INITIAL OPERATION OF THE RF SYSTEM FOR THE RCNP RING CYCLOTRON

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Abstract

The RF system for the RCNP ring cyclotron is described. The RF system consists of three single gap acceleration cavities and a single gap flat-topping cavity. The RF system is being commissioned.

Introduction

The cyclotron cascade project of RCNP approved in 1986. General features of the project and the ring cyclotron are described elsewhere.[1] Fig. 1 shows relation between orbital frequencies and acceleration frequencies in the AVF cyclotron[2] and the ring cyclotron[3] for various ions and energies. The harmonic numbers of acceleration are also shown. Frequency range of the acceleration system is 30~52 MHz and harmonic numbers of acceleration is 6, 10, 12 and 18. Third harmonic of the acceleration frequency is used in flat-topping system.[4] Characteristics of the acceleration system and the flat-topping system are summarized in Table 1. Excellent phase stability is required to get high energy quality beam with flat-topping.

Table 1
Characteristics of the RF system

	acceleration system	flat-topping system
RF frequency	30~50 MHz	90~155 MHz
Harmonic Number	6,10,12,18	
Number of cavities	3	1
RF peak voltage	500 kV	170 kV
RF voltage stability	10^{-4}	10^{-3}
RF phase excursion	±0.1°	±0.3°
RF power output	250 kW/cavity	45 kW
1st stage TR wideband	500 W	500 W
2nd stage	RS2012CJ	4CX3500A
final grounded grid	RS2042SK	4CW 50,000E
Resonator	single gap	single gap
Power feeder	inductive coupling	inductive coupling
Beam aperture	30mm×2310mm	30mm×2310mm
Acceleration gap	200~300mm	50mm

Acceleration System

The acceleration cavity is variable frequency single gap resonator. Fig. 2 shows schematic drawing of the cavity. The resonant frequency is varied by rotating a pair of tuning plates. The plates are electrically connected to a wall of the cavity through current-carrying hinges. Maximum current density at the thin copper plate of the hinge is 20 A/cm. The fine tuning is done by changing the inductance with two cylindrical trimmers.

The walls of the cavity are made of stainless steel 50 mm in thickness with water cooled copper lining. The side walls is not strong to support atmospheric pressure. The walls are supported by the neighboring magnet chambers. After full assemble of ring cyclotron, full power test of the RF system was started. Fig. 3 shows photograph of acceleration cavity and final amplifier. The cavity was excited with pulse mode operation during conditioning. After 10 hours of conditioning, CW operation was enabled. The cavity was excited stably up to 300 kV after conditioning.

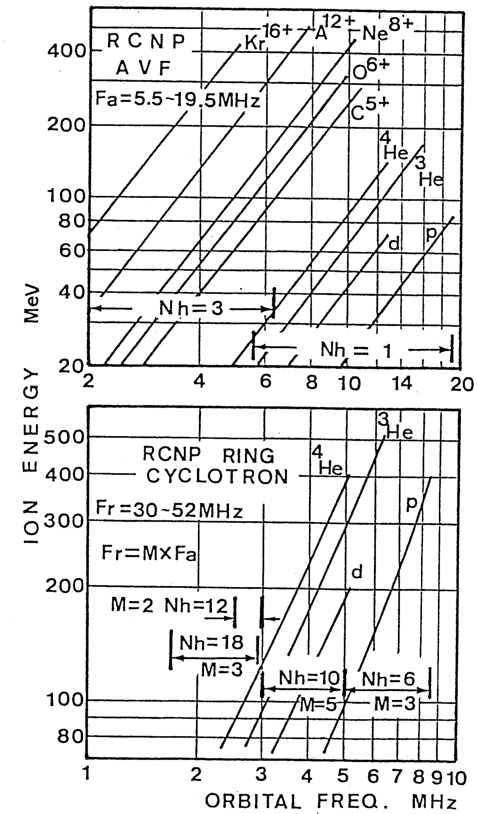

Fig. 1. Orbital frequencies, acceleration frequencies and harmonic numbers of acceleration in the present AVF cyclotron and the Ring Cyclotron. M is ratio of the RF frequency of the Ring Cyclotron to the AVF cyclotron.

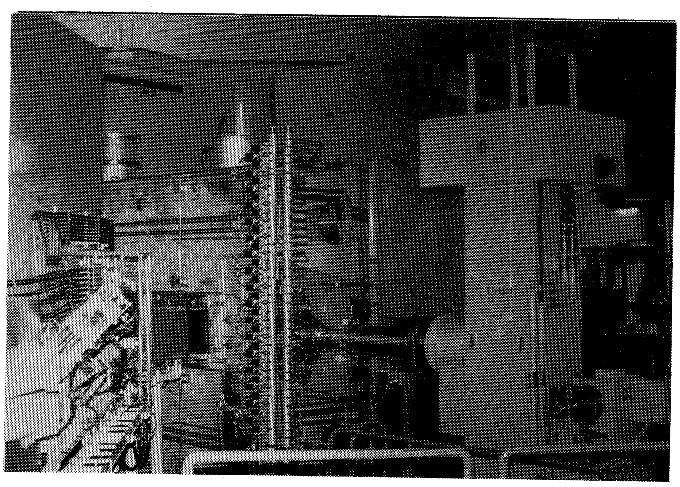

Fig. 3. Photograph of acceleration cavity and final amplifier.

Flat-topping System

A single gap resonator is also used for the flat-topping cavity. Fig. 4 is schematic drawing of the flat-topping cavity. The mechanical structure of the cavity wall is similar to that of the acceleration cavity. Resonant frequency is changed by sliding the upper and lower walls of the cavity. The flat-topping cavity is designed to get similar voltage distributions to those of the acceleration cavity.

Synchronized Operation of the System

A block diagram of the synchronized RF system is shown in Fig. 5. Acceleration frequency signal for the AVF cyclotron is used as clock signal of the whole RF system. The clock signal is converted to the acceleration frequency of the ring cyclotron. The signal generator and divider block generates flat-topping frequency, buncher frequency, local frequencies and intermediate frequency. Intermediate frequency signals are used as the sense signals of the phase control system and auto tuning servo system.

Each RF power is feed through variable length coaxial cable (50Ω) coupled to the cavity with variable coupling loop. The forward and reverse power signals are used for automatic tuning of the cavity. Relative phase stability between the cavities should be better than $\pm 0.1°$ to accelerate beams with good energy resolution ($< 10^{-4}$). A intensive effort was made to develop the delay block and signal generator and divider block. A digital delay units are used. The test of the phase control system shows phase stability better than $\pm 0.1°$.

References

1) H. Ikegami, Proc. of the 12th Conf. on Cyc. and Their Aple., Berlin (Germany) 1989, p. 30.

2) M. Kondo, IEEE Trans. NS-26 2, 1904-1911.

3) I. Miura et al., Presented at this symposium.

4) T. Saito et al., Proc. of the 12th Conf. on Cyc. and Their Aple., Berlin (Germany) 1989, p. 201.

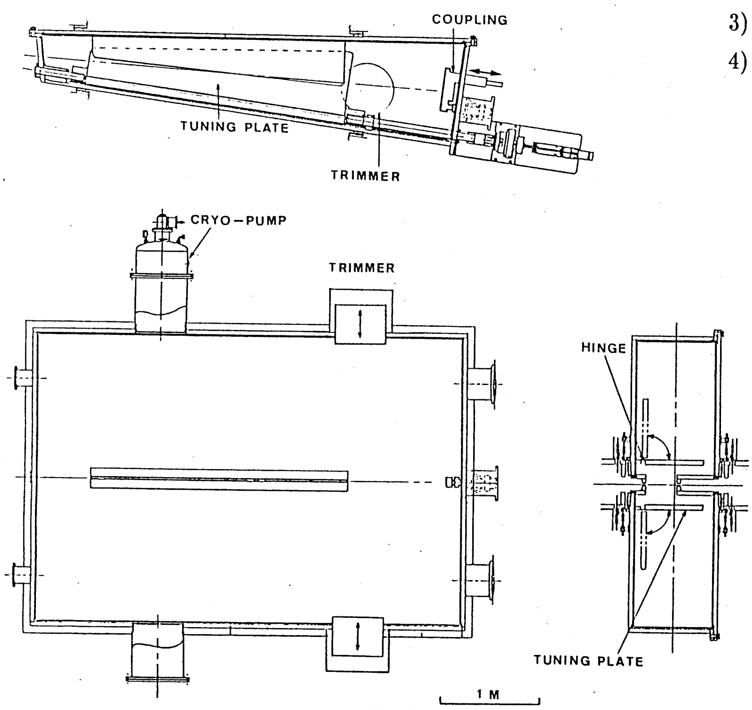

Fig. 2. Schematic drawing of the acceleration cavity.

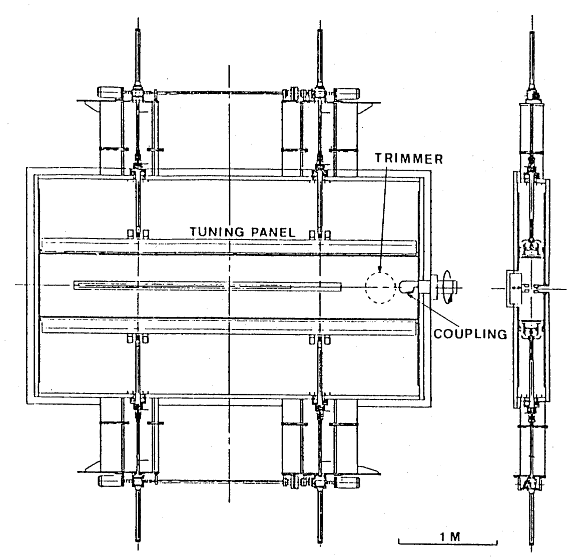

Fig. 4. Schematic drawing of the flat-topping cavity.

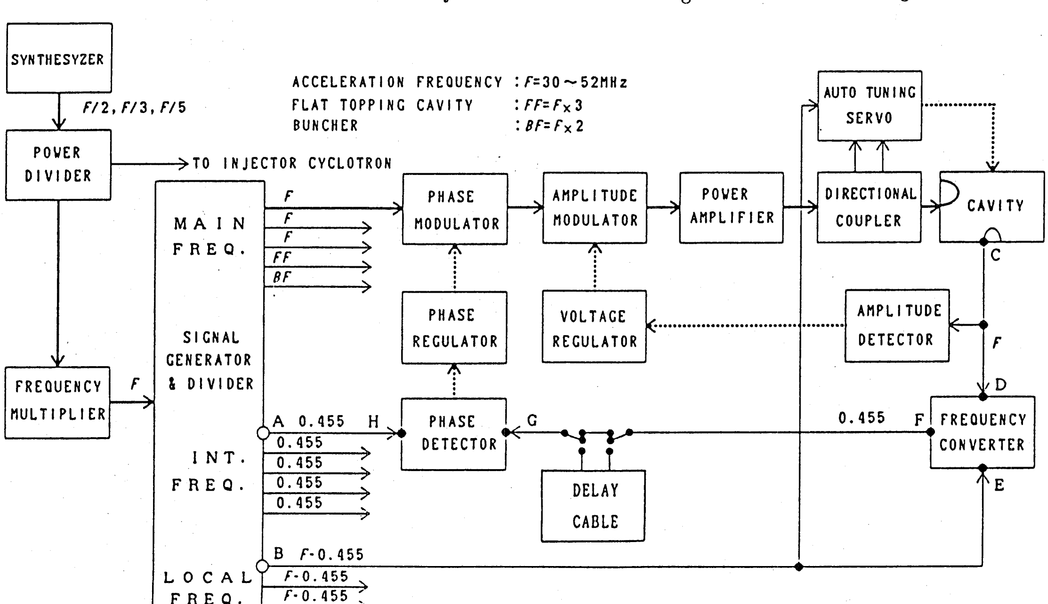

Fig. 5. Block diagram of the RF system.