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Nuclear Data Needs for Fusion Neutronics Applications

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Fusion neutronics is an important component of fusion power plant development. Neutronics informs key engineering and design decisions, including shielding specifications, safe operating procedures, and dose limits. Neutronics workflows are typically validated by simulating a prototypic experiment from which experimental data has been collected. This allows for the calculation of uncertainty estimates due to systematic and stochastic errors. Characterization of these uncertainties allows for evaluation of their relative importance to key modeling output and gives insight to engineers on design margins and trade-offs.
Currently there are insufficient benchmarks in the Shielding Integral Benchmark Archive and Database (SINBAD) [1] database to comprehensively cover all aspects of neutronics in fusion devices. Moreover, some evaluations are lacking in detail. Several crucial areas of interest have been identified by both public and private enterprises who are in the process of designing fusion pilot plants.
We propose a two-fold campaign of benchmark experiments. Firstly, a series of computation benchmark experiments which would focus on the validation of neutronics workflows used to determine quantities of interest such as: fluid activation, analysis of very large models, the skyshine effect, variance reduction techniques, the effect of homogenization, and shutdown dose rate calculations. As part of the computational analysis, we also propose a series of 1D models [2] based on the current ITER and fusion pilot plant designs to assess sensitivity to nuclear data in such configurations.
The second set of benchmarks should be new experimental benchmark designs driven by data needs that are identified by the computational benchmarks. This should include benchmarks which address the lack of data in operational regimes outside of the currently operating machines.
The presentation will include a more detailed overview of the needs of fusion neutronics analysts regarding benchmarking, uncertainty quantification, and modeling. The recent ORNL endeavor of creating a new shutdown dose rate computational benchmark experiment based on ITER geometry for the needs of a blind test will also be presented.

References
1. Kodeli et al., Radiation Shielding and Dosimetry Experiments Updates in the SINBAD Database, Radiation Protection Dosimetry (2005), Vol 116, No.1–4, pp.558–561
2. Bohm et al., Neutronics Calculations to Support the Fusion Evaluated Nuclear Data Library (FENDL). Fusion Science and Technology 77, no. 7-8 (2021): 813-828.

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