Commissioning of the rf system of SRC

N. Sakamoto, O. Kamigaito, S. Kohara, H. Okuno, M. Kase, A. Goto, and Y. Yano
Nishina Center, RIKEN

Abstract

The wide frequency range of the rf system of 18 $\sim$ 42 MHz is required for the acceleration of both light and heavy ions.

The main issue of the RIKEN RIB-factory is radioisotope production of a fission fragment method utilizing Uranium beams. Uranium beams are accelerated to 345 MeV/u by the Superconducting Ring Cyclotron (SRC) at a rf frequency of 36.5 MHz. Therefore the frequency of 36.5 MHz was chosen for the commissioning.

Installation of the resonators, power amplifiers and low-level controls started from July 2007. After the installation and a check of the rf components, the commissioning of the rf system started in the middle of November and finally the rf system became operational and successfully accelerated the Al beams up to 345 MeV/u on 28 Dec., 2007. In this year a careful conditioning of resonators and a tuning of amplifiers were made. An acceleration voltage of 2 MV/turn has been achieved and we succeeded the uranium beam acceleration.

COMPONENTS OF THE RF SYSTEM

The rf system of the SRC consists of four main resonators[1] for acceleration and a deceleration resonator for flat-top acceleration.

Table 1: Parameter specification of the rf system

cavity	main	ft
No. of resonators	4	1
Acceleration gap	single-gap	
Harmonic number	6	18 (24)
Frequency [MHz]	18$\sim$42	72$\sim$126
Q	28000(36.5 MHz)	28000 (109.5 MHz)
Rs [MΩ]	1.5(36.5 MHz)	1.6(109.5 MHz)
Max. gap voltage	600 kV	350 kV
Wall loss	120 kW	40 kW
Amplifier output	150 kW	60 kW
power tube	RS2042SK	RS2058CJ
Stability	$\Delta V/V < 10^{-4}$	$\Delta V/V < 10^{-3}$
	$\Delta\phi < 0.1°$	$\Delta\phi < 0.3°$

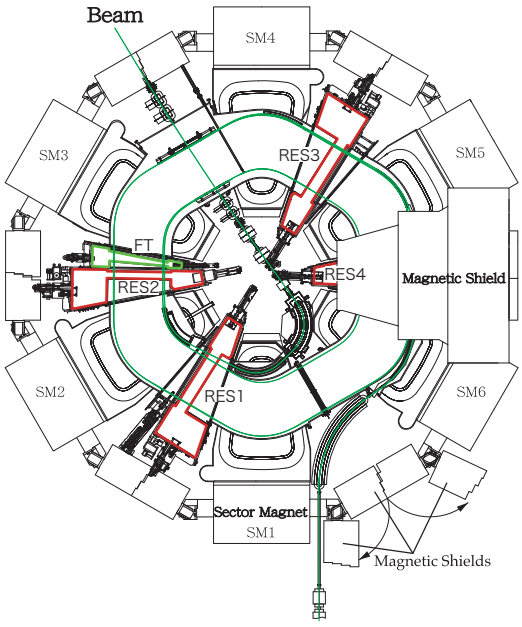

Figure 1: Schematic of SRC showing the arrangement of superconducting magnets, rf resonators(RES1$\sim$RES4,FT), etc.

The main resonators are single-gap type and work with a sextuple frequency of the beam revolution frequency (i.e. H=6). The resonant frequency of the resonator varies by symmetrical adjustment of two large capacitor panels.

The third and fourth harmonic of the acceleration frequency is employed for flat-top acceleration for the acceleration frequency of 24$\sim$42 and 18$\sim$24, respectively. The flat-top resonator, which is also single-gap type, has a pair of sliding short plate for a frequency tuning.

The four 150 kW power amplifiers utilizing a power tube RS2042SK for main resonators and a 60 kW power am-

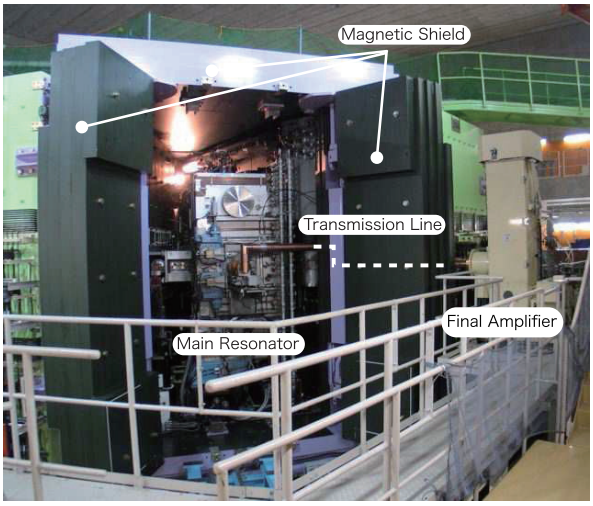

Figure 2: Photograph of the rf-system.

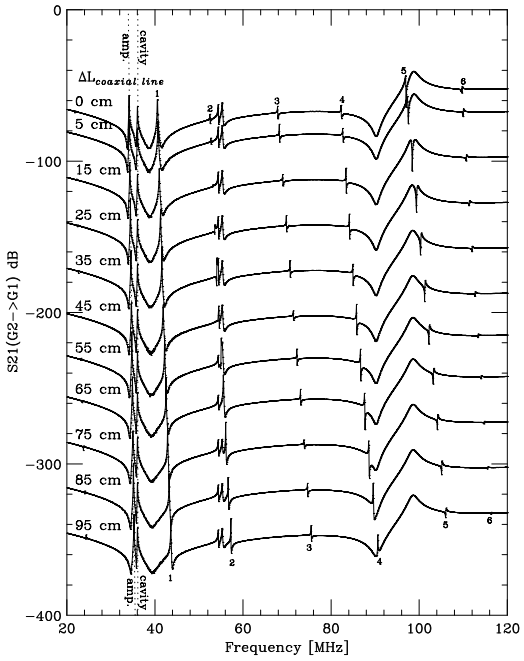

Figure 3: Resonance modes of the rf system. The resonator and amplifier are tuned to the frequency of 36.5 MHz. The resonances labeled with numbers are HOMs of the transmission line.

plifier utilizing a power tube RS2058CJ for a flat-top resonator are situated outside the magnetic shield of SRC, where stray field of the superconducting sector magnet is about 100 Gauss (vertical). Output port of the amplifiers are connected to the resonators with a 50 Ω coaxial line of WX152D for main resonators and WX120D for a flat-top resonator and the resonators are coupled with the coaxial line by inductive couplers. The couplers are tunable to match the impedance of resonator to 50 Ω. The coaxial-transmission line is equipped with a sliding system and the amplifier is placed on a movable platform so that the length of the transmission-line varies from 7 to 8 m. This is crucial to avoid the HOMs of the transmission line couple with HOMs of the amplifier and the resonator at the whole range of operational frequency. Fig. 3 shows the HOMs of the main rf-system. The 150 kW amplifier is known to have two critical modes. One is the resonance of the input stubs at 55 MHz and the other is the resonance between G1 and G2 electrodes of the power tube which appears at 96 MHz. The position of 0 cm has been selected for 36.5 MHz operation.

COMMISSIONING

After the installation of the rf-system, a power-test started on 13th November. In the beginning, the rf power is provided with a pulse mode for conditioning of the resonator observing the emvelopes of the pulsed signals of the resonator pickup, the forward and backward directional couplers on the transmission line and the vacuum pressure.

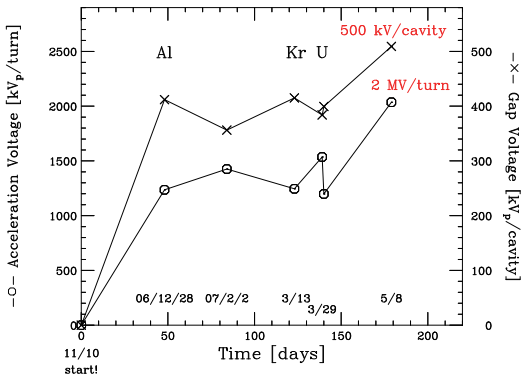

Figure 4: Improvement of the acceleration voltage.

The width of the pulse was typically a few hundred seconds and the duty was less than 1 %. In the conditioning process the peak power was decreased step by step from one hundred kW to a few ten kW. The vacuum pressure reached 10^{-5} Pa. On 27th November, the first resonator became operational in CW mode and at last the rf system has successfully accelerated aluminum beams to 345 MeV/u on 28th December, 2006 as reported in [2]. Improvement of the gap voltage was made in the first quarter of this year, by the conditioning of the resonator and tuning of amplifier, the acceleration voltage of 2 MV/turn at 36.5 MHz has been achieved and the performance of the rf-system was verified.

REFERENCES

[1] N. Sakamoto et.al., Proc. 17th Int. Conf. on Cyclotrons and Their Appplications(Tokyo 2004), p.342.

[2] N. Fukunishi et.al., “Commissioning of RI Beam Factory Accelerator Complex”, this Conference.