Subject (M1-M2): "Dose calculation in very high energy electrons radiation therapy using finite element methods to solve the Fokker-Planck transport equation"

Host structure

The Institut Curie is a major player in cancer research and treatment. It consists of a hospital and a research center with more than 3,000 employees and a strong international presence. The Orsay Proton therapy Center (CPO) founded in 1991 is part of the radiation oncology department at Institut Curie hospital group, which is one of the European-wide recognition as a Comprehensive Cancer Center of excellence. This internship will be carried out as part of a research project whose goal is to investigate **new dose calculation tools for FLASH ultra-high dose rate radiotherapy**, and is an exciting opportunity to join the radiation therapy research activities in Orsay, within the hospital and the research center.

Subject description

Within the medical physics research team based at the Institut Curie Orsay (91), we are looking for a student, with a strong interest in translational research on cancer radiation therapy. As part of the activities of our team, the student would be expected to answer the following question: "Can dose calculation in very high energy electrons radiation therapy be performed by solving the Fokker-Planck transport equation, which is an approximation of the Linear Boltzmann Transport Equation?"

Indeed, radiation therapy is currently one of the main techniques used for cancer treatment. More than 50% of patients treated for cancer - about 180,000 per year in France - benefit from it. Over the last thirty years, numerous technical advances have made it possible to considerably improve the conformation of irradiation to the specific characteristics of each tumour and to reduce their side effects. Nevertheless, the tolerance of healthy tissues remains the main limitation of this type of treatment, particularly in the case of particularly radiosensitive patients, such as children, for whom controlling the side effects of radiotherapy remains a major therapeutic challenge. Recently, pioneering work conducted at Institut Curie has shown that ultra-high dose rate irradiation (known as FLASH) has a major effect in sparing healthy tissue - while preserving anti-tumor efficacy (Favaudon et al 2014). VHEE radiotherapy (very-high energy electrons, in the energy range of 100 to 250 MeV), first proposed in the 2000s, would be particularly accurate and independent of tissue heterogeneities (unlike low energy electrons or protons), and could be applicable in a large number of anatomical localizations (Figure 1). This technique is also potentially less expensive than others, and would allow accelerated treatment, for example through magnetic scanning of particle beams, with high doses per fraction, thereby improving its effectiveness. It is also possible to take advantage of recent work on FLASH - in which a high dose is administered to the tissues in an extremely short time - allowing the simultaneous reduction in the occurrence and severity of early and late complications affecting normal tissues, while maintaining control of the tumour (Ronga et al 2021).

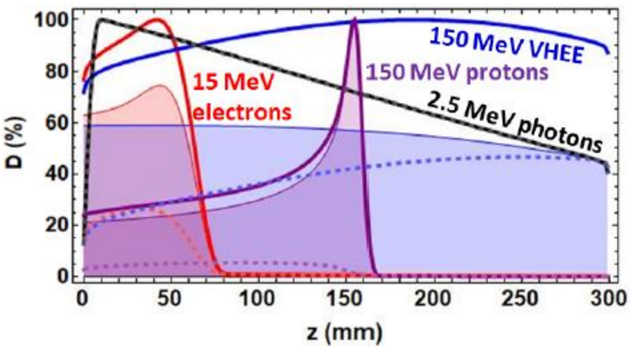

Figure 1: Depth dose distribution in water for several radiation types (photons, electrons, protons, Lagzda 2019).

Dose calculations in radiotherapy are mainly based on fast but accurate dose calculation algorithms, such as superposition/convolutions or Monte Carlo simulations, which do not currently take into account the temporal aspects of the dose delivery. For such algorithms, the dose and the optimisation of the treatment parameters are usually separated, whereas multiple dose delivery parameters are of possible importance for enabling the FLASH biological effect. A third approach to dose calculation has only recently attracted attention in the medical physics community, and is based on the deterministic kinetic equations of radiative transfer (Bedford J, 2019). As part of this project, the student will therefore carry out a literature review of the performance of such methods, and will start implementing a selected algorithm. First comparisons with algorithms already implemented in our environment (Monte Carlo simulations in particular) will be carried out.

Profile required

The candidate must be enrolled in a master degree (or equivalent) in physics or radiation/detection physics • Radiation matter interactions / radiation therapy / dosimetry / imaging • Preferred experience in programming skills (Python or MATLAB) – Monte Carlo simulations (eg Geant4/TOPAS/GATE toolkits). You will also be expected to work as part of a multidisciplinary team.

Informations sur le contrat

Type of contract: Internship
Contract duration/Starting date*: 4-6 months*
Working hours: Full time – *39h/week*
Remuneration: according to our current standards.
Benefits*:* Collective restaurant, 70% reimbursement of the transport ticket, company mutual insurance
Location: Institut Curie, Centre de protonthérapie d'Orsay, France
Reference: LBTE

Contact

Please apply by e-mail (CV + application letter) to ludovic.demarzi@curie.fr

Institut Curie is an inclusive, equal opportunity employer and is dedicated to the highest standards of research integrity. All our opportunities are open to people with disabilities.

References

Favaudon V, Caplier L, Monceau V, et al. Ultrahigh dose-rate FLASH irradiation increases the differential response between normal and tumor tissue in mice. Sci Transl Med. 2014;6(245):245ra93. doi:10.1126/scitranslmed.3008973

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Lagzda, A. VHEE Radiotherapy Studies at CLARA and CLEAR Facilities (The University of Manchester, 2019).

Bedford J. L. (2019). Calculation of absorbed dose in radiotherapy by solution of the linear Boltzmann transport equations. Physics in medicine and biology, 64(2), 02TR01. https://doi.org/10.1088/1361-6560/aaf0e2