THE ITER EC H&CD UPPER LAUNCHER: MM-WAVE DESIGN

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The main purpose of the ITER Electron Cyclotron Heating and Current Drive (EC H&CD) upper port antennas, operating at 170 GHz, will be to provide localized heating and current drive capabilities by accurately aiming mm-wave beams at chosen magnetic flux surfaces with low order rational *q* values in order to stabilise neoclassical tearing modes (NTMs).

ITER's reference design uses a front steering concept located in the four attributed upper port plugs [1], with the steered mirror close to the plasma. The beam paths are folded within the upper port plug structure to produce the beams with the required waist location in the plasma while allowing the installation of components with sufficient shielding against neutron streaming with the smallest possible aperture in the front shield. There are two steering mirrors per launcher. Setting the center of their steering ranges to two different values maximizes the functionality of the launchers for a given amount of input power. In addition to the steering mirrors, the optical components include sets of focussing and plane mirrors, allowing the transmission of eight beams per plug without risk of arcing and with a minimum of stray radiation. The design comprises invessel HE_{11} corrugated waveguide sections. Excessive heat flux peaks due to ohmic losses at the reflecting surfaces are avoided by the integration of appropriate cooling loops. The mm-wave components are fully integrated into the structure of the port plug to allow remote handling [2] in the hot cell.

The physics requirements, the high energy neutron flux present in near plasma regions and the spatial, thermo-mechanical and electro-magnetic constraints are driving the design. Among the relevant mechanical design aspects of the steering mirror are the systematic reliance on frictionless and backlash free mechanical movements based on the elastic deformation of structural components to avoid the in-vessel tribological difficulties. A set of structurally compliant inert gas pressure and remotely controlled corrugated bellows function as actuators providing highly accurate angular positioning of the steering mirror [3]. Experimental results verifying the life time prediction of these components are discussed. Control strategies and associated control hardware achieving the required angular accuracy and resolution performances have been developed.

Finally, the ongoing R&D activities, envisioned functional capabilities, recently integrated modifications and possible future modifications that could be implemented based on the experimental results are summarised.

[1] T. Omori et al., Overview of the ITER EC H&CD System and its capabilities, this conference.
[2] D.M.S. Ronden et al., The ITER EC H&CD Upper Launcher: remote handling, this conference.
[3] Collazos, A. et al., Progress on the ITER H&CD EC Upper Launcher Steering-Mirror Control System, Plasma Science, IEEE Transactions on , vol.38, no.3, pp.441-447, March 2010.