

## Transfer of GARIS-II and charge-state multiplier (CSM) cavities

Y. Watanabe,<sup>\*1</sup> M. Kase,<sup>\*1</sup> E. Ikezawa,<sup>\*1</sup> N. Fukunishi,<sup>\*1</sup> M. Fujimaki,<sup>\*1</sup> O. Kamigaito,<sup>\*1</sup> M. Komiyama,<sup>\*1</sup> K. Kumagai,<sup>\*1</sup> T. Maie,<sup>\*1</sup> K. Yamada,<sup>\*1</sup> K. Suda,<sup>\*1</sup> K. Ozeki,<sup>\*1</sup> N. Sakamoto,<sup>\*1</sup> A. Uchiyama,<sup>\*1</sup> T. Watanabe,<sup>\*1</sup> H. Yamasawa,<sup>\*1</sup> K. Morimoto,<sup>\*1</sup> D. Kaji,<sup>\*1</sup> K. Kaneko,<sup>\*2</sup> M. Tamura,<sup>\*2</sup> T. Ohki,<sup>\*2</sup> K. Oyamada,<sup>\*2</sup> H. Yamauchi,<sup>\*2</sup> A. Yusa,<sup>\*2</sup> S. Fukuzawa,<sup>\*2</sup> M. Hamanaka,<sup>\*2</sup> S. Ishikawa,<sup>\*2</sup> K. Kobayashi,<sup>\*2</sup> R. Koyama,<sup>\*2</sup> T. Nakamura,<sup>\*2</sup> M. Nishida,<sup>\*2</sup> M. Nishimura,<sup>\*2</sup> J. Shibata,<sup>\*2</sup> N. Tsukiori,<sup>\*2</sup> and K. Yadomi<sup>\*2</sup>

An upgrade of the RILAC has been proceeding since FY 2016 to date, as follows: (1) the construction of a stage for the new 28 GHz SC-ECR and the installation of the 28 GHz SC-ECR, (2) the construction of a hot laboratory for RI production, (3) the installation of a superconducting RILAC (sRILAC), and (4) the installation of a helium cooling system for the sRILAC. The RILAC will have an upgrade, which involves replacing the four CSM cavities<sup>1)</sup> (A3 - A6) with three superconducting cryomodules. Therefore, these CSM cavities were transferred from the LINAC building in 2017. GARIS-II<sup>2)</sup> (including a beam transfer (BT) line) was also transferred from the LINAC building to the Nishina building, to perform experiments with a high-intensity Vanadium (V) beam and to continue experiments during construction. In this paper, we report on the transfer of GARIS-II and the CSM cavities. During the transfer, there were three important points to be considered. First, we had to perform the transfer for approximately four months, because of the beam time, the extension and reconstruction of the LINAC building, and some regular maintenances of the accelerator facilities. Second, we had to keep some temporary storage places for GARIS-II and the CSM cavities, to arrange a period for carrying in. Third, we had to determine a transport route and a method to reverse the top and bottom of the D1 dipole magnet (heaviest magnet, weight: 16 tons) of GARIS-II. This reversal was to change the beam deflection of GARIS-II, because of the interference with a shield door of the E6 room. Table 1 shows the transfer schedule of GARIS-II and the four CSM cavities. A transfer schedule, a transport route, and some temporary storage places were planned by April. In June, the magnets of GARIS-II were carried out from the LINAC building in the following order: Q2, Q3, Q1, D2, BT line, and D1 magnet. Some radioactivated chambers and the D1 magnet were temporarily placed in the radiation-controlled area (MB2 floor in front of the SRC room) of the RIBF building, and the other magnets and BT line were placed in the D-crane area (the central machine hatch) of the RIBF building. After GARIS-II was carried out, the two CSM cavities were carried out from the LINAC building in July, in the following order: CSM-A6 and A5. Couplers, tuners, cryopumps, turbo molecular pumps, and cooling water hoses were removed from the CSM cavities in advance. The vertical space in the transport

Table 1. Transfer schedule of GARIS-II and CSM in 2017.

- April	Preparatory works.
June - July	Removal of GARIS-II and CSM cavities.
July - Aug.	Transfer of GARIS-II and CSM-A6 (D6-BEA). Storage of three CSM cavities (A3 - A5).
July - Dec.	Modification of D6-BEA and its BT line. Infrastructure improvement. Set up of GARIS-II, its BT line and D6-BEA
Dec. -	Beam time of GARIS-II

route was insufficient because of an existing BT line and the low shield door. Therefore, the CSM cavities and its stages were carried out separately. Subsequently, the other two CSM cavities (CSM-A3 and A4) were also carried out with their accessories, amplifiers, and control panels from the LINAC building in July. These four radioactive cavities and their accessories were temporarily placed on the MB2 floor, and some amplifiers and control panels were placed in the D-crane area. Here, the D1 dipole magnet was reversed with the C-crane (40 ton) in the BigRIPS room in July, and was divided into the upper yoke and lower yoke in order to transfer it using a 10 ton-crane of the E6 room. The transport route of GARIS-II was from the MB2 floor or the D-crane area to the E6 room, through the machine hatch of the Nishina building and the underground passage. Although the entrance of the E6 room was narrow, the D1 dipole magnet was carefully transferred in July. GARIS-II was installed immediately on some new stages over the D2 magnet of RIPS, and it was checked for vacuum leak after alignment. The old CSM-A6 cavity was used as the new D6-BEA (beam energy adjuster) in the D room. The D6-BEA was transferred from the MB2 floor to the D room, through the D-crane area and the side of the CNS building, in August, and was immediately installed between the QDD61 and QDD62 magnets. It was checked for vacuum leak after alignment. Then, the frequency of the D6-BEA was modified in September. Finally, the three remaining CSM cavities were transferred from the MB2 floor to the E21 room of the RIBF building, through the D-crane area and the north-machine hatch, in August, and were stored on the north side of the SCRIT area. After the transfer, some infrastructure and the BT lines to these infrastructure were installed or modified. The operational checks of GARIS-II and D6-BEA were conducted in December, and the first beam time of GARIS-II with the V beam commenced.

### References

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- 2) D. Kaji *et al.*, Accel. Prog. Rep. **42**, 179 (2009).

\*1 RIKEN Nishina Center

\*2 SHI Accelerator Service Ltd.