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Advanced Neutronics Simulation Tools and Data for Fusion Applications

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Neutronics simulations play an important role for the design and optimisation of the nuclear components of a fusion reactor and the related performance analyses. Accurate data need to be provided to predict the Tritium breeding capability, assess the shielding efficiency, estimate the nuclear power generated in all components, and produce activation and radiation damage data for the irradiated materials, as well as the resulting radiation dose loads to sensitive components/materials, or related biological dose rates.

Suitable computational approaches, tools and data need to be available to provide such data with sufficient accuracy. This includes a suitable method for the simulation of neutron transport in complex 3D geometries, high quality nuclear cross-section data to describe the nuclear interaction processes, anda simulation model which replicates the real geometry without severe restrictions. Such requirements are satisfied with the Monte Carlo particle transport technique which can handle any complex geometry and employ the nuclear cross-section data without any severe approximation. The simulations thus provide results limited only by the uncertainties of the nuclear cross-sections, the statistical uncertainty of the Monte Carlo calculation and the accuracy of the geometry model.

Key issues for reliable neutronics simulations are thus related to (i) the reliability of the employed Monte Carlo particle transport code, to be validated with fusion relevant benchmark experiments, (ii) the quality of the nuclear cross-section data evaluations for fusion applications, to be checked against integral experiments, and (iii) the capability to describe in the simulation the real reactor geometry with high fidelity and sufficient detail. All of these key issues are addressed in R&D activities embedded in the European fusion programme with the objective to make available the tools and data which are required to ensure a sufficient prediction capability of the neutronic simulations for DEMO and power reactors.

This paper reports on the recent achievements of the tools developed for the high fidelity geometry representation in the Monte Carlo particle simulation and the provision of high quality nuclear cross-section data with uncertainty assessments.

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