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WEST operational domain predictions of L-mode non-inductive discharges with an integrated modeling approach

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WEST is a machine designed for attaining Long Pulse Operation [1] with Lower-hybrid Heating and Current Drive (LHCD), superconducting coils, actively-cooled components and a W wall. In 2024, a more than six-minutes-long L-mode plasma was sustained with 1.15 GJ of injected energy. In parallel, developments were undertaken on the modeling side. The High Fidelity Pulse Simulator (HFPS) [2], an IMAS-coupled version of the integrated JINTRAC suite of codes, has been used to predict self-consistently plasma kinetic profiles and LHCD current drive efficiency for such long pulses. Predictions rely on the simultaneous evolution of the turbulent transport with TGLF-sat2 [3] and the LHCD source with METIS reduced model [4,5]. The latter estimates the current generated using a scaling law, derived from Tore Supra and JET databases analysis [6] and checked against WEST experimental data.

This workflow is used to accurately reproduce a reference experimental plasma. In particular, electron temperature and density profiles (Figure 1a and 1b), global energy confinement time and loop voltage are shown to be in good quantitative agreement. Then, the operational domain for a fully non-inductive discharge has been sought, scanning the LHCD injected power P_{LHCD}, the plasma current I_P and the electron line-averaged density n_{el}. This exploratory modeling effort has been found in very good match with subsequent experimental (P_{LHCD}, I_P) scans (Figure 1c and 1d). Finally, using this integrated modeling framework, the impact of additional physics ingredients such as low-Z impurity seeding and central ECCD can be investigated prior to the next WEST experimental campaign.

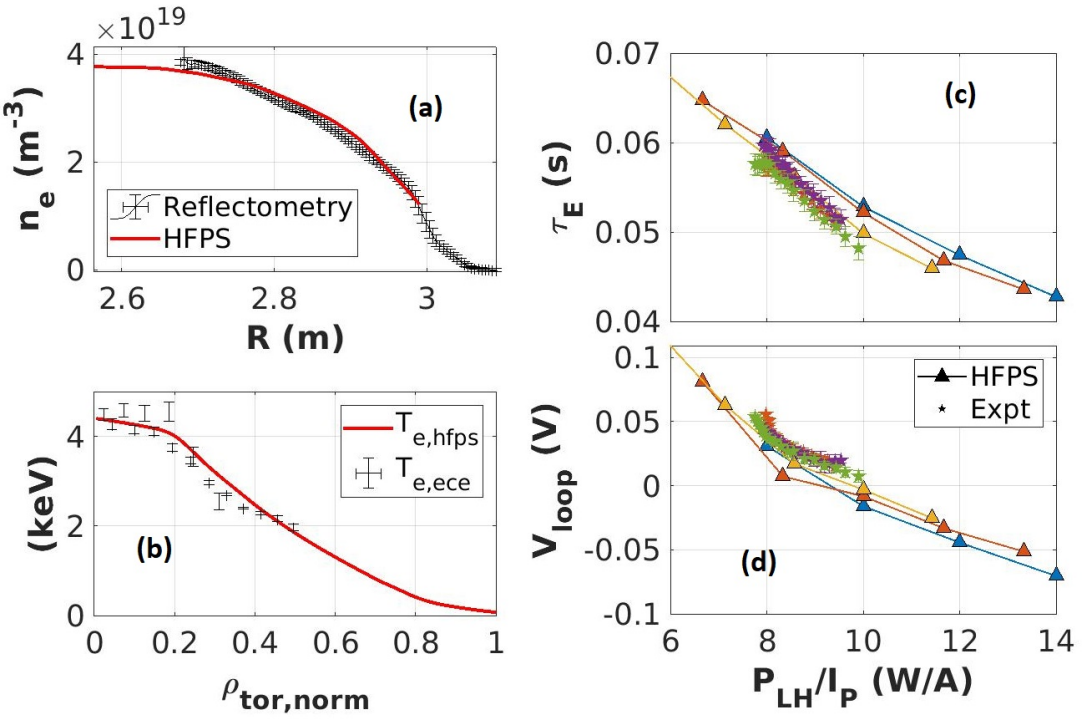

Figure 1:

Figure 1. Predicted (a) electron density profile against reflectometry measurements, and (b) electron temperature profile against ECE measurements for the reference discharge. Validation of LHCD power and plasma current scans against experiment for energy confinement time (c) and loop voltage (d).

[1]: X. Litaudon, et al., Nucl. Fusion 64, 015001 (2024).
[2]: See TSVV11 wikipages https://wiki.euro-fusion.org/wiki/TSVV-11.
[3]: C. Angioni, et al., Nucl. Fusion, 63, 126035 (2022).
[4]: J.-F. Artaud, et al., Nucl. Fusion 58, 105001 (2018).
[5]: R. Dumont, et al., Phys. Plasmas 7, 4972–4982 (2000).
[6]: M. Goniche, et al., AIP 787, 307–310 (2005).

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