Operation report on the RIKEN AVF cyclotron for 2024

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The annual report on the operation of the RIKEN AVF cyclotron (hereafter, AVF) for the period of January-December 2024 is presented. AVF delivers beams to the following experimental courses as a standalone operation: C01 (machine study; MS), C03 (RI production), E7V (CNS experiments and RI production), E7A (CRIB experiments), and E7B (student experiments and RI production). In addition, AVF is operated as an injector of the RIKEN ring cyclotron (RRC). Figure 1 shows the experimental apparatuses around AVF.

The yearly changes in operation statistics since 2021 and the beams accelerated using AVF in the period are summarized in Tables 1 and 2, respectively. The operation times for standalone operation and injection to RRC in the period were 2225 and 1953 hours, respectively. The acceleration in the AVF-RRC-SRC mode was conducted for the first time in three years, and the ^{18}O beam was supplied to the RIBF experiments for 531 hours. The beam service interrupt time caused by the trouble of the AVF was 72 hours in total.

The three major troubles in the hardware were as follows: (1) In January, a failed vacuum tube for resonator No. 1 was replaced. Because this replacement was completed within the beam tuning period, a beam supply was started as per schedule. (2) In June, a gate valve installed in a transfer line from the AVF-room to the E7-room was replaced because it got broken to be unopenable. Owing to its installation location (embedded in the wall between rooms), it took time to prepare for the work; however, the work itself was completed in a little over 2 hours. Most of the beam service interruption time can be attributed to this replacement. (3) In December, the RF and mirror coils for the 18 GHz ECR ion source were shut off abnormally. A chiller for the ion source stopped because of a lack of cooling water. Therefore, the water was refilled, and the chiller

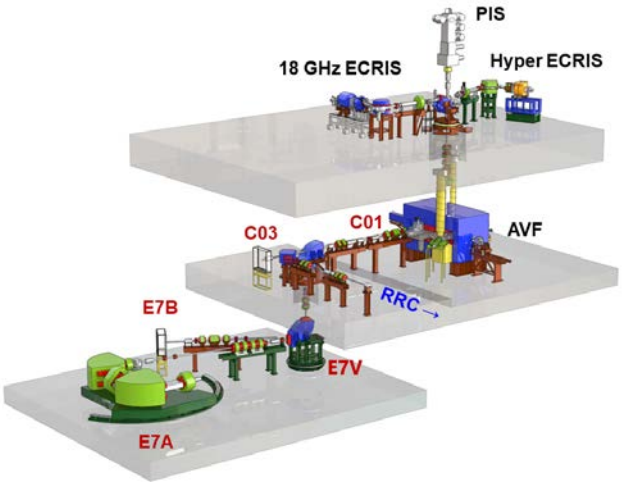

Fig. 1. Overview of the AVF with ion sources, each experimental course, and beam transport line to RRC.

Table 1. Comparison of AVF operation statistics with that in previous years.

AVF standalone operation		Year 2021	2022	2023	2024
Tuning of AVF	[h]	1149	1212	1025	912
Trouble of AVF	[h]	5	0	77	68
C01 MS	[h]	35	32	0	39
C03 Exp.	[h]	672	491	480	291
E7V Exp.	[h]	95	94	186	129
E7A Exp.	[h]	48	302	477	436
E7B Exp.	[h]	96	155	36	350
Sub total	[h]	2100	2287	2281	2225
AVF operation as injector of RRC		Year 2021	2022	2023	2024
Tuning of AVF	[h]	214	273	235	156
Trouble of AVF	[h]	1	1	2	4
RRC-Exp. & RRC-IRC Exp.	[h]	834	1300	1076	1262
RRC-SRC-Exp.	[h]	767	0	0	531
Sub total	[h]	1816	1574	1313	1953
Total	[h]	3916	3861	3594	4178

Table 2. AVF beam list in 2024.

AVF standalone operation			AVF operation as injector of RRC		
Particle	Energy [MeV/nucleon]	Experimental Course	Particle	Energy [MeV/nucleon]	Experimental Course
$^{1}H^{+}$	14	E7V	$^{2}H^{+}$	7	RRC-RARF
	17	E7V	$^{12}C^{4+}$	7	RRC-RARF
	30	C03, E7B	$^{18}O^{6+}$	4.9	RRC-SRC-RIBF
$^{2}H^{+}$	7	C01	$^{40}Ar^{11+}$	3.8	RRC-IRC-E5B
	12	C03, E7B		5.2	RRC-RARF
$^{4}He^{2+}$	6.5	E7B	$^{56}Fe^{15+}$	5	RRC-RARF
	7.3	C03, E7B	$^{84}Kr^{20+}$	4	RRC-RARF
	12.5	C03	$^{86}Kr^{20+}$	3.8	RRC-RARF
$^{7}Li^{2+}$	6	C03, E7B	$^{129}Xe^{25+}$	2.5	RRC-RARF
$^{7}Li^{3+}$	8.3	E7A			
	10	C03			
$^{12}C^{4+}$	7.3	C03			
$^{13}C^{4+}$	6	E7A			
$^{15}N^{5+}$	7	E7A			
$^{18}O^{6+}$	7	E7V, E7B			
$^{20}Ne^{8+}$	8.2	E7B			

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was restarted. Before resuming the beam supply, it took 2 hours to restart the ion source and to confirm a reproduction of the beam profile.

For a stable beam supply, repairs and countermeasures are being taken as required. For more details on the AVF and RRC operations and others, refer to Refs. 1) and 2).

References

1) J. Shibata *et al.*, Proc. of PASJ2024, (Yamagata, Japan, July, 2024), WTSP01, pp. 1112–1115.
2) M. Nishida *et al.*, Proc. of PASJ2024, (Yamagata, Japan, July, 2024), WTSP09, pp. 1135–1140.