

Towards a Tritium Breeder Digital Twin

Tuesday 9 December 2025 14:30 (25 minutes)

Currently, the LIBRTI experimental facility is being built in the UK to serve as a test environment for tritium breeder blanket systems of various types and to accelerate technology development for fusion reactors, such as STEP. In support of the LIBRTI programme, we have developed a multi-physics simulation platform for generic breeder systems, initially focussed on liquid lithium technologies. A key objective of the work is the ability to optimise breeder system designs with many free parameters (related e.g. to geometry, chemical compositions or operational conditions), and in the presence of various competing requirements. These requirements include e.g. tritium generation and heat extraction targets, corrosion resistance and space restrictions. Ultimately, this platform is planned to serve as a digital twin supporting operation, maintenance and decommissioning of the breeder system. The implemented simulations include neutronics calculations based on Monte Carlo methods coupled with nuclear activation calculations as well as analytical models. Machine Learning based surrogate models have been adopted for the neutronics/activation calculations. Trained with simulated data, these Machine Learning models are integrated into the simulation of the entire liquid lithium system and enable the multi-targeted optimisation of the system. In addition, we are exploring Machine Learning models in support of the simulation of corrosion effects.

The Machine Learning models used predict, along with the response values, also the uncertainties on these values. This enables the targeted provision of additional training data to reduce uncertainties in regions of the parameter space where it is of most interest.

The presentation outlines the physics simulation, discusses the applications of Machine Learning and provides an overview of the software infrastructure developed.

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