JAERI-Data/Code
99-008

DEVELOPMENT OF THE DCHAIN-SP CODE FOR ANALYZING DECAY AND BUILD-UP CHARACTERISTICS OF SPALLATION PRODUCTS

March 1999

Hiroshi TAKADA and Kazuaki KOSAKO

日本原子力研究所
Japan Atomic Energy Research Institute

本レポートは，日本原子力研究所が不定期に公刊している研究報告書です。
入手の問合わせは，日本原子力研究所研究情報部研究情報課（〒319-1195　茨城県那珂郡東海村）あて，お申し越しください。なお，このほかに財団法人原子力弘済会資料センター（〒319-1195　茨城県那珂郡東海村日本原子力研究所内）で複写による実費頒布をおこなっております。

This report is issued irregularly.
Inquiries about availability of the reports should be addressed to Research Information Division, Department of Intellectual Resources, Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195, Japan.

編集兼発行　　日本原子力研究所

JAERI-Data/Code 99-008

Development of the DCHAIN-SP Code for Analyzing Decay and Build-up Characteristics of Spallation Products

Hiroshi TAKADA and Kazuaki KOSAKO*

Center for Neutron Science
Tokai Research Establishment
Japan Atomic Energy Research Institute
Tokai-mura, Naka-gun, Ibaraki-ken

(Received February 2, 1999)

For analyzing the decay and build-up characteristics of spallation products, the DCHAIN-SP code has been developed on the basis of the DCHAIN-2 code by revising the decay data and implementing the neutron cross section data. The decay data are newly processed from the data libraries of EAF 3.1, FENDL/D-1 and ENSDF. The neutron cross section data taken from FENDL/A-2 data library are also prepared to take account of the transmutation of nuclides by the neutron field at the produced position. The DCHAIN-SP code solves the time evolution of decay and build-up of nuclides in every decay chain by the Beteman method. The code can estimate the following physical quantities of produced nuclides : inventory, activity, decay heat by the emission of α , β and γ -rays, and γ -ray energy spectrum, where the nuclide production rate estimated by the nucleon-meson transport code such as NMTC/JAERI97 is used as an input data.

This paper describes about the function, the solution model and the database adopted in the code and explains how to use the code.

Keywords: DCHAIN-SP, Spallation Products, Beteman Method, Inventory, Activity, Decay Heat, γ -ray Energy, Decay Data Library

* Sumitomo Atomic Energy Industries, Ltd.

核破砕生成核種の崩壊特性解析コードＤＣＨＡＩＮ-ＳＰの開発

日本原子力研究所東海研究所中性子科学研究センター
高田　　弘・小迫　和明*

（1999年２月２日受理）

核破砕核種の崩壊特性を計算するために、核種の崩壊生成解析コードＤＣＨＡＩＮ２を基に、放射性核種に関する崩壊データを改訂すると共に中性子反応断面積データを加えてＤＣＨＡＩＮ-ＳＰコードを開発した。崩壊データは　ＥＡＦ　3.１、ＦＥＮＤＥＬ/Ｄ-１及び　ＥＮＳＤＦ　データライブラリから新規に作成した。ＦＥＮＤＬ/Ａ-２　データライブラリから引用した中性子反応断面積も用意し、生成点における中性子場による核種の核変換を考慮する。ＤＣＨＡＩＮ-ＳＰコードはあらゆる崩壊系列における核種の崩壊生成を Beteman 法で解く。本コードは核種の蓄積量、誘導放射能、α、β及びγ線の放出による崩壊熱、さらにはγ線エネルギースペクトル等の物理量を評価することができる。ここで、高エネルギー核子中間子輸送コードによって評価された核種生成率が入力として使用される。

本レポートではＤＣＨＡＩＮ-ＳＰの機能、解析手法及び使用されるデータベースについて解説し、コードの使用法についても説明する。

東海研究所：〒319－1195　茨城県那珂郡東海村白方白根２－４
＊ 住友原子力工業㈱

Contents

目　　次

1. Introduction

Recently, it is proposed to use intense proton accelerators with energies of GeV not only for scientific research but also for nuclear engineering and medical applications. For example, Japan Atomic Energy Research Institute (JAERI) has a plan to construct spallation neutron utilization facilities in which the major interest lies in the spallation neutron source for material science and the experimental facility for transmutation of long-lived radioactive nuclides, especially transuranic nuclides. Various kinds of radioactive materials are produced in accelerator components, target and its surroundings such as shielding materials in these facilities. Safety handling of the radioactive materials is an important issue from the viewpoint of waste management. Therefore, it is necessary to make a firm strategy for safety management of the radioactive materials in the design stage.

Various computation codes have been developed for analyzing the burn-up characteristics of power reactors and the radiation environment of fusion reactors. It is noted that a variety of nuclides are produced by the spallation reactions. The sort of the spallation products greatly differs from those in fission and fusion reactors because of difference of nuclear reaction mechanism. Thus, neither burn-up calculation codes for power reactors nor for fusion reactors can apply to the analysis of decay characteristics of spallation products.

There already exists some burn-up calculation codes for the analysis of decay and build-up characteristic of spallation products. ORIHET code has been developed from the ORIGEN code [1] by expanding its covering nuclides regime. CINDER'90 code [2] has been developed at Los Alamos National Laboratory. However, these codes have not been available for public usage, yet. In this work, therefore, a burn-up calculation code, DCHAIN-SP, has been developed to meet the requirement for the estimation of the nuclide inventories and radiation environment of high energy accelerator related facilities.

DCHAIN-SP is based on the DCHAIN2 code [3] in which the time dependent build-up of nuclides on any decay scheme is solved by the Beteman method. In order to treat the spallation products, necessary decay data have been supplemented. DCHAIN-SP can calculate the nuclide inventory, radioactivity, decay heat and γ-ray energy spectra on the basis of the nuclide production rate calculated by the nucleon-meson transport code NMTC/JAERI97 [4]. The contribution of nuclear reactions by the neutrons with energies below 20 MeV at the produced position is also taken into account in the code.

The source program of DCHAIN-SP is tuned to be executed on the UNIX system of SUN

(FUJITSU S-7/300, OS:Solaris 2.5) in which SPARCompiler FORTRAN 77 Ver. 4.0 are implemented and HPUX-9 (HP9000/735) with an available FORTRAN compiler.

2. Overview of the Code

2.1 Analysis Method

DCHAIN-SP calculates the time evolution of build-up and decay of nuclides produced by the spallation reactions on the basis of the Beteman method [5]. As described in Ref. 3, the build-up and decay of nuclide products in spallation targets are generally expressed by the following equation.

$$\frac{dN_i(t)}{dt} = Y_i(t) + \sum_j f_{j\to i}\,\lambda_j N_j(t) + \sum_k g_{k\to i}\,\sigma_k \phi(t) N_k(t) - \{\lambda_i + \sigma_i\,\phi(t)\} N_i(t) \qquad (1)$$

where,

$N_i(t)$: number of nuclides at time t,

$Y_i(t)$: nuclide production rate at time t,

$f_{j\to i}$: branching ratio of unit decay from nuclide j to nuclide i,

λ_j : decay constant of nuclide j,

$g_{k\to i}$: production ratio of nuclide i from nuclide k per unit decay,

σ_k : average microscopic neutron reaction cross section of nuclide k,

$\phi(t)$: neutron flux at time t.

For spallation reaction, the nuclide production rate, $Y_i(t)$, is calculated by the nucleon-meson transport code with the Monte Carlo method. This rate changes dependent on the incident particle energy and target material. The second and third terms in eq. (1) represent the build-up rates of the nuclide i by the decay and nuclear reactions of other nuclides. The last term means the decay rate of the nuclide i by the decay and nuclear reactions. As described in Ref. 3, the eq. (1) can be solved by using Beteman method.

Without nuclear reaction, the solution of the linear chain including production term of $Y_i(t)$, is given as

$$N_i(t) = \sum_{k=1}^{i} \left(\prod_{j=k}^{i-1} f_j \right) \{ N_k^0 b_{i-k+1}(t; L_1, L_2, \cdots\cdots, L_{i-k+1}) + Y_k B_{i-k+1}(t; L_1, L_2, \cdots\cdots, L_{i-k+1}) \}, \tag{2}$$

with

$$b_i(t; \lambda_1, \lambda_2, \cdots\cdots, \lambda_i) = \sum_{j=1}^{i} d_j e^{-\lambda_j t}, \tag{3}$$

$$B_i(t; \lambda_1, \lambda_2, \cdots\cdots, \lambda_i) = \sum_{j=1}^{i} d_j \frac{1 - e^{-\lambda_j t}}{\lambda_i}, \tag{4}$$

$$L_j = \lambda_{j+k-1}, \tag{5}$$

and

$$d_j = 1 \ (i = j = 1),$$

$$d_j = \frac{\prod_{k=1}^{i-1} \lambda_k}{\prod_{k=1 \ (k \neq j)}^{i} (\lambda_k - \lambda_j)} \qquad (i \geq 2, j = 1 \sim i). \tag{6}$$

Here, the notations b_i and B_i represent Beteman function and integrated Beteman function, respectively. If the linear chain includes the term of nuclear reaction as in eq. (1), the effective decay constant, λ_k^*, and branching ratio, $f_{k \to i}^*$, are introduced as,

$$\lambda_k + \sigma_k \phi(t) \rightarrow \lambda_k^* \tag{7}$$

$$f_{k-i} \frac{\lambda_k}{\lambda_k^*} + g_{k-i} \frac{\sigma_k \phi(t)}{\lambda_k^*} \rightarrow f_{k-i}^* \tag{8}$$

The solution of eq. (1) is obtained by replacing the decay constant and the branching ratio with the above effective ones defined in eqs. (2) to (5).

If the decay scheme of nuclide includes complicated chain with branchings and confluence, the decay scheme is divided into simple linear chain. The decay and build-up of nuclide in each linear chain is resolved with the equations and procedure described above, then the amount of objective nuclides is obtained by superposing the solutions of each linear chain.

If the two isotopes with the same decay constant exists in a chain, it is impossible to solve

the eq. (2) because the value of the integrated Beteman function, B_i, becomes infinite as indicated in eqs. (4) and (6). For this case, eq. (2) is solved by introducing the following extended Beteman function and integrated Beteman function :

$$b_i(t;\lambda_1,\lambda_2,\cdots\cdots,\lambda_i) = \sum_{j=1,j\neq l,m}^{i} d_j e^{-\lambda_j t} - \left(\sum_{j=1,j\neq l,m}^{i} d_j\right) e^{-\lambda_l t} + \frac{\prod_{j=1}^{i-1}\lambda_j}{\prod_{j=1,j\neq l,m}^{i}(\lambda_j-\lambda_l)} t e^{-\lambda_l t} \tag{9}$$

$$B_i(t;\lambda_1,\lambda_2,\cdots\cdots,\lambda_i) = \sum_{j=1,j\neq l,m}^{i} d_j \frac{1-e^{-\lambda_j t}}{\lambda_j} - \left(\sum_{j=1,j\neq l,m}^{i} d_j\right)\frac{1-e^{-\lambda_l t}}{\lambda_l} + \frac{\prod_{j=1}^{i-1}\lambda_j}{\prod_{j=1,j\neq l,m}^{i}(\lambda_j-\lambda_l)} \cdot \frac{1}{\lambda_l}\left(\frac{1-e^{-\lambda_l t}}{\lambda_l} - t e^{-\lambda_l t}\right) \tag{10}$$

In treating a loop chain in which a nuclide transforms a certain times and then transforms to the original nuclide, the solution technique with the Beteman's equation can not be applicable. The loop chain is solved by assuming an approximated linear chain with an equal length as shown in **Fig. 1**. The code stops when the mother nuclide is found in the linear chain.

2.2 Function of the code

Figure 2 shows the program structure of the DCHAIN-SP code. **Figure 3** illustrates the flow of decay and build-up characteristics calculation of spallation products with DCHAIN-SP. The nuclide production rate, Y_i, calculated with the nucleon-meson transport code NMTC/JAERI97 [4] is used as an input data. The DCHAIN-SP code can estimate the following physical quantities using decay data :

time evolution of inventory and radioactivity [Bq] of nuclides,

decay heat [W] by the radiations accompanied with the decay,

the γ-ray spectrum [MeV] and its intensity of the produced nuclides.

The periodical combination of irradiation and cooling can be treated in the calculation. The nuclear reactions induced by the neutrons with energies below 20 MeV in the radiation field produced in the spallation target are taken into account in the code. Due to the lack of available cross section data, however, the nuclear reactions above 20 MeV are not treated in the present code but they are included in the nuclide yield data obtained by NMTC/JAERI97. In order to calculate the neutron reactions, the group-wise neutron cross section data are prepared as the data library. These data are collapsed with the group-wise neutron flux calculated by the MCNP4A code [6] linked with NMTC/JAERI97.

It is noted that the code can not estimate the build-up of fission products by the fission reaction because fission yield data are not implemented in the present data library, so that the applicable atomic number range is effectively limited to be less than 83 although the decay data and the neutron reaction cross section data are prepared for the nuclides with the atomic number of $1 \leq Z \leq 100$.

2.3 Decay Data Library

The decay data library for the DCHAIN-SP code contains half-life of nuclide, Q-value of a decay averaged with branching ratio, average energies of α, β and γ rays per decay, γ–ray energy spectra, decay mode and so on. These data of primary nuclides have been taken from the evaluated nuclear data file EAF-3.1 [7]. The data in the FENDL/D-1 [8] have been also employed for the radioactive nuclides excluded from EAF-3.1. For the other nuclides excluded from both data files, the decay data have been supplementally evaluated from the data in ENSDF [9], Table of Isotopes 8th edition [10] and Chart of the Nuclides 1996 [11].

The radioactive decay data of all nuclides used in the DCHAIN-SP code were checked and updated in comparison with the data included in Refs. 7 to 11 and the newest data published in FENDL/D-2 [12]. As a result, the present decay data library contains the data of the 3139 kinds of nuclides with the atomic number range of $1 \leq Z \leq 100$ which covers 261 kinds of stable nuclides. The nuclides contained in the decay data are listed in **Table 1** by the symbol of a chemical element and mass number. The data format of the decay data library is shown in **Appendix A**.

As far as the γ–ray energy spectra are concerned, the data are prepared for 2181 of 3139 nuclides in the decay data library. The data have been taken from the ENSDF. It is noted that

the DCHAIN-SP code assumes the single γ–ray emission with average γ–decay energy for the nuclide without γ–ray energy spectrum data. The nuclide without data relevant to the γ–decay is shown with the asterisk mark on the mass number in the second column of **Table 1**.

For the nuclide having β^+–decay mode with electron capture decay (EC), an electron capture decay ratio data library is prepared on the basis of the data in the ENSDF. The DCHAIN-SP code treats the β^+–decay accompanied with EC as two annihilation γ–rays with energy of 511 keV are emitted with the weight of β^+–decay ratio. The β^+–decay ratio given in the ENSDF is used as a weight of the annihilation γ–rays. For the nuclides whose β^+–decay ratio is unknown, on the other hand, the β^+–decay ratio has been estimated by the interpolation with the existing data. As shown in **Fig. 4**, the Q-value for β^+–decay mode with equal fraction to EC increases linearly as a function of mass number. Here, the nuclides with the Q-value above 10 MeV only give rise to the β^+–decay and those with Q-value below 1.02 MeV only give rise to EC decay, in other words 0 % β^+–decay. From these relation, the β^+–decay ratio of a nuclide is determined from its Q-value.

The present decay data library for DCHAIN-SP does not contain the energy spectrum data of the characteristics X-ray.

2.4 Neutron Reaction Cross Section Data Library

Neutron reaction cross section data library is used to take account of the transmutation of nuclides in a neutron field in the target. The cross section data were taken from the FENDL/A-2[12] library and compiled in the 175 energy group structure defined by VITAMIN-J [13]. The present library contains 13005 reactions for 735 nuclides. The nuclides produced with neutron reaction include the isomer state. The energy group structure of VITAMIN-J is shown in **Table 2**. These nuclides are shown with the underline on the mass number in the second column of **Table 1**. As shown in eq. (1), the contribution of neutron reactions on the build-up and decay of nuclides is estimated with the effective one-group neutron reaction cross section collapsed from 175-group data with the neutron flux weight in the DCHAIN-SP code. The data format of 175-group neutron flux file obtained from a MCNP4A calculation is shown in **Appendix B**.

3. User Guide for the Code

3.1 Installation

The program of DCHAIN-SP is described with the FORTRAN77 language and runs on the UNIX machines of SUN (FUJITSU S-7/300, OS: Solaris 2.5) with SPARCompiler FORTRAN77 ver. 4.0 and the Hewlett Packard HPUX-9 with available FORTRAN compiler.

The code is provided by the tar file, 'spd.tar'. First of all, the user has to make executable file of the DCHAIN-SP code on the UNIX machine according to the following procedures. Suppose that the user makes an environment for the execution of the DCHAIN-SP code under the directory of '/users/user555'. If the tar file is contained in a DAT tape, the user has to expand the file by the 'tar' command. All of files and directories the DCHAIN-SP code are duplicated under the directory of 'spd' from the DAT tape. Then, move to the directory, 'spd/src', by the 'cd' command and make an executable file by the 'make' command. The present makefile is for HPUX-9. If the user uses the SUN work station, the 9th and 10th lines of the makefile have to be changed to 'FFLAGS = -O -I$(INCDIR)' and 'LFLAGS = ', respectively. After making the executable file, the user moves to the directory 'spd'.
These procedures are shown as follows :

user > cd /users/user555
user > tar xvf /dev/rmt/0m spd.tar
user > tar xvf spd.tar
user > cd spd/src
user > make
user > cd ..

where the character '*user* >' indicates the prompt displayed on the monitor and '/dev/rmt/0m' represents the device name assigned to a DAT drive.

At this situation, the user must change the 'PATH1' parameter in the 8-th line in the file 'link.spd' to define the directory to be referred as data library storage place. If the name of directory in which data libraries are stored is '/home/user/nmtc/spd', then change the 8-th line as

set PATH1='/home/user/nmtc/spd'.

At next, the user has to make new directory 'exec' in which the DCHAIN-SP code is executed,

then moves to the directory, and runs the linkage process by 'link.spd' shell script. The executable directory name and the address of directory are arbitrary.

user > chmod u+x link.spd
user > mkdir exec
user > cd exec
user > ../link.spd

By the execution of 'link.spd' shell script, the load module of the DCHAIN-SP code, spd_ld, and necessary data libraries are linked to the current directory. On executing the calculation, the nuclide yield data file output from the nucleon-meson transport code NMTC/JAERI97, 'nmtc_yield', or alternative one with the same format as the file has to be given. The neutron flux file 'n.flux' is also required to make effective one-group neutron reaction cross section to take account of the decay and build-up of the nuclides by the neutron field in the target. Then, the code is executed with the following command.

user > spd_ld < input > out put ,

where 'input' indicates the input data file for the DCHAIN-SP code and 'output' means the output file of the calculation summary.

The DCHAIN-SP code uses several logical units for both input and output. The following logical units are assigned in the code for data input :

Logical unit 1 : Decay data library, 'dcylib'.
Logical unit 2 : 175-group neutron reaction cross section library, 'rxslib'.
Logical unit 3 : Nuclide yield data calculated with the high energy nucleon-meson transport code NMTC/JAERI97, 'nmtc_yield'.
Logical unit 4 : 175-group neutron flux data calculated with the low energy transport code such as MCNP4A, 'n.flux'.
Logical unit 5 : Input data file for DCHAIN-SP.
Logical unit 9 ; Electron capture decay rate data library, 'lib_ec'.

After finishing the calculation, the calculated results are output on the following logical units :

Logical unit 6 : Output file for calculation summary.
Logical unit 8 : Output file of calculated results of activities, decay heat and γ-ray energy spectrum and so on, 'spd-act.out'.
Logical unit 10: Output file of nuclide yield, 'yield.out'.

Here, the characters in the single quotation marks denote the fixed filename in the DCHAIN-SP code. The filename of individual input and/or output data is assigned in the main routine of the program.

3.2 Input Data Preparation

DCHAIN-SP requires 8 input cards. **Figure C-5** of **Appendix C** shows an example of input card for the sample problem illustrated in **Fig. C-1**. The type of variables used in the input card is subject to the implicit form of FORTRAN77 language unless the type is specified explicitly, i.e. the variable is an integer when its head character is written in the alphabet from "I" to "N", otherwise that is the real. The character in the parentheses after the card number represents the format of the input data. Here, the character "*" means that the card data are given by a free format. The following summarizes the input card, variables and their function.

CARD 1 (A80)

(1) HTITLE: Title for calculation (up to 80 characters).

CARD 2 (*)

(1) IMODE: Calculation option definition.
= 0 : Induced radioactivity calculation.
= 1 : Induced radioactivity and decay heat calculation.
= 2 : Induced radioactivity, decay heat and γ-ray energy spectrum calculation.

(2) JMODE: Irradiation condition option definition.
=-1: without irradiation (decay mode only).
= 0 : Irradiation with primary beam.
= 1 : Irradiation with secondary neutrons in the target.
= 2 : Irradiation with primary beam and secondary neutrons in the target.

CARD 3 (*)

(1) ITSTEP: Number of calculation steps for irradiation and cooling time. ISTEP must be set to greater than 1.
The default value is set as 1.

(2) ITOUT: Number of output times of calculation results.

The default value is set as 1.

(3) IDIVS: Number of time divisions during an irradiation time step.

The default value is set as 50.

(4) IREG: Region number for induced radioactivity and/or decay heat calculation.

Note: The region number must coincide with that defined in the nuclide yield tally option of the preceding NMTC/JAERI97 calculation. If "zero" is given in this card, the induced radioactivity and/or decay heat is calculated for all regions defined in the nuclide yield tally option of the NMTC/JAERI97 code. In case of IREG=-1, the nuclide yield data calculated with NMTC/JAERI97 are not used in the calculation.

The default value is set as 0.

(5) ITGNCL: Number of nuclides included in a target material. In case of IREG=-1, then ITGNCL has to be set.

The default value is set as 0.

(6) ICHAIN: Length and number of linear chain treated in the code.

The default value is set as 70.

(7) ITDECS: Option for transmutation calculation of target nuclides by the continuous primary beam irradiation. The option is valid in case of JMODE = 0 or 2.

= 0 : no effect.

= 1 : transmutation of target nuclides is taken into account. In this case, ITGNCL must be set to greater than 1.

The default value is set as 0.

(8) ITDECN: Option for transmutation calculation of target nuclides by the secondary neutrons. The option is valid in case of JMODE = 1 or 2.

= 0 : no effect. In this case, ITGNCL must be set to greater than 1.

= 1 : transmutation of target nuclide is taken into account.

The default value is set as 1.

(9) ISOMTR: Option for treatment of isomer in the nuclide yield file.

= 0 : isomer is distinguished from the ground state.

= 1 : isomer is treated as the ground state.

The default value is set as 0.

Note: In case of using the nuclide production rate calculated with the present NMTC/JAERI97 code, the isomer production is not taken into account.

In order to estimate the isomer production, update of the code is under progress.

CARD 4 (*)

(1) IYILD : Output option at the final output time of nuclide yield.

= 0 : no effect.

= 1 : nuclide yield is output in the file 'yield.out'.

= 2 : nuclide yield is output with target nuclides given in the CARD 8.

The default value is set as 0.

(2) IGGRP : Energy group structure option for output of γ-ray energy spectrum. This option is valid in case of IMODE ≥ 2.

= 0 : not valid.

= 1 : 22-group structure of the HILO86-R library.

= 2 : 41-group structure of the BERMUDA library with additional 3 group.

= 3 : 42-group structure of the VITAMIN-J library.

= 99: 23-group structure of the FISPACT-3 code (γ-ray intensity).

The default value is set as 3. The energy group structures of the above 4 cases are shown in **Tables 3 to 6**.

(3) IBETAP : Option for treatment of annihilation γ-ray accompanied with β^+-decay. This option is valid in case of IMODE ≥ 2. General recommended option is IBETAP=1.

= 0 : not treated.

= 1 : annihilation γ-ray emission is taken into account.

The default value is set as 1.

(4) ISTABL : Print option for stable nuclide in an output file.

= 0 : not printed.

= 1 : print.

The default value is set as 0.

(5) ACMIN : The cut-off value of the radioactivity for output .

= 0.0 : the cut-off value is automatically set as total radioactivity times 10^{-10}.

> 0.0 : the cut-off value [Bq].

< 0.0 : the minimum number density of produced nuclides [n/cc].

The default value is set as 0.0.

CARD 5 (*)

(1) AMP: Input primary beam current [mA].
This value is valid in case of JMODE = 0 or 2. The default value is set as 1.0.

(2) EBEAM : Incident particle energy [GeV].
This value is valid in case of JMODE = 0 or 2. The default value is set as 1.5.

(3) FLUX : Intensity of neutrons with energies below 20 MeV. [n/cm^2/sec].
This value is valid in case of JMODE = 1 or 2.
= -1.0 : both of intensity and neutron energy flux data are given from a file.
= 0.0 : no neutron.
> 0.0 : the neutron energy flux data are given from a file.
The default value is set as 0.0

(4) VOLUME : Volume of the target [cm^3].
The default value is 1.0.

(5) HTARGT : The identification characters of target material. (The material must be defined with 6 characters such as "Hg-200", "Fe-56 ", " W-186" and so on.)

The following card 6 must be repeated ITSTEP times.

CARD 6 (*)

(1) TBIN : Time step of irradiation and/or cooling.
Note : This time step is not equal to the elapsed time from the starting time but to individual time bin for irradiation and/or cooling. The allowable units are seconds, "s", minutes, "m", hours, "h", days, "d" and years, "y". The blank characters more than one must be placed between the number indicating the time and the units. It is not allowed to define the input time step expressed by more than two units.

(2) BEAMPW: Normalized factor for beam intensity.
The beam intensity is implicitly given by the product of AMP and EBEAM in the code. The user can change the beam intensity with this factor. In the case of cooling calculation, "zero" must be given.

The following card 7 must be repeated ITOUT times.

CARD 7 (*)

(1) TMIN : Time for calculation results output.
The user must input the elapsed time from the starting point of calculation. The input manner is the same as for the TBIN in CARD 5. If a negative value is given, it is correspond to the time from the end of the first irradiation.

The following card 8 is omitted if ITGNCL = 0.

CARD 8 (*)

(TGNZA(i), TGNND(i), i = 1, ITGNCL)

or

(HL(i), TGNND(i), i = 1, ITGNCL)

(1) TGNZA The nuclide identifier defined as IZ*1000 + IA + IM*0.1, where IZ indicates the atomic number, IA the mass number and IM the isomer designator. The ground state, the first isomer and the second one are represented as IM = 0, 1, and 2, respectively. An element is represented as IA = 0 and IM =0.
Example : Au-197m 79197.1
Fe-56 26056.0
Cr 24000.0

(1') HL The nuclide identifier with the symbol of a chemical element. The symbol of the chemical element has to be connected with atomic number by the character '-' for indicating an isotope. The ground state, the first isomer and the second one are represented by the characters 'g', 'm' and 'n', respectively.
Example : Au-197m, Fe-56, W-185g, Fe, Cr.

(2) TGNND Number density of a nuclide or an element [x 10^{24} /cm^3] .
Negative value can be used to indicate the density [g/cc] of the element. In this case, the element is represented by the variable TGNZA or HL. If -999 is given, the density at the room temperature is used for the element. The value to which the character 'B' or 'b' is attached on the top indicates the radioactivity in the unit of Bq. In case of IREG=-1, the radioactivity of the nuclide or element defined in this input is calculated in the code.

3.3 Example of input card

An example of the input card is shown as follows.

```
CARD1     DCHAIN-SP test input data
CARD2       1   0
CARD3       2   4  100   1   0   0   0   1   0
CARD4       0   0   0   0  0.0
CARD5       2.85E-4   1.5   0.0   1.0   Hg-200
CARD6       1 m       1.0
            7 d       0.0
CARD7       1 m
           -3 h
           -1 d
           -7 d
```

This example is for the irradiation of a mercury target with the beam current of 2.85 nA for 1 minute irradiation followed by the cooling of 7 days. The induced radioactivity in the region "1" of the mercury target is estimated at the 4 time steps, i.e., the end of irradiation, 3 hours, 1 day and 7 days after irradiation, respectively.

3.4 Instruction for Input Card Preparation

As shown in the above sections, the DCHAIN-SP code requires a less number of input card. However, there are some points to be paid attention for. The additional instruction is given to some input data.

(a) CARD 2 (IDIVS)

The user has to divide the irradiation time step properly and determine the value of IDIVS. Do not give too small number to IDIVS. The nuclide production rate is calculated in accordance with the time step divided by IDIVS. On the other hand, the calculation accuracy becomes poor for course time interval. Since the computation time is proportional to this number, IDIVS, long computation time is consumed in case of too fine time interval. The division number of 50 to 300 would be recommended although it depends on the periods of irradiation and/or cooling time.

(b) CARD 2 (JMODE) and CARD3 (IREG, ITGNCL)

The nuclide to be calculated is determined by the values set in the variables of JMODE, IREG and ITGNCL. In case of JMODE = 0, the nuclides with the nuclide yield calculated with NMTC/JAERI are selected for calculation if IREG ≥ 0, and the ITGNCL kinds of nuclides are selected for calculation if IREG = -1.

In case of JMODE = 1, the nuclides given in the input card is selected for calculation if ITGNCL > 0, and the nuclides included in the nuclide yield file are selected on condition that IREG ≥ 0 if ITGNCL = 0.

In case of JMODE =2, the nuclides included in the nuclide yield file are selected for calculation if IREG ≥ 0, and the ITGNCL kinds of nuclides are selected for calculation if IREG = -1, respectively, for primary beam irradiation. In the calculation of the decay and build-up of nuclide by the neutron reaction, the nuclides given in the input card is selected for calculation if ITGNCL > 0, the nuclides included in the nuclide yield file are selected if ITGNCL = 0. Consequently, the different nuclides can be selected for calculation depending on the irradiation field, i.e.,the primary beam irradiation and the neutron field.

It is noted that the calculation with the condition of JMODE =-1 is the same as the case of JMODE=1. It is forbidden to set the option as IREG=-1 and ITGNCL=0 at the same time.

(c) CARD 2 (JMODE)

In case of JMODE=-1, the function of irradiation with primary beam and neutron field does not work by setting as AMP=0.0 and FLUX=0.0 compulsorily.

(d) CARD 3 (ITSTEP, ITOUT), CARD 6 and CARD 7

In general, the calculation problem is defined by a set of irradiation and cooling time in the input card. For example, the time step of the induced activity calculation for one hour irradiation followed by 5 hour cooling is defined in the input card as follows.

If the calculation condition is set as ITSTEP=2 and ITOUT=1, then

(CARD 6) 1h 1.0 (Irradiation time step ; BEAMPW > 0)

(CARD 6) 5h 0.0 (Cooling time step ; BEAMPW = 0)

(CARD 7) 6h

If the user want to calculate the induced activities at 30 minutes from the beginning and the end of irradiation, CARD 7 is given as follows with ITOUT=2.

(CARD 7) 30m

(CARD 7) 1h

Arbitrary combination of the irradiation time step with the cooling one can be given repeatedly. For example, if ITSTEP=7,

(CARD 6) 2h 1.0
(CARD 6) 10m 0.0
(CARD 6) 30m 1.5
(CARD 6) 15m 0.8
(CARD 6) 4h 0.0
(CARD 6) 100s 3.0
(CARD 6) 60h 0.05

As shown in the example, it is possible to set an irradiation time in the last step. If the number of time step is the minimum, i.e. ITSTEP=1, the user has to give only the irradiation time step and then do not give the cooling time.

(CARD 6) 2h 1.0

The output time of the calculated results is given by the elapsed time from the beginning of the irradiation in CARD 7 for ITOUT times. If the output time is not given in the input card, i.e., ITOUT = 0, the DCHAIN-SP code calculates the decay and build-up characteristics at the final irradiation or cooling time and output the result. For example, in order to obtain the induced activity at the irradiation time of 300 day, it is allowed to set CARD 6 as

(CARD 6) 300d 1.0

with ITSTEP=1 and ITOUT=0.

(e) CARD 3 (ITDECN)

An option, ITDECN, is prepared to take account of the transmutation of target nuclides during the continuous irradiation with primary beam. Under the condition that the target is irradiated by an intense primary beam, the number of fresh target nuclides decreases with irradiation time. However, the initial nuclide yield given by the NMTC/JAERI output is constant unless the decrease of target nuclides is taken into account. If this option is selected, the nuclide yield and the number of target nuclides decreases with the ratio of non-elastic cross section to the total one.

(f) CARD 4 (ACMIN)

The cut-off value of radioactivity of nuclide, ACMIN, is used to prevent the output list

from getting too long. The cut-off value is implicitly set as 10^{-10} times of the total activity. The positive value of ACMIN means the cut-off value is given in the unit of Bq. The negative value determines the number of nuclides to be output. It is noted that this cut-off value do not affect the summation values such as total activity, decay heat and so on.

(g) CARD 5 (EBEAM)

The incident beam energy , EBEAM, is printed out on the induced radioactivity output file, but does not give any effect on the calculation results. In case of ITDECS=1, however, this values is used to obtain the non-elastic cross section of target nuclides.

(h) CARD 5 (VOLUME)

The target volume, VOLUME, is used to normalize the nuclide yield in a region to the units of $1/cm^3$. If the value of 1.0 is given to the VOLUME intentionally in spite the real volume is not 1.0, the user can regard the result as volume integrated value.

(i) CARD 5 (HTRGT)

The name of target element, HTRGT, is printed on the induced radioactivity output file. There is no problem even if the name is different from that defined in the preceding NMTC /JAERI97 calculation. The name is represented by the symbol of the chemical element, hyphen, '-', and the mass number as Pb-208. If it is natural element, it is denoted as Pb-nat.

(j) CARD 7 (TMIN)

The user can set optional time to the variable "TMIN" for the output of calculation results. It is allowed for TMIN to be different from the value of time step of the irradiation and/or cooling on the condition that the final time of TBIN must cover the time range defined by TMIN entirely.

(k) CARD 8 (TGNZA)

The target nuclides can be represent by combining ZA notation and the symbol of a chemical element. When the element is given in TGNZA or HL, the element is decomposed into isotopes with the number of atoms according to the isotope existing ratio. In case of representing the element with the isotope name, it is shown with the mass number with a hyphen as Fe-56. It is not allowed to omit the hyphen in this representation manner. TGNND

can be given by one of the following three ways: a positive real number indicating number density with a unit of 10^{24} n/cc, a negative real number indicating density with a unit of g/cc and the real number with the character 'b' on the head indicating activity with a unit of Bq. Here, the density is given only for the nuclides denoted by the symbol of a chemical element. The order of arrangement of the target nuclides is free. The example is shown as follows:

80196.	5.9595e-5	80198.	3.9611e-3	80199.	6.7025e-3
Hg-200	9.1776e-3	Hg-201	5.2364e-3	26000.	1.1863e-2
Pb	2.2795e-3	W	-19.0	H-3	b7.84e+8

3.5 Data Format of Output Files

As described in the section 3.1, the calculation summary and the calculated results of activities, decay heat and γ-ray energy spectrum and so on are output on files. The data format of these files is explained in this section using the results of the sample problem. The problem is the irradiation of 20 cm diameter and 90 cm long cylindrical mercury target with 1.5 GeV protons with current of 1mA for 30 days. The input and output data of the sample problem are summarized in **Appendix C**.

(1) Output File of Calculation Summary

The summary of a calculation is printed out to a standard output file assigned to the logical unit 6. An example of an output file for summary of a calculation is shown in **Fig. C-7** of **Appendix C**. The information included in the output file is as follows.

- Input data given by the input card for the DCHAIN-SP calculation.
- Summary of variable dimension size used in calculation.
- Nuclide yield data used in calculation. If any, the nuclide list lacked in decay data library
- Total radioactivity at each output time with the elapsed cpu time.

(2) Output File of Calculated Results.

The calculated results are printed out on a file assigned to the logical unit 8. An example of an output file of calculated results is shown in **Fig. C-8** of **Appendix C**. The output file contains the list of calculation conditions and the calculated results. This set of output is repeatedly printed out at individual output time. The details of the output file are as follows.

In the output file, the calculation conditions are listed at first. They are target material, beam current, beam energy, beam power, neutron flux created in the target and irradiation time.

The calculated results on each produced nuclide are listed in 8 columns. The first column shows the nuclide name. Then, the number of atoms and radioactivity at the given time are listed in the second and third column, respectively. If the radioactivity of the nuclide exceeds 0.01% of the total amount, the ratio to the total amount is shown in the fourth column. The decay heat from the produced nuclide is shown in the unit of watts from the fifth to seventh column, which corresponds to the components of β-ray, γ-ray and α-ray, respectively. The half life of the nuclide is shown in the units of seconds at the last column.

After the list of these physical quantities, the group-wise γ-ray energy spectrum is shown as a table if this option is selected. The total γ-ray current are also shown at the bottom of the table. Here, the annihilation γ-ray yield is independently printed out.

At the end, the nuclides with intense radioactivity are sorted out of all produced nuclides and re-arranged in decreasing order of the radioactivity from the highest to the 10th.

(3) Output File of Nuclide Yield

The nuclide yield at the final output time is printed out on a file assigned to the logical unit 10. The number of individual produced nuclides is normalized to total incident particle in the output. The data are used as the initial value of the number density for the NMTC/JAERI calculation taking account of the change of the atomic component of the target by nuclear reactions. This function is not implemented in the published version of NMTC/JAERI yet. The format and an example of the nuclide yield file are shown in **Appendix D**.

4. Summary

The DCHAIN-SP code is applicable to study the decay and build-up characteristics of the spallation products. Keeping its original virtue that any type of decay schemes can be solved by the Beteman method, the code can estimate the time evolution of inventory, activity, decay heat and the γ-ray energy spectra of produced nuclides by the use of the decay data taken from the data library of EAF 3.1, FENDL/D-1 and those evaluated from the ENSDF.

For a part of the covering nuclides, the code can take account of the transmutation of nuclides by the secondary neutrons with energies below 20 MeV in a target during the irradiation period. The transmutation rate is estimated with the effective cross sections collapsed from the 175-group neutron reaction cross section data taken from the FENDL/A-2 library with the neutron flux calculated by the MCNP4A code.

In the calculation, the nuclide production rate is required for the initial condition. The present DCHAIN-SP code implicitly assumes to use the nuclide production rate data obtained by the nucleon-meson transport code NMTC/JAERI97. It is noted that DCHAIN-SP can treat alternative nuclide production rate data such as the calculated results of the other nucleon-meson transport code such as HERMES, LAHET and so on.

It is expected that the code will be used for the radiation safety analysis such as the estimation of induced activity and dose rate of the materials irradiated in the high-energy accelerator facilities.

Acknowledgments

The authors would like to thank to Drs. Y. Ikeda, H. Yasuda and H. Nakashima of Center for Neuron Science of JAERI for their valuable discussions. They are also indebted to Dr. T. Nishida for his initial work for the expansion of the DCHAIN-2 code for treating spallation products.

References

1) Bell J.: "ORIGEN The ORNL Isotope Generation and Depletion Code", ORNL-4628, (1973).
2) Wilson W. B., England T. R., Herman M., Macfarlane R. E., Muir D. W.: "CINDER' 90 Code for Transmutation Calculations," Reffo G., Venture A., Grandi C. (eds.): Proc. of Int. Conf. on Nucl. Data for Sci. and Technol., Trieste, 19-24 May 1997, Conf. Proc. Vol. 59, Part II, pp. 1454-1457 (1997).
3) Tasaka K.: "DCHAIN2 : A Computer Code for Calculation of Transmutation of Nuclides," JAERI-M 8727, (1980).
4) Takada H., Yoshizawa N, Kosako K., Ishibashi K.: "An Upgraded Version of Nucleon Meson Transport Code, NMTC/JAERI97," JAERI-Data/Code 98-005, (1998).
5) Beteman H.: Proc. Cambridge Phil. Soc. 15, 423 (1910).
6) Briesmeister J. F. (Ed.) : "MCNP A General Monte Carlo N-Particle Transport Code, Version 4A," LA-12625 (1993).
7) Kopecky J., Nierop D.: "Contents of EAF-3, " ECN-I-92-023 (1992).
8) Pashchenko A. B.: " Status of FENDL Activation File and Plans for the Future Developments," Proc. Int. Workshop on Nucl. Data for Fusion Reactor Technol., Del Mar, California, USA, 3-6, May 1993. (1993).
9) Tuli J. K.: "Evaluated Nuclear Structure Data File," BNL-NCS-51655-Rev.87 (UC-32c), (1987) ; Used data set is taken from the version released in 1997.
10) Firestone R. B., Shirley V. S. (eds.) : Table of Isotopes Eighth Edition, A Wiley-Interscience Publication, John Wiley & Sons, Inc. (1996).
11) Horiguchi T., Tachibana T., Katakura J.: "Chart of the Nuclides 1996," JAERI/NDC (1996).
12) Forrest R. A., Mann F. M.: "FENDL/D-2.0, Decay Data Library for Fusion Applications," Summary Documentation Pashchenko A. B. and Wienke H.: Report IAEA-NDS-178 (1997).
13) Pashchenko A. B.: " Summary Report for IAEA Consultants' Meeting on Selection of Evaluations for the FENDL/A-2 Activation Cross Section Library," INDC(NDS)-341, International Atomic Energy Agency (1996).
14) Saltori E.: "ZZ-VITAMIN-J/175," NEA 1051 (1985).

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope.

Element	Mass Number
H	**1**, **2**, 3, 4, 5, 6
He	**3**, **4**, 5, 6, 7, 8, 9
Li	5, **6**, **7**, 8, 9, 10 ,11
Be	6, 7, 8, **9**, 10, 11, 12, 14
B	7,8, 9, **10**, **11**, 12, 13, 14, 15
C	8, 9, 10, 11, **12**, **13**, 14, 15, 16, 17, 18
N	11, 12, 13, **14**, **15**, 16, 17, 18, 19, 20
O	12, 13, 14, 15, **16**, **17**, **18**, 19, 20, 21, 22, 23
F	15, 16, 17, 18, **19**, 20, 21, 22, 23, 24, 25
Ne	16, 17, 18, 19, **20**, **21**, **22**, 23, 24, 25, 26, 27, 28, 29, 30
Na	20, 21, 22, **23**, 24, 24m, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35
Mg	20, 21, 22, 23, **24**, **25**, **26**, 27, 28, 29, 30, 31, 32, 33, 34, 35
Al	22, 23, 24, 24m, 25, 26, 26m, **27**, 28, 29, 30, 31, 32, 33, 34, 35
Si	24, 25, 26, 27, **28**, **29**, **30**, 31, 32, 33, 34, 35, 36, 37, 38
P	26, 27, 28, 29, 30, **31**, 32, 33, 34, 35, 36, 37, 38, 39, 40
S	29, 30, 31, **32**, **33**, **34**, 35, **36**, 37, 38, 39, 40, 41, 42, 43
Cl	31, 32, 33, 34, 34m, **35**, 36, **37**, 38, 38m, 39, 40, 41,42, 43, 44, 45
Ar	32, 33, 34, 35, **36**, 37, **38**, 39, **40**, 41, 42, 43, 44, 45, 46, 47, 48
K	35, 36, 37, 38, 38m, **39**, **40**, **41**, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54
Ca	35, 36, 37, 38, 39, **40**, 41, **42**, **43**, **44**, 45, **46**, 47, **48**, 49, 50, 51, 52, 53, 54
Sc	40, 41, 42, 42m, 43, 44, 44m, **45**, 45m, 46, 46m, 47, 48, 49, 50, 50m, 51, 52, 53, 54, 55, 56
Ti	41, 42, 43, 44, 45, **46**, **47**, **48**, **49**, **50**, 51, 52, 53, 54, 55, 56, 57, 58, 59
V	45, 46, 46m, 47, 48, 49, **50**, **51**, 52, 53, 54, 55, 56, 57, 58, 59, 60
Cr	45, 46, 47, 48, 49, **50**, 51, **52**, **53**, **54**, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Mn	48, 49, 50, 50m, 51, 52, 52m, 53, 54 ,**55**, 56, 57, 58, 58m, 59, 60, 60m, 61, 62, 63, 64, 65, 66, 67
Fe	49, 50, 51, 52, 52m, 53, 53m, **54**, 55, **56**, **57**, **58**, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68
Co	50, 51, 52, 53, 53m, 54, 54m, 55, 56, 57, 58, 58m, **59**, 60, 60m, 61, 62, 62m, 63, 64, 65, 66,67, 68, 69, 70, 71, 72*, 73*, 74*, 75*
Ni	53, 54, 55, 56, 57, **58**, 59, **60**, **61**, **62**, 63, **64**, 65, 66, 67, 68, 69, 70, 71, 72*, 73*, 74*, 75*, 76*, 77*, 78*
Cu	55, 56, 57, 58, 59, 60, 61, 62, **63**, 64, **65**, 66, 67, 68, 68m, 69, 70, 70m, 71, 72, 73, 74, 75, 76, 77*, 78*, 79*, 80*, 81*
Zn	57, 58, 59, 60, 61, 62, 63, **64**, 65, **66**, **67**, **68**, 69, 69m, **70**, 71, 71m, 72, 73, 73m, 74, 75, 76, 77, 77m, 78, 79, 80, 81*, 82*, 83*
Ga	59, 60, 61, 62, 63, 64, 65, 66, 67, 68, **69**, 70, **71**, 72, 72m, 73, 74, 74m, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84*, 85*
Ge	61, 26, 63, 64, 65, 66, 67, 68, 69, **70**, 71, 71m, **72**, **73**, 73m, **74**, 75, 75m, **76**, 77, 77m, 78, 79, 79m, 80, 81, 81m, 82, 83, 84, 85*, 86*, 87*, 88*
As	67, 68, 69, 70, 71, 72, 73, 74, **75**, 76, 77, 78, 79, 80, 81, 82, 82m, 83, 84, 84m, 85, 86, 87, 88*, 89*, 90*
Se	69, 70, 71, 72, 73, 73m, **74**, 75, **76**, **77**, 77m, **78**, 79, 79m, **80**, 81, 81m, **82**, 83, 83m, 84, 85, 86, 87, 88, 89, 90, 91, 92*, 93*
Br	70, 71, 72, 72m, 73, 74, 74m, 75, 76, 76m, 77, 77m, 78, **79**, 79m, 80, 80m, **81**, 82 , 82m, 83, 84, 84m, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94*, 95*, 96*
Kr	71, 72, 73, 74, 75, 76, 77, **78**, 79, 79m, **80**, 81, 81m, **82** , **83**, 83m, **84**, 85, 85m, **86**, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96*, 97*, 98*
Rb	74, 75, 76, 77, 78, 78m, 79, 80, 81, 81m, 82 , 82m, 83, 84, 84m, **85**, 86, 86m, **87**, 88, 89, 90, 90m, 91, 92, 93, 94, 95, 96, 97, 98, 98m, 99, 100, 101, 102
Sr	77, 78, 79, 80, 81, 82, 83, 83m, **84**, 85, 85m, **86**, **87**, 87m, **88**, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103*, 104*
Y	80, 81, 82, 83, 83m, 84, 84m, 85, 85m, 86, 86m, 87, 87m, 88, 88m, **89**, 89m, 90, 90m, 91, 91m, 92, 93, 93m, 94, 95, 96, 96m, 96n, 97, 97m, 97n, 98, 98m, 99, 100, 100m, 101, 102, 102m, 103*, 104*, 105*, 106*, 107

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Zr	81, 82, 83, 84, 85, 85m, 86, 87, 87m, 88, 89, 89m, **90**, 90m, **91**, **92**, 93, **94**, 95, **96**, 97, 98, 99, 100, 101, 102, 103, 104, 105*, 106*, 107*, 108*, 109*
Nb	84, 85, 86, 87, 87m, 88, 88m, 89, 89m, 90, 90m, 90n, 91, 91m, 92, 92m, **93**, 93m, 94, 94m, 95, 95m, 96, 97, 97m, 98, 98m, 99, 99m, 100, 100m, 101, 102, 102m, 103, 104, 104m, 105, 106, 107*, 108*, 109*, 110*, 111*, 112*
Mo	87, 88, 89, 89m, 90, 91, 91m, **92**, 93, 93m, **94**, **95**, **96**, **97**, **98**, 99, **100**, 101, 102, 103, 104, 105, 106, 107, 108, 109*, 110*, 111*, 112*, 113*, 114*, 115*
Tc	90, 90m, 91, 91m, 92, 93, 93m, 94, 94m, 95, 95m, 96, 96m, 97, 97m, 98, 99, 99m, 100, 101, 102, 102m, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113*, 114*, 115*, 116*, 117*, 118*
Ru	91, 91m, 92, 93, 93m, 94, 95, **96**, 97, **98**, **99**, **100**, **101**, **102**, 103, 103m, **104**, 105, 106, 107, 108, 109, 109m, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
Rh	94, 94m, 95, 95m, 96, 96m, 97, 97m, 98, 98m, 99, 99m, 100, 100m, 101, 101m, 102, 102m, **103**, 103m, 104, 104m, 105, 105m, 106, 106m, 107, 108, 108m, 109, 110, 110m, 111, 112, 112m, 113, 114, 114m, 115, 116, 116m, 117, 118*, 119*, 120*, 121*, 122*, 123*
Pd	94, 95, 95m, 96, 97, 98, 99, 100, 101, **102**, 103, **104**, **105**, **106**, 107, 107m, **108**, 109, 109m, **110**, 111, 111m, 112, 113, 113m, 114, 115, 115m, 116,117, 117m, 118, 119, 120*, 121*, 122*, 123*, 124*, 125*, 126*
Ag	97, 98, 99, 99m, 100, 100m, 101, 101m, 102, 102m, 103, 103m, 104, 104m, 105, 105m, 106, 106m, **107**, 107m, 108, 108m, **109**, 109m, 110, 110m, 111, 111m, 112, 113, 113m, 114, 114m, 115, 115m, 116, 116m, 117,117m, 118, 118m, 119, 119m, 120, 120m, 121, 122, 122m, 123, 124, 125*, 126*, 127*, 128*
Cd	98, 99, 100, 101, 102, 103, 104, 105, **106**, 107, **108**, 109, **110**, **111**, 111m, **112**, **113**, 113m, **114**, 115, 115m, **116**, 117, 117m, 118, 119, 119m, 120, 121, 121m, 122, 123, 123m, 124, 125, 125m, 126, 127, 128, 129, 130, 131*, 132*
In	102, 103, 104, 104m, 105, 105m, 106, 106m, 107, 107m, 108, 108m, 109, 109m, 109n, 110, 110m, 111, 111m, 112, 112m, **113**, 113m, 114, 114m, 114n, **115**, 115m, 116, 116m, 116n, 117,117m, 118, 118m, 118n, 119, 119m, 120, 120m, 120n, 121, 121m, 122, 122m, 122n, 123, 123m, 124, 124m, 125, 125m,126, 126m,127, 127m, 128, 128m, 129, 129m, 130, 130m, 130n, 131, 131m, 131n, 132, 133, 134*

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Sn	103, 104, 105, 106, 107, 108, 109, 110, 111, **112**, 113, 113m, **114**, **115**, **116**, **117**, 117m, **118**, **119**, 119m, **120**, 120m, 121, 121m, **122**, 123, 123m, **124**, 125, 125m, 126, 127, 127m, 128, 128m, 129, 129m, 130, 130m, 131, 131m, 132, 133, 134, 135*, 136*
Sb	107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 116m, 117, 117m, 118, 118m, 119, 120, 120m, **121**, 121m, 122, 122m, **123**, 124, 124m, 124n, 125, 126, 126m, 126n, 127, 128, 128m, 129, 129m, 130, 130m, 131, 131m, 132, 132m, 133, 134, 134m, 135, 136, 137*, 138*, 139*
Te	107, 108, 109, 110, 111, 112, 113, 114, 115, 115m, 116, 117, 117m, 118, 119, 119m, **120**, 121, 121m, **122**, **123**, 123m, **124**, **125**, 125m, **126**, 127, 127m, **128**, 129, 129m, **130**, 131, 131m, 132, 133, 133m, 134, 135, 136, 137, 138, 139*, 140*, 141*, 142*
I	110, 111, 112, 113, 114, 115, 116, 117, 118, 118m, 119, 120, 120m, 121, 122, 123, 124, 125, 126, **127**, 128, 129, 130, 130m, 131, 132, 132m, 133, 133m, 134, 134m, 135, 136, 136m, 137, 138, 139, 140, 141, 142, 143*, 144*, 145*
Xe	110, 111, 112, 113, 114, 115, 116,117, 118, 119, 120, 121, 122, 123, **124**, 125, 125m, **126**, 127, 127m, **128**, **129**, 129m, **130**, **131**, 131m, **132**, 132m, 133, 133m, **134**, 134m, 135, 135m, **136**, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146*, 147*
Cs	114, 115, 116, 116m, 117, 117m, 118, 118m, 119, 119m, 120, 120m, 121, 121m, 122, 122m, 122n, 123, 123m, 124, 124m, 125, 126, 127, 128, 129, 130, 130m, 131, 132, **133**, 134, 134m, 135, 135m, 136, 136m, 137, 138, 138m, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149*, 150*
Ba	117, 119, 120, 121, 122, 123, 124, 125, 126, 127, 127m, 128, 129, 129m, **130**, 130m, 131, 131m, **132**, 133, 133m, **134**, **135**, 135m, **136**, 136m, **137**, 137m, **138**, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150*, 151*, 152*
La	120, 121, 122, 123, 124, 125, 126, 127, 127m, 128, 129, 129m, 130, 131, 132, 132m, 133, 134, 135, 136, 136m, 137, **138**, **139**, 140, 141, 142, 143, 144, 145, 146, 146m, 147, 148, 149, 150*, 151*, 152*, 153*, 154*, 155*
Ce	123, 124, 125, 126, 127, 128, 129, 130, 131, 131m, 132, 132m, 133, 133m, 134, 135, 135m, **136**, 136m, 137, 137m, **138**, 138m, 139, 139m, **140**, 141, **142**, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153*, 154*, 155*, 156*, 157*

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Pr	124, 126, 127, 128, 129, 130, 131, 131m, 132, 133, 134, 134m, 135, 136, 137, 138, 138m, 139, 140, **141**, 142, 142m, 143, 144, 144m, 145, 146, 147, 148, 148m, 149, 150, 151, 152, 153, 154, 155*, 156*, 157*, 158*, 159*
Nd	127, 128, 129, 130, 131, 132, 133, 133m, 134, 135, 135m, 136, 137, 137m, 138, 139, 139m, 140, 141, 141m, **142**, **143**, **144**, **145**, **146**, 147, **148**, 149, **150**, 151, 152, 153, 154, 155, 156, 157*, 158*, 159*, 160*, 161*
Pm	130, 131, 132, 133, 134, 134m, 135, 135m, 136, 136m, 137, 138, 138m, 138n, 139, 139m, 140, 140m, 141, 142, 143, 144, 145, 146, 147, 148, 148m, 149, 150, 151, 152, 152m, 152n, 153, 154, 154m, 155, 156, 157, 158, 159*, 160*, 161*, 162*
Sm	131, 132, 133, 134, 135, 136, 137, 138, 139, 139m, 140, 141, 141m, 142, 143, 143m, 143n, **144**, 145, 146, **147**, **148**, **149**, **150**, 151, **152**, 153, 153m, **154**, 155, 156, 157, 158, 159, 160, 161*, 162*, 163*, 164*, 165*
Eu	134, 135, 136, 136m, 137, 138, 139, 140, 140m, 141, 141m, 142, 142m, 143, 144, 145, 146, 147, 148, 149, 150, 150m, **151**, 152, 152m, 152n, 153, 154, 154m, 155, 156, 157, 158, 159, 160, 161, 162, 163*, 164*, 165*
Gd	137, 138, 139, 140, 141, 141m, 142, 143, 143m, 144, 145, 145m, 146, 147, 148, 149, 150, 151, **152**, 153, **154**, **155**, 155m, **156**, **157**, **158**, 159, **160**, 161, 162, 163, 164, 165, 166, 167
Tb	140, 141, 142, 142m, 143, 144, 144m, 145, 146, 146m, 146n, 147, 147m, 148, 148m, 149, 149m, 150, 150m, 151, 151m, 152, 152m, 153, 154, 154m, 154n, 155, 156, 156m, 156n, 157, 158, 158m, **159**, 160, 161, 162, 163, 164, 165, 166, 167, 168
Dy	141, 142, 143, 144, 145, 145m, 146, 146m, 147, 147m, 148, 149, 149m, 150, 151, 152, 153, 154, 155, **156**, 157, 157m, **158**, 159, **160**, **161**, **162**, **163**, **164**, 165, 165m, 166, 167, 168, 169, 170, 171, 172, 173
Ho	144, 145, 146, 147, 148, 148m, 148n, 149, 149m, 150, 150m, 151, 151m, 152, 152m, 153, 153m, 154, 154m, 155, 156, 157, 158, 158m, 158n, 159, 159m, 160, 160m, 160n, 161, 161m, 162, 162m, 163, 163m, 164, 164m, **165**, 166, 166m, 167, 168, 168m, 169, 170, 170m, 171, 172, 173, 174
Er	147, 148, 149, 149m, 150, 151, 151m, 152, 153, 154, 155, 156, 157, 157m, 158, 159, 160, 161, **162**, 163, **164**, 165, **166**, **167**, 167m, **168**, 169, **170**, 171, 172, 173, 174, 175, 176, 177

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Tm	147, 147m, 148, 149, 150, 151, 151m, 152, 152m, 153, 153m, 154, 154m, 155, 155m, 156, 156m, 157, 158, 159, 160, 160m, 161, 162, 162m, 163, 164, 164m, 165, 166, 167, 168, **169**, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180
Yb	152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, **168**, 169, 169m, **170**, **171**, 171m, **172**, **173**, **174**, 175, 175m, **176**, 176m, 177, 177m, 178, 179, 180, 181, 182, 183
Lu	152, 153, 154, 155, 155m, 155n, 156, 156m, 157, 157m, 158, 159, 160, 160m, 161, 161m, 162, 162m, 162n, 163, 164, 165, 165m, 166, 166m, 166n, 167, 168, 168m, 169, 169m, 170, 170m, 171, 171m, 172, 172m, 173, 174, 174m, **175**, **176**, 176m, 177, 177m, 178, 178m, 179, 179m, 180, 181, 182, 183, 184, 185, 186
Hf	154, 155, 156, 156m, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 169, 170, 171, 172, 173, **174**, 175, **176**, **177**, 177m, 177n, **178**, 178m, 178n, **179**, 179m ,179n, **180**, 180m, 181, 182, 182m, 183, 184, 185, 186, 187, 188, 191
Ta	157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 169, 170, 171, 172, 173, 174, 175, 176, 176m, 177, 178, 178m, 178n, 179, **180**, 180m, **181**, 182, 182m, 182n, 183, 184, 185, 186, 187, 188, 189, 190, 191*
W	160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 179m, **180**, 180m, 181, **182**, **183**, 183m, **184**, 185, 185m, **186**, 187, 188, 189, 190, 191, 192, 193, 194, 195
Re	161, 162, 163, 164, 165, 166, 167, 168, 169, 169, 170, 171, 172, 172m, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 182m, 183, 183m, 184, 184m, **185**, 186, 186m, **187**, 188, 188m, 189, 190, 190m, 191, 192, 193, 194, 195
Os	163, 164, 165, 166, 167, 168, 169, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 181m, 182, 183, 183m, **184**, 185, **186**, **187**, **188**, **189**, 189m, **190**, 190m, 191, 191m, **192**, 192m, 193, 194, 195 , 196, 197, 198, 199, 200
Ir	167, 168, 169, 169, 170, 171, 172, 172m, 173, 173m, 174, 174m, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 186m, 187, 187m, 188, 189, 189m, 189n, 190, 190m, 190n, **191**, 191m, 191n, 192, 192m, 192n, **193**, 193m, 194, 194m, 194n, 195 , 195m, 196, 196m, 197, 197m, 198, 199, 200, 201, 202

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Pt	168, 169, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 183m, 184, 184m, 185, 185m, 186, 187, 188, 189, **190**, 191, **192**, 193, 193m, **194**, **195**, 195m, **196**, 197, 197m, **198**, 199, 199m, 200, 201, 202, 203
Au	173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 185m, 186, 187, 187m, 188, 189, 189m, 190, 190m, 191, 191m, 192, 192m, 192n, 193, 193m, 194, 194m, 194n, 195, 195m, 196, 196m, 196n, **197**, 197m, 198, 198m, 199, 200, 200m, 201, 202, 203, 204
Hg	175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 185m, 186, 187, 187m, 188, 189, 189m, 190, 191, 191m, 192, 193, 193m, 194, 195, 195m, **196**, 197, 197m, **198**, **199**, 199m, **200**, **201**, **202**, 203, **204**, 205, 205m, 206, 207, 208, 209
Tl	179, 179m, 180, 181, 182, 183, 183m, 184, 185, 185m, 186, 186m, 187, 187m, 188, 188m, 189, 189m, 190, 190m, 191, 191m, 192, 192m, 193, 193m, 194, 194m, 195, 195m, 196, 196m, 197, 197m, 198, 198m, 198n, 199, 199m, 200, 200m, 201, 201m, 202, **203**, 204, **205**, 206, 206m, 207, 207m, 208, 209, 210
Pb	182, 183, 184, 185, 186, 187, 187m, 188, 189, 190, 191, 191m, 192, 193, 193m, 194, 195, 195m, 196, 197, 197m, 198, 199, 199m, 200, 201, 201m, 202, 202m, 203, 203m, 203n, **204**, 204m, 205, 205m, **206**, **207**, 207m, **208**, 209, 210, 211, 212, 213, 214
Bi	189, 189m, 190, 190m, 191, 191m, 192, 192m, 193, 193m, 194, 194m, 194n, 195, 195m, 196, 196m, 196n, 197, 197m, 198, 198m, 198n, 199, 199m, 200, 200m, 200n, 201, 201m, 202, 203, 203m, 204, 204m, 204n, 205, 206, 206m, 207, 207m, 208, 208m, **209**, 210, 210m, 211, 212, 212m, 212n, 213, 214, 215
Po	194, 195, 195m, 196, 197, 197m, 198, 199, 199m, 200, 201, 201m, 202, 203, 203m, 204, 205, 205m, 206, 206m, 207, 207m, 208, 209, 210, 210m, 211, 211m, 212, 212m, 213, 214, 215, 216, 217, 218, 219
At	196, 197, 197m, 198, 199, 200,200m, 200n, 201, 202, 202m, 202n, 203, 204, 204m, 205, 206, 207, 208, 209, 210, 211, 212, 212m, 213, 214, 214m, 214n, 215, 216, 216m, 217, 218, 219, 220, 221, 222
Rn	198, 199, 199m,200, 201, 201m, 202, 203, 203m, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 214m, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228

Table 1 List of nuclides contained in the decay data library for DCHAIN-SP. The mass number with the underline indicates that the neutron cross section data are given for the nuclide. The mass number with the asterisk mark means that the nuclide has no γ-ray spectrum data. The mass number shown by the bold letter stands for the natural isotope (continued).

Element	Mass Number
Fr	201, 202, 203, 204, 204m, 204n, 205, 206, 206m, 207, 208, 209, 210, 211, 212, 213, 214, 214m, 215, 215m, 216, 217, 218, 218m, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231
Ra	206, 207, 207m, 208, 209, 210, 211, 212, 213, 213m, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232
Ac	209, 210, 211, 212, 213, 214, 215, 216, 216m, 217, 217m, 218, 219, 220, 221, 222, 222m, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234
Th	213, 214, 215, 216, 216m, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236
Pa	216, 217, 217m, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 234m, 235, 236, 237, 238
U	226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 235m, 236, 236m, 237, 238, 238m, 239, 240, 241, 242, 243, 244, 245
Np	229, 230, 231, 232, 233, 234, 235, 236, 236m, 237, 238, 239, 240, 240m, 241, 242, 242m, 243, 244, 245, 246
Pu	232, 233, 234, 235, 236, 237, 237m, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247
Am	237, 238, 239, 240, 241, 242, 242m, 243, 244, 244m, 245, 246, 246m, 247, 248
Cm	238, 239, 240, 241, 242, 243, 244, 244m, 245, 246, 247, 248, 249, 250, 251
Bk	242, 243, 244, 245, 246, 247, 248, 248m, 249, 250, 251
Cf	239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254
Es	243, 244, 245, 246, 247, 248, 249, 250, 250m, 251, 252, 253, 254, 254m, 255
Fm	254, 255

Table 2 175 energy group structure of VITAMIN-J.

Grp	Energy [eV]	delta-E	delta-U	Grp	Energy [eV]	delta-E	delta-U
1	1.9640E+07	2.3070E+06	1.2496E-01	51	1.9205E+06	9.3700E+04	5.0020E-02
2	1.7333E+07	4.2800E+05	2.5003E-02	52	1.8268E+06	8.9100E+04	5.0003E-02
3	1.6905E+07	4.1800E+05	2.5037E-02	53	1.7377E+06	8.4700E+04	4.9971E-02
4	1.6487E+07	8.0400E+05	4.9995E-02	54	1.6530E+06	8.0600E+04	4.9989E-02
5	1.5683E+07	7.6500E+05	5.0009E-02	55	1.5724E+06	7.6700E+04	5.0009E-02
6	1.4918E+07	3.6800E+05	2.4978E-02	56	1.4957E+06	7.3000E+04	5.0038E-02
7	1.4550E+07	3.5900E+05	2.4983E-02	57	1.4227E+06	6.9300E+04	4.9937E-02
8	1.4191E+07	3.5100E+05	2.5045E-02	58	1.3534E+06	6.6000E+04	4.9995E-02
9	1.3840E+07	3.4100E+05	2.4947E-02	59	1.2874E+06	6.2800E+04	5.0010E-02
10	1.3499E+07	6.5900E+05	5.0050E-02	60	1.2246E+06	5.9800E+04	5.0065E-02
11	1.2840E+07	3.1700E+05	2.4998E-02	61	1.1648E+06	5.6800E+04	4.9993E-02
12	1.2523E+07	3.0900E+05	2.4984E-02	62	1.1080E+06	1.0540E+05	9.9960E-02
13	1.2214E+07	5.9600E+05	5.0027E-02	63	1.0026E+06	4.0960E+04	4.1712E-02
14	1.1618E+07	5.6600E+05	4.9944E-02	64	9.6164E+05	5.4460E+04	5.8299E-02
15	1.1052E+07	5.3900E+05	4.9999E-02	65	9.0718E+05	4.4240E+04	4.9996E-02
16	1.0513E+07	5.1300E+05	5.0027E-02	66	8.6294E+05	4.2090E+04	5.0005E-02
17	1.0000E+07	4.8770E+05	4.9999E-02	67	8.2085E+05	4.0030E+04	4.9996E-02
18	9.5123E+06	4.6390E+05	4.9998E-02	68	7.8082E+05	3.8080E+04	4.9999E-02
19	9.0484E+06	4.4130E+05	5.0001E-02	69	7.4274E+05	3.6230E+04	5.0009E-02
20	8.6071E+06	4.1980E+05	5.0003E-02	70	7.0651E+05	3.4450E+04	4.9990E-02
21	8.1873E+06	3.9930E+05	5.0000E-02	71	6.7206E+05	3.2780E+04	5.0005E-02
22	7.7880E+06	3.7980E+05	4.9997E-02	72	6.3928E+05	3.1180E+04	5.0003E-02
23	7.4082E+06	3.6130E+05	5.0000E-02	73	6.0810E+05	2.9660E+04	5.0005E-02
24	7.0469E+06	3.4370E+05	5.0003E-02	74	5.7844E+05	2.8210E+04	4.9998E-02
25	6.7032E+06	1.1080E+05	1.6668E-02	75	5.5023E+05	2.6830E+04	4.9990E-02
26	6.5924E+06	2.1610E+05	3.3329E-02	76	5.2340E+05	2.5530E+04	5.0007E-02
27	6.3763E+06	3.1100E+05	5.0004E-02	77	4.9787E+05	4.7380E+04	1.0000E-01
28	6.0653E+06	2.9580E+05	4.9999E-02	78	4.5049E+05	4.2870E+04	1.0000E-01
29	5.7695E+06	2.8140E+05	5.0003E-02	79	4.0762E+05	1.9880E+04	5.0000E-02
30	5.4881E+06	2.6760E+05	4.9989E-02	80	3.8774E+05	1.8910E+04	4.9999E-02
31	5.2205E+06	2.5460E+05	4.9999E-02	81	3.6883E+05	3.5100E+04	1.0000E-01
32	4.9659E+06	2.4220E+05	5.0002E-02	82	3.3373E+05	3.1760E+04	1.0000E-01
33	4.7237E+06	2.3040E+05	5.0005E-02	83	3.0197E+05	3.4800E+03	1.1591E-02
34	4.4933E+06	4.2760E+05	1.0000E-01	84	2.9849E+05	1.2800E+03	4.2975E-03
35	4.0657E+06	3.8690E+05	9.9999E-02	85	2.9721E+05	2.6900E+03	9.0920E-03
36	3.6788E+06	3.5010E+05	1.0000E-01	86	2.9452E+05	7.2700E+03	2.4994E-02
37	3.3287E+06	1.6230E+05	4.9987E-02	87	2.8725E+05	1.4010E+04	5.0002E-02
38	3.1664E+06	1.5450E+05	5.0024E-02	88	2.7324E+05	2.6000E+04	9.9991E-02
39	3.0119E+06	1.4680E+05	4.9968E-02	89	2.4724E+05	1.2060E+04	5.0008E-02
40	2.8651E+06	1.3980E+05	5.0025E-02	90	2.3518E+05	1.1470E+04	5.0001E-02
41	2.7253E+06	1.3290E+05	4.9994E-02	91	2.2371E+05	1.0910E+04	4.9998E-02
42	2.5924E+06	1.2640E+05	4.9987E-02	92	2.1280E+05	1.0380E+04	5.0008E-02
43	2.4660E+06	8.0800E+04	3.3314E-02	93	2.0242E+05	9.8700E+03	4.9989E-02
44	2.3852E+06	1.9900E+04	8.3781E-03	94	1.9255E+05	9.3900E+03	4.9996E-02
45	2.3653E+06	1.9600E+04	8.3210E-03	95	1.8316E+05	8.9400E+03	5.0041E-02
46	2.3457E+06	3.8800E+04	1.6679E-02	96	1.7422E+05	8.4900E+03	4.9959E-02
47	2.3069E+06	7.5600E+04	3.3320E-02	97	1.6573E+05	8.0900E+03	5.0046E-02
48	2.2313E+06	1.0880E+05	4.9990E-02	98	1.5764E+05	7.6800E+03	4.9945E-02
49	2.1225E+06	1.0350E+05	4.9992E-02	99	1.4996E+05	7.3200E+03	5.0045E-02
50	2.0190E+06	9.8500E+04	5.0017E-02	100	1.4264E+05	6.9500E+03	4.9951E-02

Table 2 175 energy group structure of VITAMIN-J (continued).

Grp	Energy [eV]	delta-E	delta-U	Grp	Energy [eV]	delta-E	delta-U
101	1.3569E+05	6.6200E+03	5.0018E-02	141	1.5846E+03	3.5050E+02	2.4999E-01
102	1.2907E+05	6.3000E+03	5.0042E-02	142	1.2341E+03	2.7298E+02	2.5000E-01
103	1.2277E+05	5.9800E+03	4.9935E-02	143	9.6112E+02	2.1260E+02	2.5000E-01
104	1.1679E+05	5.7000E+03	5.0037E-02	144	7.4852E+02	1.6557E+02	2.5000E-01
105	1.1109E+05	1.3053E+04	1.2500E-01	145	5.8295E+02	1.2895E+02	2.5000E-01
106	9.8037E+04	1.1520E+04	1.2500E-01	146	4.5400E+02	1.0042E+02	2.4999E-01
107	8.6517E+04	4.0140E+03	4.7506E-02	147	3.5358E+02	7.8220E+01	2.5003E-01
108	8.2503E+04	3.0040E+03	3.7090E-02	148	2.7536E+02	6.0910E+01	2.5000E-01
109	7.9499E+04	7.5010E+03	9.9106E-02	149	2.1445E+02	4.7430E+01	2.4996E-01
110	7.1998E+04	4.6190E+03	6.6305E-02	150	1.6702E+02	3.6950E+01	2.5004E-01
111	6.7379E+04	1.0817E+04	1.7500E-01	151	1.3007E+02	2.8770E+01	2.4999E-01
112	5.6562E+04	4.0870E+03	7.5001E-02	152	1.0130E+02	2.2407E+01	2.4999E-01
113	5.2475E+04	6.1660E+03	1.2500E-01	153	7.8893E+01	1.7451E+01	2.5000E-01
114	4.6309E+04	5.4410E+03	1.2499E-01	154	6.1442E+01	1.3591E+01	2.5000E-01
115	4.0868E+04	6.5610E+03	1.7500E-01	155	4.7851E+01	1.0585E+01	2.5001E-01
116	3.4307E+04	2.4790E+03	7.5003E-02	156	3.7266E+01	8.2430E+00	2.4999E-01
117	3.1828E+04	3.3270E+03	1.1041E-01	157	2.9023E+01	6.4200E+00	2.5001E-01
118	2.8501E+04	1.5010E+03	5.4102E-02	158	2.2603E+01	4.9990E+00	2.4996E-01
119	2.7000E+04	9.4200E+02	3.5512E-02	159	1.7604E+01	3.8940E+00	2.5000E-01
120	2.6058E+04	1.2700E+03	4.9965E-02	160	1.3710E+01	3.0330E+00	2.5003E-01
121	2.4788E+04	6.1200E+02	2.4999E-02	161	1.0677E+01	2.3617E+00	2.4999E-01
122	2.4176E+04	5.9700E+02	2.5004E-02	162	8.3153E+00	1.8394E+00	2.5001E-01
123	2.3579E+04	1.7040E+03	7.5012E-02	163	6.4759E+00	1.4324E+00	2.4999E-01
124	2.1875E+04	2.5700E+03	1.2498E-01	164	5.0435E+00	1.1156E+00	2.5000E-01
125	1.9305E+04	4.2710E+03	2.5005E-01	165	3.9279E+00	8.6890E-01	2.5002E-01
126	1.5034E+04	3.3250E+03	2.4996E-01	166	3.0590E+00	6.7660E-01	2.4998E-01
127	1.1709E+04	1.1140E+03	9.9976E-02	167	2.3824E+00	5.2700E-01	2.5001E-01
128	1.0595E+04	1.4762E+03	1.5004E-01	168	1.8554E+00	4.1040E-01	2.4999E-01
129	9.1188E+03	2.0171E+03	2.5000E-01	169	1.4450E+00	3.1970E-01	2.5006E-01
130	7.1017E+03	1.5709E+03	2.5000E-01	170	1.1253E+00	2.4887E-01	2.4995E-01
131	5.5308E+03	1.2234E+03	2.5000E-01	171	8.7643E-01	1.9387E-01	2.5001E-01
132	4.3074E+03	6.0000E+02	1.5000E-01	172	6.8256E-01	1.5098E-01	2.5000E-01
133	3.7074E+03	3.5280E+02	9.9998E-02	173	5.3158E-01	1.1759E-01	2.5001E-01
134	3.3546E+03	3.1920E+02	9.9989E-02	174	4.1399E-01	3.1399E-01	1.4207E+00
135	3.0354E+03	2.8890E+02	1.0002E-01	175	1.0000E-01	9.9990E-02	9.2103E+00
136	2.7465E+03	1.3390E+02	4.9981E-02		1.0000E-05		
137	2.6126E+03	1.2740E+02	4.9993E-02				
138	2.4852E+03	2.3650E+02	1.0000E-01				
139	2.2487E+03	2.1400E+02	1.0000E-01				
140	2.0347E+03	4.5010E+02	2.5002E-01				

Table 3 HILO86R type 22+1 energy group structure for γ -ray.

Grp	Energy [MeV]	delta-E	delta-U
1	2.0000E+01	6.0000E+00	3.5667E-01
2	1.4000E+01	2.0000E+00	1.5415E-01
3	1.2000E+01	2.0000E+00	1.8232E-01
4	1.0000E+01	2.0000E+00	2.2314E-01
5	8.0000E+00	5.0000E-01	6.4539E-02
6	7.5000E+00	5.0000E-01	6.8993E-02
7	7.0000E+00	5.0000E-01	7.4108E-02
8	6.5000E+00	5.0000E-01	8.0043E-02
9	6.0000E+00	5.0000E-01	8.7011E-02
10	5.5000E+00	5.0000E-01	9.5310E-02
11	5.0000E+00	5.0000E-01	1.0536E-01
12	4.5000E+00	5.0000E-01	1.1778E-01
13	4.0000E+00	5.0000E-01	1.3353E-01
14	3.5000E+00	5.0000E-01	1.5415E-01
15	3.0000E+00	5.0000E-01	1.8232E-01
16	2.5000E+00	5.0000E-01	2.2314E-01
17	2.0000E+00	5.0000E-01	2.8768E-01
18	1.5000E+00	5.0000E-01	4.0547E-01
19	1.0000E+00	6.0000E-01	9.1629E-01
20	4.0000E-01	2.0000E-01	6.9315E-01
21	2.0000E-01	1.0000E-01	6.9315E-01
22	1.0000E-01	9.9000E-02	2.3026E+00
23	1.0000E-02	1.0000E-02	-
	0.0000E+00		

Table 4 BERMUDA type 41+3 energy group structure for γ -ray.

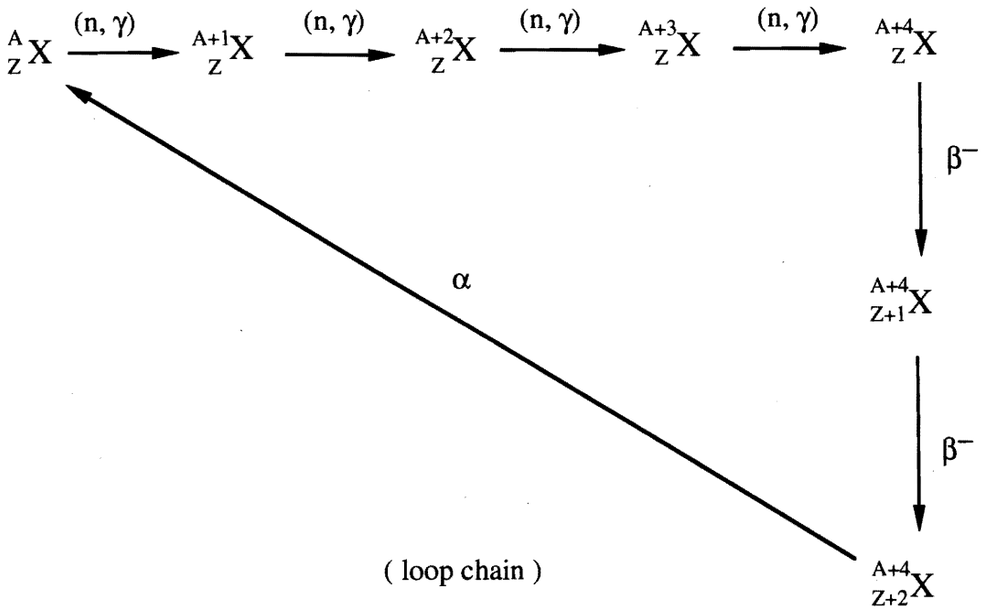
Grp	Energy [MeV]	delta-E	delta-U
1	2.0000E+01	4.0000E+00	2.2314E-01
2	1.6000E+01	2.0000E+00	1.3353E-01
3	1.4000E+01	2.0000E+00	1.5415E-01
4	1.2000E+01	2.0000E+00	1.8232E-01
5	1.0000E+01	1.0000E+00	1.0536E-01
6	9.0000E+00	1.0000E+00	1.1778E-01
7	8.0000E+00	5.0000E-01	6.4539E-02
8	7.5000E+00	5.0000E-01	6.8993E-02
9	7.0000E+00	5.0000E-01	7.4108E-02
10	6.5000E+00	5.0000E-01	8.0043E-02
11	6.0000E+00	5.0000E-01	8.7011E-02
12	5.5000E+00	5.0000E-01	9.5310E-02
13	5.0000E+00	5.0000E-01	1.0536E-01
14	4.5000E+00	5.0000E-01	1.1778E-01
15	4.0000E+00	5.0000E-01	1.3353E-01
16	3.5000E+00	5.0000E-01	1.5415E-01
17	3.0000E+00	5.0000E-01	1.8232E-01
18	2.5000E+00	2.5000E-01	1.0536E-01
19	2.2500E+00	2.5000E-01	1.1778E-01
20	2.0000E+00	2.5000E-01	1.3353E-01
21	1.7500E+00	2.5000E-01	1.5415E-01
22	1.5000E+00	1.2500E-01	8.7011E-02
23	1.3750E+00	1.2500E-01	9.5310E-02
24	1.2500E+00	1.2500E-01	1.0536E-01
25	1.1250E+00	1.2500E-01	1.1778E-01
26	1.0000E+00	1.2500E-01	1.0536E-01
27	9.0000E-01	1.0000E-01	1.1778E-01
28	8.0000E-01	1.0000E-01	1.3353E-01
29	7.0000E-01	1.0000E-01	1.5415E-01
30	6.0000E-01	8.8000E-02	2.3026E-01
31	5.1200E-01	2.0000E-03	3.9139E-03
32	5.1000E-01	6.0000E-02	1.2516E-01
33	4.5000E-01	5.0000E-02	1.1778E-01
34	4.0000E-01	1.0000E-01	2.8768E-01
35	3.0000E-01	1.0000E-01	4.0547E-01
36	2.0000E-01	5.0000E-02	2.8768E-01
37	1.5000E-01	5.0000E-02	4.0547E-01
38	1.0000E-01	2.0000E-02	2.2314E-01
39	8.0000E-02	2.0000E-02	2.8768E-01
40	6.0000E-02	1.5000E-02	2.8768E-01
41	4.5000E-02	1.5000E-02	4.0547E-01
42	3.0000E-02	1.0000E-02	4.0547E-01
43	2.0000E-02	1.0000E-02	6.9316E-01
44	1.0000E-02	1.0000E-02	-
	0.0000E+00		

Table 5 VITAMIN-J type 42 energy group structure for γ -ray.

Grp	Energy [MeV]	delta-E	delta-U
1	5.0000E+01	2.0000E+01	5.1083E-01
2	3.0000E+01	1.0000E+01	4.0547E-01
3	2.0000E+01	6.0000E+00	2.8768E-01
4	1.4000E+01	2.0000E+00	1.5415E-01
5	1.2000E+01	2.0000E+00	1.8232E-01
6	1.0000E+01	2.0000E+00	2.2314E-01
7	8.0000E+00	5.0000E-01	6.4539E-02
8	7.5000E+00	5.0000E-01	6.8993E-02
9	7.0000E+00	5.0000E-01	7.4108E-02
10	6.5000E+00	5.0000E-01	8.0043E-02
11	6.0000E+00	5.0000E-01	8.7011E-02
12	5.5000E+00	5.0000E-01	9.5310E-02
13	5.0000E+00	5.0000E-01	1.0536E-01
14	4.5000E+00	5.0000E-01	1.1778E-01
15	4.0000E+00	5.0000E-01	1.3353E-01
16	3.5000E+00	5.0000E-01	1.5415E-01
17	3.0000E+00	5.0000E-01	1.8232E-01
18	2.5000E+00	5.0000E-01	2.2314E-01
19	2.0000E+00	3.4000E-01	1.8633E-01
20	1.6600E+00	1.6000E-01	1.0135E-01
21	1.5000E+00	1.6000E-01	1.5415E-01
22	1.3400E+00	1.0000E-02	1.1280E-01
23	1.3300E+00	3.3000E-01	2.8518E-01
24	1.0000E+00	2.0000E-01	2.2314E-01
25	8.0000E-01	1.0000E-01	1.3353E-01
26	7.0000E-01	1.0000E-01	1.5415E-01
27	6.0000E-01	8.8000E-02	1.5861E-01
28	5.1200E-01	2.0000E-03	3.9139E-03
29	5.1000E-01	6.0000E-02	1.2516E-01
30	4.5000E-01	5.0000E-02	1.1778E-01
31	4.0000E-01	1.0000E-01	2.8768E-01
32	3.0000E-01	1.0000E-01	4.0547E-01
33	2.0000E-01	5.0000E-02	2.8768E-01
34	1.5000E-01	5.0000E-02	4.0547E-01
35	1.0000E-01	2.5000E-01	2.8768E-01
36	7.5000E-02	5.0000E-03	6.8993E-02
37	7.0000E-02	1.0000E-02	1.5415E-01
38	6.0000E-02	1.5000E-02	2.8768E-01
39	4.5000E-02	1.5000E-02	4.0547E-01
40	3.0000E-02	1.0000E-02	4.0547E-01
41	2.0000E-02	1.0000E-02	6.9316E-01
42	1.0000E-02	9.9000E-02	2.3026E+00
43	1.0000E-03	1.0000E-03	-
	0.0000E+00		

Table 6 FISPACT3 type 23+1 energy group structure for γ -ray.

Grp	Energy [MeV]	delta-E	delta-U
1	2.0000E+01	6.0000E+00	2.8768E-01
2	1.4000E+01	2.0000E+00	1.5415E-01
3	1.2000E+01	2.0000E+00	1.8232E-01
4	1.0000E+01	2.0000E+00	2.2314E-01
5	8.0000E+00	2.0000E+00	2.0764E-01
6	6.5000E+00	1.5000E+00	2.6234E-01
7	5.0000E+00	1.0000E+00	2.2314E-01
8	4.0000E+00	1.0000E+00	2.8768E-01
9	3.0000E+00	5.0000E-01	1.8232E-01
10	2.5000E+00	5.0000E-01	2.2314E-01
11	2.0000E+00	3.4000E-01	1.8633E-01
12	1.6600E+00	2.2000E-01	1.4217E-01
13	1.4400E+00	2.2000E-01	1.6579E-01
14	1.2200E+00	2.2000E-01	1.9885E-01
15	1.0000E+00	2.0000E-01	2.2314E-01
16	8.0000E-01	2.0000E-01	2.8768E-01
17	6.0000E-01	2.0000E-01	4.0547E-01
18	4.0000E-01	1.0000E-01	2.8768E-01
19	3.0000E-01	1.0000E-01	4.0547E-01
20	2.0000E-01	1.0000E-01	6.9316E-01
21	1.0000E-01	5.0000E-02	6.9316E-01
22	5.0000E-02	3.0000E-02	9.1629E-01
23	2.0000E-02	1.0000E-02	6.9316E-01
24	1.0000E-02	1.0000E-02	-
	0.0000E+00		



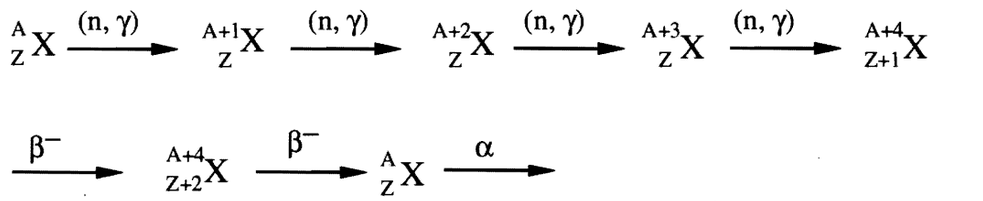


Fig. 1 Example of the loop chain and approximated linear chain with equal length.

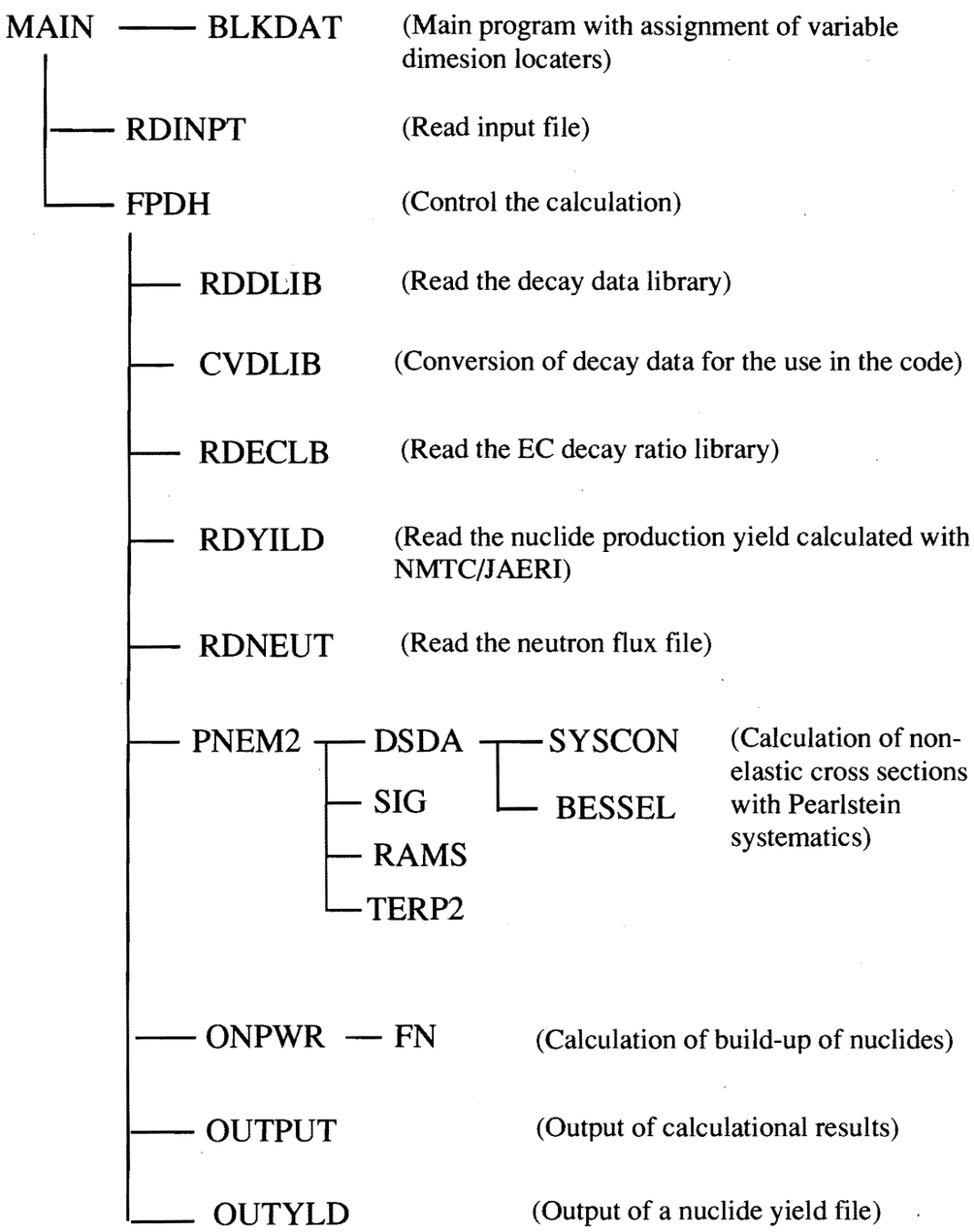


Fig. 2 Program structure of the DCHAIN-SP code.

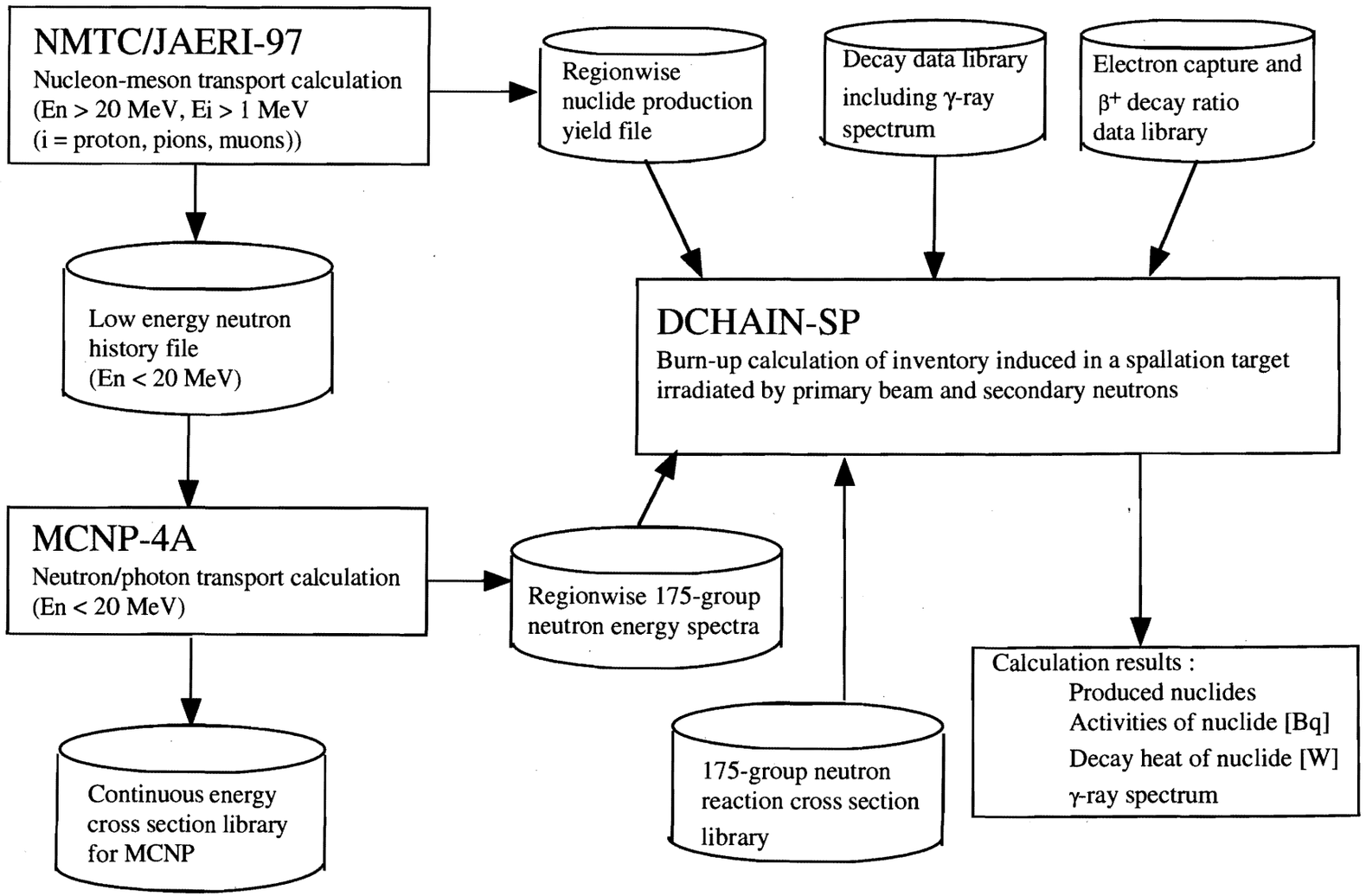


Fig. 3 Flow of the decay and build-up characteristics calculation of spallation products using DCHAIN-SP.

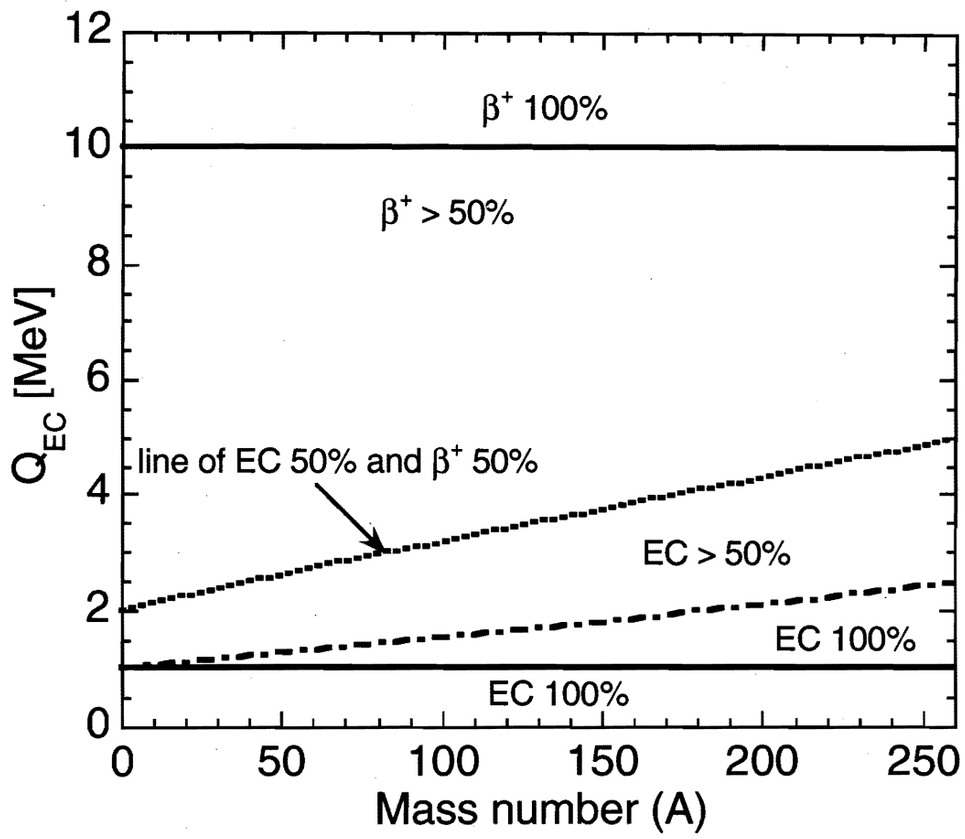


Fig. 4 Ratio of β^+ and electron capture decay as a function of the Q-value and the mass number of nuclides.

Appendix A

Data Format of Decay Data Library

A-1 Data format of decay data library.

A-2 Example of decay data.

A-1 Data format of decay data library.

1-st record ('%", 1X, A6, 2E12.5, E14.7, E12.5, A12)

1. NUCL — Name of nuclide indicated by 6 characters as the symbol of a chemical element (A2) + mass number (I3) + state identifier (A1). The nuclear state is represented by the following three kinds of characters : blank character for ground state, 'm' for first isomeric state and 'n' for second isomeric state.
2. ZA — Designation of nuclides expressed with 1000.xZ +A, where Z and A indicate the atomic and mass numbers of target nuclide.
3. AWR — Ratio of the mass of atom to that of neutron. Here, the neutron mass is taken to be 1.008665 AMU in the C-12 system.
4. T12 — Half-life of the nuclide [seconds]. If the nuclide is stable, the value of 0.0 is given.
5. QAV — Q-value of decay averaged with the weight of branching ratio [MeV].
6. THF — Explicit half-life of nuclide. The half-life is given by 12 characters which is represented by the format of (F11.6 or E11.4) plus time unit identifier (A1). The time unit is represented by the following characters : 's' for seconds, 'm' for minutes, 'h' for hours, 'd' for days and 'y' for years. The stable nuclides are designated as 'stable'.

2-nd record (A18, A54, A8)

1. REF — Reference of the decay data. 18 characters.
2. CMT — Comment for the decay data 54 characters.
3. EVDATE — Evaluated data of the decay data.

3-rd record (3I6, 4E12.5)

1. NDK — Total number of decay modes given. If the nuclide is stable, NDK=0.
2. NSP — Total number of radiation types for which spectral information is given. NSP may be zero.
3. LGAM — Flag for fission yield. (0/1 = no yield/ yield given, usually 0)
4. EBB — Average beta-decay energy [MeV].
5. EGG — Average gamma-decay energy [MeV].
6. EAA — Average alpha-decay energy [MeV].
7. SPI — The spin of the nucleus. If the spin is unknown, SPI is set as -77.777.

4-th record (F12.2, 2E12.5, 6X, A6) ; This record is given if NDK>0, and repeated NDK times.

1. RTYP — Decay mode of the nuclide

0.0	γ	Gamma decay
1.0	β^-	Beta decay
2.0	e.c., (β^+)	Beta decay
3.0	IT	Isomeric transition
4.0	α	Alpha decay
5.0	n	Neutron emission (not delayed neutron decay)
6.0	SF	Spontaneous fission
7.0	p	Proton emission
10.0	-	Unknown origin

1.1	β⁻,β⁻	Beta decay followed by beta decay
1.4	β⁻,α	Beta decay followed by alpha particle emission (N-16 decay)
1.5	β⁻,n	Beta decay followed by neutron emission (delayed neutron decay)
15.5	β⁻,2n	Beta decay followed by two neutron emission
155.5	β⁻,3n	Beta decay followed by three neutron emission
15.4	β⁻,nα	Beta decay followed by neutron and alpha particle emission
2.4	β⁺,α	Positron decay followed by two neutron emission
2.7	β⁺,p	Positron decay followed by proton emission
27.7	β⁺,2p	Positron decay followed by two proton emission
7.7	2p	Two proton emission

2. Q — Total decay energy available in the corresponding decay process [MeV].
3. BR — Fraction of the decay of the nuclide by the corresponding decay mode.
4. NUCLD — Daughter nuclide name by decay (refer 'NUCL" ; 6 characters)

5-th record (4I6, E12.5, F12.2)

1. KTYP — the radiation type

0	γ	Gamma-rays
1	β⁻	Beta-rays
2	e.c., (β⁺)	Electron capture and/or positron emission
3	IT	Isomeric transition
4	α	Alpha particles
5	n	Neutrons
6	SF	Spontaneous fission fragments
7	p	Protons
8	e-	Discrete electrons
9	x	X-rays and annihilation radiation (photons not arising as transitions between nuclear state)

2. NSPDS — Number of discrete energy spectrum set
3. NSPCN — Number of continuum energy spectrum set
4. NSPCNR — Number of interpolation ranges for continuum spectrum. If interpolation is constant of histogram ; INT=0, only or no continuum spectrum, NSPCNR =0
5. ERAV — Produced Average decay energy of radiation [MeV]
6. RTYPCN — Decay mode for continuum energy spectrum (refer 'RTYP' ; if no continuum spectrum, RTYPCN=-1.0)

6-th record (6E12.5) {if NSP > 0 and NSPDS > 0}
((SPDS (i, j), i = 1, 3), j = 1, NSPDS) {if NDK > 1}
((SPDS (i, j), i = 1, 2), j = 1, NSPDS) {If NDK > 1}
SPDS — Discrete energy spectrum set (i = 1 is discrete energy of radiation , i = 2 is intensity, and i = 3 is the decay mode (refer 'RTYP' ; if NDK =1, i =3 is not entered))

7-th record (6E12.5) {if NSP > 0 and NSPCN > 0}
((SPCN (i, j), i = 1, 2), j = 1, NSPCN+NSPCNR)
SPCN — Linearized spectrum of the continuum component (i = 1 is energy and i = 2 is intensity for j = 1, NSPCN ; i =1 is number separating the interpolation range and i =2 is interpolation scheme identification number for j = NSPCN + 1,

NSPCN+NSPCNR

If NSP > 0, sets of 5-th to 7-th records are repeated NSP times.

8-th record (6E12.5) {if LGAM = 1}
(GAMMAX(i), i = 1, 10) 10 cumulative fission yields [%]

A-2 Example of decay data.

```
% Kr 80  3.60800E+04 7.93130E+01  .0000000E+00  .00000E+00      stable
eaf3dec1.002      stable nuclide
     0     0     0  .00000E+00  .00000E+00  .00000E+00  .00000E+00
% Kr 81  3.60810E+04 8.02210E+01 7.2266898E+12 2.84000E-01 2.2900E+05y
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/01/01
     1     1     0 4.76590E-03 1.65000E-02  .00000E+00 3.50000E+00
        2.00 2.84000E-01 1.00000E+00      Br 81
     0     1     0     0 8.19690E-04       -1.00        2.00
 2.75990E-01 2.97000E-03
% Kr 81m 3.60810E+04 8.02210E+01 1.3100000E+01 1.90307E-01  13.100000s
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/07/01
     2     1     0 6.41965E-02 1.26088E-01  .00000E+00-5.00000E-01
        2.00 4.71400E-01 2.50000E-05      Br 81
        3.00 1.90300E-01 9.99975E-01      Kr 81
     0     1     0     0 1.23695E-01       -1.00        2.00
 1.90460E-01 9.99975E-01
% Kr 82  3.60820E+04 8.12960E+01  .0000000E+00  .00000E+00      stable
eaf3dec1.002      stable nuclide
     0     0     0  .00000E+00  .00000E+00  .00000E+00  .00000E+00
% Kr 83  3.60830E+04 8.22870E+01  .0000000E+00  .00000E+00      stable
eaf3dec1.002      stable nuclide
     0     0     0  .00000E+00  .00000E+00  .00000E+00  .00000E+00
% Kr 83m 3.60830E+04 8.22020E+01 6.5880000E+03 4.15600E-02   1.830000h
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/01/01
     1     1     0 3.89677E-02 2.60662E-03  .00000E+00-5.00000E-01
        3.00 4.15600E-02 1.00000E+00      Kr 83
     0     2     0     0 4.78046E-04       -1.00        3.00
 9.39600E-03 4.90000E-02 3.21473E-02 5.48800E-04
% Kr 84  3.60840E+04 8.32780E+01  .0000000E+00  .00000E+00      stable
eaf3dec1.002      stable nuclide
     0     0     0  .00000E+00  .00000E+00  .00000E+00  .00000E+00
% Kr 85  3.60850E+04 8.41830E+01 3.3943350E+08 6.87000E-01  10.755999y
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/01/01
     1     1     0 2.50488E-01 2.21016E-03  .00000E+00 4.50000E+00
        1.00 6.87000E-01 1.00000E+00      Rb 85
     0     4     0     0 2.21016E-03       -1.00        1.00
 1.29810E-01 4.34000E-09 1.51180E-01 2.17000E-08 3.62810E-01 2.17000E-08
 5.13997E-01 4.34000E-03
% Kr 85m 3.60850E+04 8.41830E+01 1.6128000E+04 8.44954E-01   4.480000h
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/01/01
     2     1     0 2.55013E-01 1.58019E-01  .00000E+00-5.00000E-01
        1.00 9.92000E-01 7.86000E-01      Rb 85
        3.00 3.04870E-01 2.14000E-01      Kr 85
     0     7     0     0 1.57289E-01       -1.00        1.00
 1.29810E-01 2.99938E-03 1.51195E-01 7.49844E-01 2.81010E-01 7.49844E-06
 3.04870E-01 1.40170E-01 4.51000E-01 1.12477E-04 5.80600E-01 7.49844E-06
 7.31600E-01 7.49844E-05
% Kr 86  3.60860E+04 8.52610E+01  .0000000E+00  .00000E+00      stable
eaf3dec1.002      stable nuclide
     0     0     0  .00000E+00  .00000E+00  .00000E+00  .00000E+00
% Kr 87  3.60870E+04 8.61670E+01 4.5780000E+03 3.88900E+00   1.271667h
JEF-2             RCOM-JUL83 JEF DECAY DATA WORKING GROUP              92/01/01
     1     1     0 1.35000E+00 7.92000E-01  .00000E+00 4.50000E+00
```

```
        1.00 3.88900E+00 1.00000E+00       Rb 87
     0    33     0     0 7.87876E-01        -1.00         1.00
 1.29400E-01 4.46400E-04 4.02587E-01 4.96000E-01 5.10780E-01 6.94400E-04
 5.82300E-01 3.47200E-04 6.73830E-01 1.88976E-02 8.14250E-01 1.63680E-03
 8.36370E-01 7.68800E-03 8.45440E-01 7.34080E-02 8.94020E-01 4.51360E-04
 9.01500E-01 2.62880E-04 9.46690E-01 1.28960E-03 9.76490E-01 5.65440E-04
 1.06310E+00 2.67840E-04 1.17540E+00 1.10608E-02 1.33800E+00 6.34880E-03
 1.38255E+00 2.87680E-03 1.38987E+00 1.19040E-03 1.46130E+00 4.96000E-04
 1.53120E+00 3.57120E-03 1.57803E+00 1.28960E-03 1.61118E+00 1.04160E-03
 1.74052E+00 2.03856E-02 1.84261E+00 1.38880E-03 2.01188E+00 2.88176E-02
 2.37850E+00 9.42400E-04 2.40850E+00 2.28160E-03 2.55480E+00 9.22560E-02
 2.55810E+00 3.91840E-02 2.65250E+00 2.33120E-04 2.81140E+00 3.22400E-03
 2.96120E+00 6.94400E-04 3.05510E+00 8.43200E-04 3.30850E+00 4.46400E-03
% Kr 88  3.60880E+04 8.71590E+01 1.0224000E+04 2.91300E+00   2.840000h
JEF-2              RCOM-JUL83 JEF DECAY DATA WORKING GROUP                92/01/01
     1     1     0 3.64330E-01 1.95106E+00  .00000E+00  .00000E+00
        1.00 2.91300E+00 1.00000E+00       Rb 88
     0    87     0     0 1.94929E+00        -1.00         1.00
 2.75130E-02 1.93760E-02 2.82600E-02 2.76800E-04 1.22270E-01 1.97220E-03
 1.65980E-01 3.10362E-02 1.68500E-01 6.92000E-05 1.76710E-01 2.42200E-04
 1.96301E-01 2.59846E-01 2.40710E-01 2.52580E-03 2.68240E-01 3.11400E-04

 3.11690E-01 1.07260E-03 3.34710E-01 1.45320E-03 3.50040E-01 1.73000E-04
 3.62226E-01 2.24900E-02 3.63500E-01 4.84400E-04 3.90543E-01 6.43560E-03
 3.91200E-01 7.95800E-04 4.21700E-01 1.03800E-04 4.71800E-01 7.26600E-03
 5.00020E-01 9.68800E-04 5.17000E-01 3.46000E-04 5.70570E-01 6.22800E-04
 5.73270E-01 7.26600E-04 5.79040E-01 2.42200E-04 6.03210E-01 4.15200E-04
 6.65940E-01 8.65000E-04 6.77340E-01 2.35280E-03 7.31010E-01 3.46000E-04
 7.41340E-01 3.46000E-04 7.74140E-01 9.68800E-04 7.79120E-01 9.68800E-04
 7.88280E-01 5.32840E-03 7.90320E-01 1.24560E-03 7.98650E-01 2.76800E-04
 8.22010E-01 8.99600E-04 8.34830E-01 1.29750E-01 8.50340E-01 1.73000E-03
 8.62327E-01 6.71240E-03 8.79510E-01 2.42200E-04 8.83060E-01 4.15200E-04
 9.44920E-01 2.94100E-03 9.50490E-01 3.80600E-04 9.61830E-01 8.30400E-04
 9.85780E-01 1.31480E-02 9.90090E-01 1.41860E-03 1.03959E+00 4.84400E-03
 1.04948E+00 1.41860E-03 1.05454E+00 3.11400E-04 1.09053E+00 6.22800E-04
 1.14133E+00 1.28366E-02 1.17951E+00 9.96480E-03 1.18495E+00 6.88540E-03
 1.20984E+00 1.41860E-03 1.21273E+00 1.38400E-03 1.24522E+00 3.63300E-03
 1.25067E+00 1.12104E-02 1.29878E+00 9.34200E-04 1.30309E+00 6.57400E-04
 1.32498E+00 1.59160E-03 1.33581E+00 6.57400E-04 1.35232E+00 1.59160E-03
 1.36950E+00 1.47742E-02 1.40694E+00 2.17980E-03 1.46484E+00 1.14180E-03
 1.51839E+00 2.15212E-02 1.52977E+00 1.09336E-01 1.60379E+00 4.56720E-03
 1.60801E+00 6.92000E-04 1.66130E+00 8.99600E-04 1.68560E+00 6.64320E-03
 1.78914E+00 4.49800E-04 1.79330E+00 3.46000E-04 1.80130E+00 3.80600E-04
 1.89276E+00 1.38400E-03 1.90870E+00 1.00340E-03 2.02984E+00 4.52914E-02
 2.03541E+00 3.73680E-02 2.18650E+00 2.87180E-03 2.19584E+00 1.31826E-01
 2.23177E+00 3.39080E-02 2.25950E+00 3.11400E-04 2.35208E+00 7.30060E-03
 2.36470E+00 3.11400E-04 2.39211E+00 3.46000E-01 2.40891E+00 1.03800E-03
 2.53552E+00 4.15200E-04 2.54840E+00 6.22800E-03 2.77102E+00 1.48780E-03
```

Appendix B

Data format of 175-group neutron flux file for collapsing the neutron reaction cross section data.

B-1 Data format of 175-group neutron flux file for collapsing the neutron reaction cross section data.

B-2 Example of 175-group neutron flux calculated with the MCNP4A code.

B-1 Data format of 175-group neutron flux file for collapsing the neutron reaction cross section data.

CARD 1 (A80)

(1) HTITL1: Title for calculation (up to 80 characters).

CARD 2 (A80)

(1) HTITL2: Title for calculation (up to 80 characters).

CARD 3 (*)

(1) NG: Number of neutron spectrum data (maximum 175).

(2) FN: Normalization constant for neutron spectrum data.
Positive real number should be given. If the 0.0 is given the neutron intensity is normalized to 1.0.

CARD 4 (*)

(SPCN(i), i=1,NG) : Neutron spectrum from first to NG group. The group structure is submitted to that taken in the VITAMIN-J. The data should be given in descending order from the highest energy.

B-2 Example of 175-group neutron flux calculated with the MCNP4A code.

```
mcnp neutron spectrum: all regions
vitamin-j 175-groups
  175         8.7735E+13
  7.8176E-05  1.4837E-05  1.4933E-05  3.0928E-05  3.1950E-05  1.6484E-05
  1.6601E-05  1.7157E-05  1.7231E-05  3.5551E-05  1.8338E-05  1.8813E-05
  3.8693E-05  4.0124E-05  4.1165E-05  4.2802E-05  4.4075E-05  4.5566E-05
  4.6683E-05  4.8062E-05  4.9793E-05  5.0595E-05  5.2025E-05  5.3342E-05
  1.8142E-05  3.6484E-05  5.5847E-05  5.7233E-05  5.8363E-05  5.9512E-05
  6.1036E-05  6.2495E-05  6.4228E-05  1.3425E-04  1.4228E-04  1.5192E-04
  7.9470E-05  8.2298E-05  8.5672E-05  8.9063E-05  9.1110E-05  9.4840E-05
  6.5206E-05  1.6695E-05  1.6578E-05  3.3762E-05  6.8592E-05  1.0688E-04
  1.1126E-04  1.1564E-04  1.2025E-04  1.2490E-04  1.2967E-04  1.3547E-04
  1.4092E-04  1.4742E-04  1.5491E-04  1.6333E-04  1.7134E-04  1.7893E-04
  1.8702E-04  3.9969E-04  1.7353E-04  2.4976E-04  2.2164E-04  2.2744E-04
  2.3197E-04  2.3573E-04  2.3941E-04  2.4182E-04  2.4329E-04  2.4288E-04
  2.4218E-04  2.3989E-04  2.3720E-04  2.3337E-04  4.5457E-04  4.3329E-04
  2.0757E-04  2.0044E-04  3.8261E-04  3.5807E-04  4.0051E-05  1.4825E-05
  3.1012E-05  8.4442E-05  1.6487E-04  3.1372E-04  1.4918E-04  1.4402E-04
  1.3898E-04  1.3424E-04  1.3096E-04  1.2930E-04  1.2188E-04  1.1684E-04
  1.1182E-04  1.0373E-04  9.3471E-05  9.1403E-05  9.5509E-05  9.6724E-05
  9.0582E-05  7.9840E-05  1.8592E-04  1.6155E-04  4.9122E-05  3.6526E-05
  8.9129E-05  6.6710E-05  1.5576E-04  4.9247E-05  1.3293E-04  8.3079E-05
  9.1223E-05  3.6908E-05  4.1417E-05  1.9862E-05  7.2918E-06  8.0112E-06
  1.1495E-05  8.6992E-06  2.2197E-05  2.9384E-05  4.3489E-05  3.0927E-05
  5.8983E-06  6.6573E-06  1.6447E-05  5.4900E-06  3.1430E-06  1.3935E-06
  8.3649E-07  6.3735E-07  4.6882E-07  1.0727E-07  8.3704E-08  5.0231E-07
  1.3276E-07  1.1417E-06  8.4722E-07  4.7414E-07  2.8644E-07  1.8045E-07
  9.7689E-08  7.1385E-08  6.5044E-08  5.0186E-08  3.2413E-08  2.7323E-08
  2.1261E-08  1.3742E-08  8.8717E-09  6.3489E-09  4.0091E-09  3.8561E-09
  2.7290E-09  2.2456E-09  2.1825E-09  1.8949E-09  1.3250E-09  1.1149E-09
  9.3291E-10  5.7705E-10  4.0632E-10  4.9933E-10  1.7895E-10   .0000E+00
   .0000E+00   .0000E+00   .0000E+00   .0000E+00   .0000E+00   .0000E+00
   .0000E+00
```

Appendix C

Sample Problem for DCHAIN-SP Calculation

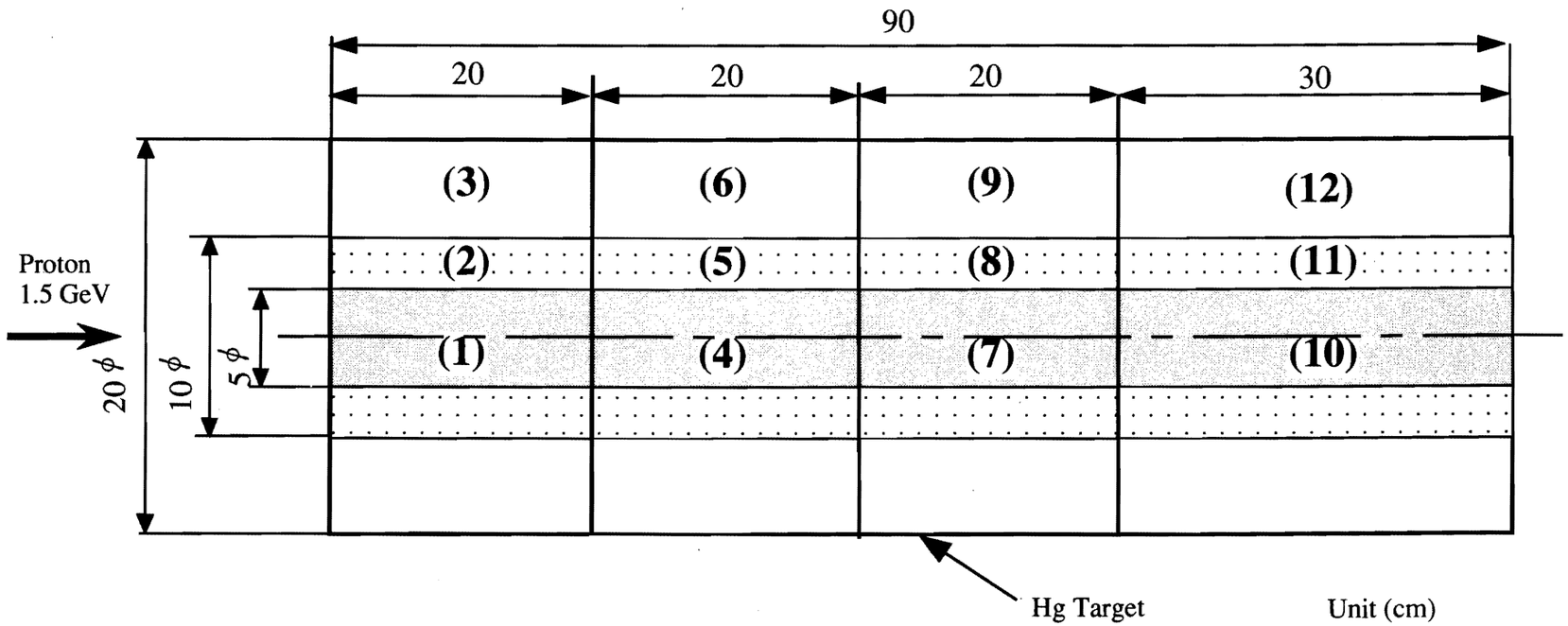


Fig. C-1 Illustration of the mercury target for sample problem. The number in parentheses indicates the region number assigned in the input card.

```
hg cylinder target (2): d=20cm,l=90cm
1.5GeV proton; activation calc.
0.  0
     1500.         1.        20.          1     10000        100          0
        1         23         21         11         0         22
       0.         0.          1          0         0          0
        1    1    2    3
       0.         7
       80.    196.   5.9595E-5
       80.    198.   3.9611E-3
       80.    199.   6.7025E-3
       80.    200.   9.1776E-3
       80.    201.   5.2364E-3
       80.    202.   1.1863E-2
       80.    204.   2.7295E-3
cylinder target
 0  0  1  0
rcc  1  0.0  0.0   0.0  0.0  0.0  20.0  2.5
rcc  2  0.0  0.0  20.0  0.0  0.0  20.0  2.5
rcc  3  0.0  0.0  40.0  0.0  0.0  20.0  2.5
rcc  4  0.0  0.0  60.0  0.0  0.0  30.0  2.5
rcc  5  0.0  0.0   0.0  0.0  0.0  20.0  5.0
rcc  6  0.0  0.0  20.0  0.0  0.0  20.0  5.0
rcc  7  0.0  0.0  40.0  0.0  0.0  20.0  5.0
rcc  8  0.0  0.0  60.0  0.0  0.0  30.0  5.0
rcc  9  0.0  0.0   0.0  0.0  0.0  20.0  10.0
rcc 10  0.0  0.0  20.0  0.0  0.0  20.0  10.0
rcc 11  0.0  0.0  40.0  0.0  0.0  20.0  10.0
rcc 12  0.0  0.0  60.0  0.0  0.0  30.0  10.0
rcc 13  0.0  0.0  -2.0  0.0  0.0  94.0  11.0
rcc 14  0.0  0.0   4.0  0.0  0.0   2.0  10.1
rcc 15  0.0  0.0   9.0  0.0  0.0   2.0  10.1
rcc 16  0.0  0.0  14.0  0.0  0.0   2.0  10.1
rcc 17  0.0  0.0  29.0  0.0  0.0   2.0  10.1
rcc 18  0.0  0.0  58.0  0.0  0.0   4.0  10.1
end
tgi    +1
tgi    +2
tgi    +3
tgi    +4
tgm    +5  -1
tgm    +6  -2
tgm    +7  -3
tgm    +8  -4
tgo    +9  -5
tgo    +10  -6
tgo    +11  -7
tgo    +12  -8
foi    +14  -9
foi    +15  -9
foi    +16  -9
foi    +17  -10
foi    +18  -11  -12
```

Fig. C-2 Input card of sample problem for the NMTC/JAERI97 calculation.

```
vod     +13  -9  -10  -11  -12  -14  -15  -16  -17  -18
out     -13
end
  1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19
  19*0
  12*1  6*1000  0
  0
no-importance
source      1
       2.50     -1.0     -1.0       1500.00          0.          0.          1.
tally       track
tally       yield
tally       heat
energy      61
energy         0.0       1.11       1.35       1.65       2.02       2.46
energy        3.01       3.68       4.49       5.49       6.70       8.19
energy       10.00      12.20      13.50      14.90      17.50      20.00
energy       22.50      25.00      27.50      30.00      35.00      40.00
energy       45.00      50.00      55.00      60.00      65.00      70.00
energy       80.00      90.00     100.00     110.00     120.00     140.00
energy      160.00     180.00     200.00     225.00     250.00     275.00
energy      300.00     325.00     350.00     375.00     400.00     450.00
energy      500.00     550.00     600.00     650.00     700.00     750.00
energy      800.00     900.00    1000.00    1100.00    1200.00    1300.00
energy      1400.0    1500.00
volume      392.699   392.699   392.699   589.049
volume      1178.10   1178.10   1178.10   1767.15
volume      4712.39   4712.39   4712.39   7068.58
volume      12.6292   12.6292   12.6292   12.6292   25.2584
region      -1
region      1  12
t-region    -1
t-region    1  17
sp-unit     1
pt-surf     2
```

Fig. C-2 Input card of sample problem for the NMTC/JAERI97 calculation (continued).

```
saei-mcnp4a  spallation target analysis for induced activity
c            Hg target (2) (d=20cm, l=90cm)
c
   1  1  3.97300E-02        -1              4      -5
   2  1  3.97300E-02        -2       1      4      -5
   3  1  3.97300E-02        -3       2      4      -5
   4  1  3.97300E-02        -1              5      -6
   5  1  3.97300E-02        -2       1      5      -6
   6  1  3.97300E-02        -3       2      5      -6
   7  1  3.97300E-02        -1              6      -7
   8  1  3.97300E-02        -2       1      6      -7
   9  1  3.97300E-02        -3       2      6      -7
  10  1  3.97300E-02        -1              7      -8
  11  1  3.97300E-02        -2       1      7      -8
  12  1  3.97300E-02        -3       2      7      -8
  21  0                    -11       3     12     -13
  22  0                    -11       3     14     -15
  23  0                    -11       3     16     -17
  24  0                    -11       3     18     -19
  25  0                    -11       3     20     -21
  26  0                    -11       3      4     -12
  27  0                    -11       3     13     -14
  28  0                    -11       3     15     -16
  29  0                    -11       3     17     -18
  30  0                    -11       3     19     -20
  31  0                    -11       3     21      -8
  32  0                    -10      11      4      -8
 101  0                     10 :    -4 :     8

   1      cz    2.5
   2      cz    5.0
   3      cz   10.0
   4      pz   -0.000001
   5      pz   20.0
   6      pz   40.0
   7      pz   60.0
   8      pz   90.0
  10      cz   11.0
  11      cz   10.1
  12      pz    4.0
  13      pz    6.0
  14      pz    9.0
  15      pz   11.0
  16      pz   14.0
  17      pz   16.0
  18      pz   29.0
  19      pz   31.0
  20      pz   58.0
  21      pz   62.0

mode   n
imp:n  1 23r 0
```

Fig. C-3 Input card of sample problem for the MCNP4A calculation.

```
m1      80196.37c  5.9595e-5    80198.37c  3.9611e-3
        80199.37c  6.7025e-3    80200.37c  9.1776e-3
        80201.37c  5.2364e-3    80202.37c  1.1863e-2
        80204.37c  2.7295e-3
fc14    -- neutron cell tally in target region
f14:n   1 10i 12
fq14    t e f
fc24    -- neutron cell tally in activation-foil region
f24:n   21 3i 25
fq24    t e f
c                                    < neutron 175-group for vitamine-j >
e0       1.00001d-11 1.00001d-07 4.13994d-07 5.31578d-07 6.82560d-07
         8.76425d-07 1.12535d-06 1.44498d-06 1.85539d-06 2.38237d-06
         3.05902d-06 3.92786d-06 5.04348d-06 6.47595d-06 8.31529d-06
         1.06770d-05 1.37096d-05 1.76035d-05 2.26033d-05 2.90232d-05
         3.72665d-05 4.78512d-05 6.14421d-05 7.88932d-05 1.01301d-04
         1.30073d-04 1.67017d-04 2.14454d-04 2.75364d-04 3.53575d-04
         4.53999d-04 5.82947d-04 7.48518d-04 9.61116d-04 1.23410d-03
         1.58461d-03 2.03468d-03 2.24867d-03 2.48517d-03 2.61259d-03
         2.74654d-03 3.03539d-03 3.35463d-03 3.70744d-03 4.30742d-03
         5.53084d-03 7.10174d-03 9.11882d-03 1.05946d-02 1.17088d-02
         1.50344d-02 1.93045d-02 2.18749d-02 2.35786d-02 2.41755d-02
         2.47875d-02 2.60584d-02 2.70001d-02 2.85011d-02 3.18278d-02
         3.43067d-02 4.08677d-02 4.63092d-02 5.24752d-02 5.65622d-02
         6.73794d-02 7.19981d-02 7.94987d-02 8.25034d-02 8.65169d-02
         9.80366d-02 1.11090d-01 1.16786d-01 1.22773d-01 1.29068d-01
         1.35686d-01 1.42642d-01 1.49956d-01 1.57644d-01 1.65727d-01
         1.74224d-01 1.83156d-01 1.92547d-01 2.02419d-01 2.12797d-01
         2.23708d-01 2.35177d-01 2.47235d-01 2.73237d-01 2.87247d-01
         2.94518d-01 2.97211d-01 2.98491d-01 3.01974d-01 3.33733d-01
         3.68832d-01 3.87742d-01 4.07622d-01 4.50492d-01 4.97871d-01
         5.23397d-01 5.50232d-01 5.78444d-01 6.08101d-01 6.39279d-01
         6.72055d-01 7.06512d-01 7.42736d-01 7.80817d-01 8.20850d-01
         8.62936d-01 9.07180d-01 9.61640d-01 1.00259d+00 1.10803d+00
         1.16484d+00 1.22456d+00 1.28735d+00 1.35335d+00 1.42274d+00
         1.49569d+00 1.57237d+00 1.65299d+00 1.73774d+00 1.82684d+00
         1.92050d+00 2.01897d+00 2.12248d+00 2.23130d+00 2.30686d+00
         2.34570d+00 2.36525d+00 2.38521d+00 2.46597d+00 2.59240d+00
         2.72532d+00 2.86505d+00 3.01194d+00 3.16637d+00 3.32871d+00
         3.67879d+00 4.06570d+00 4.49329d+00 4.72367d+00 4.96585d+00
         5.22046d+00 5.48812d+00 5.76950d+00 6.06531d+00 6.37628d+00
         6.59238d+00 6.70320d+00 7.04688d+00 7.40818d+00 7.78801d+00
         8.18731d+00 8.60708d+00 9.04837d+00 9.51229d+00 1.00000d+01
         1.05127d+01 1.10517d+01 1.16183d+01 1.22140d+01 1.25232d+01
         1.28400d+01 1.34986d+01 1.38403d+01 1.41907d+01 1.45499d+01
         1.49183d+01 1.56831d+01 1.64872d+01 1.69046d+01 1.73325d+01
         2.00000d+01
rdum    10.0  -0.00001  90.0     $ cylinder source region of target
idum    0  1                     $ number of previous sources
nps     36836654
ctme    0
prdmp   50000000  3000000  0  2
lost    10  10
print
```

Fig. C-3 Input card of sample problem for the MCNP4A calculation (continued).

```
regionwise nuclear yield (or production)  [numbers/source]
 ------------------------------------------------------------

    1-H  isotope production
 reg.          4          5          6
   1  0.000E+00 0.000E+00 0.000E+00
   2  0.000E+00 0.000E+00 0.000E+00
   3  0.000E+00 0.000E+00 0.000E+00
   4  0.000E+00 0.000E+00 0.000E+00
   5  0.000E+00 0.000E+00 0.000E+00
   6  0.000E+00 0.000E+00 0.000E+00
   7  0.000E+00 0.000E+00 0.000E+00
   8  0.000E+00 0.000E+00 1.000E-06
   9  1.000E-06 0.000E+00 0.000E+00
  10  0.000E+00 0.000E+00 0.000E+00
  11  0.000E+00 0.000E+00 0.000E+00
  12  0.000E+00 0.000E+00 0.000E+00

    3-Li isotope production
 reg.          6          7          8          9         10
  except of above mass numbers: underflow = 1.000E-06  overflow = 0.000E+00
   1  7.997E-06 3.000E-06 0.000E+00 0.000E+00 0.000E+00
   2  3.000E-06 0.000E+00 2.000E-06 0.000E+00 0.000E+00
   3  1.000E-06 0.000E+00 1.000E-06 0.000E+00 0.000E+00
   4  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   5  0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.000E-06
  except of above mass numbers: underflow = 1.000E-06  overflow = 0.000E+00
   6  9.846E-07 1.000E-06 9.904E-07 0.000E+00 0.000E+00
   7  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   8  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   9  0.000E+00 9.847E-07 0.000E+00 1.000E-06 0.000E+00
  10  1.000E-06 0.000E+00 1.000E-06 0.000E+00 0.000E+00
  11  0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                           :
                           :
                           :

  81-Tl isotope production
 reg.       197        198        199        200        201        202        203        204        205
   1  8.716E-03 9.789E-03 9.523E-03 8.294E-03 5.829E-03 4.075E-03 1.014E-03 6.808E-04 1.800E-05
   2  2.652E-03 2.793E-03 2.640E-03 2.349E-03 1.538E-03 1.067E-03 2.719E-04 1.690E-04 6.000E-06
   3  6.548E-04 6.299E-04 5.949E-04 5.089E-04 3.819E-04 2.329E-04 6.700E-05 4.600E-05 2.000E-06
   4  2.640E-04 2.430E-04 2.330E-04 1.870E-04 1.210E-04 6.300E-05 1.200E-05 1.100E-05 0.000E+00
   5  2.919E-03 2.994E-03 2.676E-03 2.230E-03 1.444E-03 9.596E-04 2.468E-04 1.440E-04 3.000E-06
   6  1.372E-03 1.474E-03 1.248E-03 1.059E-03 7.007E-04 4.438E-04 1.190E-04 5.396E-05 5.000E-06
   7  3.168E-04 3.489E-04 2.789E-04 2.559E-04 1.610E-04 1.030E-04 2.499E-05 1.800E-05 1.000E-06
   8  5.900E-05 7.198E-05 5.300E-05 4.199E-05 3.100E-05 2.300E-05 3.000E-06 3.000E-06 0.000E+00
   9  1.081E-03 1.135E-03 1.091E-03 8.803E-04 5.955E-04 3.977E-04 1.080E-04 5.790E-05 2.000E-06
  10  1.008E-03 1.061E-03 9.744E-04 8.036E-04 5.626E-04 3.088E-04 8.298E-05 4.897E-05 1.000E-06
  11  3.409E-04 3.809E-04 3.019E-04 2.499E-04 1.969E-04 1.200E-04 2.998E-05 2.000E-05 3.000E-06
  12  1.070E-04 1.210E-04 7.800E-05 6.300E-05 4.900E-05 3.500E-05 1.100E-05 6.000E-06 0.000E+00
```

Fig. C-4 Nuclide production rate data calculated with NMTC/JAERI97MCNP4A.

```
dchain-sp : 1.5GeV 1mA proton, hg02   n&p irrad.
2 2
2 8 120 0 7 70 0 0 0
0 3 1 0 -1.0
1. 1.5 -1.0 2.82743E+4 Hg-nat
30 d 1.
5000 d 0.
-1 d
-5 d
-10 d
-30 d
-100 d
-300 d
-1000 d
-5000 d
 80196.  5.9595E-5   80198.  3.9611E-3   80199.  6.7025E-3
 80200.  9.1776E-3   80201.  5.2364E-3   80202.  1.1863E-2
 80204.  2.7295E-3
```

Fig. C-5 Input card of the DCHAIN-SP calculation for sample problem.

```
#! /bin/csh
#
#  run.sh  :  shell script for running the DCHAIN-SP code.
#             test problem of hg spallation target
#             proton beam & neutron irradiation
#             (produced by k.kosako on 1998/09/28)
   set tag1=30
   set tag2=120
   set name = hg02
#
echo ' problem name ..... ' $name
#
   set tag3=Hg-nat
   set tag4=7
   set tag6=0
#
# get region-wise neutron spectrum from mcnp calculation
   set tag0 = 0
#
# For Whole Target Regions
   set reg=0
   set tag5=tt
   set vol=2.82743E+4
#
rm -f input
echo 'dchain-sp : 1.5GeV 1mA proton,' $name '  n&p irrad.' >> input
echo   2  2                                                >> input
echo   2  8  $tag2  $reg  $tag4  70  $tag6  $tag6  0       >> input
echo   0  3  1  0  -1.0                                    >> input
echo   1.  1.5  -1.0  $vol  $tag3                          >> input
echo   $tag1 d  1.                                         >> input
echo   5000 d  0.                                          >> input
echo   -1 d                                                >> input
echo   -5 d                                                >> input
echo   -10 d                                               >> input
echo   -30 d                                               >> input
echo   -100 d                                              >> input
echo   -300 d                                              >> input
echo   -1000 d                                             >> input
echo   -5000 d                                             >> input
if ( $name == 'hg02' ) then
echo ' 80196.  5.9595E-5   80198.  3.9611E-3   80199.  6.7025E-3' >> input
echo ' 80200.  9.1776E-3   80201.  5.2364E-3   80202.  1.1863E-2' >> input
echo ' 80204.  2.7295E-3'                                  >> input
endif
#
rm -f spd-act.out output
```

Fig. C-6 Example of shell script file for DCHAIN-SP calculation of sample problem.

```
#
# get region-wise neutron spectrum from mcnp calculation
cp nflux14-${tag5} n.flux
echo '   running problem .....  reg.' $tag0
#
spd_ld < input > output
#
mv spd-act.out ${name}.act-${tag0}
mv output      ${name}.out-${tag0}
#
exit
```

Fig. C-6 Example of shell script file for DCHAIN-SP calculation of sample problem.

```
*********************************************************
*                     DCHAIN-SP                         *
*                       ---                             *
*  transmutaion calculation code from nmtc yield data   *
*********************************************************
*  version: 1.0  original (1998/07/31)                  *
*********************************************************


<< start of input data >>

problem title: dchain-sp : 1.5GeV 1mA proton, hg02   n&p irrad.

primary control data
 (1) imode              2 : calculation mode
                            0 = activity
                            1 = activity and decay heat
                            2 = activity, decay heat and gamma-ray spectrum
 (2) jmode              2 : mode selection of particle beam and neutron irradiation
                            0 = particle beam irradiation
                            1 = irradiation with neutron flux below 20 [MeV]
                            2 = particle beam and neutron irradiation
                           -1 = decay (no irradiation)

calculation condition data
 (1) itstep             2 : number of time steps for irradiation and cooling (default=1)
 (2) itout              8 : number of output time of result (default=1)
 (3) idivs            120 : number of divisions of irradiation time step (default=50)
 (4) ireg               0 : region number for calculating activity in yield file (default=0)
                            (if zero, yield summed in all region is used.)
                            (if -1, yield file is not used.)
 (5) itgncl             7 : number of nuclides in taget material (default=0)
 (6) ichain            70 : length and number of linear chains (default=70)
 (7) itdecs             0 : option of target decreasing by beam irradiation
                            0 = no decrease (default)
                            1 = decrease
 (8) itdecn             0 : option of target decreasing by neutron irradiation
                            0 = no decrease
                            1 = decrease (default)
 (9) isomtr             0 : option of isomeric state of nuclide reading from yield file
                            0 = isomeric and ground state (default)
                            1 = ground state

output condition data
 (1) iyild              0 : option of yield file output at last output time
                            0 = no output
                            1 = output of decayed nuclide yield file
                            2 = output of decayed nuclide yield file (including target nuclides)
 (2) iggrp              3 : option of gamma-ray spectrum group (if imode>1, effective)
                            0 = no effect (if imode<2)
                            1 = hilo86    --- 22 groups
                            2 = bermuda   --- 41+3 groups
                            3 = vitamin-j --- 42 groups
                           99 = fispact3  --- 23+1 groups energy spectrum [MeV/s]
 (3) ibetap             1 : option of annihilation gamma-ray by beta(+) decay (if imode>1, effective)
                            0 = no annihilation gamma-ray
                            1 = include annihilation gamma-ray
 (4) istabl             0 : option for printing of stable nuclides on activation file
                            0 = no print
                            1 = print
 (5) acmin    -1.0000E+00 : lower limitation value for printing on activation file
                            0.0 = automatic lower limitation of activity (acmin=total*1.0e-10)
                            > 0., lower limitation of acitivity [Bq]
                            < 0., lower limitation of produced nuclides [n/cm**3]

spallation data
  (1) amp       1.0000E+00 : proton beam current [mA]
  (2) ebeam     1.5000E+00 : proton beam energy [GeV]
  (3) flux     -1.0000E+00 : neutron total flux intensity [n/cm**2/s]  (neutron below 20 [MeV])
  (4) volume    2.8274E+04 : volume of target region [cm**3]
  (5) htargt        Hg-nat : target nuclide or material
```

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem.

```
time histories of irradiation and cooling
  no.       time       time step [s]     rel.beam
   1         30 [d]     2.59200E+06  1.0000E+00
   2 1.3771E+01 [y]     4.32000E+08  0.0000E+00

output times of result
  no.       time [s]
   1    2.67840E+06   (-1.00000E+00 [d])
   2    3.02400E+06   (-5.00000E+00 [d])
   3    3.45600E+06   (-1.00000E+01 [d])
   4    5.18400E+06   (-3.00000E+01 [d])
   5    1.12320E+07   (-1.00000E+02 [d])
   6    2.85120E+07   (-3.00000E+02 [d])
   7    8.89920E+07   (-1.00000E+03 [d])
   8    4.34592E+08   (-5.00000E+03 [d])

target nuclides  [10**24/cm**3]  (negative: activity [Bq])
    nuclide        za   no.density     nuclide        za   no.density     nuclide        za   no.density
     Hg196    80196.0  5.95950E-05      Hg198    80198.0  3.96110E-03      Hg199    80199.0  6.70250E-03
     Hg200    80200.0  9.17760E-03      Hg201    80201.0  5.23640E-03      Hg202    80202.0  1.18630E-02
     Hg204    80204.0  2.72950E-03

<< end of input data >>


information of variable dimension size
  supplied size .....   500000
  used size .........   466491

the number of nuclides in the decay data library =    3139

nuclide list lacked in the decay data library
    8-O - 24     1.000E-06
    9-F - 27     1.000E-06
   14-Si- 39     1.000E-06
   15-P - 41     1.000E-06
   16-S - 44     1.000E-06
   18-Ar- 49     1.000E-06
   23-V - 61     1.000E-06
   64-Gd-169     1.000E-06
   65-Tb-169     1.000E-06
   69-Tm-181     1.000E-06
--- warning message from rdyild ---
         above nuclides were not found in decay data library.
         please careful about a contribution from these nuclides.
         number of nuclides =   10   lacked total yield = 1.0000E-05


the number of kinds of produced nuclides by nmtc calculation =         1512
total yield of produced nuclides per a source                 =  4.89484E+00
nuclide     yield  nuclide     yield  nuclide     yield  nuclide     yield  nuclide     yield  nuclide     yield
----------------  ----------------  ----------------  ----------------  ----------------  ----------------
 H   4  1.000E-06   Mn 58  3.318E-04   Zr 88  3.619E-04   Te117  8.610E-04   Eu142  1.050E-04   Hf183  1.199E-05
 H   6  1.000E-06   Mn 59  2.928E-04   Zr 89  6.759E-04   Te118  1.718E-03   Eu143  6.420E-04   Hf184  7.000E-06
 Li  6  1.398E-05   Mn 60  2.098E-04   Zr 90  1.049E-03   Te119  2.399E-03   Eu144  2.090E-03   Hf185  5.000E-06
 Li  7  4.985E-06   Mn 61  1.249E-04   Zr 91  8.167E-04   Te120  3.244E-03   Eu145  3.855E-03   Hf186  3.971E-06
 Li  8  4.990E-06   Mn 62  8.296E-05   Zr 92  6.688E-04   Te121  3.066E-03   Eu146  4.140E-03   Hf187  1.000E-06
 Li  9  1.000E-06   Mn 63  4.997E-05   Zr 93  5.716E-04   Te122  2.786E-03   Eu147  4.047E-03   Hf188  2.929E-06
 Li 10  1.000E-06   Mn 64  5.000E-06   Zr 94  4.857E-04   Te123  1.856E-03   Eu148  3.664E-03   Ta165  1.000E-05
 Be  7  1.600E-05   Mn 65  2.000E-06   Zr 95  4.336E-04   Te124  1.359E-03   Eu149  2.790E-03   Ta166  9.499E-05
 Be  9  9.988E-06   Mn 66  1.000E-06   Zr 96  3.267E-04   Te125  7.369E-04   Eu150  1.947E-03   Ta167  4.490E-04
 Be 10  6.998E-06   Fe 53  3.000E-06   Zr 97  2.758E-04   Te126  4.759E-04   Eu151  1.188E-03   Ta168  1.339E-03
 Be 11  5.000E-06   Fe 54  7.600E-05   Zr 98  1.659E-04   Te127  2.718E-04   Eu152  6.370E-04   Ta169  2.842E-03
 Be 12  2.000E-06   Fe 55  2.810E-04   Zr 99  9.994E-05   Te128  1.769E-04   Eu153  3.350E-04   Ta170  4.861E-03
 B   9  2.000E-06   Fe 56  4.930E-04   Zr100  5.898E-05   Te129  9.393E-05   Eu154  1.670E-04   Ta171  6.538E-03
 B  10  4.793E-05   Fe 57  5.419E-04   Zr101  2.600E-05   Te130  5.598E-05   Eu155  7.697E-05   Ta172  7.445E-03
 B  11  2.999E-05   Fe 58  4.769E-04   Zr102  1.198E-05   Te131  3.499E-05   Eu156  7.400E-05   Ta173  7.215E-03
 B  12  1.600E-05   Fe 59  4.299E-04   Zr103  3.000E-06   Te132  1.899E-05   Eu157  6.795E-05   Ta174  6.482E-03
 B  13  9.993E-06   Fe 60  3.718E-04   Nb 88  4.000E-06   Te133  4.992E-06   Eu158  4.597E-05   Ta175  4.991E-03
 B  14  4.000E-06   Fe 61  3.019E-04   Nb 89  4.199E-05   Te134  1.000E-06   Eu159  2.299E-05   Ta176  3.522E-03
```

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem (continued).

C 9	1.000E-06	Fe 62	2.937E-04	Nb 90	1.390E-04	I 117	2.100E-05	Eu160	2.599E-05	Ta177	2.071E-03
C 10	1.098E-05	Fe 63	1.819E-04	Nb 91	6.590E-04	I 118	1.450E-04	Eu161	1.096E-05	Ta178	1.209E-03
C 11	1.299E-05	Fe 64	1.249E-04	Nb 92	6.938E-04	I 119	5.470E-04	Eu162	9.996E-06	Ta179	6.427E-04
C 12	6.396E-05	Fe 65	4.496E-05	Nb 93	6.698E-04	I 120	1.124E-03	Eu163	5.000E-06	Ta180	3.168E-04
C 13	2.999E-05	Fe 66	2.599E-05	Nb 94	6.758E-04	I 121	2.203E-03	Eu164	2.000E-06	Ta181	1.040E-04
C 14	2.097E-05	Fe 67	4.000E-06	Nb 95	5.216E-04	I 122	3.076E-03	Gd142	1.000E-06	Ta182	6.097E-05
C 15	7.995E-06	Fe 68	1.000E-06	Nb 96	4.338E-04	I 123	3.223E-03	Gd143	4.000E-06	Ta183	3.298E-05
C 16	6.993E-06	Co 55	2.000E-06	Nb 97	3.558E-04	I 124	2.998E-03	Gd144	1.080E-04	Ta184	1.100E-05
C 17	3.991E-06	Co 56	5.500E-05	Nb 98	3.757E-04	I 125	2.286E-03	Gd145	7.120E-04	Ta185	6.987E-06
N 11	9.955E-07	Co 57	1.860E-04	Nb 99	2.846E-04	I 126	1.572E-03	Gd146	2.180E-03	Ta186	2.993E-06
N 12	1.974E-06	Co 58	4.430E-04	Nb100	1.819E-04	I 127	1.048E-03	Gd147	3.233E-03	Ta187	7.984E-06
N 13	8.983E-06	Co 59	4.920E-04	Nb101	1.239E-04	I 128	5.609E-04	Gd148	4.486E-03	Ta188	3.000E-06
N 14	7.896E-05	Co 60	5.480E-04	Nb102	8.499E-05	I 129	3.518E-04	Gd149	5.082E-03	Ta189	3.985E-06
N 15	4.297E-05	Co 61	5.448E-04	Nb103	3.298E-05	I 130	1.878E-04	Gd150	5.225E-03	Ta190	2.000E-06
N 16	2.699E-05	Co 62	4.517E-04	Nb104	1.100E-05	I 131	1.070E-04	Gd151	4.340E-03	Ta191	1.000E-06
N 17	3.198E-05	Co 63	3.588E-04	Nb105	7.000E-06	I 132	6.796E-05	Gd152	3.323E-03	W 167	6.000E-06
N 18	1.599E-05	Co 64	3.138E-04	Nb106	1.000E-06	I 133	4.597E-05	Gd153	2.074E-03	W 168	4.299E-05
N 19	7.000E-06	Co 65	2.278E-04	Nb107	1.000E-06	I 134	1.800E-05	Gd154	1.339E-03	W 169	2.740E-04
O 13	1.000E-06	Co 66	1.429E-04	Nb108	1.000E-06	I 135	7.000E-06	Gd155	6.930E-04	W 170	1.026E-03
O 14	1.000E-06	Co 67	7.998E-05	Mo 89	1.000E-06	I 136	9.947E-07	Gd156	3.030E-04	W 171	2.371E-03
O 15	4.000E-06	Co 68	3.498E-05	Mo 90	9.000E-06	I 138	1.000E-06	Gd157	1.359E-04	W 172	4.747E-03
O 16	4.897E-05	Co 69	1.199E-05	Mo 91	3.100E-05	Xe118	1.000E-06	Gd158	7.498E-05	W 173	7.087E-03
O 17	5.700E-05	Co 70	3.000E-06	Mo 92	3.460E-04	Xe119	1.500E-05	Gd159	5.296E-05	W 174	8.855E-03
O 18	4.999E-05	Ni 57	3.000E-06	Mo 93	5.560E-04	Xe120	1.130E-04	Gd160	3.499E-05	W 175	9.802E-03
O 19	4.598E-05	Ni 58	4.900E-05	Mo 94	7.039E-04	Xe121	4.150E-04	Gd161	3.796E-05	W 176	9.197E-03
O 20	2.699E-05	Ni 59	1.930E-04	Mo 95	7.869E-04	Xe122	1.220E-03	Gd162	2.099E-05	W 177	8.059E-03
O 21	9.993E-06	Ni 60	4.260E-04	Mo 96	7.747E-04	Xe123	2.257E-03	Gd163	1.999E-05	W 178	5.826E-03
O 22	3.000E-06	Ni 61	6.010E-04	Mo 97	6.958E-04	Xe124	3.579E-03	Gd164	1.400E-05	W 179	4.108E-03
O 23	3.000E-06	Ni 62	6.869E-04	Mo 98	5.597E-04	Xe125	4.048E-03	Gd165	2.993E-06	W 180	2.473E-03
F 15	1.000E-06	Ni 63	5.507E-04	Mo 99	4.307E-04	Xe126	4.284E-03	Gd166	4.000E-06	W 181	1.474E-03
F 16	2.000E-06	Ni 64	5.347E-04	Mo100	3.947E-04	Xe127	3.498E-03	Gd167	2.000E-06	W 182	7.584E-04
F 18	4.597E-05	Ni 65	4.178E-04	Mo101	3.157E-04	Xe128	2.570E-03	Tb145	3.000E-06	W 183	3.956E-04
F 19	4.500E-05	Ni 66	3.998E-04	Mo102	2.727E-04	Xe129	1.483E-03	Tb146	2.800E-05	W 184	2.357E-04
F 20	6.697E-05	Ni 67	2.927E-04	Mo103	1.589E-04	Xe130	1.018E-03	Tb147	4.460E-04	W 185	9.895E-05
F 21	4.598E-05	Ni 68	2.159E-04	Mo104	1.109E-04	Xe131	4.760E-04	Tb148	9.900E-04	W 186	3.695E-05
F 22	2.796E-05	Ni 69	1.349E-04	Mo105	4.496E-05	Xe132	2.939E-04	Tb149	1.934E-03	W 187	2.998E-05
F 23	1.800E-05	Ni 70	5.598E-05	Mo106	2.800E-05	Xe133	1.429E-04	Tb150	2.974E-03	W 188	1.498E-05
F 24	8.953E-06	Ni 71	1.599E-05	Mo107	7.000E-06	Xe134	8.796E-05	Tb151	3.647E-03	W 189	7.000E-06
F 25	2.000E-06	Ni 72	6.000E-06	Mo108	3.000E-06	Xe135	5.699E-05	Tb152	3.994E-03	W 190	6.000E-06
Ne 19	1.000E-06	Ni 73	1.000E-06	Tc 92	2.000E-06	Xe136	3.698E-05	Tb153	3.744E-03	W 191	2.987E-06
Ne 20	3.300E-05	Cu 59	1.000E-06	Tc 93	7.300E-05	Xe137	7.000E-06	Tb154	3.132E-03	W 192	3.000E-06
Ne 21	5.797E-05	Cu 60	8.000E-06	Tc 94	2.350E-04	Xe138	4.992E-06	Tb155	2.190E-03	Re170	3.000E-06
Ne 22	6.696E-05	Cu 61	7.700E-05	Tc 95	4.560E-04	Xe139	5.000E-06	Tb156	1.400E-03	Re171	4.299E-05
Ne 23	4.997E-05	Cu 62	2.510E-04	Tc 96	6.929E-04	Cs122	1.200E-05	Tb157	7.089E-04	Re172	2.030E-04
Ne 24	4.897E-05	Cu 63	5.410E-04	Tc 97	8.409E-04	Cs123	1.190E-04	Tb158	3.300E-04	Re173	8.429E-04
Ne 25	2.100E-05	Cu 64	6.820E-04	Tc 98	9.219E-04	Cs124	5.300E-04	Tb159	1.709E-04	Re174	2.204E-03
Ne 26	1.199E-05	Cu 65	6.599E-04	Tc 99	7.177E-04	Cs125	1.400E-03	Tb160	9.494E-05	Re175	4.279E-03
Ne 27	3.995E-06	Cu 66	6.048E-04	Tc100	6.117E-04	Cs126	2.521E-03	Tb161	4.398E-05	Re176	6.811E-03
Na 21	1.000E-06	Cu 67	5.027E-04	Tc101	4.638E-04	Cs127	3.553E-03	Tb162	4.397E-05	Re177	8.499E-03
Na 22	2.700E-05	Cu 68	4.367E-04	Tc102	4.208E-04	Cs128	4.033E-03	Tb163	3.299E-05	Re178	9.527E-03
Na 23	7.998E-05	Cu 69	3.586E-04	Tc103	3.817E-04	Cs129	3.703E-03	Tb164	3.298E-05	Re179	8.946E-03
Na 24	7.998E-05	Cu 70	2.688E-04	Tc104	2.958E-04	Cs130	2.941E-03	Tb165	2.695E-05	Re180	7.986E-03
Na 25	7.300E-05	Cu 71	1.609E-04	Tc105	2.079E-04	Cs131	1.935E-03	Tb166	1.290E-05	Re181	5.959E-03
Na 26	6.796E-05	Cu 72	8.198E-05	Tc106	1.169E-04	Cs132	1.103E-03	Tb167	8.993E-06	Re182	4.532E-03
Na 27	4.494E-05	Cu 73	4.197E-05	Tc107	6.396E-05	Cs133	5.969E-04	Tb168	4.000E-06	Re183	3.056E-03
Na 28	2.098E-05	Cu 74	1.700E-05	Tc108	4.698E-05	Cs134	3.218E-04	Dy147	2.000E-06	Re184	2.008E-03
Na 29	1.099E-05	Cu 75	1.000E-06	Tc109	2.000E-05	Cs135	1.789E-04	Dy148	9.900E-05	Re185	1.098E-03
Na 31	1.000E-06	Zn 61	1.000E-06	Tc110	5.998E-06	Cs136	1.379E-04	Dy149	3.180E-04	Re186	5.634E-04
Mg 23	1.000E-06	Zn 62	1.000E-06	Tc111	3.000E-06	Cs137	5.799E-05	Dy150	9.490E-04	Re187	2.707E-04
Mg 24	6.599E-05	Zn 63	1.800E-05	Ru 94	2.000E-06	Cs138	4.297E-05	Dy151	1.861E-03	Re188	1.199E-04
Mg 25	9.897E-05	Zn 64	1.580E-04	Ru 95	3.699E-05	Cs139	2.400E-05	Dy152	3.277E-03	Re189	6.897E-05
Mg 26	8.797E-05	Zn 65	3.270E-04	Ru 96	1.680E-04	Cs140	1.300E-05	Dy153	4.508E-03	Re190	2.599E-05
Mg 27	6.996E-05	Zn 66	6.480E-04	Ru 97	3.830E-04	Cs141	8.986E-06	Dy154	5.521E-03	Re191	1.700E-05
Mg 28	8.396E-05	Zn 67	6.299E-04	Ru 98	7.200E-04	Cs142	1.000E-06	Dy155	5.396E-03	Re192	1.198E-05
Mg 29	4.998E-05	Zn 68	6.167E-04	Ru 99	9.270E-04	Cs143	2.000E-06	Dy156	5.271E-03	Re193	4.990E-06
Mg 30	3.899E-05	Zn 69	5.318E-04	Ru100	1.084E-03	Ba124	1.000E-06	Dy157	3.677E-03	Re194	2.000E-06
Mg 31	1.800E-05	Zn 70	4.538E-04	Ru101	9.267E-04	Ba125	4.900E-05	Dy158	2.468E-03	Re195	2.000E-06
Mg 32	6.997E-06	Zn 71	3.818E-04	Ru102	8.378E-04	Ba126	3.350E-04	Dy159	1.366E-03	Os172	2.000E-06
Mg 33	1.000E-06	Zn 72	3.558E-04	Ru103	6.377E-04	Ba127	9.960E-04	Dy160	7.490E-04	Os173	5.995E-06
Al 26	3.898E-05	Zn 73	1.969E-04	Ru104	5.307E-04	Ba128	2.311E-03	Dy161	3.210E-04	Os174	9.399E-05

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem (continued).

Al 27	1.210E-04	Zn 74	1.668E-04	Ru105	4.189E-04	Ba129	3.287E-03	Dy162	1.320E-04	Os175	4.290E-04
Al 28	1.130E-04	Zn 75	5.596E-05	Ru106	3.667E-04	Ba130	4.294E-03	Dy163	6.699E-05	Os176	1.400E-03
Al 29	8.399E-05	Zn 76	2.197E-05	Ru107	2.098E-04	Ba131	4.064E-03	Dy164	4.199E-05	Os177	3.233E-03
Al 30	7.895E-05	Zn 77	7.000E-06	Ru108	1.649E-04	Ba132	3.572E-03	Dy165	3.598E-05	Os178	6.051E-03
Al 31	6.796E-05	Ga 64	1.000E-06	Ru109	9.398E-05	Ba133	2.309E-03	Dy166	2.798E-05	Os179	8.790E-03
Al 32	5.594E-05	Ga 65	1.800E-05	Ru110	4.997E-05	Ba134	1.587E-03	Dy167	2.799E-05	Os180	1.127E-02
Al 33	2.297E-05	Ga 66	1.290E-04	Ru111	2.200E-05	Ba135	7.850E-04	Dy168	2.197E-05	Os181	1.209E-02
Al 34	6.000E-06	Ga 67	3.610E-04	Ru112	1.300E-05	Ba136	4.198E-04	Dy169	7.000E-06	Os182	1.220E-02
Al 35	2.000E-06	Ga 68	5.850E-04	Rh 96	3.000E-06	Ba137	2.399E-04	Dy170	8.000E-06	Os183	1.132E-02
Si 28	3.999E-05	Ga 69	6.629E-04	Rh 97	1.400E-05	Ba138	1.489E-04	Dy171	2.000E-06	Os184	9.706E-03
Si 29	1.320E-04	Ga 70	6.509E-04	Rh 98	7.800E-05	Ba139	7.097E-05	Ho149	3.000E-06	Os185	7.683E-03
Si 30	1.030E-04	Ga 71	5.588E-04	Rh 99	2.790E-04	Ba140	6.099E-05	Ho150	1.300E-05	Os186	5.337E-03
Si 31	1.209E-04	Ga 72	4.787E-04	Rh100	5.380E-04	Ba141	3.499E-05	Ho151	9.500E-05	Os187	3.452E-03
Si 32	1.129E-04	Ga 73	4.318E-04	Rh101	7.779E-04	Ba142	2.799E-05	Ho152	3.570E-04	Os188	1.977E-03
Si 33	9.491E-05	Ga 74	3.677E-04	Rh102	1.086E-03	Ba143	1.100E-05	Ho153	8.930E-04	Os189	1.025E-03
Si 34	9.191E-05	Ga 75	2.778E-04	Rh103	9.789E-04	Ba144	7.000E-06	Ho154	1.773E-03	Os190	5.126E-04
Si 35	4.296E-05	Ga 76	1.789E-04	Rh104	9.568E-04	Ba147	1.000E-06	Ho155	3.022E-03	Os191	2.207E-04
Si 36	1.598E-05	Ga 77	1.089E-04	Rh105	7.977E-04	La126	1.000E-06	Ho156	4.044E-03	Os192	1.579E-04
Si 37	7.955E-06	Ga 78	2.699E-05	Rh106	5.988E-04	La127	1.000E-05	Ho157	4.724E-03	Os193	5.596E-05
Si 38	1.987E-06	Ga 79	1.394E-05	Rh107	4.847E-04	La128	1.140E-04	Ho158	4.589E-03	Os194	4.898E-05
P 29	1.000E-06	Ga 80	5.992E-06	Rh108	3.917E-04	La129	5.770E-04	Ho159	3.822E-03	Os195	2.200E-05
P 30	7.197E-05	Ge 66	1.000E-06	Rh109	2.848E-04	La130	1.438E-03	Ho160	2.660E-03	Os196	1.398E-05
P 31	9.597E-05	Ge 67	6.000E-06	Rh110	2.089E-04	La131	2.714E-03	Ho161	1.682E-03	Os197	8.000E-06
P 32	1.540E-04	Ge 68	9.700E-05	Rh111	1.100E-04	La132	3.632E-03	Ho162	8.988E-04	Os198	5.000E-06
P 33	1.289E-04	Ge 69	2.700E-04	Rh112	6.999E-05	La133	4.035E-03	Ho163	3.899E-04	Os199	1.000E-06
P 34	1.330E-04	Ge 70	5.750E-04	Rh113	3.299E-05	La134	3.466E-03	Ho164	1.790E-04	Os200	1.000E-06
P 35	1.220E-04	Ge 71	6.949E-04	Rh114	1.999E-05	La135	2.715E-03	Ho165	9.399E-05	Ir176	1.700E-05
P 36	8.094E-05	Ge 72	7.709E-04	Rh115	2.000E-06	La136	1.672E-03	Ho166	3.699E-05	Ir177	1.340E-04
P 37	6.193E-05	Ge 73	6.299E-04	Rh116	1.000E-06	La137	9.409E-04	Ho167	2.500E-05	Ir178	6.387E-04
P 38	2.198E-05	Ge 74	6.138E-04	Pd 97	1.000E-06	La138	4.510E-04	Ho168	2.300E-05	Ir179	1.694E-03
P 39	1.700E-05	Ge 75	4.747E-04	Pd 98	9.974E-07	La139	2.559E-04	Ho169	2.498E-05	Ir180	3.828E-03
P 40	4.983E-06	Ge 76	4.767E-04	Pd 99	6.000E-06	La140	1.239E-04	Ho170	2.196E-05	Ir181	6.286E-03
S 32	2.800E-05	Ge 77	3.087E-04	Pd100	9.200E-05	La141	7.094E-05	Ho171	1.100E-05	Ir182	9.838E-03
S 33	9.099E-05	Ge 78	2.399E-04	Pd101	2.620E-04	La142	5.797E-05	Ho172	7.000E-06	Ir183	1.223E-02
S 34	1.310E-04	Ge 79	1.309E-04	Pd102	5.390E-04	La143	4.699E-05	Ho173	2.992E-06	Ir184	1.472E-02
S 35	1.509E-04	Ge 80	8.194E-05	Pd103	9.210E-04	La144	3.200E-05	Ho174	4.000E-06	Ir185	1.518E-02
S 36	1.460E-04	Ge 81	3.399E-05	Pd104	1.216E-03	La145	1.800E-05	Er152	5.000E-06	Ir186	1.503E-02
S 37	1.069E-04	Ge 82	4.000E-06	Pd105	1.296E-03	La146	1.200E-05	Er153	5.400E-05	Ir187	1.236E-02
S 38	1.220E-04	As 69	4.000E-06	Pd106	1.403E-03	La147	4.000E-06	Er154	2.530E-04	Ir188	9.802E-03
S 39	8.498E-05	As 70	1.600E-05	Pd107	1.060E-03	La148	2.000E-06	Er155	7.150E-04	Ir189	6.681E-03
S 40	6.896E-05	As 71	2.020E-04	Pd108	8.616E-04	Ce128	2.000E-06	Er156	1.655E-03	Ir190	4.377E-03
S 41	3.297E-05	As 72	3.970E-04	Pd109	6.077E-04	Ce129	6.000E-06	Er157	2.915E-03	Ir191	2.680E-03
S 42	1.400E-05	As 73	6.299E-04	Pd110	4.817E-04	Ce130	1.610E-04	Er158	4.807E-03	Ir192	1.629E-03
S 43	3.000E-06	As 74	7.068E-04	Pd111	3.178E-04	Ce131	4.960E-04	Er159	5.921E-03	Ir193	1.072E-03
Cl 34	2.400E-05	As 75	6.748E-04	Pd112	2.809E-04	Ce132	1.464E-03	Er160	6.466E-03	Ir194	7.775E-04
Cl 35	8.500E-05	As 76	5.747E-04	Pd113	1.659E-04	Ce133	2.704E-03	Er161	5.459E-03	Ir195	5.097E-04
Cl 36	1.740E-04	As 77	5.377E-04	Pd114	1.049E-04	Ce134	4.246E-03	Er162	4.143E-03	Ir196	3.249E-04
Cl 37	1.990E-04	As 78	4.488E-04	Pd115	4.897E-05	Ce135	4.516E-03	Er163	2.636E-03	Ir197	2.778E-04
Cl 38	1.689E-04	As 79	4.147E-04	Pd116	2.397E-05	Ce136	4.598E-03	Er164	1.550E-03	Ir198	1.688E-04
Cl 39	1.579E-04	As 80	2.698E-04	Pd117	1.100E-05	Ce137	3.452E-03	Er165	7.510E-04	Ir199	9.092E-05
Cl 40	1.519E-04	As 81	1.919E-04	Pd118	1.995E-06	Ce138	2.365E-03	Er166	3.500E-04	Ir200	2.599E-05
Cl 41	1.199E-04	As 82	1.089E-04	Ag101	2.000E-06	Ce139	1.246E-03	Er167	1.650E-04	Ir201	1.599E-05
Cl 42	8.798E-05	As 83	3.393E-05	Ag102	2.600E-05	Ce140	5.900E-04	Er168	6.398E-05	Ir202	5.000E-06
Cl 43	5.092E-05	As 84	1.399E-05	Ag103	1.330E-04	Ce141	2.240E-04	Er169	3.798E-05	Pt178	1.400E-05
Cl 44	2.098E-05	As 85	1.000E-06	Ag104	3.390E-04	Ce142	1.629E-04	Er170	1.398E-05	Pt179	1.359E-04
Cl 45	4.000E-06	Se 71	1.000E-06	Ag105	6.530E-04	Ce143	1.190E-04	Er171	1.796E-05	Pt180	5.178E-04
Ar 36	9.000E-06	Se 72	3.900E-05	Ag106	1.037E-03	Ce144	7.093E-05	Er172	2.794E-05	Pt181	1.593E-03
Ar 37	1.000E-04	Se 73	1.540E-04	Ag107	1.392E-03	Ce145	5.390E-05	Er173	1.599E-05	Pt182	3.797E-03
Ar 38	1.680E-04	Se 74	4.540E-04	Ag108	1.356E-03	Ce146	4.799E-05	Er174	1.100E-05	Pt183	6.998E-03
Ar 39	1.800E-04	Se 75	6.480E-04	Ag109	1.277E-03	Ce147	2.299E-05	Er175	7.989E-06	Pt184	1.105E-02
Ar 40	1.990E-04	Se 76	8.670E-04	Ag110	9.489E-04	Ce148	1.800E-05	Er176	2.000E-06	Pt185	1.638E-02
Ar 41	1.819E-04	Se 77	7.359E-04	Ag111	7.607E-04	Ce149	2.978E-06	Er177	1.995E-06	Pt186	2.231E-02
Ar 42	1.749E-04	Se 78	7.866E-04	Ag112	5.238E-04	Ce150	3.000E-06	Tm153	1.000E-06	Pt187	2.623E-02
Ar 43	1.699E-04	Se 79	5.818E-04	Ag113	4.069E-04	Ce152	1.000E-06	Tm154	1.000E-06	Pt188	2.634E-02
Ar 44	1.120E-04	Se 80	5.427E-04	Ag114	2.688E-04	Pr131	2.000E-06	Tm155	1.000E-05	Pt189	2.525E-02
Ar 45	6.089E-05	Se 81	4.466E-04	Ag115	2.198E-04	Pr132	2.000E-05	Tm156	6.800E-05	Pt190	2.160E-02
Ar 46	3.595E-05	Se 82	4.116E-04	Ag116	1.269E-04	Pr133	2.470E-04	Tm157	2.340E-04	Pt191	1.702E-02
Ar 47	1.000E-05	Se 83	2.108E-04	Ag117	7.698E-05	Pr134	8.430E-04	Tm158	7.140E-04	Pt192	1.364E-02
Ar 48	1.000E-06	Se 84	1.549E-04	Ag118	3.700E-05	Pr135	2.098E-03	Tm159	1.752E-03	Pt193	1.006E-02
K 38	2.000E-05	Se 85	4.300E-05	Ag119	1.399E-05	Pr136	3.251E-03	Tm160	3.117E-03	Pt194	8.678E-03

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem (continued).

K	39	7.800E-05	Se	86	1.098E-05	Ag120	3.000E-06	Pr137	4.252E-03	Tm161	4.670E-03	Pt195	6.732E-03
K	40	1.660E-04	Se	87	3.000E-06	Ag121	2.000E-06	Pr138	4.247E-03	Tm162	5.355E-03	Pt196	5.872E-03
K	41	2.100E-04	Se	88	4.000E-06	Cd103	1.000E-06	Pr139	3.620E-03	Tm163	4.983E-03	Pt197	4.431E-03
K	42	2.560E-04	Br	74	4.000E-06	Cd104	3.300E-05	Pr140	2.407E-03	Tm164	4.220E-03	Pt198	3.632E-03
K	43	2.200E-04	Br	75	6.500E-05	Cd105	1.210E-04	Pr141	1.344E-03	Tm165	2.922E-03	Pt199	2.265E-03
K	44	2.429E-04	Br	76	2.410E-04	Cd106	3.250E-04	Pr142	5.060E-04	Tm166	1.998E-03	Pt200	2.022E-03
K	45	1.560E-04	Br	77	5.240E-04	Cd107	7.500E-04	Pr143	2.649E-04	Tm167	1.053E-03	Pt201	4.179E-04
K	46	1.679E-04	Br	78	6.579E-04	Cd108	1.287E-03	Pr144	1.760E-04	Tm168	5.039E-04	Pt202	3.828E-04
K	47	1.129E-04	Br	79	7.218E-04	Cd109	1.602E-03	Pr145	1.090E-04	Tm169	2.240E-04	Pt203	6.299E-05
K	48	4.096E-05	Br	80	6.899E-04	Cd110	1.841E-03	Pr146	7.990E-05	Tm170	9.998E-05	Au179	1.000E-06
K	49	2.200E-05	Br	81	6.596E-04	Cd111	1.594E-03	Pr147	5.199E-05	Tm171	5.500E-05	Au180	2.300E-05
K	50	2.000E-06	Br	82	5.398E-04	Cd112	1.495E-03	Pr148	6.097E-05	Tm172	3.599E-05	Au181	1.400E-04
K	51	1.000E-06	Br	83	4.656E-04	Cd113	1.059E-03	Pr149	3.496E-05	Tm173	2.498E-05	Au182	5.565E-04
Ca	40	9.000E-06	Br	84	4.146E-04	Cd114	7.398E-04	Pr150	1.499E-05	Tm174	1.598E-05	Au183	1.560E-03
Ca	41	7.000E-05	Br	85	2.958E-04	Cd115	5.197E-04	Pr151	1.297E-05	Tm175	1.100E-05	Au184	3.945E-03
Ca	42	1.850E-04	Br	86	1.679E-04	Cd116	3.819E-04	Pr152	5.995E-06	Tm176	9.991E-06	Au185	7.790E-03
Ca	43	2.370E-04	Br	87	5.199E-05	Cd117	2.438E-04	Pr153	3.998E-06	Tm177	1.199E-05	Au186	1.493E-02
Ca	44	2.949E-04	Br	88	4.299E-05	Cd118	1.598E-04	Pr154	1.994E-06	Tm178	7.000E-06	Au187	2.292E-02
Ca	45	2.860E-04	Br	89	8.000E-06	Cd119	1.140E-04	Nd133	1.000E-06	Tm179	1.000E-06	Au188	3.203E-02
Ca	46	2.419E-04	Kr	76	9.000E-06	Cd120	6.097E-05	Nd134	3.099E-05	Tm180	1.000E-06	Au189	3.850E-02
Ca	47	2.258E-04	Kr	77	4.600E-05	Cd121	2.798E-05	Nd135	1.720E-04	Yb156	1.000E-06	Au190	4.401E-02
Ca	48	1.968E-04	Kr	78	2.380E-04	Cd122	1.298E-05	Nd136	8.160E-04	Yb157	1.000E-06	Au191	4.599E-02
Ca	49	1.149E-04	Kr	79	4.910E-04	Cd123	3.000E-06	Nd137	1.971E-03	Yb158	4.400E-05	Au192	4.781E-02
Ca	50	6.196E-05	Kr	80	7.819E-04	Cd124	2.000E-06	Nd138	3.639E-03	Yb159	1.420E-04	Au193	4.807E-02
Ca	51	2.398E-05	Kr	81	7.708E-04	In105	2.000E-06	Nd139	4.664E-03	Yb160	5.670E-04	Au194	4.663E-02
Ca	52	1.000E-05	Kr	82	8.858E-04	In106	1.000E-05	Nd140	5.338E-03	Yb161	1.542E-03	Au195	4.879E-02
Ca	53	2.000E-06	Kr	83	6.708E-04	In107	5.000E-05	Nd141	4.488E-03	Yb162	3.217E-03	Au196	5.062E-02
Sc	42	3.996E-06	Kr	84	6.457E-04	In108	2.400E-04	Nd142	3.126E-03	Yb163	4.760E-03	Au197	5.944E-02
Sc	43	2.600E-05	Kr	85	5.018E-04	In109	5.470E-04	Nd143	1.535E-03	Yb164	6.157E-03	Au198	6.624E-02
Sc	44	1.370E-04	Kr	86	4.635E-04	In110	1.052E-03	Nd144	8.180E-04	Yb165	6.298E-03	Au199	6.342E-02
Sc	45	2.720E-04	Kr	87	2.698E-04	In111	1.659E-03	Nd145	4.790E-04	Yb166	5.714E-03	Au200	4.978E-02
Sc	46	3.279E-04	Kr	88	1.969E-04	In112	1.910E-03	Nd146	2.449E-04	Yb167	4.425E-03	Au201	4.774E-02
Sc	47	2.940E-04	Kr	89	9.295E-05	In113	2.019E-03	Nd147	1.310E-04	Yb168	3.034E-03	Au202	1.812E-02
Sc	48	3.048E-04	Kr	90	5.600E-05	In114	1.812E-03	Nd148	8.299E-05	Yb169	1.710E-03	Au203	8.800E-03
Sc	49	2.428E-04	Kr	91	2.099E-05	In115	1.343E-03	Nd149	6.799E-05	Yb170	9.159E-04	Au204	3.290E-03
Sc	50	2.069E-04	Kr	92	3.000E-06	In116	9.897E-04	Nd150	6.500E-05	Yb171	4.470E-04	Hg182	9.000E-06
Sc	51	1.439E-04	Rb	78	1.000E-06	In117	6.977E-04	Nd151	4.396E-05	Yb172	1.849E-04	Hg183	6.297E-05
Sc	52	8.699E-05	Rb	79	2.500E-05	In118	4.379E-04	Nd152	3.400E-05	Yb173	7.197E-05	Hg184	2.907E-04
Sc	53	4.100E-05	Rb	80	9.200E-05	In119	2.888E-04	Nd153	1.900E-05	Yb174	3.700E-05	Hg185	1.028E-03
Sc	54	1.100E-05	Rb	81	3.420E-04	In120	1.809E-04	Nd154	1.100E-05	Yb175	1.696E-05	Hg186	2.734E-03
Sc	55	4.000E-06	Rb	82	5.910E-04	In121	1.340E-04	Nd155	3.000E-06	Yb176	1.698E-05	Hg187	6.141E-03
Ti	44	4.000E-06	Rb	83	7.909E-04	In122	8.694E-05	Nd156	3.000E-06	Yb177	1.200E-05	Hg188	1.174E-02
Ti	45	2.200E-05	Rb	84	7.699E-04	In123	2.799E-05	Pm135	2.000E-06	Yb178	7.968E-06	Hg189	2.008E-02
Ti	46	1.290E-04	Rb	85	7.417E-04	In124	1.499E-05	Pm136	5.000E-06	Yb179	4.992E-06	Hg190	3.127E-02
Ti	47	3.050E-04	Rb	86	6.146E-04	In125	8.000E-06	Pm137	1.040E-04	Yb180	6.000E-06	Hg191	4.735E-02
Ti	48	3.780E-04	Rb	87	5.925E-04	In126	1.000E-06	Pm138	4.620E-04	Yb181	3.000E-06	Hg192	6.862E-02
Ti	49	4.169E-04	Rb	88	4.586E-04	Sn107	1.000E-06	Pm139	1.357E-03	Yb182	1.000E-06	Hg193	9.447E-02
Ti	50	3.828E-04	Rb	89	2.677E-04	Sn108	9.000E-06	Pm140	2.726E-03	Yb183	2.000E-06	Hg194	1.362E-01
Ti	51	2.628E-04	Rb	90	2.338E-04	Sn109	5.400E-05	Pm141	4.217E-03	Lu160	3.000E-06	Hg195	1.785E-01
Ti	52	2.188E-04	Rb	91	1.220E-04	Sn110	1.840E-04	Pm142	4.971E-03	Lu161	2.700E-05	Hg196	2.837E-01
Ti	53	1.658E-04	Rb	92	7.096E-05	Sn111	5.230E-04	Pm143	4.267E-03	Lu162	2.080E-04	Hg197	3.484E-01
Ti	54	1.140E-04	Rb	93	3.198E-05	Sn112	1.213E-03	Pm144	2.617E-03	Lu163	8.260E-04	Hg198	3.822E-01
Ti	55	6.497E-05	Rb	94	1.799E-05	Sn113	1.889E-03	Pm145	1.720E-03	Lu164	2.085E-03	Hg199	3.280E-01
Ti	56	3.397E-05	Rb	95	4.000E-06	Sn114	2.776E-03	Pm146	1.017E-03	Lu165	3.525E-03	Hg200	2.919E-01
Ti	57	1.100E-05	Rb	96	3.000E-06	Sn115	3.122E-03	Pm147	5.839E-04	Lu166	5.030E-03	Hg201	1.489E-01
Ti	58	3.000E-06	Sr	80	1.000E-06	Sn116	2.956E-03	Pm148	2.880E-04	Lu167	5.864E-03	Hg202	7.942E-02
V	47	9.000E-06	Sr	81	7.000E-06	Sn117	2.190E-03	Pm149	1.620E-04	Lu168	5.821E-03	Hg203	2.327E-02
V	48	1.190E-04	Sr	82	1.010E-04	Sn118	1.876E-03	Pm150	7.797E-05	Lu169	4.814E-03	Hg204	8.001E-03
V	49	2.420E-04	Sr	83	2.950E-04	Sn119	1.088E-03	Pm151	6.098E-05	Lu170	3.582E-03	Tl185	1.993E-06
V	50	4.339E-04	Sr	84	6.180E-04	Sn120	6.867E-04	Pm152	4.898E-05	Lu171	2.237E-03	Tl186	3.190E-05
V	51	3.949E-04	Sr	85	7.409E-04	Sn121	4.219E-04	Pm153	3.500E-05	Lu172	1.390E-03	Tl187	1.148E-04
V	52	3.749E-04	Sr	86	1.065E-03	Sn122	3.088E-04	Pm154	3.198E-05	Lu173	7.119E-04	Tl188	4.005E-04
V	53	2.897E-04	Sr	87	8.689E-04	Sn123	1.549E-04	Pm155	2.297E-05	Lu174	3.439E-04	Tl189	9.572E-04
V	54	2.698E-04	Sr	88	7.497E-04	Sn124	1.149E-04	Pm156	1.100E-05	Lu175	1.440E-04	Tl190	2.010E-03
V	55	2.089E-04	Sr	89	4.976E-04	Sn125	5.097E-05	Pm157	4.000E-06	Lu176	5.299E-05	Tl191	3.549E-03
V	56	1.409E-04	Sr	90	4.336E-04	Sn126	4.299E-05	Pm158	3.000E-06	Lu177	2.395E-05	Tl192	5.882E-03
V	57	1.019E-04	Sr	91	3.767E-04	Sn127	1.100E-05	Pm159	3.000E-06	Lu178	1.900E-05	Tl193	8.260E-03
V	58	3.597E-05	Sr	92	2.368E-04	Sn128	4.000E-06	Sm138	3.000E-06	Lu179	1.400E-05	Tl194	1.170E-02
V	59	1.899E-05	Sr	93	1.789E-04	Sn129	1.000E-06	Sm139	4.400E-05	Lu180	9.993E-06	Tl195	1.462E-02
V	60	4.000E-06	Sr	94	1.080E-04	Sb111	1.000E-06	Sm140	4.110E-04	Lu181	9.000E-06	Tl196	1.662E-02

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem (continued).

```
 Cr 48  1.000E-06   Sr 95  4.398E-05   Sb112  1.000E-05   Sm141  1.227E-03   Lu182  8.000E-06   Tl197  1.949E-02
 Cr 49  1.100E-05   Sr 96  2.596E-05   Sb113  1.300E-04   Sm142  2.971E-03   Lu183  7.991E-06   Tl198  2.104E-02
 Cr 50  7.600E-05   Sr 97  5.000E-06   Sb114  3.980E-04   Sm143  4.890E-03   Lu184  6.000E-06   Tl199  1.969E-02
 Cr 51  3.240E-04   Sr 98  1.000E-06   Sb115  9.750E-04   Sm144  5.723E-03   Lu185  2.000E-06   Tl200  1.692E-02
 Cr 52  5.640E-04   Y  83  6.000E-06   Sb116  1.768E-03   Sm145  4.452E-03   Hf163  1.500E-05   Tl201  1.161E-02
 Cr 53  4.940E-04   Y  84  2.200E-05   Sb117  2.461E-03   Sm146  3.652E-03   Hf164  1.930E-04   Tl202  7.829E-03
 Cr 54  4.029E-04   Y  85  1.740E-04   Sb118  2.527E-03   Sm147  2.591E-03   Hf165  6.680E-04   Tl203  1.991E-03
 Cr 55  3.549E-04   Y  86  4.110E-04   Sb119  2.550E-03   Sm148  1.724E-03   Hf166  1.760E-03   Tl204  1.259E-03
 Cr 56  3.187E-04   Y  87  7.340E-04   Sb120  1.966E-03   Sm149  9.470E-04   Hf167  3.274E-03   Tl205  4.100E-05
 Cr 57  2.458E-04   Y  88  9.237E-04   Sb121  1.313E-03   Sm150  5.400E-04   Hf168  5.168E-03   Pb188  2.994E-06
 Cr 58  2.268E-04   Y  89  9.497E-04   Sb122  8.448E-04   Sm151  2.340E-04   Hf169  6.373E-03   Pb189  1.198E-05
 Cr 59  1.229E-04   Y  90  6.467E-04   Sb123  4.829E-04   Sm152  1.459E-04   Hf170  6.997E-03   Pb190  1.298E-05
 Cr 60  8.098E-05   Y  91  4.908E-04   Sb124  3.069E-04   Sm153  8.795E-05   Hf171  6.163E-03   Pb191  2.195E-05
 Cr 61  2.600E-05   Y  92  4.348E-04   Sb125  2.078E-04   Sm154  5.794E-05   Hf172  4.916E-03   Pb192  3.692E-05
 Cr 62  1.499E-05   Y  93  3.767E-04   Sb126  1.269E-04   Sm155  4.997E-05   Hf173  3.448E-03   Pb193  3.591E-05
 Cr 63  9.785E-07   Y  94  3.058E-04   Sb127  7.596E-05   Sm156  3.500E-05   Hf174  2.263E-03   Pb194  6.388E-05
 Cr 64  1.000E-06   Y  95  1.958E-04   Sb128  2.599E-05   Sm157  2.599E-05   Hf175  1.265E-03   Pb195  5.176E-05
 Mn 51  4.000E-06   Y  96  1.250E-04   Sb129  1.499E-05   Sm158  2.498E-05   Hf176  6.429E-04   Pb196  5.174E-05
 Mn 52  8.400E-05   Y  97  5.896E-05   Sb130  9.995E-06   Sm159  1.599E-05   Hf177  2.978E-04   Pb197  3.282E-05
 Mn 53  3.160E-04   Y  98  3.300E-05   Sb131  2.000E-06   Sm160  5.000E-06   Hf178  1.339E-04   Pb198  3.179E-05
 Mn 54  4.860E-04   Y  99  1.199E-05   Sb132  1.000E-06   Sm161  2.000E-06   Hf179  7.296E-05   Pb199  1.884E-05
 Mn 55  4.680E-04   Y 100  3.000E-06   Te114  9.000E-06   Sm162  1.987E-06   Hf180  2.297E-05   Pb200  3.980E-06
 Mn 56  4.798E-04   Zr 86  1.800E-05   Te115  6.200E-05   Eu140  1.000E-06   Hf181  1.597E-05   Pb201  2.987E-06
 Mn 57  3.958E-04   Zr 87  8.199E-05   Te116  3.220E-04   Eu141  9.000E-06   Hf182  9.000E-06   Pb202  2.982E-06

start of irradiation and cooling calculation   ... cpu time     53.30 [s]
-------------------------------------------
   initial proton flux  =  6.24151E+15 [n/cm**2/s]
   initial neutron flux =  8.77350E+13 [n/cm**2/s]  below 20 MeV

 during cooling time ---
 summation of activity     =  3.56025E+11 [Bq]  at         31 [d]
                                                       cpu time    2055.92 [s]  (   2002.62 [s])

 during cooling time ---
 summation of activity     =  1.56037E+11 [Bq]  at         35 [d]
                                                       cpu time    2057.21 [s]  (      1.30 [s])

 during cooling time ---
 summation of activity     =  9.35827E+10 [Bq]  at         40 [d]
                                                       cpu time    2058.47 [s]  (      1.25 [s])

 during cooling time ---
 summation of activity     =  3.91504E+10 [Bq]  at         60 [d]
                                                       cpu time    2059.65 [s]  (      1.18 [s])

 during cooling time ---
 summation of activity     =  1.36360E+10 [Bq]  at        130 [d]
                                                       cpu time    2060.74 [s]  (      1.09 [s])

 during cooling time ---
 summation of activity     =  3.88502E+09 [Bq]  at        330 [d]
                                                       cpu time    2061.78 [s]  (      1.04 [s])

 during cooling time ---
 summation of activity     =  5.17444E+08 [Bq]  at 2.8200E+00 [y]
                                                       cpu time    2062.77 [s]  (      1.00 [s])

 during cooling time ---
 summation of activity     =  5.95444E+07 [Bq]  at 1.3771E+01 [y]
                                                       cpu time    2063.73 [s]  (      0.95 [s])

end of DCHAIN-SP calculation process
------------------------------  good bye... .. .
```

Fig. C-7 Output of DCHAIN-SP calculation summary for sample problem (continued).

```
target material ...  Hg-nat
beam current ......  1.0000E+00 [mA]
beam energy .......  1.5000E+00 [GeV]
beam power ........  1.5000E+00 [MW]
neutron flux ......  8.7735E+13 [n/cm**2/s]
irradiation time ..          30 [d]

 --- output time ---          31 [d]    ( 2.67840E+06 [s])
```

nuclide	atoms	activity [Bq]	rate [%]	decay heat [W] beta	gamma	alpha	half-life [s]
H 3	2.2149E+14	3.9456E+05		3.607E-10	0.000E+00	0.000E+00	3.891E+08
Be 7	4.2362E+12	6.3774E+05		2.933E-08	5.068E-09	0.000E+00	4.604E+06
Be 10	4.0042E+12	5.8245E-02		2.354E-15	0.000E+00	0.000E+00	4.765E+13
C 14	1.5204E+13	5.8283E+01		4.620E-13	0.000E+00	0.000E+00	1.808E+11
F 18	1.0873E+07	1.1440E+03		4.582E-11	0.000E+00	0.000E+00	6.588E+03
Na 22	1.5269E+13	1.2889E+05		4.042E-09	2.631E-08	0.000E+00	8.211E+07
Na 24	7.8122E+11	1.0041E+07		8.888E-07	6.635E-06	0.000E+00	5.393E+04
Mg 28	1.1597E+12	1.0678E+07		2.540E-07	2.345E-06	0.000E+00	7.528E+04
Al 26	2.2301E+13	6.6194E-01		4.735E-14	1.949E-13	0.000E+00	2.335E+13
Al 28	2.0751E+09	1.0697E+07		2.121E-06	3.056E-06	0.000E+00	1.345E+02
Si 31	9.4923E+08	7.1060E+04		6.774E-09	1.009E-11	0.000E+00	9.259E+03
Si 32	1.0194E+14	1.3018E+04		1.349E-10	0.000E+00	0.000E+00	5.428E+09
P 32	4.4180E+13	2.4852E+07		2.767E-06	0.000E+00	0.000E+00	1.232E+06
P 33	9.3856E+13	2.9644E+07		3.637E-07	0.000E+00	0.000E+00	2.195E+06
S 35	1.6074E+14	1.4737E+07		1.153E-07	0.000E+00	0.000E+00	7.560E+06
S 38	1.3921E+09	9.4444E+04		7.263E-09	2.603E-08	0.000E+00	1.022E+04
Cl 36	9.9550E+13	7.2643E+00		3.183E-13	2.760E-17	0.000E+00	9.499E+12
Cl 38	3.8913E+08	1.2084E+05		2.949E-08	2.892E-08	0.000E+00	2.232E+03
Cl 39	4.3253E+03	8.9870E-01		1.185E-13	2.088E-13	0.000E+00	3.336E+03
Ar 37	4.2305E+13	9.6860E+06		3.655E-09	5.021E-10	0.000E+00	3.027E+06
Ar 39	2.4787E+14	2.0240E+04		7.090E-10	0.000E+00	0.000E+00	8.489E+09
Ar 41	7.8105E+07	8.2312E+03		5.829E-10	1.693E-09	0.000E+00	6.577E+03
Ar 42	1.5897E+14	1.0613E+05		3.962E-09	0.000E+00	0.000E+00	1.038E+09
K 40	9.4975E+13	1.6297E-03		1.188E-16	4.105E-17	0.000E+00	4.039E+16
K 42	9.5100E+11	1.4814E+07		3.364E-06	6.615E-07	0.000E+00	4.450E+04
K 43	5.3776E+12	4.6431E+07	0.01	2.303E-06	7.187E-06	0.000E+00	8.028E+04
Ca 41	4.0052E+13	8.5410E+00		1.724E-13	5.982E-16	0.000E+00	3.250E+12
Ca 45	2.7051E+14	1.3314E+07		1.643E-07	5.026E-13	0.000E+00	1.408E+07
Ca 47	3.7026E+13	6.5486E+07	0.02	3.464E-06	1.054E-05	0.000E+00	3.919E+05
Sc 43	1.6130E+09	7.9817E+04		5.371E-09	1.078E-09	0.000E+00	1.401E+04
Sc 44	8.9421E+09	4.3843E+05		4.184E-08	8.240E-08	0.000E+00	1.414E+04
Sc 44m	8.7071E+06	2.8628E+01		1.505E-13	1.263E-12	0.000E+00	2.108E+05
Sc 45m	1.7980E+00	3.9438E+00		6.571E-15	2.009E-16	0.000E+00	3.160E-01
Sc 46	1.6480E+14	1.5779E+07		2.838E-07	5.080E-06	0.000E+00	7.239E+06
Sc 47	5.3629E+13	1.2654E+08	0.04	3.272E-06	2.254E-06	0.000E+00	2.938E+05
Sc 48	1.0429E+13	4.5973E+07	0.01	1.617E-06	2.467E-05	0.000E+00	1.572E+05
Sc 49	1.1043E+04	2.2304E+00		2.922E-13	3.573E-16	0.000E+00	3.432E+03
Ti 44	2.2872E+12	1.0253E+03		1.150E-11	2.267E-11	0.000E+00	1.546E+09
Ti 45	3.5048E+08	2.1910E+04		1.313E-09	1.179E-11	0.000E+00	1.109E+04
V 48	3.6765E+13	1.8465E+07		4.260E-07	7.100E-06	0.000E+00	1.380E+06
V 49	1.3999E+14	3.4032E+06		1.091E-07	5.163E-10	0.000E+00	2.851E+07
V 50	2.4828E+14	3.8952E-11		3.744E-24	8.881E-24	0.000E+00	4.418E+24
Cr 48	1.1427E+10	1.0205E+05		3.106E-10	6.867E-09	0.000E+00	7.762E+04

Fig. C-8 Example of output file of calculation results of sample problem.

Cr 51	1.2873E+14	3.7281E+07	0.01	1.195E-06	1.946E-07	0.000E+00	2.393E+06
Mn 51	1.4628E+00	3.6577E-04		5.482E-17	3.950E-19	0.000E+00	2.772E+03
Mn 52	1.1139E+13	1.5983E+07		1.900E-07	8.078E-06	0.000E+00	4.831E+05
Mn 53	1.8252E+14	1.0719E+00		3.091E-14	2.363E-16	0.000E+00	1.180E+14
Mn 54	2.6841E+14	6.8990E+06		1.769E-07	9.241E-07	0.000E+00	2.697E+07
Mn 56	4.6325E+09	3.4592E+05		4.535E-08	9.375E-08	0.000E+00	9.283E+03
Fe 55	1.6012E+14	1.2883E+06		1.445E-08	3.447E-10	0.000E+00	8.615E+07
Fe 59	3.8907E+14	7.0137E+07	0.02	1.326E-06	1.336E-05	0.000E+00	3.845E+06
Fe 60	3.8140E+14	5.5849E+00		4.563E-14	0.000E+00	0.000E+00	4.734E+13
Co 55	1.5579E+10	1.7101E+05		1.178E-08	3.315E-08	0.000E+00	6.314E+04
Co 56	2.7340E+13	2.8386E+06		5.458E-08	1.546E-06	0.000E+00	6.676E+06
Co 57	1.0377E+14	3.0631E+06		9.815E-08	5.977E-08	0.000E+00	2.348E+07
Co 58	2.1750E+14	2.4639E+07		1.184E-06	3.241E-06	0.000E+00	6.119E+06
Co 58m	3.8949E+07	8.1960E+02		2.994E-12	2.452E-13	0.000E+00	3.294E+04
Co 60	3.1173E+14	1.2990E+06		2.011E-08	5.212E-07	0.000E+00	1.663E+08
Co 60m	5.0601E+03	5.5849E+00		5.077E-14	6.053E-15	0.000E+00	6.280E+02
Co 61	8.1224E+07	9.4781E+03		7.027E-10	1.467E-10	0.000E+00	5.940E+03
Ni 56	3.9793E+03	5.4108E-03		6.135E-18	1.492E-15	0.000E+00	5.098E+05
Ni 57	7.6689E+10	4.1477E+05		9.503E-09	1.003E-07	0.000E+00	1.282E+05
Ni 59	1.1100E+14	3.2080E+01		2.231E-14	1.220E-14	0.000E+00	2.398E+12
Ni 63	6.5344E+14	1.4338E+05		3.928E-10	0.000E+00	0.000E+00	3.159E+09
Ni 65	2.7183E+09	2.0769E+05		2.073E-08	1.826E-08	0.000E+00	9.072E+03
Ni 66	2.6293E+13	9.2718E+07	0.03	9.656E-07	0.000E+00	0.000E+00	1.966E+05
Cu 61	2.0263E+09	1.1705E+05		5.814E-09	3.638E-09	0.000E+00	1.200E+04
Cu 62	3.0977E+07	3.6741E+04		7.538E-09	4.203E-11	0.000E+00	5.844E+02
Cu 64	2.6796E+12	4.0625E+07	0.01	7.876E-07	5.012E-08	0.000E+00	4.572E+04
Cu 66	4.0995E+10	9.2862E+07	0.03	1.583E-05	1.163E-06	0.000E+00	3.060E+02
Cu 67	4.7709E+13	1.4835E+08	0.04	6.655E-06	2.743E-06	0.000E+00	2.229E+05
Zn 62	1.7219E+09	3.6092E+04		1.850E-10	2.041E-09	0.000E+00	3.307E+04
Zn 65	1.8870E+14	6.1976E+06		6.454E-09	5.600E-07	0.000E+00	2.110E+07
Zn 69	1.1633E+06	2.3828E+02		1.225E-11	2.329E-16	0.000E+00	3.384E+03
Zn 69m	1.5548E+07	2.1756E+02		7.712E-13	1.452E-11	0.000E+00	4.954E+04
Zn 71	1.0422E+04	4.9144E+01		8.234E-12	2.480E-12	0.000E+00	1.470E+02
Zn 71m	2.0007E+09	9.7275E+04		8.379E-09	2.453E-08	0.000E+00	1.426E+04
Zn 72	1.6544E+13	6.8504E+07	0.02	1.126E-06	1.623E-06	0.000E+00	1.674E+05
Ga 66	2.4565E+11	4.9839E+06		7.905E-07	1.500E-06	0.000E+00	3.416E+04
Ga 67	2.6583E+13	6.5393E+07	0.02	3.143E-07	1.624E-06	0.000E+00	2.818E+05
Ga 68	9.2410E+09	1.5788E+06		1.872E-07	9.359E-09	0.000E+00	4.057E+03
Ga 72	8.6187E+12	1.1769E+08	0.03	9.485E-06	5.104E-05	0.000E+00	5.076E+04
Ga 72m	1.1771E+05	2.0551E+06		0.000E+00	3.941E-08	0.000E+00	3.970E-02
Ga 73	1.2213E+11	4.8385E+06		3.765E-07	2.729E-07	0.000E+00	1.750E+04
Ge 66	1.6470E+06	1.4032E+02		2.248E-12	9.892E-12	0.000E+00	8.136E+03
Ge 68	5.3284E+13	1.5784E+06		7.587E-09	1.047E-09	0.000E+00	2.340E+07
Ge 69	8.0332E+12	3.9538E+07	0.01	7.602E-07	4.498E-06	0.000E+00	1.408E+05
Ge 71	2.2297E+14	1.5650E+08	0.04	1.201E-07	1.053E-07	0.000E+00	9.876E+05
Ge 71m	2.7582E+04	9.3719E+05		0.000E+00	2.402E-08	0.000E+00	2.040E-02
Ge 73m	3.1698E+07	4.3943E+07	0.01	3.933E-07	7.767E-08	0.000E+00	5.000E-01
Ge 75	7.5311E+06	1.0508E+03		7.090E-11	5.881E-12	0.000E+00	4.968E+03
Ge 77	9.9019E+11	1.6872E+07		1.738E-06	2.914E-06	0.000E+00	4.068E+04
Ge 78	5.4745E+06	7.1705E+02		2.720E-11	3.194E-11	0.000E+00	5.292E+03
As 70	9.2283E+01	2.0268E-02		2.728E-15	1.031E-14	0.000E+00	3.156E+03
As 71	1.1769E+13	3.4711E+07		6.451E-07	1.535E-06	0.000E+00	2.350E+05
As 72	7.2406E+12	5.3785E+07	0.02	8.876E-06	7.592E-06	0.000E+00	9.331E+04

Fig. C-8 Example of output file of calculation results of sample problem (continued).

As 73	3.9194E+14	3.9157E+07	0.01	3.620E-07	9.956E-08	0.000E+00	6.938E+06
As 74	2.2923E+14	1.0349E+08	0.03	4.440E-06	7.743E-06	0.000E+00	1.535E+06
As 76	9.2185E+12	6.7437E+07	0.02	1.146E-05	4.682E-06	0.000E+00	9.475E+04
As 77	3.0487E+13	1.5117E+08	0.04	5.474E-06	1.925E-07	0.000E+00	1.398E+05
As 78	9.3324E+07	1.1887E+04		2.438E-09	2.552E-09	0.000E+00	5.442E+03
Se 72	7.6034E+12	7.2593E+06		2.617E-08	3.989E-08	0.000E+00	7.260E+05
Se 73	1.2323E+11	3.3185E+06		2.074E-07	2.497E-07	0.000E+00	2.574E+04
Se 75	4.0521E+14	2.7143E+07		6.374E-08	1.704E-06	0.000E+00	1.035E+07
Se 77m	1.4189E+07	5.6654E+05		6.744E-09	7.961E-09	0.000E+00	1.736E+01
Se 79	6.5297E+14	2.2065E+01		1.834E-13	0.000E+00	0.000E+00	2.051E+13
Se 81	4.1761E+01	2.6148E-02		2.547E-15	3.355E-17	0.000E+00	1.107E+03
Se 81m	8.7934E+01	1.7735E-02		2.429E-16	5.056E-17	0.000E+00	3.437E+03
Se 82	3.0014E+14	4.7089E-14		7.532E-27	7.532E-27	0.000E+00	4.418E+27
Br 75	2.1195E+11	2.5243E+07		2.022E-06	1.913E-06	0.000E+00	5.820E+03
Br 76	1.7214E+12	2.0459E+07		2.131E-06	7.297E-06	0.000E+00	5.832E+04
Br 77	2.7891E+13	9.4152E+07	0.03	1.358E-07	4.842E-06	0.000E+00	2.053E+05
Br 77m	5.6010E+03	1.5106E+01		2.077E-13	4.671E-14	0.000E+00	2.570E+02
Br 80	1.2520E+05	8.1810E+01		9.497E-12	6.947E-13	0.000E+00	1.061E+03
Br 80m	1.7528E+06	7.6356E+01		7.581E-13	2.956E-13	0.000E+00	1.591E+04
Br 82	1.3637E+13	7.4381E+07	0.02	1.632E-06	3.155E-05	0.000E+00	1.271E+05
Br 83	2.0296E+09	1.6283E+05		8.345E-09	1.793E-10	0.000E+00	8.640E+03
Kr 76	4.9627E+10	6.4563E+05		1.727E-09	4.396E-08	0.000E+00	5.328E+04
Kr 77	9.7538E+04	1.5145E+01		1.699E-12	4.922E-13	0.000E+00	4.464E+03
Kr 79	1.2901E+13	7.0892E+07	0.02	2.646E-07	2.090E-06	0.000E+00	1.261E+05
Kr 81	6.3936E+14	6.1324E+01		4.683E-14	1.621E-13	0.000E+00	7.227E+12
Kr 81m	3.7423E+07	1.9801E+06		2.037E-08	4.000E-08	0.000E+00	1.310E+01
Kr 83m	4.0221E+11	4.2317E+07	0.01	2.642E-07	1.767E-08	0.000E+00	6.588E+03
Kr 85	3.2798E+14	6.6977E+05		2.688E-08	2.372E-10	0.000E+00	3.394E+08
Kr 85m	4.2963E+10	1.8465E+06		7.544E-08	4.675E-08	0.000E+00	1.613E+04
Kr 87	9.9342E+05	1.5041E+02		3.253E-11	1.909E-11	0.000E+00	4.578E+03
Kr 88	2.2518E+09	1.5266E+05		8.911E-09	4.772E-08	0.000E+00	1.022E+04
Rb 80	9.0981E+02	1.8548E+01		6.062E-12	5.474E-13	0.000E+00	3.400E+01
Rb 81	4.8379E+10	2.0356E+06		6.066E-08	1.130E-07	0.000E+00	1.647E+04
Rb 82	1.3315E+09	1.2084E+07		2.734E-06	2.284E-07	0.000E+00	7.638E+01
Rb 82m	1.1972E+06	3.5616E+01		5.421E-13	1.538E-11	0.000E+00	2.330E+04
Rb 83	5.4628E+14	5.0839E+07	0.01	2.973E-07	3.991E-06	0.000E+00	7.448E+06
Rb 84	3.1932E+14	7.8183E+07	0.02	1.992E-06	7.837E-06	0.000E+00	2.831E+06
Rb 86	2.0415E+14	8.7907E+07	0.02	9.394E-06	1.331E-06	0.000E+00	1.610E+06
Rb 87	5.2699E+14	2.4369E-04		3.202E-18	0.000E+00	0.000E+00	1.499E+18
Rb 88	2.6233E+08	1.7044E+05		5.628E-08	1.740E-08	0.000E+00	1.067E+03
Sr 80	1.6976E+05	1.8449E+01		1.064E-13	9.695E-13	0.000E+00	6.378E+03
Sr 82	3.8482E+13	1.2083E+07		9.776E-09	1.526E-08	0.000E+00	2.208E+06
Sr 83	6.6950E+12	3.9772E+07	0.01	9.495E-07	3.441E-06	0.000E+00	1.167E+05
Sr 85	4.3198E+14	5.3448E+07	0.02	7.445E-08	4.396E-06	0.000E+00	5.602E+06
Sr 85m	7.8319E+08	1.3372E+05		2.999E-10	4.628E-09	0.000E+00	4.060E+03
Sr 87m	2.2260E+12	1.5291E+08	0.04	1.669E-06	7.864E-06	0.000E+00	1.009E+04
Sr 89	4.0036E+14	6.3564E+07	0.02	5.937E-06	1.004E-08	0.000E+00	4.366E+06
Sr 90	4.1350E+14	3.1558E+05		9.892E-09	0.000E+00	0.000E+00	9.082E+08
Sr 91	1.0203E+12	2.0399E+07		2.099E-06	2.304E-06	0.000E+00	3.467E+04
Sr 92	2.0866E+09	1.4825E+05		4.537E-09	3.176E-08	0.000E+00	9.756E+03
Y 85	1.0786E+09	7.7475E+04		6.169E-09	4.965E-09	0.000E+00	9.650E+03
Y 85m	6.8013E+03	2.6939E-01		2.469E-14	3.280E-14	0.000E+00	1.750E+04
Y 86	2.4628E+12	3.2172E+07		1.155E-06	1.676E-05	0.000E+00	5.306E+04

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Y 87	6.1262E+13	1.4781E+08	0.04	1.800E-06	1.786E-05	0.000E+00	2.873E+05
Y 87m	4.1397E+11	5.9616E+06		7.546E-08	2.932E-07	0.000E+00	4.813E+04
Y 88	5.0101E+14	3.7687E+07	0.01	4.124E-08	1.628E-05	0.000E+00	9.215E+06
Y 89m	2.9699E+09	1.2818E+08	0.04	1.585E-07	1.851E-05	0.000E+00	1.606E+01
Y 90	3.6740E+13	1.1036E+08	0.03	1.651E-05	3.536E-08	0.000E+00	2.308E+05
Y 90m	1.0570E+05	6.3798E+00		4.876E-14	6.483E-13	0.000E+00	1.148E+04
Y 91	4.8010E+14	6.5828E+07	0.02	6.352E-06	3.812E-08	0.000E+00	5.055E+06
Y 91m	5.6375E+10	1.3101E+07		5.882E-08	1.108E-06	0.000E+00	2.983E+03
Y 92	5.6192E+10	3.0563E+06		7.081E-07	1.237E-07	0.000E+00	1.274E+04
Y 93	1.3465E+12	2.5467E+07		4.775E-06	3.793E-07	0.000E+00	3.665E+04
Zr 86	1.2424E+11	1.4498E+06		7.085E-09	6.433E-08	0.000E+00	5.940E+04
Zr 87	7.9076E+06	9.0627E+02		1.307E-10	4.545E-12	0.000E+00	6.048E+03
Zr 88	1.8378E+14	1.7678E+07		4.532E-08	1.140E-06	0.000E+00	7.206E+06
Zr 89	5.2275E+13	1.2833E+08	0.04	2.077E-06	5.346E-07	0.000E+00	2.824E+05
Zr 89m	5.6194E+03	1.5531E+01		7.962E-14	1.575E-12	0.000E+00	2.508E+02
Zr 90m	1.2599E+07	1.0792E+07		2.939E-08	3.981E-06	0.000E+00	8.092E-01
Zr 93	6.6240E+14	9.5093E+00		7.161E-14	2.742E-15	0.000E+00	4.828E+13
Zr 95	3.2723E+14	4.1007E+07	0.01	7.598E-07	4.842E-06	0.000E+00	5.531E+06
Zr 97	2.4633E+12	2.8047E+07		3.280E-06	8.682E-07	0.000E+00	6.088E+04
Nb 89	1.4764E+07	1.4961E+03		2.675E-10	1.609E-10	0.000E+00	6.840E+03
Nb 90	8.1834E+11	1.0792E+07		6.916E-07	6.323E-06	0.000E+00	5.256E+04
Nb 90m	2.6885E+06	9.9070E+04		6.254E-10	1.308E-09	0.000E+00	1.881E+01
Nb 90n	8.8390E+02	9.8978E+04		0.000E+00	3.452E-09	0.000E+00	6.190E-03
Nb 91	3.9475E+14	1.2751E+04		1.091E-11	2.427E-11	0.000E+00	2.146E+10
Nb 91m	9.2707E+09	1.2221E+03		1.762E-11	8.223E-12	0.000E+00	5.258E+06
Nb 92	3.9699E+14	2.5129E-01		2.939E-16	6.790E-14	0.000E+00	1.095E+15
Nb 92m	3.5274E+09	2.7881E+03		2.502E-12	4.326E-10	0.000E+00	8.770E+05
Nb 93m	7.1754E+09	9.7709E+00		4.390E-14	2.951E-15	0.000E+00	5.090E+08
Nb 94	3.8668E+14	4.1838E+02		9.774E-12	1.055E-10	0.000E+00	6.406E+11
Nb 95	2.6966E+14	6.1855E+07	0.02	4.294E-07	7.590E-06	0.000E+00	3.022E+06
Nb 95m	1.8413E+11	4.0938E+05		1.122E-08	4.191E-09	0.000E+00	3.118E+05
Nb 96	5.6957E+12	4.6966E+07	0.01	1.887E-06	1.824E-05	0.000E+00	8.406E+04
Nb 97	1.8859E+11	3.0218E+07		2.257E-06	3.231E-06	0.000E+00	4.326E+03
Nb 97m	2.0207E+09	2.6578E+07		6.392E-08	3.101E-06	0.000E+00	5.270E+01
Mo 90	3.1117E+09	1.0567E+05		3.403E-09	4.740E-09	0.000E+00	2.041E+04
Mo 93	3.5987E+14	1.9761E+03		9.498E-12	1.235E-11	0.000E+00	1.262E+11
Mo 93m	1.3125E+05	3.6893E+00		6.088E-14	1.365E-12	0.000E+00	2.466E+04
Mo 99	4.8566E+13	1.4181E+08	0.04	8.899E-06	3.413E-06	0.000E+00	2.374E+05
Tc 93	5.4307E+08	3.8023E+04		2.680E-10	8.602E-09	0.000E+00	9.900E+03
Tc 94	4.3620E+10	1.7199E+06		1.273E-08	7.040E-07	0.000E+00	1.758E+04
Tc 94m	1.7869E+02	3.9697E-02		4.802E-15	7.798E-15	0.000E+00	3.120E+03
Tc 95	4.9534E+12	4.7686E+07	0.01	4.661E-08	6.097E-06	0.000E+00	7.200E+04
Tc 95m	1.9024E+08	2.5022E+01		5.893E-14	2.882E-12	0.000E+00	5.270E+06
Tc 96	6.8867E+13	1.2909E+08	0.04	1.689E-07	5.177E-05	0.000E+00	3.698E+05
Tc 97	6.8379E+14	5.7766E+00		4.628E-15	1.092E-14	0.000E+00	8.205E+13
Tc 97m	6.8985E+10	6.1424E+03		8.562E-11	9.251E-12	0.000E+00	7.785E+06
Tc 98	5.2750E+14	2.7586E+00		5.260E-14	6.244E-13	0.000E+00	1.325E+14
Tc 99	8.3097E+14	8.6461E+01		1.177E-12	8.059E-18	0.000E+00	6.662E+12
Tc 99m	4.2350E+12	1.3568E+08	0.04	3.553E-07	2.746E-06	0.000E+00	2.164E+04
Ru 94	8.4758E+00	1.8903E-03		2.514E-18	1.575E-16	0.000E+00	3.108E+03
Ru 95	2.7914E+06	3.2713E+02		4.193E-12	5.776E-11	0.000E+00	5.915E+03
Ru 97	2.4994E+13	6.9143E+07	0.02	1.396E-07	2.521E-06	0.000E+00	2.506E+05
Ru103	5.2995E+14	1.0829E+08	0.03	1.909E-06	8.395E-06	0.000E+00	3.392E+06

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Ru105	8.2455E+10	3.5757E+06		2.521E-07	4.077E-07	0.000E+00	1.598E+04
Ru106	2.8476E+14	6.1110E+06		9.826E-09	0.000E+00	0.000E+00	3.230E+07
Rh 99	8.5870E+13	4.2790E+07	0.01	3.976E-07	3.442E-06	0.000E+00	1.391E+06
Rh 99m	9.9999E+08	4.1014E+04		2.563E-10	3.568E-09	0.000E+00	1.690E+04
Rh100	7.8332E+12	7.2491E+07	0.02	6.957E-07	3.229E-05	0.000E+00	7.490E+04
Rh101	4.5098E+14	3.0017E+06		1.270E-08	1.358E-07	0.000E+00	1.041E+08
Rh101m	2.8568E+13	5.2805E+07	0.01	1.675E-07	2.572E-06	0.000E+00	3.750E+05
Rh102	5.8916E+14	2.2834E+07		5.853E-07	1.071E-06	0.000E+00	1.788E+07
Rh102m	1.2200E+10	9.2399E+01		1.776E-13	3.153E-11	0.000E+00	9.152E+07
Rh103m	1.2882E+12	2.6518E+08	0.07	5.098E-07	7.010E-08	0.000E+00	3.367E+03
Rh105	3.9799E+13	2.1671E+08	0.06	5.336E-06	2.697E-06	0.000E+00	1.273E+05
Rh105m	6.5182E+07	1.0040E+06		1.528E-08	5.469E-09	0.000E+00	4.500E+01
Rh106	2.6273E+08	6.1110E+06		1.383E-06	2.043E-07	0.000E+00	2.980E+01
Rh106m	2.2079E+03	1.9471E-01		9.775E-15	9.045E-14	0.000E+00	7.860E+03
Pd100	7.5672E+12	1.6724E+07		1.742E-07	2.278E-07	0.000E+00	3.136E+05
Pd101	3.5964E+11	8.1759E+06		4.048E-08	3.943E-07	0.000E+00	3.049E+04
Pd103	3.3437E+14	1.5788E+08	0.04	1.075E-06	4.098E-07	0.000E+00	1.468E+06
Pd107	1.0449E+15	3.5309E+00		5.261E-15	0.000E+00	0.000E+00	2.051E+14
Pd109	4.6983E+12	6.6025E+07	0.02	4.633E-06	1.238E-07	0.000E+00	4.932E+04
Pd111	1.9511E+04	9.6323E+00		1.285E-12	7.404E-14	0.000E+00	1.404E+03
Pd111m	3.5019E+05	1.2259E+01		4.007E-13	2.859E-13	0.000E+00	1.980E+04
Pd112	3.9774E+12	3.6415E+07	0.01	5.282E-07	3.016E-08	0.000E+00	7.571E+04
Ag103	4.2499E+04	7.4729E+00		2.395E-13	6.741E-13	0.000E+00	3.942E+03
Ag104	2.4403E+05	4.0741E+01		6.266E-13	1.673E-11	0.000E+00	4.152E+03
Ag104m	1.5466E+03	5.3335E-01		4.358E-14	6.930E-14	0.000E+00	2.010E+03
Ag105	3.4287E+14	6.6619E+07	0.02	1.996E-07	5.465E-06	0.000E+00	3.567E+06
Ag105m	2.9728E+02	4.7501E-01		1.880E-15	4.338E-16	0.000E+00	4.338E+02
Ag106m	1.8633E+09	1.8054E+03		3.587E-12	8.128E-10	0.000E+00	7.154E+05
Ag107m	8.8041E+08	1.3775E+07		1.766E-07	2.781E-08	0.000E+00	4.430E+01
Ag108	3.2520E+00	1.5852E-02		1.551E-15	3.962E-17	0.000E+00	1.422E+02
Ag108m	3.4675E+09	1.8221E-01		4.408E-16	4.753E-14	0.000E+00	1.319E+10
Ag109m	4.9898E+09	8.7340E+07	0.02	1.077E-06	1.539E-07	0.000E+00	3.960E+01
Ag110	4.7455E+01	1.3371E+00		2.539E-13	6.556E-15	0.000E+00	2.460E+01
Ag110m	3.0613E+09	9.8319E+01		1.181E-12	4.331E-11	0.000E+00	2.158E+07
Ag111	2.1238E+14	2.2870E+08	0.06	1.286E-05	9.689E-07	0.000E+00	6.437E+05
Ag111m	1.2071E+03	1.2912E+01		1.143E-13	1.580E-14	0.000E+00	6.480E+01
Ag112	7.0361E+11	4.3282E+07	0.01	9.570E-06	4.788E-06	0.000E+00	1.127E+04
Ag113	1.6497E+11	5.9149E+06		7.215E-07	6.818E-08	0.000E+00	1.933E+04
Cd104	1.1173E+03	2.2369E-01		1.039E-15	8.996E-15	0.000E+00	3.462E+03
Cd105	2.0211E+03	4.2071E-01		1.584E-14	6.525E-14	0.000E+00	3.330E+03
Cd107	4.6445E+11	1.3758E+07		1.874E-07	5.973E-08	0.000E+00	2.340E+04
Cd109	1.2309E+15	2.1288E+07		2.773E-07	7.777E-08	0.000E+00	4.008E+07
Cd111m	1.6050E+08	3.8153E+04		6.580E-10	1.764E-09	0.000E+00	2.916E+03
Cd113	9.4928E+14	2.2420E-09		3.351E-23	0.000E+00	0.000E+00	2.935E+23
Cd113m	3.0551E+12	4.7591E+03		1.434E-10	1.372E-13	0.000E+00	4.450E+08
Cd115	3.5015E+13	1.2611E+08	0.04	6.446E-06	3.898E-06	0.000E+00	1.925E+05
Cd115m	5.5082E+12	9.9080E+05		9.579E-08	5.239E-09	0.000E+00	3.853E+06
Cd117	1.1343E+09	8.7709E+04		6.239E-09	1.086E-08	0.000E+00	8.964E+03
Cd117m	4.2952E+08	2.4613E+04		9.346E-10	8.039E-09	0.000E+00	1.210E+04
Cd118	4.6058E+02	1.0578E-01		4.180E-15	0.000E+00	0.000E+00	3.018E+03
In108	8.9334E+03	1.7793E+00		4.960E-14	8.376E-13	0.000E+00	3.480E+03
In109	5.5506E+10	2.5446E+06		1.835E-08	2.405E-07	0.000E+00	1.512E+04
In110	1.9822E+11	7.7887E+06		1.622E-08	3.868E-06	0.000E+00	1.764E+04

Fig. C-8 Example of output file of calculation results of sample problem (continued).

In110m	5.8951E+09	9.8553E+05		9.948E-08	1.467E-07	0.000E+00	4.146E+03
In111	1.3179E+14	3.7694E+08	0.11	2.022E-06	2.446E-05	0.000E+00	2.423E+05
In113m	6.3055E+11	7.3216E+07	0.02	1.543E-06	3.052E-06	0.000E+00	5.970E+03
In114	3.6372E+05	3.5064E+03		4.334E-10	1.140E-12	0.000E+00	7.190E+01
In114m	2.2635E+10	3.6677E+03		8.427E-11	5.552E-11	0.000E+00	4.278E+06
In115	1.1565E+15	5.7600E-08		1.412E-21	2.215E-24	0.000E+00	1.392E+22
In115m	3.1980E+12	1.3726E+08	0.04	3.827E-06	3.394E-06	0.000E+00	1.615E+04
In117	9.4427E+08	2.5251E+05		1.068E-08	2.800E-08	0.000E+00	2.592E+03
In117m	3.3095E+09	3.2902E+05		1.423E-08	4.792E-09	0.000E+00	6.972E+03
Sn110	1.5142E+10	7.0938E+05		1.489E-09	3.330E-08	0.000E+00	1.480E+04
Sn113	1.0497E+15	7.3172E+07	0.02	1.620E-06	3.278E-06	0.000E+00	9.944E+06
Sn117m	8.5987E+11	5.0723E+05		1.268E-08	1.284E-08	0.000E+00	1.175E+06
Sn119m	2.3658E+13	6.4754E+05		8.103E-09	1.183E-09	0.000E+00	2.532E+07
Sn121	9.5341E+12	6.7838E+07	0.02	1.230E-06	0.000E+00	0.000E+00	9.742E+04
Sn121m	1.0084E+13	4.0272E+03		2.271E-11	3.226E-12	0.000E+00	1.736E+09
Sn123	8.1961E+13	5.0893E+06		4.239E-07	5.626E-09	0.000E+00	1.116E+07
Sn125	1.1429E+13	9.5116E+06		1.230E-06	5.099E-07	0.000E+00	8.329E+05
Sn126	2.5171E+13	5.5287E+00		1.107E-13	5.004E-14	0.000E+00	3.156E+12
Sn127	9.6083E+06	8.8094E+02		7.325E-11	2.621E-10	0.000E+00	7.560E+03
Sn128	2.0710E+02	4.0503E-02		1.632E-15	3.890E-15	0.000E+00	3.544E+03
Sb116	1.3639E+08	9.9725E+04		7.909E-09	2.743E-08	0.000E+00	9.480E+02
Sb117	3.2567E+10	2.2395E+06		1.008E-08	5.992E-08	0.000E+00	1.008E+04
Sb118	1.1072E+11	3.5531E+08	0.10	5.027E-05	3.131E-06	0.000E+00	2.160E+02
Sb118m	2.1606E+05	8.3201E+00		4.132E-14	3.439E-12	0.000E+00	1.800E+04
Sb119	1.8363E+14	9.2582E+08	0.26	3.560E-06	3.431E-06	0.000E+00	1.375E+05
Sb120m	1.4279E+09	1.9887E+03		1.415E-11	7.857E-10	0.000E+00	4.977E+05
Sb122	4.9077E+13	1.4455E+08	0.04	1.309E-05	1.021E-05	0.000E+00	2.353E+05
Sb124	1.4676E+14	1.9557E+07		1.201E-06	5.819E-06	0.000E+00	5.201E+06
Sb125	1.3974E+14	1.1128E+06		2.246E-08	7.898E-08	0.000E+00	8.704E+07
Sb126	3.3390E+13	2.1499E+07		1.212E-06	9.484E-06	0.000E+00	1.077E+06
Sb126m	9.1647E+03	5.5287E+00		5.571E-13	1.374E-12	0.000E+00	1.149E+03
Sb126n	8.1948E+01	5.1638E+00		1.857E-14	2.060E-16	0.000E+00	1.100E+01
Sb127	7.6827E+12	1.6009E+07		8.038E-07	1.703E-06	0.000E+00	3.326E+05
Sb128	4.2638E+10	9.1117E+05		7.387E-08	4.514E-07	0.000E+00	3.244E+04
Sb128m	4.4254E+01	4.9158E-02		7.537E-15	1.504E-14	0.000E+00	6.240E+02
Sb129	1.8404E+09	8.0534E+04		5.123E-09	1.884E-08	0.000E+00	1.584E+04
Te116	1.1533E+09	8.9178E+04		8.287E-10	1.072E-09	0.000E+00	8.964E+03
Te117	1.0661E+05	1.9865E+01		6.302E-13	4.058E-12	0.000E+00	3.720E+03
Te118	2.6563E+14	3.5517E+08	0.10	3.130E-07	1.132E-06	0.000E+00	5.184E+05
Te119	1.9352E+13	2.3244E+08	0.07	4.804E-07	2.793E-05	0.000E+00	5.771E+04
Te119m	2.0844E+09	3.5580E+03		1.026E-11	8.642E-10	0.000E+00	4.061E+05
Te121	1.7921E+15	8.5679E+08	0.24	1.235E-06	7.921E-05	0.000E+00	1.450E+06
Te121m	2.5812E+12	1.3447E+05		1.659E-09	4.675E-09	0.000E+00	1.331E+07
Te123	4.2390E+15	8.4644E-06		3.526E-21	3.551E-22	0.000E+00	3.471E+20
Te123m	2.5111E+11	1.6830E+04		2.714E-10	3.998E-10	0.000E+00	1.034E+07
Te125m	3.3423E+11	4.6714E+04		8.158E-10	2.657E-10	0.000E+00	4.959E+06
Te127	1.2384E+12	2.5502E+07		9.116E-07	1.994E-08	0.000E+00	3.366E+04
Te127m	5.4194E+12	3.9887E+05		5.240E-09	7.245E-10	0.000E+00	9.418E+06
Te128	1.4046E+14	4.0066E-19		2.054E-32	0.000E+00	0.000E+00	2.430E+32
Te129	1.6551E+09	2.7472E+05		2.391E-08	2.773E-09	0.000E+00	4.176E+03
Te129m	1.2092E+12	2.8872E+05		1.230E-08	1.712E-09	0.000E+00	2.903E+06
Te130	3.7749E+13	6.6332E-16		1.063E-28	0.000E+00	0.000E+00	3.945E+28
Te131	6.2590E+06	2.8923E+03		3.319E-10	1.956E-10	0.000E+00	1.500E+03

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Te131m	2.0018E+09	1.2847E+04		3.999E-10	2.940E-09	0.000E+00	1.080E+05
Te132	1.4176E+12	3.5496E+06		5.757E-08	1.325E-07	0.000E+00	2.768E+05
I 120	9.2790E+06	1.3234E+03		2.756E-10	4.018E-10	0.000E+00	4.860E+03
I 121	2.6692E+09	2.4242E+05		3.146E-09	1.107E-08	0.000E+00	7.632E+03
I 122	3.7463E+10	1.1923E+08	0.03	2.080E-05	3.171E-06	0.000E+00	2.178E+02
I 123	2.6238E+13	3.8070E+08	0.11	1.683E-06	1.054E-05	0.000E+00	4.777E+04
I 124	2.9011E+14	5.5680E+08	0.16	1.749E-05	7.601E-05	0.000E+00	3.612E+05
I 125	3.7048E+15	5.0030E+08	0.14	1.435E-06	3.374E-06	0.000E+00	5.133E+06
I 126	4.2778E+14	2.6177E+08	0.07	6.123E-06	1.766E-05	0.000E+00	1.133E+06
I 129	2.6298E+14	3.6791E-01		3.249E-15	1.474E-15	0.000E+00	4.955E+14
I 130	6.9292E+11	1.0794E+07		4.986E-07	3.698E-06	0.000E+00	4.450E+04
I 131	2.6976E+13	2.6982E+07		8.275E-07	1.649E-06	0.000E+00	6.930E+05
I 132	4.3737E+10	3.6693E+06		2.888E-07	1.341E-06	0.000E+00	8.262E+03
I 133	5.4673E+11	5.0609E+06		3.315E-07	4.928E-07	0.000E+00	7.488E+04
I 134	1.2704E+02	2.7955E-02		2.777E-15	1.169E-14	0.000E+00	3.150E+03
I 135	4.1916E+09	1.2284E+05		7.420E-09	3.242E-08	0.000E+00	2.365E+04
Xe120	1.2568E+00	3.6299E-04		3.199E-18	2.176E-17	0.000E+00	2.400E+03
Xe121	4.9245E+00	1.4187E-03		1.123E-16	2.192E-16	0.000E+00	2.406E+03
Xe122	1.2409E+13	1.1887E+08	0.03	1.904E-07	1.295E-06	0.000E+00	7.236E+04
Xe123	1.9096E+09	1.7677E+05		5.268E-09	1.098E-08	0.000E+00	7.488E+03
Xe125	4.0290E+13	4.5902E+08	0.13	2.400E-06	1.874E-05	0.000E+00	6.084E+04
Xe127	3.4564E+15	7.6179E+08	0.21	3.742E-06	3.308E-05	0.000E+00	3.145E+06
Xe127m	2.8368E+05	2.8416E+03		5.873E-11	7.649E-11	0.000E+00	6.920E+01
Xe129m	3.2562E+10	2.9417E+04		8.588E-10	2.537E-10	0.000E+00	7.672E+05
Xe131m	3.8816E+11	2.6301E+05		6.007E-09	8.327E-10	0.000E+00	1.023E+06
Xe133	2.4648E+13	3.7715E+07	0.01	8.218E-07	2.780E-07	0.000E+00	4.530E+05
Xe133m	8.0500E+10	2.9489E+05		9.071E-09	1.937E-09	0.000E+00	1.892E+05
Xe135	1.2420E+11	2.6164E+06		1.327E-07	1.042E-07	0.000E+00	3.290E+04
Xe135m	2.4018E+07	1.8147E+04		2.861E-10	1.255E-09	0.000E+00	9.174E+02
Cs125	2.9092E+02	7.4686E-02		3.949E-15	3.984E-15	0.000E+00	2.700E+03
Cs126	4.9519E+05	3.4882E+03		7.489E-10	1.755E-10	0.000E+00	9.840E+01
Cs127	2.2989E+12	7.0822E+07	0.02	3.518E-07	4.119E-06	0.000E+00	2.250E+04
Cs128	1.2773E+11	4.0317E+08	0.11	5.620E-05	1.253E-05	0.000E+00	2.196E+02
Cs129	1.7208E+14	1.0334E+09	0.29	2.749E-06	4.653E-05	0.000E+00	1.154E+05
Cs131	1.5875E+15	1.3145E+09	0.37	1.200E-06	4.823E-06	0.000E+00	8.371E+05
Cs132	1.6954E+14	2.0993E+08	0.06	5.382E-07	2.369E-05	0.000E+00	5.598E+05
Cs134	1.8145E+14	1.9302E+06		5.070E-08	4.809E-07	0.000E+00	6.516E+07
Cs134m	1.2563E+05	8.3323E+00		1.462E-13	3.578E-14	0.000E+00	1.045E+04
Cs135	1.3884E+14	1.3259E+00		1.196E-14	0.000E+00	0.000E+00	7.258E+13
Cs136	3.7615E+13	2.2930E+07		4.960E-07	7.825E-06	0.000E+00	1.137E+06
Cs137	3.7183E+13	2.7160E+04		1.088E-09	8.703E-12	0.000E+00	9.489E+08
Ba126	2.9699E+07	3.4310E+03		9.895E-12	3.139E-10	0.000E+00	6.000E+03
Ba128	1.2199E+14	4.0275E+08	0.11	5.356E-07	4.259E-06	0.000E+00	2.100E+05
Ba129	5.7106E+09	4.9306E+05		6.320E-08	1.104E-08	0.000E+00	8.028E+03
Ba129m	5.3744E+07	4.7686E+03		1.834E-10	1.253E-09	0.000E+00	7.812E+03
Ba131	1.8153E+15	1.2664E+09	0.36	9.049E-06	9.293E-05	0.000E+00	9.936E+05
Ba133	5.3017E+15	1.1054E+07		9.687E-08	7.141E-07	0.000E+00	3.325E+08
Ba133m	8.4807E+09	4.1976E+04		1.500E-09	4.506E-10	0.000E+00	1.400E+05
Ba135m	8.6341E+09	5.7924E+04		1.934E-09	5.568E-10	0.000E+00	1.033E+05
Ba136m	1.1631E+06	2.6141E+06		4.478E-08	8.056E-07	0.000E+00	3.084E-01
Ba137m	5.6638E+06	2.5639E+04		2.639E-10	2.454E-09	0.000E+00	1.531E+02
Ba139	9.9385E+05	1.3823E+02		1.989E-11	1.019E-12	0.000E+00	4.984E+03

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Ba140	1.9775E+13	1.2441E+07		6.254E-07	3.644E-07	0.000E+00	1.102E+06
La131	1.6815E+05	3.2924E+01		1.092E-12	2.113E-12	0.000E+00	3.540E+03
La132	1.3800E+12	5.5355E+07	0.02	4.904E-06	1.369E-05	0.000E+00	1.728E+04
La133	1.7163E+12	8.4475E+07	0.02	8.797E-08	1.104E-06	0.000E+00	1.408E+04
La134	5.0717E+11	9.0838E+08	0.26	1.103E-04	1.150E-05	0.000E+00	3.870E+02
La135	1.4378E+14	1.4197E+09	0.40	1.365E-06	8.120E-06	0.000E+00	7.020E+04
La137	6.1137E+15	2.1365E+03		2.020E-12	8.660E-12	0.000E+00	1.983E+12
La138	2.5812E+14	5.3995E-05		2.422E-19	1.070E-17	0.000E+00	3.314E+18
La140	6.4395E+12	3.0785E+07		2.607E-06	1.142E-05	0.000E+00	1.450E+05
La141	7.6528E+09	3.7589E+05		5.676E-08	1.626E-09	0.000E+00	1.411E+04
La142	2.7578E+06	3.4971E+02		4.718E-11	1.392E-10	0.000E+00	5.466E+03
Ce132	5.2219E+10	2.8645E+06		7.756E-09	1.253E-07	0.000E+00	1.264E+04
Ce133	5.5729E+11	2.1898E+07		2.140E-07	5.796E-06	0.000E+00	1.764E+04
Ce133m	3.2905E+01	3.9189E-03		5.086E-16	7.705E-17	0.000E+00	5.820E+03
Ce134	3.5758E+14	9.0710E+08	0.25	9.156E-07	4.229E-06	0.000E+00	2.732E+05
Ce135	5.4250E+13	5.9013E+08	0.17	2.742E-06	7.762E-05	0.000E+00	6.372E+04
Ce137	1.7900E+13	3.8295E+08	0.11	8.467E-07	2.485E-06	0.000E+00	3.240E+04
Ce137m	2.4700E+09	1.3825E+04		4.497E-10	1.227E-10	0.000E+00	1.238E+05
Ce139	5.5566E+15	3.2388E+08	0.09	1.712E-06	8.302E-06	0.000E+00	1.189E+07
Ce139m	6.8530E+05	8.6681E+03		7.638E-11	9.712E-10	0.000E+00	5.480E+01
Ce141	1.4044E+14	3.4667E+07		9.490E-07	3.894E-07	0.000E+00	2.808E+06
Ce142	1.4304E+14	6.2838E-11		5.638E-24	0.000E+00	0.000E+00	1.578E+24
Ce143	4.1070E+12	2.3934E+07		1.677E-06	9.804E-07	0.000E+00	1.189E+05
Ce144	6.0508E+13	1.7039E+06		2.501E-08	5.296E-09	0.000E+00	2.461E+07
Pr136	7.6638E+02	6.7584E-01		8.121E-14	1.646E-13	0.000E+00	7.860E+02
Pr137	2.8026E+07	4.2158E+03		1.283E-10	7.632E-11	0.000E+00	4.608E+03
Pr138	4.2115E+09	3.3554E+07		6.236E-06	3.064E-07	0.000E+00	8.700E+01
Pr138m	1.5790E+00	1.4341E-04		5.193E-18	4.825E-18	0.000E+00	7.632E+03
Pr139	1.2138E+12	5.2995E+07	0.01	3.821E-07	3.651E-07	0.000E+00	1.588E+04
Pr140	4.4643E+11	1.5213E+09	0.43	1.327E-04	7.069E-06	0.000E+00	2.034E+02
Pr142	4.6470E+12	4.6796E+07	0.01	6.066E-06	4.381E-07	0.000E+00	6.883E+04
Pr143	1.2451E+14	7.3612E+07	0.02	3.715E-06	3.656E-09	0.000E+00	1.172E+06
Pr144	2.5488E+09	1.7040E+06		3.298E-07	7.890E-09	0.000E+00	1.037E+03
Pr144m	4.6726E+06	7.4973E+03		5.526E-11	1.526E-11	0.000E+00	4.320E+02
Pr145	7.7243E+10	2.4854E+06		2.683E-07	7.288E-09	0.000E+00	2.154E+04
Nd136	2.1968E+03	5.0105E-01		7.305E-15	1.927E-14	0.000E+00	3.039E+03
Nd137	8.4305E+00	2.5297E-03		1.402E-16	3.417E-16	0.000E+00	2.310E+03
Nd138	8.7411E+11	3.3393E+07		3.906E-08	2.354E-07	0.000E+00	1.814E+04
Nd139	2.2490E+04	8.7480E+00		2.901E-13	2.271E-13	0.000E+00	1.782E+03
Nd139m	1.9271E+06	6.7464E+01		1.167E-12	1.655E-11	0.000E+00	1.980E+04
Nd140	6.3862E+14	1.5203E+09	0.43	1.461E-06	6.966E-06	0.000E+00	2.912E+05
Nd141	3.9129E+10	3.0257E+06		7.272E-09	2.472E-08	0.000E+00	8.964E+03
Nd144	6.1597E+14	5.9081E-09		0.000E+00	0.000E+00	1.732E-21	7.227E+22
Nd147	5.0848E+13	3.7152E+07	0.01	1.611E-06	8.307E-07	0.000E+00	9.487E+05
Nd149	1.3946E+07	1.5539E+03		1.247E-10	8.912E-11	0.000E+00	6.221E+03
Nd150	4.7485E+13	1.0430E-12		2.172E-25	0.000E+00	0.000E+00	3.156E+25
Pm142	4.1959E+04	7.1811E+02		1.574E-10	8.284E-12	0.000E+00	4.050E+01
Pm143	5.3802E+15	1.6288E+08	0.05	1.905E-07	8.220E-06	0.000E+00	2.290E+07
Pm144	1.4525E+15	3.2102E+07		8.281E-08	7.998E-06	0.000E+00	3.136E+07
Pm145	1.1178E+15	1.3871E+06		3.027E-09	7.378E-09	1.445E-15	5.586E+08
Pm146	5.7871E+14	2.2986E+06		3.364E-08	2.792E-07	0.000E+00	1.745E+08
Pm147	3.9949E+14	3.3448E+06		3.323E-08	2.353E-12	0.000E+00	8.279E+07
Pm148	3.6623E+13	5.4713E+07	0.02	6.364E-06	5.032E-06	0.000E+00	4.640E+05

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Pm148m	6.7274E+09	1.3071E+03		3.539E-11	4.153E-10	0.000E+00	3.567E+06
Pm149	1.2076E+13	4.3804E+07	0.01	2.572E-06	8.267E-08	0.000E+00	1.911E+05
Pm150	4.8270E+08	3.4679E+04		4.395E-09	8.289E-09	0.000E+00	9.648E+03
Pm151	2.1450E+12	1.4542E+07		6.990E-07	7.665E-07	0.000E+00	1.022E+05
Sm142	4.4641E+06	7.1143E+02		3.830E-12	4.331E-12	0.000E+00	4.349E+03
Sm145	4.5452E+15	1.0725E+08	0.03	4.983E-07	1.117E-06	0.000E+00	2.938E+07
Sm146	4.2125E+15	8.9830E-01		0.000E+00	0.000E+00	3.640E-13	3.250E+15
Sm147	2.9633E+15	6.1403E-04		0.000E+00	0.000E+00	2.273E-16	3.345E+18
Sm148	1.4903E+15	4.6761E-09		0.000E+00	0.000E+00	1.488E-21	2.209E+23
Sm149	1.0698E+15	1.1749E-08		0.000E+00	0.000E+00	3.519E-21	6.312E+22
Sm151	1.9913E+14	4.8597E+04		9.733E-10	5.217E-13	0.000E+00	2.840E+09
Sm153	5.4085E+12	2.2506E+07		9.712E-07	2.234E-07	0.000E+00	1.666E+05
Sm156	8.9994E+10	1.8434E+06		5.941E-08	3.283E-08	0.000E+00	3.384E+04
Eu145	6.9881E+14	9.4540E+08	0.27	3.787E-06	1.878E-04	0.000E+00	5.124E+05
Eu146	5.3913E+14	9.4230E+08	0.26	7.005E-06	3.350E-04	0.000E+00	3.966E+05
Eu147	2.9115E+15	9.6919E+08	0.27	6.367E-06	6.605E-05	1.021E-08	2.082E+06
Eu148	1.7208E+15	2.5331E+08	0.07	1.136E-06	8.685E-05	1.053E-12	4.709E+06
Eu149	3.7196E+15	3.2052E+08	0.09	4.314E-07	3.266E-06	0.000E+00	8.044E+06
Eu150	1.1130E+15	6.6252E+05		2.792E-09	1.593E-07	0.000E+00	1.164E+09
Eu150m	2.1220E+09	3.1919E+04		1.544E-09	1.994E-10	0.000E+00	4.608E+04
Eu152	3.6366E+14	5.9006E+05		1.201E-08	1.113E-07	0.000E+00	4.272E+08
Eu152m	3.1878E+08	6.5915E+03		5.320E-10	3.014E-10	0.000E+00	3.352E+04
Eu152n	4.6240E+02	5.5644E-02		5.920E-16	9.212E-16	0.000E+00	5.760E+03
Eu154	9.5212E+13	2.4337E+05		1.087E-08	4.886E-08	0.000E+00	2.712E+08
Eu155	8.6939E+13	4.0108E+05		4.177E-09	4.048E-09	0.000E+00	1.502E+08
Eu156	3.6919E+13	1.9499E+07		1.319E-06	3.837E-06	0.000E+00	1.312E+06
Eu157	5.7133E+11	7.2463E+06		3.483E-07	3.390E-07	0.000E+00	5.465E+04
Eu158	2.4485E+01	6.1627E-03		9.479E-16	1.272E-15	0.000E+00	2.754E+03
Gd146	1.1708E+15	1.9459E+08	0.05	3.922E-06	5.436E-06	0.000E+00	4.171E+06
Gd147	1.0801E+14	5.4641E+08	0.15	5.165E-06	1.159E-04	0.000E+00	1.370E+05
Gd148	3.2177E+15	9.4740E+05		0.000E+00	0.000E+00	4.965E-07	2.354E+09
Gd149	1.4868E+15	1.2853E+09	0.36	1.367E-05	9.933E-05	2.745E-09	8.018E+05
Gd150	5.0431E+15	6.1881E+01		0.000E+00	0.000E+00	2.785E-11	5.649E+13
Gd151	5.1143E+15	3.3089E+08	0.09	1.643E-06	3.403E-06	1.406E-12	1.071E+07
Gd152	6.1767E+15	1.2562E-06		0.000E+00	0.000E+00	4.438E-19	3.408E+21
Gd153	5.7219E+15	1.9000E+08	0.05	1.212E-06	3.216E-06	0.000E+00	2.087E+07
Gd159	8.2370E+11	8.5825E+06		4.286E-07	1.181E-07	0.000E+00	6.652E+04
Tb147	4.9122E+07	5.5635E+03		4.760E-10	1.671E-09	0.000E+00	6.120E+03
Tb148	7.8189E+04	1.5055E+01		1.985E-12	4.465E-12	0.000E+00	3.600E+03
Tb149	1.9037E+11	8.9011E+06		5.134E-08	1.824E-06	9.710E-07	1.482E+04
Tb150	1.2099E+11	6.6944E+06		5.760E-07	1.805E-06	1.924E-09	1.253E+04
Tb151	4.3023E+13	4.7042E+08	0.13	5.728E-06	7.009E-05	2.503E-08	6.339E+04
Tb152	6.3173E+13	6.9506E+08	0.20	2.450E-05	1.417E-04	0.000E+00	6.300E+04
Tb153	4.6906E+14	1.6081E+09	0.45	1.092E-05	7.910E-05	0.000E+00	2.022E+05
Tb154	3.5613E+13	3.1893E+08	0.09	2.759E-06	1.133E-04	0.000E+00	7.740E+04
Tb154m	4.6337E+08	9.4913E+03		6.995E-11	2.000E-09	0.000E+00	3.384E+04
Tb154n	3.1610E+08	2.6812E+03		4.811E-11	8.791E-10	0.000E+00	8.172E+04
Tb155	1.5054E+15	2.2701E+09	0.64	2.655E-05	6.692E-05	0.000E+00	4.596E+05
Tb156	1.7742E+14	2.6605E+08	0.07	3.610E-06	7.771E-05	0.000E+00	4.622E+05
Tb156m	5.1135E+09	4.0350E+04		8.146E-11	2.392E-10	0.000E+00	8.784E+04
Tb156n	6.9599E+07	2.5284E+03		3.370E-11	1.774E-12	0.000E+00	1.908E+04
Tb157	6.9744E+15	2.1576E+06		1.279E-09	3.301E-09	0.000E+00	2.241E+09
Tb158	1.8933E+14	2.3103E+04		4.183E-10	2.913E-09	0.000E+00	5.680E+09

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Tb160	4.6777E+13	5.1905E+06		2.114E-07	9.351E-07	0.000E+00	6.247E+06
Tb161	1.5457E+13	1.8023E+07		5.634E-07	9.760E-08	0.000E+00	5.944E+05
Dy152	9.0443E+09	7.3168E+05		1.372E-10	3.364E-08	4.369E-10	8.568E+03
Dy153	2.9618E+12	8.9105E+07	0.03	1.099E-06	1.122E-05	4.776E-09	2.304E+04
Dy154	4.3174E+15	3.1610E+01		0.000E+00	0.000E+00	1.492E-11	9.467E+13
Dy155	2.0046E+13	3.8988E+08	0.11	1.562E-06	3.710E-05	0.000E+00	3.564E+04
Dy157	1.4377E+13	3.4007E+08	0.10	6.756E-07	1.858E-05	0.000E+00	2.930E+04
Dy159	6.8975E+15	3.8321E+08	0.11	7.122E-07	2.783E-06	0.000E+00	1.248E+07
Dy165	1.4184E+08	1.1701E+04		8.362E-10	4.980E-11	0.000E+00	8.402E+03
Dy166	3.4174E+12	8.0635E+06		2.054E-07	5.126E-08	0.000E+00	2.938E+05
Ho155	3.2773E+03	7.8877E-01		2.780E-14	4.766E-14	0.000E+00	2.880E+03
Ho156	1.3007E+05	2.6832E+01		1.720E-12	5.954E-12	0.000E+00	3.360E+03
Ho158	9.3625E+08	9.5716E+05		2.157E-07	2.157E-07	0.000E+00	6.780E+02
Ho158m	2.6285E+09	1.0845E+06		1.165E-08	2.172E-11	0.000E+00	1.680E+03
Ho159	5.4903E+01	1.9191E-02		1.605E-16	1.012E-15	0.000E+00	1.983E+03
Ho160	2.1983E+12	9.9203E+08	0.28	1.589E-06	2.607E-04	0.000E+00	1.536E+03
Ho160m	3.9233E+13	1.5048E+09	0.42	2.689E-04	1.350E-04	0.000E+00	1.807E+04
Ho161	7.6097E+11	5.9080E+07	0.02	3.029E-07	5.556E-07	0.000E+00	8.928E+03
Ho161m	4.7277E+07	4.8476E+06		8.233E-08	8.077E-08	0.000E+00	6.760E+00
Ho162	8.0309E+00	6.1851E-03		5.847E-17	1.259E-16	0.000E+00	9.000E+02
Ho162m	4.4904E+01	7.7426E-03		1.240E-17	6.599E-16	0.000E+00	4.020E+03
Ho163	7.7869E+15	3.7426E+04		5.996E-12	0.000E+00	0.000E+00	1.442E+11
Ho166	1.9361E+12	1.3894E+07		1.647E-06	6.480E-08	0.000E+00	9.659E+04
Ho166m	1.4602E+10	2.6728E-01		5.567E-15	6.870E-14	0.000E+00	3.787E+10
Ho167	1.0849E+09	6.7385E+04		2.483E-09	3.879E-09	0.000E+00	1.116E+04
Er158	1.0270E+10	8.6349E+05		1.522E-08	1.290E-08	0.000E+00	8.244E+03
Er159	5.2974E+00	1.6999E-03		2.342E-17	2.377E-16	0.000E+00	2.160E+03
Er160	1.8628E+14	1.2550E+09	0.35	1.307E-05	7.399E-06	0.000E+00	1.029E+05
Er161	2.6924E+11	1.6149E+07		1.190E-06	2.439E-06	0.000E+00	1.156E+04
Er163	5.2596E+09	8.1016E+05		8.697E-10	5.218E-09	0.000E+00	4.500E+03
Er165	1.2540E+14	2.3306E+09	0.65	2.464E-06	1.411E-05	0.000E+00	3.730E+04
Er167m	8.9161E+09	2.7237E+09	0.77	4.844E-05	4.233E-05	0.000E+00	2.269E+00
Er169	1.4973E+13	1.2779E+07		2.106E-07	3.047E-11	0.000E+00	8.122E+05
Er171	2.9190E+10	7.4777E+05		4.960E-08	4.469E-08	0.000E+00	2.706E+04
Er172	1.4095E+12	5.5046E+06		1.138E-07	4.256E-07	0.000E+00	1.775E+05
Tm163	2.3811E+09	2.5330E+05		3.003E-09	4.963E-08	0.000E+00	6.516E+03
Tm164	6.4038E+05	3.6990E+03		3.254E-10	1.926E-10	0.000E+00	1.200E+02
Tm165	2.6763E+14	1.7143E+09	0.48	1.318E-05	1.637E-04	0.000E+00	1.082E+05
Tm166	9.5991E+13	2.4003E+09	0.67	4.192E-05	7.284E-04	0.000E+00	2.772E+04
Tm167	3.1948E+15	2.7708E+09	0.78	5.460E-05	6.481E-05	0.000E+00	7.992E+05
Tm168	2.5666E+14	2.2116E+07		2.835E-07	4.061E-06	0.000E+00	8.044E+06
Tm170	5.2578E+13	3.2800E+06		1.734E-07	2.575E-09	0.000E+00	1.111E+07
Tm171	4.8390E+13	5.5357E+05		2.253E-09	5.534E-11	0.000E+00	6.059E+07
Tm172	4.4723E+12	1.3539E+07		1.154E-06	1.020E-06	0.000E+00	2.290E+05
Tm173	5.5225E+10	1.2904E+06		6.368E-08	8.022E-08	0.000E+00	2.966E+04
Yb164	2.3630E+07	3.6014E+03		5.770E-12	8.974E-12	0.000E+00	4.548E+03
Yb166	6.1108E+14	2.0751E+09	0.58	1.293E-05	2.872E-05	0.000E+00	2.041E+05
Yb167	1.8919E+04	1.2489E+01		1.601E-13	5.143E-13	0.000E+00	1.050E+03
Yb169	6.5074E+15	1.6301E+09	0.46	2.899E-05	8.149E-05	0.000E+00	2.767E+06
Yb169m	1.2883E+09	1.9412E+07		6.780E-08	4.043E-09	0.000E+00	4.600E+01
Yb171m	2.2975E+07	3.0334E+09	0.85	4.180E-05	4.471E-06	0.000E+00	5.250E-03
Yb175	3.4882E+12	6.6867E+06		1.396E-07	4.285E-08	0.000E+00	3.616E+05
Yb177	9.5001E+06	9.5717E+02		6.717E-11	2.929E-11	0.000E+00	6.880E+03

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Yb178	2.9390E+04	4.5883E+00		7.351E-15	2.867E-13	0.000E+00	4.440E+03
Lu167	3.6757E+04	8.2454E+00		7.636E-14	1.773E-12	0.000E+00	3.090E+03
Lu169	3.4327E+14	1.9405E+09	0.55	9.949E-06	4.048E-04	0.000E+00	1.226E+05
Lu170	7.6669E+14	3.0754E+09	0.86	2.710E-05	1.252E-03	0.000E+00	1.728E+05
Lu170m	1.4645E+06	1.5151E+06		2.112E-08	8.739E-10	0.000E+00	6.700E-01
Lu171	3.4618E+15	3.3704E+09	0.95	4.822E-05	3.494E-04	0.000E+00	7.119E+05
Lu172	2.8999E+14	3.4723E+08	0.10	6.509E-06	1.076E-04	0.000E+00	5.789E+05
Lu172m	3.6670E+10	1.1450E+08	0.03	7.154E-07	2.623E-08	0.000E+00	2.220E+02
Lu173	1.0550E+16	1.6914E+08	0.05	4.417E-07	3.252E-06	0.000E+00	4.323E+07
Lu174	1.9527E+14	1.2958E+06		8.927E-09	2.388E-08	0.000E+00	1.045E+08
Lu174m	3.8129E+10	2.1541E+03		4.038E-11	2.071E-11	0.000E+00	1.227E+07
Lu176	3.0327E+13	1.7858E-05		3.290E-19	1.402E-18	0.000E+00	1.177E+18
Lu176m	4.6384E+06	2.4569E+02		1.535E-12	5.629E-13	0.000E+00	1.309E+04
Lu177	8.0176E+12	9.5518E+06		2.248E-07	5.372E-08	0.000E+00	5.818E+05
Lu177m	1.8595E+08	9.3004E+00		3.979E-13	1.370E-12	0.000E+00	1.386E+07
Lu178	1.8305E+04	7.4459E+00		8.995E-13	1.447E-13	0.000E+00	1.704E+03
Lu179	2.8308E+09	1.1875E+05		8.752E-09	6.012E-10	0.000E+00	1.652E+04
Hf170	8.3989E+13	1.0101E+09	0.28	1.489E-05	7.768E-05	0.000E+00	5.764E+04
Hf171	5.4098E+13	8.6083E+08	0.24	8.275E-05	1.517E-04	0.000E+00	4.356E+04
Hf172	9.7478E+15	1.1449E+08	0.03	2.697E-06	1.926E-06	0.000E+00	5.901E+07
Hf173	2.8014E+14	2.2855E+09	0.64	1.721E-05	1.454E-04	0.000E+00	8.496E+04
Hf174	1.1384E+16	1.2503E-07		0.000E+00	0.000E+00	5.000E-20	6.312E+22
Hf175	1.0191E+16	1.1680E+09	0.33	8.234E-06	6.812E-05	0.000E+00	6.048E+06
Hf177m	1.1347E+01	7.2825E+00		2.800E-13	1.144E-12	0.000E+00	1.080E+00
Hf177n	1.2981E+00	2.9175E-04		1.173E-17	5.422E-17	0.000E+00	3.084E+03
Hf178n	2.0025E+07	1.4188E-02		1.446E-16	2.807E-15	0.000E+00	9.783E+08
Hf179n	9.7366E+07	3.1182E+01		1.074E-12	4.451E-12	0.000E+00	2.164E+06
Hf180m	3.1347E+05	1.0974E+01		2.585E-13	1.748E-12	0.000E+00	1.980E+04
Hf181	1.2446E+13	2.3555E+06		7.499E-08	1.955E-07	0.000E+00	3.662E+06
Hf182	1.0299E+13	2.5134E-02		3.302E-16	9.624E-16	0.000E+00	2.840E+14
Hf183	4.5876E+03	8.2784E-01		5.849E-14	9.961E-14	0.000E+00	3.841E+03
Hf184	1.0837E+09	5.0645E+04		3.741E-09	1.866E-09	0.000E+00	1.483E+04
Ta172	1.5754E+01	4.9456E-03		3.360E-16	1.245E-15	0.000E+00	2.208E+03
Ta173	2.7892E+11	1.7103E+07		6.522E-07	1.189E-06	0.000E+00	1.130E+04
Ta174	4.5352E+06	8.3162E+02		5.250E-11	8.927E-11	0.000E+00	3.780E+03
Ta175	5.0386E+13	9.2395E+08	0.26	9.178E-06	1.553E-04	0.000E+00	3.780E+04
Ta176	3.4182E+13	8.1353E+08	0.23	1.030E-05	2.789E-04	0.000E+00	2.912E+04
Ta177	1.1053E+15	3.7626E+09	1.06	1.338E-05	4.039E-05	0.000E+00	2.036E+05
Ta178	2.3503E+12	2.9164E+09	0.82	1.710E-05	5.140E-05	0.000E+00	5.586E+02
Ta178m	1.5506E+05	1.2651E+01		3.304E-13	2.171E-12	0.000E+00	8.496E+03
Ta179	1.3685E+16	1.6516E+08	0.05	1.482E-07	7.409E-07	0.000E+00	5.743E+07
Ta180	3.8623E+11	9.1222E+06		7.892E-08	6.972E-08	0.000E+00	2.935E+04
Ta180m	4.0816E+09	7.4709E-14		0.000E+00	9.013E-28	0.000E+00	3.787E+22
Ta182	3.1725E+13	2.2242E+06		7.328E-08	4.637E-07	0.000E+00	9.887E+06
Ta183	6.6423E+12	1.0449E+07		5.725E-07	4.938E-07	0.000E+00	4.406E+05
Ta184	5.0562E+10	1.1190E+06		9.610E-08	2.886E-07	0.000E+00	3.132E+04
Ta185	2.3022E+01	5.3837E-03		6.357E-16	1.242E-15	0.000E+00	2.964E+03
W 175	5.0425E+00	1.6549E-03		7.954E-17	1.501E-17	0.000E+00	2.112E+03
W 176	6.5610E+10	5.0531E+06		5.117E-08	1.261E-07	0.000E+00	9.000E+03
W 177	3.3931E+10	2.9036E+06		4.280E-08	4.224E-07	0.000E+00	8.100E+03
W 178	7.8498E+15	2.9155E+09	0.82	2.149E-06	7.754E-06	0.000E+00	1.866E+06
W 179	7.4388E+01	2.3195E-02		2.044E-17	1.984E-16	0.000E+00	2.223E+03
W 181	1.4238E+16	9.4245E+08	0.26	1.238E-06	6.040E-06	0.000E+00	1.047E+07

Fig. C-8 Example of output file of calculation results of sample problem (continued).

W 183m	3.9193E+06	5.2244E+05		1.515E-08	1.071E-08	0.000E+00	5.200E+00
W 185	5.5933E+13	5.9750E+06		1.216E-07	4.787E-11	0.000E+00	6.489E+06
W 187	5.2563E+11	4.2667E+06		2.126E-07	2.939E-07	0.000E+00	8.539E+04
W 188	1.0236E+13	1.1833E+06		1.888E-08	3.583E-10	0.000E+00	5.996E+06
Re181	2.7777E+14	2.6875E+09	0.75	5.813E-05	3.139E-04	0.000E+00	7.164E+04
Re182	2.5630E+14	7.7106E+08	0.22	2.631E-05	2.078E-04	0.000E+00	2.304E+05
Re182m	2.8679E+14	4.3479E+09	1.22	5.225E-05	8.178E-04	0.000E+00	4.572E+04
Re183	1.7251E+16	1.9771E+09	0.56	3.326E-05	4.751E-05	0.000E+00	6.048E+06
Re184	8.6931E+14	1.8353E+08	0.05	1.591E-06	2.623E-05	0.000E+00	3.283E+06
Re184m	2.1996E+10	1.0442E+03		2.342E-11	6.508E-11	0.000E+00	1.460E+07
Re186	4.8561E+13	1.0316E+08	0.03	5.591E-06	3.190E-07	0.000E+00	3.263E+05
Re186m	1.7952E+09	1.9715E-04		4.043E-18	6.633E-19	0.000E+00	6.312E+12
Re187	1.7663E+14	8.9187E-05		1.429E-20	0.000E+00	0.000E+00	1.373E+18
Re188	9.8486E+11	1.1141E+07		1.392E-06	1.030E-07	0.000E+00	6.128E+04
Re189	1.1247E+12	8.9113E+06		4.569E-07	8.566E-08	0.000E+00	8.748E+04
Re190	2.1508E+00	8.0153E-03		9.118E-16	1.734E-15	0.000E+00	1.860E+02
Re190m	2.8742E+02	1.7294E-02		1.056E-15	2.555E-15	0.000E+00	1.152E+04
Os181	3.0768E+09	3.3852E+05		5.261E-09	6.957E-08	0.000E+00	6.300E+03
Os182	3.1719E+14	2.7634E+09	0.78	2.355E-05	1.926E-04	0.000E+00	7.956E+04
Os183	1.0449E+14	1.5475E+09	0.43	1.800E-05	1.319E-04	0.000E+00	4.680E+04
Os183m	2.6984E+13	5.2481E+08	0.15	2.607E-06	8.686E-05	0.000E+00	3.564E+04
Os185	2.4002E+16	2.0572E+09	0.58	5.471E-06	2.258E-04	0.000E+00	8.087E+06
Os186	3.4691E+16	3.8098E-07		0.000E+00	0.000E+00	1.723E-19	6.312E+22
Os189m	4.0848E+13	1.3560E+09	0.38	6.279E-06	4.063E-07	0.000E+00	2.088E+04
Os190m	1.2011E+05	1.4016E+02		2.625E-12	3.567E-11	0.000E+00	5.940E+02
Os191	7.2559E+13	3.7799E+07	0.01	7.958E-07	4.536E-07	0.000E+00	1.331E+06
Os191m	2.8870E+08	4.2432E+03		4.541E-11	5.099E-12	0.000E+00	4.716E+04
Os193	1.2355E+12	7.7995E+06		4.998E-07	8.585E-08	0.000E+00	1.098E+05
Os194	2.9019E+13	1.0623E+05		5.503E-10	3.976E-11	0.000E+00	1.893E+08
Ir183	8.1694E+05	1.6272E+02		1.590E-11	2.679E-11	0.000E+00	3.480E+03
Ir184	5.1391E+11	3.2022E+07		1.370E-06	9.132E-06	0.000E+00	1.112E+04
Ir185	2.2147E+14	2.9612E+09	0.83	3.954E-04	3.590E-04	0.000E+00	5.184E+04
Ir186	1.0549E+14	1.2207E+09	0.34	2.151E-05	3.092E-04	0.000E+00	5.990E+04
Ir186m	2.1680E+11	2.0872E+07		5.016E-07	4.347E-06	0.000E+00	7.200E+03
Ir187	2.0743E+14	3.8037E+09	1.07	3.047E-04	1.616E-04	0.000E+00	3.780E+04
Ir187m	2.7057E+04	6.1895E+05		1.505E-08	3.401E-09	0.000E+00	3.030E-02
Ir188	3.1368E+15	1.4553E+10	4.09	1.143E-04	4.897E-03	0.000E+00	1.494E+05
Ir189	2.4825E+16	1.5088E+10	4.24	1.027E-04	1.886E-04	0.000E+00	1.140E+06
Ir189m	6.2794E+06	3.2726E+08	0.09	9.385E-06	1.012E-05	0.000E+00	1.330E-02
Ir190	1.1092E+15	7.5536E+08	0.21	8.895E-06	1.715E-04	0.000E+00	1.018E+06
Ir190m	4.3572E+02	6.9912E-02		2.554E-16	2.240E-17	0.000E+00	4.320E+03
Ir190n	2.3790E+06	1.4094E+02		2.348E-12	3.496E-11	0.000E+00	1.170E+04
Ir191m	1.7367E+09	2.4369E+08	0.07	3.666E-06	2.924E-06	0.000E+00	4.940E+00
Ir192	8.0599E+14	8.7581E+07	0.02	3.034E-06	1.144E-05	0.000E+00	6.379E+06
Ir192n	2.4000E+10	2.1873E+00		5.316E-14	1.199E-15	0.000E+00	7.605E+09
Ir193m	6.8371E+10	5.2090E+04		6.409E-10	1.920E-11	0.000E+00	9.098E+05
Ir194	7.1720E+12	7.2110E+07	0.02	9.358E-06	1.051E-06	0.000E+00	6.894E+04
Ir195	1.9750E+09	1.5211E+05		9.261E-09	1.413E-09	0.000E+00	9.000E+03
Ir195m	2.0902E+04	1.0591E+00		3.462E-14	6.044E-14	0.000E+00	1.368E+04
Ir196m	6.7424E+00	9.2727E-04		6.685E-17	3.670E-16	0.000E+00	5.040E+03
Pt185	2.6767E+07	4.3614E+03		3.494E-10	2.446E-10	1.553E-13	4.254E+03
Pt186	2.3384E+10	2.2512E+06		6.673E-09	2.199E-07	2.183E-12	7.200E+03
Pt187	1.3025E+11	1.0672E+07		1.653E-06	7.899E-07	0.000E+00	8.460E+03

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Pt188	1.6089E+16	1.2654E+10	3.55	1.596E-04	4.177E-04	2.112E-09	8.813E+05
Pt189	2.3687E+14	4.1956E+09	1.18	4.100E-05	2.622E-04	0.000E+00	3.913E+04
Pt190	5.6587E+16	1.9122E-03		0.000E+00	0.000E+00	9.954E-16	2.051E+19
Pt191	7.4819E+15	2.0698E+10	5.81	2.388E-04	9.816E-04	0.000E+00	2.506E+05
Pt193	9.0447E+16	3.9732E+07	0.01	1.188E-07	1.337E-08	0.000E+00	1.578E+09
Pt193m	9.1283E+11	1.6913E+06		3.712E-08	3.414E-09	0.000E+00	3.741E+05
Pt195m	3.4482E+12	6.8814E+06		2.018E-07	8.379E-08	0.000E+00	3.473E+05
Pt197	5.1154E+13	4.9515E+08	0.14	1.991E-05	2.007E-06	0.000E+00	7.161E+04
Pt197m	7.1537E+06	8.6618E+02		4.441E-11	1.152E-11	0.000E+00	5.725E+03
Pt200	7.7612E+12	1.1955E+08	0.03	4.616E-06	1.134E-06	0.000E+00	4.500E+04
Pt202	9.3425E+07	9.8117E+03		2.562E-10	2.562E-10	0.000E+00	6.600E+03
Au190	6.5003E+03	1.7545E+00		8.433E-15	6.245E-13	0.000E+00	2.568E+03
Au191	2.2336E+12	1.3524E+08	0.04	1.668E-06	1.211E-05	0.000E+00	1.145E+04
Au192	7.1528E+13	2.7879E+09	0.78	3.931E-05	8.232E-04	0.000E+00	1.778E+04
Au193	1.4061E+15	1.5339E+10	4.31	1.352E-04	4.301E-04	0.000E+00	6.354E+04
Au193m	1.7291E+05	3.0731E+04		4.480E-10	9.749E-10	0.000E+00	3.900E+00
Au194	1.3132E+15	6.6501E+09	1.87	4.262E-05	1.120E-03	0.000E+00	1.369E+05
Au195	1.3095E+17	5.6450E+09	1.59	4.052E-05	7.841E-05	0.000E+00	1.608E+07
Au195m	2.8400E+09	6.4542E+07	0.02	1.200E-06	2.081E-06	0.000E+00	3.050E+01
Au196	7.4438E+15	9.6584E+09	2.71	5.571E-05	7.350E-04	0.000E+00	5.342E+05
Au196m	6.1888E+05	5.2960E+04		6.856E-10	2.656E-11	0.000E+00	8.100E+00
Au196n	2.6674E+09	5.2947E+04		2.350E-09	1.985E-09	0.000E+00	3.492E+04
Au197m	2.3668E+09	2.1223E+08	0.06	6.019E-06	7.889E-06	0.000E+00	7.730E+00
Au198	3.8205E+15	1.1372E+10	3.19	7.671E-04	7.404E-04	0.000E+00	2.329E+05
Au198m	2.4552E+11	8.6769E+05		3.253E-08	7.368E-08	0.000E+00	1.961E+05
Au199	4.5928E+15	1.1738E+10	3.30	2.708E-04	1.681E-04	0.000E+00	2.712E+05
Au200	5.3885E+11	1.2862E+08	0.04	1.525E-05	5.626E-06	0.000E+00	2.904E+03
Au200m	4.2440E+11	4.3697E+06		2.016E-07	1.411E-06	0.000E+00	6.732E+04
Au202	4.0946E+05	9.8547E+03		1.958E-09	2.709E-10	0.000E+00	2.880E+01
Hg191	6.8194E+04	1.6078E+01		2.730E-12	1.128E-12	0.000E+00	2.940E+03
Hg192	1.3460E+13	5.3435E+08	0.15	5.308E-06	2.389E-05	0.000E+00	1.746E+04
Hg193	5.6679E+12	2.8718E+08	0.08	2.853E-05	4.141E-05	0.000E+00	1.368E+04
Hg193m	2.2155E+09	3.6151E+04		7.240E-10	6.521E-09	0.000E+00	4.248E+04
Hg194	8.4685E+16	3.5771E+06		1.605E-09	1.249E-09	0.000E+00	1.641E+10
Hg195	4.1805E+14	8.1305E+09	2.28	7.985E-05	2.644E-04	0.000E+00	3.564E+04
Hg195m	3.0382E+13	1.4089E+08	0.04	3.160E-06	3.624E-06	0.000E+00	1.495E+05
Hg197	2.5057E+16	7.5219E+10	21.13	6.869E-04	8.436E-04	0.000E+00	2.309E+05
Hg197m	3.7474E+14	3.0316E+09	0.85	1.049E-04	3.837E-05	0.000E+00	8.568E+04
Hg199m	2.7739E+04	7.5225E+00		4.170E-13	2.242E-13	0.000E+00	2.556E+03
Hg203	8.2806E+16	1.4252E+10	4.00	2.261E-04	5.424E-04	0.000E+00	4.027E+06
Tl195	1.1548E+07	1.9168E+03		2.334E-11	3.645E-10	0.000E+00	4.176E+03
Tl196	4.1716E+09	4.3652E+05		1.399E-08	1.142E-07	0.000E+00	6.624E+03
Tl197	1.8171E+11	1.2319E+07		1.066E-07	8.724E-07	0.000E+00	1.022E+04
Tl198	5.5560E+12	2.0184E+08	0.06	1.229E-06	6.468E-05	0.000E+00	1.908E+04
Tl198m	7.2391E+01	7.4536E-03		2.257E-16	1.364E-15	0.000E+00	6.732E+03
Tl199	1.7820E+13	4.6241E+08	0.13	4.149E-06	1.845E-05	0.000E+00	2.671E+04
Tl200	2.6782E+14	1.9757E+09	0.55	1.203E-05	3.940E-04	0.000E+00	9.396E+04
Tl201	7.7197E+14	2.0386E+09	0.57	1.568E-05	3.005E-05	0.000E+00	2.625E+05
Tl202	2.0348E+15	1.3348E+09	0.37	4.384E-06	9.987E-05	0.000E+00	1.057E+06
Tl204	7.1451E+14	4.1518E+06		1.583E-07	7.467E-10	0.000E+00	1.193E+08
Pb198	8.5434E+07	6.8540E+03		7.687E-11	3.986E-10	0.000E+00	8.640E+03
Pb199	4.9443E+05	6.3466E+01		5.491E-13	9.640E-12	0.000E+00	5.400E+03
Pb200	4.5251E+10	4.0524E+05		6.168E-09	1.350E-08	0.000E+00	7.740E+04

Fig. C-8 Example of output file of calculation results of sample problem (continued).

Pb201	5.3716E+09	1.1085E+05	1.083E-09	1.343E-08	0.000E+00	3.359E+04
Pb202	1.7063E+12	7.1388E-01	1.716E-16	2.516E-16	2.972E-15	1.657E+12
Pb202m	2.8652E+02	1.5628E-02	3.105E-16	4.983E-15	0.000E+00	1.271E+04
Pb203	6.9600E+06	2.5834E+01	2.024E-13	1.283E-12	0.000E+00	1.867E+05
Pb205	5.5663E+07	7.9909E-08	6.401E-23	3.073E-23	0.000E+00	4.828E+14

gamma-ray spectrum (42-groups) [n/s]

grp.	energy [MeV] upper	energy [MeV] lower	spectrum
1	50.000	30.000	0.0000E+00
2	30.000	20.000	0.0000E+00
3	20.000	14.000	0.0000E+00
4	14.000	12.000	0.0000E+00
5	12.000	10.000	0.0000E+00
6	10.000	8.000	0.0000E+00
7	8.000	7.500	0.0000E+00
8	7.500	7.000	0.0000E+00
9	7.000	6.500	0.0000E+00
10	6.500	6.000	0.0000E+00
11	6.000	5.500	8.7958E-17
12	5.500	5.000	2.0133E-15
13	5.000	4.500	9.6274E+04
14	4.500	4.000	3.5688E+05
15	4.000	3.500	8.9679E+05
16	3.500	3.000	1.8848E+08
17	3.000	2.500	9.3515E+08
18	2.500	2.000	9.9258E+09
19	2.000	1.660	5.8670E+09
20	1.660	1.500	2.7394E+09
21	1.500	1.340	4.3182E+09
22	1.340	1.330	1.8323E+08
23	1.330	1.000	1.5051E+10
24	1.000	0.800	9.6800E+09
25	0.800	0.700	8.3134E+09
26	0.700	0.600	1.2936E+10
27	0.600	0.512	9.2947E+09
28	0.512	0.510	8.7575E+09
29	0.510	0.450	6.0294E+09
30	0.450	0.400	1.8012E+10
31	0.400	0.300	3.2514E+10
32	0.300	0.200	3.2054E+10
33	0.200	0.150	2.7163E+10
34	0.150	0.100	1.2233E+10
35	0.100	0.075	2.2351E+10
36	0.075	0.070	2.3837E+08
37	0.070	0.060	3.9982E+09
38	0.060	0.045	1.7490E+09
39	0.045	0.030	4.0387E+09
40	0.030	0.020	3.5666E+09
41	0.020	0.010	3.8996E+09
42	0.010	0.001	4.3836E+09

Fig. C-8 Example of output file of calculation results of sample problem (continued).

```
total gamma-ray current                2.6042E+11 [n/s]
total energy of gamma-ray spectrum     1.3637E+11 [MeV]
annihilation gamma-ray by beta(+)      7.2909E+09 [n/s]  (Eg=0.511 [MeV])

  dominant nuclides (top 10)
  --------------------------
  no. nuclide    activity   [%]    nuclide        heat   [%]
   1   Hg197   7.5219E+10 21.13     Ir188   5.0108E-03 16.88
   2   Pt191   2.0698E+10  5.81     Hg197   1.5305E-03  5.16
   3   Au193   1.5339E+10  4.31     Au198   1.5075E-03  5.08
   4   Ir189   1.5088E+10  4.24     Lu170   1.2795E-03  4.31
   5   Ir188   1.4553E+10  4.09     Pt191   1.2203E-03  4.11
   6   Hg203   1.4252E+10  4.00     Au194   1.1624E-03  3.92
   7   Pt188   1.2654E+10  3.55     Re182m  8.7006E-04  2.93
   8   Au199   1.1738E+10  3.30     Au192   8.6252E-04  2.91
   9   Au198   1.1372E+10  3.19     Au196   7.9075E-04  2.66
  10   Au196   9.6584E+09  2.71     Tm166   7.7029E-04  2.60

 total activity          3.56025E+11 [Bq]
 total decay heat        2.96774E-02 [W]
              (beta)     5.89753E-03 [W]          19.872%
              (gamma)    2.37784E-02 [W]          80.123%
              (alpha)    1.51483E-06 [W]           0.005%
 activated atoms         8.79974E+17

................................................................................
..........
```

Fig. C-8 Example of output file of calculation results of sample problem (continued).

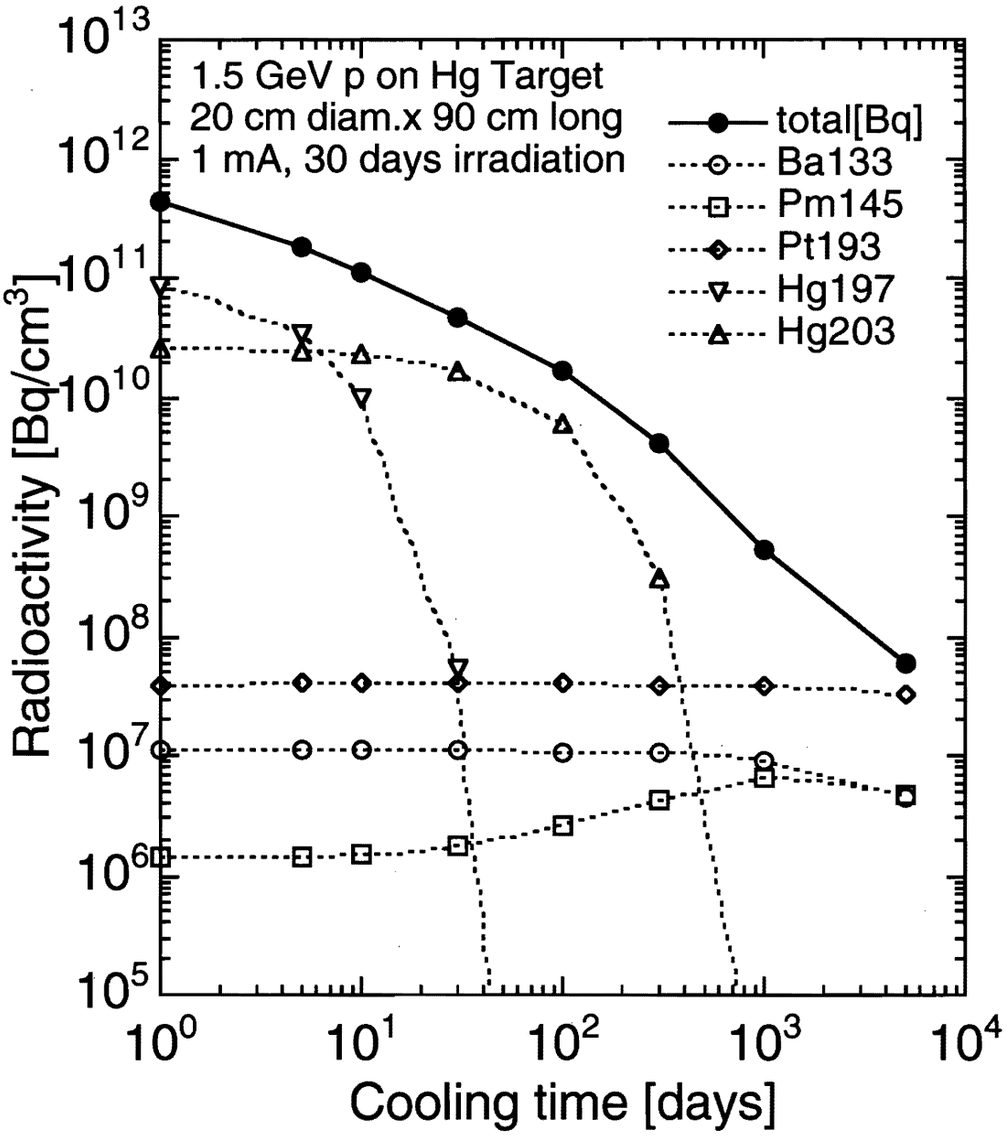


Fig. C-9 Calculated results of time evolution of induced radioactivity in Hg target irradiated by 1.5 GeV protons with current of 1 mA for 30 days.

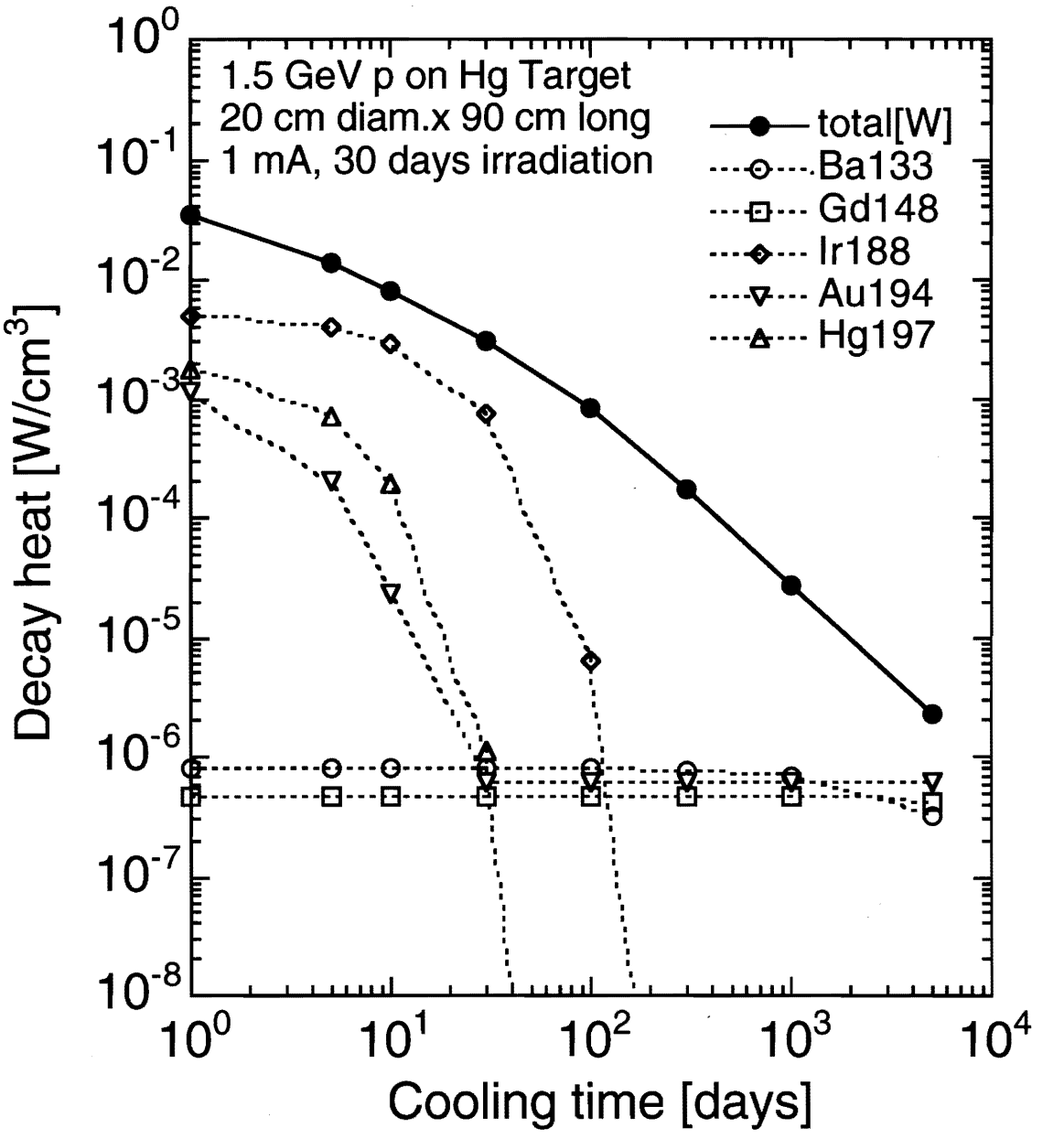


Fig. C-10 Calculated results of time evolution of decay heat in Hg target irradiated by 1.5 GeV protons with current of 1 mA for 30 days.

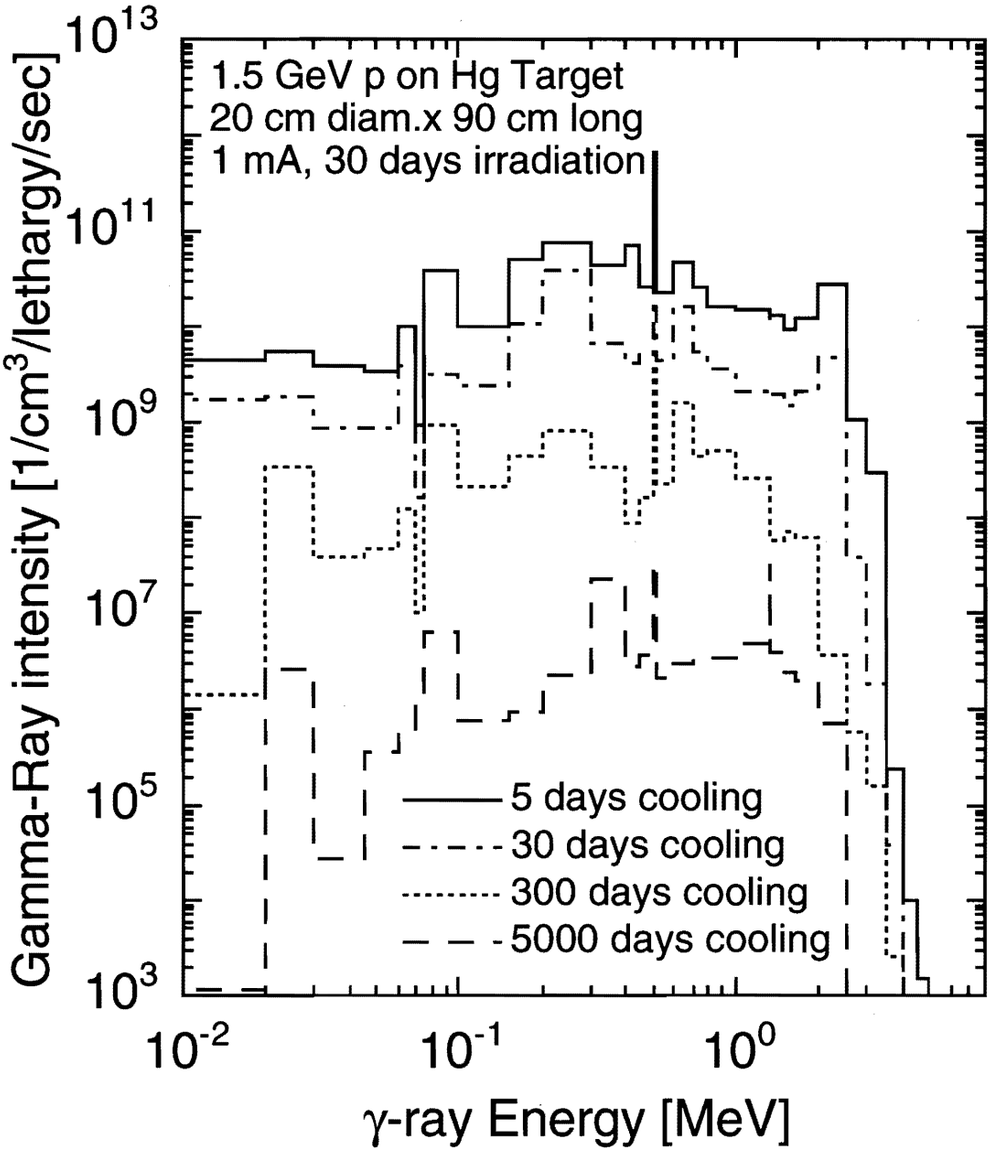


Fig. C-11 Calculated results of time evolution of γ-ray energy spectrum in Hg target irradiated by 1.5 GeV protons with current of 1 mA for 30 days.

Appendix D

Data format of nuclide yield output.

D-1 Data format of nuclide yield output file.

D-2 Example of nuclide yield output.

D-1 Data format of nuclide yield output file.

1-st record (A80)
1. TITLE Title for this nuclide yield data file.
For example, if NMTC/JAERI97,
title is ' regionwise nuclear yield (or production) [numbers/source]',
and if DCHAIN-SP output,
title is ' nuclide production yield by decay [10**24 numbers/cm**3]'

2-nd record (A80)
1. HDUMY Dummy title record.

3-rd record (-)
Blank record.

4-th record (I5, '-', 2A, 1X, 'isotope production')
1. IZ Atomic number of produced element.
2. HZ Symbol of a chemical element (2 characters; the first character is a capital letter and the second is a small letter).

5-th record (1X, 'reg.', 12(I9, A1))
(IA(i), HS(i), i=1,12)
IA(i) Mass number of i-th produced nuclide.
HS(i) Isomeric state identifier of i-th nuclide (1 character; blank character for ground state, 'm' for first isomeric state and 'n' for second isomeric state).

6-th records (I4, 12E10.3)
(IREG(j), PRDN(i,j), i=1,12)
IREG(j) J-th region number.
PRDN(i,j) I-th nuclide production yield in j-th region (the unit of NMTC/JAERI97 is [n/source] and DCHAIN-SP is [1024/cm3]).

6-th records are repeated until a blank record or EOF (end-of-file) is found.
If a blank record is found, 4-th to 6-th records are continued.

D-2 Example of nuclide production yield output.

regionwise nuclear yield (or production) [numbers/source]

75-Re isotope production

reg.	188m	189	190	190m	191	192	193	194	195
1	2.900E-05	3.399E-05	9.000E-06	9.000E-06	1.300E-05	5.000E-06	3.000E-06	9.944E-07	2.000E-06
2	6.500E-06	8.000E-06	2.500E-06	2.500E-06	.000E+00	1.000E-06	2.000E-06	.000E+00	.000E+00
3	2.993E-06	.000E+00	5.000E-07	5.000E-07	1.000E-06	.000E+00	.000E+00	.000E+00	.000E+00
4	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
5	7.972E-06	1.099E-05	1.000E-06	1.000E-06	3.993E-06	1.000E-06	1.000E-06	.000E+00	.000E+00
6	4.498E-06	3.000E-06	5.000E-07	5.000E-07	2.990E-06	1.000E-06	9.904E-07	.000E+00	.000E+00
7	.000E+00	2.000E-06	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
8	.000E+00	.000E+00	.000E+00	.000E+00	1.000E-06	.000E+00	.000E+00	.000E+00	.000E+00
9	8.486E-06	2.974E-06	1.000E-06	1.000E-06	1.000E-06	2.000E-06	9.935E-07	.000E+00	.000E+00
10	2.000E-06	2.000E-06	1.000E-06	1.000E-06	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
11	5.000E-07	1.000E-06	5.000E-07	5.000E-07	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
12	5.000E-07	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00

76-Os isotope production

reg.	173	174	175	176	177	178	179	180	181	181m	182	183
1	6.000E-06	5.599E-05	2.450E-04	7.319E-04	1.577E-03	2.852E-03	3.950E-03	4.809E-03	2.552E-03	2.552E-03	5.069E-03	2.394E-03
2	1.000E-06	1.500E-05	8.498E-05	2.660E-04	5.779E-04	9.778E-04	1.369E-03	1.715E-03	9.152E-04	9.152E-04	1.709E-03	7.261E-04
3	.000E+00	9.000E-06	2.900E-05	8.400E-05	1.640E-04	3.170E-04	4.510E-04	5.269E-04	2.589E-04	2.589E-04	4.748E-04	2.079E-04
4	.000E+00	1.000E-06	4.000E-06	1.400E-05	3.700E-05	7.300E-05	1.220E-04	1.310E-04	6.549E-05	6.549E-05	1.120E-04	4.450E-05
5	.000E+00	7.995E-06	2.998E-05	1.039E-04	2.958E-04	5.706E-04	9.012E-04	1.204E-03	6.858E-04	6.858E-04	1.397E-03	7.146E-04
6	.000E+00	5.000E-06	1.300E-05	6.798E-05	1.799E-04	3.419E-04	5.837E-04	7.075E-04	4.191E-04	4.191E-04	8.013E-04	4.055E-04
7	1.000E-06	1.000E-06	7.000E-06	2.700E-05	4.895E-05	8.898E-05	1.500E-04	1.950E-04	1.135E-04	1.135E-04	2.467E-04	1.059E-04
8	.000E+00	1.000E-06	.000E+00	.000E+00	9.990E-06	1.800E-05	1.700E-05	4.300E-05	2.399E-05	2.399E-05	5.000E-05	1.949E-05
9	.000E+00	1.000E-06	1.199E-05	5.690E-05	1.368E-04	2.897E-04	4.676E-04	6.732E-04	3.976E-04	3.976E-04	8.841E-04	4.478E-04
10	1.000E-06	4.000E-06	1.700E-05	4.698E-05	1.849E-04	3.538E-04	6.005E-04	7.865E-04	5.022E-04	5.022E-04	9.674E-04	4.206E-04
11	.000E+00	1.000E-06	3.000E-06	2.699E-05	6.400E-05	1.510E-04	2.220E-04	2.839E-04	1.644E-04	1.644E-04	3.168E-04	1.549E-04
12	.000E+00	.000E+00	.000E+00	5.000E-06	2.000E-05	2.700E-05	5.200E-05	7.698E-05	3.749E-05	3.749E-05	8.100E-05	4.599E-05

76-Os isotope production

reg.	183m	184	185	186	187	188	189	189m	190	190m	191	191m
1	2.394E-03	4.215E-03	3.291E-03	2.412E-03	1.565E-03	8.833E-04	2.478E-04	2.478E-04	1.179E-04	1.179E-04	5.848E-05	5.848E-05
2	7.261E-04	1.243E-03	9.495E-04	6.534E-04	3.817E-04	2.179E-04	6.895E-05	6.895E-05	4.049E-05	4.049E-05	1.449E-05	1.449E-05
3	2.079E-04	3.328E-04	1.890E-04	1.309E-04	1.030E-04	4.799E-05	1.149E-05	1.149E-05	8.997E-06	8.997E-06	1.500E-06	1.500E-06
4	4.450E-05	6.599E-05	4.900E-05	2.799E-05	1.600E-05	6.982E-06	4.000E-06	4.000E-06	1.000E-06	1.000E-06	5.000E-07	5.000E-07
5	7.146E-04	1.225E-03	1.015E-03	7.168E-04	4.919E-04	2.536E-04	6.588E-05	6.588E-05	3.248E-05	3.248E-05	1.099E-05	1.099E-05
6	4.055E-04	6.425E-04	5.124E-04	3.694E-04	1.998E-04	1.298E-04	3.395E-05	3.395E-05	1.398E-05	1.398E-05	7.988E-06	7.988E-06
7	1.059E-04	1.479E-04	1.199E-04	7.897E-05	4.694E-05	3.797E-05	1.048E-05	1.048E-05	4.000E-06	4.000E-06	5.000E-07	5.000E-07
8	1.949E-05	3.700E-05	3.200E-05	1.400E-05	9.996E-06	5.000E-06	5.000E-07	5.000E-07	.000E+00	.000E+00	5.000E-07	5.000E-07
9	4.478E-04	7.379E-04	5.839E-04	4.123E-04	2.446E-04	1.397E-04	4.446E-05	4.446E-05	2.046E-05	2.046E-05	9.490E-06	9.490E-06
10	4.206E-04	7.183E-04	5.614E-04	4.165E-04	2.357E-04	1.329E-04	3.294E-05	3.294E-05	1.298E-05	1.298E-05	1.048E-05	1.048E-05
11	1.549E-04	2.708E-04	1.939E-04	1.239E-04	7.390E-05	4.299E-05	6.997E-06	6.997E-06	5.992E-06	5.992E-06	2.500E-06	2.500E-06
12	4.599E-05	5.697E-05	6.798E-05	2.900E-05	2.696E-05	1.399E-05	4.500E-06	4.500E-06	3.000E-06	3.000E-06	1.000E-06	1.000E-06