REMOTE-STEERING DESIGN OF THE ITER ECRH UPPER-PORT LAUNCHER

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The design of the mm-wave system for the ITER upper ports is being carried out with the aim to inject Electron Cyclotron Waves (ECW) in the ITER plasma in order to stabilize neoclassical tearing modes (NTM). Four ports are reserved for the upper launchers which are equipped with six to eight mm-wave lines, each capable of transmitting high power up to 2 MW at 170 GHz.

In order to exploit the capability of ECW for localized heating and current drive over a large range of plasma radii in ITER, the ECH&CD upper port launcher needs a beam steering capability. Two alternative approaches are being studied in Europe under EFDA tasks [1]. The "classic" lay-out, Front Steering (FS), has rotating mirrors near the plasma. To avoid moving water-cooled components at the plasma-facing end of the launcher, e.g., mirrors and cooling lines, an alternative solution, Remote Steering (RS) is studied by a number of European institutes, as well.

In the case of RS, the mm-wave beam is brought into the ITER vacuum vessel by a 4-m long square corrugated waveguide. Provided that the waveguide has the correct dimensions, the mm-wave beam will leave the waveguide at the plasma side under the same variable angle as the input angle. The mm-wave beams will subsequently be guided through penetrations in the front-shield blanket module by a set of 2 mirrors towards the ITER plasma. This "dog-leg" set-up will have focusing properties in both directions.

The design analysis has demonstrated the feasibility of the remote-steering approach in the ITER environment. Furthermore, a full-scale mock-up line at 170 GHz has been designed and successfully tested both at low power at Rijnhuizen and at high power on the coaxial, short pulse gyrotron at FZK, Karlsruhe [2, 3].

New design efforts are ongoing in order to improve the limited current-drive capability of the RS set-up at the relevant NTM positions. An increase of the square waveguide length to 8 m is foreseen to enable the efficiency to increase the current-drive capability to the minimum levels that are needed to stabilize the 3/2 and 2/1 NTM modes in nearly all ITER scenarios.

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[1] R. Heidinger, *et al.*, "Critical Structural Design Issues of the ECRH Upper Launcher for ITER", submitted for presentation at this workshop.
[2] M.F. Graswinckel, *et al.*, "High power measurements on a remote steering upper port launcher mock up for ITER", submitted for presentation at this workshop.
[3] I. Danilov, *et al.*, "Thermo-hydraulic performance and high power transmission characteristics of the RS torus window prototype", submitted for presentation at this workshop.