Decay properties of neutron-rich nuclei around mass $A = 100$

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The neutron-rich nuclei around the mass $A \sim 100$ are expected to have rapid changes in nuclear shapes and possible shape coexistence. The decay properties are expected to be sensitive to the structural changes and are desired to be measured experimentally.[1)] The β-decay half-lives $T_{1/2}$ and the delayed-neutron emission probabilities P_{n} in the mass $A = 90-125$ are considered as critical physics inputs in the astrophysical rapid-neutron capture process (r process), where the underestimation of r-process distribution in the mass $A = 110$–125 as well as the origin of elemental deviation of Zr to Cd ($Z = 40$–48) in the extremely metal-poor stars are still open questions.[2)]

The BRIKEN project, which aims to survey several hundreds of decay properties toward the neutron drip-line, has been launched at RIBF. The progenitors of the r-process elements in the mass $A = 90$–125 were produced following the projectile fission of a 345 MeV/nucleon ^{238}U beam with primary beam intensity of above 60 pnA. Two data sets centered on ^{100}Br and ^{115}Nb isotopes in the BigRIPS separator were collected with 2- and 2.5-days of measurement times, respectively. The selected and identified isotopes were transported through the ZeroDegree spectrometer and implanted into two types of β-counting systems, namely WAS3ABi Si array[3)] and segmented-YSO scintillation detector,[4)] which were positioned in the center of the state-of-the-art neutron detector BRIKEN at the F11 focal point. BRIKEN consists of 140 ^{3}He neutron proportional counters arranged in a high-density polyethylene (HDPE: $90\times90\times75$ cm^3) matrix to achieve constant detection efficiency of above 65% up to neutron energies of 1 MeV.[5)] In addition, two high-purity Ge clover detectors were inserted from side-holes of the HDPE and placed in closed geometry of the β-counters to maximize the γ-ray detection efficiency. The experiment was conducted successfully and the problematic backgrounds of neutrons and light particles were securely reduced by closing the stainless-steel collimators prepared at the F2 focal plane.

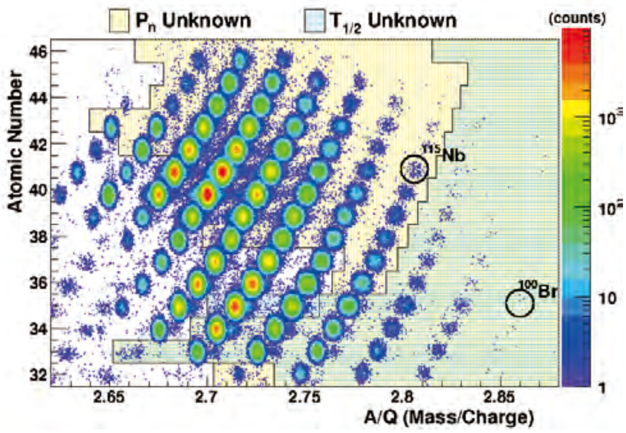

Fig. 1. Particle-identification plot and the areas of isotopes for unknown P$_n$ and unknown T$_{1/2}$, respectively.

The particle identification plot of the accumulated measurement is shown in Fig. 1. A careful analysis of β decay, γ rays, and neutrons in coincident measurement is in progress for one hundred isotopes to deduce $T_{1/2}$, P_{n}, the multi-neutron emitters ($P_{x\mathrm{n}}$), new isomers, and level schemes of low-lying states. These decay properties are expected to give significant feedback to nuclear theories and improve the reliability of r-process abundance in the network calculations.

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References

1) P. Sarriguren, Phys. Rev. C **91**, 044304, 1 (2015).
2) C. Sneden, J. J. Cowan, R. Gallino, Annu. Rev. Astro. Astrophys. **46**, 241 (2008).
3) S. Nishimura *et al.*, RIKEN Accel. Prog. Rep. **46**,182 (2013).
4) R. Grzywacz *et al.*, in this report.
5) A. Tarifeño-Saldivia *et al.*, J. Instrum. **12**, P04006 (2017).