

Radiological Safety Analysis Document for Charge Proton Radius (PRad) experiment in Hall B

This Radiological Safety Analysis Document (RSAD) will identify the general conditions associated with running the Charge Proton Radius (PRad) experiment in Hall B, and controls with regard to production, movement, or import of radioactive materials.

1 Description

The run of Charge Proton Radius (PRad) experiment, E12-11-106, may take place in spring-summer of 2016 in the experimental Hall-B. The PRad run will use a detector located on the Space Frame of the Hall-B. The setup will use the Hybrid Calorimeter (HyCal) with GEM detector mounted on its face. This calorimeter was previously used in PRIMEX experiment. The experiment will use windowless cold hydrogen gas target located downstream of the tagger magnet. The target density will be of the order 10^{18} atoms/cc. The length of the cell is 4 cm. The cell has openings for the beam passage. The diameter of the openings is 4 mm. Between the target and detectors there will be large 5-meter-long vacuum chamber with downstream diameter of about 2 m. The downstream end of the vacuum chamber has a 0.063"-thick aluminum window with an opening in the center. There is a 1.375" beam pipe attached to the center of the window. The beam passes through this pipe going through central hole of the calorimeter. Downstream of the calorimeter all the way to the Faraday cup there will be 3" beam pipe. There will be continuous vacuum in the beam line with no windows anywhere.

There are two different beam configurations.

In calibration configuration the tagged photon beam produced by 2.2 GeV electrons incident on 10^{-5} r.l. radiator will be used. The beam current will be 0.1 nA. The electron beam will be dumped in the tagger dump. The calorimeter will be placed directly into the photon beam. The photon beam will be stopped in the calorimeter.

In production configuration the electron beam with energies of 1.1 and 2.2 GeV will be used. The beam current will not exceed 75 nA. The beam will be dumped in the Faraday cup. There will be halo counters mounted on the upstream and downstream sections of the beam line. They will be included in the machine fast shutdown system (FSD) to terminate beam delivery in case of missteered beam hitting anything along the beam line.

The run times approved for this experiment are 3 PAC days at 1.1 GeV and 3 PAC days at 2.2 GeV beam energies.

2 Summary and Conclusions

The PRad experimental runs as planned are 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. Residual activation from the experiment is expected to be low; however, beam tune up procedures and occasional beam missteerings may cause Radiation Areas and possibly High Radiation Areas in the Hall. Activation of radiators, collimators and beam line hardware must be considered. As specified in Sections 4 (4.2) and 7, the manipulation and/or handling of radiators, targets and beam line hardware (potential radioactive material), the transfer of radioactive material, or modifications to the beam line after the initial assembly must be reviewed and approved by the RCD. **Adherence to this RSAD is vital.**

3 Calculations of Radiation Dose at the Boundary

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

Calculations of the contribution to Jefferson Lab's annual radiation budget that would result from running under a broad variety of conditions typical of Hall B operations indicate that the contribution from this experiment will be negligible. With this expectation, we have not carried out calculations for the specific running conditions of this experiment.

This expectation will be verified during the run by using the active monitors at the Jefferson Lab site boundary. If it appears that the radiation budget will be exceeded, 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 site boundary. If the site boundary 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 Jefferson Lab 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 exit doors will be activated. Persons trained to sweep the area will enter by keyed access (Controlled 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. 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 HIT THE 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.

4.2 Activation of Target and Beam line Components

All radioactive materials brought to Jefferson Lab shall be identified 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 survey all experimental setups before experiments begin as a baseline for future measurements.

The RCD will coordinate all movement of used targets, collimators, and shields. The RCD will assess the radiation exposure conditions and will 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. Remote movement of target configurations shall be permitted, providing the method of movement has been reviewed and approved 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, etc.). Such activities must be conducted only with specific permission and control of the RCD.

5 Incremental Shielding or Other Measures to be Taken to Reduce Radiation Hazards

As it is mentioned in Section 1, there will be halo counters mounted on the upstream and downstream sections of the beam line. They will be included in the machine fast shutdown system (FSD) to terminate beam delivery in case of missteered beam hitting anything along the beam line. This measure is directed on prevention of electron beam steering errors that would lead to possible activation of the beam line components during the beam delivery.

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 also include, but are not limited to, Radiation Work Permits, Temporary Operational Safety Procedures, and Operational Safety Procedures, or any verbal instructions from the Radiation Control Department. A general access RWP is in place that governs access to Hall B and the accelerator enclosure, which may be found in the Machine Control Center (MCC); it must be read and signed by all participants in the experiment. Any individual with a need to handle radioactive material at Jefferson Lab shall first complete Radiation Worker (RW I) training.

The RCD will commission a Quick Access Monitoring System for the PRad experiment. Once approved by RCD, this system will allow access to the hall **during Controlled Access only** without a manual radiation survey, in accordance with Safety System Operator instructions. The monitoring panel for the Quick Access system is just outside the access gate to the hall. The beacon on the panel shall be tested prior to entry by pressing the test button. At that time, the SSO will allow access to the hall by authorized personnel. The attached addendum to this RSAD describes the monitoring scheme of this system, and gives an overview of the restrictions on access and work while using the QAS. These are summarized as follows:

- No entry to roped off radiation areas without a radiation survey
- No hands-on beamline maintenance anywhere in the hall without a radiation survey
- No access to the beamline between the space frame and CLAS12 detector without a survey
- A full survey of the hall shall be conducted prior to a change to Restricted Access

The attachment shows areas covered by the system and restricted zones.

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 activation, contamination, and personnel exposure.

No scattering chamber or downstream component may be altered outside the scope of this RSAD without formal Radiation Control Department review. Alteration of these components (including the exit beamline itself) may result in increased radiation production from the Hall and a resultant increase in site boundary dose.

Any requested changes outside of the experimental parameters submitted for the RSAD evaluation (i.e., current, energy, target material, target thickness, run time) for this experiment shall require a formal review by the RCD, and a new revision to the RSAD.

7 Decommissioning and Decontamination of Radioactive Components

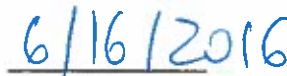
Experimenters shall retain all targets and experimental equipment brought to Jefferson Lab for temporary use during the experiment. After sufficient decay of the radioactive target configurations, they shall be returned to the experimenter's home institution for final disposition. All transportation shall be done in accordance with United States Department of Transportation Regulations (Title 49, Code of Federal Regulations) or International Air Transport Association 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. Jefferson Lab cannot store indefinitely radioactive targets and experimental equipment.

The Radiation Control Department may be reached at any time through the Accelerator Crew Chief (269-7050).

Approvals:



Radiation Control Department Head



Date