Radiological Safety Analysis Document

This Radiological Safety Analysis Document (RSAD) will identify 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

Experiment E04-018, Elastic Electron Scattering off ^{3}He and ^{4}He at Large Momentum Transfers, will be run in Hall A from approximately November 29, 2006 to December 21, 2006 and February 24, 2007 to April 24, 2007. The current for this experiment will be 100 microamps with liquid hydrogen, helium, and aluminum targets. The energy will vary from 0.687 to 4.328 GeV. A description of the experiment may be found at: http://www.jlab.org/exp_prog/proposals/04/PR04-018.pdf

II. Summary and Conclusions

The experiment is calculated to use **61.7%** of the annual design goal at the Jefferson Lab boundary for **1944.2** hours run-time. There will be no need for manual manipulations of the target or need to access the target platform during the experiment. The experiment will be periodically monitored by the Radiation Control Department to ensure that the site boundary goal is not exceeded. The experiment will likely cause Radiation Areas and High Radiation Areas in the Hall. **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, the Director of Jefferson Lab, and the Department of Energy.

The radiation budget for experiment **E04-018**, with Physics Liaison Javier Gomez, is approximately **6.17 mrem**, or **61.7%** of Jefferson Lab's annual design goal. The attached spreadsheet details the calculations.

The Hall's budget will be verified during the experiment 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 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 stop until a resolution can be reached.

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 and the Experimenter's home institution 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 lights will dim and Run-Safe boxes will indicate "OPERATIONAL" and "UNSAFE". IF YOU ARE IN THE HALL AT ANY TIME THAT THE RUN-SAFE BOXES INDICATE "OPERATIONAL" AND/OR "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.

If airborne radioactivity concentration as monitored by the AMS-4 air monitor in the experimental hall exceeds an average of 1.0E-6 microCurie/cm^3 for a period of greater than 5 consecutive days, the Radiation Control Department (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 reduce the airborne radioactivity levels to ensure that Jefferson Lab dose to the public from release of airborne radioactivity limits are not exceeded.

B. From Activation of Target and Beamline Components

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 will survey all experimental setups before experiments begin as a baseline for future measurements.

The Radiation Control Department will coordinate all movement of used targets, collimators, and shields. The Radiation Control Department 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 Radiation Control Department. Remote movement of target configurations shall be permitted, providing the method of movement has been reviewed and approved by the Radiation Control Department.

No work is to be performed on beamline 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 Radiation Control Department.

Containers of He-3 (other than He glass target cells) shall be verified to contain less than 10 mCi of H-3 in the experimental hall. Additionally, He-3 containers should not be stored in the experimental hall when not in use.

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.

V. Incremental Shielding or Other Measures to be Taken to Reduce Radiation Hazards

None appears to be necessary. It is up to Physics Division management to consider the potential dose from this experiment and its impact on the annual dose budget.

VI. 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 the Halls and the accelerator enclosure, which may be found in the Machine Control Center (MCC) and the Counting House; 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.

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.

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 calculation of the radiation budget (i.e., 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.

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 delivered 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 funds transfers for disposal of the material. Jefferson Lab cannot store indefinitely any radioactive targets or 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.

Attachment A

Hall: A **RADIATION BUDGET FORM**

Exp. # E04-018 **rev:** **run dates: 2007** **name of liaison: J. Gomez**

setup number			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
beam	energy	GeV	0.687	0.687	0.687	0.817	0.817	0.817	0.915	0.915	0.915	1.056	1.056	1.056	1.199	1.199	1.199	1.337	1.337
	current	uA(CW)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
exp't target	element		He3	H	Al	He3	H	Al	He3	H	Al	He3	H	Al	He3	H	Al	He3	H
	thickness	mg/cm2	960	1416	614	960	1416	614	960	1416	614	960	1416	614	960	1416	614	960	1416
	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		2	1	13	2	1	13	2	1	13	2	1	13	2	1	13	2	1
	A		3	1	27	3	1	27	3	1	27	3	1	27	3	1	27	3	1
cryo tgt window	element		Al	Al		Al	Al		Al	Al		Al	Al		Al	Al		Al	Al
	thickness	mg/cm2	81	81		81	81		81	81		81	81		81	81		81	81
	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		13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13
	A		27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	27	27
critical window	radius	cm	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125
	dist. to pivot	m	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
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	hours	21.8	1.1	1.1	65.5	3.3	3.3	218.2	10.9	10.9	436.4	21.8	21.8	87.3	4.4	4.4	240	12
	(100% eff.)	days	0.9	0.0	0.0	2.7	0.1	0.1	9.1	0.5	0.5	18.2	0.9	0.9	3.6	0.2	0.2	10.0	0.5
	installation	hours																	
	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	0.0	0.0	0.0	0.0
dose rate at	method 1	urem/hr	1.80	1.89	1.61	2.18	2.07	1.87	2.50	2.22	2.09	2.82	2.29	2.29	2.82	2.12	2.24	2.84	2.00
the fence post	method 2	urem/hr																	
(run time)	conservative	urem/hr	1.80	1.89	1.61	2.18	2.07	1.87	2.50	2.22	2.09	2.82	2.29	2.29	2.82	2.12	2.24	2.84	2.00
dose per setup		urem	39	2	2	143	7	6	545	24	23	1229	50	50	246	9	10	682	24
% of annual dose budget		%	0.39	0.02	0.02	1.43	0.07	0.06	5.45	0.24	0.23	12.29	0.50	0.50	2.46	0.09	0.10	6.82	0.24

date form issued: November 9, 2006 *authors:* P.Degtiarenko

Hall: A

RADIATION BUDGET FORM

Exp. # E04-018 **rev: 0** **run dates: 2007** **name of liaison: J. Gomez**

setup number			18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
beam	energy	GeV	1.337	2.194	2.194	2.194	3.261	3.261	3.261	3.287	3.287	3.287	3.920	3.920	3.920	4.328	4.328	4.328	*totals:*
	current	uA(CW)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
exp't	element		Al	He	H	Al	He	H	Al	He3	H	Al	He	H	Al	He	H	Al	
target	thickness	mg/cm2	614	1240	1416	614	1240	1416	614	960	1416	614	1240	1416	614	1240	1416	614	
	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	
	Z		13	2	1	13	2	1	13	2	1	13	2	1	13	2	1	13	
	A		27	4	1	27	4	1	27	3	1	27	4	1	27	4	1	27	
cryo tgt	element			Al	Al		Al	Al		Al	Al		Al	Al		Al	Al		
window	thickness	mg/cm2		81	81		81	81		81	81		81	81		81	81		
	dist. to pivot	m		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0		
	Z		0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	
	A		0	27	27	0	27	27	0	27	27	0	27	27	0	27	27	0	
critical	radius	cm	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	
window	dist. to pivot	m	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	
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	
time	run time	hours	12	21.8	1.1	1.1	21.8	1.1	1.1	261.8	13.1	13.1	196.4	9.8	9.8	196.4	9.8	9.8	1944.2
	(100% eff.)	days	0.5	0.9	0.0	0.0	0.9	0.0	0.0	10.9	0.5	0.5	8.2	0.4	0.4	8.2	0.4	0.4	81.0
	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	0.0	0.0	0.0	0.0
dose rate at	method 1	urem/hr	2.21	3.80	1.64	2.24	4.31	1.52	2.41	3.49	1.52	2.41	4.56	1.48	2.50	4.71	1.47	2.56	
the fence post	method 2	urem/hr																	
(run time)	conservative	urem/hr	2.21	3.80	1.64	2.24	4.31	1.52	2.41	3.49	1.52	2.41	4.56	1.48	2.50	4.71	1.47	2.56	
dose per setup		urem	27	83	2	2	94	2	3	914	20	32	896	15	24	925	14	25	6166.1
% of annual dose budget		%	0.27	0.83	0.02	0.02	0.94	0.02	0.03	9.14	0.20	0.32	8.96	0.15	0.24	9.25	0.14	0.25	61.661
% of allowed dose for the total time																			277.83
% of allowed dose for the run time only																			277.83

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

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