24th IAEA Fusion Energy Conference - IAEA CN-197

Contribution ID: **513** Type: **Poster**

ITR/P5-28: Assessing the Nuclear Environment for ITER Port Plugs and Port-based Diagnostics

Thursday 11 October 2012 08:30 (4 hours)

ITER diagnostic systems will operate in a harsh nuclear environment. Component protection and nuclear shielding is realized by housing diagnostics inside massive steel port plug structures. The diagnostic port plugs must be optimized to provide adequate diagnostic throughput while minimizing the flux of escaping nuclear radiation and staying under a total dry weight of 45 metric tons. Most diagnostic systems are in the conceptual design phase and the optimization of this balance between performance, weight and shielding has not yet been realized. Sophisticated analysis tools are needed to predict the performance of components in ITER since actual measurements of the environment may not be realized for some time. The commercially available discrete-ordinates code Attila® has been used for the conceptual phase analysis of several ITER diagnostics and diagnostic port plugs. Assessment of the diagnostic port plug nuclear environment with Attila is essentially a 3-step process involving a neutron transport run, a calculation of the activation and depletion in steel structures and finally the transport of the activated steel gamma rays.
This paper will survey current neutronics results for a selection of Upper and Equatorial port plugs and the diagnostic systems in these ports. General port plug neutronics results like total nuclear heating and general shielding issues will be described. Specific diagnostic design studies will also be presented with a focus on meeting diagnostic measurement requirements while achieving adequate shielding. For example, the Core Imaging X-Ray Spectrometer diagnostic cannot use labyrinths to mitigate neutron and gamma flux. A multi-faceted solution approach was needed. This includes the use of radial baffles to limit streaming to only collimated neutrons and the narrowing of apertures that limits streaming while still allowing for minimum system performance. Many diagnostics have mirrors and shutters in the very front of the port plugs where nuclear heating is on the order of 6 W/cc. This paper will summarize the current diagnostic first wall and shield block neutronics around these "first mirrors".

This work is supported by DOE contract numbers DE-AC02-09CH11466 (PPPL) and DE-AC05-00OR22725 (UT-Battelle, LLC). The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

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Session Classification: Poster: P5

Track Classification: ITR - ITER Activities