CALCULATION OF PROMPT DOSES INDUCED BY FUSION EXPERIMENTS IN LASER MEGAJOULE FACILITY

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The future experiments conducted in the LaserMegajoule facility (LMJ) will produce during peak operations up to 10^{19} neutrons/4π in few nanoseconds when laser beams will interact with the deuterium-tritium filled target. A large part of these 14 MeV neutrons will be scattered off the target chamber wall and absorbed, while the other part will stream out through the laser and diagnostic ports and propagate into the target bay and the switchyards. Neutron fluxes and secondary gamma rays resulting from (n,γ) reactions are responsible of prompt doses during ~300 ns in the experiment hall that contains the major part of equipments related to plasma diagnostics and chamber/target operations. This harsh radiation environment and its consequences on electronics have already been discussed in ref [1]. As for the impact of the radiation effective dose equivalent (EDE) to workers, the Target Bay area is obviously strictly forbidden during shot operations and for a post-shot period depending of the level of the occupational residual dose after operation [2]. This analysis of activation and delayed dose rates due to equipments has been published in [3] and was used to optimize designs and maintenance activities. At the opposite, rooms located outside the experiment hall and protected by a 2m thick concrete wall will host employees involved in the experiment during the shot. Consequently, radiation levels in these rooms must be lower than authorized values. Although the LMJ building was constructed from thick concrete walls to provide sufficient shielding, a large number of penetrations for utilities, diagnostics and personnel access have been dealt on a case-by-case basis requiring making minor retrofits and corrections to the facility design in an effort to reduce prompt EDEs. Therefore new detailed and complete three-dimensional Monte Carlo modelling of the facility was required and new calculations have been performed to ensure that the radiological designs will be met. Neutron and gamma doses have been calculated for both occupied and unoccupied areas inside and outside the LMJ facility with the Monte-Carlo code TRIPOLI [4]. An automatic conversion tool, developed at CEA in the framework of this project, was used to build the three-dimensional geometry from the detailed CAD model of LMJ building [5]. Only main bulk structures, such as target chamber, floors and thick walls (1m and 2m) were taken into account to calculate the prompt dose in the different locations of LMJ building, including experiment hall, laser hall and shot operation rooms. This model, intentionally limited to the main elements participating to radiation shielding, representing the worst case for the safety assessments is meant to be conservative in terms of doses assessments. The neutron attenuation from source to locations behind these thick concrete walls is close to 10^{12} that implies to optimize Monte Carlo simulations. Such optimization is obtained by generating an importance map that allows a correct spatial weighting. By using this technique, we obtain a standard deviation which is always <10% even for rooms located far from the source and behind thick concrete walls. Dose values limited to few µSv per shot was calculated in most rooms of the shot operation building. These results meet safety requirements and allow us to validate shielding designs.

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[5] J-C. Trama et al., M&C 2009, Saratoga Springs, NY, 2009.