

Operation report on ring cyclotrons in the RIBF accelerator complex

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This paper presents an operation report on ring cyclotrons in the RIBF accelerator complex from January to December 2024. Table 1 presents data on beam intensity, beam service time, and the availability of ring cyclotrons during this period. The information is classified by acceleration mode, beam particle, energy, and beam course. The availability is defined as the ratio of actual beam service time to requested beam service time, which serves as an index of the stable operation of accelerators. For calculating each availability, requested times were identified with actual times if the beam services were completed earlier than requested. In addition, multiple experiments supplying identical beams were considered as one and presented in a row. The total actual beam service time was 3025.6 hours, which is the fourth longest since the beginning of statistics for RIBF in 2009.

The RIBF experiments were conducted from April 2024, sixteen months after the recovery of SRC from two major problems.¹⁾ The actual beam service time was 2004.5 hours, which is ~ 780 hours longer than that in 2022 before the problems, with an availability of 94.9%.

During the tuning for the ¹²⁴Xe 345 MeV/nucleon beam, the extracted beam intensity from fRC was not stable. This problem was solved by attaching a

pendant-shaped electrode to the electrostatic deflection channel of fRC,¹⁾ and we succeeded to supply a stable beam for experiments conducted by nine groups for a long period of one month.

The availability for the ²³⁸U 345 MeV/nucleon beam supply was as low as 91.9% because a severe failure occurred in the radio frequency system for fRC-W in November. One of two high-voltage transformers for the plate power supply had a ground fault caused by insufficient air cooling. It took 2.5 days to replace the two transformers and resume beam service.

In the RARF, the requested beam service time was 1107.0 hours, which was almost the same as last year of 1063.9 hours. The actual beam service time was 1021.1 hours with an availability of 92.2%. The availability for ⁸⁴Kr 70 MeV/nucleon (E5A) was as low as 78.0% because the beam service was canceled due to a leakage of cooling water from an upper movable box (MB) of the RRC No.1 resonator in January.¹⁾ The leakage was repaired by exchanging an O-ring attached between the MB and the supporting post. Then, several beam services were conducted to compensate for this cancellation.

Reference

- 1) M. Nishida *et al.*, Proc. 21st Ann. Meet. of Particle Accelerator Society of Japan, (2024), p. 1135.

Table 1. Summary of the accelerated beams in 2024.

Acceleration mode	Beam particle	Energy [MeV/nucleon]	Beam course	Beam intensity [particle nA]		Beam service time [h]		Availability [%]
				Requested	Actual	Requested	Actual	
RARF								
AVF-RRC	² H	135	E3A (Nuclear physics)	30	85.0	45.7	45.7	100.0
	¹² C	135	E5B (Biology)	5	250	19.3	19.3	100.0
	⁴⁰ Ar	95	E5A (Industry)	1	69.4	186.3	186.3	100.0
	⁵⁶ Fe	90	E5B (Biology)	2	3.0	5.2	5.2	100.0
	⁸⁴ Kr	70	E3A (JAXA)	1	3.2	17.6	17.6	100.0
	⁸⁴ Kr	70	E5A (Industry)	1	6.6	390.8	304.8	78.0
	⁸⁶ Kr	66	E6 (RIPS)	1	9.1	45.7	45.7	100.0
	¹²⁰ Xe	35.58	E3A (JAXA)	1	1.6	11.9	11.9	100.0
	¹²⁰ Xe	35.58	E5A (Industry)	1	1.6	23.8	23.8	100.0
	RILAC2-RRC	⁴ He	7.25	E3B (RI Production)	35000	37000	22.2	22.2
⁵¹ V		6	E6 (KEK/MRTOF)	2500	2692	202.4	202.4	100.0
¹³⁶ Xe		8.60	E6 (KEK/MRTOF)	50	270	23.4	23.4	100.0
¹³⁶ Xe		10.75	E2B (KEK/KISS)	500	700	94.9	94.9	100.0
⁴⁰ Ar		160	E5B (Biology)	2	32.2	18.0	18.0	100.0
				Subtotal		1107.0	1021.1	92.2
RIBF								
RILAC2-RRC-IRC-SRC	⁷⁰ Zn	345	BigRIPS/SHARAQ/ZD spectrometer/F12	500	517	312.0	311.4	99.8
	¹³⁶ Xe	345	BigRIPS/SHARAQ/SAMURAI/ZD spectrometer/Rare RI Ring	140	138	720.0	676.3	93.9
	¹³⁶ Xe	345	BigRIPS-F12/SAMURAI	40	54	204.0	194.1	95.1
	²³⁸ U	345	BigRIPS-F12/ZD spectrometer	70	70	456.0	419.0	91.9
RILAC2-RRC-SRC	¹⁸ O	250	BigRIPS/SAMURAI	500	488	420.0	403.7	96.1
				Subtotal		2112.0	2004.5	94.9
				Total		3219.0	3025.6	94.0

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