Lifetime measurement of $3/2_1^+$ state of ^{117}Sn

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Introduction

Several low-lying isomers are observed in Sn isotopes with N>64, which primarily arise from the proximity of relatively higher angular momentum and opposite parity of $\nu 1h_{11/2}$ orbit compared to the other positive parity ones ($2d_{3/2}$, $3s_{1/2}$), which are near the Fermi level of these isotopes. We have reported preliminary results from the measurement of half-lives of negative parity isomers and low lying positive parity isomers in ^{117,118}Sn [1].

In this present work, we shall report the half-life of $3/2_1^+$ state of ^{117}Sn obtained from different setups and techniques. The difficulty in determination of the lifetime of this state lies in resolving feeding transition and decaying transition of the 158 keV state ($I^\pi = 3/2_1^+$) as the difference between two gammas is only 2 keV (Fig.1). Using commonly used fast timing detectors, it is impossible to resolve these two energies and consequently, both sides of delayed spectrum contain information of lifetime. The adopted level lifetime is 0.279(9)ns [2] based on measurements done in early 1970s in Ref. [3]. However, some other results have around 12-30% deviation from the adopted value.

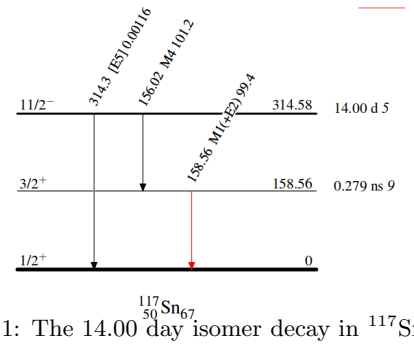

FIG. 1: The 14.00 day isomer decay in ^{117}Sn.

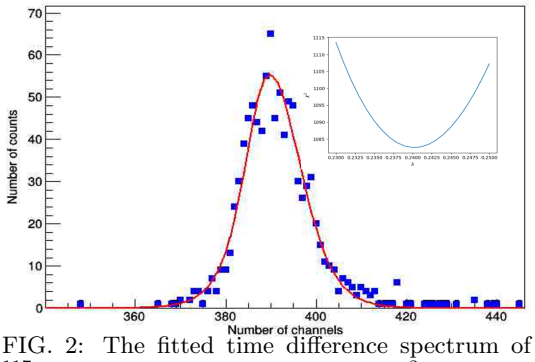

FIG. 2: The fitted time difference spectrum of ^{117}Sn for first setup and inset shows χ^2 vs. λ plot indicating minimum.

Experiment, Analysis and Results

Natural Indium(^{115}In(95.71%), ^{113}In(4.29%)) was bombarded by α-beam at 32 MeV energy delivered by the K-130 Cyclotron, VECC Kolkata. The irradiated foil were transferred to the laboratories for off-line measrement. In this experiment[1], the $3/2_1^+$ excited state of ^{117}Sn at 158 keV was populated via two decay processes: EC decay of ^{117m}Sb ($T_{1/2}$=2.80(1)hr) and Isomeric decay of ^{117m}Sn ($T_{1/2}$=14.00(5)day). Two

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independent set-ups have been utilised to remeasure this half-life.

Measurement I

The set-up consisted of $LaBr_3$(Ce)and BaF_2 scintillators along with necessary analog electronics to generate timing spectra by selecting specified (154-160 keV) energy region. The time calibration was 0.09ns/chn [1]. The prompt time spectrum was obtained with similar energy gate in a ^{22}Na source energy spectra.

When the prompt resolution is almost of the same order or more than the level lifetime, deconvolution technique has to be adopted. However, normal deconvolution method doesn't work if the feeding and decaying gammas have unresolved energies [3]. Moreover, since two different kinds of detectors were involved in the set-up, the prompt spectrum was an asymmetrical one. So, the prompt distribution has been fitted with two gaussian functions having two different width parameters. So, the deconvolution equation for two unresolved gammas as mentioned in Ref. [3] has been modified.

By varying the decay parameter of exponential function, the best fit of the delayed spectrum has been obtained by minimisation of chi-square Fig. 2. The procedure has been executed numerically. The half-life obtained is $T_{1/2}$=0.289 ± 0.002 ns. The error quoted here is only statistical error.

Measurement II

VENTURE array[4] consisting of six (6) $CeBr_3$ detectors and associated standard NIM based electronics and VME based data acquisition were used. The zero suppressed LIST mode data has been collected under condition of logic signal $M_\gamma \geq 2$ using majority logic unit. The time difference between two different detector has been generated using common start technique[4]. Special care has been taken to keep the CFD cut-off below 20 keV. The symmetric nature of 158 keV vs 158 keV time difference spectrum is demonstrated in the two dimensional plot of Time diff vs Energy (Fig 3a and b). However, as the 156 keV transition is a M4 transition and therefore highly converted. So we are testing the possibility of using the Sn K Xray at 25 keV vs 158 keV time difference plot to extract the lifetime more confidently. The said spectrum is shown in Fig 3c. The preliminary results indicate a very long life for the isomer. We are in the process to minimise the uncertainty in the result.

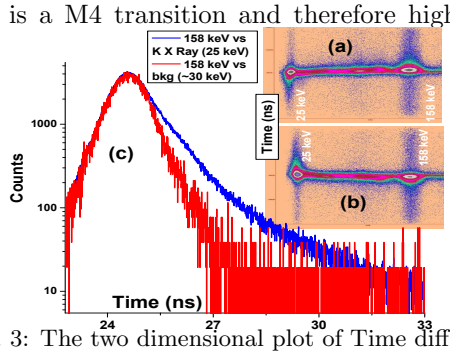

FIG. 3: The two dimensional plot of Time diff vs Energy (Fig. 3a and 3b) and the time difference curve for 158 keV vs K Xray. The prompt time curve at that energy is shown for comparison.

Acknowledgments

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