

## Research Facility Development Division Accelerator Group

### 1. Abstract

The Accelerator Group, consisting of seven teams, pursues various upgrade programs on the world-leading heavy-ion accelerator facility, RI Beam Factory (RIBF), to enhance the accelerator performance and operation efficiency. The programs include the R&D of superconducting ECR ion source, charge stripping systems, beam diagnostic devices, radio-frequency systems, control systems, and beam simulation studies. We are also maintaining the large infrastructure to realize effective operation of the RIBF. Moreover, we are actively promoting the applications of the facility to various research fields.

Our primary mission is to supply intense, stable heavy-ion beams for the users through effective operation, maintenance, and upgrade of the RIBF accelerators and related infrastructure. The director members oversee the development programs that are not dealt with by a single team, such as intensity upgrade and effective operation. We also discuss the future plans of RIBF along with other laboratories belonging to the RIBF research division.

### 2. Major Research Subjects

- (1) Intensity upgrade of RIBF accelerators (Okuno)
- (2) Effective and stable operation of RIBF accelerators (Fukunishi)
- (3) Stable operation of the upgraded RILAC facility
- (4) Promotion of applied research through collaborations
- (5) Promotion of the RIBF upgrade plan

### 3. Summary of Research Activity

- (1) Various improvements and developments have been carried out for the RIBF accelerators in order to upgrade the beam intensities and stability. Owing to the efforts, we succeeded in accelerating the zinc beam of 830 particle nA through SRC in December 2022, which corresponds to the beam power of 20 kW.
- (2) In December 2022, the high intensity zinc beam damaged the beam pipe in the last magnetic deflection channel (MDC3) in SRC, causing a vacuum leak and stopping beam service. We plan to repair the damaged part, investigate the cause, and implement remedial measures.
- (3) In the upgraded RILAC, replacement of the low-level rf control units has been carried out with newly developed ones based on digital circuit technology. The temperature control device for the cooling water in the normal-conducting cavity has been improved, and the accuracy of the temperature has been dramatically improved. Pulsed-rf conditioning of the superconducting cavities, where field emission had become severe, was also successfully performed. So far, a high-intensity vanadium beam has been stably supplied to the experiments for the synthesis of a new superheavy element.
- (4) We have supplied a wide variety of beams for applied research aimed at solving social problems, such as ion beam breeding, irradiation of semiconductors for space applications, and radioactive isotope production. Since 2017, we have cooperated in producing and supplying At-211 to various research activities. In particular, we contributed to the initiation of a physician-led clinical trial at Osaka University in 2021. A high-power target for mass production of At-211 is under development with RI Application Research Group of RNC, using the high-intensity alpha beam from RRC. It will be installed and tested in the SRILAC facility in near future.
- (5) An intensity-upgrade plan of the RIBF has been further investigated. The main focus of this plan is to increase the effective transmission efficiency of the accelerator chain from the current 5% to 50% by installing two Charge Stripper Rings (CSRs). The final goal of this plan is to increase the uranium beam intensity by 20 times of the present value, namely up to 2000 particle nA, at the exit of SRC. Detailed orbit calculations for the first of these CSRs have progressed, and design, prototyping, and testing of focusing and extraction magnets have been carried out with the involvement of companies. Good results have been obtained so far. In 2022, a detailed study of the entire plan, including the elements other than CSR, was initiated by young group members.

## Members

### Director

Osamu KAMIGAITO

### Deputy Directors

Hiroki OKUNO (for intensity upgrade)

Nobuhisa FUKUNISHI (for stable and efficient operation)

### Research Consultants

Tadashi FUJINAWA

Masayuki KASE

**Visiting Scientists**

Eiji KAKO (KEK)  
Hirotaka NAKAI (KEK)  
Kensei UMEMORI (KEK)  
Hiroshi SAKAI (KEK)

Masahiro OKAMURA (BNL)  
Noboru SASAO (Okayama Univ.)  
Yasutaka IMAI (Okayama Univ.)

**Assistant**

Karen SAKUMA

**Administrative Part-time Worker**

Ryoko UMEZAKI

**List of Presentation**

**Presentation**

**[International Conference/Workshop]**

O. Kamigaito (invited), "High beam power operations at RIKEN RIBF: Technical developments, challenges and resolutions," 15th International Conference on Heavy Ion Accelerator Technology (HIAT2022), Darmstadt, Germany, June 27–July 1, 2022.