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NCDATA - Nuclear Collision Data for Nucleon-Nucleus Collisions in the Energy Range 25 to 400 MeV

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NCDATA - Nuclear Collision Data for Nucleon-Nucleus Collisions in the Energy Range 25 to 400 MeV

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Abstract

A computer code written in FORTRAN IV is described which interpolates between analytic fits to intranuclear-cascade data and gives for either neutrons or protons, in the energy range 25 to 400 MeV, incident on a nucleus of atomic weight A (between 12 and 238):

1. the nonelastic cross section as a function of energy,
2. the cascade neutron- and proton-emission spectra in the angular intervals 0-30°, 30-60°, 60-90°, and 90-180°,
3. the evaporation neutron- and proton-emission spectra (assumed isotropic), and
4. the cascade neutron- and proton-emission spectra integrated over all angles.

In addition to numerical values for each of these quantities, the code also gives the values of the coefficients that occur in an analytic expression for each of these quantities.

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I. INTRODUCTION

Using an intranuclear-cascade model, H. W. Bertini has generated a large amount of data on the nonelastic cross section and the energy and angular distributions of emitted neutrons and protons when neutrons or protons in the energy range 25 to 400 MeV are incident on a variety of targets.[1,2] In a previous paper[3] (hereinafter referred to as 3) analytic fits to these intranuclear-cascade data were given. In this report a code, written in FORTRAN IV, is described which interpolates between these analytic fits and gives cross sections and particle-emission spectra for incident particle energies and target elements not given explicitly in 3.* This code treats all incident neutron and proton energies in the range 25 to 400 MeV and all target nuclei with atomic weight between 12 and 238. The code does not distinguish between targets with the same atomic weight but different atomic numbers; that is, the approximation is made that the cross-section and particle-emission spectra are independent of the atomic number of the target. The numerical data given in 3 are included as permanent data in the present code, and for those incident particle energies (25, 50, 100, 150, 200, 250, 300, 350, and 400 MeV) and atomic weights (12, 16, 27, 52, 65, 100, 140, 184, 207, and 238) considered in 3 the data supplied by the code are the same as those given in 3.

*The code is available on request from the Radiation Shielding Information Center of the Oak Ridge National Laboratory.

For any nucleon-nucleus collision in the above-mentioned ranges, the code is capable of supplying

1. the total nonelastic cross section as a function of energy,
2. the cascade neutron- and proton-emission spectra in the angular intervals $0\text{-}30^\circ$, $30\text{-}60^\circ$, $60\text{-}90^\circ$, and $90\text{-}180^\circ$,
3. the evaporation neutron and proton-emission spectra (assumed isotropic), and
4. the cascade neutron- and proton-emission spectra integrated over all angles.

In addition to numerical values for each of these quantities, the code also gives the values of the coefficients which occur in an analytic expression for each of these quantities.

In section II the method of interpolation is discussed. In section III the operation of the code is described, and sample results are given.

II. METHOD OF INTERPOLATION

A. Nonelastic Cross Section

Except for trivial modifications,† the cross-section fits in 3 are of the form

$$\sigma(E,A) = \mathrm{EXP}\left[\sum_{j=0}^{5} a_j(A)\left(\frac{E}{400}\right)^j\right] . \qquad (1)$$

†In 3 the cross section fits were of the form,

$$\sigma(E,A) = \frac{1}{400}\,\mathrm{EXP}\left[\sum_{j=0}^{4} a_j(A)\left(\frac{E}{400}\right)^j\right] .$$

The factor of $\frac{1}{400}$ before the exponential is somewhat superfluous and has been eliminated in the code described here; that is, the coefficient a_0 in the cross-section fits has been redefined to conform to Eq. 1. Also, a coefficient a_5, which is, however, always zero, has been included so all of the fits have the same number of parameters.

To obtain the cross section as a function of incident particle energy for an element of atomic weight A^*, linear interpolation in the logarithm of the cross section is used. Let A_i and A_{i+1} be atomic weights for which data are given in 3 such that

$$A_i \leq A^* \leq A_{i+1} .$$

Then

$$\log \sigma(E,A^*) = \sum_{j=o}^{5} a_j(A_i) \left(\frac{E}{400}\right)^j + \left[\frac{A^* - A_i}{A_{i+1} - A_i}\right] \left\{ \sum_{j=o}^{5} [a_j(A_{i+1}) - a_j(A_i)] \left(\frac{E}{400}\right)^j \right\} \tag{2}$$

and

$$\sigma(E,A^*) = \mathrm{EXP}\left[\sum_{j=o}^{5} a_j(A^*) \left(\frac{E}{400}\right)^j \right] , \tag{3}$$

where

$$a_j(A^*) = a_j(A_i) + \left[\frac{A^* - A_i}{A_{i+1} - A_i}\right] [a_j(A_{i+1}) - a_j(A_i)] . \tag{4}$$

The coefficients $a_j(A^*)$ may be calculated from Eq. 4, and when this is done Eq. 3 may be used to calculate the nonelastic cross section as a function of incident-particle energy.

B. Particle-Emission Spectra

In 3 the cascade-particle-emission spectra in various angular regions and integrated over all angles are expressed in the form,

$$F(E,A,E_o) = \frac{1}{E_o} \mathrm{EXP}\left[\sum_{j=o}^{5} a_j(A,E_o) \left(\frac{E}{E_o}\right)^j \right] \quad E_{MIN}(A,E_o) \leq E \leq E_{MAX}(A,E_o) , \tag{5}$$

where

E = emitted particle kinetic energy,

A = atomic weight,

E_o = incident particle energy,

$E_{MIN}(A,E_o), E_{MAX}(A,E_o)$ = minimum and maximum energy, respectively, for which the fits are valid,

and the evaporation-particle spectra are expressed in the form,

$$G(E,A,E_o) = \frac{1}{25} \text{EXP}\left[\sum_{j=o}^{5} a_j(A,E_o)\left(\frac{E}{25}\right)^j\right] \quad E_{MIN}(A,E_o) \le E \le E_{MAX}(A,E_o) \tag{6}$$

with the same notation as above. In this section the method of interpolation used to find F and G for values of A and E_o, not given in 3, is described. Since the interpolation to find G and the interpolation to find F corresponding to a specific angular interval is not essentially different from the interpolation to find F corresponding to integration over all angles, only this latter case will be considered explicitly. For future reference, we note that

Number of particles emitted at

$$\text{all angles} = C_{NUM}(A,E_o)$$

$$= \int_{E_{MIN}(A,E_o)}^{E_{MAX}(A,E_o)} F(E,A,E_o)dE \ . \tag{7}$$

In order to carry through the interpolation, it is convenient to change variables by means of the equations

$$\eta = \frac{E - E_{MIN}(A,E_o)}{E_{MAX}(A,E_o) - E_{MIN}(A,E_o)} \tag{8}$$

$$F(\eta,A,E_o)d\eta = \frac{1}{C_{NUM}} F(E,A,E_o)dE \ , \tag{9}$$

so

$$\begin{aligned} \eta &= 1 \qquad E = E_{MAX}(A,E_o) \\ \eta &= 0 \qquad E = E_{MIN}(A,E_o) \ , \end{aligned} \tag{10}$$

and

$$F(\eta,A,E_o) = \left[\frac{E_{MAX}(A,E_o)-E_{MIN}(A,E_o)}{C_{NUM}}\right] F(E,A,E_o) \ . \tag{11}$$

The function $F(\eta,A,E_o)$ is defined on the interval 0 to 1 for all values of E_{MIN} and E_{MAX} and has an integral over this interval which is independent of A and E_o. In terms of η, Eq. 11 becomes

$$F(\eta,A,E_o) = EXP\left[\sum_{j=o}^{5} b_j(A,E_o)\eta^j\right] \ , \tag{12}$$

where if

$$\begin{aligned} \varepsilon &= \frac{E_{MIN}(A,E_o)}{E_o} \\ \delta &= \frac{E_{MAX}(A,E_o)-E_{MIN}(A,E_o)}{E_o} \ , \end{aligned} \tag{13}$$

then

$$b_o(A,E_o) = \varepsilon^5 a_5 + \varepsilon^4 a_4 + \varepsilon^3 a_3 + \varepsilon^2 a_2 + \varepsilon a_1 + a_o - \log C_{NUM} + \log \delta$$

$$b_1(A,E_o) = 5 \delta \varepsilon^4 a_5 + 4 \delta \varepsilon^3 a_4 + 3 \delta \varepsilon^2 a_3 + 2 \delta \varepsilon a_2 + \delta a_1$$

$$b_2(A,E_o) = 10 \delta^2 \varepsilon^3 a_5 + 6 \delta^2 \varepsilon^2 a_4 + 3 \delta^2 \varepsilon a_3 + \delta^2 a_2 \qquad (14)$$

$$b_3(A,E_o) = 10 \delta^3 \varepsilon^2 a_5 + 4 \delta^3 \varepsilon a_4 + \delta^3 a_3$$

$$b_4(A,E_o) = 5 \delta^4 \varepsilon a_5 + \delta^4 a_4$$

$$b_5(A,E_o) = \delta^5 a_5 \ .$$

The interpolation is now carried out using linear interpolation in the logarithm of $F(\eta,A,E_o)$.

Let E_o^* and A_o^* be values of incident-particle energy and atomic weight such that

$$E_{oi} \le E_o^* \le E_{oi+1} \qquad (15)$$

$$A_i \le A^* \le A_{i+1} \qquad (16)$$

where E_{oi}, E_{oi+1}, A_i, and A_{i+1} are values for which data are given in Eq. 6. Then

$$\log F(\eta,A^*,E_o^*) = \sum_{j=o}^{5} b_j(A_i,E_{oi})\eta^j$$

$$+ \left[\frac{E_o^*-E_{oi}}{E_{oi+1}-E_{oi}}\right]\left[\sum_{j=o}^{5} \left(b_j(A_i,E_{oi+1}) - b_j(A_i,E_{oi})\right)\eta^j\right]$$

$$+ \left[\frac{A^*-A_i}{A_{i+1}-A_i}\right]\left[\sum_{j=o}^{5} \left(b_j(A_{i+1},E_{oi}) - b_j(A_i,E_{oi})\right)\eta^j\right] \qquad (17)$$

$$+ \left[\frac{E_o^*-E_{oi}}{E_{oi+1}-E_{oi}}\right]\left[\frac{A_o^*-A_i}{A_{i+1}-A_i}\right]\left[\sum_{j=o}^{5} \left(b_j(A_{i+1},E_{oi+1})-b_j(A_{i+1},E_{oi})\right.\right.$$

$$\left.\left. - b_j(A_i,E_{oi+1})+b_j(A_i,E_{oi})\right)\eta^j\right]$$

and

$$F(\eta,A^*,E_o^*) = \mathrm{EXP}\left[\sum_{j=o}^{5} C_j(A^*,E_o^*)\eta^j\right] , \qquad (18)$$

where

$$C_j(A^*,E_o^*) = b_j(A_i,E_{oi})$$

$$+ \left[\frac{E_o^*-E_{oi}}{E_{oi+1}-E_{oi}}\right][b_j(A_i,E_{oi+1})-b_j(A_i,E_{oi})]$$

$$+ \left[\frac{A^*-A_i}{A_{i+1}-A_i}\right][b_j(A_{i+1},E_{oi})-b_j(A_i,E_{oi})] \qquad (19)$$

$$+ \left[\frac{E_o^*-E_{oi}}{E_{oi+1}-E_{oi}}\right]\left[\frac{A^*-A_i}{A_{i+1}-A_i}\right][b_j(A_{i+1},E_{oi+1})$$

$$-b_j(A_{i+1},E_{oi})$$

$$-b_j(A_i,E_{oi+1})$$

$$+b_j(A_i,E_{oi})] .$$

To transform Eq. 18 into energy rather than η, it is necessary to first find $E_{MIN}(A^*,E^*)$, $E_{MAX}(A^*,E^*)$, and $C_{NUM}(A^*,E^*)$. The values of $E_{MIN}(A^*,E^*)$ and $E_{MAX}(A^*,E_o^*)$ are obtained by linear interpolation, and the value of $C_{NUM}(A^*,E^*)$ is obtained by three-point Lagrangian interpolation. With these values known, the inverse transformation (see Eqs. 8 and 9) gives

$$F(E,A^*,E_o^*) = \frac{1}{E_o^*} \text{EXP}\left[\sum_{j=o}^{5} a_j(A^*,E^*)\left(\frac{E}{E_o^*}\right)^j\right] , \tag{20}$$

where

$$\delta(A^*,E_o^*) = \frac{E_{MAX}(A^*,E_o^*)-E_{MIN}(A^*,E_o^*)}{E_o^*}$$

$$\varepsilon(A^*,E_o^*) = \frac{E_{MIN}(A^*,E_o^*)}{E_o^*} ,$$

$$a_o(A^*,E_o^*) = -\varepsilon^5 \frac{C_5}{\delta^5} + \varepsilon^4 \frac{C_4}{\delta^4} - \varepsilon^3 \frac{C_3}{\delta^3} + \varepsilon^2 \frac{C_2}{\delta^2} - \varepsilon \frac{C_1}{\delta}$$

$$+ C_o - \log \delta + \log C_{NUM}$$

$$a_1(A^*,E_o^*) = 5\,\varepsilon^4 \frac{C_5}{\delta^5} - 4\,\varepsilon^3 \frac{C_4}{\delta^4} + 3\,\varepsilon^2 \frac{C_3}{\delta^3} - 2\,\varepsilon \frac{C_2}{\delta^2} + C_1$$

$$a_2(A^*,E_o^*) = -10\,\varepsilon^3 \frac{C_5}{\delta^5} + 6\,\varepsilon^2 \frac{C_4}{\delta^4} - 3\,\varepsilon \frac{C_3}{\delta^3} + \frac{C_2}{\delta^2} \tag{21}$$

$$a_3(A^*,E_o^*) = 10\,\varepsilon^2 \frac{C_5}{\delta^5} - 4\,\varepsilon \frac{C_4}{\delta^4} + \frac{C_3}{\delta^3}$$

$$a_4(A^*,E_o^*) = -5\,\varepsilon \frac{C_5}{\delta^5} + \frac{C_4}{\delta^4}$$

$$a_5(A^*,E_o^*) = \frac{C_5}{\delta^5} .$$

Equation 20, together with the coefficients given in Eq. 21, now constitutes an analytic expression for $F(E,A^*,E_o^*)$.

III. CODE OPERATION

In order to operate the code, the data that must be specified are:

NCAS = number of cases

AW = atomic weight of target element

EZ = E_o = incident particle kinetic energy

IP = index specifying the type of incident particle (1 for incident protons, 2 for incident neutrons)

IM = index specifying the type of emergent particle (1 for emergent protons, 2 for emergent neutrons)

ITYP = index specifying the type of data desired (1 for cascade spectra, 2 for evaporation spectra, and 3 for the non-elastic cross section).

IANG = index specifying the angular interval desired. (1 = 0-30°, 2 = 30-60°, 3 = 60-90°, 4 = 90-180°, and 5 = 0-180°.) (Evaporation spectra are assumed to be isotropic so for ITYP = 2 only IANG = 5 is allowed.)

E1,E2 = minimum and maximum values of the energy at which the cross section is desired. These quantities are used only when ITYP = 3; when ITYP $\neq$ 3 the values of E1 and E2 are not used. E1 must always be $\geq$ 25 MeV and E2 must always be $\leq$ 400 MeV.

NE = number of energy points in printed out spectra or cross section (must be 2 or greater).

A case is defined to be a specification of a single value for each of the last nine variables listed above. The first data card must contain the number of cases, NCAS, in a format I5 and for each case there must be a data card specifying the nine variables in the order listed above with a format (2F10.2, 4I5, 2F10.2,I5). In the case of the cross section ITYP = 3, values of IANG and IM are not required and the place for these variables on the data card should be blank. In the case of emission spectra, values of E1 and E2 are not required and the place for these variables on the data card should be blank. In addition to these input data, the code also requires permanent data which are stored on tape and are referred to as logical 8 in the source deck.

As an example, Table 1 shows the data cards needed to obtain all available data from 375-MeV protons incident on iron. There are thirteen cases, and the information requested by data cards 2 to 14 is:

2. nonelastic cross section between 25 and 400 MeV
3. cascade proton-emission spectrum in the angular interval 0 to 30°
4. cascade proton-emission spectrum in the angular interval 30° to 60°
5. cascade proton-emission spectrum in the angular interval 60° to 90°
6. cascade proton-emission spectrum in the angular interval 90° to 180°
7. cascade proton-emission spectrum in the angular interval 0 to 180°

8. cascade neutron-emission spectrum in the angular interval 0 to 30°
9. cascade neutron-emission spectrum in the angular interval 30° to 60°
10. cascade neutron-emission spectrum in the angular interval 60° to 90°
11. cascade neutron emission spectrum in the angular interval 90° to 180°
12. cascade neutron-emission spectrum in the angular interval 0 to 180°
13. evaporation proton-emission spectrum
14. evaporation neutron-emission spectrum.

The output for each of these 13 cases is shown in Tables 2 through 14. At the top of each table the input data are given. Below this, the values of EMIN, EMAX, and the coefficients to be used in the analytic expressions (Eqs. 1, 5, or 6) are printed. The analytic expressions are valid only for EMIN $\leq$ E $\leq$ EMAX and should not be used outside of this range. In the case of emission spectra, EMIN and EMAX are calculated for each case, but in the case of the nonelastic cross section EMIN is always 25 MeV and EMAX is always 400 MeV. Below the coefficients the cross section or the emission spectrum is printed as a function of energy for the number of energy points specified by NE. It should be carefully noted that for IANG = 1, 2, 3, or 4 the coefficients are defined so that the analytic expression gives the energy spectra averaged over the angular interval, while for IANG = 5 the coefficients are defined so that the analytic expression gives the energy spectra

integrated over all angles. Finally, below the emission spectra the code prints CNUM and EOUT/EO defined by

$$\text{CNUM} = 2\pi(\cos\theta_1 - \cos\theta_2) \int_{\text{EMIN}}^{\text{EMAX}} F(E)\, dE$$

$$\frac{\text{EOUT}}{\text{EO}} = \frac{1}{\text{EO}} \int_{\text{EMIN}}^{\text{EMAX}} F(E)E\, dE$$

ITYP = 1

IANG = 1,2,3,4

$$\text{CNUM} = \int_{\text{EMIN}}^{\text{EMAX}} F(E)\, dE$$

$$\frac{\text{EOUT}}{\text{EO}} = \frac{1}{\text{EO}} \int_{\text{EMIN}}^{\text{EMAX}} F(E)E\, dE$$

ITYP = 1

IANG = 5

$$\text{CNUM} = \int_{\text{EMIN}}^{\text{EMAX}} G(E)\, dE$$

$$\frac{\text{EOUT}}{\text{EO}} = \int_{\text{EMIN}}^{\text{EMAX}} G(E)E\, dE$$

ITYP = 2

IANG = 5

In a few instances in 3, it was found that the intranuclear-cascade data were too meager to be fitted. In the present code when the interpolation formulas to produce a requested set of data involve the use of these unfitted data, the error message "Sorry but we are unable to fit this interval" is printed and the code proceeds to the next case.

CODED BY _____

DATE _____ REQUEST NO. _____

FORTRAN

PROBLEM _____

PROGRAM _____

PAGE _____ OF _____

Table 1

STATEMENT TYPE	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION
	13			
		5	55.85 375.00 1 3 25.00 400.00 20	
		5	55.85 375.00 1 1 1 1 20	
		5	55.85 375.00 1 1 1 2 20	
		5	55.85 375.00 1 1 1 3 20	
		5	55.85 375.00 1 1 1 4 20	
		5	55.85 375.00 1 1 1 5 20	
		5	55.85 375.00 1 2 1 1 20	
		5	55.85 375.00 1 2 1 2 20	
		5	55.85 375.00 1 2 1 3 20	
		5	55.85 375.00 1 2 1 4 20	
		5	55.85 375.00 1 2 1 5 20	
		5	55.85 375.00 1 1 2 5 20	
		5	55.85 375.00 1 2 2 5 20	

Table 2

A # 55.85

INC. PART. P ITYP # CROSS SECT.

EMIN # 25.00 EMAX # 400.00

A(0) # 0.71062602E 01 A(1) # -0.32224132E 01 A(2) # 0.67607829E 01

A(3) # -0.64560860E 01 A(4) # 0.23298326E 01 A(5) # 0.

E(MEV)	F(MB)
0.2500000E 02	0.1022216E 04
0.4473684E 02	0.9175980E 03
0.6447368E 02	0.8430636E 03
0.8421053E 02	0.7898479E 03
0.1039474E 03	0.7520091E 03
0.1236842E 03	0.7253779E 03
0.1434210E 03	0.7069300E 03
0.1631579E 03	0.6944041E 03
0.1828947E 03	0.6860708E 03
0.2026316E 03	0.6805929E 03
0.2223684E 03	0.6769436E 03
0.2421053E 03	0.6743619E 03
0.2618421E 03	0.6723290E 03
0.2815789E 03	0.6705569E 03
0.3013158E 03	0.6689828E 03
0.3210526E 03	0.6677664E 03
0.3407895E 03	0.6672873E 03
0.3605263E 03	0.6681476E 03
0.3802632E 03	0.6711810E 03
0.4000000E 03	0.6774775E 03

Table 3

A # 55.85 EO # 375.00 ANG. INT. 0. TO 30.0

INC. PART. P EMERG. PART. P ITYP # CASCADE

EMIN # 2.78 EMAX # 371.11

A(0) # 0.50715098E 00 A(1) # -0.22684995E 02 A(2) # 0.97366825E 02

A(3) # -0.21751686E 03 A(4) # 0.24569271E 03 A(5) # -0.10434511E 03

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.3762467E-02
0.2216575E 02	0.1560938E-02
0.4155155E 02	0.9131979E-03
0.6093736E 02	0.6695767E-03
0.8032316E 02	0.5647658E-03
0.9970896E 02	0.5170391E-03
0.1190948E 03	0.4960102E-03
0.1384806E 03	0.4902957E-03
0.1578664E 03	0.4978160E-03
0.1772522E 03	0.5222924E-03
0.1966380E 03	0.5721673E-03
0.2160238E 03	0.6612405E-03
0.2354096E 03	0.8106059E-03
0.2547954E 03	0.1049972E-02
0.2741812E 03	0.1411482E-02
0.2935670E 03	0.1898526E-02
0.3129528E 03	0.2406628E-02
0.3323386E 03	0.2633574E-02
0.3517244E 03	0.2205957E-02
0.3711102E 03	0.1208384E-02

CNUM # 0.3610844E 00 EOUT/EO # 0.2104556E 00

Table 4

A # 55.85 EO # 375.00 ANG. INT. 30.0 TO 60.0

INC. PART. P EMERG. PART. P ITYP # CASCADE

EMIN # 2.78 EMAX # 324.26

A(0) # 0.65974267E 00 A(1) # -0.27778191E 02 A(2) # 0.14594290E 03

A(3) # -0.33155945E 03 A(4) # 0.34698226E 03 A(5) # -0.14340214E 03

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.4231400E-02
0.1969982E 02	0.1713573E-02
0.3661969E 02	0.1042062E-02
0.5353956E 02	0.8354769E-03
0.7045942E 02	0.7970144E-03
0.8737929E 02	0.8365592E-03
0.1042992E 03	0.9124371E-03
0.1212190E 03	0.9943377E-03
0.1381389E 03	0.1056361E-02
0.1550588E 03	0.1079786E-02
0.1719786E 03	0.1056791E-02
0.1888985E 03	0.9904370E-03
0.2058184E 03	0.8906270E-03
0.2227382E 03	0.7688247E-03
0.2396581E 03	0.6345165E-03
0.2565780E 03	0.4947134E-03
0.2734978E 03	0.3560961E-03
0.2904177E 03	0.2279741E-03
0.3073376E 03	0.1228892E-03
0.3242575E 03	0.5171963E-04

CNUM # 0.6446766E 00 EOUT/EO # 0.2074011E 00

Table 5

A # 55.85 EO # 375.00 ANG. INT. 60.0 TO 90.0

INC. PART. P EMERG. PART. P ITYP # CASCADE

EMIN # 2.78 EMAX # 216.47

A(0) # 0.60573892E 00 A(1) # -0.29372239E 02 A(2) # 0.18535058E 03

A(3) # -0.59069485E 03 A(4) # 0.81626071E 03 A(5) # -0.42437327E 03

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.3970030E-02
0.1402678E 02	0.2050098E-02
0.2527361E 02	0.1328858E-02
0.3652043E 02	0.1008144E-02
0.4776726E 02	0.8456717E-03
0.5901409E 02	0.7498111E-03
0.7026092E 02	0.6789112E-03
0.8150774E 02	0.6121996E-03
0.9275457E 02	0.5405435E-03
0.1040014E 03	0.4626569E-03
0.1152482E 03	0.3821811E-03
0.1264951E 03	0.3047001E-03
0.1377419E 03	0.2352152E-03
0.1489887E 03	0.1767222E-03
0.1602355E 03	0.1299883E-03
0.1714824E 03	0.9410975E-04
0.1827292E 03	0.6730508E-04
0.1939760E 03	0.4757863E-04
0.2052229E 03	0.3312522E-04
0.2164697E 03	0.2250856E-04

CNUM # 0.4058589E 00 EOUT/EO # 0.5626947E-01

Table 6

A # 55.85 EO # 375.00 ANG. INT. 90.0 TO 180.0

INC. PART. P EMERG. PART. P ITYP # CASCADE

EMIN # 2.78 EMAX # 115.93

A(0) # 0.21360639E 00 A(1) # -0.42668289E 02 A(2) # 0.23430257E 03

A(3) # -0.84563183E 03 A(4) # 0.16162320E 04 A(5) # -0.17134816E 04

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.2436746E-02
0.8735260E 01	0.1373594E-02
0.1469057E 02	0.8481457E-03
0.2064588E 02	0.5646032E-03
0.2660119E 02	0.3995968E-03
0.3255650E 02	0.2970370E-03
0.3851182E 02	0.2294466E-03
0.4446713E 02	0.1824678E-03
0.5042244E 02	0.1481711E-03
0.5637775E 02	0.1219693E-03
0.6233306E 02	0.1011097E-03
0.6828837E 02	0.8389810E-04
0.7424368E 02	0.6928176E-04
0.8019899E 02	0.5661353E-04
0.8615431E 02	0.4551244E-04
0.9210962E 02	0.3577498E-04
0.9806493E 02	0.2731277E-04
0.1040202E 03	0.2010309E-04
0.1099755E 03	0.1414591E-04
0.1159309E 03	0.9425959E-05

CNUM # 0.2139172E 00 EOUT/EO # 0.1274926E-01

Table 7

A # 55.85 EO # 375.00 ANG. INT. 0. TO 180.0

INC. PART. P EMERG. PART. P ITYP # CASCADE

EMIN # 2.78 EMAX # 371.11

A(0) # 0.29013301E 01 A(1) # -0.29652799E 02 A(2) # 0.14279230E 03

A(3) # -0.32936880E 03 A(4) # 0.34734894E 03 A(5) # -0.13527190E 03

E(MEV)	F(NO/MEV)
0.2779949E 01	0.3925392E-01
0.2216575E 02	0.1299334E-01
0.4155155E 02	0.7040448E-02
0.6093736E 02	0.5195218E-02
0.8032316E 02	0.4550842E-02
0.9970896E 02	0.4296350E-02
0.1190948E 03	0.4108989E-02
0.1384806E 03	0.3851014E-02
0.1578664E 03	0.3499965E-02
0.1772522E 03	0.3103912E-02
0.1966380E 03	0.2731997E-02
0.2160238E 03	0.2438961E-02
0.2354096E 03	0.2254064E-02
0.2547954E 03	0.2185244E-02
0.2741812E 03	0.2222253E-02
0.2935670E 03	0.2325298E-02
0.3129528E 03	0.2394619E-02
0.3323386E 03	0.2250011E-02
0.3517244E 03	0.1722988E-02
0.3711102E 03	0.9198701E-03

CNUM # 0.1646792E 01 EOUT/EO # 0.4991703E 00

Table 8

A # 55.85 EO # 375.00 ANG. INT. 0. TO 30.0

INC. PART. P EMERG. PART. N ITYP # CASCADE

EMIN # 2.78 EMAX # 370.30

A(0) # 0.65749216E 00 A(1) # -0.23781810E 02 A(2) # 0.10328296E 03

A(3) # -0.23023033E 03 A(4) # 0.24649430E 03 A(5) # -0.97290165E 02

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.4338831E-02
0.2212332E 02	0.1733976E-02
0.4146669E 02	0.9954327E-03
0.6081006E 02	0.7229452E-03
0.8015343E 02	0.6044633E-03
0.9949680E 02	0.5447783E-03
0.1188402E 03	0.5076749E-03
0.1381835E 03	0.4787001E-03
0.1575269E 03	0.4540067E-03
0.1768703E 03	0.4354648E-03
0.1962136E 03	0.4277769E-03
0.2155570E 03	0.4371137E-03
0.2349004E 03	0.4712284E-03
0.2542438E 03	0.5405454E-03
0.2735871E 03	0.6588734E-03
0.2929305E 03	0.8402344E-03
0.3122739E 03	0.1083646E-02
0.3316172E 03	0.1335586E-02
0.3509606E 03	0.1446978E-02
0.3703040E 03	0.1228598E-02

CNUM # 0.2628191E 00 EOUT/EO # 0.1256016E 00

Table 9

A # 55.85 EO # 375.00 ANG. INT. 30.0 TO 60.0

INC. PART. P EMERG. PART. N ITYP # CASCADE

EMIN # 2.57 EMAX # 310.67

A(0) # 0.91658533E 00 A(1) # -0.30922158E 02 A(2) # 0.15469846E 03

A(3) # -0.36328123E 03 A(4) # 0.39624152E 03 A(5) # -0.16763677E 03

E(MEV)	F(NO/MEV/SR)
0.2571224E 01	0.5433320E-02
0.1878698E 02	0.2000294E-02
0.3500274E 02	0.1096789E-02
0.5121850E 02	0.7899135E-03
0.6743426E 02	0.6768304E-03
0.8365001E 02	0.6398947E-03
0.9986577E 02	0.6319714E-03
0.1160815E 03	0.6282105E-03
0.1322973E 03	0.6144632E-03
0.1485130E 03	0.5848150E-03
0.1647288E 03	0.5401147E-03
0.1809446E 03	0.4853490E-03
0.1971603E 03	0.4264820E-03
0.2133761E 03	0.3680487E-03
0.2295918E 03	0.3121241E-03
0.2458076E 03	0.2585148E-03
0.2620234E 03	0.2057965E-03
0.2782391E 03	0.1529890E-03
0.2944549E 03	0.1015601E-03
0.3106706E 03	0.5649060E-04

CNUM # 0.4745729E 00 EOUT/EO # 0.1136498E 00

Table 10

A # 55.85 EO # 375.00 ANG. INT. 60.0 TO 90.0

INC. PART. P EMERG. PART. N ITYP # CASCADE

EMIN # 2.78 EMAX # 210.49

A(0) # 0.66083317E 00 A(1) # -0.28983813E 02 A(2) # 0.17823528E 03

A(3) # -0.61930340E 03 A(4) # 0.94148891E 03 A(5) # -0.53302034E 03

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.4205298E-02
0.1371212E 02	0.2206770E-02
0.2464428E 02	0.1415961E-02
0.3557645E 02	0.1040299E-02
0.4650862E 02	0.8304748E-03
0.5744078E 02	0.6918120E-03
0.6837295E 02	0.5836806E-03
0.7930511E 02	0.4885787E-03
0.9023728E 02	0.4006285E-03
0.1011694E 03	0.3198293E-03
0.1121016E 03	0.2483387E-03
0.1230338E 03	0.1880944E-03
0.1339659E 03	0.1397199E-03
0.1448981E 03	0.1024572E-03
0.1558303E 03	0.7464475E-04
0.1667624E 03	0.5429189E-04
0.1776946E 03	0.3950081E-04
0.1886268E 03	0.2868369E-04
0.1995589E 03	0.2062645E-04
0.2104911E 03	0.1447345E-04

CNUM # 0.3682115E 00 EOUT/EO # 0.4211638E-01

Table 11

A # 55.85 EO # 375.00 ANG. INT. 90.0 TO 180.0

INC. PART. P EMERG. PART. N ITYP # CASCADE

EMIN # 2.78 EMAX # 113.68

A(0) # 0.5675462DE 00 A(1) # -0.63312838E 02 A(2) # 0.63576568E 03

A(3) # -0.39502466E 04 A(4) # 0.11601751E 05 A(5) # -0.12719408E 05

E(MEV)	F(NO/MEV/SR)
0.2779949E 01	0.3041616E-02
0.8616763E 01	0.1468845E-02
0.1445358E 02	0.8615010E-03
0.2029039E 02	0.5779595E-03
0.2612720E 02	0.4231090E-03
0.3196402E 02	0.3261853E-03
0.3780083E 02	0.2581452E-03
0.4363764E 02	0.2062353E-03
0.4947446E 02	0.1647589E-03
0.5531127E 02	0.1311531E-03
0.6114809E 02	0.1041296E-03
0.6698490E 02	0.8279730E-04
0.7282171E 02	0.6631918E-04
0.7865853E 02	0.5384245E-04
0.8449534E 02	0.4453458E-04
0.9033215E 02	0.3762859E-04
0.9616897E 02	0.3243989E-04
0.1020058E 03	0.2835293E-04
0.1078426E 03	0.2479773E-04
0.1136794E 03	0.2125072E-04

CNUM # 0.2279215E 00 EOUT/EO # 0.1326080E-01

Table 12

A # 55.85 EO # 375.00 ANG. INT. 0. TO 180.0

INC. PART. P EMERG. PART. N ITYP # CASCADE

EMIN # 2.78 EMAX # 370.30

A(0) # 0.27585416E 01 A(1) # -0.19426048E 02 A(2) # 0.47103090E 02

A(3) # -0.53547438E 02 A(4) # 0.22231766E 02 A(5) # 0.

E(MEV)	F(NO/MEV)
0.2779949E 01	0.3652250E-01
0.2212332E 02	0.1558854E-01
0.4146669E 02	0.8151114E-02
0.6081006E 02	0.5027371E-02
0.8015343E 02	0.3534793E-02
0.9949680E 02	0.2748611E-02
0.1188402E 03	0.2301741E-02
0.1381835E 03	0.2029091E-02
0.1575269E 03	0.1847554E-02
0.1768703E 03	0.1711324E-02
0.1962136E 03	0.1594178E-02
0.2155570E 03	0.1482109E-02
0.2349004E 03	0.1369851E-02
0.2542438E 03	0.1258541E-02
0.2735871E 03	0.1153595E-02
0.2929305E 03	0.1062830E-02
0.3122739E 03	0.9953387E-03
0.3316172E 03	0.9618063E-03
0.3509606E 03	0.9771637E-03
0.3703040E 03	0.1067590E-02

CNUM # 0.1348549E 01 EOUT/EO # 0.3021080E 00

Table 13

A # 55.85 EO # 375.00 ANG. INT. 0. TO 180.0

INC. PART. P EMERG. PART. P ITYP # EVAPORATION

EMIN # 2.11 EMAX # 18.25

A(0) # -0.43842491E 01 A(1) # 0.74405740E 02 A(2) # -0.31747780E 03

A(3) # 0.51718462E 03 A(4) # -0.29540998E 03 A(5) # 0.

E(MEV)	F(NO/MEV)
0.2107308E 01	0.3717200E-01
0.2956858E 01	0.8663152E-01
0.3806409E 01	0.1398137E 00
0.4655959E 01	0.1699722E 00
0.5505510E 01	0.1677240E 00
0.6355060E 01	0.1433938E 00
0.7204611E 01	0.1123069E 00
0.8054162E 01	0.8439944E-01
0.8903712E 01	0.6314528E-01
0.9753263E 01	0.4834088E-01
0.1060281E 02	0.3855320E-01
0.1145236E 02	0.3230506E-01
0.1230191E 02	0.2841396E-01
0.1315146E 02	0.2596119E-01
0.1400101E 02	0.2415599E-01
0.1485057E 02	0.2222801E-01
0.1570012E 02	0.1945874E-01
0.1654967E 02	0.1544276E-01
0.1739922E 02	0.1048770E-01
0.1824877E 02	0.5699366E-02

CNUM # 0.1068580E 01 EOUT/EO # 0.2022005E-01

Table 14

A # 55.85 EO # 375.00 ANG. INT. 0. TO 180.0

INC. PART. P EMERG. PART. N ITYP # EVAPORATION

EMIN # 0. EMAX # 14.16

A(0) # 0.23170709E 01 A(1) # 0.15528729E 01 A(2) # -0.57441275E 02

A(3) # 0.15301887E 03 A(4) # -0.13780708E 03 A(5) # 0.

E(MEV)	F(NO/MEV)
0.	0.4058365E 00
0.7455172E 00	0.4055021E 00
0.1491034E 01	0.3742639E 00
0.2236551E 01	0.3256684E 00
0.2982069E 01	0.2719696E 00
0.3727586E 01	0.2213147E 00
0.4473103E 01	0.1777084E 00
0.5218620E 01	0.1422130E 00
0.5964137E 01	0.1142604E 00
0.6709654E 01	0.9260426E-01
0.7455172E 01	0.7586899E-01
0.8200689E 01	0.6280273E-01
0.8946206E 01	0.5236252E-01
0.9691723E 01	0.4372214E-01
0.1043724E 02	0.3625739E-01
0.1118276E 02	0.2953554E-01
0.1192828E 02	0.2331579E-01
0.1267379E 02	0.1755011E-01
0.1341931E 02	0.1236133E-01
0.1416483E 02	0.7974483E-02

CNUM # 0.20040004E 01 EOUT/EO # 0.1888347E-01

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