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BEAM DIAGNOSTICS OF THE NEWGAIN PROJECT

C. Jamet[1,†], S. Leloir[1], P. Salou[1], T. Andre[1], C. Potier de Courcy[1], G. Ledu[1], G. Monier[1], C. Hocini[1], E. Dessay[1], J-C. Foy[1], G. Brunet[1], S. Ferey[1], M. Michel[1], C. Maazouzi[2], T. Adam[2], P. Graehling[2]
[1]GANIL, Caen, France
[2]IPHC, Strasbourg, France

Abstract

The aim of the NEWGAIN Project (NEW GAnil INJector), is to build a second injector on the SPIRAL2 accelerator to produce and accelerate heavier beams with A/q up to 7. The NEWGAIN injector is based on 2 ECR ion sources, two LEBT, one RFQ and MEBT lines to send new ion beams in the LINAC and the S3 experimental room.

Diagnostic monitors are planned to measure and control beam intensities, profiles, phases, energies and emittances. A presentation of beam characteristics and a description of the diagnostic monitors are done. Modifications of the beam duty cycle system and the machine protection system are also detailed.

INTRODUCTION

The NEWGAIN project aims to increase the capabilities of SPIRAL2 LINAC with the build of a second injector designed for A/q = 3 to 7 ions, to produce very intense heavy ion beams up to uranium, exceeding the performance of the existing injector. NEWGAIN will be integrated in the SPIRAL2 facility with these two experimental rooms named NFS (Neutron For Science), S^3 (Super Separator Spectrometer) and the low beam experimental room DESIR (Decay, Excitation and Storage of Radioactive Ions) under construction (Fig. 1).

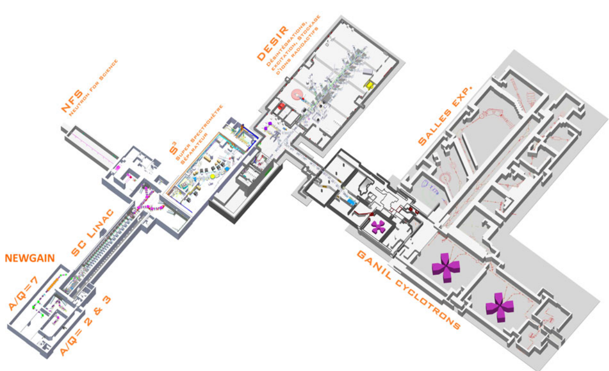

Figure 1: General Layout of GANIL, SPIRAL2 Facilities.

The project includes a new superconducting ion source (ASTERICS), developed to complement the existing sources, two low energy beam transport lines, a second Radio Frequency Quadrupole (RFQ) and medium energy beam lines connecting the SPIRAL2 LINAC with the possibility to send the beam into an experimental area (to be built) in the future (Fig. 2) [1].

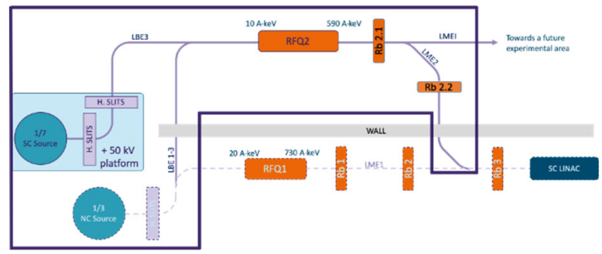

Figure 2: NEWGAIN principle layout (in dotted lines are the existing elements of SPIRAL2).

The injector will be installed in an existing cave in the SPIRAL2 building. The view of the injector inside the existing facility is shown on Fig. 3. Table 1 lists the main injector parameters and Table 2 [2] shows the beam characteristics of the two reference beams considered for the design.

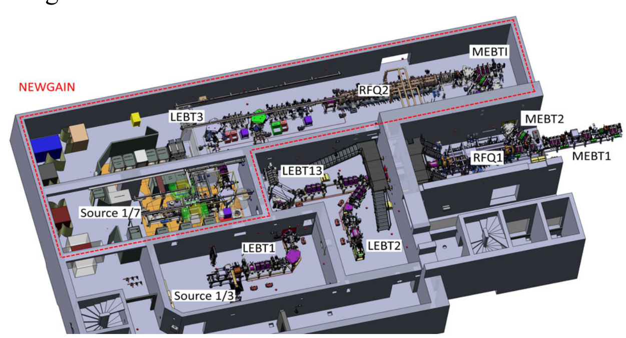

Figure 3: General 3D Layout of the NEWGAIN injector.

Table 1: NEWGAIN Parameters

Main Frequency	**88.0525**	**MHz**
LEBT Input energy	10	A.keV
MEBT Input energy	0.59	A.MeV
HEBT Input energy for A/q = 7	7	A.MeV

Table 2: Beam Characteristics

Reference Beam	$^{48}Ca^{11+}$	$^{238}U^{34+}$	
Normalised RMS emittance	0.2	0.15	π.mm.mrad
Beam intensity	210	340	µA
LEBT beam power	10	24	W
MEBT beam power	0.54	1.4	kW
HEBT beam power	6.9	16.7	kW

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Diagnostic monitors will have to measure beam characteristics with a low beam current of 1 µAe.

BEAM DIAGNOSTIC MONITORS

The different types of beam diagnostics were defined in order to tune beam profiles, to measure beam intensities and emittances in the LEBT lines from sources to the RFQ entrance and in the MEBT lines from the RFQ to the existing SPIRAL2 MEBT. Phases and energy will be measured to qualify the beam at the RFQ exit and to tune the two NEWGAIN rebunchers. Longitudinal beam shape and emittance are planned to be measured by a Fast Faraday cup at the RFQ exit. Most of the diagnostics are the same as those in SPIRAL2 [3]

Diagnostic monitors are listed in the Table 3.

Table 3: Diagnostic List

Diagnostic type	LEBT	MEBT	Total
Profile monitor	9	6	15
Faraday cup	2	2	4
AC Current Transformer	1	1	2
Emittancemeter	1	1	2
Phase electrode		3	3
Fast Faraday cup		1	1

Profile Monitors

Multi-wire profilers are composed of 47 tungsten wires in horizontal and vertical planes with a constant spacing of 1 mm. The wire diameter is 150 µm (Fig. 4). The diagnostics and electronics are the same as for SPIRAL2. Their operating range is from a few nA to mA.

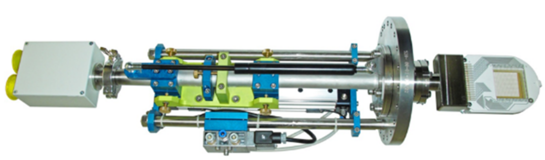

Figure 4: View of a multi-wire profiler.

Faraday Cups

Water cooled Faraday cups, with a 100 mm aperture, will be installed in the LEBT and MEBT. The maximum beam power is 3 kW (Fig. 5).

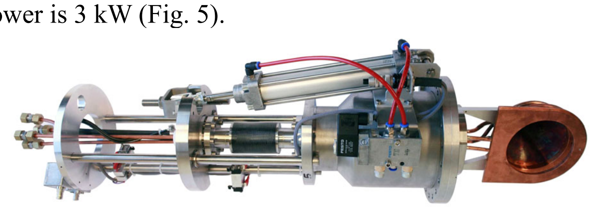

Figure 5: Picture of a water cooled Faraday Cup.

A new I/V converter (1 mA/10 V), currently under development, will be installed near the Faraday cup to obtain a bandwidth of 150 kHz. The output voltage is sent to moving average electronic with an integration time of 1s (SPIRAL2 electronic board), to measure the average intensity of the beam. This voltage is also sent to a fast digitising electronic at 1 MHz sampling rate to display the chopped beam over time and measure the peak beam intensity.

AC Current Transformers

A new design of the ACCT integration was defined for NEWGAIN, an In-Flange integration which is different of the external integration of the SPIRAL2 ACCT's. This choice was done to optimize the measurement sensitivity and decrease external electromagnetic perturbations (Fig. 6). The 2 ACCT's are installed as close as possible to the entrance and exit of the RFQ for the intensity transmission measurement of the RFQ. ACCT's are made with nanocrystalline torus with an internal diameter of 100 mm and 50 turns on the secondary coil.

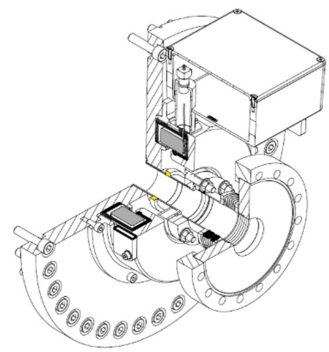

Figure 6: Design of the torus integration on the RFQ Flange with an I/V converter box.

The New I/V conversion box (1 mA/10 V) will be installed as close as possible to the ACCT. The ACCT low drop can be tuned on the box to obtain a very low value of 2 %/s. The output voltage is sent to an amplitude detection card. From these cards, signals of beam intensities and transmissions are averaged with moving average electronics like those of Faraday cups, signals are also digitized by a fast acquisition electronic.

The intensities and transmissions from ACCT will be monitored and compared with thresholds. If exceeded, a beam cut request is sent to the Thermal Machine Protection System (T-MPS) in order to protect the equipment against current overruns or beam losses.

Intensity Tests

As on the SPIRAL2 accelerator, test signals can be sent remotely to the ACCT and Faraday cup electronic boxes. A common test generator can be switched to the selected diagnostic. Tests allow to verify the measurement accuracy of the intensity chains of CF and ACCT.

Emittancemeters

2 water cooled scanner emittancemeters (Allison scanner) will be installed, one on the LEBT and the second in the MEBT line in order to measure transverse emittances. The LEBT emittancemeter is under construction at the IPHC laboratory at Strasbourg, France. The process which controls positions, voltage and current measurements will

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be done by an industrial PLC solution unlike the traditional PLC/VME combination of the SPIRAL2 MEBT emittancemeter. The currently SPIRAL2 MEBT emittancemeter will be moved on the NEWGAIN MEBT. The position scan 80 mm range with a slit opening of 0.2 mm in LEBT and 0.12 mm in MEBT.

Phase Electrodes

Three phase electrodes, identical to the one on the SPIRAL2 MEBT, will be installed in the 2 NEWGAIN MEBT lines. The internal diameter of the electrodes is 84 mm (Fig. 7).

Figure 7: Picture of a phase electrode.

Voltage and phase of the 2 NEWGAIN rebunchers will be tuned from the beam phase measurements of the electrodes signals. The RFQ exit energy will be measured precisely from the 2 first electrode phases (Time Of Flight method) on the MEBTI (Interdisciplinary MEBT) line (Fig. 8).

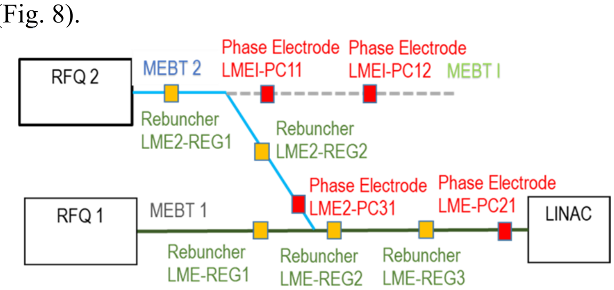

Figure 8: Synoptic of lines with electrodes and rebunchers.

Initially, the same electronic system as SPIRAL2 to measure beam phases will be used. New measurement system, based on a recent FPGA, are currently being defined. The development of this new system is being carried out by the laboratory LP2IB at Bordeaux.

Fast Faraday Cup

A Fast Faraday Cup (FFC) will measure longitudinal beam profile and emittance in the MEBTI line. This is the same design that the SPIRAL2 FFC with a diameter of 44 mm, a max power of 40 W, a bandwidth of 3 GHz which allows to measure pulses of 300 ps at half height (Fig. 9). A preamplifier is planned to be add at low beam intensities.

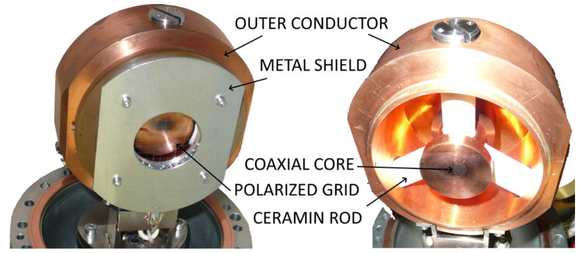

Figure 9: Picture of the Fast Faraday Cup.

Longitudinal emittance measurements are planned to do by measuring the beam length measurements from the FFC in function of the voltage of the first rebuncher.

Time Structure

The time structure done by choppers is defined by the frequency included between 1 Hz to 1 kHz and the pulse length between 1 µs to CW. A beam cut of 200 µs each second is apply in the CW mode for the ACCT operation.

Duty cycles and cuts are managed by the electronic device named ECSF (Electronic Beam Structure Control). Modifications are planned to manage the 2 new choppers and to add new duty cycles for NEWGAIN.

Machine Protection System

The operation principle of the Thermal Machine Protection System (T-MPS) is to separate the accelerator in different zones, a zone is activated when the beam can be inside. In case of beam cut request in an actived zone, the beam is quickly stopped by a chopper. T-MPS will be modified to integrate two new zones, one for LEBT and one for MEBT of NEWGAIN and the two new choppers. Monitoring of beam intensities at RFQ input and output, RFQ and MEBT2 transmissions will be taken into account in these zones in addition to existing monitoring of SPIRAL2.

CONCLUSION

Mechanical production of diagnostics is in progress or will start in 2025. Electronic developments are limited to I/V converter boxes for the Faraday cups and ACCT and a new beam phase measurement device. Electronic devices are planned to be built in 2026 and tested in 2027.

The existing ECSF (Electronic Beam Structure Control) must be modified and upgraded in order to integrate NEWGAIN injector as well as the T-MPS (Thermal Machine Protection System). 2028 should be the year of production of the first beams in NEWGAIN.

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