Radiological Safety Analysis Document for E-01-006

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 into Jefferson Lab.

I. Description

Experiment 01-006, colloquially know as "Resonances Spin Structure (RSS)", will commence in Hall C. The principal investigators/spokesmen are Oscar Rondon amd Mark Jones. It will be a low current run for the hall - the average will be between 100 and 200 nA and the maximum current for this experiment will be 500 nA for brief periods of time during BCM current calibrations. Because of the polarization necessary for the experiment, high magnetic fields in the vicinity of the target are present. The post target beam line configuration is unique. This experiment has three configurations of the target magnetic field relative to the beam direction:

a) magnetic field perpendicular to the beam direction. In this configuration the beam is deflected significantly, requiring a chicane of two electromagnets for the incoming electron beam to be horizontal at the center of the target. The outgoing electron beam will be directed to a specially constructed dump in the hall; the photon beam will enter the high power beam dump tunnel.
b) magnetic field parallel to the beam direction. In this configuration the chicane magnets are turned off, and the beam enters the high power beam dump tunnel.
c) magnetic field at 10 degrees relative to the beam. In this configuration the chicane magnets are also used, but the beam deflection is small enough so the beam enters the high power beam dump tunnel.

The target is comprised of frozen ammonia (NH_3) and deuterated ammonia (ND_3), which was originally irradiated in the Free Electron Laser (FEL) and other low energy electron beam facilities to prepare its spin centers for this experiment. Other than monitoring the dose rate during transfer or target change, there are no special radiological hazard associated with changing the target. The beam will be directed into the high power beam dump line during BCM current calibrations above 200 nA. There is a need for several current calibrations in configuration a) i.e., using the low power dump. In this case, the empty target should be used to minimize the dose (empty target = 28 mg/cm2 Be + 202 mg/cm2 Al + 132 mg/cm2 Cu).

Information on this experiment can be found at at the following URL:
http://www.jlab.org/exp_prog/generated/apphallc.html.
A full description of the goals of the experiment may be found at
the following URL:
http://www.jlab.org/exp_prog/proposals/01/PR01-006.pdf

II. Summary and Conclusions

During the 1998 run of Experiment 93-026, which used the same target as E-01-006, steer-up efforts produced hot spots downstream of the target that are normally not there during other experiments. It is not unreasonable to expect similar conditions at the satrt of the experiment. The area around the target and beam line are going to have a rather large magnetic field present much of the time, both during the experiment and during access periods. We have already determined that the magnetic fields render the normal radiation detection devices (such as the Bicron Microrem meter and the FAG teleprobe) useless. There is the potential while using these instruments that the instrument may read zero (0) dose rate while there is in fact a more-than-zero dose rate. Only instruments specifically designated for use in Hall C may be used. Assigned Radiation Monitors (ARMs) and the Radiation Control Group are aware of the limitations in the Hall and are directed to use the "yellow" Automess Teletector (also identified as the Eberline Model 6112 B). One such unit will be staged in the MCC Control Room.

There is no need for RadCon coverage during manual target manipulations. However, in all cases, removal of a target from the scattering chambers requires a radiation survey by RadCon or a qualified ARM.

The experiment is calculated to use 2.9 % of the annual design goal at the Jefferson Lab boundary for 490 hours of run-time. The experiments will be periodically monitored by the Radiation Control Group to ensure that the site boundary goal is not exceeded. This experiment will likely cause general Radiation Areas and localized High Radiation Areas in the Hall adjacent to the "in-hall" dump and the scattering chamber. This experiment may also cause temporary Contamination Areas on the exterior of the "in-hall" dump. Adherence to this RSAD is vital to ensuring compliance with applicable Jefferson Lab and DOE requirements for occupational radiation safety.

III. Calculations of Site Boundary Radiation Dose

The radiation budget is the amount of radiation that may be measured at the site boundary as a result of a given set of experiments. This measured radiation is specified in terms of mrem at site boundary. The DOE annual dose limit is 100 mrem per year. The Jefferson Lab design goal is 10% of the DOE annual dose limit to the public, or 10 mrem, and cannot be exceeded without prior written consent from the Radiation Control Group Head, the Director of Jefferson Lab, and the Department of Energy.

The radiation budget for experiment E-01-006, with principal investigator O. A. Rondon is approximately 0.29 mrem, or 2.9 % Jefferson Lab's annual design goal. The attached spreadsheet (Attachment A) details the budget calculations.

The 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 Group (RCG) 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.

Every effort shall be made to contain post target beam in the down stream beamline installed in the hall for this experimental configuration. Where air gaps exist between the scattering chamber and the entry window for the downstream beamline, an evacuated or helium filled tube or bag shall be used to contain the beam. If this presents an untenable situation, local filtered ventilation shall be installed with a capacity suitable for collecting airborne radioactive particulates genertated in the air gap.

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, there are several actions that 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 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.

B. From Activation of Target and Beam line Components

All radioactive materials brought to Jefferson Lab shall be identified to the Radiation Control Group. 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 RCG inventories and tracks all radioactive materials on site. If you are using radioactive material or radioactive components, the Radiation Control Group will

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

All movement of used targets, collimators, and shields will be coordinated by the Radiation Control Group unless otherwise stated. The Radiation Control Group will assess the radiation exposure conditions and will provide coverage for Jefferson Lab Radiation Workers to move them.

All activated experimental targets will be retained in a Jefferson Lab-provided security box when not in the target chamber. The security box is in the experimental hall, and is well shielded. The Radiation Control Group will control the lock for the security box. No work is to be performed on beam line components that 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 Group.

As in most experiments, the beam will activate the beam dump and the scattering chamber. These locations will likely be Radiation Areas for some period of time after shutdown. In this experiment, there are additional hazards at the scattering chamber: high magnetic fields and microwave radiation. A special teleprobe will be staged in the MCC for use around the scattering chamber. The detector head is relatively insensitive to high magnetic fields and will allow the ARM or RadCon Staff member to measure the radiation levels from several feet away. Observe locally posted instructions regarding exposure to high magnetic fields and microwave radiation. There are two additional locations which may become localized radiation areas: the BE and BZ1 magnets. A radiation survey should include a measurement in both locations.

The “in-hall” dump consists of a stack of stainless steel plates welded together to form a block. With the current limits in place, this beam dump will not experience heating to the extent that it presents a burn or ignition hazard. It will become radioactive and the measured dose rate is likely to be several rem/hr on contact and several hundred mrem/hr at a meter just after shutdown. A considerable portion of the radioactive material will decay with a half-life of about 10 minutes. Although it is not likely for this experiment, if the exposure rate at one meter for any location is in excess of 1000 mrem/hr, the hall may be kept in controlled access as long as is needed to limit access and notify entrants that a high radiation area is present in the hall. If a high radiation area is present, a special access procedure is already in place to manage these changes. Note: diagnostic radiation detectors may be used to monitor the relative beam loss at the locations mentioned above to provide data to operation, the experimenters, and to better approximate the radiation levels after shutdown. If diagnostic radiation monitors are used, the data will be made available under the MEDM, RadCon button and is archived. The data is available by using archive viewer software.

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

None is necessary.

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 Group. A general access RWP is in place that governs access to Hall C 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.

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 Group review. Alteration of these components (including the exit beam line itself) may result in increased radiation production from the Hall and a resultant increase in site boundary dose.

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 other experimental components that are not needed for future use by
Jefferson Lab will be returned to the experimenter's home institution. 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 funds transfers for disposal of the material. Jefferson Lab cannot store indefinitely any radioactive targets or experimental equipment. Jefferson Lab is required by the DOE to dispose of radioactive waste within one year of generation.

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

Robert May
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Attachment A

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

Exp. # E01-006 **rev: A** **run dates: 2001** **name of liaison: O. Rondon**

setup number			1	2	3	4	5	6	7	8	9	10	11	12	
beam	energy	GeV	5.784	5.784	5.784	5.784	5.784	5.784	5.784	5.784	5.784	5.784	5.784	5.784	*totals:*
	current	uA(CW)	0.1	0.1	0.1	0.15	0.1	0.3	0.1	0.1	0.2	0.2	0.1	0.1	
exp't	element		H	D	H	D	H	Fe	C	C	C	C	Cu	Cu	
target	thickness	mg/cm2	275	543	275	543	334	3	1553	1553	461	461	2048	2048	
add'l	element		N	N	N	N	N								
target 1	thickness	mg/cm2	1375	1357	1375	1357	1226								
add'l	element		He	He	He	He	He		He	He	He	He	He	He	
target 2	thickness	mg/cm2	320	320	320	320	320		480	480	550	550	547	547	
add'l	element		Be	Be					Be		Be	Be	Be		
target 3	thickness	mg/cm2	28	28					28		28	28	28		
add'l	element		Cu	Cu	Cu	Cu	Cu		Cu	Cu	Cu	Cu	Cu	Cu	
target 4	thickness	mg/cm2	132	132	132	132	132		132	132	132	132	132	132	
cryotgt	element		Al	Al	Al	Al	Al		Al	Al	Al	Al	Al	Al	
window	thickness	mg/cm2	202	202	202	178	202		202	202	202	202	202	202	
exit	element		Be	Be	Be	Be	Be	Be	Be	Be	Be	Be	Be	Be	
window	thickness	mg/cm2	94	94	94	94	94	94	94	94	94	94	94	94	
dumpline	element		He	He	He	He	He	He	He	He	He	He	He	He	
scattering	thickness	mg/cm2	212	212	212	212	212	212	212	212	212	212	212	212	
dumpline	element		He	He	He	He	He	He	He	He	He	He	He	He	
nonscatt.	thickness	mg/cm2	230	230	230	230	230	230	230	230	230	230	230	230	
time	run time	hours	76	78	52	70	140	24	8	20	13	5	2	2	490
	(100% eff.)	days	3.2	3.3	2.2	2.9	5.8	1.0	0.3	0.8	0.5	0.2	0.1	0.1	20.4
	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	method 1	uterm/hr	0.02	0.02	0.02	0.03	0.02	0.13	0.02	0.02	0.03	0.03	0.05	0.05	
the fence post	method 2	uterm/hr	1.39	1.39					1.39		2.78	2.78	1.39		
(run time)	conservative	uterm/hr	1.39	1.39	0.02	0.03	0.02	0.13	1.39	0.02	2.78	2.78	1.39	0.05	
dose per setup		uterm	105.6	108.4	1.1	2.3	2.8	3.2	11.1	0.5	36.1	13.9	2.8	0.1	287.98
% of annual dose budget		%	1.056	1.084	0.011	0.023	0.028	0.032	0.111	0.005	0.361	0.139	0.028	0.001	2.8798
% of allowed dose for the total time															51.483
% of allowed dose for the run time only															51.483

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

date form issued: December 7, 2001 *authors:* R. May, P. Degtiarenko