Feasibility study for a fast-ion loss detector and an imaging neutral particle analyzer for the DTT tokamak

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The Divertor Tokamak Test (DTT) facility [1] is a compact, high-field tokamak being designed and constructed with the primary goal of studying heat exhaust in conditions similar to those of ITER and DEMO in steady-state. Up to 10 MW of negative-ion based neutral beam injection (NBI) with an injection energy of 510 keV, and 6 MW of ion cyclotron resonance heating (ICRH) are currently being considered which will provide an external source of fast-ions. Due to the large electron cyclotron resonance heating power fraction, high electron temperatures are expected leading to long slowing down times for fast-ions which may facilitate energetic particle physic studies. To this end, a comprehensive suite of fast-ion diagnostics is being planned for DTT. In this work a feasibility study for a scintillator based fast-ion loss detector (FILD) and an imaging neutral particle analyzer (INPA) is presented, where the high power 5.5 MA / 5.85 T scenario has been used as baseline.

A preliminary design of the FILD diagnostic is presented including the probe head and manipulator. A double collimator system is proposed for the simultaneous measurement of co- and counter-going ions. The probe head is designed to allow measurements of H, D, and He ions from ~50 keV up to 1.5 MeV, covering the full energy spectrum expected for the ICRF and NBI fast-ion distributions. The collimator factor and velocity-space resolution of the system are optimized using the FILDSIM code [2]. In the case of the INPA diagnostic, simulations with the INPASIM code [3] have been conducted for an estimation of the signal levels and velocity-space coverage for different poloidal positions of the detector. The 510 keV NBI is used as the active source of neutrals, leading to relatively low signal levels due to the lower cross-section for charge exchange reactions at these energies. On the other hand, all positions considered provide similar velocity-space coverage with pitch-angles ($v_{||}/v_{tot}$) from -0.2 to 0.9 as a function of the radial coordinate. Preliminary thermal load estimations are calculated for the different possible localizations of the FILD and INPA probe heads.

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*[2] J.Galdon-Quiroga et al., Plasma Phys. Control. Fusion **60** 105005 (2018)*
*[3] J.Rueda-Rueda et al., Rev. Sci. Instrum. **92** 043544 (2021)*