Concrete Shielding Experiment at FNG: Benchmarking MCNP Simulations using JEFF 3.3 and JEFF 4.0 nuclear data libraries

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Concrete is a widely used material in nuclear facilities, combining structural mechanical performance with effective radiation shielding capability. The design of bioshields and reactor buildings strongly relies on the ability of computational tools to accurately predict neutron and photon transport. In this context, the validation of numerical codes against experimental benchmarks is essential to ensure the reliability of safety assessments and shielding design. In recent years, the EUROfusion consortium has supported experimental campaigns to investigate neutron transport in concrete under fusion-relevant irradiation conditions: this work presents the results of the concrete shielding experiment, carried out at the Frascati Neutron Generator (FNG) facility at the ENEA Frascati Research Centre, using a 14 MeV neutron source.

The experimental setup consisted of a concrete mock-up assembled from 13 slabs ($50\times50\times10$ cm^3 each), irradiated with 14 MeV D-T neutron source. Activation foils (Al, Au, Fe, In, Nb, Ni, W) were placed at specific positions within the assembly, providing sensitivity to a broad neutron energy range, through reactions characterized by different energy thresholds. Gamma spectroscopy after each irradiation was performed with corrections applied for dead time, self-absorption, geometric efficiency, and decay during both irradiation and acquisition. A detailed post-analysis has been carried out with a high-fidelity MCNP5 model of the full experimental setup, including the irradiation facility and surrounding bunker, to calculate reaction rates and determine calculated-to-experimental (C/E) ratios. A comparison of the results using JEFF 3.3 and JEFF 4.0 nuclear data libraries was performed.

Results confirm a generally reliable description of fast neutron transport through concrete. High-threshold reactions show good agreement: ^{93}Nb(n,2n) slightly underestimates measurements (~10%), while ^{56}Fe(n,p) closely reproduces experimental data. Larger discrepancies are observed for ^{27}Al(n,α) and ^{58}Ni(n,p). ^{115}In(n,n') shows a systematic positional dependence, indicating sensitivity to local variations of the neutron energy spectrum within the mock-up. Thermal reactions display greater deviations, consistent with their increased sensitivity to neutron moderation effects. Generally JEFF 4.0 improves agreement relative to JEFF 3.3, particularly for thermal reactions, likely due to updated cross-section evaluations. Nevertheless, residual discrepancies, even among reactions with similar energy thresholds, highlight effects beyond the transport modelling, emphasizing the need for further sensitivity and uncertainty analyses.

Type of contribution:	Poster session	☐
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