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A PROGRAM IN BASIC FOR CALCULATION OF CAVITY THEORY CORRECTIONS

Erling Bugge Christensen, Arne Miller

Abstract. A program in BASIC for a desk-top calculator HP 9830A is described. The program allows calculation of cavity theory corrections according to Burlin's general cavity theory. The calculations are made by using tabulated values for stopping powers and energy absorption coefficients, stored either as coefficients to a fitted polynomial or as the actual table data.

INIS-descriptors: BASIC; COMPUTER CALCULATIONS; ~~CALCULATIONS~~; ENERGY TRANSFER; GAMMA DOSIMETRY; PHOTONS; STOPPING POWER; X-RAY DOSIMETRY.

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1. INTRODUCTION

The accurate calculation of weighted stopping power ratios and weighted absorption coefficient ratios are tedious work without the availability of large computers and sophisticated computer codes. This report describes how a desk-top calculator may be employed for an approximate calculation, with errors being introduced mainly in the determination of stopping power ratios at the higher energies (> 10 MeV). For the calculation, the secondary electron and photon energy spectra must be known approximately. The theoretical background for this program is described elsewhere[1]. This reference also contains examples of calculations made by the use of this program. Other calculations may be made upon request.

2. GENERAL DESCRIPTION OF PROGRAM PARTS

2.1. Stopping Power Program

The program divides into 3 parts:

1. Routine for fitting of tabulated data to a ninth-order polynomial.

2. Routine for calculating stopping powers at specific energies.

3. Routine for plotting stopping powers as a function of energy.

2.1.1. Fitting

The stopping power data published by Berger and Seltzer[2], or by Pages et al.[3] are loaded into the calculator, stored on tape for later use, and a print is provided of the stored table.

The data are then fitted to a ninth-order polynomial by a polynomial regression fit routine from HP Plotter Pac[4] for the HP 9830A calculator/HP 9862A plotter. The routine is modified slightly to adapt to this problem. After completion of the fit a print is provided of the 10 coefficients as well as a table over the deviations of values calculated by the polynomial from the actual table values. Fits have been made for 34 elements and the maximum deviation was found to be 0.3%, but in most cases the deviations were less than 0.1%. The coefficients must for the time being be transferred manually to the tape containing the stopping power calculating and plotting routines.

2.1.2. Calculation

This routine can calculate stopping power and stopping power ratios at specific energies according to selected input data. The values will be calculated by use of the ninth-order polynomial found by the fitting routine.

The calculation can be made for one material only, or it can be made for two materials simultaneously, and in that case the ratio is also calculated. Each material can be regarded as compounds containing maximum 8 elements each, and in that case the stopping power is calculated as the sum of the individual stopping powers multiplied by their weight fraction.

The energy information is put into the routine as a histogram spectrum with arbitrary scaling. Each interval is given a weight according to its area relative to the total area of the spectrum.

A choice can be made not to include the spectrum in the calculations. In that case the stopping powers are calculated at the beginning of each interval. This is arranged in order to facilitate tables of stopping power versus energy.

If the spectrum is included in the calculations then the stopping powers are calculated at the average energy of each interval, and the stopping powers are multiplied by the weight of

that interval. Thus a total stopping power for the material exposed to the selected energy spectrum is obtained by summing these values, and the stopping power ratio for two materials is found by dividing the summed values into each other.

2.1.3. Plotting

A graph of the stopping power variation versus energy for the materials and for the stopping power ratio can be provided by this routine. There is also included a possibility of providing a plot of the secondary electron energy spectrum used in the above calculations.

The scaling of the plot is preset logarithmic on the abscissa over 4 decades (0.01 - 100 MeV) and linearly on the ordinate (0-8 $MeV \cdot cm^2 \cdot g^{-1}$) by standard procedures. The plot is made by calculating the stopping powers at specific energies with equal logarithmic intervals, and drawing straight lines between the calculated values.

2.2. Energy Absorption Coefficient Program

This calculator has a limited memory capacity (3808 words) and the program utilizes almost all this capacity. It has therefore been needed to build some space-saving into the program, which may make it somewhat difficult to survey.

The program divides into 3 parts:

1. Routine for loading data into the calculator.

2. Routine for calculating (μ_{en}/ρ) at specific energies.

3. Routine for plotting (μ_{en}/ρ) as a function of energy.

2.2.1. Input

The photon cross sections ($\simeq$ energy absorption coefficients) published by Storm and Israel[5] are loaded into the calculator,

stored on tape and a print is provided. The routine is preset to follow the outline of the tables by Storm and Israel with 53 energy steps between 0.01 and 100 MeV.

Unlike the stopping power program, this program stores the table values directly. We attempted to make a fit to a suitable polynomial, but as the number of constants needed was approaching the number of data points, we decided to store the data points.

If μ_{en}/ρ for an element contains discontinuities (K, L, etc.), this information is loaded into the calculator with information about the energy of the discontinuity and the two μ-values (μ^+ and μ^-).

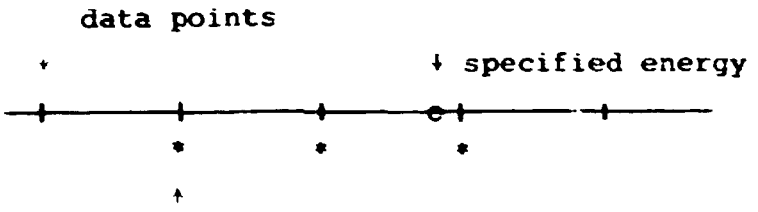
2.2.2. Calculation of Energy Absorption Coefficient

This routine will calculate energy absorption coefficient at specific energies according to the selected input data.

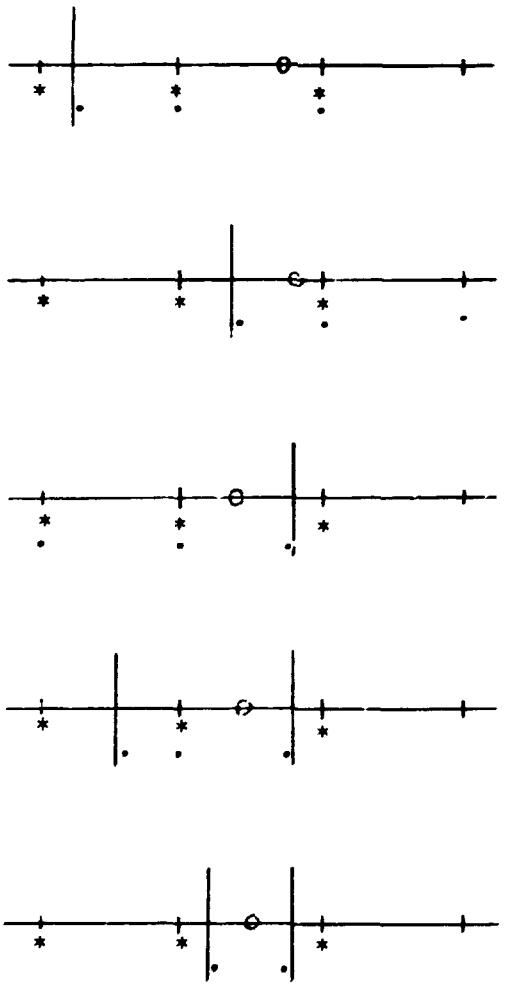
It is possible to transfer material data from the stopping power program if it has been used prior to this program, but new data can be entered as well. The procedure for doing so is the same as for the stopping power program with maximum 8 elements in each material, but the total number of different elements may not exceed 12.

The energy spectrum information is put into the calculator as in the stopping power program and it is used in the same way.

For calculation of μ for an element at a specific energy an interpolation routine is applied (2nd order Lagrange): 3 data points are chosen close to the specified energy and a parabola is fitted to these points. The wanted value of μ is then calculated by the expression for this parabola. The data points are chosen according to the following:



If discontinuities are included in the energy interval to be used for interpolation, the choice of data points are made in the following way:



discontinuity

* data points originally to be used for interpolation

○ specified energy

• new data points to be used for interpolation

| data points

in this case linear interpolation is applied.

If the relative area of each energy interval has to be taken into account in the calculations, it is done as in the stopping power program with the discontinuity as a special case as follows:

If a discontinuity is included in the energy interval, then this interval is divided into 2 intervals by the discontinuity. The coefficient is calculated for the average energy of each interval and the average coefficient is found by averaging these two subintervals.

2.2.3. Plotting

A graph of the energy absorption coefficient variation versus energy for the materials and for the ratio can be provided by this routine. There is also included a possibility of providing a plot of the photon energy spectrum used in the above calculations.

The scaling of the plot is preset logarithmic on the acscissa over 4 dacades (0.01 - 100 MeV) and logarithmic on the ordinate over 3 decades (0.1 - 10 $cm^2 \cdot g^{-1}$) by standard procedures. The plot is made by calculating the energy absorption coefficient at specific energies with equal logarithmic intervals, and drawing straight lines between the calculated points.

2.3. Calculation of the Final Correction Factor

This routine calculates f according to Burlin's general cavity theory[6]:

$$f = d \cdot \frac{S_1}{S_2} + (1-d) \frac{\mu_1}{\mu_2}$$

$$d = \frac{1-e^{-\mu \cdot g}}{\mu \cdot g}$$

$$g = 4 \cdot \frac{\text{volume}}{\text{area}}$$

$$\varepsilon = \frac{16}{(E_{max} - 0.036)^{1.4}}$$

Information about E_{max}, $\frac{S_1}{S_2}$ and $\frac{\rho_1}{\rho_2}$ is transferred from the stopping power and energy absorption programs. Volume and area have to be entered in units of $g \cdot cm^{-2}$.

3. LIST OF VARIABLES IN STOPPING POWER PROGRAMS

KS[92,10]	Coefficients for ninth-order polynomial
N[1]	Number of elements in material 1 (max 8)
N[2]	Number of elements in material 2 (max 8)
N[3]	Number of intervals in energy spectrum
N[4]	Number of materials (1 or 2)
M[a,b]	Atomic number of elements in current problem (a,b) = (element no., material no.)
P[a,b]	Percentages of elements M[a,b]
A,E9,Z	Variables for intermediate use
E[1]	Beginning of first interval of energy spectrum
E[A]	End of A^{th} interval
W[A]	Height of A^{th} interval, arbitrary numbers
W[31]	Area of spectrum

Q	1 ➡ Stopping power calc. with spectrum 0 ➡ " " " without spectrum
G[1]	Stopping power for material 1, Σ $SP1_i \cdot W_i$ at specific energy
G[2]	Stopping power for material 2, Σ $SP2_i \cdot W_i$ at specific energy
G[3]	Summation of SP1 over energy spectrum
G[4]	Summation of SP2 over energy spectrum
G[5]	G[3]/G[4]
G[6]	G[1]/G[2]
D8 = G[5]	for transfer to calculation of final correction factor

Variables in plot routine for Stopping Power

A = log (energy)

E = energy.

4. LIST OF VARIABLES IN ENERGY ABSORPTION PROGRAMS

Generally the same variables are used as in the stopping power programs, but some more are added:

KS[a]	Contains information about discontinuities
YS[b,c]	Energy absorption coefficient table values (b,c) = (value (34), element no. (max. 12))
TS[d]	Energies for coefficient table (33)

N9 Counter to locate table values in Y-array, M[element, material no. + 2] = N9

P1 Ratio of energy absorption coefficients.

5. PROGRAMS

5.1 Stopping power fit program

5.2 Stopping power calculation program

5.3 Stopping power plot program

5.4 Absorption coefficient data input program

5.5 Absorption coefficient calculation program

5.6 Absorption coefficient plot program

5.7 Correction factor calculation program

6. APPENDIX

The Organization of Energy absorption Coefficient Table Values

If one element is present in both materials, then the data for this element is only stored once in order to save space. This is arranged as follows:

The M-array is an 8 × 4 matrice. In the first column is stored the atomic numbers of the elements in the first material, and

in the third column these elements are numbered in succession. In the second column is stored the atomic numbers of the elements in the second material, and in the fourth column these elements are numbered in succession, but if an element in the second material is present in the first material, then the number of this element in the third column is transferred to the fourth column. The numbers in the third and fourth column point to the location in the Y-array containing the data for the respective elements.

7. REFERENCES

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2. Berger, M.J. and Seltzer, S.M., NASA-SP-3012 (1964).

3. Pages, L., Bartel, E., Jeffre, H., and Sklavenitis, L., Atomic Data 4 no 1, 1 (1972).

4. Hewlett-Packard Calculator 9830A Plotter Pac, Model 30.

5. Storm, B. and Israel, H.I., Nuclear Data Tables A7, 565 (1970).

6. Burlin, T.E., Br. J. Radiol. 39, 727 (1966).

5.1 Stopping power fit program

```
1 REM ***** ROUTINE FOR FIT OF SP. DATA TO A 9TH DEG. POLYNOMIUM *****
4 REM ***** DATA INPUT ROUTINE *****
5 DIM C[66],B[11],ES[80],QS[80],KS[2]
6 PRINT "#","ENERGY","STOPPING POWER"
10 FOR X=1 TO 55
15 DISP "#";X;"E,SP";
20 INPUT E[X],Q[X]
30 PRINT X,E[X],Q[X]
40 NEXT X
50 DISP "LOAD SP TABLETAPE"
60 STOP
70 DISP "ATOMIC NUMBER";
80 INPUT Z9
90 STORE  DATA Z9,Q
100 DISP "PRESS START FOR CALC."
110 END
```

```
4 REM ***** FIT ROUTINE FROM HP PLOTTER PAC FOR THE HP 9830A / HP 9862A
5 D2=9
6 P9=0
20 FOR I=1 TO 11
30 C[I]=B[I]=0
40 NEXT I
50 FOR I=12 TO 66
60 C[I]=0
70 NEXT I
80 B[1]=1
90 W=N=S1=S2=S3=S4=S5=0
170 Q4=FNA1
180 Q4=FNB1
190 Q4=FNC1
200 Q4=FND1
210 END
```

5.1 Stopping power fit program

```
5 REM ***** ROUTINE FOR TRANSFER OF DATA TO CALCULATION OF FIT *****
10 DEF FNA(F7)
30 IF W THEN 90
40 FOR A=1 TO 55
50 B[2]=LGTE[A]
60 Y=Q[A]
70 IF FNX1 THEN 80
80 NEXT A
90 DISP "DONE"
100 RETURN 1
```

```
5 REM ***** HP PLOTTER PAC SUBROUTINE *****
10 DEF FNB(F7)
20 IF N <= D2-W THEN 320
30 D1=9
40 IF D1 <= D2-W THEN 70
50 DISP "MAX DEG=";D2-W
60 END
70 IF W=0 THEN 310
80 T=0
90 FOR I=1 TO D1+1
100 B[I]=0
110 FOR J=1 TO D1-I+2
120 R=(I+J-1)*(D2+2-0.5*(I+J))
130 B[I]=B[I]+C[T+J]*C[R]
135 NEXT J
140 O3=INTLGTABSB[I]
150 O5=0.5
160 IF B[I] >= 0 THEN 180
170 O5=-O5
180 B[I]=B[I]+O5*10↑(O3-6)
190 K[1]=B[I]
200 B[I]=K[1]
210 T=I*(D2+(3-I)/2)
220 NEXT I
230 R1=0
240 FOR I=2 TO D1+1
250 R1=R1+C[I*(D2+(3-I)/2)]↑2
260 NEXT I
270 T0=C[(D2+1)*(D2+2)/2]
280 T0=T0-C[D2+1]↑2
290 DISP "DONE"
300 RETURN 1
310 IF N>D2 THEN 340
320 DISP "NOT ENOUGH POINTS"
330 END
```

5.1 Stopping power fit program

```
340 P=W=1
350 D2=D2+1
360 FOR J=1 TO D2
370 IF C[P] >= 0 THEN 420
380 PRINT "MATRIX UNSTABLE-USE LOWER MAXIMUM DEGREE !"
390 PRINT
400 PRINT
410 END
420 C[P]=SQR(C[P])
430 FOR I=1 TO D2-J+1
440 C[P+I]=C[P+I]/C[P]
450 NEXT I
460 R=P+I
470 S=R
480 FOR L=1 TO D2-J
490 P=P+1
500 FOR M=1 TO D2+2-J-L
510 C[R+M-1]=C[R+M-1]-C[P]*C[P+M-1]
520 NEXT M
530 R=R+M-1
540 NEXT L
550 P=S
560 NEXT J
570 T=(D2+1)*(D2+2)/2
580 FOR I=1 TO D2-1
590 T=T-1-I
600 C[T]=1/C[T]
610 FOR J=1 TO D2-I
620 P=D2+1-I-J
630 P=P*(D2+1-(P-1)/2)-I
640 R=P-J
650 S=0
660 U=I+J+1
670 V=P
680 FOR K=1 TO J
690 V=V+U-K
700 S=S-C[R+K]*C[V]
710 NEXT K
720 C[P]=S/C[R]
730 NEXT J
740 NEXT I
750 C[1]=1/C[1]
760 GOTO 80
```

5.1 Stopping power fit program

```
4 REM ***** HP PLOTTER PAC SUBROUTINE FOR OUTPUT *****
5 DEF FNC(F7)
10 IF W=0 THEN 120
20 PRINT
30 PRINT "COEFFICIENTS"
40 PRINT
50 FORMAT F3.0,E13.5
60 FOR I=1 TO D1+1
70 WRITE (15,50)"B("I-1")="B[I]
80 NEXT I
90 PRINT
100 PRINT "R SQUARE = "R1/T0
110 PRINT
120 RETURN 1
```

```
5 REM ***** SUBROUTINE FOR DEVIATION EVALUATION *****
10 DEF FND(F7)
20 PRINT
30 PRINT
40 PRINT "ENERGY MEV","ERROR IN % OF TABLEVALUE"
50 PRINT "ORDER ="D1,"ATOMIC NUMBER ="Z9
60 PRINT
70 FOR X=1 TO 51 STEP 5
80 WRITE (15,90)E[X],
90 FORMAT F6.2
100 FOR A2=0 TO 4
110 WRITE (15,150)(1-FNZLGTE[X+A2]/Q[X+A2])*100,
120 NEXT A2
130 PRINT
140 NEXT X
150 FORMAT F12.3
160 PRINT
170 PRINT
180 RETURN 1
```

```
10 DEF FNP(Z)
20 RETURN 1
```

5.1 Stopping power fit program

```
5 REM ***** HP PLOTTER PAC SUBROUTINE *****
10 DEF FNX(Z)
20 FOR I=2 TO D2
30 B[I+1]=B[I]*B[2]
40 NEXT I
50 B[D2+2]=Y
60 R=0
70 FOR I=1 TO D2+2
80 FOR J=I TO D2+2
90 R=R+1
100 C[R]=C[R]+B[I]*B[J]*Z
110 NEXT J
120 NEXT I
130 S1=S1+B[2]*Z
140 S2=S2+B[2]↑2*Z
150 S3=S3+Y*Z
160 S4=S4+Y*Y*Z
170 S5=S5+B[2]*Y*Z
180 N=N+Z
190 IF P9#1 THEN 220
200 IF Z#1 THEN 230
210 WRITE (15,250)N,B[2],Y
220 RETURN FNPZ
230 WRITE (15,260)"DELETE"B[2],Y
240 RETURN FNPZ
250 FORMAT F6.0,2F14.4
260 FORMAT 2F14.4
```

```
5 REM ***** HP PLOTTER PAC SUBROUTINE *****
10 DEF FNZ(X)
20 Y=B[D1+1]
30 FOR J=D1 TO 1 STEP -1
40 Y=Y*X+B[J]
50 NEXT J
60 RETURN Y
```

```
5 REM ***** ROUTINE FOR MANUAL TRANSF. OF COEFF'S TO SP. CALC TAPE *****
10 DIM K$[92,10]
20 DISP "LOAD SP CALC.TAPE";
30 STOP
40 LOAD  DATA 7,K
50 DISP "ATOMIC #";
60 INPUT Z9
70 FOR X=1 TO 10
80 PRINT "B(";X-1;")";
90 INPUT K[Z9,X]
100 PRINT K[Z9,X]
110 NEXT X
120 STORE  DATA 7,K
130 END
```

5.2 Stopping power calculation program

```
5 REM ********** ELEMENT INPUT ROUTINE **********
10 DISP "HOW MANY MATERIALS, 1 OR 2";
20 INPUT N[4]
30 PRINT N[4]
40 FOR A3=1 TO N[4]
50 PRINT "MATERIAL NR";A3;"HOW MANY ELEMENTS";
60 INPUT N[A3]
70 NEXT A3
80 FOR A3=1 TO N[4]
85 REM  ***** LOOP OVER MATERIALS *****
90 PRINT "MATERIAL NR";A3;"#","ATOMIC NR","%"
100 FOR A=1 TO N[A3]
105 REM *******  LOOP OVER ELEMENTS IN EACH MATERIAL *******
110 DISP "NR";A;" ATOMIC NR,%";
120 INPUT M[A,A3],P[A,A3]
125 REM ********* THE M ARRAY IS ATOMIC NUMBERS, P IS % FOR THE ELEM
130 PRINT "    ",A,M[A,A3],P[A,A3]
140 NEXT A
150 NEXT A3
155 REM ******** LINE 160-250 IS CHECK OF ELEMENT PRECENCE *******
160 FOR A3=1 TO N[4]
170 FOR A=1 TO N[A3]
180 RESTORE
185 REM ******* RESET DATA POINTER TO FIRST DATA POINT *******
190 FOR A1=1 TO 34
195 REM ******* THE UPPER BOUND IS # OF ELEMENTS CURRENTLY SPECIFIED
200 READ Z9
210 IF M[A,A3]=Z9 THEN 240
220 NEXT A1
230 PRINT "ELEMENT NR";M[A,A3];"ISN'T PRESENT"
240 NEXT A
250 NEXT A3
260 REM ***** LINE 270-340 IS "100 % CHECK" ** ****
270 FOR A3=1 TO N[4]
275 E9=0
280 FOR A=1 TO N[A3]
290 E9=E9+P[A,A3]
295 REM ***** SUMMATION OF % ********
300 NEXT A
310 IF 99.8<E9 AND E9<100.2 THEN 340
320 PRINT "TOTAL % IS NOT 100 FOR MATERIAL NR";A3
330 GOTO 80
340 NEXT A3
350 DATA 1,2,3,4,6,7,8,9,10,12,13,18,26,29,36,47,50,54,62,74,79,82,92
351 DATA 5,11,14,15,16,17,19,20,28,30,35
360 END
```

5.2 Stopping power calculation program

```
5 REM ******* SPECTRUM INPUT ROUTINE ********
10 PRINT "HOW MANY INTERVALS";
20 INPUT N[3]
30 PRINT N[3]
40 PRINT "BEGINNING OF FIRST INTERVAL";
50 INPUT E[1]
60 PRINT E[1]
65 REM ******* LINE 70-110 IS INPUT LOOP FOR SPECTRUM ******
70 FOR A=2 TO N[3]+1
80 DISP "END OF INTERVAL,WEIGHT";
90 INPUT E[A],W[A]
100 PRINT E[A-1];"-";E[A],W[A]
110 NEXT A
120 W[31]=0
125 REM ***** CALC. OF TOTAL AREA OF SPECTRUM ******
130 FOR A=2 TO N[3]+1
140 W[31]=W[31]+((E[A]-E[A-1])*W[A])
150 NEXT A
160 PRINT "   ENERGY INTERVALS","HEIGHT","REL.AREA"
170 FOR A=2 TO N[3]+1
175 REM ******* PRINT OF SPECTRUM WITH NORMALIZED WEIGHTS *******
180 WRITE (15,200)E[A-1],E[A],W[A],W[A]*(E[A]-E[A-1])/W[31]
190 NEXT A
200 FORMAT E11.3,"  -",E11.3,F10.2,F15.3
210 END
```

```
10 COM D8,MI[8,4],PS[8,2],ES[30],WS[31],NI[4],KS[92,10]
20 DIM GS[6]
30 LOAD  DATA 7,K
40 LOAD  KEY 3
50 END
```

5.2 Stopping power calculation program

```
5 REM ******* CALC. OF STOPPING POWER ROUTINE *******
10 DISP "CALC.TABLE WITH SPECTRUM,ENTER 1 ELSE 0";
20 INPUT Q
30 G[3]=G[4]=G[5]=G[6]=0
40 PRINT "ENERGY SPECTRUM";
50 IF Q THEN 70
60 PRINT " NOT";
70 PRINT " INCLUDED IN CALCULATIONS"
80 IF N[4]=1 THEN 280
90 PRINT "ENERGY INTERVALS";TAB(30)"SP1";TAB(41)"SP2";TAB(50)"SP1/SP2"
100 FOR A1=2 TO N[3]+1
105 REM ***** LOOP OVER ENERGY INTERVALS *****
110 G[1]=G[2]=0
112 REM * IF SPECTRUM INCLUDED IN CALCULATIONS, THE ENERGY
113 REM * IS THE AVERAGE OF THE INTERVAL, ELSE THE ENERGY IS THE
114 REM * BEGINNING OF THE INTERVAL ******
115 E=E[A1-1]
116 IF  NOT Q THEN 130
120 E=(E[A1]+E[A1-1])/2
130 FOR A2=1 TO N[4]
135 REM ***** LOOP OVER MATERIALS *****
140 FOR A3=1 TO N[A2]
145 REM ***** LOOP OVER ELEMENTS IN MATERIALS *****
150 G[A2]=G[A2]+(FNSE*P[A3,A2]/100)*((W[A1]*(E[A1]-E[A1-1])/W[31]))↑Q
155 REM ***** FNSE : SUBROUTINE FOR CALC. OF SP
156 REM ***** P(*) : % OF ELEMENT
157 REM ***** W(A1)*..... : WEIGHT FOR THIS ENERGY INTERVAL *
158 REM ***** Q : IF 0 WEIGHT NOT INCLUDED, IF 1 WEIGHT INCLUDED
160 NEXT A3
170 NEXT A2
180 G[6]=G[1]/G[2]
200 G[3]=G[3]+G[1]
210 G[4]=G[4]+G[2]
220 WRITE (15,460)E[A1-1],E[A1],G[1],G[2],G[6]
230 NEXT A1
232 G[5]=G[3]/G[4]
235 D8=G[5]
236 REM ***** D8 IS USED FOR CALCULATION OF FINAL CORRECTION FACTOR
240 IF Q=0 THEN 270
250 PRINT "SUMMATION"
260 WRITE (15,470)G[3],G[4],G[5]
270 GOTO 500
```

5.2 Stopping power calculation program

```
270 GOTO 500
280 PRINT "ENERGY INTERVALS ","STOPPING POWER"
290 PRINT
300 G[3]=0
310 A2=1
320 FOR A1=2 TO N[3]+1
325 REM ***** LOOP OVER ENERGY INTERVALS *****
330 G[1]=0
333 REM ***** SEE REMARKS AT LINE 112 *****
335 E=E[A1-1]
336 IF  NOT 0 THEN 350
340 E=(E[A1]+E[A1-1])/2
350 FOR A3=1 TO N[1]
355 REM ***** LOOP OVER ELEMENTS *****
360 G[1]=G[1]+(FNSE*P[A3,1]/100)*(W[A1]*(E[A1]-E[A1-1])/W[31])↑0
365 REM ***** SEE REMARKS AT LINE 155 *****
370 NEXT A3
380 G[3]=G[3]+G[1]
390 WRITE (15,490)E[A1-1],E[A1],G[1]
400 NEXT A1
410 PRINT
420 IF 0=0 THEN 450
430 PRINT "SUMMATION"
440 WRITE (15,480)G[3]
450 PRINT
460 FORMAT E10.2,"  -",E10.2,F11.3,F11.3,F11.3
470 FORMAT F34.3,F11.3,F11.3
480 FORMAT F35.3
490 FORMAT E10.2,"  -",E10.2,F12.3
500 PRINT
510 END
```

```
5 REM ***** SUBROUTINE FOR CALCULATION OF SP. *****
6 REM ***** SP=A10*LOG(E)↑9+A9*LOG(E)↑8+.....+A0
7 REM ***** THE POLYNOMIUM'S COEFF'S ARE STORED IN THE K ARRAY,
8 REM ***** M(A3,A2) IS A SPECIFIC ELEMENT *****
10 DEF FNS(E)
30 X=K[M[A3,A2],10]
40 FOR J=9 TO 1 STEP -1
50 X=X*LGTE+K[M[A3,A2],J]
60 NEXT J
70 RETURN X
```

5.3 Stopping power plot program

```
10 REM ***** ROUTINE FOR PLOT OF STOPPING POWER VS. ENERGY *****
20 SCALE -2,2,0,8
30 XAXIS 0,1
40 YAXIS -2,1
50 PEN
60 PLOT -2,1,-1
70 FOR X=1 TO 7
80 LABEL (*,1.5,1.7,0,0.65)X
90 CPLOT 0,6
100 NEXT X
110 PLOT -1.95,0.2,-1
120 FOR X=-2 TO 1
130 LABEL (*,1.5,1.7,0,0.65)10↑X
140 CPLOT 26+X,1
150 NEXT X
160 PLOT 1.4,0.2,-1
170 LABEL (*,1.5,1.7,0,0.65)"ENERGY MEV"
180 PLOT -1.9,7.7,-1
190 LABEL (*,1.5,1.7,0,0.65)"STOPPING POWER"
200 CPLOT -14,-1
210 LABEL (*,1.5,1.7,0,0.65)"MEV*CM↑2/G"
220 PLOT -0.4,7.7,-1
230 LABEL (*,1.5,1.7,0,0.65)"MASS COLLISION STOPPING POWER"
231 DISP "ENT 1 SKIP SPECT,2 SKIP SP1&SP2";
232 INPUT H
233 IF H#0 THEN 360
235 REM ***** LINE 240-350 PLOT OF NORMALIZED SPECTRUM *****
240 X=W[2]
250 FOR 0=3 TO N[3]+1
260 IF W[0] <= X THEN 286
270 X=W[0]
280 NEXT 0
290 W[1]=0
300 PLOT LGTE[1],0
310 FOR 0=2 TO N[3]+1
320 PLOT LGTE[0-1],W[0]*5/X
330 PLOT LGTE[0],W[0]*5/X
340 NEXT 0
350 PLOT LGTE[N[3]+1],0
360 PEN
370 PLOT 2,8,-1
375 REM ***** LINE 380-470 IS CALCULATION OF STOPPING POWER *****
380 A4=0
390 FOR A=-2 TO 2 STEP 0.07
400 G[1]=G[2]=0
410 E=10↑A
420 FOR A2=1 TO N[4]
430 FOR A3=1 TO N[A2]
440 G[A2]=G[A2]+(FNSE*P[A3,A2]/100)
450 NEXT A3
460 NEXT A2
470 A4=A4+1
475 IF H=2 THEN 490
480 PLOT A,G[1]
485 REM ***** PLOT OF SP1 *****
490 IF N[4]=1 THEN 520
500 R[A4]=G[1]/G[2]
510 L[A4]=G[2]
520 NEXT A
```

5.3 Showing power plot program

```
530 PEN
540 IF M(4)=2 THEN 560
550 END
560 YAXIS 2,2.5
570 PLOT 1.7,7.7,-1
580 LABEL (*,1.5,1.7,0,0.65)"SP1/SP2"
590 PLOT -0.4,7.7,-1
600 CPLOT 0,-1
610 LABEL (*,1.5,1.7,0,0.65)"-SP1"
620 PLOT 1.9,2.5,-1
630 FOR X=1 TO 3
640 LABEL (*,1.5,1.7,0,0.65)X
650 CPLOT 0,13.11
660 NEXT X
670 PLOT 2,8,-1
675 IF N=2 THEN 750
680 DISP "CHANGE PEN"
690 STOP
700 A4=1
710 FOR A=-2 TO 2 STEP 0.07
720 PLOT A,L(A4)
725 REM ***** PLOT OF SP2 *****
730 A4=A4+1
740 NEXT A
750 PEN
760 A4=1
770 FOR A=-2 TO 2 STEP 0.07
780 PLOT A,R(A4)*2.5
785 REM ***** PLOT OF RATIO *****
790 A4=A4+1
810 NEXT A
815 PEN
820 PLOT -0.4,7.7,-1
830 CPLOT 0,-2
840 LABEL (*,1.5,1.7,0,0.65)"-SP2"
850 PLOT 2,8,-1
860 END
```

5.3 Stopping power plot program

```
5 REM ***** SUBROUTINE FOR CALCULATION OF SP. *****
6 REM ***** SP=A10*LOG(E)↑9+A9*LOG(E)↑8+.....+A0
7 REM ***** THE POLYNOMIUM'S COEFF'S ARE STORED IN THE K ARRAY,
8 REM ***** M(A3,A2) IS A SPECIFIC ELEMENT *****
10 DEF FNS(E)
30 X=K[M[A3,A2],10]
40 FOR J=9 TO 1 STEP -1
50 X=X*LGTE+K[M[A3,A2],J]
60 NEXT J
70 RETURN X
```

```
10 COM D8,MI[8,4],PS[8,2],ES[30],WS[31],NI[4],KS[92,10]
20 DIM GS[6],LS[100],RS[100]
40 LOAD  KEY 5
50 END
```

5.4 Absorption coefficient data input program

```
5 REM ***** PHOTON CROSS SECTION DATA INPUT PROGRAM *****
10 DIM T[33],Y[33]
11 DISP "LOAD PCS TABLE TAPE"
12 STOP
20 LOAD  DATA 0,T
30 DISP "ATOMIC #";
40 INPUT Z9
50 DISP "CONVERSION FACTOR";
60 INPUT C
65 REM ***** THE PCS MUST CORRESPOND TO THE ENERGIES SHOWN *****
70 PRINT "ENERGY","PCS","MU"
80 FOR X=1 TO 33
90 DISP T[X];"PCS";
100 INPUT Y[X]
110 PRINT T[X],Y[X],Y[X]*C
120 Y[X]=Y[X]*C
130 NEXT X
140 STORE  DATA Z9,Y
150 DISP "DONE"
160 END
```

5.5 Absorption coefficient calculation program

```
5 REM ***** INPUT ROUTINE FOR MU CALCULATIONS *****
10 DISP "ENT 1 SKIP INPUT";
12 REM ***** THIS OPTION ALLOWS DATA TO BE TRANSFERRED FROM SP PROGRAM
15 INPUT H
20 IF H THEN 420
30 DISP "MATERIALS 1 OR 2";
40 INPUT N[4]
50 PRINT N[4]
60 FOR A3=1 TO N[4]
70 DISP "MAT.NR";A3;"# OF ELEMENTS";
80 INPUT N[A3]
90 NEXT A3
100 FOR A3=1 TO N[4]
105 REM ***** INPUT LOOP STARTS HERE *****
110 PRINT "MATERIAL NR";A3;"#","ATOMIC NR","%"
115 E9=0
120 FOR A=1 TO N[A3]
130 DISP "NR";A;" ATOMIC NR,%";
140 INPUT M[A,A3],P[A,A3]
145 E9=E9+P[A,A3]
150 PRINT "    ",A,M[A,A3],P[A,A3]
160 NEXT A
162 REM ***** CHECK OF PERCENTAGES IS PERFORMED HERE *****
165 IF ABS(E9-100)<0.2 THEN 170
166 PRINT E9"%"
167 GOTO 115
170 NEXT A3
420 N9=1
430 FOR A2=1 TO N[4]
435 REM ***** LOOP OVER MATERIALS STARTS HERE *****
440 FOR A3=1 TO N[A2]
445 REM ***** LOOP OVER ELEMENTS STARTS HERE *****
450 FOR A4=1 TO N9-1
455 REM ***** THIS LOOP CHECKS IF AN ELEMENT HAS BEEN READ IN BEFORE
460 IF M[A3,A2]=Y[34,A4] THEN 570
470 NEXT A4
480 LOAD  DATA M[A3;A2],T
485 REM ***** DATA IS HERE READ INTO THE BUFFER ARRAY T *****
490 FOR A=1 TO 33
495 REM ***** THIS LOOP TRANSFERS THE BUFFER TO THE Y ARRAY *****
500 Y[A,N9]=T[A]
510 NEXT A
520 Y[34,N9]=M[A3,A2]
522 REM ***** ELEMENT'S ATOMIC # STORED WITH DATA *****
525 M[A3,A2+2]=N9
530 N9=N9+1
540 NEXT A3
550 NEXT A2
560 GOTO 590
570 M[A3,A2+2]=A4
580 GOTO 540
590 LOAD  DATA 0,T
595 REM ***** THE ENERGY VALUES ARE STORED IN THE T ARRAY *****
600 END
```

5.5 Absorption coefficient calculation program

```
5 REM ***** SPECTRUM INPUT ROUTINE *****
10 PRINT "INTERVALS";
20 INPUT N[3]
30 PRINT N[3]
40 PRINT "LOWEST ENERGY";
50 INPUT E[1]
60 PRINT E[1]
65 REM ***** LINE 70-110 IS INPUT LOOP FOR SPECTRUM *****
70 FOR A=2 TO N[3]+1
80 DISP "END OF INT.,WEIGHT";
90 INPUT E[A],W[A]
100 PRINT E[A-1];"-";E[A],W[A]
110 NEXT A
140 W[31]=0
145 REM ***** CALC. OF TOTAL AREA OF SPECTRUM *****
150 FOR A=2 TO N[3]+1
160 W[31]=W[31]+((E[A]-E[A-1])*W[A])
170 NEXT A
190 PRINT "   ENERGY INTERVALS","HEIGHT","REL.AREA"
200 FOR A=2 TO N[3]+1
205 REM ***** PRINT OF SPECTRUM WITH NORMALIZED WEIGHTS *****
210 WRITE (15,270)E[A-1],E[A],W[A],W[A]*(E[A]-E[A-1])/W[31]
230 NEXT A
270 FORMAT E11.3,"  -",E11.3,F10.2,E18.2
280 END
```

5.5 Absorption coefficient calculation program

```
5 REM ***** MU CALC. ROUTINE *****
10 DISP "WITH SPECT.ENTER 1";
20 INPUT Q
30 G[3]=G[4]=G[5]=G[6]=0
40 PRINT "WITH";
50 IF Q=1 THEN 70
60 PRINT "OUT";
70 PRINT " SPECTRUM"
80 IF N[4]=1 THEN 110
90 PRINT "INTERVALS";TAB29"MU1";TAB41"MU2";TAB51"MU1/MU2"
100 GOTO 120
110 PRINT "INTERVALS","MU"
120 PRINT
130 FOR A1=2 TO N[3]+1
135 REM ***** LOOP OVER ENERGY INTERVALS *****
140 G[1]=G[2]=0
150 FOR A2=1 TO N[4]
155 REM ***** LOOP OVER MATERIALS *****
160 FOR A3=1 TO N[A2]
165 REM ***** LOOP OVER ELEMENTS *****
170 Z=M[A3,A2]
175 REM ***** ATOMIC # OF ELEMENT *****
180 D=E[A1-1]
181 IF Q THEN 190
182 G[A2]=G[A2]+FNA(E[A1-1])*P[A3,A2]/100
183 GOTO 320
185 REM ***** LINE 182-183 IS CALCULATION WITHOUT SPECTRUM *****
186 REM ***** P(**) IS THE PERCENTAGE OF THE ELEMENTS *****
187 REM ***** FNA IS THE ROUTINE FOR MU CALCULATION *****
```

5.5 Absorption coefficient calculation program

```
5 REM ***** MU INTERPOLATION ROUTINE *****
10 DEF FNA(E)
20 FOR A=33 TO 2 STEP -1
30 IF T[A] <= E THEN 70
40 NEXT A
50 DISP "ILLEGAL ENERGY,<.015 MEV"
55 REM ***** THIS LIMIT IS NEEDED IN ORDER TO ALLOW
56 REM ***** PROPER INTERPOLATION
60 STOP
70 D=T[A]
80 C=E
90 IF FNB1=0 THEN 300
100 E0=K[X]
110 Y0=LGTK[X+2]
120 B=E
130 C=T[A+1]
140 IF FNB1=0 THEN 190
150 E1=K[X]
160 Y1=LGTK[X+1]
170 P=(Y1-Y0)/(E1-E0)*(E-E0)+Y0
180 RETURN 10↑P
190 E1=T[A+1]
200 Y1=LGTY[A+1,M[A3,A2+2]]
210 C=T[A+2]
220 B=T[A+1]
230 IF FNB1=0 THEN 270
240 E2=K[X]
250 Y2=LGTK[X+1]
260 GOTO 480
270 E2=T[A+2]
280 Y2=LGTY[A+2,M[A3,A2+2]]
290 GOTO 480
300 E1=T[A]
310 Y1=LGTY[A,M[A3,A2+2]]
320 B=T[A-1]
330 C=T[A]
340 IF FNB1=0 THEN 380
350 E0=K[X]
360 Y0=LGTK[X+2]
370 GOTO 400
380 E0=T[A-1]
390 Y0=LGTY[A-1,M[A3,A2+2]]
400 B=E
410 C=T[A+1]
420 IF FNB1=0 THEN 460
430 E2=K[X]
440 Y2=LGTK[X+1]
450 GOTO 480
460 E2=T[A+1]
470 Y2=LGTY[A+1,M[A3,A2+2]]
480 P=(E-E1)*(E-E2)/(E0-E1)/(E0-E2)*Y0
490 P=P+(E-E0)*(E-E2)/(E1-E0)/(E1-E2)*Y1
500 P=P+(E-E0)*(E-E1)/(E2-E0)/(E2-E1)*Y2
510 RETURN 10↑P
```

5.5 Absorption coefficient calculation program

```
185 REM ***** LINE 190-310 IS MU CALCULATION WITH SPECTRUM *****
190 C=E[A1]
200 A7=FNB(1)
205 REM ***** DISCONTINUITY CHECK *****
210 D2=D
220 C1=C
230 IF A7=0 THEN 270
240 A9=K[X]
250 A8=C
260 C1=K[X]
270 H=(C1-D2)/(E[A1]-E[A1-1])
275 G[A2]=G[A2]+FNA((C1+D2)/2)*H*P[A3,A2]*0.01*(E[A1]-E[A1-1])
276 REM *****W: SPECTRUM WEIGHT ***** //  *W(A1)/W(31)
280 IF A7=0 THEN 320
290 D=A9
300 C=A8
310 GOTO 200
320 NEXT A3
330 NEXT A2
340 IF N[4]=1 THEN 380
345 REM ***** JUMP IF ONLY 1 MATERIAL *****
350 G[6]=G[1]/G[2]
370 G[4]=G[4]+G[2]
380 G[3]=G[3]+G[1]
390 IF N[4]=1 THEN 480
400 WRITE (15,550)E[A1-1],E[A1],G[1],G[2],G[6]
410 NEXT A1
415 G[5]=G[3]/G[4]
420 PRINT
430 IF Q=0 THEN 460
440 PRINT "SUM";TAB51"WEIGHTED"
450 WRITE (15,560)G[3],G[4],G[5]
455 P1=G[5]
457 REM ***** P1 IS USED FOR CALC. OF FINAL CORR. FACTOR *****
460 PRINT
470 END
480 WRITE (15,580)E[A1-1],E[A1],G[1]
490 NEXT A1
500 IF Q=0 THEN 530
510 PRINT "SUM"
520 WRITE (15,570)G[3]
530 PRINT
540 END
550 FORMAT E10.2,"  -",E10.2,E12.2,E12.2,F12.3
560 FORMAT E35.2,E12.2,F12.3
570 FORMAT F35.3
580 FORMAT E10.2,"  -",E10.2,E12.2
590 END
```

5.5 Absorption coefficient calculation program

```
5 REM *****DISCONTINUITY CHECK ROUTINE *****
10 DEF FNB(S)
30 RESTORE 140
40 FOR X1=1 TO 9
50 READ Z1,N1,D1
60 IF Z1=M[A3,A2] THEN 90
65 REM ***** IS ELEMENT INCLUDED IN DISCONTINUITY LIST ? *****
70 NEXT X1
80 RETURN 0
90 FOR X=N1 TO N1+D1 STEP 3
100 IF D<K[X] AND K[X] <= C THEN 130
105 REM ***** DOES ENERGY LIE IN ENERGY INTERVAL ? *****
110 NEXT X
120 RETURN 0
130 RETURN 1
135 REM ***** DATA STATEMENT IS ORGANIZED IN GROUPS OF 3:
136 REM ***** 1: ATOMIC NUMBER
137 REM ***** 2: POINTER TO START OF DATA FOR THIS ELEMENT IN K
138 REM ***** 3: LENGTH-1 OF DATA FOR THIS ELEMENT
140 DATA 36,1,2,47,4,2,50,7,2,54,10,2,74,13,8,79,22,11,82,34,11
141 DATA 92,46,11,35,58,2
```

```
10 COM D8,MI[8,4],PS[8,2],ES[30],WS[31],NI[4],KS[75],YS[34,12],TS[33]
20 DIM GS[6]
30 LOAD  DATA 3,K
40 LOAD  KEY 5
70 END
```

5.6 Absorption coefficient plot program

```
1 REM ***** ROUTINE FOR PLOT OF MU VS. ENERGY *****
2 REM ***** LINE 10-220 IS AXIS PLOTTING & LABELING *****
10 SCALE -2,2,-2,1
20 XAXIS -2,1
30 YAXIS -2,1
40 PEN
50 PLOT -2,-1.9,-1
60 FOR X=-2 TO 1
70 LABEL (*,1.5,1.7,0,0.65)10↑X
81 CPLOT 0,12.8
82 CPLOT 0,0.5
90 NEXT X
100 PLOT -2,-1.9,-1
110 FOR X=-2 TO 1
120 LABEL (*,1.5,1.7,0,0.65)10↑X
125 CPLOT 0,1
130 CPLOT 24,0
131 CPLOT -X,0
140 NEXT X
150 PLOT 1.4,-1.9,-1
160 LABEL (*,1.5,1.7,0,0.65)"ENERGY MEV"
170 PLOT -1.9,0.8,-1
180 LABEL (*,1.5,1.7,0,0.65)"MU  CM↑2/G"
210 PLOT -0.4,0.8,-1
220 LABEL (*,1.5,1.7,0,0.65)"MASS ENERGY ABSORBTION COEFFICIENTS"
221 DISP "ENT 1 SKIP SPECT,2 SKIP MU1&MU2";
222 INPUT H
223 IF H#0 THEN 350
225 REM ***** LINE 230-350 PLOT OF NORMALIZED SPECTRUM *****
230 X=W[2]
240 FOR O=3 TO N[3]+1
250 IF W[O] <= X THEN 270
260 X=W[O]
270 NEXT O
280 W[1]=-2
290 PLOT LGTE[1],-2
300 FOR O=2 TO N[3]+1
310 PLOT LGTE[O-1],(W[O]*2/X)-2
320 PLOT LGTE[O],(W[O]*2/X)-2
330 NEXT O
340 PLOT LGTE[N[3]+1],-2
350 PEN
```

5.6 Absorption coefficient plot program

```
355 REM ***** LINE 360-490 IS CALC. OF MU & PLOT OF MU1 *****
360 A4=0
370 FOR A1=-1.8 TO 2 STEP 0.07
380 G[1]=G[2]=0
390 FOR A2=1 TO N[4]
400 FOR A3=1 TO N[A2]
410 G[A2]=G[A2]+(FNA(10*A1)*P[A3,A2]/100)
420 NEXT A3
430 NEXT A2
435 A4=A4+1
436 IF N=2 THEN 450
440 PLOT A1,LGTG[1]
450 IF N[4]=1 THEN 480
460 R[A4]=G[1]/G[2]
470 L[A4]=G[2]
480 NEXT A1
490 PEN
500 IF N[4]=2 THEN 520
510 END
515 REM ***** LINE 520-630 IS AXIS PLOTTING & LABELING *****
520 YAXIS 2,1
530 PLOT 1.7,0.8,-1
540 LABEL (*,1.5,1.7,0,0.65)"MU1/MU2"
550 PLOT -0.4,0.8,-1
560 CPLOT 0,-1
570 LABEL (*,1.5,1.7,0,0.65)"-MU1"
580 PLOT 1.9,-1,-1
590 FOR X=1 TO 3
600 LABEL (*,1.5,1.7,0,0.65)X
610 CPLOT 0,13
615 CPLOT 0,1
620 NEXT X
630 PLOT 2,1,-1
640 DISP "CHANGE PEN"
650 STOP
655 REM ***** LINE 659-730 IS PLOT OF MU2 & M1/M2 *****
659 A3=0
660 FOR A1=-1.8 TO 2 STEP 0.07
665 A3=A3+1
666 IF N=2 THEN 680
670 PLOT A1,LGTL[A3]
680 NEXT A1
690 PEN
695 A3=0
700 FOR A1=-1.8 TO 2 STEP 0.07
705 A3=A3+1
710 PLOT A1,R[A3]-2
730 NEXT A1
735 PEN
737 REM ***** PLOT MU2 LABEL IN DIFFERENT COLOUR *****
740 PLOT -0.4,0.8,-1
750 CPLOT 0,-2
760 LABEL (*,1.5,1.7,0,0.65)"-MU2"
770 PLOT 2,1,-1
780 END
```

5.6 Absorption coefficient plot program

```
5 REM ***** MU INTERPOLATION ROUTINE *****
10 DEF FNA(E)
20 FOR A=33 TO 2 STEP -1
30 IF T[A] <= E THEN 70
40 NEXT A
50 DISP "ILLEGAL ENERGY,<.015 MEV"
60 STOP
70 D=T[A]
80 C=E
90 IF FNB(1)=0 THEN 300
100 E0=K[X]
110 Y0=LGTK[X+2]
120 D=E
130 C=T[A+1]
140 IF FNB(1)=0 THEN 190
150 E1=K[X]
160 Y1=LGTK[X+1]
170 P=(Y1-Y0)/(E1-E0)*(E-E0)+Y0
180 RETURN 10↑P
190 E1=T[A+1]
200 Y1=LGTY[A+1,M[A3,A2+2]]
210 C=T[A+2]
220 D=T[A+1]
230 IF FNB(1)=0 THEN 270
240 E2=K[X]
250 Y2=LGTK[X+1]
260 GOTO 480
270 E2=T[A+2]
280 Y2=LGTY[A+2,M[A3,A2+2]]
290 GOTO 480
300 E1=T[A]
310 Y1=LGTY[A,M[A3,A2+2]]
320 D=T[A-1]
330 C=T[A]
340 IF FNB(1)=0 THEN 380
350 E0=K[X]
360 Y0=LGTK[X+2]
370 GOTO 400
380 E0=T[A-1]
390 Y0=LGTY[A-1,M[A3,A2+2]]
400 D=E
410 C=T[A+1]
420 IF FNB(1)=0 THEN 460
430 E2=K[X]
440 Y2=LGTK[X+1]
450 GOTO 480
460 E2=T[A+1]
470 Y2=LGTY[A+1,M[A3,A2+2]]
480 P=(E-E1)*(E-E2)/(E0-E1)/(E0-E2)*Y0
490 P=P+(E-E0)*(E-E2)/(E1-E0)/(E1-E2)*Y1
500 P=P+(E-E0)*(E-E1)/(E2-E0)/(E2-E1)*Y2
510 RETURN 10↑P
```

5.6 Absorption coefficient plot program

```
5 REM *****DISCONTINUITY CHECK ROUTINE *****
10 DEF FNB(S)
30 RESTORE 140
40 FOR X1=1 TO 9
50 READ Z1,N1,D1
60 IF Z1=M[A3,A2] THEN 90
65 REM ***** IS ELEMENT INCLUDED IN DISCONTINUITY LIST ? *****
70 NEXT X1
80 RETURN 0
90 FOR X=N1 TO N1+D1 STEP 3
100 IF D<K[X] AND K[X] <= C THEN 130
105 REM ***** DOES ENERGY LIE IN ENERGY INTERVAL ? *****
110 NEXT X
120 RETURN 0
130 RETURN 1
135 REM ***** DATA STATEMENT IS ORGANIZED IN GROUPS OF 3:
136 REM ***** 1: ATOMIC NUMBER
137 REM ***** 2: POINTER TO START OF DATA FOR THIS ELEMENT IN K
138 REM ***** 3: LENGTH-1 OF DATA FOR THIS ELEMENT
140 DATA 36,1,2,47,4,2,50,7,2,54,10,2,74,13,8,79,22,11,82,34,11
141 DATA 92,46,11,35,58,2
```

```
10 COM D8,MI[8,4],PS[8,2],ES[30],WS[31],NI[4],KS[75],YS[34,12],TS[33]
20 LOAD  KEY 7
30 DIM GS[6],LS[100],RS[100]
40 END
```

5.7 Correction factor calculation program

```
5 REM ***** ROUTINE FOR CALC. OF F *****
6 REM ***** THIS ROUTINE IS ACCESSED WITH A LINK 9 *****
7 REM ***** FROM THE MU CALC. PROGRAM *****
10 PRINT "THICKNESS IN G/CM↑2";
15 REM ***** FOR LARGE CAVITY INPUT NEGATIVE VALUE *****
20 INPUT G
25 PRINT G
30 IF G>0 THEN 80
40 PRINT "VOL,AREA (G/CM↑2)↑3, (G/CM↑2)↑2";
50 INPUT V,A
60 G=4*V/A
70 PRINT V,A
80 DISP "SP1/SP2";
90 INPUT D7
100 IF D7>0 THEN 120
110 D7=D8
120 B=16/(E[NE[3]+1]-0.036)↑1.4
130 D3=(1-EXP(-B*G))/B/G
140 PRINT "D=";D3
150 F=D3*D7+(1-D3)*P1
160 PRINT "F=";F
170 END
```

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Title and author(s)

A Program in BASIC for Calculation of Cavity Theory Corrections

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38 pages + tables + illustrations

Abstract

A program in BASIC for a desk-top calculator HP 9830A is described. The program allows calculation of cavity theory corrections according to Burlin's general cavity theory. The calculations are made by using tabulated values for stopping powers and energy absorption coefficients, stored either as coefficients to a fitted polynomial or as the actual table data.

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