Studies and Design of a Dual Beam Axial Injection System Using H^- Cusp Source and ECR Ion Source for He for IBA C70 Cyclotron

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Abstract At the moment, a 70MeV cyclotron is under construction by the IBA company. This cyclotron will be able to accelerate H^- beam from a multicusp source and with a beam intensity in the range of 10mA at the source extraction. A He^{1+2+} beam is also required. This beam will be produced by a PANTECHNIK ECR ion source (SUPERNANOGAN) with an extracted current of 1 to 2mA. In this paper the studies and design of the two sources with a common axial injection in the cyclotron are described.

Key words ECR, beam, H^-, cyclotron

1 Introduction

The I.B.A.company has been selected by SUBATECH in Nantes (France) to build a 70MeV proton Alpha cyclotron for isotope production and medical applications. Through a collaboration contract, I.B.A and PANTECHNIK have decided to collaborate for some main components of this cyclotron. PANTECHNIK is particularly in charge of the following studies:

- improvement and construction of a multicusp ion source 10mA H^- (I.B.A. source).

- SUPERNANOGAN (Pantechnik) for the production of the Alpha beam

- common beam transport system to the entrance in the yoke with diagnostics, RF buncher, and low energy beaml choper

- RF resonator (two half wave structure), at 30MHz and 100kW amplifier with magnetic coupling loop

- electrostatic deflector for Alpha particles

- nigh energy beam chopper

We will describe the design of the two sources and the optical beam transport system.

2 Multicusp ion source for H^-

The goal for intensity is to obtain an H^- beam of 10mA or more. During the first test , the source (Fig. 1) has been improved from 5.5 to 8mA and the H^- beam extracted with and extraction voltage of 30—40kV and with an emittance of 190π·mm·mrad. New improvements will be tested before the end of this year in order to obtain 10mA or more.

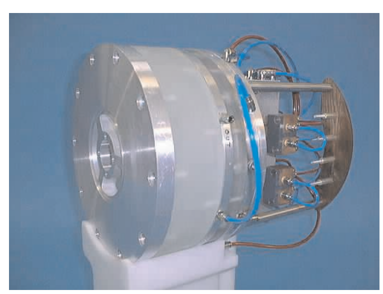

Fig. 1. The H^- IBA source.

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3 Production of HE^{2+} beam with SUPERNANOGAN ECR source

The SUPERNANOGAN ECR source (Fig. 2), working at 14.5GHz and using only permanent magnet is well known by the Hadron Therapy project in Europe. (HICAT, CNAO) and solid state physic (JAERI, HMI, VECC...)

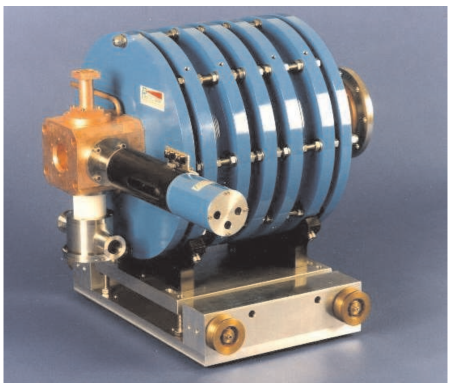

Fig. 2. SUPERNANOGAN a full permanent magnet ECR ion source at 14.5GHz.

This source is able to produce with less than 400W the following ions with an extraction voltage between 16 to 30kV

Table 1. Beam currents for various ions.

	eμA
H^{+}	2000
He^{2+}	2000
C^{4+}	200
C^{6+}	4
Ar^{8+}	200
Xe^{25+}	10
Au^{26+}	10

With micro oven, sputtering or MIVOC techniques, a large variety of metallic ions can be produced, up to tens of eμA.

4 Beam transport, analysis system

Both sources are mounted on the same horizontal axis on the top of the cyclotron yoke and on both sides of a two faces 30° magnet with the face on vertical axis at 0 (Fig. 3).

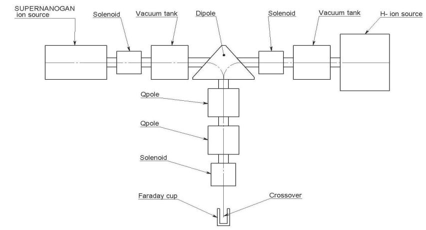

Fig. 3. Schematic view of the injection beam in the C70 IBA cyclotron.

Beam transport studies have been done with space charge effect using the TRANSPORT codes (P.S.I.) and GALOPR (GANI). This solution, with the quadrupôle after the magnet, allows compensation of the dissymmetry generated by the dipole. So the gradient is smaller (<2T/m) and the internal diameter is limited to 60mm. The lost of the two alignment parameters will be replaced by a double steering magnet between the second quadrupôle and the main magnet yoke. (Figs. 4 and 5).

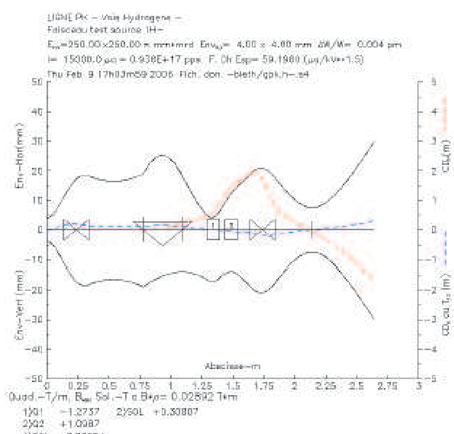

Fig. 4. Calculated envelop of the He^{2+} beam.

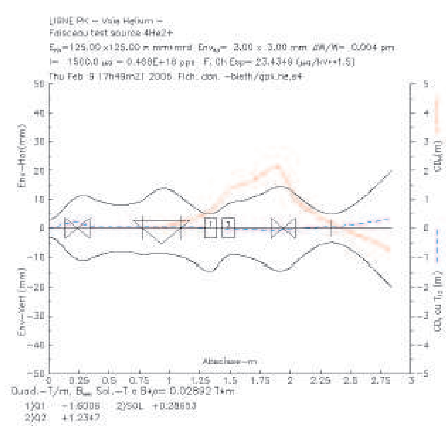

Fig. 5. Calculated envelop of the H^{-} beam.

This solution is a good compromise to keep the two planes symmetric and to finalise the desired cross-over before or after the entrance in the yoke.

5 Other equipment of the axial injection system

On both source, after the extraction from the source, we have a pumping tank with 2 TPM for SUPERNANOGAN and 3 TPM for the H^-, which are more sensitive to beam losses with high pressure.

The characteristic of the magnet components are given in Table 2.

Table 2. Typical parameters of the magnet components.

Dipole	
Radius	200mm
Deflection angle	2×90°
Entrance faces angle	32°
Exit face angle	0°
Magnetic gap	70mm
Useful width	80mm
Maximum field	1450Gauss
Quadrupole	
Magnetic length	100mm
Mecanic length	150mm
Pole diameter	60mm
Maximum gradient	2T/m
Dipolar component	10Gauss
Solenoïd	
Magnetic length	200mm
Mecanic length	250mm
Pole diameter	60mm
Maximum field	3800Gauss

The Fig. 6 shows all the component of the dual beam injection bench

The vertical quadrupole, after the 90° deflecting magnet is followed by a double steering magnet and then by a solenoid; this equipment is followed by a vacuum tank which includes three devices:

- a klystron buncher on the harmonic 1
- a low energy beam chopper (300μs peak beam)
- a movable water cooled Faraday cup

Before the yoke, a vacuum valve, and in the yoke, we will have a beam stopper for the deflected beam and the end of the focusing system before the spiral inflector in the cyclotron centre.

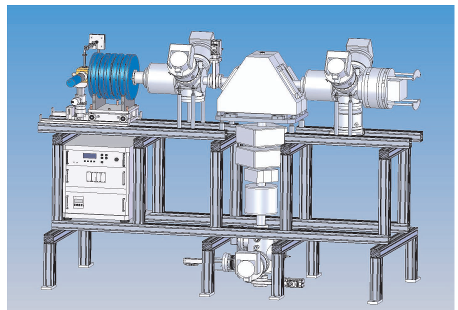

Fig. 6. Dual beam axial injection bench.

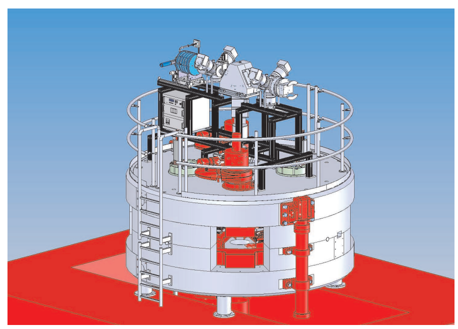

Fig. 7. Full injection bench mounted on the top of the C70 IBA cyclotron yoke.

Final parameters of the injection line will be given by the calculations of IBA for the central region.

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