RSAD for Fall 2017/Spring 2018 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 fall of 2017 and spring of 2018 in Hall C, consisting of experiments E12-06-107, E12-10-002, E12-10-003, E12-10-008 and E12-09-017. Beam energy and current span from 2.2 to 10.6 GeV and up to 80 μA. Detailed descriptions of these experiments can be found at https://www.jlab.org/Hall-C/upgrade/12gev_experiments.html. The run also includes about one week dedicated to detector commissioning.

II. Summary and Conclusions

The boundary dose accumulation due to this run in Hall C is estimated to be approximately **3.13 mrem**, i.e. **31%** of the annual design goal. It should be noted that since the experiment period extends from one calendar year into the next, the dose contribution will be divided between 2017 and 2018, but the vast majority of the dose is expected to occur in 2018. Dose rate averaged over the run time is approximately 328% of the design average dose rate, which is higher than the alert threshold of 200%. This has been discussed with Physics Division, and it is not expected to significantly impact work in the hall or subsequent experimental runs. 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 fall 2017-spring 2018 run in Hall C is approximately **3.13 mrem**, or **31%** of Jefferson Lab's annual design goal. The attached Radiation Budget Form details the calculations.

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 and Beamline Components and Other Materials in the Hall

1. **Given the conditions for this run period, it is expected that Radiation Areas will develop near the target area and beam dump/hall interface.** It is possible that these areas may also contain High Radiation Areas. Always confer with RCD prior to entry to any posted Radiation or High Radiation Area.
2. **The target chamber area and downstream beamline are expected to become mildly activated.** No work on these portions of the beamline should be conducted without RCD review.
3. 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.
4. **Low levels of surface contamination may occur in some areas**. 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.

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

No specifically prescribed shielding is planned for this experiment. It is up to the Operations Director in conjunction with Physics Division management to consider the potential dose from this experiment and its impact on the annual dose budget.

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 ewith 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 from 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

11/20/2017

Date

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Hall: C **RADIATION BUDGET FORM** *page:* 1 of 2

Exp. # Group Run **rev:** **run dates: 2017-2018** **name of liaison: O. Hansen**

E12-06-107,E12-10-002,E12-10-008,E12-10-003,E12-09-017

setup number			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
beam	energy	GeV	2.2	2.2	6.4	6.4	6.6	6.6	6.6	10.6	10.6	10.6	10.6	10.6	6.6	6.6	10.6	10.6	10.6
	current	uA(CW)	50.0	50.0	50.0	50.0	80.0	80.0	80.0	65.0	65.0	65.0	65.0	65.0	40.0	40.0	65.0	65.0	65.0
exp't target	element		C	H	C	H	C	C	H	C	H	H	D	Al	D	Al	H	C	Be
	thickness	mg/cm2	868	710	868	710	524	2068	710	2068	710	710	1690	536	1690	536	284	666	1300
	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	0.0	0.0	0.0	0.0	0.0
	Z		6	1	6	1	6	6	1	6	1	1	1	13	1	13	1	6	4
	A		12	1	12	1	12	12	1	12	1	1	2	27	2	27	1	12	9
cryo tgt window	element			Al		Al			Al		Al	Al	Al		Al		Al		
	thickness	mg/cm2		137		137.2			137.2		137.2	137.2	137.2		137.2		137.2		
	dist. to pivot	m		0.0		0.0			0.0		0	0	0		0		0		
	Z		0	13	0	13	0	0	13	0	13	13	13	0	13	0	13	0	0
	A		0	27	0	27	0	0	27	0	27	27	27	0	27	0	27	0	0
critical window	radius	cm	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62	2.62
	dist. to pivot	m	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96
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	0.50	0.50	0.50	0.50	0.50
time	run time (100% eff.)	hours	24	24	24	24	4	16	4	125	31	82	40	19	2.4	2.4	12	43	12
		days	1.0	1.0	1.0	1.0	0.2	0.7	0.2	5.2	1.3	3.4	1.7	0.8	0.1	0.1	0.5	1.8	0.5
	installation time	hours																	
		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	0.0	0.0	0.0	0.0
dose rate at the fence post (run time)	method 1	urem/hr	3.17	2.35	2.60	1.15	2.34	12.27	1.82	10.36	1.23	1.23	3.93	2.38	2.39	1.51	0.77	2.54	4.95
	method 2	urem/hr																	
	conservative	urem/hr	3.17	2.35	2.60	1.15	2.34	12.27	1.82	10.36	1.23	1.23	3.93	2.38	2.39	1.51	0.77	2.54	4.95
dose per setup		urem	76	56	62	28	9	196	7	1296	38	100	157	45	6	4	9	109	59
% of annual dose budget		%	0.8	0.6	0.6	0.3	0.1	2.0	0.1	13.0	0.4	1.0	1.6	0.5	0.1	0.0	0.1	1.1	0.6

date form issued: November 17, 2017 *authors:* P. Degtiarenko

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Hall: C **RADIATION BUDGET FORM** *page:* 2 of 2

Exp. # Group Run **rev: 0** **run dates: 2017-2018** **name of liaison: O. Hansen**

E12-06-107,E12-10-002,E12-10-008,E12-10-003,E12-09-017

setup number			18	19	20	21	22	23		
beam	energy	GeV	10.6	10.6	10.6	10.6	10.6	10.6		*totals:*
	current	uA(CW)	65.0	65.0	70.0	70.0	50.0	40.0		
exp't target	element		B	B	D	H	D	Al		
	thickness	mg/cm2	463	473	1690	710	1620	536		
	dist. to pivot	m	0.0	0.0	0.0	0.0	0.0	0.0		
	Z		5	5	1	1	1	13		
	A		9	9	2	1	2	27		
cryo tgt window	element		C	C	Al	Al	Al			
	thickness	mg/cm2	139	129	137.2	137	137			
	dist. to pivot	m	0	0	0	0.0	0.0			
	Z		6	6	13	13	13	0		
	A		12	12	27	27	27	0		
critical window	radius	cm	2.62	2.62	2.62	2.62	2.62	2.62		
	dist. to pivot	m	2.96	2.96	2.96	2.96	2.96	2.96		
scattering weighting factor			0.50	0.50	0.50	0.50	0.50	0.50		
time	run time	hours	12	12	72	114	114	24		836.8
	(100% eff.)	days	0.5	0.5	3.0	4.8	4.8	1.0		34.9
	installation time	hours								0
		days	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	2.26	2.25	4.24	1.32	2.90	1.47		
	method 2	urem/hr								
	conservative	urem/hr	2.26	2.25	4.24	1.32	2.90	1.47		
dose per setup		urem	27	27	305	150	331	35		3134.8
% of annual dose budget		%	0.3	0.3	3.0	1.5	3.3	0.4		31.348
% of allowed dose for the total time										328.16
% of allowed dose for the run time only										328.16

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

date form issued: November 17, 2017 *authors:* P. Degtiarenko