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Neutron yield studies in JET H-modes

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The ability to calculate and predict the neutron yield is essential for the planning of fusion experiments, such as the future Deuterium/Tritium experiment in JET. The fusion yield expected in JET from fast ion orbit calculations using NUBEAM/TRANSP has been systematically compared to the measurements from a set of three Uranium fission chambers, which were recalibrated in 2013. In many JET discharges the measured neutron rates fall short of the predicted ones by up to a factor 2, depending on plasma parameters. In JET, unlike ITER, neutrons are primarily from beam-thermal reactions and the causes of the neutron deficit are believed to be due to processes affecting the fast ion-thermal reactivity, such as fuel dilution, NBI deposition and fast ion transport. The study presented here is based on Deuterium discharges, mostly from the JET carbon phase (until 2009) and cover a wide range of plasma conditions in H-mode, together with a few L-mode samples. NUBEAM/TRANSP simulations were produced for a set of 320 discharges which are representative of the entire JET operating domain. The deficit correlates with plasma parameters, being smallest or absent in discharges with highest toroidal rotation, Te, Ti, and beta_N, such as realised in "hybrid scenarios", which provide the highest fusion yields in JET and are considered to be the best option for D-T experiments. Contrary to widespread belief, Zeff and dilution appear to play at best a minor role. Modelling of the neutron deficit assuming fast ion diffusion with D_f=chi_i, is inconsistent with the observed parameter dependencies for the deficit, suggesting that fast ion transport and thermal heat transport are of different nature. MHD instabilities such as sawtooth crashes modelled by TRANSP and NTM's modelled using ASCOT, appear to have too small an effect to explain the deficit. The fact that neutron rates at high beta_N (>2.5) generally agree within errors with the measurements, gives confidence in our predictions of the fusion performance of high beta_N plasmas in the future DT campaign.

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Primary author: Mr WEISEN, Henri (JET EFDA)

Co-authors: Dr YURIY, Baranov (UKAEA); Dr GIROUD, Carine (CCFE); Dr KEELING, David (UKAEA); Dr KIM, Hyun-Tae (UKAEA); Dr BUCHANAN, James (UKAEA); Dr STRACHAN, Jim (PPPL); Dr DAMIAN, King (UKAEA); Dr ZASTROW, Klaus-Dieter (UKAEA); Dr GIACOMELLI, Luca (CNR); Mr WEISEN, Mathias (Strathclyde University); Dr FITZGERALD, Michael (UKAEA); Dr SCOTT, Steven (MIT); Dr KOSKELA, Tuomas (Aalto University)

Presenter: Mr WEISEN, Henri (JET EFDA)

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