

## Study of high spin states of $^{190}\text{Tl}$

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### Introduction

Thallium nuclei with  $Z=81$  lie in the transitional region between deformed rare-earth elements and spherical lead nucleus. In recent days many experimental investigations are carried out for odd-odd Tl isotopes. Odd-odd Tl isotopes exhibit different shapes and structures from near spherical to super deformed. Heavier isotopes like  $^{202,206}\text{Tl}$  shows single particle excitations [1-2], whereas, the lighter Tl isotopes with  $A \leq 200$  show oblate deformed structure [3-8] based on  $\pi h_{9/2} \otimes \nu i_{13/2}$  configuration. Interestingly, triaxial shapes are also reported in  $^{194,198}\text{Tl}$  [5,7] but decoupled oblate band structures are reported in  $^{192}\text{Tl}$  [4]. Prolate and oblate shape co-existence are known in the odd-A Tl nuclei with  $A < 190$  [9]. Therefore, the band structure of odd-odd  $^{190}\text{Tl}$  is important to study the shape evolution in Tl isotopes. However, the level scheme of  $^{190}\text{Tl}$  is not well known [3] and only one band is known. Therefore, the aim of the present work is to study the high spin states of  $^{190}\text{Tl}$ .

### Experiment

The fusion-evaporation reaction  $^{165}\text{Ho}(^{30}\text{Si}, 5n)$  was used to populate the high spin states of  $^{190}\text{Tl}$ . The 157-MeV,  $^{30}\text{Si}$  beam was obtained from the BARC-TIFR Pelletron LINAC facility in Mumbai, India. A self-supported 7.3 mg/cm<sup>2</sup> thick  $^{165}\text{Ho}$  target was used. The emitted  $\gamma$ -rays were detected using the Indian National Gamma Array (INGA), configured, for the present experiment, with 17 Compton-suppressed clover high-purity Ge (HPGe) detectors. The detectors

were placed in six different angles with three detectors each at 40°, 115°, 140° and 157°, four detectors at 90° and one detector at 65°. For the two or more-fold coincidence data collection, a fast digital data acquisition system based on Pixie-16 modules of XIA LLC [10] was used. Energy calibration of each detector was done with standard  $^{133}\text{Ba}$  and  $^{152}\text{Eu}$  sources.

### Data Analysis

Sorting of raw data was done by BasIc Nuclear Data Analysis Software (BINDAS, developed at VECC, Kolkata) [11] and was analyzed using RADWARE software packages. A symmetric  $\gamma$ - $\gamma$  coincidence matrix was formed with the addback data from all the clover detectors to obtain the coincidence relations between gamma rays. The PACE-4 calculations show (Fig.1) the production of other nuclei ( $^{191}\text{Tl}$ ,  $^{192}\text{Tl}$ ,  $^{189}\text{Tl}$ ,  $^{187}\text{Au}$ ,  $^{191}\text{Hg}$  and  $^{190}\text{Hg}$ ) in addition to  $^{190}\text{Tl}$ , among them  $^{191}\text{Tl}$  and  $^{190}\text{Hg}$  were confirmed from the observation from their characteristic  $\gamma$ -rays as shown in the gated spectra in Fig. 2.

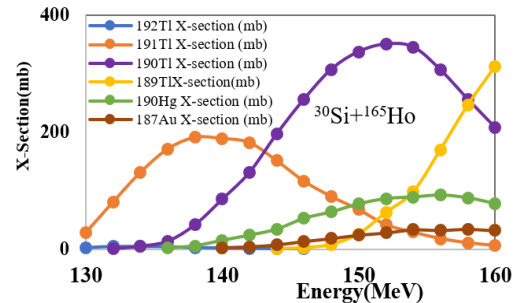
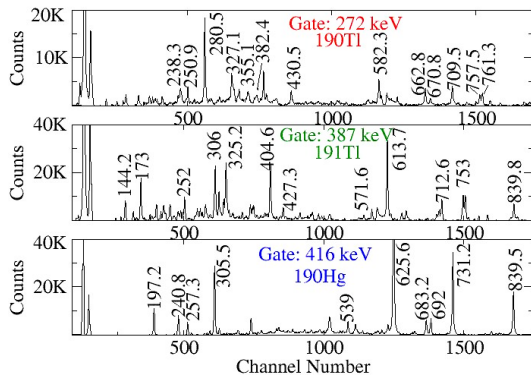


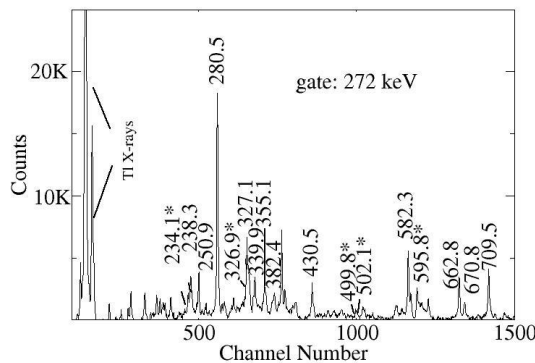
Fig. 1 Excitation function, calculated by PACE-4

**Result and Discussion**



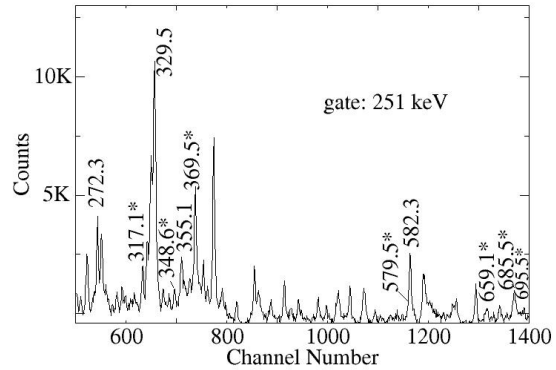
**Fig. 2** Gated spectra of observed nuclei

All the known gamma rays of  $^{190}\text{Tl}$  have been observed in the spectrum gated by the low-lying, known 272 keV transition, from the present data (Fig.3).



**Fig. 3** Spectrum with gate on 272 keV of  $^{190}\text{Tl}$

Fig. 4 represents the gated spectra with gate on 251 keV transition which is a known gamma ray in the side band of  $^{190}\text{Tl}$ . The spin-parity of the levels of this band is not known. In addition to the known gamma rays, few new transitions have also been identified from the primary analysis. New gamma lines are marked with asterisk in Fig. 3 and 4. The new gamma rays indicate that the level scheme of  $^{190}\text{Tl}$  will be extended further. However, in order to assign spin parities to the states, further work will be done to determine DCO and polarization asymmetry ratio.



**Fig. 4** Spectrum with gate on 251 keV of  $^{190}\text{Tl}$

**Summary**

In the present work, from primary analysis new  $\gamma$ -rays in  $^{190}\text{Tl}$  have been identified from different gated spectra from  $\gamma$ - $\gamma$  coincidence matrix. Further analysis to find out the nature of the newly found  $\gamma$ -rays and to place them in the level scheme is in progress.

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