# THE BEAM PROFILE MONITORS FOR SPIRAL 2

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*Abstract*

In order to visualize the SPIRAL 2 beam dynamics, several beam profile monitors are under development. Multiwires beam profile monitors (SEM) will be used on the driver and RIB lines. Non interceptive beam profile monitor (RGM) should be mounted on the LINAC diagnostics box before experiments room, and low intensity beam profile monitor (EFM) on the RIB lines For the signals acquisition of all this kind of monitor, a new associated electronics will be used. These electronics digitize 94 channels in a parallel system. Each channel integrates the current of the associated wire or strip and performs a current-voltage conversion. The dedicated GANIL data display software has been adapted for these different new monitors.

## SPIRAL2 DESCRIPTION

The SPIRAL2 facility is based on a high-power superconducting driver LINAC which delivers a high-intensity, 40-MeV deuteron beam, as well as a variety of heavy-ion beams with mass-to-charge ratio equal to 3 and energy up to 14.5 MeV/u (Table 1). The driver accelerator will send stable beams to a new experimental area and to a cave for the production of Radioactive Ion Beams (RIB). The Accelerator building construction (phase1) will started in 2010 and the RIB production building (phase 2) in 2012 (Fig. 1). The commissioning of the driver should start in 2011 at GANIL.

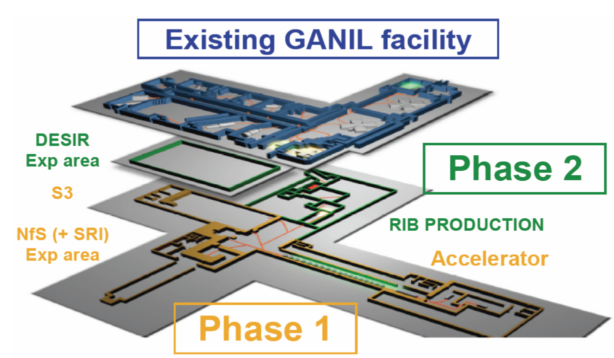



Figure 1 : SPIRAL 2 and GANIL facilities.

## DRIVER ACCELERATOR

The Injector, dedicated to protons, deuterons and ions of Q/A=1/3, is mainly composed of two ECR ion sources with their associated LEBT (Low Energy), a warm RFQ and the MEBT (Medium Energy) line connected to the LINAC. The LINAC accelerator is based on superconducting independently-phased resonators. It is composed of 2 families of quarter-wave resonators (QWR) at 88 MHz, 12 resonators with $\beta$=0.07 (1 cavity/cryomodule), and 14 resonators at $\beta$=0.12 (2 cavities/cryomodule).

## STABLE BEAM CHARACTERISTICS

Table 1: SPIRAL 2 Stable Beam Characteristics

| | Q/A | Intensity range (mA) | Energy range (Mev/u) | CW beam Power (kWatt) |
|---|---|---|---|---|
| **Protons** | 1 | 0-5 | 2-33 | 165 |
| **Deuterons** | 1/2 | 0-5 | 2-20 | 200 |
| **Ions** | ≥1/3 | 0-1 | 2-14.5 | 43.5 |
| **Ions** | ≥1/6 | 0-1 | 2-8.5 | 51 |

## RIB PRODUCTION

The 40 MeV, 5 mA deuteron beam impinging on the converter produces an intense neutron flux with a energy centered at 14 MeV. Neutrons induce fission in the UC target located downstream of the target converter. The converter has to withstand up to 200kW beam power. The converter is a high speed rotating target which limits the peak surface temperature of converter materials far below 2000°C. The thermal power deposit in the converter material is dissipated only by thermal radiation.

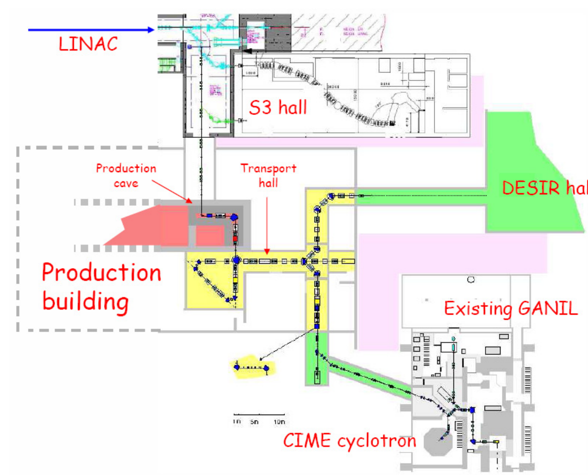



Figure 2 : Radioactive beam facilities.

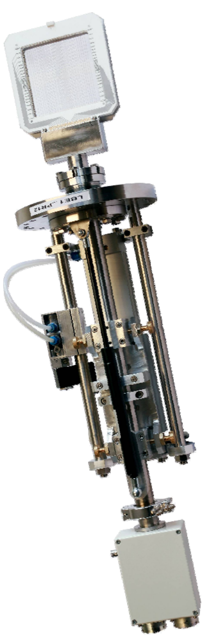
Table 2: Radioactive Beam Characteristics

| | Line 1+ | Line n+ | Existing ganil |
|---|---|---|---|
| **Ion mass range** | 6 to 240 | 6 to 160 | 6 to 160 |
| **Intensity range (pps)** | $10^3$ to $10^{11}$ | $10^3$ to $10^{10}$ | $10^3$ to $10^9$ |
| **Beam energy** | 10 to 60 keV | 10 to 45 keV | 1.2 to 20 MeV/u |
| **Example of RIB** | 132 $Sn^{1+}$ 20 keV | 132 $Sn^{20+}$ 400 keV | 132 $Sn^{20+}$ 792 MeV |

## BEAM DIAGNOSTICS

In order to drive the SPIRAL2 beam along the beam transport three kinds of beam profile monitor have been developed at GANIL.

### *Secondary Emission Monitor (SEM)*



These monitors are composed of an horizontal and a vertical grid of golden tungsten wires of 150 µm.

Three kinds of grid can be installed, depending on the maximum size needed to be measured:
- 47 wires with 1 mm spacing for maximum beam size of 30 mm
- 47 wires with three different spacing (1, 2, or 3 mm) for maximum beam size of 80 mm.
- 100 wires with 1 mm spacing for maximum beam size of 100 mm

These wires are welded on an alumina board to obtain a maximum out-gassing rate of $10^{-8}$ $Pa.m^3.s^{-1}$. The total mechanical precision of this diagnostic is 0.2 mm.

Figure 3 : SEM profiler.

In order to resist the beam power, different duty cycle should be applied and depending on the location on the line. Simulations have been done in order to estimate the temperature of the wires About 70 secondary emission monitors will be installed on the different lines of the SPIRAL 2 facilities.

Table 3 : 5 mA Deuterons on 150 microns tungsten wire.

| | LEBT | MEBT | LINAC |
|---|---|---|---|
| **Energy** | 40 keV | 1.5 MeV | 40 MeV |
| **Wires temperature** | 650 °C | 900 °C | 900 °C |
| **Duty cycle** | 4 ms/s | 0.5 ms/s | 2 ms/s |

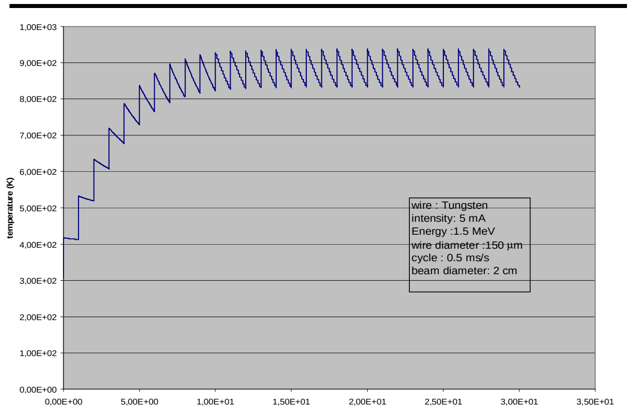
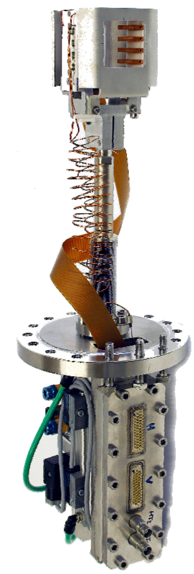



Figure 4: Temperature variation vs beam time on wire.

### *Non-Interceptive Beam Profile Monitor (RGM)*



The principle of this profiler is based on the ionization of the residual gas of the lines by the beam. This diagnostic gives a one-dimensional profile and is composed by a drift space and a signal amplification stage (one micro-channel plate) with an anode of 35 strips spaced by 0.3, 0.5 or 1 mm. The working pressure is $10^{-8}$ mbar and the desired resolution is 1mm. In order to obtain a low out-gassing, the profiler should be baking at 150 °C.

Figure 5 : RGM profiler.

It will be set up when a high intensity beam monitoring will be needed and will be mounted between the six first Linac cryogenic cavity and just before the high intensity target of experimental rooms.

### *Low Intensity Beam Profile Monitor (EFM)*

A secondary emission foil profiler is under development and will be used on the SPIRAL 2 radioactive beam lines and the experimental rooms. It will monitor low intensity in the range of $10^{1}$ to $10^{9}$ pps and low energy beams from 200 keV in order to replace the standard low intensity beam profile witch used gas at 1 atmosphere and has a threshold energy of about 3 MeV by nucleon.

The impact between the beam and the foil will create secondary electrons. These electrons are guided by electric and magnetic field through a drift space.

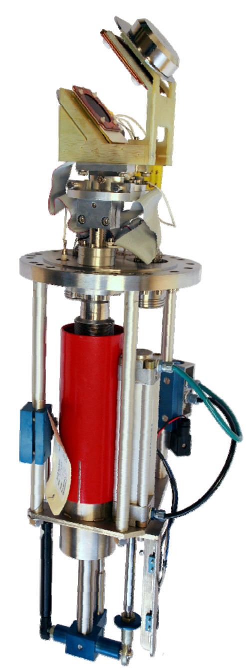
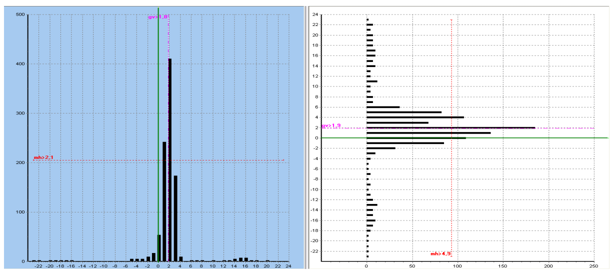


Figure 6 : EFM profiler.

Micro-channel plates will amplify the number of electrons in order to be collected on an X-Y grid. The desired resolution is 1mm in each dimension.

During a test with a $^{12}C^{2+}$ Beam at 5 Mev/u with $10^5$ particles per second, the EFM Beam Profile has been compared with a standard gas monitor profile. Acquisition results are shown below.

**Standard gas beam profile**
Horizontal plane Vertical plane



**EFM beam profile**
Horizontal plane Vertical plane

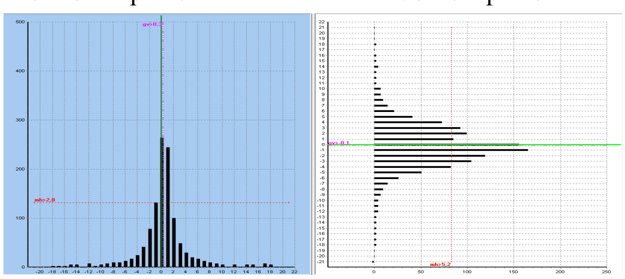


Figure 7 : Beam profile acquisition.

This detector is under redesigning in order to have an homogeneous magnetic field.

## ASSOCIATED ELECTRONICS FOR ALL BEAM PROFILE MONITORS

These electronics digitize 94 channels in a parallel system. Each channel integrates the current of the associated wire or strip and performs a current-voltage conversion with two possibilities: passive system for high intensity beams and active system for low intensity beams and electronic deportation (about 20 m for the LINAC).
The front end (active or passive signal integration) is implanted on 12 daughter boards of 8 channels to streamline the maintenance and to keep the electronic modularity. For the digitalization, we have chosen a heavily parallel organization for a good A/D conversion speed (about 4 µs) and a best signal shape conservation. Acquisition of this digital data and their treatments is done by a FPGA (ALTERA Cyclone 3). All the automatisms related to the sensor (high voltages, insertion, Micro-channels plates protection, front end protection) are managed by a microcontroller (FREESCALE 68HCS12). Communication with the command/control (Modbus protocol over TCP/IP) and global equipment setup (integrated WEB server) are managed by a microprocessor (FREESCALE coldfire 5282) executing RTOS. A first prototype of this electronic system (without control of automatisms) was successfully tested in 2008. A pilot series with all facilities will be developed in 2009. The series of 20 electronics for LBE and LME will have to be ready for the end of 2010.

## ACQUSITION AND DATA DISPLAY SOFTWARE

Current acquisition and data display software have been modified for the preliminary test with the SPIRAL2 ions source (LPSC, Grenoble) and the new profile monitors. Software provides data display and calculations (Gravity, FWMH) for both normal and variable wires grid monitors. Communication with hardware (TCP/IP Modbus) have been improved to add special controls provided by new profile monitor electronic design (beam over range securities, high supplies, acquisition etc.). All current data storage features and tools (ProfilerDisplay) remain available.

## CONCLUSION

The development of these three different kinds of beam profile will permit to cover all the dynamic of the SPIRAL 2 energy and intensity beam. Last test are now in progress to perform RGM and EFM profile solution before fabrication. The first series of the SEM are now installed on the ion source LBE line and will soon be tested under high intensity beam.

## REFERENCES

[1] R. Anne et al., A non interceptive heavy ion beam profile monitor on residual gas ionisation, NIM, A329 (1993) 21-28.
[2] R. Anne et al., Beam profile and beam time structure monitors for the extracted beams from the Ganil cyclotrons, 15th International Conference and their application. Caen France 14 – 19 June 1998.