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HETFIS
High-Energy Nucleon-Meson Transport Code with Fission

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ABSTRACT

A model that includes fission for predicting particle production spectra from medium-energy nucleon and pion collisions with nuclei ($Z \geqslant 91$) has been incorporated into the nucleon-meson transport code, HETC. This report is primarily concerned with the programming aspects of HETFIS (High-Energy Nucleon-Meson Transport Code With Fission). A description of the program data and instructions for operating the code are given. HETFIS is written in FORTRAN IV for the IBM computers and is readily adaptable to other systems.

I. INTRODUCTION

For several applications, e.g., in designing facilities to produce an intense source of low-energy neutrons by using medium-energy protons[1] and for studies of the feasibility of converting fertile-to-fissile material using medium-energy protons,[2] it is necessary to carry out calculations of the transport of medium- and low-energy nucleons and pions through fissionable material. In a previous paper,[3] a model was developed for predicting differential particle-production data from the collisions of medium-energy nucleons and pions with fissionable nuclei ($Z \geqslant 91$). This model has been incorporated into the high-energy transport code, HETC.[4] Also, in a previous paper,[5] calculated results obtained with this updated version of HETC are compared with experimental data from medium-energy ($\leqslant 1.47$ GeV) protons incident on thick uranium targets.

This report is primarily concerned with the programming aspects of HETFIS. It is assumed here that the reader is familiar with HETC and the analysis of the history information produced by HETC. Those readers who are not should read Refs. 4 and 7 in conjunction with the present report. The program, HETC, was modified to include fission in such a way that the exclusion of the fission channel in HETFIS would produce history information for analysis that is identical to that produced by HETC. Modifications to HETC are given in Section II, data input description is given in Section III, and analysis modifications are outlined in Section IV. The HETFIS package as well as the HETC program are available from the Radiation Shielding Information Center (RSIC) at the Oak Ridge National Laboratory. Only the modified and new subroutines used to include fission in HETC are included in the HETFIS package.

II. MODIFICATIONS TO HETC

Basic changes to HETC to include fission are as follows:

a) fission data are input via a block data routine and an auxiliary storage device on logical unit 11;

b) several subroutines have been added and a few subroutines have been modified;

c) the history information provided for analysis has been modified to include data from the fission process.

Listed below are the new or modified routines for use with HETFIS.

Routine	Purpose or Changes
BLOCK DATA	Contains some of the data needed for the operations of the fission channel.
DRES	Modified to include the possibility of fission.
ENERGY	Changed to obtain nearest integer value of A and integer value of Z when calling with noninteger values of A or Z. Includes calls to DRES to evaporate particles from fission fragments; the history information provided for analysis was modified to include data from the fission process.
FLTRN	Calls FLRAN and converts random number to single precision.
FSINFO	Fission subroutine, called when a fission occurs. The A, Z, excitation energy and kinetic energy of each fragment is calculated.

Routine	Purpose or Changes
GAMR	Calculates ratio of neutron width to fission width.
INPUTF	Fission data obtained from fitting the experimental data of Epperson[6] is read in. (See Ref. 3, Section III.B of this report)
INTERP	All quantities needed for subsequent call to QMAXX are obtained for nearest integer A value of either fission fragment, by interpolation in excitation energy, E_F, of fissioning nucleus.
KEAVE	All quantities needed for subsequent call to QMAXX are obtained by double interpolation in heavy fission fragment A_2 value and excitation energy, E_F, of fissioning nucleus.
PAIRR	Calculates sum of pairing energies for two fission fragments.
QMAXX	The unnormalized probability for obtaining a heavy fission fragment with given A_2 at fixed excitation energy, E_F, of fissioning neptunium nucleus is calculated.
QNRG	Changed to obtain nearest integer values of A_1 and A_2 and integer values of Z_1 and Z_2 when calling with noninteger values.
ZPROBF	Most probable noninteger values for Z_1 and Z_2 of the fission fragments are calculated.

III. DATA DESCRIPTION AND CODE OPERATION

Insofar as possible, HETFIS was designed so that operation of the code without fission would be identical to operating the HETC program. To achieve this, data for the fissioning channel are input via BLOCK DATA and an auxiliary storage device on logical unit 11. The user must also supply all data required for a normal HETC run.

A. Block Data Parameters

Many of the parameters required for using the fission channel are included in BLOCK DATA. The parameters IANLG and BZERO that occur in BLOCK DATA are user supplied. All other parameters in BLOCK DATA are permanent and should not be changed unless the user is very familiar with the statistical model of fission as used in the code and wishes to make fundamental changes in the model. The parameter IANLG is defined by

IANLG = 1 if the fission channel is to be used,

= 0 if the fission channel is not to be used,

and BZERO is the level density parameter (see Eq. (16) in Ref. 3). In general, BZERO should be used to be between 8.0 and 15.0. In Ref. 3 it is indicated that BZERO = 10.0 is the "best" value when fission is included and incident energies $\lesssim$1 GeV are considered. When fission is not included BZERO = 8.0 has usually been used in HETC.

B. Statistical Data on Auxiliary Device

To a large extent the physical data that occur in the statistical model used here have been derived from the experimental measurements of D. H. Epperson.[6] Data tables for incident proton energies of 7, 10, 15, 20, 25 and 30 MeV have been prepared and stored on logical unit 11 to be input in subroutine INPUTF. The method used to obtain these data is

described in Ref. 3. A brief description of these data follows:

AINFO(1) = 236.0 The atomic mass of neptunium.

AINFO(2) = 93.0 The charge number of neptunium.

AINFO(3) = 92.0 The charge number for uranium.

AINFO(4) thru AINFO(9) Kinetic energies of the excited neptunium compound nuclei for the six incident proton energies considered.

AINFO(10) thru AINFO(15) = Average excitation energies, E_F, from which fission in Neptunium for the six incident proton energies considered.

AINFO(16) = 2.0 Meaningful only to code that produced data tables.

AINFO(17) = 8.0 A specific value for level density parameter BZERO. (See Eq. (16) in Ref. 3)

AINFO(18) = 1.5 A pararmeter, y_o, that occurs in the level density expression. (See Eq. (16) in Ref. 3)

AINFO(19) = 15.0 A specific value for level density parameter BZERO.

AINFO(20) Same as AINFO(18).

EPKIN(i,j) Relative kinetic energy of fission fragments from Neptunium as a function of 80 A (mass) values and the 6 average excitation energies.

SIGKE(i,j) Standard deviations of the EPKIN values.

DELEXC(i,j,k) Equals ΔE_c in Eq. (33) of Ref. 3. It is used to compute the total deformation energy of Neptunium fission fragments at the scission point and is a function of 80A values, six average excitation energies, and two values of B_o.

Fission data for DELEXC are supplied for BZERO = 8.0 and BZERO = 15.0. When BZERO in BLOCK DATA is specified to be any value between 8 and 15, linear interpolation in $\frac{1}{\text{BZERO}}$ is used to obtain the required fission data.

IV. ANALYSIS CHANGES WHEN FISSION OCCURS

Since analysis of the history information supplied by HETC and HETFIS is largely left up to the user, no attempt is made here to outline an analysis of an HETFIS run. More information on the analysis procedure may be found in Ref. 7. The history information supplied for analysis is different from that supplied by HETC only if a fission occurred.

A simple "if" test allows one to determine if a fission occurred in a given collision. If a fission has occurred the values of APR and ZPR (on the history tape) for this collision are:

APR = 1000*APR1+APR2

ZPR = 1000*ZPR1+ZPR2

where

APR1 = the mass number A_1 of 1st fragment.

APR2 = the mass number A_2 of 2nd fragment.

ZPR1 = the charge number Z_1 of 1st fragment.

ZPR2 = the charge number Z_2 of 2nd fragment.

So the user only has to test APR or ZPR for a value greater than 1000 to see if fission has occurred at a particular collision.

Changes in the history information supplied (carried out in ERUP) due to fission are listed below. The general scheme is that 0.0 is placed in various arrays to separate the various types of fission information. When a fission occurs,

1) all current NPART(j) values for j = 1,6 are incremented by 1,

2) a 0.0 is stored in EPART(NPART(j),j) for j = 1,2, to separate prefission neutrons and protons from post-fission neutrons and protons,

3) a 0.0 is stored in HEPART(NPART(J+2),j) for j = 1,4, to separate prefission evaporation light ions (deuterons, tritons, ^{3}He, and alpha particles) from post-fission evaporation light ions,

4) DRES is called to get evaporation products for the first fission fragment.

5) all NPART(j) values for j = 1,6 are incremented by 1,

6) a 0.0 is stored in EPART(NPART(j),j) for j = 1,2, to separate postfissioning evaporation neutrons and protons produced by the first fission fragment from postfission evaporation neutrons and protons produced by the second fission fragment,

7) a 0.0 is stored in HEPART(NPART(j+2,j)) for j = 1,4, to separate postfission evaporation light ions produced by the first fission fragment from postfission evaporation light ions produced by the second fission fragment,

8) DRES is called to get evaporation products for the second fission fragment.

9) Fission fragment data are stored in the remainder of the HEPART array for tritons (tritons should require the least space) as follows:

I = NPART(4) + 1.

HEPART(I,2) = 0.0, separator.

HEPART(I+1,2) = ERN1, the kinetic recoil energy of the first fragment residual after all evaporations.

HEPART(I+2,2) = E1, the excitation energy of the first fragment prior to evaporation.

HEPART(I+3,2) = HEVS1, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the first fragment.

HEPART(I+4,2) = USE1, the excitation energy of the first fragment residual after all evaporations.

HEPART(I+5,2) = ERN2, the kinetic recoil energy of the second fragment residual after all evaporations.

HEPART(I+6,2) = E2, the excitation energy of the second fragment prior to evaporation.

HEPART(I+7,2) = HEVS2, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the second fragment.

HEPART(I+8,2) = USE2, the excitation energy of the second fragment residual after all evaporations.

HEPART(I+9,2) = HEVSO, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the original nucleus.

HEPART(I+10,2) = APR1, mass number A (after all evaporation) of the first fission fragment.

HEPART(I+11,2) = APR2, mass number A (after all evaporation) of the second fission fragment.

HEPART(I+12,2) = ZPR1, charge number Z (after all evaporation) of the first fission fragment.

HEPART(I+13,2) = ZPR2, charge number Z (after all evaporation) of the second fission fragment,

10) Stores balance of data as follows:

NPART(4) = NPART(4)+14

APR = 1000*APR1+APR2

ZPR = 1000*ZPR1+ZPR2

EREC = ERN1+ERN2

HEVSUM = HEVS0+HEVS1+HEVS2

UU = USE1+USE2.

V. SAMPLE PROBLEM

The sample problem consisted of a 720-MeV proton beam incident on a depleted uranium cylinder surrounded by a water bath. Cylindrical geometry was used for 10 incident protons per batch and 10 batches. The

depleted uranium region was 5.1 cm in radius and 61 cm in length centered in a water bath of radius 95 cm and length of 181 cm with a void region (5.1 cm radius) for the incident proton beam in front of the uranium. Table I is a listing of source subroutine SORS and Table II is a listing of input data for the sample problem. This problem required 24.2 seconds on the IBM 370/3033 at ORNL.

VI. EDIT OF HETFIS HISTORY TAPE

Table III is a partial edit of the history tape created by running the sample problem. Two complete histories are shown. A description of such an edit is given in Ref. 7 which should be familiar to all HETC (or NMTC) users. Table III is included to demonstrate the few changes made in the history information to include fission information.

The first particle event describes a source particle and can be ignored. The second particle event describes a nuclear interaction and since APR and ZPR are greater than 1000 it has fission information. In the evaporation tables for the 6 types of particles, zero energy values are used as separators when a fission occurs. Any nonzero values prior to the first zero are the energy values of the prefission evaporation products. Any nonzero values prior to the second zero are the energy values of the postfission evaporation products from the first fission fragment. Any nonzero values after the second zero (prior to the third zero for tritons) are the energy values of the postfission evaporation products from the second fission fragment. The NPART for each type counts zero values as well as nonzero values of energies. For tritons there will be an additional 13 values for fragment data.

Table I. Subroutine SORS Listing

```
      SUBROUTINE SORS(NCOL)
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
C
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
      COMMON/COMON/A(10,17),ALPHA(60),APR,ARG(17),BETA(60),BLZ(3000),
     1 COSKS,COSPHI,COSTH,D,DELSIG,DEN(10,17),DENH(17),OKWT,
     2 E(3000),EA(99),EB(99),EC(3000),EION(10,17),EMAX,EMIN(7),
     3 EP(60),EPART(100,2),EREC,EX,GAM(60),HEVSUM,HSIGG(5,17),
     4 HSIG,IBERT,ITYP,KIND(60),LELEM,MAT,MAXBCH,MAXCAS,
     5 MXMAT,N,NABOV,NAMAX,NAME(3000),NAMEA(99),NBELO,NBERTP,NBOGUS,
     6 NEGEX,NEL(17),NEUTNO,NEUTP,NGROUP,NP1DK,NMED(3000),NO,
     7 NOBCH,NOCAS,NOMAX,NOPART,NPART(6),NQUIT,OLDWT
     8,SIGG(10,17),SIGMX(7,17),SINKS,SINPHI,SINTH,TIP(3000),
     9 TIPA(99),TIPB(99),U(3000),UA(99),UB(99),UMAX,UU,V(3000),
     1 VA(99),VB(99),W(3000),WA(99),WB(99),WT(3000),WTA(99),
     2 WTB(99),X(3000),XC(3000),Y(3000),YC(3000),Z(3000),ZC(3000),
     3 ZZ(10,17),ZPR
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
      NGO = NCOL + 5
      GO TO (100,110,101,102,101,103,101,101,101,101,101,101,101), NGO
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
C                                END OF RUN
  100 CONTINUE
      RETURN
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
C                               END OF BATCH
  110 CONTINUE
      RETURN
C
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
  101 CALL ERROR
      RETURN
C
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
C
C                                START OF RUN
  102 CONTINUE
      RETURN
C
C
C    *X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*X*
C
C
C****************************** GET SOURCE PARTICLE
C
  103 CONTINUE
      X(1)=0.0
      Y(1)=0.0
      U(1)=0.0
      V(1)=0.0
      W(1)=1.0
      WT(1)=1.0
      TIP(1)=0.0
C***   TIP = 0 FOR PROTONS AND = 1 FOR NEUTRONS INCIDENT
      E(1)=720.00
      Z(1)=60.0001
      RAN=ELTRNF(RAN)
      X(1)=SQRT(RAN)
      RETURN
      END
```

Table II. Sample Problem Input Data

```
720 MEV CASE------ 1CM RADIUS UNIFORM BEAM
 720 MEV CASE------ 1CM RADIUS UNIFORM BEAM
121518193213
    820.0 15.00      15.00                2          10          10          0
          1          0          -1        11          0          59          2
                   0.0          1          1          0           1
      100.           3          5          1
0.0                  2          0
92.0        238.0     4.784692-2          0
92.0        235.0     1.054953-4          0
6.691689-2           1          1
8.0          16.0     3.345844-2          3
92000     2     0    10    238.0    U DIRECTLY FROM PB
     0.10000E+09     2.56
     0.90000E+08     2.74
     0.80000E+08     2.65
     0.70000E+08     2.46
     0.60000E+08     2.13
     0.50000E+08     2.03
     0.40000E+08     2.08
     0.30000E+08     2.65
     0.20000E+08     3.63
     0.10000E+08     2.96

92000    71     0    15    238.0    F1 U FROM PB
     0.10000E+09     0.98569E+00
     0.80000E+08     0.97576E+00
     0.70000E+08     0.96461E+00
     0.60000E+08     0.94309E+00
     0.50000E+08     0.90631E+00
     0.40000E+08     0.88482E+00
     0.30000E+08     0.90993E+00
     0.25000E+08     0.91979E+00
     0.20000E+08     0.90848E+00
     0.18017E+08     0.88497E+00
     0.17139E+08     0.87497E+00
     0.16303E+08     0.86545E+00
     0.15508E+08     0.85289E+00
     0.14751E+08     0.83890E+00
     0.10000E+08     0.83890E+00

92000     2     0    10    235.0    U DIRECTLY FROM PB
     0.10000E+09     2.56
     0.90000E+08     2.74
     0.80000E+08     2.65
     0.70000E+08     2.46
     0.60000E+08     2.13
     0.50000E+08     2.03
     0.40000E+08     2.08
     0.30000E+08     2.65
     0.20000E+08     3.63
     0.10000E+08     2.96

92000    71     0    15    235.0    F1 U FROM PB
     0.10000E+09     0.98569E+00
     0.80000E+08     0.97576E+00
     0.70000E+08     0.96461E+00
     0.60000E+08     0.94309E+00
     0.50000E+08     0.90631E+00
     0.40000E+08     0.88482E+00
     0.30000E+08     0.90993E+00
     0.25000E+08     0.91979E+00
     0.20000E+08     0.90848E+00
     0.18017E+08     0.88497E+00
     0.17139E+08     0.87497E+00
     0.16303E+08     0.86545E+00
     0.15508E+08     0.85289E+00
     0.14751E+08     0.83890E+00
     0.10000E+08     0.83890E+00
```

Table II. (Cont'd)

```
8000     2     0    13  16.00000 OXYGEN ELASTIC          JOANOU
   0.10000E 09     0.37000E 00                                        8000     2     1
   0.90000E 08     0.45000E 00                                        8000     2     2
   0.80000E 08     0.52000E 00                                        8000     2     3
   0.70000E 08     0.61000E 00                                        8000     2     4
   0.60000E 08     0.71000E 00                                        8000     2     5
   0.50000E 08     0.82000E 00                                        8000     2     6
   0.40000E 08     0.93000E 00                                        8000     2     7
   0.30000E 08     0.10000E 01                                        8000     2     8
   0.25000E 08     0.10200E 01                                        8000     2     9
   0.20000E 08     0.94000E 00                                        8000     2    10
   0.18000E 08     0.84000E 00                                        8000     2    11
   0.15000E 08     0.74400E 00                                        8000     2    12
   0.14750E 08     0.73500E 00                                        8000     2    13
                                                              END OF   8000     2    14
8000    71     8    10  16.00000 OXYGEN ELASTIC F1       JOANOU
   0.10000E 09     0.96704E 00                                        8000    71     1
   0.80000E 08     0.96059E 00                                        8000    71     2
   0.70000E 08     0.95541E 00                                        8000    71     3
   0.60000E 08     0.94785E 00                                        8000    71     4
   0.50000E 08     0.93622E 00                                        8000    71     5
   0.40000E 08     0.91607E 00                                        8000    71     6
   0.30000E 08     0.88105E 00                                        8000    71     7
   0.25000E 08     0.85093E 00                                        8000    71     8
   0.20000E 08     0.80413E 00                                        8000    71     9
   0.14750E 08     0.72100E 00                                        8000    71    10
                                                              END OF   8000    71    11
    2      MALE
5.1
95.0                                                                                BLANK

60.0        6666     2
121.00         1     2
181.0          2     2                                                                BLANK
```

Table III. HETFIS History Tape Edit

```
                                   READING LOG. 59 AS NMT TAPE

     MAXBCH  MAXCAS   MXMAT  NGROUP   NPIDK   NICOL   NOUIT  NEXITE  NSPRED  NWSPRD  NSEUDO  NBERTP
       10      10       2    2048       0       0       1       1       1       0       1       1

                                   EMAX    0.8200E 03

                                 CUTOFF ENERGIES FOR TYPES 1-7
     0.1000E 01  0.1500E 02  0.1000E 01  0.1000E 01  0.1000E 01  0.1000E 01  0.1000E 01

MEDIUM    1

  NUCLIDE NO.      Z NO.          A NO.       'GEOMETRIC' XSECT (PER CM)
      1          0.9200E 02     0.2380E 03          0.1257E 00
      2          0.9200E 02     0.2350E 03          0.2754E-03

  TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM      1 IN PER CM
   0.1259E 00  0.1259E 00  0.1364E 00  0.0          0.1364E 00  0.1158E-03  0.1158E-03

  MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM     1 IN PER CM
   0.0         0.0         0.0         0.0         0.0

MEDIUM    2

  NUCLIDE NO.      Z NO.          A NO.       'GEOMETRIC' XSECT (PER CM)
      1          0.8000E 01     0.1600E 02          0.2852E-01

  TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM      2 IN PER CM
   0.1088E 00  0.7168E-01  0.5242E-01  0.0          0.4356E-01  0.1158E-03  0.1158E-03

  MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM     2 IN PER CM
   0.8030E-01  0.4316E-01  0.1338E-01  0.0          0.4530E-02

NCOL  NOCAS   NAME    MAT   NMEC  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 1     1      1       1     1     0     0      0      0     0      0      0      0      0      0     00000042   00000042
                      Y           Z           XC           YC           ZC          OLDWT        WT          E          EC
        X
   0.6950E 00  0.0          0.6000E 02  0.0          0.0          0.0          0.1000E 01  0.1000E 01  0.7200E 03  0.0
        U           V                   W           TIP          APR          ZPR          EREC        EX          HEVSUM       UU
   0.0         0.0          0.1000E 01  0.0          0.0          0.0          0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMEC  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 2     1      1       1     1     1     2      1      1     14     2      2     16     2      2     00000042   00000042
                      Y           Z           XC           YC           ZC          OLDWT        WT          E          EC
        X
   0.6950E 00  0.0          0.6000E 02  0.5831E 00  0.2897E-01  0.6320E 02  0.1000E 01  0.1000E 01  0.7200E 03  0.6441E 03
        U           V                   W           TIP          APR          ZPR          EREC        EX          HEVSUM       UU
  -0.6978E-01  0.1130L-01  0.9975E 00  0.0          0.1101E 06  0.4505E 05  0.1614E 03  0.8371E 02  0.0         0.4759E 01

                NAMEA       TIPA        EA          LA          VA          WA          WTA
                  2       0.1000E 01  0.5476E 03 -0.1595E 00  0.2626E 00  0.9516E 00  0.1000E 01

                  TIPB        EB          LB          VB          WB          WTB
                0.1000E 01  0.5519E 01 -0.6156E 00  0.3748E 00  0.6932E 00  0.1000E 01

                  WTEVAP     EPART ARRAY(EVAP  NEUTRON  ENERGY)
                0.1000E 01  0.4322E 01  0.1691E 01  0.0         0.4837E 01  0.5543E 01  0.8328E 00  0.4393E 01  0.0
                            0.4436E 01  0.1810E 01  0.1667E 01  0.2529E 01  0.2728E 01  0.6987E 00

                  WTEVAP     EPART ARRAY(EVAP  PROTON   ENERGY)
                0.1000E 01  0.0         0.0
```

Table III. (Cont'd)

```
                    ATEVAP    HEPART ARRAY(EVAP DEUTERON  ENERGY)
                  0.1000E 01  0.0          0.0

                    ATEVAP    HEPART ARRAY(EVAP  TRITON   ENERGY)
                  0.1000E 01  0.0          0.0          0.0          0.8257E 02  0.3901E 02  0.0          0.1473E 01  0.7882E 02
                              0.5730E 02  0.0          0.3287E 01  0.0          0.1100E 03  0.1150E 03  0.4500E 02  0.4800E 02

                    ATEVAP    HEPART ARRAY(EVAP  HE 3    ENERGY)
                  0.1000E 01  0.0          0.0

                    ATEVAP    HEPART ARRAY(EVAP  ALPHA    ENERGY)
                  0.1000E 01  0.0          0.0

NCCL  NCCAS   NAME    NAT   NMEC  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
 2      1      2      1     1     1     5     8     3    24     3     2    16     2     2  00000042  00000042
          X            Y            Z           XC           YC           ZC          CLDWT          WT           E           EC
        0.5831E 00  0.2897E-01  0.6320E 02  0.2661E 00  0.5507E 00  0.6509E 02  0.1000E 01  0.1000E 01  0.5476E 03  0.5476E 03
          U            V            W           TIP          APR          ZPR          EREC          EX        HEVSUM        UU
       -0.1595E 00  0.2626E 00  0.9516E 00  0.1000E 01  0.9112E 05  0.4005E 05  0.1458E 03  0.2903E 03  0.0         0.9741E 01

                  NAMEA        TIPA         EA           LA           VA           WA           WTA
                    3       0.3000E 01  0.4373E 02 -0.4640E 00 -0.3670E 00 -0.8062E 00  0.1000E 01
                    4       0.0         0.3426E 02  0.1717E 00  0.8581E 00  0.4839E 00  0.1000E 01
                    5       0.1000E 01  0.1927E 02  0.7731E 00 -0.1456E 00  0.5173E 00  0.1000E 01
                    6       0.1000E 01  0.1671E 02 -0.5875E 00 -0.5732E 00 -0.5712E 00  0.1000E 01
                    7       0.1000E 01  0.2523E 02  0.8690E 00  0.2227E 00  0.4418E 00  0.1000E 01
                    8       0.1000E 01  0.2194E 02  0.3862E 00  0.6643E 00  0.6400E 00  0.1000E 01
                    9       0.1000E 01  0.1623E 02 -0.7757E 00  0.2743E 00 -0.5684E 00  0.1000E 01
                   10       0.0         0.9864E 01 -0.4039E 00 -0.3349E-02  0.9148E 00  0.1000E 01

                    TIPB         EB           LB           VB           WB           WTB
                  0.1000E 01  0.9530E 01  0.6104E 00 -0.1950E 00 -0.7677E 00  0.1000E 01
                  0.1000E 01  0.7847E 01  0.8039E 00  0.4200E 00  0.4212E 00  0.1000E 01
                  0.1000E 01  0.2963E 01 -0.8672E 00  0.5977E-01  0.4943E 00  0.1000E 01

                    ATEVAP    HEPART ARRAY(EVAP  NEUTRON  ENERGY)
                  0.1000E 01  0.3828E 01  0.4911E 01  0.5433E 01  0.4686E 01  0.0          0.1927E 02  0.1671E 02  0.2523E 02
                              0.2194E 02  0.1623E 02  0.1095E 02  0.2002E 01  0.2599E 01  0.4548E 01  0.2787E 01  0.8991E 00
                              0.0         0.3060E 01  0.2846E 01  0.1322E 01  0.5805E 01  0.2272E 01  0.3857E 00  0.3524E 01

                    ATEVAP    HEPART ARRAY(EVAP  PROTON   ENERGY)
                  0.1000E 01  0.0          0.9864E 01  0.0

                    ATEVAP    HEPART ARRAY(EVAP DEUTERON  ENERGY)
                  0.1000E 01  0.0          0.0

                    ATEVAP    HEPART ARRAY(EVAP  TRITON   ENERGY)
                  0.1000E 01  0.0          0.0          0.0          0.8621E 02  0.2201E 03  0.0          0.4631E 01  0.5963E 02
                              0.7159E 02  0.0          0.5109E 01  0.0          0.9100E 02  0.1210E 03  0.4000E 02  0.5000E 02

                    ATEVAP    HEPART ARRAY(EVAP  HE 3    ENERGY)
                  0.1000E 01  0.0          0.0

                    ATEVAP    HEPART ARRAY(EVAP  ALPHA    ENERGY)
                  0.1000E 01  0.0          0.0

NCCL  NCCAS   NAME    NAT   NMEC  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
 3      1      4      1     1     0     0     0     0     0     0     0     0     0     0  00000042  00000042
          X            Y            Z           XC           YC           ZC          CLDWT          WT           E           EC
        0.2661E 00  0.5507E 00  0.6509E 02  0.2912E 00  0.6762E 00  0.6516E 02  0.1000E 01  0.1000E 01  0.3426E 02  0.1000E 01
          U            V            W           TIP          APR          ZPR          EREC          EX        HEVSUM        UU
        0.1717E 00  0.8581E 00  0.4839E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NCCAS   NAME    NAT   NMEC  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
 6      1      5      1     1     1     0     0     0     8     2     2    16     2     2  00000042  00000042
          X            Y            Z           XC           YC           ZC          CLDWT          WT           E           EC
        0.2661E 00  0.5507E 00  0.6509E 02  0.2419E 01  0.1452E 00  0.6681E 02  0.1000E 01  0.1000E 01  0.1927E 02  0.1927E 02
```

Table III. (Cont'd)

```
          U            V            X            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.7731E 00 -0.1456E 00  0.6173E 00 -0.1000E 01 -0.1151E-06 -0.4605E-05 -0.1549E-03 -0.2621E 02  0.0          0.4926E 01

          WTEVAP       EPART ARRAY(EVAP  NEUTRON  ENERGY)
     0.1000E 01  0.5266E 01  0.0          0.3612E 01  0.2155E 01  0.1748E 01  0.0          0.3182E 01  0.2948E 01

          WTEVAP       EPART ARRAY(EVAP  PROTON   ENERGY)
     0.1000E 01  0.0          0.0

          WTEVAP       HEPART ARRAY(EVAP DEUTERON  ENERGY)
     0.1000E 01  0.0          0.0

          WTEVAP       HEPART ARRAY(EVAP  TRITON   ENERGY)
     0.1000E 01  0.0          0.0          0.0          0.8021E 02  0.2894E 02  0.0          0.2729E 01  0.7469E 02
                 0.2154E 02  0.0          0.6197E 01  0.0          0.1150E 03  0.1180E 03  0.4600E 02  0.4600E 02

          WTEVAP       HEPART ARRAY(EVAP   HE 3    ENERGY)
     0.1000E 01  0.0          0.0

          WTEVAP       HEPART ARRAY(EVAP  ALPHA    ENERGY)
     0.1000E 01  0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  7     1      6      1     2     0     0     0     0     0     0     0     0     0     0  00000042  00001082
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.2661E 00  0.5507E 00  0.6509E 02 -0.3793E 01 -0.3410E 01  0.6115E 02  0.1000E 01  0.1000E 01  0.1671E 02  0.1671E 02
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
    -0.5875E 00 -0.5732E 00 -0.5712E 00  0.1000E 01  0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  2     1      6      2     2    -1     2     1     1     0     0     0     0     0     0  00001082  00000081
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
    -0.3793E 01 -0.3410E 01  0.6115E 02 -0.5520E 01 -0.5095E 01  0.5947E 02  0.1000E 01  0.1000E 01  0.1671E 02  0.1671E 02
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
    -0.5875E 00 -0.5732E 00 -0.5712E 00  0.1000E 01  0.0          0.0          0.0          0.0          0.0          0.0

          NAMEA        TIPA         EA           LA           VA           WA           WTA
          11      0.0          0.3979E 01 -0.6265E 00  0.4334E 00 -0.6478E 00  0.1000E 01

          TIPB         EB           LB           VB           WB           WTB
     0.1000E 01  0.1273E 02 -0.3244E 00 -0.8992E 00 -0.2938E 00  0.1000E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  3     1     11      2     2     0     0     0     0     0     0     0     0     0     0  00000081  00000081
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
    -0.5520E 01 -0.5095E 01  0.5947E 02 -0.5533E 01 -0.5086E 01  0.5945E 02  0.1000E 01  0.1000E 01  0.3979E 01  0.1000E 01
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
    -0.6265E 00  0.4334E 00 -0.6478E 00  0.0          0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  7     1      7      1     2     0     0     0     0     0     0     0     0     0     0  00000042  00001082
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.2661E 00  0.5507E 00  0.6509E 02  0.4804E 01  0.1714E 01  0.6740E 02  0.1000E 01  0.1000E 01  0.2523E 02  0.2523E 02
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.8590E 00  0.2227E 00  0.4418E 00  0.1000E 01  0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  2     1      7      2     2    -1     2     1     1     0     0     0     0     0     0  00001082  00000082
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.4804E 01  0.1714E 01  0.6740E 02  0.1027E 02  0.3116E 01  0.7018E 02  0.1000E 01  0.1000E 01  0.2523E 02  0.2523E 02
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.8590E 00  0.2227E 00  0.4418E 00  0.1000E 01  0.0          0.0          0.0          0.0          0.0          0.0

          NAMEA        TIPA         EA           LA           VA           WA           WTA
          12      0.1000E 01  0.2496E 02  0.8988E 00  0.2630E 00  0.3506E 00  0.1000E 01

          TIPB         EB           LB           VB           WB           WTB
```

Table III. (Cont'd)

```
                    0.0          0.2759E 00 -0.2387E 00 -0.3739E 00  0.8963E 00  0.1000E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 5     1      12      2     2     0     -1      0      0     0      0      0      0      0      0   00000082   00000082
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
     0.1027E 02   0.3116E 01   0.7018E 02   0.1170E 02   0.3534E 01   0.7074E 02   0.1000E 01   0.1000E 01   0.2496E 02   0.2496E 02
        U             V            W            TIP           APP           ZPR          EREC          EX         HEVSLM        UU
     0.8988E 00   0.2630E 00   0.3506E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 5     1      12      2     2     1     -1      0      0     0      0      0      0      0      0   00000082   00000082
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
     0.1170E 02   0.3534E 01   0.7074E 02   0.5446E 02   0.1605E 02   0.8742E 02   0.1000E 01   0.1000E 01   0.2496E 02   0.2496E 02
        U             V            W            TIP           APP           ZPR          EREC          EX         HEVSLM        UU
     0.6988E 00   0.2630E 00   0.3506E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 6     1      12      2     2     1     0       0      0     2      0      0      0      0      0   00000082   00000082
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
     0.5446E 02   0.1605E 02   0.8742E 02   0.5454E 02   0.1607E 02   0.8745E 02   0.1000E 01   0.1000E 01   0.2496E 02   0.2496E 02
        U             V            W            TIP           APR           ZPR          EREC          EX         HEVSLM        UU
     0.8988E 00   0.2630E 00   0.3506E 00   0.1000E 01   0.1500E 02   0.8000E 01   0.2228E 01   0.3046E 02   0.0          0.4889E 01

                    WTEVAP       EPART ARRAY(EVAP  NEUTRON  ENERGY)
                  0.1000E 01   0.1240E 01   0.3798E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 2     1      8       1     1     1     1       0      1     6      2      2     16      2      2   00000042   00000042
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
     0.2661E 00   0.5507E 00   0.6509E 02   0.9011E 00   0.1643E 01   0.6615E 02   0.1000E 01   0.1000E 01   0.2194E 02   0.2194E 02
        U             V            W            TIP           APR           ZPR          EREC          EX         HEVSLM        UU
     0.3862E 00   0.6643E 00   0.6400E 00   0.1000E 01   0.9414E 05   0.3805E 05   0.1670E 03   0.1714E 02   0.0          0.1161E 02

                    TIPB         ER           UB           VB           WB           WTB
                  0.1000E 01   0.4801E 01   0.7286E 00   0.4840E-02   0.6849E 00   0.1000E 01

                    WTEVAP       EPART ARRAY(EVAP  NEUTRON  ENERGY)
                  0.1000E 01   0.3041E 00   0.0          0.3597E 01   0.0          0.4795E 00   0.6642E 00

                    WTEVAP       EPART ARRAY(EVAP  PROTON   ENERGY)
                  0.1000E 01   0.0          0.0

                    WTEVAP       HEPART ARRAY(EVAP DEUTERON  ENERGY)
                  0.1000E 01   0.0          0.0

                    WTEVAP       HEPART ARRAY(EVAP  TRITON   ENERGY)
                  0.1000E 01   0.0          0.0          0.0          0.9894E 02   0.1076E 02   0.0          0.5408E 01   0.6809E 02
                               0.1580E 02   0.0          0.6201E 01   0.0          0.9400E 02   0.1400E 03   0.3800E 02   0.5400E 02

                    WTEVAP       HEPART ARRAY(EVAP   HE 3    ENERGY)
                  0.1000E 01   0.0          0.0

                    WTEVAP       HEPART ARRAY(EVAP  ALPHA    ENERGY)
                  0.1000E 01   0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 7     1      9       1     2     0     0       0      0     0      0      0      0      0      0   00000042   00001082
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
     0.2661E 00   0.5507E 00   0.6509E 02 -0.4571E 01   0.2261E 01   0.6155E 02   0.1000E 01   0.1000E 01   0.1623E 02   0.1623E 02
        U             V            W            TIP           APR           ZPR          EREC          EX         HEVSLM        UU
    -0.7757E 00   0.2743E 00 -0.5684E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 5     1      9       2     2     0     -1      0      0     0      0      0      0      0      0   00001082   00000081
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
    -0.4571E 01   0.2261E 01   0.6155E 02 -0.1494E 02   0.5929E 01   0.5395E 02   0.1000E 01   0.1000E 01   0.1623E 02   0.1623E 02
        U             V            W            TIP           APR           ZPR          EREC          EX         HEVSLM        UU
    -0.7757E 00   0.2743E 00 -0.5684E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD       BLZ
 2     1      9       2     2     1     0       1      0     0      1      0      0      0      0   00000081   00000081
        X             Y            Z            XC            YC            ZC          CLDWT          WT           E          EC
    -0.1494E 02   0.5929E 01   0.5395E 02 -0.1855E 02   0.7205E 01   0.5131E 02   0.1000E 01   0.1000E 01   0.1623E 02   0.1623E 02
        U             V            W            TIP           APR           ZPR          EREC          EX         HEVSLM        UU
    -0.7757E 00   0.2743E 00 -0.5684E 00   0.1000E 01   0.1600E 02   0.7000E 01   0.5526E 00   0.2226E 02   0.0          0.4713E 01
```

Table III. (Cont'd)

```
NAMEA        TIPA          EA            LA            VA            WA            WTA
 13          0.0          0.4188E 01 -0.2798E 00 -0.4497E 00  0.8483E 00  0.1000E 01

  *TEVAP      EPART ARRAY(EVAP  PROTON   ENERGY)
0.1000E 01  0.4188E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 3      1      13      2      2      0      0      0      0      0      0      0      0      0      0  00000081  00000081
        X             Y             Z            XC            YC            ZC          CLDWT            WT             E            EC
-0.1855E 02  0.7205E 01  0.5131E 02 -0.1855E 02  0.7194E 01  0.5133E 02  0.1000E 01  0.1000E 01  0.4188E 01  0.1000E 01
        U             V             W           TIP           APR           ZPR          EREC            EX        HEVSUM            UU
-0.2798E 00 -0.4497E 00  0.8483E 00  0.0         0.0           0.0           0.0           0.0           0.0           0.0           0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 3      1      10      1      1      0      0      0      0      0      0      0      0      0      0  00000042  00000042
        X             Y             Z            XC            YC            ZC          CLDWT            WT             E            EC
 0.2661E 00  0.5507E 00  0.6509E 02  0.2589E 00  0.5506E 00  0.6511E 02  0.1000E 01  0.1000E 01  0.9864E 01  0.1000E 01
        U             V             W           TIP           APR           ZPR          EREC            EX        HEVSUM            UU
-0.4039E 00 -0.3349E-02  0.9148E 00  0.0         0.0           0.0           0.0           0.0           0.0           0.0           0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 1      2       1      1      1      0      0      0      0      0      0      0      0      0      0  00000042  00000042
        X             Y             Z            XC            YC            ZC          CLDWT            WT             E            EC
 0.7298E 00  0.0          0.6000E 02  0.2661E 00  0.5507E 00  0.6509E 02  0.1000E 01  0.1000E 01  0.7200E 03  0.5476E 03
        U             V             W           TIP           APR           ZPR          EREC            EX        HEVSUM            UU
 0.0         0.0          0.1000E 01  0.0         0.0           0.0           0.0           0.0           0.0           0.0           0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 2      2       1      1      1      1      5      4      1     12      2      2     16      2      2  00000042  00000042
        X             Y             Z            XC            YC            ZC          CLDWT            WT             E            EC
 0.7298E 00  0.0          0.6000E 02  0.5707E 00 -0.1003E 01  0.7071E 02  0.1000E 01  0.1000E 01  0.7200E 03  0.4466E 03
        U             V             W           TIP           APR           ZPR          EREC            EX        HEVSUM            UU
-0.7779E-01 -0.8223E-01  0.9956E 00  0.0         0.1091E 06  0.4505E 05  0.1511E 03  0.7524E 02  0.0         0.1327E 02

NAMEA        TIPA          EA            LA            VA            WA            WTA
 2          0.1000E 01  0.2378E 02  0.4256E 00 -0.8227E 00 -0.3769E 00  0.1000E 01
 3          0.1000E 01  0.1114E 03  0.2648E 00  0.3472E 00  0.8996E 00  0.1000E 01
 4          0.1000E 01  0.5036E 02 -0.8865E 00  0.1510E 00  0.4373E 00  0.1000E 01
 5          0.1000E 01  0.2023E 02  0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01

  TIPB          EB            LB            VB            WB            WTB
0.1000E 01  0.9304E 01 -0.8126E 00 -0.7902E 00  0.1482E-01  0.1000E 01

  *TEVAP      EPART ARRAY(EVAP  NEUTRON  ENERGY)
0.1000E 01  0.0          0.7708E 00  0.4503E 01  0.6167E 01  0.3855E 01  0.3108E 01  0.0         0.1063E 02
            0.1032E 02  0.1494E 01  0.1109E 01  0.1930E 01

  *TEVAP      EPART ARRAY(EVAP  PROTON   ENERGY)
0.1000E 01  0.0          0.0

  *TEVAP     HEPART ARRAY(EVAP DEUTERON  ENERGY)
0.1000E 01  0.0          0.0

  *TEVAP     HEPART ARRAY(EVAP  TRITON   ENERGY)
0.1000E 01  0.0          0.0          0.0          0.7809E 02  0.4808E 02  0.0         0.6552E 01  0.7298E 02
            0.5900E 02  0.0          0.6717E 01  0.0         0.1090E 03  0.1160E 03  0.4500E 02  0.4800E 02

  *TEVAP     HEPART ARRAY(EVAP   HE 3    ENERGY)
0.1000E 01  0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 7      2       3      1      2      0      0      0      0      0      0      0      0      0      0  00000042  00001082
        X             Y             Z            XC            YC            ZC          CLDWT            WT             E            EC
 0.5707E 00 -0.1003E 01  0.7071E 02  0.3869E 01  0.3323E 01  0.8192E 02  0.1000E 01  0.1000E 01  0.1114E 03  0.1114E 03
        U             V             W           TIP           APR           ZPR          EREC            EX        HEVSUM            UU
 0.2648E 00  0.3472E 00  0.8996E 00  0.1000E 01  0.0         0.0           0.0           0.0           0.0           0.0           0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NPELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6     BOLD        BLZ
 5      2       3      2      2      0     -1      0      0      0      0      0      0      0      0  00001082  00000043
```

Table III. (Cont'd)

```
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.3809E 01   0.3323E 01   0.8192E 02   0.2582E 02   0.3211E 02   0.1565E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  5     2      3      2     2     0     -1      0      0     0      0      0      0      0      0    00000043    00000043
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.2582E 02   0.3211E 02   0.1565E 03   0.2885E 02   0.3608E 02   0.1668E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  5     2      3      2     2     0     -1      0      0     0      0      0      0      0      0    00000043    00000043
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.2885E 02   0.3608E 02   0.1668E 03   0.2979E 02   0.3731E 02   0.1700E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  5     2      3      2     2     0     -1      0      0     0      0      0      0      0      0    00000043    00000043
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.2979E 02   0.3731E 02   0.1700E 03   0.3001E 02   0.3761E 02   0.1708E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  5     2      3      2     2     0     -1      0      0     0      0      0      0      0      0    00000043    00000043
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.3001E 02   0.3761E 02   0.1708E 03   0.3179E 02   0.3993E 02   0.1768E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  2     2      3      2     2    -1     2       1      1     0      0      0      0      0      0    00000043    00000043
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.3179E 02   0.3993E 02   0.1768E 03   0.3295E 02   0.4146E 02   0.1807E 03   0.1000E 01   0.1000E 01   0.1114E 03   0.1114E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2648E 00   0.3472E 00   0.8996E 00   0.1000E 01   0.0          0.0          0.0          0.0          0.0          0.0

                NAMEA        TIPA         EA           LA           VA           WA           WTA
                 6        0.0          0.1104E 03   0.2550E 00   0.4291E 00   0.8665E 00   0.1000E 01

                 TIPB         EB           LB           VB           WB           WTB
               0.1000E 01   0.9292E 00   0.1223E 00  -0.9010E 00   0.4162E 00   0.1000E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  4     2      6      2     0     0     0       0      0     0      0      0      0      0      0    00000043    00000044
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.3295E 02   0.4146E 02   0.1807E 03   0.3303E 02   0.4159E 02   0.1810E 03   0.1000E 01   0.1000E 01   0.1104E 03   0.1083E 03
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
     0.2550E 00   0.4291E 00   0.8665E 00   0.0          0.0          0.0          0.0          0.0          0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD        BLZ
  6     2      4      1     1     1     0       0      0     10     2      2      16     2      2    00000042    00000042
          X            Y            Z            XC           YC           ZC           OLDWT        WT           E            EC
     0.5707E 00  -0.1003E 01   0.7071E 02  -0.4850E 00  -0.8228E 00   0.7123E 02   0.1000E 01   0.1000E 01   0.5036E 02   0.5036E 02
          U            V            W            TIP          APR          ZPR          EREC         EX           HEVSLM       UU
    -0.8865E 00   0.1510E 00   0.4373E 00   0.1000E 01   0.1111E 06   0.4505E 05   0.1723E 03   0.5718E 02   0.0          0.1231E 02

                NTEVAP       EPART ARRAY(EVAP  NEUTRON  ENERGY)
               0.1000E 01   0.1220E 01   0.2322E 01   0.1946E 01   0.0          0.2013E 01   0.2415E 01   0.4732E 01   0.0
                            0.8007E-02   0.1788E 00

                NTEVAP       EPART ARRAY(EVAP  PROTON   ENERGY)
               0.1000E 01   0.0          0.0

                NTEVAP      HEPART ARRAY(EVAP  DEUTERON  ENERGY)
               0.1000E 01   0.0          0.0

                NTEVAP      HEPART ARRAY(EVAP  TRITON   ENERGY)
               0.1000E 01   0.0          0.0          0.0          0.8640E 02   0.2860E 02   0.0          0.7120E 01   0.8592E 02
                            0.1781E 02   0.0          0.5189E 01   0.0          0.1110E 03   0.1200E 03   0.4500E 02   0.4700E 02

                NTEVAP      HEPART ARRAY(EVAP  HE 3     ENERGY)
               0.1000E 01   0.0          0.0
```

Table III. (Cont'd)

```
                    WTEVAP    HEPART ARRAY(EVAP  ALPHA     ENERGY)
                  0.1000E 01  0.0          0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     2       5     1     1     0     -1      0      0     0      0      0      0      0      0   00000042  00000042
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.5707E 00 -0.1003E 01  0.7071E 02  0.1269E 01 -0.1157E 01  0.7284E 02  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     2       5     1     1     0     -1      0      0     0      0      0      0      0      0   00000042  00000042
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.1269E 01 -0.1157E 01  0.7284E 02  0.3520E 01 -0.1653E 01  0.7971E 02  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  7     2       5     1     2     0     0       0      0     0      0      0      0      0      0   00000042  00001082
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.3520E 01 -0.1653E 01  0.7971E 02  0.4725E 01 -0.1919E 01  0.8339E 02  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     2       5     2     2     0     -1      0      0     0      0      0      0      0      0   00001082  00000082
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.4725E 01 -0.1919E 01  0.8339E 02  0.6248E 01 -0.2254E 01  0.8804E 02  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     2       5     2     2     1     -1      0      0     0      0      0      0      0      0   00000082  00000082
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.6248E 01 -0.2254E 01  0.8804E 02  0.9167E 01 -0.2898E 01  0.9594E 02  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  2     2       5     2     2     -1    2       1      1     0      0      0      0      0      0   00000082  00000082
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.9167E 01 -0.2898E 01  0.9594E 02  0.1044E 02 -0.3179E 01  0.1008E 03  0.1000E 01  0.1000E 01  0.2023E 02  0.2023E 02
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
      0.3107E 00 -0.6849E-01  0.9480E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

                    NAMEA       TIPA        EA          LA          VA          WA          WTA
                      7         0.0         0.1144E 02 -0.3791E 00  0.5913E-01  0.9235E 00  0.1000E 01

                    TIPB        EB          LB          VB          WB          WTB
                  0.1000E 01  0.8793E 01  0.9054E 00 -0.1717E 00  0.3884E 00  0.1000E 01

NCCL  NOCAS   NAME    MAT   NMED  LELEM NCPART  NABCV  NBELC NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     2       7     2     2     0     0       0      0     0      0      0      0      0      0   00000082  00000082
          X           Y           Z           XC          YC          ZC          OLDWT       WT          E          EC
      0.1044E 02 -0.3179E 01  0.1008E 03  0.1038E 02 -0.3170E 01  0.1010E 03  0.1000E 01  0.1000E 01  0.1144E 02  0.1000E 01
          U           V           W           TIP         APR         ZPR         EREC        EX         HEVSUM       UU
     -0.3791E 00  0.5913E-01  0.9235E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0
```

With the above information, looking at Table III for particle event 2 of the first history, one knows there was a fission and that only neutrons were evaporated. In particular, two prefission evaporation neutrons were produced, four postfission evaporation neutrons were produced from the first fission fragment, and six postfission evaporation neutrons were produced from the second fission fragment. The last 13 values in the triton table (after third zero value) give the fragment data as follows:

I = 3 (for this particle event since no tritons were evaporated).

HEPART(I+1,2) = ERN1, the kinetic recoil energy of the first fragment after evaporation. (ERN1 = 82.57)

HEPART(I+2,2) = E1, the excitation energy of the first fragment prior to evaporation. (E1 = 39.01)

HEPART(I+3,2) = HEVS1, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the first fragment. (HEVS1 = 0.0)

HEPART(I+4,2) = USE1, the excitation energy of the first fragment residual after evaporation. (USE1 = 1.473)

HEPART(I+5,2) = ERN2, the kinetic recoil energy of the second fragment after evaporation. (ERN2 = 78.82)

HEPART(I+6,2) = E2, the excitation energy of the second fragment prior to evaporation. (E2 = 57.30)

HEPART(I+7,2) = HEVS2, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the second fragment. (HEVS2 = 0.0)

HEPART(I+8,2) = USE2, the excitation energy of the second fragment residual after evaporation. (USE2 = 3.287)

HEPART(I+9,2) = HEVSO, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation from the original nucleus. (HEVSO = 0.0)

HEPART(I+10,2) = APR1, mass number A, of the first fission fragment. (APR1 = 110.0)

HEPART(I+11,2) = APR2, mass number, A, of the second fission fragment. (APR2 = 115.0)

HEPART(I+12,2) = ZPR1, charge number, Z, of the first fission fragment. (ZPR1 = 45.0)

HEPART(I+13,2) = ZPR2, charge number, Z, of the second fission fragment. (ZPR2 = 48.0)

The header information for this particle event contains some fragment data combined as follows:

APR = 1000*APR1+APR2 (APR = 0.1101E06)

ZPR = 1000*ZPR1+ZPR2 (ZPR = 0.4505E05)

EREC = ERN1+ERN2, the sum of the kinetic recoil energies of both fission fragments after evaporation. (EREC = 0.1614E03)

HEVSUM = HEVSO+HEVS1+HEVS2, sum of the kinetic energies of all charged particles, except protons, emitted during evaporation. (HEVSUM = 0.0)

UU = USE1+USE2, the sum of the excitation energies of both fission fragments after evaporation. (UU = 0.4759E01)

The next particle event also describes a nuclear interaction in which fission occurred.

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75-122. Given High-Energy Accelerator Shielding distribution

123-149. Technical Information Center (TIC)