CCFE
CULHAM CENTRE FOR FUSION ENERGY

UK Atomic Energy Authority

UKAEA-CCFE-PR(23)157

Costanza Maggi

Foreword to Nuclear Fusion Special Issue on JET T & D-T

Foreword to Nuclear Fusion Special Issue on JET T & D-T

Costanza Maggi

This is a preprint of a paper submitted for publication in Nuclear Fusion

Foreword to NF SI on JET T & D-T

Costanza Maggi
Guest Editor and former EUROfusion/JET Task Force Leader
UKAEA, Culham Science Centre, Abingdon, OX14 3DB, United Kingdom

In 2021 we carried out the second major JET deuterium-tritium campaign (DTE2), almost 25 years after DTE1. Exploiting JET's unique capability to operate with tritium (T) and D-T fuel and with an ITER-like Be/W wall, DTE2 represented the culmination of a plan started in 2006. JET's carbon wall, with unacceptably high T fuel retention for a fusion reactor, was replaced in 2009-2011 by the ITER-like combination of Be in the main chamber and W in the divertor. Already at that time a high fusion yield D-T experiment was envisaged, to test crucial physics and technology aspects of reactor-relevant D-T fusion plasmas ahead of ITER's operations. Furthermore, a full T campaign at high power would address issues of isotopic effects on particle, energy and momentum transport and plasma-wall interactions, which had remained largely unexplored since the TFTR and JET D-T experiments in the 1990's. Alpha particle effects had been weak and difficult to understand in DTE1, thus in DTE2 emphasis was also placed on demonstrating unambiguous α-particle effects.

Following the installation of the metallic wall, a decade of JET experiments, analyses and modelling confirmed the reduced hydrogen fuel retention rate in the Be/W wall, demonstrated in D plasmas the compatibility of ITER scenarios with the ITER-like wall and investigated a large breadth of isotope physics issues in dedicated H, D, T, and H-D, H-T campaigns. In support of the T and DTE2 experiments, a series of JET enhancements were completed over the years, e.g.: new fusion diagnostics, new T injection capabilities, refurbishment of the T plant, increased auxiliary heating, in-vessel calibration of 14MeV neutron yield monitors.
Significant advances in plasma theory and modelling were accomplished in the fusion community since DTE1. The JET T and D-T experiments were guided by intense "predict-first" modelling using different codes and modelling assumptions. The most significant output of DTE2 is the validation of current models and physics workflows in the most D-T fusion reactor relevant conditions to date.

We planned and executed the JET T and DTE2 experiments along six main goals:

i) Demonstrate high fusion power, sustained for 5s (this duration limited by the thermal inertia (and between pulse cooling) of the tokamak's wall and copper magnetic coils)
ii) Demonstrate an ITER-relevant, Ne-seeded radiative scenario in D-T with the Be/W wall
iii) Demonstrate clear α-particle effects
iv) Clarify isotope effects on energy and particle transport and explore consequences of mixed species plasma
v) Address key plasma-wall interaction issues
vi) Demonstrate radio-frequency heating schemes relevant to ITER D-T operation

The JET T and DTE2 experiments were carefully conducted to ensure safe operation with tritium and were successfully completed on 21st December 2021. On that day JET broke a new world record, generating 59 MJ of fusion energy in one plasma pulse.

In December 2021, during the final, intense phase of DTE2, we started compiling the list of a first set of 'must have' journal papers stemming from the JET T & DTE2 experiments, to focus the analysis and modelling activities in 2022. Around that time, we were approached by the Nuclear Fusion board, who invited us to submit a collection of dedicated articles on JET T and DTE2 results in a Special Issue (SI) of Nuclear Fusion, to recognize the high significance of the experiments. We gratefully agreed to such a project, but also wondered how the collection of SI papers would connect (and not interfere) with contributions on the same topics at the 29th Fusion Energy Conference (October 2023, London, UK). The IAEA, in consultation with the conference Chair and journal Board, thus proposed a timeline such that the SI would be published at the start of FEC 2023 to highlight the JET T and DTE2 results at the conference. The JET T and D-T FEC Overview paper is a new work for the conference and will be published in Nuclear Fusion's FEC OV SI, but also linked to this SI. It pulls together and reports on the contents of the JET T & D-T FEC contributed papers, as well as on the articles of this SI, and contains the full list of the many JET contributors to the T and DTE2 campaigns.

I take this opportunity to thank the Nuclear Fusion board for promoting this Special Issue on JET T and DTE2, the journal editorial team and the IAEA FEC secretariat for assistance and support from conception to completion of the SI and the many reviewers for helping to improve the quality of the papers.

This SI is dedicated to the exceptional team of scientists, engineers and technicians who ensured the success of the JET T and DTE2 experiments.