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P4.1073 Optimal exploitation of the electron cyclotron heating and current drive system in ITER for reduced magnetic field operations

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In the current ITER research plan, the path toward the full-performance DT plasma is based on a staged approach. The power available from the external Heating and Current Drive (H&CD) systems will be limited during the first phases of operation, the Electron Cyclotron (EC) system being the only one available for the first plasma [1]. The EC H&CD system, operating at 170 GHz, has been designed for optimal performances in the reference B0 = 5.3 T scenarios, with the injected Omode wave interacting with the plasma at the first harmonic resonance. However, the first plasma will be obtained at B0 = 2.65 T, half of the nominal magnetic field strength, and one-third-field operations are foreseen during the first Pre-Fusion Power Operation (PFPO) phase in order to reduce the L-H transition power threshold and demonstrate H-mode in an early phase [2, 3]. This strategy means that the EC system will operate under potentially non-optimal conditions for an extended period. X-mode injection in half-field scenarios allows good H&CD efficiency at the second harmonic, but third harmonic absorption on the low field side may affect the CD performance of the EC Equatorial Launcher (EL). At one-third-field EC absorption can be incomplete at low temperature, due to the lower efficiency of higher order harmonics, while on the other hand the simultaneous presence of 3rd and 4th harmonic resonances in the plasma can deteriorate CD localization and efficiency. The work presented here aims at providing an overview of the EC H&CD performances expected at half- and one-third-field, with a particular focus on critical issues such as beam shine-through due to partial absorption, delocalized absorption over multiple harmonics causing loss of CD efficiency, and imperfect mode coupling because of polarization mismatch. The results are presented for a wide range of plasma parameters, and different beam injection geometries, in order to assess the best strategy to make optimal use of the EC system in the most demanding situations.

[1] M. Henderson et al, Phys. Plasmas 22, 021808 (2015) [2] Y. R. Martin et al, Journal of Physics: Conference Series 123 (2008) 012033 [3] M. Schneider et al, Nuclear Fusion, submitted (2018)

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