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P2.224 Mesh based Variance Reduction Technique in Shielding Calculations of the Stellarator Power Reactor HELIAS

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The Helical-Axis Advanced Stellarator (HELIAS) is the leading stellarator concept in Europe and developed at the Max-Planck-Institute for Plasma Physics (IPP). Based on the 5-field-period symmetry, the HELIAS-5B engineering design study emerged which aims at a stellarator power reactor designed for 3000 MW fusion power.
The stellarator confines hot plasma only by external superconducting field coils, which are very sensitive for the neutron flux, leading to a complex 3D topology of the magnetic configuration. These coils define the shape of the device and limit the space available outside the plasma chamber for the vacuum vessel and the in-vessel components required for breeding, shielding and heat removal. It is thus necessary to identify the locations where minimum space for the shielding is available and check there the radiation loads to the magnetic field coils in order to proof a sufficient shielding capability.
This requires a suitable computational approach to simulate the generation of source neutrons in the plasma chamber and the neutron transport through the complex HELIAS geometry. The approach is based on the Monte Carlo (MC) particle transport technique applied with the Direct Accelerated Geometry Monte Carlo (DAGMC) method. The particle transport to regions far away from the plasma source typically results in higher statistical uncertainties when using the standard analogue MC particle transport simulation technique. The statistics can be greatly improved by running non-analogue calculations with the application of suitable variance reduction (VR) techniques.
The paper presents results of the shielding calculations performed for HELIAS and discusses the application of the mesh based weight window VR technique to achieve statistically reliable tally results in the region of the non-planar shaped field coils. The calculated nuclear responses are compared to the design values specified as limits for the radiation loads to the superconducting toroidal field coils of the DEMO tokamak.

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