

Operations of RIBF ring cyclotrons (RRC, fRC, IRC, and SRC)

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The yearly report on the operation of the four RIBF ring cyclotrons RRC, fRC, IRC, and SRC, including statistics of beam service time as well as developments and troubles in the January–December 2013 period, is presented.

The yearly operation status of the RIBF ring cyclotrons is summarized in Table 1. The medium-energy beams accelerated by the RRC in the last stage were used for the experiments and machine studies (MS) for 1166 h in total. Similarly, the high-energy beams accelerated by the SRC in the last stage were used for 1646 h in total. The total operation time of RIBF ring cyclotrons was 2812 h, of which only 304 h involved temporary suspension due to the accelerator troubles. We achieved a high beam availability of 94%. The beam availability is defined as the ratio of the actual beam time after deduction of temporary suspension time to the scheduled beam time.

The notable events in those operations are as follows (itemized figures correspond to those in Table 1):

- The highest-energy beam ever of 400 MeV/nucleon was successfully extracted from the SRC in the MS using an ⁴⁰Ar beam in May.
- Two gas strippers using He and air were used in the double charge-exchanging process down-

stream of the RRC and fRC, respectively, in June for the first time. Owing to the gas strippers and other continuous efforts, a 345 MeV/nucleon-¹²⁴Xe beam of 38 particle nA was provided to the beam users with an availability as high as 91%.

- Layer short of the RRC main-coil of the west-sector magnet was fixed by replacing it with a new one in August. Its soundness was confirmed in the MS of 50.5 MeV/nucleon-⁴⁰Ca acceleration in September.
- The improvement of efficiency of injection to the RRC from RILAC2 was confirmed when a saw-tooth wave was used for the prebuncher instead of a usual sine wave in the MS of 11 MeV/nucleon-¹²⁴Xe acceleration in December. The acceleration at harmonic numbers $h = 12$ and $h = 18$ instead of the usual $h = 9$ was also tested for the future upgrade of the RRC in the same MS. The obtained data is now under analysis.

For more details of those operations and others, refer to Ref. 1.

References

- R. Koyama et al.: Proc. of PASJ10, Nagoya, Aichi, August 2013, SAP013, in press.

Table 1. Yearly operation results of the RIBF ring cyclotrons. For notable events a)–d), see text.

Last stage cyclotron	Preaccelerators	Particle	Energy [MeV/nucleon]	Experimental course	Intensity [particle nA]		Beam time [h]		Temporary suspension [h]	Availability [%]	Notable events
					Requested	Actual	Scheduled	Actual			
RRC 	RILAC	⁴⁰ Ca	50.5	RRC	MS	143	84.0	84.0	0.0	100	c)
		⁴⁸ Ca	63	E6	200	294	156.0	156.6	28.5	82	
		⁵⁸ Ni			> 200	87	144.0	157.5	10.4	102	
	RILAC2	⁸⁶ Kr	36	E3A	1	38	12.0	12.7	0.0	106	
		²³⁸ U	10.75	E5A	2	29	24.0	24.0	0.0	100	
		¹²⁴ Xe		E2B	10	772	48.0	47.2	0.0	98	
				D-room	MS	1211	24.0	24.0	0.0	100	d)
	AVF	¹² C	70	E6	400	383	312.0	305.8	9.3	95	
			135	E5B	10	367	52.0	52.0	0.0	100	
		⁴⁰ Ar	95		1	26	34.5	34.5	0.0	100	
		⁵⁰ Fe	90	E2B/E5B	1	4	199.0	199.0	0.0	100	
		⁸¹ Rb	66	E6	1	0.1	48.0	68.9	0.7	142	
Subtotal of medium-energy experiment at old facility:							1137.5	1166.1	49.0	98	
SRC 	AVF-RRC	¹⁸ O	250	SAMURAI	200	231	108.0	123.0	6.2	108	
	RILAC-RRC	³⁴ S	345	BigRIPS	100	313	120.0	132.0	33.7	82	
	-IRC	⁴⁰ Ar	400		MS	16@beam duty2%	137.5	137.5	0.0	100	a)
	RILAC2-RRC	²³⁸ U	345	BigRIPS/ZDS	> 5	13	660.0	700.3	109.9	89	
	-fRC-IRC	¹²⁴ Xe			> 20	38	492.0	553.3	105.3	91	b)
Subtotal of high-energy experiment at new facility:							1517.5	1646.1	255.2	92	
Total:							2655.0	2812.2	304.1	94	

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[†]Availability = (Actual beam time - Suspension)/(Scheduled beam time)×100