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- Home
- Dates/Announcements
- Scope and Programme
- Awards at ICPEAC
- Conference venue
- Accommodation
- Registration
- Travel
- Abstracts
  - Submission
  - Search
  - Posters
- Proceedings
- Social programme
- Satellite meetings
- Exhibitors/Sponsors
- Local research
- About ICPEAC
- Notice board
- Contacts

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New Search

1

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Modelling low energy electron and positrons tracks for biomedical applicat

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1

Modelling low energy electron and positron tracks for biomedical applications

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Synopsis In order to incorporate the effect of low energy electrons and positron in radiation damage models, the simulation method proposed here is based on experimental and theoretical cross section data and energy loss spectra we have previously derived. After a summary of the main techniques used to obtain reliable input data, the basis of a Low Energy Particle Track Simulation (LEPTS) procedure is established. Single electron and positron tracks in liquid water are presented and the possibility of using these results to develop tools for nanodosimetry is discussed.

Biomedical uses of radiation are demanding an increased level of detail in order to describe the interaction processes initiating radiation damage. In particular, reduced volume irradiation techniques such as brachytherapy [1], in which radiation emitters are placed close to the target, not only require traditional dosimetric methods to prescribe the treatment but also for the evaluation of possible side effects in surrounding sensitive areas.

The important role of low energy, sub-ionising, secondary electrons to induce damage in biomolecular systems has been widely studied in the last decade [2,3]. According to these studies, realistic radiation interaction models should include low energy electron interactions up to their final thermalisation in the medium. In addition, the interest in developing similar models for positrons is rapidly increasing as their use in Positron Emission Tomography (PET) is requiring a better understanding of the physical processes underlying this technique.

Recently, this need of describing radiation effects at the molecular level has led to the development of the concept of nanodosimetry, namely a procedure to quantify radiation damage in nano-volumes. Absorbed dose is not obviously a proper parameter to describe effects at the nanoscale, rather a detailed description of the interaction processes occurring in a nano-size target and their implications in terms of radiation damage (number of dissociative events, type of radicals generated, etc...) are what is really required. As this nano-region of interest could be relatively far (tens of microns or even millimetres) from the original track of the incident high energy primary particles, an accurate description of single tracks of secondary particles will be essential for that purpose.

These reasons motivated the present study in which we describe a new low energy particle track simulation (LEPTS) code, especially designed to provide interaction details at the nano-scale. The simulation procedure is based on a step by step Monte Carlo code, which uses as input parameters the experimental and theoretical electron and positron scattering cross sections and energy loss distribution functions we have previously obtained. Information about the experimental and theoretical methods used for this purpose, as well as input data we used for the electron and positron interactions in water, will be presented. We also provide details about the simulation procedure. Finally, single electron and positron tracks in water will be shown to provide examples of output data capable to quantify radiation damage in nano-volumes.

References

[1] M Fuss *et al* 2009 *Rev. Esp. Fis* **23** 40
[2] B Boudaïffa *et al* 2000 *Science* **287** 1658
[3] M A Huels *et al* 2003 *JACS* **125** 4467

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