Experimental cross sections of the radiative proton-capture reaction ^{112}Cd(p,γ) ^{113}In inside the Gamow window

P. Vasileiou[1], A. Khaliel[1], C. Andrikopoulos[1], C. Fakiola[1], I. Karakasis[1], A. Kotsovolou[1], S. Pelonis[1], I. Sideris[1], A. Zyriliou[1], T.J. Mertzimekis[1], M. Axiotis[2], A. Lagoyannis[2]

[1]*Department of Physics, National Kapodistrian University of Athens, Zografou Campus, Athens, Greece*
[2]*INPP, NCSR "Demokritos", Aghia Paraskevi, Greece*

Introduction and Motivation

Importance:

- ^{113}In is generally considered a *p* nucleus, known to be significantly underproduced in most astrophysical models
- Measurements of reaction rates and cross sections in this mass regime provide stringent tests to the theoretical models
- Measurements of cross sections inside the Gamow window (1.8-4.5 MeV) are expected to provide data for better understanding the *p* process in this mass region

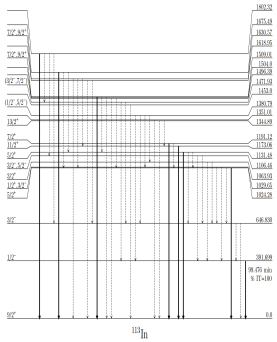

Fig. 1: Partial level scheme of the low-lying energy states of ^{113}In. Solid arrows correspond to transitions feeding the g.s., which were observed in the spectra [1]

Data analysis

- De-excitations to the g.s. were measured in-beam (* in Fig. 7)
- The activation method was employed for the measurement of the isomeric cross section, σ_{is}
- σ_{is} was also measured via the in-beam method by measuring decays to the isomeric state in the in-beam spectra (# in Fig. 7)

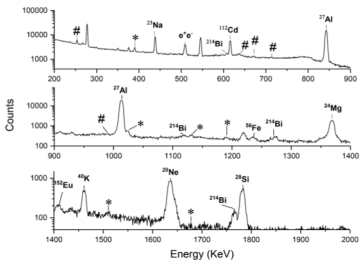

Fig. 7 Horizontal split-view (0.3-2.0 MeV) of a typical in-beam spectrum (subfigure y-axes not in scale)

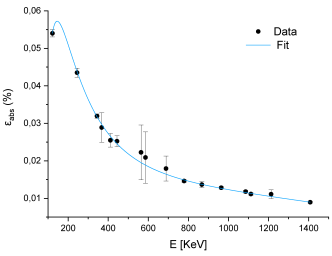

Fig. 8 Typical absolute efficiency curve for the detectors employed in this experiment.

The Target

An isotopic ^{112}Cd (enriched 97.7%) layer, evaporated on a ^{nat}Bi layer, backed by a ^{nat}In and a thick ^{nat}Cu layer was used. The target thickness was measured via:

- Rutherford Backscattering Technique (RBS)
- X-Ray Fluorescence (XRF) [2]

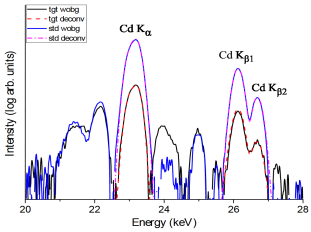

Fig. 2 XRF spectrum of the target (tgt) compared with that of a reference (std) Cd sample [2]

Fig. 3 The ^{112}Cd target used in this experiment.

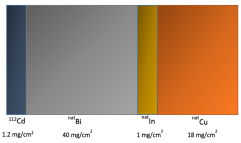

Fig. 4 Target layout.

Results

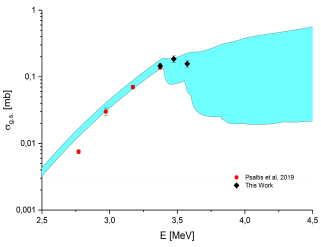

Fig.9 Comparison of our experimental data for σ_{gs} with those of previous works and with TALYS v1.9 theoretical calculations (shaded area in the graph) [1,2]

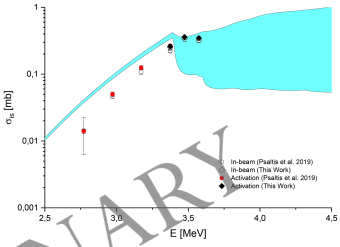

Fig.10 Same as in Fig.9, for the cross section of the isomeric 392 KeV state, σ_{is}. [1,2]

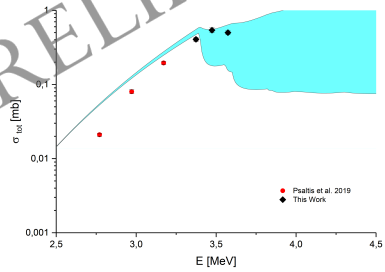

Fig. 11 Total reaction cross section obtained experimentally, compared with published experimental data from previous works of our group [2] and with a full range of TALYS v1.9 theoretical calculations (shaded area in the graph) [1]. Please note that the old and new measurement at 3.4 MeV overlap fully.

Experimental details

- The reaction ^{112}Cd(p,γ)^{113}In was studied at beam energies of 3.4, 3.5, and 3.6 MeV provided by the 5.5 MV Tandem Accelerator at NCSR "*Demokritos*"
- The subsequent γ decays were detected using an array of three HPGe detectors at 55, 90 and 165 degrees, respectively
- The induced neutron-emission channel was additionally studied

Fig. 5 The 5.5 MV Tandem accelerator at NCSR "Demokritos".

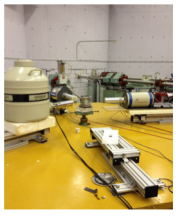

Fig. 6 The array of HPGe detectors.

Discussion and Future Directions

- The present experimental data confirm recently published data from our group [2] and extend the results to energies above the neutron emission threshold
- Hauser-Feshbach calculations with TALYS agree well with the results for the g.s., but overestimate the results for the isomeric state
- Additional measurements to obtain the astrophysical S-factor and the nuclear reaction rate in this energy region are underway
- Future work involves detailed calculations with the most recent TALYS v1.95 code to improve our knowledge of the OMP, NLD and γSF in this region

References

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2. A. Psaltis et al., Phys. Rev. C 99, 065807 (2019)
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