DETERMINATION OF NEW LEVELS IN ^{172}Yb LEVEL SCHEME BASED ON GAMMA-GAMMA COINCIDENCE SPECTROMETER

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Abstract: Nuclear level scheme permits to determine nuclear level density, gamma strength function, and to evaluate nuclear models. Compare to light nuclei, structure of heavy nuclei is much more complicated because of their strong deformation. In order to study nuclear level scheme, gamma-gamma coincidence spectrometer has advantages of low Compton background and ability of identifying correlated gamma transitions. This paper presents the study on level scheme of ^{172}Yb using gamma – gamma coincidence spectrometer at Dalat Nuclear Research Institute. 9 transitions and 3 levels, which currently do not exist in ENSDF library, will be reported.

Keywords: gamma - gamma coincidence, nuclear level scheme, ^{172}Yb

I. INTRODUCTION

Until now, level scheme, gamma transitions and their intensity are primary “ingredient” to determine level density parameters and gamma strength function of nucleus in excited energy region from 2 MeV to less than neutron binding energy. In ENSDF library, obtained nuclear levels and gamma transitions of ^{172}Yb are fully determined by analyzing experimental data from ^{171}Yb(n,γ)^{172}Yb reaction [1]. Most of ^{172}Yb data in ENSDF library are contributed by three publications [2][3][4]. In these works, authors used Germanium detectors and enriched target from 88% to 98%. Gamma-gamma coincidence was used however just for a few intense transition [3]. The last updated of ^{172}Yb data in ENSDF library was in 1988.

In this work, we measured gamma cascades of ^{172}Yb from ^{171}Yb(n,γ)^{172}Yb reaction using gamma-gamma coincidence spectrometer. The first advantage of coincidence spectrometer is low Compton background. Then, data from coincidence spectrometer include evidences for determining initial level and final level. The main disadvantage of coincidence method is long measurement time because of very low efficiency. For that reason, we tried to make a long time measurement in order to be able to find some new transitions.

9 transitions and 3 levels, which now do not exist in ENSDF library, are reported in this paper.

II. EXPERIMENTAL

Experiment was performed at the tangential beam port of Dalat Nuclear Research Reactor (DNRR) using a gamma coincidence spectrometer, which was designed for measuring cascade gamma transition. The neutron flux at target position was $\sim 1.7 \times 10^5$ n.cm^{-2}s^{-1} and beam diameter was $\sim$2.5 cm. The Cadmium ratio was ~160 using Cadmium box with thickness of 0.5 mm. Target was measured for approximately 800 hours.

Experiment arrangement and detector parameters

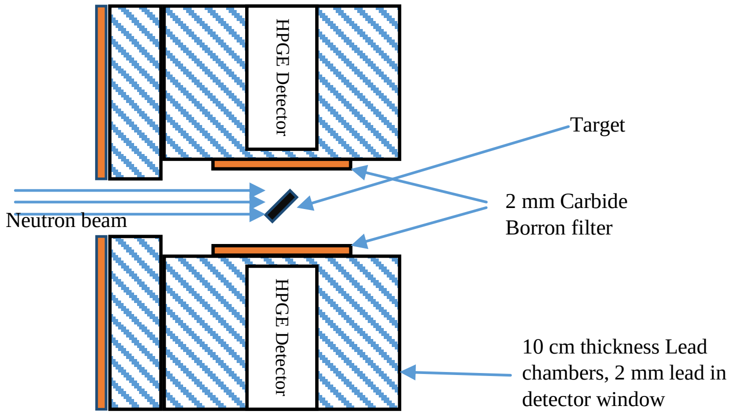

Figure 1. Experimental arrangement for gamma coincidence

As shown in Figure 1, two detectors were used. These were ORTEC coaxial HPGe detector type GMX35. Both had relative efficiency of 35% and energy resolution is 1.8 keV at 1332 keV peak of ^{60}Co. The detectors were located opposite to each other, perpendicular to neutron beam. Cube lead chambers of 10 cm thickness surrounded detectors for shielding from gamma background in reactor building. In front of detector windows, a lead plate of 2 mm was put in order to cut down X-rays, back-scattered and the other low-energy photons, which would only increase the dead time of electronics. Between neutron beam and detectors, carbide boron filters were placed to protect detectors from neutron damage.

Target was put in the center of neutron beam, between the two detectors. The distance from detector windows to target was 5 cm.

Electronics arrangements

Electronics arrangement of gamma coincidence spectrometer is given in Figure 2 and the detailed operating principle is given in [5]. However, two amplifiers, ORTEC 572A model, were replaced by 672 model ones. The range of time-to-amplitude (TAC) converter was set to 100 ns, and the coincidence resolving time was around 15 ns at Full Width Half Maximum (FWHM).

Target information

Ytterbium target was in powder form, and put in plastic bag. The target chemical form is Yb_2O_3, and the Ytterbium net mass is 500 mg. Abundance of ^{171}Yb in target is more than 95.5% , certificated by The Open Joint Stock Company “Isotope”.

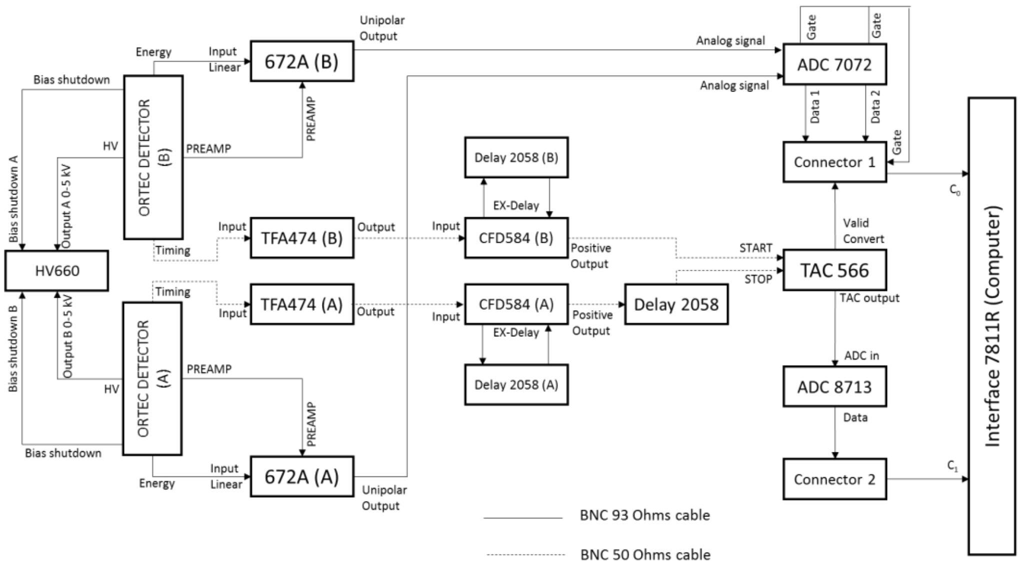

Figure 2. Electronics configuration for gamma-gamma coincidence setup

III. Data analysis

The detail of data treatment process can be found in [6]. Below, we explain two main types of spectrum that we used.

Summation spectrum: frequency histogram of summation of absorbed energy in two detectors for each coincident event. Information in summation spectrum is then used to create Two-Steps-Cascade (TSC) spectra.

TSC spectrum: frequency histogram of coincident events which contribute to summation peaks (peaks appear in summation spectrum).

IV. Results and discussion

The summation spectrum of ^{172}Yb is given in Figure 3. We found 6 summation peaks, correspond with 6 TSC spectra. The summation energies are marked in Figure 3.

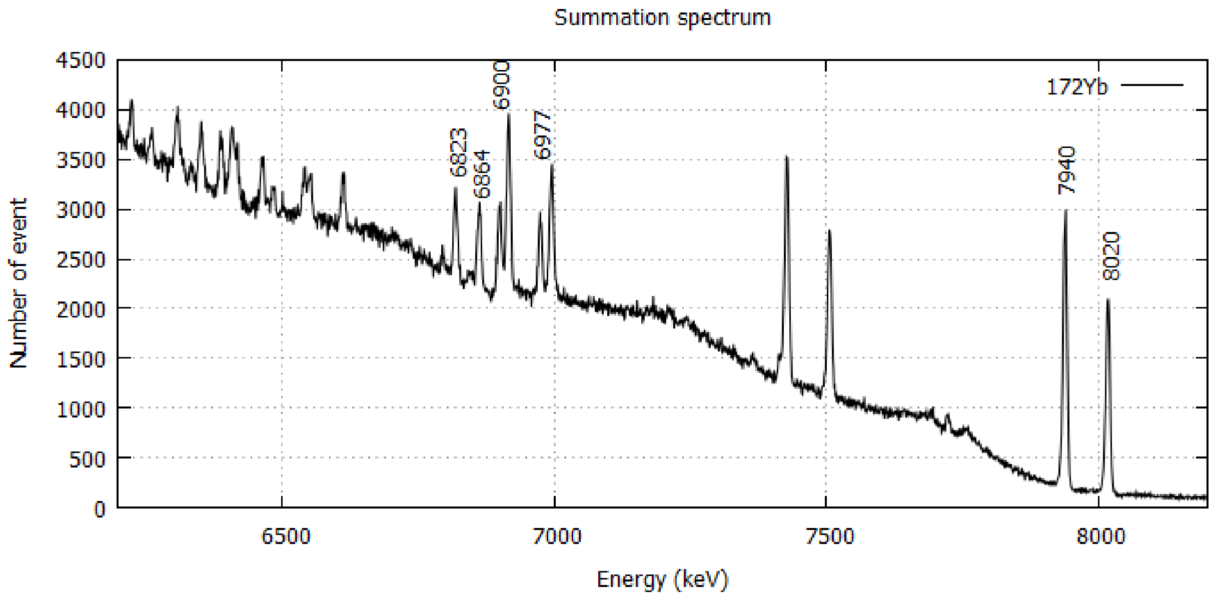

Figure 3. Summation spectrum of ^{172}Yb

Figure 4 is 6 TSC spectra, correspond with 6 summation peaks. Few gamma cascade transitions that at least one transition does not exist in library are marked.

By analyzing, we found that 5140 keV transition appeared in two TSC spectra and coincided with 2879 keV and 2801 keV. Knowing that 78.74 keV level exists in library. The most appropriate level arrangement is given in Figure 5 (a). By the same way, we can build two other arrangements, correspond to primary gamma transition 4493 keV and 4211 keV (Figure 5 (b) and (c)).

Compare to ENSDF library, we found 9 new gamma transitions as following: 5140 ± 2 keV, 4493 ± 2 keV, 4211 ± 2 keV, 2879 ± 2 keV, 2801 ± 2 keV, 3447 ± 2 keV, 2330 ± 2 keV, 3809 ± 2 keV, 3730 ± 2 keV; and 3 new levels: 2879 keV, 3526 keV and 3809 keV.

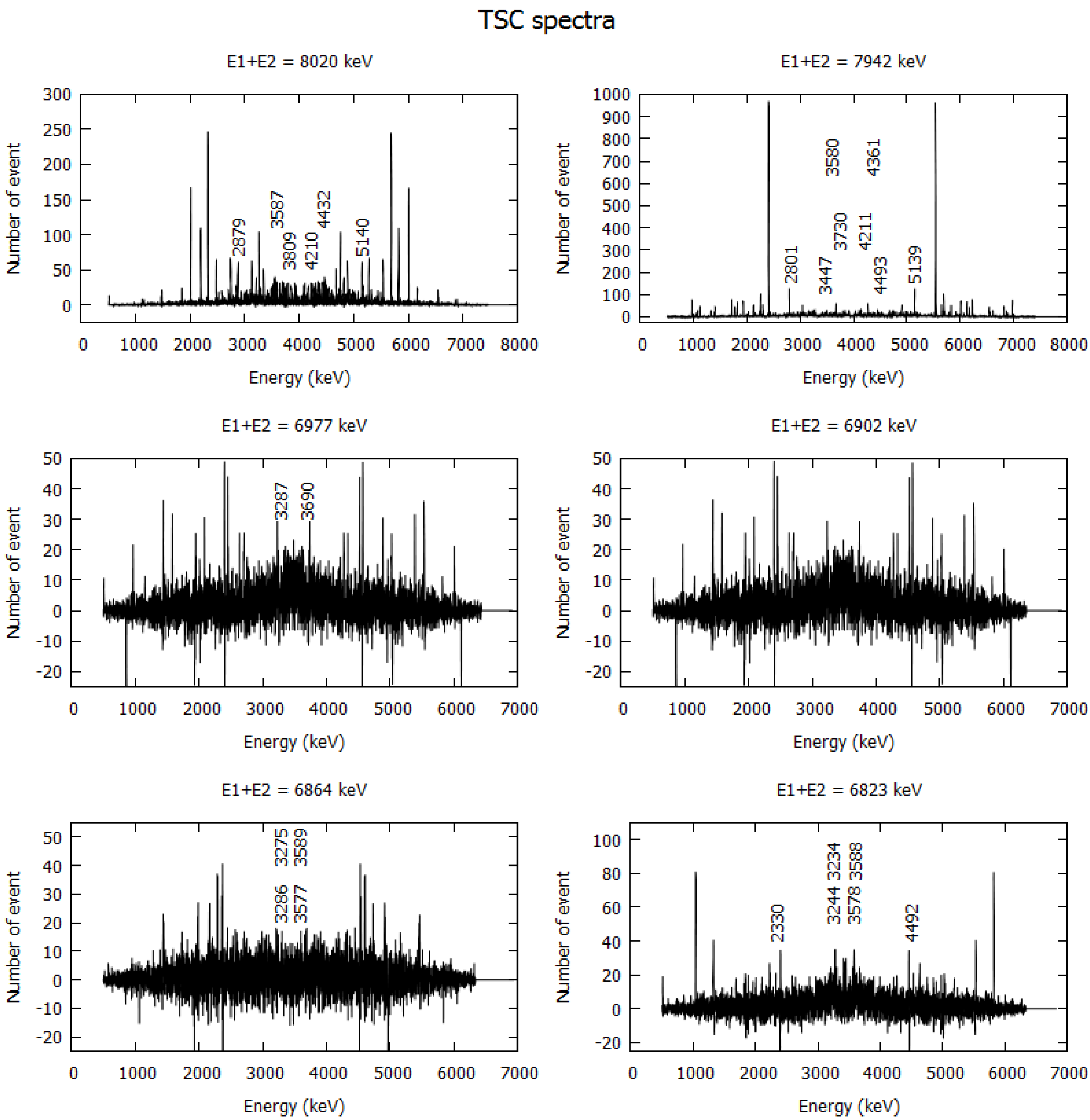

Figure 4. TSC spectrum of ^{172}Yb

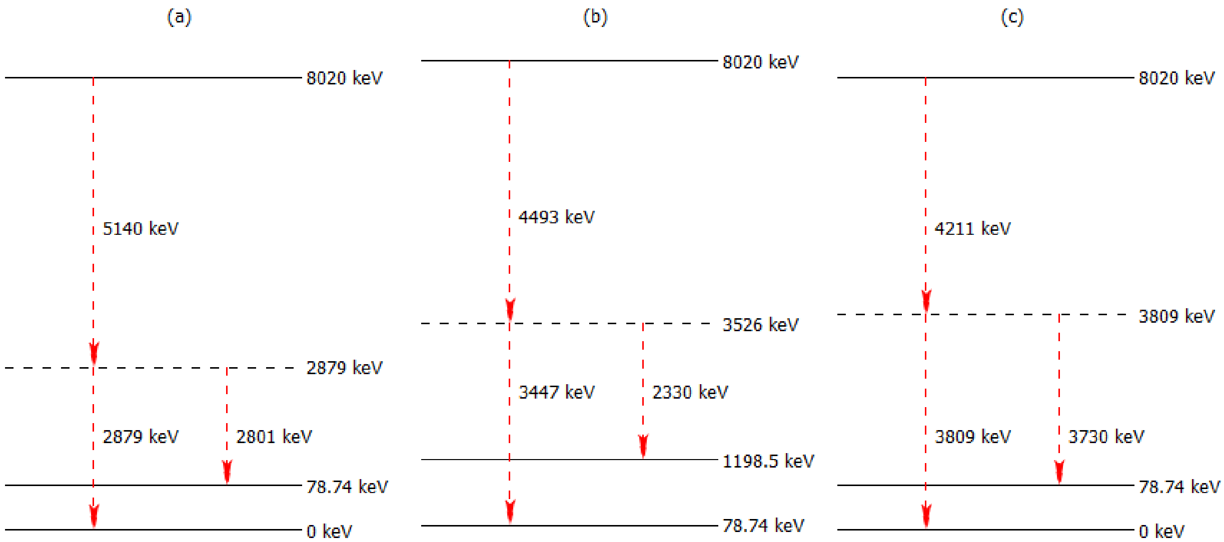

Figure 5. Arrangement in determining new levels

V. Conclusion

The gamma transitions and levels, which complement nuclear data library, can aid the calculation of cross-section more accurate. However, in order to officially apply the new gamma transitions and new levels, it is necessary to calculate their intensities and evaluate spin and parity.

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XÁC ĐỊNH MỨC MỚI TRONG SƠ ĐỒ MỨC CỦA ^{172}Yb BẰNG HỆ PHỔ KẾ TRÙNG PHÙNG GAMMA - GAMMA

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Tóm tắt: Sơ đồ mức hạt nhân cho phép tính toán mật độ mức hàm lực, và đánh giá các mô hình hạt nhân. So với các hạt nhân nhẹ, cấu trúc của các hạt nhân nặng phức tạp hơn nhiều do chúng bị biến dạng mạnh. Trong nghiên cứu sơ đồ mức hạt nhân, hệ phổ kế trùng phùng có ưu điểm là nền phông Compton thấp và cho phép nhận diện các cặp chuyển dời có tương quan với nhau về mặt thời gian (chuyển dời nối tầng). Báo cáo này trình bày về nghiên cứu sơ đồ mức của hạt nhân ^{172}Yb sử dụng hệ phổ kế trùng phùng gamma – gamma tại Viện Nghiên cứu hạt nhân. 9 chuyển dời và 3 mức chưa xuất hiện trong thư viện ENSDF đã được xác định trong nghiên cứu này.

Từ khóa: trùng phùng gamma-gamma, sơ đồ mức hạt nhân, ^{172}Yb