OPERATION OF THE RCNP CYCLOTRON

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Summary of the performance of the AVF cyclotron and the Ring cyclotron in the fiscal year 2002 is given in Table.1. About 92 % of beam time was carried out with using the Ring cyclotron. The beam time for the WS course was over 2000 hours, which corresponds to ~70 % of all beam time using Ring cyclotron.

We had ~160 hours of unscheduled shutdown in 2002, which is mainly due to the following severe machine troubles;

1) burnout of a power supply for a switching magnet. It should be noted that we still have some possibilities for other power supplies to severely break down, because those are very old (~30 years).
2) water leakage from a cooling-water tube in a coaxial RF resonator of the AVF cyclotron. Though the hole was not be filled, the cyclotron can be operated without cooling water at the restricted area.
3) water leakage from a cooling-water tube at an electric-power feeder of the cavity #2 in the Ring cyclotron. A similar trouble happened out in 2001. A newly-designed feeder was constructed and installed.
4) breakdowns of turbo molecular pumps in the HIPIS ion source system. Two 2800 l/sec pumps were simultaneously broken. The reason is still unknown.
5) breakdown of a 24 V DC power supply for control devices in a power supply for the trim coil #35 in the Ring cyclotron.

Table 1: A summary of operational statistics

Beam time	Beam time for experiments	G	181h15min
		H	1h00min
		I	63h35min
		WS	2070h30min
		WSS	99h30min
		N0	310h40min
		ES	49h00min
		ESS	226h50min
		total	3002h20min
	Tuning of beam for experiments		375h30min
	Preparation for Acceleration and Developments		1902h00min
	Total		5279h50min
Maintenance			1395h20min
Shutdown	Scheduled shutdown and holidays		1921h00min
	Unscheduled shutdown		163h50min
Total			8760h00min

The beam usage of the cyclotrons is summarized in Table 2. In 2002, more than 90 % of the beam

time was carried out for the light ions. Since various kinds of studies were carried out using the RCNP cyclotron complex, various kinds of requirements for beams were addressed, typical examines of which are as follows; 1) higher-quality beams 2) more intense beams and 3) new energies and new ion species.

High-quality beams have still been required and the best energy resolutions in our laboratory were obtained for some ions. For example, 89 keV and 150 keV of the energy resolutions were obtained for 420 MeV and 450 MeV herium-3 beams, 108 keV for 400 MeV herium-4 beams, respectively. Though it is hard to describe quantitatively, availability and reliability of each beam seemed to become better. One weak evidence is reproducibility of an energy resolution. We have three independent beam times for 450 MeV herium-3 ions in this fiscal year. The observed energy resolutions were 187 keV, 150 keV and 165 keV, respectively. For 420 MeV herium-3 ions, we have two beam times and the energy resolutions were 89 keV and 90 keV, respectively. Namely, reproducibility is quite good, one reason of which is that the temperature of the cyclotron was kept in constant in all seasons, as far as possible[1], [2]. Another reason is a significant improvement of an operation technique for the AVF cyclotron described elsewhwre[3].

Intense beams have also been required. We obtained 1000 nA and 700 nA of target currents for 200 MeV and 300 MeV proton beams, and 440 nA for 210 MeV herium-4 beam, respectively. It should be noted that a beam current is limited to less than 1100 nA by means of radiation control.

In the fiscal year 2002, H_2 molecular ions were firstly required to accelerate to 140 MeV and were successfully accelerated with ~20 nA.

For stable operation of the RCNP cyclotron complex, many small, but important, improvements were done. Newly techniques for accelerator elements, such as vacuum pumps, electrical circuits, cooling systems, power supplies and so on, were tested and some of them were installed.

Table 2: A summary of the beam usage of the RCNP cyclotrons

Particles	
Proton	$1050^{h}05^{min}$
Pol. Proton	$1108^{h}00^{min}$
Deutron	$131^{h}20^{min}$
Pol. Deutron	$108^{h}00^{min}$
H_2	$60^{h}00^{min}$
^{3}He	$1304^{h}30^{min}$
Alpha	$1189^{h}20^{min}$
^{6}Li	$84^{h}30^{min}$
^{7}Li	$244^{h}05^{min}$
Total	$5279^{h}50^{min}$

The operation statistics from 1977 are shown in fig. 1. The unscheduled shutdown in 2002 slightly decreased as compared with that in 2001. During the last five fiscal years, unscheduled shutdown periods were always less than 270 hours, which were only less than 5% of beam times.

References

[1] S. Ninomiya et. al., elsewhere in this report.

[2] S. Ninomiya et. al., RCNP Annual Report 2001 p.148

[3] S. Ninomiya et. al., elsewhere in this report.

Fig.1 Operating Statistics