MAIN SECTOR MAGNET OF THE RCNP RING CYCLOTRON

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Abstract

The main magnet system of the RCNP ring-cyclotron is briefly described and the results of the magnetic field measurement are presented in this report.

Introduction

The construction of the RCNP ring-cyclotron which can accelerate protons and light ions up to 400 MeV 100 MeV/nucleon respectively, was finished in March, 1991. The parameters of the spiral sector magnet are listed in Table 1. The shape and the geometrical size of the magnet are shown in Fig. 1. The maximum magnetic field required for the ring cyclotron is 17.5 kG. The maximum magneto-motive force is 1.4×10^5 ampere-turns. The main coil and the auxilliary coil consist of 80 turns and 20 turns, respectively. We can control the magnetic field of 500 Gauss by the auxilliary coil for each sector. In order to reproduce isochronous fields for various ions and energies, the trim coils of 36 pairs are mounted on the pole faces. Fig. 2. show the sector magnets installed in the cyclotron vault. The field measurement was performed for six sector magnets. In this paper, the results of the field measurement are presented.

Field Measurement

Twenty Hall generators arranged radially were used for the measurement. The measuring system and the power supplies are controlled by a computer (μ-VAX). We measured field maps with azimuthal interval of 0.4° step or 0.8 step and with the radial interval of 20 mm step over the whole region.

Main Base Field

Measurement of the base field distributions of six sectors was carried out for seven main coil currents of 250A, 350A, 400A, 450A, 500A, 550A and 650A. These coil currents correspond to the field strength of 8.5 kG 11.7 kG, 13.2 kG, 14.5 kG, 15.6 kG, 16.3 kG and

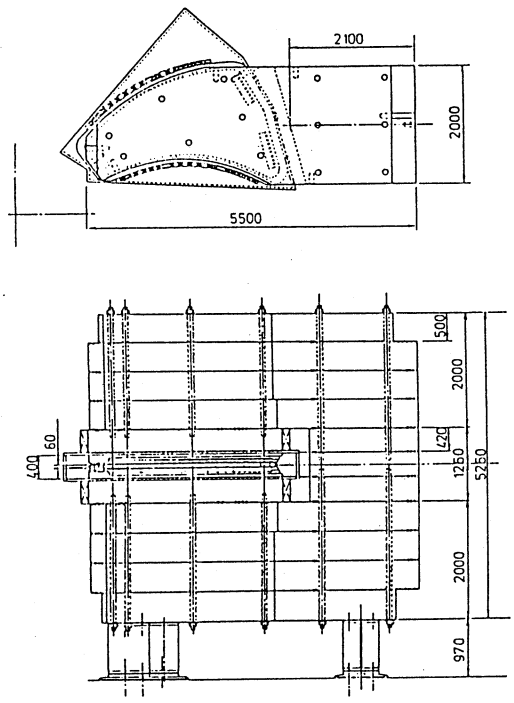

Fig. 1 Shape and geometrical size of the sector magnet.

Table 1
Final parameters of the spiral-sector magnet

Number of sector magnets	6
Gap width	60 mm
Hight of magnet	5.26 m
Overall diameter	14.4 m
Total weight	~2200 tons
Injection radius	2 m
Extraction radius	4 m
Maximum magnetic field	17.5 kG
Maximum ampere turns	1.4×10^5 A.T
Maximum current	900 A
Maximum power	440 kW
Number of trim coils	36 pairs×6
Maximum current	500 A
Total trim coil power	~350 kW

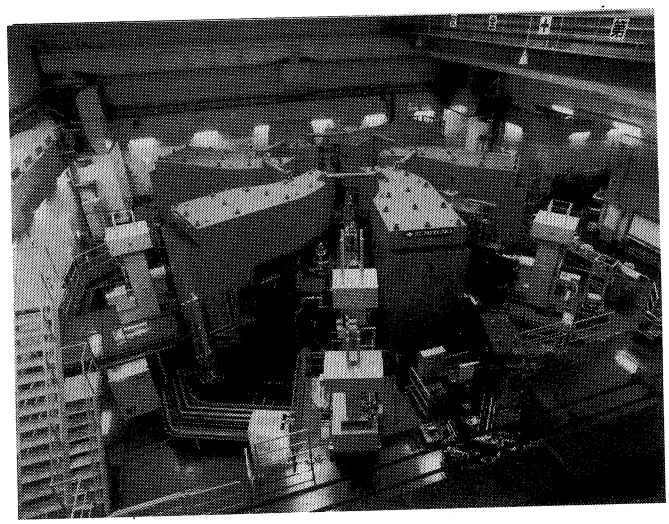

Fig. 2 Photograph of the sector magnets.

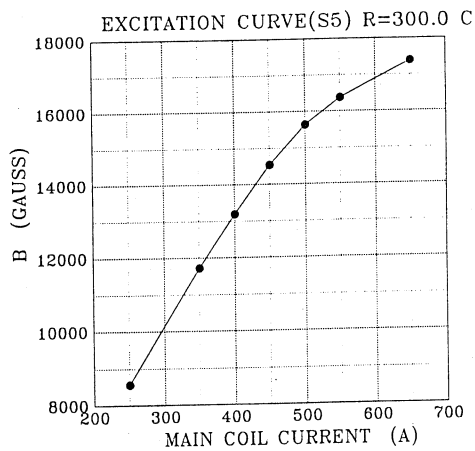

Fig. 3 Excitation curve of the sector magnet.

17.5 kG, respectively. The injection and the extraction elements were excited during the measurement. Current stability of main coil power supply was better than $\pm 2 \times 10^{-6}$ for eight hours. Fig. 3 show the excitation curve. The base field distributions along the center line of the No.5-sector for the seven levels of the main coil currents and the relative strength are shown in Fig. 4. Perturbation due to the injection and the extraction elements were observed, more or less, in all the sector magnets. The ratio $K_b = Bc/\bar{B}$) between the field strength averaged along the closed orbit ($\bar{B}$) and that at the sector center line (Bc) and the ratio ($Kr = Rc/\bar{R}$) were calculated using the measured map data of field distribution. Those of each sector at 500A (14.5 kG) excitation are shown in Fig. 5. The difference of the field distributions among six sectors are seen in the injection and the extraction region.

Trim Coil Field

Measurement of the trim coil fields was performed for the No.5-sector magnet only in the base of the main coil currents of 250A, 450A, 550A and 650A. In order obtain non-linear effectiveness of the trim coil field, four kinds of the measurement were carried out for each level of the main coil current. The field gradient of isochronous field distribution is positive for protons of higher energy than 200 MeV and is negative for heavier ions than protons. In the measurement, the current was fed to each trim coil to make the field gradient corresponding to the gradient of the isochronous field distributions of 300 MeV and 400 MeV protons (positive gradient) and 400 MeV and 100 MeV alpha particles (negative gradient). Figure 6 shows the examples of the trim coil field distributions along the sector center line in the cases of the field gradients corresponding to the 400 MeV proton and to the 400 MeV alpha field gradients at the 450A base field, respectively. In order to estimate the difference of the effectiveness of the trim coil fields among the six sectors, the field maps with the field gradients were also measured for each sector.

Summary

Field measurements for the RCNP ring-cyclotron were carried out and the basic field characteristics were analyzed. The results including pole profile and the field distribution are satisfactory and we do not have serious problems. The isochronous fields for the accelerated ions have been produced by using all of the measured data and by taking account of detailed correction for the differences among the six sector magnets. We are accelerating protons up to 400 MeV.

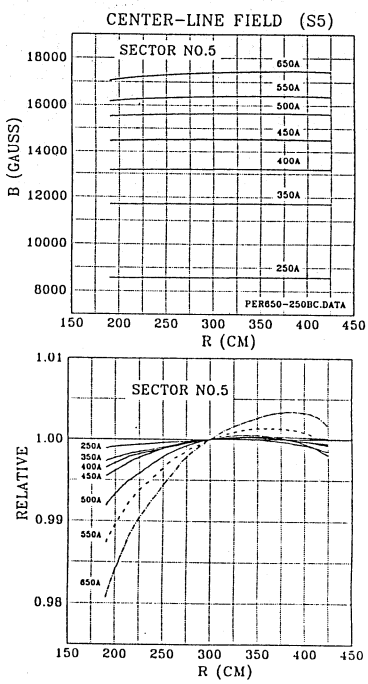

Fig. 4. The base field distributions along the center line of the No.5-sector for the main coil currents and the relative strangth.

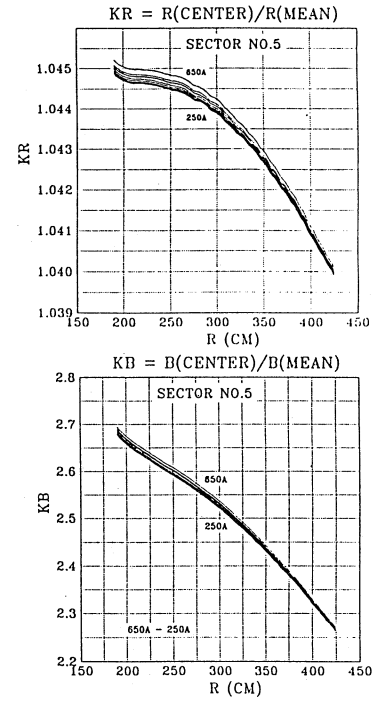

Fig. 5. K_b and K_r values of the six sectors at 500A excitation.

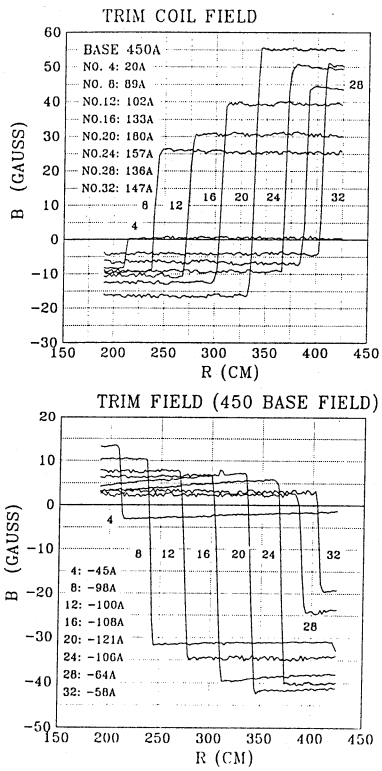

Fig. 6. Examples of trim coil field distributions along the sector center line in the case of the field gradients corresponding to the 400 MeV proton and 400 MeV alpha particle field gradients at 450A base field.