Radiological Safety Analysis Document for Photon Beam Commissioning to Hall D

This Radiological Safety Analysis Document (RSAD) will identify the general conditions associated with the photon beam commissioning to Hall D, and controls with regard to production, movement, or import of radioactive materials.

1 Description

The Hall D photon beam commissioning run is scheduled for approximately 4 weeks between October 2014 and December 2014. It will utilize up to 10 μA of tune mode (1.524% duty cycle) and 50-200 nA of CW mode ~10.5 GeV electron beams. The following radiators will be used:

1. 1.5 microns Al (1.7×10^{-5} radiation length)
2. 10 microns Al (11.2×10^{-5} radiation length)
3. 30 microns Al (33.7×10^{-5} radiation length)

The photon beam will be commissioned without a target, as well as with up six solid targets, which can be moved 12 cm downstream to 32 cm upstream relative to the nominal Hall D target position (60 cm downstream of the downstream end of the upstream solenoid endcap). The targets to be used during this run are:

1. 10mm-thick 3.19cm-diameter disk of CH2 (HDPE, high density polyethylene)
2. 2mm-thick 3.19cm-diameter disk of CH2 (HDPE)

3. CH2 (HDPE) cup of 2mm thickness for the 2mm-inner diameter and 7mm for the outer ring
4. 3.4mm-thick 3.19cm-diameter C12 graphite disk
5. Aluminum cross made of 1.59mm-diameter wires
6. 1cm-long aluminum cylinder with an equilateral triangular hole inside. The triangle edge lengths are 2.5 cm

Other planned alterations of the beamline downstream of the radiator include collimator alignment and movement of the beam profile monitor along the beam line to measure the profile at various locations. A permanent beam profiler with a 10% radiator in front of it may be installed in front of the photon beam dump. The run plan consists of the following steps:

1. Tune Electron Beam
2. Tune Photon Beam and Initial Detector Checkout
3. One Week Pause in Running
4. Collect Beam Data for Detector Checkout
5. Optimize Detector Settings
6. Drift Chamber Alignment
7. Collect More Regular Data

2 Summary and Conclusions

The commissioning run is not expected to produce significant levels of radiation at the site boundary. However, it will be continuously monitored by the Radiation Control Department (RCD) to ensure that the site boundary goal is not exceeded. The main radiological consideration is validation of radiation shielding around Hall D and Hall D Tagger building. RCD will conduct appropriate radiation surveys and measurements in the areas potentially affected by the commissioning process. Activation of targets, collimators and beam line hardware must also be considered. As specified in Sections 4 (4.2) and 7, the

manipulation and/or handling of targets and 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 RCD.

Adherence to this RSAD is vital.

3 Calculations of Radiation Deposited in the Experimental Hall (the Experiment Operations Envelope)

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 experiments. 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 RCD Head, the Director of Jefferson Lab, and the Department of Energy.

Comparison of the beam configuration parameters of the Hall D commissioning run with the parameters used in the "Shielding Basis for Hall D Complex" (JLAB-TN-08-033) indicate that the commissioning run will have negligible contribution to the site boundary dose.

This expectation will be verified during the commissioning process by using the active monitors at the Jefferson Lab site boundary. If it appears that the radiation budget will be exceeded, RCD will require a meeting with the experimenters and the Head of the Physics Division to determine if the run 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 commissioning program will stop until a resolution can be reached.

4 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.

4.1 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 "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.

4.2 Activation of Target and Beam line Components

All radioactive materials brought to Jefferson Lab shall be identified to the RCD. 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 RCD inventories and tracks all radioactive materials onsite. The RCD will survey all experimental setups before experiments begin as a baseline for future measurements.

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

No work is to be performed on beam line 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 RCD.

5 Incremental Shielding or Other Measures to be Taken to Reduce Radiation Hazards

None.

6 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 Hall D 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 radiator and the target are well known. Exceeding these power restrictions may lead to excessive and unnecessary contamination, activation, and personnel exposure.

The radiator assembly and the downstream beam-line components may not be altered outside the scope of this RSAD without formal RCD review. Alteration of these components may increase radiation production in the Hall and subsequently increase the site boundary dose.

7 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 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 transfer of funds for disposal of the material. Jefferson Lab cannot store indefinitely radioactive targets and experimental equipment.

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

Approvals:

V. Vm — 8/25/2014

Radiation Control Department Head — Date

Appendix A: Radiation Damage to the Hall D Electronics

Radiation damage levels from long-term Hall D operation were evaluated using Monte-Carlo modeling and reported in JLAB-TN-11-005, "Calculation of Radiation Damage to Silicon Photomultipliers in GlueX Experiment". Radiation damage levels in Hall D with the assumption of photon spectrum produced on a diamond radiator are presented in Figure 1.

Radiation damage rates during the Hall D commissioning are expected to be lower for the following reasons: 1) Photon spectrum will be softer due to the use of aluminum radiators instead of diamond; 2) Lower average interaction rate in the target region is expected (part of the run will have no target and the rest will have targets smaller, or comparable with the liquid hydrogen target used in the calculations).

Therefore, due to relatively low radiation damage rates and the low overall beam power planned to be delivered to the hall during the commissioning run, no problems are anticipated with respect to radiation damage to the electronics, including the most vulnerable silicon photomultipliers.

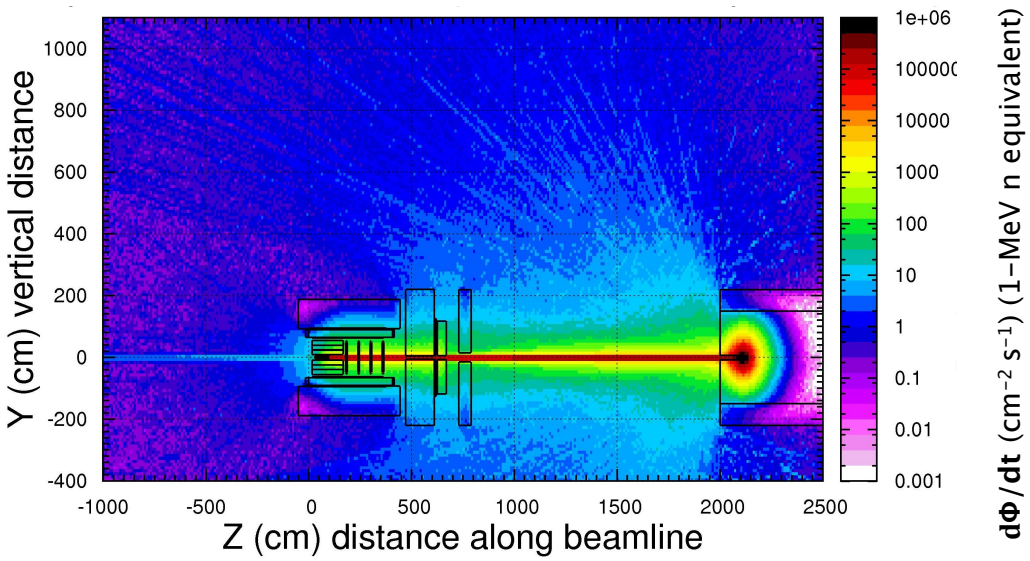

Figure 1. Particle fluence rates in Hall D in terms of 1 MeV neutron equivalent in silicon calculated using GlueX photon beam (Fig. 2)

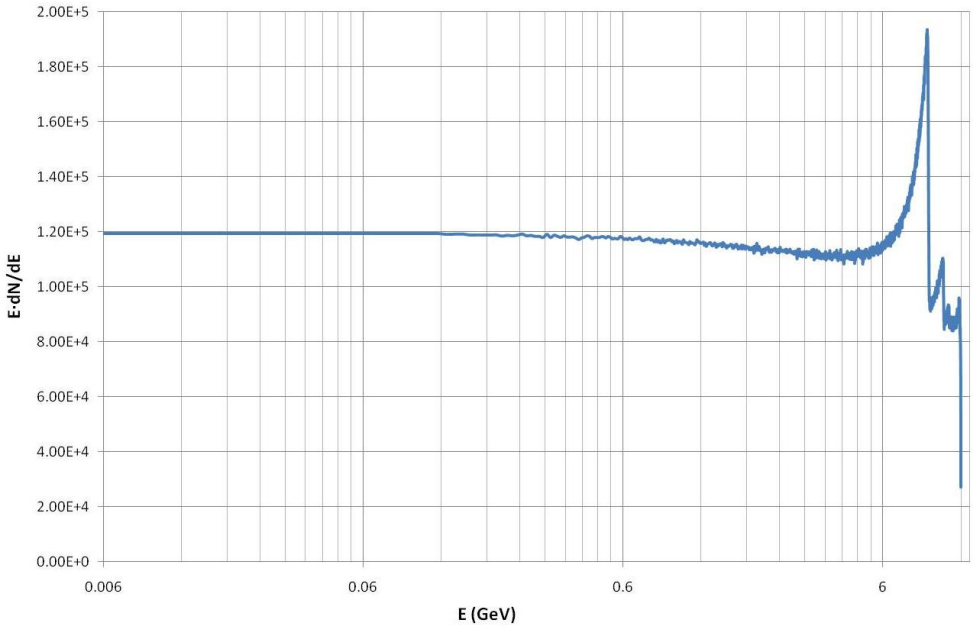

Figure 2. Calculated photon energy spectrum used to evaluate radiation damage levels (spectrum was calculated for the GlueX polarized beam produced on the diamond radiator, yielding conservative estimates of damage, compared to the spectra produced on the aluminum radiators of the commissioning run).