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^{235}U RESOLVED RESONANCE PARAMETERS FOR ENDF/B, VERSION III

J.R. Smith and R.C. Young

Aerojet Nuclear Company

NATIONAL REACTOR TESTING STATION

Idaho Falls, Idaho — 83401

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ABSTRACT

A new set of resolved resonance parameters for ^{235}U has been derived for inclusion in Version III of the Evaluated Nuclear Data File B. Single-level parameters plus a complementary smooth file describe the cross sections between 7 and 82 eV. The parameters were developed by simultaneously fitting three sets of fission cross section data and one set each of total and capture cross sections. The Automated Cross Sections Analysis Program (ACSAP) was used in the fitting.

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I. INTRODUCTION

Uranium-235 has long been the principal nuclear fuel, and the standard against which other reactor fuels are compared. The resonances of ^{235}U are closely spaced and subject to severe distortions in shape due to the phenomenon of interference in the fission process. This combination of importance and resonance complexity makes ^{235}U the most challenging of all resonance analysis problems. The present analysis was undertaken by assignment from the Cross Sections Evaluation Working Group, for the purpose of revising and extending the ENDF/B resolved resonance file for ^{235}U. The task has two aspects: Selection and normalization of data sets, and fitting the selected data sets with a consistent set of single-level parameters. These two parts of the problem are about equal in complexity and importance.

II. PREPARATION OF DATA

1. Selection of Data Sets

There is a great wealth of data from many measurements of the cross sections of ^{235}U. It would be impractical to fit all the available data. On the other hand, no one experiment is so definitive that it completely dominates the field of view. The following data sets were selected for prime consideration for the reasons given. As noted, there are some problems with each data set.

1. Simultaneous capture and fission measurements by deSaussure et al.[1]. These data were used principally to indicate the ratio of capture to fission for the resonances. The strength of this experiment is that it measured the two most important partial cross sections of ^{235}U simultaneously, under the same conditions of resolution and background. Moreover, care was taken to correct for such effects as backgrounds, resonance self-shielding, and scattering in the fission chamber. The resolution, however, was poorer than that of the other data used in this analysis. The most severe problem with these data is that the resolution was evidently substantially different from that to be deduced from the experimental parameters given by the authors in their report. Moderation time for neutrons slowed down in the moderator is probably responsible for most of the resolution problem. The moderation time contributes a width to the resolution function proportioned to $E^{-\frac{1}{2}}$ [2]
   During most of the present analysis this effect was simulated by an ad hoc adjustment of the resolution function. An asymmetric resolution function was used, and the flight path uncertainty was increased at low energies to give a resolution that would allow the deSaussure data to be fit by the same parameters as fit the higher resolution data sets. Subsequent studies indicated that this treatment was equivalent to a moderation time of $\frac{1.5\mu\,\text{sec}}{\sqrt{E\,(\text{eV})}}$

2. Total cross section measurements of Michaudon.[2] These data were obtained at liquid nitrogen temperatures and fairly high resolution. They turned out to give, in most cases, the best indication of the total widths of the resonances. The data were available only as cross section versus energy, with results from several samples mixed together. Total cross sections are measured from transmissions of samples, and the analysis should really be performed on the transmission data for each sample. In many resonances the partial cross sections did not add to give the total cross section properly. It is suspected that the total cross sections were at least partially responsible for the discrepancy. This problem is discussed further in the section on normalization of data.

3. Fission cross sections measured by Blons et al.[3] on the Saclay linear accelerator. These data were obtained at liquid nitrogen temperature, with resolution similar to that of Michaudon's total cross section measurement. This low temperature in effect gives the Blons data the best resolution of all the fission data. The principal problem is that below about 35 eV the normalization becomes progressively more erratic because of difficulty in interpreting the backgrounds in the presence of a ^{10}B filter used to eliminate low energy overlap neutrons. Normalization by a fourth order polynomial in energy adjusted these data to match the deSaussure normalization.

4. Fission cross sections measured by Cao et al.[4] on the linear accelerator at C.B.N.M. (Geel). These data are the highest resolution of the room temperature measurements of σ_f for ^{235}U. They are useful for comparing with the Blons data to confirm the effectiveness of the Doppler corrections in the analysis code. They go to a lower energy than the Blons data, 6 eV versus 17 eV. However, the Cao data have a fairly broad statistical spread, and are troubled by erratic background corrections in the vicinity of resonances in filters used to determine backgrounds.

In addition, the total cross section data of Shore and Sailor[5] were used for display purposes to observe the fit below 2 eV, but did not figure directly in the fitting.

2. Energy Normalization

It seems almost inevitable that experiments on different machines will show slightly different energy scales. To compare energy scales, large scale plots of fission data were made over 15 resonances from 7 eV (where the Cao data begin) to 100 eV. The Blons and Cao data showed energy differences small enough to be ignored. The Michaudon data, which were not obtained until after the energy comparison had been made, also fit the same energy scale. It is likely that the Blons and Cao measurements were normalized in energy to the Michaudon data, which predate them. The deSaussure data indicated a slight shift, which increased with energy, as compared to the other data sets. Since the European data agreed, and used flight paths that were roughly twice as long as that of the deSaussure experiment, the latter data were shifted in energy to bring them into agreement. An energy shift, linear in energy, was derived from a least squares fit to the apparent displacement of resonances. The constants for this shift are given in Table I.

The shifted deSaussure data agreed well enough with the other data to allow simultaneous fitting. However, as the analysis progressed, it became apparent that the data had been overcorrected below about 8 eV and above 60 eV. The constant term in the correction equation is too large. A straight correction of about 0.1% would probably be prefereable. As a matter of fact, the plots of the deSaussure data, shown in Appendix A, used the unnormalized data below 8 eV.

3. Cross Section Normalization

Since this analysis covered only the resonance region above 1.0 eV, it was necessary to normalize all data to the existing ENDF/B-II low energy file. The low energy file is in turn normalized to the IAEA evaluation of 2200 m/sec[6]. Of the principal data sets, only the deSaussure measurements go as low as 1 eV. These data were raised by 1.5% to bring the integral from 0.45 eV to 1.0 eV into better agreement with that from the ENDF/B low energy file. The calculated difference in the capture integrals was 2.4%; nevertheless, the capture was raised only 1.5% in order that deSaussure's α ratios might be preserved.

A series of partial integrals of the Blons, Cao, and deSaussure fission data were calculated as part of the normalization study. The energy intervals were chosen such that their boundaries fell in the valleys between resonances to minimize boundary errors. Ratios of the partial integrals from each data set to the others were calculated and compared. A plot of these is shown in Figure 1. The effects pointed out by Krebs[7] and Ribon[8] are evident. The ratios between data sets are not constant over the energy range of the experiments. The most severe departures seem to be associated with the use of filters to determine backgrounds in the linear accelerator experiments. The Cao data are severely distorted in the vicinity of resonances in the notch filters used for background determination. deSaussure also discusses such problems in his experiment, but the data he supplied for the present analysis had been at least partially corrected in the vicinity of the 28 eV resonance in cadmium. The Blons data progressively fall off in relative magnitude below about 40 eV. This is apparently associated with the decreasing transmission of the boron filter used to eliminate overlap neutrons. The distortions are associated with treatment of experimental backgrounds.

The Cao data were raised 7% to bring them into agreement with the renormalized deSaussure data. No attempt was made to normalize piece-wise in the vicinity of the distortions caused by the background filters. The Cao data were simply ignored in such regions. The Blons data, which already agreed well with the renormalized deSaussure data above 40 eV, were given an energy-dependent renormalization. The ratios of the incremental integrals from Blons data to the corresponding integrals from deSaussure's data were fitted with a fourth degree polynomial. The coefficients from the fit are listed in Table I. This polynomial was then used to normalize the Blons data. The resulting correction ranged from about 19% at 18 eV to zero at 40 eV. The polynomial introduced some fluctuations of less than half a percent above 40 eV, but these were deemed to be of no consequence to the fit. This correction applies only to 100 eV. If applied above that energy, it would introduce severe fluctuations.

Total cross section data are in principal the easiest of all data to assign absolute values. It is consequently difficult not to favor the total cross section values when discrepancies arise between them and the sum of the partial cross sections. Nevertheless, there are discrepancies between the total and partial data that do not appear to be attributed completely to partial cross section normalization errors or to resolution effects. The total cross sections tend to go higher on the peaks than the sum of the partial measurements would indicate. Raising the partial cross section values would put them out of line with the low energy measurements to which they are normalized. Some of the effect is likely due to resolution differences, but this does not seem to be the answer to the disagreement over the broad resonances near 14 eV. Some of the discrepancy may arise from normalizations in the total cross section data. Michaudon used five samples in his experiment. Two of these were well calibrated, and served as the basis for normalization of all the data. Any error in this internormalization would tend to give the strong resonances an apparently different normalization from the weaker ones.

Since neither the total nor the partial cross sections seemed to be free from suspicion in the normalization discrepancy, a compromise was in order. The values of Γ_n^o reported here represent averages from separate fits to the total and partial cross section data, using the same values for the total widths.

4. Resolution

For any shape analysis of resonance data to be meaningful, it is absolutely essential that the experimental resolution function be well understood. We have already mentioned the resolution problems encountered with the deSaussure data. Lesser difficulties were experienced with the other data sets. A thorough study of all the resolution problems of each experiment was not possible within the time allotted for this study. The resolution functions were adjusted so that all data sets were well fit by the same parameters. The experimental resolutions assumed are summarized in Table II. It is possible that these detailed breakdowns may not be strictly correct, but the overall resolution functions should be reasonably close to reality.

The resolution parameters for Michaudon's total cross section data were left essentially as we understood them to be from Michaudon's report. The effect of the moderator, however, was introduced only as an uncertainty in flight path, without using the $E^{-\frac{1}{2}}$ term. The omission of this latter term may contribute a slight bias to the resonance widths we derived. However, these widths are in most cases in good agreement with those derived by Michaudon in his analysis, so the overall resolution functions should be fairly close. The total cross sections seemed to come closest to being matched by the theoretical resolution function. Therefore, the total widths are based mainly on the analysis of these data.

For both Blons' and Cao's fission data, a moderator contribution $\frac{2\mu\text{sec}}{\sqrt{E(\text{eV})}}$ was added to the resolution function. In addition, a flight path uncertainty (moderator thickness in this case) of 5 cm was used for the Blons data rather than the theoretical 2 cm. The fact that more moderator effect was needed for the Blons fission data than for Michaudon's total data, measured on the same machine, suggests that the true source of the difference does not lie in the moderator at all. The impression is that fission experiments show lower resolution than total measurements on the same machine. This may be due to scattering of neutrons within or in the vicinity of the fission chamber. deSaussure et al. made corrections for this effect in their data, but the other experimenters do not seem to have done so.

III. FITTING OF DATA

1. The Automated Cross Section Analysis Program (ACSAP)

The principal computer code used in this evaluation was the Automated Cross Section Analysis Program (ACSAP). The program is described in detail elsewhere[9]. We give only a brief summary of its capabilities here. Either single-level or Reich-Moore multilevel parameters can be used in ACSAP. The fitting procedure is an iterative one. For each resonance to be fit, one to three points and a set of trial parameters are selected. The program adjusts the parameters to force the calculated cross section curve to pass through the selected points. When three points have been selected, it is possible to adjust the resonance energy Eo, the reduced neutron width Γ_n^o, and one other partial width, either the capture width $\Gamma\gamma$ or the fission width Γ_f. Such an adjustment is termed a shape fit. When only one point has been selected for a resonance, only one partial width can be adjusted. Since such points are usually chosen near the peak of a resonance, this adjustment is referred to as a peak fit. The peak fit is very useful for two special circumstances. The first is the case where a resonance is too poorly resolved to perform a reliable shape fit. The second is the case where the resonance energy and total width have been determined by a previous shape fit, and it is next desired to adjust the partial widths to fit one or more sets of partial cross sections data. After ACSAP has finished adjusting parameters, it will upon request plot a calculated curve, appropriately broadened for Doppler and resolution effects, along with the corresponding experimental data. These calculation and plotting procedures may be repeated at will in the same run so that several sets of data may be plotted and compared with the theoretical curves, each one broadened according to the actual conditions under which the data were taken.

These calculating and plotting features proved as useful in this evaluation as the actual fitting routines. They were used directly to examine sets of experimental data and compare them to existing sets of parameters. During the course of the fitting, the repetitive plotting capabilities made it possible routinely to follow the effects parameter changes had upon all the sets of data used.

2. Derivation of Resonance Parameters

Single level parameters were derived by fitting the experimental data by means of the automatic iterative fitting features of ACSAP. One set of data was chosen as prime set, and one to three points per resonance selected to represent these data. After ACSAP had adjusted parameters so the calculated curve would pass through these points, it calculated and plotted theoretical fits to all the experimental data sets, using the newly derived parameters. Visual inspection of the curves was the guide to modifying input for subsequent runs. Each of the five data sets was used as prime set at various times during the analysis. This procedure allowed detailed examination of the data sets to determine whether anomalies were common to several experiments or peculiar to one. It also allowed comparison of experiments as to consistency with resolution parameters indicated by their authors. From the principle of perversity of nature, it was deemed highly unlikely that any true resolution would be higher than that derived from the known properties of the experimental system. This criterion led to the acceptance of Michaudon's total cross section measurements as the truest available indicator of the natural widths of most resonances. Exceptions to this rule were made in the cases of the 1.1 eV resonance, which Michaudon did not measure, several resonances distorted by the presence of impurities, and several others for which inter-sample normalization problems are suspected. On the whole, however, the most productive fitting sequence seemed to be to shape-fit the total data, peak-fit the deSaussure fission and capture data, and merge the parameters to maintain the total widths from the total data and the alpha values from deSaussure's data.

The only problem with this procedure is that it can really be done only over a very limited energy region. The present analysis was carried well beyond the region where shape fitting can be considered accurate. A pure area analysis, on the other hand, becomes impractical for ^{235}U, because of the close spacing and assymetry of the resonances. A fit to the peak of data with the same resolution function (deSaussure σ_f and σ_c), with the total width fixed,is comparable to an area fit of the same data. The combination of shape analysis of sets of data having different resolution functions, with peak fitting to the partial cross section data, partially overcomes some of the limitations inherent in the shape analysis approach.

3. Construction of Smooth Files (ENDF/B File 3)

Because the ^{235}U resonances are asymmetric, it is not possible to get a good fit using a reasonable number of single-level resonance parameters alone. It may not even be possible using an unreasonable number. The ENDF/B format makes it possible to circumvent this problem by using an auxiliary file of pointwise data. These "smooth" data, when added to the cross sections calculated from the resonance parameters, yield the same overall cross section to be derived from a good multilevel fit.

ACSAP will upon request print and plot the differences between experimental points and the cross sections calculated from parameters. Such difference outputs were used in constructing the smooth files. In order to maintain proper α values, the deSaussure data were used as much as possible in constructing these different files. However, this ideal had to be abandoned above about 35 eV, as degraded resolution spread the influence of intrinsic resolution to energies significantly far from the resonances to which they apply.

In the present analysis, an effort was made to keep the smooth file small, sometimes by splitting a resonance into separate capture and fission resonances. Such efforts were not always successful, however, and the smooth file contribution remains substantial, particularly below 15 eV. The fact that there is less smooth file structure in the upper part of the resonance region is doubtless due to the fact that degraded resolution obscures the true resonance shapes at higher energies.

The treatment of the scattering file should be clarified. No scattering data were explicitly fit. The only constraints placed on the scattering cross sections were that they should be consistent with the resonance parameters, should match the low energy file at 1 eV, and should not go negative. A value of 11.5 b was used for the potential scattering cross section. This is the value used in the IAEA analysis of low energy cross section standards[(5)], and is consistent with the recent determination of 11.7 barns by Poortmans et al.[(10)]

Scattering cross sections computed from the single-level parameters are a first approximation to the true values, but are faulty on two counts. In the first place, scattering is intrinsically a multilevel process, and the single-level approximation gives erroneous results. It may even go negative under some circumstances[11]. In the second place, any finite set of parameters will show an imbalance at both ends of its energy region, because interference terms extend in energy infinitely far in both directions. These interference contributions tend to make scattering too low at the low energy end, and too high at the high energy end. To arrive at a balanced scattering estimate, a special scattering calculation was made, using the Reich-Moore multilevel formula[12]. For this calculation, the single-level parameters described herein were used, but the negative energy resonance was adjusted in Γ_n^o to give the same cross section at 1 eV (12.9 b) as found in the low energy file. To balance the upper end, a mock resonance file was generated to 110 eV by reflecting a 30 eV band of resonances around 80 eV. The difference between this calculation and the single-level prediction became the scattering smooth file. By means of an interpolation routine, the scattering smooth file was put on the same energy mesh as the total smooth file. The latter file was also compensated for the change in scattering. The scattering smooth file, when added to the scattering cross section given by the Version II parameters, therefore essentially yields a multilevel scattering cross section. This is still not the "true" scattering cross section, because spins are not assigned to the resonances. It does, however, seem to be the best available estimate.

IV. RESULTS

The final ENDF/B, Version III resolved resonance parameters for ^{235}U are shown in Table III. It should be kept in mind that these parameters are to be applied only between 1 and 82 eV. Resonances below 1 eV and above 82 eV are included only to aid continuity between energy regions, and have not been adjusted in the current investigation. The two resonances below 1 eV are those used in ENDF/B, Versions I and II, while the two resonances above 82 eV are from Blons. The parameters of the negative energy resonance are really no longer appropriate, since the current analysis used a different value for σ_{pot} than did Version I. The two resonances above 82 eV do not give an adequate description of the cross sections above that energy, because they ignore an unanalyzed bouquet of resonances between 82 and 87 eV. Nevertheless, these resonances should be left in the calculations because they were there when the current resonance parameters and smooth file were constructed.

Appendix A displays a series of plots representing the fit to all data sets analyzed between 1 and 82 eV. The contributions of the parameters alone are represented as a dashed line, while the complete cross sections, parameters plus smooth file, are given as solid lines. While no set of data is fit perfectly, the reason for departure from a given data set in a particular energy region will usually be evident from an examination of the fit to the other data sets over the same region. In Table IV is a comparison of cross section integrals from the fit and from the fission and capture data sets. Table V presents a similar comparison for total cross section data. The errors associated with the analysis are discussed in Appendix B.

The principal difference between the present file and previous ENDF/B files for ^{235}U is that the present total widths are systematically narrower. This difference is not obvious for resonances that are either wide or poorly resolved, but is clear in a comparison of narrow, well-resolved resonances. This difference has its origin in the resolution problems with the ORNL-RPI measurements, which were the only data considered in the previous analysis. It may have a substantial effect in applications where self-shielding must be considered.

A word might be said concerning capture widths. These are expected to vary but slightly from an average value, following a chi-squared distribution with many degrees of freedom. Purists tend to become upset with sets of resonance parameters showing large variations in the capture widths. Experience gained during the present investigation has led to the conclusion that a large part of such variations may be due to resolution limitations. A resonance that appears to have twice the normal radiation width may in truth be a doublet, consisting of two resonances having normal widths. Moreover, the degradation in resolution with increasing energy may, if not properly accounted for, induce an apparent growth in the resonance widths at higher energies. These thoughts have guided the present fitting effort. Nevertheless, the emphasis has been on reproducing neutron cross sections, as opposed to deriving subtle conclusions concerning nuclear structure. Accordingly, the present file contains a few examples of what may be artificial radiation widths. In view of these considerations, it is not thought profitable to speculate on the number of degrees of freedom represented by the distribution in radiation widths.

This study has shown once again the central role that experimental resolution plays in resonance analysis. It is unfortunate that the present climate does not encourage the detailed study of resolution characteristics and background composition of the new machines. Since the principal points of disagreement between experiments seem to be traceable to problems with instrumental backgrounds and resolution, it would seem that such studies should be assigned the highest priority.

We feel that the present analysis provides a description of the ^{235}U resonance cross sections that is about as good as the experimental data, and close to the quality that could be expected from a multilevel fit. An improved description would require improved experimental data. A remeasurement of the total cross section would be very advantageous, but only if it were made using a well-calibrated set of precision metal samples, at low temperatures, using high resolution that is well understood. Simultaneous measurements of capture and fission cross section at low temperature and high resolution would also be welcomed, though these would be more difficult to achieve. Meticulous attention to details such as resolution details, all backgrounds, scattering corrections, and self shielding corrections will be required if new measurements are to improve the present picture.

V. ACKNOWLEDGMENT

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VII. TABLES

TABLE I

DATA NORMALIZATION

Data Set	Energy Change	Cross Section Normalization Factor
deSaussure Fission and Capture	$\Delta E = .0161 - .00117E$	1.015
Blons Fission	none	$1.7376 - .0475E + .001097E^2 - 1.086X10^{-5} E^3 + 3.9X10^{-8} E^4$
Cao Fission	none	1.070
Michaudon Total	none	1.000
Shore Total	none	1.000

TABLE II

EXPERIMENTAL CONDITIONS

ASSUMED FOR DOPPLER AND RESOLUTION BROADENING

	deSaussure Fission and Capture	Blons Fission	Cao Fission	Michaudon Total
Instrument	LINAC (RPI)	LINAC (Saclay)	LINAC (Geel)	LINAC (Saclay)
Flight Path (meters)	25.45	50.07	60.58	53.41
Effective Temp. (°K)	298	96	300	96
Sample Thicknesses (barns/atom)	------------	------------	-------------	39.1 100.0 231.4 708.7 4460.
Flight Path Uncertainty (detector and moderator thicknesses) (cm)	4.1	5	3.7 (below 41eV) 4.2 (above 41eV)	3.6
K^* (ev)	1.5^+	2	2	0
Resolution Shape	Asymmetric	Gaussian	Gaussian	Gaussian
Accelerator Burst (u sec)	.25 .10	.05	.03 .08	as shown
Channel width (u sec) (Energy range, ev)	2.56 (1-3) 1.28 (3-6) .64 (6-12) .32 (12-27) .16 (63-82)	.4 (17-31) .2 (31-68) .1 (68-82)	.64 (47-8) .32 (8-26) .16 (26-43) 1.28 (43-47) .08 (30-82)	Chan. / Burst 1 (1.3-7.5), 2 .5 (7.5-50), .5 .15(50-82), .1

* K is the moderation time uncertainty at 1eV. The term $K/\sqrt{E(eV)}$ is included in the resolution width.

+ During most of the analysis the moderation time effect was simulated by letting the flight path uncertainty vary from 6.4 cm at 1eV to 4.1 cm above 60 eV.

Table III

U-235 Resolved Resonance Parameters for ENDF/B-III

Resonance Energy (eV)	Resonance Spin	Total Width (eV)	Gamma-N (eV)	Gamma-N-Nought (eV)	Gamma-Gamma (eV)	Gamma-F (eV)
-1.4900E 00	3.5000E 00	2.3768E-01	3.6820E-03	3.0164E-03	2.7000E-02	2.0700E-01
2.9000E-01	3.5000E 00	1.3500E-01	3.0157E-06	5.6000E-06	3.6000E-02	9.9000E-02
1.1400E 00	3.5000E 00	1.5082E-01	1.5161E-05	1.4200E-05	3.4600E-02	1.1620E-01
2.0350E 00	3.5000E 00	4.4696E-02	7.6605E-06	5.3700E-06	3.4874E-02	9.8140E-03
2.9200E 00	3.5000E 00	2.2000E-01	4.8530E-06	2.8400E-06	2.0000E-02	2.0000E-01
3.1470E 00	3.5000E 00	1.3961E-01	2.2405E-05	1.2630E-05	3.3210E-02	1.0637E-01
3.6090E 00	3.5000E 00	8.4379E-02	4.5594E-05	2.4000E-05	3.3696E-02	5.0637E-02
4.8480E 00	3.5000E 00	3.9592E-02	6.0352E-05	2.7410E-05	3.5945E-02	3.5870E-03
5.4480E 00	3.5000E 00	9.0120E-02	3.3611E-06	1.4400E-06	6.0000E-02	3.0117E-02
5.6000E 00	3.5000E 00	6.4192E-01	3.3319E-05	1.4080E-05	2.0000E-02	6.2189E-01
6.2100E 00	3.5000E 00	2.3090E-01	6.3795E-05	2.5600E-05	4.3469E-02	1.8736E-01
6.3820E 00	3.5000E 00	4.4788E-02	2.6834E-04	1.0622E-04	3.4972E-02	9.5480E-03
7.0770E 00	3.5000E 00	6.3934E-02	1.2660E-04	4.7590E-05	3.5574E-02	2.8233E-02
8.7810E 00	3.5000E 00	1.2329E-01	1.1234E-03	3.7910E-04	3.1170E-02	9.1000E-02
9.2860E 00	3.5000E 00	1.1076E-01	1.6364E-04	5.3700E-05	3.5600E-02	7.5000E-02
9.7300E 00	3.5000E 00	2.6905E-01	5.3028E-05	1.7000E-05	3.2000E-02	2.3700E-01
1.0180E 01	3.5000E 00	1.0056E-01	6.1898E-05	1.9400E-05	3.8000E-02	6.2500E-02
1.0800E 01	3.5000E 00	9.3509E-01	9.3332E-05	2.8400E-05	6.7000E-02	8.6800E-01
1.1666E 01	3.5000E 00	4.7277E-02	6.2744E-04	1.8370E-04	4.0400E-02	6.2500E-03
1.2396E 01	3.5000E 00	6.3262E-02	1.2622E-03	3.5850E-04	3.4500E-02	2.7500E-02
1.2861E 01	3.5000E 00	1.1955E-01	5.3076E-05	1.4800E-05	3.3500E-02	8.6000E-02
1.3275E 01	3.5000E 00	1.5144E-01	3.9350E-05	1.0800E-05	2.8600E-02	1.2280E-01
1.3700E 01	3.5000E 00	1.2394E-01	3.7013E-05	1.0000E-05	3.0400E-02	9.3500E-02
1.3996E 01	3.5000E 00	4.9654E-01	5.3723E-04	1.4360E-04	2.6000E-02	4.7000E-01
1.4544E 01	3.5000E 00	5.6215E-02	1.1517E-04	3.0200E-05	3.5200E-02	2.0900E-02
1.5406E 01	3.5000E 00	7.8837E-02	2.3707E-04	6.0400E-05	3.5300E-02	4.3300E-02
1.6088E 01	3.5000E 00	5.0361E-02	3.6099E-04	9.0000E-05	3.1383E-02	1.8617E-02
1.6667E 01	3.5000E 00	1.3327E-01	2.7300E-04	6.6870E-05	3.2105E-02	1.0089E-01
1.8052E 01	3.5000E 00	1.6038E-01	3.8451E-04	9.0500E-05	3.5000E-02	1.2500E-01
1.8960E 01	3.5000E 00	1.0512E-01	1.1582E-04	2.6600E-05	5.0000E-02	5.5000E-02
1.9297E 01	3.5000E 00	9.8194E-02	3.1936E-03	7.2700E-04	3.4821E-02	6.0179E-02
2.0130E 01	3.5000E 00	2.4009E-01	8.7714E-05	1.9550E-05	1.3910E-02	2.2609E-01
2.0200E 01	3.5000E 00	5.0013E-02	1.3034E-05	2.9000E-06	4.9280E-02	7.2000E-04
2.0610E 01	3.5000E 00	8.4191E-02	1.9117E-04	4.2110E-05	4.0485E-02	4.3515E-02
2.1072E 01	3.5000E 00	7.3503E-02	1.5027E-03	3.2736E-04	4.0342E-02	3.1658E-02

Table III (Cont'd)

Resonance Energy (eV)	Resonance Spin	Total Width (eV)	Gamma-N (eV)	Gamma-N-Nought (eV)	Gamma-Gamma (eV)	Gamma-F (eV)
2.2939E 01	3.5000E 00	7.5436E-02	4.3584E-04	9.1000E-05	3.2670E-02	4.2330E-02
2.3412E 01	3.5000E 00	3.2204E-02	7.0372E-04	1.4544E-04	2.6500E-02	5.0000E-03
2.3629E 01	3.5000E 00	2.2586E-01	8.5577E-04	1.7605E-04	4.3000E-02	1.8200E-01
2.4245E 01	3.5000E 00	5.8268E-02	2.6835E-04	5.4500E-05	3.1000E-02	2.7000E-02
2.4370E 01	3.5000E 00	1.0015E-01	1.4958E-04	3.0300E-05	3.5000E-02	6.5000E-02
2.5200E 01	3.5000E 00	8.5068E-01	6.7624E-C4	1.3471E-04	2.5000E-02	8.2500E-01
2.5590E 01	3.5000E 00	3.8556E-01	5.6455E-04	1.1160E-04	2.5000E-02	3.6000E-01
2.6480E 01	3.5000E 00	1.9248E-01	4.7599E-04	9.2500E-05	3.2000E-02	1.6000E-01
2.6740E 01	3.5000E 00	2.5009E-01	8.5685E-05	1.6570E-05	3.0000E-02	2.2000E-01
2.7149E 01	3.5000E 00	1.1559E-01	8.5139E-05	1.6340E-05	4.2000E-02	7.3500E-02
2.7796E 01	3.5000E 00	1.2067E-01	6.7447E-04	1.2793E-04	3.2000E-02	8.8000E-02
2.8090E 01	3.5000E 00	6.5031E-02	3.1164E-05	5.8800E-06	4.0000E-02	2.5000E-02
2.8351E 01	3.5000E 00	1.4919E-01	1.8854E-04	3.5410E-05	3.1700E-02	1.1730E-01
2.8710E 01	3.5000E 00	1.3004E-01	4.5009E-05	8.4000E-06	5.0000E-02	8.0000E-02
2.9644E 01	3.5000E 00	6.1177E-02	1.7744E-04	3.2590E-05	3.7000E-02	2.4000E-02
3.0590E 01	3.5000E 00	1.5523E-01	2.2732E-04	4.1100E-05	4.5094E-02	1.0990E-01
3.0860E 01	3.5000E 00	5.4532E-02	5.3235E-04	9.5830E-05	3.5269E-02	1.8731E-02
3.2070E 01	3.5000E 00	9.9823E-02	1.8233E-03	3.2197E-04	3.7724E-02	6.0276E-02
3.3520E 01	3.5000E 00	5.6859E-02	1.8595E-03	3.2117E-04	3.1861E-02	2.3139E-02
3.4370E 01	3.5000E 00	8.7253E-02	2.2527E-03	3.8425E-04	4.3160E-02	4.1840E-02
3.4850E 01	3.5000E 00	1.1610E-01	1.0977E-03	1.8595E-04	3.8247E-02	7.6753E-02
3.5187E 01	3.5000E 00	1.0350E-01	3.5004E-03	5.9010E-04	3.1402E-02	6.8598E-02
3.5300E 01	3.5000E 00	6.9157E-01	1.5675E-03	2.6383E-04	4.0000E-02	6.5000E-01
3.6400E 01	3.5000E 00	1.5401E 00	1.1994E-04	1.9880E-05	4.0000E-02	1.5000E 00
3.7500E 01	3.5000E 00	1.5402E 00	1.6638E-04	2.7170E-05	4.0000E-02	1.5000E 00
3.8300E 01	3.5000E 00	3.0834E-01	3.3592E-04	5.4280E-05	4.2191E-02	2.6581E-01
3.9410E 01	3.5000E 00	9.5523E-02	2.5233E-03	4.0195E-04	3.4488E-02	5.8512E-02
3.9900E 01	3.5000E 00	1.5024E-01	2.3637E-04	3.7420E-05	3.3177E-02	1.1682E-01
4.0536E 01	3.5000E 00	2.0938E-01	3.8029E-04	5.9730E-05	3.4323E-02	1.7468E-01
4.1350E 01	3.5000E 00	4.4564E-01	6.4484E-04	1.0028E-04	4.5000E-02	4.0000E-01
4.1590E 01	3.5000E 00	1.6522E-01	2.2391E-04	3.4720E-05	3.0907E-02	1.3409E-01
4.1873E 01	3.5000E 00	4.1233E-02	1.2325E-03	1.9047E-04	2.8951E-02	1.1049E-02
4.2230E 01	3.5000E 00	1.4545E-01	4.4722E-04	6.8820E-05	4.8240E-02	9.6760E-02
4.2690E 01	3.5000E 00	6.1345E-02	3.4518E-04	5.2830E-05	4.4322E-02	1.6678E-02
4.3398E 01	3.5000E 00	7.0754E-02	7.5449E-04	1.1453E-04	4.5880E-02	2.4120E-02
4.3900E 01	3.5000E 00	1.1020E-01	2.0096E-04	3.0330E-05	4.1036E-02	6.8964E-02
4.3970E 01	3.5000E 00	2.5034E-01	3.4547E-04	5.2100E-05	1.7309E-02	2.3269E-01
4.4600E 01	3.5000E 00	1.7584E-01	8.3866E-04	1.2558E-04	4.5978E-02	1.2902E-01
4.4950E 01	3.5000E 00	5.3576E-01	7.5700E-04	1.1291E-04	3.0739E-02	5.0426E-01

Table III (Cont'd)

Resonance Energy (eV)	Resonance Spin	Total Width (eV)	Gamma-N (eV)	Gamma-N-Nought (eV)	Gamma-Gamma (eV)	Gamma-F (eV)
4.5790E 01	3.5000E 00	1.3419E-01	1.8791E-04	2.7770E-05	4.0807E-02	9.3193E-02
4.6790E 01	3.5000E 00	1.5280E-01	8.0305E-04	1.1740E-04	3.7000E-02	1.1500E-01
4.7011E 01	3.5000E 00	1.3994E-01	9.3659E-04	1.3660E-04	4.2000E-02	9.7000E-02
4.7970E 01	3.5000E 00	9.3988E-02	9.8834E-04	1.4270E-04	4.5710E-02	4.7290E-02
4.8300E 01	3.5000E 00	1.6577E-01	7.7094E-04	1.1093E-04	2.4715E-02	1.4028E-01
4.8800E 01	3.5000E 00	6.5691E-02	6.9061E-04	9.8360E-05	2.5431E-02	3.9569E-02
4.9000E 01	3.5000E 00	2.4018E-01	1.7675E-04	2.5250E-05	2.0000E-02	2.2000E-01
4.9418E 01	3.5000E 00	6.1013E-02	1.0132E-03	1.4413E-04	4.2913E-02	1.7087E-02
5.0108E 01	3.5000E 00	5.4353E-02	3.1585E-04	4.4620E-05	3.1094E-02	2.2943E-02
5.0466E 01	3.5000E 00	7.5964E-02	9.6365E-04	1.3565E-04	3.2030E-02	4.2970E-02
5.0780E 01	3.5000E 00	3.3019E-01	1.8955E-04	2.6600E-05	3.0000E-02	3.0000E-01
5.1268E 01	3.5000E 00	1.8854E-01	3.5448E-03	4.9507E-04	5.1974E-02	1.3303E-01
5.1630E 01	3.5000E 00	7.4346E-02	3.4569E-04	4.8110E-05	3.3454E-02	4.0546E-02
5.2221E 01	3.5000E 00	3.6351E-01	2.5076E-03	3.4700E-04	3.1000E-02	3.3000E-01
5.3438E 01	3.5000E 00	1.3554E-01	5.3729E-04	7.3500E-05	3.3463E-02	1.0154E-01
5.4132E 01	3.5000E 00	1.5021E-01	2.1410E-04	2.9100E-05	4.4000E-02	1.0600E-01
5.5064E 01	3.5000E 00	1.1117E-01	3.1685E-03	4.2699E-04	4.8539E-02	5.9461E-02
5.5840E 01	3.5000E 00	2.5135E-01	2.3549E-03	3.1514E-04	3.8719E-02	2.1028E-01
5.6070E 01	3.5000E 00	1.8077E-01	7.6677E-04	1.0240E-04	6.0000E-04	1.7940E-01
5.6498E 01	3.5000E 00	1.1992E-01	4.9208E-03	6.5466E-04	3.9167E-02	7.5833E-02
5.7800E 01	3.5000E 00	2.2113E-01	1.1252E-03	1.4800E-04	3.5000E-02	1.8500E-01
5.8060E 01	3.5000E 00	6.5354E-02	1.3539E-03	1.7768E-04	3.2315E-02	3.1685E-02
5.8674E 01	3.5000E 00	1.3633E-01	1.3328E-03	1.7400E-04	3.3000E-02	1.0200E-01
5.9760E 01	3.5000E 00	2.5527E-01	2.7057E-04	3.5000E-05	4.2000E-02	2.1300E-01
6.0188E 01	3.5000E 00	2.5513E-01	1.1265E-03	1.4520E-04	3.4000E-02	2.2000E-01
6.0837E 01	3.5000E 00	1.2046E-01	4.6253E-04	5.9300E-05	3.0000E-02	9.0000E-02
6.1130E 01	3.5000E 00	1.2536E-01	3.6278E-04	4.6400E-05	4.0000E-02	8.5000E-02
6.1570E 01	3.5000E 00	5.3023E-01	2.2520E-04	2.8700E-05	3.0000E-02	5.0000E-01
6.1900E 01	3.5000E 00	5.3017E-01	1.7073E-04	2.1700E-05	3.0000E-02	5.0000E-01
6.2400E 01	3.5000E 00	4.6026E-01	2.6163E-04	3.3120E-05	6.0000E-02	4.0000E-01
6.3020E 01	3.5000E 00	2.4009E-01	9.0896E-05	1.1450E-05	4.0000E-02	2.0000E-01
6.3320E 01	3.5000E 00	2.5010E-01	1.0209E-04	1.2830E-05	5.0000E-02	2.0000E-01
6.3690E 01	3.5000E 00	6.2107E-01	1.0744E-03	1.3463E-04	6.0000E-02	5.6000E-01
6.4300E 01	3.5000E 00	4.7545E-02	1.2447E-03	1.5523E-04	3.9000E-02	7.3000E-03
6.5800E 01	3.5000E 00	9.6423E-02	4.2327E-04	5.2180E-05	5.0000E-02	4.6000E-02
6.6402E 01	3.5000E 00	8.9449E-02	4.4948E-04	5.5160E-05	4.5000E-02	4.4000E-02
6.7247E 01	3.5000E 00	9.0081E-02	8.0938E-05	9.8700E-06	4.1000E-02	4.9000E-02
6.8440E 01	3.5000E 00	2.5004E-01	3.7641E-05	4.5500E-06	5.0000E-02	2.0000E-01
6.8530E 01	3.5000E 00	1.6011E-01	1.0836E-04	1.3090E-05	6.0000E-02	1.0000E-01

Table III (Cont'd)

Resonance Energy (eV)	Resonance Spin	Total Width (eV)	Gamma-N (eV)	Gamma-N-Nought (eV)	Gamma-Gamma (eV)	Gamma-F (eV)
6.9293E 01	3.5000E 00	2.0072E-01	7.1530E-04	8.5930E-05	4.0000E-02	1.6000E-01
7.0404E 01	3.5000E 00	1.7272E-01	2.7156E-03	3.2364E-04	5.0000E-02	1.2000E-01
7.0750E 01	3.5000E 00	2.3741E-01	2.4091E-03	2.8641E-04	3.5000E-02	2.0000E-01
7.1610E 01	3.5000E 00	1.6029E-01	2.9136E-04	3.4430E-05	4.0000E-02	1.2000E-01
7.2390E 01	3.5000E 00	1.3861E-01	2.6115E-03	3.0694E-04	3.1000E-02	1.0500E-01
7.2910E 01	3.5000E 00	3.6037E-01	3.6717E-04	4.3000E-05	4.0000E-02	3.2000E-01
7.4544E 01	3.5000E 00	1.0167E-01	2.7287E-03	3.1604E-04	3.8000E-02	6.0937E-02
7.5170E 01	3.5000E 00	2.9089E-01	8.8833E-04	1.0246E-04	5.0000E-02	2.4000E-01
7.5541E 01	3.5000E 00	2.3336E-01	1.3621E-03	1.5672E-04	3.2000E-02	2.0000E-01
7.6750E 01	3.5000E 00	1.1611E-01	1.0732E-04	1.2250E-05	3.6000E-02	8.0000E-02
7.7492E 01	3.5000E 00	1.1299E-01	9.8681E-04	1.1210E-04	4.0000E-02	7.2000E-02
7.8117E 01	3.5000E 00	1.4822E-01	1.2245E-03	1.3854E-04	4.7000E-02	1.0000E-01
7.9672E 01	3.5000E 00	1.2979E-01	7.8557E-04	8.8010E-05	4.4000E-02	8.5000E-02
8.0357E 01	3.5000E 00	1.7484E-01	8.3851E-04	9.3540E-05	4.0000E-02	1.3400E-01
8.1434E 01	3.5000E 00	1.3204E-01	1.0433E-03	1.1561E-04	4.1000E-02	9.0000E-02
8.3590E 01	3.5000E 00	1.1827E-01	1.1703E-03	1.2800E-04	4.8000E-02	6.9100E-02
8.6880E 01	3.5000E 00	8.0120E-02	7.1958E-04	7.7200E-05	5.2000E-02	2.7400E-02

Table IV

COMPARISON OF RESONANCE INTEGRALS FOR U-235 IN GAM INTERVALS

		$\int \sigma_f dE/E$ (b)				$\int \sigma_c dE/E$ (b)		α	
Energy Interval (eV)	Width (Lethargy)	ORNL-RPI	SACLAY	GEEL	ENDF/B Version III	ORNL-RPI	ENDF/B Version III	ORNL-RPI	ENDF/B Version III
0.532-0.876	0.5	31.30			31.00	3.27	3.18	0.1043	0.1026
0.876-1.44	0.5	29.24			28.97	6.39	6.47	0.2187	0.2233
1.44-2.38	0.5	7.61			7.38	4.11	4.22	0.5405	0.5718
2.38-3.93	0.5	11.50			11.49	4.67	4.66	0.4062	0.4063
3.93-6.48	0.5	8.41			8.55	15.70	15.78	1.8435	1.8435
6.48-10.68	0.25	29.47		29.58	30.03	13.78	13.38	0.4674	0.4454
10.68-13.7	0.25	11.75		11.47	12.03	17.47	17.75	1.4872	1.4755
13.7-17.6	0.25	8.29		8.33	8.45	4.51	4.44	0.5438	0.5254
17.6-22.6	0.25	16.95	16.99	16.26	17.05	11.34	11.30	0.6689	0.6628
22.6-29.0	0.25	11.05	11.19	10.77	11.36	5.25	5.28	0.4756	0.4648
29.0-37.3	0.25	13.80	13.75	13.71	14.08	8.94	8.88	0.6480	0.6307
37.3-47.9	0.25	8.57	8.60	8.27	8.65	4.58	4.51	0.5345	0.5214
47.9-61.4	0.25	13.87	14.14	13.56	14.04	5.89	6.06	0.4243	0.4316
61.4-78.9	0.25	5.73	5.91	5.68	5.96	2.35	2.40	0.4090	0.4026
78.9-82.0	0.04	0.63	0.67	0.63	0.63	0.28	0.25	0.4405	0.3968
1-82	4.41	169.1			170.6	104.3	104.5	0.6171	0.6125
RMS fractional difference between fit and data set.		0.020	0.026	0.038		0.033		0.036	

TABLE V

Total Cross Section Resonance Integral

		$\int \sigma_T \, dE$ (b-ev)			$\int \sigma_T \frac{dE}{E}$ (b)		
Energy Interval (ev)	Width (Lethargy)	Shore	Michaudon	END F/B III	Shore	Michaudon	ENDF/B
0.532 - 0.876	0.5	28.38		27.91	41.24		41.00
.876 - 1.44	0.5	48.12		46.26	43.33		42.02
1.44 - 2.38	0.5	35.20	32.28	33.63	18.51	17.14	17.85
2.38 - 3.93	0.5	74.15	70.24	70.57	22.93	21.78	21.87
3.93 - 6.48	0.5		166.68	169.87		29.30	29.75
6.48 - 10.68	0.25		439.44	420.66		50.89	48.75
10.68 - 13.7	0.25		407.66	398.29		33.47	32.69
13.7 - 17.6	0.25		247.81	236.89		16.17	15.46
17.6 - 22.6	0.25		657.82	626.86		33.36	31.78
22.6 - 29.0	0.25		498.15	491.30		19.89	19.62
29.0 - 37.3	0.25		885.19	883.80		26.20	26.14
37.3 - 47.9	0.25		693.12	686.82		16.40	16.24
47.9 - 61.4	0.25		1278.9	1271.2		23.64	23.49
61.4 - 78.9	0.25		811.87	824.75		11.48	11.69
78.9 - 82.0	0.04		109.31	112.03		1.36	1.39
.532 - 82*						385.65	379.74
RMS fractional difference		.040	.028		.034	.026	

* Using Shore data below 1.44 eV, Michaudon data above.

VIII. FIGURES

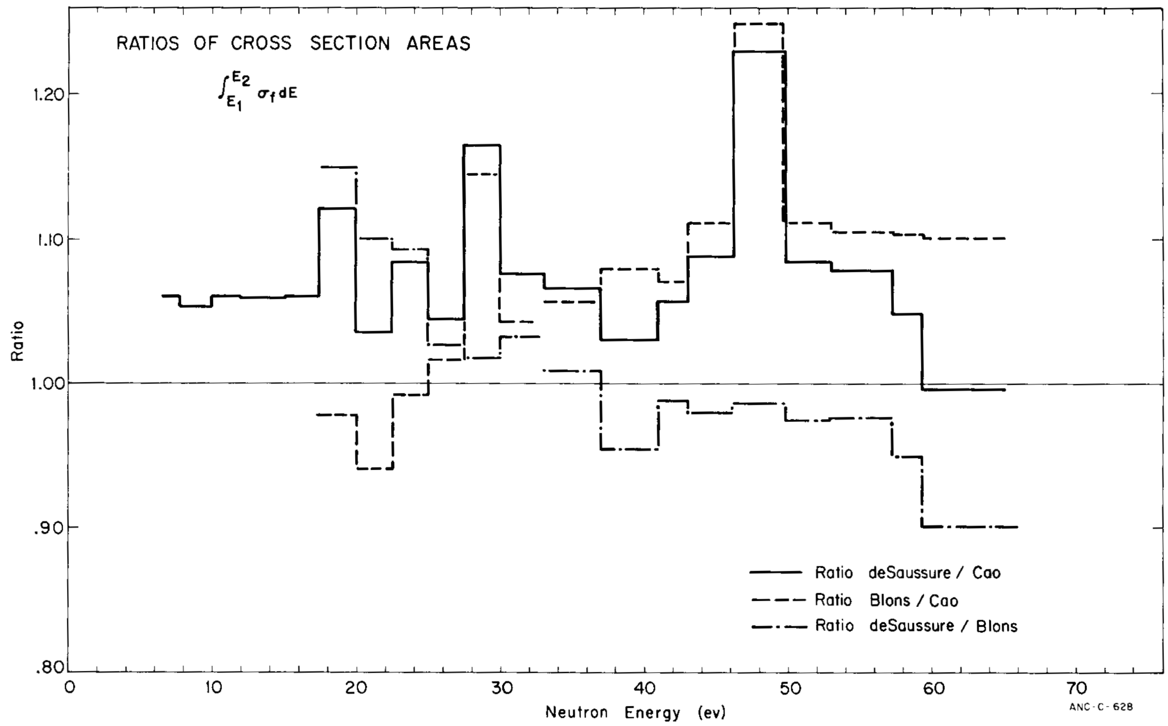


Fig. 1

Normalization comparisons of the three fission data sets. Partial resonance integrals were computed for each data set, using energy intervals whose end points fell in valleys between resonances. The histograms represent ratios between corresponding integrals for the indicated pairs of data sets.

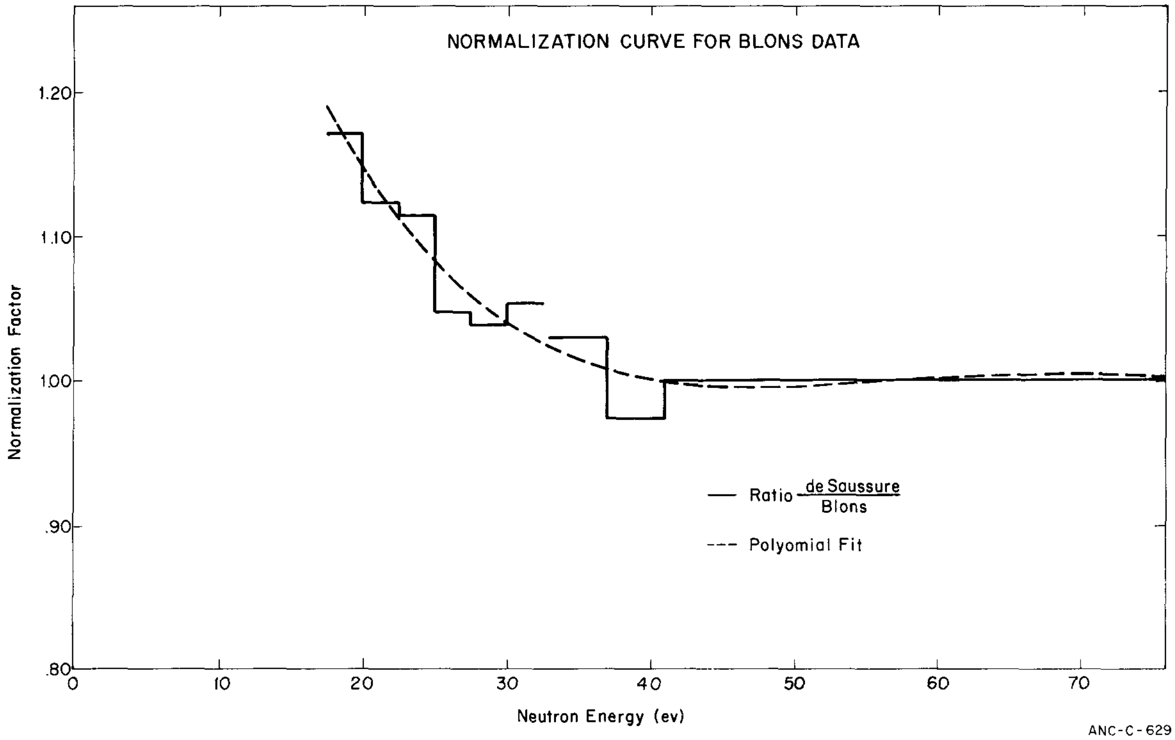


Fig. 2

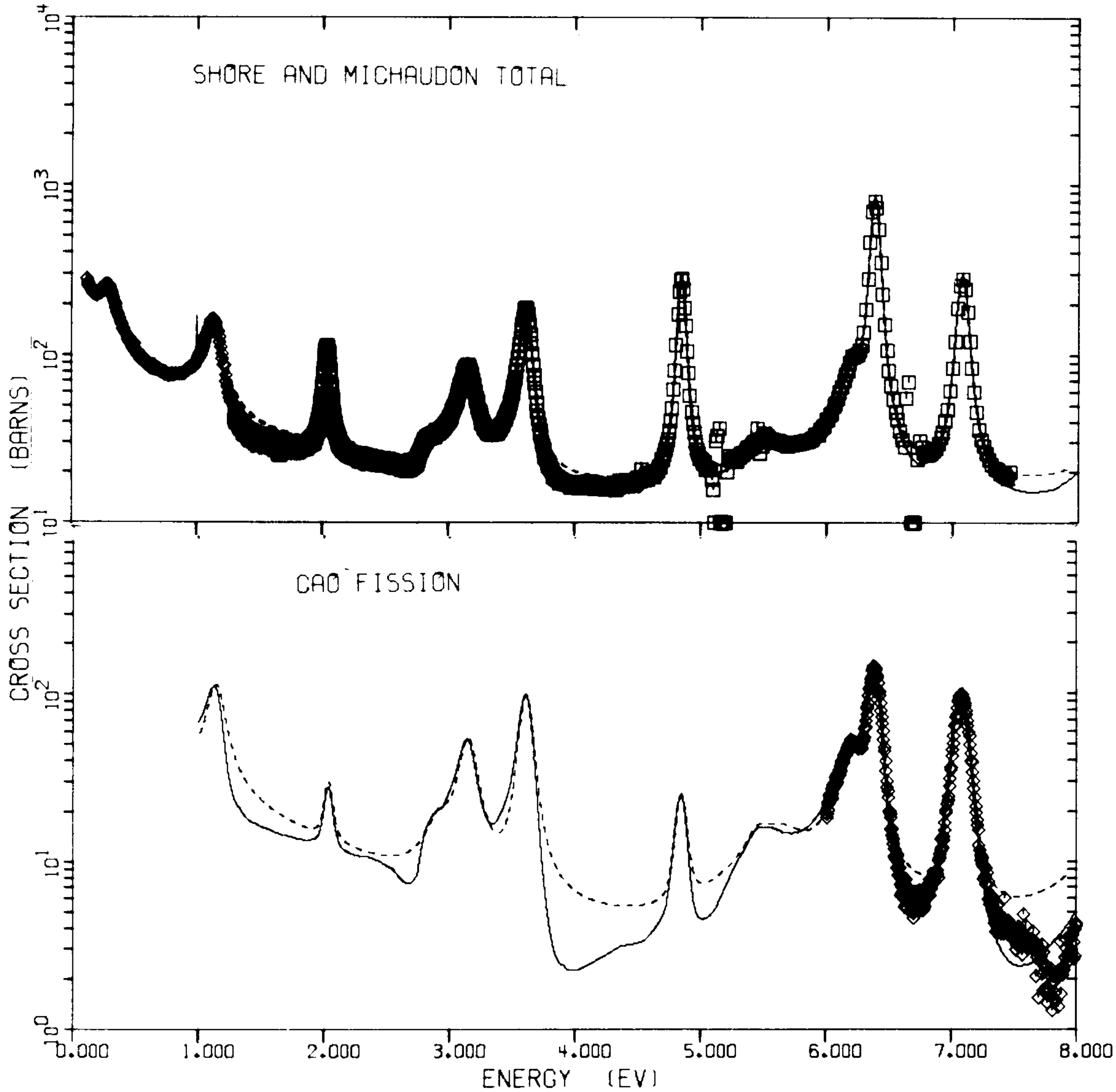
Curve used to renormalize the Blons fission data. The histogram represents ratios of incremental integrals from Blons data to corresponding quantities from the renormalized deSaussure data. The curve is a least squares fit to the histogram, using the polynominal

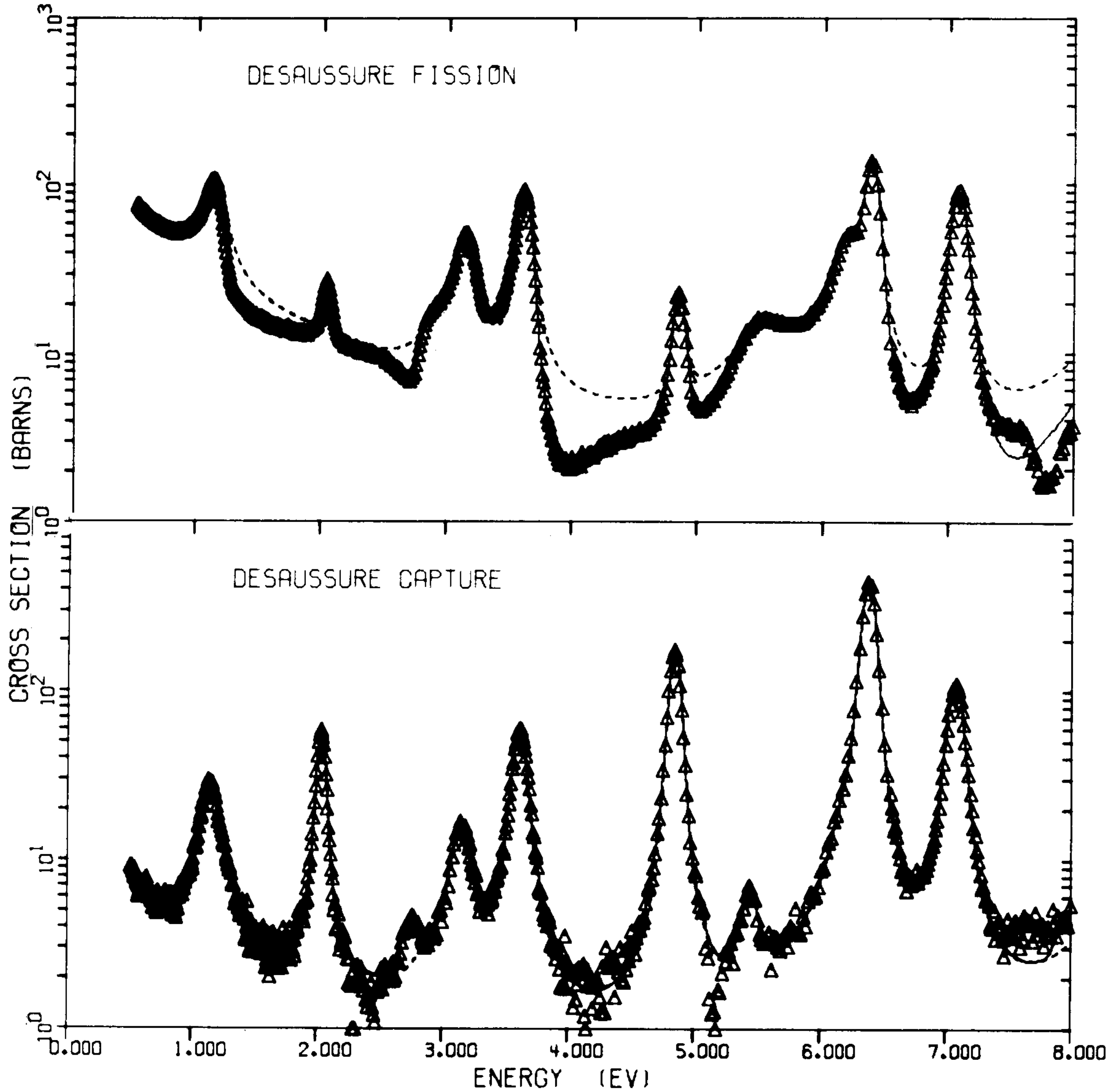
$$\sigma = \sigma_o \,(1.736 - 4.7457 \times 10^{-2} E + 1.0971 \times 10^{-3} E^2 - 1.0858 \times 10^{-5} E^3 + 3.8965\ 10^{-8} E^4).$$

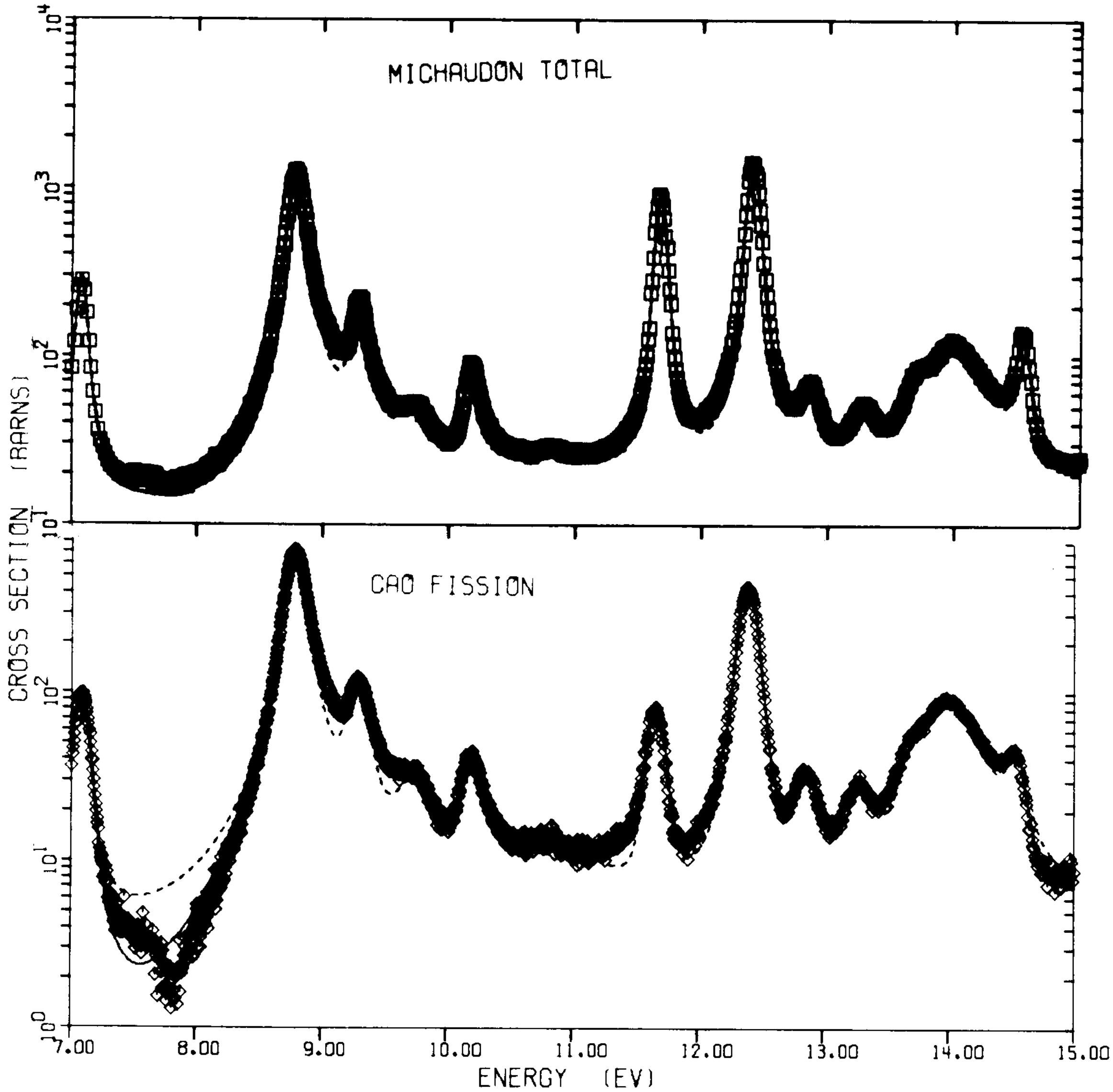
APPENDIX A

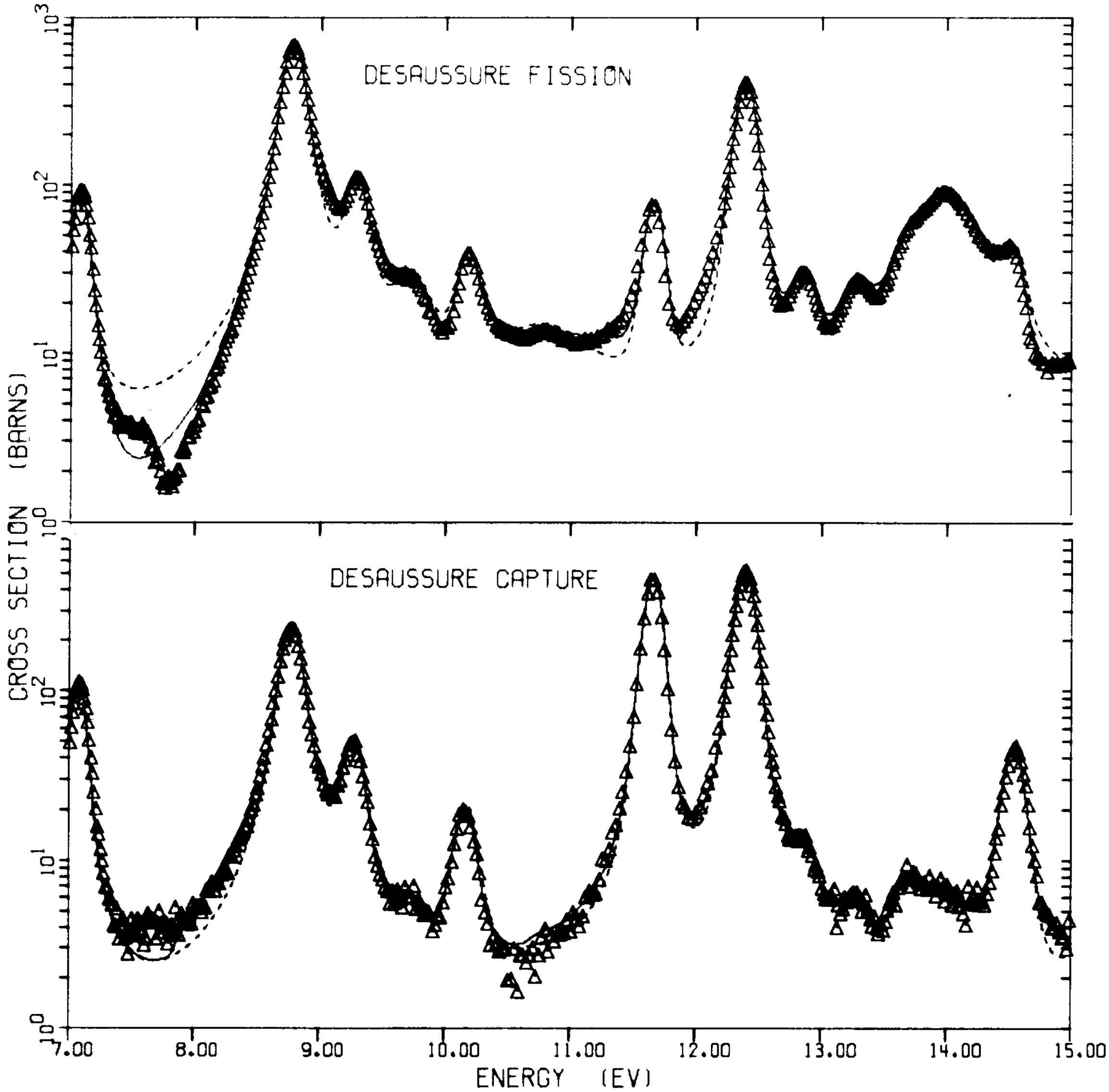
PLOTS OF THE FITS TO THE PRINCIPAL DATA SETS

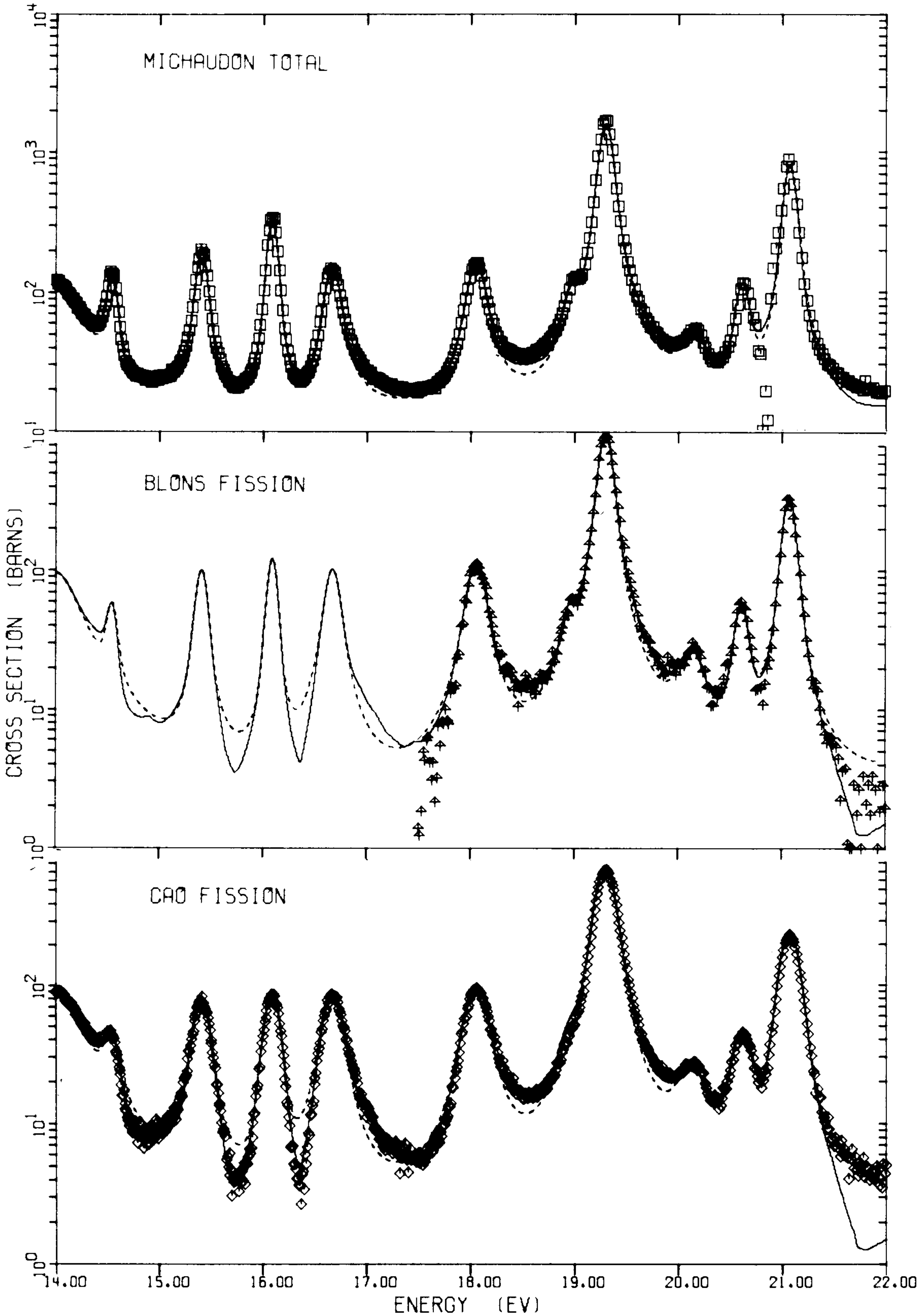
Total, fission, and capture cross sections for U-235. The dashed lines represent the contributions of the single level resonance parameters submitted for ENDF/B, Version III. The solid lines represent the complete parameters and smooth file. The fit begins at 1 eV. The curves have been resolution- and Doppler-broadened to match the conditions under which the various sets of data were collected. Shown are the total cross section data of Cao[4], and DeSaussure[1], and capture data of DeSaussure[1]. In addition the total cross section data of Shore and Sailor[5] are shown below 1.8 eV.


SHORE AND MICHAUDON TOTAL
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000

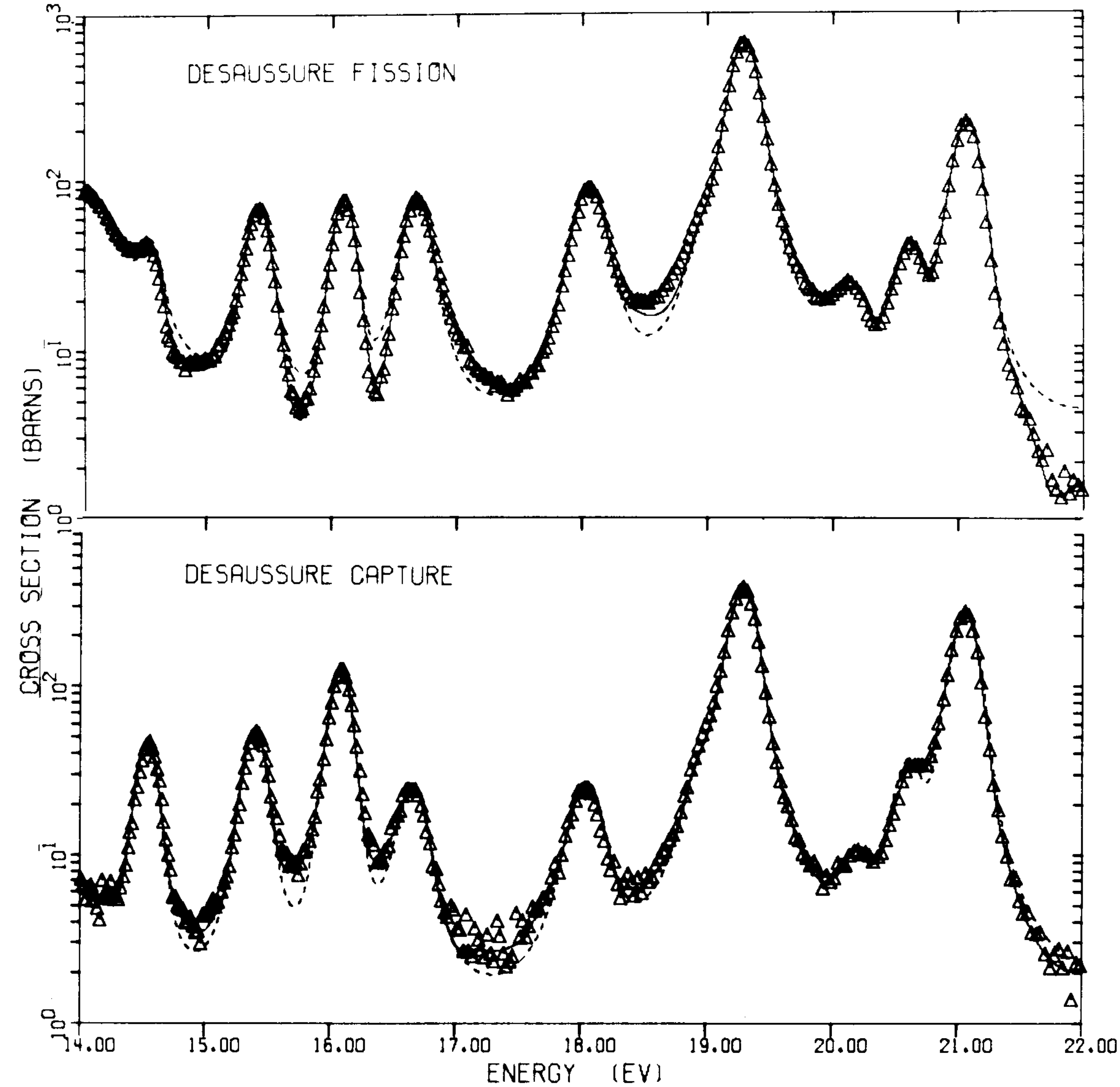

DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000

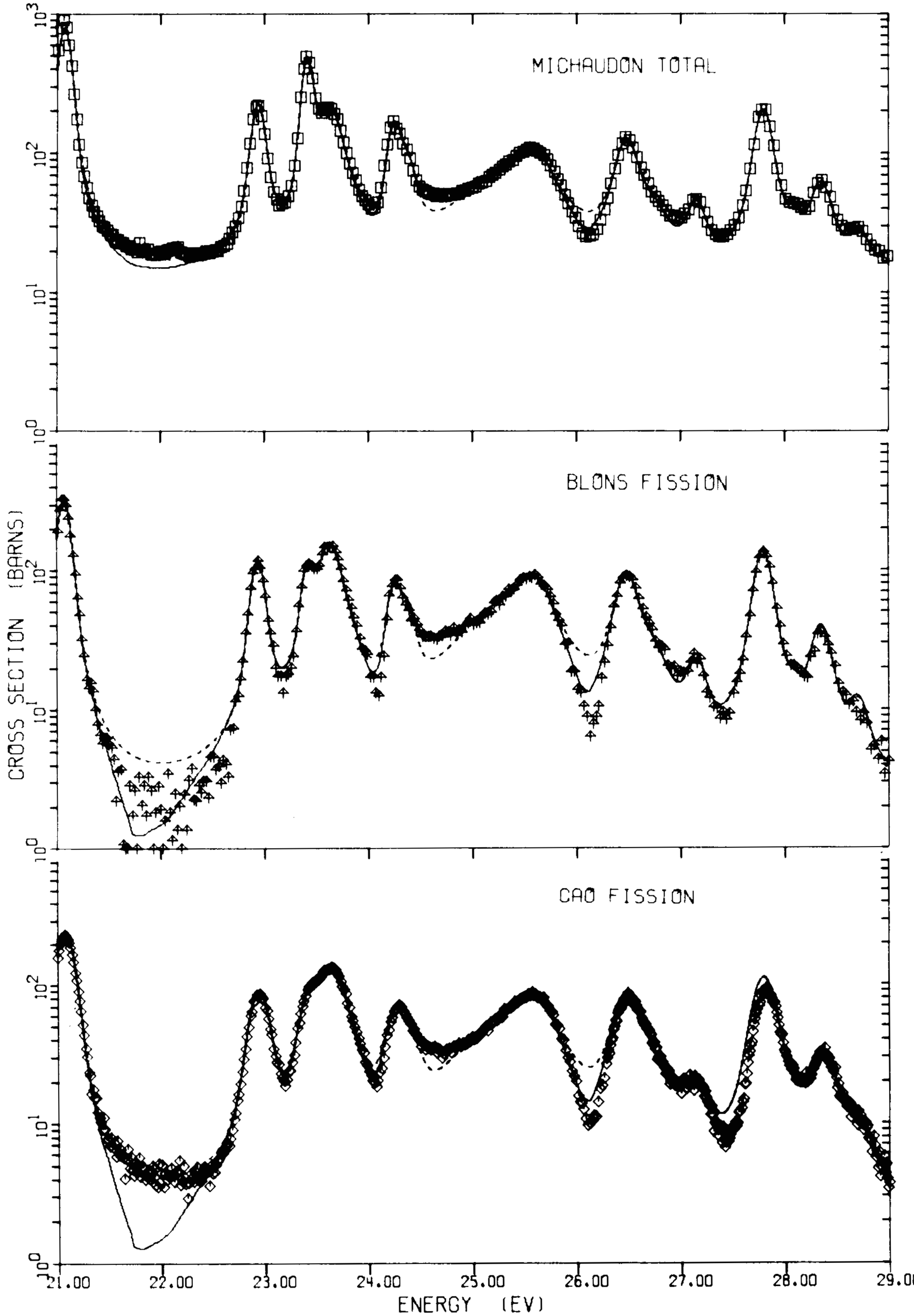

MICHAUDON TOTAL
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00

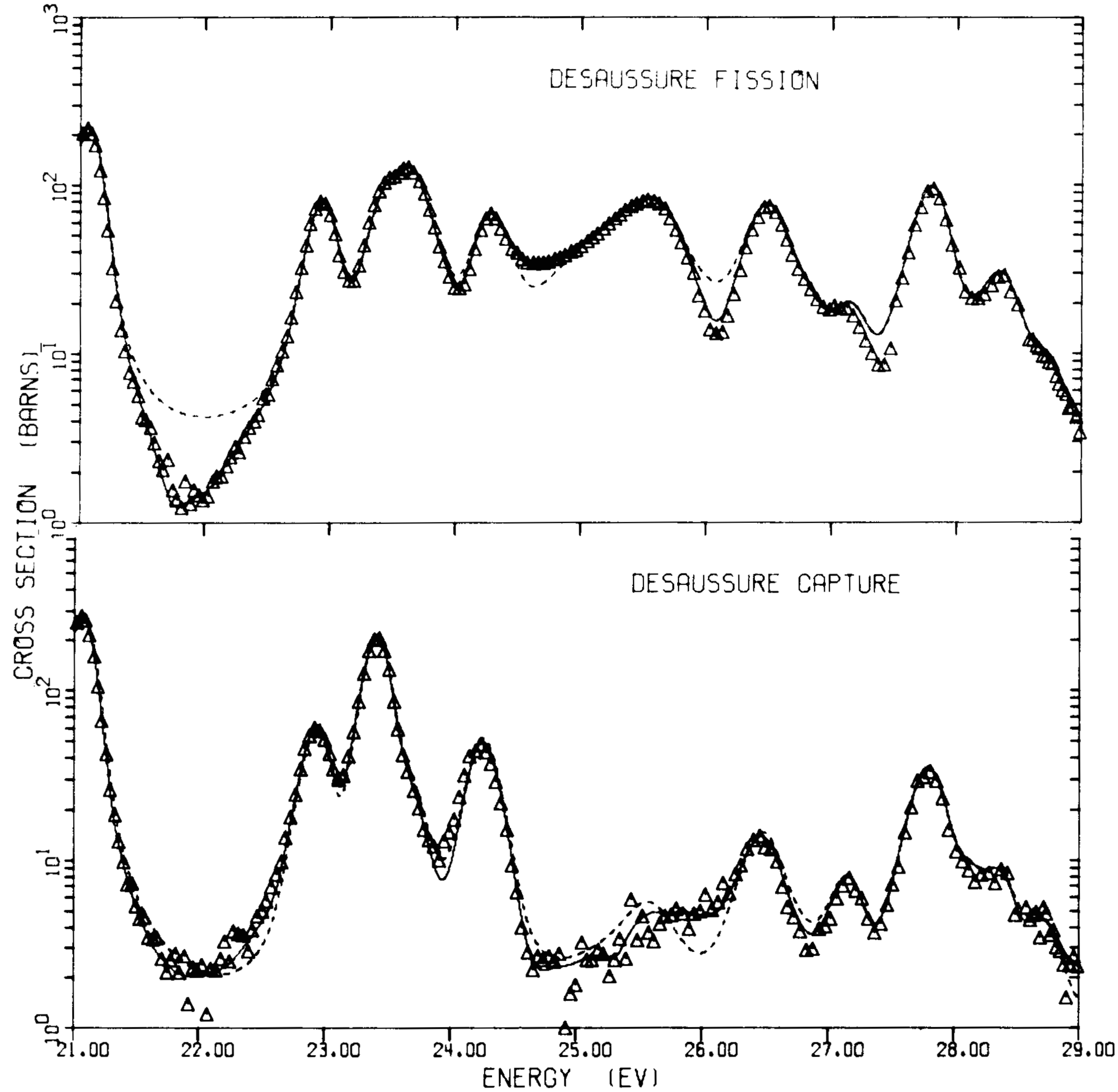

DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00

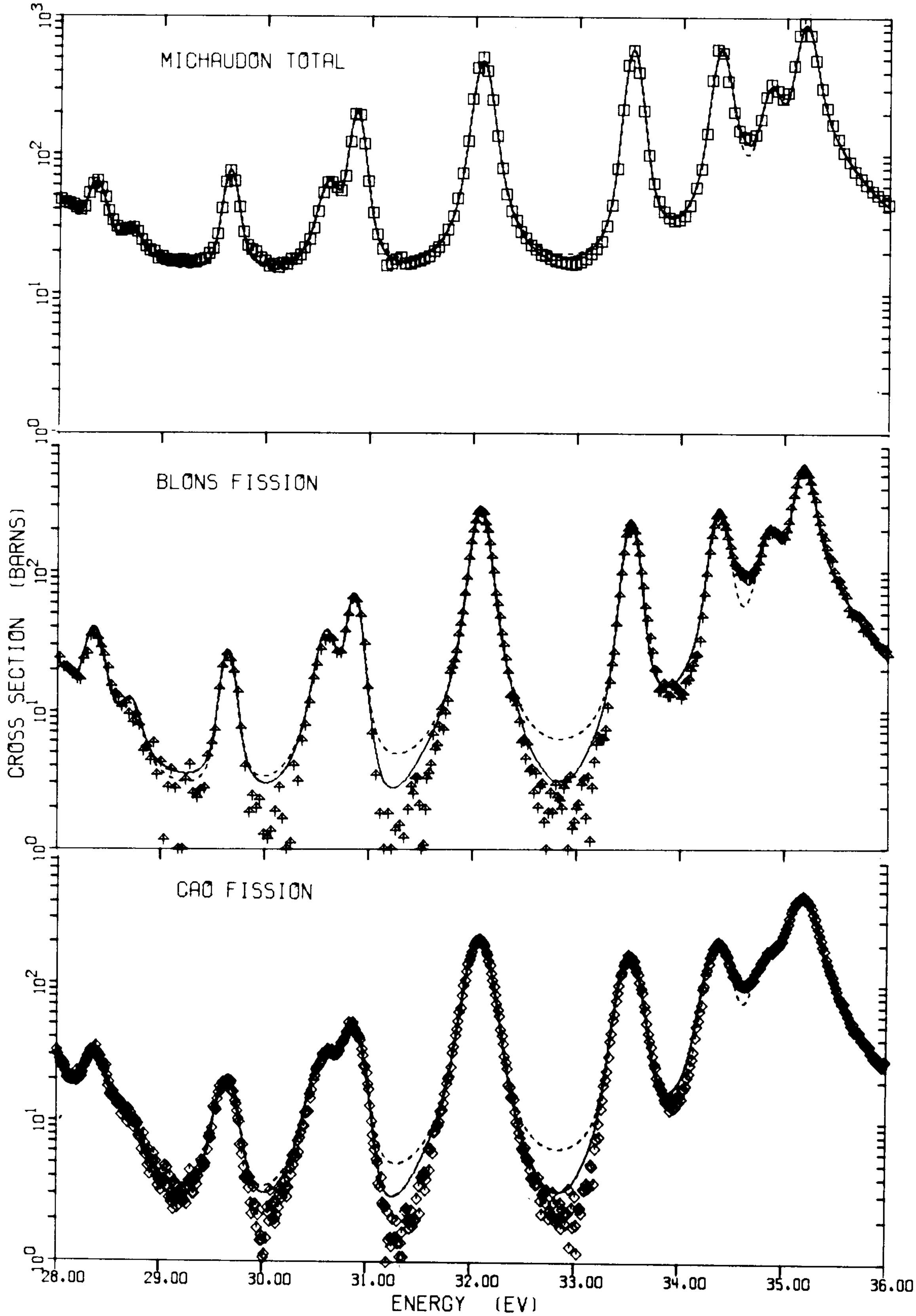


MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00

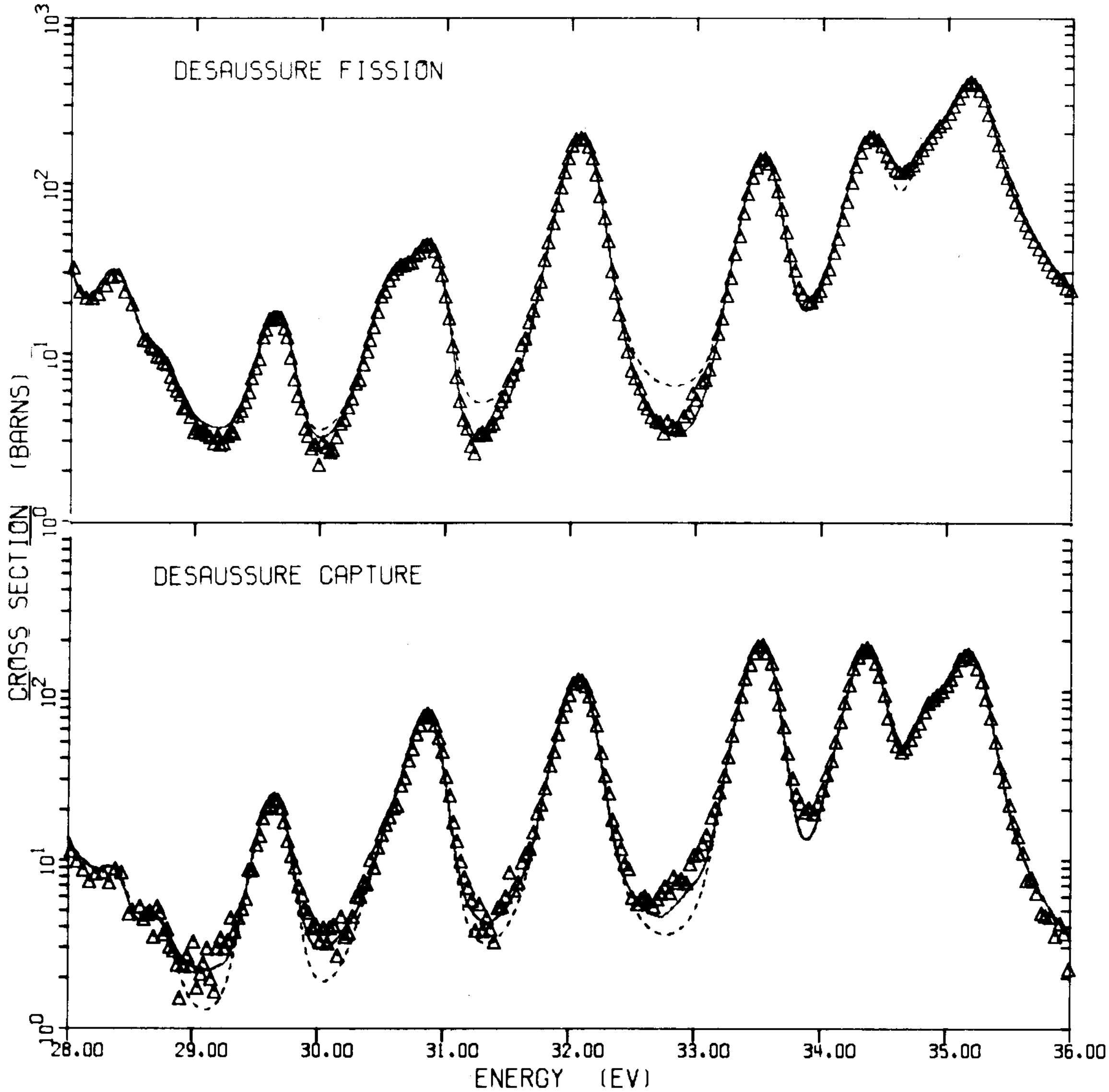

DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00


MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00

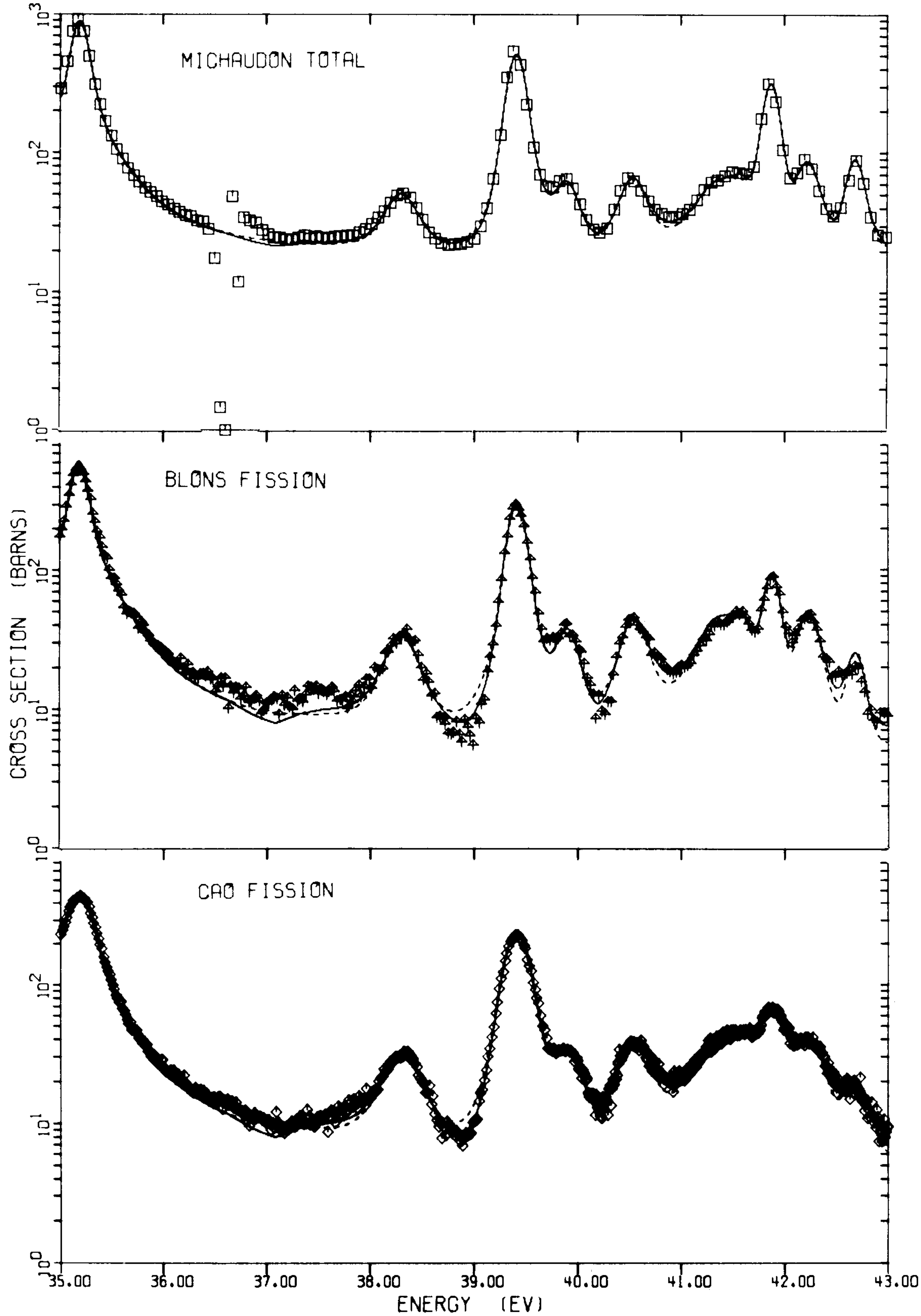

DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00

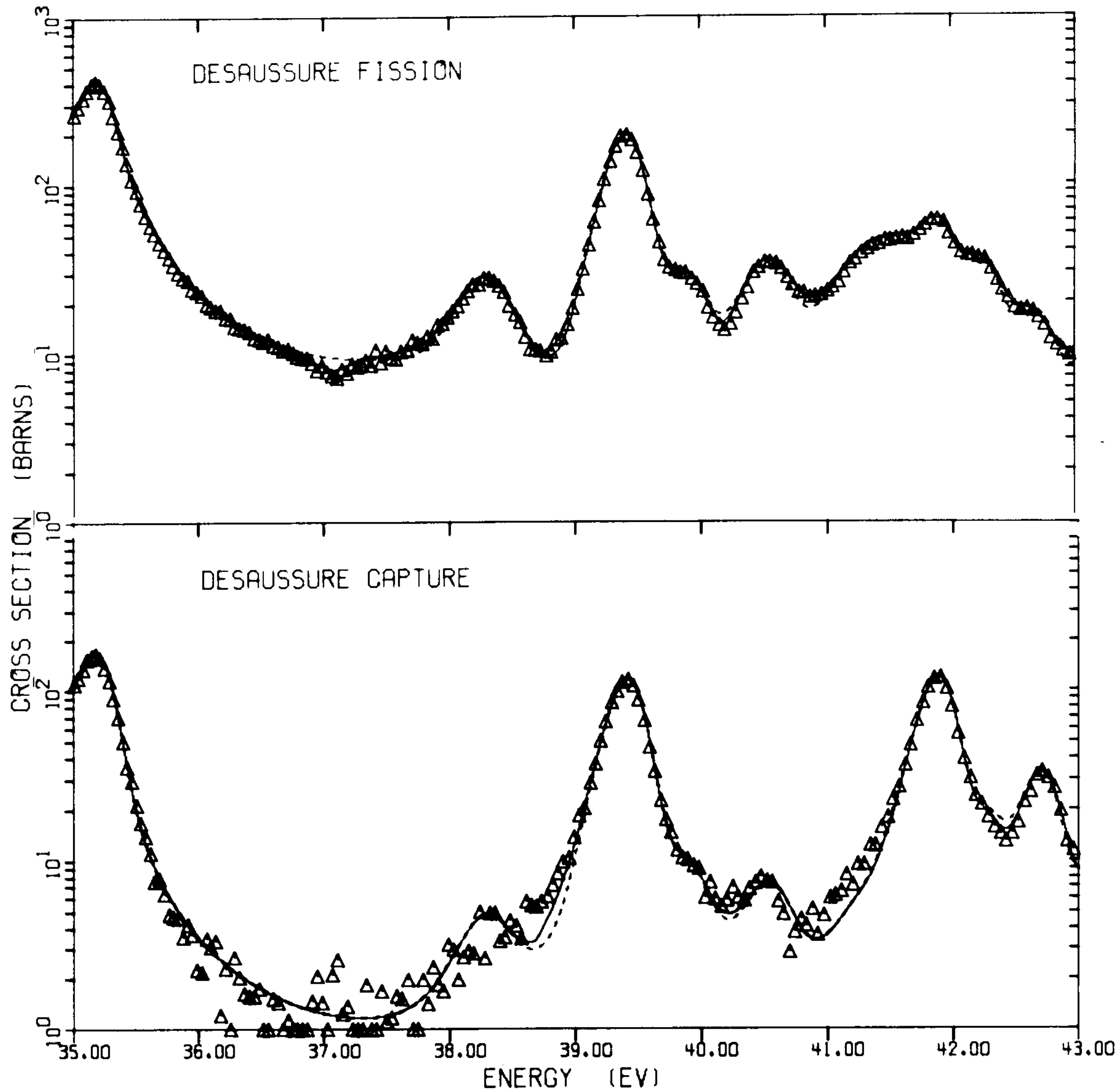


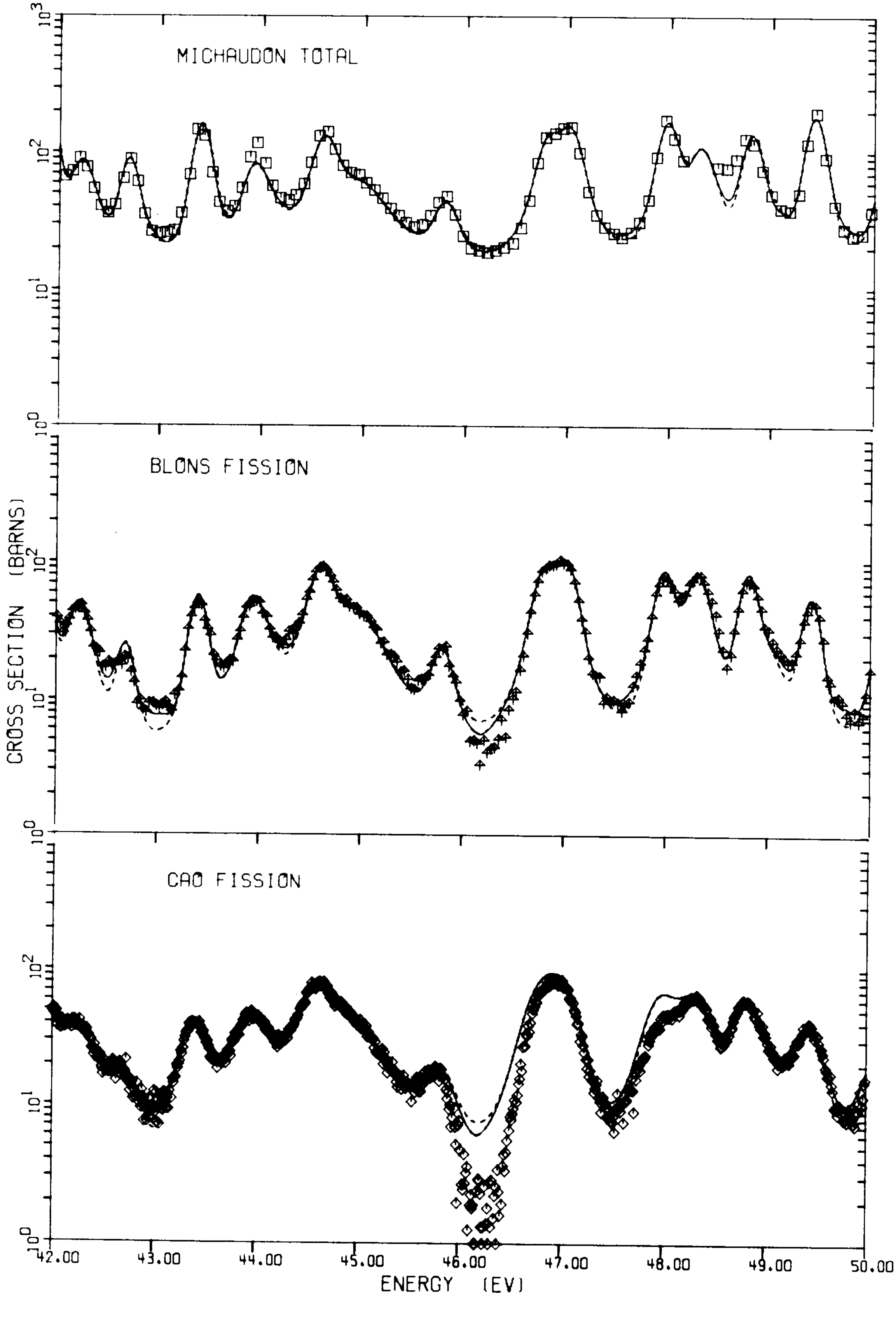
MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
28.00
29.00
30.00
31.00
32.00
33.00
34.00
35.00
36.00

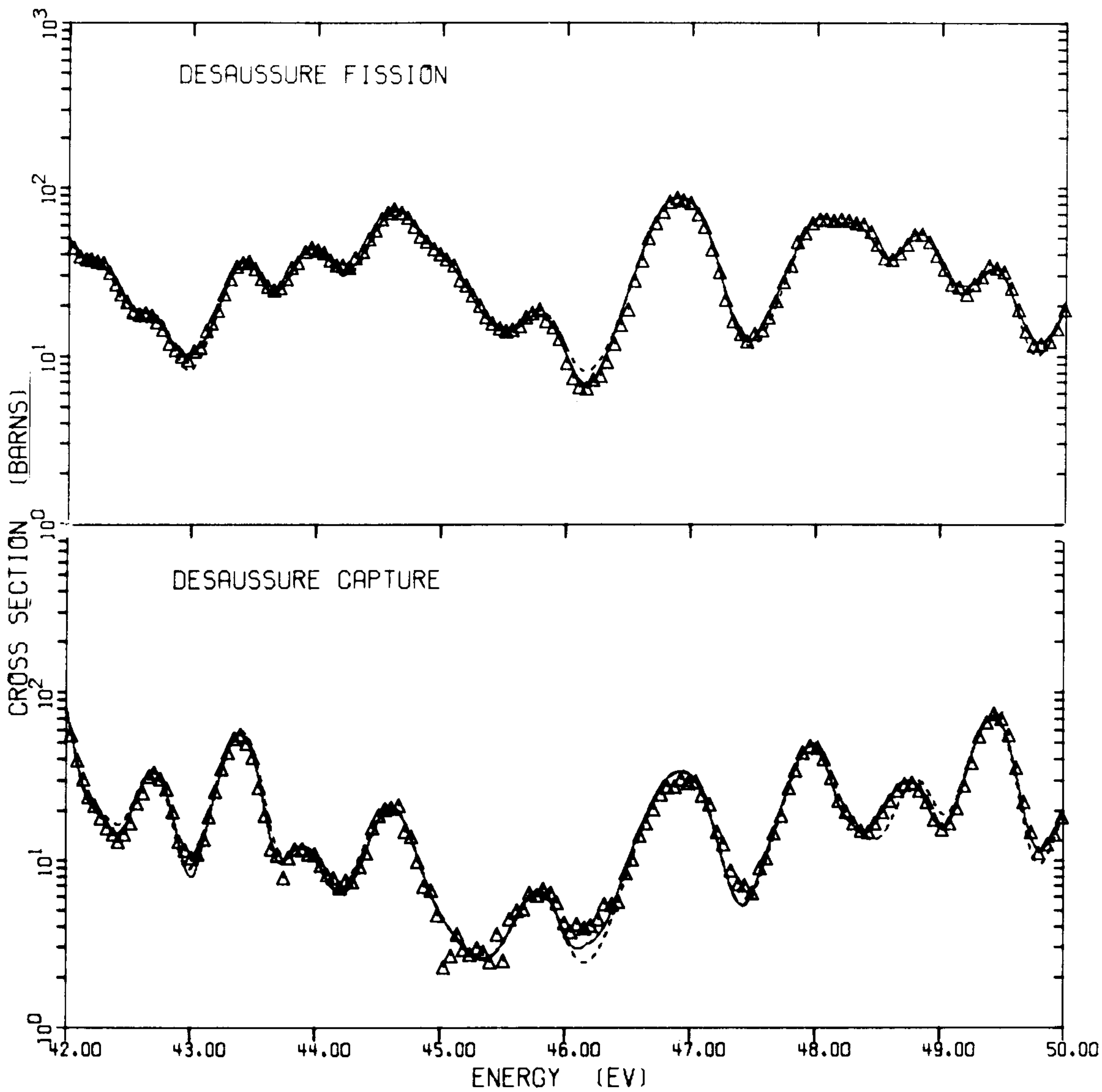


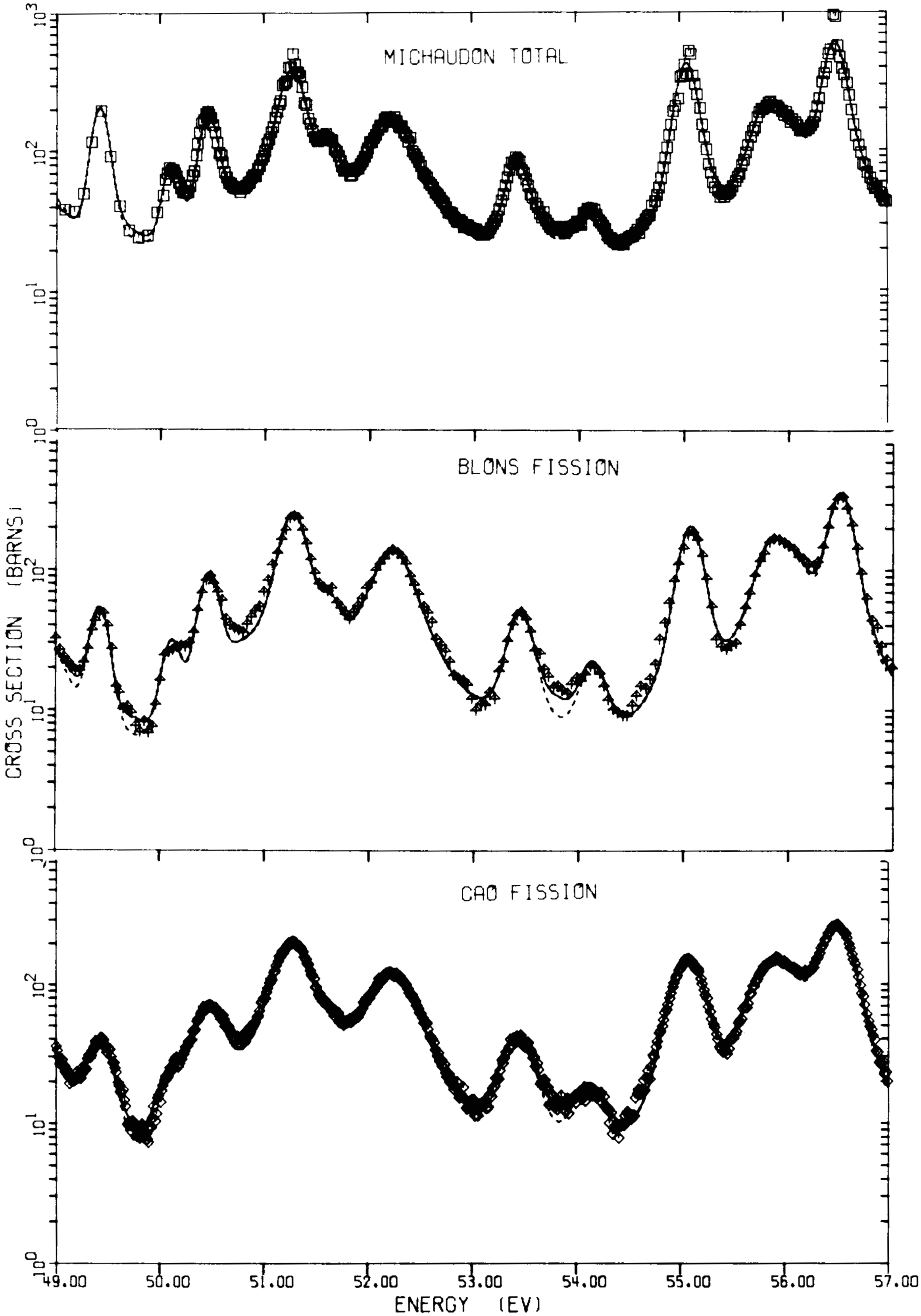
DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
28.00
29.00
30.00
31.00
32.00
33.00
34.00
35.00
36.00

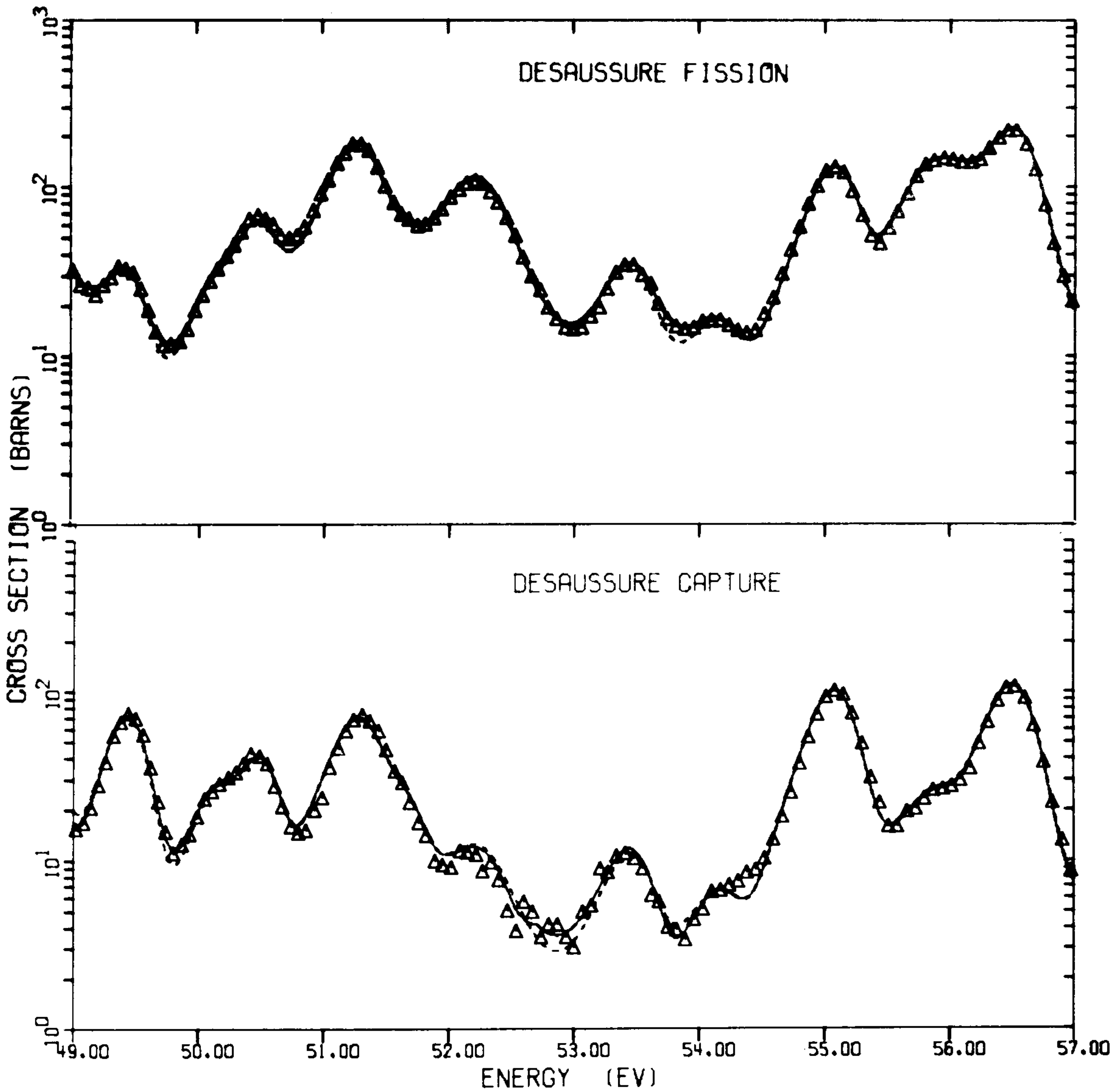

MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
35.00
36.00
37.00
38.00
39.00
40.00
41.00
42.00
43.00


DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
35.00
36.00
37.00
38.00
39.00
40.00
41.00
42.00
43.00

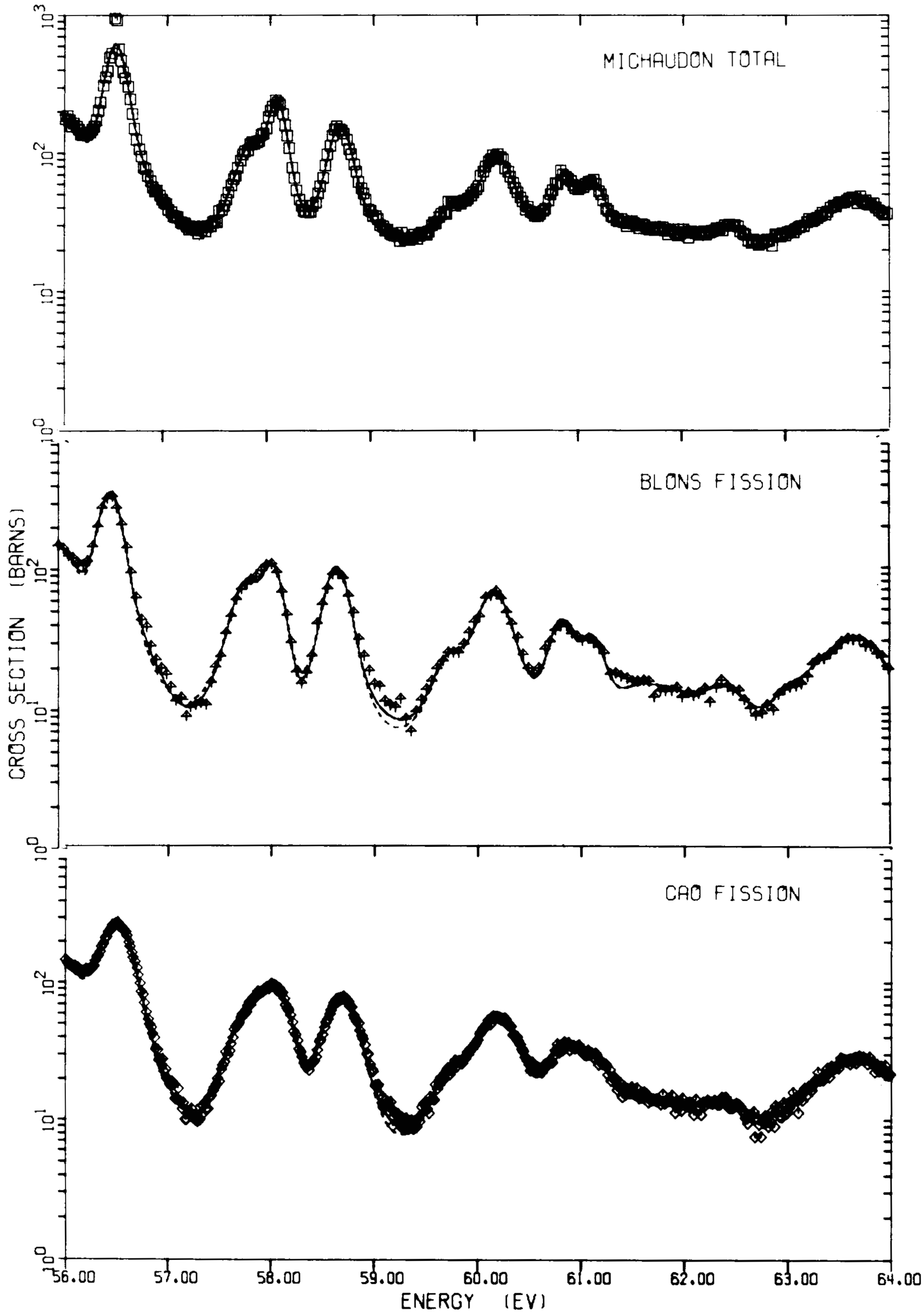

MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00


DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00

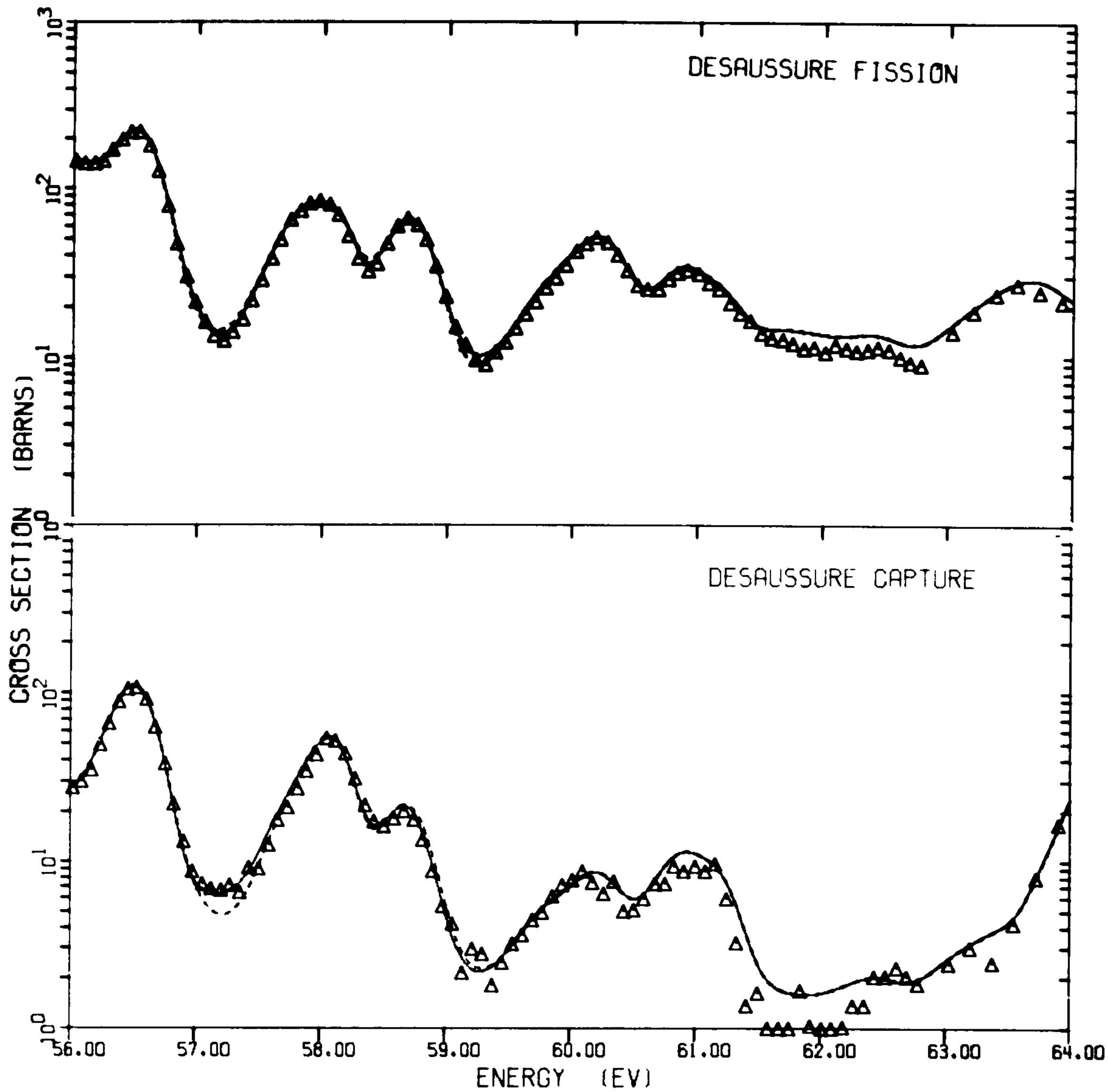

MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
49.00
50.00
51.00
52.00
53.00
54.00
55.00
56.00
57.00



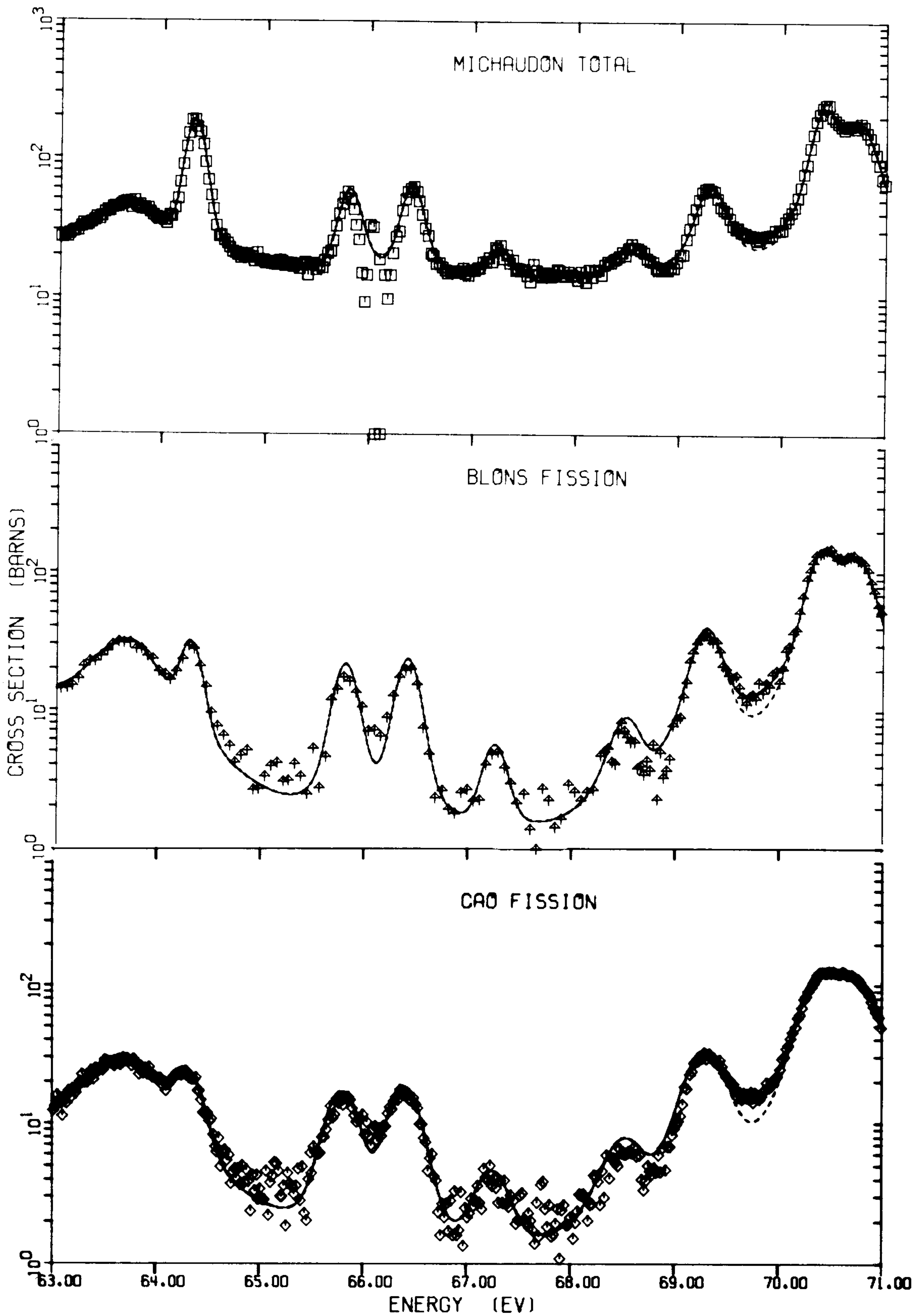
DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
49.00
50.00
51.00
52.00
53.00
54.00
55.00
56.00
57.00

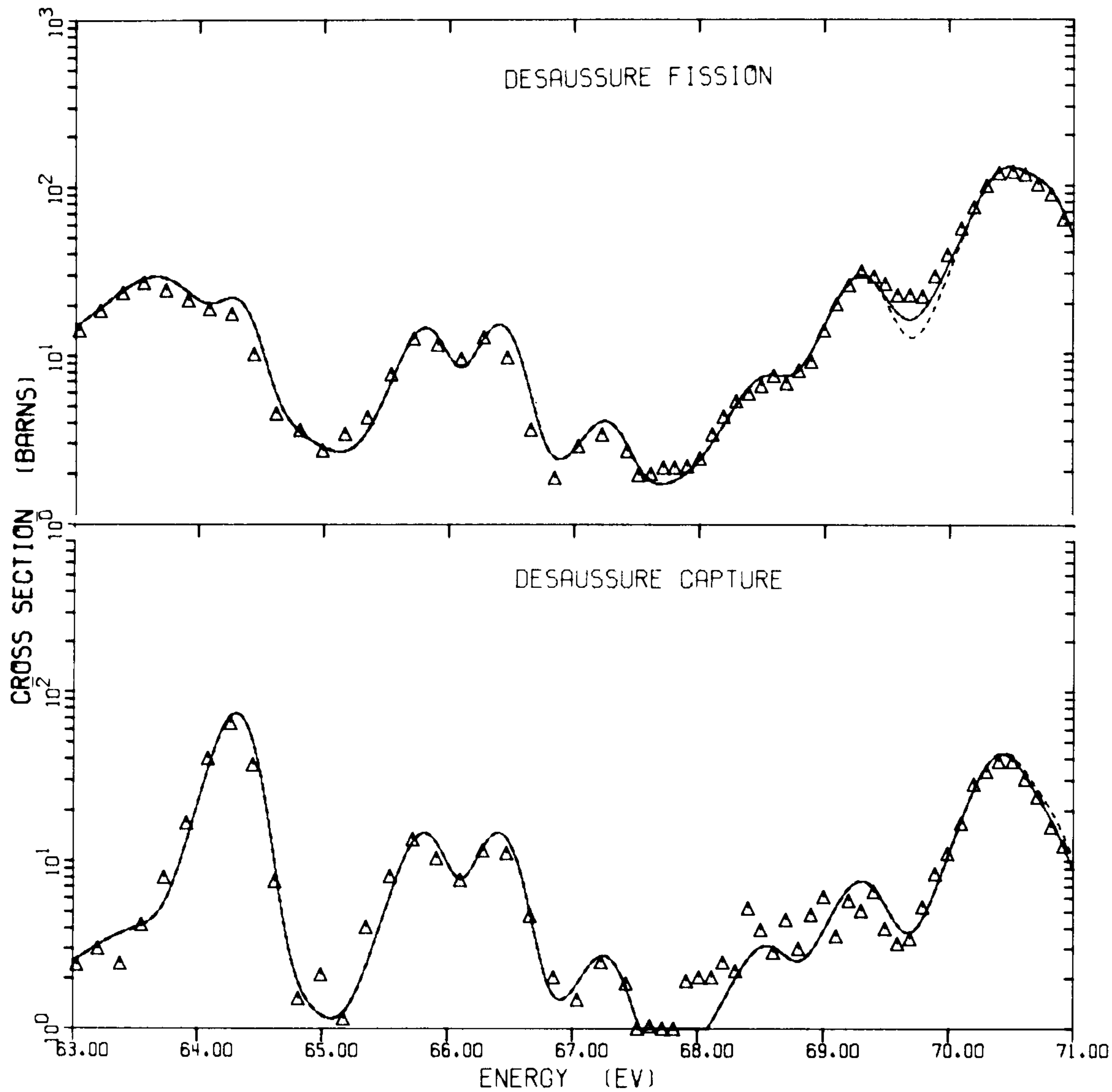


MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
10^0
10^1
10^2
10^3
56.00
57.00
58.00
59.00
60.00
61.00
62.00
63.00
64.00
ENERGY (EV)

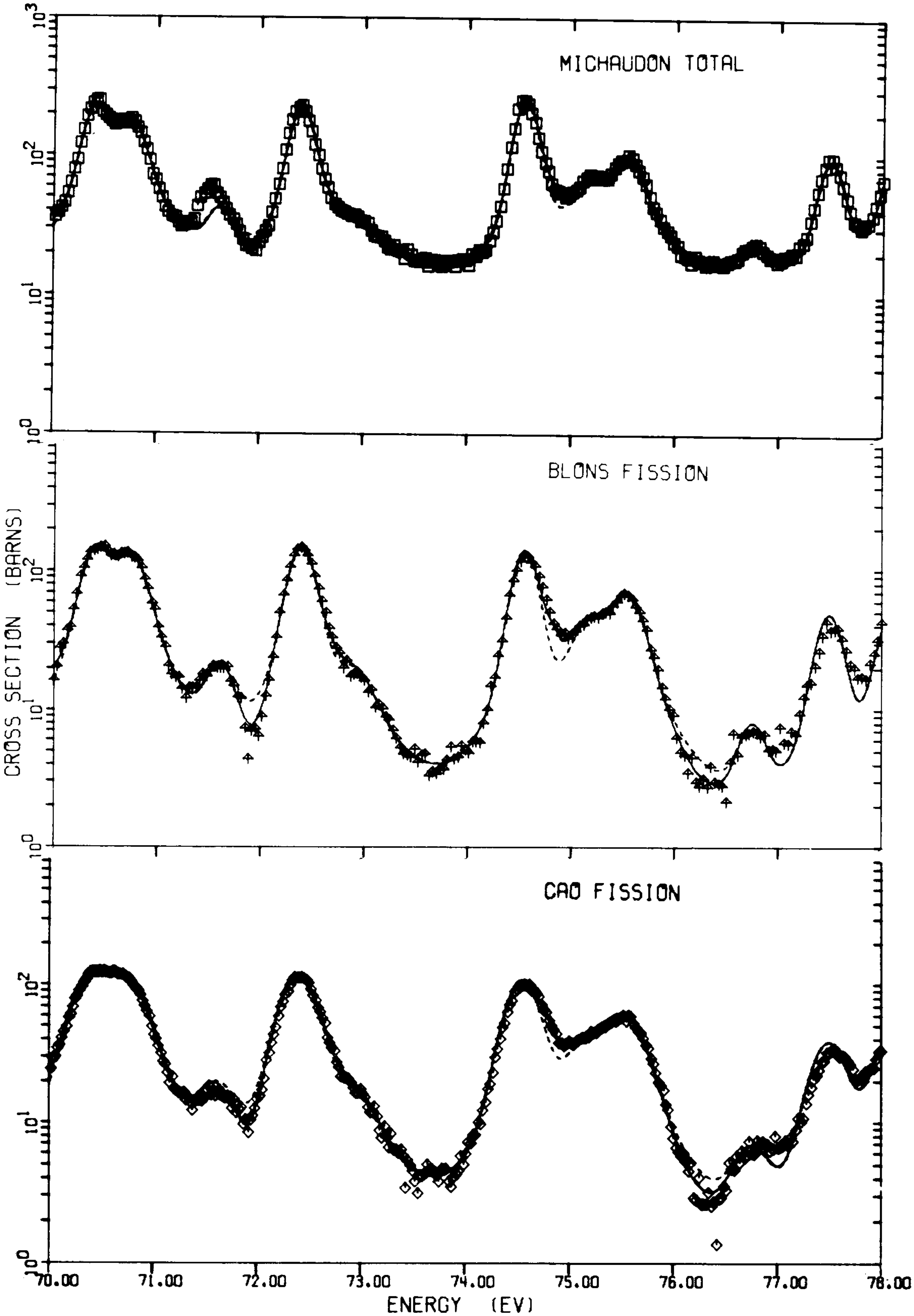


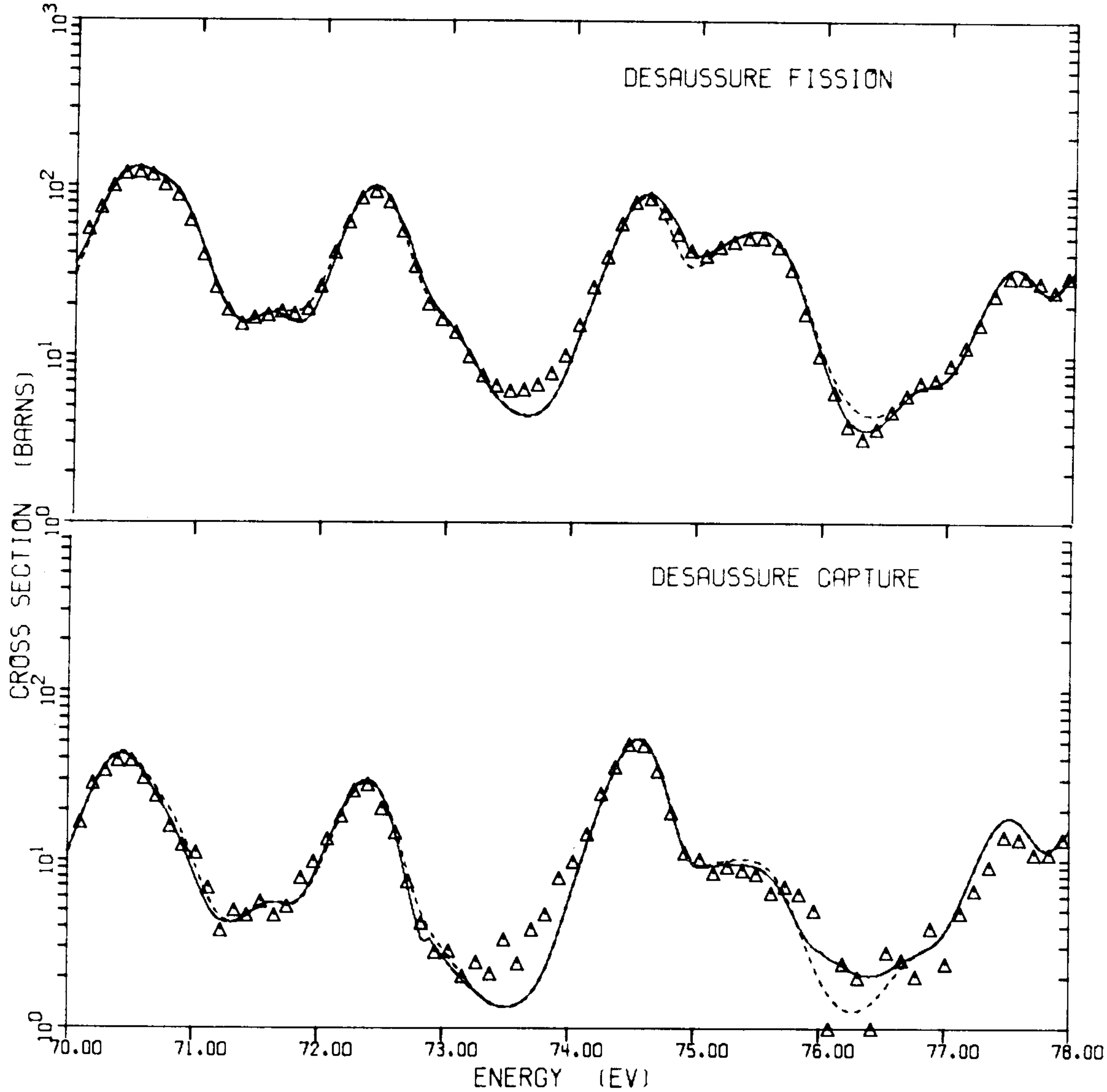
DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
56.00
57.00
58.00
59.00
60.00
61.00
62.00
63.00
64.00


MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
63.00
64.00
65.00
66.00
67.00
68.00
69.00
70.00
71.00

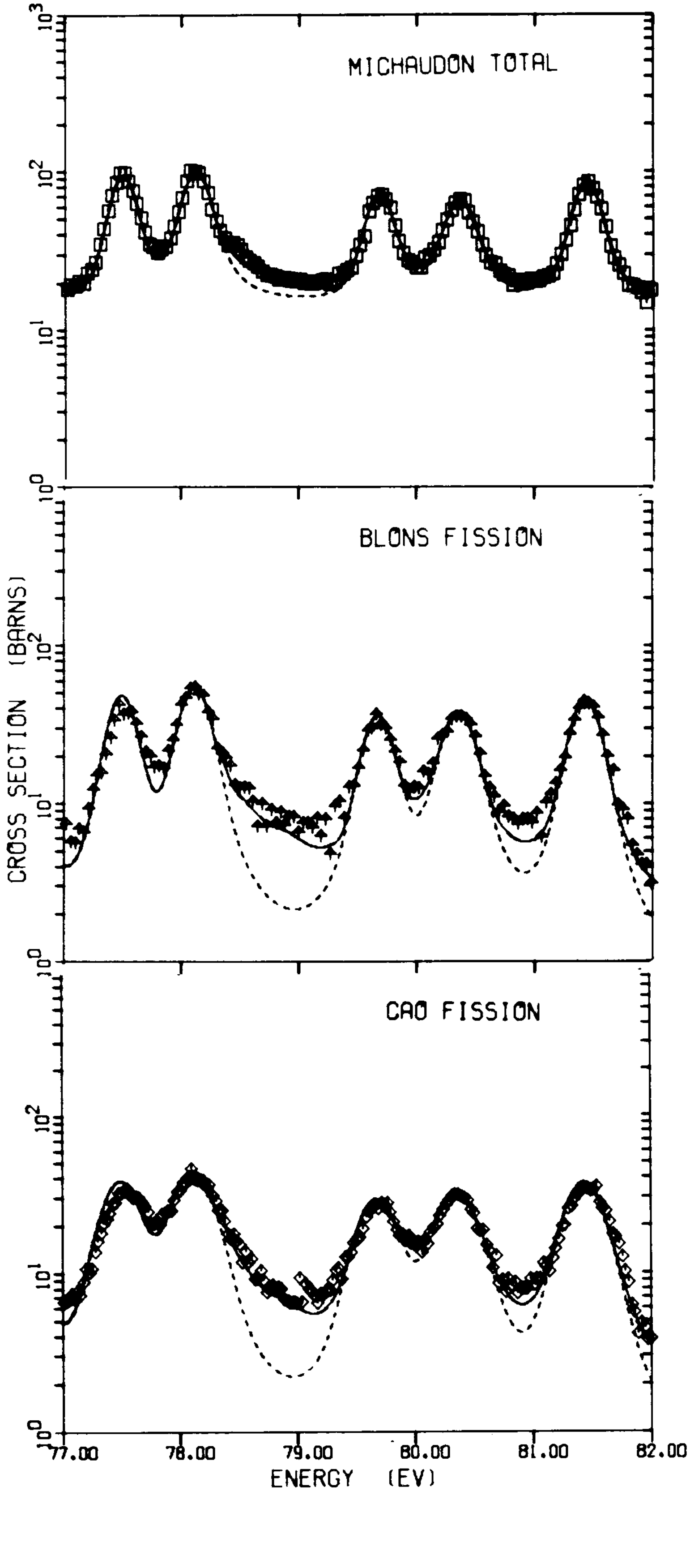


DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
63.00
64.00
65.00
66.00
67.00
68.00
69.00
70.00
71.00

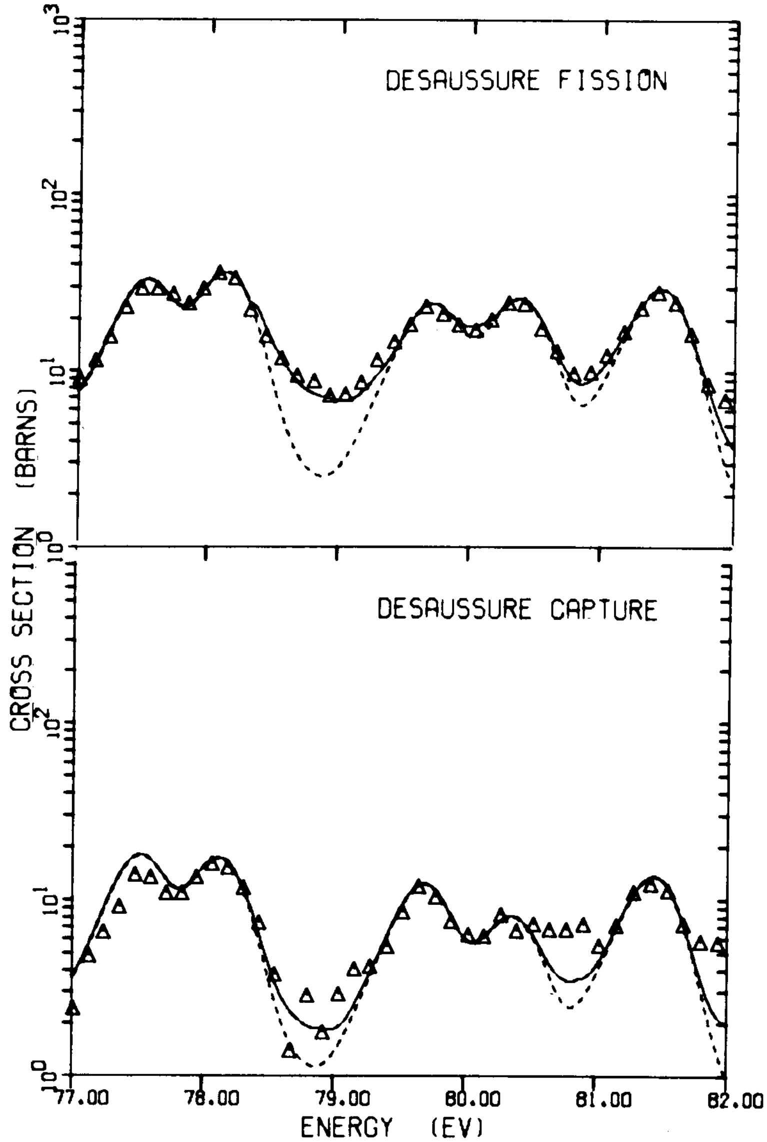

MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
ENERGY (EV)
70.00
71.00
72.00
73.00
74.00
75.00
76.00
77.00
78.00



DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
70.00
71.00
72.00
73.00
74.00
75.00
76.00
77.00
78.00



MICHAUDON TOTAL
BLONS FISSION
CAO FISSION
CROSS SECTION (BARNS)
10^0
10^1
10^2
10^3
77.00
78.00
79.00
80.00
81.00
82.00
ENERGY (EV)



DESAUSSURE FISSION
DESAUSSURE CAPTURE
CROSS SECTION (BARNS)
ENERGY (EV)
77.00
78.00
79.00
80.00
81.00
82.00

APPENDIX B

ESTIMATES OF ERROR

Although ACSAP will, upon command, calculate and print out the value of Chi -squared for a given run, it does not produce a complete error summary. A thorough error analysis is beyond the scope of the present effort. Consequently, the following error estimates are based upon a variety of considerations, combined in a none too rigorous manner.

We discussed differences in energy scales earlier. The uncertainty in energy scale is estimated to be about 0.1%, representing the difference between the deSaussure and European energy scales. The error in locating the resonance energy in the centroid of the experimental points representing the resonance is estimated at 0.010 eV. Because of interference in the fission channels, the centroids of the total, fission, and capture peaks may all be located at different energies. We chose the total peak as representing the best compromise position, but the capture peak is probably nearer to the true resonance energy. We assign an uncertainty of 0.020 eV in E_0 to represent this interference effect. The overall uncertainty in E_0 is thus dependent upon energy, but averages about 0.050 eV.

The fission and capture partial widths should be good to 10%. This figure is estimated from considerations of observable differences in the fits. The neutron widths, which were adjusted to make a compromise between the total and partial cross section data, have errors determined essentially by this normalization uncertainty. The discrepancies were as high as 7% in the region 8-16 eV.

From the incremental resonance integrals displayed in Tables IV and V we have calculated root mean square fractional differences between the fit and the various data sets.* These values appear in the tables, and indicate an

*The quantity calculated is $\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{F_i - d_i}{d_i}\right)^2\right]^{1/2}$, where the F_i are from the fit and the d_i from the indicated set of data.

average fit of about 3½%. Although this figure includes the effects of the normalization discrepancy discussed in the preceding paragraph, it does not fully include normalization errors. Neither does it face up to the fact that the residuals may not have a normal distribution. Making some allowances for these factors, we estimate the overall accuracy of the fit to be 5%, at a 67% confidence level.