How GANIL facilities and their programs improve our knowledge in neutron data related to heavy ions interactions, radioprotection, nuclear safety, calculation codes management and environment sciences

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A. Thick Target Neutron Yields for radioprotection, Monte Carlo codes benchmarks and heavy ion accelerators operation and control

The neutrons are the major hazards in particle accelerator facilities. These neutrons are emitted by the interaction of accelerated ions (light or heavy) with different components of the accelerator (dipole, walls, Faraday chambers, Current measurement instruments …). The neutrons are emitted following a continuous spectrum that depends on several factors (nature of the incident particle, its energy, angle emission). The intensity of the neutron flux depends on the accelerated ion current but also on the energy of this ion, its nature and the emission angle. In order to quantify the hazards of these neutrons and, in consequence, the necessary biological protection to establish in the facility, we need to characterize the double differential (angle, energy) neutron flux generated by the interaction of the ion on thick targets. Some Monte Carlo codes (MCNP, PHITS, FLUKA) allow modelling these interactions and are able to calculate these neutron fluxes. But often we find serious disperancies between these models. So to accomplish these characterizations, GANIL facilities give us exceptional experimental environment to make the neutron measurement with incident heavy ions for a wide energy interval [3 ; 95] MeV/n and within an important interval mass [12 ; 238]. These neutron data are of a great interest to manage the radioprotection in accelerator environment and especially to dimension radio-biological shielding but also for the operation of the accelerators (determination of the maximum of particles intensity that could be used in experiments). These data are also important to benchmark Monte Carlo codes used for modelling and simulation of heavy ions and to improve physics models that are implemented in these codes. These were and are the main goals of a program developed in GANIL called TTNY (Thick Target Neutron Yields).

B. Calculation platform

The different projects of GANIL during ten last years allowed to not only to develop an important scientific expertise in Monte Carlo calculation and simulation but also to install and test techniques adapted to new needs in calculation, to manage the safety of the access to these codes. To cover the needs of calculation GANIL installed several calculation cluster for different usages (High performance calculation, parallel computation). It appears that the current needs are now focused on grid computational clusters that allow the larger types of uses. In the coming next years, we need to keep and develop the acquired competences, as well as our expertise in data storage and management, and to steer towards new innovative fields like machine learning or deep learning.

C. Radioprotection, nuclear safety and environment

Radioprotection is a major element in the operation of nuclear facilities. GANIL is a very specific nuclear facility since it is the unique accelerator classified as an INB (Installation Nucléaire de Base) with big radioprotection and nuclear safety constraints. To respect these constraints, Radioprotection and nuclear safety teams, during last decades, developed several specific systems dedicated to the control access in the facility and/or to the calculation of dose rates generated by high energy neutrons which are induced by the interaction of heavy ions with different materials. These calculation tools allow namely to control the effectiveness of biological protections. Furthermore, among the control systems we mention UGA (access control unit) which is linked to UGB (gamma, X-rays and neutrons radiations detectors control unit) and SAAF (beam stop unit). As a matter of fact, GANIL is a major facility with a strong expertise, in heavy ions radioprotection, acquired during the last 30 years. Moreover, this expertise is reinforced on the occasion of every new enlargement project and new facilities (SPIRAL 2 LINAC, DESIR, …).

Another example is the BLM system that was recently developed for the new facility (LINAC of SPIRAL2) in collaboration with some European partners. One of the real problems that we meet in accelerators is the loss of the beam which induces direct consequences on radioprotection and nuclear safety. The BLMs will allow to monitor the operation of the LINAC regarding the measurement of beam losses. It is the first time that a such system is used in GANIL and even in France. This system was verified under weak power during the commissioning of the LINAC last months. More verifications will be done during next months, even next years, when the accelerator reaches higher powers. One the great interests of this system will be the benchmarks of some Monte Carlo codes used in nuclear simulation of light and heavy ions transport.

As for the radioprotection and nuclear safety, the environmental issues in GANIL are also specific and they ask specific manners to deal with. As an example, we mention the air activation that it is generated by high energy neutrons. So, the calculation of the neutron flux produced by the interaction of the beams with the materials in experimental areas is now necessary to complete the National Radioactive Waste Agency’s (ANDRA) requirements in terms of nuclear wastes characterization. The National Agency is particularly aware about the pure beta emitters presents in the materials. Consequently, the methods used by environment teams depend strongly on nuclear data and the quality of the precision of these data (cross sections, decay modes and half-lives…).