Measurement of production branching ratios following nuclear muon capture for palladium isotopes using an in-beam activation method†

M. Niikura,[*1,*2] T. Y. Saito,[*2,*3,*4] T. Matsuzaki,[*1] K. Ishida,[*1,*5] and A. Hillier[*6]

The energy distribution of excited states populated by the nuclear muon capture reaction can help understand the reaction mechanism; however, existing experimental data are limited. We developed an in-beam activation method to measure the production probability of residual nuclei through muon capture. In the method, decaying γ rays are measured simultaneously with beam irradiation by exploiting the time structure of the pulsed muon beam. Combining in-beam and offline activation methods enables the measurement of a majority of the β-decaying states across a wide range of half-lives, ranging from milliseconds to years. For the first application of the new method, we have measured the muon-induced activation of five isotopically enriched palladium targets of ^{104,105,106,108,110}Pd.

The experiment was conducted at the RIKEN-RAL muon facility of the Rutherford Appleton Laboratory (RAL) in the UK.[1] Figure 1 illustrates the experimental setups. A pulsed muon beam irradiated the enriched palladium targets. γ rays resulting from β and isomeric decays of the reaction residues were measured using high-purity germanium detectors. Activities ranging from milliseconds to hours were measured at in-beam and offline setups installed at the RAL (Figs. 1(a) and (b)), and those ranging from days to years were measured using an ultra low background offline setup installed at the University of Tokyo (Fig. 1(c)).

Production branching ratios of residual nuclei resulting from muon capture for five palladium isotopes were determined. The results were compared with a model calculation using the particle and heavy ion transport system (PHITS) code,[2] in which the muon interaction models have recently been implemented.[3] The comparison indicates that the model calculation reproduced the general trend of the obtained branching ratios rather well.

For the first time, this study provides experimental data on the distribution of production branching ratios without any theoretical estimations or assumptions in the interpretation of data analysis.

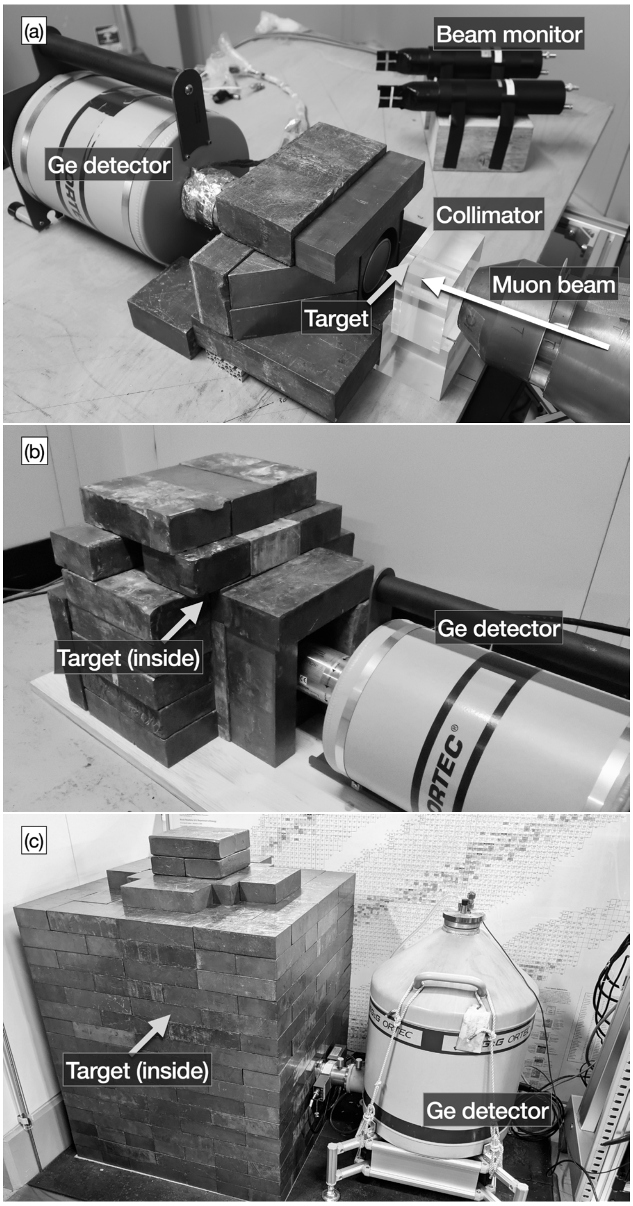

Fig. 1. Photos of the experimental setup for (a) in-beam activation measurement at Port-1 in RAL, (b) offline measurement at RAL, and (c) offline measurement at the University of Tokyo.

† Condensed from the article in Phys. Rev. C **109**, 014328 (2024)
*1 RIKEN Nishina Center
*2 Department of Physics, University of Tokyo
*3 Atomic, Molecular, and Optical Physics Laboratory, RIKEN
*4 Center for Nuclear Study (CNS), University of Tokyo
*5 High Energy Accelerator Research Organization (KEK)
*6 SFTC, Rutherford Appleton Laboratory (RAL)

References
1) T. Matsuzaki *et al.*, Nucl. Instrum. Methods Phys. Res. A **465**, 365 (2001).
2) T. Sato *et al.*, J. Nucl. Sci. Technol. **50**, 913 (2013).
3) S. Abe and T. Sato, J. Nucl. Sci. Technol. **54**, 101 (2017).

DOI:10.34448/RIKEN.APR.57-018