2nd Fusion Neutronics Meeting (KIT): Abstract submission

Title: **W7-X neutronics simulations for new neutron diagnostics with application to fast-ion confinement**

By the end of 2028 it is foreseen that the W7-X stellarator will switch from Hydrogen to Deuterium fuel, starting DD operation. The DD fusion reactions will lead to the production of 2.5 MeV neutrons together with fast Tritium nuclei which can themselves fuse with Deuterium thermal plasma creating 14 MeV DT neutrons.
The detection of these two different species of neutrons, namely 2.5 MeV DD neutrons and 14 MeV DT neutrons, is a well-established method, known as triton burn-up study, to assess the fast-ion confinement. Tritium burn-up studies were already employed in other fusion experiment devises, both tokamaks (such as ASDEX-Upgrade and JET), as well as stellarator (LHD). Understanding, improving and predicting the behaviour of fast ions, especially their confinement, in present-day fusion devices is a major scientific objective especially for stellarators.

Future fusion reactors will work on a DT fuel mixture whose reaction gives birth to highly energetic alpha-particles (3.5 MeV Helium-4 ions). For a burning plasma, the internal heating has to be provided by the alpha-particles, which must be well confined in the plasma to transfer their energy to the thermal plasma particles. Compared to less energetic particles, fast ions require different and more challenging conditions, as they are in a different collisional regime and less well confined by the magnetic field. Unlike in tokamaks, the three-dimensional magnetic field configuration of stellarators leads to losses of the helically trapped fast-ions. An optimization criterion for a good fast-ion confinement is a high plasma pressure. The validation and improvement of these conditions for the W7-X stellarator is a crucial step to demonstrate a possible path towards reactor relevant conditions in stellarators.

For a triton burn-up study, appropriate neutron diagnostics need to be set-up which can distinguish between fast neutrons of different energies such as DD and DT neutrons. Previous studies have researched the feasibility of using scintillating fiber (SciFi) neutron detector for W7-X triton burn-up measurement. These SciFi detectors are not installed yet at W7-X, therefore neutronics simulations are necessary to appropriately set up the diagnostics and interpret the detector response in relation to the physics. The aim of our research is to perform high-fidelity Monte Carlo neutronics simulations using OpenMC code on an updated CAD-based W7-X geometry model for the evaluation of the optimal positions of the SciFi detectors, their expected response and connection to fast-ion confinement analysis. In broader terms, this study will contribute to the development of a simulation technique which can be applied to neutronics analyses for neutron diagnostics evaluation in future fusion reactors.