Thick Target Neutron Yields with a proton projectile for Proton-Therapy (TTNY-PT project)

I. Introduction: Proton-therapy in France and over Europe

The radiotherapy takes a place more and more important in the medical European map for the treatments of some cancers and tumours. In France, each year about 200 000 patients are submitted to radiotherapy which presents about 60 % of patients suffering from cancers [1]. In 2014, about 1 % of these patients were treated by proton-therapy. Three centres for proton-therapy are now in operation in France: Curie Institute at Orsay with three treatment lines, Antoine Lacassagne Centre at Nice with two treatment lines (235 MeV proton) and the most recent ARCHADE centre at Caen in Normandy with one treatment line (235 MeV proton). That means one treatment line for each 11 millions of inhabitants in France. Another proton-therapy centre is under conception for an eventual construction next years at Toulouse in the frame of the project PERICLES 2 « protonthérapie et recherche innovante en cancérologie et systèmes » [2].

In Europe, we can mention several proton therapy centres: Proton Therapy Centre in Prague, Heidelberg University Hospital in Germany, Cyclotron Centre Bronowice (CCB) in Poland, Centro di AdroTerapiae Applicazioni Nucleari Avanzate in Italy ...

II. Neutrons as secondary particles in proton beam irradiations

During a proton-therapy (or the hadrontherapy in general) session, neutrons, as secondary particles, are generated and emitted. We can then distinguish two types of neutron sources: neutrons induced by the interaction of protons before reaching the patient and neutrons induced in the patient cells.

Several studies were done to determine the doses generated by these neutrons. The most of them are based on the simulation with Monte Carlo codes. The most important are MCNP (ENDF library), PHITS (JENDL library) and GEANT4 (uses several libraries). Nevertheless, we find very few measurements in the energy range [100 MeV – 300 MeV] of protons done to determine the neutrons yields on a thick target with elements presenting the human tissue like Carbon, Hydrogen, Nitrogen… This kind of experimental data are of great interest since they allow to benchmark and improve the data in the libraries and the calculation codes.

III. Internship study

The principal and final objective of this internship is to optimise, by simulation, the different possibilities of an experimental work dedicated to the measurement of neutrons

yields of induced by the interaction of protons in the interval [70 MeV – 300 MeV] with thick target.

The internship will be divided into three parts:

Part 1: Bibliography study: the objective is to complete the bibliography done by GANIL about available nuclear data and existing experimental works about TTNY with protons.

Part 2: Simulation: the objective is to use Mont Carlo codes to simulate TTNY induced by protons and to compare results with available nuclear data and experimental works.

Part 3: Modelling and simulation of experimental conditions to measure TTNY induced by protons with different targets and calculation of the inventory of radioisotopes present in the target after irradiation for gamma-spectroscopy measurements. Thermal studies of the target during irradiation will be also performed.

Expected skills: Nuclear physics knowledge, good level in programming, interest for nuclear physics simulations, basic knowledge of Monte Carlo methods

It is possible and encouraged to continue this work in a framework of a PhD thesis.

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IV. References

[1] Institut National du Cancer « Protonthérapie : indications et capacités de traitement », June 2016

[2] Implantation d'un centre de protonthérapie à Toulouse, 15e législature, Question orale n° 0042S, publiée dans le JO Sénat du 27/07/2017 - page 2382