

## AVF operations in 2015

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In 2015, the total annual operation time of the K70 AVF cyclotron (denoted as AVF hereafter) was 3282 hours as shown in Table 1. The total beam supply time was 2051 hours, which was increased by 349 hours compared with that in 2014. The beam supply time was classified into four categories: “Injection to RRC”, “Injection to RRC-SRC”, “Injection to RRC-IRC-E5”, and “AVF standalone”. One of the categories “Injection to RRC-IRC-E5” was a new beam course. The beam was supplied for the first time in January 2015. The supply time for the AVF standalone was 1587 hours, which was 548 hours longer than that in 2014. It was increased mainly by CRIB experiments, and the supply time to the CRIB was three times longer than that in 2014. The beam tuning times for the AVF and the others are shown in Table 1. The tuning time for the AVF is defined as the sum of periods from the start of the cycling of AVF magnets to the end of the spot tuning (in the case of AVF standalone) or to the start of beam transport to the RRC.

All of the beams accelerated by the AVF in 2015 are listed in Table 2. The following beams were accelerated for the first time in 2015:  $\alpha$  (7.25, 10.0 MeV/u) and  $^{16}\text{O}$  (6.6 MeV/u). The supplied courses were as follows (in order of the decreasing supplied time): E7A (CRIB), C03 (RI production), RRC-E5, RRC-SRC, RRC-E6, E7B (student experiment), and RRC-IRC-E5.

Table 1. AVF operation statistics in 2015.

|                                  | 2014 | 2015 |
|----------------------------------|------|------|
| Total operation time (h)         | 2942 | 3282 |
| Beam tuning (AVF)                | 773  | 785  |
| Beam tuning (others)             | 467  | 446  |
| Injection to RRC (E5 or E6)      | 208  | 324  |
| Injection to RRC-SRC             | 455  | 124  |
| Injection to RRC-IRC-E5          | -    | 15   |
| AVF standalone                   | 1039 | 1587 |
| Beam course (AVF standalone) (h) |      |      |
| E7A (CRIB)                       | 335  | 1097 |
| E7B (student experiment)         | 58   | 28   |
| C03 (RI production)              | 646  | 462  |

The total fault time was 47 hours (included in the supply time). The main faults are listed in Table 3 in descending order of the time spent on restoration, and the details are indicated below.

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Table 2. AVF beam list in 2015.

| Particle         | $E$ (MeV/u) | Course       | Supplied time (h) |
|------------------|-------------|--------------|-------------------|
| $p$              | 12          | C03          | 69                |
| $d$              | 12          | C03          | 172               |
| $d$              | 3.97        | RRC-SRC      | 124               |
| $\alpha$         | 6.5         | Student exp. | 28                |
| $\alpha$         | 7.25        | C03          | 23                |
| $\alpha$         | 10          | C03          | 8                 |
| $\alpha$         | 12.5        | C03          | 101               |
| $^7\text{Li}$    | 5.6         | E7A          | 81                |
| $^{11}\text{B}$  | 5           | E7A          | 181               |
| $^{12}\text{C}$  | 3.97        | RRC-E6       | 114               |
| $^{12}\text{C}$  | 7           | C03 / RRC-E5 | 32.4 / 46.4       |
| $^{15}\text{N}$  | 7           | E7A          | 186               |
| $^{16}\text{O}$  | 6.6         | E7A          | 217               |
| $^{18}\text{O}$  | 5.5         | E7A          | 432               |
| $^{18}\text{O}$  | 6.07        | C03          | 56                |
| $^{40}\text{Ar}$ | 3.8         | RRC-IRC-E5   | 15                |
| $^{40}\text{Ar}$ | 5.2         | RRC-E5       | 70                |
| $^{56}\text{Fe}$ | 5           | RRC-E5       | 22                |
| $^{84}\text{Kr}$ | 3.97        | RRC-E5       | 72                |

(1) During  $d$  beam tuning, a loss of vacuum occurred at the RF cavity No.2. An O-ring between the insulator ceramics and a coupling terminal plate was damaged. We replaced it with a new one. In addition, the high-voltage plate power supply of the RF system was interrupted due to a failure of two cooling fans. These fans were replaced.

(2) During  $^{40}\text{Ar}$  beam supply, the RF system No.1 failed, and could not be operated. There was no output from the power unit of a wide band amplifier. We replaced the unit with a spare.

(3) During  $^{15}\text{N}$  beam tuning, a mirror coil, an extraction high-voltage, and a vacuum pump of the HYPER-ECR ion source failed. The beam was supplied by the SC-ECR ion source instead of the HYPER-ECR because time was needed to investigate the cause of the failure.

Table 3. Main faults in 2015. See text for details.

|     | Date           | Time for restoration (h) |
|-----|----------------|--------------------------|
| (1) | September 2nd  | 9                        |
| (2) | July 5th       | 8                        |
| (3) | September 20th | 4                        |