Internship in accelerator target physics

GEANT4 simulation of the interaction of a 15-30-kV-electron gun with thin nuclear-physics target

Intense ion beams of the newly superconducting linear accelerator (LINAC) of the new SPIRAL2 infrastructure at GANIL in conjunction with the facilities NFS (Neutron For Sciences) or “Super Separator Spectrometer” (*S*^{3}), provide to researchers the opportunity to explore new domains of nuclear physics studies. Among the main issues GANIL will continue to address, the understanding of the structure of exotic nuclei in the “superheavy” region (SHN) (atomic number Z > 104) and the fission mechanisms are of first priority. These experiments require the combination of an intense heavy-ion low-energy beam and thin targets. A major experimental concern is the behaviour of these targets under irradiation of such beams, a factor of five to ten in intensity as compared with the present ones. The target material will then undergo severe damage due to heating, radiation or mechanical stress. For the success of experiments, focused developments on the fabrication of targets and their characterization are primordial in addition to the design and construction of a specific target station with its instrumentation.

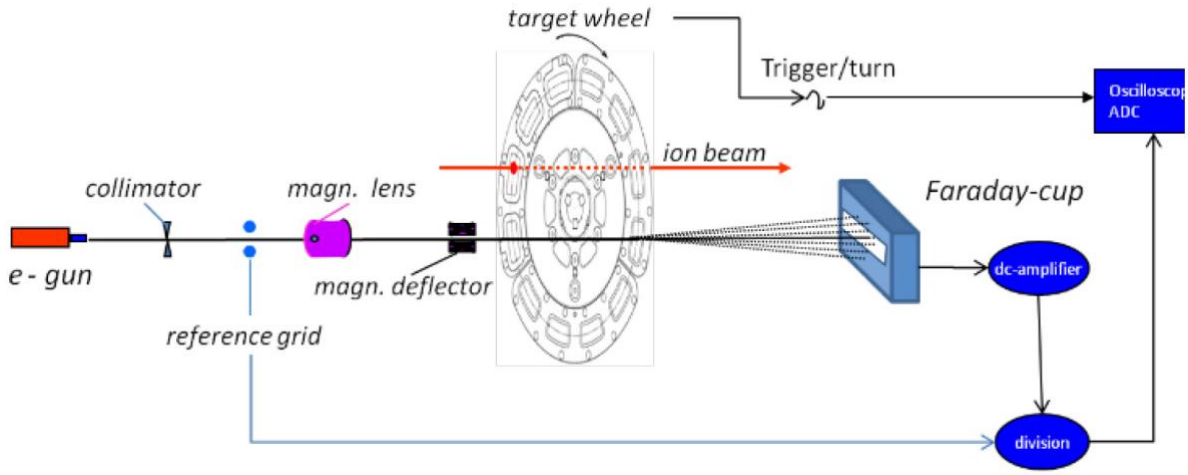

Figure 1: **Scheme of the electron gun with associated electronics and target wheel [4].**

In parallel to the development of target fabrication with detailed investigation of materials’ properties (layer thickness and homogeneity, composition, morphology, and surface roughness) prior to irradiation, transformation of materials under irradiation conditions must be carefully controlled during the use of these targets in order to ensure safety and target durability. An efficient method to control the targets is to measure the attenuation of electrons through the material [1]. Indeed, by comparing the emitted current of an electron beam of 20 *kV* with the scattered one passing through a material, a relative thickness measurement of targets is obtained [2] [3]. When targets are mounted on a wheel, the relative thickness information over the target area is achieved by deflecting the electron beam in the radial direction (with a magnetic deflector) across the rotation, as depicted in Figure 1.

Due to the narrow width of the electron beam, the position resolution is about 0.5 *mm* and the accuracy in the determination of the relative thickness is ± 2 %. As the electron beam, delivered by an electron gun, is parallel to the heavy ion beam used for the nuclear reaction, the targets

can be analysed during irradiation. This method allows first to identify clearly the position of the beam on the target and secondly to evaluate the process of pin-holes of less than 0.5 *mm* diameter or surface cracks formation according to heavy ion beam dose. With this information, the heavy ion beam position and time structure on the targets can be corrected on-line, moreover it helps in the decision of replacing the targets due to material losses [4]. It proved to be efficient for thin targets like lead evaporated on carbon (thicknesses of 300-500 *µg/cm²* on C 30 *µg/cm²*) but due to the range of these electrons in matter, the signal is less sensitive for thicker targets such as Ti backing of 2 *µm*.

The purpose of the proposed internship is the building-up of a complete numerical simulation of the interaction of the electrons, accelerated by the electron-gun, with thin targets of different material with the complete geometry of the experimental setup. The outcome of this work will focus both on the interpretation of the measurement with the Faraday cup and on the design of possible additional diagnostics which may help diagnosing the thin targets.

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Expected skills

Atomic physics, material science, Monte-Carlo simulations, C++, object-oriented programming

This work cannot be pursued by a PhD-thesis

Contact: Christelle Stodel
GANIL, BP 55027, 14076 Caen France

Phone: +33 (0)2 31 45 46 46
mail: christelle.stodel@ganil.fr