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

This Radiological Safety Analysis Document (RSAD) identifies the general conditions associated with the CLAS12 (Run Group E [RG-E]) 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-E will take place on spring of 2024 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-E run will use up to 11 GeV or the maximum energy possible at 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. The whole target system (Double-Target fabricated in CCTVal/UTFSM, Chile) will be located inside the vacuum scattering chamber installed within the central detector in the center of the 5 T solenoid magnet.

The RG-E Double-Target system utilizes a combination of the JLab/CLAS12 cryotarget and various solid material targets, which can be interchanged during different run periods using a piezo-motor device. These solid targets are affixed to a specialized flexible band. The cryotarget will contain deuterium (D2) or Hydrogen (H), while solid targets are of five different types: ^{208}Pb,^{120}Sn, ^{63}Cu, ^{27}Al, ^{12}C. The entire Double-Target system has the capability to position the solid targets aligned with the cryotarget in front of the beam with a spacial precision 0.04 mm.

The band system with solid targets is enclosed within a vacuum vessel, co-located with the cryogenic system. Surrounding the target system area is a scattering chamber constructed from 1.2 mm thick Carbon fiber. Aluminum windows are utilized at the liquid cell's entrance and exit, as well as at the scattering chamber's exit. Comprehensive details of all components, including windows and

cells, along with their thicknesses and locations, are outlined in the beamline drawing available at the Hall B beamline.

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

Energy (GeV)	**Target**	**Target Thickness Liquid /Solid** (cm)	**Target Density Liquid / Solid** (g cm^{-3})	**Target Areal Density Liquid / Solid** (mg cm^{-2})	T/X_o **Liquid /Solid** (%)	**Beam Current** (nA)	**Per-nucleon Luminosity** (10^{35} cm^{-2} s^{-1})
11 *(or maximum possible)*	LD2 / 12C	2 / 0.148	0.16 / 2.26	328 / 334	0.26 / 0.77	100	2.48
	LD2 / 27Al	2 / 0.120	0.16 / 2.70	328 / 324	0.26 / 1.35	100	2.45
	LD2 / 63Cu	2 / 0.036	0.16 / 8.96	328 / 323	0.26 / 2.51	90	2.19
	LD2 / 120Sn	2 / 0.030	0.16 / 7.31	328 / 219	0.26 / 2.49	90	1.84
	LD2 / 208Pb	2 / 0.014	0.16 / 11.35	328 / 159	0.26 / 2.49	90	1.64
	LH2 / 208Pb	2 / 0.014	0.071 / 11.35	142 / 159	0.22 / 2.49	90	1.02
	Empty / 208Pb	0.014	11.35	159	2.49	165	0.99

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

The Double-Target will be arranged in various configurations, as outlined in Table 1. The beam current values inside the table represent the maximum possible requested values. However, during the production run, the expected beam current will be 70 nA for all configurations with liquid target cell full. Simultaneously, the liquid target and one solid target will be exposed to the beam. The liquid cell, measuring 2 cm in length, will contain Deuterium or Hydrogen. The solid targets consist of 5.25 mm squares affixed to the band.

The downstream endcap of the liquid target is positioned within the solenoid magnet at the beam axis, specifically at z= -2 cm. Here, we consider z= 0 cm as the solenoid magnet center, meanwhile, the solid target is situated at z=2 cm. The beam current setting specified in Table 1 is expected for RG-E run periods, aiming for up to 2.5 times the CLAS12 nominal luminosity of 10^{35} cm^{-2} s^{-1}.

Periodic luminosity scans will be conducted for detector efficiency studies, during which the beam current may be increased up to 200 nA.