Advanced Research Center for Beam Science – Particle Beam Science –

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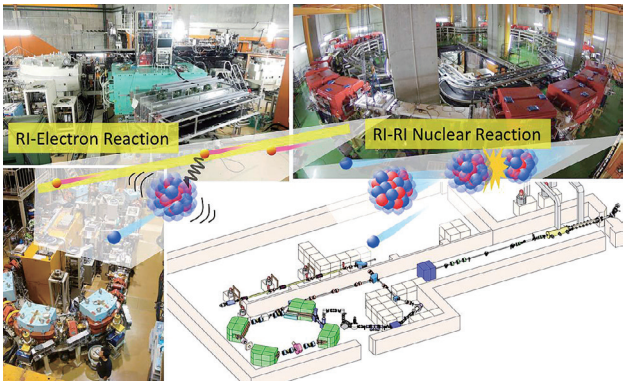
Scope of Research

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
Accelerator Physics
Neutron Optics
Storage Ring
Unstable Nuclear Physics

Recent Selected Publications

Wakasugi, M.; Togasaki, M.; Ohnishi, T.; Kurita, K.; Toba, R.; Watanabe, M.; Yamada, K., FRAC: Fringing-RF-Field-Activated DC-to-Pulse Converter for Low-Energy Ion Beam, *Rev. Sci. Instrum.*, **89,** 095107 (2018).

Iwashita, Y.; Fuwa, Y.; Ishida, T.; Kino, K., Magnified Neutron Imaging with Modulating Permanent Magnet Sextupole Lens, *Proc. Int. Conf. Neutron Optics (NOP2017)*, **22,** [011008-1]-[011008-7] (2018).

Tsukada, K.; Enokizono, A.; Ohnishi, T.; Adachi, K.; Fujita, T.; Hara, M.; Hori, M.; Hori, T.; Ichikawa, S.; Kurita, K.; Matsuda, K.; Suda, T.; Tamae, T.; Togasaki, M.; Wakasugi, M.; Watanabe, M.; Yamada, K., First Elastic Electron Scattering from ^{132}Xe at the SCRIT Facility, *Phys. Rev. Lett.*, **118,** 262501 (2017).

Kitaguchi, M.; Iwashita, Y.; Shimizu, H. M., Concentration of the Velocity Distribution of Pulsed Neutron Beams, *Prog. Theor. Exp. Phys.*, **2017,** 043D01 (2017).

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Development of Resonant-extraction Charge Breeder (RECB) for RUNBA

RUNBA (Recycled-Unstable-Nuclear Beam Accumulator) project aims at developing and establishing a beam recycling technique in a storage ring for nuclear reaction studies with rare RI ions. This project is addressed under the joint research program between ICR Kyoto University and RIKEN Nishina Center.

RI ions injected with the energy of 10 keV/u are accelerated to 10 MeV/u in RUNBA for nuclear reaction experiments. For an efficient acceleration, it is essential that RI ions are in highly charged state. Although an EBIT (Electron beam ion trap) type charge breeder (CB) is widely used to convert the singly charge state to the highly charge state, the efficiency has so far been around only 20 %. The low efficiency is fatal to research the rare-RI nuclear reaction. To improve the efficiency, we developed a novel type of CB named a resonant extraction charge breeder (RECB). Only desired charge state ions are selectively extracted from RECB with expecting the conversion efficiency of 100 %.

Ions injected to RECB are trapped by electrostatic potential with quadratic shape in the longitudinal direction and a large current of thin electron beam. The longitudinal motion of ions is a simple harmonic oscillation, and its frequency depends on the mass-to-charge ratio. Thus, when we oscillate the electro statistic potential at a certain frequency, the ions with a unique charge state are excited and they overcome the potential barrier. Then the ions of only a selected charge state are extracted from the RECB, and the others are left.

In this year, we tried proof-of-principle experiments of the RECB by using residual gas ions. Figure 1 shows some examples of spectrum for extracted $^{12}C^{1\sim4+}$ ions. The $^{12}C^{1\sim4+}$ ions are extracted with the frequency of 32, 51, 59, 73 kHz, respectively. These results demonstrated the possibility of the charge-state-selectable extraction from RECB. In a future work, we will optimize the potential oscillation design to improve thefrequency resolution.

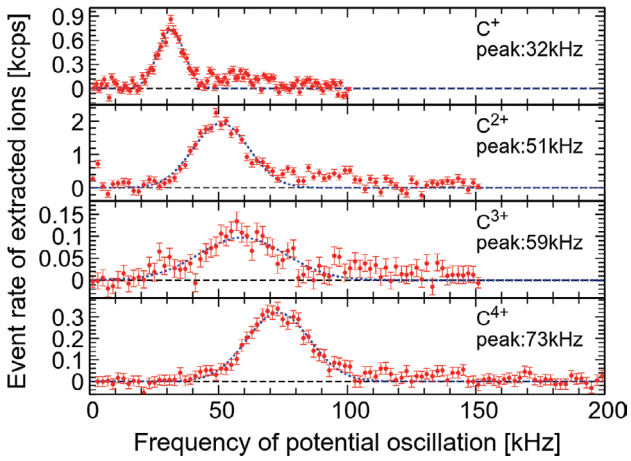

Figure 1. Event rate of extracted ions depended on a potential oscillation frequency in RECB.

Development of a Control System for KAKEN Accelerators

We have been developed a radiation management system (RMS) based on Experimental Physics and Industrial Control System (EPICS) for operating KAKEN Electron Linac (KEL) and KAKEN Storage Ring (KSR). A controller and I/O modules of the RMS are FA-M3 Programable Logic Controllers (PLC, Yokogawa Electric Corp.). RMS core programs are ladder logic programs for personal protection systems (PPS), and EPICS Input Output Controllers (IOC) for an accelerator control, and a FPGA-based timing system for accelerator triggers using CompactRIO (National Instrument Corp.). Figure 2 shows an operation interface of KEL/KSR status monitor made by Controll-System Studio (CSS). We plan to release the RMS and to drive the KEL and KSR during this year.

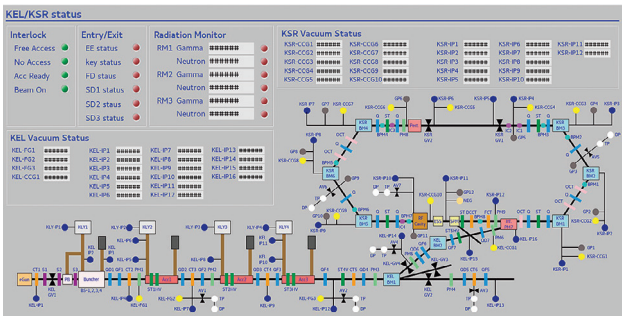

Figure 2. KEL/KSR status monitor made by CSS software.