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 operates satisfactorily and proton beams were successfully accelerated.

1. INTRODUCTION

The cyclotron cascade project of RCNP approved in 1986 and was completed in 1991. General features of the cyclotron are described elsewhere.1) Excellent phase and amplitude stability of the RF system are required to get high quality beam with the ring cyclotron.

2. ACCELERATION SYSTEM

Characteristics of the acceleration system and the flat- topping system are summarized in Table 1. The acceleration cavity is variable frequency single gap resonator. 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 and silver contacts. The hinge is consists of thin copper plates.2) Maximum current density at the plates is 20A/cm. The copper plates operate satisfactorily but silver contacts were replaced newly designed ones after 6 months operation. Each cavity is powered by a power amplifier capable of delivering 250kW in a frequency range of 30-52 MHz. The RF power is fed through a 50 Ω coaxial line which is coupled with the resonator by means of variable coupling loop. The forward and the reverse power signals are used for automatic tuning of the cavity. The fine tuning is done by changing the inductance with two cylindrical trimmers. The dynamic range of the trimmer is more than 0.2% in frequency.

The walls of the cavity are made of stainless steel 50mm in thickness with water cooled copper lining. The side walls of the cavity are not strong enough to support atmospheric pressure. The walls

Table 1
Characteristics of the RF system.

	acceleration	flat-topping
RF frequency	30～52MHz	90～155MHz
Harmonic Number	6, 10, 12, 18	
Number of cavities	3	1
RF power	250kW/cavity	45kW
1st stage (TR wideband)	500W	500W
2nd stage	RS2012CJ	4CW3500A
Final stage (grounded grid)	RS2042SK	4CW50,000E
Resonator	single gap	single gap
Power feeder	inductive coupling	inductive coupling
Beam aperture	30mmx2310mm	30mmx2310mm
Acceleration gap	200～300mm	50mm

are supported by the neighboring magnet chambers. Fig.1 shows photograph of the acceleration cavity and power amplifier. Fig.2 shows Q-value and angle of the tuning plates vs. resonant frequency.

A single gap resonator is also used for 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. Fig.3 shows voltage distributions of the acceleration cavity and the flat-topping cavity.

Frequency conversion method and intermediate frequency (0.455MHz) is employed on the control circuits of the RF system.2) These circuits are working fairly well but it remains final adjustments for better stability.

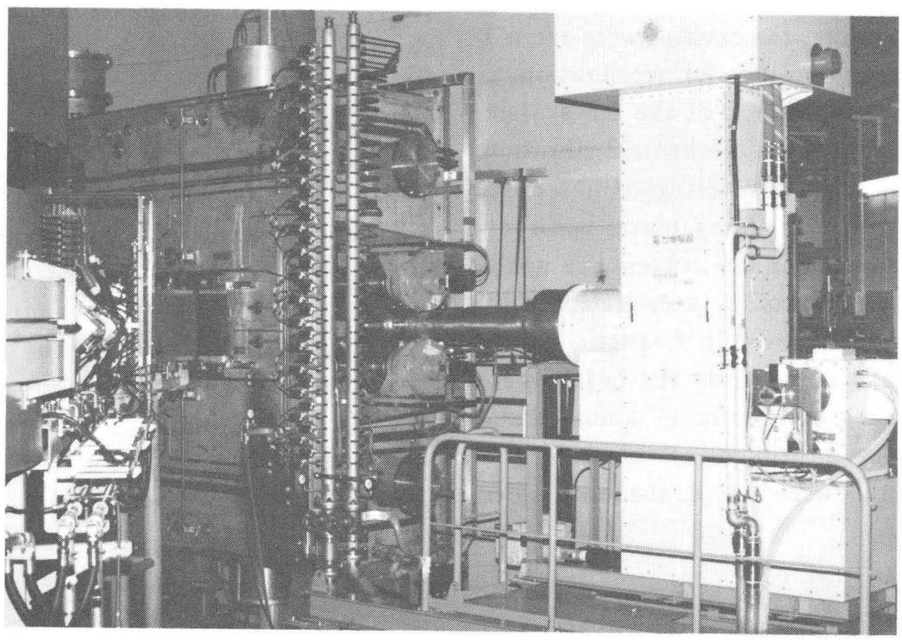

Fig. 1. Photograph of the acceleration cavity and the power amplifier.

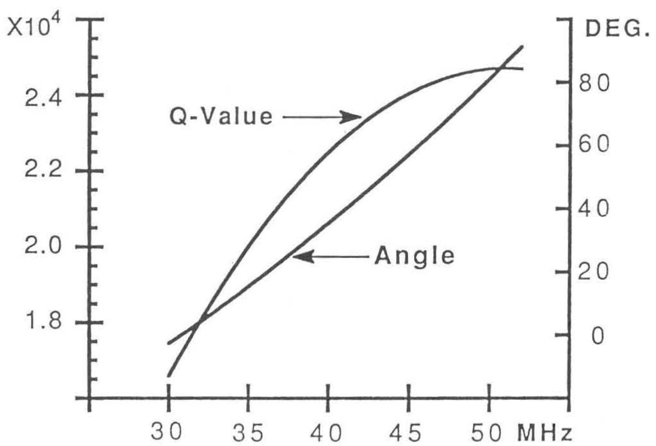

Fig. 2. Q-value and angle of the tuning plates of the acceleration cavity vs. resonant frequency.

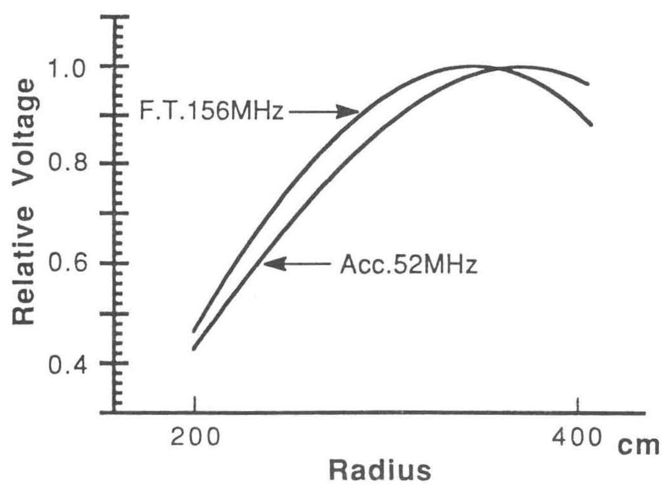

Fig. 3. Voltage distributions of the acceleration cavity and the flat-topping cavity.

3. POWER OPERATION

The power amplifiers have been tested separately on dummy loads in 1990, and proved to be able to generate enough power and have sufficient open loop stability at every frequency. After full assemble of the ring cyclotron, full power test of the RF system was started. The cavities were excited with pulse mode operation during conditioning. After about 10 hours of conditioning, CW operation of the acceleration cavities were enabled and less conditioning time was needed for the flat- topping cavity. After conditioning, the cavities were excited up to more than enough voltage for acceleration.

Typical data of operation of the RF system are shown in Table 2. Effect of mechanical vibration on stability of the acceleration voltage is observed. Mechanical strength of the tuning plates is strong enough for stable operation, the influence is not a serious problem. Stabilities of the acceleration voltage and phase will be improved in August.

The RF leakage power from the beam aperture of the flat-topping cavity caused serious damage to the trim coil feeds-through. RF shields for the trim coil feed-through were set on the both sides of the flat-topping cavity. The leakage RF signal also disturbs another electric instruments of the cyclotron. The leakage is induced by vertical asymmetry of the resonator, symmetric settings of the sliding walls are very important.

4. BEAM BUNCHER

A post-injector beam buncher being settled between the injector cyclotron and the ring cyclotron is also completed and used for the beam tuning. To inject longitudinally focused beam into the ring cyclotron, the buncher is essentially required in the achromatic beam line between two accelerators. The bunching is achieved by beam velocity modulation given by a synchronized higher harmonics RF voltage at two gaps of the buncher drift tube. The buncher resonator is a quarter wave variable frequency (60-104 MHz) coaxial type. A π-mode drift tube and the coaxial tuner made of polished OFHC copper is mounted on a cylindrical copper chamber. RF power is fed into the resonator through an adjustable capacitor to be matched to the 50 Ω coaxial feeder from the grounded grid power amplifier (4CW 25,000) mounted 1.5m apart from the resonator. To achieve phase focusing along with

Table 2
Typical operating data of the RF system.

Acceleration system (Ep=400MeV)	
Frequency	50.5361MHz
RF peak voltage(power)	520kV (115kW)
RF voltage stability	5×10^{-4}
	(goal 1×10^{-4})
RF phase excursion	less than ±1°
	(goal ±0.1°)
Flat-toppig system (Ep=300MeV)	
Frequency	138.75MHz
RF peak voltage(power)	120kV (25kW)
RF voltage stability	10^{-3}
RF phase excursion	less than ±1°
	(goal ±0.1°)

80m injection line drift space, the RF voltage required is 150kV with H_B=6 (102MHz) for the injection of 65MeV protons (400MeV from ring cyclotron). Fig.4 shows photograph of the resonator of the beam buncher.

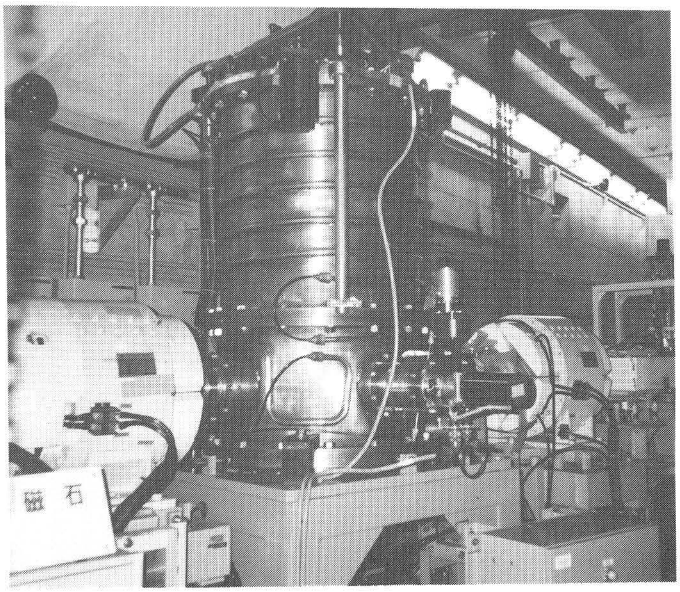

Fig. 4. Photograph of the resonator of the beam buncher.

5. REFERENCES

1) I. Miura et al., in these proceedings.
2) T. Saito, et al.,"The RF system for the RCNP ring cyclotron", in Proceedings of the 12th Conf. on Cyclotrons and Their Applications, (Berlin,1989)pp.201-204.