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Shielding Design for the ETOILE Hadron Therapy Center

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The IBA Company is the industry leader in proton therapy (PT) technology with seven PT centers treating patients every day in the USA and Asia and nine additional centers in construction and installation in the USA and in Europe.

IBA now develops a hadron therapy system that is complementary to its proton therapy systems. It is based on a K=1600 superconducting cyclotron delivering 400 MeV/u 12C ion beams. Other ion species such as 4He, 6Li and 10B can also be produced.

That solution has been selected by the GCS (Groupement de Coopération Sanitaire) in Lyon, France to equip the ETOILE hadron therapy center. It will include two fixed beam irradiation rooms and two gantry rooms, one devoted to proton beams and the other one to ion beams.

The radiation sources are computed with the PHITS Monte Carlo code for 4He, 6Li, 10B and 12C beams with energies ranging between 100 MeV/u and 400 MeV/u and impinging on various thick targets. Besides the secondary neutrons representing the major radiation source, the production of secondary charged particles 1H, 2H and 4He is also taken into account. The secondary neutron fluxes predicted by PHITS for 4He and 12C primary ions are benchmarked against experimental data measured at the HIMAC facility.

Secondary particles transport through the shielding is achieved with the MCNPX 2.5.0 code. The passive shielding of the ETOILE center is modeled in details and the ambient dose equivalent is assessed at all locations outside and inside the center using various operating conditions. The use of PHITS to compute the neutron source and MCNPX to transport these neutrons is validated by reproducing the measurements obtained by the CONRAD benchmark exercise that took place in GSI cave A in 2006.

As the ion beams are extracted from the IBA cyclotron with a fixed energy of 400 MeV/u, an energy selection system (ESS) based upon a graphite degrader is needed to modulate the beam energy. The transmission efficiency of this ESS is computed with PHITS and MCNPX, these two codes giving rather similar results.

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