THE FLAT-TOP SYSTEM FOR THE RCNP AVF CYCLOTRON

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Abstract

To improve beam quality of the AVF cyclotron, which is used as the injector of the Ring cyclotron, a flat-top system is designed. The flat-top frequencies are fifth, seventh and ninth harmonic of the acceleration frequency. The 180degree dee of the AVF cyclotron has a transverse resonance mode, of which resonance frequency is in the region of the flat-top frequency. To remove effect of the transverse resonance mode, a new slotted dee electrode is designed. The possibility of the flat-top system is examined by using a 5th-scale resonator model.

INTRODUCTION

The RCNP cyclotron cascade system has been operated to serve various kind of high quality beams for various experiments. The cyclotron cascade system is consisting of the injector AVF cyclotron and the ring cyclotron. The flat-top acceleration system of the RCNP ring cyclotron is indispensable for operation of the cyclotron to accelerate high quality beams. The flat-top system of the ring cyclotron operates successfully to provide high quality beams with very low energy spread and high extraction efficiency. At present the beam quality of the ring cyclotron is restricted by the performance of the injector AVF cyclotron. To improve furthermore the beam quality of the AVF cyclotron, a flat-top system is proposed. The system generates a flat-top voltage by superposing the fundamental and odd higher harmonic voltage on the same dee electrode with adding an additional resonator at the main acceleration resonator. [1]

MODEL TEST

The specifications of the RF system for the AVF cyclotron are shown in Table 1.

The maximum RF power is estimated with even scale resonator model and an equivalent circuit model analysis. The lowest frequency of the flat-top system is limited by voltage or current density at the flat-top resonator. To use ninth harmonic frequency, the maximum voltage and current density is limited below 80kVpeak and 50A/cm, respectively at low acceleration frequency region. The flat-top frequency range covers full frequency range of acceleration. The AVF cyclotron is of the three-sector type. It has a single 180degree dee with the coaxial quarter wavelength resonator.

A horizontal cross section of the AVF cyclotron is shown in Figure 1. The acceleration RF power is fed

Table 1: Specifications of the RF system.

Acceleration Frequency	6 – 18 MHz
Max. Acceleration Voltage	100kVpeak
Flat-top Harmonic No.	5,7,9
Flat-top Frequency	54-90MHz
Max. Flat-top Voltage	5kVpeak
Max. Q-value of Flat-top resonator	2000
Max. Flat-top RF Power	15 kW
Max. Flat-top resonator voltage	80kVpeak
Max. Flat-top resonator current density	50A/cm

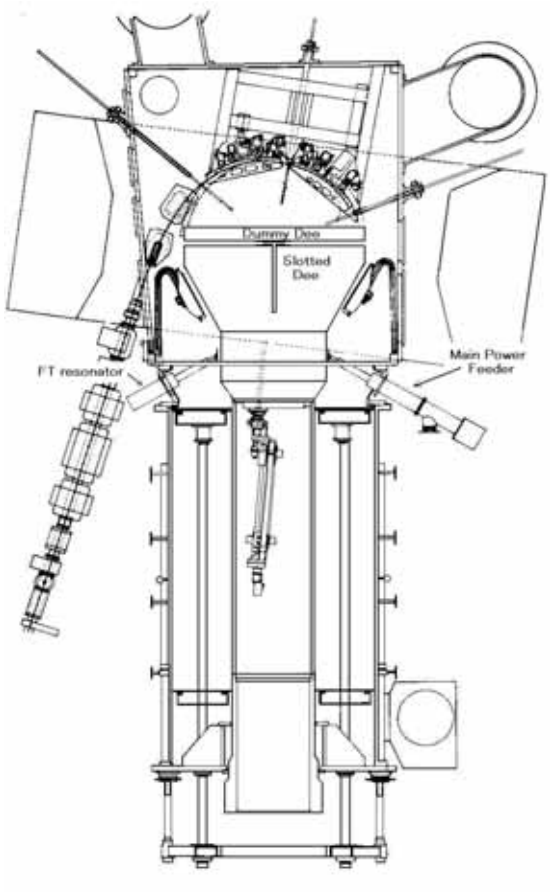

Figure 1: Horizontal cross section of the RCNP AVF cyclotron.

through the main power feeder. The additional resonator and power feeder for the flat-top system are capacitively coupled to the resonator at the left side as shown in Figure 1.

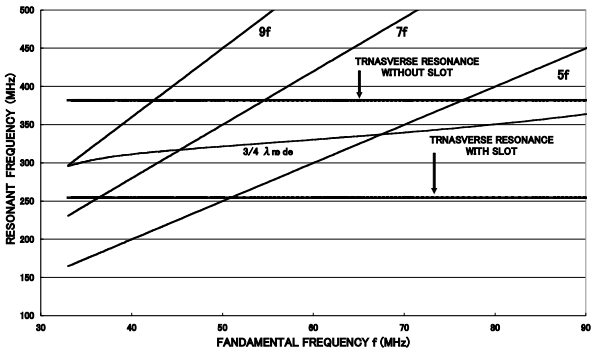

Figure 2: Measured resonant frequencies of higher mode of coaxial TEM mode and transverse modes vs. those of fundamental mode of the one-fifth scale model resonator. The flat-top frequencies are shown by the solid lines labelled 5f, 7f and 9f, respectively.

Measured resonant frequencies of the model resonator are shown in Figure 2. A transverse resonance mode of frequency 382 MHz is observed other than coaxial TEM mode resonance. The voltage distribution of this mode is shown in Figure 3. This resonance mode has a node at the centre of the acceleration electrode, and the RF phase is inverted at that point. Therefore around this frequency region, it is impossible to generate higher harmonic voltage with a flat voltage distribution along the acceleration gap.[2]

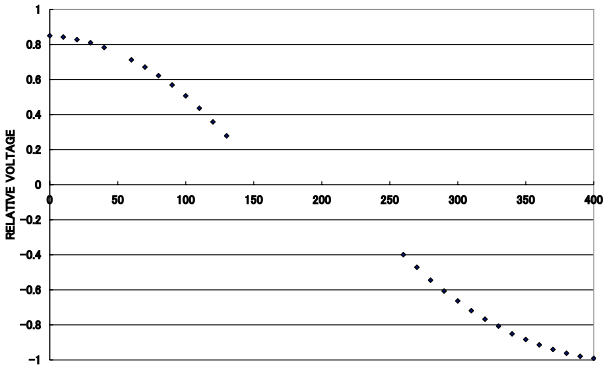

Figure 3: Voltage distribution of the transverse resonance mode along the acceleration gap.

To get around the difficulty, a new slotted dee is proposed. As shown in Figure 1, there is a cut extending over 1000 mm at the centre of the dee electrode. With the effect of the slot, the resonant frequency of the transverse mode is reduced about 130MHz as shown in Figure 2.

An influence on the voltage distribution by the slot is investigated by using the one-fifth scale model. Figure 4 shows voltage distribution of the fundamental mode resonance along the acceleration gap.

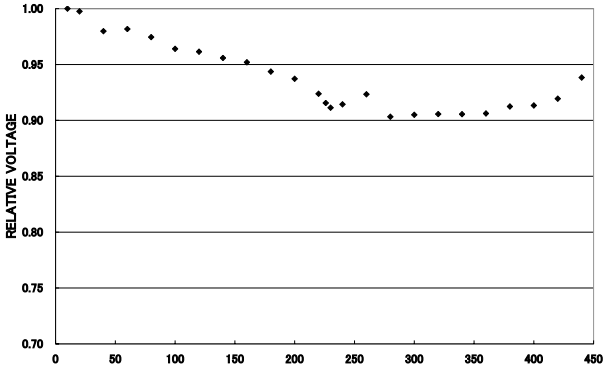

Figure 4: Acceleration voltage distribution along the acceleration gap of the slotted dee electrode.

The measured voltage distribution shows no effect of the slot. Nearly the same voltage distribution is also observed on the higher mode of the acceleration voltage and flat-top voltage. Because of the structure of the resonator, flat-top resonance modes have the same voltage distribution. So the flat-top system is effective all over the accelerating region.

FLAT-TOP SYSTEM

Based on the result of model tests and analysis of the equivalent circuit, a new slotted dee electrode and flat-top resonator are designed. The width of the slot is 20mm and the length is 1000mm. Deterioration of mechanical rigidity caused by the slot is small. The slotted dee electrode has enough stiffness against deformation or vibration of the electrode. There are no jointing insulators at the slot. Beam phase selection slit systems are provided in the dee electrode.

The flat-top resonator is a quarter wavelength coaxial type. The diameter of the water cooled outer conductor is 170mm. The maximum length of the resonator is about 700 mm.

A high power transistorized wide band amplifier is used as the flat-top RF power source. Control system for the flat-top RF signal is similar to that of the flat-top system of the ring cyclotron.[3] The new system will be installed by march 2005.

CONCLUSIONS

The undesirable effect of the transverse resonance mode for the flat-top system of the AVF cyclotron is effectively avoided by introducing a slotted dee electrode. Installation of a flat-top system of the AVF cyclotron will improve the beam quality and transmission efficiency. The better quality injection beam will contribute easier and stable acceleration of high quality beam of the ring cyclotron, and an ultra high quality beam will be offered for various experiments.

REFE RENCES

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