Effect of 3D magnetic perturbations on fast ion confinement in the European DEMO

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The current European DEMO design, with a fusion power of 1.8 GW and up to 51 MW of external NBI heating, will produce copious amounts of energetic particles both in 3.5 MeV fusion-born alphas as well as 800 keV NBI ions. Good confinement of these particles is necessary not only for efficient heating and current drive, but also for machine protection. Losses introduced by the toroidal ripple can result in localized heat loads on the first wall, the design of which is already constrained by the requirements for tritium breeding and power plant operation [1].

To study the 3D effects of the toroidal ripple on fast particles, a high-resolution vacuum magnetic field was constructed from realistic coil geometry. Additionally, the ripple-mitigating effect of ferritic inserts was included by modelling the perturbations using the finite element solver COMSOL, previously applied to similar studies for ITER [2]. Fast ion confinement and losses were simulated using the Monte Carlo orbit following code ASCOT both for thermonuclear alpha particles as well as NBI ions, for which an injector model was developed based on the latest DEMO reference design [3].

The fast ion confinement in the European DEMO design was found to be good, with alpha power losses remaining below 500 kW and wall loads below 100 kW/m\textsuperscript{2} in all cases. The ferritic inserts effectively mitigated the toroidal ripple, reducing the losses nearly to the level of an axisymmetric field. Finally, the confinement of the NBI particles was found to be excellent, with losses remaining below 0.1 %, resulting in minimal deterioration in power deposition and current drive.

References