BEAM DIAGNOSTIC OVERVIEW OF THE SPIRAL2 RNB SECTION

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Abstract

An extension to the existing GANIL facility in Caen, France is under construction. The new SPIRAL 2 construction will be realized in two phases, for the first phase the construction started in January 2011 and will consists of the accelerator buildings with two experimental facilities S3 and Neutrons for science (NFS). The second phase is the so called production building where radioactive ions are produced through the ISOL (Isotope Separation On Line) method. The produced radioactive ion beams (RIBs) will be extracted and accelerated up to 60 keV from the ion sources, after beam purification the beam will be driven in the secondary beam lines either to a new experimental facility DESIR (Decay, excitation and storage of radioactive ions) constructed during the second phase of the new installation or the RIBs will be charge breed to form multi-charged ions that will be driven to the existing GANIL facility and post accelerated in the CIME cyclotron [1].

This overview article gives a description of the secondary beam lines, the foreseen beam diagnostics which will allow tuning and controlling the radioactive ion beams in the secondary beam lines constructed in the SPIRAL2 Phase 2 program [2].

THE RADIOACTIVE ION BEAM PRODUCTION

The RIBs will be produced through neutron induced fission reactions, fusion reactions or transfer reactions on different target types. Primary beams of up to 5 mA deuterons of 40 MeV and/or 1 mA heavy ions up to 14.5 MeV/u will be available for these reactions. The ISOL targets and ion sources (Surface ion source, laser ion source, electron cyclotron resonance (ECR) ion source and Febiad ion source) are being developed in collaboration with several French laboratories (IPNO, CENBG and GANIL) and a neutron converter consisting of a rotating graphite wheel - for neutron induced fission reactions, is under development at LNL-INFN in Italy. The dimensioning reactions for the RIBs are the neutron induced fission in a uranium target. The neutron converter, target, ion source and extraction electrodes are positioned in a production module. When a different production mechanism or target is to be used the whole production module is replaced in the production cave.

SECONDARY BEAM SECTION

The secondary beams section is shown in Figure 1. The different colours in the figure are delimiting the calculated expected maximum radioactive dose rates in the different sections. The diagnostic integration depends on the dose rates in the different zones.

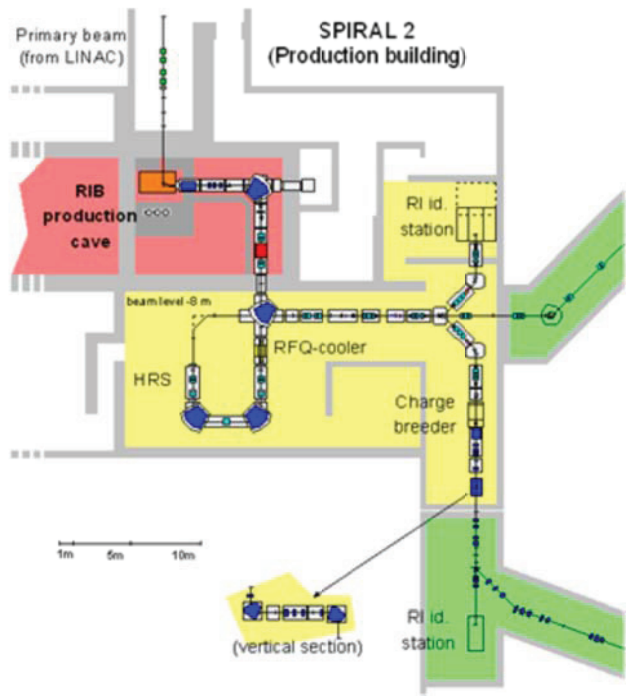

Figure 1: Layout of the RNB Section.

Inside the production cave (red coloured zone in Figure 1), where the dose rate exceeds 100 mSv/h, the extracted 1^+ ions are mass selected in a pre-separator ($\Delta M/M$ = from1/300 to 1/1200).

In the following section (yellow in Figure 1), where the dose rate is between 25 µSv/h to 2 mSv/h., there is a beam identification station for the single charged ions. If needed the ion beam can be further separated in a High Resolution Separator (HRS). To increase the efficiency of the HRS a Radio Frequency Quadruple (RFQ) cooler is under development at LPC Caen, after ion cooling the HRS is designed for a resolution of ($\Delta M/M$ = from 1/15000 to 1/30000). The RIB can now be driven to DESIR or to the Charge breeder. Directly after the charge breeder the multi charge ion beams are driven in a vertical beam line to a second identification station in one of the low level radioactive zones (seen in green colour in Figure 1), the dose rates in these zones are estimated to be between 7,5 µSV/h to 25µ Sv/h. This division in zones according to the estimated radioactive dose rates impose that beam line and diagnostic design will be able to function and be maintained differently.

BEAM DIAGNOSTIC INTEGRATIONS

In the production cave, the 1^+ production line will be composed by modules which will be removed by remote control and human access will be limited. The diagnostics in this line will consist of Faraday Cups (FC) with standard actuator and segmented diaphragms in place of profilers. In the intermediate zone, each module of the lines will be connected and disconnected manually. Special actuators with two vacuum valves are foreseen to separate movables diagnostics without risk of contamination. Three types of profile monitors are foreseen, classical secondary emission monitors to visualise stable beams, secondary emission foil profile monitors and very low intensity monitors for radioactive beams. Beam current measurement will be performed by movable FCs and a device to measure the intensity of the radioactive beam (described below). This device, in the 1+ transport line, composed by a chopper and a fixed Faraday cup will allow to measure beam current by a semi-interceptive method. This survey will be necessary to control the radioactivity and the associated beam contamination.

To optimize the limited space in on the beam lines the diagnostics will be installed with an angle of 45° regarding to the beam line vertical axis.

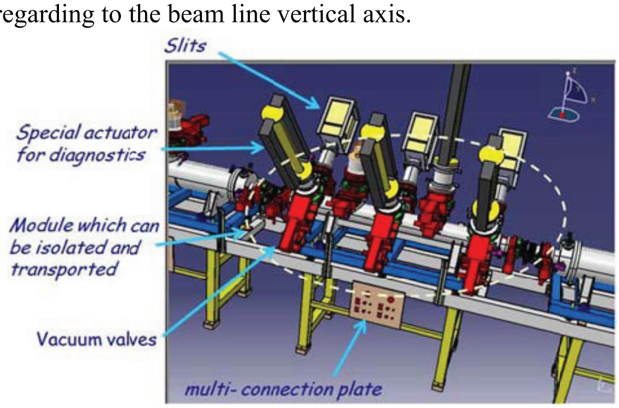

Figure 2: Example of a module in the yellow zone.

At the exit of the charge breeder, the vertical line allows to pass of the SPIRAL 2 line level (- 8 m) to the current SPIRAL 1 level (-1,75 m). A special structure to fix the line and allow to access is foreseen.

In the low radiation zone a classical design of the beam line is planned. The same kind of diagnostics as in the previous section will be used although with classical actuators.

PRIMARY BEAM CONTROL

The primary beam impinging on the production target or the neutron converter in the production cave needs to be monitored. A primary beam control will be performed to survey the intensity and the beam position on the target. At the entrance of the production module a segmented collimator with four current measurements will allow to control the beam size. During the commissioning of the installation, diagnostics like a Faraday Cup and a profile monitor are foreseen in place of the target and ion source to characterize the primary beam inside the production module (Figure 3).

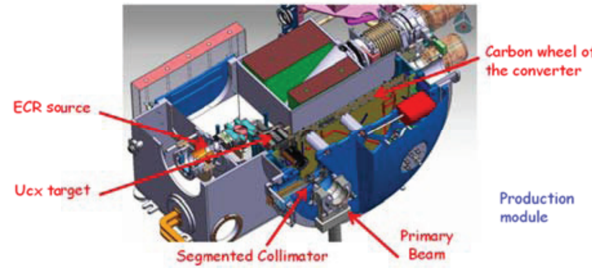

Figure 3: Horizontal cut of the production module.

BEAM CURRENT MEASUREMENTS

Faraday cups are under development based on an optimization of the current SPIRAL 1 FC design. The new design will improve the magnetic field which repel factor of the secondary emission electrons (Figure 4) . A second design optimization is planned to minimize the intervention time during maintenance to minimize the dose rate of the beam diagnostic equipments and the personnel.

Figure 4: SPIRAL 1 FC and a new converter current/voltage.

A new converter for current/voltage was tested at GANIL to measure low intensity beam current for the RNB Section. Different calibres from 1pA/V to 10µA/V open up the possibility of a large range of measurement.

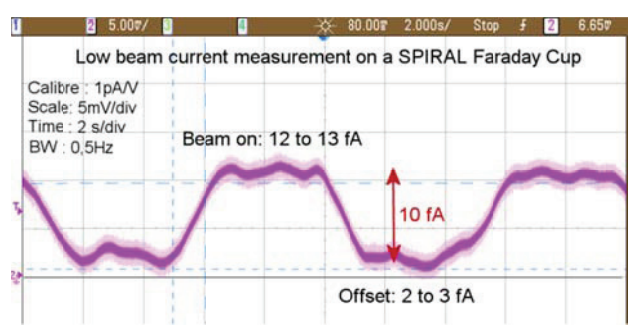

Figure 5: Low beam current measurement.

The results in Figure 5 shows a sensitivity high enough to measure a current difference around 10 fA at a distance of 20 meters between Faraday cup and the converter. These results are possible by using a triax cable and a float electronic input which eliminate ground currents.

BEAM RADIOLOGICAL CONTROL

A special control system dedicated to the survey the total activity transported by the exotic beams will be installed at the exit of the production cave. The principle consists to extract a fraction of the RIB by using a beam shopper. The intensity of the deviated beam is measured by a fixed FC. This semi-interceptive method gives the possibility to measure very low beam currents. With a deflection of 5% of the time and with the accuracy of the new electronic converter, measured currents of a few pA (10^7 pps) is expected. That gives current thresholds and limits around few 10 pA (10^8 pps).

BEAM PROFILE MEASUREMENTS

Secondary Emission Foil Profile Monitor

Beam profiler monitors with very low energy limit (E ~ 10 kV/A) are being developed (Figure 6-Figure 8) for the use in the 1^+ and n^+ beam lines. The principle consists of collecting secondary electrons emitted on an aluminum foil in a drift space, guided by an electromagnetic field. The number of electrons is amplified with a micro-channel plates (MCP) stage and collected on an x-y grid for a required resolution below 1 mm. The range of intensity measurable will be between 10 to 10^{11} pps.

Figure 6: Head of secondary emission foil profiler.

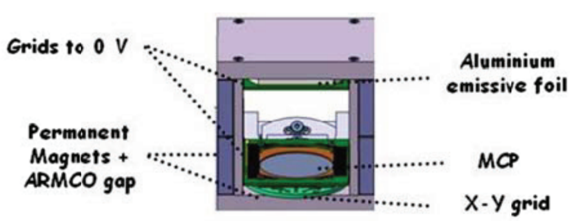

Figure 7: Head design details of the secondary emission foil profiler.

A new design has been created with two grids at 0V. The first grid, positioned in front of the aluminium foil, accelerates the electrons; the second grid is located in front of the MCP. The electric field is equal to zero in the drift space, and electrons are only subject to the magnetic field.

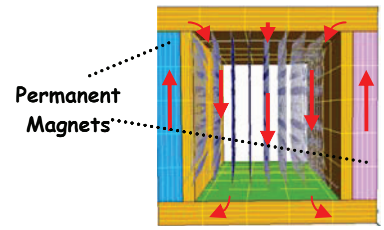

Figure 8: Magnetic field produced by permanent magnets.

The configuration of electric and magnetic fields have been optimized to ensure correct guidance of the electrons emitted. New beam tests are scheduled during 2011 to validate the concept.

IMPLANTATION OF ELECTRONICS

Due to the low beam current level, electronics for the different devices need to be installed close to the diagnostics. An underground level is planned to install electronics, control systems and power-supplies.

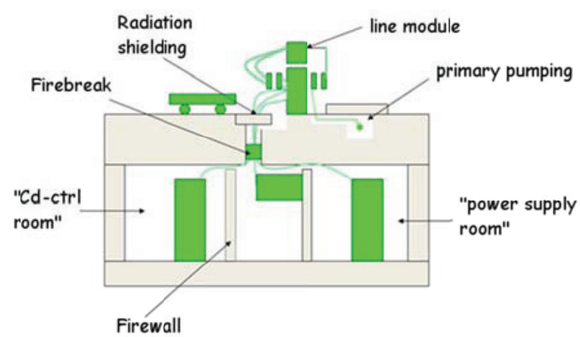

Figure 9: Cut of lines and associated places.

CONCLUSION

In the upcoming two years, the line definition and the diagnostic needs have to be defined. The developments of low current monitors and Secondary Emission Foil Profile Monitors are underway. The next steps involve the mechanical integration of the diagnostics on the beam line, the definition of diagnostic interfaces. Therefore beam tests are scheduled at GANIL to validate the new diagnostic principles with exotic radioactive ion beams.

REFERENCES

[1] M. H. Moscatello and al., Technical report of the radioactive beam section of SPIRAL2. Ganil report (2007, December).

[2] P. Anger and al., Beam Diagnostics For SPIRAL2 RNB Facility, DIPAC09, Basel, Switzerland.