Erasmus Mundus internship subject:

Simulating the β^+ emitters production in the body during a carbon therapy irradiation session

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Hadrontherapy is currently being used in the treatment of radio-resistant cancerous tumors as a more efficient technique compared to conventional radiotherapy. Whether by using protons or heavier ions, several studies are being conducted world-wide on their use as well as their biological effects on short or long term bases. Carbon therapy, however, still has to deal with nuclear interactions with matter that reduce the number of primary ions and generate a so-called mixed irradiation field composed of lighter and faster nuclei with different radio-biological efficiencies. Those nuclear interactions also lead to the creation of radio-isotopes that can be β^+ emitters. Using those produced by the target nuclei to evaluate the position of the deposited dose by the beam is usually done by Positron Emission tomography (PET) and called either off-line (or in-room) PET imaging when performed after the irradiation or on-line PET when made during the irradiation. The dose distribution can then be verified qualitatively by comparing the PET images with ones calculated using Monte Carlo simulations. However, those simulations are usually based on insufficient and inaccurate experimental data and fail to reproduce with the required accuracy the nuclear interactions that the beam particles undergo.

In this context, we measured the production cross-sections of several β^+ emitters[1] resulting from the interaction of a carbon beam and targets of medical interest. First comparisons with a state-of-the-art Monte Carlo simulation showed discrepancies up to two orders of magnitude.

Work to do: Based on our measured cross-sections, the student(s) will have to simulate the production of the β^+ emitters distributed along the path of a carbon beam. The beam and its energy in a phantom can be generated analytically or using a Monte Carlo simulation such as Geant4. Ultimately, the β^+ emitters production could be used in a PET imaging simulation and compared to the litterature if the skills of the students and the time allows it.

Requirements: The student must have some knowledge in Monte Carlo simulation and programming as well as some introduction to hadrontherapy.

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[1] S. Salvador, J. Colin, D. Cussol, C. Divay, J.M. Fontbonne, et al. Cross section measurements for production of positron emitters for PET imaging in carbon therapy. Phys.Rev.C, 2017, 95 (4), pp.044607