Operation report on the RIKEN AVF cyclotron for 2019

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The yearly report on the operation of the RIKEN AVF cyclotron (denoted as AVF hereafter) for the period January - December 2019 is presented here. AVF has four beam courses as stand-alone operations: C03 (RI production), E7A (CRIB), E7B (student experiment), and C12 (a new course for nuclear physics). The beam courses are shown schematically in Fig. 1. In addition, AVF is used as an injector of RRC. In this mode, there are three beam delivery schemes: RRC-RARF, RRC-IRC-E5, and RRC-SRC.

The yearly operation statistics and beams accelerated using AVF are summarized in Tables 1 and 2, respectively. The total operation time was 3603 h, of which 3166 h was dedicated to AVF stand-alone experiments and 437 h to operations as the injector of RRC. The latter decreased by 1114 h compared with that in the last year. New experiments were conducted at the C12 course in the E7 experimental hall. It is remarkable that there was no trouble in AVF during beam services in this year. The phase slit that leaked cooling water in the last year was replaced by a new one during a maintenance period in the summer. In the same period, the SC-ECR ion source operated for AVF since 2008 was removed owing to the difficulty of maintenance. As an alternative,

the 18 GHz ECR ion source used for RILAC to produce intense metallic ions was installed. At the end of 2019, the ion source became operational as an injector for AVF.

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

AVF stand-alone operation		2018	2019
Tuning of AVF	[h]	886	1314
Trouble of AVF	[h]	6	0
C03 exp.	[h]	2067	873
E7A exp.	[h]	262	789
E7B exp.	[h]	274	152
C12 exp.	[h]	0	36
Sub total	[h]	3489	3166
AVF operation as injector of RRC		2018	2019
Tuning of AVF	[h]	132	117
Trouble of AVF	[h]	1	0
RRC-RARF exp.	[h]	600	239
RRC-IRC-E5 exp.	[h]	820	81
Sub total	[h]	1551	437
Total	[h]	5042	3603

Table 2. AVF beam list in 2019.

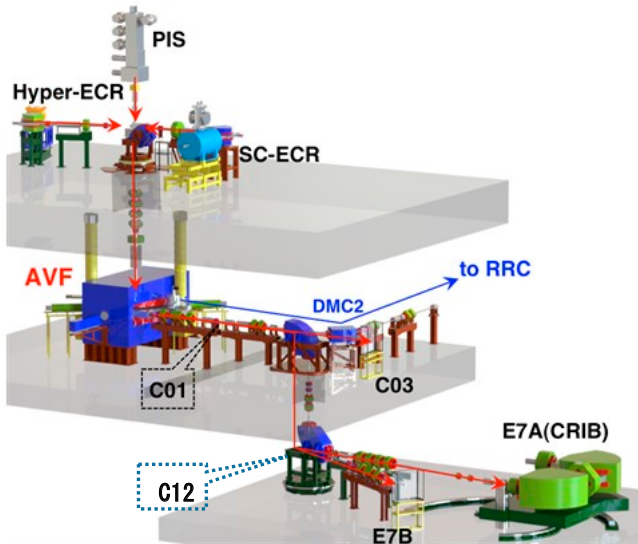| Particle	Energy [MeV/nucleon]	Course/Scheme
AVF stand-alone operation		
p	12	C03
d	12	C03
^{4}He	6.5	E7B
^{4}He	7.25	C03, E7B
^{4}He	12.5	C03
^{6}Li	11.2	E7A
^{7}Li	6	C03, E7B
^{10}B	7	E7A
^{18}O	6	C03
^{18}O	6	C03
^{18}O	6	C12
^{18}O	7	C12
^{19}F	6	C03
^{20}Ne	5	E7B
^{24}Mg	7	E7A
^{24}Mg	8	E7A
AVF operation as injector of RRC		
^{12}C	7	RRC-RARF
^{14}N	7	RRC-RARF
^{40}Ar	5.19	RRC-IRC-E5
^{56}Fe	5	RRC-RARF

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

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