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System Level Design and Performances of the ITER Radial Neutron Camera

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The paper describes the on-going work performed by a Consortium of European institutes on the design of the ITER Radial Neutron Camera (RNC) within a framework contract placed by Fusion For Energy (F4E), the ITER European Domestic Agency. The RNC will measure the uncollided 14 MeV and 2.5 MeV neutrons from deuterium-tritium (DT) and deuterium-deuterium (DD) fusion reactions through an array of flux monitors/spectrometers located in collimated lines of sight (LOS) viewing the plasma through Equatorial Port #1. The line-integrated neutron fluxes are used to evaluate, through reconstruction techniques, the radial profile of the neutrons emitted per unit time and volume (neutron emissivity) and therefore the neutron yield and the alpha particles birth profile. The major operational role of the RNC is the plasma burn real-time control.
The RNC is presently at the System Level Design (SLD) stage, whose final scope is the definition of an Intermediate System Architecture (ISA) for the diagnostic to be put under configuration control. The goal is achieved through a System Engineering process in which different RNC architectural options are proposed and ultimately are ranked according to selection criteria. The paper concentrates on the part of the process that, starting from the diagnostic functions, leads to the analysis of the RNC measurement performances during DD and DT operations.
Based on a set of top level RNC functions ("to provide Plasma Coverage", "to provide Field of View"and to "to Detect Particle/Radiation") six RNC global options have been identified and their performances studied by means of three different emissivity reconstruction algorithms: 1) 1D algorithm based on Tikhonov regularization with derivative objective functional; 2) Tomography Algorithm based on Tikhonov regularisation with Minimum Fisher Information objective functional; 3) 1D algorithm based on neural networks. The Analysis was carried out using a set of DT and DD ITER plasma scenarios covering the required neutron emissivity measurement range and including statistical and background errors. Results indicate that, considering only background and statistical uncertainties, the challenging requirements set for the use of the RNC for real-time plasma control operations (10% accuracy, 10 ms time resolution, 10ˆ14 –6 × 10ˆ18 sˆ(-1) mˆ(-3) measurement range) might be achieved.

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