**Radiological Safety Analysis Document**

**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**

Experiments [E08-027](http://hallaweb.jlab.org/experiment/E08-027/documents.html), A Measurement of $g\_{2}^{p}$ and the Longitudinal-Transverse Spin Polarizability (g2p) and [E08-007](http://hallaweb.jlab.org/experiment/E08-007/home2.html), Measurement of the Proton Elastic Form Factor Ratio at Low *Q*2 (GEp) will be conducted using low-current beam in Hall A running from approximately mid-February, 2012 to May 17, 2012. The experiments will use the same hardware and experimental target setup. Beam parameters include energies of 1.158, 1.706, 2.254 and 3.35 GeV at currents up to 200 nA\*, using with a solid (frozen) NH3 target. Experiment documentation can be found at <http://hallaweb.jlab.org/experiment/g2p/>, and <http://hallaweb.jlab.org/experiment/E08-007/>.

\* Limited-duration operation at higher currents up to 10 µA may be needed for current calibration and optics tuning.

### II. Summary and Conclusions

The experiment is calculated to use **4.0%** of the annual design goal at the Jefferson Lab boundary for 341hours run-time. The experiment will be periodically monitored by the Radiation Control Department to ensure that the site boundary goal is not exceeded. This experiment utilizes a dump positioned in the Hall proper, near the target area. Significant residual radiation fields are expected; Radiation and High Radiation Areas will occur in the vicinity of the dump. There will be manual manipulations of the solid target fixture during the experiment. Target fixtures will be removed/exchanged with fresh target material periodically. In addition, a fixture containing activation foils at the dump entrance will be manipulated to exchange foils and radiator plate. Written work authorizations for these activities will be in place prior to any such work. **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 experiment **E08-007/E08-027**, with Spokesperson J. P. Chen is approximately **0.4 mrem**, or **4%** of Jefferson Lab's annual design goal. The attached spreadsheet details the calculations.

The Hall’s contribution to the boundary dose 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 not proceed until a resolution is reached and approved by the Site 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 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 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. This experiment may create regions of increased radiation outside the hall in areas not normally controlled for radiological purposes. The RadCon Department 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. External Exposure due to Activated Materials
2. General:

The g2p/GEp experiment will produce significant activation in the “local” beam dump just downstream from the target chamber. Beam current for this experiment is low compared to typical experiments, but relatively more beam power is deposited locally in the hall due to this configuration. General area radiation levels in the hall are expected to be comparable to conditions from a typical high-current run with a thick target. Dose rate from activation in the local dump may exceed 1 R/h at 30 cm. Local beamline configuration is expected to mitigate this condition such that personnel access to such dose rates is not possible without mechanical disassembly of the hardware. However, these conditions cannot be predicted precisely, and measures to ensure positive access controls should be available in the event they are needed. This can be achieved through use of lockable fences/gates around the target/dump area. RadCon shall concur in the configuration of any such controls and will control the access to all such areas.

Beamline hardware configurations that functionally provide the positive access control to an area with >1 R/h whole body dose rates shall be marked/posted with appropriate warnings to alert personnel to the existence of the high radiation conditions (e.g. sheet metal covers that can be removed with hand tools will be labeled to warn of conditions within the cover). RadCon will concur in such postings and direct their use when required.

Supplemental shielding may be efficacious in mitigating streaming radiation from any gaps in the integral shielding of the local dump. Installation of such shielding must be conducted in concurrence with RadCon.

1. Target changeout and maintenance:

The frozen ammonia targets will be changed on a periodic basis. A written procedure (TOSP) will be established for this task, and the procedure will be incorporated into a Radiation Work Permit (RWP). At a minimum, radiation surveys will be required for any removal of an irradiated target from the target/magnet assembly. Other target system maintenance activities requiring access to radiation or high radiation areas will be addressed by the RWP.

1. Activation foil changeout:

A parasitic activation analysis experiment is being conducted by RadCon, using an exposure fixture built into the local dump. The arrangement allows activation foils to be loaded into the face of the dump and exchanged with fresh foils by removing the fixture and replacing it with a fresh radiator and foils. Performing this work requires access to the target platform area and will involve work in radiation and high radiation areas. All standard requirements for accessing the platform shall apply. A TOSP will be written for the task of changing foils; this procedure will be incorporated into the appropriate RWP.

In consideration of ALARA, the administrative procedures, positive access controls and supplemental shielding described above should be, to the extent feasible, planned, designed and installed prior to operation of the experiment. This is to be priority based, such that plans be developed and implemented first for areas likely to have highest exposure rates based on current best estimates. RadCon and Hall A personnel will develop and implement these controls.

1. Contamination control

The increased beam power deposition in the local dump may result in higher than typical production of airborne radioactivity, which can lead to contamination build-up around the dump/target area and in any equipment in the hall that circulates air. Surfaces in the immediate vicinity of the dump are expected to develop low level surface contamination. To mitigate the impact of particulate airborne activity on/in other equipment, a local “negative pressure” HEPA unit will be positioned to apply local negative ventilation in the vicinity of the dump. This HEPA unit is maintained and controlled by RadCon and meets the specifications of the Rad-HEPA program.

Air gaps in the beam line at the target/dump area will be enclosed and purged with helium gas. This gas stream will be ventilated from the hall. Any breach of the boundary of this helium purge system shall be done with RadCon concurrence with appropriate contamination surveys/controls.

Refer to the General Access RWP for details regarding controls for other potentially contaminated systems.

1. Environmental releases

As noted above, somewhat higher than typical levels of airborne radioactivity may occur in the hall due to the presence of the local dump. Strict limits are established by EPA for radionuclide air emissions. Since dose to members of the public is calculated and reported based on monitoring of the levels in the hall, an Alert Level is established for gaseous activity concentration in the hall. For g2p/GEp operations, this level is set at 5E-6 µCi/cc. If the average measured concentration exceeds this value for a period of 2 consecutive days, or at any time the measured concentration exceeds 6E-5 µCi/cc, RadCon will convene a meeting with the experimenters and the Head of Physics Division to assess actions needed to reduce the airborne radioactivity levels to (1) ensure that public dose from release of airborne radioactivity does not exceed applicable limits, and (2) address/mitigate potential internal doses to workers and buildup of contamination in the hall.

1. Standard procedures

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

Standard RSAD controls apply: RadCon 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 (E. Folts) using the ATLis work planning tool.**

**Radiation Surveys:** Due to the high magnetic fields associated with the target area, standard radiation surveys may not be feasible while the magnets are energized. Use of radiation monitoring instruments will comply with standard safety precautions in place for tools and equipment in the vicinity of the target magnet. RadCon will devise a survey protocol that takes these restrictions into account and will provide training to RadCon staff and ARMs to familiarize them with the protocol. This protocol may require posting of radiological “keep out” zones that must be surveyed upon removal of the magnetic field prior to allowing personnel access. Such areas will be prominently posted with survey requirements.

**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 RadCon 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**

It is up to Physics Division management to consider the potential dose from this experiment and its impact on the annual dose budget.

As described in section IV. B., supplemental shielding may be determined to be needed in the vicinity of the local dump. Specification and installation of this shielding shall be coordinated through the RadCon department. Such shielding should be installed in a way that deters easy removal and, once installed shall be labeled and controlled under the RadCon shielding configuration control system.

The RCD Head 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 (i.e. General Access RWP revision). The RCD head will recommend engineered or other controls considered necessary to prevent significant degradation of the radiological conditions in the hall.

**VI. Operations Procedures**

1. **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. This RWP can be read and electronically signed online at: <http://www.jlab.org/accel/RadCon/pdf_forms/Gen%20Acc%20RWP.pdf>
2. Any individual with a need to handle radioactive material at Jefferson Lab shall first complete Radiation Worker (RW-I) training.
3. **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/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>.
4. **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.
5. **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**

g2p will generate radioactivity in various experimental equipment. This includes typical materials such as aluminum, steel, copper, etc. In addition, some unusual materials and quantities of material will be activated. This material includes a quantity of lead and tungsten. Some of these components have no reasonable expectation for re-use as they are unique to the experiment. Final determination of the amount of impacted material will be made upon decommissioning. Funding for recovery and recycling of activated lead with no re-use potential will be provided by Physics Division. Disposal of large quantities of waste beyond the scope of the RadCon waste program will be negotiated with Physics.

**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.**

**Approvals:**

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Radiation Control Department Head Date

**Attachment A**

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