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P3.173 V&V analyses of the GEANT4 Monte Carlo code with computational and experimental fusion neutronics benchmarks

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The high-energy particle physics Monte Carlo code toolkit GEANT4 has been expanded for fusion energy-range neutron transport simulations based on evaluated nuclear cross-section libraries. Verification and Validation (V&V) analyses were conducted with nuclear data from the ENDF/B-VII.0 and the JEFF-3.1 library to show the suitability for fusion applications. Two computational benchmarks with a single fusion-relevant isotope at a time and one experimental benchmark were performed with GEANT4 in comparison with MCNP5.
The differential computational benchmark assumes a neutron beam with isolethargic energy distribution along the axis of a cylinder with length 2m and radius 1µm. After a single material interaction, the scattered or secondary neutrons passing through the cylinder side surface are recorded. The accumulative deviation between GEANT4 and MCNP5 throughout the energy spectrum is <1% for all isotopes and libraries.
The integral computational benchmark is a 30cm radius sphere with an isotropic 14.1MeV neutron source in the centre. The neutron flux averaged over the sphere volume is recorded. The total flux deviation between GEANT4 and MCNP5 is <1% for all isotopes and libraries with some larger deviations in individual energy groups for some isotopes.
The considered experimental benchmark, performed by the Institute of Physics and Power Engineering, Obninsk, is on the transmission of 14MeV neutrons through iron shells of different thicknesses (2.5 – 28cm). Geometry and source description were processed from the Shielding Integral Benchmark Archive and Database (SINBAD). In this experiment, neutron leakage spectra were measured at a distance of 679cm from the centre of the iron shells. The obtained Calculation/Experiment (C/E) ratios are acceptable for most of the energy spectra with a larger deviation in the range of 4 – 10.5MeV.
In summary, the results of the V&V analyses obtained in this work indicate the suitability of GEANT4 for the application to fusion neutronics problems.

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