

Research Facility Development Division  
 Research Instruments Group  
 BigRIPS Team

### 1. Abstract

This team is in charge of design, construction, development and operation of BigRIPS in-flight separator and its related research instruments at RI beam factory (RIBF). They are employed not only for the production of RI beams but also the experimental studies using RI beams.

### 2. Major Research Subjects

Design, construction, development and operation of BigRIPS in-flight separator, RI-beam transport lines, and their related research instruments.

### 3. Summary of Research Activity

This team is in charge of design, construction, development and operation of BigRIPS in-flight separator, RI-beam transport lines, and their related research instruments such as ZeroDegree spectrometer at RI beam factory (RIBF). They are employed not only for the production of RI beams but also various kinds of experimental studies using RI beams. The research subjects may be summarized as follows:

- (1) General studies on RI-beam production using in-flight scheme;
- (2) Studies on ion-optics of in-flight separators, including particle identification of RI beams;
- (3) Simulation and optimization of RI-beam production;
- (4) Development of beam-line detectors and their data acquisition system;
- (5) Experimental studies on production reactions and unstable nuclei;
- (6) Experimental studies of the limits of nuclear binding;
- (7) Development of superconducting magnets and their helium cryogenic systems;
- (8) Development of a high-power production target system;
- (9) Development of a high-power beam dump system;
- (10) Development of a remote maintenance and remote handling systems;
- (11) Operation, maintenance and improvement of BigRIPS separator system, RI-beam transport lines, and their related research instruments such as ZeroDegree spectrometer and so on;
- (12) Experimental research using RI beams.

## Members

### Team Leader

Koichi YOSHIDA

### Senior Research Scientists

Yoshiyuki YANAGISAWA  
 Naohito INABE

Kensuke KUSAKA  
 Masao OHTAKE

### Technical Scientists

Naoki FUKUDA  
 Yohei SHIMIZU

Hiroshi SUZUKI  
 Hiroyuki TAKEDA

### Contract Researcher

Yasuhiro TOGANO

### Postdoctoral Researcher

Masahiro YOSHIMOTO

### Visiting Scientists

Deuk Soon AHN (Inst. for Basic Sci.)  
 Daniel P. BAZIN (Michigan State Univ.)  
 Hans GEISSEL (GSI)  
 Naohito IWASA (Tohoku Univ.)

Yutaka MIZOI (Univ. of Electro-Commun.)  
 Sadao MOMOTA (Kochi Univ. Tech.)  
 David MORRISSEY (Michigan State Univ.)  
 Oleg TARASOV (Michigan State Univ.)

### Student Trainees

Mika EGETA (Tohoku Univ.)

Taiga HAGINOUCI (Tohoku Univ.)

## List of Publications & Presentations

### Publications

#### [Original Papers]

- M. Duer, T. Aumann, R. Gernhäuser, V. Panin, S. Paschalis, D. M. Rossi, N. L. Achouri, D. Ahn, H. Baba, C. A. Bertulani, M. Böhmer, K. Boretzky, C. Caesar, N. Chiga, A. Corsi, D. Cortina-Gil, C. A. Douma, F. Dufter, Z. Elekes, J. Feng, B. Fernández-Domínguez, U. Forsberg, N. Fukuda, I. Gasparic, Z. Ge, J. M. Gheller, J. Gibelin, A. Gillibert, K. I. Hahn, Z. Halász, M. N. Harakeh, A. Hirayama, M. Holl, N. Inabe, T. Isobe, J. Kahlbow, N. Kalantar-Nayestanaki, D. Kim, S. Kim, T. Kobayashi, Y. Kondo, D. Körper, P. Koseoglou, Y. Kubota, I. Kuti, P. J. Li, C. Lehr, S. Lindberg, Y. Liu, F. M. Marqués, S. Masuoka, M. Matsumoto, J. Mayer, K. Miki, B. Monteagudo, T. Nakamura, T. Nilsson, A. Obertelli, N. A. Orr, H. Otsu, S. Y. Park, M. Parlog, P. M. Potlog, S. Reichert, A. Revel, A. T. Saito, M. Sasano, H. Scheit, F. Schindler, S. Shimoura, H. Simon, L. Stuhl, H. Suzuki, D. Symochko, H. Takeda, J. Tanaka, Y. Togano, T. Tomai, H. T. Törnqvist, J. Tscheuschner, T. Uesaka, V. Wagner, H. Yamada, B. Yang, L. Yang, Z. H. Yang, M. Yasuda, K. Yoneda, L. Zanetti, J. Zenihiro, and M. V. Zhukov, "Observation of a correlated free four-neutron system," *Nature* **606**, 678 (2022).
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- V. H. Phong, S. Nishimura, G. Lorusso, T. Davinson, A. Estrade, O. Hall, T. Kawano, J. Liu, F. Montes, N. Nishimura, R. Grzywacz, K. P. Rykaczewski, J. Agramunt, D. S. Ahn, A. Algora, J. M. Allmond, H. Baba, S. Bae, N. T. Brewer, C. G. Bruno, R. Caballero-Folch, F. Calviño, P. J. Coleman-Smith, G. Cortes, I. Dillmann, C. Domingo-Pardo, A. Fijalkowska, N. Fukuda, S. Go, C. J. Griffin, J. Ha, L. J. Harkness-Brennan, T. Isobe, D. Kahl, L. H. Kheim, G. G. Kiss, A. Korgul, S. Kubono, M. Labiche, I. Lazarus, J. Liang, Z. Liu, K. Matsui, K. Miernik, B. Moon, A. I. Morales, P. Morrall, N. Nepa, R. D. Page, M. Piersa-Siłkowska, V. F. E. Pucknell, B. C. Rasco, B. Rubio, H. Sakurai, Y. Shimizu, D. W. Stracener, T. Sumikama, H. Suzuki, J. L. Tain, H. Takeda, A. Tarifeño-Saldivia, A. Tolosa-Delgado, M. Wolińska-Cichočka, P. J. Woods, and R. Yokoyama, " $\beta$ -delayed one and two neutron emission probabilities southeast of  $^{132}\text{Sn}$  and the odd-even systematics in  $r$ -process nuclide abundances," *Phys. Rev. Lett.* **129**, 172701 (2022).
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- A. I. Stefanescu, V. Panin, L. Trache, T. Motobayashi, H. Otsu, A. Saastamoinen, T. Uesaka, L. Stuhl, J. Tanaka, D. Tudor, I. C. Stefanescu, A. E. Spiridon, K. Yoneda, H. Baba, M. Kurokawa, Y. Togano, Z. Halasz, M. Sasano, S. Ota, Y. Kubota, D. S. Ahn, T. Kobayashi, Z. Elekes, N. Fukuda, H. Takeda, D. Kim, E. Takada, H. Suzuki, K. Yoshida, Y. Shimizu, H. N. Liu, Y. L. Sun, T. Isobe, J. Gibelin, P. J. Li, J. Zenihiro, F. M. Marqués, M. N. Harakeh, G. G. Kiss, A. Kurihara, M. Yasuda, T. Nakamura, S. Park, Z. Yang, T. Harada, M. Nishimura, H. Sato, I. S. Hahn, K. Y. Chae, J. M. Elson, L. G. Sobotka and C. A. Bertulani, “Silicon tracker array for RIB experiments at SAMURAI,” *Eur. Phys. J. A* **58**, 223 (2022).
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### [Proceeding]

- S. Kim, J. Hwang, Y. Satou, N. A. Orr, T. Nakamura, Y. Kondo, J. Gibelin, N. L. Achouri, T. Aumann, H. Baba, F. Delaunay, P. Doornenbal, N. Fukuda, N. Inabe, T. Isobe, D. Kameda, D. Kanno, N. Kobayashi, T. Kobayashi, T. Kubo, S. Leblond, J. Lee, F. M. Marqués, R. Minakata, T. Motobayashi, D. Murai, T. Murakami, K. Muto, T. Nakashima, N. Nakatsuka, A. Navin, S. Nishi, S. Ogoshi, H. Otsu, H. Sato, Y. Shimizu, H. Suzuki, K. Takahashi, H. Takeda, S. Takeuchi, R. Tanaka, Y. Togano, A. G. Tuff, M. Vandebrouck, and K. Yoneda, “Spectroscopy of  $^{17}\text{C}$  above the neutron separation energy,” *Few-Body Syst.* **63**, 21 (2022).

## Presentations

### [International Conferences/Workshops]

- H. Suzuki (invited), “Studies of the two-step scheme with a  $^{132}\text{Sn}$  beam for next-generation RI-beam production in the medium-heavy very-neutron-rich region,” The 19th International Conference on Electromagnetic Isotope Separators and Related Topics (EMIS), Daejeon, Korea, October 3–7, 2022.
- M. Yoshimoto (oral), N. Fukuda, H. Otsu, Y. Shimizu, T. Sumikama, H. Suzuki, H. Takeda, J. Tanaka, K. Yoshida, R. Matsumura, D. Nishimura, and H. Takahashi, “Development of new ionization chamber specialized in high-Z beam,” The 19th International Conference on Electromagnetic Isotope Separators and Related Topics (EMIS), Daejeon, Korea, October 3–7, 2022.
- K. Yoshida (oral), Y. Yanagisawa, M. Ohtake, and T. Kubo, “Operational experiences of high-power production target and high-power beam dump at BigRIPS separator at RIKEN RI beam factory,” The 19th International Conference on Electromagnetic Isotope Separators and Related Topics (EMIS), Daejeon, Korea, October 3–7, 2022.

### [Domestic Conferences/Workshops]

- 金子雅紀 (口頭発表), 村上哲也, 磯部忠昭, 倉田 (西村) 美月, 小野章, 池野なつ美, J. Barney, G. Cerizza, J. Estee, G. Jhang, J. W. Lee, W. G. Lynch, C. Santamaria, C. Y. Tsang, M. B. Tsang, R. Wang, D. S. Ahn, G. L. Atar, H. T. Aumann, 馬場秀忠, K. Boretzky, J. Brzychczyk, 千賀信幸, 福田直樹, I. Gašparić, B. Hong, A. Horvat, 市原卓, 家城和夫, 稲辺尚人, Y. J. Kim, 小林俊雄, 近藤洋介, P. Lasko, H. S. Lee, Y. Leifels, J. Łukasik, J. Manfredi, A. B. McIntosh, P. Morfouace, 中村隆司, 中塚徳継, 西村俊二, R. Olsen, 大津秀暁, P. Pawłowski, K. Pelczar, D. Rossi, 櫻井博儀, 佐藤広海, H. Scheit, R. Shane, 清水陽平, H. Simon, 炭竈聡之, 鈴木大介, 鈴木宏, 竹田浩之, S. Tangwanchaoen, 梶野康宏, H. Törnqvist, H. Z. Xiao, S. J. Yennello, J. Yurkon, Y. Zhang, 「RI ビームを用いた重イオン衝突における水素同位体生成と高密度核物質の対称エネルギー」, 日本物理学会第 77 回年次大会 (2022 年), オンライン, 2022 年 3 月 15–19 日.
- 篠原悠介 (口頭発表), 市川雄一, 郷慎太郎, 西畑洗希, 安藤蒼太, 荒殿和希, 旭耕一郎, 馬場秀忠, 福田直樹, G. Georgiev, A. Gladkov, 今村慧, 梶原孝文, 岸本侃己, R. Lozeva, 向井もも, 新倉潤, M. N. Nurhafiza, 小田原厚子, 清水陽平, M. Si, C. K. Stoychev, 鈴木宏, 立川柊平, 田島美典, 高峰愛子, 竹田浩之, 竹中京平, 武重祥子, 上野秀樹, 若狭智嗣, 山下渉, 山崎展樹, 横田望海, 吉本雅浩, J. M. Daugas, 「分散整合二回散乱法による  $^{99}\text{Zr}$  アイソマー状態のスピン整列」, 日本物理学会 2022 年秋季大会, 岡山市 (岡山理科大学), 2022 年 9 月 6–8 日.
- H. Lee(oral), T. Nakamura, N. Nakatsuka, A. Y. Kondo, K. J. Cook, S. Ogoshi, A. T. Saito, N. L. Achouri, T. Aumann, E. H. Baba, F. Delaunay, Q. Deshayes, P. Doornenbal, N. Fukuda, J. Gibelin, J. W. Hwang, N. Inabe, T. Isobe, D. Kameda, D. Kanno, S. Kim,

N. Kobayashi, T. Kobayashi, T. Kubo, S. Leblond, J. Lee, F. M. Marques, R. Minakata, T. Motobayashi, K. Muto, T. Murakami, D. Murai, T. Nakashima, A. Navin, S. Nishi, N. A. Orr, H. Otsu, H. Sato, Y. Satou, Y. Shimizu, H. Suzuki, K. Takahashi, H. Takeda, S. Takeuchi, R. Tanaka, Y. Togano, J. Tsubota, A. G. Tuff, M. Vandebrouck, and K. Yoneda, "Coulomb dissociation of  $^{17}\text{B}$ ," 日本物理学会 2022 年秋季大会, 岡山市 (岡山理科大学), 2022 年 9 月 6–8 日.