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/nucleon. (Typically 6-7 MeV/nucleon for fission fragments) by the existing CIME cyclotron.

ACCELERATOR

The accelerator is composed of 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 ($\beta_0 = 0.07$, $\beta = 0.12$). 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 Emittancemeter
- 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 CARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>Intensity</th>
<th>Energy</th>
<th>Power</th>
</tr>
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<tbody>
<tr>
<td>LEBT1 (ions)</td>
<td>1 mA</td>
<td>20 keV/A</td>
<td>60 W</td>
</tr>
<tr>
<td>LEBT2 (deuterons)</td>
<td>5 mA</td>
<td>40 keV</td>
<td>200 W</td>
</tr>
<tr>
<td>MEBT</td>
<td>5 mA</td>
<td>750 keV/A</td>
<td>7.5 kW</td>
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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: 7.5 kW
Accuracy: ~ 10⁻³
Materials: cupper 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: <1μA/√Hz

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

EMITTANCEMETER

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

Principle of an Allison emittancemeter

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/Leff)

For each position of the emittancemeter, 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.m$^3$.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.

BUCH LENGTH MEASUREMENT

FAST CURRENT TRANSFORMER (FCT)

FCT will be used for bunch length visualizations.

Characteristics:
FCT-0122-201 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° ($\sigma = 6^\circ$). That gives a bunch length total of about 1.3 ns.

REFERENCES

[1] T. Junquera & al, The high intensity superconducting Linac for the SPIRAL2 project at Ganil, Proceedings of LINAC06, Knoxville, Tennessee USA