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Nuclear design of a shielded cabinet for electronics: the ITER Radial Neutron Camera case study

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The Radial Neutron Camera (RNC) is a diagnostic system located in the ITER Equatorial Port #1, probing a poloidal section of the plasma through a set of fan-shaped Lines of Sight (LOS). The RNC is designed to provide spatial and time-resolved measurement of the neutron and α particles source profiles as well as the total neutron source strength, as a result of reconstruction techniques applied to the line-integrated neutron fluxes.
The uncollided 14 MeV and 2.5 MeV neutrons, generated through deuterium-tritium (DT) and deuterium-deuterium (DD) fusion reactions, are measured by means of an array of neutron flux detectors located in dedicated cassettes at the end of the collimated LOSs. Signals from RNC detectors (i.e. fission chambers, single Crystal Diamonds and scintillators) need preamplification because of their low amplitude; consequently, the preamplifiers have to be located as close as possible to the detectors in order to minimize the detrimental effect of signal degradation on the RNC measurement performances. On the other hand, the electronic devices must be protected against the severe radiation environment during normal operating conditions, due to the intense neutron streaming directly from the plasma and the effects of secondary gammas generated through the interaction of neutrons with the surrounding machine components.
The solution adopted is to host the preamplifiers in a shielded cabinet located in a dedicated area of the Port Cell, behind the Bioshield Plug.
The overall design of the cabinet must ensure the necessary magnetic, thermal and nuclear shielding and, at the same, satisfy weight and allocated volume constraints and maintain its structural integrity. The aim of the present work is the nuclear design of a suitable shielded cabinet, performed by means of 3D particle transport calculations (MCNP), taking into account the radiation streaming through the Bioshield penetrations and the cross-talk effect from the neighboring Lower and Upper Ports. The assessment of its nuclear shielding performances is presented, as well as the analysis of the compliancy with the alert thresholds for commercial electronics in terms of neutron flux and cumulated ionizing dose.

Scientific Topic 1

Scientific Topic 2

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Radiation damage to materials

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