ART-45

# FASTER-III, A GENERALIZED-GEOMETRY MONTE CARLO COMPUTER PROGRAM FOR THE TRANSPORT OF NEUTRONS AND GAMMA RAYS

## VOLUME II - USERS MANUAL

by

T.M. Jordan

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS3-14400

NOVEMBER 1970







A.R.T. RESEARCH CORPORATION

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## ABSTRACT

A description of the FASTER-III program for Monte Carlo calculation of photon and neutron transport in complex geometries is presented. Major revisions include the capability of calculating minimum weight shield configurations for primary and secondary radiation and optimal importance sampling parameters. The program description includes a users manual describing the preparation of input data cards, the printout from a sample problem including the data card images, definitions of Fortran variables, the program logic, and the control cards required to run on the IBM 7094, IBM 360, UNIVAC 1108 and CDC 6600 computers.

## Section 1

## INTRODUCTION

The FASTER-III program is designed for accurate calculations of photon and neutron fluxes at specified points in a complex geometry. Alternatively, the program will compute fluxes averaged over specified regions and surfaces of the geometry. The Monte Carlo method is employed in the generation and tracking of particle histories. Importance sampling is employed in all the random sampling phases of the particle histories to minimize the variance of calculated fluxes.

The program is designed to permit the user to prepare data for the most simple or complex problem with very little data manipulation other than entering numbers on data cards. The most simple problem would require the compositions and microscopic cross sections for the materials, the radiation source description, the equations for the surfaces bounding material regions, the description of the material regions, and the locations of the detectors. More complex problems may involve multiple radiation sources, optional outputs such as the flux by order-of-scatter, user-supplied importance sampling parameters, etc..

Among the many options available to the user is the capability of performing minimum weight shield calculations for rectangular, cylindrical, and/or spherical shield systems subject to specified constraints on primary and secondary response functions. The program will also calculate, as an option, optimal values of importance sampling parameters which can then be used in subsequent similar problems.

# Section 2

# PROGRAM DOCUMENTATION

The documentation for the program is detailed in the appendices to this report. This provides the most flexibility for any additions, modifications and corrections.

## 2.1 Data Preparation

The instructions for preparing data cards are given in Appendix A. The input data has been divided into many "input sections". The user supplies only those sections necessary to describe a problem. Alternatively, for multiple problem runs, only those input sections which change are input.

The program will accept data cards in either fixed-field or variable-field formats as outlined in Appendix A. The printout from the problem includes the data card images for a permanent record of the problem input.

The discussion of the input sections includes information on how to interpret any printout resulting from that input.

## 2.2 Sample Printout

The complete printout from a sample problem is contained in Appendix B. The printout includes the data card images. The data cards include numerous comments which should help relate the input data to the input instructions in Appendix A.

## 2.3 Fortran Variables

The fixed location integer and real variables are stored in named common blocks. These variables are defined in Appendix C. Many of the variables are the starting location, in blank common, of variable-dimensioned arrays. The definitions of these location variables includes the name and dimensionality of the associated array.

## 2.4 Program Logic

The program logic for data input and particle tracking is shown in Appendix D. This appendix also includes a short discussion of the role played by each of the subprograms.

## 2.5 Machine Considerations

Appendix E lists the control cards required for a compile and execute on the IBM 7094, IBM 360, UNIVAC 1108 and CDC 6600 computers. This appendix also gives the procedure for converting from single to double precision and for making installation-dependent changes such as input and output unit designations.

## Appendix A

## INPUT INSTRUCTIONS

This appendix details the preparation of input data for the program. The printout resulting from the various inputs is also described. An understanding of the program logic may clarify the role played by various inputs. This logic is discussed in Appendix D, Program Description.

### 1. Input Logic

The data required by the program has been divided into many "input sections". Each input section is classified as, belonging to one of the following general categories:

1) Material properties -- compositions, cross sections, etc.

2) Source distributions -- spatial, angular, energy, etc.

3) Geometry -- bounding surfaces, material regions, etc.

4) Output requests -- detectors, response functions, edits, etc.

5) Importance sampling -- scaling parameters, energy importance, etc.

6) Control -- execute, stop,define tapes, etc.

Each category includes one or more input sections.

The general order of input should follow the above pattern. While the input section order is not always critical, there are instances where one input section defines parameters which are essential to the correct processing of data in a subsequent input section. If the input order given in this manual is adhered to, no problems of this nature will occur.

The reason for dividing the data into so many input sections is to simplify the setup of multiple-case problems. Thus, each case uses the data of the previous case except for parameters changed through one or more input sections.

The program has been designed so that all input data will be scanned for errors. Thus, if any input errors are detected by the program, an error indicator is set and a message is entered on the printout. The problem will not be run if any errors are detected. However, processing of input will continue as long as no unforeseen catastrophic error occurs.

Most error messages are associated with particular input sections and are discussed in conjunction with the instructions for those sections. One error, however, which can occur in many of the input sections has to do with data storage allocation.

In general, all data arrays are packed into blank common using variable dimensioning techniques. The length of blank common is sufficient for fairly complex problems. However, unusually large problems -- particularly problems which request many of the optional output edits -- may exceed the available storage.

The error message associated with insufficient storage is

    NØGØ*DATA REQUIRES IJKL LØCATIØNS*NØGØ

where IJKL represents the computed storage requirement.

Once the available storage is exceeded, the program scans the rest of the input only to the extent necessary to determine the maximum storage requirement for the problem. The user is then able to decide whether to decrease the problem size or go to a more spacious computer.

An error which may occur on multiple-case problems has to do with manipulating arrays whose dimensions have changed. The program attempts to preserve the array so that all old elements within the new limits are preserved. All old elements outside the new limits are discarded and any new elements outside the old limits are given a value of zero.

If storage is tight, there is insufficient room to perform the above process and elements may not be preserved. The error message is

NØGØ*STØRAGE CØNFLICT ØN ARRAY XYZ*NØGØ

where XYZ denotes the name of a data array.

Editing of input continues but the problem will not be run.

If this problem occurs, it can be circumvented by setting up the problem as an independent case, i.e., the difficulty can only occur on change case problems.

## 2. Input Sections

The various input sections have several common features in terms of card input and the internal machinations of the program. In particular, each input section is signaled to the program by a "header card" . The header card for each input section has a unique three letter "identifier" in card columns 1-3. For example, the data section for describing the radiation SØUrce has the identifier SØU. The remainder of the header card may be blank or contain any mixture of alphanumeric data.

Until the input process is terminated, e.g., by the STØp input section, the program searches for a header card with a recognized identifier. At the commencement of the search, a line of asterisks is entered on the printout. Data cards are then read, scanned for the identifier, and if no identifier is found, printed as a "comment card". These lines of printout have the form:

```
CARD IMAGE ***.000.XXX.H                  card image
```

The value of XXX is a serial numbering of the comment cards since the search for a header card started. The H indicates the header card input format. If a new printout page is started during the search another line of asterisks is printed at the top of the page.

This search for the input section identifier has several convenient features. It permits the entering of any number of comment cards into the printout for later identification. It allows the program to quit processing a particular input section because of an error condition and proceed to the next input section. It also permits continued input processing when the number of data cards in an input section is not correct.

When a valid header card is recognized two lines are entered on the printout

```
****************************1234567890123....890
CARD IMAGE ABC.000.001.H        card image
```

where ABC denotes the input section identifier, 000 denotes the zeroth input statement of section ABC, 001 denotes the first card for the zeroth input statement, and H denotes input via the header card format.

The remainder of the data cards in the recognized input section will then be printed unless a "no print" flag was turned on by prior processing of the PRInt input section.

If a new printout page is started after the header card is found, and before the search starts for the next input section, two lines are entered on the printout, a line of asterisks, and a line identical to the one printed over the header card.

After the header card is recognized, the data cards must correspond to the detailed input formats for that input section. In particular, the first data card following the header card in every input section must be the "option card". The option card contains integer data representing input option flags, other options, and array limits. None, one, or more data cards may follow the option card depending on the data section and the input option flags. The option card will always appear on the printout immediately below the header card as

```
    CARD IMAGE ABC.001.001.I            card image
```

where ABC denotes the input section, the first 001 denotes the first input statement following the header card, the second 001 denotes the first card of that input statement, and the I denotes an integer format interpretation of the card.

The following logic is employed on all option cards. The first integer word IN1, on the option card tells the program whether the limits and options (if any) for that input section should be interpreted from third and following fields on the card. If IN1≤0, they are not interpreted. If IN1>0, they are interpreted unless the input section does not involve any. Normally, IN1 would be greater than zero on the first case. IN1 would be zero on a change case where the limits and options from the previous case still apply.

The second integer word, IN2, on the option card tells the program whether subsequent data cards (if any) for that input section will be input. The general procedure here is if IN2=0, no other input is provided for the input section and, if IN2>0, input is provided (unless that input section has no other input). In some instances, IN2 may also denote the quantity of input, e.g., the number of material regions being described.

In a few instances IN2<0, may tell the program to compute the remainder of the input with no additional data cards for the input section. In particular, this is the case for all of the importance sampling parameters. The importance sampling parameters will also be computed if they are never input for any case.

After the option card has been fully interpreted according to the defined input section, storage is then allocated, according to the latest maximum dimensions, for all data arrays (if any) associated with input data. If the data will fit, the remainder of the cards for that section are interpreted. If the data will not fit the program generates the following error message

***INPUT SECTIØN DATA LIST, INSUFFICIENT STØRAGE FØR ACTUAL INPUT***

The search for the next input section then commences.

Several other error messages may be generated during the processing of an input section. If another input section must be processed first, the following message appears

NØGØ* ABC INPUT SECTIØN MUST BE INPUT BEFØRE THE XYZ INPUT SECTIØN *NØGØ

and the search for the next input section commences. If the input section involves any ordered arrays and inversions in the order of the array elements are detected the following message is generated

NØGØ* N INVERSIØNS IN THE FØLLØWING DATA *NØGØ

The array is then listed with the label ERRØR ARRAY appended at the left side of each printout line.

Several of the input sections involve user-supplied indices on which data is stored. If one of these indices is outside the permissible range established by input limits, the following message is printed

NØGØ* I IS ØUTSIDE THE RANGE 1-IMAX *NØGØ

where IMAX is the upper limit on I. The value of I is set to one by the program and input continues.

3. <u>Fixed Field Input Formats</u>

The program uses a variety of fixed field formats for input data. These formats have varying combinations of the following data fields:

I3 field (3 card columns), integer data

E9.0 field (9 card columns), decimal data

Only card columns 1 through 72 are used for the data fields.

The formats and the appearance of the corresponding printout for a card read by that format are summarized below:

| Format | Printout Line | |
|---|---|---|
| I(24I3) | CARD IMAGE ABC.XXX.YYY.I | card image |
| II(12(2I3)) | .II | |
| IS(12(2I3)) | .IS | |
| E(8E9.0) | .E | |
| EE(4(2E9.0)) | .EE | |
| IE(6(I3,E9.0)) | .IE | |
| ES(6(I3,E9.0)) | .ES | |
| S(3I3,7E9.0) | .S | |
| R(12I3,4E9.0) | .R | |
| A(24A3) | CARD IMAGE ABC.XXX.YYY.A | card image |

I denotes an all integer format with a maximum of 24 integers on the card, E denotes an all decimal format with 8 pieces of data per card. The II and EE indicate formats where the data is input as logical pairs, e.g., $\left[x_i, f(x_i)\right]$ , $i = 1, 2, \ldots$ The IS and ES formats are used for logical pair input where the first number of the pair is the index of the second number, e.g., $\left[i, f_i\right]_j$, $j = 1, 2, \ldots$ The S and R formats were so designated because they were first used for the description of surfaces and regions respectively.

All alphanumeric data is entered in a 24A3 format, 3 columns per data word, 24 words per card. If alphanumeric data is read during the header card search, the format is designated H.

If such data is read as a normal part of the data for an input section it would appear as the A format shown above.

The ABC in the printout line indicates the input section as mentioned before, XXX is an internal serial number for the input statements encountered in section ABC, and YYY is the serial number of the physical data cards input via input statement XXX.

Now, as to why all the card images have the information SECTIØN.INPUT STATEMENT.CARDCØUNT.FØRMAT appended to them. With the exception of alphanumeric data which is always fixed field, the integer and decimal data are actually interpreted via a variable field format to be described later. Since the resulting printout line contains the card image, it is impossible to tell how the card is interpreted unless a catastrophic error causes the program to bomb off the machine while giving a reverse call sequence. By scanning the printout with the appended information it becomes rather easy to verify that the card was interpreted in the correct input section via the correct format, and, with a little more effort, that the interpretation occurred with the proper sequential input statement and card count.

Since a variable format is actually used for interpreting the integer and decimal data from the card image, one relaxation in the ASA standards has been made. Namely, all leading <u>and</u> trailing blanks in a data field are ignored rather than being treated as zeros. Therefore, integers, including the exponents of decimal data, do <u>not</u> need to be right adjusted in the data field. Embedded blanks are treated as zeros in the usual manner.

## 4. Variable Field Input Formats

The program will also accept integer and decimal data in a variable length field format. Alphanumeric data is always entered in the fixed A3 field of the H and A formats.

The data formats given in the detailed input instructions correspond to using the fixed field input. The use of the variable length field is signaled to the program by a comma in the first column of the data card. The absence of the comma therefore indicates the use of the fixed field format for that card. With appropriate care, the two formats can be used interchangeably even within a multiple card input statement.

The rules followed in preparing variable length field data are summarized below:

a) Card column 1 must contain a comma (,),

b) before any data is interpreted from the card, the locations receiving the data are filled with zeros except for the IS and ES formats where the locations are not defined,

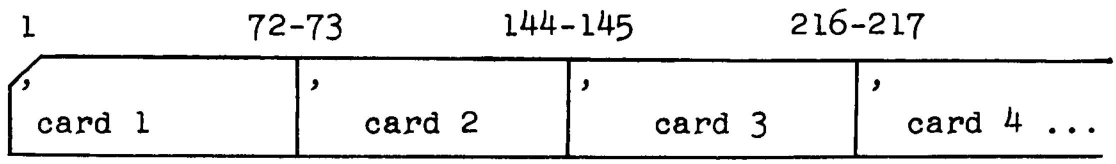
c) data fields are separated by commas,

d) a slash (/) indicates immediate termination of input for the input statement -- equivalent to a zero fill, except for the IS and ES formats, due to b) above,

e) any number of blank columns -- including none -- between two commas is interpreted as a minus zero,

f) data is entered only in card columns 1 through 72,

g) the comma in card column 1 in multiple card input statements should be visualized as a comma in column 73 of the preceding card, i.e., the multiple cards should be visualized as one long card




e.g., a comma in column 72 of one card followed by a comma in column 1 of the next card is equivalent to inputting one piece of data interpreted as a minus zero,

h) data lists on a card exceeding the list length of the input statement are assumed to belong to the next input statement,

i) a slash followed by a comma (/,) terminates input for the present input statement but signifies the next input statement will continue interpreting data from the same card; anything else after the slash indicates the next input statement will start with the next card,

j) if a slash is not followed by a comma, the remainder of the card is ignored and can be used for comments,

k) the program has a repeat feature such that if an asterisk (*) is encountered between two consecutive commas on the same card the columns preceding the asterisk are the number of entries (a minimum of 1) of the columns following the asterisk; this repeat option can be used to non-zero fill since the repeat does not continue into the next input statement and the repeat is truncated -- without an error indication -- if the number of repeats exceeds the length of the input statement list,

l) all alphanumeric data is entered in a fixed field format starting in column 1.

Comment cards can be placed anywhere in a data deck except immediately preceding A format alphanumeric data cards. Comment cards should contain a C in column 1 and column 2 should be blank. The remainder of the columns can contain any combination of alphanumeric information.

There are two error messages which are generated during the interpretation of data cards. Either error will suppress the execution of the problem even though the input will continue. The first message has to do with non-numeric data within the field

NØGØ*INVALID PUNCHES IN CØLUMNS II-JJ ØF CARD ABC.XXX.YYY.F*NØGØ

where F is the card format under which the card was originally interpreted (with variable field input, various formats may be used on the same physical card). An invalid punch is interpreted as a zero.

The second message has to do with the exponent of decimal data

NØGØ*THE ABSØLUTE VALUE ØF THE EXPØNENT IN CØLUMNS
II-JJ ØF CARD ABC.XXX.YYY.F EXCEEDS ZZ*NØGØ

where ZZ is presently 38. The exponent is then fixed in magnitude at 38 with the correct sign.

5. Input Section Formats

The remainder of this section covers the detailed input instructions for the input sections available to the user of the program. The header card identifiers are listed in Table A.1 in the same order as they appear in the instructions. The same order should be used in supplying data with the obvious exception of the control input sections. Control input sections should be supplied in the order the user wants the control functions performed with respect to the other input sections.

In the description of individual cards in an input section, each card is given an identification of the form ABC.XX.F(format) where ABC denotes the input section identifier, XX denotes a serial number, and F denotes a format type. Note that the serial numbering system used on the input section card description is not necessarily the input statement number printed out when the card is input. It will be for most input sections, however.

After the card identification is given, a few words are used to give the card a more meaningful title. Below this, the data on the card are then described. If the data are all of the same type there may be a simple explanation of what the data is, its units (if any), and the order in which it is input. If the data on the card have different functions then the data words are numbered consecutively as they appear on the card and are then described individually.

If variable length input formats are being used, it should be noted that the option card input statement expects 24 integers. These and other input statement list lengths are given in the input instructions.

TABLE A.1

LIST OF INPUT SECTIONS

ZERout Core
TAPe Units
LABel for Printout
MATerial Compositions
MIXture Table
GAMma Ray Cross Sections
PHØton Cross Sections
MULtigroup Neutron Cross Sections
NEUtron Cross Sections
SECondary Production Cross Sections
ADDress Modification
SØUrce Distributions
PRØfiles of Source Time Dependence
SURfaces
HELical Surfaces
REGions
CYLindrical Geometry
SPHerical Geometry
AIR Density
CHEck Ray Trace
CØRrelated Calculations
DETectors
FLUx Groups
RESponse Functions
BIRth Regions
ØRDer of Scatter
SCAttering Regions
BØUndary Crossings
ANGular Fluxes

TABLE A.1 (Cont'd)

SØLid Angle Fluxes
TRAnslation Time
MØMents of Temporal Fluxes
TIMe Interval Fluxes
GRØup Edit on Fluxes
NØRmal Derivatives
MINimum Weight Shield
DEPosition in Regions
LEAkage of Energy
CHAnnel Detectors
NØIse Functions
PLØt Output
QUIck Plot of Results
ØPTimum Importance Parameters
BIAsing Options
PSEudo Spherical Source
RELative Source Importance
RATios of Source Variable Importance
PREferred Point
SPAtial Importance
CAPture Importance
SHØrt Circuit
RØTate and Translate
ARRay Direct Input
DUMp Requests
PRInt Suppression
NEXt Case
EXEcute the Problem
CØNtinue a Previous Run
STØp Processing

ZERout Core

This section permits a complete erasure of all data in core so that only subsequent data cards define the succeeding problem. The random number generator is not reset, so a different random number sequence will be used for the subsequent problem than would be used if the problem were actually the first problem in this run.

ZER.0.H(24A3) Header Card

Must have ZER in columns 1-3.

ZER.1.I(24I3) Option Card

1.-24. Input but not used.

## TAPe Units

This section defines the logical designations of any tape units used by the program.

### TAP.0.H(24A3) Header Card

Must contain TAP in columns 1-3.

### TAP.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-8 from this card.

2. IN2, not used.

3. M3, logical designation of the cross section tape unit

4. M4, logical designation of the restart tape unit.

5. M5, logical designation of the collision tape unit.

6. M6, logical designation of the secondary source tape unit.

7. M7, logical designation of the census tape unit.

8. M8, logical designation of the scratch tape unit.

A zero indicates the tape unit is not used. Supply a zero tape unit designation unless directed otherwise in the input instructions for the remainder of the problem.

Affixing a minus sign to a nonzero unit designation means that unit will not be rewound when this card is read. All positively designated units will be rewound.

9.-24. Input but not used.

## LABel for Printout

This section provides for entering two lines of descriptive information at the top of each printout page. If not used, the printout headings will contain asterisks.

LAB.0.H(24A3) Header Card

Must have LAB in columns 1-3.

LAB.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) cards LAB.2 and LAB.3 are input.

3.-24. Input but not used.

LAB.2.A(24A3) First Label Card

Any mixture of alphanumeric data.

LAB.3.A(24A3) Second Label Card

Any mixture of alphanumeric data.

MATerial Compositions

This input section defines the number of different material compositions to be used in this and possibly succeeding problems. More materials can be defined than are actually designated later to be located in specific regions.

The definition of the compositions requires the input of the constituent isotopes or elements and their partial density in each material.

The compositions are defined independent of the microscopic cross sections since the composition data may be used in forming macroscopic cross sections for more than one radiation type in a given computer run.

The order in which element data is provided here must also be followed in later supplying the microscopic cross section data.

MAT.0.H(24A3) Header Card

Must have MAT in columns 1-3.

MAT.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret limits and options from this card, data words 3, 4, and 5 below.

2. IN2, (0,>0)=(no,yes) data cards MAT.2 are being input.

3. NIMAX, number of elements and/or isotopes.

4. NMMAX, number of materials to be formed from the elements.

5. NUNITD, (0,1)=($10^{24}$ atoms/cc, gram/cc) partial density units option.

6.-24. Input but not used.

MAT.2.E(8E9.0) Compositions

Supply this card for each element I=1,2,..., NIMAX starting a new card for each element.

1. ATW(I), atomic weight of element I (amu)

2. ATN(I), atomic number of element I

3. ATD(1,I) ... ATD(NMMAX,I), density of element I in material 1, material 2, ..., through material NMMAX

NOTES:

The partial densities for each material should sum to the correct reference density for the material. These densities can then be scaled in the geometry description to account for regions which have a lesser or greater density. For example, the compositions for all materials can be specified to yield a reference density of 1.0 gm/cc. Then the geometry description would include density scale factors equal to the actual density in each region.

## MIXture Table

This input section is used to set up a table of materials for which only the hydrogen content varies from specified materials described in the MATerial input section. This capability is provided for neutron and photon problems only.

MIX.0.H(24A3) Header Card

Must have MIX in columns 1-3.

MIX.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) card MIX.2 is being input.

3. MIXED, total number of mixtures to be formed.

4. NUNITD, (0,1)=($10^{24}$atoms/cc, grams/cc) hydrogen density units.

5.-24. Input but not used.

MIX.2.IE(6(I3,E9.0)) Mixtures

Supply MIXED pairs of data. The first member of the pair is an integer denoting the basic material comprising the mixture -- a zero indicates none. The second member of each pair is a decimal number giving the hydrogen content-- replacing the hydrogen content in the base material--of the mixture with units according to NUNITD above.

The mixtures defined through this data are given material indices of NMMAX+1, ..., NMMAX+MIXED, where NMMAX is the number of basic materials.

GAMma Ray Cross Sections

This input section provides the microscopic cross section data necessary for tracking gamma rays. This data includes the number of energy groups to be used in this problem, the energy group boundaries, and the microscopic total cross section data for each element described in the MAT input section.

GAM.0.H(24A3) Header Card

Must have GAM in columns 1-3.

GAM.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret limits and options from this card, data word 3 below.

2. IN2, (0,>0)=(no,yes) data cards GAM.2, etc. are being input.

3. NEPMAX, number of photon energy groups.

4.-24. Input but not used.

GAM.2.E(8E9.0) Energy Groups Boundaries

This card gives the energy group boundaries in Mev in order of decreasing energy, ELP(1), ELP(2), ..., ELP(NEPMAX+1). The cross section data below can be input at different energy points and is then log-log interpolated to get cross sections at these energy points.

Supply a set of cards GAM.3, GAM.4, ... for each element, I=1, 2, ..., NIMAX, in the same order as the compositions were input.

GAM.3.I(24I3) Element Option Card

1. LRLØPT=0, total cross sections are read on card GAM.5 for energy points defined according to NETAB below.

   LRLØPT=1, total cross sections are input via card GAM.6 at energy points defined on card GAM.6.

2. NUNITX,(0,1)=(barns/atom,$cm^2$/gm) cross section unit option.

3. NETAB < 0, cross section input energy points are the same as those on the GAM.2 card.

   NETAB=0, energy points are the same as for the previously input element.

   NETAB>0, energy break points are input via card GAM.4 below.

   NETAB is not used if LRLØPT=1.

4. MX, number of points in the total cross section input.

5.-24. Input but not used.

GAM.4.E(8E9.0) Energy Points

Supply this card if NETAB>0, with NETAB energy points in Mev using decreasing energies.

GAM.5.E(8E9.0) Cross Sections

Supply this card if LRLØPT=0 with MX microscopic total cross sections for the first MX GAM.2 energy points or the first MX GAM.4 energy points, XST(1), XST(2), ... XST(MX).

GAM.6.EE(4(2E9.0)) Energies and Cross Sections

Supply this card if LRLØPT=1 with MX pairs of energy and cross section, ETP(1), XST(1), ETP(2), XST(2), ..., ETP(MX), XST(MX).

PHØton Cross Section

This input section provides microscopic photon cross section data. Input includes the photon energy group structure. Cross section data are tabulated for a separate energy point table and are log-log interpolated to obtain the data for the photon energy group boundaries. During calculations, linear interpolation is used for intermediate energies.

Cross section data for the elements must be supplied in the order associated with the MATerial compositions.

PHØ.0.H(24A3) Header Card

Must have PHØ in columns 1-3.

PHØ.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-5 from this card.

2. IN2, (0,>0)=(no,yes) cards PHØ.2, etc. are being input.

3. NEPMAX, number of photon energy groups.

4. NFØRM, number of points in the tabulated form factors for coherent and Compton scattering.

   NFØRM=0, coherent scattering is neglected; all electrons are assumed free.

5. NEDGES, maximum number of photoelectric edges for any element.

   NEDGES=0, the photoelectric process is neglected in the generation of flourescence and/or photoelectrons.

6.-24. Input but not used.

PHØ.2.E(8E9.0) Energy Groups

Photon energy group boundaries are supplied in Mev and descending values, ELP(1), ELP(2), ..., ELP(NEPMAX+1).

PHØ.3.E(8E9.0) Form Factor Argument

Omit this card if NFØRM=0. Supply NFØRM values of the electron momentum (q, dimensionless), increasing values, at which form factor data will be tabulated. See cards PHØ.7 and PHØ.8 for more detailed discussion.

Supply PHØ.4, etc., cards in sets; one set per element.

PHØ.4.I(24I3) Element Option Card

1. LRLØPT=0, microscopic cross sections are input for the energies defined through data word 3 below.

   LRLØPT=1, energy points and cross sections are input in logical pairs; four pairs per card, $E_i$, $\sigma_i$, i = 1,2,...

   LRLØPT=2, energy points are input starting on one set of cards $E_i$, i = 1,2,... followed by cross sections starting on another set of cards, $\sigma_i$, i = 1,2,...

2. NUNITX, (0,1)=(barns/atom,$cm^2$/gm) cross section units.

3. NETAB, used only if LRLØPT=0.

   NETAB<0, energy points for input are identical to card PHØ.2 data.

   NETAB=0, energy points defined for the previous element are used for input data.

   NETAB>0, energy points are being input.

4. MXST, points in total cross section. If not input, MXST=0, the total cross section is calculated by summing partial cross sections as defined below.

5. MXSI, points in incoherent scattering (Compton). If not input, MXSI=0, the cross section is computed internally neglecting electron binding effects.

6. MXSC, points in coherent scattering (Rayleigh). If not input, MXSC=0, the cross section is set to zero, consistent with the Compton option above.

7. MXSP, points in pair production data. Cross section set to zero if MXSP=0.

8. MXSE, points in the photoelectric data. Cross section set to zero if MXSE=0.

9. MEDGES, number of edges for this element.

10. MXCØM, (0,>0)=(no,yes) Compton form factors are input.

11. MXCØH, (0,>0)=(no,yes) coherent form factors are input.

12.-24. Input but not used.

PHØ.5.E(8E9.0) Tabulation Energies

Input this card only if NETAB>0. Supply NETAB energies (Mev) in descending values.

PHØ.6.$\left\{\begin{matrix}\text{E(8E9.0)}\\ \text{EE(4(2E9.0))}\end{matrix}\right\}$ Microscopic Cross Sections

Input card PHØ.6 for each cross section type for which the input list length, data words 4 through 8 above, is greater than zero. Input in that order according to the discussion for LRLØPT and NETAB on card PHØ.4. Start a new card for each cross section type (and separate tabulation energies if LRLØPT=2).

PHØ.7.E(8E9.0) Form Factor-Incoherent

Omit this card if MXCØM=0. Supply NFØRM values of $1-\frac{1}{Z}k(q,Z)$ if MXCØM=1 or $k(q,Z)$ if MXCØM=2, where $k(q,Z) = \sum_{i=1}^{Z}\left|f_o^{(i)}(q)\right|^2$ is the form factor as a function of q corresponding to the q points listed on the PHØ.3 card.

$q = \alpha\sqrt{1-2\mu\rho+\rho^2}$ , $\alpha = E_\gamma/m_oc^2$, $\rho = \left[1+\alpha(1-\mu)\right]^{-1}$, and $\mu$ is the cosine of the photon scattering angle.

PHØ.8.E(8E9.0) Form Factor - Coherent

Omit this card if MXCØH=0. Supply NFØRM values of $\frac{1}{Z^2}|F(q,Z)|^2$ if MXCØH=1 or $F(q,Z)$ if MXCØH=2 where $F(q,Z)$ is the form factor as a function of momentum corresponding to the q points listed on the PHØ.3 card and $q = \alpha\sqrt{2(1-\mu)}$ where $\alpha$ and $\mu$ are defined in conjunction with the PHØ.7 card.

PHØ.9.E(8E9.0) Photoelectric Edges

Omit this card if MEDGES=0. Supply four pieces of data for each edge J -- two edges per card -- in the order of increasing edge energy.

EDG(J), edge energy in Mev.

SED(J), edge cross section (maximum) - units according to NUNITX.

FLØ(J), flourescence yield.

FLE(J), flourescence energy (Mev).

NOTES:

The photon energy group structure supplied on card PHØ.2 is also used for the output of photon fluxes unless an alternate output group structure is supplied via the FLUx group input section.

Form factor data consistent with the use of MXCØM=MXCØH=2 can be obtained for many elements from AFWL-TR-65-171, Volume 1. The values of ETA at which these form factors are tabulated are 137 times the q values expected by this program on card PHØ.3.

This program will also accept LRL format cross sections. All the above definitions hold except that any of the partial cross sections controlled by data words 4 through 8 will be accepted in the LRL format by affixing a minus sign to the data word. This format contains several integers in columns 1 through 14 of each data card followed by three pairs of energy and cross section in fields of 10 columns each with the energies in ascending order. The first 14 columns of the card are ignored by the program. Data entered using this option is designated as L format data.

MULtigroup Neutron Cross Sections

This input section provides multigroup cross section data for tracking neutrons. The data includes the number of energy groups and several other limits and options. The data also describes the energy group structure and the microscopic cross sections for each element.

The program has numerous options for processing cross section data, including:

1) transport correction or removal of the transport correction from the total and elastic transfer cross sections,

2) processing of $P_2$ cross section data to obtain histrogram transfer probabilities which preserve moments and are nonnegative,

3) acceptance of DTF-IV format cross section data from either cards or tape.

These and other options are described below.

MUL.0.H(24A3) Header Card

Must have MUL in columns 1-3.

MUL.1.I(24I3) Option Card

1. IN1, (0,1)=(no,yes) interpret limits and options, data words 3-10 below.

2. IN2, (0,1)=(no,yes) input data cards MUL.2, etc.

3. NEMMAX, number of neutron energy groups.

4. NØRDER, 1 + order of Legendre expansion of cross section data.

5. NDØWN, 1 + maximum group-to-group transfer from elastic collisions. DTF-IV format data will be collapsed to this value if it is exceeded.

6. INELAS, number of groups from which nonelastic transfer can be initiated.

7. NTRANS, 1 + maximum group-to-group transfer from non-elastic collisions.

8. LFIXUP, (0,>0)=(no,yes) use histogram model for $P_\ell$ scattering (use it!).

9. MGSLØW, number of groups which will not be treated explicitly. Neutrons scattered into the lowest MGSLØW groups are assumed to slow down locally and the flux from these groups are an estimate only. The estimate is better than a strict Monte Carlo calculation in most cases.

10. NUNITX, (0,1)=(barns/atom, $cm^2/gm$) cross section units options.

11.-24. Input but not used.

MUL.2.E(8E9.0) Neutron Energy Group Boundaries

This card gives the neutron energy group boundaries in Mev in order of decreasing energy, ELM(1),ELM(2),... ELM(NEMMAX+1).

Supply the following cards in sets, one set for each element, I = 1, 2, ..., NIMAX, in the same order as was used to input material compositions.

MUL.3.I(24I3) Element Option Card - FASTER Format

1. LMAX, 1 + order of Legendre expansion of cross sections for this element. Affixing a minus sign to LMAX indicates the total cross section data which follows has been transport corrected. LMAX≤NØRDER+1. If LMAX=NØRDER+1, the cross sections are truncated with a correction factor.

2. NDSM, 1 + maximum elastic group transfer for this element.

3. KMAX, number of groups for which inelastic transfer is initiated for this element.

4. KMX(1),
   ⋮
   KMX(J), 1 + maximum group transfer for nonelastic transfer initiated in group J.
   ⋮
   KMX(KMAX)

MUL.4.E(8E9.0) Total Cross Section - FASTER Format

Total (or transport if LMAX<0) cross section for each energy group.

MUL.5.E(8E9.0) Elastic Transfer Cross Sections - FASTER Format

Omit this card for hydrogen. This contains the Legendre coefficients for elastic transfer in the following sequence:

New card - coefficients for $P_o$ in group transfer, NEMMAX entries.

New card - coefficients for $P_o$ down 1 group transfer, NEMMAX-1 entries.

⋮

New card - coefficients for $P_o$ down NDSM-1 groups transfer, NEMMAX+1-NDSM entries.

New card - coefficients for $P_1$ in group transfer, NEMMAX entries.

⋮

New card - coefficients for $P_{LMAX-1}$ down NDSM-1 groups transfer, NEMMAX+1-NDSM entries.

MUL.6.E(8E9.0) Nonelastic Transfer Cross Sections - FASTER Format

Omit this card for hydrogen or if KMAX=0. Nonelastic transfer is assumed isotropic and is supplied in the following sequence:

New card - cross sections for transfer from group 1 to groups 1 through KMX(1).

New card - cross sections for transfer from group 2 to groups 2 through 2+KMX(2)-1.

⋮

New card - cross sections for transfer from group KMAX to groups KMAX through KMAX+KMX(KMAX)-1.

MUL.7.I(24I3) Element Option Card - DTF-IV Format

1. LMAX, same definition as card MUL.3.

2. NDSM, location of the in group scattering cross section in the data table with a minus sign affixed (the minus tells the program that the DTF format is being used).

3. KMAX, length of the cross section table for each energy group.

4. IDEL>0, identification of the $P_0$ cross section array for this element on tape M3 (requires prior input of the TAPe input section).

   IDEL=0, cross section input from cards.

5. MELAST, number of energy groups in input data set. Only the first NEMMAX groups are used.

   MELAST=0, NEMMAX group data are assumed to be input.

6. NGTSEC=0, no effect.

   NGTSEC=1, this is a coupled neutron-photon cross section set and, if the SEC input section has been input, the microscopic production cross sections are stripped from the input and added to the macroscopic secondary production cross sections.

7-24. Input but not used.

<u>MUL.8.F(6(I2,A1,E9.0))</u> Cross sections

This card contains the cross section data in the following order:

$$(((\sigma_{k,j,\ell}\ ,\ k=1,\ KMAX),\ j=1,\ MAXO(NEMMAX,MELAST)),\ \ell=1,IMAX)$$

A limited version of the DTF format capabilities is provided. The following interpretations of the data fields are made:

If all three fields of the triplet I2, A1, E9.0 are blank, no data is assumed. If the first two fields I2, A1 of the triplet are blank and the third field E9.0 is not blank, one data word is assumed. If the first field I2 is not blank, then the numerical value of this field is assumed to be the number of repeats of the data in the third field. Many other input options are available in the DTF-IV format depending on the entry in the second A1 field of each triplet. These options are not included in this program.

NEUtron Cross Sections

This input section supplies point value cross sections for neutron transport problems. All cross sections are in barns/atom.

NEU.0.H(24A3) Header Card

Has NEU in columns 1-3.

NEU.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-8 from this card.

2. IN2, (0,>0)=(no,yes) cards NEU.2, etc. are being input.

3. NNEMAX, number of energy groups.

4. NAAMAX, number of points used to tabulate anisotropic elastic scattering distributions. These distributions will be linearly interpolated during the calculations.

5. MAXANI, maximum number of energy groups for any element for which elastic scattering is anisotropic in the center-of-mass coordinate system.

6. NANISØ, total number of different anisotropic angular distributions for all elements.

7. NØNELA, maximum number of groups for which nonelastic scattering can occur.

8. NDRØPS, maximum number of groups to which a neutron may be transferred via a nonelastic event.

9.-24. Input but not used.

## NEU.2.E(8E9.0) Energy Groups

Supply the neutron energy group boudaries (Mev) in the order of decreasing energy, ELN(1), ELN(2), ..., ELN(NNEMAX+1).

## NEU.2.E(8E9.0) Tabulation Cosines

Omit this card if NAAMAX=0. Supply NAAMAX values of the cosine of the center-of-mass scattering angle in order of increasing cosine.

## NEU.4.I(24I3) Element Options

Supply cards NEU.4, etc. in sets, one set per element in the order associated with the MATerial compositions.

1. LMAX, number of different models to be used in generating the nonelastic transfer matrix. See card NEU.9 for more details.

2. NDSM, number of energy group boundaries with a nonzero, nonelastic scattering cross section.

3. KMAX, number of energy groups for which elastic scattering is anisotropic in the center-of-mass.

   KMAX=0, all elastic scattering is isotropic in the center-of-mass scattering system.

4. KMX(1)
   ⋮
   KMX(J)<0, the anistropic angular distribution for energy group J is the same as for group K = -KMX(J) where K<J.

KMX(J)>0, the anisotropic angular distribution is input as tabulated data on card NEU.7 at the center-of-mass cosines listed on card NEU.3.

KMX(J)>100, the anisotropic angular distribution is input on card NEU.7 via Legendre expansion coefficients to order L = KMX(J) - 101, i.e., KMX(J) - 100 coefficients are input (including the $P_o$ coefficient).

⋮

KMX(KMAX)

<u>NEU.5.E(8E9.0)</u> Total Cross Section

The microscopic cross section is input for the energy group boundaries listed on card NEU.2, NNEMAX+1 pieces of data.

<u>NEU.6.E(8E9.0)</u> Elastic Scattering Cross Section

Omit this card for hydrogen. The microscopic elastic scattering cross section is input for the energy group boundaries listed on card NEU.2.

<u>NEU.7.E(8E9.0)</u> Anisotropic Distribution

Omit this card for hydrogen or if KMAX=0. Start a new card for each energy group J for which KMX(J)>0. Supply these cards in ascending order of energy group indices. The data consists of either values of the distribution at the cosines listed on card NEU.3 (if KMX(J)<100) or Legendre expansion coefficients (if KMX(J)>100). Neither type of data needs to be normalized -- this is done by the program.

<u>NEU.8.E(8E9.0)</u> Nonelastic Scattering Cross Sections

Omit this card for hydrogen or if NDSM*LMAX=0. Supply the nonelastic cross section for the first NDSM energy points listed on card NEU.2.

NEU.9.S/E(3I3,7E9.0/(8E9.0)) Nonelastic Scattering Models

Omit this card for hydrogen or if NDSM*LMAX=0. Supply LMAX sets of this card containing the following data:

1. NGT=1, evaporation model, distribution of secondary neutron energies is calculated from $\rho(E') = E' \exp\left[-E'\sqrt{\alpha/E}\right]$ (properly normalized, of course).

   NGT=2, discrete level model, distribution of secondary neutron energies is calculated from $\rho(E') = \delta(E-\alpha)$ where $\alpha$ is the energy level in Mev.

   NGT=3, uniform model, distribution of secondary neutron energies is calculated from $\rho(E') = \frac{1}{E-\alpha}$ , $E' \leq E-\alpha$

2. MIN, first primary neutron energy group for which this model is used (any or all models can apply to any or all primary energy groups).

3. MAX, last primary neutron energy group for which this model is used.

4. ALPHA, the numerical value of $\alpha$ for the selected models.

5. PNE(MIN)
   
   ⋮
   
   PNE(J), fraction of nonelastic scattered primary neutrons in energy group J which interact according to the selected models.
   
   ⋮
   
   PNE(MAX)

## SECondary Production Cross Sections

This section provides microscopic cross sections for the production of secondary gamma rays from neutron interactions or secondary neutrons from high-energy gamma ray interactions.

SEC.0.H(24A3) Header Card

Contains SEC in columns 1-3.

SEC.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-5 from this card.

2. IN2, (0,>0)=(no,yes) card SEC.2 or SEC.3 is being input.

3. NPEMAX, number of primary energy groups which can initiate secondary production. These are assumed to be the NPEMAX highest energy groups.

4. NSEMAX, number of secondary energy groups in which secondary particles are produced. These are the NSEMAX highest energy groups.

5. NUNITX, (0,1)=(barns/atom,$cm^2$/gm) cross section units option..

6. IN6, (0,>0)=(SEC.2,SEC.3) cross section input format.

7.-24. Input but not used.

SEC.2.E(8E9.0) Cross Sections

If IN6=0 input these cross sections in sets, one set for each element in the order associated with the MATerial compositions. The set for each element contains the following data:

New card: for primary group 1, secondary production cross section times the number of secondaries produced in each secondary energy group, NSEMAX pieces of data.

•
•
•

New card: for primary group NPEMAX, secondary production cross section times the number of secondaries produced in each secondary energy group, NSEMAX pieces of data.

SEC.3.F(6(I2,A1,E9.0)) Cross Sections-DTF Format

If IN6>0, input the cross sections in the DTF-ANISN format in the same order as indicated for card SEC.2. This is the same order produced on punched cards by PØPØP4.

## ADDress Modification

This input section permits a modification of the input data indices on which sources, surfaces, regions, and detectors are entered. Its purpose is to provide a fairly simple means for combining the geometric descriptions of several independent problems into one problem. The use of the RØTate input section may also be required to move portions of the geometry.

ADD.1.H(24A3) Header Card

Has ADD in columns 1-3.

ADD.2.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-6 from this card.

2. IN2, not used.

3. IAD1, index modifier for any source indices input in the SØUrce or REGion input sections.

4. IAD2, index modifier for any surface indices input in the SURface, HELix, REGion, or DETector input sections.

5. IAD3, region index modifier for any region indices input in the REGion and DETector input sections.

6. IAD4, detector index modifier for any detector indices input in the DETector input section.

7. IAD5, composition index modifier for any non-zero composition indices input in the REGion input section.

8.-24. Input but not used.

## SØUrce Distributions

This section defines the spatial, angular and energy distributions of independent radiation sources. The radiation type is determined by the last cross section header card processed.

SØU.0.H(24A3) Header Card

Must have SØU in columns 1-3.

SØU.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2>0, number of sources being described via cards SØU.2, etc.

   IN2=0, no sources are being input.

3. NVMAX, total number of independent sources.

4. NXMAX, maximum number of points required to tabulate a spatial or angular distribution. A minimum of two points is required for any continuous distribution such as equiprobable azimuthal angles.

5-24. Input but not used.

SØU.2.R(12I3,4E9.0) Fixed Source Constants

Card SØU.2 is input for IN2 different sources. This card indicates whether cards SØU.3 and SØU.4 are required. If they are required, they are placed immediately behind card SØU.2.

1. I, index of source being described, $1 \le I \le NVMAX$.

The next six variables depend on the source geometry.

| | | | rectangular | cylindrical | spherical |
|---|---|---|---|---|---|
| 2. | NSG(I) | | 0 | 1 | 2 |
| 3. | NPC(1,I) | number of tabulation points for (1 for delta function, 2 or more for continuous, e.g. NPC(4,I)= NPC(5,I)=2 for isotropic sources) | x(cm) | r(cm) | $\rho$(cm) |
| 4. | NPC(2,I) | | y(cm) | $\theta$ (radians) | $\theta$(radians) |
| 5. | NPC(3,I) | | z(cm) | z(cm) | $\mu$ |
| 6. | NPC(4,I) | | Θ'(radians) | Θ'(radians) | Θ'(radians) |
| 7. | NPC(5,I) | | $\mu'$ | $\mu'$ | $\mu'$ |

See Figure SØU.1 for the relationships of the variables.

8. MAX, number of energy points or energy groups required to describe the input spectrum. The input spectrum will be regrouped internally to conform to the particle group structure.

9. NØRM, spectrum normalization option (the total source strength is carried in the spectrum).

   NØRM=0, normalize to total source in particles.

   NØRM=1, normalize to total source in Mev.

   NØRM=2, multiply spectrum by constant.

10. ISP, input spectrum units option.

   ISP=0, differential number spectrum at energy points.

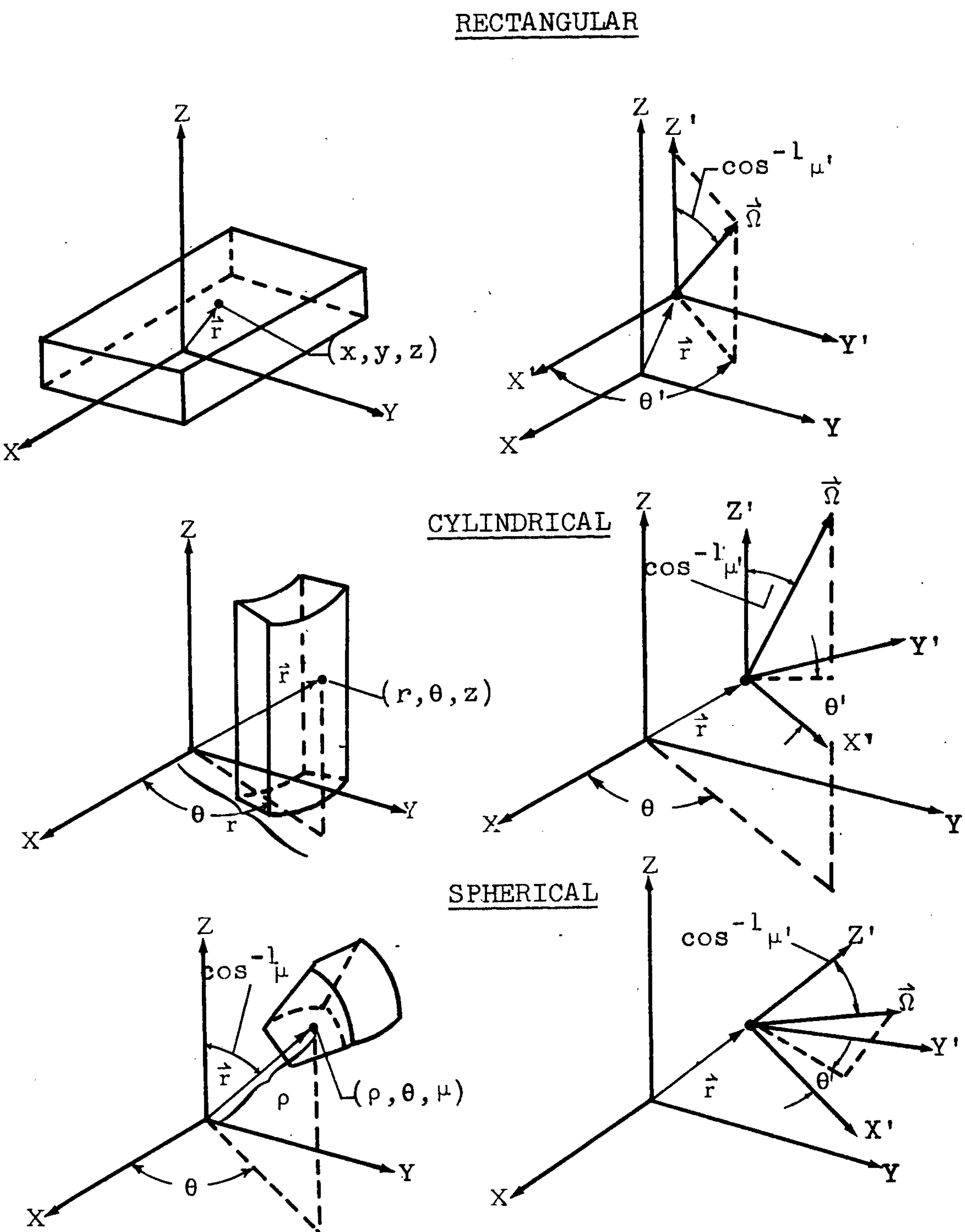



FIGURE SØU-1. SOURCE DISTRIBUTION VARIABLES

ISP=1, differential energy spectrum at energy points.

ISP=2, groupwise number spectrum (particles in group).

ISP=3, groupwise energy spectrum (energy in group).

11. JAL, spectrum format option.

JAL=0, alternating values of energy points and spectrum.

JAL=1, spectrum input only using energy previously input for this case.

JAL=2, energy point input (or calculation) followed by spectrum input on separate card (or calculation).

12. IDM, internal spectrum generation option.

IDM=0, no effect.

IDM=1, calculate energy points and neutron fission spectrum.

IDM=2, calculate energy points and black body photon spectrum.

IDM=3, calculate energy points and gamma ray fission spectrum.

13. TØT, source normalization constant, particles if NØRM=0, Mev if NØRM = 1, multiplying constant if NØRM=2.

14. XTR(1,I), x component of the translation of the source coordinate system origin from the geometry coordinate system origin (cm).

15. XTR(2,I), y component of the source translation (cm).

16. XTR(3,I), z component of the source translation (cm).

## SØU.3.EE(4(2E9.0)) Source Variable Distributions

A distribution function is input for each of the three spatial, J = 1, 2, and 3, and the two angular source variables, J = 4, and 5. The distributions are input in the order indicated on card SØU.2. A new card is started for each variable. Each card contains alternating values of the variable and the relative distribution at the variable, a total of NPC(J,I) pairs. The first and last values of each variable must be the end points of the range of that variable. The distribution data is normalized internally. To avoid numerical difficulties it is sometimes necessary to decrement the minimum value of a variable and increment the maximum value. In particular, for azimuthal distributions use 3.1416 for $\pi$ rather than 3.14159. A delta function distribution would have one input pair.

In describing multiple sources, several distribution functions may be identical. If this occurs for the Jth source variable simply place the index of the source having the same distribution for its Jth variable in NPC(J,I) (card SØU.2) and affix a minus sign in front of it. Then omit card SØU.3 for that variable.

## SØU.4.E(8E9.0) Source Spectrum

If ISP=0,1, the differential spectrum is tabulated at discrete energy points where

E(1) is the maximum spectrum energy (Mev).
⋮
E(MAX) is the minimum spectrum energy.

EN(K) is the differential spectrum corresponding to the Kth energy point E(K). The units of EN(K) are particles/Mev if ISP=0 or Mev/Mev if ISP=1.

JAL=0, the input on card SØU.4 consists of alternating values of energy and spectrum

E(1), EN(1), E(2), EN(2), ..., E(MAX), EN(MAX).

JAL=1, the energy points are already defined by prior input on card SØU.4 for this case (they will not be available from a previous case). The input consists of the relative spectrum at these points

EN(1), EN(2), ..., EN(MAX).

JAL=2, the energy points are defined first

E(1), E(2), ..., E(MAX).

and then followed by another card with the corresponding spectrum

EN(1), EN(2), ..., EN(MAX).

If ISP=2,3, a groupwise integrated spectrum is tabulated by group where

EBG(1) is the upper energy boundary of group 1.

⋮

EBG(MAX+1) is the lower energy boundary of the last spectrum group.

ENG(K) is the integral spectrum for the Kth group with units of particles in group K if ISP=2, or Mev in group K if ISP=3.

JAL=0, the input on card SØU.4 consists of alternating values of energy group boundaries and group spectrum

EBG(1), ENG(1), EBG(2), ENG(2), ..., EBG(MAX), ENG(MAX), EBG(MAX+1).

JAL=1, the energy group boundaries are already defined and the groupwise spectrum is supplied on card SØU.4.

ENG(1), ENG(2), ..., ENG(MAX).

JAL=2, the energy group boundaries are defined first

EBG(1), EBG(2), ..., EBG(MAX+1).

and then followed by another card with the groupwise spectrum

ENG(1), ENG(2), ..., ENG(MAX).

The description of multiple sources may involve several sources which have the same relative spectrum. If this source has the same relative spectrum as a previously described source, place the index of that prior source in MAX, affix a minus sign, and omit card SØU.4. If this option is used in conjunction with NØRM=2, remember that the input spectrum of the prior source has already been normalized.

If ISP=0, JAL=2, and IDM>0, the energy points and spectrum are computed internally. If, in this situation, IDM=2, or IDM=3, card SØU.4 is input with one piece of data, $\alpha$. The energy points are calculated by subdividing each cross section group so that the total number of energy points is less than or equal to the value of MAX on card SØU.2. The relative spectrum is then calculated at these points as:

IDM=1, $n(E) = \exp[-E/0.965] \sinh(2.29E)$

IDM=2, $n(E) = \dfrac{E^3}{\exp[E/\alpha]-1.0}$

IDM=3, $n(E) = \exp[-\alpha E]$

where $\alpha$ is the black body temperature if IDM=2.

NOTES:

The program assumes the source emits particles at a constant rate per second equal to the total source strength. This assumption is modified in time-dependent versions of the program by time profiles supplied via the PRØfile input section.

## PRØfiles of Source Time-Dependence

This section provides the input description of the time-dependence of the independent sources. The source time profiles are input as histogram distribution functions to simplify the folding of the profiles with the time-dependent fluxes which are calculated assuming a delta function source time-dependence. The distributions are normalized internally.

PRØ.0.H(24A3) Header Card

Contains PRØ in columns 1-3.

PRØ.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2, (0,>0)=(no,yes) profiles are input on cards PRØ.2.

3. NPFMAX, total number of time profiles.

4. NPTMAX, number of sections in the time profiles.

5.-24. Input but not used.

PRØ.2.EE(4(2E9.0)) Source Time Profiles

The source time profiles are input as histogram distribution functions. The distributions are normalized internally. A new card is started for each profile I = 1, 2, ..., NPFMAX. The data for each profile consists of alternating values of time (seconds) and the relative distribution (arbitrary units) for a total of NPTMAX time points -- each profile has the same number of points. Time points can coincide and can be repeated several times to provide the NPTMAX tabulation points. All profiles are assumed to start at time zero. The relative form of the data is:

$$t_1, h_1, t_2, h_2, \ldots, t_{NPTMAX}, h_{NPTMAX}$$

where

$$\begin{aligned} f(t) &= h_1 && 0<t<t_1 \\ &= h_2 && t_1<t<t_2 \\ &\vdots \end{aligned}$$

NOTES:

The program will generate a single Poisson time distribution for use in time-dependent problems where $p(t) = \tau^{N-1}\exp(-\tau)$, where $\tau = t/a$ and t is the real time in seconds. On data card PRØ.1

3. NPFMAX = 0
4. NPTMAX = 0
5. MAJØR, number of major time steps.
6. MINØR, number of small time steps at the start of each large time step.
7. N, exponent of $\tau$ in the Poisson distribution.

Then if MAJØR>0, omit PRØ.2 and supply

PRØ.3.E(8E9.0) Poisson Parameters

Omit this card if MAJØR = 0.

1. ALPHA, $\alpha$( seconds) in the Poisson distribution.
2. TMAX (seconds), major time step length.
3. TMIN (seconds), minor time step length.
4. TZER (seconds), start time for the first major time step.

## SURfaces

This section provides input for describing quadric surfaces which form the boundaries of material regions.

SUR.0.H(24A3) Header Card

Contains SUR in columns 1-3.

SUR.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2>0, number of surfaces being input on card SUR.2.

   IN2=0, no surfaces are being input.

3. NSMAX, total number of surfaces.

4. NAMAX, maximum number of coefficients in any surface equation. NAMAX=3 if all the surfaces are planes, NAMAX=6 if there are any regular curved surfaces, and NAMAX=9 if there are any rotated surfaces.

5.-24. Input but not used.

SUR.2.S(3I3,7E9.0) Surface Equations

Supply this card for IN2 surfaces.

1. I, index of the surface being described.

2. NTP(I), index (j) of the last nonzero coefficient if the surface is in the expanded form; calculated internally for all other surfaces.

3. NEX, form ($n_x$) of the surface as input. 0, already in expanded form. 1≤NEX≤13, special form as indicated in Figures SUR.1, SUR.2 and SUR.3 and Table SUR.1.

4. AA(1), first parameter defining the surface.

5. AA(2), second parameter defining the surface.

⋮

10. AA(7), seventh parameter defining the surface.

The requisite parameters are listed in the last column of Table SUR.1 and are input in the order shown. If the surface is in the expanded form and rotational terms are involved, supply these on the continuation card SUR.4 before supplying card SUR.3 for the next input surface.

<u>SUR.3.E(8E9.0)</u> Rotated Surface Equation Terms

Supply this card as required to finish the description of a surface, omit otherwise.

1. A(7,I), coefficient of xy in the general surface equation.

2. A(8,I), coefficient of yz in the general surface equation.

3. A(9,I), coefficient of zx in the general surface equation.

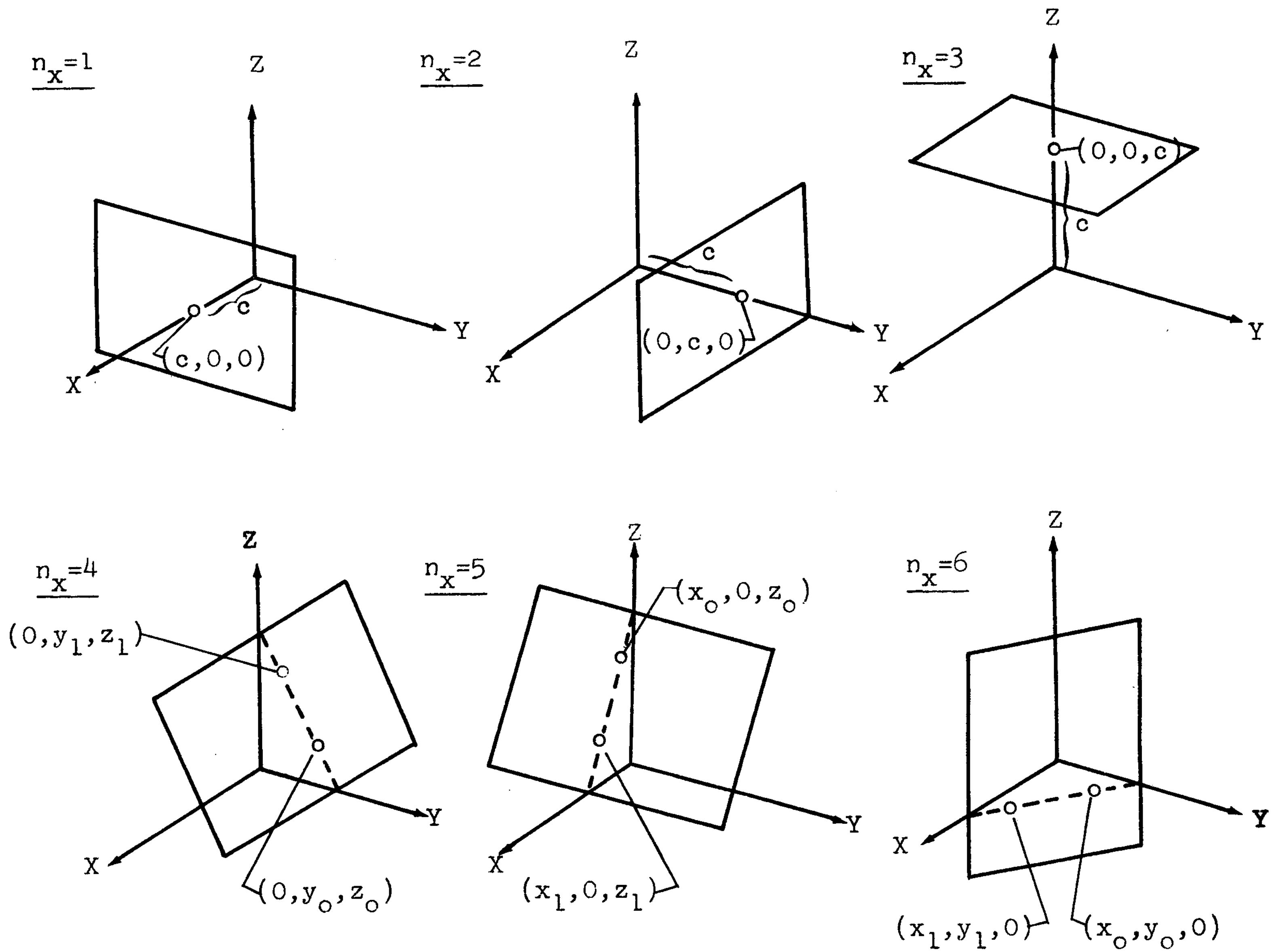



FIGURE SUR.1 PLANE SURFACES

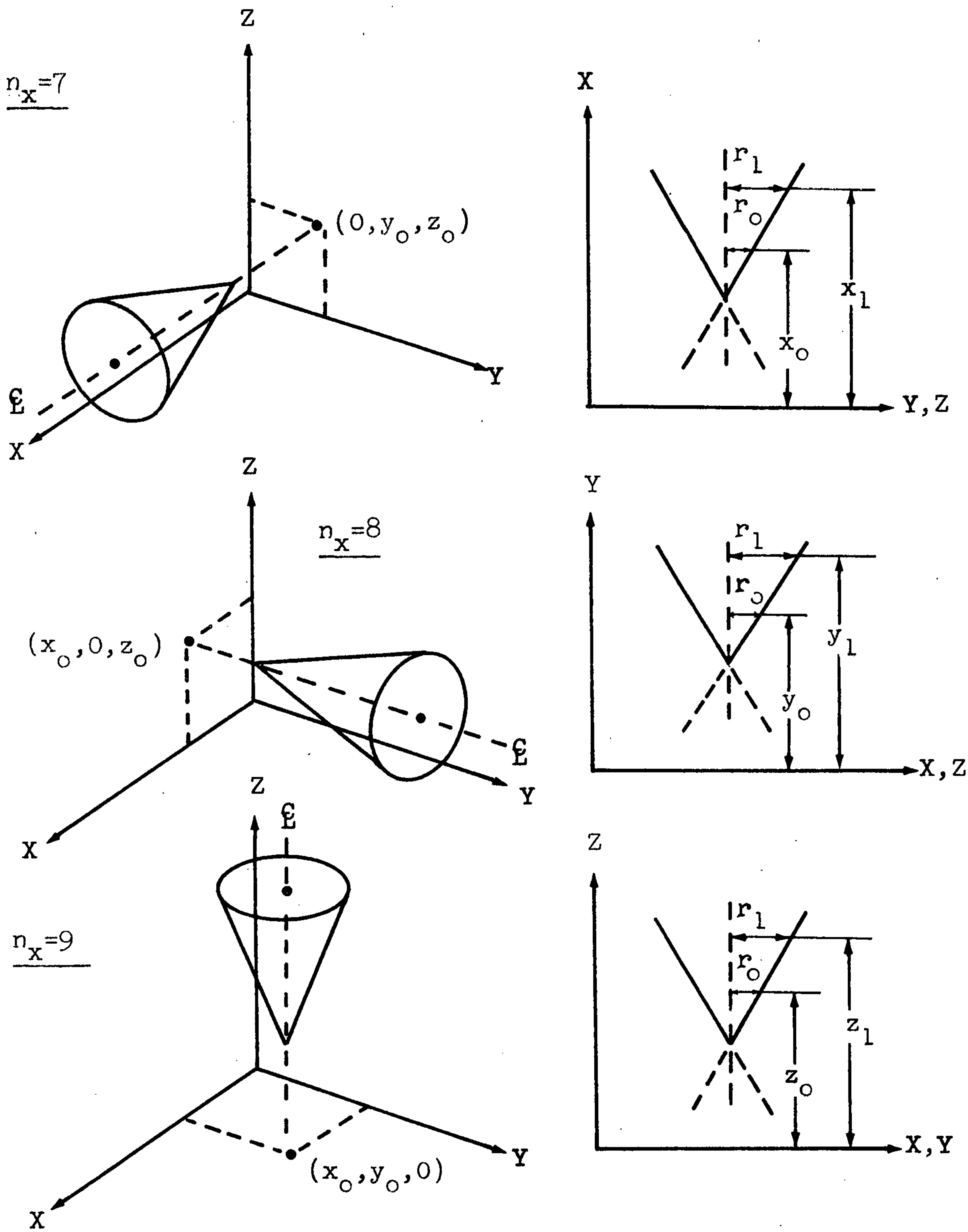



FIGURE SUR.2 CONICAL SURFACES

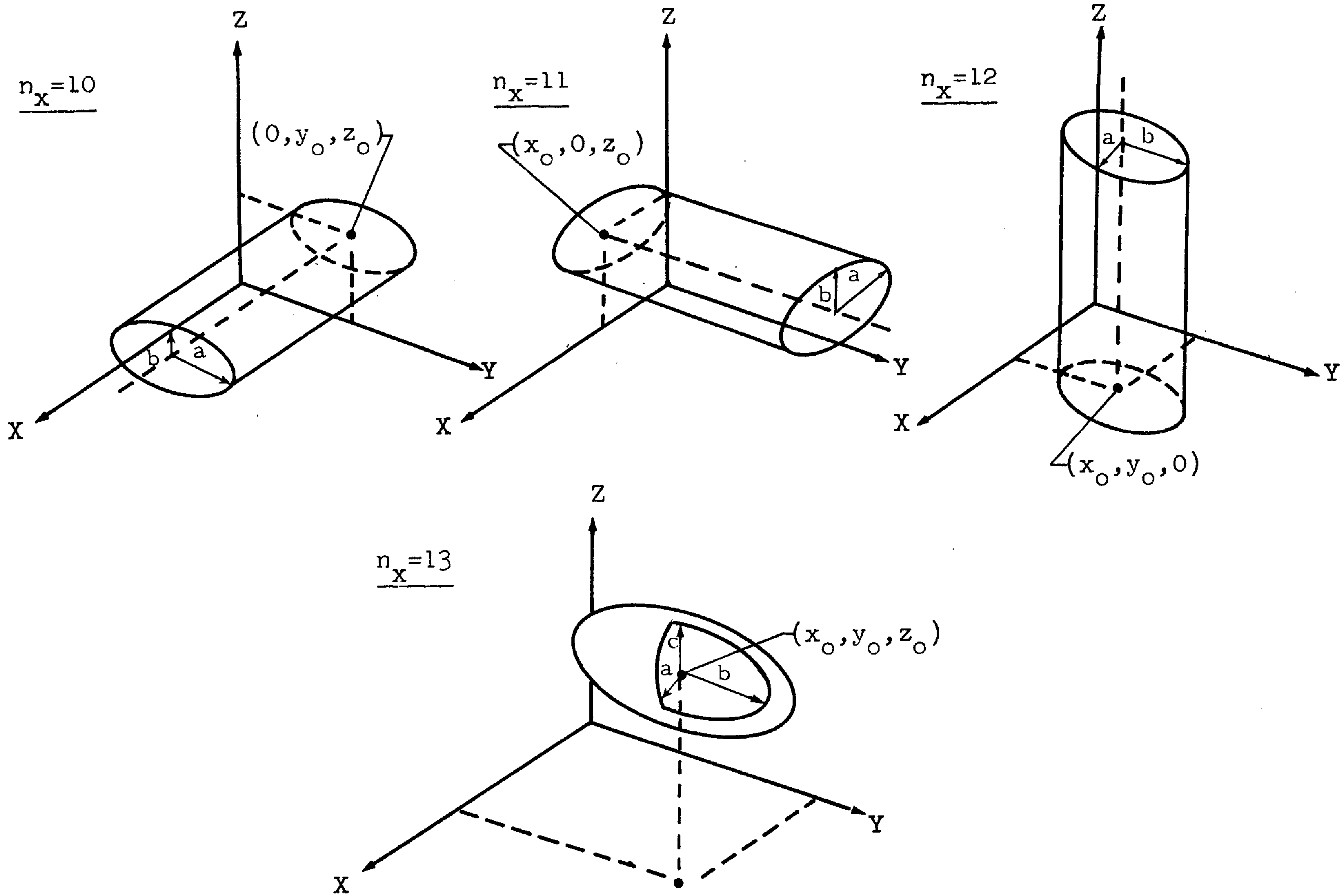



FIGURE SUR.3 ELLIPTICAL CYLINDERS AND ELLIPSOIDS

TABLE SUR.1

SPECIAL SURFACE EQUATIONS

| Surface type | Surface equation | Last term | Type $n_x$ | Input |
|---|---|---|---|---|
| Quadric | $a_0+a_1x+a_2y+a_3z+a_4x^2+a_5y^2+a_6z^2+a_7xy+a_8yz+a_9zx=0$ | j | 0 | $a_0,a_1,\ldots,a_j$ |
| Plane ⊥ x-axis | $x = c$ | 1 | 1 | c |
| Plane ⊥ y-axis | $y = c$ | 2 | 2 | c |
| Plane ⊥ z-axis | $z = c$ | 3 | 3 | c |
| Plane ∥ x-axis | $(y-y_0)/(z-z_0) = (y_1-y_0)/(z_1-z_0)$ | 3 | 4 | $y_0,z_0,y_1,z_1$ |
| Plane ∥ y-axis | $(x-x_0)/(z-z_0) = (x_1-x_0)/(z_1-z_0)$ | 3 | 5 | $x_0,z_0,x_1,z_1$ |
| Plane ∥ z-axis | $(x-x_0)/(y-y_0) = (x_1-x_0)/(y_1-y_0)$ | 2 | 6 | $x_0,y_0,x_1,y_1$ |
| Cone ∥ x-axis | $\left([(y-y_0)^2+(z-z_0)^2]^{\frac{1}{2}}-r_0\right)/(x-x_0)=(r_1-r_0)/(x_1-x_0)$ | 6 | 7 | $y_0,z_0,r_0,x_0,r_1,x_1$ |
| Cone ∥ y-axis | $\left([(x-x_0)^2+(z-z_0)^2]^{\frac{1}{2}}-r_0\right)/(y-y_0)=(r_1-r_0)/(y_1-y_0)$ | 6 | 8 | $x_0,z_0,r_0,y_0,r_1,y_1$ |
| Cone ∥ z-axis | $\left([(x-x_0)^2+(y-y_0)^2]^{\frac{1}{2}}-r_0\right)/(z-z_0)=(r_1-r_0)/(z_1-z_0)$ | 6 | 9 | $x_0,y_0,r_0,z_0,r_1,z_1$ |
| Cylinder ∥ x-axis | $(y-y_0)^2/a^2 + (z-z_0)^2/b^2 = 1$ | 6 | 10 | $y_0,a,z_0,b$ |
| Cylinder ∥ y-axis | $(x-x_0)^2/a^2 + (z-z_0)^2/b^2 = 1$ | 6 | 11 | $x_0,a,z_0,b$ |
| Cylinder ∥ z-axis | $(x-x_0)^2/a^2 + (y-y_0)^2/b^2 = 1$ | 5 | 12 | $x_0,a,y_0,b$ |
| Ellipsoid | $(x-x_0)^2/a^2 + (y-y_0)^2/b^2 + (z-z_0)^2/c^2 = 1$ | 6 | 13 | $x_0,a,y_0,b,z_0,c$ |

HELical Surfaces

This input section provides input for describing helical (or toroidal) surfaces. This section is actually an alternate to the SURface input section and represents an extension of that section. Since intersections are calculated by an iterative procedure, regions bounded by these surfaces should be defined so that the helix makes only a fraction of a turn for each region, e.g., $45^{\circ}$ turn per region.

HEL.O.H(24A3) Header Card

Has HEL in columns 1-3.

HEL.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2>0, number of helical and quadric surfaces being input.

   IN2=0, no surface input.

3. NSMAX, total number of surfaces of all types.

4. NAMAX, maximum number of coefficients in any surface equation, 3 if all surfaces are planes, 6 if there are any helical or quadratic surfaces, and 9 if there are any rotated or quadric surfaces.

5.-24. Input but not used.

HEL.2.S(3I3,7E9.0) Surface

1. I, index of surface.

2. NTP, not used.

3. NEX, 16 if the helix turns around the x axis.
17 if the helix turns around the y axis.
18 if the helix turns around the z axis.

4. AA(1), $x_1^o$
5. AA(2), $x_2^o$
6. AA(3), $x_3^o$

the origin of the helical surface where $x_1, x_2, x_3, =(x,y,z)$ if NEX = 16.
$=(y,z,x)$ if NEX = 17.
$=(z,x,y)$ if NEX = 18.

7. AA(4), L(cm) the period of the helix. If zero, a torus results.

8. AA(5), R(cm) the distance of the helix centerline from the axis about which the helix turns.

9. AA(6), a(cm) the radius of the circular cross section of the helix.

10. Input but not used.

where the helical surface equation is

$$\phi(r) = \left\{\left[(x_j-x_j^o)^2+(x_k-x_k^o)^2\right]^{\frac{1}{2}} -R\right\}^2$$

$$+ \frac{1}{1+(\frac{L}{2\pi R})^2}\left[\frac{L}{2\pi}\tan^{-1}\left(\frac{x_k-x_k^o}{x_j-x_j^o}\right)^2 -(x_i-x_i^o)\right]^2 -a^2$$

i = NEX-15
j = i+1 modulo 3
k = j+1 modulo 3

## REGions

This section describes the material regions comprising the geometry. Care must be taken in describing these regions to avoid ambiguities. After all data has been input for a problem, the program checks for some of these ambiguities. If any errors are detected, the following message is written:

NØGØ*THE PØINT IN REGIØN I IS ALSØ IN REGIØN J*NØGØ

This error is usually the result of defining regions which overlap.

REG.O.H(24A3) Header Card

Contains REG in columns 1-3.

REG.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2>0, number of regions being input.

   IN2=0, no regions are being input.

3. NRMAX, total number of regions.

4. NBMAX, maximum number of boundaries per region.

5.-24. Input but not used.

REG.2.R(12I3,4E9.0) Regions

Supply card REG.2 (and REG.3 as required) for IN2 regions.

1. I, index of the region being described.

2. ISV(I), index of the volume source superimposed over this region. 0, indicates none.

3. MTL(I) > 0, index of the composition for the region. MTL(I)=0, the region is void.

4. NS(1,I), first boundary surface index.

5. NS(2,I), second boundary surface index. 0 or blank if all boundaries have been listed.

⋮

NS(J,I), Jth boundary surface index. 0 or blank if all boundaries have been listed.

⋮

12. NS(9,I), >0, ninth boundary surface index if the region has exactly nine boundaries. 0, or blank if all boundaries have been listed (less than nine boundaries). -1, if the region has more than nine boundaries; the ninth and remaining boundaries are listed on card REG.4.

13. RHØ(I), density scale factor for the region.

14. XR(1,I), x-coordinate of any point in the region (cm).

15. XR(2,I), y-coordinate of the point in the region (cm).

16. XR(3,I), z-coordinate of the point in the region (cm).

REG.3.I(24I3) Additional Region Boundaries

Supply this card(s) for each region having more than nine boundaries, immediately behind card REG.2 for the region; omit otherwise. This card contains data up to and including the maximum number of boundaries (more than 1 physical card if NBMAX>32).

1. NS(9,I), ninth boundary surface index.

2. NS(10,I), tenth boundary surface index.

3. NS(11,I), eleventh boundary surface index. 0 or blank if all boundaries are lised.

   ⋮

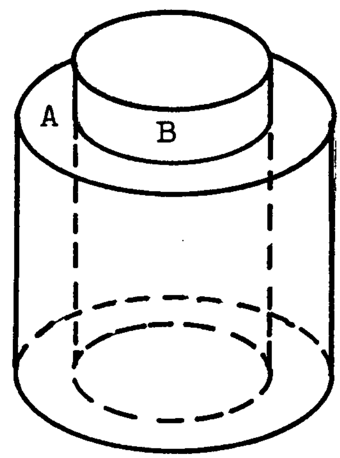
   NS(NBMAX,1), last boundary surface index. 0 or blank if all boundaries are listed.

NOTES:

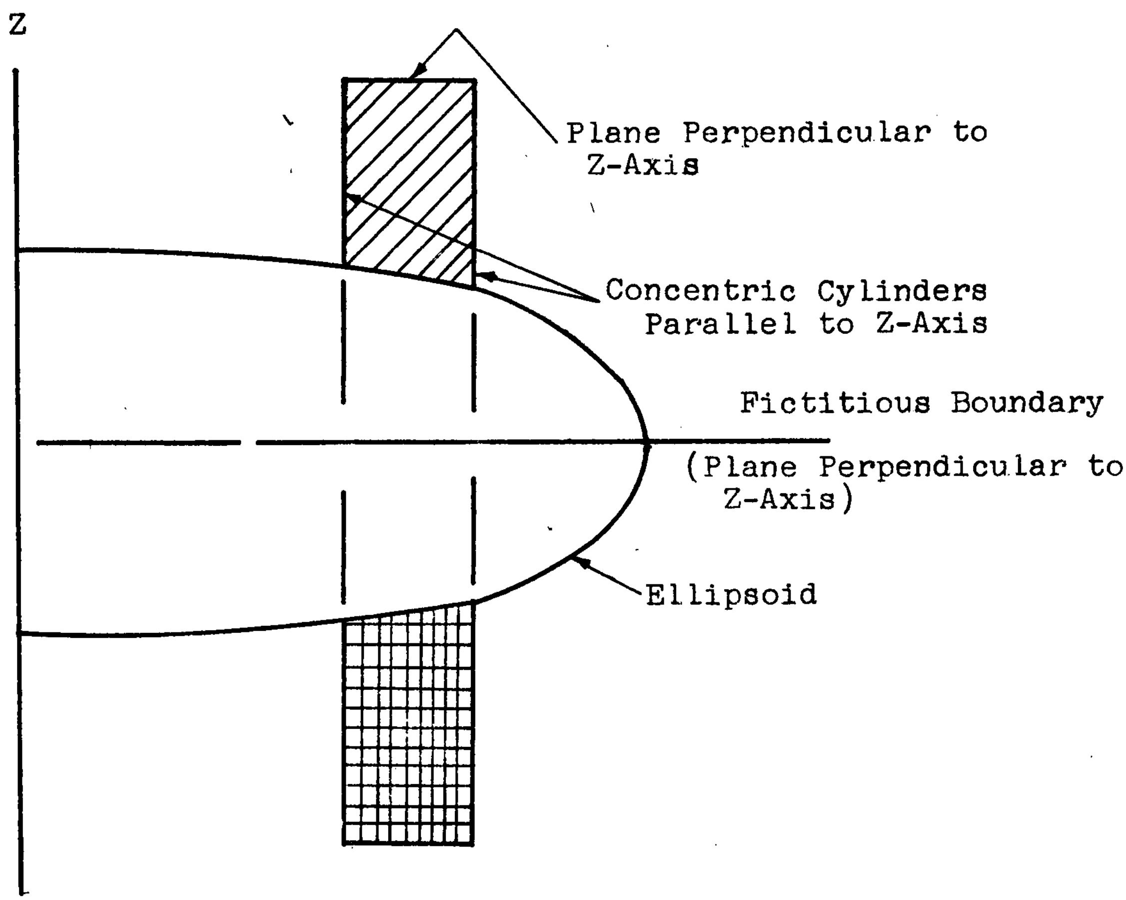
Restrictions must be imposed on possible region shapes to ensure that all points in a region are always on the same side of each region boundary. For example, the single region indicated in Figure REG.1a is unacceptable since there are points in the region which are both inside and outside boundaries A and B. The obvious solution is to use two regions to describe such geometric shapes.

It is sometimes necessary to introduce fictitious boundaries. Figure REG.1b shows a typical situation requiring these boundaries. Examination of the hatched and cross hatched regions reveals that they form two sections of a single region since ambiguity indices of the boundaries have the same values for both sections. This condition can cause trouble if only one section of the region is desired, even if other regions occupy the second section. The specification of the fictitious boundary eliminates the problem without otherwise affecting the geometric calculations. These fictitious boundaries must be included in the initial surface descriptions.

The final page of printout of each problem is sometimes helpful in correcting geometric errors. It contains a listing, by region, of the bounding surfaces (with the sign of ambiguity index affixed) and the region entered the last time a ray crossed these boundaries (most probable-next-regions). Most-probable-next-region indices less than zero indicate that there was no next region and should correspond to the outer boundaries of the problem. A zero indicates the boundary was never crossed.




a. Ambiguous Region Boundaries




b. Disjoint Regions

FIGURE REG.1 PROBLEMS IN REGION DESCRIPTIONS

CYLindrical Geometry

This input section permits a simplified input of a symmetric cylindrical geometry.

CYL.0.H(24A3) Header Card

Contains CYL in columns 1-3.

CYL.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-6 from this card.

2. IN2, (0,>0)=(no,yes) cards CYL.2 and CYL.3 are being input.

3. NRRMAX, number of radial subdivisions.

4. NZZMAX, number of axial subdivisions.

5. ISV, index of the volume source superimposed over the regions. ISV=0 denotes none.

6. MTL, index of the material contained in the regions. The relative density is set at 1.0 unless MTL=0 (void).

7.-24. Input but not used.

CYL.2.E(8E9.0) Radial Boundaries

This card contains the radial boundaries (cm) in increasing order. A radius of 0.0 must be the first entry on this card so that a total of NRRMAX+1 entries are required.

CYL.3.E(8E9.0) Axial Boundaries

This card contains the boundaries (cm) of the axial subdivisions, a total of NZZMAX+1 entries.

NOTES:

The program responds to the above input by generating NRRMAX cylindrical surfaces, concentric with the z-axis and numbered 1 through NRRMAX, and NZZMAX+1 plane surfaces, perpendicular to the z-axis and numbered NRRMAX+1 through NRRMAX+NZZMAX+1. The program then generates NRRMAX*NZZMAX regions numbered outward radially for the first axial zone, then the second axial zone, etc.

## SPHerical Geometry

This input section provides for input description of concentric spherical regions.

### SPH.0.H(24A3) Header Card

Contains SPH in columns 1-3.

### SPH.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3.-5. from this card.

2. IN2, (0,>0)=(no,yes) the spherical region boundaries are being input on card SPH.2.

3. NSHELL, number of spherical regions to be described.

4. ISV, index of the volume source, if any, superimposed over the regions, 0 denotes none.

5. MTL, index of the material located in the regions.

6.-24. Input but not used.

### SPH.2.E(8E9.0) Sphere Boundaries

This card contains the outer boundaries (cm) of the spherical zones in order of increasing radius. The program generates NSHELL spherical surfaces numbered 1 through NSHELL. It then generates NSHELL regions also numbered 1 through NSHELL. Each region is given a density of 1.0 which will be replaced by a variable air density through the use of the AIR input section. Additional surfaces and regions can be added to this basic geometry using the SUR and REG input sections.

AIR Density

This section provides for input of an exponential atmosphere to be used in conjunction with the SPH input section for air transport problems. The air density is exponentially interpolated to obtain the density at the boundaries of the spherical zones and is then linearly interpolated for particle transport.

AIR.0.H(24A3) Header Card

Must have AIR in columns 1-3.

AIR.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2<0, use the built-in air density variation (1959 ARDC) with altitude. The air composition given in the MATerials section should have a density of 1.0.

   IN2=0, previously defined air density variation holds.

   IN2>0, air density profile is input.

3. NAIRPT, number of points in the input tabulation of air density with altitude.

4.-24. Input but not used.

AIR.2.EE(4(2E9.0)) Air Density

Supply this card if IN2>0 with NAIRPT pairs of data consisting of radius (cm) from the earth's center and the air density relative to the air composition given in the MATerials section.

## CHEck Ray Trace

This input section is utilized in the checkout of complex geometries. It provides information used by the program to ensure that ray traces terminate at the outer boundaries of the geometry rather than at the boundaries of undefined volumes within the geometry.

CHE.0.H(24A3) Header Card

Has CHE in columns 1-3.

CHE.1.I(24I3) Option Card

1. IN1, (0, >0)=(no,yes) interpret data words 3-5 from this card.

2. IN2, (0, >0)=(no,yes) card CHE.2 is being input.

3. NCHECK, total number of region-surface combinations forming the outer boundary of the geometry.

4. LCHECK=0, no effect.
   LCHECK>0, terminate the problem if this number of ray traces doesn't terminate at the region-surface combinations tabulated on card CHE.2.

5.-24. Input but not used.

CHE.2II(12(2I3)) Outer Boundaries

The outer boundary of the geometry is defined by listing NCHECK pairs of indices of the region and surface forming the outer boundary.

NOTES:

If, during a ray trace, a region-surface combination at the apparent outer boundary of the geometry does not match with one of the listed pairs, the following message is printed

***RAY TERMINATES AT SURFACE I WHERE IT BØUNDS REGIØN J***

If LCHECK>0, the following information is also printed: the values of $\underline{x}$ (the ray origin) including the square and cross products, the values of $\underline{c}$ (the ray direction cosine) including the direct and cross products with $\underline{x}$, the square and cross products of $\underline{c}$, the quantities used in calculating the intersection of the ray with the surfaces, and the region, surface crossed, and partial path lengths along the ray.
If LCHECK>0 and the number of errors equals LCHECK, the problem is terminated with the following message:

***TERMINATING RUN DUE TØ RAY TRACE ERRØRS***

The termination is not immediate. Internal counters are set so that the problem will hopefully make it to the output routines to give a somewhat normal print of results with possibly incorrect labeling on the detector index and the number of histories run.

CØRrelated Calculations

This section provides for the simultaneous solution of multiple problems which have small differences in either the source description or the material composition of regions.

CØR.O.H(24A3) Header Card

Has CØR in columns 1-3.

CØR.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3.-5. from this card.

2. IN2>0, number of correlated sources and/or regions being input on card CØR.2.

3. NCCMAX, number of correlated problems.

4. NCSMAX, number of sources which are different from the base problem.

5. NCRMAX, number of regions which differ in composition from the base problem.

6.-24. Input but not used.

CØR.3.I(24I3) Correlation Sets

Supply IN2 sets of this card.

1. I>0, index of the count on correlated sources.

   I<0, index of the count on correlated regions.

2. ICS(I), index of the base case source if I>0.
   or
   ICR(-I), index of the base case region if I<0.

3. JCS(1,I) if I>0.

   JCR(1,-I) if I<0.

   ⋮

   JCS(J,I), index of the source to be used in place of source ICS(I) in the Jth correlated calculation, if I>0.

   JCR(J,-I), index of the material in region ICR(-I) to be used in the Jth correlated calculation if I<0.

   ⋮

   JCS(NCCMAX,I) if I>0.

   JCR(NCCMAX,-I) if I<0.

DETectors

This section provides for the description of point, surface, and/or volume detectors. The transport calculation yields, as basic output, the differential number flux at each of these detectors. Other optional outputs can be invoked through other input sections.

DET.0.H(24A3) Header Card

Columns 1-3 contain DET.

DET.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2>0, number of detectors being described via card DET.2.
   IN2=0, no detectors are being input.

3. NDMAX, total number of detectors.

4.-24. Input but not used.

DET.2.S(3I3,7E9.0) Detectors

1. I, index of the detector being described.

2. IDR(I)=0, for point detector.
   IDR(I)>0, region index for a surface or volume detector.

3. IDS(I)=0, for a point detector.
   IDS(I)=0, for a volume detector.
   IDS(I)>0, surface index for a surface detector (the detector is that part of surface IDS(I) which bounds region IDR(I)).

4. VØL(I), scale factor for point detector (i.e., multiplies output by this number); region volume ($cm^3$) for volume detector; detector area ($cm^2$) for surface detector (1.0 yields surface-or volume-integrated fluxes).

5. CDT(1,I), relative direction cosine with respect to the x-axis of the unit direction vector used in obtaining angular fluxes, e.g., Legendre moments (not used for surface detectors, angular moments are obtained with respect to the surface normal).

6. CDT(2,I), relative direction cosine with respect to the y-axis.

7. CDT(3,I), relative direction cosine with respect to the z-axis; the 3 direction cosines are normalized by the program.

8. XDT(1,I), x coordinate if a point detector (cm).

9. XDT(2,I), y coordinate if a point detector (cm).

10. XDT(3,I), z coordinate if a point detector (cm).

NOTES:

After processing all the input data, the program then generates particle histories and finally prints the fluxes for each detector. The output for each detector starts a new printout page and is headed by the line

***FLUXES FØR DETECTØR I AFTER J PACKETS***

where I is the detector index and J is the number of histories which were processed. Immediately below this line are column headings followed by a printout line for each energy group.

The appropriately titled columns consist of groupwise values for the coefficient of variation (fractional standard deviation) of the number flux by group, the average energy for each group (Mev), the differential number flux for the group (particles/$cm^2$/sec/Mev), the differential energy flux for the group (Mev/$cm^2$/sec/Mev), the integrated number flux in each group (particles/$cm^2$/sec), the integrated number flux down through the current group (particles/$cm^2$/sec), and finally the integrated energy flux down through the current group (Mev/$cm^2$/sec).

A second set of output is then printed for the detector and is headed by the line:

***NUMBER FLUX RESPØNSES FØR DETECTØR I AFTER J PACKETS***

The first two columns NUMBER FLUX and ENERGY FLUX, in this set of output are always obtained and are essentially repeats of the group-integrated fluxes obtained in the first output set. Other columns are also printed, with appropriate title, of any response functions input using the RESponse input section. The lines of output for each energy group are the integrated response for that group. After all the group lines are printed, four additional lines are printed, TØTALS consisting of the total response for all energy groups, MIN ERRØR the coefficient of variation in the total response if the response for each energy is independent, MØD ERRØR the coefficient of variation using the usual equation for the variance, and MAX ERRØR the coefficient of variation if the responses for the groups are strictly dependent.

A final set of output is then printed for each detector and is labeled

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

and gives various breakdowns on the differential number fluxes by energy group. The first column in this set of output is always obtained. It is labeled ITERANT K and consists of the average flux for the histories run between the (K-1)th and Kth print cycles for the problem. Other columns are added depending on requested output options such as flux by order-of-scatter (ØRD input section), etc. After the group lines are printed for this output set, the various response functions are then evaluated by integrating over each column, and are then printed with appropriate line titles.

The printout would continue in this manner for each detector. If the problem involved multiple printouts during the calculation, the printout for the next group of histories would appear farther downstream. The order of printing is reversed when only point detectors are run. The multiple prints for detector one are followed by the multiple prints for detector two, etc.

The input of point detector coordinates for air transport problems can be accommodated in terms of more convenient parameters. The detector index is flagged with a minus sign. Then the following interpretations are made:

XDT(1,I) = the distance of the detector from the earths center (cm) -- earth radius = $6.356766\text{x}10^8$ cm.

XDT(2,I) = the look angle (degrees) of the detector measured from the vertical.

XDT(3,I) = the azimuthal angle (degrees) of the detector measured from the x-axis.

FLUx Groups

This section provides for the definition of flux groups which are different from the cross section groups.

FLU.0.H(24A3) Header Card

Columns 1-3 contain FLU.

FLU.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) flux group boundaries are being input on card FLU.2.

3. NGMAX, number of flux groups.

4.-24. Input but not used.

FLU.2.E(8E9.0) Group Boundaries

Supply the flux group boundaries in order of decreasing energy (Mev), ELF(1), ELF(2), ..., ELF(NGMAX+1).

RESponse Functions

This input section provides the data for response functions used to weight the basic number fluxes output for each detector. The program has two response functions built-in, number and energy flux, to provide for the calculation of the coefficients of variations on their totals.

RES.0.H(24A3) Header Card

Must contain RES in columns 1-3.

RES.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2>0, number of response functions being input on card RES.2 and RES.3.

   IN2=0, no responses are being input.

3. NFMAX, total number of response functions besides those built-in.

4.-24. Input but not used.

RES.2.A(24A3) Response Titles

This card contains a title for each response function being input. Each title is allowed 12 columns, i.e., the first title is in columns 1-12, the second in columns 13-24, etc.

RES.3.S(3I3,7E9.0) Response Function

Supply this card (and RES.4 as required) in sets, one set for each of the IN2 responses being input.

1. I, index of the response function being input.

2. NFT=0 if this is a number flux response, i.e., response per particle/cm$^2$• sec.

   NFT=1 if this is an energy flux response, i.e., response per Mev/cm$^2$• sec.

3. NTL>0, this is an energy absorption response function for material NTL, omit data words 5-10 on this card.

   NTL=0, this is an input-described response function.

4. SCA, scale factor to convert the response function from its present units to more desirable units. Do not input 0.0. The units of energy absorption responses, NTL>0, are Mev/cm per particle/cm$^2$• sec, i.e., Mev/cm$^3$• sec.

5. RSP(1,I), response function at the upper boundary of flux group 1.

   •
   •
   •

10. RSP(6,I), response function at the lower boundary of flux group 6.

<u>RES.4.E(8E9.0)</u> Response Continuation Card

Omit this card if NTL>0 or if there are less than six flux groups. This card contains the response function at the lower energy boundaries of flux groups six through NGMAX.

BIRth Regions

This input section provides for the optional output of obtaining a breakdown on fluxes according to the geometric region in which the radiation was emitted from an independent or secondary source. The resulting output for each detector appears under the general heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I is the detector index and J is the number of histories run. The specific columns are headed SØURCE K where K denotes the region index. The entries in each column are the differential number flux (particles/cm$^2$/Mev/sec) for each flux group followed by the contribution to each response function.

BIR.0.H(24A3) Header Card

BIR is entered in column 1-3.

BIR.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) card BIR.2 is being input.

3. NVMØD, number of regions for which this output is required.

4.-24. Input but not used.

BIR.2.I(24I3) Birth Region Indices

List the indices of the regions for which this output is required, NVMØD entries.

ØRDer of Scatter

This input section provides for a breakdown of fluxes at each detector according to the number of collisions which the particles have before reaching the detector. The resulting output for each detector appears under the general heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I is the detector index and J is the number of histories run.

The specific columns are headed SCATTER K where K denotes the number of collisions. The entries in the column are the differential number flux (particles/$cm^2$/Mev/sec) for each flux group followed by the contribution to each response function.

ØRD.0.H(24A3) Header Card

Contains ØRD in columns 1-3.

ØRD.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NCMAX, maximum order of scatter up to which the breakdown is obtained, i.e., NCMAX columns of output are produced containing the uncollided flux, single scattered flux,..., (NCMAX-1)th scattered flux.

4.-24. Input but not used.

## SCAttering Regions

This input section will yield a breakdown on the differential number flux by the region(s) in which the particles scatter. The resulting output for each detector will appear under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I and J denote the detector index and number of histories respectively. The columns containing this output will have headings of the form REGIØN K where K is a region index. The output in each column consists of the differential number flux (particles/cm$^2$/sec/Mev) by energy group followed by the contribution to each of the response functions.

SCA.0.H(24A3) Header Card

Must have SCA in columns 1-3.

SCA.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) card SCA.2 is being input.

3. NSRMAX, number of regions for which the breakdown is required.

4.-24. Input but not used.

SCA.2.I(24I3) Region Indices

Supply this card with the indices of the scattering regions, NSRMAX entries.

## BØUndary Crossings

This input section provides a breakdown of the particle fluxes according to region boundaries crossed by the particle in reaching the detectors. The resulting output for each detector appears under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I and J denote the detector index and histories respectively. The columns containing this output have headings of the form CRØSSING K where K is the index of the crossing. The output in each column consists of the differential number flux (particles/$cm^2$•sec•Mev) by energy group followed by the contribution to each of the response functions.

BØU.0.H(24A3) Header Card

Contains BØU in columns 1-3.

BØU.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) card BØU.2 is being input.

3. NBCMAX, number of different boundaries for which the breakdown is required.

4.-24. Input but not used.

BØU.2.II(12(2I3)) Boundary Definitions

This card contains NBCMAX pairs of numbers. The first number in each pair is the index of a region. The second number of the pair is the index of a surface bounding that region.

The output is generated for particles which cross the surface (in either direction) only where it bounds the region.

ANGular Fluxes

This input section provides for the calculation of angular fluxes. The output for each detector consists of azimuthally-averaged Legendre moments of the angular flux. The output appears under the general heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I and J denote the detector index and number of histories, respectively. The columns containing the output have headings of the form ANGULAR K where K denotes the Legendre moment index. The K=-1 moment is the backward hemisphere component of the $P_1$ moment and the K=1 moment is the forward hemisphere component of the $P_1$ moment. For K>1, the column contains the $P_K$ Legendre moment. These moments are generated with respect to the fixed directions specified in the DETector input section except for surface detectors. For surface detectors, the moments are with respect to the surface normal.

The output in each column is the Legendre moment of the differential number flux (particles/$cm^2$•sec•Mev) by energy group followed by moments of the response functions.

ANG.0.H(24A3) Header Card

Contains ANG in columns 1-3.

ANG.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2, not used.

3. NLMAX, number of Legendre moments requested. Output will include moments to order NLMAX-1.

4. NAFMAX, number of discrete directions at which the Legendre series is to be evaluated.

5.-24. Input but not used.

NOTES:

If NAFMAX>0, additional output is generated on the last print cycle for each detector, This output appears after the regular outputs and has the general heading

***ANGULAR FLUXES FØR DETECTØR I AFTER J PACKETS***

where I and J are the detector index and number of histories, respectively. Individual columns have the headings CØS=±X.XXXX where ±X.XXXX is the cosine of the polar angle with respect to the direction associated with the detector. NAFMAX polar angle cosines are generated by the program, equally spaced between -1.0 and +1.0 including these points. The output in each column is the azimuthally-averaged differential angular number flux (particles/$cm^2$•sec•Mev•steradian) by energy group followed by the contributions to the angular responses (response/steradian).

## SØLid Angle Fluxes

This input section will provide angular fluxes for each detector which are averaged over specified solid angle elements. The output for each detector appears under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I and J are the detector index and number of histories, respectively. The individual columns are headed by CØNE K where K is the index of a solid angle element. The output in each column consists of the average differential angular number flux (particles/$cm^2$• sec•Mev•steradian) by energy group followed by the contribution to the response functions (response/steradian).

SØL.0.H(24A3) Header Card

Contains SØL in columns 1-3.

SØL.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3. from this card.

2. IN2, (0,>0)=(no,yes) card SØL.2 is being input.

3. NABMAX, number of solid angle elements.

4.-24. Input but not used.

SØL.2.E(8E9.0) Solid Angle Boundaries

This card contains four pieces of data for each solid angle element--two elements per card. The data for each element in the order of input, are the lower and upper limits on the azimuthal angle ($-\pi \leq \theta \leq \pi$) and the lower and upper limits on the cosine of the polar angle. The azimuthal and polar angles are measured in a rotated coordinate system whose z axis is along the direction associated with each detector.

TRAnslation Time

This input section provides for the translation of the time scale at each detector to make the physical numbers more manageable. The time input in this section for each detector is subtracted from the particle flight time before any time-dependent tallies are made for the detector.

TRA.0.H(24A3) Header Card

Has TRA in columns 1-3.

TRA.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (≤0,>0)=(no,yes) card TRA.2 is being input.

   IN2 = -1, the minimum time is computed internally as the time required to travel from the center of the closest source to the detector for particles in the most energetic energy group.

   IN2 = -2, the minimum time is computed internally as the required time required for light to travel from the closest source to each detector.

TRA.2.E(8E9.0) Minimum Flight Time

This card contains the minimum time (sec) required for particles to travel from a source to each detector in the order of detector index, one entry for each detector described via the DETector input section. For secondary particle transport problems, this time includes the flight time of the primary particles.

## MØMents of Temporal Fluxes

This input section provides for the calculation of temporal moments of the particle fluxes. The output for each detector appears under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I and J denote the detector index and number of histories, respectively. The columns containing the output have the heading TEMPØRAL K where K is the index of the moment. The output in each column consists of the Kth moment of the differential number flux, i.e., $\int \phi(t) t^K dt$ (particles/cm$^2$·sec$^{1-K}$·Mev), by energy group followed by the moments of the response function.

MØM.0.H(24A3) Header Card

This card has MØM in columns 1-3.

MØM.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2, (0,>0)=(no,yes) card MØM.2 is being input.

3. NTMAX, number of temporal moments.

4. NTAMAX, number of times at which the time dependence is to be reconstructed from the moments.

5.-24. Input but not used.

MØM.2.E(8E9.0) Evaluation Times

This card contains NTAMAX times (sec) in ascending order at which the time dependence will be reconstructed from the temporal moments.

NOTES:

If NTAMAX>0, additional output is generated for each detector. This output is generated after all other output for the detector and is headed by the line

***TEMPØRAL FLUXES FØR DETECTØR I AFTER J PACKETS FØR TIME PRØFILE K***

where I denotes the detector index, J the number of histories, and K the source time profile. K=0 corresponds to a delta function source profile.

The columns under this heading are labeled by the times at which the time dependence is evaluated. The entries in the columns then consist of the differential number flux (particle/ $cm^2$/sec/Mev) by energy group followed by the time-dependent responses.

## TIMe Interval Fluxes

This input section provides for the calculation of time interval averaged temporal fluxes. The output for each detector appears under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

where I is the detector index and J is the number of histories. The columns containing the output have the more specific heading TIME BIN K where K is the index of the time interval. The output in each column consists of the differential number flux (particles/$cm^2$·sec·Mev) by energy group averaged over the Kth time interval followed by the contribution to each response function and calculated as though all particles started at time t=0.

TIM.0.H(24A3) Header Card

This card must contain TIM in columns 1-3.

TIM.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) data card TIM.2 is being input.

3. NTBMAX, number of time intervals.

4.-24. Input but not used.

TIM.2.E(8E9.0) Time Interval Boundaries

This card contains the maximum time (sec) boundaries, in ascending order, for the time intervals, NTBMAX entries.

## GRØup Edit on Fluxes

This input section provides for an edit of fluxes at each detector by the energy group in which particles were emitted from the source.

GRØ.0.H(24A3) Header Card

Has GRØ in columns 1-3.

GRØ.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NGRØUP, number of groups for which the edit is required. These will be the NGRØUP highest energy groups.

4.-24. Input but not used.

NOTES:

The output generated for each detector appears under the heading

***NUMBER FLUX MØMENTS FØR DETECTØR I AFTER J PACKETS***

The output appears under the columns headed GRØUP K where K is the index of the source group, K=1,2,...,NGRØUP. The entries in the column are the differential number flux (particles/cm$^2$·sec·Mev) by energy group followed by the integrated response for each response function.

## NØRmal Derivatives

The section specifies the locations at which partial derivatives of the fluxes with respect to normal thicknesses of a region dimension are to be calculated.

NØR.0.H(24A3) Header Card

Has NØR in columns 1-3.

NØR.1.I(24I3) Option Card

1. IN1, (0, > 0) interpret data words 3 and 4 from this card.

2. IN2, (0, > 0) cards NØR.2 and NØR.3 are being input.

3. NØRMLD, number of locations at which normal derivatives are requested.

4. NØRCØM, number of subsegments of the flux where each subsegment involves different combinations of the NØRMLD possible locations which particles can cross in arriving at a detector, i.e., one subsegment may consist of fluxes due to particles which cross all NØRMLD locations, another subsegment may consist of fluxes due to particles which do not cross any of the NØRMLD locations, etc.

5.-24. Input but not used.

NØR.2.II(12(2I3)) Partial Derivative Locations

This card contains NØRMLD pairs of numbers giving the indices of the region and corresponding surface at which normal derivatives will be calculated.

NØR.3.I(24I3) Normal Derivative Components Definition

This card defines the dependence of the NØRCØM components of the fluxes. NØRCØM cards are entered in sets for each detector in the problem, a total of NDMAX sets. Each of the cards in a set contains NØRMLD numbers giving the indices of the normal derivatives which each of the flux components sees. If one component involves all of the normal derivatives, the data card would contain the integers 1 through NØRMLD. If another component involves only the Ith normal derivative, the first piece of data on the card would be I followed by NØRMLD-1 zeros, etc..

NOTES:

The output resulting from this input appears after the optional flux edits and is headed by the line.

***SHIELD DERIVATIVES FØR DETECTØR I AFTER J PACKETS***

The columns under this heading consist of the energy group index, the total differential flux (particles/$cm^2 \cdot$ sec$\cdot$Mev)-- labeled SEGMENT I where I is the index on the NØRCØM components, and the derivatives of the flux (particles/$cm^2 \cdot$ sec$\cdot$Mev)/cm -- labeled NØRMAL J where J is the index on the NØRMLD possible derivatives. After the results are printed for each flux group, the response function weighted values are printed with the response title on the left side of the printout.

MINimum Weight Shield

This input section will cause the program to calculate a minimum weight shield configuration using the derivatives resulting from the NØR input section.

MIN.O.H(24A3) Header Card

Has MIN in columns 1-3.

MIN.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-6 from this card.

2. IN2, (0,>0)=(no,yes) cards MIN.2 and IN2 cards MIN.3 are being input.

3. IPRESP, index of the response function to be used in defining the dose rate for the primary radiation type if this is a primary only problem. If this is a primary plus secondary problem, IPRESP is the response function index for the secondary problem.

4. ISRESP, index of the response function for the primary particle if this is a primary and secondary problem.

5. ITPRIN, number of iterations in the shield optimization between prints.

6. ITERMX, maximum number of iterations in the shield optimization.

7.-24. Input but not used.

MIN.2.E(8E9.0) Dose Rate Constraints

This card contains the dose rate constraint for each detector, NDMAX entries.

MIN.3.S(3I3,7E9.0) Shield Definitions

Input card MIN.3 IN2 times.

1. I, index of the shield based on its order of definition in the NØR input section.

2. IGS(I), (0,1,2)=(rectangular,cylindrical,spherical), shield geometry type.

3. IDF(I), index of the next shield lying at a larger radius than this shield. Not significant if all shields have rectangular geometry. A zero would be input for the outer shield of a series of concentric cylindrical or spherical shields.

4. TIN(I), initial thickness (cm) of this shield.

5. TMN(I), minimum thickness (cm) of this shield.

6. TMX(I), maximum thickness (cm) of this shield.

7. RIN(I), inner radius (cm) if this is the innermost shield of a set.

8. RSH(I), density (gm/cm$^3$) of the shield material times any non-built-in geometric factors (area for rectangular, height for cylindrical).

9. DWN(I), maximum weight increment (gm) per iteration.

10. Input but not used.

NOTES:

The output generated from this input appears after the derivative information is printed. The output is preceded by the line

***SHIELD ØPTIMIZATIØN FØR DETECTØR I***

Each print cycle is preceded by the lines

***ITERATIØN***WEIGHT(GM)***DØSE(1)***DØSE(2)***DØSE(TØT)**UNSHIELDED***

| | | | | | |
|---|---|---|---|---|---|
| J | W | $D_1$ | $D_2$ | $D_t$ | $D_u$ |

where J is the number of iterations during the shield optimization, W is the total shield system weight (grams), $D_1$ is the dose rate due to the last particle type, i.e., primary if only a one-particle type problem-secondary if a primary plus secondary problem, $D_2$ is the dose rate from primary particles in a primary plus secondary problem, $D_t$ is the total dose rate, and $D_u$ is the dose rate due to particles which did not cross any of the shields.

Following the above lines, are lines labeled DIMENSIØNS, the thickness of each shield in cm; WEIGHT(GM), the weight of the individual shields; DWDT(GM/CM), the partial derivatives of the total shield weight with respect to thickness, DDDT( /CM) the partial derivatives of the dose rate with respect to thickness, and DDDW( /GM) the ratios of the dose and weight derivatives.

The last set of output during the optimization iterations is preceded by the line

***TERMINATIØN=K(0/1/2/3)=(DIMENSIØN CØNSTRAINTS/ITERATIØNS/
UNSHIELDED/DØSE CØNSTRAINT)***

and indicates the condition under which optimization terminated.

## DEPosition in Regions

This input section instructs the program to calculate the energy deposited in each region for problems which include one or more surface and/or volume detectors.

DEP.O.H(24A3) Header Card

This card must have DEP in columns 1-3.

DEP.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NDEPØS, (0,>0)=(no,yes) calculate energy deposition.

NOTES:

The output from this option is printed preceding the output for the individual detectors. The output is headed by the line

***ENERGY DEPØSITIØNS FØR CALCULATIØNAL SET K***

where K is a sequential number of the base-line problem and any correlated problems described via the CØR input section. The output includes x,y, and z coordinates of a point in the region to simplify the region identification. The output also includes the coefficient of variation of total deposition (ERRØR), the total deposition (MEV/SEC), the deposition from particle histories terminated due to energy cutoff (E-CUTØFF), the deposition from particle histories terminated at the collision cutoff (C-CUTØFF), and finally the deposition due to weight cutoff (W-CUTØFF).

## LEAkage of Energy

This input section instructs the program to calculate the energy leakage at the outer boundaries of the problem for those problems which contain surface and/or volume detectors.

LEA.0.H(24A3) Header Card

Has LEA in columns 1-3.

LEA.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NLEAKS, number of different region-boundary combinations from which leakage can occur.

4.-24. Input but not used.

NOTES:

The output associated with this section appears just before the output for the individual detectors. The output is headed by the printout line

***ENERGY LEAKAGES FØR CALCULATIØNAL SET K***

where K is a sequential numbering of the base-line problem and any correlated problems input via the CØR input section. The output includes the region and surface indices for the boundaries through which the leakage occurred, the leakage in Mev/sec and the computed coefficient of variation. The total leakage is also output.

## CHAnnel Detectors

This input section provides for the calculation of detector responses as a function of the energy deposited from a primary particle.

CHA.0.H(24A3) Header Card

Has CHA in columns 1-3.

CHA.1.I(24I3) Option Card

1. IN1 (0,>0)=(no,yes) interpret data words 3-5 from this card.

2. IN2>0, card CHA.2 and card CHA.3 for IN2 channels are input.

   IN2=0, cards CHA.2 and CHA.3 are not input.

3. NUMVØL, number of channel detectors.

4. NUMREG, maximum number of regions to be included in the definition of a channel detector.

5. NCEMAX, number of energy channels.

6.-24. Input but not used.

CHA.2.E(8E9.0) Channel Boundaries

This card contains the upper energy boundaries (Mev), in decreasing order, of the channels -- a total of NCEMAX entries.

CHA.3.I(24I3) Channel Detectors

This card describes the sensitive volume for each channel detector.

1. I, index of the detector.

2. MX, number of regions comprising the detector.

3. $\left.\begin{array}{l} \text{NUM(1,I)} \\ \vdots \\ \text{NUM(MX,I)} \end{array}\right\}$ indices of the regions comprising the detector.

## NØIse Functions

This input section provides the capability for analytically calculating the effect of electronic noise on the count rates of channel detectors.

NØI.0.H(24A3) Header Card

Contains NØI in columns 1-3.

NØI.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0,>0)=(no,yes) card NØI.2 is being input.

3. NØISE, number of different noise functions.

4.-24. Input but not used.

NØI.2.E(8E9.0) Gaussian Parameters

This card contains the noise parameters consisting of the full width at half maximum in Mev, a total of NØISE entries.

NOTES:

The output for each channel detector appears under the normal output and is headed by the line

***CHANNEL AND THRESHØLD CØUNT SPREAD DUE TØ NØISE***

The columns under this heading are the channel index, the upper and lower energy boundaries of the channel and then pairs of columns for each noise function. The first column of each pair contains the adjusted count rate for each channel. The second column is the threshold count rate for all channels down through the given channel.

PLØt Output

This input section provides for the plotting and punching of calculated quantities.

PLØ.0.H(24A3) Header Card

Columns 1-3 contain PLØ.

PLØ.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NPLØT, (0, 1, 2,3) = (neither,plot,punch,both) option for the differential number flux at each detector.

4.-24. Input but not used.

QUIck Plot of Results

This input section provides a graphical printout of calculated results. The output is provided only on the last print cycle.

QUI.0.H(24A3) Header Card

Has QUI in columns 1-3.

QUI.1.I(24I3) Option Card

1. IN1, (0, > 0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0, > 0)=(no,yes) card QUI.2 is being input.

3. NQUICK, number of different quick plots.

4.-24. Input but not used.

QUI.2.II(12(2I3)) Plot Requests

This card contains NQUICK pairs of integers. The first integer IQU(I) of each pair usually denotes the quantity (ordinate) being plotted. The second integer JQU(I) usually denotes the independent variable (abscissa).

NOTES:

The requested plots appear after the normal printout of the quantities being plotted. Present options include:

| IQU(I) | | JQU(I) | |
|---|---|---|---|
| 1. | DEPosition | 0 | versus region index |
| | | 1,2 or 3 | versus region x,y, or z coordinates |
| | | 4,5 or 6 | versus region radius $\perp$ x,y, or z-axis |
| | | 7 | versus region spherical radius |
| 2 | LEAkage output | 0,1,..,7 | versus outer region index, coordinate or radius as in DEP output. |
| 3 | CHAnnel output | 0 | counts in channel vs. channel index |
| | | 1 | counts in channel vs. channel energy |
| | | 2 | cumulative counts vs. channel index |
| | | 3 | cumulative counts vs. channel energy |
| 10 | Total flux | 1 | differential number flux versus energy |
| 11 | Flux by source region | 2 | differential energy flux versus energy |
| 12 | Scattering region | 3 | cumulative number flux versus energy |
| 13 | Order of scatter | 4 | cumulative energy flux versus energy |
| 14 | Angular moment | | |
| 15 | Temporal moment | | |
| 16 | Boundary crossing | | |

| IQU(I) | | JQU(I) | |
|---|---|---|---|
| 17 | Solid angle element | | |
| 18 | Time interval | | |
| 19 | Initial group | | |
| 21 | Response by source region | >0 | response function index |
| . | | -1 | total number flux |
| . | | 0 | total energy flux |
| . | | | |
| 29 | Response by initial group | | |
| 30 | Shield optimization output | 0 | dose versus iteration |
| | | 1 | weight versus iteration |
| | | 2 | shield thicknesses versus iteration |

## ØPTimum Importance Parameters

This input section tells the program to calculate, based on partial derivatives of the variance, better importance sampling parameters.

ØPT.O.H(24A3) Header Card

Has ØPT in columns 1-3.

ØPT.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, not used.

3. NØBIAS, (0,1)=(no,yes) calculate optimum importance.

4.-24. Input but not used.

NOTES:

If the value of NØBIAS=1, additional output is generated for each response function. The output appears just below the total response and response error output and is preceded by the printout line

***SUGGESTED CHANGES IN THE IMPØRTANCE SAMPLING PARAMETERS***

This line is followed by printout lines labeled SPA I. The numbers on this line are suggested changes in the spatial importance of region I for each response function. If these suggested changes are used for a particular response function they would be entered via the SPA input section. After all the spatial importance parameters are printed, four lines labeled PRE I, I=1,2,3 and 4 are printed. These lines contain suggested values of AT, BT, AS, and BS which are entered via the PRE input section. The four PRE lines are followed by three lines labeled PSE I, I = 1,2 and 3 containing suggested changes for the values of ATA, ATB, and ATC entered in the PSE input section.

The next series of lines are labeled REL I where I is a source index and correspond to the relative source importances defined through the REL input section. The final set of lines are labeled RAT 10*I+J where I is a source index and J=1,2,...,5 corresponding to the relative importance of source variables entered via the RAT input section.

If the problem was run for secondary particles a second set of similar output is generated and contains suggested importance parameter increments in the primary particle run to improve the secondary calculations.

Both the REL and RAT labeled output contain output for one more source than was specified in the SØU input section. The REL labeled output is of no consequence. The RAT labeled output for the additional source is important for the angular biasing of secondary sources.

## BIAsing Options

This input section provides for changing the probability density function models used in selecting source and scattering points.

BIA.0.H(24A3) Header Card

Contains BIA in columns 1-3.

BIA.1.I(24I3) Option Card

1. IN1=0, no effect.
   IN1>0, interpret data words 3-6 from this card.

2. IN2≥0, no effect
   IN2<0, set up the models according to the built-in criteria.

3. MØDELP, option for selecting initial particle coordinates.

   MØDELP=0, select the source and then select the spatial source variables in the coordinate system for that source. This model must be used if there are one or more point sources, e.g., when running secondary source tapes. This model uses built-in data which may be changed via the REL input section for selecting the source and built-in data which may be changed by the RAT input section for selecting the spatial variables.

   MØDELP=1, the spatial coordinates are selected using a spherical coordinate system centered at the "preferred point". The built-in preferred point can be changed via the PRE input section for surface and volume detector problems. For point detector problems where each detector is run separately, the preferred point is the detector being run. To use this option all sources must be volumetric with each source volume completely covering one or more regions. To restrict the range of the solid angle part of the spherical coordinate selection process, a pseudo spherical source which completely contains all the volume sources is built-in but can be changed via the PSE input section.

The program built-in option is MØDELP=1 unless one or more sources have discrete values for one or more of their spatial variables; in this event MØDELP=0.

4. MØDELQ, initial direction selection model.

   MØDELQ=0, select the angular source variables in the source coordinate system. This model must be used if any sources have a discrete value for either or both of the angular source variables. The built-in data used to select the angular variables can be changed via the RAT input section.

   MØDELQ=1, select the initial direction as though the initial source point were a scattering point, i.e., according to MØDELV below. The direction before scattering is defined as a unit vector from the center of the sphere containing all the sources to the selected source point. All the radiation sources must be angular or isotropic.

   MØDELQ=2, like MØDELQ=0 except the angular source variables are defined in a rotated coordinate system with the z'-axis towards the preferred point.

   The program built-in option is MØDELQ=1 unless one or more sources have discrete values for one or more of their angular variables; in this event MØDELQ=0.

5. MØDELU, distance to scattering point selection model.

MØDELU=0, use the exponential transformation.

MØDELU=1, use a curve fit of an approximation to the optimal pdf for the distance to collision.

MØDELU=2, for individual point detectors use the exponential transformation and the approximate optimal criterion for the decision on whether to work forward or backward in selecting the distance to collision.

MØDELU=3, for individual point detectors use the curve fit and the optimal criterion for the forward-backward decision. This is the model built into the program.

6. MØDELV, scattered direction selection model.

MØDELV=0, select the polar angle first measured from the direction before scattering. Then select the azimuthal angle measured from a unit vector directed towards the preferred point.

MØDELV=1, select the polar angle first, measured from the direction towards the preferred point. Then select the azimuthal angle measured from the direction before scattering.

MØDELV=2, very strong preference towards preferred point. Do not use this model.

MØDELV=4, the unit directions towards the preferred point and in the direction before scattering are weighted by approximate importance to give an overall preferred direction from which the polar angle is measured. Azimuthal angles are selected as being equiprobable. This is the model built into the program.

7. MØDELE, energy importance. The importance of particles in each energy group is proportional to $\bar{E}^n$ where $\bar{E}$ is the midpoint energy and n=MØDELE.

MØDELE=1 is built in, i.e., the relative importance of equal weight particles is set equal to their energy.

8. MØDELM, (0,1)=(continuous,discrete) treatment of energy dependence. MØDELM=0 is built in. If MØDELM=1, the spectrum of energies spanned by a packet is sampled to produce a single mono-energetic packet equivalent to a discrete energy particle.

9. MØDELR, (0,1)=(yes,no) play Russian roulette with the packet based on its last contribution to the calculated results. This is a two step decision based on the contribution from the current collision of a history compared to contributions from all previous collisions of the same history and on the contribution from this history compared to the contribution from all the previous histories. MØDELR=0 is built in.

10.-24. Input but not used.

PSEudo Spherical Sources

This input section defines the sphere enclosing all volume sources which is used to restrict the solid angle range for the MØDELP=1 option.

PSE.0.H(24A3) Header Card

Has PSE in columns 1-3.

PSE.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card PSE.2 is being input.

   IN2<0, the built-in data is used, omit card PSE.2.

3.-24. Input but not used.

PSE.2.E(8E9.0) Spherical Source

1. RADIUS, radius (cm) of the smallest sphere which encloses all the sources.

2. XCT(1), x-coordinates (cm) of the center of the sphere.

3. XCT(2), y-coordinates (cm) of the center of the sphere.

4. XCT(3), z-coordinates (cm) of the center of the sphere.

5. ATA, spherical pseudo source sampling, polar angle importance adjustment.

   ATA=1.0, all angles equally important. This is built in.

ATA>1.0, shifts importance towards small angle.

ATA<1.0, shifts importance towards large angle, numbers in the range 1.0≤ATA≤10.0 work fine. (This number must be greater than 0.0)

6. ATB, spherical pseudo source sampling, azimuthal angle importance adjustment.

   ATB=1.0, all angles equally important.

   ATB>1.0, shifts importance towards $0^{o}$.

   ATB<1.0, shifts importance away from $0^{o}$.

   This angle is measured in a rotated coordinate system and a little difficult to relate to the true coordinate system. The usual procedure is to use ATB=1.0 (this number must be greater than 0.0) -- the built-in value.

7. ATC, spherical pseudo source sampling, spatial importance adjustment. The built-in value is ATC=0.7.

   ATC=1.0, uses built-in estimate of spatial importance.

   ATC>1.0, shifts importance to lower source energies (source points closer to the detector).

   ATC<1.0, shifts importance to higher source energies (source points further away).

   General use of numbers 0.7<ATC<1.3 yield good results.

   (The program can be tricked for leakage-type surface and volume detector calculations by putting the preferred point in the center of the source and using ATC≈-1.0).

8. ATD, flux contribution importance used in cutoff considerations; if all contributions to all detector groups on 2 successive inner iterations of a given outer iteration are less than ATD times the flux already obtained in this outer iteration, then the inner iterations are terminated. The built-in value is ATD = 0.001.

## RELative Source Importance

This input section provides the relative importance of each source to be used with MØDELP=0 in the selection of the source from which a particle starts.

REL.0.H(24A3) Header Card.

This card has REL in columns 1-3.

REL.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card REL.2 is being input.

   IN2<0, define the source importance internally and omit REL.2.

3.-24. Input but not used.

REL.2.E(8E9.0) Source Importance

This card contains the relative importance of each source, a total of NVMAX entries. Any input source which should not be used for this problem should have an entry of 0.0. The built-in definition of these data uses the total source intensity in Mev/sec as the importance.

RATios of Source Variable Importance

This input section gives the preferred value of each source variable and the relative importance of the preferred value expressed as a ratio.

RAT.0.H(24A3) Header Card

Contains RAT in columns 1-3.

RAT.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card RAT.2 is being input.
   IN2<0, use built-in definitions and omit card RAT.2.

3.-24. Input but not used.

RAT.2.E(8E9.0) Source Variable Importance

This card is input as two physical cards per source with a set of cards for each source, NVMAX sets--2*NVMAX cards. The first card of each set contains the preferred value of each of the 5 source variables (3 spatial - 2 angular) in the order defined on card SØU.2. This preferred value must be in the range of the variable given on card SØU.3 including the end points. The second card of each set gives the relative importance -- expressed as a ratio -- of the preferred value of the variable to the end point farthest away from it. The numbers on the second card of this set must be greater than zero since their logarithms are calculated.

The first three parameters on each card are used if MØDELP=0. The last two are used if MØDELQ=0.

If these data are computed internally, they are defined so that the sampling is equally probable over the range of each variable.

PREferred Point

This input section defines the preferred point for surfaces and/or volume detectors.

PRE.0.H(24A3) Header Card

This card must contain PRE in columns 1-3.

PRE.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card PRE.2 is being input.
   IN2<0, the built-in data is used. Omit card PRE.2.

3.-24. Input but not used.

PRE.2.E(8E9.0) Preferred Point

1. DELTA, radius (cm) of a sphere which covers the volume in space where fluxes are being calculated. The center of this sphere is the preferred point if NPØINT=0.

2. BDC(1), x-coordinate (cm) of the center of the sphere.

3. BDC(2), y-coordinate (cm) of the center of the sphere.

4. BDC(3), z-coordinate (cm) of the center of the sphere.

5. AT, scaling factor for the spatial importance on the first leg of the scattering triangle.

   AT=1.0, uses built-in parameters.

   AT<1.0, shifts importance to higher energies.

AT>1.0, shifts importance to lower energies.

General use of numbers 0.6<AT<1.2 yields good results (must be greater than 0.0). AT = 0.9 is built-in.

6. BT, scaling factor for the spatial importance on the second leg of the scattering triangle; should approximate higher order scattering effects, so it is generally less than AT. BT=0.7 for photons and BT=0.5 for neutrons are built-in.

   If MØDELU=0, it must be less than AT in absolute magnitude, i.e., BT<AT.

   Numbers on the order of 0.4<BT<0.9 yield good results.

   If the <u>trick</u> mentioned in discussing ATC is used, it should also be used here; i.e., -0.9<BT < -0.4. This number cannot = 0.0.

7. AS, scaling factor for preferred direction (towards detector) importance.

   AS=1.0, uses built-in parameter.

   AS>1.0, forces even more.

   AS<1.0, forces less.

   AS=0.0, yields no effect.

   AS<0.0, forces away and should be used when ATC and BT are < 0.0.

   Use of 1.0 yields good results for point detectors (built-in value).

8. BS, scaling factor for scattered direction importance.

   BS=1.0, uses group-averaged parameter.

   BS>1.0, forces even more.

   BS<1.0, forces less.

   BS=0.0, no effect from scattered direction.

   Use of 1.0 yields good results (built-in value).

## SPAtial Importance

This input section provides for an artificial increase in the importance of scattering in selected regions, particularly useful in generating secondary sources.

SPA.0.H(24A3) Header Card

Must have SPA in columns 1-3.

SPA.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card SPA.2 is being input.

   IN2<0, built-in definition is used and card SPA.2 is omitted.

3.-24. Input but not used.

SPA.2.E(8E9.0) Importance Factors

This card contains the relative importance of scattering in each geometric region, a total of NRMAX entries.

CAPture Importance

This input section will eliminate the strong forward bias used in calculating fast neutron dose and substitute a more analog bias consistent with calculating good capture source distributions. The decision is made at random on each neutron collision.

CAP.0.H(24A3) Header Card

Contains CAP in columns 1-3.

CAP.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card CAP.2 is being input.

3.-24. Input but not used.

CAP.2.E(8E9.0) Capture Model Probabilities

This card contains an entry for every region, NRMAX total entries. Each entry is the probability, given that a collision occurs in the region, that the packet will be followed by an "analog" rather than a strongly biased technique.

SHØrt Circuit

This section provides for the definition of a sphere of influence such that if a particle and point detector are on opposite sides, the plane defining the half spaces used in the selection of the next scattering point subdivides the line between the particle and detector at the intersection of the line with the sphere rather than at the line midpoint.

SHØ.0.H(24A3) Header Card

Contains SHØ in columns 1-3.

SHØ.1.I(24I3) Option Card

1. IN1, not used.

2. IN2, (0,>0)=(no,yes) card SHØ.2 is being input.
   IN2<0, use built-in definition and omit card SHØ.2.

3.-24. Input but not used.

SHØ.2.E(8E9.0) Sphere

1. DIM, radius (cm) of sphere.

2. CØR(1), x-coordinate (cm) of sphere.

3. CØR(2), y-coordinate (cm) of sphere.

4. COR(3), z-coordinate (cm) of sphere.

5. PTH(1), detector out, particle out of sphere
6. PTH(2), detector out, particle in sphere
7. PTH(3), detector in, particle out of sphere
8. PTH(4), detector in, particle in sphere

, minimum probability with which the scattering point is selected by working backward from the detector

## RØTate and Translate

This input section provides for the rotation and/or translation of surfaces, points in region, detector points, pseudo source center, preferred point, and sources.

RØT.O.H(24A3) Header Card

Columns 1-3 contain RØT.

RØT.1.I(24I3) Option Card

1. IN1,(0,>0)=(no,yes) interpret data word 3 from this card.

2. IN2, (0, > 0)=(no,yes) card RØT.2 is being input.

3. NRØTRA, total number of rotations and/or translations.

4.-24. Input but not used.

RØT.2.R(12I3,4E9.0) Rotation Parameters

Input this card NRØTRA times.

1. NAXIS, (1,2,3) = rotate (x into y, y into z, z into x).
   NAXIS=0, translation only.

2. MINS, index of first surface. MINS=0, no surface operations.

3. MAXS, index of last surface.

4. MINR, index of first region. MINR=0, no region operations.

5. MAXR, index of last region.

6. MIND, index of first detector. MIND=0, no detector operations.

7. MAXD, index of last detector.

8. IDM(8), (0,>0)=(no,yes) operate on pseudo source center.

9. IDM(9), (0,>0)=(no,yes) operate on preferred point.

10. IDM(10), index of first source to be rotated or translated.

11. IDM(11), index of last source to be rotated or translated.

12. Input but not used.

13. THETA≠0.0, rotation in degrees.
    THETA=0.0, translation.

14. XTR(1)

15. XTR(2) origin for rotation if NAXIS>0, translation vector (cm) if NAXIS=0.

16. XTR(3)

## ARRay Direct Input

This section can be used for direct input of the elements in a data array. The use of this section can simplify the data input for some problems. However, an intimate knowledge of the program is recommended before using this input section. The array names are given in Appendix C.

ARR.0.H(24A3) Header Card

Columns 1-3 must contain ARR.
The name of the array is extracted from the first set of 3 nonblank columns starting with column 7 or 10, or 13, ..., or 70.

ARR.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-12 (as required) from this card.

2. IN2, (0,>0)=(no,yes), card ARR.2 or ARR.3 is being input.

3. IFT=1, the elements of the array are being input between specified limits on I,J, and K (all arrays are assumed 3-dimensional).

   IFT=2, the index of each element (as a one-dimensional array) is read and then the element is read -- logical pair input. This option is not available for BCD arrays.

   IFT=3, the entire array is being input.

4. MNK = number of logical pairs being input if IFT=2.

5. MXK

6. MDK

7. MNJ

8. MXJ

9. MDJ

10. MNI

11. MXI

12. MDI

used only if IFT=1; see ARR.2 below

13.-24. Input but not used.

ARR.2. {I(24I3) / E(8E9.0) / A(24A3)} Array Elements

Input all array elements on this card if IFT=3.
If IFT=1, input the following elements:

(((ARR(K,J,I),K=MNK,MXK,MDK),J=MNJ,MXJ,MDJ),I=MNI,MXI,MDI)

ARR.3. {IS(12(2I3)) / ES(6(I3,E9))} Index and Array Elements

If IFT=2, input MNK pairs of data consisting of the index of an array element followed by the element itself.

## DUMp Requests

This section provides for the dumping of specified named common blocks and arrays at selected points in most subprograms. See Appendix C for the common blocks and arrays.

DUM.0.H(24A3) Header Card

This card has DUM in columns 1-3.

DUM.1.I(24I3) Option Card

1. IN1, (0, >0)=(no,yes) interpret data words 3 and 4 from this card.

2. IN2, (0, >0)=(no, number of dump requests) input on cards DUM.2 and DUM.3.

3. NDUMPS, number of dump points.

4. NVAMAX, maximum number of arrays to be dumped at a dump point.

5. NCBMAX, maximum number of named common blocks.

6.-24. Input but not used.

Input cards DUM.2 and DUM.3 in sets, a total of IN2 sets.

DUM.2.I(24I3) Dump Limits

1. I, index of the dump request, 1≤I≤NDUMPS.

2. NVA(I) , number of arrays in this dump request.

NVA(I)<0, use array list for dump request J = -NVA(I).
NVA(I)≥500, dump all arrays.

3. IFN(I), dump point, e.g., 1 = subroutine entrance point, 9 = exit point.

4. NDN(I), index of the first pass through the routine on which the dump will be given.

5. NDX(I), index of the last pass on which the dump will be made.

6. MXC, number of common blocks to be dumped.
MSC≥100, dump all common blocks.

7.
8.
.
.
. Indices of named common blocks, e.g., 41 for named common C41; omit if MSC≥100.

DUM.3.A(24A3) Subroutine and Array Names

1.-2. name of the subroutine in which the dump will be made.

3.,4,..., names of arrays to be dumped or blanks. Omit if NVA(I) ≥ 500.

Blank A3 words on this card are ignored so that the input can be prepared in a more readable manner.

## PRInt Suppression

This section permits suppression of printing of input card images with the exception of header cards and comment cards encountered while searching for a header card. This section also permits the resumption of printing card images following a prior suppression. The suppression does not carry over into succeeding cases.

PRI.O.H(24A3) Header Card

Must contain PRI in columns 1-3.

PRI.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret the third data word on this card.

2. IN2, not used.

3. LINØUT, (0,1)=(yes,no) print input card images.

4.-24. Input but not used.

## NEXt Case

This control section tells the program to proceed to the next case without executing the problem data. The program responds by incrementing the case index and initializing the page and line count indices.

NEX.0.H(24A3) Header Card

Must contain NEX in columns 1-3.

NEX.1.I(24I3) Option Card

1.-24. Input but not used.

EXEcute the Problem

This section tells the program that all the necessary inputs have been provided. The program then allocates storage for additional arrays used during the execution of the problem. A printout line is then written.

***THIS CASE USES I LØCATIØNS FØR INPUT, J LØCATIØNS TØ RUN***

If any errors are detected during data input, the above line is followed by the line

***PRØCEEDING TØ THE NEXT CASE***

and the execution is not performed. If the input data is acceptable, the following line is printed

GØ*GØ*GØ*GØ*GØ*GØ*GØ

and the problem is then executed.

EXE.0.H(24A3) Header Card

Must have EXE in columns 1-3.

EXE.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-6 from this card.

2. IN2, not used.

3. NPØINT=0, calculate fluxes for surface, volume and/or point detectors using only one set of particle histories. Any point detectors should not lie in a source volume

or scattering medium if a meaningful, finite variance, answer is desired.

NPØINT=1, calculate fluxes for point detectors using a different set of particle histories for each detector. Point detectors can be located anywhere since the history set generated for each detector ensures a finite variance flux calculation.

4. NPRINT >0, number of printouts of calculated fluxes during the calculation. The intermediate prints permit partial salvage of the results for problems which terminate abnormally. Alternatively, if a nonzero restart unit is designated on card TAP.1, the problem data will be saved on the restart tape at the start of each print loop for possible use later; see the CØNtinue input section.

   NPRINT=0, the program performs all steps up to the actual execution of the problem and then proceeds to the next case even though the error indicator is not set.

5. NUNITS, number of histories to be generated between each printout.

6. KALIDE, maximum number of collisions per particle.

7.-24. Input but not used.

## CØNtinue a Previous Run

This input section tells the program to read the restart tape generated during a previous run and continue execution of the problem on that tape.

CØN.0.H(24A3) Header Card

Must contain CØN in columns 1-3.

CØN.1.I(24I3) Option Card

1. IN1, (0,>0)=(no,yes) interpret data words 3-6 from this card.

2. IN2, not used.

3. NPØINT
4. NPRINT
5. NUNITS
6. KALIDE

Same definitions (possibly different values) as the same variables in the EXEcute input section

7.-24. Input but not used.

## STØp Processing

This section permits termination of the computer run by a programmed stop rather than terminating the run by encountering an end of file while trying to read input data for a nonexistent problem.

STØ.0.H(24A3) Header Card

Must have STØ in columns 1-3.

STØ.1.I(24I3) Option Card

1.-24. Input but not used.

## Appendix B

## SAMPLE PROBLEM PRINTOUT

This appendix contains the complete printout from a sample problem. The problem involved the calculations of dose rates at a specified point from primary neutrons and photons and from secondary photons for a spherical reactor-shield configuration. The dose rates and dose rate derivatives with respect to shield thickness were then used to calculate a minimum weight shield configuration. The complete problem description and results of full length runs are given in Volume I of this report.

The printout includes all the data card images -- with one exception -- so a separate listing of these data cards is not given. A part of the lengthy printout of microscopic cross section card images is not included. Numerous comment cards are included in the data deck to clarify the problem description.

```
   THE FASTER-III PROGRAM **********************************************************************************CASE     1
T.M.JORDAN-A.R.T.RESEARCH**********************************************************************************PAGE     1

************************************************************************************************************************
CARD IMAGE ***.000.001.H   C ZEROUT INPUT SECTION IS NOT INPUT SINCE CORE IS ZEROED BEFORE FIRST CASE
CARD IMAGE ***.000.002.H   C ZEROUT SECTION WOULD BE USED BETWEEN MULTIPLE INDEPENDENT PROBLEMS
CARD IMAGE ***.000.003.H   C ZEROUT DOES NOT ZEROUT TAPE LOGICAL DESIGNATIONS, EVERYTHING ELSE
**************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE TAP.000.001.H   TAP E UNITS
CARD IMAGE TAP.001.001.I   C IN1 = 1, TAPE UNITS ARE BEING SPECIFIED
CARD IMAGE TAP.001.002.I   C IN2 = 0, NOT USED
CARD IMAGE TAP.001.003.I   C M5 = 9, NEUTRON COLLISION PARAMETERS WILL GO ON THIS TAPE
CARD IMAGE TAP.001.004.I     1  0  0  0  9  0  0  0
************************************************************************************************************************
**************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE LAB.000.001.H   LAB EL FOR PRINTOUT
CARD IMAGE LAB.001.001.I   C IN1 = 1, NOT USED ANYWAY
CARD IMAGE LAB.001.002.I   C IN2 = 1, LABEL CARDS ARE BEING INPUT
CARD IMAGE LAB.001.003.I   C NO COMMENT CARDS CAN FOLLOW THE NEXT CARD SINCE AN A FORMAT IS USED FOR INPUT
CARD IMAGE LAB.001.004.I     1  1
CARD IMAGE LAB.002.001.A   ************************UNIT SHIELD TEST PROBLEM************************
CARD IMAGE LAB.002.002.A   ***************************PRIMARY NEUTRONS***************************
************************************************************************************************************************
**************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE MAT.000.001.H   MAT ERIAL COMPOSITIONS
CARD IMAGE MAT.001.001.I   C IN1 = 1, LIMITS AND OPTIONS ARE BEING INPUT
CARD IMAGE MAT.001.002.I   C IN2 = 1, COMPOSITIONS ARE BEING INPUT
CARD IMAGE MAT.001.003.I   C NIMAX = 9, NINE ELEMENTS IN COMPOSITION TABLE
CARD IMAGE MAT.001.004.I   C NMMAX = 7, SEVEN MATERIALS ARE BEING DEFINED
CARD IMAGE MAT.001.005.I   C NUNITD = 0(IMPLIED), COMPOSITIONS IN E+24 ATOMS/CC
CARD IMAGE MAT.001.006.I   ,1,1,9,7/
CARD IMAGE MAT.002.001.E   C HYDROGEN
CARD IMAGE MAT.002.002.E   ,1.0813,1,.0197,,,,0451,.0516,.058,.0645/ H
CARD IMAGE MAT.003.001.E   C BERYLLIUM
CARD IMAGE MAT.003.002.E   ,9.013,4,0,.12/
CARD IMAGE MAT.004.001.E   C BORON
CARD IMAGE MAT.004.002.E   ,11,5,,,,.000671,.000766,.000862,.000958/ B
CARD IMAGE MAT.005.001.E   C OXYGEN
CARD IMAGE MAT.005.002.E   ,16,8,.01146,,,.0235,.0268,.0302,.0337/ O
CARD IMAGE MAT.006.001.E   C ALUMINUM
```

```
*******************************************************************************************************
**************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE MAT.006.002.E    ,26.98,13,.005126/
CARD IMAGE MAT.007.001.E    C ZIRCONIUM
CARD IMAGE MAT.007.002.E    ,91.22,40,.01747/
CARD IMAGE MAT.008.001.E    C TUNGSTEN
CARD IMAGE MAT.008.002.E    ,183.86,74/
CARD IMAGE MAT.009.001.E    C URANIUM 235
CARD IMAGE MAT.009.002.E    ,235,92,.000979/
CARD IMAGE MAT.010.001.E    C URANIUM 238
CARD IMAGE MAT.010.002.E    ,238.07,92,7.8-5,,.0482,.01446,.00964,.00482/
*******************************************************************************************************
CARD IMAGE ***.000.001.H    C MIX TURE TABLE IS NOT INPUT
CARD IMAGE ***.000.002.H    C GAM MA RAY CROSS SECTIONS ARE NOT INPUT
CARD IMAGE ***.000.003.H    C PHO TON CROSS SECTIONS ARE NOT INPUT
CARD IMAGE ***.000.004.H    C MUL TIGROUP NEUTRON CROSS SECTIONS WILL BE INPUT OUT OF ORDER
CARD IMAGE ***.000.005.H    C NEU TRON CROSS SECTIONS ARE NOT BEING INPUT
**************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE SEC.000.001.H    SEC ONDARY PRODUCTION CROSS SECTIONS
CARD IMAGE SEC.001.001.I    C IN1 = 1, LIMITS AND OPTIONS ARE BEING INPUT
CARD IMAGE SEC.001.002.I    C IN2 = 1, MICROSCOPIC DATA IS BEING INPUT
CARD IMAGE SEC.001.003.I    C NPEMAX = 26, TWENTY-SIX PRIMARY GROUPS(NEUTRON)
CARD IMAGE SEC.001.004.I    C NSEMAX = 15, FIFTEEN SECONDARY GROUPS(PHOTON)
CARD IMAGE SEC.001.005.I    C NUNITX = 0(IMPLIED), CROSS SECTIONS IN PHOTON*BARNS/ATOM
CARD IMAGE SEC.001.006.I    C IN6 = 0(IMPLIED), SEC.2 INPUT FORMAT FOR MICROSCOPIC DATA
CARD IMAGE SEC.001.007.I      1  1 26 15
CARD IMAGE SEC.002.001.E    C HYDROGEN, ALL ZEROES ARE INPUT(NEUTRON CAPTURE DATA IS BUILT IN)
CARD IMAGE SEC.002.002.E    ,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/ H
CARD IMAGE SEC.028.001.E    C BERYLLIUM DATA, ALL ZEROES, ACTUAL DATA WILL BE STRIPPED FROM
CARD IMAGE SEC.028.002.E    C                    COUPLED NEUTRON PHOTON MULTIGROUP DATA
CARD IMAGE SEC.028.003.E    ,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/,/ BE
CARD IMAGE SEC.054.001.E    C BORON CAPTURE, MICROSCOPIC DATA IS NOT AVAILABLE IN COUPLED SET
CARD IMAGE SEC.054.002.E    ,11*0,.126/,11*0,.152/,11*0,.166/,11*0,.148/,11*0,.135/,11*0,.125/
CARD IMAGE SEC.060.001.E    ,11*0,.099/,11*0,.069/,11*0,.066/,11*0,.103/,11*0,.095/,11*0,.059/
CARD IMAGE SEC.066.001.E    ,11*0,.051/,11*0,.071/,11*0,.122/,11*0,.269/,11*0,.835/,11*0,1.61/
CARD IMAGE SEC.072.001.E    ,11*0,3.29/,11*0,7.81/,11*0,16.3/,11*0,28.5/,11*0,49.0/,11*0,86.2/
CARD IMAGE SEC.078.001.E    ,11*0,141./,11*0,668./
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CARD IMAGE SEC.080.001.E    C OXYGEN
CARD IMAGE SEC.080.002.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ O
CARD IMAGE SEC.106.001.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ AL
CARD IMAGE SEC.132.001.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ ZR
CARD IMAGE SEC.158.001.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ W
CARD IMAGE SEC.184.001.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ U5
CARD IMAGE SEC.210.001.E    '/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/'/ U8
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CARD IMAGE MUL.000.001.H    MULTIGROUP
CARD IMAGE MUL.001.001.I    C IN1 = 1, LIMITS AND OPTIONS ARE BEING INPUT
CARD IMAGE MUL.001.002.I    C IN2 = 1, MICROSCOPIC CROSS SECTIONS ARE BEING INPUT
CARD IMAGE MUL.001.003.I    C NEMMAX = 26, TWENTY SIX NEUTRON ENERGY GROUPS
CARD IMAGE MUL.001.004.I    C NORDER = 1, TRANSPORT CORRECTED CALCULATION
CARD IMAGE MUL.001.005.I    C NDOWN = 4, DOWN 3 ELASTIC SCATTER
CARD IMAGE MUL.001.006.I    C INELAS = 16, INELASTIC SCATTER CAN INITIATE IN TOP 16 GROUPS
CARD IMAGE MUL.001.007.I    C NTRANS = 16, INELASTIC SCATTER CAN TRANSFER NEUTRONS TO 16 FINAL GROUPS
CARD IMAGE MUL.001.008.I    C LFIXUP = 1, HISTOGRAM FIXUP FOR P SUB L TRANSFER PROBABILITIES
CARD IMAGE MUL.001.009.I    C MGSLOW = 10, DIFFUSION MODEL FOR BOTTOM 10 GROUPS
CARD IMAGE MUL.001.010.I      1  1 26  1  4 16 16  1 10
CARD IMAGE MUL.002.001.E    C ENERGY GROUP BOUNDARIES
CARD IMAGE MUL.002.002.E    14.92     12.21     10.0      8.19      6.07      4.97      4.07      3.01      1.3.1
CARD IMAGE MUL.002.003.E    2.47      2.23      1.83      1.35      1.11      0.91      0.55      0.41      1.3.2
CARD IMAGE MUL.002.004.E    0.11      0.015     0.00335   0.000583  0.000101  2.90     -51.07    -53.06    -61.3.3
CARD IMAGE MUL.002.005.E    1.13     -64.10    -70.0     -7                                               1.3.4
CARD IMAGE MUL.003.001.I    C HYDROGEN OPTION CARD( FASTER FORMAT)
CARD IMAGE MUL.003.002.I      1 26                                                                     H-TOTAL
CARD IMAGE MUL.004.001.E    C HYDROGEN TOTAL CROSS SECTION
CARD IMAGE MUL.004.002.E       0.7331    0.8705    1.0277    1.2808    1.5243    1.7408    2.0799    2.4088
CARD IMAGE MUL.004.003.E       2.6425    2.8788    3.3221    3.7966    4.2483    5.1394    6.2448    9.2469
CARD IMAGE MUL.004.004.E      15.5361   19.1853   19.8069   20.1413   20.2952   20.3923   20.6466   20.9659
CARD IMAGE MUL.004.005.E      21.471023.8
CARD IMAGE MUL.005.001.I    C BERYLLIUM DATA 26 NEUTRON 15 GROUP GAMMA NASA LEWIS
CARD IMAGE MUL.005.002.I    C LMAX = 4, P3 DATA IS BEING INPUT
CARD IMAGE MUL.005.003.I    C NDSM = 4, LOCATION OF IN GROUP SCATTER IN TABLE
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CARD IMAGE MUL.005.004.I   C IDEL = 0, CARD INPUT OF DATA
CARD IMAGE MUL.005.005.I   C MELAST = 41, FORTY-ONE GROUP DATA- COUPLED SET
CARD IMAGE MUL.005.006.I   C NGTSEC =1, TELLS CODE THE EXTRA GROUPS OF DATA ARE FOR SECONDARY PRODUCTION
CARD IMAGE MUL.005.007.I   C            SINCE SEC INPUT SECTION IS ALREADY IN, DATA WILL BE STRIPPED FROM
CARD IMAGE MUL.005.008.I   C            THIS INPUT SET
CARD IMAGE MUL.005.009.I     4 -4 44  0 41  1
CARD IMAGE MUL.006.001.F   C P0
CARD IMAGE MUL.006.002.F    0 +14260- 6 0 +     0+ 0 0 +15021- 4 0 +64478- 540R+     0+ 0                          1
CARD IMAGE MUL.006.003.F    0 +23608- 6 0 +     0+ 0 0 +15975- 4 0 +65700- 5 0 +50896- 539R+     0+ 0               1
CARD IMAGE MUL.006.004.F    0 +31389- 6 0 +     0+ 0 0 +17008- 4 0 +69130- 5 0 +46179- 5 0 +51233- 5               1
CARD IMAGE MUL.006.005.F   38R+     0+ 0                                                                            2
CARD IMAGE MUL.006.006.F    0 +38372- 6 0 +     0+ 0 0 +18598- 4 0 +79692- 5 0 +67035- 5 0 +75232- 5               1
CARD IMAGE MUL.006.007.F    0 +33481- 537R+     0+ 0                                                                2
CARD IMAGE MUL.006.008.F    0 +55429- 6 0 +     0+ 0 0 +19113- 4 0 +72798- 5 0 +38765- 5 0 +49911- 5               1
CARD IMAGE MUL.006.009.F    0 +23670- 5 0 +16310- 736R+     0+ 0                                                    2
CARD IMAGE MUL.006.010.F    0 +75169- 6 0 +     0+ 0 0 +19490- 4 0 +73124- 5 0 +35705- 5 0 +42147- 5               1
CARD IMAGE MUL.006.011.F    0 +30889- 5 0 +20970- 636R+     0+ 0                                                    2
CARD IMAGE MUL.006.012.F    0 +96405- 6 0 +     0+ 0 0 +24878- 4 0 +95848- 5 0 +47559- 5 0 +46747- 5               1
CARD IMAGE MUL.006.013.F    0 +57449- 5 0 +75263- 636R+     0+ 0                                                    2
CARD IMAGE MUL.006.014.F    0 +93792- 6 0 +     0+ 0 0 +32290- 4 0 +14170- 4 0 +56633- 5 0 +20285- 5               1
CARD IMAGE MUL.006.015.F    0 +37724- 5 0 +18820- 536R+     0+ 0                                                    2
CARD IMAGE MUL.006.016.F    0 +68500- 6 0 +     0+ 0 0 +20101- 4 0 +50797- 5 0 +52081- 5 0 +16253- 5               1
CARD IMAGE MUL.006.017.F    0 +12639- 5 0 +17926- 5 0 +38188- 635R+     0+ 0                                       2
CARD IMAGE MUL.006.018.F    0 +52873- 6 0 +     0+ 0 0 +16753- 4 0 +59312- 5 0 +67627- 5 0 +71571- 5               1
CARD IMAGE MUL.006.019.F    0 +21722- 5 0 +30834- 5 0 +23661- 5 0 +15495- 634R+     0+ 0                          2
CARD IMAGE MUL.006.020.F    0 +20766- 6 0 +     0+ 0 0 +20298- 4 0 +90887- 5 0 +90245- 5 0 +72678- 5               1
CARD IMAGE MUL.006.021.F    0 +35239- 5 0 +19505- 5 0 +40654- 5 0 +11227- 534R+     0+ 0                          2
CARD IMAGE MUL.006.022.F    0 +46510- 7 0 +     0+ 0 0 +29521- 4 0 +10138- 4 0 +81260- 5 0 +12062- 5               1
CARD IMAGE MUL.006.023.F    0 +     0+ 0 0 +81250- 7 0 +23195- 5 0 +13256- 5 0 +22600- 733R+     0+ 0             2
CARD IMAGE MUL.006.024.F    0 +34000- 8 0 +     0+ 0 0 +34346- 4 0 +11759- 4 0 +13359- 4 0 +27807- 5               1
CARD IMAGE MUL.006.025.F   2R+     0+ 0 0 +44101- 6 0 +19753- 5 0 +64319- 633R+     0+ 0                          2
CARD IMAGE MUL.006.026.F   2R+     0+ 0 0 +40396- 4 0 +22608- 4 0 +22583- 4 0 +59770- 5 0 +95120- 7               1
CARD IMAGE MUL.006.027.F    0 +     0+ 0 0 +37990- 7 0 +11863- 5 0 +26730- 5 0 +20639- 632R+     0+ 0             2
CARD IMAGE MUL.006.028.F   2R+     0+ 0 0 +35703- 4 0 +16453- 4 0 +16074- 4 4R+     0+ 0 0 +18114- 6             1
CARD IMAGE MUL.006.029.F    0 +27792- 6 0 +61011- 632R+     0+ 0                                                    2
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CARD IMAGE MUL.006.030.F    2R+    0+ 0 0 +45065- 4 0 +38183- 4 0 +19250- 4 0 +17137- 5 3R+    0+ 0       1
CARD IMAGE MUL.006.031.F    0 +10154- 6 0 +39296- 6 0 +41775- 6 0 +62715- 631R+    0+ 0                2
CARD IMAGE MUL.006.032.F    2R+    0+ 0 0 +56436- 4 0 +51305- 4 0 +68816- 5 5R+    0+ 0 0 +23500- 7    1
CARD IMAGE MUL.006.033.F    0 +    0+ 0 0 +16900- 631R+    0+ 0                                        2
CARD IMAGE MUL.006.034.F    2R+    0+ 0 0 +58102- 4 0 +50294- 4 0 +51313- 5 8R+    0+ 0 0 +11330- 7    1
CARD IMAGE MUL.006.035.F   30R+    0+ 0                                                                2
CARD IMAGE MUL.006.036.F    2R+    0+ 0 0 +58102- 4 0 +51310- 4 0 +78072- 5 9R+    0+ 0 0 +12000- 8    1
CARD IMAGE MUL.006.037.F   29R+    0+ 0                                                                2
CARD IMAGE MUL.006.038.F    0 +10500- 8 0 +    0+ 0 0 +58103- 4 0 +51274- 4 0 +67915- 539R+    0+ 0    1
CARD IMAGE MUL.006.039.F    0 +21900- 8 0 +    0+ 0 0 +58104- 4 0 +48831- 4 0 +68277- 539R+    0+ 0    1
CARD IMAGE MUL.006.040.F    0 +38400- 8 0 +    0+ 0 0 +58105- 4 0 +46082- 4 0 +92704- 539R+    0+ 0    1
CARD IMAGE MUL.006.041.F    0 +67600- 8 0 +    0+ 0 0 +58108- 4 0 +48628- 4 0 +12020- 439R+    0+ 0    1
CARD IMAGE MUL.006.042.F    0 +11670- 7 0 +    0+ 0 0 +58113- 4 0 +46172- 4 0 +94736- 539R+    0+ 0    1
CARD IMAGE MUL.006.043.F    0 +18940- 7 0 +    0+ 0 0 +58120- 4 0 +46383- 4 0 +11929- 439R+    0+ 0    1
CARD IMAGE MUL.006.044.F    0 +88600- 7 0 +    0+ 0 0 +70100- 4 0 +70000- 4 0 +11718- 439R+    0+ 0    1
CARD IMAGE MUL.006.045.F   C PHOTON PART OF P0
CARD IMAGE MUL.006.046.F    0 +25460- 6 0 +    0+ 0 0 +29707- 5 0 +25400- 6 0 +77436- 7 0 +16557- 7    1
CARD IMAGE MUL.006.047.F    0 +10198- 7 0 +59074- 8 0 +33530- 8 0 +19127- 8 0 +92093- 933R+    0+ 0    2
CARD IMAGE MUL.006.048.F    0 +19500- 6 0 +    0+ 0 0 +34028- 5 0 +89500- 7 0 +11730- 639R+    0+ 0    1
CARD IMAGE MUL.006.049.F    0 +17100- 6 0 +    0+ 0 0 +36012- 5 0 +10900- 6 0 +18450- 6 0 +11940- 6    1
CARD IMAGE MUL.006.050.F   38R+    0+ 0                                                                2
CARD IMAGE MUL.006.051.F    0 +14500- 6 0 +    0+ 0 0 +38363- 5 0 +13560- 6 0 +22530- 6 0 +18550- 6    1
CARD IMAGE MUL.006.052.F    0 +12300- 637R+    0+ 0                                                    2
CARD IMAGE MUL.006.053.F    0 +11940- 6 0 +    0+ 0 0 +41224- 5 0 +17320- 6 0 +28130- 6 0 +22670- 6    1
CARD IMAGE MUL.006.054.F    0 +18900- 6 0 +12880- 636R+    0+ 0                                        2
CARD IMAGE MUL.006.055.F    0 +94100- 7 0 +    0+ 0 0 +44771- 5 0 +22890- 6 0 +36090- 6 0 +28350- 6    1
CARD IMAGE MUL.006.056.F    0 +23230- 6 0 +19650- 6 0 +13780- 6 0 +36149- 7 0 +77292- 8 0 +47606- 8    2
CARD IMAGE MUL.006.057.F    0 +27577- 8 0 +15653- 8 0 +89287- 9 0 +42991- 928R+    0+ 0                3
CARD IMAGE MUL.006.058.F    0 +70800- 7 0 +    0+ 0 0 +48747- 5 0 +24720- 6 0 +38370- 6 0 +29100- 6    1
CARD IMAGE MUL.006.059.F    0 +23310- 6 0 +19420- 6 0 +16560- 6 0 +12010- 6 0 +86296- 8 0 +18451- 8    2
CARD IMAGE MUL.006.060.F    0 +11365- 8 0 +65833- 9 0 +37367- 9 0 +21315- 9 0 +10263- 927R+    0+ 0    3
CARD IMAGE MUL.006.061.F    0 +49400- 7 0 +    0+ 0 0 +53194- 5 0 +33350- 6 0 +51440- 6 0 +38590- 6    1
CARD IMAGE MUL.006.062.F    0 +29960- 6 0 +24470- 6 0 +20720- 6 0 +18010- 6 0 +13300- 6 0 +10100- 7    2
CARD IMAGE MUL.006.063.F    0 +21596- 8 0 +13302- 8 0 +77053- 9 0 +43735- 9 0 +24948- 9 0 +12012- 9    3
CARD IMAGE MUL.006.064.F   26R+    0+ 0                                                                4
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CARD IMAGE MUL.006.065.F    0 +28600- 7 0 +     0+ 0 0 +58883- 5 0 +47410- 6 0 +69710- 6 0 +51690- 6     1
CARD IMAGE MUL.006.066.F    0 +39930- 6 0 +31850- 6 0 +26580- 6 0 +22390- 6 0 +20160- 6 0 +15250- 6     2
CARD IMAGE MUL.006.067.F   32R+     0+ 0                                                                3
CARD IMAGE MUL.006.068.F    0 +10900- 7 0 +     0+ 0 0 +67099- 5 0 +83410- 6 0 +11202- 5 0 +79270- 6     1
CARD IMAGE MUL.006.069.F    0 +61290- 6 0 +49130- 6 0 +40460- 6 0 +34580- 6 0 +30320- 6 0 +27080- 6     2
CARD IMAGE MUL.006.070.F    0 +20970- 631R+     0+ 0                                                    3
CARD IMAGE MUL.006.071.F    0 +19000- 8 0 +     0+ 0 0 +80022- 5 0 +15625- 5 0 +17848- 5 0 +11571- 5     1
CARD IMAGE MUL.006.072.F    0 +88060- 6 0 +71870- 6 0 +60180- 6 0 +51290- 6 0 +44920- 6 0 +40080- 6     2
CARD IMAGE MUL.006.073.F    0 +36260- 6 0 +28670- 6 0 +82487- 8 0 +17637- 8 0 +10863- 8 0 +62926- 9     3
CARD IMAGE MUL.006.074.F    0 +35717- 9 0 +20374- 9 0 +98099-1023R+     0+ 0                            4
CARD IMAGE MUL.006.075.F    2R+     0+ 0 0 +10470- 4 0 +45503- 5 0 +38472- 5 0 +23414- 5 0 +17849- 5    1
CARD IMAGE MUL.006.076.F    0 +14857- 5 0 +12819- 5 0 +11161- 5 0 +97780- 6 0 +87130- 6 0 +78650- 6     2
CARD IMAGE MUL.006.077.F    0 +71700- 6 0 +57320- 6 0 +15151- 7 0 +32394- 8 0 +19952- 8 0 +11558- 8     3
CARD IMAGE MUL.006.078.F    0 +65602- 9 0 +37422- 9 0 +18018- 922R+     0+ 0                            4
CARD IMAGE MUL.006.079.F    2R+     0+ 0 0 +13683- 4 0 +49186- 5 0 +31630- 5 0 +16007- 5 0 +12015- 5    1
CARD IMAGE MUL.006.080.F    0 +97620- 6 0 +83030- 6 0 +72220- 6 0 +63020- 6 0 +55160- 6 0 +49030- 6     2
CARD IMAGE MUL.006.081.F    0 +44120- 6 0 +40110- 6 0 +31830- 628R+     0+ 0                            3
CARD IMAGE MUL.006.082.F    2R+     0+ 0 0 +16185- 4 0 +86429- 5 0 +77941- 5 0 +27570- 5 0 +98990- 6    1
CARD IMAGE MUL.006.083.F    0 +53720- 6 0 +34740- 6 0 +25000- 6 0 +18960- 6 0 +14560- 6 0 +11300- 6     2
CARD IMAGE MUL.006.084.F    0 +90700- 7 0 +74800- 7 0 +63000- 7 0 +42300- 727R+     0+ 0                3
CARD IMAGE MUL.006.085.F    2R+     0+ 0 2R+19102- 4 0 +75420- 5 0 +97080- 638R+     0+ 0               1
CARD IMAGE MUL.007.001.F   C P1
CARD IMAGE MUL.007.002.F    2R+     0+ 0 0 +83738- 5 0 +16991- 440R+     0+ 0                           1
CARD IMAGE MUL.007.003.F    2R+     0+ 0 0 +92835- 5 0 +17259- 4 0 +42476- 539R+     0+ 0               1
CARD IMAGE MUL.007.004.F    2R+     0+ 0 0 +10168- 4 0 +18192- 4 0 +44522- 5 0 -12122- 538R+     0+ 0   1
CARD IMAGE MUL.007.005.F    2R+     0+ 0 0 +11591- 4 0 +20010- 4 0 +34364- 5 0 -16356- 5 0 -83940- 7    1
CARD IMAGE MUL.007.006.F   37R+     0+ 0                                                                2
CARD IMAGE MUL.007.007.F    2R+     0+ 0 0 +12526- 4 0 +18679- 4 0 +34575- 5 0 -11066- 538R+     0+ 0   1
CARD IMAGE MUL.007.008.F    2R+     0+ 0 0 +13300- 4 0 +18606- 4 0 +43694- 5 0 -22679- 538R+     0+ 0   1
CARD IMAGE MUL.007.009.F    2R+     0+ 0 0 +17588- 4 0 +23051- 4 0 +17771- 5 0 -32860- 5 0 -17879- 6    1
CARD IMAGE MUL.007.010.F   37R+     0+ 0                                                                2
CARD IMAGE MUL.007.011.F    2R+     0+ 0 0 +23819- 4 0 +34306- 4 0 +55909- 5 0 -18140- 538R+     0+ 0   1
CARD IMAGE MUL.007.012.F    2R+     0+ 0 0 +17076- 4 0 +13326- 4 0 +82960- 5 0 -25136- 538R+     0+ 0   1
CARD IMAGE MUL.007.013.F    2R+     0+ 0 0 +14113- 4 0 +14017- 4 0 +90136- 5 0 -83871- 5 0 -42595- 5    1
CARD IMAGE MUL.007.014.F   37R+     0+ 0                                                                2
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CARD IMAGE MUL.044.049.F    0 -20620- 429R+      0+ 0                                                        3
CARD IMAGE MUL.044.050.F    3R+      0+ 0 0 +18361- 3 0 -92816- 4 0 +39621- 4 0 +53386- 4 0 +48791- 4        1
CARD IMAGE MUL.044.051.F    0 +42595- 4 0 +36982- 4 0 +31782- 4 0 +27190- 4 0 +23589- 4 0 +20729- 4           2
CARD IMAGE MUL.044.052.F    0 +18422- 4 0 +13847- 428R+      0+ 0                                            3
CARD IMAGE MUL.044.053.F    3R+      0+ 0 0 +77956- 4 0 -42209- 4 0 +41704- 4 0 -62083- 5 0 -17340- 4        1
CARD IMAGE MUL.044.054.F    0 -17546- 4 0 -15784- 4 0 -13818- 4 0 -11846- 4 0 -10039- 4 0 -85970- 5           2
CARD IMAGE MUL.044.055.F    0 -74451- 5 0 -65167- 5 0 -46988- 527R+      0+ 0                                3
CARD IMAGE MUL.044.056.F    3R+      0+ 0 0 +52635- 4 0 -14391- 5 0 -42309- 438R+      0+ 0                  1
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CARD IMAGE ***.000.001.H    C ADDRESS MODIFICATION IS NOT REQUIRED
***************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE SOU.000.001.H    SOURCE
CARD IMAGE SOU.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
CARD IMAGE SOU.001.002.I    C IN2 = 1, ONE SOURCE IS BEING INPUT
CARD IMAGE SOU.001.003.I    C NVMAX = 1, THIS PROBLEM HAS ONLY ONE SOURCE
CARD IMAGE SOU.001.004.I    C NXMAX = 2, THERE ARE A MAXIMUM OF TWO POINTS IN ANY SOURCE DISTRIBUTION
CARD IMAGE SOU.001.005.I      1   1   1   2
CARD IMAGE SOU.002.001.R    C SPHERICAL GEOMETRY EQUIPROBABLE SPATIAL AND ANGULAR DISTRIBUTIONS
CARD IMAGE SOU.002.002.R    C FISSION NEUTRON SPECTRUM GENERATED INTERNALLY
CARD IMAGE SOU.002.003.R      1   2   2   2   2   2   2 80   0   0   2   1 2.91+19
CARD IMAGE SOU.003.001.EE   C RADIAL DISTRIBUTION
CARD IMAGE SOU.003.002.EE   ,0,1,87,1/
CARD IMAGE SOU.004.001.EE   C AZIMUTHAL DISTRIBUTION(SPATIAL)
CARD IMAGE SOU.004.002.EE   -3.1416  1.0       3.1416   1.0
CARD IMAGE SOU.005.001.EE   C POLAR DISTRIBUTION(SPATIAL)
CARD IMAGE SOU.005.002.EE   -1.0     1.0       1.0      1.0
CARD IMAGE SOU.006.001.EE   C AZIMUTHAL DISTRIBUTION(ANGULAR)
CARD IMAGE SOU.006.002.EE   -3.1416  1.0       3.1416   1.0                                          2.4.2.4
CARD IMAGE SOU.007.001.EE   C POLAR DISTRIBUTION(ANGULAR)
CARD IMAGE SOU.007.002.EE   -1.0     1.0       1.0      1.0                                          2.4.2.5
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CARD IMAGE ***.000.001.H    C PROFILES OF SOURCE TIME DEPENDENCE ARE NOT INPUT
***************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE SUR.000.001.H    SURFACES
CARD IMAGE SUR.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
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*************************************************************************************************************
**************************1234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD IMAGE SUR.001.002.I    C IN2 = 8, EIGHT SURFACES ARE BEING INPUT
CARD IMAGE SUR.001.003.I    C NSMAX = 8, EIGHT SURFACES TOTAL FOR THIS PROBLEM
CARD IMAGE SUR.001.004.I    C NAMAX = 6, ALL SURFACES HAVE SIX COEFFICIENTS
CARD IMAGE SUR.001.005.I    ,1,8,8,6/
CARD IMAGE SUR.002.001.S    C CORE BOUNDARY
CARD IMAGE SUR.002.002.S    ,1,,13,,87,,87,,87/
CARD IMAGE SUR.003.001.S    C REFLECTOR BOUNDARY
CARD IMAGE SUR.003.002.S    ,2,,13,,90,,90,,90/
CARD IMAGE SUR.004.001.S    C DEPLETED URANIUM SHIELD BOUNDARY
CARD IMAGE SUR.004.002.S    ,3,,13,,95,,95,,95/
CARD IMAGE SUR.005.001.S    C SHIELD MIX1 BOUNDARY
CARD IMAGE SUR.005.002.S    ,4,,13,,152,,152,,152/
CARD IMAGE SUR.006.001.S    C SHIELD MIX2 BOUNDARY
CARD IMAGE SUR.006.002.S    ,5,,13,,167,,167,,167/
CARD IMAGE SUR.007.001.S    C SHIELD MIX3 BOUNDARY
CARD IMAGE SUR.007.002.S    ,6,,13,,182,,182,,182/
CARD IMAGE SUR.008.001.S    C BORATED WATER SHIELD BOUNDARY
CARD IMAGE SUR.008.002.S    ,7,,13,,299,,299,,299/
CARD IMAGE SUR.009.001.S    C LARGE OUTER BOUNDARY TO ENCLOSE POINT DETECTOR
CARD IMAGE SUR.009.002.S    ,8,,13,,1000000,,1000000,,1000000/
*************************************************************************************************************
CARD IMAGE ***.000.001.H    C HEL ICAL SURFACES ARE NOT INVOLVED IN THE GEOMETRY
**************************1234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD IMAGE REG.000.001.H    REGIONS
CARD IMAGE REG.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
CARD IMAGE REG.001.002.I    C IN2 = 8, EIGHT REGIONS ARE BEING INPUT
CARD IMAGE REG.001.003.I    C NRMAX = 8, THERE ARE EIGHT REGIONS IN THIS PROBLEM
CARD IMAGE REG.001.004.I    C NBMAX = 2, THERE ARE A MAXIMUM OF TWO BOUNDARIES PER REGION
CARD IMAGE REG.001.005.I    ,1,8,8,2/
CARD IMAGE REG.002.001.R    C CORE
CARD IMAGE REG.002.002.R      1  1  1  1                          1.0        0.0
CARD IMAGE REG.003.001.R    C REFLECTOR
CARD IMAGE REG.003.002.R      2  0  2  1  2                       1.0        88.0
CARD IMAGE REG.004.001.R    C DEPLETED URANIUM SHIELD
CARD IMAGE REG.004.002.R      3  0  3  2  3                       1.0        92.0
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*********************************************************************************************************************
**************************1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE REG.005.001.R    C MIX1 SHIELD
CARD IMAGE REG.005.002.R      4  0  4  3  4                         1.0       120.0
CARD IMAGE REG.006.001.R    C MIX2 SHIELD
CARD IMAGE REG.006.002.R      5  0  5  4  5                         1.0       160.0
CARD IMAGE REG.007.001.R    C MIX3 SHIELD
CARD IMAGE REG.007.002.R      6  0  6  5  6                         1.0       170.0
CARD IMAGE REG.008.001.R    C BORATED WATER SHIELD
CARD IMAGE REG.008.002.R      7  0  7  6  7                         1.0       200.0
CARD IMAGE REG.009.001.R    C VOID
CARD IMAGE REG.009.002.R      8  0  0  7  8                         0.0       400.0
*********************************************************************************************************************
CARD IMAGE ***.000.001.H    C CYL INDRICAL GEOMETRY IS NOT USED
CARD IMAGE ***.000.002.H    C SPH ERICAL GEOMETRY COULD HAVE BEEN USED IN PART
CARD IMAGE ***.000.003.H    C AIR DENSITY IS USED ONLY FOR TRANSPORT IN THE UPPER ATMOSPHERE
CARD IMAGE ***.000.004.H    C CHE CK RAY TRACE OPTION IS NOT USED FOR THIS SIMPLE GEOMETRY
CARD IMAGE ***.000.005.H    C COR RELATED CALCULATIONS ARE NOT PERFORMED
**************************1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE DET.000.001.H    DETECTOR
CARD IMAGE DET.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
CARD IMAGE DET.001.002.I    C IN2 = 1, ONE DETECTOR IS BEING INPUT
CARD IMAGE DET.001.003.I    C NDMAX = 1, THERE IS ONLY ONE DETECTOR FOR THIS PROBLEM
CARD IMAGE DET.001.004.I      1  1  1
CARD IMAGE DET.002.001.S    C POINT DETECTOR AT 30 FEET FROM CORE CENTER
CARD IMAGE DET.002.002.S    ,1,0,0,1,0,0,1,0,0,914.14/
*********************************************************************************************************************
CARD IMAGE ***.000.001.H    C FLU X GROUPS ARE NOT INPUT, THE OUTPUT WILL BE IN THE CROSS SECTION GROUPS
**************************1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE RES.000.001.H    RESPONSES
CARD IMAGE RES.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
CARD IMAGE RES.001.002.I    C IN2 = 4, FOUR RESPONSES ARE BEING INPUT
CARD IMAGE RES.001.003.I    C NFMAX = 4, THERE ARE A TOTAL OF FOUR RESPONSE FUNCTIONS
CARD IMAGE RES.001.004.I    C COMMENT CARDS CANNOT FOLLOW THE NEXT CARD
CARD IMAGE RES.001.005.I      1  4  4
CARD IMAGE RES.002.001.A      MEV/CC-H20    RADS/HOUR REM/HR(TMJ) REM/HR(GHA)
CARD IMAGE RES.003.001.S    C PICKUP ENERGY ABSORBTION FOR BORATED WATER = MATERIAL 7
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*****************************************************************************************************
*************************123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE RES.003.002.S     1  0   7 7.69-5
CARD IMAGE RES.004.001.S     2  0   0 1.0-5   2.05      2.05      2.05      1.84      1.76      1.66
CARD IMAGE RES.005.001.E   1.51      1.37     1.15      1.12      1.08      0.94      0.83      0.72
CARD IMAGE RES.005.002.E   0.65      0.54     0.17      0.032     0.0072    0.0013    0.00036   3.6-4
CARD IMAGE RES.005.003.E   5.4-4     9.5-4    1.5-3     4.0-3     0.0
CARD IMAGE RES.006.001.S     3  0   0 1.0-4   1.15      1.15      1.15      1.12      1.07      1.09
CARD IMAGE RES.007.001.E   1.10      0.95     0.95      0.95      0.93      0.91      0.90      0.80
CARD IMAGE RES.007.002.E   0.60      0.54     0.54      0.21      0.05      0.05      0.05      0.05
CARD IMAGE RES.007.003.E   0.05      0.05     0.05      0.05      0.05
CARD IMAGE RES.008.001.S     4  0   0 1.0-4   1.51      1.51      1.51      1.48      1.44      1.37
CARD IMAGE RES.009.001.E   1.30      1.26     1.24      1.22      1.26      1.28      1.31      1.25
CARD IMAGE RES.009.002.E   0.85      0.69     0.32      0.06      0.06      0.06      0.06      0.06
CARD IMAGE RES.009.003.E   0.06      0.06     0.06      0.06      0.06
*****************************************************************************************************
*************************123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE BIR.000.001.H   BIRTH
CARD IMAGE BIR.001.001.I   C IN1 = 1, LIMIT IS BEING INPUT
CARD IMAGE BIR.001.002.I   C IN2 = 1, INDICES OF BIRTH REGIONS ARE BEING INPUT
CARD IMAGE BIR.001.003.I   C NVMOD = 7, THE PROGRAM WILL PRINT THE FLUXES BY BIRTH REGION FOR SEVEN REGIONS
CARD IMAGE BIR.001.004.I   C LIST OF BIRTH REGIONS
CARD IMAGE BIR.001.005.I   ,1,1,7/,1,2,3,4,5,6,7/
*****************************************************************************************************
*************************123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE ORD.000.001.H   ORDER
CARD IMAGE ORD.001.001.I   C IN1 = 1, INTERPRET LIMIT
CARD IMAGE ORD.001.002.I   C IN2 = 0, NOT USED
CARD IMAGE ORD.001.003.I   C NCMAX = 8, ORDER OF SCATTER FLUXES THROUGH SEVENTH SCATTER
CARD IMAGE ORD.001.004.I     1  0  8
*****************************************************************************************************
*************************123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE SCA.000.001.H   SCATTERING REGIONS
CARD IMAGE SCA.001.001.I   C IN1 = 1, INTERPRET LIMIT
CARD IMAGE SCA.001.002.I   C IN2 = 1, SCATTERING REGIONS ARE BEING DEFINED
CARD IMAGE SCA.001.003.I   C NSRMAX = 7, SEPARATE TALLY OF SCATTERED FLUX FROM ALL SEVEN NON-VOID REGIONS
CARD IMAGE SCA.001.004.I     1  1  7
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*************************************************************************************************************
*************************1234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD IMAGE SCA.002.001.I    C SCATTERING REGION INDICES
CARD IMAGE SCA.002.002.I       1  2  3  4  5  6  7
*************************************************************************************************************
CARD IMAGE ***.000.001.H    C BOU NDARY CROSSING TALLY NOT REQUESTED
CARD IMAGE ***.000.002.H    C ANG ULAR FLUXES NOT REQUESTED
CARD IMAGE ***.000.003.H    C SOL ID ANGLE FLUXES ARE NOT REQUESTED
CARD IMAGE ***.000.004.H    C TRA NSLATION TIME IS USED ONLY FOR TIME DEPENDENT PROBLEMS
CARD IMAGE ***.000.005.H    C MOM ENTS OF TEMPORAL FLUXES NOT REQUESTED
CARD IMAGE ***.000.006.H    C TIM E INTERVAL FLUXES ARE NOT REQUESTED
CARD IMAGE ***.000.007.H    C GRO UP EDIT ON FLUXES IS NOT REQUESTED
*************************1234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD IMAGE NOR.000.001.H    NORMAL
CARD IMAGE NOR.001.001.I    C IN1 = 1, LIMITS ARE BEING INPUT
CARD IMAGE NOR.001.002.I    C IN2 = 1, NORMAL DERIVATIVE LOCATIONS ARE BEING DEFINED BY INPUT
CARD IMAGE NOR.001.003.I    C NORMLD = 5, THERE ARE FIVE NORMAL DERIVATIVE LOCATIONS
CARD IMAGE NOR.001.004.I    C NORCOM = 2, TWO COMPONENTS ARE ALLOWED--THE SECOND SHOULD GET ALL ZERO
CARD IMAGE NOR.001.005.I    C             RESULTS SINCE ALL PARTICLES SHOULD SEE THE FIRST COMPONENT SHIELDS
CARD IMAGE NOR.001.006.I    ,1,1,5,2/
CARD IMAGE NOR.002.001.II   C DEFINITION OF BOUNDARY CROSSINGS AT WHICH DERIVATIVES WILL BE COMPUTED
CARD IMAGE NOR.002.002.II   ,3,3,4,4,5,5,6,6,7,7/
CARD IMAGE NOR.003.001.I    C DEFINITION OF FIRST COMPONENT
CARD IMAGE NOR.003.002.I    ,1,2,3,4,5/
CARD IMAGE NOR.004.001.I    C DEFINITION OF SECOND COMPONENT
CARD IMAGE NOR.004.002.I    ,0,0,0,0,0/
*************************************************************************************************************
*************************1234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD IMAGE MIN.000.001.H    MINIMUM WEIGHT
CARD IMAGE MIN.001.001.I    C IN1 = 1, LIMITS AND OPTIONS ARE BEING INPUT
CARD IMAGE MIN.001.002.I    C IN2 = 5, DOSE RATE CONSTRAINT AND FIVE INITIAL CONDITION CARDS ARE INPUT
CARD IMAGE MIN.001.003.I    C IPRESP = 1, INDEX OF RESPONSE FOR SECONDARY
CARD IMAGE MIN.001.004.I    C ISRESP = 4, INDEX OF RESPONSE FOR PRIMARY(NEUTRON)
CARD IMAGE MIN.001.005.I    C ITPRIN = 10, PRINTOUT EVERY TEN ITERATIONS DURING SHIELD OPTIMIZATION
CARD IMAGE MIN.001.006.I    C ITERMX = 1000, MAXIMUM NUMBER OF ITERATIONS DURING OPTIMIZATION
CARD IMAGE MIN.001.007.I    ,1,5,1,4,10,1000/
CARD IMAGE MIN.002.001.E    C DOSE RATE CONSTRAINT
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*******************************************************************************************************************
*************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE MIN.002.002.E    ,1-6/ DOSE RATE CONSTRAINT SET LOW TO ENSURE ITERATIONS WITH FEW HISTORIES
CARD IMAGE MIN.003.001.S    C SHIELD ONE, DEPLETED URANIUM OUTER BOUNDARY
CARD IMAGE MIN.003.002.S    ,1,2,2,5,0,1000,90,19,2+6/
CARD IMAGE MIN.004.001.S    C SHIELD TWO, MIX1 OUTER BOUNDARY
CARD IMAGE MIN.004.002.S    ,2,2,3,57,0,1000,95,6.4,7+5/
CARD IMAGE MIN.005.001.S    C SHIELD THREE, MIX2 OUTER BOUNDARY
CARD IMAGE MIN.005.002.S    ,3,2,4,15,0,1000,152,4.6,4+5/
CARD IMAGE MIN.006.001.S    C SHIELD FOUR, MIX3 OUTER BOUNDARY
CARD IMAGE MIN.006.002.S    ,4,2,5,15,0,1000,167,2.8,2+5/
CARD IMAGE MIN.007.001.S    C SHIELD FIVE, BORATED WATER OUTER BOUNDARY
CARD IMAGE MIN.007.002.S    ,5,2,0,117,0,1000,182,1,1+5/
*******************************************************************************************************************
CARD IMAGE ***.000.001.H    C DEP OSITION IN REGIONS IS NOT REQUESTED(POINT DETECTOR ONLY)
CARD IMAGE ***.000.002.H    C LEA KAGE OF ENERGY IS NOT REQUESTED(POINT DETECTOR ONLY)
CARD IMAGE ***.000.003.H    C CHA NNEL DETECTORS ARE NOT DEFINED
CARD IMAGE ***.000.004.H    C NOI SE FUNCTIONS ONLY APPLY TO CHA NNEL DETECTORS
CARD IMAGE ***.000.005.H    C PLO T OUTPUT IS NOT REQUESTED(CALCOMP)
*************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE QUI.000.001.H    QUICK PLOT
CARD IMAGE QUI.001.001.I    C IN1 = 1, INTERPRET LIMIT
CARD IMAGE QUI.001.002.I    C IN2 = 1, REQUESTS ARE BEING INPUT
CARD IMAGE QUI.001.003.I    C NQUICK = 8, EIGHT QUICK PLOTS
CARD IMAGE QUI.001.004.I    ,1,1,8/
CARD IMAGE QUI.002.001.II   C N(E) VERSUS E
CARD IMAGE QUI.002.002.II   C INTEGRAL OF N(E) VERSUS E
CARD IMAGE QUI.002.003.II   C TOTAL ENERGY FLUX VS SOURCE REGION
CARD IMAGE QUI.002.004.II   C TOTAL ENERGY FLUX VS SCATTERING REGION
CARD IMAGE QUI.002.005.II   C TOTAL ENERGY FLUX VS ORDER OF SCATTER
CARD IMAGE QUI.002.006.II   C DOSE VS SHIELD OPTIMIZATION ITERATION
CARD IMAGE QUI.002.007.II   C WEIGHT VS SHIELD OPTIMIZATION ITERATION
CARD IMAGE QUI.002.008.II   C SHIELD THICKNESSES VERSUS SHIELD OPTIMIZATION ITERATION
CARD IMAGE QUI.002.009.II   ,10,0,10,2,21,0,22,0,23,0,30,0,30,1,30,2/
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********************************************************************************************************
**************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE OPT.000.001.H   OPTIMUM
CARD IMAGE OPT.001.001.I   C IN1 = 1, INTERPRET LIMIT-OPTION
CARD IMAGE OPT.001.002.I   C IN2 = 0, THIS SECTION HAS NO OTHER INPUT
CARD IMAGE OPT.001.003.I   C NOBIAS = 1, THE PROGRAM WILL CALCULATE OPTIMUM BIASING PARAMETERS
CARD IMAGE OPT.001.004.I     1  0  1
********************************************************************************************************
CARD IMAGE ***.000.001.H   C BIA SING OPTIONS ARE USED AS BUILT IN
CARD IMAGE ***.000.002.H   C PSE UDO SPHERICAL SOURCE IS USED AS BUILT IN
CARD IMAGE ***.000.003.H   C REL ATIVE SOURCE IMPORTANCE IS USED AS BUILT IN
CARD IMAGE ***.000.004.H   C RAT IOS OF SOURCE VARIABLE IMPORTANCE ARE USED AS BUILT IN(NOT USED)
CARD IMAGE ***.000.005.H   C PRE FERRED POINT DATA IS USED AS INPUT
CARD IMAGE ***.000.006.H   C SPA TIAL IMPORTANCE IS USED AS BUILT IN
**************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE CAP.000.001.H   CAPTURE
CARD IMAGE CAP.001.001.I   C IN1 = 0, NOT USED
CARD IMAGE CAP.001.002.I   C IN2 = 1, CAPTURE RATIOS ARE BEING INPUT
CARD IMAGE CAP.001.003.I     0  1
CARD IMAGE CAP.002.001.E   C PROBABILITY OF GOING TO A ANALOG SLOWING DOWN CALCULATION = 1/4 PER COLLISION
CARD IMAGE CAP.002.002.E   ,10*0.25/
********************************************************************************************************
CARD IMAGE ***.000.001.H   C SHO RT CIRCUIT IS NOT REQUIRED FOR UNIT SHIELD PROBLEMS
CARD IMAGE ***.000.002.H   C ROT ATE AND TRANSLATE OPTION IS NOT REQUIRED
CARD IMAGE ***.000.003.H   C ARR AY DIRECT INPUT IS NOT USED
CARD IMAGE ***.000.004.H   C DUM PS ARE NOT REQUESTED
CARD IMAGE ***.000.005.H   C PRI NT SUPPRESSION COULD HAVE BEEN USED FOR THE MULTIGROUP CROSS SECTIONS
CARD IMAGE ***.000.006.H   C NEX T CASE INPUT HERE WOULD INCREMENT THE CASE NUMBER ONLY
**************************1234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE EXE.000.001.H   EXECUTE
CARD IMAGE EXE.001.001.I   C IN1 = 1, INTERPRET LIMITS
CARD IMAGE EXE.001.002.I   C IN2 = 0, NOT USED
CARD IMAGE EXE.001.003.I   C NPOINT = 1, RUN POINT DETECTORS INDIVIDUALY
CARD IMAGE EXE.001.004.I   C NPRINT = 1, ONE PRINTOUT(FINAL) ONLY
CARD IMAGE EXE.001.005.I   C NUNITS = 16, GENERATE 16 HISTORIES
CARD IMAGE EXE.001.006.I   C KALIDF = 15, A MAXIMUM OF FIFTEEN COLLISIONS PER HISTORY
CARD IMAGE EXE.001.007.I     1  0  1  1 16 15
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*********************THIS CASE USES 10316 LOCATIONS FOR INPUT, 15278 LOCATIONS TO RUN*********************
GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO

THE FASTER-III PROGRAM ****************************UNIT SHIELD TEST PROBLEM****************************CASE 1
T.M.JORDAN-A.R.T.RESEARCH********************************PRIMARY NEUTRONS********************************PAGE 72

DETECTOR... 1 0 0 1.0000+00 0.0000 0.0000 1.0000+00 0.0000 0.0000 9.1414+02

******************************FLUXES FOR DETECTOR 1 AFTER 16 PACKETS******************************

| | CALCULATED PRECISION | AVERAGE ENERGY-MEV | NUMBER FLUX DERIVATIVE | ENERGY FLUX DERIVATIVE | NUMBER FLUX THIS GROUP | ENERGY FLUX THIS GROUP | NUMBER FLUX CUMULATIVE | ENERGY FLUX CUMULATIVE |
|---|---|---|---|---|---|---|---|---|
| GROUP 1... | 3.2634-01 | 1.3222+01 | 6.2303-03 | 8.2374-02 | 1.6884-02 | 2.2323-01 | 1.6884-02 | 2.2323-01 |
| GROUP 2... | 3.3976-01 | 1.0869+01 | 2.1231-02 | 2.3076-01 | 4.6920-02 | 5.0998-01 | 6.3804-02 | 7.3321-01 |
| GROUP 3... | 3.6396-01 | 8.9050+00 | 2.7423-02 | 2.4420-01 | 4.9636-02 | 4.4201-01 | 1.1344-01 | 1.1752+00 |
| GROUP 4... | 3.8336-01 | 6.8775+00 | 8.0280-03 | 5.5212-02 | 1.7019-02 | 1.1705-01 | 1.3046-01 | 1.2923+00 |
| GROUP 5... | 5.9562-01 | 5.4121+00 | 3.3140-04 | 1.7936-03 | 3.6454-04 | 1.9730-03 | 1.3082-01 | 1.2942+00 |
| GROUP 6... | 6.1128-01 | 4.4266+00 | 1.7982-05 | 7.9601-05 | 1.6184-05 | 7.1641-05 | 1.3084-01 | 1.2943+00 |
| GROUP 7... | 8.5210-01 | 3.4703+00 | 5.3348-08 | 1.8513-07 | 5.6549-08 | 1.9624-07 | 1.3084-01 | 1.2943+00 |
| GROUP 8... | 6.9655-01 | 2.7139+00 | 4.0605-07 | 1.1020-06 | 2.1927-07 | 5.9508-07 | 1.3084-01 | 1.2943+00 |
| GROUP 9... | 6.2985-01 | 2.3786+00 | 1.4125-07 | 3.3597-07 | 3.3900-08 | 8.0633-08 | 1.3084-01 | 1.2943+00 |
| GROUP 10... | 8.7180-01 | 2.0338+00 | 3.7038-09 | 7.5330-09 | 1.4815-09 | 3.0132-09 | 1.3084-01 | 1.2943+00 |
| GROUP 11... | 9.3474-01 | 1.5175+00 | 6.3812-11 | 9.6833-11 | 3.0630-11 | 4.6480-11 | 1.3084-01 | 1.2943+00 |
| GROUP 12... | 9.6676-01 | 1.2371+00 | 7.1528-13 | 8.8491-13 | 1.7167-13 | 2.1238-13 | 1.3084-01 | 1.2943+00 |
| GROUP 13... | 9.6815-01 | 1.0062+00 | 1.1080-15 | 1.1148-15 | 2.2160-16 | 2.2297-16 | 1.3084-01 | 1.2943+00 |
| GROUP 14... | 9.6821-01 | 6.5513-01 | 1.8001-13 | 1.1793-13 | 6.4805-14 | 4.2456-14 | 1.3084-01 | 1.2943+00 |
| GROUP 15... | 9.6825-01 | 5.0924-01 | 7.3367-19 | 3.7362-19 | 1.0271-19 | 5.2306-20 | 1.3084-01 | 1.2943+00 |
| GROUP 16... | 0.0000 | 2.7726-01 | 6.8930-23 | 1.9112-23 | 2.0679-23 | 5.7335-24 | 1.3084-01 | 1.2943+00 |
| GROUP 17... | 0.0000 | 6.2500-02 | 7.8259-35 | 4.8912-36 | 7.4346-36 | 4.6466-37 | 1.3084-01 | 1.2943+00 |
| GROUP 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |
| GROUP 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3084-01 | 1.2943+00 |

************************NUMBER FLUX RESPONSES FOR DETECTOR 1 AFTER 16 PACKETS************************

| | NUMBER FLUX | ENERGY FLUX | MEV/CC-H20 | RADS/HOUR | REM/HR(TMJ) | REM/HR(GHA) |
|---|---|---|---|---|---|---|
| GROUP 1... | 1.6884-02 | 2.2323-01 | 1.4667-07 | 3.4612-07 | 1.9417-06 | 2.5495-06 |
| GROUP 2... | 4.6920-02 | 5.0998-01 | 3.7696-07 | 9.6186-07 | 5.3958-06 | 7.0849-06 |
| GROUP 3... | 4.9636-02 | 4.4201-01 | 3.9027-07 | 9.5448-07 | 5.6180-06 | 7.4049-06 |
| GROUP 4... | 1.7019-02 | 1.1705-01 | 1.2735-07 | 3.0473-07 | 1.8535-06 | 2.4767-06 |
| GROUP 5... | 3.6454-04 | 1.9730-03 | 2.5898-09 | 6.1979-09 | 3.9442-08 | 5.0968-08 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GROUP | 6... | 1.6184-05 | 7.1641-05 | 1.1232-10 | 2.5400-10 | 1.7738-09 | 2.1488-09 |
| GROUP | 7... | 5.6549-08 | 1.9624-07 | 3.5775-13 | 8.0910-13 | 5.7405-12 | 7.2234-12 |
| GROUP | 8... | 2.1927-07 | 5.9508-07 | 1.2084-12 | 2.7395-12 | 2.0831-11 | 2.7388-11 |
| GROUP | 9... | 3.3900-08 | 8.0633-08 | 1.7634-13 | 3.8597-13 | 3.2205-12 | 4.1777-12 |
| GROUP | 10... | 1.4815-09 | 3.0132-09 | 7.5223-15 | 1.6303-14 | 1.3929-13 | 1.8365-13 |
| GROUP | 11... | 3.0630-11 | 4.6480-11 | 1.3809-16 | 3.0288-16 | 2.8087-15 | 3.8992-15 |
| GROUP | 12... | 1.7167-13 | 2.1238-13 | 7.1995-19 | 1.5249-18 | 1.5541-17 | 2.2216-17 |
| GROUP | 13... | 2.2160-16 | 2.2297-16 | 8.7623-22 | 1.7127-21 | 1.8794-20 | 2.8339-20 |
| GROUP | 14... | 6.4805-14 | 4.2456-14 | 1.9958-19 | 4.3448-19 | 4.2668-18 | 6.2654-18 |
| GROUP | 15... | 1.0271-19 | 5.2306-20 | 2.8473-25 | 6.3475-25 | 5.9834-24 | 8.2522-24 |
| GROUP | 16... | 2.0679-23 | 5.7335-24 | 4.2060-29 | 7.7813-29 | 1.1167-27 | 1.0883-27 |
| GROUP | 17... | 7.4346-36 | 4.6466-37 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| TOTALS...... | | 1.3084-01 | 1.2943+00 | 1.0439-06 | 2.5736-06 | 1.4850-05 | 1.9569-05 |
| MIN ERROR... | | 1.9538-01 | 1.9427-01 | 1.9456-01 | 1.9579-01 | 1.9573-01 | 1.9561-01 |
| MOD ERROR... | | 3.5096-01 | 3.4955-01 | 3.5052-01 | 3.5077-01 | 3.5084-01 | 3.5087-01 |
| MAX ERROR... | | 3.5363-01 | 3.5006-01 | 3.5290-01 | 3.5274-01 | 3.5331-01 | 3.5338-01 |

**************************SUGGESTED CHANGES IN THE IMPORTANCE SAMPLING PARAMETERS**************************

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SPA | 1... | 8.1903-01 | 7.7411-01 | 8.1219-01 | 8.0737-01 | 8.1575-01 | 8.1650-01 |
| SPA | 2... | 9.9491-01 | 9.9656-01 | 9.9488-01 | 9.9552-01 | 9.9501-01 | 9.9499-01 |
| SPA | 3... | 8.5151-01 | 8.0997-01 | 8.4540-01 | 8.4099-01 | 8.4873-01 | 8.4933-01 |
| SPA | 4... | 1.1818+00 | 1.2405+00 | 1.1910+00 | 1.1959+00 | 1.1859+00 | 1.1849+00 |
| SPA | 5... | 9.8516-01 | 9.8318-01 | 9.8487-01 | 9.8457-01 | 9.8501-01 | 9.8504-01 |
| SPA | 6... | 9.9363-01 | 9.9278-01 | 9.9350-01 | 9.9338-01 | 9.9356-01 | 9.9358-01 |
| SPA | 7... | 9.9301-01 | 9.9201-01 | 9.9285-01 | 9.9271-01 | 9.9292-01 | 9.9294-01 |
| SPA | 8... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| PRE | 1... | 1.2731+00 | 1.1597+00 | 1.2602+00 | 1.2497+00 | 1.2668+00 | 1.2684+00 |
| PRE | 2... | -3.4725-01 | -4.0135-01 | -3.5870-01 | -3.6613-01 | -3.5280-01 | -3.5162-01 |
| PRE | 3... | 1.4730+00 | 1.5309+00 | 1.4841+00 | 1.4885+00 | 1.4778+00 | 1.4766+00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PRE | 4... | 1.6542+00 | 1.6972+00 | 1.6627+00 | 1.6698+00 | 1.6591+00 | 1.6578+00 |
| PSE | 1... | 1.0000+01 | 1.0000+01 | 1.0000+01 | 1.0000+01 | 1.0000+01 | 1.0000+01 |
| PSE | 2... | 1.0107-01 | 4.7256-02 | 9.1232-02 | 8.2640-02 | 9.5897-02 | 9.7002-02 |
| PSE | 3... | 1.0692+00 | 1.1996+00 | 1.0902+00 | 1.0996+00 | 1.0782+00 | 1.0761+00 |
| REL | 1... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| REL | 2... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| RAT | 11... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| RAT | 12... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 13... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 14... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 15... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 21... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 22... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 23... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 24... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 25... | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 | 1.0000+00 |

************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS************************

| | | ITERANT 1 | SOURCE 1 | SOURCE 2 | SOURCE 3 | SOURCE 4 | SOURCE 5 | SOURCE 6 | SOURCE 7 |
|---|---|---|---|---|---|---|---|---|---|
| GROUP | 1... | 6.2303-03 | 6.2303-03 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 2... | 2.1231-02 | 2.1231-02 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 3... | 2.7423-02 | 2.7423-02 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 4... | 8.0280-03 | 8.0280-03 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 5... | 3.3140-04 | 3.3140-04 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 6... | 1.7982-05 | 1.7982-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 7... | 5.3348-08 | 5.3348-08 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 8... | 4.0605-07 | 4.0605-07 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 9... | 1.4125-07 | 1.4125-07 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 10... | 3.7038-09 | 3.7038-09 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 11... | 6.3812-11 | 6.3812-11 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 12... | 7.1528-13 | 7.1528-13 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 13... | 1.1080-15 | 1.1080-15 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 14... | 1.8001-13 | 1.8001-13 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 15... | 7.3367-19 | 7.3367-19 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 16... | 6.8930-23 | 6.8930-23 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 17... | 7.8259-35 | 7.8259-35 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP | 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GROUP 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NUMBER FLUX | 1.3084-01 | 1.3084-01 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| ENERGY FLUX | 1.2943+00 | 1.2943+00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MEV/CC-H20 | 1.0439-06 | 1.0439-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| RADS/HOUR | 2.5736-06 | 2.5736-06 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| REM/HR(TMJ) | 1.4850-05 | 1.4850-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| REM/HR(GHA) | 1.9569-05 | 1.9569-05 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS***************************

| | REGION 1 | REGION 2 | REGION 3 | REGION 4 | REGION 5 | REGION 6 | REGION 7 | SCATTER 0 |
|---|---|---|---|---|---|---|---|---|
| GROUP 1... | 2.7251-04 | 0.0000 | 8.6033-05 | 1.8109-03 | 3.4202-07 | 9.6627-09 | 9.4686-09 | 4.0605-03 |
| GROUP 2... | 1.0474-03 | 7.8132-06 | 2.3413-04 | 7.4497-03 | 4.5381-06 | 1.4583-07 | 2.2149-07 | 1.2487-02 |
| GROUP 3... | 1.3721-03 | 1.7357-05 | 2.3540-04 | 1.1048-02 | 1.3984-05 | 2.1343-06 | 9.6279-07 | 1.4733-02 |
| GROUP 4... | 3.6424-04 | 7.9133-06 | 4.0850-05 | 4.3953-03 | 2.8632-05 | 3.8467-06 | 3.8789-06 | 3.1833-03 |
| GROUP 5... | 1.0577-05 | 4.2962-07 | 8.0463-07 | 2.2568-04 | 2.0210-06 | 1.7287-07 | 5.2541-06 | 8.6459-05 |
| GROUP 6... | 3.0794-07 | 2.2786-08 | 1.5247-08 | 1.1492-05 | 6.5371-07 | 3.5551-07 | 2.8626-06 | 2.2725-06 |
| GROUP 7... | 2.4630-11 | 2.3958-12 | 5.0763-13 | 2.0786-09 | 9.9169-10 | 1.0190-09 | 4.9042-08 | 1.8956-10 |
| GROUP 8... | 1.1399-09 | 2.4493-10 | 2.2146-11 | 7.8034-08 | 1.9510-08 | 2.3946-08 | 2.7698-07 | 6.1822-09 |
| GROUP 9... | 1.1458-09 | 3.2508-10 | 1.9910-11 | 2.7950-08 | 1.8122-08 | 8.2501-10 | 8.7603-08 | 5.2579-09 |
| GROUP 10... | 6.3960-14 | 2.4410-14 | 6.8414-16 | 1.2033-11 | 1.1162-11 | 3.1508-12 | 3.6770-09 | 3.7907-13 |
| GROUP 11... | 3.3119-18 | 1.6109-18 | 1.9631-20 | 3.3964-15 | 1.2699-14 | 2.4211-14 | 6.3771-11 | 2.1449-17 |
| GROUP 12... | 4.0591-24 | 3.3527-24 | 1.1019-26 | 2.4246-20 | 3.3940-19 | 4.9929-18 | 7.1528-13 | 3.2446-23 |
| GROUP 13... | 0.0000 | 0.0000 | 0.0000 | 4.4459-26 | 1.3920-24 | 3.7504-25 | 1.1080-15 | 0.0000 |
| GROUP 14... | 0.0000 | 0.0000 | 0.0000 | 2.5287-23 | 3.8541-22 | 4.4710-22 | 1.8001-13 | 0.0000 |
| GROUP 15... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0397-34 | 7.2215-33 | 7.3367-19 | 0.0000 |
| GROUP 16... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.8930-23 | 0.0000 |
| GROUP 17... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.8259-35 | 0.0000 |
| GROUP 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GROUP 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NUMBER FLUX | 6.3209-03 | 6.5953-05 | 1.2641-03 | 5.0946-02 | 9.9795-05 | 1.2891-05 | 1.9061-05 | 7.2112-02 |
| ENERGY FLUX | 6.2414-02 | 5.8547-04 | 1.3101-02 | 4.8738-01 | 7.7880-04 | 9.6819-05 | 1.2106-04 | 7.2983-01 |
| MEV/CC-H20 | 5.0402-08 | 5.1478-10 | 1.0187-08 | 4.0370-07 | 7.6182-10 | 9.7864-11 | 1.3960-10 | 5.7815-07 |
| RADS/HOUR | 1.2438-07 | 1.2668-09 | 2.5146-08 | 9.9388-07 | 1.8454-09 | 2.3587-10 | 3.3287-10 | 1.4266-06 |
| REM/HR(TMJ) | 7.1761-07 | 7.4220-09 | 1.4407-07 | 5.7639-06 | 1.1042-08 | 1.4224-09 | 2.0813-09 | 8.2027-06 |
| REM/HR(GHA) | 9.4558-07 | 9.8044-09 | 1.8963-07 | 7.6025-06 | 1.4655-08 | 1.8865-09 | 2.7127-09 | 1.0802-05 |

*************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS***************************

| | SCATTER 1 | SCATTER 2 | SCATTER 3 | SCATTER 4 | SCATTER 5 | SCATTER 6 | SCATTER 7 |
|---|---|---|---|---|---|---|---|
| GROUP 1... | 1.6858-03 | 4.3508-04 | 3.2970-05 | 1.5183-05 | 7.1050-07 | 7.7727-08 | 1.0755-08 |
| GROUP 2... | 5.3401-03 | 3.1956-03 | 1.3273-04 | 6.8073-05 | 6.4975-06 | 7.9635-07 | 1.9122-07 |
| GROUP 3... | 6.5782-03 | 5.7482-03 | 2.3434-04 | 1.0807-04 | 1.7135-05 | 3.3964-06 | 4.2969-07 |
| GROUP 4... | 1.7827-03 | 2.8094-03 | 1.2713-04 | 8.5465-05 | 3.0184-05 | 5.8620-06 | 2.8442-06 |
| GROUP 5... | 7.4834-05 | 1.3653-04 | 1.2485-05 | 1.2880-05 | 2.3162-06 | 6.3381-07 | 1.2285-06 |
| GROUP 6... | 3.8472-06 | 5.2341-06 | 1.2427-06 | 1.4556-06 | 6.3858-07 | 4.2800-07 | 2.8387-07 |
| GROUP 7... | 3.3574-10 | 6.9749-10 | 3.9718-10 | 6.3206-10 | 9.3405-10 | 1.1161-09 | 6.9187-09 |
| GROUP 8... | 1.3582-08 | 2.0619-08 | 2.5645-08 | 1.6367-08 | 1.8980-08 | 2.7489-08 | 6.3244-08 |
| GROUP 9... | 3.9944-09 | 6.9812-09 | 4.8951-09 | 1.1657-08 | 1.8114-08 | 2.6978-09 | 6.7450-08 |
| GROUP 10... | 1.0553-12 | 2.8627-12 | 3.8561-12 | 3.4676-12 | 9.2653-12 | 5.7142-12 | 4.3827-10 |
| GROUP 11... | 9.2907-17 | 1.5959-16 | 5.5786-16 | 1.6126-15 | 9.4541-15 | 2.8242-14 | 3.6645-13 |
| GROUP 12... | 3.4555-22 | 8.8750-22 | 6.7070-21 | 1.3370-20 | 2.9514-19 | 5.0346-18 | 2.6127-15 |
| GROUP 13... | 0.0000 | 1.2875-29 | 6.7362-28 | 1.3882-26 | 3.3865-25 | 1.4455-24 | 1.2740-20 |
| GROUP 14... | 4.9771-27 | 3.2426-26 | 3.6383-25 | 2.0606-23 | 1.0856-22 | 7.1647-22 | 2.5391-19 |
| GROUP 15... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0397-34 | 7.2215-33 | 2.1560-28 |
| GROUP 16... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.5705-34 |
| GROUP 17... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GROUP 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NUMBER FLUX | 3.2142-02 | 2.4756-02 | 1.0912-03 | 5.8387-04 | 1.1443-04 | 2.1645-05 | 8.9239-06 |
| ENERGY FLUX | 3.2116-01 | 2.2679-01 | 1.0080-02 | 5.2496-03 | 9.1416-04 | 1.6765-04 | 6.1975-05 |
| MEV/CC-H20 | 2.5701-07 | 1.9445-07 | 8.5899-09 | 4.5696-09 | 8.7695-10 | 1.6502-10 | 6.6576-11 |
| RADS/HOUR | 6.3367-07 | 4.7828-07 | 2.1078-08 | 1.1195-08 | 2.1285-09 | 3.9923-10 | 1.5988-10 |
| REM/HR(TMJ) | 3.6511-06 | 2.7907-06 | 1.2298-07 | 6.5581-08 | 1.2692-08 | 2.3951-09 | 9.7640-10 |
| REM/HR(GHA) | 4.8101-06 | 3.6849-06 | 1.6235-07 | 8.6634-08 | 1.6833-08 | 3.1739-09 | 1.2918-09 |

************************SHIELD DERIVATIVES FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | SEGMENT 1 | NORMAL 1 | NORMAL 2 | NORMAL 3 | NORMAL 4 | NORMAL 5 |
|---|---|---|---|---|---|---|
| GROUP 1... | 6.2303-03 | -1.2893-03 | -7.8975-04 | -7.0241-04 | -6.1760-04 | -5.2594-04 |
| GROUP 2... | 2.1231-02 | -4.2595-03 | -2.7443-03 | -2.4610-03 | -2.1847-03 | -1.8829-03 |
| GROUP 3... | 2.7423-02 | -5.3984-03 | -3.6892-03 | -3.3405-03 | -2.9988-03 | -2.6211-03 |
| GROUP 4... | 8.0280-03 | -1.6346-03 | -1.1994-03 | -1.0973-03 | -9.9551-04 | -8.7986-04 |
| GROUP 5... | 3.3140-04 | -5.9628-05 | -5.5692-05 | -5.2050-05 | -4.8080-05 | -4.3753-05 |
| GROUP 6... | 1.7982-05 | -3.5164-06 | -3.0478-06 | -2.9892-06 | -2.8239-06 | -2.7669-06 |
| GROUP 7... | 5.3348-08 | -8.4427-09 | -5.9606-09 | -8.1082-09 | -7.1277-09 | -1.1083-08 |
| GROUP 8... | 4.0605-07 | -8.4895-08 | -5.5612-08 | -6.7151-08 | -6.3885-08 | -7.6905-08 |
| GROUP 9... | 1.4125-07 | -4.4026-08 | -1.8572-08 | -1.9410-08 | -1.9374-08 | -2.7048-08 |
| GROUP 10... | 3.7038-09 | -5.7996-10 | -4.4820-10 | -6.4632-10 | -5.7479-10 | -9.1843-10 |
| GROUP 11... | 6.3812-11 | -8.7433-12 | -6.9679-12 | -1.0111-11 | -8.6051-12 | -1.9494-11 |
| GROUP 12... | 7.1528-13 | -9.0590-14 | -7.1592-14 | -1.0313-13 | -8.5027-14 | -2.7059-13 |
| GROUP 13... | 1.1080-15 | -1.3967-16 | -1.1111-16 | -1.5970-16 | -1.3148-16 | -5.3349-16 |
| GROUP 14... | 1.8001-13 | -2.2686-14 | -1.8081-14 | -2.5971-14 | -2.1377-14 | -7.8055-14 |
| GROUP 15... | 7.3367-19 | -9.2736-20 | -7.6301-20 | -1.1010-19 | -9.0982-20 | -4.6714-19 |
| GROUP 16... | 6.8930-23 | -8.9423-24 | -8.7097-24 | -1.3099-23 | -1.1126-23 | -5.2757-23 |
| GROUP 17... | 7.8259-35 | -1.0186-35 | -9.9598-36 | -1.5074-35 | -1.2835-35 | -9.0919-35 |
| GROUP 18... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 19... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 20... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 21... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 22... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 23... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 24... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 25... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 26... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NUMBER FLUX | 1.3084-01 | -2.6213-02 | -1.7489-02 | -1.5775-02 | -1.4096-02 | -1.2247-02 |
| ENERGY FLUX | 1.2943+00 | -2.5972-01 | -1.7151-01 | -1.5445-01 | -1.3775-01 | -1.1942-01 |

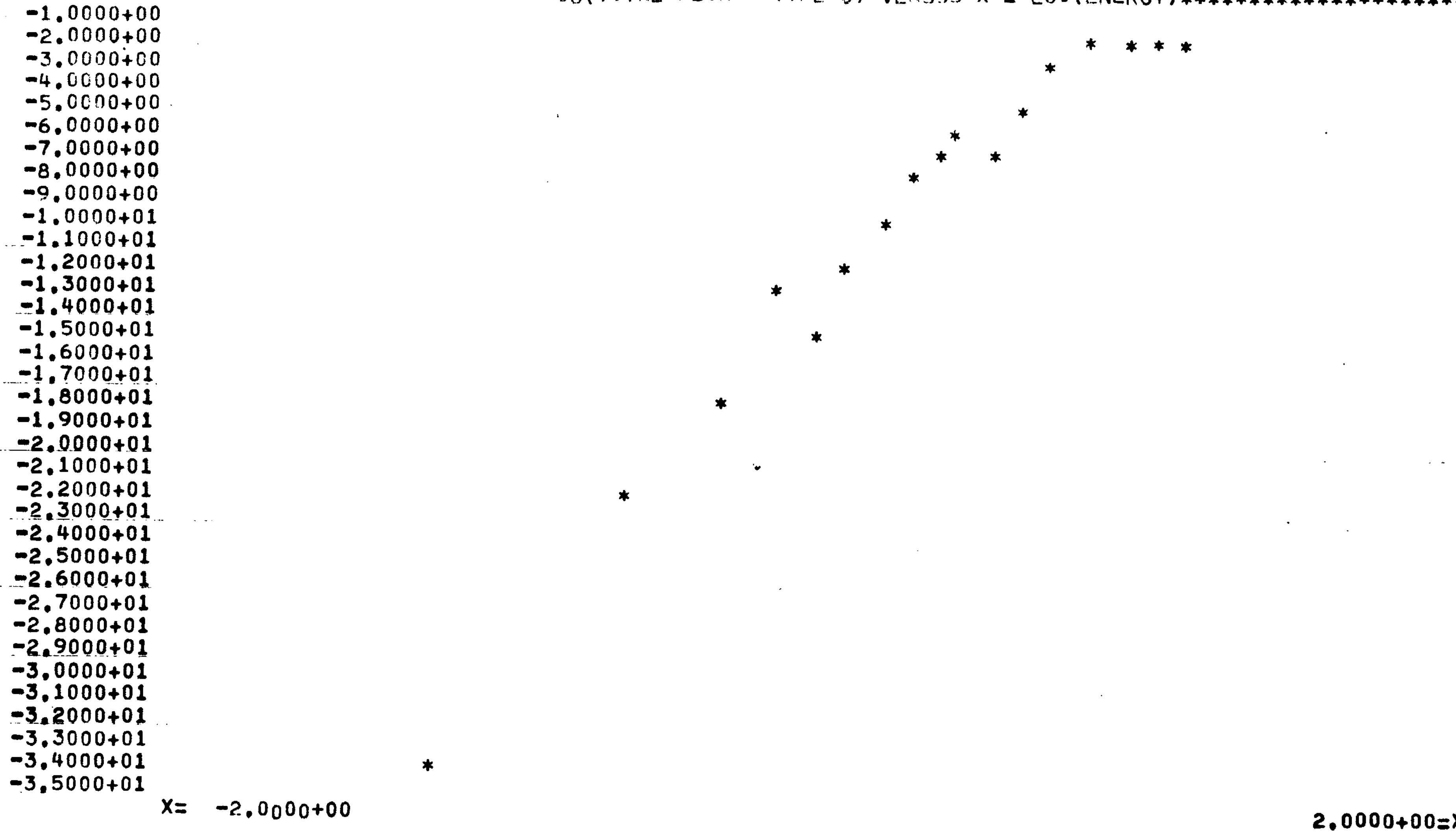
| | | | | | | |
|---|---|---|---|---|---|---|
| MEV/CC-H2O | 1.0439-06 | -2.0922-07 | -1.3930-07 | -1.2560-07 | -1.1219-07 | -9.7433-08 |
| RADS/HOUR | 2.5736-06 | -5.1571-07 | -3.4322-07 | -3.0945-07 | -2.7639-07 | -2.4001-07 |
| REM/HR(TMJ) | 1.4850-05 | -2.9751-06 | -1.9832-06 | -1.7885-06 | -1.5979-06 | -1.3881-06 |
| REM/HR(GHA) | 1.9569-05 | -3.9206-06 | -2.6141-06 | -2.3575-06 | -2.1064-06 | -1.8299-06 |

************************SHIELD DERIVATIVES FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | SEGMENT 2 |
|---|---|
| GROUP 1... | 0.0000 |
| GROUP 2... | 0.0000 |
| GROUP 3... | 0.0000 |
| GROUP 4... | 0.0000 |
| GROUP 5... | 0.0000 |
| GROUP 6... | 0.0000 |
| GROUP 7... | 0.0000 |
| GROUP 8... | 0.0000 |
| GROUP 9... | 0.0000 |
| GROUP 10... | 0.0000 |
| GROUP 11... | 0.0000 |
| GROUP 12... | 0.0000 |
| GROUP 13... | 0.0000 |
| GROUP 14... | 0.0000 |
| GROUP 15... | 0.0000 |
| GROUP 16... | 0.0000 |
| GROUP 17... | 0.0000 |
| GROUP 18... | 0.0000 |
| GROUP 19... | 0.0000 |
| GROUP 20... | 0.0000 |
| GROUP 21... | 0.0000 |
| GROUP 22... | 0.0000 |
| GROUP 23... | 0.0000 |
| GROUP 24... | 0.0000 |
| GROUP 25... | 0.0000 |
| GROUP 26... | 0.0000 |
| NUMBER FLUX | 0.0000 |
| ENERGY FLUX | 0.0000 |
| MEV/CC-H2O | 0.0000 |
| RADS/HOUR | 0.0000 |
| REM/HR(TMJ) | 0.0000 |

REM/HR(GHA) 0.0000

*********************QUICK PLOT OF Y = LOG(TOTAL FLUX - TYPE 0) VERSUS X = LOG(ENERGY)*********************



```
**********************QUICK PLOT OF Y = LOG(TOTAL FLUX - TYPE 2) VERSUS X = LOG(ENERGY)*********************
 -1.0000+00
 -1.0588+00
 -1.1176+00
 -1.1765+00       *    *    *    *    *    *       *       *      *        *     **  ** ******
 -1.2353+00                                                                                    *
 -1.2941+00
 -1.3529+00
 -1.4118+00
 -1.4706+00
 -1.5294+00
 -1.5882+00                                                                                     *
 -1.6471+00
 -1.7059+00
 -1.7647+00
 -1.8235+00
 -1.8824+00
 -1.9412+00
 -2.0000+00
 -2.0588+00
 -2.1176+00
 -2.1765+00                                                                                      *
 -2.2353+00
 -2.2941+00
 -2.3529+00
 -2.4118+00
 -2.4706+00
 -2.5294+00
 -2.5882+00
 -2.6471+00
 -2.7059+00
 -2.7647+00
 -2.8235+00
 -2.8824+00
 -2.9412+00
 -3.0000+00
             X=  -7.0000+00                                                                    2.0000+00=X
```

******************QUICK PLOT OF Y = LOG(    SOURCE ENERGY FLUX) VERSUS X = COMPONENT INDEX******************
**************************************THE RANGE OF X AND/OR Y IS ZERO**************************************

```
*****************QUICK PLOT OF Y = LOG(   REGION ENERGY FLUX) VERSUS X = COMPONENT INDEX*****************
  0,0000
-1,4706-01
-2,9412-01                                                 *
-4,4118-01
-5,8824-01
-7,3529-01
-8,8235-01
-1,0294+00
-1,1765+00 *
-1,3235+00
-1,4706+00
-1,6176+00
-1,7647+00
-1,9118+00                                 *
-2,0588+00
-2,2059+00
-2,3529+00
-2,5000+00
-2,6471+00
-2,7941+00
-2,9412+00                                                                  *
-3,0882+00
-3,2353+00                  *
-3,3824+00
-3,5294+00
-3,6765+00
-3,8235+00                                                                                 *                *
-3,9706+00
-4,1176+00
-4,2647+00
-4,4118+00
-4,5588+00
-4,7059+00
-4,8529+00
-5,0000+00
            X=   1,0000+00                                                                        7.0000+00=X
```

```
******************QUICK PLOT OF Y = LOG(  SCATTER ENERGY FLUX) VERSUS X = COMPONENT INDEX*****************
  0.0000
-1.4706-01 *
-2.9412-01
-4.4118-01              *
-5.8824-01                            *
-7.3529-01
-8.8235-01
-1.0294+00
-1.1765+00
-1.3235+00
-1.4706+00
-1.6176+00
-1.7647+00
-1.9118+00
-2.0588+00                                         *
-2.2059+00
-2.3529+00                                                       *
-2.5000+00
-2.6471+00
-2.7941+00
-2.9412+00
-3.0882+00                                                                    *
-3.2353+00
-3.3824+00
-3.5294+00
-3.6765+00
-3.8235+00                                                                                  *
-3.9706+00
-4.1176+00
-4.2647+00                                                                                               *
-4.4118+00
-4.5588+00
-4.7059+00
-4.8529+00
-5.0000+00
          X=   0.0000                                                                       7.0000+00=X
```

**********************BOUNDARY SEARCH PARAMETERS, (SURFACE,MOST PROBABLE NEXT REGION)**********************

```
REGION    1(    1,    2)
REGION    2(   -1,    1)(    2,    3)
REGION    3(   -2,    2)(    3,    4)
REGION    4(   -3,    3)(    4,    5)
REGION    5(   -4,    4)(    5,    6)
REGION    6(   -5,    5)(    6,    7)
REGION    7(   -6,    6)(    7,    8)
REGION    8(   -7,    7)(    8,  -11)
```

```
*****************************************************************************************************************
***************************123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE TAP.000.001.H   TAPES
CARD IMAGE TAP.001.001.I   C DEFINE SOURCE TAPE CONTAINING FLUXES FOR SECONDARY SOURCES
CARD IMAGE TAP.001.002.1      1  0  0  0  0  9  0  0
```

```
*******************************************************************************************************
**************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE LAB.000.001.H   LABEL
CARD IMAGE LAB.001.001.I     0  1
CARD IMAGE LAB.002.001.A   ************************UNIT SHIELD TEST PROBLEM***********************
CARD IMAGE LAB.002.002.A   ****************************SECONDARY PHOTONS*************************
*******************************************************************************************************
**************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE PHO.000.001.H   PHOTON CROSS SECTIONS
CARD IMAGE PHO.001.001.I     1  1 15  0  0
CARD IMAGE PHO.002.001.E   C ENERGY GROUPS
CARD IMAGE PHO.002.002.E   ,8,5.5,5,4.5,4,3.5,3,2.6,2.2,1.8,1.35,.9,.4,.26,.15,.08/
CARD IMAGE PHO.003.001.I   C HYDROGEN
CARD IMAGE PHO.003.002.I     0  0 14  0  0  0 14 14
CARD IMAGE PHO.004.001.E   C TAB ENERGIES
CARD IMAGE PHO.004.002.E   ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.005.001.E   C PAIR PRODUCTION
CARD IMAGE PHO.005.002.E   ,2.7-3,2.2-3,1.5-3,1.2-3,8.7-4,5.2-4,1.8,4,4.4-5/
CARD IMAGE PHO.006.001.E   C PHOTOELECTRIC
CARD IMAGE PHO.006.002.E   ,7*0,1.8-9,5.2-9,2.1-8,6.6-8,4.5-7,1.0-6,6.0-6/
CARD IMAGE PHO.007.001.I   C BERYLLIUM
CARD IMAGE PHO.007.002.I     0  0 14  0  0  0 14 14
CARD IMAGE PHO.008.001.E   C TAB ENERGIES
CARD IMAGE PHO.008.002.E   ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.009.001.E   C PAIR PRODUCTION
CARD IMAGE PHO.009.002.E   ,3.7-2,2.82-2,2.28-2,1.84-2,1.32-2,8.2-3,2.8-3,7.-4/
CARD IMAGE PHO.010.001.E   C PHOTOELECTRIC
CARD IMAGE PHO.010.002.E   ,7.2-8,9.3-8,1.3-7,1.6-7,2-7,3.7-7,9-7,1.7-6,4-6,1.6-5,5-5,3.5-4,8.2-4
CARD IMAGE PHO.010.003.E   ,5.2-3/
CARD IMAGE PHO.011.001.I   C BORON
CARD IMAGE PHO.011.002.I     0  0 14  0  0  0 14 14
CARD IMAGE PHO.012.001.E   C TAB ENERGIES
CARD IMAGE PHO.012.002.E   ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.013.001.E   C PAIR PRODUCTION
CARD IMAGE PHO.013.002.E   ,5.9-2,4.8-2,3.7-2,3.0-2,2.2-2,1.3-2,4.5-2,1.1-3/
CARD IMAGE PHO.014.001.E   C PHOTOELECTRIC
CARD IMAGE PHO.014.002.E   ,2.2-7,2.9-7,4.1-7,5.2-7,7-7,1-6,2.5-6,4.6-6,1.2-5,5-5,1.6-4,1.1-3,2.4-3
```

9



```
************************************************************************************************************
***************************12345678901234567890123456789012345678901234567890123456789012345678901234567690
CARD IMAGE PHO.014.003.E    ,1.6-2/
CARD IMAGE PHO.015.001.I    C OXYGEN
CARD IMAGE PHO.015.002.I      0  0 14  0  0  0 14 14
CARD IMAGE PHO.016.001.E    C TAB ENERGIES
CARD IMAGE PHO.016.002.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.017.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.017.002.E    ,1.4-1,1.15-1,8.8-2,7.09-2,5.34-2,3.21-2,1.11-2,2.8-3/
CARD IMAGE PHO.018.001.E    C PHOTOELECTRIC
CARD IMAGE PHO.018.002.E    ,2.3-6,3.2-6,4.8-6,6.2-6,8.5-6,1.25-5,2.2-5,4.5-5,1.2-4,4-4,1.1-3,6.5-3
CARD IMAGE PHO.018.003.E    ,2-2,1.5-1/
CARD IMAGE PHO.019.001.I    C ALUMINUM
CARD IMAGE PHO.019.002.I      0  0 14  0  0  0 14 14
CARD IMAGE PHO.020.001.E    C TAB ENERGIES
CARD IMAGE PHO.020.002.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.021.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.021.002.E    ,3.61-1,3-1,2.99-1,1.87-1,1.406-1,8.62-2,3-2,7.6-3/
CARD IMAGE PHO.022.001.E    C PHOTOELECTRIC
CARD IMAGE PHO.022.002.E    ,3-5,4.9-5,5.4-5,6.6-5,8.5-5,1.2-4,2.5-4,5-4,1.2-3,4-3,1.3-2,9.2-2
CARD IMAGE PHO.022.003.E    ,2.15-1,1.57/
CARD IMAGE PHO.023.001.I      0  0 14  0  0  0 14 14
CARD IMAGE PHO.024.001.E    C TAB ENERGIES
CARD IMAGE PHO.024.002.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.025.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.025.002.E    ,3.27,2.78,2.16,1.8,1.36,.85,.31,.084/
CARD IMAGE PHO.026.001.E    C PHOTOELECTRIC
CARD IMAGE PHO.026.002.E    ,8.5-3,1.2-2,1.6-2,2.1-2,2.5-2,3.8-2,6.5-2,.115,.24,.7,2.05,15.5,35,251/
CARD IMAGE PHO.027.001.I    C TUNGSTEN
CARD IMAGE PHO.027.002.I      0  0 14  0  0  0 14 14
CARD IMAGE PHO.028.001.E    C TAB ENERGIES
CARD IMAGE PHO.028.002.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.08/
CARD IMAGE PHO.029.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.029.002.E    ,10.24,8.71,7.03,5.968,4.684,3.1309,1.32,.41/
CARD IMAGE PHO.030.001.E    C PHOTOELECTRIC
CARD IMAGE PHO.030.002.E    ,.18,.23,.31,.4,.5,.72,1.2,2,4,11,30,185,410,3500/
CARD IMAGE PHO.031.001.I    C URANIUM 235
```

```
*************************************************************************************************************************
*************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE PHO.031.002.I     0  0 16  0  0  0 16 16
CARD IMAGE PHO.032.001.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.11501,.115,.08/
CARD IMAGE PHO.033.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.033.002.E    ,15.06,12.84,10.42,9.01,7.264,5.091,2.35,.77/
CARD IMAGE PHO.034.001.E    C PHOTOELECTRIC
CARD IMAGE PHO.034.002.E    ,.46,.6,.82,1,1.3,1.9,3.3,5.2,10.5,29,73,440,920,1750,640,1700/
CARD IMAGE PHO.035.001.I    C URANIUM 238
CARD IMAGE PHO.035.002.I     0  0 16  0  0  0 16 16
CARD IMAGE PHO.036.001.E    ,10,8,6,5,4,3,2,1.5,1,.6,.4,.2,.15,.11501,.115,.08/
CARD IMAGE PHO.037.001.E    C PAIR PRODUCTION
CARD IMAGE PHO.037.002.E    ,15.06,12.84,10.42,9.01,7.264,5.091,2.35,.77/
CARD IMAGE PHO.038.001.E    ,.46,.6,.82,1,1.3,1.9,3.3,5.2,10.5,29,73,440,920,1750,640,1700/
*************************************************************************************************************************
*************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE SOU.000.001.H    SOURCE
CARD IMAGE SOU.001.001.I     0  1
CARD IMAGE SOU.002.001.R    C SOURCE DISTRIBUTIONS REMAIN EXCEPT FOR INTERNAL GAMMA SPECTRUM
CARD IMAGE SOU.002.002.R     1  2 -1 -1 -1 -1 -1 75  1  0  2  3 1.74+20
CARD IMAGE SOU.003.001.E    1,1
*************************************************************************************************************************
*************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE RES.000.001.H    RESPONSE FUNCTION
CARD IMAGE RES.001.001.I     1  1  1
CARD IMAGE RES.002.001.A          REM/HR
CARD IMAGE RES.003.001.S     1  1  0 1.14-7  9.23      10.25     10.6      10.9      11.2      11.7
CARD IMAGE RES.004.001.E    12.2      12.4      13.3      14.14     15.2      16.35     17.0      16.2
CARD IMAGE RES.004.002.E    14.45     13.7
*************************************************************************************************************************
*************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE EXE.000.001.H    EXECUTE
CARD IMAGE EXE.001.001.I     1  0  1  1 16  5
*********************THIS CASE USES 10972 LOCATIONS FOR INPUT, 15228 LOCATIONS TO RUN**********************
GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO*GO
```

DETECTOR... 1 0 0 1.0000+00 0.0000 0.0000 1.0000+00 0.0000 0.0000 9.1414+02

*******************************FLUXES FOR DETECTOR 1 AFTER 16 PACKETS*******************************

| | CALCULATED PRECISION | AVERAGE ENERGY-MEV | NUMBER FLUX DERIVATIVE | ENERGY FLUX DERIVATIVE | NUMBER FLUX THIS GROUP | ENERGY FLUX THIS GROUP | NUMBER FLUX CUMULATIVE | ENERGY FLUX CUMULATIVE |
|---|---|---|---|---|---|---|---|---|
| GROUP 1... | 7.9446-01 | 6.7496+00 | 1.9223-01 | 1.2975+00 | 4.8059-01 | 3.2439+00 | 4.8059-01 | 3.2439+00 |
| GROUP 2... | 8.4969-01 | 5.2500+00 | 9.7274-01 | 5.1069+00 | 4.8637-01 | 2.5534+00 | 9.6696-01 | 5.7973+00 |
| GROUP 3... | 7.4457-01 | 4.7390+00 | 1.2659+00 | 5.8426+00 | 9.3296-01 | 4.4213+00 | 1.8999+00 | 1.0219+01 |
| GROUP 4... | 8.8214-01 | 4.2500+00 | 2.1581+00 | 9.1718+00 | 1.0790+00 | 4.5859+00 | 2.9790+00 | 1.4804+01 |
| GROUP 5... | 7.7055-01 | 3.7522+00 | 2.5190+00 | 9.4516+00 | 1.2595+00 | 4.7258+00 | 4.2384+00 | 1.9530+01 |
| GROUP 6... | 7.0412-01 | 3.2352+00 | 2.1146+00 | 6.8413+00 | 1.0573+00 | 3.4207+00 | 5.2958+00 | 2.2951+01 |
| GROUP 7... | 6.6495-01 | 2.7904+00 | 1.7944+00 | 5.0071+00 | 7.1775-01 | 2.0028+00 | 6.0135+00 | 2.4954+01 |
| GROUP 8... | 6.1086-01 | 2.4028+00 | 4.3957-01 | 1.0562+00 | 1.7583-01 | 4.2248-01 | 6.1893+00 | 2.5376+01 |
| GROUP 9... | 9.6811-01 | 2.1682+00 | 3.9207-02 | 8.5010-02 | 1.5683-02 | 3.4004-02 | 6.2050+00 | 2.5410+01 |
| GROUP 10... | 9.6765-01 | 1.4282+00 | 2.8586-02 | 4.0827-02 | 1.2864-02 | 1.8372-02 | 6.2179+00 | 2.5429+01 |
| GROUP 11... | 9.4247-01 | 9.5941-01 | 3.5139+00 | 3.3712+00 | 1.5812+00 | 1.5171+00 | 7.7991+00 | 2.6946+01 |
| GROUP 12... | 5.6773-01 | 5.3010-01 | 1.0624-01 | 5.6317-02 | 5.3119-02 | 2.8158-02 | 7.8522+00 | 2.6974+01 |
| GROUP 13... | 9.1194-01 | 3.7667-01 | 2.4253-03 | 9.1355-04 | 3.3954-04 | 1.2790-04 | 7.8526+00 | 2.6974+01 |
| GROUP 14... | 9.5658-01 | 2.4098-01 | 3.7353-04 | 9.0015-05 | 4.1089-05 | 9.9016-06 | 7.8526+00 | 2.6974+01 |
| GROUP 15... | 6.6802-01 | 1.0970-01 | 2.9864-09 | 3.2761-10 | 2.0905-10 | 2.2933-11 | 7.8526+00 | 2.6974+01 |

************************NUMBER FLUX RESPONSES FOR DETECTOR 1 AFTER 16 PACKETS************************

| | NUMBER FLUX | ENERGY FLUX | REM/HR |
|---|---|---|---|
| GROUP 1... | 4.8059-01 | 3.2439+00 | 3.5670-06 |
| GROUP 2... | 4.8637-01 | 2.5534+00 | 3.0322-06 |
| GROUP 3... | 9.3296-01 | 4.4213+00 | 5.4177-06 |
| GROUP 4... | 1.0790+00 | 4.5859+00 | 5.7722-06 |
| GROUP 5... | 1.2595+00 | 4.7258+00 | 6.1584-06 |
| GROUP 6... | 1.0573+00 | 3.4207+00 | 4.6582-06 |
| GROUP 7... | 7.1775-01 | 2.0028+00 | 2.8078-06 |
| GROUP 8... | 1.7583-01 | 4.2248-01 | 6.1678-07 |
| GROUP 9... | 1.5683-02 | 3.4004-02 | 5.1772-08 |
| GROUP 10... | 1.2864-02 | 1.8372-02 | 3.1349-08 |
| GROUP 11... | 1.5812+00 | 1.5171+00 | 2.7907-06 |
| GROUP 12... | 5.3119-02 | 2.8158-02 | 5.3649-08 |
| GROUP 13... | 3.3954-04 | 1.2790-04 | 2.4652-10 |
| GROUP 14... | 4.1089-05 | 9.9016-06 | 1.8074-11 |
| GROUP 15... | 2.0905-10 | 2.2933-11 | 3.6954-17 |
| TOTALS...... | 7.8526+00 | 2.6974+01 | 3.4958-05 |

| | | | | |
|---|---|---|---|---|
| MIN ERROR... | | 3.0304-01 | 2.9073-01 | 2.8705-01 |
| MOD ERROR... | | 7.8845-01 | 7.7893-01 | 7.7932-01 |
| MAX ERROR... | | 8.0096-01 | 7.8670-01 | 7.8798-01 |

**************************SUGGESTED CHANGES IN THE IMPORTANCE SAMPLING PARAMETERS**************************

| | | | | |
|---|---|---|---|---|
| SPA | 1... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| SPA | 2... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| SPA | 3... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| SPA | 4... | 9.9994-01 | 1.0015+00 | 1.0014+00 |
| SPA | 5... | 1.0084+00 | 1.0089+00 | 1.0088+00 |
| SPA | 6... | 1.0094+00 | 1.0051+00 | 1.0059+00 |
| SPA | 7... | 9.8895-01 | 9.8661-01 | 9.8684-01 |
| SPA | 8... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| PRE | 1... | 9.1749-01 | 8.2401-01 | 8.4494-01 |
| PRE | 2... | 6.7972-01 | 7.7096-01 | 7.5064-01 |
| PRE | 3... | 1.0407+00 | 9.9796-01 | 1.0056+00 |
| PRE | 4... | 1.0665+00 | 9.5417-01 | 9.7470-01 |
| PSE | 1... | 1.0000+01 | 1.0000+01 | 1.0000+01 |
| PSE | 2... | 9.9938-01 | 9.9915-01 | 9.9921-01 |
| PSE | 3... | 6.9993-01 | 6.9991-01 | 6.9992-01 |
| REL | 1... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| REL | 2... | 0.0000 | 0.0000 | 0.0000 |
| RAT | 11... | 0.0000 | 0.0000 | 0.0000 |
| RAT | 12... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 13... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 14... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 15... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 21... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 22... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 23... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 24... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 25... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| SPA | 1... | 9.8254-01 | 9.7722-01 | 9.7886-01 |
| SPA | 2... | 1.0170+00 | 1.0201+00 | 1.0191+00 |
| SPA | 3... | 9.6371-01 | 9.5447-01 | 9.5738-01 |
| SPA | 4... | 9.9731-01 | 9.9492-01 | 9.9545-01 |
| SPA | 5... | 9.8903-01 | 9.8961-01 | 9.9012-01 |
| SPA | 6... | 9.9135-01 | 9.8795-01 | 9.8885-01 |

| | | | | |
|---|---|---|---|---|
| SPA | 7... | 9.9657-01 | 9.9811-01 | 9.9612-01 |
| SPA | 8... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| PRE | 1... | 2.7446-01 | 2.9158-01 | 2.9205-01 |
| PRE | 2... | 6.3339-01 | 6.7960-01 | 6.6587-01 |
| PRE | 3... | 1.0910+00 | 1.1168+00 | 1.1110+00 |
| PRE | 4... | 1.2948+00 | 1.3950+00 | 1.3729+00 |
| PSE | 1... | 1.0000+01 | 1.0000+01 | 1.0000+01 |
| PSE | 2... | 7.6493-01 | 7.3285-01 | 7.4379-01 |
| PSE | 3... | 6.4791-01 | 6.3762-01 | 6.4090-01 |
| REL | 1... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| REL | 2... | 0.0000 | 0.0000 | 0.0000 |
| RAT | 11... | 0.0000 | 0.0000 | 0.0000 |
| RAT | 12... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 13... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 14... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 15... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 21... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 22... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 23... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 24... | 1.0000+00 | 1.0000+00 | 1.0000+00 |
| RAT | 25... | 1.0000+00 | 1.0000+00 | 1.0000+00 |

**************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS**************************

| | | ITERANT 1 | SOURCE 1 | SOURCE 2 | SOURCE 3 | SOURCE 4 | SOURCE 5 | SOURCE 6 | SOURCE 7 |
|---|---|---|---|---|---|---|---|---|---|
| GROUP | 1... | 1.9223-01 | 8.1184-05 | 3.2565-07 | 1.1310-06 | 1.1751-01 | 6.2711-02 | 7.4078-03 | 4.5205-03 |
| GROUP | 2... | 9.7274-01 | 3.6148-04 | 0.0000 | 1.1767-05 | 6.7483-01 | 2.8184-01 | 1.2673-02 | 3.0276-03 |
| GROUP | 3... | 1.8659+00 | 5.7912-04 | 0.0000 | 1.9437-05 | 1.3772+00 | 4.7411-01 | 1.3974-02 | 1.5993-05 |
| GROUP | 4... | 2.1581+00 | 7.9833-04 | 0.0000 | 2.4389-05 | 1.4527+00 | 6.8394-01 | 2.0542-02 | 1.3134-05 |
| GROUP | 5... | 2.5190+00 | 9.3426-04 | 0.0000 | 2.2813-05 | 1.7356+00 | 7.5994-01 | 2.2460-02 | 1.0361-05 |
| GROUP | 6... | 2.1146+00 | 7.7363-04 | 3.0164-07 | 1.3342-05 | 1.4470+00 | 6.3969-01 | 2.2881-02 | 4.2890-03 |
| GROUP | 7... | 1.7944+00 | 6.1125-04 | 3.1844-08 | 7.5305-06 | 1.1906+00 | 5.8598-01 | 1.7086-02 | 4.4564-05 |
| GROUP | 8... | 4.3957-01 | 5.7636-05 | 1.5790-09 | 5.1539-07 | 2.6909-01 | 1.6491-01 | 5.4809-03 | 2.5217-05 |
| GROUP | 9... | 3.9207-02 | 1.1388-12 | 0.0000 | 9.0720-15 | 3.9206-02 | 1.5409-06 | 2.2773-07 | 4.6713-08 |
| GROUP | 10... | 2.8586-02 | 6.8303-11 | 0.0000 | 1.5384-16 | 2.8569-02 | 1.3536-05 | 1.5365-07 | 2.5367-06 |
| GROUP | 11... | 3.5139+00 | 4.7407-12 | 1.5503-18 | 2.3077-14 | 3.4328+00 | 7.9615-02 | 9.9208-04 | 4.8138-04 |
| GROUP | 12... | 1.0624-01 | 5.7521-24 | 0.0000 | 0.0000 | 7.9325-02 | 2.5820-02 | 2.2198-04 | 8.7020-04 |
| GROUP | 13... | 2.4253-03 | 0.0000 | 0.0000 | 0.0000 | 2.5274-07 | 1.0284-03 | 7.0667-04 | 6.8996-04 |
| GROUP | 14... | 3.7353-04 | 0.0000 | 0.0000 | 0.0000 | 4.3366-32 | 3.2959-27 | 4.8956-16 | 3.7353-04 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GROUP 15... | 2.9864-09 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.6117-34 | 2.9864-09 |
| NUMBER FLUX | 7.8526+00 | 2.1939-03 | 9.7832-07 | 5.1920-05 | 5.8343+00 | 1.9258+00 | 7.4468-02 | 1.5798-02 |
| ENERGY FLUX | 2.6974+01 | 9.1293-03 | 6.0202-06 | 2.2114-04 | 1.8845+01 | 7.6891+00 | 3.3905-01 | 9.1813-02 |
| REM/HR | 3.4958-05 | 1.1476-08 | 6.7591-12 | 2.7700-10 | 2.4689-05 | 9.7399-06 | 4.1319-07 | 1.0389-07 |

*************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | REGION 1 | REGION 2 | REGION 3 | REGION 4 | REGION 5 | REGION 6 | REGION 7 | SCATTER 0 |
|---|---|---|---|---|---|---|---|---|
| GROUP 1... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.9223-01 |
| GROUP 2... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 9.7274-01 |
| GROUP 3... | 0.0000 | 0.0000 | 0.0000 | 2.9550-01 | 0.0000 | 0.0000 | 0.0000 | 1.5704+00 |
| GROUP 4... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.1581+00 |
| GROUP 5... | 0.0000 | 0.0000 | 0.0000 | 3.0989-01 | 0.0000 | 0.0000 | 3.3216-02 | 2.1759+00 |
| GROUP 6... | 0.0000 | 0.0000 | 0.0000 | 2.9518-01 | 0.0000 | 0.0000 | 1.4756-01 | 1.6719+00 |
| GROUP 7... | 0.0000 | 0.0000 | 0.0000 | 1.3609-01 | 0.0000 | 0.0000 | 3.3675-01 | 1.3215+00 |
| GROUP 8... | 0.0000 | 0.0000 | 0.0000 | 1.3312-02 | 0.0000 | 2.6018-02 | 1.1203-01 | 2.8821-01 |
| GROUP 9... | 0.0000 | 0.0000 | 4.0303-15 | 2.8306-06 | 0.0000 | 5.2456-07 | 3.9202-02 | 1.7024-06 |
| GROUP 10... | 0.0000 | 0.0000 | 2.0831-12 | 1.8059-09 | 1.6442-08 | 1.3016-05 | 2.8572-02 | 8.0180-07 |
| GROUP 11... | 0.0000 | 0.0000 | 2.5026-12 | 1.4747-04 | 1.3911-02 | 3.3859-01 | 3.1543+00 | 6.8933-03 |
| GROUP 12... | 0.0000 | 0.0000 | 0.0000 | 7.9382-10 | 9.4002-05 | 5.4343-03 | 1.0060-01 | 1.0524-04 |
| GROUP 13... | 0.0000 | 0.0000 | 0.0000 | 9.2782-28 | 6.4070-11 | 3.8028-08 | 2.4253-03 | 4.3794-09 |
| GROUP 14... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.1593-30 | 7.6488-26 | 3.7353-04 | 4.7139-10 |
| GROUP 15... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.9060-09 | 8.0427-11 |
| NUMBER FLUX | 0.0000 | 0.0000 | 2.0652-12 | 5.1012-01 | 6.3067-03 | 1.6549-01 | 1.7686+00 | 5.4021+00 |
| ENERGY FLUX | 0.0000 | 0.0000 | 2.4228-12 | 1.9238+00 | 6.0306-03 | 1.7263-01 | 2.2256+00 | 2.2646+01 |
| REM/HR | 0.0000 | 0.0000 | 4.2773-18 | 2.4976-06 | 1.1095-08 | 3.0817-07 | 3.7297-06 | 2.8411-05 |

*************************NUMBER FLUX MOMENTS FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | SCATTER 1 | SCATTER 2 | SCATTER 3 | SCATTER 4 | SCATTER 5 | SCATTER 6 | SCATTER 7 |
|---|---|---|---|---|---|---|---|
| GROUP 1... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 2... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 3... | 2.9550-01 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 4... | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 5... | 3.0989-01 | 3.3216-02 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 6... | 2.9518-01 | 1.4756-01 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 7... | 1.3596-01 | 3.3689-01 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 8... | 1.6073-02 | 1.3529-01 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 9... | 2.9902-06 | 3.9203-02 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 10... | 5.9748-06 | 9.9900-06 | 2.4805-02 | 3.7637-03 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 11... | 1.0621-02 | 1.7405-02 | 3.5019-01 | 3.1287+00 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GROUP 12... | 7.6051-04 | 1.1074-02 | 4.3[illegible]4-02 | 5.0703-02 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 13... | 1.6093-06 | 2.5172-05 | 1.6439-03 | 7.5465-04 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 14... | 2.2691-07 | 8.7346-06 | 5.[illegible]-05 | 3.0630-04 | 0.0000 | 0.0000 | 0.0000 |
| GROUP 15... | 1.1283-10 | 2.4629-10 | 1.0236-09 | 1.5353-09 | 0.0000 | 0.0000 | 0.0000 |
| NUMBER FLUX | 5.1626-01 | 3.0832-01 | 1.9078-01 | 1.4351+00 | 0.0000 | 0.0000 | 0.0000 |
| ENERGY FLUX | 1.9311+00 | 8.5152-01 | 1.7878-01 | 1.3667+00 | 0.0000 | 0.0000 | 0.0000 |
| REM/HR | 2.5100-06 | 1.1944-06 | 3.2751-07 | 2.5147-06 | 0.0000 | 0.0000 | 0.0000 |

*************************SHIELD DERIVATIVES FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | SEGMENT 1 | NORMAL 1 | NORMAL 2 | NORMAL 3 | NORMAL 4 | NORMAL 5 |
|---|---|---|---|---|---|---|
| GROUP 1... | 1.9223-01 | -3.1870-02 | -4.8454-02 | -4.1399-02 | -2.3684-02 | -5.3197-03 |
| GROUP 2... | 9.7274-01 | -1.4408-01 | -2.5771-01 | -2.1250-01 | -1.2076-01 | -3.0099-02 |
| GROUP 3... | 1.8659+00 | -3.5276-01 | -5.0672-01 | -4.0624-01 | -2.3180-01 | -6.0689-02 |
| GROUP 4... | 2.1581+00 | -3.1464-01 | -5.7137-01 | -4.7544-01 | -2.7314-01 | -7.4667-02 |
| GROUP 5... | 2.5190+00 | -4.6470-01 | -6.7092-01 | -5.5324-01 | -3.2080-01 | -9.2747-02 |
| GROUP 6... | 2.1146+00 | -4.0584-01 | -5.5815-01 | -4.6347-01 | -2.7181-01 | -8.3731-02 |
| GROUP 7... | 1.7944+00 | -3.0479-01 | -4.6797-01 | -3.9223-01 | -2.3183-01 | -7.6581-02 |
| GROUP 8... | 4.3957-01 | -7.5624-02 | -1.0987-01 | -9.7154-02 | -6.0707-02 | -2.3971-02 |
| GROUP 9... | 3.9207-02 | -5.5226-03 | -1.0360-02 | -7.3871-03 | -4.5507-03 | -2.8436-03 |
| GROUP 10... | 2.8586-02 | -3.8351-03 | -6.9182-03 | -4.8074-03 | -2.7919-03 | 3.0314-03 |
| GROUP 11... | 3.5139+00 | -5.1467-01 | -6.6923-01 | -9.0385-01 | -6.4352-01 | -2.7306-01 |
| GROUP 12... | 1.0624-01 | -2.2039-02 | -2.1962-02 | -2.2676-02 | -1.7477-02 | 4.3784-04 |
| GROUP 13... | 2.4253-03 | -9.5934-04 | -2.7032-04 | -3.5919-04 | -7.6228-04 | -2.3783-04 |
| GROUP 14... | 3.7353-04 | -1.4958-04 | -3.3653-05 | -2.9764-05 | -3.7321-05 | 6.2403-05 |
| GROUP 15... | 2.9864-09 | -8.3584-10 | -1.9720-10 | -2.0010-10 | -1.6486-10 | -4.9033-10 |
| NUMBER FLUX | 7.8526+00 | -1.3196+00 | -1.9542+00 | -1.7779+00 | -1.0869+00 | -3.4694-01 |
| ENERGY FLUX | 2.6974+01 | -4.5970+00 | -7.0067+00 | -5.9539+00 | -3.4932+00 | -1.0075+00 |
| REM/HR | 3.4958-05 | -5.9509-06 | -9.0221-06 | -7.7497-06 | -4.5795-06 | -1.3502-06 |

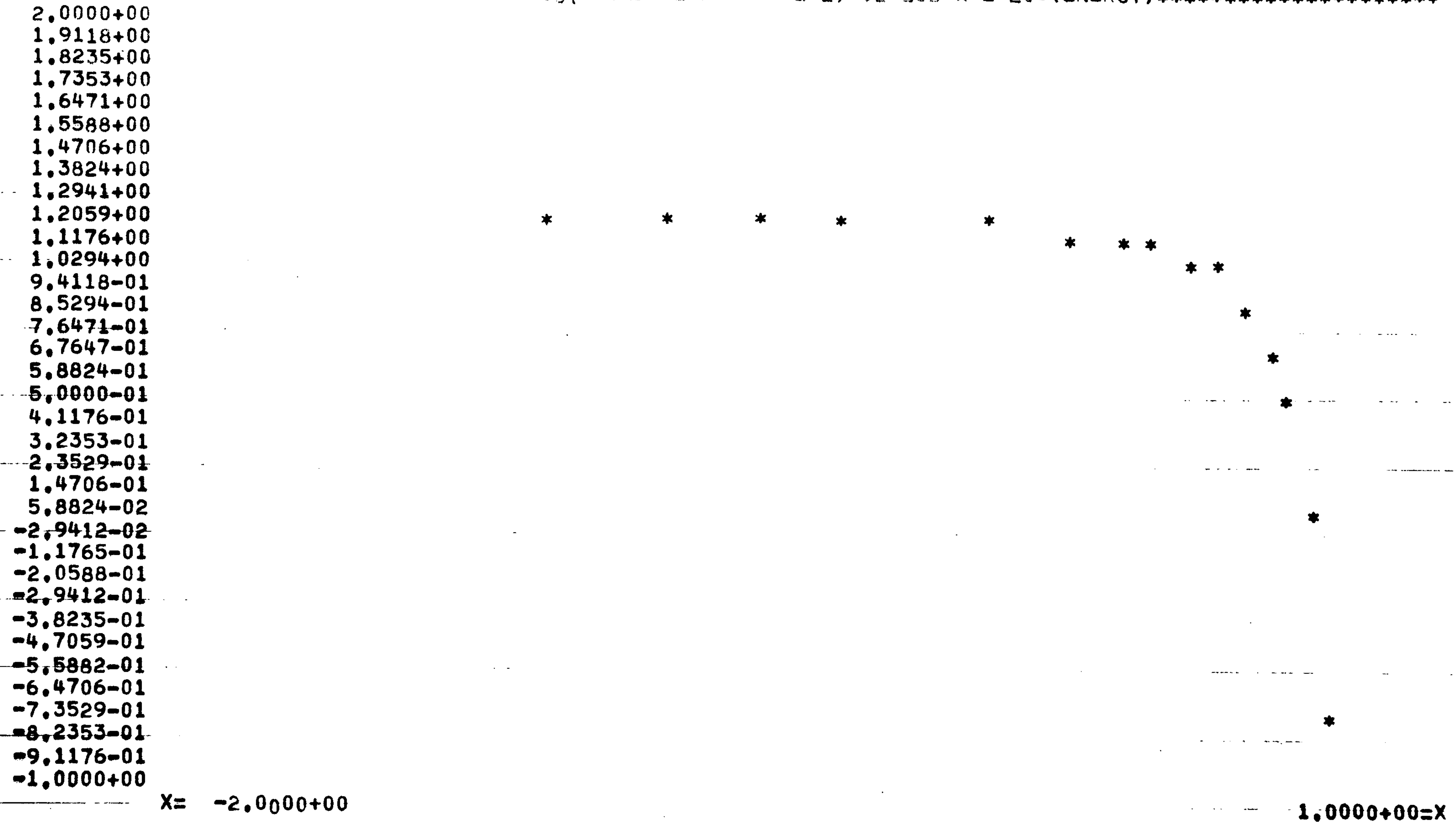
*************************SHIELD DERIVATIVES FOR DETECTOR 1 AFTER 16 PACKETS*************************

| | SEGMENT 2 |
|---|---|
| GROUP 1... | 0.0000 |
| GROUP 2... | 0.0000 |
| GROUP 3... | 0.0000 |
| GROUP 4... | 0.0000 |
| GROUP 5... | 0.0000 |
| GROUP 6... | 0.0000 |
| GROUP 7... | 0.0000 |
| GROUP 8... | 0.0000 |

```
GROUP    9...   0.0000
GROUP   10...   0.0000
GROUP   11...   0.0000
GROUP   12...   0.0000
GROUP   13...   0.0000
GROUP   14...   0.0000
GROUP   15...   0.0000
  NUMBER FLUX   0.0000
  ENERGY FLUX   0.0000
       REM/HR   0.0000
```

**********************QUICK PLOT OF Y = LOG(TOTAL FLUX - TYPE 0) VERSUS X = LOG(ENERGY)**********************

********************QUICK PLOT OF Y = LOG(TOTAL FLUX - TYPE 2) VERSUS X = LOG(ENERGY)********************



```
******************QUICK PLOT OF Y = LOG(    SOURCE ENERGY FLUX) VERSUS X = COMPONENT INDEX******************
 2.0000+00
 1.7647+00
 1.5294+00
 1.2941+00                                                    *
 1.0588+00
 8.2353-01                                                                     *
 5.8824-01
 3.5294-01
 1.1765-01
-1.1765-01
-3.5294-01                                                                                      *
-5.8824-01
-8.2353-01
-1.0588+00                                                                                                     *
-1.2941+00
-1.5294+00
-1.7647+00
-2.0000+00 *
-2.2353+00
-2.4706+00
-2.7059+00
-2.9412+00
-3.1765+00
-3.4118+00
-3.6471+00                                   *
-3.8824+00
-4.1176+00
-4.3529+00
-4.5882+00
-4.8235+00
-5.0588+00
-5.2941+00                  *
-5.5294+00
-5.7647+00
-6.0000+00
           X=   1.0000+00                                                                           7.0000+00=X
```

```
  THE FASTER-III PROGRAM ***************************UNIT SHIELD TEST PROBLEM****************************CASE    2
T.M.JORDAN-A.R.T.RESEARCH***************************SECONDARY PHOTONS*******************************PAGE   13

******************QUICK PLOT OF Y = LOG(   REGION ENERGY FLUX) VERSUS X = COMPONENT INDEX*****************
  1.0000+00
  6.1765-01
  2.3529-01                             *                                                                                  *
 -1.4706-01
 -5.2941-01
 -9.1176-01                                                                                     *
 -1.2941+00
 -1.6765+00
 -2.0588+00                                                         *
 -2.4412+00
 -2.8235+00
 -3.2059+00
 -3.5882+00
 -3.9706+00
 -4.3529+00
 -4.7353+00
 -5.1176+00
 -5.5000+00
 -5.8824+00
 -6.2647+00
 -6.6471+00
 -7.0294+00
 -7.4118+00
 -7.7941+00
 -8.1765+00
 -8.5588+00
 -8.9412+00
 -9.3235+00
 -9.7059+00
 -1.0088+01
 -1.0471+01
 -1.0853+01
 -1.1235+01
 -1.1618+01 *
 -1.2000+01
            X=   3.0000+00                                                                            7.0000+00=X
```

```
  THE FASTER-III PROGRAM ***************************UNIT SHIELD TEST PROBLEM***************************CASE    2
T.M.JORDAN-A.R.T.RESEARCH********************************SECONDARY PHOTONS*****************************PAGE   14

******************QUICK PLOT OF Y = LOG(  SCATTER ENERGY FLUX) VERSUS X = COMPONENT INDEX******************
  2.0000+00
  1.9118+00
  1.8235+00
  1.7353+00
  1.6471+00
  1.5588+00
  1.4706+00
  1.3824+00 *
  1.2941+00
  1.2059+00
  1.1176+00
  1.0294+00
  9.4118-01
  8.5294-01
  7.6471-01
  6.7647-01
  5.8824-01
  5.0000-01
  4.1176-01
  3.2353-01                          *
  2.3529-01                                                                                                *
  1.4706-01
  5.8824-02
 -2.9412-02                                                *
 -1.1765-01
 -2.0588-01
 -2.9412-01
 -3.8235-01
 -4.7059-01
 -5.5882-01
 -6.4706-01                                                                        *
 -7.3529-01
 -8.2353-01
 -9.1176-01
 -1.0000+00
            X=    0.0000                                                                       4.0000+00=X
```

```
*************************************SHIELD OPTIMIZATION FOR DETECTOR   1*************************************
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED**************************
                          0   2.0625+08   3.5385-05   1.9593-05   5.4978-05   0.0000
DIMENSIONS      5.0000+00   5.7000+01   1.5000+01   1.5000+01   1.1700+02
WEIGHT(GM)      1.0217+07   7.1161+07   2.2075+07   1.6081+07   8.6718+07
DWDT(GM/CM)     4.4551+06   3.0261+06   2.5035+06   1.8727+06   1.1234+06
DDDT(  /CM)    -9.9406-06  -1.1723-05  -1.0218-05  -6.7649-06  -3.2131-06
DDDW(  /GM)    -2.2313-12  -3.8740-12  -4.0816-12  -3.6124-12  -2.8600-12
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED**************************
                         10   2.1025+08   2.4878-05   1.6184-05   4.1062-05   0.0000
DIMENSIONS      5.0000+00   5.7000+01   1.6587+01   1.5000+01   1.1700+02
WEIGHT(GM)      1.0217+07   7.1161+07   2.4658+07   1.6375+07   8.7844+07
DWDT(GM/CM)     4.4922+06   3.0633+06   2.5407+06   1.8978+06   1.1354+06
DDDT(  /CM)    -9.5129-05  -1.1073-04  -9.6496-05  -6.4259-05  -3.1114-05
DDDW(  /GM)    -2.1176-11  -3.6148-11  -3.7981-11  -3.3860-11  -2.7404-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED**************************
                         20   2.1426+08   1.7586-05   1.3407-05   3.0992-05   0.0000
DIMENSIONS      5.0000+00   5.7000+01   1.8151+01   1.5000+01   1.1700+02
WEIGHT(GM)      1.0217+07   7.1161+07   2.7252+07   1.6667+07   8.8961+07
DWDT(GM/CM)     4.5291+06   3.1001+06   2.5775+06   1.9227+06   1.1473+06
DDDT(  /CM)    -1.5954-04  -1.8348-04  -1.5987-04  -1.0705-04  -5.2747-05
DDDW(  /GM)    -3.5226-11  -5.9184-11  -6.2026-11  -5.5677-11  -4.5976-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED**************************
                         30   2.1826+08   1.2496-05   1.1137-05   2.3633-05   0.0000
DIMENSIONS      5.0000+00   5.7000+01   1.9693+01   1.5000+01   1.1700+02
WEIGHT(GM)      1.0217+07   7.1161+07   2.9856+07   1.6957+07   9.0069+07
DWDT(GM/CM)     4.5658+06   3.1368+06   2.6142+06   1.9474+06   1.1590+06
DDDT(  /CM)    -2.0876-04  -2.3744-04  -2.0689-04  -1.3923-04  -6.9688-05
DDDW(  /GM)    -4.5722-11  -7.5694-11  -7.9140-11  -7.1496-11  -6.0128-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED**************************
                         40   2.2226+08   8.9234-06   9.2767-06   1.8200-05   0.0000
DIMENSIONS      5.0000+00   5.7000+01   2.1214+01   1.5000+01   1.1700+02
WEIGHT(GM)      1.0217+07   7.1161+07   3.2470+07   1.7246+07   9.1169+07
DWDT(GM/CM)     4.6021+06   3.1732+06   2.6506+06   1.9719+06   1.1706+06
DDDT(  /CM)    -2.4673-04  -2.7783-04  -2.4210-04  -1.6368-04  -8.3081-05
DDDW(  /GM)    -5.3612-11  -8.7557-11  -9.1337-11  -8.3005-11  -7.0971-11
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**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                    50    2.2627+08   6.4083-06   7.7471-06   1.4156-05   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.2714+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   3.5094+07   1.7533+07   9.2260+07
DWDT(GM/CM)   4.6383+06   3.2093+06   2.6867+06   1.9963+06   1.1822+06
DDDT(  /CM)  -2.7631-04  -3.0836-04  -2.6872-04  -1.8244-04  -9.3760-05
DDDW(  /GM)  -5.9572-11  -9.6082-11  -1.0002-10  -9.1390-11  -7.9312-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                    60    2.3027+08   4.6163-06   6.4860-06   1.1102-05   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.4194+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   3.7728+07   1.7819+07   9.3344+07
DWDT(GM/CM)   4.6742+06   3.2453+06   2.7227+06   2.0205+06   1.1936+06
DDDT(  /CM)  -2.9957-04  -3.3163-04  -2.8903-04  -1.9697-04  -1.0234-04
DDDW(  /GM)  -6.4089-11  -1.0219-10  -1.0616-10  -9.7489-11  -8.5743-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                    70    2.3427+08   3.3430-06   5.4434-06   8.7864-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.5654+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   4.0370+07   1.8104+07   9.4419+07
DWDT(GM/CM)   4.7099+06   3.2810+06   2.7584+06   2.0445+06   1.2049+06
DDDT(  /CM)  -3.1801-04  -3.4954-04  -3.0468-04  -2.0833-04  -1.0929-04
DDDW(  /GM)  -6.7518-11  -1.0654-10  -1.1046-10  -1.0190-10  -9.0703-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                    80    2.3827+08   2.4314-06   4.5792-06   7.0106-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.7096+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   4.3022+07   1.8386+07   9.5487+07
DWDT(GM/CM)   4.7454+06   3.3165+06   2.7939+06   2.0683+06   1.2162+06
DDDT(  /CM)  -3.3275-04  -3.6345-04  -3.1685-04  -2.1729-04  -1.1495-04
DDDW(  /GM)  -7.0119-11  -1.0959-10  -1.1341-10  -1.0506-10  -9.4521-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                    90    2.4228+08   1.7759-06   3.8609-06   5.6367-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.8560+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   4.5683+07   1.8668+07   9.6548+07
DWDT(GM/CM)   4.7807+06   3.3517+06   2.8291+06   2.0920+06   1.2273+06
DDDT(  /CM)  -3.4462-04  -3.7433-04  -3.2638-04  -2.2442-04  -1.1960-04
DDDW(  /GM)  -7.2085-11  -1.1168-10  -1.1536-10  -1.0727-10  -9.7445-11
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**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                   100    2.4628+08   1.3023-06   3.2624-06   4.5648-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   2.9956+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   4.8352+07   1.8948+07   9.7601+07
DWDT(GM/CM)   4.8158+06   3.3868+06   2.8642+06   2.1156+06   1.2384+06
DDDT(  /CM)  -3.5425-04  -3.8292-04  -3.3391-04  -2.3013-04  -1.2343-04
DDDW(  /GM)  -7.3559-11  -1.1306-10  -1.1658-10  -1.0878-10  -9.9666-11
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                   110    2.5028+08   9.5883-07   2.7626-06   3.7215-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   3.1315+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   5.1030+07   1.9227+07   9.8647+07
DWDT(GM/CM)   4.8507+06   3.4217+06   2.8991+06   2.1390+06   1.2494+06
DDDT(  /CM)  -3.6211-04  -3.8975-04  -3.3992-04  -2.3475-04  -1.2660-04
DDDW(  /GM)  -7.4651-11  -1.1390-10  -1.1725-10  -1.0975-10  -1.0133-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                   120    2.5428+08   7.0862-07   2.3443-06   3.0529-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   3.2687+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   5.3715+07   1.9504+07   9.9686+07
DWDT(GM/CM)   4.8854+06   3.4564+06   2.9338+06   2.1622+06   1.2603+06
DDDT(  /CM)  -3.6857-04  -3.9522-04  -3.4473-04  -2.3850-04  -1.2924-04
DDDW(  /GM)  -7.5443-11  -1.1435-10  -1.1751-10  -1.1030-10  -1.0255-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                   130    2.5829+08   5.2565-07   1.9932-06   2.5189-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   3.4043+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   5.6409+07   1.9780+07   1.0072+08
DWDT(GM/CM)   4.9198+06   3.4909+06   2.9683+06   2.1853+06   1.2711+06
DDDT(  /CM)  -3.7390-04  -3.9964-04  -3.4863-04  -2.4157-04  -1.3145-04
DDDW(  /GM)  -7.5998-11  -1.1448-10  -1.1745-10  -1.1054-10  -1.0342-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED*************************
                   140    2.6229+08   3.9132-07   1.6981-06   2.0894-06   0.0000
DIMENSIONS    5.0000+00   5.7000+01   3.5384+01   1.5000+01   1.1700+02
WEIGHT(GM)    1.0217+07   7.1161+07   5.9111+07   2.0055+07   1.0174+08
DWDT(GM/CM)   4.9541+06   3.5252+06   3.0026+06   2.2083+06   1.2818+06
DDDT(  /CM)  -3.7833-04  -4.0324-04  -3.5180-04  -2.4409-04  -1.3331-04
DDDW(  /GM)  -7.6366-11  -1.1439-10  -1.1717-10  -1.1053-10  -1.0400-10
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  THE FASTER-III PROGRAM ***************************UNIT SHIELD TEST PROBLEM***************************CASE    2
T.M.JORDAN-A.R.T.RESEARCH******************************SECONDARY PHOTONS****************************PAGE   16

**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                    150    2.6629+08   2.9233-07   1.4494-06   1.7417-06   0.0000
DIMENSIONS     5.0000+00   5.7000+01   3.6709+01   1.5000+01   1.1700+02
WEIGHT(GM)     1.0217+07   7.1161+07   6.1820+07   2.0329+07   1.0276+08
DWDT(GM/CM)    4.9882+06   3.5593+06   3.0367+06   2.2312+06   1.2925+06
DDDT(  /CM)   -3.8202-04  -4.0617-04  -3.5440-04  -2.4618-04  -1.3487-04
DDDW(  /GM)   -7.6585-11  -1.1412-10  -1.1671-10  -1.1034-10  -1.0435-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                    160    2.7029+08   2.1912-07   1.2393-06   1.4585-06   0.0000
DIMENSIONS     5.0000+00   5.7000+01   3.8020+01   1.5000+01   1.1700+02
WEIGHT(GM)     1.0217+07   7.1161+07   6.4537+07   2.0601+07   1.0378+08
DWDT(GM/CM)    5.0222+06   3.5932+06   3.0706+06   2.2539+06   1.3031+06
DDDT(  /CM)   -3.8512-04  -4.0859-04  -3.5654-04  -2.4792-04  -1.3619-04
DDDW(  /GM)   -7.6684-11  -1.1371-10  -1.1611-10  -1.1000-10  -1.0452-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                    170    2.7429+08   1.6478-07   1.0617-06   1.2264-06   0.0000
DIMENSIONS     5.0000+00   5.7000+01   3.9316+01   1.5000+01   1.1700+02
WEIGHT(GM)     1.0217+07   7.1161+07   6.7261+07   2.0872+07   1.0478+08
DWDT(GM/CM)    5.0559+06   3.6269+06   3.1043+06   2.2764+06   1.3136+06
DDDT(  /CM)   -3.8773-04  -4.1059-04  -3.5831-04  -2.4938-04  -1.3731-04
DDDW(  /GM)   -7.6687-11  -1.1321-10  -1.1542-10  -1.0955-10  -1.0453-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                    180    2.7830+08   1.2432-07   9.1104-07   1.0354-06   0.0000
DIMENSIONS     5.0000+00   5.7000+01   4.0599+01   1.5000+01   1.1700+02
WEIGHT(GM)     1.0217+07   7.1161+07   6.9992+07   2.1142+07   1.0578+08
DWDT(GM/CM)    5.0895+06   3.6605+06   3.1379+06   2.2989+06   1.3240+06
DDDT(  /CM)   -3.8993-04  -4.1226-04  -3.5979-04  -2.5060-04  -1.3827-04
DDDW(  /GM)   -7.6614-11  -1.1262-10  -1.1466-10  -1.0901-10  -1.0443-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                    190    2.7910+08   1.1336-07   8.8498-07   9.9835-07   0.0000
DIMENSIONS     4.8039+00   5.7000+01   4.1171+01   1.5000+01   1.1700+02
WEIGHT(GM)     9.7953+06   7.0939+07   7.1063+07   2.1222+07   1.0608+08
DWDT(GM/CM)    5.0922+06   3.6691+06   3.1478+06   2.3055+06   1.3271+06
DDDT(  /CM)   -3.9191-04  -4.1374-04  -3.6111-04  -2.5170-04  -1.3913-04
DDDW(  /GM)   -7.6964-11  -1.1276-10  -1.1472-10  -1.0917-10  -1.0484-10
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**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                       200   2.7899+08   1.1298-07   8.8918-07   1.0022-06   0.0000
DIMENSIONS    4.7425+00   5.7000+01   4.1235+01   1.5000+01   1.1700+02
WEIGHT(GM)    9.6637+06   7.0869+07   7.1150+07   2.1222+07   1.0608+08
DWDT(GM/CM)   5.0900+06   3.6687+06   3.1479+06   2.3055+06   1.3271+06
DDDT(  /CM)  -3.9389-04  -4.1522-04  -3.6242-04  -2.5279-04  -1.3999-04
DDDW(  /GM)  -7.7386-11  -1.1318-10  -1.1513-10  -1.0965-10  -1.0549-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                       210   2.7903+08   1.1259-07   8.8783-07   1.0004-06   0.0000
DIMENSIONS    4.7395+00   5.7000+01   4.1253+01   1.5000+01   1.1700+02
WEIGHT(GM)    9.6571+06   7.0866+07   7.1186+07   2.1225+07   1.0609+08
DWDT(GM/CM)   5.0902+06   3.6691+06   3.1483+06   2.3058+06   1.3273+06
DDDT(  /CM)  -3.9587-04  -4.1669-04  -3.6372-04  -2.5388-04  -1.4085-04
DDDW(  /GM)  -7.7770-11  -1.1357-10  -1.1553-10  -1.1011-10  -1.0612-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                       220   2.7903+08   1.1251-07   8.8757-07   1.0001-06   0.0000
DIMENSIONS    4.7387+00   5.7000+01   4.1257+01   1.5000+01   1.1700+02
WEIGHT(GM)    9.6555+06   7.0865+07   7.1193+07   2.1226+07   1.0610+08
DWDT(GM/CM)   5.0903+06   3.6692+06   3.1484+06   2.3058+06   1.3273+06
DDDT(  /CM)  -3.9784-04  -4.1816-04  -3.6503-04  -2.5497-04  -1.4171-04
DDDW(  /GM)  -7.8156-11  -1.1397-10  -1.1594-10  -1.1057-10  -1.0677-10
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                       230   2.7904+08   1.1250-07   8.8752-07   1.0000-06   0.0000
DIMENSIONS    4.7385+00   5.7000+01   4.1257+01   1.5000+01   1.1700+02
WEIGHT(GM)    9.6551+06   7.0865+07   7.1195+07   2.1226+07   1.0610+08
DWDT(GM/CM)   5.0903+06   3.6692+06   3.1484+06   2.3059+06   1.3273+06
DDDT(  /CM)  -3.9981-04  -4.1963-04  -3.6633-04  -2.5606-04  -1.4257-04
DDDW(  /GM)  -7.8544-11  -1.1437-10  -1.1636-10  -1.1105-10  -1.0742-10
********TERMINATION =     3 (0/1/2/3)=(DIMENSION CONSTRAINTS/ITERATIONS/UNSHIELDED/DOSE CONSTRAINT)*********
**************ITERATION**WEIGHT(GM)***DOSE( 1 )***DOSE( 2 )***DOSE(TOT)**UNSHIELDED************************
                       235   2.7904+08   1.1249-07   8.8750-07   1.0000-06   0.0000
DIMENSIONS    4.7385+00   5.7000+01   4.1257+01   1.5000+01   1.1700+02
WEIGHT(GM)    9.6551+06   7.0865+07   7.1195+07   2.1226+07   1.0610+08
DWDT(GM/CM)   5.0903+06   3.6692+06   3.1484+06   2.3059+06   1.3273+06
DDDT(  /CM)  -4.0060-04  -4.2021-04  -3.6686-04  -2.5649-04  -1.4292-04
DDDW(  /GM)  -7.8699-11  -1.1453-10  -1.1652-10  -1.1124-10  -1.0768-10
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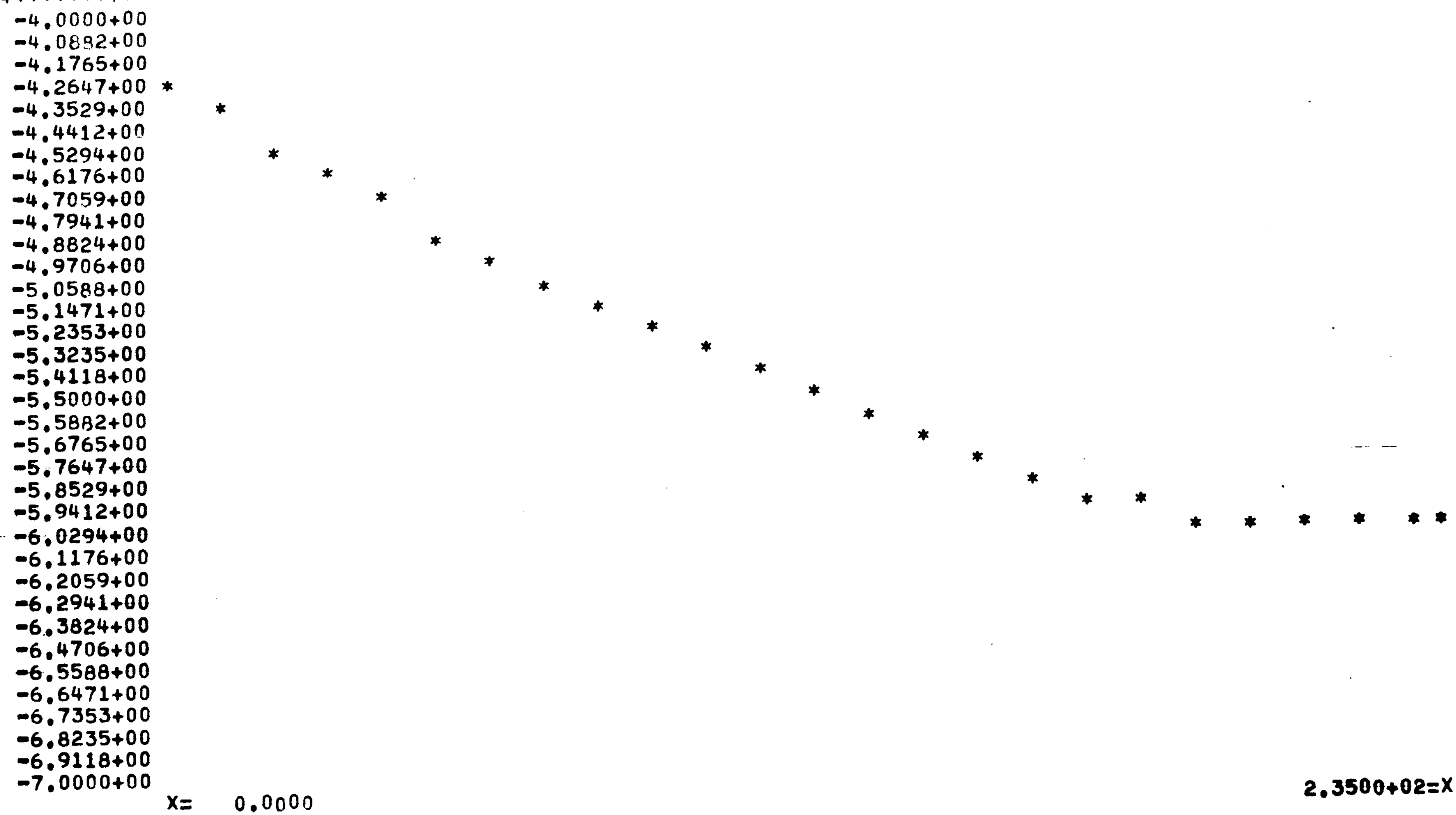
THE FASTER-III PROGRAM ************************UNIT SHIELD TEST PROBLEM****************************CASE 2
T.M.JORDAN-A.R.T.RESEARCH*********************************SECONDARY PHOTONS****************************PAGE 20

************************QUICK PLOT OF Y = LOG(DOSE RATE) VERSUS X = ITERATION INDEX************************



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**********************QUICK PLOT OF Y = LOG(WEIGHT-GRAMS) VERSUS X = ITERATION INDEX**********************
  9.0000+00
  8.9706+00
  8.9412+00
  8.9118+00
  8.8824+00
  8.8529+00
  8.8235+00
  8.7941+00
  8.7647+00
  8.7353+00
  8.7059+00
  8.6765+00
  8.6471+00
  8.6176+00
  8.5882+00
  8.5588+00
  8.5294+00
  8.5000+00
  8.4706+00
  8.4412+00                                                                                 *    *    *    *    *    *    *    * *
  8.4118+00                                                            *    *    *    *    *
  8.3824+00                                            *    *    *    *
  8.3529+00                            *    *    *    *
  8.3235+00 *    *    *
  8.2941+00
  8.2647+00
  8.2353+00
  8.2059+00
  8.1765+00
  8.1471+00
  8.1176+00
  8.0882+00
  8.0588+00
  8.0294+00
  8.0000+00
             X=    0.0000                                                                                     2.3500+02=X
```

```
**********************QUICK PLOT OF Y = SHIELD THICKNESS VERSUS X = ITERATION INDEX**********************
 1.1700+02 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 1.1370+02
 1.1040+02
 1.0709+02
 1.0379+02
 1.0049+02
 9.7189+01
 9.3887+01
 9.0586+01
 8.7284+01
 8.3982+01
 8.0680+01
 7.7378+01
 7.4076+01
 7.0775+01
 6.7473+01
 6.4171+01
 6.0869+01
 5.7567+01 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 5.4266+01
 5.0964+01
 4.7662+01
 4.4360+01
 4.1058+01                                                       *  *  *  *  *  *  *
 3.7757+01                                              *  *  *
 3.4455+01                                        *  *
 3.1153+01                               *  *  *
 2.7851+01                         *  *
 2.4549+01                   *  *
 2.1248+01          *  *  *
 1.7946+01    *  *
 1.4644+01 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
 1.1342+01
 8.0403+00
 4.7385+00 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
           X=   0.0000                                                       2.3500+02=X
```

**********************BOUNDARY SEARCH PARAMETERS, (SURFACE,MOST PROBABLE NEXT REGION)**********************

```
REGION    1(    1,    2)
REGION    2(   -1,    1)(    2,    3)
REGION    3(   -2,    2)(    3,    4)
REGION    4(   -3,    3)(    4,    5)
REGION    5(   -4,    4)(    5,    6)
REGION    6(   -5,    5)(    6,    7)
REGION    7(   -6,    6)(    7,    8)
REGION    8(   -7,    7)(    8,  -11)
```

```
**********************************************************************************************************
*************************12345678901234567890123456789012345678901234567890123456789012345678901234567890
CARD IMAGE STO.000.001.H    STOP
CARD IMAGE STO.001.001.I    C THE PROGRAM REACHED A STOP CARD AND WILL NOW GIVE A NORMAL TERMINATION
CARD IMAGE STO.001.002.I
****STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP*STOP****
```

# Appendix C

## FORTRAN VARIABLE DEFINITIONS

All variables, except for variable-dimensioned arrays, are stored in named common blocks. Variable-dimensioned arrays are all stored in blank common.

The fixed-location integer and real variables are listed and defined in Tables C.1, C.2, C.3, etc. corresponding to common block names C01, C02, C03, etc. Many of the integer variables in these tables give the first location, in blank common, where variable-dimensioned arrays are stored. These array location integers all have a Fortran name starting with I followed by one, two, or three letters which are the array name, e.g., IA would be the first location in blank common occupied by the A array. In the tables, these location integers have been listed in the form:

I A(KMAX,JMAX,IMAX) definition of A array

i.e., the table gives the array name, the array dimensions, and the array definition. The variables in the named common blocks as well as the elements of the arrays stored in blank common can be dumped at specified control points in the program by input of the DUMp input section described in Appendix A.

Several of the variables listed in these tables are used only by versions of the program proprietary to A.R.T. Research Corporation.

TABLE C.1

DEFINITION OF VARIABLES STORED IN NAMED COMMON C01

| | |
|---|---|
| M1 | input unit logical designation |
| M2 | output unit logical designation |
| M3 | cross section tape unit logical designation |
| M4 | restart tape unit logical designation |
| M5 | collision tape unit logical designation |
| M6 | source tape unit logical designation |
| M7 | census tape unit logical designation |
| M8 | scratch tape unit logical designation |

TABLE C.2

DEFINITION OF VARIABLES STORED IN NAMED COMMON CO2

| | |
|---|---|
| KASE | problem index |
| NPAGE | printout page index |
| LINES | line count |
| LINEX | maximum lines per printout page |
| LINØUT | (0,1)=(print,no print) input cards |
| I LAB(24,2) | problem title |

TABLE C.3

DEFINITION OF VARIABLES STORED IN NAMED COMMON CO3

| | |
|---|---|
| IBMCDC | machine dependency flag, not used |
| NSTØRE | length of blank common |
| NERRØR | error count |
| NNEXT | next available location in blank common |
| NARRAY | maximum number of arrays |
| MARRAY | number of arrays in the directory |
| LENFLØ | (1,2)=(single,double), floating point word length |
| LENBCD | integer (base 10) to overflow a byte (base computer) |
| I NAM(NARRAY) | names of arrays in the directory |
| I LØC(NARRAY) | first location occupied by array |
| I MXI(NARRAY) | dimension of third index of each array |
| I MXJ(NARRAY) | dimension of second index of each array |
| I MXK(NARRAY) | dimension of first index of each array |
| I IFB(NARRAY) | array type, (0,1,2)=(integer,real,BCD) |

TABLE C.4

DEFINITION OF VARIABLES STORED IN NAMED COMMON CO4

| | |
|---|---|
| IN1 | option for interpreting IN3 etc. from option card |
| IN2 | option for input of subsequent data cards |
| IN3-IN24 | definition depends on input section |

TABLE C.5

DEFINITION OF VARIABLES STORED IN NAMED COMMON C05

| | |
|---|---|
| IDRAND | index of last input section in subroutine RANDØM |
| IDRESU | index of last input section handled by subroutine RESULT |
| IDGEØM | index of last input section handled by subroutine GEØMIN |
| IDSZER | index of last input section handled by subroutine SZERØ |
| IDINSE | index of last input section handled by subroutine INSECT |
| MINPUT | maximum number of input sections |
| KARDID | index of the last input section input |
| I KAR(100) | input section identifiers |
| I INA(MINPUT) | input section indicator (0,1)=(never input,input) |
| I INB(MINPUT) | input section indicator, (0,1)=(no,yes), input this case |
| I INC(MINPUT) | input section indicator, value of IN2 for sections input |

TABLE C.6

DEFINITION OF VARIABLES STORED IN NAMED COMMON C06

| | |
|---|---|
| NIMAX | number of elements |
| NMMAX | number of materials |
| NUNITD | composition units $(0,1)=(10^{24}$ atoms/cc, gm/cc) |
| INDEXH | index of hydrogen in element list |
| I ATN(NIMAX) | atomic numbers of elements |
| I ATW(NIMAX) | atomic weights of elements |
| I ATD(NMMAX,NIMAX) | compositions in $10^{24}$ atoms/cc |
| MIXES | number of materials and mixtures with different hydrogen content |
| I MIX(MIXES) | index of material associated with the mixtures |
| I RHH(MIXES) | hydrogen density in the mixture |
| I RHM(NMMAX) | material density (gm/cc) |
| I DEN(3,MIXES) | sum of partial densities times atomic numbers to powers 1-3 |
| NUNITX | composition units option |
| NVØLTS | internal EMP calculation flag |
| I PØT(8,NMMAX) | macroscopic materials properties |
| MIXED | number of hydrogen-material mixtures |

TABLE C.7

DEFINITION OF VARIABLES STORED IN NAMED COMMON C07

| | |
|---|---|
| NEPMAX | number of photon energy groups |
| NFØRM | number of tabulation points in form factors |
| NEDGES | maximum number of photoelectric edges per element |
| NEPMØD | NEPMAX+1 |
| I ELP(NEPMØD) | photon energy group boundaries (Mev) |
| I EWP(NEPMAX) | photon energy group width (Mev) |
| I AEP(NEPMAX) | photon average group energy (Mev) |
| I VEP(NEPMAX) | photon average group velocity (cm/sec) |
| I PST(NEPMØD,NMMAX) | photon total cross section ($cm^{-1}$) |
| I PEA(NEPMØD,NMMAX) | photon energy absorption coefficient (Mev/cm) |
| I FXX(NFØRM) | form factor tabulation points |
| I FFC(NFØRM,NMMAX) | coherent scattering form factors |
| I FFI(NFØRM,NMMAX) | incoherent scattering form factors |
| I SPP(NEPMØD,NMMAX) | total pair production cross section ($cm^{-1}$) |

TABLE C.7 (cont'd)

| | |
|---|---|
| I SEL(NEPMØD,NIMAX) | microscopic photoelectric cross section (barns/atom) |
| I EDG(4,NEDGES,NIMAX) | photoelectric edge data |
| I PSH(NEPMØD) | microscopic total photon cross section for hydrogen |

TABLE C.8

DEFINITION OF VARIABLES STORED IN NAMED COMMON C08

| | |
|---|---|
| NEMMAX | energy groups for multigroup neutron cross sections |
| NØRDER | 1 + order of Legendre expansion of cross sections |
| NDØWN | 1 + maximum elastic down scatter |
| INELAS | groups initiating nonelastic transfer |
| NTRANS | 1 + maximum nonelastic transfer |
| LFIXUP | = 1 |
| MGSLØW | number of diffusion groups, multi-group neutron cross sections |
| NEMMØD | NEMMAX+1 |
| I ELM(NEMMØD) | multigroup energy group boundaries (Mev) |
| I EWM(NEMMAX) | multigroup width |
| I AEM(NEMMAX) | multigroup average energy |
| I VEM(NEMMAX) | multigroup average velocity |
| I STM(NEMMØD,NMMAX) | total multigroup cross section ($cm^{-1}$) |
| I EAM(NEMMØD,NMMAX) | elastic scattering energy absorption, multigroup neutron (Mev/cm) |

| | |
|---|---|
| I SHM(NEMMØD) | total hydrogen cross section, multigroup neutron (barns/atom) |
| I SGS(max(3,NORDER), NEMMAX*NDØWN,NMMAX) | multigroup elastic scattering data |
| I SGI(NTRANS,INELAS, NMMAX) | nonelastic scattering multigroup cross sections ($cm^{-1}$) |
| NIDE | table length for $P_\ell$ histogram |
| IIDE | dummy variable |

TABLE C.9

DEFINITION OF VARIABLES STORED IN NAMED COMMON C09

| | |
|---|---|
| NNEMAX | number of neutron energy groups, point value cross sections |
| NAAMAX | number of c.m. cosines for anisotropic distributions |
| MAXANI | maximum number of groups with anisotropic elastic scattering |
| NANISØ | total number of anisotropic distributions |
| NØNELA | maximum number of groups with nonelastic scattering |
| NDRØPS | maximum transfer due to nonelastic scattering |
| NBSLØW | number of diffusion groups, point value neutron cross sections |
| NNEMØD | NNEMAX+1 |
| I ELN(NNEMØD) | neutron energy group boundaries (Mev) |
| I EWN(NNEMAX) | neutron energy group widths (Mev) |
| I AEN(NNEMAX) | neutron average group energy |
| I VEN(NNEMAX) | neutron average group velocity |
| I CSA(NAAMAX) | tabulation cosines for anisotropic pdf's |
| I TSN(NNEMØD,NMMAX) | total neutron cross section ($cm^{-1}$) |

TABLE C.9 (cont'd)

| | |
|---|---|
| I EAN(NNEMØD,NMMAX) | energy absorption for neutron (Mev/cm) |
| I HSN(NNEMØD) | total hydrogen cross section (barns) |
| I ESN(NNEMØD,NIMAX) | elastic scattering cross section (barns) |
| I GSN(NDRØPS,NØNELA, NMMAX) | nonelastic transfer matrix ($cm^{-1}$) |
| I PAN(NAAMAX,NANISØ) | anistropic scattering distributions |
| I NAS(NØNELA,NIMAX) | indices of scattering distributions |

TABLE C.10

DEFINITION OF VARIABLES STORED IN NAMED COMMON C10

| | |
|---|---|
| NEEMAX | number of electron energy groups |
| NTABE | number of energies in input electron library |
| NTABZ | number of elements in input electron library |
| LØGANA | electron transport step size option |
| NESLØW | number of range-energy approximation groups |
| NEEMØD | NEEMAX+1 |
| I ELE(NEEMØD) | electron energy group boundaries (Mev) |
| I EWE(NEEMAX) | electron energy group widths (Mev) |
| I AEE(NEEMAX) | average electron group energy |
| I VEB(NEEMAX) | average electron group velocity |
| I DET(NEEMØD,NMMAX) | total electron stopping power (Mev/cm) |
| I DER(NEEMØD,NMMAX) | radiative electron stopping power (Mev/cm) |
| I THS(NEEMØD,NMMAX) | mean square angular deflection per cm |
| I EST(NEEMØD,NMMAX) | total electron large-angle cross section ($cm^{-1}$) |
| I DEA(NEEMØD,NMMAX) | total small-angle stopping power (Mev/cm) |

TABLE C.10 (cont'd)

| | |
|---|---|
| I PEE(NEEMØD,NMMAX) | total electron-electron cross section ($cm^{-1}$) |
| I HSE(NEEMØD) | dummy hydrogen electron total cross section (all zeros) |

TABLE C.11

DEFINITION OF VARIABLES STORED IN NAMED COMMON C11

| | |
|---|---|
| NGPMAX | number of photon flux groups |
| NGPMØD | NGPMAX+1 |
| NFPMAX | number of photon response functions |
| I FLP(NGPMØD) | photon flux group boundaries |
| I FNP(NGPMAX) | photon flux group widths |
| I TDG(4,NFPMAX) | photon response titles |
| I RSG(NGPMØD,NFPMAX) | photon response functions |

TABLE C.12

DEFINITION OF VARIABLES STORED IN NAMED COMMON C12

| | |
|---|---|
| NGMMAX | number of multigroup flux groups |
| NGMMØD | NGMMAX+1 |
| NFMMAX | number of multigroup response functions |
| I FLM(NGMMØD) | multigroup flux boundaries |
| I FWM(NGMMAX) | multigroup flux group widths |
| I TDM(4,NFMMAX) | multigroup response titles |
| I RSM(NGMMØD,NFMMAX) | multigroup response functions |

TABLE C.13

DEFINITION OF VARIABLES STORED IN NAMED COMMON C13

| | |
|---|---|
| NGNMAX | number of neutron flux groups |
| NGNMØD | NGNMAX+1 |
| NFNMAX | number of neutron response functions |
| I FLN(NGNMØD) | neutron flux group boundaries |
| I FWN(NGNMAX) | neutron flux group widths |
| I TDN(4,NFNMAX) | neutron response titles |
| I RSN(NGNMØD,NFNMAX) | neutron response functions |

TABLE C.14

DEFINITION OF VARIABLES STORED IN NAMED COMMON C14

| | |
|---|---|
| NGEMAX | number of electron flux groups |
| NGEMØD | NGEMAX+1 |
| NFEMAX | number of electron response functions |
| I FLE(NGEMØD) | electron flux group boundaries |
| I FWE(NGEMAX) | electron flux group widths |
| I TDE(4,NFEMAX) | electron response titles |
| I RSE(NGEMØD,NFEMAX) | electron response functions |

## TABLE C.15

## DEFINITION OF VARIABLES STORED IN NAMED COMMON C15

| | |
|---|---|
| NVMAX | number of sources |
| NXMAX | maximum number of points per source distribution |
| NESMAX | maximum number of groups in any processed source spectrum |
| I NXS(NVMAX) | source particle type |
| I NSG(NVMAX) | source geometry type |
| I JSN(NVMAX) | index of first non-empty source group |
| I JSX(NVMAX) | index of last non-empty source group |
| I SUV(NVMAX) | total source intensity (Mev/sec) |
| I RSI(NVMAX) | relative source importance |
| I XTR(3,NVMAX) | source translation vector |
| I NPC(5,NVMAX) | number of tabulation points in the spatial and angular source distributions |
| I VMD(5,NVMAX) | preferred values of the spatial and angular source variables |
| I ALP(5,NVMAX) | slope of exponential for selecting spatial and angular variables |
| I VEE(NXMAX,5,NVMAX) | tabulation points for source distributions |

TABLE C.15 (cont'd)

| | |
|---|---|
| I VAL(NXMAX,5,NVMAX) | value of source distribution at tabulation points |
| I SPW(NESMAX,NVMAX) | particles in each source group |
| I SPE(NESMAX,NVMAX) | average energy of particles in each source group |

TABLE C.16

DEFINITION OF VARIABLES STORED IN NAMED COMMON C16

| | |
|---|---|
| NPFMAX | number of source time profiles |
| NPTMAX | number of histrogram sections in each time profile |
| I TTB(NPTMAX,NPFMAX) | tabulation times for time profiles |
| I TSP(NPTMAX,NPFMAX) | value of time distribution |

TABLE C.17

DEFINITION OF VARIABLES STORED IN NAMED COMMON C17

| | |
|---|---|
| NSMAX | number of surfaces |
| NAMAX | maximum number of coefficients in the quadric surface equation |
| I NPT(NSMAX) | number of coefficients in each surface |
| I AZ(NSMAX) | $a_o$ term in surface equation |
| I A(NAMAX,NSMAX) | other terms in surface equation |
| I ND(NSMAX) | status of ray tracing calculation by surface |
| I XD(NSMAX) | dummy array for selecting source or collision point |
| I U(NSMAX) | constant term in quadratic equation for distance to surface |
| I V(NSMAX) | linear coefficient term in quadratic equation for distance to surface; also data in calculation of distance to collision |
| I W(NSMAX) | quadratic coefficient in equation for distance to a surface |
| I SI(2,NSMAX) | roots of equation for distance to a surface; also data in calculation of distance to collision |

TABLE C.18

DEFINITION OF VARIABLES STORED IN NAMED COMMON C18

| | |
|---|---|
| NRMAX | number of regions |
| NBMAX | maximum number of boundaries per region |
| I MTL(NRMAX) | index of material in region |
| I ISV(NRMAX) | index of volume source overlying a region |
| I RHØ(NRMAX) | relative material density of region |
| I RIM(NRMAX) | relative scattering importance of region |
| I SGM(NRMAX) | average cross section (except hydrogen) by region |
| I SGH(NRMAX) | average cross section for hydrogen by region |
| I ALT(NRMAX) | average logarithm of the ratio of forward-to-backward scattering |
| I SGA(NRMAX) | total cross section for the average energy group |
| I BIG(NRMAX) | region volume |
| I XR(3,NRMAX) | coordinates of a point in region |
| I NS(NBMAX,NAMAX) | surface index of boundary |
| I NXT(NBMAX,NAMAX) | index of most probable next region |

TABLE C.19

DEFINITION OF VARIABLES STORED IN NAMED COMMON C19

| | |
|---|---|
| NCCMAX | number of correlated calculations |
| NCCMØD | NCCMAX+1 |
| NCSMAX | number of correlated sources |
| NCRMAX | number of correlated regions |
| I ICS(NCSMAX) | indices of correlated sources |
| I JCS(NCCMAX,NCSMAX) | indices of replacement sources |
| I ICR(NCRMAX) | indices of correlated regions |
| I JCR(NCCMAX,NCRMAX) | indices of replacement regions |
| I KCS(NVMAX) | correlated source table index |
| I KCR(NRMAX) | correlated region table index |

TABLE C.20

DEFINITION OF VARIABLES STORED IN NAMED COMMON C20

| | |
|---|---|
| NDMAX | number of detectors |
| NPDMAX | number of point detectors |
| NVDMAX | number of volume detectors |
| NSDMAX | number of surface detectors |
| NVDMØD | number of surface and volume detectors |
| I IDR(NDMAX) | region index of detector |
| I IDS(NDMAX) | surface index of detector |
| I VØL(NDMAX) | area, volume, or scale factor for detector |
| I STD(NDMAX) | translation time for detector |
| I CDT(3,NDMAX) | fixed direction for detector |
| I XDT(3,NDMAX) | point detector coordinates |
| NDMØD | number of detectors for which fluxes are being calculated |
| NDMUD | NDMØD*NCCMØD |

TABLE C.21

DEFINITION OF VARIABLES STORED IN NAMED COMMON C21

| | |
|---|---|
| NSHELL | number of spherical zones in the atmosphere |
| I RAD(NSHELL) | spherical zone boundaries (cm) |
| NAIRPT | number of points in the tabulated air density |
| I AIR(NAIRPT) | air density tabulation points (cm) |
| I REL(NAIRPT) | relative air densities |
| I AAD(NSHELL) | constant term in linear air density curve |
| I BAD(NSHELL) | slope of linear air density curve |

TABLE C.22

DEFINITION OF VARIABLES STORED IN NAMED COMMON C22

| | |
|---|---|
| NRRMAX | number of radial intervals in cylindrical geometry option |
| NRRMØD | NRRMAX+1 |
| I ARE(NRRMAX+1) | radii of intervals |
| NZZMAX | number of axial zones in the cylindrical geometry |
| NZZMØD | NZZMAX+1 |
| I ZEE(NZZMØD) | axial zone boundaries (cm) |
| I CUE(NRRMAX,NZZMAX,4) | initial value of charge and current |
| I CUP(NRRMAX,NZZMAX, 4*MVØLTS) | charge and current on current time step |
| I VØT(NRRMAX,NZZMAX, 4*MVØLTS) | scalar and vector potentials for finite difference solution |
| I WØT(NRRMAX,NZZMAX, 4*MVØLTS) | scalar and vector potentials for finite difference solution |
| I VJH(NRRMØD,NZZMAX) | boundary potentials, radial |
| I VIH(NRRMAX,NZZMØD) | boundary potentials, axial |
| I DIE(NRRMAX,NZZMAX) | dielectric constant by cell |

TABLE C.22 (cont'd)

| | |
|---|---|
| I PER(NRRMAX,NZZMAX) | permeability by cell |
| I VTP(NRRMAX,NZZMAX, 4*MVØLTS) | scalar and vector potentials last time step |
| I VPP(NRRMAX,NZZMAX, 4*MVØLTS) | scalar and vector potentials last-1 time step |
| I CUR(NRRMAX,NZZMAX, 4*MVØLTS) | total charge and current by mesh cell |

TABLE C.23

DEFINITION OF VARIABLES STORED IN NAMED COMMON C23

| | |
|---|---|
| NDUMPS | number of dump requests |
| NLISTS | number of dump requests |
| NVAMAX | maximum number of arrays per dump request |
| NCBMAX | maximum number of named commons to be dumped |
| I NVA(NDUMPS) | number of arrays in each dump |
| I IDA(NVAMAX,NDUMPS) | lists of arrays to be dumped |
| I SUB(2,NDUMPS) | subprogram names for dumps |
| I IFN(NDUMPS) | point in subprogram at which dump is taken |
| I KAL(NDUMPS) | number of passes through dump point |
| I NDN(NDUMPS) | index of pass on which first dump occurs |
| I NDX(NDUMPS) | index of pass on which last dump occurs |
| I LST(NDUMPS) | LST(I) = I |
| I KBN(NCBMAX+1,NDUMPS) | indices of named commons to be dumped |

TABLE C.24

DEFINITION OF VARIABLES STORED IN NAMED COMMON C24

| | |
|---|---|
| MØDELP | biasing model, initial particle source point |
| MØDELQ | biasing model, initial particle direction |
| MØDELU | biasing model, distance to collision |
| MØDELV | biasing model, scattered direction |
| MØDELE | energy importance model |
| MØDELM | discrete particle-packet model |
| I GIM(NEXMAX) | cross section group importance |
| I AIM(NEXMAX) | linear buildup coefficients |
| I ALM(NEXMAX) | forward-backward scattering ratio |
| I ALH(NEXMAX) | forward-backward scattering ratio for hydrogen |
| MØDELR | Russian roulette model |

TABLE C.25

DEFINITION OF VARIABLES STORED IN NAMED COMMON C25

| | |
|---|---|
| NPØINT | 0, fluxes at all detectors simultaneously<br>1, fluxes at point detectors individually |
| NPRINT | number of prints per cycle |
| NUNITS | number of packets per print |
| KALIDE | maximum number of collisions per history |
| NPDRUN | number of point detectors which have been run |
| IIIØUT | cycle index |
| IØUTER | number of cycles |
| IPRINT | print loop index |
| NTØTAL | number of packets generated |
| MTØTAL | number of histories run on previous print |

TABLE C.26

DEFINITION OF VARIABLES STORED IN NAMED COMMON C26

| | |
|---|---|
| NPEMAX | number of primary energy groups yielding secondaries |
| NSEMAX | number of secondary energy groups which receive secondaries |
| I SEC(NSEMAX,NPEMAX, NMMAX) | macroscopic secondary production cross sections |
| I SHA(MAXO(NEMMAX, MEMAX)) | hydrogen capture cross section |
| NREACT | primary-secondary combination indicator |
| IREACT | reaction indicator |
| MXSECT | index of primary producing the secondary |

TABLE C.27

DEFINITION OF VARIABLES STORED IN NAMED COMMON C27

| | |
|---|---|
| NPLØT | plot option flag |
| MPLØT | number of plots generated |
| IPLØ | location of plot buffer |

TABLE C.28

DEFINITION OF VARIABLES STORED IN NAMED COMMON C28

| | |
|---|---|
| IXSECT | NXSECT+1 for particle type being run |
| JXSECT | MXSECT+1 for particle type of prior run |
| NXSECT | (0,1,2,3)=(photons,multigroup neutrons, point cross section neutrons, electrons) |
| NEXMAX | number of cross section groups for particle being run |
| NEXMØD | NEXMAX+1 |
| IELX | location of cross section group boundaries |
| IEWX | location of cross section group widths |
| ISSH | location of cross section for hydrogen |
| IESB | location of average group energy |
| IVEL | location of average group velocity |
| ISGT | location of total cross section |
| IEAC | location of energy absorption cross section |
| NSLØW | number of groups treated by approximate slowing down |
| LSLØW | (NSLØW*(NSLØW+1))/2 |
| NFAST | number of neutron groups undergoing explicit slowing down |
| I DØN(LSLØW,NMMAX+1) | neutron slowing down cross sections |

TABLE C.29

DEFINITION OF VARIABLES STORED IN NAMED COMMON C29

| | |
|---|---|
| NEMAX | number of energy groups for particle type being run |
| NEMØD | NEMAX+1 |
| IELL | location of energy group boundaries |
| IELW | location of energy group widths |
| I JWN(NCCMØD) | index of the first non-empty group out of collision or source |
| I JWX(NCCMØD) | index of the last non-empty group out of collision or source |
| I KWN(NCCMØD) | index of the first non-empty group into collision |
| I KWX(NCCMØD) | index of the last non-empty group into collision |
| I WS(NEMAX,NCCMØD) | packet weights out of collision or source |
| I TS(NEMAX,NCCMØD) | average time of flight out of collision or source |
| I ES(NEMAX,NCCMØD) | average energies out of collision or source |
| I WC(NEMAX,NCCMØD) | packet weights into collision |
| I EC(NEMAX,NCCMØD) | average energies into collision |

TABLE C.29 (cont'd)

| | |
|---|---|
| I TC(NEMAX,NCCMØD) | average times into collision |
| I XMP(NEMØD,NCCMØD) | mean free paths traversed by particle |
| I SGR(NEMØD,NCCMØD) | total cross section in the last region traversed |
| I SGB(NEMØD,NCCMØD) | mean free paths from source point |
| I VAF(NEMAX,NCCMØD) | path length-averaged weight |
| I VAE(NEMAX,NCCMØD) | path length-averaged energy |
| I VAT(NEMAX,NCCMØD) | path length-averaged time |
| I XAS(NEMAX) | mean square electron deflection, integrated |
| I AJJ(NEMAX) | dummy array for electron transport kernel |



α

TABLE C.30

DEFINITION OF VARIABLES STORED IN NAMED COMMON C30

| | |
|---|---|
| NGMAX | number of flux groups for particle type being run |
| NGMØD | NGMAX+1 |
| NFMAX | number of response functions for particle type being run |
| IELF | location of flux group boundaries |
| IFGW | location of flux group widths |
| ITDS | location of response titles |
| IRSP | location of response functions |
| I FXA(NGMAX,MØMENT, NDMUD) | optional flux moments storage |
| I FXT(NGMAX,NDMØD, NCCMØD) | total number flux |
| I FXE(NGMAX,NDMØD, NCCMØD) | total energy flux |
| I FXS(NGMAX,NDMØD, NCCMØD) | sum of flux squared |
| I FXP(NGMAX,NDMØD, NCCMØD) | flux from current history |
| I IDØ(MØMENT) | indices of flux moments |
| I TLE(3,MØMENT) | title of flux moments |
| MØMENT | total number of optional flux edits |

## TABLE C.31

## DEFINITION OF VARIABLES STORED IN NAMED COMMON C31

| | |
|---|---|
| NLEAKS | number of leakage boundaries |
| NDEPØS | region energy deposition option (0,1) |
| I ILR(NLEAKS,NCCMØD) | index of leakage boundary region |
| I ILS(NLEAKS,NCCMØD) | index of leakage boundary surface |
| I ØUL(NLEAKS,NCCMØD) | energy leakage from boundary |
| I ØUS(NLEAKS,NCCMØD) | energy leakage squared for boundary |
| I ØUP(NLEAKS,NCCMØD) | energy leakage for current particle |
| I DEV(NRMAX,NCCMØD, NDEPØS) | energy deposition in regions |
| I DES(NRMAX,NCCMØD, NDEPØS) | energy deposition squared |
| I DEP(NRMAX,NCCMØD, NDEPØS) | energy deposition for current particle |
| I CUT(NRMAX,NCCMØD, NDEPØS) | energy deposition, collision cutoff |
| I EUT(NRMAX,NCCMØD, NDEPØS) | energy deposition, energy cutoff |
| I WUT(NRMAX,NCCMØD, NDEPØS) | energy deposition, weight cutoff |

TABLE C.32

DEFINITION OF VARIABLES STORED IN NAMED COMMON C32

| | |
|---|---|
| NUMVØL | number of channel detectors |
| NUMTØT | = NUMVØL |
| I NUM(NUMREG,NUMVØL) | indices of regions comprising channel detector |
| NUMREG | maximum number of regions per channel detector |
| NCEMAX | number of channels |
| I ELC(NCEMAX) | channel boundaries (Mev) |
| I ETT(NCEMAX,NUMTØT, NCCMØD*DEPØS) | channel detector counts |
| I ETP(NCEMAX,NUMTØT, NCCMØD*NDEPØS) | channel detector counts, current particle |
| I ETS(NCEMAX,NUMTØT, NCCMØD*NDEPØS) | channel detector counts squared |
| NØISE | number of Gaussian noise functions |
| I GAU(NCEMAX,NCEMAX, NØISE) | Gaussian transfer function |
| I WHM(NØISE) | full widths at half maximum (Mev) |
| I WST(NCCMØD) | initial total weight of secondary particles |

TABLE C.33

DEFINITION OF VARIABLES STORED IN NAMED COMMON C33

| | |
|---|---|
| NCHECK | number of outer region-boundary combinations |
| MCHECK | maximum number of ray trace errors |
| LCHECK | count of ray trace errors |
| I NRC(NCHECK) | indices of outer regions |
| I NBC(NCHECK) | indices of boundaries of outer regions |

## TABLE C.34

### DEFINITION OF VARIABLES STORED IN NAMED COMMON C34

| | |
|---|---|
| NRØTRA | total number of rotation-translation inputs |
| I IRN(NRØTRA) | index of first source to be rotated-translated |
| I IRX(NRØTRA) | index of last source to be rotated-translated |
| I RZP(3,NRØTRA) | translation component of rotation-translation |
| I RZM(3,3,NRØTRA) | rotation component of rotation-translation |

TABLE C.35

DEFINITION OF VARIABLES STORED IN NAMED COMMON C35

| | |
|---|---|
| NCMAX | number of order-of-scatter edits |
| NVMØD | number of birth region edits |
| I IDV(NVMØD) | indices of birth regions for edits |
| NSRMAX | number of scattering region edits |
| I ISR(NSRMAX) | indices of scattering regions for edits |
| NBCMAX | number of boundary crossing edits |
| I IRB(NBCMAX) | region index for boundary crossing |
| I JRB(NBCMAX) | boundary crossing flag |
| I KRB(NBCMAX) | surface index for boundary crossing |
| NLMAX | number of angular flux Legendre moment edits |
| NAFMAX | number of cosines at which Legendre angular fluxes will be calculated |
| NABMAX | number of solid angle intervals for angular flux edits |
| I AFB(4,NABMAX) | solid angle interval boundaries |
| NTAMAX | number of times at which the time dependence will be evaluated |
| NTMØD | NTMAX+1 |

TABLE C.35 (cont'd)

| | |
|---|---|
| NTBMAX | number of time bins |
| I TBB(NTBMAX) | time bin boundaries |
| NGRØUP | number of groups for edit by initial group |
| I DUE(NEMAX*NEMØD/2, NCCMØD,min(1, NGRØUP)) | weight contribution by initial group |
| I FRØ(NEMAX*NEMØD/2, NCCMØD,min(1, NGRØUP)) | weight contribution by initial group at collision |

TABLE C.36

DEFINITION OF VARIABLES STORED IN NAMED COMMON C36

| | |
|---|---|
| KINMAX | number of skin depth biasing locations |
| I KIN(KINMAX) | region index for skin depth bias |
| I KIM(KINMAX) | surface index for skin depth bias |
| I SKD(KINMAX) | skin depth |
| I SKI(KINMAX) | importance factor |

TABLE C.37

DEFINITION OF VARIABLES STORED IN NAMED COMMON C37

| | |
|---|---|
| LENINT | integers per collision tape record |
| LENGTH | reals per collision tape record |
| MENINT | integers per source tape record |
| MENGTH | number of reals per source tape record |
| MGMAX | number of flux groups for primary particle |
| MRSP | location of primary response data |
| MAXPAR | number of biasing parameters for primaries |
| MALIDE | collisions per primary particle |
| MFLW | location of primary flux group widths |
| I KNS(NCCMØD) | first non-empty group for primary particles from tape |
| I KXS(NCCMØD) | last non-empty group for primary particles from tape |
| I ISS(NØRMLD) | shield crossing flags for primaries |
| I WSS(MEMAX,NCCMØD) | packet weights for primary particles from tape |
| I ESS(MEMAX NCCMØD) | packet energies for primary particles from tape |
| I TSS(MEMAX,NCCMØD) | packet times for primary particles from tape |

TABLE C.37 (cont'd)

| | |
|---|---|
| IDSS(NØRMLD,MEMAX, NCCMØD) | shield worth derivatives for primaries |
| MEMAX | number of primary particle energy groups |

TABLE C.38

DEFINITION OF VARIABLES STORED IN NAMED COMMON C38

| | |
|---|---|
| I DFN(NØRMLD+1,MGMAX, NØRCØM*NDMUD) | detector dose derivatives, present particle |
| I ISN(NØRMLD) | shield dependence, source packet |
| I ICN(NØRMLD) | shield dependence,collision packet |
| I DWS(NØRMLD,NEMAX, NCCMØD) | shield derivatives for source packet |
| I DWC(NØRMLD,NEMAX, NCCMØD) | shield derivatives for collision packet |
| I WGJ(NØRMLD) | shield weights |
| I WGD(NØRMLD) | shield weight derivatives |
| I DFS(NØRMLD+1,MGMAX, NØRCØM) | detector dose derivatives, primary particle |
| I DØS(NØRCØM,2) | dose by component and particle type |
| I DDØ(NØRMLD,NØRCØM,2) | dose derivative by shield, component, and particle |
| I DDT(NØRMLD) | dose derivatives |
| I QAL(NØRMLD) | dose/weight derivatives |
| I IPN(NØRMLD) | tally shield dependence |

## TABLE C.39

## DEFINITION OF VARIABLES STORED IN NAMED COMMON C39

| | |
|---|---|
| MVØLTS | time steps in the internal EMP calculation |
| MAXWEL | iterations in the solution of Poisson's equation |
| MINØRS | number of small time steps per time step |
| I XXB(3,NSTMAX,MVØLTS) | coordinates of particle at a region boundary |
| I CCB(3,NSTMAX,MVØLTS) | direction of particle at a region boundary |
| I BVW(NSTMAX,MVØLTS) | weight of particle at a boundary |
| I BVE(NSTMAX,MVØLTS) | energy of particle at a boundary |
| I BVT(NSTMAX,MVØLTS) | time of particle at a boundary |
| I JGB(NSTMAX,MVØLTS) | group of particle at a boundary |

TABLE C.40

DEFINITION OF VARIABLES STORED IN NAMED COMMON C40

| | |
|---|---|
| NMB | random number iteration counter |

TABLE C.41

DEFINITION OF VARIABLES STORED IN NAMED COMMON C41

| | |
|---|---|
| I T(NTMØD) | flight time raised to powers |
| I P(max(2,NLMAX)NØRDER) | evaluated Legendre polynomials |
| I AN(NTMØD) | temporary storage of transformed time moments |
| I BN(NTMØD) | temporary storage of transformed time moments |
| I CN(NTMØD) | temporary storage of transformed time moments |
| I DN(NTMØD) | temporary storage of transformed time moments |
| I AII(2*NTMØD) | factorials |
| I BJI(NTMØD,NTMØD) | inverted coefficient matrix for time moments |
| I CJI(NTMØD,NTMØD) | original coefficient matrix for time moments |
| I XIN(NTMØD) | temporary storage of time moments |
| I FLX(NTAMAX) | time dependence output array |
| I PAG(8,NFMAX) | output array for responses |
| I EMD(NFMAX,NDMØD) | sum of response squared for variance calculation |

TABLE C.41 (cont'd)

| | |
|---|---|
| I TDC(NTMØD,NGMAX) | time dependence polynomial coefficients |
| I AE(NGMAX) | upper boundary coefficient for flux group interpolation |
| I BE(NGMAX) | lower boundary coefficient |
| I TDA(NGMAX) | time dependence exponential slopes |
| I ERR(NGMAX) | variance by flux group |
| I PFE(NGMAX) | average energies for plots |

TABLE C.42

DEFINITION OF VARIABLES STORED IN NAMED COMMON C42

| | |
|---|---|
| NZERØ | index of region containing the preferred point |
| JZERØ | average source energy group index |
| JMIN | =1 |
| JMAX | >0 if any packets have non-zero weights |
| JBAR | average energy group index |
| IIII | point detector index |
| KKKK | collision index |
| MØN | index of source in optional edit request |
| INSR | index of scattering region in optional edit request |
| NTALLY | number of significant flux contributions from current collision |
| LLREG | index of the source from which the particle started |
| NN | index of the region in which the particle is located |
| NNNN | index on primary collision which generated a secondary |
| MMMM | dummy variable |

TABLE C.42 (cont'd)

| | |
|---|---|
| IIIDET | detector index for tallying |
| NNC | index of region in which the particle collides |

TABLE C.43

DEFINITION OF VARIABLES STORED IN NAMED COMMON C43

| | |
|---|---|
| RADIUS | radius of pseudo spherical source (cm) |
| XCT(3) | center of pseudo spherical source (cm) |
| ATA | cosine selection parameter |
| ATB | azimuthal angle selection parameter |
| ATC | distance selection parameter |
| ATD | fractional weight cutoff |
| STZERØ | distance from preferred point to center of pseudo spherical source |
| PHIMIN | 1-cosine of angle subtended by pseudo spherical source |
| ATX | cosine selection parameter |
| RØZ(3,3) | rotation matrix from coordinate system used in sampling pseudo spherical source |

TABLE C.44

DEFINITION OF VARIABLES STORED IN NAMED COMMON C44

| | |
|---|---|
| DELTA | radius of sphere containing the preferred point (cm) |
| BDC(3) | preferred point coordinate (cm) |
| AT | distance to collision selection parameter, from particle position |
| BT | distance to collision selection parameter, from preferred point |
| AS | scattered direction selection parameter, towards preferred point |
| BS | scattered direction selection parameter, in original direction |
| CUTANG | cosine of small angle-large angle division |

TABLE C.45

DEFINITION OF VARIABLES STORED IN NAMED COMMON C45

| | |
|---|---|
| DIM | radius of "short circuit" sphere |
| CØR(3) | center of "short circuit" sphere |
| PTH(4) | minimum probabilities for backwards selection of scattering point |

TABLE C.46

DEFINITION OF VARIABLES STORED IN NAMED COMMON C46

| | | |
|---|---|---|
| XQ(9) | coordinates of particle | set aside for future elimination of arguments from the ray tracing call sequence |
| CQ(9) | direction cosines of particle | |
| CXQ(9) | | |

TABLE C.47

DEFINITION OF VARIABLES STORED IN NAMED COMMON C47

| | |
|---|---|
| DPDFDA | partial derivative of importance functions, this pass |
| DPDFDB | partial derivative of importance functions, last pass |
| PSØRS | value of fixed source pdf |
| PDFCØL | value of pdf used in selecting collision point |
| CØSDET | cosine of angle at which particle crosses detector |
| VØLDET | scale factor for all detector tallies |
| TØTALN | total weighted number flux tallied at detector |
| TØTALE | total weighted energy flux tallied at detector |
| SNØRM | = 1.0 |
| XC(3) | coordinates of particle at collision |
| CC(3) | direction of particle at collision |
| CAB(3) | direction cosines of detector fixed direction |
| CØP(3) | cosines of the particle as it crosses the detector |

TABLE C.47 (cont'd)

| | |
|---|---|
| BUILDN | weighted sum of number flux tallied at detector |

TABLE C.48

DEFINITION OF VARIABLES STORED IN NAMED COMMON C48

| | |
|---|---|
| NSTMAX | maximum number of regions which can be traversed by a ray |
| I NRG(NSTMAX) | indices of regions traversed |
| I NSC(NSTMAX) | indices of surfaces crossed |
| I NRP(NSTMAX) | alternate array for regions traversed |
| I NSP(NSTMAX) | alternate array for surfaces crossed |
| I ST(NSTMAX) | partial path lengths in the regions traversed |
| I STP(NSTMAX) | alternate array for partial path lengths |
| NSTLIM | total number of regions traversed by a ray |
| I RMU(NSTMAX) | distance to preferred point from ray boundary crossing |
| I ØME(NSTMAX) | cosine of angle to preferred point from ray boundary crossing |
| I DNM(NSTMAX) | derivative of collision pdf with respect to left boundary |
| I DNP(NSTMAX) | derivative of collision pdf with respect to right boundary |

TABLE C.49

DEFINITION OF VARIABLES STORES IN NAMED COMMON C49

| | |
|---|---|
| NØRMLD | number of shields |
| NØRCØM | number of flux components seeing different shield combinations |
| IPRESP | index of response for shield optimization of last particle type |
| ISRESP | index of response for shield optimization of first (if any) particle type |
| ITERMX | maximum iterations in shield optimization |
| ITPRIN | iterations per print in shield optimization |
| I DRC(NDMAX) | dose rate constraint by detector |
| I IGS(NØRMLD) | shield geometry |
| I IDF(NØRMLD) | effect of shield on adjacent shield |
| I TIN(NØRMLD) | initial thickness of shield |
| I TMN(NØRMLD) | minimum thickness of shield |
| I TMX(NØRMLD) | maximum thickness of shield |
| I RIN(NØRMLD) | inner radius of shield |
| I RSH(NØRMLD) | shield weight coefficient except geometry factor |

TABLE C.49 (cont'd)

| | |
|---|---|
| I DWX(NØRMLD) | maximum shield weight increment per iteration |
| I INR(NØRMLD) | region index of shield |
| I INS(NØRMLD) | surface index of shield |
| I IDN(NØRMLD) | not used |
| I TVL(NØRMLD) | current shield thickness |

TABLE C.50

DEFINITION OF VARIABLES STORED IN NAMED COMMON C50

| | |
|---|---|
| NØBIAS | (0,1)=(no,yes) calculate variance derivatives with respect to importance parameters |
| NAXPAR | total number of importance parameters |
| I DDB(NFMAX,NAXPAR, NDMUD) | parameter derivatives, sum |
| I DSB(NFMAX,NAXPAR, NDMUD) | parameter derivatives, weighted sum |
| I SDB(NAXPAR) | parameter derivatives |
| I DPB(NFMAX,NAXPAR, NDMUD) | parameter derivatives,current packet |

TABLE C.51

DEFINITION OF VARIABLES STORED IN NAMED COMMON C51

| | |
|---|---|
| PSI | cosine of scattering angle |
| RHØ | density scale factor for scattering region |
| RHH | hydrogen density for scattering region |
| PDS | pdf scale factor |
| MM | mixture number for scattering region |
| MTL | material number for scattering region |
| JDEN | location of electron density for scattering region |
| LCC | dummy variable |
| JWS | location of source packet weights |
| JES | location of source packet energies |
| JTS | location of source packet times |
| JDWS | location of source packet shield derivatives |
| JWC | location of collision packet weights |
| JEC | location of collision packet energies |
| JTC | location of collision packet times |
| JDWC | location of collision packet shield derivatives |

TABLE C.51 (cont'd)

| | |
|---|---|
| KMIN | first non empty collision group |
| KMAX | last non empty collision group |
| JMINB | first non empty primary particle group |
| JMAXB | last non empty primary particle group |
| JWSS | primary particle packet weight |
| JESS | primary particle packet energies |
| JTSS | primary particle packet times |
| JDSS | primary particle packet shield derivatives |

TABLE C.52

DEFINITION OF VARIABLES STORED IN NAMED COMMON C52

| | |
|---|---|
| NQUICK | number of quick plots |
| I IQU(NQUICK) | quick plot primary identifier |
| I JQU(NQUICK) | quick plot secondary identifier |
| I XQU(MAXP) | abscissa of quick plot |
| I YQU(MAXP) | ordinate of quick plot |
| I KWI(95) | storage for quick plot output line |

TABLE C.53

DEFINITION OF VARIABLES STORED IN NAMED COMMON C53

| | |
|---|---|
| MØDELC | 0, normal biasing<br>1, altered biasing for neutron capture |
| I CAP(NRMAX) | capture biasing probability |
| I ELR(NEEMØD,NMMAX) | residual electron range |
| IAD1 | source index modifier |
| IAD2 | surface index modifier |
| IAD3 | region index modifier |
| IAD4 | detector index modifier |
| IAD5 | composition index modifier |

# Appendix D

## PROGRAM LOGIC

The functions performed by the program are divided into three categories; data input and preparation, particle tracking, and output of results. These operations are controlled by the main program as shown schematically in Figure D.1.

The data input and preparation operations are controlled by subroutine DEFINE. The basic flow of this subroutine is shown in Figure D.2. This subroutine controls all the input functions described in Appendix A.

The particle tracking may be controlled by one of two subroutines. Subroutine SØBER controls the tracking if the same particle histories are used to calculate point, surface and volume detector fluxes. The flow of this subroutine is shown in Figure D.3. Alternatively, if particle histories are generated specifically for a particular point detector, the particle tracking is controlled by subroutine SØLVER as sketched in Figure D.4.

The output of calculated fluxes is controlled by subroutine ANSWER. The output process is not complicated by any logical decisions worthy of a flow diagram.

The remainder of this appendix is devoted to a brief description of the subprograms. Since each subprogram performs a very specific task, the definitions of the named common variables in conjunction with the subprogram function should be sufficient for anyone capable of modifying the program to do so.

FIGURE D.1

BASIC PROGRAM LOGIC

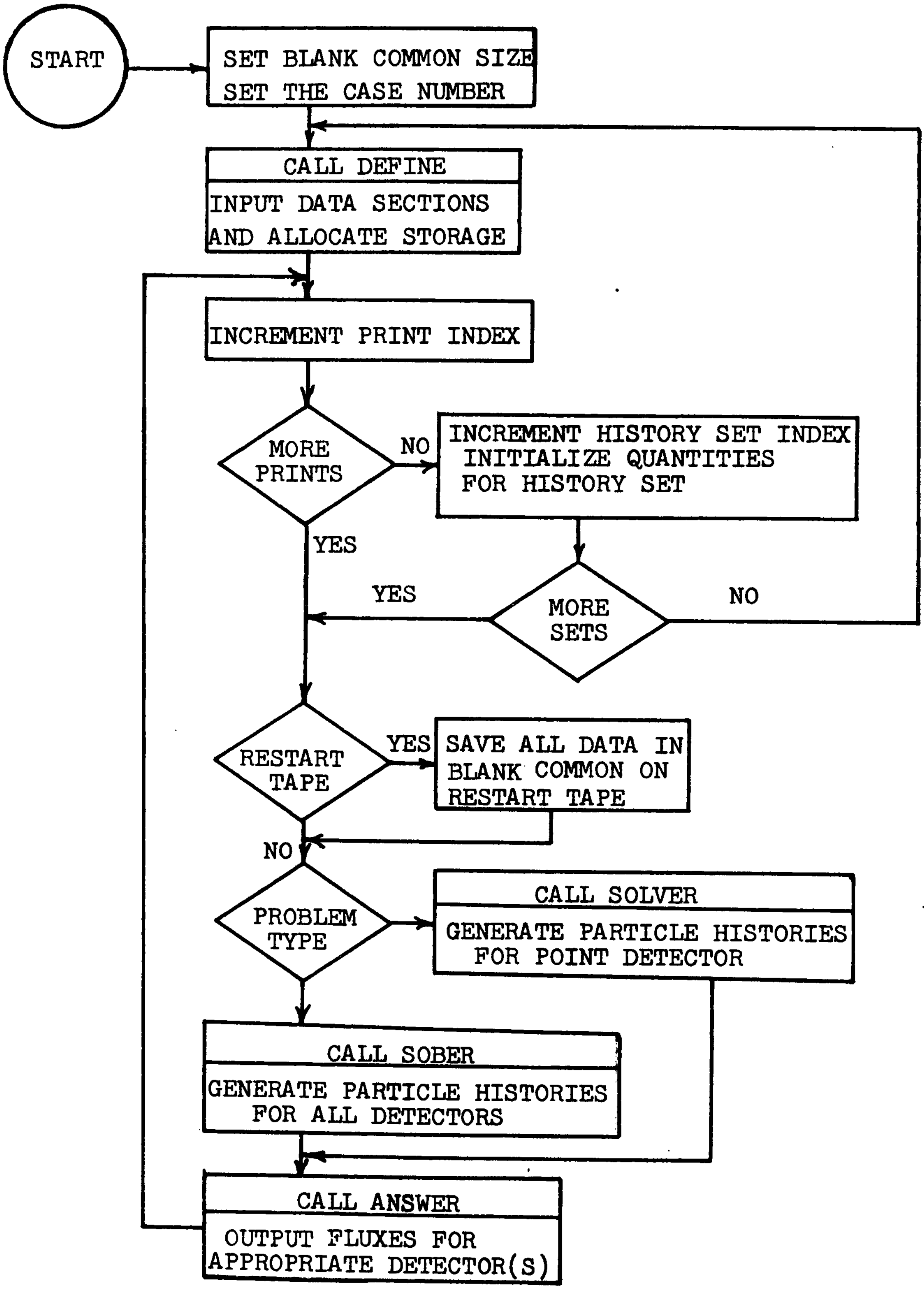


FIGURE D.2

DATA INPUT LOGIC

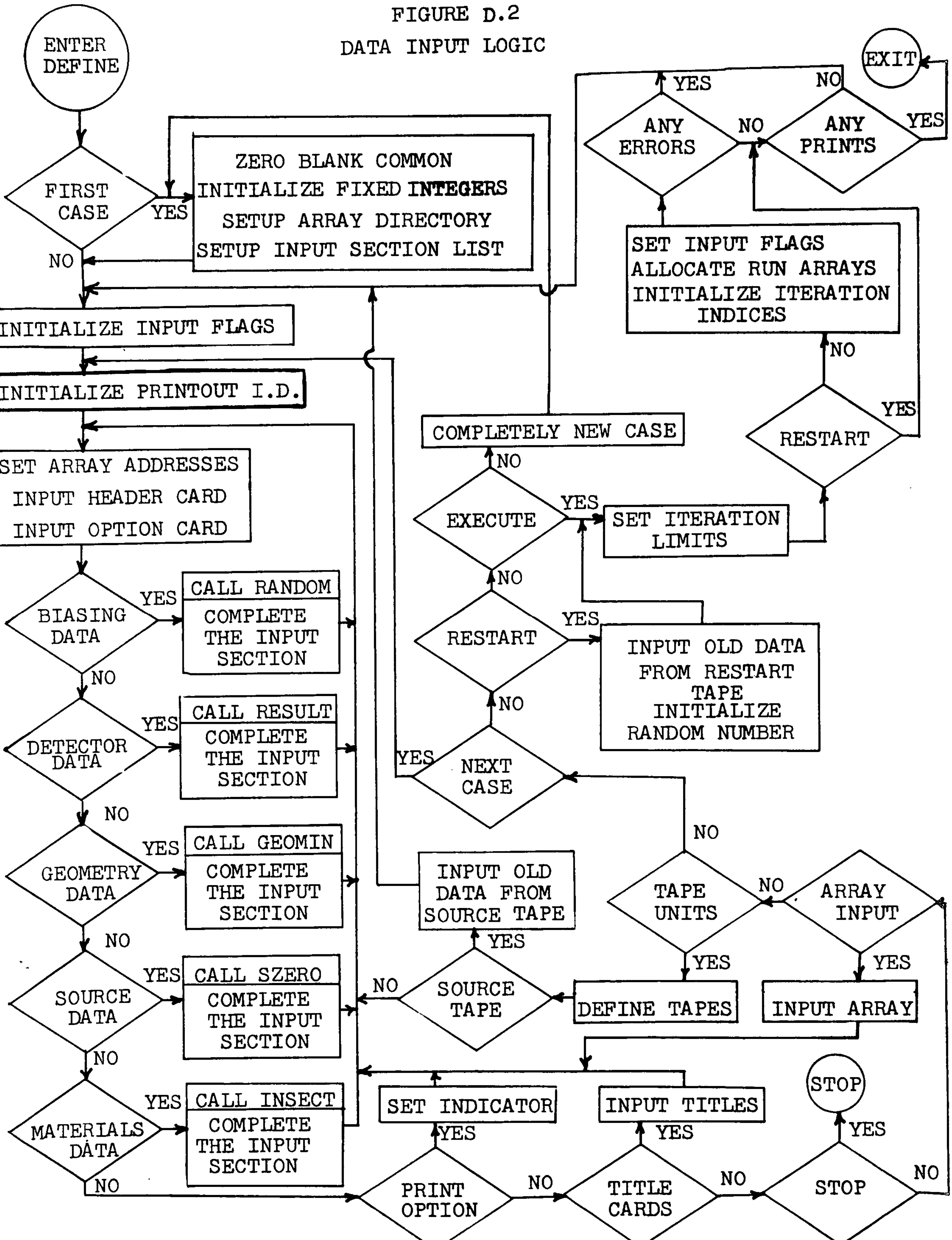


FIGURE D.3

PARTICLE TRACKING FOR MULTIPLE DETECTORS

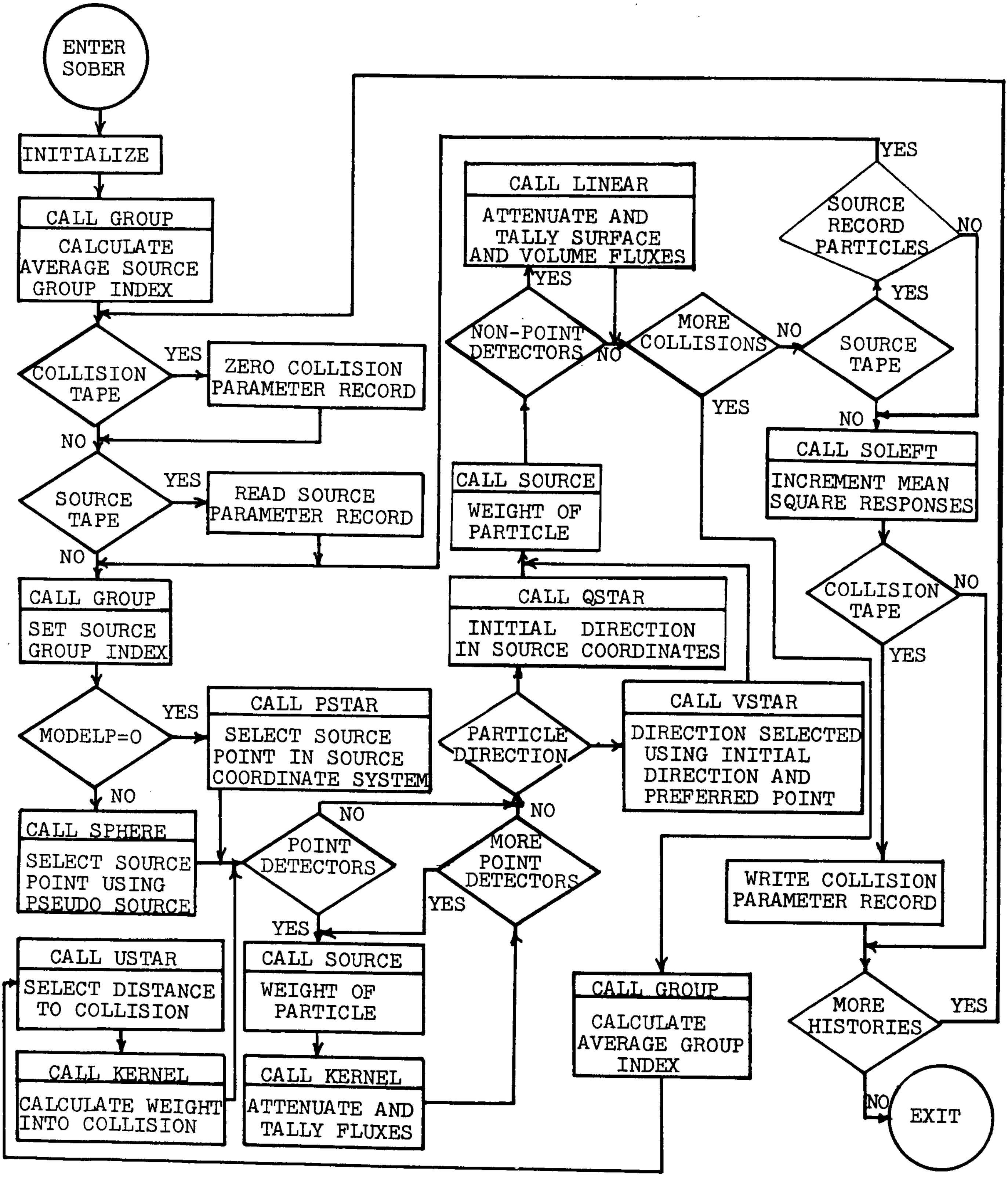
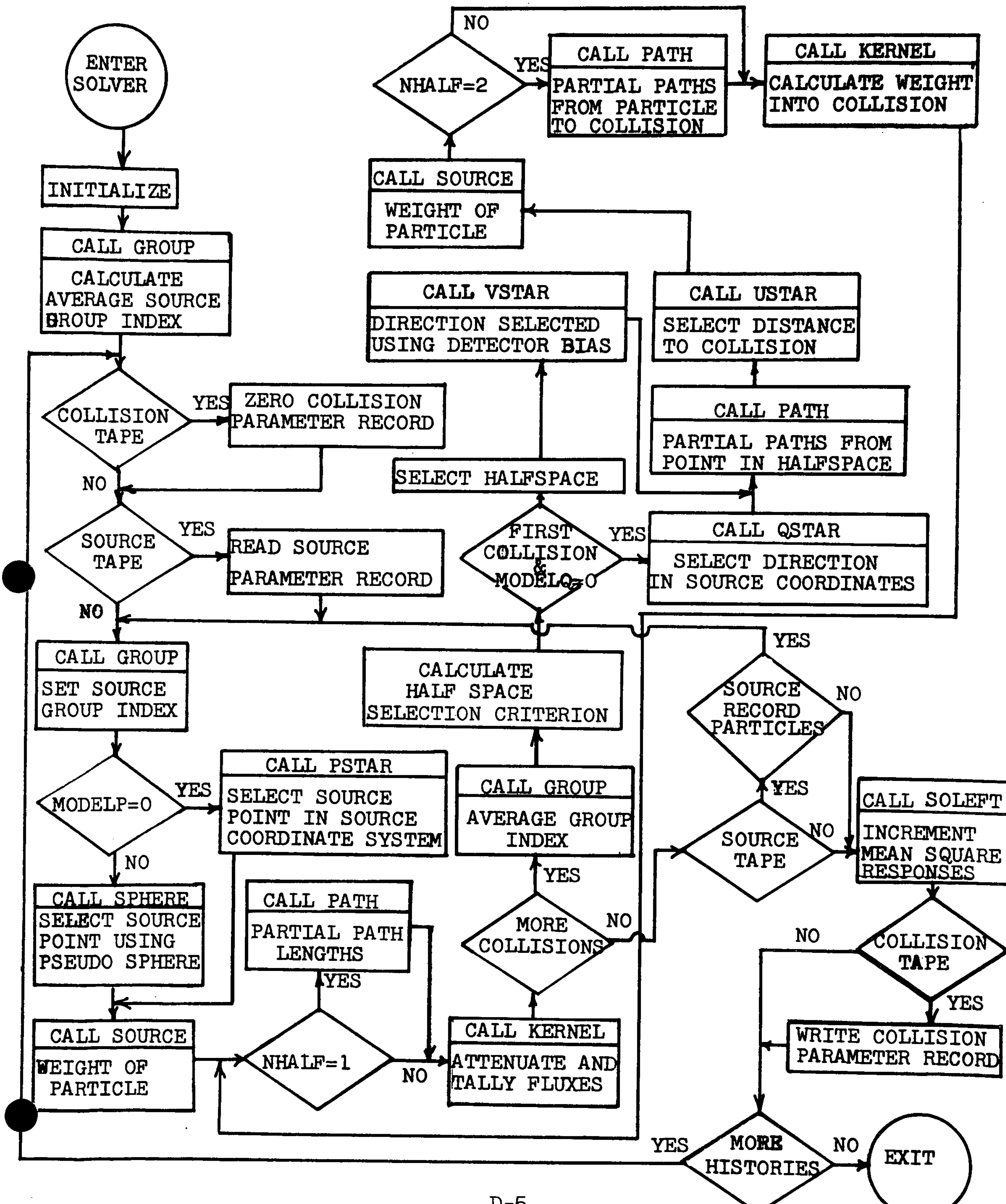


FIGURE D.4

PARTICLE TRACKING FOR INDIVIDUAL POINT DETECTORS



A tabulation of each subprogram along with a brief description, is presented in Table D.1.

TABLE D.1

SUBPROGRAMS

| Subprogram | Function |
|---|---|
| MAIN | Provides the calling sequence to the subprograms which control the input, particle tracking and output of results. |
| INTZ | Calculates the largest integer $\leq$ the absolute value of the argument. |
| ZMIN1 | Calculates the minimum of two arguments. |
| AMAX1 | Calculates the maximum of two arguments. |
| ZBS | Calculates the absolute value of an argument. |
| ZQRT | Computes the square root of the argument. |
| ZXP | Exponentiates the argument (base e). |
| ZLØG | Computes the natural logarithm of the argument. |
| ZTAN2 | Calculates the arctangent of the arguments. |
| ZIN | Computes the sine of the argument. |
| ZØS | Calculates the cosine of the argument. |
| VECTØR | Calculates the distance and direction between two points. |

| | |
|---|---|
| RØTATC | Calculates the sine and cosine of two rotation angles given the direction cosines. |
| RØTATE | Calculates the direction vector rotation matrix given the sines and cosines of the rotation angles. |
| CENTER | Controls the rotation-translation of source coordinates. |
| RØTATX | Performs the rotation-translation of source coordinates. |
| CØSINE | Computes the cosine of the angle between two direction vectors. |
| RANNØ | Generates pseudo random numbers uniformly distributed on the open interval (0,1). |
| SAMPLE | Selects points at random from a truncated exponential distribution. |
| LABEL | Counts printout lines and inserts printout headings at the top of each page. |
| DUMPIT | Prints the elements of variable-dimensioned arrays and named common blocks as requested by input data. |
| KØMMØN | Controls the initialization, input and output of named common blocks. |
| INTCØM | Performs the initialization, input and output of named common blocks. |

| | |
|---|---|
| LØCATE | Calculates the index of the region in which a particle is located. |
| HELIX | Calculates quantities related to helical and toroidal surfaces. |
| DEFINE | Controls the input and data preparation phases of a problem. |
| INDEX | Allocates storage for variable-dimensioned arrays. |
| ICHECK | Checks order of ordered arrays. |
| JCHECK | Checks index against permissible range. |
| KCHECK | Checks input-section input order. |
| READH | Inputs H format data (header card). |
| READA | Inputs A format (24A3) hollerith data. |
| READI | Inputs I format (24I3) integer data. |
| READIS | Inputs IS format (12(2I3)) indices and integer data. |
| READE | Inputs E format (8E9.0) decimal data. |
| READEE | Inputs EE format (4(2E9.0)) logical pair decimal data. |
| READIE | Inputs IE format (6(I3,E9.0)) logical pair integer-decimal data. |

| | |
|---|---|
| READES | Inputs ES format (6(I3,E9.0)) indices and decimal data. |
| READS | Inputs S format (3I3,7E9.0) integer and decimal data. |
| READR | Inputs R format (12I3,4E9.0) integer and decimal data. |
| READF | Inputs F format (6(I2,A1,E9.0)) DTF-IV cross section data. |
| READL | Inputs L format (14X,6E10.0) LRL photon cross section data. |
| READIT | Inputs all data cards in a variable field length format |
| IARRAY | Allocates storage for input arrays. |
| ARRAY | Inputs elements of a specified array. |
| INSECT | Inputs materials compositions and controls microscopic cross section inputs. |
| MULTIX | Forms macroscopic cross sections from microscopic multigroup neutron cross sections. |
| MATRIX | Inputs multigroup neutron cross sections. |
| GAMMAX | Inputs photon cross sections and calculates macroscopic cross sections. |

| | |
|---|---|
| BASICX | Inputs and prepares point value neutron cross sections. |
| SLØWER | Inputs and prepares electron cross sections. |
| SZERØ | Controls the input and normalization of the spatial, angular, and energy distributions of the source distributions. |
| GEØMIN | Inputs both simple geometries and the more general surface-region descriptions. |
| RESULT | Controls the input of detectors and output requests. |
| REXTRA | Inputs optional output requests. |
| RANDØM | Inputs biasing options and biasing parameters. |
| RLIMIT | Sets limits used during particle tracking. |
| RARRAY | Allocates storage for run arrays. |
| DØWN | Calculates coefficients for neutron slowing down model. |
| REGIØN | Checks the input geometry |
| ASKFØR | Sets up data for flux output. |
| BIASIT | Sets the values of all biasing options and parameters not input. |

| | |
|---|---|
| SØLVER | Controls the generation and tracking of particle histories for individual point detectors. |
| SØBER | Controls the generation and tracking of particles for point, surface and volume detectors. |
| DØSES | Calculates the sums of the mean square responses at each detector from each particle. Writes collision records on tape. |
| LINEAR | Controls the calculation of surface-and volume-averaged fluxes along a particle path. |
| SØURCE | Controls the calculation of particle weights from the independent source, from scattering events, and from secondary interactions. |
| SINPUT | Calculates packet weights from input sources. |
| CAPTUR | Calculates secondary gamma ray weights. |
| CØMPTN | Calculates secondary electron weights |
| BREMSS | Calculates secondary bremsstrahlung weights |
| SCATTR | Performs the calculation of scattered particle weights from pre-collision weights using multigroup cross sections. |

| | |
|---|---|
| PHØTØN | Performs the calculation of scattered photon weights from the pre-collision weights. |
| NEUTRN | Calculates scattered neutron weights using point value cross sections. |
| BETAS | Calculates scattered electron weights. |
| THERML | Calculates slow neutron weights using approximate slowing down model. |
| UNITRA | Calculates scattered components of shield derivative worth, etc. |
| PATH | Calculates the partial path lengths from an initial position along a specified direction up to a maximum total distance. |
| NØRMAL | Calculates the surface normal at a specified point on a surface. |
| KERNEL | Calculates the particle attenuation along the particle path and generates the pre-collision particle weights. |
| AHEAD | Calculates the electron attenuation and slowing down along segments of the particle path. |
| DETECT | Performs all the tallies of particle fluxes for all the detector types. |
| GRØUP | Calculates the group index to be used in the biased selection of scattering points and direction for all the particles. |

| | |
|---|---|
| SPHERE | Selects the initial particle position from the fixed sources in a spherical coordinate system centered at a preferred point. |
| PSTAR | Selects the initial particle position by first selecting the source and then selecting the spatial coordinates in the source coordinate system. |
| QSTAR | Selects the initial particle direction in the coordinate system for the originating source. |
| USTAR | Selects the distance to collision from the exponential transformation or from a curve fit of an approximation to the optimal distribution for collision points. |
| VSTAR | Selects the initial or scattered particle direction in a rotated coordinate system which forces particles both in their pre-collision direction and in the direction of the preferred point. |
| ANSWER | Controls the output of fluxes and other quantities for all of the detectors. |
| DEPØS | Outputs energy deposition by region, energy leakage, and channel detector tallies |
| FLUXES | Outputs basic flux quantities and optional edits. |

| | |
|---|---|
| PLØTNE | Generates plotted and/or punched output. |
| TIMER | Calculates time-dependent fluxes from time moments. |
| DERIVE | Outputs flux components and derivatives with respect to surface normals. |
| ØPTIMA | Adjusts shield dimensions to give the minimum weight shield which meets a specified dose contraint. |
| TEMPER | Controls the time-dependent tracking of electrons for internal EMP calculations. |
| VØLTS | Controls the finite difference solution of Maxwell's equations for the scalar and vector potentials. |
| PØTENT | Solves Maxwell's equation by iterative finite difference techniques. |
| LØØKC | Controls output of most quick plots. |
| QUICKP | Prints quick plot output. |

## Appendix E

## MACHINE CONSIDERATIONS

This appendix outlines the differences in the program source deck when used on the IBM 7090, IBM 360, UNIVAC 1108 and CDC 6600 series computers.

### 1. General Considerations

BLANK CØMMØN SIZE

It may be necessary on various computers to increase or decrease the size of blank common. The necessary changes are made in the main program and consist of changing two Fortran statements. To change the size to N locations, the following cards should be substituted.

```
DIMENSIØN    LA(N)
NSTØRE = N
```

DØUBLE PRECISIØN

The program can be converted to double precision in a routine manner on the IBM 360 and UNIVAC 1108 computers by use of the following implicit statement in the main program and each subprogram

```
IMPLICIT    REAL*8(A-H,Ø-Z)
```

In addition, the single precision function calls in subprograms INTZ, ZMIN1, ZMAX1, ZBS, ZQRT, ZXP, ZLØG, ZTAN2, ZIN, and ZØS should be changed to their double precision equivalents. Finally, one Fortran statement in the main program must be changed to read

```
IBMCDC = 5
```

## PRINTØUT

The number of printout lines per page can be changed for different paper sizes by altering one card in the main program to read

```
LINEX = L
```

where L is the desired maximum line count.

## INPUT AND ØUTPUT UNITS

The logical designation of the input unit can be changed from 5 to I by substituting the following card in the main program

```
M1=I
```

where I denotes the desired logical designation. Similarly, the logical designation of the output tape can be changed from 6 to J by substituting the following card in the main program

```
M2=J
```

## EBCDIC DATA CØMPATIBILITY

There is a DATA statement in subroutine READIT which allows the program to interpret both BCD and EBCDIC data cards. Some compilers will not accept this statement, and the following change (BCD) should be made:

replace DATA JEBCDP/1H$\overset{12}{\underset{8}{6}}$/ by DATA JEBCDP/1H+/

CALCØMP PLØTTING

The program interfaces with the Calcomp plot package through four entry points PLØT, PLØTS, SYMBØL, and NUMBER. If plotting is required, the dummy subprograms with these names should be removed. The plot output is generated on logical unit 10. If a different unit, I, is used at a particular installation the following card should be changed in the main program

M9=I

2. Program Segmentation

Segmentation of the program permits the execution of much larger problems since the size of blank common can be adjusted to its maximum. The maximum degree of segmentation for efficient operation is shown in Figure E.1 and the various subprograms included in each segment (link, overlay) are listed in Table E.1. This degree of segmentation (if any) is not used on all computer systems.

3. IBM 360 ØS Control Cards

The program should use overlays on the 360 to minimize storage requirements for the object deck. The maximum level of overlaying is not required, however. For some problems it is best to use the double precision conversion described above. The necessary control cards for a compile and execute are given in Table E.2.

4. IBM 7090 Control Cards

The program will run problems on a 7094 with a direct couple operating system. The maximum amount of overlaying is used.

FIGURE E.1

OVERLAY STRUCTURE

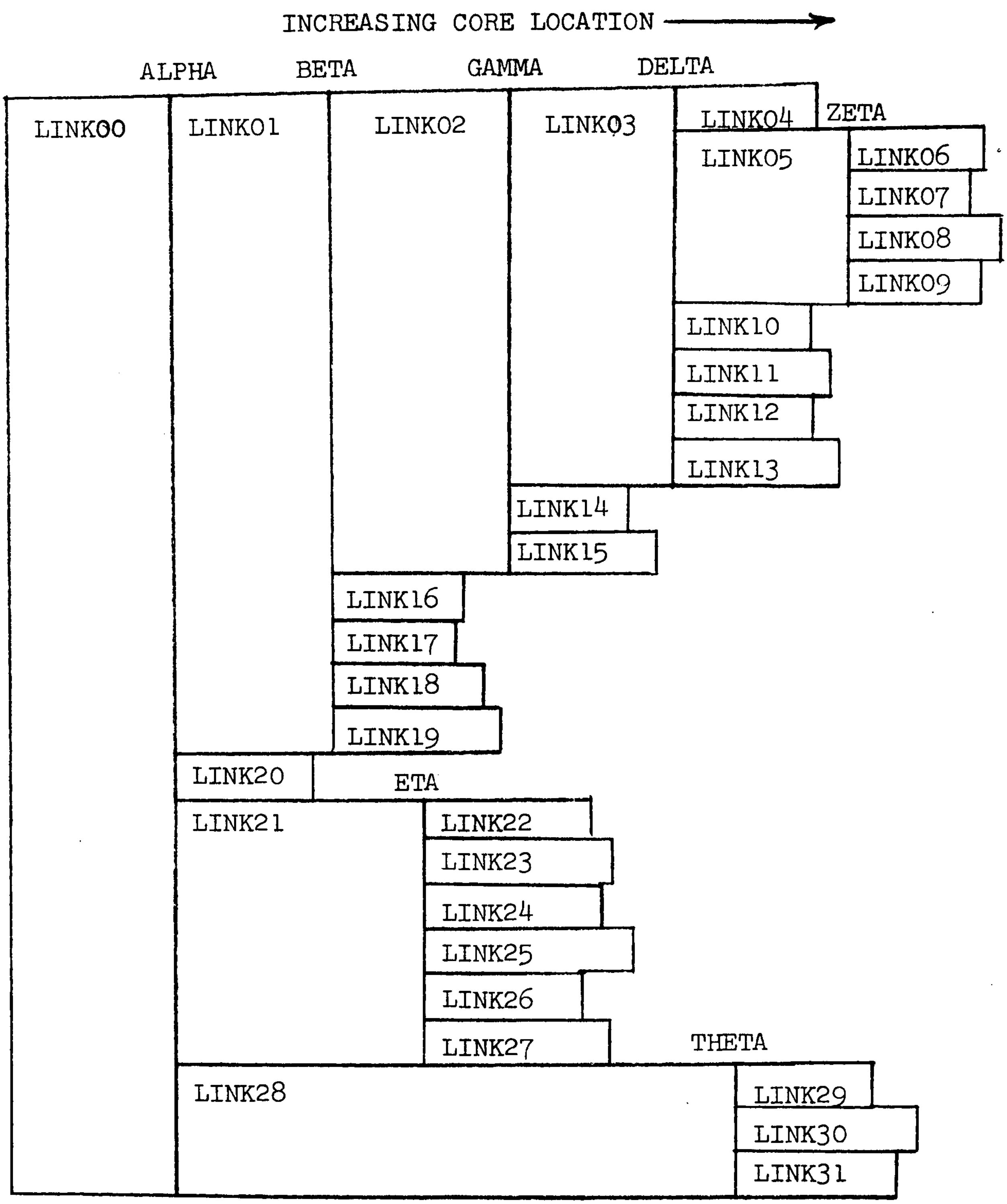


TABLE E.1

OVERLAY DEFINITION

| Segment | Subprogram | IBM Deck Name |
| --- | --- | --- |
| LINKOO | MAIN | MAIN |
| | INTZ | INTL |
| | ZBS | ZBSL |
| | ZQRT | ZQRL |
| | ZXP | ZXPL |
| | ZLØG | ZLØL |
| | ZIN | ZINL |
| | ZØS | ZØSL |
| | ZMIN1 | ZMIL |
| | ZMAX1 | ZMAL |
| | ZTAN2 | ZTAL |
| | LABEL | LABE |
| | DUMPIT | DUML |
| | KØMMØN | KØMM |
| | INTCØM | INTC |
| | CØSINE | CØSI |
| | VECTØR | VECT |
| | RØTATE | RØTA |
| | RØTATC | RØTC |
| | CENTER | CENT |
| | RØTATX | RØTX |
| | LØCATE | LØCA |
| | HELIX | HELI |
| | SAMPLE | SAMP |
| | RANNØ | RANN |
| | PLØTS | PLØM |
| | PLØT | PLØN |
| | SYMBØL | SYMB |
| | NUMBER | NUMB |

TABLE E.1 (Cont'd)

| Segment | Subprogram | IBM Deck Name |
|---|---|---|
| LINK01 | DEFINE | DEFI |
| LINK02 | INDEX | INDE |
| | ICHECK | ICHE |
| | JCHECK | JCHE |
| | KCHECK | KCHE |
| LINK03 | READIT | READ |
| | READH | HREA |
| | READA | AREA |
| | READI | IREA |
| | READII | IIRE |
| | READIS | ISRE |
| | READE | EREA |
| | READEE | EERE |
| | READIE | IERE |
| | READES | ESRE |
| | READS | SREA |
| | READR | RREA |
| | READF | FREA |
| | READL | LREA |
| | IARRAY | IARR |
| LINK04 | ARRAY | ARRA |
| LINK05 | INSECT | INSE |
| LINK06 | MULTIX | MULT |
| | MATRIX | MATR |
| LINK07 | GAMMAX | GAMM |
| LINK08 | BASICX | BASI |
| LINK09 | SLØWER | SLØW |
| LINK10 | SZERØ | SZER |
| LINK11 | GEØMIN | GEØM |

TABLE E.1 (Cont'd)

| Segment | Subprogram | IBM Deck Name |
|---|---|---|
| LINK12 | RESULT | RESU |
| | REXTRA | REXT |
| LINK13 | RANDØM | RAND |
| LINK14 | RLIMIT | RLIM |
| LINK15 | RARRAY | RARR |
| LINK16 | DØWN | DØWL |
| LINK17 | REGIØN | REGI |
| LINK18 | ASKFØR | ASKF |
| LINK19 | BIASIT | BIAS |
| LINK20 | VØLTS | VØLT |
| | PØTENT | PØTE |
| LINK21 | ANSWER | ANSW |
| | LØØKC | LØØK |
| | QUICKP | QUIC |
| LINK22 | DEPØS | DEPØ |
| LINK23 | FLUXES | FLUX |
| LINK24 | PLØTNE | PLØL |
| LINK25 | DERIVE | DERI |
| LINK26 | TIMER | TIME |
| LINK27 | ØPTIMA | ØPTI |
| LINK28 | SØURCE | SØUR |
| | SINPUT | SINP |
| | CAPTUR | CAPT |
| | BREMSS | BREM |
| | CØMPTN | CØMP |
| | PHØTØN | PHØT |
| | SCATTR | SCAT |
| | NEUTRN | NEUT |
| | BETAS | BETA |
| | THERML | THER |
| | UNITRA | UNIT |
| | PATH | PATL |

TABLE E.1 (Cont'd)

| Segment | Subprogram | IBM Deck Name |
|---|---|---|
| | NØRMAL | NØRM |
| | KERNEL | KERN |
| | AHEAD | AHEA |
| | DETECT | DETE |
| | DØSES | DØSE |
| | GRØUP | GRØU |
| | SPHERE | SPHE |
| | PSTAR | PSTA |
| | QSTAR | QSTA |
| | USTAR | USTA |
| | VSTAR | VSTA |
| LINK29 | TEMPER | TEMP |
| LINK30 | SØLVER | SØLV |
| LINK31 | SØBER | SØBE |
| | LINEAR | LINE |

TABLE E.2

IBM SYSTEM 360/OPERATING SYSTEM CONTROL CARDS

```
JOB-ACCOUNTING CARD
// EXEC ZFORTG,PARM=BCD (OMIT PARM=BCD IF DECK IS IN EBCDIC)
//FORT.SYSIN DD *
      SOURCE DECK FOR THE MAIN PROGRAM AND ALL SUBPROGRAMS
/*
// EXEC ZLINKFRT,PARM.LKEDT='LIST,MAP,OVLY,LET,SIZE(200K,100K)',          *
//               COND.GO=(8,LT)
//LKEDT.SYSIN DD *
  INSERT MAIN,INTZ,ZBS,ZQRT,ZXP,ZLOG,ZIN,ZOS,ZMIN1,ZMAX1,ZTAN2,LABEL
  INSERT DUMPIT,KOMMON,INTCOM,COSINE,VECTOR,ROTATE,ROTATC,CENTER,ROTATX
  INSERT LOCATE,HELIX,SAMPLE,RANNO,PLOTS,PLOT,NUMBER,SYMBOL
  OVERLAY ALPHA
  INSERT DEFINE
  OVERLAY BETA
  INSERT INDEX,ICHECK,JCHECK,KCHECK
  OVERLAY GAMMA
  INSERT READIT,READH,READA,READI,READII,READIS,READE,READEE,READIE
  INSERT READES,READS,READR,READF,READL,IARRAY
  OVERLAY DELTA
  INSERT ARRAY
  OVERLAY DELTA
  INSERT INSECT
  OVERLAY ZETA
  INSERT MULTIX,MATRIX
  OVERLAY ZETA
  INSERT GAMMAX
  OVERLAY ZETA
  INSERT BASICX
  OVERLAY ZETA
  INSERT SLOWER
  OVERLAY DELTA
  INSERT SZERO
  OVERLAY DELTA
  INSERT GEOMIN
  OVERLAY DELTA
  INSERT RESULT,REXTRA
  OVERLAY DELTA
  INSERT RANDOM
  OVERLAY GAMMA
  INSERT RLIMIT
  OVERLAY GAMMA
  INSERT RARRAY
  OVERLAY BETA
  INSERT DOWN
  OVERLAY BETA
  INSERT REGION
  OVERLAY BETA
  INSERT ASKFOR
  OVERLAY BETA
  INSERT BIASIT
```

```
   OVERLAY ALPHA
   INSERT VOLTS,POTENT
   OVERLAY ALPHA
   INSERT ANSWER,LOOKC,QUICKP
   OVERLAY ETA
   INSERT DEPOS
   OVERLAY ETA
   INSERT FLUXES
   OVERLAY ETA
   INSERT PLOTNE
   OVERLAY ETA
   INSERT DERIVE
   OVERLAY ETA
   INSERT TIMER
   OVERLAY ETA
   INSERT OPTIMA
   OVERLAY ALPHA
   INSERT SOURCE,SINPUT,CAPTUR,BREMSS,COMPTN,PHOTON,SCATTR,NEUTRN,BETAS
   INSERT THERML,UNITRA,PATH,NORMAL,KERNEL,AHEAD,DETECT,DOSES,GROUP
   INSERT SPHERE,PSTAR,QSTAR,USTAR,VSTAR
   OVERLAY THETA
   INSERT TEMPER
   OVERLAY THETA
   INSERT SOLVER
   OVERLAY THETA
   INSERT SOBER,LINEAR
   ENTRY MAIN
/*
//GO.SYSIN DD *
       DATA DECKS
/*
//
```

For some installations, it may be necessary to include a unit routine. The control cards for this computer are given in Table E.3.

5. UNIVAC 1108 Control Cards

The program is run on the 1108 in single precision. The control cards for a compile and execute run under the EXEC-2 operating system are given in Table E.4. The control cards for EXEC-8 are given in Table E.5.

6. Control Data 6600 Control Cards

The program is normally run in single precision on the 6600. The control cards for running without overlays are shown in Table E.6. Overlaying on the 6600 would require several minor source program changes.

TABLE E.3

IBM 7090 CONTROL CARDS

```
$JOB-ACCOUNTING CARD
$IBSYS          IBJOB
$IBJOB          GO,MAP,SOURCE,FIOCS
$IBFTC MAIN     DECK
      SOURCE DECK FOR MAIN PROGRAM
$IBFTC INTL     DECK
      SOURCE DECK FOR SUBPROGRAM INTZ, ETC.
$IBFTC ZBSL     DECK
$IBFTC ZQRL     DECK
$IBFTC ZXPL     DECK
$IBFTC ZLOL     DECK
$IBFTC ZINL     DECK
$IBFTC ZOSL     DECK
$IBFTC ZMIL     DECK
$IBFTC ZMAL     DECK
$IBFTC ZTAL     DECK
$IBFTC LABE     DECK
$IBFTC DUML     DECK
$IBFTC KOMM     DECK
$IBFTC INTC     DECK
$IBFTC COSI     DECK
$IBFTC VECT     DECK
$IBFTC ROTA     DECK
$IBFTC ROTC     DECK
$IBFTC CENT     DECK
$IBFTC ROTX     DECK
$IBFTC LOCA     DECK
$IBFTC HELI     DECK
$IBFTC RANN     DECK
$IBFTC SAMP     DECK
$IBFTC PLOM     DECK
$IBFTC PLON     DECK
$IBFTC SYMB     DECK
$IBFTC NUMB     DECK
$ORIGIN         ALPHA
$IBFTC DEFI     DECK
$ORIGIN         BETA
$IBFTC INDE     DECK
$IBFTC ICHE     DECK
$IBFTC JCHE     DECK
$IBFTC KCHE     DECK
$ORIGIN         GAMMA
$IBFTC READ     DECK
$IBFTC HREA     DECK
$IBFTC AREA     DECK
$IBFTC IREA     DECK
$IBFTC IIRE     DECK
$IBFTC ISRE     DECK
$IBFTC EREA     DECK
$IBFTC EERE     DECK
```

```
$IBFTC IERE    DECK
$IBFTC ESRE    DECK
$IBFTC SREA    DECK
$IBFTC RREA    DECK
$IBFTC FREA    DECK
$IBFTC LREA    DECK
$IBFTC IARR    DECK
$ORIGIN        DELTA
$IBFTC ARRA    DECK
$ORIGIN        DELTA
$IBFTC INSE    DECK
$ORIGIN        ZETA
$IBFTC MULT    DECK
$IBFTC MATR    DECK
$ORIGIN        ZETA
$IBFTC GAMM    DECK
$ORIGIN        ZETA
$IBFTC BASI    DECK
$ORIGIN        ZETA
$IBFTC SLOW    DECK
$ORIGIN        DELTA
$IBFTC SZER    DECK
$ORIGIN        DELTA
$IBFTC GEOM    DECK
$ORIGIN        DELTA
$IBFTC RESU    DECK
$IBFTC REXT    DECK
$ORIGIN        DELTA
$IBFTC RAND    DECK
$ORIGIN        GAMMA
$IBFTC RLIM    DECK
$ORIGIN        GAMMA
$IBFTC RARR    DECK
$ORIGIN        BETA
$IBFTC DOWL    DECK
$ORIGIN        BETA
$IBFTC REGI    DECK
$ORIGIN        BETA
$IBFTC ASKF    DECK
$ORIGIN        BETA
$IBFTC BIAS    DECK
$ORIGIN        ALPHA
$IBFTC VOLT    DECK
$IBFTC POTE    DECK
$ORIGIN        ALPHA
$IBFTC ANSW    DECK
$IBFTC LOOK    DECK
$IBFTC QUIC    DECK
$ORIGIN        ETA
$IBFTC DEPO    DECK
```

α

TABLE E.3 (Cont'd)

```
$ORIGIN          ETA
$IBFTC FLUX      DECK
$ORIGIN          ETA
$IBFTC PLOL      DECK
$ORIGIN          ETA
$IBFTC DERI      DECK
$ORIGIN          ETA
$IBFTC TIME      DECK
$ORIGIN          ETA
$IBFTC OPTI      DECK
$ORIGIN          ALPHA
$IBFTC SOUR      DECK
$IBFTC SINP      DECK
$IBFTC CAPT      DECK
$IBFTC BREM      DECK
$IBFTC COMP      DECK
$IBFTC PHOT      DECK
$IBFTC SCAT      DECK
$IBFTC NEUT      DECK
$IBFTC BETA      DECK
$IBFTC THER      DECK
$IBFTC UNIT      DECK
$IBFTC PATL      DECK
$IBFTC NORM      DECK
$IBFTC KERN      DECK
$IBFTC AHEA      DECK
$IBFTC DETE      DECK
$IBFTC DOSE      DECK
$IBFTC GROU      DECK
$IBFTC SPHE      DECK
$IBFTC PSTA      DECK
$IBFTC QSTA      DECK
$IBFTC USTA      DECK
$IBFTC VSTA      DECK
$ORIGIN          THETA
$IBFTC TEMP      DECK
$ORIGIN          THETA
$IBFTC SOLV      DECK
$ORIGIN          THETA
$IBFTC SOBE      DECK
$IBFTC LINE      DECK
$DATA
      DATA DECK
```

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TABLE E.4

UNIVAC 1108, EXEC-2 CONTROL CARDS

```
@JOB-ACCOUNTING CARD
@I FOR MAIN,MAIN
      SOURCE DECK FOR MAIN PROGRAM
@I FOR INTZ,INTZ
      SOURCE DECK FOR SUBPROGRAM INTZ
      .
      .
      .
@I FOR LINEAR,LINEAR
      SOURCE DECK FOR SUBPROGRAM LINEAR
@ MAP PROGRM
    SEG MAIN-INTZ-LABEL-DUMPIT-KOMMON-INTCOM-COSINE-VECTOR-ROTATE-        ;
    ROTATC-RANNO-ZBS-ZQRT-ZXP-ZLOG-ZIN-ZOS-ZMIN1-ZMAX1-ZTAN2-CENTER-      ;
    ROTATX-LOCATE-HELIX-SAMPLE-*(DEFINE-*(INDEX-ICHECK-JCHECK-KCHECK-*(;
    READIT-READH-READA-READI-READII-READIS-READE-READEE-READIE-READES-  ;
    READS-READR-READF-READL-IARRAY-*(ARRAY,INSECT-*(MULTIX-MATRIX,      ;
    GAMMAX,BASICX,SLOWER),SZERO,GEOMIN,RESULT-REXTRA,RANDOM),RLIMIT,    ;
    RAPRAY),DOWN,REGION,ASKFOR,BIASIT),VOLTS-POTENT,ANSWER-LOOKC-       ;
    QUICKP-*(DEPOS,FLUXES,PLOTNE,DERIVE,TIMER,OPTIMA),SOURCE-SINPUT-    ;
    CAPTUR-BREMSS-COMPTN-PHOTON-SCATTR-NEUTRN-BETAS-THERML-UNITRA-PATH-;
    NORMAL-KERNEL-AHEAD-DETECT-DOSES-GROUP-SPHERE-PSTAR-QSTAR-USTAR-    ;
    VSTAR-*(TEMPER,SOLVER,SOBER-LINEAR))
@ XQT PROGRM
      DATA DECK
```

TABLE E.5 PRECEDING PAGE BLANK NOT FILMED

UNIVAC 1108, EXEC-8 CONTROL CARDS

```
@JOB-ACCOUNTING CARD
@FREE TPF$
@ASG,T TPF$,///2000
@FOR,IS MAIN,MAIN
      SOURCE DECK FOR MAIN PROGRAM
@FOR,IS INTZ,INTZ
      SOURCE DECK FOR SUBPROGRAM INTZ
      .
      .
      .
@FOR,IS LINEAR,LINEAR
      SOURCE DECK FOR SUBPROGRAM LINEAR
@MAP,I RUNIT
SEG LINK00*
IN MAIN,INTZ,ZBS,ZQRT,ZXP,ZLOG,ZIN,ZOS,ZMIN1,ZMAX1,ZTAN2,LABEL,DUMPIT
IN KOMMON,INTCOM,COSINE,VECTOR,ROTATE,ROTATC,CENTER,ROTATX,LOCATE,HELIX
IN SAMPLE,RANNO,PLOTS,PLOT,NUMBER,SYMBOL
SEG LINK01*,(LINK00)
IN DEFINE
SEG LINK02*,(LINK01)
IN INDEX,ICHECK,JCHECK,KCHECK
SEG LINK03*,(LINK02)
IN READIT,READH,READA,READI,READII,READIS,READE,READEE,READIE,READES
IN READS,READR,READF,READL,IARRAY
SEG LINK04*,(LINK03)
IN ARRAY
SEG LINK05*,(LINK03)
IN INSECT
SEG LINK06*,(LINK05)
IN MULTIX,MATRIX
SEG LINK07*,(LINK05)
IN GAMMAX
SEG LINK08*,(LINK05)
IN BASICX
SEG LINK09*,(LINK05)
IN SLOWER
SEG LINK10*,(LINK03)
IN SZERO
SEG LINK11*,(LINK03)
IN GEOMIN
SEG LINK12*,(LINK03)
IN RESULT,REXTRA
SEG LINK13*,(LINK03)
IN RANDOM
SEG LINK14*,(LINK02)
IN RLIMIT
SEG LINK15*,(LINK02)
IN RARRAY
SEG LINK16*,(LINK01)
IN DOWN
```

TABLE E.5 (Cont'd)

```
SEG LINK17*,(LINK01)
IN REGION
SEG LINK18*,(LINK01)
IN ASKFOR
SEG LINK19*,(LINK01)
IN BIASIT
SEG LINK20*,(LINK00)
IN VOLTS,POTENT
SEG LINK21*,(LINK00)
IN ANSWER,LOOKC,QUICKP
SEG LINK22*,(LINK21)
IN DEPOS
SEG LINK23*,(LINK21)
IN FLUXES
SEG LINK24*,(LINK21)
IN PLOTNE
SEG LINK25*,(LINK21)
IN DERIVE
SEG LINK26*,(LINK21)
IN TIMER
SEG LINK27*,(LINK21)
IN OPTIMA
SEG LINK28*,(LINK00)
IN SOURCE,SINPUT,CAPTUR,BREMSS,COMPTN,PHOTON,SCATTR,NEUTRN,BETAS,THERML
IN UNITRA,PATH,NORMAL,KERNEL,AHEAD,DETECT,DOSES,GROUP,SPHERE,PSTAR
IN QSTAR,USTAR,VSTAR
SEG LINK29*,(LINK28)
IN TEMPER
SEG LINK30*,(LINK28)
IN SOLVER
SEG LINK31*,(LINK28)
IN SOBER,LINEAR
@XQT
      DATA DECK
```

## TABLE E.6

## CDC 6600 SCOPE CONTROL CARDS

```
JOB-ACCOUNTING CARD
FASTER,PRIORITY,TIME LIMIT,FIELD LENGTH.  FORMAT VARIES
RUN(S,,,,,,,777777,1) ASA OPTION
LGO.

7 (END OF RECORD)
8
9
      PROGRAM FASTER(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      SOURCE DECK FOR THE MAIN PROGRAM
      SOURCE DECKS FOR ALL SUBPROGRAMS

7 (END OF RECORD)
8
9
      DATA DECKS

6 (END OF FILE)
7
8
9
```