

Research Facility Development Division
Accelerator Group
Cyclotron Team

1. Abstract

The mission of the RIKEN Radioactive Isotope Beam Facility (RIBF)¹⁾ is to improve our understanding of the mechanism of element synthesis in the universe through experiments using intense heavy-ion beams. According to the medium-term targets of the RNC, our team's mission is to maintain and improve the highly reliable operation of the RIBF accelerator complex, in collaboration with other teams of the RNC. The stable operation of the RF system is crucial for handling very high-power beams. Our goal is to develop a highly reliable/stable radio-frequency (RF) system for RIBF cyclotrons and linacs, enabling high-power beam operations. A highly stabilized system makes it possible to achieve single-turn extraction for each cyclotron over a long-term beam service. Single turn-turn extraction is crucial to minimize the loss of high-power beam at extraction. Furthermore, RIBF is a unique facility where the deuteron spin orientation can be freely controlled at the target position owing to the single-turn extraction operation.²⁾

Recently, we successfully achieved energy and intensity upgrades for the injector RILAC, which are required for super-heavy element synthesis experiments, by introducing the superconducting linac SRILAC. After three years of hardware improvements on the linac, we achieved a beam intensity of 4.2 particle μA with a duty factor of 86%.³⁾ Since FY2021, this team has been assigned to take over the duties under an outsourcing contract for the operation staff.

References

- 1) H. Okuno *et al.*, Prog. Theor. Exp. Phys. **2012**, 03C002.
- 2) N. Sakamoto *et al.*, TUB04, Proc. CYCLOTRONS2016.
- 3) K. Yamada *et al.*, MOIXA04, Proc. SRF2023.

2. Major Research Subjects

- (1) Room-temperature and superconducting RF technology for heavy-ion accelerators
- (2) Development of superconducting linac
- (3) Operation of RIBF accelerator complex

3. Summary of Research Activity

- Room-temperature and superconducting RF technology for heavy-ion accelerators. We have successfully constructed a superconducting linac for the SHE experiment. Thanks to the newly developed digital feedback circuit, the amplitude and phase of the accelerating electric field are highly stabilized. The existing analog feedback circuits for the room-temperature RF system will be replaced by the newly developed digital feedback circuit.
- After commissioning the hardware of the superconducting linac, the next target is to achieve long-term operation with high reliability. One of the most significant issues with superconducting cavities is the increase in field emission due to prolonged operation. We are currently working on finding a solution to restore the original performance of the superconducting cavity by utilizing high-power pulsed conditioning.
- User beam services are performed by the operation staff. To ensure effective operation and software and hardware maintenance, a weekly operation meeting is held. During these meetings, problems and difficulties are discussed among members of the hardware groups and the safety management group.

Members

Team Leader

Naruhiko SAKAMOTO

Research/Technical Scientists

Kazutaka OZEKI (Senior Technical Scientist)

Kenji SUDA (Technical Scientist)

List of Publications & Presentations

Publications

[Proceedings]

R. Koyama, K. Ozeki, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Moteki, T. Nakamura, M. Nishida, M. Nishimura, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, T. Dantsuka, M. Fujimaki, T. Fujinawa, N. Fukunishi, H. Hasebe, Y. Higurashi, E. Ikezawa, H. Imao, O. Kamigaito, M. Kidera, M. Komiyama, K. Kumagai, T. Maie, Y. Miyake, T. Nagatomo, T. Nakagawa, M. Nakamura, J. Ohnishi, H. Okuno, N. Sakamoto, K. Suda, A. Uchiyama, S. Watanabe, T. Watanabe, Y. Watanabe, and K. Yamada, "Operation report on ring cyclotrons in the RIBF accelerator complex," Proceedings of the 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023, TWSP01, (2023), pp. 1012–1016, https://www.pasj.jp/web_publish/pasj2023/proceedings/PDF/TWSP/TWSP01.pdf.

- M. Nishimura, K. Suda, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Koyama, R. Moteki, T. Nakamura, M. Nishida, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, M. Fujimaki, N. Fukunishi, H. Hasebe, Y. Higurashi, H. Imao, O. Kamigaito, M. Kidera, M. Komiyama, K. Kumagai, T. Maie, Y. Miyake, T. Nagatomo, T. Nakagawa, T. Nishi, J. Ohnishi, H. Okuno, K. Ozeki, N. Sakamoto, G. Saquilayan, A. Uchiyama, S. Watanabe, T. Watanabe, Y. Watanabe, K. Yamada, K. Kamakura, and Y. Kotaka, “Status report on the operation of RIKEN AVF cyclotron,” Proceedings of the 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023, TWSP12, (2023), pp. 1049–1053, https://www.pasj.jp/web_publish/pasj2023/proceedings/PDF/TWSP/TWSP12.pdf.
- A. Yusa, H. Yamauchi, K. Oyamada, M. Tamura, K. Kaneko, J. Suzuki, T. Ohki (SHI Accelerator Service Ltd.), Y. Higurashi, N. Sakamoto, M. Fujimaki, H. Imao, M. Kidera, T. Nakagawa, T. Nagatomo, T. Nishi, K. Ozeki, K. Suda, A. Uchiyama, T. Watanabe, Y. Watanabe, K. Yamada, and O. Kamigaito, “Present status of RILAC,” Proceedings of the 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023, TWSP05, (2023), pp. 1024–1028, https://www.pasj.jp/web_publish/pasj2023/proceedings/PDF/TWSP/TWSP05.pdf.
- N. Sakamoto, O. Kamigaito, K. Ozeki, K. Suda, and K. Yamada, “Degradation and recovery of cavity performance in the SRILAC cryomodules at RIBF,” Proceedings of the 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023, FRP21, (2023), pp. 884–890, https://www.pasj.jp/web_publish/pasj2023/proceedings/PDF/FRP2/FRP21.pdf.
- K. Yamada, M. Fujimaki, H. Imao, O. Kamigaito, M. Komiyama, K. Kumagai, T. Nagatomo, T. Nishi, H. Okuno, K. Ozeki, N. Sakamoto, K. Suda, A. Uchiyama, T. Watanabe, and Y. Watanabe, “Operational experience for RIKEN superconducting linear accelerator,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023, MOIXA04, (2023), pp. 30–37, <https://accelconf.web.cern.ch/srf2023/papers/moixa04.pdf>.
- T. Nishi, O. Kamigaito, N. Sakamoto, T. Watanabe, K. Yamada, and T. Adachi, “Development of non-destructive beam envelope measurements in SRILAC with low beta heavy ion beams using BPMs,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023, MOPMB086, (2023), pp. 319–323, <https://accelconf.web.cern.ch/srf2023/papers/mopmb086.pdf>.
- N. Sakamoto, O. Kamigaito, K. Ozeki, K. Suda, and K. Yamada, “Degradation and recovery of cavity performance in SRILAC cryomodules at RIBF,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023, WEPWB085, (2023), pp. 784–789, <https://accelconf.web.cern.ch/srf2023/papers/wepwb085.pdf>.
- K. Ozeki, O. Kamigaito, N. Sakamoto, K. Suda, and K. Yamada, “Present status of RIKEN power couplers for SRILAC,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023, WEPWB101, (2023), pp. 823–826, <https://accelconf.web.cern.ch/srf2023/papers/wepwb101.pdf>.

Presentations

[International Conferences/Workshops]

- K. Yamada (invited), M. Fujimaki, H. Imao, O. Kamigaito, M. Komiyama, K. Kumagai, T. Nagatomo, T. Nishi, H. Okuno, K. Ozeki, N. Sakamoto, K. Suda, A. Uchiyama, T. Watanabe, and Y. Watanabe, “Operational experience for RIKEN superconducting linear accelerator,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023.
- T. Nishi (poster), O. Kamigaito, N. Sakamoto, T. Watanabe, K. Yamada, and T. Adachi, “Development of non-destructive beam envelope measurements in SRILAC with low beta heavy ion beams using BPMs,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023.
- N. Sakamoto (poster), O. Kamigaito, K. Ozeki, K. Suda, and K. Yamada, “Degradation and recovery of cavity performance in SRILAC cryomodules at RIBF,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023.
- K. Ozeki (poster), O. Kamigaito, N. Sakamoto, K. Suda, and K. Yamada, “Present status of RIKEN power couplers for SRILAC,” 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 27–July 2, 2023.
- N. Sakamoto, “Degradation and recovery of cavity performance in SRILAC cryomodules at RIBF (pulsed RF conditioning),” TTC Meeting, Chicago, Illinois, USA, December 5–8, 2023.
- K. Yamada, “Contamination prevention measures when installing the SRILAC cryomodules to a 40-years-old dirty beamline,” TTC Meeting, Chicago, Illinois, USA, December 5–8, 2023.

[Domestic Conferences/Workshops]

- R. Koyama (poster), K. Ozeki, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Moteki, T. Nakamura, M. Nishida, M. Nishimura, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, M. Dantsuka, M. Fujimaki, T. Fujinawa, N. Fukunishi, H. Hasebe, Y. Higurashi, E. Ikezawa, H. Imao, O. Kamigaito, M. Kidera, M. Komiyama, K. Kumagai, T. Maie, Y. Miyake, T. Nagatomo, T. Nakagawa, M. Nakamura, J. Ohnishi, H. Okuno, N. Sakamoto, K. Suda, A. Uchiyama, S. Watanabe, T. Watanabe, Y. Watanabe, and K. Yamada, “Operation report on ring cyclotrons in the RIBF accelerator complex,” 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023.
- M. Nishimura (poster), K. Suda, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Koyama, R. Moteki, T. Nakamura, M. Nishida, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, M. Fujimaki, N. Fukunishi, H. Hasebe, Y. Higurashi, H. Imao, O. Kamigaito, M. Kidera, M. Komiyama, K. Kumagai, T. Maie, Y. Miyake, T. Nagatomo, T. Nakagawa, T. Nishi, J. Ohnishi, H. Okuno, K. Ozeki, N. Sakamoto, G. Saquilayan, A. Uchiyama, S. Watanabe, T. Watanabe, Y. Watanabe, K. Yamada, K. Kamakura, and Y. Kotaka, “Status report on the operation of RIKEN AVF cyclotron,” 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023.

- A. Yusa (poster), H. Yamauchi, K. Oyamada, M. Tamura, K. Kaneko, J. Suzuki, T. Ohki, Y. Higurashi, N. Sakamoto, M. Fujimaki, H. Imao, M. Kidera, T. Nakagawa, T. Nagatomo, T. Nishi, K. Ozeki, K. Suda, A. Uchiyama, T. Watanabe, Y. Watanabe, K. Yamada, and O. Kamigaito, “Present status of RILAC,” 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023.
- N. Sakamoto (poster), O. Kamigaito, K. Ozeki, K. Suda, and K. Yamada, “Degradation and recovery of cavity performance in the SRILAC cryomodules at RIBF,” 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi (Nihon University), Japan, August 29–September 1, 2023.