69

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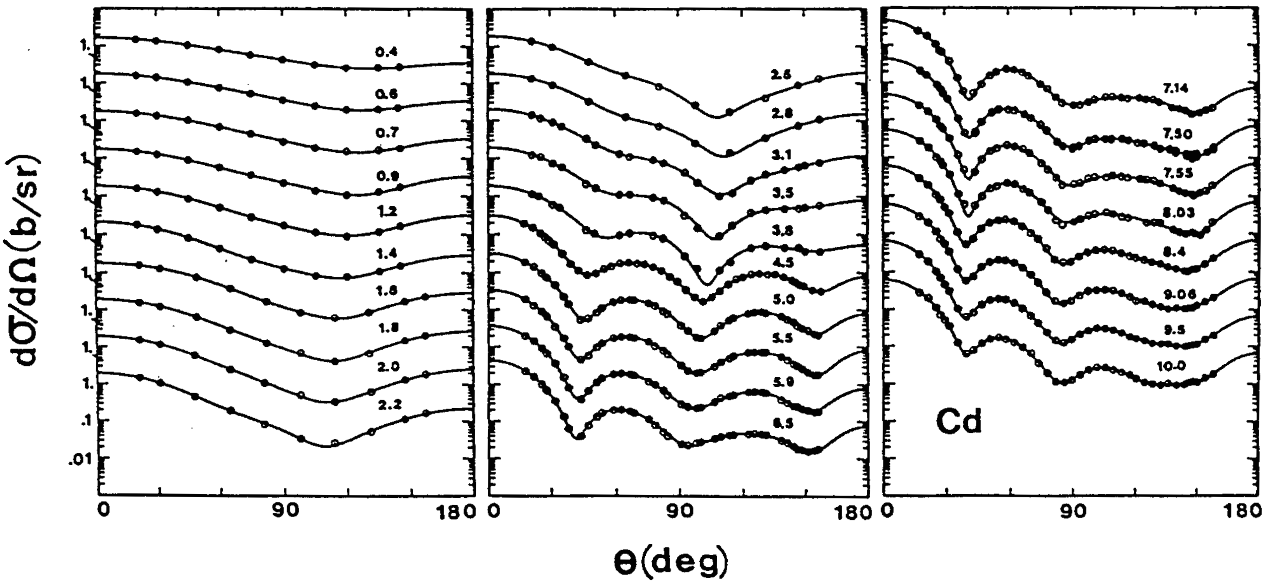
ANL/NDM-139 [ENDF-358]

The Simultaneous Evaluation of the Standards and Other Cross Sections of Importance for Technology

W.P. Poenitz and S.E. Aumeier

September 1997



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ANL/NDM-139 [ENDF-358]

The Simultaneous Evaluation of the Standards and Other Cross Sections of Importance for Technology[a]

by

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U.S.A.

September 1997

STANDARDS. ENDF/V-VI. Simultaneous evaluation. Generalized least-squares method. Data evaluation codes. Data compilations. Data files. Data corrections. Differential cross-section data. Spectrum-average cross-section data. Absolute data. Ratio data. Shape data. Sum data. Thermal constants. Neutrons. Nuclear reactions: ^{6}Li(n,α), ^{6}Li(n,n), ^{10}B(n,α_0), ^{10}B(n,α_1), ^{10}B(n,n), ^{197}Au(n,γ), ^{238}U(n,γ), ^{235}U(n,f), ^{239}Pu(n,f), ^{238}U(n,f). ^{252}Cf neutron spectrum.

[a] This work was supported by the U.S. Department of Energy, Energy Research Programs, under Contract W-31-109-Eng-38.

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Table of Contents

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The Simultaneous Evaluation of the Standards and Other Cross Sections of Importance for Technology[a]

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Abstract

The simultaneous evaluation of the cross sections of ^{6}Li(n,α), ^{6}Li(n,n), ^{10}B(n,α_0), ^{10}B(n,α_1), ^{10}B(n,n), ^{197}Au(n,γ), ^{238}U(n,γ), ^{235}U(n,f), ^{239}Pu(n,f), and ^{238}U(n,f) and the thermal constants was part of the evaluation of these data for ENDF/B-VI. The FORTRAN codes and the data files used for the simultaneous evaluation are documented in the present report. Corrections for some data reported in the literature and the addition of several new data sets results in negligible changes except for the fission cross sections where minor changes occur relative to the evaluation for ENDF/B-VI.

[a] This work was supported by the U.S. Department of Energy, Energy Research Programs, under Contract W-31-109-Eng-38.

I. Introduction

Evaluations of interaction cross sections for the Evaluated Nuclear Data File (ENDF)[1] prior to version ENDF/B-VI were often based on subjective judgement about existing experimental data. The technique employed, in some cases, involved drawing a smooth curve through a plot of available experimental values which, more often than not, displayed substantial discrepancies. In addition, these evaluations were hierarchical in nature since the lighter element interaction cross sections were evaluated first and independently of existing ratio measurements to cross sections of heavier elements, for which absolute data existed as well. The prior evaluated light element cross sections were used in order to convert the ratio measurements to additional cross section data for the heavier nuclei evaluations. However, if two experimental values are available, one for a light nuclei interaction cross section (e.g. $^{10}B(n,\alpha)$) and one for a heavy nuclei cross section (e.g. $^{235}U(n,f)$), then an additional measurement of the ratio of the two cross sections should be utilized in an evaluation of these data such that the $^{235}U(n,f)$ cross section influences the evaluated $^{10}B(n,\alpha)$ cross section and the experimental $^{10}B(n,\alpha)$ cross section influences the evaluated $^{235}U(n,f)$ cross section.

The history of the ENDF/B-VI evaluation of the standards and other important neutron interaction cross sections goes back to substantial criticism voiced against subjective procedures used in the evaluations of some cross sections for prior versions of ENDF, as indicated above. In response, a conference on 'Nuclear Data Evaluation Methods and Procedures' was held at Brookhaven National Laboratory in 1981[2]. It was demonstrated at this conference that a simultaneous evaluation of interrelated nuclear cross sections of a vector space of ~ 1000 with generalized least-squares (GLS) was feasible with the available computer technology[3]. However, use of GLS alone for all the standards would have ignored valuable information, specifically data for charged particle channels, angular distributions, and polarization for reactions leading to ^{7}Li and ^{11}B, data which are applicable via R-matrix theory[4]. Subsequently it was shown that the results from a GLS evaluation and from separate R-matrix parameter fits of the ^{7}Li and ^{11}B systems can be combined in order to derive final results for all cross sections involved[5]. The Standards Subcommittee of the Cross Section Evaluation Working Group (CSEWG) then decided to perform the evaluation of the standards and other important cross sections for ENDF/B-VI by using these objective techniques. This 'Global Evaluation' has been discussed at various occasions (e.g. Refs. 6,7) and is shown in schematic in Fig. 1. The evaluation of the standards was documented in Ref. 8. The present report documents the data base and the FORTRAN codes used in the GLS part of the global evaluation. Program changes and funding restrictions have delayed this documentation for eight years. However, it was considered important to document the data file and the associated programs in order to facilitate later updating of the evaluation resulting from added new and/or corrected experimental data. The various computer programs associated with the evaluation have changed from original punched-card to magnetic-tape to hard-disk based operations.

H(n,p) Ref.11	Thermal Parameters Ref.9

↓ ↓

GMA - Simultaneous Evaluation Ref.3	**EDA R-Matrix Analysis** Ref.4
Parameters: ^{6}Li(n,t), ^{6}Li(n,n), ^{10}B(n,α_0), ^{10}B(n,α_1), ^{10}B(n,n), ^{197}Au(n,γ), ^{238}U(n,γ), ^{235}U(n,f), ^{238}U(n,f), and ^{239}Pu(n,f) cross sections on an energy grid or energy interval averages, thermal constants, and normalization constants of shape data sets. **Data:** Absolute cross sections and ratios, total cross sections, shape data, and fission spectrum integral data.	**Parameters:** Two sets of R-matrix parameters. **Data:** Total cross sections, angle-integrated and differential cross sections, polarization and inverse reaction data of the ^{7}Li and ^{11}B systems.

↓ ↓

Combination Procedure
Ref.5

↓

Cross Section Smoothing

Fig. 1. Schematic of the Global Evaluation for ENDF/B-VI

II. The Generalized Least-Squares Fit

The method of least-squares estimation of a number of parameters, over determined by a larger number of experimental data, was devised by Gauss and independently by Legendre nearly 200 years ago. The Gauss-Markov theorem is the proof that the least-squares estimator is an unbiased estimator with minimum variance. The method was extended (generalized) to correlated data by Aitken. The Fortran code developed for the evaluation of the standards and other important cross sections was named after Gauss, Markov and Aitken: **GMA**. Associated codes are **RCL** (which is used to edit, list and expand the basic data file **GMDATA.CRD**) and **DAT** (which is used to reduce the cross section data to a common energy grid). The use of the programs and files is indicated in Figs. 2, 3 and 4.

GMDATA.CRD	RCL.INP
This is the file of the experimental data.	The file which contains options, parameters, and data for editing and listing of, and adding to GMDATA.CRD.

↓ ↓

RCL.F
Reads, copies, lists and edits GMDATA.CRD

↓ ↓

RCL.RES	RCL.LST
This is the modified basic data file which should be renamed GMDATA.CRD.	This is the file which contains listings of data sets, or the data file, as requested with options set in RCL.INP.

Fig. 2. The FORTRAN Code RCL.F and its Input and Output Files.

GMDATA.CRD	DAT.INP
The current basic data file.	This file contains the a priori and options.

↓ ↓

DAT.F
This code reduces the cross sections of the original data sets to the energy grid of the a priori.

↓ ↓

DAT.RES	DAT.LST
This file becomes the input file for the least-squares fit. Rename to DATA.GMA.	This file is a listing of DAT.RES and may contain additional notes and warnings.

Fig. 3. The FORTRAN Code DAT.F and its Input and Output Files.

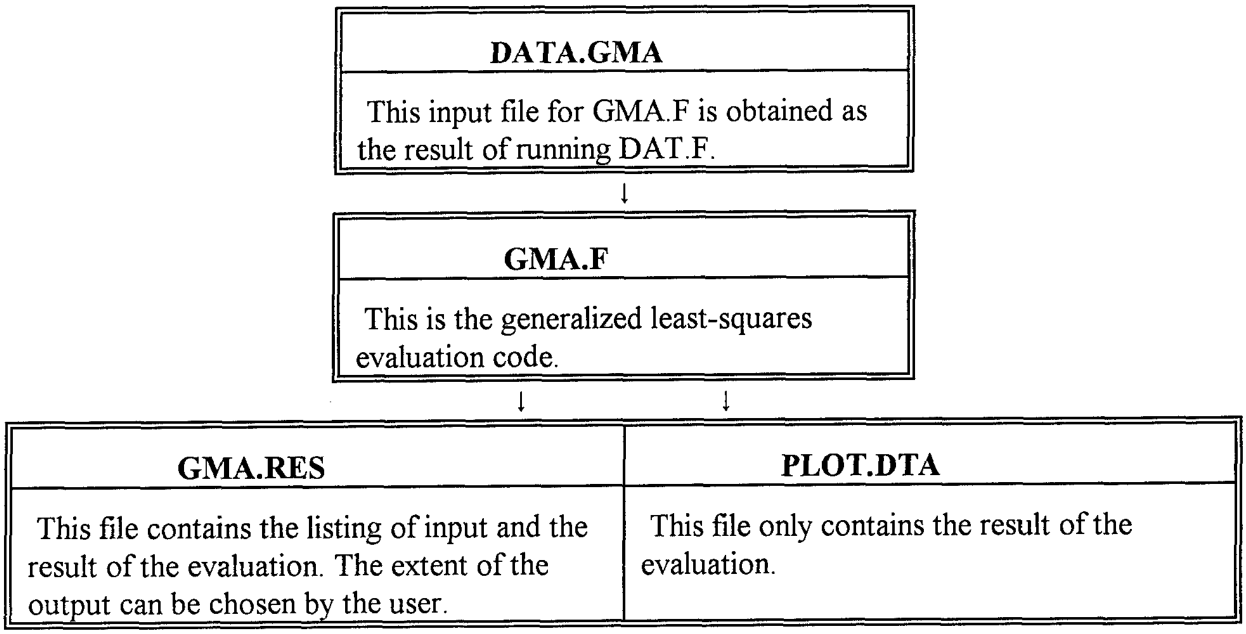


Fig. 4. The FORTRAN Code GMA.F and its Input and Output Files.

These codes were developed for the specific evaluation of the standards and other important cross sections. They evolved during the time of the multiple steps of the global evaluation process outlined in the introduction. Therefore, it may be difficult to use these codes for other least-squares problems, e. g., cross section names and energies were carried along as labels though they are not part of the actual formalism. Provisions were only made for data types which are in the data base (see Table 2). Specific decisions are made in the codes which are valid only for the parameters and measurement types involved in the present evaluation.

II.1 Parameters

The principle objects of the evaluation were the cross sections of ^{6}Li(n,t), ^{10}B(n,α_0), ^{10}B(n,α_1), ^{197}Au(n,γ), and ^{235}U(n,f), which are standards, and ^{238}U(n,γ), ^{238}U(n,f), and ^{239}Pu(n,f) which are of interest for nuclear energy applications. The latter are often interrelated through measurements with the former and independent measurements are available for them because of their practical importance. (Note that the ^{10}B(n,α_0) cross section is not considered a standard, but ^{10}B(n,α_0+α_1) is a standard.[6]) The ^{6}Li(n,n) and ^{10}B(n,n) cross sections were added to the parameter set in order to utilize total cross section data for these nuclei, and also because of their involvement in the R-matrix fits. Low resolution smooth cross sections were defined as parameters for an energy grid above 20 keV which was identical for all cross sections. However, the high energy termination of the parameter space differed for the various cross sections. The energy grid was chosen to represent gross structure of the various cross sections in sufficient detail. Decimal energy interval averages of the heavy nuclei cross sections have been used as parameters between 0.1 and 20 keV and labeled with their center interval energy. E. g., 3.5 keV indicates the average over the 3 to 4 keV range. The integral over the

7.8 to 11 eV range of the $^{235}U(n,f)$ cross section is involved in the normalization of several measurements and was included as a parameter labeled with 9.4eV. The thermal constants of the fissile nuclei ($\sigma_{n,f}$, $\sigma_{n,\gamma}$, $\sigma_{n,n}$, g_f, g_a, and ν-bar of ^{233}U, ^{235}U, ^{239}Pu, ^{241}Pu and the ν-bar value of ^{252}Cf) were included as parameters because many measurements of the fission cross sections of ^{235}U and ^{239}Pu were normalized at thermal energy. The results for these parameters and their covariance matrix from an evaluation by Axton[9] were used as input data for the GLS fit. The normalization constants of all the shape data sets become further parameters of the fit. The parameters are summarized in Table 1.

Table 1. Parameters of the Simultaneous Evaluation (Status for ENDF/B-VI)

Cross Sections		**ID**	Energies	Number of Parameters
^{6}Li	(n,t) (n,n)	1 2	thermal, 9.4 eV, and 0.00015 to 2.8 MeV	80 80
^{10}B	(n,α_0) (n,α_1) (n,n)	3 4 5		70 70 70
^{197}Au	(n,γ)	6		69
^{238}U	(n,γ)	7	thermal and 0.00015 to 2.2 MeV	75
^{235}U	(n,f)	8	thermal, 9.4 9.4 eV, and 0.00015 to 20.0 MeV	111
^{239}Pu	(n,f)	9	thermal and 0.00015 to 20.0 MeV, not 0.235 MeV	109
^{238}U	(n,f)	10	1.0 to 20.0 MeV	42
Thermal Parameters { σ(n,f) of ^{235}U and ^{239}Pu already included above }			thermal	23
Normalization constants			all energies	136
Total				**935**

II.2 The Basis for GMA

The adjustments on the a priori vector of the parameters are obtained from the normal equations

$$\boldsymbol{\delta} = (\mathbf{A}^T\mathbf{C}_M^{-1}\mathbf{A})^{-1}\mathbf{A}^T\mathbf{C}_M^{-1}\mathbf{M}$$

where δ is the adjustment vector, **A** is the coefficient matrix, **C** is the correlation matrix of the measurement vector **M**, superscript T denotes the transpose, and -1 the inverse matrices. The variance-covariance matrix of δ follows from error propagation:

$$\mathbf{C}_\delta = (\mathbf{A}^T\mathbf{C}_M^{-1}\mathbf{A})^{-1}.$$

The formalism is given in many textbooks (see e.g. Ref. 13). Specific transformations involved in the code **GMA** are described in detail in Ref.3. The more than 10 000 data values in the experimental data file result in a measurement vector of size m ~5500 after reduction to the chosen energy grid. The covariance matrix has the size m · m, and the coefficient matrix has the size m · n, where n is the number of parameters (935). At the time of the Brookhaven conference[2], the storage and matrix inversion of such systems appeared near impossible and certainly cost prohibitive. However, it was shown in Ref. 3 that after reordering the data file such that correlated data sets are consecutively arranged in sub-blocks, the correlation matrix consists of smaller squares on the diagonal, with the rest of the matrix filled with zeros. It is well known that the inverse of such matrix has the same structure as the original matrix with the squares on the diagonal consisting of the inverses of the original squares. Thus the product $(\mathbf{A}^T\mathbf{C}_M^{-1}\mathbf{A})$ can be obtained from additive contributions from each correlated data block. This has been discussed in detail in Ref. 3.

III. Data Types, Relations and the Data File Structure

Setting up the coefficient matrix, the correlation matrix and the measurement vector, **A**, **C**, and **M** as defined above, requires that the data file contains certain information. Some of the requirements are discussed below. Data file requirements were also discussed in Ref. 12. The structure and formats of the data file are defined in Appendix A. The content of the data file is given in Appendix E.

III.1 Data Types

Various types of data can be the result of a neutron cross section experiment. The measurement of an 'absolute' cross section at one or more neutron energies requires the determinations of the neutron flux, the sample mass and detection efficiency. A cross section 'shape' is the energy dependence of a cross section with undetermined normalization. Shape data can be arbitrarily normalized for the evaluation without affecting the result. Often cross section ratios have been measured based on the assumption that one of the cross sections was well enough known to derive the other. The advantage of such measurements is that the determination of the neutron flux is not required. Ratio measurements can be absolute or of the 'shape' type. Other measurements produce the sum of cross sections which again can be absolute or shape data. A transmission measurement results in a total cross section which is the sum of partial cross sections. The advantage of a transmission measurement is that absolute cross section values are obtained without requiring any neutron flux measurements.

Another type of data is an absolute cross section averaged over a neutron spectrum. Such data are useful contributions for the normalization of cross sections if they are insensitive to the shape of the neutron spectrum. This is the case for the neutron induced fission cross sections of ^{235}U and ^{239}Pu averaged over the neutron spectrum of the spontaneously fissioning ^{252}Cf (SF). Such values are valuable additions to the data base because different techniques are applied for the neutron source strength measurements than in other neutron flux determinations. The various types of data used in the GLS evaluation are listed in Table 2. Each data type requires different entries in the coefficient matrix (see Ref. 3), thus the data type ('MT') has been specified in the data file.

Table 2. Data Types Used in the Simultaneous Evaluation

MT	Data Type	Example
1	Absolute cross section	$\sigma_{n,f}(^{235}U)$
2	Cross section shape	$c \cdot \sigma_{n,\alpha}(^{6}Li)$, c unknown
3	Absolute cross section ratio	$\sigma_{n,f}(^{238}U)/\sigma_{n,f}(^{235}U)$
4	Ratio shape	$c \cdot \sigma_{n,f}(^{239}Pu)/\sigma_{n,\alpha}(^{6}Li)$ c unknown
5	Sum of cross sections	$\sigma_{tot}(^{6}Li) = \sigma_{n,n}(^{6}Li) + \sigma_{n,\alpha}(^{6}Li)$
6	Spectrum averaged cross section	$\sigma_{n,f}(^{239}Pu)$, Av. ^{252}Cf SF
7	Absolute ratio of cross section vs. sum of cross sections	$\sigma_{n,\gamma}(^{238}U)/\sigma_{n,\alpha}(^{10}B)$ $\sigma_{n,\alpha} = \sigma_{n,\alpha 0} + \sigma_{n,\alpha 1}$
8	Shape of type 5 data	
9	Shape of type 7 data	

III.2 Originally Measured Quantities

Data listed in journal publications and reports or available from nuclear data file libraries are frequently not the originally measured quantities. The experimenters/authors may have measured a cross section ratio but converted it to cross sections using some reference cross section. Data used to derive this reference cross section may also be in the data base. Other cross sections may have used the same reference cross section. Thus the same data (and their errors) would be in the data base more than once and carry undeserved weight. Many reported data were the result of measurements of the shapes of cross sections or cross section ratios including thermal energy. The data were then normalized with the supposedly well known thermal cross sections. However, the normalization should be determined by all absolute data and the associated uncertainty and correlation information. Another common procedure was to measure a cross section or ratio shape in segments and subsequently to normalize these fragments in overlap regions to one-another. However, the normalization of each segment should be determined by all available data and, depending on uncertainties and correlations, might be quite different than that resulting from the procedure used for the reported data.

In order to properly use the data in this database, the originally measured quantities have been reconstructed to the extent possible. Unfortunately not all publications state what reference cross sections or normalizations were used. In case of the normalization of a data set to an external absolute cross section value (e.g. at thermal energy), the simple and exact solution was to declare the data as a shape measurement. However, if an undefined energy dependent reference cross section was involved, the problem was more complex. It occurred most often in the context of measurements relative to the $^{10}B(n,\alpha)$ cross section. The assumption was made that a 1/V shape had been used for early measurements and the evaluation by Sowerby[10] was used for later measurements. For more recent measurements, converted with unspecified reference cross sections, the use of standards of ENDF/B versions was assumed. Data measured relative to the H(n,n) cross section were renormalized to the ENDF/B-VI version[11].

III.3 Uncertainties and Correlations: Data Sets and Data Blocks

The basic data unit is a data set which consists of one to m data values at different energies which are all of the same data type. A data set also contains associated uncertainty and correlation information and data set specifications. Uncertainties can be 'normalization' uncertainties (e.g. the sample mass), which exist only for absolute data (MT = 1, 3, 5, 6, and 7), or they can be energy dependent uncertainties (e. g. statistics, background, etc.). The values in a data set having more then one value are usually correlated. The normalization uncertainties of absolute data contributes to the correlation coefficients between any two energies with the square of their size, whereas the statistical uncertainty does not contribute to the correlation except that it reduces correlation by contributing to the total uncertainty. Other energy dependent uncertainty components contribute to the correlation between two energies (E_1,E_2) by the product of their sizes and two factors which have been introduced in order to reduce correlations at more distant energies. These factors are determined from three parameters, a, b, and c, given in the file. The factor at E_1 is given by a+b. The factor at E_2 is calculated as a+b(E_2), with $b(\frac{1}{2}\cdot c\cdot E_1) = \frac{1}{2}\cdot b$. Parameter values of a = b = c = 0.5 are used as default values. A data set is identified with a data set number. Data sets and uncertainty components can be 'tagged' in order to investigate the effect of some classification (e. g., one could tag all preliminary data with one number and then see what effect the down weighting of these data has). However, the tags have not been set in a consistent manner and have not been used for the evaluation of ENDF/B-VI.

Several data sets might be correlated because of the use of common elements in the measurements (e.g. the same sample mass or the same neutron detector). Such correlated data sets are contained in a 'data block'. The cross correlation between the data sets is specified for each data set by identifying the data set number of each preceding correlated data set and the indices of the uncertainty components which are correlated. Factors (≤ 1.0) are given in order to permit a reduction of the strength of these cross correlations.

III.4 Data Selection and Status of GMDATA.CRD

The evaluation of a set of parameters ideally would be based upon all available experimental data for these parameters or combinations thereof. A majority of the data have been included in the data file (see Appendix E). However, problems with the definition of some data sets could not be resolved and they are not yet included. Data for some measurements could not be obtained. Some older measurements were left out, because their large uncertainties would be expected to result in a negligible effect on the outcome. Some data with gross discrepancies were left out as well. Improvements, additions and changes to the data file can easily be made with the data set editing and data addition options of the code RCL.F (see Fig. 2 and Appendix B).

Corrected data have been reported for some data sets used in the ENDF/B-VI evaluation since the conclusion of the evaluation. The corresponding data in the file have been replaced. New data available in 1992 have been discussed in Ref. 14 and some of these new data sets have been added to the data file. The more recent resolution of the ^{239}Pu(n,f) cross section discrepancy[15,16] has been incorporated by including the new data set of Ref. 15 and by removing the thermal cross section from the older data set. Data replacements and additions are indicated in the comments columns of the tables of Appendix E.

A comparison has been made between the results obtained with the old data file (as used for the evaluation of ENDF/B-VI) and with the current updated data file. The differences are negligible for most cross sections and in most energy regions. The reason is that the updated and new data are outweighed by the large number of other data sets available in these regions. Specifically, there are negligible changes for the ^{10}B cross sections and the ^{239}Pu(n,f) cross section below several hundred keV. The new data either agree with the evaluation for ENDF/B-VI or have uncertainties too large to affect the outcome. The changes for the fission cross sections are shown in Figs. 5 - 7. At most energies these changes are minor (small compared with the uncertainties), except for the energy range 13-16 MeV. These changes are caused by major revisions of data, as indicated in Ref. 17, and some new data. The largest change is for ^{238}U(n,f) at 14.5 MeV which affects ^{235}U(n,f) and ^{239}Pu(n,f) due to strong correlations caused by numerous ratio measurements.

Fig. 5. Differences for $^{235}U(n,f)$

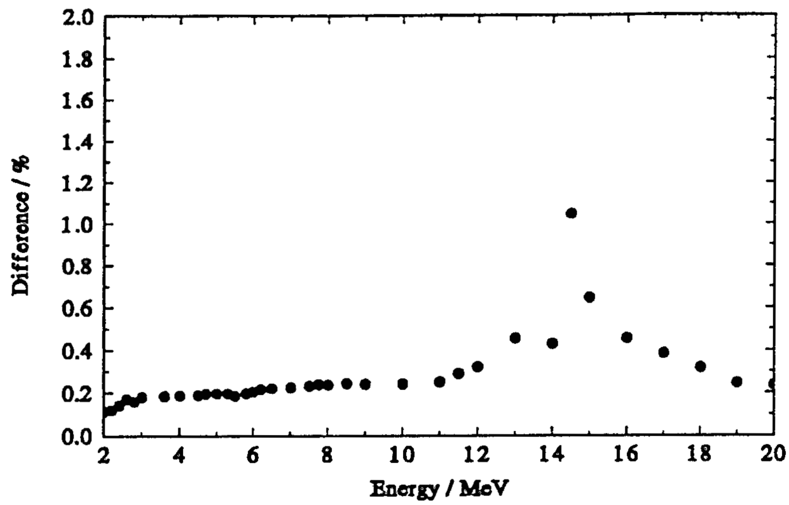


Fig. 6. Differences for $^{239}Pu(n,f)$

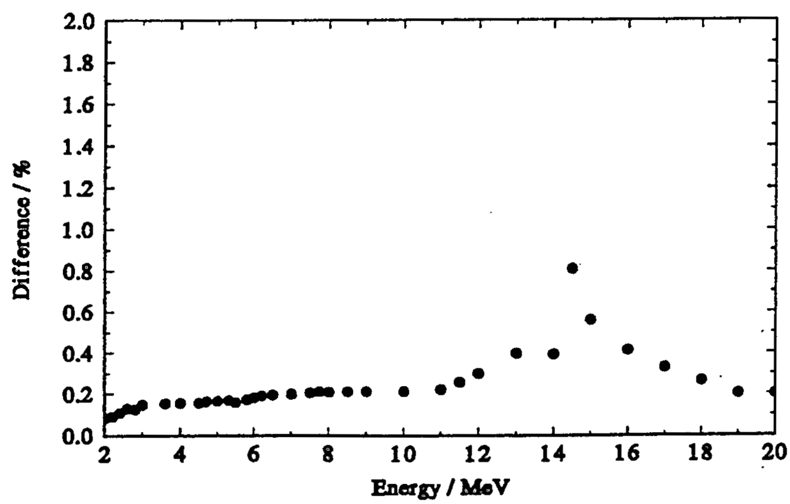
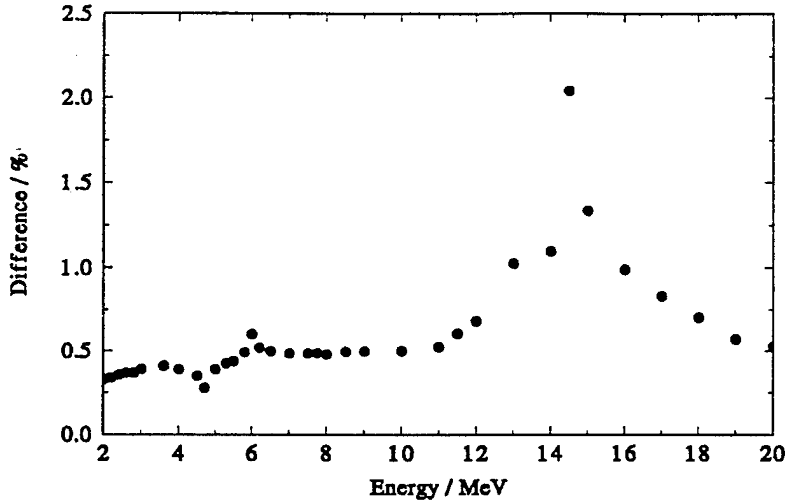


Fig. 7. Differences for $^{238}U(n,f)$



IV. Data Reduction with DAT.F

The original file of the experimental data contains cross section measurements made with different energy scales. In order to facilitate the use of ratios (and sums) of cross sections a common energy grid has been used for all cross sections, though not all cross sections are parameters at all energies. The data reduction is achieved with the code DAT.F. The experimental data are extrapolated to the energy grid using the shape of the a priori cross sections. For an energy grid sequence E_{i-1}, E_i, E_{i+1} all data within $(E_{i-1} + E_i)/2$ and $(E_i + E_{i+1})/2$ are extrapolated to E_i. The value of the quantity (cross section, ratio, etc.) and the systematic uncertainty components at the grid energy are obtained as the weighted averages if more than one experimental value contributes. A reduced statistical uncertainty is calculated, based upon assumed counting statistics. The procedure has been described in Ref. 3. The user is requested to specify a multiple of the standard deviations by which an experimental value is permitted to deviate from the a priori until it is down weighed as discrepant. All other input is given in DAT.INP. The file requirements for the code DAT.F are described in Appendix C (see also Fig. 3).

Concluding Note

The data files and the FORTRAN source codes will be available from the National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973; and the Radiation Shielding Information Center, Oak Ridge National Laboratory, P. O. Box 2008, Oak Ridge, TN 38831-6362.

Appendix A: Data File GMDATA.CRD - Structure and Formats

The data base for the simultaneous evaluation of the standards and other important cross sections is the file GMDATA.CRD. Its original structure was determined by the limitations of punched data cards. This format has been retained for the data file now in use, however the card is referred to as a line in the following description. An interpretive listing of the file can be obtained with the code RCL.F. The data file consists of data blocks which end with the line EB. A data block contains one or more data sets. A data set ends with the line ES if it is not at the same time the end of a data block, in which case it ends with EB. The end of the file is indicated with a data set number of 9999. Thus the structure of the file is:

```
Data set
ES
Data set
EB
Data set
EB

etc.

Data set
EB
9999
```

The structure and formats of a data set are as follows:

1. Line

```
NR NY  (NQT(l),l=1,12) (NAU(k),k=1,14) (NREF(i),i=1,10)
I4 I4     12A2            14A2           10A2
```

where NR is the data set number
NY is the year of the measurement or publication date
NQT is a label of the type of measured quantity
NAU is a label of the authors of the publication
NREF is a label for the reference of the publication (for a more detailed reference see Appendix E.)

note: NR, NY have or may have operational or reference use and should be correct.
NQT,NAU, and NREF are for label purpose only.

2. Line

NQ NT NCO NCS NCCO NO (NID(l),l=1,5)
I2 I2 I2 I2 I3 I5 5I3

where NQ is a data set tag which may be used for selective purpose
MT is the ID for the type of quantity of the data set (see Table 2)
NCO is the source of the correlation matrix
NCS is the number of preceding data sets for which correlations are given
NCCO is the number of comment lines
NO is the number of data values
NID are the ID's of the parameters involved for the given quantity (see Table 1)

note All entries have or may have operational or reference use and should be correct

Lines 3.01 to max. 3.50 (NCCO Lines)

(NCOM(l,k),l=1,40)
40A2

where NCOM are comments

4. Line (not used for shape data: MT = 2, 4, 8, 9)

(ENF(l),l=1,10) (NENF(l),l=1,10)
10F5.1 10I3

where ENF are the normalization uncertainty components in %
NENF are tags for these components

Lines 5.01 to 5.11 and line 5.12

((EPA(l,k),l=1,3),k=1,11)
3F5.2

(NETG(k),k=1,11)
11I3

where EPA are parameters for the energy dependent uncertainty components
NETG are tags for the energy dependent uncertainty components

Lines 6.001 to max 6.399 (No. of Lines of data)

E(k) S(k) (F(l,k),l=1,12)
E10.4 E10.4 12F5.1

where E(k) is the energy of the k.th data value
S(k) is the k.th data value
F are the E-uncertainty, E-resolution, statistical uncertainty, and systematic uncertainties

note E is a dummy entry for spectrum averaged values (NT=6).
F(12,k) is the total uncertainty calculated in the programs RCL and GMA.

Lines 7.01 to max 7.20 (NCS Lines), only if more sets than one are in the block

NCST(k) (NEC(1,l,k), NEC(2,l,k),l=1,10)
I5 20I2

where NCST(k) is the data set number of a set preceding the current data set in the same data block with which correlations exist
NEC are uncertainty component pair indexes (present set, preceding set) which are correlated

note The NEC pairs given for the normalization uncertainty components are identical to their indexes, for energy dependent uncertainty component pairs 10 must be added to the index, e. g., if the 4.th energy dependent uncertainty component of the preceding data set correlated with the 5.th of the present data set, the entry for the pair would be 15 14.

(FCFC(l,k),l=1,10)
10F5.1

where FCFC are correlation strength reduction factors for the correlated pairs ($\leq$1.0).

Lines 8.01 to max 8.30 (NCO Lines)

(ECOR(k,l),l=1,k)
10f8.5

where ECOR is the lower triangle of a given correlation matrix of the data block, the diagonal 1.00 included.

Last Line

NQQ

A2

where NQQ is ES or EB as discussed above for terminating a data set or a data block.

Appendix B: Input Description for RCL

The FORTRAN program RCL.F can be used to list the basic GMA data file GMDATA.CRD. It also can be used to add data sets and/or data blocks to this file, insert the uncertainty and correlation information and add comments. The program reads the file GMDATA.CRD and lists to the file RCL.LST. The edited and/or appended data file is written to the file RCL.RES which should be renamed as the new file GMDATA.CRD. All listing and/or editing instructions, parameters and data are contained in the file RCL.INP. Control options are given in the following tables.

GM	Reading, Copying and Listing of the GMDATA.CRD File.
Control Command **GM N1 NX** (A2,I1,I5)	
GM2 NX	Copy the file to (and including) data set NX (which may be the last set in a data block) and prepare to add one or more data sets to this block.
GM3 NX	Copy the file from the data set following the set NX (NX excluded) to the end of the file.
GM4	Copy the file from the first data set to the last data set and prepare to add one or several new data blocks.
GM5 NX	Copy the file up to data set NX and read the next data set for editing.
GM6	List the present data set.
GM7 NX GM7	Find, read, and list the data set NX. If NX = 0, all data sets of the file will be listed.
GM8	List the library (short form of the data set listing) of the file.
GM9 NX	Write the present data set to the file as one set in a block (NX = 1), or as the last set of a block (NX = 2).
Note:	The command EF may be required after some of the GM commands in order to close the file.

DI	Data input with selected (preprogrammed) formats.
Control Command **DI N1** (A2, I1)	
DI1	Data in the ANL76 and ANL83 conference format. Other formats must be programmed for other N1 values.

CO	Input of comments.
Control Command **CO N1 NX** (A2, I1, I5)	
CO2	Input a new set of comments. The control command is followed by a maximum of n = 50 lines of 40A2. If n<50 the last terminating line should be E*.
CO3	Add comment lines to previously stored comments.
CO4 NX	Replace the comment line NX. Note: the file listing provides a numbering of the comments.

AU	Add/construct uncertainties.
Control Command **AU N1 NX** (A2, I1, I5)	
AU1 NX	Set or reset the energy dependent uncertainty component NX. The uncertainties are a linear interpolation between the uncertainties at the lowest and highest energies of the data set. The control command must be followed by: T1, T2 (2F5.1) which are the uncertainties at the min./max. energies in percent.
AU2	Input of the normalization uncertainty components, followed by required input: Nr, Tag, % (2I2, F5.2). The maximum is 10 components. If n<10 the terminating line is with Nr = 0.
AU3	Input of energy dependent uncertainty components given as interpolation intervals. Input is Nr, Tag, Three correlation parameters (2I2, 3F5.2) E_1, % (E8.2, F5.2) E_2, % . E_n, % Terminate with $E_{n+1} = 0.0$. Up to 10 interpolation intervals are permitted for up to 10 uncertainty components. Terminate with Nr = 0 for <10.
AU5 NX	Designates uncertainty component NX as statistical error component.

CC	Cross correlation information input.
Control Command **CC** (A2)	
CC	Cross correlations of a data set with other data sets preceding the present set within the same data block can be given. Required input following the control command: Preceding data set Nr, present uncertainty component index, preceding uncertainty component index (I5, 20I3) Correlation strength factors for each pair of uncertainty components. (10f5.1) The latter factors should be ≤ 1.0 and can be used to reduce the correlations as given by the uncertainty components. Correlations with up to 10 preceding data sets can be given for up to 10 uncertainty component pairs. Termination is achieved by setting the preceding data set Nr = 0. Note that the index Nr's for CC are 1 - 10 for the normalization uncertainties and 11 - 21 for the energy dependent uncertainties.
CC2 NX	Replace or add correlation information with index Nr NX.
CC3 NX	Replace the correlation strength factors for index Nr NX.

DS	Data set specifications.
Control Command **DS N1** (A2, I1)	
DS1	Input of all data set specifications Data set Nr, Quantity label (I5, 12A2) Year, Tag, Type(Tabl.2), Param. ID's (Tabl. 1) (I5, 7I2) Authors (14A2) Reference (10A2)
DS2	Change of Set Nr, Quantity label (I5, 12A2)
DS3	Change of Year, Tag, Type, Param. ID's (I5, 7I2)
DS4	Change of Authors (14A2)
DS5	Change of Reference (10A2)
Note	DS2 - DS5 are used for editing an existing data set.

Control Commands	Miscellaneous Commands
NS (A2)	Clear all data and data set information. Use before DS.
EF (A2)	Write file-end for RCL.RES.
SP8 (A2, I1)	Stop, provides for orderly termination of the program.
TG N1 (A2, I1)	Reset data set tag to N1.
RN	Input of renormalization constants for shape data sets as determined by GMA.

Example 1

The following example of the file RCL.INP will cause RCL to copy GMDATA.CRD up to and including data set 756 (GM2 756), then set up a data set 991 which is correlated with data set 756. First, all data set information is cleared (NS), then the data set specifications established (DS1), then the data are given (DI1), then 3 comment lines are given (CO2), a fourth comment is added (CO3) and the third comment line is replaced by a new comment (CO4 3). Next, the 4.th and 5.th energy dependent error components are established by the given interpolation intervals (AU3). The third energy dependent error component is declared as the statistical uncertainty (AU5 3). Cross correlation with set 756 is between the 4.th error component of set 756 and the 5.th error component of set 991 (CC). The set 991 will be written after set 756 as the last data set in this data block (GM9 2). The rest of the data sets of the original file will then be copied (GM3 756), after which the end of the file will be written (EF) and an orderly exit achieved with SP8.

```
GM2  756
NS
DS1
 991B(n,a1)/B(n,a0+a1),shape
 1999 2 9 4 3 4
N.M.Doe
J.Fantasy 5,629
DI1
0.1435E+010.0000E+000.0000E+000.2053E+010.0200E+000.0100E+00
0.2435E+010.0000E+000.0000E+000.2553E+010.0200E+000.0100E+00
0.3435E+010.0000E+000.0000E+000.3553E+010.0200E+000.0100E+00
0.4435E+010.0000E+000.0000E+000.4053E+010.0200E+000.0100E+00
0.0
CO2
UNCERTAINTIES
3 STATISTICS
4 SCATTERING
```

```
E*
CO3
5 TESTADD
E*
CO4   3
4 SCATTERING + BACKGROUND
AU3
 4 2 0.50 0.50 0.50
0.10E+01 1.20
0.30E+01 2.50
0.50E+01 5.00
0.0
 5 2 0.50 0.50 0.50
0.10E+01 1.20
0.30E+01 0.50
0.50E+01 1.00
0.0
 0
AU5   3
CC
  756  4  5
  0.8
   0
GM9   2
GM3  756
EF
SP8
```

Example 2

This example of the file RCL.INP will cause the file GMDATA.CRD to be copied in its entirety, and a new data block will be added which consists of one data set with set number 992.

```
GM4
NS
DS1
 99210B(n,a1)
 1999 2 1 4
N.M.TEST1
REFERENCE
DI1
0.1435E+010.0000E+000.0000E+000.2053E+010.0200E+000.0100E+00
0.2435E+010.0000E+000.0000E+000.2553E+010.0200E+000.0100E+00
```

```
0.3435E+010.0000E+000.0000E+000.3553E+010.0200E+000.0100E+00
0.4435E+010.0000E+000.0000E+000.4053E+010.0200E+000.0100E+00
0.0
CO2
UNCERTAINTIES
3 STATISTICS
4 SCATTERING
E*
AU2
 1 1 1.20
 2 1 0.85
 0
AU3
 4 2 0.50 0.50 0.50
0.10E+01 1.20
0.30E+01 2.50
0.50E+01 5.00
0.0
 0
AU5   3
GM9   2
EF
SP8
```

Appendix C: Input Description for DAT

The purpose of the FORTRAN program DAT.F is to prepare the input file for the generalized least squares fitting program GMA.F. DAT first requests the operator to specify the number of standard deviations any data value is permitted to differ from the a priori. This feature will reduce the effect of discrepant data, improves the χ^2, and should only be used after substituting the a priori with the result from a prior evaluation step. DAT reads the parameters from the file DAT.INP and transfers those needed by GMA to the file DAT.RES. The first and last values of the a priori of each cross section are not parameters of the evaluation but are needed by DAT for the extrapolation procedure. The controls transfered to the input file for GMA are explained in Appendix D. DAT then reads the data sets from the file GMDATA.CRD and extrapolates the measured cross sections to and averages at the energy grid points as defined by the a priori cross sections. These processed data sets are added to the file DAT.RES with appropriate delimiters for data sets and data blocks.

Appendix D: Input Description for GMA

The input file for the FORTRAN code GMA.FTN is DATA.GMA which is the renamed result of DAT.F. DATA.GMA contains a number of control codes which are copied or produced by DAT.F. The format for these controls is:

CONT MC1 MC2 ...... MC8   A4,8I5,

where

CONT = APRI indicates the a priori cross sections.

MC1 = NE   is the total number of parameters.

MC2 = NC   is the number of parameter types (cross sections) involved.

APRI is followed by the a priori as transferred by DAT.

CONT = I/OC   is the output control which limits the amount of information written to the result file GMA.RES.

MC1 ≠ 0   the a priori cross sections will be listed.

MC2 ≠ 0   the input data will be listed.

MC3 ≠ 0   the correlation matrices of the data blocks will be listed.

MC4 ≠ 0   the $B = A^T C^{-1} A$ matrix product will be listed.

MC5 ≠ 0   the inverted correlation matrix of a data block will be listed.

MC6 ≠ 0   the correlation matrix of the result will be listed.

MC7 ≠ 0   additional information for checking the code will be listed.

CONT = FIS*   controls the fission spectrum required for the fission spectrum averaged cross sections.

MC1 ≠ 0   input of ENFIS(k), FIS(k) (2E13.5), ending with 0.0, where ENFIS are the energies of the a priori of one of the fission cross sections for which data exist and FIS is the product of fission flux and bin width.

MC2	is the average energy of a Maxwellian fission spectrum in keV (for MC1=0).
MC3	is the id of the cross section for which the energy grid is used (for MC1=0).

CONT = ELIM controls the exclusion of data sets from the evaluation.

MC1 number of data sets to be excluded. The data set numbers follow the ELIM with format 16I5.

CONT = MODE controls correlation matrix construction and weighing options.

MC1	= 1	input of the correlation matrix.
	= 2	all data are considered uncorrelated (for testing).
	= 3	construction of the correlation matrix from the error components and correlation information given on the file.
MC2	= 0	no down weighting of any data set.
	= 1	data sets with data set tag numbers ≠ 1 will be downweighted.
	=10	down weighting of specified data sets, the data set numbers follow the MODE line in format 16I5.
	>1000	data sets from a year before the given value will be down weighted.

MC 10*factor for multiplying uncertainties (down weighting, if used). e. g., if down weighting is chosen with MC2 and MC set to 40, all error components will be multiplied with a factor 4.0.

MC4 controls the number of repetitions of the LS fit with the a priori replaced by the result of the previous fit.

CONT = DATA precedes a data set.

MC1 = NS is the data set number.

MC2 = MT is the type of measurement.

MC = NCOX if ≠ 0, the correlation matrix is given. This is an exception for the thermal constants, where the matrix is given for the data block.

MC4 = NCT is the number of cross section types involved in MT.

MC5,MC6,MC7 are the ID's of the cross sections.

MC8 = NNCOX	uncertainties will be divided by a factor of 10. This is an exception for the thermal constants where the uncertainties had been multiplied by a factor of 10. This procedure was required in order to preserve the exceptional precision of the thermal constants.
CONT = BLCK **= EDBL**	precede and end a data block.
CONT = END*	indicates the end of the data file and initiates the least squares fit.

Appendix E: Data File Contents Description

The following Tables summarize the content of the data file GMDATA.CRD ordered by data type and cross sections involved. Not listed are 'DUMMY' data sets which assure that there is at least one input value for every parameter. Large uncertainties have been assigned to these DUMMIES which assures that they have no effect on the result of the evaluation. Three 'THEORY' cross section shape data sets represent the well known 1/v behavior of the Li and B (n,α) cross sections. These sets were introduced after more and more data sets for Li and B had to be transferred to the R-matrix fit (ERA) in order to stabilize the latter.

Absolute Cross Section Data

^{6}Li(n,t)

Set	Reference	Year	Data Values	Energy Range	Comments
238	C. M. Bartle, Nucl. Phys. **A330**, p.1.	1979	23	2.2 - 9.7 MeV	
702	W. P. Poenitz, Pre-evaluation based on data collected by N. E. Holden, BNL-NCS-51388, excluding set 707.	1985	1	Thermal	Data of set 707 had to be excluded due to their use in the EDA fit.
707	J. W. Meadows, Symp. on Neutron Standards and Flux Normalization, Argonne National Laboratory, AEC Symposium Series 23, p.129.	1970	1	Thermal	Not used for GMA, but included in the EDA fit.
241	W. P. Poenitz and J. W. Meadows, Panel on Neutron Standards Ref. Data, Vienna, STI/PUB/371, p.95.	1972	23	0.085 - 0.6 MeV	See also Z. f. Physik **268**, p.359 (1974). These values were not entered because of resolution problems.
198	H. Condé et al., Arkiv Fysik **29**, p.45.	1964	1	0.1 MeV	

285	J. C. Overley et al., Nucl. Phys. **A221**, p.573	1974	25	0.1 - 1.8 MeV	

^{6}**Li(n,n)**

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
210	V. P. Alfimenkov et al., Conf. on Nucl. Data for Science and Technology, Antwerp, p.353.	1982	24	0.7 - 80 keV	See also Sov. J. Nucl. Phys **36**, p.637.
215	H. H. Knitter et al., Euratom Report EUR-5726E.	1977	40	0.22 - 3.0 MeV	
223	A. B. Smith et al., Nucl. Phys. **A373**, p.305.	1982	26	1.5 - 4.0 MeV	
178	A. Asami and M. C. Moxon, Conf. on Nucl. Data for Reactors, Helsinki, STI/PUB/259, Vol. I, p. 153.	1970	24	0.9 - 110 keV	
253 254 255	R. O. Lane et al., Ann. Phys. **12**, p. 135.	1961	18 6 10	0.05 - 1.0 MeV 0.22 - 0.27 MeV 1.1 - 2.2 MeV	
212	H. H. Knitter and M. Coppola, Euratom Report EUR-3454E.	1967	14	1.0 - 2.3 MeV	

$^{10}B(n,\alpha_0)$

Set	Reference	Year	Data Values	Energy Range	Comments
112	R. M. Sealock et al., Nucl. Phys. **A357**, p.279.	1981	72	6 - 500 keV	Data derived from the inverse reaction $^{7}Li(\alpha,n)^{10}B$ angular distribution measurements obtained from the authors in private communication.
118	M. D. Olson and R. W. Kavanagh, Phys. Rev. **C30**, p.1375.	1984	54	8 - 750 keV	Not used for GMA but included in the EDA fit.
114	J. H. Gibbons and R. L. Macklin, Phys. Rev. **114**, p.571.	1959	11	99 - 770 keV	Data derived from inverse reaction integral data shown in the publication.
110	R. M. Sealock and J. C. Overley, Phys. Rev. **C13**, p.2149.	1976	21	0.1 - 0.6 MeV	

$^{10}B(n,\alpha_1)$

Set	Reference	Year	Data Values	Energy Range	Comments
107	D. O. Nellis et al., Phys. Rev. **C1**, p.847.	1970	30	0.05 - 4.9 MeV	
111	R. M. Sealock and J. C. Overley, Phys. Rev. **C13**, p.2149.	1976	22	0.34 - 0.86 MeV	

$^{10}B(n,n)$

Set	Reference	Year	Data Values	Energy Range	Comments
167	F. P. Mooring et al., Nucl. Phys. **82**, p.16.	1966	53	0.01 - 0.5 MeV	
178	A. Asami and M. C. Moxon, Harwell Report AERE-R-5980, also J. Nucl. Energy **24**, p.85.	1969	30	0.5 - 130 keV	
170	R. O. Lane et al., Phys. Rev. **C4**, p. 380.	1971	63	0.075 - 2.2 MeV	Not used for GMA but included in the EDA fit.
175	H. B. Willard et al., Phys. Rev. **98**, p.669.	1955	3	0.55 - 1.5 MeV	

$^{197}Au(n,\gamma)$

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
332	K. K. Harris et al., Nucl. Phys. **69**, p.37.	1965	15	0.013 - 0.68 MeV	
704	N. E. Holden, Brookhaven National Lab. Report BNL-NCS-51388.	1981	1	Thermal	Pre-evaluated value used as input for simultaneous evaluation. Note that the thermal capture cross section has been used in the evaluation of the thermal constants and it was assumed to be constant.
358 359	W. P. Poenitz, J. Nucl. Energy **A/B20**, p.825.	1966	1 2	30 keV 30, 64 keV	

344	S. Joly et al., Nucl. Sci. Eng. **70**, p.53.	1979	5	0.5 - 3.0 MeV	
342 343	C. Le Rigoleur et al., Saclay Report CEA-R-4788.	1976	29 37	0.017 - 0.16 MeV 0.08 - 0.54 MeV	
345	E. Fort and C. Le Rigoleur, Conf. on Nucl. Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, p. 957.	1975	9	0.12 - 0.5 MeV	
348	A. N. Davletshin et al., Sov. J. At. Energy **65**, p. 913.	1988	15	0.17 - 1.2 MeV	New data added to the file.
347	A. N. Davletshin et al., At. Energ. **58**, p.183.	1985	19	0.16 - 1.14 MeV	New data added to the file based on corrected values given in the ref. of data set 348.
350	A. N. Davletshin et al., Sov. J. Atomic Energy **48**, p.97.	1980	8	0.35 - 1.4 MeV	Data replaced with corrected values given in the ref. of set 348.
452	S. Sakamoto et al., Nucl. Sci. Eng. **109**, 215.	1991	2	23, 967 keV	New data added to the file.
355	A. T. G. Ferguson and E. B. Paul, J. Nucl. Energy **A10**, p.19.	1959	3	0.15 - 1.0 MeV	
335	L. W. Weston and W. S. Lyon, Phys. Rev. **123**, p.948.	1961	2	30, 64 keV	
311	W. P. Poenitz, Nucl. Sci. Eng. **57**, p.300.	1975	1	1 MeV	

330	H. W. Schmitt and C. W. Cook, Nucl. Phys. **20**, p.202.	1960	1	22 keV	Monte Carlo Re-interpretations by F. Froehner, Conf. on Nucl. Data for Reactors, Vienna, Vol. **1**, p.197 (1970), and by T. T. Semler, private communication (1972) have been used.
337 338	A. Paulsen et al., Atomkernenergie **26**, p.80.	1975	14 5	0.2 - 2.5 MeV 2 - 3 MeV	
370	Chen Ying et al., Conf. on Nucl. Data for Science and Technology, Antwerp, p.462, also Chin. J. Nucl. Phys. **3**, p.52.	1981	4	0.46 - 1.5 MeV	
372	Shengyun et al., Chin. J. Nucl. Phys. **6**, p.1.	1984	1	30 keV	
367	T. B. Ryves et al., J. Nucl. Energy **23**, p.205, and **25**, p.557.	1971	2	22, 970 keV	See also J. Nucl. Energy **20**, p.249 (1966).
315	H. A. Hussain and S. E. Hunt, Int'l J. Appl. Radiat. Isot. **34**, p.731.	1983	7	2.1 - 3.6 MeV	

$^{238}U(n,\gamma)$

Set	Reference	Year	Data Values	Energy Range	Comments
480	G. DeSaussure et al., Oak Ridge National Lab. Report ORNL/TM-6152.	1978	12	0.15 - 3.5 keV	
705	W. P. Poenitz, Pre-evaluated value at thermal energy.	1984	1	Thermal	
464	Yu. G. Panitkin and L. E. Sherman, Sov. J. Atomic Energy **39**, p.591.	1975	1	30 keV	
420	H. O. Menlove and W. P. Poenitz, Nucl. Sci. Eng. **33**, p.24.	1968	1	30KeV	
428	C. Le Rigoleur et al., Conf. on Nucl. Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **II**, p.953.	1975	25	0.017 - 0.53 MeV	
453	E. Quang and G. F. Knoll, Nucl. Sci. Eng. **119**, p. 282.	1992	2	23, 967 keV	New data added to the file.
436	A. N. Davletshin et al., Sov. J. Atomic Energy **48**, p.97.	1980	15	0.35 - 1.4 MeV	Data replaced with corrected values given in Sov. J. At. Energy **65**, 920 (1988).
432	K. Dietze, Zentralinst. f. Kernforsch. Report, Rossendorf, ZFK-341.	1977	20	0.25 - 30 keV	

435	T. S. Belanova et al., J. Nucl. Energy **A/B20**, p.411	1966	1	22 keV	The value from the Monte Carlo reinterpretation by L. B. Miller and W. P. Poenitz, NSE **35**, 295(1977), and by K. Dietze (see set 432) was used.
438	Yu. Ya. Stavisskii et al., At. Energia **20**, p.431.	1966	1	22 keV	

^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
643	Li Jingwen et al., Conf. on Nucl. Data for Science and Technology, Antwerp, p.55.	1982	1	14.7 MeV	
645	Li Jingwen et al., Int. Nucl. Data Comm. Doc. INDC(CPR)-009/L.	1986	1	14.2 MeV	
564	M. C. Davis et al., Annals Nucl. Energy **5**, p.569.	1978	4	0.14 - 0.96 MeV	
567	R. K. Smith et al., private communication by G. Hansen, Los Alamos National Lab.	1975	27	2.2 - 20 MeV	
570	O. A. Wasson et al., Nucl. Sci. Eng. **81**, p.196.	1981	37	0.24 - 1.2 MeV	

523	A. D. Carlson et al., Meeting on Nucl. Standard Reference Data, Geel, IAEA-TECDOC-335, p.162.	1984	67	0.3 - 2.8 MeV	
518	G. F. Knoll and W. P. Poenitz, J. Nucl. Energy **21**, p.643.	1967	1	30 keV	
522	N. N. Buleeva et al., Sov. J. At. Energy **65**, p. 920.	1988	13	0.62 - 0.78 MeV	New data added to the file.
520	K. Kari, Kernforsch. Zentr. Karlsruhe Report KFK-2673	1978	121	1.0 - 20 MeV	
581	F. Kaeppeler, Kernforsch. Zentr. Karlsruhe report KFK-1772.	1973	7	0.55 - 1.2 MeV	
580	D. M. Barton et al., Nucl. Sci. Eng. **60**, p.369.	1976	41	1.0 - 6.0 MeV	
499 500 501 502	P. H. White, J. Nucl. Energy **A/B19**, p.325.	1965	8 3 2 1	0.04 - 0.51 keV 0.51 - 2.2 MeV 2.2 - 5.4 MeV 14 MeV	
725	J. L. Perkin et al., J. Nucl. Energy **A/B19**, p.423.	1965	1	22 keV	
503	I. Szabo et al., Symp. on Neutron Standards and Flux Normalization, Argonne Nat'l Lab., AEC Symposium Series 23, p. 257.	1970	31	0.017 - 1.0 MeV	Data finalized at the Conf. on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab. Report ANL-76-90, p.208.

504	I. Szabo et al., Conf. on Neutron Cross Sections and Technology, Knoxville, CONF-710301, p.573.	1971	15	0.011 - 0.3 MeV	See comment for set 503 above.
505	I. Szabo et al., Conf. on Neutron Physics, Kiev, Vol. **3**, p.27.	1973	35	0.017 - 2.6 MeV	See comment for set 503 above.
506	I. Szabo et al., Conf. on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab. Report ANL-76-90, p.208.	1976	13	2.3 - 5.5 MeV	
596	M. Cancé and G. Grenier, Nucl. Sci. Eng. **68**, p.197.	1978	2	13.9, 14.6 MeV	
597	M. Cancé and G. Grenier, Saclay Report CEA-N-2194.	1981	2	2.5, 4.5 MeV	
598	M. Cancé and G. Grenier, private communication.	1983	1	2.5 MeV	
599	O. A. Wasson et al., Nucl. Sci. Eng. **80**, p.282.	1982	1	14.1 MeV	

591 592 593 590 587	K. Merla et al., Conf. on Nucl. Data for Science and Technology, Jülich, p.510.	1983 1984 1985	1 1 1 1 1	2.6 MeV 8.5 MeV 14.7 MeV 4.5 MeV 18.8 MeV	The data are from a collaboration between the Technical Univ. of Dresden and the Chlopin Radium Inst. of Leningrad. The given Ref. contains the latest revised values. Data available for the ENDF/B-6 evaluation were from V. N. Dushin et al., Meeting on the ^{235}U Fast-Neutron Fission Cross Section, Smolenice, p.53., R. Arlt et al., Meeting on Nucl. Standard Reference Data, Geel, IAEA-TECDOC-335, p.174, and C. M. Herbach et al., Tech. Univ. Dresden Report INDC/GDR/37/G. Two data values (at 14.0 and 14.5 MeV) have been removed, as Merla does not provide corrected values.
554 555	W. P. Poenitz, Nucl. Sci. Eng. **64**, p.894.	1977	45 18	0.19 - 4.4 MeV 4.4 - 8.3 MeV	
557 558 560 561	W. P. Poenitz, Nucl. Sci. Eng. **53**, p.370.	1974	1 1 1 6	0.8 MeV 3.5 MeV 0.5 MeV 0.45 - 0.64 MeV	

528	K. Yoshida et al., Tohoku Univ. Report NETU-44, p.30.	1983	3	13.5 - 15.0 MeV	
738	Yan Wuguang et al., At. En. Sci. Tech. **2**, p.1.	1975	2	0.5, 1.0 MeV	
525	E. A. Schagrov et al., Conf. on Neutron Physics, Kiev, Vol. 3, p.45.	1980	2	0.046, 0.12 MeV	
573	B. C. Diven, Phys. Rev. **105**, p.1350.	1957	1	1.3 MeV	
735	W. D. Allen and A. T. G. Ferguson, Proc. Phys. Soc. **LXX**, p.573.	1957	2	0.55, 1.8 MeV	
878	I. M. Kuks et al., Conf. on Neutron Physics, Kiev, Vol.**4**, p.18.	1973	1	2.5 MeV	
919	E. J. Axton, Ref. 9.	1986	1	Thermal	This value is part of the evaluation of the thermal constants.
526	C. A. Uttley and J. A. Phillips, Harwell Report AERE-NP/R1996.	1956	1	14 MeV	
584	A. Moat, private communication to J. Nucl. Energy **A/B14**, p.85.	1958	1	14 MeV	

^{238}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
850	Wu Jingxia et al., Chinese J. Nucl. Phys. **5**, p.158.	1983	4	4.0 - 5.5 MeV	
648	R. K. Smith et al., private communication by G. Hanson, Los Alamos Nat'l Lab., 1975.	1956	43	1.0 - 22 MeV	
809	G. Winkler et al., Conf. on Nuclear Data for Science and Technology, Jülich, p. 514.	1991	1	14.5 MeV	New data added to the file.
812	M. Cancé and G. Grenier, Nucl. Sci. Eng. **68**, p.197.	1978	2	13.9, 14.6 MeV	
811	K. Merla et al., Conf. on Nucl. Data for Science and Technology, Jülich, p.510.	1983	1	14.7 MeV	See comment for set 591 (for ^{235}U(n,f)). Only the 14.7 MeV value was available for the ENDF/B-VI evaluation. Four more values are given in this Ref.
810	K. Merla et al., Conf. on Nucl. Data for Science and Technology, Jülich, p. 510.	1991	4	4.8 - 18.8 MeV	New data added to the file.
857	K. Yoshida et al., Tohoku Univ. Report NETU-44, p.30.	1983	3	13.5 - 15.0 MeV	

877	I. M. Kuks et al., At. Energia **30**, p.55.	1971	1	2.5 MeV	
869	C. A. Uttley and J. A. Phillips, Harwell Report AERE-NP/R1996.	1956	1	14 MeV	
860	N. N. Flerov et al., At. Energ. **5**, p.657.	1958	1	15 MeV	
861	A. Moat, private communication to J. Nucl. Energy **A/B14**, p.85.	1958	1	14 MeV	

^{239}Pu(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
644	Li Jingwen et al., Conf. on Nucl. Data for Science and Technology, Antwerp, p.55.	1982	1	14.7 MeV	
521	K. Kari, Kernforsch. Zentr. Karlsruhe Report KFK-1772.	1978	169	0.99 - 21 MeV	
619	J. L. Perkin et al., J. Nucl. Energy **A/B19**, p.423.	1965	1	22 keV	
620	I. Szabo et al., Symp. on Neutron Standards and Flux Normalization, Argonne Nat'l Lab., p.257.	1970	21	0.035 - 0.97 MeV	Data finalized at the Conf. on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab. Report ANL-76-90, p.208.

621	I. Szabo et al., Conf. on Neutron Cross Sections and Technology, Knoxville, CONF-710301, p.573.	1971	15	0.011 - 0.20 MeV	See comment for set 620 above.
622	I. Szabo et al., Conf. on Neutron Physics, Kiev, Vol. **3**, p.27.	1973	20	0.81 - 2.6 MeV	See comment for set 620 above.
623	I. Szabo et al., Conf. on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab. Report ANL-76-90, p.208.	1976	13	2.5 - 5.5 MeV	
612	M. Cancé and G. Grenier, Nucl. Sci. Eng. **68**, p.197.	1978	2	13.9, 14.6 MeV	
611 617 615 616	K. Merla et al., Conf. on Nucl. Data for Science and Technology, Jülich, p.510. (1991).	1983 1983 1985 1985	1 1 1 1	14.7 MeV 8.65 MeV 4.9 MeV 18.8 MeV	See comments for $^{235}U(n,f)$ set 591.
672	W. D. Allen and A. T. G. Ferguson, Proc. Phys. Soc. **LXX**, p.573.	1957	2	0.55, 1.5 MeV	
925	E. J. Axton, Ref. 9.	1986	1	Thermal	This value is part of the evaluation of the thermal constants.
628	C. A. Uttley and J. A. Phillips, Harwell Report AERE-NP/R1996.	1956	1	14 MeV	

657	A. Moat, private communication to J. Nucl. Energy **A/B14**, p.85.	1958	1	14MeV	

Cross Section Shape Data

^{6}Li(n,t)

Set	Reference	Year	Data Values	Energy Range	Comments
226	H. Condé, Conf. on Nucl. Data for Science and Technology, Antwerp, p.447.	1982	16	0.24 - 2.8 MeV	
202	C. Renner, Thesis, Univ. of Sao Paulo, Brasil.	1978	12	0.081 - 0.47 MeV	Data not used for GMA but included in the EDA fit.
280 281	P. J. Clements and I. C. Rickard, Harwell Report AERE-R7075.	1972	20 25	0.16 - 0.64 MeV 0.33 - 2.4 MeV	
290 291 292	E. Fort and J. P. Marquette, Euro.-Amer. Nucl. Data Committee Doc. EANDC(E)-148"U".	1972	25 20 73	0.014 - 0.17 MeV 0.021 - 0.17 MeV 0.12 - 1.7 MeV	^{6}Li content problem of sample remained unresolved, therefore data were taken as shape data. Increased uncertainty due to flux as changes for fission cross sections were not made for ^{6}Li.
294	E. Fort, Conf. on Nucl. Data for Reactors, Helsinki, Vol. I, p.252.	1970	40	0.082 - 0.52 MeV	See comment for set 290 above.
246	S. J. Friesenhahn et al., Intelcom Radiation Technology Report INTEL-RT7011-001.	1974	151	0.0024 - 1.7 MeV	

205	M. S. Coates et al., Panel on Neutron Standard Reference Data, Vienna, STI/PUB/371, p.105.	1972	170	0.001 - 0.4 MeV	

^{10}B(n,α_0)

Set	Reference	Year	Data Values	Energy Range	Comments
126	R. L. Macklin and J. H. Gibbons, Phys. Rev. **165**, p.1147.	1968	16	0.03 - 0.52 MeV	Data not used for GMA but included in the EDA fit.

^{10}B(n,α_1)

Set	Reference	Year	Data Values	Energy Range	Comments
105	R. A. Schrack et al., Nucl. Sci. Eng. **68**, p.189.	1978	36	0.005 - 0.63 MeV	
347	R. A. Schrack et al., Nucl. Sci. Eng. **114**, p. 352.	1993	65	0.2 - 4.0 MeV	New data added to the file.
103	S. J. Friesenhahn et al., Intelcom Radiation Technology Report INTEL-RT7011-001.	1974	56	0.02 - 0.98 MeV	
135 136 137	G. Viesti and H. Liskien, Annals Nucl. Energy **6**, p.13.	1979	7 11 16	0.098 - 0.69 MeV 0.29 - 1.4 MeV 0.51 - 2.2 MeV	Data not used for GMA but included in the EDA fit.

128	M. S. Coates et al., Panel on Neutron Standard Reference Data, Vienna, STI/PUB/371, p.129.	1972	95	0.001 - 0.30MeV	

^{197}**Au(n,γ)**

Set	Reference	Year	Data Values	Energy Range	Comments
360	W. P. Poenitz et al., J. Nucl. Energy **22**, p.505.	1968	22	0.025 - 0.47 MeV	
301	M. P. Fricke et al., Conf. on Nuclear Data for Reactors, Helsinki, STI/PUB/259, Vol. **2**, p.265.	1970	20	0.069 - 1.1 MeV	
310	W. P. Poenitz, Nucl. Sci. Eng. **57**, p.300.	1975	18	0.40 - 3.5 MeV	
371	Chen Ying et al., Conf. on Nuclear Data for Science and Technology, Antwerp, p.462, also Chinese J. Nucl. Phys. **3**, p.52 (1981).	1982	6	0.13 - 0.90 MeV	

^{238}U(n,γ)

Set	Reference	Year	Data Values	Energy Range	Comments
421	H. O. Menlove and W. P. Poenitz, Nucl. Sci. Eng. **33**, p.24.	1968	9	0.024 - 0.50 MeV	

401	M. P. Fricke et al., Conf. on Neutron Cross Sections and Technology, Knoxville, CONF-710301, Vol. **1**, p.252.	1971	21	0.08 - 0.75MeV	
455	T. B. Ryves, J. Nucl. Energy **27**, p.519.	1973	5	0.025eV - 0.62MeV	

^{235}U(n,f)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
586	O. A. Wasson, Nucl. Sci. Eng. **81**, p.196.	1982	22	0.0055 - 0.75 MeV	
588	D. B. Gayther, Conf. on Neutron Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **2**, p.564.	1975	27	0.0015 - 0.95 MeV	
582	F. Kaeppeler, Kernforschungs-Zentrum Karlsruhe Report KFK 1772.	1973	13	0.51 - 1.2 MeV	
508 509	A. D. Carlson and B. H. Patrick, Conf. on Neutron Physics and Nucl. Data for Reactors and Other Applied Purposes, Harwell, p.880.	1978	13 29	1.2 - 3.1 MeV 2.8 - 6.2 MeV	
524	A. D. Carlson et al., Conf. on Nucl. Data for Science and Technology, Jülich, p. 518.	1991	44	3.0 - 30.0 MeV	New data set added to the file.

510	J. B. Czirr and G. S. Sidhu, Nucl. Sci. Eng. **57**, p.18.	1975	61	3.0 - 20.0 MeV	
511	J. B. Czirr and G. S. Sidhu, Nucl. Sci. Eng. **58**, p.371.	1975	27	0.75 - 4.1 MeV	
553	W. P. Poenitz, Nucl. Sci. Eng. **64**, p.894.	1977	10	0.22 - 0.31 MeV	
556 559	W. P. Poenitz, Nucl. Sci. Eng. **53**, p.370.	1974	39 52	0.4 - 2.8 MeV 0.035 - 3.5 MeV	
572	B. C. Diven, Phys. Rev. **105**, p.1350.	1957	14	0.40 - 1.6 MeV	
568	W. D. Allen and A. T. G. Ferguson, Proc. Phys. Soc. **LXX**, p.573.	1957	24	0.03 - 3.0 MeV	
721	V. M. Pankratov et al., J. Nucl. Energy **16**, p.494.	1962	16	10.5 - 21.4 MeV	
722	V. M. Pankratov, Sov. J. At. Energy **14**, p.167.	1964	35	6.1 - 25.7 MeV	

^{238}U(n,f)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
835	B. Adams et al., J. Nucl. Energy A/B **14**, p.85.	1961	14	13.0 - 19.0MeV	
839	P. E. Vorotnikov et al., Int'l Nucl. Data Com. Report INDC(CCP)-66, p. 6.	1975	71	0.16 - 1.6MeV	

873	V. M. Pankratov et al., J. Nucl. Energy **16**, p.496.	1962	16	10.5 - 21.4 MeV	
874	V. M. Pankratov et al., Sov. J. At. Energy **14**, p.167.	1964	35	5.1 - 37.0 MeV	
875	P. Kalinin and V. M. Pankratov, Conf. on the Peaceful Uses of Atomic Energy, Geneva, Vol. **16**, p.136.	1962	7	3.1 - 6.4 MeV	
881	M. Mangialajo et al., Nucl. Phys. **43**, p.124.	1963	8	14.0 - 15.0 MeV	

^{239}Pu(n,f)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
589	D. B. Gayther, Conf. on Neutron Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. 2, p.564.	1975	29	0.0015 - 0.95 MeV	
671	W. D. Allen and A. T. G. Ferguson, Proc. Phys. Soc. **LXX**, p.573.	1957	22	0.03 - 3.0 MeV	

Absolute Cross Section Ratios

$^{10}B(n,\alpha_0)/^{10}B(n,\alpha_1)$

Set	Reference	Year	Data Values	Energy Range	Comments
142	M. L. Stelts et al., Phys. Rev. **C19**, p.1159.	1979	3	0.025 eV - 0.024 MeV	Data not used for GMA but included in the EDA fit.
706	W. P. Poenitz, Meeting on Nuclear Standard Reference Data, Geel, IAEA-TECDOC-335, p.112.	1984	1	Thermal	This is a pre-evaluated value based on the data in the given reference.
122	E. A. Davis et al., Nucl. Phys. **27**, p.448.	1961	81	0.22 - 7.6 MeV	
104	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **109**, p. 113.	1991	25	0.02 - 0.96 MeV	New data added to the file.
125	R. L. Macklin and J. H. Gibbons, Phys. Rev. **165**, p.1147.	1968	8	0.025 eV - 0.51 MeV	Data not used for GMA but included in the EDA fit.
149	R. L. Macklin and J. H. Gibbons, Phys. Rev. **B140**,p.324.	1965	9	0.025 eV - 0.7 MeV	
145	G. P. Lamaze et al., Nucl. Sci. Eng. **56**, p.94.	1975	1	0.79 MeV	
162 163	B. Petree et al., Phys. Rev. **83**, p.1148.	1951	9 10	0.025 eV - 1.3 MeV 0.95 - 2.6 MeV	

^{197}Au(n,γ)/^{6}Li(n,t)

Set	Reference	Year	Data Values	Energy Range	Comments
312	R. L. Macklin et al., Phys. Rev. **C11**, p.1270.	1975	54	0.015 - 0.55 MeV	
313	R. L. Macklin, Nucl. Sci. Eng. **79**, p.265.	1981	16	0.1 - 1.9 MeV	

^{197}Au(n,γ)/^{10}B(n,α_1)

Set	Reference	Year	Data Values	Energy Range	Comments
380	K. Rimawi and R. E. Chrien, Conf. on Neutron Cross sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol **2**, p.920.	1975	1	0.024 MeV	
340	N. Yamamuro et al., J. Nucl. Sci. Tech. (Japan) **20**, p.797.	1983	1	Thermal	

^{197}Au(n,γ)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
314	R. L. Macklin, Nucl. Sci. Eng. **79**, p.265.	1981	62	0.1 - 1.9 MeV	
302	M. Lindner et al., Nucl. Sci. Eng. **59**, p.381.	1976	23	0.12 - 2.7 MeV	

331	H. A. Grench et al., European-American Nucl. Data Committee Report EANDC-79, also private communication.	1965	12	0.14 - 1.2 MeV	
519	G. F. Knoll and W. P. Poenitz, J. Nucl. Energy **A/B21**, p.64.	1967	2	30, 64 keV	
349	A. N. Davletshin et al., Sov. J. At. Energy **65**, p. 913.	1988	11	0.62 - 0.78 MeV	New data added to the file.
320	J. F. Barry, J. Nucl. Energy **A/B18**, p.491.	1964	11	0.13 - 1.8 MeV	
363	P. Anderson et al., Nucl. Phys. **A443**, p.404.	1985	5	2.0 - 2.9 MeV	The original measurements were relative to the capture cross section of indium. Measurements by D. L. Smith and J. W. Meadows were used to convert to the present ratio.

^{235}U(n,f)/^{10}B(n,α_1)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
540	A. V. Mursin et al., Conf. on Neutron Physics, Kiev, Vol. **2**, p.257.	1980	1	24 keV	

$^{238}U(n,\gamma)/^{6}Li(n,t)$

Set	Reference	Year	Data Values	Energy Range	Comments
482 483	L. E. Kazakov et al., Yadern. Konst. **3**, no. 3, p.37.	1986	33 33	0.0045 - 0.125 MeV 0.0045 - 0.125 MeV	Uncertainty information updated based on available English and German translations of the original Russian paper.

$^{238}U(n,\gamma)/^{10}B(n,\alpha_1)$

Set	Reference	Year	Data Values	Energy Range	Comments
440	K. Rimawi and R. E. Chrien, Conf. on Neutron Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **2**, p.920.	1975	1	0.024 MeV	
450	M. C. Moxon, Harwell Report AERE-R6074	1971	23	0.55 keV - 0.095 MeV	
446	Yu. V. Adamchuk et al., Sov. J. At. Energy **65**, p. 930.	1988	22	0.1 - 50.0 keV	New data added to the file.
445	Yu. V. Adamchuk et al., Conf. on Neutron Phys., Kiev, Vol. **2**, p.192.	1977	19	0.25 keV - 0.025 MeV	
471	B. L. Quan and R. C. Block, AEC Report COO-2479-14.	1976	6	0.024 - 0.18 MeV	

$^{238}U(n,\gamma)/^{197}Au(n,\gamma)$

Set	Reference	Year	Data Values	Energy Range	Comments
441	K. Rimawi and R. E. Chrien, Conf. on Neutron Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **2**, p.920.	1975	1	0.024 MeV	
461	W. P. Poenitz et al., Nucl. Sci. Eng. **78**, p.239.	1981	3	0.025 eV - 0.5 MeV	
437	N. N. Buleeva et al., Sov. J. At. Energy **65**, p.920.	1988	2	0.62, 0.78 MeV	New data added to the file.
346	L. E. Kazakov et al., Jadernye Konstanty Vol. 3.	1986	56	0.004 - 0.42 MeV	New data added to the file.
412	W. P. Poenitz, Nucl. Sci. Eng. **57**, p.300.	1975	54	0.02 - 1.2 MeV	
419	H. O. Menlove and W. P. Poenitz, Nucl. Sci. Eng. **33**, p.24.	1968	1	30 keV	
470	R. C. Block et al., Conf. on New Developments in Reactor Physics and Shielding, Kiamesha Lake, CONF-720901, Vol. **2**, p.1107.	1972	1	24 keV	
430 431	K. Wisshak and F. Kaeppeler, Nucl. Sci. Eng. **66**, p.363.	1978	19 20	0.016 - 0.071 MeV 0.020 - 0.072 MeV	

^{238}U(n,γ)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
460	W. P. Poenitz et al., Nucl. Sci. Eng. **78**, p.239.	1981	17	0.03 - 3.0 MeV	
406	W. P. Poenitz, Nucl. Sci. Eng. **40**, p.383.	1970	5	0.03 - 0.9 MeV	
443	N. N. Buleeva et al., Sov. J. At. Energy **65**, p. 920.	1988	2	0.62, 0.78 MeV	New data added to the file.
415	J. F. Barry et al., J. Nucl. Energy **A/B18**, p.481.	1964	13	0.13 - 7.6 MeV	
410	W. Lindner et al.,Nucl. Sci. Eng. **59**, p.381.	1976	23	0.12 - 2.7 MeV	
478	G. DeSaussure and L. W. Weston, Oak Ridge Nat'l Lab. Report ORNL-3360, p.51.	1963	2	30, 64 keV	

^{238}U(n,γ)/^{239}Pu(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
407	W. P. Poenitz, Nucl. Sci. Eng. **40**, p.383.	1970	5	0.40 - 1.4 MeV	

^{238}U(n,f)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
853	A. A. Goverdovskii et al., Conf. on Neutron Physics, Kiev, Vol. **2**, p.159.	1983	27	5.4 - 10.0 MeV	
854	A. A. Goverdovskii et al., Sov. J. At. Energy **56**, p.173.	1984	5	14 - 15 MeV	
863	I. Garlea et al., Int'l Nucl. Data Committee Report INDC(ROM)-15	1983	1	14.75 MeV	
646	Li Jingwen et al., Int'l Nucl. Data Comm. Report INDC(CPR)-009/L.	1986	1	14.7 MeV	
816 817 818	W. P. Poenitz and R. J. Armani, J. Nucl. Energy **26**, p.483.	1972	1 1 1	2.5 MeV 2.5 MeV 2.5 MeV	
844	B. I. Fursov et al., At. Energ. **43**, p.181.	1977	4	1.5 - 3.0 MeV	
805	J. W. Behrens and G. W. Carlson, Nucl. Sci. Eng. **63**, p.250.	1977	152	0.14 - 29 MeV	
803	J. W. Meadows, Argonne Nat'l Lab. Report ANL/NDM-83.	1983	69	0.9 - 10 MeV	
865	J. W. Meadows, Argonne Nat'l Lab. Report ANL/NDM-97.	1986	1	14.7 MeV	

815	P. H. White and G. P. Warner, J. Nucl. Energy **21**, p.671.	1967	3	2.2 - 14 MeV	
808	F. C. Difilippo et al., Nucl. Sci. Eng. **68**, p.43.	1978	149	0.15 - 24 MeV	
821	R. W. Lamphere, Phys. Rev. **104**, p.1654.	1956	90	0.42 - 3.0 MeV	
822	W. E. Stein et al., Conf. on Nuclear Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 299, Vol. **1**, p.627.	1968	14	1.5 - 5.0 MeV	
832	M. Cancé and G. Grenier, Meeting on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab., ANL-76-90, p.141.	1976	9	2.6 - 7.0 MeV	
856	F. Manabe et al., Tohoku Univ. Report NETU-47.	1986	4	13 - 15 MeV	
855	G. A. Jarvis et al., Los Alamos Nat'l Lab. Report LA-1571.	1953	1	2.5 MeV	
848	M. Varnagy and J. Csikai, Nucl. Instr. and Methods **196**, p.465.	1982	6	14 - 15 MeV	
870	A. A. Berezin et al., At. Energ. **5**, p.659.	1958	1	14.7 MeV	
871	R. H. Iyer and R. Sampathkumar, Conf. on Nucl. Phys. and Solid State Phys., Roorkee, Vol. **2**,p.289.	1969	1	14 MeV	

859	O. Sato et al., Tohoku Univ. Report NETU-41, p.33.	1982	4	4.6 - 6.1MeV	
830	C. Nordborg et al., Meeting on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab., ANL-76-90, p.128.	1976	23	4.7 - 8.9MeV	

^{239}Pu(n,f)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
633	I. Garlea et al., Int'l Nucl. Data Comm. Report INDC(ROM)-15.	1983	1	14.7 MeV	See also Rev. Roumaine Phys. **26**, p.643.
637	M. Mahdavi et al., Conf. on Nucl. Data for Science and Technology, Antwerp, p.58.	1982	1	14.7 MeV	
653	B. I. Fursov et al., At. Energ. **43**, p.261.	1977	13	0.13 - 7.0 MeV	
600	G. W. Carlson and J. W. Behrens, Nucl. Sci. Eng. **66**, p.205.	1978	107	0.85 keV - 30 MeV	
602	J. W. Meadows, Argonne Nat'l Lab. Report ANL/NDM-83.	1983	75	Thermal - 9.9 MeV	
685	J. W. Meadows, Argonne Nat'l Lab. Report ANL/NDM-97.	1986	1	14.7 MeV	

605	E. Pfletschinger and F. Kaeppeler, Nucl. Sci. Eng. **40**, p.375.	1070	48	5.2 keV - 1.0 MeV	
626	W. P. Poenitz, Nucl. Sci. Eng. **40**, p.383.	1970	11	0.15 - 1.4 MeV	
608	P. H. White et al., Conf. on Physics and Chemistry of Fission, Salzburg, Vol. **I**, p.219.	1965	5	0.04 - 0.51 MeV	
609	P. H. White and G. P. Warner, J. Nucl. Energy **21**, p.671.	1967	4	1.0- 14 MeV	
631	K. D. Zhuravlev et al., At. Energ. **42**, p.56.	1977	5	Thermal - 0.14 MeV	Eng. Trans. in Sov. J. At. En. **42**, p.62.
666	M. Varnagy and J. Csikai, Nucl. Instr. and Methods **196**, p.465.	1982	6	14 - 15 MeV	
668	R. H. Iyer and R. Sampathkumar, Conf. on Nucl. Physics and Solid State Physics, Roorkee, Vol **2**, p.289.	1969	1	14 MeV	

Cross Section Ratio Shape Data

^{6}Li(n,α)/^{10}B(n,α_1)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
132	M. G. Sowerby et al., J. Nucl. Energy **24**, p.323.	1970	48	0.52 keV - 0.074 MeV	

^{6}Li(n,α)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
270	J. B. Czirr and G. S. Sidhu, Nucl. Sci. Eng. **60**, p.383.	1976	16	0.085 - 0.67 MeV	
250	W. P. Poenitz and J. W. Meadows, Unpublished.	1976	28	0.059 - 0.54 MeV	
261	D. B. Gayther, Annals Nucl. Energy **4**, p.515.	1977	112	0.003 - 0.81 MeV	
288	J. F. Barry, Conf. on Neutron Cross Section Technology, Washington, DC, AEC Report CONF-660303, Vol. **2**, p.763.	1966	4	Thermal - 0.1 MeV	
200	R. L. Macklin et al., Nucl. Sci. Eng. **71**, p.205.	1979	106	0.07 - 3.0 MeV	

^{6}Li(n,α)/^{238}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
282	P. J. Clements and I. C. Rickard, Harwell Report AERE-R7075.	1972	23	1.7 - 3.9 MeV	

^{10}B(n,α_0)/^{10}B(n,α_1)

Set	Reference	Year	Data Values	Energy Range	Comments
140 141	M. G. Sowerby, J. Nucl. Energy **20**, p.135.	1966	23 19	26 eV - 0.098 MeV 83 eV - 0.48 MeV	

^{197}Au(n,γ)/^{10}B(n,α_1)

Set	Reference	Year	Data Values	Energy Range	Comments
341	N. Yamamuro et al., J. Nucl. Sci. Tech. (Japan) **20**, p.797.	1983	21	4.5 keV - 0.25 MeV	
352	V. N. Kononov et al., Yad. Fiz. **26**, p.947.	1977	70	0.01 - 0.34 MeV	

^{197}Au(n,γ)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
378	J. B. Czirr and M. L. Stelts, Nucl. Sci. Eng. **52**, p.299.	1973	26	0.89 keV - 0.53 MeV	
325	A. E. Johnsrud et al., Phys. Rev. **116**, p.927.	1959	22	Thermal - 5.4 MeV	

$^{238}U(n,\gamma)/^{10}B(n,\alpha_1)$

Set	Reference	Year	Data Values	Energy Range	Comments
448	K. Kobayashi et al.,Conf. on Nucl. data for Science and Technology, Jülich, p.65.	1991	3	0.024, 0.055, 0.146 keV	New data added to the file.
484 485	L. E. Kazakov et al., Jadernye Konstanty Vol. 3.	1986	42 42	0.03 - 0.46 MeV 0.03 - 0.46 MeV	Data now correctly entered as ratio shape values.
422	N. Yamamuro et al., J. Nucl. Sci. Tech. (Japan) **17**, p.583.	1980	15	4.5 keV - 0.073 MeV	

$^{238}U(n,\gamma)/^{197}Au(n,\gamma)$

Set	Reference	Year	Data Values	Energy Range	Comments
457	R. R. Spencer and F. Kaeppeler, Conf. on Nucl. Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **II**, p.620.	1975	22	0.025 - 0.54 MeV	

$^{238}U(n,\gamma)/^{235}U(n,f)$

Set	Reference	Year	Data Values	Energy Range	Comments
465	Yu. G. Panitkin and V. A. Tolstikov, At. Energ. **33**, p.782.	1972	11	1.2 - 4.0 MeV	

466	Yu. G. Panitkin et al., Conf. on Nucl. Data for Reactors, Helsinki, STI/PUB/259, Vol. **2**, p.57.	1971	21	0.024 - 1.1 MeV	See also Conf. on Neutron Physics, Kiev, Vol. **1**, p.321.
405	W. P. Poenitz, Nucl. Sci. Eng. **40**, p.383.	1970	14	Thermal - 1.4 MeV	
458	R. R. Spencer and F. Kaeppeler, Conf. on Nucl. Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, Vol. **II**, p.620.	1975	20	0.025 - 0.54 MeV	
425	G. A. Linenberger et al., Los Alamos Nat'l Lab. Report LA-179.	1944	13	Thermal - 1.3 MeV	

^{235}U(n,f)/^{6}Li(n,α)

Set	Reference	Year	Data Values	Energy Range	Comments
244	J. R. Lemley et al., Nucl. Sci. Eng. **43**, p.281.	1971	16	Thermal - 0.095 MeV	
531 527	F. Corvi, EURATOM, Central Bureau of Nucl. Measurements, Geel, private communication.	1983	33 10	0.15 keV - 0.13 MeV 9.4 eV - 0.95 keV	
271 272	J. B. Czirr and G. W. Carlson, Nucl. Sci. Eng. **64**, p.892.	1977	11 17	Thermal - 0.95 keV Thermal - 0.073 MeV	
585	O. A. Wasson, Nucl. Sci. Eng. **81**, p.196.	1976	11	9.4 eV - 0.025 MeV	

542	C. Wagemans et al., Conf. on Nucl. Cross Sections for Technology, Knoxville, NBS Spec. Publ. 594, p.961.	1979	3	Thermal - 0.15 keV	
533	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **88**, p.567.	1984	27	0.15 keV - 0.095 MeV	
562	W. P. Poenitz, Nucl. Sci. Eng. **53**, p.370.	1974	10	0.034 - 0.25 MeV	

^{235}**U(n,f)/**^{10}**B(n,α_1)**

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
538	G. W. Muradian et al., Conf. on Neutron Physics, Kiev, Vol. **3**, p.119.	1977	21	0.15 keV - 0.025 MeV	

^{238}**U(n,f)/**^{235}**U(n,f)**

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
845	B. I. Fursov et al., At. Energ. **43**, p.181.	1977	39	0.98 - 7.0 MeV	
819	W. P. Poenitz and R. J. Armani, J. Nucl. Energy **26**, p.483.	1972	3	2.0 - 3.0 MeV	

824	S. Cierjacks et al., Meeting on Fast Neutron Fission Cross Sections, Argonne Nat'l Lab. ANL-76-90, p.94.	1976	91	1.4 - 30 MeV	
826	M. S. Coates et al., Conf. on Nucl. Cross Sections for Technology, Washington, NBS Spec. Publ. 425, Vol.**II**, p.568, also private communication.	1975	224	0.63 - 22 MeV	
828	W. Blons et al., Private communication.	1977	194	0.53 - 4.0 MeV	
836	B. Adams et al., J. Nucl. Energy **14**, p.84.	1961	13	13 - 19 MeV	

^{239}Pu(n,f)/^{6}Li(n,α)

Set	**Reference**	**Year**	**Data Values**	**Energy Range**	**Comments**
547	C. Wagemans et al., Annals Nucl. Energy 7, p.495.	1980	14	Thermal - 4.5 keV	
535	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **88**, p.567.	1984	27	0.15 keV - 0.095 MeV	

^{239}Pu(n,f)/^{235}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
635	W. K. Letho, Nucl. Sci. Eng. **39**, p.361.	1970	27	Thermal - 0.024 MeV	
654	B. I. Fursov et al., At. Energ. **43**, p.261.	1977	79	0.024 - 7.4 MeV	
549	C. Wagemans et al., Annals Nucl. Energy **7**, p.495.	1980	8	0.15 keV - 0.015 MeV	
536	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **84**, p.248.	1983	124	Thermal - 21 MeV	

^{239}Pu(n,f)/^{238}U(n,f)

Set	Reference	Year	Data Values	Energy Range	Comments
837	B. Adams et al., J. Nucl. Energy **14**, p.85.	1961	13	13 - 19 MeV	

Absolute Data of Sums of Cross Sections

^{6}Li(tot)=^{6}Li(n,t)+^{6}Li(n,n)

Set	Reference	Year	Data Values	Energy Range	Comments
214	H. H. Knitter et al., EURATOM Report EUR-5726E.	1977	222	0.078 - 3.0 MeV	

218 219	A. B. Smith et al., Argonne Nat'l Lab. Report ANL/NDM-29.	1977	93 92	0.12 - 0.35 MeV 0.12 - 0.35 MeV	
220 221 222	P. Guenther et al., Argonne Nat'l Lab. Report ANL/NDM-52.	1980	76 60 62	0.55 - 4.7 MeV 0.98 - 4.7 MeV 0.98 - 4.7 MeV	See also Nucl. Phys. **A373**, 305(1982).
235	C. A. Uttley et al., Symp. on Neutron Standards and Flux Normalization, Argonne Nat'l Lab., p.80.	1970	373	0.1 - 0.88 MeV	
257	C. A. Goulding et al., US Nucl. Data Committee Report USNDC-3, p.161.	1972	122	0.71 - 2.0 MeV	
274 275 276 277	J. Harvey and N. Hill, Conf. on Nucl. Cross Sections and Technology, Washington, DC, NBS Spec. Publ. 425, p.244, and private communication.	1975	108 23 23 23	0.063 - 0.54 MeV 0.63 - 2.8 MeV 0.28 - 6.7 keV 0.011 - 0.24 keV	These data were included in the EDA fit and therefore excluded from the GMA fit.
229	J. W. Meadows and J. F. Whalen, Nucl. Sci. Eng. **48**, p.221.	1972	86	0.1 - 1.5 MeV	

$^{10}B(n,\alpha)={}^{10}B(n,\alpha_0)+{}^{10}B(n,\alpha_1)$

Set	Reference	Year	Data Values	Energy Range	Comments
703	J. W. Meadows, Symp. on Neutron Standards and Flux Normalization, Argonne Nat'l Lab., p.129.	1970	1	Thermal	
708	G. H. Debus and P. J. DeBievre, J. Nucl. Energy **21**, p.373.	1967	1	Thermal	Data not used for GMA but included in the EDA fit.
121	E. A. Davis et al., Nucl. Phys. **27**, p.448.	1961	100	0.22 - 7.9 MeV	
115	S. A. Cox and F. R. Pontet, J. Nucl. Energy **21**, p.271.	1966	12	0.011 - 0.25 MeV	

$^{10}B(tot)={}^{10}B(n,\alpha_0)+{}^{10}B(n,\alpha_1)+{}^{10}B(n,n)$

Set	Reference	Year	Data Values	Energy Range	Comments
180	G. F. Auchampaugh et al., Nucl. Sci. Eng. **69**, p.30.	1979	274	1.0 - 14 MeV	
181	N. G. Nereson, Los Alamos Nat'l Lab. Report LA-1655.	1954	26	2.8 - 9.7 MeV	
182	C. K. Bockelman et al.,Phys. Rev. **84**, p.69.	1951	197	0.02 - 3.4 MeV	
183	J. H. Coon et al., Phys. Rev. **88**, p.562.	1952	1	14 MeV	

185	R. L. Becker and H. H. Barschall, Phys. Rev. **102**, p.1384.	1956	67	4.4 - 8.6 MeV	
186	W. Rohrer, private communication, see Ann. Phys. **10**, p.455.	1960	41	3 keV - 0.082 MeV	
187	F. P. Mooring et al., Nucl. Phys. **82**, p.16.	1966	55	0.011 - 0.5 MeV	
188	G. J. Saffort et al., Phys. Rev. **119**, p.1291.	1960	10	0.0046 - 0.1 eV	
189	H. W. Schmitt et al., Nucl. Phys. **17**, p.109.	1960	82	0.019 - 0.04 eV	
191	K. Tsukada and O. Tanaka, unpublished.	1963	59	3.2 - 5.1 MeV	
192 193	R. R. Spencer et al., Nucl. Sci. Eng. **70**, p.98.	1979	52 57	0.093 - 0.29 MeV 0.19 - 0.42 MeV	These data sets were included in the EDA fit and therefore excluded from the GMA fit.
194 195 196	K. M. Diment, Harwell Report AERE-R-5224.	1967	14 52 31	6 keV - 0.027 MeV 0.076 keV - 0.027 MeV 0.03 - 0.95 MeV	These data sets were included in the EDA fit and therefore excluded from the GMA fit.

Shape Data of Sums of Cross Sections

^{10}**B(n,α)**

Set	Reference	Year	Data Values	Energy Range	Comments
100	S. J. Friesenhahn et al., Intelcom Radiation Technology Report INTEL-RT-7011-001.	1974	152	0.0024 - 1.7 MeV	
124	H. Bichsel and T. W. Bonner, Phys. Rev. **108**, p.1025.	1957	98	0.02 - 4.8 MeV	
130	D. Bogart and L. L. Nichols, Nucl. Phys. **A125**, p.463.	1969	27	0.029 - 0.82 MeV	

^{10}**B(tot)**

Set	Reference	Year	Data Values	Energy Range	Comments
190	D. J. Hughes et al., Report WASH-745, p.9.	1958	49	0.054 keV - 0.013 MeV	

Absolute Ratio Data of Cross Section vs. the Sum of Cross Sections

^{197}**Au(n,γ)/**^{10}**B(n,α)**

Set	Reference	Year	Data Values	Energy Range	Comments
265	V. A. Konks et al., Zh. Eksp. Teor. Fiz. **46**, p.80.	1964	3	0.017 - 0.041 MeV	Engl. translation in Sov. Phys. JETP **19**, p.59.

300	M. P. Fricke et al., Conf. on Nuclear Data for Reactors, Helsinki, STI/PUB/259, Vol. **2**, p.265.	1970	33	0.01 - 0.084 MeV	
304 305	R. Gwin et al.,Nucl. Sci. Eng. **59**, p.79.	1976	4 4	0.015 - 0.045 MeV 0.015 - 0.045 MeV	

^{238}U(n,γ)/^{10}B(n,α)

Set	Reference	Year	Data Values	Energy Range	Comments
408	G. DeSaussure et al., Nucl. Sci. Eng. **51**, p.385.	1973	27	0.15 keV - 0.095 MeV	
423	N. Yamamuro et al., J. Nucl. Sci. Technology (Japan) **15**, p.637.	1978	1	24 keV	
400	M. P. Fricke et al., Conf. on Neutron Cross Sections and Technology, CONF-710301, Vol. **1**, p.252.	1971	16	1.5 keV - 0.075 MeV	
475	Yu. Ya. Stavisskii et al., Int'l Nucl. Data Committee Report INDC(CCP)-43/L, p.225.	1972	23	1.1 keV - 0.03 MeV	

Shape Ratio Data of Cross Section vs. the Sum of Cross Sections

^{6}Li(n,t)/^{10}B(n,α)

Set	Reference	Year	Data Values	Energy Range	Comments
297	C. Bastian and H. Riemenschneider, Meeting on Nuclear Standard Reference Data, Geel, IAEA-TECDOC-335, p.118.	1984	101	2.7 eV - 0.4 MeV	
120	J. B. Czirr and A. D. Carlson, Conf. on Nucl. Cross Sections for Technology, Knoxville, NBS Spec. Publ. 594, p.84.	1979	17	1.1 eV - 0.79 keV	
131	M. J. Sowerby et al., J. Nucl. Energy **24**, p.323.	1970	34	0.01 - 1.2 keV	
160	A. A. Bergman et al., Zh. Eksp. Teor. Fiz. **33**, p.9.	1957	39	9 eV - 2.6 keV	Engl. translation in Sov. Phys. JETP **6**, p.6.

^{235}U(n,f)/^{10}B(n,α)

Set	Reference	Year	Data Values	Energy Range	Comments
732	C. D. Bowman	1963	2	Thermal, 9.4 eV	
731	A. J. Deruytter and C. Wagemans, J. Nucl. Energy **25**, p.263.	1971	2	Thermal, 9.4 eV	

730	G. DeSaussure et al., Conf. on Nuclear Data for Reactors, Paris, Vol. **II**, p.233.	1966	2	Thermal, 9.4 eV	These values are often quoted as the result of an ORNL/RPI cooperation.
578	See Ref. for set 730 above.	1966	6	0.15 - 4.5 keV	
718	J. Blons, Nucl. Sci. Eng. **51**, p.130.	1973	8	0.15 - 25 keV	
530	T. A. Mostavaya et al., Conf. on Neutron Physics, Kiev, Vol.**3**, p.30.	1980	26	0.15 keV - 0.095 MeV	
710 711 712 713 714	R. Gwin et al., Nucl. Sci. Eng. **88**, p.37.	1984	2 14 14 2 2	Thermal, 9.4 eV Thermal - 0.025 MeV Thermal - 0.025 MeV Thermal, 9.4 eV Thermal, 9.4 eV	
541 543	C. Wagemans et al., Conf. on Nucl. Cross Sections for Technology, Knoxville, NBS Spec. Publ. 594, p.961.	1979	3 20	Thermal - 0.15 keV 0.15 - 25 keV	
544	C. Wagemans and A. J. Deruytter, Annals Nucl. Energy **3**, p.437.	1976	20	0.15 - 25 keV	
545 546	C. Wagemans and A. J. Deruytter, Meeting on Nuclear Standard Reference Data, Geel, IAEA-TECDOC-335, p.156.	1984	20 2	0.15 - 25 keV Thermal, 9.4 eV	

550 552	A. A. Bergman et al., Conf. on Neutron Physics, Kiev, Vol. **3**, p.49.	1980	23 23	Thermal - 0.045 MeV Thermal - 0.045 MeV	
532	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **88**, p.567.	1984	11	Thermal - 0.95 keV	
515	K. D. Zhuravlev et al., At. Energ. **42**, p.56.	1977	5	Thermal - 0.14 MeV	
513	R. B. Perez et al., Nucl. Sci. Eng. **55**, p.203.	1974	17	2.5 - 95 keV	
514	R. B. Perez et al., Nucl. Sci. Eng. **52**, p.46.	1973	18	0.15 - 9.5 keV	
728	A. Michaudon et al., J. Phys. Radium **21**, p429.	1960	6	0.15 - 4.5 keV	
727	Van Shi-di et al., Conf. on Physics and Chemistry of Fission, Salzburg, p.287.	1965	25	0.15 - 25 keV	

^{239}Pu(n,f)/^{10}B(n,α)

Set	Reference	Year	Data Values	Energy Range	Comments
719	J. Blons, Nucl. Sci. Eng. **51**, p.130.	1973	20	0.15 - 25 keV	
548	C. Wagemans et al., Annals Nucl. Energy 7, p.495.	1980	20	0.15 - 25 keV	
551	A. A. Bergman et al., Conf. on Neutron Physics, Kiev, Vol. **3** p.49.	1980	23	Thermal - 45 keV	

534	L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **88**, p.567.	1984	9	0.15 - 0.95 keV	Thermal value eliminated based on NSE**115**, 164 (1993) and NSE**115**, 173 (1993).
715	L. W. Weston and J. H. Todd, Nucl. Sci. Eng **115**, p. 164.	1993	10	Thermal - 1.0 keV	New data added to the file.
630	K. D. Zhuravlev et al., At. Energ. **42**, p.56.	1977	5	Thermal - 0.14 MeV	Engl. translation in Sov. J. At. En. **42**, p.62.
660 661 662 663	Yu. V. Ryabov, At. Energ. **46**, p.154.	1971	27 45 22 38	0.15 - 95 keV 0.15 - 92 keV 0.15 - 12 keV 0.15 - 35 keV	
676	R. Gwin et al., Nucl. Sci. Eng. **61**, p.116.	1976	29	Thermal - 0.15 MeV	
677	L. W. Weston and J. H. Todd, private communication to R. Chrien.	1972	18	0.15 - 9.5 keV	
678	L. Bollinger et al., Conf. on Peaceful Uses of Atomic Energy, Geneva, Vol. **15**, p.127.	1958	18	0.15 - 9.5 keV	
679	G. D. James, Conf. on Nuclear Data for Reactors, Helsinki, STI/PUB/259, Vol. **I**, p.267.	1970	18	0.15 - 15 keV	

680	M. Schomberg et al., Conf. on Nuclear Data for Reactors, Helsinki, STI/PUB/259, Vol. **I**, p.289.	1970	20	0.15 - 25 keV	
681 682	R. Gwin et al., Nucl. Sci. Eng. **45**, p.25.	1971	18 20	Thermal - 15 keV Thermal - 15 keV	

Cross Sections Averaged over the ^{252}Cf Spontaneous Fission Neutron Spectrum

<u>^{235}U(n,f) and ^{239}Pu(n,f)</u>

Set	Reference	Year	Data Values	Energy Range	Comments
565 U 641 Pu	M. C. Davis and G. F. Knoll, Annals Nucl. Energy **5**, p.583.	1978	1 1	Fission Spectrum	
575 U	V. M. Adamov et al., Int'l Nucl. Data Comm. Report INDC(CCP)-180L.	1982	1	Fission Spectrum	
576 U 674 Pu	H. T. Heaton et al., Memo to G. Grundl, Trans. Amer. Nucl. Soc. **44**, p.533.	1982 1983	1 1	Fission Spectrum	See also Conf on Neutron Cross Sections for Technology, NBS Spec. Publ. 425, pp. 266 and 270 (1975).
517 U 614 Pu	I. G. Schroeder et al, Meeting on Nucl. Standard Reference Data, Geel, IAEA-TECDOC-335, p.320.	1984	1 1	Fission Spectrum	Also private communication.

Thermal Constants

Set	E. J. Axton, Ref. 9 Thermal Parameter	Year	Data Values	Energy Range	Comments
910	$g_\gamma(^{233}U)$	1986	1	Thermal	
911	$g_f(^{233}U)$	1986	1	Thermal	
912	$\sigma_{n,n}(^{233}U)$	1986	1	Thermal	
913	$\sigma_{n,f}(^{233}U)$	1986	1	Thermal	
914	$\sigma_{n,\gamma}(^{233}U)$	1986	1	Thermal	
915	ν-bar(^{233}U)	1986	1	Thermal	
916	$g_\gamma(^{235}U)$	1986	1	Thermal	
917	$g_f(^{235}U)$	1986	1	Thermal	
918	$\sigma_{n,n}(^{235}U)$	1986	1	Thermal	
920	$\sigma_{n,\gamma}(^{235}U)$	1986	1	Thermal	
921	ν-bar(^{235}U)	1986	1	Thermal	
922	$g_\gamma(^{239}Pu)$	1986	1	Thermal	
923	$g_f(^{239}Pu)$	1986	1	Thermal	
924	$\sigma_{n,n}(^{239}Pu)$	1986	1	Thermal	
926	$\sigma_{n,\gamma}(^{239}Pu)$	1986	1	Thermal	
927	ν-bar(^{239}Pu)	1986	1	Thermal	
928	$g_\gamma(^{241}Pu)$	1986	1	Thermal	
929	$g_f(^{241}Pu)$	1986	1	Thermal	
930	$\sigma_{n,n}(^{241}Pu)$	1986	1	Thermal	
931	$\sigma_{n,f}(^{241}Pu)$	1986	1	Thermal	
932	$\sigma_{n,\gamma}(^{241}Pu)$	1986	1	Thermal	
933	ν-bar(^{241}Pu)	1986	1	Thermal	
934	ν-bar(^{252}Cf)	1986	1	Thermal	

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1. The Evaluated Nuclear Data File ENDF. For more information contact the National Nuclear Data Center, Brookhaven National Laboratory, Bldg. 197-D, Upton, NY 11973.

2. Proc. Conf. on Nuclear Data Evaluation Methods and Procedures, Brookhaven National Laboratory Report BLN-NCS-51363, Vol. I and II, B.A. Magurno and S. Pearlstein, Editors (1981).

3. W.P. Poenitz, ibid. Ref. 2, Vol. I, p.249 (1981).

4. G.M. Hale, ibid. Ref. 2, Vol. II, p.509 (1981).

5. R.W. Peelle, Memorandum to the Cross Section Evaluation Working Group (1986), see National Institute of Standards and Technology Report NISTIR 5177, Appendix C (1993).

6. A.D. Carlson, W.P. Poenitz, G.M. Hale and R.W. Peelle, Proc. Adv. Group Meeting on Nucl. Standard Reference Data, Int'l Atomic Energy Agency Report IAEA-TECDOC-335, p. 77 (1984).

7. A.D. Carlson, W.P. Poenitz, G.M. Hale, and R.W. Peelle, Proc. Int'l Conf. on Nucl. Data for Basic and Applied Science, P. Young et al. Eds., Gordon and Breach, Vol.2, p. 1429 (1986).

8. A.D. Carlson et al., 'The ENDF/B-VI Neutron Cross Section Measurement Standards', Nat'l Institute of Standards and Technology Report NISTIR 5177 (1993).

9. E.J. Axton, Central Bureau for Nuclear Measurements Report GE/PH/01/86, and private communications (1986).

10. M.J. Sowerby, J. Nucl. Energy **24**, 323 (1970).

11. D.C. Dodder and G.M. Hale, private communication to CSEWG (1987).

12. W.P. Poenitz, ibid. Ref. 6, p. 426 (1984).

13. S.L. Meyer, "Data Analysis for Scientists and Engineers", John Wiley and Sons, Inc. (1975).

14. W.P. Poenitz and A.D. Carlson, Int.l Symp. on Nuclear Data Evaluation Methodology, C.L. Dunford, Ed., p. 75 (1992).

15. L.W. Weston et al., Nucl. Sci. Eng. **115**, 164 (1993).

16. C. Wagemans et al., Nucl. Sci. Eng. **115**, 173 (1993).

17. K. Merla et al., Proc. Conf. on Nucl. Data for Science and Technology, Juelich, p. 510 (1991).

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