An upgraded TCV for tokamak physics in view of ITER and DEMO

A. Fasoli and the TCV Team

Ecole Polytechnique Fédérale de Lausanne (EPFL), Centre de Recherches en Physique des Plasmas, Association EURATOM-Confédération Suisse, CH-1015 Lausanne, Switzerland

To extend its operational domain towards the burning plasma regime and enhance the reactor relevance of its results, major upgrades are being implemented on the TCV tokamak. Improving understanding and control capabilities of burning plasmas is a major scientific challenge, which requires accessing plasma regimes and configurations with relatively high density, high normalised pressure (1.5<$\beta_N<$3), comparable ion and electron temperatures, and significant populations of fast ions. It is possible to achieve these conditions on TCV by installing a 1MW neutral beam heating system (energy 20-35keV, 1-2s duration, D) and by injecting additional 2MW of microwave power at the EC third harmonic (X3). For a configuration similar in shape to ITER, the condition $T_i=T_e$ is met for $P_{NBH}=0.8$MW in discharges with 1.3MW of X3 power. Detailed studies confirmed the feasibility of inserting a port with an aperture of 170×230 mm$^2$ and of injecting tangentially through it a 1.0MW beam. On the EC side, a predesign is underway for two sources of 1MW/126GHz, based on the 1MW/170GHz ITER gyrotron concept. The existing three 118GHz gyrotrons would be connected via high-power microwave switches through lateral low-field-side launchers currently used for X2. Bulk electron heating will be ensured by waves injected from the top, while the localised deposition necessary for MHD control will be possible from the side. Maintaining shape flexibility in the presence of stronger additional heating requires modifications of the first wall in areas that were subject so far to relatively low power levels.

The upgrades will put TCV in a unique position to contribute to the ITER and DEMO physics basis. TCV will contribute to disentangling effects of electron-ion coupling, rotation, $q_95$, edge density control and shape, in L and H-modes, with $\beta_N$ values in the same range of ITER or higher. TCV will also be able to explore heat, particle and momentum transport, and turbulence in dominantly electron-heated discharges with varying $T_e/T_i$ (0.02<$T_e/T_i<$3). The existing shape flexibility will be kept, to investigate diverted plasmas with negative triangularity and snowflake divertor plasmas, as well as more exotic configurations such as doublets.