

Towards Accurate Uncertainty Estimates in High-Fidelity Radiation Transport Simulations of Fusion Power Plants

Wednesday 10 December 2025 10:50 (30 minutes)

Accurate predictions of neutron behavior are central to the design of fusion power plants, yet the confidence we can place in those predictions is often just as important as the nominal results. This talk will examine the landscape of uncertainty in high-fidelity Monte Carlo (MC) and deterministic radiation transport simulations and the steps being taken to bring rigorous uncertainty quantification (UQ) into existing fusion digital engineering workflows.

Sources of uncertainty arise at many levels: nuclear data uncertainties affect estimates of quantities like the tritium breeding ratio, structural activation, or energy deposition; geometric fidelity, particularly in complex first wall and blanket assemblies, strongly impacts localized damage and heating, streaming, and shielding predictions; and statistical uncertainties from MC sampling affect complex MC-coupled workflows like shut-down dose rates. Other high-impact uncertainty sources include material property data for advanced coolants and structural alloys, where uncertainties propagate into both thermal and nuclear performance estimates.

This presentation will highlight which uncertainties can be reliably addressed in current digital engineering workflows for neutron transport and where critical gaps remain. Recent progress in OpenMC towards handling these challenges in CAD-based engineering workflows will be presented with a focus on unique integrated capabilities for both forward and adjoint solutions on complex geometries. By clarifying this landscape and presenting ongoing work to close some gaps in uncertainty analysis, we aim to guide where digital engineering efforts can most effectively reduce risk and build confidence in fusion power plant design.

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