

INJECTOR DIAGNOSTICS OVERVIEW OF SPIRAL2 ACCELERATOR

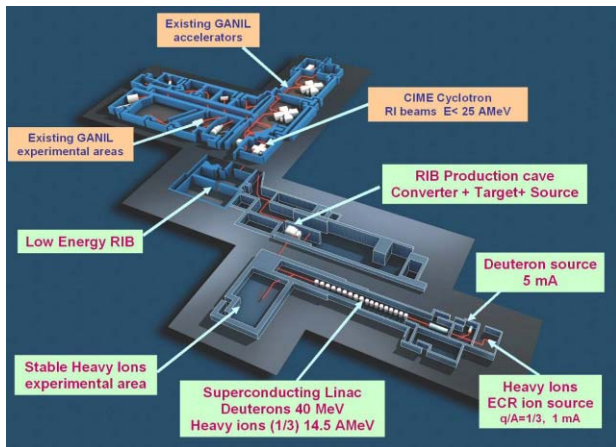
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Abstract

The SPIRAL2 project is based on a multi-beam driver in order to allow both ISOL and low-energy in-flight techniques to produce Radioactive Ion beams (RIB). A superconducting light/heavy-ion linac capable of accelerating 5 mA deuterons up to 40 MeV and 1 mA ions up to 14.5 MeV/u is used to bombard both thick and thin targets. These beams could be used for the production of intense RIB by several reaction mechanisms (fusion, fission, transfer, etc.). The post acceleration of RIB in the SPIRAL2 project is assured by the existing CIME cyclotron. SPIRAL2 beams, both before and after acceleration, can be used in the present experimental area of GANIL.

The construction phase of SPIRAL2 is being started since the 1st of July 2005. An injector design overview is presented with diagnostics used to tune and qualify beams.

SPIRAL2 DESCRIPTION

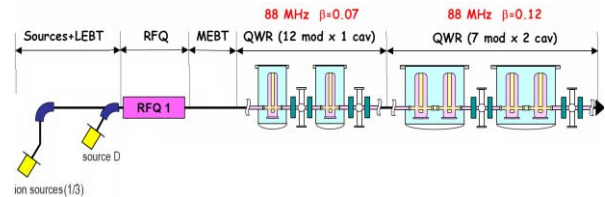


The SPIRAL 2 facility is based on a high-power, superconducting driver LINAC, which will deliver a high-intensity, 40 MeV deuteron beam as well as a variety of heavy-ion beams with mass-to-charge ratio equal to 3 and energy up to 14.5 MeV/u. The driver accelerator will send stable beams in a new experimental area and in a cave for the production of Radioactive Ion Beam (RIB). The commissioning of the driver should start in 2011 at GANIL.

Using a carbon converter, fast neutrons from the break-up of the 5 mA of deuterons impinging on a uranium carbide target will induce a rate of up to 10^{14} fissions/s.

The extracted RIB will subsequently be accelerated to energies of up to 20 MeV/nucl. (Typically 6-7 MeV/nucl. for fission fragments) by the existing CIME cyclotron.

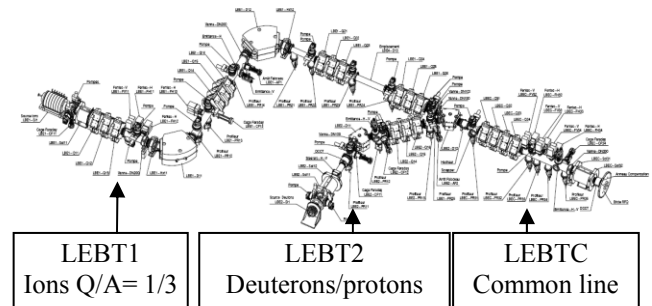
ACCELERATOR



The accelerator is composed by an injector, a superconducting linac and a high energy line. In the injector part, we found a deuteron/proton line, an ion line (LEBT), a RFQ and a MEBT. Two kinds of superconductivity cavity are used for the Linac ($\beta=0.07$, $\beta=0.12$). In a first time, the injector will be built at the Saclay Laboratory (near Paris). First beams are scheduled in the middle of 2009.

INJECTOR

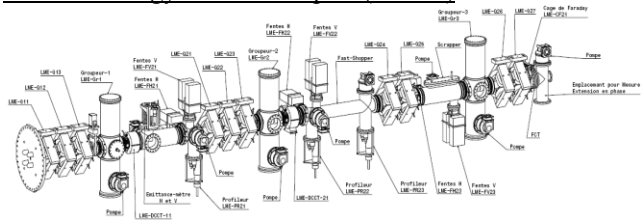
Low Energy Beam Transport (LEBT)



Diagnostics used on the LEBT are:

- 16 Beam profile monitors
- 3 Emittancemeters (H and V)
- 2 DCCT
- 5 Faraday cups

Medium Energy Beam Transport (MEBT)

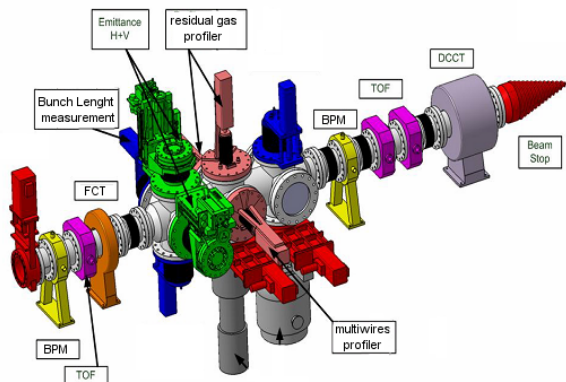


Diagnostics used on the MEBT are:

- 3 Beam profile monitors
- 1 Emittancemeter (H and V)
- 1 DCCT
- 1 Faraday cup
- 1 FCT (Fast current transformer)
- 1 bunch length measurement

INJECTOR TEST BENCH

During the commissioning of the RFQ and the MEBT, an Injector Test Bench (BTI) will be used to qualify the beam at the output of the RFQ.



Diagnostics used on the BTI are:

- 2 Beam profiler monitors (SEM and gas residual)
- 1 Emittance meter
- 1 DCCT
- 1 Faraday cup
- 1 FCT (Fast current transformer)
- 1 bunch length measurement
- Time of flight measurement Pick-up
- Beam Position Monitor

INJECTOR BEAM CHARACTERISTICS

Maximum values

	Intensity	Energy	Power
LEBT1 (ions)	1 mA	20 keV/A	60 W
LEBT2 (deuterons)	5 mA	40 keV	200 W
MEBT	5 mA	750 keV/A	7.5 kW

In LEBT, diagnostics should support a power density of 2 kw.cm⁻².

FARADAY CUP

Faraday cups will measure with a good precision beam currents and efficiencies in lines.

Imax: 10 mA

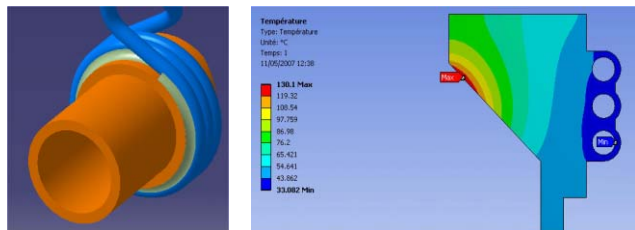
Maximum Beam size: 80 mm

LME Maximum Power: 7,5kW

Accuracy: ~ 10⁻³

Materials: copper for ions, nickel for deuterons

Temperature simulation



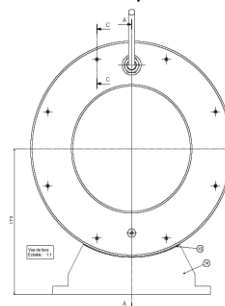
DC CURRENT TRANSFORMER

New PCT of Bergoz has been chosen to measure beam current. The NPCT works on the principle of the zero-flux DC current transformer.

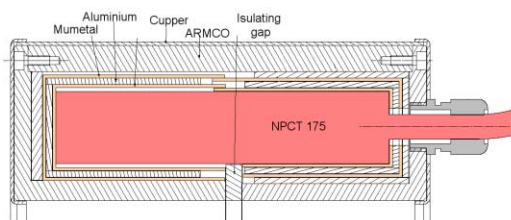
NPCT-175

Full scale range: +/-20mA

High resolution model: <math> < 1\mu A / \sqrt{Hz}</math>



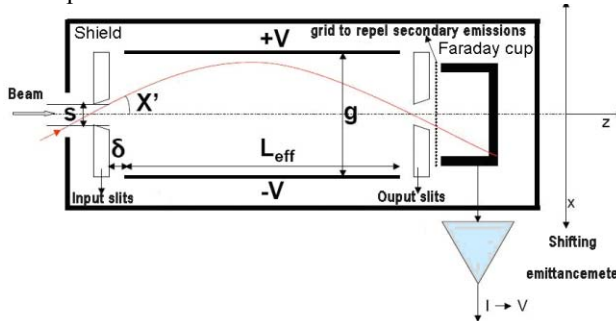
Magnetic shielding is composed by three materials (ARMCO and mumetal separated by aluminium).



EMITTANCEMETER

Each emittance meter consist of two Allison scanners, in the horizontal and vertical plane.

Principle of an Allison emittance meter



With an energy q.U, an ion (charge q) enters with an angle x', is deviated by a voltage V and goes through output slits. The equation of V is given by:

$$V = 2.U.x'.(g/L_{eff})$$

For each position of the emittance meter, a voltage is applied to measure a maximum current on the Faraday cup.

Maximum beam diameter capability: 80 mm

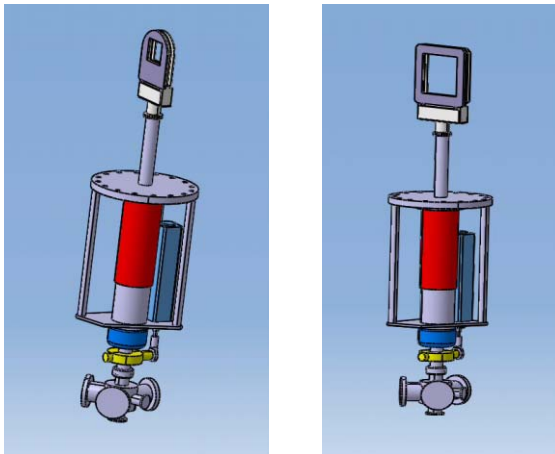
Maximum Voltage: 1.5kV

BEAM PROFILE MONITOR

Secondary-emission monitors (SEM)

Monitors are composed by a horizontal and vertical grid of 47 gold tungsten wires of 150 μm. These wires are welded on alumina board to obtain a maximum out gazing rate of 1.10⁻⁸ Pa.m³.s⁻¹ (after a baking at 150 °C). Two kinds of grid can be installed, in function of the maximum size needed to be measured: 47 wires spaced of 1 mm for maximum beam size of 30 mm and 47 wires spaced of 3 different steps (1, 2, 3 mm) for maximum beam size of 80 mm. In order to resist to the beam power, a maximum rate of 5 ms/s will be applied on the beam.

The total mechanical precision of this diagnostic will be 0.2 mm.



BUNCH LENGTH MEASUREMENT

FAST CURRENT TRANSFORMER (FCT)

FCT will be used for bunch length visualizations.

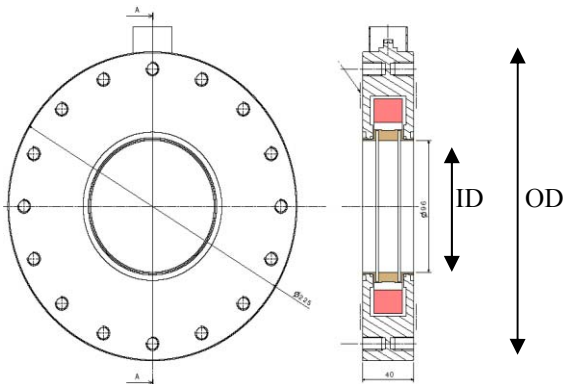
Characteristics:

FCT-0122-20:1 of Bergoz

Pulse response: 150ps

Upper cut-off frequency: 1.6 GHz

In flange CT: ID = 96 mm OD = 225 mm



The beam phase extension in the MEBT is estimated to 40° (σ = 6°). That gives a bunch length total of about 1.3ns.

COAXIAL FARADAY CUP

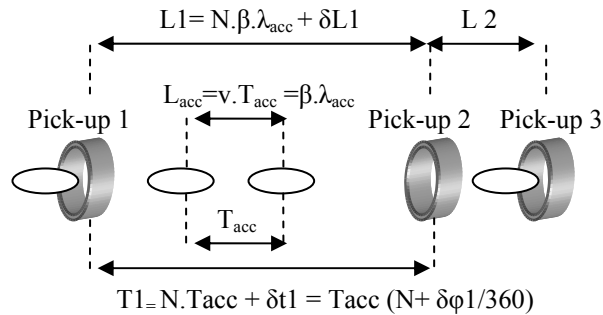
An interceptive diagnostic like a coaxial Faraday cup will be used to measure bunch lengths. The bandwidth should be upper than 2 GHz to have a fast rise time (< 200 ps.).



TIME OF FLIGHT MEASUREMENT

The beam energy will be calculated from the time of flight measurement.

$$\text{The non-relativist relation gives } E = \frac{1}{2}mv^2 = \frac{m}{2} \cdot \left(\frac{L}{T}\right)^2$$



The third pick-up is used to determine the number N of bunches between pick-up 1 and pick-up 2.

Energy	E (MeV/u)	0.75
Velocity	β=v/c	0.04
Frequency	F _{acc} (MHz)	88.05
Wavelength	λ _{acc} (m)	3.4
Length	L _{acc} (mm)	136
Length	L1(m)	1.5
Diameter	(mm)	80

Phase of pick-up signals will be measured to deduce time of flight and energy.

The energy accuracy depends of the length and the phase measurement accuracy.

$$\left| \frac{\Delta E}{E} \right| = 2 \cdot \left| \frac{\Delta L}{L} \right| + 2 \cdot \left| \frac{\Delta \rho}{360 \cdot N + \Delta \rho} \right|$$

REFERENCES

[1] T. Junquera & al, The high intensity superconducting Linac for the SPIRAL2 project at Ganil, Proceedings of LINAC06, Knoxville, Tennessee USA
 [3] P. Bertrand, JL Biarrotte and D. Uriot, Beam dynamics studies for the Spiral2 project, Proceedings of EPAC06, Edinburgh (UK) 2006.
 [4] M.H. Moscatello & A. Mosnier, “Design of the high Intensity exotic beams Spiral 2 project”, PAC’05, Knoxville, TN, USA.
 [5] “The SPIRAL2 project APD report”, January 2005.