Measuring fast ions in fusion plasmas with neutron diagnostics at JET - DTU Orbit (31/03/2019)

Measuring fast ions in fusion plasmas with neutron diagnostics at JET

Fast ions in fusion plasmas often leave characteristic signatures in the neutron emission from the plasma. In this paper, we show how neutron measurements can be used to study fast ions and give examples of physics results obtained on present day tokamaks. The focus is on measurements with dedicated neutron spectrometers and with compact neutron detectors used in each channel of neutron profile monitors. A measured neutron spectrum can be analyzed in several different ways, depending on the physics scenario under consideration. Gross features of a fast ion energy distribution can be studied by applying suitably chosen thresholds to the measured spectrum, thus probing ions with different energies. With this technique it is possible to study the interaction between fast ions and MHD activity, such as toroidal Alfvén eigenmodes (TAEs) and sawtooth instabilities. Quantitative comparisons with modeling can be performed by a direct computation of the neutron emission expected from a given fast ion distribution. Within this framework it is also possible to determine physics parameters, such as the supra-thermal fraction of the neutron emission, by fitting model parameters to the data. A detailed, model-independent estimate of the fast ion distribution can be obtained by analyzing the data in terms of velocity space weight functions. Using this method, fast ion distributions can be resolved in both energy and pitch by combining neutron and gamma-ray measurements obtained along several different sightlines. Fast ion measurements of the type described in this paper will also be possible at ITER, provided that the spectrometers have the dynamic range required to resolve the fast ion spectral features in the presence of the dominating thermonuclear neutron emission. A dedicated high-resolution neutron spectrometer has been designed for this purpose.