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Electron Cyclotron power management in ITER, the path from the commissioning phase to demonstration discharges

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Among the external heating systems planned in ITER, the Electron Cyclotron system has the highest flexibility. By combining the equatorial and the upper launcher, the EC can cover the whole plasma radius, from the axis to the edge, allowing for combined central heating, current profile tailoring and MHD stability control.

This work discusses how to best use the EC system in synergy with the other systems for MHD control and optimal plasma performance, by looking separately at the different phases of the discharge, moving from non-active operation to the demonstration baseline.
Time-dependent simulations with the TRANSP transport solver evolve self-consistently the plasma pressure and the heating and current drive profiles.
Priority in the study is given to the power requirements for the stabilization of the Neoclassical Tearing Modes (NTMs), because this sets constraints on the power that is available for the other applications, like active control of sawteeth and profile tailoring.
The evolution of the NTMs is calculated during the discharge and a real-time controller in TRANSP manages the steering of the Upper Launcher, calculates the power needed for stabilization and distributes the power between mirrors for combined applications. Simulations indicate that the NTMs evolve to their saturated size on time scales of a few seconds and that losing alignment with the NTM island, for example because of sawtooth crash, can be deleterious. This implies that pre-emptive control might be more effective than active control, especially in the case of the more dangerous (2,1) mode. It is found that at half-field, an optimal steering of the neutral beams can change the sawtooth period by a factor three. Discharge design plays therefore an important role in the EC power management, by relaxing some of the requirements for MHD stability over central heating and profile tailoring.

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