New fast-timing measurement system at RIBF, IDATEN

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The radioactive isotope beam factory (RIBF) has provided remarkable opportunities to conduct decay spectroscopic studies of exotic nuclei since its first operation in 2007. The EURICA project for high-resolution decay spectroscopy was conducted from 2012–2016.[1)] Subsequently, the BRIKEN experiments focused on measuring neutron emission probabilities following β decays.[2)] Despite the success of these projects, critical nuclear properties are yet to be explored to further advance nuclear models. One such property is the reduced transition strength of electromagnetic transitions, which can be deduced by measuring the lifetimes of the short-lived excited states. This property plays an important role in constraining the overlap of wave functions and corresponding multipole operators between the initial and final states, and therefore, it provides significant insights into the underlying nuclear structure phenomena, including collective and single-particle motions.

The International Detector Assembly for fast-Timing measurements of Exotic Nuclei (IDATEN) project was launched in 2021 to precisely measure sub-nanosecond lifetimes. The full IDATEN array includes 82 $LaBr_3$(Ce) detectors (46 provided by the KHALA collaboration[3)] and 36 provided by the FATIMA collaboration.[4)]) These detectors are designed for the fast-timing measurement of γ rays, and they achieve an impressive time resolution of ∼335 ps at 511 keV in full width at half maximum.

In June 2024, the IDATEN commissioning experiment was performed for 30 hours of physics beam time at the F11 experimental hall. Unfortunately, only the KHALA detectors were installed for this experiment because of the scheduling conflicts of the FATIMA detectors. A segmented plastic scintillator detector, GARi,[5)] with a 6 mm thickness was installed at the center of the IDATEN array to implant ions and detect β rays. Neutron-deficient rare isotopes in the southern region of ^{100}Sn were produced via the in-flight fragmentation of a ^{124}Xe primary beam, as indicated in Fig. 1. A high-rate beam setting (∼8 kcps) was used to test the compatibility of the data acquisition system with isomeric decays, while a low-rate beam setting (∼100 cps) focused on β decays to evaluate the performance of the GARi detector. The fast-timing performance was evaluated using ^{96}Pd as the main target nucleus through measurements of the half-lives of 4_1^+ ($T_{1/2} = 1.0(1)$ ns) and 6_1^+ ($T_{1/2} = 6.3(6)$ ns) states, which were populated in the decay from the 8_1^+ state.[6)] The analysis is currently underway not only for ^{96}Pd but also for the other nuclei, such as ^{94}Pd and $^{92-94}$Ru, to explore the seniority features in this nuclear region.

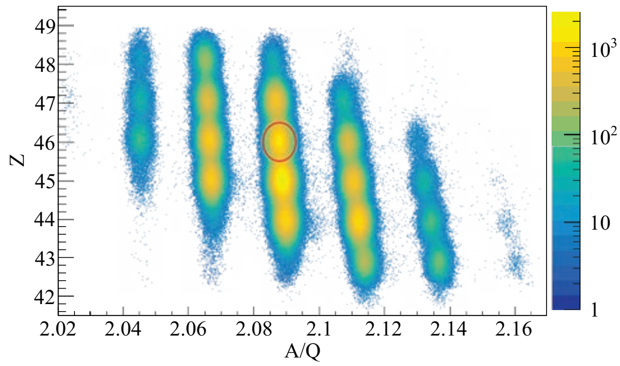

Fig. 1. Mass-to-charge ratio (A/Q) versus atomic number (Z) plot obtained from the BigRIPS separator. ^{96}Pd is marked by a red circle.

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References
1) P. -A, Söderström *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 649 (2013).
2) A. Tolosa-Delgado *et al.*, Nucl. Instrum. Methods Phys. Res. A **925**, 133 (2019).
3) B. Moon *et al.*, Nucl. Instrum. Methods Phys. Res. B **541**, 253 (2023).
4) M. Rudigier *et al.*, Nucl. Instrum. Methods Phys. Res. A **969**, 163967 (2020).
5) Q. Zeng *et al.*, RIKEN Accel. Prog. Rep. **57**, 117 (2024).
6) H. Mach *et al.*, Phy. Rev. C **95**, 014313 (2017).

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