RSAD for Spring 2019 Run in Hall C

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.

I. Description

This RSAD covers the suite of experiments scheduled for the spring of 2019 in Hall C, consisting of the two groups of experiments: E12-16-007 and E12-09-002, utilizing wide-aperture beam line downstream the target, - and E12-09-011, E12-06-101, E12-07-105, E12-15-001 with the narrow downstream beam line. Beam energy and current span from 4.55 to 10.6 GeV and up to 90 μA. Detailed descriptions of these experiments can be found at https://www.jlab.org/Hall-C/upgrade/12gev_experiments.html.

II. Summary and conclusions

The boundary dose accumulation due to this run in Hall C is estimated to be approximately **3.9 mrem**, i.e. **39%** of the annual design goal. Dose rate averaged over the run time in the first group of experiments is approximately 550% of the design average dose rate, and is about 190% for the second group. The average for the run period is expected, correspondingly, to be about 350%, which is above the alert threshold of 200%. Radiation levels will be continually recorded and periodically checked by the Radiation Control Department to ensure that the site boundary goal is not exceeded. Radiation hazards associated with activation of the beam line hardware require special consideration. As specified in Sections IV, VI, and VII, the manipulation and/or handling of target(s) or beam line hardware (potential radioactive material), the transfer of radioactive material, or modifications to the beam line after the target assembly must be reviewed and approved by the Radiation Control Department.
Adherence to this RSAD is vital.

III. Calculations of radiation dose at site 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 experimental conditions. 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 Radiation Control Department Head and the Director of Jefferson Lab.

The radiation budget for the spring 2019 run in Hall C is approximately **3.9 mrem**, or **39%** of Jefferson Lab's annual design goal. The attached Radiation Budget Forms (see Appendix A and Appendix B below) detail the calculations for the two groups of experiments with different configurations of the beam line downstream the target.

The Hall's contribution to the boundary dose will be verified during the run period by using the active monitors at the Jefferson Lab site boundary to keep up with the dose for the individual setups. If it appears that the radiation budget will be exceeded, the Radiation Control Department (RCD) will require a meeting with 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 Lab Director.

IV. 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 policies.

A. From 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. 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 (RCD) will monitor the CARMs and make surveys as necessary to assess the impact of the experiment on radiation levels around the hall.

B. From activation of target, radiator, beamline components, and other materials in the hall

1. **Given the conditions for this run period, it is expected that High Radiation Areas will develop near the target area. Radiation Areas will likely occur at the beam dump/hall interface, and it is possible that this may become a High Radiation Area.** Always confer with RCD prior to entry to any posted Radiation or High Radiation Area.
2. **The 10% Cu radiator and the surrounding area are expected to become significantly activated during and after the corresponding runs**. This area is expected to become a High Radiation Area and remain so for several days following the corresponding run period.
3. **After the experiment commences, ALL work in the vicinity of the target chamber (within several meters up and downstream)** requires RCD review.
4. 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 the experimental hall exceeds an average of 1.0E-6 μCi/cc for a period of greater than 5 consecutive days**, RCD will 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 to control/minimize contamination inside the hall.

5. **Low levels of surface contamination are expected in some areas, including directly on/around the target chamber and vicinity beamline upstream/downstream.** The RCD will monitor for the presence of this hazard as appropriate, and will require administrative controls and/or PPE 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.
6. **Some sections of beamline may contain indium gaskets/seals**. These components should always be considered potentially contaminated. Always consult with RCD prior to disassembling any beamline components incorporating indium seals.

C. Other sources

All radioactive materials brought to Jefferson Lab shall be identified 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, or He-3 containers. The RCD inventories and tracks all radioactive materials onsite. The Radiation Control Department may survey the experimental setup before experiments begin 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 the tritium content before use. Additionally, He-3 containers should not be stored in the experimental hall when not in use.

V. Incremental shielding or other measures to be taken to reduce radiation hazards

A small supplemental shield package is applied to the copper radiator assembly. This shielding is intended to reduce radiation damage in electronics in the area upstream of the target. However, this shielding also serves a personnel protection purpose, and has been evaluated by RCD specifically for reduction of dose rate in the area due to activation. The configuration will be under standard RCD shielding configuration control, labeled, inspected and tracked. No alteration of this shielding shall be conducted without prior notification and approval of RCD.

The RCD Manager will notify the Operations Director and Accelerator Division Safety Officer of any identified trends which might impact access to the hall or create conditions requiring broad changes to radiological working standards (i.e. General Access RWP revision). The RCD Manager will recommend engineered or other controls considered necessary to prevent significant degradation of the radiological conditions in the hall.

VI. Operations procedures

A. 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 governing access to the Halls and the accelerator enclosure must be read and followed by all participants in the experiment.

B. Any individual with a need to handle radioactive material at Jefferson Lab shall first complete Radiation Worker (RW-I) training.

C. **There shall be adequate communication between the experimenter(s) and the Accelerator Crew Chief and/or Program Deputy** to ensure that all beam restrictions are understood and not exceeded. Exceeding these power restrictions may lead to excessive and unnecessary contamination, activation, and personnel exposure. The beam current/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

D. **No target 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 in the Hall and a resultant increase in site boundary dose.

E. **Any requested changes outside of the experimental parameters submitted for the calculation of the radiation budget (e.g., current, energy, target material, target thickness, run time)** for this experiment shall require a formal review by the Radiation Control Department, and a new revision to the RSAD.

F. **Standard procedures**

Radiation Work Permits (RWPs) are the standard work authorization documents used to control radiological work. RCD will require RWPs based on established trigger levels.

Standard RSAD controls apply: RCD shall be contacted for any of the following activities:

1. Entry to Radiation Areas or High Radiation Areas
2. Movement of shielding or collimators
3. Breaching the target chamber physical envelope
4. Any work on beamline components downstream of the target
5. Maintenance of known or potentially contaminated systems
6. 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 (W. Kellner) using the ATLis work planning tool.

VII. 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 Civil Aviation Organization (ICAO) 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 indefinitely store radioactive targets and experimental equipment.

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 Shift, and Owl Shift, requests for RadCon support should be made through the Crew Chief. This will ensure that there is prompt response with no duplication of effort.

Approvals:

Radiation Control Department Head

5/16/2019
Date

Attachment A (runs with narrow-aperture downstream beamline

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

Exp. # Run group E12-16-007, E12-09-002 **rev:** **run dates: Spring, 2019** **name of liaison: Ole Hansen**

setup number			1	2	3	4	5	
beam	energy	GeV	10.6	10.6	10.6	10.6	10.6	*totals:*
	current	uA(CW)	50.0	50.0	25.0	50.0	40.0	
radiator	element		Cu					
	thickness	mg/cm2	1157					
	dist. to pivot	m	-1.00					
	Z		29	0	0	0	0	
	A		64	0	0	0	0	
exp't target	element		H	D	D	H	Al	
	thickness	mg/cm2	723	1670	1670	723	525	
	dist. to pivot	m	0.0	0.0	0.0	0.0	0.0	
	Z		1	1	1	1	13	
	A		1	2	2	1	27	
cryo tgt window	element		Al	Al	Al	Al		
	thickness	mg/cm2	137	137	137	137		
	dist. to pivot	m	0.0	0.0	0.0	0.0		
	Z		13	13	13	13	0	
	A		27	27	27	27	0	
critical window	radius	cm	6.32	6.32	6.32	6.32	6.32	
	dist. to pivot	m	5.57	5.57	5.57	5.57	5.57	
scattering weighting factor			0.50	0.50	0.50	0.50	0.50	
time	run time	hours	264	68	68	24	24	448
	(100% eff.)	days	11.0	2.8	2.8	1.0	1.0	18.7
	installation time	hours						0
		days	0.0	0.0	0.0	0.0	0.0	0.0
dose rate at the fence post (run time)	method 1	urem/hr	9.34	2.80	1.40	0.79	1.31	
	method 2	urem/hr						
	conservative	urem/hr	9.34	2.80	1.40	0.79	1.31	
dose per setup		urem	2466	191	95	19	31	2802.1
% of annual dose budget		%	24.7	1.9	1.0	0.2	0.3	28.021
% of allowed dose for the total time								547.9
% of allowed dose for the run time only								547.9

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

date form issued: January 9, 2019 *authors:* P. Degtiarenko

Attachment B (runs with wide-aperture downstream beamline)

Hall: C

RADIATION BUDGET FORM

page: 1 of 1

Exp. # Run group **rev:** **run dates: Fall, 2018** **name of liaison: Ole Hansen**

E12-09-011, E12-06-101, E12-07-105, E12-15-001

setup number			1	2	3	4	5	6	7	8	9	10	11	12	
beam	energy	GeV	8.50	8.50	6.40	6.40	2.75	2.75	3.65	3.65	4.55	4.55	4.55	4.55	*totals:*
	current	uA(CW)	70.0	40.0	70.0	40.0	90.0	40.0	90.0	40.0	90.0	40.0	90.0	40.0	
exp't target	element		H	Al	H	Al	H	Al	H	Al	H	Al	H	Al	
	thickness	mg/cm2	723	525	723	525	723	525	723	525	723	525	723	525	
	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	1	13	1	13	1	13	1	13	1	13	
	A		1	27	1	27	1	27	1	27	1	27	1	27	
cryo tgt window	element		Al		Al		Al		Al		Al		Al		
	thickness	mg/cm2	137		137		137		137		137		137		
	dist. to pivot	m	0.0		0.0		0.0		0.0		0.0		0.0		
	Z		13	0	13	0	13	0	13	0	13	0	13	0	
	A		27	0	27	0	27	0	27	0	27	0	27	0	
critical window	radius	cm	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	
	dist. to pivot	m	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	
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	hours	240	24	62.4	9.6	21.6	2.4	21.6	2.4	21.6	2.4	108	12	528
	(100% eff.)	days	10.0	1.0	2.6	0.4	0.9	0.1	0.9	0.1	0.9	0.1	4.5	0.5	22.0
	installation	hours													0
	time	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	1.62	1.54	1.87	1.60	4.29	2.18	3.45	1.90	2.96	1.74	2.96	1.74	
	method 2	urem/hr													
	conservative	urem/hr	1.62	1.54	1.87	1.60	4.29	2.18	3.45	1.90	2.96	1.74	2.96	1.74	
dose per setup		urem	389	37	117	15	93	5	75	5	64	4	319	21	1143.2
% of annual dose budget		%	3.9	0.4	1.2	0.2	0.9	0.1	0.7	0.0	0.6	0.0	3.2	0.2	11.432
% of allowed dose for the total time															189.66
% of allowed dose for the run time only															189.66

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

date form issued: January 9, 2019 *authors:* P. Degtiarenko