Institut de Physique des 2 Infinis de Lyon
www.ip2i.in2p3.fr

Proposition de stage – Année 2020-2021

Niveau du stage : M2

Durée du stage : 6 mois

Ouverture éventuelle vers un sujet de thèse : Oui

Type de financement envisagé : Labex PRIMES (confirmé)

Responsable du stage : Michaël Beuve

Téléphone : 04 72 44 83 63

Email : michel.beuve@univ-lyon1.fr

Adresse : IP2I Lyon
Domaine Scientifique de la Doua – Bât. Van de Graaff
4 rue Enrico Fermi – 69622 Villeurbanne Cedex - France

Equipe d'encadrement :

- IP2I : Etienne Testa, Michaël Beuve

- CREATIS : Jean Michel Létang

- LPC Clermont : Lydia Maigne

- CHU Lyon sud : Olivier Chapet, Ariane Lapierre

Lieu

Institut de physique des deux infinis de Lyon

Thématique : Interface physique, biologie et santé

Intitulé du stage : Comparison of biological dose profiles in patients treated by proton, helium and carbon hadrontherapy

Contexte :

- **Hadrontherapy and biological dose**

Hadrontherapy is an innovative radiotherapy technique based on irradiating well-localized tumors with high-energy ion beams. It is based on a ballistic advantage, in relation to the ion-matter interaction, which makes it possible to increase the differential between the dose deposited in the tumor and the dose delivered to healthy tissues, compared to conventional radiotherapy. An increased biological effect, qualified by the definition of a biological dose, is added to this benefit

Hadrontherapy was first developed as proton therapy. Two first centers were built in France in the 1990s, followed more recently by a third center. 86 proton therapy currently centers exist around the world. The 1990s were also marked by the construction in Japan of a first treatment center using carbon ions. Since then, Japan has built two more centers and Europe three. Compared to the biological dose deposited by protons, the biological dose deposited in tumors by carbon ions is much greater, which justifies the interest of this therapy. On

the other hand, the cost of building and operating a carbon ion therapy center is larger. It is therefore relevant to ask the question of a compromise between the curative effectiveness of treatments and the financial cost of the infrastructure. One way to approach this question is to evaluate the benefit of the therapy in terms of biological dose depending on the type of particles. The answer to this question, very probably, depends on the characteristics of the tumor and in particular on its location, size and radioresistance.

While current models of the interaction of ions with matter provide relatively precise calculations of the physical dose, efforts are needed in the biophysical modeling of the biological effects of these ions.

- **NanOx and MKM models**

The PRISME team has been working for several years on the development of a new model, called NanOx. The very recent comparison of NanOx predictions with experimental data showed that the performance of this model was very competitive with existing models. This comparison work was carried out with data acquired with monoenergetic beams, but the team also carried out calculations under so-called spread Bragg peak conditions, which correspond to conditions close to those of clinical irradiation of tumors. In other words, the NanOx model can be used to evaluate the benefit of ion beam therapy. Another interesting model is the MKM model, which provides also interesting predictions and is currently in use through a modified version in clinics for carbon-ion therapy in Japan.

Description du travail demandé :

The objective of the internship is to perform calculations of biological dose in spread out Bragg peaks (close to clinical irradiations) obtained with proton, helium and carbon-ion beams. First, the calculations will be performed in a volume of water, representing human tissue, then with patient data. The calculations will be performed with one or more irradiation fields and a systematic study will be carried out depending on the depth and volume of the tumor. The tumor geometry will correspond to clinical examples. Biological dose calculations will be performed using the NanOx model and the MKM model. The Monte Carlo Geant4 simulation tool via the GATE interface will be used for the penetration of ions and the combination of the biological effects inherent in a mixed field.
Depending on the progress of the work and the context, a calculation carried out with a clinical treatment planning system will allow a study with irradiation fields optimized with biological dose.

Profile and expected skills:
- Education: physics or medical physics, engineer
- Aptitude and interest in simulation and computer programming
- Interest in topics at the interface of physics, biology and health
- Knowledge on the interaction of particles with matter will be appreciated