Research Facility Development Division Accelerator Group Ion Source Team

1. Abstract

Ion sources are critical devices that determine the performance of accelerator facilities. The Ion Source Team has produced several world-class ECR ion sources over a long period of research and development. We currently operate three ECR ion sources, including two superconducting ECR ion sources, to produce intense heavy-ion beams that are accelerated in the RI Beam Factory. We are also conducting research and development to further increase the intensity and stability of the beams.

2. Major Research Subjects

- (1) Operation of the ECR ion sources for the RIBF beam time
- (2) Improvement for efficient operation of the ECR ion sources
- (3) Development for performance upgrade of the ECR ion sources
- (4) Peripheral device preparation for long-term operation
- (5) Support of the research activity of SPDR

3. Summary of Research Activity

(1) Operation

We are operating three ECR ion sources (ECRIS). Main beams delivered from these ion sources in FY2023 are: krypton and xenon from 18-GHz normal-conducting ECRIS for application research, xenon and vanadium from 28-GHz superconducting ECRIS (SUI) for nuclear physics, and vanadium beam from 28-GHz superconducting ECRIS (KURENAI) exclusively for synthesis of a new element. (Saquilayan, Higurashi, and Nagatomo)

(2) Improvement

We have done daily maintenance and improvements throughout FY2023 as usual, such as introduction of a new control panel for vacuum equipment in the extraction beam line of 18-GHz ECRIS. (Nagatomo, Saquilayan, Higurashi, Ohnishi, and Nakagawa)

(3) Development

In FY2023, basic studies on the relationship between beam emittance and space-charge effects were carried out. In addition, fabrication of a test bench to test the micro-oven for generating the lead beam was started. (Nagatomo, Saquilayan, Higurashi, Ohnishi, and Nakagawa)

(4) Peripheral device preparation

Recently, the production of a small refrigerator and a 28-GHz gyrotron for the superconducting ECRIS was discontinued. Therefore, we have started to test a successor model of the refrigerator and to fabricate a new gyrotron. They are expected to be delivered by the end of the next fiscal year. (Nagatomo, Higurashi, Ohnishi, Nakagawa, Yamada, and Kamigaito)

(5) SPDR activity

This fiscal year the SPDR (Morita) carried out various research activities based on his own plan: testing the automatic operation of the RILAC injector section, machine-learning based analysis of the emission patterns of the ion source plasma, and introduction of a new analysis method for the pepper-pot emittance meter. The last subject also helped to improve the operational performance of the ion source. (Morita, Nagatomo, and Kamigaito)

Members

Team Leader Osamu KAMIGAITO

Senior Technical Scientist Takashi NAGATOMO

Postdoctoral Researcher Glynnis Mae Q. SAQUILAYAN

Special Postdoctoral Researcher Yasuyuki MORITA

List of Publications & Presentations

Publications

[Original Paper]

Y. Morita, T. Washio, and Y. Nakashima, "Accelerator tuning method using autoencoder and Bayesian optimization," Nucl. Instrum. Methods Phys. Res. A **1057**, 168730 (2023).

[Proceeding]

森田泰之, 福田光宏, 依田哲彦, 中島悠太, 鷲尾隆, 「ベイズ最適化とオートエンコーダを用いた最適化手法の開発」, Proceedings of the 20th Annual Meeting of Particle Accelerator Society of Japan, Funabashi, August 29–September 1, 2023.

Presentations

[International Conferences/Workshops]

- T. Nagatomo (oral), G. Q. Saquilayan, J. Ohnishi, K. Kamakura, and Y. Higurashi, "Space-charge effects on transverse emittance at the extraction region of RIKEN 28-GHz ECRIS," 20th International Conference on Ion Sources (ICIS2023), Victoria, Canada, September 16–22, 2023.
- Y. Higurashi (oral), J. Ohnishi, T. Nagatomo, and G. Q. Saquilayan, "Production of intense vanadium ion beam for super-heavy element research experiments," 20th International Conference on Ion Sources (ICIS2023), Victoria, Canada, September 16–22, 2023.
- G. Q. Saquilayan (poster), J. Ohnishi, T. Nakagawa, T. Nagatomo, Y. Higurashi, and O. Kamigaito, "Beam emittance growth of highly charged ion beams from the RIKEN 28-GHz SC-ECRIS," 20th International Conference on Ion Sources (ICIS2023), Victoria, Canada, September 16–22, 2023.
- Y. Morita (poster), T. Nagatomo, and Y. Nakashima, "Development of an image analysis method for pepperpot emittance monitors," 20th International Conference on Ion Sources (ICIS2023), Victoria, Canada, September 16–22, 2023.
- Y. Higurashi (poster), J. Ohnishi, H. Haba, and G. Q. Saquilayan, "Production of intense uranium ion beam for RIKEN RI Beam Factory," 20th International Conference on Ion Sources (ICIS2023), Victoria, Canada, September 16–22, 2023.
- Y. Morita (poster), "Development of beam transport system optimization method using VAE and Bayesian optimization," 4th ICFA Beam Dynamics Mini-Workshop on Machine Learning Applications for Particle Accelerators, Gyeongju, South Korea, March 5–8, 2024.

[Domestic Conferences/Workshops]

森田泰之 (ポスター発表), 「ベイズ最適化とオートエンコーダを用いた最適化手法の開発」, 第 20 回日本加速器学会年会, 船橋市 (日本大学船橋キャンパス), 2023 年 8 月 29 日–9 月 1 日.

森田泰之 (口頭発表), 「VAE とベイズ最適化によるビーム輸送系の最適化」, 加速器・ビーム物理の機械学習ワークショップ 2023, 和光市 (理化学研究所仁科ホール), 2023 年 11 月 27–29 日.

Patent

森田泰之,長友傑,「イオンビームの位置・角度分布の高分解能測定方法」,2023-143339,2023年9月5日.

Other

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森田泰之, 西隆博, 研究会「加速器・ビーム物理の機械学習ワークショップ 2023」主催, 和光市 (理化学研究所仁科ホール), 2023
年 11 月 27–29 日.
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