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NATIONAL BUREAU OF STANDARDS REPORT

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ELECTRON AND PHOTON TRANSPORT PROGRAMS

I. Introduction and Notes on Program DATAPAC 4

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NATIONAL BUREAU OF STANDARDS REPORT

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ELECTRON AND PHOTON TRANSPORT PROGRAMS

I. Introduction and Notes on Program DATAPAC 4

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This work was supported by NASA under Contract No. R-80

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1. Introduction

During the past few years we have developed a number of Monte Carlo computer programs for calculating the transport of electrons and photons through extended media. All generations of secondary electrons and photons can be included in the calculation. A beam of electrons or photons, with specified direction and spectral composition, is assumed to be incident on a plane-parallel target that is of finite thickness in one dimension and unbounded in the other two. The following items are calculated: (i) the reflection and transmission of radiation by the target, (ii) the production of secondary bremsstrahlung and characteristic X-ray photons in the target and their emergence from it, (iii) the deposition of energy and charge by electrons as function of the depth in the target, and (iv) the flux of electrons as function of the depth in the target. The method of calculation, many computational details, and results for specific problems have been presented in a number of papers.[1-8/]

The work has now reached the stage where the emphasis is shifted from the writing and checking-out of new programs to the production of data. Systematic calculations are in progress which involve comparisons with corresponding experimental results, and the tabulation of transport data of general interest.

It is unlikely that we will have the time and opportunity to exploit the programs with sufficient thoroughness. We would like, therefore, to begin with this report the documentation of the programs, in order to put other potential users in a position to run the programs for the conditions of interest to them.

The first phase of documentation will emphasize programming rather than physics aspects. A fairly elaborate set of running instructions is provided, indicating the various program options, the nature of the input variables, the relation of the various programs to each other, and the functions of the many subprograms. In addition, complete program listings are given as well as print-outs of short sample runs including the input data and results.

For various reasons we approach the documentation of our programs with some misgivings. Even though the development of the programs has reached an advanced stage, they are not in final form, and some of them may be changed somewhat in the future, possibly as the result of feedback from comparisons with experimental data. The programs have been checked out carefully and appear to be in good working order. However, we have from time to time discovered various minor errors and cannot rule out the possibility of finding others. The number of options under which the programs can be run is very large, and we have not been in a position to check out all cases.

Another difficulty arises from the fact that a large number of input parameters must be chosen, and that these choices must be made with some understanding of the physical implications. Conceivably this aspect might be troublesome for people who would like to run the programs as "black boxes".

2. Organization of the System of Programs

The various programs fall into four categories. Those in the first category are used to produce a data library which is stored on magnetic tape. This library contains cross section data, and information of a general nature, for a large number of different media. Programs in the second category accept data from the library tape, process and expand these data, and produce tabular arrays suitable for rapid table look-ups. The most important program in the second category currently in use is DATAPAC 4, which will be discussed in Section 4. In the third category are Monte Carlo programs which generate, by random sampling, large sets of electron and photon histories, on the basis of the physical information supplied by DATAPAC 4 or similar programs. The electron and photon histories, in the course of production, are concurrently analyzed to obtain information about radiation transmission and reflection, energy

deposition, flux, etc. The most important program in the third category currently in use is ETRAN 15; more details about this program will be given in NBS Report 9837. Finally, programs in the fourth category organize and analyze the output of the Monte Carlo programs, and in some instances extend the random sampling results through the use of other computational methods.

The programs to be discussed in this and subsequent reports have all been written in FORTRAN, and are presented in the version currently in operation on a Univac 1108 computer at the National Bureau of Standards. Essentially the same programs, in scaled-up versions with larger cross sections and output arrays, are operational on an IBM 360/91 computer at the NASA Goddard Space Flight Center.

3. Data Library

Many of the programs for generating the tape library were run a long time ago on a 7094 computer, the result being a body of information stored on cards as well as on tape and amounting to approximately 20,000 BCD card images. A program called DATATAPE produces the actual library tape with the appropriate format.

The library tape contains information about the following processes: (i) elastic scattering of electrons and positrons by atoms (Mott[9/] cross section); (ii) bremsstrahlung production

by electrons, mean radiative energy loss, spectral and angular distribution of emitted photons (based on Bethe-Heitler theory combined with Coulomb correction, Elwert factor, rigorous high-frequency limit, and an empirical correction factor[10/]); (iii) collision energy loss fluctuations (Landau[11/] distribution); (iv) angular distribution of photo-electrons (based on Sauter[12/] and Fischer[13/] cross sections); (iv) energy distributions for electron-positron pairs (as given by Bethe and Ashkin[14/]); (v) density effect correction to the mean collision energy loss (stopping power) (taken from the work of Sternheimer[15/]).

With the exception of item (v), all information is stored for every element from atomic number Z=1 to Z=100, and it is assumed that DATAPAC 4 will later perform the required combinations for mixtures and compounds. Information about the density effect (item (v)) is limited to those materials for which reliable density effect parameters are available from the work of Sternheimer. The fifty-four materials in this category are listed in Table I. The composition by weight of the compounds and mixtures in this list is shown in Table II. If a user is interested in generating data for a material not listed in Table I, it is possible for him to insert his own density effect parameters and related data in program DATAPAC 4.

TABLE I

DATAPAC CODE LIST

CODE (IZIP)	MATERIAL	CODE (IZIP)	MATERIAL	CODE (IZIP)	MATERIAL
1	H_2 (gas)	54	Xe (gas)	114	Toluene $C_7 H_8$
2	He (gas)	74	W	115	Acetylene $(CH)_2$
3	Li	79	Au	116	Polystyrene $(C_8 H_8)_n$
4	Be	82	Pb	117	Stilbene $C_{14} H_{12}$
6	C (graphite)	92	U	118	Anthracene $C_{14} H_{10}$
7	N_2 (gas)	101	Liquid H	119	Lucite $(C_5 H_8 O_2)_n$
8	O_2 (gas)	102	H_2O	120	Freon CF_3 Br
10	Ne (gas)	103	CO_2	121	Muscle
12	Mg	104	Li F	122	Bone
13	Al	105	Li I	123	Air
14	Si	106	Na I	124	Emulsion
18	A (gas)	107	Ag Cl	125	$Li_2 B_4 O_7$
26	Fe	108	Ag Br	126	N. E. 102
29	Cu	109	Methane CH_4	127	Sapphire $Al_2 O_3$
32	Ge	110	Propane $C_3 H_8$	128	Li Al Glass
36	Kr (gas)	111	Ethylene $(CH_2)_2$	129	H - Ne Mixture
47	Ag	112	Polyethylene $(CH_2)_n$	130	Ca F_2
50	Sn	113	Xylene $C_8 H_{10}$	131	Cs I

TABLE II

Assumed Composition by Weight for Compounds & Mixtures

H_2O	CO_2	LiF	LiI	NaI
11.19% H	27.291% C	26.754% Li	5.185% Li	15.337% Na
88.81% O	72.709% O	73.246% F	94.815% I	84.663% I

Ag Cl	Ag Br	Methane CH_4	Propane C_3H_8	Ethylene, $(CH_2)_2$
24.737% Cl	42.555% Br	25.132% H	18.287% H	14.372% H
75.263% Ag	57.445% Ag	74.868% C	81.713% C	85.628% C

Polyethylene $(CH_2)_n$	Xylene C_8H_{10}	Toluene C_7H_8	Acetylene $(CH)_2$	Polystyrene $(C_8H_8)_n$
14.372% H	9.494% H	8.752% H	7.743% H	7.743% H
85.628% C	90.506% C	91.248% C	92.257% C	92.257% C

Stilbene $C_{14}H_{12}$	Anthracene $C_{14}H_{10}$	Lucite $(C_5H_8O_2)_n$	Freon CF_3Br	Muscle
6.711% H	5.655% H	8.054% H	8.065% C	10.20 % H
93.289% C	94.345% C	59.984% C	38.274% F	12.30 % C
		31.962% O	53.661% Br	3.50 % N
				72.90 % O
				0.08 % Na
				0.02 % Mg
				0.20 % P
				0.50 % S
				0.30 % K

Air	Bone	Emulsion	LiAl Glass
75.5 % N	6.4 % H	1.410% H	7.1 % Li
23.2 % O	27.8 % C	7.226% C	52.0 % O
1.3 % A	2.7 % N	1.932% N	11.5 % Al
	41.0 % O	6.611% O	29.4 % Si
	0.2 % Mg	0.189% S	
	7.0 % P	34.910% Br	
	0.2 % S	47.410% Ag	
	14.7 % Ca	0.312% I	

$Li_2B_4O_7$	N.E. 102	Sapphire Al_2O_3	H-Ne Mixture	CsI
8.205% Li	8.488% H	47.077% O	4.757% H	48.845% I
25.585% B	91.512% C	52.923% Al	95.243% Ne	51.155% Cs
66.210% O				

CaF_2
48.668% F
51.332% Ca

The empirical modification of the Bethe-Heitler bremsstrahlung cross section (item (ii)) consists of a factor which depends on the electron energy only. This factor changes the mean energy loss by radiation and the bremsstrahlung efficiency but leaves the spectral and intrinsic angular distribution of the bremsstrahlung photons unaltered. This modification has been found sufficient to bring calculated and measured data on thick-target bremsstrahlung into reasonable agreement.

Three library tapes have been prepared, each based on a different bremsstrahlung correction factor:

DATATAPE 0: empirical correction factor set equal to unity (no correction);

DATATAPE 1: empirical correction factor derived from experimental data given in a review article by Koch and Motz,[10/] and essentially equivalent to the correction factor deduced by these authors;

DATATAPE 2: empirical correction factor derived from the more recent experiments of Aiginger,[16/] and of Rester and Dance[17/].

The experimental correction factors are directly available for the elements aluminum and gold, and have been obtained for other elements by interpolation, assuming the factor to be unity for hydrogen[18/]. The correction factors used in DATATAPE 2 are intermediate between those of DATATAPE 0 and DATATAPE 1. They constitute a reasonable compromise, and are currently being used by us. Many of our earlier calculations were done with the equivalent of DATATAPE 1. In some instances, the best agreement with experimental thick-target bremsstrahlung data is obtained with DATATAPE 0.[6/] The situation needs to be clarified by the introduction of better experimental and theoretical bremsstrahlung data. When information is sought about electron transport rather than thick-target bremsstrahlung, the differences between the results obtained with the three data tapes are generally very small.

The numerous programs needed to generate the data library will not be discussed here, and it will be assumed that the user has available to him one or more of the data tapes described above. If he should want to make up his own data library based on different improved cross sections, he can find out the required organization and format of the data to be stored on tape from the listing of the input statements of DATAPAC 4 in Appendix B.

4. Notes on Program DATAPAC 4

Using the input from the library tape, DATAPAC 4 evaluates the following quantities: (i) the mean energy loss per unit pathlength which an electron (or positron) suffers in collisions with atomic electrons (evaluated according to the Bethe stopping power theory as formulated by Rohrlich and Carlson[19/]); (ii) the mean radiative energy loss of an electron per unit pathlength (evaluated with the bremsstrahlung cross sections described in Section 3); (iii) the mean electron (or positron) range (calculated in the continuous-slowing-down approximation[18/]); (iv) the thick-target bremsstrahlung efficiency for an unbounded medium (calculated in the continuous-slowing-down approximation[18/]); (v) the cumulative (and if desired the differential) distribution of angular deflections resulting from multiple elastic scattering of electrons (or positrons) by atoms (according to the multiple scattering theory of Goudsmit and Saunderson,[20/] evaluated with the Mott[9/] single scattering cross section corrected for screening according to the prescription of Molière[21/]); (vi) cumulative probability distributions pertaining to the spectral and intrinsic angular distribution with which bremsstrahlung photons are emitted.

The input from the library tape is read on logical channel 9. In addition, at least three cards of BCD input are always required; one indicates the number of materials to be considered, the second is a title card, and the third lists essential parameters including options. Depending on the value of the parameter ITERM, different amounts of information are generated. For use with ETRAN 15, the maximum amount of information is required, and the option ITERM=5 must be used. Additional card input may be required in non-standard cases, i.e., when the density effect parameters for the desired material cannot be obtained from the library tape.

Runs of program DATAPAC 4 are generally short, on the order of 1-5 minutes per case. It is possible to cover a wide span of energies in one run, so that a tape can be used for a large number of different Monte Carlo runs with ETRAN 15. On the IBM 360/65, 75 and 91 (32 bit wordlength) the program has usually been run in double precision, with no overlay, requiring about 500,000 "bytes" of memory. On the Univac 1108 (36 bit wordlength) the program has been run in single precision, with overlay, requiring about 50,000 words of memory.

The following overlay arrangement is used:

(i) The main program, DATAPAC 4, and the subroutines QPOL and INT are always in the memory.

(ii) The following subroutines are called in as separate segments: RANGE, SCATT, BREX, BRANG and KXRAY. Other subroutines needed within a segment are pulled into the memory with the segment.

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APPENDIX A

Program Notes

Required Format for Card Input

Significance of the Card Input Variables

Significance of the Tape Input Variables

Meaning of the BLOCK DATA Variables and
Their Possible Modification

Brief Explanations of the Tasks Performed
by the Subroutines Contained in DATAPAC 4

```
C                    FORMAT FOR CARD INPUT FOR DATAPAC 4
C
C     NREC                                          I6
C     TAG                                           18A4
C     MSET,ITRM,IZIP,ISGN,ISUB,
C          INEL,ICYC,NCYC,NMAX,FMAX                 9I6,1PF16.5
C
C     THE FOLLOWING INPUT IS NOT STANDARD, BUT IS ONLY CALLED FOR ON
C     SPECIAL OPTION (SEE EXPLANATION OF CARD INPUT VARIABLES).
C
C     JMAX,LMAX                                     2I6
C
C     NEXT TWO CARDS TO BE REPEATED FOR EACH CONSTITUENT OF THE MEDIUM
C     IN ORDER OF INCREASING ATOMIC NUMBER
C
C     Z,A,                                          3F12.5
C     CUFP,HFC,HFS,PK                               4F12.5
C
C     NEXT THREE CARDS TO BE REPEATED LMAX TIMES
C
C     PI,PID                                        2F12.5
C     PS,C,B,DM,X1,X0                               6F12.5
C     PS,C,B,DM,X1,X0                               6F12.5
C
C     (NSUB(N),N=1,-ISUB)                           12I6
C
C     SCON                                          F12.5
C
C     CAY,APRAB,BPRAB                               3F12.5
C
C     LINMAX                                        I6
C     (TLIN(L),L=1,LINMAX)                          6F12.5
C
C     SEPARATE SET OF THE FOLLOWING ARRAY FOR EACH CONSTITUENT OF THE
C     MEDIUM IN ORDER OF INCREASING ATOMIC NUMBER.  EACH SET CONSISTS OF
C     LINMAX NUMBERS FOR EACH OF FIVE ANGLES, WITH A NEW ANGLE STARTING
C     A NEW CARD
C
C     RATLIN                                        6F12.5
```

```
C        MEANING OF CARD INPUT VARIABLES FOR PROGRAM DATAPAC 4
C
C   NREC        NUMBER OF SETS TO BE RUN
C   TAG         COMMENT
C   NSET        NUMBER OF SET
C   ITERM       DETERMINES THE AMOUNT OF INFORMATION TO BE GENERATED AND
C               PUT ON TAPE BY DATAPAC 4.  CHOICE DEPENDS ON THE REQUIRE_
C               MENTS OF THE MONTE CARLO PROGRAM IN WHCH THE DATA ARE
C               TO BE USED
C                 1  COMPUTES TABLES OF MEAN ENERGY LOSS, RANGE, INTRINSIC
C                    BREMSSTRAHLUNG EFFICIENCY AND RELATED QUANTITIES
C                 2  COMPUTES IN ADDITION MULTIPLE SCATTERING ANGULAR
C                    DISTRIBUTIONS
C                 3  COMPUTES IN ADDITION STOPPING POWER RATIOS (WITHOUT
C                    AND WITH BREMSSTRAHLUNG LOSS)
C                 4  COMPUTES IN ADDITION TABLES PERTAINING TO BREMS-
C                    STRAHLUNG PRODUCTION, AND THE LANDAU AND BLUNCK-
C                    LEISEGANG ENERGY LOSS DISTRIBUTIONS
C                 5  COMPUTES IN ADDITION TABLES PERTAINING TO THE
C                    PRODUCTION OF K-XRAYS, ANGULAR DISTRIBUTION OF PHOTO-
C                    ELECTRONS, AND ENERGY DISTRIBUTION OF PAIR ELECTRONS
C   IZIP        CODE NUMBER INDICATING THE MEDIUM FOR WHICH CROSS
C               SECTIONS AND MULTIPLE SCATTERING DISTRIBUTIONS ARE TO
C               BE PREPARED.  CODE NUMBERS IZIP LESS THAN 101 REPRESENT
C               THE ATOMIC NUMBER OF ELEMENTS.  CODE NUMBERS IZIP
C               GREATER THAN 100 REPRESENT COMPOUNDS OR
C               MIXTURES, THE CORRESPONDENCE BEING INDICATED ON AN
C               ACCOMPANYING TABLE.  THE VALUE IZIP=0 INDICATES THAT
C               THE MEDIUM IS A SPECIAL ONE FOR WHICH THE DENSITY EFFECT
C               PARAMETERS ARE NOT STORED ON THE TAPE WRITTEN
C               BY THE PROGRAM DATATAPE AND MUST BE READ IN ON CARDS AS
C               INPUT FOR DATAPAC 4
C   ISGN        ASSUMED FORM OF ELASTIC SCATTERING CROSS SECTION
C                 1  MOTT SCATTERING FOR ELECTRONS
C                 2  MOTT SCATTERING FOR POSITRONS
C                 3  RUTHERFORD SCATTERING FOR ELECTRONS
C                 4  RUTHERFORD SCATTERING FOR POSITRONS
C               IN ALL CASES, CORRECTIONS ARE MADE WHICH TAKE INTO ACCOUNT
C               SCREENING AND THE CONTRIBUTION OF INELASTIC SCATTERING
C   ISUB        PARAMETERS RELATING TO THE DIVISION OF THE ELECTRON PATH
C               INTO STEPS AND SUBSTEPS
C               ISUB EQUAL TO OR GREATER THAN 1.  INDICATES THAT SIZE OF
C                  SUBSTEPS = SIZE OF STEPS DIVIDED BY ISUB.  ISUB HAS THE
C                  SAME VALUE AT ALL ENERGIES AND IS LATER REFERRED TO AS
C                  NSUB IN THE PROGRAM
C               ISUB EQUAL TO OR LESS THAN -1.  INDICATES THAT THE FIRST
C                  -ISUB STEPS ARE EACH DIVIDED BY A DIFFERENT DIVISOR TO
C                  OBTAIN A SUBSTEP.  THESE DIVISORS (NSUB LIST) MUST BE
C                  READ IN.  IF -ISUB IS SMALLER THAN NMAX, THE REMAINING
C                  DIVISORS ARE EACH SET EQUAL TO THE LAST NSUB VALUE
C                  READ IN
C   INEL        PARAMETER INDICATING THE KIND OF SCREENING FUNCTION USED
C               IN THE ELASTIC SCATTERING CROSS SECTION
C                 1  SCREENING ANGLE AS GIVEN BY THE THEORY OF MOLIERE
C                 2  SCREENING ANGLE AS GIVEN BY THE THEORY OF NIGAM AND WU
C                 3  SCREENING ANGLE AS GIVEN BY THE FIRST TERM OF THE
C                    MOLIERE EXPRESSSION, BUT WITH THE FACTOR 1.13 REPLACED
```

```
C                 BY A FACTOR SCON THAT IS READ IN
C               WITH OPTIONS 2 AND 3 ADDITIONAL INPUT IS REQUIRED
C   ICYC        PARAMETER INDICATING THE NATURE OF THE LOGARITHMIC ENERGY
C               GRID USED IN THE CALCULATION
C               1  STRAIGHT LOGARITHMIC GRID SUCH THAT THAT SUCCESSIVE
C                  ENERGIES ARE REDUCED BY A CONSTANT FACTOR
C               2  GRID WHICH IS ALMOST LOGARITHMIC BUT IN WHICH CERTAIN
C                  SELECTED ENERGIES ALSO APPEAR.  SELECTED ENERGIES ARE
C                  100,50,20,AND 10 MEV AND ALL ENERGIES OBTAINED FROM
C                  THIS LIST THROUGH MULTIPLICATION BY POWERS OF TEN
C   NCYC        PARAMETER INDICATING FINENESS OF ENERGY GRID. THE NUMBER
C               OF GRID INTERVALS REQUIRED TO REDUCE THE ENERGY BY A
C               FACTOR OF TWO IS EQUAL TO NCYC
C   EMAX        TOP ENERGY OF ENERGY GRID
C
C          *** FOR IZIP=0, THE PARAMETERS JMAX, LMAX, Z, A, W, CUFP, HFC,
C               HFS, PK, PI, PID, PS, C, D, DM, X1 AND X0 MUST BE READ IN.
C               FOR THE MEANING OF THESE PARAMETERS SEE THE EXPLANATION
C               OF TAPE INPUT VARIABLES
C
C
C          *** FOR ISUB LESS THAN OR EQUAL TO -1, THE NSUB ARRAY MUST BE
C               READ IN
C   NSUB        STEP DIVISOR (SEE ISUB)
C
C
C          *** FOR INEL=2 OR 3, THE PARAMETER SCON MUST BE READ IN
C   SCON        FOR INEL=2, THE MULTIPLIER OF SCREENING PARAMETER CHI-ZERO
C               FOR INEL=3, THE MULTIPLIER OF SCREENING PARAMETER ETA
C
C          *** FOR INEL=3, THE PARAMETERS CAY, APRAB AND BPRAB MUST BE
C               READ IN
C   CAY         KESSLER PARAMETER TO CORRECT FOR DIFFRACTION EFFECTS
C   APRAB       COEFFICIENT OF LINEAR TERM IN PARABOLA CONNECTING KESSLER
C               AND MOTT CROSS SECTIONS
C   BPRAB       COEFFICIENT OF QUADRATIC TERM IN PARABOLA CONNECTING
C               KESSLER AND MOTT CROSS SECTIONS
C               SIGMA=(CAY**2+(1-CAY**2)*PHI)*SIGMA(MOTT)
C               PHI=0.5*APRAB*(1-COS(TH))+0.25*BPRAB*(1-COS(TH))**2
C
C
C          *** FOR ILIN=1 IN THE BLOCK DATA DATA STATEMENT, THE
C               PARAMETERS LINMAX, TLIN AND RATLIN MUST BE READ IN
C   LINMAX      NUMBER OF ENERGY BASE POINTS FOR LIN RATIOS
C   TLIN        ENERGY BASE POINTS (IN MEV, IN DESCENDING ORDER)
C   RATLIN      RATIOS OF SCREENED TO UNSCREENED ELASTIC SCATTERING CROSS
C               SECTION OBTAINED FROM PHASE SHIFT ANALYSIS. THE RATIOS ARE
C               SUPPLIED FOR ANGLES OF 0, 45, 90, 135 AND 180 DEGREES, IN
C               THAT ORDER
```

```
C                IN THE CALCULATION OF DENSITY EFFECT PARAMETERS
C   C            STERNHEIMER PARAMETER C
C   A            STERNHEIMER PARAMETER A
C   DM           STERNHEIMER PARAMETER M
C   X1           STERNHEIMER PARAMETER X1
C   X0           STERNHEIMER PARAMETER X0
C   COFF         RADIO CORRECTION FOR INELASTIC SCATTERING, USED IN THE
C                CALCULATION OF THE MULTIPLE SCATTERING DISTRIBUTION
C   HFC          RATIO OF PHOTON TO ELECTRON ENERGY ABOVE WHICH THE BREMS-
C                STRAHLUNG CROSS SECTION (DIFFERENTIAL IN ENERGY) IS
C                EXTRAPOLATED.  THE EXTRAPOLATION IS LINEAR, USING THE
C                VALUES AT HFC AND 2HFC-1.  THE EXTRAPOLATION IS USED ONLY
C                AT ELECTRON ENERGIES BELOW 1 MEV.
C   HFS          RATIO OF PHOTON TO ELECTRON ENERGY ABOVE WHICH THE BREMS-
C                STRAHLUNG CROSS SECTION (DIFFERENTIAL IN ENERGY) IS JOINED
C                TO THE HIGH-FREQUENCY LIMIT BY LINEAR INTERPOLATION.  THE
C                INTERPOLATION IS BASED ON THE VALUES AT HFS AND THE HIGH-
C                FREQUENCY LIMIT (PHOTON ENERGY = ELECTRON ENERGY)
C   PK           K-SHELL BINDING ENERGY (KEV)
C
C      SUBROUTINE RADGF
C   TR           ENERGY BASE POINTS (MEV) FOR PHI-RAD
C   R            PHI-RADS IN UNITS OF PHI-BAR.  THIS QUANTITY IS PROPORTIONAL
C                TO THE CROSS SECTION FOR THE ENERGY LOST BY AN ELECTRON TO
C                RADIATION AS DEFINED BY HEITLER
C
C      SUBROUTINE PREP
C   FR           ENERGY BASE POINTS (MEV) FOR THE MOTT/RUTHERFORD CROSS
C                SECTION RATIOS
C   R            MOTT/RUTHERFORD RATIOS AT ENERGIES FR AND FIVE ANGLES,
C                I.E. 45, 90, 135, AND 180 DEGREES
C   UX           COS(GAMMA) IN THE MOTT CROSS SECTION FORMULA FOR ELASTIC
C                SCATTERING OF ELECTRONS
C
C      SUBROUTINE BREM
C   TW           ENERGY BASE POINTS (MEV) FOR THE COULOMB CORRECTION
C                SWITCHING WEIGHTS
C   SWB          COULOMB CORRECTION SWITCHING WEIGHTS
C   TC           ENERGY BASE POINTS (MEV) FOR THE PHI-RAD CORRECTION FACTORS
C   COF          PHI-RAD CORRECTION FACTORS
C   THF          ENERGY BASE POINTS (MEV) FOR THE SCALED HIGH-FREQUENCY
C                LIMITS
C   HFL          SCALED HIGH-FREQUENCY LIMITS
C
C      MAIN ROUTINE
C   NLAN         NUMBER OF END-POINTS OF THE INTERVALS INTO WHICH THE SPACE
C                OF THE LANDAU VARIABLE IS DIVIDED (BETWEEN -4.0 AND 100.0).
C                EACH INTERVAL HAS AN EQUAL PROBABILITY WEIGHT (WE HAVE
C                USED NLAN=501)
C   NGUS         NUMBER OF END-POINTS OF THE INTERVALS INTO WHICH THE SPACE
C                OF A GAUSSIAN VARIABLE WITH UNIT VARIANCE IS DIVIDED
C                (BETWEEN -4.0 AND 4.0). EACH INTERVAL HAS AN EQUAL PROB-
C                ABILITY WEIGHT (WE HAVE USED NGUS=101)
C   GAUSS        GAUSSIAN VARIABLE VALUES FOR INTERVAL END-POINTS
C   TL           LANDAU VARIABLE VALUES FOR INTERVAL END-POINTS
C   INSET        SET NUMBER IDENTIFYING PHOTO-ELECTRON ANGULAR DISTRIBUTION
C                TABULATION
C   NPEL         NUMBER OF ANGLES AT WHICH THE CUMULATIVE ANGULAR DISTRI-
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C                 BUTTON OF PHOTO-ELECTRONS IS TABULATED
C   NEEL          NUMBER OF PHOTON ENERGIES AT WHICH THE CUMULATIVE ANGULAR
C                 DISTRIBUTION OF PHOTO_ELECTRONS IS TABULATED
C   PEL           SET OF EQUALLY SPACED POINTS BETWEEN 0 AND 1, NPEL IN
                  NUMBER
C   EEL           PHOTON ENERGIES (MEV) AT WHICH THE ANGULAR DISTRIBUTION OF
C                 PHOTO_ELECTRONS IS GIVEN
C   CEL           REDUCED ANGLES CORRESPONDING TO CUMULATIVE PROBABILITIES
C                 PEL
C   INSET         SET NUMBER IDENTIFYING PAIR ELECTRON ENERGY DISTRIBUTION
C                 TABULATION
C   NPPS          NUMBER OF ENERGIES AT WHICH THE CUMULATIVE ENERGY DISTRI_
C                 BUTION OF PAIR ELECTRONS IS TABULATED.  DISTRIBUTION
C                 PERTAINS TO THE MEMBER OF THE ELECTRON-POSITRON PAIR WITH
C                 THE SMALLER ENERGY
C   NEPS          NUMBER OF PHOTON ENERGIES AT WHICH THE CUMULATIVE PAIR
C                 PRODUCTION CROSS SECTION IS TABULATED
C   PEL           SET OF EQUALLY SPACED POINTS BETWEEN 0. AND 1, NPPS IN
C                 NUMBER
C   EEL           PHOTON ENERGIES (MEV) AT WHICH THE ENERGY DISTRIBUTION OF
C                 PAIR ELECTRONS IS GIVEN
C   CEL           RATIOS OF PAIR ELECTRON ENERGY TO PHOTON ENERGY
C                 CORRESPONDING TO CUMULATIVE PROBABILITIES PEL
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C        MEANING OF BLOCK DATA VARIABLES FOR PROGRAM DATAPAC 4
C
C     CERTAIN PARAMETERS ARE NORMALLY LEFT ALONE BUT CAN BE MODIFIED
C     BY CHANGING PERTINENT DATA STATEMENTS IN THE PROGRAM.  THESE
C     PARAMETERS ARE LISTED BELOW AND THEIR NORMAL VALUES ARE INDICATED
C     BY THE LETTER N.
C
C     BLOCK DATA
C  LMAX        240 N
C              NUMBER OF TERMS INCLUDED IN LEGENDRE EXPANSION OF
C              GOUDSMIT-SAUNDERSON MULTIPLE SCATTERING DISTRIBUTION
C  LIST        280 N
C              STARTING POINT OF BACKWARD RECURSION IN THE EVALUATION
C              OF THE ASSOCATED LEGENDRE FUNCTIONS NEEDED FOR THE
C              COMPUTATION OF THE GOUDSMIT-SAUNDERSON SERIES
C  IAV         1    AVERAGE COSINE OF MULTIPLE SCATTERING DEFLECTION PER
C                   GRID INTERVAL NOT STORED ON OUTPUT TAPE
C              2N   THE ABOVE STORED ON OUTPUT TAPE
C  MMAX        35 N
C              NUMBER OF ANGLES AT WHICH THE MULTIPLE SCATTERING
C              ANGULAR DISTRIBUTION IS TABULATED
C  IDST        1N   NO DIFFERENTIAL MULTIPLE SCATTERING ANGULAR
C                   DISTRIBUTION GENERATED
C              2    DIFFERENTIAL ANGULAR DISTRIBUTION GENERATED AND PUT
C                   ON TAPE
C              3    IN ADDITION TO ABOVE, DIFFERENTIAL ANGULAR
C                   DISTRIBUTION FOR CUMULATED PATHLENGTH ALSO GENERATED
C                   AND PRINTED
C  ILAN        1N   MULTIPLE SCATTERING DISTRIBUTION EVALUATED AT MEAN
C                   ENERGY FOR STEP
C              2    MULTIPLE SCATTERING DISTRIBUTION EVALUATED AT AN
C                   ENERGY CORRESPONDING TO A VALUE OF THE LANDAU
C                   DISTRIBUTION PARAMETER LAMBDA = TLAN
C  ANG         LIST OF ANGLES AT WHICH DISTRIBUTION OF MULTIPLE
C              SCATTERING DEFLECTIONS IS TABULATED.  NORMAL LIST INCLUDES
C              THE FOLLOWING ANGLES (IN DEGREES) -
C              1(1)5,12(3)30,35(5)50,60(10)180
C  ETC         10**(-4) N
C              WHEN THE SCREENING PARAMETER ETA IS SMALLER THAN ETC,
C              FORWARD RECURSION IS USED TO CALCULATE THE ASSOCIATED
C              LEGENDRE FUNCTIONS NEEDED FOR THE EVALUATION OF THE
C              GOUDSMIT-SAUNDERSON DISTRIBUTION.  IF ETA IS GREATER THAN
C              ETC, BACKWARD RECURSION IS USED
C  HCOMP       10**(-6) N
C              WHEN TERMS IN GOUDSMIT-SAUNDERSON LEGENDRE SERIES HAVE
C              BECOME SMALLER THAN HCOMP, SERIES IS ASSUMED TO HAVE
C              CONVERGED AND NO FURTHER TERMS ARE ADDED
C  ILIN        1    SCREENING CORRECTION FROM LIN PHASE-SHIFT CALCULATION
C                   USED IN ELASTIC SCATTERING CROSS SECTION
C              2N   LIN CORRECTION NOT USED
C  TLAN        0.0 N
C              FOR ILAN=2, THE VALUE OF LANDAU LAMDA THAT DETERMINES
C              ENERGY IN STEP AT WHICH THE MULTIPLE SCATTERING DISTT-
C              BUTION IS EVALUATED.  FOR THE MOST PROBABLE ENERGY LOSS,
C              TLAN=-0.225
C
C     SUBROUTINE RANGE
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C   IDENS        1N  DENSITY EFFECT CORRECTION INCLUDED IN STOPPING POWER
C                2   DENSITY EFFECT NOT INCLUDED
C   AEL          0.0 N
C   BEL          1.0 N
C                THE PROGRAM GUARANTEES THAT THE ENERGY LOSS IN A SINGLE
C                COLLISION WITH AN ATOMIC ELECTRON CANNOT EXCEED THE VALUE
C                AEL+BEL*(INITIAL ENERGY). THE ADDITIONAL REQUIREMENT IS
C                IMPOSED THAT THE ENERGY LOSS IN A SINGLE COLLISION CAN
C                NEVER EXCEED EITHER ONE-HALF THE INITIAL ENERGY FOR
C                ELECTRONS OR THE INITIAL ENERGY FOR POSITRONS
C   KMAX         10 N
C                NUMBER OF INTEGRATION POINTS IN THE CALCULATION OF THE
C                PATHLENGTH DRG BETWEEN TWO ADJACENT GRID POINTS (IN THE
C                CONTINUOUS-SLOWING-DOWN APPROXIMATION)
C   HCUT         0.0 N
C                ELECTRON ENERGY BELOW WHICH THE RADIATIVE ENERGY LOSS IS
C                NOT INCLUDED IN THE COMPUTATION OF THE MEAN ENERGY LOSS
C
C      SUBROUTINE SCAT1
C   IPRT         1N  COMPLETE PRINT-OUT OF MULTIPLE SCATTERING DATA
C                2   ONLY CUMULATIVE MULTIPLE SCATTERING DISTRIBUTION
C                    INCLUDED IN PRINT-OUT
C
C      SUBROUTINE SING
C   WFAC         1.0 N
C                WFAC IS A MULTIPLIER FOR THE ELASTIC SCATTERING CROSS
C                SECTION
C
C      SUBROUTINE BREM
C   KMAX         48 N
C                NUMBER OF K/T RATIOS AT WHICH BREMSSTRAHLUNG TABLE IS
C                PREPARED
C   R            NORMAL VALUES AS GIVEN IN PROGRAM LISTING
C                LIST OF K/T VALUES FOR BREMSSTRAHLUNG TABULATION, IN
C                ASCENDING ORDER
C   ALPHA        0.001 N
C                LOWEST K/T RATIO IN LIST (CUT-OFF VALUE)
C   NPTS         11 N
C                NUMBER OF INTEGRATION POINTS USED IN EVALUATION OF BREM
C   IPRT         1   DIFFERENTIAL BREMSSTRAHLUNG CROSS SECTIONS PRINTED OUT
C                2N  THE ABOVE NOT PRINTED OUT
C
C      SUBROUTINE BRANG
C   KMAX         25 N
C                NUMBER OF K/T RATIOS AT WHICH BREMSSTRAHLUNG CROSS SECTION
C                IS PRINTED OUT
C   R            NORMAL VALUES AS GIVEN IN PROGRAM LISTING
C                LIST OF K/T RATIOS, IN DESCENDING ORDER
C   NPTS         21 N
C                NUMBER OF POINTS AT WHICH CUMULATIVE ANGULAR DISTRIBUTION
C                OF INTRINSIC BREMSSTRAHLUNG EMISSION IS CALCULATED
C   NANG         21 N
C                NUMBER OF INTEGRATION POINTS USED IN CROSS SECTION
C                OF INTRINSIC ANGULAR DISTRIBUTION
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C   BRIEF DESCRIPTION OF SUBROUTINES USED IN PROGRAM DATAPAC 4
C
C   BLOCK DATA
C   SUPPLIES DATA FOR COMMON STORAGE SHARED BY PROGRAMS SCATT, PREP,
C   SING, MULT, AND INELS
C
C   SUBROUTINE RANGE
C   CALCULATES MEAN ENERGY LOSS OF ELECTRONS (OR POSITRONS) BY COLLISIONS
C   WITH ATOMIC ELECTRONS AND BY BREMSSTRAHLUNG. CALCULATES MEAN RANGE
C   IN CONTINUOUS-SLOWING-DOWN APPROXIMATION, INTRINSIC BREMSSTRAHLUNG
C   EFFICIENCY, AND OTHER RELATED QUANTITIES.
C
C   SUBROUTINE ELIST
C   GENERATES ELECTRON ENERGY GRID AT WHICH VARIOUS QUANTITIES OF
C   INTEREST ARE COMPUTED. GRID EXTENDS AT LEAST DOWN TO 1 KEV.
C   RESULTS FOR GRID INDEX I GREATER THAN NMAX ARE PRINTED OUT BUT NOT PUT ON
C   TAPE OR USED IN SUBSEQUENT CALCULATIONS IN DATAPAC 4.
C
C   SUBROUTINE DENSR
C   CALCULATES THE DENSITY EFFECT CORRECTION IN THE STOPPING POWER
C   FORMULA.  USES INPUT PARAMETERS AS PROVIDED BY CALCULATIONS OF
C   STERNHEIMER (FOR DETAILS, SEE WRITEUP OF PROGRAM DATATAPE)
C
C   SUBROUTINE PREP
C   READS DATA INTO MEMORY FROM MAGNETIC TAPE WRITTEN BY PROGRAM
C   DATATAPE. PREPARES DATA FOR LATER USE BY SUBROUTINES SCATT, SING,
C   MULT AND INELS.
C
C   SUBROUTINE SING
C   CALCULATES, FOR AN ELECTRON OF GIVEN ENERGY AND RESIDUAL RANGE,
C   THE SCATTERING PARAMETERS S(L) NEEDED TO EVALUATE THE GOUDSMIT-
C   SAUNDERSON MULTIPLE SCATTERING DISTRIBUTION. THE CALCULATION IS BASED
C   ON THE USE ON A CROSS SECTION FOR ELASTIC SCATTERING BY ATOMS THAT
C   COMBINES THE MOTT CROSS SECTION WITH A CORRECTION FACTOR THAT TAKES
C   INTO ACCOUNT THE SCREENING OF THE NUCLEAR CHARGE BY ATOMIC ELECTRONS.
C   THE CONTRIBUTION OF INELASTIC SCATTERING BY ATOMIC ELECTRONS IS TAKEN
C   INTO ACCOUNT THROUGH REPLACING THE FACTOR Z**2 IN THE CROSS SECTION
C   BY Z(Z+1), WHERE Z IS THE ATOMIC NUMBER. A FURTHER CORRECTION,
C   APPLICABLE AT LARGE ANGLES, IS MADE IN SUBROUTINE INELS.
C
C   SUBROUTINE MULT
C   CALCULATES THE MULTIPLE SCATTERING ANGULAR DISTRIBUTION FOR ELECTRONS
C   OR POSITRONS THAT HAVE TRAVELED A GIVEN PATHLENGTH.  THE CALCULATION
C   IS BASED ON THE EVALUATION OF THE GOUDSMIT-SAUNDERSON LEGENDRE
C   SERIES, AND MAKES USE OF THE CONTINUOUS-SLOWING-DOWN APPROXIMATION.
C   THE CUMULATIVE ANGULAR PROBABILITY DISTRIBUTION IS CALCULATED , AND
C   ON OPTION, THE DIFFERENTIAL ANGULAR DISTRIBUTION.
C
C   SUBROUTINE INELS
C   CORRECTS THE MULTIPLE ANGULAR DISTRIBUTION WITH RESPECT TO THE
C   CONTRIBUTION DUE TO INELASTIC SCATTERING BY ATOMIC ELECTRONS.
C   THE PROGRAM REPLACES THE FACTOR Z(Z+1) BY Z(Z+ETA), WHERE ETA=1 FOR
C   ANGLES SMALLER THAN A CUT-OFF VALUE, AND WHERE ETA=0 OTHERWISE.  THE
C   CUT-OFF ANGLE IS CHOSEN TO BE EQUAL TO THE MAXIMUM DEFLECTION WHICH
C   AN ELECTRON (OR POSITRON) COULD HAVE WHEN IT IS SCATTERED
C   INELASTICALLY BY A FREE ELECTRON, AND IS DETERMINED WITH THE USE
C   OF THE MOLLER CROSS SECTION FOR ELECTRON-ELECTRON SCATTERING OR THE
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C   PHABHA CROSS SECTION FOR POSITRON-ELECTRON SCATTERING. FOR ELECTRON-
C   ELECTRON SCATTERING THE CUT-OFF DEFLECTION IS TAKEN TO BE THAT
C   CORRESPONDING TO A LOSS OF ONE-HALF THE INITIAL ELECTRON ENERGY.
C
C   SUBROUTINE BREM
C   CALCULATES THE EXPECTED NUMBER OF BREMSSTRAHLUNG EVENTS PER UNIT
C   PATHLENGTH OF AN ELECTRON  ALSO CALCULATES THE CUMULATIVE PROBABILITY
C   DISTRIBUTION OF THE BREMSSTRAHLUNG PHOTON ENERGIES (K/T RATIOS)
C   CALCULATION IS BASED ON BREMSSTRAHLUNG CROSS SECTIONS IN SUBROUTINES
C   BREX6 AND XSEC.
C
C   SUBROUTINE BREX6
C   CALCULATES THE BREMSSTRAHLUNG CROSS SECTION (DIFFERENTIAL IN PHOTON
C   ENERGY BUT INTEGRATED OVER THE EMISSION ANGLE) USING A COMBINATION
C   OF VARIOUS ANALYTICAL FORMULAS AND AN EMPIRICAL CORRECTION
C   FACTOR THAT DEPENDS ON THE ELECTRON ENERGY.  THE ANALYTICAL CROSS
C   SECTIONS ARE VARIOUS VERSIONS AND ELABORATIONS OF THE BETHE-HEITLER
C   THEORY, AND THEIR EVALUATION IS CARRIED OUT IN SUBROUTINE XSEC. THE
C   EMPIRICAL CORRECTION FACTOR IS SUPPLIED BY THE TAPE
C   PREPARED BY PROGRAM DATATAPE.
C
C   SUBROUTINE XSEC
C   CALCULATES THE BREMSSTRAHLUNG CROSS SECTIONS (DIFFERENTIAL IN PHOTON
C   ENERGY BUT INTEGRATED OVER EMISSION ANGLE) DENOTED AS 3BN, 3BS, 3CS,
C   AND 3BN(B) IN THE NOMENCLATURE OF THE REVIEW ARTICLE BY KOCH AND
C   MOTZ.  ALSO CALCULATES THE ELWERT CORRECTION FACTOR.
C
C   SUBROUTINE BRANG
C   CALCULATES CUMULATIVE PROBABILITY DISTRIBUTION FOR THE INTRINSIC
C   BREMSSTRAHLUNG PHOTON EMISSION ANGLE (WITH RESPECT TO THE DIRECTION
C   OF THE ELECTRON).  MAKES USE OF CROSS SECTION CALCULATIONS IN
C   SUBROUTINES BRAX1 AND SCREEN.
C
C   SUBROUTINE BRAX1
C   CALCULATES BREMSSTRAHLUNG CROSS SECTION DIFFERENTIAL IN PHOTON ENERGY
C   AND ANGLE, USING FORMULAS DESIGNATED AS 2BN AND 2CS IN NOMENCLATURE
C   OF KOCH AND MOTZ.
C
C   SUBROUTINE SCREEN
C   CALCULATES SCREENING TERM IN BREMSSTRAHLUNG FORMULA 2CS AS GIVEN BY
C   OLSEN AND MAXIMON.
C
C   SUBROUTINE KXRAY
C   CALCULATES THE MEAN NUMBER OF K-IONIZATION EVENTS PER UNIT PATHLENGTH
C   OF AN ELECTRON, ACCORDING TO THE THEORY OF ARTHURS AND MOTSEWITCH.
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APPENDIX B

Listing of DATAPAC 4

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      BLOCK DATA, [illegible] 87.
      BLOCK DATA
      COMMON  /SCR /  APRAB,BPRAB,CAY,RATLIN(50,5,20),SCOR,TLIN(50),
     1   ANG(50),ETC,nCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,NMAX,
     2   LINMAX,ILIN
      DATA  LMIX,LIST/240,280/,NMAX/33/,IAVE/2/,IDST/1/,ILAN/1/,ILIN/2/,
     1            (ANG(N),N=1,33)/1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,
     2   12.0,15.0,18.0,21.0,24.0,27.0,30.0,35.0,40.0,45.0,50.0,60.0,
     3   70.0,80.0,90.0,100.0,110.0,120.0,130.0,140.0,150.0,160.0,170.0,
     4   180.0/,ETC/1.0E-04/,nCOMP/1.0E-06/,TLAN/0.0/,
     5   ASCL,BSCL/0.0,0.0/
      END
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      DATAPAC=4, 1) FOR 68.
      DIMENSION  CEL(50,25),EEL(25),PEL(50),
     1   GROSS(101),IL(501),TRASH(6,20),TIG(18)
      COMMON  /MAIL/A(20),B(20,2),C(20,2),CUFP(20),DR(2),2),DRG(501),
     1   E(501),EDEOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PIG(20),PR(20),PS(20,2),RG(501),RGMAX,T(501),TAG(18),X0(20,2),
     3   X1(20,2),X(20),Z(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),JMAX,
     4   GSUB,LMAX,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NDEL,NNOT,NRAD,NSW1
      COMMON  /RAN/  DELTY(501)
      COMMON  /SCR/  APRAD,BPRAD,CAY,RATLIN(50,5,20),SCON,TLIN(50),
     1   AND(50),ZIC,NCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,MMAX,
     2   LIMMAX,ILIN
      DATA  IEND/131/
      REWIND 11
      READ   (5,100) NREC
      WRITE  (6,100) NREC
  100 FORMAT (50H0 NUMBER OF DATAPAC SETS TO BE RUN =I3)
      WRITE  (1,100) NREC
      DO 300 NRUN=1,NREC
      WRITE  (6,110)
  110 FORMAT (1H1)
      READ   (5,120) (TAG(I),I=1,18)
      WRITE  (6,120) (TAG(I),I=1,18)
      WRITE  (11,120) (TAG(I),I=1,18)
  120 FORMAT (18A4)
      WRITE  (6,130)
  130 FORMAT (6H0 NSET  IFAN  IZIP  ISGN  ISUB  IDEL  IOUT  NDEL  NRAD
     1        NNOT)
      READ   (5,140) NSET,IFAN,IZIP,ISGN,ISUB,IDEL,IOUT,NDEL,NRAD,
      WRITE  (6,140) NSET,IFAN,IZIP,ISGN,ISUB,IDEL,IOUT,NDEL,NRAD,
  140 FORMAT (9I10,I10,I10,I10)
      REWIND 9
      WRITE  (6,150)
 1500 FORMAT (43H0INPUT OF DATA FOR IDENTIFICATION)
      READ (9,160) (TAG(I),I=1,18)
      WRITE (6,160) (TAG(I),I=1,18)
      READ   (5,170)  NAME,NAME,NAME,NAME,NAME,NAME,NAME,NAME,NAME,NAME,
     1   NAME
      IF (IZIP.GT.0) GO TO 185
      READ   (5,175) GRAMMAX
      DO 177 O=1,20
      READ   (5,176) Z(O),PI(O)
      READ   (5,176) HFC(O),HFS(O),PIG(O)
  185 FORMAT (6F12.6)
  177 CONTINUE
      DO 188 L=1,NSET
      READ   (5,186) NSUB(L),IL(L)
      READ   (5,186) (B(L,M),C(L,M),B(L,M),A(L,M),X0(L,M),
     1   M=1,2)
  188 CONTINUE
      NSUB=1
      DO 190 I=1,20
      READ   (5,192) (A(I),B(I),C(I),X0(I),X1(I),PR(I),PS(I),
      READ   (5,192) (A(I),B(I),C(I),X0(I),X1(I),PR(I),PS(I),
     1   (B(I,M),C(I,M),B(I,M),X1(I,M),X0(I,M),PS(I,M),M=1,2),
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     2    L=1,LMAX),(COFP(J),HFC(J),HFS(J),PK(J),J=1,JMAX)
 190 FORMAT (10F12.5)
 200 CONTINUE
     IF (Z(1).GT.0.0) GO TO 220
     WRITE  (6,210) NSET
 210 FORMAT (74H0PROPERTIES OF MATERIAL SPECIFIED ARE UNKNOWN, DATAPAC
    1CANNOT COMPLETE SET I4)
     STOP
 220 IBEG=IZIP+1
     IF (IBEG.GT.IEND) GO TO 235
 225 DO 230 I=IBEG,IEND
     READ     (9,190) NZIPT,JMAXT,LMAXT
     READ     (9,190) ((TRASH(M,J),M=1,3),J=1,JMAXT),
    1    ((TRASH(M,L),M=1,2),L=1,LMAXT),((TRASH(M,L),TRASH(M,L),M=1,6),
    2    L=1,LMAXT),((TRASH(M,J),M=1,4),J=1,JMAXT)
 230 CONTINUE
 235 IF (ISUB.GT.0) GO TO 170
     ISUB=2
     NSMAX=-ISUB
     WRITE  (6,150)
 150 FORMAT (14HOVARIABLE NSUB)
     READ     (5,160) (NSUB(N),N=1,NSMAX)
     WRITE  (6,160) (NSUB(N),N=1,NSMAX)
 160 FORMAT (12I6)
     IF (NSMAX.GE.NMAX) GO TO 165
     NSMAX=NMAX+1
     DO 180 N=NSMAX,NMAX
 180 NSUB(N)=NSUB(NSMAX)
     GO TO 185
 170 ISUB=1
     DO 190 N=1,NMAX
 190 NSUB(N)=ISUB
 185 IF (IVOL.EQ.1) GO TO 144
     WRITE  (6,141)
 141 FORMAT (20H0 MULTIPLE SCATTERING AUXILIARY DATA)
     WRITE  (6,142)
 142 FORMAT (20H0SCATTERING ANGLE CONSTANT)
     READ     (5,150) ISCAT
     WRITE  (6,150) ISCAT
     IF (ISCAT.GE.0) GO TO 144
     WRITE  (6,14)
  14 FORMAT (20H0 SCATTERING CURVE PARAMETERS - A,A,B)
     READ     (5,150) CATA,AMAB,BMAB
     WRITE  (6,150) CATA,AMAB,BMAB
     DO 15 (I=1,NMAX),IZIP
1440 WRITE  (6,15)
  15 FORMAT (20H0SCATTERING RATIOS)
     READ     (5,150) WRATIO
     WRITE  (6,150) WRATIO
     WRITE  (6,150)
  16 FORMAT (20H0 [illegible] (L,J))
     READ     (5,150) ((L,J),L=1,LMAX)
     WRITE  (6,150) ((L,J),L=1,LMAX)
     DO [illegible]
     READ     [illegible]
     WRITE  [illegible]
  17 FORMAT [illegible]
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      DO 19 K=1,5
      READ  (5,100) (RATLIN(L,K,J),L=1,LINMAX)
      WRITE (6,100) (RATLIN(L,K,J),L=1,LINMAX)
   19 CONTINUE
  144 CALL RANGE
      WRITE  (11,241) NSET,ITRM,IZIF,ISGN,ISUB,INEL,ICYC,NCYC,NMAX,
     1   LMAX,T(NMAX1),RGMAX,JMAX
  241 FORMAT (9I6,1P3E15.7,I6)
      WRITE (11,245) (Z(J),A(J),W(J),J=1,JMAX)
      GO TO (242,246,246,246,246),ITRM
  242 WRITE  (11,244) NSET
  244 FORMAT (36H RANGE TABLE RESULTS FOR DATAPAC SETI4,32H
     1                    )
      WRITE  (11,245) (T(N),N=1,NMAX1),(EBLOS(N),N=1,NMAX1),
     1   (DEDX(N),N=1,NMAX1),(RG(N),N=1,NMAX1)
  245 FORMAT (1P6E15.7)
      GO TO 300
  246 CALL SCATT
      GO TO (500,500,260,260,260),ITRM
  260 WRITE  (11,270) NSET
  270 FORMAT (47H COLLISION / TOTAL DE/DX RATIOS FOR DATAPAC SETI4,21H
     1                    )
      WRITE  (11,245) (T(N),N=1,NMAX),(ERAT(N),N=1,NMAX)
      GO TO (500,500,500,275,275),ITRM
  275 CALL BREM
      CALL BRANG
      WRITE  (11,290)
  290 FORMAT (72H LANGAUSS - EQUIPROBABLE ENDPOINTS FOR INTERPOLATION
     1                    )
      READ    (9,100) NLAN,NGUS
      NLAN1=NLAN-1
      NGUS1=NGUS-1
      WRITE  (11,100) NLAN1,NGUS1
      READ    (9,245) (TL(N),N=1,NLAN),(GAUSS(N),N=1,NGUS)
      WRITE  (11,245) (TL(N),N=1,NLAN),(GAUSS(N),N=1,NGUS)
      GO TO (500,500,500,500,310),ITRM
  310 CALL XRAY
      WRITE  (11,320)
  320 FORMAT (72H PHOTOELECTRON ANGULAR DISTRIBUTIONS
     1                    )
      READ    (9,100) INSET,NPEL,NEEL
      WRITE  (11,100) INSET,NPEL,NEEL
      READ    (9,245) (PEL(N),N=1,NPEL),(EEL(N),N=1,NEEL),
     1   ((CEL(N,NE),N=1,NPEL),NE=1,NEEL)
      WRITE  (11,245) (PEL(N),N=1,NPEL),(EEL(N),N=1,NEEL),
     1   ((CEL(N,NE),N=1,NPEL),NE=1,NEEL)
      WRITE  (11,340)
  340 FORMAT (72H PAIR ELECTRON ENERGY DIVISION DISTRIBUTION (LEAD)
     1                    )
      READ    (9,100) INSET,NPPS,NEPS
      WRITE  (11,100) INSET,NPPS,NEPS
      READ    (9,245) (PEL(N),N=1,NPPS),(EEL(N),N=1,NEPS),
     1   ((CEL(N,NE),N=1,NPPS),NE=1,NEPS)
      WRITE  (11,245) (PEL(N),N=1,NPPS),(EEL(N),N=1,NEPS),
     1   ((CEL(N,NE),N=1,NPPS),NE=1,NEPS)
  500 CONTINUE
      END FILE 11
      STOP
      END
```

```
C     SUBROUTINE QUOL(S,X,Y,N,T)
      SUBROUTINE QUOL(S,X,Y,N,T)
      DIMENSION X(501),Y(501)
      IF(X(1)-X(N))10,10,95
   10 IF(S-X(2))20,15,30
   15 T=Y(2)
      RETURN
   20 I=1
      J=2
      K=3
      GO TO 100
   30 N1=N-1
      N2=N-2
      IF(S-X(N1))35,35,40
   35 T=Y(N1)
      RETURN
   40 I=N2
      J=N1
      K=N
      GO TO 100
   50 DO 60 MS=3,N1
      IF(S-X(MS))70,190,60
   60 CONTINUE
   70 IF(S-0.5*(X(MS-2)+X(MS+1)))90,90,80
   80 I=MS-1
      J=MS
      K=MS+1
      GO TO 100
   90 I=MS-2
      J=MS-1
      K=MS
      GO TO 100
   95 IF(S-X(2))110,97,100
   97 T=Y(2)
      RETURN
  100 I=1
      J=2
      K=3
      GO TO 100
  110 N1=N-1
      N2=N-2
      IF(S-X(N1))120,115,130
  115 T=Y(N1)
      RETURN
  120 I=N2
      J=N1
      K=N
      GO TO 100
  130 DO 140 MS=3,N1
      IF(S-X(MS))140,190,150
  140 CONTINUE
  150 IF(S-0.5*(X(MS-2)+X(MS+1)))160,160,170
  160 I=MS-1
      J=MS
      K=MS+1
      GO TO 100
  170 I=MS-2
```

```
      J=MS-1
      K=MS
160   F=(S-X(J))*(S-X(K))*Y(I)/(X(I)-X(J))/(X(I)-X(K))+
     1  (S-X(I))*(S-X(K))*Y(J)/(X(I)-X(J))/(X(K)-X(J))+
     2  (S-X(I))*(S-X(J))*Y(K)/(X(K)-X(I))/(X(K)-X(J))
      RETURN
190   F=Y(MS)
      RETURN
      END
```

```
C       SUBROUTINE INT(DELTA,G,N,RESULT), (N=1).
        SUBROUTINE INT(DELTA,G,N,RESULT)
        DIMENSION G(501)
        NL1=N-1
        NL2=N-2
        IF (FLOAT (N) -2.0*FLOAT (N/2)) 100,100,10
   10   IF (N-1) 15,15,20
   15 SIGMA=0.0
        GO TO 70
   20 IF(N-3) 30,30,40
   30 SIGMA=G(1)+4.0*G(2)+G(3)
        GO TO 70
   40 SUM4=0.0
        DO 50 K=2,NL1,2
   50 SUM4=SUM4+G(K)
        SUM2=0.0
        DO 60 K=3,NL2,2
   60 SUM2=SUM2+G(K)
        SIGMA=G(1)+4.0*SUM4+2.0*SUM2+G(N)
   70 RESULT=DELTA*SIGMA
        RETURN
  100 IF(N-2)110,110,120
  110 SIGMA=1.5*(G(1)+G(2))
        GO TO 70
  120 IF(N-4)130,130,140
  130 SIGMA=1.125*(G(1)+3.0*G(2)+3.0*G(3)+G(4))
        GO TO 70
  140 IF(N-6)150,150,160
  150 SIGMA=G(1)+3.875*G(2)+2.625*G(3)+2.625*G(4)+3.875*G(5)+G(6)
        GO TO 70
  160 IF (N-8)170,170,180
  170 SIGMA=G(1)+3.875*G(2)+2.625*G(3)+2.625*G(4)+3.875*G(5)+2.0*G(6)
     1+4.0*G(7)+G(8)
        GO TO 70
  180 SIGMA=G(1)+3.875*G(2)+2.625*G(3)+2.625*G(4)+3.875*G(5)+G(6)
        SUM4=0.0
        DO 190 K=7,NL1,2
  190 SUM4=SUM4+G(K)
        SUM2=0.0
        DO 200 K=8,NL2,2
  200 SUM2=SUM2+G(K)
        SIGMA=SIGMA+G(6)+4.0*SUM4+2.0*SUM2+G(N)
        GO TO 70
        END
```

```
      SUBROUTINE RANGE, 30 OCT 67.
      SUBROUTINE RANGE
      DIMENSION   BETASQ(501),BL(100),BLOS(501),BSQ(100),D(100),
     1   DENCOR(501),            DS(2),DSUB(20),            EL(100),
     2   ELOS(501),FE(501),FEACC(501),GEBL(100),GREBL(100),
     3   R(50,20),RATEB(501),ST(100),TR(50),TRASH(50),WAZ(20),YE(501),
     4   PSL(20,2),DPSL(20),PIDL(20)
      COMMON  /MANE/A(20),B(20,2),C(20,2),CUFP(20),DM(20,2),DREB(501),
     1   E(501),EBLOS(501),EMAX, RAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PK(20),PS(20,2),REB(501),RGMAX,T(501),TAG(13),X0(20,2),
     3   X1(20,2),W(20),Z(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),JMAX,
     4   JSUB,LMAX,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,NMOT,NRAD,NSWT
      COMMON  /RAN/  DENNY(501)
      DATA  IDENSI/1/,AEL,BEL/0.0,1.0/,KMAX/10/,BCUT/0.0/
      WRITE  (6,70)
   70 FORMAT (1H0)
      WRITE  (6,80)
   80 FORMAT (12H0RANGE TABLE)
      NMAX1=NMAX+1
      IF (NMAX1.LE.257) GO TO 95
      WRITE (6,85)
   85 FORMAT (28H0ENERGY LIST EXCEEDS STORAGE)
      STOP
   95 CALL ELIST (ECAL)
      WRITE  (6,110)
  110 FORMAT (12H0 JMAX  LMAX)
      WRITE  (6,120) JMAX,LMAX
  120 FORMAT (1216)
      WRITE (6,160)
  160 FORMAT (33H0        Z            A              W)
      WRITE (6,170)
     1            (Z(J),A(J),W(J),J=1,JMAX)
  170 FORMAT (3F12.5)
      WRITE (6,180)
  180 FORMAT (21H0        PI           PID)
      WRITE (6,190)
     1            (PI(L),PID(L),L=1,LMAX)
  190 FORMAT (2F12.5)
      WRITE (6,200)
  200 FORMAT (72H0  --------------------PARAMETERS FOR DENSITY EFFECT---
     1-----------------)
      WRITE (6,210)
  210 FORMAT (69H        PI            C             B             DM
     1X1            X0)
      DO 220 L=1,LMAX
      WRITE  (6,211)
  211 FORMAT (1H )
      IF (PID(L)) 212,212,215
  212 PID(L)=PI(L)
  215 WRITE (6,216)
     1            (PS(L,I),C(L,I),B(L,I),DM(L,I),X1(L,I),X0(L,I),I=1,2)
  216 FORMAT (6F12.5)
      DO 217 I=1,2
  217 PSL(L,I)=ALOG(PS(L,I))
      DPSL(L)=PSL(L,1)-PSL(L,2)
  220 PIDL(L)=ALOG(PID(L))
```

```
      WRITE (6,225)
  225 FORMAT (18H0PHI RAD / PHI BAR)
      READ    (9,230)
     1          (TR(I),I=1,NRAD)
  230 FORMAT (10F12.5)
      IZBEG=1
      DO 240 J=1,JMAX
      IZ(J)=Z(J)
      IZZ=IZ(J)
      DO 235 II=IZBEG,IZZ
      READ    (9,232) IFZ
  232 FORMAT (49X,I4)
      READ    (9,230) (R(I,J),I=1,NRAD)
  235 CONTINUE
      IF (IFZ) 236,236,236
  236 WRITE  (6,237) NSET
  237 FORMAT (99H0PHI RAD / PHI BAR IS NOT KNOWN FOR ALL ELEMENTS OF MAT
     1ERIAL SPECIFIED, DATAPAC CANNOT COMPLETE SETI4)
      STOP
  238 IZBEG=IZZ+1
  240 CONTINUE
      IF (IZBEG.GT.100) GO TO 247
      DO 245 II=IZBEG,100
      READ (9,232) IFZ
      READ    (9,230) (TRASH(I),I=1,NRAD)
  245 CONTINUE
  247 WRITE (6,250)
  250 FORMAT (32H  I     I (MEV)    PHI RAD/PHI BAR)
      WRITE (6,260)
     1          (IZ(J),J=1,JMAX)
  260 FORMAT (121,10I9)
      DO 280 I=1,NRAD
      WRITE (6,270)
     1          I,TR(I),(R(I,J),J=1,JMAX)
  270 FORMAT (I3,F11.5,11F9.4)
      TR(I)=ALOG(TR(I)/0.510976)
  280 CONTINUE
      ZA=0.0
      ZP=0.0
      DO 360 J=1,JMAX
      CON=0.000349*Z(J)*(Z(J)+1.0)/A(J)
      DO 350 I=1,NRAD
  350 R(I,J)=CON*R(I,J)
      WAZ(J)=W(J)*Z(J)/A(J)
      ZA=ZA+WAZ(J)
  360 ZP=ZP+W(J)*(Z(J)**1.3333333)
      IF (LMAX-1) 370,370,380
  370 IJ=1
      P=P1(1)/(0.510976E 06)
      GO TO 400
  380 IJ=2
      PL=0.0
      DO 390 J=1,JMAX
  390 PL=PL+ALOG(P1(J))*WAZ(J)
      P=EXP (PL/ZA)/(0.510976E 06)
  400 POUT=P*0.510976E 06
      C1=0.00058*ZP
      C2=ALOG(2.0*P*P)
```

```
      CS=0.510976*C1
      KMAXM1=KMAX-1
      NCALM1=NCAL-1
      FAC=FLOAT (KMAXM1)
      AELO=AEL
      AEL=AEL/0.510976
      SCOUT=SCOUT/0.510976
      DO 610 N=1,NCALM1
      ST(1)=E(N)
      ST(KMAX)=E(N+1)
      DELTA=(ST(1)-ST(KMAX))/FAC
      DEL=0.510976*DELTA/3.0
      DO 410 K=2,KMAXM1
  410 ST(K)=ST(K-1)-DELTA
      DO 600 K=1,KMAX
      TL=ST(K)+1.0
      STL=ALOG(ST(K))
      DL(K)=0.0
      IF (ST(K)-SCOUT) 430,415,415
  415 DO 420 J=1,JMAX
      CALL WPOL (STL,TR,R(1,J),NRAD,ANS)
  420 DL(K)=DL(K)+ANS*TE*W(J)
      DL(K)=0.510976*DL(K)
  430 GAM=ST(K)+2.0
      DSQ(K)=ST(K)*GAM/(TL**2)
      TCEL=AEL+DEL*ST(K)
      TCPL=TCEL
      IF (IDENS1) 510,510,515
  510 D(K)=0.0
      GO TO 570
  515 DO 530 L=1,LMAX
      DO 520 I=1,2
      CALL DENSE (ST(K),C(L,I),B(L,I),DM(L,I),XI(L,I),XO(L,I),DS(I))
  520 A0=(DS(2)*PSL(L,1)-DS(1)*PSL(L,2))/DPSL(L)
      B0=(DS(1)-DS(2))/DPSL(L)
      DSOD(L)=A0+B0*PLOL(L)
      IF (DSOD(L)) 525,530,530
  525 DSOD(L)=0.0
  530 CONTINUE
      GO TO (540,550),IO
  540 D(K)=DSOD(1)
      GO TO 570
  550 SUMD=0.0
      DO 560 J=1,JMAX
  560 SUMD=SUMD+DSOD(J)*WAZ(J)
      D(K)=SUMD/ZR
  570 GO TO (575,591,575,591),ISGN
  575 S=ST(K)/2.0
      IF (S-TCEL) 580,590,590
  580 TCEL=S
  590 EL(K)=C1*(ALOG(TCEL*(ST(K)-TCEL)*GAM)-C2+0.386294-DSQ(K)+ST(K)/
     1(ST(K)-TCEL)+((TCEL**2)/2.0+(2.0*ST(K)+1.0)*ALOG((ST(K)-TCEL)/
     2ST(K)))/(TL**2)-D(K))*0.510976/DSQ(K)
      GO TO 530
  591 IF (ST(K)-TCPL) 592,595,595
  592 TCPL=ST(K)
  595 EL(K)=C1*(ALOG(TCPL*ST(K)*GAM)-C2+1.386294-DSQ(K)*(ST(K)+TCPL*(2.0
     1-1.0/(GAM**2))-(TCPL**2)*(3.0/GAM+1.0/(GAM**3))/2.0+2.0*(TCPL**3)*
```

```
     ELL/(3.0*(GAM**3))-(TCPL**4)/(4.0*(GAM**3)))/ST(K)-D(K))*0.510976/
     BSQ(K)
 590 GEBL(K)=1.0/(EL(K)+BL(K))
 600 GREBL(K)=BL(K)*GEBL(K)
     CALL INT (DEL,GEBL,KMAX,DREB(N))
     CALL INT (DEL,DREBL,KMAX,FE(N))
     BLOS(N)=BL(1)
     ELOS(N)=EL(1)
     BETASQ(N)=BSQ(1)
     DENNT(N)=D(1)
 610 DENCOR(N)=C3*D(1)/BETASQ(N)
     DREB(NCAL)=0.0
     FE(NCAL)=0.0
     BLOS(NCAL)=BL(KMAX)
     ELOS(NCAL)=EL(KMAX)
     BETASQ(NCAL)=BSQ(KMAX)
     DENNT(NCAL)=D(KMAX)
     DENCOR(NCAL)=C3*D(KMAX)/BETASQ(NCAL)
     DO 615 N=1,NCAL
     EBLOS(N)=ELOS(N)+BLOS(N)
 615 RATEB(N)=BLOS(N)/ELOS(N)
     IF (RATEB(1)-1.0) 618,616,616
 616  IF (RATEB(NCAL)-1.0) 617,617,618
 617 CALL NPOL (1.0,RATEB,T,NCAL,TCRITE)
     GO TO 6220
 618 TCRITE=0.0
6220 RED(NCAL)=0.5*T(NCAL)/EBLOS(NCAL)
     FEACC(NCAL)=0.0
     DO 620 N=2,NCAL
     L=NCAL-N+2
     RED(L-1)=RED(L)+DRED(L-1)
 620 FEACC(L-1)=FEACC(L)+FE(L-1)
     RMAX=RED(1)
     DO 627 N=1,NMAX
 627 RAT(N)=(ELOS(N)+ELOS(N+1))/(EBLOS(N)+EBLOS(N+1))
     DO 635 N=1,NCAL
 635 TE(N)=FEACC(N)/T(N)
     GO TO (672,676,672,676),ISGN
 672 WRITE  (6,674)
 674 FORMAT (69H1                                                        EL
    1ECTRON RESULTS)
     GO TO 679
 676 WRITE  (6,678)
 678 FORMAT (69H1                                                        PO
    1SITRON RESULTS)
 679 WRITE  (6,680) ZA,POUT,TCRITE
 680 FORMAT (21H0     EFFECTIVE Z/A =F8.5,42H     EFFECTIVE MEAN IONIZA
    1TION POTENTIAL =F8.2,25H EV     CRITICAL ENERGY =F8.3,4H MEV)
     WRITE  (6,682)
 682 FORMAT (117H0          ENERGY            STOPPING POWER            RAN
    1GE    RADIATION    BETA**2    DENSITY    RAD/COL    DRANGE    DYIELD)
     WRITE  (6,684)
 684 FORMAT  (60H    N                    COLLISION RADIATION    TOTAL
    1 -     YIELD                    CORR)
     WRITE  (6,686)
 686 FORMAT (107H                MEV       MEV CM2/G MEV CM2/G MEV CM2/G    G/C
    1M2                          MEV CM2/G                G/CM2)
     WRITE  (6,211)
```

```
      DO 720 N=1,NCAL
      L=NCAL-N+1
      WRITE (6,710) L,T(L),ELOS(L),ELOS(L),EBLOS(L),REB(L),TE(L),
     1   BETASQ(L),DENCOR(L),RATEB(L),DREB(L),FE(L)
  710 FORMAT (I5,1PE12.4,2(1X,1P5E10.3))
  720 CONTINUE
      WRITE (6,730)
  730 FORMAT (22H1STRAGGLING PARAMETERS)
      WRITE (6,740)
  740 FORMAT (65H0    N     ENERGY        E/E      BSQ/BSQ    DELTA T     A*DR
     1G      B**2)
      WRITE (6,750)
  750 FORMAT (55H            MEV                                  MEV        [illegible]
     1)
      C4=(2.0E-05)*ZP
      DO 770 N=1,NCALM1
      L=NCALM1-N+1
      RT=T(L)/T(L+1)
      RB=BETASQ(L)/BETASQ(L+1)
      DT=T(L)-T(L+1)
      APARM=C3*DREB(L)/BETASQ(L)
      BPARM=C4*DT/(APARM**2)
      WRITE (6,760) L,T(L),RT,RB,DT,APARM,BPARM
  760 FORMAT (I5,1PE12.4,1X,0P2F10.7,1P3E10.3)
  770 CONTINUE
      RETURN
      END
```

```
C     SUBROUTINE ELIST (NCAL), 30 OCT 67.
      SUBROUTINE ELIST (NCAL)
      COMMON  /MAIN/A(20),B(20,2),C(20,2),CUFP(20),DR(20,2),DRG(501),
     1   E(501),EDLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PR(20),PS(20,2),RG(501),RGMAX,T(501),TAG(18),XD(20,2),
     3   X1(20,2),Z(20),Z(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),JMAX,
     4   JSUB,LMAX,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NMFL,NMOT,NRAD,NSW1
      T(1)=EMAX
      ND(1)=1
      EFAC=0.5**(1.0/FLOAT(NCYC))
      GO TO (10,70),ICYC
   10 DO 20 N=2,NMAX1
      T(N)=T(N-1)*EFAC
   20 CONTINUE
      IF (T(NMAX1).GT.0.001) GO TO 22
      NCAL=NMAX1
      GO TO 50
   22 NMAX2=NMAX1+1
      DO 23 N=NMAX2,501
      T(N)=T(N-1)*EFAC
      IF (T(N).LE.0.001) GO TO 40
   23 CONTINUE
   25 WRITE  (6,30) NSET
   30 FORMAT (92H0RANGE TABLE ELIST CANNOT REACH 1 KEV WITHOUT EXCEEDING
     1 STORAGE, DATAFAC CANNOT COMPLETE SETI4)
      STOP
   40 NCAL=N
   50 DO 60 N=1,NCAL
   60 E(N)=T(N)/0.511976
      DO 65 N=2,NCAL
      GO TO (62,63),ICYC
   62 ND(N)=ND(N-1)+NCYC
   63 IF (ND(N).GT.NMAX) GO TO 67
   65 CONTINUE
      NDMAX=NMAX
      GO TO 95
   67 NDMAX=N
      N(NDMAX)=NMAX
   68 GO TO (690,720),ICYC
  690 WRITE  (6,695)
  695 FORMAT (72H0      EMAX        NCYC        EFAC        NMAX     T(NMAX+1)
     1 NCAL      T(NCAL))
      WRITE  (6,700) EMAX,NCYC,EFAC,NMAX,T(NMAX1),NCAL,T(NCAL)
  700 FORMAT (2PE1[illegible].5,I6,1PE14.5))
      GO TO 740
  710 WRITE  (6,720)
  720 FORMAT(112H0      EMAX        NCYC        EFAC       NCYC2       EFAC2
     1NPRIM       EFACP       NMAX     T(NMAX+1)    NCAL      T(NCAL))
      WRITE  (6,730) EMAX,NCYC,EFAC,NCYC2,EFAC2,NPRIM,EFACP,NMAX,
     1   T(NMAX1),NCAL,T(NCAL)
  740 RETURN
  750 NCYC2=1.0219 0*FLOAT(NCYC)+0.5
      EFAC2=0.5**(1.0/FLOAT(NCYC2))
      EMAXL=ALOG10(EMAX)
      IEMAX=EMAXL
      DELTA=EMAXL-FLOAT(IEMAX)
```

```
      N=1
      NDMAX=1
      IF (AMANT.LE.0.39697) GO TO 90
      DIFL=AMANT-0.39697
      NPRIM=FLOAT(NCYC)*DIFL/0.30103+0.5
      IF (NPRIM.LE.0) GO TO 150
      EFACP=10.0**(-DIFL/FLOAT(NPRIM))
      DO 80 N=1,NPRIM
   80 T(N+1)=T(N)*EFACP
      N=NPRIM+1
      NDMAX=NDMAX+1
      ND(NDMAX)=N
      GO TO 150
   90 IF (AMANT.LE.0.30103) GO TO 110
      DIFL=AMANT-0.30103
      NPRIM=FLOAT(NCYC2)*DIFL/0.39794+0.5
      IF (NPRIM.LE.0) GO TO 170
      EFACP=10.0**(-DIFL/FLOAT(NPRIM))
      DO 100 N=1,NPRIM
  100 T(N+1)=T(N)*EFACP
      N=NPRIM+1
      NDMAX=NDMAX+1
      ND(NDMAX)=N
      GO TO 170
  110 NPRIM=FLOAT(NCYC)*AMANT/0.30103+0.5
      IF (NPRIM.LE.0) GO TO 130
      EFACP=10.0**(-AMANT/FLOAT(NPRIM))
      DO 120 N=1,NPRIM
  120 T(N+1)=T(N)*EFACP
      N=NPRIM+1
      NDMAX=NDMAX+1
      ND(NDMAX)=N
  130 DO 140 M=1,NCYC
      N=N+1
      T(N)=T(N-1)*EFAC
      IF (N.LT.NMAX1) GO TO 140
      IF (T(N).LE.0.001) GO TO 40
      IF (N.GE.500) GO TO 25
  140 CONTINUE
      NDMAX=NDMAX+1
      ND(NDMAX)=N
  150 DO 160 M=1,NCYC2
      N=N+1
      T(N)=T(N-1)*EFAC2
      IF (N.LT.NMAX1) GO TO 160
      IF (T(N).LE.0.001) GO TO 40
      IF (N.GE.500) GO TO 25
  160 CONTINUE
      NDMAX=NDMAX+1
      ND(NDMAX)=N
  170 DO 180 M=1,NCYC
      N=N+1
      T(N)=T(N-1)*EFAC
      IF (N.LT.NMAX1) GO TO 180
      IF (T(N).LE.0.001) GO TO 40
      IF (N.GE.500) GO TO 25
  180 CONTINUE
      NDMAX=NDMAX+1
```

```
N=(NDMAX)=N
GO TO 130
END
```

```
C     SUBROUTINE DENSE (E,C,B,DM,X1,X0,D), 14 JUL 67.
      SUBROUTINE DENSE (E,C,B,DM,X1,X0,D)
      X=0.4342945*ALOG(SQRT (2.0*E+E*E))
      IF (X-X0) 50,50,10
   10 IF (X-X1) 20,20,30
   20 D=4.000*X+C+B*((X1-X)**DM)
      GO TO 40
   30 D=4.000*X+C
   40 IF (D) 50,60,60
   50 D=0.0
   60 RETURN
      END
```

```
C     SUBROUTINE SCATT, 6 FEB 68.
      SUBROUTINE SCATT
      COMMON/MAIL/ATP(20),B(20,2),C(20,2),CUFP(20),DA(20,2),DRG(501),
     1   F(501),EBLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PK(20),PS(20,2),RG(501),RGMAX,E(501),TAG(18),X0(20,2),
     3   X1(20,2),ZP(20),ZP(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),ICMAX,
     4   JSUB,LDUM,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,IMAX,NRAD,NSWT
      COMMON  /PRIP/ACON,AMAT(5,5),          BMAT(5),CALPH(50),CHB(280),
     1   COSAV(256),ER(30),     G(50),GD(51),H(300),       P(300),
     2   Q(300),R(50,5,20),S(300),SGN,SPR(300),SUB(256),ETA,ETAPR,
     3   T(6,301),      UB(280),V1(301),V2(301),V3(301),V4(301),V5(301),
     4   V6(301),V7(301),V8(301),V9(301),V10(301),V11(301),Y(5),
     5   ZTHP(20),                                          LMAX,      MMAX1,
     6   NSCAL
      COMMON  /INEAS/ COM(51),COR,CORC(50),CORD(51),CTHMAX,DCOM(50),
     1   WT(20),RMIN,RMIN1,N,HMAX,HCUM(300),HC(300),HCMAX,SC(51),
     2   COSAC(256)
      COMMON  /SCRA/  APRAB,BPRAB,CAY,RATLIN(50,5,20),SCON,TLIN(50),
     1   ANG(50),ETC,HCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,MMAX,
     2   LINMAX,ILIN
      DATA IPRI/1/
      CALL PREP
      WRITE (6,15)
   15 FORMAT (1H )
      INDEX=JSUB+10*IAVE+100*(1+IDST/2)
      WRITE (6,22) NSET,NMAX,MMAX,NSUB(1),INDEX,RGMAX
      WRITE (11,22)NSET,NMAX,MMAX,NSUB(1),INDEX,RGMAX
   22 FORMAT(30H DATAPREP DATA FOR DATAPAC SETI4,4I6,1PE14.6)
      DO 23 L=1,LMIX
   23 HCOM(L)=1.0
      DO 110 N=1,NMAX
      IF(N-NSCAL)20,20,29
   20 EN1=E(N)+E(N+1)
      EN2=(E(N)-E(N+1))/SUB(N)
      RA1=RG(N)+RG(N+1)
      RA2=(RG(N)-RG(N+1))/SUB(N)
      ENERG1=0.5*(EN1+EN2)
      RANGE1=0.5*(RA1+RA2)
      CALL SINO(1,ENERG1,RANGE1)
      GO TO (205,205,160),ICYC
  205 ENERG2=0.5*(EN1-EN2)
      RANGE2=0.5*(RA1-RA2)
      GO TO(275,27),ILAN
   27 TAU=ENERG1/0.511976
      TAU2=(TAU+1.0)**2
      ASTEP=ACON*DRG(N)*TAU2/(SUB(N)*TAU*(TAU+2.0))
      EARL=ALOG(ENERG1/ASTEP)-0.806-(1.261*TAU+0.693)/TAU2
      ECORR=ASTEP*(TLAN-EARL)
      ENERG1=ENERG1-ECORR
      ERAT=(ENERG1-ENERG2)/(ENERG1-ENERG2)
      GO TO 28
  275 ENERG1=ENERG2
      ECORR=0.0
      ERAT=1.0
   28 CALL SINO(2,ENERG1,RANGE2)
      GO TO (285,285,160),ICYC
```

```
285 CALL MULT  (RANGE1,RANGE2)
 29 GO TO (300,290,290),IOST
290 WRITE  (11,295) (GO(M),M=1,MMAX1)
295 FORMAT (1P8E15.7)
300 WRITE  (11,295) (G(M),M=1,MMAX)
    GO TO (310,310,104),IOST
310 DO 100 K=1,NOMAX
    IF(N-NO(K))100,30,100
 30 ANGLIN=57.2957795* ACOS(CTHMAX)
    WRITE (6,31)
 31 FORMAT(90H0     N        E(N)        ENERG1       ENERG2       ECORR
   1     ELRAT        COSIN        ANGLIN)
    WRITE (6,40)
   1          N,E(N),ENERG1,ENERG2,ECORR,ELRAT,CTHMAX,ANGLIN
 40 FORMAT(I6,7F12.5)
    WRITE (6,42)
 42 FORMAT (90H0 LMAX          ETA1          HMAX         HCOF1         HCOF2
   1       HCOF3         HCOF4         HCOF5)
    WRITE (6,43) LMAX,ETAPR,HMAX,(BMAT(J),J=1,5)
 43 FORMAT (I5,1P7E12.4)
    GO TO (45,71),IPRT
 45 WRITE (6,50)
 50 FORMAT(41H0SINGLE SCATTERING EXPANSION COEFFICIENTS)
    WRITE (6,60)
   1          (SPX(L),L=2,LMAX)
 60 FORMAT(10F12.5)
    WRITE (6,70)
 70 FORMAT(42H0MULTIPLE SCATTERING LEGENDRE COEFFICIENTS)
    WRITE (6,60)
   1          (H(L),L=2,LMAX)
 71 GO TO (72,72,72),IOST
 72 WRITE (6,73)
 73 FORMAT (50H0CORRECTION TO INELASTIC SCATTERING FACTOR (2+1)/2)
    WRITE (6,90) (CORD(M),M=1,MMAX1)
    WRITE (6,75)
 75 FORMAT (40H0DIFFERENTIAL MULTIPLE SCATTERING DISTRIBUTION)
    WRITE (6,77)
   1          (GO(M),M=1,MMAX1)
 77 FORMAT (1P12E10.2)
 78 WRITE (6,73)
    WRITE (6,90) (CORC(M),M=1,MMAX)
    WRITE (6,80)
 80 FORMAT(44H0CUMULATIVE MULTIPLE SCATTERING DISTRIBUTION)
    WRITE (6,90)
   1          (G( ),M=1,MMAX)
 90 FORMAT(12F10.5)
    GO TO 102
100 CONTINUE
102 GO TO 110
104 COSIN=-1.0
    ANGLIN=-180.0
    WRITE (6,31)
    WRITE (6,40) N,E(N),ENERG1,ENERG2,ECORR,ELRAT,COSIN,ANGLIN
    WRITE (6,42)
    WRITE (6,43) LMAX,ETAPR,HCMAX,(BMAT(J),J=1,5)
    GO TO (106,107),IPRT
106 WRITE (6,70)
    WRITE (6,60) (HC(L),L=2,LMAX)
```

```
107 WRITE (6,108)
108 FORMAT (35H0COMPOUND DIFFERENTIAL MULTIPLE SCATTERING DISTRIBUTION
   1)
    WRITE (6,77) (CC(M),M=1,MMAX1)
    COSAC(N)=HC(2)+HCMAX
110 COSAV(N)=H(2)+HMAX
    WRITE (6,125)
125 FORMAT(69H0ENDPOINT DEFLECTION COSINES FOR SAMPLING FROM CUMULATIV
   1E DISTRIBUTION WITH INTERPOLATION)
    WRITE (6,90)
   1          (CALPH(M),M=1,MMAX)
    WRITE (6,131)
131 FORMAT(50H0     N          E(N)              DRG(N)    NSUB    COSAV)
    WRITE (6,15)
    DO 133 N=1,NMAX
    WRITE (6,132)
   1          N,E(N),DRG(N),NSUB(N),COSAV(N)
132 FORMAT(I6,2F15.7,I6,2F9.5)
133 CONTINUE
    GO TO (1370,1370,1330),IDST
1330 WRITE (6,1340)
1340 FORMAT (45H0     N          E(N+1)        S(G/CM2)     COSAV)
    WRITE (6,15)
    PATH=0.0
    DO 1360 N=1,NMAX
    PATH=PATH+DRG(N)
    WRITE (6,1350) N,E(N+1),PATH,COSAC(N)
1350 FORMAT (I6,1P2E15.5,0PF9.5)
1360 CONTINUE
1370 DRG(NMAX1)=ASET
    WRITE (11,295) (CALPH(M),M=1,MMAX),(E(N),N=1,NMAX1),
   1   (DRG(N),N=1,NMAX1)
    GO TO (135,134),IAVE
134 WRITE  (11,295) (COSAV(N),N=1,NMAX)
135 GO TO (150,136),JSUB
136 WRITE  (11,200) (NSUB(N),N=1,NMAX)
200 FORMAT (20I5)
150 CONTINUE
160 RETURN
    END
```

```
C     SUBROUTINE PREP, 30 OCT 67.
      SUBROUTINE PREP
      DIMENSION    TRASH(150)
      COMMON/MAGNE/ATP(20),B(20,2),C(20,2),CUFP(20),DR(20,2),DRC(501),
     1   F(501),EGLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PS(20),PS(20,2),RG(501),RGMAX,E(501),TAG(19),X0(20,2),
     3   X1(20,2),ZP(20),ZP(20),ICYC,IN1,INEL,IC1,IP,IR,I2(20),ICMAX,
     4   JSUB,LDUM,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,IMAX,NRAD,NSWT
      COMMON  /PRIP/ACON,AMAT(5,5),          BMAT(5),CALPH(50),CHS(280),
     1   COSAV(256),ER(30),     G(50),GD(51),H(300),       P(300),
     2   Q(300),R(30,5,20),S(300),SGN,SPR(300),SUB(256),ETA,ETAPR,
     3   T(6,301),      UB(280),V1(301),V2(301),V3(301),V4(301),V5(301),
     4   V6(301),V7(301),V8(301),V9(301),V10(301),V11(301),Y(5),
     5   ZTHP(20),                                          LMAX,      MMAX1,
     6   NSCAL
      COMMON  /INLAS/ COM(51),COR,CORC(50),CORD(51),CTHMAX,DCOV(50),
     1   WT(20),KMIN,KMIN1,NTHMAX,HCUM(300),HC(300),HCMAX,GC(51),
     2   COSAC(256)
      COMMON  /SCRT/  APRAD,BPRAD,CAY,RATLIN(50,5,20),SCOL,TLIN(50),
     1   ANG(50),ETC,MCOMP,ILAN,ASCL,BSCL,IAVE,ICST,ILAN,LIST,LMIX,MMAX,
     2   LIMMAX,ILIN
      WRITE  (6,2)
    2 FORMAT (9H1DATAPREP)
      WRITE (6,3)
    3 FORMAT (7HDANGLES)
      WRITE (6,4) (ANG(M),M=1,MMAX)
    4 FORMAT (12F10.4)
      LAST2=LIST-2
      MMAX1=MMAX+1
      ACON=0.0
      WRITE (6,40)
   40 FORMAT(27H0   ZP       ATP      CUFP      WP)
      COROP=0.0
      CORDN=0.0
      ZZ=0.0
      WATE=0.0
      DO 50 IC=1,ICMAX
      WRITE (6,50)
     1            ZP(IC),ATP(IC),CUFP(IC),WP(IC)
   50 FORMAT(F6.1, F6.2, F6.1, F9.5)
      WT(IC)=ZP(IC)*WP(IC)/ATP(IC)
      COROP=COROP+WT(IC)*ZP(IC)
      CORDN=CORDN+WT(IC)*(ZP(IC)+1.0)
      ZZ=ZZ+WT(IC)*ZP(IC)
      WATE=WATE+WP(IC)/ATP(IC)
      ACON=ACON+WT(IC)
   60 ZTHP(IC)=ZP(IC)**0.666667
      COR=COROP/CORDN
      ZEFF=SQRT(ZZ/WATE)
      ACON=0.10359*ACON
      ESCAL=ASCL+BSCL*ZEFF
      DO 65 N=1,NMAX
      IF (ESCAL.GT.E(N)) GO TO 70
   65 CONTINUE
      NSCAL=NMAX
      GO TO 75
```

```
 70 NSCAL=N-1
 75 WRITE  (6,80) ZEFF,ESCAL,NSCAL
 80 FORMAT (7H0ZEFF =0PF8.3,12H      ESCAL =1PE11.4,16H MEV      NSCAL =
   114)
    GO TO (90,100,105,105),ISGN
 90 SGN=1.0
    GO TO 110
100 SGN=-1.0
    GO TO 110
105 SGN=0.0
110 WRITE  (6,112)
112 FORMAT (6H0 NSUB)
    GO TO (114,116),JSUB
114 WRITE  (6,115) NSUB(1)
115 FORMAT (2016)
    GO TO 116
116 WRITE  (6,115) (NSUB(N),N=1,NMAX)
118 DO 120 N=1,NMAX
120 SUB(N)=NSUB(N)
    WRITE (6,160)
160 FORMAT(16H0MOTT/RUTH RATIO)
    NTR=5*IMAX
    IZBEG=1
    WRITE  (6,162)
162 FORMAT (25H0ENERGY BASE POINTS (MEV))
    READ   (9,180)
   1            (ER(I),I=1,IMAX)
    WRITE (6,180)
   1            (ER(I),I=1,IMAX)
    DO 190 IC=1,ICMAX
    IZZ=IZ(IC)
    DO 170 II=IZBEG,IZZ
165 FORMAT (4X,I5)
    GO TO (168,167,168,167),ISGN
167 READ   (9,165) IFF
    READ   (9,180) (TRASH(N),N=1,NTR)
168 READ   (9,165) IFZ
    READ   (9,180) ((R(I,J,IC),I=1,IMAX),J=1,5)
    GO TO (169,170,169,170),ISGN
169 READ   (9,165) IFF
    READ   (9,180) (TRASH(N),N=1,NTR)
170 CONTINUE
    IF (IFZ) 176,172,176
172 WRITE  (6,174) NSET
174 FORMAT(101H0MOTT/ROTHERFORD RATIOS NOT KNOWN FOR ALL ELEMENTS OF M
   1ATERIAL SPECIFIED, DATAPAC CANNOT COMPLETE SETI4)
    STOP
176 WRITE  (6,178) IFZ
178 FORMAT (4H0Z =I5)
    DO 179 J=1,5
    WRITE (6,180)
   1            (R(I,J,IC),I=1,IMAX)
179 CONTINUE
180 FORMAT(10F12.5)
189 IZBEG=IZZ+1
190 CONTINUE
    IF (IZBEG.GT.100) GO TO 196
    DO 197 II=IZBEG,100
```

```
      DO 197 III=1,2
      READ (9,165) IF2
      READ   (9,165) (TRASH(N),N=1,NTR)
  197 CONTINUE
  190 US(1)=2.79
      DO 200 I=2,280
  200 US(I)=US(I-1)-0.01
      READ   (9,205) (CHE(NC),NC=1,280)
  205 FORMAT (1P8E15.7)
      WRITE (6,206)
  206 FORMAT(10HUCHB TABLE READ IN)
      TH=0.0
      DTH=3.14159/4.0
      Y(1)=0.0
      DO 210 J=2,5
      TH=TH+DTH
  210 Y(J)=1.0-COS (TH)
      IF (INEL.NE.3) GO TO 216
      WRITE (6,211)
  211 FORMAT (20HADJUSTED 4DIT/RUTH RATIO)
      RAT=1.0
      DO 214 J=1,5
      PHIP=(CAT**2)+(1.0-(CAY**2))*(0.5*APRAB*Y(J)+0.25*BPRAB*(Y(J)**2))
      DO 214 IC=1,ICMAX
      DO 214 I=1,IMAX
      GO TO (2110,214),ILIN
 2110 IF (ER(I).GT.TLIN(LINMAX)) GO TO 212
      RAT=RATLIN(LINMAX,J,IC)+(ER(I)-TLIN(LINMAX))*(RATLIN(LINMAX,J,IC)-
     1   RATLIN(LINMAX-1,J,IC))/(TLIN(LINMAX)-TLIN(LINMAX-1))
      GO TO 214
  212 IF (ER(I).LE.TLIN(1)) GO TO 213
      RAT=RATLIN(1,J,IC)
      GO TO 214
  213 CALL SPOL (ER(I),TLIN,RATLIN(1,J,IC),LINMAX,RAT)
  214 R(I,J,IC)=PHIP*RAT*R(I,J,IC)
      WRITE (6,182)
      WRITE (6,180) (ER(I),I=1,IMAX)
      DO 215 IC=1,ICMAX
      WRITE (6,170) IZ(IC)
      DO 215 J=1,5
      WRITE (6,180) (R(I,J,IC),I=1,IMAX)
  215 CONTINUE
  216 DO 250 L=2,LMAX12
      V=L-1
      IF (L.LT.3) GO TO 223
      V1(L)=(V+V-1.0)/(V-1.0)
      V2(L)=V/(V-1.0)
  220 V3(L)=(V+V+3.0)/(V+2.0)
      V4(L)=(V+1.0)/(V+2.0)
      V5(L)=(V+1.0)/(V+V+1.0)
      V6(L)=V/(V+V+1.0)
      V7(L)=(V+V-1.0)/(V+1.0)
      V8(L)=(V-2.0)/(V+1.0)
      V9(L)=(V+V-1.0)/V
      V10(L)=(V-1.0)/V
      V11(L)=V+0.5
  250 CONTINUE
      COM(1)=1.0
```

```
      CORD(1)=1.0
      DO 240 M=1,MMAX
      CALPH(M)=COS(ANG(M)/57.2957795)
      COM(1)=1.0
      COM(M+1)=CALPH(M)
      DCOM(M)=COM(M)-COM(M+1)
      CORD(M+1)=1.0
240   CONTINUE
      GO TO(247,242,247,242),ISGN
242   DO 243 M=1,MMAX1
      IF (COM(M)) 245,245,243
243   CONTINUE
245   MMIN=M
      MMIN1=MMIN-1
      CTHMAX=0.0
247   RETURN
      END
```

```
C     SUBROUTINE SING (ICALL,ENERGY,RANGE), Z*B/137 MODEL, 8 APR 68.
      SUBROUTINE SING (ICALL,ENERGY,RANGE)
C      SGN = 1.0,0.0,-1.0 FOR MOTT-EL,RUTH OR MOTT-POS, RESPECTIVELY
      COMMON/MAIN/ATP(20),B(20,2),C(20,2),CUFP(20),DM(20,2),DRG(501),
     1   F(501),EBLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PK(20),PS(20,2),RG(501),RGMAX,E(501),TAG(18),X0(20,2),
     3   X1(20,2),WP(20),ZP(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),ICMAX,
     4   JSUB,LDUM,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,IMAX,NRAD,NSWT
      COMMON  /PRIP/ACON,AMAT(5,5),          BMAT(5),CALPH(50),CHP(280),
     1   COSAV(256),ER(30),     G(50),GD(51),H(300),       P(300),
     2   Q(300),R(30,5,20),S(300),SGN,SPR(300),SUB(256),ETA,ETAPR,
     3   T(6,301),      UB(280),V1(301),V2(301),V3(301),V4(301),V5(301),
     4   V6(301),V7(301),V8(301),V9(301),V10(301),V11(301),Y(5),
     5   ZTTHP(20),                                        LMAX,      MMAX1,
     6   NSCAL
      COMMON  /INLAS/ COM(51),COR,CORC(50),CORD(51),CTHMAX,HCOM(50),
     1   WT(20),KMIN,KMIN1,N,HMAX,HCUM(300),HC(300),HCMAX,GC(51),
     2   COSAC(256)
      COMMON  /SCRN/  APRAB,BPRAB,CAY,RATLIN(50,5,20),SCON,TLIN(50),
     1   ANS(50),ETC,HCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,MMAX,
     2   LINMAX,ILIN
      DATA  WFAC/1.0/
      DO 5 L=2,LMIX
      SPR(L)=S(L)
    5 S(L)=0.0
      ETAPR=ETA
      HMAX=0.0
      DO 310 IC=1,ICMAX
      Z=ZP(IC)
      AT=ATP(IC)
      CUF=CUFP(IC)
      ZTTH=ZTTHP(IC)
      TAU=ENERGY/0.510976
      TAU1=(TAU+1.0)**2
      TAU4=TAU*(TAU+2.0)
      BETAQ=TAU4/TAU1
      BETA=SQRT (BETAQ)
      IF(SGN) 8,30,8
    8 U=Z/(137.0*BETA)
   30 ZFAC=1.7006E-05*ZTTH/TAU4
      GO TO (32,38,34),INEL
   32 CON1=1.13
      CON2=3.76
      GO TO 36
   34 CON1=SCON
      CON2=0.0
   36 ETA=(CON1+CON2*(U**2))*ZFAC
      GO TO 40
   38 CHIMU=SCON*SQRT(ZFAC)
      ETA=0.25*((EXP((1.0+(2.0*U*CHIMU)*(1.0-BETAQ))*ALOG(CHIMU)+
     1   (2.0*U*CHIMU)*(0.23105+1.448*BETAQ)))**2)
   40 ET1=1.0+1.0/ETA
      ET2=2.0*ETA
      ET3=1.0+ET2
      ET4=1.0/(1.0+ETA)
      ET5=ET4/ET2
```

```
      LTC=ALOG(ET1)
      LT7=LTC-LT4
      ALT=1.0-LT2*(SQRT (ET1)-1.0)
      AFAC=4.0*AET*SQRT (AET)/(ALT+1.0)
      EPS  =  (COF-ALOG((0.16/ZTTH)*(1.0+3.33*(U**2))))/((Z+1.0)*
     1   ALOG(4.0*LTA))
      *=0.30050*AFAC*(Z+1.0)*              RANGE/(TAU4*SETAQ)
      IF (SGN)50,90,50
   50 IF(U-2.79)55,52,52
   52 CH=0.0
      GO TO 56
   55 CALL GPOL (U,U5,CHB,280,CH)
   56 CHIFAC  =  3.14159*U*CH*SGN*SETAQ
      DO 70 J=1,5
      CALL GPOL (LENGTY,ERR(1,J,IC),IMAX,BMAT(J))
      BMAT(J)=BMAT(J)-1.0-CHIFAC*SQRT(Y(J)+2.0*ETA)/1.414214
      AMAT(J,1)=1.0
      DO 70 JK=2,5
   70 AMAT(J,JK)=AMAT(J,JK-1)*(Y(J)+2.0*ETA)
      CALL SINEQ (5,1,AMAT,BMAT,BMAT,D)
      IF (D.NE.0.0) GO TO 90
      WRITE (6,80)
   80 FORMAT (25H0ILL CONDITIONED MATRIX AMAT)
      STOP
   90 GO TO (95,92),ICALL
   92 IF (SGN) 920,930,920
  920 S(2)=S(2)+W*T(IC)*((1.0+BMAT(1))*ET7+CHIFAC*AFAC+BMAT(2)*
     1   (2.0*ET4+ET7-LT5*ET7)+2.0*(BMAT(3)+BMAT(4)*(ET3+0.33333333)+
     2   BMAT(5)*(LT3**2+0.66666667*ET3+0.33333333)))
      GO TO 310
  930 S(2)=S(2)+W*T(IC)*ET7
      GO TO 310
   93 LMAX=     EXP(1.794-0.397*ALOG(ETA))
      IF (LMAX.LE.LMIX) GO TO 95
      LMAX=LMIX
      LAST=LIST
      GO TO 100
   95 IF(LMAX.GE.10)GO TO 97
      LMAX=10
   97 LAST=LMAX+40
  100 LMAX1=LMAX+1
      LAST1=LAST-1
      LAST2=LAST-2
      LAST3=LAST-3
      T(1,1)=0.0
      IF(LTA-LTC)110,110,130
  110 T(1,2)=LT7
      DO 120 L=3,LMAX1
  120 T(1,L)=V1(L)*ET5*T(1,L-1)-V2(L)*T(1,L-2)-V1(L)*LT4
      GO TO 170
  130 T(1,LAST)=0.0
      T(1,LAST1)=1.0E-25
      L=LAST2
      DO 140 LL=1,LAST3
      T(1,L)=V3(L)*T(1,L+1)*ET3-V4(L)*T(1,L+2)
  140 L=L-1
      TFAC=(LT7-LT5)/T(1,2)
      DO 150 L=3,LMAX1
```

```
150 T(1,L)=T(1,L)*TFAC+ET5
    T(1,2)=ET7
170 IF(SUM) 180,302,180
180 T(2,2)=AFAC
    SUM=1.0
    AP=1.0
    DO 190 L=3,LMAX
    AP=AP*ALT
    SUM=SUM+AP
190 T(2,L)=AFAC*SUM
    DO 200 L=2,LMAX
200 T(3,L)=ET3*T(1,L)+T(1,2)-V5(L)*T(1,L+1)-V6(L)*T(1,L-1)
    DO 210 L=2,LMAX
210 T(4,L)=2.0
    T5=2.0*ET3
    T(5,2)=T5+0.6666667
    DO 220 L=3,LMAX
220 T(5,L)=T5
    T6=2.0*(ET3*ET3+0.3333333)
    T(6,2)=T6+0.3666667*T5
    T(6,3)=T6-0.2666667
    DO 230 L=4,LMAX
230 T(6,L)=T6
    DO 300 L=2,LMAX
    STEMP=(1.0+SMAT(1))*T(1,L)+CHIFAC*T(2,L)
    DO 290 K=2,5
290 STEMP=STEMP+SMAT(K)*T(K+1,L)
300 S(L)=S(L)+STEMP*W*WT(IC)
    GO TO 310
302 DO 304 L=2,LMAX
304 S(L)=S(L)+T(1,L)*W*WT(IC)
310 CONTINUE
    RETURN
    END
```

```
C     SUBROUTINE SIMEQ (NMAX,MMAX,A,B,X,D), 3 OCT 67.
      SUBROUTINE SIMEQ (NMAX,MMAX,A,B,X,D)
      DIMENSION A( 5, 5),AP( 5, 5),B( 5, 1),BP( 5, 1),X( 5, 1)
      IF (NMAX-1) 2,2,7
    2 DO 5 MC=1,MMAX
    5 X(1,MC)=B(1,MC)/A(1,1)
      D=A(1,1)
      GO TO 135
    7 SIGN=+1.0
      DO 20 N=1,NMAX
      DO 10 M=1,NMAX
   10 AP(N,M)=A(N,M)
      DO 20 M=1,MMAX
   20 BP(N,M)=B(N,M)
      NMAX1=NMAX-1
      DO 130 ND=1,NMAX1
      MAX=ND
      ND1=ND+1
      DO 30 N=ND1,NMAX
      IF (ABS (AP(N,ND))-ABS (AP(MAX,ND))) 30,30,40
   40 MAX=N
   50 CONTINUE
      IF (MAX-ND) 50,85,60
   60 SIGN=-SIGN
      DO 70 M=1,NMAX
      T=AP(MAX,M)
      AP(MAX,M)=AP(ND,M)
   70 AP(ND,M)=T
      DO 80 M=1,MMAX
      T=BP(MAX,M)
      BP(MAX,M)=BP(ND,M)
   80 BP(ND,M)=T
   85 IF (ABS (AP(ND,ND)/AP(1,1))-1.0E-06) 90,100,100
   90 D=0.0
      RETURN
  100 DO 120 N=ND1,NMAX
      ALF=-AP(N,ND)/AP(ND,ND)
      DO 110 M=ND1,NMAX
  110 AP(N,M)=AP(N,M)+ALF*AP(ND,M)
      DO 120 M=1,MMAX
  120 BP(N,M)=BP(N,M)+ALF*BP(ND,M)
  130 CONTINUE
      DO 150 MC=1,MMAX
      X(NMAX,MC)=BP(NMAX,MC)/AP(NMAX,NMAX)
      DO 150 N=1,NMAX1
      NR=NMAX-N
      SUB=0.0
      DO 140 M=1,N
      NK=NMAX-M+1
  140 SUB=SUB+AP(NR,NK)*X(NK,MC)
  150 X(NR,MC)=(BP(NR,MC)-SUB)/AP(NR,NR)
  160 CONTINUE
      D=SIGN*AP(1,1)
      DO 170 N=2,NMAX
  170 D=D*AP(N,N)
  180 RETURN
      END
```

```
C     SUBROUTINE MULT(RANGE1,RANGE2), 30 OCT 67.
      SUBROUTINE MULT(RANGE1,RANGE2)
      COMMON/MAIN/ATP(20),B(20,2),C(20,2),CUFP(20),DA(20,2),DRG(501),
     1   F(501),EBLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PR(20),PS(20,2),RG(501),RGMAX,E(501),TAG(18),X0(20,2),
     3   X1(20,2),WP(20),ZP(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),ICMAX,
     4   JSUB,LDUM,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NMFL,IMAX,NRAD,NSWT
      COMMON  /PRIP/ACON,AMAT(5,5),          BMAT(5),CALPH(50),CHB(280),
     1   COSAV(256),ER(30),     G(50),GD(51),H(300),        P(300),
     2   Q(300),R(30,5,20),S(300),SGN,SPR(300),SUB(256),ETA,ETAPR,
     3   T(6,301),      UB(280),V1(301),V2(301),V3(301),V4(301),V5(301),
     4   V6(301),V7(301),V8(301),V9(301),V10(301),V11(301),Y(5),
     5   ZTTMP(20),                                        LMAX,      MMAX1,
     6   NSCAL
      COMMON  /INLES/ COM(51),COR,CORC(50),CORD(51),CTHMAX,DCOM(50),
     1   WT(20),KMIN,KMIN1,M,HMAX,HCOM(300),HC(300),HCMAX,GC(51),
     2   COSAC(256)
      COMMON  /SCRA/  APRAG,BPRAG,CAY,RATLIN(50,5,20),SCON,TLIN(50),
     1   ANG(50),ETC,HCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,MMAX,
     2   LINMAX,ILIN
      TT=RANGE2/RANGE1
      ALPHA=(SPR(2)-TT*S(2))/(S(2)-SPR(2))
      TA=TT*(1.0+ALPHA)/(TT+ALPHA)
      H(1)=1.0
      XFAC=(1.0+ALPHA)/ALPHA
      DO 10 L=2,LMAX
   10 H(L)=TA**(XFAC*SPR(L))
      HMAX=H(LMAX)
      DO 11 L=1,LMAX
   11 H(L)=H(L)-HMAX
      DO 40 M=1,MMAX
      X=CALPH(M)
      Q(1)=1.0-X
      Q(2)=(1.0-X**2)/2.0
      G(M)=0.5*H(1)*Q(1)+1.5*H(2)*Q(2)
      GO TO (15,12,12),IDST
   12 P(1)=1.0
      P(2)=X
      GD(M+1)=0.5*H(1)*P(1)+1.5*H(2)*P(2)
   15 DO 30 L=3,LMAX
      IF(H(L)-HCOMP)+0,20,20
   20 Q(L)=V7(L)*X*Q(L-1)-V8(L)*Q(L-2)
      G(M)=G(M)+V11(L)*H(L)*Q(L)
      GO TO (30,25,25),IDST
   25 P(L)=V9(L)*X*P(L-1)-V10(L)*P(L-2)
      GD(M+1)=GD(M+1)+V11(L)*H(L)*P(L)
   30 CONTINUE
   40 CONTINUE
      GO TO (60,50,50),IDST
   50 GD(1)=0.5*H(1)+1.5*H(2)
      DO 70 L=3,LMAX
      IF (H(L)-HCOMP) 60,70,70
   70 GD(1)=GD(1)+V11(L)*H(L)
   60 CALL INELS
      GO TO (100,100,90),IDST
   90 DO 100 L=1,LMAX
```

```
100 HCOM(L)=HCOM(L)*((H(L)+HMAX)**NSUB(N))
    HCMAX=HC(LMAX)
    DO 110 L=1,LMAX
110 HC(L)=HCOM(L)-HCMAX
    DO 140 M=1,MMAX
    X=CALPH(M)
    P(1)=1.0
    P(2)=X
    GC(M+1)=0.5*HC(1)*P(1)+1.5*HC(2)*P(2)
    DO 130 L=3,LMAX
    IF (HC(L)-HCOMP) 140,120,120
120 P(L)=V9(L)*X*P(L-1)-V10(L)*P(L-2)
    GC(M+1)=GC(M+1)+V11(L)*HC(L)*P(L)
130 CONTINUE
140 CONTINUE
    GC(1)=0.5*HC(1)+1.5*HC(2)
    DO 150 L=3,LMAX
    IF (HC(L)-HCOMP) 160,150,150
150 GC(1)=GC(1)+V11(L)*HC(L)
160 RETURN
    END
```

```
C     SUBROUTINE INELS, 30 OCT 67.
      SUBROUTINE INELS
      COMMON/NANE/ATP(20),B(20,2),C(20,2),CUFP(20),DM(20,2),DRG(501),
     1   F(501),EBLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),PK(20),PS(20,2),RG(501),RGMAX,E(501),TAG(18),X0(20,2),
     3   X1(20,2),ZP(20),ZP(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),ICMAX,
     4   JSUB,LDUM,NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,IMAX,NRAD,NSWT
      COMMON  /PRIP/ACON,AMAT(5,5),          BMAT(5),CALPH(50),CHB(280),
     1   COSAV(256),ER(30),     G(50),GD(51),H(300),        P(300),
     2   Q(300),R(30,5,20),S(300),SGN,SPR(300),SUB(256),ETA,ETAPR,
     3   T(6,301),      UB(280),V1(301),V2(301),V3(301),V4(301),V5(301),
     4   V6(301),V7(301),V8(301),V9(301),V10(301),V11(301),Y(5),
     5   ZTTHP(20),                                        LMAX,      MMAX1,
     6   NSCAL
      COMMON  /INLAS/ COM(51),COR,CORC(50),CORD(51),CTHMAX,DCOM(50),
     1   WT(20),KMIN,KMIN1,N,HMAX,HCUM(300),HC(300),HCMAX,GC(51),
     2   COSAC(256)
      COMMON  /SCRN/  APRAB,BPRAB,CAY,RATLIN(50,5,20),SCON,TLIN(50),
     1   ANG(50),ETC,HCOMP,TLAN,ASCL,BSCL,IAVE,IDST,ILAN,LIST,LMIX,MMAX,
     2   LIMMAX,ILIN
      GO TO (10,40,10,40),ISGN
   10 GAM3=0.5*(E(N)+E(N+1))/0.510976+4.0
      CTHMAX=SQRT(1.0-2.0/GAM3)
      DO 20 M=1,MMAX1
      IF (CTHMAX-COM(M)) 20,30,30
   20 CONTINUE
   30 KMIN=M
      KMIN1=KMIN-1
   40 DO 50 K=1,KMIN1
   50 CORC(K)=1.0
      CORC(KMIN1)=1.0+(COR-1.0)*(CTHMAX-COM(KMIN))/DCOM(KMIN1)
      DO 60 K=KMIN,MMAX
   60 CORC(K)=COR
      GMAX=G(MMAX)
      DO 70 M=2,MMAX
      K=MMAX+2-M
   70 G(K)=G(K)-G(K-1)
      G(1)=G(1)*CORC(1)
      DO 80 M=2,MMAX
   80 G(M)=G(M-1)+G(M)*CORC(M)
      DO 90 M=1,MMAX
   90 G(M)=G(M)*GMAX/G(MMAX)
      GO TO (140,100,100),IDST
  100 DO 110 K=1,KMIN1
  110 CORD(K)=1.0
      DO 120 K=KMIN,MMAX1
  120 CORD(K)=COR
      DO 130 M=1,MMAX1
  130 GD(M)=GD(M)*CORD(M)
  140 RETURN
      END
```

```
C     SUBROUTINE [illegible] 30 OCT 67.
      SUBROUTINE [illegible]
      DIMENSION [illegible](100),[illegible](20),[illegible](100),R(100),RP(100),P(257),Q(257),
     1   S(100),SQ(100),SQ(257),SRP(50),TRASH(50)
      COMMON /[illegible]/M(20),[illegible](20,2),C(20,2),CUFP(20),[illegible](20,2),DRG(501),
     1   E(501),[illegible](501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PIP(20),PR(20),PS(20,2),RG(501),RGMAX,T(501),TAU(15),X0(20,2),
     3   X1(20,2),[illegible](20),[illegible](20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),JMAX,
     4   [illegible],NOMMAX,[illegible](256),NUMMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,NHFL,NOUT,NRAD,NSAT
      COMMON /[illegible]/COF(50,20),CON(20),FZ(20),HFC2(20),HFECUT(20),
     1   HFL(50,20),[illegible](50,20),TC(50),THF(50),TW(50),ZC(20),ZL(20),
     2   ZR(20)
      DATA [illegible]/[illegible](K,K=1,45)/0.00125,0.0015,0.0175,0.002,0.0025,
     1   0.003,[illegible],0.004,0.0045,0.005,0.0055,0.006,0.007,0.008,0.009,
     2   0.01,0.015,0.015,0.017,0.02,0.025,0.03,0.035,0.04,0.045,0.05,
     3   0.055,[illegible],0.07,0.08,0.09,0.1,0.125,0.15,0.175,0.2,0.25,0.3,
     4   0.35,[illegible],0.5,0.55,0.6,0.7,0.8,0.9,0.99999/,ALPHA/0.001/,
     5   [illegible]/1/,[illegible]/1/,[illegible]/2/
      [illegible] (6,1)
   10 FORMAT ([illegible]
      WRITE (1,4) [illegible]
   40 FORMAT (1H1,[illegible]DIFFERENTIAL CROSS SECTIONS FOR DATAPAC S
     1[illegible])
      WRITE (6,50)
   50 FORMAT (5H0[illegible]      HFC       HFECUT       HFS)
      [illegible]
      HFECUT(J)=1.
      WRITE (6,1[illegible])
     1   [illegible](J),HFC(J),HFECUT(J),HFS(J)
      HFC2(J)=[illegible]HFC(J)-1.0
   70 HFECUT(J)=HFECUT(J)/0.510976
      WRITE (6,100)
  100 FORMAT (5H0[illegible]      Z          A          LTA          W
      [illegible]
      [illegible]
      WRITE (6,1[illegible])
     1   [illegible](J),A(J)
  [illegible]
  [illegible]
      WRITE (6,1[illegible])
  [illegible]
      WRITE (6,1[illegible])
  [illegible]
     1   [illegible]
      [illegible]
  170 [illegible]
      WRITE [illegible]
  180 FORMAT ([illegible]
      [illegible]
      WRITE [illegible]
      [illegible]
      [illegible]
  185 [illegible]
```

```
  190 CONTINUE
      WRITE (6,200)
  200 FORMAT (27H0PHI RAD CORRECTION FACTORS)
      WRITE (6,170)
      READ   (9,140)
     1           (TC(I),I=1,NCOR)
      WRITE (6,140)
     1           (TC(I),I=1,NCOR)
      DO 210 I=1,NCOR
  210 TC(I)=ALOG(TC(I)/0.510976)
      IZBEG=1
      DO 230 J=1,JMAX
      WRITE (6,220) IZ(J)
  220 FORMAT (16H0FACTORS FOR Z =I4)
      IZZ=IZ(J)
      DO 222 II=IZBEG,IZZ
      READ    (9,221) IFZ
  221 FORMAT (3X,I4)
      READ    (9,140) (COR(I,J),I=1,NCOR)
  222 CONTINUE
      IF (IFZ) 224,224,226
  224 WRITE  (6,225) NSET
  225 FORMAT(105H0PHI RAD CORRECTION FACTORS NOT KNOWN FOR ALL ELEMENTS
     1IN MATERIAL SPECIFIED, DATAPAC CANNOT COMPLETE SET I4)
      STOP
  226 WRITE (6,140)
     1           (COR(I,J),I=1,NCOR)
  230 IZBEG=IZZ+1
      IF (IZBEG.GT.100) GO TO 2310
      DO 2300 II=IZBEG,100
      READ (9,221) IFZ
      READ    (9,140) (TRASH(I),I=1,NCOR)
 2300 CONTINUE
 2310 WRITE (6,231)
  231 FORMAT (22H0HIGH FREQUENCY LIMITS)
      WRITE (6,170)
      READ    (9,140)
     1           (THF(I),I=1,NHFL)
      WRITE (6,140)
     1           (THF(I),I=1,NHFL)
      DO 232 I=1,NHFL
  232 THF(I)=ALOG(THF(I)/0.510976)
      IZBEG=1
      DO 233 J=1,JMAX
      WRITE (6,233) IZ(J)
  233 FORMAT (15H0LIMITS FOR Z =I4)
      IZZ=IZ(J)
      DO 2314 II=IZBEG,IZZ
      READ    (9,2312) IFZ
 2312 FORMAT (4X,I4)
      READ    (9,140) (HFL(I,J),I=1,NHFL)
 2314 CONTINUE
      IF (IFZ) 2320,2320,2340
 2320 WRITE  (6,2330) NSET
 2330 FORMAT(105H0HIGH FREQUENCY LIMITS NOT KNOWN FOR ALL ELEMENTS IN MA
     1TERIAL SPECIFIED, DATAPAC CANNOT COMPLETE SET I4)
      STOP
 2340 WRITE (6,140)
```

```
     1            (WFL(I,J),I=1,NWFL)
      CF=(0.029 [illegible] +(Z(J)**2)*W(J)/A(J)
      DO 234 I=1,NWFL
234   WFL(I,J)=[illegible](CF*WFL(I,J))
235   IZBLB=IZBLB+1
      IF (IZBLB.GT.100) GO TO 410
      DO 236 II=1,IZBLB,100
      READ (9,3122) AFZ
      READ   (9,140) (TRASH(I),I=1,NWFL)
236   CONTINUE
410   DO 420 J=1,JMAX
      ZL(J)=ALOG(Z(J))/3.0
      ZX(J)=Z(J)**(1.0/3.0)
      AF=Z(J)/107.32
      ZS(J)=0.[illegible]*AF
      AS=AF*AF
      FZ(J)=AS*(1.0/(1.0+AS)+0.2020-0.0309*AS+0.0083*(AS*AS)-
     1   0.0028*(AS*AS)*AS)
420   W(J)=(0.49 [illegible])*Z(J)*(Z(J)+ETA(J))*W(J)/A(J)
      DO 430 K=1,KMAX
430   KP(K)=K(K)
      KP(KMAX)=1.0
      NMAX1=NMAX+1
      NMAX=NMAX/NDIF+1
      WRITE (11,440)
     1            NDIFK,NDIF,KMAX,NMAX,ALPHA
440   FORMAT (3I10,F10.0)
      WRITE  (11,140) (KP(K),K=1,KMAX)
      DFAL=FLOAT (NFLD-1)
      NFLD=NMAX*NFLD
      DFLD=FLOAT (NFLD-1)
      WRITE (6,450)
450   FORMAT (40H RATIOS FOR CUMULATIVE PROBABILITIES)
      WRITE (6,460)
     1            (KP(K),K=1,KMAX)
460   FORMAT (10F12.7)
      GO TO (470,470,7),IPRT
470   WRITE (6,480)
480   FORMAT (40H RATIOS FOR DIFFERENTIAL CROSS SECTION)
      WRITE (6,460) (KP(K),K=1,KMAX)
470   NN=1
      NFLI=1
      DO 500 J=1,JMAX
      [illegible]
      IF [illegible] GO TO 500
475   NN=NN+NDIF
      DO 500 K=1,KMAX
      IF (K-1) 430,490,490
490   DLE(K)=DLE(K)+TD
      GO TO 500
490   DLE(K)=DLE(K)+TD
500   DELTA=DLE/(DFAL*TD)
      DLE=R(K)+TD
      DO 510 [illegible]=1,NFLD
510   [illegible]=DLE+[illegible]/DFAL
      CALL [illegible]
      IF (NDIF.EQ.1) GO TO 525
      DO(I)=S(NFLD)
```

```
515 SD(K+1)=S(1)
    DO 520 NP=1,NPTS
520 S(NP)=S(NP)/EK(NP)
530 CALL INT(DELTA,S,NPTS,G(K))
    DO 540 K=2,KMAX
540 G(K)=G(K)+G(K-1)
    P(N)=G(KMAX)
    DO 550 K=1,KMAX
550 G(K)=G(K)/P(N)
    G(KMAX)=1.0
    WRITE  (11,552) (G(K),K=1,KMAX)
552 FORMAT (1P8E15.7)
    IF (N.NE.ND(MDET)) GO TO 600
    IF (MDET.GE.NDMAX) GO TO 553
    MDET=MDET+1
553 WRITE (6,554)
   1            N,T(N)
554 FORMAT (3H0T(I3,3H) =1PE11.4,4H MEV)
    WRITE (6,556)
556 FORMAT (37H0 NORMALIZED CUMULATIVE PROBABILITIES)
    WRITE (6,400)
   1            (G(K),K=1,KMAX)
    GO TO (557,600),IPRT
557 WRITE (6,558)
558 FORMAT (17H0 K*DS/DK (CM2/G))
    WRITE (6,559) (SD(K),K=1,KMAX1)
559 FORMAT (1P10E12.4)
    GO TO 600
560 DE=(R(KMAX)-ALPHA)*TO
    E1=R(KMAX)*TO
    DELTA=DE/(3.0*DFO)
    DO 570 NP=1,NPO
570 EK(NP)=E1-DE*FLOAT (NP-1)/DFO
    CALL BREAK6(TO,NPO,EK,S)
    DO 580 NP=1,NPO
580 S(NP)=S(NP)/EK(NP)
590 CALL INT(DELTA,S,NPO,P(N))
600 CONTINUE
    DO 602 N=1,NMAX
602 Q(N)=0.5*(P(N)+P(N+1))*DRG(N)
    SQ(1)=Q(1)
    DO 605 N=2,NMAX
605 SQ(N)=SQ(N-1)+Q(N)
    Q(NMAX1)=0.0
    SQ(NMAX1)=0.0
    WRITE (6,610)
610 FORMAT (75H0     N      ENERGY (MEV)          PROB/PATH          NUM IN
   1STEP          CUM NUM)
    WRITE (6,615)
615 FORMAT (1H )
    DO 630 N=1,NMAX1
    WRITE (6,620) N,T(N),P(N),Q(N),SQ(N)
620 FORMAT (I6,1P4E18.7)
630 CONTINUE
    WRITE  (11,552) (P(N),N=1,NMAX1)
650 CONTINUE
    RETURN
    END
```

```
C     SUBROUTINE [illegible] (TO,KMAX,EK,S), 30 OCT 67.
      SUBROUTINE [illegible] (TO,KMAX,EK,S)
      DIMENSION [illegible] (20),[illegible](100),EK(100),ELFAC(100),              S(100),
     1   S3BN(100),S3BND(100),S3BS(100),S3CS(100),SX(2),WT(20)
      COMMON /[illegible]/A(20),B(20,2),C(20,2),CUFP(20),D[illegible](20,2),DRG(501),
     1   E(501),[illegible](501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2   PID(20),[illegible](20),PS(20,2),RG(501),RGMAX,T(501),TAG(16),X0(20,2),
     3   X1(20,2),[illegible](20),Z(20),ICYC,IN1,INEL,IO1,IP,IR,IZ(20),JMAX,
     4   JSUB,[illegible],NCYC,ND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5   NCOR,[illegible],[illegible],[illegible],NSWT
      COMMON /[illegible]/COP(50,20),CON(20),FZ(20),HFC2(20),HFECUT(20),
     1   [illegible](50,20),[illegible](50,20),TC(50),THF(50),TW(50),ZC(20),ZL(20),
     2   [illegible](20)
      IF (TO-[illegible]) 10,10,20
   10 DO 15 J=1,JMAX
   15 WT(J)=[illegible]
      GO TO 60
   20 IF ([illegible]) 40,30,30
   30 DO 35 J=1,[illegible]
   35 WT(J)=[illegible]
      GO TO 60
   40 DO 50 J=1,[illegible]
   50 CALL [illegible] ([illegible],SW(1,J),NSWT,WT(J))
   60 DO 80 K=1,[illegible]
   80 S(K)=[illegible]
      TOL=[illegible](TO)
      DO 200 J=1,JMAX
      CALL [illegible] ([illegible],TC,COP(1,J),NCOR,COR(J))
      IF (TO-HFECUT(J)) 90,160,160
   90 IX=1
      DK(2)=HFC(J)*TO
      DO 100 K=1,[illegible]
      IF (EK(K)-DK(2)) 230,230,100
  100 GO TO (110,140),IX
  110 IX=2
      DK(1)=HFC[illegible]*TO
      CALL [illegible] ([illegible],ZC(J),ZL(J),FZ(J),  2 ,TO,DK,ELFAC,S3BN,
     1   [illegible]
      DO 130 [illegible]
      FAC=S3BN(KX)+[illegible]+WT(J)*(S3CS(KX)-S3BS(KX))
      IF (FAC-[illegible]) 120,130,130
  120 SX(KX)=[illegible]
      GO TO 130
  130 SX(KX)=[illegible]
  135 CONTINUE
  140 S(K)=S(K)+([illegible]+SX(2)*DK(1)-SX(1)*DK(2))/
     1   (DK(1)-DK(2))
  150 CONTINUE
      GO TO 200
  160 IX=1
      DK(1)=[illegible]
      DO 220 [illegible]
      IF ([illegible]) [illegible]
  170 [illegible]
  180 IX=[illegible]
      CALL [illegible]
      SMFL=EXP([illegible])
```

```
      CALL ASEC (CUR(J),ZC(J),ZL(J),ZR(J),FZ(J),   1 ,TO,DK,ELFAC,S3BN,
     1    S3BS,S3CS,S3BNB)
      FAC=S3BN(1)+S3BS(1)-S3BNB(1)+WT(J)*(S3CS(1)-S3CS(1))
      IF (FAC-1.0E-20) 190,200,200
  190 SX(1)=0.0
      GO TO 210
  200 SX(1)=CUR(J)*ELFAC(1)*FAC
  210 S(K)=S(K)+((SX(1)-SHFL)*ER(K)+SHFL*UX(1)-SX(1)*TO)/(UX(1)-TO)
  220 CONTINUE
      GO TO 250
  230 KMIN=K
      KCON=KMIN-1
      IF (KCON) 245,245,235
  235 DO 240 K=KMIN,KMAX
      KD=K-KCON
  240 UX(KD)=ER(K)
      KUPP=KMAX-KCON
      CALL ASEC (CUR(J),ZC(J),ZL(J),ZR(J),FZ(J),KUPP,TO,DK,ELFAC,S3BN,
     1    S3BS,S3CS,S3BNB)
      DO 243 K=1,KCON
      FAC=S3BN(K)+S3BS(K)-S3BNB(K)+WT(J)*(S3CS(K)-S3CS(K))
      IF (FAC-1.0E-20) 241,242,242
  241 FAC=0.0
      GO TO 243
  242 FAC=CUR(J)*ELFAC(K)*FAC
      KD=K+KCON
      S(KD)=S(KD)+FAC
  243 CONTINUE
      GO TO 280
  245 CALL ASEC (CUR(J),ZC(J),ZL(J),ZR(J),FZ(J),KMAX,TO,DK,ELFAC,S3BN,
     1    S3BS,S3CS,S3BNB)
      DO 270 K=1,KMAX
      FAC=S3BN(K)+S3BS(K)-S3BNB(K)+WT(J)*(S3CS(K)-S3CS(K))
      IF (FAC-1.0E-20) 250,260,260
  250 FAC=0.0
      GO TO 270
  260 FAC=CUR(J)*ELFAC(K)*FAC
      S(K)=S(K)+FAC
  270 CONTINUE
  280 CONTINUE
      RETURN
      END
```

```
C     [illegible]
      [illegible] KMAX,T,EPHOT,ELFAC,[illegible],XBS,XCS,
     1   [illegible])
C     ZC=TWO*PI/137
C     ZC=LOGF(Z)/3.0
C     ZX=Z**(1.0/3.0)
C     F2=[illegible] CORRECTION TERM
      DIMENSION [illegible],ELFAC(100),XBN(100),              XBS(100),
     1   XCS(100),[illegible](100)
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
C        ***  [illegible]  ***
      [illegible]
      IF [illegible]
    2 [illegible]
     1          [illegible]
    4 [illegible] IN XSEC, [illegible] =1PE15.7,[illegible] FOR T =1PE15.7,[illegible]
     1 [illegible] =1PE15.7)
      STOP
    3 [illegible]
      [illegible]
      [illegible]
      [illegible]
C        ***  [illegible]  ***
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
C        ***  [illegible]  ***
      [illegible]
      IF [illegible]
   10 [illegible]
      [illegible]
      [illegible]
      [illegible]
   20 [illegible]
      [illegible]
   30 [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
```

```
      XCS(K)=C04*(H1-H2)
C          ***    3BN     ***
      H1=H1F-H2F
      H2=ALOG(2.0*.0/EPHOT(K))-0.5
   40 XBND(K)=C04*H1*H2
      RETURN
      END
```

```
C     [illegible]
      [illegible]
C     [illegible] DISTRIBUTION AND CUMULATIVE PROBABILITIES OF
C     [illegible] BY SAUTER AND ELSEN-MAXIMON FORMULAS.
      [illegible] A(20),CHI(51),CHIM(20),CHIS(51),CTH(51),CTHS(51),
     1  ER(51),ET(50),APRIN1(51),F(51),R(51),RP(51),XI(51),XIS(51)
      COMMON /[illegible]/(20),B(20,2),C(20,2),CUFP(20),DM(20,2),DRG(501),
     1  E(501),ESLOS(501),EMAX,ERAT(256),HFC(20),HFS(20),PI(20),
     2  PIB(20),PS(20),PS(20,2),RG(501),RGMAX,T(501),TAG(18),X0(20,2),
     3  XI(20,2),[illegible](20),Z(20),ICYC,IN1,INEL,IO1,IP,IP,IZ(20),JZMAX,
     4  [illegible],ELMAX,NCYCAND(256),NDMAX,NMAX,NMAX1,NSET,NSUB(256),ISGN,
     5  [illegible]
      COMMON /[illegible]/ C1(20),C15,C2(20),C3(20),C4(20),S(51,51),JMAX
      DATA [illegible]/(R(K),K=1,25)/0.99990,0.8,0.6,0.5,0.4,0.3,0.2,0.15,
     1  0.1,0.08,0.06,0.05,0.04,0.03,0.02,0.015,0.01,0.008,0.006,0.005,
     2  [illegible]/,NPTS/21/,NAMO/21/,NDIF/8/,
     3  [illegible] 4/,(APRIN1(K),K=1,4) /1,     9,      17,
     4  [illegible]/
      [illegible]
      [illegible]
   20 FORMAT ([illegible])
      [illegible]
   30 FORMAT ([illegible] CUMULATIVE BREMSSTRAHLUNG ANGULAR DISTRIBUTIONS FOR DA
     1 [illegible]
      [illegible]
   90 FORMAT ([illegible]                    A                ETA              W)
      C15=0.0
      DO 100 J=1,JMAX
      CIA(J)=1.0
      [illegible]
     1          Z(J),A(J),ETA(J),W(J)
      C1(J)=[illegible]-C4*Z(J)*(Z(J)+ETA(J))*W(J)/A(J)
      C15=C15+C1(J)
      ZP=Z(J)**(1.0/3.0)
      C2(J)=100.0/(15.0+ZP)
      AS=(Z(J)/137.0)**2
      [illegible]*(1.0/(1.0+AS)+0.2020-0.0369*AS+0.0083*(AS*AS)-0.002*
     [illegible]
      [illegible]
  100 C3(J)=0.[illegible]
      C15=C15+C15
      [illegible]
      [illegible]
  102 [illegible]
      [illegible]
      P(NPTS)=[illegible]
      DO 105 [illegible]
  105 R(K)=R(K)
      [illegible]
      [illegible]
      [illegible] NPTS,NMAX,NDIF,IMAX,NMAX
  107 FORMAT ([illegible])
      [illegible] (R(K),K=1,NMAX)
      [illegible]
      [illegible]
      [illegible]=[illegible]/[illegible]
      DELTA=[illegible]/2.0
```

```
      DO 110 L=1,NANG
  110 CHIS(L)=1.0-CCHI(L-1)*CCHI
      CHIS(1)=1.0
      CHIS(NANG)=0.0
      DO 120 L=1,NANG,2
      M=NANG1-(L+1)/2
  120 CHIM(M)=CHIS(L)
  140 FORMAT (10F10.5)
      WRITE (6,150)
  150 FORMAT (55HNORMALIZED CUMULATIVE PROBABILITIES)
      WRITE (6,140)
     1            (P(NP),NP=1,NPTS)
      GO TO (152,154),IPRT
  152 WRITE (6,154)
  154 FORMAT (55HNCHI FOR DIFFERENTIAL DISTRIBUTIONS)
      WRITE (6,140)
     1            (CHIS(L),L=1,NANG)
  160 DO 340 K=1,NKMAX
      R(K)=(K/2.0-.25)
      DELTA=SQRT(10.*(10.+2.5*T)/(T+10.))
      DO 170 K=1,NKMAX
  170 ER(K)=R(K)*DELTA
      CALL DRAX1 (10,KMAX,ER,NANG,CHIS,XIS,CTHS)
      NK=1
      DO 340 K=1,KMAX
      ACS(KMAX)=0.0
      DO 180 L=2,NANG/2
      M=NANG1-(L+1)/2
  180 ACS(M)=ACS(M+1)+S(L-2,K)+4.0*S(L-1,K)+S(L,K)
      DS=ACS(1)
      DO 182 M=1,KMAX
  182 ACS(M)=ACS(M)/DS
      DS=DS*DELTA
      DO 190 NP=1,NPTS
      CALL GPOL (P(NP),ACS,CHIP,KMAX,CHI(NP))
      IF (CHI(NP).GE.0.0) GO TO 192
      CHI(NP)=0.0
      GO TO 196
  192 IF (CHI(NP).LE.1.0) GO TO 196
      CHI(NP)=1.0
  196 CONTINUE
      WRITE (11,199) (CHI(NP),NP=1,NPTS)
  199 FORMAT (1P5E15.7)
      IF (K.NE.KPRINT(NK)) GO TO 340
      IF (NK.GE.NKMAX) GO TO 230
      NK=NK+1
  230 GO TO (265,275),IPRT
  265 DO 270 L=1,NANG
  270 S(L,K)=S(L,K)/DS
  275 DO 280 NP=1,NPTS
      XI(NP)=(2.0*DELTA*CHI(NP)+1.0-BETA)/(1.0+BETA)
  280 CHI(NP)=(1.0-(1.0-BETA)/XI(NP))/BETA
      DS=DS*ER(K)
      ER(K)=0.51099*ER(K)
      WRITE (6,290) NT(K),KP(K),ER(K),DS
  290 FORMAT (5H0T(,I5,3H) =1PE11.4,7H MEV      K/T =1PE5.3,9H      K =1PE
     111.4,15H MEV      K*DS/DK =1PE11.4,8H CM2/G)
      WRITE (6,325)
```

```
325 FORMAT (35H0  CHI FOR CUMULATIVE PROBABILITIES)
    WRITE (6,240)
   1            (CHI(NP),NP=1,NPTS)
    WRITE (6,330)
330 FORMAT (34H0  XI FOR CUMULATIVE PROBABILITIES)
    WRITE (6,240)
   1            (XI(NP),NP=1,NPTS)
    WRITE (6,335)
335 FORMAT (35H0  CTH FOR CUMULATIVE PROBABILITIES)
    WRITE (6,240)
   1            (CTH(NP),NP=1,NPTS)
    GO TO (336,340),IPRT
336 WRITE (6,337)
337 FORMAT (35H0  XI FOR DIFFERENTIAL DISTRIBUTION)
    WRITE (6,240)
   1            (XIS(L),L=1,NANG)
240 FORMAT (1P10 12.4)
    WRITE (6,338)
338 FORMAT (36H0  CTH FOR DIFFERENTIAL DISTRIBUTION)
    WRITE (6,240)
   1            (CTHS(L),L=1,NANG)
    WRITE (6,339)
339 FORMAT (39H0  NORMALIZED DIFFERENTIAL DISTRIBUTION)
    WRITE (6,240)
   1            (S(L,K),L=1,NANG)
340 CONTINUE
    RETURN
    END
```

```
      SUBROUTINE BRAXI (TO,KMAX,EK,NANG,CHI,XI,CTH), 14 JUL 67.
      SUBROUTINE BRAXI (TO,KMAX,EK,NANG,CHI,XI,CTH)
      DIMENSION  CHI(51),CTH(51),EK(51),XI(51)
      COMMON  /BRAS/ C1(20),C1S,C2(20),C3(20),C4(20),S(51,51),JMAX
      EO=TO+1.0
      EO2=EO**2
      PO2=TO*(TO+2.0)
      PO=SQRT (PO2)
      BETA=PO/EO
      DO 10 L=1,NANG
      XI(L)=(2.0*BETA*CHI(L)+1.0-BETA)/(1.0+BETA)
   10 CTH(L)=(1.0-(1.0-BETA)/XI(L))/BETA
      IF (TO.GT.30.0) GO TO 160
      DEN1=(1.0-BETA)*EO
      DEN2=DEN1*PO2
      DEN3=DEN2*(DEN1**2)
      SAC2=8.0*(2.0*EO2+1.0)/DEN3
      FAC10=4.0/DEN1
      IF (TO.GT.4.0) GO TO 60
      DO 30 K=1,KMAX
      E=EO-EK(K)
      E2=E**2
      P=SQRT (((TO-EK(K))+2.0)*(TO-EK(K)))
      EOE=EO*E
      POP=PO*P
      EK2=EK(K)**2
      EOEFAC=PO2-EK(K)*EO
      POPFAC=SQRT(PO2*(PO2-2.0*EK(K)*EO+EK2))
      DEN=EOEFAC-POPFAC
      IF (DEN.GT.0.0) GO TO 20
      EL=ALOG((EOEFAC+POPFAC)/(0.5*EK2*(1.0/(BETA**2)-1.0)))
      GO TO 30
   20 EL=ALOG((EOEFAC+POPFAC)/DEN)
   30 EPS=ALOG((1.0+(P/E))/(1.0-(P/E)))
      FAC1=C1S*P/((1.0+BETA)*EO*PO*EK(K))
      FAC2=SAC2
      FAC3=2.0*(3.0*EO2+2.0*EOE+3.0)/DEN2
      FAC4=2.0*(PO2-EK2)/DEN1
      FAC5=4.0*E/PO2
      FAC6=4.0*EO*(3.0*EK(K)-PO2*E)/DEN3
      FAC7=(4.0*EO2*(EO2+E2)+2.0-2.0*(7.0*EO2-3.0*EOE+E2))/DEN2
      FAC8=2.0*EK(K)*(EO2+EOE-1.0)/PO2
      FAC9=4.0*EPS/P
      FAC11=6.0*EK(K)
      FAC12=2.0*EK(K)*(PO2-EK2)
      DO 40 L=1,NANG
      Q2=PO2+EK2-2.0*PO*EK(K)*CTH(L)
      Q=SQRT (Q2)
      EPSQ=ALOG((Q+P)/(Q-P))
   40 S(L,K)=FAC1*(FAC2*((XI(L)**3)*(1.0-CTH(L)**2))-(FAC3+
     1    FAC4/Q2)*XI(L)+FAC5+(EL/POP)*(FAC6*((XI(L)**3)*(1.0-
     2    CTH(L)**2))+FAC7*XI(L)+FAC8)-FAC9+(EPSQ/(P*Q))*(FAC10*XI(L)-
     3    FAC11-FAC12/Q2))/XI(L)
   50 CONTINUE
      RETURN
   60 DO 150 K=1,KMAX
      DO 80 L=1,NANG
```

```
80 S(L,K)=0.0
   L=L0-LK(K)
   L2=L**2
   DO 140 L=1,NN
   U=E02/(L2(U)+E2)
   IF (DELTA.EQ.0) GO TO 110
90 FAC1=4.0*C1(L)*DELTA/((1.0+DELTA)*E02*EK(K))
   FAC2=E02*E2
   FAC3=2.0*E02+E2
   DELTA=EK(K)/FAC3
   OMMFAC=ALOG(DELTA)+2.0
   FAC4=C4(L)/DELTA
   DO 100 L=1,NN
   SFAC=FAC4*X1(L)
   CALL SCHECK (SFAC,SF)
   SFAC=SF-SFAC
100 S(L,K)=S(L,K)+FAC1*(FAC2*(OMMFAC-2.0*GAM)-FAC3*(1.0+4.0*(1.0-X1(L))*
  1   X1(L)*OMMFAC))
   GO TO 140
110 P=SQRT(((1.0-L (K))+L.0)*(1.0-EK(K)))
   P2=P**2
   P0=P0+P
   EK2=EK(K)**2
   E2EFAC=P02-L(K)*E0
   FOMFAC=SQRT(P02*(P02-2.0*EK(K)*E0+EK2))
   SUMFAC=E2EFAC-FOMFAC
   IF (SUMFAC.LE.0.0) GO TO 112
   DELFAC=(E02-FOMFAC)/(P.0*EK2*(1.0/(BETA**2)-1.0)))
   GO TO 117
112 DELFAC=E02/((P*E0+P0*FOMFAC)/DEN2)
117 FAC5=DELFAC*(1.0+(P/L))/(1.0-(P/L)))
   FAC1=4.0*C1(L)*P/((1.0+DELTA)*E0*P0*EK(K))
   FAC2=DELFAC
   FAC3=2.0*(3.0*E0L+2.0*E0L+3.0)/DEN2
   FAC4=4.0*(P02-EK2)/DEN1
   FAC5=1.0*L/P2
   FAC6=4.0*E0*(3.0+EK(K)-P02*L)/DEN3
   FAC7=(4.0*E0*(E02+E2)+2.0-2.0*(7.0*E02-3.0*E0F+E2))/DEN2
   FAC8=(1.0/(P02-1.0)/P02
   FAC9=4.0*P0/P
   FAC10=3.0*EK(K)
   FAC11=2.0*EK(K)*(P02-EK2)
   DO 120 L=1,NN
   SUMFAC=(L-2.0*E0)*EK(K)*CTH(L)
   IF (SUMFAC.LE.0.0)
   SUMFAC=SUMFAC/(SUMFAC+1.0)
120 S(L,K)=S(L,K)+FAC1*(FAC2*((XI(L)**3)*(1.0-CTH(L)**2))-(FAC3+
  1   FAC4/(1.0-XI(L))+FAC5+(EL/P0F)*(FAC6*((XI(L)**3)*(1.0-
  2   CTH(L)**2))/(FAC7*XI(L)+FAC8)-FAC9+(EPS0/(P*0))*(FAC10*XI(L)-
  3   FAC11-FAC6*(L/2))/XI(L)
140 CONTINUE
150 CONTINUE
    RETURN
160 DO 190 K=1,NN
    DO 170 L=1,NN
170 S(L,K)=0.0
    L=L0-LK(K)
    L2=L**2
```

```
      DO 180 J=1,[illegible]
      FAC1=4.0*C1([illegible])*DELTA/((1.0+DELTA)*EO2*EK(K))
      FAC2=EO2+EE
      FAC3=2.0*EO*[illegible]
      DELTA=EK(K)/FAC3
      GAMFAC=ALOG(DELTA)+C3(J)
      ARG=C4(J)/DELTA
      DO 180 L=1,[illegible]
      SARG=ARG*X1([illegible])
      CALL SCREE[illegible]
      GAM=SF-GAMFAC
  180 S(L,K)=S(L,K)+FAC1*(FAC2*(3.0+2.0*GAM)-FAC3*([illegible]*
     1    X1(L)*GAM))
  190 CONTINUE
      RETURN
      END
```

```
C     SUBROUTINE SCREEN (ARG,ANS), 14 JUL 67.
      SUBROUTINE SCREEN (ARG,ANS)
C        CALCULATION OF SCREENING FACTOR FOR THOMAS-FERMI MODEL AS USED
C        BY MOLIERE.
      DIMENSION  A(3),B(3)
      DATA  (A(I),I=1,3)/0.1,0.55,0.35/,(B(I),I=1,3)/1.0,0.2,0.05/
      FAC1=0.0
      FAC2=0.0
      DO 120 I=1,3
      TI=(ARG*B(I))**2
      IF (TI.GT.0.1) GO TO 40
      TL=0.0
      W=1.0
      DO 20 N=1,9
      W=W*TI/FLOAT (N)
      IF ((ABS(W)/TI).LT.1.0E-09) GO TO 50
   20 TL=TL+W
      GO TO 50
   40 TL=EXP(1.0+TI)
   50 FAC1=FAC1+TL*(A(I)**2)
      DO 120 J=1,3
      IF (I.EQ.J) GO TO 120
      TJ=(ARG*B(J))**2
      IF (TJ.GT.0.1) GO TO 100
      TL=0.0
      W=1.0
      DO 80 N=1,9
      W=W*TJ/FLOAT (N)
      IF ((ABS(W)/TJ).LT.1.0E-09) GO TO 110
   80 TL=TL+W
      GO TO 110
  100 TL=EXP(1.0+TJ)
  110 FAC2=FAC2+A(I)*A(J)*((1.0+TJ)*TL/(TI-TJ)+0.5)
  120 CONTINUE
      ANS=0.5*FAC1+FAC2
      RETURN
      END
```

```
C     SUBROUTINE [illegible]
      SUBROUTINE [illegible]
      DIMENSION [illegible] (25),C [illegible] (20),CZ(20),ICZ(20),[illegible](50),S(50),
     1   SCU(20),[illegible](20),[illegible]
      COMMON [illegible] (20,2),C(20,2),CUFP(20),[illegible](20,2),DRG(501),
     1   E(501),[illegible] (20),[illegible](20),[illegible]FC(20),[illegible](20),PI(20),
     2   PID(20),[illegible] (20,2),[illegible](501),[illegible],T(501),TAO(1[illegible]),[illegible](20,2),
     3   X1(20,2),[illegible],IC[illegible],I[illegible],IC1,IP,I[illegible],17,[illegible]),[illegible],
     4   [illegible],[illegible],[illegible],[illegible],[illegible],[illegible],[illegible],[illegible],[illegible],[illegible],
     5   [illegible],[illegible],[illegible],[illegible]
      DATA [illegible]/22/,([illegible]=1,22)/1[illegible],50.[illegible],45.[illegible],[illegible],35.[illegible],30.[illegible],[illegible],
     1   20.0,1[illegible],1[illegible],14.[illegible],12.[illegible],1[illegible],[illegible],8.0,7.[illegible],[illegible],5.0,4.0,3.[illegible],2.[illegible],
     2   1.0/,([illegible]=1,22)/17.0,17.0,16.9,16.8,16.7,16.4,16.1,15.6,
     3   15.5,15.0,14.6,14.[illegible],13.2,12.8,12.3,11.7,11.0,10.0,8.8,6.9,3.5,
     4   0.0/,RAS/50.0/,SAS/17.0/
   40 FORMAT (10F[illegible])
      WRITE (6,70)
   70 FORMAT (20X1 X-RAY PROBABILITY)
      WRITE (11,80) NSET
   80 FORMAT (35H X X-RAY PRODUCTION FOR DATAPAC SET14,35H
     1                    )
      WRITE (6,90)
   90 FORMAT (57H0          Z            A              W          IK(MEV)
     1WK)
      DO 210 J=1,JMAX
      WK(J)=1.0
      PK(J)=(1.0E-03)*PK(J)
      WRITE (6,40)
     1          Z(J),[illegible](J),[illegible](J),[illegible](J),WK(J)
      IF (Z(J).GT.1.0) GO TO 200
      CON(J)=1.4111E 03*W(J)*WK(J)/A(J)
      GO TO 210
  200 CON(J)=2.6222E 03*W(J)*WK(J)/(A(J)*((Z(J)-0.5)**2))
  210 CONTINUE
      IF (JMAX.GT.1) GO TO 2100
      IPRT=2
      GO TO 2120
 2100 IPRT=1
      WRITE (6,2110)
 2110 FORMAT (74H0      [illegible]      ENERGY              TOTAL      PERCENT PROBABIL
     1ITY OF CONSTITUENTS)
      WRITE (6,211) ([illegible])
  211 FORMAT ([illegible]                  [illegible])          PROB/RAD    Z=[illegible]
 2120 DO 230 N=1,[illegible]
      EISQ=(T(N)/0.5[illegible]+1.[illegible]**2
      CN(N)=0.0
      DO 225 J=1,JMAX
      R=T(N)/PK(J)
      IF (R-1.0) 2[illegible]
  212 A[illegible]=0.0
      GO TO 225
  214 IF (R-RAS) [illegible]
  216 A[illegible]=SAS
      GO TO 22[illegible]
  218 CALL [illegible]
  220 CZ(J)=CO[illegible]
  225 CN(N)=CN(N)+CZ(J)
```

```
      IF (CQ(N).GT.0.0) GO TO 227
      DO 226 J=1,JMAX
  226 ICZ(J)=0.0
      CQZ(N)=0.0
      GO TO 2260
  227 DO 228 J=1,JMAX
  228 ICZ(J)=100.0*CZ(J)/CQ(N)+0.5
      TFAC=2ISQ/(2ISQ-1.0)
      CQ(N)=TFAC*CQ(N)
      CQZ(N)=TFAC*CZ(JMAX)
 2280 GO TO (2290,230),IPRT
 2290 WRITE (6,229) N,T(N),CQ(N),(ICZ(J),J=1,JMAX)
  229 FORMAT (1H,1P2E18.7,10,1914)
  230 CONTINUE
      GO TO (232,234),IPRT
  232 WRITE (6,233)
  233 FORMAT (31H1 -IONIZATION FOR THE HIGHEST Z)
  234 DO 235 N=1,NMAX
  235 CQP(N)=0.5*(CQZ(N)+CQZ(N+1))*DRG(N)
      SCQ(1)=CQP(1)
      DO 240 N=2,NMAX
  240 SCQ(N)=SCQ(N-1)+CQP(N)
      CQP(NMAX1)=0.0
      SCQ(NMAX1)=0.0
      WRITE (6,260)
  260 FORMAT (75H0      N       ENERGY (MEV)          PROB/PATH          NUM IN
     1STEP          COMMON)
      WRITE (6,270)
  270 FORMAT (1H )
      DO 300 N=1,NMAX1
      WRITE (6,280) N,T(N),CQZ(N),CQP(N),SCQ(N)
  280 FORMAT (1C,1P4E18.7)
  300 CONTINUE
      WRITE (11,310) (CQZ(N),N=1,NMAX1)
  310 FORMAT (1P8E15.7)
  320 CONTINUE
      RETURN
      END
```

APPENDIX C

Printout of Sample Run of ETRAN 15

DATAPAC-4, SET 56 - [illegible], 2 MEV, 8/4. 11 MAR 68

NSET	ITRM	IZIP	ISOR	ISUB	INEL	ICYC	NCYC	NMAX	EMAX
56	5	13	1	4	1	1	8	17	2.00000+00

INPUT DATA TAPE IDENTIFICATION
DATATAPE-1 (MOTZ PHI-RAD CORR), 54 STERNHEIMER SETS, Z=1-100. 31 JAN 68

RANGE TABLE

EMAX	NCYC	EFAC	NMAX	T(NMAX+1)	NCAL	T(NCAL)
2.00000+00	8	9.17304-01	17	4.58502-01	89	9.76562-04

JMAX	LMAX
1	1

Z	A	W
13.00000	26.98000	1.00000

PI	PID
163.00000	.00000

----------PARAMETERS FOR DENSITY EFFECT----------

PI	C	S	DM	X1	X0
150.00000	-4.16000	.03600	4.25000	3.00000	.39000
163.00000	-4.21000	.09060	3.51000	3.00000	.05000

PHI RAD / PHI BAR

I	T (MEV)	PHI RAD/PHI BAR 13
1	999.99994	17.1479
2	799.99994	17.0829
3	599.99995	16.9614
4	500.00000	16.9053
5	400.00000	16.7964
6	300.00000	16.6375
7	200.00000	16.6497
8	150.00000	16.0976
9	100.00000	15.6723
10	80.00000	15.5980
11	60.00000	15.6015
12	50.00000	14.7226
13	40.00000	14.5554
14	30.00000	13.6341
15	20.00000	13.0164
16	15.00000	12.5615
17	10.00000	11.4165
18	8.00000	10.8936
19	6.00000	10.5822
20	5.00000	10.1260
21	4.00000	9.7545
22	3.00000	9.3952
23	2.00000	8.6753
24	1.50000	8.5022

25	1.00000	0.0762
26	.00000	7.3465
27	.00000	7.3564
28	.00000	7.3598
29	.40000	7.4175
30	.00000	0.0025
31	.20000	0.3009
32	.15000	0.4033
33	.10000	0.3521
34	.00000	0.3063
35	.05000	0.2809
36	.05000	0.2975
37	.04000	0.3091
38	.00010	0.4040
39	.02300	0.0007
40	.01500	0.7572
41	.01000	0.7071
42	.00800	7.3241
43	.00300	7.1119
44	.00200	7.1560
45	.00400	7.2307
46	.00300	7.2564
47	.00200	7.2701
48	.00100	7.3209
49	.00100	7.3444

ELECTRON RESULTS

EFFECTIVE Z/A = .4931 EFFECTIVE MEAN IONIZATION POTENTIAL = 163.00 EV CRITICAL ENERGY = .000 MEV

N	ENERGY MEV	STOPPING POWER COLLISION MEV CM2/G	RADIATION MEV CM2/G	TOTAL MEV CM2/G	RANGE G/CM2	RADIATION YIELD	BETA**2	DENSITY CORR MEV CM2/G	RAD/COL	DRANGE G/CM2	DYIELD
39	9.7656-04	7.543+01	8.655-03	7.543+01	6.473-06	0.000	3.811-03	0.000	1.174-04	0.000	0.000
38	1.0649-03	7.227+01	8.652-03	7.227+01	7.670-06	9.954-06	4.155-03	0.000	1.225-04	1.197-06	1.060-08
37	1.1613-03	6.911+01	8.643-03	6.912+01	9.034-06	1.952-05	4.530-03	0.000	1.280-04	1.364-06	1.207-08
36	1.2684-03	6.599+01	8.644-03	6.600+01	1.059-05	2.878-05	4.939-03	0.000	1.340-04	1.557-06	1.377-08
35	1.3811-03	6.291+01	8.639-03	6.292+01	1.237-05	3.778-05	5.384-03	0.000	1.405-04	1.779-06	1.573-08
34	1.5001-03	5.989+01	8.634-03	5.990+01	1.441-05	4.659-05	5.869-03	0.000	1.475-04	2.037-06	1.800-08
33	1.6424-03	5.694+01	8.629-03	5.695+01	1.674-05	5.528-05	6.398-03	0.000	1.551-04	2.335-06	2.062-08
32	1.7910-03	5.407+01	8.624-03	5.408+01	1.942-05	6.390-05	6.974-03	0.000	1.632-04	2.680-06	2.365-08
31	1.9531-03	5.129+01	8.618-03	5.130+01	2.250-05	7.250-05	7.601-03	0.000	1.719-04	3.079-06	2.716-08
30	2.1299-03	4.860+01	8.611-03	4.861+01	2.604-05	8.114-05	8.285-03	0.000	1.813-04	3.541-06	3.122-08
29	2.3227-03	4.601+01	8.605-03	4.602+01	3.012-05	8.987-05	9.029-03	0.000	1.913-04	4.078-06	3.591-08
28	2.5329-03	4.351+01	8.796-03	4.352+01	3.482-05	9.873-05	9.841-03	0.000	2.021-04	4.700-06	4.135-08
27	2.7621-03	4.112+01	8.787-03	4.113+01	4.024-05	1.078-04	1.072-02	0.000	2.137-04	5.421-06	4.766-08
26	3.0121-03	3.883+01	8.777-03	3.884+01	4.650-05	1.171-04	1.169-02	0.000	2.261-04	6.258-06	5.496-08
25	3.2847-03	3.664+01	8.767-03	3.665+01	5.373-05	1.267-04	1.273-02	0.000	2.393-04	7.230-06	6.342-08
24	3.5820-03	3.454+01	8.755-03	3.455+01	6.209-05	1.366-04	1.387-02	0.000	2.534-04	8.359-06	7.323-08
23	3.9062-03	3.255+01	8.742-03	3.256+01	7.176-05	1.469-04	1.512-02	0.000	2.686-04	9.671-06	8.460-08
22	4.2598-03	3.065+01	8.728-03	3.066+01	8.295-05	1.577-04	1.647-02	0.000	2.847-04	1.119-05	9.778-08
21	4.6453-03	2.885+01	8.712-03	2.886+01	9.592-05	1.689-04	1.794-02	0.000	3.020-04	1.297-05	1.131-07
20	5.0658-03	2.714+01	8.695-03	2.715+01	1.109-04	1.807-04	1.954-02	0.000	3.204-04	1.503-05	1.308-07
19	5.5243-03	2.552+01	8.677-03	2.553+01	1.284-04	1.931-04	2.128-02	0.000	3.400-04	1.742-05	1.513-07
18	6.0243-03	2.399+01	8.657-03	2.399+01	1.486-04	2.062-04	2.317-02	0.000	3.609-04	2.021-05	1.752-07
17	6.5695-03	2.253+01	8.636-03	2.254+01	1.720-04	2.199-04	2.523-02	0.000	3.832-04	2.346-05	2.028-07
16	7.1641-03	2.116+01	8.613-03	2.117+01	1.993-04	2.345-04	2.746-02	0.000	4.070-04	2.723-05	2.349-07
15	7.8125-03	1.987+01	8.588-03	1.987+01	2.309-04	2.498-04	2.989-02	0.000	4.323-04	3.163-05	2.720-07
14	8.5196-03	1.864+01	8.563-03	1.865+01	2.677-04	2.661-04	3.253-02	0.000	4.593-04	3.675-05	3.151-07
13	9.2907-03	1.749+01	8.536-03	1.750+01	3.104-04	2.833-04	3.540-02	0.000	4.880-04	4.270-05	3.651-07
12	1.0132-02	1.641+01	8.509-03	1.642+01	3.600-04	3.015-04	3.851-02	0.000	5.185-04	4.964-05	4.230-07
11	1.1049-02	1.539+01	8.480-03	1.540+01	4.177-04	3.209-04	4.188-02	0.000	5.510-04	5.771-05	4.902-07
10	1.2049-02	1.443+01	8.449-03	1.444+01	4.848-04	3.414-04	4.554-02	0.000	5.856-04	6.711-05	5.681-07
9	1.3139-02	1.353+01	8.418-03	1.354+01	5.629-04	3.632-04	4.951-02	0.000	6.223-04	7.806-05	6.583-07
8	1.4328-02	1.268+01	8.386-03	1.269+01	6.537-04	3.863-04	5.381-02	0.000	6.613-04	9.080-05	7.628-07
7	1.5625-02	1.189+01	8.354-03	1.189+01	7.593-04	4.108-04	5.846-02	0.000	7.028-04	1.056-04	8.840-07
6	1.7039-02	1.114+01	8.322-03	1.115+01	8.822-04	4.368-04	6.350-02	0.000	7.469-04	1.229-04	1.024-06
5	1.8561-02	1.044+01	8.286-03	1.045+01	1.025-03	4.644-04	6.895-02	0.000	7.934-04	1.430-04	1.187-06
4	2.0263-02	9.789+00	8.256-03	9.797+00	1.191-03	4.938-04	7.483-02	0.000	8.434-04	1.663-04	1.375-06
3	2.2097-02	9.177+00	8.229-03	9.185+00	1.385-03	5.249-04	8.119-02	0.000	8.968-04	1.935-04	1.595-06
2	2.4097-02	8.604+00	8.205-03	8.612+00	1.610-03	5.581-04	8.804-02	0.000	9.537-04	2.250-04	1.849-06
1	2.6276-02	8.068+00	8.174-03	8.076+00	1.872-03	5.933-04	9.543-02	0.000	1.013-03	2.617-04	2.142-06
50	2.8656-02	7.568+00	8.162-03	7.576+00	2.176-03	6.308-04	1.034-01	0.000	1.079-03	3.043-04	2.485-06
49	3.1250-02	7.100+00	8.157-03	7.108+00	2.529-03	6.707-04	1.119-01	0.000	1.149-03	3.537-04	2.885-06
48	3.4078-02	6.663+00	8.151-03	6.672+00	2.940-03	7.134-04	1.211-01	0.000	1.223-03	4.110-04	3.350-06
47	3.7163-02	6.256+00	8.164-03	6.264+00	3.418-03	7.590-04	1.310-01	0.000	1.305-03	4.774-04	3.894-06
46	4.0526-02	5.876+00	8.191-03	5.884+00	3.972-03	8.078-04	1.416-01	0.000	1.394-03	5.544-04	4.533-06
45	4.4194-02	5.522+00	8.241-03	5.530+00	4.616-03	8.604-04	1.529-01	0.000	1.492-03	6.434-04	5.286-06
44	4.8194-02	5.192+00	8.295-03	5.200+00	5.362-03	9.170-04	1.649-01	0.000	1.598-03	7.464-04	6.171-06
43	5.2555-02	4.885+00	8.353-03	4.893+00	6.227-03	9.780-04	1.778-01	0.000	1.710-03	8.652-04	7.203-06
42	5.7513-02	4.599+00	8.414-03	4.608+00	7.230-03	1.043-03	1.915-01	0.000	1.829-03	1.002-03	8.405-06
41	6.2500-02	4.334+00	8.490-03	4.342+00	8.390-03	1.114-03	2.061-01	0.000	1.959-03	1.160-03	9.808-06
40	6.8157-02	4.087+00	8.579-03	4.095+00	9.732-03	1.189-03	2.215-01	0.000	2.099-03	1.342-03	1.146-05

39	7.4325-02	3.657+00	8.662-03	3.866+00	1.126-02	1.271-03	2.378-01	0.000	2.251-03	1.551-03	1.339-05
38	8.1052-02	3.645+00	8.796-03	3.653+00	1.307-02	1.359-03	2.551-01	0.000	2.414-03	1.791-03	1.565-05
37	8.8388-02	3.447+00	8.927-03	3.456+00	1.514-02	1.453-03	2.732-01	0.000	2.590-03	2.066-03	1.831-05
36	9.6388-02	3.265+00	9.073-03	3.274+00	1.752-02	1.555-03	2.922-01	0.000	2.779-03	2.380-03	2.142-05
35	1.0511-01	3.095+00	9.234-03	3.105+00	2.026-02	1.664-03	3.121-01	0.000	2.983-03	2.738-03	2.506-05
34	1.1465-01	2.939+00	9.413-03	2.948+00	2.340-02	1.782-03	3.329-01	0.000	3.203-03	3.146-03	2.934-05
33	1.2500-01	2.794+00	9.611-03	2.804+00	2.702-02	1.909-03	3.545-01	0.000	3.439-03	3.610-03	3.434-05
32	1.3631-01	2.661+00	9.819-03	2.671+00	3.115-02	2.045-03	3.768-01	0.000	3.690-03	4.137-03	4.017-05
31	1.4865-01	2.536+00	1.007-02	2.548+00	3.588-02	2.192-03	3.999-01	0.000	3.967-03	4.732-03	4.706-05
30	1.6210-01	2.425+00	1.035-02	2.435+00	4.129-02	2.350-03	4.237-01	0.000	4.267-03	5.404-03	5.517-05
29	1.7673-01	2.321+00	1.067-02	2.332+00	4.745-02	2.521-03	4.480-01	0.000	4.597-03	6.161-03	6.473-05
28	1.9278-01	2.226+00	1.101-02	2.237+00	5.446-02	2.706-03	4.728-01	0.000	4.947-03	7.010-03	7.600-05
27	2.1022-01	2.135+00	1.138-02	2.150+00	6.242-02	2.906-03	4.980-01	0.000	5.323-03	7.961-03	8.915-05
26	2.2925-01	2.059+00	1.179-02	2.070+00	7.144-02	3.121-03	5.235-01	0.000	5.726-03	9.023-03	1.046-04
25	2.5000-01	1.986+00	1.222-02	1.998+00	8.165-02	3.352-03	5.491-01	0.000	6.155-03	1.0[illegible]1-02	1.226-04
24	2.7263-01	1.915+00	1.271-02	1.925+00	9.320-02	3.602-03	5.748-01	7.218-03	6.643-03	1.155-02	1.440-04
23	2.9730-01	1.853+00	1.324-02	1.867+00	1.062-01	3.871-03	6.004-01	6.657-03	7.142-03	1.302-02	1.689-04
22	3.2421-01	1.800+00	1.384-02	1.814+00	1.209-01	4.161-03	6.257-01	6.395-03	7.690-03	1.463-02	1.980-04
21	3.5355-01	1.751+00	1.449-02	1.766+00	1.373-01	4.473-03	6.507-01	6.403-03	8.272-03	1.640-02	2.324-04
20	3.8555-01	1.708+00	1.518-02	1.723+00	1.556-01	4.808-03	6.752-01	6.661-03	8.887-03	1.835-02	2.723-04
19	4.2045-01	1.669+00	1.591-02	1.685+00	1.761-01	5.166-03	6.990-01	7.149-03	9.536-03	2.049-02	3.186-04
18	4.5850-01	1.634+00	1.667-02	1.651+00	1.989-01	5.548-03	7.222-01	7.855-03	1.020-02	2.263-02	3.716-04
17	5.0000-01	1.603+00	1.755-02	1.621+00	2.243-01	5.956-03	7.445-01	8.767-03	1.094-02	2.538-02	4.341-04
16	5.4525-01	1.576+00	1.853-02	1.595+00	2.525-01	6.393-03	7.660-01	9.881-03	1.176-02	2.816-02	5.079-04
15	5.9460-01	1.553+00	1.965-02	1.572+00	2.836-01	6.863-03	7.864-01	1.119-02	1.265-02	3.117-02	5.952-04
14	6.4842-01	1.533+00	2.095-02	1.553+00	3.181-01	7.369-03	8.058-01	1.269-02	1.360-02	3.444-02	6.974-04
13	7.0711-01	1.515+00	2.215-02	1.538+00	3.561-01	7.912-03	8.240-01	1.439-02	1.462-02	3.798-02	8.166-04
12	7.7111-01	1.501+00	2.358-02	1.525+00	3.979-01	8.495-03	8.412-01	1.628-02	1.571-02	4.181-02	9.560-04
11	8.4090-01	1.489+00	2.515-02	1.515+00	4.438-01	9.121-03	8.571-01	1.837-02	1.688-02	4.593-02	1.119-03
10	9.1700-01	1.480+00	2.686-02	1.507+00	4.942-01	9.793-03	8.720-01	2.067-02	1.815-02	5.038-02	1.310-03
9	1.0000+00	1.473+00	2.874-02	1.502+00	5.494-01	1.051-02	8.856-01	2.317-02	1.951-02	5.518-02	1.534-03
8	1.0905+00	1.468+00	3.080-02	1.499+00	6.097-01	1.129-02	8.982-01	2.588-02	2.098-02	6.034-02	1.796-03
7	1.1892+00	1.465+00	3.306-02	1.498+00	6.756-01	1.212-02	9.097-01	2.881-02	2.257-02	6.588-02	2.104-03
6	1.2966+00	1.463+00	3.549-02	1.499+00	7.474-01	1.301-02	9.201-01	3.196-02	2.425-02	7.184-02	2.463-03
5	1.4142+00	1.463+00	3.823-02	1.502+00	8.257-01	1.397-02	9.296-01	3.535-02	2.613-02	7.825-02	2.884-03
4	1.5422+00	1.465+00	4.127-02	1.506+00	9.108-01	1.501-02	9.381-01	3.897-02	2.817-02	8.512-02	3.383-03
3	1.6818+00	1.467+00	4.463-02	1.512+00	1.003+00	1.612-02	9.457-01	4.281-02	3.041-02	9.250-02	3.972-03
2	1.8340+00	1.471+00	4.833-02	1.520+00	1.104+00	1.735-02	9.525-01	4.695-02	3.289-02	1.004-01	4.671-03
1	2.0000+00	1.476+00	5.247-02	1.523+00	1.213+00	1.864-02	9.586-01	5.105-02	3.555-02	1.089-01	5.492-03

STRAGGLING PARAMETERS

N	ENERGY MEV	C/E	USG/BSG	DELTA T MEV	A*DRG MEV	B**2
88	1.0649-03	1.0905077	1.0902255	3.839-05	2.132-05	1.188+02
87	1.1613-03	1.0905077	1.0902060	9.639-05	2.228-05	1.187+02
86	1.2664-03	1.0905077	1.0901722	1.051-04	2.333-05	1.181+02
85	1.3811-03	1.0905077	1.0901420	1.146-04	2.446-05	1.171+02
84	1.5061-03	1.0905077	1.0901090	1.250-04	2.568-05	1.158+02
83	1.6424-03	1.0905077	1.0900730	1.363-04	2.701-05	1.142+02
82	1.7910-03	1.0905077	1.0900338	1.486-04	2.844-05	1.124+02
81	1.9531-03	1.0905077	1.0899911	1.621-04	2.998-05	1.103+02
80	2.1299-03	1.0905077	1.0899446	1.768-04	3.163-05	1.080+02
79	2.3227-03	1.0905077	1.0898939	1.928-04	3.342-05	1.055+02
78	2.5329-03	1.0905077	1.0898367	2.102-04	3.534-05	1.029+02
77	2.7621-03	1.0905077	1.0897735	2.292-04	3.741-05	1.002+02
76	3.0121-03	1.0905077	1.0897130	2.500-04	3.963-05	9.731+01
75	3.2847-03	1.0905077	1.0896415	2.726-04	4.202-05	9.440+01
74	3.5820-03	1.0905077	1.0895638	2.973-04	4.459-05	9.143+01
73	3.9062-03	1.0905077	1.0894792	3.242-04	4.735-05	8.842+01
72	4.2598-03	1.0905077	1.0893870	3.535-04	5.031-05	8.539+01
71	4.6453-03	1.0905077	1.0892866	3.855-04	5.350-05	8.235+01
70	5.0658-03	1.0905077	1.0891774	4.204-04	5.692-05	7.932+01
69	5.5243-03	1.0905077	1.0890585	4.585-04	6.061-05	7.631+01
68	6.0243-03	1.0905077	1.0889292	5.000-04	6.456-05	7.333+01
67	6.5695-03	1.0905077	1.0887884	5.452-04	6.882-05	7.038+01
66	7.1641-03	1.0905077	1.0886353	5.946-04	7.339-05	6.749+01
65	7.8125-03	1.0905077	1.0884689	6.484-04	7.831-05	6.464+01
64	8.5196-03	1.0905077	1.0882879	7.071-04	8.359-05	6.186+01
63	9.2907-03	1.0905077	1.0880913	7.711-04	8.928-05	5.914+01
62	1.0132-02	1.0905077	1.0878776	8.409-04	9.540-05	5.649+01
61	1.1049-02	1.0905077	1.0876454	9.170-04	1.020-04	5.391+01
60	1.2049-02	1.0905077	1.0873934	1.000-03	1.091-04	5.140+01
59	1.3139-02	1.0905077	1.0871199	1.090-03	1.167-04	4.897+01
58	1.4328-02	1.0905077	1.0868231	1.189-03	1.249-04	4.662+01
57	1.5625-02	1.0905077	1.0865013	1.297-03	1.337-04	4.435+01
56	1.7039-02	1.0905077	1.0861525	1.414-03	1.432-04	4.216+01
55	1.8581-02	1.0905077	1.0857747	1.542-03	1.534-04	4.004+01
54	2.0263-02	1.0905077	1.0853655	1.682-03	1.645-04	3.801+01
53	2.2097-02	1.0905077	1.0849229	1.834-03	1.763-04	3.606+01
52	2.4097-02	1.0905077	1.0844443	2.000-03	1.891-04	3.418+01
51	2.6278-02	1.0905077	1.0839272	2.181-03	2.029-04	3.238+01
50	2.8656-02	1.0905077	1.0833669	2.378-03	2.178-04	3.066+01
49	3.1250-02	1.0905077	1.0827667	2.594-03	2.338-04	2.901+01
48	3.4076-02	1.0905077	1.0821177	2.826-03	2.511-04	2.743+01
47	3.7163-02	1.0905077	1.0814191	3.084-03	2.697-04	2.592+01
46	4.0526-02	1.0905077	1.0806678	3.364-03	2.898-04	2.448+01
45	4.4194-02	1.0905077	1.0798608	3.668-03	3.115-04	2.311+01
44	4.8194-02	1.0905077	1.0789951	4.000-03	3.349-04	2.181+01
43	5.2556-02	1.0905077	1.0780676	4.362-03	3.601-04	2.057+01
42	5.7313-02	1.0905077	1.0770755	4.757-03	3.873-04	1.938+01
41	6.2500-02	1.0905077	1.0760160	5.187-03	4.167-04	1.826+01
40	6.8157-02	1.0905077	1.0748862	5.657-03	4.484-04	1.720+01
39	7.4325-02	1.0905077	1.0736839	6.169-03	4.827-04	1.619+01
38	8.1052-02	1.0905077	1.0724068	6.727-03	5.197-04	1.523+01
37	8.8383-02	1.0905077	1.0710531	7.336-03	5.596-04	1.432+01
36	9.6388-02	1.0905077	1.0696213	8.000-03	6.027-04	1.346+01
35	1.0511-01	1.0905077	1.0681105	8.724-03	6.492-04	1.265+01

34	1.1403-01	1.0905077	1.0665205	9.513-03	6.995-04	1.189+01
33	1.2366-01	1.0905077	1.0648515	1.037-02	7.538-04	1.116+01
32	1.3391-01	1.0905077	1.0631046	1.131-02	8.124-04	1.048+01
31	1.4485-01	1.0905077	1.0612815	1.234-02	8.757-04	9.837+00
30	1.5210-01	1.0905077	1.0593851	1.345-02	9.439-04	9.231+00
29	1.7676-01	1.0905077	1.0574169	1.467-02	1.018-03	8.661+00
28	1.9278-01	1.0905077	1.0553874	1.600-02	1.097-03	8.125+00
27	2.1022-01	1.0905077	1.0532962	1.745-02	1.183-03	7.621+00
26	2.2925-01	1.0905077	1.0511518	1.903-02	1.276-03	7.148+00
25	2.5000-01	1.0905077	1.0489617	2.075-02	1.375-03	6.704+00
24	2.7260-01	1.0905077	1.0467341	2.263-02	1.467-03	6.252+00
23	2.9730-01	1.0905077	1.0444782	2.467-02	1.605-03	5.855+00
22	3.2421-01	1.0905077	1.0422039	2.691-02	1.730-03	5.494+00
21	3.5355-01	1.0905077	1.0399214	2.934-02	1.866-03	5.154+00
20	3.8555-01	1.0905077	1.0376417	3.200-02	2.012-03	4.834+00
19	4.2045-01	1.0905077	1.0353756	3.490-02	2.169-03	4.534+00
18	4.5855-01	1.0905077	1.0331346	3.805-02	2.339-03	4.251+00
17	5.0000-01	1.0905077	1.0309296	4.150-02	2.523-03	3.987+00
16	5.4525-01	1.0905077	1.0287718	4.525-02	2.720-03	3.739+00
15	5.9460-01	1.0905077	1.0266685	4.935-02	2.933-03	3.506+00
14	6.4842-01	1.0905077	1.0246318	5.382-02	3.163-03	3.286+00
13	7.0711-01	1.0905077	1.0226592	5.869-02	3.411-03	3.084+00
12	7.7111-01	1.0905077	1.0207681	6.400-02	3.678-03	2.892+00
11	8.4096-01	1.0905077	1.0189946	6.979-02	3.966-03	2.713+00
10	9.1700-01	1.0905077	1.0172936	7.611-02	4.276-03	2.544+00
9	1.0000+00	1.0905077	1.0156896	8.300-02	4.611-03	2.387+00
8	1.0905+00	1.0905077	1.0141832	9.051-02	4.971-03	2.239+00
7	1.1892+00	1.0905077	1.0127773	9.870-02	5.360-03	2.101+00
6	1.2966+00	1.0905077	1.0114714	1.076-01	5.778-03	1.971+00
5	1.4142+00	1.0905077	1.0102645	1.174-01	6.230-03	1.849+00
4	1.5422+00	1.0905077	1.0091544	1.280-01	6.716-03	1.735+00
3	1.6818+00	1.0905077	1.0081382	1.396-01	7.239-03	1.628+00
2	1.8340+00	1.0905077	1.0072124	1.522-01	7.802-03	1.529+00
1	2.0000+00	1.0905077	1.0063727	1.660-01	8.409-03	1.435+00

DATAPREP

ANGLES

1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	12.0000	15.0000	18.0000
21.0000	24.0000	27.0000	30.0000	35.0000	40.0000	45.0000	50.0000	60.0000	70.0000	80.0000	90.0000
100.0000	110.0000	120.0000	130.0000	140.0000	150.0000	160.0000	170.0000	180.0000			

ZP	ATP	COFP	WP
13.0	26.98	-5.2	1.00000

ZEFF = 13.000 ESCAL = 0.0000 MEV NSCAL = 17

NSUB
4

MOTT/ROTH RATIO

ENERGY BASE POINTS (MEV)

1000.00000	100.00000	10.00000	7.00000	4.00000	2.00000	1.00000	.70000	.40000	.20000
.10000	.07000	.04000	.02000	.01000	.00500	.00100	.00010		

Z = 13

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000		
.93446	.93446	.93466	.93495	.93579	.93898	.94684	.95370	.96785	.98764
1.00362	1.00909	1.01409	1.01569	1.01423	1.01102	1.00163	1.00005		
.57436	.57426	.57539	.57644	.58043	.59384	.62821	.65795	.72155	.81488
.89767	.93641	.96762	.99442	1.00736	1.01235	1.00922	.99753		
.17216	.17229	.17425	.17620	.18306	.20739	.26992	.32413	.44099	.61298
.76861	.83152	.90494	.96093	.99147	1.00734	1.01793	1.00979		
.00000	.00003	.00240	.00471	.01305	.04211	.11631	.18108	.32005	.52565
.71226	.78809	.87705	.94575	.98413	1.00506	1.02250	1.02122		

CMB TABLE READ IN

DATAPREP DATA FOR DATAPAC SET 56 17 33 4 121 1.212646+00

N	E(N)	ENERG1	ENERG2	ECORR	ELRAT	COSIN	ANGLIN
1	2.00000	1.95775	1.89626	.00000	1.00000	.86139	30.52713

LMAX	ETA1	ETAMAX	HCOF1	HCOF2	HCOF3	HCOF4	HCOF5
240	4.9884-06	0.0000	-6.3359-04	-5.5202-01	-8.8108-02	4.2529-02	-7.7865-03

SINGLE SCATTERING EXPANSION COEFFICIENTS

1.19469	3.38610	6.41641	10.19864	14.66801	19.77937	25.49400	31.77906	38.60599	45.94953
53.78707	62.09611	70.88592	80.06729	89.69227	99.72401	110.14865	120.95316	132.12530	143.65367
155.52671	167.73462	180.26727	193.11523	206.26946	219.72132	233.46256	247.48521	261.78163	276.34449
291.16672	306.24148	321.56221	337.12252	352.91628	368.93750	385.18044	401.63951	418.30929	435.18458
452.26011	469.53107	486.99258	504.63995	522.46863	540.47415	558.65221	576.99858	595.50914	614.17389
633.00890	651.98535	671.11439	690.38790	709.80278	729.35573	749.04335	768.86232	788.80941	808.88145
829.07331	849.38600	869.81658	890.35793	911.00945	931.76827	952.63162	973.59686	994.66131	1015.82246
1037.07770	1058.42500	1079.86030	1101.38370	1122.99120	1144.68100	1166.45080	1188.29830	1210.22160	1232.21830
1254.28500	1276.42590	1298.62630	1320.89910	1343.23290	1365.62820	1388.08320	1410.59590	1433.16470	1455.78780
1478.45500	1501.18070	1523.96520	1546.78820	1569.65700	1592.57020	1615.52590	1638.52270	1661.55930	1684.63390
1707.74510	1730.89130	1754.07190	1777.28450	1800.52820	1823.80150	1847.10320	1870.43200	1893.78660	1917.16550
1940.56790	1963.99200	1987.43720	2010.90170	2034.38480	2057.88500	2081.40150	2104.93300	2128.47840	2152.03670
2175.60630	2199.18750	2222.77941	2246.37780	2269.98510	2293.59900	2317.21890	2340.84350	2364.47220	2388.10380
2411.73750	2435.37240	2459.00776	2482.64240	2506.27570	2529.90690	2553.53490	2577.15910	2600.77860	2624.39270

2648.00060	2671.60150	2695.19480	2718.77950	2742.35520	2765.92080	2789.47590	2813.01970	2836.55150	2860.07070
2883.57600	2907.06360	2930.54600	2954.00820	2977.45450	3000.88440	3024.29730	3047.69250	3071.06960	3094.42780
3117.76670	3141.08570	3164.38420	3187.66170	3210.91790	3234.15200	3257.36350	3280.55220	3303.71710	3326.85790
3349.97420	3373.06520	3396.13080	3419.17040	3442.18350	3465.16970	3488.12860	3511.05970	3533.96270	3556.83720
3579.63260	3602.49850	3625.26470	3648.04070	3670.76620	3693.46070	3716.12400	3738.75560	3761.35520	3783.92230
3806.45630	3828.95620	3851.42620	3873.86040	3896.26060	3918.62640	3940.95770	3963.25400	3985.51510	4007.74050
4029.93030	4052.08370	4074.20070	4096.28090	4118.32430	4140.33050	4162.29900	4184.22990	4206.12290	4227.97760
4249.79390	4271.57160	4293.31000	4315.00940	4336.66940	4358.28980	4379.87030	4401.41070	4422.91100	4444.37070
4465.79000	4487.16830	4508.50570	4529.80180	4551.05650	4572.26950	4593.44070	4614.57000	4635.65710	4656.70230
4677.70490	4698.66480	4719.58220	4740.45680	4761.28830	4782.07660	4802.82160	4823.52320	4844.18120	

MULTIPLE SCATTERING LEGENDRE COEFFICIENTS

.97216	.92304	.85924	.78580	.70702	.62656	.54740	.47183	.40152	.33754
.28046	.23044	.18732	.15070	.12003	.09469	.07401	.05733	.04403	.03353
.02532	.01893	.01411	.01041	.00763	.00555	.00401	.00288	.00205	.00146
.00103	.00072	.00050	.00035	.00024	.00016	.00011	.00008	.00005	.00003
.00002	.00002	.00001	.00001	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	

CORRECTION TO INELASTIC SCATTERING FACTOR (Z+1)/Z

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	1.00000	.93564	.92857	.92857	.92857	.92857	.92857	.92857	.92857
.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857			

CUMULATIVE MULTIPLE SCATTERING DISTRIBUTION

.00831	.03273	.07186	.12351	.18493	.25310	.32497	.39769	.46882	.65581	.78875	.87207
.92091	.94907	.96565	.97586	.98501	.99000	.99301	.99496	.99723	.99841	.99907	.99946
.99969	.99983	.99991	.99995	.99998	.99999	1.00000	1.00000	1.00000			

N	E(N)	ENERG1	ENERG2	ECORR	ELRAT	COSIN	ANGLIN
9	1.00000	.96888	.94813	.00000	1.00000	.81217	35.69137

LMAX	ETA1	HMAX	HCOF1	HCOF2	HCOF3	HCOF4	HCOF5
240	1.4871-05	0.0000	-1.0374-03	-5.0384-01	-9.0225-02	4.4248-02	-8.1761-03

SINGLE SCATTERING EXPANSION COEFFICIENTS

1.57067	4.40820	9.28215	13.06731	18.67593	25.03993	32.10345	39.81914	48.14593	57.04757
66.49164	76.44887	86.89257	97.79827	109.14337	120.90692	133.06938	145.61249	158.51911	171.77311
185.33926	199.26517	213.47120	227.97035	242.74834	257.79337	273.09425	288.64025	304.42113	320.42707
336.64664	353.07002	369.71293	386.51860	403.51581	420.68683	438.02420	455.52075	473.16951	490.96382

508.89719	526.96341	545.15645	563.47039	581.89967	600.43878	619.08244	637.82550	656.66301	675.59013
694.60219	713.69403	732.86519	752.10346	771.41137	790.78286	810.21406	829.70116	849.24050	868.82849
888.40165	908.13658	927.85002	947.59870	967.37976	987.18993	1007.02642	1026.88630	1046.76680	1066.66520
1086.57900	1106.50550	1126.44230	1146.38690	1166.33700	1186.29040	1206.24470	1226.19780	1246.14750	1266.09200
1286.02910	1305.95000	1325.87340	1345.77710	1365.66590	1385.53800	1405.39180	1425.22580	1445.03820	1464.82770
1484.59240	1504.33110	1524.04230	1543.72450	1563.37630	1582.99670	1602.58400	1622.13720	1641.65490	1661.13610
1680.57940	1699.98390	1719.34840	1738.67180	1757.95320	1777.19150	1796.38570	1815.53490	1834.63830	1853.69480
1872.70370	1891.66400	1910.57500	1929.43600	1948.24590	1967.00420	1985.71020	2004.36320	2022.96230	2041.50710
2059.99690	2078.43110	2096.80910	2115.13030	2133.39410	2151.60000	2169.74760	2187.83610	2205.86520	2223.83450
2241.74320	2259.59120	2277.37810	2295.10320	2312.76650	2330.36730	2347.90530	2365.38020	2382.79180	2400.13960
2417.42300	2434.64270	2451.79740	2468.88730	2485.91200	2502.87120	2519.76480	2536.59230	2553.35390	2570.04910
2586.67750	2603.23590	2619.73520	2636.16340	2652.52450	2668.81820	2685.04470	2701.20350	2717.29490	2733.31840
2749.27420	2765.16200	2780.98190	2796.73370	2812.41740	2828.03300	2843.58020	2859.05930	2874.46990	2889.81220
2905.08600	2920.29150	2935.42660	2950.49730	2965.49760	2980.42960	2995.29310	3010.08840	3024.81560	3039.47430
3054.06500	3068.58730	3083.04160	3097.42790	3111.74620	3125.99640	3140.17890	3154.29370	3168.34080	3182.32040
3196.23250	3210.07730	3223.85470	3237.56500	3251.20810	3264.78440	3278.29400	3291.73680	3305.11310	3318.42280
3331.66610	3344.84320	3357.95400	3370.99880	3383.97770	3396.89090	3409.73850	3422.52060	3435.23750	3447.88910
3460.47500	3472.99740	3485.45440	3497.84680	3510.17490	3522.43880	3534.63870	3546.77480	3558.84720	3570.85620
3582.80200	3594.68470	3606.50400	3618.26170	3629.95630	3641.58850	3653.15850	3664.66650	3676.11290	3687.49770
3698.82110	3710.08320	3721.28440	3732.42490	3743.50480	3754.52440	3765.48360	3776.38300	3787.22270	

MULTIPLE SCATTERING LEGENDRE COEFFICIENTS

.95919	.88965	.80278	.70709	.60935	.51470	.42677	.34778	.27886	.22022
.17142	.13163	.09978	.07472	.05530	.04048	.02932	.02102	.01493	.01050
.00732	.00507	.00347	.00237	.00160	.00107	.00071	.00047	.00031	.00020
.00013	.00009	.00006	.00004	.00002	.00001	.00001	.00001	.00000	.00000
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.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	

CORRECTION TO INELASTIC SCATTERING FACTOR (Z+1)/Z

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	1.00000	1.00000	.93796	.92857	.92857	.92857	.92857	.92857	.92857
.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857			

CUMULATIVE MULTIPLE SCATTERING DISTRIBUTION

.00570	.02257	.04992	.08665	.13134	.13237	.23799	.29645	.35611	.52850	.67235	.77903
.85222	.90025	.93124	.95134	.97104	.98109	.98696	.99068	.99490	.99705	.99825	.99895
.99938	.99963	.99979	.99988	.99994	.99997	.99999	1.00000	1.00000			

N E(N) ENERG1 ENERG2 ECORR ELRAT COSIN ANGLIN

17	.50000	.48444	.47406	.00000	1.00000	.77134	39.52532

LMAX	ETA1	MMAX	HCOF1	HCOF2	HCOF3	HCOF4	HCOF5
240	3.9560-05	1.0643-31	-1.5192-03	-4.1551-01	-9.8763-02	5.0729-02	-9.6715-03

SINGLE SCATTERING EXPANSION COEFFICIENTS

1.83337	5.06982	9.42411	14.73942	20.90498	27.83490	35.45680	43.71719	52.55865	61.93797
71.81495	82.15538	92.92055	104.08653	115.62389	127.50735	139.71346	152.22049	165.00815	178.05748
191.35674	204.37124	218.60332	232.53219	246.64391	260.92529	275.36385	289.94779	304.66588	319.50748
334.46249	349.52127	364.67469	379.91405	395.23102	410.61770	426.06654	441.57033	457.12219	472.71559
488.34423	504.00212	519.68355	535.38301	551.09528	566.81536	582.53846	598.26001	613.97562	629.68110
645.37244	661.04582	676.69755	692.32415	707.92223	723.48858	739.02014	754.51398	769.96726	785.37731
800.74158	816.05759	831.32305	846.53570	861.69342	876.79416	891.83599	906.81710	921.73569	936.59010
951.37370	966.09999	980.75251	995.33489	1009.84585	1024.28410	1038.64870	1052.93820	1067.15180	1081.28840
1095.34710	1109.32710	1123.22750	1137.04760	1150.78650	1164.44360	1178.01850	1191.51030	1204.91850	1218.24290
1231.49270	1244.63750	1257.70710	1270.69110	1283.58910	1296.40080	1309.12590	1321.76440	1334.31580	1346.78010
1359.15730	1371.44710	1383.64930	1395.76410	1407.79140	1419.73100	1431.58310	1443.34760	1455.02460	1466.61420
1478.11640	1489.53150	1500.85930	1512.10020	1523.25430	1534.32180	1545.30260	1556.19730	1567.00600	1577.72880
1588.36630	1598.91790	1609.38480	1619.76690	1630.06450	1640.27800	1650.40750	1660.45350	1670.41620	1680.29610
1690.09350	1699.80640	1709.44160	1718.99330	1728.46390	1737.85390	1747.16340	1756.39290	1765.54290	1774.61390
1783.60610	1792.51990	1801.35580	1810.11420	1818.79570	1827.40060	1835.92920	1844.38210	1852.75980	1861.06260
1869.29110	1877.44550	1885.52650	1893.53440	1901.46980	1909.33310	1917.12480	1924.84520	1932.49490	1940.07440
1947.58420	1955.02460	1962.39610	1969.69930	1976.93470	1984.10270	1991.20370	1998.23810	2005.20650	2012.10920
2018.94750	2025.72600	2032.42890	2039.07420	2045.65620	2052.17550	2058.63250	2065.02770	2071.36150	2077.63440
2083.84690	2089.99940	2096.09240	2102.12630	2108.10180	2114.01900	2119.87860	2125.68110	2131.42690	2137.11630
2142.75000	2148.32810	2153.85130	2159.31990	2164.73430	2170.09510	2175.40270	2180.65750	2185.85990	2191.81050
2196.10970	2201.15770	2206.15530	2211.10260	2216.00020	2220.84840	2225.64740	2230.39800	2235.10030	2239.75500
2244.36230	2248.92270	2253.43640	2257.90410	2262.32600	2266.70270	2271.03430	2275.32130	2279.56420	2283.76330
2287.91900	2292.03170	2296.10170	2300.12930	2304.11500	2308.05900	2311.96190	2315.82380	2319.64530	2323.42650
2327.16810	2330.87020	2334.53330	2338.15770	2341.74370	2345.29170	2348.80190	2352.27490	2355.71070	

MULTIPLE SCATTERING LEGENDRE COEFFICIENTS

.94641	.85875	.75347	.64229	.53370	.43341	.34471	.26898	.20625	.15361
.11506	.08479	.06136	.04388	.03103	.02171	.01505	.01034	.00704	.00476
.00319	.00213	.00141	.00093	.00061	.00039	.00026	.00017	.00011	.00007
.00004	.00003	.00002	.00001	.00001	.00000	.00000	.00000	.00000	.00000
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.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

CORRECTION TO INELASTIC SCATTERING FACTOR (2+1)/2

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	1.00000	1.00000	.99287	.92857	.92857	.92857	.92857	.92857	.92857
.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857	.92857			

CUMULATIVE MULTIPLE SCATTERING DISTRIBUTION

.00448	.01776	.03941	.06870	.10472	.14637	.19245	.24175	.29304	.44813	.58820	.70177
.78726	.84858	.89140	.92099	.95168	.96890	.97854	.98464	.99151	.99500	.99695	.99811
.99862	.99927	.99956	.99974	.99986	.99993	.99997	.99999	1.00000			

ENDPOINT DEFLECTION COSINES FOR SAMPLING FROM CUMULATIVE DISTRIBUTION WITH INTERPOLATION

.99985	.99939	.99863	.99756	.99619	.99452	.99255	.99027	.98769	.97815	.96593	.95106
.93358	.91355	.89101	.86603	.81915	.76604	.70711	.64279	.50000	.34202	.17365	.00000
-.17365	-.34202	-.50000	-.64279	-.76604	-.86603	-.93969	-.98481	-1.00000			

N	E(N)	DRG(N)	NSUB	COSAV
1	2.0000000	.1089272	4	.97216
2	1.8340081	.1004255	4	.97063
3	1.6817928	.0925050	4	.96907
4	1.5422108	.0851236	4	.96747
5	1.4142135	.0782476	4	.96584
6	1.2968395	.0718423	4	.96419
7	1.1892071	.0658810	4	.96253
8	1.0905077	.0603351	4	.96086
9	1.0000000	.0551777	4	.95919
10	.9170040	.0503848	4	.95754
11	.8408964	.0459343	4	.95588
12	.7711054	.0418059	4	.95424
13	.7071067	.0379806	4	.95260
14	.6484197	.0344412	4	.95099
15	.5946035	.0311714	4	.94948
16	.5452538	.0281558	4	.94793
17	.4999999	.0253792	4	.94641

BREMDIF

HFC	HFLCUT	HFS
.99500	1.00000	.98000

Z	A	ETA	W
13.00000	26.98000	1.00000	1.00000

SWITCHING WEIGHTS

ENERGY BASE POINTS (MEV)

50.00000	40.00000	30.00000	20.00000	15.00000	12.50000	10.00000	8.00000	6.00000	5.00000
4.00000	3.00000	2.00000							

WEIGHTS FOR ALL Z

1.00000	.98000	.94000	.85500	.77000	.71000	.62500	.52000	.38300	.29800
.20500	.10500	.00000							

PHI RAD CORRECTION FACTORS

ENERGY BASE POINTS (MEV)

1000.00000	500.00000	200.00000	100.00000	50.00000	30.00000	20.00000	15.00000	10.00000	7.00000
5.00000	3.00000	2.00000	1.50000	1.00000	.70000	.50000	.30000	.20000	.15000
.10000	.07000	.05000	.03000	.02000	.01500	.01000	.00700	.00500	.00300
.00200	.00099								

FACTORS FOR Z = 13

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.01300
1.04900	1.12700	1.20400	1.25800	1.33500	1.37100	1.37600	1.33100	1.25700	1.19700
1.12800	1.07700	1.04000	1.00500	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000								

HIGH FREQUENCY LIMITS

ENERGY BASE POINTS (MEV)

1000.00000	700.00000	500.00000	400.00000	300.00000	200.00000	100.00000	70.00000	50.00000	40.00000
30.00000	20.00000	15.00000	10.00000	8.00000	6.00000	5.00000	4.00000	3.00000	2.00000
1.50000	1.00000	.80000	.60000	.50000	.40000	.30000	.20000	.15000	.10000
.03000	.06000	.05000	.04000	.03000	.02000	.01500	.01000	.00099	

LIMITS FOR Z = 13

.48000	.48200	.48400	.48600	.48800	.49000	.49500	.49800	.50200	.50400
.51000	.51800	.52000	.52700	.53500	.54000	.55000	.55700	.56500	.59300
.62500	.72700	.90000	1.19000	1.46000	1.90000	2.69000	4.38000	6.13000	9.81000
12.00000	17.50000	21.50000	27.50000	38.00000	60.50000	83.90000	132.00000	1570.00000	

N/T RATIOS FOR CUMULATIVE PROBABILITIES

.0012500	.0015000	.0017500	.0020000	.0025000	.0030000	.0035000	.0040000	.0045000	.0050000
.0055000	.0060000	.0072000	.0080000	.0090000	.0100000	.0125000	.0150000	.0175000	.0200000
.0250000	.0300000	.0350000	.0400000	.0450000	.0500000	.0550000	.0600000	.0700000	.0800000
.0900000	.1000000	.1250000	.1500000	.1750000	.2000000	.2500000	.3000000	.3500000	.4000000
.4500000	.5000000	.5500000	.6000000	.7000000	.8000000	.9000000	1.0000000		

T(1) = 2.0000+00 MEV

NORMALIZED CUMULATIVE PROBABILITIES

.0420918	.0765349	.1033325	.1303484	.1720405	.2059936	.2346155	.2593410	.2810945	.3005061
.3180250	.3339625	.3621626	.3864721	.4078294	.4268608	.4669129	.4993473	.5265360	.5498924
.5704614	.5894612	.6455085	.6673479	.6865039	.7033937	.7184569	.7320178	.7555626	.7754245
.7925005	.8074197	.8377984	.8611865	.8798580	.8951548	.9187677	.9361280	.9493687	.9597296
.9679805	.9746015	.9801046	.9845728	.9912801	.9957730	.9986037	1.0000000		

T(9) = 1.0000+00 MEV

NORMALIZED CUMULATIVE PROBABILITIES

.0445454	.0817319	.1111760	.1374331	.1810656	.2164790	.2462465	.2718977	.2944157	.3144696
.3325352	.3439831	.3779084	.4028093	.4246321	.4440345	.4847281	.5175370	.5449341	.5683892
.6069465	.6377953	.6633593	.6850842	.7038981	.7204322	.7351358	.7483396	.7711945	.7904379
.8069319	.8212682	.8502368	.8723946	.8899879	.9043337	.9263475	.9424158	.9545903	.9640557
.9715517	.9775672	.9824400	.9864111	.9923112	.9962208	.9986933	1.0000000		

T(17) = 5.0000-01 MEV

NORMALIZED CUMULATIVE PROBABILITIES

.0474236	.0857486	.1178518	.1454360	.1910593	.2278894	.2587087	.2851634	.3083078	.3288571
.3473164	.3640642	.3934725	.4186718	.4406799	.4601871	.5009165	.5335725	.5607176	.5838669
.6217446	.6518073	.6767628	.6978299	.7160217	.7319709	.7461256	.7588151	.7807511	.7991594
.8148693	.8285598	.8560709	.8770944	.8937765	.9073804	.9282776	.9435701	.9551978	.9642764
.9715019	.9773601	.9820806	.9859788	.9918420	.9958206	.9984449	1.0000000		

N	ENERGY (MEV)	PROB/PATH	NUM IN STEP	CUM NUM
1	2.0000000+00	5.7377980-01	4.1041669-02	4.1041669-02
2	1.6340051+00	5.7978134-01	3.8461648-02	7.9503317-02
3	1.6817928+00	5.8619221-01	3.6048588-02	1.1555190-01
4	1.5422108+00	5.9319462-01	3.3795308-02	1.4934722-01
5	1.4142135+00	6.0083487-01	3.1691992-02	1.8103921-01
6	1.2966395+00	6.0920019-01	2.9729275-02	2.1076848-01
7	1.1892071+00	6.1841608-01	2.7935703-02	2.3870418-01
8	1.0905077+00	6.2964665-01	2.6229176-02	2.6493336-01
9	9.9999996-01	6.3980165-01	2.4563099-02	2.8949645-01
10	9.1700400-01	6.5052568-01	2.2988971-02	3.1248543-01
11	8.4039687-01	6.6201810-01	2.1501844-02	3.3398727-01
12	7.7110536-01	6.7418924-01	2.0096596-02	3.5408386-01
13	7.0710678-01	6.8723484-01	1.8771736-02	3.7285560-01
14	6.4841973-01	6.0125547-01	1.7524000-02	3.9037959-01
15	5.9460351-01	6.1656290-01	1.6349625-02	4.0672921-01
16	5.4525681-01	6.3265684-01	1.5245502-02	4.2197472-01
17	4.9999995-01	6.5028959-01	1.4207920-02	4.3618263-01
18	4.5850127-01	6.6935991-01	0.0000000	0.0000000

BRANO

Z	A	ETA	W
13.00000	26.98000	1.00000	1.00000

NORMALIZED CUMULATIVE PROBABILITIES

1.00000	.95000	.90000	.85000	.80000	.75000	.70000	.65000	.60000	.55000
.50000	.45000	.40000	.35000	.30000	.25000	.20000	.15000	.10000	.05000
.00000									

T(1) = 2.0000+00 MEV K/T = 1.00000 K = 1.9998+00 MEV K*DS/DK = 1.4481-04 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	5.2942-02	1.0021-01	1.4179-01	1.7388-01	2.1018-01	2.4610-01	2.8128-01	3.1734-01	3.5311-01
3.9005-01	4.2735-01	4.6583-01	5.0619-01	5.4707-01	5.9185-01	6.3789-01	6.9155-01	7.4796-01	8.0402-01
1.0000+00									

XI FOR CUMULATIVE PROBABILITIES

1.0573-02	6.2955-02	1.0972-01	1.5087-01	1.8261-01	2.1653-01	2.5407-01	2.8888-01	3.2456-01	3.5995-01
3.9550-01	4.3390-01	4.7148-01	5.1142-01	5.5186-01	5.9616-01	6.4172-01	6.9481-01	7.5062-01	8.0610-01
1.0000+00									

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	6.3190-01	8.2659-01	8.7971-01	9.0434-01	9.2357-01	9.3726-01	9.4739-01	9.5552-01	9.6200-01
9.6747-01	9.7212-01	9.7604-01	9.7958-01	9.8264-01	9.8552-01	9.8807-01	9.9061-01	9.9290-01	9.9486-01
1.0000+00									

T(1) = 2.0000+00 MEV K/T = .10000 K = 2.0000-01 MEV K*DS/DK = 4.9343-02 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	4.6604-02	9.3545-02	1.4058-01	1.8730-01	2.3741-01	2.8981-01	3.4454-01	4.0062-01	4.5836-01
5.1595-01	5.7377-01	6.2988-01	6.8474-01	7.3702-01	7.8707-01	8.3448-01	8.7928-01	9.2185-01	9.6209-01
1.0000+00									

XI FOR CUMULATIVE PROBABILITIES

1.0573-02	5.0763-02	1.0313-01	1.4967-01	1.9589-01	2.4547-01	2.9732-01	3.5147-01	4.0696-01	4.6409-01
5.2108-01	5.7628-01	6.3380-01	6.8807-01	7.3980-01	7.8932-01	8.3623-01	8.8056-01	9.2268-01	9.6249-01
1.0000+00									

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	6.4467-01	8.1414-01	8.7858-01	9.1227-01	9.3431-01	9.4949-01	9.6057-01	9.6886-01	9.7532-01
9.8036-01	9.8441-01	9.8765-01	9.9031-01	9.9248-01	9.9430-01	9.9581-01	9.9710-01	9.9821-01	9.9917-01
1.0000+00									

T(1) = 2.0000+00 MEV K/T = .01000 K = 2.0000-02 MEV K*DS/DK = 8.3856-02 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	4.1395-02	8.4385-02	1.2897-01	1.7455-01	2.2383-01	2.7617-01	3.3135-01	3.8958-01	4.4986-01
5.1055-01	5.7128-01	6.3002-01	6.8700-01	7.4064-01	7.9129-01	8.3874-01	8.8290-01	9.2463-01	9.6366-01
1.0000+00									

XI FOR CUMULATIVE PROBABILITIES

1.0573-02	5.1553-02	9.4066-02	1.3818-01	1.8527-01	2.3203-01	2.8382-01	3.3842-01	3.9603-01	4.5568-01
5.1553-01	5.7511-01	6.3393-01	6.9031-01	7.4338-01	7.9349-01	8.4045-01	8.8414-01	9.2542-01	9.6404-01
1.0000+00									

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	6.0035-01	7.9417-01	8.6671-01	9.0476-01	9.2927-01	9.4[illegible]-01	9.5822-01	9.6741-01	9.7447-01

```
 9.7992-01   9.8426-01   9.8766-01   9.9041-01   9.9262-01   9.9444-01   9.9594-01   9.9720-01   9.9828-01   9.9920-01
 1.0000+00

I(  1) =  2.0000+00 MEV     K/T =  .00100     K =  2.0000-03 MEV     K*DS/DK =  1.1240-01 CM2/G

 CHI FOR CUMULATIVE PROBABILITIES
-0.0000      3.9393-02   3.0366-02   1.2442-01   1.6945-01   2.1833-01   2.7054-01   3.2598-01   3.8488-01   4.4550-01
 5.0793-01   5.7618-01   6.3004-01   6.0791-01   7.4209-01   7.9295-01   8.4041-01   8.8429-01   9.2568-01   9.6425-01
 1.0000+00

 XI FOR CUMULATIVE PROBABILITIES
 1.0573-02   4.9550-02   9.0584-02   1.3368-01   1.7823-01   2.2560-01   2.7826-01   3.3311-01   3.9138-01   4.5136-01
 5.1313-01   5.7472-01   6.3395-01   6.9121-01   7.4482-01   7.9514-01   8.4210-01   8.8552-01   9.2647-01   9.6463-01
 1.0000+00

 CTH FOR CUMULATIVE PROBABILITIES
-1.0000+00   5.9005-01   7.8544-01   8.6149-01   9.0146-01   9.2706-01   9.4457-01   9.5721-01   9.6677-01   9.7402-01
 9.7972-01   9.8419-01   9.8766-01   9.9045-01   9.9268-01   9.9449-01   9.9599-01   9.9724-01   9.9830-01   9.9922-01
 1.0000+00

I(  9) =  1.0000+00 MEV     K/T = 1.00000     K =  9.9990-01 MEV     K*DS/DK =  1.2829-04 CM2/G

 CHI FOR CUMULATIVE PROBABILITIES
-0.0000      9.1547-02   1.5686-01   1.9231-01   2.3557-01   2.7335-01   3.1162-01   3.4859-01   3.8370-01   4.1957-01
 4.5438-01   4.9032-01   5.2686-01   5.6298-01   6.0182-01   6.4043-01   6.8398-01   7.2747-01   7.8289-01   8.2671-01
 1.0000+00

 XI FOR CUMULATIVE PROBABILITIES
 3.0353-02   1.1912-01   1.8245-01   2.1682-01   2.5877-01   2.9540-01   3.3251-01   3.6836-01   4.0240-01   4.3719-01
 4.7094-01   5.0579-01   5.4122-01   5.7624-01   6.1390-01   6.5135-01   6.9357-01   7.3575-01   7.8948-01   8.3197-01
 1.0000+00

 CTH FOR CUMULATIVE PROBABILITIES
-1.0000+00   5.3704-01   7.1947-01   7.7387-01   8.2067-01   8.5067-01   8.7433-01   8.9265-01   9.0703-01   9.1941-01
 9.2967-01   9.3883-01   9.4693-01   9.5396-01   9.6063-01   9.6649-01   9.7234-01   9.7751-01   9.8331-01   9.8736-01
 1.0000+00

I(  9) =  1.0000+00 MEV     K/T =  .10000     K =  1.0000-01 MEV     K*DS/DK =  4.8613-02 CM2/G

 CHI FOR CUMULATIVE PROBABILITIES
-0.0000      4.8498-02   9.7116-02   1.4585-01   1.9454-01   2.4586-01   2.9874-01   3.5347-01   4.0900-01   4.6570-01
 5.2197-01   5.7823-01   6.3291-01   6.8640-01   7.3764-01   7.8694-01   8.3388-01   8.7854-01   9.2115-01   9.6163-01
 1.0000+00

 XI FOR CUMULATIVE PROBABILITIES
 3.0353-02   7.7379-02   1.2452-01   1.7178-01   2.1899-01   2.6875-01   3.2003-01   3.7309-01   4.2694-01   4.8191-01
 5.3848-01   5.9104-01   6.4405-01   6.9542-01   7.4561-01   7.9340-01   8.3892-01   8.8223-01   9.2354-01   9.6200-01
 1.0000+00

 CTH FOR CUMULATIVE PROBABILITIES
-1.0000+00   2.5353-01   3.5983-01   6.9815-01   7.7672-01   8.2966-01   8.6698-01   8.9480-01   9.1597-01   9.3269-01
 9.4594-01   9.5666-01   9.6540-01   9.7264-01   9.7864-01   9.8370-01   9.8798-01   9.9164-01   9.9482-01   9.9758-01
 1.0000+00

I(  9) =  1.0000+00 MEV     K/T =  .01000     K =  1.0000-02 MEV     K*DS/DK =  5.4967-02 CM2/G

 CHI FOR CUMULATIVE PROBABILITIES
-0.0000      4.1968-02   8.3549-02   1.3092-01   1.7763-01   2.2766-01   2.8053-01   3.3597-01   3.9414-01   4.5409-01
```

5.1461-01	5.7420-01	6.3220-01	6.8847-01	7.4154-01	7.9176-01	8.3891-01	8.8291-01	9.2455-01	9.6357-01	
1.0000+00										

XI FOR CUMULATIVE PROBABILITIES

3.0333-02	7.0941-02	1.1530-01	1.5730-01	2.0259-01	2.5110-01	3.0236-01	3.5613-01	4.1253-01	4.7066-01	
5.2875-01	5.8712-01	6.4537-01	6.9793-01	7.4939-01	7.9808-01	8.4380-01	8.8647-01	9.2684-01	9.6468-01	
1.0000+00										

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	1.8030-01	5.1002-01	6.6460-01	7.5359-01	8.1328-01	8.5555-01	8.8681-01	9.1085-01	9.2959-01	
9.4421-01	9.5597-01	9.6539-01	9.7290-01	9.7906-01	9.8416-01	9.8841-01	9.9198-01	9.9506-01	9.9771-01	
1.0000+00										

T(9) = 1.0000+00 MEV K/T = .00100 K = 1.0000-03 MEV K*DS/DK = 1.1696-01 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	3.9553-02	8.1339-02	1.2536-01	1.7117-01	2.2059-01	2.7322-01	3.2892-01	3.8788-01	4.4907-01	
5.1049-01	5.7230-01	6.3170-01	6.8910-01	7.4291-01	7.9347-01	8.4070-01	8.8444-01	9.2573-01	9.6425-01	
1.0000+00										

XI FOR CUMULATIVE PROBABILITIES

3.0333-02	6.6705-02	1.0922-01	1.5191-01	1.9633-01	2.4425-01	2.9528-01	3.4929-01	4.0646-01	4.6579-01	
5.2555-01	5.8525-01	6.4285-01	6.9854-01	7.5071-01	7.9973-01	8.4553-01	8.8795-01	9.2798-01	9.6533-01	
1.0000+00										

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	1.5138-01	4.6941-01	6.5047-01	7.4373-01	8.0629-01	8.5059-01	8.8337-01	9.0858-01	9.2820-01	
9.4344-01	9.5564-01	9.6522-01	9.7298-01	9.7921-01	9.8432-01	9.8856-01	9.9210-01	9.9514-01	9.9775-01	
1.0000+00										

T(17) = 5.0000-01 MEV K/T = 1.00000 K = 4.9995-01 MEV K*DS/DK = 1.5562-04 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	1.3625-01	2.0089-01	2.4900-01	2.6772-01	3.2823-01	3.6552-01	3.9955-01	4.3437-01	4.6710-01	
5.0035-01	5.3459-01	5.6732-01	6.0214-01	6.3612-01	6.7342-01	7.1387-01	7.5260-01	7.9897-01	8.4575-01	
1.0000+00										

XI FOR CUMULATIVE PROBABILITIES

7.3613-02	2.1336-01	2.5972-01	3.0429-01	3.4016-01	3.7768-01	4.1223-01	4.4375-01	4.7601-01	5.0633-01	
5.3760-01	5.6865-01	5.9917-01	6.3142-01	6.6290-01	6.9746-01	7.3493-01	7.7081-01	8.1377-01	8.5710-01	
1.0000+00										

CTH FOR CUMULATIVE PROBABILITIES

-1.0000+00	4.3112-01	5.4701-01	6.3654-01	6.9171-01	7.3814-01	7.7340-01	8.0078-01	8.2505-01	8.4505-01	
8.6330-01	8.7955-01	8.9369-01	9.0723-01	9.1918-01	9.3106-01	9.4268-01	9.5275-01	9.6363-01	9.7350-01	
1.0000+00										

T(17) = 5.0000-01 MEV K/T = .10000 K = 5.0000-02 MEV K*DS/DK = 5.4984-02 CM2/G

CHI FOR CUMULATIVE PROBABILITIES

-0.0000	4.3375-02	9.7458-02	1.4697-01	1.9772-01	2.4986-01	3.0304-01	3.5751-01	4.1236-01	4.6790-01	
5.2293-01	5.7779-01	6.3129-01	6.8378-01	7.3442-01	7.8346-01	8.3051-01	8.7566-01	9.1896-01	9.6041-01	
1.0000+00										

XI FOR CUMULATIVE PROBABILITIES

7.3613-02	1.1543-01	1.6398-01	2.0976-01	2.5678-01	3.0508-01	3.5435-01	4.0480-01	4.5562-01	5.0707-01	
5.5605-01	6.0667-01	6.5643-01	7.0766-01	7.5697-01	7.9940-01	8.4299-01	8.8481-01	9.2493-01	9.6332-01	
1.0000+00										

CH1 FOR CUMULATIVE PROBABILITIES

-1.0000+00	-1.6534-01	1.3928-01	4.0128-01	5.4001-01	6.3800-01	7.1042-01	7.6633-01	8.1011-01	8.4551-01
8.7411-01	8.9791-01	9.1755-01	9.3416-01	9.4814-01	9.6012-01	9.7040-01	9.7931-01	9.8710-01	9.9395-01
1.0000+00									

T(17) = 5.0000-01 MEV K/T = .01000 K = 5.0000-03 MEV K*DS/DK = 9.7054-02 CM2/G

CH1 FOR CUMULATIVE PROBABILITIES

-0.0000	4.1446-02	8.5028-02	1.3074-01	1.7840-01	2.2896-01	2.8223-01	3.3780-01	3.9584-01	4.5539-01
5.1477-01	5.7451-01	6.3176-01	6.8756-01	7.4035-01	7.9046-01	8.3765-01	8.8186-01	9.2375-01	9.6313-01
1.0000+00									

XI FOR CUMULATIVE PROBABILITIES

7.3015-02	1.1201-01	1.5238-01	1.9473-01	2.3388-01	2.8571-01	3.3507-01	3.8655-01	4.4031-01	4.9548-01
5.5449-01	6.0564-01	6.5686-01	7.1056-01	7.5946-01	8.0569-01	8.4960-01	8.9056-01	9.2937-01	9.6585-01
1.0000+00									

CH1 FOR CUMULATIVE PROBABILITIES

-1.0000+00	-2.5993-01	1.1598-01	3.4279-01	4.9363-01	6.0269-01	6.8462-01	7.4779-01	7.9799-01	8.3818-01
8.7923-01	8.9652-01	9.1771-01	9.3526-01	9.4966-01	9.6172-01	9.7187-01	9.8047-01	9.8792-01	9.9438-01
1.0000+00									

T(17) = 5.0000-01 MEV K/T = .00100 K = 5.0000-04 MEV K*DS/DK = 1.3577-01 CM2/G

CH1 FOR CUMULATIVE PROBABILITIES

-0.0000	3.9111-02	8.0743-02	1.2490-01	1.7130-01	2.2108-01	2.7403-01	3.2987-01	3.8882-01	4.4981-01
5.1093-01	5.7235-01	6.3142-01	6.8854-01	7.4218-01	7.9268-01	8.3994-01	8.8382-01	9.2526-01	9.6399-01
1.0000+00									

XI FOR CUMULATIVE PROBABILITIES

7.3015-02	1.0994-01	1.4641-01	1.8932-01	2.3231-01	2.7842-01	3.2747-01	3.7920-01	4.3381-01	4.9031-01
5.4893-01	6.0583-01	6.5655-01	7.1146-01	7.6116-01	8.0794-01	8.5173-01	8.9237-01	9.3077-01	9.6664-01
1.0000+00									

CH1 FOR CUMULATIVE PROBABILITIES

-1.0000+00	-2.8789-01	3.3092-02	3.1946-01	4.7481-01	5.8812-01	6.7362-01	7.3982-01	7.9258-01	8.3479-01
8.8555-01	8.9575-01	9.1760-01	9.3555-01	9.5013-01	9.6222-01	9.7233-01	9.8083-01	9.8818-01	9.9452-01
1.0000+00									

K X-RAY PROBABILITY

Z	A	W	IK(MEV)	WK
13.00000	26.98000	1.00000	.00156	1.00000

N	ENERGY (MEV)	PROB/PATH	NUM IN STEP	CUM NUM
1	2.0000000+00	1.1501510+01	1.2568198+00	1.2568198+00
2	1.6540031+00	1.1574806+01	1.1665979+00	2.4234176+00
3	1.0817928+00	1.1658289+01	1.0825383+00	3.5062560+00
4	1.5422196+00	1.1753167+01	1.0050507+00	4.5113067+00
5	1.4142155+00	1.1860760+01	9.3283878-01	5.4441454+00
6	1.2960395+00	1.1982504+01	8.6578803-01	6.3099334+00
7	1.1892071+00	1.2119461+01	8.0357604-01	7.1135093+00
8	1.0905077+00	1.2274522+01	7.4585421-01	7.8593636+00
9	9.9999[illegible]-01	1.2448918+01	6.9229086-01	8.5516544+00
10	9.1700400-01	1.2644230+01	6.4256583-01	9.1942401+00
11	8.4089637-01	1.2862595+01	5.9645990-01	9.7907000+00
12	7.7110536-01	1.3107220+01	5.5365452-01	1.0344354+01
13	7.0710673-01	1.3379694+01	5.1392893-01	1.0858283+01
14	6.4841973-01	1.3683001+01	4.7706297-01	1.1335346+01
15	5.9460351-01	1.4020038+01	4.4285191-01	1.1778198+01
16	5.4525381-01	1.4393931+01	4.1110197-01	1.2189300+01
17	4.9999995-01	1.4808056+01	3.8162898-01	1.2570929+01
18	4.5850197-01	1.5266064+01	0.0000000	0.0000000

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