Determining the absolute tritium and deuterium fuel densities at JET through Bayesian inference using multiple neutron diagnostics and simulations

B. Eriksson[1], S. Conroy[1], G. Ericsson[1], J. Eriksson[1], A. Hjalmarsson[1], F. Auriemma[2], C. Challis[2], D. Keeling[2], D. King[2], K. Kirov[2], M. Poradzinski[2], JET contributors[3]

[1]*Department of Physics and Astronomy, Uppsala University, Lägerhyddsvägen 1, Uppsala, 752 37, Sweden*
[2]*United Kingdom Atomic Energy Authority, Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, OX14 3DB, United Kingdom*
[3]*See the author list of 'Overview of JET results for optimising ITER operation' by J. Mailloux et al. 2022 Nucl. Fusion 62 042026*

Corresponding Author Email: benjamin.eriksson@physics.uu.se

The absolute fuel ion densities of tritium (T) and deuterium (D) as well as the fuel ion ratio $n_{\mathrm{T}}/(n_{\mathrm{T}} + n_{\mathrm{D}})$, are important parameters for reactor control in fusion experiments. The fuel ion densities typically need to be determined for a wide range of experimental conditions, anywhere between pure deuterium plasmas with trace amounts of T to pure tritium plasmas with trace amounts of D. Given the significantly larger cross section for D + T fusion reactions, compared to D + D or T + T, introducing small amounts of tritium to a deuterium plasma (or vice versa) quickly has a large impact on the neutron emission rates and the neutron energy spectrum. For experiments that use the neutron emission rate as a figure of merit, or for simulations, the time-resolved tritium ratio often needs to be considered. In this paper, we present a method for determining the absolute densities of tritium and deuterium and the fuel ion ratio using multiple neutron diagnostics together with simulations utilizing the plasma transport code TRANSP and the synthetic neutron diagnostic code DRESS. The method is set up utilizing a Bayesian framework to estimate the most likely distribution of tritium and deuterium densities given the available data and simulations. The method is applied to experiments conducted at the Joint European Torus of the hybrid plasma scenario involving deuterium-dominated plasmas with trace amounts of tritium, heated by D neutral beam injection and ion cyclotron resonance frequency heating.

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 - EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.