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Evaluation of decommissioning of proton therapy centers based on the selection of shielding materials at the building stage of the facility

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Introduction
Proton therapy centers are growing fast, both in Spain and all around the world. Prompt radiation attenuation is essential to achieve legal dose limits, but not enough to develop efficient radiation protection of these facilities. Activation of mechanical elements, ambient (air, water, ground), and of course, the shielding, is a relevant issue, linked with radiation protection conditions, as well as future dismantling and management of radioactive materials. To estimate and reduce decommissioning costs, a sensitive part of total investment, it is essential to study the cycle of life of the facility, thus, the goal of this work was to carry out comparative analyze of neutron activation in shielding of three compact proton therapy centers, depending on the concrete used.

Methods
Calculations were developed using two Monte Carlo codes (MCNP and PHITS), in three types of proton therapy centers, similar to those working now or planned for Spain, and four types of concrete (conventional, high-density with magnetite, high-hydrogen-content, and low activation). Considering the energy of neutrons, up to 230 MeV, and the generation of radioisotopes through capture and spallation reactions, both, several physics models, and nuclear data libraries were used and benchmarked, namely, ENDF/B VIII.0, JENDL-4.0, JEFF-4T2 and TENDL2017/19.

Results
From the activation point of view, best concretes are those with low impurities. The type of activation, and the isotopes present, depend on the channel of the reaction. From the attenuation point of view, the four concretes largely meet the necessary dose attenuation conditions.

Conclusions
Induced radioactivity remains in the walls of centers for several years, even decades, after their closure, therefore, a good inventory estimation, depending on the choice of the shielding material, could be advisable in the early stages of projects. Considering the flux and neutron spectrum in each area of the center, it would be more suitable to use different concrete for each area, optimizing the selection based on attenuation, activation, and cost.

Scientific Topic 1

Scientific Topic 2

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Induced radioactivity and decommissioning

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