1143

INDC(FR) - 42/L

EVALUATION OF 237 Np NEUTRON CROSS-SECTIONS IN THE ENERGY RANGE FROM 10^{-5} ev TO 14 MeV

H. DERRIEN, J.P. DOAT, E. FORT, D. LAFOND

Section de Physique des Neutrons Rapides
Centre d'Etudes Nucléaires de Cadarache
France

Septembre 1980

INDC(FR) - 42/L

EVALUATION OF 237 Np NEUTRON CROSS-SECTIONS IN THE ENERGY RANGE FROM 10^{-5} ev TO 14 MeV

H. DERRIEN, J.P. DOAT, E. FORT, D. LAFOND

Section de Physique des Neutrons Rapides
Centre d'Etudes Nucléaires de Cadarache
France

Septembre 1980

ABSTRACT

The Np237 neutron cross-sections have been evaluated in the neutron energy range from 10^{-5} ev to 14 MeV. A set of evaluated resonance parameters is given. In the unresolved resonance region and at higher energies, the total cross-sections and the reaction cross-sections have been obtained from a coupled channel optical model calculation. A statistical model code has been used to calculate the elastic, inelastic, capture and fission cross-sections. These partial cross-sections have been adjusted to reproduce the experimental capture and fission data. The results of the evaluation are available in ENDF/B format.

INTRODUCTION

Several sets of experimental data are available for ^{237}Np. The resonance region has been particularly investigated from total and fission cross-section measurements in view of studying the intermediate structure which was discovered at Saclay in 1966 (1). Experimental capture cross-sections are available up to about 1 Mev neutron energy. The fission cross-sections have been measured in the entire energy range. Unfortunatly no total cross-section measurements exist begond several Kev neutron energy. One of the difficulties of the evaluation arise from this lack of total cross-section in the high energy range ; the evaluation is then based on a coupled channel optical model calculation of the total cross-section starting from optical model parameters available in the litterature.

A careful examination of the numerous set of experimental fission cross-sections existing in the high energy range have been made, since this nucleus could be used as a standard in fission cross-section measurements, or for dosimetry purpose.

The details of the evaluation are described in this report and the results are given in ENDF format.

THE THERMAL REGION

Total[2,3], capture[4,5,6] and fission[7] cross sections are available in the thermal region. The total cross-section values obtained by SMITH et al[2] and by ADAMCHUK et al[3] at 0.0253 ev are respectively 180 ± 22 barns and 240 ± 20 barns corresponding to capture values of about 165 barns and 225 barns. The absorption cross-section measured by TATTERSALL et al[4] by pile oscillation method is equal to 169 ± 3 barns and the value obtained by EBERLE et al[5] by reactor irradiation is equal to 184 ± 6 barns. The values retained in ENDF/B-V evaluation is 169.1 barns for the capture cross-section and 186.6 barns for the total cross-section in agreement with SMITH and TATTERSALL measurements.

The most recent measurement of the absorption cross-section in the thermal region is due to WESTON et al[6] as a part of measurement in a wide energy range from 0.008 ev to several hundred Kev. Preliminary values of the WESTON data have been published, normalized at 0.0253 ev to ENDF/B-V capture cross-section. As a matter of fact, the WESTON data could also be normalized to the absorption cross-section obtained from a total cross-section in the resonance region. The average value of the WESTON preliminary data is equal to 65.48 barns in the energy range 0.75 ev to 45.85 ev. The corresponding average value of the PAYA et al[8] total cross-section is equal to 83.43 barns. The average elastic scattering cross-section calculated in the same energy range from the PAYA set of resonance parameters is 12.07 barns. One obtains 70.36 barns for the absorption cross-section by difference between the total and the elastic scattering cross-section, i.e. 7.5 % larger than the WESTON preliminary value. That means also that the $2g\Gamma n$ values which could be deduced from the WESTON data, should be on average 7.5 % smaller than those obtained from the PAYA total cross-section. It seems then reasonable to normalize the WESTON data on the absorption deduced from the PAYA total cross-section rather than on the thermal value of ENDF/B-V. Consequently, the thermal capture value adopted is :

$$\sigma(n,\gamma)\ (0.0253\ ev) = 181 \pm 9 \text{ barns},$$

obtained by multiplying the WESTON value by the factor 1.075.*

This thermal value and the shape of the WESTON data at low energy are well reproduced (Fig. 1) by the resonance parameters shown in Table I associated with the other resolved resonance parameters (see next section). The Γf value of the 0.49 ev resonance has been choosen to reproduce the fission data of LEONARD et al[7] below 1 ev.

Table II shows the results of the present evaluation compared to the experimental data and to ENDF/B-V at 0.0253 ev.

* Remark : It is worthwhile to mention that when evaluating the Am241 data[9] the situation was different ; a good agreement was found between the WESTON[10] $2g\Gamma n$ values and those from Saclay[11] ; in that evaluation the ENDF/B-V thermal values were kept ; the Saclay total cross-section was corrected in the resonance region to take into account a 1/v smooth component found in the WESTON absorption cross-section, corresponding to a correction of 1 to 2% in the normalisation of the Saclay transmission data.

THE RESONANCE PARAMETERS

The resonance parameters obtained from some old measurements [2,3,12,13] have not been considered. We have examined 5 important sets of experimental data obtained by PAYA et al[8] from transmission and fission measurements, by PLATTARD et al[14] from fission measurements, by MEWISSEN et al[15] from transmission, capture and scattering measurements, by KOLAR et al[16] from fission measurements, and by KEYWORTH et al[17] from polarization measurements. In the following, we compare the parameters obtained by these experimentalists.

The neutron widths

Two sets of neutron width values are available. The first has been obtained by PAYA et al[8] at Saclay ; it contains 249 values in the 1 ev to 236 ev energy range. The second is due to MEWISSEN et al[15] from Geel ; it contains 200 values in the 8 ev to 205 ev energy range. In the low energy part where the resolution is very good in both experiments, there is an excellent agreement between the two sets of data. The agreement is within 1 % on the average ; the differences do not exced $\pm$ 2 % on the individual large values. Above 50 ev the Geel values are significantly smaller : 4.6 %, 2.1 % and 4.6 % on average in the energy ranges 50 ev to 100 ev, 100 ev to 150 ev and 150 ev to 205 ev respectively. Part of the discrepancy is due to the experimental resolution ; 160 resonances are seen in the Saclay total cross-section and only 144 in the Geel data in the 50 ev to 205 ev energy range. Taking into account the effect of some doublets and of small resonances not seen in the Geel data the above discrepancies reduce to 4.1 %, 0.3 % and 3.1 %.

The capture widths

The capture widths have been obtained for 25 resonances by MEWISSEN et al[15] in the 8 ev to 52 ev energy range and for 79 resonances by PAYA et al[8] in the 1.32 ev to 106 ev energy range. The former have used area and shape analysis of the transmission and capture data. The latter obtained the total width by shape analysis of the transmission data and deduced the capture width by difference between the total width and the $2g\Gamma n$ value, assuming that the fission width is negligible ; the systematic error introduced by taking $2g\Gamma n$ instead of Γn is also negligible (less than

1 % in most cases). There are 24 common values in the two sets of data, in very good agreement for 19 of them as it is shown in table III. For the 5 other resonances the desagreement is important not always compatible in the error bars. The average value given by PAYA is (40.00 ± 1.20) mev ; the one given by MEWISSEN is (41.2 ± 2.9) mev.

Some of the capture widths given by PAYA above 50 ev neutron energy are much larger than the mean value obtained in the low energy range. That is mainly due to the following reasons :

1. *the accuracy in the determination of the total width by the shape analysis method becomes very poor when the resolution and the Doppler widths increase ,*

2. *the probability of finding resonance multiplets is also increasing. It is obvious that the very large values of $\Gamma\gamma$ with a relatively small error bar correspond to such multiplets.*

These irregular $\Gamma\gamma$ values should be considered as "fictitious" capture widths of resonance multiplets and should be used with the corresponding total widths to calculate the capture cross-section. Consequently, there is no reason to replace the large values of $\Gamma\gamma$ by the average value as it is done by several evaluators in such cases. For instance, the resonance at 113.71 ev, for which PAYA gives a total width Γ = (95 ± 10) mev and a neutron width $2g\Gamma n$ = (4.3 ± 0.3) mev, is obviously at least a doublet. One must use $\Gamma\gamma$ = 91 mev to calculate the capture cross-section ; using 40 mev will result in a systematic error of - 5.4 % in the calculate total capture area of the resonance.

The fission widths

A complete set of Γf values is found in the Saclay data in the energy range 0.49 ev to 155 ev, with the fluctuations typical of the class I state fission widths in the fission intermediate structure. In the vicinity of the class II states the fission widths can reach several millibarns, but they are not greater than a few microbarns elsewhere. The fission area of the class II states are also given in the energy range 150 ev to 3.8 Kev, but they are not used in our evaluation ; in this energy range the fission cross-section is directly obtained from PLATTARD et al[14] experimental data.

As a matter of fact, two series of fission measurements have been performed at Saclay : the first one by PAYA et al[8] and the second one by PLATTARD et al[14]. According to the authors, we should adopt the results of PLATTARD et al obtained in improved experimental conditions. In any case, the Γf widths from both measurements are in agreement, after a renormalization of PAYA et al data by a factor of 0.625 (reevaluation of the U235 amount in the sample). The fission widths were also measured at Geel (KOLAR et al [16]) in the energy range 20-50 ev with the purpose of studying the properties of the 40 ev class II state. There is a complete inconsistency in these results when compared to the Saclay data. The discrepancies are of 1 or 2 orders of magnitude. Due to the lack of information concerning the normalization, we have therefore disregarded the data of KOLAR et al.

At low energy, it is possible to compare a few values obtained by GRAVILOV et al[18], LEONARD et al[7] and PAYA et al[8] as it is shown in table IV. The results are consistent and, in particular, show that the fission cross-sections of Saclay match reasonably well the LEONARD data just above the thermal region.

The spin of resonances

Transmission and fission measurements have been performed by KEYWORTH et al[17] on polarized targets and polarized neutron beams ; they were able to assign the spin of 94 resonances in the energy range 1.4 ev to 101 ev. Data for 10 resonances are also reported by MEWISSEN et al[15] from transmission and scattering measurements in complete agreement with KEYWORTH et al. Up to 101 ev neutron energy one third of the resonances are not spin assigned ; they correspond mainly to weak values of $2g\Gamma n$. For these resonances the statistical factor g should be taken equal to 0.5 instead of 5/12 (2^+ level) or 7/12 (3^+ level) ; it is the same in the energy range above 101 ev where there is no spin measurement.

The recommended resonance parameters

One can conclude that there is no severe discrepancies in the most recent data of Np237 resonance parameters. The best experimental conditions were achieved by PAYA et al[8] and PLATTARD et al[14] on their transmission and fission measurements. Then the most complete set of resonance parameters is therefore the one obtained by the Saclay group. We have chosen this set as the basis of our evaluation, prefering a consistent set obtained by one group of experimentalists to the one which could be obtained by averaging all the available data.

Finally, the recommended set of resonance parameters can be summarized as follow :

1. *the parameters of the negative level and of the resonance at 0.49 ev have been chosen to reproduce the shape of WESTON et al[6] capture data renormalized to 181 barns at 0.0253 ev, and the shape of LEONARD et al[7] fission data ;*

2. *above the thermal region, the energies, $2g\Gamma n$ and $\Gamma\gamma$ values are those from PAYA et al[8]. However, the capture widths have been sligthly modified when the resonance spin is assigned ($\Gamma\gamma = \Gamma - \Gamma n$ instead of $\Gamma\gamma = \Gamma - 2g\Gamma n$). The Γf values are from PLATTARD et al[14] ;*

3. *the value of $\Gamma\gamma$ = 40 mev is assigned to the resonances for which there is no measured value ;*

4. *the spin assignments are those from KEYWORTH et al[17].*

The set of recommended resonance parameters is listed in table V

THE AVERAGE RESONANCE PARAMETERS

The following values have been deduced from the above set of recommended resonance parameters :

s-wave strength function	So	$= (0.994 \pm 0.120)10^{-4}$
s-wave level spacing	D	$= (0.56 \pm 0.05)$ ev
s-wave capture width	$\langle\Gamma\gamma\rangle$	$= (40.00 \pm 1.20)$ mev
Effective potential scattering radius	R'	$= (9.54 \pm 0.50)$ fm

The values of So and $\langle\Gamma\gamma\rangle$ are those evaluated by Paya et al[14]. As for the level spacing and the effective potential scattering radius, the evaluation has been done as follows.

Level spacing

An accurate determination of the level spacing from the resonance data cannot be done without a good estimation of the number of the missed levels in the experimental cross-sections. The methods used for this estimation are based on the deviation existing between the statistical properties of the observed parameters and those corresponding to the Porter-Thomas (P-T) and Wigner distributions. As a matter of fact, the results obtained by several authors working on the same sample of data are often contradictory. The 237Np evaluation of the level spacing has been done by Mewissen et al[15] and by Paya et al[8]. The first author obtained D = (0.742 ± 0.032)ev from the P-T distribution of the neutron widths in the energy range 0-200 ev ; the second obtained D = 0.50 ev from a Monte-Carlo simulation of the total cross-section between 0 ev and 50 ev and from the P-T distribution up to 100 ev. It should be however noted that the value proposed by Mewissen et al[15] is larger than the experimental value of 0.68 ev which is observed in the energy range 0-50ev.

We think that the determination of the 237Np level spacing must be done on the sample of 73 resonances observed in the 0-50 ev energy interval where the variation of the number of reso-

nances detected between 0 and E remains a linear fonction of the energy E. Nevertheless, even in this sample one can hardly describe the $2g\Gamma n^0$ experimental distribution by a P-T law only by taking into account the missed weak values of $2g\Gamma n^0$ (figure 2) ; one observes on the experimental distribution a lack of values around $2g\Gamma n^0 = 0.14$ followed by an excess of values around $2g\Gamma n^0 = 0.23$. This effect can be attributed to the presence of several doublets of unresolved resonances. Figure 2 shows an example of a distribution which can be obtained after correction of the effect of 5 doublets ; the resulting distribution is well described by a P-T law with D = 0.56 ev (73 observed resonances + 10 non observed weak resonances + effect of 5 doublets). This value is identical to that obtained for 241 Am which presents the same experimental features in the resonance region[11].

Effective potential scattering radius

The effective potential scattering radius R' can be obtained from a least square shape analysis of the experimental transmission in the resonance region including a large number of resonances. The accuracy achieved on the potential scattering cross-section $4\pi R'^2$ is limited by the thickness of the sample used in the transmission measurement ($dT/T = - nd\sigma$). For 237 Np the best conditions were obtained at Saclay with a sample of n = 0.0064 at/barn. But, with such a thin sample, 1% error on the transmission leads to 1.6 barns error on the potential scattering cross-section, i.e. 6.7% error on R'. The value R' = (9.54 ± 0.50)fms that we recommend has been obtained from the analysis of the Saclay transmission in the energy range 22-30 ev where the accuracy on the transmission is expected to be better than 1%.

THE CROSS-SECTIONS IN THE UNRESOLVED REGION (0.15 KeV to 40 KeV)

The experimental data

A general view of the experimental data is shown in figure 3. More details on capture and total cross-section at low energy are given in figure 4. Some important sets of data have been obtained at Los Alamos from bomb-shot experiments : elastic scattering, capture and fission from HOFFMANN et al[19], fission from BROWN et al[20] and from GIACOLETTI et al[21]. These data, at least in the low energy part, are not consistent with the data obtained from classical experiments or with what we should expect from rough systematics. They have not been considered in this evaluation. The other data are the total cross-section from PAYA et al[8] (up to 4 KeV) and from ADAMCHUCK et al[3] (up to 12 KeV), the preliminary absorption cross-section of WESTON et al[6], the fission cross-section from PLATTARD et al[14] and an absolute fission cross-section measurement at 0.024 MeV by PERKIN et al[22]. The two available total cross-sections are not accurate because they have been obtained from transmission of thin samples. Up to 100 KeV the WESTON absorption is very close to the capture cross-section, for the fission cross-section remains always less than 1% of the capture, but these data are still preliminary and the correction due to the renormalisation made at thermal energy should also be applied at higher energies. As for PLATTARD fission cross-section, according to the author, there was some difficulties in the background evaluation and the experimental values are probably too low in this energy region as it can be seen in figure 3.

Calculated data

A Hauser-Fesbach statistical model calculation of the total, elastic and capture cross-sections has been performed between 0.15 KeV and 40 KeV by using the strength functions S_0 and S_1 as input in the FISINGA code. The contribution of higher angular momentum (less than 0.6% at 40 KeV) has been neglected. The s-wave neutron average parameters D, S_0 and $\Gamma\gamma$ are those obtained previously in the resolved resonance region. As for the p-wave neutrons no experimental data are available. The p-wave average capture width has been taken equal to that of s-wave. At 40 KeV the WESTON capture cross-sections, renormalized as it is explained above, is equal to 1.86 barns. This value and the shape of the capture data is quite well reproduced by using the following p-wave strength function :

$$S_1 = (1.82 \pm 0.20)10^{-4}$$

The error bar takes into account the uncertainties due to the renormalisation of the WESTON data.

Due to the intermediate structure in the fission channels, a statistical model calculation of the fission cross-section in this energy range is not possible. We therefore chose the experimental data of PLATTARD[14] up to 4 KeV. Between 4 KeV and 40 KeV, the cross-sections are very low and should be obtained by interpolation between the PLATTARD data (0.0085 barn around 4 KeV) and the value of 0.011 barn obtained from the calculation at 40 KeV (see the next section).

This interpolation gives a value of 0.0098 barn at 24 KeV in agreement with the absolute value of (0.011 ± 0.002) barn obtained by PERKIN et al[22] at this energy. The value of 0.011 barns at 40 KeV is also in agreement with the value of 0.0112 barns obtained by WHITE et al[23] (figure 5).

THE CROSS-SECTIONS IN THE ENERGY RANGE 0.040 MeV to 5 MeV

This energy range corresponds roughly to the region from the inelastic and the fission thresholds to the second chance fission threshold. The calculations involve a large number of parameters to be used in very complex and sophisticated models. These complicated calculations cannot be avoided since the experimental data base is far from complete in this energy range. In addition, when experimental data are available, it is hard and computer time consuming to fit a calculated curve to the experimental points, owing to the complexity of the formalism, to the large number of parameters involved and to the scarcity of the systematics concerning these parameters. For 237 Np a large number of experimental fission cross-sections is available above 40 KeV neutron energy. The first step of the evaluation must be the determination of the most probable fission values from the set of experimental cross-sections. After that, a calculation should be done to approach as close as possible the experimental evaluation, to allow the determination of the other partial cross-sections.

The experimental fission data

Most of the experimental fission cross-sections available in the energy range 40 KeV to 5 MeV are given in the references 23 to 35. There are only two absolute measurements. The first from HOCHBERG et al[27] in the energy range 0.15 MeV to 1.5 MeV is relatively old and not well documented. The second is a very recent one from GRADY et al[35] at 770 KeV and 964 KeV, but only preliminary values have been published. The other measurements have been performed relatively to U235 fission cross-section [20,21,24,25,29,30,31,33,34], or relatively to U238 fission cross-section [28], or normalized to other measurements or evaluated data of 237 Np[26,32]. To compare these numerous data it was necessary to renormalize all of them

relatively to the same standard. The standard choosen is the U235 ENDF/B-V fission cross-section . The results of the renormalisation are shown on figure 6. The absolute values of HOCHBERG et al[27] and of GRADY et al[35] are also shown on the figure . The very old data of KLEMA (1947)[24] and the relatively old data of HENKEL (1957)[25] for which no indication of standard has been found, were not considered. The values from KOBAYASHI[31] have not been renormalized because there is not enough information in the corresponding publication (abstract in a progress report).

The following conclusions can be drawn from the examination of the figure 6 :

1) most of the data agree on the shape of the cross-section ;

2) the experimental values normalized on the same standard are contained in a band whose width is equal to about 10% of the mean value ;

3) the results of PLATTARD et al[32] obtained from a very high quality of resolution measurement do not show any structure, which is confirmed by the results of the good quality of resolution measurement of BEHRENS et al[33]. Consequently the structures appearing on SCHMIDT et al[28] data and on BROWN et al[20] data should be considered as statistical fluctuations or systematical errors ;

4) the results of the absolute measurement of HOCHBERG et al[27] deviate strongly from the other experimental data above 0.8 MeV. The deviation of about 15% at 1.5 MeV, is too large to be explained by a systematic error on the U235 ENDF/B-V fission cross-sections used to normalize the other data and which is known with an accuracy of about 3%. Due to the lack of information on HOCHBERG measurement, these results should be disregarded at least above 0.8 MeV ;

5) the absolute values at 0.770 MeV and 0.964 MeV from GRADY et al[35] are in agreement with the values obtained from the relative measurements.

Evaluation of the fission cross-section from the experimental data

The values adopted in the energy range 0.040 MeV to 0.3 MeV are shown on figure 5. They are a continuation of the data adopted below 0.040 MeV, starting from PLATTARD's at 4 KeV, close to the absolute value of PERKIN at 24 KeV and continuing close to WHITE values up to 0.130 MeV ; between 0.130 MeV and 0.3 MeV they are in agreement with BEHRENS. This choice has been made to follow the shape of the calculated cross-section.

In the slope of the first fission threshold, between 0.3 MeV and 1 MeV, the fission cross-section increases rapidly. In this region, the comparison between the different cross-sections is prevented by a possible error in the energy scale. The normalisation of the energy scale is a rather difficult problem, since the details concerning the determination of the neutron energy are rarely given by the experimentalists. However, when two sets of cross-sections agree both in the increasing part and in the plateau, the problem of energy has not to be settled. That is the case for the results of PLATTARD and BEHRENS when normalized to the same cross-section standard, as it is shown on table VI. Therefore, the adopted values between 0.3 MeV and 1 MeV are obtained by averaging PLATTARD and BEHRENS data ; they agree exactly with the absolute value of GRADY at 0.770 MeV and are 1.6% larger at 0.964 MeV.

In the beginning of the first chance fission plateau, between 1 MeV and 2 MeV, it does not seem advisable to take into account the data of SCHMITT et al[28] and BROWN et al[20] which show large fluctuations not present in the more accurate data of PLATTARD and BEHRENS. The adopted values are still obtained

by averaging PLATTARD's and BEHRENS' data. Above 2 MeV the data from SCHMITT et al[28], WHITE et al[23], GRUNDL et al[29], STEIN et al[30] and BEHRENS et al[33] have been averaged ; the results are very close to BEHRENS data.

The definitive values are obtained by drawing a smooth curve through the above adopted or averaged values ; they are shown on figures 6 and 7.

The calculated cross-sections

In the first step of the theoretical evaluation the neutron transmission coefficients are calculated by using the coupled channel optical model code ECIS which gives also the total, elastic and direct inelastic cross-sections. The optical model parameters, including the deformation parameters, are generally obtained by fitting the experimental total cross-sections or angular distributions. The results of such investigations are available from several authors. In particular the parameters published by LAGRANGE[36] for 232Th, 238U and the Pu isotopes constitute an excellent basis for the actinide cross-section calculations. Starting from the results of LAGRANGE a set of parameters have also been found by FORT et al[37] by fitting the 241Am experimental total cross-sections measured by PHILLIPPS et al[38]. For 237Np, there is no experimental total cross-sections or angular distributions available at high energy. In this case, the only way to obtain a set of parameters suitable for the high energy cross-section calculations is to compare, at low energy, the cross-sections obtained from the statistical parameters (R', S0, S1) to those calculated by using the optical model. That has been done by taking as starting values the parameters obtained for 241Am. The results are given in Table VII. The corresponding total elastic, direct inelastic and compound nucleus formation cross-sections calculated by ECIS in the energy range 1 KeV to 16 MeV are given in Table VIII.

In the second step of the calculations the transmission coefficients obtained from ECIS are used as input in the statistical model code FISINGA in order to calculate the fission, capture and inelastic cross-sections. The total cross-sections and the compound nucleus formation cross-sections are also, of course, calculated by FISINGA and should be the same as those calculated by ECIS. A difficulty arose from the fact that the coupled channels code calculates two values of the transmission ceofficient $T(l,J,j,\pi)$ corresponding to $j = l \pm 1/2$ for a given value of the compound nucleus angular momentum J, when the statistical code FISINGA uses directly $T(l,J,\pi)$. The following relation has been used to obtain the $T(l,J,\pi)$ values :

$$T(l,J,\pi) = \frac{l\ T(l,J,j^-,\pi) + (l+1)\ T(l,J,j^+,\pi)}{2l+1}$$

using this relation, the agreement between ECIS and FISINGA is better than 1% in most cases as it is shown in Table VIII.

The other important parameters used in FISINGA concern the fission channels and the inelastic scattering channels. A double humped fission barrier shape has been assumed for the fissionning 238Np nucleus and the method proposed by LYNN[39] has been used to calculate the penetrabilities of the barriers. The densities of the fission channels were those recommended by LYNN for the odd-odd fissionning nuclei, starting at : V_A = 0.59 MeV and V_B = 0.50 MeV above the neutron binding energy, with $\hbar\omega_A$ = 0.50 MeV and $\hbar\omega_B$ = 0.40 MeV. For the inelastic scattering channels, the discrete low-lying levels of 237Np were taken from Nuclear Data Sheets[40] and a Fermi gaz level density relation was assumed for excitation energy larger than 0.850 MeV with a level density parameter a = 27.90. The level density parameter of 238Np compound nucleus was choosen according to $\langle D\rangle_{l=0}$ = 0.56ev at neutron binding energy which corresponds to a = 28.10.

The calculated fission cross-sections are compared in figure 7 to the values evaluated from the experimental data ; they are also shown in Table IX. The deviation between the calculated and the evaluated data is less than 15% in most cases. The largest differences occur around 1 MeV neutron energy. They are due to the fact that the sequence of 237Np low-lying levels is far from complete above 0.5 MeV excitation energy as it is shown on figure 8. Then, matching the region of discrete levels to the continuum, it is particularly difficult ; it results in a distorted shape of the fission cross-section due to an underestimation of the calculated inelastic cross-section.

Evaluation of the other partial cross-sections

Since the adopted fission cross-section is not the calculated one, it is necessary to correct the other calculated partial cross-sections to take into account the differences between the calculated and the evaluated fission values. The corrections should be applied proportionnally to those parts of the other partial cross-sections which correspond to the compound nucleus formation. However, the corrections are negligible below about 0.5 MeV and should be mostly applied to the inelastic cross-section above this energy.

As it is shown on figure 9, the values obtained for the capture cross-sections agree fairly well with the experimental results of LINDNER et al[41], as well as with the WESTON et al[6] absorption data corrected for the fission contribution. Above 0.5 MeV, they desagree with the results of STUPEGIA et al[42] by a factor of 2 at 0.7 MeV and a factor of 3 at 1.4 MeV. According to LINDNER et al, the large values of STUPEGIA et al are due to an experimental effect (difficulties of correcting the fission products high energy gamma rays contribution).

Figures 10 to 12 show the evaluation results of the total inelastic and some partial inelastic scattering cross-sections. The direct contributions to the levels $7/2^+$ and $9/2^+$ are given ; these contributions were calculated from ECIS code by coupling the $7/2^+$ and $9/2^+$ states to the fundamental $5/2^+$ in the rotationnal band ($5/2^+$, $7/2^+$, $9/2^+$,...).

THE CROSS-SECTIONS IN THE ENERGY RANGE 5 MeV to 16 MeV

In this energy range, the second chance fission, the (n,2n) and (n,3n) cross-sections have been calculated by the SI2N code[46]. The details of the evaluation are given in an other publication by E. FORT et al[47].

Fig. 13 shows the experimental and calculated fission cross-sections. The spread of the experimental data is quite large above 8 MeV (more than 20% around 15 MeV). The most recent results are those from BEHRENS et al[33] and those from CARLSON et al[34] ; they show an important discrepancy around 10 MeV, but agree above 12 MeV. The results of our evaluation are closer to BEHRENS data than to CARLSON data and are in good agreement with the recent absolute measurement of ARLT et al[44] at 14.7 MeV (7% above BEHRENS value).

The shape of the (n,2n) cross-section has been obtained by using the same formalism as JARY et al[48] and normalized to the few experimental data available between 14 MeV and 15 MeV (PERKIN et al[49], LANDRUM et al[50], LINDEKE et al[51], NISHI et al[52]) and at 9.6 MeV (NISHI et al). However all these experiments used the activation technique, i.e. a measurement of the cross-section

for the 236Pu formation. Th 237Np (n,2n) total cross-section is obtained by applying the β^-/EC branching ratio of 236mNp which is known to be 48% for β^- decay and 52% for EC (SCHMORAK et al[53]), and the isomeric ratio of the 236mNp formation which is supposed to be 0.75 (MYERS et al[54]). It is well known that using the reverse procedure to obtain the 236Pu formation cross-section from the evaluated (n,2n) total leads to a value averaged on a fission spectrum which is about twice as large as the result of the integral measurement of PAULSON et al[55].

This discrepancy has been reviewed by PATRICK[56] in the last NEANDC-INDC discrepancy file. He concludes that the inconsistency in the data is not necessary due to the measurements and may be the result of wrong assumptions in the data analysis. One of the most important assumption when converting the 236Pu formation cross-section to the 237Np (n,2n) total cross-section is to take the isomeric ratio independant of energy. That is probably true for the high excitation energy of 236Np. The isomeric ratio of 0.75 which has been obtained by MYERS et al in a neutron spectrum with a maximum around 14 MeV, should be used in this energy region. But at lower energy the ratio could be smaller, and then the discrepancy between the measured and calculated integral cross-section should reach a value consistent with the data, in particular since the contribution to the integral comes for more than 80% from the energy range 7 MeV to 10 MeV. For instance, the discrepancy falls to 20% if one takes an isomeric ratio varying from 0.25 at 7.5 MeV to 0.75 at 11 MeV.

THE UNCERTAINTIES ON THE EVALUATED CROSS-SECTIONS

The evaluation of the uncertainties is rather difficult since there is seldom a complete information about the experimental errors in the publications of the experimentalists. It is still more difficult to find the error correlations for the covariance matrices. There are more than 40 experimental data sets for the 237Np cross-sections and resonance parameters. The complete evaluation of the errors and covariance matrices would require several months of work in collaboration with the experimentalists themselves. That is not always possible. In this evaluation we give only the estimation of the incertainties with, when possible, some indications on the error correlations.

The thermal region

The shape of WESTON et al[6] absorption data is well reproduced by our set of resonance parameters. The statistical error is negligible. The systematic error of 8% is due to the uncertainty on the normalisation of the WESTON data ; this error applies to the overall energy range.

The scattering cross-section has not been measured in the thermal region. The calculated values depend mainly on the choice of the negative resonance parameters and of the scattering radius. The systematic error is about 10%.

The resonance region

The neutron widths are well known up to 50 ev neutron energy, with an accuracy of 2 or 3% on the largest values. The capture widths, when given, are known with an accuracy better than 15% for most of them. The calculated average capture cross-section should be obtained with an accuracy of about 3%.

Between 50 ev and 150 ev the uncertainties on the neutron widths become more and more important when the energy increases (about 10% at 150 ev). However, they have been obtained from a least square shape analysis of the Saclay transmission data and give a good representation of the measured total cross-section . As for the capture widths, they are inaccurate or not known in this energy range ; consequently, the uncertainties on the calculated point-wise capture cross-sections should be very large ; however, the statistical errors on the average values are espected to be not more than 10%.

Most of the fission widths are given with an error of 50% to 100%. Only the resonances in the vicinity of the 40 ev and 120 ev class II states emerge from the residual cross-section. The fission cross-section averaged between 30 ev and 50 ev (class II state) is equal to (190 ± 60)mb. Between 70 and 80 ev (minimum effect of the class II states) the average value is (24 ± 24)mb.

The accuracy of the calculated total and elastic cross-sections corresponds mainly to the uncertainty on the effective scattering radius R', i.e. at least 2 barns as systematic absolute error.

The unresolved resonance region (0.15 KeV to 40 KeV)

The uncertainties on the calculated cross-sections are mainly due to the errors on the statistical parameters R', D, S_0 and S_1 (see above). The fluctuationsdue to the Porter-Thomas distribution of the resonance parameters are obviously not reproduced. The accuracy resulting from the statistical and systematic errors is estimated at 10% on the capture cross-section and 18% on the elastic scattering cross-section.

Between 0.15 KeV and 4 KeV the fission cross-sections are those averaged from PLATTARD[14] data. They reproduce the fluctuations due to the class II states. The systematic errors can be estimated at 30% and the statistical errors are negligible. Between 4 KeV to 40 KeV the accuracy varies from 30% to 20%.

The energy range 40 KeV to 5 MeV

The fission cross-section has been evaluated from the experimental data. The shape of the cross-section seems to be well known. The averaging method used in the data evaluation allows the statistical errors to be neglected. The spread of the data, after the renormalisation, is ± 5% which we propose as the systematic error due to the normalisation. However, one must point out that the evaluated data agree within 2% with two recent absolute measurements : GRADY et al[35], at 0.770 and 0.964 MeV, and GRENIER et al[43] at 2.5 MeV (Table X).

The compound nucleus formation cross-section, the shape elastic and direct inelastic cross-section are calculated from the optical model code ECIS. The accuracy on the elastic scattering cross-section is roughly the same as at 40 KeV which is the reference point in adjusting the optical model parameters, i.e. 18%.

The compound nucleus formation cross-section varies between 2.6 and 3.2 barns with an uncorrelated error of about 10%. The total inelastic cross-section is practically obtained by difference (constraint from the experimental fission and capture data) and the error is estimated by a quadratic combination of the errors on the other cross-sections with the following results :

100%	at	40 KeV
50%	at	100 KeV
23%	at	500 KeV
24%	at	1 MeV
17%	at	3 MeV
18%	at	5 MeV

The energy range 5 MeV to 15 MeV

Up to 8 MeV the shape of the fission cross-section is still well defined with 5% of accuracy on the absolute values. Above 8 MeV neither the shape nor the absolute values are well known, in spite of the recent measurements of BEHRENS et al[33] *and CARLSON et al*[34] *; the accuracy is not better than 10% to 15%. Nevertheless, our evaluated value is very close to the result of a recent absolute measurement by ARLT et al*[44] *at 14.7 MeV who claim an accuracy of 1% (Table X).*

There is no capture measurement in this energy range. The calculated capture values are very small and depend strongly on the way the other cross-sections are calculated and on the parameters used in the 238Np level density calculation. The results should be considered as a rough estimation ; particularly, the shape of the cross-section above 7 MeV is not to be interpreted as a real physical feature.

The total inelastic cross-section remains relatively large at high energy. That is due to the direct contribution of the $7/2^+$ and $9/2^+$ levels coupled to the $5/2^+$ ground state in the ECIS calculation. The accuracy is estimated to be 20% at 6 MeV and 50% at 14 MeV.

The evaluation of the (n,2n) total cross-section is based on the few differential measurement results. The accuracy should be 15% at 9.5 MeV, 20% around 12 MeV and 15% at 14 MeV, according to the authors of the measurements.

REFERENCES

(1) *D. PAYA, H. DERRIEN, A. FUBINI, A. MICHAUDON, P. RIBON*
Nuclear data for reactors.
Paris 1966, page 128, Vol. II.

(2) *M.S. SMITH, R.R. SMITH, E.G. JOKI, J.E. EVANS*
Phys. Rev. 107, 525 (1957).

(3) *Y.B. ADAMCHUK et al*
Sov. J. Nucl. En. 6, 420 (1960).

(4) *TATTERSALL et al*
J. Nucl. En. 12, 32 (1960).

(5) *EBERLE et al*
KFK-1456, 51 (1971).

(6) *L.W. WESTON and J.H. TODD*
Private communication (1979).

(7) *B.R. LEONARD and E.J. SEPPI*
Bull. Am. Phys. Soc. 4, 31 (1959).

(8) *D. PAYA*
FRNC-TH-431 (Thesis) (1972).

(9) *H. DERRIEN, E. FORT, D. LAFOND*
Proceedings of the specialist's meeting on nuclear data of Pu and Am isotopes for reactor applications.
P. 71 (BNL 1978).

(10) *L.W. WESTON and J.H. TODD*
Nuclear Science and Engineering, 61, 356 (1976).

(11) H. DERRIEN and B. LUCAS
Proc. Conf. Nuclear cross-section Technology.
Vol. 2, p. 367, NBS publication 425, Washington D.C. (1975).

(12) SLAUGHTER et al
Bull. Am. Phys. Soc. 6, 70 (1961).

(13) J.E. CLINE, E.H. MOGLEBY and W.H. BURGUS
Bull. Am. Phys. Soc. 4, 270 (1959).

(14) S. PLATTARD
Thesis (Orsay 1973).

(15) L. MEWISSEN, F. POORTMANS, E. CORNELIS, G. VANPRAET,
A. ANGELETTI, G. RHOR, H. WEIGMANN
Nuclear Science and Engineering 70(2), 155 (1979).

(16) W. KOLAR, J.P. THEOBALD and G. LAUZANO
Zeitschrift für Physik, 248, 355 (1971).

(17) G.A. KEYWORTH, J.R. LEMLEY, C.E. OLSEN, F.T. SEIBEL,
J.N.T. DABBS and N.W. HILL
Phys. Rev. 8, 2352 (1973).

(18) K.A. GRAVILOV et al
Atomnaya Energiya 28, 362 (1969).

(19) M.M. HOFFMAN, G. BERZINS, W.M. SANDERS and J.J. BROWN
Bull. Am. Phys. Soc. 16, 1181 (1971).

(20) W.K. BROWN, D.R. DIXON and D.M. DRAKE
Nuclear Physics A156, 609 (1970).

(21) R.J. GIACOLETTI, W.K. BROWN, H.G. OLSON
Nuclear Science and Engineering 48, 412 (1972).

(22) J.L. PERKIN et al
J. Nucl. En. 19, 423 (1965).

(23) P.H. WHITE, J.D. HODKINSON and G.J. WALL
Symp. Phys. Chem. Fission 1, 219 (Salzburg, 1965).

(24) E.D. KLEMA
Physical Review 72, 88 (1947).

(25) R.L. HENKEL et al
LA-1495 (1952).

(26) S.P. KALININand V.M. PANKRATOV
2nd Int. Conf. Peace. uses At. En. 16, 136 (Geneva, 1958).

(27) B.M. HOCHBERG et al
AEC-TR-6398 (1961).

(28) H.X. SCHMITT and R.B. MURRAY
Physical review 116, 1575 (1959).

(29) J.A. GRUNDL
Nuclear Science and Engineering 30, 39 (1967).

(30) W.E. STEIN, R.K. SMITH and H.L. SMITH
Proc. Conf. Neutron cross-section and Techn.
NBS special publs. 299, I, 627 (Washington 1968).

(31) K. KOBAYASHI, I. KIMURA, H. GOTOH, H. YAGI
KURRI-TR-6, 1 (1973).

(32) S. PLATTARD and J. BLONS
Nuclear Science and Egineering 61, 477 (1976).

(33) J.W. BEHRENS et al
UCID-17370 (1977).

(34) A.D. CARLSON and B.H. PATRICK
Nuclear cross-sections for Technology, Knoxville (1979).

(35) GRADY et al
Nuclear cross-sections for Technology, Knoxville (1979).

(36) C. LAGRANGE
CEA-N-1970 (1977).
C. LAGRANGE, Acta Physica Slovaca 26 (1976), N°1
C. LAGRANGE, JAERI-M-5984.

(37) E. FORT, M. DARROUZET, H. DERRIEN, P. HAMMER, L. MARTIN-DEIDIER
Nuclear cross-sections for Technology, Knoxville (1979).

(38) T.W. PHILLIPS and R.E. HOWE
UCRL-81176 (1978).

(39) J.E. LYNN
AERE-R-7468 (1975).

(40) Y.A. ELLIS
Nuclear Data Sheets, Vol. 23, N°1 (1978).

(41) M. LINDNER, R.J. NAGLE and J.H. LANDRUM
Nuclear Science and Engineering 59, 381 (1976).

(42) D.C. STUPEGIA, M. SCHMIDT, C.R. KEEDY
Nuclear Science and Engineering 29, 218 (1967).

(43) G. GRENIER et al
Private communication

(44) R. ARLT et al
Nuclear cross-sections for Technology, IB9, Knoxville (1979).

(45) P.F. RAGO et al
Health Physics, 14, 595 (1968).

(46) E. FORT et al
Note Technique DRNR/SEDC/SPNR/79/5703.

(47) E. FORT et al
To be published

(48) J. JARY
Rapport CEA-R-4647 (1975).

(49) J.L. PERKIN and R.F. COLEMAN
J. Nucl. Ener., Parts A/B 14,69 (1961).

(50) J.H. LANDRUM et al
Phys. Rev. C8, 1938 (1973).

(51) K. LINDEKE et al
Phys. Rev. C12, 1507 (1975).

(52) T. NISHI et al
NEANDC(J) 42L (1975).

(53) M.R. SCHMORAK
Nuc. Data Sheets 20, 192 (1977).

(54) W.A. MYERS et al
J. Inorg. Chem. 37, 637 (1975).

(55) C.K. PAULSON
Nucl. Sci. Eng. 55, 24 (1974).

(56) B.H. PATRICK
NEANDC-124 A, INDC(UK)-33/G, page 42.

(57) PANKRATOV V.M.
Sov. J. At. En. 14, 167 (1969).

TABLE I - RESONANCE PARAMETERS FOR THE THERMAL REGION

Energie (ev)	2g Γ_n (mev)	Γ_γ (mev)	Γ_f (mev)
- 1.000	1.8960	40.0	4.40×10^{-3}
0.490	0.0384	40.0	0.89×10^{-3}

TABLE II - CROSS-SECTIONS AT 0.0253 ev

	Experimental data (barns)	ENDF/B-V	Present evaluation
Total	180 ± 22 (Ref 2) 240 ± 20 (Ref 3)	186.5	195.14
Capture	184 ± 6 (Ref 5) 169 ± 3 (Ref 4) 173 (Ref 6)	169.1	181.0
Fission		0.017	0.018
Scattering		17.5	14.12

TABLE III - CAPTURE WIDTHS FROM PAYA ET AL[8] AND MEWISSEN ET AL(16)

ENERGY Ref. (16)	PAYA		MEWISSEN	
	Γ_γ	$\Delta\Gamma_\gamma$	Γ_γ	$\Delta\Gamma_\gamma$
8.32	37.7	2.3	38.5	1.0
8.99	38.4	2.3	39.0	1.5
9.31	42.2	2.6	41.0	1.0
10.86	44.5	2.7	45.0	4.0
11.11	43.0	2.6	43.0	2.0
12.63	41.5	2.5	42.0	2.0
16.11	48.8	3.5	50.0	2.0
16.88	34.4	3.5	45.0	2.5
17.61	39.4	4.0	40.0	3.0
19.15	48.1	16.9	42.6	3.0
20.42	40.6	3.3	42.5	3.0
21.12	34.9	5.3	56.0	4.0
22.04	40.3	4.2	41.0	2.0
22.90	39.6	6.0	44.0	3.0
23.70	40.0	5.0	40.5	1.5
25.02	44.1	3.9	40.0	2.0
26.59	41.8	5.4	40.0	3.0
30.45	38.2	5.1	40.0	3.0
37.20	44.9	8.4	39.0	2.0
38.24	61.9	12.4	66.0	3.0
38.98	55.6	11.5	66.0	3.0
41.40	37.4	6.0	41.0	4.0
49.89	41.3	7.0	47.0	7.0
50.46	39.3	7.2	51.0	5.0

TABLE IV - THE FISSION WIDTHS AT LOW ENERGY

Resonance energy ev	$\Gamma f \times 10^6$ ev		
	PAYA x $\frac{5}{8}$	GRAVILOV	LEONARD
0.490	0.78	1.3	1.0
1.320	3.37	4.1	4.3
1.480	0.98	1.1	1.0

TABLE V.1 - RESONANCE PARAMETERS IN ENDF/B FORMAT, i.e., FOR EACH RECORD :

E, J, Γ_t, Γ_n, Γ_γ, Γ_f, MAT, MF, MT

-0.1000E+01	0.2500E+01	0.4190E-01	0.1896E-02	0.4000E-01	0.4410E-05	3371	2151
0.4900E+00	0.2500E+01	0.4004E-01	0.3840E-04	0.4000E-01	0.8940E-06	3371	2151
0.1320E+01	0.2500E+01	0.3984E-01	0.3700E-04	0.3980E-01	0.3500E-05	3371	2151
0.1480E+01	0.2000E+01	0.4835E-01	0.1740E-03	0.4817E-01	0.9800E-06	3371	2151
0.1970E+01	0.3000E+01	0.4123E-01	0.1457E-04	0.4121E-01	0.2300E-05	3371	2151
0.3860E+01	0.3000E+01	0.4165E-01	0.2091E-03	0.4143E-01	0.3710E-05	3371	2151
0.4260E+01	0.2000E+01	0.3753E-01	0.3120E-04	0.3749E-01	0.1880E-06	3371	2151
0.4860E+01	0.2000E+01	0.3873E-01	0.4080E-04	0.3869E-01	0.7000E-07	3371	2151
0.5770E+01	0.3000E+01	0.4483E-01	0.5331E-03	0.4429E-01	0.5000E-05	3371	2151
0.6370E+01	0.3000E+01	0.3819E-01	0.7971E-04	0.3811E-01	0.1400E-05	3371	2151
0.6670E+01	0.2000E+01	0.4791E-01	0.1440E-04	0.4790E-01	0.2900E-05	3371	2151
0.7180E+01	0.2000E+01	0.3541E-01	0.9600E-05	0.3540E-01	0.1500E-05	3371	2151
0.7410E+01	0.3000E+01	0.3985E-01	0.1251E-03	0.3972E-01	0.4200E-05	3371	2151
0.8300E+01	0.3000E+01	0.3781E-01	0.9171E-04	0.3772E-01	0.2100E-05	3371	2151
0.8970E+01	0.3000E+01	0.3853E-01	0.1037E-03	0.3842E-01	0.8800E-05	3371	2151
0.9300E+01	0.2000E+01	0.4272E-01	0.6264E-03	0.4210E-01	0.3000E-06	3371	2151
0.1023E+02	0.2000E+01	0.3813E-01	0.3000E-04	0.3809E-01	0.1300E-05	3371	2151
0.1068E+02	0.3000E+01	0.3611E-01	0.4337E-03	0.3567E-01	0.1500E-05	3371	2151
0.1084E+02	0.3000E+01	0.4538E-01	0.7543E-03	0.4463E-01	0.8000E-06	3371	2151
0.1109E+02	0.2000E+01	0.4389E-01	0.1062E-02	0.4282E-01	0.4000E-06	3371	2151
0.1220E+02	0.3000E+01	0.4966E-01	0.5314E-04	0.4961E-01	0.1900E-05	3371	2151
0.1261E+02	0.2000E+01	0.4230E-01	0.9540E-03	0.4134E-01	0.5000E-06	3371	2151
0.1314E+02	0.3000E+01	0.4002E-01	0.1714E-04	0.4000E-01	0.1600E-05	3371	2151
0.1580E+02	0.3000E+01	0.4010E-01	0.8743E-04	0.4001E-01	0.1800E-05	3371	2151
0.1608E+02	0.2000E+01	0.4972E-01	0.1109E-02	0.4862E-01	0.5000E-06	3371	2151
0.1685E+02	0.2000E+01	0.3464E-01	0.2916E-03	0.3435E-01	0.3000E-06	3371	2151
0.1702E+02	0.2500E+01	0.4001E-01	0.6000E-05	0.4000E-01	0.4900E-05	3371	2151
0.1759E+02	0.3000E+01	0.3958E-01	0.1577E-03	0.3943E-01	0.5000E-06	3371	2151
0.1789E+02	0.2500E+01	0.4002E-01	0.1800E-04	0.4000E-01	0.3900E-05	3371	2151
0.1888E+02	0.2000E+01	0.4004E-01	0.4440E-04	0.3999E-01	0.2600E-05	3371	2151
0.1912E+02	0.3000E+01	0.4821E-01	0.9086E-04	0.4812E-01	0.3100E-05	3371	2151
0.1992E+02	0.3000E+01	0.3598E-01	0.6430E-04	0.3582E-01	0.3000E-05	3371	2151
0.2039E+02	0.2000E+01	0.4173E-01	0.1356E-02	0.4037E-01	0.7000E-06	3371	2151
0.2109E+02	0.3000E+01	0.3542E-01	0.4423E-03	0.3497E-01	0.1900E-05	3371	2151
0.2130E+02	0.2500E+01	0.4003E-01	0.2300E-04	0.4000E-01	0.5800E-05	3371	2151
0.2201E+02	0.2000E+01	0.4156E-01	0.1512E-02	0.4005E-01	0.1000E-05	3371	2151
0.2286E+02	0.3000E+01	0.4005E-01	0.3831E-03	0.3966E-01	0.4100E-05	3371	2151
0.2367E+02	0.3000E+01	0.4169E-01	0.1449E-02	0.4024E-01	0.3000E-06	3371	2151
0.2397E+02	0.2000E+01	0.6097E-01	0.2052E-03	0.6077E-01	0.6000E-06	3371	2151
0.2497E+02	0.3000E+01	0.4871E-01	0.3951E-02	0.4476E-01	0.3600E-05	3371	2151
0.2618E+02	0.3000E+01	0.4007E-01	0.2049E-03	0.3983E-01	0.3060E-04	3371	2151
0.2654E+02	0.3000E+01	0.4466E-01	0.2434E-02	0.4221E-01	0.2250E-04	3371	2151
0.2707E+02	0.2500E+01	0.4003E-01	0.2500E-04	0.4000E-01	0.4300E-05	3371	2151
0.2848E+02	0.2000E+01	0.4015E-01	0.1752E-03	0.3997E-01	0.2000E-06	3371	2151
0.2892E+02	0.2000E+01	0.4011E-01	0.1320E-03	0.3998E-01	0.1000E-06	3371	2151
0.2946E+02	0.2000E+01	0.4011E-01	0.1032E-03	0.4000E-01	0.9900E-05	3371	2151
0.3040E+02	0.3000E+01	0.4204E-01	0.3223E-02	0.3874E-01	0.7980E-04	3371	2151
0.3072E+02	0.2500E+01	0.5343E-01	0.3270E-03	0.5310E-01	0.5100E-05	3371	2151
0.3129E+02	0.3000E+01	0.3628E-01	0.2383E-03	0.3604E-01	0.6900E-05	3371	2151
0.3165E+02	0.2500E+01	0.4005E-01	0.4800E-04	0.4000E-01	0.3900E-05	3371	2151

TABLE V.2

0.3341E+02	0.3000E+01	0.2804E-01	0.3754E-03	0.2766E-01	0.3700E-05	3371 2151
0.3390E+02	0.2000E+01	0.6596E-01	0.5496E-03	0.6541E-01	0.4100E-05	3371 2151
0.3467E+02	0.3000E+01	0.4019E-01	0.1577E-03	0.4003E-01	0.6600E-05	3371 2151
0.3519E+02	0.2000E+01	0.3723E-01	0.3924E-03	0.3683E-01	0.2100E-05	3371 2151
0.3636E+02	0.3000E+01	0.6867E-01	0.1363E-03	0.6852E-01	0.1270E-04	3371 2151
0.3681E+02	0.2500E+01	0.4011E-01	0.7200E-04	0.4000E-01	0.3470E-04	3371 2151
0.3714E+02	0.3000E+01	0.4640E-01	0.1166E-02	0.4509E-01	0.1423E-03	3371 2151
0.3792E+02	0.2500E+01	0.4011E-01	0.6400E-04	0.4000E-01	0.5060E-04	3371 2151
0.3816E+02	0.3000E+01	0.6192E-01	0.1380E-02	0.6050E-01	0.8600E-05	3371 2151
0.3892E+02	0.3000E+01	0.5727E-01	0.1106E-02	0.5578E-01	0.3802E-03	3371 2151
0.3922E+02	0.3000E+01	0.4698E-01	0.5571E-03	0.4609E-01	0.3331E-03	3371 2151
0.3969E+02	0.2500E+01	0.4175E-01	0.6200E-04	0.4000E-01	0.1687E-02	3371 2151
0.3990E+02	0.3000E+01	0.4142E-01	0.4766E-03	0.4008E-01	0.3647E-03	3371 2151
0.4134E+02	0.3000E+01	0.3988E-01	0.1937E-02	0.3772E-01	0.2167E-03	3371 2151
0.4238E+02	0.2500E+01	0.4010E-01	0.9100E-04	0.4000E-01	0.1110E-04	3371 2151
0.4281E+02	0.2500E+01	0.4035E-01	0.1170E-03	0.4000E-01	0.2368E-03	3371 2151
0.4363E+02	0.2000E+01	0.4200E-01	0.3480E-03	0.4164E-01	0.5300E-05	3371 2151
0.4570E+02	0.2000E+01	0.6259E-01	0.5796E-03	0.6200E-01	0.4700E-05	3371 2151
0.4601E+02	0.3000E+01	0.4094E-01	0.5649E-03	0.4009E-01	0.2761E-03	3371 2151
0.4634E+02	0.3000E+01	0.4677E-01	0.2631E-02	0.4414E-01	0.2400E-05	3371 2151
0.4731E+02	0.2000E+01	0.4570E-01	0.2880E-02	0.4282E-01	0.4000E-06	3371 2151
0.4847E+02	0.2500E+01	0.4012E-01	0.1100E-03	0.4000E-01	0.1230E-04	3371 2151
0.4878E+02	0.2000E+01	0.4064E-01	0.6360E-03	0.4000E-01	0.7900E-05	3371 2151
0.4980E+02	0.3000E+01	0.4639E-01	0.4363E-02	0.4203E-01	0.4600E-05	3371 2151
0.5038E+02	0.3000E+01	0.4830E-01	0.7654E-02	0.4065E-01	0.2320E-04	3371 2151
0.5169E+02	0.2500E+01	0.4010E-01	0.9100E-04	0.4000E-01	0.8700E-05	3371 2151
0.5219E+02	0.2000E+01	0.4037E-01	0.4476E-03	0.3993E-01	0.7000E-06	3371 2151
0.5262E+02	0.2000E+01	0.4071E-01	0.8436E-03	0.3986E-01	0.2800E-05	3371 2151
0.5303E+02	0.2500E+01	0.4008E-01	0.6200E-04	0.4000E-01	0.1810E-04	3371 2151
0.5386E+02	0.2000E+01	0.4039E-01	0.4644E-03	0.3992E-01	0.3200E-05	3371 2151
0.5422E+02	0.2500E+01	0.4014E-01	0.1310E-03	0.4000E-01	0.6900E-05	3371 2151
0.5502E+02	0.3000E+01	0.4033E-01	0.2717E-03	0.4005E-01	0.1550E-04	3371 2151
0.5603E+02	0.2000E+01	0.1090E+00	0.2388E-02	0.1066E+00	0.1100E-05	3371 2151
0.5836E+02	0.3000E+01	0.4046E-01	0.3969E-03	0.4007E-01	0.1300E-05	3371 2151
0.5860E+02	0.2500E+01	0.4031E-01	0.2950E-03	0.4000E-01	0.1300E-04	3371 2151
0.5949E+02	0.2000E+01	0.4501E-01	0.2412E-02	0.4260E-01	0.1100E-05	3371 2151
0.6002E+02	0.3000E+01	0.4591E-01	0.2314E-02	0.4359E-01	0.5100E-05	3371 2151
0.6093E+02	0.3000E+01	0.4063E-01	0.1569E-02	0.3906E-01	0.6000E-06	3371 2151
0.6162E+02	0.3000E+01	0.4053E-01	0.4483E-03	0.4007E-01	0.2900E-05	3371 2151
0.6245E+02	0.3000E+01	0.8220E-01	0.1800E-02	0.8040E-01	0.4900E-05	3371 2151
0.6289E+02	0.3000E+01	0.4722E-01	0.1474E-02	0.4575E-01	0.1200E-05	3371 2151
0.6394E+02	0.2500E+01	0.4028E-01	0.2760E-03	0.4000E-01	0.5400E-05	3371 2151
0.6494E+02	0.3000E+01	0.4471E-01	0.8657E-03	0.4384E-01	0.3000E-06	3371 2151
0.6568E+02	0.3000E+01	0.5055E-01	0.3900E-02	0.4665E-01	0.1700E-05	3371 2151
0.6746E+02	0.3000E+01	0.4398E-01	0.4954E-02	0.3903E-01	0.2100E-05	3371 2151
0.6794E+02	0.2000E+01	0.4599E-01	0.2868E-02	0.4312E-01	0.1300E-05	3371 2151
0.6875E+02	0.3000E+01	0.4036E-01	0.3077E-03	0.4005E-01	0.2100E-05	3371 2151
0.7023E+02	0.3000E+01	0.6804E-01	0.1834E-02	0.6621E-01	0.1600E-05	3371 2151
0.7066E+02	0.2500E+01	0.4050E-01	0.5000E-03	0.4000E-01	0.4800E-05	3371 2151
0.7118E+02	0.3000E+01	0.4230E-01	0.1971E-02	0.4033E-01	0.1200E-05	3371 2151

TABLE V.3

0.7144E+02	0.2500E+01	0.4268E-01	0.2680E-02	0.4000E-01	0.9000E-06	3371 2151
0.7386E+02	0.2500E+01	0.4032E-01	0.3100E-03	0.4000E-01	0.9600E-05	3371 2151
0.7426E+02	0.2000E+01	0.4147E-01	0.1764E-02	0.3971E-01	0.1400E-05	3371 2151
0.7454E+02	0.2500E+01	0.4052E-01	0.5100E-03	0.4000E-01	0.5900E-05	3371 2151
0.7509E+02	0.2500E+01	0.4012E-01	0.1100E-03	0.4000E-01	0.5500E-05	3371 2151
0.7653E+02	0.2500E+01	0.4019E-01	0.1860E-03	0.4000E-01	0.7000E-06	3371 2151
0.7697E+02	0.2500E+01	0.4038E-01	0.3750E-03	0.4000E-01	0.2800E-05	3371 2151
0.7833E+02	0.3000E+01	0.7875E-01	0.2100E-02	0.7665E-01	0.2800E-05	3371 2151
0.7924E+02	0.2000E+01	0.5412E-01	0.3024E-02	0.5110E-01	0.2000E-05	3371 2151
0.8035E+02	0.2500E+01	0.4016E-01	0.1570E-03	0.4000E-01	0.4900E-05	3371 2151
0.8060E+02	0.3000E+01	0.4054E-01	0.4646E-03	0.4008E-01	0.9000E-06	3371 2151
0.8159E+02	0.2500E+01	0.4042E-01	0.4200E-03	0.4000E-01	0.2600E-05	3371 2151
0.3209E+02	0.3000E+01	0.4082E-01	0.7011E-03	0.4012E-01	0.1200E-05	3371 2151
0.8339E+02	0.2500E+01	0.4311E-01	0.3110E-02	0.4000E-01	0.1000E-05	3371 2151
0.8370E+02	0.2500E+01	0.4555E-01	0.5550E-02	0.4000E-01	0.1100E-05	3371 2151
0.8519E+02	0.2500E+01	0.6408E-01	0.1170E-02	0.6290E-01	0.8800E-05	3371 2151
0.8607E+02	0.2500E+01	0.4084E-01	0.8350E-03	0.4000E-01	0.4500E-05	3371 2151
0.8650E+02	0.3000E+01	0.4902E-01	0.4903E-02	0.4412E-01	0.2000E-05	3371 2151
0.8765E+02	0.2000E+01	0.4370E-01	0.4440E-02	0.3926E-01	0.7000E-06	3371 2151
0.8813E+02	0.2500E+01	0.4103E-01	0.1030E-02	0.4000E-01	0.3600E-05	3371 2151
0.8890E+02	0.2500E+01	0.4185E-01	0.1350E-02	0.4000E-01	0.1800E-05	3371 2151
0.8943E+02	0.2500E+01	0.5129E-01	0.4290E-02	0.4700E-01	0.2900E-05	3371 2151
0.9084E+02	0.3000E+01	0.5488E-01	0.4269E-02	0.5061E-01	0.1600E-05	3371 2151
0.9132E+02	0.2500E+01	0.4016E-01	0.1580E-03	0.4000E-01	0.3200E-05	3371 2151
0.9195E+02	0.2500E+01	0.4052E-01	0.5100E-03	0.4000E-01	0.8800E-05	3371 2151
0.9275E+02	0.2500E+01	0.4020E-01	0.1890E-03	0.4000E-01	0.9100E-05	3371 2151
0.9336E+02	0.2000E+01	0.4880E-01	0.2160E-02	0.4664E-01	0.3100E-05	3371 2151
0.9422E+02	0.2500E+01	0.4037E-01	0.3680E-03	0.4000E-01	0.1400E-05	3371 2151
0.9537E+02	0.2500E+01	0.4036E-01	0.3580E-03	0.4000E-01	0.7000E-05	3371 2151
0.9614E+02	0.2500E+01	0.4006E-01	0.5500E-04	0.4000E-01	0.2700E-05	3371 2151
0.9661E+02	0.2500E+01	0.4035E-01	0.3500E-03	0.4000E-01	0.1800E-05	3371 2151
0.9772E+02	0.2000E+01	0.6528E-01	0.4176E-02	0.6110E-01	0.2300E-05	3371 2151
0.9846E+02	0.2000E+01	0.7738E-01	0.2856E-02	0.7452E-01	0.4100E-05	3371 2151
0.9899E+02	0.2500E+01	0.4012E-01	0.1000E-03	0.4000E-01	0.2130E-04	3371 2151
0.9949E+02	0.2500E+01	0.5174E-01	0.1940E-02	0.4980E-01	0.3200E-05	3371 2151
0.1002E+03	0.2500E+01	0.5840E-01	0.5300E-02	0.5310E-01	0.1900E-05	3371 2151
0.1010E+03	0.2500E+01	0.6251E-01	0.5410E-02	0.5710E-01	0.4200E-05	3371 2151
0.1016E+03	0.2500E+01	0.4124E-01	0.1230E-02	0.4000E-01	0.5100E-05	3371 2151
0.1019E+03	0.2500E+01	0.4167E-01	0.1670E-02	0.4000E-01	0.5000E-06	3371 2151
0.1021E+03	0.2500E+01	0.4030E-01	0.3000E-03	0.4000E-01	0.2600E-05	3371 2151
0.1038E+03	0.2500E+01	0.4160E-01	0.1600E-02	0.4000E-01	0.3000E-05	3371 2151
0.1045E+03	0.2500E+01	0.4035E-01	0.3400E-03	0.4000E-01	0.6000E-05	3371 2151
0.1052E+03	0.2500E+01	0.7969E-01	0.2180E-02	0.7750E-01	0.5100E-05	3371 2151
0.1057E+03	0.2500E+01	0.4440E-01	0.3290E-02	0.4110E-01	0.1270E-04	3371 2151
0.1070E+03	0.2500E+01	0.4052E-01	0.5140E-03	0.4000E-01	0.7000E-05	3371 2151
0.1088E+03	0.2500E+01	0.4082E-01	0.8140E-03	0.4000E-01	0.1200E-05	3371 2151
0.1091E+03	0.2500E+01	0.4229E-01	0.2290E-02	0.4000E-01	0.2100E-05	3371 2151
0.1103E+03	0.2500E+01	0.4121E-01	0.1210E-02	0.4000E-01	0.1900E-05	3371 2151
0.1106E+03	0.2500E+01	0.4109E-01	0.1090E-02	0.4000E-01	0.3400E-05	3371 2151
0.1110E+03	0.2500E+01	0.6800E-01	0.3070E-02	0.6490E-01	.1000E-06	3371 2151

TABLE V.4

0.1117E+03	0.2500E+01	0.4327E-01	0.3270E-02	0.4000E-01	0.1000E-06	3371 2151
0.1122E+03	0.2500E+01	0.4041E-01	0.3980E-03	0.4000E-01	0.1230E-04	3371 2151
0.1133E+03	0.2500E+01	0.4121E-01	0.1210E-02	0.4000E-01	0.3200E-05	3371 2151
0.1137E+03	0.2500E+01	0.9500E-01	0.4300E-02	0.9070E-01	0.5000E-06	3371 2151
0.1147E+03	0.2500E+01	0.4390E-01	0.2210E-02	0.4170E-01	0.4000E-06	3371 2151
0.1155E+03	0.2500E+01	0.4050E-01	0.4980E-03	0.4000E-01	0.4500E-05	3371 2151
0.1158E+03	0.2500E+01	0.6800E-01	0.2076E-02	0.6510E-01	0.2250E-04	3371 2151
0.1168E+03	0.2500E+01	0.4045E-01	0.4400E-03	0.4000E-01	0.5700E-05	3371 2151
0.1176E+03	0.2500E+01	0.4206E-01	0.2020E-02	0.4000E-01	0.3770E-04	3371 2151
0.1191E+03	0.2500E+01	0.4179E-01	0.1240E-02	0.4000E-01	0.5474E-03	3371 2151
0.1195E+03	0.2500E+01	0.4303E-01	0.7500E-03	0.4000E-01	0.2276E-02	3371 2151
0.1201E+03	0.2500E+01	0.4045E-01	0.3250E-03	0.4000E-01	0.1228E-03	3371 2151
0.1220E+03	0.2500E+01	0.4041E-01	0.3500E-03	0.4000E-01	0.6430E-04	3371 2151
0.1238E+03	0.2500E+01	0.4047E-01	0.4040E-03	0.4000E-01	0.6600E-04	3371 2151
0.1250E+03	0.2500E+01	0.4124E-01	0.1210E-02	0.4000E-01	0.3100E-04	3371 2151
0.1257E+03	0.2500E+01	0.4271E-01	0.2710E-02	0.4000E-01	0.4600E-05	3371 2151
0.1262E+03	0.2500E+01	0.4174E-01	0.1740E-02	0.4000E-01	0.4300E-05	3371 2151
0.1271E+03	0.2500E+01	0.4050E-01	0.5010E-03	0.4000E-01	0.3500E-05	3371 2151
0.1275E+03	0.2500E+01	0.4041E-01	0.4060E-03	0.4000E-01	0.2700E-05	3371 2151
0.1295E+03	0.2500E+01	0.4097E-01	0.9700E-03	0.4000E-01	0.1300E-05	3371 2151
0.1297E+03	0.2500E+01	0.4022E-01	0.2000E-03	0.4000E-01	0.2500E-04	3371 2151
0.1314E+03	0.2500E+01	0.4063E-01	0.6300E-03	0.4000E-01	0.4000E-05	3371 2151
0.1318E+03	0.2500E+01	0.4115E-01	0.1140E-02	0.4000E-01	0.6600E-05	3371 2151
0.1328E+03	0.2500E+01	0.4021E-01	0.2000E-03	0.4000E-01	0.6300E-05	3371 2151
0.1335E+03	0.2500E+01	0.5170E-01	0.5540E-02	0.4620E-01	0.2300E-05	3371 2151
0.1341E+03	0.2500E+01	0.4043E-01	0.4080E-03	0.4000E-01	0.1840E-04	3371 2151
0.1374E+03	0.2500E+01	0.4353E-01	0.3520E-02	0.4000E-01	0.7200E-05	3371 2151
0.1385E+03	0.2500E+01	0.4498E-01	0.4980E-02	0.4000E-01	0.2000E-05	3371 2151
0.1390E+03	0.2500E+01	0.4168E-01	0.1670E-02	0.4000E-01	0.9300E-05	3371 2151
0.1400E+03	0.2500E+01	0.4136E-01	0.1350E-02	0.4000E-01	0.8000E-05	3371 2151
0.1412E+03	0.2500E+01	0.4169E-01	0.1690E-02	0.4000E-01	0.3000E-05	3371 2151
0.1422E+03	0.2500E+01	0.4045E-01	0.4400E-03	0.4000E-01	0.5700E-05	3371 2151
0.1443E+03	0.2500E+01	0.8230E-01	0.4930E-02	0.7740E-01	0.2000E-05	3371 2151
0.1455E+03	0.2500E+01	0.4064E-01	0.6400E-03	0.4000E-01	0.3900E-05	3371 2151
0.1466E+03	0.2500E+01	0.4159E-01	0.1590E-02	0.4000E-01	0.1600E-05	3371 2151
0.1472E+03	0.2500E+01	0.4190E-01	0.1900E-02	0.4000E-01	0.4000E-05	3371 2151
0.1485E+03	0.2500E+01	0.4104E-01	0.1030E-02	0.4000E-01	0.6100E-05	3371 2151
0.1497E+03	0.2500E+01	0.4194E-01	0.1940E-02	0.4000E-01	0.1300E-05	3371 2151
0.1503E+03	0.2500E+01	0.4302E-01	0.3020E-02	0.4000E-01	0.3300E-05	3371 2151
0.1505E+03	0.2500E+01	0.4323E-01	0.3230E-02	0.4000E-01	0.8000E-06	3371 2151
0.1522E+03	0.2500E+01	0.4287E-01	0.2870E-02	0.4000E-01	0.1700E-05	3371 2151
0.1542E+03	0.2500E+01	0.9840E-01	0.2730E-02	0.9570E-01	.7000E-06	3371 2151
0.1553E+03	0.2500E+01	0.4118E-01	0.1170E-02	0.4000E-01	0.6400E-05	3371 2151
0.1563E+03	0.2500E+01	0.4182E-01	0.1820E-02	0.4000E-01	0.0	3371 2151
0.1568E+03	0.2500E+01	0.4082E-01	0.8200E-03	0.4000E-01	0.0	3371 2151
0.1580E+03	0.2500E+01	0.4150E-01	0.1500E-02	0.4000E-01	0.0	3371 2151
0.1584E+03	0.2500E+01	0.4399E-01	0.3990E-02	0.4000E-01	0.0	3371 2151
0.1606E+03	0.2500E+01	0.7362E-01	0.5320E-02	0.6830E-01	0.0	3371 2151
0.1618E+03	0.2500E+01	0.4098E-01	0.9800E-03	0.4000E-01	0.0	3371 2151
0.1629E+03	0.2500E+01	0.4612E-01	0.3920E-02	0.4220E-01	0.0	3371 2151

TABLE V.5

0.1642E+03	0.2500E+01	0.4221E-01	0.2210E-02	0.4000E-01	0.0	3371	2151
0.1651E+03	0.2500E+01	0.4039E-01	0.3900E-03	0.4000E-01	0.0	3371	2151
0.1668E+03	0.2500E+01	0.4478E-01	0.4780E-02	0.4000E-01	0.0	3371	2151
0.1689E+03	0.2500E+01	0.4505E-01	0.5050E-02	0.4000E-01	0.0	3371	2151
0.1700E+03	0.2500E+01	0.4158E-01	0.1580E-02	0.4000E-01	0.0	3371	2151
0.1709E+03	0.2500E+01	0.4385E-01	0.3850E-02	0.4000E-01	0.0	3371	2151
0.1722E+03	0.2500E+01	0.4114E-01	0.1140E-02	0.4000E-01	0.0	3371	2151
0.1730E+03	0.2500E+01	0.4238E-01	0.2380E-02	0.4000E-01	0.0	3371	2151
0.1748E+03	0.2500E+01	0.4126E-01	0.1260E-02	0.4000E-01	0.0	3371	2151
0.1752E+03	0.2500E+01	0.4285E-01	0.2850E-02	0.4000E-01	0.0	3371	2151
0.1762E+03	0.2500E+01	0.4446E-01	0.4460E-02	0.4000E-01	0.0	3371	2151
0.1768E+03	0.2500E+01	0.4644E-01	0.6440E-02	0.4000E-01	0.0	3371	2151
0.1801E+03	0.2500E+01	0.9630E-01	0.6900E-02	0.8700E-01	0.0	3371	2151
0.1810E+03	0.2500E+01	0.4292E-01	0.2920E-02	0.4000E-01	0.0	3371	2151
0.1823E+03	0.2500E+01	0.4236E-01	0.2360E-02	0.4000E-01	0.0	3371	2151
0.1832E+03	0.2500E+01	0.4192E-01	0.1920E-02	0.4000E-01	0.0	3371	2151
0.1840E+03	0.2500E+01	0.8151E-01	0.6010E-02	0.7550E-01	0.0	3371	2151
0.1856E+03	0.2500E+01	0.4034E-01	0.3420E-03	0.4000E-01	0.0	3371	2151
0.1862E+03	0.2500E+01	0.4071E-01	0.7150E-03	0.4000E-01	0.0	3371	2151
0.1879E+03	0.2500E+01	0.5189E-01	0.1189E-01	0.4000E-01	0.0	3371	2151
0.1891E+03	0.2500E+01	0.4145E-01	0.6350E-02	0.3500E-01	0.0	3371	2151
0.1906E+03	0.2500E+01	0.4607E-01	0.6070E-02	0.4000E-01	0.0	3371	2151
0.1916E+03	0.2500E+01	0.4124E-01	0.1240E-02	0.4000E-01	0.0	3371	2151
0.1935E+03	0.2500E+01	0.4333E-01	0.3330E-02	0.4000E-01	0.0	3371	2151
0.1945E+03	0.2500E+01	0.4132E-01	0.1320E-02	0.4000E-01	0.0	3371	2151
0.1957E+03	0.2500E+01	0.4300E-01	0.3000E-02	0.4000E-01	0.0	3371	2151
0.1966E+03	0.2500E+01	0.5208E-01	0.1548E-01	0.3650E-01	0.0	3371	2151
0.1984E+03	0.2500E+01	0.4057E-01	0.5730E-03	0.4000E-01	0.0	3371	2151
0.1998E+03	0.2500E+01	0.4128E-01	0.1280E-02	0.4000E-01	0.0	3371	2151
0.2008E+03	0.2500E+01	0.4227E-01	0.2270E-02	0.4000E-01	0.0	3371	2151
0.2029E+03	0.2500E+01	0.4053E-01	0.5300E-03	0.4000E-01	0.0	3371	2151
0.2042E+03	0.2500E+01	0.4325E-01	0.3250E-02	0.4000E-01	0.0	3371	2151
0.2056E+03	0.2500E+01	0.4128E-01	0.1280E-02	0.4000E-01	0.0	3371	2151
0.2066E+03	0.2500E+01	0.4865E-01	0.8650E-02	0.4000E-01	0.0	3371	2151
0.2078E+03	0.2500E+01	0.4339E-01	0.3390E-02	0.4000E-01	0.0	3371	2151
0.2103E+03	0.2500E+01	0.4700E-01	0.7000E-02	0.4000E-01	0.0	3371	2151
0.2130E+03	0.2500E+01	0.4181E-01	0.1810E-02	0.4000E-01	0.0	3371	2151
0.2145E+03	0.2500E+01	0.4134E-01	0.1340E-02	0.4000E-01	0.0	3371	2151
0.2170E+03	0.2500E+01	0.5293E-01	0.1293E-01	0.4000E-01	0.0	3371	2151
0.2184E+03	0.2500E+01	0.4215E-01	0.2150E-02	0.4000E-01	0.0	3371	2151
0.2192E+03	0.2500E+01	0.4078E-01	0.7800E-03	0.4000E-01	0.0	3371	2151
0.2201E+03	0.2500E+01	0.4143E-01	0.1430E-02	0.4000E-01	0.0	3371	2151
0.2220E+03	0.2500E+01	0.4418E-01	0.4180E-02	0.4000E-01	0.0	3371	2151
0.2242E+03	0.2500E+01	0.4412E-01	0.4120E-02	0.4000E-01	0.0	3371	2151
0.2264E+03	0.2500E+01	0.1065E-00	0.1405E-01	0.9200E-01	0.0	3371	2151
0.2282E+03	0.2500E+01	0.4228E-01	0.2280E-02	0.4000E-01	0.0	3371	2151
0.2290E+03	0.2500E+01	0.4439E-01	0.4390E-02	0.4000E-01	0.0	3371	2151
0.2316E+03	0.2500E+01	0.9695E-01	0.1515E-01	0.8170E-01	0.0	3371	2151
0.2328E+03	0.2500E+01	0.4248E-01	0.2480E-02	0.4000E-01	0.0	3371	2151
0.2340E+03	0.2500E+01	0.4256E-01	0.2560E-02	0.4000E-01	0.0	3371	2151
0.2353E+03	0.2500E+01	0.4264E-01	0.2640E-02	0.4000E-01	0.0	3371	2151

TABLE VI - COMPARISON BETWEEN THE FISSION CROSS SECTION FROM PLATTARD[32] AND BEHRENS[33]. PLATTARD's DATA HAVE BEEN NORMALIZED ON BEHRENS DATA BETWEEN 1 MeV AND 2 MeV (The top of the plateau). THE AGREEMENT REMAINS EXCELLENT BETWEEN 0.1 AND 1 MeV (In the slope below the plateau).

ENERGY RANGE (MeV)	AVERAGE FISSION	
	BEHRENS	PLATTARD
0.3 - 0.4	0.105	0.102
0.4 - 0.5	0.283	0.304
0.5 - 0.6	0.612	0.587
0.6 - 0.7	0.894	0.897
0.7 - 0.8	1.153	1.124
0.8 - 0.9	1.296	1.296
0.9 - 1.0	1.392	1.408
1.0 - 1.2	1.447	1.451
1.2 - 1.4	1.505	1.516
1.4 - 1.6	1.569	1.556
1.6 - 1.8	1.571	1.594
1.8 - 2.0	1.645	1.620

TABLE VII - OPTICAL MODEL PARAMETERS USED IN THE COUPLED CHANNELS CODE ECIS

Potential	Depth (MeV)	Radius (fm)	Diffuseness (fm)
Real	47.569-0.3E	7.643	0.620
Surface imaginary	2.7 +0.4E	7.643	0.620
Real spin orbit	7.5	7.674	0.620
Deformation parameters β_2 = 0.218 ; β_4 = 0.055			

TABLE VIII - *TOTAL ELASTIC ; DIRECT INELASTIC ; COMPOUND NUCLEUS FORMATION CROSS-SECTIONS CALCULATED BY ECIS AND FISINGA*

ENERGY MEV	$\frac{5}{2}$ +	$\frac{7}{2}$ +	$\frac{9}{2}$ +	COMPOUND	
				ECIS	FISINGA
0.040	10.000	0.001		3.270	3.258
0.100	8.920	0.018	0.003	2.928	2.911
0.200	7.664	0.053	0.026	2.796	2.775
0.300	6.748	0.079	0.046	2.720	2.701
0.400	6.037	0.097	0.061	2.666	2.653
0.500	5.469	0.112	0.072	2.630	2.622
0.700	4.635	0.136	0.092	2.604	2.611
1.000	3.894	0.172	0.120	2.651	2.692
1.200	3.630	0.195	0.138	2.742	2.776
1.500	3.464	0.226	0.160	2.883	2.940
1.800	3.497	0.249	0.175	2.978	3.040
2.000	3.578	0.260	0.180	3.017	3.078
2.500	3.862	0.271	0.180	3.035	3.082
3.000	4.116	0.268	0.173	2.991	3.019
4.000	4.306	0.250	0.155	2.889	2.875
5.000	4.147	0.230	0.141	2.844	2.837
6.000	3.812	0.212	0.128	2.837	2.831
8.000	3.117	0.179	0.103	2.837	
10.000	2.710	0.148	0.081	2.837	
12.000	2.632	0.146	0.077	2.765	
14.000	2.800	0.142	0.072	2.711	
16.000	3.076	0.136	0.067	2.661	

TABLE IX - CALCULATED FISSION CROSS-SECTIONS (Column 1) COMPARED TO THOSE EVALUATED FROM EXPERIMENTAL DATA (Column 2). THE DIFFERENCE IS GIVEN IN % IN COLUMN 3

ENERGY (MeV)	1	2	3	ENERGY (MeV)	1	2	3
0.040	0.0106	0.0109	+ 3	1.250	1.5907	1.5030	- 6
0.060	0.0117	0.0123	+ 5	1.500	1.5496	1.5620	+ 1
0.080	0.0128	0.0140	+ 9	1.750	1.5426	1.6160	+ 4
0.100	0.0146	0.0161	+ 9	2.000	1.5596	1.6540	+ 6
0.150	0.0213	0.0237	+10	2.250	1.5696	1.6630	+ 6
0.200	0.0340	0.0339	- 0	2.500	1.6238	1.6530	+ 2
0.300	0.0942	0.0700	-34	2.750	1.6243	1.6350	+ 1
0.400	0.2355	0.1830	-28	3.000	1.6236	1.6120	+ 1
0.500	0.4981	0.4470	-11	3.250	1.5691	1.5780	+ 1
0.600	0.8167	0.7470	- 9	3.500	1.5313	1.5470	+ 1
0.700	1.1101	1.0170	- 9	3.750	1.5121	1.5170	+ 0
0.750	1.2232	1.1346	- 8	4.000	1.5182	1.4860	- 2
0.800	1.3292	1.2320	- 7	4.250	1.4888	1.4590	- 2
0.850	1.4287	1.3030	- 9	4.500	1.4930	1.4350	- 4
0.900	1.5225	1.3530	-12	4.750	1.5141	1.4210	- 6
1.000	1.6273	1.4180	-14	5.000	1.5522	1.4150	-10

TABLE X - EVALUATED FISSION CROSS-SECTIONS COMPARED TO SOME RECENT ABSOLUTE MEASUREMENTS

En MeV	GRADY et al (35)	GRENIER et al (43)	ARLT et al (44)	EVALUATED VALUES
0.770	1.191			1.176
0.964	1.365			1.395
2.500		1.66 ± 0.03		1.653
14.700			2.226±0.024	2.179

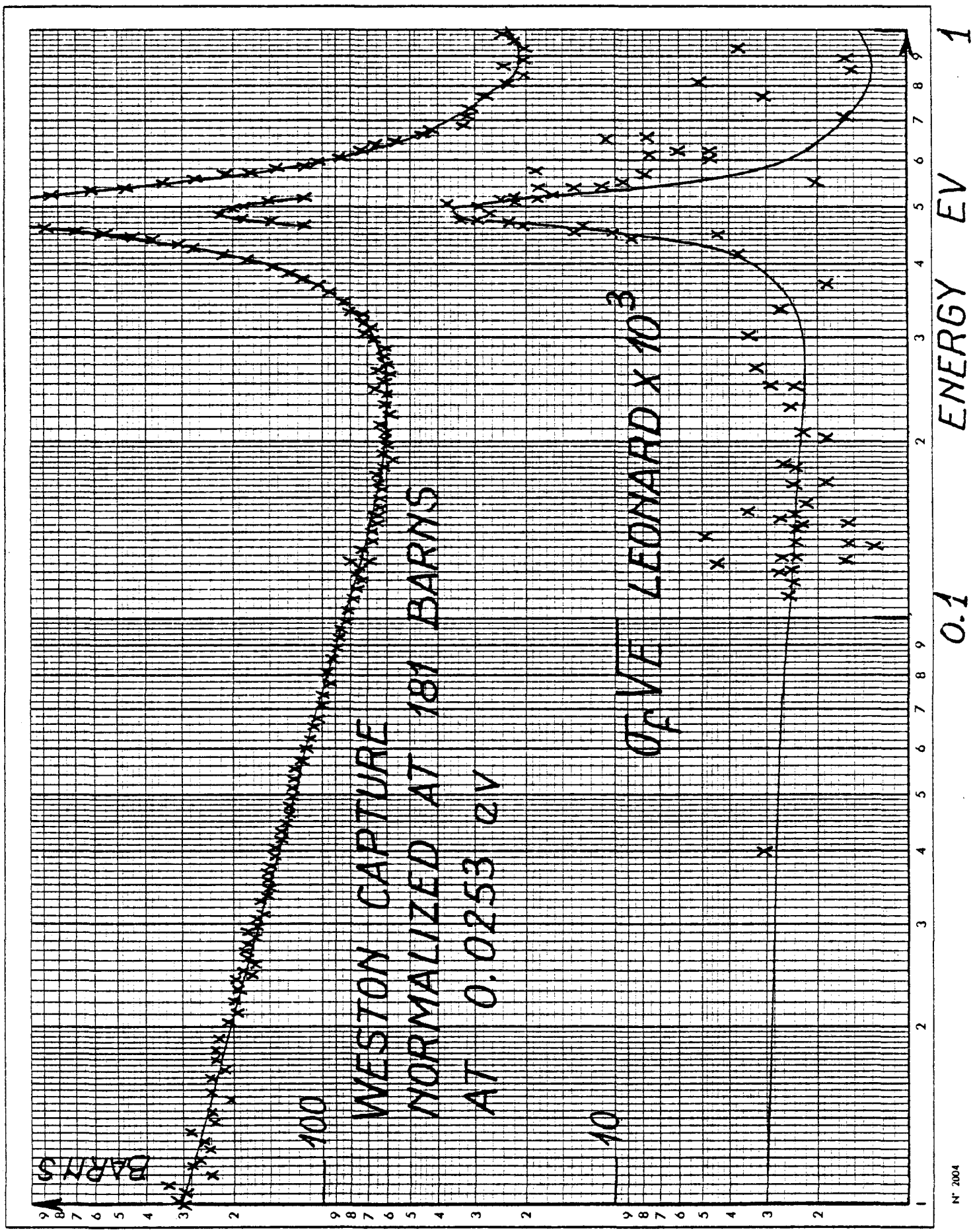

FIGURE 1 - CAPTURE AND FISSION CROSS-SECTIONS IN THE THERMAL REGION

N° 2004

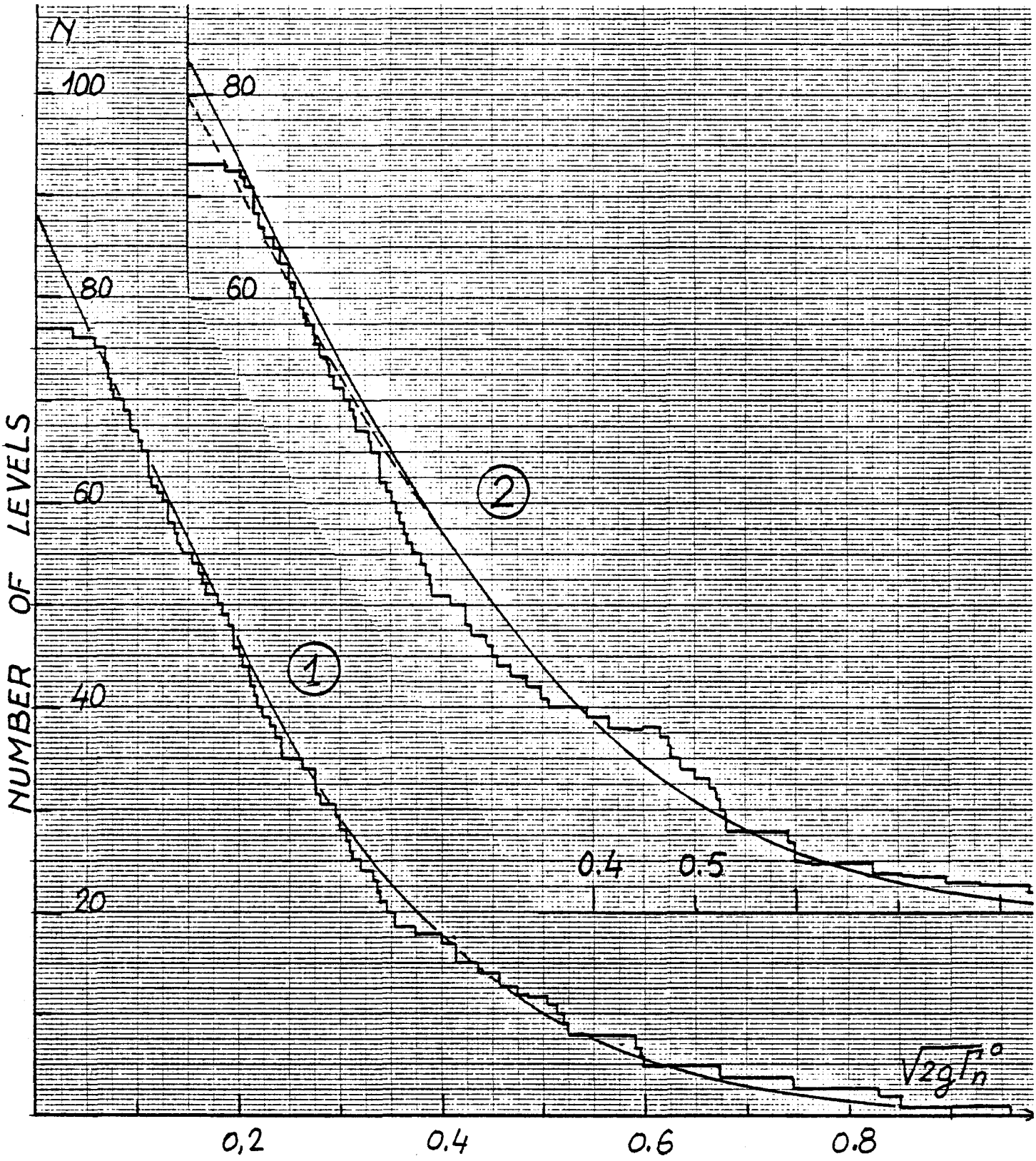

FIGURE 2 - *PORTER-THOMAS DISTRIBUTION OF THE REDUCED NEUTRON WIDTHS* :

1) *Corrected to take into account the effect of 5 doublets*

2) *Not corrected*

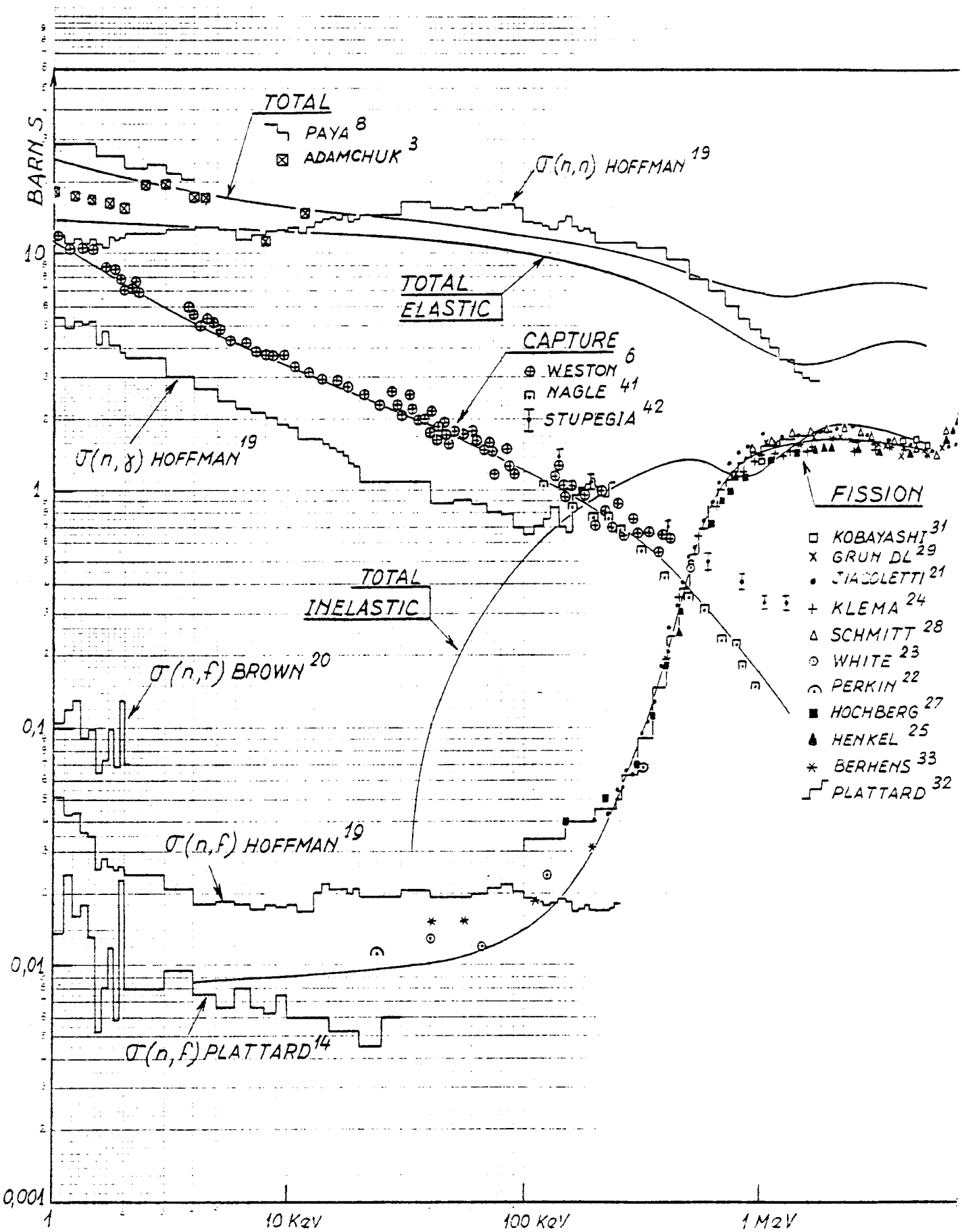

FIGURE 3 - GENERAL VIEW OF THE EXPERIMENTAL DATA AND EVALUATION

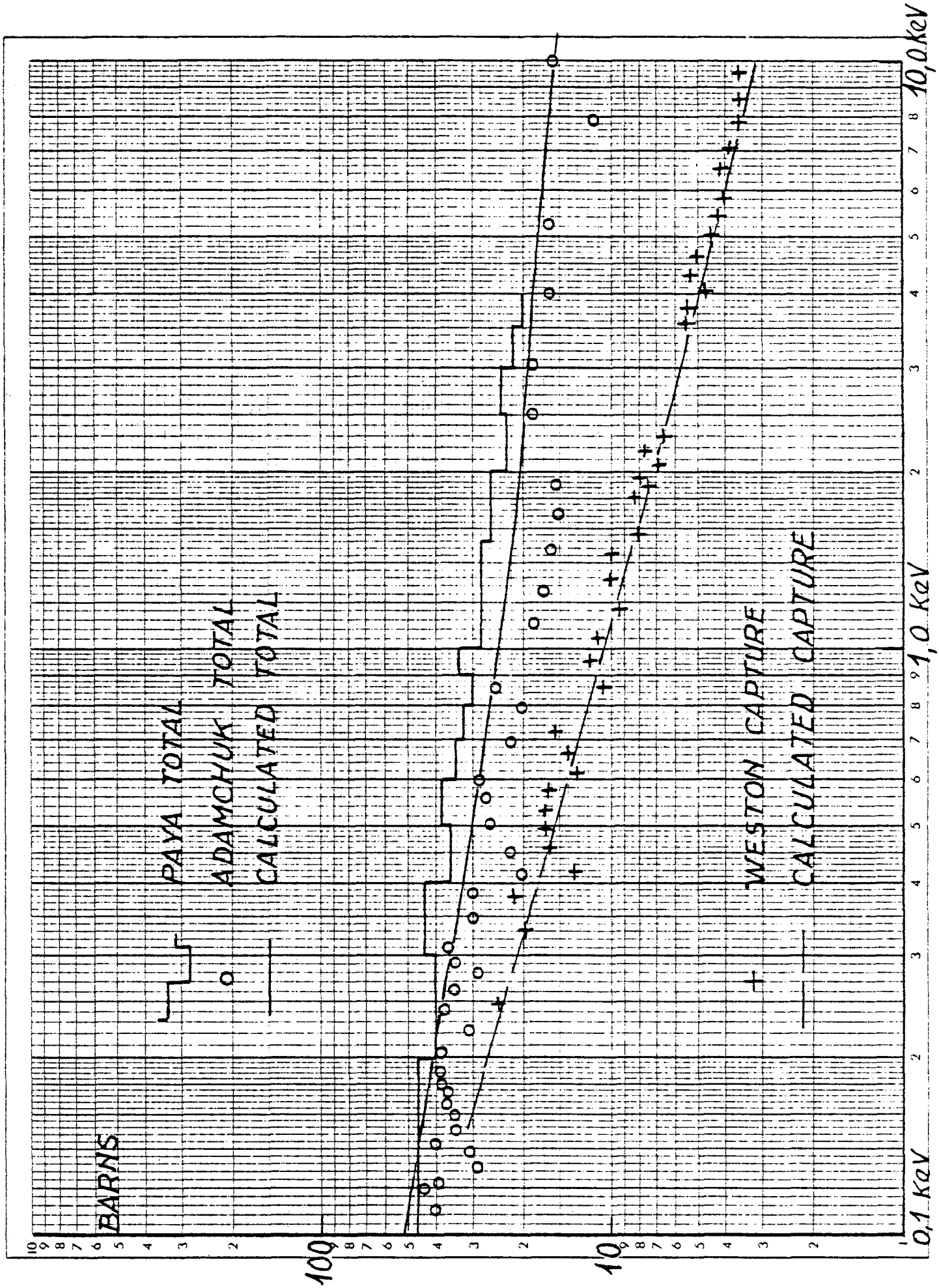

FIGURE 4 - TOTAL AND CAPTURE CROSS-SECTION BETWEEN 0.1 KeV and 10 KeV

N° 2104

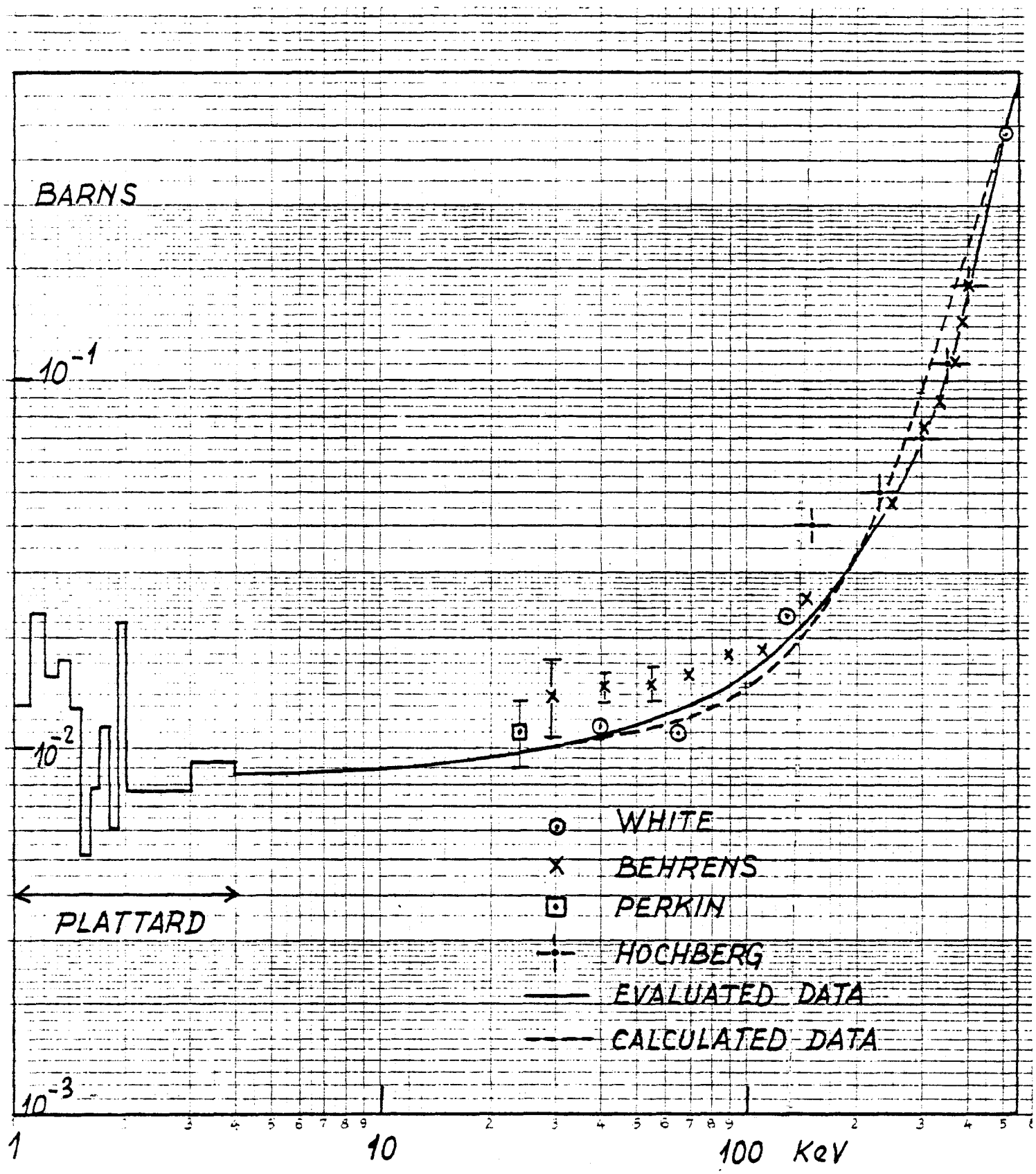

FIGURE 5 — FISSION CROSS-SECTION BETWEEN 1 KeV AND 400 KeV

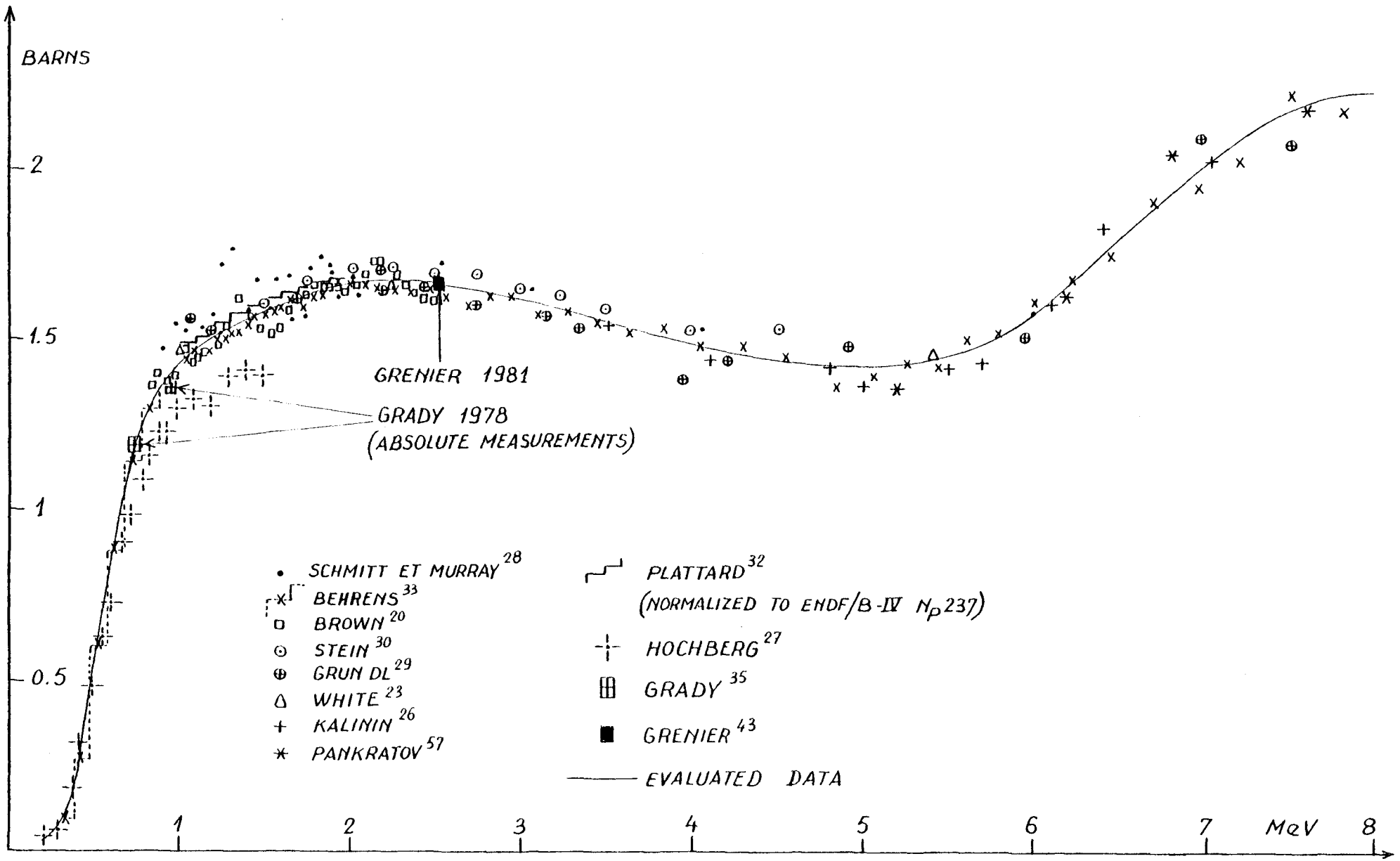

FIGURE 6 - FISSION CROSS-SECTION BETWEEN 0.3 MeV AND 8 MeV

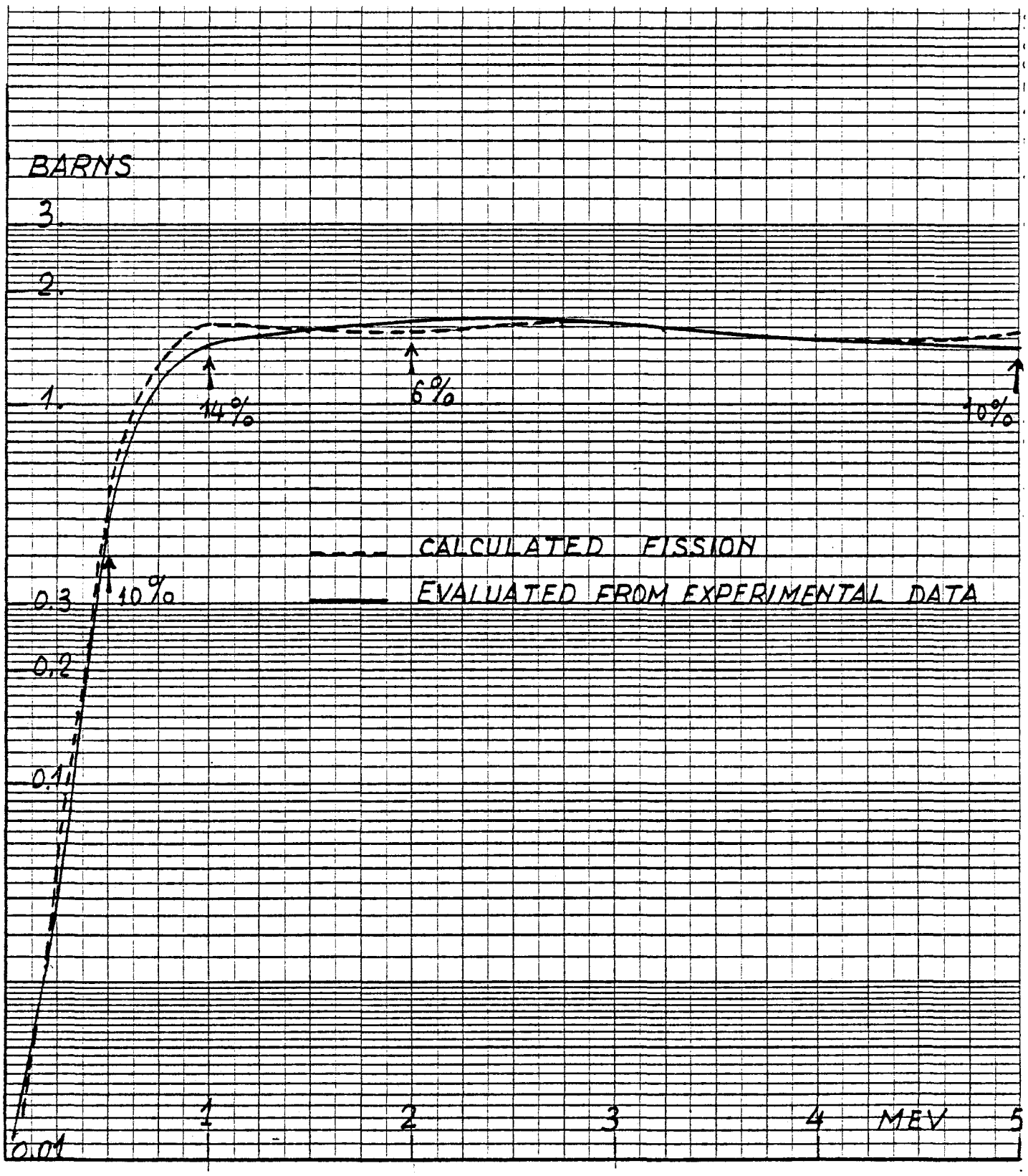

FIGURE 7 - EVALUATED AND CALCULATED FISSION CROSS-SECTION BETWEEN 50 KeV and 5 MeV

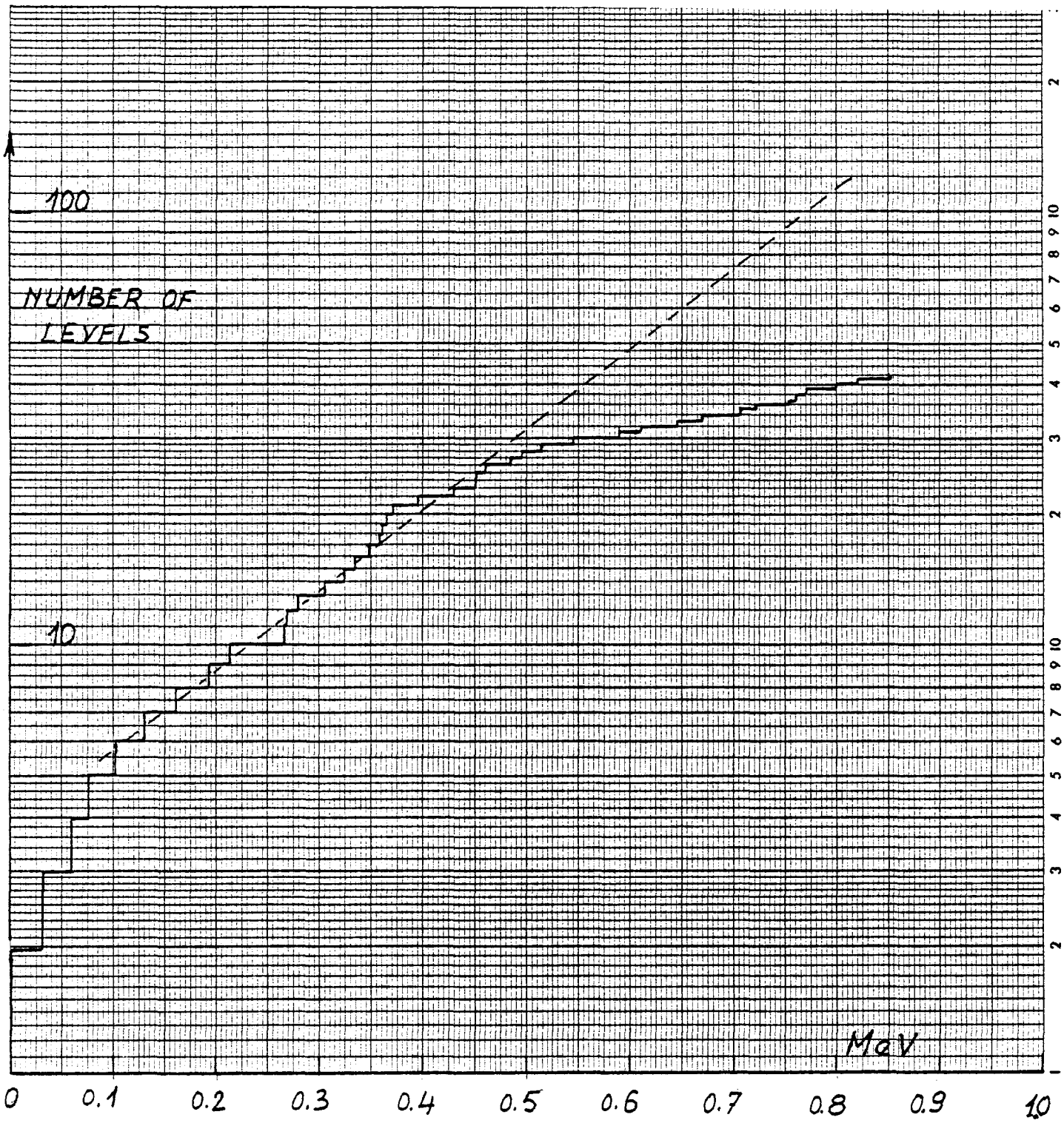

FIGURE 8 - DISTRIBUTION OF 237Np LOW-LYING LEVELS

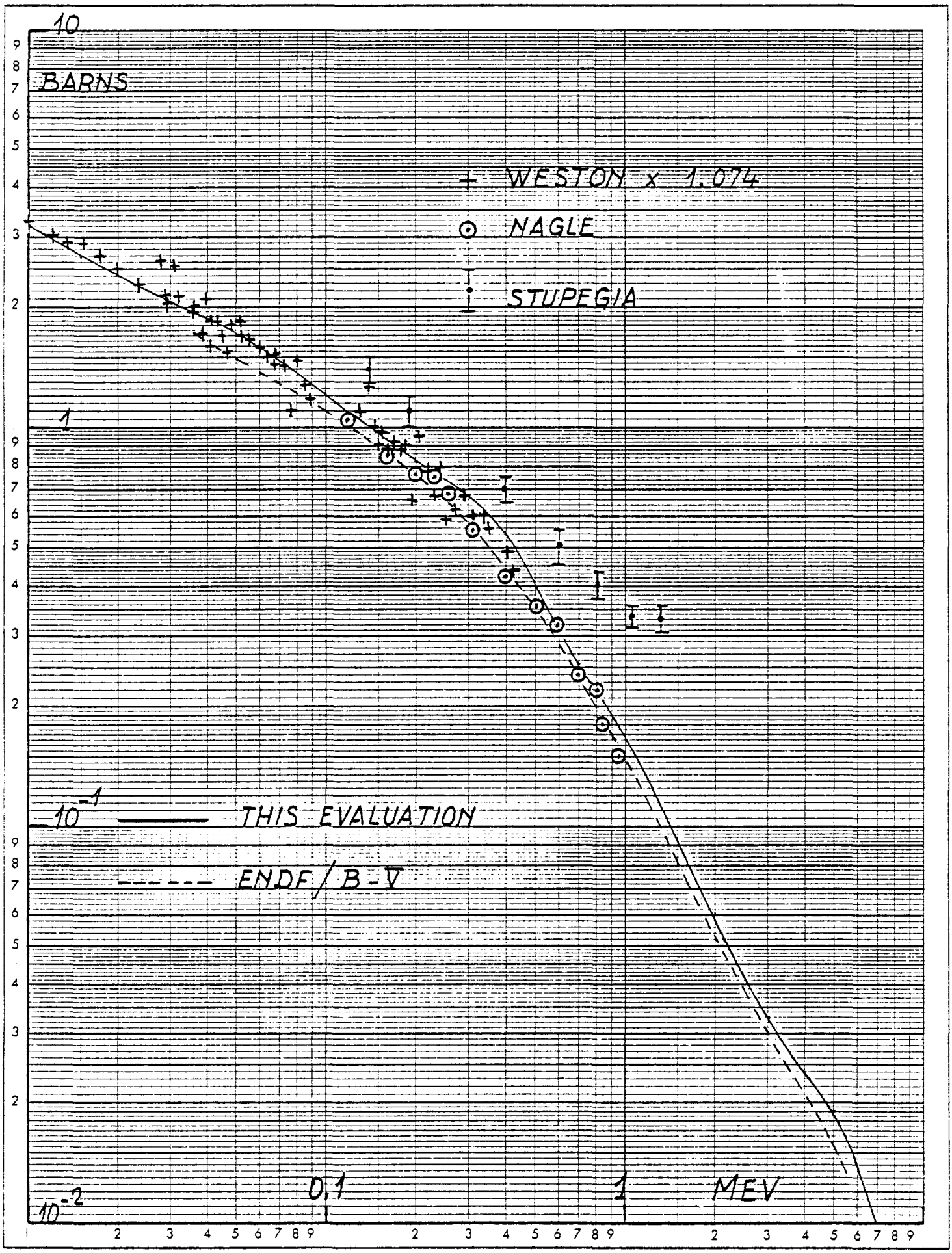

FIGURE 9 - CAPTURE CROSS-SECTION BETWEEN 10 KeV AND 5 MeV

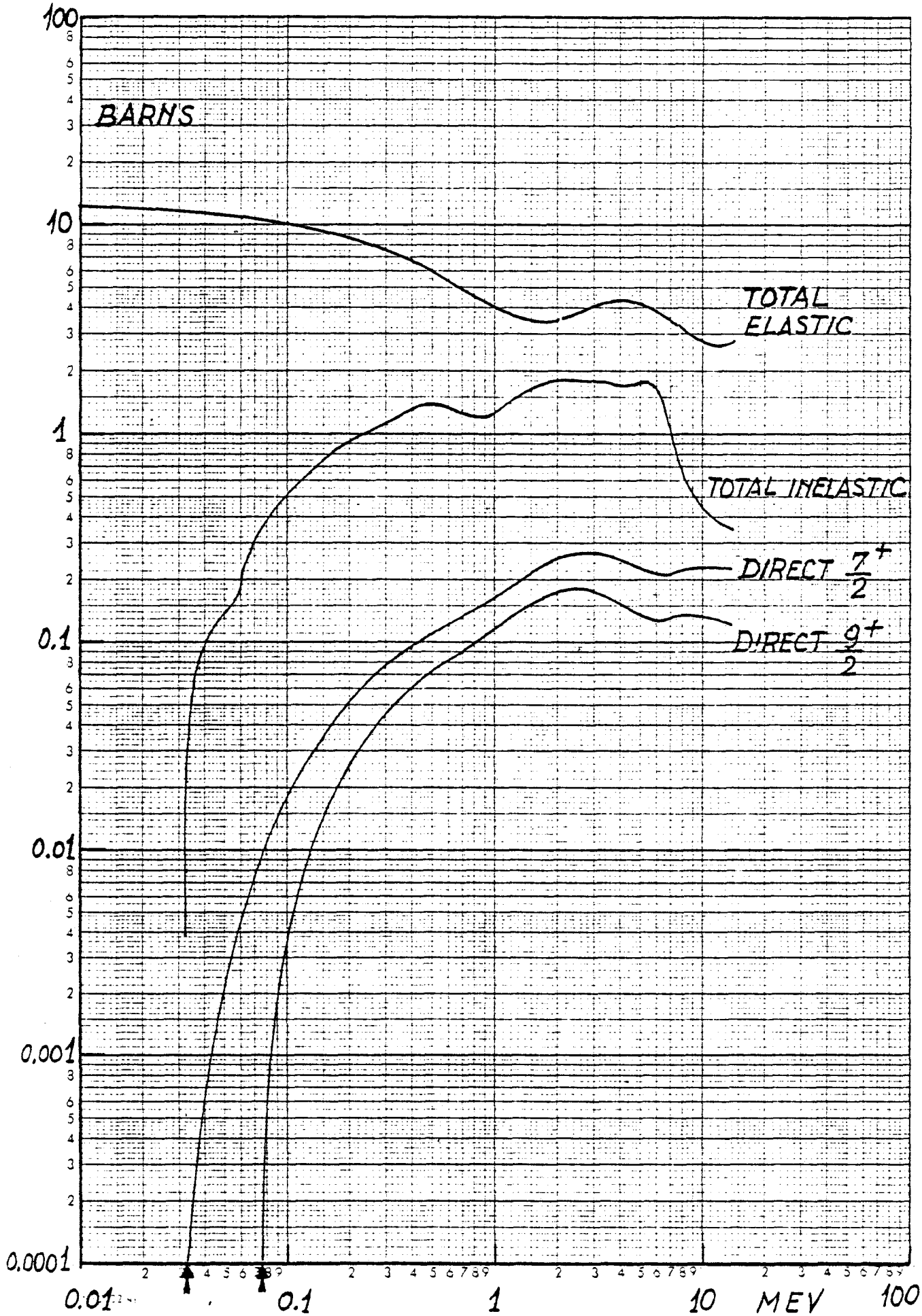

FIGURE 10 - TOTAL ELASTIC AND TOTAL INELASTIC CROSS-SECTION

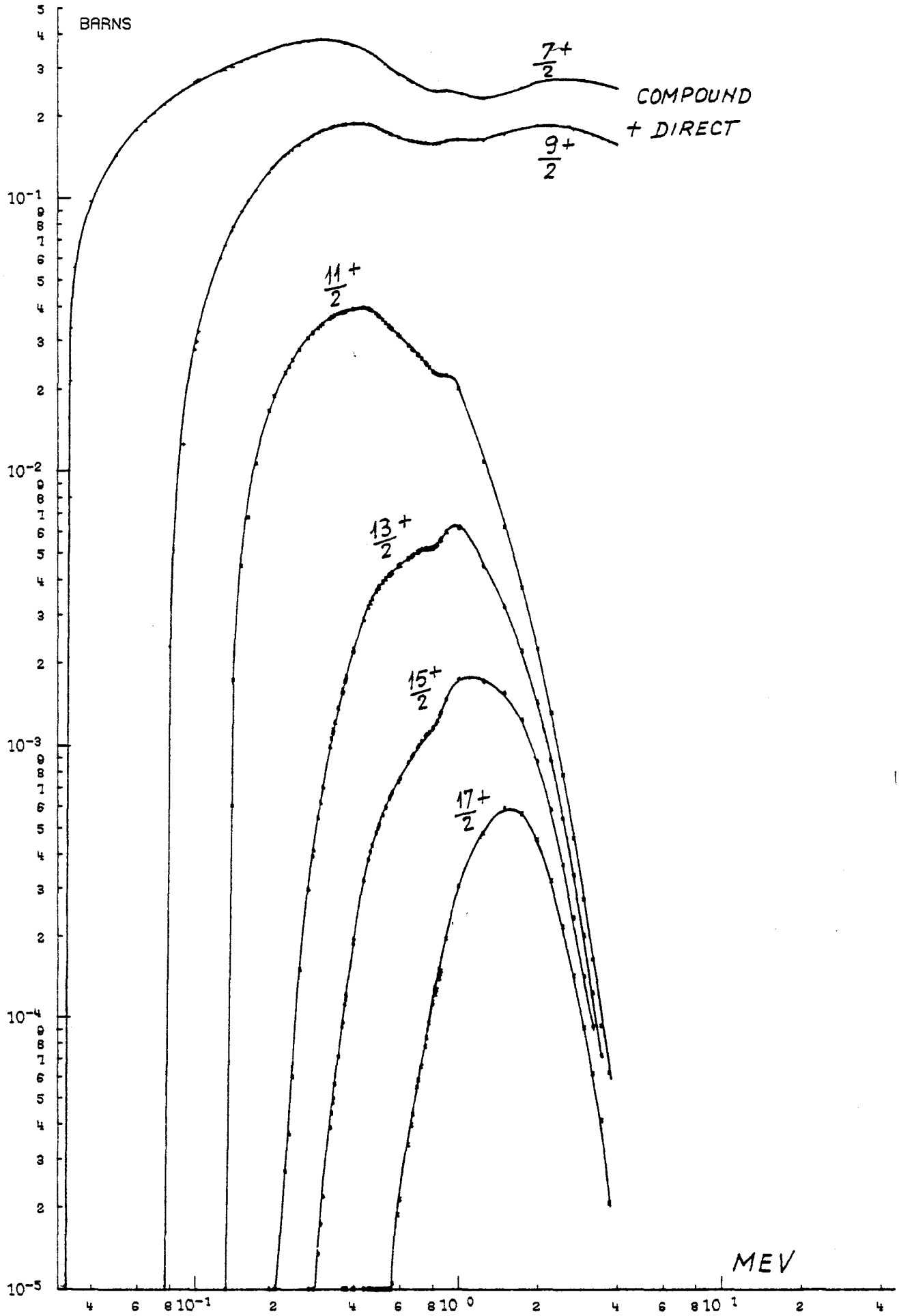

FIGURE 11 - CALCULATED INELASTIC SCATTERING TO THE LEVELS OF THE 5/2 (642) BAND

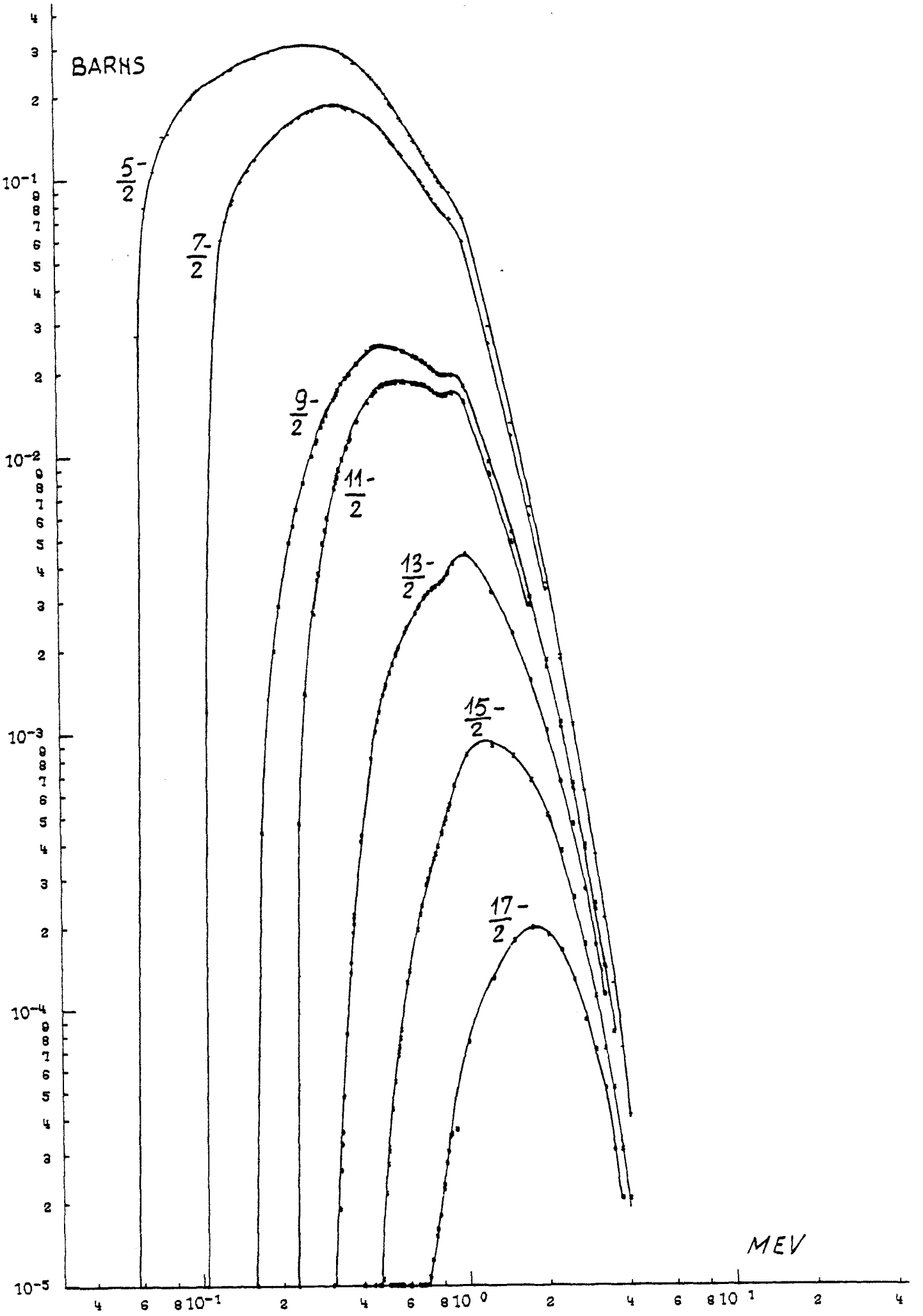

FIGURE 12 - CALCULATED INELASTIC SCATTERING CROSS-SECTION TO THE LEVELS OF THE 5/2 (523) BAND

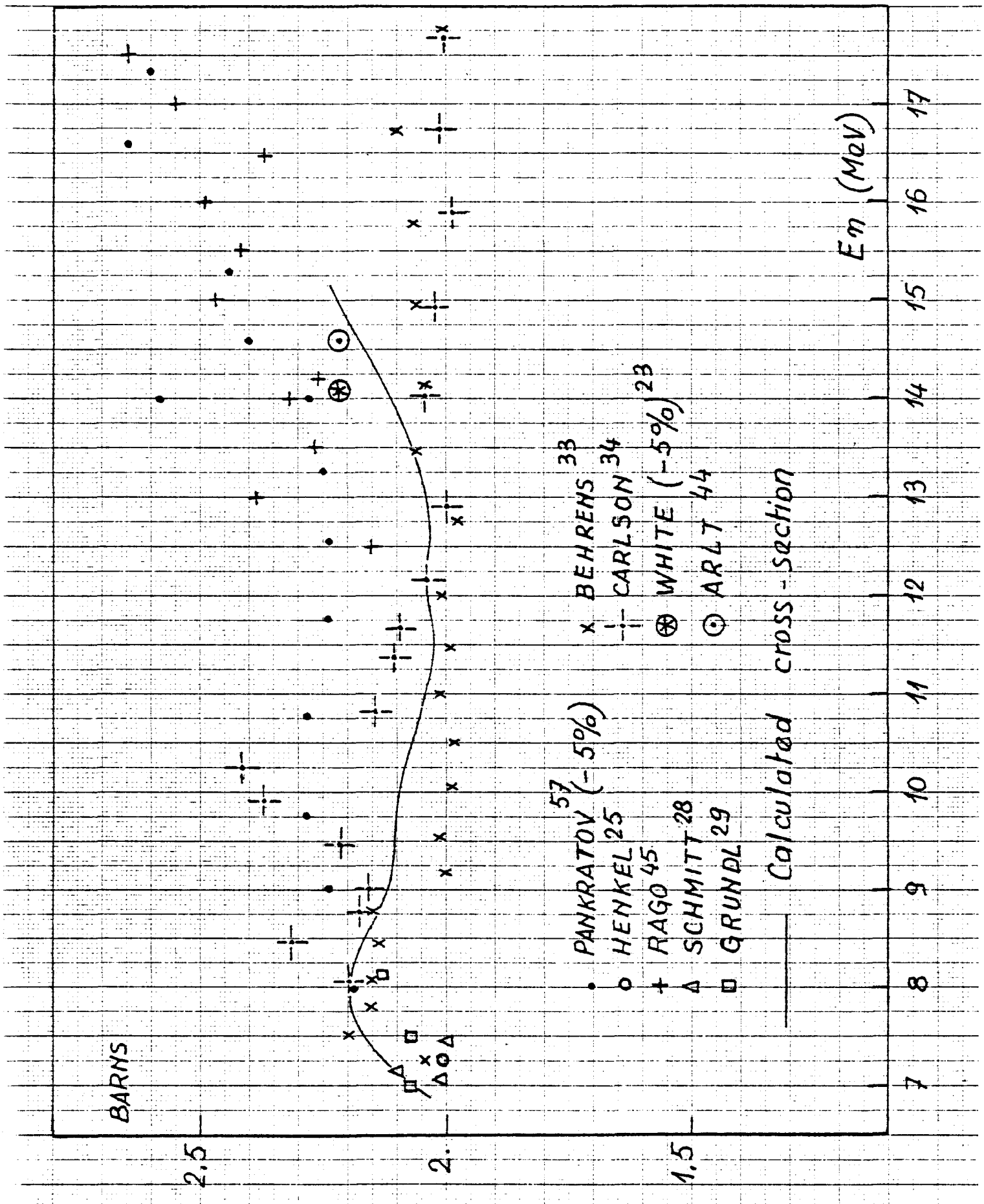

FIGURE 13 - FISSION CROSS-SECTION IN THE ENERGY RANGE 7-17 MeV

LORENZ, DR. A.
NUCLEAR DATA SECTION
IAEA