| | Proposal Code: PDF – FT_0008 |
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| Title | Uncertainty Quantification Studies for Fusion Reactor Nuclear Responses Using the Covariance Methodology |
| Abstract | In fusion reactor design, neutronics calculations are crucial for developing breeding blankets, designing shielding for reactor components & personnel, and selecting structural and functional materials. The design and optimization of reactor components rely heavily on radiation transport codes, which, in turn, depend on nuclear cross-section libraries. These cross-section libraries are evaluated using experimental data along with theoretical physics models. However, significant uncertainties in the nuclear data persist. These uncertainties can propagate and significantly get amplified during transport through tokamak structures introducing uncertainties in tritium breeding rate, radiation damage in first wall, gas production in blanket & Vacuum Vessel, activation of reactor components, volumetric heat in electromagnets and in various other response functions. Accurate quantification of uncertainties in various nuclear responses arising from uncertainties and their correlations in microscopic cross-section data is essential for the reliable design and safety assessment of fusion systems. This can be achieved by utilizing the “Covariance Methodology”. To address this basic requirement, it is proposed to develop a computational framework at IPR for scientifically based uncertainty quantification in neutronics calculations, starting with the data such as International Reactor Dosimetry File (IRDFF), ENDF/B-VIII.0, JENDL-5.0 & TENDL2025 cross-section libraries along with the IAEA-EXFOR database. These specialised nuclear data libraries already include covariance data, and experimental uncertainties in specified neutron and gamma flux spectra and integral data are also well-documented in the literature. The proposed project will be tailored as a first basic step to understand the basic engineering approach to reactor design responses related to fusion reactors. The project aims to lay a scientific foundation for characterizing propagation of uncertainties to obtain design margins in response functions from safety and operational point of view. This activity of covariance methodology needs to be continued in the long term as a regular and basic part of design processes involving fusion neutronics. |
| Research Focus Areas | Proposed work is aligned with the core activities related to fusion reactor design |
| Qualifications | Ph.D. in Nuclear Physics or Nuclear Engineering, |
| Desired Experience | Specialization in nuclear data covariance studies is essential. |
| Other remarks | |