High power baseline H-mode Deuterium plasmas with ion temperature exceeding the electron temperature in JET-ILW

Hyun-Tae Kim¹, C. D. Challis², A.C.C. Sips³, F. Rimini², L. Garzotti², E. Lerche²,⁷, L. Frassinetti⁴, M. Beurskens⁵, X. Yuan⁶, S. Kaye⁶, and JET contributors* 

¹EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK  
²EUROfusion Programme Management Unit, Culham Science Centre, Abingdon, OX14 3DB, UK  
³Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, OX14 3DB, UK  
⁴JET Exploitation Unit, Culham Science Centre, Abingdon, OX14 3DB, UK  
⁵Max Planck Institute for Plasma Physics, Wendelsteinstraße 1, 17491 Greifswald, Germany  
⁶Princeton Plasma Physics Laboratory, Princeton University, USA  
⁷LPP-ERM/KMS, Association EUROfusion-Belgian State, TEC partner, Brussels, Belgium 

E-mail contact of main author: hyun-tae.kim@euro-fusion.org

Neutron data of 115 high beam power Deuterium discharges (>25MW) in 2016 JET experimental campaigns with the ITER-Like Wall (ILW) have been analysed with interpretive TRANSP simulations [1]. The statistical analysis found that even in high nₑ baseline H-mode discharges with Tᵢ > Tₑ, were produced by the high beam power. Tᵢ > Tₑ was seen in hybrid discharges and advanced tokamak plasmas, but typically C-wall baseline plasmas exhibited Tᵢ > Tₑ at high electron density (<nₑ> > 5e19 m⁻³)[2]. In all TRANSP analysis executed, Tᵢ=Tₑ was assumed with Tₑ profile data obtained from High Resolution Thomson Scattering (HRTS) measurements, and Yazı data given by bremsstrahlung measurement was roughly constant (i.e. Zₑeff = 1.1~1.8). The neutrons are mostly from beam-target reactions, rather than thermal reactions. Despite the smaller sensitivity of the beam-target neutrinos to Tₑ, the neutrons measured by fission chambers exceed the neutrons calculated using TRANSP in the high neutron yield regime, i.e. neutron surplus in measurement, implying Tᵢ > Tₑ in the high power discharges (Figure (a)). The neutron surplus is significantly correlated with the increase in effective collisionality νₑeff (Figure (b)), which reduces the e-i equilibration power. The high beam power in the recent JET-ILW experimental campaign increased Tₑ, reducing the e-i equilibration power, and this enables Tᵢ to deviate from Tₑ. In addition, the TRANSP analysis also shows that the fraction of beam heating to ions i.e. Pₑbeam/(Pₑbeam+Pₑbeam) increases as Tₑ increases, providing an additional contribution for obtaining Tᵢ > Tₑ. These experiments are the basis for high performance JET-DT experiments planned for 2019, with the aim of Pₑ⁺>10MW for 5s. The ability to obtain Tᵢ > Tₑ and understanding why these conditions occur in the core of the plasma will help in achieving that aim.

**Figure (a)** Measured neutrons vs Calculated neutrons. The error bars are the calculated neutrons with different impurity assumptions i.e. 100% Be or 100% Ni (2) Neutron surplus vs Effective collisionality


This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

*See the author list of “Overview of the JET results in support to ITER” by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016)