ES&H DIVISION
RADIATION CONTROL
DEPARTMENT

radiological safety analysis document

Hall A Spring 2025 Run

E12-07-109, E12-24-010

Liaison: Don Jones

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RCD-RSAD-01.22.2025-HA

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Thomas
Jefferson
National
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Facility

Jefferson Lab
Thomas Jefferson National Accelerator Facility

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Halls A & C

Contents

This Radiological Safety Analysis Document (RSAD) identifies the radiation budget for the experiment, the verification process for the radiation budget, and controls with regard to production, movement, or import of radioactive materials.

1 DESCRIPTION

Experiments **E12-07-109** and **E12-24-010** will determine the ratio of the proton's elastic electric to magnetic form factor by measuring the recoil polarization components of elastically scattered protons. The measurement will be done at four beam energies to cover four Q^2 points with the highest at $Q^2 = 12$ GeV^2. The elastically scattered electron will be detected in the large electron calorimeter (ECAL) in coincidence with the proton detected in the large hadron calorimeter (HCAL). The recoil polarization components of the scattered proton are measured in a focal plane polarimeter placed after the Super BigBite magnet and before the HCAL. **E12-24-010** is a high precision measurement of a low Q^2 kinematic point which is a necessary part of a proposed measurement of two-photon exchange effects in elastic scattering with the complementary measurement of the same Q^2 point with a positron beam (see LOI12+**23-008**).

2 SUMMARY and CONCLUSIONS

The boundary dose accumulation in the run period due to this group of experiments in Hall A is estimated to be approximately **2.9 mrem**, i.e., **29%** of the annual design goal. Radiation levels will be continually recorded and periodically checked by the Radiation Control Department (RCD or RadCon) to ensure that the site boundary goal is not exceeded. Radiation hazards associated with activation of the targets and the beam line hardware require special consideration. The experiment will likely cause radiation areas (RAs) and high radiation areas (HRAs) in the Hall. There will be regular need to access the target platform during the experiment. As specified in Sections 4, 6, and 7, the manipulation and/or handling of targets or beam line hardware (potential radioactive material), the transfer of radioactive material, or modifications to the beam line downstream from the target assembly must be reviewed and approved by the RCD.

Adherence to this RSAD is vital.

3 CALCULATIONS of RADIATION DOSE at the SITE BOUNDARY

The radiation budget for a given experiment or group of experiments is the amount of radiation that is expected at the site boundary as a result of a given set of experimental conditions. This budget may be specified in terms of dose accumulation (in mrem) at the site boundary, or as a percentage of the Jefferson Lab design goal for dose to the public, which is 10 mrem per year. 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 and TJNAF Director.

The radiation budget for the spring 2025 Run in Hall A is approximately **2.9 mrem**, or **29%,** of Jefferson Lab's annual design goal. The Radiation Budget (refer to Section 8) illustrates the calculations, performed jointly for the two experiments, using the standard calculation tools by the RCD Radiation Physics Group. The maximum beam current for the run is planned to be set at 70 μA, as shown in the Radiation Budget.

The Hall's contribution to the boundary dose will be verified during the run period by using the active monitors at the site boundary to keep up with the dose for the individual setups. If it appears that the radiation budget will be exceeded, RadCon will request a meeting with the experimenters and the Head of the Physics Division to determine if the experimental 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 experimental program will not proceed until a resolution is reached and approved by the TJNAF Director.

4 RADIATION HAZARDS

To better protect the environment and the equipment from the radiation damages, and to prevent unnecessary exposure of personnel, all persons involved shall:

- comply with the experimenter's home institution policies;
- adhere to federal, state, and local regulations; and,
- abide by the controls listed below.

4.1 Beam in the Hall

When the Hall status is *Beam Permit*, there are potentially lethal conditions present. As such, 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 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 radiological surveys as necessary to assess the impact of the experiment on radiation levels around the Hall.

Note: Any indication that radiation levels may exceed 5 mrem/h dose rate in an occupied area will require immediate mitigation, with continued operations contingent upon a formal review of conditions and operational parameters. Approval of operations exceeding this threshold is required by the Radiation Control Department Manager, in consultation with Physics and Accelerator Division Safety Officers.

4.2 Activation of Target and Beamline Components & with Other Materials in the Hall

Some potential exists for unusual radiological conditions in the Hall during and after the run. The customary radiation protection measures must be taken for all beamline-related work. The following controls and precautions must be adhered to.

- **Given the conditions for this run period, a radiation area is expected to develop near the target and downstream of the beamline interface. High radiation areas are also possible.** The presence of a beam collimation device just upstream of the target may cause higher-than-normal activation levels. The magnitude of activation is not possible to accurately predict. A support system will be installed in this area to facilitate installation of shielding if necessary. A radiological work permit (RWP) will govern the installation of shielding and all work in the target area. Dose goals of no more than 25 mrem per work day for any worker and 250 mrem collective dose for the run period will be established. Special monitoring will be deployed to assess conditions as the experiment proceeds. If there is *any* indication that these dose goals may be exceeded, or that the area dose rate may exceed 1 rem/h upon entry, a meeting between the RCD and Hall leadership to develop plans for mitigation will be triggered.

- **The target enclosure area and downstream beamline may become contaminated.** No work on this portion of the beamline is to be conducted without RCD review. It is possible that the work will need formal approval by the

Jefferson Lab Radiation Review Panel (due to the potential for high localized levels of contamination). All work on or around the target area will require, at a minimum, a Job-specific RWP.

Special Ventilation Configuration: In an effort to prevent buildup of contamination, the target enclosure hut is equipped with negative ventilation. This system is also required to be operating (for ODH purposes) when access to the hut is made because of the presence of a nitrogen gas purge system in the hut. A flow monitoring and alarm system is installed on the ventilation duct. When the purge is active, no access to the hut is allowed unless the ventilation is on and the alarm is clear. An OSP covers target hut access.

- **The area around the beam dump or hall interface will become an RA and may become an HRA.** The area around the Moller polarimeter targets may also become a radiation area. ***Always confer with the RCD prior to entry to any posted radiation or high radiation area*.**

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

- **This experiment is expected to produce low levels of airborne radioactivity which may impact environmental effluent standards and produce localized or generalized buildup of surface contamination in the Hall.** Airborne radioactivity concentration in the Hall is measured continuously.

  If airborne radioactivity concentration as monitored by the AMS-4 air monitor in Experimental Hall A exceeds an average of 1.0E-6 µCi/cc for a period of greater than 5 consecutive days, the RCD will request and schedule require a meeting with the experimenters and the Head of the Physics Division to determine if the experimental conditions are accurate; and, to assess what actions may be needed to reduce the airborne radioactivity effluent levels, and control & minimize contamination inside the Hall.

- **Low levels of surface contamination are expected in the target enclosure and on the downstream beamline**. Locally high contamination levels may be present on windows, target cells, and adjacent surfaces as well as the potential for ***hot particle*** contamination. This may occur from degradation of aluminum covers associated with beryllium windows, or if a target cell were to rupture. The RCD will monitor for the presence of this hazard, as appropriate, and will implement controls commensurate with the conditions. ***All posted guidance for contamination control must be observed.*** Refer to the General Access RWP for details regarding controls for potentially affected systems.

- **Under high-current running conditions, deposition of short-lived air activation products may occur in general areas of the Hall.** RadCon personnel will periodically monitor for this condition. In the event that such conditions are detected, the RCD, in consultation with the Physics Division, will institute an appropriate access delay protocol to allow time for these radionuclides to decay prior to entry to the Hall.

- **Some sections of beamline may contain indium gaskets or seals**. These components should always be considered as *potentially contaminated*. Always consult with RCD prior to disassembling any beamline components incorporating indium seals.

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

4.3 Other Sources

All radioactive materials brought to Jefferson Lab shall be reported to the Radiation Control Department. These materials include, but are not limited to, radioactive check sources (of any activity, exempt or nonexempt); previously used targets or radioactive beamline components; previously used shielding or collimators; and, He-3 containers. The RCD inventories and tracks *all* radioactive materials onsite. RadCon may survey the experimental setup before experiments begin to use as a baseline for future measurements if significant residual activity levels are present.

Tanks or cylinders of He-3 containing more than 10 mCi of tritium (H-3) shall not be stored or used in an experimental hall without the express, written permission of the RCD Manager. Any containers of He-3 brought on site shall be assessed for tritium content before use. Additionally, He-3 containers should not be stored in any experimental hall when not in use.

5 INCREMENTAL SHIELDING or OTHER MEASURES to REDUCE RADIATION HAZARDS

The RCM will notify the Hall Leader and Physics Division Safety Officer of any identified trends, which might impact access to the hall or create conditions requiring broad changes to radiological working standards (e.g., General Access RWP revision). In case of detecting such trends, the RCM will recommend engineered or other controls considered necessary to prevent significant degradation of the radiological conditions in the hall.

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, radiological work permits (RWPs), temporary operational safety procedures(TOSPs), and operational safety procedures (OSPs), or any verbal instructions from the Radiation Control Department. The General Access RWP governing access to the experimental halls and the accelerator enclosure must be read and signed (signifying understanding of its contents). All participants involved in the experiment must abide by the contents of the GARWP. This RWP can be read and electronically signed online via this website: https://www.jlab.org/esh/radcon/operations/RWPs

- Any individual with a need to handle radioactive material at Jefferson Lab shall first complete Radiation Worker Level (RW-I) 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 target are well known. Exceeding these power restrictions may lead to excessive and unnecessary contamination, activation, and personnel exposure. The beam current and/or power and other beam parameter restrictions shall be documented in the Operational Restrictions list at http://opweb.acc.jlab.org/internal/ops/ops_webpage/restrictions/ops_restrictions.html

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

- **Any requested changes outside of the experimental parameters (e.g., current, energy, target material, target thickness, run time) submitted for calculation of the radiation budget** of this experiment shall require formal review by the Radiation Control Department. If changes to the parameters of the experiment covered by this RSAD results in adjustments to the original radiation budget, this RSAD will be revised to reflect such.

- **Standard procedures**
  Radiological work permits are the standard work authorization documents used to control radiological work. Permits are required based on established trigger levels.

  Standard RSAD controls apply. The RCD shall be contacted before *any* of the following activities take place.
  - entry to radiation areas or high radiation areas
  - movement of shielding or collimators
  - breaching the target enclosure 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: 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 (49 CFR Transportation) 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 to TJNAF for disposal of the material.

TJNAF cannot store indefinitely any radioactive targets or experimental equipment.

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, ensuring prompt response with no duplication of effort.

8 RADIATION BUDGET

Hall: A **RADIATION BUDGET FORM** *page:* 1 of 1

Exp. # E12-07-109 E12-24-010 **rev:** **run dates: Spring 2025** **name of liaison: Don Jones**

setup number			1	2	3	4	5	6	7	8	9	10	11	12	
beam	energy	GeV	6.5	6.5	6.5	8.6	8.6	8.6	10.7	10.7	10.7	4.4	4.4	4.4	*totals:*
	current	uA(CW)	70.0	40.0	70.0	70.0	40.0	70.0	70.0	40.0	70.0	70.0	40.0	70.0	
exp't target	element		H	Al	C	H	Al	C	H	Al	C	H	Al	C	
	thickness	mg/cm2	2130	700	308	2130	700	308	2130	700	308	2130	700	308	
	dist. to pivot	m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Z		1	13	6	1	13	6	1	13	6	1	13	6	
	A		1	27	12	1	27	12	1	27	12	1	27	12	
cryo tgt window	element		Al			Al			Al			Al			
	thickness	mg/cm2	67.5			67.5			67.5			67.5			
	dist. to pivot	m	0.0			0.0			0.0			0.0			
	Z		13	0	0	13	0	0	13	0	0	13	0	0	
	A		27	0	0	27	0	0	27	0	0	27	0	0	
critical window	radius	cm	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	
	dist. to pivot	m	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10	
scattering weighting factor			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
time	run time (100% eff.)	hours	127.2	2.4	2.4	363.6	6	2.4	1053.6	12	2.4	45.6	1.2	1.2	1620
		days	5.30	0.10	0.10	15.15	0.25	0.10	43.90	0.50	0.10	1.90	0.05	0.05	67.50
	installation time	hours													0
		days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dose rate at the fence post (run time)	method 1	urem/hr	1.73	1.33	0.78	1.78	1.44	0.86	1.82	1.50	0.90	1.70	1.19	0.69	
	method 2	urem/hr													
	conservative	urem/hr	1.73	1.33	0.78	1.78	1.44	0.86	1.82	1.50	0.90	1.70	1.19	0.69	
dose per setup		urem	220	3	2	646	9	2	1917	18	2	77	1	1	2899
% of annual dose budget		%	2.2	0.0	0.0	6.5	0.1	0.0	19.2	0.2	0.0	0.8	0.0	0.0	28.99
% of allowed dose for the total time															156.8
% of allowed dose for the run time only															156.8

If > 200%, discuss result with Physics Research EH&S officer

date form issued: December 13, 2024 *authors:* P. Degtiarenko