A VERSATILE BEAM SPLITTING SYSTEM FOR SIMULTANEOUS DELIVERY OF THREE BEAMS TO INDUSTRIAL APPLICATIONS AT THE GANIL ACCELERATOR

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Abstract

The demand for heavy-ion irradiation in space applications has grown significantly in recent years, surpassing the available beam time at GANIL. To address this, we are developing an innovative beam splitting system combining stripper/degrader techniques with two large-aperture DC magnetic septa. The originality of this approach lies in generating and transporting three different charge states obtained through partial stripping (typically from a $^{129}Xe^{48+}$ beam at 50 MeV/u). These charge states are selected, separated from each other by the two septa and directed to three independent beamlines. These lines remain adjustable to accommodate various ion beams and magnetic rigidities. A key challenge is ensuring full operational independence of the beamlines, including control of beam intensity and access to experimental areas, which requires significant reconfiguration of the facility. Unlike time-sharing systems using fast switching magnets, our concept optimizes ion accelerator efficiency through a full parallel operation with a 100% duty cycle. This upgrade will enable simultaneous irradiations in three experimental areas, greatly enhancing GANIL's capacity to support high-demand, long-term irradiation programs. Moreover, this concept could be applied to other accelerator facilities desiring to feed multiple irradiations setup simultaneously without switching magnets.

MANUSCRIPTS

GANIL (Grand Accélérateur National d'Ions Lourds) [1] is one of the world's leading international laboratories dedicated to research using ion beams, ranging from ^{12}C to ^{238}U accelerated from 0.1 and 95 MeV/u. The facility house five cyclotrons and a superconducting LINAC. Equipped with high-performance detection instruments, the facility enables researchers from around the globe to conduct unique experiments across diverse fields, including nuclear physics, atomic physics, condensed matter physics, astrophysics, and radiobiology.

Alongside its scientific mission, GANIL also devotes a portion of its activities to industrial applications. In recent years, there has been a sharp increase in beam demand from the space applications for radiation testing of electronic equipment [2-6]. To meet this growing need and the other various demands of the scientific community, GANIL continually adapts and improves its beam production and guidance capabilities [7].

To significantly expand the beam time allocated to industry from 400 hours in 2023 to approximately 2,000 hours per year by 2030, several projects are being carried out simultaneously. One of these solutions is beam sharing.

Operating a complex accelerator requires substantial resources, including high initial investment, specialized personnel, and significant electricity consumption, all for a limited number of scientific experiments. Beam sharing, a strategy identified early in GANIL's development, aims to maximize the return on investment. The concept of conducting simultaneous experiments to enhance the accelerator's scientific impact has been successfully implemented at GANIL, notably on the medium-energy (SME, 1990) and low-energy (IRRSUD, 2003) beamlines.

Beam sharing has been employed at GANIL for several years by pulsing magnets to alternately direct the beam into two separate experimental caves at a frequency of every 10 seconds [8]. Similar multi-user platforms, relying on pulsed magnets, have also been implemented at other facilities worldwide [9].

To address these challenges, we propose to develop a new multi-users platform (shown on Fig. 1) for industrial applications at GANIL, designed to enable fully simultaneous experiments. Our approach involves splitting the high-energy $^{129}Xe^{48+}$ beam (50 MeV/u) into several distinct charge states via partial stripping. Three charge states are then selected and separated using large-aperture DC magnetic septa, whose design and integration require dedicated studies, and then guided in three different beamlines.

In this paper, we present a detailed design of this beam-splitting system, highlighting its potential to implement multi-user access at GANIL.

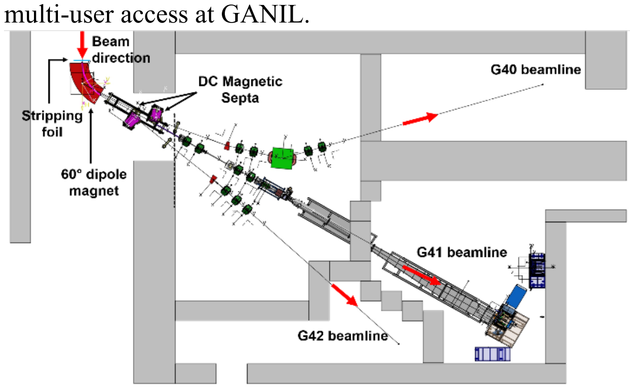

Figure 1: Schematic view of the three beamlines dedicated to the industrial applications at GANIL. The middle beamline is already in use, the others are in study.