 Al	< 2	0.5	PS calibration
3.9 x10^{-4} X_0 Diamond	< 300	0.5	Trigger and detector studies

* standard running conditions

2 SUMMARY and CONCLUSIONS

The SRC/CT Hall D run is not expected to produce significant levels of radiation at the site boundary. However, it will be continuously monitored by the Radiation Control Department (RCD) to ensure that the site boundary goal is not exceeded. Activation of targets, collimators, and beam line hardware must also be considered. As specified in Sections 4 and 7, the manipulation and/or handling of targets and beam line hardware (potentially radioactive material), the transfer of radioactive material, or modifications to the beam line after the target assembly, must be reviewed and approved by the RCD.

Adherence to this RSAD is vital.

3 CALCULATIONS of RADIATION DEPOSITED in the EXPERIMENTAL HALL

The radiation budget for a given experiment is the amount of radiation that is expected at the site boundary as a result of a given set of experiments. This budget may be specified in terms of mrem at the site boundary or as a percentage of the Jefferson Lab design goal (10 mrem per year) for dose to the public. The design goal is 10% of the DOE annual dose limit to the public, and cannot be exceeded without prior written consent from the RCD Manager (RCM) and the TJNAF Director.

The dose-equivalent accumulation for the experiment has been evaluated (see Figure 1) for the deuterium target and does not present much difference from the helium running condition that has been tested in Hall D.

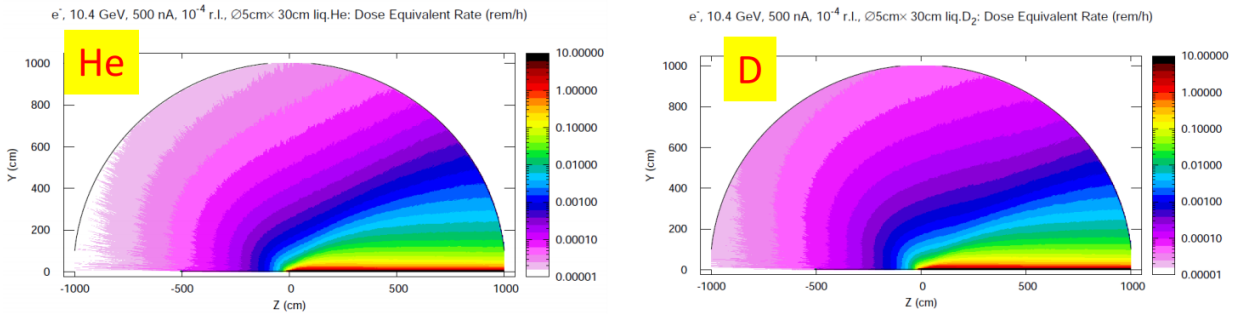

Figure 1. Dose equivalent map - comparison of helium and deuterium targets with 500 nA current at 10.4 GeV beam

The SRC/CT will also have two different solid-target conditions: 7.9%X0 carbon and 8.5%X0 copper targets.

Hall D has solid-target run experience with the PRIMEX-eta experiment (5%X0 Be target). The radiation length of the target with the SRC/CT experiment will be higher than the previous experiment, but the current used for this run will be less than half of the one used during the PRIMEX-eta run. For this reason, running conditions are expected to be acceptable. Neutron backgrounds will be monitored; beam intensity will be adjusted if needed.

The expectation of the small contribution of Hall D to the boundary dose accumulation will be verified during the run using the active monitors at the Jefferson Lab site boundary. If it appears that the radiation budget will be exceeded, the RCD will require a meeting with the experimenters and the Head of the Physics Division to determine if the run conditions are accurate, and to assess what actions may reduce the dose rates at the site boundary. If the dose approaches or exceeds 10 mrem during any calendar year, the run program will stop until a resolution can be reached.

4 RADIATION HAZARDS

The following controls shall be used to prevent the unnecessary exposure of personnel and to comply with Federal, State, and local regulations, as well as with TJNAFs and the experimenter's home institution policies.

4.1 Beam in the Hall

When the Hall status is Beam Permit, there are potentially lethal conditions present. Therefore, prior to going to Beam Permit, several actions will occur. Announcements will be made over the intercom system notifying

personnel of a change in status from Restricted Access (free access to the Hall is allowed with appropriate dosimetry and training) to Sweep Mode. All magnetic locks on the exit doors will be activated. Persons trained to sweep the area will enter by Controlled Access (keyed access) and search in all areas of the Hall to check for personnel.

After the sweep, another announcement will be made indicating a change to Power Permit, followed by Beam Permit. The Run-Safe boxes will indicate "OPERATIONAL" and "UNSAFE".

IF YOU ARE IN THE HALL AT ANY TIME THAT THE RUN-SAFE BOXES INDICATE "UNSAFE", *IMMEDIATELY* PRESS THE "PUSH TO SAFE" BUTTON ON THE BOX.

Controlled area radiation monitors (CARMs) are located in strategic areas around the Hall and the Counting House to ensure that unsafe conditions do not occur in occupiable areas. The Radiation Control Department will monitor the CARMs and prepare surveys, as necessary, to assess the impact of the experiment on radiation levels around the Hall.

4.2 Activation of Target and Beamline Components

All radioactive materials brought to Jefferson Lab shall be identified and reported to the RCD. These materials include, but are not limited to, radioactive check sources (of any activity, exempt or non-exempt); previously used targets or radioactive beam line components; or previously used shielding or collimators. The RCD inventories and tracks *all* radioactive materials onsite.

The RCD will coordinate all movement of used targets, collimators, and shields. RadCon will further assess the radiation exposure conditions and implement controls, as necessary, based on the radiological hazards.

There shall be no local movement of activated target configurations without direct supervision by the RCD.

No work is to be performed on beam line components which could result in dispersal of radioactive material (e.g., drilling, cutting, welding). Such activities must be conducted only with specific permission and control of the Radiation Control Department.

5 INCREMENTAL SHIELDING or OTHER RADIATION-REDUCTION MEASURES

None

6 OPERATIONS PROCEDURES

- All experimenters must comply with experiment-specific administrative controls. These controls begin with the measures outlined in the experiment's Conduct of Operations document, and include, but are not limited to, Radiological Work Permits (RWPs), Temporary Operational Safety Procedures (TOSPs) and Operational Safety Procedures (OSPs), or any verbal instructions from the Radiation Control Department. A general access RWP governing access to the Halls and the accelerator enclosure must be read and followed by all participants in the experiment. This RWP can be read and electronically signed online at: https://misportal.jlab.org/railsForms/rad_work_permits/108811/briefing.

- Any individual with a need to handle radioactive material shall first successfully complete Radiation Worker Level 1 (RW-1) training.

- There shall be adequate communication between the experimenter(s) and the Accelerator Crew Chief and/or Program Deputy to ensure that all power restrictions on the radiator and the target are well known. Exceeding these power restrictions may lead to excessive and unnecessary contamination, activation, and personnel exposure.
- The radiator assembly and the downstream beam line components may not be altered outside the scope of this RSAD without formal RCD review. Alteration of these components may increase radiation production in the Hall and subsequently increase dose at the site boundary.
- Radiological work permits are the standard work authorization documents used to control radiological work. RadCon will require RWPs based on established trigger levels.
- Standard RSAD controls apply; the RCD shall be contacted for any of the following activities.
  - entry to Radiation Areas or High Radiation Areas
  - movement of shielding or collimators
  - breaching the target chamber physical envelope
  - any work on beamline components downstream of the target
  - maintenance of known or potentially contaminated systems
  - any destructive modifications to activated components (drilling, cutting, welding, etc.)

All posted guidance and instructions for contamination controls, shielding configuration, and access to radiological areas must be adhered to.

Note: Work planning for all radiological work shall be coordinated through the Hall Work Coordinator using the ATLis work planning tool.

7 DECOMMISSIONING and DECONTAMINATION of RADIOACTIVE COMPONENTS

Experimenters shall retain all targets and experimental equipment brought to Jefferson Lab for temporary use during the experiment.

After sufficient decay of the radioactive target configurations, they shall be returned to the experimenter's home institution for final disposition.

All transportation shall be conducted in accordance with United States Department of Transportation Regulations (Title 49, Code of Federal Regulations). In the event that the experimenter's home institution cannot accept the radioactive material due to licensing requirements, the experimenter shall arrange for appropriate transfer of funds for disposal of the material. TJNAF cannot indefinitely store radioactive targets and experimental equipment.

8 RADIATION DAMAGE to HALL D ELECTRONICS

Due to the low overall beam power planned to be delivered to the Hall during the SRC/CT fall 2021 run, no problems are anticipated with respect to radiation damage to the electronics, including the most vulnerable silicon photomultipliers (SiPM).

The neutron background for deuterium is higher than the scaled values for the other targets. Neutron background calculations for the deuterium target were performed and compared with the helium target. The reason for this is that the same helium target has already been used in Hall D with more than twice the current (PRIMEX-eta experiment) that is going to be used for this experiment. Figure 2 shows that the neutron background (> 1 MeV) is only 1.5 to 2 times higher for the deuterium target than for ^{4}He. It should be noted that the main neutron damage is accumulated damage that, for GlueX, was estimated for a time period of over a year of running. The proposed deuterium run time is very short (8 days) and will, therefore, have negligible accumulated effect. Neutron backgrounds will be monitored and, if needed, the beam intensity will be reduced for the deuterium running with increased beam time at the expense of the solid targets.

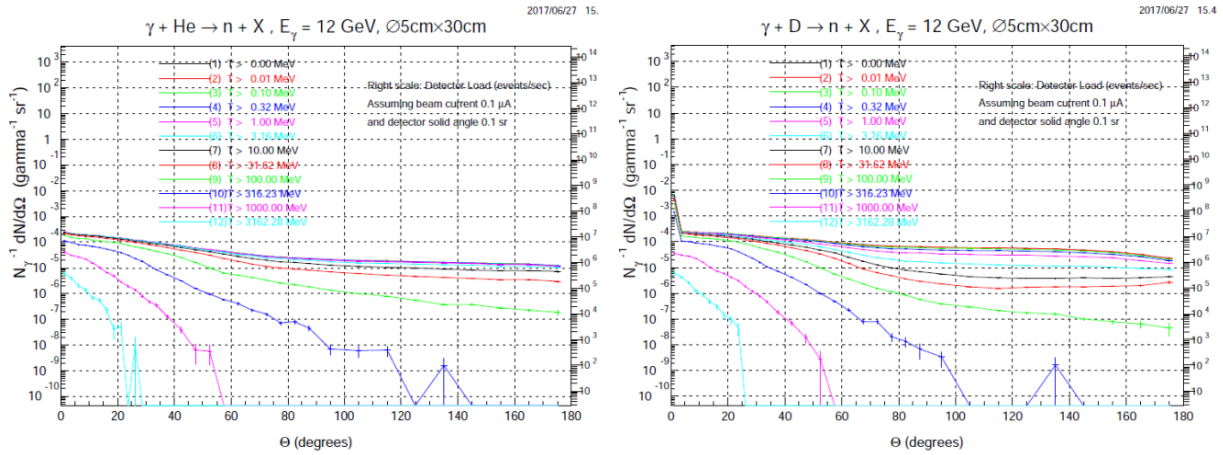

Figure 2. Calculated neutron fluxes for a realistic Hall D photon beam spectrum and targets (deuteron [right] and ^{4}He [left])

Damage to electronics has been evaluated and a simulation conducted to check the level of irradiation for the SiPM detector parts that are known to be susceptible to damage in high neutron-flux conditions (Figure 3).

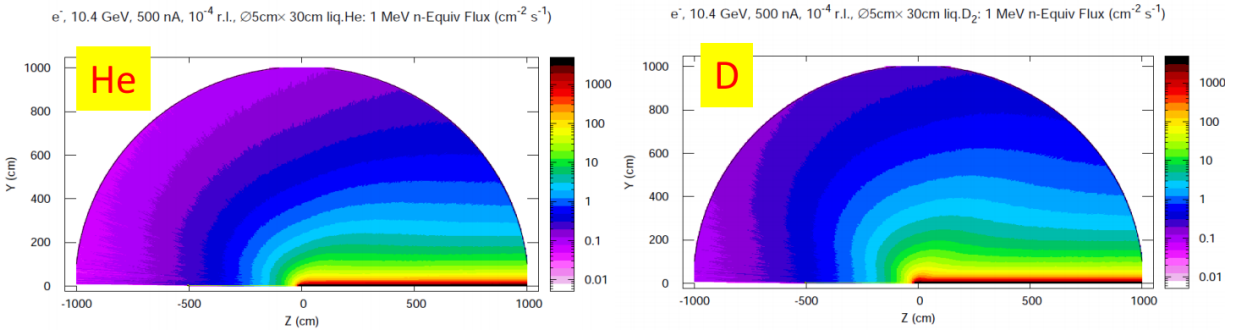

Figure 3. 1 MeV-eq flux comparison between helium and deuterium targets for 500 nA beam current at 10.4 GeV
(levels of irradiation in HD will be comparable between the two targets; see SiPM details in Table 2)

Table 2 shows that the expected run time will not affect much of the life expectancy for the SiPM detectors.

Table 2: Expected SiPM lifetime with continuous running* condition

	GlueX Design	**SRC/CT**	
	LH target	LHe_4 target	LD target
BCAL	5 years	19.9 years	6.5 years
ST	2.1 years	2.6 years	245 days

* the SRC/CT experiment will have ten days run time with LHe_4 and eight days with LD

The Radiation Control Department may be reached at any time through the Accelerator Crew Chief (269-7045) or directly by calling the RadCon cell phone (876-1743). On weekends, swing, and owl shifts, requests for RadCon support should be made through the Crew Chief. This will ensure prompt response with no duplication of effort.