Design of an 18 GHz ECRIS for the RILAC

T. Nakagawa, T.Kageyama, A. Goto, N. Inabe, O. Kamigaito, M. Nagase,
T. Chiba, M. Hemmi, M. Kase, Y. Miyazawa, E. Ikezawa, and Y. Yano
The Institute of Physical and Chemical Research (RIKEN)
Wako-shi , Saitama 351-01, Japan

Abstract

A RIKEN 18 GHz ECRIS has been designed as an ion source for the RILAC for upgrading the beam intensity of medium mass ions. This will be connected to a new type of variable frequency RFQ that is also being designed as a pre-accelerator for the RILAC.

I. INTRODUCTION

Electron Cyclotron Resonance Ion Source technology has developed rapidly since the original pioneering work of R. Geller and his group at Grenoble in the early 1970s. These ion sources are capable of producing intense beams of highly charged positive ions and are used extensively for cyclotron injection, linac injection and atomic physics research.[1] Recently, the intense beam of the medium mass ions, mainly metallic ions, becomes one of the major requests in RIKEN Accelerator Research Facility. Therefore, to increase the beam intensity of such ions, the new RIKEN ECRIS is being designed for use in the RILAC(Riken Heavy Ion Linac)[2]-Ring cyclotron complex . According to the scaling law for beam intensity extracted from ECRIS, which is proposed by R.Geller[1], the beam intensity of highly charged ions increases with increasing the operational frequency of micro wave and the strength of magnetic field. The new RIKEN ECRIS which will operate at 18 GHz is expected to provide significantly enhanced performance in terms of intensity and maximum charge states for heavy-ion beams compared to the present NEOMAFIOS which operates at 8 GHz. To inject heavy ions to the RILAC, the ECRIS is installed on the high voltage terminal to obtain the sufficient velocity. In this condition, supplying the electric power to the present ECRIS is strongly restricted(50KVA max). This is a strong limitation to make the new ECRIS. In order to avoid such a limitation, the new RIKEN ECRIS will be connected to a new type of variable frequency RFQ[3]which is also being designed as an injector for the RILAC.

II. BASIC DESIGN OF THE 18 GHZ ECRIS

A. Magnetic Field Configuration

The axial confinement of the plasma is obtained by two solenoid coils which provide a magnetic mirror. The source is completely enclosed with an iron york in order to reduce the requirements of the solenoid coils. The expected power consumption is about 90 kW. The coils are independently powered and can be moved with respect to each other so as to tailor the mirror ratio without changing the strength of the peak field. The mirror ratio has a nominal value of 2.5. Figure 1 shows an example of the expected on-axis magnetic field for the source, calculated by using the computer code PANDIRA.

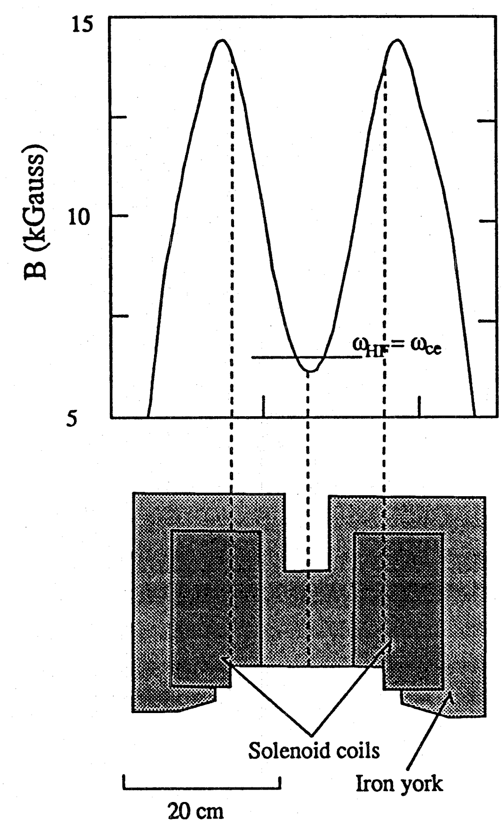

Fig.1 Longitudinal distribution of the magnetic field inside the mirror coil calculated along the axis of symmetry.

In order to optimize the magnetic confinement of the plasma, we use a hexapole magnet structure proposed by Halbach[4] as shown in Figure 2. The hexapole magnet consists of 24 segments made of Nd-Fe-B permanent magnets. The outer diameter(OD) and inner diameter(ID) are 180 and 60 mm, respectively . All of the segments are made of a material with high coercitivity(NEOMAX-40 Sumitomo Special Metals Co., LTD.). The design of the magnetic structure has been optimized by using the computer code PANDIRA as also shown in Figure 2. The field strength at the surface of the magnet is about 1.4 T.

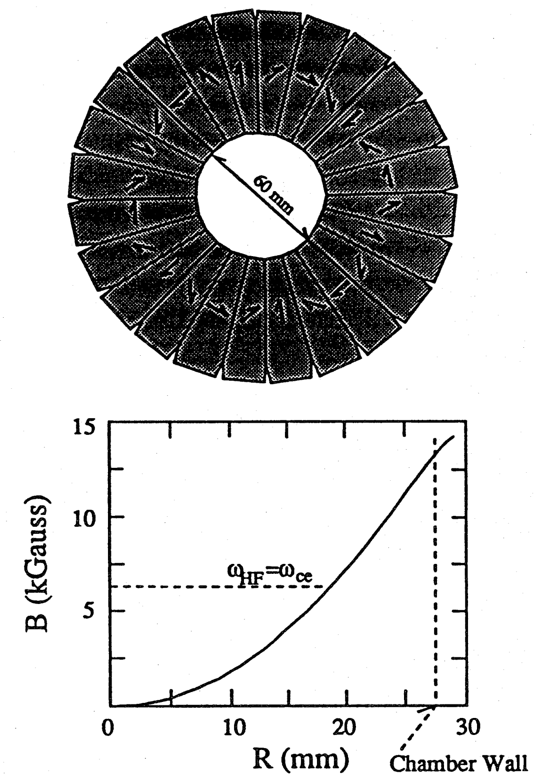

Fig.2 Cross sectional view of the hexapole magnet and calculated value of the magnetic field.

B. Mechanical Assembly

A schematic over view of the mechanical assembly is shown in Figure 3. To protect the hexapole magnet from demagnetization by high temperature, a water cooled plasma-chamber with ID=55mm and OD=60 mm is used.

The high vacuum of the plasma chamber is very important to produce the intense beam of highly charged ions.[5] This may be due to the effect of the recombination of the ions. In the case of the 18 GHz ECRIS, the plasma chamber is evacuated with the 500 and 150 l/s turbo molecular pumps. Using this pumping system, the ultimate vacuum of the plasma chamber will be order of 10^{-8} Torr. The design parameters are listed in Table1.

C. Electron Injection

According to recent upgrading of ECRIS[5,6], electron injection to the main stage plasma is a useful method to increase the beam intensity of highly charged ions. Especially the plasma cathode method has several advantages[5]: 1) long life time, 2) low consumption rate of gas, and 3) one dose not need gas-mixing method to obtain the intense beam of highly charged ions. To increase the beam intensity, we also use this structure for the 18 GHz ECRIS as shown in Figure3b). The first stage is isolated from the main stage and supply a negative bias to inject electrons from the first stage to the main stage plasma.

III. REFERENCES

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Table 1. Main parameter of the designed RIKEN 18GHz ECRIS.

Mirror coil		
	Maximum Current	700A
	Maximum field on axis	1.4T
	Mirror ratio	2.5
Multipole magnet		
	Multipolarity	Hexapole
	Inner diameter	60 mm
	Length	200 mm
	Material	Nd-Fe-B
	Field strength on Surface	1.4T
Micro wave		
	Frequency	18GHz
	Maximum power	2 kW
	Chamber diameter	55mm
Vacuum		
	Turbomolecular pump	150l/s and 500l/s

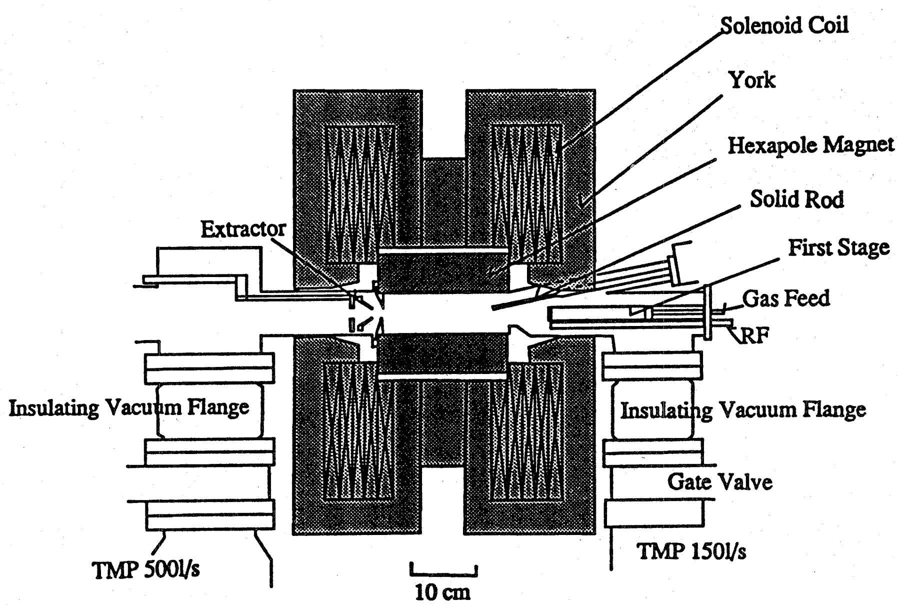

Fig.3 a. Schematic drawing of the designed RIKEN 18 GHz ECRIS.

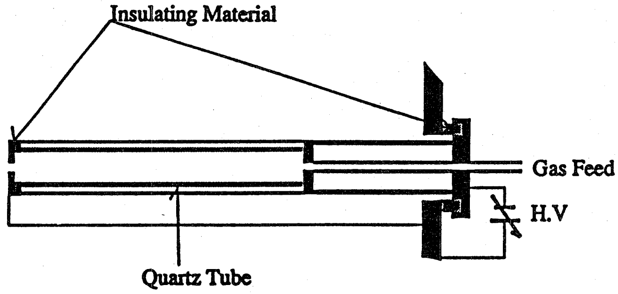

Fig.3.b Schematic drawing of the first stage of the gesigned RIKEN18 GHz ECRIS.