ES&H DIVISION
RADIATION CONTROL DEPARTMENT

Radiological Safety Analysis Document

Heavy Photon Search

Hall B Run Group I

Liaison: Stepan Stepanyan

July 2021

RCD-RSAD-07.23.2021-HB

Priority review level	1
Document classification	4
Next review due	n/a

Submit for approval	yes	no
	☐	☑

Thomas
Jefferson
National
Accelerator
Facility

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Heavy Photon Search

Hall B Run Group I

RCD-RSAD-07.23.2021-HB

Approved by

Keith Welch (Jul 24, 2021 09:52 EDT)

Jul 24, 2021

Keith Welch, Manager

Radiation Control Department

Date

Preparer/ Reviewer

Lorenzo Zana (Jul 24, 2021 21:39 EDT)

Jul 24, 2021

Lorenzo Zana, Radiation Physicist

Radiation Control Department

Date

Preparer/ Reviewer

St.Stepanyan (Jul 26, 2021 13:05 EDT)

Jul 26, 2021

Stepan Stepanyan, Deputy Leader

Hall B

Date

Contents

This Radiological Safety Analysis Document (RSAD) identifies the general conditions associated with running the Heavy Photon Search (HPS) experiment in Hall B. The controls regarding production, movement, or import of radioactive materials are delineated as well.

1 DESCRIPTION

The Heavy Photon Search experiment (E12-11-006) in Hall B will run from August 23 to October 16, 2021. The HPS uses a detector located in the downstream alcove of Hall B. The setup is based on a three-magnet chicane where the first and the last dipoles serve as bending magnets, while the middle one, 18D36 dipole, will be used as a spectrometer magnet. The beam will be transported through the all to the HPS target in a vacuum using the standard 2 to 3-inch beam pipes. There are no other targets or vacuum windows along the beam line before or after the HPS target along the way to the beam dump at the Faraday cup. The target and tracking detector are located in the vacuum; a set of vacuum chambers will allow passage of the beam to the dump within the vacuum. The vacuum beamline and chicane magnets are configured in such a way that the beam will have a clear passage to the Hall B electron beam dump whether or not the chicane magnets are energized. Chicane magnet power supplies are interlocked to beam delivery via the fast shutdown (FSD) system. Beam delivery will be terminated in the event of a magnet power supply trip.

For production data collection, HPS will use an 8 μm-thick (0.25% r.l.) tungsten target located at the beginning of the analyzing magnet and up to 300 nA, 3.77 GeV electron beam. There will be other target foils mounted on the target ladder (a frame that moves vertically), 15 μm and 20 μm tungsten foils (0.47% and 0.625% r.l., respectively), and a 0.5 mm carbon (0.3% r.l.) to be used for calibration purposes. There are no supports between the different target foils on the ladder.

The maximum luminosity during the run will be ~10^{34} sec^{-1} cm^{-2} per nucleon. During runs with beam currents above 40 nA, the Hall B 5 kW beam stopper (a 30 cm-long copper absorber with active cooling) will be positioned in front of the Faraday Cup. The bremsstrahlung photons produced in the target will have a 30 mrad angle relative to the electron beam and have a free path to the photon beam dump mounted behind the first shielding wall between the Hall B downstream alcove and the tunnel. The photon dump (a lead cave in the downstream tunnel with a tungsten insert) is the same as what was used during the 2015, 2016, and 2019 HPS runs. It is. For the beam tune before sending it to the Hall proper for HPS, the primary electron beam of up to 50 nA will be defected into the Hall B Tagger beam dump at the end of the tunnel inserted into the floor of Hall B.

The HPS detectors are located close to the electron beam plane. Radiation damage to the detectors and electronics has been studied using simulations first, then with the beam data from the 2015, 2016, and 2019 runs. As expected, no significant effects on the detectors or electronics have been observed. Some of the electronics (front end boards, for example) will be upgraded with new, more radiation-hard elements for this run. The current run conditions are very close to those during the 2019 run; we do not expect any issues with the proposed luminosity during operation of the HPS detector.

2 SUMMARY and CONCLUSIONS

The HPS 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 (RadCon or RCD) to ensure that the site boundary goal is not exceeded. Manipulation and/or handling of the target(s) or beam line hardware are the primary considerations with regard to potential radioactive material (RAM). As specified in Sections 4 and 7 below, the transfer of radioactive material, or modifications to the beam line after the target assembly, must be reviewed and approved by the Radiation Control Department Manager (RCM).

Adherence to this RSAD is vital.

3 CALCULATIONS of RADIATION DEPOSITED in the EXPERIMENTAL HALL

The radiation budget for an experiment is the amount of radiation expected at the site boundary, specified in mrem or percentage of the design goal (10 mrem/y) 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 RCM.

Calculations of the contributions to TJNAFs 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. Given this expectation, we have not carried out radiation budget calculations for the specific running conditions of Run Group I.

During the experiment, verification of the above expectations will be made via the active monitors at the Jefferson Lab site boundary. If it appears that the radiation budget will be exceeded, RadCon will require a meeting with the experimenters and Head of the Physics Division to

- determine whether the experimental conditions are accurate, and
- assess what actions may reduce the dose rates at the site boundary.

If the dose at the site boundary 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 unnecessary exposure of personnel;
- comply with Federal, State, and local regulations;
- adhere to TJNAF procedures; and,
- meet the Experimenter's home institution policies.

4.1 Beam in the Hall

When Hall B is in *Beam Permit* status, potentially lethal conditions are present; as such, several actions shall take place prior to switching. Announcements will be made over the intercom system notifying personnel of the change in status from *Restricted Access* (free access to the Hall is allowed, with appropriate dosimetry and training) to *Sweep Mode*. Magnetic locks on all exit doors will be activated; persons trained to sweep the area will enter via keyed-access-only (*Controlled Access*) and search the entirety of Hall B, checking for personnel.

Once the sweep is complete, 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 ”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 Radiation Control Department 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,
- previously used shielding or collimators.

The RCD inventories and tracks all radioactive materials onsite. As a baseline for future measurements, surveys may be conducted on experimental setups before experiments begin.

RadCon will coordinate movement of all used targets, collimators, and shields. RadCon staff 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 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 RCM.

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

5 INCREMENTAL SHIELDING or OTHER MEASURES to REDUCE RADIATION HAZARDS

None

6 OPERATIONS PROCEDURES

All experimenters must comply with experiment-specific administrative controls which begin with the measures outlined in the experiment's Conduct of Operations document. These controls may include radiological work permits (RWP), temporary operational safety procedures (TOSP), operational safety procedures (OSP), and/or any verbal instructions from RadCon. A General Access RWP (GARWP) that governs 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 HPS experiment must be read 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 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 dose at the site boundary.

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 such 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 (Title 49, Code of Federal 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. *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 (269-7050).