ES&H DIVISION
RADIATION CONTROL DEPARTMENT

radiological safety analysis document

CLAS12

Hall B Run Group L

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Thomas
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Experimental Hall B

Contents

This Hall B Radiological Safety Analysis Document (RSAD) identifies the general conditions associated with the CLAS12 Run Group L (RG-L), as well as the controls associated with production, movement, or import of radioactive materials (RAM).

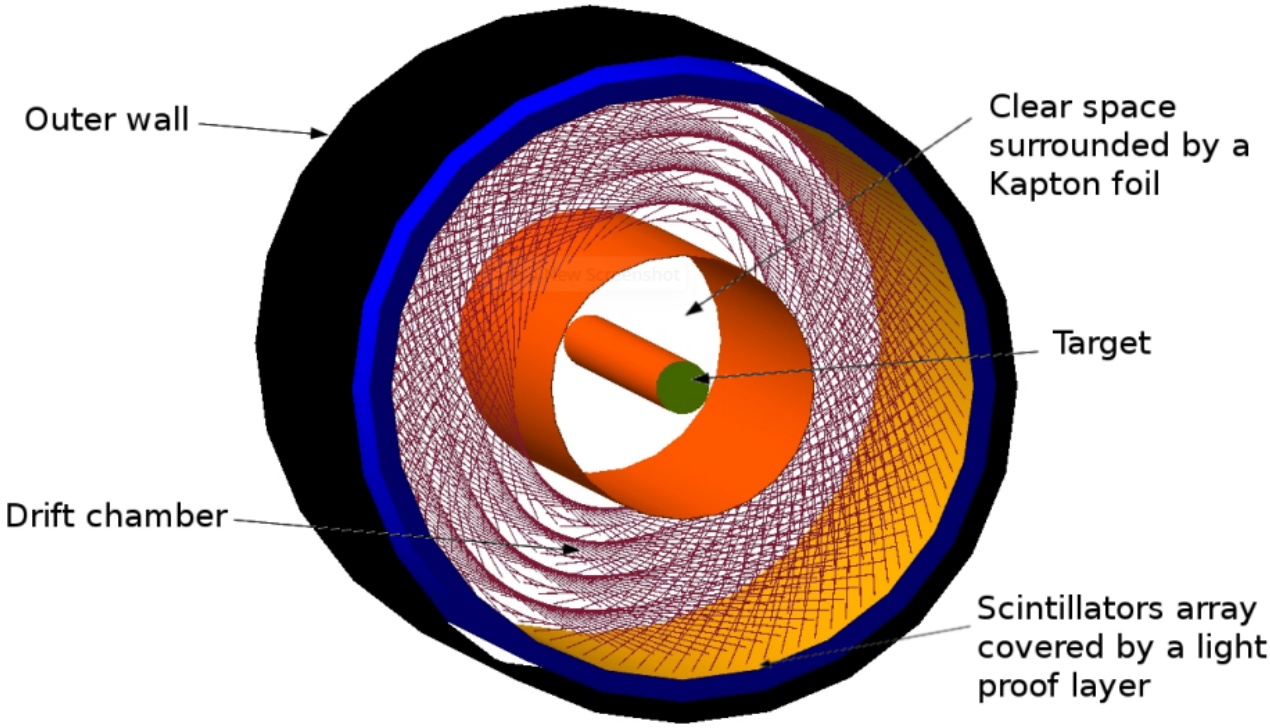
1 DESCRIPTION

The Physics Division CLAS12 RG-L run will take place during the spring and summer of 2025 in Experimental Hall B. CLAS12 is a multi-purpose detector system based on toroidal and solenoid superconducting magnets in the forward and central regions, respectively, of CLAS12. The detector system includes Cherenkov counters, drift chambers, scintillator counters, micromegas gas detectors, and calorimeters in the forward region.

In the central region, the experiment will employ the new ALERT detector (refer to the figure below) consisting of two sub-detectors; the AHDC hyperbolic drift chamber surrounding the target; and, the ATOF time-of-flight detector system located radially outward of the AHDC.

During this run period, the CLAS12 Forward Detector system will be used in its standard detector and shielding configuration with the Forward Tagger (FT) **ON**. In the central region within the solenoid, the CVT (Central Vertex Tracker) will be replaced by the new ALERT-detector system (AHDC + ATOF). At backward angles the BAND neutron detector will be installed. This run will employ a high-pressure gas target cell (filled with H, D, and ^{4}He) placed along the beamline inside the ALERT detector (see figure below). The target cell will be a 45-cm-long aluminized Kapton straw of 0.6 cm diameter and 50 μm wall thickness that will be operated at a nominal pressure of 68 psi (4.6 atm). The straw has entrance and exit windows made of 30 μm-thick aluminum. The center of ALERT is defined as the midpoint of the ATOF scintillators. The ALERT detector center is positioned at the solenoid center, which is 130.3 cm upstream of the Hall center in the nominal CLAS12 coordinate system.

The vacuum will be disconnected between the upstream and downstream beamlines with 1 cm of air between the upstream beam pipe window (30 μm thick aluminum) and the upstream target window. ALERT will have a helium extension tube on the downstream end with a 30 μm aluminum window. There will be a 4 cm air gap between this window and the 75 μm thick window on the downstream beam pipe.



Target and ALERT detector system with accurate track position (Drif Chamber) and Time of Flight (Scintillators)

The ALERT run will collect data using 2.2 GeV (1 pass) beam for detector calibrations and both 6.4 GeV (3 pass) and 11 GeV (5 pass) polarized electron beams. Production data collection will take place with beam currents up to 1000 nA during the 11 GeV run and with beam currents up to 500 nA for the two lower beam energies. The nominal beam-target luminosity during data taking will be $\lesssim 2.8\text{x}10^{35}$ $\text{cm}^{-2}\text{s}^{-1}$. For beam tuning and Möller runs, the beam will be directed into the Hall B Tagger dipole magnet yoke as has been standard for operations in the Hall. The Faraday Cup with beam blocker has been approved for 17 kW operation. The maximum power at the dump for each energy level is expected to be reached only for short periods of time. The expected power at each energy is planned as follows:

<u>Energy 2.1 GeV</u>

- 100 nA on H target and 210 W at dump for 4 days
- 50 nA on He target and 105 W at dump for 4 days
- 50 nA on D target and 105 W at dump for 1 day

<u>Energy 11 GeV</u>

- 250 nA on He target and 2.75 kW at dump for 38 days
- 500 nA on He target and 5.5 kW at dump for 20 days
- 350 nA on D target and 3.85 kW at dump for 40 days

<u>Energy 6.4 GeV</u>

- 50 nA on He target and 320 W at dump for 1 day
- 250 nA on He target and 1.6 kW at dump for 36 days

The maximum power reached in Hall B during nominal beam operation has been 2.8 kW. At 11 GeV and 1000 nA the power will reach 11 kW. Since the experiment uses a gas target and the luminosity at the CLAS12 detector will be optimized (tuning the current around the value showed before, with current that will be up to 1000 nA), radiation in the Hall is expected to be similar to that during nominal run conditions. The increased power with relative radiation at the beam dump system has been checked and is not expected to have a significant impact on the radiation budget, since it is mitigated by the new position of the Faraday cup and beam blocker at the end of the dump tunnel. The dump tunnel itself is expected to reach higher levels of activation with respect to normal running conditions, but is expected to decrease consistently in a matter of days, leaving a high-activation area in the proximity of the beam dump system.

The details of all beamline and target components for ALERT are shown on the beamline drawings at: https://wiki.jlab.org/Hall-B/engineering/hallb_eng_wiki/index.php/Main_Page.

2 SUMMARY and CONCLUSIONS

This experiment is not expected to produce significant levels of radiation at the site boundary. It will, however, be monitored periodically by the Radiation Control Department (RCD or RadCon) to ensure that the site boundary goal is not exceeded. The main consideration is the manipulation and/or handling of target(s) or beam-line hardware. As specified in Sections 4.2 and 7, the manipulation and/or handling of target(s) or 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 RadCon staff.

Adherence to this RSAD is vital.

3 CALCULATIONS of RADIATION DEPOSITED in the EXPERIMENTAL HALL & SITE BOUNDARY

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 (10 mrem per year) for dose to the public. The 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 Manager, the TJNAF Director, 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 site boundary to keep up with the dose for the individual setups from Hall B and the other experimental halls. If it appears that the radiation budget will be exceeded, RadCon 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 site boundary dose rates. 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 TJNAF 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. As such, 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 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* 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.

4.2 Activation of Target and Beamline Components

The RCD shall be notified of all radioactive materials brought to Jefferson Lab. 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.

All radioactive materials onsite are inventoried and tracked by RadCon staff. If RAM is incorporated into an experimental setup, surveys may be conducted on the setup before experiments begin.

Movement of all used targets, collimators, and shields is coordinated by RadCon, who will further assess the radiation exposure conditions and implement controls, as necessary, based on the radiological hazards.

There shall be no local movement of activated target configurations without coordination with RadCon. Remote change of target configurations shall be permitted, providing the method has been reviewed and approved by the RCD.

No work (e.g., drilling, cutting, or welding) that could result in dispersal of radioactive material is to be performed on beamline components. Such activities must be conducted only with specific permission and control of the RCD.

5 INCREMENTAL SHIELDING or OTHER MEASURES to REDUCE RADIATION HAZARDS

n/a

6 OPERATIONS PROCEDURES

All experimenters must comply with experiment-specific administrative controls which begin with the measures outlined in the experiments Conduct of Operations document. These controls may include radiological work permits (RWP), standard operating procedures (SOP), other types of work control documents (WCD), and/or any verbal instructions from RadCon. The General Access RWP (GARWP) governing access to Hall B and the accelerator enclosure is in place and may be found in the Machine Control Center (MCC). All those who participate in the RG-L experiment must read, understand, and electronically sign the GARWP signifying that they understand and will abide by the permit. Any individual with a need to handle radioactive material at Jefferson Lab shall first complete Radiation Worker Level I (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 review by the Radiation Control Department. Alteration of these components (including the exit beamline itself) may result in increased radiation production from the Hall and a resultant increase in dose at the site boundary.

7 DECOMMISSIONING and DECONTAMINATION of RADIOACTIVE COMPONENTS

Experimenters shall retain all targets and experimental materials and equipment brought to Jefferson Lab for temporary use during the experiment.

After sufficient decay of such target configurations, they shall be delivered to the experimenter's home institution for final disposition.

All transportation shall be conducted in accordance with United States Department of Transportation (49 CFR Transportation) 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 to TJNAF for disposal of the material.

TJNAF cannot store indefinitely any radioactive targets or experimental equipment.

The Radiation Control Department may be reached at any time through the Accelerator Crew Chief (757-269-7045) or directly by calling the RadCon cell phone (757-876-1743). On weekends, swing, and owl shifts, requests for RadCon support should be made through the Crew Chief. This will ensure prompt response with no duplication of effort.