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EVALUATION OF THE $^{58}Ni(n,2n)^{57}Ni$ REACTION CROSS SECTIONS

EWALUACJA PRZEKROJÓW CZYNNYCH REAKCJI $^{58}Ni(n,2n)^{57}Ni$

ОЦЕНКА ЭФФЕКТИВНЫХ СЕЧЕНИЙ РЕАКЦИИ $^{58}Ni(n,2n)^{57}Ni$

Lesław Adamski
Michał Herman
Andrzej Marcinkowski

Abstract

The excitation curve for the $^{58}Ni(n,2n)^{57}Ni$ reaction has been evaluated on the basis of 15 experimental data sets or single-energy cross sections. The recommended cross sections are given in 0.1 MeV energy steps, from the threshold energy to 28 MeV. The estimated accuracy is 11.4% below 14 MeV, 8.7% between 14 MeV and 16 MeV, and worse at higher energies.

Streszczenie

Ewaluowano krzywą wzbudzenia reakcji $^{58}Ni(n,2n)^{57}Ni$. Uwzględniono wyniki 15-stu prac eksperymentalnych. Zalecane przekroje czynne podano w tabeli co 0.1 MeV, poczynając od progu, aż do 28 MeV. Oszacowane dokładności przekrojów czynnych wynoszą 11.4% dla energii neutronów niższych od 14 MeV i 8.7% dla energii od 14 MeV do 16 MeV. Powyżej 16 MeV dokładność jest gorsza.

Аннотация

Произведено оценку эффективных сечений реакции $^{58}Ni(n,2n)^{57}Ni$ для энергии нейтронов от порога до 28 МэВ. Точность оцененных сечений составляет 11.4% для энергии нейтронов ниже 14 МэВ и 8.7% для энергии от 14 МэВ до 16 МэВ. При высших энергиях получена точность худшая.

The data is available as EXFOR V0008.

I. INTRODUCTION

The aim of this work is to evaluate the excitation function of the $^{58}Ni(n,2n)^{57}Ni$ reaction for neutron energies ranging from the threshold energy equal 12.4154 MeV [Gue 75] up to 28 MeV. The cross sections of the $^{58}Ni(n,2n)^{57}Ni$ reaction have been requested in WRENDA 76/77 by A.Michaudon (Ref. No 250) for fission reactor development, as well as by D.Breton (Ref. No 1409), Y.Seki (Ref. No 1410) and G.D.Mc Cracken (Ref. No 1411) for fusion reactor purposes. The $^{58}Ni(n,2n)^{57}Ni$ reaction is commonly used for reactor dosimetry applications, mainly for neutron spectra unfolding by multiple-foil activation technique. The energy range of special interest /90% response in a fission neutron spectrum/ is between 13 and 17 MeV.

We have compiled 23 publications (Fig. 2 and 3) concerning the $^{58}Ni(n,2n)^{57}Ni$ reaction, the last of which was published in 1976. The experimental cross sections are widely scattered at higher neutron energies, ranging between the lowest values measured by Jeronymo et al. and those obtained by Bayhurst et al. in 1975. The discrepancy between the two data sets reaches a factor 2.2 despite of both have been obtained in careful experiments. As a result of evaluation eight data sets or single data have been omitted in the final consideration. All the accepted data sets or single data values have been considered equivalent. This is because we have concluded that the differences in the errors attached by the authors are dim or insignificant.

The recommended data set presented in chapter V has been compared with the results of previous evaluations and with the statistical model estimates accounting for the γ -decay of unbound states and precompound emission.

II. GENERAL DATA ON THE REACTION STUDIED AND THE COMPETITIVE REACTIONS

The Q values, threshold energies and the cross sections at 14 MeV neutron energy for the $^{58}Ni(n,2n)^{57}Ni$ reaction and the competing reactions are listed in Table 1.

The data in the Table 1 were taken from the evaluation of Guenther et al. [Gue 75] . Exceptionally the $^{58}Ni(n,2n)^{57}Ni$ reaction cross section as evaluated in the present work is given.

TABLE 1

Reaction	σ mb	Q MeV	Threshold MeV
$^{58}Ni(n,2n)^{57}Ni$	22.9	-12.203	12.4154
$^{58}Ni(n,np+pn)^{57}Co$	550*	- 8.1772	8.319
$^{58}Ni(n,p)^{58}Co$	337	0.3947	
$^{58}Ni(n,\alpha)^{55}Fe$	113	2.8902	
$^{58}Ni(n,d)^{57}Co$	17.7	- 5.952	6.056
$^{58}Ni(n,3n)^{56}Ni$		-22.471	22.862

* This value corresponds to 14.5 MeV.

III. METHOD OF MEASUREMENT AND THE RECOMMENDED STANDARDS

All experimental data collected in the present work have been obtained with aid of the activation method. The ^{57}Ni produced in the $^{58}Ni(n,2n)^{57}Ni$ reaction decays with a half-life 36.0 h via β^+ emission and electron capture. Branchings are known to the 1.37 MeV, 1.49 MeV and 1.89 MeV levels of ^{57}Co. The possible weak transition to the 1.75 MeV level of ^{57}Co has been neglected in the analysis of the measured activities.

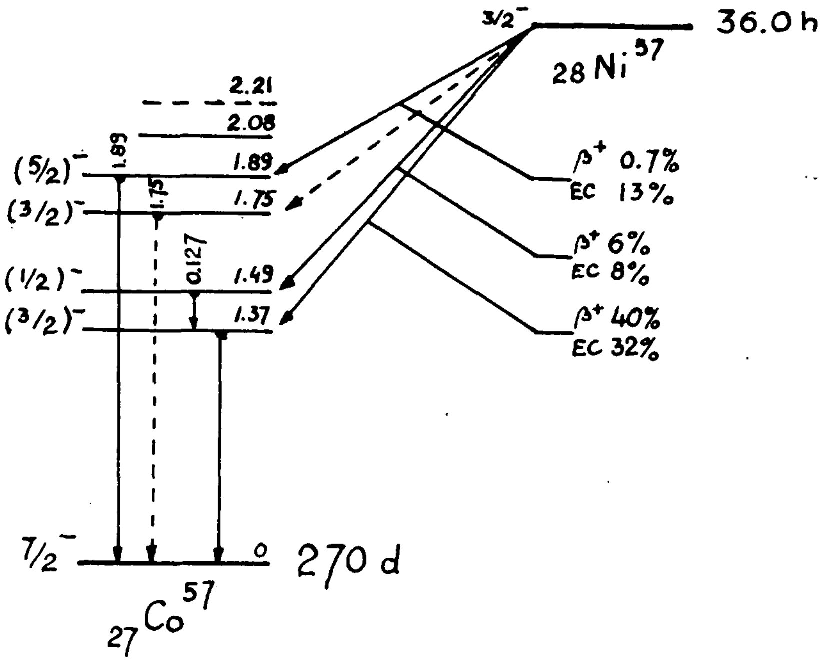

Fig. 1. Decay scheme of ^{57}Ni [Led 68] .

Most often β^+ or the 511 keV annihilation γ-quanta are counted in order to determine the ^{57}Ni activity. Some authors use also counting of the 1.37 MeV γ-rays. When β^+ or annihilation quanta are counted, the activity belonging to the decay of ^{57}Ni has to be separated from the activities due to the decay of other reaction products. This is done by chemical separation or decay time analysis.

The following decay data have been adopted as recommended standards in the present analysis:

- half-life of ^{57}Ni ground state $T_{1/2} = 36.0$ h,
- number of emitted β^+ per decay of the ^{57}Ni ground state $I^{\gamma}_{\beta+} = 0.46$,
- number of 511 keV annihilation quanta per decay of the ^{57}Ni ground state I^{γ}_{γ} (511 keV) = 0.934,
- number of emitted 1370 keV γ-rays per decay of the ^{57}Ni ground state I^{γ}_{γ} (1370 keV) = 0.86.

Three different methods are commonly applied in the determination of the neutron flux:

- the associated alpha-particle method is based on counting the recoiled alpha particles accompanying each neutron emitted in the $T(d,n)^4He$ reaction. This accurate and reliable method is limited to neutron energies close to 14 MeV only.
- in the proton recoil telescope the protons recoiled from a polyethylene foil bombarded with neutrons are counted in a thin scintillation or semiconductor detector. This method requires the knowledge of the H (n,n)H reaction cross sections. In the present evaluation these cross sections were taken from ENDF/B-IV (MAT.1269).

- the reference reaction method makes use of the radioactivity produced in a monitoring reaction of known cross section . The accuracy of the reference reaction method is limited by the error of the monitoring reaction cross section. On the other hand the uncertainties of the attenuation of the neutron flux in the sample and the target-sample geometry can be significantly reduced within this method.

Wherever possible we have accepted the ENDF/B recommended cross sections for the monitoring reactions. These data are both new and follow best the mean behaviour of the remaining evaluated curves /UKNDL, KEDAK, [Lap 75] /. The monitoring reactions used in the experiments entering this evaluation and the decay constants accepted as standards are following:

<u>$^{27}Al(n,\alpha)^{24}Na$</u> - the ^{24}Na ground state decays by β^- emission with the half-life $T^{\tau}_{1/2}$= 15.0 h [Led 68] to excited states of ^{24}Mg. The β^- or the 1369 keV γ - rays from the decay of the 1369 keV excited state in ^{24}Mg have been used in determining of the activity of ^{24}Na ground state. For the purpose of the present work the cross sections given in ENDF/B-IV (MAT.6193) [You 75] have been accepted. Taking into account the precise measurement of Vonach et al. [Von 70] we have estimated the accuracy of these cross sections within 4.2%.

<u>$^{238}U(n,f)$</u> - for neutron energies surpassing 14 MeV the cross sections of the $^{238}U(n,f)$ evaluated by various authors differ by less then 3%. We have accepted the ENDF/B-IV (MAT.6262) [Pai 74] data as a recommended standard.

<u>$^{56}Fe(n,p)^{56}Mn$</u> - the ^{56}Mn ground state decays by β^- emission to the excited states of ^{56}Fe with a half-life $T^{\tau}_{1/2}$= 2.576 h [Led 68]. Among the

γ - rays accompanying the deexcitation of the ^{56}Fe levels the 847 keV transition is most prominent and most often measured. Its intensity equals 0.989 per decay of ^{56}Mn ground state. The excitation curve for this reaction has been evaluated by Kanda et al. [Kan 72] and by Dudey and Kennerley in ENDF/B-III (MAT.6410) [Dud 75]. These evaluations differ by less then 2% (Fig. 5). We have used the ENDF/B-III data as standard.

$^{65}Cu(n,2n)^{64}Cu$ - the ^{65}Cu decays with a 19% branch via β^{+} to the ^{64}Ni ground state. A 38% branch of β^{-} leads to the ^{64}Zn ground state. The half-life of this decay equals 12.8 h. We have assumed that the discrepancies between different evaluations, amounting 3%, define the accuracy of the evaluated standard cross sections. Again the ENDF/B-IV (MAT.6412) data [Ros 75] have been used in the present work.

$^{63}Cu(n,2n)^{62}Cu$ - the ^{62}Cu produced in this reaction decays with 97$\pm$1% branch via β^{+} emission to ^{62}Ni levels. The half-life $T_{1/2}$ equals 9.8 min. Considerable deviations exist between the two available evaluations. We have arbitrarily chosen the UKNDL (DFN 250) data which seem to be more consistent with the analyzed cross sections for the $^{58}Ni(n,2n)^{57}Ni$ reaction than the UKNDL (DFN 681) data.

IV. COMPILATION AND EVALUATION

Out of the 23 compiled papers (Fig. 2 and 3), after thorough examination, 8 works have been rejected. These are the works of:

- S.Chojnacki et al. [Cho 65], who obtained an excitation curve rising much steeper than all the other data.
- W.G.Cross et al. [Cro 62]. Only the abstract of this work was available

and the 40 $\pm$ 5 mb value for the cross section at 14.5 MeV exceeds the average by more than three standard deviations.

- R.W.Fink and Wen-Deh Lu [Fin 70]. Only the abstract of this work was available and the 38 $\pm$ 5 mb value for the cross section exceeds the average by four standard deviations.
- D.J.Hughes and R.B.Schwartz [Hug 58]. The data in [Hug 58] are given in a graphical form only. No information allowing a renormalization was available. The cross section values exceed the average by about five standard deviations:

E_n MeV	σ mb
13.5	25.4
15.4	60.5
17.1	85.0
18.2	95.5

- J.M.F.Jeronymo et al. [Jer 63]. This excitation curve deviates from the other results in the whole energy range, being about twice lower. No explanation for this fact has been found;

E_n MeV	σ mb
12.55 ± 0.2	1 ± 1
13.55 ± 0.2	8 ± 2
14.90 ± 0.2	19 ± 3
16.50 ± 0.2	24 ± 3
18.15 ± 0.2	34 ± 4
19.60 ± 0.2	39 ± 4
20.60 ± 0.2	45 ± 4
21.00 ± 0.2	38 ± 4

- E.B.Paul and R.L.Clarke [Pau 53]. The result 40.6 ± 12 mb at 14.5 MeV exceeds the average by four standard deviations.
- I.L.Preiss and R.W.Fink [Prf 60]. The result 52 ± 5 mb at 14.8 MeV is extremely high.
- K.H.Purser and E.W.Titterton [Pur 59]. The result 38 ± 8 mb at 14.1 MeV is higher than the average by seven standard deviations.

For the 15 accepted data sets the evaluation forms have been prepared. They contain the most important information about the experiment and the standards adopted in the analysis of the measured activities or the counted emission rates. When deviations were met between the standards used by the authors and the recommended standards listed in chapter III an appropriate normalization has been performed. For differing half-lifes approximate linear extrapolation was applied. In some cases it was assumed that the authors used the right standards. The relative errors attached by the authors have been conserved.

Evaluation form No 1

AUTHOR: L. A. Rayburn

REFERENCE: Physical Review 122 /1961/ 168, [Ray 61].

LABORATORY: Argonne National Laboratory, Argonne, Illinois.

QUANTITY MEASURED: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at neutron energy 14.4 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread ± 0.3 MeV, cross section $\pm 1.5\%$.

STANDARDS: $T_{1/2}(^{57}Ni) = 43.7$ h, $I_\gamma(511\ keV) = 0.938$ per decay of ^{57}Ni, $^{63}Cu(n,2n)^{62}Cu$ $\sigma = 503$ mb $\pm 7.3\%$ at 14.4 MeV, $I_\gamma(511\ keV) = 1.864$ per decay of ^{62}Cu.

NEUTRON SOURCE: 120 kV Cockcroft-Walton accelerator, $T(d,n)^4He$ reaction on thick Zr-T target.

SAMPLE: Sample in cylindrical Lucite container 1 inch in diameter.

FLUX DETERMINATION: Associated particle method.

EXPERIMENTAL ARRANGEMENT: Sample placed 3 cm and 10 cm from target at angle 45^o, irradiation not longer than 7 h.

ACTIVITY MEASUREMENT: 511 keV annihilation γ-rays measured with two 1.5 x 1.5 inch NaI(Tl) spectrometers in coincidence, absolute efficiency determined by activity measurement from $^{63}Cu(n,2n)^{62}Cu$ reaction with known cross section.

CORRECTIONS: For selfabsorption by extrapolating to zero-thickness sample.

ERRORS: All known contributions with the uncertainty of $^{63}Cu(n,2n)^{62}Cu$ cross section included.

EVALUATORS' COMMENT: No information given on numerical value of $T_{1/2}(^{62}Cu)$ used.

NORMALIZATION-RESULT: Rayburn's result normalized according to recommended $T^{r}_{1/2}(^{57}Ni)$, $I^{r}_{\gamma}(511\ keV)$ per decay of ^{57}Ni, and $^{63}Cu(n,2n)^{62}Cu$ cross section.

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	R_B	R_T	σ_4 [mb]	$\Delta\sigma_4$ [%]
14.4	0.3	34.2	503	525	1.004	0.824	29.5	7.5

σ_1 - cross section for $^{58}Ni(n,2n)^{57}Ni$ given by author,

σ_2 - value of $^{63}Cu(n,2n)^{62}Cu$ cross section used by author,

σ_3 - recommended value of $^{63}Cu(n,2n)^{62}Cu$ cross section,

R_B - normalization factor:

R_B - $I_{\gamma}(511\ keV) / I^{r}_{\gamma}(511\ keV) = 0.938/0.934 = 1.004$,

R_T = normalization factor:

R_T = $T^{r}_{1/2}(^{57}Ni) / T_{1/2}(^{57}Ni) = 36.0/43.7 = 0.824$,

σ_4 - adopted $^{58}Ni(n,2n)^{57}Ni$ cross section,

$\Delta\sigma_4$ - cross section error.

Evaluation form No 2

AUTHORS: R.J.Prestwood, B.P.Bayhurst

REFERENCE: Physical Review 121 /1961/ 1438, [Pre 61].

LABORATORY: Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico.

QUANTITY MEASURED: Cross sections of $^{58}Ni(n,2n)^{57}Ni$ reaction for 9 neutron energies from 13.5 to 19.8 MeV.

METHOD: Activation.

ACCURACY: Neutron energy spread $\pm$ 100 to 430 keV, cross section $\pm$ 5 to 8%.

STANDARDS: $T_{1/2}(^{57}Ni) = 36.0$ h, $I_{\beta} = 0.469$ per decay of ^{57}Ni [Str 58], $^{238}U(n,f)$ cross section $\sigma = 1.38$ b [Bay 61], $^{27}Al(n,\alpha)^{24}Na$ cross sections.

NEUTRON SOURCE: Cockcroft-Walton accelerator, $T(d,n)^4He$ reaction on Zr-T target for neutron energies from 13.5 to 14.8 MeV; 6 MeV Van de Graaff accelerator, $T(d,n)^4He$ reaction on gas target for neutron energies from 16.5 to 18 MeV.

SAMPLES: Circular metal foils 9.5 mm in diameter.

FLUX DETERMINATION: In case of solid Zr-T target measured activity of ^{24}Na produced in $^{27}Al(n,\alpha)^{24}Na$ reaction and counted associated α- particles; in case of gas target $^{238}U(n,f)$ counter checked by radiochemical analysis of fission product ^{99}Mo in ^{238}U foils irradiated at 7 and 8 MeV.

EXPERIMENTAL ARRANGEMENT:

- Cockcroft-Walton accelerator: samples positioned on thin plastic hemispherical shell of 5 cm radius at angles from 0° to 165°, aliminium monitor foils placed with each sample, additional aluminium foil placed at 90° and at 10.0 ± 0.1 cm distance used as primary monitor.
- Van de Graaff accelerator: calibrated fission counter in conjunction with ^{238}U foil placed behind sample stack on beam axis.

ACTIVITY MEASUREMENT: β^{+} counted in proportional counter.

CORRECTIONS: In case of gas target stacks of ^{58}Ni foils alternated with ^{238}U placed on beam axis served for determining of flux attenuation, fission fragment loss accounted for.

ERRORS: Errors account for consistency of experimental data with theoretical excitation function based on statistical model, absolute errors not included.

NORMALIZATION - RESULTS: Authors' cross section referred presumably to cross section given in ref. [Kni 58] and ref. [Bay 61a] have been renormalized according to recommended cross section of reference reaction $^{27}Al(n,\alpha)^{24}Na$ and $^{238}U(n,f)$, and I_{β} per decay of ^{57}Ni renormalized to recommended value.

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	R_B	σ_4 [mb]	$\Delta\sigma_4$ [mb]
13.52	0.15	13.9	130.6	128	1.004	13.7	0.7
13.88	0.10	21.4	128.5	126	1.004	21.1	1.1
14.09	0.10	23.5	128.3	123.5	1.004	26.7	1.7
14.31	0.13	31.1	123.6	121	1.004	30.5	1.6
14.50	0.20	34.3	119.8	119	1.004	34.2	1.7
14.81	0.31	39.3	114.1	115.5	1.004	89.8	2.0
16.50	0.30	53.3	1380	1350	1.004	52.3	4.2
17.95	0.32	67.6	1380	1320	1.004	65.0	3.3
19.76	0.43	77.4	1380	1410	1.004	79.4	4.0

σ_1 - cross section given by authors,

σ_2 - cross section of $^{27}Al(n,\alpha)^{24}Na$ and $^{238}U(n,f)$ used by authors,

σ_3 - recommended cross section of $^{27}Al(n,\alpha)$ and $^{238}U(n,f)$,

R_B - normalization factor:

$R_B = I_\beta / I_\beta^r = 0.469/0.467 = 1.004$,

σ_4 - adopted cross section: $\sigma_4 = R_B(\sigma_3/\sigma_2)\sigma_1$,

$\Delta\sigma_4$ - cross section error: $\Delta\sigma_4 = R_B(\sigma_3/\sigma_2)\Delta\sigma_1$.

Evaluation form No 3

AUTHORS: R.N.Glover and E.Weigold

REFERENCE: Nuclear Physics 29 /1962/ 309, [Glo 62].

LABORATORY: Dept. of Nuclear Physics, Australian National University, Canberra, A.C.T.

QUANTITY MEASURED: Cross section for $^{58}Ni(n,2n)^{57}Ni$ for 9 energy values from 13.9 to 14.9 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$100 to 300 keV, cross section $\pm$ 8%.

STANDARDS: $T_{1/2}(^{57}Ni)$ = 37 h, I_γ (511 keV) = 0.928 per decay of ^{57}Ni, $^{65}Cu(n,2n)^{64}Cu$ cross sections.

NEUTRON SOURCE: 250 keV Cockcroft-Walton accelerator, $T(d,n)^4He$ reaction on Ti-T target.

SAMPLE: Circular foils of 1 cm^2 area and of various thickness.

FLUX DETERMINATION: Associated α-particle method for flux determination and monitoring, $^{65}Cu(n,2n)^{64}Cu$ reaction used to determine neutron angular distribution.

EXPERIMENTAL ARRANGEMENT: Sample positioned 5 cm from neutron source at angles from 0° to 110°, sample foils sandwiched or interleaved between copper monitor foils.

ACTIVITY MEASUREMENT: Annihilation quanta counted with two 7.6x7.6 cm NaI(Tl) crystals (10 cm apart) in coincidence, samples placed between aluminium absorbers to stop positons.

CORRECTIONS: Decay during irradiation accounted for, flux corrected for neutron scattering from target chamber.

ERRORS: Individual error sources:

- absolute neutron flux determination 6%
- uncertainty in sample position with respect to target 2%
- measurement of detector geometry 3 to 4%
- statistical errors in coincidence counts and/or in counts ratios range from 0.5 to 4%.

EVALUATORS' COMMENT: Work contains complete information about used standards.

NORMALIZATION-RESULTS: Authors' results renormalized according to recommended $T^r_{1/2}(^{57}Ni)$ and I^r_{γ} (511 keV) per decay of ^{57}Ni, no renormalization connected with $^{65}Cu(n,2n)^{64}Cu$ cross section was necessary.

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	R_T	R_B	σ_2 [mb]	$\Delta\sigma_2$ [%]
13.86	0.10	18.7	0.973	0.994	18.1	8
14,11	0.10	22.9	0.973	0.994	22.1	8
14.24	0.10	27.2	0.973	0.994	26.3	8
14.37	0.15	29.3	0.973	0.994	28.3	8
14.49	0.20	31.7	0.973	0.994	30.7	8
14.59	0.20	33.5	0.973	0.994	32.4	8
14.69	0.25	35.9	0.973	0.994	34.7	8
14.77	0.25	36.2	0.973	0.994	35.0	8
14.88	0.30	39.5	0.973	0.994	38.2	8

σ_1 - cross section given by authors,

R_T - normalization factor:
$R_T = T^r_{1/2}(^{57}\mathrm{Ni})/T_{1/2}(^{57}\mathrm{Ni}) = 36.0/37.0 = 0.973$,

R_B - normalization factor:

$R_B = I_\gamma(511\ \mathrm{keV})/I^r_\gamma\ (511\ \mathrm{keV}) = 0.928/0.934 = 0.994$,

σ_2 - adopted cross section $\sigma_2 = \sigma_1 \times R_T \times R_B$,

$\Delta\sigma_2$ - cross section error .

Evaluation form No 4

AUTHORS: N.T.Bramlitt, R.W.Fink.

REFERENCE: Phys. Rev. 131 /1963/ 2649 [Bra 63].
Some experimental details taken from [Bra 62].

LABORATORY: Department of Chemistry, University of Arkansas, Fayetteville, Arkansas, USA.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 14.7 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 200 keV, cross section $\pm$ 12.9%.

STANDARDS: $^{27}Al(n,\alpha)^{24}Na$ cross section σ = 114 mb at 14.7 MeV, I_{γ}(1370 keV) = 0.75$\pm$0.06 per decay of ^{57}Ni.

NEUTRON SOURCE: Arkansas 400 keV Cockcroft-Walton accelerator.

SAMPLES: Nickel foils.

FLUX DETERMINATION: Al monitoring foils placed in front and in back of sample.

ACTIVITY MEASUREMENT: Two-crystal (3" x 3") NaI(Tl) scintillation spectrometer with 200-channel analyzer used for counting 1370 keV gamma-rays.

CORRECTIONS: Neutron output decrease from Ti-T targets observed and taken into account.

ERRORS: Individual sources of error:

- absolute counting correction factor $\pm$ 5%
- photopeak area uncertainty $\pm$ 10%.

NORMALIZATION - DATA:

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	R_B	σ_4 [mb]	$\Delta\sigma_4$ [mb]
14.7	0.2	31.0	114	117	0.872	27.7	3.6

σ_1 - cross section given by authors,

σ_2 - $^{27}Al(n,\alpha)^{24}Na$ cross section used by authors,

σ_3 - $^{27}Al(n,\alpha)^{24}Na$ recommended cross section,

R_B - normalization factor:

$R_B = I_\gamma(1370\ \text{keV}) / I_\gamma^r(1370\ \text{keV}) = 0.75/0.86 = 0.872$,

σ_4 - adopted cross section: $\sigma_4 = \sigma_1 \times R_B \times \sigma_3/\sigma_2$,

$\Delta\sigma_4$ - cross section error: $\Delta\sigma_4 = \Delta\sigma_1 \times R_B \times \sigma_3/\sigma_2$.

Evaluation form No 5

AUTHORS: A.Paulsen and H.Liskien.

REFERENCE: Nucleonik 7 /1965/ 117, [Pau 65].

LABORATORY: Central Bureau for Nuclear Measurements, EURATOM, Geel, Belgium.

QUANTITY: Cross sections for $^{58}Ni(n,2n)^{57}Ni$ for 25 energy values from 12.98 MeV to 19.58 MeV.

METHOD OF MEASUREMENTS: Activation.

ACCURACY: Neutron energy spread $\pm$ 170 keV to $\pm$ 470 keV, cross section $\pm$ 7 % and $\pm$ 10%.

STANDARDS: $T_{1/2}(^{57}Ni)=35.8$ h, $I_\gamma(511$ keV$) = 0.938$ photons per decay of ^{57}Ni, neutron flux evaluated from formula of Gammel [Gam 63] for total n-p scattering cross section, neutron angular distribution taken from compilation [Pau 64].

NEUTRON SOURCE: 3-MeV Van de Graaff accelerator, Ti-t targets bombarded with 1 MeV and 3 MeV deuterons.

SAMPLES: Metallic discs 20 mm in dia., 5 mm thick.

FLUX DETERMINATION: Proton recoil telescope absolute measurement, flux variations monitored by means of long counter.

EXPERIMENTAL ARRANGEMENT: Samples placed at distance 84.5 mm from the target, deuteron beam limited by aperture 3x8 mm.

ACTIVITY MEASUREMENTS: 0.511 MeV gamma rays counted with NaI(Tl) crystals 1.75" x 2.0" and 4.0" x 3.0", counter efficiency calibrated with ^{22}Na source of β^+ decay rate known to $\pm$ 5%.

CORRECTIONS: Left-right assymetry accounted for, photopeak area corrected for ^{58}Co activity, 1.9% correction for loss of neutron flux due to scattering and absorption in samples, 6.0% correction for effects observed under photopeak due to gamma rays of higher energies.

ERRORS: Cross sections determined with accuracy 7% except of threshold region where $\leqslant$10%, individual error sources:

- neutron flux determination	$\pm$ 4%,
- irradiation geometry	$\pm$ 1.7% to $\pm$ 3.8%,
- neutron angular distribution	$\pm$ 2.5%,
- efficiency of gamma ray detection	$\pm$ 1.5% to $\pm$ 2.3%,
- counting rate statistics, background, dead time, decay constants	$\pm$ 0.6% to $\pm$ 2.0%,
- neutron absorption and scattering	$\pm$ 0.5%,
- chemical purity	$\pm$ 0.3%,
- flux variation in time	$\pm$ 0.1%,
- sample weight	$\pm$ 0.1%.

EVALUATORS COMMENT: Work covers broad energy range with densely spaced experimental points giving detailed shape of excitation curve.

NORMALIZATION-RESULTS: Authors results normalized according to recommended $T^r_{1/2}$ (^{57}Ni) and I^r_γ (511 keV) per decay of ^{57}Ni.

DATA:

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	R_T	R_B	σ_2 [mb]	$\Delta\sigma_2$ [mb]
12.98	0.17	3.2	1.0056	1.0043	3.2	0.3
13.10	0.18	4.6	1.0056	1.0043	4.6	0.4
13.38	0.21	10.1	1.0056	1.0043	10.2	0.7
13.54	0.22	11.9	1.0056	1.0043	12.0	0.8
13.88	0.24	19.6	1.0056	1.0043	19.8	1.4
14.05	0.25	22.0	1.0056	1.0043	22.2	1.5
14.42	0.26	29.4	1.0056	1.0043	29.7	2.1
14.61	0.26	33.4	1.0056	1.0043	33.7	2.3
14.99	0.27	38.0	1.0056	1.0043	38.4	2.7
15.18	0.26	39.5	1.0056	1.0043	39.9	2.8
15.55	0.24	43.0	1.0056	1.0043	43.4	3.0
15.71	0.23	44.5	1.0056	1.0043	44.9	3.1
16.03	0.21	46.1	1.0056	1.0043	46.6	3.2
16.24	0.20	47.1	1.0056	1.0043	47.6	3.3
16.59	0.19	50.4	1.0056	1.0043	50.9	3.5
16.93	0.47	49.9	1.0056	1.0043	50.4	3.5
17.27	0.46	51.2	1.0056	1.0043	51.7	3.6
17.59	0.44	55.1	1.0056	1.0043	55.7	3.9
17.90	0.42	55.0	1.0056	1.0043	55.5	3.9
18.19	0.39	56.4	1.0056	1.0043	57.0	4.0
18.47	0.36	58.5	1.0056	1.0043	59.1	4.1
18.71	0.33	60.4	1.0056	1.0043	61.0	4.2
18.94	0.29	60.5	1.0056	1.0043	61.1	4.2
19.29	0.20	63.8	1.0056	1.0043	64.4	4.5
19.58	0.19	66.5	1.0056	1.0043	67.2	4.7

σ_1 - cross section of $^{58}Ni(n,2n)^{57}Ni$ given by authors,

R_T - normalization factor:

$R_T = T^r_{1/2}(^{57}Ni)/T_{1/2}(^{57}Ni) = 36.0/35.8 = 1.0056,$

R_B - normalization factor:

$R_B = I_\gamma(511\ keV)/I^r_\gamma(511\ keV) = 0.938/0.934 = 1.0043,$

σ_2 - adopted cross section for $^{58}Ni(n,2n)^{57}Ni$,

$\Delta\sigma_2$ - cross section error.

Evaluation form No 6

AUTHORS: M.Bormann, F.Dreyer, N.Fretwurst, F.Schenka

REFERENCE: EANDC(E) 66U42 [Bor 66], additional references: Nuclear Physics 63 /1965/ 438 [Bor 65], Nuclear Data 1A /1966/ 103 [Jes 66].

LABORATORY: Institut für Experimentalphysik, Universität Hamburg.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ for 10 energy values from 12.95 to 19.6 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 0.2 to 0.4 MeV, cross section $\pm$ 6.8%.

STANDARDS: No information.

NEUTRON SOURCE: 3 MeV Van de Graaff and 150 keV Cockcroft--Walton accelerators, $T(d,n)^{3}He$ reaction on Ti-T target [Bor 65].

SAMPLE: No information.

FLUX DETERMINATION: Recoiled protons detected in 2.5x2.5 cm stilbene scintillation counter [Bor 65].

EXPERIMENTAL ARRANGEMENT: Samples placed at different angles around neutron source [Bor 65].

ACTIVITY MEASUREMENT: No information.

CORRECTIONS: Self-absorption and self-scattering accounted for by extrapolating to zero thickness [Bor 65].

ERRORS: Absolute flux determination 4.5% [Bor 65], errors do not include decay schemes uncertainties.

EVALUATORS COMMENT: Data taken from CCDN file, report EANDC(E)66U42 unavailable. No normalization because of lack of information.

RESULTS:

E_n [MeV]	ΔE_n [MeV]	σ [mb]	$\Delta\sigma$ [mb]
12.95	0.20	4.7	0.3
13.50	0.25	11.9	0.8
14.10	0.25	22.7	1.4
14.90	0.30	34.6	2.4
15.60	0.35	40.6	2.8
16.50	0.35	44.3	3.0
17.25	0.40	48.2	3.3
18.00	0.35	51.3	3.5
18.90	0.3	52.1	3.5
19.60	0.25	53.5	3.6

σ - cross section given by authors,

$\Delta\sigma$ - cross section error,

Evaluation form No 7

AUTHOR: J.Csikai,

REFERENCE: ATOMKI Közlemények 8 /1966/ 79, [Csi 66]. Some details and data taken from other papers by J.Csikai [Csi 65, Csi 67, Csi 68].

LABORATORY: Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary.

QUANTITY: Cross section of $^{58}Ni(n,2n)^{57}Ni$ for 25 energy values from 13.56 to 15.40 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 2%, cross section $\pm$ 8 to 15%.

STANDARDS: Cross section 541 mb at 14.6 MeV for the $^{63}Cu(n,2n)^{62}Cu$ obtained by normalization of measured relative excitation curve to the 488 mb of Letessier [Let 64] at 14.1 MeV.

NEUTRON SOURCE: ATOMKI neutron generator. Ti-T target bombarded with 80 keV deuterons.

SAMPLES: Thin metal wires.

FLUX DETERMINATION: Flux monitored by long counter and plastic scintillator.

EXPERIMENTAL ARRANGEMENT: Wire samples placed radially at various angles around target.

ACTIVITY MEASUREMENT: NaI(Tl) crystal connected to 100 or 125-channel analyzer. 511 keV gamma-rays counted. System calibrated with ^{203}Hg, ^{54}Mn, ^{137}Cs and ^{88}Y gamma-ray sources.

CORRECTIONS: No information.

ERRORS: Energy spread mainly from stopping of deuterons in target equals several keV at 14.0 MeV, more than 100 keV at 13.5 and 14.7 MeV. Main error source is statistics.

EVALUATORS' COMMENT: The aim of this work is an investigation of cross section fluctuations. Relative numerical values obtained on request. Author's normalization equals 37 ± 3 mb at 14.6 MeV. No information about errors in [Csi 66].

NORMALIZATION - DATA:

σ_1 - relative yield given by author,

σ_2 - absolute cross section according to author's normalization,

σ_3 - $^{63}Cu(n,2n)^{62}Cu$ cross section used by author,

σ_4 - $^{63}Cu(n,2n)^{62}Cu$ recommended cross section,

σ_5 - adopted cross section: $\sigma_5 = \sigma_2 \times \sigma_4/\sigma_3$,

$\Delta\sigma_5$ - cross section error: $\Delta\sigma_5 = \Delta\sigma_2 \times \sigma_4/\sigma_3$.

E_n [MeV]	ΔE_n [MeV]	σ_1	σ_2 [mb]	σ_3 [mb]	σ_4 [mb]	σ_5 [mb]	$\Delta\sigma_5$ [mb]
13.56		0.60	22.2			23.1	
13.61		0.61	22.6			23.5	
13.66		0.62	22.9			23.9	
13.71		0.67	24.8			25.8	
13.76		0.70	25.9			27.0	
13.81		0.73	27.0			28.1	
13.86		0.74	27.4			28.5	
13.91		0.73	27.0			28.1	
13.96		0.70	25.9			27.0	
14.01		0.80	29.6			30.8	
14.06		0.80	29.6			30.8	
14.11		0.79	29.2			30.4	
14.16		0.86	31.8			33.1	
14.21		0.81	30.0			31.2	
14.26		0.82	30.3			31.6	
14.31		0.89	32.9			34.3	
14.36		0.95	35.1			36.6	
14.41		0.90	33.3			34.7	
14.46		1.00	37.0			38.5	
14.51		0.96	35.5			37.0	
14.56		1.00	37.0			38.5	
14.61		1.02	37.7	541	563	39.3	
14.66		1.04	38.5			40.0	
14.71		1.00	37.0			38.5	
14.7	0.3		37			38.5	3.0 §
15.40	0.3		45	488	488	45	7.0 §

§ - from [Csi 68].

Evaluation form No 8

AUTHOR: J.K.Templerley.

REFERENCE: Nucl. Sci. Eng. 32 /1968/ 195, [Tem 68].

LABORATORY: U.S.Army Nuclear Defense Lab., Edgewood Arsenal, Maryland, USA.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 6 energy values from 13.72 to 14.79 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 200 to 320 keV, cross section $\pm$ 10 %.

STANDARDS: $T_{1/2}(^{58}Ni) = 37.0$ h, $I_{\gamma}(511 \text{ keV}) = 0.938$ per decay of ^{57}Ni, from [Way 60].

NEUTRON SOURCE: USANDL Cockcroft-Walton accelerator. Ti-T targets bombarded with 180 and 150 keV deuterons.

SAMPLES: Chemically pure Ni powder in plastic holder with cavity 2 cm in dia. and 4 mm deep.

FLUX DETERMINATION: Absolute measurement, associated α - particle counting at 135°, counting rate monitored continuously and maintained constant within $\pm$ 5%.

EXPERIMENTAL ARRANGEMENT: Samples placed at various angles at mean distance of 4.5 cm from neutron source, bombarded 9 hours. Targets changed every 3 hours.

ACTIVITY MEASUREMENT: Absolute 511 keV gamma-ray counting with 3" x 3" NaI(Tl) crystal, calibrated with single gamma-ray sources of known activity.

CORRECTIONS: Photopeak areas corrected for self-absorption of gamma-rays in samples.

ERRORS: Individual error sources:

- absolute neutron flux $\pm$ 8%
- absolute gamma-ray activity $\pm$ 5%.

NORMALIZATION - DATA: Author's results normalized according to recommended $T^r_{1/2}(^{57}Ni)$ and $I^r_\gamma(511\ keV)$ per decay of ^{57}Ni.

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	R_T	R_B	σ_2 [mb]	$\Delta\sigma_2$ [%]
13.72	0.20	19.0	0.973	1.0043	18.6	10
13.95	0.20	24.4	0.973	1.0043	23.8	10
14.20	0.25	25.5	0.973	1.0043	24.9	10
14.31	0.31	28.1	0.973	1.0043	27.5	10
14.53	0.32	27.3	0.973	1.0043	26.7	10
14.79	0.30	29.1	0.973	1.0043	28.4	10

σ_1 - cross section given by author,

R_T - normalization factor:

$R_T = T^r_{1/2}(^{57}Ni)/T_{1/2}(^{57}Ni) = 36.0/37.0 \doteq 0.973$,

R_B - normalization factor:

$R_B = I_\gamma(511\ keV)/I^r_\gamma(511\ keV) = 0.938/0.934 = 1.0043$,

σ_2 - adopted cross section: $\sigma_2 = R_T \cdot R_B \cdot \sigma_1$,

$\Delta\sigma_2$ - cross section error.

Evaluation form No 9

AUTHORS: R.C.Barrall, M.Silbergeld, D.G.Gardner.

REFERENCE: Nuclear Physics A138 /1969/ 387, [Bar 69].

LABORATORY: Stanford University, California, USA;
Lawrence Radiation Laboratory, University of California,
Livermore, USA.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 14.8 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 200 keV, cross section $\pm$ 8.3%.

STANDARDS: I_{γ}(1370 keV) = 0.86 per decay of ^{57}Ni.

NEUTRON SOURCE: Insulated Core Transformer accelerator at LRL. Ti-T target bombarded with 200 keV deuterons.

SAMPLES: 7.6 x 7.6 x 0.1 cm metallic sheets covered with 0.75 mm cadmium.

FLUX DETERMINATION: Proton-recoil telescope used for absolute measurement of neutron flux above 9 MeV.

EXPERIMENTAL ARRANGEMENT: Samples placed on large rotating disc, their centres 36.8 cm from target, at angle of 26.5° to deuteron beam. Disc rotated at 5 rpm.

ACTIVITY MEASUREMENT: 7.6 x 7.6 cm NaI(Tl) crystal calibrated with US National Bureau of Standards point-source gamma-ray standards.

ERRORS: Two sigma error limits about 8%. Major source of error is measurement of neutron flux, at sample position, by means of proton recoils counting.

NORMALIZATION - DATA: No normalization needed.

E_n [MeV]	ΔE_n [MeV]	σ [mb]	$\Delta\sigma$ [mb]
14.8	0.2	36	3

Evaluation form No 10

AUTHORS: J.Araminowicz and J.Dresler.

REFERENCE : Institute of Nuclear Research, report No 1464/I/A [Ara 73], details taken from [Ara 72].

LABORATORY: Institute of Physics, University of Łódź.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at energy 14.6 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 0.38 MeV [Ara 72], cross section $\pm$ 10 %.

STANDARDS: $T_{1/2}(^{57}Ni)$ = 42.39 h, I_{γ} (511 keV) = 0.938 per decay of ^{57}Ni, $T_{1/2}(^{62}Cu)$ = 10.24 min [Ara 72], $^{63}Cu(n,2n)^{62}Cu$ cross section σ = 533 mb [Ara 72].

NEUTRON SOURCE: 180 keV Cockcroft-Walton, $T(d,n)^{4}He$ reaction, deuteron beam diameter 8 mm [Ara 72].

SAMPLES: Metallic powder in plexiglass container ϕ 25x9 mm [Ara 72].

FLUX DETERMINATION: Measured γ-activity of ^{62}Cu produced in $^{63}Cu(n,2n)^{62}Cu$ reaction, neutron flux monitored by means of associated α-particle method.

EXPERIMENTAL ARRANGEMENT: Sample irradiated simultaneously with reference sample at angle 45° [Ara 72].

ACTIVITY MEASUREMENT: Photons counted with two NaI(Tl) crystals 38x25 mm, in coincidence, distance between crystals 20 mm, iron shield used, [Ara 72].

CORRECTIONS: Divergence of neutron beam accounted for, corrections made for selfabsorption and for target waste [Ara 72].

ERRORS: Only statistical.

EVALUATORS COMMENT: $^{63}Cu(n,2n)^{62}Cu$ cross section $\sigma = 538$ mb given in [Ara 73] assumed erroneous. Accepted $\sigma = 533$ mb [Ara 72] for normalization.

NORMALIZATION-RESULT: Authors result normalized according to recommended $T^{r}_{1/2}(^{57}Ni)$, I^{r}_{γ} (511 keV) per decay of ^{57}Ni, and $^{63}Cu(n,2n)^{62}Cu$ cross section,

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	R_T	R_B	σ_4 [mb]	$\Delta\sigma_4$ [mb]
14.6	0.38	37.9	533	562	0.849	1.004	34.1	3.4

σ_1 - cross section given by authors,
σ_2 - $^{63}Cu(n,2n)^{62}Cu$ cross section used by authors,
σ_3 - recommended $^{63}Cu(n,2n)^{62}Cu$ cross section,
R_T - normalization factor:
$R_T = T^{r}_{1/2}(^{57}Ni)/T_{1/2}(^{57}Ni) = 36.0/42.39 = 0.849$,
R_B - normalization factor:
$R_B = I_{\gamma}(511\text{ keV})/I^{r}_{\gamma}(511\text{ keV}) = 0.938/0.934 = 1.004$,
σ_4 - adopted cross section $\sigma_4 = \sigma_1(\sigma_3/\sigma_2)R_T R_B$,
$\Delta\sigma_4$ - cross section error $\Delta\sigma_4 = \Delta\sigma_1(\sigma_3/\sigma_2)R_T R_B$.

Evaluation form No 11

AUTHOR: J.D.Hemingway.

REFERENCE: J. Nuclear Energy 27 /1973/ 241, [Hem 73].

LABORATORY: Londonderry Lab. for Radiochemistry, University of Durham, England.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 14.7 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 200 keV, cross section $\pm$ 8%.

STANDARDS: $^{56}Fe(n,p)^{56}Mn$ cross section at 14.7 MeV equal 97.8 mb [Hem 66]. Isotopic abundances and decay data taken from Nuclear Data Sheets.

NEUTRON SOURCE: Ti-T target bombarded with 150 keV deuterons.

SAMPLES: Nickel oxide mixed with iron granules irradiated in polyethylene container 8 mm x 15 mm in dia.

FLUX DETERMINATION: Variations in flux monitored with proton recoil counter.

EXPERIMENTAL ARRANGEMENT: Sample placed 3 mm away from target (of 10 mm diameter) in forward direction.

ACTIVITY MEASUREMENT: Magnetically separated iron dissolved in standard acid mixture and counted in G-M counter of known efficiency. ^{57}Co chemically separated from dissolved NiO, ^{57}Co gamma-rays 122 + 136 keV measured using 76 x 76 mm NaI(Tl) crystal.

System calibrated for ^{57}Co by $4\pi\beta-\gamma$ coincidence counting. Second chemical separation of cobalt from nickel carried out some ten days after irradiation. From two ^{57}Co measurements, contribution of $^{58}Ni(n,2n)$ and $^{58}Ni(n,np\ etc.)$ reactions could be separated.

CORRECTIONS: No information.

ERRORS: Individual error sources:

- counting $\pm 2.7\%$,
- reference cross section $\pm 4.5\%$,
- counter efficiency below $\pm 2\%$.

Two latter errors taken as systematic error of $\pm 5.5\%$.
Estimated neutron energy spread covers variation of neutron energy with emission angle and energy loss inside target.

NORMALIZATION - DATA: Author's results normalized according to recommended reference cross section.

E_n MeV	ΔE_n MeV	σ_1 mb	σ_2 mb	σ_3 mb	σ_4 mb	$\Delta\sigma_4$ mb
14.7	0.2	32.6	97.8	104.0	34.7	2.9

σ_1 - cross section given by author,
σ_2 - $^{56}Fe(n,p)^{56}Mn$ cross section used by author,
σ_3 - $^{56}Fe(n,p)^{56}Mn$ recommended cross section,
σ_4 - adopted cross section: $\sigma_4 = \sigma_1 \times \sigma_3/\sigma_2$,
$\Delta\sigma_4$ - cross section error: $\Delta\sigma_4 = \Delta\sigma_1 \times \sigma_3/\sigma_2$.

Evaluation form No 12

AUTHORS: R.Spangler, E.Linn Draper, Jr., T.A.Parish.

REFERENCE: Trans. Amer. Nucl. Soc. 22 /1975/ 818, [Spa 75].

LABORATORY: University of Texas, Austin, USA.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 14.1 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Cross section $\pm$ 12.5%.

STANDARDS: $^{27}Al(n,\alpha)^{24}Na$ cross section σ = 115 mb at 14.1 MeV [Bar 69], $I_\gamma(511\ keV)$ = 0.92 per decay of ^{57}Ni.

NEUTRON SOURCE: Texas Nuclear neutron generator.

SAMPLES: Foils of various sizes.

FLUX DETERMINATION: No information.

EXPERIMENTAL ARRANGEMENT: No information.

ACTIVITY MEASUREMENT: 511 keV gamma-rays counted using NaI(Tl) crystal and multichannel analyzer.

CORRECTIONS: No information.

ERRORS: No information.

NORMALIZATION - DATA: Authors' results normalized according to recommended $I_\gamma^r(511\ keV)$ and recommended reference cross section.

E_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	R_B	σ_4 [mb]	$\Delta\sigma_4$ [mb]
14.1	24	115	123.5	0.985	25.4	3.2

σ_1 - cross section given by authors,

σ_2 - $^{27}Al(n,\alpha)^{24}Na$ cross section used by authors,

σ_3 - $^{27}Al(n,\alpha)^{24}Na$ recommended cross section,

R_B - normalization factor:

$R_B = I_\gamma(511\text{ keV}) / I_\gamma^r(511\text{ keV}) = 0.92/0.934 = 0.985$,

σ_4 - adopted cross section: $\sigma_4 = \sigma_1 \times R_B \times \sigma_3/\sigma_2$,

$\Delta\sigma_4$ - cross section error: $\Delta\sigma_4 = \Delta\sigma_1 \times R_B \times \sigma_3/\sigma_2$.

Evaluation form No 13

AUTHORS: S.M.Qaim and N.I.Molla.

REFERENCE: Procedings of the 9th Symposium on Fusion Technology, Pergamon Press and New York 1976 [Qai 76], and private communication [Qai 77].

LABORATORY: Institut für Chemie der Kernforschungsanlage Jülich.

QUANTITY: Cross section for $^{58}Ni(n,2n)^{57}Ni$ at 14.7 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 0.3 MeV, cross section $\pm$ 8.6%.

STANDARDS: $T_{1/2}(^{57}Ni) = 36.0$ h [Qai 77], $I_\gamma(1370 \text{ keV}) = 0.86$ per decay of ^{57}Ni [Qai 77], $^{27}Al(n,\alpha)^{24}Na$ cross section $\sigma = 121$ mb, $T_{1/2}(^{24}Na) = 15.05$ h [Qai 77].

NEUTRON SOURCE: Tritium target bombarded with deuterons, flux density $(2 \div 3) \times 10^9$ cm^{-2} sec^{-1}.

SAMPLE: Natural element.

FLUX DETERMINATION: Measured activity of ^{24}Na produced in $^{27}Al(n,\alpha)^{24}Na$ reaction.

EXPERIMENTAL ARRANGEMENT: No information.

ACTIVITY MEASUREMENT: 1370 keV gamma rays counted with Ge/Li/ spectrometer.

CORRECTIONS: No information.

ERRORS: No information.

NORMALIZATION-RESULT: Authors results normalized according to recommended $^{27}Al(n,\alpha)^{24}Na$ cross section.

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	σ_4 [mb]	$\Delta\sigma_4$ [mb]
14.7	0.3	35	121	117	34	3

σ_1 - cross section given by authors,

σ_2 - $^{27}Al(n,\alpha)^{24}Na$ cross section used by authors ,

σ_3 - $^{27}Al(n,\alpha)^{24}Na$ recommended cross section,

σ_4 - adapted cross section $\sigma_4 = (\sigma_3/\sigma_2)\times\sigma_1$,

$\Delta\sigma_4$ - cross section error $\Delta\sigma_4 = (\sigma_3/\sigma_2)\Delta\sigma_1$.

Evaluation form No 14

AUTHORS: B.P.Bayhurst, J.S.Gilmore, R.J.Prestwood, J.B.Wilhelmy, Nelson Jarmie, B.M.Eskkila and R.A.Hardekopf.

REFERENCE: Physical Review C 12 /1975/ 451 [Bay 75].

LABORATORY: University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

QUANTITY MEASURED: Cross sections of $^{58}Ni(n,2n)^{57}Ni$ for 10 energy values from 16 to 28 MeV.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 0.09 to 0.17 MeV, cross section $\pm$ 3.8 to 7.1%.

STANDARDS: $T_{1/2}(^{57}Ni) = 36.0$ h, $^{27}Al(n,\alpha)^{24}Na$ cross sections, $T_{1/2}(^{24}Na) = 15.0$ h, $^{90}Zr(n,2n)^{89}Zr$ cross sections, $T_{1/2}(^{89}Zr) = 78.4$ h, $H(n,n)H$ cross sections.

NEUTRON SOURCE: Van de Graaff accelerator with

- $D(d,n)^3He$ for 16.2 MeV
- $T(d,n)^4He$ for 17.2 MeV, 18.2 MeV, 20.0 MeV, 22.0 MeV,
- $D(t,n)^4He$ for 21.3 MeV, 23.3 MeV, 24.5 MeV, 26.0 MeV, 28.0 MeV.

SAMPLE: Circular foils 9.5 mm in diameter and 0.06 mm thick.

FLUX DETERMINATION: At 16.2 MeV measured activity of ^{89}Zr produced in $^{90}Zr(n,2n)^{89}Zr$ reaction and recoiled protons, at energies 17.2, 18.2, 20.0, 21.3, 22.0, 23.3, 24.5 MeV measured only activity of ^{24}Na produced in $^{27}Al(n,\alpha)^{24}Na$ reaction, proton recoil telescope used for energies higher than 21.0 MeV, at 28.0 MeV exceptionally measured activity of ^{89}Zr from $^{90}Zr(n,2n)^{89}Zr$ reaction also.

EXPERIMENTAL ARRANGEMENT: Sample stacks consisting of alternate monitor and sample foils in a steel holder placed at distance 10 - 15 mm from gas target (3 cm long), reaction product separated chemically.

ACTIVITY MEASUREMENT: β^+ spectroscopy with use of proportional counter, decay curves analysed by least-squares method.

CORRECTIONS: Activity induced by the low energy neutrons from (d,n) or (t,n) reactions on gold and other constructional elements accounted for.

ERRORS: Absolute counting efficiency, weighing, decay constants, flux determination

- 5% for $^{90}Zr(n,2n)^{89}Zr$ cross section
- 3 to 5% for $^{27}Al(n,\alpha)^{24}Na$ cross section
- 2 to 3% for recoil proton telescope.

EVALUATORS' COMMENT: Only work containing results for energies exceeding 20 MeV. Cross sections obtained at neutron energies between 16 MeV and 20 MeV are considerably higher than other results. No explanation for this discrepancy was found. This excitation curve has been accepted for evaluation in the 20 to 28 MeV energy region.

RESULTS:

E_n MeV	ΔE_n MeV	σ mb	$\Delta\sigma$ mb
16.21	0.11	63	3
17.23	0.17	70	5
18.24	0.09	76	5
19.99	0.11	92	6
21.26	0.18	93	4
22.01	0.13	97	4
23.36	0.11	102	4
24.49	0.12	96	4
26.06	0.12	87	4
28.05	0.14	72	3

σ - cross section for $^{58}Ni(n,2n)^{57}Ni$ given by authors .

Evaluation form No 15

AUTHORS: L.Adamski, M.Herman, A.Marcinkowski.

REFERENCE: Unpublished [Mar 77] .

LABORATORY: Institute of Nuclear Research, Warsaw.

QUANTITY MEASURED: Cross sections for $^{58}Ni(n,2n)^{57}Ni$ at 4 neutron energies.

METHOD OF MEASUREMENT: Activation.

ACCURACY: Neutron energy spread $\pm$ 0.07 to 0.80 MeV, cross section $\pm$ 8 to 12%.

STANDARDS: $T_{1/2}(^{57}Ni) = 36.0$ h, $I_{\gamma}(1370\ \text{keV}) = 0.86$ per decay of ^{57}Ni, $^{27}Al(n,\alpha)^{24}Na$ cross sections, $T_{1/2}(^{24}Na) = 15.0$ h, $^{56}Fe(n,p)^{56}Mn$ cross sections, $T_{1/2}(^{56}Mn) = 2.576$ h.

NEUTRON SOURCE: 3 MeV Van de Graaff accelerator, $T(d,n)^{4}He$ reaction on Ti-T target.

SAMPLE: Foils of Ni and reference foils of Fe and Al rolled together in plexiglas container 4 mm in diameter.

FLUX DETERMINATION: Measured activity of ^{24}Na and ^{56}Mn produced in $^{27}Al(n,\alpha)^{24}Na$ and $^{56}Fe(n,p)^{56}Mn$ reactions, respectively.

EXPERIMENTAL ARRANGEMENT: Samples placed 2 cm from target at various angles.

ACTIVITY MEASUREMENT: 1370 keV γ-rays counted with 40 ccm Ge(Li) spectrometer.

CORRECTIONS: For selfabsorption by Monte-Carlo calculations.

ERRORS: Individual error sources

- statistical errors — 5% ,
- sample weight — 0.1% ,
- flux variation in time — 0.3% ,
- reference cross section — 5% for $^{56}Fe(n,p)^{56}Mn$, 4.2% for $^{27}Al(n,\alpha)^{24}Na$,
- Ge(Li) relative efficiency — 1% (only for ^{56}Mn γ- rays).

EVALUATIONS' COMMENT: Work undertaken specially for the purpose of this evaluation.

RESULTS:

E_n [MeV]	ΔE_n [MeV]	σ_1 [mb]	σ_2 [mb]	σ_3 [mb]	$\Delta\sigma_3$ [mb]
14.02	0.80	111.5		18.0	2.1
16.42	0.68	70.0		48.3	4.1
17.42	0.44		73.0	56.8	5.8
17.42	0.44	64.2		59.0	6.2
17.85	0.07		66.5	60.0	6.1
17.85	0.07	60.0		62.5	6.4

σ_1 - $^{56}Fe(n,p)^{56}Mn$ cross section,
σ_2 - $^{27}Al(n,\alpha)^{24}Na$ cross section,
σ_3 - $^{58}Ni(n,2n)^{57}Ni$ cross section,
$\Delta\sigma_3$ - cross section error.

V. RECOMMENDED DATA SET

Considering the $^{58}Ni(n,2n)^{57}Ni$ experimental cross sections we have distinguished three regions, in which different criteria of evaluation have been assumed. The first region extends from the threshold energy up to about 16 MeV neutron energy. In this region the accepted data are consistent within the experimental errors and concentrated along a smoothly increasing, with increasing energy, line. In the second region between 16 MeV and 20 MeV there exist the data of the four excitation curves measured by Prestwood et al. [Pre 61], Paulsen and Liskien [Pau 65], Bormann et al. [Bor 66] and Bayhurst et al. [Bay 75]. These four data sets diverge evidently with increasing neutron energy. The excitation curve of Bayhurst et al. extends into the third region up to 28 MeV and therefore it will be considered independently. In treating the remaining three divergent excitation curves the polynomial $P(E) = \sum_{i \leq 6} a_i E^i$ has been fitted separately to each of the data sets in the energy range from 15.0 MeV to 20.0 MeV supplying P_I, P_{II} and P_{III}. Separate polynomial P_{IV} has been fitted to all the single energy data including the cross sections belonging to the mentioned three data sets, which lie below the 15 MeV limit. The latter fit extends from 13 MeV to 18 MeV. The polynomial P_V has been then fitted to P_I, P_{II}, P_{III} and P_{IV}, assuming a constant energy step. Such a procedure ascribes an equal weight to the three data sets [Pre 61], [Pau 65] and [Bor 66], not depending on the number of points in each excitation curve. This was our intention.

As a next step the polynomial fit to the Csikai [Csi 66] data, in the energy range 13.6 - 15.4 MeV, as well as an independent polynomial fit to the whole curve measured by Bayhurst et al. [Bay 75], both lying well above the average trend displayed by the remaining data, have been performed. The resulting polynomials were normalized to the P_V, the normalization constants being 0.79 and 0.76, respectively. After normalization the two latter polynomials and the P_I, P_{II} and P_{III} were at last fitted to the $P(E)=\sum_{i=0}^{5} a_i E^i$ giving the recommended data set displayed in Fig. 4 and 5 and in Table 2.

The mean square deviation of the data from the recommended data curve /excitation curve treated as single measurement/ together with the average experimental error, assumed to be 7.5% below 14 MeV and 8.0% above 14 MeV, served for determining the errors of the recommended cross section below 16 MeV. The same being true for the lower limit of the errors in whole energy range. The upper limit above 22 MeV equals to the average deviation of the data points given by Bayhurst et al. [Bay 75] from the recommended curve. A linear interpolation in the transition region reflects existence of an overlap between the overestimated data of Bayhurst et al. and the remaining ones.

VI. CONCLUSIONS

A great attention has been paid to the $^{58}Ni(n,2n)^{57}Ni$ reaction used as a neutron monitor. This resulted in the evaluations of Barrall UKNDL (DFN.236) [Bar 65], Bhat ENDF/B-IV (Mat. 6419), Guenther et al. [Gue 75] and Lapenas [Lap 75] published recently. These evaluations range up to 20 MeV in neutron energy. Their results are compared with the recommended data obtained in the present work in Fig. 6 .

The data of Guenther et al. and of Lapenas agree with our evaluation within 3% and 5%, respectively. The other two evaluations deviate from our data for energies lower than 14 MeV and higher than 17 MeV. In the latter energy region the excitation curves of both Barrall and Bhat follow the data obtained by Bormann et al. [Bor 66], which are lower than the average trend. Our recommended cross sections extend above the 20 MeV limit basing on the results of the experiment performed in 1975 by Prestwood et al. [Pre 75].

The statistical model [Dec 72] estimates do not facilitate the evaluation, the theoretical cross sections being much higher than the experimental ones. The compound nucleus cross sections should be corrected in order to allow for the precompound emission [Aug 77], however this correction is very small and the prediction of the theory remains too high by about 4 times. This discreapancy is a known fact, which has not found explanation until now. The theoretical cross sections are compiled in Table 3.

TABLE 3.

E_n [MeV]	σ_{comp} [mb]	R	$\sigma_{theo.}$ [mb]	σ_r [mb]
13.0	43.6	1.009	44.0	4.1
15.0	147.9	1.005	148.6	36.0
17.0	201.4	1.096	220.7	52.6

$\sigma_{comp.}$ - statistical model estimates,

R - correction factor accounting for the precompound emission,

$\sigma_{theo.}$ - theoretical predictions,

σ_r - recommended experimental cross section.

The recommended cross sections are tabelarized in 100 keV energy steps from 12.9 MeV to 28.0 MeV in Table 2. The absolute errors, described in chapter V, are attached. Unfortunately they exceed slightly the 10% error limit requested by Michaudon [Wrenda 76/77], reaching 11.4% from the threshold energy up to 14.0 MeV. In the energy range from 14.0 MeV to 16.0 MeV the accuracy reaches 8.7%. At still higher energies the estimated accuracy is again worse because of the inconsistency of the results of Prestwood et al. with the average trend displayed by the data at lower energies.

TABLE 2

RECOMMENDED CROSS SECTIONS FOR $^{58}Ni(n,2n)^{57}Ni$

(The recommended cross sections are described by the 5^{th} order polynomial with the following coefficients:

$$a_0 = -3230.7$$
$$a_1 = 755.26$$
$$a_2 = -70.268$$
$$a_3 = 3.2762$$
$$a_4 = -.075663$$
$$a_5 = .00068650).$$

NEUTRON ENERGY MEV	CROSS SECTION MB	ABSOLUTE ERROR MB	
12.9	1.8	+ .2	- .2
13.0	4.1	+ .5	- .5
13.1	6.3	+ .7	- .7
13.2	8.5	+ 1.0	-1.0
13.3	10.5	+ 1.2	-1.2
13.4	12.5	+ 1.4	-1.4
13.5	14.4	+ 1.6	-1.6
13.6	16.2	+ 1.8	-1.8
13.7	18.0	+ 2.0	-2.0
13.8	19.7	+ 2.2	-2.2
13.9	21.3	+ 2.4	-2.4
14.0	22.9	+ 2.0	-2.0
14.1	24.4	+ 2.1	-2.1
14.2	25.9	+ 2.3	-2.3
14.3	27.3	+ 2.4	-2.4
14.4	28.7	+ 2.5	-2.5
14.5	30.0	+ 2.6	-2.6
14.6	31.3	+ 2.7	-2.7
14.7	32.5	+ 2.8	-2.8
14.8	33.7	+ 2.9	-2.9
14.9	34.9	+ 3.0	-3.0
15.0	36.0	+ 3.1	-3.1
15.1	37.1	+ 3.2	-3.2
15.2	38.1	+ 3.3	-3.3
15.3	39.1	+ 3.4	-3.4
15.4	40.1	+ 3.5	-3.5
15.5	41.1	+ 3.6	-3.6
15.6	42.0	+ 3.7	-3.7
15.7	42.9	+ 3.7	-3.7
15.8	43.7	+ 3.8	-3.8
15.9	44.6	+ 3.9	-3.9
16.0	45.4	+ 4.1	-4.0
16.1	46.2	+ 4.3	-4.0
16.2	47.0	+ 4.5	-4.1
16.3	47.7	+ 4.7	-4.2
16.4	48.5	+ 4.9	-4.2
16.5	49.2	+ 5.1	-4.3
16.6	49.9	+ 5.3	-4.3
16.7	50.6	+ 5.5	-4.4
16.8	51.3	+ 5.7	-4.5
16.9	51.9	+ 5.9	-4.5
17.0	52.6	+ 6.2	-4.6
17.1	53.2	+ 6.4	-4.6
17.2	53.8	+ 6.6	-4.7
17.3	54.4	+ 6.8	-4.7
17.4	55.0	+ 7.1	-4.8
17.5	55.6	+ 7.3	-4.8
17.6	56.2	+ 7.5	-4.9
17.7	56.7	+ 7.7	-4.9
17.8	57.3	+ 8.0	-5.0
17.9	57.8	+ 8.2	-5.0

NEUTRON ENERGY MEV	CROSS SECTION MB	ABSOLUTE ERROR MB	
18.0	58.4	+ 8.5	-5.1
18.1	58.9	+ 8.7	-5.1
18.2	59.4	+ 8.9	-5.2
18.3	59.9	+ 9.2	-5.2
18.4	60.4	+ 9.4	-5.3
18.5	60.9	+ 9.7	-5.3
18.6	61.4	+ 9.9	-5.3
18.7	61.9	+10.2	-5.4
18.8	62.4	+10.4	-5.4
18.9	62.9	+10.7	-5.5
19.0	63.3	+10.9	-5.5
19.1	63.8	+11.2	-5.6
19.2	64.3	+11.4	-5.6
19.3	64.7	+11.7	-5.6
19.4	65.1	+11.9	-5.7
19.5	65.6	+12.2	-5.7
19.6	66.0	+12.5	-5.7
19.7	66.4	+12.7	-5.8
19.8	66.8	+13.0	-5.8
19.9	67.2	+13.3	-5.8
20.0	67.6	+13.5	-5.9
20.1	68.0	+13.8	-5.9
20.2	68.4	+14.1	-6.0
20.3	68.8	+14.3	-6.0
20.4	69.2	+14.6	-6.0
20.5	69.5	+14.9	-6.0
20.6	69.9	+15.1	-6.1
20.7	70.2	+15.4	-6.1
20.8	70.5	+15.7	-6.1
20.9	70.9	+15.9	-6.2
21.0	71.2	+16.2	-6.2
21.1	71.5	+16.5	-6.2
21.2	71.8	+16.7	-6.2
21.3	72.1	+17.0	-6.3
21.4	72.3	+17.3	-6.3
21.5	72.6	+17.5	-6.3
21.6	72.9	+17.8	-6.3
21.7	73.1	+18.0	-6.4
21.8	73.3	+18.3	-6.4
21.9	73.5	+18.5	-6.4
22.0	73.7	+18.8	-6.4
22.1	73.9	+18.8	-6.4
22.2	74.1	+18.9	-6.4
22.3	74.3	+18.9	-6.5
22.4	74.4	+19.0	-6.5
22.5	74.5	+19.0	-6.5
22.6	74.6	+19.0	-6.5
22.7	74.7	+19.1	-6.5
22.8	74.8	+19.1	-6.5
22.9	74.9	+19.1	-6.5
23.0	74.9	+19.1	-6.5

NEUTRON ENERGY MEV	CROSS SECTION MB	ABSOLUTE ERROR MB	
23.1	75.0	+19.1	-6.5
23.2	75.0	+19.1	-6.5
23.3	75.0	+19.1	-6.5
23.4	75.0	+19.1	-6.5
23.5	74.9	+19.1	-6.5
23.6	74.9	+19.1	-6.5
23.7	74.8	+19.1	-6.5
23.8	74.7	+19.1	-6.5
23.9	74.6	+19.0	-6.5
24.0	74.5	+19.0	-6.5
24.1	74.3	+19.0	-6.5
24.2	74.2	+18.9	-6.5
24.3	74.0	+18.9	-6.4
24.4	73.8	+18.8	-6.4
24.5	73.5	+18.8	-6.4
24.6	73.3	+18.7	-6.4
24.7	73.0	+18.6	-6.4
24.8	72.7	+18.5	-6.3
24.9	72.4	+18.5	-6.3
25.0	72.1	+18.4	-6.3
25.1	71.7	+18.3	-6.2
25.2	71.4	+18.2	-6.2
25.3	71.0	+18.1	-6.2
25.4	70.6	+18.0	-6.1
25.5	70.1	+17.9	-6.1
25.6	69.7	+17.8	-6.1
25.7	69.2	+17.6	-6.0
25.8	68.7	+17.5	-6.0
25.9	68.2	+17.4	-5.9
26.0	67.7	+17.3	-5.9
26.1	67.1	+17.1	-5.8
26.2	66.5	+17.0	-5.8
26.3	66.0	+16.8	-5.7
26.4	65.3	+16.7	-5.7
26.5	64.7	+16.5	-5.6
26.6	64.1	+16.3	-5.6
26.7	63.4	+16.2	-5.5
26.8	62.7	+16.0	-5.5
26.9	62.1	+15.8	-5.4
27.0	61.4	+15.6	-5.3
27.1	60.6	+15.5	-5.3
27.2	59.9	+15.3	-5.2
27.3	59.2	+15.1	-5.1
27.4	58.4	+14.9	-5.1
27.5	57.6	+14.7	-5.0
27.6	56.8	+14.5	-4.9
27.7	56.0	+14.3	-4.9
27.8	55.2	+14.1	-4.8
27.9	54.4	+13.9	-4.7
28.0	53.6	+13.7	-4.7
28.1	52.8	+13.5	-4.6

REFERENCES

Ara 70 J.Araminowicz: Ph.D.Thesis, University of Łódź /1972/.

Ara 73 J.Araminowicz, J.Dresler: INR Report 1464/I/A /1973/,

Aug 77 W.Augustyniak, M.Herman, A.Marcinkowski, B.Zwięgliński: Nuclear Physics A285 /1977/ 145.

Bar 65 R.C.Barrall et al.: UKNDL, DFN 236 /1965/.

Bar 69 R.C.Barrall at el.: Nuclear Physics A 138 /1969/ 387.

Bay 61 B.P.Bayhurst, R.J.Prestwood: J.Inorg. Nucl. Chem. 23 /1961/ 173.

Bay 75 B.P.Bayhurst et al.: Phys. Rev. C 12 /1975/ 451.

Bha 75 M.R.Bhat: BNL-NCS-50446 /1975/ 108.

Bla 71 M.Blann: UR-3591-20 /1971/.

Bor 65 M.Bormann et al.: Nuclear Physics 63 /1965/ 438.

Bor 66 M.Bormann et al.: EANDC/E/66U42.

Bra 62 E.T.Bramlitt: TID-16949 / thesis/ /1962/.

Bra 63 E.T.Bramlitt, R.W.Fink: Phys. Rev. 131 /1963/ 2649.

Cho 65 S.Chojnacki et al.: INR Report 680/I/PH /1965/.

Cro 62 W.G.Cross et al.: Bull, Amer, Phys. Soc. 7 /1962/ 335.

Csi 65 J.Csikai: Proc. Intern. Conf. on Study of Nuclear Structure with Neutrons, Antwerp, July 1965, paper 102.

Csi 66 J.Csikai: ATOMKI Közlemények 8 /1966/ 79.

Csi 67 J.Csikai, G.Pető: Acta Phys. Acad. Scient. Hungar. 23 /1967/ 87.

Csi 68 J.Csikai: Magyar Fizikai Folyóirat 16 /1968/ 123.

Dec 72 P.Decowski, W.Grochulski, A.Marcinkowski: Nuclear Physics A 194 /1972/ 380.

Dud 75 N.D.Dudey, R.Kennerley: BNL-NCS-50446 /1975/ 80.

Fin 70 R.W.Fink, Wen-Deh Lu: Bull. Amer. Phys. Soc. 15 /1970/ 1372.

Gam 63 J.L.Gammel: In "Fast Neutron Physics" /Editors: J.B.Marion, J.L.Fowler, Interscience Publishers /1963/ /,pt. II, p.2209.

Glo 62 R.N.Glover, E.Weigold: Nuclear Physics 29 /1962/ 309.

Gue 75 P.Guenther et al.: ANL/NDM-11 /1975/.

Hem 66 J.D.Hemingway et al.: Proc. Royal Soc. A 292 /1966/ 180.

Hem 73 J.D.Hemingway: J. Nuclear Energy 27 /1973/ 241.

Hug 58 D.J.Hughes, R.B.Schwartz: BNL-325 /1958/ /Unpublished Los Alamos data/.

Jer 63 J.M.F.Jeronymo et al.: Notas de Fisica 11 /1963/ No. 1.

Jes 66 P.Jessen, M.Bormann et al.: Nuclear Data 1 A /1966/ 103.

Kan 72 Y.Kanda, R.Nakasima: JAERI-1207 /1972/.

Kni 58 J.D,Knight et al.: Phys. Rev. 112 /1958/ 259.

Lap 75 A.A.Lapenas: "Izmerenie spektrov Nejtronov Aktivacionnym Metodom", Publishing House "Zinatne", Riga /1975/.

Led 68 C.M.Lederer et al.: "Table of Isotopes", Sixth Edition, J.Wiley Sons /1968/.

Let 64 J.Letessierr, J.Damals: Comptes Rendus 259 /1964/ 4620.

Lis 65 H.Liskien, A.Paulsen: J.Nuclear Energy A/B 19 /1965/ 73.

Ada 77 L.Adamski, M.Herman, A.Marcinkowski: This work.

Pac 53 E.B.Paul, R.L.Clarke: Canad. J. Phys. 31 /1953/ 267.

Pai 74 N.C.Paik: BNL-NCS-50446 /1975/ 108.

Pau 64 A.Paulsen, H.Liskien: Nuclear Physics 56 /1964/ 394.

Pau 65 A.Paulsen, H.Liskien: Nukleonik 7 /1965/ 117.

Pre 61 R.J.Prestwood, B.P.Bayhurst: Phys. Rev. 121 /1961/ 1438.

Prf 60 I.L.Preiss, R.W.Fink: Nuclear Physics 15 /1960/ 326.

Pur 59 K.H.Purser, E.W.Titterton: Australian J. Phys. 12 /1959/ 103.

Qai 76 S.M.Qaim, N.I.Molla: Proc. 9th Symp. on Fusion Technology, Pergamon Press /1976/ 589.

Qai 77 S.M.Qaim: Private communication.

Ray 61 L.A.Rayburn: Phys. Rev. 122 /1961/ 168.

Ros 75 P.F.Rose: BNL-NCS-50446 /1975/ 143.

Sow 73 M.G.Sowerby et al.: AERE - R72/73 /1973/.

Spa 75 R.Spangler et al.: Trans. Amer. Nucl. Soc. 22 /1975/ 818.

Str 58 D.Strominger et al.: Reviews Modern Physics 30 /1958/ 585.

Tem 68 J.K.Temperley: Nucl. Sci. Eng. 32 /1968/ 195.

Vla 76 M.Vlasov et al.: Proc. Int. Conf. on Interactions of Neutrons with Nuclei, Lowell /1976/ 1186 /CONF 760715/.

Von 70 H.Vonach et al.: Z. Physik 237 /1970/ 155.

Way 60 K.Way et al.: "Nuclear Data Sheets", National Academy of Sciences, National Research Council, Washington /1960, 1961/.

You 75 P.G.Young, D.G.Foster: BNL-NCS-50446 /1975/ 24.

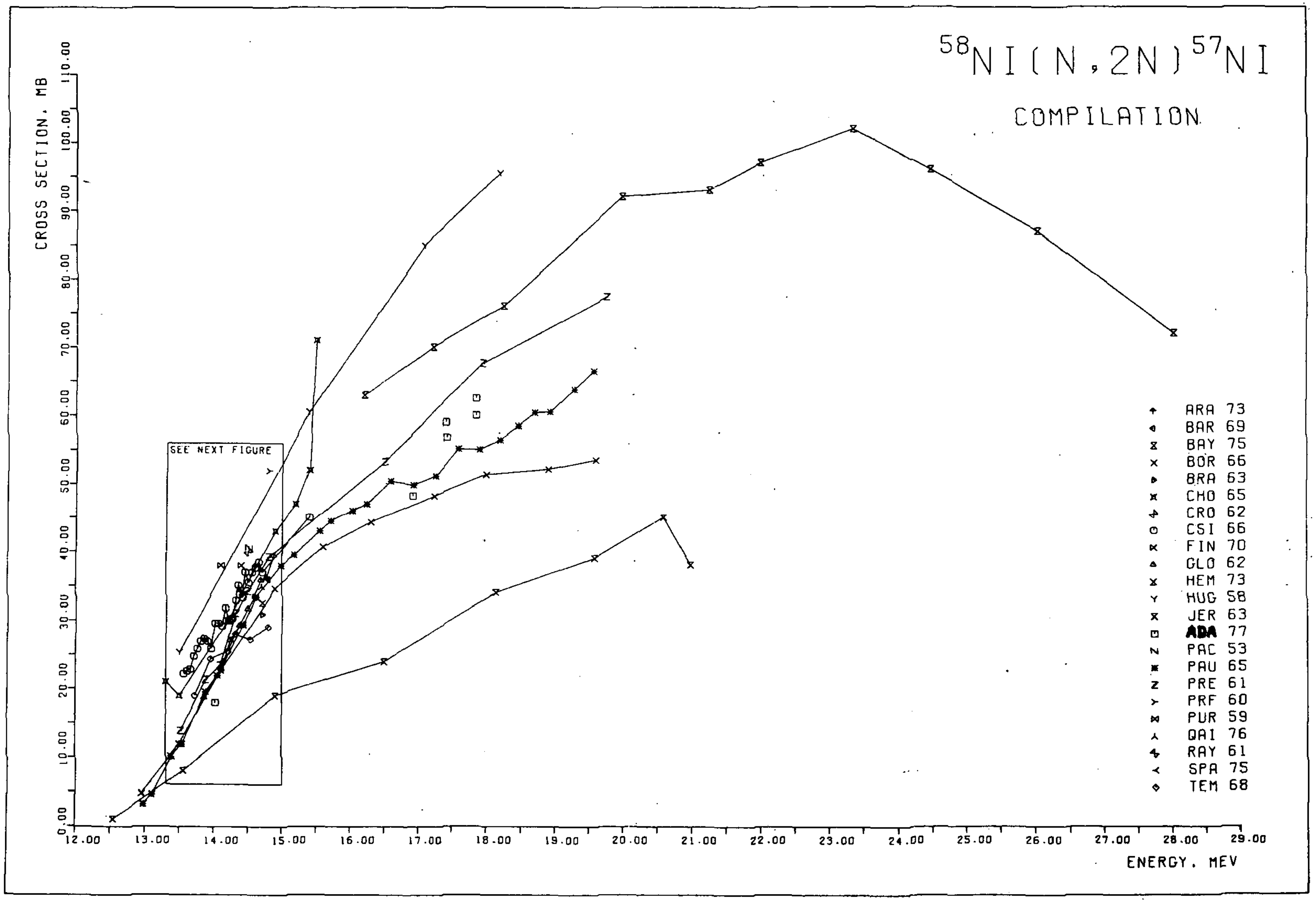

Fig. 2. Compilation of data for $^{58}Ni(n,2n)^{57}Ni$ reaction cross section

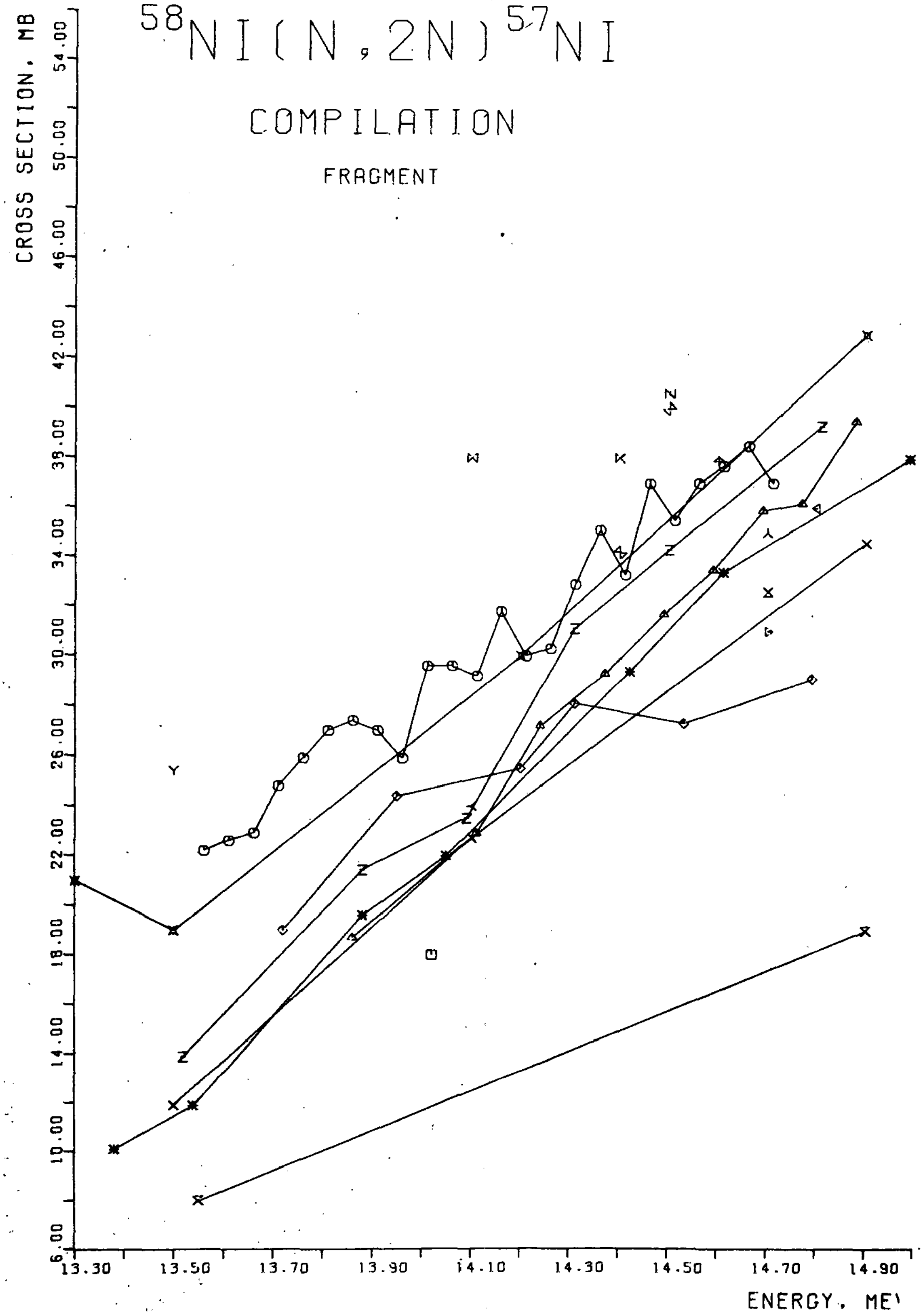

Fig. 3. Compilation of data for $^{58}Ni(n,2n)^{57}Ni$ reaction cross section /fragment/.

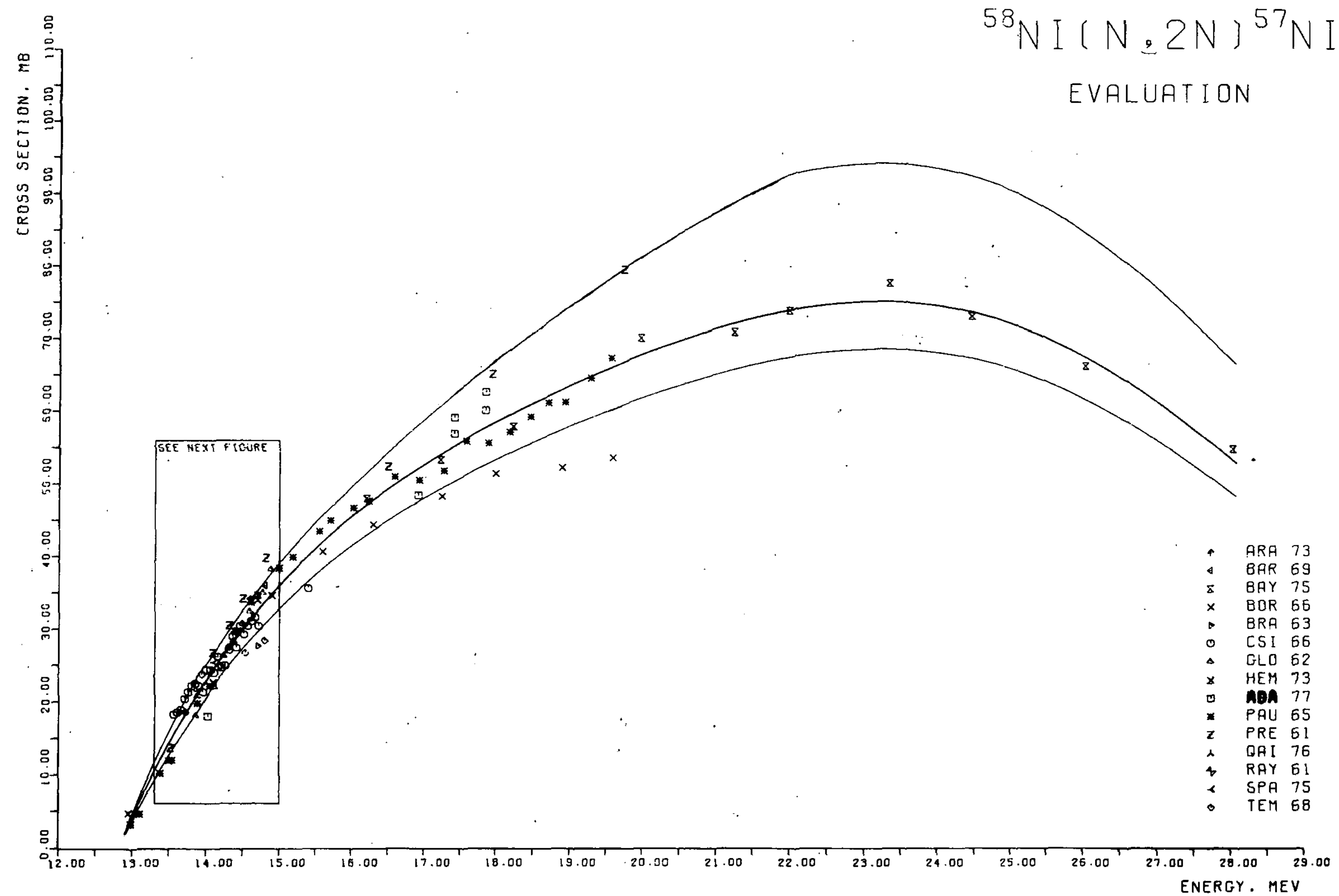

Fig. 4. Evaluation of $^{58}Ni(n,2n)^{57}Ni$ reaction cross section. Solid lines represent the recommended cross sections and the error limits.

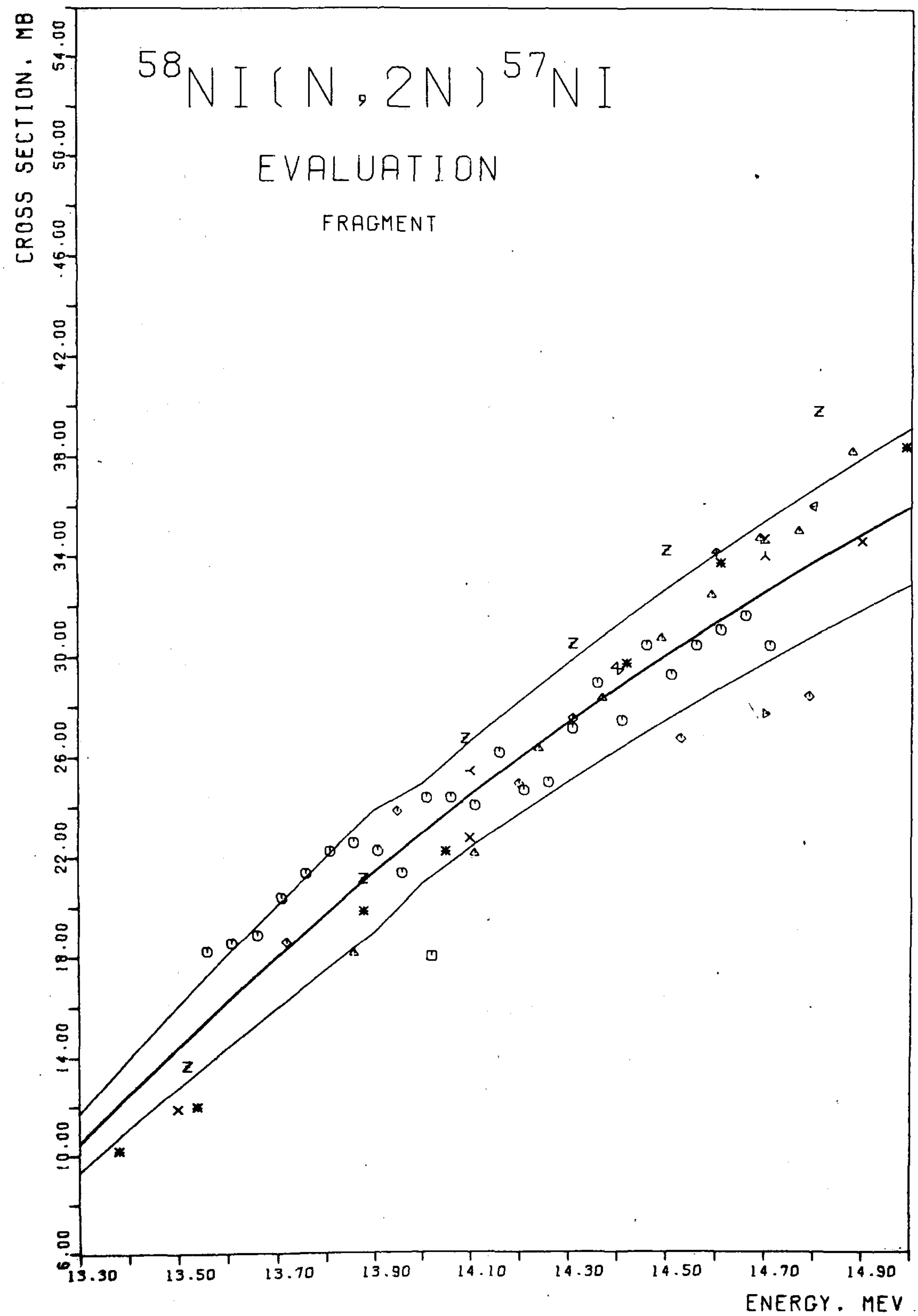

Fig. 5. Evaluation of $^{58}Ni(n,2n)^{57}Ni$ reaction cross section /fragment/.

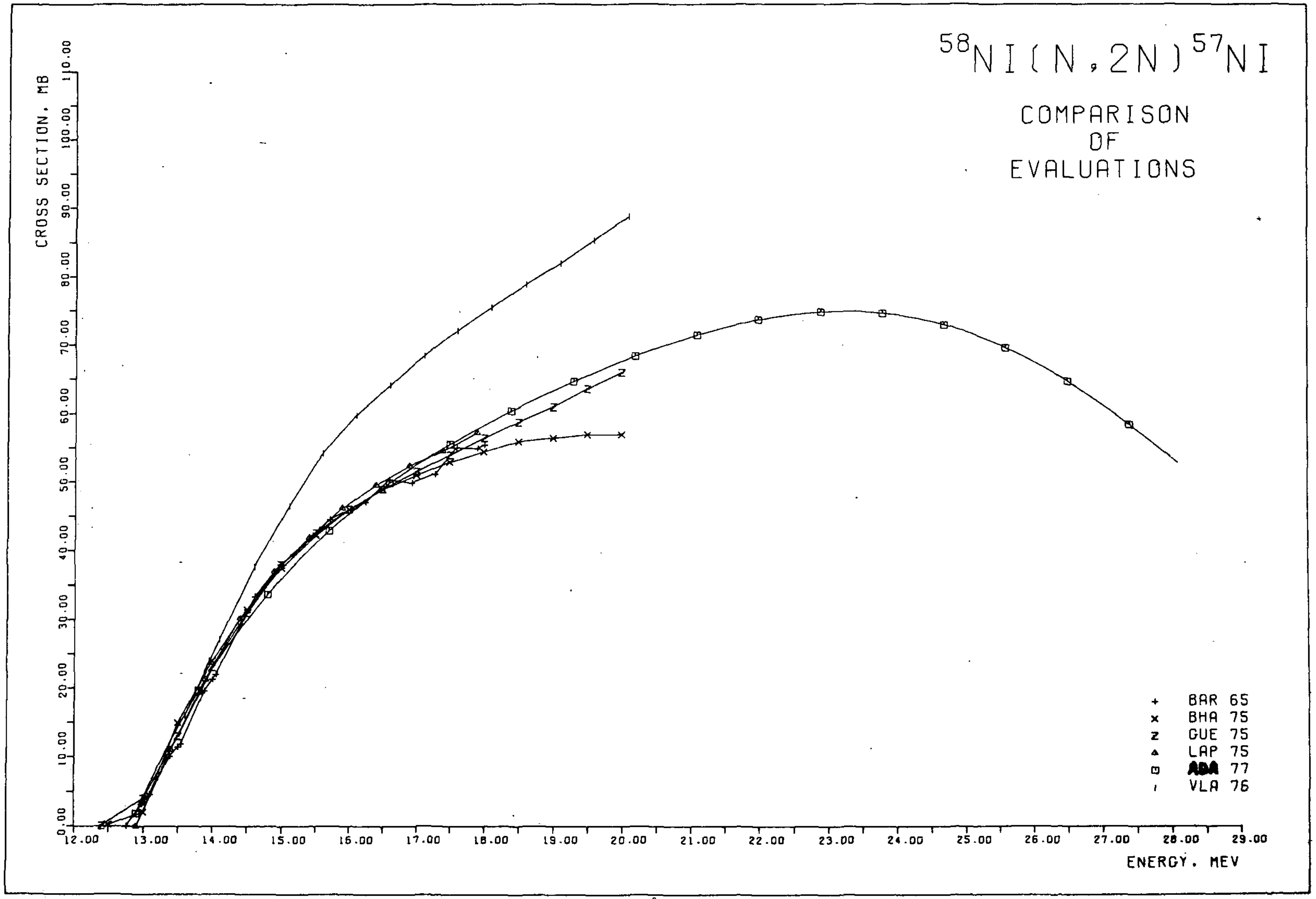

Fig. 6. Comparison of evaluations for $^{58}Ni(n,2n)^{57}Ni$ cross sections. The possible trend assumed by Vlasov [Vla 76] is also shown.