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Cross Sections and Thick Target Yields of Alpha-Induced Reactions

An Extraction from Final Report of Contract 2499/R1/RB
(1 December 1980 to 1 December 1981)

O. Bonesso, O.A. Capurro, M.J. Ozafrán, M.J. Tavelli, M. de la Vega Vedoya,
C. Wasilevsky, S.J. Nassiff

National Atomic Energy Commission (CNEA), Argentina

February 2017

IAEA Nuclear Data Section, Vienna International Centre, A-1400 Vienna, Austria

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Produced by the IAEA in Austria
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Abstract

Four sections of the final report of Contract 2499/R1/RB "Charged-particle cross-section data and their evaluation and systematization" (Sonia F.J. Nassiff, National Atomic Energy Commission (CNEA), Argentina, 1 December 1980-1 December 1981) are extracted to archive the results of these unpublished works.

February 2017

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Editorial Note

This is a part of the document (L82-24137) originally prepared as the final report of the Contract 2499/R1/RB "Charged-particle cross-section data and their evaluation and systematization" with the National Atomic Energy Commission (CNEA), Argentina (1 December 1980 – 1 December 1981, Principal Scientific Investigator: Dr. Sonia F.J. Nassiff). Some of the newly measured experimental cross sections tabulated in this report were unpublished though they have been compiled in the EXFOR Library (Entry number D0046) since 1983. Therefore a part of the document relevant to this EXFOR entry was reproduced from the original report, and published as an INDC report to make the data source traceable for EXFOR users. See also O. Capurro et al., J. Radioanal. Nucl. Chem. **89** (1985) 519 for the ^{197}Au(α, 4n)^{197}Tl cross sections tabulated in this report.

A special cross section quantity $\sigma_p \sum_i a_i/\bar{A}$ is introduced in this report. This quantity (often referred to as *cumulative cross section* by the CNEA group) can be converted to the usual production cross section for a natural target (elemental cross section) by multiplying the atomic mass of the target element. See also Appendix of M.J. Ozafrán et al., J. Radioanal. Nucl. Chem. **131** (1989) 467. Two thick target yield quantities $\Sigma A_{t/10}$ and ΣA_{1h} introduced in this report are also often reported in the articles from this research group (*e.g.*, Tables 3 to 5 of the Ozafrán et al.'s article). The group does not define the these quantities explicitly in their publications, but most probably they are the end-of-bombardment thick target yield after irradiation time of $T_{1/2}/10$ and physical thick target yield, respectively. See N. Otuka and S. Takács, Radiochim. Acta **103** (2015) 1 for the definitions of the end-of-bombardment thick target yield and physical thick target yield.

Ms Siyi Sun and Mr Ryota Hasegawa (Interns from University of Tokyo) reproduced this report from a hard copy of the original report. Dr .Oscar Capurro (Lab. TANDAR, CNEA, a former collaborator of Dr. Nassiff) helped us to clarify the definition of their cumulative cross section.

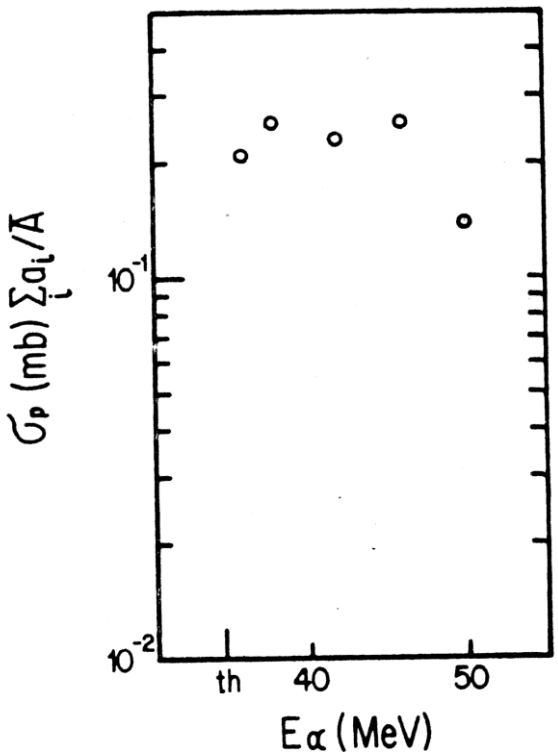
2017-02-13
Naohiko Otuka
IAEA Nuclear Data Section

ENGLISH TRANSLATION

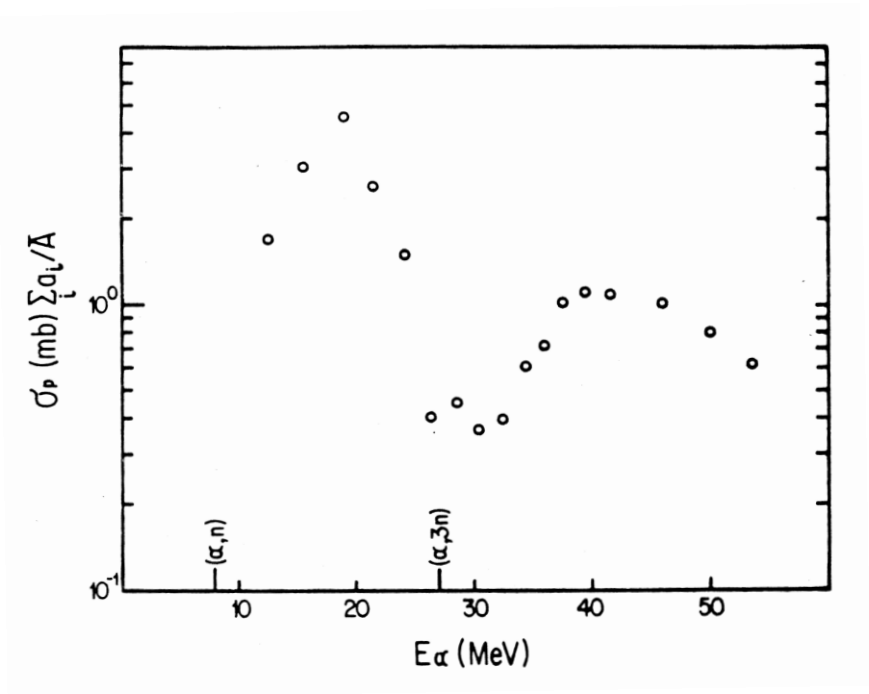
1. REACTIONS WITH ALPHA PARTICLES FOR THE PRODUCTION OF ^{61}Cu, ^{63}Zn + ^{63}Ga and ^{66}Ga

The experimental study on the formation cross-sections for ^{61}Cu shows that this isotope is produced in the following reactions: ^{63}Cu(α, α2n)^{61}Cu, ^{65}Cu(α, α4n)^{61}Cu and ^{63}Cu(α, 2p4n)^{61}Cu. As a result of this study, we were also able to determine the absolute formation cross-sections for ^{63}Zn + ^{63}Ga through the ^{63}Cu(α, p3n) and ^{63}Cu(α, 4n) reactions, respectively, and lastly, the formation cross-sections for ^{66}Ga through the ^{63}Cu(α, n) and ^{65}Cu(α, 3n) reactions. The methodology used consisted essentially of irradiation with alpha particles in the CNEA synchrocyclotron using stacked copper foils and subsequent study of the gamma spectra measured with a high-resolution intrinsic Ge detector.

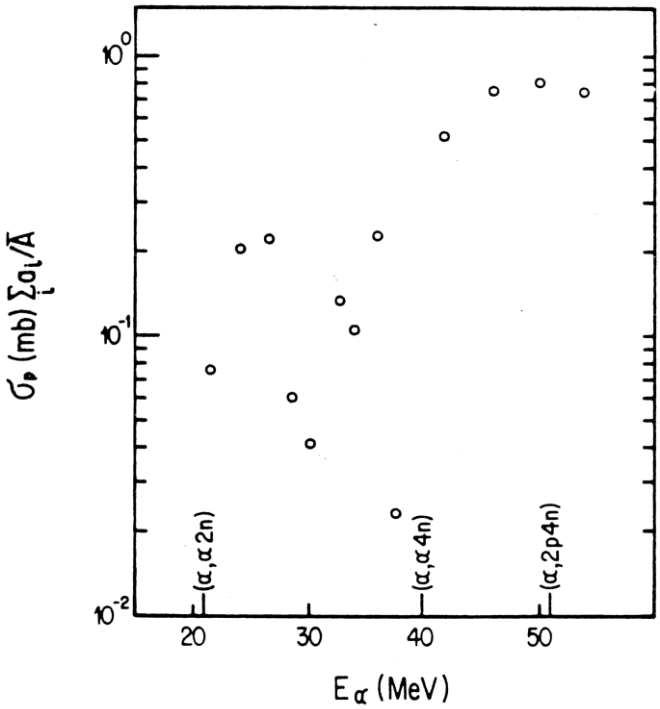
E_α (MeV)	$\sigma_p \sum_i a_i/\bar{A}$ (mb)		
	^{61}Cu	^{66}Ga	^{63}Zn
53.78	$7.54 \times 10^{-1} \pm 4.92 \times 10^{-2}$	$6.30 \times 10^{-1} \pm 7.59 \times 10^{-2}$	
50.02	$8.04 \times 10^{-1} \pm 4.89 \times 10^{-2}$	$8.13 \times 10^{-1} \pm 7.96 \times 10^{-2}$	$1.40 \times 10^{-1} \pm 1.31 \times 10^{-1}$
46.00	$7.78 \times 10^{-1} \pm 4.80 \times 10^{-2}$	$1.04 \times 10^{0} \pm 2.81 \times 10^{-2}$	$2.60 \times 10^{-1} \pm 1.25 \times 10^{-1}$
41.76	$5.26 \times 10^{-1} \pm 4.30 \times 10^{-2}$	$1.14 \times 10^{0} \pm 9.12 \times 10^{-2}$	$2.29 \times 10^{-1} \pm 1.32 \times 10^{-1}$
39.42		$1.18 \times 10^{0} \pm 1.43 \times 10^{-1}$	
37.72	$2.30 \times 10^{-2} \pm 7.63 \times 10^{-2}$	$1.05 \times 10^{0} \pm 1.45 \times 10^{-1}$	$2.56 \times 10^{-1} \pm 1.99 \times 10^{-1}$
35.98	$2.30 \times 10^{-1} \pm 9.40 \times 10^{-2}$	$7.41 \times 10^{-1} \pm 3.43 \times 10^{-2}$	$2.13 \times 10^{-1} \pm 1.04 \times 10^{-1}$
34.19	$1.09 \times 10^{-1} \pm 9.21 \times 10^{-2}$	$6.26 \times 10^{-1} \pm 1.10 \times 10^{-1}$	
32.29	$1.30 \times 10^{-1} \pm 7.31 \times 10^{-2}$	$4.03 \times 10^{-1} \pm 2.59 \times 10^{-2}$	
30.33	$4.18 \times 10^{-2} \pm 3.84 \times 10^{-2}$	$3.84 \times 10^{-1} \pm 9.09 \times 10^{-2}$	
28.41	$6.04 \times 10^{-2} \pm 8.12 \times 10^{-2}$	$4.60 \times 10^{-1} \pm 2.63 \times 10^{-2}$	
26.35	$2.25 \times 10^{-1} \pm 7.12 \times 10^{-2}$	$4.47 \times 10^{-1} \pm 1.12 \times 10^{-1}$	
24.08	$2.19 \times 10^{-1} \pm 8.36 \times 10^{-2}$	$1.53 \times 10^{0} \pm 4.91 \times 10^{-2}$	
21.55	$7.60 \times 10^{-2} \pm 9.81 \times 10^{-2}$	$2.68 \times 10^{0} \pm 2.11 \times 10^{-1}$	
18.80		$4.71 \times 10^{0} \pm 1.94 \times 10^{-1}$	
15.75		$3.08 \times 10^{0} \pm 2.05 \times 10^{-1}$	
12.24		$1.69 \times 10^{0} \pm 1.46 \times 10^{-1}$	



σ_p (mb) $\sum_i a_i/\bar{A}$ for the production of $^{63}Zn+^{63}Ga$



σ_p (mb) $\sum_i a_i/\bar{A}$ for the production of ^{66}Ga



σ_p (mb) $\sum_i a_i/\bar{A}$ for the production of ^{61}Cu

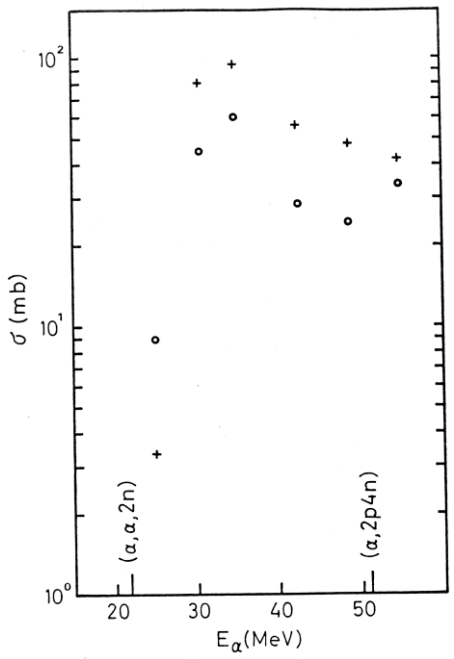
2. CROSS-SECTIONS AND YIELD RATIOS FOR THE ISOMERIC PAIR $^{87m}Y/^{87g}Y$ FORMED IN THE (α, α2n) REACTION

We give in the form of tables and graphs the excitation functions for the formation of ^{87m}Y and ^{87g}Y, and also the cross-section ratios for the above isomeric pair as a function of incident-particle energy. The thick-target yields in the production of ^{87g}Y were also evaluated. The quantitative formation behaviour of isomeric pairs produced in the (α, α2n) reactions is very difficult to predict because of the small volume of data available on these reactions. The experiments were performed by exposing ^{89}Y metal foils, by the stacked metal foil method, to the external beam of the CNEA synchrocyclotron. The population of the levels of each isomer was determined by measuring its gamma spectra with a high-resolution intrinsic Ge detector. The data obtained were processed subsequently by means of calculation programs using the IBM 370 computer of the CNEA Computer Centre.

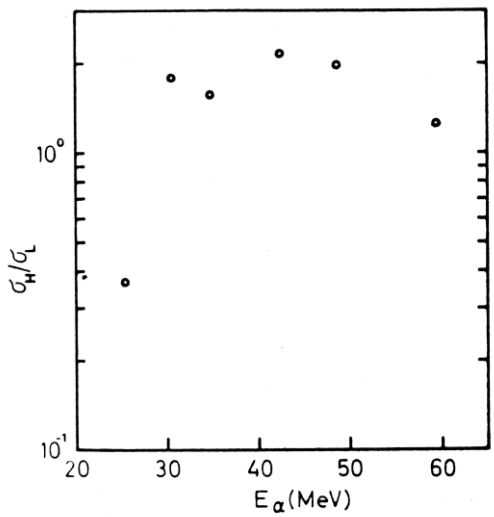
E_α (MeV)	σ (mb)		σ_H/σ_L
	$^{89}Y(\alpha, \alpha 2n)\,^{87m}Y$	$^{89}Y(\alpha, \alpha 2n)^{87g}Y$	
25.03	9.111 ± 0.159	3.38 ± 3.03	2.695 ± 2.508
30.40	44.45 ± 4.76	81.31 ± 8.22	0.547 ± 0.0805
34.95	59.85 ± 2.36	94.66 ± 6.99	0.632 ± 0.0529
42.30	28.73 ± 1.44	56.54 ± 5.59	0.508 ± 0.0563
48.76	24.13 ± 1.94	48.36 ± 4.45	0.499 ± 0.0610
54.50	34.08 ± 2.81	42.03 ± 4.48	0.811 ± 0.109

Thick target yields for the production of ^{87g}Y

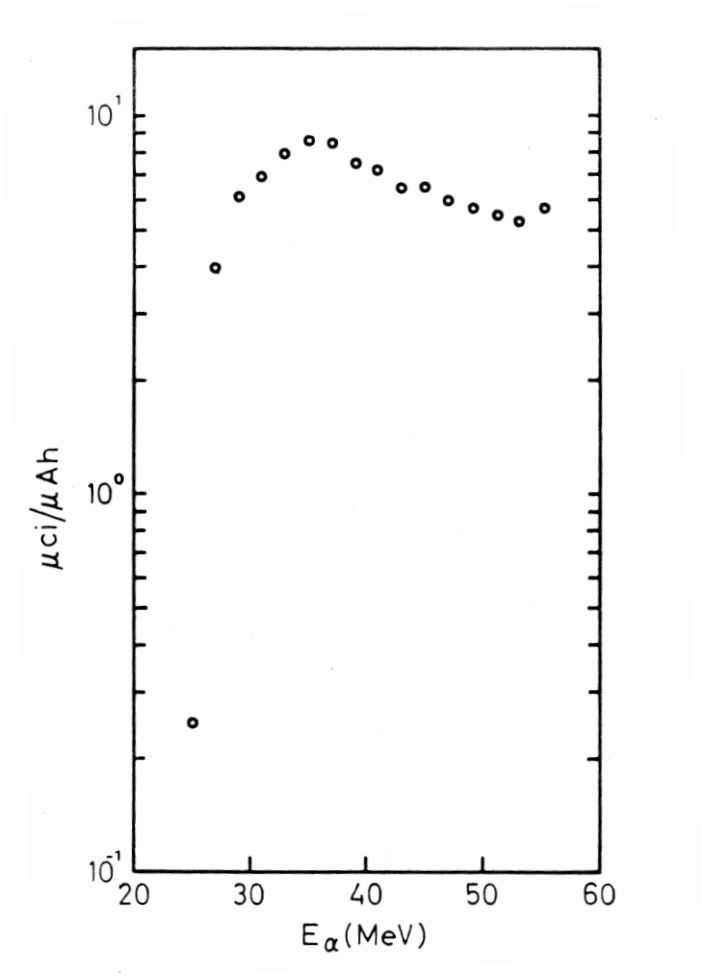
Energy range (MeV)	Target thickness (mg/cm^2)	Cross-section (m.b.)	Saturation activity (μ Ci/A)	ΣSaturation activity (μ Ci/A)	$\Sigma A_{t/10}$ (μ Ci/μA)	ΣA_{1h} (μ Ci/Ah)
56 - 54	27.46	42	6.592×10^2	1.140×10^4	7.632×10^2	9.795×10^1
54 - 52	24.27	44	6.104×10^2	1.074×10^4	7.190×10^2	9.228×10^1
52 - 50	24.27	46	6.381×10^2	1.013×10^4	6.781×10^2	8.703×10^1
50 - 48	24.00	49	6.721×10^2	9.488×10^3	6.354×10^2	8.155×10^1
48 - 46	23.00	53	6.967×10^2	8.816×10^3	5.904×10^2	7.577×10^1
46 - 44	23.00	58	7.624×10^2	8.120×10^3	5.437×10^2	6.979×10^1
44 - 42	21.00	62	7.441×10^2	7.357×10^3	4.927×10^2	6.323×10^1
42 - 40	21.00	70	8.401×10^2	6.613×10^3	4.429×10^2	5.684×10^1
40 - 38	20.00	76	8.687×10^2	5.773×10^3	3.866×10^2	4.962×10^1
38 - 36	20.00	85	9.716×10^2	4.904×10^3	3.284×10^2	4.215×10^1
36 - 34	19.00	92	9.990×10^2	3.933×10^3	2.633×10^2	3.380×10^1
34 - 32	18.00	90	9.259×10^2	2.933×10^3	1.964×10^2	2.521×10^1
32 - 30	17.00	83	8.064×10^2	2.008×10^3	1.344×10^2	1.725×10^1
30 - 28	17.00	73	7.093×10^2	1.201×10^3	8.044×10^1	1.032×10^1
28 - 26	15.00	54	4.629×10^2	4.919×10^2	3.294×10^1	4.228×10^1
26 - 24	15.00	3.38	2.898×10^1	2.898×10^1	1.940×10^0	2.490×10^1



○ Cross-sections for the reaction $^{89}Y(\alpha, \alpha 2n)^{87m}Y$
+ Cross-sections for the reaction $^{89}Y(\alpha, \alpha 2n)^{87g}Y$



σ_m / σ_g for the reaction $^{89}Y(\alpha, \alpha 2n)^{87m}Y/^{87g}Y$

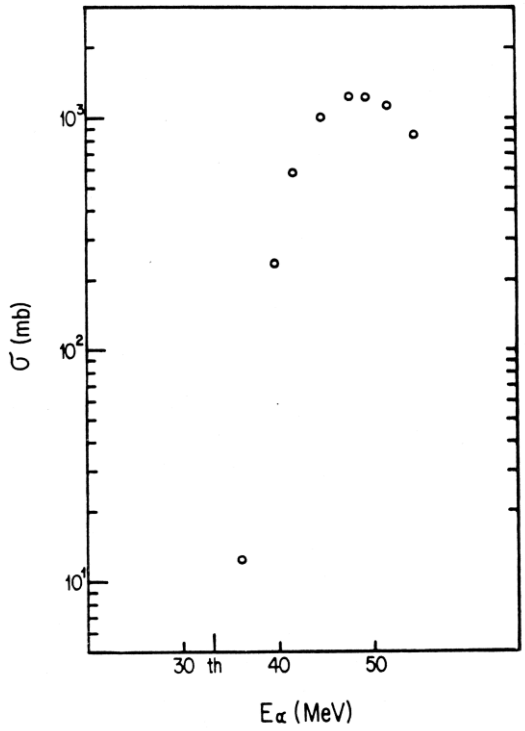


Thick target yields for the production of ^{87g}Y

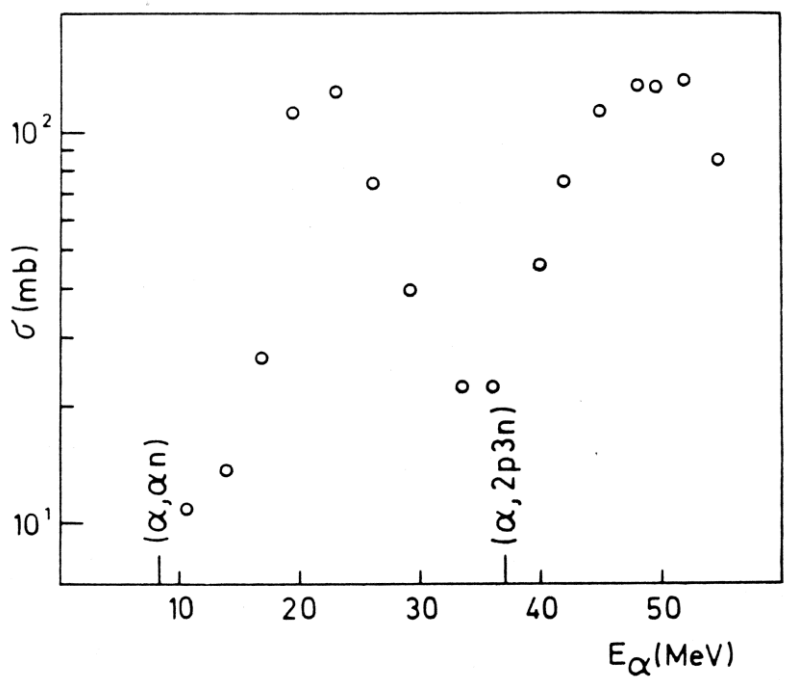
3. (α, 4n) REACTIONS FOR THE FORMATION OF ^{197}Tl and (α, αn) and (α, 2p3n) REACTIONS FOR THE FORMATION OF ^{196g}Au

The formation cross-sections for these isotopes were determined by irradiating metal foils of natural gold with alpha particles. In the case of ^{197}Tl, since only one nuclear reaction was involved, the values obtained directly gave the absolute cross-sections. In the case of ^{196g}Au, it was necessary to apply the method described by Landolt and Börnstein (Numerical Data and Functional Relationship in Science and Technology, Vol. 5, 1974) and Svoboda (U.J.V. Report 2258, 1969) to separate the excitation functions of the reactions (α, αn) and (α, 2p3n), respectively, with allowance for the thresholds of these reactions. The methodology used consisted basically of determining the activity of the product isotope by gamma-spectrometry using a high-resolution intrinsic Ge detector and subsequent processing of the data by computer programs of the CNEA Radiochemistry Program Library.

E_α (MeV)	σ (mb)	
	^{197}Au(α, 4n)^{197}Tl	^{197}Au(α, αn)^{196g}Au
54.47	849.27 ± 254.29	85.15 ± 21.18
51.82	1161.12 ± 347.67	133.73 ± 33.23
49.48	1233.89 ± 369.47	130.64 ± 33.32
47.41	1243.49 ± 372.36	133.61 ± 33.24
44.79	1012.25 ± 303.13	113.25 ± 28.11
41.84	583.98 ± 174.89	75.24 ± 18.67
39.86	237.89 ± 71.27	46.28 ± 11.46
36.21	126.58 ± 38.95	22.47 ± 6.02
33.48		22.70 ± 6.61
29.04		39.45 ± 10.43
26.10		74.42 ± 18.38
22.89		128.26 ± 31.87
19.43		112.47 ± 27.74
16.88		26.39 ± 14.90
13.75		13.87 ± 3.42
10.42		10.89 ± 2.85



Cross-sections for the reaction $^{197}Au(\alpha, 4n)^{197}Tl$

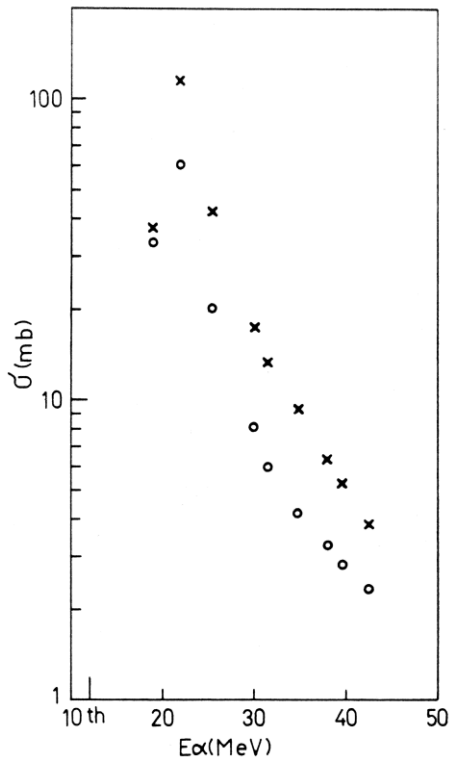


Cross-sections for the reactions $^{197}Au(\alpha, \alpha n)^{196g}Au$ and $^{197}Au(\alpha, 2p3n)^{196g}Au$

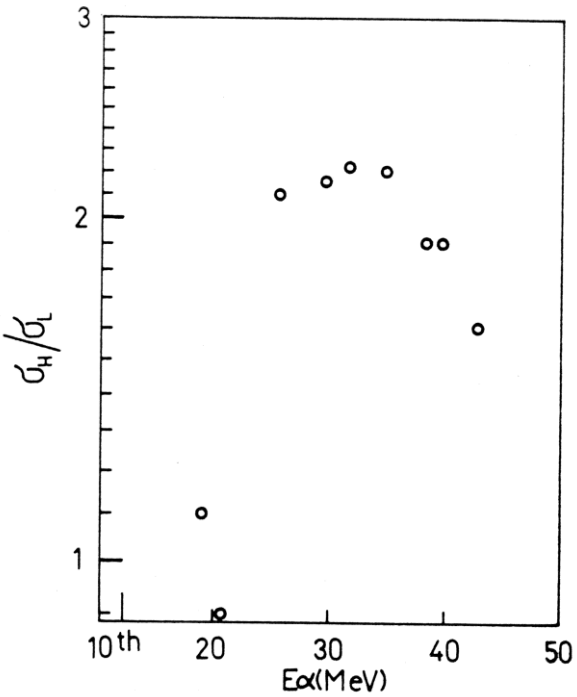
4. CROSS-SECTIONS AND ISOMERIC RATIOS FOR THE $^{184m}/^{184g}$Re PAIR OBTAINED IN THE ^{181}Ta(α, n) REACTION

The experiments consisted in exposing tantalum targets in the form of stacked metal foils to the external beam of the CNEA synchrocyclotron. The absolute activities of ^{184m}Re and ^{184g}Re were obtained from the 920-keV and 792-keV gamma rays, respectively. Correction was made for the activity of ^{184g}Re due to isomeric transition from ^{184m}Re.

E_α (MeV)	σ (mb)		σ_H/σ_L
	^{184g}Re	^{184g}Re	
18.81	33.24 ± 5.98	37.54 ± 7.13	1.13
20.69	55.71 ± 12.26	48.12 ± 10.11	0.86
25.47	20.00 ± 3.80	42.03 ± 7.15	2. 10
29.82	8.01 ± 1.76	17.12 ± 3.25	2.14
31.41	5.89 ± 1.01	13.11 ± 2.36	2.23
34.83	4.13 ± 0.66	9.27 ± 1.95	2.24
38.18	3.27 ± 0.72	6.31 ± 1.39	1.93
39.67	2.81 ± 0.56	5.30 ± 1.11	1.89
42.78	2.36 ± 0.45	3.87 ± 0.74	1.64



× Cross-sections for the reaction $^{181}Ta(\alpha, n)^{184m}Re$
○ Cross-sections for the reaction $^{181}Ta(\alpha, n)^{184g}Re$



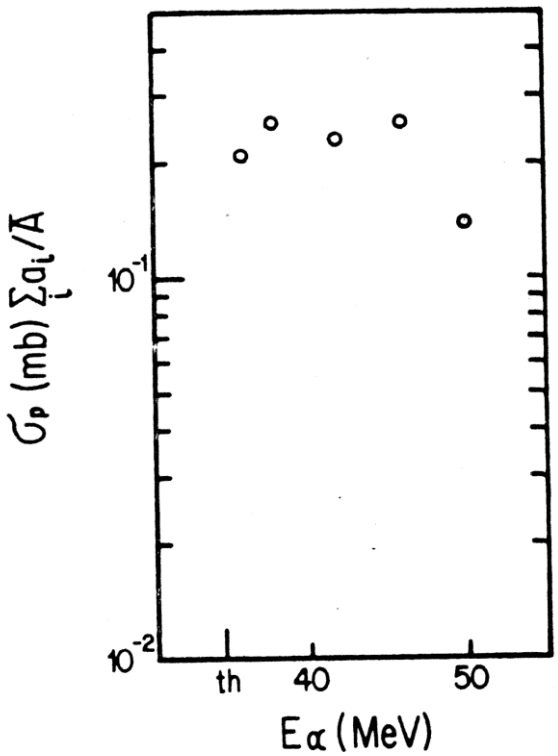
$\sigma(^{184m}Re)/\ \sigma(^{184g}Re)$

ORIGINAL (Spanish)

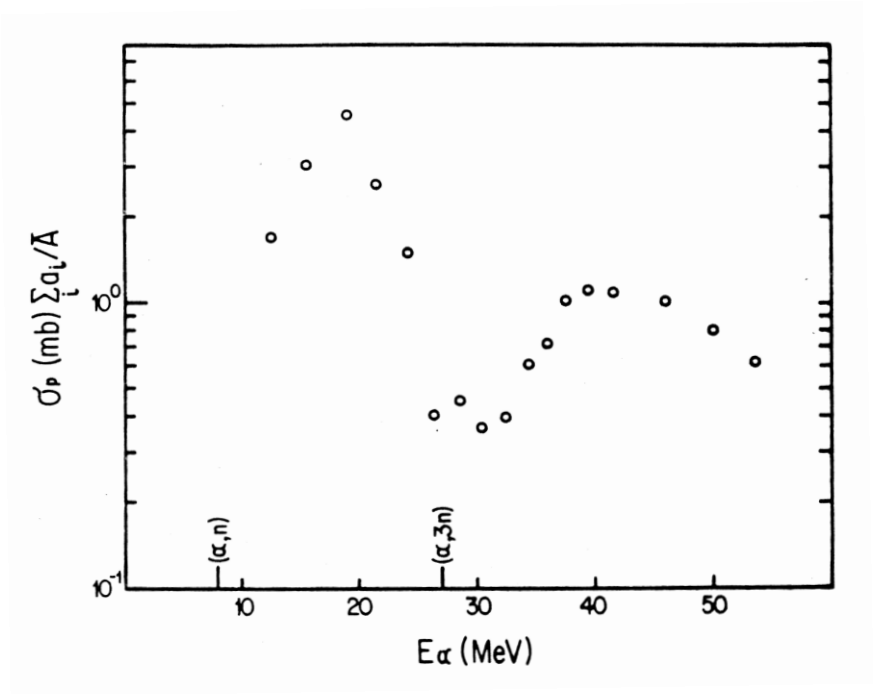
1. REACCIONES CON PARTICULAS ALFA PARA LA PRODUCCION DE ^{61}Cu, ^{63}Zn + ^{63}Ga y ^{66}Ga

El estudio experimental de las secciones eficaces de producción del ^{61}Cu mostraron que dicho nucleído se produce por las siguientes reacciones: ^{63}Cu (α, α2n) ^{61}Cu, ^{65}Cu (α, α4n) ^{61}Cu y ^{63}Cu (α, 2p4n)^{61}Cu. Este trabajo permitió determinar también las secciones eficaces absolutas para la formación de ^{63}Zn+^{63}Ga a través de las reacciones ^{63}Cu (α**,** p3n) y ^{63}Cu (α, 4n) respectivamente. Por último, las secciones eficaces de producción del ^{66}Ga a través de las reacciones ^{63}Cu (α, n) y ^{65}Cu (α, 3n). La metodología utilizada consistió escuetamente, en irradiaciones con partículas alfa en el Sincrociclotrón de la Comisión Nacional de Energía Atómica utilizando el método de las hojuelas de Cobre superpuestas y el estudio posterior de los espectros gama con un detector de Ge intrínseco de alta resolución.

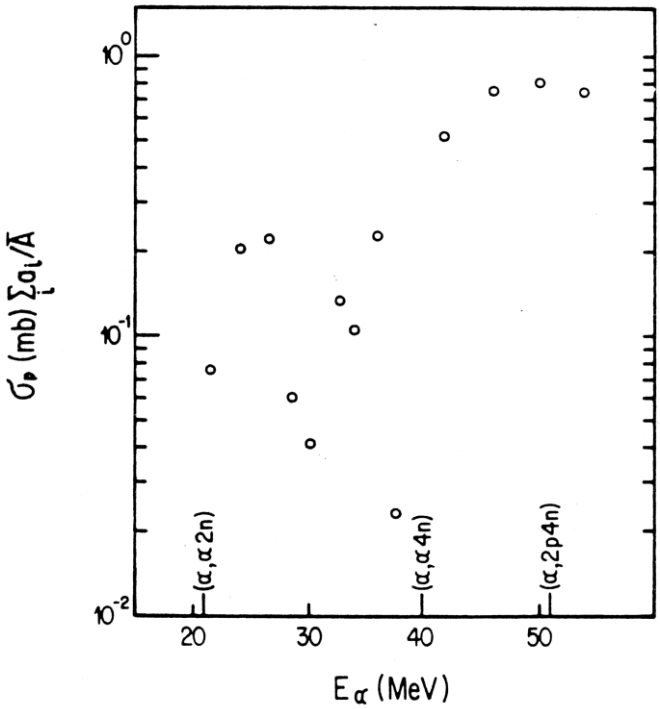
E_α (MeV)	$\sigma_p \sum_i a_i/\bar{A}$ (mb)		
	^{61}Cu	^{66}Ga	^{63}Zn
53.78	$7.54 \times 10^{-1} \pm 4.92 \times 10^{-2}$	$6.30 \times 10^{-1} \pm 7.59 \times 10^{-2}$	
50.02	$8.04 \times 10^{-1} \pm 4.89 \times 10^{-2}$	$8.13 \times 10^{-1} \pm 7.96 \times 10^{-2}$	$1.40 \times 10^{-1} \pm 1.31 \times 10^{-1}$
46.00	$7.78 \times 10^{-1} \pm 4.80 \times 10^{-2}$	$1.04 \times 10^{0} \pm 2.81 \times 10^{-2}$	$2.60 \times 10^{-1} \pm 1.25 \times 10^{-1}$
41.76	$5.26 \times 10^{-1} \pm 4.30 \times 10^{-2}$	$1.14 \times 10^{0} \pm 9.12 \times 10^{-2}$	$2.29 \times 10^{-1} \pm 1.32 \times 10^{-1}$
39.42		$1.18 \times 10^{0} \pm 1.43 \times 10^{-1}$	
37.72	$2.30 \times 10^{-2} \pm 7.63 \times 10^{-2}$	$1.05 \times 10^{0} \pm 1.45 \times 10^{-1}$	$2.56 \times 10^{-1} \pm 1.99 \times 10^{-1}$
35.98	$2.30 \times 10^{-1} \pm 9.40 \times 10^{-2}$	$7.41 \times 10^{-1} \pm 3.43 \times 10^{-2}$	$2.13 \times 10^{-1} \pm 1.04 \times 10^{-1}$
34.19	$1.09 \times 10^{-1} \pm 9.21 \times 10^{-2}$	$6.26 \times 10^{-1} \pm 1.10 \times 10^{-1}$	
32.29	$1.30 \times 10^{-1} \pm 7.31 \times 10^{-2}$	$4.03 \times 10^{-1} \pm 2.59 \times 10^{-2}$	
30.33	$4.18 \times 10^{-2} \pm 3.84 \times 10^{-2}$	$3.84 \times 10^{-1} \pm 9.09 \times 10^{-2}$	
28.41	$6.04 \times 10^{-2} \pm 8.12 \times 10^{-2}$	$4.60 \times 10^{-1} \pm 2.63 \times 10^{-2}$	
26.35	$2.25 \times 10^{-1} \pm 7.12 \times 10^{-2}$	$4.47 \times 10^{-1} \pm 1.12 \times 10^{-1}$	
24.08	$2.19 \times 10^{-1} \pm 8.36 \times 10^{-2}$	$1.53 \times 10^{0} \pm 4.91 \times 10^{-2}$	
21.55	$7.60 \times 10^{-2} \pm 9.81 \times 10^{-2}$	$2.68 \times 10^{0} \pm 2.11 \times 10^{-1}$	
18.80		$4.71 \times 10^{0} \pm 1.94 \times 10^{-1}$	
15.75		$3.08 \times 10^{0} \pm 2.05 \times 10^{-1}$	
12.24		$1.69 \times 10^{0} \pm 1.46 \times 10^{-1}$	



σ_p (mb) $\sum_i a_i/\bar{A}$ para la Producción de $^{63}Zn+^{63}Ga$



σ_p (mb) $\sum_i a_i/\bar{A}$ para la Producción de ^{66}Ga



σ_p (mb) $\sum_i a_i/\bar{A}$ para la Producción de ^{61}Cu

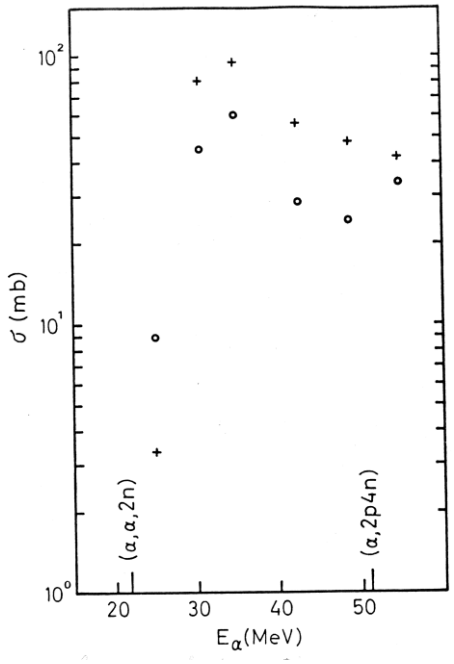
2. SECCIONES EFICACES Y RELACIONES DE RENDIMIENTOS DEL PAR ISOMERICO $^{87m}Y/^{87g}Y$ FORMADO EN LA REACCION (α, α2n)

Se presentan en forma de tablas y gráficos las funciones de excitación para la formación del ^{87m}Y y el ^{87g}Y, asimismo, las relaciones de secciones eficaces del par isomérico indicado, en función de la energía de la partícula incidente. Los rendimientos para blancos gruesos en la producción del ^{87g}Y fueron también evaluados. El comportamiento en la formación cuantitativa de pares isoméricos que se producen en reacciones (α, α2n) es muy difícil de preveer ya que el número de datos con respecto a estas reacciones son muy escasos. Las experiencias se realizaron sometiendo láminas metálicas de ^{89}Y, según el método de las hojuelas metálicas superpuestas, al haz externo del Sincrociclotrón de la Comisión Nacional de Energía Atómica. La población de los niveles de cada uno de los isómeros se determinó mediante la medición de sus espectros gama con un detector de Ge intrínseco de alta resolución. El procesamiento posterior de los datos obtenidos se realizó con programas de cálculo utilizando la computadora IBM 370 del Centro de Cómputos de la Comisión Nacional de Energía Atómica.

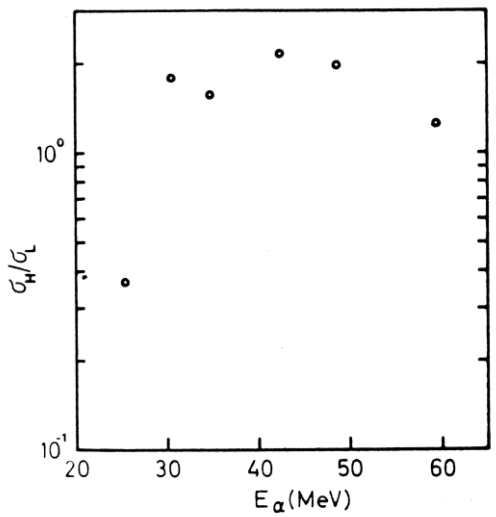
E_α (MeV)	σ (mb)		σ_H/σ_L
	$^{89}Y(\alpha, \alpha 2n)\,^{87m}Y$	$^{89}Y(\alpha, \alpha 2n)^{87g}Y$	
25.03	9.111 ± 0.159	3.38 ± 3.03	2.695 ± 2.508
30.40	44.45 ± 4.76	81.31 ± 8.22	0.547 ± 0.0805
34.95	59.85 ± 2.36	94.66 ± 6.99	0.632 ± 0.0529
42.30	28.73 ± 1.44	56.54 ± 5.59	0.508 ± 0.0563
48.76	24.13 ± 1.94	48.36 ± 4.45	0.499 ± 0.0610
54.50	34.08 ± 2.81	42.03 ± 4.48	0.811 ± 0.109

Rendimientos de Blancos Gruesos para la Producción de ^{87g}Y

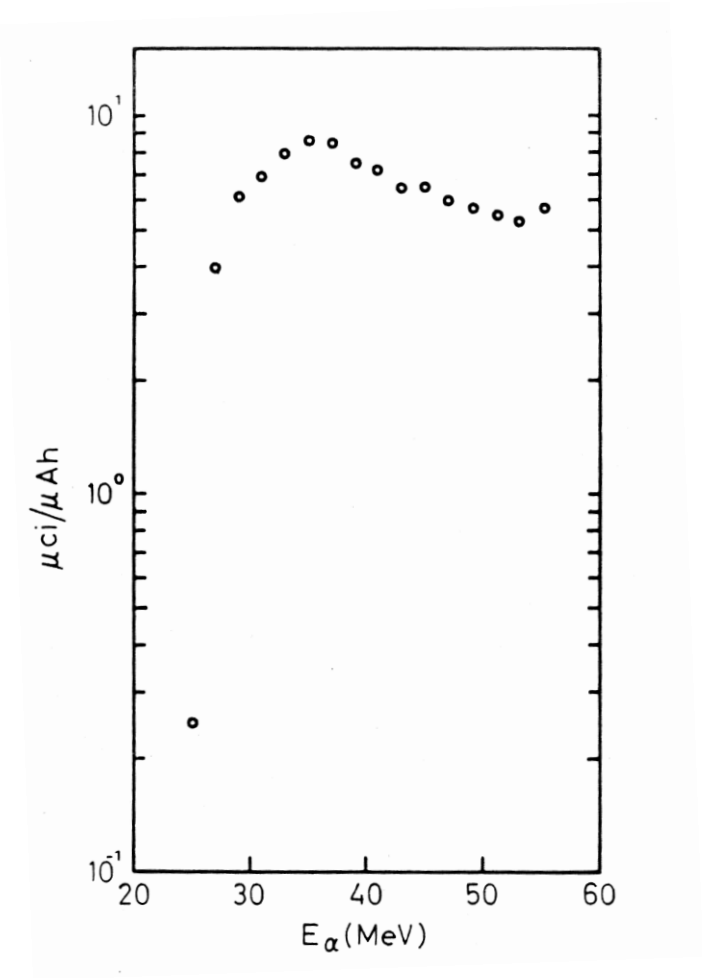
Intervalo de energía (MeV)	Espesor del blanco (mg/cm^2)	Sección eficaz (m.b.)	Actividad a saturación (μ Ci/A)	ΣActividad a saturación (μ Ci/A)	$\Sigma A_{t/10}$ (μ Ci/μA)	ΣA_{1h} (μ Ci/Ah)
56 - 54	27.46	42	6.592×10^2	1.140×10^4	7.632×10^2	9.795×10^1
54 - 52	24.27	44	6.104×10^2	1.074×10^4	7.190×10^2	9.228×10^1
52 - 50	24.27	46	6.381×10^2	1.013×10^4	6.781×10^2	8.703×10^1
50 - 48	24.00	49	6.721×10^2	9.488×10^3	6.354×10^2	8.155×10^1
48 - 46	23.00	53	6.967×10^2	8.816×10^3	5.904×10^2	7.577×10^1
46 - 44	23.00	58	7.624×10^2	8.120×10^3	5.437×10^2	6.979×10^1
44 - 42	21.00	62	7.441×10^2	7.357×10^3	4.927×10^2	6.323×10^1
42 - 40	21.00	70	8.401×10^2	6.613×10^3	4.429×10^2	5.684×10^1
40 - 38	20.00	76	8.687×10^2	5.773×10^3	3.866×10^2	4.962×10^1
38 - 36	20.00	85	9.716×10^2	4.904×10^3	3.284×10^2	4.215×10^1
36 - 34	19.00	92	9.990×10^2	3.933×10^3	2.633×10^2	3.380×10^1
34 - 32	18.00	90	9.259×10^2	2.933×10^3	1.964×10^2	2.521×10^1
32 - 30	17.00	83	8.064×10^2	2.008×10^3	1.344×10^2	1.725×10^1
30 - 28	17.00	73	7.093×10^2	1.201×10^3	8.044×10^1	1.032×10^1
28 - 26	15.00	54	4.629×10^2	4.919×10^2	3.294×10^1	4.228×10^1
26 - 24	15.00	3.38	2.898×10^1	2.898×10^1	1.940×10^0	2.490×10^1



○ Secciones Eficaces para la Reacción $^{89}Y(\alpha, \alpha 2n)^{87m}Y$
+ Secciones Eficaces para la Reacción $^{89}Y(\alpha, \alpha 2n)^{87g}Y$



σ_m / σ_g para la Reacción $^{89}Y(\alpha, \alpha 2n)^{87m}Y/^{87g}Y$

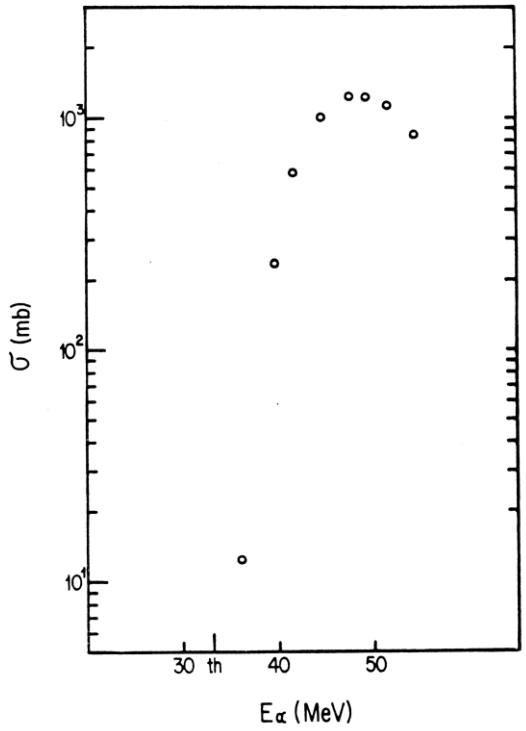


Rendimientos de Blancos Gruesos para la Producción de ^{87g}Y

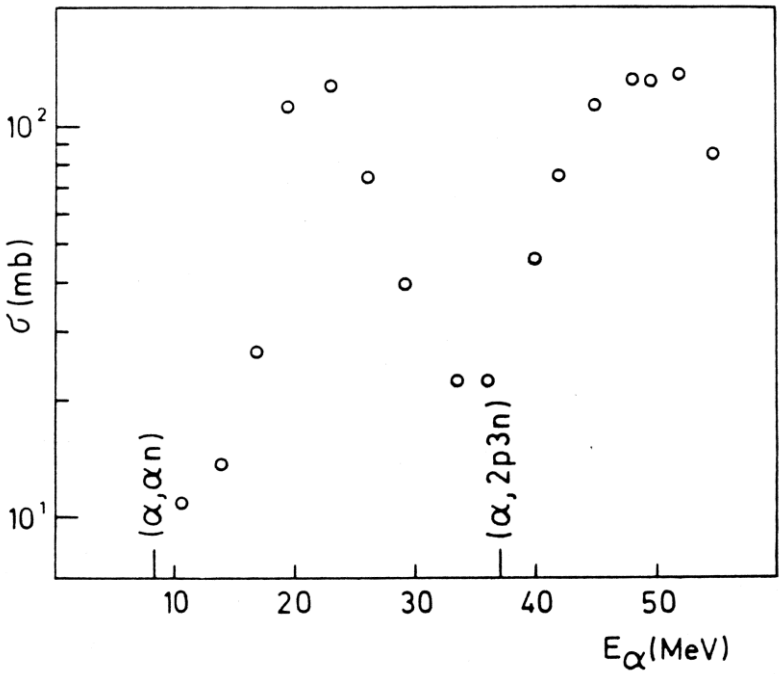
3. REACCIONES (α, 4n) PARA LA FORMACION DE ^{197}Tl y (α, αn) y (α, 2p3n) PARA LA FORMACION DE ^{196g}Au

De la irradiación de laminillas metálicas de Oro natural con partículas alfa se determinaron las secciones eficaces para la producción de los nucleídos indicados en el título. En el caso del ^{197}Tl, por tratarse de una sola reacción nuclear, los valores obtenidos significaron directamente las secciones eficaces absolutas. En cuanto al ^{196g}Au, hubo que recurrir al método que se decribe en Landolt and Börnstein (Numerical Data and Functional Relationship in Science and Technology, Vol. 5, 1974) y Svoboda (U. J. V. Report 2258, 1969) para separar las funciones de excitación de las reacciones (*α, α*n) y (α, 2p3n) respectivamente, teniendo en cuenta los umbra les de dichas reacciones. La metodología utilizada consistió fundamentalmente en determinación de la actividad del nucleído producto mediante espectrometría gama con un detector de Ge intrínseco de alta resolución y posterior procesamiento de datos con programas computacionales de nuestra biblioteca, Radioquímica -Comisión Nacional de Energía Atómica.

E_α (MeV)	σ (mb)	
	^{197}Au(α, 4n)^{197}Tl	^{197}Au(α, αn)^{196g}Au
54.47	849.27 ± 254.29	85.15 ± 21.18
51.82	1161.12 ± 347.67	133.73 ± 33.23
49.48	1233.89 ± 369.47	130.64 ± 33.32
47.41	1243.49 ± 372.36	133.61 ± 33.24
44.79	1012.25 ± 303.13	113.25 ± 28.11
41.84	583.98 ± 174.89	75.24 ± 18.67
39.86	237.89 ± 71.27	46.28 ± 11.46
36.21	126.58 ± 38.95	22.47 ± 6.02
33.48		22.70 ± 6.61
29.04		39.45 ± 10.43
26.10		74.42 ± 18.38
22.89		128.26 ± 31.87
19.43		112.47 ± 27.74
16.88		26.39 ± 14.90
13.75		13.87 ± 3.42
10.42		10.89 ± 2.85



Secciones Eficaces para la Reacción $^{197}Au(\alpha, 4n)^{197}Tl$

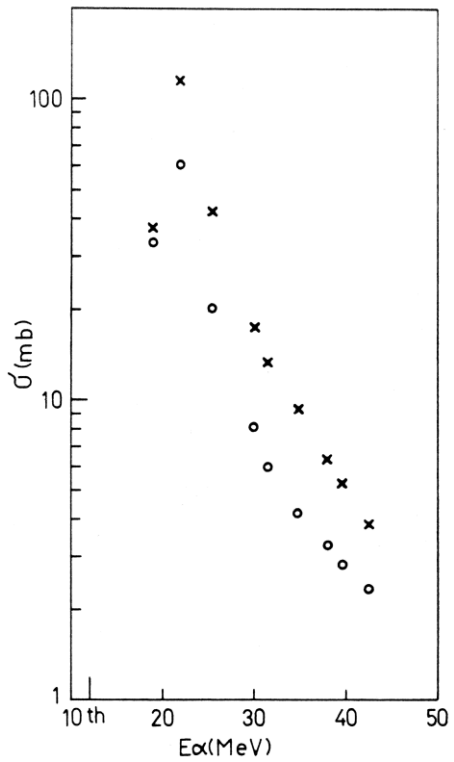


Secciones Eficaces para las Reacciones $^{197}Au(\alpha, \alpha n)^{196g}Au$ y $^{197}Au(\alpha, 2p3n)^{196g}Au$

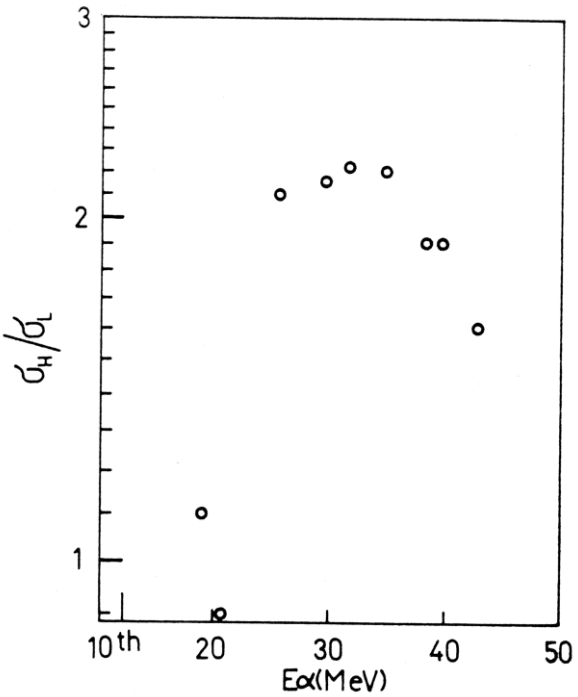
4. SECCIONES EFICACES Y RELACIONES ISOMERICAS PARA EL PAR $^{184m}/^{184g}$Re OBTENIDO EN LA REACCION ^{181}Ta(α, n)

Las experiencias se realizaron sometiendo los b1ancos de Tantalio en forma de hojue1as metálicas superpuestas a1 haz externo del Sincrocic1otrón de 1a Comisión Nacional de Energía Atómica Argentina. Las actividades abso1utas del ^{184m}Re y ^{184g}Re se obtuvieron a través de los rayos gama de 920 KeV y 792 KeV respectivamente. Se hizo 1a corrección de 1a actividad del ^{184g}Re proveniente de 1a transición isomérica a partir del ^{184m}Re.

E_α (MeV)	σ (mb)		σ_H/σ_L
	^{184g}Re	^{184g}Re	
18.81	33.24 ± 5.98	37.54 ± 7.13	1.13
20.69	55.71 ± 12.26	48.12 ± 10.11	0.86
25.47	20.00 ± 3.80	42.03 ± 7.15	2. 10
29.82	8.01 ± 1.76	17.12 ± 3.25	2.14
31.41	5.89 ± 1.01	13.11 ± 2.36	2.23
34.83	4.13 ± 0.66	9.27 ± 1.95	2.24
38.18	3.27 ± 0.72	6.31 ± 1.39	1.93
39.67	2.81 ± 0.56	5.30 ± 1.11	1.89
42.78	2.36 ± 0.45	3.87 ± 0.74	1.64



× Secciones Eficaces para la Reacción $^{181}Ta(\alpha, n)^{184m}Re$
○ Secciones Eficaces para la Reacción $^{181}Ta(\alpha, n)^{184g}Re$



$\sigma(^{184m}Re)/ \sigma(^{184g}Re)$

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