5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Integrated modeling of the Divertor Tokamak Test facility plasma scenarios

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The Divertor Tokamak Test facility (DTT) [1,2] is a new tokamak under construction in Frascati, Italy, with metallic wall and focus on power and particle exhaust. Its main parameters are R=2.19 m, a=0.70 m, $B_T \leq 6$T, $I_p \leq 5.5$ MA, $P_{tot} \leq 45$ MW, pulse length ≤ 100 s. An intensive integrated modelling work using the JINTRAC [3] and ASTRA [4] 1.5 D frameworks has been performed for the baseline day-0, day-1 and full power DTT scenarios with the Single Null divertor configuration. This has provided reference scenarios to support the design of the device, e.g. for the optimization of the heating mix and of the fuelling systems, for the diagnostics, neutron shield and control coil design, for neutron licensing, for MHD stability studies, for the evaluation of fast particle losses, as well as to help the elaboration of a DTT scientific research plan.

The flat-top phase has been simulated using the quasi-linear transport models TGLF [5] and QuaLiKiz [6], with validation against gyrokinetics for the specific parameter regimes of DTT [7]. The pedestal has been predicted by EUROped [8]. The separatrix density and temperature were chosen to be consistent with scrape-off layer parameters in detached conditions. The chosen heating mix includes power on plasma ECH (170 GHz) 29 MW, negative NBI (510 keV) 10 MW, ICH (60-90 MHz) 6 MW. For n_e/n_{GW}~0.5, central T_e~ 15 keV, T_i~ 9 keV, n_{e0}~2.5 10^{20} m^{-3} are predicted, with β_N~ 1.4 , τ_E ($P=P_{sep}$) ~ 0.5 s , H98Y~0.9, total neutron emission~1 10^{17} neutron/s, Z_{eff}~1.6 with mildly peaked profile. Ar or Ne are envisaged as seeding gas. Rotation is rather small and does not provide significant ExB turbulence stabilization. Edge neutrals penetrate up to ρ_{tor}~0.8, with a required gas puff level which is marginal with respect to achievable pumping capacity, therefore the additional use of pellets for fuelling is recommended. A pellet system with injection from Oblique High Field side, pellets size r ~ 1 mm, velocity ~ 500 m/s is under design. Simulations with the QuaLiKiz model indicate that an injection frequency ~ 16 Hz is required to maintain the density pedestal for zero gas puff, with edge density perturbations < 20%.

First attempts to simulate the complete time evolution of a full power discharge have been made using the 0.5 D METIS code [9], tuned to the quasi-linear simulations. The simulations make use of the plasma boundaries generated by the CREATE-NL free-boundary solver [10] and optimize the heating location and timing to be consistent with the prescribed time evolution of β and internal inductance l_i, with a current ramp lasting 27 s and L-H transition at t=32.8 s. The use of off-axis ECH during the current ramp is envisaged to keep l_i low. Time dependent simulations with ASTRA using quasi-linear models for the core and the IMEP [11] edge model are ongoing to provide a physics based prediction of the discharge evolution.

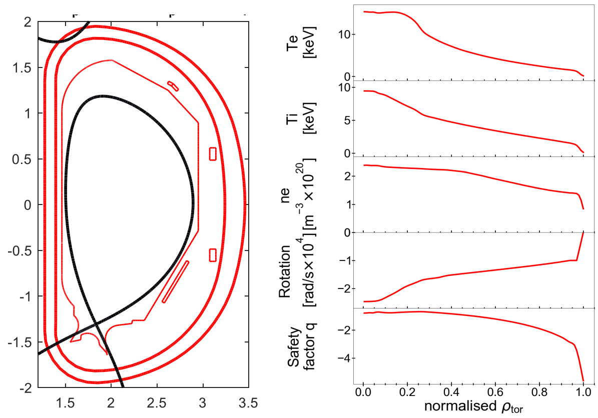

Figure 1: Plasma boundary and main plasma profiles for DTT full power scenario at flat-top. B_T and Ip have opposite sign, hence the negative safety factor. NBI are co-current.

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