CONSTRUCTION OF THE RIKEN IRC

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Abstract

Construction of the RIKEN Intermediate-stage Ring Cyclotron (IRC) started in 1998. Four sector magnets are completed. Magnetic field measurement of the sector magnet is in progress. Two main resonators are assembled. Fine adjustments of the resonators are going on. Almost all the other components are also completed.

1 INTRODUCTION

The IRC is a room temperature ring cyclotron with four sectors that is utilized for RIKEN RI-Beam Factory[1]. It will be installed at the pre-stage of the superconducting ring cyclotron (SRC). The injector of the IRC is the existing RIKEN Ring cyclotron (RRC) and can be the proposed fixed frequency cyclotron (fRC) optionally[1]. The maximum energy and the maximum magnetic rigidity of ions accelerated by the IRC is 126.7 MeV/nucleon and 4.57 Tm, respectively. A plan view of the IRC is shown in Fig. 1. Main components of the IRC are installed in the area of 14 meters square. Main parameters of the IRC are listed in Table 1.

Table 1: Main parameters of the IRC

K-value		980
Number of sectors		4
Harmonics		7
Average radius	Injection	2.77 m
	Extraction	4.15 m
Velocity gain factor		1.5
Max. energy of ions		126.7 MeV/nucleon
Max. magnetic rigidity of ions		4.57 Tm
Number of resonators	Main	2
	Flattop	1
RF frequency	Main	18.0-38.2 MHz
	Flattop	72.0-114.6 MHz

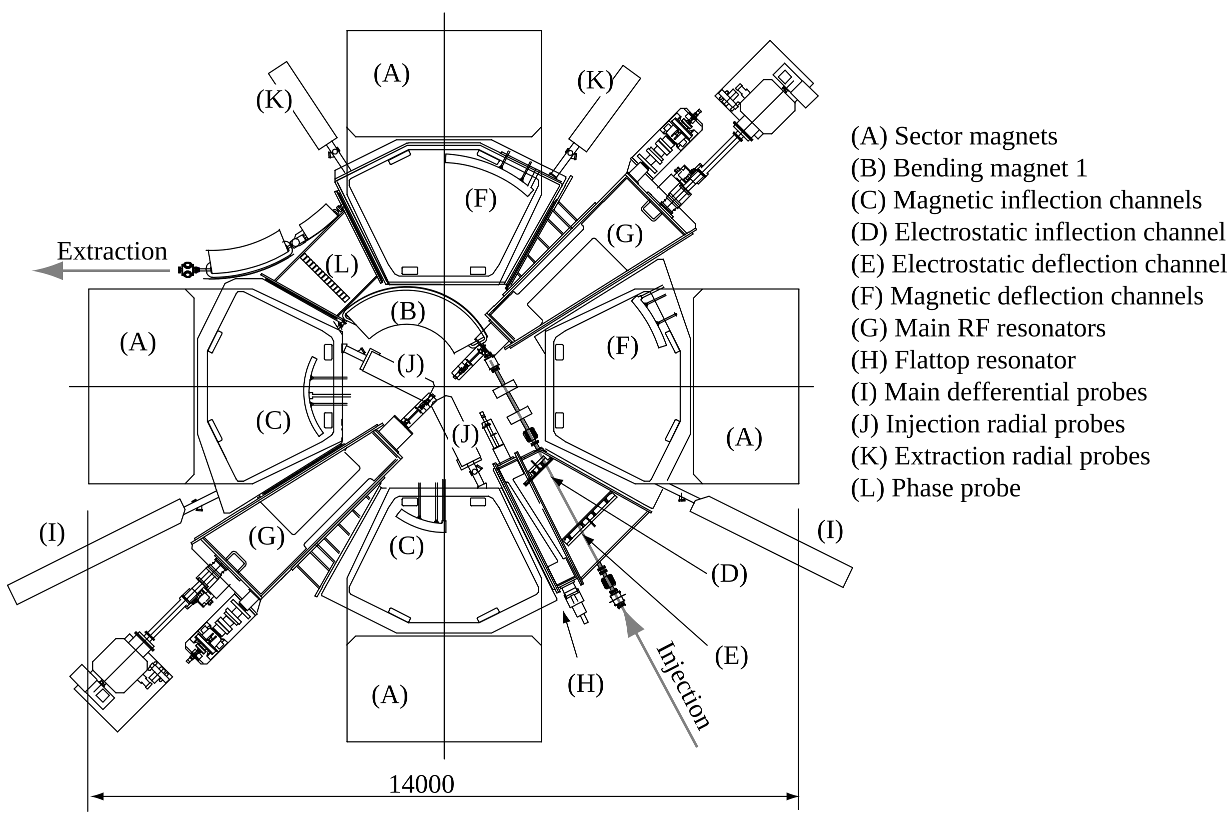

Figure 1: Plan view of the IRC

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2 SECTOR MAGNETS

The sector magnets of the IRC were designed based on the design of the sector magnets of the RRC. Fundamental structure of the poles and yokes is a stack of low carbon steel plates with the thickness of 260 mm or 280 mm. Carbon content of the steel is typically 0.002%. Main parameters of the sector magnets are listed in Table 2.

Table 2: Main parameters of the sector magnets

Pole gap	80 mm
Sector angle	53 degree
Purcell gap	1 mm
Weight	680 ton
Height	5.2 m
Maximum magnetic field	1.9 T
Main coil	
Maximum current	450 A
Maximum excitation current	178 kA/sector
Current stability	2×10^{-5}
Power consumption (total)	330 kW
Trim coil	
Number of trim coils	20 pairs/sector
Maximum current	400, 500, 600 A
Current stability	5×10^{-4}
Power consumption (total)	180 kW

The main coils of the sector magnets are designed to be of a low power consumption type. The maximum power consumption of the main coils is suppressed at 70% of that of the RRC, although the maximum magnetic field is higher than that of the RRC. Temperature rises of cooling water by the main coils are less than 10 degrees.

Twenty pairs of trim coils are mounted on the pole surface, where the vacuum is separated from that for the beams by thin stainless steel plates with thickness of 4 mm. Electric insulation of the trim coils is done by flash-coated with fused aluminium oxide. The innermost three and the outermost three trim coils are excited independently among the sector magnets. Thirty-eight switching power supplies in total are used for the excitation of the trim coils. Average temperature of the cooling water for trim coils will be precisely controlled in order to achieve good stability, because the temperature of the poles and the pole spacers that can cause the field instability depend on those of trim coils[2].

The vacuum chamber of the sector magnet and the upper and lower poles are designed so that they can be treated as one unit (Fig. 2). This structure will simplify the assembling of the sector magnet at the RIKEN site.

All sector magnets were completed in Dec. 2000. Magnetic field measurements of the sector magnets are now in progress. Two sector magnets are aligned. The magnetic field map of two sector magnets can be measured together. Details of the measurements are reported at this conference[3]. Figure 3 shows a photograph of the sector magnets and the magnetic field mapping device.

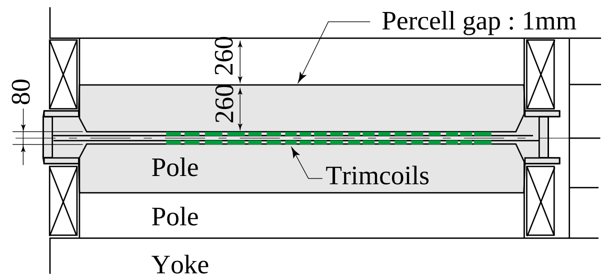

Figure 2: Cross-sectional view of the pole and the beam chamber of the sector magnet. Grey area shows the parts treated as one unit.

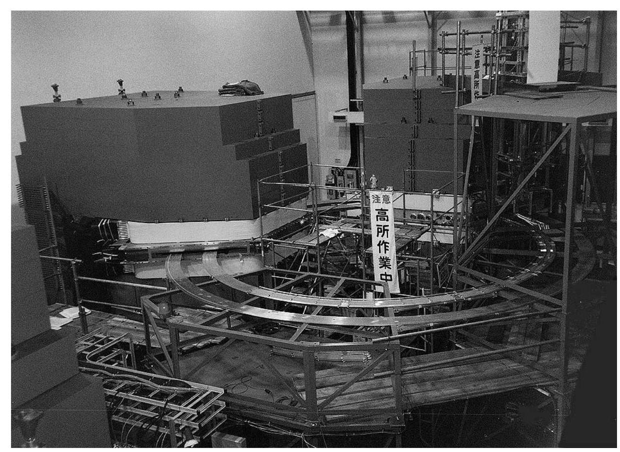

Figure 3: Photograph of the two sector magnets and the magnetic field mapping device at Sumitomo Heavy Industries, Ltd. in Ehime prefecture.

3 INJECTION AND EXTRACTION SYSTEM

The injection system consists of one electrostatic inflection channel (EIC), two magnetic inflection channels (MIC1 and MIC2), one bending magnet (BM1) and two quadrupole magnets. The MIC1 and MIC2 are equipped with iron shims with thickness of 2.2 mm and 5 mm, respectively. The extraction system consists of one electrostatic deflection channel (EDC), two magnetic deflection channels (MDC1 and MDC2) and two bending magnets (EBM1 and EBM2). All magnetic channels are installed in the 52-mm gap of beam vacuum in the sector magnets.

The material of septum for the EIC is stainless steel. For the EDC, copper is used in consideration of heat load. Figure 4 shows a photograph of the entrance of the

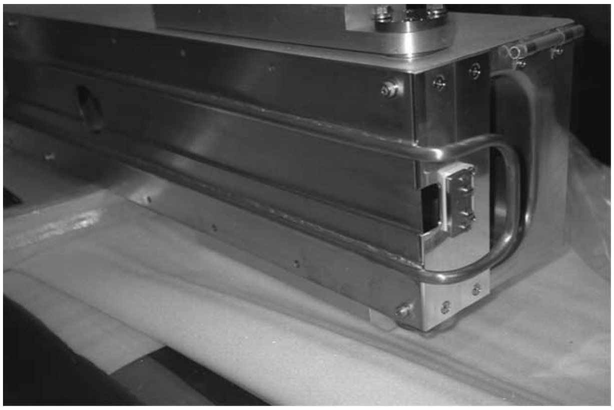

Figure 4: Photograph of the entrance of the EDC.

EDC. Gap width of the EIC and the EDC is 12 mm. Power supplies of 120 kV are prepared. For usual use, 80 kV/cm is enough for both electrostatic channels. Table 3 shows characteristics of the injection and extraction elements.

Table 3: Characteristics of the injection and extraction elements.

Magnetic elements

Element	Bend angle (deg.)	Radius (m)	Field (T)
BM1	105	1.65	1.82
MIC1	30	1.53	0.12
MIC2	60	1.43	0.25
MDC1	20	2.55	-0.07
MDC2	35	2.63	-0.12
EBM1	13	3.3	1.43
EBM2	32	2.8	1.68

Electrostatic elements

Element	Length(m)	Radius(m)	Field(kV/cm)
EIC	0.7	30	100
EDC	1.3	90	100

4 RF SYSTEM

Two kinds of resonators are adopted for the IRC: two main resonators and one flattop resonator. The main resonators are of a single-gap type with flapping panels for changing resonant frequency. This type of resonator has a large advantage in that the area of sliding RF contact can be minimized. The maximum voltage is supposed to be 600 kV for one resonator. The flattop resonator is of a single-gap type with shorting plates. Details of the RF system for the IRC are reported at this conference[4]. Figure 5 shows a photograph of the main resonators.

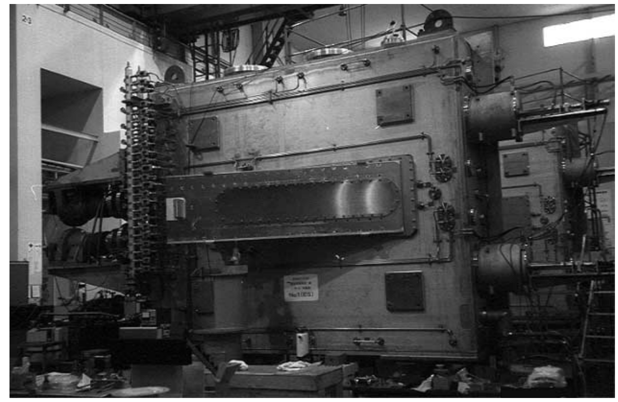

Figure 5: Photograph of the main resonators.

5 BEAM MONITORS

The beam monitor system consists of two main differential probes (MDP1 and MDP2), two injection radial probes (IRP1 and IRP2), two extraction radial probes (ERP1 and ERP2) and one phase probe. Strokes of MDP1 and the MDP2 are 2.7 m and 2.4 m, respectively. Moving speed of the probes is designed to be 2 m/min. The beam sensor part of IRP2 is of a block type, and those of the IRP1 and ERPs are of a wire type with three tungsten filaments. The phase probe is equipped with sixteen pairs of electrodes.

6 VACUUM SYSTEM

The main vacuum system consists of 12 cryopumps with pumping speed of 10,000 L/sec and 2 cryopumps with pumping speed of 4,000 L/sec. The required pressure is about 1×10^{-6} Pa. Eight turbo-molecular pumps with pumping speed of 350 L/sec are used for sub vacuum parts of the main resonators, which are loosely separated from the beam vacuum[5].

7 CONCLUSION

The construction of the IRC started in 1998. Almost all the components of the IRC are completed. Installation of the IRC will start in April 2003 immediately after the completion of the buildings.

REFERENCES

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