Operation of the RCNP Cyclotron

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A summary of the performance of the AVF cyclotron and the Ring cyclotron in 2004 is given in Table. 1. About 90 % of beam time was carried out with using the Ring cyclotron. The beam time for the WS course was less than 2000 hours, which was the smallest among the last four years.

We had ~250 hours of unscheduled shutdown in 2004, which was the largest among the last four years. The most serious trouble was happened in the last September. Extracted beams from the injector AVF cyclotron became unstable in about two weeks. Finally, it was found that a deflector voltage sometimes decreased. An installed resistance to protect a power supply of the deflector much increased, which caused a voltage reduction by charge-up by a beam halo. Other troubles are listed below.

1) A set position of a phase-probe unit[1] of the AVF cyclotron was incorrect. A part of a beam hit the unit and melted it. Finally the melted object disturbed main beams and prevented them from being extracted.
2) In order to try to solve the beam instability described above, we checked an electrical deflector and exchanged it. At that time, an entrance beam probe was broken by human error. Vacuum leakages were also happened which led to excess shutdown time.
3) An insulator of the cavity #3 of the Ring cyclotron was broken. In order to exchange it, the vacuum of the cyclotron was intentionally broken by using nitrogen gas, which was got to warn up liquid nitrogen by water. Unfortunately, we have a pin hole on the water section and much water came into the vacuum chamber. We wiped up the water inside the chamber and dried it. The unscheduled shutdown time for this trouble was about 3 days. Now a nitrogen bottle is used for such a purpose.
4) A capacitor inside an AVF Rf amplifier was broken. The same trouble was happened in 2001[2].
5) A sprinkler inside the cooling tower was broken twice. The quantity of the water for the cooling tower was found to be too much. Redistribution of cooling water to the three cooling tower we have is now planned.

Table 1:A summary of operational statistics

Beam time	Beam time for experiments	G	164^{h}25^{min}
		H	22^{h}40^{min}
		I	179^{h}56^{min}
		WS	1963^{h}57^{min}
		WSS	93^{h}35^{min}
		N0	670^{h}28^{min}
		ES	71^{h}20^{min}
		Total	3440^{h}01^{min}
	Tuning of beam for experiments		367^{h}16^{min}
	Preparation for Acceleration and Developments		1847^{h}41^{min}
	Total		5654^{h}58^{min}
Maintenance			1172^{h}40^{min}
Shutdown	Scheduled shutdown and holidays		1713^{h}00^{min}
	Unscheduled shutdown		243^{h}22^{min}
Total			8784^{h}00^{min}

The beam usage of the cyclotrons is summarized in Table 2. About 90 % of the beam time was carried out for the light ions. Polarized and non-polarized proton beams were required over 3900 hours, which corresponds to ~70 % of the machine time. Nevertheless, some heavy ions were accelerated in 2004. Especially, ^{15}N was firstly required to accelerate to 1064 *MeV*.

In RCNP, not only energy resolutions themselves but also availability and reliability of such high-quality beam are required. Previously, it had been observed that beam quality became somewhat worse in summer. In this year, the best energy resolutions of 100 *MeV* (25 *keV*)and 300 *MeV* (35 *keV*) proton beams were recorded. Especially, the former was obtained in June, i.e., high beam quality is now realized throughout the year by careful control of the AVF room temperature[3].

Intense beams have also been required. In 2004, we obtained 800 *nA* and 1000 *nA* of target currents for 350 *MeV* and 392 *MeV* proton beams, respectively. It should be noted that a beam current is limited to less than 1100 *nA* by means of radiation control and more than 700 *nA* of beam currents have been realized for several kinds of proton beams with different energies(150-392 *MeV*).

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

Particles	
Proton	1872 ^{h}25^{min}
Pol. Proton	2066^{h}43^{min}
Deuteron	55^{h}40^{min}
Pol. Deuteron	207^{h}15^{min}
^{3}He	528^{h}50^{min}
Alpha	272^{h}25^{min}
^{6}Li	134^{h}30^{min}
^{7}Li	48^{h}00^{min}
^{15}N	81^{h}30^{min}
^{16}O	21^{h}50^{min}
^{18}O	365^{h}50^{min}
Total	5654^{h}58^{min}

The operation statistics from 1977 are shown in fig. 1. Until 2002, statistics in the FISCAL YEAR are shown and statistics in the CALENDAR YEAR are shown for 2003 and 2004.

References

[1] S. Ninomiya *et. al.*, RCNP Annual Report 2003 p.150
[2] S. Ninomiya *et. al.*, RCNP Annual Report 2001 p.145
[3] S. Ninomiya *et. al.*, elsewhere in this report.

Fig.1 Operation Statistics