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 Through our dedicated efforts and well-planned maintenance and replacement of outdated equipment such as power supplies, vacuum pumps, and control systems, we have improved RILAC's availability to over 90%, despite a significantly reduced annual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 2024, we constructed a new beamline for the mass production of ^{211}At for medical applications. In December, we successfully commissioned He^{2+} beam acceleration using SRILAC and transported the beam to the midpoint of the beamline. In parallel, we designed and fabricated a new octupole magnet to generate a flat-shaped beam spot, thereby reducing heat damage to the target. Future efforts will focus on developing the target system, installing the octupole magnet, and conducting tests at higher beam intensities.

We also developed a method to estimate the transverse beam envelope in SRILAC using BPM signals. This method will be applied for daily beam delivery monitoring.

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]

K. Kaneko, Y. Higurashi, H. Yamauchi, K. Oyamada, M. Tamura, A. Yusa, J. Suzuki, 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 21th Annual Meeting of Particle Accelerator Society of Japan, Yamagata, Japan, July 31–August 3, 2024, WTSP07, (2024) pp. 1129–1132, https://www.pasj.jp/web_publish/pasj2024/proceedings/PDF/WTSP/WTSP07.pdf.

M. Nishida, K. Suda, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Koyama, R. Moteki, T. Nakamura, M. Nishimura, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, T. Dantsuka, M. Fujimaki, 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, T. Nishi, J. Ohnishi, H. Okuno, K. Ozeki, N. Sakamoto, G. Saquilayan, A. Uchiyama, T. Watanabe, Y. Watanabe, and K. Yamada, "Status report on the operation of RIBF ring cyclotron," Pceedings of the 21th Annual Meeting of Particle Accelerator Society of Japan, Yamagata, Japan, July 31–August 3, 2024, WTSP09, (2024), pp. 1135–1140, https://www.pasj.jp/web_publish/pasj2024/proceedings/PDF/WTSP/WTSP09.pdf.

J. Shibata, K. Ozeki, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Koyama, R. Moteki, T. Nakamura, M. Nishida, M. Nishimura, 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, N. Sakamoto,

G. Saquilayan, K. Suda, A. Uchiyama, S. Watanabe, T. Watanabe, Y. Watanabe, K. Yamada, K. Kamakura, and Y. Kotaka, "Status report on the operation of RIKEN AVF cyclotron," Pceedings of the 21th Annual Meeting of Particle Accelerator Society of Japan, Yamagata, Japan, July 31–August 3, 2024, WTSP01, (2024), pp. 1112–1115, https://www.pasj.jp/web_publish/pasj2024/proceedings/PDF/WTSP/WTSP01.pdf.

西隆博, 内山暁仁, 清水陽平, 杉本崇, 炭竈聡之, 福田直樹, 森田泰之, 「理研 RIBF における機械学習を用いたビーム輸送最適化の研究」, 第 36 回タンデム加速器及びその周辺技術の研究会報告集, 和光, 理研, 日本, 6 月 (2024).

Presentations

[International Conference/Workshop]

T. Nishi (invited oral), "Development of automatic beam tuning system using Bayesian optimization for high intensity heavy ion beams at RIBF," The 8th International Expert Meeting on Challenging Issues of Next-generation High-intensity in-flight Separators, Wako, RIKEN, Japan, January 2025.

[Domestic Conferences/Workshops]

K. Kaneko (ポスター), Y. Higurashi, H. Yamauchi, K. Oyamada, M. Tamura, A. Yusa, J. Suzuki, Hiroshi 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," the 21th Annual Meeting of Particle Accelerator Society of Japan, Yamagata, Japan, July 31–August 3, 2024, WTSP07, 2024.

M. Nishida (ポスター), K. Suda, S. Fukuzawa, M. Hamanaka, S. Ishikawa, K. Kobayashi, R. Koyama, R. Moteki, T. Nakamura, M. Nishimura, J. Shibata, N. Tsukiori, K. Yadomi, T. Adachi, T. Dantsuka, M. Fujimaki, 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, T. Nishi, J. Ohnishi, H. Okuno, K. Ozeki, N. Sakamoto, G. Saquilayan, A. Uchiyama, T. Watanabe, Y. Watanabe, andK. Yamada, "Status report on the operation of RIBF ring cyclotron," 21th Annual Meeting of Particle Accelerator Society of Japan, Yamagata, Japan, July 31–August 3, 2024, WTSP09, 2024.

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西隆博 (口頭発表), 森田泰之, 藤井洋樹, 「RIBF における重イオンビームの光学系調整のための安全関数を用いたベイズ最適化」, 第 3 回加速器・ビーム物理の機械学習ワークショップ, 佐用郡佐用町（理化学研究所）, 2024 年 11 月 25–27 日.

西隆博 (招待講演), 内山暁仁, 清水陽平, 杉本崇, 炭竈聡之, 福田直樹, 森田泰之, 「理研 RIBF における機械学習を用いたビーム輸送最適化の研究」, 第 36 回タンデム加速器及びその周辺技術の研究会, 和光市（理化学研究所）, 2024 年 6 月 27 日.