

## 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 govern 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.

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, for example, we succeeded in accelerating the uranium beam of 117 particle nA through SRC in October 2020. This surpassed the long-standing target of 100 particle nA, and also means that one of goals of the current mid-term plan of RNC has been achieved. Moreover, the beam availability for the RIBF experiments has increased to 98.3% in 2021, which is the highest value since RIBF started operation.

At the RILAC facility, upgraded with a superconducting ECR ion source and superconducting booster linac, synthesis experiments of new elements has been conducted since 2020. In the first half of 2021, major repairs were made to the normal-conducting cavities. The coupler part of the superconducting cavities, which had a vacuum leak problem, were modified during the summer shutdown. As a result, a high intensity beam of  $^{51}\text{V}$  is now being supplied stably. Moreover, construction of a new beam line for the R&D of mass production method of  $^{211}\text{At}$  has been almost completed, in cooperation with the Safety Management Group under the leadership of the RI Application Research Group.

An upgrade plan of RIBF for further increasing uranium beam has been continuously discussed. Based on the basic design of the “charge-stripper ring (CSR),” which will be used to increase the overall stripping efficiency of the uranium beam, a pair of quadrupole magnets was fabricated as a prototype. The measured magnetic field was in good agreement with the simulations, including the magnetic field leaking around the magnets. Design study of the extraction bending magnet was also performed.

### 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 the upgrade plan of RIBF

### 3. Summary of Research Activity

- (1) The beams were provided for the RIBF experiments at the intensities requested by the users.
- (2) The beam availability for the RIBF experiments was 98.3% in 2021. This is the highest value since RIBF started operation.
- (3) A high intensity beam of  $^{51}\text{V}$  was supplied stably to the synthesis experiments of new elements at the upgraded RILAC facility.
- (4) An intensity-upgrade plan of the RIBF has been further investigated. Elemental R&D of the first charge-stripper ring (CSR1) is under progress.

## Members

### Director

Osamu KAMIGAITO

### Deputy Directors

Hiroki OKUNO (for intensity upgrade)

Nobuhisa FUKUNISHI (for stable and efficient operation)

### Junior Research Associate

Kaori NAKAMURA

### Research Consultants

Tadashi FUJINAWA

Masayuki KASE

### Visiting Scientists

Eiji KAKO (KEK)

Taro KONOMI (KEK)

Hirohisa NAKAI (KEK)

Masahiro OKAMURA (BNL)

Kensei UMEMORI (KEK)

Noboru SASAO (Okayama Univ.)

Hiroshi SAKAI (KEK)

Yasutaka IMAI (Okayama Univ.)

**Assistant**

Karen SAKUMA

**Administrative Part-time Worker II**

Ryoko UMEZAKI

**List of Publications & Presentations**

**Publication**

**[Original Paper]**

O. Kamigaito, "Scale invariance of electrodynamics in radio-frequency linear accelerators," arXiv:2109.14273.