

Operation report of the ring cyclotrons in the RIBF accelerator complex

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The operation report of the ring cyclotrons in the RIBF accelerator complex from Jan. to Dec. 2018 is presented. Table 1 presents a summary of the beams accelerated by these cyclotrons. The availability is defined as the ratio of the actual beam service time to the scheduled beam service time, which is an index of the stable operation of accelerators. Multiple experiments supplying identical beams are shown as a block, whereas the experiments with the ⁵¹V beam are not shown, because the new element search experiments are conducted as the closed beam time under the Nishina Center Director. The total beam supply time was 1719.4 h excluding the V beam supply. The service of RRC was not available due to the upgrade of the resonators¹⁾ during the period of two months from February. In the old facility (RARF), the actual beam service time was 477.0 h, and the availability was 108.5%. Stable beams were supplied as usual. In the new facility (RIBF), two beam services were carried out. The total beam supply time was 1242.4 h, and the availability was 84.2%.

For the synthesis of the 119th element, three beam services were carried out. The ⁵¹V beams were supplied with the availability of 73.5%. The availability was low due to the vacuum leakages caused by cooling water leakage at the new resonators of RRC and had to be aborted for repairs.

For the beam supply of ¹⁸O, the maximum beam intensity was 600 particle nA, and the availability was 100.6% for seven experiments. There were failures in the RRC, namely in the plate and filament power supplies for an intermediate amplifier of RF No.1 and in a vacuum control system, which seemed to be caused mainly by radiation.

A ²³⁸U beam at 345 MeV/nucleon was supplied for eight experiments, and the maximum beam intensity of 72 particle nA was the highest ever. The availability decreased to 67.8% owing to several troubles. The beam supply was started 7.5 d later than scheduled due to the failures and repairs of the SRC-EIC and -EDC, abnormal termination of the rotating charge stripper, and a severe beam tuning to reduce beam losses. The rotation-stops of the charge stripper occurred frequently even during the beam supply. Finally, a ferrofluidic seal was exchanged to recover stable operation. Furthermore, a vacuum leakage happened again at the RRC resonator No.1 in November, and the repair was performed. It took 8 d for the repair and beam tuning to resume the beam supply.

Reference

- 1) K. Yamada *et al.*, “Remodeling of acceleration cavity resonators for RIKEN Ring Cyclotron”, in this report.

Table 1. Summary of the accelerated beams in 2018.

Beam particle	Energy (MeV/nucleon)	Acceleration mode	Beam course	Beam intensity (particle nA)		Beam service time (h)		Availability (%)
				Requested	Actual	Scheduled	Actual	
RARF								
¹² C	135	AVF-RRC	E5B (Biology)	1	467	36.0	17.9	87.0
¹⁴ N	135		E3B (RI production)	500	600	76.0	74.2	97.6
⁴⁰ Ar	95		E5A (Industry)	1	8.8	20.0	35.0	174.8
⁵⁶ Fe	90		E5B (Biology)	1	0.6	6.0	5.2	100.0
⁸⁴ Kr	70		E3A (JAXA) / E5A (Industry)	1	6.6	154.0	174.4	113.2
⁸⁶ Kr	66		E3A (JAXA / Industry)	1	1.6	26.0	25.0	99.6
¹³⁶ Xe	10.75		RILAC2-RRC	E2B (KEK/KISS)	250	340	48.0	47.7
¹³⁶ Xe	10.75	E3A (JAXA) / E5A (Industry)		1	330	57.0	55.5	110.1
²³⁸ U	10.75	E5A (Material)		2	2.2	24.0	24.9	103.6
⁴⁰ Ar	160	AVF-RRC-IRC	E5B (Biology)	1	23	25.0	17.2	100.0
RIBF								
¹⁸ O	230	AVF-RRC-SRC	BigRIPS/SAMURAI	> 700	600.0	540.0	543.0	100.6
²³⁸ U	345	RILAC2-RRC-fRC-IRC-SRC	BigRIPS/BigRIPS-F12/ZDS/Rare RI Ring	> 60	72.0	1032.0	699.4	67.8
Total						2044.0	1719.4	89.8

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