université PARIS-SACLAY

PHENIICS Doctoral School
&
IDEX Paris-Saclay
***Initiative Doctorale Interdisciplinaire* (IDI)**

PhD Thesis Subject Proposal 2018

Laboratory & research team:

- Laboratoire Leprince-Ringuet, École polytechnique
- Médical (PEPITES project)

Title:

Development of an ultra-thin monitor for charged particle beams.

Thesis project:

Proton therapy dose delivery requires a continuous and precise measurement of beam properties, intensity, position and profile. When crossing the monitor material thicknesses, the beam undergoes a dispersion that should lead to a maximum submillimeter lateral spreading at the patient to be tolerable. For monitors located a few meters upstream of the patient, this constraint leads to a material budget lower than 15-µm water equivalent thickness (WET).

The continuous presence of the monitor in the line also requires good resistance to radiation. Even if the intensities of the beams used in the medical field are relatively low (a few nA) the exposure time results in integrated doses of some 10^6 à 10^8 Gy per year.

The solution developed by the LLR team exploits the methods of thin films to build the active part of the detector, which is made of a pattern deposited on a thin membrane. The use of these techniques in the beam monitoring field is new and is expected to have many advantages: thinness (less than 10 µm WET) leading to minimal beam spreading; freedom on the pattern with which to sample the beam profile (strips, pads, etc.); sub-millimeter accuracy for beam profiles and positions; broad dynamic range, from hundreds of fA to hundreds of nA of beam intensities; good resistance to radiation damages; less prone to heating effects from beam interaction; etc. If the technique is relevant for the mid-energies, where it is competitive, nothing prevents from using it well above. This approach may hence have a range of applications that is well beyond the foreseen proton therapy framework.

The Arronax[1] center has expressed its interest for a 10 µm water-equivalent system to be operated for proton, deuteron and alpha beams in energy ranges 17-70 MeV, 8-17 MeV/u and 17 MeV/u for protons, deuterons and alphas, respectively, in the sub-pA to 10 nA beam intensity range. Achieving a working prototype responding to these constraints would demonstrate the viability of the approach and would constitute a generic proof of principle to a wide set of monitors based on the same principles.

The thesis project proposes to carry out a complete prototype (sensitive part and readout) to ascertain proof of principle of the approach and establish the performances of such a system. Studies

[1] Accélérateur pour la Recherche en Radiochimie et Oncologie à Nantes Atlantique

PhD Thesis Subject Proposal 2018

will mainly rely on beam tests at Arronax facility and at least one test beam will occur at CPO (Centre de Protonthérapie d'Orsay), for protons from 70 to 230 MeV.

The candidate will work on the followings tasks:

- participation to beam tests with basic prototypes and study of the signal generation in targeted beam current and energy ranges
- comparison of merits by simulation between different patterns (strips, pads, etc.);
- study of radiation hardness, nuclear activation and thermal damages for various substrates and sensitives areas. These studies of irradiated samples will be done with the use of dedicated diagnosis apparatus to investigate microscopic damages and macroscopic changes of behavior (loss of mechanical resistance, alteration of electrical properties of the patterns, etc.). The results will lead to the choice of the material and technique for building the sensitive area of the final prototype;
- characterization of a low noise electronic readout system developed by our CEA partner. This study will occur when the final readout will be inserted on the final detector.
- with all elements put together, acquisition chain built and validated, the full prototype will be characterized in a last test beams and its performances established.

This work will assess in what extent thin film techniques are relevant to beam diagnostic. Several technical benefits are expected: small beam perturbation, applicability to a large range of beam currents and energies, lower thermal stress, etc. If these expectations are verified, the technique will be of great interest for medical charged particles accelerators, and would contribute to improve both proton and ions cancer therapies.

The subject constitutes a perfect multidisciplinary case. It is a particle physics spin-off, involving nanometer scale technologies, with foreseen application to the medical field. It will give the candidate the opportunity to work on a project with a time scale fitting the PhD grant duration.

Master and doctoral school:

- Master 2 in particle physics
- PHENIICS doctoral school – Université Paris-Saclay

Local team:

Medical applications group (resp. Marc VERDERI).

Contact:

Marc VERDERI verderi@in2p3.fr
Christophe THIEBAUX thiebaux@llr.in2p3.fr