RI beam production at BigRIPS in 2024

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This report summarizes the radioactive isotope (RI) beams produced at the BigRIPS fragment separator[1] in 2024. The experimental programs performed using the BigRIPS separator this year are listed in Table 1.

The 250-MeV/nucleon ^{18}O, 345-MeV/nucleon ^{70}Zn, and 345-MeV/nucleon ^{124}Xe were provided for experimental programs with BigRIPS as the primary beams in the spring of 2024. The experimental program with BigRIPS begun on April 9 after a four-day tuning period for the ^{18}O beam from the accelerator complex in RIBF. This was followed by an operation check of the system, such as tuning the magnets from the incident beam line to BigRIPS and starting up the beam line detectors.

The ^{18}O beam was utilized for two physics experiments at the SAMURAI spectrometer[2] and three machine studies (MS) for system development. BigRIPS provided ^{10}B and ^{8}Li for the search program for short-range correlations in proton-neutron pairs in neutron-rich nuclei, and ^{11}Li and nearby RI beams for the search program for predicted multi-neutron systems in nuclei beyond the neutron drip line. Three MS programs were also conducted: To improve the performance of the BigRIPS separator, the position of the rotational Be production target relative to the primary beam was examined,[3] and RI-production cross sections and momentum distributions for the RIs produced in the fragmentation process of the ^{18}O beam were measured.[4] In addition, an experimental device for SAMURAI was developed in conjunction with the SAMURAI physics experiments. Delivery of the ^{18}O beam was completed on April 26.

The ^{70}Zn beam was provided from May 11 to 24 for three physics experiments. The ^{50}Ca beam was produced and delivered to the OEDO-SHARAQ system[5] for a spectroscopic study of the neutron shell structure on the neutron-rich ^{50}Ca nucleus.

Reaction cross section measurements for $^{49-55}$Ca were conducted using BigRIPS and ZeroDegree spectrometer. These experiments aimed to investigate the development of nuclear size of Ca isotopes as the function of the neutron number. In the framework of the TRIP use case,[6] the reaction cross sections for $^{31-39}$P, ^{39,41}Ca, ^{47}Cr, ^{48}V, and ^{54,56}Co isotopes were also measured using BigRIPS and elastic scattering measurements on ^{44}Ti and ^{50}Ca were performed at F12.

In June, the ^{124}Xe beam was accelerated and five physics experiments were conducted to study neutron-deficient medium-mass nuclei. To promote an experiment determining the nuclear structure of doubly-magic ^{100}Sn, BigRIPS provided ^{101}Sn and delivered it to the ZeroDegree spectrometer. Additionally, an experiment motivated by the α-emission nature in the vicinity of ^{100}Sn nuclei was performed, for which BigRIPS was set for a production of Xe isotopes around the proton drip line. For future physics programs with IDATEN,[7] the ^{94}Pd beam was delivered and commissioned. The ^{84}Mo-centered beam was provided for precise atomic mass measurements by using MR-TOF system. Through the beam delivery in 2024, the series of heavy-ion-heavy-ion (HI-HI) collision measurements were completed. In ^{124}Xe, the first part of the measurements was completed. Three MSs were conducted using proton-rich beams to improve the total performance of RIBF: One is an ion-optical development of Rare-RI Ring, which was performed using a faint primary beam. The performance inspection and development of the temperature measurement system of the BigRIPS beam dump were conducted for a future increase of the heavy-ion beam intensity.[9] The ^{89}Rh beam was produced to improve the data on loosely-bound neutron-deficient nuclei.[10]

In the autumn, the ^{136}Xe beam was delivered in November 1–10 after a two-day tuning for the accelerator complex. The second half of the HI-HI collision experimental program was performed with the same detector setup, for which the intensity-controlled ^{136}Xe beam was delivered to the SAMURAI spectrometer. Sequentially, the reaction cross section for $^{91-99}$Zr and the elastic scattering for ^{136}Xe with the liquid hydrogen target were measured using the ^{136}Xe primary beam within the TRIP framework.

Since November 13, the complex accelerated and provided a ^{238}U beam at 345 MeV/nucleon. Four physics experimental programs were completed in this campaign. An experiment within the DTAS project[8] for β-decay and isomer spectroscopy was performed, where BigRIPS attempted to produce heavy isotopes beyond $N = 126$ using a beam-line magnet setting optimized for ^{214}Hg. During this experiment, the facility inspection was completed. After the DTAS experiments, two types of the nuclear moment measurements were performed to investigate the nuclear structure around ^{132}Sn. The ^{132}Sn beam was delivered to the F12 focal plane to measure its nuclear moment. In addition, for nuclear moment measurements of ^{130}Sn, the tertiary RI beam of spin-aligned ^{130}Sn was produced by using the dispersion-matching technique with the wedge-shaped target at F5. Three MSs were performed using the ^{238}U beam towards the RIBF facility upgrade project.[11] During the beam time, a wide

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Table 1. List of experimental programs with RI beams produced at the BigRIPS separator in 2024.

Primary beam/ Energy [MeV/nucleon] (Delivary period)	Proposal Number	Spokesperson	Course
^{18}O/250	NP1912-SAMURAI53-02	H. Wang	SAMURAI
(Apr. 9–26)	MS-EXP24-02	H. Otsu	SAMURAI
	MS-EXP24-01	H. Suzuki	BigRIPS
	MS-EXP24-07	M. Yoshimoto	BigRIPS
	NP1812-SAMURAI47-02	T. Nakamura	SAMURAI
^{70}Zn/345	NP1812-SHARAQ12R1-03	D. Suzuki	SHARAQ
(May 11–24)	NP1812-RIBF152R1-02	R. Kanungo	ZeroDegree
	PE24-01	M. Wada	ZeroDegree
	TRIP24-01-01	H. Baba	BigRIPS, F12
^{124}Xe/345	NP2112-RIBF211-01	J. Lee	ZeroDegree
(Jun. 1–Jul. 3)	MS-EXP24-05	Y. Yamaguchi	Rare-RI Ring
	NP2012-SAMURAI63-01	W. Lynch	SAMURAI
	NP2212-RIBF168R1-01	R. Grzywacz	ZeroDegree
	MS-EXP24-04	Y. Togano	BigRIPS
	MS-EXP24-06	H. Suzuki	ZeroDegree
	PE24-02	M. Wada	ZeroDegree
	NP2112-RIBF212-02	B. Moon	ZeroDegree
	NP2212-RIBF205R1-01	S. Kimura	ZeroDegree
^{136}Xe/345	TRIP24-01-02	H. Baba	BigRIPS, F12
(Nov. 1–10)	NP2012-SAMURAI63-02	W. Lynch	SAMURAI
^{238}U/345	NP2112-RIBF208-01	A. I. Morales Lopez	ZeroDegree
(Nov. 18–Dec. 8)	PE24-04	S. Nishimura	ZeroDegree
	INSPECTION24-02	K. Tanaka	F12
	NP1912-RIBF143R2-01	G. Georgiev	F12
	NP2212-RIBF225-01	G. Georgiev	F12
	MS-EXP24-09-01	H. Suzuki	ZeroDegree
	PE24-03	H. Ishiyama	ZeroDegree
	MS-EXP24-08-01	Y. Shimizu	ZeroDegree
	MS-EXP24-10-01	Y. Shimizu	ZeroDegree

range of RI beam production cross sections was studied using the ^{238}U beam.[10,12]

During the spring (three months) and autumn (one month) irradiation periods, the planned BigRIPS operations proceeded smoothly and were almost completed successfully. RI beam production at BigRIPS from the start of the operation in March 2007 is summarized in our database available at https://ribeam.riken.jp/.

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