

## PhD position

- **Laboratories**

Laboratoire de Physique Corpusculaire de Clermont-Ferrand,  
UMR6533, IN2P3-CNRS/Université Blaise Pascal.

Director : Alain Falvard.

Institut de physique nucléaire, Lyon,

UMR5822, IN2P3-CNRS/Université Claude Bernard Lyon I.

Director : Guy Chanfray.

- **Subject of the PhD :**

**Study of the performances under clinical beam conditions of a detector dedicated to the ballistic control in hadrontherapy. Study of the possible evolutions toward a multimodal system.**

- **Director :**

**MARTIN Franck, Professor (HDR 2010)**

- **Co-directors**

**BUSATO Emmanuel (Associate Professor, University Blaise Pascal, HDR)**

**TESTA Etienne (Associate Professor, University Lyon I, HDR)**

- **Team composition :**

**BUSATO Emmanuel**

**MARTIN Franck**

**MONTAROU Gérard, Research Director CNRS LPC**

**LETANG Jean-Michel, Associate Professor CREATIS, HDR**

**TESTA Etienne**

- **Detailed description of the PhD subject :**

Various types of therapies are used to treat tumors. Techniques using ion beams (protons or light ions) have encountered a large interest during the last two decades. The use of light ions allows a precise dose deposition inside the body, located at the end of the particle path in a region known as the Bragg peak. The preferred targets for such a therapy are radio resistant tumors or tumors for which a very high ballistic precision is needed, because of the presence of organs at risk located near the tumor. The delivered dose depends on the patient positioning and on the ion path across the patient tissues. Therefore, an important improvement would be to set up a high-performance system for the ballistic control, ensuring the treatment quality while minimizing the risks for the patient. Ideally, the system should allow to switch off the beam and to stop the treatment if the measurements are in disagreement with the treatment planning.

One possibility for this ballistic control is based on the measurement of the spatial distribution of the positron emitters produced by the nuclear reactions between the ion and the target, and so on the coincidence detection of two 511 keV gamma. Another possibility is to use the high energy  $\gamma$  (prompt  $\gamma$ , with an energy up to 10 MeV) also produced by the nuclear reactions between the ion and the target.

The first studies performed in our laboratory and at various facilities (GANIL at Caen, CPO at Paris, HIT at Heidelberg) have led to the definition of a detector for the  $\beta^+$  emitter spatial distribution measurement called DPGA. This detector, whose construction has been finished in 2014, corresponds to one of the modality under study as part of a regional research program (LABEX PRIMES) and two national research programs ("Groupe de Recherche" MI2B of the IN2P3, and French national project France HADRON).

The PhD student will work on the characterization of the performances of the DPGA detector and on its use on a clinical beam within the ProtoBeamLine project at the Lacassagne facility at Nice.

Two series of experiments will be carried out:

- Preliminary experiments will be conducted on the Médicyc cyclotron clinical line (65 MeV) in 2016.
- In depth experiments will be conducted on the new S2C2 cyclotron beam line (230 MeV) in 2017. These experiments will lead to the conception of finalized instruments to be used in clinical routine.

Instrumental developments performed at the Lacassagne facility will be hopefully transposable to other French protontherapy facilities, which should also be equipped with the S2C2 cyclotron.

The main tasks of the PhD student will be:

- Implementation of the time calibration of the DPGA DRS4 ASIC.
- Installation of the DPGA on the high energy (230 MeV) line. One of the main tasks will be the validation the new acquisition system based on the  $\mu$ TCA standard (this standard will eventually be used for all treatment control instruments).
- Characterization of the detector performances (energy, time and spatial resolutions, background measurement)
- Study of the performances of the various trigger algorithms.
- Reconstruction of the beam ballistic using various algorithms.
- Finally, study of the detector response under different irradiation conditions corresponding to various treatment plans and definition of the specifications of a clinical detector.

This first part of the PhD thesis will be conducted under the supervision of Messrs. Martin and Busato (LPC Clermont-Ferrand).



The second part of the PhD thesis will be devoted to a prospective study of a multimodal system. A multimodal system would combine the complementary informations from a  $\gamma$  prompt detector (like a collimated camera), a  $\beta^+$  detector (like the DPGA) and a beam detector (like a scintillating fiber hodoscope). It should provide a better ballistic control than each of these detectors used alone.

This prospective study will be carried out using the GEANT4 simulation software. It will be supervised by MM. Martin, Busato (LPC Clermont-Ferrand) and M. Testa (IPN Lyon) and will be done in close collaboration with the CREATIS laboratory. All this simulation work will serve as a basis for the instrumental development of a multimodal system at Nice.

This work takes place at the interface between physics and medical physics, and is a collaborative project between various research groups. The candidate might collaborate with other groups working on the same topics. It is foreseen that the first part of the PhD thesis will be conducted at Clermont-Ferrand, while the second will be conducted at Lyon, even if this point could be discussed.

Candidates should send, as soon as possible, and before May 20, 2016, the following documents:

- 1/ CV
- 2/ Attestation of the last diploma
- 3/ Master rating and ranking (if the Master is not yet finished, all informations available at the time this application is sent should be provided)
- 4/ Rating and ranking of the previous years (engineer diploma, licence, foreign diploma...)
- 5/ Motivation Letter
- 6/ Recommendation Letter (at least from the training period supervisor)
- 7/ Short description of the trainings performed in the past years.
- 8/ List of referent peoples (training supervisors, master director...)

To:

[e.testa@ipnl.in2p3.fr](mailto:e.testa@ipnl.in2p3.fr)

[emmanuel.busato@clermont.in2p3.fr](mailto:emmanuel.busato@clermont.in2p3.fr)

[franck.martin@clermont.in2p3.fr](mailto:franck.martin@clermont.in2p3.fr)