Propagation of swift protons in liquid water and generation of secondary electrons in biomaterials

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Synopsis We have simulated the energy deposited by swift protons at different depths in liquid water (the most abundant material in living tissues). The angular and energetic distributions of the secondary electrons generated in biomaterials by these incident protons are reliably calculated by using the dielectric formalism. The energy deposited around the proton tracks by secondary electron cascades is computed by a Monte Carlo simulation.

The use of swift proton beams for cancer treatment is a promising technique that requires a deep knowledge of the energy deposited in biological materials, as well as its transport by the generated secondary electrons [1,2].

A detailed simulation of the transport of protons in biomaterials is performed by the SEICS code [3], obtaining depth-dose curves of proton beams in liquid water as shown in Fig. 1.

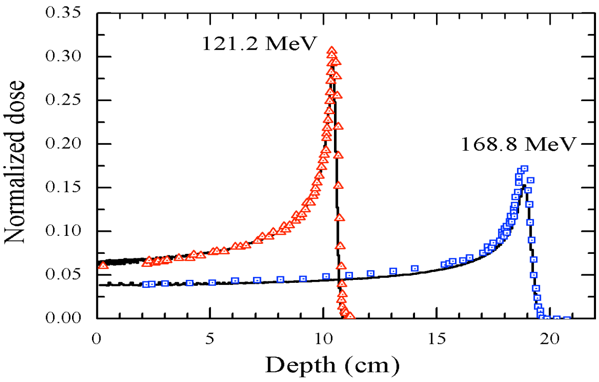

Figure 1. Measured (symbols [4]) and simulated (lines [5]) depth-dose curves of protons in water.

The energy and angular distributions of secondary electrons generated by proton impact in biomaterials at depths around the Bragg peak can be reliably calculated in the framework of the dielectric formalism [6].

The transport of all generated secondary electrons are simulated by the SEED code [7], which takes into account the main interactions between the electrons and target, paying special attention to its condensed phase nature. The simulated radial doses around proton tracks in PMMA for several energies are shown in Fig. 2.

Combination of realistic proton and electron trajectories in condensed matter, accounting for appropriate electron production and interaction cross sections, yields reliable distributions of energy deposition on the nanoscale, which determine the biological outcomes of irradiation.

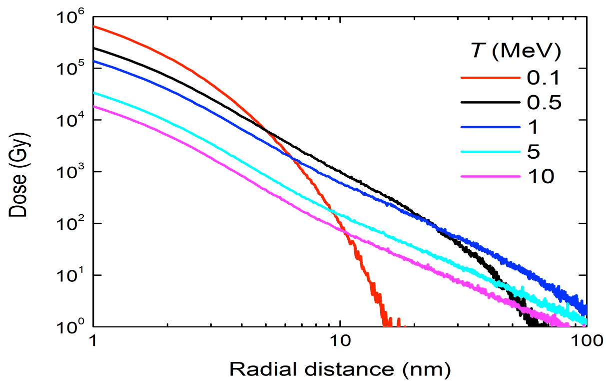

Figure 2. Radial dose deposited by secondary electrons along the track of protons incident with energy *T* in PMMA, as obtained with the SEED code.

References

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