======================================================================= Virgin

Virgin

PROGRAM VIRGIN Virgin

VERSION 76-1 (NOVEMBER 1976) Virgin

VERSION 84-1 (JUNE 1984) \*DOUBLE PRECISION ENERGY Virgin

VERSION 86-1 (JANUARY 1986)\*FORTRAN-77/H VERSION Virgin

VERSION 88-1 (JULY 1988) \*OPTION...INTERNALLY DEFINE ALL I/O Virgin

FILE NAMES (SEE, SUBROUTINE FILEIO Virgin

FOR DETAILS). Virgin

\*IMPROVED BASED ON USER COMMENTS. Virgin

VERSION 89-1 (JANUARY 1989)\*PSYCHOANALYZED BY PROGRAM FREUD TO Virgin

INSURE PROGRAM WILL NOT DO ANYTHING Virgin

CRAZY. Virgin

\*UPDATED TO USE NEW PROGRAM CONVERT Virgin

KEYWORDS. Virgin

\*ADDED LIVERMORE CIVIC COMPILER Virgin

CONVENTIONS. Virgin

VERSION 92-1 (JANUARY 1992)\*COMPLETE RE-WRITE Virgin

\*OUTPUT IN PLOTTAB FORMAT Virgin

\*UP TO 2000 THICKNESSES Virgin

\*INCREASED INCORE PAGE SIZE TO 6000 Virgin

CROSS SECTION POINTS Virgin

\*ADDED PHOTON CALCULATIONS Virgin

\*ADDED BLACKBODY SPECTRUM Virgin

\*ADDED MULTIPLE LAYERS Virgin

\*ADDED SPATIALLY DEPENDENT DENSITY Virgin

\*ADDED FORTRAN SAVE OPTION Virgin

\*COMPLETELY CONSISTENT I/O ROUTINES - Virgin

TO MINIMIZE COMPUTER DEPENDENCE. Virgin

VERSION 92-2 (MAY 1992) \*CORRECTED TO HANDLE MULTIGROUP CROSS Virgin

SECTIONS AS INPUT IN ENDF/B FORMAT. Virgin

VERSION 96-1 (JANUARY 1996) \*COMPLETE RE-WRITE Virgin

\*IMPROVED COMPUTER INDEPENDENCE Virgin

\*ALL DOUBLE PRECISION Virgin

\*ON SCREEN OUTPUT Virgin

\*UNIFORM TREATMENT OF ENDF/B I/O Virgin

\*IMPROVED OUTPUT PRECISION Virgin

\*DEFINED SCRATCH FILE NAMES Virgin

VERSION 99-1 (MARCH 1999) \*CORRECTED CHARACTER TO FLOATING Virgin

POINT READ FOR MORE DIGITS Virgin

\*UPDATED TEST FOR ENDF/B FORMAT Virgin

VERSION BASED ON RECENT FORMAT CHANGE Virgin

\*GENERAL IMPROVEMENTS BASED ON Virgin

USER FEEDBACK Virgin

VERS. 2000-1 (FEBRUARY 2000)\*GENERAL IMPROVEMENTS BASED ON Virgin

USER FEEDBACK Virgin

VERS. 2002-1 (MAY 2002) \*OPTIONAL INPUT PARAMETERS Virgin

VERS. 2004-1 (MARCH 2004) \*ADDED INCLUDE FOR COMMON Virgin

\*UP TO 2000 THICKNESSES Virgin

\*INCREASED INCORE PAGE SIZE TO 60,000 Virgin

VERS. 2007-1 (JAN. 2007) \*CHECKED AGAINST ALL ENDF/B-VII. Virgin

\*INCREASED INCORE PAGE SIZE TO Virgin

240,000 FROM 60,000. Virgin

VERS. 2007-2 (DEC. 2007) \*72 CHARACTER FILE NAME. Virgin

VERS. 2010-1 (Apr. 2010) \*General update based on user feedback Virgin

\*INCREASED INCORE PAGE SIZE TO Virgin

600,000 FROM 240,000. Virgin

VERS. 2012-1 (Aug. 2012) \*Added CODENAME Virgin

\*32 and 64 bit Compatible Virgin

\*Added ERROR stop Virgin

VERS. 2015-1 (Jan. 2015) \*Extended OUT9. Virgin

\*Replaced ALL 3 way IF Statements. Virgin

\*Generalized TART Group Structures. Virgin

\*Generalized SAND-II Group Structures. Virgin

\*Extended SAND-II to 60, 150, 200 MeV. Virgin

Virgin

OWNED, MAINTAINED AND DISTRIBUTED BY Virgin

------------------------------------ Virgin

THE NUCLEAR DATA SECTION Virgin

INTERNATIONAL ATOMIC ENERGY AGENCY Virgin

P.O. BOX 100 Virgin

A-1400, VIENNA, AUSTRIA Virgin

EUROPE Virgin

Virgin

ORIGINALLY WRITTEN BY Virgin

------------------------------------ Virgin

Dermott E. Cullen Virgin

Virgin

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Virgin

PURPOSE Virgin

------- Virgin

THIS PROGRAM IS DESIGNED TO CALCULATE UNCOLLIDED (I.E. VIRGIN) Virgin

FLUX AND REACTIONS DUE TO TRANSMISSION OF A MONODIRECTIONAL Virgin

BEAM OF NEUTRONS THROUGH ANY THICKNESS OF MATERIAL. IN ORDER Virgin

TO SIMULATE AN EXPERIMENTAL MEASUREMENT THE RESULTS ARE GIVEN Virgin

AS INTEGRALS OVER ENERGY TALLY GROUPS (AS OPPOSED TO POINTWISE Virgin

IN ENERGY). BY TAKING THE RATIO OF REACTIONS TO FLUX IN EACH Virgin

GROUP AN EQUIVALENT SPATIALLY DEPENDENT GROUP AVERAGED CROSS Virgin

SECTION IS CALCULATED BY THE PROGRAM. Virgin

Virgin

EVALUATED DATA Virgin

-------------- Virgin

THE EVALUATED DATA MUST BE IN THE ENDF/B FORMAT. HOWEVER IT Virgin

MUST BE LINEAR-LINEAR INTERPOLABLE IN ENERGY-CROSS SECTION Virgin

BETWEEN TABULATED POINTS. SINCE ONLY CROSS SECTIONS (FILE 3 OR 23) Virgin

ARE USED, THIS PROGRAM WILL WORK ON ANY VERSION OF ENDF/B Virgin

(I.E. ENDF/B-I, II, III, IV, V OR VI). Virgin

Virgin

RELATED COMPUTER CODES Virgin

---------------------- Virgin

IN ORDER TO CONVERT ENDF/B DATA TO THE FORM REQUIRED BY THIS CODE Virgin

THE FOLLOWING COMPUTER CODES MAY BE USED, Virgin

Virgin

LINEAR - CONVERT FROM GENERAL ENDF/B INTERPOLATION TO LINEAR- Virgin

LINEAR INTERPOLATION. Virgin

RECENT - ADD THE RESONANCE CONTRIBUTION TO TABULATED BACKGROUND Virgin

CROSS SECTIONS TO OBTAIN LINEAR-LINEAR INTERPOLABLE Virgin

RESULTS. Virgin

SIGMA1 - DOPPLER BROADEN CROSS SECTION TO OBTAIN LINEAR-LINEAR Virgin

INTERPOLABLE RESULTS. Virgin

MIXER - MIX INDIVIDUAL MATERIALS TOGETHER TO DEFINE COMPOSITE Virgin

MIXTURES, E.G., COMBINE MATERIALS TO DEFINE STAINLESS Virgin

STELL. Virgin

Virgin

IN ORDER TO PLOT THE OUTPUT RESULTS OF THIS CODE USE PROGRAM Virgin

PLOTTAB. Virgin

Virgin

COPIES OF ANY OR ALL OF THESE CODES MAY BE OBTAINED FROM D.E. Virgin

CULLEN AT THE ABOVE ADDRESS. Virgin

Virgin

OUTPUT FORMAT Virgin

------------- Virgin

FOR ALL VERSIONS OF THIS PROGRAM PRIOR TO VERSION 92-1 OUTPUT WAS Virgin

IN TABULAR FORM. Virgin

Virgin

FOR VERSION 92-1 AND LATER VERSIONS OF THIS CODE ALL OUTPUT IS IN Virgin

THE PROGRAM PLOTTAB FORMAT TO ALLOW RESULTS TO BE EASILY PLOTTED. Virgin

FOR A COPY OF PROGRAM PLOTTAB CONTACT D.E. CULLEN AT THE ABOVE Virgin

ADDRESS. Virgin

Virgin

TALLY GROUPS Virgin

------------ Virgin

THE TALLY GROUP STRUCTURE MAY BE ANY SET OF MONONTONICALLY Virgin

INCREASING ENERGY BOUNDARIES. THERE MAY BE UP TO 2000 TALLY Virgin

GROUPS. BY USING THE INPUT PARAMETERS THE USER MAY SPECIFY ANY Virgin

ARBITRARY TALLY GROUP STRUCTURE OR SELECT ONE OF THE FOLLOWING Virgin

BUILT-IN GROUP STRUCTURES. Virgin

Virgin

(0) TART 175 GROUPS Virgin

(1) ORNL 50 GROUPS Virgin

(2) ORNL 126 GROUPS Virgin

(3) ORNL 171 GROUPS Virgin

(4) SAND-II 620 GROUPS - 1.0e-4 eV UP TO 18 MEV Virgin

(5) SAND-II 640 GROUPS - 1.0e-4 eV UP TO 20 MEV Virgin

(6) WIMS 69 GROUPS Virgin

(7) GAM-I 68 GROUPS Virgin

(8) GAM-II 99 GROUPS Virgin

(9) MUFT 54 GROUPS Virgin

(10) ABBN 28 GROUPS Virgin

(11) TART 616 GROUPS TO 20 MeV Virgin

(12) TART 700 GROUPS To 1 GeV Virgin

(13) SAND-II 665 GROUPS - 1.0e-5 eV UP TO 18 MEV Virgin

(14) SAND-II 685 GROUPS - 1.0e-5 eV UP TO 20 MEV Virgin

(15) TART 666 GROUPS TO 200 MeV Virgin

(16) SAND-II 725 GROUPS - 1.0e-5 eV UP TO 60 MEV Virgin

(17) SAND-II 755 GROUPS - 1.0e-5 eV UP TO 150 MEV Virgin

(18) SAND-II 765 GROUPS - 1.0e-5 eV UP TO 200 MEV Virgin

Virgin

INCIDENT SPECTRUM Virgin

----------------- Virgin

THE INCIDENT SPECTRUM MAY BE ANY TABULATED FUNCTION THAT IS Virgin

GIVEN BY A SET OF POINTS THAT IS MONOTONICALLY INCREASING IN Virgin

ENERGY AND LINEAR-LINEAR INTERPOLABLE IN ENERGY-SPECTRUM Virgin

BETWEEN TABULATED POINTS. THERE IS NO LIMIT TO THE NUMBER OF Virgin

POINTS USED TO DESCRIBE THE SPECTRUM. THERE ARE FIVE BUILT-IN Virgin

OPTIONS FOR THE SPECTRUM. Virgin

Virgin

(1) CONSTANT...ENERGY INDEPENDENT (INPUT 0) Virgin

(2) 1/E (INPUT 1) Virgin

(3) BLACKBODY - PHOTON SPECTRUM Virgin

(4) BLACKBODY - ENERGY SPECTRUM (E TIMES THE PHOTON SPECTRUM) Virgin

(5) TRANSMITTED SPECTRUM FROM PREVIOUS CASE Virgin

Virgin

NORMALIZATION OF SPECTRUM Virgin

------------------------- Virgin

ANY INCIDENT SPECTRUM, EITHER READ AS INPUT OR ONE OF THE Virgin

BUILT-IN SPECTRA, WILL BE NORMALIZED TO UNITY WHEN INTEGRATED Virgin

OVER THEIR ENTIRE ENERGY RANGE. Virgin

Virgin

TRANSMITTED SPECTRA WILL NOT BE RE-NORMALIZED, SINCE IT ALREADY Virgin

INCLUDES THE NORMALIZATION OF THE INCIDENT SPECTRUM. Virgin

Virgin

NOTE, INCIDENT SPECTRA IS NORMALIZED TO UNITY OVER THEIR ENTIRE Virgin

ENERGY RANGE - NOT OVER THE ENERGY RANGE OF THE GROUPS. IF THE Virgin

ENERGY RANGE OF THE GROUPS IS LESS THAN THAT OF THE SPECTRUM Virgin

ONLY THAT PORTION OF THE SPECTRUM WILL BE USED AND THIS WILL Virgin

NOT BE RE-NORMALIZED TO UNITY. Virgin

Virgin

COMPOSITION OF A LAYER Virgin

---------------------- Virgin

YOU MAY RUN PROBLEMS INVOLVING Virgin

1) A LAYER OF UNIFORM DENSITY - DENSITY FOR ATTENUATION IS THAT Virgin

OF THE TOTAL. DENSITY FOR REACTIONS IS THAT OF THE REACTION. Virgin

2) A LAYER OF UNIFORM DENSITY - DENSITY IS THE SUM OF THE TOTAL Virgin

AND REACTION DENSITIES - THE SUM OF THE CROSS SECTIONS IS Virgin

USED FOR ATTENUATION AND REACTIONS. Virgin

3) A LAYER OF VARYING DENSITY BASED ON A UNIFORM TOTAL DENSITY Virgin

PLUS A VARIATION BETWEEN 0 AND A MAXIMUM BASED ON THE Virgin

REACTION DENSITY - 0 AT 0 THICKNESS AND MAXIMUM AT MAXIMUM Virgin

THICKNESS. IN THIS CASE THE AVERAGE REACTION DENSITY IS EQUAL Virgin

TO THE INPUT REACTION DENSITY. THE VARIATION IN REACTION Virgin

DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin

4) A LAYER OF VARYING DENSITY BASED ON A TOTAL DENSITY WHICH Virgin

VARYING FROM MAXIMUM AT 0 THICKNESS TO 0 AT MAXIMUM THICKNESS Virgin

PLUS A REACTION DENSITY WHICH VARIES FROM 0 AT 0 THICKNESS Virgin

TO MAXIMUM AT MAXIMUM THICKNESS. IN THIS CASE THE AVERAGE Virgin

DENSITY OF THE TOTAL AND REACTION WILL BOTH BE EQUAL TO THE Virgin

INPUT TOTAL AND REACTION DENSITIES. THE VARIATION IN TOTAL Virgin

AND REACTION DENSITY CAN BE LINEAR, SQUARE OR CUBIC. Virgin

Virgin

IN THE FIRST CASE THE TWO REQUESTED CROSS SECTIONS ARE CONSIDERED Virgin

TO BE INDEPENDENT - THE TOTAL CROSS SECTION IS USED TO CALCULATE Virgin

ATTENUATION AND THE REACTION CROSS SECTION IS USED TO CALCULATE Virgin

REACTIONS, E.G., TRANSMISSION THROUGH NATURAL URANIUM (THE TOTAL Virgin

CROSS SECTION SHOULD BE THAT OF NATURAL URANIUM) AND REACTIONS Virgin

IN A U-235 DETECTOR (THE REACTION CROSS SECTION SHOULD BE THAT OF Virgin

U-235). Virgin

Virgin

IN THE OTHER THREE CASES THE TWO REQUESTED CROSS SECTIONS ARE Virgin

TREATED AS TWO CONSTITUENTS OF A MIXTURE OF TWO MATERIALS AND Virgin

THE TWO CROSS SECTIONS ARE USED BOTH TO DEFINE A TOTAL CROSS Virgin

SECTION FOR ATTENUATION AND A REACTION CROSS SECTION TO DEFINE Virgin

REACTIONS. IN THESE CASES THE MIXTURE WILL VARY CONTINUOUSLY, Virgin

E.G., IN CASE 4) HALF WAY THROUGH THE LAYER THE COMPOSITION WILL Virgin

BE 1/2 THE MATERIAL DEFINED BY THE TOTAL AND 1/2 THE MATERIAL Virgin

BASED ON THE REACTION. IN THESE CASES RATHER THAN THINKING OF Virgin

THE TWO CROSS SECTIONS AS A TOTAL AND REACTION CROSS SECTION, Virgin

IT IS BETTER TO THINK OF THEM AS THE TOTAL CROSS SECTIONS FOR Virgin

MATERIALS A AND B AND THE CALCULATED REACTIONS WILL BE BASED Virgin

ON THESE TWO TOTAL CROSS SECTIONS. Virgin

Virgin

MULTIPLE LAYERS Virgin

--------------- Virgin

THIS CODE MAY BE USED TO RUN EITHER A NUMBER OF INDEPENDENT Virgin

PROBLEMS, EACH INVOLVING TRANSMISSION THROUGH A SINGLE LAYER OF Virgin

MATERIAL, OR TRANSMISSION THROUGH A NUMBER OF LAYERS ONE AFTER Virgin

THE OTHER. Virgin

Virgin

IN THE CASE OF MULTIPLE LAYERS, ONE LAYER AFTER ANOTHER, THE Virgin

TRANSMITTED ENERGY DEPENDENT SPECTRUM IS USED AS THE INCIDENT Virgin

SPECTRUM FOR THE NEXT LAYER. THERE IS NO LIMIT TO THE NUMBER Virgin

OF LAYERS WHICH MAY BE USED - EACH LAYER IS TREATED AS A Virgin

COMPLETELY INDEPENDENT PROBLEM WITH A DEFINED INCIDENT SOURCE, Virgin

AND AS SUCH THE CYCLE OF TRANSMISSION THROUGH EACH LAYER AND Virgin

USING THE TRANSMITTED SPECTRUM AS THE INCIDENT SPECTRUM FOR THE Virgin

NEXT LAYER MAY BE REPEATED ANY NUMBER OF TIMES. Virgin

Virgin

REMEMBER - THE INCIDENT SPECTRUM IS ASSUMED TO BE LINEARLY Virgin

INTERPOLABLE IN ENERGY AND SPECTRUM BETWEEN THE ENERGIES AT Virgin

WHICH IT IS TABULATED. THE TRANSMITTED SPECTRUM WILL BE TABULATED Virgin

AT THE UNION OF ALL ENERGIES OF THE INCIDENT SPECTRUM AND CROSS Virgin

SECTIONS (TOTAL AND REACTION). IN ORDER TO INSURE THE ACCURACY Virgin

OF THE RESULT WHEN PERFORMING MULTIPLE LAYER CALCULATION BE SURE Virgin

TO SPECIFY THE INCIDENT SPECTRUM ON THE FIRST LAYER TO SUFFICIENT Virgin

DETAIL (ENOUGH ENERGY POINTS CLOSELY SPACED TOGETHER) IN ORDER TO Virgin

ALLOW THE TRANSMITTED SPECTRUM TO BE ACCURATELY REPRESENTED BY Virgin

LINEAR INTERPOLATION BETWEEN SUCCESSIVE ENERGY POINTS - THERE IS Virgin

NO LIMIT TO THE NUMBER OF POINTS ALLOWED IN THE INCIDENT SPECTRUM, Virgin

SO IF YOU ARE IN DOUBT, SIMPLY USE MORE ENERGY POINTS TO SPECIFY Virgin

THE INCIDENT SPECTRUM. Virgin

Virgin

RESULT OUTPUT UNITS Virgin

------------------- Virgin

FLUX = EXACTLY AS CALCULATED Virgin

REACTIONS = 1/CM OR 1/GRAM Virgin

AVERAGE = 1/CM - MACROSCOPIC UNITS Virgin

CROSS Virgin

SECTION Virgin

Virgin

THICKNESS AND DENSITY Virgin

--------------------- Virgin

THE UNCOLLIDED CALCULATION ONLY DEPENDS ON THE PRODUCT OF Virgin

THICKNESS AND DENSITY (I.E. GRAMS PER CM SQUARED). THIS FACT Virgin

MAY BE USED TO SIMPLIFY INPUT BY ALLOWING THE THICKNESS AND Virgin

DENSITY TO BE GIVEN EITHER AS CM AND GRAMS/CC RESPECTIVELY Virgin

OR ELSE TO GIVE THICKNESS IN GRAMS/(CM\*CM) AND INPUT A Virgin

DENSITY OF 1.0 - OR IN ANY OTHER CONVENIENT UNITS AS LONG AS Virgin

THE PRODUCT OF THICKNESS AND DENSITY IS IN THE CORRECT GRAMS Virgin

PER CENTIMETER SQUARED. Virgin

Virgin

GRAMS/(CM\*CM) ARE RELATED TO ATOMS/BARN THROUGH THE RELATIONSHIP Virgin

Virgin

GRAMS/(CM\*CM)=(ATOMS/BARN)\*(GRAMS/MOLE)\*(MOLE/ATOM) Virgin

Virgin

OR... Virgin

Virgin

GRAMS/(CM\*CM)=(ATOMS/BARN)\*(ATOMIC WEIGHT)/0.602 Virgin

Virgin

CROSS SECTIONS AT A SPACE POINT AND OPTICAL THICKNESS Virgin

----------------------------------------------------- Virgin

THIS PROGRAM ALLOWS LAYERS OF EITHER UNIFORM DENSITY OR Virgin

CONTINUOUSLY VARYING DENSITY. THE DENSITY CAN BE ONE OF THE Virgin

FOLLOWING FORMS, Virgin

1) C = UNIFORM DENSITY Virgin

2) C\*2\*(X/T) = LINEAR VARIATION FROM 0 TO C Virgin

3) C\*(2-2\*(X/T)) = LINEAR VARIATION FROM C TO 0 Virgin

4) C\*3\*(X/T)\*\*2 = SQUARE VARIATION FROM 0 TO C Virgin

5) C\*(3-3\*(X/T)\*\*2)/2 = SQUARE VARIATION FROM C TO 0 Virgin

6) C\*4\*(X/T)\*\*3 = CUBIC VARIATION FROM 0 TO C Virgin

7) C\*(4-4\*(X/T)\*\*3)/3 = CUBIC VARIATION FROM C TO 0 Virgin

Virgin

IN ORDER TO CALCULATE REACTIONS AT A POINT THE MICROSCOPIC Virgin

REACTION CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES. Virgin

Virgin

IN ORDER TO CALCULATE TRANSMISSION WE MUST DEFINE THE OPTICAL Virgin

PATH LENGTH WHICH MAY BE DEFINED BY INTEGRATING EACH OF THE Virgin

ABOVE DENSITY FORMS TO FIND, Virgin

1) C\*X Virgin

2) C\*X\*(X/T) Virgin

3) C\*X\*(2-(X/T)) Virgin

4) C\*X\*(X/T)\*\*2 Virgin

5) C\*X\*(3-(X/T)\*\*2)/2 Virgin

6) C\*X\*(X/T)\*\*3 Virgin

7) C\*X\*(4-(X/T)\*\*3))/3 Virgin

Virgin

IN ORDER TO CALCULATE TRANSMISSION TO A POINT THE MICROSCOPIC Virgin

TOTAL CROSS SECTION NEED MERELY BE SCALED BY THESE DENSITIES Virgin

TO DEFINE THE OPTICAL PATH LENGTH. Virgin

Virgin

THE VARIATION OF THE DENSITY THROUGH THE LAYER MAY BE DEFINED Virgin

BY SETTING X = 0 OR X = T TO FIND, Virgin

X = 0 X = T Virgin

----- ----- Virgin

1) C C Virgin

2) 0 2\*C Virgin

3) 2\*C 0 Virgin

4) 0 3\*C Virgin

5) 3\*C/2 0 Virgin

6) 0 4\*C Virgin

7) 4\*C/3 0 Virgin

Virgin

THE OPTICAL PATH THROUGH A LAYER OF THICKNESS T MAY BE DEFINED Virgin

FROM THE ABOVE EXPRESSIONS BY SETTING X=T TO FIND THAT IN ALL Virgin

CASES THE ANSWER WILL BY C\*T. THE CONSTANTS IN THE ABOVE Virgin

EXPRESSIONS HAVE BEEN INTRODUCED IN ORDER TO FORCE THIS RESULT. Virgin

WITH THESE FACTORS THE OPTICAL PATH LENGTH THROUGH THE LAYER Virgin

WILL EXACTLY CORRESPOND TO AN AVERAGE DENSITY CORRESPONDING TO Virgin

THAT INPUT FOR THE TOTAL AND/OR REACTION, I.E., C CORRESPONDS Virgin

TO THE INPUT DENSITY. Virgin

Virgin

NOTE - FOR THE SAME OPTICAL PATH LENGTHS THROUGH THE LAYER THE Virgin

TRANSMISSION WILL BE EXACTLY THE SAME. HOWEVER, VARYING THE Virgin

DENSITY WILL ALLOW YOU TO MODIFY THE REACTION RATES AT SPECIFIC Virgin

DEPTHS INTO THE LAYER. Virgin

Virgin

COMPUTATION OF INTEGRALS Virgin

------------------------ Virgin

STARTING FROM TOTAL CROSS SECTIONS, REACTION CROSS SECTIONS AND Virgin

A SOURCE SPECTRUM ALL OF WHICH ARE GIVEN IN TABULAR FORM WITH Virgin

LINEAR INTERPOLATION BETWEEN TABULATED POINTS ALL REQUIRED Virgin

INTEGRALS CAN BE DEFINED BY ANALYTICAL EXPRESSIONS INVOLVING Virgin

NOTHING MORE COMPLICATED THAN EXPONENTIALS. THE INTEGRALS THAT Virgin

MUST BE EVALUATED ARE OF THE FORM... Virgin

Virgin

FLUX Virgin

---- Virgin

(INTEGRAL EK TO EK+1) (S(E)\* EXP(-XCT(E)\*Z)\*DE) Virgin

Virgin

REACTIONS Virgin

--------- Virgin

(INTEGRAL EK TO EK+1) (S(E)\*XCR(E)\*EXP(-XCT(E)\*Z)\*DE) Virgin

Virgin

WHERE.. Virgin

EK TO EK+1 = LONGEST ENERGY INTERVAL OVER WHICH S(E), XCT(E) AND Virgin

XCR(E) ARE ALL LINEARLY INTERPOLABLE. Virgin

S(E) = ENERGY DEPENDENT WEIGHTING SPECTRUM Virgin

XCR(E) = REACTION CROSS SECTION Virgin

XCT(E) = OPTICAL PATH LENGTH (BASED ON TOTAL CROSS SECTION) Virgin

Z = MATERIAL THICKNESS Virgin

Virgin

S(E), XCR(E) AND XCT(E) ARE ALL ASSUMED TO BE GIVEN IN TABULAR Virgin

FORM WITH LINEAR INTERPOLATION USED BETWEEN TABULATED POINTS. Virgin

IN OTHER WORDS BETWEEN TABULATED POINTS EACH OF THESE THREE IS Virgin

DEFINED BY A FUNCTION OF THE FORM... Virgin

Virgin

F(E)=((E - EK)\*FK+1 + (EK+1 - E)\*FK)/(EK+1 - EK) Virgin

Virgin

EACH OF THESE THREE CAN BE CONVERTED TO NORMAL FORM BY THE Virgin

CHANGE OF VARIABLES.... Virgin

Virgin

X=(E - 0.5\*(EK+1 + EK))/(EK+1 - EK) Virgin

Virgin

IN WHICH CASE X WILL VARY FROM -1 (AT EK) TO +1 (AT EK+1) AND Virgin

EACH FUNCTION REDUCES TO THE NORMAL FORM... Virgin

Virgin

F(X)=0.5\*(FK\*(1 - X) + FK+1\*(1 + X)) Virgin

=0.5\*(FK+1 + FK) + 0.5\*(FK+1 - FK)\*X Virgin

Virgin

BY DEFINING THE AVERAGE VALUE AND 1/2 THE CHANGE ACROSS THE Virgin

INTERVAL. Virgin

Virgin

AVF=0.5\*(FK+1 + FK) Virgin

DF= 0.5\*(FK+1 - FK) Virgin

DE= 0.5\*(EK+1 - EK) Virgin

Virgin

EACH OF THE THREE FUNCTIONS REDUCES TO THE SIMPLE FORM... Virgin

Virgin

F(X)=AVF+DF\*X Virgin

Virgin

AND THE TWO REQUIRED INTEGRALS REDUCE TO... Virgin

Virgin

FLUX Virgin

---- Virgin

DE\*EXP(-AVXCT\*Z) \* (INTEGRAL -1 TO +1) Virgin

((AVS+DS\*X)\*EXP(-DXCT\*Z\*X)\*DX) Virgin

Virgin

REACTION Virgin

-------- Virgin

DE\*EXP(-AVXCT\*Z) \* (INTEGRAL -1 TO +1) Virgin

((AVS\*AVXCR+(AVS\*DXCR+AVXCR\*DS)\*X+DS\*DXCR\*X\*X)\*EXP(-DXCT\*Z\*X)\*DX) Virgin

Virgin

WHERE Virgin

Virgin

AVXCT = AVERAGE VALUE OF THE TOTAL CROSS SECTION Virgin

AVXCR = AVERAGE VALUE OF THE REACTION CROSS SECTION Virgin

AVS = AVERAGE VALUE OF THE SOURCE Virgin

DXCT = 1/2 THE CHANGE IN THE TOTAL CROSS SECTION Virgin

DXCR = 1/2 THE CHANGE IN THE REACTION CROSS SECTION Virgin

DS = 1/2 THE CHANGE IN THE SOURCE Virgin

DE = 1/2 THE CHANGE IN THE ENERGY Virgin

Virgin

NOTE THAT IN THIS FORM THE ENERGY ONLY APPEARS IN FRONT OF THE Virgin

INTEGRALS AND THE INTEGRALS ARE EXPRESSED ONLY IN TERMS OF THE Virgin

TABULATED VALUES OF S(E), XCT(E) AND XCR(E). IN PARTICULAR NO Virgin

DERIVATIVES ARE USED, SO THAT THERE ARE NO NUMERICAL INSTABILITY Virgin

PROBLEMS IN THE VACINITY OF DISCONTINUITIES IN S(E), XCT(E) OR Virgin

XCR(E). INDEED, SINCE (EK+1 - EK) APPEARS IN FRONT OF THE INTEGRAL Virgin

POINTS OF DISCONTINUITY AUTOMATICALLY MAKE ZERO CONTRIBUTION TO Virgin

THE INTEGRALS. Virgin

Virgin

THE REQUIRED INTEGRALS CAN BE EXPRESSED IN TERMS OF THE THREE Virgin

INTEGRALS IN NORMAL FORM.... Virgin

Virgin

F(A,N) = (INTEGRAL -1 TO 1) (X\*\*N\*EXP(-A\*X)\*DX), N=0,1 AND 2. Virgin

Virgin

THESE THREE INTEGRALS CAN BE EVALUATED TO FIND... Virgin

Virgin

N=0 Virgin

--- Virgin

F(A,0) = (EXP(A)-EXP(-A))/A Virgin

Virgin

N=1 Virgin

--- Virgin

F(A,1) = ((1-A)\*EXP(A)-(1+A)\*EXP(-A))/(A\*A) Virgin

Virgin

N=2 Virgin

--- Virgin

F(A,2) = ((2-2\*A+A\*A)\*EXP(A)-(2+2\*A+A\*A)\*EXP(-A))/(A\*A\*A) Virgin

Virgin

HOWEVER THESE EXPRESSIONS ARE NUMERICALLY UNSTABLE FOR SMALL Virgin

VALUES OF A. THEREFORE FOR SMALL A THE EXPONENTIAL IN THE Virgin

INTEGRALS ARE EXPANDED IN A POWER SERIES... Virgin

Virgin

EXP(-AX)=1.0-(AX)+(AX)\*\*2/2-(AX)\*\*3/6+(AX)\*\*4/24-........ Virgin

=(SUM K=0 TO INFINITY) (-AX)\*\*K/(K FACTORIAL) Virgin

Virgin

AND THE INTEGRAL REDUCES TO THE FORM.... Virgin

Virgin

(SUM K=0 TO INFINITY) ((-A)\*\*K/(K FACTORIAL)) \* Virgin

(INTEGRAL -1 TO 1) (X\*\*(N+K))\*DX Virgin

Virgin

WHICH CAN BE ANALYTICALLY EVAULATED TO FIND.... Virgin

(K(N) = K FACTORIAL) Virgin

Virgin

N=0 Virgin

--- Virgin

F(A,0) = 2\*(1+(A\*\*2)/K(3)+(A\*\*4)/K(5)+(A\*\*6)/K(7)+.... Virgin

Virgin

N=1 Virgin

--- Virgin

F(A,1) = -2\*A\*(2/K(3)+4\*(A\*\*2)/K(5)+6\*(A\*\*4)/K(7)+8\*(A\*\*6)/K(9)+.. Virgin

Virgin

N=2 Virgin

--- Virgin

F(A,2) = 2\*(2/K(3)+3\*4\*(A\*\*2)/K(5)+5\*6\*(A\*\*4)/K(7)+ Virgin

7\*8\*(A\*\*6)/K(9)+.... Virgin

Virgin

THESE EXPANSIONS ARE USED WHEN THE ABSOLUTE VALUE OF A IS LESS Virgin

THAN 0.1. BY TRUNCATING THE ABOVE SERIES BEFORE A\*\*8 THE ERROR Virgin

RELATIVE TO THE LEADING TERM OF THE SERIES WILL BE 10\*\*(-10), Virgin

YIELDING 10 DIGIT ACCURACY. Virgin

Virgin

AFTER EVALUATING THE ABOVE FUNCTIONS, EITHER DIRECTLY OR BY USING Virgin

THE EXPANSION THE TWO REQUIRED INTEGRALS CAN BE WRITTEN AS... Virgin

Virgin

FLUX Virgin

---- Virgin

DE\*EXP(-AVXCT\*Z)\*(AVS\*F(A,0) + DS\*F(A,1)) Virgin

Virgin

REACTIONS Virgin

--------- Virgin

DE\*EXP(-AVXCT\*Z)\* Virgin

(AVS\*AVXCR\*F(A,0) + (AVS\*DXCR+AVXCR\*DS)\*F(A,1) + DS\*DXCR\*F(A,2)) Virgin

Virgin

INPUT FILES Virgin

----------- Virgin

FILENAME UNIT DESCRIPTION Virgin

-------- ---- ----------- Virgin

INPUT 2 INPUT LINES Virgin

ENDFIN 10 EVALUATED DATA IN ENDF/B FORMAT Virgin

Virgin

OUTPUT FILES Virgin

------------ Virgin

FILENAME UNIT DESCRIPTION Virgin

-------- ---- ----------- Virgin

OUTPUT 3 OUTPUT LISTING Virgin

Virgin

SCRATCH FILES Virgin

------------- Virgin

FILENAME UNIT DESCRIPTION Virgin

-------- ---- ----------- Virgin

SCR1 12 REACTION, FLUX AND CROSS SECTION RESULTS (BCD) Virgin

(SORTED AT END OF RUN AND OUTPUT SEPARATELY) Virgin

SCR2 13 TALLY GROUP ENERGY BOUNDARIES (BINARY) Virgin

SCR3 14 SOURCE SPECTRUM (BINARY) Virgin

SCR4 15 TOTAL CROSS SECTION (BINARY) Virgin

SCR5 16 REACTION CROSS SECTION (BINARY) Virgin

Virgin

OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILIO1 AND FILEIO2) Virgin

---------------------------------------------------------------- Virgin

UNIT FILE NAME FORMAT Virgin

---- ---------- ------ Virgin

2 VIRGIN.INP BCD Virgin

3 VIRGIN.LST BCD Virgin

10 ENDFB.IN BCD Virgin

11-15 (SCRATCH) BINARY Virgin

16 PLOTTAB.CUR PLOTTAB OUTPUT FORMAT DATA Virgin

Virgin

INPUT LINES Virgin

----------- Virgin

ANY NUMBER OF CASES MAY BE RUN ONE AFTER THE OTHER. AFTER THE Virgin

FIRST CASE HAS BEEN RUN THE FOLLOWING CASES MAY USE THE SAME Virgin

THICKNESSES, GROUP STRUCTURE AND SPECTRUM AS THE PRECEDING CASE. Virgin

IN ADDITION THE TRANSMITTED SPECTRUM FROM ONE CASE MAY BE USED Virgin

AS THE INCIDENT SPECTRUM IN THE NEXT CASE, TO ALLOW MULTIPLE Virgin

LAYERS OF DIFFERENT MATERIALS. Virgin

Virgin

LINE COLS. FORMAT DESCRIPTION Virgin

---- ----- ------ ---------- Virgin

1 1-60 ENDF/B INPUT DATA FILENAME Virgin

(STANDARD OPTION = ENDFB.IN) Virgin

Virgin

LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL Virgin

THEN USE STANDARD FILENAMES. Virgin

Virgin

2-3 1-72 18A4 TWO LINE TITLE DESCRIBING PROBLEM Virgin

4 1- 6 I6 ZA (1000\*Z+A) OF TARGET FOR TOTAL Virgin

7-11 I5 MT OF TOTAL Virgin

12-22 E11.4 DENSITY FOR TOTAL Virgin

23-28 I6 ZA (1000\*Z+A) OF TARGET FOR REACTION Virgin

29-33 I5 MT OF REACTION Virgin

= 0 - NO REACTION CALCULATION (ONLY FLUX). Virgin

= GREATER THAN 0 - CALCULATE REACTIONS. Virgin

34-44 E11.4 DENSITY FOR REACTION Virgin

45-50 I6 NUMBER OF TARGET THICKNESSES Virgin

= GREATER THAN 0 = READ FROM INPUT Virgin

(1 TO 2000 ALLOWED) Virgin

= 0 = SAME AS LAST CASE Virgin

51-55 I5 NUMBER OF TALLY GROUPS Virgin

(REMEMBER NUMBER OF GROUP BOUNDARIES Virgin

IS ONE MORE THAN THE NUMBER OF GROUPS) Virgin

UP TO 2000 GROUPS ARE ALLOWED Virgin

BUILT-IN GROUP STRUCTURES. Virgin

= GREATER THAN 0 = READ FROM INPUT Virgin

= 0 TART 175 GROUPS Virgin

= -1 ORNL 50 GROUPS Virgin

= -2 ORNL 126 GROUPS Virgin

= -3 ORNL 171 GROUPS Virgin

= -4 SAND-II 620 GROUPS..1.0e-4 eV TO 18 MEV Virgin

= -5 SAND-II 640 GROUPS..1.0e-4 eV TO 20 MEV Virgin

= -6 WIMS 69 GROUPS Virgin

= -7 GAM-I 68 GROUPS Virgin

= -8 GAM-II 99 GROUPS Virgin

= -9 MUFT 54 GROUPS Virgin

=-10 ABBN 28 GROUPS Virgin

=-11 TART 616 GROUPS TO 20 MeV Virgin

=-12 TART 700 GROUPS TO 1 GeV Virgin

=-13 SAND-II 665 GROUPS..1.0e-5 eV TO 18 MEV Virgin

=-14 SAND-II 685 GROUPS..1.0e-5 eV TO 20 MEV Virgin

=-15 TART 666 GROUPS TO 200 MeV Virgin

=-16 SAND-II 725 GROUPS..1.0e-5 eV TO 60 MEV Virgin

=-17 SAND-II 755 GROUPS..1.0e-5 eV TO 150 MEV Virgin

=-18 SAND-II 765 GROUPS..1.0e-5 eV TO 200 MEV Virgin

56-60 I5 NUMBER OF POINTS IN SOURCE SPECTRUM Virgin

(MUST BE AT LEAST TWO POINTS) Virgin

= GREATER THAN 1 = READ FROM INPUT Virgin

= 0 = SAME AS LAST CASE Virgin

= -1 = CONSTANT (ENERGY INDEPENDENT) Virgin

= -2 = 1/E Virgin

= -3 = BLACKBODY - PHOTON SPECTRUM Virgin

= -4 = BLACKBODY - ENERGY SPECTRUM Virgin

= -5 = TRANSMITTED SPECTRUM FROM LAST CASE Virgin

NOTE, ALL SPECTRA, EXCEPT THE TRANSMITTED Virgin

SPECTRUM FROM THE LAST CASE, WILL BE Virgin

NORMALIZED SUCH THAT ITS INTEGRAL OVER Virgin

ENERGY WILL BE UNITY. Virgin

61-64 1X,3I1 SPATIALLY DEPENDENT OUTOUT Virgin

= 0 = NO Virgin

= 1 = YES Virgin

FOR THE 3 QUANTITIES Virgin

COLUMN 67 FLUX Virgin

68 REACTIONS Virgin

69 AVERAGE CROSS SECTION Virgin

65-65 I1 ENERGY DEPENDENT OUTOUT Virgin

= 0 = NONE Virgin

= 1 = INCIDENT SPECTRUM Virgin

= 2 = TRANSMITTED SPECTRUM Virgin

= 3 = INCIDENT REACTIONS Virgin

= 4 = TRANSMIITED REACTIONS Virgin

= 5 = TOTAL CROSS SECTION Virgin

= 6 = REACTION CROSS SECTION Virgin

5 1-11 E11.4 BLACKBODY TEMPERATURE IN eV Virgin

12-22 E11.4 FLUX NORMALIZATION Virgin

23-33 E11.4 REACTION NORMALIZATION Virgin

CALCULATIONS WILL BE BASED ON THE SPECTRUM Virgin

AND CROSS SECTIONS AS READ. AT OUTPUT THE Virgin

RESULTS WILL BE MULTIPLIED BY THESE Virgin

NORMALIZATION FACTORS. Virgin

34-44 I11 DENSITY PROFILE Virgin

= 0 - UNIFORM - BASED ON TOTAL DENSITY Virgin

= 1 - UNIFORM - TOTAL + REACTION DENSITY Virgin

= 2 - TOTAL + LINEAR REACTION Virgin

= 3 - LINEAR (TOTAL + REACTION) Virgin

= 4 - TOTAL + SQUARE REACTION Virgin

= 5 - SQUARE (TOTAL + REACTION) Virgin

= 6 - TOTAL + CUBIC REACTION Virgin

= 7 - CUBIC (TOTAL + REACTION) Virgin

6-N 1-66 6E11.4 TARGET THICKNESSES IN CM Virgin

IF SAME AS LAST CASE THIS SECTION IS NOT Virgin

INCLUDED IN THE INPUT. Virgin

VARY 1-66 6E11.4 TALLY GROUP ENERGY BOUNDARIES Virgin

(NUMBER OF BOUNDARIES IS ONE MORE THAN Virgin

THE NUMBER OF TALLY GROUPS) Virgin

IF THE STANDARD OPTION (-14 TO 0) IS Virgin

SELECTED THIS SECTION IS NOT INCLUDED Virgin

IN THE INPUT Virgin

VARY 1-66 6E11.4 SOURCE SPECTRUM IN ENERGY (eV)-SOURCE PAIRS Virgin

(MUST BE AT LEAST TWO POINTS) Virgin

IF STANDARD OPTION (-5 TO 0) IS SELECTED THIS Virgin

SECTION IS NOT INCLUDED IN THE INPUT Virgin

Virgin

ANY NUMBER OF CASES MAY BE RUN ONE AFTER ANOTHER. Virgin

Virgin

EXAMPLE INPUT NO. 1 Virgin

------------------- Virgin

CALCULATE THE UNCOLLIDED FLUX AND CAPTURE (MT=102) THROUGH Virgin

30 CM OF IRON (DENSITY 7.87 G/CC). TALLY THE RESULTS USING Virgin

THE TART 175 GROUP STRUCTURE. THE SOURCE WILL BE CONSTANT Virgin

FROM 1 KEV TO 20 MEV. USE THE STANDARD ENDF/B INPUT DATA Virgin

FILENAME. Virgin

Virgin

ENDFB.IN Virgin

IRON 0 TO 30 CM THICK. Virgin

CONSTANT SOURCE FROM 1 KEV TO 20 MEV. Virgin

26000 1 7.87000+ 0 26000 102 7.87000+ 0 2 0 2 1100 Virgin

0.00000+ 0 1.00000+ 0 1.00000+ 0 0 0.00000+00 Virgin

0.00000+00 3.00000+01 Virgin

1.0000E+03 1.0000E+00 2.0000E+07 1.0000E+00 Virgin

Virgin

EXAMPLE INPUT NO. 2 Virgin

------------------- Virgin

CALCULATE THE UNCOLLIDED PHOTON FLUX THROUGH A MIXTURE OF SILICON Virgin

AND IRON FOR 100 MEV PHOTONS INCIDENT. THE TRANSMISSION WILL BE Virgin

CALCULATED FOR 21 THICKNESSES VARYING BETWEEN 0 AND 1 CM. THERE Virgin

WILL BE ONLY 1 TALLY GROUP SPANNING A VERY NARROW ENERGY RANGE Virgin

NEAR 100 MEV, AND THE SOURCE SPECTRUM WILL BE CONSTANT OVER THE Virgin

SAME ENERGY RANGE. USE THE STANDARD ENDF/B INPUT DATA FILENAME Virgin

BY LEAVING THE FIRST INPUT LINE BLANK. Virgin

Virgin

(THIS IS A BLANK LINE TO USE THE STANDARD INPUT FILENAME) Virgin

100 MEV PHOTONS Virgin

SILICON + 5 % IRON Virgin

14000 521 2.30000+ 0 26000 521 1.15000- 1 21 1 2 1000 Virgin

0.00000+ 0 1.00000+ 0 1.00000+ 0 1 0.00000+00 Virgin

0.00000+00 5.00000-01 1.00000+00 1.50000+00 2.00000+00 2.50000+00 Virgin

3.00000+00 3.50000+00 4.00000+00 4.50000+00 5.00000+00 5.50000+00 Virgin

6.00000+00 6.50000+00 7.00000+00 7.50000+00 8.00000+00 8.50000+00 Virgin

9.00000+00 9.50000+00 1.00000+01 Virgin

9.99000+ 7 1.00100+ 8 Virgin

9.99000+ 7 1.00000+ 4 1.00100+ 8 1.00000+ 4 Virgin

Virgin

======================================================================= Virgin