STATUS REPORT ON THE SACLAY HIGH-INTENSITY PROTON INJECTOR PROJECT (IPHI)

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Abstract

High-power accelerators are studied for several projects based on high-flux neutron sources driven by proton or deuteron beams. Since the front end is considered as the most critical part of such accelerators, the two French national research agencies CEA and CNRS decided to collaborate to study and build a High-Intensity Proton Injector (IPHI). The construction of this prototype designed to accelerate beams up to 100 mA with an energy up to 10 MeV is now in progress. The first beam is scheduled for January 2003. The different parts of the accelerator are described. The last results obtained by the ECR source SILHI, the status of the construction as well as the installation schedule are presented.

1 INTRODUCTION

Over the last 10 years, in-depth studies have been carried out on the feasibility of high-power proton accelerators capable of producing beams of several tens of MW. With heavy targets, such beams can produce extremely intense spallation neutron flux. Several applications could benefit from the performance of this new generation of high-power proton accelerators [1]:

- spallation neutron sources for condensed matter studies,
- hybrid reactors for nuclear waste transmutation,
- neutrino and muon factories,
- technological irradiation tool,
- production of radioactive ion beams,
- production of radioisotopes,
- etc.

IPHI ("Injector of Protons for High-Intensity beams") is a 1 MW low energy demonstrator project which could be used as front end for these high-power proton accelerators [2].

2 IPHI SUBSYSTEMS

2.1 General Layout

Figure 1 presents the general layout showing the main parts of the IPHI prototype : ECR source, 5 MeV RFQ, 10 MeV DTL and diagnostics line for accurate measurements of the beam characteristics.

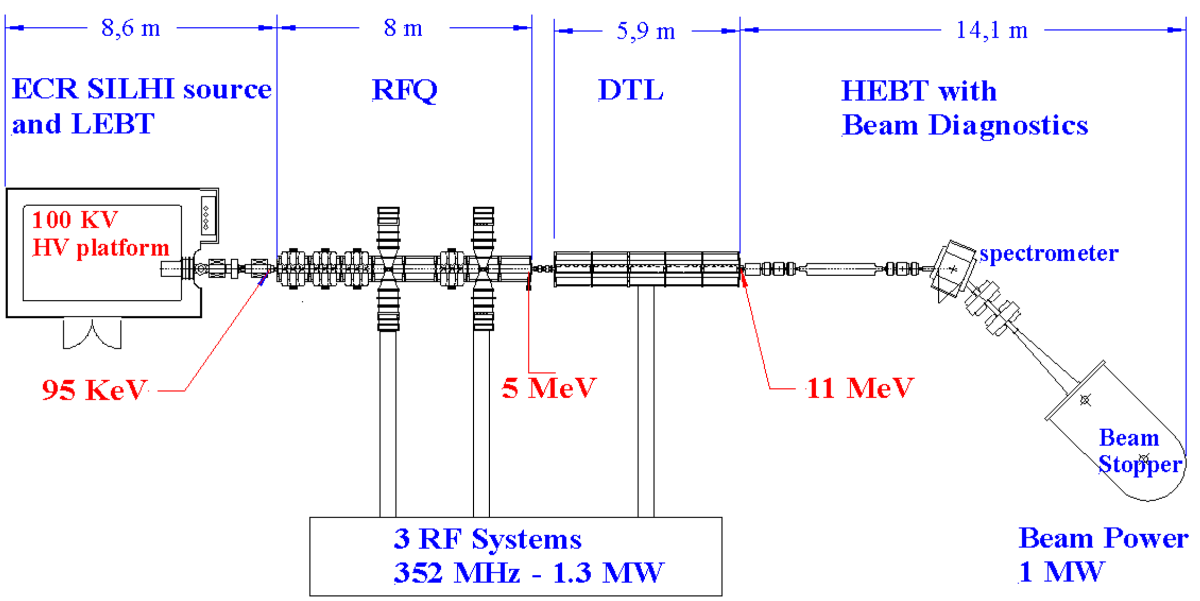

Figure 1 : Layout of the IPHI project

2.2 SILHI ECR source [3] [4] and LEBT (Low Energy Beam Transport) (see fig. 2).

The ion source operates at 2.45 GHz with an ECR axial magnetic field of 875 Gauss. The source and its ancillaries are installed on a high voltage platform to produce 95 keV beams. The RF power is produced by a 1.2 kW magnetron source. This source will be replaced soon by a generator based on a 3 GHz, 1 kW klystron, for a better flexibility in pulsed mode.

Figure 2 : The high-intensity ECR source SILHI, LEBT and emittance measurement unit

The LEBT is made up of two solenoids and two couples of magnetic steerers to match the beam to the RFQ acceptance. A set of diagnostics (position, intensity, emittance, species ratio) and a collimator, arranged all along this LEBT, allows a complete control of the beam.

2.3 RFQ

Beam dynamics computations [5] [6] [7] using several complementary codes (PARMTEQ, LIDOS, TOUTATIS), have led to choose a 8 meter long cavity with an output energy of 5 MeV. Table 1 sums up the main characteristics and theoretical performances for a 100 mA proton beam with an 0.25π.mm.mrad input rms normalized emittance.

Table 1 : IPHI RFQ parameters

Structure	4 vanes
Frequency	352.2 MHz
Total length	8, (8 one meter sections)
Resonant coupling plate	3
Vane voltage	87 to 123 kV (Kp ≤ 1.7)
Output energy	5 MeV
Theoretical transmission	99.1 %(accelerated)
Beam power	500 kW
Max total power	1650 kW (two 1.3 MW klystrons)

2.4 DTL (see table 2).

The construction of the 10 MeV DTL tank is not yet funded. Nevertheless, complete beam dynamics computations have been done for the transition transport line between the RFQ and the DTL and for the DTL (table 2).

Table 2 : main DTL tank characteristics

Number of cells	51
Total RF power	1.00 MW
Power dissipation in copper	0.34 MW
Beam power	0.66 MW
Efficiency	66.1 %
Average effective shunt impedance	32.8 MΩ/m
Maximum electric field	0.89 Kilpatrick
Output energy	11.63 MeV
Tank diameter	50.5 cm
Tank length	5.48 m

2.5 Diagnostics line and beam stop

The first section of the HEBT (0.6 m long), is dedicated to longitudinal phase spread, energy and intensity measurements. The second section dedicated to emittance measurements combines two quadrupole triplets separated by a 3 meter long drift space allowing non-interceptive position and profile acquisitions. The third part of this line combines a 45° deviation and a set of two quadrupoles to match the beam to the beam stop acceptance.

3 CONSTRUCTION STATUS

Source.

The SILHI source is presently under test and fulfils the main requirements to inject the beam into the RFQ. The last long run with only one "beam trip" for 103 hours uninterrupted operation demonstrated an availability of 99.96%. Some new studies [8] [9], developments and improvements are scheduled before moving to the IPHI building :

- Emittance and space-charge compensation studies,
- Test operation during 500 hours,
- Installation of a new extraction system,
- Development of non-interceptive diagnostics,
- Setting up of the LEBT in its final configuration…

RFQ.

The machining and brazing of a one meter long prototype of cavity is in progress. The delivery of the first section is expected for the end of 2000 and will be completed at the end of 2001 for the 8 sections. The definition of the vacuum system and cooling system are practically complete. A two meter long cold prototype is in operation to validate the codes and to optimize the RF tuning procedures. Four sections will be added to form a six meter long cold model.

DTL.

The construction of a 352 MHz short DTL tank equipped with three drift tubes is in progress. Two drift tubes will be dedicated to the test of two technologies of quadrupole and the third one to thermal measurements. RF low-level tests are scheduled for next September, high-power tests from December. The construction of this cavity will allow us to validate the technological choices, the RF codes as well as the magnetic measurements and alignment procedures.

HEBT and diagnostics.

The definition of the High Energy Beam Transport, (HEBT) is for the main part complete and diagnostics are under development. Most part of the magnetic elements and their power supplies are already available. The present R & D work is focused on the conception of non-interceptive diagnostics.

4 INSTALLATION AND COMMISSIONING SCHEDULE.

IPHI will be installed in the building of the decommissioned synchrotron SATURNE II (Figure 3). The selected site will be available from July 2001.

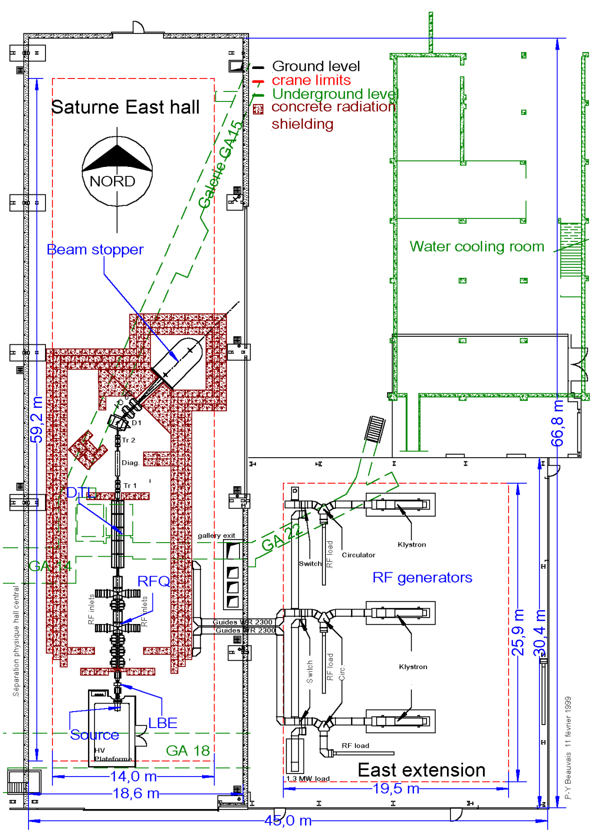

Figure 3 : Implantation in IPHI building.

The moving of SILHI is scheduled to operate again the source from April 2002. Assembly of the RFQ and RF system should be finished in September 2002 to begin the RF conditioning in October. The first 5 MeV beam with a low duty cycle is expected for January 2003 and CW beam planned 6 months later.
The DTL construction, if decided, should begin in 2001, the installation taking place during the first semester of 2004 allowing a first 10 MeV beam in July 2004.

4 CONCLUSIONS

The IPHI construction process is progressing well. The ECR source SILHI already fulfils the IPHI requirements. A four week continuous operation scheduled for October 2000 should confirm the excellent result obtained last year. The tests in the conditions of beam matching to the RFQ are in progress and should be completed for July 2002. The DTL construction decision is expected for 2001. Studies already done on this cavity will permit to schedule the construction in two years. R&D work on HEBT is focused on the conception of non-interceptive diagnostics based on fluorescence or light absorption principle.

Acceleration of a 5 MeV, 100 mA CW (500 kW) high-quality beam with a high availability is still the objective of the IPHI project.

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