CLAS12
Hall B Run Group D (RG-D)
Radiological Safety Analysis Document (RSAD)

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

1. Description

The physics run of the CLAS12 RG-D will take place on summer of 2023 in the experimental Hall-B. CLAS12 is a multipurpose detector system based on toroidal (forward detector) and solenoid (central detector) superconducting magnets. The detector system includes Cherenkov Counters, Drift Chambers, Scintillator Counters, Silicon-strip detectors, Micro-mega gas detectors, and Calorimeters. During this run period, CLAS12 will be used in its standard detector and shielding configuration with the Forward Tagger (FT) OFF and the large Moller cone installed. The RG-D run will use up to 11 GeV or the maximum energy possible (up to 5 passes) polarized electron beam, with currents up to 200 nA during the luminosity scans. This run will use several targets varying from cryogenic liquid targets to heavy, solid targets. Targets will be located inside the vacuum scattering chamber installed within the central detector in the center of the 5 T solenoid magnet.

The target system employed for RG-D is the new JLab cryo target, a system that is currently under construction and will be used for the first time in the RG-D run in Hall B, and the so-called flag assembly, built by the Hall-B engineers, for solid targets. CLAS12 RG-D will use the following liquid targets in the new JLab cryo target system (H2, D2) as well as three types of solid foils (^{118}Sn, ^{63}Cu, ^{12}C) in the flag assembly. This target system will be able to support all the targets of interest. The flag assembly is housed in a vacuum vessel along with the cryogenic system. A scattering chamber is installed around the target cell area. This is made from Rohacell foam with a wall thickness of 6.5 mm. Aluminum windows are used at the entrance and exit of the liquid cell, and at the exit of the scattering chamber. The details of all components, such as windows and cells, are shown on the beamline drawing, including thicknesses and locations. The beamline drawings can be found at the Hall B beamline.

Table 1. Target configurations for CLAS12 RG-D run-periods

Energy (GeV)	**Target**	**Thickness (2 foils)** (cm)	**Density** ($g\ cm^{-3}$)	**Areal Density** ($mg\ cm^{-2}$)	T/X_o[1] (%)	**Beam Current** (nA)	**Per-nucleon Luminosity** ($10^{35}\ cm^{-2}\ s^{-1}$)
11 *(or maximum possible)*	LH2	5	0.071	355	0.56	100	1.3
	LD2	5	0.164	820	0.65	50	1.5
	^{12}C	0.2 (0.4)	2.20	440	1.03 (2.06)	50	1.7
	^{63}Cu / ^{118}Sn	0.009 / 0.018	8.96 / 7.31	80.64 / 131.6	0.63 / 1.49	150	1.2
	Empty	-	-	–	–	165[2]	1

P.S.: Liquid targets are denoted by ”L” and solid targets are simply listed with their chemical composition

The targets will be set up in several configurations which are detailed in Table 1. One will be a 5 cm long liquid (L) cell for Hydrogen and Deuterium. The remaining solid targets are composed of two-foil targets mounted in the flag assembly. These two-foil targets are made of either Carbon or isotropically pure ^{63}Cu and ^{118}Sn.

The liquid targets are centered in the solenoid magnet at the beam axis z= -5 cm, assuming z= 0 cm is the solenoid/CLAS12 center, with lateral extent of 2.5 cm. The flag two-foil assembly of Carbon (2 foils), or Copper + Tin are spaced at intervals of -7.5 cm and -2.5 cm in the z-axis. This is done as a way to approximate the acceptance of the liquid target 5 cm lateral extent in the solid targets for compatible experimental comparison.

The beam current setting in Table 1 is anticipated for the RG-D run-periods with up to 1.7 times the CLAS12 nominal luminosity of $10^{35}\ cm^{-2}\ s^{-1}$. However, we will time-to-time perform luminosity scans for detector efficiency studies in which the beam current will be increased up to 200 nA for LD2, LH2, and simultaneously mounted ^{63}Cu and ^{118}Sn foils configuration, and up to 100 nA for the two Carbon foils setup.

1 Areal Density (T) per radiation length (X_o)

2 Considered in this estimation the empty liquid cell windows of 30 microns each.