

Operation report on the ring cyclotrons in the RIBF accelerator complex

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In this report, the operation of the ring cyclotrons in the RIBF accelerator complex from Jan. to Dec. 2017 is presented. Table 1 presents a summary of the beams accelerated by these cyclotrons. The “availability” in the table represents the ratio of the actual beam time to the scheduled beam time. For the old facility, multiple experiments supplying identical beams are shown as a block. For the new facility, each experiment is shown separately because each operation is long-running.

In the old facility, the actual beam time was 870.5 h, and the availability was 96.0%. Stable beams were supplied as usual. In the RIBF, six machine times were carried out. The total beam supply time was 2546.8 h, and the availability was 91.3%.

The beam supply of ⁴⁸Ca was started 1.5 days ahead of schedule. The down time caused by the accelerator was 4.5 h, which was spent to replace the charge stripper foils.

The beam supply of ⁷⁰Zn (1st) was started about 1 day later than scheduled, was stopped for three days due to the vacuum leakage at the bellows in the injection beam line to the SRC, and was aborted due to the vacuum leakage at a plastic insulation pipe used for the ion source.

The maximum beam intensity of ⁷⁰Zn (2nd), 250 particle nA, was about twice higher than ever before. This intensity was achieved by changing the acceleration mode from the variable-frequency mode to the fixed-frequency mode using RILAC2. Because of a malfunction

of the fRC RF-W, the beam supply was stopped temporarily for beam tuning.

The averaged beam intensity of ²³⁸U (1st) over a week, in which a high-intensity and stable beam was supplied, was 52 particle nA. In order to repair the failed fRC RF-W and fRC-EDC, the schedule for beam tuning was readjusted and the beam time was extended for 0.5 day.

During the beam supply of ¹⁸O, a voltage breakdown of the AVF spiral inflector took place. Therefore, the maintenance of the insulator was carried out. The cryogenic pumps for the SRC valley box and the RRC RF#2 failed, possibly caused by radiation.

For the beam supply of ²³⁸U (2nd), the transmission efficiency down to the A02 gas stripper was improved, owing to the refinement of the RRC tuning and the introduction of N₂ gas-jet system to the gas stripper. The supply of uranium vapor from the oven used in the ion source was greatly reduced five times because of the blockade in its ejection hole.

For the synthesis of the 119th element, the beam supply of ⁵¹V using RILAC2-RRC acceleration was started. For the experiment, the beam energy adjuster (D6-BEA) was installed in the D-room. In the experiment conducted in Dec. 2017, beams decelerated to 4.50–4.87 MeV/nucleon using both D6-BEA and rotating charge strippers with various thicknesses were also supplied. These beams were used for the experiment system check.

Table 1. Summary of the accelerated beams in 2017.

Beam particle	Energy (MeV/nucleon)	Acceleration mode	Beam course	Beam intensity (particle nA)		Beam time (h)		Down time (h)	Availability (%)
				Requested	Actual	Scheduled	Actual		
⁵⁶ Fe	90		E5B (Biology)	1	1.2	21.0	28.9	0	100.0
²² Ne	70		E6 (RIPS)	> 200	220.0	122.0	121.9	0.4	99.9
¹² C	135	AVF-RRC	E5B (Biology)	1	200.0	28.5	22.2	0	100.0
⁴⁰ Ar	95		E5B (Biology)	1	77.6	13.0	8.3	0	100.0
⁸⁴ Kr	70		E5A (Industry)	0.1	5.7	72.0	77.3	0	107.3
⁸⁶ Kr	66		E3A (JAXA)	1	4.0	24.0	23.5	0	98.0
¹⁹⁷ Au	18.4		E5A (Industry)	0.1	2.1	3.0	2.2	0	72.2
¹⁹⁷ Au	18.4	RILAC-RRC	E3A (JAXA)	1	0.8	8.0	11.8	0	147.9
¹³⁶ Xe	39		E3A (JAXA/Industry)	1	1.4	24.0	6.8	0	39.7
¹³⁶ Xe	39		E5A (Industry)	0.1	0.8	3.0	3.8	0	125.6
¹³⁶ Xe	10.75		E2B (KEK/KISS)	250	214.3	147.0	146.1	0	99.4
¹³⁶ Xe	7.2		E2B (KEK/KISS)	250	55.0	48.0	46.1	0	96.0
⁵¹ V	6	RILAC2-RRC	D18/M11 (MS)	4000	3083.0	78.0	81.9	0	105.0
⁵¹ V	6		E6 (GARIS2)	N/A	1923.1	324.0	206.3	1.1	63.7
²³⁸ U	10.75		E2B (KEK/KISS)	140	342.9	48.0	47.6	0.2	98.6
²³⁸ U	10.75		E5A (Material)	2	34.3	24.0	25.3	0	105.3
⁴⁰ Ar	160	AVF-RRC-IRC	E5B (Biology)	1	17.2	10.5	10.5	5.0	74.0
⁴⁸ Ca	345	RILAC-RRC-IRC-SRC	BigRIPS/ZDS	> 530	493.0	96.0	120.0	12.0	125.0
¹⁸ O	220	AVF-RRC-SRC	SAMURAI	> 300	550.0	492.0	474.6	17.5	96.5
⁷⁰ Zn (1st)	345		BigRIPS/ZDS/SAMURAI	as much as possible	193.0	228.0	94.4	133.6	41.4
⁷⁰ Zn (2nd)	345	RILAC2-RRC-IRC-SRC	BigRIPS/SAMURAI	as much as possible	250.0	432.0	435.2	44.8	100.7
¹³⁸ U (1st)	345		BigRIPS/ZDS/PALIS/SHARAO	> 50	58.0	570.7	502.7	68.0	88.1
²³⁸ U (2nd)	345		BigRIPS/ZDS/PALIS/SHARAO/Rare-RI Ring	> 50	71.0	960.0	919.9	220.1	95.8
Total						3776.7	3417.3	502.7	92.5

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