National Research Centre
"Kurchatov Institute"

The GRUCON Code Package for Evaluated Nuclear Data Processing

User's Manual

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Abstract

The GRUCON-D processing code package, certificate of state registration №2014663246, version 2021-12 is described.

The package contains functional modules allowing to

- read data files in the ENDF, GNDS(restricted), PENDF and GENDF (NJOY) formats;
- reconstruct point-wise cross sections from resonance parameters for given temperatures;
- reconstruct Legendre coefficients from resonance parameters with smoothing for given temperatures;
- reconstruct cross sections moments and prepare subgroup parameters in the unresolved resonance range;
- prepare subgroup parameters with matrices of subgroup correlations between materials, temperatures, reactions, consequent collisions in the resolved resonance range - “generalized subgroup parameters”;
- calculate the energy-angular distributions of neutrons scattered on nuclei in free gas and resonant scattering approaches;
- calculate the energy-angular distributions of neutrons scattered on bound nuclei in thermal energy range;
- prepare group cross sections, group transition and fission matrices for neutrons;
- prepare photon and particle production group matrices for neutron reactions;
- prepare group cross sections and group transition matrices for photo-atomic interaction;
- prepare group cross sections from activation data library;
- convert processed data to the ENDF, PENDF, GENDF, ACE, BNAB, TEMBR, MATXS and CCCC data formats.

Programming language is Fortran-90. The package is available for 32- and 64- bit computers with Windows, Linux and Mac operating systems. The distributive includes installation procedure for Gfortran, Intel, Lahey compilers and testing procedures with 20 tests The package has been verified by comparison with calculations performed through NJOY-2016.62 and PREPRO-2021 processing codes.

List of Abbreviations

PAP - package of applied programs
SR - standard representation
CSR - cluster of standard representations
LSR - library of standard representations
PS - processing scenario
PD - processed data
CP - control parameters
LP - local parameters

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INTRODUCTION

"Data processing" is understood as the calculations whose objective is to alter the way of data representation in the working data libraries to be used in various applications using the fundamental libraries of evaluated nuclear data. Thus, the data processing ensures a linkage between two types of activities in the field of nuclear science and nuclear technology, they are:

- acquiring and accumulation of experimental and theoretical data about microscopic processes of interaction;
- description of macroscopic systems whose behaviour and characteristics are defined by nuclear reactions and transformations.

The tasks listed below can be referred to subordinate tasks that also base on the data processing, these are: processing the measured data from microscopic experiments, evaluation of these data, compilation of evaluated data files, preparation of working data libraries for transport calculations and their validation, assessment of uncertainty in the assumptions used, etc. For the purpose of these tasks, the algorithms and methods, which were elaborated to prepare the applied libraries, can be also used.

The variety of data types, methods of data parameterisation and storage formats define the variety of algorithms and calculation methods along with their structure, which is expressed in the selected architecture of the processing program. Many of the processing systems duplicate the configuration of the software package.

The package, or rather "Software package", as per Ref. [**1**], is typically understood as the structure of computer code that provides the following:

- language of the command describing the computation scenarios;
- set of functional modules;
- system support ensuring the command interpretation, successive call of the modules, and data exchange between them.

This manual represents a description of data processing package GRUCON and has been addressed to the developers of applied libraries important for the calculation of irradiation transport. It is assumed that the well-documented processing systems NJOY[**2**], PREPRO[**3**], FUDGE[Ошибка! Источник ссылки не найден.], FRENDY[**5**] are available to a reader, so the main attention will be focused not on the description of common functions, but on the specifics of the GRUCON package - the internal data organization and the means of user communication with the package, that is the command language.

It should be recognized that the command language of program GRUCON is more complicated as compared to the command languages of programs NJOY or PREPRO, for example. This is caused by the fact that the functions of GRUCON modules are more limited than those of the above mentioned programs, so, the amount of module combinations and of available computational chains is essentially greater. In addition, knowledge of the internal data representation types and calculation schemes is required, to prepare input task. Nevertheless, we have the reason to expect that the efforts spent to study the program language will be compensated for by the numerous capabilities provided by the program for advanced user.

The universal character of the package and variety of calculations proposed by package GRUCON do not allow preparing an explicit user manual, we can only explain the philosophy that lays the basis for GRUCON and demonstrate the main techniques of operation. Our manual represents an effort to do so.

Background. The Package GRUCON is a product of computer-aided processing the nuclear data, which started from the development of formats for storing the data from microscopic

experiments and also evaluated nuclear data aimed at generating computer libraries. The evaluated data should be non-contradicting, unambiguous and complete (in view of the application they are intended for). In order to satisfy these requirements, the measured data undergo an evaluation procedure that includes the analysis of contradictions between the data from various experiments and the selection of parameterization methods that ensure an unambiguous restoration of selected data. Where the evaluation procedure is impossible (due to the lack of measured data), the parameters are calculated on the basis of theoretical models, or determined from systematics. Data evaluation activities are being conducted by the world community (in pursuance with the Agreement adopted at 1-st Geneva Conference in 1955), and has the target to create local libraries of evaluated nuclear data to be presented in a certain format. Normally, there has been several formats for storage of evaluated data, they are: UKNDL in Great Britain, KEDAK in Germany, ENDL in Livermore National Laboratory and ENDF in other US laboratories, and SOKRATOR in the USSR. Initially, these formats were not compatible and this hindered the international data exchange.

The objective to create computer programs for the production of constants for the calculations of fast neutron reactors and the radiation shielding using evaluated data (of system SOKRATOR) was conceived at the beginning of the 1970's, Ref. [6,**7**]. By that time, the Laboratory of Constants (Institute for Physics and Power Engineering) headed by prof. M. Nikolaev had accumulated the experience of generating the libraries of multigroup constants BNAB-26, Ref. [**8**], important for calculation of fast neutron reactors and the radiation shielding using computer programs in ALGOL-60 language designed for electronic computers M-20 and M-220, namely:

URAN, Ref. [**9**] - calculation of multi-group cross-sections and resonance self-shielding factors in the region of resolved resonances using a single-level Breit-Wigner formula,

MUF, Ref. [**10**] – calculation of multi-group cross-sections and resonance self-shielding factors in the region of resolved resonances using a multi-level Lukyanov formula,

NERPA, Ref. [**11**] – calculation of multi-group constants from averaged resonance parameters in the unresolved resonance region,

PRUSSAK, Ref. [**12**] – calculation of multi-group constants from table presentation of cross-sections,

UMBLOK, Ref. [**13**] – calculation of averaged multi-group values for angular moments of scattering cross-section and transmission functions,

MANNERS, Ref. [14] –calculation of matrices of the inter-group transfers for elastic and inelastic scattering

UGRA, Ref. [**15**] – calculation of anisotropy parameters of angular distributions,

SOM, Ref. [**16**] – calculation of subgroup parameters of resonance structure from cross-section moments, etc...

The objective to create an automated system of computer programs for the production of multigroup constants was supposed to implement by developing the interfaces to those programs and integrating the programs into software package called GRUCON, Ref. [**17**]. In the process of

designing the package, there were found the shortcomings of mere “mechanical” integration of the programs. Since the programs were written by independent authors, the input and output data were not coordinated, the programs demanded too bulky interfaces, and some of the programs used identical algorithms in terms of their functional designation. All these things led to a failure and the software package became obsolete before it was completed.

Toward the end of the 1970's, the existing park of computers was getting updated: more efficient electronic computers BESM-6 came to replace M-220, language ALGOL was replaced by language FORTRAN. In parallel, the process of standardized representation of libraries of evaluated data was going on. The variety of formats was rejected. All the countries changed over to a uniform ENDF format (modern version is ENDF-6, Ref. [**18**]). The data were structured and the system's information content was elaborated. On the basis of the system's information content, the programs of multigroup data calculation on the basis of resonance parameters were developed to form an integrated applied software package named GRUCON-1, Refs. [**19**-**24**]. In the year 1984, this version was presented in international *"Processing Code Verification Project"* coordinated by IAEA where GRUCON-1 demonstrated its competitiveness, Ref. [**25**].

Version PAP GRUCON-2, Ref. [**26**-27], appeared due to the adaptation of the program package to the more efficient ES computers. Also, the functional capabilities of the package were extended (modules of data processing on the basis of angular and energy distributions were added and new algorithms were developed (convolution of cross-sections and generation of subgroup parameters using *Padé-II* approximation, Refs. Refs. [29,**30**]). The second version of the package was maintained and developed up till the end of the 1980's.

As personal computers appeared, the development of third version started. This version of the package was expected to include the capability to process the information about photo-nuclear interactions. However, the third version was never completed because the budgeting was closed. The termination of **GRUCON** project was motivated by the propagation of US data processing program NJOY, which de facto became a standard data processing tool adopted everywhere in the world. It took about twenty years to realize the shortcomings of program NJOY and the necessity to create an alternative program to satisfy the domestic needs. Nevertheless, this understanding came, and in the year 2012 the **GRUCON** project was reset in NRC "Kurchatov Institute". This was caused by the need to update the computer libraries of constants to be used in mathematical simulation of physical processes of nuclear plants in order to substantiate their nuclear safety. To justify the operability of the package in a modern computing environment, it was prepared and registered the demo version of the package GRUCON-D (December 2014, certificate of state registration №2014663246).

Works on the maintenance and development of the package are being carried out at the NRC “Kurchatov Institute” with the support of the Nuclear Data Section of the IAEA. The present Manual corresponds to the status of the GRUCON-D processing code package on Decembre, 2021.

1. ARCHITECTURE OF THE PROGRAM PACKAGE

1.1 Principle of data standardization and unification

The method of building of the GRUCON package is based on the principle of standardization and unification of internal data structures.

According to this principle, a set of data structures, complete enough to cover the diversity of data types and parametrization ways in some application problem, supplemented by unique names, is defined - so called, “standardized structures”.

Then, within each standard structure, the data is ordered by the type of variables (text, integer, real), and, within each type - by dimension (simple variables, arrays) and functional purpose (descriptors, parameters, data itself), forming “unified structure”.

The standardized and unified structure is supplemented by a header with a minimum set of characteristics sufficient for searching and exchanging data between different memory locations.

For what purposes is this being done?

First of all, the standardization and unification of data structures allows implementing a compact set of algorithms for searching and exchanging data, as well as packing and unpacking structures in accordance with their unique name, in a small set of system support modules, which simplifies the programmer's work and ensures the openness of the package and the possibility of expanding its functions.

Secondly, standardization allows transferring the function of constructing computational schemes and organizing the computational process to the user, by providing him with the necessary tool - a language for describing the data processing scenario, which makes the software system flexible and expands the range of tasks that can be solved by the same algorithms.

And, finally, thirdly - the standardization allows to minimise dependence software on external data presentation formats. Communication with external "non-standard" structures is provided by a set of converter modules (data input / output functions), which are developed independently of the main part of the program that implements the conversion algorithms.

1.2 Content of the package

Program package GRUCON consists of a set of modules based on cross-section data conversion algorithms. These data are important for generating the working files of cross-sections for computer programs from the libraries of evaluated nuclear data. The set of modules were created on the basis of data structures derived using the methods of normalizing the data used both in the libraries of evaluated data, or the working libraries of detailed and multi-group types.

For the purpose of operational storage of standard data structures, a disc memory is used, where numerated files of direct access are stored. These files form a working library of the program

(LSR). Entering the data into the library, as well as search of data in the operational memory and exchange of data with the operational memory are performed using the modules of system support. Library content and addresses of the data to be transmitted to a current module are stored in the operational memory as a library's catalogue and the module's registers.

For the purpose of describing the order in which modules are called and data flow is controlled in the process of data processing ("processing scenario"), a special language is used – the language of program GRUCON. This language consists of the commands which affect the successive execution of the functional modules and the data allocation address at each at each successive processing step.

Functional modules, system support and the programming languages created on the basis of standard data structures allow presenting program GRUCON, as «the package of applied programs with normalized functional content», herein called as «package GRUCON».

As the program package develops, the set of standard structures and functional modules can be extended and amended. Meanwhile, the language structures and system content of the package stay, practically, unchanged. This allows considering package GRUCON as the program capable to be extended.

1.3 Flow diagram of the GRUCON package

Figure 1 shows the flow diagram of package GRUCON.

The run of data processing program begins with the reading in of set of commands (scenario) by interpreter and entering them to the operational memory. Then, a successive interpretation and execution of each command is carried out.

The data processing commands include the information about address allocations of the data to be processed in the form of a number of LSR catalogue record which contains the registration of these data (the input data), or a number of LSR catalogue record where the data shall be registered (the results of data processing). On the basis of this information, the interpreter calculates the minimum and the maximum number of words occupied, or can be assigned to these data in LSR and operational memory, performs the input determination of the current location addresses, and enters the information into module registers.

Besides the processing commands, scenario may include the servicing commands which indicate the scribing of LSR segments, the display of the catalogue's information content, termination or end of the data processing operation.

After the setting of the addresses, on the basis of the content of the command, the executor of commands defines the name of the module for which these data are intended, and calls the module. The modules can be separated according to the designation in three main types, they are :

- input modules that read in the parameters and data from the files at the peripherals, convert them to internal representations and transform and record them in the library of standard representations;
- data processing modules and a multi-group of service modules and utility (adjustment) modules

that read in the processed data and parameters from the LSR library, perform a required computational operation and record the results into the LSR library and register them in the catalogue;

- output modules that read in the data from the LSR library and convert them into tables and records for visual representation in tabulated or graphic form, or for subsequent application in the format of working libraries.

Each record in the library of standard representations is followed by entering the name and allocation address of the data to LSR catalogue – a «data registration».

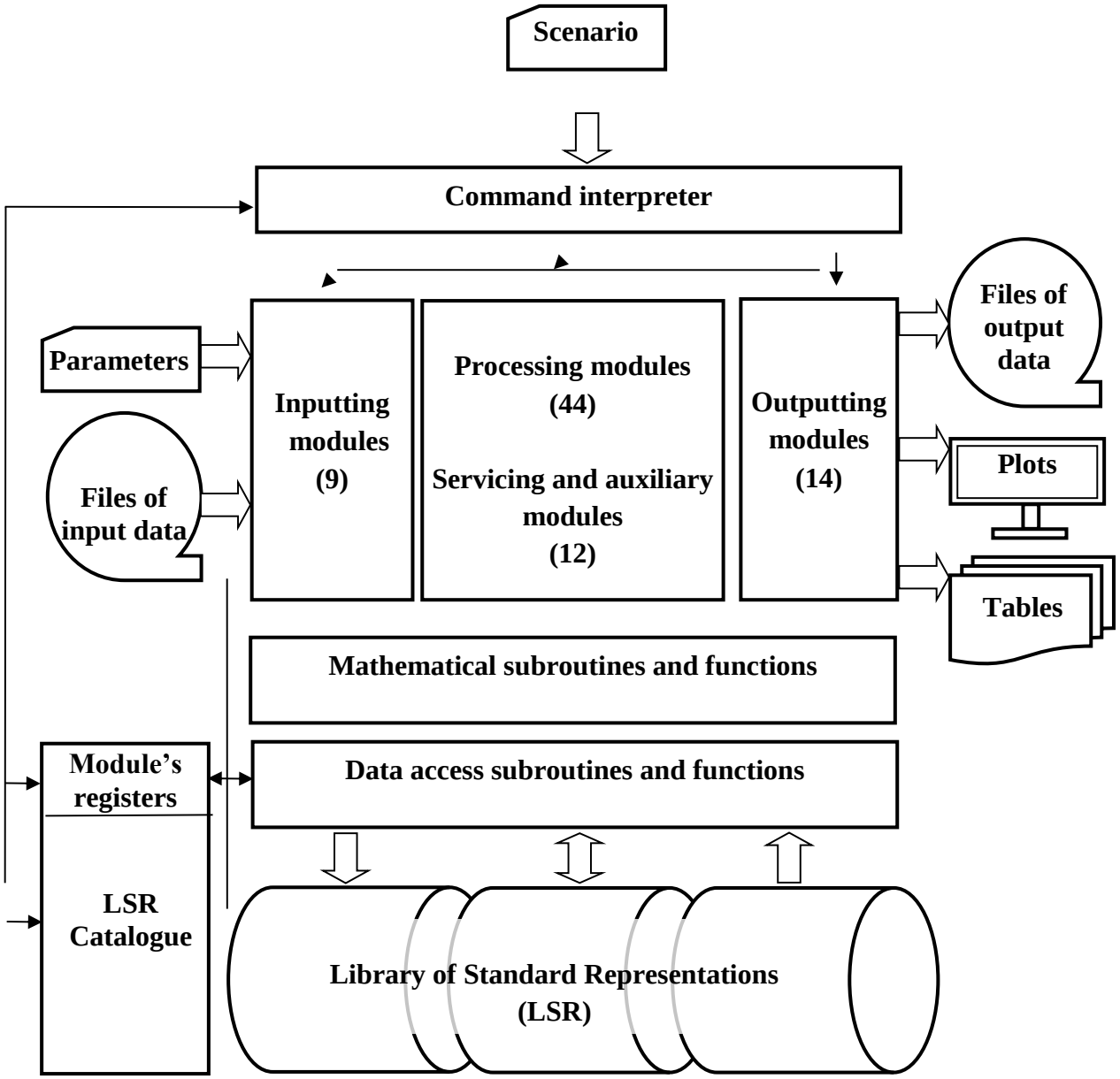

Figure1. Flow diagram of the GRUCON package

2. DATA STRUCTURES

2.1 Standard representation of the data

For the purpose of unification of searching means and the means of data exchange between operational memory and disc storage, program GRUCON uses an internal format, a so called "standard representation".

Standard Representation (SR) - is a structure of ten fields

<HDS(2)><MAT> <MZAS> <MZAP> <LH> <LI> <LR> <HA(LH)>, <IA(LI)>, <RA(LR)>

where

HDS(2) is the name of a data structure – two words character (4) ;
MAT is an integer identification label corresponding to the material number;
MZAS is an integer identification label which identifies the charge-mass-state parameter of the nuclide: MZ*100000 + MA*100 + MS;
MZAP is an integer identification label which identifies the charge-mass-state parameter of the impinging particle: MZ*100000 + MA*100 + MS;
LH is the length of word information;
LI is a length of integer numbers;
LR is a length of real numbers;
HA(LH) is a character array (4) that includes a word description of the data;
IA(LI) is an integer array (4) that includes integer identification labels and parameters of the data;
RA(LR) is a real array (8) that includes real parameters and data on the interaction between irradiation and substance.

The first seven fields form header of the standard representation.

Obviously, this structure designed for general applications is also applicable to the solution of more specific problems, such as: to present any numeric information about the interaction cross-sections without a detailed decoding, to be allocated in the computer memory, and to be applied in tracing and read-writing the data. The extraction of the data structure is performed as necessary in accordance with the structure name which unambiguously reflects the successive order of the elements.

In order to store and accommodate the standard parameters in the program package, the working data library is used.

The GRUCON working data library, so-called “The Library of Standard Representations” (LSR) consist of one or several files of direct access - LSR segments consisting of the records of fixed length (pages). The LSR segments are scribed at the beginning of data processing procedure by a special initiating command and used for the data allocation in standard

representation for the time period of the data processing. The page exchange between the LSR segments and the operational memory is performed via the buffer arrays.

In order to perform multi-group operations and organize the cycles, the input data are organized in the form of so called clusters.

Cluster of standard representations (CSR) –one or several standard representations stored one behind the other in a single segment of the LSR library, and registered under one name in the "catalogue".

LSR catalogue (internal) is the array of information on the locations of clusters in the LSR library. The LSR catalogue consists of strings, containing 4 fields:

<HDC>,<N>,<M>,<L>
where
<HDC> is the name assigned to the data cluster by the user;
<*N*> - number of the LSR segment that is used to accommodate the data cluster;
<*M*> - initial address of the cluster in the segment;
<*L*> - length of the data cluster.

Each data cluster in the LSR library is uniquely associated with catalogue line number, so, to highlight required cluster of the plurality of others, it is sufficient to indicate the corresponding catalogue line number. This was the basis for building an input task command language for the package GRUCON.

The internal catalogue reflects the current LSR state on each step of the data processing. Should there appear a necessity to organize a long-term storage of the data to be used in the subsequent conversions or calculations, we suggest using an external catalogue.

External LSR catalogue is a word file containing the information on the locations of CSR in a single segment of the LSR library to be generated in the course of processing the data for a long-term storage (in the "archival" segment). The external catalogue file consists of records - lines of 4 fields each, such as
<HDA>,<HDC>,<M>,<L>

where
<HDA> is the name assigned to the archived data;
<HDC> is input name of the data cluster;
<M> is initial address of the data cluster in the archive segment;
<L> is the number words taken up by the data cluster in archive segment.

Name <HDA>, unlike <HDC> name of the data cluster, shall be unique because in the external catalogue the numbers of records are omitted. The <N> numbers of the segments in the external catalogue are also omitted because the external catalogue is generated individually for each archive segment, e.g. contains one and the same number that can be changed in the subsequent conversion operations.

2.2 Classification of the data

According to the role played in the processing operation, data are subdivided into two types.

Processed data (PD) are data on the interaction cross sections in the entire variety of their representations - parametric, detailed or averaged in groups, in the form of integrals of functions, matrices, and approximations of their parametric dependencies.

Control parameters (CP) are additional information in the form of flags and parameters, required to specify the data conversion algorithm and the means of representing the data processing results.

The PD structure is determined by the class of data. The present version of program GRUCON uses 32 PD structures each of which has a unique assigned name used to decode the PD-type structure by system modules LOAD (see paragraph 4.4) into parameters, characters and arrays. The description of the PD processed data structure is given in APPENDIX A.

The CP-type structure is determined by the purpose and conversion algorithm. The CP name is used twice in the computational task: in the data processing code in order to call the applicable functional module, and in the body of the task, which defines the values of control parameters (see paragraph 3.3). In order to make it easier to remember the names of CP parameters and make their usage more flexible, the synonyms and abbreviations are envisaged to be used. For instance, symbol "*" , which is required for a syntax emphasizing of the parameters in order to entering them, can be omitted when calling the module, while symbols "/" and "-" in the name of CP parameters may be replaced by symbol "x".
For instance, parameters*R/T-S will become module RXTXS which will search and enter these data. The parameters of module COPY consist of a single word, e.g. they are an «empty record», since no additional data are required to fulfil this operation. Similarly, the records of parameters of modules IN, OUT, SELECT, CONTENT, TABLE are also empty.
The description of CP structures is given in APPENDIX B.

3. COMMAND LANGUAGE

An input task of the GRUCON package in the general case cam consists of thee partitions: a one compulsory section "processing scenario" (PS) and, depending on its content, two additional, namely, “local parameters” (LP) and "control parameters" (CP). Let us discuss the functions and syntax of each part of the task.

3.1 Structure of the command

The processing scenario (PS) defines the sequence in which the functional modules are called and the allocation of the processed data in the LSR library. The PS consists of a series of commands, each of which is recorded in individual line. The maximum line length is 256 characters. Alphabetic characters can be upper, lower, or mixed case. A “!” character terminates line entry. Anything that follows the “!” is interpreted as a comment.

The command line can contain up to seven fields, separated by a comma:

<I>, <J>, <K>, <D>, <N>, <M>, <L>

The command fields assignment:
<I> is number of the catalogue record which contains the address of the input data cluster;
<J> is number of the catalogue record which contains the control parameters or the name of the processing operation (the name of the command), if the parameters are absent;
<K> is number of the catalogue record which should contain the address of the processed data cluster;
<D> is the name to be assigned in the catalogue for the identification of the processed data cluster;
<N> is number of the segment;
<M> is number of first word;
<L> is upper limit of words, reserved for record.

The values of the fields can be specified explicitly, or remain empty in order to be implied by virtue of their omission. Empty fields are specified by commas if they are located at the beginning or middle of the command; if the empty fields are located at the end of the command, it is necessary to specify them by comma’s, it is enough to leave in the command the last filled field.
Let us discuss how to indicate the regions of the memory in the working library of the program GRUCON – the LSR library. In the course of processing the data, up to four segments of the LSR library can be used.
A segment of the LSR library is a file of direct access consisting of fixed length records – pages. In the operational memory, we singled out a buffer which is capable of accommodating three pages. The data exchange between the LSR segments and operative memory is performed by pages, the exchanging frequency depends on the size of pages, and therefore, the various versions of the code package may differ in the number of words in a page. In the standard version of the program, the length of the page is fixed to a maximum of 1000 words assigned with a double precision – real (8). These characteristics are important for the assessment of the available resources of the memory which will be involved in the processing operations. In order to indicate the address and size of the memory region in the LSR library, it is necessary to specify the number of segment <N>, serial number of the first word in this memory region

<M>, and the number of occupied words <L>. In order to specify the quantities of <M>and <L>, it is possible to use either the number of word/words, or the number of pages/pages. Word symbol "K"[1)] represents the page: as an example, record 123K4 in the standard version of GRUCON shall be interpreted as the number 123*1000+4=123004 of words.

3.2 System of commands

In the system of commands, according to their designation, 5 groups of command can be identified:
- declarative and control commands;
- commands to input the data;
- commands to process the data;
- commands to output the data;
- servicing and auxiliary commands.

3.2.1 Declarative and control commands

INIT – initiation of segment (since the GRUCON-2019 version of the package, the INIT command is optional and can be omitted) Any processing operation is initiated by assigning the working space –segments of the LSR library. The assignment of a new segment of the library is performed by the initiation command, such as:

,,,INIT{,<N>{,<M>{,<L>}}}

where
<N> – number of the LSR segment {1};
<M> – initial address in the segment {0};
<L> – length of the segment - number of pages {1000K}.

Curly brackets incorporated in the body of the command reflect the possibility of assigning the values to the elements of the command on default. The initiation command results in the file of direct access FILE0N. The numbers of the created files are defined by the logical numbers of free units, e.g. these may be any numbers except numbers 5-9 (these belong to the files used by the system for input/output of the parameters and interior data), and also of the files whose numbers do not coincide with the numbers assigned by the user himself for reading/writing the external data. Normally, it is sufficient to create four files with the numbers ranging between 1 and 4. The size of the files is defined by the size of available disk space and the expected volumes of processed data. In the processing program, it is necessary to account for the possibility of recurrent usage of the files in the temporary storage of intermediate data.

Example 1: initiation of LSR segments

,,,INIT
,,,INIT,2,0,20000K
,,,INIT,3,0,30000K

1) Hereinafter, the names and word constants encountered by the processing program of the GRUCON will be printed in capital letters, although the task interpreter makes no difference between the uppercase and the lowercase.

The commands initiate three segments of the LSR library in the form of the direct access files, such as file1, file2 and file3. Segment 1(by default) includes 1000 pages, of in volume, segment 2 includes 20000 pages, and segment 3 - 30000 pages .

OPEN – opening of the segment. The segments of the LSR library can be used not only in the capacity of the temporary storages, but also as the archives of the data. The advantages of the archiving procedure become obvious when it is required to address many times the large amount of data during the time separated runs of the program, because these advantages make it possible to access any fragment of the data through the catalogue of the LSR library omitting the procedure of reading from the sequentially accessed files.
In order to open the earlier generated segment with the data, there is a command
,,,OPEN,<N>,<M>,<L>
where
<N> – number of the segment;
<M> – initial address in the segment;
<L> – length of the segment.
With the help of the command OPEN it is possible to single out a certain region in the required segment available for reading and/or recording of the information, this is sub-segment N. The region begins with the address M and has the L length. The overrunning of this memory region – "sub-segment" - will be controlled, at the same time, this guarantees the preservation of the integrity of other data stored in the archival segment of the memory. How to extract the information about the data stored in the archival memory segment will be discussed in the subsequent chapters. In the examples given below we will assume that this is the available information. The specifying of the values by default in command OPEN is not needed.

Example 2: opening of access to the segment of the LSR library
,,,OPEN,3,10K,100K

In segment 3 (file3), the sub-segment pages from 10 and up to 109 inclusive (100 pages) open for reading/ recording of information.

The controlling of the data conversion process is performed by two commands given below:

STOP- termination of the data processing operation. In the course of debugging the data processing program, or in case of partial usage of PS designed to perform a more general task, there may appear a necessity of terminating at a certain step the series of data processing operations using the minimal changes in the PS text. For this purpose, the terminating command shall be used, such as:
,,,STOP

END – end of the data processing program. The processing program shall be stopped by the command, such as:
,,,END

On the command END, the entering of the commands stops, and the command interpreter changes over to the execution. The PS can include only one command END.

3.2.2 The input commands

In order to enter the input data to the GRUCON program, we have a family of functional modules called with the help of the applicable commands. The data to be processed are the following: global parameters, control parameters and, of course, processed data. Let us stop and discuss the methods of entering to the GRUCON program of each type of the mentioned data and their place in the body of the task.

Input the local parameters. The local parameters (LP) are a part of the parameters comprising the control parameters and their values are determined in advance in order they could be subsequently used for the purpose of substitution. The importance of singling out the local parameters from the control parameters is defined by the possibility of making convenient the editing of the control parameters and compact their assignment. Within the local parameters, it is reasonable to distinguish the most important, the so called key parameters (for clarity purposes), or the parameters which are used at a time in several sets of control parameters of equal values, particularly, if they represent the arrays of variables (for compactness). The key names of the local parameters are assigned by user proceeding from the convenience of the remembering. The values of the local parameters are stored in the operational memory, therefore, the command to enter the local parameters does not need the information to be registered in the library's catalogue, and has the following form:

,IN

The value of the parameters can be assigned in the interactive manner using a keyboard in response to the request displayed in the screen of the monitor. For this purpose, instead of the parameter value, the "?" sign should be putted. In the capacity of the request, the parameter arbitrary name with symbol "=" at the end can be used.

Example 3: Input the local parameters
,IN
,,,END
*NT: 1,
*TEM: T=?
By the command IN, the local parameters with key names *NT (number of temperatures equal 1) and *TEM (temperature value) are entered and remembered in the operational memory. The latter shall be entered by the keyboard in response to the request
T=

Input the control parameters. The control parameters (CP) are also entered by the command IN, however, since the CP are entered in the LSR and registered in the library's catalogue, it is required to specify in the command the number of the record where the control parameters must be registered. Other fields, which include the name and address variables, permit an implicit assigning of the parameters. The rules of using the empty fields and determination of the implicitly assigned values will be discussed in the subsequent chapters of this paper together with the description of the data processing commands. In the general case and taking into account the above stated, the command for entering the CP will be the following:

,IN,<K>{,<D>{,<N> {,<M>{,<L>}}}}

Where

<K> - the number of the catalogue record where the data must be registered;
<D> - the name of the CP that corresponds to the name of the module for which the CP parameters are intended for;
<N> - number of the segment;
<M>- number of the word in the segment from which the data will be read in;
<L> - number of words reserved for the data.

If the CP data are present in the input task, they are specified behind the data processing program and behind the LP. Just like the LP, the control parameters can include the comments and can be entered in the interactive manner.

Example 4: Task for the input of control parameters

```
,IN
,IN,1,ENDF
,IN,2,R/T-S
,,,END
*DE: EL=1.E-5, EH=10.
*ENDF: NTAPE=20, NMAT=0, NMF=2, NMT=4, MF=2,3, MT=1,2,18,102
*R/T-S: NFORM=0, NT=1, *DE, EPS=0.001, TEM=0.
```

When this task is fulfilled, control parameters for the modules ENDF (read data in ENDF format) and R/T-S (reconstruct cross-sections from resonance parameters) will be recorded in the LSR library. The energy interval is determined in the form of local parameter DE.

Reading of data for processing. For the purpose of input of the processed data into the program GRUCON, the special modules are intended. The names of these modules indicate to the format of the data representation, namely:

READ - input data file in the GRUCON internal (standard) representation;
ENDF - input the evaluated data file in the ENDF format;
PENDF – input file with detailed cross-sections in PENDF format (NJOY internal format);
GENDF - input file with group-averaged cross-sections in GENDF format (NJOY internal format);
BNAB - input data from the files of group-averaged constants in the ABBN format [32].

The input modules perform the reading of data from the sequentially accessed file, the data conversion to a standard format, and recording of the data in the LSR library.
As for the data that have been already converted to a standard representation format, the input from the sequentially accessed file to the LSR library is performed by module READ.

The modules of entering the processed data require the control parameters; therefore, the input of the processed data to the LSR library is performed by two commands, such as:

```
,IN,<J>{,<name of input module>{,N {,M{,L}}}}
,<J>,<K>,{<D>{,<N> {,<M>{,<L>}}}}
```

The name of the processed data <D>, under which these data are registered in the library's catalogue, does not affect the result of the operation, and shall be chosen proceeding from mnemonic considerations.

Example 5: Task for entering the file of data in standard representation

```
,IN,1,READ
,1,10,DATA
,,,END
*READ: TAPE=20
```

Example 6: Task for entering the data file in ENDF format

```
,IN,1,ENDF
,1,10,DATA
,,,END
*ENDF: NTAPE=20, NMAT=0,NMF=0,NMT=0
```

3.2.3 The output commands

In order to output the data from the LSR library in the format convenient for the visual perception or the usage in the subsequent calculations, the GRUCON package has the modules, such as

WRITE – writing data in the internal GRUCON (standard) representation;
ENDF – output of evaluated data in the ENDF format;
PENDF – output of detailed data in the PENDF format;
GENDF – output of group averaged data in the GENDF format;
ACE – output of detailed cross-section data in the ACE format for the MCNP Monte-Carlo particle transport calculation code system [31];
BNAB – output of group cross sections and matrices in the ABBN format [32] for the CONSYST code for preparing group cross section working libraries for paricle transport calculation codes;
TEMBR – output of group and subgroup cross sections and matrices in the TEMBR format for preparing working data libraries for the SAPFIR Monte Carlo paricle transport calculation code system [33];
MATXS – output of group cross sections and matrices in the MATXS format for the TRANSX code [34] for interfacing of group vross sections with transport codes;
CCCC – output of group cross sections and matrices in the CCCC format for C4P processing system [35] ;
PLOT – output data in format of input file for NJOY/VIEWR module;
ZVD – output data in format of input file for ZVV visualization code.

In order to call the output modules, the two commands are required (similar to the case of input modules):

```
,IN, <J> {, <DC>{, <N> {, <M>{, <L>}}}}
<I>, <J>
```

where <DC> - name of the module of control parameters.

The software package has two modules for the output of the data and they do not require control parameters; they are

OUT - output of data in standard representation;
TAB - printing of the output data in the form of annotated tables.

To call them, the name is enough, such as:

<I>, OUT
or
<I>, TAB

The output data yielded by these modules are recorded in files ***grucon.out*** and ***grucon.tab***, accordingly.
It should be pointed out that the input/output modules can bear similar names. The function, for the execution of which the module will be debugged by the system, is defined by the type of the command.

Example 8: Commands for input/output of the data file in ENDF format

```
,IN,1,ENDF
,IN,2,ENDF
,1,10,S
10,2
,,,END
ENDF: NTAPE=20,NMAT=0,NMF=1,NMT=0,MF=3
ENDF: NTAPE=30,NMAT=0,NMF=0,NMT=0
```

3.2.4 Data processing commands

The data processing operations are executed by the family of conversion modules. All of these modules work using one and the same scheme: read the control parameters and data from the LSR library, process the data and record the results into selected segment of the library of standard representations. The command to call them is generally the following:

<I>,<J>,<K>{,<D>{,<N> {,<M>{,<L>}}}}

At this step of discussing the command language of PS, it is worthwhile to formulate some general rules of interpretation of commands with blank fields (default defined).

Let us discuss the case where the data are registered in the record of the catalogue, which was not used in the preceding commands, so, record <K> is empty. In this case, empty files are allowed in the address part of the command (fields <N>,<M>,<L>) which denoted as follows:
<N>- number of the segment – (is taken to be equal 1 on default);
<M> - the number of the first word which is calculated as the first free word that follows the maximum word of all those registered in the catalogue of the memory regions occupied by other data in segment <N>;
<L> - number of words behind <M> remained free in segment <N>.
It must be pointed out that the number of the first word <M> depends on the number of segment <N>, while the number of words <L> depends on the values of <N> and <M>, therefore, the explicitly assigned one of the preceding fields influences upon the specification of all the subsequent fields by default. The explicit assignment of any of the values is accepted by the interpreter as guidance, and this can result in the arbitrary overlapping of the unused memory regions, therefore, the explicit assignment of values must be used with great care.

Now, let us assume that record <K> is not empty, e.g. the processed data from the preceding steps were already registered in this record. How can the user use the information stored in the catalogue? Let us discuss the two cases.

1).The earlier obtained data must be saved, and the new results shall be added to the saved data. In this case, the fields <D>, <N> and <M> of commands remain empty. Field <L> may be omitted only if the data cluster registered in record <K> is the last in the segment and there is enough free space left behind it, otherwise, field<L> must be specified explicitly with allowance for the fact that the data stored in this part of the memory can appear corrupted.

2).The old data can be superseded by the newly obtained results.
In this case, only the field of the data name <D> in the command shall be specified explicitly; as for the address variables <N>, <M> and <L>, the data from the catalogue can be used on default.

Example 7. Input deck (with comments) for the calculation of the cross-sections within a specified energy interval.

```
,IN     !  reading the local parameters
!   ---     reading the control parameters
,IN,1,ENDF
,IN,2,S/I-S
,IN,3,R/T-S
,IN,4,U/D-S
,IN,5,S/C-S
! --- data processing
,1,10,RUS     !  read cross-sections and resonance parameters from ENDF File
10,2,11,S     !  linearize of the tables of cross-sections
10,3,11       !  restore of cross-sections from resonance parameters
10,4,11       !  calculate cross-sections from average resonance parameters
11,5,12,S     !  unite the cross-sections from cluster *S* in one table
12,TAB        !  print the table
,,,END
! --- local parameters: to request the energy interval and tolerance parameter
*DE: DE=?,
*EPS: EPS=?
! --- control parameters
*ENDF: NTAPE=20, NMAT=0,NMF=2,NMT=4,MF=2,3,MT=1,2,18,102
*S/I-S: KINT=2,*DE,*EPS
*R/T-S: NFORM=0, NT=1,*DE,*EPS,TEM=0.
*U/D-S: NFUN=0, KINT=2,NT=1,*DE,*EPS,TEM=0.
*S/C-S: NMAT=0, NS=0,*DE,*EPS
```

3.2.5 Service commands

To perform auxiliary functions when working with data (copying, removing, editing, etc.) provides a set of service modules. The full list is given in APPENDIX B4. The following are the most common ones.

COPY, CP - copying the data clusters within the LSR segments. The copying of the clusters is executed by command
<I>,CP,<K>{,<D> {,<N>{,<M>{,<L>}}}}
If the values of address fields are not specified, they will be determined according to the rules from paragraph 3.2.3. For example, in order to add the data to those registered in K-record ("concatenation" of the data clusters), it is only necessary to indicate the number of record and the number of words:
<I>,CP,<K>{,,,,<L>}
The value of <L> may be omitted, if the data cluster registered in record <K> is the last in the segment; otherwise, <L> must be explicitly specified.

SELECT, SEL - concatenation (merger) of data with name specified in the command line. The command takes the following form

<I>,SEL,<K>

This command is used to select the structures according to their names indicated in record <K> (this should be a standard name) from the data cluster registered in the record <I> of the library's catalogue, and to add the selected structures to the data cluster registered in this record.

PACK - defragmentation of the data cluster. The explicit assigning of addresses in the commands may result in the appearance of empty parts of memory in the cluster of standard parameters, or the parts of memory with fragments of corrupted data. In order to delete them the following command is used
<I>,PACK{,,,,,<L>}

In the memory region registered in record <I>, this command initiates the search of the headings of standard representations, determine the lengths of the data block included in the data representation, and, if free memory parts are found, the SR will be transferred and the value of <L> will be specified anew in the library's catalogue.

Output of the catalogue content. In order to trace and extract the data saved in the LSR library after the computation is completed, it is necessary to have the location address of the data clusters in the LSR library. This information is stored in the library's catalogue whose content can be looked through using the command
<I>,,,
or simply
<I>
(separating signs "," may be omitted).
The executed command will result in the table of values of non-empty records in the catalogue starting at the record number <I>. The table will be allocated in the protocol of the task execution (file OUTPUT). This command is recommended to be used in every complicated data processing operation.

Registration of the data. In order to ensure the access to the data stored in the LSR library, it is necessary to register these data in the library's catalogue. This operation is executed using the command

,,<K>,<D>,<N>,<M>,<L>

where <K> - is the number of the catalogue record where the name and address of the data cluster shall be entered. All the fields are assumed to have been explicitly specified.

Re-registration of the data. The same data can be registered in several records of the catalogue under different names. This allows, for example, using the same data to call the functional modules with identical control parameters (for example, S/G-F and F/G-F, U/D-F и U/D-S). A recurrent registration of the data is executed with the command (second field is empty):

<I>,,<K>,<D>

Here <I> is the record number in catalogue where the input data are registered,
<K> - is the number of the record where the input data will be registered under the name <D>.

Example 9. Input of the S/G-F control parameters and re-registration under the name F/G-F

```
,IN,10,S/G-F
10,,11,F/G-F
,,,END
*S/G-F:NFUN=1,NG=28,NIG=1,IWT=4,NR=0,NP=10,NL=-2,NH=0,
NNG=1,NSG=1,NMG=1,EPS=0.001,
SIGZ=1.0e-10,1.,1.e1,5.e1,1.e2,3.e2,1.e3,1.e4,1.e5,1.e6,
W=0.215443,0.025,8.e5,1.4e6,
EG=1.00000e-04,2.15443e-01,4.64159e-01,
1.00000e+00,2.15443e+00,4.64159e+00,
1.00000e+01,2.15443e+01,4.64159e+01,
1.00000e+02,2.15443e+02,4.64159e+02,
1.00000e+03,2.15443e+03,4.64159e+03,
1.00000e+04,2.15443e+04,4.64159e+04,
1.00000e+05,2.00000e+05,4.00000e+05,
8.00000e+05,1.40000e+06,2.50000e+06,
4.00000e+06,6.50000e+06,1.05000e+07,
1.39818e+07,1.50196e+07
```

Output of the data cluster content. In order to get information about the allocation address of certain standard parameters in the data cluster, the following command I used
<I>,CONT
Here, <I>- is the number of the catalogue record where the data cluster is registered. This command initiates the recording of the table of names and addresses of standard parameters from the data cluster to the protocol.

The archives of the LSR library and the external catalogue. The segments of the LSR library together with the temporary storage of processed data can also be used as the archives of data important for the subsequent computations. The information about the structure of the archival segments is stored in the external catalogues, the run of which is realized with the help of the following commands

To simplify access to the archive segment, information about its content should be transferred into the external catalogue by the command

<I>, OUTCAT, - <N>,<DA>

Here <I> - is the number of the record in the internal catalogue,
<N> - is the number of the archive segment (with sign "-"),
<DA> - is the name under which the data must be registered in the external catalogue.

The data in the archive segment should have unique names, because the external catalogue rejects equal names. This is due to the fact, that in order to identify the data explicitly, the external catalogue uses a name but not a number of record, like it is done in internal catalogue. As a result of this command, a new record will appear in the FILE0N.CAT, namely

<DA><D><M><L>

The name of data cluster <D> and its address in the segment <M><L> are taken from the internal archive, while the number of the segment is omitted, because in the subsequent addressing to the data, the number assigned to the segment can be arbitrary since what is only important is the correspondence of the direct access file with archive segment - FILE0N- to its catalogue FILE0N.CAT.

In order to add the new data to the archival segment FILE0N, it is necessary to open this archival segment by the following command

,,, OPEN,<N>,<M>,<L>

and to register relevant external catalogue FILE0N.CAT by command

,EXTCAT, -<N>

where <N> - is the number of the segment (with sign "-")
After that, new data can be add to segment by command described above:

<I>, OUTCAT, - <N>,<DA>

In order to read the data from the archive segment, it is necessary to open the segment with the help of the command

,,,OPEN,<N>,<M>,<L>

and use the command initiating the reading of the records from the external catalogue, such as:

-<N>,INCAT,<K>,<DA>

This command initiates the transmission of the information about the allocation address of the data with the name <DA> from the external catalogue of segment <N> to the <K>-record in the internal catalogue. If the task does not envisage the record of the data to the archive file, the command for opening the catalogue can be omitted.
It is not reasonable to print out the external catalogue, because it is sufficiently illustrative in the text file.

3.3 Control and local parameters

The parameters of the data processing operations are assigned behind the data processing program in the order of the interpretation of the ,IN command (if it is present in the processing scenario PS).

Parameters used in processing are jointed in structures and placed in text lines up to 256 characters. The structure of parameters consists of header and set of integer and/or real numbers. The header should be placed in the beginning of the line. The numerical values of the parameters are listed separated by a comma "," and can span multiple lines. The absence of the "," separator at the end of the line is interpreted as a flag of the end of the structure. Blank lines are skipped when you enter; also passed the text of standing in line after the exclamation mark "!". The combination of characters "*/" before the name of the parameter structure is used to pass the input of the whole structure.

Functionally, parameter structures are divided into two types – the control and local ones.

The control parameters (CP) are uniquely associated with the respective functional module. The names and sequence of entering values in the CP are strictly fixed (see APPENDIX B), and any deviations from this order leads to misinterpretation of task and, as a rule, to emergency stop.

The local parameters (LP) contain some values form the set of CP, which is convenient to separate from the others and to determine advance, because of their importance and/or to avoid multiple entry of the same value. The LP can have arbitrary names, defined by user. These names are then used in the CP instead of parameter values, defined in the LP.

The structures of control and local parameters are similar and can be written in the form:

*<HP>{<MAT>{<MZAS>}}:{{<CI>=}<I>}{{,<CR>=}<R>},

where structure header is delimited by asterisk “*” and colon ”:” characters and can include
<HP> - structure name - text constant up to 7 characters in length (mandatory)
<MAT> - material number flag and
<MZAS> - charge-mass-state flag (optionally).

The flags can be present in the CP and are used to select the structures from the input cluster by material and charge-mass-state numbers given in the header (the exception is the CP for convolution modules S/C-S, F/C-F, M/C-M , in which these flags are used for definition of result parameters, see APPENDIX B). The values of flags in the header are separated by blank character “ “; absence of flags means “for all structures”.

<I>, <R> - the fields for placing of integer or real numbers or number arrays. Presence of a dot "." in real numbers is mandatory.

The value of the parameter can be preceded by
<CI>=, <CR>= - parameter indicators - arbitrary text constant without the blanks and ending with the sign of equality "=". If it is necessary to insert comma "," to the indicator, it must be doubled as ",,". Indicators are used for illustration purposes only – when line is entered, they are skipped.

Besides numerical values, the fields <I> and <R> can contain:
"?" - question mark, to request parameter value from the keyboard,
*<LP> - a local parameter name, to substitute its value to the CP structure.

With the help of a single command IN, it is possible to input several local or control parameters at a time, so called, a “cluster of parameters”. To input a cluster, the structure of

parameters should be ended by comma “,” , and the next structure should be placed on the new line.

The cluster of control parameters is registered in the catalogue record indicated in the command. The CP structures from cluster are read in loop by related module to perform prescribed actions.

Example 10. Input deck for preparation of cross-sections for the natural mixture of uranium isotopes.

```
!  -------  Processing program

,IN               ! Input of the local parameters
,IN,1,ENDF    ! Input of the control parameters
,IN,2,S/I-S
,IN,3,R/T-S
,IN,4,U/D-S
,IN,5,S/C-S
,IN,6,S/E-S
,IN,7,WRITE
,1,10,RUS       ! Input of the data for the isotopes U-234, U-235 and U-238
10,2,11,S       ! Linearization of the tables of cross-sections
10,3,11          ! Calculation of cross-sections from resonance parameters
10,4,11          ! Calculation of cross-sections in the region of unresolved resonances
11,5,12,S       ! Unite cross-sections
12,6,13,S       ! Delete redundant points
13,7              ! Record in file
,,,END
! ------------ Local parameters
*DE: Energy_interval_EL,,EH=?,
*NMT: Number_of_reactions=4,
*MT: List of_reactions=1,2,18,102,
*EPS: Tolerance=0.001
! ------------ Control parameters
!  Input of the *ENDF cluster
*ENDF: NTAPE=20,NMAT=0,NMF=2,*NMT,MF=2,3,*MT,
*ENDF: NTAPE=21, NMAT=0, NMF=2, *NMT, MF=2,3,*MT,
*ENDF: NTAPE=22, NMAT=0, NMF=2, *NMT, MF=2,3,*MT
*S/I-S: NINT=2,*DE, *EPS
*R/T-S: NFOR=0, NT=1,*DE, EPS=0.001,TEM=0.
*U/D-S: NFUN=0,NINT=2,NT=1,*DE,*EPS
*S/C-S 9200 9200000: NMAT=3, NS=0, MAT=9234,9235,9238,
          *DE,*EPS, RO=0.000054, 0.007204, 0.992742
*S/E-S: *EPS
*WRITE: NTAPE=30
```

3.4 Command options

Function modules of the GRUCON package may allow additional control by means of so-called "command options" - control parameter, defined in the command line itself. Command option - it is an integer number provided by the symbol "&", used as a flag, the value of which is transferred to the functional module by the command itself. The command parameter should be placed on the 3th command field (the <J> -field).

Example 11. Usage of the command option in the SEL command for separation data by names

```
 ,IN,1,ENDF
 ,1,10,DATA
 10,SEL,11,S       ! select all *S* data
10,SEL&1 ,12,S  ! select all data except *S*
 ,,,END
*ENDF: NTAPE=20, NMAT=0, NMF=0, NMT=0
```

In current version of the software package the command options are available for the modules ENDF, PENDF, SXIXS, SXEXS, SXTXS, SXGXF, SXXPXPN, UXDXF, UXDXS, SEL, EXTR, ARITH. Description of its using together with control parameters is given in the APPENDIX B .

4. SYSTEM'S CONTENT

The GRUCON system's content consists of two families of subprograms, they are ***Task Interpreter*** and the data ***Access Functions***.

The family of task interpreter includes the subprograms for reading and step-by-step performance of the processing program. The processing steps are the following:

- decoding of the command,
- preparation of the information about allocation address of the data to be processed, and entering of this information into the module's registers,
- call up of the functional module,
- registration of the data processing results in the library's catalogue.

The data access functions ensure the following operations in accordance with the content of the module's registers:

- retrieval of the required data from the LSR library,
- exchange (through the buffer pages) of the data arrays stored in the external units and operational memory of the LSR library,
- control of the data allocation in reserved parts of the memory.

4.1 Main program units

The GRUCON package contains two program modules: **MODULE LOCAL** and **MODULE GLOBAL**.

The **MODULE LOCAL** sets the value of parameter KQ, that determines the length of the word: KQ = 8 corresponds to double precision, KQ = 16 - quadruple precision. To configure the program to the required accuracy, it is enough to change the value of this parameter.

The **MODULE GLOBAL** specifies the volume of RAM and the size of the buffer pages, allocates appropriate arrays. Its main parameters are:

LPOOL - length of COMMON/BPOOL/ in the operational memory, dedicated to the modules for the dynamic storage of integer and real data arrays {LPOOL=1000000},
NBUF - number of buffer pages dedicated to the data exchange with the disk memory {NBUF=3}
LBUF - size of buffer page {LBUF=1000}.

The main program of the software package is the **PROGRAM GRUCON**.
It has the following functions:

- reading of the data processing program and loading of the commands into the operational part of memory;
- successive decoding of the commands, determination of their functions and parameters specified by default;
- preparing of the LSR segments;
- assigning the exchange channel numbers for the module and formation of channel

registers on the basis of the addresses specified in the command and rows of the LSR catalogue;

- call up of the functional module required for the execution of command;
- writing in the catalogue of the name and address of the data obtained as a result of executed command;
- organization of work with external catalogue;
- execution of command controlling calculation process.

These operations are fulfilled by subroutines and functions of the GRUCON system's content, namely:

INCOM - subprogram designed for the input of the data processing program.
Its responsibilities include: decoding strings containing the processing command, selection fields of commands and writing its values in the array mc, after the registers of the module; determining the number of rows of the catalog and the reservation elements of the mc array for its location.

DINIT - subprogram for initiation of the LSR segment;
input parameters:
NUNIT - number of the unit (this number is equal to the number of segment specified in the command);
NBLOCK - number of record-blocks scribed in the direct access file (library's segment); the length of the record is equal to the length of a buffer page LBUF.

DOPEN- subprogram that opens the access to the existing and scribed LSR segment;
input parameter:
NUNIT - number of unit = number of the LSR segment.

PROCES - subprogram for calling up the functional module with a given name;
input parameter:
HMOD - text name of the module.

IOCAT – subprogram for records exchange between operational and external catalogues.
Input parameter:
MCI - address of the record in the array mc.

4.2 Channels of the module

The functional module of the GRUCON package is represented in the form of a software unit that performs the data exchange with the LSR segments specified in the command in fields < i>, <j>, <k> through the conventional reading/writing units, the so called *channels* (indicated by arrows, which bear the numbers 1, 2 and 3) with the help of the operational memory common/bpool/ which is intended for the storage of intermediate results of the data processing using channel No. 0 (see Fig.2).

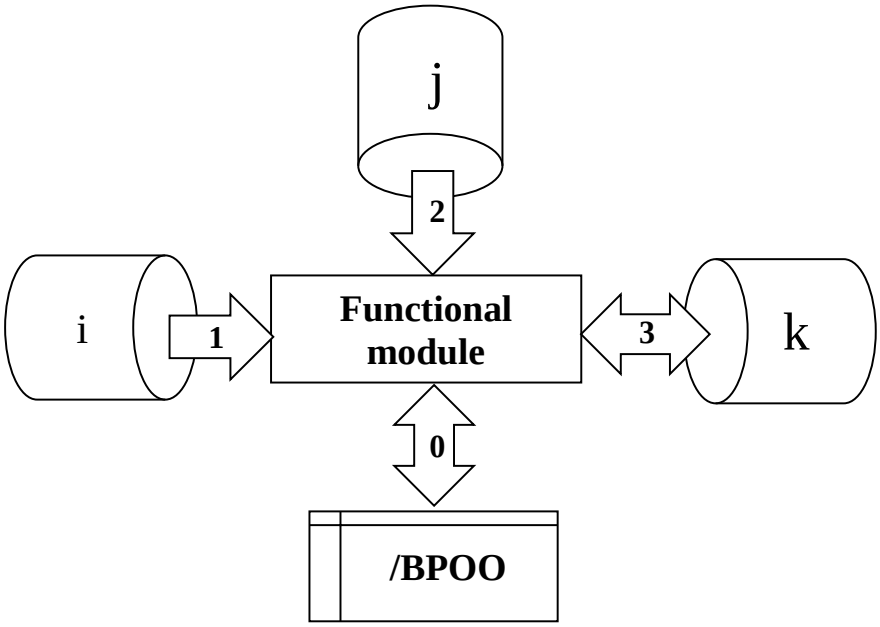

Figure 2 Flow diagram of the functional module

Channel 1 is used for reading the input data from the segment number, specified in the <i> command field, channel 2 is used for reading of the control parameters from the segment number, specified in the <j> command field, and channel 3 is used for the generation and accommodation of the data processing results in the segment number, specified in the <k> command field. The data exchange through the chanal 3 is available in two directions: reading and recording.

Data eschage with the operational memory is performed through the channel 0; zero channel, just like the third channel, allowes data exhange in the two directions.

4.3 The channels' registers

The exchange of information via the channels is realized on the basis of the value of the ***registers***. The registers represent an array of 9 words - MC(1:9), located at the beginning of the COMMON/BPOOL/ . The same MC array, starting from MC(11) is used also for the catalogue of LSR accommodation (MC(10) is reserved, not used) . Registers define:

MC(1) – address of the ith record in the catalogue (number of word in mc array) which contains the information about input data,
MC(2) – address of the jth record in the catalogue which contains the control parameters,
MC(3) - address of the kth record in the catalogue which contains the data processing results,
MC(4) - the current number of the word in channel 1 (when calling the module, this number is equal to the number of the first word in the cluster of processed data
MC(5) - the current number of the word in channel 2 (when calling the module, this number is equal to the number of the first word in the cluster of control parameters),
MC(6) - the current number of the word in channel 3 (when calling the module, this number is equal to the number of the first word in the cluster of results of data processing operation),
MC(7) - number of the first free word in the COMMON/BPOOL/,
MC(8) - number of words in the COMMON/BPOOL/,
MC(9) - command option.

The length of word in field COMMON/BPOOL/ is determined by the value of parameter KQ specified in MODULE LOCAL. In the distributed version of the program package, the KQ=8 is specified, that defines the real(8) word type.

4.4 Data access functions

The family of access functions consists of the following subprograms:

The **FOUND** function is assigned for data search. It performs sequential reading of headers of standard data structures from input data clusters – cluster of processed data and cluster of control parameters.
The function has the following parameters:
NC - channel number, NC=1 - for input data, NC=2 - for control parameters.
HSD - text name of standard data structure,
MAT - material number.
A gap instead of the name of standard structured data is interpreted as “any name”, similarly, the number of mat equal to 0 is interpreted as “any material”.
With the first calling of the function the tracing starts from the beginning of the data cluster, while with the subsequent calling of the function the tracing begins from the current address. The tracing function takes the form TRUE, if the data are detected, and form FALSE, if the required data are not detected in the rest part of the data cluster. The heading of a found out representation is entered in the COMMON/BFOUND/NAM(8).

The **LOAD** subprogram is designed for the exchange of standard structured data between the operational memory and the LSR library. The parameters of this subprogram are:
HS - name of standard structure,
NC - number of the exchange channel.
The program package GRUCON uses 32 standard structures for processed data representation, 18 of which are used of accommodation the processed evaluated data:

H, *S*, *R*, *RM*, *U*, *A*, *E*, *AE*, *TC*, *TI*, *TH*, *NU*, *EF*, *GS*, *GP*, *NP*, *NY*, *FP*;

6 structures are assigned for output data – parametrical functions, approximation parameters, double-differential cross sections in point-wise and group-wise representations:

F, *P*, *PN*, *PC*, *D*, *M*;

and, finally, 8 structures – text images of the evaluated data, which have no processing modules and can only be copied. Such data are the characteristics of radioactive decay and covariance matrices:

RD, *CP*, *CN*, *CR*, *CS*, *CA*, *CE*, *CY*.

The numbers of channels NC=1 and NC=2 are used for data transfer from the LSR library into the operational memory, NC=3 – for data recoding from the operational memory into the LSR library.
When reading/recording, the registers of the channels, which contain the numbers of the current words (MC(3+NC), NC=1,2,3 - for disk segments of LSR, MC(7) - for the COMMON/BPOOL/ in the RAM) are shifted by the number of read/recorded words. Subprogram LOAD reads and writes all the variables and arrays of specified standard representation except the very last table,

that includes the main data (see structures of processed data in the APPENDIX A). The last table is read/recorded fictitiously, e.g. only the register MC(3+NC) changes, which is responsible for the location address of the word in the LSR library. The purpose of the fictitious reading/recording is reducing the limitations imposed by COMMON/BPOOL/ on the amount of data. In the process of computation, the exchange of data between the operational memory and the LSR library is realized by the fragments whose size is selected according to the convenience of computation. For the purpose of the exchange of fragments, the following subprograms are used.

The **TRAC** subprogram serves to transfer the data blocks from disc memory (through channels 1, 2 and 3) to operational memory (channel 0) and vice versa. The data block exchange is performed via the buffer pages. This procedure has the following input parameters:

NC - number of the channel (with a sign);
L - the length of the data block;
ARR - data block of type real(kq),
IARR - data block of type integer(4),
IMLT – flag of type and accommodation of the transmitted data:
IMLT= 0, if the ARR array is used for data transmission,
IMLT=IMULT, if the IARR array is used for data transmission, and this array is accommodated in the COMMON/BPOOL/,
(IMULT=KQ/4 is a constant specified in the MODULE GLOBAL)
IMLT= 1, if the IARR array is used for data transmission, and this array is located outside the COMMON/BPOOL/.

The values of parameter NC are specify the following data exchange variants (options):
NC = 1 - reading of the information from the LSR library to the operational memory by means of channel 1 from the address indicated in the register MC(4);
NC = 2 - reading of the information from the LSR library to the operational memory by means of channel 2 from the address indicated in the register MC(5) ;
NC = 3 - recoding of information from the operational memory to the LSR library by means of channel 3, starting with the address MC(6);
NC = -3 - reading of the information from the LSR library to the operational memory by means of channel 3 from the address indicated in the register MC(6).
As a result of the transfer of the information block, the value of the register returned by the subprogram TRAC shifts by the length of the information block: MC(3+|NC|)= MC(3+|NC|)+L.

The **MWTRAC** subprogram-function serves to transfer the information block within the indicated input and output channels, or, if the numbers of input and output channels are equal, serves to determine the current address and shift it by a specified length (reservation of free space in the channel). This subprogram has the following parameters:
NCI - the number of the data reading channel (NCI = 0, 1, 2, 3);
LC - length of the data block,
NCO - the number of the data recording channel (NCO = 0 ,3).
The reading/recording of the information is realized from the addresses received from the

registers of the channels. The number of the channel 0 is used for data exchange with COMMON/BPOOL/. The number of the first free word in this array is given by register MC(7). Making records in channels 1 and 2 is prohibited. As a result of the data exchange, the applicable values of registers are shifted by the length of the data block LC. The value of the register of channel NCO is assigned to the function MWTRAC before the data transfer starts (e.g. the location address of the beginning of the data in channel NCO). If the numbers of input and output channels are equal (NCI=NCO), only the value of the applicable register is redefined – no data transfer takes place.

The following subprogram-functions are used to reserve the space in the memory:

The **MFREE** subprogram-function serves to determine the number of the first free word in the field common/bpool/ (in channel 0) and to reserve a space of the memory in this channel. This subprogram has the following parameters:
±L - is the length of the reserved memory in channel 0. The constant L can have two interpretations, depending on whether it is positive or negative:

if L>0, zero values are assigned to the elements of the field COMMON/BPOOL/ reserved for the data block;

if L<0, they are accepted by the system without any change.

The value of function MFREE - the value of register MC(7) – allocation address of the beginning data block in channel 0. When calling the function MFREE, the value of the registered is shifted by the length of the data block: MC(7)= MC(7)+|L|. In order to preserve the integrity of the data, the condition of MC(7)≤MC(8) must be satisfied, which is checked with every change of the address. The break of this condition leads to the diagnostics procedure and termination of the data processing operations. The values of function MFREE with parameter L=0 gives the address of the first free word in the COMMON/BPOOL/.

The **MSHIFT** subprogram-function allows reserving a memory space of a specified size in any channel. Moreover, the function is capable of using the memory space in the channel on the both ends –from the first or from the last free word, opening the possibility to allocate the data in the optimal manner. This subprogram has the following parameters:
NC – number of the channel, NC=0, 1, 2, 3
±LC - number of the reserved words.
A sign of LC indicates where to allocate the data block: at the beginning of the free part of the memory in the channel (if LC>0), or at the end (if LC<0). Accordingly, the address of the first free word and of the last free word in the channel will be redefined. The register changing algorithm is shown in the table:

	NC =0	NC=1,2,3
LC>0	MC(7)=MC(7)+LC	MC(3+NC)= MC(3+NC)+LC
LC<0	MC(8)=MC(8)+1-|LC|	MC(4+NC)= MC(4+NC)+1-|LC|

If the obtained values do not meet the condition MC(7)≤MC(8) (for NC=0) or MC(3+NC) ≤ MC(4+NC) (for NC=1, 2 and 3), i.e., the data overlapping is occurred, the warning message is issued and data processing operations is terminated.

The **SHIFT** subprogram serves to move the data within the channel NC=3. This subprogram has the following parameters:
LC – length of the data set,
±LS – is the number of words by which it is required to shift the data in the direction of increasing (LS>0) or decreasing (LS<0) the address value relatively the current value of MC(6). When the data array is moving, the register MC(6) is not changed.

5. INSTALLATION AND LAUNCH OF THE PROGRAM PACKAGE GRUCON

5.1 Installation procedure

The program package GRUCON is distributed in the form of the archival file ***Install_Grucon_YYYY_MM.zip*** (YYYY_MM – year and month of issue), with included folders, named as ***Documents, Data, Programs, Procedures, Tests*** and ***Temp*** and command procedures for installating, testing and monitoring the execution of tests by comparing resulting listings with original: ***1_install, 2_test, 3_compare***. One can use also procedure, which performs all three installation steps in one run - ***make_all***.

Procedures are given for three operational systems: Windows (files with extension ***bat***) , Linux (***sh***) and Mac (***mac***).

Before running the procedures, thay should be configered by choosing one of the proposed compilers and computers option and (in different deliveries they may differ), for example

comp=intel
bits=64

In the Linux and Mac operational systems, the initiation command ***chmod a+x *.sh*** or ***chmod a+x *.mac*** can be required, correspondingly, to make executable command file.

The installation includes the following steps:
- preparing of the upd (program editor) executable,
- launch of the program upd and formation of the f90 texts for the grucon program from the src source file and upn edits with required installation parameters,
- compiling and linking of the grucon executable file.

As a result of the executed procedure, in the ***Program/Exe*** folder will appear the grucon executable file with flags pointing the computing envirement, for example:

t***grucon-win-intel64.exe*** or ***grucon-lin-gfort64.exe*** , etc.

After running testing procedure, the ***Tests/Listings*** and ***Test/Results//N*** folders will apper, with listings and test results (*N* is the test number) obtained for input decks from the ***Tests/Inputs*** folder.

The ***Temp*** folder is used for placing of direct access files – segments of the LSR working library.

The results of test calculation contain the task listing ***testNN.lst*** and some other output files, depending on the input: “tapes” (***tapeNN***, *NN* – tape number), tables (***testNN_KK.tab***), standard representation files (***testNN_KK.out***) and graphic files (***testNN_KK.ps***), where *NN* is the test numbers and *KK* is the catalogue row number from input task.

For autonomous launch of the program package, the ***run_grucon*** command file, taken from the ***Procedures*** folder can be used, after editing paths to grucon executable and working data library.

5.2 Requirements and restrictions

To install the package using the installation procedure, it is needed ~ 4GB of computer memory (RAM), ~ 10GB of disk memory and the presence of one of the compilers Intel, gfortran or Lahey under Windows, Linuz or Mac operating systems.

The ZVView program is required for visualization of *.zvd files; it is available on the IAEA website

https://www-nds.iaea.org/public/zvview/

Disk memory is used for placement of direct access files of working library (BSP), or "segments". The maximal number of segments, available for user, is defined by parameter lunit, located in the LOCAL module. In the distributed version, ths parameters is set as lunit= 5. The volume of segments depend on processing scenario, prepared by user, with one restriction – available disk capacity.

Restriction on the RAM is defined by the summary volume of information, loaded to the from BSP for current calculation step. This restriction is controlled by parameter LPOOL, located in the LOCAL module. In the distributed version, the parameter value is equal to LPOOL= 32000000.

The GRUCON package performs calculations with double precision, that is controlled by parameter KQ=8 in the LOCAL module. There is a possibility to perform calculation with quadruple precision by setting the parameter value KQ=16.

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APPENDIX A. Processed Data Structures

A1. *H* - Descriptive Data

HTEXT	Text documentation of the cross section data
LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT)
LRP	=-1 - no resonance parameter data are given =0 - resonance parameter data contain the effective scattering radius only =1 - resonance parameters are given, background cross sections should be added =2 - resonance parameters are given without background cross sections
LFI	flag indicating whether this material fissions: 0/1 = no/yes
NLIB	Library identifier
NMOD	Modification number
LIS	State number of the target nucleus (0 – ground)
LISO	Isomeric state number (LIS0 ≤LIS)
ISTA	Target stability flag: 0/1 = stable/unstable
NFOR	Library format number
LREL	Library release number
NSUB	Sub-library number
NVER	Library version number
LDRV	Evaluation flag: 0/1 = primary evaluation/special derived evaluation
NROW	Number of rows in descriptive text
LROW	Number of characters in row
ELIS	Excitation energy of the target nucleus
EMAX	Upper limit of the energy range for evaluation
EPS	Data processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
AWI	Mass of the projectile (C^{12})
TEMP	Target temperature (Kelvin)

A2. *S* - Table of Cross Sections & Collision Functions

LMF	Class identifier of the ENDF original data (MF)
NKS	Total number of subsections
IKS	Serial number of the current subsection
LRA	Number of reaction characteristics in the MLR list, additional to the MT reaction type identifier (LRA=4 for collision function)
NE	Number of *x* points
NR	Number of reaction types
NT	Number of temperatures
±KINT	>0 – Interpolation scheme identification number: =1 – *y* is constant in *x* (histogram) =2 – *y* is linear in *x* =3 – *y* is linear in ln(*x*) =4 – ln(*y*) is linear in *x* =5 – ln(*y*) is linear in ln(*x*) <0 – interpolation type is given in the interpolation table (see MINT)
MLR(NR,LRA+1)	List of the reaction identifiers (MT) and LRA additional reaction characteristics; in case of collision function (LRA=4), this is: 2I, I - target nucleus spin, L - orbital moment, 2s , s - channel spin, 2J , J - total moment
MINT(2,-KINT)	Interpolation table (KINT<0): MINT(1,I) – interpolation scheme in the I-th range, MINT(2,I) – serial number of the *x* point separating I-th and (I+1)-th interpolation ranges
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
QM(NR)	Mass-difference *Q* values (eV)
QR(NR)	Reaction *Q* values (eV)
TEM(NT)	Temperature values (Kelvin)
TAB(*)	Cross section table: (E(IE),XS(NT,NS,IE),IE=1,NE)

A3. *R* - Resolved Resonance Parameters

LMF	Class identifier of the ENDF original data (MF)
NFOR	Resonance formalisms flag: =1 - single-level Breit-Wigner (SLBW) =2 - multilevel Breit-Wigner (MLBW) =3 - Reich-Moore (RM) =4 - Adler-Adler (AA)
NISOT	Number of isotopes in the material
ISOT	Serial number of the current isotope
NLS	Number of neutron orbital angular momenta (*l*-values)
ILS	Serial number of *l*
NJS	Number of total angular momenta (*J* -values)
IJS	Serial number of *J*
LS	Value of orbital angular momentum *l*
LSC	Number of *l* –values which must be used to obtain accurate elastic angular distributions
LRA	LRA=NRO*10+NAPS – flag controlling the calculation and usage of channel and scattering radii in the penetrability P_l, shift factors S_l and in the hard-sphere phase φ_l calculations NRO- flag designating energy dependence of the scattering radius (corresponds to the ENDF format) : NRO=1/0 (yes/no) NAPS - flag pointing the radii calculation: NAPS=0 – channel radius is calculated from the Equation: $a = 0.123 \times AWRI^{1/3} + 0.08$; scattering radius is taken from file; NAPS=1 – channel and scattering radii are the same and taken from file NAPS=2 – channel and scattering radii are different and taken from file
NRES	Number of resolved resonances for given *l* and *J* values
NRC	Number of reaction channels
NRW	Number of resonance widths
NRPC	Number of energy points at which channel radius is given
NRPS	Number of energy points at which scattering radius is given
NSB	Number of sets of background constants given (for NFORM=4 only)
±KIRPC	Interpolation scheme for the channel radius energy dependence (KIRPC=0, if channel radius is constant)
±KIRPS	Interpolation scheme for the scattering radius energy dependence (KIRPS=0, if scattering radius is constant)
LRC(NRC)	List of reaction channel identification numbers
LRW(NRW)	Index number in array of resonance parameters for widths of each reaction channel
MIRPC(2,-KIRPC)	Interpolation table for channel radius (KIRPN<0)
MIRPS(2,-KIRPS)	Interpolation table for scattering radius (KIRPS<0)
EL	Lower limit of the energy range (eV)

EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
ABN	Abundance (a number fraction) of an isotope in the material
SI	Target nucleus *I* (spin)
±**PI**	*I* parity = ±1.0
SJ	Total moment *J* (spin)
±**PJ**	*J* parity = ±1.0
QX	Q-value for use in the penetrability factor for competitive width (eV)
RPC(*, NRPC)	Channel radius parameters; single value, if KIRPC=0, otherwise table (10^{-12} cm)
RPS(*, NRPS)	Scattering radius parameters; single value, if KIRPS=0, otherwise table (10^{-12} cm)
SB(6,NSB)	Background cross section parameters (NFORM=4)
TAB(*)	Table of resonance parameters depending on formalisms: /NFORM=1, 2, 3/ (ER(IRES)(GR(IP,IRES),IP=1,NP(NLP)),IRES=1,NRES) , ER - resonance energies (eV), GR - resonance widths (eV) /NFORM=4/ (ER(IP,IRES),WR(IP,IRES),GS(IP,IRES),GA(IP,IRES), IP=1,NP(NLP),IRES=1,NRES), ER – resonance energy (eV), WR - value of Γ/2 (eV), GS - symmetrical cross section parameter, GA - asymmetrical cross section parameter

A4. *RM* - Multichannel-Multilevel Resonance Parameters

LMF	Class identifier of the ENDF original data (MF)
KRM	Flag to specify which formulae for the R-matrix are to be used: =1 for single-level Breit-Wigner (SLBW) =2 for multilevel Breit-Wigner (MLBW) =3 for Reich-Moore (RM) =4 for full R-matrix
NISOT	Number of isotopes in the material
ISOT	Serial number of the current isotope
NJS	Number of *J* total angular momenta
IJS	Serial number of *J*
KIFG	Channel width representation flag: =0 - channel width in eV, =1 - reduced-width amplitude in $eV^{1/2}$.
KRL	Kinematics flag: nonrelativistic/relativistic (KRL=0/1)
NR	Number of reactions (particle pairs)
NCH	Number of channels
NRES	Number of resonances
KRB	Flag of background R matrix parameter representation: =0 – no terms are added to the R-matrix =1 – tabulated complex function of energy =2 – SAMMY's logarithmic parameterization =3 – Fröhner's parameterization
KSH	Flag of non-hard-sphere phase shift parameter representation: KSH=0 – hard-sphere phase shift, no additional information KSH=1 – phase shift is tabulated complex function of energy
LRB	Length of the RB array with background R matrix parameters
LSH	Length of SH array with phase shift representation parameters
LR(NR)	List of reactions (pair-particle identification numbers)
LZAR(2,NR)	List of charge values for particles in pair
LPNT(NR)	List of flags if penetrability is to be calculated: = 1 - calculate penetrability; = –1 - do not calculate penetrability; = 0 - assign value depending on the MT number; default value: = -1 for fission (MT=19) or capture (MT=102), = 1 for other MT numbers
LSHF(NR)	List of flags if shift factor is to be calculated: SHF=+1 calculate the shift factor; SHF=–1 do not calculate the shift factor
LRCH(NCH)	Particle-pair identification number for channel
LCH(NCH)	Values of orbital angular momenta *l*
NRB(4)	Descriptors of the RB array with background R matrix parameters: NRB(1) = number of points in real part of function NRB(2) = interpolation law for real part of function NRB(3) = number of points in imaginary part of function NRB(4) = interpolation law for imaginary part of function
KRBR(2,-NRB(2)	Interpolation table for real part of the background R matrix (NRB(2)<0)

KRBI(2,-NRB(4))	Interpolation table for imaginary part of the background R matrix (NRB(4)<0)
NSH(4)	Descriptors of the SH array with phase shift parameters NSH(1) = number of points in real part of function NSH(2) = interpolation law for real part of function NSH(3) = number of points in imaginary part of function NSH(4) = interpolation law for imaginary part of function
KSHR(2,-NSH(2))	Interpolation table for real part of the shift parameters (NSH(2)<0)
KSHI(2,-NSH(4))	Interpolation table for imaginary part of the shift parameters (NSH(4)<0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
ABN	Abundance (a number fraction) of an isotope in the material
±SJ	Total moment *J* (spin); sign indicates parity
±PJ	Parity (used only if SJ=0.0): PJ=±1.0; sign indicates parity
AR(2,NR)	Mass of particles in pair (C^{12})
QR(NR)	*Q*-value for particle-pairs (eV)
SPR(4,NR)	SPR(1,IR) = spin of first particle in the IR-pair SPR(2,IR) = parity of first particle in the IR-pair SPR(3,IR) = spin of second particle in the IR-pair SPR(4,IR) = parity of second particle in the IR-pair
SCH(NCH)	Channel spin
BND(NCH)	Boundary condition for channel (needed when SHF=+1)
APE(NCH)	Effective channel radius (scattering radius), used for phase shift (10^{-12} cm)
APT(NCH)	True channel radius, used for calculation of penetrability and shift factors (10^{-12} cm)
RB(LRB)	Background R matrix parameters
SH(LSH)	Phase shift parameters
TAB(*)	Table of resonance parameters: (ER(IRES),(GR(ICH,IRES),ICH=1,NCH),IRES=1,NRES) ER – resonance energies (eV), GR – resonance widths (eV) or reduced-width amplitude ($eV^{1/2}$), depending from KIFG value (0 or 1)

A5. *U* - Unresolved Resonance Parameters

LMF	Class identifier of the ENDF original data (MF)
NFORM	Resonance formalisms number: =1 – single-level Breit-Wigner =2 – multilevel Breit-Wigner
NISOT	Number of isotopes in the material
ISOT	Serial number of the current isotope
NLS	Number of neutron orbital angular momenta (*l*-values)
ILS	Serial number of *l*
NJS	Number of *J* total angular momenta
IJS	Serial number of *J*
LSSF	Flag governing the interpretation of the File 3 cross sections. LSSF=0 – File 3 contains partial ”background” cross sections, to be added to the average unresolved cross sections calculated from the parameters in File 2. LSSF=1 – File 3 contains the entire dilute cross section for the unresolved resonance region. File 2 is to be used solely for the calculation of the self-shielding factors
LS	Value of orbital angular momentum *l*
LRA	LRA=NRO*10+NAPS – flag controlling the calculation and usage of channel and scattering radii in the penetrability P_l, shift factors S_l and in the hard-sphere phase φ_l calculations NRO- flag designating energy dependence of the scattering radius (corresponds to the ENDF format) : NRO=1/0 (yes/no) NAPS - flag pointing the radii calculation: NAPS=0 – channel radius is calculated from the Equation: $a = 0.123 \times AWRI^{1/3} + 0.08$; scattering radius is taken from file; NAPS=1 – channel and scattering radii are the same and taken from file NAPS=2 – channel and scattering radii are different and taken from file
NE	Number of energy points at which energy-dependent average distribution parameters are tabulated
NR	Number of reactions
NRPC	Number of energy points at which channel radius is given
NRPS	Number of energy points at which scattering radius is given
±KIRPC	Interpolation scheme for the channel radius energy dependence (KIRPC=0, if channel radius is constant)
±KIRPS	Interpolation scheme for the scattering radius energy dependence (IKRPS=0, if scattering radius is constant)
KINP	Interpolation law for parameters
KINS	Interpolation law for cross-section functions
MLR(NR)	List of reactions
MIRPC(2,-KIRPC)	Interpolation table for channel radius (KIRPN<0)
MIRPS(2,-KIRPS)	Interpolation table for scattering radius (KIRPS<0)
EL	Lower limit of the energy range (eV)

EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
ABN	Abundance (a number fraction) of an isotope in the material
±**SI**	Value of target nucleus I (spin); sign indicates parity (±)
±**PI**	Parity (used only if SI=0.0): PI=±1.0; sign indicates parity
±**SJ**	Value of total moment *J* (spin); sign indicates parity
±**PJ**	Parity (used only if SJ=0.0): PJ=±1.0; sign indicates parity
QX	Q-value for use in the penetrability factor for competitive width (eV)
RPC(*, NRPC)	Channel radius parameters; single value, if KIRPC=0, otherwise table (10^{-12} cm)
RPS(*, NRPS)	Scattering radius parameters; single value, if KIRPS=0, otherwise table (10^{-12} cm)
XNU(NR+1)	Flags controlling distribution law for level spacing XNU(1) and IR-reaction widths XNU(1+IR): -1.0 – Wigner distribution, 0.0 – delta-function (a constant value) >0.0 –number of degrees of freedom in chi-square distribution
TAB(*)	Table of average resonance parameters: (E(IE),D(IE),(GR(IR,IE),IR=1,NR),IE=1,NE) ; E – energy (eV) D – average level spacing (eV) GR – average reduced width for neutron channel ($eV^{1/2}$) , average reaction widthes for others (eV)

A6. *A* - Angular Distribution Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
NK	Total number of subsections
IK	Serial number of the current subsection
IZAS	MZ*100000+MA*100+MS – reaction product characteristics: MZ- charge, MA-atomic mass, MS-state number
LI	Flag to specify whether all the angular distributions are isotropic =0 – not all isotropic, =1 – all isotropic
LIS	Number of isotropic angular distributions
LCT	Flag to specify the frame of reference used =1 – the data are given in the LAB system =2 – the data are given in the CM system
LTT	Flag to specify the angular dependency representation used: =0, all angular distributions are isotropic =l, the data are given as Legendre expansion coefficients, $a_l(E)$ =2, the data are given as tabulated probability distributions, $f(\mu,E)$ =3, low energy region is represented by as Legendre coefficients; higher region is represented by tabulated data
NER	Number of energy intervals
NEA	Number of energy subintervals with the same angular parameters
NE	Number of projectile energies at which angular distributions are given
MNER(3,NER)	Representation characteristics of angular dependence in each energy range: MNER(1,IER) = NEI – number of energy point in energy range MNER(2,IER) = ±INTE - interpolation law MNER(3,IER) = LAP - angle representation law: LAP=0 - point-wise representation LAP=1 - average values in the equal intervals of scattering angle cosine LAP=2 - Legendre polynomial coefficients LAP=3 - breaks of equally-likely cosines LAP=4 - equally-likely discrete cosines
NA(2,NE)	NA(1,IE) =NAP - number of angular points at the IE energy point, NA(2,IE) =±INTA - interpolation law
MINTE(2,-INTE)	Interpolation table for energy dependence (INTE<0)
MINTA(2,-INTA)	Interpolation table for angular dependence
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
PAR1	Reaction characteristics, depending from projectile particle: =QM - mass-difference for neutron reaction /LMF=4/ =EGK – photon energy /LMF=14/
PAR2	Reaction characteristics, depending from projectile particle: PAR2=Q - *Q* value (eV) for neutron reaction /LMF=4/ PAR2=ESK - Energy of the level for photon reaction (eV) /LMF=14/
TEM	Temperature value ((°K)
TAB(*)	Table of distribution function parameter values

	(EI(IE),(PA(IA)=1,NAP(IE)), IE=1,NE)

A7. *E* - Energy Distribution Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
NK	Total number of partial energy distributions
IK	Serial number of the current partial energy distribution
IZAS	MZ*100000+MA*100+MS – charge-mass-state characteristics of reaction product
LAW	Distribution law: = 1 – arbitrary tabulated function = 5 – general evaporation law = 7 – simple Maxwellian fission spectrum = 9 – evaporation spectrum =11 – energy-dependent Watt spectrum =12 – energy-dependent fission neutron spectrum (Madland and Nix)
NPD	Number of projectile energies at which fractional part of the particular energy distribution is given
±INTD	Interpolation scheme for fractional part energy dependency:
NPE	Number of projectile energies at which a tabulated distribution is given (LAW=1) or number of distribution parameter tables (LAW>1)
±INTE	Interpolation scheme for projectile energies for LAW=1; not used (=0) for other laws
MIND(2,-INTD)	Interpolation table for fractional part (INTD<0)
MINE (2,-INTE)	Interpolation law for distribution parameters (INTE<0)
NPX(2,NPE)	NPX(1,IPE)= NX – number of points at which function is given NPX(2,IPE)= ±INTX – interpolation law for function given
MNPX(2,-INTX)	Interpolation table for distribution parameters (INTX<0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
U	Constant that defines the upper energy limit for the product particle so that $0 \le E' \le E - U$ (given in the LAB coordinate system)
PD(2,NPD)	Table of fraction part
TAB(*)	Distribution function parameter values LF=1: *g(E-> E')* (EI(IE),(EK(KE),G(KE),KE=1,NF(IE)),IE=1,NPE) LF=5: *G(x), x=E'/θ(E)* (EI(IE),TETA(IE),IE=1,NE),(X(IE),G(IE),IE=1,NX) LF=7,9: *θ(E)* (EI(IE),TETA(IE),IE=1,NE) LF=11: *a(E), b(E)* (EI(IE),A(IE),IE=1,NE),(EI(IE),B(IE),IE=1,NE) LF=12: $E_F(L)$, $E_F(H)$, $T_M(E)$ EFL,EFH,(EI(IE),TMI(IE),IE=1,NE)

A8. *AE* - Reaction Product Energy-Angle Distribution Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
NK	Total number of subsections. Each subsection describes one reaction product
IK	Serial number of the current subsection
IZAS	MZ*100000+MA*100+MS – charge-mass-state characteristics of reaction product
JP	flag to provide information about neutrons and photons JP=JPP*10+JPN JX(JPP .OR. JPN) = 0 - yi and fi are given (yield and distributions) 1 - yi=P(nu,E)/<nu> - probability of emitting nu particles 2 - P(nu,E) and f - average spectrum for nu particles if JP > 0, LAW < 0 and format is equal LAW=0
LIP	Product modifier flag. The ENDF format allows various of usage. Its main use is to identify the isomeric state of a product nucleus. In this case, LIP=0 for the ground state, LIP=1 for the first isomeric state, etc. These values should be consistent with LISO in File 8, MT=457. Multiple emission: In some cases, it may be useful to use LIP to distinguish between different subsections with the same value of ZAP for light particles. Other possible uses might be to indicate which compound system emitted the particles, or to distinguish between the neutron from the (n,np) channel and that from the (n,pn) channel
LCT	Flag to specify the frame of reference used =1 – the data are given in the LAB system =2 – the data are given in the CM system
LAW	Flag to distinguish between different representations of the distribution function: =0, unknown distribution; =1, continuum energy-angle distribution; =2, two-body reaction angular distribution; =3, isotropic two-body distribution; =4, recoil distribution of a two-body reaction; =5, charged-particle elastic scattering; =6, n-body phase-space distribution; and =7, laboratory angle-energy law <0 (for fission only with JP>0) the average particle distributions are given in MF=4/5 (for neutrons) or MF=14/15 (for photons). The format here is equivalent to LAW=0, giving only the incident energy-dependent probability table
IPAR	LAW-dependent flag, distinguishing: LAW=1: IPAR - angular dependence representation, =1, Legendre coefficients; =2, Kalbach-Mann systematics LAW=2: IPAR - angular dependence representation,

	=0, Legendre expansion; =12, tabulation with $p_i(\mu)$ linear in μ; =14, tabulation with *log(pi)* linear in μ LAW=5: IPAR indicates that the particles are identical (IPAR=1) or not (IPAR=0); LAW=6: IPAR - number of particles distributed according to the phase-space law
NY	Number of energy points in the reaction product yield or multiplicity
INTY	Interpolation law for the reaction product yield or multiplicity
NE	Number of energy points in distribution function parameters (NE=0, if LAW=0,3,4,6)
NEA	Number of angle (cosine) points (LAW=7)
INTE	Interpolation law for projectile energies
INTEP	Interpolation law for reaction product energies
MNA(NE)	Number of angle (cosine) points
MNW(NE)	LAW- dependent flag: LAW=1,2,5: MNW(IE) - number of distribution parameters for each energy point LAW=7: ±MNW(IE) – interpolation law for angular distribution function
MNEP(NEP)	LAW- dependent flag: LAW=1: MNEP(IEP) – number of reaction product energy points for each projectile energy (IEP=1,…,NEP=NE) LAW=7: MNEP(IEP) – number of reaction product energy points for each angle and projectile energy point(IEP=1,…,NEP=NEA)
MND(NE)	LAW- dependent flag: LAW=1: MND(IE) – number of discrete lines at each projectile energy point LAW=2: MND(IE) – angle distribution representation flag at each projectile energy point; =0, Legendre expansion =12, tabulation with $p_i(\mu)$ linear in μ =14, tabulation with *log(pi)* linear in μ LAW=5: MND(IE) – distribution function representation flag, =1 nuclear amplitude expansion, =2 residual cross section expansion as Legendre coefficients =12 nuclear plus interference distribution with P_{NI} linear in μ =14 tabulation with $ln(P_{NI})$ linear in μ =15 tabulation with P_{NI} linear in μ LAW=7: ±MND(IE) – interpolation law for reaction product energies for each projectile energy point
MINTY(2,-INTY)	Interpolation table for yields or multiplicities (INTY<0)
MINTE(2,-INTE)	Interpolation table for projectile energies (INTE<0)
MINTA	Interpolation tables for angle distributions (MNW(IE)<0, LAW=7)
MINTEP	Interpolation tables for angle distributions (MND(IE)<0, LAW=7)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})

AWP	Mass of reaction product (C^{12})
RPAR	LAW-dependent flag: LAW=5: RPAR=SI – spin of particle LAW=6: RPAR=APXS – total mass (C^{12}) of the n particles being treated by the law
Y(2,NY)	Reaction product yield or multiplicity values
EI(NE)	Projectile energy values
TAB(*)	Table of energy-angular distribution parameters

A9. *TC* - Coherent Elastic Thermal Scattering Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
LI	Elastic scattering type number (LI=1 – coherent)
NT	Number of temperatures
NEB	Number of Bragg edges given
±KINT	Interpolation law for temperatures
±KINE	Interpolation law for projectile energies
MINT(2,-KINT)	Interpolation table for temperatures (KINT<0)
MINE(2,-KINE)	Interpolation table for projectile energies
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
TEM(NT)	Temperatures (Kelvin)
EB(NEB)	Energies of Bragg edges (eV)
SB(NEB,NT)	Structure factors (eV· barn)

A10. *TI* - Incoherent Elastic Thermal Scattering Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
LI	Elastic scattering type number (LI=2 – incoherent)
NT	Number of temperatures
±KINT	Interpolation law for temperatures
MINT(2,-KINT)	Interpolation table for temperatures (KINT<0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
SB	Characteristic ultimate scattering section (barn)
TEM(NT)	Temperatures (Kelvin)
W(NT)	Debye-Waller integral divided by the atomic mass (eV^{-1}) as a function of temperature (Kelvin).

A11. *TH* - Incoherent Inelastic Thermal Scattering Parameters

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT)
LAT	Flag indicating which temperature has been used to compute α and β =0, the actual temperature has been used, =1, the constant $T_0 = 0.0253$ eV has been used.
LASYM	Flag indicating whether an asymmetric S(α,β,T) is given =0 – symmetric, =1 – asymmetric
LLN	Flag indicating the form of S(α,β,T) stored in the file =0 – linear, =1 - logarithmic
NSA	Number of non-principal scattering atom types
NBET	Total number of β (energy transfer) values given
±KINB	Interpolation law for β
NALF	Total number of α (momentum transfer) values
NTEM	Total number of temperature values
LAW(NSA+1)	LAW(IA) is a test indicating the type of analytic function used for each atom type (including principal one) = 0, use the atom in SCT approximation only (see below) = 1, use a free gas scattering law = 2, use a diffusive motion scattering law
MNSA(NSA+1)	Number of atoms each type
MNALF(2,NBET)	MNALF(1,IBET) - number of α values for each β point ±MNALF(2,IBET) - interpolation law for α
MNTEM(2,NBET)	MNTEM(1,IBET) - number of temperatures for each β point ±MNTEM(2,IBET) - interpolation law for temperatures
MNTEF(2,NSA+1)	MNTEF(1,IA) - number of effective temperatures for each atom ±MNTEM(2,IA) - interpolation law for effective temperature
MINTB((2,-KINB)	Interpolation table for β
MINTA(2,NALF)	Interpolation tables for α, NALF = ∑ MNALF(1,I)
MINTT(2,NTEM)	Interpolation tables for temperatures, NTEM=∑ MNTEM(1,I)
MINTEF(2,NTEF)	Interpolation tables for effective temperatures, NTEF= ∑MNTEF(1,I)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
EKTMAX	The value of E/kT above which the static model is adequate
EFGMAX	The upper energy limit for the constant scattering cross section free atom approximation
SF(NSA+1)	Constant scattering cross sections for free atoms
AW(NSA+1)	Atomic weights (C12)
BET(NBET)	β values
ALF(NALF)	α values
TEM(NTEM)	Temperatures T (Kelvin)
TEF(2,NTEF)	Effective temperatures (Kelvin)
TAB(*)	S(α,β,T) - Tabulated scattering law data

A12. *NU* - Prompt and Delayed Neutron Yields

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format): =452 – number of neutrons per fission, $\overline{\nu}$ =455 – delayed neutron data, $\overline{\nu}_d$ =456 – number of prompt neutrons per fission, $\overline{\nu}_p$
LDG	Flag indicating energy dependence of delayed-group constants: LDG=1/0 (yes/no)
LNU	Test indicating which representation is used: = 1 - polynomial expansion coefficients = 2 - tabulated representation
NNF	Number of precursor families considered
LALD	Length of array with decay parameters
NPD	Number of energy points at which the delayed-group data are given
±KIND	Interpolation scheme for the delayed-group energy dependence
NPNU	Number of energies at which $\overline{\nu}$(E) are given (LNU=2)
NCNU	Number of terms in the polynomial expansion of $\overline{\nu}$(E) (LNU=1)
±KINU	Interpolation scheme for the $\overline{\nu}$(E) energy dependence (LNU=2)
MINTD(2,-KIND)	Interpolation table for the delayed-group data (KIND<0)
MINTN(2,-KINU)	Interpolation table for $\overline{\nu}$(E) energy dependence (KINU<0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
ALD(LALD)	LDG=0: Decay constant λ (sec^{-1}) RLAM(NPD,NNF) LDG=1: Delay-group abundances and decay constants, (α , λ) E(IE),(ALF(IN,IE),RLAM(IN,IE),IN=1,NNF),IE=1,NED)
TAB(*)	LNU=1: $\overline{\nu}$(E) polynomial expansion coefficients (CN(INU),INU=1,NCNU) LNU=2: tabulated $\overline{\nu}$(E) values (E(INU),RNU(INU),INU=1,NPNU)

A13. *EF* - Components of Energy Release Due to Fission

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
LFC	Representation Flag: 0/1 = polynomial/tabular
NEFC	Number of components (LFC=1) or 0 (LFC=0)
NPLY	Order of the polynomial expansion
MNFC(NEFC)	Number of energy points for each component (NEFC>0)
MLDRV(NEFC)	List of flags LDRV=1 - derived data, = 2- primary evaluation (NEFC>0)
MKINT(NEFC)	Interpolation law (NEFC>0)
MINT(*)	Interpolation table (NEFC>0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
TAB(*)	Table of energy release components: ET – sum of the partial energies EFR - kinetic energy of the fission products ENP - kinetic energy of the prompt fission neutron END - kinetic energy of the delayed fission neutrons EGP - total energy released by the emission of prompt γ rays EGD - total energy released by the emission of delayed γ rays EB - total energy released by delayed β 's ENU - energy carried away by neutrinos ER - total energy less the energy of the neutrinos

A14. *GS* - Delayed Photon Data

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
LO	Representation type option: =1 - discrete =2 - continuous
NPAR	LO=1: NPAR=NG - number of discrete photons LO=2: NPAR=NNF - number of precursor families
MNRNP(2,NG)	LO=1: Interpolation scheme parameters: MNRNP(1,IG)= ±NR - interpolation law (>0) or number of ranges(<0) MNRNP(2,IG) = NP - number of points for each discrete photon LO=2: not used
MINT(*)	LO=1: table of interpolation laws (if NR < 0) LO=2: not used
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
EG(NG)	Energies of the discrete photons [eV] (if LO=1 only)
TAB(*)	LO=1: Ti(t) – time dependence of i-th photon multilplicity LO=2: λ_i - decay constant (sec^{-1}) for the i-th precursor (LO=2)

A15. *GP* - Photon Yields or Photon Production Cross Sections

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
LO	Flag: LO = 0 - photon production cross sections LO = 1 - multiplicities LO = 2 - transition probability arrays
LG	LO=0,1: LG = 0 – not used LO =2: LG = 1 - all transitions are γ-emission L G= 2 - competing processes occur
NPAR	LO=0,1: NPAR = NK - number of discrete photons including continuum LO=2: NPAR = NS – number of the levels below the present one
NY	LO = 0,1: Number of points in the total yield (if NK >1) LO=2: not used
±KINTY	Interpolation flag for total yield
MINTY(-2*KINTY)	List of interpolation laws for total yield (if KINTY<0)
MLPLF(*)	Option LO=0,1: array (LP,LF),where LP=0 - origin of photons is not designated or not known, and the photon energy is EG_k; LP=1 - for non-primary photons where the photon energy is EG_k; LP=2 - for primary photons where the photon energy EG'_k is given by $EG'_k = EG_k + AWR/(AWR + 1)\, E_n$ LF=1 - a normalized tabulated function LF=2 - a discrete photon energy Option LO=2: LP (see above)
MNRNP(*)	Option LO=0,1: Interpolation parameters (NR,NP), where ±NR - interpolation law(>0) or number of ranges(<0) NP - and number of points for each discrete photon Option LO=2: NT – number of transitions
MINTEP(*)	List of interpolation laws for photon production data (if NR < 0)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
Y(2,NY)	Yield table
EGES(*)	Option LO=0,1: array (EGk,ESk),where EG_k - photon energy (LP=0 or 1), binding energy (LP=2) ES_k - energy of the level or zero, if the level is unknown or continuous photon spectrum is produced Option LO=2: ES_{NS} – energy of NS-level
TAB(*)	LO=0: Table of photon production cross section LO=1: Table of multiplicities LO=2: Table of transition probabilities

A16. *NP* - Radioactive Nuclide Production Data

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
LIS	State flag of original nuclide
LISO	Isomeric state number of the original nuclide
NS	Number of final states
NO	Flag denoting information completeness: =0 - yes =1 - no
MLMF(NS)	File numbers in which the multiplicity or cross section is given
MZAP(NS)	flag of nuclide - decay product
MND(NS)	Number of branches
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
ELFS(NS)	Excitation energies (eV)
TAB(6,NS)	Array of decay characteristics: HL - half-life of the nuclide zap (sec) RTYP - decay mode ZAN - next nuclide along the chain BR - branching ratio END - endpoint energy of the particle emitted (eV) CT – chain terminator

A17. *NY* - Multiplicities and Nuclide Production Cross Sections

LMF	Class identifier of the ENDF original data (MF)
NKS	Total number of subsections
IKS	Serial number of the current subsection
LRA	Number of reaction characteristics in the MLR list, additional to the MT reaction type identifier
NE	Number of *x* points
NR	Number of reaction types
±KINT	>0 – Interpolation scheme identification number: =1 – *y* is constant in *x* (histogram) =2 – *y* is linear in *x* =3 – *y* is linear in ln(*x*) =4 – ln(*y*) is linear in *x* =5 – ln(*y*) is linear in ln(*x*) <0 – interpolation type is given in the interpolation table (see MINT)
MLR(NR,LRA+1)	List of the reaction identifiers (MT) and LRA additional reaction characteristics
MINT(2,-KINT)	Interpolation table (KINT<0): MINT(1,I) – interpolation scheme in the I-th range, MINT(2,I) – serial number of the *x* point separating I-th and (I+1)-th interpolation ranges
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
QM(NR)	Mass-difference *Q* values (eV)
QR(NR)	Reaction *Q* values (eV)
TAB(*)	Cross section table: (E(IE),XS(NT,NS,IE),IE=1,NE)

A18. *FP* - Fission Product Yield Data

LMF	Class identifier of the ENDF original data (MF)
LMT	R type identifier (MT in the ENDF format)
NE	Number of energy points
MINT(NE)	List of interpolation laws
MNFP(NE)	Number of fission product nuclide states
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
AW	Mass of the target nucleus (C^{12})
TAB(*)	Fission product yield data (E, ZAFP,Y,DY), independent (LMT=454): ZAFP - identifier for a particular fission product YI - independent yield for a particular fission product DYI - 1σ yield uncertainty or cumulative (LMT=459): ZAFP - identifier for a particular fission product YC - independent yield for a particular fission product DYC - 1σ yield uncertainty

A19. *RD* - Radioactive Decay Data (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A20. *AR* - Atomic Relaxation Data

LMF	Class identifier of the ENDF original data (MF)
LMT	Reaction type identifier (MT in the ENDF format)
NSS	Number of subshells
LTR	Total number of transitions
NTR(NSS)	Number of transitions from subshell
MELN(NSS)	Number of electron in subshell when neutral
MSUBI(NSS)	Subshell designator
MSUBJ(NSS)	Secondary subshell designator
MSUBK(NSS)	Tertiary subshell designator
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Relative processing uncertainty (zero for evaluated data)
ZA	Material charge parameter
AW	Material mass parameter (C^{12})
EBI(NSS)	Binding energy for subshell (eV)
ETR(LTR)	Energy of transition (eV)
FTR(LTR)	Fractional probability of transition

A21. *CP* - Covariances of Model Parameters (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A22. *CN* - Covariances of the Average Number of Neutrons per Fission (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A23. *CR* - Covariances of Resonance Parameters (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A24. *CS* - Covariances of Neutron Cross Sections (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A25. *CA* - Covariances for Angular Distributions (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A26. *CE* - Covariances for Energy Distributions (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A27. *CY* - Covariances for Radionuclide Production (Text Image)

LMF	Class identifier of the ENDF original data (MF)
LMT	Data type identifier (MT in the ENDF format)
NROW	Number of text records
LROW	Length of text record

A28. *F* - Cross Section Moments

LMF	Class identifier of the ENDF original data (MF)
NFUN	Function type: NFUN=1 – binomial moments (shielded cross sections) NFUN=2 – exponential moments (transmission functions)
±NEG	Number of groups (NEG>0) , or energy points (NEG<0)
INTE	Interpolation law for energies
NT	Number of temperatures
NR	Number of reactions
NP	Number of moment parameters
NL	Minimal moment order
NH	Maximal moment order
MLR(NR)	List of reaction types
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty
AW	Mass of the target nucleus (C^{12})
QM(NR)	Mass-difference *Q* values (eV)
QR(NR)	Reaction *Q* values (eV)
TEM(NT)	Temperature values (Kelvin)
PAR(NP)	Parameter values depending from function type NFUN: NFUN=1 - dilution cross sections (barn) NFUN=2 - target thicknesses (atoms/barn)
EG(NEG+1)	Group breaks (eV)
TAB(*)	Table of moment values (RG(IG),WG(IG), (((FG(IL,IR,IP,IT,IG),IL=1,NH- NL+1),IR=1,NR+1),IP=1,NP),IT=1,NT),IG=1,NE) |RG| = energy value (eV) (EG=RG, RG>0) or group number (IG= -RG, RG<0) WG – weight function group integral (WG=0 for discrete energies)

A29. *P* - Subgroup Parameters and Probability Tables

LMF	Class identifier of the ENDF original data (MF)
±NEG	Number of groups (NEG>0) or energy points (NEG<0)
NTYP	Type of subgroup parameters: NTYP=0 – subgroup parameters with temperature independent fractions NTYP=1 – subgroup parameters with temperature dependent fractions NTYP=2 – fractions depend on temperature and reaction type
±NB	|NB| - maximal number of subgroups; NB>0 – subgroup table contains only one set of parameters with KB≤NB, NB<0 – subgroup table contains parameters for subgroup sets with IB=1,..., KB≤ | NB|;
NR	Number of reaction types
NT	Number of temperatures
INTE	Interpolation law for projectile energies
INTT	Interpolation law for temperatures
MLR(NR)	List of reaction type identifiers (MT)
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty
AW	Mass of the target nucleus (C^{12})
QM(NR)	Mass-difference *Q* values (eV)
QR(NR)	Reaction *Q* values (eV)
TEM(NT)	Temperatures (Kelvin)
EG(NEG+1)	Group breaks (eV) (NEG>0)
TAB(*)	Table of subgroup parameters: (RG(IE),WG(IE), (((A(IT,IR,IB,IE),IT=1,KT),IR=1,KR),((XP(IT,IR,IB,IE), IT=1,NT),IR=1,NR), IB=JB,KB), IE=1,NE); |RG| = energy value (eV) (EG=RG, RG>0) or group number (IG= -RG, RG<0) WG – weight function group integral (WG=0 for discrete energies) Depending on NP : NB >0: JB=KB=NB NB<0: JB=1,KB=| NB|; Depending on NTYP: NTYP=1: KT=1, KR=1 NTYP=2: KT=NT, KR=1 NTYP=3: KT=NT, KR=NR

A30. *PN* - Energy Ordered Subgroups

LMF	Class identifier of the ENDF original data (MF)
LR	Reaction type identifier (MT)
NE	Number of energies
NB	Number of subgroups
NG	Number of groups
NIG	Number of weight function domains
MIG(NIG)	Serial numbers of groups breaking weight function domains
IWF(NIG)	Weight function type in each domain: 1 - E^R, where R – spectrum parameter number of parameters LW=1) (i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum); 2 - fission spectrum , $T=9.65\cdot10^5(0.76+0.1\nu)$ $b=2.29\cdot10^{-6}(0.76+0.1\nu)$ Parameter ν – number of fission neutrons (LW=1); 3 - Maxwellian spectrum $E\cdot e^{-E/kT}$ with parameter T – neutron gas temperature parameter (LW=1) 4 - superposition of spectra $C_m E\cdot e^{-E/\mathrm{Tm}}$, $E<E_m$ $1/E$, $E_m<E<E_f$ $C_f\sqrt{E}\cdot e^{-E/T_f}$, $E_f<E$ where E_m, T_m, E_f, T_f - parameters (LW=4); coefficients C_m , C_f are defined from the function continuity condition 5 - $\delta(E-E_g)$, delta function; E_g=lower bound of energy group (LW=0) 6 - $C\cdot e^{-E/T}\mathrm{sh}(\sqrt{\mathrm{bE}})$, T, b, C – parameters (LW=3) 7 - $C\sqrt{E}\cdot e^{(E/T_f)}\mu(E)$, $\mu(E)=A_i+B_iE$, $E_i<E\le E_i+1$; $i=0,3$; $E_0=0$; $\mu(E)=C_5exp(A_5+B_5E)$, $E>E_4$ Parameters: T,C, E_1, E_2, E_3, E_4, A_1, B_1, A_2, B_2, A_3, B_3, A_4, B_4, A_5, B_5, C_5 (LW=17) N<0 - function table; parameters: $(Ei,,Si)$, $i=1,\|N\|$; (LW=2*|N|)
KNG(NG-1)	Number of energy point, breaking group interval
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty
TEM	Temperature (Kelvin)
WF(*)	Weight function parameters
EG(NG+1)	Group breaks (eV)
TAB(*)	Table of subgroup numbers (EI(IE),BI(IE),IE=1,NE) , EI - energy(eV), BI - subgroup serial number

A31. *PC* - Subgroup Correlation Matrices

LMF	Class identifier of the ENDF original data (MF)
LR	Reaction type identifier (MT) of the first set of parameters
NG	Number of groups in the first set of parameters
NB	Number of subgroup in the first set of parameters
MAT2	material number in the second set of parameters
MZAS2	= MZ2*10000 +MA2*10 + MS2 – charge-mass-state characteristics of nucleus in the second set of parameters
LR2	Reaction type identifier (MT) of the second set of parameters
NB2	Number of subgroup in the second set of parameters
NBC(2,NB,NG)	Subgroup correlation matrix descriptors: NBC(1,IB,IG) - number of the first nonzero element in the IB-row of correlation matrix for the IG-group NBC(2,IB,IG) - number of the last nonzero element in the IB-row of correlation matrix for the IG-group
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty
TEM1	Temperature value for the first set of parameters (Kelvin)
TEM2	Temperature value for the second set of parameters (Kelvin)
TAB(*)	Subgroup correlation matrix (((PC(IB,IB2,IG),IB=1,NB), IB2=1,NB2),IG=1,NG)

A32. *D* - Reaction Product Energy-Angle Distribution Tables

LMF	Class identifier of the ENDF original data (MF)
LR	Reaction type identifier (MT)
NK	Total number of subsections; each subsection describes one product particle
IK	Serial number of the current subsection
IZAS	MZ*100000+MA*100+MS – charge-mass-state characteristics of reaction product
INED	Interpolation flag for initial energy
LEP	Flag to specify the energy distribution representation used: =0 – point-wise representation =1 – group-wise representation =2 – equally-likely discrete energies
LAP	Flag to specify the angular distribution representation used: <0 – delta function =0 – point-wise representation =1 – average values in the equiangular intervals =2 – Legendre polynomial coefficients =3 – breaks of equally-likely cosines =4 – equally-likely discrete cosines
NT	Number of temperatures
NY	Number of energies in the yield array
NE	Number of projectile energy points
NG	=0, if LEP=0 or LEP=2 = Number of energy groups for reaction particle, if LEP=1
NAN	Number of angular distribution parameters
MNE(2,NT,NE)	MNE(1,IT,IE) =MO – position of the distribution parameters in the TAB for IE-energy and IT-temperature points MNE(2,IT,IE) =NO – total number of energies (NO=NEO) or groups (NO=NGO) of reaction product
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Data processing uncertainty
AW	Mass of the target nucleus (C^{12})
AWP	Mass of the reaction product (C^{12})
TEM(NT)	Temperatures (Kelvin)
Y(2,NY)	Yields as function of energy (if NY>0)
EP(NE)	Projectile energies (eV)
EG(NG+1)	Group energy breaks for reaction product (if LEP=1)
TAB(*)	Table of energy-angle distribution function: ((RO(IE),PO(IE),AN(NA,NO,IE)),IE=1,NE) |RO| - reaction product energy value (eV) (EO=RG, RG>0) or group number (IGO= -RO, RO<0) PO – probabilities, AN – angular distribution parameters

A33. *M* - Group Transition and Particle Production Matrices

LMF	Class identifier of the ENDF original data (MF)
LR	Reaction type identifier (MT)
NK	Total number of subsections; each subsection describes one reaction product
IK	Subsection number
IZAS	(MZ*1000+MA)*100+MS – charge-mass-state characteristics of reaction product
NT	Number of temperatures
NY	Number of energies in the yield array
NGI	Number of projectile energy groups
NGO	Number of reaction product energy groups
NA	Number of angular parameters
NSIG	Number of dilution cross sections
LAP	Flag to specify the angular dependency representation used: =0 – point-wise representation =1 – average values in the equiangular intervals =2 – Legendre polynomial coefficients =3 – equally-likely cosine intervals =4 – equally-likely discrete cosines
NGS	Number of source groups
MGS(4,NT,NGS)	Scattering /production matrix descriptors: MGI(1,IT,IG) – position of vector of group transition cross section for IG initial group and IT-temperature in the TAB array MGI(2,IT,IG) – initial energy group number MGI(3,IT,IG) – number of secondary energy groups MGI(4,IT,IG) – the lowest secondary energy group
EL	Lower limit of the energy range (eV)
EH	Upper limit of the energy range (eV)
EPS	Processing uncertainty
AW	Mass of the target nucleus (C^{12})
AWP	Mass of the reaction product (C^{12})
QM	Mass-difference (eV)
QR	*Q* value of reaction (eV)
TEM(NT)	Temperature values (Kelvin)
Y(2,NY)	Yields as function of energy (if NY>0)
SIG(NSIG)	Dilution cross section values (barn)
EGI(NGI+1)	Group breaks for projectile energies (eV)
EGO(NGO+1)	Group breaks for reaction product energies (eV)
TAB(*)	Table of group flux and group transitions/productions matrix ((FL(NA,NSIG+1,IT,IG), (XS(NA,NSIG+1,IGO,IT,IG),IGO=1,MGI(2,IT,IG)),IT=1,NT),IG=1,NGS)

APPENDIX B. Module Control Parameters

B1. Input Modules

B1.1 *IN: Entering of Control Parameters from Input Data File	
	No parameters

B1.2 *INCAT: Reading of External Catalogue from CAT file	
	No parameters

B1.3 *READ: Reading of Data File in Internal Format	
±NTAPE	Number of input unit; NTAPE>0 – formatted mode, NTAPE<0 - binary mode
Example: read data in standard representation from the tape30 binary file *read: ntape=-30	

B1.4 *ENDF: Reading of Data File in the ENDF Format	
Command option: &0 = leave input data as is (default) &1 = in case of any discrepancies in the data, make the proposed corrections	
NTAPE	Number of input unit
NMAT	Number of materials to be entered (0 = all materials on tape)
NMF	Number of data classes to be entered (0 = all files on tape)
NMT	Number of reaction types to be entered (0 = all sections on tape)
MAT(NMAT)	List of the material numbers (if NMAT>0)
MF(NMF)	List of the data class numbers (if NMF>0)
MT(NMT)	List of the reaction type numbers (if NMT>0)
Example: to read any ENDF material, the MF3 file, the MT1,MT2, MT102 sections from tape20 and to convert them to standard representation *endf: ntape=20,nmat=0,nmf=1,nmt=3,mf=3,mt=1,2,102	

B1.5 *PENDF: Reading of Data File in the PENDF Format	
±NTAPE	Number of input unit and record mode NTAPE>0 – formatted mode, NTAPE<0 – binary mode
NMAT	Number of materials to be entered (0 = all materials on tape)
NTM	Number of temperatures to be entered (0 = all temperatures)
NMF	Number of data classes to be entered (0 = all files on tape)
NMT	Number of reaction types to be entered (0 = all sections on tape)
MAT(NMAT)	List of the material numbers (if NMAT>0)
MTM(NTM)	List of temperature serial numbers (if NTM>0)
MF(NMF)	List of the data class numbers (if NMF>0)
MT(NMT)	List of the reaction type numbers (if NMT>0)
Example: to read from tape20 with point-wise data (PENDF format) all cross sections from file MF3 for the 3-rd temperature and to convert them to standard representations *pendf: ntape=20,nmat=0,ntm=1,nmf=1,nmt=0,mtm=3,mf=3	

B1.6 *GENDF: Reading of Group Data File in the GENDF Format	
±NTAPE	Number of input unit and record mode NTAPE>0 – formatted mode, NTAPE<0 – binary mode
NMAT	Number of materials to be entered (0 = all materials on tape)
NTM	Number of temperatures to be entered (0 = all temperatures)
NMF	Number of data classes to be entered (0 = all files on tape)
NMT	Number of reaction types to be entered (0 = all sections on tape)
MAT(NMAT)	List of the material numbers (if NMAT>0)
MTM(NTM)	List of temperature serial numbers (if NTM>0)
MF(NMF)	List of the data class numbers (if NMF>0)
MT(NMT)	List of the reaction type numbers (if NMT>0)
Example: to read from tape30 with group-wise cross sections and matrices (GENDF format) all data and to convert them to standard representations *gendf: ntape=30,nmat=0,ntm=0,nmf=0,nmt=0	

B1.7 *BNAB: Reading of Group Data Tables in the BNAB Format	
NTAPE	Number of input unit
NMF	Number of the BNAB table identification nuimbers (0 = all)
LMF(NMF)	List of the BNAB table identification numbers (NMF>0); current version allows: - to read the table MF=1/301 of main group/multigroup cross sections and prepare structure *S*, - to read self-shielding factors MF=4/304 and to form cross section moments structure *F*
Example: to read the BNAB table with multigroup cross section set (MF301) from tape30 and convert it to the *S* standard representation *bnab: ntape=30,nmf=1,lmf=301	

B1.8 *TEMBR: Reading of Group Data Tables in the TEMBR Format	
NTAPE	Number of input unit
NMS	Number of sections (0=all sections)
NTEM	Number of temperatures
LMS(NLS)	List of sections MS (NMS>0); current version allows to get MS=47 – subgroup parameters in the *P* structure MS=60 – main cross sections set in the *S* structure
TEM(NTEM)	temperature values (ºK)
Example: to read the TEMBR section with main cross section set (MS=60) from tape30 and convert it to the *S* standard representation *tembr: ntape=30,nmt=1,ntem=1,lms=60,tem=300.	

B1.9 *GNDS: Reading of the Generalized Nuclear Data Structures in the XML Format	
NTAPE	Number of input unit
NMS	Number of structure types
NMT	Number of reaction types
LMS(NMS)	List of structure types MS; current version allows to read MS=2 – cross sections *S* MS=3 – resonance parameters *R*
LMT(NMT)	List of reaction types LR
Example: to read from the GNDS on tape 20 the total cross section table and to convert it to the *S* standard representation *gnds: ntape=20,nms=1,nmt=2,lms=2,lmt=1	

B2. Output Modules

B2.4 *WRITE: Recording of File in the Internal Format	
±NTAPE	Output unit number and record mode: >0 – formatted mode, <0 – binary mode
Example: to write data from LSR to tape30 binary file *write: ntape=-30	

B2.1 *OUT: Recording of Data in the Internal Format to the *.OUT File	
	No parameters

B2.2 *OUTCAT: Recording of External Catalogue to the *.CAT File	
	No parameters

B2.3 *TAB: Recording of Annotated Table to the *.TAB File	
Command option &1 allows: for *F* - to reverse group order in the table for *P* - to normalize subgroup parameters	
	No parameters

B2.5 *ENDF: Recording of File in the ENDF Format

Command options:
&0 = real numbers with fixed f number of digits (default)
&1 = real numbers with increased precision
&2 = real numbers with maximum accuracy

NTAPE	Output unit number
NMAT	Number of materials (0 = all materials)
NMF	Number of data classes (0 = all classes)
NMT	Number of reaction types (0 = all reactions)
MAT(NMAT)	List of material numbers (if NMAT>0)
MF(NMF)	List of data class numbers (if NMF>0)
MT(NMT)	List of reaction type numbers (if NMT>0)

Example: convert data from LSR to the ENDF format and to write them to the tape21 file
*endf: ntape=21,nmat=0,nmf=0,nmt=0

B2.6 *PENDF: Recording of File in the PENDF Format

Command options:
&0 = real numbers with fixed f number of digits (default)
&1 = real numbers with increased precision
&2 = real numbers with maximum accuracy

±NTAPE	Output unit number and record mode: >0 – formatted mode, <0 – binary mode
NMAT	Number of materials (0 = all materials)
NTM	Number of temperatures (0=all temperatures on tape)
NMF	Number of data classes (0 = all classes)
NMT	Number of reaction types (0 = all reactions)
MAT(NMAT)	List of material numbers (if NMAT>0)
MTM(NT)	List of serial number of temperatures (if NTM>0)
MF(NMF)	List of data class numbers (if NMF>0)
MT(NMT)	List of reaction type numbers (if NMT>0)

Example: to write data from LSR to the PENDF binary file tape21
*pendf: ntape=-21, ntm=0,nmat=0,nmf=0,nmt=0

B2.7 *GENDF: Recording of File in the GENDF Format

Command options:
&0 = real numbers with fixed f number of digits (default)
&1 = real numbers with increased precision
&2 = real numbers with maximum accuracy

±NTAPE	Output unit number and record mode: >0 – formatted mode, <0 – binary mode
NMAT	Number of materials (0 = all materials)
NTM	Number of temperatures (0=all temperatures on tape)
NMF	Number of data classes (0 = all classes)
NMT	Number of reaction types (0 = all reactions)
MAT(NMAT)	List of material numbers (if NMAT>0)
MTM(NT)	List of serial number of temperatures (if NTM>0)
MF(NMF)	List of data class numbers (if NMF>0)
MT(NMT)	List of reaction type numbers (if NMT>0)

Example: to write group cross sections from LSR to the GENDF text file tape30
*gendf: ntape=30,ntm=0,nmat=0,nmf=1,nmt=0,mf=3

B2.8 *ACE: Recording of File in the ACE Format	
NACE	Unit number for the ACE output file
NXSD	Unit number for the XSDIR output string
NTYP	Data type: =1 – fast neutron and gamma-production data =2 – thermal neutron scattering data =3 – not used =4 – photo-atomic and atomic relaxation data
NIZA	Number of moderator components (NTYP=2), or 0 (NTYP=1 or 4)
NSUF	Length of array with suffix values MSUF; if NSUF=0, the values will be assigned automatically: 0,1,2,…
NTEM	Number of temperatures (NTEM=0 - all temperatures)
MTREF	=0 , if NTYP=1 or 4 = Interaction type of thermal neutron with nucleus (NTYP=2); 220<MTREF<250, MTREF=221 for scattering on free nuclei
NBINE	=0 , if NTYP=1 or 4 = Number of equally-likely energies in scattering spectrum (NTYPE=2)
IFENG	Weighting option: =0 – constant, =1 – "skewed@ (1,4,10,…10,…,10,4,1)
MIZA(NIZA)	Array of MZ*1000+MZA flags for moderator components (NIZA >0)
EL	Lower limit of energy range (eV)
EH	Upper limit of energy range (eV)
TEM(NTEM)	Temperature values (Kelvin), (if NTEM>0)

Example 1: to convert and output data from LSR in ACE file for fast neutron

```
*ace:nace=50,nxsd=51,ntyp=1,niza=0,nsuf=0,ntem=1,mtref=0, nbin=32,
      iwt=1,de=1.e-5,20.e6,tem=293.6
```

Example 2: to convert data from LSR for thermal scattering data for H in H2O and write to file in the ACE format

```
*ace: nace=50,nxsd=51,ntyp=2, nsuf=1,niza=1, ntem=1,mtref=222, nbin=32, iwt=1,
      miza=1001, msuf=80, de=1.e-5,20.e6, tem=293.6
```

B2.9 *BNAB: Recording Group Data in the BNAB Format	
NTAPE	Output unit number
NMF	Number of the BNAB data tables (0=all tables)
LMF(NMF)	List of the BNAB data table identification numbers (NMF>0): = 1/301 - the main neutron group /multigroup cross section set = 2/502 - inelastic group/multigroup transition probability matrix = 3/303 - anlular momenta of elastic group/multigroup transitions = 4/304 - group/multigroup resonance self-shielding factors = 15/315 – group/multigroup delayed neutron spectra = 18/518 - total and prompt fission group/multigroup spectra = 19/519 - delayed neutron group/multigroup parameters = 701 - detailed cross sections Comment: the table format (group/multigroup wise) is defined automatically, depending on number of groups in the input data; for table definition, the first flag of table (before slash) can be used.
Example: to output all group data to file tape30 in the BNAB format *bnab: ntape=30, nmf=0	

B2.10 *TEMBR: Recording Group Data in the TEMBR Format	
NTAPE	Output unit number
NMS	Number of the TEMBR sections (0=all sections)
NTEM	Number of reference temperatures
LMS(NMS)	List of the TEMBR sections (NMS>0): 1 - heading 2 - comment 11 - activation cross sections 21 - total fission neutron nu-bar 24 - relative delayed neutron yield 25 - delayed neutron characteristics 31 - prompt fission energy release 40 - matrix of elastic group transition cross sections 41 - matrix of elastic group transition cosines 42 - matrix inelastic group transition cross sections 43 - matrix of (n,kn) reactions group transition cross sections (k>1) 44 - matrix of (n,xn) reactions transition cross sections (ms42+ms43) 45 - matrix of (n,xn) reactions group transition cosines 47 - subgroup parameters 49 - matrix of subgroup transitions due to elastic scattering 60 - main group cross sections set 66 - self-shielding factors at room temperature 67 - self-shielding factors at higher temperatures 69 - matrix of subgroup correlations for temperatures 70 - matrix of subgroup correlations for materials 80 - total fission spectrum 81 - prompt fission spectrum 82 - delayed neutron spectrum 85 - matrix of (n,n) inelastic group transition cosines 86 - matrix of (n,kn) reactions group transition cosines 90 - multigroup neutron multiplicities in (n,kn) reactions 91 - multigroup total nu-bar 92 - multigroup total fission spectrum 93 - main multigroup cross sections set 94 - matrix of elastic multigroup transition cross sections 95 - multigroup elastic slow-down cross sections 96 - matrix of (n,xn) reaction multigroup transition cross sections 97 - multigroup slow-down cross sections for (n,xn) reaction
TEM(NTEM)	List of reference temperatures (^{o}K)
Example: write group data in the TEMBR format	

*tembr: ntape=30, nms=0,ntem=4,tem=300.,1027.,2200.,3000.

B2.11 *CCCC: Recording Group Data in the CCCC Extended Format	
NISOTXS	Output unit for the isotxs file
NBRKOXS	Output unit for the brkoxs file
NNFLUX	> 0 output unite for neutron group spectrum = 0, if not required
NGFLUX	> 0 output unite for photon group spectrum =0, if not required
NLORD	> 0 maximal number of angular moments; = 0, if should be defined from input data
MAXUP	> 0 maximal number of upscatter groups; = 0 defined from input data, < 0 upscattering should be excluded
MAXDN	> 0 maximal number of downscatter groups; = 0 if shoud be defined from input data
ITHERM	Flag of scattering model used in the thermal energy range = 0 defined by input data (free gas or bound nuclei model) > 0 simple slow-down model < 0 data not used
ICHIST	Flag of fission spectrum = 0 defined by input data < 0 not required
IDELAY	Flag of delay neutron spectrum = 0 defined by input data < 0 not required
JSIGZ	> 0 scattering matrices should be defined at dilution cross section SIGZ(JSIGZ) = 0 infinite dilution cross section should be used
NMOM	Flag of self-shielding factors set for cross sections: =0 total, capture, fission, transport, elastic =L+1 total, capture,fission,transport, 0 - moment of elastic and elastic slow-down, ……

	L - moment of elastic and elastic slow-down
NTI	>0 number of tempearures, temperature values are given < 0, the first |NTI| tempearures from input data should be used
KMAXTH	>0 number of energy groups for thermal scattering data =0 defined from input data
KMAXIN	Number of the lowest group in inelastic scattering and (n,xn) matrices
KMAXME	Number of groups in the output data
TEM(NTI)	Temperatire values (NTI > 0)
SIGZ(NZI)	Dilution cross sectgon values (NZI > 0)

B2.12 *MATXS: Recording Group Data in the MATXS Format	
NTAPE	Output unit number for matxs file

B2.13 *PLOT: Preparing of Input Data File for NJOY/VIEWR Module	
Command options &N defines set of output files: N=0 - prepare input file for the NJOY/VIEWR module (*.viewr) N=1 - prepare image Postscript file (*.ps) N=2 - output both files	
NSTR	Number of data from cluster (0 = the entire cluster)
LMOD	Flag of compared curves, depending on structure. *S* structures: LMOD=0 - libraries LMOD =1 - nuclides LMOD =2 - reactions LMOD =3 - temperatures LMOD =4 - spin groups *F* structures: NFUN=1 LMOD< 10 - self-shielded factors 10 < LMOD - shielded cross sections NFUN=2 LMO D < 10 - transmission function T(t) 10 < LMOD < 20 - observed cross sections -ln(T(t))/t 20 < LMOD < - absorption function (1-T(t)) IMOD=mod(LMOD,10)

	IMOD=1 - nuclides IMOD=2 - reactions IMOD=3 – temperatures *P* structures: LMOD=0 – distributions, normalized on unit LMOD=1 – distributions, normalized on cross section *A* structures: LMOD=0 – angular distribution functions LMOD=1 – cumulative density functions LMOD is not defined for other structures.
LTYP	Type for primary axes =0 - define automatically =2 - linear X - linear Y; =3 - log X – linear Y; =4 - linear X – log Y; =5 - log X – log Y
NCON	Number of connection options (0=will be defined automatically)
NSYM	Number of symbols (0=will be defined automatically)
NDASH	Number of type of lines (0=will be defined automatically)
NCOL	Number of colors (0=will be defined automatically)
NR	Number of reaction types (0 = all reactions)
NTEM	Number of temperatures (0 = all temperatures)
LR(NR)	List of reaction types (if NR >0)
LCON(NCON)	Connection options (if NCON>0) =0 - points connected, no symbols =-i - points not connected, symbol at every i-th point =i - points connected, symbol at every i-th point

LSYM(NSYM)

List of symbol numbers to be used (if NSYM >0).
Table of symbol numbers

0	square	13	exed octagon
1	octagon	14	triangle and square
2	triangle	15	filled circle
3	cross	16	open circle
4	ex	17	open square
5	diamond	18	filled square
6	inverted triangle	19	filled diamond
7	exed square	20	filled triangle
8	crossed ex	21	filled inverted triangle
9	crossed diamond	22	crossed circle
10	crossed octagon	23	exed circle
11	double triangle	24	exed diamond
12	crossed square		

LDASH(NDASH)

List of line types (if NDASH >0).
Table of line type number:

0	solid	3	chain dot
1	dashed	4	dot
2	chain dash	5	invisible

<table>
<tr><td>LCOL(NCOL)</td><td>List of color numbers (if (NCOL >0).
List of color numbers:
<table><tr><td>0</td><td>black</td><td>5</td><td>cyan</td></tr><tr><td>1</td><td>red</td><td>6</td><td>brown</td></tr><tr><td>2</td><td>green</td><td>7</td><td>purple</td></tr><tr><td>3</td><td>blue</td><td>8</td><td>orange</td></tr><tr><td>4</td><td>magenta</td><td></td><td></td></tr></table></td></tr>
<tr><td>EPS</td><td>Allowable difference between function parameter values</td></tr>
<tr><td>EL</td><td>Lower limit of the projectile energy range (eV)</td></tr>
<tr><td>EH</td><td>Upper limit of the projectile energy range (eV)</td></tr>
<tr><td>ELO</td><td>Lower limit of the reaction product energy range (eV), if used</td></tr>
<tr><td>EHO</td><td>Upper limit of the reaction product energy range (eV), if used</td></tr>
<tr><td>XMIN</td><td>Lower limit of X-axe</td></tr>
<tr><td>XMAX</td><td>Upper limit of X-axis;
XMIN=XNAX=0.0 - define automatically</td></tr>
<tr><td>XSTEP</td><td>X axis step</td></tr>
<tr><td>YMIN</td><td>Lower limit of Y-axis</td></tr>
<tr><td>YMAX</td><td>Upper limit of Y-axe;
YMIN=YMAX=0.0 - define automatically</td></tr>
<tr><td>YSTEP</td><td>Y axis step</td></tr>
<tr><td>XLEG</td><td>X-position of tag title</td></tr>
<tr><td>YLEG</td><td>Y-position of tag title; if XLEG=YLEG=0.0, position of tag title will be defined automatically</td></tr>
<tr><td>TEM(NTEM)</td><td>Temperature values (Kelvin)</td></tr>
<tr><td colspan="2">Example: prepare file for NJOY/VIEWR, reaction type and temperature should be requested from keyboard
*plot: nstr=0,imod=2,kint=5,natr=0,0,0,0,nr=1,ntem=1,mt=?,
eps=0.001,dei=1.e-5,20.e6,deo=0.,0.,xx=0.,0.,0.,yy=0.,0.,0., xyleg=0.,0.,tem=?</td></tr>
</table>

B2.14 *ZVD: Preparing of Input Data File for ZVView Code	
NSTR	Number of data from cluster (0 = the entire cluster)
NMOD	Data set: =0 - nuclide & reaction & temperature =1 - reaction & temperature =2 - nuclide & temperature =3 - nuclide & reaction
KINT	Scale of primary axes: =0 - used default; =2 - linear X - linear Y; =3 - log X – linear Y; =4 - linear X – log Y; =5 - log X – log Y
NR	Number of reaction types (0 = all types)
NTEM	Number of temperatures (0 = all temperatures)
LR(NR)	List of reaction types
EPS	Allowable difference between function parameter values
EL	Lower limit of the projectile energy range (eV)
EH	Upper limit of the projectile energy range (eV)
ELO	Lower limit of the reaction product energy range (eV) or 0.0, if not defined
EHO	Upper limit of the reaction product energy range (eV) or 0.0, if not defined
TEM(NTEM)	Temperature values (Kelvin)
Example: prepare file for ZVViewr (<task_name>.zvd), reaction type and temperature should be requested from keyboard *zvd: nstr=0,imod=3,kint=5,nr=1,ntem=1,mt=?, eps=0.001,de=1.e-5,20.e6,deo=0.,0.,tem=?	

B3. Processing Modules

B3.1 *A/-A: Changing the Representation Type of Angular Distribution Parameters	
±LAPO	Required representation type: =0 - point-wise representation =1 - average values in the equal intervals of scattering angle cosine =2 - Legendre polynomial coefficients =3 - breaks of equally-likely intervals =4 - equally-likely discrete cosines <0 - do not change
±LCTO	Required reference frame = 1 - laboratory system = 2 - center of mass system <0 - do not change
±NAPO	Number of angular parameters (if LAPO > 0) <0 – do not change
EPS	Tolerance parameter
Example 1: prepare table of distribution, averaged in the equal angle cosine intervals *a/-a: lapo=1,lcto=-1, napo=100,eps=0.001 Example 2: thinning of energy points for interpolation tolerance parameters *a/-a: lapo=-1,lcto=-1, napo=-1, eps=0.001	

B3.2 *A/-S: Operation with Angular Distribution Parameters	
Command option &N dewfines type of output value: N = 0 - continuous slowing down parameters μ, ξ, γ; N > 0 - angular momets - production of Legendre polynomial coefficients and elastic cross section; N – catalogue row number with elastic cross section; N < 0 - angular distribution parameter at the position |N| in the table of the *A* structure	
EPS	Tolerance parameter
Example: *a/-s: eps=0.001	

B3.3 *A/E-A: Thinning of the Energy Points in the Angular Distributions	
Command option &N gives a flag, defining the energy range for thinning: N=0 – thin energy grid points in all energy range (default) N>0 , where N - number of catalogue string , in which resonance parameters are registered; this option allows to perform thinning in the resolved resonance range only	
EPS	Tolerance parameter
Example: *a/e-a: eps=0.001	

B3.4 *D/A-D: Changing the Angular Distribution Representation Type	
LAP	Required representation type: =0 - equi-distant discrete cosines =1 - averaged in equi-cosine intervals =2 - Legendre coefficients =3 - equi-likely cosine interval breaks =4 - equi-likely cosines
NAP	Number of parameters, depending on LAP
Example: *d/a-d: lap=4,nap=32	

B3.5 *D/E-D: Conversion of Reaction Product Energy Distributions from Detailed to Group-wise Representation

Command option:
&N – flag controlling selection of initial energies:
=0 – initial energies are kept the same
>0 – initial energies are selected to provide given interpolation accuracy

MZAP	Reaction product identifier (0=any product)
NGO	Number of secondary energy groups
NIG	Number of group intervals
MIG(NIG)	Serial number of lower group in each group interval
MING(NIG)	Scale for group interval subdividing =1 – linear =2 - logarithmic
MNG(NIG)	Number of multi-groups in the interval
EL	Lower limit of the projectile energy range (eV)
EH	Upper limit of the projectile energy range (eV)
EPS	Tolerance parameter
EGO(NGO+1)	Group boundaries for reaction product energies (ngo>0)

Example: average energy distributions od secondary neutrons in groups

```
*d/e-d:zap=100,ng=40,nig=1,mig=1,ming=1,mng=1,
        de=1.e-5,1.,eps=0.001,
        eg=1.000000e-5, 6.25000E-04,2.50000E-03,5.62500E-03,1.00000E-02,
            1.56250E-02, 2.25000E-02,3.06250E-02,4.00000E-02,5.06250E-02,
            6.25000E-02, 7.56250E-02,9.00000E-02,1.05625E-01,1.22500E-01,
            1.40625E-01, 1.60000E-01,1.80625E-01,2.02500E-01,2.25625E-01,
            2.50000E-01, 2.75625E-01,3.02500E-01,3.30625E-01,3.60000E-01,
            3.90625E-01, 4.22500E-01,4.55625E-01,4.90000E-01,5.25625E-01,
            5.62500E-01, 6.00625E-01,6.40000E-01,6.80625E-01,7.22500E-01,
            7.65625E-01,  8.10000E-01,8.55625E-01,9.02500E-01,9.50625E-01,
            1.00000E+00
```

B3.6 *F/-S: Conversion of Data Structures from *F* to *S* Representation	
NR	Number of reactions (0 = all reactions)
KM	Moment value
KT	Serial number of temperature (0 = all temperatures)
KD	Serial number of dilution cross section (0= infinite dilution);
LR(NR)	List of reaction identifiers (if NR>0)
Example: extract all infinitely diluted cross sections for the first temperature *f/-s: nr=0,km=0,kt=1,kd=0	

B3.7 *F/C-F: Convolving of Cross Section Moments	
Сщььфтв щзешщт &N is a flag, allowing to restrict convolution by unresolved resonance energy range: N = 0 (default) – convolution is performed in the all energy range N > 0, N= the number of catalogue string, in which the average resonance parameters, containing the bounds of unresolved energy range, have been registered	
NMET	Flag of convolution scheme, NMET=N1*100+N2*10+N3: N1 - approximation type: =1 - Padé-I - Gauss quadrature, =2 - Padé-II - rational approximation (default), =3 - collapsing by dilution cross section iteration technique (for binomial moments only) N2 - required cross section: =1 - micro- or macroscopic (default), =2 - shielded cross sections N3 - resulting function type: =0 - the same as input (default), =1 - binomial moments, =2 - exponential moments; NMET=0 - all default - is equivalent to NMET=210
NMAT	Number of materials (0= all materials in input cluster)
NMT	Number of reaction types (0= all reactions)
NP	Number of parameters values (0 = take from input cluster)
NL	Minimal value of moment in sequence
NH	Maximal value of moment in sequence

LMAT(NMAT)	List of material identifiers (NMAT>0)
LMT(NMT)	List of reaction identifiers (NMT>0)
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TOL	Radiator thickness for self-indication function calculations (atom/barn), (N3=2), TOL=0.0 for other cases
PAR(NP)	Parameter values, depending from function type (NP>0): - dilution cross sections (barn), if N3=1 - target thickness (atom/barn), if N3=2
RO(NMAT)	Concentration of materials in composition (NMAT>0)
Example: convolve moments (-2:0) by Pade-I technique for given dilutions *f/c-f:nfun=100,nmat=0,nmt=0,nz=23, nl=-2,nh=0, de=1.e-5,20.e6,eps=0.001, tol=0., sigz=1.e-10,0.1,0.215,0.465,1.,2.15,4.65,10.,21.5,46.5,100.,215.,465., 1.e3,2.15e3,4.65e3,1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6	

B3.8 *F/E-P: Calculation of Subgroup Parameters from Moments

KGR	Group serial number (0= all groups)
±NBMAX	Maximal number of subgroups: >0 - keep subgroup parameters for KB=1,…,NB; NB≤NBMAX <0 - keep subgroup parameters for only KB = -NBMAX
NTYP	Subgroup type: =0 – fractions are temperature independent =1 – fractions are defined for each temperature
NMET	Initial values of separate parameter: =0 - take from input cluster =1 - define by Padé-II approximation =2 - define by Padé-II technique with simultaneous approximation of all partial moments
NOPT	Iinitial approach for consistent set of parameters =0 - don't use preliminary optimization =1 - use least square technique to adjust fractions

NSET	Set of adjusted parameters: =0 – all parameters =1 – fractions only =2 – total cross sections only =3 – cross sections of separate reactions
NREL	The type of error to be minimized: =1 - relative, =2 - absolute
KINT	Interpolation law for temperature dependence: =0 - interpolation is not included to adjustment procedure >0 - interpolation type: =2 - *y* is linear in *x* =3 - *y* is linear in ln(*x*) =4 - ln(*y*) is linear in *x* =5 - ln(*y*) is linear in ln(*x*) =6 – *y* is linear in *sqrt(x)*
NMOD	Function type: =0 - moments =1 - self-shielding factors for all temperatures =2 - self-shielding factors for the first temperature, Doppler increments for other temperatures =3 - self-shielding factors for the first temperature, Doppler coefficients for others
SL	the lower end of the range of function parameter values, in which the approximation error should be minimized
SH	the upper end of the range of function parameter values, in which the approximation error should be minimized
EPS	Tolerance parameter
Example: prepare subgroup parameters with temperature dependent fractions *f/e-p:kg=0,nsub=4,ntyp=1,nmet=2,nopt=1,nset=0,nrel=1,kint=0,nmod=1, sigz=0.,1.e10,eps=0.001	

B3.9 *F/F-F: Matching of Moments by Type of Reactions	
F	Input structure - *F* moments, obtained from average resonance parameters in the unresolved resonance range. Control data - *F* moments, calculated from resolved resonance parameters, renamed to * F / F-F to call corresponding modules. Result is the moments *F* for unresolved resonance range, added by

	reactions from resolved resonance range.
Example: Input *F* structure contains moments for unresolved resonance range with MT=1,2,18 and 102. Control *F/F-F structure contains moments *F* for resolved esonance range with MT=1,2,18,19,101 and 102. Resulting *F* structure contains moments for MT=1,2,18,19(=18),101(=102) and 102 reaction types.	

B3.10 *F/G-F: Group Averaging of the Cross Section Moments	
Comment: instead of *F/G-F, the *S/G-F parameters can be used	
NG	Number of groups
NIG	Number of groups intervals differing in multigroup definition
NWF	Weight function flag. = 1 – 6 parametric weight functions (see WF) = 10 – 17 weight functions build in code: 10 epri-cell light water reactor 11 thermal+1/e+fission+fusion 12 similar to 11, temperature dependent 13 thermal+1/e+fast reactor +fusion 14 claw 15 claw, temperature dependent 16 vitamin-e 17 vitamin-e, temperature dependent = 40 – 99 weight functions given in the file tapeNWF =7-9, 18-39 not used, reserved
MIG(NIG)	Group numbers defining the low borders of group intervals with different multigroup partitioning
MSG(NIG)	Scale for multigroup partitioning of group at each group interval 1 - linear (energy scale) , 2 – logarithmic (lethargy scale), 3 - $1/\sqrt{E}$ (time of flight scale)
MNG(NIG)	Number of multigroups in group for each group interval
EPS	Tolerance parameters
WF(*)	Weight function parameters for NWF=1-6

	=1 - E^R, where R – parameter,
	i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum;
	(Number of parameters LW=1)
	=2 - (1-R)/E+R , R - parameter (LW=1)
	=3 - $\delta(E-E_r)$, delta function; E_r - parameter (LW=1)
	=4 - thermal maxwellian + 1/e + fission,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E$
	where E_m, T_m, E_f, T_f - parameters (LW=4);
	coefficients C_m , C_f are defined from the continuity condition
	=5 - thermal maxwellian + 1/e + fission + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, T_f, E_c - parameters (LW=5);
	coefficients C_m ,C_f, C_c are defined from the continuity condition
	
	=6 - thermal maxwellian + 1/e + Watt spectrum + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f \cdot e^{-E/T(\nu_f)}\mathrm{sh}(\sqrt{b(\nu_f)E})$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, ν_f, E_c - parameters (LW=5);
	$T(\nu_f) = 9.65 \cdot 10^5 (0.76 + 0.1\nu_f)$
	$b(\nu_f) = 2.29 \cdot 10^{-6} (0.76 + 0.1\nu_f)$
	coefficients C_m , C_f, C_c are defined from the continuity condition

EG(NG+1)	Energy group boundaries (eV)

Example: average cross section moments in the BNAB-28 group structure

```
*f/g-f: ng=28,nig=1, nwf=4,mig=1,msg=1,mng=1,
      eps=0.001,
      w=0.215443,0.025,8.e5,1.4e6,
      eg=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00,
         1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02,
         1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04,
         1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06,
         4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07
```

B3.11 *F/O-F: Computing of Functions of Cross Section Moments	
NMOD	Physical value flag, depending on initial representation type. Binomial moments (NFUN=1) can be converted to =1 - self-shielding factors, current weighted for total and flux weighted for reactions =2 - self-shielding factors for the 1-st temperature, Doppler increments for others =3 - self-shielding factors for the first temperature, Doppler coefficients for others =4 - flux weighted self-shielding factors =5 - current weighted self-shielding factors =6 - shielded cross-sections, current weighted for total and flux weighted for reactions =7 - flux weighted shielded cross-sections =8 - current weighted shielded cross-sections =9 - correlation functions Exponential moments(NFUN=2) can be converted to =1 - transmission and self-indicating functions =2 - observed cross sections =3 - observed to average cross section ratios
Example: computing self-shielding factors and Doppler increments from the moments *f/o-f: nmod=2	

B3.12 *NU/-S: Conversion of Data Structures *NU* to *S*	
EPS	Tolerance parameter
Example: *nu/-s:eps=0.001	

B3.13 *MXCXM: Convolving of Group Transitions Matrices

Command option &N defines algorithm of convolution:
N = 0 (default) summation of matrices multiplied by concentrations is performed for each separate reaction
N > 0, N = number of catalogue string , in which the structure *F* with total group cross section moments depended on dilution cross section is registered; moments used for convolution of transition cross sections and singular moments by dilution cross section iteration technique

NMAT	Number of materials
NMT	Number of reaction types (0= all reactions)
LMAT(NMAT)	List of material identifiers
LMT(NMT)	List of reaction identifiers (NMT>0)
EPS	Tolerance parameter
RO(NMAT)	Concentration of materials in composition

Example: convolve matrices of the iron isotopes to the natural mixture matrices
*m/c-m: nmat=4,nmt=0,lmat=2625,2631,2634,2637,
eps=0.001, ro= 0.05845,0.91754,0.02119,0.00282

B3.14 *PN/D-PC: Calculation of Subgroup Matrices of Cross Section Correlations under Collisions

Command option &N defines a catalogue line with address of data
(a) *S* - average cosine, as a function of energy, prepared by the AXXS module
(b) *D* - energy-angle distribution, prepared by the THXXDS or SXTXDS modules with using or free gas or resonance scattering model

NMOD	Energy distribution type =0 - equally-likely energy distribution in all energy range (no correlation) =1 - constant in the interval of maximal loss of energy =2 - constant in the interval of average logarithmic loss of energy =3 - detail distribution in *S* or *D* structure, pointed in the command option
EPS	Tolerance parameter

B3.15 *PN/PN-PC: Calculation of Subgroup Matrices of Cross Section Correlations for Different Reactions and Temperatures	
PN	Data structure of PN* energy ordered subgroups, called by the *PN/PN-PC module name

B3.16 *PN/P-S: Conversion of Subgroup Parameters to Point-wise Cross Sections	
P	Data structure of *P* subgroup parameters, called by the *PN/P-S module name

B3.17 *P/D-F: Calculation of Cross Section Moments from Subgroup Parameters	
NFUN	Function type: =1 – binomial moments, =2 – exponential moments
KG	>0 - group serial number, =0 – all groups
NP	Number of function parameter values
NL	Minimal moments order
NH	Maximal moments order
PAR(NP)	Values of function parameter, depending on function type: if NFUN=1 - dilution cross sections (barn) if NFUN=2 – target thicknesses (atom/barn)
Example: prepare moments from subgroup parameters for given dilutions *p/d-f:nfun=1,kg=0,nz=23, nl=-2, nh=0, sigz= 1.e-10,1.e-1,2.15e-1, 4.65e1, 1.,2.15, 4.65,1.e1, 2.15e1,4.65e1, 1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,1.e4,2.15e4,4.65e4, 1.e5,2.15e5,4.65e5,1.e6	

B3.18 *P/PC-P: Convolution of the Subgroup Parameters with Correlation Matrices

Command option:
NTYP - Type of outputted subgroup parameters:
NTYP =0 – weights are independent on temperatures and reaction types
=1 – weights are independent reaction types
=2 – weights are defined for each temperature and reaction type

PC	Data structure with *PC* matrix of subgroup correlations, called by the *P/PC-P module name

B3.19 *P/C-P: Merging the *P* Structures

NG	Number of groups
NIG	Number of groups intervals differing in multigroup definition
MIG(NIG)	Group numbers defining the low borders of group intervals with different multigroup partitioning
MSG(NIG)	Scale for multigroup partitioning of group at each group interval 1 - linear (energy scale) , 2 – logarithmic (lethargy scale), 3 - $1/\sqrt{E}$ (time of flight scale)
MNG(NIG)	Number of multigroups in group for each group interval
EG(NG+1)	Energy group boundaries (eV)

Example: merge subgroup parameters in 28 group structure

```
*p/c-p: ng=28,nig=1,
      mig=1,msg=1,mng=1,
      eg=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00,
         1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02,
         1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04,
         1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06,
         4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07
```

B3.20 *R/T-S: Reconstruction of Cross Sections from Resonance Parameters	
Command options &N defines output data type: N=0 (default) - cross sections reconstructed from resonance parameters N=1 – real and imaginal parts of (1-U) complex scattering function, needed for computing of angular distribution parameters by Blatt-Biedencharn formulae	
NFORM	Formula number, used for reconstruction : =0 - formula, prescribed by input data =1 - single-level Breit-Wigner (SLBW) =2 - multilevel Breit-Wigner (MLBW) =3 - Reich-Moore (RM) =4 - Adler-Adler (AA)
±NTEM	Number of temperatures with sign, used as a flag: if NT<0, the temperature values, defined in the TEM array, are used for extending of energy interval on Doppler width, not for resonance broadening (they will be defined for zero temperature).
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(|NTEM|)	Temperature values; are used only if NFORM=1 or 2.
Example: reconstruct cross section from resonance parameters with given interpolation tolerance 0.1% *r/t-s:nfor=0,ntem=1,de=1.e-,20.e6,eps=0.001, tem=0.	

B3.21 *S/A-S: Computing the Redundant Cross Sections

&N – command option; used to include to the MTO list the MT values for which resonance parameters are available; N – the number of the catalog line with data structures * R *, * RM *, * U *

NOP	Number of operations with cross sections
MTI(NOP)	List of the MT reaction identifiers for operands. Combination MT_1, -MT_2 in the list of MTI means "for all MTi from interval $MT_1 \le MTi \le MT_2$"; MTI=0 can been used for preparing redundant cross sections MTO=1,4,13,14,16,18,19,27,101,103,104,105,106,107; 13 is used for cross sections sum of all reaction (n,xn), except elastic scattering and fission; 14 is similar to 13, but cross sections are summing with neutron yields; zero value in the MTI list means "all components of MTO, according to the ENDF definition"
MTO(NOP)	List of MT reaction identifiers for calculations result.
KOP(NOP)	Flag of arithmetic operation with cross sections or other data {MTI }, {MTO} corresponding to MTI and MTO reactions types: = 0 - {MTI} => {MTO} = 1 - {MTI}+{MTO} => {MTO} = 2 - {MTO} –{MTI} => {MTO} = 3 - {MTI}*{MTO} => {MTO} = 4 - {MTO}/{MTI} =>{MTO} = 5 - {MTI} * NY => {MTO} , NY – nuetron multiplicity factor

Example 1: calculate total cross section as sum of partial ones

```
*S/A-S: NOP=12,MTI=2, 4,-5,11,16,-17, 22,-37,41,-42,44,-45,
                      152,-154,156,-181,183,-190,194,-196,198,-200,
                MTO= 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
                KOP=  1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
```

Example 2: the same, but default list of partial cross sections for summation is used; the operaion flag KOP is not used (is set to 0)

```
*S/A-S: NOP=1,MTI=0,MTO=1,KOP=0
```

B3.22 *S/C-S: Merging and Summing of Cross sections	
NMAT	Flag controlling the algorithm of summing =0 - cross sections for each material are summarized separately, >0 - number of materials in sum
NR	Number of reaction types (0= all reactions)
LMAT(NMAT)	List of material identification numbers (if NMAT>0)
LR(NR)	List of reaction types (if NR>0)
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
RO(NMAT)	Concentrations of materials in mixture (if NMAT>0)
Example: bring all cross sections to a common energy grid and combine in the one table *s/c-s:ncom=0,ns=0,de=1.e-5,20.e5, eps=0.001	

B3.23 *S/E-S: Thinning of Energy Points in Cross Sections	
Command option &N gives a flag, defining the energy range for thinning: N = 0 (default) thinning of the energy grid points is performes in the all energy range N > 0, N = number of catalogue string , in which threshold cross sections are registered, means requirement to keep energy grid of threshold cross section in thinning procedure	
EPS	Interpolation error tolerance parameter
Example: *s/e-s: eps=0.001	

B3.24 *S/G-F: Calculation of Group Cross Section Moments

Command Option &N gives a flag, controlling usage of information about energy range of unresolved resonances:
N = 0 (default) – calculation is performed in the all energy range
N > 0, N = number of catalogue string, in which the *U* data structures with unresolved resonance parameters are registered; is used to skip energy points, belonging to the unresolved resonance energy range;
N < 0, |N| is similar to the previous case, but is used to skip energy groups, containing such poins

NFUN	Function type: =1 – binomial cross section moments, =2 – exponential cross section moments
NEG	Number of groups
NIG	Number of groups intervals differing in multigroup definition
NWF	Weight function flag. = 1 – 6 parametric weight functions (see WF) = 10 – 17 weight functions build in code: 10 epri-cell light water reactor 11 thermal+1/e+fission+fusion 12 similar to 11, temperature dependent 13 thermal+1/e+fast reactor +fusion 14 claw 15 claw, temperature dependent 16 vitamin-e 17 vitamin-e, temperature dependent = 40 – 99 weight functions read from tapeNWF =7-9, 18-39 not used, reserved
NR	Number of reaction types
NP	Number of function parameter values
NL	Minimal moments order
NH	Maximal moments order
MIG(NIG)	Group numbers defining the low borders of group intervals with different multigroup partitioning
MSG(NIG)	Scale for multigroup partitioning of group at each group interval 1 - linear (energy scale) , 2 – logarithmic (lethargy scale),

	3 - $1/\sqrt{E}$ (time of flight scale)
MNG(NIG)	Number of multigroups in group for each group interval
LR(NR)	List of reaction identifiers
EPS	Tolerance parameter
PAR(NP)	Function parameter values (if NP>0); depending from function type: NFUN=1 - dilution cross section (barn) NFUN=2 - target thickness (atom/barn)

WF(*)	Weight function parameters for NWF=1-6
	=1 - E^R, where R – parameter,
	i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum;
	(Number of parameters LW=1)
	=2 - (1-R)/E+R , R - parameter (LW=1)
	=3 - $\delta(E-E_r)$, delta function; E_r - parameter (LW=1)
	=4 - thermal maxwellian + 1/e + fission,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E$
	where E_m, T_m, E_f, T_f - parameters (LW=4);
	coefficients C_m , C_f are defined from the continuity condition
	=5 - thermal maxwellian + 1/e + fission + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, T_f, E_c - parameters (LW=5);
	coefficients C_m , C_f, C_c are defined from the continuity condition
	=6 - thermal maxwellian + 1/e + Watt spectrum + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f \cdot e^{-E/T(\nu_f)}\mathrm{sh}(\sqrt{b(\nu_f)E})$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, ν_f, E_c - parameters (LW=5);
	$T(\nu_f) = 9.65 \cdot 10^5 (0.76 + 0.1\nu_f)$
	$b(\nu_f) = 2.29 \cdot 10^{-6} (0.76 + 0.1\nu_f)$
	coefficients C_m , C_f, C_c are defined from the continuity condition

EG(NEG+1)	Energy group boundaries (eV)
Example: calculate cross section moments from point-wise data in the BNAB 28-group structure	

```
*s/g-f: nfun=1,neg=28,nig=1,nwf=4,nr=0,nz=23,nl=-2,nh=0,
          mig=1,msg=1,mng=1,
          eps=0.001,
          sigz=1.e-10,1.e-1,2.15e-1,4.65e-1,
                1.,2.15,4.65,1.e1,2.15e1,4.65e1,
                1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
                1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
        w=0.215443,0.025,8.e5,1.4e6,
        eg=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00,
           1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02,
           1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04,
           1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06,
           4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07
```

B3.25 *S/AE-FM: Computing Group Vectors and Matrices	
Command option: &N N = 0, calculating group cross sections with resonance shielding dependence N > 0, calculating matricies of group transitions and reaction products fromation; N - number of catalogue string, in which the reaction product yields and energy-angle distributions are registered	
MZAP	(MZ*1000+MA)*100+MS charge/mass/state parameter of reaction product; MZAP=0 for photons
NMT	Number of reaction (0 means “all reactions from the input data cluster”)
NEGI	Number of energy groups for incident particle
NEGO	Number of energy groups for secondary particle
NIG	Number of groups intervals differing in multigroup definition
NWF	Weight function flag. = 1 - 6 parametric weight functions (see WF) = 10 - 17 weight functions build in code: 10 epri-cell light water reactor 11 thermal+1/e+fission+fusion 12 similar to 11, temperature dependent 13 thermal+1/e+fast reactor +fusion 14 claw 15 claw, temperature dependent 16 vitamin-e 17 vitamin-e, temperature dependent = 40 - 99 weight functions read from tapeNWF =7-9, 18-39 not used, reserved
NWC	Flux calculator flag = 0, skip flux calculation, > 0, run flux calculator, if 40 ≤ NWC < 90 calculated flux will be written to file tapeNWC; < 0, read calculated flux from file tape|NWC|
NTEM	Number of temperatures
NSIGZ	Number of dilution cross sections
LAN	Flag of angular distribution representation (now is available LAN=2 – Legendre polynomial coefficients)

NORD	Number of angular distribution parameters
ISMOOTH	Flag, used to control the extending of low-energy distribution part = 0, distribution should be used as is, = 1, smooth low energy part
MT(NMT)	List of reaction types (if NMT > 0)
MIG(NIG)	Group numbers defining the low borders of group intervals with different multigroup partitioning
MSG(NIG)	Scale for multigroup partitioning of group at each group interval 1 – linear (energy scale) , 2 – logarithmic (lethargy scale), 3 – $1/\sqrt{E}$ (time of flight scale)
MNG(NIG)	Number of multigroups in group for each group interval
EPS	Tolerance parameter
TEM(NTEM)	Temperature values (^{o}K)
SIGZ(NSIGZ)	Dilution cross section values (barns)

WF(*)	Weight function parameters for NWF=1-6
	=1 – E^R, where R – parameter,
	i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum;
	(Number of parameters LW=1)
	=2 – (1-R)/E+R , R - parameter (LW=1)
	=3 – $\delta(E-E_r)$, delta function; E_r- parameter (LW=1)
	=4 – thermal maxwellian + 1/e + fission,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E$
	where E_m, T_m, E_f, T_f - parameters (LW=4);
	coefficients C_m , C_f are defined from the continuity condition
	=5 – thermal maxwellian + 1/e + fission + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, T_f, E_c - parameters (LW=5);
	coefficients C_m ,C_f, C_c are defined from the continuity condition
	=6 – thermal maxwellian + 1/e + Watt spectrum + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$

	$1/E$, $E_m < E < E_f$ $C_f \cdot e^{-E/T(\nu_f)} \mathrm{sh}(\sqrt{b(\nu_f)E})$, $E_f < E < E_c$ C_c = const , $E_c < E$ where E_m, T_m, E_f, ν_f, E_c - parameters (LW=5); $T(\nu_f) = 9.65 \cdot 10^5 (0.76 + 0.1\nu_f)$ $b(\nu_f) = 2.29 \cdot 10^{-6} (0.76 + 0.1\nu_f)$ coefficients C_m, C_f, C_c are defined from the continuity condition
WC(9)	Flux parameters (given, if NWC > 0) (1) EBOT – lower energy for flux calculation (eV) (2) ETOP – upper range for flux calculation (eV) (3) SIGPOT – potential scattering cross sections(not very critical about 10 barns for fissile nuclei) (4) SIGZR – reference value of dilution cross section (5) ALPHA2 – energy loss for admixed moderator, $\alpha_m = [(AWR-1)/(AWR+1)]^2$ (6) SAM – admixed moderator cross section per absorber atom (7) BETA – heterogeneity parameter, $\beta = \frac{V_f \sigma_e}{V_m \sigma_m}$ $\beta \to 0$ - isolated rod limit, $\beta \to 1$ - close packed lattice limit (8) ALPHA3 – energy loss for external moderator (9) GAMMA – fraction of admixed moderator cross section in the external moderator cross section
EGI(NEGI+1)	Group breaks for incident particle (eV)
EGO(NEGO+1)	Group breaks for reaction product (eV) (given, if NEGO > 0, otherwise NEGO=NEGI, EGO=EGI)

Example 1: calculate neutron group transition matrices in BNAB 28-group structure

```
*s/ae-fm: mzap=100, nmt=0,negi=28,nego=0,nig=1,nwf=4,nwc=0,ntem=1,nsigz=23,
          lan=2,nord=5,ismooth=1,
          mig=1,msg=1,mng=1,
          eps=0.001,tem=300.,
          sigz=1.e-10,1.e-1,2.15e-1,4.65e-1,1.,2.15,4.65,1.e1,2.15e1,4.65e1,
               1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
               1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
          wf=0.215443,0.025,8.e5,1.4e6,
          egi=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00,
            1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02,
            1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04,
            1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06,
            4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07
```

Example 2: calculate shielded cross sections of uranium for homogeneous mixture of uranium and hydrogen

```
*s/ae-fm: mzap=100, nmt=4,negi=28,nego=0,nig=1,nwf=4,nwc=0,ntem=1,nsigz=23,
          lan=2,nord=0,ismooth=0,mt=1,2,18,101,
          mig=1,msg=1,mng=1,
          eps=0.001,tem=300.,
          sigz=1.e-10,1.e-1,2.15e-1,4.65e-1,1.,2.15,4.65,1.e1,2.15e1,4.65e1,
               1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
               1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
             ! wf parameters:
              em=0.215443, tm=0.025,ef=8.e5,tf=1.4e6,
             ! wc parameters:
              ebot=0.1,etop=215.443,sigpot=10.6,sigzr=1.,
              alpha2=0.,sam=0.,beta=1.,alpha3=1.e-7,gamma=0.,
          egi=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00,
            1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02,
            1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04,
            1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06,
            4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07
```

B3.26 *S/D-M: Calculation Neutron Transition Matrices from Double-Differential Cross Sections for Thermal Scattering

Comment: instead of *S/D-M, the *S/G-F parameters can be used

NEG	Number of groups
NIG	Number of groups intervals differing in multigroup definition
NWF	Weight function flag. = 1 - 6 parametric weight functions (see WF) = 10 - 17 weight functions build in code: 10 epri-cell light water reactor 11 thermal+1/e+fission+fusion 12 similar to 11, temperature dependent 13 thermal+1/e+fast reactor +fusion 14 claw 15 claw, temperature dependent 16 vitamin-e 17 vitamin-e, temperature dependent = 40 - 99 weight functions read from tapeNWF =7-9, 18-39 not used, reserved

NR	Number of reaction types
NSIGZ	Number of dilution cross sections
NL	Minimal moments order
NH	Maximal moments order
MIG(NIG)	Group numbers defining the low borders of group intervals with different multigroup partitioning
MSG(NIG)	Scale for multigroup partitioning of group at each group interval 1 – linear (energy scale) , 2 – logarithmic (lethargy scale), 3 – $1/\sqrt{E}$ (time of flight scale)
MNG(NIG)	Number of multigroups in group for each group interval
LR(NR)	List of reaction identifiers
EPS	Tolerance parameter
SIGZ(NSIGZ)	Dilution cross section values (barn)

WF(*)	Weight function parameters for NWF=1-6
	=1 – E^R, where R – parameter,
	i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum;
	(Number of parameters LW=1)
	=2 – (1-R)/E+R , R - parameter (LW=1)
	=3 – $\delta(E\text{-}E_r)$, delta function; E_r- parameter (LW=1)
	=4 – thermal maxwellian + 1/e + fission,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E$
	where E_m, T_m, E_f, T_f - parameters (LW=4);
	coefficients C_m , C_f are defined from the continuity condition
	=5 – thermal maxwellian + 1/e + fission + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f\sqrt{E} \cdot e^{-E/T_f}$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, T_f, E_c - parameters (LW=5);
	coefficients C_m ,C_f, C_c are defined from the continuity condition
	=6 – thermal maxwellian + 1/e + Watt spectrum + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$

	$C_f \cdot e^{-E/T(v_f)} \mathrm{sh}(\sqrt{b(v_f)E})$, $E_f < E < E_c$ C_c = const , $E_c < E$ where E_m, T_m, E_f, v_f, E_c - parameters (LW=5); $T(v_f) = 9.65 \cdot 10^5 (0.76 + 0.1 v_f)$ $b(v_f) = 2.29 \cdot 10^{-6} (0.76 + 0.1 v_f)$ coefficients C_m , C_f , C_c are defined from the continuity condition
EG(NEG+1)	Energy group boundaries (eV)

Example: calculate group transition matrices for thermal neutron scattering
on light water reactor spectrum

```
*s/d-m: neg=40,nig=1,nwf=10,nr=0,nz=23,nl=-2,nh=0,
        mig=1,msg=1,mng=1,
        eps=0.001,
        sigz=1.e-10,1.e-1,2.15e-1,4.65e-1,
             1.,2.15,4.65,1.e1,2.15e1,4.65e1,
             1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
             1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
         eg= 1.000000e-5,
              6.25000E-04,2.50000E-03,5.62500E-03,1.00000E-02,1.56250E-02,
              2.25000E-02,3.06250E-02,4.00000E-02,5.06250E-02,6.25000E-02,
              7.56250E-02,9.00000E-02,1.05625E-01,1.22500E-01,1.40625E-01,
              1.60000E-01,1.80625E-01,2.02500E-01,2.25625E-01,2.50000E-01,
              2.75625E-01,3.02500E-01,3.30625E-01,3.60000E-01,3.90625E-01,
              4.22500E-01,4.55625E-01,4.90000E-01,5.25625E-01,5.62500E-01,
              6.00625E-01,6.40000E-01,6.80625E-01,7.22500E-01,7.65625E-01,
              8.10000E-01,8.55625E-01,9.02500E-01,9.50625E-01,1.00000E+00
```

B3.27 *S/G-FM: Calculation of Photo-atomic Group Cross Sections and Matrices	
NEG	Number of groups
IWF	Weight function type IWT=2 – constant IWT=3 – 1/E with roll-off factor
LAP	Angular distribution representation type =0 – point-wise representation =1 – average values in the equal intervals of scattering angle cosine =2 – Legendre polynomial coefficients =3 – breaks of equally-likely cosines =4 – equally-likely discrete cosines
NAP	Number of angular distribution parameters
NR	Number of reaction types
LR(NR)	List of reaction type identifiers
EPS	Tolerance parameter
EG(NEG+1)	Energy group boundaries (eV)

Example: calculate group cross section and Compton scattering matrix (MT=504) for given 19-group structure, with angular distribution represented by 32 equally-likely cosines

```
*s/g-mf: neg=19,nw=3,lang=4,nang=32,nmt=1,mt=504,eps=0.001,
    eg=0.01e6,0.02e6,0.04e6,0.08e6,0.15e6,0.35e6,0.75e6,1.25e6,1.75e6,
        2.50e6,3.50e6,4.50e6,5.50e6,7.00e6,9.00e6,11.0e6,13.0e6,15.0e6,17.0e6,20.0e6
```

B3.28 *S/I-S: Changing of Interpolation Law

Command option:
&1 = check consistency of threshold energy and reaction Q values and fix threshold energy, if necessary

KINT	Required interpolation law: =2 – y is linear in x =3 – y is linear in ln(x) =4 – ln(y) is linear in x =5 – ln(y) is linear in ln(x)
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Interpolation error tolerance

Example:
*s/i-s: kint=2, de=1.e-5,20.e6,eps=0.001

B3.29 *S/L-A: Calculation of Angular Distributions from Scattering Function

Command option &N is a flag controlling the usage of angular distributions from original ENDF MF4 file
N=0 - *A* tables from ENDF MF4 file are not used
N>0 - number of catalogue string, in which the *A* table from ENDF MF4 file is registered; a new *A* structure will be prepared from this table by replacing the file data by values calculated from resonance parameters

NL	Number of angular moments
NR	Number of reactions
MLR(NR)	List of reactions
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter for interpolation

Example:
*s/l-a: nl=10,ns=1,mls=2, de=1.e-5,20.e6,eps=0.001

B3.30 *S/NU-S: Calculation of Fission Cross Section Multiplied by Fission Neutron Number	
Command Option : =0 – fission neutron yields are multiplied by cross sections =1 – cross section is constant equal to 1	
NU	Data structure *NU*, called by the module name *S/NU-S

B3.31 *S/O-S: Paramentric Function Calculation, Smoothing of Cross Sections	
NTYP	Computation type flag: = 1 – calculation of parametric function = 2 – smoothing with kernel
NMOD	Function/Kernel modification flag NTYP=1: = 1 – transmittion function $T(l)=\exp(-\sigma l)$ = 2 – observed cross section – $log(T(l))/l$ NTYP=2: = 1 – step function = 2 – gaussian
NPAR	Number of function/kernal parameters
KINF	Interpolation law for function
KINP	Interpolation law for parameter
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Interpolation tolerance parameter
PAR(NPAR)	Function/Kernal parameter values NTYP=1: NMOD=1/2 – target thickness (nuclei/barns) NTYP=2: NMOD=1/2 – relative step width / Gaussian half-width (1/eV)
Example 1: compution of transmission function for target thickness tol=0.05 nuclei/barns *s/o-s: ntyp=1,nmod=1,npar=1,kinf=2,kinp=0,el=10.,eh=1.e3,eps=0.001,tol=0.05 Example 2: smoothing with Gaussian, with relative half-width hw=0.01 *s/o-s:ntyp=2,nmod=1,npar=1,kinf=2,kinp=0,el=10.,eh=1.e3,eps=0.001,hw=0.01	

B3.32 *S/P-S: Approximation of Point-wise Cross Sections by Subgrpoups - "Ordering of Subgroups"	
P	Data structure *P*, called by the module name *S/P-S

B3.33 *S/T-DS: Calculation of Cross Sections and Energy-Angle Distributions of Neutrons, Scattered at Resonances	
NAPR	Scattering model flag: =0 – elastic cross section is constant (free gas approach) =1 – resonant elastic scattering
NEI	Initial number of equal energy bins for scattered neutrons
NEO	Final number of energy bins for scattered neutrons
LEP	Energy distribution representation type: = 0 – averaged in equal intervals = 2 – equi-likely energies
IWE	Weight function for energy distribution = 0 – constant = 1 – variable
NAI	Initial number of equal angle bins for scattered neutrons
NAO	Final number of angle bins for scattered neutrons
LAP	=1 – average values in the equal intervals of scattering angle cosine =2 – Legendre polynomial coefficients =3 – breaks of equally-likely intervals =4 – equally-likely discrete cosines
NTEM	Number of temperature
NHIST	Number of histories
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
TEM(NTEM)	Temperature values (ºK)
Example: *s/t-ds: napr=1,nei=2000,neo=100,lep=0,iwe=0, nai=200,nao=16,lap=3, ntem=2, nhist=100000000, de=1.e-5,20.,tem=600.,900.	

B3.34 *S/T-S: Doppler Broadening of Cross Sections

Command option &N is a flag, controlling usage of additional information about energy range of unresolved resonances and threshold reactions:
N=0 - Doppler broadening can be performed for all energy range (default)
N>0 – N is catalogue string number, in which *U* and/or *S* data structures with threshold reactions are registered; Doppler broadening will be performed under unresolved resonance range and/or the lowest threshold energy;

NTEM	Number of temperatures
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(NTEM)	Temperature values (ºK)

Example:
*s/t-s:nt=3,de=1.e-5,20.e6,eps=0.001,tem=300.,900.,2100.

B3.35 *S/-P-PN: Calculation of Subgroup Parameters from Detailed Cross Sections

Command Option &N gives a flag, controlling usage of information about energy range of unresolved resonances:
N=0 – calculation can be performed in all energy range (default)
N>0, where N is number of catalogue string, in which the *U* data structures with unresolved resonance parameters are registered , means requirement to skip unresolved resonance energy range

NREG	Flag restricted the energy range of *P* tables (if command option N>0) =0 – prepare *P*- probability tables in all energy range =1 – prepare *P* tables in low (resonance) energy range =2 – prepare *P* tables in high (non-resonance) energy range
NEG	Number of groups
KEG	Serial number of group, for which probability tables are required (0= all groups)
NWF	Weight function flag. = 1 – 6 parametric weight functions (see WF) = 10 – 17 weight functions build in code:

	10 epri-cell light water reactor 11 thermal+1/e+fission+fusion 12 similar to 11, temperature dependent 13 thermal+1/e+fast reactor +fusion 14 claw 15 claw, temperature dependent 16 vitamin-e 17 vitamin-e, temperature dependent = 40 – 99 weight functions read from tapeNWF =7-9, 18-39 not used, reserved
KINE	Energy representation: = 0 – group-wise =1 – point-wise (histogram)
±NSUB	Number of subgroups > 0 - in range of cross section values $[\sigma_i, \sigma_{i+1}]$, $\lg(\sigma_{i+1/} \sigma_{i)=1}$ < 0 - in all range of cross section values
NTYP	Type of subgroup parameters: =0 – weights are independent on temperatures and reaction types =1 – weights are independent reaction types =2 – weights are defined for each temperature and reaction type
NSCALE	Cross sections scale : =1 – linear =2 – logarithmic
NORD	Flag controlling of output data set =0 – probability tables *P* =1 – probability tables *P* and ordered subgroup numbers *PN*
WF(*)	Weight function parameters for NWF=1-6 =1 - E^R, where R – parameter, i.e. R=0.0 – constant, R= –1.0 – Fermi spectrum; (Number of parameters LW=1) =2 (1-R)/E+R , R - parameter (LW=1) =3 - $\delta(E-E_r)$, delta function; E_r - parameter (LW=1) =4 - thermal maxwellian + 1/e + fission, $C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$ $1/E$, $E_m < E < E_f$ $C_f \sqrt{E} \cdot e^{-E/T_f}$, $E_f < E$ where E_m, T_m, E_f, T_f - parameters (LW=4); coefficients C_m , C_f are defined from the continuity condition =5 - thermal maxwellian + 1/e + fission + constant,

	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f \sqrt{E} \cdot e^{-E/T_f}$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, T_f, E_c - parameters (LW=5);
	coefficients C_m , C_f , C_c are defined from the continuity condition
	
	=6 - thermal maxwellian + 1/e + Watt spectrum + constant,
	$C_m E \cdot e^{-E/\mathrm{Tm}}$, $E < E_m$
	$1/E$, $E_m < E < E_f$
	$C_f \cdot e^{-E/T(\nu_f)} \mathrm{sh}(\sqrt{b(\nu_f)E})$, $E_f < E < E_c$
	C_c = const , $E_c < E$
	where E_m, T_m, E_f, ν_f, E_c - parameters (LW=5);
	$T(\nu_f) = 9.65 \cdot 10^5 (0.76 + 0.1 \nu_f)$
	$b(\nu_f) = 2.29 \cdot 10^{-6} (0.76 + 0.1 \nu_f)$
	coefficients C_m , C_f , C_c are defined from the continuity condition

EG(NEG+1)	Energy group boundaries (eV)
Example: calculate 30-subgroup parameters in resolved resonance energy range for the BNAB 28-group structure *s/-p-pn:nreg=1,neg=28,keg=0, nwf=4,,nsub=-30,ntyp=2,nscale=2,nset=0, wf=0.215443,0.025,8.e5,1.4e6, eg=1.00000e-04,2.15443e-01,4.64159e01,1.00000e+00,2.15443e+00,4.64159e+00, 1.00000e+01,2.15443e+01,4.64159e+01,1.00000e+02,2.15443e+02,4.64159e+02, 1.00000e+03,2.15443e+03,4.64159e+03,1.00000e+04,2.15443e+04,4.64159e+04, 1.00000e+05,2.00000e+05,4.00000e+05,8.00000e+05,1.40000e+06,2.50000e+06, 4.00000e+06,6.50000e+06,1.05000e+07,1.39818e+07,1.50196e+07	

B3.36 *S/-A: Reconstruction of *A* Angular Distribution Parameters from*S* Structure with Legendre Coefficients Multiplied by Cross Sections

Command option &N is a flag that controls the usage of additional data from *A* structure
N=0 - additional *A* structure is not not used
N>0 - number of catalogue string with data in *A* structure, that should be added to

parameters reconstructed from *S* structure	
EPS	Tolerance parameter
Example: prepare structures for each reaction and temperature *s/-a: eps=0.001	

B3.37 *S/-S: Unpacking of the *S* Structures on Reactions and Temperatures

NMT	Number of required reaction types (0=all reactions)
NTEM	Number of required temperatures (0=all temperatures)
LMT(NMT)	List of reaction types (if NMT>0)
TEM(NTEM)	List of temperature values (Kelvin), (if NTEM>0)
Example: prepare structures for each reaction and temperature *s/-s: nmt=0, ntem=0	

B3.38 *TH/-DS: Calculation of Cross Sections and Energy-Angle Distributions for Neutrons Scattered at Bound and Free Nuclei	
LRI	Inelastic scattering identifier number; elastic scattering identifier LRE=LRI+1
ISET	A set of scattering types for each a cross section is to be obtained: =0 - inelastic and elastic (if exist) =1 – inelastic only =2 – elastic only
NATOM	Number of principal atoms
KINT	Interpolation law for cross sections
NTEM	Number of temperatures
NAP	Number of angular distribution parameters
LAP	Type of angular distribution representation =1 - average values in the equal intervals of scattering angle cosine =2 - Legendre polynomial coefficients =3 - breaks of equally-likely intervals =4 - equally-likely discrete cosines
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(NTEM)	Temperature values (Kelvin)
Example: calculate cross sections and energy-angle distributions of neutrons for incoherent inelastic scattering on H in H2O *th/-ds:lri=222,iset=0, natom=2,kint=2,ntem=9,nang=32,ntypa=4, de=1.e-5,5.,eps=0.001, tem=293.6,350.,400.,450.,500.,550.,600.,650.,800.	

B3.39 *U/D-F: Calculation of Cross Section Moments in the Unresolved Energy Range	
Command option &N is a flag controlling usage of *S* tables (with backgrounds or cross sections) in calculations of moments N=0 - *S* tables are not used in calculation of moments (default) N>0 - number of catalogue string, in which the *S* tables with backgrounds or cross sections are registered	
NFOR	NFOR=N1*1000+N2*100+N3*10+N4, where N1- function type : N1 =1 – binomial moments N1= 2 – exponential moments N2 – resonance formulae: N2 =1 - one-level Breight-Wigner N2= 2 - multi-level Breight-Wigner N3- resonance width's distribution: N3=0 - delta function (no fluctuations), N3=1 - Porter-Thomas distribution N4- level spacing distribution: N4=0 - delta-function (no fluctuations) , N4=1 - Wigner distribution NFOR=0 is equivalent to default value NFOR=1110
KI40	Interpolation flag for function energy dependency: KINF = 0 – functions are calculated at the energy points, at which resonance parameters are defined; law, pointed in the *U*, is prescribed for function interpolation KINF >0 – energy points are selected to satisfy KINF interpolation law for function energy dependency; parameters are interpolated by law, pointed in the *U* data structure
NT	Number of temperatures
NP	Number of function parameter values
NL	Minimal order in moments sequence
NH	Maximal order in moments sequence
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(NTEM)	Temperature values (Kelvin)
PAR(NP)	Function parameter values

Example:
*u/d-f: nfor=0,kinf=0,nt=1,nz=1,nl=-10,nh=9,
de=1.e-5,20.e6, eps=0.001, tem=293.6, sigz=0.

B3.40 *U/D-S: Calculation of Cross Sections in the Unresolved Energy Range

Command option &N is a flag controlling usage of *S* tables with background in cross section calculations
N=0 - background is not used in calculation of cross sections (default)
N>0 - number of catalogue string, in which the *S* tables with backgrounds are registered

NFOR	Flag NFOR=N1*1000+N2*100+N3*10+N4, where N1 - not used (=0) N2 - resonance formulae: N2 =1 - one-level Breight-Wigner N2= 2 - multi-level Breight-Wigner N3- resonance width's distribution: N3=0 - delta function (no fluctuations), N3=1 - Porter-Thomas distribution N4- level spacing distribution: N4=0 - delta-function (no fluctuations) , N4=1 - Wigner distribution NFOR=0 is equivalent to default value NFOR=110
KINS	Interpolation flag for function energy dependency: KINS=0 – functions are calculated at the energy points, at which resonance parameters are defined; law, pointed in the *U*, is prescribed for cross sections interpolation KINS>0 – energy points are selected to satisfy KINF interpolation law for function energy dependency; parameters are interpolated by law, pointed in the *U* data structure
NT	Number of temperatures
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(NT)	Temperature values (Kelvin)

Example:
*u/d-s: nfor=0,kins=0,nt=1,
de=1.e-5,20.e6, eps=0.001, tem=293.6

B3.41 *U/E-P: Calculation of Probabililty Tables in the Unresolved Energy Range

Command option &N is a flag controlling usage of *S* tables with background in cross section calculations
N=0 - background is not used in calculation of cross sections (default)
N>0 - number of catalogue string, in which the *S* tables with backgrounds are registered

NBIN	Number of bins in the probability table
NLAD	Number of generated resonance sequences (ladders)
NT	Number of temperatures
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
TEM(NT)	Temperature values (Kelvin)

Example:
*u/e-p: nbin=20,nlad=50,nt=1,
el=1.e-5,eh=20.e6, eps=0.001, tem=293.6

B3.42 *ACTIV: Calculation of Activation Cross Sections

S	Data structure with radioactive nuclide yields , named as *ACTIV, to call the ACTIV module

B3.43 *EXTEND: Extending of Energy Distributions to Low Energy Range

ELOW	Low limit of secondary neutron energy distribution
EFACT	Factor for shape function SQRT(E)

Example:

*extend:elow=40.,efact=0.84

B3.44 *PROD: Particle and Photon Production Cross Sections Calculation	
NMT	Number of cross sections
NTEM	Number of temperatures
LMT(NMT)	List of the total production cross sections for 201 - neutrons 202 - photons 203 - protons 204 - deuterons 205 - tritons 206 - He^3 207 – alpha's
EPS	Tolerance parameter
TEM(NTEM)	Temperature values (K)
Example: prepare photon production cross section for temperature T=300K *prod: nmt=1, ntem=1, lmt= 202,eps =0.001, tem=300.	

B4. Modules of Service and Special Assignment

B4.1 *ABUND: Entering and Editing of Isotope Concentration Data	
NMAT	Number of materials
MAT(NMAT)	List of materials
ABN(NMAT)	Factor values
Example: preparation of cross sections for natural mixture of erbium isotopes *abund: nmat=6, mat=6825,6831,6837,6840,6843,6849, abn=0.00139,0.01601,0.33503,0.22869,0.26978,0.14910	

B4.2 *ARITH: Performing Arithmetic Operations on *S* and *F* Data	
Command option &N – arithmetic operation type &1 = add &2 = subtract &3 = multiply &4 = divide	
	Data with the same structure as input data (*S* or *F*), called by the ARITH module name

B4.3 *CON[T[E[NT]]]: Output to Listing of the Content of a Structures Cluster	
	No parameters

B4.4 *C[O]P[Y]: Copying of Structure Cluster in the LSR	
	No parameters

B4.5 *DISTU: Perturbation of Parameters of *U* Structure for Sensitivities Calculation	
NDIS	Flag of perturbation mode: = 1 – new parameter value = 2 – relative value of parameter perturbation = 3 – sets of data with initial, increased and decreased parameter values on given perturbation value
KIS	Serial number of isotope (0 = for all isotopes)
KL	Serial number of l-orbital momentum (0= for all l)
KJ	Serial number of J-total spin (0 = for all J)
KE	Serial number of energy point (0= for all energy points)
DR	Perturbation of scattering radius
DD	Perturbation of average level spacing
DGN	Perturbation of average neutron width
DGF	Perturbation of average fission width
DGG	Perturbation of average capture width
DGCOM	Perturbation of average competitive width
Example: prepare data with perturbed scattering radius *distu: ndis=3,kis=1,kl=1,kj=1,ke=0,dr=0.01,dd=0.,dgn=0.,dgf=0.,dgg=0.,dgcom=0.	

B4.6 *EXT[R[A[CT]]]: Extract Structure with Specified Name and Identificator from the Cluster

Commanding options &+- N is used to include MT values for which resonance parameters are available in the reaction list, N - number of the catalog line with * R *, * RM *, * U * data structures

The sign defines the mode of operation:

N> 0 extract the cross sections with MT numbers for which the resonance parameters are given;

N <0 extract the cross sections with MT numbers for which there are no resonance parameters.

NDAT

= 0 the name of structure is given in the command line, on the field number 4. The name can be complex and include several names, with summary length no more than 12 characters (length of command filed). The included names should be separated by symbol "&". In particular, complex name "S&A&E" means " S or A or E". To reverse selection by names, symbol "/" can be used. So, name /S&A&E will result selection all data, except S, A and E.

> 0 structure number according to the table:

Structure Identifier Numbers

1=	*H*	11=	*TH*	21=	*CP*	31=	*PC*
2=	*S*	12=	*NU*	22=	*CN*	32=	*D*
3=	*R*	13=	*EF*	23=	*CR*	33=	*M*
4=	*RM*	14=	*GS*	24=	*CS*		
5=	*U*	15=	*GP*	25=	*CA*		
6=	*A*	16=	*NP*	26=	*CE*		
7=	*E*	17=	*NY*	27=	*CY*		
8=	*AE*	18=	*FP*	28=	*F*		
9=	*TC*	19=	*RD*	29=	*P*		
10=	*TI*	20=	*AR*	30=	*PN*		

±NTYP

Data identifier flag:
|NTYP| =1 - material identification number (MAT)
=2 - data type identification number (MF)
=3 - reaction type identification number (MT)
=4 - charge-mass-state identification number (MZAS)
NTYP>0 - extract data pointed in the LIST array
NTYP<0 - extract all data except pointed in the LIST array

NLIST

NLIST - length of LIST (only positive numbers are taken into account)

LIST(*)

List of identification numbers;
LIST(I)>0 and LIST(I+1)<0 means interval from LIST(I) to |LIST(I+1)|

Example: extract cross sections for reactions pointed in the list
*extract: kdat=2,ntyp=3,nr=6, lr=1,2,4,16,18,102,-107

B4.7 *EXTTEM: Extract Data for a Set of Temperatures

Command option:
&1 = extract data for all temperatures except that of pointed in the control parameters
Comment: function is implemented for *S*,*F* and *M* structures only

±NTEM	|NTEM| = Number of temperatures
TEM(NTEM)	Temperature values (NTEM > 0) or
KTEM(-NTEM)	Temperature serial numbers in the input data structures (NTEM < 0)

Example 1: from data, containing temperatures TEM1=0, TEM2=300.,900.,2100., extract data for temperature TEM=300.
*exttem: ntem=1, tem=300.
Example 2: from data, containing temperatures TEM1=0, TEM2=300.,900.,2100., extract data for temperatures TEM=0.,300.
*exttem: ntem=-1, ktem=1

B4.8 *INXXS: Generating *S* structures with special values

Command option &N give catalogue string number with data, containing identification numbers MAT and MZA to assign them to the generated structure

MT	Special value identifier 257 – neutron energy (to calculate average energy in groups) 258 – neutron lethargy (to calculate average lethargy in groups) 259 – neutron inverse velocity (sec/m)
NPAR	Number of parameters of generated value (reserved; for the values mentioned above NPAR = 0)
EL	Lower bound of energy range (eV)
EH	Upper bound of energy range (eV)
EPS	Tolerance parameter
PAR(NPAR)	Parameter values (NPAR>0)

B4.9 *PACK: Defragmentation of the Cluster

	Rewrites structures of the cluster, removing whitespace, without parameters.

B4.10 *REDEF: Redefinition of Structure Identification Flags	
NTYP	Data identificators: =1 - material identification flag (MAT) =2 - data type identification flag (MF) =3 - reaction type identification flag (MT) =4 - charge-mass-state identification flag of target (MZAS) =5 - charge-mass-state identification flag of projectile (MZAP)
NLIST	Length of identifier values list
LISTI(NLIST)	List of initial values
LISTO(NLIST)	List of new values
Example: change material numbers 2625,2631,2634,2637 to 2600 *redef: ntyp=4, nlist=1,mati=2625,2631, 2634,2637, mato=2600,2600,2600,2600	

B4.11 *SEL[E[C[T]]]: Selection of Structures with the Specified Name	
Command options: &MF = select data obtained from the ENDF MF data file (MF=0 – default value – means “from any file”) The names of selected data structures are given in the command line, on the field number 4. The name can be complex and include several names, with summary length no more than 12 characters (length of command filed). The included names should be separated by symbol “&”. In particular, complex name “S&A&E” means “ S or A or E”. To reverse selection, symbol “/” can be used. So, name /S&A&E will result selection all data, except S,A and E.	
	No parameters, data name is given in the command line.

B4.12 *SORT: Sorting Structures in Cluster at the Specified Parameter

NDAT

> 0 structure number
= 0 any structure

Structure Identifier Numbers

1=	*H*	11=	*TH*	21=	*CP*	31=	*PC*
2=	*S*	12=	*NU*	22=	*CN*	32=	*D*
3=	*R*	13=	*EF*	23=	*CR*	33=	*M*
4=	*RM*	14=	*GS*	24=	*CS*		
5=	*U*	15=	*GP*	25=	*CA*		
6=	*A*	16=	*NP*	26=	*CE*		
7=	*E*	17=	*NY*	27=	*CY*		
8=	*AE*	18=	*FP*	28=	*F*		
9=	*TC*	19=	*RD*	29=	*P*		
10=	*TI*	20=	*AR*	30=	*PN*		

±NTYP

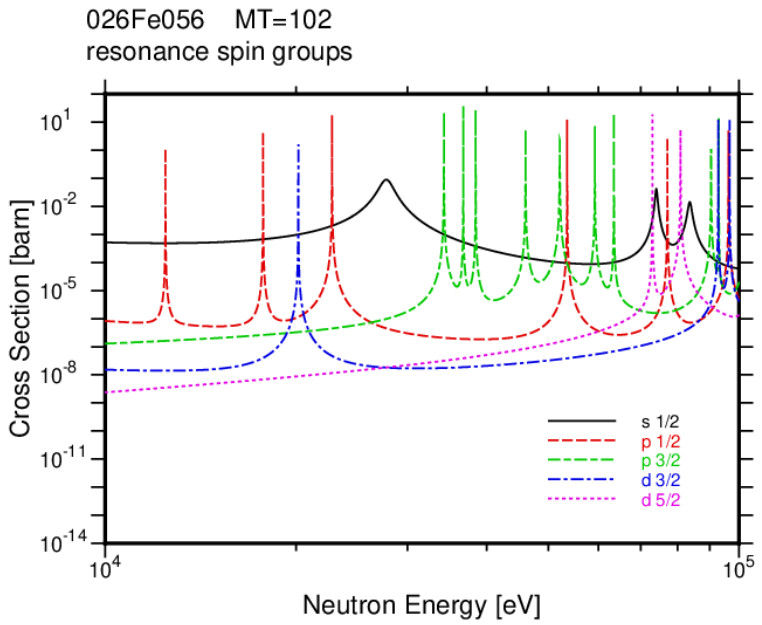
Flag of identifier or parameter and reordering rule (>0 – ascending, <0 descending):
|NTYP| - parameter flag
=1 - material (MAT)
=2 – reaction type (MT)
=3 – reaction type (MT)
=4 – charge-mass-state (MZAS)
=5 – reaction Q (for *S* structures only)

Example: arrange cross sections in ascending order of threshold energies = -Q*(A+1)/A
*sort: ndat=2, ntyp=-5

APPENDIX C. Examples of Calculation Tasks

C1. Cross Sections of Resonance Spin Groups

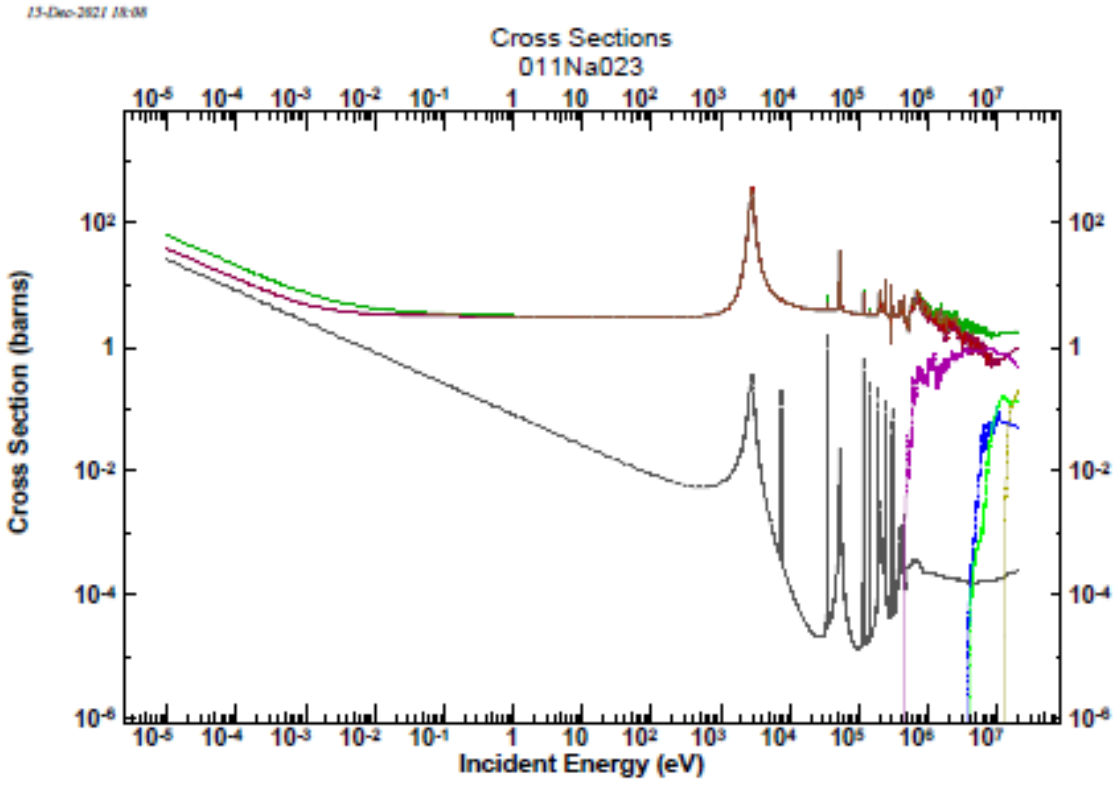
```
! Test 1: Cross sections for spin groups
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,r/t-s     !
,in,3,u/d-s     !
,in,4,plot      !
,1,20,data      ! read endf file
20,2,21,s       ! reconstruct xs in the RRR
20,3,21         ! reconstruct xs in the URR
21,4&2          ! write file in the viewr format
,,,end
!---------------------------------------------------
!    local parameters
*de:1.e4,1.e5,
*eps:0.001
!---------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=1,nmt=0,mf=2
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,nt=1,
       *de,*eps,tem=0.
*plot: nplot=0,imod=4,kint=5,
       natr=0,0,0,0,nr=1,nt=1,mt=102,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=1.e-14,1.e2,0.,
       xyleg=0.7,0.3,
       tem=0.
```



C2. Reconsruction of Cross Sections from Resonance Parameters

```
! Test 2: Cross sections reconstruction and Doppler broadening
,in               ! enter local parameters
,in,1,endf        ! enter control parameters
,in,2,s/i-s       !
,in,3,s/c-s       !
,in,4,s/a-s       !
,in,5,r/t-s       !
,in,6,u/d-s       !
,in,7,s/e-s       !
,in,8,s/t-s       !
,in,9,s/a-s       !
,in,10,extra      !
,in,11,extra      !
,in,12,s/a-s      !
,in,13,extra      !
,in,14,endf       !
,in,15,zvd        !
,1,20,data        ! read endf file
20,cp,21,s        ! copy cross sections
21,2,22,s         ! linearize cross sections
22,3,23,s         ! combine all cross sections
23,4&20,32,s,2    ! prepare background cross sections
20,5&20,32        ! reconstruct xs in the RRR
20,6&20,32        ! reconstruct xs in the URR
32,3,33,s,3       ! combine resonance cross sections
33,7&20,32,s      ! thin energy grid
32,8&20,33,s      ! Doppler broaden
33,7,32,s         ! thin energy grid
32,9,33,s         ! prepare MT3 and mt19
32,7,33           ! add resonance xs except mt19
23,10,24,s        ! extract non resonance cross sections
32,11,24          ! add all others
24,3,25,s         ! unite
25,12,33          ! prepare redundant cross sections
23,13&20,33       ! add all others
33,14             ! write endf file
33,15             ! prepare zvd file for ZVV viewr
,,,end
```

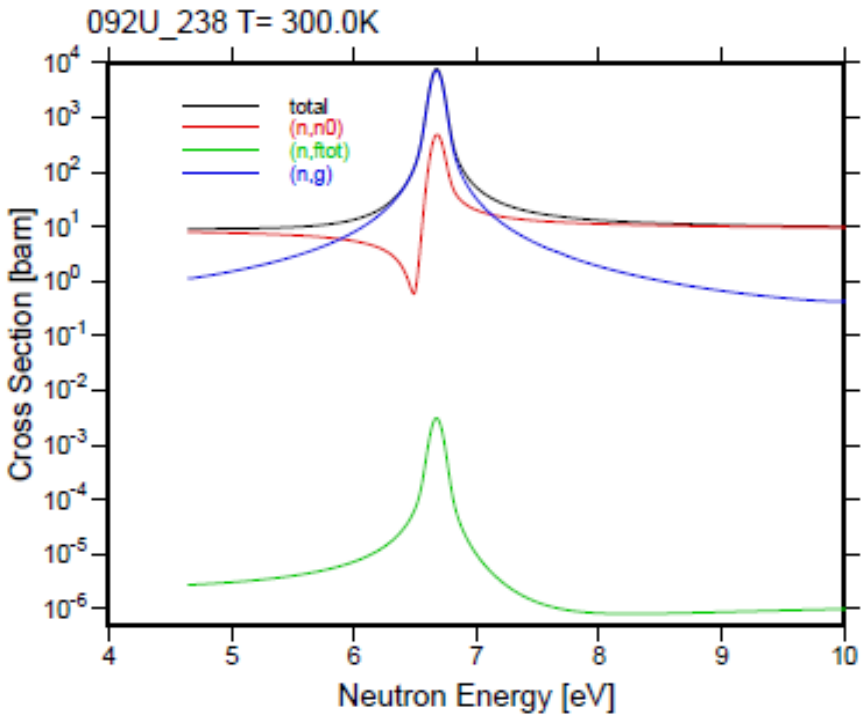
```
!-----------------------------------------------------
!    local parameters
*de:1.e-5,150.e6,
*nt:1,
*tem:293.6,
*eps:0.001
!-----------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=0
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,nt=1,*de,*eps,tem=0.
*s/e-s:*eps
*s/t-s:*nt,*de,*eps,*tem
*s/a-s:nop=2,mti= 1,2,0,mto= 3,3,19,lop=1,2,0
*extra:kdat=2,nmod=3,nmt=-1,mt=19
*extra:kdat=2,nmod=3,nmt=-5,mt=1,2,18,19,102
*s/a-s:nop=8,mti=0,0,0,0,0,0,0,0,
             mto=4,16,17,103,104,105,106,107,
             lop=0,0,0,0,0,0,0,0
*extra:kdat=2,nmod=3,nmt=-3,mt=1,-4,16,-19,103,-117
*endf:ntape=50,nmat=0,nmf=0,nmt=0
*zvd:ncur=0,imod=0,kint=5,nmt=6,*nt,mt=1,2,4,16,18,102,-117,
     *eps,*de,deo=0.,0.,*tem
```

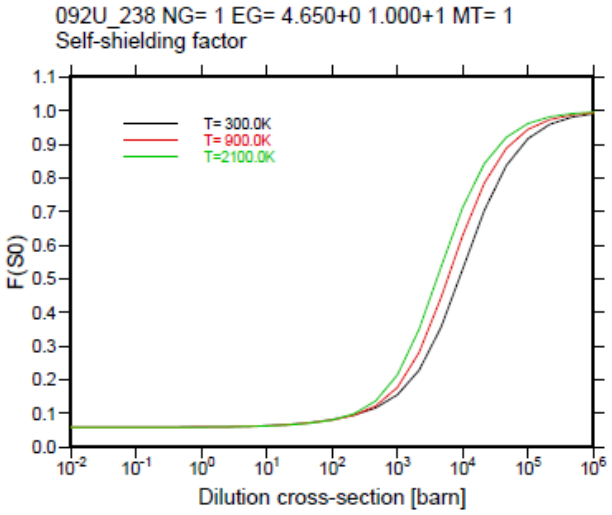


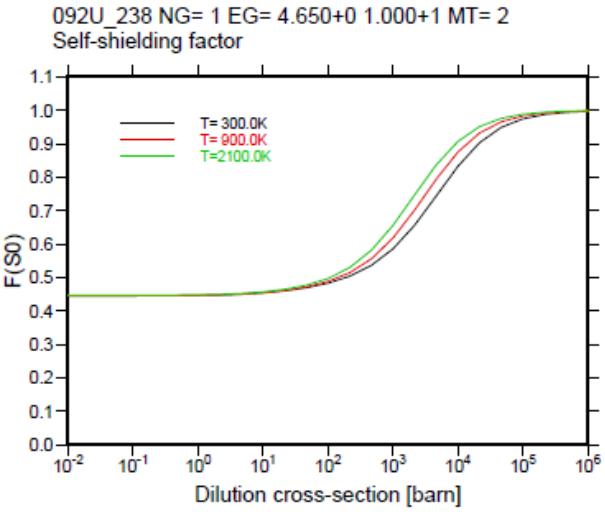
C3. Resonance Self-Shielding Factors

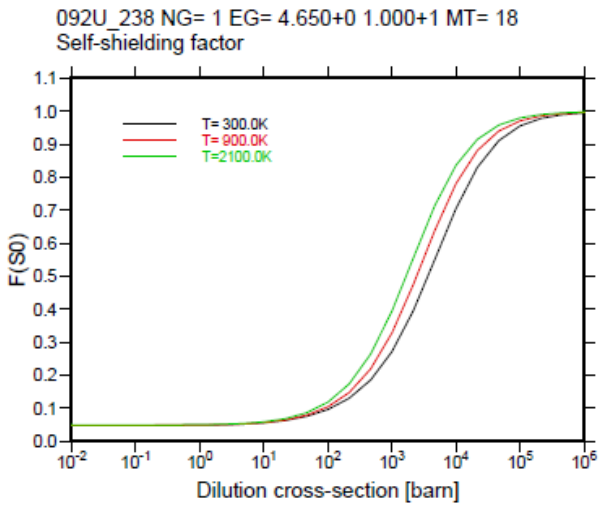
```
! Test 3: Self-shielding factors calculation
!         in given energy interval
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s
,in,3,s/a-s
,in,4,r/t-s
,in,5,u/d-f
5,,6,u/d-s
,in,7,s/c-s
,in,8,s/t-s
,in,9,s/g-f
9,,10,f/g-f
,in,11,f/c-f
,in,12,plot
,in,13,plot
,1,20,data      ! read endf file
20,2,21,s       ! linearize xs
21,3&20,22,s    ! prepare background xs
22,cp,32,s,2    !
20,4,32         ! reconstruct xs in the RRR
20,6&21,32      ! reconstruct xs in the URR
32,7,33,s,3     ! unite xs
33,8&20,32,s    ! Doppler broaden
32,12&2         ! write file for viewr to plot cross sections
32,9&20,33,f    ! integrate detailed cross sections
20,5&20,23,f    ! reconstruct moments in the URR
23,11,24,f      ! convolve moments in the URR
24,10,33        ! integrate
33,11,32,f      ! unite all moments
32,10,33,f      ! re-integrate moments
33,13&2         ! write file for viewr
,,,end
```

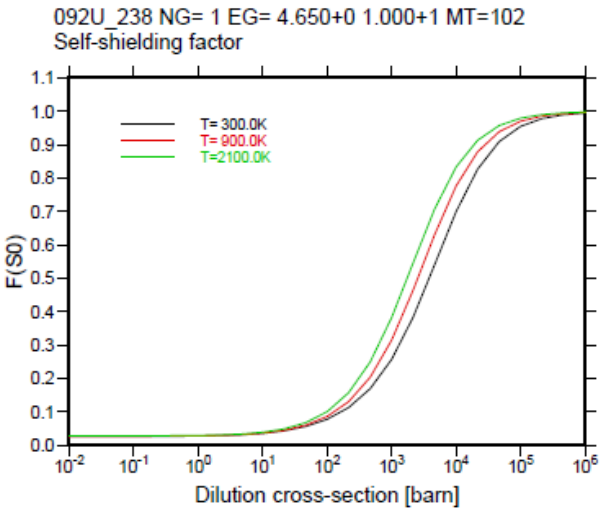
```
!-------------------------------------------------
!    local parameters
*de:4.65,10.,
*nt:3,
*tem:300.,900.,2100.,
*nz:23,
*sigz:1.e-10,1.e-1,2.15e-1,4.65e-1,
      1.,2.15,4.65,1.e1,2.15e1,4.65e1,
      1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
      1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
*nw:4,
*w:0.125,0.025,8.2085E+05,1.273E+06,
*eps:0.001
!-------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=0,mf=2,3
*s/i-s:nint=2,*de,*eps
*s/a-s:nop=0
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-f:nfor=0,int=0,*nt,nz=1,nl=-3,nh=2,
      *de,*eps,*tem,sigz=0.
*s/c-s:ncom=0,ns=0,*de,*eps
*s/t-s:*nt,*de,*eps,*tem
*s/g-f:nfun=1,ng=1,nig=1,*nw,nr=0,*nz,nl=-2,nh=0,
      nng=1,nsg=1,nmg=1,
      *eps,*sigz,*w,*de
*f/c-f:nfun=0,nmat=0,ns=0,*nz,nl=-2,nh=0,
      *de,*eps,tr=0.,*sigz
*plot: nplot=0,imod=2,kint=4,
       natr=0,0,0,0,nr=4,nt=1,
       mt=1,2,18,102,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.95,
       tem=300.
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=1,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.9,*tem,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=2,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.9,*tem,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=18,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.9,*tem,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=102,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.9,*tem
```


092U_238 T= 300.0K
total
(n,n0)
(n,ftot)
(n,g)
Cross Section [barn]
Neutron Energy [eV]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 1
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 2
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]

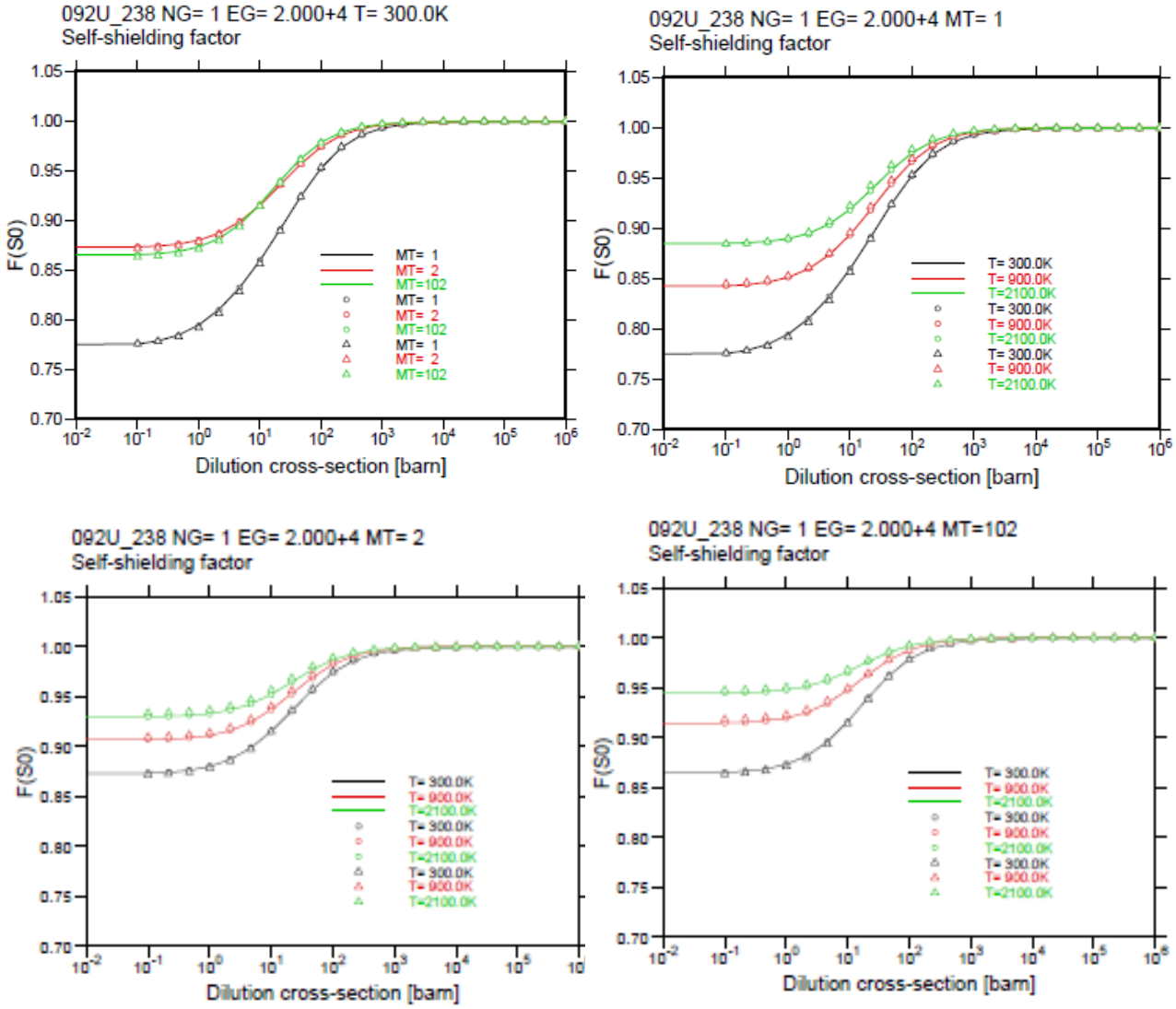

092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 18
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT=102
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]

C4. Moments, Subgroup Parameters and Probability Tables

```
! Test 4: Moments, Subgroup parameters, Probability Tables
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s
,in,3,s/c-s
,in,4,s/a-s
,in,5,s/e-s
,in,6,u/d-f
,in,7,f/c-f
,in,8,f/e-p
,in,9,u/e-p
,in,10,p/d-f
,in,11,plot
,1,20,data
20,2&1,21,s      ! linearize
21,3,22,s        ! unite
22,4&20,23,s     ! prepare background cross sections
23,5&21,24,s     ! thin energy points grid
20,6&24,25,f     ! calculate moments
25,7,32,f,2      ! convolve moments
32,8,27,p        ! calculate subgroup parameters from moments
20,9&20,27       ! calculate probability tables
27,10,32         ! prepare moments from parameters
32,11&2          ! prepare plot
,,,end
!---------------------------------------------------
!    local parameters
*de:2.e4,2.e4,
*nt:3,
*tem:300.,900.,2100.,
*nz1:1,
*sigz1:0.,
*nz:23,
*sigz:1.e-10,1.e-1,2.15e-1,4.65e-1,
      1.,2.15,4.65,1.e1,2.15e1,4.65e1,
      1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
      1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
*eps:0.001
!---------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=0,mf=2,3
*s/i-s:nint=2,*de,*eps
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=0
*s/e-s:*eps
*u/d-f:nfor=0,nint=0,*nt,*nz1,nl=-10,nh=9,
       *de,*eps,*tem,*sigz1
*f/c-f:nfun=100,nmat=0,ns=0,*nz,nl=-2,nh=0,
       *de,*eps,tr=0.,*sigz
*f/e-p:kgr=0,nmax=5,ntyp=1,nmet=2,nopt=1,nset=0,
```

```
       nrel=1,kint=0,nmod=1,sigz=0.,1.e10,*eps
*u/e-p:nbin=20,nladr=30,*nt,*de,*eps,*tem
*p/d-f:nfun=1,kg=0,*nz,nl=-2,nh=0,*sigz
*plot: nplot=0,imod=2,kint=3,natr=0,0,0,0,
       nr=0,nt=1,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.7,1.05,0.05,xyleg=0.,0.,tem=300.,
*plot: nplot=0,imod=3,kint=3,natr=0,0,0,0,
       nr=1,*nt,mt=1,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.7,1.05,0.05,xyleg=0.,0.,*tem,
*plot: nplot=0,imod=3,kint=3,natr=0,0,0,0,
       nr=1,*nt,mt=2,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.7,1.05,0.05,xyleg=0.,0.,*tem,
*plot: nplot=0,imod=3,kint=3,natr=0,0,0,0,
       nr=1,*nt,mt=102,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.7,1.05,0.05,xyleg=0.,0.,*tem
```



C5. ACE Files for Fast Neutrons

```
! Test 5: ACE file preparation
,in              ! enter local parameters
,in,1,endf       ! enter control parameters
,in,2,s/i-s
,in,3,extend
,in,4,s/c-s
,in,5,s/a-s
,in,6,r/t-s
,in,7,u/d-s
,in,8,s/e-s
,in,9,s/t-s
,in,10,s/a-s
,in,11,extra
,in,12,extra
,in,13,s/a-s
,in,14,extra
,in,15,u/e-p
,in,16,prod
,in,17,prod
,in,18,ace
,1,20,data       ! read endf data
20,2,21,s        ! linearize cross sections
20,sel,22,nu     ! select nu-bardata *nu*
20,sel,23,a      ! select angular distribution parameters
20,3,24,e&ae     ! extend low energies in *e* and *ea* data
20,sel,25,gp     ! select gamma-production data *gp*
21,4,26,s        ! combine all cross sections
26,5&20,27,s     ! prepare background cross sections
27,cp,32,s       ! copy
20,6&27,32       ! reconstruct cross sections in the RR energy
range
20,7&27,32       ! reconstruct cross sections in the UR energy
range
32,4,33,s,3      ! unite resonance cross sections
33,8&21,32,s     ! thin energy grid points
32,9&20,33,s     ! doppler broadenning
33,8&21,32,s     ! thin energy grid points
32,10,33,s       ! prepare nonelastic and first chanse fission,
if exists
32,11,33         ! add all others reconance xs except mt19
26,12&20,28,s    ! extract nonresonance reactions
32,12,28         ! add resonance threshold cross sections
28,4,29,s        ! unite
29,13,33         ! prepare redundant cross sectons and add to
others
26,14&20,33       ! extract rest of cross sections
20,15&21,33      ! prepare probability tables
33,16&20,32,s    ! prepare gamma production cross section
32,4,33          !
33,17&20,32,s    ! prepare particle production cross sections
```

```
32,4,33
22,cp,33        ! add *nu*
23,cp,33        ! add *a*
24,cp,33        ! add *e* and *ae*
25,cp,33        ! add *gp*
33,18           ! write ace file
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*nsuf:0,
*ntem:1,
*tem:293.6,
*eps:0.001
! ---------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*extend:elow=40.,efact=0.84
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=0
*r/t-s:nfor=0,ntem=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,ntem=1,*de,*eps,tem=0.
*s/e-s:*eps
*s/t-s:*ntem,*de,*eps,*tem
*s/a-s:nop=3,li=1,2,0,
             lo=3,3,19,
             lop=1,2,0
*extra:kdat=2,nmod=3,nr=-1,lr=19
*extra:kdat=2,nmod=3,nr=-5,lr=1,2,18,19,102
*s/a-s:nop=8,li=0,0,0,0,0,0,0,0,
             lo=4,16,17,103,104,105,106,107,
             lop=0,0,0,0,0,0,0,0
*extra:kdat=2,nmod=3,nr=-5,lr=3,4,16,17,103,-107
*u/e-p:nbin=20,nladr=30,*ntem,*de,*eps,*tem
*prod:nmt=1,*ntem,mt=202,*eps,*tem
*prod:nmt=1,*ntem,mt=203,-207,*eps,*tem
*ace:nace=50,nxsd=51,ntyp=1,niza=0,*nsuf,*ntem,lr=0,
             nbin=16,iwt=1,*de,*tem
```

Fragment of the U235 Listing

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

**************************************************************************
ace     ...                                                      1750.0s
        writes ace and xsdir files
name= 092U_235    mat=9228  mza= 92235.00c  tem= 293.6
  1. ESZ  - Cross sections table
  2. NU   - Fission nu-bar data
  3. MTR  - List of reaction excluding elastic
 acetab3 warning: neutron spectrum not found for mt=  19
  4. LQR  - Q-values
  5. TYR  - Neutron releases table
  6. LSIG - Reaction cross-section locaters
  7. SIG  - Reaction cross-section values
  8. LAND - Angular distribution locators
  9. AND  - Angular distributions
 10. LDLW - Energy distribution locators
 11. DLW  - Energy distributions
 12. GPD  - Photon-production data
 13. MTRP - Photon-production MT
 14. LSIGP- Photon-production cross section locators
 15. SIGP - Photon-production yields or cross sections
 16. LANDP- Photon-production angular distribution locators
 17. ANDP - Photon-production angular distributions
 18. LDLWP- Photon-production energy distribution locators
 19. DLWP - Photon-production energy distributions
 20. YP   - Neutron MT needed as photon-production yield multipliers
 21. FIS  - Fission cross section
 23. UNR  - Probability table
 24. DNU  - Delayed nu-bar data
 25. BDD  - Precursor energy distribution
 26. DNEDL- Delayed neutron energy distribution locators
 27. DNED - Delayed neutron energy distributions
**************************************************************************
*end                                                              1855.0s
```

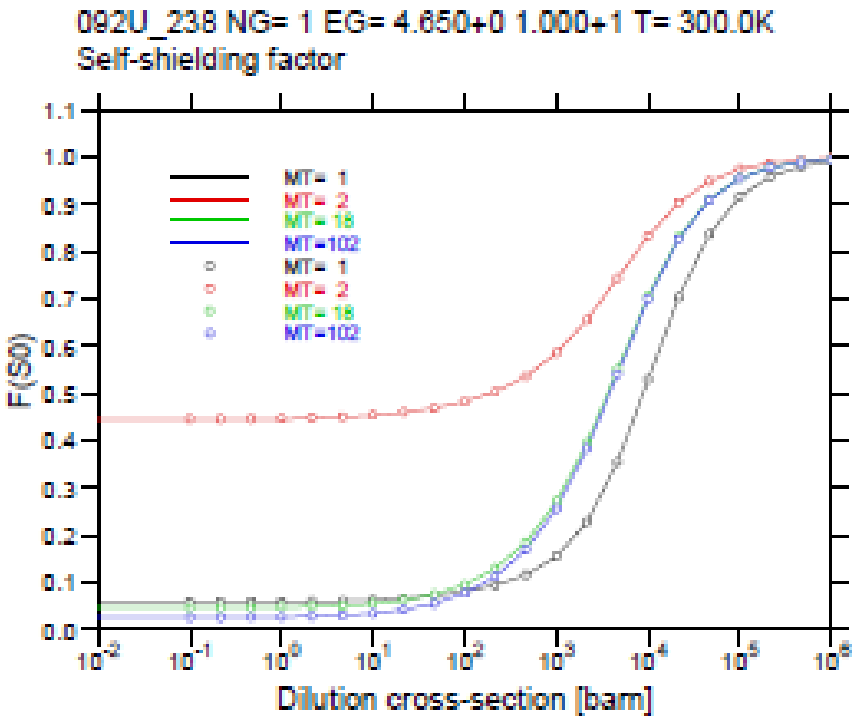
Fragment of the U235 ACE File

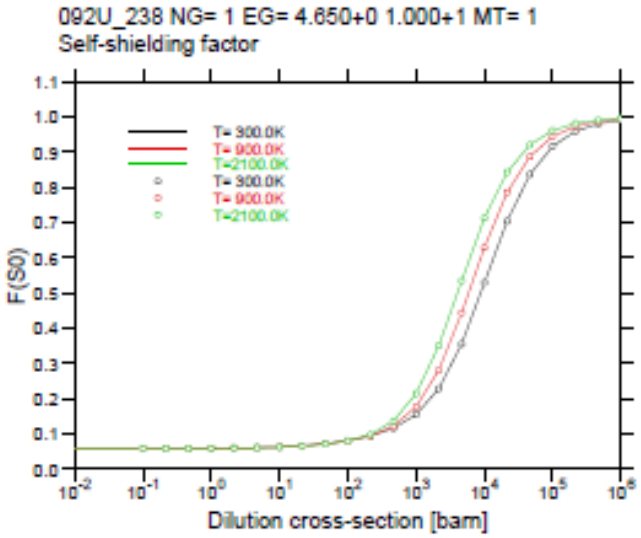
```
92235.00c  233.024800  2.5301E-08   16/12/21
 092U_235    processed by GRUCON-2021.12d                                mat9228
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
  3939687         0    52173        90       44      583         6         6
        0         0        0         0        0        0         0         0
        1    260866   261213    261303   261393   261483    261573   2705838
  2705883   2904551  2904595   3695640  3747813  3753894   3748396   3754477
  3755060   3755060  3755643   3939606   313807  3939687   3682354   3684659
  3684672   3684714  3684720         0        0        0         0         0
   1.00000000000E-11   1.09051600000E-11   1.17641300000E-11   1.25710500000E-11
   1.33223700000E-11   1.47467300000E-11   1.59140700000E-11   1.68498300000E-11
   1.83575100000E-11   2.00000000000E-11   2.18102400000E-11   2.35281000000E-11
   2.51418600000E-11   2.66444400000E-11   2.94931400000E-11   3.18278100000E-11
   3.36993100000E-11   3.67147900000E-11   4.00000000000E-11   4.36203900000E-11
   4.70560400000E-11   5.02834900000E-11   5.32885800000E-11   5.89859600000E-11
   6.36552900000E-11   6.73982800000E-11   7.34293500000E-11   8.00000000000E-11
   8.72407900000E-11   9.41123000000E-11   1.00567900000E-10   1.06578700000E-10
   1.17973700000E-10   1.27312600000E-10   1.34798800000E-10   1.46860300000E-10
   1.60000000000E-10   1.74482100000E-10   1.88225100000E-10   2.01135400000E-10
   2.13156100000E-10   2.35945800000E-10   2.54623200000E-10   2.69595200000E-10
   2.93718800000E-10   3.20000000000E-10   3.48963300000E-10   3.76448600000E-10
   4.02268400000E-10   4.26309300000E-10   4.71888300000E-10   5.09243000000E-10
   5.39187000000E-10   5.87435300000E-10   6.40000000000E-10   6.97925800000E-10
   7.52895700000E-10   8.04534500000E-10   8.52615500000E-10   9.43773500000E-10
   1.01848300000E-09   1.07837100000E-09   1.17486800000E-09   1.28000000000E-09
   1.39585100000E-09   1.50579000000E-09   1.60906700000E-09   1.70522800000E-09
   1.88754400000E-09   2.03696200000E-09   2.15673800000E-09   2.34973400000E-09
   2.56000000000E-09   2.79170100000E-09   3.01157800000E-09   3.21813100000E-09
   3.41045300000E-09   3.77508400000E-09   4.07392000000E-09   4.31347200000E-09
   4.69946600000E-09   5.12000000000E-09   5.58340000000E-09   6.02315400000E-09
   6.43625900000E-09   6.82090300000E-09   7.18553400000E-09   7.55016500000E-09
   8.14783800000E-09   8.62694000000E-09   9.39893000000E-09   1.02400000000E-08
   1.11668000000E-08   1.20463100000E-08   1.28725200000E-08   1.36418000000E-08
   1.47017275000E-08   1.51003300000E-08   1.62956700000E-08   1.72538800000E-08
   1.87978600000E-08   2.04800000000E-08   2.15912400000E-08   2.33721700000E-08
   2.53000000000E-08   2.75898500000E-08   2.97628500000E-08   3.18041600000E-08
   3.37048400000E-08   3.61962021875E-08   3.73084200000E-08   4.02617600000E-08
   4.26292000000E-08   4.64439200000E-08   5.06000000000E-08   5.51796900000E-08

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

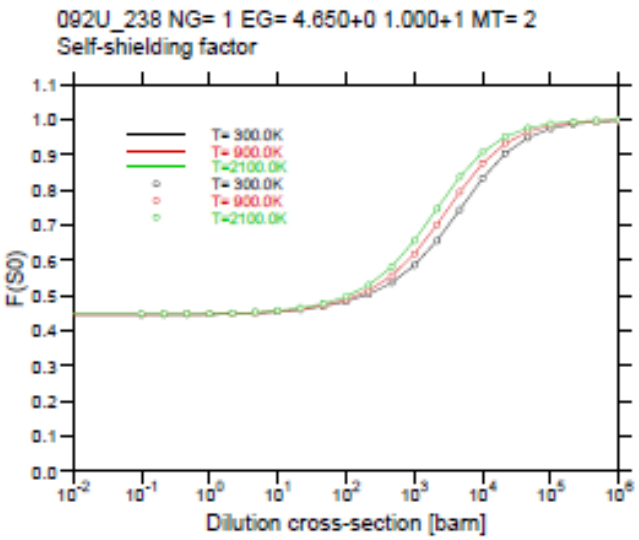
C6. Generalized Subgroups in the Resolved Resonance Range

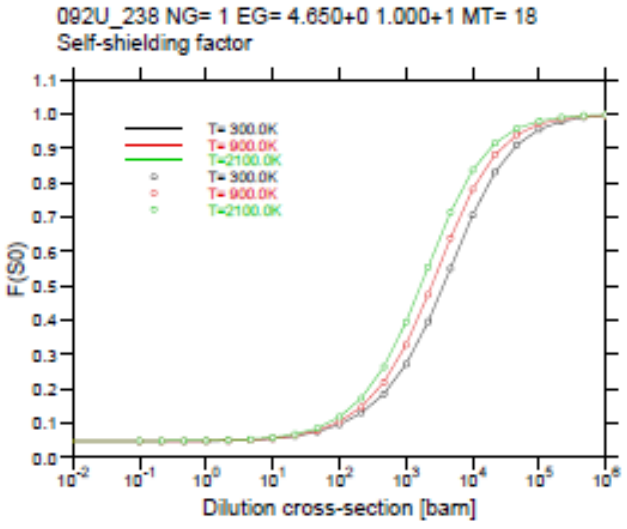
```
! Test 6: Probability tables and self-shielding factors
!         in given energy interval
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s     !
,in,3,s/c-s     !
,in,4,s/a-s     !
,in,5,r/t-s     !
,in,6,u/d-s     !
,in,7,s/e-s     !
,in,8,s/t-s     !
,in,9,s/g-f     !
,in,10,s/-p-pn  !
,in,11,p/d-f    !
,in,12,plot     !
,1,20,data      ! read endf file
20,2,21,s       ! linearize cross sections
21,3,22,s       ! unite
22,4&20,23,s    ! prepare background xs
23,cp,32,s,2    !
20,5,32         ! reconstruct *s* from resonance parameters
20,6&23,32      ! reconstruct *s* from average resonance
parameters
32,3,33,s,3     ! unite resonance cross sections
33,7&20,32,s    ! thin energy grid
32,8,33,s       ! Doppler broadening
33,9,23,f       ! prepare shielded cross sections from detailed
cross sections
33,10,32,p      ! probability tables preparation
23,cp,25,f      ! copy factors
32,11,25        ! prepare shielded cross sections from
probability tables
25,tab
25,12&2         ! write file for viewr to compare temperatures
,,,end
```

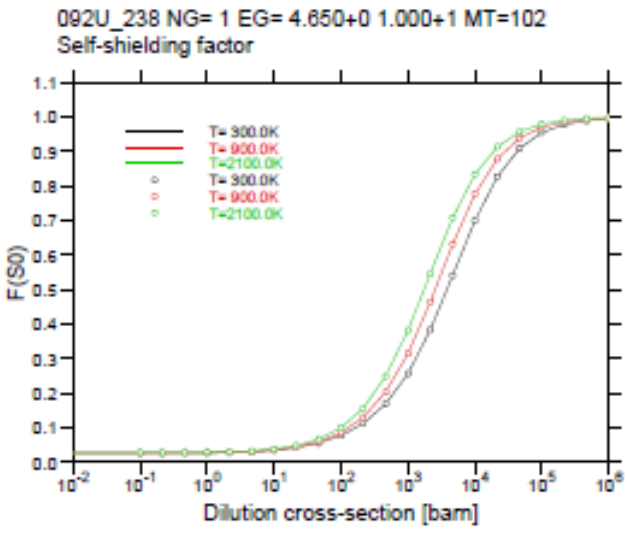
```
!-------------------------------------------------
!    local parameters
*de:4.65,10.,
*nt:3,
*tem:300.,900.,2100.,
*ntyp:1,
*nz:23,
*sigz:1.e-10,1.e-1,2.15e-1,4.65e-1,
      1.,2.15,4.65,1.e1,2.15e1,4.65e1,
      1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
      1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
*nw:4,
*w:0.125,0.025,8.2085E+05,1.273E+06,
*eps:0.001
!-------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=0,mf=2,3
*s/i-s:nint=2,*de,*eps
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=1,mti=0,mto=1,lop=1
*r/t-s:nfor=0,nt=-1,*de,*eps,tem=2100.
*u/d-s:nfun=0,nin=0,nt=1,
       *de,*eps,tem=0.
*s/e-s:*eps
*s/t-s:*nt,*de,*eps,*tem
*s/g-f:nfun=1,ng=1,nig=1,*nw,nr=0,*nz,
       nl=-2,nh=0,nng=1,nsg=1,nmg=1,
      *eps,*sigz,*w,*de
*s/-p-pn:nreg=1,ng=1,keg=0,*nw,kine=0,nsub=10,*ntyp,
      nscale=2,nset=0,*eps,*w,*de
*p/d-f:nfun=1,kg=0,*nz,nl=-2,nh=0,*sigz
*plot: nplot=0,imod=2,kint=3,
       natr=0,0,0,0,nr=3,nt=1,mt=1,2,102,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,1.1,0.1,xyleg=0.1,0.9,tem=300.,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=1,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,1.1,0.1,xyleg=0.1,0.9,*tem,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=2,*eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,1.1,0.1,xyleg=0.1,0.9,*tem,
*plot: nplot=0,imod=3,kint=3,
       natr=0,0,0,0,nr=1,*nt,mt=102,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,1.1,0.1,xyleg=0.1,0.9,*tem
```


092U_238 NG= 1 EG= 4.650+0 1.000+1 T= 300.0K
Self-shielding factor
MT= 1
MT= 2
MT= 18
MT=102
F(S0)
Dilution cross-section [barn]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 1
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 2
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]


092U_238 NG= 1 EG= 4.650+0 1.000+1 MT= 18
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]

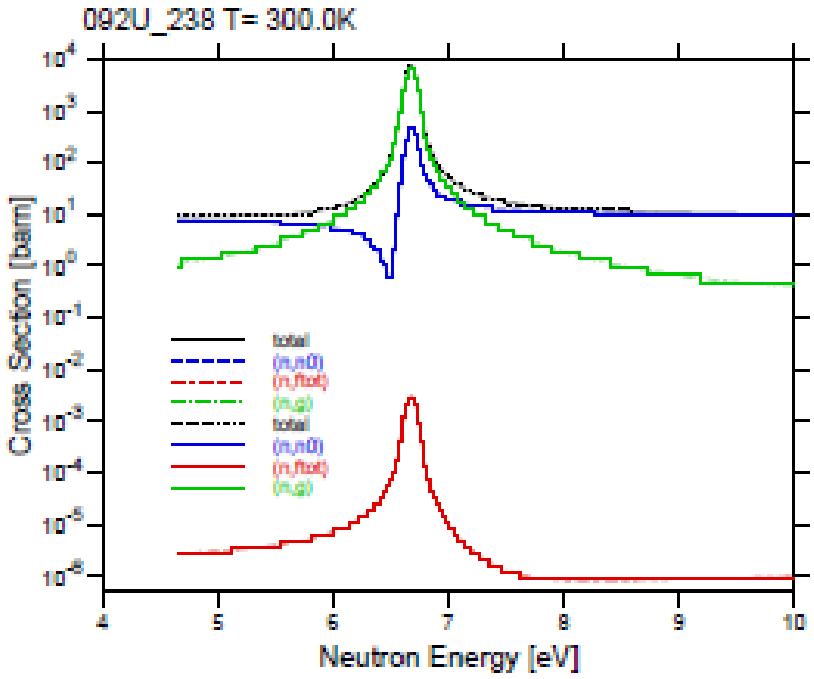

092U_238 NG= 1 EG= 4.650+0 1.000+1 MT=102
Self-shielding factor
T= 300.0K
T= 900.0K
T=2100.0K
F(S0)
Dilution cross-section [barn]

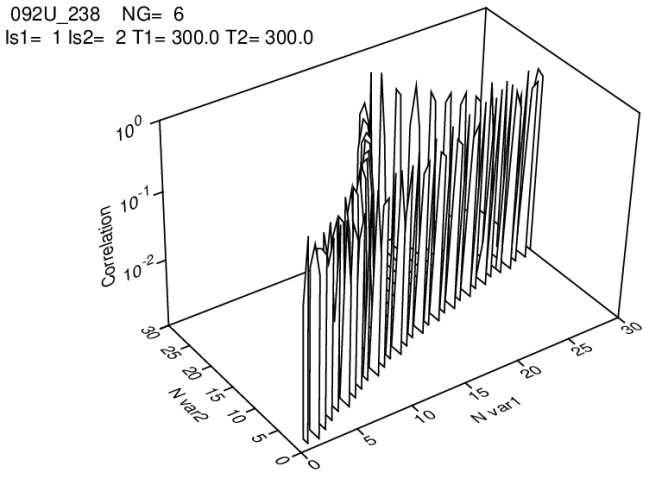
C7. Generalized Subgroups and Correlation Matrices

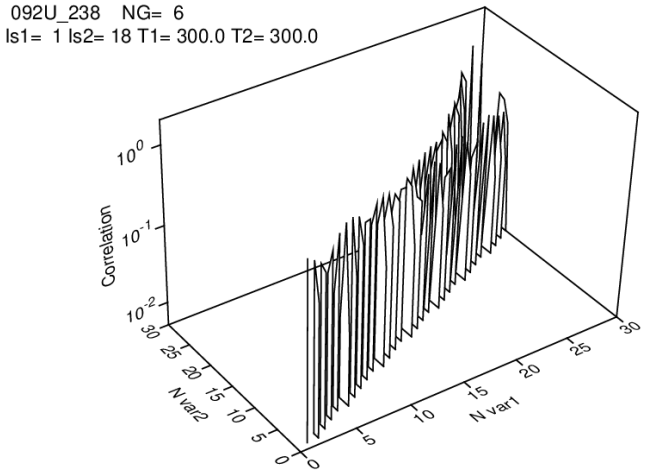
```
! Test 7: Generalized subgroup correlation matrices
,in              ! enter local parameters
,in,1,endf       ! enter control parameters
,in,2,s/i-s      !
,in,3,r/t-s      !
,in,4,u/d-s      !
,in,5,s/c-s      !
,in,6,s/e-s      !
,in,7,s/t-s      !
,in,8,s/-p-pn    !
,in,9,a/-s       !
,in,10,plot      !
,in,11,plot      !
,in,12,plot      !
,1,20,data       ! read endf file
20,2,32,s,2      ! linearize cross sections
20,3&32,32       ! reconstruct *s* from resonance parameters
20,4&32,32       ! reconstruct *s* from average resonance
parameters
32,5,33,s,3      ! unite in one structure
33,6&20,32,s     ! exclude redundant energy points
32,7,33,s        ! broaden cross sections
33,8,21,ppn      ! prepare probability tables
21,sel,22,pn     ! extract *pn*
21,sel,23,p      ! extract *p*
23,,30,pn/p-s    ! rename *p* to *pn/p-s
33,cp,25,s       ! copy cross sections
22,30,25         ! add ordered subgroups
25,10&2          ! plot cross sections
22,,30,pn/pn-pc  ! re-registrate *pn* as *pn/-pn-pc
22,30,26,pc      ! prepare correlation matrices
26,11&2          ! write file for viewr to plot correlations
20,9,25,s        ! calculate slow-down parameters
25,,30,pn/d-pc    ! rename *d* to *pn/d-pc
21,30,27,pc      ! prepare correlation matrices
27,12&2          ! write file for viewr to plot correlations in
collisions
,,,end
```

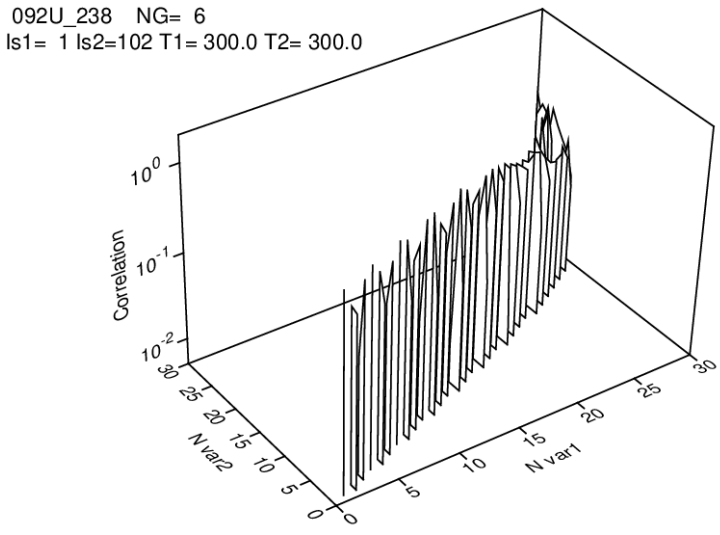
```
!-------------------------------------------------
!    local parameters
*de:4.65,10.,
*nt:3,
*tem:300.,900.,2100.,
*ntyp:2,
*nz:23,
*sigz:1.e-10,1.e-1,2.15e-1,4.65e-1,
      1.,2.15,4.65,1.e1,2.15e1,4.65e1,
      1.e2,2.15e2,4.65e2,1.e3,2.15e3,4.65e3,
      1.e4,2.15e4,4.65e4,1.e5,2.15e5,4.65e5,1.e6,
*ng:30,
*eg:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*nw:4,
*w:0.125,0.025,8.2085E+05,1.273E+06,
*eps:0.001
!-------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=3,nmt=4,mf=2,3,4,mt=1,2,18,102
*s/i-s:nint=2,*de,*eps
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=0,nt=1,
       *de,*eps,tem=0.
*s/c-s:ncom=0,ns=0,*de,*eps
*s/e-s:*eps
*s/t-s:*nt,*de,*eps,*tem
*s/-p-pn:nreg=1,*ng,keg=0,*nw,kine=0,nsub=10,*ntyp,
         nscale=2,nord=1,*eps,*w,*eg
*a/-s:*eps
*plot:nplot=0,imod=2,kint=4,
   ncon=4,nsym=0,ndash=0,ncol=4,nr=4,nt=1,
   mt=1,2,18,102,lcon=0,0,0,0,lcol=0,3,1,2,
   *eps,*de,deo=0.,0.,
   dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.5,
   tem=300.
*plot:ncur=1,igr=0,kint=2,
   natr=0,0,0,0,nr=1,nt=1,mtr=1,
   eps=0.001,*de,deo=0.,0.,
   dx=0.,0.,5.,dy=0.,0.,5.,xyleg=0.,0.,
   tem=300.
*plot:ncur=1,igr=0,kint=2,
   natr=0,0,0,0,nr=1,nt=3,mtr=1,
   eps=0.001,*de,deo=0.,0.,
   dx=0.,0.,5.,dy=0.,0.,5.,xyleg=0.,0.,
   tem=300.,900.,2100.
```

Correlation of partial with total subgroup cross sections

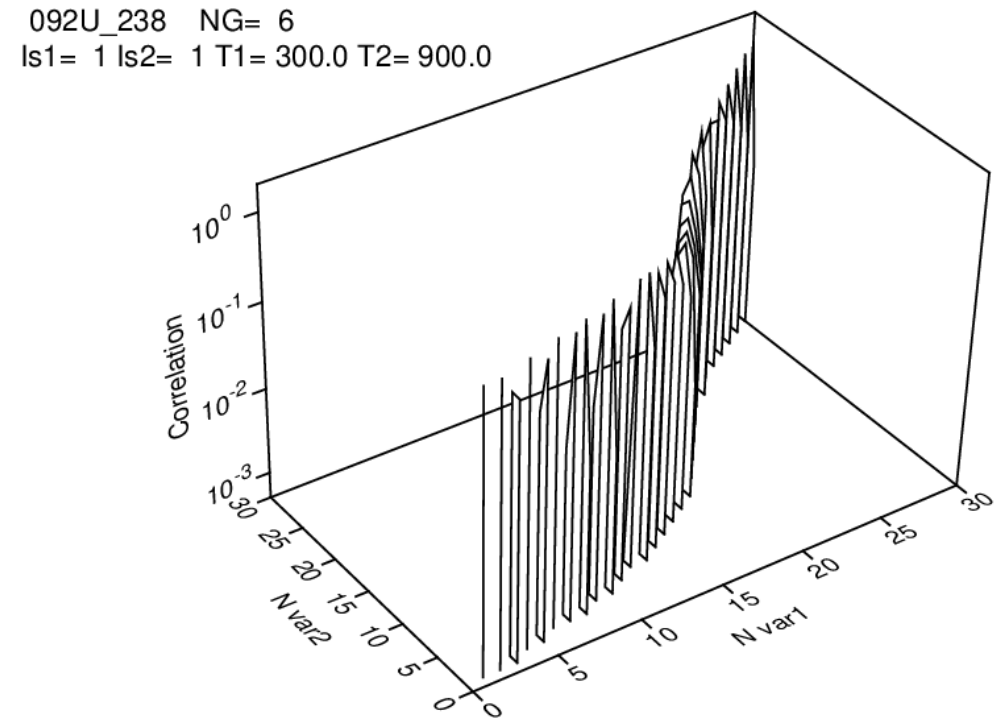


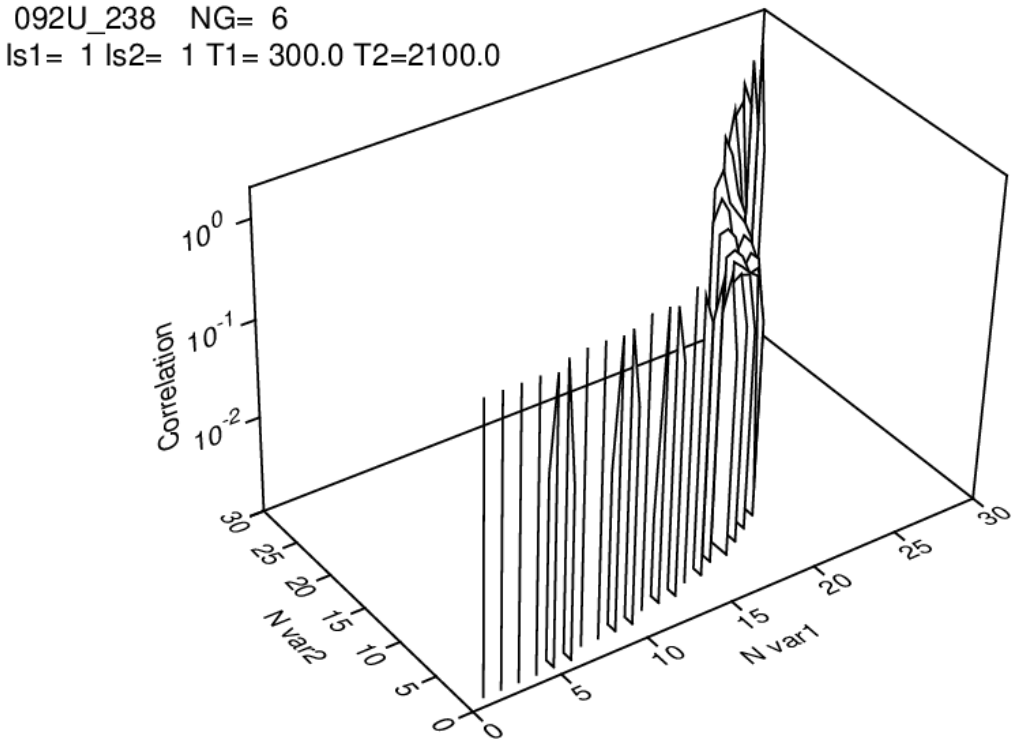




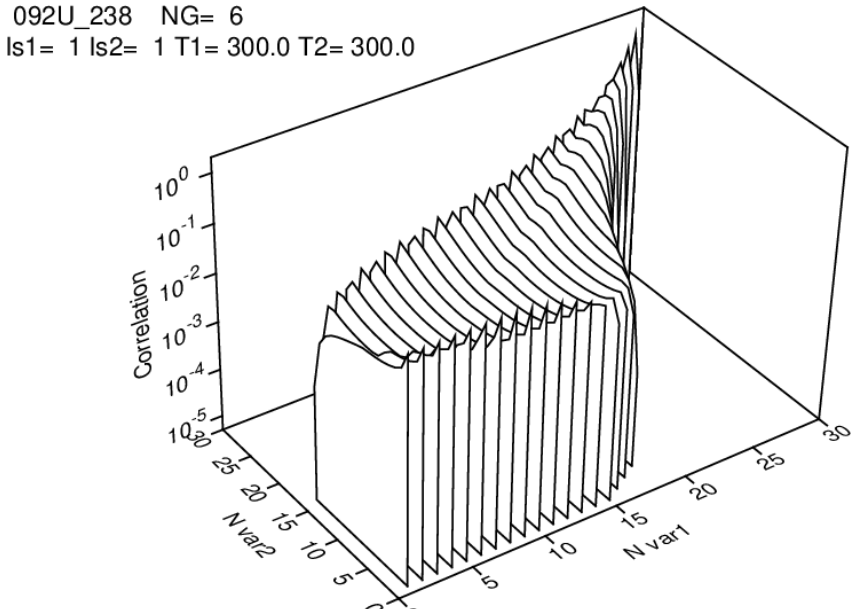


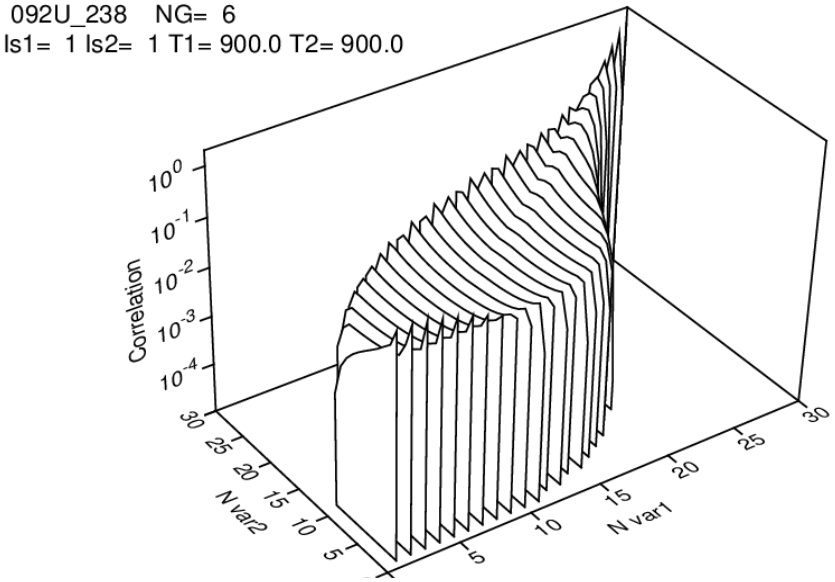
Correlations in subgroup cross sections for different temperatures

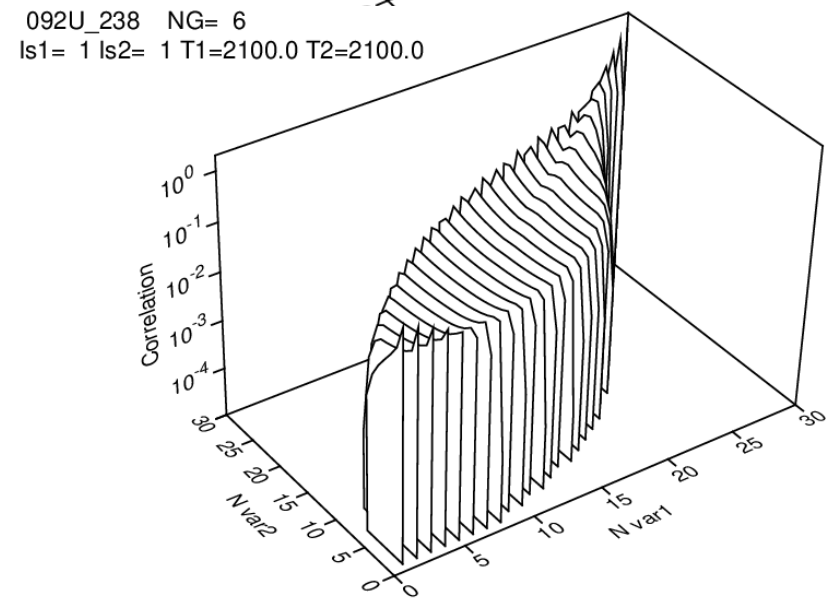




Correlations in subgroup cross sections in successive collisions

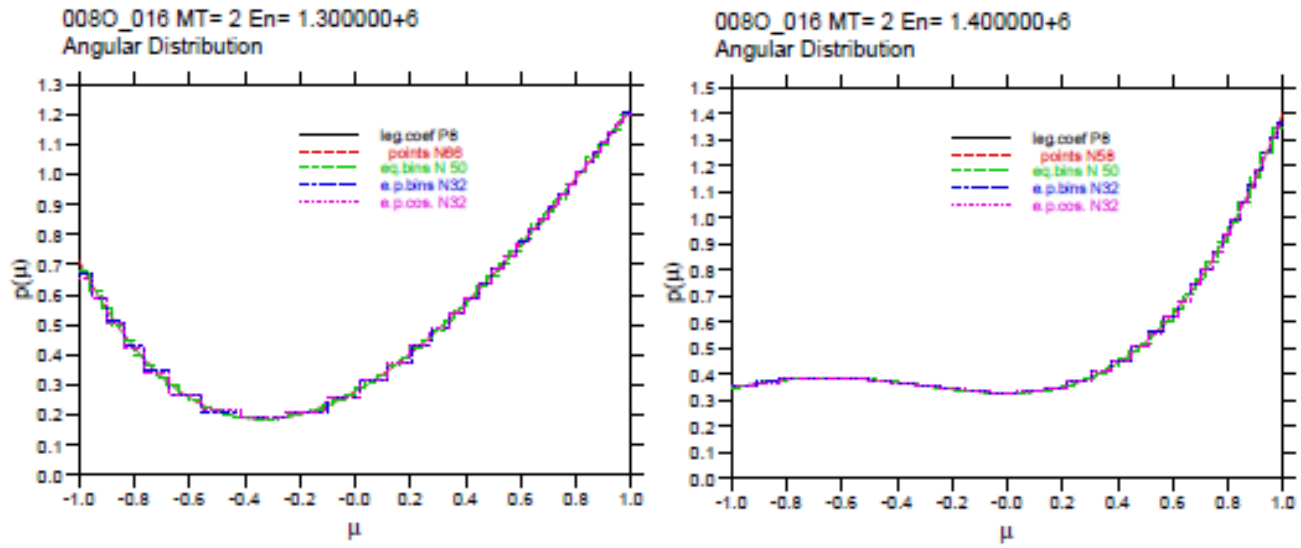






C8. Angular Distribution Representations

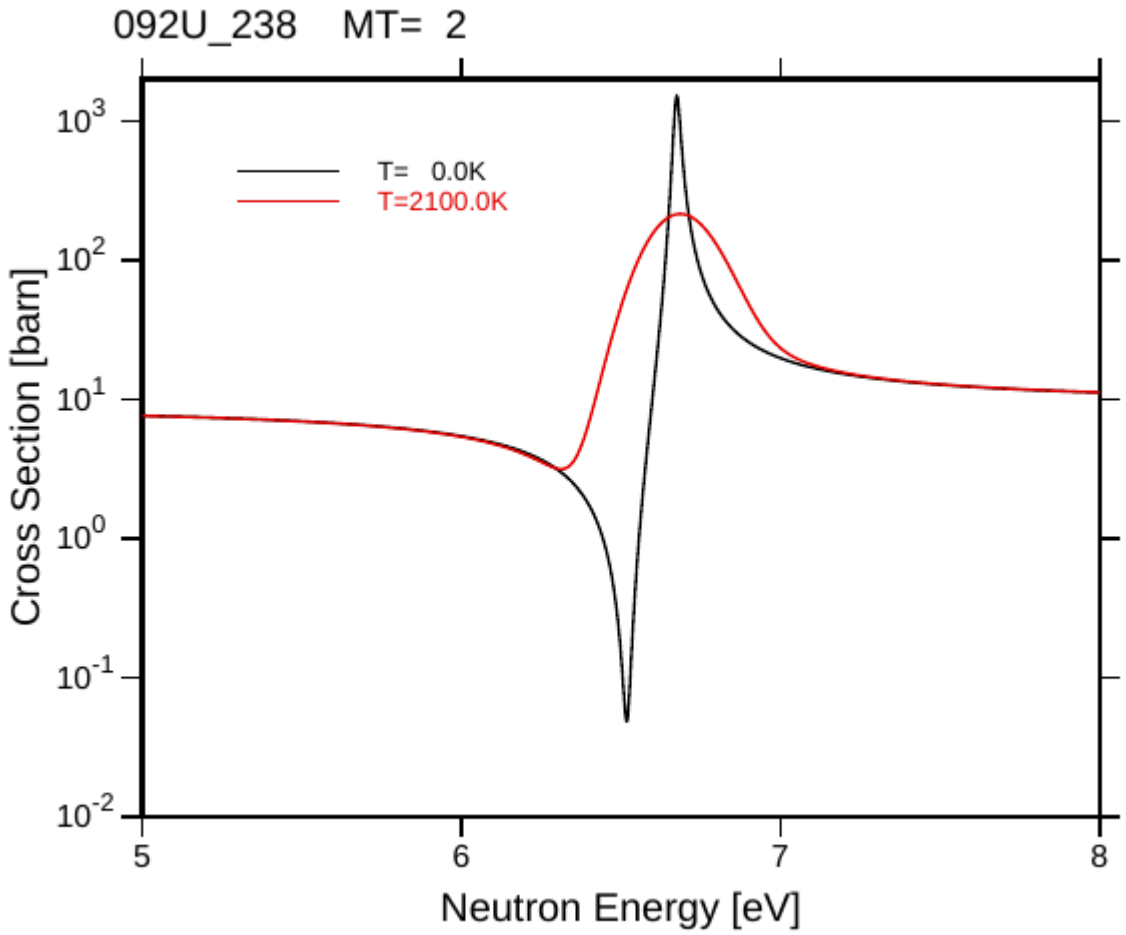
```
! Test 8: Angular distribution representations
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,a/-a
,in,3,plot
,1,20,a
20,2,21,a       ! change angular representation type
21,3&2          ! write file fo viewr to plot angular
distributions
,,,end
! -------------------------
!    local parameters
*de:1.3e6,1.5e6,
*eps:0.001
!  lap < 0 - the same as in the input data
!  lap = 0 - point by point representation
!  lap = 1 - equiangle averaged probabilities
!  lap = 2 - Legendre polynomial coefficients
!  lap = 3 - equiprobable cosine bins
!  lap = 4 - equiprobable cosines
! -------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=1,mf=3,4,mt=2
*a/-a:lap=-1,lct=-1,na=0,*eps,
*a/-a:lap=0,lct=-1,na=0,*eps,
*a/-a:lap=1,lct=-1,na=50,*eps,
*a/-a:lap=3,lct=-1,na=32,*eps,
*a/-a:lap=4,lct=-1,na=32,*eps
*plot:ncur=0,imod=0,kint=2,
      ncon=0,nsym=0,ndash=0,ncol=0,nr=1,nt=1,mt=2,
      eps=0.001,*de,deo=0.,0.,
      dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.,0., tem=0.
```

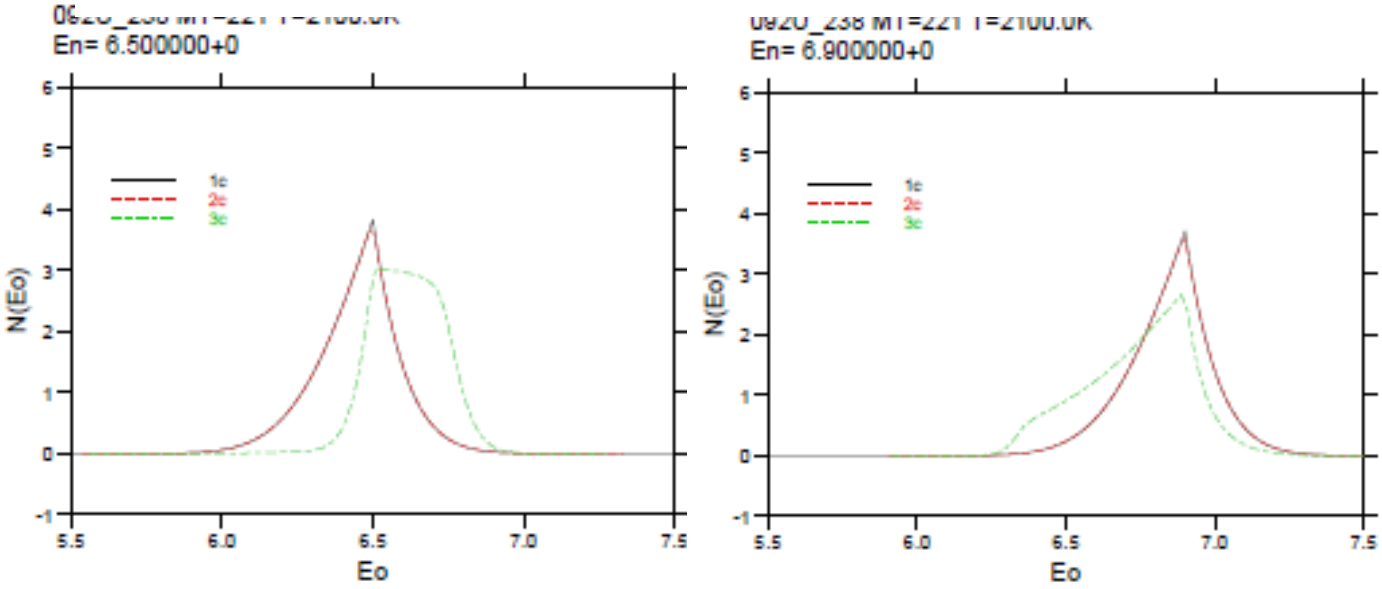


C9. Neutron Scattering at Resonances

```
! Test 9: Scattering at resonances
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s
,in,3,r/t-s
,in,4,s/c-s
,in,5,s/e-s
,in,6,s/t-s
,in,7,th/-ds
,in,8,s/t-ds
,in,9,s/t-ds
,in,10,plot
,in,11,plot
,1,20,data
20,2,21,s      ! linearize
20,3&21,21     ! reconstruct from resonance parameters
21,4,22,s      ! unite
22,5,23,s      ! thin energy points grid
23,6&20,24,s   ! doppler broaden
24,5,25,s      ! thin energy points grid
25,10&2
25,7,26,ds     ! free gas approximation in th/-ds
25,8,27,ds     ! free gas approximation in s/t-ds
25,9,28,ds     ! scattering on resonances in s/t-ds
26,sel,30,d    ! select *d* for free gas in th/-ds
27,sel,30      ! add *d* for free gas in s/t-ds
28,sel,30      ! add *d* for scattering on resonances in s/t-ds
30,11&2        ! write viewr file for plotting *d*
,,,end
! -------------------------------
!    local parameters
*de:5.,10.,
*ep1:6.5,
*ep2:6.9,
*nt:1,
*nt1:2,
*tem:2100.,
*nhist:20000000,
*deo1:6.2,6.8,
*deo2:6.6,7.2,
*eps:0.001
```

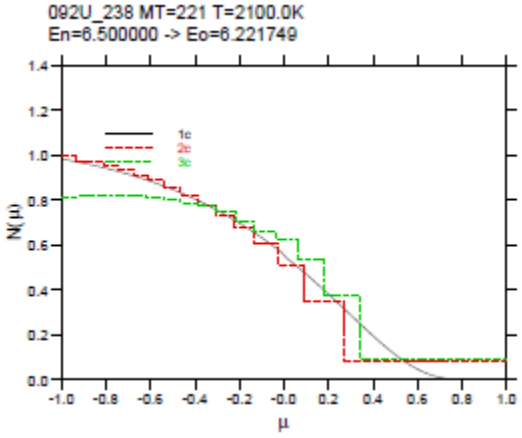
```
!--------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=2,mf=2,3,mt=1,2
*s/i-s:nint=2,*de,*eps
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*s/c-s:nmat=0,ns=1,ls=2,*de,*eps
*s/e-s:*eps
*s/t-s:*nt1,*de,*eps,0.,*tem
*th/-ds:ls=221,iset=0,natom=1,kint=2,*nt,nang=100,lap=0,
        *ep1,*ep1,*eps,*tem,
*th/-ds:ls=221,iset=0,natom=1,kint=2,*nt,nang=100,lap=0,
        *ep2,*ep2,*eps,*tem
*s/t-ds:napr=0,nei=200,neo=200,lep=0,iwe=1,
        nai=200,nao=16,lap=4,*nt,*nhist,
        *ep1,*ep1,*tem,
*s/t-ds:napr=0,nei=200,neo=200,lep=0,iwe=1,
        nai=200,nao=16,lap=4,*nt,*nhist,
        *ep2,*ep2,*tem
*s/t-ds:napr=1,nei=200,neo=200,lep=0,iwe=1,
        nai=200,nao=16,lap=4,*nt,*nhist,
        *ep1,*ep1,*tem,
*s/t-ds:napr=1,nei=200,neo=200,lep=0,iwe=1,
        nai=200,nao=16,lap=4,*nt,*nhist,
        *ep2,*ep2,*tem
*plot: iplot=0,imod=3,kint=4,
       natr=0,0,0,0,nr=1,nt=2,mt=2,
       *eps,*de,*de,
       dx=5.,8.,1.,dy=0.,0.,0.,xyleg=0.1,0.9,tem=0.,*tem
*plot: iplot=0,imod=0,kint=2,
       natr=0,0,0,0,nr=1,*nt,mt=221,
       *eps,*ep1,*ep1,*deo1,
       dx=0.,0.,0.,dy=0.,1.4,0.2,xyleg=0.1,0.9,*tem
*plot: iplot=0,imod=0,kint=2,
       natr=0,0,0,0,nr=1,*nt,mt=221,
       *eps,*ep2,*ep2,*deo2,
       dx=0.,0.,0.,dy=0.,1.2,0.2,xyleg=0.7,0.9,*tem,
*plot: iplot=0,imod=10,kint=2,
       natr=0,0,0,0,nr=1,*nt,mt=221,
       *eps,*ep1,*ep1,*deo1,
       dx=5.5,7.5,0.5,dy=0.,5.,1.,xyleg=0.1,0.9,*tem,
*plot: iplot=0,imod=10,kint=2,
       natr=0,0,0,0,nr=1,*nt,mt=221,
       *eps,*ep2,*ep2,*deo2,
       dx=5.5,7.5,0.5,dy=0.,5.,1.,xyleg=0.1,0.9,*tem
```

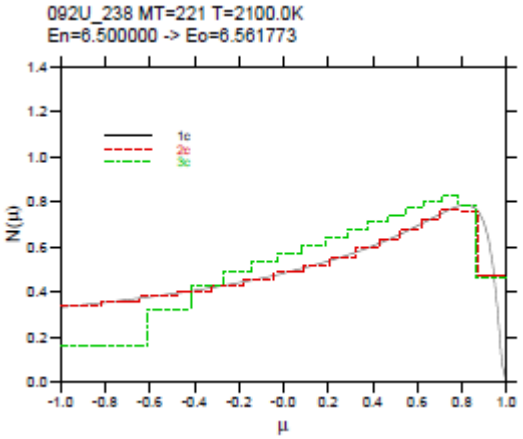


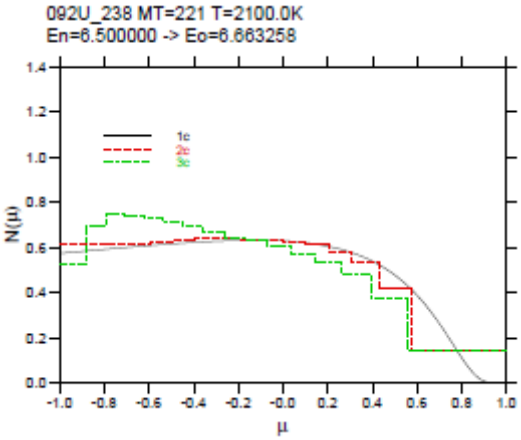


Comment:
1c - the THXXDS module, free gas model
2c - the SXTXDS moodule, free gas model
3c - the SXTXDS module, resonance scattering model

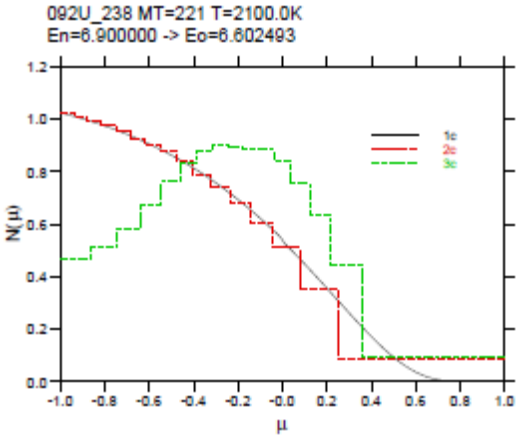
En=6.5eV

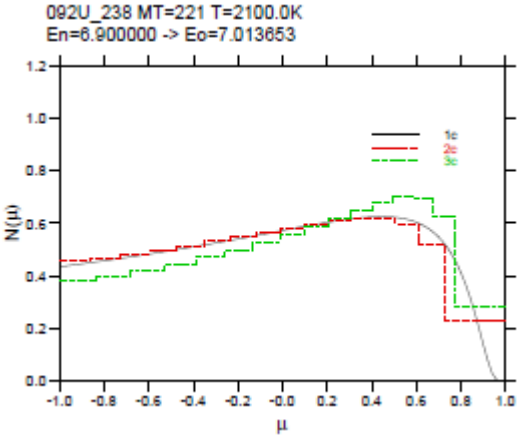


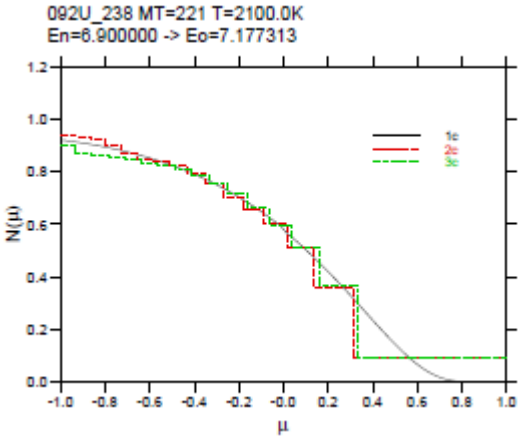




En=6.9eV







Comment:

1c - the THXXDS module, free gas model

2c - the SXTXDS moodule, free gas model

3c - the SXTXDS module, resonance scattering model

C10. ACE Files with Data for Neutron Scattered at Resonances

```
! Test 10: ACE file for neutron resonance scattering data
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s
,in,3,r/t-s
,in,4,s/c-s
,in,5,s/e-s
,in,6,s/t-s
,in,7,s/t-ds
,in,8,ace
,1,20,data
20,2,21,s     ! linearize
20,3&21,21    ! reconstruct from resonance parameters
21,4,22,s     ! unite cross sections
22,5,23,s     ! thin energy points
23,6,24,s     ! Doppler broaden
24,5,25,s     ! thin energy points after broadening
25,7,26,data ! calculate cross sections and disributions
26,con
26,8,,U238r   ! write to ACE file
,,,end
! -------------------------------
!    local parameters
*de:1.e-5,10.,
*de1:1.e-5,20.,
*de2:1.e-5,30.,
*nsuf:0,
*nt:1,
*nt1:2,
*tem:300.,
*nhist:1000000,
*eps:0.001
!--------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=4,mf=2,3,mt=1,2,18,102
*s/i-s:nint=2,*de1,*eps
*r/t-s:nfor=0,nt=1,*de2,*eps,tem=0.
*s/c-s:nmat=0,ns=1,ls=2,*de2,*eps
*s/e-s:*eps
*s/t-s:*nt1,*de1,*eps,tem=0.,*tem
*s/t-ds:napr=1,nei=1000,neo=0,lep=0,iwe=0,
        nai=100,nao=32,lap=4,*nt,*nhist,
        *de,*tem
*ace:nace=50,nxsd=51,ntyp=2,niza=0,*nsuf,*nt,mt=221,
         nbin=32,iwe=1,*de,*tem
```

Fragment of Listing

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

**************************************************************************
con     ...                                                          889.0s
        prints cluster content
  n name     mat mf   mt   target  part    el      eh    nu       mw      lw
  1 *s*     9237  3  221  092U_238   n  1.0000-5 1.0000+1  1     61475     790
  2 *d*     9237  3  221  092U_238   n  1.0000-5 1.0000+1  1     62265  4980170
**************************************************************************
ace     ...                                                          889.0s
        writes ace and xsdir files
tem= 300.0
**************************************************************************
end                                                                  896.0s
```

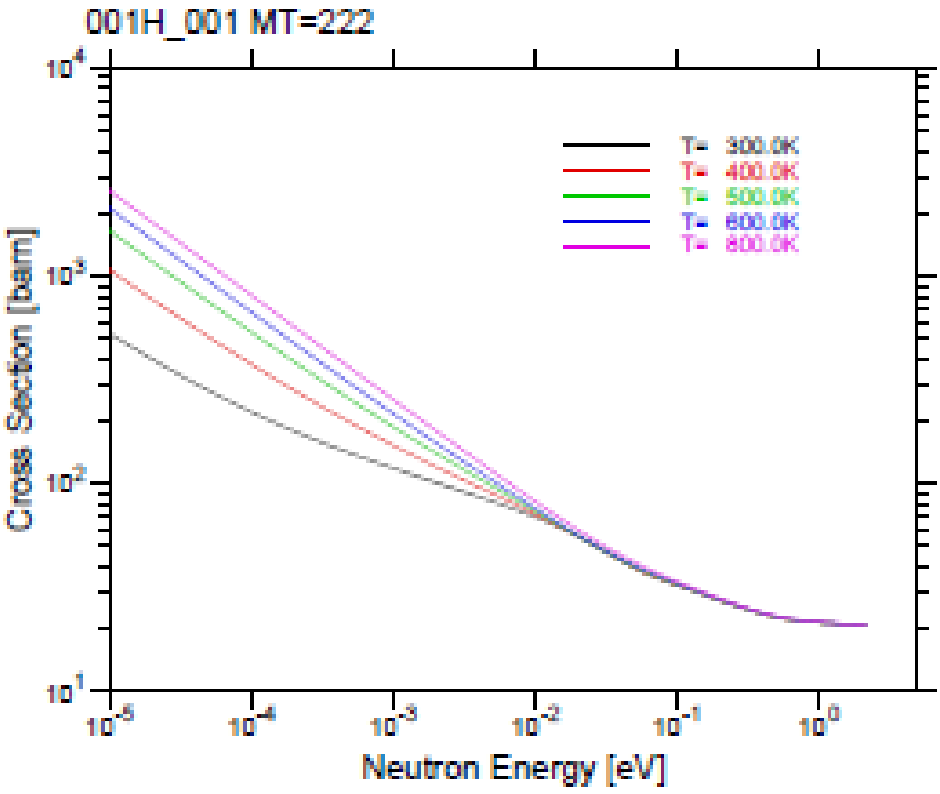
Fragment of the U238r ACE file

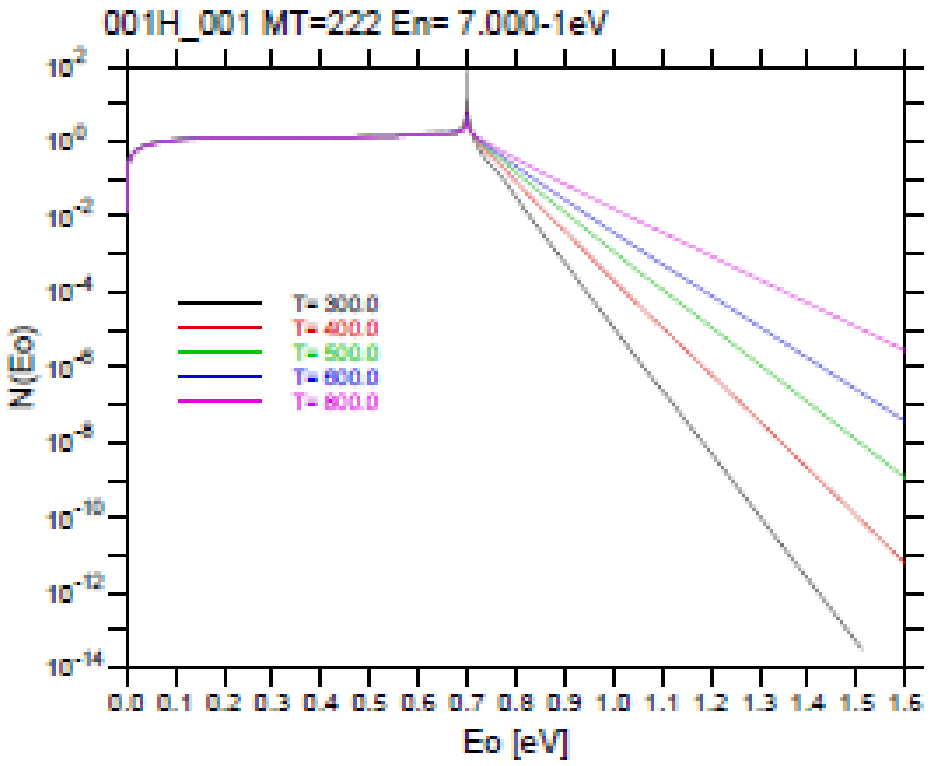
```
U238r.00t  236.005800  2.5852E-08   16/12/21
* processed by grucon-2021.12d                                          mat9237
  92238         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
   405215         3       31       32        0        0        1        0
        0         0        0        0        0        0        0        0
        1       385      768        0        0        0        0        0
        0         0        0        0        0        0        0        0
        0         0        0        0        0        0        0        0
        0         0        0        0        0        0        0        0
                383   1.00000000000E-11   1.10277621587E-11   1.20555243174E-11
   1.30832864761E-11   1.41110486348E-11   1.54813981798E-11   1.71943351110E-11
   1.89072720422E-11   2.09627963596E-11   2.30183206770E-11   2.50738449944E-11
   2.78145440843E-11   3.05552431742E-11   3.32959422641E-11   3.60366413540E-11
   4.01476899889E-11   4.42587386237E-11   4.83697872586E-11   5.38511854384E-11
   5.93325836182E-11   6.48139817980E-11   7.30360790677E-11   8.12581763373E-11
   8.94802736070E-11   1.00443069967E-10   1.08665167236E-10   1.19627963596E-10
   1.36072158135E-10   1.52516352675E-10   1.74441945394E-10   1.96367538113E-10
   2.29255927192E-10   2.62144316271E-10   2.95032705349E-10   3.38883890788E-10
   4.04660668945E-10   4.48511854384E-10   5.36214225260E-10   6.67767781576E-10
   7.99321337891E-10   9.74726079644E-10   1.23783319227E-09   1.58864267578E-09
   2.11485690104E-09   3.16728535156E-09   4.92133276910E-09   9.83266553819E-09
   2.24618069444E-08   8.98172277778E-08   1.73333148889E-06   2.75257186667E-06

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

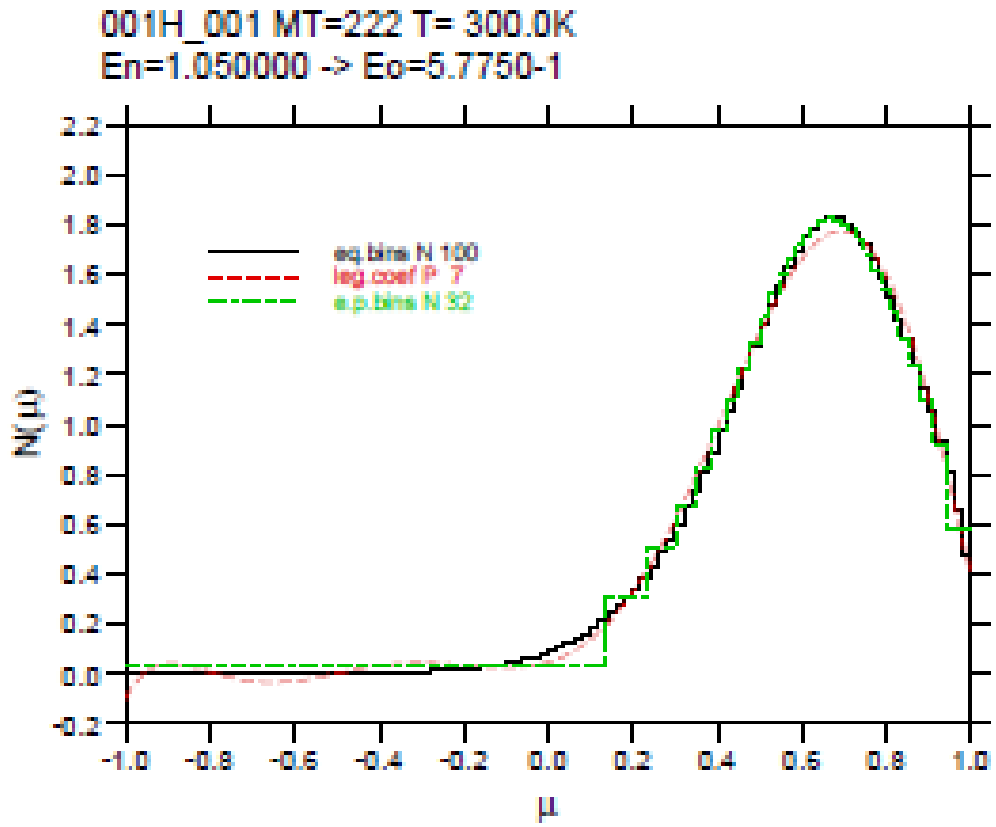
C11. Thermal Neutron Scattering at Bound Nuclei

```
! Test 11: Thermal neutron scattering at bound nuclei
,in                ! enter local parameters
,in,1,endf         ! enter control parameters
,in,2,th/-ds
,in,3,th/-ds
,in,4,plot
,in,5,plot
,in,6,plot
,1,20,th
20,2&1,32,ds,2    ! reconstruct cross section
32,sel,21,s
21,4&2            ! plot cross sections
32,sel,22,d
22,5&2            ! plot energy distributions
20,3&1,32,ds,2    ! prepare angular distributions
32,sel,23,d
23,6&2            ! plot angular distributions
,,,end
!------------------------------
!    local parameters
*mt:222,
*iset:0,
*natom:2,
*de:1.e-5,2.15,
*nt:5,
*tem:300.,400.,500.,600.,800.,
*tem1:300.,
*eps:0.01
```

```
!------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=1,nmt=0,mf=7
*th/-ds:*mt,*iset,*natom,nint=2,*nt,nang=100,ntypa=1,
       *de,*eps,*tem
*th/-ds:*mt,*iset,*natom,nint=2,nt=1,nang=100,ntypa=1,
       *de,*eps,*tem1,
*th/-ds:*mt,*iset,*natom,nint=2,nt=1,nang=7,ntypa=2,
       *de,*eps, *tem1,
*th/-ds:*mt,*iset,*natom,nint=2,nt=1,nang=32,ntypa=3,
       *de,*eps,*tem1
*plot:nadd=0,imod=3,kint=5,
      ncon=0,nsym=0,ndash=0,ncol=0,nr=1,*nt,*mt,
      *eps,*de,deo=0.,0.,
      dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.6,0.9,*tem
*plot:nadd=0,imod=11,kint=4,
      ncon=0,nsym=0,ndash=0,ncol=0,
      nr=1,*nt,*mt,
      *eps,dei=0.6,1.,de=1.e-5,4.65,
      dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.1,0.7,*tem
*plot:nadd=0,imod=1,kint=2,
      ncon=0,nsym=0,ndash=0,ncol=0,
      nr=1,nt=1,*mt,
      *eps,dei=1.05,1.05,deo=0.5,0.6,
      dx=0.,0.,0.,dy=-0.2,2.2,0.2,xyleg=0.1,0.9,*tem1
```




001H_001 MT=222 En= 7.000-1eV
N(Eo)
Eo [eV]
T= 300.0
T= 400.0
T= 500.0
T= 600.0
T= 800.0


001H_001 MT=222 T= 300.0K
En=1.050000 -> Eo=5.7750-1
N(μ)
μ
eq.bins N 100
leg.coef P 7
e.p.bins N 92

C12. Preparation of ACE File for Neutron Scattering at Bound Nuclei

```
! Test 12: ACE file for neutron thermal scattering
!          at hydrogen in water
,in                ! enter local parameters
,in,1,endf         ! enter control parameters
,in,2,th/-ds       !
,in,3,ace          !
,1,20,th           ! read scattering law data from endf file
20,2,21,data       ! reconstruct differential cross section
21,con
21,3,,H_H2O        ! prepare ace file
,,,end
!------------------------------
!    local parameters
*mt:222,
*nsuf:0,
*iset:0,
*natom:2,
*niza:1,
*miza:1001,
*de:1.e-5,4.65,
*nt:1,
*tem:293.6,
*eps:0.001
!------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=1,nmt=0,mf=7
*th/-ds:*mt,*iset,*natom,nint=2,*nt,nang=32,ntypa=4,
        *de,*eps,*tem
*ace:nace=50,nxsd=51,ntyp=2,*niza,*nsuf,*nt,*mt,nbin=32,
     iwt=1,*miza,*de,*tem
```

Fragment of Listing

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
**************************************************************************e
ndf     ...                                                          0.0s
         reads endf file tape20
mat/mf/mt=   1/ 7/  4
**************************************************************************
thxxds   ...                                                          4.0s
         calculates thermal neutron cross sections and energy-angle
distributions
         incoherent inelastic scattering, mt=222
         adaptive energy grid is used
 nep=   92
 it/nt= 1/ 1   T=  293.6
   iep/    nep      ei      nepo
    10/     92 2.21200E-05   926
    20/     92 6.20000E-05   904
    30/     92 2.05300E-04   918
    40/     92 8.84200E-04   961
    50/     92 4.55000E-03   967
    60/     92 2.43000E-02   936
    70/     92 6.70500E-02   989
    80/     92 3.14789E-01   936
    90/     92 3.09350E+00  1186
    92/     92 4.65000E+00  1080
**************************************************************************
con      ...                                                        176.0s
         prints cluster content
n name     mat mf   mt   target  part    el       eh    nu        mw       lw
1 *s*        1  7  222  001H_001   n  1.0000-5 4.6500+0  1   1344522      208
2 *d*        1  7  222  001H_001   n  1.0000-5 4.6500+0  1   1344730  2943241
**************************************************************************
ace      ...                                                        176.0s
         writes ace and xsdir files
tem= 293.6
**************************************************************************
end                                                                 178.0s
```

Fragment of the H_H2O ACE file

```
H_H2O.00t    0.999167  2.5301E-08   16/12/21
* processed by grucon-2021.12d                                    mat   1
   1001         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
    97337        3       31       32       0        0        1        0
        0        0        0        0       0        0        0        0
        1       94      186        0       0        0        0        0
        0        0        0        0       0        0        0        0
        0        0        0        0       0        0        0        0
        0        0        0        0       0        0        0        0
                  92   1.00000000000E-11   1.07800000000E-11   1.15600000000E-11
   1.23400000000E-11   1.31200000000E-11   1.46800000000E-11   1.62400000000E-11
   1.78000000000E-11   1.99600000000E-11   2.21200000000E-11   2.42800000000E-11
   2.70000000000E-11   3.00000000000E-11   3.30000000000E-11   3.65000000000E-11
   4.10000000000E-11   4.55000000000E-11   5.00000000000E-11   5.60000000000E-11
   6.20000000000E-11   7.00000000000E-11   7.90000000000E-11   8.80000000000E-11
   1.00000000000E-10   1.13000000000E-10   1.26000000000E-10   1.43000000000E-10
   1.60000000000E-10   1.80000000000E-10   2.05300000000E-10   2.31800000000E-10
   2.66200000000E-10   3.07600000000E-10   3.50000000000E-10   4.06000000000E-10
   4.71600000000E-10   5.49600000000E-10   6.42000000000E-10   7.50000000000E-10
   8.84200000000E-10   1.03380000000E-09   1.20820000000E-09   1.41900000000E-09
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

C13. Preparation of ACE File for Neutron Scattering at Free Nuclei

```
! Test 13: ACE file for neutron thermal scattering at free
nuclide
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s
,in,3,r/t-s
,in,4,s/c-s
,in,5,s/e-s
,in,6,s/t-s
,in,7,th/-ds
,in,8,ace
,1,20,data
20,2,21,s      ! linearize
20,3&21,21     ! reconstruct from resonance parameters
21,4,22,s      ! unite
22,5,23,s      ! thin energy points gric
23,6&20,24,s   ! doppler broaden
24,7,25,ds     ! th/-ds free gas approximation
25,con
25,8,,O16f     ! write ace file
,,,end
! --------------------------------
!    local parameters
*mt:221,
*nsuf:0,
*iset:0,
*de1:1.e-5,15.,
*de:1.e-5,10.,
*nt:1,
*tem:300.,
*eps:0.001
!--------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=1,mf=2,3,mt=2
*s/i-s:nint=2,*de,*eps
*r/t-s:nfor=0,nt=1,*de1,*eps,tem=0.
*s/c-s:nmat=0,ns=1,ls=2,*de1,*eps
*s/e-s:*eps
*s/t-s:*nt,*de,*eps,*tem
*th/-ds:*mt,*iset,natom=1,kint=2,*nt,nang=32,lap=4,
        *de,*eps,*tem
*ace:nace=50,nxsd=51,ntyp=2,niza=0,*nsuf,*nt,*mt,
     nbin=32,iwt=1,*de,*tem
```

Fragment of Listing

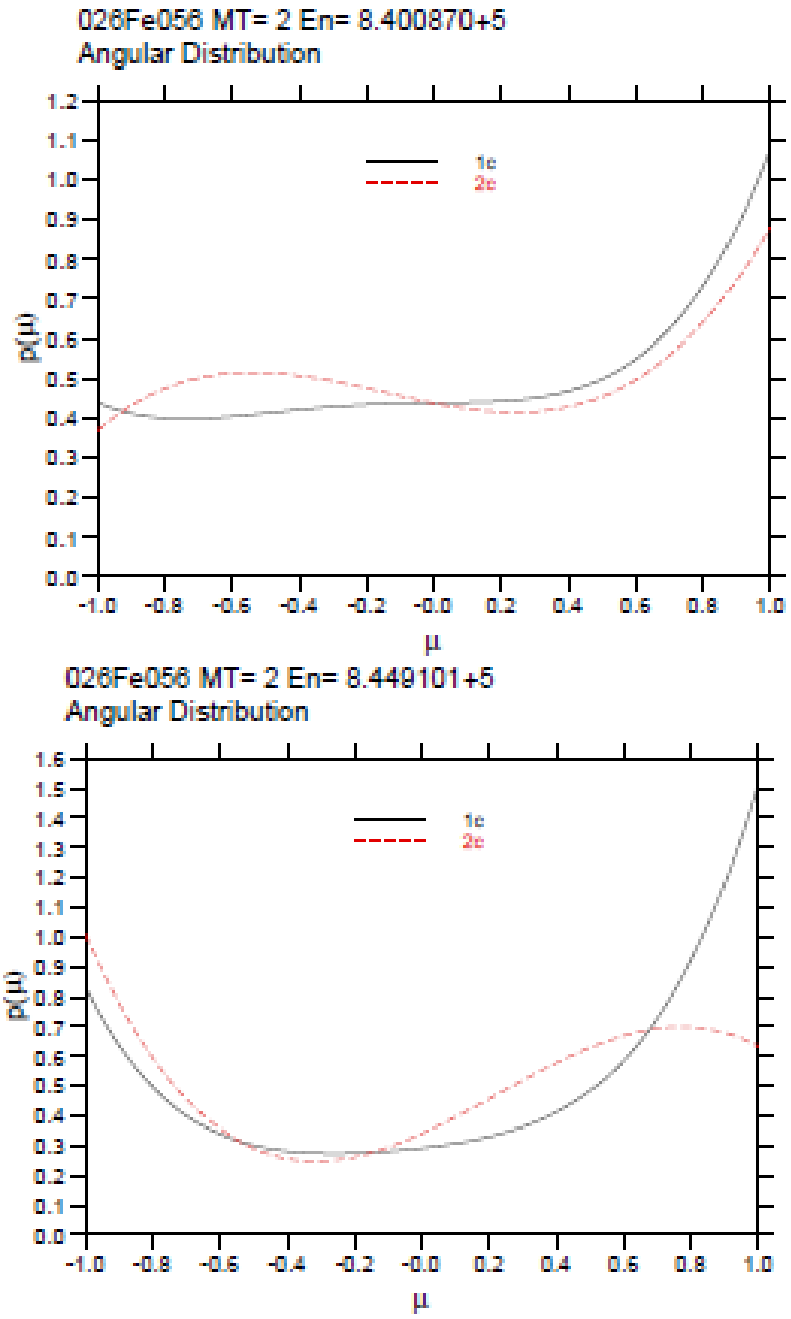
```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
**************************************************************************
con      ...                                                            33.0s
         prints cluster content
n name     mat mf  mt     nucl   part    el       eh    nu        mw       lw
1 *s*      825  3 221   008O_016    n 1.0000-5 1.0000+1  1      5537      572
2 *d*      825  3 221   008O_016    n 1.0000-5 1.0000+1  1      6109  3192191
**************************************************************************
ace      ...                                                            33.0s
         writes ace and xsdir files
tem= 300.0
**************************************************************************
end                                                                     38.0s
```

Fragment of the O16f ACE file

```
 O16f.00t   15.857510  2.5852E-08   16/12/21
* processed by grucon-2021.12d                                        mat 825
   8016         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
   289893        3       31       32        0        0        1        0
        0        0        0        0        0        0        0        0
        1      276      550        0        0        0        0        0
        0        0        0        0        0        0        0        0
        0        0        0        0        0        0        0        0
        0        0        0        0        0        0        0        0
                 274   1.00000000000E-11   1.04238510132E-11   1.06357765198E-11
   1.08477020264E-11   1.10596275330E-11   1.12715530396E-11   1.16954040527E-11
   1.21192550659E-11   1.25431060791E-11   1.29669570923E-11   1.33908081055E-11
   1.38146591187E-11   1.42385101318E-11   1.46623611450E-11   1.50862121582E-11
   1.55100631714E-11   1.59339141846E-11   1.63577651978E-11   1.67816162109E-11
   1.72054672241E-11   1.76293182373E-11   1.80531692505E-11   1.84770202637E-11
   1.89008712769E-11   1.93247222900E-11   1.97485733032E-11   2.01724243164E-11
   2.05962753296E-11   2.10201263428E-11   2.14439773560E-11   2.18678283691E-11
   2.22916793823E-11   2.27155303955E-11   2.35632324219E-11   2.44109344482E-11
   2.52586364746E-11   2.61063385010E-11   2.69540405273E-11   2.78017425537E-11
   2.86494445801E-11   2.94971466064E-11   3.03448486328E-11   3.11925506592E-11
   3.20402526855E-11   3.28879547119E-11   3.37356567383E-11   3.45833587646E-11
   3.54310607910E-11   3.62787628174E-11   3.71264648438E-11   3.88218688965E-11
   3.96695709229E-11   4.05172729492E-11   4.13649749756E-11   4.22126770020E-11
   4.30603790283E-11   4.39080810547E-11   4.47557830811E-11   4.56034851074E-11
   4.72988891602E-11   4.89942932129E-11   5.06896972656E-11   5.23851013184E-11
   5.40805053711E-11   5.57759094238E-11   5.74713134766E-11   5.91667175293E-11
   6.08621215820E-11   6.25575256348E-11   6.42529296875E-11   6.59483337402E-11
   6.76437377930E-11   6.93391418457E-11   7.10345458984E-11   7.27299499512E-11
   7.44253540039E-11   7.61207580566E-11   7.78161621094E-11   7.95115661621E-11
   8.12069702148E-11   8.29023742676E-11   8.45977783203E-11   8.62931823730E-11
   8.79885864258E-11   8.96839904785E-11   9.13793945312E-11   9.47702026367E-11
   9.81610107422E-11   1.01551818848E-10   1.04942626953E-10   1.08333435059E-10
   1.11724243164E-10   1.15115051270E-10   1.18505859375E-10   1.21896667480E-10
   1.25287475586E-10   1.28678283691E-10   1.32069091797E-10   1.35459899902E-10
   1.38850708008E-10   1.42241516113E-10   1.45632324219E-10   1.49023132324E-10
   1.52413940430E-10   1.55804748535E-10   1.59195556641E-10   1.62586364746E-10
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

C14. Reconstruction of Angular Distributions from Resonance Parameters

```
! Test 14: Reconstruction of angular distributions
! from resonance parameters
,in                  ! enter local parameters
,in,1,endf           ! enter control parameters
,in,2,rxtxs          !
,in,3,sxlxa          !
,in,4,axexa          !
,in,5,endf           !
,in,6,plot           !
,1,20,data           ! read *r* and *a* from mf2 and mf4 endf
files
20,2&-10,21,s        ! calculate collision function
21,3&20,22,a         ! reconstruct angular distributions
22,4,23,a            ! thin energy points grid
23,5&1               ! write endf MF4 file
20,sel,24,a          ! compare original and reconstructed angular
distributions
22,cp,24             !
24,6&2               ! write ps-file for viewing
,,,end
!-------------------------------------------------
!    local parameters
*mt:2,
*de:8.4e5,8.45e5,
*eps:0.001
!-------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=2,nmt=1,mf=2,4,*mt
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*s/l-a:nl=0,ns=1,*mt,*de,*eps
*a/e-a:*eps
*endf:ntape=50,nmat=0,nmf=1,nmt=0,mf=4
*plot: nstr=0,lmod=3,ltyp=2,
       ncon=0,nsym=0,ndash=0,ncol=0,
       nr=1,nt=1,*mt,
       *eps,*de,deo=0.,0.,
       dx=0.,0.,0.,dy=0.,0.,0.,
       xyleg=0.,0.,
       tem=0.
```



Comment:

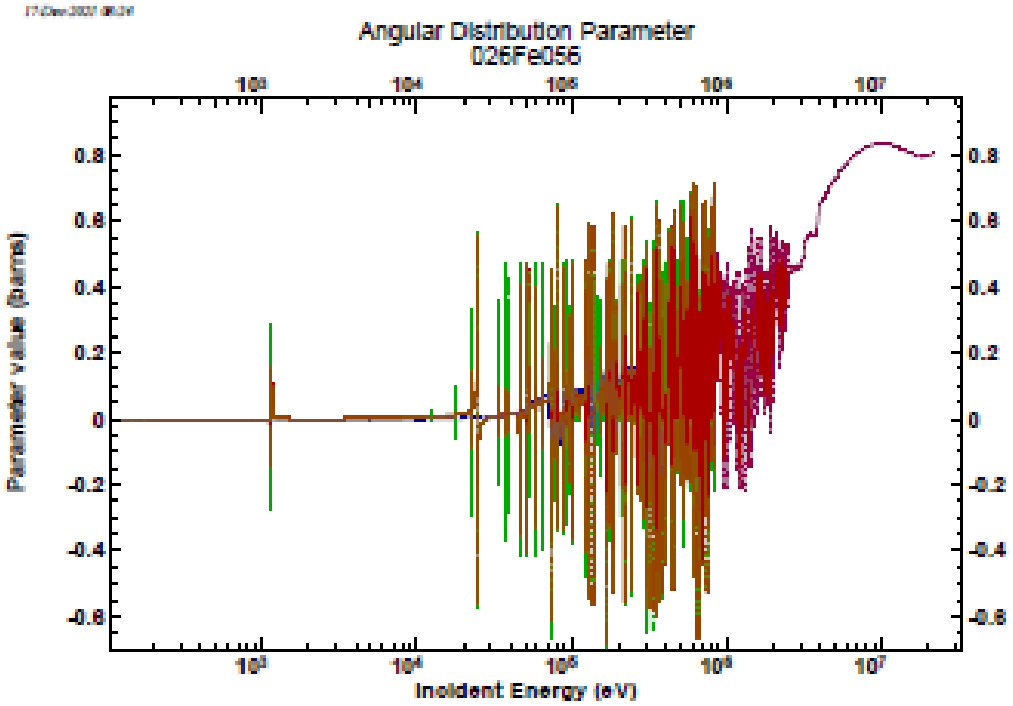
1c – angular distributions are obtained from the MF4 data file

2c – angular distributions are reconstructed from resonance parameters MF2

C15. Doppler Smoothing of Legendre Polynomial Coefficients

```
! Test15: Doppler smoothing of Legendre polynomial coefficients
,in                  ! enter local parameters
,in,1,endf           ! enter control parameters
,in,2,sxixs          !
,in,3,rxtxs          !
,in,4,sxcxs          !
,in,5,sxexs          !
,in,6,sxlxa          !
,in,7,axxs           !
,in,8,sxtxs          !
,in,9,sxxa           !
,in,10,axexa         !
,in,11,endf          !
,in,12,zvd           !
,1,20,data           ! read *r*,*s* and *a* from endf files
20,2,32,s,2          ! linearize non-resonance cross section
20,3,32              ! reconstruct cross section from resonance
parameters
32,4,33,s,3          ! join cross section components
33,5,21,s            ! thin energy points grid in *s* data
20,3&-10,32,s        ! calculate collision function
32,6,33,a            ! prepare angular distribution parameters
33,10,22,a           ! thin energy points grid  in *a* structure
22,7&21,33,s         ! convert to *s* structure
33,5,32,s            ! thin energy points grid in *s* structure
32,8&20,33,s         ! doppler smoothing
33,9&20,32,a         ! convert to *a* structure
32,10,23,a           ! thin energy points grid in *a* structure
23,11                !
20,sel,24,a
22,cp,24
23,cp,24
24,7&-1,25,s
25,12
,,,end

!-------------------------------------------------
!    local parameters
*mt:2,
*de:1.e-5,20.e6,
*nt:1,
*tem:293.6,
*eps:0.001
```

```
!---------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=3,nmt=1,mf=2,3,4,*mt
*s/i-s:nint=2,*de,*eps
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*s/c-s:ncom=0,ns=1,*mt,*de,*eps
*s/e-s:*eps
*s/l-a:nl=0,ns=1,*mt,*de,*eps
*a/-s:*eps
*s/t-s:*nt,*de,*eps,*tem
*s/-a:*eps
*a/e-a:*eps
*endf:ntape=50,nmat=0,nmf=1,nmt=0,mf=4
*zvd:ncur=0,imod=0,kint=3,nr=1,nt=0,mt=1002,
     *eps,*de,deo=0.,0.
```

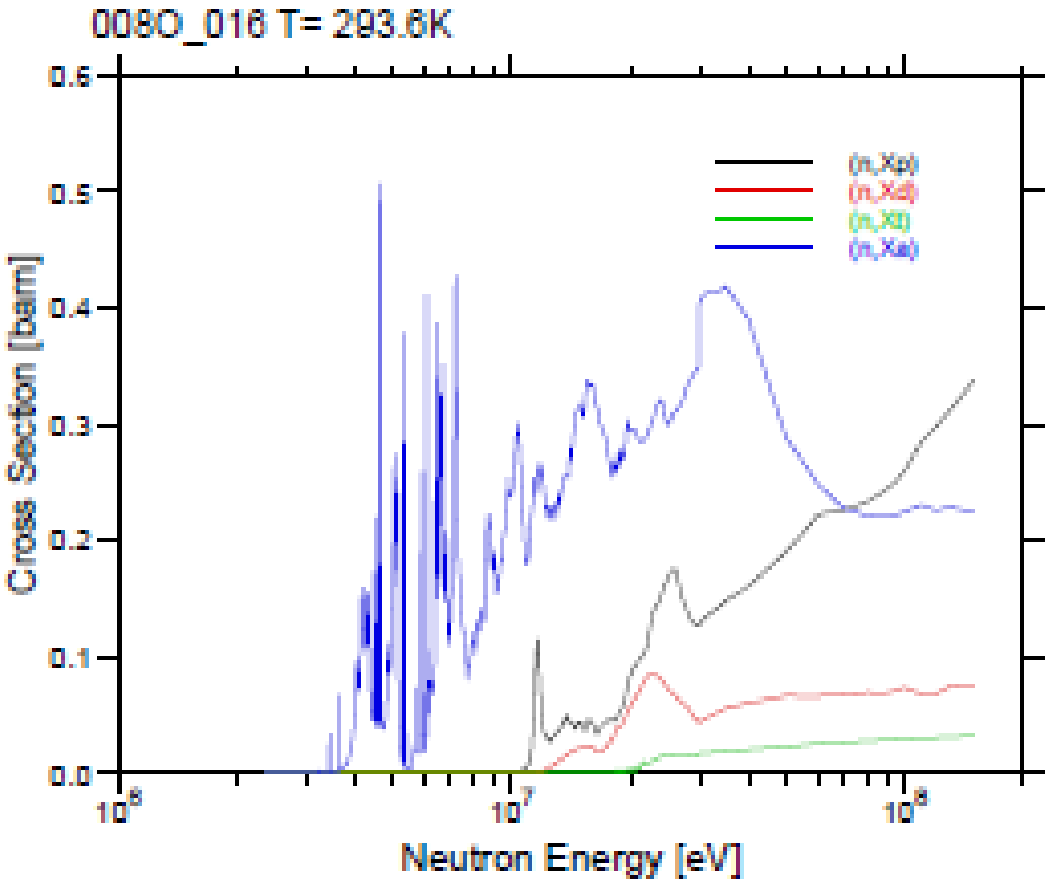


Comment: Average cosine of neutron elastic scattering at Fe^{56}:
blue line – obtained from the MF4 data file with angular distribution parameters,
green line – reconstructed from resonance parameters (MF2 file) at T=0K,
red line – reconstructed and smoothed for room temperature.
Visualization is performed by ZVViewr.

C16. Light Particle Production Cross Sections

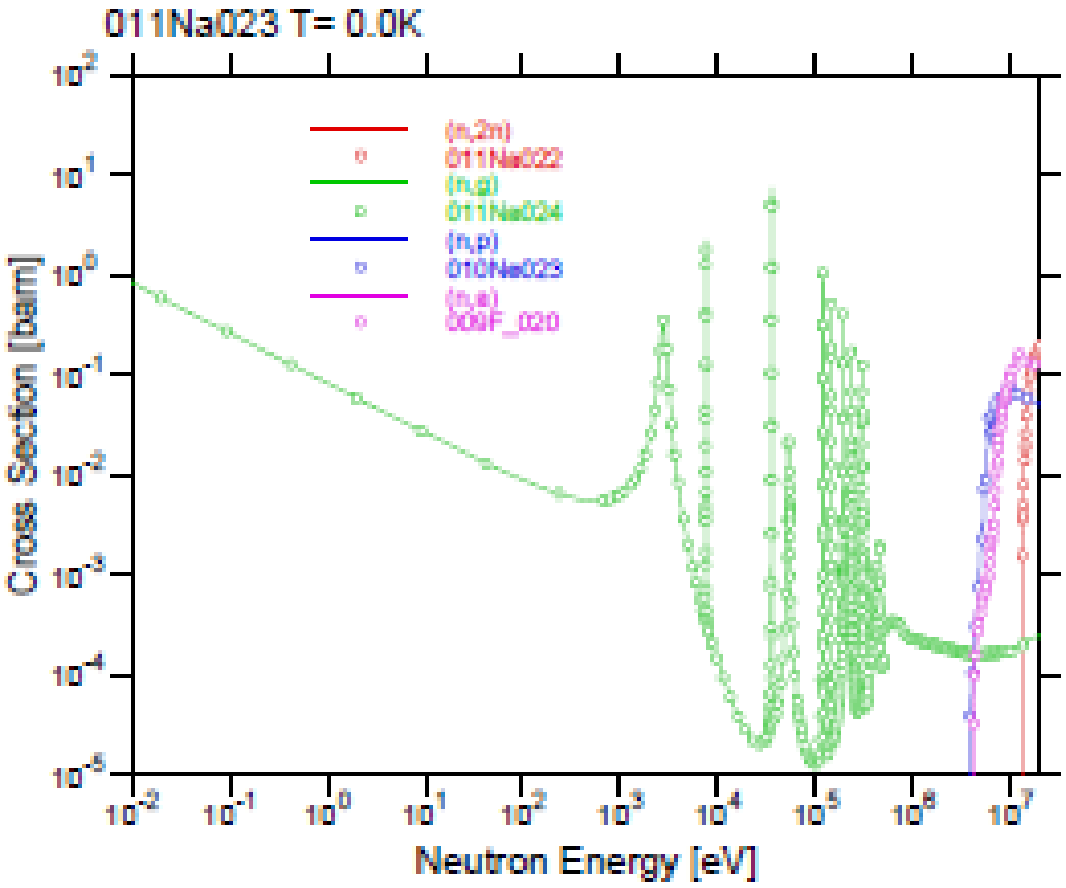
```
! Test16: Light Particle Production Cross Sections
,in              ! enter local parameters
,in,1,endf       ! enter control parameters
,in,2,s/i-s
,in,3,s/c-s
,in,4,s/a-s
,in,5,r/t-s
,in,6,u/d-s
,in,7,s/e-s
,in,8,sxaxs
,in,9,extra
,in,10,s/t-s
,in,11,prod
,in,12,plot
,1,20,data        ! read endf data
20,2&1,21,s       ! linearize cross sections with threshold
correction
21,3,22,s         ! combine all cross sections
22,4&21,23,s      ! prepare balanced background cross section
23,cp,24,s        !
20,5,24           ! reconstruct cross sections in the RR energy
range
20,6&23,24        ! reconstruct cross sections in the UR energy
range
24,3,25,s         ! unite resonance cross sections
25,7&21,26,s      ! thin energy points grid
22,8,26           ! add redundant cross sections
21,9&20,26        ! add non-resonance cross sections
26,10&20,27,s     ! doppler broaden
27,7&21,28,s      ! thin energy points grid
28,11&20,29,s     ! prepare partial particle production
29,3,30,s         ! prepare total particle production
30,12&2           ! prepare plot
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,150.e6,
*nt:1,
*tem:293.6,
*eps:0.001
! ---------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=0
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,nt=1,
       *de,*eps,tem=0.
*s/e-s:*eps
```

```
*s/a-s:nop=8,
 li=0,0,0,0,0,0,0,0,
 lo=4,16,17,103,104,105,106,107,
 lop=0,0,0,0,0,0,0,0
*extra:kdat=2,nmod=3,nr=-4,lr=4,16,17,103,-107
*s/t-s:*nt,*de,*eps,*tem
*prod:nmt=1,*nt,mt=203,-207,*eps,*tem
*plot:nadd=0,imod=2,kint=3,
      ncon=0,nsym=0,ndash=0,ncol=0,
      nr=0,nt=0,
      eps=0.001,*de,deo=0.,0.,
      dx=0.,0.,0.,dy=0.,0.6,0.1,
      xyleg=0.7,0.9
```



C17. Nuclide Production Cross Sections

```
! Test 17: Nuclide production cross sections
,in          ! enter local parameters
,in,1,endf   ! enter control parameters
,in,2,s/i-s
,in,3,r/t-s
,in,4,u/d-s
,in,5,s/c-s
,in,6,extra
,in,7,plot
,1,20,data    ! read the endf data
20,2,21,s     ! linearize cross sections
20,3,21       ! reconstruct cross sections in the rrr
20,4,21       ! reconstruct cross sections in the urr
21,5,22,s     ! join cross sections
20,6,22       ! extract multiplicities and branching ratios
20,sel,23,np  ! extract nuclide production data
23,,23,activ  ! set the module name
22,23&20,24,s ! multiply cross sections on yields
24,7&2        ! prepare plot
,,,end
!---------------------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*eps:0.001
!---------------------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,nt=1,
       *de,*eps,tem=0.
*s/c-s:ncom=0,ns=0,*de,*eps
*extra:kdat=17,nmod=2,nr=2,lr=9,10
*plot:nplot=8,imod=2,kint=5,
      natr=8,8,8,8,nr=0,nt=0,
      ml=0,-1,0,-20,0,-20,0,-10,
      ml=0,1,0,1,0,1,0,1,
      ml=0,0,0,0,0,0,0,0,
      mc=1,1,2,2,3,3,4,4,
      *eps,*de,deo=0.,0.,
      dx=1.e-2,20.e6,10.,dy=1.e-5,100.,5.,
      xyleg=0.2,0.95
```


011Na023 T= 0.0K
(n,2n)
011Na022
(n,g)
011Na024
(n,p)
010Ne023
(n,a)
009F_020
Cross Section [barn]
Neutron Energy [eV]

C18. ACE file Preparing for Photo-Atomic and Atomic Relaxation Data

```
! Test 18: ACE file Preparing for Photo-Atomic and Atomic
Relaxation Data
,in,,              ! enter local parameters
,in,1,endf         ! enter control parameters
,in,2,endf         !
,in,3,sxixs        !
,in,4,sxcxs        !
,in,5,ace          !
,1,20,s            ! read photo-atomic interaction data
,2,21,ar           ! read atom relaxation data
20,sel&23,22,s     ! select smooth cross sections
22,3,23,s          ! linearize
23,4,24,s          ! join
20,sel&27,24       ! add form factors and scattering functions
21,cp,24           ! add atomic relaxation data
24,5,,ENDFB8_0     ! prepare ace file
,,,end
!------------------------------
*de:1.e-5,1.e11,
*eps:0.001
!    local parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*endf:ntape=21,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*s/c-s:nmat=0,ns=0,*de,*eps
*ace:nace=50,nxsd=51,ntyp=4,nza=0,nsuf=0,nt=0,mt=0,nbin=0,
     ifeng=0,*de
```

::

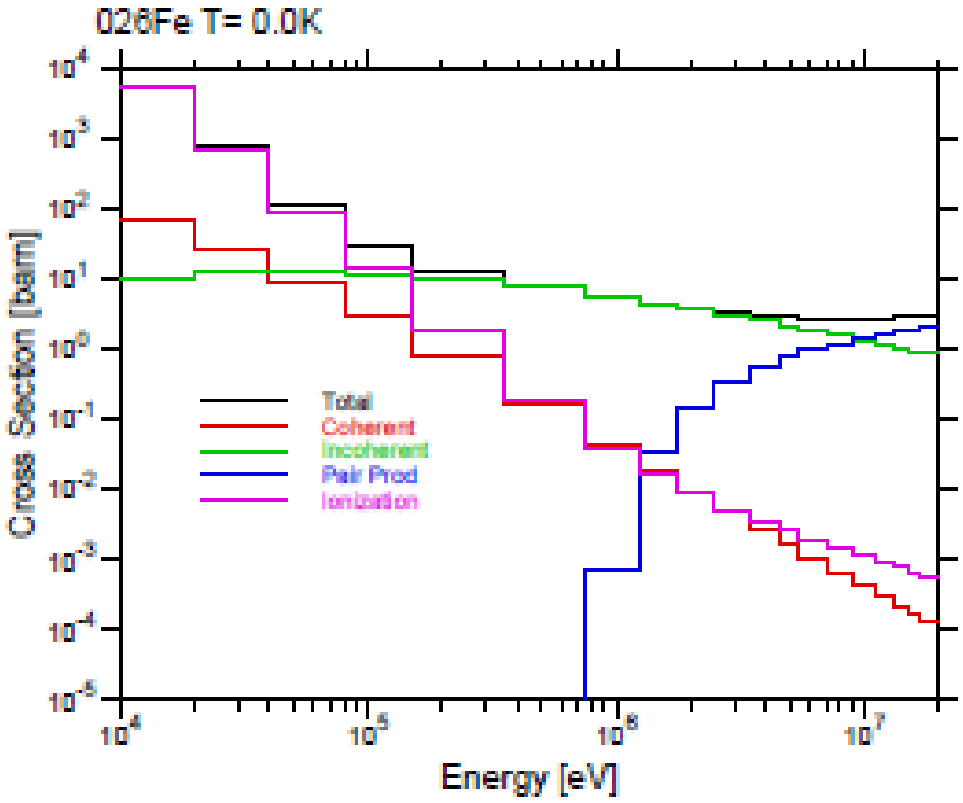
Fragment of the Fe Photo-Atomic ACE file

```
26000.00p   55.367300  0.0000E+00   17/12/21
     ENDFB8_0/Fe photoatomic processed by GRUCON-2021.12d              mat2600
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
    39003       26     6476        4        0        0        0        0
       0        0        0        0        0        0        0        0
       1    32381    32402    32512    32528        0        0        0
       0        0        0        0        0        0        0        0
       0        0        0        0        0        0        0        0
       0        0        0        0        0        0        0        0
  -6.90775527898E+00  -6.90487703510E+00  -6.90049226861E+00  -6.89977251619E+00
  -6.88963020505E+00  -6.88737697428E+00  -6.88688800294E+00  -6.88544895522E+00
  -6.88507761211E+00  -6.88472942051E+00  -6.88144948047E+00  -6.87928221157E+00
  -6.86878368339E+00  -6.86337466068E+00  -6.86170314551E+00  -6.86044422721E+00
  -6.85882529602E+00  -6.85839745691E+00  -6.85630683213E+00  -6.85308543406E+00
  -6.85144400275E+00  -6.85019568840E+00  -6.85019039221E+00  -6.84061139849E+00
  -6.83939719293E+00  -6.83827568197E+00  -6.83436019016E+00  -6.83354802604E+00
  -6.83181240415E+00  -6.82716472141E+00  -6.82070509191E+00  -6.82050875964E+00
  -6.81565205415E+00  -6.81325423553E+00  -6.81086216178E+00  -6.81053937985E+00
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

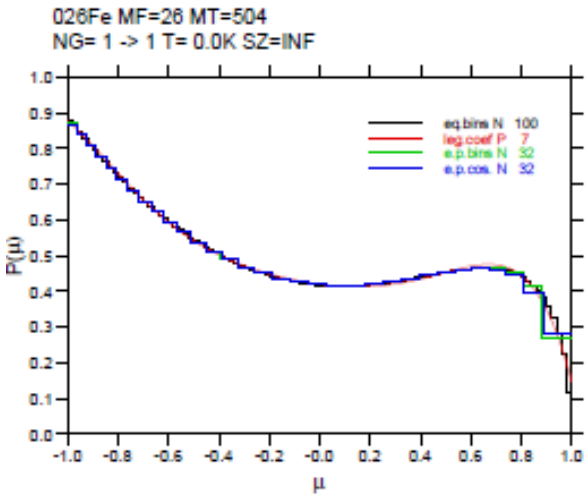
C19. Photo-Atomic Group Cross Sections and Matrices

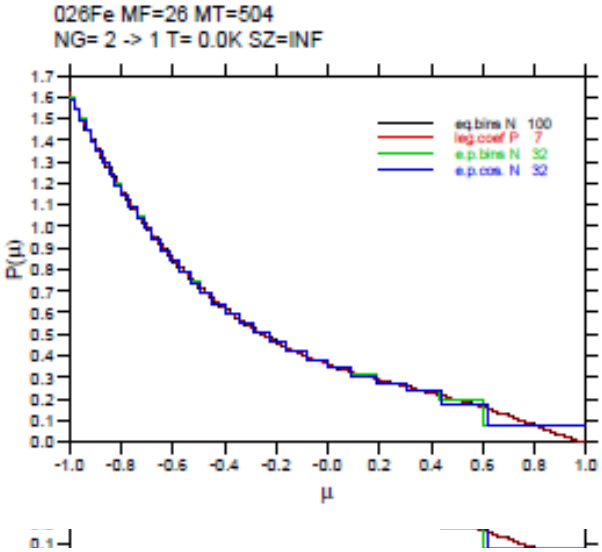
```
! Test 19: Photoatomic group cross sections and angular
distributions
,in             ! enter local parameters
,in,1,endf      ! enter control parameters
,in,2,s/i-s     !
,in,3,s/g-fm    !
,in,4,s/g-fm    !
,in,5,f/-s      !
,in,6,extra     !
,in,7,plot      !
,in,8,plot      !
,1,20,data      ! read endf file
20,2,21,s       ! linearize data
21,3,22,fm      ! calculate group functions *f* and matrices *m*
22,5,23,s       ! convert *f* to *s*
23,7&2          ! write file for viewr to plot cross sections
22,sel,24,m     ! select matrices
21,4,24         ! calculate for different angular representations
24,6,25,m       ! extract matrix for required reaction type
25,8&2          ! write file for viewr to plot angular
distributions
,,,end
! --------------------------
!    local parameters
*de:1.,20.e6,
*dei:1.e3,20.e6,
*nmt:1,
*mt:504,
*eps:0.001,
*nmod:2,
*ng:19,
*iwt:3,
*nl:5,
*eg:0.01e6,0.02e6,0.04e6,0.08e6,0.15e6,0.35e6,0.75e6,1.25e6,
    1.75e6,2.50e6,3.50e6,4.50e6,5.50e6,7.00e6,9.00e6,11.0e6,
    13.0e6,15.0e6,17.0e6,20.0e6
```

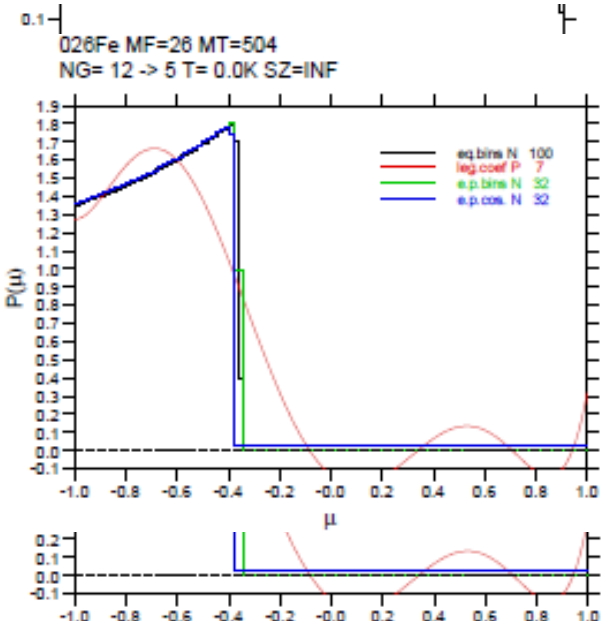
```
! -------------------------
!    control parameters
*endf:ntape=20,nmat=0,nf=2,nmt=0,mf=23,27
*s/i-s:nint=2,*de,*eps
*s/g-fm:*ng,*iwt,lang=1,nang=100,nmt=0,*eps,*eg
*s/g-fm:*ng,*iwt,lang=2,nang=7,nmt=1,*mt,*eps,*eg,
*s/g-fm:*ng,*iwt,lang=3,nang=32,nmt=1,*mt,*eps,*eg,
*s/g-fm:*ng,*iwt,lang=4,nang=32,nmt=1,*mt,*eps,*eg
*f/-s:nr=5,km=0,kt=1,kp=1,mt=501,502,504,516,522
*extra:ntyp=0,nmod=3,nr=1,*mt
*plot:ncur=0,imod=2,kint=5,
    natr=0,0,0,0,nr=0,ntem=1,
    *eps,*dei,deo=0.,0.,
    dx=0.,0.,0.,dy=1.e-5,1.e4,10.,xyleg=0.1,0.5,
    tem=0.
*plot:ncur=0,imod=2,kint=2,
    natr=0,0,0,0,nr=1,ntem=1,*mt,
    *eps,*dei,deo=0.,0.,
    dx=0.,0.,0.,dy=0.,0.,0.,xyleg=0.6,0.9,
    tem=0.
```

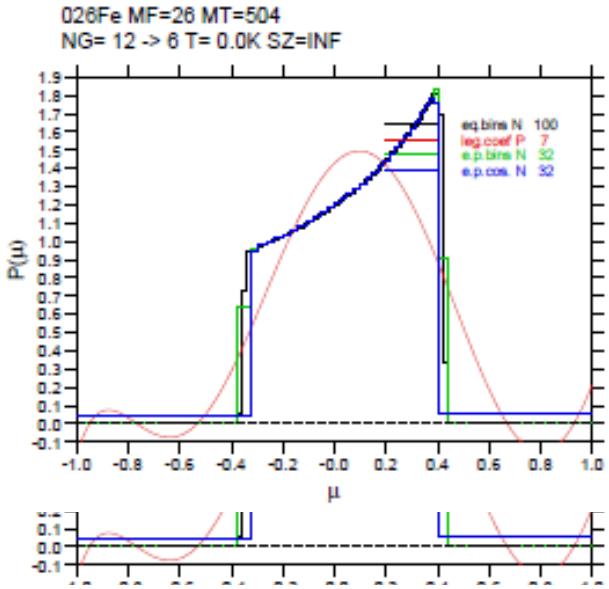


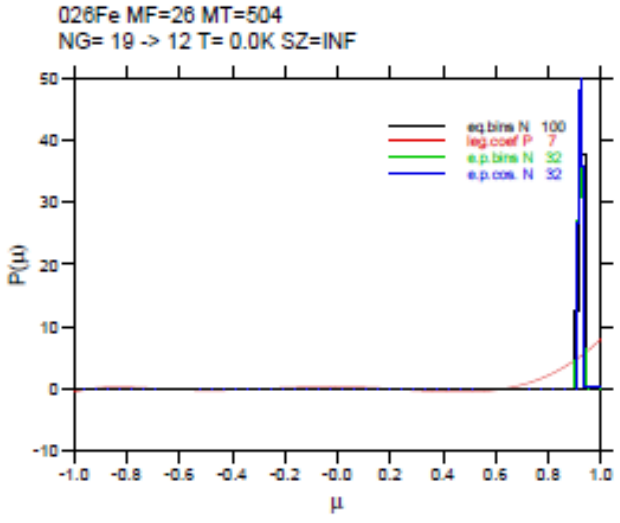
Угловые распределения гамма-квантов

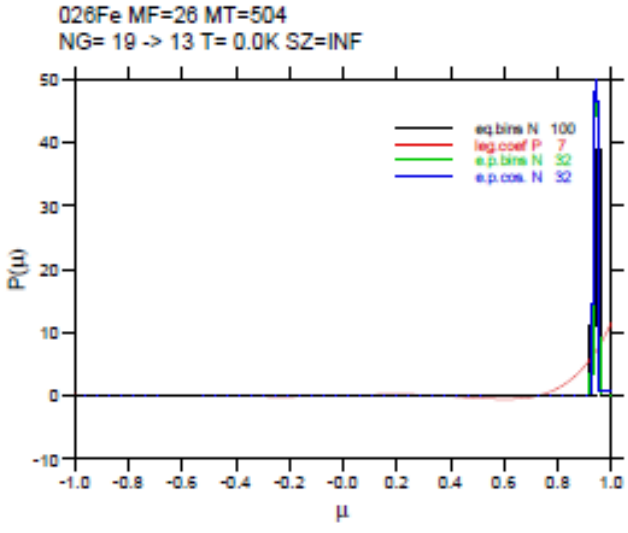












C20. Preparing of the Couplet Neutron-Photon Group Data Set in the MATXS Format

```
::::::::::::::
test20_01.inp
::::::::::::::
! test20_01: read endf file, linearize cross sections abd extend
energy distributions
,in                ! enter local parameters
,in,1,endf         ! enter control parameters
,in,2,s/i-s        !
,in,3,extend       !
,in,4,write        !
,1,20,data         ! read endf file
20,sel,21,s        ! select cross section data
20,sel,22,e&ae     ! select energy distribution parameters
20,sel,23,/s&e&ae! select rest of data
21,2,24,s          ! linearize xs
22,3,24            ! extend e- and ae-data
23,cp,24           ! add rest of data
24,4               ! write tape21
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*eps:0.001
! ---------------------------------------
!    control parameters
*endf:ntape=20,nmat=0,nmf=0,nmt=0
*s/i-s:nint=2,*de,*eps
*extend:elow=40.,efact=0.84
*write:-21
```

```
::::::::::::::
test20_02.inp
::::::::::::::
! test20_02: reconstruct cross sections from resonance
parameters
,in            ! enter local parameters
,in,1,read     ! enter control parameters
,in,2,s/i-s    !
,in,3,s/c-s    !
,in,4,s/a-s    !
,in,5,r/t-s    !
,in,6,u/d-s    !
,in,7,extra    !
,in,8,s/a-s    !
,in,9,s/e-s    !
,in,10,sxaxs   !
,in,11,extra   !
,in,12,write   !
,in,13,write   !
,1,20,data     ! read tape with endf data
20,sel,21,s    ! select cross sections
21,3,22,s      ! join all cross sections
22,4&20,23,s   ! prepare background xs
23,cp,32,s,2   !
20,5&23,32     ! add reconstructed xs in the RRR
20,6&23,32     ! add reconstructed xs in the URR
32,3,33,s,3    ! join all spin components
33,7,32,s      ! extract all except mt19
33,8,32        ! add mt19
32,3,33,s      ! join all resonance cross sections
33,9&21,32,s   ! thin energy grid
22,10&20,33,s  ! recalculate redundant cross sections
22,11&20,33    ! extract all nonresonance cross sections
32,12          ! write resonance cross sections to tape22
33,13          ! write all others to tape23
,,,end
! ---------------------------------------
! local parameters
*de:1.e-5,20.e6,
*eps:0.001
! ---------------------------------------
! control parameters
*read:ntape=-21
*s/i-s:nint=2,*de,*eps
*s/c-s:ncom=0,ns=0,*de,*eps
*s/a-s:nop=0
*r/t-s:nfor=0,nt=1,*de,*eps,tem=0.
*u/d-s:nfun=0,nin=2,nt=1,*de,*eps,tem=0.
*extra:kdat=2,nmod=3,nr=-1,lr=19
*s/a-s:nop=1,li=0,lo=19,lop=0
*s/e-s:*eps
```

```
*s/a-s:nop=8,
li=0,0,0,0,0,0,0,0,
lo=4,16,17,103,104,105,106,107,
lop=0,0,0,0,0,0,0,0
*extra:kdat=2,nmod=3,nr=-3,mtr=1,-4,16,-19,102,-117
*write:-22
*write:-23
```

```
::::::::::::::
test20_03.inp
::::::::::::::
! test20_03: doppler broadening
,in              ! enter local parameters
,in,1,read       ! enter control parameters
,in,2,read       !
,in,3,s/t-s      !
,in,4,s/e-s      !
,in,5,write      !
,1,20,data       ! read tape with endf data
,2,32,s,2        ! read tape with resonance xs
32,3&-20,33,s,3 ! doppler broaden
33,4&20,32,s     ! thin energy grid
32,5             ! write to tape24
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*eps:0.001
! ---------------------------------------
!    control parameters
*read:ntape=-21
*read:ntape=-22
*s/t-s:*ntem,*de,*eps,*tem
*s/e-s:*eps
*write:-24
```

```
::::::::::::::
test20_04.inp
::::::::::::::
! task20_04: prepare probabililty tables in the URR
,in              ! enter local parameters
,in,1,read       ! enter control parameters
,in,2,u/e-p      !
,in,3,write      !
,1,20,data       ! read tape with endf data
20,2&20,21,p     ! reconstruct probability tables
21,3             ! write to tape25
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*eps:0.001
! ---------------------------------------
!    control parameters
*read:ntape=-21
*u/e-p:nbin=20,nladr=50,*ntem,*de,*eps,*tem
*write:-25
```

```
::::::::::::::
test20_05.inp
::::::::::::::
! test20_04: prepare particle production cross sections
,in              ! enter local parameters
,in,1,read       ! enter control parameters
,in,2,read       !
,in,3,read       !
,in,4,s/a-s      !
,in,5,prod       !
,in,6,prod       !
,in,7,s/c-s      !
,in,8,s/e-s      !
,in,9,write      !
,1,20,data       ! read endf data
,3,32,s,2        ! read resonance broadened xs
32,4,33,s,3      ! calculate nonelastic xs
33,cp,32         ! add nonelastic to resonance xs
,2,32            ! add nonresonance xs
32,5&20,33,s     ! calculate partial gamma production xs
32,6&20,21,s     ! calculate partial gas production xs
33,7,32,s        ! calculate total gamma production
21,7,32          ! calculate total gas production
32,8,33,s        ! thin energy grid
33,9             ! write to tape
,,,end
! ---------------------------------------
!    local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*eps:0.001
! ---------------------------------------
!    control parameters
*read:ntape=-21
*read:ntape=-23
*read:ntape=-24
*s/a-s:nop=2,mti=1,2,mtoo=3,3,lop=1,2
*prod:nmt=1,*ntem,mt=202,*eps,*tem
*prod:nmt=1,*ntem,mt=203,-207,*eps,*tem
*s/c-s:ncom=0,ns=0,*de,*eps
*s/e-s:*eps
*write:-26
```

```
::::::::::::::
test20_06.inp
::::::::::::::
! test20_06: prepare unshielded group cross sections
,in          ! enter local parameters
,in,1,read   ! enter control parameters
,in,2,read
,in,3,s/-s
,in,4,extra
,in,5,extra
,in,6,a/-s
,in,7,nu/-s
,in,8,in/-s
,in,9,s/i-s
,in,10,s/c-s
,in,11,s/g-f
,in,12,f/-s
,in,13,s/a-s
,in,14,s/a-s
,in,15,write
,1,20,data    ! read endf data
,2,32,s,2     ! read resonance xs
32,3,33,s,3   ! extract xs at the 1-st temperature
33,4&-20,21,s  ! extract nonresonance xs
,8&20,21      ! calculate inverted neutron velocities
33,5,32,s     ! extract elastic and fission xs
20,6,32       ! calculate mu,ksi,gamma
20,7,32       ! calculate nu-bar
32,10,33,s    ! join
33,13,32,s    ! multiply xs to mu,ksi,gamma,nu-bar
32,11,33,f    ! integrate in groups
33,12,32,s    ! convert to s
32,14,33,s    ! reconstruct mu,ksi,gamma,nu-bar
33,9,32,s     ! linearize
21,cp,32      !
32,10,33,s    ! join
33,11,32,f    ! integrate in groups
32,15         ! write to tape
,,,end
! ---------------------------------------
! define local parameters
*de:1.e-5,20.e6,
*ngn:30,
*egn:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*iwn:4,
*wn:0.125,0.025,8.2085E+05,1.273E+06,
*eps:0.001
```

```
! ----------------------------------------
! control parameters
*read:ntape=-21
*read:ntape=-23,
*read:ntape=-24,
*read:ntape=-26
*s/-s:ns=0,ntem=-1
*extra:kdat=2,nmod=3,nr=0
*extra:kdat=2,nmod=3,nr=2,lr=2,18
*a/-s:*eps
*nu/-s:*eps
*in/-s:ntyp=259,npar=0,*de,*eps
*s/i-s:nint=2,*de,*eps
*s/c-s:nmat=0,ns=0,*de,*eps
*s/g-f:nfun=1,*ngn,nig=1,*iwn,nr=0,nsigz=0,nl=0,nh=0,
       mig=1,msg=1,mng=1,
       *eps,*wn,*egn
*f/-s: nr=0,km=0,kt=0,kp=0
*s/a-s:nls=14,
      lsi=2,2,251,2,252,2,253,18,18,452,18,455,18,456,
      lso=2,251,251,252,252,253,253,18,452,452,455,455,456,456,
      nop=0,0,3,0,3,0,3,0,0,3,0,3,0,3
*s/a-s:nls=12,
      lsi=251,2,252,2,253,2,452,18,455,18,456,18,
      lso=251,251,252,252,253,253,452,452,455,455,456,456,
      nop=0,4,0,4,0,4,0,4,0,4,0,4
*write:ntape=-30
```

```
::::::::::::::
test20_07.inp
::::::::::::::
! test20_07: prepare shielded group cross sections
,in ! enter local parameters
,in,1,read ! enter control parameters
,in,2,read ! enter control parameters
,in,3,read
,in,4,extra
,in,5,extra
,in,6,s/c-s
,in,7,s/a-s
,in,8,s/ae-fm
,in,9,write
!----------- prepare main cross section table
,1,20,s         ! read endf
,2,21,s         ! read reconstructed xs
21,4&20,32,s,2 ! extract shielded xs
32,6,33,s,3    ! join
33,7&20,32,s   ! calculate dissapearance xs (mt101)
33,5&20,32     ! extract resonance xs
32,6,33,s      ! join
,3,33          ! add probability table
33,8,32,f      ! integrate
32,9           ! write to tape
,,,end
! ---------------------------------------
! define local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*nsigz:9,
*sigz:1.,1.e1,3.e1,1.e2,3.e2,1.e3,1.e4,1.e5,1.e6,
*ngn:30,
*egn:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*iwn:4,
*iwc:0,
*wn:0.125,0.025,8.2085E+05,1.273E+06,
*eps:0.001
! ---------------------------------------
! control parameters
*read:ntape=-21
*read:ntape=-23,
*read:ntape=-24
*read:ntape=-25
*extra:kdat=2,nmod=3,ns=1,mt=103,-117
*extra:kdat=2,nmod=3,ns=0
```

```
*s/c-s:nmat=0,ns=0,*de,*eps
*s/a-s:nls=1,lsi=102,-117,lso=101,nop=1
*s/ae-fm:mzap=100,nmt=0,*ngn,ngg=0,nig=1,*iwn,iwc=0,
    *ntem,*nsigz,lan=2,nord=0,ismth=1,
    mig=1,msg=1,mng=1,
    *eps,*tem,*sigz,*wn,*egn
*write:ntape=-31
```

```
::::::::::::::
test20_08.inp
::::::::::::::
! test20_08: prepare neutron group transition matrices
,in           ! enter local parameters
,in,1,read    ! enter control parameters
,in,2,read
,in,3,read
,in,4,sxaexfm
,in,5,write
,1,20,data    ! read endf file
,2,21,s       ! read reconstructed cross sections
,3,21         ! read and cross section moments in the urr
21,4&20,22,m  ! compute neutron transistion matrices
22,5          ! write to tape
,,,end
! ---------------------------------------
! define local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*nsigz:9,
*sigz:1.,1.e1,3.e1,1.e2,3.e2,1.e3,1.e4,1.e5,1.e6,
*nord:3,
*ngn:30,
*egn:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*iwn:4,
*wn:0.125,0.025,8.2085E+05,1.273E+06,
*iwc:0,
*eps:0.001
! ---------------------------------------
! control parameters
*read:ntape=-21
*read:ntape=-23,
*read:ntape=-24
*read:ntape=-25
*s/ae-fm:mzap=100,nmt=0,*ngn,ngg=0,nig=1,*iwn,*iwc,
    *ntem,*nsigz,lan=2,*nord,ismth=1,
     mig=1,msg=1,mng=1,
    *eps,*tem,*sigz,*wn,*egn
*write:ntape=-32
```

```
::::::::::::::
test20_09.inp
::::::::::::::
! test20_09: prepare thermal free gas scattering
!            group cross sections and matrices
,in            ! enter local parameters
,in,1,read     ! enter control parameters
,in,2,th/-ds
,in,3,d/e-d
,in,4,s/g-f
 4,,5,s/d-m
,in,6,write
,1,20,data      ! read cross sections
20,2,21,ds      ! prepare free gas distribution
21,3,22,d       ! integrate secondary energies
21,4,23,f       ! calculate group cross sections
21,5&22,23      ! calculate group transition matrices
23,6            ! write to tape
,,,end
!-------------------------------------------------
!    local parameters
*de:1.e-5,4.641589,
*ntem:2,
*tem:300.,900.,
*nsigz:9,
*sigz:1.,1.e1,3.e1,1.e2,3.e2,1.e3,1.e4,1.e5,1.e6,
*ngn:30,
*egn:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*iwn:4,
*wn:0.125,0.025,8.2085E+05,1.273E+06,
*nlord:5,
*eps:0.001
!-------------------------------------------------
!    control parameters
*read:-24
*th/-ds:mtref=221,iel=0,natom=1,nint=2,*ntem,
     *nlord,ntype=2,*de,*eps,*tem
*d/e-d:zap=100,*ngn,nig=1,mig=1,msg=1,mng=1,
       *de,*eps,*egn
*s/g-f:nfun=1,*ngn,nig=1,*iwn,nr=0,*nsigz,nl=-2,nh=0,
       mig=1,msg=1,mng=1,
      *eps,*sigz,*wn,*egn
*write:-33
```

```
::::::::::::::
test20_10.inp
::::::::::::::
! test20_10: prepare gamma production matrices
,in           ! enter local parameters
,in,1,read    ! enter control parameters
,in,2,read
,in,3,read
,in,4,sxaexfm
,in,5,write
,1,20,data    ! read endf file
,2,21,s       ! read reconstructed cross sections
,3,21         ! read and cross section moments in the urr
21,4&20,22,m  ! compute photon production matrices
22,5          ! write to tape
,,,end
! ---------------------------------------
! define local parameters
*de:1.e-5,20.e6,
*ntem:2,
*tem:300.,900.,
*nsigz:9,
*sigz:1.,1.e1,3.e1,1.e2,3.e2,1.e3,1.e4,1.e5,1.e6,
*nord:3,
*ngn:30,
*egn:1.e-4,0.2154434,0.4641589,1.0,2.154434,4.641589,
     10.0,21.54434,46.41589,100.,215.4434,464.1589,
     1.e3,2.154434e3,4.641589e3,1.E4,2.154434e4,4.641589e4,
     1.E5,2.e5,4.e5,8.e5,1.4e6,2.5e6,4.e6,6.5e6,10.5e6,
     13.9818e6,15.0196e6,17.3318e6,20.e6,
*iwn:4,
*wn:0.125,0.025,8.2085E+05,1.273E+06,
*iwc:0,
*ngg:19,
*egg:0.01e6,0.02e6,0.04e6,0.08e6,0.15e6,
     0.35e6,0.75e6,1.25e6,1.75e6,2.50e6,
     3.50e6,4.50e6,5.50e6,7.00e6,9.00e6,
     11.0e6,13.0e6,15.0e6,17.0e6,20.0e6,
*eps:0.001
! ---------------------------------------
! control parameters
*read:ntape=-21
*read:ntape=-23,
*read:ntape=-24
*read:ntape=-25
*s/ae-fm:mzap=0,nmt=0,*ngn,*ngg,nig=1,*iwn,*iwc,
    *ntem,*nsigz,lan=2,*nord,ismooth=0,
     mig=1,msg=1,mng=1,
    *eps,*tem,*sigz,*wn,*egn,*egg
*write:ntape=-34
```

```
::::::::::::::
test20_11.inp
::::::::::::::
! test20_10: prepare photo-atomic group cross sections
!            and transition matrices
,in        ! enter local parameters
,in,1,endf ! enter control parameters
,in,2,sxixs
,in,3,sxgxfm
,in,4,write
,1,20,data
20,2,21,s
21,3,22,fm
22,4
,,,end
! ---------------------------------------
! define local parameters
*de:1.e-5,20.e6,
*ngg:19,
*egg:0.01e6,0.02e6,0.04e6,0.08e6,0.15e6,
     0.35e6,0.75e6,1.25e6,1.75e6,2.50e6,
     3.50e6,4.50e6,5.50e6,7.00e6,9.00e6,
     11.0e6,13.0e6,15.0e6,17.0e6,20.0e6,
*iwt:3,
*lord:5,
*eps:0.001
! ---------------------------------------
! control parameters
*endf:ntape=40,nmat=0,nf=2,nmt=0,mf=23,27
*s/i-s:nint=2,*de,*eps
*s/g-fm:*ngg,*iwt,lang=2,*lord,nmt=0,*eps,*egg
*write:ntape=-41
```

```
::::::::::::::
test20_12.inp
::::::::::::::
! test20_11: convert couplet neutron and photon group data
!            to the matxs format
,in,1,read        ! enter control parameters
,in,2,read        !
,in,3,read        !
,in,4,matxs       !
,1,20,data        ! read neutron data
,2,20             ! read photo-production matrices
,3,20             ! read photo-atomic interaction xs
20,4,,ENDFB8_0    ! prepare matxs file
,,,end
! ----------------------------------------
!    control parameters
*read:-30,
*read:-31,
*read:-32,
*read:-33
*read:-34
*read:-41
*matxs:50
```

Fragment of the MATXS File with couplet neutron-photon group cross sections and matrices

```
0v   matxs *                 *     0
 1d        2     3     9     1  5000   322
 2d
 lib=ENDFB8_0     mat=2631  processed by grucon-2021.12d at 17/12/21
 3d     n       g       nscat   ntherm  ng      Fe56
    30    19     1     1     1     1     1     2    23     0
 4d          2.0000000+7 1.7331800+7 1.5019600+7 1.3981800+7 1.0500000+7
 6.5000000+6 4.0000000+6 2.5000000+6 1.4000000+6 8.0000000+5 4.0000000+5
 2.0000000+5 1.0000000+5 4.6415890+4 2.1544340+4 1.0000000+4 4.6415890+3
 2.1544340+3 1.0000000+3 4.6415890+2 2.1544340+2 1.0000000+2 4.6415890+1
 2.1544340+1 1.0000000+1 4.6415890+0 2.1544340+0 1.0000000+0 4.6415890-1
 2.1544340-1 1.0000000-4
 4d          2.0000000+7 1.7000000+7 1.5000000+7 1.3000000+7 1.1000000+7
 9.0000000+6 7.0000000+6 5.5000000+6 4.5000000+6 3.5000000+6 2.5000000+6
 1.7500000+6 1.2500000+6 7.5000000+5 3.5000000+5 1.5000000+5 8.0000000+4
 4.0000000+4 2.0000000+4 1.0000000+4
 5d Fe56     5.5454430+1
 3.0000000+2 1.000000+10     1    92    43     0
 3.0000000+2 1.0000000+6     1     7     1    88
 3.0000000+2 1.0000000+5     1     7     1    92
 3.0000000+2 1.0000000+4     1     7     1    96
 3.0000000+2 1.0000000+3     1     7     1   100
 3.0000000+2 3.0000000+2     1     7     1   104
 3.0000000+2 1.0000000+2     1     7     1   108
 3.0000000+2 3.0000000+1     1     7     1   112
 3.0000000+2 1.0000000+1     1     7     1   116
 3.0000000+2 1.0000000+0     1     7     1   120
 9.0000000+2 1.000000+10     1     7     1   124
 9.0000000+2 1.0000000+6     1     7     1   128
 9.0000000+2 1.0000000+5     1     7     1   132
 9.0000000+2 1.0000000+4     1     7     1   136
 9.0000000+2 1.0000000+3     1     7     1   140
 9.0000000+2 3.0000000+2     1     7     1   144
 9.0000000+2 1.0000000+2     1     7     1   148
 9.0000000+2 3.0000000+1     1     7     1   152
 9.0000000+2 1.0000000+1     1     7     1   156
 9.0000000+2 1.0000000+0     1     7     1   160
 3.0000000+2 1.000000+10     2     1     1   164
 9.0000000+2 1.000000+10     2     1     1   168
 3.0000000+2 1.000000+10     3     0    71   172
 6d     nwt0    nwt1    ntot0   ntot1   nelas   ninel   nx      n2n
n01     n02     n03     n04     n05     n06     n07     n08     n09
n10     n11     n12     n13     n14     n15     n16     n17     n18
n19     n20     n21     n22     n23     n24     n25     n26     n27
n28     n29     n30     n31     n32     n33     n34     n35     n36
n37     n38     n39     ncn     nabs    ng      np      na      .gam
.h1     .h2     .h3     .he3    .he4    mubar   xi      gamma   invel
p00     p01     p02     p03     p04     p05     p06     p07     p08
p09     pcn     a00     a01     a02     a03     a04     a05     a06
a07     a08     a09     a10     a11     a12     a13     a14     a15
a16     a17     a18

::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
```