Research Facility Development Division
Accelerator Group
RILAC Team

1. Abstract

Our team is responsible for the operation, maintenance, and upgrade of the RIKEN heavy-ion linear accelerator (RILAC), as well as the maintenance of the vacuum system for the entire accelerator complex of the RI Beam Factory (RIBF). RILAC is a unique variable-frequency linac that has been in operation since 1980, and was upgraded in the 1990s as part of the RIBF project and significantly contributed to the synthesis and discovery of element 113, nihonium, a new chemical element recognized by the super-heavy element (SHE) research group. In 2019, RILAC underwent a major upgrade again with the introduction of the new superconducting linac booster (SRILAC) and a superconducting electron-cyclotron-resonance ion source (SC-ECRIS). These enhancements were designed to advance the super-heavy element synthesis program beyond Nihonium and to improve the efficiency of medical radioisotope production. Since the upgraded RILAC became operational in 2020, we have continuously provided beam service, addressing various issues such as water leaks and vacuum leaks associated with the older parts of the accelerator. Through our dedicated efforts and well-planned maintenance and replacement of outdated equipment such as power supplies, vacuum pumps, and control systems, we have improved RILAC's availability to over 90%, despite a significantly reduced annual budget.

2. Major Research Subjects

(1) Efficient operation, maintenance and management of the vacuum equipment in the RIBF accelerators
(2) Development of technology to operate RILAC for high intense and stable beam supply
(3) Construction and maintenance of the RILAC beamlines
(4) Efficient maintenance and upgrade of the vacuum system for the RIBF accelerators

3. Summary of Research Activity

In 2023, significant improvements were made to the RILAC through collaboration with other teams in the Accelerator Group, aimed at ensuring the provision of high-intensity beams with greater stability. Notably, the renewal of electromagnet power supplies for magnets and their control systems in the Low Energy Beam Transport (LEBT) and High Energy Beam Transport (HEBT) stands out as a highlight of our maintenance efforts this year. A key focus has been the preparation of the beamline, dedicated to the mass production of ^{211}At for medical applications. Under the guidance of the RI Application Research Group and with the support of other teams within the Accelerator Group, ongoing work has included optical calculations for beam transportation, design work for radiation shielding, and overall beamline construction. Additionally, meticulous maintenance of the vacuum system has been carried out, considering the aging of vacuum pumps and adhering to efficient annual maintenance schedules established with a keen eye on cost-effectiveness.

Members

Team Leader

Yoshihide HIGURASHI

Research/Technical Scientists

Yutaka WATANABE (Senior Technical Scientist)
Takahiro NISHI (Research Scientist)

List of Publications & Presentations

Publications

[Proceedings]

A. Yusa, Y. Higurashi, H. Yamauchi, K. Oyamada, M. Tamura, K. Kaneko, J. Suzuki, T. Ohki, H. Imao, A. Uchiyama, K. Ozeki, M. Kidera, N. Sakamoto, K. Suda, T. Nagatomo, T. Nakagawa, T. Nishi, M. Fujimaki, K. Yamada, T. Watanabe, Y. Watanabe, 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.

T. Nishi, T. Adachi, O. Kamigaito, N. Sakamoto, T. Watanabe, and K. Yamada, "Development of non-destructive beam envelope measurements in SRILAC with low beta heavy ion beams using BPMs," Proceedings of the 21st International Conference on RF Superconductivity (SRF2023), Grand Rapids, Michigan, USA, June 25–30, 2023, MOPM086, (2023), pp. 319–323, https://accelconf.web.cern.ch/srf2023/papers/mopmb086.pdf.

T. Nishi, T. Adachi, O. Kamigaito, N. Sakamoto, T. Watanabe, and K. Yamada, "Development of non-destructive beam envelope measurements using BPMs for low beta heavy ion beams in SRF cavities," Proc. HB2023, 68th ICFA Advanced Beam Dynamics Workshop, Geneva, Switzerland, October 9–13, 2023, WEA4I1, (2023), pp. 284–289, https://accelconf.web.cern.ch/hb2023/papers/wea4i1.pdf.

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.

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," Proceedings of the 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.

N. Sakamoto, O. Kamigaito, K. Ozeki, K. Suda, and K. Yamada, "Degradation and recovery of cavity performance in SRILAC Cryomodules at RIBF," Proceedings of the 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," Proceedings of the 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]

T. Nishi (Poster), T. Adachi, O. Kamigaito, N. Sakamoto, T. Watanabe, and K. Yamada, "Development of non-destructive beam envelope measurements in SRILAC with low beta heavy ion beams using BPMs," 21st International Conference on RF Superconductivity (SRF2023), MOPM086, Grand Rapids, Michigan, USA, June 25–30, 2023.

T. Nishi (Invited), T. Adachi, O. Kamigaito, N. Sakamoto, T. Watanabe, and K. Yamada, "Development of non-destructive beam envelope measurements using BPMs for low beta heavy ion beams in SRF cavities," HB2023, 68th ICFA Advanced Beam Dynamics Workshop, WEA4I1, Geneva, Switzerland, October 9–13, 2023.

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.

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]

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.

西隆博 (口頭発表), 「シミュレーションを併用した重イオンビームトランスポートラインのベイズ最適化に関する研究」, 加速器・ビーム物理の機械学習ワークショップ 2023, 和光市 (理化学研究所), 2023 年 11 月 27 日.

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, 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," 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.

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.

Outreach Activities

[Workshop for Junior and Senior High School Students]

T. Nishi, Y. Miyake, and Accel Kitchen LLC, "Cosmic ray measurement workshop for junior and senior high school students at RIBF," Wako (RIKEN), August 29, 2023.