Overview of the third JET deuterium-tritium campaign

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JET returned to deuterium-tritium operations in 2023 (DTE3 campaign), approximately two years after DTE2. DTE3 was designed as an extension of JET's deuterium campaigns in 2022-2023 [1], which focused on developing scenarios for ITER and DEMO, integrating in-depth physics understanding and control schemes. These scenarios were assessed with mixed D-T fuel, utilizing the only tritium-compatible tokamak until its closure in 2023.

ITER requires high confinement scenarios that are capable of managing the heat loads to the divertor via impurity seeding. In DTE3, the operational space of the Ne-seeded ITER baseline scenario [2], developed further in the recent D campaigns, was expanded in D-T. This provided high performance plasmas from a high recycling to a partially detached regime at both low (2.5MA) and high current (3.0-3.2MA), so that the impact of mixed D-T fuel on the core-edge integration can be assessed. Peeling limited pedestals [3], as expected in the low collisionality plasmas of ITER, were studied across isotopes from D, to DT, to T-rich plasmas. Furthermore, the 'temperature-gradient screening' of tungsten at the plasma edge, predicted for ITER [4] and demonstrated experimentally in JET [5], was validated in a wider parameter space.

Looking also towards DEMO, both small or no ELM regimes, and scenarios aiming at maximising the radiative power dissipation were investigated. The QCE small-ELMs regime [6], which requires strong shaping close to double null and strong fuelling, was demonstrated to be compatible with D-T operation. Furthermore, the X-point radiation regime [7] was accessed in D-T, supporting its application in ITER [8]. DEMO compatible diagnostics were utilised to control the radiator location in real-time.

Control schemes relevant to D-T plasmas were demonstrated, such as the control of the isotope mix with gas and pellets. Tritium retention was investigated with gas-balance techniques, and also with a novel-laser based diagnostic [9], demonstrating an in-situ fuel retention diagnostic method important for fusion reactors. Finally, motivated by the analysis of DTE2 experiments [10], further investigations to complete the physics understanding and demonstrate the reproducibility of sustained high fusion power production were executed.

The DTE3 campaign benefited from the fact that the previous D-T operations were very recent, implementing the lessons learned [11]. Building on the previous D and DTE2 campaigns, DTE3 expanded our understanding of D-T plasmas, in particular in scenarios relevant to next-generation devices such as ITER and DEMO.

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[9] M. Zlobinski et al, IAEA FEC, London 2023
[10] C.F. Maggi et al, IAEA FEC, London 2023
[11] D.B. King et al, IAEA FEC, London 2023

[a] See the author list of "Overview of T and D-T results in JET with ITER-like wall" by C.F. Maggi et al, to be published in Nuclear Fusion Special Issue
[b] See the author list of "Progress on an exhaust solution for a reactor using EUROfusion multi-machines capabilities" by E. Joffrin et al, to be published in Nuclear Fusion Special Issue from the 29th Fusion Energy Conference (London, UK, 2023)