Research Facility Development Division
Accelerator Group
Ion Source Team

1. Abstract

Ion sources are fundamental components that determine the overall performance of accelerator facilities. The Ion Source Team has developed several world-leading ECR ion sources through many years of research and innovation. At present, we operate three ECR ion sources—including two superconducting types—to generate intense heavy-ion beams for acceleration at the RI Beam Factory. In parallel, we are actively engaged in research and development efforts to further enhance both the intensity and stability of these beams.

2. Major Research Subjects

(1) Operation of ECR ion sources during RIBF beam time
(2) Optimization for efficient and stable operation of ECR ion sources
(3) Research and development to enhance ECR ion source performance
(4) Preparation and maintenance of peripheral systems for long-term operation

3. Summary of Research Activity

(1) Operation

We are currently operating three ECR ion sources (ECRIS). The main beams delivered from these sources in FY2024 were as follows: hydrogen, helium, nitrogen, oxygen, neon, argon, krypton, and xenon beams from the 18-GHz normal-conducting ECRIS, primarily for application research; zinc, xenon, vanadium, uranium, and helium beams from the 28-GHz superconducting ECRIS (SUI) for nuclear physics experiments and RI production; and a vanadium beam from the 28-GHz superconducting ECRIS (KURENAI), dedicated to superheavy element synthesis. (Saquilayan, Higurashi, and Nagatomo)

(2) Improvement

In FY2024, a new GM-JT refrigerator was delivered, tested, and installed on the 28-GHz superconducting ECRIS (SUI), along with helium recovery piping. The analysis software for the pepper-pot emittance meter was improved, and a new pepper-pot emittance meter was installed on the 18-GHz ECRIS beamline. (Higurashi, Ohnishi, Nagatomo, Morita, Saquilayan, and Nakagawa)

(3) Research and Development

We conducted a study on the emittance growth of highly charged ion beams extracted from the ECR ion source. In addition, we investigated the effects of axial and radial magnetic fields on the production of highly charged ion beams, focusing particularly on the so-called High-B mode. A lead ion beam was developed using a high-temperature oven, and a sample deposition shield was fabricated for use with this oven. Furthermore, a new extraction electrode was manufactured using the F-REI budget, with the goal of increasing the intensity of the alpha beam. A camera system and data acquisition setup for plasma light monitoring were also developed to support the analysis of plasma emissions using machine learning. (Saquilayan, Higurashi, Ohnishi, Nagatomo, Morita, Kamigaito, and Nakagawa)

(4) Peripheral Device Preparation

A new 28-GHz gyrotron is currently under fabrication. (Nagatomo, Higurashi, Nakagawa, Yamada, and Kamigaito)

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List of Publications & Presentations

Publications

[Original Papers]

Y. Higurashi, G. Q. Saquilayan, J. Ohnishi, and T. Nagatomo, "Producing intense uranium ion beam for Riken Ri Beam Factory," J. Phys. Conf. Ser. **2743**, 012051 (2024).

Y. Higurashi, G. Q. Saquilayan, J. Ohnishi, and T. Nagatomo, "Intense vanadium ion beam production for super-heavy element research experiments," J. Phys. Conf. Ser. **2743**, 012052 (2024).

Y. Morita, T. Nagatomo, and Y. Nakashima, "Development of an image analysis method for pepperpot emittance monitors," J. Phys. Conf. Ser. **2743**, 012071 (2024).

G. Q. Saquilayan, T. Nagatomo, Y. Higurashi, J. Ohnishi, T. Nakagawa, and O. Kamigaito, "Beam emittance growth of highly charged ion beams from the RIKEN 28-GHz SC-ECRIS," J. Phys. Conf. Ser. **2743**, 012081 (2024).

T. Nagatomo, K. Kamakura, Y. Morita, G. Q. Saquilayan, Y. Higurashi, and J. Ohnishi, "Space-charge effects on transverse emittance in the extraction region of the RIKEN 28-GHz ECRIS," J. Phys. Conf. Ser. **2743**, 012082 (2024).

Presentations

[International Conferences/Workshops]

Y. Morita (oral), K. Kamakura, A. Kasagi, and N. Oka, "Beam intensity prediction using ECR plasma images and machine learning," 26th International Workshop on ECR Ion Sources (ECRIS2024) Darmstadt, Germany, September 15–19, 2024.

G. Q. Saquilayan (oral), T. Nagatomo, Y. Higurashi, J. Ohnishi, and O. Kamigaito, "Development towards intense uranium ion beam production of the RIKEN 28 GHz SC-ECRIS," 26th International Workshop on ECR Ion Sources (ECRIS2024) Darmstadt, Germany, September 15–19, 2024.

Y. Morita (poster), K. Kamakura, A. Kasagi, N. Oka, and T. Nishi, "Beam intensity prediction using ECR plasma images and machine learning," 13th ITER International School, Aichi, Japan, (Nagoya Prime Central Tower), December 9–13, 2024,

Y. Morita (Oral), K. Kamakura, A. Kasagi, N. Oka, and T. Nishi, "Development on the use of machine learning at the RIKEN Nishina Center," Expert Meeting 2025, Wako, Saitama, Japan, (RIKEN Nishina Center), January 14–16, 2025.

[Domestic Conferences/Workshops]

長友傑 (ポスター発表), 日暮祥英, 大西純一, 上垣外修一, 「理研 28 GHz 超伝導 ECR イオン源の高温オーブンを用いた鉛ビーム生成」, 21 回日本加速器学会年会, 山形市 (山形テルサ), 2024 年 7 月 31 日–8 月 3 日.

Saquilayan Glynnis Mae Quinones (ポスター発表), 日暮祥英, 長友傑, 大西純一, 上垣外修一, 「Status of the Highly Charged Ion Beam Production from the RIKEN 18 GHz ECRIS」, 21 回日本加速器学会年会, 山形市 (山形テルサ), 2024 年 7 月 31 日–8 月 3 日.

森田泰之 (口頭発表), 長友傑, 中島悠太, 「高精度ペッパーポット型エミッタンスモニターの開発」, 21 回日本加速器学会年会, 山形市 (山形テルサ), 2024 年 7 月 31 日–8 月 3 日.

森田泰之, 鎌倉恵太, 笠置歩, 岡直哉, 西隆博, 「理研仁科センターにおける NN の活用」, 加速器・ビーム物理の機械学習ワークショップ 2024, 佐用郡佐用町 (国立開発研究法人理化学研究所播磨キャンパス), 2024 年 11 月 25 日–27 日.

森田泰之, 鎌倉恵太, 笠置歩, 岡直哉, 西隆博, 「ECR イオン源のプラズマ光と機械学習を用いたビーム強度予測システムの開発」, ECR イオン源スモールミーティング, オンライン, 2024 年 12 月 26 日.

Patent

鎌倉恵太, 森田泰之, 笠置歩, 「イオン源のビーム強度予測方法および予測装置 」, 出願番号：2024-147025 提出日：2024 年 08 月 28 日.