Model Test of the RIKEN-IRC Main Resonator

Naruhiko SAKAMOTO, Osamu KAMIGAITO, Yoshitoshi MIYAZAWA, Toshiya Chiba,
Akira GOTO, and Yasushige YANO

RIKEN, 2-1 Hirosawa Wako Saitama 351-0198, Japan

Abstract

A 1/5 scale model of the acceleration resonator for the RIKEN intermediate-stage ring cyclotron (IRC) in RIBF[1] was built to measure its rf characteristics. The resonant frequency range was almost consistent with the calculated values obtained from MAFIA[2] calculations. The measured Q-values were 60-70 % of the theoretical values. The size of the inductive coupler for the 1/1 scale resonator was determined by using this model. The electric fields were measured by using a perturbation method.

1 Introduction

The IRC which is the first stage booster in the RIKEN RI Beam Factory consists of four normal conducting sector magnets, two acceleration resonators and one flat-top resonator[3]. The frequency range of the acceleration resonators are from 18.2 to 38.2 MHz. In order to obtain a sufficient turn separation at extraction of about 6 mm, the maximum dee voltage is required to be 600 kV at the frequency of 38.2 MHz. The geometrical design has been made by using a three dimensional rf calculation code MAFIA. In order to find the accuracy of the calculated frequencies and how large is the Q-values in comparison with the theoretical ones, a 1/5 scale model was built and test measurements were performed.

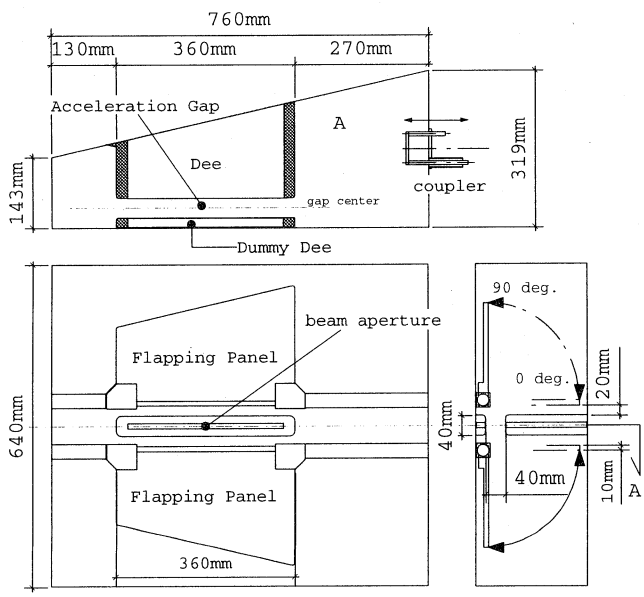

Fig. 1 Schematic drawing of the 1/5 scale model.

2 Design of the 1/5 scale model

A schematic drawing of the 1/5 scale model is shown in Fig. 1. The resonator is an wedge shaped single-gap-type. The resonant frequencies of the resonator are tuned by flapping panels which locate symmetrically with the median plane. The rf characteristics of the 1/5 scale model were calculated by using MAFIA(see Table 1). The frequencies and Q-values of the model are 5 and $\sqrt{5}$ times larger than those of the 1/1 scale resonator, respectively.

Since the calculated Q-values are rather large, the mechanical design was carefully made and simulated the structure of the 1/1 scale resonator in order to evaluate accurately how large the Q-values are in comparison with the calculated ones. To know the realistic Q-values is crucial in determining the rf power and the coupler size of the 1/1 resonator.

The conductive parts of the model were made of copper. The contact fingers and contact strips were used to reduce a resistivity between the conductive parts. The screw bolts were copper plated. The overall geometrical misalignment was less than 0.3 mm. The rf power was fed by using an inductive coupler which was located at the center of the rear wall as shown in Fig. 1.

Table 1
The calculated resonant frequencies and Q-values by using MAFIA.

Flapping Panel	0 deg.	90 deg.
Frequency	89.8 MHz	193.6 MHz
Q-value	12970	16550

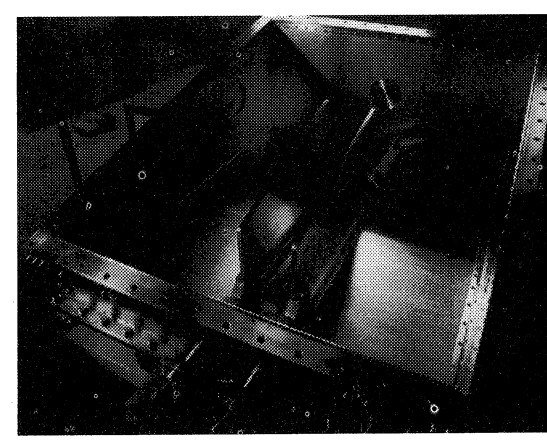

Fig. 2 Photograph of the model resonator. Flapping panels are set to be the position of the lowest frequency of the resonator (0 deg.).

3 Test measurements

3.1 resonant frequencies and Q-values

The resonant frequencies and the Q-values were measured by using a network analyzer with an S-parameter test set(HB8753E). Two pickup loops were used, one was for excitation and the other for detection. These loops were identical and were very weakly coupled to the resonator. Fig. 3 shows the measured resonant frequencies and Q-values. The measured resonant frequency were rather high in comparison with calculated values(compare Table 1 and 2). The Q-values were large enough as 63-71 % of the calculated values.

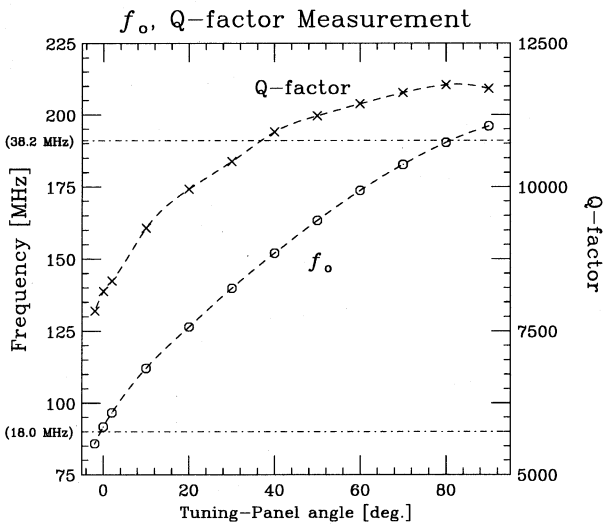

Fig. 3 Measured resonant frequencies and Q-values for the 1/5 scale model

Table 2
Measured resonant frequencies and Q-values at the panel angles of 0 deg. and 90 deg. .

Flapping Panel	0 deg.	90 deg.
Frequency	91.69 MHz	196.05 MHz
Q unloaded	8190(63%)	11710(71 %)
loaded	4190	5840

() ratio to the theoretical values listed in Table 1

3.2 Coupler test

The coupler was an inductive type one whose coupling could be varied by changing the cross section of the loop. A schematic drawing of the coupler for the model is shown in Fig. 4. The part of the coaxial transmission was designed so that its impedance was 50 Ω. By sliding the coupler position$l$ = 14~35 mm, the input impedance of the resonator could be matched to 50 Ω[1] and the S_{11} were less than -50 dB for the whole frequency range. The loaded Q-values were almost 50 % of the unloaded ones (see Table2).

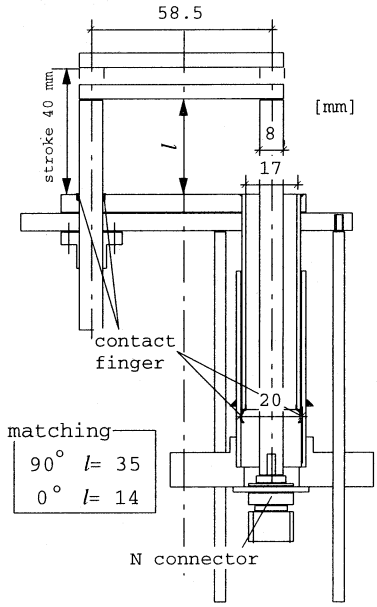

Fig. 4 Schematic drawing of the coupler

3.3 Electric field measurement

The measurement of the electric field distributions were performed by using a perturbation method. A setup of the measurement is shown in Fig. 5. A spherical field perturbator(3/8"ϕ) made of Teflon were used. The contour plots of the measured field strength were made in Fig. 6. The peak of the field distribution along the beam direction is shifted to the dee side from the gap-center as shown in Fig. 6. By integrating the field strength distribution along the beam orbit, gap voltages were obtained as Fig. 7. The accelerating voltage distribution were found to be in good agreement with the MAFIA calculation.

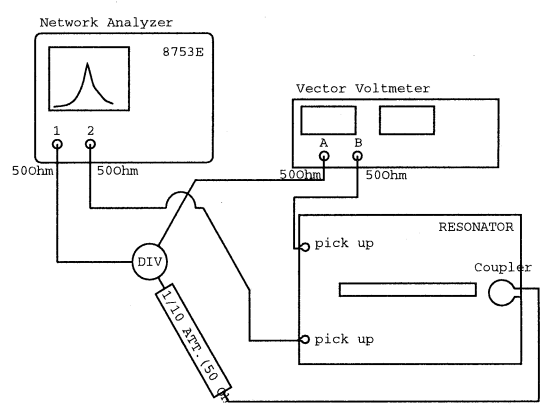

Fig. 5 Setup of the electric field measurement

[1]impedance of the power feeding circuits

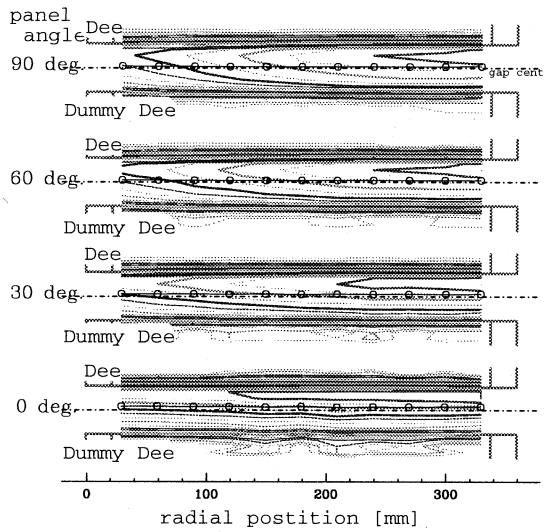

Fig. 6 Measured electric distribution

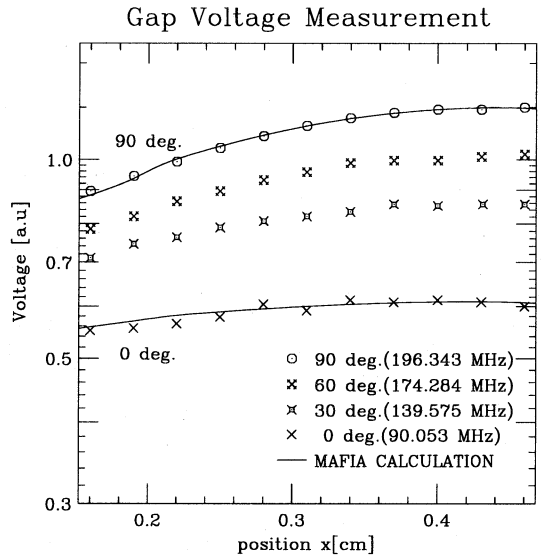

Fig. 7 Gap voltage distribution. Curves are obtained by MAFIA

4 Feedback to the 1/1 scale resonator

- According to the result of the frequency measurement, a gap size between the flapping panel and the dee surface at the panel position of 0 deg. was reduced by 5 mm (original 100 mm → new 95 mm) so as to the lowest frequency became lower.
- The size of the coupler was decided to be 5 times larger than the model coupler i.e. the margin of the coupling size is about 50 %.
- The alignment of the gap of the flat-top resonator was rearranged according to the measured electric field distribution.

5 Summary

A 1/5 scaled model of the RIKEN-IRC acceleration resonator was built for the test of its rf characteristics. The resonant frequency range was higher than the calculated values. The measured Q-values were about 70 % of the theoretical values. The electric fields were measured by using a perturbation method. These results have been fed back to the design of the 1/1 scale resonator which is now under construction.

Acknowledgement

One of the author, N. Sakamoto, is grateful to Mr. Y. Kumata for discussion on the design of the 1/1 scale resonator. The model was manufactured by Morishima Works, co. Ltd. The model coupler was manufactured by Mr. S. Hirasawa.

References

[1] Y. Yano et al., Proc. of 1997 Partl. Accel. Conf., p.930.
[2] The MAFIA collaboration, User's Guide MAFIA Version 4.0, CST GmbH, Lauteschägerstraße 38, D-64289, Darmstadt, Germany.
[3] N. Sakamoto et al., Proc. the 15th Int. Conf on Cyclotrons and Their Applications, (1998 Caen), p 223.