Radiation Shielding for Fusion Reactors

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Radiation shielding for fusion reactors introduces numerous and different problems than encountered in the shielding of fission reactors and accelerators. Fusion devices, particularly tokamak reactors, are complicated by geometry constraints that often preclude the disposition of fully effective shielding. Numerous penetrations (heating and diagnostic) that violate the bulk shielding further weaken overall radiation-protection effectiveness. This paper summarizes shielding issues and suggested solutions for a tokamak reactor. The propositions presented here are based largely on experiences analyzing and assessing the shielding requirements for the International Thermonuclear Experimental Reactor (ITER).

Radiation transport calculations are essential for predicting and confirming the neutronic performance of the reactor and, as such, must be an essential part of the reactor design process. Development and optimization of reactor components from the first wall and primary shielding to the penetrations and containment shielding must be carried out in a sensible progression. Initial results from one-dimensional transport calculations are used for scoping studies and are followed by detailed two- and three-dimensional analyses to effectively characterize the overall radiation environment. These detail model calculations are essential for accounting for the radiation leakage through ports and other penetrations in the bulk shield. Careful analysis of component activation and radiation damage is cardinal for defining remote handling requirements, in-situ replacement of components, and personnel access at specific locations inside the reactor containment vessel. For these analyses to be meaningful and self-consistent, validation of analytic methods and data should be supported by measurements.