

## Gamma-Spectroscopy around $^{100}\text{Sn}$

D. Lubos,<sup>\*1,\*2</sup> J. Park,<sup>\*3</sup> M. Lewitowicz,<sup>\*4</sup> R. Gernhäuser,<sup>\*1</sup> R. Krücken,<sup>\*3</sup> S. Nishimura,<sup>\*2</sup> H. Sakurai,<sup>\*5</sup> H. Baba,<sup>\*2</sup> B. Blank,<sup>\*6</sup> A. Blazhev,<sup>\*7</sup> P. Boutachkov,<sup>\*8</sup> F. Browne,<sup>\*9,\*2</sup> I. Celikovic,<sup>\*4</sup> P. Doornenbal,<sup>\*2</sup> T. Faestermann,<sup>\*1</sup> Y. Fang,<sup>\*10,\*2</sup> G. de France,<sup>\*3</sup> N. Goel,<sup>\*8</sup> M. Gorska,<sup>\*8</sup> S. Ilieva,<sup>\*11</sup> T. Isobe,<sup>\*2</sup> A. Jungclaus,<sup>\*12</sup> G. D. Kim,<sup>\*13</sup> Y.-K. Kim,<sup>\*13</sup> I. Kojouharov,<sup>\*8</sup> M. Kowalska,<sup>\*14</sup> N. Kurz,<sup>\*8</sup> Z. Li,<sup>\*15</sup> G. Lorusso,<sup>\*2</sup> K. Moschner,<sup>\*7</sup> I. Nishizuka,<sup>\*16,\*2</sup> Z. Patel,<sup>\*17,\*2</sup> M. M. Rajabali,<sup>\*3</sup> S. Rice,<sup>\*17,\*2</sup> H. Schaffner,<sup>\*8</sup> L. Sinclair,<sup>\*18,\*2</sup> P.-A. Söderström,<sup>\*2</sup> K. Steiger,<sup>\*1</sup> T. Sumikama,<sup>\*16</sup> H. Watanabe,<sup>\*19</sup> Z. Wang,<sup>\*3</sup> J. Wu,<sup>\*12,\*2</sup> and Z. Y. Xu<sup>\*5,\*2</sup>

An experiment for studying the superallowed Gamow-Teller decay of the doubly magic nucleus  $^{100}\text{Sn}$  was performed in June 2013 at the high-resolution separator BigRIPS of the RIBF at the RIKEN Nishina Center. A 4-mm  $^9\text{Be}$  target was bombarded with a  $^{124}\text{Xe}$  beam of 345 MeV/u at intensities up to 36.4 p nA to produce  $^{100}\text{Sn}$  and a large cocktail<sup>3)</sup> of its neighboring nuclei down to neutron numbers  $N = (Z - 2)$  by fragmentation. The nuclei were implanted into the WAS3ABi silicon detector that consists of 3 detectors with high granularity extended by 10 additional single-sided, seven-fold segmented detectors in a closed stack geometry to absorb the emitted  $\beta$ -particles at a maximum efficiency. This WAS3ABi detector was surrounded by 84 Ge- and 18 LaBr-detectors of the  $4\pi$ - $\gamma$ -ray spectrometer EURICA.

In order to study the branching ratios of the  $\beta$ -decays, derive level schemes of exotic nuclei and determine isomeric ratios as well as lifetimes of the isomers, a reliable efficiency calibration has been performed. Owing to the special geometry of the WAS3ABi and the failure of several Ge-detectors, the calibration was performed using a  $\gamma\gamma$ -coincidence method. Cascading  $\gamma$ -transitions in  $^{98}\text{Cd}$ ,  $^{94}\text{Pd}$  and  $^{96}\text{Pd}$ , fed by different isomers, are available with a large number of counts. For example the delayed  $\gamma$ -emission in  $^{98}\text{Cd}$  always contains a complete chain for the energies 147 keV, 198 keV, 687 keV and 1395 keV. Thus, the ratio of coincident events of a pair of transitions and the total number of events for one of them directly yields the efficiency at the corresponding energy. This method is of great advantage since the radiation, originating in the implantation region, contains the detector-specific absorption effects and it does not introduce systematic

uncertainties that is usually introduced by simulation based methods. Efficiency calibrations, consistent with

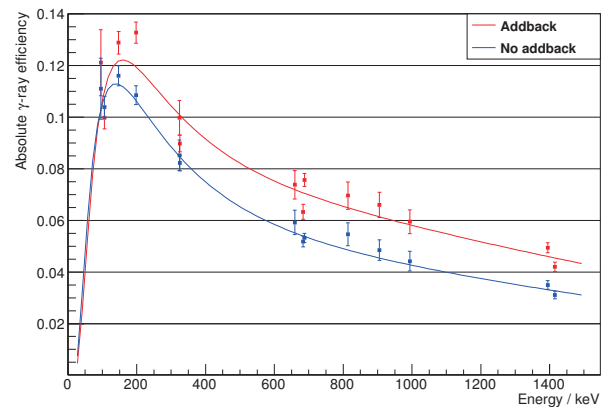


Fig. 1. Absolute  $\gamma$ -ray efficiency of the HPGe clusters of EURICA.  $\gamma$ -rays from isomers of  $^{98}\text{Cd}$ ,  $^{96}\text{Pd}$  and  $^{94}\text{Pd}$ , are used for the fit. Bars indicate the statistical uncertainty of the efficiencies.

previous works<sup>4)</sup>, using this  $\gamma\gamma$ -coincidence method are shown in Fig. 1.

In addition, greater precision of known isomer half-lives was attainable owing to high statistics in this experiment and preliminary half-lives of  $8^+$  and  $12^+$  isomers in  $^{98}\text{Cd}$  were determined as  $181^{+35}_{-25}$  ns and  $228^{+5}_{-5}$  ns, respectively. This would lead to better constraints on the transition strengths for the test of modern shell models. Previously reported  $\gamma$ -rays in the  $\beta$ -decay of  $^{100}\text{Sn}$ <sup>1)</sup> were reproduced, allowing an unprecedented  $\beta\gamma\gamma$ -coincidence analysis for  $^{100}\text{In}$ . Moreover a new high-spin isomeric state in  $^{96}\text{Cd}$  has been observed with a half-life of about 200 ns, with a decay branch into both, the  $16^+$  isomer and the  $(10^+)$  state, which has a prompt decay cascade to the ground state. Further analysis is underway to finalize experimental results and compare these to large-scale shell model calculations.

### References

- 1) C. Hinke et al.: Nature, **486**, 341 (2012).
- 2) B. S. Nara Singh et al.: Phys. Rev. Lett. **107**, 172502 (2011).
- 3) D. Lubos, RIKEN Accel. Prog. Rep.: **47** (2014)
- 4) K. Steiger: PhD thesis TU München (2010)

\*1 Physik Department E12, Technische Universität München

\*2 RIKEN Nishina Center

\*3 TRIUMF

\*4 GANIL

\*5 Department of Physics, University of Tokyo

\*6 CENBG

\*7 Institut für Kernphysik, Universität zu Köln

\*8 GSI Darmstadt

\*9 School of Comp., Eng. and Maths., Brighton University

\*10 Department of Physics, Osaka University

\*11 Institut für Kernphysik, TU Darmstadt

\*12 IES CSIS

\*13 Institute for Basic Science

\*14 CERN

\*15 School of Physics, Peking University

\*16 Department of Physics, Tohoku University

\*17 Department of Physics, Surrey University

\*18 Department of Physics, University of York

\*19 Department of Physics, Beihang University