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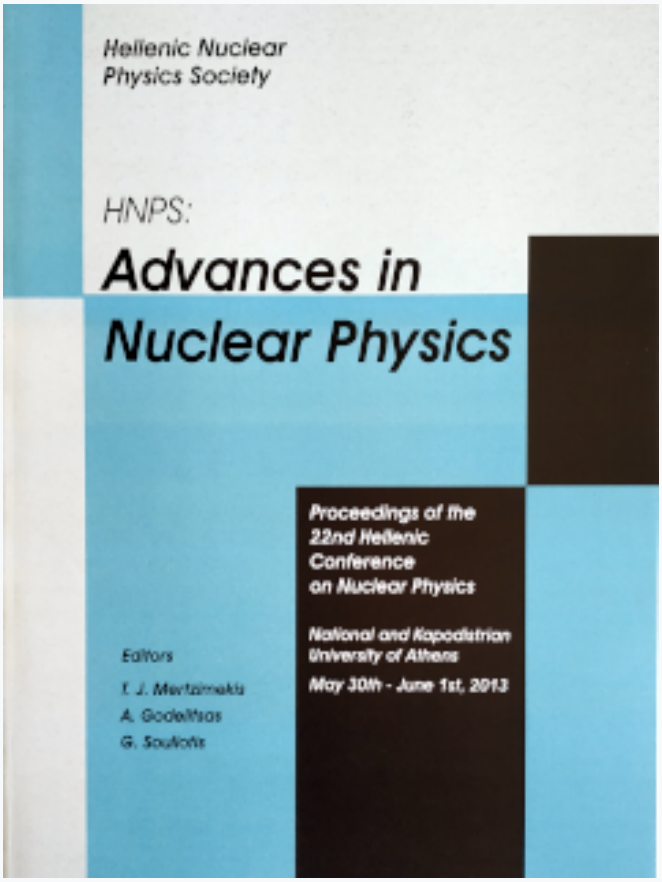

Neutron streaming calculations in the JET entrance labyrinth

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Neutron streaming calculations in the JET entrance labyrinth

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Abstract

Neutron streaming along the entrance labyrinth of the Joint European Torus (JET) was evaluated. Monte Carlo simulations using MCNP code were performed to calculate neutron fluence and ambient dose equivalent along the length of the labyrinth. The results of this work aim to assist operational radiation protection activities in the JET facility and contribute to the validation of the safety assessment calculations made for ITER.

Keywords: Neutron streaming, Monte Carlo simulations, Radiation Protection, JET

1. Introduction

The Joint European Torus (JET) is the largest tokamak in the world and the only operational fusion experiment capable of producing fusion energy. The experiments and design studies performed by JET are consolidated to a large extent into the design of its successor ITER and the demonstration reactor DEMO [1]. Therefore, a study performed at JET aiming at validating the calculation of neutron streaming through ducts and of the dose rates outside of the JET torus hall will be of importance since it enables validation of the neutron streaming and safety assessment calculations methodology used for ITER.

Scope of the present work was the estimation of neutron streaming and, in particular, the prediction of neutron fluence and ambient dose equivalent, along the South-West (SW) personnel entrance maze of the JET hall.

2. Simulations

The SW entrance maze is a multiple turn labyrinth (M1-M6) composed of concrete and borated concrete (Figure 1). Monte Carlo code MCNP-X [2] was used for the calculations. Cross-section data were obtained from ENDF-B/VI.8 library [3]. A stage-by-stage simulation approach was employed. Firstly, a detailed model of the JET torus taking into consideration the actual distribution of the toroidal deuterium plasma neutron source was used to produce a surface neutron source (SSW) on a quarter sphere with center at the SW hall corner and radius of $5.0\,m$. The SSW file was then used as Surface Source Read (SSR) input file for the subsequent calculations performed in the context of this work. Neutron fluence was calculated in spherical cells of $0.3\,m$ in radius along the main axes of the maze sections (M1-M6) at $1.0\,m$ height from the

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floor level. In addition, ambient dose equivalent, $H^*(10)$, was calculated using track length estimate tallies of neutron flux (F4) weighted by ambient dose equivalent to neutron fluence conversion factors as a function of neutron energy [4].

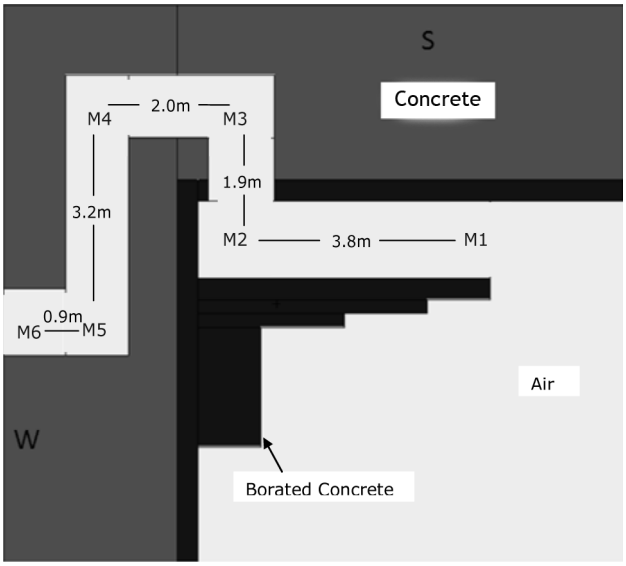

Figure 1: Modeled geometry of JET hall SW entrance maze (x-y cross section)

3. Results

The results of MCNP calculations of neutron fluence and ambient dose equivalent along the SW labyrinth are shown in Figures 2a and 2b, respectively, as a function of parameter $L/A^{0.5}$. L is the distance from the mouth and A is the geometrical cross-section area of the labyrinth. The results are normalized per JET neutron. Neutron fluence is reduced along the total length of the maze by about four orders of magnitude. The total neutron fluence incident on the SW personnel entrance door for the total duration of JET C30 campaign were estimated at $\left(1.21 \times 10^{18} n\right) \times \left(1.00 \times 10^{-13} cm^{-2} n^{-1}\right) \cong 1.21 \times 10^{5} cm^{-2}$. From Figure 2b it can be derived that the labyrinth neutron dose attenuation factor was 1.5×10^{-5}. It has to be stressed that neutrons contribute only a small part of radiation dose at the entrance which is dominated by the gamma radiation component, not calculated in this work.

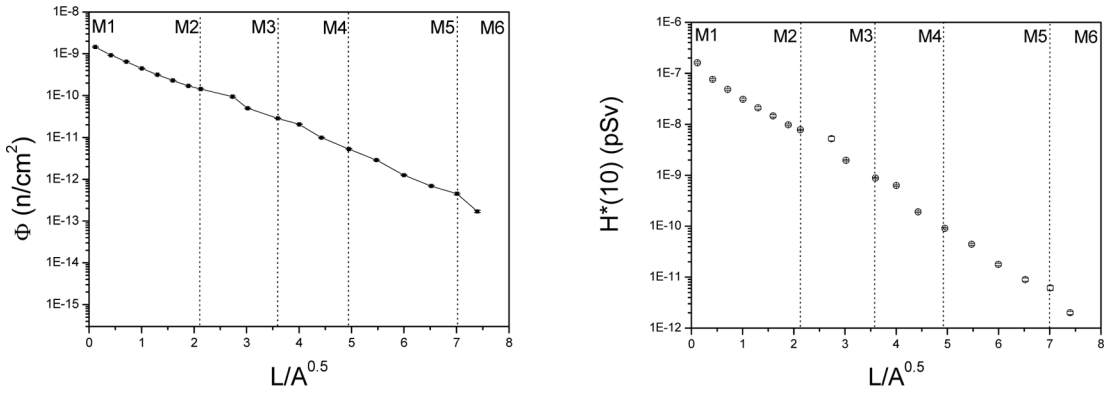

Figure 2: Neutron fluence and ambient dose equivalent ($H^*(10)$) along the SW entrance maze (per source neutron)

4. Conclusions and Further Work

Neutron streaming along the SW personnel entrance maze at the JET hall was evaluated. Neutron fluence and ambient dose equivalent were calculated along the total length of the labyrinth. Future work will be directed towards the experimental verification of the simulation results. The results of the calculations will be compared against measurements performed using thermoluminescence detectors (TLD), positioned within cylindrical polyethylene moderators at selected locations in the JET Torus Hall and through the labyrinth. The results of this study assist operational radiation protection activities in the JET facility and will contribute to the validation of the safety assessment calculations for ITER.

Acknowledgements

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