

# Influence of target excitation models on the radial dose distribution around proton tracks in liquid water

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**Synopsis** The radial dose deposited by secondary electrons around proton tracks in liquid water is studied for two models of the target excitation spectrum. Although both take into account condensed phase effects through the dielectric response function of the medium, they differ in details that influence the generation and transport of secondary electrons. These models have been implemented in two well-established Monte Carlo codes (MC4L and SEED) to compute the radial dose distribution due to the secondary electrons around swift proton tracks.

The prominent role of low energy electrons in biodamage [1] requires a deep understanding of their transport and interactions through liquid water, which is the most abundant material in biological tissues.

Secondary electrons are generated by swift proton beams when interacting with matter. Further ionizations by these electrons produce a cascade of new electrons that carry the incident projectile energy away from its path. The amount of energy and the extent to which this energy is transported around the projectile track are important quantities that affect how sensible biomolecules can be damaged.

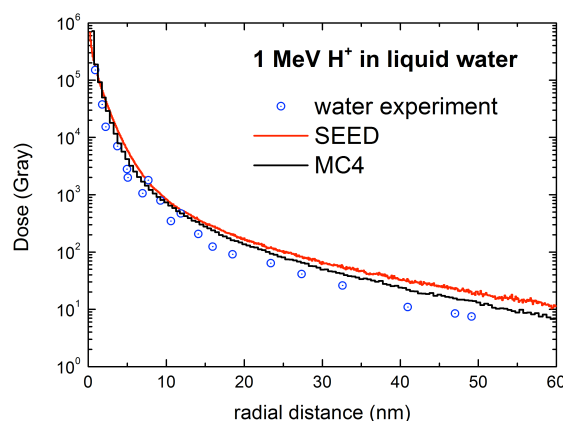
The energy deposited by swift proton beams as a function of the depth (i.e. the Bragg or depth-dose distribution) is calculated by means of the SEICS code [2], which simulates the main inelastic and elastic interactions that an ion beam experiences when moving through condensed matter. Part of this deposited energy produces ionizations around the ion path. The calculated distribution of generated electrons [3] is used as the input in two well established simulation codes, in order to obtain the radial dose around the proton track.

These codes are MC4L [4] and SEED [5]. The main differences between both simulation codes lie in the manner they account for the excitation spectrum of the liquid water target, which is what ultimately will govern the transport of the secondary electrons through matter.

Since experimental measurements of the radiation dose distribution with nanometer resolution in the condensed phase are not

feasible, the comparison of different Monte Carlo simulation codes provides an important step for validating theoretical data before being implemented into biophysical models of radiation action at the cellular and DNA level.

Figure 1 shows our simulated radial dose distributions in liquid water and available experimental data for tissue equivalent gas [6].



**Figure 1.** Radial dose distribution of 1 MeV proton in liquid water. Results of two Monte Carlo simulations based on different electron cross sections (black curve: [4]; red curve: [3,5]) are compared to experimental results for tissue equivalent gas [6].

## References

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