Prompt γ spectroscopy following thermal neutron capture in DHRUVA reactor facility

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Introduction

Low-spin, low-excitation regime has always been a fertile ground in γ ray spectroscopy to explore severel phenomena, such as, β and γ vibration, multi-phonon structures, and even octupole-hexadecapole deformation. Cd isotopes, with two proton holes, are mostly spherical or near spherical nucleus, and are expected to exhibit vibrational level structures at low excitation energies. However, the ^{114}Cd nucleus with N=66, rests exactly at the middle between the N=50 and 80 closed shells. Thus, it has been suggested earlier that besides the low-lying quadrupole vibrational modes, other excitation modes might play an important role in this nucleus. The ^{114}Cd nucleus was mostly studied following ^{113}Cd(n$_{th}$,γ) reaction [1, 2], monoenergetic accelerated neutron bombardment on ^{114}Cd [3], and also with heavy-ion induced reaction [4]. Here in this paper, we report a new spectroscopic measurement for the ^{114}Cd nucleus using thermal neutron from the DHRUVA reactor facility at BARC.

Experimental details

The experiment was performed at DHRUVA reactor employing DURGA (**D**hruva **U**tilization for **R**esearch using **G**amma **A**rray) facility. Thermal neutrons from the reactor bombarded a natutal Cd target of thickness ~0.18 mm. It is to be noted that in natural Cd, the isotope with A=113 has the maximum thermal neutron capture cross section (σ=20600±400 b). However, its (^{113}Cd) natural abundance is only 12.22%. The neutron-flux at the target position was ~10^8 neutrons/cm^2/sec. Following thermal neutron capture by the target, the emitted γ rays, predominantly from the ^{113}Cd(n$_{th}$,γ)^{114}Cd reaction, were detected by an array of four high purity clover Ge and five LaBr$_3$(Ce) fast scintillator detectors. Out of the six suppressed clover Ge detectors, three were at 90°, and the remaining one was at 60° forward angle with respect to the beam direction. Four LaBr$_3$(Ce) detectors were mounted in the median plane of the array at angles of 30°, 60°, 90° and 120° with respect to the beam direction. The fifth LaBr$_3$(Ce) detector was mounted at 45° forward angle. Triggerless, Compton suppressed data were collected employing a multi-frequency, high resolution digital signal processing based data acquisition system which has been developed in-house, in collaboration with CAEN S.p.A., Italy [5]. The data, thus acquired, were used to build a much smaller event file with a user supplied coincidence conditions.

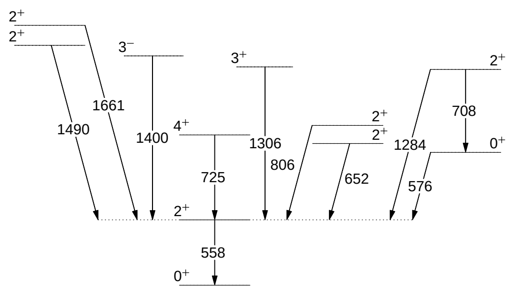

FIG. 1: Partial preliminary level scheme of ^{114}Cd nucleus as obtained in DHRUVA reactor facility following ^{113}Cd(n$_{th}$, γ) reaction.

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Results and discussion

The strong γ transitions in ^{114}Cd were clearly visible in the spectra recorded by the LaBr$_3$(Ce) fast scintillator detectors (Fig. 2). Symmetric γ-γ matrix was constructed using the coincidence data from the clover detectors.

Preliminary analysis of γ-γ coincidence matrix has resulted in a level scheme (Fig. 1) that agrees well with the previously published work on ^{114}Cd. The projection spectrum of the symmetric γ-γ matrix is shown in Fig. 3. It has been estimated that more statistics in the data are needed to carry out a detailed study on this nucleus. Further experiments are going on in this direction.

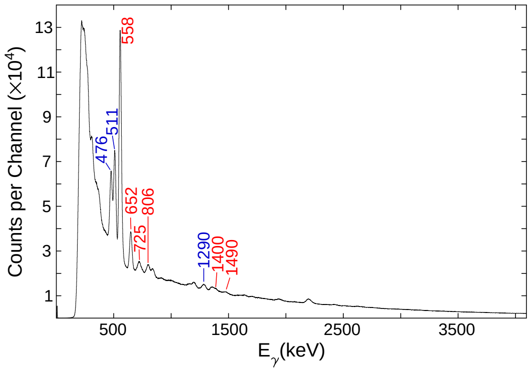

FIG. 2: In-beam singles spectrum for ^{114}Cd nucleus as recorded using LaBr$_3$(Ce) detector in DHRUVA reactor facility. The γ transitions that are labeled in red colour belong to the nucleus of interest (^{114}Cd).

The data from the LaBr$_3$(Ce) detectors were also used to construct γ-γ matrix. With timing resolution of $\sim$350 ps when integrated with the digital data acquisition system [5], these fast scintillator detectors will be useful to measure lifetimes, even in the sub-nanosecond region, of excited states in ^{114}Cd. The timing spectra corresponding to energy gates from the LaBr$_3$(Ce) detectors' data are being generated, and lifetimes of a particular level in ^{114}Cd will be extracted from the resultant time-difference spectrum. Results, analysis techniques, and interpretation in detail,

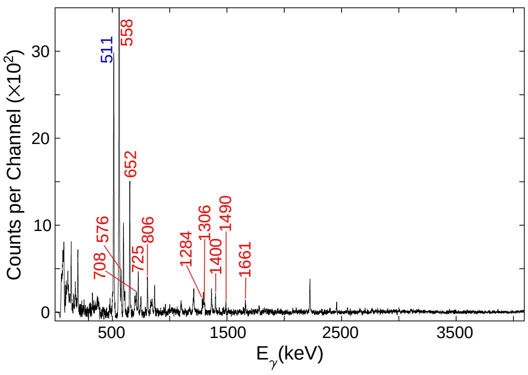

FIG. 3: Projection spectrum of γ-γ matrix. The γ transitions in ^{114}Cd that are observed and placed in the level scheme (Fig. 1), are labeled in red colour.

will be presented during the symposium. Additionally, results and level schemes that will be obtained from a few other similar experimental efforts with spherical and deformed targets in this newly commissioned experimental facility will also be presented.

Acknowledgments

The authors would like to thank the operation crew and staff at DHRUVA reactor facility for their help and cooperation during the experiment. A. D. would like to acknowledge the financial support from BRNS, BARC, Mumbai (Sanction No. 37(3)/14/17/2016-BRNS).

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