Radiological Safety Analysis Document for the CLAS12 Commissioning Run

This Radiological Safety Analysis Document (RSAD) will identify the general conditions associated with the commissioning run of the CLAS12 detector in Hall B and the controls associated with regard to production, movement, or import of radioactive materials.[1]

1 Description

The commissioning run of the CLAS12 detector will take place in 2017 in experimental Hall B. CLAS12 is a multipurpose detector system based on a toroidal (forward detector) and a solenoid (central detector) magnet. The detector system includes Cherenkov Counters, Drift Chambers, Scintillator Counters, Silicon-strip detectors, Micro-mega gas detectors, and Calorimeters. The target for CLAS12 will be located approximately in the middle of the experimental Hall B inside the central detector. Beams of various energies, up to 11 GeV (3 to 5 pass), and beam currents up to 100 nA will be used for the commissioning run.

The commissioning run is divided into two segments. In the first segment, Feb. - Mar. 2017, CLAS12 will run with a solid target, using low current beams to demonstrate the 12 GeV Project Key Performance Parameters (KPPs). In the second segment, Oct. - Dec. 2017, commissioning of the whole system will be done to achieve the design parameters. For this segment, a cryotarget with liquid hydrogen and up to 100 nA, $\sim$11 GeV beam will be used.

[1] Contact person: Stepan Stepanyan

For the KPP run, CLAS12 will use a 500 μm thick (0.25% r.l.) carbon wire target located approximately in the center of the Hall B and up to 2 nA, $\sim$6.6 GeV electron beam. The wire will be mounted on the 2H01 harp ladder, which will allow the target to be moved in and out of the beam without interference of support frames. The peak luminosity during the KPP run will be $< 10^{33}$ cm^{-2}s^{-1} per target nucleon. On the same ladder, there are 25 μm diameter tungsten wires that will be used to measure the beam profile. For the beam profile measurements, the CLAS12 detectors will be off and beam currents up 5 nA will be used. In this setup the beamline vacuum will be contiguous and the beam will be transported to the Hall B electron beam dump (Faraday cup dump) in vacuum without interruptions.

For the second segment of the run, CLAS12 commissioning will use an LH_2 target located inside the central detector in the center of the 5 T solenoid magnet. The target cell is a 20 mm diameter, 5 cm long Kapton tube installed inside the beam vacuum, in a foam scattering chamber. The vacuum will be disconnected between the upstream and downstream beamlines, with $\sim$20 cm of air between the exit window of the target scattering chamber and the entrance window of the downstream beamline. Both windows are 50 μm thick aluminum. The beam energy for this run will be $\sim$11 GeV, with beam currents of up to 100 nA. The maximum luminosity during the run will be $\sim 10^{35}$ cm^{-2}s^{-1}, the nominal design luminosity for CLAS12. During running with beam currents above 15 nA at 11 GeV ($\sim$160 W), the Hall B beam stopper (a 30 cm long cooled-copper absorber) will be positioned before the Faraday Cup to prevent overheating.

For the beam tune and Möller runs, the beam will be directed into a newly constructed beam dump in the Hall B Tagger dipole yoke. On top of the Tagger yoke, additional lead shielding will be added to limit radiation leaking through to the CLAS12 detectors and electronics. The additional shielding and the nickel collimator have been thoroughly simulated using a GEANT model of the beamline and the Tagger dipole magnet (see the expected neutron radiation dose on the electronics described in the Appendix).

2 Summary and Conclusions

The experiment is not expected to produce significant levels of radiation at the site boundary. However, it will be periodically monitored by the Radiation Control Department to ensure that the site boundary goal is not exceeded. The main consideration is the manipulation and/or handling of target(s) or beamline hardware. As specified in Sections IV (B) and VII, the manipulation and/or handling of target(s) or beamline hardware (potential radioactive material), the transfer of radioactive material, or modifications to the beamline after the target assembly must be reviewed and approved by the Radiation Control Department. 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 the site boundary as a result of a given set of experiments. This budget may be specified in terms of mrem at the 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.

Calculations of the contribution to Jefferson Lab's annual radiation budget that would result from running under a broad variety of conditions typical of Hall B operations indicate that the contribution from this experiment will be negligible. With this expectation, we have not carried out calculations for the specific running conditions of this experimental group.

This expectation 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 from Hall B and the other Halls. If it appears that the radiation budget will be exceeded, the Radiation Control Department 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 the 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.

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 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 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 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 non-exempt), previously used targets or radioactive beamline components, or previously used shielding or collimators. The Radiation Control Department 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.

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 B 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 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 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 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 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 fund 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 (269-7050).

Approvals:

________________________________ ________________

Radiation Control Department Head Date

8 Appendix: Radiation Damage to the CLAS12 Electronics from the Beam Dump in the Hall B Tagger Dipole Magnet Yoke

While most of the CLAS12 electronics are located away from the beamline, the front-end electronics boards (FE boards) of the SVT and the MVT are in close proximity to the beamline, about 2 m to 3 m upstream of the target location.

8.1 Radiation Damage to the Standard Electronics Components in the Hall

The experiment is not expected to produce significant levels of neutron radiation that may cause damage to the Hall B electronics located on the Forward Carriage or on the Space Frame. The beam energies and the integrated luminosity of the experiment are in the same range as for the CLAS nuclear target experiments. Furthermore, all sensitive electrons that are mounted close to the beamline are upstream of the target where not much radiation is expected. Most of produced electromagnetic radiation (Möller electrons) will be guided by 5 T solenoid field into tungsten shield pipe. Part of that radiation will be absorbed by shield part will be guided to the beam dump. Some of electronics modules mounted on Forward Tagger will be beyond the tungsten shield and will not see much radiation.