Characterization of Compton Suppression System performance using VERDI multi-foil detectors

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The VERDI detector was developed for accurate neutron measurements in the plasma-facing modules of a tokamak. The detector comprises a low activation ceramic capsule, capable to withstand the harsh conditions encountered in the fusion environment, containing a defined mass of metallic elements in the form of disc-shaped foils. The neutron fluence and energy spectrum is derived by the analysis of the multiple gamma lines produced by the neutron activation of the metallic elements. To this end, gamma spectrometry measurements using High Purity Germanium (HPGe) detectors are selected, since the best possible energy resolution is required.

In this work, the use of a Compton Suppression Spectrometer (CSS) is explored aiming to enhance the sensitivity of VERDI detectors analysis and to improve the detection limits of the radionuclides of interest. The CSS consists of a 40% HPGe primary detector coupled to a set of NaI secondary detectors that work as an active shielding. The CSS was set in anti-coincidence mode discarding signals that were simultaneously recorded on both primary and secondary detectors, therefore lowering the Compton continuum and enhancing the detection capabilities especially for single-gamma emitting isotopes. The analyzed VERDI detectors were irradiated at the Joint European Torus (JET) during the 2019 Deuterium-Deuterium (DD) campaign.

The performance of the CSS was studied by calculating suppression factors, as well as by evaluating the ability of the system to accentuate smaller peaks in the higher continuum areas. The advantage introduced by Compton suppressed gamma spectrometry for each nuclide of interest is presented and the suitability of the technique for VERDI detector measurements is discussed.

Keywords: neutron dosimetry, gamma spectrometry, Compton Suppression System, VERDI detector, fusion