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DATA ACTIVITIES IN POLAND

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Compiled by
A. Marcinkowski

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Editor's Note

This progress Report on nuclear data research in Poland /May 1978 - April 1978/ contains only information on research, which is closely related to the activities of the International Data Committee of the International Atomic Energy Agency in the field of charged particles and neutron physics. It does not include any information about other nuclear research as for example the use of neutrons for solid state physics studies.

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Uwagi od wydawcy

Raport ten zawiera informacje o badaniach w zakresie fizyki jądrowej średnich energii przeprowadzonych w Polsce /maj 1977 - kwiecień 1978/ i związanych z działalnością Komitetu Danych Jądrowych Międzynarodowej Agencji Energii Atomowej.

Pominięto wyniki badań w innych dziedzinach fizyki jądrowej, w tym również badań w zakresie fizyki ciała stałego przy użyciu neutronów. Poszczególne prace zawierają wstępne omówienie wyników badań nie wyczerpujące poruszanych tematów i nie powinny być cytowane bez zgody autorów.

Замечания от редакции

Этот сборник содержит сообщения о проведенных в Польше в период от мая 1977 до апреля 1978 исследованиях в области физики средних энергий, связанных с деятельностью Комитета по Ядерным Данным Международного Агентства Атомной Энергии. Не включены результаты исследований с области применения нейtronов в физике твердого тела. Доклады не являются полными и не рекомендуется ссылаться на них без согласия авторов.

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ANGULAR DISTRIBUTIONS OF ALPHA PARTICLES
FROM $^{14}\text{N}(\text{n},\alpha)^{11}\text{B}$ REACTION AT 12.2 MeV

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Angular distribution of the alpha particles emitted in the $^{14}\text{N}(\text{n},\alpha)^{11}\text{B}$ reaction was measured by registration of alphas with a telescopic system [1]. 12.2 MeV neutrons from $^3\text{H}(\text{d},\text{n})^4\text{He}$ reaction were obtained using the 2 MeV deuteron beam from Van de Graaff accelerator. The thickness of the melamine ($\text{C}_3\text{H}_6\text{N}_6$) target amounted to 1.1 mg/cm^2 . The three-dimensional analysis of each event recorded in the telescope was performed with Nuclear Data 4420 multiparameter system. In the alpha particle spectra the groups corresponding to the ground (α_0) and the first (α_1) excited states of the ^{11}B nucleus could be distinguished. Fig.1 and Fig.2 present the angular distributions of these alpha particles. The numerical data are presented in Table I and Table II. The data are given in the c.m. system. The angular spreads were calculated with a Monte Carlo method [2]. The indicated errors are statistical only.

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2. L.Zemło, Inst. of Nucl. Research, Report 1464/I/PL/B.

TABLE I

 $E_n = 12.2 \text{ MeV}$ $^{14}\text{N}(n, \alpha) ^{11}\text{B}$

ϑ [deg]	$\Delta\vartheta$ [deg]	$d\sigma/d\Omega$ [mb/sr]	$\Delta(d\sigma/d\Omega)$ [mb/sr]
8.3	5.0	0.85	0.16
24.5	5.0	1.50	0.30
36.0	4.5	1.50	0.20
46.6	4.0	1.50	0.30
68.4	3.5	0.90	0.30
78.8	3.5	1.10	0.50
89.4	3.0	1.30	0.30
109.3	3.0	1.90	0.30
118.8	3.0	1.00	0.30
128.1	2.5	1.60	0.96
146.0	2.5	0.80	1.30

TABLE II

 $E_n = 12.2 \text{ MeV}$ $^{14}\text{N}(n, \alpha_4) ^{11}\text{B}$

ϑ [deg]	$\Delta\vartheta$ [deg]	$d\sigma/d\Omega$ [mb/sr]	$\Delta(d\sigma/d\Omega)$ [mb/sr]
9.0	5.0	1.60	0.20
24.7	5.0	1.40	0.30
36.0	4.5	1.00	0.15
47.2	4.5	0.60	0.23
69.3	3.7	0.34	0.17
79.8	3.7	0.40	0.30
90.4	3.3	0.57	0.19
110.3	3.0	0.00	1.70
120.0	3.0	0.60	1.30
128.0	2.5	0.00	2.20
146.7	2.5	4.50	2.30

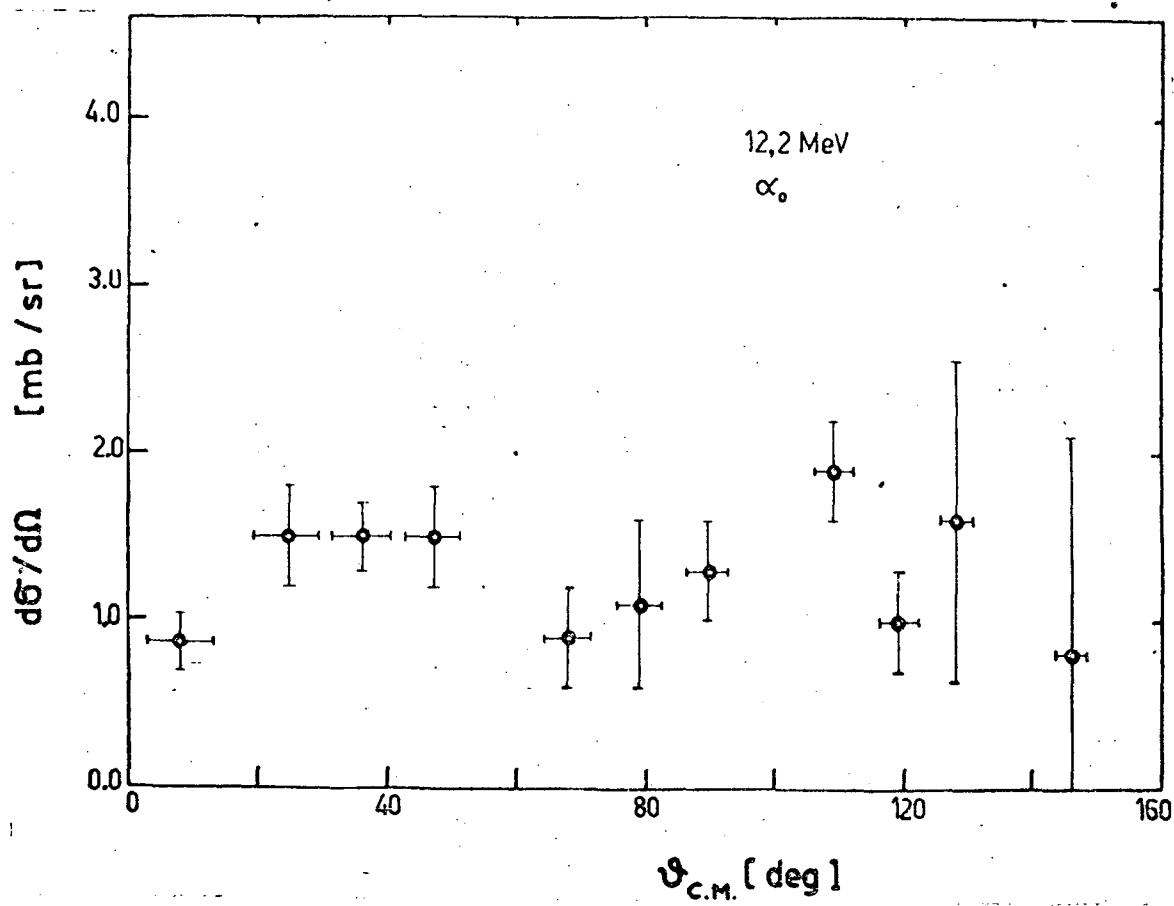


Fig. 1. The angular distribution of alpha particles leading to the ground state of ^{11}B

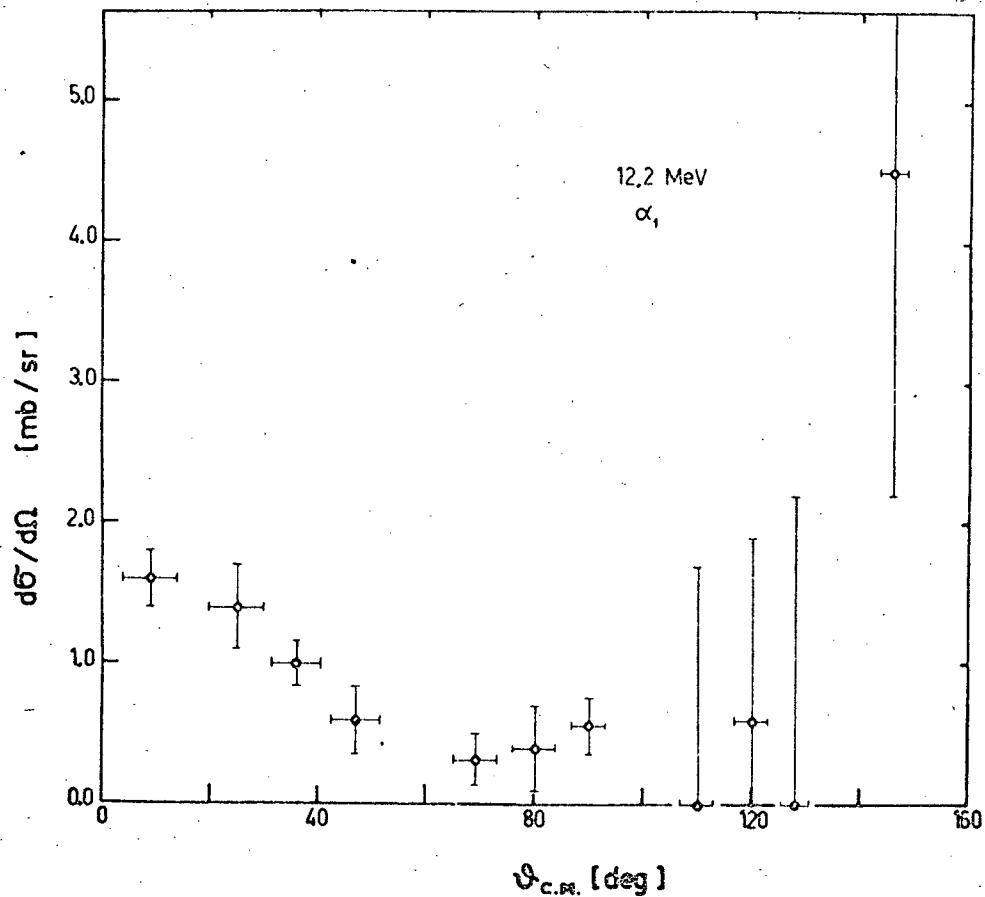


Fig. 2. The angular distribution of alpha particles leading to the first excited state of ^{11}B

ANGULAR DISTRIBUTIONS OF ALPHA PARTICLES FROM THE
 $^{143}\text{Nd}(\text{n},\alpha)^{140}\text{Ce}$ REACTION INDUCED BY 14.1 AND 18.2 MeV
 NEUTRONS

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Angular distributions of α -particles emitted in the $^{143}\text{Nd}(\text{n},\alpha)^{140}\text{Ce}$ reaction at $E_n = 14.1$ and 18.2 MeV were measured by direct registration of α -particles. The experimental arrangement used in the measurements was described in our earlier work [1]. The neutrons were obtained from the $^3\text{H}(\text{d},\text{n})^4\text{He}$ reaction with deuterons accelerated up to 2 MeV in the Van de Graaff accelerator "LECH". The neutron energy was selected by a suitable choice of the emission angle. The neutron energy spreads due to the deuteron energy loss in the ^3H -Ti target and geometrical conditions were 120 and 140 keV for 14.1 and 18.2 MeV neutrons, respectively. The neutron flux was measured by counting the recoil protons from a thin polyethylene foil. The recoil protons were registered in a thin CsI(Tl) scintillator followed by photomultiplier and standard electronics. The absolute calibration of the neutron monitor was performed by measuring the 847 keV γ -transition in ^{56}Fe produced in $^{56}\text{Fe}(\text{n},\text{p})^{56}\text{Mn}$ reaction with successive β^- -decay of ^{56}Mn . The cross sections for the $^{56}\text{Fe}(\text{n},\text{p})^{56}\text{Mn}$ reaction were taken as 110 mb and 57 mb for neutron energies 14.1 and 18.2 MeV respectively [2]. Uncertainty of the monitor calibration amounts to about 15%.

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The investigated targets were made of neodymium oxide enriched in ^{143}Nd to about 88.4 %. The Nd_2O_3 layers of about 2.5 mg/cm^2 ($E_n = 14.1 \text{ MeV}$) and 3.3 mg/cm^2 ($E_n = 18.2 \text{ MeV}$) were deposited onto thick carbon backings by means of sedimentation from suspensions in isopropyl alcohol.

The energy calibration of the alpha spectrometer was performed with employment of alphas from ThC and ThC' and from the reaction $^{28}\text{Si}(n,\alpha)^{25}\text{Mg}$ produced in the silicon detector by the incident neutrons.

The angular distributions of α -particles emitted in the $^{143}\text{Nd}(n,\alpha)^{140}\text{Ce}$ reaction at 14.1 and 18.2 MeV neutrons are presented in tables 1 and 2. These distributions contain all α -particles with energies corresponding the excitation of the final nucleus up to 5.5 MeV. In the bottom of the tables the angular spreads of the measurements are also shown. These spreads were calculated by Monte-Carlo method [3]. The errors indicated in the tables are only statistical.

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1. M.Jaskóla, J.Turkiewicz, L.Zemło, W.Osakiewicz, Acta Phys. Pol., B2 /1971/ 521,
2. D.C.Santry, J.Butler, Can. J. Phys., 42 /1964/ 1030,
3. L.Zemło, INR Report, 1464/I/PL/B /1973/.

TABLE I

Angular distribution of α -particles for $^{143}\text{Nd}(n, \alpha) ^{140}\text{Ce}$

reaction at $E_n = 14.1 \text{ MeV}$

$\vartheta [\text{deg}]$	$d\sigma/d\Omega$ [mb/sr]
26	0.90 ± 0.05
46	0.56 ± 0.06
63	0.34 ± 0.04
90	0.03 ± 0.04
117	0.05 ± 0.05
135	0.00 ± 0.06
156	0.05 ± 0.08

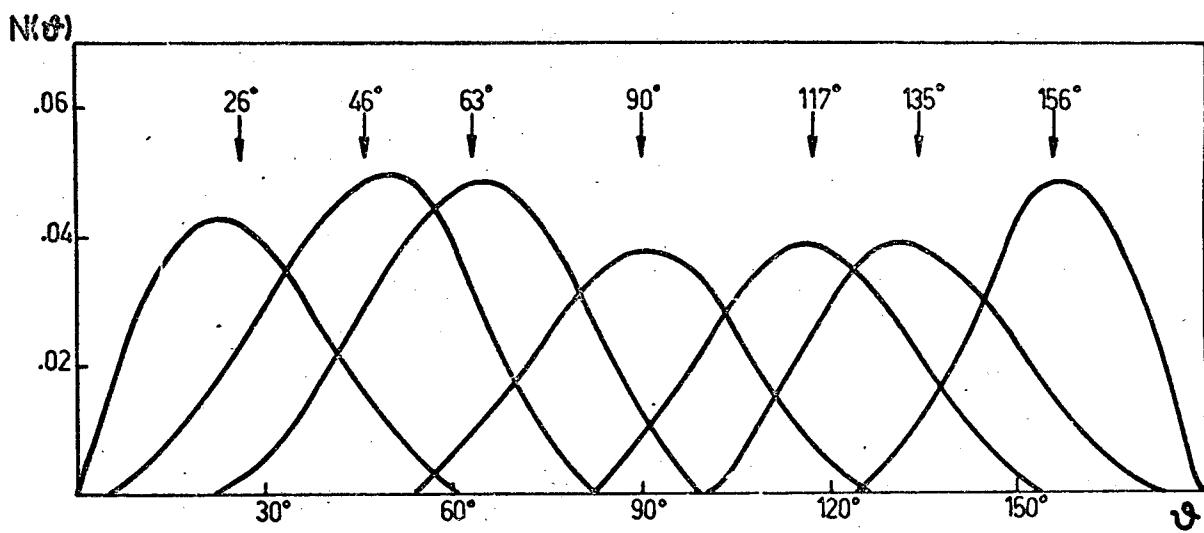
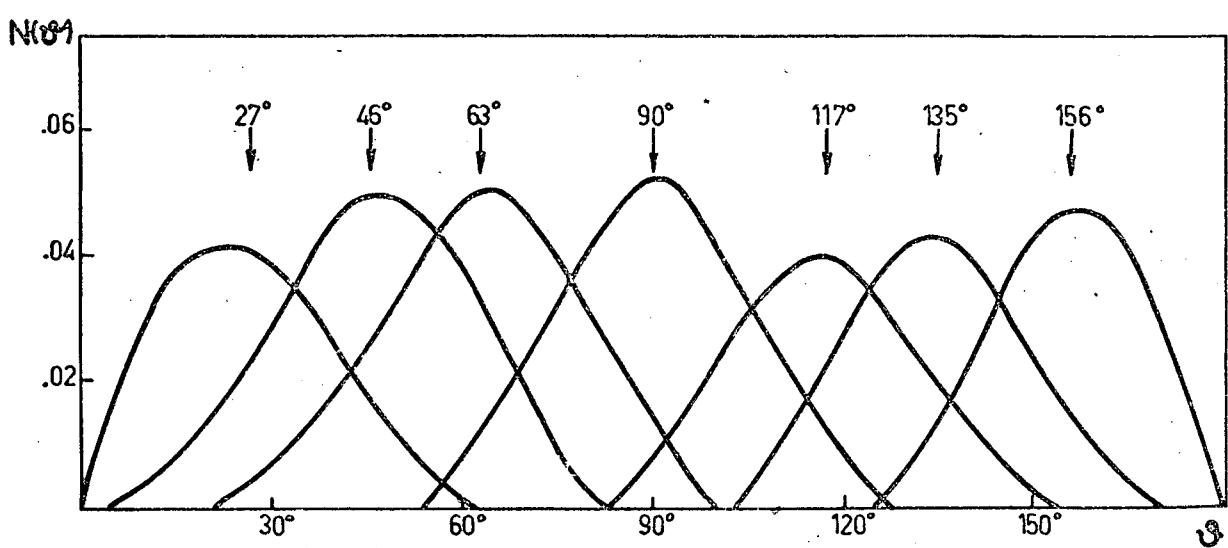


TABLE II

Angular distribution of α -particles for $^{143}\text{Nd}(n,\alpha)^{140}\text{Ce}$
reaction at $E_n = 18.2 \text{ MeV}$

ϑ [deg]	$d\sigma/d\Omega$ [mb/sr]
27	1.42 ± 0.04
46	0.55 ± 0.06
63	0.47 ± 0.06
90	0.00 ± 0.06
117	0.00 ± 0.07
135	0.04 ± 0.08
156	0.10 ± 0.06



DIFFERENTIAL CROSS SECTIONS FOR THE (n,α) REACTIONS
 INDUCED BY FAST NEUTRONS IN ^{149}Sm and ^{143}Nd NUCLEI

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Using semiconductor α -particles spectrometer [1] the energy distribution of α -particles from the $^{149}\text{Sm}(n,\alpha)^{146}\text{Nd}$ and the $^{143}\text{Nd}(n,\alpha)^{140}\text{Ce}$ reactions at $E_n = 12.27 \pm 0.05 \text{ MeV}$ and $E_n = 14.05 \pm 0.06 \text{ MeV}$, respectively, have been measured. The neutrons were obtained in the Van de Graaff accelerator LECH from the $^3\text{H}(d,n)^4\text{He}$ reaction. The neutron flux was monitored by counting the recoil protons from thin polyethylene foil. The absolute calibration of neutron monitor was performed by using the activation method. The measurements were referred to $^{56}\text{Fe}(n,p)^{56}\text{Mn}$ reaction, the cross section for which was accepted as 110 mb for both neutron energies [2]. Uncertainty of the monitor calibration amounts to about 15%. The samples of samarium and neodymium were made of oxides (Sm_2O_3 and Nd_2O_3) isotopically enriched in ^{149}Sm (96.9%) and ^{143}Nd (88.4%) with target thicknesses equal to 2 mg/cm^2 and 3 mg/cm^2 , respectively.

The results of the absolute differential cross sections are listed in tables 1, 2 and also presented in Fig. 1 and Fig. 3. Only statistical errors are included. As it can be seen from Fig. 1 the characteristic feature of the α -particle spectrum is the presence of two peaks corresponding to the ground state and excited states of the residual nucleus ^{140}Ce .

In Fig. 2 and 4 the energy distribution of neutrons, the angular spread and the energy spread of measurements are shown. These spreads were calculated by Monte Carlo method [3].

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Acta Phys. Pol., B2 /1971/ 521,
2. D.C.Santry, J.Butler, Can. J. Phys., 42 /1964/ 1030,
3. L.Zemło, INR Report 1464/I/PL/B/ /1973/.

TABLE I

Differential cross sections for the $^{149}\text{Sm}(\text{n},\alpha)^{146}\text{Nd}$ reaction
at $E_n = 12.27 \text{ MeV}$

E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr}\cdot\text{MeV}$]	E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr}\cdot\text{MeV}$]	E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr}\cdot\text{MeV}$]
15.00	-15.7 ± 67.7	I 17.40	118.7 ± 37.9	I 19.80	68.7 ± 17.7
15.10	-14.1 ± 67.2	I 17.50	92.9 ± 38.4	I 19.90	58.1 ± 14.1
15.20	7.1 ± 67.7	I 17.60	157.1 ± 38.9	I 20.00	63.6 ± 15.2
15.30	-17.7 ± 66.7	I 17.70	189.9 ± 35.4	I 20.10	60.6 ± 15.2
15.40	39.4 ± 60.6	I 17.80	137.4 ± 31.8	I 20.20	62.1 ± 17.2
15.50	82.3 ± 60.6	I 17.90	92.9 ± 35.9	I 20.30	60.6 ± 16.7
15.60	94.4 ± 57.6	I 18.00	146.5 ± 33.8	I 20.40	28.3 ± 10.6
15.70	74.2 ± 57.1	I 18.10	117.7 ± 31.8	I 20.50	19.2 ± 12.6
15.80	193.9 ± 50.5	I 18.20	103.0 ± 25.8	I 20.60	32.3 ± 12.1
15.90	105.5 ± 49.0	I 18.30	81.8 ± 29.8	I 20.70	28.8 ± 14.6
16.00	125.2 ± 52.0	I 18.40	83.8 ± 25.8	I 20.80	19.2 ± 9.1
16.10	80.3 ± 51.0	I 18.50	53.0 ± 23.2	I 20.90	21.7 ± 12.6
16.20	129.8 ± 48.0	I 18.60	84.3 ± 26.3	I 21.00	43.4 ± 13.1
16.30	59.6 ± 50.5	I 18.70	59.1 ± 21.7	I 21.10	26.3 ± 9.6
16.40	72.7 ± 46.0	I 18.80	86.4 ± 21.2	I 21.20	51.0 ± 17.7
16.50	150.0 ± 42.9	I 18.90	87.4 ± 24.2	I 21.30	52.5 ± 13.6
16.60	169.7 ± 42.4	I 19.00	116.7 ± 26.3	I 21.40	29.3 ± 10.6
16.70	119.7 ± 38.9	I 19.10	108.1 ± 23.2	I 21.50	25.3 ± 10.1
16.80	150.5 ± 44.9	I 19.20	162.6 ± 29.3	I 21.60	38.9 ± 13.6
16.90	155.0 ± 39.4	I 19.30	106.6 ± 21.2	I 21.70	16.2 ± 6.1
17.00	222.2 ± 41.9	I 19.40	114.1 ± 22.7	I 21.80	15.2 ± 7.6
17.10	182.8 ± 42.4	I 19.50	116.7 ± 22.2	I 21.90	11.6 ± 7.6
17.20	194.4 ± 37.9	I 19.60	101.5 ± 21.7	I 22.00	6.6 ± 6.6
17.30	108.6 ± 36.4	I 19.70	118.7 ± 21.7	I	I

Cross section integrated in the 15.00 - 22.00 MeV range is
equal $0.59 \pm 0.03 \text{ mb/sr}$.

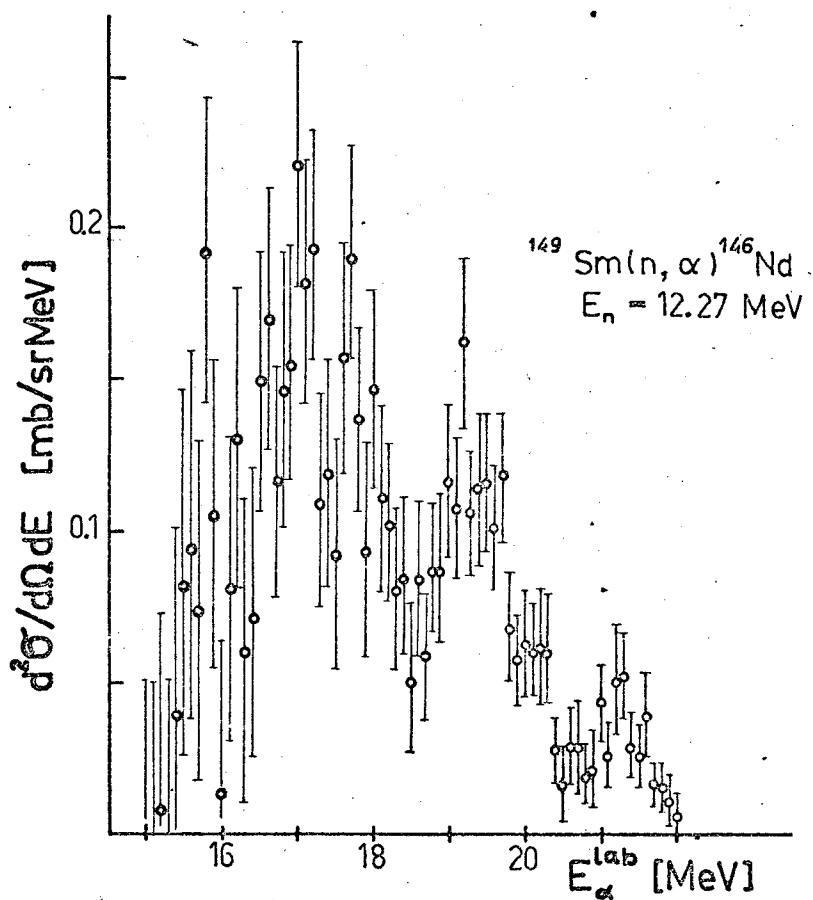


Fig. 1. Energy spectrum of α -particles from the $^{149}\text{Sm}(n, \alpha)^{146}\text{Nd}$ reaction at $E_n = 12.27 \text{ MeV}$

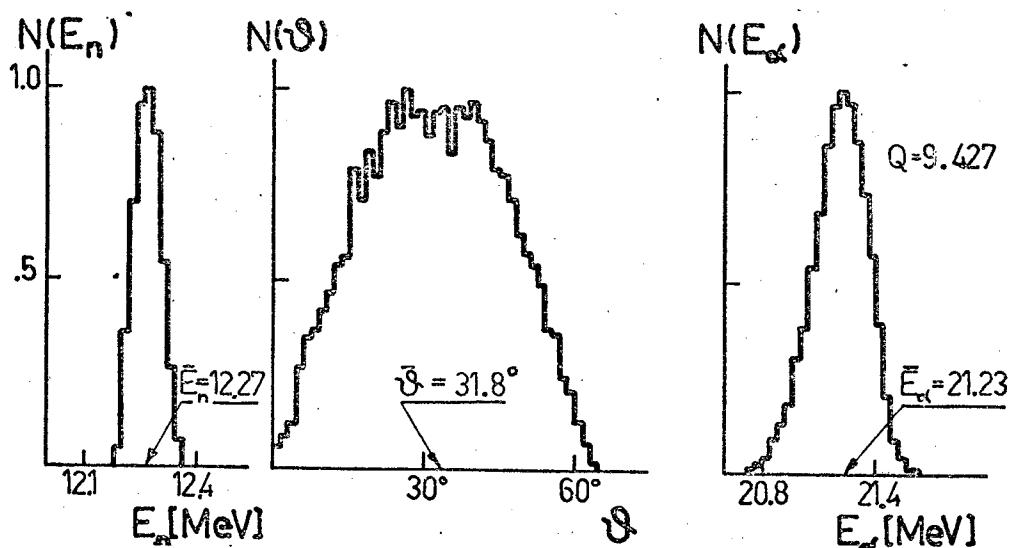


Fig. 2. The experimental energy distribution of neutrons as well as energy and angular spreads of α -particles

TABLE II

Differential cross sections for the $^{143}\text{Nd}(\text{n},\alpha)^{140}\text{Ce}$ reaction
at $E_n = 14.05 \text{ MeV}$

E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr.Mev}$]	E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr.Mev}$]	E_α^{lab} [MeV]	$\frac{d^2\sigma}{d\Omega dE}$ [$\mu\text{b}/\text{sr.Mev}$]
16.00	-116.7 ± 129.9	18.70	294.4 ± 73.1	21.40	20.3 ± 30.5
16.10	238.6 ± 129.9	18.80	271.1 ± 77.2	21.50	85.3 ± 29.4
16.20	173.5 ± 127.9	18.90	284.3 ± 73.1	21.60	25.4 ± 29.4
16.30	113.7 ± 129.9	19.00	399.0 ± 73.1	21.70	52.8 ± 21.3
16.40	132.0 ± 125.9	19.10	419.3 ± 70.0	21.80	50.8 ± 26.4
16.50	218.3 ± 119.8	19.20	327.9 ± 69.0	21.90	50.8 ± 29.4
16.60	174.5 ± 110.7	19.30	392.9 ± 67.0	22.00	-3.0 ± 24.4
16.70	211.2 ± 108.6	19.40	375.6 ± 60.9	22.10	50.8 ± 25.4
16.80	94.4 ± 103.5	19.50	390.9 ± 52.9	22.20	19.3 ± 18.3
16.90	140.1 ± 104.6	19.60	241.5 ± 58.9	22.30	41.6 ± 20.3
17.00	127.9 ± 108.6	19.70	256.8 ± 55.0	22.40	38.6 ± 19.3
17.10	112.7 ± 94.4	19.80	411.2 ± 71.1	22.50	20.3 ± 15.2
17.20	234.5 ± 95.4	19.90	447.7 ± 64.0	22.60	25.4 ± 17.3
17.30	257.9 ± 96.4	20.00	428.4 ± 62.9	22.70	74.1 ± 25.4
17.40	108.6 ± 95.4	20.10	321.8 ± 55.8	22.80	56.9 ± 20.3
17.50	148.2 ± 91.4	20.20	251.3 ± 53.8	22.90	28.4 ± 20.3
17.60	47.7 ± 95.4	20.30	165.5 ± 47.7	23.00	45.7 ± 20.3
17.70	159.4 ± 84.3	20.40	251.8 ± 51.8	23.10	74.1 ± 22.3
17.80	175.6 ± 83.2	20.50	149.2 ± 43.7	23.20	48.7 ± 20.3
17.90	185.8 ± 80.2	20.60	51.8 ± 27.4	23.30	86.3 ± 26.4
18.00	141.1 ± 81.2	20.70	58.9 ± 35.5	23.40	107.6 ± 28.4
18.10	161.4 ± 73.1	20.80	80.2 ± 32.5	23.50	106.6 ± 27.4
18.20	267.0 ± 74.1	20.90	69.0 ± 36.5	23.60	89.3 ± 22.3
18.30	277.1 ± 78.2	21.00	70.0 ± 32.5	23.70	94.4 ± 25.4
18.40	206.1 ± 79.2	21.10	35.5 ± 30.5	23.80	40.6 ± 17.3
18.50	234.5 ± 75.1	21.20	0.0 ± 30.5	23.90	10.2 ± 14.2
18.60	140.1 ± 68.0	21.30	56.9 ± 24.4	24.00	20.3 ± 11.2

Cross section integrated in the 16.00 - 24.00 MeV range is
equal $1.22 \pm 0.06 \text{ mb/sr}$

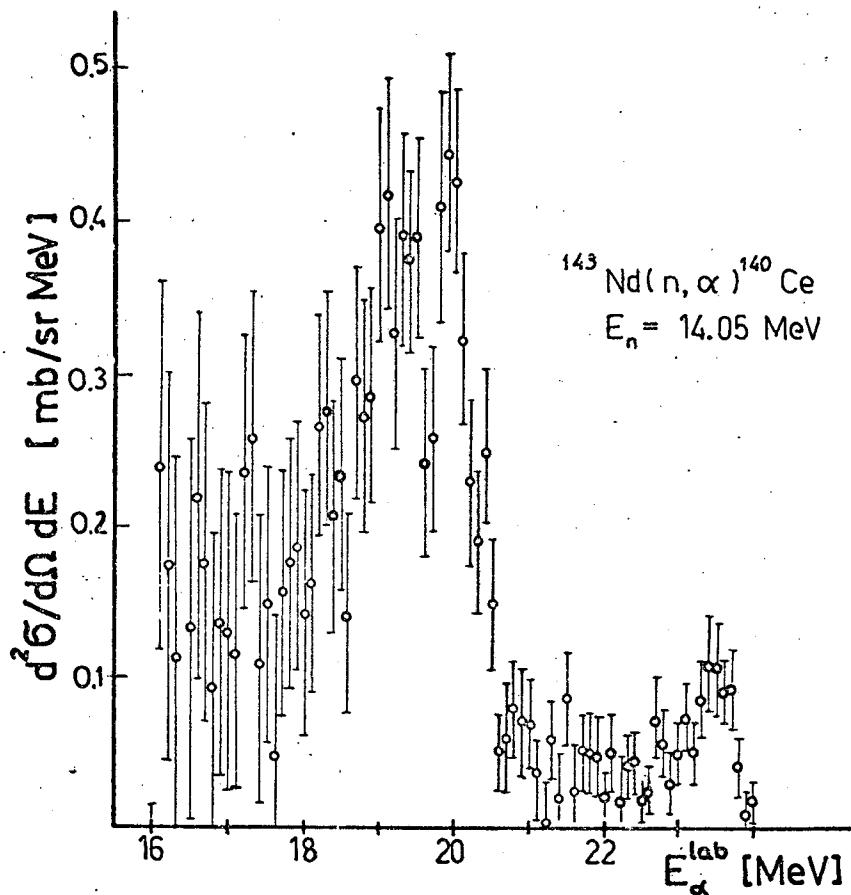


Fig. 3. Energy spectrum of α -particles from the $^{143}\text{Nd}(n, \alpha)^{140}\text{Ce}$ reaction at 14.05 MeV

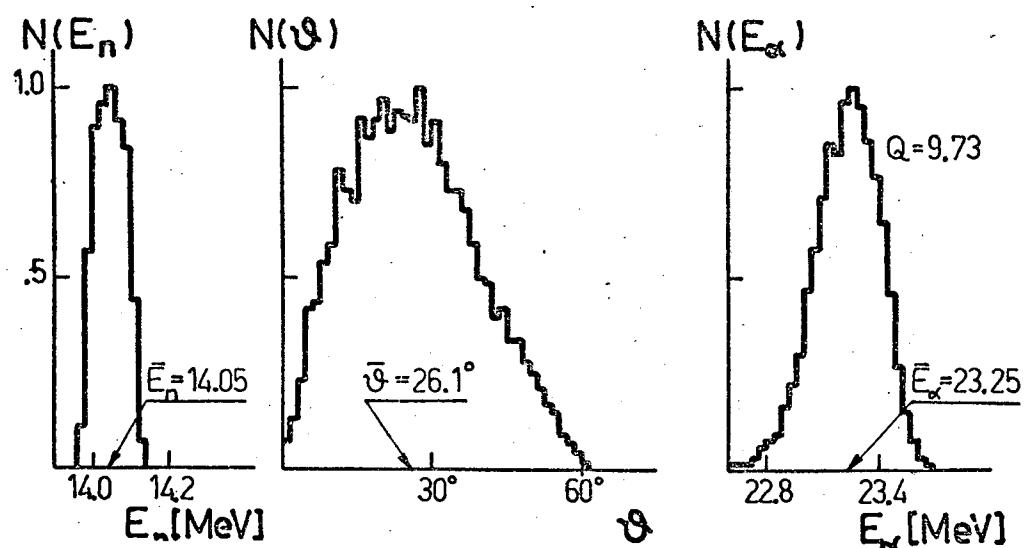


Fig. 4. The experimental energy distribution of neutrons as well as energy and angular spreads of α -particles

CROSS-SECTION MEASUREMENTS
OF THE (n,α) REACTION AT $E_n = 14.6$ MeV

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Cross sections for the (n,α) reaction, induced by 14.6 MeV neutrons on ^{27}Al , ^{30}Si , ^{31}P , ^{51}V , ^{55}Mn , ^{59}Co and ^{75}As target nuclei have been measured. The neutrons were obtained from the $^3\text{H}(d,n)^4\text{He}$ reaction on the electrostatic cascade accelerator. The neutron flux was $5 \cdot 10^9$ neutrons/s. Samples of pure elements, both natural and enriched were used. The neutron flux was determined by using the $^{56}\text{Fe}(n,p)^{56}\text{Mn}$ reaction as the reference. We accepted the cross-section for this reaction as 105 ± 4 mb [1]. The cross-sections measured are listed in table 1.

TABLE I

Isotope	Cross-section (mb)
^{27}Al	141 ± 8
^{30}Si	108 ± 25
^{31}P	104 ± 12
^{51}V	20 ± 3
^{55}Mn	27 ± 4
^{59}Co	35 ± 3
^{75}As	12 ± 2

The errors given in Table 1 include statistical errors and the error of the cross-section of the reference reaction.

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1. M.D.Goldberg et al. BNL 325, 1966.

CROSS-SECTIONS FOR FAST NEUTRON
CAPTURE ON Pd, Cd and Ir

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Activation cross sections for the (n,γ) reaction were measured at four neutron energies 0.53 MeV, 0.86 MeV, 1.20 MeV and 1.31 MeV, on ^{108}Pd , ^{110}Pd , ^{114}Cd , ^{116}Cd and ^{193}Ir . Samples of high purity natural material have been irradiated with neutrons from the $^3\text{H}(p,n)^3\text{He}$ reaction. Tritium absorbed targets were bombarded with protons accelerated to 2.2 MeV energy. The neutron energies were selected by a suitable choice of the emission angle. The product nuclei were identified by their characteristic γ -decay. The γ -activity induced by neutron irradiation was then measured with a 60 cm³ Ge(Li) spectrometer, the relative detection efficiency of which has been determined with help of ^{75}Se , ^{113}Ba and ^{226}Ra sources. The details of the decay characteristics of the investigated residual nuclei, adopted in the present data analysis were taken from refs. [1, 2]. The measured cross sections were referred simultaneously to the capture cross section of ^{115}In , ref. 3. and to the cross sections of the $^{115}\text{In}(n,n')$ ^{115m}In reaction evaluated for the purpose of the present experiment / see the following report/.

The results of cross section measurements are presented in table 1. These cross sections have been corrected for the attenuation of the γ -rays in the samples. The errors attached contain the

TABLE I

Neutron Capture Cross Sections -mb

Reactions	Neutron Energy - MeV			
	0.53 ± 0.14	0.86 ± 0.21	1.20 ± 0.15	1.31 ± 0.70
$^{108}\text{Pd}(n,\gamma)^{109m}\text{Pd}$	5.7 ± 0.7	4.8 ± 0.6	4.3 ± 0.5	4.4 ± 0.5
$^{108}\text{Pd}(n,\gamma)^{109g}\text{Pd}$	103 ± 12	78.5 ± 9.2	69.0 ± 7.6	50.0 ± 5.7
$^{110}\text{Pd}(n,\gamma)^{111m}\text{Pd}$	6.1 ± 0.8	5.2 ± 0.7	4.1 ± 0.5	3.6 ± 0.4
$^{114}\text{Cd}(n,\gamma)^{115}\text{Cd}$	46.2 ± 5.7	30.0 ± 3.7	27.5 ± 3.3	25.7 ± 3.2
$^{116}\text{Cd}(n,\gamma)^{117m}\text{Cd}$	23.9 ± 2.9	15.8 ± 2.3	16.9 ± 2.2	15.6 ± 2.0
$^{116}\text{Cd}(n,\gamma)^{117g}\text{Cd}$	17.0 ± 2.3	12.0 ± 1.7	10.3 ± 1.4	8.3 ± 1.1
$^{193}\text{Ir}(n,\gamma)^{194}\text{Ir}$	138 ± 16	117 ± 15	73 ± 12	61 ± 6

statistical errors as well as the systematic ones. The latter are dominated by the uncertainties of cross sections of the reference reactions, which have been estimated to amount to 10%. The neutron energy spread was determined from the energy distribution of neutrons incident on the samples, calculated with a Monte Carlo method.

The use of two reference reactions, having excitation curves of opposite slope has allowed us to neglect effects of low energy background neutrons.

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EVALUATION OF THE $^{115}\text{In}(n,n')$ ^{115m}In REACTION CROSS SECTIONS
IN THE ENERGY RANGE FROM THRESHOLD TO 1.5 MeV

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The $^{115}\text{In}(n,n')$ ^{115m}In reaction leading to the 4.3 h isomer is widely used for neutron flux monitoring in reactor dosimetry. A large body of consistent experimental cross sections exists for this reaction in the neutrally energy range up to 20 MeV [1-8]. We have found it to be a usefull reference reaction for neutron capture activation cross section measurement in the 1 - 3 MeV region. Due to the (n,n') reaction threshold the activity of the ^{115}In isomer is insensitive to low-energy background neutrons, which, if present, will affect the investigated capture cross sections. However the yield of the $^{115}\text{In}(n,n')$ ^{115m}In reaction, when compared with the activity of the 54 min isomer in ^{116}In , induced via the $^{115}\text{In}(n,\gamma)$ ^{116m}In reaction in the same irradiation, allows one to estimate the influence of the background neutrons.

We have found that the cross sections of the $^{115}\text{In}(n,n')$ ^{115m}In reaction, measured with reference to the known excitation curve of the $^{115}\text{In}(n,\gamma)$ ^{116m}In reaction, fit well the data obtained in different experiments (see Fig. 1), thus indicating negligible background neutron effects. The measurement has been performed at four neutron energies listed in table 1. The neutrons were obtained from a tritium absorbed in titanium target bombarded with protons of 2.2 MeV energy. The γ -activities of the ^{115}In and ^{116}In isomers

were followed with a Ge(Li) spectrometer. The decay data adopted in the analysis of the activities were taken from refs.[9, 10].

The cross sections presented in table I are averages of three experimental runs and the errors quoted contain statistical errors as well as the systematic ones.

TABLE I

$E_n \pm \Delta E$ MeV	$\sigma \pm \Delta \sigma$ mb
1.31 ± 0.07	135 ± 15
1.21 ± 0.15	94 ± 10
0.86 ± 0.21	37 ± 4
0.57 ± 0.14	7.3 ± 0.9

The results of our measurements from table 1 are compared with previously measured cross sections in Fig.1, showing good agreement between different data sets. There exists only slight discrepancy of the order of 20% between the early high energy resolution measurements of Ebel et al. [1] and the rest of data, in the neutron energy range from 1.0 MeV to 1.2 MeV. Our "guide by eye" line, considered as the recommended excitation curve follows the newer cross section data sets [2, 3, 7, 8] in this energy region.

The method of referring the measured capture cross sections to two monitoring reactions, having excitation curves of opposite slopes has been applied in neutron activation measurements on Pd, Cd and Os isotopes.

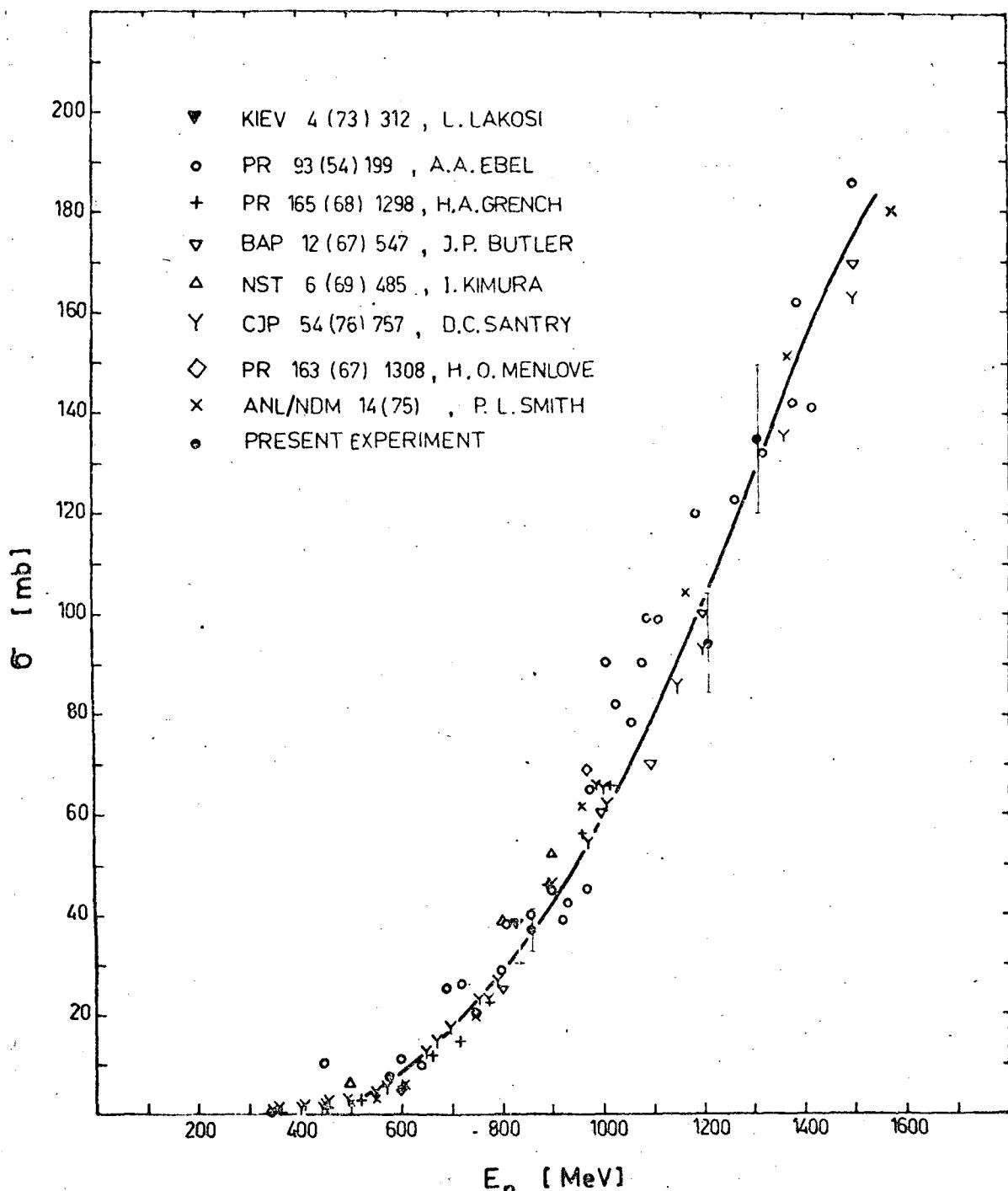


Fig. 1. Compilation of the $^{115}\text{In}(n,n)^{115m}\text{In}$ reaction cross sections. The solid line is the recommended excitation curve /guide by eye/.

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GAMMA-GAMMA COINCIDENCE MEASUREMENTS
IN THE ^{130}Ba NUCLEUS

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The level structure of ^{130}Ba has been studied from the decay of ^{130}La by observing gamma rays and gamma - gamma coincidences. The ^{130}La isotope was produced in the $^{130}\text{Ba}(\text{p},\text{n})^{130}\text{La}$ reaction with 10 MeV proton beam from the linear accelerator of the Institute of Nuclear Research at Swierk.

The results of these measurements are consistent with the previously reported decay schemes [1, 2] which were constructed on the basis of energy sums and differences only. The coincidence measurements allowed us to establish a few new high excited energy levels in ^{130}Ba as well.

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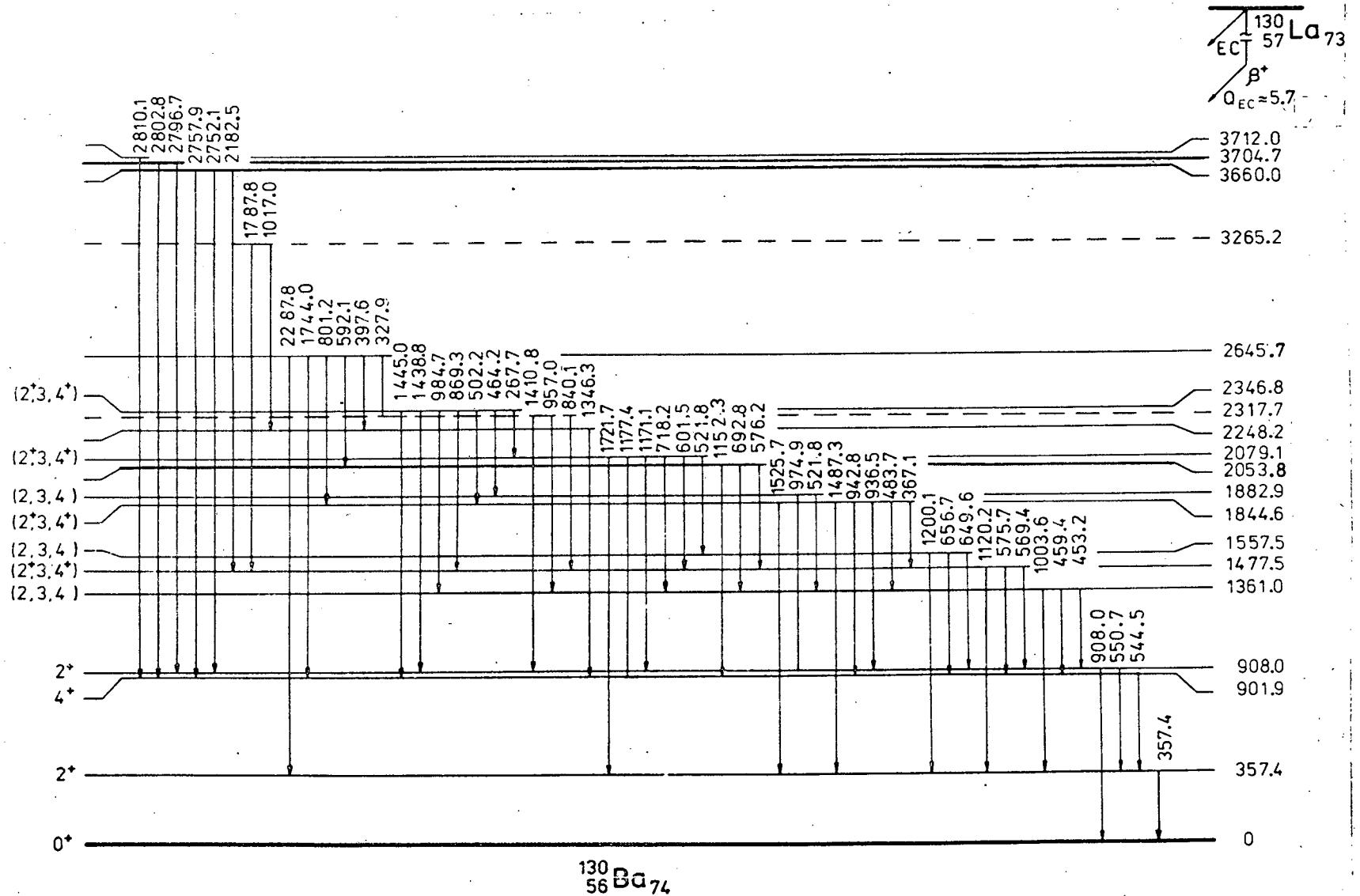


Fig. 1. Decay scheme of ^{130}Ba

LEVELS OF ^{126}Cs EXCITED BY THE DECAY OF ^{126}Ba

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Radioactive sources of ^{126}Ba obtained in spallation reaction have been studied with Ge(Li), Si(Li) and NaI(Tl) detectors. The experiments were performed using chemically and isotopically separated samples. Conversion electron spectra have been measured using Si(Li) detector. The electrons were separated from the positrons and γ -rays by means of a homogeneous magnetic field. The assignment of γ -rays to the daughter activity of ^{126}Cs has been done by measuring γ -ray spectra gated by known γ -rays of ^{126}Cs . On the basis of γ -ray energies, γ -ray multipolarities, intensities, energy sums, $\gamma - \gamma$ and KX-ray - γ coincidence informations, the decay scheme has been proposed for ^{126}Ba .

TABLE I

Gamma-rays observed in the decay of ^{126}Ba . Intensities of the γ lines are normalized to the intensity of the most intense 388.5 keV transition of ^{126}Cs

E_γ (keV)	I_γ	E_γ keV	I_γ
KX-ray	200(30)		
47.5 (1)	0.15 (5)	328.2 (1)	4.5 (4)
54.5 (1)	0.32 (4)	348.3 (1)	1.8 (1)
70.4 (1)	0.23 (5)	353.0 (2)	1.3 (2)
72.6 (1)	0.37 (7)	361.7 (2)	1.0 (2)
73.6 (1)	0.35 (6)	392.2 (2)	1.6 (4)
74.7 (2)	0.87 (11)	400.4 (1)	2.5 (4)
76.8 (3)	0.10 (3)	c 415.0	1.0 } (1.4 (3)
86.3 (2)	0.29 (6)	c 415.7	0.4 }
87.0 (2)	0.14 (4)	474.6 (2)	0.9 (1)
90.2 (3)	0.16 (11)	489.1 (4)	8.2 (1.2)
93.2 (3)	0.54 (8)	525.7 (2)	0.6 (1)
102.9 (2)	0.43 (6)	535.6 (2)	0.6 (1)
106.7 (2)	1.2 (1)	538.7 (2)	3.9 (3)
126.3 (2)	1.3 (2)	542.3 (2)	1.7 (2)
129.4 (1)	2.6 (3)	c 548.2	0.6 }
149.9 (2)	0.9 (2)	c 549.0	0.7 } 1.3 (2)
200.6 (2)	1.6 (3)	551.5	1.5 (2)
203.1 (2)	0.7 (2)	c 559.0	0.2 }
208.0 (1)	1.5 (2)	c 560.4	0.6 } 0.8 (1)
213.8 (2)	0.4 (2)	578.6 (2)	0.5 (1)
217.7 (1)	9.4 (7)	583.2 (2)	0.7 (1)
231.8 (2)	2.0 (3)	589.4 (6)	0.2 (1)
233.4 (1)	46.4 (2.8)	596.5 (3)	0.5 (1)
239.2 (2)	2.2 (2)	602.3 (2)	0.5 (1)
240.7 (1)	14.4 (1.0)	610.9 (2)	1.2 (2)
257.3 (1)	18.7 (1.2)	640.2 (2)	1.1 (2)

TABLE I /continued/

281.0 (1)	7.6 (6)	642.8 (3)	0.7 (2)
284.8 (2)	1.2 (2)	667.9 (1)	0.7 (1)
290.5 (2)	1.8 (2)	681.5 (1)	10.5 (7)
308.9 (4)	0.4 (2)	685.6 (1)	1.1 (2)
321.0 (5)	\approx 0.2	691.7 (1)	2.2 (3)
698.6 (2)	0.8 (2)	*934.3 (3)	0.2 (1)
703.4 (6)	0.2 (1)	c 952.7	0.5
709.8 (2)	3.0 (4)	c 952.8	0.4 } 0.9 (2)
744.3 (2)	0.9 (2)	964.4 (2)	0.3 (1)
756.0 (7)	\approx 0.2	c 976.4	3.5
759.2 (2)	0.4 (1)	c 976.7	2.0 } 5.5 (4)
768.8 (7)	\approx 0.1	983.5 (1)	2.2 (3)
779.2 (3)	0.5 (1)	992.9 (2)	5.4 (4)
781.6 (3)	1.0 (2)	1000.4 (2)	0.5 (1)
839.8 (5)	1.4 (4)	1007.3 (8)	1.7 (2)
841.3 (3)	2.2 (6)	1011.4 (2)	1.6 (2)
848.2 (3)	0.6 (2)	1035.2 (1)	3.4 (3)
856.3 (2)	1.4 (2)	1051.8 (1)	2.6 (3)
863.8 (2)	2.9 (3)	1059.4 (2)	0.7 (2)
881.9 (3)	0.7 (3)	1097.5 (2)	1.9 (2)
903.1 (2)	0.9 (2)	1210.2 (2)	4.1 (4)
906.0 (2)	1.0 (2)	1234.0 (3)	4.7 (4)
*910.2 (2)	0.6 (1)	1241.2 (3)	2.4 (2)
912.6 (2)	1.0 (2)	1293.0 (4)	9.0 (7)
929.0 (2)	1.2 (2)		

The errors of the experimental data are given in parenthesis in units of the last digit.

Lines marked by an asterisk are not placed in the level scheme.

c = energies and intensities /left side of the parenthesis/ deduced from the $\gamma - \gamma$ coincidence data.

TABLE II

Conversion coefficients of gamma transitions in the decay
of ^{126}Ba

E_{γ} (keV)	I_{K-ce}	I_{L-ce}	$\alpha_K \times 10$	$\alpha_L \times 10$	Assigned multipolarity
126.3	> 22	\approx 3.8	> 26	\approx 4.5	M1 + (E2)
129.4	> 33	\approx 5.2	> 20	\approx 3.1	M1 + (E2)
149.9		2.3		4.0	M1 + (E2)
200.6	8.6		8.4		M1, E2
203.1	4.2		9.9		M1, E2
208.0	8.0		8.3		M1, E2
217.7	68.3	13.0	11.3	2.2	E2 + (M1)
233.4	256.1	27.2	8.2	0.9	M1 + (E2)
240.7	16.1	1.8	1.5	0.2	E1
257.3	70.4	9.5	5.9	0.8	M1 + (E2)
281.0	23.5		4.8		M1, E2
284.0	3.0		3.9		M1, E2
290.5	5.2		4.5		M1, E2
328.2	10.2	1.1	3.5	0.4	M1 + (E2)
348.3	2.8		2.4		M1, E2
353.0	1.6		2.0		M1, E2
400.4	2.7	0.3	1.7	0.2	M1, E2
441.5	0.5		1.1		M1, E2
453.4	0.4		1.6		M1, E2
456.8	1.1		1.2		M1, E2
474.6	1.1		1.1		M1, E2
489.1	5.0	0.9	0.9	0.17	M1, E2

TABLE II /continued/

525.7	0.3	0.9	M1, E2
542.5	0.8	0.7	M1, E2
548.8	0.6	0.7	M1, E2
578.6	0.35	1.0	M1, E2
640.2	0.6	0.7	M1, E2
642.8	0.3	0.6	M1, E2
681.5	3.2	0.5	M1, E2
691.7	0.8	0.5	M1, E2
709.8	0.73	0.45	M1, E2
856.3	< 0.13	< 0.14	E1
863.8	0.45	0.24	M1, E2
839.8	0.24	0.27	M1, E2
841.3	0.33	0.25	M1, E2
992.9	0.15	0.04	E1
1234.1	0.37	0.12	M1, E2
1293.1	0.58	0.10	M1, E2

The experimental conversion coefficients were normalized to
the α_K value of the 388.5 E2 transition.

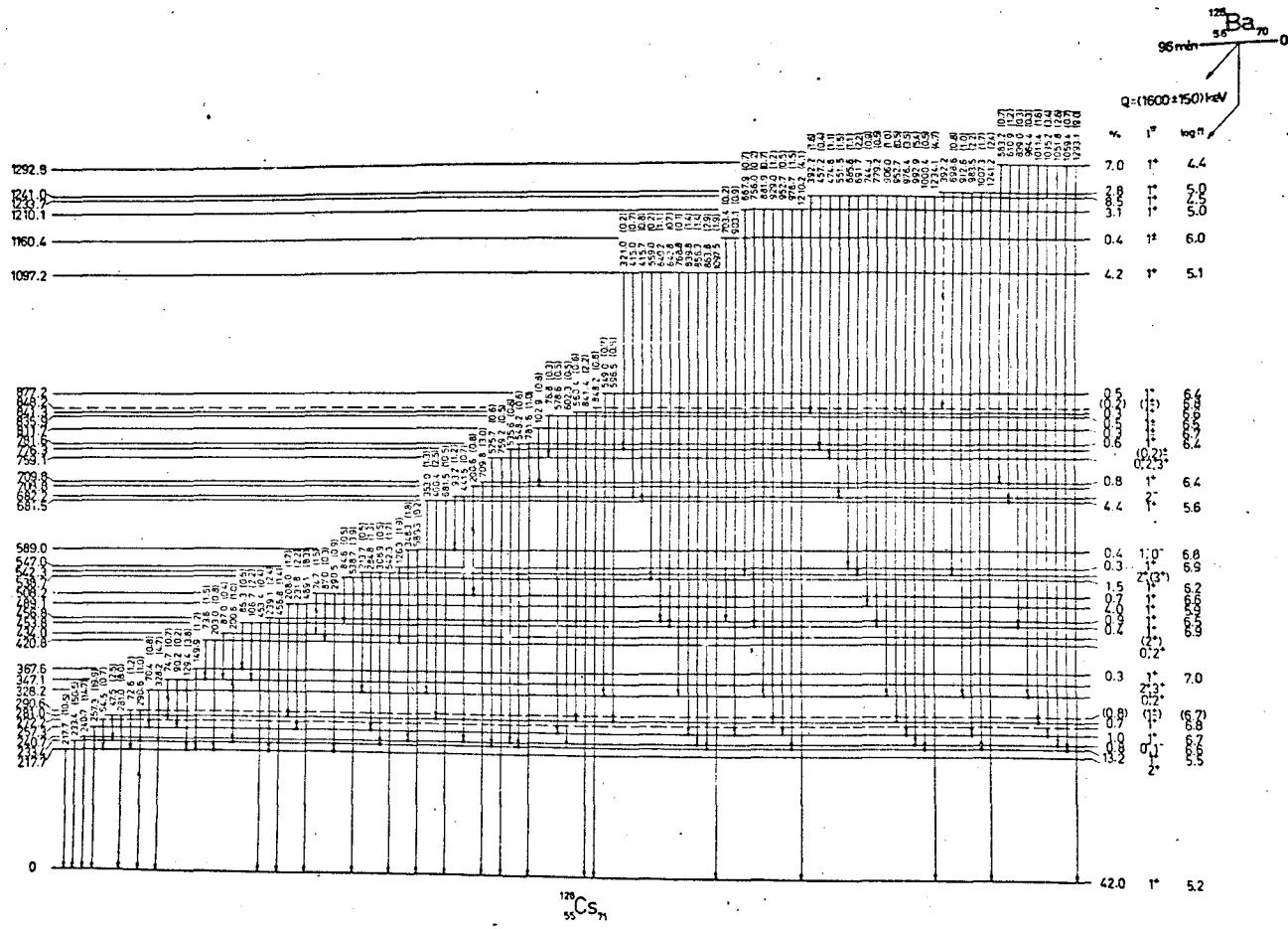


Fig. 1

IN-BEAM STUDY OF ^{128}Xe and ^{130}Xe STRUCTURE

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The level schemes of $^{128},^{130}\text{Xe}$ have been investigated by means of in-beam γ -ray spectroscopy. Targets of $\sim 20 \text{ mg/cm}^2$ of $^{128},^{130}\text{TeO}_2$ /enriched to $\sim 98\%$ each/ were irradiated with the α -particle beam of the U - 120 cyclotron at the Institute of Nuclear Physics in Cracow. The nuclei $^{128},^{130}\text{Xe}$ have been produced in $(\alpha, 2n)$ reaction at $E_\alpha \approx 26 \text{ MeV}$.

The in-beam and off-beam γ -ray singles spectra, $\gamma-\gamma$ coincidence spectra and γ -angular distributions were measured. In order to search for delayed transitions we studied decays of several levels in the nanosecond region for each nucleus. Two isomeric states have been found, namely: $T_{1/2} \approx 90 \text{ ns}$ /level 2787.2 keV/ in ^{128}Xe and $T_{1/2} \approx 5 \text{ ns}$ /level 2973.3 keV/ in ^{130}Xe . Eight new levels for ^{128}Xe and sixteen for ^{130}Xe were established.

The level schemes constructed for ^{128}Xe and ^{130}Xe are presented. Tables 1 and 2 give the lists of energies and intensities of γ -transitions observed in each nucleus.

Preliminary calculations have been performed for positive parity states in ^{128}Xe in the frame of the collective model which takes into account the γ -dependence of the inertial functions [1]. The satisfactory agreement with experimental data was achieved only when some renormalization of the microscopic inertial functions was assumed. It

is worth while to note that the renormalization for ^{128}Xe is identical with the one needed to reproduce the experimental data for $^{124,126}\text{Xe}$ [2].

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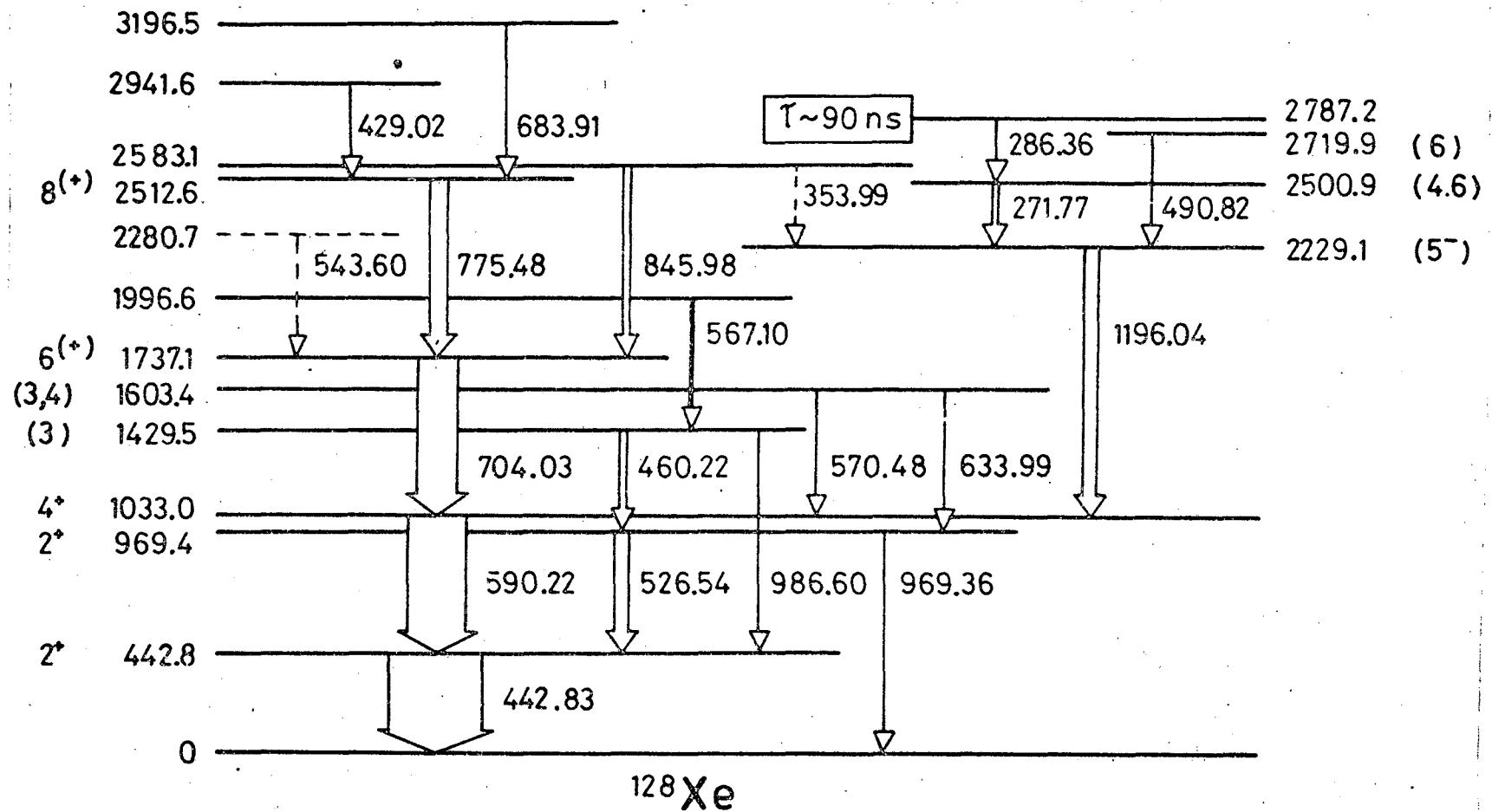


Fig. 1. Decay scheme of ^{128}Xe

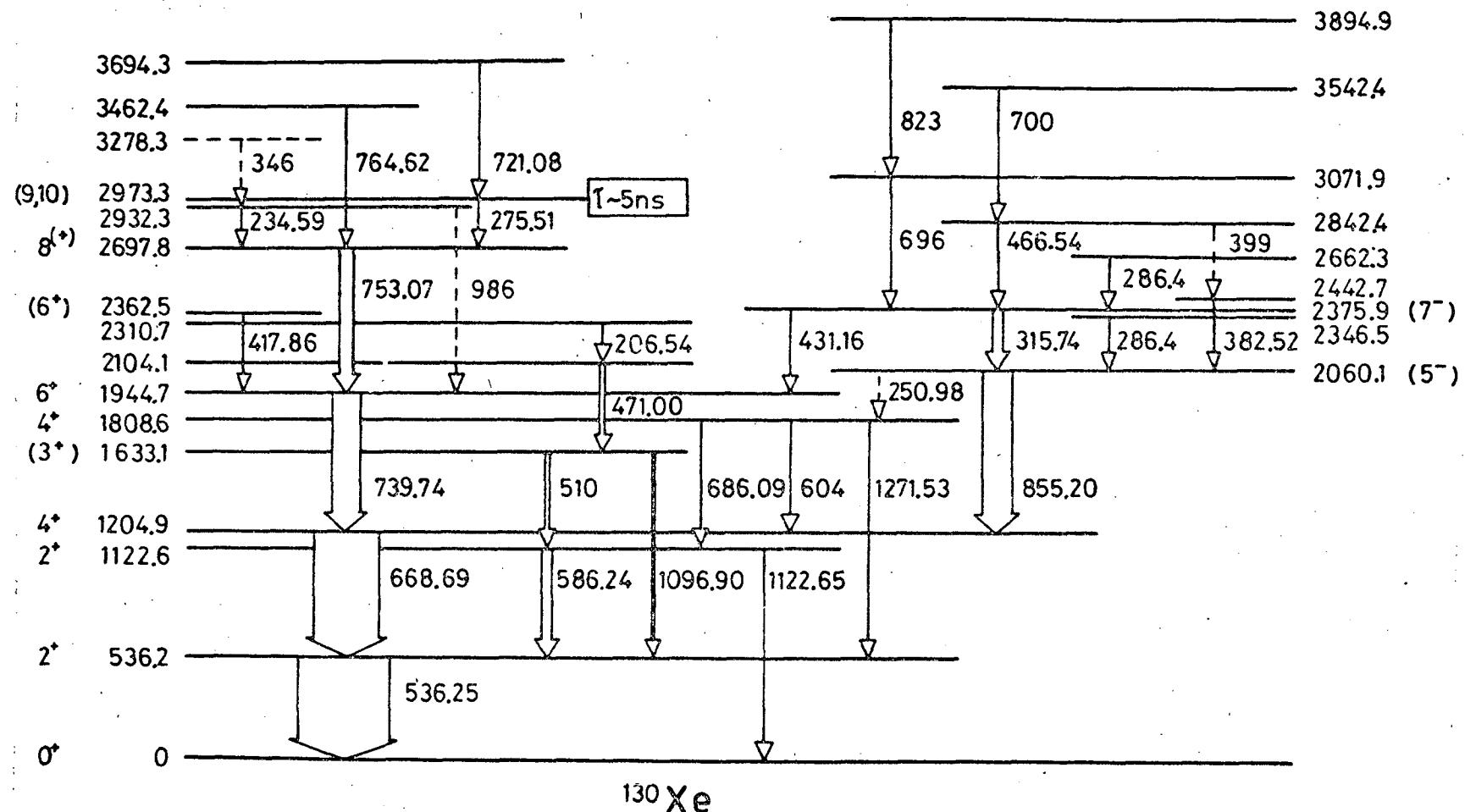


Fig. 2. Decay scheme of ^{130}Xe

TABLE I

Energies and intensities of gamma transitions observed in ^{128}Xe

E_{γ} (keV)	I_{γ}	E_{γ} (keV)	I_{γ}
271.77 (3)	7.07 (18)	570.48 (6)	4.22 (13)
286.36 (5)	2.33 (12)	590.22 (3)	69.1 (19)
353.99 (11)	1.54 (12)	633.99 (4)	3.91 (14)
429.02 (6)	1.99 (17)	683.91 (8)	3.0 (3)
442.83 (3)	100.0 (17)	704.03 (3)	40.0 (8)
460.22 (6)	5.6 (4)	775.48 (3)	16.4 (4)
490.82 (3)	2.16 (10)	845.98 (7)	7.5 (10)
526.54 (3)	10.71 (19)	969.36 (7)	2.70 (12)
543.60 (6)	3.04 (11)	986.60 (6)	4.14 (9)
567.10 (5)	4.94 (13)	1196.04 (4)	12.4 (3)

The errors of the experimental data are given in parenthesis in units of the last digits

TABLE II

Energies and intensities of gamma transitions observed in ^{130}Xe

E_{γ} (keV)	I_{γ}	E_{γ} (keV)	I_{γ}
206.54 (3)	3.41 (8)	604 (1)	$\sim 1.3^{\text{a)}$
234.59 (5)	2.05 (7)	663.69 (4)	79.3 (14)
250.98 (4)	0.90 (7)	686.09 (15)	1.5 (2)
275.51 (3)	6.4 (3)	696 (1)	$\sim 4.7^{\text{a)}$
286.4 (1)	5.74 (12) ^{b)}	700 (1)	$\sim 1.0^{\text{a)}$
315.74 (4)	12.3 (3)	721.08 (8)	1.86 (16)
346 (1)	$\sim 0.7^{\text{a)}$	739.74 (4)	28.4 (6)
382.52 (4)	2.89 (6)	753.07 (4)	15.9 (4)
399 (1)	$\sim 0.4^{\text{a)}$	764.62 (17)	1.61 (16)
417.86 (6)	2.88 (12)	823 (1)	$\sim 1.8^{\text{a)}$
427.71 (10)	1.13 (11)	843 (1)	$\sim 2.1^{\text{a)}$
431.16 (7)	1.94 (11)	855.20 (4)	30.5 (7)
466.54 (5)	4.2 (5)	898 (1)	$\sim 2.1^{\text{a)}$
471.00 (5)	6.79 (14)	987 (1)	$\sim 0.6^{\text{a)}$
510 (1)	$\sim 7.0^{\text{a)}$	1096.90 (10)	4.41 (16)
536.25 (4)	100.0 (15)	1122.65 (7)	1.60 (12)
586.24 (4)	11.1 (2)	1271.5 (5)	1.4 (5)

The errors are given in parenthesis in units of the last digits.

- a) The intensity of the line was extracted from the $\gamma-\gamma$ coincidence data
- b) The $\gamma-\gamma$ coincidence data suggest that there exist two transitions in ^{130}Xe with similar energy ~ 286.4 keV. The intensity is the total intensity of the two transitions.

DECAY SCHEME OF ^{134}Nd AND EXCITED STATES OF ^{134}Pr

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The decay of ^{134}Nd has been investigated with Ge(Li) and Si(Li) detectors. The radioactive sources, obtained in the spallation reaction from gadolinium and tantalum targets, were chemically and isotopically separated. The experiments involved of singles γ -ray, conversion electron and coincidence γ -ray spectra. The γ - γ coincidences have been measured using large volume Ge(Li) detectors and a three parameter analyzer system. From the relative $\frac{EC}{\beta^+} (4.4 \pm 0.8)$ feeding of the 163.2 keV excited state in ^{134}Pr the total decay energy of ^{134}Nd has been deduced to be $Q = 2770 \pm 150$ keV. A decay scheme incorporating all γ -transitions observed in this experiment is proposed on the basis of coincidence measurements and energy sums. Spins for the excited states in ^{134}Pr have been suggested on the basis of β -decay characteristics and the multipolarities of the few low-energy γ -transitions.

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TABLE I

Gamma - rays observed in the decay of ^{134}Nd

E_{γ} (keV)	I_{γ}	E_{γ} (keV)	I_{γ}
90.1 (2)	3.8 (4)	288.9 (2)	22.4 (2.0)
93.3 (3)	0.5 (2)	295.0 (5)	2.9 (6)
101.2 (2)	4.0 (4)	309.4 (5)	2.9 (5)
104.1 (2)	3.0 (7)	320.0 (5)	1.8 (4)
115.7 (2)	3.8 (5)	336.0 (5)	≈ 0.7
119.4 (3)	1.0 (3)	352.0 (5)	1.5 (5)
126.0 (5)	0.5 (3)	379.1 (5)	1.8 (4)
130.6 (5)	≈ 0.5	458.0 (5)	1.1 (5)
144.3 (3)	1.8 (5)	467.9 (5)	4.8 (8)
147.8 (5)	1.5 (4)	483.0 (6)	4.0 (7)
163.2 (2)	100	583.0 (6)	2.0 (4)
183.5 (3)	1.1 (3)	673.0 (6)	2.0 (4)
189.4 (3)	1.4 (5)	993 (1.5)	3.1 (4)
216.8 (2)	20.6 (3.0)	1000 (1.5)	7.0 (8)

Experimental errors are given in parenthesis in units of the last digit.

TABLE II

Conversion coefficients of low-energy γ -transitions in the decay of ^{134}Nd

E (keV)	I_{K-ce}	α_K	Assigned multipolarity
90.1	5.5	1.4	M1, E2
93.3	0.9	1.8	M1, E2
101.2	1.2	0.3	E1
104.1	4.0	1.0	M1, E2
115.7	3.6	0.9	M1, E2
119.4	0.9	0.9	M1, E2
163.2	5.5	$0.06 \left(\frac{K}{L} = 6.6 \right)$	E1
288.9	< 0.4	0.02	E1

Uncertainties of the experimental conversion coefficients values do not exceed 25%.

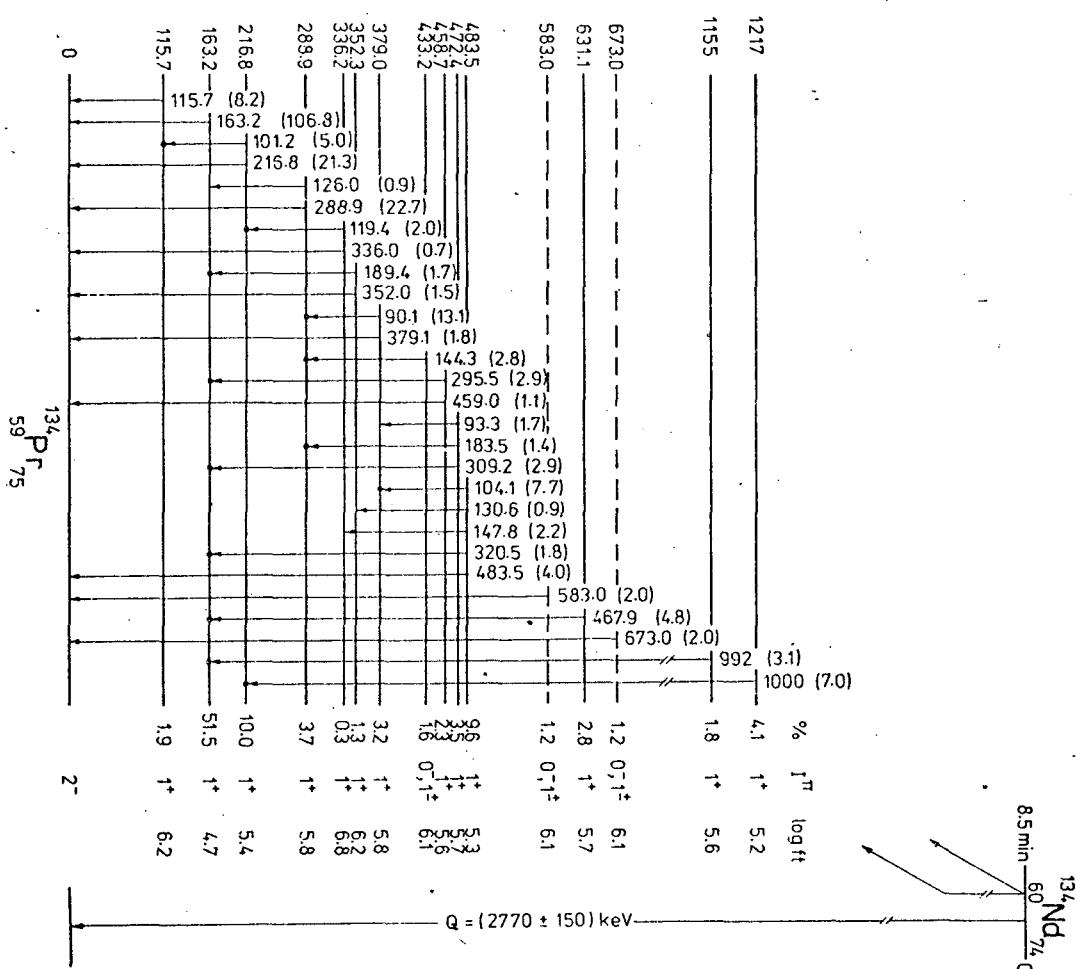


Fig. 1

THE CORIOLIS COUPLED BAND IN ^{233}Pa

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A re-investigation of the ^{237}Np decay scheme has been performed with magnetic and semiconductor spectrometers and using delayed coincidence technique. The obtained results [1] confirmed confirm the previous data presented in the compilation of Artna-Cohen [2]. New information on half-life of the 57.1 keV ($7/2^+$) level have been obtained.

The 4 mg of NpCl_4 sample was purified with the use of ion-exchange chromatography. The sources were prepared by a microcolumne technique. The source strength was about 2 μCi .

The experimental set-up for life-time measurements included a time-to-amplitude converter, constant fraction triggers and two scintillation detectors. The γ -rays and X-rays were detected in a 10 mm thick NE-111 scintillator mounted on the 56-DUVP photomultiplier, while a 1 mm thick NE-111 scintillator with the XP-1021 photomultiplier was used for electron detection. The source and detectors were placed in a "zero-distance" geometry. The equipment was tested with the prompt coincidences between 25 keV K X-rays and K-conversion electrons from the 88 keV E3 transition in ^{109}Ag . This particular choice matches well the energies encountered in the present experiment. With the ^{109}Cd source, the time resolution was 0.96 ns and the slopes of the coincidence distribution showed apparent half-lives of 0.11 ns and 0.20 ns for elec-

trons and γ -rays, respectively. In a control experiments, improved energy selection was achieved with a long-lens magnetic spectrometer [3] as electron detector. The experimental delayed-coincidence curves have been analyzed by the convolution method [4, 5] with the use of an experimentally determined prompt distribution.

The 57.1 keV level. This level is fed mainly ($\approx 94\%$) by the 29.3 keV transition and decays through the 57.1 keV rotational E2 transition. Coincidence spectra between the 29.3 keV γ -rays and L57.1 conversion electrons were recorded (see Fig.1), and the average value obtained from several sets of experiments is $T_{1/2} = 224^{+10}$ ps, corresponding to a reduced transition probability $B(E2) = 2.32^{+0.14} e^2 \cdot b^2$. This value is based on the conversion coefficients of Hager and Seltzer [6] with an assigned error of 5%. Hence, the intrinsic quadrupole moment Q_0 of the ^{233}Pa ground state is $9.5^{+0.3}$ b, and the formula $Q_0 = \frac{4}{5} Z R_0^2 \xi \left(1 + \frac{1}{2} \xi + \frac{4}{9} \xi^2\right)$ with $R_0 = 1.2 A^{1/3}$ fm finally yields a deformation parameter $\xi = 0.211^{+0.005}$ for the ground state of ^{233}Pa .

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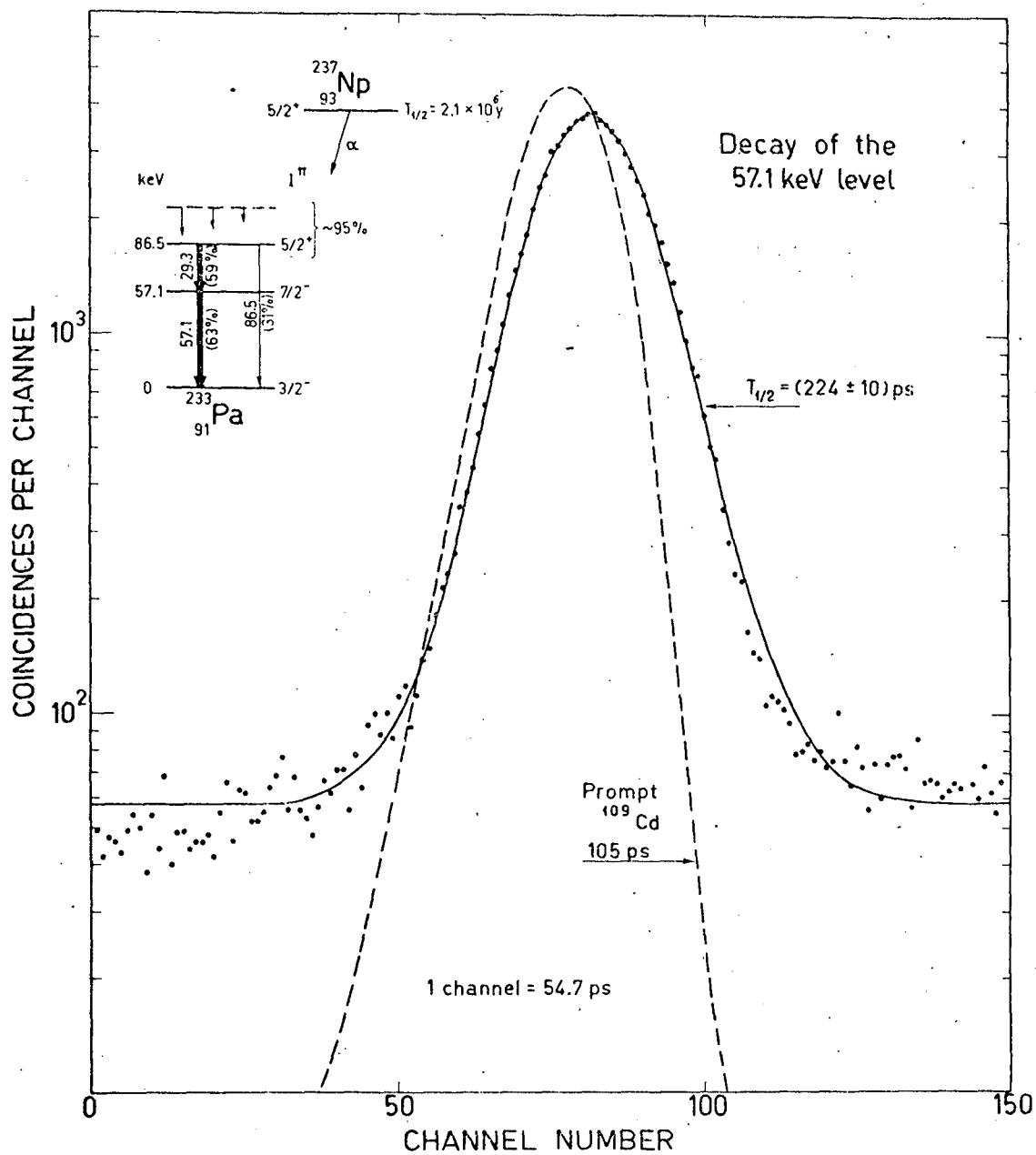


Fig. 1. Time spectrum of the delayed coincidences between the 29.3 keV γ -rays and the L57.1 conversion electrons. The prompt distribution was recorded with a ^{109}Cd source for identical settings of the equipment.

GAMMA-RAY STRENGTH FUNCTIONS
FOR $^{71,73,75}\text{As}$ ISOTOPES

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In order to determine the γ -ray strength function from measuring the proton-capture cross sections a special procedure was applied. On the assumption, that the observed high-energy primary transitions from an initial compound state λ to particular lower states i and k /both of the same spin and parity/ are of electric-dipole type, the following expression may be obtained from the statistical model of nuclear reactions:

$$\frac{\langle \sigma_{p,\gamma_i} \rangle}{\langle \sigma_{p,\gamma_k} \rangle} = \frac{f_{i\lambda}(E_{\gamma_i})}{f_{k\lambda}(E_{\gamma_k})} \left(\frac{E_{\gamma_i}}{E_{\gamma_k}} \right)^3, \quad (1)$$

where $\langle \sigma_{p,\gamma_i} \rangle$ and $\langle \sigma_{p,\gamma_k} \rangle$ are the averaged cross sections for the (p,γ) reactions populating two levels, i and k , $f_{i\lambda}(E_{\gamma_i})$ and $f_{k\lambda}(E_{\gamma_k})$ are the strength functions for decay of states λ , at energy E , to states i and k , at energy E_i and E_k , respectively, and E_{γ_i} and E_{γ_k} are transition energies ($E_{\gamma_i} = E_\lambda - E_i$, $E_{\gamma_k} = E_\lambda - E_k$).

^{x/} Experimental part of this work was performed in the Joint Institute for Nuclear Research at Dubna.

For the purpose of making the formula (1) applicable to transitions to states of any I^{π} -value we introduced a coefficient $C_{I^{\pi}}$, which is defined by the formula:

$$C_{I^{\pi}} = \frac{\sigma_{p,\gamma_0}^{th}(E_{\gamma}=E_{\lambda}, I_0^{\pi_0})}{\sigma_{p,\gamma_i}^{th}(E_{\gamma}=E_{\lambda}, I_i^{\pi_i})}, \quad (2)$$

where $\sigma_{p,\gamma}^{th}$ is the cross section calculated from the Hauser and Feshbach theory, and γ_0 denotes the ground state transition. With this coefficient a more general expression was obtained:

$$f_{i\lambda}(E_{\gamma_i}) = C_{I_i^{\pi_i}} f_{0\lambda}(E_{\lambda}) \left(\frac{E_{\lambda}}{E_{\lambda}-E_i} \right)^3 \frac{\langle \sigma_{p,\gamma_i} \rangle}{\langle \sigma_{p,\gamma_0} \rangle}. \quad (3)$$

The value $f_{0\lambda}(E_{\lambda})$ which denotes the strength function for the ground state transition can be taken from other experiments, e.g. it can be deduced from the giant dipole Lorentzian tail.

In our experiment the (p,γ) reactions on separated $^{70,72,74}\text{Ge}$ isotopes were studied using a Ge(Li) detector. In order to obtain an averaged spectrum of the high-energy γ -rays which populate the individual levels of arsenic isotopes, the measurements were performed at about 50 values of proton energy being changed in steps of the size small enough (ca 15 keV) to avoid serious smearing of the γ -ray resolution.

The energy range of proton beam for the reactions under investigation is shown in Table 1.

TABLE 1

Reaction	Energy range of proton beam MeV	Cross section / ^{ub}	$\frac{\Delta \langle \tilde{\sigma}_{p,\delta_i} \rangle}{\langle \tilde{\sigma}_{p,\delta_i} \rangle} \%$
$^{70}\text{Ge}(p,\delta)^{71}\text{As}$	3.0 - 3.9	17 ± 2	4.1
$^{72}\text{Ge}(p,\delta)^{73}\text{As}$	3.0 - 3.9	15 ± 2	2.5
$^{74}\text{Ge}(p,\delta)^{75}\text{As}$	2.0 - 2.8	14 ± 2	2.6

The detailed description of averaging the γ -spectra has been given in [1].

The relative averaged cross sections for population of low lying levels in $^{71,73,75}\text{As}$, $\langle \tilde{\sigma}_{p,\delta_i} \rangle / \langle \tilde{\sigma}_{p,\delta_0} \rangle$, are shown in Tables 2, 3 and 4. In the last column the γ -ray strength functions are given, calculated from the formula (3). The averaged ground state cross sections, $\langle \tilde{\sigma}_{p,\delta_0} \rangle$, as well as the contributions of the Porter - Thomas fluctuations to the error of these cross sections, $\Delta \langle \tilde{\sigma}_{p,\delta_0} \rangle / \langle \tilde{\sigma}_{p,\delta_0} \rangle$, are indicated in the Table 1.

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TABLE II

Relative gamma-ray intensities and strength functions for ^{71}As .

i	Level energy /keV/	Spin and parity	$\frac{\langle \delta p \delta_i \rangle}{\langle \delta p \delta_0 \rangle}$	$\frac{\leftarrow f_{i\lambda}}{f_{i\lambda} \times 10^8} \times 10^8$ /MeV $^{-3}$ /
0	0	5/2 $^-$	1.000 \pm 0.052	5.46 \pm 0.28
1 ^d	147	3/2 $^-$	2.701 \pm 0.114	
		3/2 $^-$		
2	508	5/2 $^-$	0.711 \pm 0.052	3.97 \pm 0.29
3	831	3/2 $^-$	0.360 \pm 0.052	4.13 \pm 0.25
4	871	5/2 $^-$	0.570 \pm 0.037	4.40 \pm 0.28
5	890	7/2 $^-$, 1/2 $^-$	0.411 \pm 0.043	
6	994	3/2 $^-$	0.849 \pm 0.052	4.58 \pm 0.28
7	1008	5/2 $^+$	0.647 \pm 0.041	4.45 \pm 0.28
8	1132	5/2 $^+$	0.606 \pm 0.043	4.40 \pm 0.31
9	1247	3/2 $^-$	0.690 \pm 0.048	4.16 \pm 0.29
10	1416	3/2 $^-$	0.556 \pm 0.041	3.62 \pm 0.27
11	1446	3/2 $^+, 1/2^+, 5/2^-$	0.442 \pm 0.031	
12	1469	3/2 $^-$	0.622 \pm 0.041	4.14 \pm 0.27
13	1493	3/2 $^+, 1/2^+, 5/2^-$	0.382 \pm 0.035	
14	1537	1/2 $^+$	0.368 \pm 0.031	3.85 \pm 0.32
15 ^d	1613	3/2 $^-$, 7/2 $^-$, 1/2 $^-$	0.727 \pm 0.048	
16	1702	$\leq 7/2$	0.279 \pm 0.029	
17	1735	7/2 $^+$	0.172 \pm 0.027	4.14 \pm 0.65
18	1758	3/2 $^-, 5/2^+$	0.409 \pm 0.035	
19	1831	5/2 $^+$	0.355 \pm 0.031	3.56 \pm 0.31
20	1853	5/2 $^+$	0.351 \pm 0.031	3.51 \pm 0.30

d - unresolved doublet

TABLE III

Relative gamma-ray intensities and strength functions for ^{73}As .

i	Level energy /keV/	Spin and parity	$\frac{\langle \delta p \delta_i \rangle}{\langle \delta p \delta_0 \rangle}$	$f_{i\alpha} \times 10^8$ /MeV $^{-3}$ /
0	0	3/2 $^-$	1.000 \pm 0.035	7.81 \pm 0.27
1	67	5/2 $^-$	0.530 \pm 0.038	9.18 \pm 0.65
2	84	3/2 $^-$	0.963 \pm 0.042	7.73 \pm 0.34
3	254	1/2 $^-$	0.631 \pm 0.034	7.89 \pm 0.42
4	394	3/2 $^-$	0.815 \pm 0.035	7.27 \pm 0.31
5	428	9/2 $^+$	0.080 \pm 0.022	9.53 \pm 2.62
6	510	5/2 $^+$	0.397 \pm 0.028	6.82 \pm 0.48
7 ^d	577	1/2 $^-$ 5/2 $^-$	0.856 \pm 0.044	
8	656	1/2 $^-$	0.504 \pm 0.033	7.24 \pm 0.47
9	769	1/2 $^+, 1/2^-, 3/2^+$	0.461 \pm 0.040	
10 ^d	857	5/2 $^+$ 7/2 $^-$	0.535 \pm 0.035	
11	886	1/2 $^+$	0.485 \pm 0.028	7.74 \pm 0.43
12	994	7/2 $^-$	0.174 \pm 0.041	5.50 \pm 1.29
13 ^d	1032	7/2 $^-$ 3/2 $^-$	0.730 \pm 0.040	
14	1190	3/2 $^-$	0.401 \pm 0.034	5.46 \pm 0.40
15 ^d	1216	3/2 $^-$ 3/2 $^-$	0.980 \pm 0.044	
16 ^d	1302	3/2 $^-$ 5/2 $^+$	0.724 \pm 0.040	
17	1324	3/2 $^+$	0.347 \pm 0.034	6.78 \pm 0.66
18	1344	7/2 $^-$	0.176 \pm 0.035	6.35 \pm 1.26
19	1540	1/2 $^+, 1/2^-, 3/2^+$	0.246 \pm 0.022	

^d - unresolved doublet

TABLE IV

Relative gamma-ray intensities and strength functions for ^{75}As .

i	Level energy /keV/	Spin and parity	$\frac{\langle \delta_{P\delta_i} \rangle}{\langle \delta_{P\delta_0} \rangle}$	$f_{i\gamma} \times 10^8$ /MeV $^{-3}$ /
0	0	3/2 $^-$	1.000 \pm 0.030	9.28 \pm 0.28
1	199	1/2 $^-$	0.718 \pm 0.029	8.73 \pm 0.35
2	265	3/2 $^-$	0.837 \pm 0.035	8.46 \pm 0.35
3	279	5/2 $^-$	0.298 \pm 0.023	12.11 \pm 0.93
4	304	9/2 $^+$	0.022 \pm 0.013	5.27 \pm 3.12
5	401	5/2 $^+$	0.274 \pm 0.016	6.69 \pm 0.39
6	469	1/2 $^+, 1/2^-$	0.535 \pm 0.030	
7	573	5/2 $^-$	0.256 \pm 0.017	11.47 \pm 0.76
8	619	1/2 $^-$	0.587 \pm 0.032	8.22 \pm 0.45
9	822	7/2 $^+$	0.028 \pm 0.017	7.42 \pm 4.50
10	861	1/2 $^+$	0.452 \pm 0.025	8.73 \pm 0.48
11	886	7/2 $^-$	0.099 \pm 0.014	6.50 \pm 0.92
12	1044	7/2 $^+$	0.029 \pm 0.017	8.31 \pm 4.87
13	1075	3/2 $^-$	0.513 \pm 0.025	6.85 \pm 0.33
14	1129	1/2 $^-$	0.421 \pm 0.021	7.05 \pm 0.35
15	1204	1/2 $^-$	0.419 \pm 0.022	7.21 \pm 0.38
16	1264	3/2 $^+, 5/2^+$	0.221 \pm 0.021	
17	1351	3/2 $^-$	0.451 \pm 0.024	6.67 \pm 0.35
18	1371	7/2 $^-$	0.064 \pm 0.021	5.01 \pm 1.64
19	1433	3/2 $^-$	0.447 \pm 0.024	6.81 \pm 0.36
20	1504	3/2 $^+$	0.205 \pm 0.023	5.52 \pm 0.62
21	1606	3/2 $^-$	0.442 \pm 0.025	7.20 \pm 0.41
22	1874	3/2 $^-$	0.341 \pm 0.030	6.17 \pm 0.54
23	2069	3/2 $^-$	0.297 \pm 0.023	5.81 \pm 0.45
24 ^d		1/2 $^-$	0.421 \pm 0.038	

d - unresolved doublet

ANALYZING POWER FOR $^{12}\text{C}(\overset{\rightarrow}{^6\text{Li}}, \text{d})^{16}\text{O}$ REACTIONS MEASURED
AT 20.0 MeV USING A VECTOR-POLARIZED ^6Li BEAM

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Experimental data were obtained using the Heidelberg polarized lithium beam (1) at the EN-Tandem. Beam polarization is known to be $P = /0.63 \pm 0.03/$ and relative polarization was continuously monitored during the experiment. Data were gathered in successive runs with polarized and unpolarized beams, by two symmetric counter telescopes in a conventional scattering chamber. Spectra were accumulated with an on-line computer in two-dimensional matrices each of 512×128 cells, and extracted one-dimensional spectra had energy resolution better than 200 keV.

The results of analyzing power for $^{12}\text{C}(\overset{\rightarrow}{^6\text{Li}}, \text{d})^{16}\text{O}$ reactions to discrete final states are presented in the following tables. The errors quoted are statistical only. The angles are given in the CM system. For an unpolarized beam the measured cross-sections are in good agreement with previously published results (2).

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TABLE I

$^{12}\text{C}(^{6}\text{Li}, \text{d})^{16}\text{O}$
g.s.,
final state 0.00MeV, 0^+

θ [deg]	Asymmetry	\pm Error
18.1	.388	.190
24.1	.350	.179
30.1	.375	.187
36.0	.234	.166
41.9	-.150	.133
47.9	-.335	.101
53.9	-.388	.086
59.3	-.088	.129
64.9	.241	.152
70.5	.270	.146
76.0	.539	.117
81.4	-.118	.189
86.7	-.074	.152
92.0	-.341	.233
97.1	.028	.313
102.1	.483	.171
107.1	.679	.152
112.0	.412	.264
116.7	.130	.211
121.4	-.176	.290

TABLE II

$^{12}\text{C}(^{6}\text{Li}, \text{d})^{16}\text{O}$, final states
6.05MeV, 0^+ and 6.13MeV, 3^-

θ [deg]	Asymmetry	\pm Error
18.8	.134	.054
25.0	.254	.056
31.2	.078	.064
37.3	.140	.059
43.4	.026	.058
49.5	-.053	.057
55.4	-.215	.050
61.3	-.266	.076
67.1	-.219	.071
72.8	.044	.076
78.4	.013	.064
83.9	-.096	.071
89.3	-.090	.067
94.6	.042	.118
99.7	.030	.126
104.8	.179	.071
109.7	-.018	.076
114.6	-.051	.092
119.3	-.007	.075
123.9	.122	.101
128.4	.078	.099
132.8	.235	.089
137.1	.513	.070
141.3	.334	.076
145.4	.503	.058
149.5	.438	.059
153.4	.256	.067
157.3	.402	.060
161.2	.295	.068

Table III
 $^{12}\text{C}(\overset{6}{\text{Li}}, \text{d})^{16}\text{O}$, final
state 6.92 MeV, 2⁺

Θ [deg]	Asymmetry	Error	Θ [deg]	Asymmetry	Error
18.9	-.076	.048	18.9	-.069	.119
25.2	-.122	.053	25.2	-.316	.103
31.4	-.098	.064	31.5	-.227	.113
37.6	-.032	.060	37.6	-.78	.100
43.7	-.138	.055	43.8	-.232	.098
49.8	-.128	.060	49.8	-.114	.107
55.7	-.153	.079	55.8	-.226	.124
61.7	.122	.110	61.8	.179	.150
67.5	.071	.078	67.6	.326	.138
73.2	.049	.065	73.3	.181	.133
78.8	-.067	.057	78.9	.109	.130
84.3	-.264	.065	84.5	-.268	.129
89.3	-.372	.060	89.9	-.266	.100
95.1	-.301	.105	95.2	-.343	.161
100.2	-.200	.108	100.4	-.251	.169
105.3	-.223	.071	105.4	-.089	.129
110.2	-.070	.068	110.4	-.146	.129
115.1	-.118	.092	115.2	.122	.174
119.8	-.188	.074	119.9	.161	.154
124.3	.000	.102	124.5	.233	.196
133.2	.246	.101	133.3	.093	.198
137.5	.295	.093	137.6	.077	.169
141.7	.329	.080	141.8	-.031	.140
145.7	.365	.068	145.8	.091	.125
149.8	.374	.065	149.8	.078	.130
153.7	.363	.062	153.8	.247	.107
157.6	.403	.061	157.6	.476	.097
161.4	.245	.066	161.5	.332	.099

Table IV
 $^{12}\text{C}(\overset{6}{\text{Li}}, \text{d})^{16}\text{O}$, final
state 7.12 MeV, 1⁻

Table V
 $^{12}\text{C}(\overset{6}{\text{Li}}, \text{d})^{16}\text{O}$, final
state 8.87 MeV, 2⁻

Θ [deg]	Asymétry \pm	Error	Θ [deg]	Asymetry \pm	Error
25.7	.070	.096	106.7	.102	.115
32.0	.067	.110	111.7	.075	.114
38.3	.093	.118	116.5	.138	.148
44.5	-.117	.123	121.2	.333	.113
50.7	.005	.130	125.7	-.073	.156
56.8	-.143	.132	130.1	.426	.157
62.7	-.024	.145	134.4	.285	.199
68.6	-.137	.124	138.6	.444	.157
74.4	-.121	.118	142.7	.053	.173
80.1	-.351	.089	146.8	.291	.148
85.7	.027	.110	150.7	.282	.142
91.2	.068	.095	154.5	.191	.141
96.5	.229	.151	158.3	.118	.124
100.4	.199	.155	162.0	.244	.116

Table VI

$^{12}\text{C}(\overset{6}{\text{Li}}, \text{d})^{16}\text{O}$, final
state 10.34 MeV, 4^+
(not resolved from 10.35 MeV)

Θ [deg]	Asymmetry	\pm Error
87.0	.077	.049
92.5	.017	.043
97.9	.079	.067
103.1	.005	.067
108.1	.059	.048
113.1	.101	.049
117.9	.145	.067
122.5	.191	.056
127.0	.079	.077
131.4	.271	.088
135.6	.294	.084
139.8	.334	.031
143.6	.376	.073
147.7	.414	.062
151.5	.370	.065
155.3	.342	.061
159.0	.451	.054
162.6	.308	.057

Table VII

$^{12}\text{C}(\overset{6}{\text{Li}}, \text{d})^{16}\text{O}$, final
state 11.08 MeV, 3^+
(not resolved from 11.10 MeV, 4^+)

Θ [deg]	Asymmetry	\pm Error
103.9	-.011	.077
109.0	-.086	.054
113.9	.028	.057
118.7	-.090	.080
123.4	.129	.064
127.8	.157	.086
132.2	.131	.096
136.4	.239	.095
140.5	.028	.095
144.5	.072	.082
148.3	.032	.075
152.1	.078	.072
155.8	.098	.071
159.4	.041	.073
162.9	.069	.075

INVESTIGATION OF $^{12}\text{C}(\overset{\circ}{\text{Li}}, \text{alpha})^{14}\text{N}$ REACTIONS AT 20.0 MeV
USING A VECTOR-POLARIZED ^6Li BEAM

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The $^{12}\text{C}(\overset{\circ}{\text{Li}}, \text{alpha})^{14}\text{N}$ transfer channel was experimentally investigated with a polarized lithium beam /1/. The measurements were performed with the same experimental technique as that used in $^{12}\text{C}(\overset{\circ}{\text{Li}}, \text{d})^{16}\text{O}$ measurements /see contribution to the Progress Report/. The energy resolution depended somewhat on the detecting angle and was always better than 200 keV, hence transitions to 4.91 MeV and 5.11 MeV were resolved. The cross-section measurements were more restrictive than the asymmetry measurements. As levels of excitation energy around 9 MeV were not resolved, the cross-section was obtained for the whole unresolved peak. The analyzing power was measured separately for each component; separately for alpha particles corresponding to levels 8.907 + 8.963 + 8.979 MeV, and to levels 9.129 + 9.172 MeV.

The results of measurements are presented in the following tables. The angles are given in the CM system. The cross-sections are given in arbitrary units of approximately 0.1 mb/sr. The errors of cross-sections are statistical only. For low-lying states of ^{14}N nucleus, the errors of asymmetry are statistical only. For transitions to 8.49 MeV level and the higher excited levels the errors contain also systematic

errors due to the uncertainty of background. The uncertainty of continuous background of spectra of alpha-outgoing particles was estimated to be 10%.

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Table I

$$^{12}\text{C}(\overset{6}{\text{Li}}, \text{alpha})^{14}\text{N}_{\text{g.s.}}$$
, final state 0.00 MeV, 1^+

θ [deg]	Asymmetry \pm Error	Cross-sec. \pm Error [arbitrary unit]
19.4	.175	.0847 .0023
25.8	.041	.0511 .0018
32.1	.115	.0125 .0009
38.4	.165	.0199 .0015
44.7	.013	.0276 .0016
50.9	.225	.0133 .0010
57.0	.137	.0151 .0011
63.0	.238	.0169 .0013
68.9	.216	.0146 .0010
74.7	.284	.0268 .0014
80.4	.180	.0408 .0015
86.0	.261	.0409 .0018
91.5	.375	.0368 .0014
96.8	.615	.0490 .0025
102.0	.542	.0557 .0027
107.1	.335	.0487 .0018
112.0	.215	.0430 .0018
116.8	.443	.0428 .0022
121.5	.645	.0446 .0021
126.0	.524	.0419 .0025
130.4	.142	.0361 .0027
134.7	.229	.0470 .0031
138.9	.332	.0515 .0032
143.0	.389	.0566 .0033
147.0	.303	.0435 .0027
150.9	.016	.0361 .0025
154.7	.255	.0451 .0029
158.4	.092	.0650 .0035
162.1		.0727 .0032

Table II

$^{12}\text{C}(\overset{6}{\text{Li}}, \alpha)^{14}\text{N}$, final state 3.95 MeV, 1^+		
Θ [deg]	Asymmetry \pm	Error
19.8	.107	.049
26.4	.451	.044
32.5	.260	.032
39.3	.112	.069
45.7	-.297	.111
52.0	.327	.070
58.2	-.269	.060
64.4	-.305	.077
70.4	.222	.066
76.3	.184	.051
82.1	-.158	.052
87.7	-.048	.089
93.2	-.023	.077
93.6	-.181	.093
103.8	-.063	.120
108.9	.056	.118
113.8	-.176	.089
118.6	.060	.104
123.2	.561	.082
127.7	.493	.123
132.1	-.561	.113
136.3	-.562	.093

Table III

$$^{12}\text{C}(\overset{6}{\text{Li}}, \text{alpha})^{14}\text{N}$$
, final state 4.91 MeV, 0°

Θ [deg]	Asymmetry	+ Error	Cross-sec	+ Error
			[arbitrary unit]	
19.9	.498	.059	8.67	.50
26.5	.246	.042	7.45	.30
32.9	.392	.052	3.36	.20
39.6	.182	.115	2.22	1.13
46.0	-.472	.032	2.01	.13
52.4	-.871	.101	.225	.042
58.6	-.672	.076	1.42	.10
64.8	-.720	.049	2.82	.16
70.8	-.142	.102	1.85	.11
76.8	.477	.109	1.44	.10
82.6	.217	.078	2.63	.12
88.2	.237	.087	2.51	.14
93.8	.310	.180	.612	.056
99.1	.364	.226	.770	.099
104.4	.322	.172	1.38	.14
109.5	.583	.091	1.61	.11
114.4	.890	.067	.781	.076
119.1	.782	.149	.410	.070
123.8	-.572	.167	.600	.078
128.2			.726	.211

Table IV
 $^{12}\text{C}(\text{Li}, \text{alpha})^{14}\text{N}$, final state 5.11 MeV, 2⁻

Θ [deg]	Asymmetry \pm Error		Cross-sec. \pm Error
			[arbitrary unit]
20.0	-.010	.040	10.55 .56
26.6	-.218	.047	9.66 .34
33.1	-.422	.052	3.98 .22
39.6	-.436	.103	6.05 .25
46.1	-.190	.058	8.03 .27
52.4	-.009	.072	4.38 .18
58.7	.127	.077	2.78 .14
64.9	.070	.075	3.84 .19
70.9	-.010	.079	3.93 .16
76.9	.096	.086	3.18 .15
82.7	-.188	.081	2.49 .12
88.3	.074	.084	3.26 .16
93.9	.579	.049	3.65 .14
99.3	.525	.088	3.04 .20
104.5	.572	.094	2.49 .18
109.6	.501	.112	2.17 .12
114.5	.320	.087	2.92 .15
119.3	.248	.085	3.95 .22
123.9	-.026	.074	5.74 .24
128.3	-.006	.108	5.50 .29

Table V
 $^{12}\text{C}(\overset{6}{\text{Li}}, \alpha)^{14}\text{N}$, final
state 5.69 MeV, 1

Table VI
 $^{12}\text{C}(\overset{6}{\text{Li}}, \alpha)^{14}\text{N}$, final
state 5.83 MeV, 3

Θ [deg]	Asymmetry	Error	Θ [deg]	Asymmetry	Error
20.1	-.253	.058	20.1	.093	.065
26.7	-.292	.052	26.7	.078	.095
33.1	.301	.078	33.3	.051	.055
39.8	-.014	.017	39.9	-.088	.080
46.3	-.450	.100	46.3	.014	.091
52.7	.049	.196	52.7	.067	.083
58.9	-.324	.129	59.0	-.257	.091
65.1	-.039	.117	65.2	-.245	.094
71.2	.100	.111	71.3	-.066	.081
77.2	-.119	.139			
83.0	.240	.333	77.2	.007	.116
88.7	.000	.125	83.1	-.249	.073
94.2	-.400	.115	88.8	-.588	.095
99.6	-.376	.197	94.3	-.306	.289
104.9	.446	.161	99.7	-.309	.168
109.9	.222	.143	104.9	-.307	.134
114.9	-.227	.125	110.0	-.481	.102
119.6	-.120	.241	114.9	-.438	.119
124.2	.449	.177	119.7	-.030	.138
128.7	.161	.285	124.3	.105	.247

Table VII

$$^{12}\text{C}(\text{Li}, \text{alpha})^{14}\text{N}$$
, final state 6.20 MeV, 1^+

θ [deg]	Asymmetry	\pm Error	Cross-sec $^+$	Error
			[arbitrary unit]	
20.1	-.331	.031	21.31	.50
26.8	-.329	.061	6.06	.27
33.3	-.256	.035	18.89	.34
40.0	-.181	.053	8.22	.29
46.5	-.158	.086	3.17	.17
52.9	-.546	.049	4.11	.18
59.2	-.349	.067	2.83	.14
65.4	.013	.115	2.64	.16
71.5	.263	.080	2.44	.13
77.4	.204	.134	2.26	.13
83.3	-.233	.069	3.12	.13
89.0	-.260	.081	2.62	.14
94.9	-.040	.096	1.95	.10
99.9	.053	.106	3.12	.20
105.2	-.008	.082	4.70	.25
110.3	-.124	.057	5.06	.19
115.3	-.180	.078	3.98	.17
119.9	-.384	.085	3.59	.21
124.5	.007	.119	3.73	.41

Table VIII

$$^{12}\text{C}(\overset{6}{\text{Li}}, \text{alpha})^{14}\text{N}$$
, final state 6.44 MeV, 3^+

Θ [deg]	Asymmetry \pm Error	Cross-sec. \pm Error [arbitrary unit]
20.2	-.026 .043	14.43 .41
26.9	-.414 .022	19.58 .34
33.5	-.376 .023	18.63 .33
40.0	.058 .045	10.62 .32
46.5	.197 .034	15.68 .37
53.0	-.025 .039	12.10 .30
59.3	-.111 .054	5.64 .20
65.5	.002 .058	6.39 .25
71.6	-.044 .047	7.01 .22
77.6	-.127 .056	4.54 .18
83.4	-.008 .055	5.18 .17
89.1	.365 .053	8.57 .25
94.7	.492 .031	11.26 .24
100.1	.380 .049	10.54 .36
105.3	.348 .059	8.32 .33
110.4	.417 .058	7.78 .23
115.3	.584 .044	8.60 .25
120.1	.614 .039	11.05 .37
124.7	.533 .127	6.28 .55

Table IX

$^{12}\text{C}(\overset{6}{\text{Li}}, \alpha)^{14}\text{N}$, final
state 7.03 MeV, 2^+

Table X

$^{12}\text{C}(\overset{6}{\text{Li}}, \alpha)^{14}\text{N}$, final
state 7.97 MeV, 2^-

Θ [deg]	Asymmetry	\pm Error	Θ [deg]	Asymmetry	\pm Error
20.3	.223	.038	20.5	-.073	.052
27.0	.060	0.57	27.2	.093	.048
33.6	-.474	.057	33.9	-.156	.052
40.2	-.358	.081	40.6	-.413	.116
46.8	.027	.108	47.2	-.036	.109
53.2	-.230	.112	53.7	-.122	.078
59.6	-.448	.069			
65.8	-.314	.078	60.1	-.112	.084
71.9	.148	.086	66.3	.274	.102
77.9	-.009	.113	72.5	.555	.071
83.8	.143	.119	78.5	.369	.085
89.5	.037	.098	84.4	.454	.088
95.1	.403	.081	90.2	.561	.086
100.5	.363	.154	95.8	.432	.143
105.8	-.002	.153	101.2	.436	.167
110.8	.122	.106	106.5	.440	.120
115.8	.071	.092	111.5	.257	.118
120.5	.102	.189	116.5	.283	.221

Table XI

$^{12}\text{C}(^{6}\text{Li}, \alpha)^{14}\text{N}$, final
state 8.49 MeV, 4^+

Table XII
 $^{12}\text{C}(^{6}\text{Li}, \alpha)^{14}\text{N}$,
final states

8.96 MeV, 5^+ and 8.98 MeV, 2^+
(not resolved from 8.91 MeV, 3^-)

Θ [deg]	Asymmetry	\pm Error	Θ [deg]	Asymmetry	\pm Error
20.6	.179	.066	20.7	.083	.020
27.4	.137	.061	27.5	-.246	.029
34.1	.241	.052	34.3	-.231	.022
40.8	.232	.061	41.0	.058	.038
47.4	.102	.071	47.6	-.063	.034
53.9	-.178	.074	54.2	-.316	.032
60.3	-.139	.059	60.6	-.081	.042
66.7	-.060	.066	67.0	.032	.052
72.9	-.190	.061	73.2	-.306	.043
78.9	-.042	.077	79.3	-.278	.048
84.8	-.253	.072	85.2	.243	.048
90.6	-.259	.070	91.0	.347	.045
96.2	-.341	.062			
101.6	-.189	.108	96.6	-.181	.036
106.9	-.215	.091	102.0	-.225	.056
112.0	-.004	.086	107.3	-.296	.066

Table XIII

Asymmetry for $^{12}\text{C}(\text{Li}, \alpha)^{14}\text{N}$ transition to 9.13 MeV, 2^- state. The state 9.13 MeV, 2^- was not resolved from the state 9.17 MeV, 2^+ .

Cross-section for $^{12}\text{C}(\text{Li}, \alpha)^{14}\text{N}$ reactions leading to 8.91, 8.96, 8.98, 9.13 and 9.17 MeV states.

θ [deg]	Asymmetry \pm Error	θ [deg]	Cross-sec. \pm Error [arbitrary unit]
20.7	-.09 .09	20.7	51.61 .59
27.5	-.14 .13	27.5	44.58 .79
34.3	-.15 .10	34.3	30.28 .46
41.1	-.23 .12	41.0	18.96 .47
47.7	.20 .12	47.6	19.97 .44
54.3	.24 .13	54.2	16.97 .39
60.75	.22 .10	60.6	11.80 .31
67.1	.40 .12	67.0	12.29 .36
73.3	.16 .11	73.2	16.51 .42
79.4	.23 .08	79.3	10.83 .28
85.35	.25 .08	85.2	10.27 .27
91.15	.13 .13	91.0	12.77 .31
96.75	.39 .10	96.67	13.52 .28
102.2	-.04 .19	102.1	14.40 .45
107.45	-.06 .18	107.37	11.35 1.17

Table XIV

$$^{12}\text{C}(\overset{6}{\text{Li}}, \text{alpha})^{14}\text{N}$$
, final state 9.39 MeV, 2⁻

θ [deg]	Asymmetry \pm Error		Cross-sec. \pm Error	
			[arbitrary unit]	
20.8	.019	.064	11.45	.33
27.6	.197	.068		
34.4	-.189	.055	7.84	.26
41.2	-.364	.082	4.98	.25
47.8	-.320	.102	3.30	.23
54.4	-.167	.080	3.74	.21
60.9	-.123	.077	3.66	.19
67.3	.131	.084	3.70	.22
73.5	.047	.095	2.79	.17
79.6	.270	.074	3.40	.17
85.5	.350	.063	3.58	.17
91.3	.350	.089	2.66	.18
97.0	.197	.107	1.77	.13
102.4			1.91	.48
107.7			3.23	.39

Table XV

$^{12}\text{C}(^{6}\text{Li}, \alpha)^{14}\text{N}$, final
state 9.70 MeV, 1^+

Table XVI

$^{12}\text{C}(^{6}\text{Li}, \alpha)^{14}\text{N}$

final states

10.06 MeV and 10.10 MeV

Θ [deg]	Asymmetry	\pm Error	Θ [deg]	Asymmetry	\pm Error
20.8	.070	.060	20.9	.059	.113
27.7	.047	.070	27.8	-.126	.078
34.5	.058	.056	34.7	-.175	.063
41.3	.175	.122	41.5	-.102	.082
48.0	-.096	.093	48.2	.117	.109
54.6	-.374	.079	54.8	.051	.096
61.1	-.283	.105	61.4	.024	.079
67.5	.139	.099	67.8	.099	.071
73.7	.129	.080	74.1	.085	.078
79.8	.030	.079	80.2	-.099	.082
85.8	.239	.145	86.2	-.240	.098
91.6	.354	.173	92.0	.050	.108
97.3	.114	.102	97.6	-.055	.097
102.7	-.197	.196	103.1	-.286	.103

Table XVII

$$^{12}\text{C}(\overset{\rightarrow}{^6\text{Li}}, \text{alpha}) ^{14}\text{N}, \text{final state } 10.81 \text{ MeV}, 4^+$$

θ [deg]	Asymmetry \pm Error	Cross-sec. \pm Error [arbitrary unit]
21.1	.034	.143
28.1	.125	.097
35.0	.017	.086
41.9	.086	.110
48.6	.248	.112
53.3	.409	.030
61.9	.128	.067
68.3	.094	.031
74.7	.189	.083
80.9	.268	.078
89.9	.258	.099
92.7	.143	.107
98.4	.298	.159

α - INDUCED REACTIONS ON ^{155}Gd
TARGET IN THE ENERGY RANGE 47 MeV - 130 MeV

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This paper presents tables containing a complete list of energies and intensities of gamma transitions observed in α - induced reactions with ^{155}Gd target in the energy range between 47 MeV and 130 MeV. Enriched, self supporting metallic target of ^{155}Gd was bombarded with alpha particles from the 280 cm diameter AVF Groningen cyclotron. The gamma - ray spectra obtained in the experiments were analysed with the code "SAMPO" on the "CYBER 72" CDC computer in Swierk. The gamma - ray intensities are normalized to those of the KX- rays of the target atoms. The intensity values given represent therefore cross - sections for gamma - ray production in mb units. The internal conversion is not included. The errors of each value include the uncertainties of the fit for individual gamma lines and the detection efficiency. The overall uncertainty of the normalizing factor, estimated to be about 10 %, should be added to the error value of each cross - section entry.

The details of experimental procedure and of the error analysis are given in Ref. 41.

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Energy of gamma transition	Alpha particles bombarding energy			xn	Assignment	Ref.
	E (keV)	47 MeV	56 MeV			
1	2	3	4	5	6	7
53.13	180. \pm 10.	410. \pm 10			^{73m}Ge	8
60.0			670. \pm 90.			
65.8	39.4 \pm 2.9	97.9 \pm 4.7		p3n	^{155}Tb , $5/2^+ \rightarrow 3/2^+$ [411]. ^{73m}Ge , ^{157}Dy ,	13 8,37
69.8	31.4 \pm 2.7					
72.4	223.4 \pm 7.6	216.7 \pm 7.6	80. \pm 15.		Pb, K α_1	40
74.4	270.0 \pm 10.	470. \pm 20.	190. \pm 20.		Pb, K α_2	40
75.5			350. \pm 40.	6n	^{153}Dy , $13/2^+ \rightarrow 11/2^-$	17
84.2	14. \pm 5. ^R)	31.8 \pm 2.3 ^R)			Pb, K β_1	40
86.5	70.1 \pm 4.9	54.7 \pm 4.9	60. \pm 10.	2n	^{157}Dy , $7/2^- \rightarrow 5/2^-$ [521]	10
				4n	^{155}Dy , $7/2^- \rightarrow 3/2^-$ [521]	11
90.0	17.0 \pm 1.5		220. \pm 20.		^{27}Al (n, α) ^{24}Na	8
					^{155}Tb , $7/2^+ \rightarrow 5/2^+$	13
92.6	26.5 \pm 1.8		130. \pm 20.			
104.8	10. \pm 1.	20.8 \pm 2.3				
108.9	8.4 \pm 1.	18.1 \pm 1.6			^{157}Tb	13

1	2	3	4	5	6	7	8
110.0			290. \pm 10.		impurity, ^{19}F (n, n')		
114.0	4.2 \pm 1.2 ^R	6.0 \pm 2.					
117.3		8.2 \pm 2.2					
122.8	20.1 \pm 1.1	31.4 \pm 3.4 ^R	56.6 \pm 9.3		$^{154}\text{Gd}, 2^+ \rightarrow 0^+$	15	
125.2		13.1 \pm 6.5			^{157}Tb	13	
137.3	224.0 \pm 7.0	122.7 \pm 4.4	110. \pm 10.	3n	$^{156}\text{Dy}, 2^+ \rightarrow 0^+$	12	
139.6	42. \pm 2. ^R)	55.5 \pm 2.8 ^R)	97.0 \pm 10. ^R)		$^{155}\text{Tb}, 19/2^- \rightarrow 17/2^-, 75^m\text{Ge},$	13,8	
146.8	18.6 \pm 1.1	24.5 \pm 2.2	30.2 \pm 9.4	2n	$^{157}\text{Dy}, 7/2^- \rightarrow 3/2^-$	10	
				4n	$^{155}\text{Dy}, 11/2^- \rightarrow 7/2^-$	11	
				p5n	$^{153}\text{Tb}, 3/2^+ \rightarrow 5/2^+$	18	
153.6	3.7 \pm 1.			3n	$^{156}\text{Dy}, 2^+ \rightarrow 0_1^+$	12	
157.2		8.5 \pm 1.4		p3n	$^{155}\text{Tb}, 13/2^- \rightarrow 11/2^- [532]$	13	
160.5	5.0 \pm 1.	7.2 \pm 1.3					
162.3			55.7 \pm 9.2				
166.4		3.3 \pm 1.5 ^R)			$^{155}\text{Tb}, 13/2^+ \rightarrow 11/2^+ [411]$	13	
170.7		11.7 \pm 1.7	39.0 \pm 8.6		$^{27}\text{Al}(n, n')$	8	
175.0	19.1 \pm 1.4	13.9 \pm 2.5 ^R)		2n	$^{155}\text{Tb}, 15/2^+ 13/2^+ 411$	13	
176.		8.2 \pm 2.6 ^R)			$^{157}\text{Dy}, 13/2^- 11/2^-, 71^m\text{Ge}$	8,10	
184.2		43.6 \pm 3.4	220. \pm 20.		$^{16}\text{O}(\alpha, pn)^{18}\text{F}, 155\text{Tb}, 7/2^- \rightarrow 5/2^+$	13	
185.6	21.7 \pm 1.3	13.2 \pm 2.9	30. \pm 15.		$^{65}\text{Cu}(n, \gamma)^{66}\text{Cu}$	8	
191.5	10.7 \pm 1.	8.3 \pm 2.		4n	$^{155}\text{Dy}, 11/2^- \rightarrow 7/2^- [521]$	11	
196.9	40.4 \pm 3.5	56.8 \pm 3.5	61.6 \pm 4.2	2n	$^{157}\text{Dy} 15/2^- \rightarrow 13/2^- [505]$		
					$17/2^+ \rightarrow 15/2^+$		
					$9/2^- \rightarrow 5/2^- ; 71^m\text{Ge}$	10,8	

1	2	3	4	5	6	7
198.4	33.3 ± 2.7	47.8 ± 3.6	$190. \pm 30.$			
202.3	102.3 ± 4.7	83.2 ± 2.9		4n	$^{155}\text{Tb}, 19/2^+ \rightarrow 17/2^+$ [411]	13
					$^{155}\text{Dy}, 13/2^- \rightarrow 11/2^-$ [505]	11
211.0		11.9 ± 1.8				
213.0	6.6 ± 1.2			2n	$^{157}\text{Dy}, 17/2^- \rightarrow 15/2^-$ [505]	10
219.6	$20. \pm 2.$	45.8 ± 2.4	$50. \pm 9.$			
221.3	$44. \pm 2.4$			4n	$^{155}\text{Dy}, 15/2^- \rightarrow 13/2^-$ [505]	11
227.0	$340. \pm 10.^R$	$520. \pm 20.^R$	$230. \pm 20.^R$	p3n	$^{155}\text{Tb}, 5/2^- \rightarrow 3/2^+$	13
					$^{155}\text{Dy}, 17/2^+ \rightarrow 13/2^+$	11
235.0	3.4 ± 1.4	6.9 ± 1.7		2n	^{157}Dy	10
238.6	29.5 ± 1.6	41.0 ± 2.0	$40. \pm 10.$	p3n	$^{155}\text{Tb}, 13/2^- \rightarrow 9/2^-$ [532]	13
				4n	$^{155}\text{Dy}, 17/2^- \rightarrow 15/2^-$	11
243.4		19.6 ± 1.5	$52. \pm 12.$			
247.6	28.2 ± 1.5	42.0 ± 1.9			$^{154}\text{Gd}, 4^+ \rightarrow 2^+$; ^{156}Dy	15,12
253.2	17.2 ± 3.3	55.7 ± 2.6		p3n	$^{155}\text{Tb}, 11/2^+ \rightarrow 7/2^+$	13
254.7	28.5 ± 3.3				$^{153}\text{Tb}, 7/2^+ \rightarrow 5/2^+$ [402]	
				4n	$^{155}\text{Dy}, 19/2^- \rightarrow 17/2^-$	11
266.5	$320. \pm 20.$	152.4 ± 8.2	$122. \pm 15.$	3n	$^{156}\text{Dy}, 4^+ \rightarrow 2^+$	12
267.8		19.2 ± 2.7				
275.2		7.9 ± 2.5	$27.0 \pm 13.$	p3n	$^{155}\text{Tb}, 15/2^- \rightarrow 11/2^-$ [532]	13
280.9	10.8 ± 1.4	11.4 ± 1.7^R		3n	^{156}Dy	12
289.4	7.5 ± 1.5					
291.7	10.8 ± 2.1	12.2 ± 2.0		2n	$^{157}\text{Dy}, 13/2^- \rightarrow 9/2^-$	
296.9	15.7 ± 1.9	20.1 ± 2.4	$130. \pm 15.$	4n	$^{155}\text{Dy}, 13/2^- \rightarrow 9/2^-$ [521]	11
				3n	^{156}Dy	12

1	2	3	4	5	6	7
298.8			20. \pm 13.			
300.0		9.9 \pm 2.3		3n	^{156}Dy	37
303.1			23.2 \pm 12.8			
308.2			90. \pm 10.			
310.9	16.1 \pm 1.5	9.7 \pm 2.3		2n	^{157}Dy , $21/2^+ \rightarrow 17/2^+$	10
314.9			50. \pm 15.			
319.6	17.6 \pm 1.8	7.4 \pm 2.5				
325.5	24.6 \pm 1.2	20.3 \pm 3.2			^{157}Tb	13
332.1	34.8 \pm 2.9			2n	^{157}Dy	10
334.4	10.8 \pm 1.6 ^R)	430. \pm 30. ^R)	940. \pm 50.	5n	^{154}Dy , $2^+ \rightarrow 0^+$	11
338.4	25.1 \pm 2.4					
339.8	50.0 \pm 4.0			p3n	^{155}Tb , $15/2^+ \rightarrow 13/2^+$ [411]	13
344.2		22.3 \pm 4.7 ^R)		4n	^{155}Dy , $15/2^+ \rightarrow 11/2^+$	11
348.9	15.7 \pm 1.9			2n	^{157}Dy , $15/2^- \rightarrow 11/2^-$ [521]	37
				3n	^{156}Dy , $6_1^+ \rightarrow 4_1^+$	12
352.2	24.4 \pm 2.4	25.0 \pm 2.7		4n	^{155}Dy	11
359.5	34.3 \pm 3.6		30. \pm 15.	3n	^{156}Dy , $14_1^+ \rightarrow 12_1^+$	12,37
363.1	250. \pm 20.	270.0 \pm 20.	220.0 \pm 20.	3n	^{156}Dy , $8^+ \rightarrow 6^+$	12,37
				4n	^{155}Dy , $21/2^+ \rightarrow 17/2^+$	11
366.3	230. \pm 20.	130. \pm 10.	110. \pm 20.	3n	^{156}Dy , $6^+ \rightarrow 4^+$	12,37
374.3	7.7 \pm 17.					
381.7		21.5 \pm 3.0				
389.6	11.6 \pm 2.4	30.3 \pm 3.2 ^R)	1100. \pm 60.		^{71}Ga (n, n')	8
391.7	27.4 \pm 3.7			3n	^{156}Dy , $12_1^+ \rightarrow 10_1^+$	12,37
405.7	17. \pm 2.	43.4 \pm 4.4		5n	^{154}Dy , $6_1^+ \rightarrow 4_1^+$	11

1	2	3	4	5	6	7
411.8	16.1 ± 2.2	$360. \pm 30.$	$910. \pm 60.$	5n	$^{154}\text{Dy}, 4^+ \rightarrow 2^+$	11
413.3	5.8 ± 2.0				$^{152}\text{Gd}, 4^+ \rightarrow 2^+$	16
415.5		58.8 ± 7.6			$^9\text{Be} (\text{d}, \text{n}) ^{10}\text{B}$	8
417.3	12.4 ± 1.9		$1500. \pm 80.$			
420.5		8.4 ± 4.0		3n	$^{156}\text{Dy}, 8^+ \rightarrow 6^+$	12
422.3	39.8 ± 4.4	22.3 ± 8.0		4n	$^{155}\text{Dy}, 15/2^- \rightarrow 11/2^-$	11
424.7	$65.7 \pm 5.9^R)$	43.4 ± 7.9		3n	$^{156}\text{Dy}, 2_1^+ \rightarrow 4^+$	12
					$^{157}\text{Dy}, 19/2^- \rightarrow 15/2^- [521]$	
					$^{154}\text{Gd}, 8^+ \rightarrow 6^+$	15
432.4	33.4 ± 3.8	21.6 ± 3.2		3n	$^{156}\text{Dy}, 8^+ \rightarrow 6^+$	12
435.5		21.7 ± 3.0	$240. \pm 20.$			
438.6		79.7 ± 6.9	$520. \pm 40.$		$^{23}\text{Na} (\text{n}, \text{n}')$	8
440.4	43.3 ± 4.2		$1700. \pm 90.$			
445.0	$320. \pm 30.$	$100. \pm 10.$		3n	$^{156}\text{Dy}, 8^+ \rightarrow 6^+$	12
451.6	12.6 ± 2.3		$150. \pm 40.$	3n	^{156}Dy	12
455.2	10.1 ± 2.5	15.2 ± 2.2				
457.4	36.9 ± 3.6			3n	$^{156}\text{Dy}, 10_1^+ \rightarrow 8_1^+$	12
464.3	$150. \pm 10.$	$230. \pm 20.$	$150. \pm 20.$	4n	$^{155}\text{Dy}, 25/2^+ \rightarrow 21/2^+$	11
470.7		40.7 ± 6.1				
472.7			$490. \pm 30.$		$^{155}\text{Tb}, 27\text{Al} (\text{n}, \alpha) ^{24}\text{Na}$	13,8
476.5	15.6 ± 2.1	$290. \pm 20.$	$820. \pm 50.$	5n	$^{154}\text{Dy}, 6^+ \rightarrow 4^+$	11
478.4		19.3 ± 3.7			$^{10}\text{B} (\text{n}, \alpha) ^7\text{Li}$	8
480.2	14.8 ± 2.2					
484.7		4.9 ± 2.4			^{155}Tb	13

1	2	3	4	5	6	7
491.5	12.9 ± 1.9	25.9 ± 3.6	$50. \pm 25.$	3n	$^{156}\text{Dy}, 10^+_1 \rightarrow 8^+_1$	12
493.6	27.0 ± 3.0			4n	$^{154}\text{Gd}, 10^+ \rightarrow 8^+$	15
					$^{155}\text{Dy}, 19/2^- \rightarrow 15/2^-$ [505]	12
499.5	14.6 ± 2.5	20.0 ± 3.4				
502.6		48.3 ± 6.1				
511.0						
518.7		38.4 ± 7.9			^{155}Tb	13
520.8	30.3 ± 3.6		$130. \pm 25.$		$^{155}\text{Tb}; ^{156}\text{Dy}, 11^+_1 \rightarrow 9^+_1$	13,12
523.4	12.7 ± 3.7	$220. \pm 20.$ R	$660. \pm 40.$	5n	$^{154}\text{Dy}, 8^+ \rightarrow 6^+$	11
527.5	8.3 ± 2.7					
533.1			$52.4 \pm 22.$			
536.9	26.5 ± 2.9	32.8 ± 3.5		3n	$^{156}\text{Dy}, 0^+_1 \rightarrow 0^+$	12
544.5	86.5 ± 7.9	144.7 ± 13.0		4n	$^{155}\text{Dy}, 29/2^+ \rightarrow 25/2^+$	11
547.5	3.8 ± 1.8	27.8 ± 5.0				
550.4	28.6 ± 3.2					
557.3	53.4 ± 5.4	$160. \pm 20.$	$560. \pm 130.$	5n	$^{154}\text{Dy}, 10^+ \rightarrow 8^+$	11
559.8	78.9 ± 7.6	22.6 ± 5.6	$1160. \pm 140.$			
563.4		$90. \pm 9.$				
570.8	41.9 ± 4.5	9.8 ± 4.7			^{155}Tb	13
576.6		32.3 ± 5.5	$100. \pm 20.$			
579.1						
583.2	20.8 ± 2.6	69.9 ± 8.4	$910. \pm 70.$	3n,5n	$^{156}\text{Dy}; ^{154}\text{Dy}, 18^+ \rightarrow 16^+$	12,11
586.0		61.3 ± 8.6	$2200. \pm 100.$	5n	$^{154}\text{Dy}, 12^+ \rightarrow 10^+$	
594.8		$100. \pm 10.$				

1	2	3	4	5	6	7
597.0	66.2 ± 8.1		$80. \pm 40.$	5n	$^{74}\text{Ge} (\text{n},\text{n}')$; $^{154}\text{Dy}, 16^+ \rightarrow 14^+$	11
602.4	62.3 ± 7.8		$230. \pm 40.$	3n	$^{156}\text{Dy}, 14^+ \rightarrow 12^+$	12
610.9	10.7 ± 3.3				$^{74}\text{Ge} (\text{n},\text{n}')$	8
614.1		51.3 ± 6.7				
616.3	11.6 ± 2.9		$150. \pm 30.$	5n	$^{154}\text{Dy}, 14^+ \rightarrow 12^+$	11
621.1	16.8 ± 4.2	15.5 ± 3.4				
624.1	$16.5 \pm 3.0^R)$					
636.1	$21.5 \pm 2.8^R)$		$120. \pm 30.$			
643.4	9.0 ± 2.3			3n	$^{156}\text{Dy}, 8_1^+ \rightarrow 8^+$	12
652.4		36.4 ± 4.7	$250. \pm 30.$			
655.1	$17.4 \pm 2.4^R)$					
662.0		9.5 ± 3.1				
668.0	16.3 ± 2.6	$14.6 \pm 24.$		3n	$^{156}\text{Dy}, 6_1^+ \rightarrow 6^+$	12
670.6	$10.2 \pm 2.2^R)$					
672.3		40.8 ± 5.1				
675.6		22.8 ± 5.0				
684.6	17.1 ± 2.6			3n	$^{156}\text{Dy}, 4_1^+ \rightarrow 4^+$	12
693.6	66.8 ± 7.3		$660. \pm 60.$		$^{72}\text{Ge} (\text{n},\text{n}')$	8
708.6	16.8 ± 3.0		$200. \pm 40.$			
724.0						
738.6	13.9 ± 2.0	21.9 ± 3.5				
746.4	4.8 ± 2.0					
756.1			$300. \pm 30.$			
770.8	6.2 ± 1.8					

1	2	3	4	5	6	7
772.5			90. ± 30.			
783.4	4.4 ± 1.9	17.8 ± 3.2				
802.5	100. ± 10.	130. ± 10.				
806.1	36.2 ± 9.4	20.8 ± 5.0				
816.9		14.6 ± 2.6				
832.1	2.7 ± 2.2	29.0 ± 4.7				
836.1	15.7 ± 3.0	20.5 ± 5.5	190. ± 50.			
841.7		80. ± 10.				
844.4	24.5 ± 5.0	57.6 ± 7.5	930. ± 80.	$^{27}\text{Al} (\text{n},\text{n}')$	8	
847.6	70. ± 10.			$^{56}\text{Fe} (\text{n},\text{n}')$	8	
863.9			60. ± 30.			
865.9	19.2 ± 2.9	16.4 ± 3.6				
869.3	18.0 ± 2.7					
878.5		29.5 ± 4.4				
881.9	11.6 ± 2.4			^{156}Dy		12
884.7		8.4 ± 3.6		^{156}Dy , $3^+ \rightarrow 2^+$		12
888.5		16.8 ± 4.2				
890.7			690. ± 50.	^{156}Dy , $2^+ \rightarrow 0^+$		12
895.3		35.6 ± 7.1				
897.1		22.1 ± 6.6				
899.0	27.9 ± 3.3					
959.4	18.9 ± 2.6	41.0 ± 6.1				
975.0	7.5 ± 2.5 ^{R)}		1300. ± 120.	^{156}Dy , $9^+ \rightarrow 8^+$		12
989.0	15.6 ± 3.7	28.4 ± 4.5				
1006.9	8.0 ± 2.4					

1	2	3	4	5	6	7
1014.4	67.9 ± 7.5	$130. \pm 10.$	$1700. \pm 100.$		$^{27}\text{Al}(\text{n},\text{n}'')$	8
1040.6	47.4 ± 7.1			3n	$^{70}\text{Ge} (\text{n},\text{n}'')$; ^{156}Dy , $7^- \rightarrow 6^+$	8,12
1043.5	26.5 ± 9.0					

Energy of gamma transition	Alpha particles bombarding energy			xn	Assignment	Ref.	
	67 MeV	71 MeV	80 MeV				
E (keV)	1	2	3	4	5	6	7
60.9	20.6 ± 2.9					157Dy, 5/2 ⁻ → 3/2 ⁺ [521]	10
65.9	29.7 ± 3.6	32. ± 3.5				155Tb, 5/2 ⁺ → 3/2 ⁺ ; 157Dy	13,10
67.7	12.8 ± 4.0						
70.3	11.4 ± 3.6	23.4 ± 4.0					
73.1	10.5 ± 3.7	26.3 ± 3.1			4n	155Dy	11
75.7	100. ± 4.	196. ± 5.	196. ± 6.		6n	153Dy, 13/2 ⁺ → 11/2 ⁻	30
80.9	53.7 ± 2.4	75.3 ± 2.9	45. ± 4.			153Tb, 7/2 ⁺ → 5/2 ⁺ ;	18
						155Tb, 11/2 ⁻ → 9/2 ⁻	13
83.5	13.6 ± 2.4	22.8 ± 2.3	25.3 ± 3.8			153Tb, 11/2 ⁻ → 7/2 ⁺ ;	
						153Gd, 3/2 ⁺ → 3/2 ⁻	18
86.6	11.2 ± 0.6	5.3 ± 0.3	41. ± 3.7	2n		157Dy, 7/2 ⁻ → 5/2 ⁻ [521]	
						155Dy, 5/2 ⁻ → 3/2 ⁻ [521]	11
90.6	19.2 ± 1.9	21.5 ± 2.8	22.5 ± 2.8				
97.6	6.1 ± 0.3	8.3 ± 2.2	9.6 ± 2.0				
100.0	39.6 ± 2.0	43.4 ± 2.2				153Tb, 9/2 ⁻ → 11/2 ⁻	18
102.9	9.3 ± 2.5	10.1 ± 2.0		4n		155Dy, 11/2 ⁻ → 13/2 ⁺ ;	11
						153Gd, 3/2 ⁺ → 5/2 ⁻	18
105.6	9.0 ± 3.8	11.1 ± 2.2					

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1	2	3	4	5	6	7
108.5	31.6 ± 2.5	33.8 ± 2.4	8.8 ± 1.9		$^{153}\text{Gd}, 5/2^- \rightarrow 3/2^-$	18
115.7	12.3 ± 1.9	8.1 ± 2.2	13.5 ± 2.2			
118.7	27.0 ± 1.6	20.0 ± 2.0	$30. \pm 2.0$		$^{155}\text{Tb}, 15/2^- \rightarrow 13/2^-$	13
123.2	68.4 ± 1.4	64.7 ± 1.9	37.6 ± 1.9		$^{154}\text{Gd}, 2^+ \rightarrow 0^+$	15
133.9		21.0 ± 1.9	$17. \pm 2.$		$^{155}\text{Tb}, 11/2^+ \rightarrow 9/2^+$	13
137.9	41.8 ± 7.5	35.4 ± 2.5	17.3 ± 2.6	4n,3n	$^{156}\text{Dy}, 2^+ \rightarrow 0^+ ; ^{155}\text{Dy}, 11/2^- \rightarrow 9/2^+$	12,11
139.7	14.8 ± 7.4	28.7 ± 2.4	13.0 ± 2.7		$^{75m}\text{Ge}, ^{155}\text{Tb}, 19/2^- \rightarrow 17/2^-$	8,13
140.9	$10. \pm 4.$					
143.0	5.0 ± 3.4		7.8 ± 4.6	2n	$^{157}\text{Dy}, 11/2^- \rightarrow 9/2^- [521]$	10
147.1	$35. \pm 15.$	25.7 ± 2.3	15.9 ± 2.4	3n	$^{153}\text{Tb}, 3/2^+ \rightarrow 5/2^+ ; ^{156}\text{Dy}, 4^+ \rightarrow 3^+$	18,12
				4n,2n	$^{155}\text{Dy}, 11/2^- \rightarrow 7/2^- ; ^{157}\text{Dy}, 7/2^- \rightarrow 3/2^-$	11,10
151.7			5.5 ± 0.8			
154.2		10.6 ± 1.6	$12. \pm 1.1$	3n.	$^{156}\text{Dy}, 2^+ \rightarrow 0^+$	12
157.3		7.2 ± 1.5	5.6 ± 1.7		$^{155}\text{Tb}, 13/2^- \rightarrow 11/2^-$	13
162.0		24.2 ± 1.7	6.4 ± 1.4		impurity	8
163.6			7.8 ± 1.9			
167.0		22.1 ± 2.0	14.3 ± 9.0		$^{155}\text{Tb}, 13/2^+ \rightarrow 11/2^+$	13
169.0	21.0 ± 5.0	54.7 ± 2.9	29.8 ± 7.1		$^{27}\text{Al}(n,n')$	8
170.8	$17. \pm 5.$	20.0 ± 3.0	13.4 ± 5.8		$^{155}\text{Tb}, 15/2^+ \rightarrow 13/2^+ ; ^{153}\text{Gd}, 3/2^+ \rightarrow 3/2^-$	13,18
175.7	4.0 ± 0.3	16.2 ± 2.4			$^{71m}\text{Ge} ; ^{157}\text{Dy}, 13/2^- \rightarrow 11/2^- [505]$	8,10
180.6	15.7 ± 1.9	12.1 ± 2.2	7.7 ± 2.4			
184.3	137.2 ± 2.0	16.0 ± 0.3	74.2 ± 3.0		$^{16}_0(\alpha, pn)^{18}\text{F} ; ^{155}\text{Tb}, 7/2^- \rightarrow 5/2^+$	13
189.5	10.3 ± 1.8	8.5 ± 2.8			$^{153}\text{Tb}, 9/2^+ \rightarrow 7/2^+ [402]$	32
191.9	13.0 ± 1.8			4n	$^{155}\text{Dy}, 11/2^- \rightarrow 7/2^- [521]$	11

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	1	2	3	4	5	6	7
				4.7 ± 2.4			
194.0							
197.3	26.1 ± 2.6	29.3 ± 3.7	17.1 ± 3.2		2n	$^{71m}\text{Ge}; ^{157}\text{Dy}$, $9/2^- \rightarrow 5/2^+$ [521]	
						$15/2^- \rightarrow 13/2^-$ [505]	
						$17/2^+ \rightarrow 15/2^+$	8,10
199.0	19.8 ± 2.6	37.1 ± 3.7	35.1 ± 3.5				
202.4	16.2 ± 1.8	15.9 ± 2.2	18.1 ± 3.2		4n	^{155}Dy , $13/2^- \rightarrow 11/2^-$ [505]	11
204.6		6.2 ± 2.0	12.5 ± 3.7			^{153}Tb , $11/2^+ \rightarrow 9/2^+$ [404]	32
209.2	4.9 ± 1.6		8.0 ± 3.4			^{155}Tb , $9/2^+ \rightarrow 5/2^+$	13
211.7	33.0 ± 2.0	61.5 ± 2.5	13.1 ± 3.9			^{155}Tb , $17/2^+ \rightarrow 15/2^+$	13
						^{153}Gd , $3/2^+ \rightarrow 3/2^-$	13,18
213.8	$27. \pm 2.$	45.3 ± 2.5	27.7 ± 3.6			^{157}Dy , $17/2^- \rightarrow 15/2^-$ [505]	10
218.0	$15. \pm 3.$	14.4 ± 2.7	$9. \pm 4.$			^{153}Tb , $13/2^+ \rightarrow 11/2^+$ [402]	32
221.1	9.4 ± 2.2	11.2 ± 2.5	8.5 ± 3.6		4n	^{155}Dy , $15/2^- \rightarrow 13/2^-$ [505]	11
227.2	174.1 ± 2.6	144.1 ± 2.9	75.0 ± 3.7		4n	^{155}Dy , $17/2^+ \rightarrow 13/2^+$; ^{155}Tb , $5/2^- \rightarrow 3/2^+$	11,13
						^{153}Gd , $17/2^+ \rightarrow 13/2^+$	18
229.8			8.8 ± 3.2			^{155}Tb , $23/2^+ \rightarrow 21/2^+$	13
235.5	4.4 ± 3.6				2n	^{157}Dy	10
238.3	21.6 ± 3.4	18.0 ± 2.3	12.3 ± 3.0			^{155}Tb , $13/2^- \rightarrow 9/2^-$	13
243.9	36.9 ± 2.3	40.6 ± 3.4	28.3 ± 3.1			^{155}Tb , $17/2^- \rightarrow 13/2^-$; ^{153}Tb , $9/2^+ \rightarrow 7/2^+$	13,32
248.0	61.2 ± 2.4	49.1 ± 3.4	35.7 ± 3.9			^{154}Gd , $4^+ \rightarrow 2^+$	15
249.7	18.9 ± 5.5					^{155}Tb , $21/2^+ \rightarrow 19/2^+$	13
251.9	50.4 ± 5.5						
253.7	53.5 ± 5.3	43.7 ± 3.9	59.7 ± 4.8	6n		^{153}Dy , $13/2^- \rightarrow 11/2^-$; ^{153}Tb , $7/2^+ \rightarrow 5/2^+$	11,18,32
256.7	36.0 ± 7.2	91.1 ± 3.6	27.1 ± 4.3				
262.5	12.6 ± 2.6	18.1 ± 3.4	16.7 ± 4.0	6n		^{153}Dy , $15/2^- \rightarrow 13/2^-$	11

	1	2	3	4	5	6	7
266.5	56.2 ± 2.2	63.7 ± 4.4	28.8 ± 4.3		$3n$	$^{156}\text{Dy}, 4^+ \rightarrow 2^+$ $^{152}\text{Gd}, 0_1^+ \rightarrow 2^+$; $^{155}\text{Tb}, 5/2^+ \rightarrow 3/2^+$	12 16
271.0	39.1 ± 2.3	23.6 ± 2.4					
273.0	5.4 ± 2.3						
274.9	24.3 ± 2.0	31.7 ± 1.9				$^{155}\text{Tb}, 15/2^- \rightarrow 11/2^-$	13
277.7		11.9 ± 1.9			$6n$	$^{153}\text{Dy}, 17/2^- \rightarrow 15/2^-$; ^{152}Tb	30, 16
283.6	$8. \pm 4.$		14.9 ± 2.8			$^{152}\text{Tb}, 4^- \rightarrow 2^-$	16
287.4	25.2 ± 6.3	11.1 ± 2.0					
290.8		11.7 ± 2.3			$6n, 2n$	$^{153}\text{Dy}, 19/2^- \rightarrow 17/2^-$; $^{157}\text{Dy}, 13/2^- \rightarrow 9/2^-$	30, 10
292.4	4.9 ± 0.3						
296.0	44.5 ± 2.7	89.5 ± 1.9	78.5 ± 3.4		$4n$	$^{155}\text{Dy}, 13/2^- \rightarrow 9/2^-$ [521]	10
					$6n$	$^{153}\text{Dy}, 9/2^- \rightarrow 7/2^-$	18
301.7		13.6 ± 2.0	9.3 ± 3.4		$6n$	$^{153}\text{Dy}, 21/2^- \rightarrow 19/2^-$ $^{155}\text{Tb}, 13/2^+ \rightarrow 9/2^+$	18 13
312.8	5.8 ± 1.3						
315.2	23.4 ± 7.0	17.7 ± 3.5	14.0 ± 3.5			$^{152}\text{Gd}, 2_1^+ \rightarrow 0_1^+$	16
320.8			10.7 ± 3.7			$^{155}\text{Tb}, 21/2^- \rightarrow 19/2^-$	13
327.5		24.4 ± 3.4	31.3 ± 4.4		$6n$	$^{157}\text{Dy} \rightarrow 157\text{Tb}; ^{153}\text{Dy}$	13, 30
334.5	$515. \pm 5.0$	$420. \pm 6.0$	$180. \pm 6.$		$5n$	$^{154}\text{Dy}, 2^+ \rightarrow 0^+$	11
338.0	25.6 ± 2.8					$^{155}\text{Tb}, 15/2^+ \rightarrow 11/2^+$	13
340.1	22.5 ± 2.8						
344.4	$290. \pm 4.$	$150. \pm 6.$	26.5 ± 5.0	$(\alpha, \alpha 3n)$		$^{152}\text{Gd}, 2^+ \rightarrow 0^+$	16
347.3	46.3 ± 2.8	25.4 ± 5.0	64.6 ± 4.5	$(\alpha, \alpha n)$		$^{154}\text{Gd}, 6^+ \rightarrow 4^+$	15
352.1	20.7 ± 2.2	18.2 ± 3.6	18.3 ± 3.8		$4n$	$^{152}\text{Gd}, 4^+ \rightarrow 2^+$; ^{155}Dy	16, 11
360.4			14.7 ± 4.1				

1	2	3	4	5	6	7
363.0	83.2 ± 2.5	73.8 ± 3.7	46.7 ± 4.2	4n	$^{155}\text{Dy}, 21/2^+ \rightarrow 17/2^+$; $^{153}\text{Gd}, 21/2^+ \rightarrow 17/2^+$	11, 18
364.4	43.1 ± 2.0	49.5 ± 3.5	38.8 ± 4.3	6n	$^{153}\text{Dy}, 19/2^+ \rightarrow 17/2^-$	30, 18
				3n	$^{156}\text{Dy}, 6^+ \rightarrow 4^+$	12
371.2	2.7 ± 1.9					
379.7	23.4 ± 2.0	$30. \pm 3.$				
383.2	31.9 ± 1.9	25.0 ± 3.2			$^{155}\text{Tb}, 17/2^+ \rightarrow 13/2^+$	13
394.8		5.6 ± 4.3				
397.9			21.9 ± 4.4			
401.7		$26. \pm 3.$	$44. \pm 5.$	6n	$^{153}\text{Dy}, 27/2^+ \rightarrow 23/2^+$	30
404.0	$16. \pm 6.$		$38. \pm 5.$	6n	$^{153}\text{Dy};$ $^{153}\text{Gd}, 15/2^- \rightarrow 11/2^-$	30 18
406.4	$42. \pm 20.$	$50. \pm 5.$	$23. \pm 5.$	5n	$^{154}\text{Dy}, 6_1^+ \rightarrow 4_1^+$	11
407.1	$23. \pm 1.$					
412.4	$490. \pm 5.$	$410. \pm 8.$	$210. \pm 7.$	5n	$^{154}\text{Dy}, 4^+ \rightarrow 2^+; ^{152}\text{Gd}, 4^+ \rightarrow 2^+$	11, 16
416.6	$25. \pm 3.$	$31. \pm 6.$				
431.2			15.5 ± 5.3			
433.3		$13. \pm 3.$				
438.8		$19. \pm 4.$	$15. \pm 5.$		$^{23}\text{Na} (\nu, n); ^{153}\text{Tb}, 15/2^+ \rightarrow 11/2^+ [404]$	8, 32
441.2	$7.0 \pm 3.$	$43. \pm 4.$	$50. \pm 4.$	6n	$^{153}\text{Dy},$	30
444.6	$24. \pm 4.$	$32. \pm 3.$		3n	$^{156}\text{Dy}, 8^+ \rightarrow 6^+$	12
447.7	$74. \pm 3.$	$164. \pm 4.$	$221. \pm 6.$	6n	$^{153}\text{Dy}, 17/2^+ \rightarrow 13/2^+;$ $^{153}\text{Tb}, 11/2^+ \rightarrow 7/2^+$	30, 18 32
454.4			$27. \pm 5.$		$^{153}\text{Tb}, 19/2^+ \rightarrow 15/2^+, 404$	32
456.7			25.0 ± 6.0			
461.7	$45. \pm 5.$	$49. \pm 4.$	$39. \pm 6.$	6n	$^{153}\text{Dy}, 23/2^+ \rightarrow 19/2^+$	30

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	1	2	3	4	5	6	7
464.5	74. \pm 5.	54. \pm 4.	23. \pm 6.	4n	^{155}Dy , $25/2^+ \rightarrow 21/2^+$	11	
467.1	18. \pm 5.		50. \pm 7.	3n	^{153}Gd , $25/2^+ \rightarrow 21/2^+$; ^{156}Dy , $9^+ \rightarrow 10^+$	18, 12	
471.9					^{152}Gd , $6^+ \rightarrow 4^+$	16	
471.9	50. \pm 5.	61. \pm 5.	37. \pm 6.		^{27}Al (n, α) ^{24}Na ; $23/2^- \rightarrow 19/2^-$	^{155}Tb , 8, 13	
474.2			26. \pm 6.				
476.9	426. \pm 7.	377. \pm 7.	164. \pm 6.	5n	^{154}Dy , $6^+ \rightarrow 4^+$; ^{153}Gd , $19/2^- \rightarrow 5/2^-$	11, 18	
480.8	35. \pm 4.	63. \pm 6.	81. \pm 6.	6n	^{153}Dy ; ^{155}Tb , $23/2^+ \rightarrow 19/2^+$	30, 13	
484.6	20. \pm 5.				^{155}Tb	13	
488.1	65. \pm 4.	112. \pm 7.	170. \pm 5.	6n	^{153}Dy , $21/2^+ \rightarrow 17/2^+$	30, 18	
491.1	1.8 \pm 1.5			3n	^{156}Dy , $10^+ \rightarrow 8^+$	12	
493.4	26. \pm 3.		63. \pm 5.	4n	^{154}Gd , $10^+ \rightarrow 8^+$; ^{155}Dy , $19/2^- \rightarrow 15/2^-$	[505] 15, 11	88
496.2	14. \pm 3.		17. \pm 5.	4n	^{155}Dy , $19/2^- \rightarrow 15/2^-$	11	
499.4	8. \pm 4.						
519.4	34. \pm 4.	25. \pm 6.	20. \pm 8.		^{155}Tb ; ^{152}Gd , $8^+ \rightarrow 6^+$	13, 16	
523.5	350. \pm 20.	317. \pm 9.	129. \pm 9.	5n	^{154}Dy , $8^+ \rightarrow 6^+$	11	
527.5	24. \pm 5.				^{152}Gd , $4^+ \rightarrow 4^+$	16	
532.1	40. \pm 13.	95. \pm 6.	104. \pm 8.	6n	^{153}Dy , $25/2^+ \rightarrow 21/2^+$	30	
541.0	45. \pm 6.	61. \pm 6.	67. \pm 6.	6n	^{153}Dy , $13/2^- \rightarrow 9/2^-$	30	
544.1	40. \pm 4.	32. \pm 5.	17. \pm 6.	4n	^{155}Dy , $29/2^+ \rightarrow 25/2^+$	11	
546.7	19. \pm 3.		23. \pm 8.		^{154}Gd	15	
552.2	14. \pm 4.		44. \pm 6.	6n	^{153}Dy	30	
554.0			30. \pm 6.	7n	^{152}Dy , $5^- \rightarrow 3^-$	17	
556.9	260. \pm 10.	203. \pm 8.	89. \pm 5.	5n	^{154}Dy , $10^+ \rightarrow 8^+$	11	

1	2	3	4	5	6	7
560.4	41. ± 4.	17. ± 6.	163. ± 5.	7n	^{152}Dy , $7^- \rightarrow 5^-$	17
				6n	^{153}Dy	30
563.4			40. ± 4.	7n	^{152}Dy , $9^- \rightarrow 7^-$; ^{76}Ge (n, n')	17,8
566.4			24. ± 5.			
570.0		12. ± 3.				
577.7	58.0 ± 3.	38. ± 3.	17. ± 6.			
581.7	74. ± 4.	87. ± 4.	87. ± 6.	6n	^{153}Dy , $29/2^+ \rightarrow 25/2^+$	30
586.1	44. ± 4.				^{152}Gd , $2^+ \rightarrow 2^+$	16
588.7	137. ± 4.	107. ± 4.	38. ± 6.	5n	^{154}Dy , $12^+ \rightarrow 10^+$	11
591.6	46. ± 4.	42. ± 4.	30. ± 6.	3n	^{156}Dy , $10_p^+ \rightarrow 10^+$	12
596.5	58. ± 3.	83. ± 5.	26. ± 7.		^{74}Ge (n, n')	8
602.2	17. ± 3.		20. ± 7.	3n	^{156}Dy , $14^+ \rightarrow 12^+$	12
604.7	24. ± 3.	16. ± 4.	52. ± 6.	4n	^{155}Dy , $33/2^+ \rightarrow 29/2^+$	11
609.8	12. ± 3.		44. ± 6.	7n	^{152}Dy ; ^{74}Ge (n, n')	17,8
612.8	27. ± 3.	32. ± 4.	165. ± 7.	7n	^{152}Dy , $2^+ \rightarrow 0^+$	17
616.0	106. ± 4.	91. ± 5.	37. ± 6.	5n	^{154}Dy , $14^+ \rightarrow 12^+$	11
617.9	17. ± 3.	28. ± 5.		6n, 3n	^{153}Dy , $17/2^- \rightarrow 13/2^-$; ^{156}Dy , $3^+ \rightarrow 4^+$	30,12
623.7	12. ± 6.					
626.9	23. ± 5.	37. ± 5.	35. ± 6.	6n	^{153}Dy , $33/2^+ \rightarrow 29/2^+$	30,18
630.4	19. ± 8.					
633.0	22. ± 5.					
636.8	188. ± 4.	333. ± 7.	417. ± 9.	6n	^{153}Dy , $11/2^- \rightarrow 7/2^-$	30
643.0	11. ± 3.			3n	^{156}Dy , $8_p^+ \rightarrow 8^+$	12
647.2			163.0 ± 7.0	7n	^{152}Dy , $4^+ \rightarrow 2^+$	17
650.2	17. ± 3.		24. ± 5.			

1	2	3	4	5	6	7
654.6	5.4 ± 0.4					
659.6	28. ± 3.	30. ± 3.	35. ± 5.			
664.4	12.1 ± 23					
668.9			35. ± 7.	6n	^{153}Dy	30
673.7	73. ± 3.	71. ± 4.	41. ± 6.	6n	^{153}Dy , $37/2^+ \rightarrow 33/2^+$	30
677.6	11. ± 3.					
683.8	10. ± 2.		95. ± 7.	7n	^{152}Dy , $6^+ \rightarrow 4^+$	17
692.7	5.4 ± 0.3				$^{72}\text{Ge} (n,n')$	8
694.6	39. ± 5.	88. ± 10.	59. ± 7.			
696.3	61. ± 6.		45. ± 7.			
713.7		9. ± 4.				
718.1		120. ± 4.	66. ± 5.		$^{10}\text{B} (n,n')$	8
728.4		27. ± 4.				
740.8		15. ± 4.		3n	^{156}Dy , $8^+_g \rightarrow 8^+$	12
745.6			16. ± 8.	7n	^{152}Dy	30, 17
747.6			13. ± 8.			
763.9		10. ± 3.				
772.2		16. ± 3.		6n	^{153}Dy , $11/2^- \rightarrow 9/2^-$	30
778.7	31. ± 3.	22. ± 3.				
810.5		27. ± 3.				
819.0		21.0 ± 3.0				
830.7	23. ± 7.					
834.8	124. ± 6.	112. ± 4.	40. ± 6.		$^{72}\text{Ge} (n,n')$	8
843.7		82. ± 4.	62. ± 6.		$^{27}\text{Al}(n,n')$	8
846.6		90. ± 4.	52. ± 7.		$^{56}\text{Fe} (n,n')$	8

1	2	3	4	5	6	7
850.0			24. \pm 7.			
867.8		19. \pm 4.			^{73}Ge (n,γ) ^{74}Ge	8
917.0		11. \pm 3.				
920.7	4.5 \pm 0.4					
925.2	6.3 \pm 0.3					
931.2	28. \pm 6.		10. \pm 7.		^{152}Gd , $2_1^+ \rightarrow 0^+$	16
936.9		137. \pm 5.	55. \pm 6.			
953.1		9. \pm 3.				
974.1		18. \pm 3.				
984.3		16. \pm 3.			^{27}Al ($n,p\gamma$) ^{27}Mg	8
1011.		20. \pm 4.				8
1014.3		130. \pm 5.	72. \pm 7.		^{27}Al (n,n')	8

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Energy of gamma transition	xn			Assignment	Ref.	
	80 MeV	84 MeV	90 MeV			
1	2	3	4	5	6	7
75.5	196. ± 6.	193. ± 6.	77. ± 3.	6n	^{153}Dy , $13/2^+ \rightarrow 11/2^-$	18
80.8	45. ± 4.	56. ± 3.	80. ± 10.		^{155}Tb , $11/2^- \rightarrow 9/2^-$; ^{153}Tb , $7/2^+ \rightarrow 5/2^+$	13, 18
83.5	25.3 ± 3.8	31. ± 3.			^{153}Tb , $11/2^- \rightarrow 7/2^+$	18
86.4	41.0 ± 3.7	53. ± 3.		2n	^{157}Dy , $7/2^- \rightarrow 5/2^-$ [521]	10
				4n	^{155}Dy , $5/2^- \rightarrow 3/2^-$ [521]	11
90.3	22.5 ± 3.6	20. ± 4.	72. ± 5.		$^{27}\text{Al}(n, \alpha)^{44}\text{Na}$; ^{155}Tb , $7/2^+ \rightarrow 5/2^+$	8, 13
93.3			84. ± 5.		^{153}Tb , $5/2^+ \rightarrow 3/2^+$; ^{153}Gd	18
95.7	9.6 ± 2.0	26. ± 2.	19. ± 4.		^{153}Tb , $9/2^- \rightarrow 11/2^-$	18
102.4		7. ± 2.				
105.5		13. ± 2.	35. ± 4.			
108.3	8.8 ± 1.9	32. ± 3.			^{153}Gd , $5/2^- \rightarrow 3/2^-$	18
110.4		14. ± 3.			impurity, $^{16}\text{O}(\alpha, p)^{19}\text{F}$	8
115.8	13.5 ± 2.2	11. ± 3.				
118.7	30. ± 2.	25. ± 4.			^{155}Tb , $15/2^- \rightarrow 13/2^-$	13
120.3		8. ± 4.				
123.1	37.6 ± 1.9	60. ± 3.	33.3 ± 8.2		^{154}Gd , $2^+ \rightarrow 0^+$	15
126.1		9. ± 3.				

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1	2	3	4	5	6	7
133.9	17. ± 2.	22. ± 3.			^{155}Tb , $11/2^+ \rightarrow 9/2^+$	13
134.7		22. ± 3.				
137.9	17.3 ± 2.6	20. ± 2.	14. ± 3.	3n, 4n	^{156}Dy , $2^+ \rightarrow 0^+$; ^{155}Dy , $11/2^- \rightarrow 9/2^+$	12, 11
139.8	13.0 ± 2.7	47. ± 4.	19. ± 3.		^{75m}Ge ; ^{155}Tb , $19/2^- \rightarrow 17/2^-$	8, 13
143.2	7.8 ± 4.6			2n	^{157}Dy , $11/2^- \rightarrow 9/2^-$ [521]	10
147.2	15.9 ± 2.4	14. ± 2.	14. ± 2.	2n, 3n	^{157}Dy , $7/2^- \rightarrow 3/2^-$, ^{156}Dy , $4^+ \rightarrow 3^+$	10, 12
				4n	^{155}Dy , $11/2^- \rightarrow 7/2^-$; ^{153}Tb , $3/2^+ \rightarrow 5/2^+$	13, 18
151.2	5.5 ± 0.8				^{155}Tb , $23/2^- \rightarrow 21/2^-$	13
154.3	12.0 ± 1.1			3n	^{156}Dy , $2^+ \rightarrow 0^+$	12
157.3	5.6 ± 1.7				^{155}Tb , $13/2^- \rightarrow 11/2^-$	13
162.3	6.4 ± 1.4	30. ± 3.	13. ± 3.		impurity; ^{155}Tb , $9/2^+ \rightarrow 7/2^+$	8, 13
163.6	7.8 ± 1.9					
167.4	14.3 ± 9.0	25. ± 3.			^{155}Tb , $13/2^+ \rightarrow 11/2^+$	13
169.3	29.8 ± 7.1	73. ± 3.			^{27}Al (n, n')	8
171.2	13.4 ± 5.8				^{155}Tb , $15/2^+ \rightarrow 13/2^+$	13
		23. ± 2.			^{153}Gd , $3/2^+ \rightarrow 3/2^-$	18
175.0					^{71m}Ge ; ^{157}Dy , $13/2^- \rightarrow 11/2^-$ [505]	8, 10
180.5	7.7 ± 2.4	160. ± 20.				
184.5	74.2 ± 3.0	120. ± 3.	23. ± 2.		$^{16}_0(\alpha, pn)^{18}\text{F}$; ^{155}Tb , $7/2^+ \rightarrow 5/2^+$	8, 13
190.0		8. ± 3.			^{153}Tb , $9/2^+ \rightarrow 7/2^+$	32
193.4	4.7 ± 2.4	15. ± 3.				
197.6	17.1 ± 3.2	37. ± 6.	17. ± 4.		^{71m}Ge	8
199.	35.1 ± 3.5	60. ± 6.	43. ± 4.			
202.9	18.1 ± 3.2	25. ± 3.	11. ± 3.	4n	^{155}Dy , $13/2^- \rightarrow 11/2^-$ [505]	11
				7n	^{152}Dy , $9^- \rightarrow 8^+$; ^{155}Tb , $9/2^+ \rightarrow 5/2^-$	17, 13

	1	2	3	4	5	6	7
205.7	12.5 ± 3.7	$16. \pm 4.$	$29. \pm 5.$			$^{153}\text{Tb}, 11/2^+ \rightarrow 9/2^+$, [404]	32
209.1	8.0 ± 3.4	$6. \pm 3.$				$^{155}\text{Tb}, 9/2^+ \rightarrow 5/2^+$	13
211.7	13.1 ± 3.9	$65. \pm 4.$				$^{155}\text{Tb}, 17/2^+ \rightarrow 15/2^+$	13
						$^{153}\text{Gd}, 3/2^+ \rightarrow 3/2^-$	18
213.9	27.8 ± 3.6	$34. \pm 4.$				$^{157}\text{Dy}, 17/2^- \rightarrow 15/2^-$ [505]	10
217.9	$9. \pm 4.$						
220.7	8.5 ± 3.6	12.5 ± 0.9	$6. \pm 2.$	4n		$^{155}\text{Dy}, 15/2^- \rightarrow 13/2^-$ [505]	11
227.0	75.0 ± 3.7	$68. \pm 3.$	$50. \pm 3.$	4n		$^{155}\text{Dy}, 17/2^+ \rightarrow 13/2^+$	11
						$^{155}\text{Tb}, 5/2^- \rightarrow 3/2^+$	13
						$^{153}\text{Gd}, 17/2^+ \rightarrow 13/2^+$	18
230.0	8.8 ± 3.2	$13. \pm 3.$	$13. \pm 3.$			$^{155}\text{Tb}, 23/2^+ \rightarrow 21/2^+$	13
238.4	12.3 ± 3.0	$11. \pm 3.$				$^{155}\text{Tb}, 13/2^- \rightarrow 9/2^-$	13
243.9	28.3 ± 3.1	$34. \pm 3.$	$19. \pm 5.$			$^{155}\text{Tb}, 17/2^- \rightarrow 13/2^-$	13
						$^{153}\text{Tb}, 9/2^+ \rightarrow 7/2^+$ [404]	32
247.9	35.7 ± 3.9	$55. \pm 3.$	$37. \pm 5.$			$^{154}\text{Gd}, 4^+ \rightarrow 2^+$	15
253.9	59.7 ± 4.8	$120. \pm 5.$		6n		$^{153}\text{Tb}, 7/2^+ \rightarrow 5/2^+$; $^{155}\text{Tb}, 11/2^+ \rightarrow 7/2^+$	18, 13
				7n		$^{152}\text{Dy}, 10^- \rightarrow 9^-$	17
						$^{153}\text{Dy}, 13/2^- \rightarrow 11/2^-$	18
256.7	27.1 ± 4.3	$139. \pm 5.$				$^{152}\text{Dy}, 152\text{Tb}, 1^+ \rightarrow 2^-$	
262.4	16.7 ± 4.0	$28. \pm 4.$	$13. \pm 5.$	6n, 7n		$^{152}\text{Dy}; 153\text{Dy}, 15/2^- \rightarrow 13/2^-$	17, 18
266.5	28.3 ± 4.3	$39. \pm 5.$	$19. \pm 5.$	3n		$^{156}\text{Dy}, 4^+ \rightarrow 2^+$	12
283.3	14.9 ± 2.8	$26. \pm 3.$	$51. \pm 3.$			$^{152}\text{Tb}, 4^- \rightarrow 2^-$	16
287.6	11.1 ± 2.8	$22. \pm 3.$					
296.0	78.5 ± 3.4	$74. \pm 3.$	$47. \pm 3.$	4n		$^{155}\text{Dy}, 13/2^- \rightarrow 9/2^-$ [521]	10
				6n		$^{153}\text{Dy}, 9/2^- \rightarrow 7/2^-$	18

1	2	3	4	5	6	7
301.9	9.3 ± 3.4	$8. \pm 4.$		6n	^{155}Tb , $13/2^+ \rightarrow 9/2^+$; ^{153}Dy , $21/2^- \rightarrow 19/2^-$	13 18
315.5	14.0 ± 3.5	$9. \pm 2.$			^{152}Gd , $2^+ \rightarrow 0^+$	16
320.4	10.7 ± 3.7	$7. \pm 2.$			^{155}Tb , $21/2^- \rightarrow 19/2^-$	13
326.1		$14. \pm 4.$				
327.9	31.3 ± 4.4	$27. \pm 4.$		6n	^{153}Dy ; $^{157}\text{Dy} \rightarrow ^{157}\text{Tb}$	30, 13
334.5	$180. \pm 6.$	$160. \pm 3.$	$113. \pm 4.$	5n	^{154}Dy , $2^+ \rightarrow 0^+$	11
344.4	26.5 ± 5.0	$127. \pm 4.$	$60. \pm 2.$	($\alpha, \alpha' 3n$)	^{152}Gd , $2^+ \rightarrow 0^+$	16
347.7	64.6 ± 4.5	$64. \pm 4.$	$47. \pm 3.$	($\alpha, \alpha' n$)	^{154}Gd , $6^+ \rightarrow 4^+$	15
351.9	18.3 ± 3.8	$45. \pm 4.$		4n	^{152}Gd , $4_1^+ \rightarrow 2_1^+$; ^{155}Dy	16, 11
360.4	14.7 ± 4.1					
362.8	46.7 ± 4.2	$46. \pm 4.$	$25. \pm 5.$	4n	^{155}Dy , $21/2^+ \rightarrow 17/2^+$ ^{155}Tb , $17/2^- \rightarrow 13/2^-$ ^{153}Gd , $21/2^+ \rightarrow 17/2^+$	11 13 18
366.6	38.8 ± 4.3	$28. \pm 4.$	$40. \pm 10.$	3n	^{156}Dy , $6^+ \rightarrow 4^+$	12
				6n	^{153}Dy , $19/2^+ \rightarrow 17/2^-$	18, 30
371.6	8.2 ± 4.8			2n	^{157}Dy , $15/2^- \rightarrow 11/2^-$ [505] ^{157}Dy , $17/2^- \rightarrow 13/2^-$ [521]	10
398.0	21.9 ± 4.4	$36. \pm 3.2$	$48. \pm 5.$	7n	^{152}Dy , $7^- \rightarrow 6^+$	17
401.6	$38. \pm 5.$	$19. \pm 4.$		6n	^{153}Gd , $15/2^- \rightarrow 11/2^-$	18
					^{153}Dy	30
406.5	$23. \pm 5.$		$20. \pm 4.$	5n	^{154}Dy , $6_1^+ \rightarrow 4_1^+$	11
412.1	$210. \pm 7.$		$120. \pm 6.$	5n	^{154}Dy , $4^+ \rightarrow 2^+$; ^{152}Gd , $4^+ \rightarrow 2^+$	11, 16
431.5	15.5 ± 5.3	$23. \pm 4.$	$38. \pm 4.$			
439.1	$15. \pm 5.$	$55. \pm 7.$			^{23}Na (n, n'); ^{153}Tb	8, 32

	1	2	3	4	5	6	7
441.3	50. ± 4.	55. ± 7.			6n	^{153}Dy	30
444.4		33. ± 4.			3n	$^{156}\text{Dy}, 8^+ \rightarrow 6^+$; ^{153}Tb	12,32
447.7	221. ± 6.	180. ± 5.	100. ± 6.	6n	$^{153}\text{Dy}, 17/2^+ \rightarrow 13/2^+$; ^{153}Tb	18,30,32	
454.3	27. ± 5.	22. ± 4.				^{153}Tb	32
457.0	25. ± 6.						
462.0	39. ± 6.	34. ± 5.		6n	$^{153}\text{Dy}, 23/2^+ \rightarrow 19/2^+$	30	
464.7	23. ± 6.			4n	$^{155}\text{Dy}, 25/2^+ \rightarrow 21/2^+$	11	
466.9	50. ± 7.	36. ± 7.	30. ± 4.	3n	$^{153}\text{Gd}, 25/2^+ \rightarrow 21/2^+$ $^{156}\text{Dy}, 9^+ \rightarrow 10^+$	18 12	
472.0	37. ± 6.	77. ± 5.			$^{152}\text{Gd}, 6^+ \rightarrow 4^+$ $^{27}\text{Al} (n,\alpha) ^{24}\text{Na}$ $^{155}\text{Tb}, 23/2^- \rightarrow 19/2^-$	16 8 13	
474.2	26. ± 6.						
476.9	164. ± 6.	146. ± 6.	66. ± 6.	5n	$^{154}\text{Dy}, 6^+ \rightarrow 4^+$ $^{153}\text{Gd}, 19/2^- \rightarrow 5/2^-$	11 18	
480.7	81. ± 6.	75. ± 6.		6n	$^{153}\text{Dy}; ^{155}\text{Tb}, 23/2^+ \rightarrow 19/2^+$	30,13	
488.1	170. ± 5.	136. ± 6.	80. ± 5.	6n	$^{153}\text{Dy}, 21/2^+ \rightarrow 17/2^+$	18,30	
492.6	63. ± 5.	88. ± 5.	88. ± 5.	7n	$^{152}\text{Dy}, 8^+ \rightarrow 6^+$; ^{154}Gd	17,15	
496.0	17. ± 5.	20. ± 6.		4n	$^{155}\text{Dy}, 19/2^- \rightarrow 15/2^-$	11	
511.0							
520.3	20. ± 8.	50. ± 6.	37. ± 6.	7n	$^{152}\text{Dy}, 5^- \rightarrow 4^+$; $^{152}\text{Gd}, 8^+ \rightarrow 6^+$	17,16	
523.7	129. ± 9.	123. ± 6.	85. ± 6.	5n	$^{154}\text{Dy}, 8^+ \rightarrow 6^+$	11	
527.2			48. ± 5.	8n	$^{152}\text{Gd}, 4^+_1 \rightarrow 4^+$ $^{151}\text{Dy}, 9/2^- \rightarrow 7/2^-$	16 27	

	1	2	3	4	5	6	7
532.3	104. \pm 8.	85. \pm 5.	64. \pm 5.	6n	^{153}Dy , $25/2^+ \rightarrow 21/2^+$	30	
541.3	67. \pm 6.	47. \pm 5.		6n	^{153}Dy , $13/2^- \rightarrow 9/2^-$	30	
544.0	17. \pm 6.	26. \pm 5.		4n	^{155}Dy , $29/2^+ \rightarrow 25/2^+$	11	
547.0	23. \pm 8.				^{154}Gd ,	15	
551.8	44. \pm 6.			6n	^{153}Dy	30	
553.9	30. \pm 6.	20. \pm 6.		7n	^{152}Dy , $5^- \rightarrow 3^-$	17	
557.0	89. \pm 5.	59. \pm 5.	30. \pm 8.	5n	^{154}Dy , $10^+ \rightarrow 8^+$	11	
560.2	63. \pm 5.	45. \pm 5.		6n, 7n	^{152}Dy , $7^- \rightarrow 5^-$; ^{153}Dy	30, 17	
563.2	40. \pm 4.	60. \pm 5.	76. \pm 8.	7n	^{76}Ge (n, n'); ^{152}Dy , $9^- \rightarrow 7^-$	8, 17	
566.3	24. \pm 5.	9. \pm 4.					
577.3	17. \pm 6.						
581.6	87. \pm 6.	62. \pm 5.	42. \pm 6.	6n	^{153}Dy , $29/2^+ \rightarrow 25/2^+$	18	
584.5		25. \pm 4.					
588.0	38. \pm 6.	19. \pm 4.		5n	^{154}Dy , $12^+ \rightarrow 10^+$	11	
591.5	30. \pm 6.			3n	^{156}Dy , $10^+ \rightarrow 10^+$	12	
587.3							
596.6	26. \pm 7.	120. \pm 7.	60. \pm 7.		^{74}Ge (n, n')	8	
600.8	20. \pm 7.	30. \pm 6.					
604.6	52. \pm 6	97. \pm 6.	76. \pm 7.	4n, 7n	^{155}Dy , $33/2^+ \rightarrow 29/2^+$; ^{152}Dy	11, 17	
609.6	44. \pm 6.	91. \pm 6.		7n	^{74}Ge (n, n'); ^{152}Dy	8, 17	
613.7	165. \pm 7.	275. \pm 8.	260. \pm 10.	7n	^{152}Dy , $2^+ \rightarrow 0^+$	17	
617.0	37. \pm 6.	37. \pm 6.		5n, 6n	^{153}Dy , $17/2^- \rightarrow 13/2^-$; ^{154}Dy	30, 11	
622.2		11. \pm 6.					
626.8	35. \pm 6.	35. \pm 6.	26. \pm 7.	6n	^{153}Dy , $33/2^+ \rightarrow 29/2^+$	18, 30	
631.0		6. \pm 5.					

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	1	2	3	4	5	6	7
636.7	420. \pm 10.	360. \pm 7.	260. \pm 10.	6n	^{153}Dy , $11/2^- \rightarrow 7/2^-$	30	
647.1	163. \pm 7.	260. \pm 5.	310. \pm 10.	7n	^{152}Dy , $4^+ \rightarrow 2^+$	17	
650.5	24. \pm 5.	20. \pm 5.					
659.7	35. \pm 5.			7n	^{152}Dy	17	
668.6	35. \pm 7.	26. \pm 7.		6n	^{153}Dy	30	
670.0		11. \pm 7.					
672.8	41. \pm 6.	17. \pm 7.		6n	^{153}Dy , $37/2^+ \rightarrow 33/2^+$	30	
674.0		36. \pm 7.		6n	^{153}Dy , $37/2^+ \rightarrow 33/2^+$	30	
683.3	95. \pm 7.	186. \pm 5.	221. \pm 5.	7n	^{152}Dy , $6^+ \rightarrow 8^+$	17	
693.0	59. \pm 7.		78. \pm 8.		^{72}Ge (n,n')	8	
696.0	45. \pm 7.						
718.2	66. \pm 5.	160. \pm 7.		6n	^{10}B (n,n'); ^{153}Dy	8,30	
735.8		43. \pm 15.	61. \pm 5.	8n,7n	^{152}Dy ; ^{151}Dy	17,27	
745.7	16. \pm 8.		43. \pm 5.	7n	^{152}Dy	17	
747.1	13. \pm 8.						
758.5			31. \pm 5.	7n	^{27}Al (n,n'); ^{152}Dy , $8^+ \rightarrow 6^+$	8,17	
775.2			62. \pm 5.	8n	^{151}Dy , $11/2^- \rightarrow 7/2^-$	27	
809.1		50. \pm 7.		7n	^{152}Dy	17	
834.8	40. \pm 6.	139. \pm 5.	74. \pm 4.		^{72}Ge (n,n')	8	
843.7	62. \pm 6.	112.0 \pm 4.			^{27}Al (n,n')	8	
846.7	52. \pm 7.	124. \pm 5.	46. \pm 9.		^{56}Fe (n,n')	8	
850.1	24. \pm 7.						
868.2		49. \pm 5.			^{73}Ge (n,δ) ^{74}Ge	8	
932.5	10. \pm 7.						
937.0	55. \pm 6.	100. \pm 6.					
941.6	9. \pm 5.						

1	2	3	4	5	6	7	8
1014.6	72. ± 7.	180. ± 7.	90. ± 6.		^{27}Al (n, n')		
1097.7			26. ± 6.				
1779.5			80. ± 7.		^{27}Al , (n, n')		8

Energy of gamma transition	Alpha particles bombarding energy			xn	Assignment	Ref.
	E (keV)	110 MeV	120 MeV			
1	2	3	4	5	6	7
52.9			980. \pm 30.			
65.6			250. \pm 10.		^{151}Tb , $29/2^+ \rightarrow 27/2^+$	28
72.4			390. \pm 10.		Pb, $K\alpha_1$	40
74.3		18. \pm 6.	720. \pm 30.		Pb, $K\alpha_2$	40
75.7	30. \pm 10.			6n	^{153}Dy , $13/2^+ \rightarrow 11/2^-$	14
76.2	20. \pm 14.	45. \pm 5.				
81.3	23. \pm 2.	29. \pm 4.			^{153}Tb , $7/2^+ \rightarrow 5/2^+$	18
84.5			250. \pm 20. ^R)		Pb, $K\beta_1$	40
86.8	37. \pm 2.	37. \pm 4.	80. \pm 7.	4n	^{155}Tb , ^{155}Dy , $5/2^- \rightarrow 3/2^-$ [521]	11
90.2	15. \pm 2.		150. \pm 8.		^{27}Al (n, α) ^{24}Na	8
93.0			250. \pm 10.			
98.7	38. \pm 2.	33. \pm 4.				
100.2		15. \pm 4.				
104.9			85. \pm 4.		^{155}Tb	11
108.9		6. \pm 2.	43. \pm 3.		impurity, ^{16}O (α, p) ^{19}F	8
115.6	24. \pm 4.	19. \pm 2.	9. \pm 3.			
117.8	12. \pm 3.	19. \pm 2.				
119.3	16. \pm 3.				^{155}Tb , $15/2^- \rightarrow 13/2^-$	13

1	2	3	4	5	6	7
123.1	47. \pm 2.	45. \pm 2.	55. \pm 3. R)		^{154}Gd , $2^+ \rightarrow 0^+$	15
132.0	14. \pm 2.	16. \pm 2.				
134.5	12. \pm 2.	10. \pm 2.	26. \pm 3.		^{155}Tb , $11/2^+ \rightarrow 9/2^+$	13
140.4	14. \pm 2.	12. \pm 2.	200. \pm 7. R)		^{75}mGe ; ^{155}Tb , $19/2^- \rightarrow 17/2^-$	8,13
146.8	10. \pm 2.	12. \pm 2.	16. \pm 4.	4n	^{153}Tb , $3/2^+ \rightarrow 5/2^+$; ^{155}Dy , $11/2^- \rightarrow 7/2^-$	
						18,11
150.0	5. \pm 2.	18. \pm 2.	15. \pm 3.		^{155}Tb , $23/2^- \rightarrow 21/2^-$	13
154.5	4. \pm 2.		15. \pm 4.3	3n	^{156}Dy , $2^+ \rightarrow 0^+$	12
159.4	24. \pm 2.	24. \pm 2.	50. \pm 4. R)		^{152}Tb , $8^+ \rightarrow 5^-$	16
162.3	54. \pm 2.	40. \pm 2.	31. \pm 3.	8n	impurity, ^{151}Dy ; ^{155}Tb , $9/2^+ \rightarrow 7/2^+$	27,8
169.6	15. \pm 3.	20. \pm 2.			^{27}Al (n,n')	8
174.5			63. \pm 5.		^{71}mGe	8
180.7	17. \pm 2.					
184.1	47. \pm 3.	33. \pm 2.	26. \pm 4. R		$^{160}(\alpha, pn)^{18}\text{F}$; ^{155}Tb , $7/2^+ \rightarrow 5/2^+$	8,13
193.2	30. \pm 3.	23. \pm 3.	26. \pm 4. R	8n	$\left\{ \begin{array}{l} ^{151}\text{Dy}, 13/2^+ \rightarrow 11/2^- \\ ^{151}\text{Tb}, 27/2^- \rightarrow 25/2^- \end{array} \right.$	27,28
195.0	19. \pm 3.	21. \pm 3.				
198.4	36. \pm 2.	33. \pm 3.	214. \pm 8.		^{71}mGe	8
200.4		34. \pm 3.				
206.0		55. \pm 2.	42. \pm 3.	9n	^{150}Dy ; ^{153}Tb , $11/2^+ \rightarrow 9/2^+$ [404]	19,32
210.0	15. \pm 2.	18. \pm 2.				
213.4	13. \pm 2.	26. \pm 2.				
221.1	8. \pm 2.			4n	^{155}Dy , $15/2^- \rightarrow 13/2^-$ [505]	11
225.7			51. \pm 4. R			
227.2	34. \pm 2.	40. \pm 2.		4n	$\left\{ \begin{array}{l} ^{155}\text{Dy}, 17/2^+ \rightarrow 13/2^+ \\ ^{153}\text{Gd}, 17/2^+ \rightarrow 13/2^+ \end{array} \right.$	11,18

	1	2	3	4	5	6	7
198.4	33.3 ± 2.7	47.8 ± 3.6	$190. \pm 30.$				
202.3	102.3 ± 4.7	83.2 ± 2.9		4n	$^{155}\text{Tb}, 19/2^+ \rightarrow 17/2^+$ [411]	13	
					$^{155}\text{Dy}, 11/2^- \rightarrow 11/2^-$ [505]	11	
211.0		11.9 ± 1.8					
213.0	6.6 ± 1.2			2n	$^{157}\text{Dy}, 17/2^- \rightarrow 15/2^-$ [505]	10	
219.6	$20. \pm 2.$	45.8 ± 2.4	$50. \pm 9.$				
221.3	$44. \pm 2.4$			4n	$^{155}\text{Dy}, 15/2^- \rightarrow 13/2^-$ [505]	11	
227.0	$340. \pm 10.$ R)	$520. \pm 20.$ R)	$230. \pm 20.$ R)	p3n	$^{155}\text{Tb}, 5/2^- \rightarrow 3/2^+$	13	
					$^{155}\text{Dy}, 17/2^+ \rightarrow 13/2^+$	11	
235.0	3.4 ± 1.4	6.9 ± 1.7		2n	^{157}Dy	10	
238.6	29.5 ± 1.6	41.0 ± 2.0	$40. \pm 10.$	p3n	$^{155}\text{Tb}, 13/2^- \rightarrow 9/2^-$ [532]	13	
				4n	$^{155}\text{Dy}, 17/2^- \rightarrow 15/2^-$	11	
243.4		19.6 ± 1.5	$52. \pm 12.$				
247.6	28.2 ± 1.5	42.0 ± 1.9			$^{154}\text{Gd}, 4^+ \rightarrow 2^+; ^{156}\text{Dy}$	15,12	
253.2	17.2 ± 3.3	55.7 ± 2.6		p3n	$^{155}\text{Tb}, 11/2^+ \rightarrow 7/2^+$	13	
254.7	28.5 ± 3.3				$^{153}\text{Tb}, 7/2^+ \rightarrow 5/2^+$ [402]		
				4n	$^{155}\text{Dy}, 19/2^- \rightarrow 17/2^-$	11	
266.5	$320. \pm 20.$	152.4 ± 8.2	$122. \pm 15.$	3n	$^{156}\text{Dy}, 4^+ \rightarrow 2^+$	12	
267.8		19.2 ± 2.7					
275.2		7.9 ± 2.5	$27.0 \pm 13.$	p3n	$^{155}\text{Tb}, 15/2^- \rightarrow 11/2^-$ [532]	13	
280.9	10.8 ± 1.4	11.4 ± 1.7 R		3n	^{156}Dy	12	
289.4	7.5 ± 1.5						
291.7	10.8 ± 2.1	12.2 ± 2.0		2n	$^{157}\text{Dy}, 13/2^- \rightarrow 9/2^-$		
296.9	15.7 ± 1.9	20.1 ± 2.4	$130. \pm 15.$	4n	$^{155}\text{Dy}, 13/2^- \rightarrow 9/2^-$ [521]	11	
				3n	^{156}Dy	12	

1	2	3	4	5	6	7
325.0			70. \pm 7. R)			
329.4	18. \pm 2.	20. \pm 2.	50. \pm 8.			
334.8	53. \pm 2.	30. \pm 9.	43. \pm 6. R)	5n	^{154}Dy , $2^+ \rightarrow 0^+$	11
339.2		9. \pm 3.			impurity	8
344.4	170. \pm 5.	156. \pm 4.	149. \pm 13. R)	8n	^{151}Dy , $21/2^- \rightarrow 17/2^-$; ^{152}Gd , $2^+ \rightarrow 0^+$	27, 16
347.7	46. \pm 3.	51. \pm 3.	55. \pm 7.		^{154}Gd , $6^+ \rightarrow 4^+$	15
354.7	48. \pm 3.	60. \pm 3.	57. \pm 7.	8n	^{151}Dy ,	
360.3			23. \pm 6.			
363.2	18. \pm 3.	24. \pm 3.	23. \pm 6.		^{155}Tb , $17/2^- \rightarrow 13/2^-$; ^{153}Gd , $21/2^+ \rightarrow 17/2^+$	13, 18
366.9	13. \pm 3.	17. \pm 3.		3n	^{155}Dy , $21/2^+ \rightarrow 17/2^+$	11
				6n	^{156}Dy , $6^+ \rightarrow 4^+$	12
371.5	15. \pm 3.		15. \pm 6.	2n	^{153}Dy , $19/2^+ \rightarrow 17/2^-$	18, 30
					^{157}Dy , $15/2^- \rightarrow 11/2^-$ [505]	
					^{157}Dy , $17/2^- \rightarrow 13/2^-$ [521]	10
376.6	5. \pm 3.		22. \pm 6.			
379.3	22. \pm 3.	25. \pm 3.	46. \pm 6.			
386.2	11. \pm 2.	8. \pm 3.	16. \pm 4.			
394.0	10.4 \pm 0.3	146. \pm 4.	140. \pm 10.	9n	^{150}Dy , $6^+ \rightarrow 4^+$; ^{151}Tb , $15/2^+ \rightarrow 15/2^-$	19, 28
397.1	58. \pm 3.	77. \pm 3.	58. \pm 8. R)	7n	^{152}Dy , $7^- \rightarrow 6^+$	17
407.4	30. \pm 3.			5n	^{150}Dy , 150Tb , $1^+ \rightarrow 2^-$	29
				8n	^{154}Dy , $6_1^+ \rightarrow 4_1^+$	11
411.8	92. \pm 4.	90. \pm 9.	110. \pm 10. R)	5n	^{151}Dy , $17/2^- \rightarrow 15/2^-$	27
414.0		30. \pm 8.			^{154}Dy , $4^+ \rightarrow 2^+$; ^{152}Gd , $4^+ \rightarrow 2^+$	11, 16

1	2	3	4	5	6	7
417.2	18. ± 4.	14. ± 5.				
428.3		9. ± 2.			^{154}Gd , $8^+ \rightarrow 6^+$	15
431.7	45. ± 2.	36. ± 2.	37. ± 6.			
435.6	14. ± 2.	10. ± 2.	15. ± 5.	8n	^{151}Dy	27
438.8	48. ± 4.	63. ± 3.	64. ± 8. ^R)		^{23}Na (n, n'); ^{153}Tb	8, 32
441.	30. ± 4.	20. ± 3.		6n	^{153}Dy	30
444.4	7. ± 2.			3n	^{156}Dy , $8^+ \rightarrow 6^+$; ^{153}Tb	12, 32
448.1	44. ± 2.	33. ± 3.	24. ± 4.	6n	^{153}Dy , $17/2^+ \rightarrow 13/2^+$; ^{153}Tb	30, 32
455.1	24. ± 3.	29. ± 3.	17. ± 4. ^R)		^{153}Tb	32
467.3	24. ± 3.	19. ± 3.	21. ± 5.	8n	^{151}Dy	
472.4	50. ± 3.	46. ± 3.	54. ± 8. ^R)		^{152}Gd , $6^+ \rightarrow 4^+$	16
					^{27}Al (n, α) ^{24}Na ; ^{155}Tb	8, 13
477.0	53. ± 3.	40. ± 3.		5n	^{154}Dy , $6^+ \rightarrow 4^+$; ^{153}Gd , $19/2^- \rightarrow 15/2^-$	11, 18
481.8	22.4 ± 2.9	24. ± 3.	29. ± 6.	6n	^{153}Dy ; ^{155}Tb , $23/2^+ \rightarrow 19/2^+$	30, 13
488.7	40. ± 2.	31. ± 10.	37. ± 7.	6n	^{153}Dy , $21/2^+ \rightarrow 17/2^+$	30
493.	47. ± 2.	36. ± 9.	60. ± 8.	7n	^{152}Dy , $8^+ \rightarrow 6^+$	17
496.7	21.1 ± 1.9	36. ± 9.		4n	^{155}Dy , $19/2^- \rightarrow 15/2^-$	11
499.7			56. ± 8.			
503.2	38. ± 2.	68.5 ± 8.9	63. ± 9.	9n	^{150}Dy	19
511.		62. ± 2.				
516.1		35. ± 3.	24. ± 7.			
520.2	32. ± 3.	18. ± 4.		7n	^{152}Dy , $5^- \rightarrow 4^+$; ^{152}Gd	17, 16
523.8	56. ± 3.	40. ± 4.	48. ± 9.	5n	^{154}Dy , $8^+ \rightarrow 6^+$	11
527.3	122.4 ± 3.7	93.3 ± 3.7	80. ± 10.	8n	^{151}Dy , $9/2^- \rightarrow 7/2^-$; ^{152}Gd	27, 16

1	2	3	4	5	6	7
532.8	17.5 ± 2.8			6n	^{153}Dy , $25/2^+ \rightarrow 21/2^+$	30
542.5	28. ± 3.	22. ± 2.	28. ± 7.	7n	^{152}Dy	17
546.	6. ± 3.					
551.1	47. ± 4.	84.7 ± 5.9	76.2 ± 9.4	9n	^{150}Dy , $8^+ \rightarrow 6^+$	19
553.6	12. ± 4.			7n	^{152}Dy , $5^- \rightarrow 3^-$	17
558.1	35.7 ± 3.3	39.1 ± 5.5	700. ± 60.	5n	^{154}Dy , $10^+ \rightarrow 8^+$	11
563.0	50. ± 3.	15.4 ± 2.9		7n	^{76}Ge (n, n') ^{152}Dy , $(9^+) \rightarrow (7^-)$ ^{151}Tb , $27/2^+ \rightarrow 23/2^+$	8 17 28
566.0	2.5 ± 0.5		60. ± 10. ^R)			
569.9	67. ± 3.	37. ± 5.	110. ± 13.	8n	^{151}Dy , $17/2^- \rightarrow 13/2^-$	27
575.			24. ± 6.			
581.9	10. ± 2.			6n	^{153}Dy , $29/2^+ \rightarrow 25/2^+$	30
584.9	20. ± 2.6					
592.3	13. ± 3.					
596.6	54. ± 3.	51. ± 4.	460. ± 50. ^R)		^{74}Ge (n, n') ^{151}Tb , $23/2^+ \rightarrow 19/2^+$	8 28
598.3			110. ± 10.			
600.2	10.7 ± 2.3		83. ± 10.			
604.7	123. ± 3.	131. ± 4.		7n	^{152}Dy ; ^{151}Tb , $15/2^- \rightarrow 11/2^-$	17, 28
608.3			73. ± 10.			
610.3	34. ± 2.	27.5 ± 3.8		7n	^{152}Dy	17
613.9	124.5 ± 4.2	83. ± 7.	70. ± 10.	7n	^{152}Dy , $2^+ \rightarrow 0^+$	17

1	2	3	4	5	6	7
616.0	45. \pm 3.	59. \pm 8.			^{151}Tb , $19/2^- \rightarrow 15/2^-$	28
624.5	43. \pm 3.	68. \pm 5.	60. \pm 10.	7n	^{152}Dy	17
				9n	^{150}Dy , $8^+ \rightarrow 8^+$	19
627.3		28. \pm 4.		6n	^{153}Dy , $33/2^+ \rightarrow 29/2^+$	30
630.7			70. \pm 10.			
632.0	23.5 \pm 3.4	36.8 \pm 3.3				
637.7	153.9 \pm 4.9	144. \pm 23.	180. \pm 20. R)	6n	^{153}Dy , $11/2^- \rightarrow 7/2^- \rightarrow 11/2^-$	30
647.6	174. \pm 7.		130. \pm 15.	7n	^{152}Dy , $4^+ \rightarrow 2^+$	17
649.7	90. \pm 6.	162. \pm 11.	200. \pm 20. R	8n	^{151}Dy	27
653.2	123. \pm 5.	130. \pm 10.	150. \pm 20	9n	^{150}Dy , $4^+ \rightarrow 2^+$	19
660.6	10.4 \pm 3.3					
669.3			26.1 \pm 5.9	8n	^{151}Dy , $21/2^+ \rightarrow 17/2^+$	27
676.8		13.0 \pm 4.	44. \pm 7.	8n	^{151}Dy , $25/2^+ \rightarrow 21/2^+$	27
679.1			20. \pm 7. R)		^{151}Tb , $35/2^- \rightarrow 31/2^-$	28
683.0	112.5 \pm 2.9	90. \pm 3.	130. \pm 60.	7n	^{152}Dy , $6^+ \rightarrow 4^+$	
					^{151}Tb , $23/2^- \rightarrow 19/2^-$	28
686.7			30. \pm 10.			
692.6			210. \pm 20.		^{72}Ge (n, n')	8
695.5			120. \pm 14.			
707.8			65. \pm 9.			
718.5	45. \pm 3.	52. \pm 4.			^{10}B (n, n')	8
721.8		19. \pm 3.				
725.2			40. \pm 7.			
735.7	52. \pm 2.	40. \pm 3.	46. \pm 8.	7n, 8n	^{152}Dy ; ^{151}Dy , $15/2^- \rightarrow 11/2^-$	17, 27

1	2	3	4	5	6	7
742.0	22. ± 2.	31. ± 4.	39. ± 7.	9n	^{150}Dy	19
746.8	20.6 ± 1.9		34. ± 7.	7n	^{152}Dy	17
753.6	25.5 ± 1.9	18. ± 3.	15. ± 6.		^{151}Tb , $31/2^- \rightarrow 27/2^-$	28
758.6	25.4 ± 1.9	40. ± 3.	48. ± 8.	7n	^{152}Dy , $8^+ \rightarrow 6^+$	17
765.0	39. ± 2.	54. ± 3.	83. ± 11.	8n	^{151}Dy , $17/2^+ \rightarrow 13/2^+$	27
769.3			50. ± 13.	7n	^{152}Dy	17
775.5	144. ± 4.	112. ± 4.	100. ± 10.	8n	^{151}Dy , $11/2^- \rightarrow 7/2^-$	27
785.0	78. ± 3.	95. ± 4.	116. ± 16.			
787.9	16. ± 2.	38.6 ± 3.9				
796.0	400. ± 50.	66. ± 3.	70. ± 10.			
800.1	12. ± 3.					
803.5	78. ± 4.	110. ± 3.	260. ± 30.	9n	^{150}Dy , $2^+ \rightarrow 0^+$	19
805.9			60. ± 9.			
809.	93. ± 4.	110. ± 3.	100. ± 10.	7n	^{152}Dy	17
				9n	^{150}Dy , $12^+ \rightarrow 10^+$	19
821.3	74.7 ± 3.2	50. ± 3.	33. ± 8.	8n	^{151}Dy , $13/2^- \rightarrow 9/2^-$	27
827.9.	18. ± 3.	45. ± 4.				
833.7	35. ± 3.	53. ± 6.			^{72}Ge (n, n')	8
839.0	30. ± 3.			8n	^{151}Dy	27
843.8	7.5 ± 0.3	58. ± 3.	90. ± 10.		^{27}Al (n, n')	8
847.0	43. ± 3.	40.2 ± 2.9	190. ± 20. ^R)		^{56}Fe (n, n')	8
849.1			45. ± 10.			
853.			40. ± 10.			
857.			24. ± 9.			

1	2	3	4	5	6	7
868.			137. \pm 16. ^R)		^{73}Ge (n,γ) ^{74}Ge	8
871.3			26. \pm 10.			
881.			35. \pm 7.			
883.3	21. \pm 2.	14. \pm 3.				
897.7			60.4 \pm 8.7		^{154}Gd , $4^+ \xrightarrow{\gamma} 4^+$	15
937.5	22. \pm 2.					
942.4			20.4 \pm 6.2			
961.4			50.2 \pm 7.9			
984.1			45.3 \pm 7.6		^{27}Al ($n,p\gamma$) ^{27}Mg	8
990.8			17. \pm 6.			
997.3	18. \pm 3.	46.4 \pm 3.5	54. \pm 8.		^{154}Gd , $2^+ \xrightarrow{\gamma} 0^+$	15
1006.2	18.5 \pm 2.5	20.7 \pm 2.9	40. \pm 7.		^{154}Gd , $3^+ \xrightarrow{\gamma} 2^+$	15
1014.9	118.8 \pm 3.9	110. \pm 4.	150. \pm 20.		^{27}Al (n,n')	8
1040.8		11.3 \pm 3.6			^{70}Ge (n,n')	8
1042.8			43.4 \pm 7.5 ^R)			
1048.			29.0 \pm 6.			
1052.5			21.5 \pm 6.			
1062.5			17. \pm 5.			
1065.4			18.6 \pm 2.9			
1067.7				34.3 \pm 6.9		
1074.6			35. \pm 6.			
1079.0			24. \pm 5.	60. \pm 10. ^R		
1103.3				19. \pm 7.		
1107.9				23. \pm 7.		

1 2 3 4 5 6 7

1274.6 30. ± 2.
1369.4 93.7 ± 4.7

^{27}Al (n, α) ^{24}Na

8