

ES&H DIVISION
RADIATION CONTROL DEPARTMENT

radiological safety analysis document

Hall D Summer-Fall 2022 Run

Charged Pion Polarizability (CPP) (E12-13-008)

PRIMEX-Eta (E12-10-011)

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

1 DESCRIPTION

There are two experiments that are scheduled to run in Hall D in Summer and Fall of 2022 – Charged Pion Polarizability (CPP) (E12-13-008) and the final set of measurements for the PRIMEX-Eta experiment (radiative decay width via the Primakoff effect) (E12-10-011). Both the experiments will use the Hall D solenoid magnet. CPP will be utilizing a 0.3 mm-thick lead target (at $z=1$ cm in the GlueX coordinate system, compared to the regular target position of $z=65$ cm), whereas PRIMEX-Eta will be using a 30 cm-long liquid helium target (at $z=65$ cm). The CPP experiment will use the 3.4 mm collimator; the PRIMEX-Eta experiment will use the 5 mm collimator.

Both the experiments will use the standard GlueX equipment, with a few modifications. For the CPP experiment, a muon detector consisting of wire chambers separated by absorbers will be installed downstream of the FCAL. For the PRIMEX-Eta experiment, the muon detector will be removed, and the COMCAL will be installed, and a beam pipe between the FCAL and CCAL filled with He will be installed downstream of the FCAL. A lead shielding wall (4" along the beam, 24" in X and 18" in Y) will be installed around the beam pipe in front of the solenoid magnet.

The run conditions for both the experiments are summarized in Tables 1 and 2 below. Both the experiments plan to use the highest electron beam energy available, 11.57 GeV.

Table 1. Summary of the CPP run plan. The maximum beam current is 350 nA (<10 h). Regular beam current is below 50 nA.

Radiator	Target	Current	Duration (PAC days)	Comment
Diamond (thickness ~50 microns)	Pb (0.3 mm)	<50 nA	20	Production
Diamond	blank	<50 nA	1.5	Empty target
Diamond		<50 nA	0.5	Diamond alignment
Diamond	Pb (0.3 mm)	<100 nA	1.3	Trigger commissioning
Diamond	Pb (0.3 mm)	< 100 nA	0.1	Lead shield alignment in front of muon detector
Diamond		100 nA	~0.1	Beam energy measurement, collimator blocking for 5 min, periodically
Al ($2 \times 10^{-5} X_0$)		< 2 nA	1.5	TAC/PS calibration

Table 2. Summary of the PRIMEX-Eta run plan. The maximum beam current is 600 nA (<10 h). Regular beam current is below 320 nA.

Radiator	Target	Current	Duration (PAC days)	Comment
Al ($1 \times 10^{-4} X_0$)	Liquid Helium (3.9% X_0)	< 320 nA	4	Beam setup, detector checkout, etc.
Al ($1 \times 10^{-4} X_0$)	Liquid Helium (3.9% X_0)	< 320 nA	19.5	Production
Al ($1 \times 10^{-4} X_0$)	empty (helium gas)	< 320 nA	13	Empty target
Al ($1 \times 10^{-4} X_0$)	Beryllium (1.78 cm thick, 5% X_0)	< 320 nA	1.5	
Al ($2 \times 10^{-5} X_0$)		< 2 nA	1.5	COMCAL/PS calibration

2 SUMMARY and CONCLUSIONS

Both experiments scheduled in Hall D run are not expected to produce significant levels of radiation at the site boundary that will exceed the integrated maximum boundary dose limit of 10mrem. 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 and at BOUNDARY

The radiation budget for given experiments 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.

Dedicated calculations for the dose rate at the site boundary for these two experiments were not carried out; however, expected conditions were compared against previous experiments. Previous PREMIX-Eta data collection run in 2021 was performed with similar current, radiators and targets but for a longer period of time of approximately 50 PAC days (against 40 PAC days requested for the current run). The running conditions for the CPP experiment are compared against those for SRC-CT (spring 2019 run). Targets used were 7.9% X_0 carbon and 8.5% X_0 copper. Most of running time at CPP will be with 0.3mm (5.3% X_0) lead target. Although there is a difference in neutron yield for these materials, the beam current planned for most of the time for CPP is 3 times lower than that for SRC-CT.

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 or in proximity 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

Silicon photomultipliers (SiPM) are the most sensitive electronics to the radiation damage in Hall D. Similar to the discussion of the dose at boundary, the lifetime of SiPM was compared to estimations obtained for

previous experiments. For example, the shortest estimated lifetime for the SRC-CT experiment that ran solid targets in the past, was 245 days for 500nA at 10.4GeV (see Table 3). The CPP experiment, that will use a lead target and currents up to 50nA for 20 days, is not expected to cause sudden hard failures.

Table 3. Expected lifetime of Silicon PM at 500 nA and 10.4 GeV electron beam.

Expected life time of SiPMs			
	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 Radiation Control Department may be reached at any time through the Accelerator Crew Chief (757-269-7045) or directly by calling the RadCon cell phone (757-876-1743). 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.