Predictive modelling of JET baseline scenarios from DTE2 towards DTE3

V.K. Zotta[1], L. Garzotti[2], S. Gabriellini[1], R. Gatto[1], C. Bourdelle[3], C. Giroud[2], L. Frassinetti[4], D. Frigione[5], D.B. King[2], D.L. Keeling[2], D. Kos[2], M. Lennholm[2], K. Lawson[2], C. Leoni [1], P. Lomas[2], C. Lowry[2], S. Menmuir[2], G. Pucella[6], F.G. Rimini[2], D. Van Eester[7], S. Wiesen[8], A. Kappatou[9], N. Vianello[10], M. Wischmeier[9], JET Contributors* and the EUROfusion Tokamak Exploitation Team**

[1]Dipartimento di Ingegneria Astronautica, Elettrica ed Energetica, Sapienza Università di Roma, via Eudossiana 18, 00184, Roma, Italy; [2]United Kingdom Atomic Energy Authority, Culham Science Centre, Abingdon, Oxon, OX14 3DB, United Kingdom of Great Britain and Northern Ireland; [3]CEA, IRFM, F-13108 Saint Paul Lez Durance, France; [4]Fusion Plasma Physics, EECS, KTH Royal Institute of Technology, SE-10044 Stockholm, Sweden; [5]University of Rome Tor Vergata, Via del Politecnico 1, Rome, 00133, Italy; [6]Dip.to Fusione e Tecnologie per la Sicurezza Nucleare, ENEA C. R. Frascati, via E. Fermi 45, 00044 Frascati (Roma), Italy; [7]Laboratory for Plasma Physics, LPP-ERK/KMS, Bruxelles Belgium; [8]DIFFER - Dutch Institute for Fundamental Energy Research, De Zaale 20, 5612 AJ Eindhoven, Netherlands; [9]Max-Planck-Institut für Plasmaphysik, Garching, Germany; [10]Consorzio RFX, Corso Stati Uniti, 4, Padova, 35127 Italy;

* *See the author list of C.F. Maggi et al. 2024 Nucl. Fusion(https://doi.org/10.1088/1741-4326/ad3e16);*
** *See the author list of E.H. Joffrin et al 2024 Nucl. Fusion (https://doi.org/10.1088/1741-4326/ad2be4);*

INTRODUCTION

The multi-year effort on the *Joint European Torus* (JET) for investigating key physics aspects of ITER operations has culminated with the last two deuterium-tritium (DT) experimental campaigns. While 2021 DT experiments (DTE2) focused mainly on the stationarity of the high fusion performance [1], 2023 D-T experiments (DTE3) aimed at the integration of reactor relevant scenarios in view of ITER and DEMO [2]. The high-current high-performance baseline scenario for DTE2 (from now on JET baseline scenario) has been successfully developed and sustained for 5 s in D, but when translated in T and DT it could not be sustained for more than 2-3 s [3]. The JET baseline scenario has been executed in DTE2 mainly at 3.5 MA and 3.3 T in presence of 50-50 DT beams using D pacing pellets. In DTE2, only two pulses were performed at 3.0 MA and 2.8 T with additional heating power $P_{aux} \approx 25$ MW. One of the two JET baseline pulses at 3.0 MA has been performed with neon (Ne) seeding aiming at demonstrating in DT the same beneficial effect of Ne on confinement demonstrated in D [4, 5, 6].

With Ne seeding, at lower plasma current (2.5 MA and 2.8 T), in a different divertor configuration and higher triangularity, the core-edge integrated scenario (from now on ITER baseline scenario) has been demonstrated for the first time in DTE2 [7]. However, the development of the ITER baseline scenario in DTE2 has been hindered by the constraints on the D-T neutral beam (NBI) heating power due to re-ionization heat load on limiters and duct pressure [7] found at higher fuelling rates. Both scenarios, JET and ITER baseline, have been successfully executed in DTE3 in presence of pure D-NBI, with an additional heating power $P_{aux} \geq 30$ MW, achieving good performance for at least 5 s [8].

In this contribution we investigate the fuel mix control in DT plasmas and how the 50-50 DT mixture is achieved through the balance of the different fuelling channels. Despite the relevance of fuel mix control for future fusion reactors, this topic is not often covered by integrated modelling due to the large uncertainties on particle sources from gas puffing in the edge region and in the scrape-off layer. However, progress has been made in the analysis and in the prediction of the last JET DT campaigns [9, 10, 11] and we are now presenting how, based on integrated modelling, a 50-50 DT JET baseline scenario has been achieved in presence of D-NBI. We present the validation done on DTE2 data, the blind predictions of the JET baseline scenario for DTE3 and the modelling results on actual DTE3 data for both scenarios.

INTEGRATED MODELLING OF DTE2 AND DTE3 PLASMAS

DTE2 has been preceded by a multi-year activity of predictive modelling [12] and it has been followed by an intense validation activity on multiple transport codes and first-principle