Search for β-delayed two and three-neutron emitters in the vicinity of N=28 using the BRIKEN array

V. H. Phong,[*1,*2] S. Nishimura,[*1] J. Agramunt,[*3] D. S. Ahn,[*1] A. Algora,[*3] H. Baba,[*1] S. Bae,[*4] N. T. Bewer,[*5] R. Caballero-Folch,[*6] T. Davinson,[*7] I. Dillmann,[*6] A. Estrade,[*1,*8] S. Go,[*9] C. J. Griffin,[*7] R. Grzywacz,[*5,*9] J. Ha,[*1,*4] O. Hall,[*7] D. Kahl,[*7] G. Kiss,[*1] M. Labiche,[*10] J. Liu,[*11] K. Matsui,[*1] B. Moon,[*12] N. Nepal,[*8] H. Sakurai,[*1] Y. Shimizu,[*1] P.-A. Söderström,[*1] H. Suzuki,[*1] B.C. Rasco,[*5] K. P. Rykaczewski,[*5] H. Takeda,[*1] J. L. Tain,[*3] A. Tarifeño-Saldivia,[*13] and A. Tolosa[*3]

The measurement of β-delayed multi-neutron emission probability (P_{2n}, P_{3n}, and so on) is an experimental challenge. Most of the existing P_{2n} values are for isotopes with masses below A=100, while only four P_{3n} values were reported so far[1]: ^{11}Li, ^{17}B and the upper limits for ^{19}B and ^{23}N. The BRIKEN project (beta-delayed neutron emission measurement at RIKEN) offers a unique opportunity to measure this rare decay mode. The BRIKEN setup, illustrated in Fig. 1, consists of an array of ^{3}He detectors embedded in a high-density polyethylene matrix as moderator,[3] surrounding a stack of silicon detectors called AIDA (Advanced Implantation Detector Array).[2] The ^{3}He array serves as an efficient neutron counter, which detects the delayed neutrons following the β decay of neutron-rich nuclei implanted in AIDA. In addition, two clover-type HPGe detectors placed close to the implantation point are employed to identify the daughter nuclei by the detection of delayed γ rays.

For the purpose of commissioning of the BRIKEN detection system for the β-delayed multi-neutron emission measurement and evaluation of the statistical errors, neutron background conditions and β-delayed γ identification, an experiment has been performed in the parasitic mode with the in-beam gamma ray experiment,[4] targeting the neutron-rich nuclei around N=28.

The secondary beam, produced by the reaction of a 345-MeV/nucleon ^{48}Ca beam on a rotating Be target, was impinged on a fixed target at the F8 focal plane surrounded by the DALI2 gamma ray detector. The reaction products and unreacted beam were transported through the ZeroDegree spectrometer and eventually reached the BRIKEN setup at the F11 focal plane.

*1 RIKEN Nishina Center
*2 Faculty of Physics, VNU Hanoi University of Science
*3 IFIC (CSIC-University of Valencia)
*4 Department of Physics, Seoul National University
*5 Oak Ridge National Laboratory
*6 TRIUMF
*7 School of Physics and Astronomy, University of Edinburgh
*8 College of Science and Engineering, Central Michigan University
*9 Department of Physics and Astronomy, University of Tennessee
*10 STFC Daresbury Laboratory
*11 Department of Physics, University of Hong Kong
*12 Department of Physics, Korea University
*13 Secció d'Enginyeria Nuclear,Universitat Politecnica de Catalunya (UPC)

Figure 2 shows a preliminary particle identification plot of RI in the ZeroDegree spectrometer, which is assumed to be implanted into the AIDA detector. In this region, the β-delayed multi-neutron emission of $^{41-43}$Si, $^{38-42}$Al and $^{35-40}$Mg predicted by Ref.[5] are expected to be measured for the first time. Moreover, the effect of the degrader setting on the neutron background can be clarified, providing useful information to optimize the background condition for the main BRIKEN experiments.

The data are currently being analyzed.

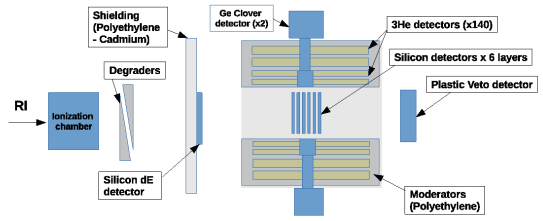

Fig. 1. A schematic view of the experimental setup.

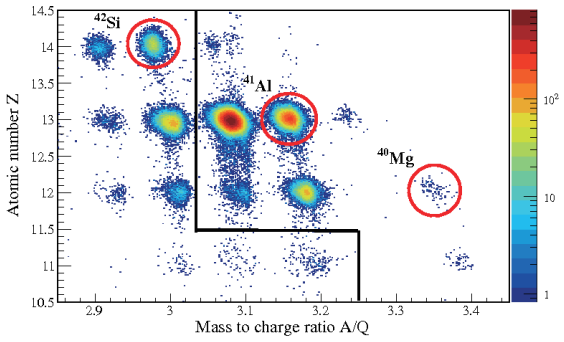

Fig. 2. A preliminary particle identification spectrum of the RI identified by the ZeroDegree spectrometer. The RI with known half lives are on the left side of the black solid line. The N=28 isotopes are tagged by red circles.

References

1) M. Birch et al., Nucl. Data Sheet **128**, 131 (2015).
2) C. J. Griffin et al.; Proc. XIII Nuclei in the Cosmos, Vol.**1** (2014), p. 97.
3) A. Tarifeño-Saldivia et al., arXiv:1606.05544.
4) NP1312-RIBF03R1
5) P. Moller et al., Phys. Rev. C **67.5**, 055802 (2013).