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Recent results on the new fragment in-flight separator at INFN-LNS

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Abstract. A project for an upgrade of the Superconducting Cyclotron is underway at INFN-LNS. One of the goals of this project is the production of RIBs (Radioactive Ion Beams) of high intensity. To reach this purpose, a dedicated facility consisting of a new fragment separator FRAISE (FRAgment In-flight SEparator) is ongoing, exploiting primary beams with a power up to ≈ 2-3 kW. The high intensity achievable with FRAISE requires the use of appropriate diagnostics and tagging systems that can operate also in a strong radioactive environment. In this framework, a R&D program has been started to develop the FRAISE facility as well as the diagnostics and the tagging systems.

1. Introduction

At Laboratori Nazionali del Sud of INFN (INFN-LNS), in Catania (Italy), an important project of upgrade of the Superconducting Cyclotron (CS) is in progress. The project, named POTLNS [1], aims also at the production of high intensity ion beams and it consists of a set of upgrade actions of existing and operating devices, designed for the fundamental research in Nuclear Physics.
The upgrade of the CS will provide stable ion beams with a power up to 10 kW at intermediate energies with intensities up to $10^{13} - 10^{14}$ pps, for ions from carbon to argon. In addition, the building of a new fragment separator FRAISE (FRAgment In-flight SEparator) [2][3] will benefit of the CS upgrade, providing high quality radioactive beams with intensity ranging from 10^3 pps, for nuclei further away from the stability valley, up to 10^7 pps, for nuclei close to the stability valley.

2. FRAISE: a new FRAgment In-Flight SEparator @INFN-LNS

FRAISE is a fragment separator, which will be installed in a new dedicated experimental hall at INFN-LNS (more details in [4]). It is designed to use the in-flight fragmentation method; as shown in the left panel of Fig. 1, FRAISE is composed of 4 dipoles and 6 quadrupoles, arranged in a symmetrical configuration and 2 sextupoles, used to adjust the aberration effect. These magnets have two identical sets and the second part of 2 dipoles and 3 quadrupoles will be installed in a mirror position as the first part as shown in the left panel of Fig. 1, for maintaining the achromatic condition of the system. A maximum rigidity of Bϱ ≈3.2 Tm will be reached. The addition of a wedge, as an aluminium degrader, will guarantee the delivery of an almost pure secondary beam.[5].

2.1. New fragmentation target

FRAISE facility will include a production target replica of CLIM [6], shown in the right panel of Fig.1. The design implies a rotating system of circular beryllium or carbon targets used to increase the active surface and to avoid depositing the total intensity of the beam on a single spot. Considering the high exposure to radioactive ions, the target will be equipped with a remote-control system to automatically proceed with the replacement of the target and its storage in an appropriate area.

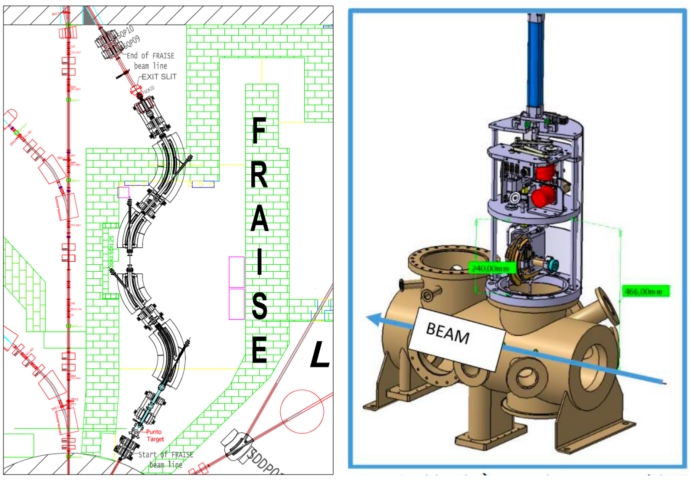

FIG.1: view of the FRAISE facility [2][3] (left panel); the production target, with a rotating system and remote-controlled mechanism (right panel).

3. FRAISE diagnostics and tagging systems

The higher intensity, which will allow to increase the power beam of a factor 20 with respect to the FRIBs facility, the previous RIBs facility employed at INFN-LNS decades [7], requires a revision and improvement of the diagnostics and tagging systems [8]. Inside the Fragment Separator point-to-point measurements of cocktail intensity, relative composition, energy distribution, 2D profile, angular distribution during beam optimization are necessary. In addition, in the ending point of the fragment separator, an event by event tagging of cocktail beam and trajectory measurements are planned.

The R&D activities developed in the last years at INFN-LNS and the features of the SiC, as emerging technology for the future sensing and electronic devices fabrication [9], have triggered a feasibility study, which already had performed simulations and preliminary tests, to evaluate the possibility of using SiC detectors for diagnostics and tagging systems.

The basic idea is to use an array of detectors based on SiC technology, where the single detection unit pad will be a 100 μm thick fully depleted SiC with an area of 5×5 mm^2; this solution would assure a radiation hard multi pad sensor, able to sustain high rate (up to 10^7 pps) with Δt of the order of 100 ps. A sandwich configuration of the two detection arrays is under study, as reported in detail in [5]. At the same time dedicated fast integrated electronics is under study [10].

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LISE++ simulations were also performed for several primary beams whose extraction by stripping in the upgraded CS has been studied in detail. In the left panel of Fig.2, the results are presented for ^{18}O primary beam at 55 MeV/nucleon, with a power of 2 kW on a ^{9}Be production target, to produce ^{15}C unstable beam, using two100 μm SiC detectors. The use of the first SiC detector, located in the dispersive plane, providing the start signal, and the second SiC, located at the exit of the fragment separator, delivering the stop and the energy loss signals, enables to benefit of the ΔE-TOF method for the identification of the cocktail beam. The insertion of a passive Al wedge with an optimized thickness can be efficiently used to obtain a purer beam and to completely remove other contaminants, as shown in Fig.2 (right panel).

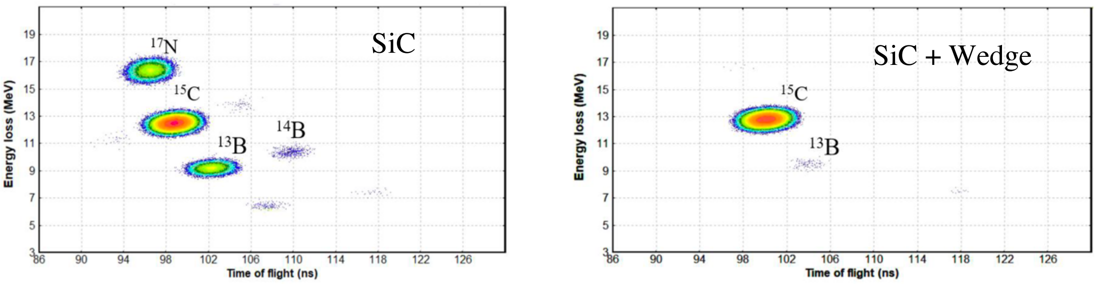

Fig.2: Simulation of ΔE-TOF plot related to the production of ^{15}C, without the use of Al degrader (left) and with the use of an Al wedge (right).

4. Conclusions

The FRAISE facility will be operating at INFN-LNS as soon as the upgraded CS will provide stable beams with a power up to 10 KW. Using primary beams up to 2-3 KW (due to radioprotection constraints), FRAISE will provide high quality radioactive beams with intensity ranging from 10^3 pps, for nuclei further away from the stability valley, up to 10^7 pps, for nuclei close to the stability valley.
Preliminary investigations have been performed with both tests and LISE++ simulations for primary beams whose extraction by stripping has been carefully studied as well as primary beams without detailed studies [8]. The features of diagnostics and tagging systems based on SiC detectors have been outlined and the validation and characterization of a SiC array are in progress.

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