Advanced Research Center for Beam Science
– Particle Beam Science –

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Prof
WAKASUGI, Masanori
(D Sc)

Assoc Prof
TSUKADA, Kyo
(D Sc)

Assist Prof*
OGAWARA, Ryo
(D Med Sc)

Techn Staff
TONGU, Hiromu

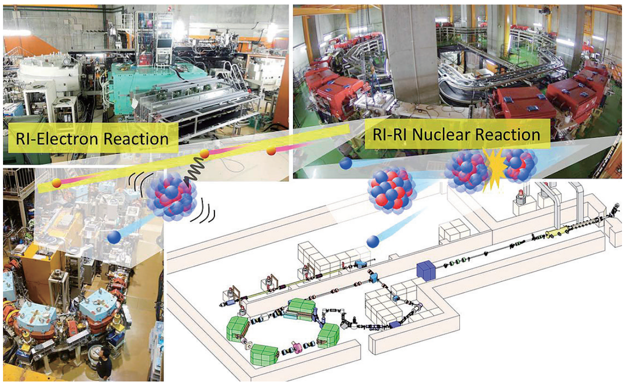
*New Research Field Development Project

Students

YOSHIDA, Satoru (M2)   TACHIBANA, Mariko (M1)   MAEDA, Yusei (M1)

Scope of Research

One of our research is an experimental research for unstable nuclear structures by means of the electron and heavy-ion accelerators. We address the technical development in an RI beam production driven by a high-energy electron beam, an electron scattering from the RI's in combination with the RI target inserted in an electron storage ring, and the precision mass measurement for extremely short-lived and rare exotic nuclei using a heavy-ion storage ring. We will address some technical development aiming at a nuclear photo-absorption cross-section measurement and the beam recycling in a heavy-ion storage ring to study the nuclear reactions involving rare exotic nuclei.



KEYWORDS

Beam Physics
Unstable Nuclear Physics
Electron Linac
Accelerator Physics
Storage Ring

Recent Selected Publications

Tsukada, K.; Abe, Y.; Enokizono, A.; Goke, T.; Hara, M.; Honda, Y.; Hori, T.; Ichikawa, S.; Ito, Y.; Kurita, K.; Legris, C.; Maehara, Y.; Ohnishi, T.; Ogawara, R.; Suda, T.; Tamae, T.; Wakasugi, M.; Watanabe, M.; Wauke, H., First Observation of Electron Scattering from Online-Produced Radioactive Target, *Phys. Rev. Lett.*, **131,** 092502 (2023).

Ogawara, R.; Abe, Y.; Ohnishi, T.; Enokizono, A.; Hara, M.; Hori, T.; Ichikawa, S.; Kurita, K.; Maehara, Y.; Suda, T.; Tsukada, K.; Wakasugi, M.; Watanabe, M.; Wauke, H., Ion-Trapping Properties of SCRIT: Time Evolutions of 138Ba Charge State Distributions, *Nucl. Instr. Met.*, **B541,** 90-92 (2023).

Miyata, K.; Ogawara, R.; Ishikawa, M., Improvement of Crystal Identification Accuracy for Depth-of-Interaction Detector System with Peak-to-Charge Discrimination Method, *Sensors*, **23,** 4584 (2023).

Li, H. F.; Naimi, S.; Sprouse, T. M.; Mumpower, M. R.; Abe, Y.; Yamaguchi, Y.; Nagae, D.; Suzaki, F.; Wakasugi, M.; Arakawa, H.; Dou, W. B.; Hamakawa, D.; Hosoi, S.; Inada, Y.; Kajiki, D.; Kobayashi, T.; Sakaue, M.; Yokoda, Y.; Yamaguchi, T.; Kagesawa, R.; Kamioka, D.; Moriguchi, T.; Mukai, M.; Ozawa, A.; Ota, S.; Kitamura, N.; Masuoka, S.; Michimasa, S.; Baba, H.; Fukuda, N.; Shimizu, Y.; Suzuki, H.; Takeda, H.; Ahn, D. S.; Wang, M.; Fu, C. Y.; Wang, Q.; Suzuki, S.; Ge, Z.; Litvinov, Yu. A.; Lorusso, G.; Walker, P. M.; Podolyak, Zs.; Uesaka, T., First Application of Mass Measurements with the Rare-RI Ring Reveals the Solar r-Process Abundance Trend at A = 122 and A = 123, *Phys. Rev. Lett.*, **128,** 152701 (2022).

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Topics

Electron Scattering for Determining Charge Density Distribution of Unstable Nuclei

As demonstrated in the 1950s by Hofstadter and his colleagues, high-energy electron scattering is one of the most powerful and reliable methods to reveal the internal structure of atomic nuclei. This is because of the following features: 1) an electron is an elementary particle and has no internal structure, 2) the electro-magnetic interaction is well understood and there is almost no ambiguity in theoretical calculations, and 3) electrons can probe deep inside the nucleus without causing any serious disturbance. In the latter half of the 20th century, many nuclei were investigated by electron scattering, and numerous basic and important features of nuclei, especially stable nuclei, were established.

After progresses of accelerator technique and detector developments, it became possible to artificially create unstable nuclei (RI) and extract them as RI beams. Recently, research on short-lived RIs has become very active all over the world following discoveries of exotic phenomena, such as neutron halo/skin, new magic numbers and disappearance of the magic numbers. Although electron scattering should be useful even for internal structure of such Ris, it has never been applied to short-lived Ris due to difficulty for preparing target with thickness enough to perform electron scattering experiment.

To overcome this challenge, we have developed a groundbreaking technique known as SCRIT (Self-Confining Radioactive Isotope Ion Target). This innovative method leverages the ion trapping of residual gases in an electron ring, a phenomenon typically responsible for electron beam instability but ingeniously utilized in this context.

Following successful commissioning, construction of the SCRIT electron scattering facility (see Fig. 1) began at the RI Beam Factory at RIKEN in 2009 and was completed in recent years.

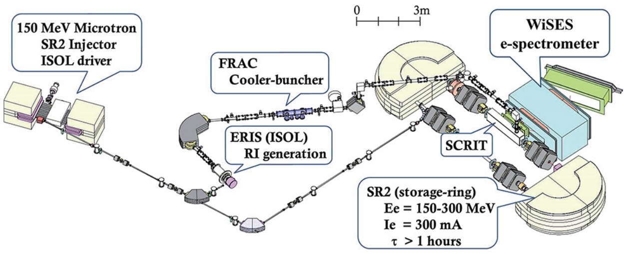

Figure 1. Overview of SCRIT electron scattering facility.

Our research has specifically focused on electron scattering experiments targeting atomic nuclei around a neutron magic number of N = 82. Notably, an experiment involving 137Cs, generated by the photofission reaction of uranium, represents the world's first electron scattering experiment with online produced RI and was published in the Physical Review Letters journal this year. Fig. 2 shows obtained momentum and angular distributions. This achievement has garnered significant attention, including a featured article in Physics Today.

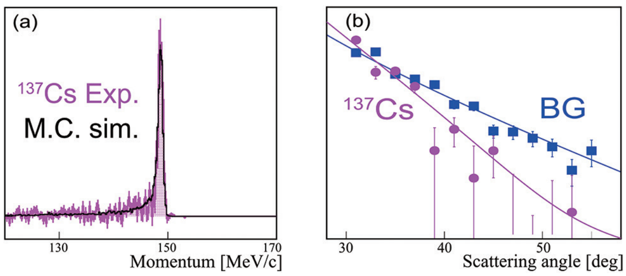

Figure 2. (a) Reconstructed momentum distribution of scattered electrons, (b) Obtained angular distribution of ^{137}Cs (pink) and background (blue) and theoretical calculations (solid lines).