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Conceptual design of a High Resolution Neutron Spectrometer system for ITER

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The proposed High Resolution neutron Spectrometer (HRNS) system for ITER is composed of a suite of neutron spectrometers with the primary function to provide measurements of the fuel ion ratio, nT/nD , in the plasma core. Supplementary functions are to assist or provide information on fuel ion temperature, T_i , energy distributions of fuel ions and confined alpha-particles and neutron emission profiles. The ITER requirement for the HRNS primary function is to obtain nT/nD with 20% uncertainty and a time resolution of 100 ms for full power DT plasmas.

In this contribution, a conceptual HRNS system design and its measurement performance for nT/nD is presented. The HRNS system in this study is based on established instrumental techniques and its performance is assessed using simplified, yet realistic response functions for the individual spectrometers used in the system. The main interfacing requirements for the HRNS is a 10 cm diameter aperture in the ITER first wall and a tapered collimation towards the HRNS instrument, resulting in a neutron flux in the order of 10^9 n/cm²/s on an area of 10 cm² at a distance of 16 m from the first wall.

For optimum use of the available neutron flux, the system is divided into two sections; “low efficiency” neutron spectrometers in the front and “high efficiency” in the rear. It is also investigated to use an adjustable collimator between the front and rear spectrometers in order to enhance the dynamic range and overlap of the “low efficiency” and “high efficiency” systems.

The neutron spectrometers presented here are a combination of thin-foil, diamond and time-of-flight techniques; it is shown that the system fulfills the ITER requirement on nT/nD over an order of magnitude in fusion power, $40 < P_{fus} < 500$ MW. In the performance study, background contributions due to neutron scattering in the vessel walls, collimator and beam dump are included together with a component of neutron induced gamma-rays.

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