# THE BEAM PROFILE MONITORS FOR SPIRAL 2 RIB AND EXPERIMENTAL ROOMS

Jean Luc Vignet, Eloïse Guéroult, Patrice Gangnant, Alexandre Delannoy
GANIL, BP 55027, 14076 Caen Cedex 5, France

In order to visualize the SPIRAL 2 radioactive ion beams, several beam profile monitors are under development.

Multiwires beam profile monitors (SEM), low pressure gas monitor (LPGM) and low intensity beam profile monitor (EFM) will be used on the RIB lines.

For the signals acquisition of all this kind of monitors, a new associated electronics will be used. This electronic digitizes 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. 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 (phase 1) will started in 2010 and the RIB production building (phase 2) in 2012. (Figure 1)

The commissioning of the driver should start in 2011 at GANIL.

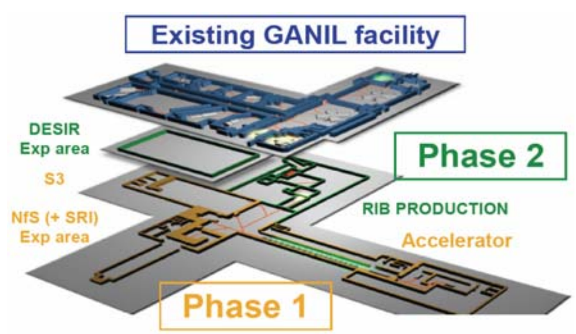



Figure 1 : Spiral 2 and GANIL facilities

## RIB PRODUCTION

The 40 MeV, 5 mA deuteron beam impinging on the converter, produces an intense neutron flux with an 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).

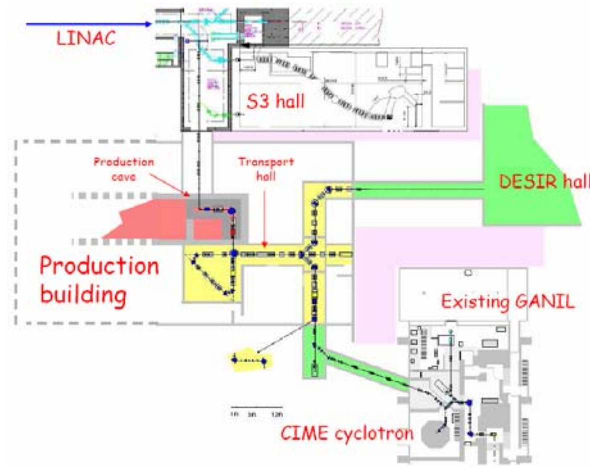



Figure 2 : radioactive beam facilities

## RADIOACTIVE BEAM CHARACTERISTICS

| | Line 1+ | Line n+ | Existing ganil |
|---|---|---|---|
| Ion mass range | 6 to 240 | 6 to 160 | 6 to 160 |
| Intensity range | $10^3$ to $10^{11}$ pps | $10^3$ to $10^{10}$pps | $10^3$ to $10^9$pps |
| Beam energy | 10 to 60 keV | 10 to 45 keV | 1.2 to 25 MeV/u |
| Example of RIB | 132 $Sn^{1+}$ | 132 $Sn^{20+}$ | 132 $Sn^{20+}$ |
| | 20 keV | 400 keV | 792 MeV |

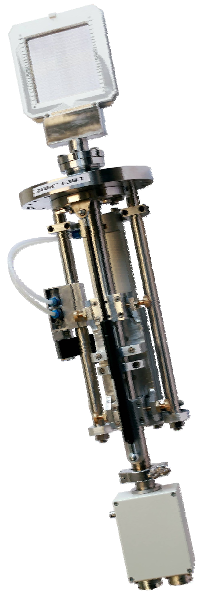
## BEAM DIAGNOSTICS

In order to drive the SPIRAL2 radioactive beam along the beam transport three kinds of beam profile monitor are under development at GANIL.

| Profiler type | Energy range | Intensity range | Quantity needed |
|---|---|---|---|
| EMS | 20 keV<E | $10^8$pps<I<$10^{11}$pps | 40 |
| LPGM | 500keV/A<E | 10 pps<I<$10^7$pps | 10 |
| EFM | 20 keV<E | 10 pps<I<$10^9$pps | 10 |

EMS profilers are the same as those used for the Spiral2 accelerator lines. Gas profilers are soon in used at Ganil and have been adapted for the low energy and the low intensity Spiral2 beam (LPGM). Emissive foil profilers (EFM) are new kind of profile monitors and should be operational in 2013.

## SECONDARY EMISSION MONITOR (SEM)



These monitors are composed of an horizontal and a vertical grid of golden tungsten wires of 150 µm diameter. Three kinds of grid can be installed, depending on the maximum size needed to be measured (Figure 3).
These wires are welded on an alumina board to obtain a maximum out-gassing rate of $1.10^{-8}$ $Pa.m^3.s^{-1}$.
The total mechanical precision of this diagnostic is 0.2 mm.

Figure 3 : SEM profiler

## LOW PRESSURE GAZ MONITOR (LPGM)

In order to visualize radioactive beam energy in the range of 0.5 MeV/u - 25 MeV/u with intensity of a few pps to $10^{7}$ pps a new kind of beam profile have been studied (Figure 4).
A low pressure gas monitor working like a ionization chamber and is constituted by a secondary electron emission profiler that is in a octafluoropropane (C3F8) pressure of 10 mBar. The gas volume is contained in the profiler head with a 6 microns Mylar entrance window.
A gas regulation central is connected to the Profiler in order to regulate the gas pressure. The signal amplification depending of the beam characteristics is adjusted by the hight voltage applied on grid that are disposed on each side of the wires plane ( Figure 5 and 6).

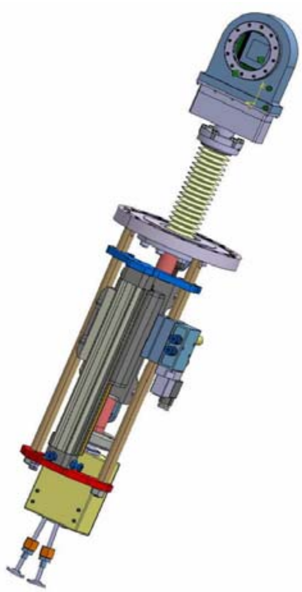


Figure 4 : LPGM profiler

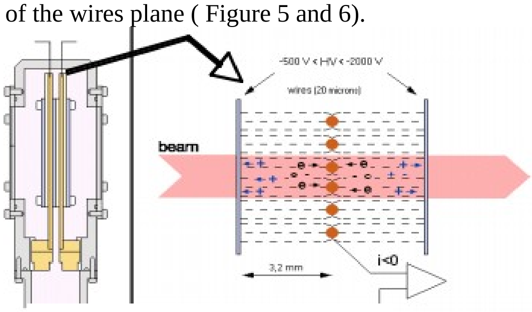



Figure 5 : operating principle

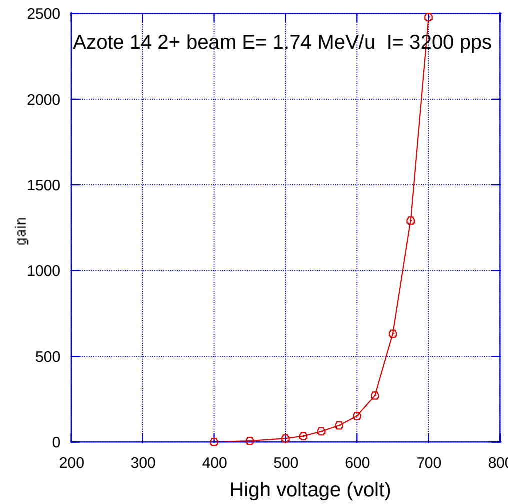



**Figure 6: amplification signal versus high voltage variation**

The acquisition datas are read by the standard electronics Ganil device and displayed on PC with Ganil acquisition software (Figure 7).

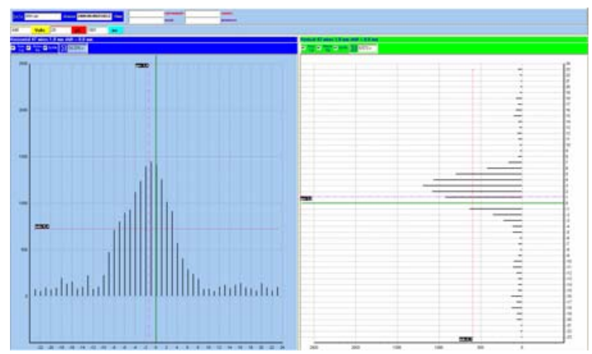


Figure 7 : Azote14 2+ beam profile
E= 1.74 MeV/u, I= 3200 pps

## LOW INTENSITY BEAM PROFILE MONITOR (EFM)

A secondary emission foil profiler is under development (Figure 8) 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 20 keV.
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.
Micro-channel plates will amplify the number of electrons in order to be collected on an X-Y grid.

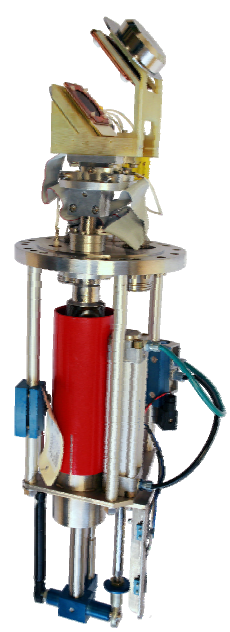


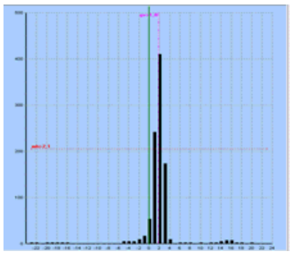
Figure 8 : EFM profiler

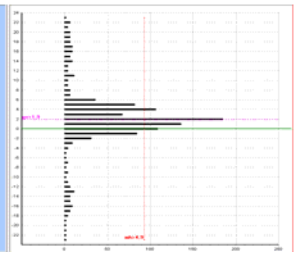
The desired resolution is 1mm in each dimension.

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 (Figure 9).

**Standard gas beam profile**

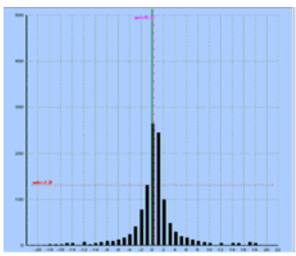
Horizontal plane Vertical plane





**EFM beam profile**

Horizontal plane Vertical plane



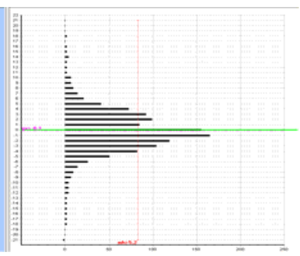


Figure 9 : beam profile acquisition

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.
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 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.

## CONCLUSIONS

The development of these different kinds of beam profile will permit to cover all the dynamic of the Spiral 2 energy and intensity radioactive beam. Last test are now in progress to perform LPGM and EFM profile solution before fabrication.

## 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 $14^{th}$ – 19 th June 1998

[3] JL Vignet et al., The beam profile monitors for SPIRAL2. DIPAC 2009 (TUPB07)

[4] P. Anger et al. Beam diagnostics for SPIRAL2 RNB facility. DIPAC 2009 (MOPD30