Contribution ID: **42** Type: **Invited oral**

Overview of the PSFC blanket and fuel cycle modelling activities

Tuesday 9 December 2025 14:00 (30 minutes)

Achieving reliable tritium self-sufficiency remains one of the defining challenges for fusion power-plant design, making accurate tritium fuel cycle modelling essential.
At the MIT Plasma Science and Fusion Center, we are developing a unified digital framework that connects material-scale physics, component-level behaviour, and system-level fuel-cycle performance, informed and validated by experimental platforms.
At the material scale, we combine thermo-desorption analysis (TDS), parametric optimisation for experimental validation (NRA, permeation experiments…), supported by the development of an open-source database of tritium transport properties (HTM).
We also investigate fuel cycle component performances by leveraging multi-physics workflows (OpenFOAM, OpenMC, FESTIM): tritium transport dynamics in the ARC breeding blanket, extraction efficiency of a PAV extractor, tritium contamination in a heat exchanger…
Finally, at the system level, we integrate these component models within a system modelling code (PathSim and it's graphical interface PathView) to analyse complete systems, from lab-scale experiments like LIBRA/BABY to full power-plant concepts like ARC.
This multiscale, multiphysics modelling strategy highlights how digital engineering can accelerate design, improve predictive capability, and support the development of tritium-robust fusion reactors.

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Session Classification: Simulation and Modelling Techniques

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