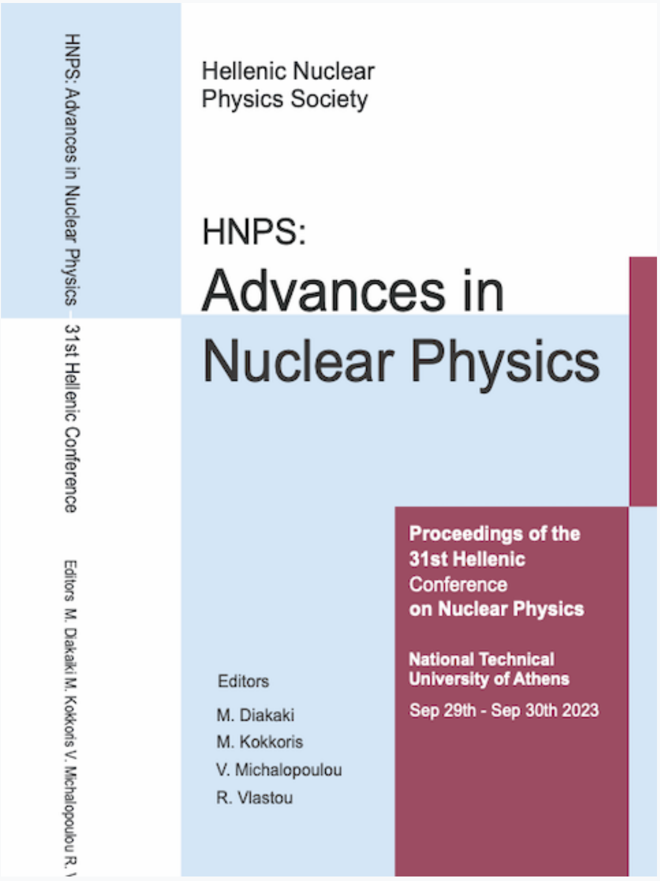
HNPS Advances in Nuclear Physics

Vol 30 (2024)

HNPS2023



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doi: 10.12681/hnpsanp.6355

To cite this article:

Kagioglou, M., Vlastou, R., Diakaki, M., Kokkoris, M., Chasapoglou, S., Bari, Z., Axiotis, M., & Lagogiannis, A. (2024). Neutron Induced Reactions on 203Tl at 15.7MeV, 16.0MeV and 18.0MeV. *HNPS Advances in Nuclear Physics*, *30*, 203–206. https://doi.org/10.12681/hnpsanp.6355

Neutron Induced Reactions on ^{203}Tl at 15.7 MeV, 16.0 MeV and 18.0 MeV

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Abstract The aim of the present work is to study the potential channels that result from the interaction of ^{203}Tl with neutrons by bombarding natural TlCl pellet targets with neutron beams at 15.7, 16.0 and 18.0 MeV. The monoenergetic neutron beams were produced at the 5.5 MV Tandem Van de Graff accelerator laboratory of NCSR "Demokritos" by means of the ^{3}H(d,n)^{4}He reaction. The cross section measurements were based on the activation technique and deduced with respect to the ^{197}Au(n,2n)^{196}Au and ^{27}Al(n,α)^{24}Na reference reactions. After the end of the irradiations, the induced activity in the target and reference foils was measured by γ-ray spectroscopy, using High Purity Germanium detectors (HPGe).

Keywords thallium, cross section, neutron activation analysis

INTRODUCTION

In many facets of daily life, including electronic equipment, nuclear medicine, infrared detectors, and fiber optics, thallium is widely employed. However, in the literature, there is little information about neutron-induced reactions on Thallium isotopes, and there seem to be significant discrepancies in the existing data of the most studied reaction, ^{203}Tl(n,2n)^{202}Tl, especially in the energy range of 12 MeV and above [1], as illustrated in Fig. 1. This work constitutes a continuation of a previous work of our group with measurements at 16.4, 18.9 and 19.3 MeV, in order to cover the high energy range of neutron beams that can be produced at NCSR "Demokritos" [2,3].

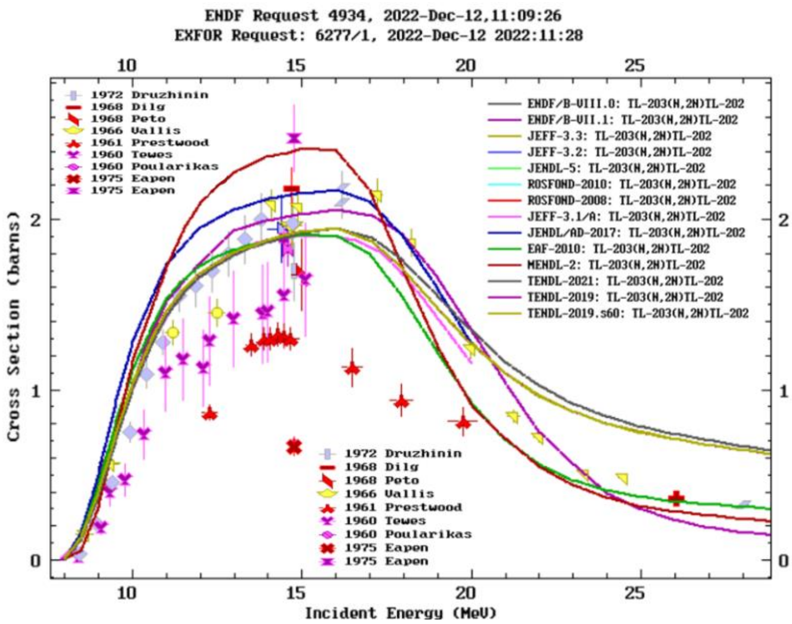

Figure 1. *Existing experimental data and ENDF evaluations of the ^{203}Tl(n,2n)^{202}Tl reaction*

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EXPERIMENTAL DETAILS

Reaction

In this experiment, only the ^{203}Tl isotope of the two Thallium isotopes (^{205}Tl and ^{203}Tl with 70.47% and 29.53% abundances, respectively) could be studied. Bombarding the ^{203}Tl isotope with neutrons the excited compound nucleus ^{204}Tl* is created and its deexcitation can lead to many reaction channels, as shown in Fig. 2. Among the possible exit channels that are generated, only the (n,2n) channel could be measured, with the properties shown in the Figure.

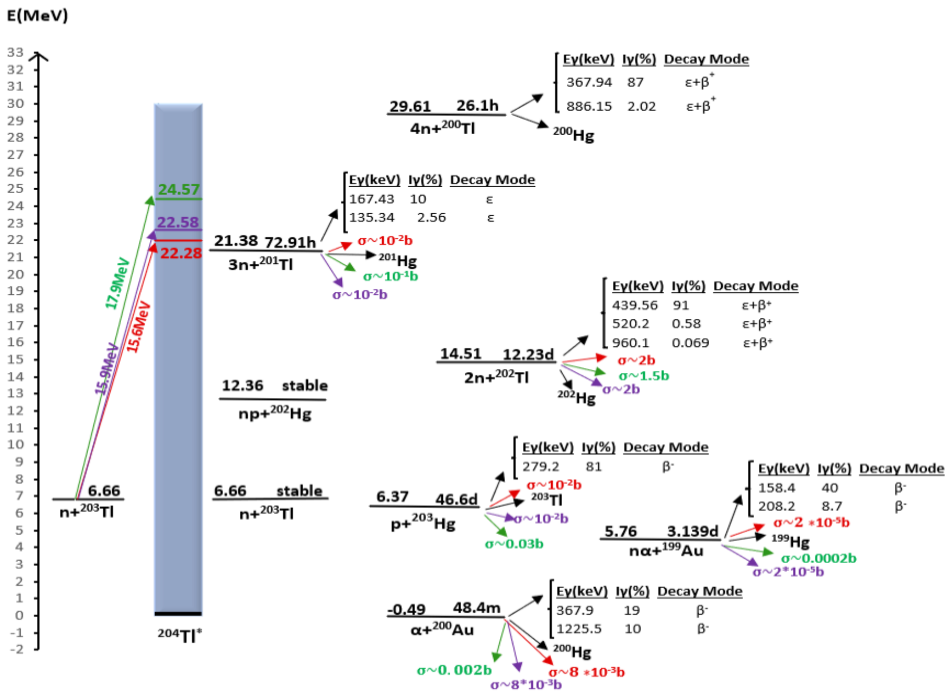

Figure 2. *Energy diagram of neutron–induced reactions on ^{203}Tl*

Experimental Procedure

The experiments were carried out at the 5.5 MV Tandem accelerator of N.C.S.R. "Demokritos", while the production of the isotropic and monoenergetic neutron beam was based on the ^{3}H(d,n)^{4}He process using a CuTiT target, as it is shown in Fig. 3. During the irradiation, a BF_3 detector was used to monitor the beam's fluctuation. The Tl targets were natural TlCl pellets of ~1 g mass and 13 mm diameter, while the reference targets were high purity Al and Au foils of the same diameter.

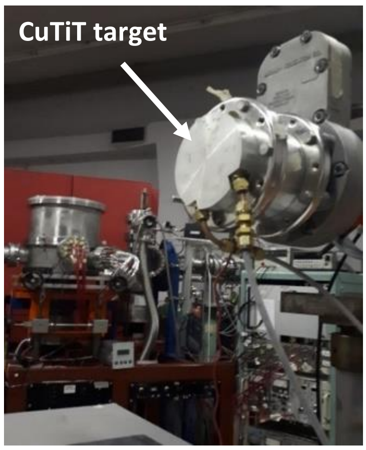

Figure 3. *CuTiT target*

Following the end of the irradiation, the induced activities of the Tl target and the reference foils were measured. For this purpose, two 80% relative efficiency HPGe detectors were used while the absolute efficiency of the detectors was determined with the use of a calibrated ^{152}Eu point source of (217±3) kBq activity, adopting the same source-to-detector distance, at 10 cm in front of the detectors, to eliminate pile-up and summing effects.

The parameters of the conducted irradiations are shown in Table 1, along with the measurement time of the target foil's induced radiation. In particular, the induced radiation of the target foil under the 15.7 MeV irradiation was measured at two distinct times.

Table 1. *Characteristics of the irradiations*

Neutron Energy (MeV)	Irradiation time (h)	Measurement time (h)	Deuteron Energy (MeV)
15.7	~5	~22 ~2	2.145
16.0	~8	~19	2.153
18.0	~7	~22	2.916

The resulting Thallium gamma-ray spectrum compared to the background spectrum is shown in Fig. 4.

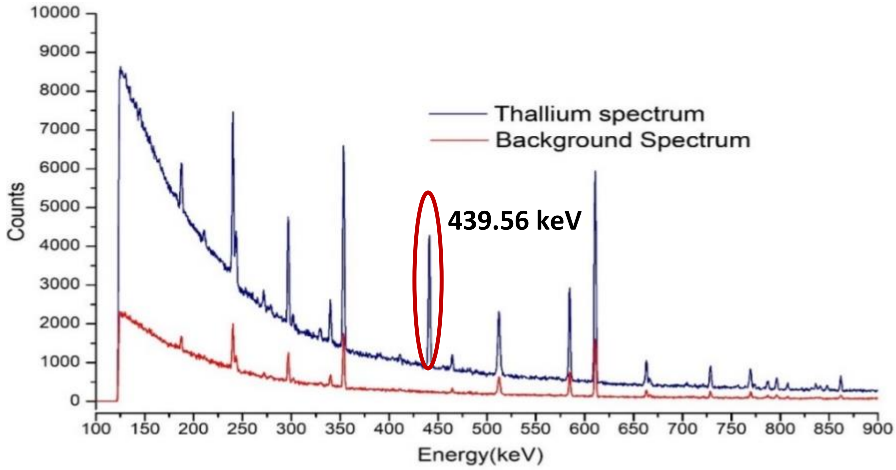

Figure 4. *Thallium spectrum at 15.7 MeV in comparison with the background spectrum*

CROSS SECTION MEASUREMENT

The measurement of the cross section (σ) was based on the Neutron Activation Analysis (NAA) and was calculated using the following expression:

$$\sigma = \frac{N_p}{N_\tau} \cdot \frac{1}{\Phi}$$

Where:

- N_p: the number of unstable nuclei produced by the neutron irradiation.
- N_τ: the number of irradiated target nuclei.
- Φ: neutron flux calculated with Monte Carlo simulations via the MCNP code [4] and compared with experimental fluxes from the reference reactions.

For the determination of the neutron flux (Φ) of the reaction ^{203}Tl(n,2n)^{202}Tl, the reference reactions ^{197}Au(n,2n)^{196}Au and ^{27}Al(n,α)^{24}Na were used, along with MCNP simulations using the geometry of the irradiation setup, shown in Fig. 5.

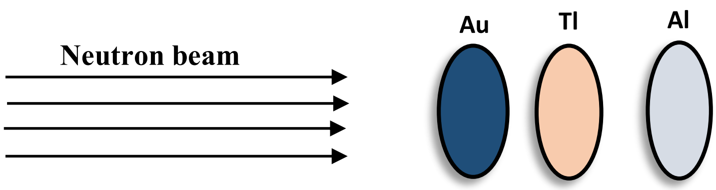

Figure 5. *Schematic representation of the irradiated target and reference foils*

RESULTS AND DISCUSSION

The preliminary results of the experimental cross section (σ) at energies 15.7 MeV, 16.0 MeV and 18.0 MeV are presented in Table 2 as well as in Fig. 6 shown in blue, along with the previous measurements from our group at 16.4, 18.9 and 19.3 MeV shown in green [2,3] and existing data in literature.

Table 2. *Experimental Cross-section preliminary results*

	σ ± δσ (barn)
Neutron Energy (MeV)	**$^{203}Tl(n,2n)^{202}Tl$**
15.7	1.96 ± 0.09
16.0	1.91 ± 0.10
18.0	1.67 ± 0.11

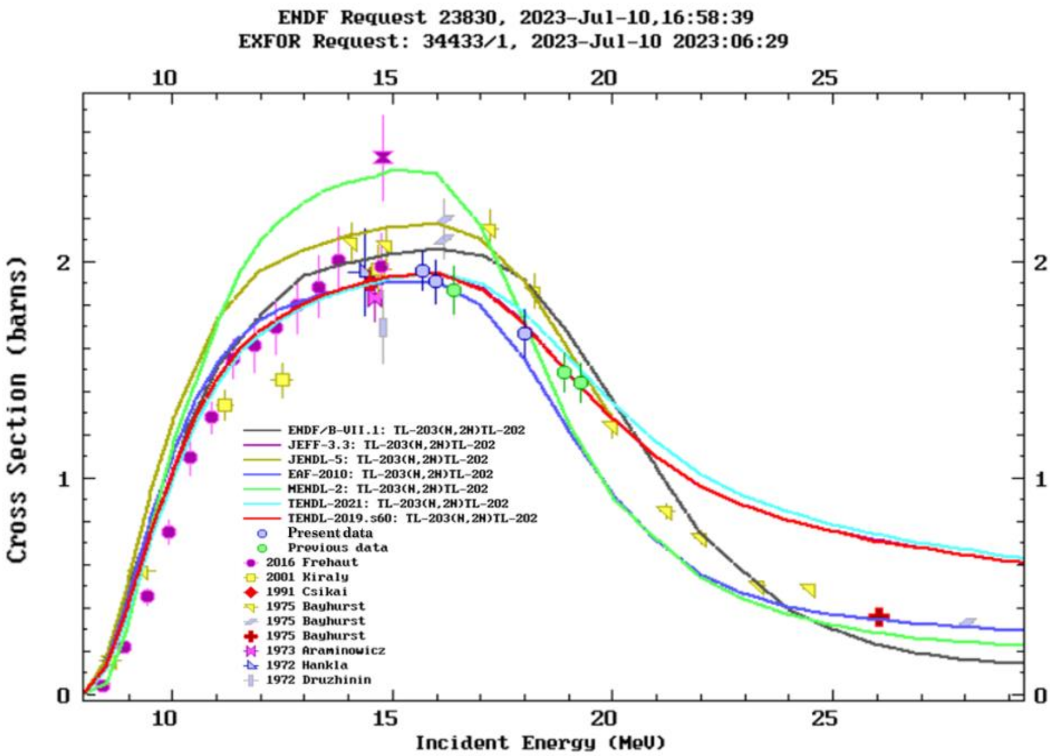

Figure 6. *Existing and present experimental data along with evaluations [4]*

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