SECTOR MAGNETS OF THE RCNP RING-CYCLOTRON

K. Hosono, M. Kibayashi, I. Miura, J. Abe*, Y. Kimura* and I. Taguchi*
Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567
*Sumitomo Heavy Industries, Ltd.,
Accelerator Business Center, Technical Department,
Niihama, Ehime 792

Abstract

The main magnet system of the RCNP ring-cyclotron is briefly described and the results of the preliminary measurements of the magnetic field performed at the factory are present in this report.

Introduction

A ring-cyclotron (Separated Sector Cyclotron) which can accelerate protons and light ions up to 400 MeV and 100 MeV/nucleon respectively, is being constructed at RCNP. The main magnet system consists of six spiral-sectors. The first and the second sector magnets of the six sectors were assembled at the factory of Sumitomo Heavy Industries (SHI) and the preliminary measurements of the magnetic field have been performed. It was found that the spiral sector magnets have a good performance and do not require a serious modification from the results of the measurement.

Sector magnet

The design parameters of the spiral sector magnet are listed in Table 1. The shape and geometrical size of the magnet are shown in Fig. 1. A vacuum chamber made by SUS is welded at the side faces of the pole. The detailed cross sectional view of the pole edge section is shown in Fig. 2.

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 auxiliary coil consist of 80 turns and 20 turns of copper hollow conductors, respectively. For each sector, we can control the magnetic field of 500 Gauss by the auxiliary coil.

Table 1
Final design parameters of the spiral-sector magnet

Number of sector magnets	6
Sector angle	22° ~27.5°
Gap width	60 mm
Height 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

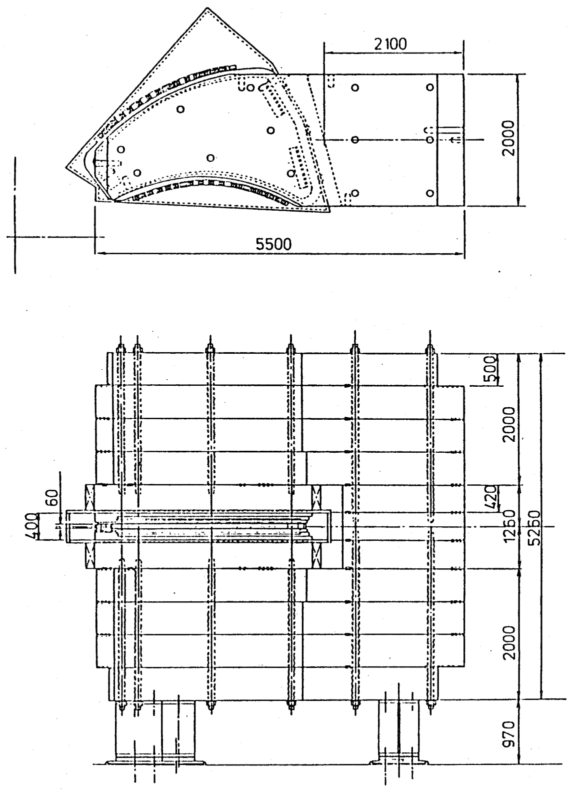

Fig. 1 Shape and geometrical size of the sector magnet.

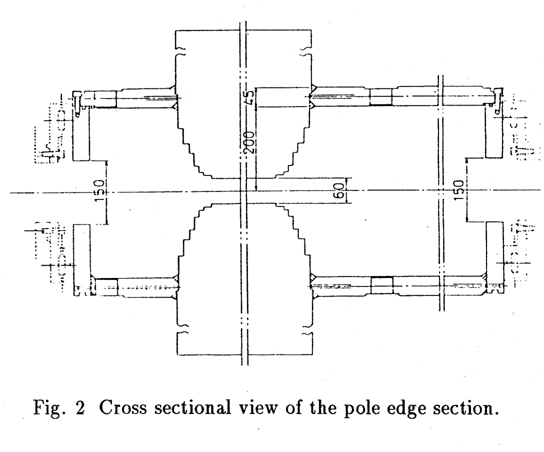

Fig. 2 Cross sectional view of the pole edge section.

In order to reproduce isochronous fields for various ions and energies, the trim coils of 36 pairs are mounted on the pole faces. Two pairs among them are also used as harmonic coils. They have a shape of hard-edge pattern of the equilibrium orbit and are made by copper-plates of 8 mm in thickness. Each trim coil is coated with alumina-ceramics (Al_2O_3) for insulation and is fixed on the pole face by SUS-Fe bolts. A photograph of trim coils mounted on the pole face is shown in Fig. 3. The detail of the sector magnet system can be seen elsewhere.[1)]

Field measurement

Preliminary field measurement has been performed at SHI. Twenty Hall generators arranged radially have been used for the measurement. The measuring system and power supplies are controlled by a computer (μ-VAX). By the field mapping system, we can measure field maps with the azimuthal interval of 0.4° step and with the radial interval of 10 mm or 20 mm step over the whole region.

Field measurements have been performed using two sectors. Fig. 4 is a photograph of the two sector magnets. Excitation characteristic of a sector magnet is shown in Fig. 5. Base field maps have been measured for four levels of main coil currents (300, 500, 600 and 700 A). These main coil currents correspond to the base fields of 10, 15, 16.8, 17.8 kG, respectively. The results of the base field distributions along the hill center line are shown in Fig. 6. The sector width obtained from the measured effective boundary of the field distributions was compared with the designed sector width and the results is shown in Fig. 7.

Orbital calculations have been made using the results of the measured field distributions. Fig. 8 shows the betatron frequencies calculated from the measured field and the designed values. It is founded from the results that the requirement for the sector magnet of the ring-cyclotron is fulfilled sufficiently.

The effective fields produced by the trimming coils have also been measured at the 16.8 kG base field. An example of the results is shown in Fig. 9. We could obtained the effective field strength as designed. Fig. 10 shows the comparison between the ideal isochronous field for the 400 MeV proton and the calculated field distribution using the measured base field and trim coil fields.

Summary

The preliminary measurements of the magnetic field of the main sector magnet have been performed. The results including pole profile are quite satisfactory and we do not have serious problems.

Installation of the magnet-system at RCNP will be started in February, 1990. The complete field measurements of the whole magnet system including magnets of injection and extraction system are scheduled to start in August, 1990.

Reference

1) K. Hosono et al.; Proc. 12- Int. Conf. on Cyclotrons and Their Applications, Berlin (1989),

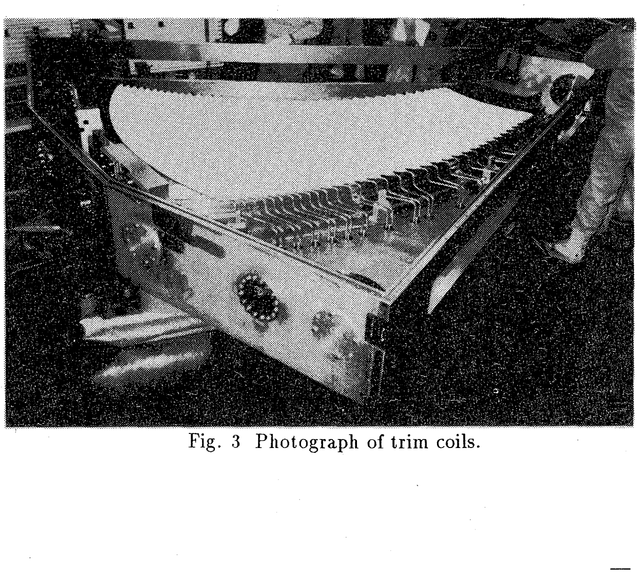

Fig. 3 Photograph of trim coils.

Fig. 4 Photograph of the sector magnets

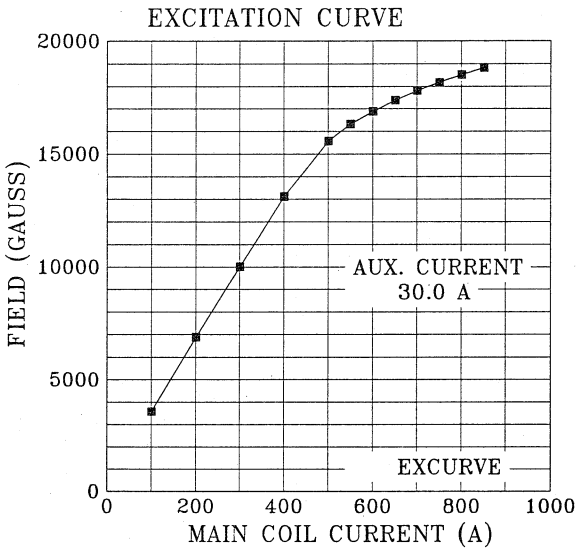

Fig. 5 Excitation curve of the sector magnet

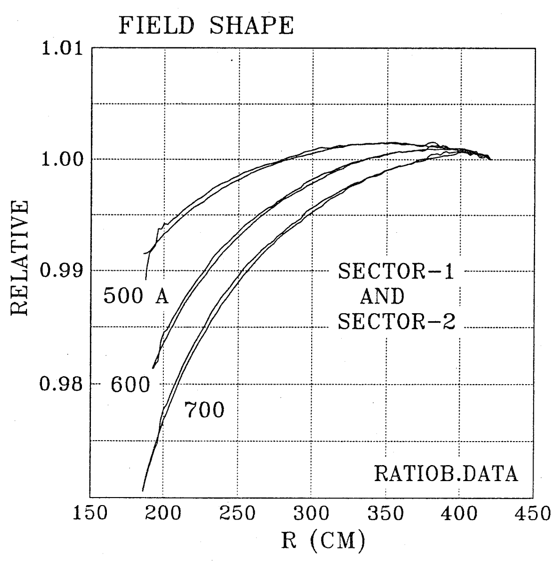

Fig. 6 Relative field distribution along the sector center line

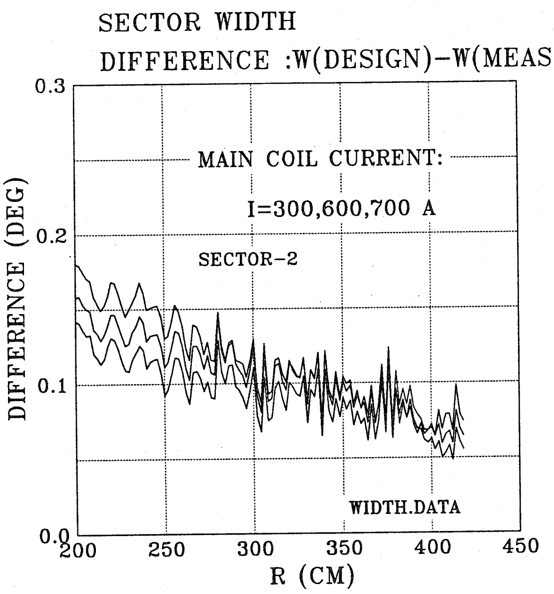

Fig. 7 Comparison between the designed and the measured sector width obtained from the effective field boundary

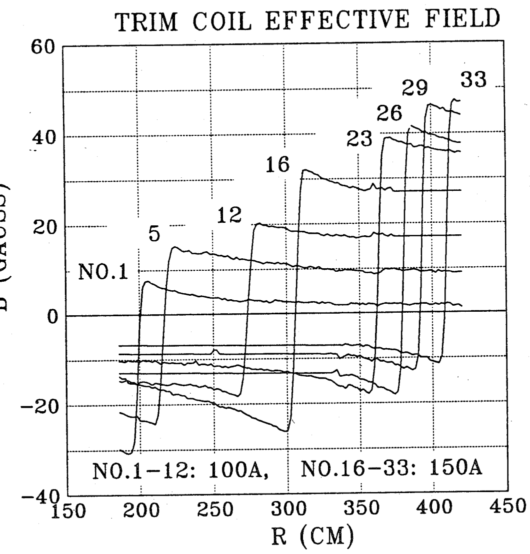

Fig. 9 Effective fields of the trim coils

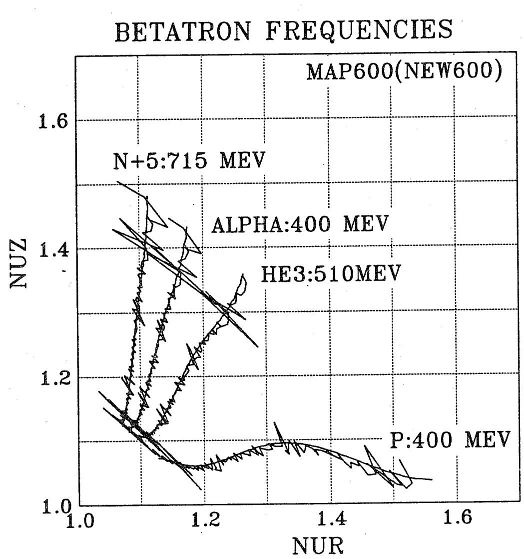

Fig. 8 Comparison between betatron frequencies calculated form the measured base field of 16.8 kG and the designed ones

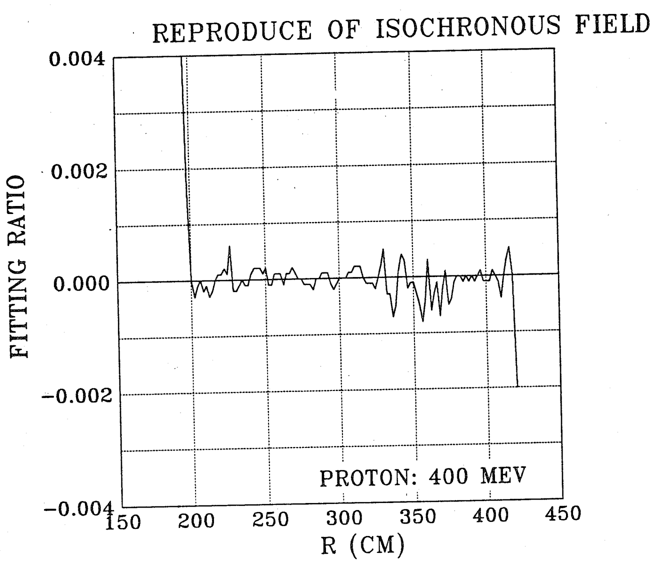

Fig. 10 Comparison between the ideal isochronous field for 400 MeV proton and the caluculated field distribution using the measured base field and trim coil fields