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===== Sigma1
PROGRAM SIGMA1
===== Sigma1
VERSION 73-1 (MARCH 1973) Sigma1
VERSION 76-1 (FEBRUARY 1976) Sigma1
VERSION 76-2 (OCTOBER 1976) Sigma1
VERSION 77-1 (JANUARY 1977) Sigma1
VERSION 78-1 (JULY 1978) Sigma1
VERSION 79-1 (JULY 1979) CDC-7600 AND CRAY-1 VERSION. Sigma1
VERSION 80-1 (MAY 1980) IBM, CDC AND CRAY VERSION Sigma1
VERSION 80-2 (DECEMBER 1980) IMPROVED BASED ON USER COMMENTS. Sigma1
VERSION 81-1 (MARCH 1981) DOUBLE PRECISION IBM VERSION Sigma1
VERSION 81-2 (AUGUST 1981) IMPROVED IBM SPEED AND STABILITY Sigma1
VERSION 82-1 (JANUARY 1982) IMPROVED COMPUTER COMPATIBILITY Sigma1
VERSION 83-1 (JANUARY 1983) *MAJOR RE-DESIGN. Sigma1
*PAGE SIZE INCREASED - 1002 TO 2004. Sigma1
*ELIMINATED COMPUTER DEPENDENT CODING. Sigma1
*NEW, MORE COMPATIBLE I/O UNIT NUMBER. Sigma1
*ADDED STANDARD ALLOWABLE ERROR OPTION Sigma1
(CURRENTLY 0.1 PER-CENT). Sigma1
*UNRESOLVED RESONANCE REGION COPIED. Sigma1
*1/V EXTENSION OF CROSS SECTIONS Sigma1
OUTSIDE OF TABULATED ENERGY RANGE AND Sigma1
INTO UNRESOLVED ENERGY RANGE. Sigma1
VERSION 83-2 (OCTOBER 1983) *IMPROVED BASED ON USER COMMENTS. Sigma1
VERSION 84-1 (APRIL 1984) *IMPROVED NUMERICAL STABILITY. Sigma1
*PARTIAL EVALUATION TREATMENT. Sigma1
VERSION 85-1 (APRIL 1985) *ITERATE TO CONVERGENCE (USING THE SAME Sigma1
ENERGY GRID FOR HOT CROSS SECTION AS Sigma1
COLD CROSS SECTIONS WAS FOUND TO BE Sigma1
INACCURATE). Sigma1
*NEW FASTER HIGH ENERGY BROADENING. Sigma1
*UPDATED FOR ENDF/B-VI FORMATS. Sigma1
*SPECIAL I/O ROUTINES TO GUARANTEE Sigma1
ACCURACY OF ENERGY. Sigma1
*DOUBLE PRECISION TREATMENT OF ENERGY Sigma1
(REQUIRED FOR NARROW RESONANCES). Sigma1
VERSION 85-2 (AUGUST 1985) *FORTRAN-77/H VERSION Sigma1
VERSION 86-1 (JANUARY 1986) *ENERGY DEPENDENT SCATTERING RADIUS Sigma1
VERSION 88-1 (JULY 1988) *OPTION...INTERNALLY DEFINE ALL I/O Sigma1
FILE NAMES (SEE, SUBROUTINE FILEIO Sigma1
FOR DETAILS). Sigma1
*IMPROVED BASED ON USER COMMENTS. Sigma1
VERSION 89-1 (JANUARY 1989) *PSYCHOANALYZED BY PROGRAM FREUD TO Sigma1
INSURE PROGRAM WILL NOT DO ANYTHING Sigma1
CRAZY. Sigma1
*UPDATED TO USE NEW PROGRAM CONVERT Sigma1
KEYWORDS. Sigma1
*ADDED LIVERMORE CIVIC COMPILER Sigma1
CONVENTIONS. Sigma1
VERSION 90-1 (JUNE 1990) *UPDATED BASED ON USER COMMENTS Sigma1
*ADDED FORTRAN SAVE OPTION Sigma1
*NEW MORE CONSISTENT ENERGY OUTPUT Sigma1
ROUTINES Sigma1
VERSION 91-1 (JULY 1991) *WARNING...INPUT PARAMETER FORMAT Sigma1
HAS BEEN CHANGED - SEE BELOW FOR Sigma1
DETAILS. Sigma1
*ADDED CHARGED PARTICLE PROJECTILES Sigma1
*OUTPUT ENERGY RANGE IS ALWAYS AT Sigma1
LEAST AS LARGE AS INPUT ENERGY RANGE. Sigma1
*NO 1/V EXTENSION OF CROSS SECTIONS Sigma1
FROM UNRESOLVED ENERGY RANGE. Sigma1
VERSION 92-1 (JANUARY 1992) *INSURE MINIMUM AND MAXIMUM CROSS Sigma1
SECTIONS ARE ALWAYS KEPT (NOT THINNED) Sigma1
*MT=19 (FIRST CHANCE FISSION) TREATED Sigma1
THE SAME AS FISSION. Sigma1
*VARIABLE MINIMUM CROSS SECTION OF Sigma1
INTEREST - TO ALLOW SMALL CROSS Sigma1
SECTIONS NEAR THRESHOLDS TO BE Sigma1
TREATED PROPERLY. Sigma1

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	*ALL ENERGIES INTERNALLY ROUNDED PRIOR TO CALCULATIONS.	Sigma1
	*COMPLETELY CONSISTENT I/O AND ROUNDING ROUTINES - TO MINIMIZE COMPUTER DEPENDENCE.	Sigma1
VERSION 92-2 (JULY 1992)	*CORRECTED BUG ASSOCIATED WITH THRESHOLD REACTIONS.	Sigma1
	*UNRESOLVED REGION COPIED WITHOUT THINNING (IT SHOULD BE EXACTLY THE SAME AT ALL TEMPERATURES).	Sigma1
	*NO THINNING OF REACTIONS (MT) THAT WERE NOT BROADENED.	Sigma1
VERSION 93-1 (APRIL 1993)	*INCREASED PAGE SIZE FROM 2004 TO 24000 ENERGY POINTS.	Sigma1
VERSION 94-1 (JANUARY 1994)	*VARIABLE ENDF/B DATA FILENAMES TO ALLOW ACCESS TO FILE STRUCTURES (WARNING - INPUT PARAMETER FORMAT HAS BEEN CHANGED)	Sigma1
	*CLOSE ALL FILES BEFORE TERMINATING (SEE, SUBROUTINE ENDIT)	Sigma1
VERSION 96-1 (JANUARY 1996)	*COMPLETE RE-WRITE	Sigma1
	*IMPROVED COMPUTER INDEPENDENCE	Sigma1
	*ALL DOUBLE PRECISION	Sigma1
	*ON SCREEN OUTPUT	Sigma1
	*UNIFORM TREATMENT OF ENDF/B I/O	Sigma1
	*IMPROVED OUTPUT PRECISION	Sigma1
	*DEFINED SCRATCH FILE NAMES	Sigma1
	*ALWAYS INCLUDE THERMAL VALUE	Sigma1
VERSION 97-1 (APRIL 1997)	*OPTIONALLY SET NEGATIVE CROSS SECTIONS = 0 ON INPUT AND OUTPUT.	Sigma1
	*INCREASED PAGE SIZE FROM 24000 TO 60000 ENERGY POINTS.	Sigma1
VERSION 99-1 (MARCH 1999)	*CORRECTED CHARACTER TO FLOATING POINT READ FOR MORE DIGITS	Sigma1
	*UPDATED TEST FOR ENDF/B FORMAT VERSION BASED ON RECENT FORMAT CHANGE	Sigma1
	*TREAT LOW ENERGY INITIAL CROSS SECTIONS AS LOG-LOG INTERPOLABLE	Sigma1
	*CONSTANT (RATHER THAN 1/V) EXTENSION TO HIGHER ENERGY.	Sigma1
	*UPDATED CONSTANTS BASED ON CSEWG SUBCOMMITTEE RECOMMENDATIONS	Sigma1
	*GENERAL IMPROVEMENTS BASED ON USER FEEDBACK	Sigma1
VERSION 99-2 (JUNE 1999)	*EXTENDED RANGE OF INTEGRALS FROM 4 TO 5 UNITS ON EACH SIDE OF ENERGY POINT TO ALLOW FOR LARGER VARIATION IN THE LOCAL CROSS SECTION	Sigma1
	*ASSUME ENDF/B-VI, NOT V, IF MISSING MF=1, MT-451.	Sigma1
VERSION 99-3 (OCTOBER 1999)	*IMPROVED ERFC FUNCTION DEFINITION. I THANK BOB MACFARLANE (LANL) FOR SUPPLYING A MORE ACCURATE ERFC FUNCTION.	Sigma1
VERS. 2000-1 (FEBRUARY 2000)	*CORRECTED LOW ENERGY INTERPOLATION FOR NON-POSITIVE CROSS SECTIONS	Sigma1
	*GENERAL IMPROVEMENTS BASED ON USER FEEDBACK	Sigma1
VERS. 2002-1 (MAY 2002)	*OPTIONAL INPUT PARAMETERS	Sigma1
VERS. 2004-1 (JAN. 2004)	*OPTIONALLY IGNORE UNRESOLVED REGION	Sigma1
	*CORRECTED PROBLEM AT THE RESOLVED/ UNRESOLVED ENERGY BOUNDARY.	Sigma1
	*CORRECTED HIGH ENERGY CONSTANT CROSS SECTION EXTENSION.	Sigma1
	*TIGHTER CRITERIA FOR INITIAL ENERGY POINT SPACING	Sigma1
	*TEMPERATURE DEPENDENT ENERGY POINT SPACING.	Sigma1
	*ADDED NEW REICH-MOORE (LRF=7) TO FILE2 TO ALLOW COPY TO FIND ANY	Sigma1

	FOLLOWING UNRESOLVED PARAMETERS	Sigma1
VERS. 2005-1 (JUNE 2005)	*CORRECTED ERROR IN EHOT3 EQUIVALENCE TO EHOT - THIS ONLY EFFECTS VERY BIG OUTPUT FILES.	Sigma1
VERS. 2007-1 (JAN. 2007)	*CHECKED AGAINST ALL ENDF/B-VII.	Sigma1
	*INCREASED PAGE SIZE FROM 60,000 TO 360,000 ENERGY POINTS.	Sigma1
VERS. 2008-1 (APRIL 2008)	*1/2 INITIAL ENERGY POINT SPACING	Sigma1
	*72 CHARACTER FILE NAMES.	Sigma1
VERS. 2010-1 (Apr. 2010)	*ASSUME LOW ENERGY LOG-LOG VARIATION UP TO 1/A (eV) FOR ALL BUT TOTAL AND ELASTIC.	Sigma1
	*CHANGED DEFAULT UNCERTAINTY TO 0.01% FROM 0.1%	Sigma1
	*ALLOW MULTIPLE, ADJACENT UNRESOLVED RESONANCE REGIONS = COMBINE INTO ONE LARGER ENERGY RANGE TO COPY.	Sigma1
	*DO NOT BROADEN SECTIONS THAT START ABOVE 1 MILLION KT - PREVIOUSLY IT WAS ASSUMED TOTAL, ELASTIC, CAPTURE AND FISSION, AND LARGE SECTIONS (OVER 10,000 ENERGY POINTS) WOULD BROADEN.	Sigma1
VERS. 2012-1 (Aug. 2012)	*CHANGE COPY CRITERIA TO HANDLE NEW (N,N') DATA = THRESHOLD MAY BE VERY HIGH (OLD CRITERIA) BUT INCLUDES MANY TABULATED ENERGY POINTS (NEW ADDED CRITERIA).	Sigma1
	*ADDED STOP IF INCIDENT PARTICLE DATA CANNOT BE DOPPLER BROADENED, E.G., PHOTON INCIDENT.	Sigma1
	*Added CODENAME	Sigma1
	*32 and 64 bit Compatible	Sigma1
	*Added ERROR stop	Sigma1
VERS. 2013-1 (Nov. 2013)	*Added NO broadening above 10 MeV - this is to handle newer evaluations that extend to higher energies and may do "strange" things to stop one MT and then include it as part of a sum at higher energies, e.g. this change will copy ALL points above 10 MeV, thus avoiding problems near transition energies at 20. 30, etc. MeV or higher energies.	Sigma1
VERS. 2015-1 (Jan. 2015)	*Replaced ALL 3 way IF Statements.	Sigma1
	*Replaced ALL LOGICAL by INTEGER.	Sigma1
	*Extended OUT9.	Sigma1
	OWNED, MAINTAINED AND DISTRIBUTED BY	Sigma1
	-----	Sigma1
	THE NUCLEAR DATA SECTION	Sigma1
	INTERNATIONAL ATOMIC ENERGY AGENCY	Sigma1
	P.O. BOX 100	Sigma1
	A-1400, VIENNA, AUSTRIA	Sigma1
	EUROPE	Sigma1
	ORIGINALLY WRITTEN BY	Sigma1
	-----	Sigma1
	Dermott E. Cullen	Sigma1
	PRESENT CONTACT INFORMATION	Sigma1
	-----	Sigma1
	Dermott E. Cullen	Sigma1
	1466 Hudson Way	Sigma1
	Livermore, CA 94550	Sigma1
	U.S.A.	Sigma1
	Telephone 925-443-1911	Sigma1
	E. Mail RedCullen1@Comcast.net	Sigma1
	Website http://home.comcast.net/~redcullen1	Sigma1
	Acknowledgement 2004	Sigma1
	-----	Sigma1

Currently almost all improvements to this code are based upon	Sigma1
feedback from code users who report problems. This feedback	Sigma1
benefits ALL users of this code, and ALL users are encouraged	Sigma1
to report problems.	Sigma1
Improvements on the 2004 version of this code based on user	Sigma1
feedback including,	Sigma1
1) Bret Beck - reported a problem at the resolved/unresolved	Sigma1
energy boundary.	Sigma1
2) S. Ganesan - reported a problem for small temperature changes.	Sigma1
AUTHORS MESSAGE	Sigma1
-----	Sigma1
THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION	Sigma1
FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDERED	Sigma1
THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASE	Sigma1
READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY	Sigma1
THE COMMENTS CONCERNING MACHINE DEPENDENT CODING.	Sigma1
AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER	Sigma1
INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE	Sigma1
OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT	Sigma1
IT WOULD BE APPRECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY	Sigma1
COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO	Sigma1
IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF	Sigma1
THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR	Sigma1
COMPUTER.	Sigma1
PURPOSE	Sigma1
-----	Sigma1
THIS PROGRAM IS DESIGNED TO DOPPLER BROADEN NEUTRON INDUCED	Sigma1
CROSS SECTIONS. EACH SECTION OF CROSS SECTIONS (FILE 3) IS READ	Sigma1
FROM THE ENDF/B FORMAT. THE DATA IS DOPPLER BROADENED, THINNED	Sigma1
AND OUTPUT IN THE ENDF/B FORMAT.	Sigma1
IN THE FOLLOWING DISCUSSION FOR SIMPLICITY THE ENDF/B TERMINOLOGY	Sigma1
---ENDF/B TAPE---WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE	Sigma1
TAPE, CARDS, DISK OR ANY OTHER MEDIUM.	Sigma1
ENDF/B FORMAT	Sigma1
-----	Sigma1
THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS	Sigma1
OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION	Sigma1
OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II, III, IV OR V FORMAT).	Sigma1
IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B	Sigma1
FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS	Sigma1
ASSUMED THAT THE MAT, MF AND MT ON EACH CARD IS CORRECT. SEQUENCE	Sigma1
NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE	Sigma1
CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451	Sigma1
AND ALL SECTIONS OF MF=3 MUST BE CORRECT. THE PROGRAM COPIES ALL	Sigma1
OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE TO	Sigma1
THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS.	Sigma1
ALL CROSS SECTIONS THAT ARE USED BY THIS PROGRAM MUST BE TABULATED	Sigma1
AND LINEARLY INTERPOLABLE IN ENERGY AND CROSS SECTION (ENDF/B	Sigma1
INTERPOLATION LAW 2). FILE 3 CROSS SECTIONS MAY BE MADE LINEARLY	Sigma1
INTERPOLABLE BY USING PROGRAM LINEAR (UCRL-50400, VOL.17, PART A).	Sigma1
FILE 2 RESONANCE PARAMETERS MAY BE USED TO RECONSTRUCT ENERGY	Sigma1
DEPENDENT CROSS SECTIONS AND ADD IN FILE 3 BACKGROUND CROSS	Sigma1
SECTIONS TO DEFINE LINEARLY INTERPOLABLE CROSS SECTIONS BY USING	Sigma1
PROGRAM RECENT (UCRL-50400, VOL. 17, PART C). IF THIS PROGRAM	Sigma1
FINDS THAT THE FILE 3 CROSS SECTIONS ARE NOT LINEARLY INTERPOLABLE	Sigma1
THIS PROGRAM WILL TERMINATE EXECUTION.	Sigma1
UNRESOLVED RESONANCE REGION	Sigma1
-----	Sigma1
IN THE UNRESOLVED RESONANCE REGION IT IS NOT POSSIBLE TO EXACTLY	Sigma1
DEFINE THE ENERGY DEPENDENCE OF THE CROSS SECTIONS. THE AVERAGE	Sigma1
WIDTHS AND SPACINGS GIVEN IN ENDF/B ARE ONLY ADEQUATE TO DEFINE	Sigma1
AVERAGE VALUES OF THE CROSS SECTIONS. THEREFORE ALL CROSS SECTIONS	Sigma1

IN THE ENDF/B FORMAT FOR THE UNRESOLVED REGION ARE REALLY AVERAGE VALUES WHICH CANNOT BE DOPPLER BROADENED USING THE SIGMA1 METHOD (WHICH REQUIRES TABULATED, LINEARLY INTERPOLABLE, ENERGY DEPENDENT CROSS SECTIONS).

THEREFORE,

(1) ALL TABULATED POINTS WITHIN THE UNRESOLVED RESONANCE REGION WILL BE COPIED, WITHOUT MODIFICATION OR BROADENING. ADOPTION OF THIS CONVENTION WILL ALLOW SUBSEQUENT PROGRAMS TO PROPERLY DEFINE SELF-SHIELDED, DOPPLER BROADENED CROSS SECTIONS IN THE UNRESOLVED RESONANCE REGION.

(2) CROSS SECTIONS WILL BE EXTENDED AS 1/V ABOVE THE UPPER ENERGY LIMIT OF THE RESOLVED RESONANCE REGION AND BELOW THE LOWER ENERGY LIMIT OF THE CONTINUUM REGION (I.E. INTO THE UNRESOLVED RESONANCE REGION). THIS CONVENTION WILL GUARANTEE A SMOOTH BEHAVIOR CLOSE TO THE UNRESOLVED RESONANCE REGION BOUNDARIES.

OUTPUT FORMAT  
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IN THIS VERSION OF SIGMA1 ALL FILE 3 ENERGIES WILL BE OUTPUT IN F (INSTEAD OF E) FORMAT IN ORDER TO ALLOW ENERGIES TO BE WRITTEN WITH UP TO 9 DIGITS OF ACCURACY. IN PREVIOUS VERSIONS THIS WAS AN OUTPUT OPTION. HOWEVER USE OF THIS OPTION TO COMPARE THE RESULTS OF ENERGIES WRITTEN IN THE NORMAL ENDF/B CONVENTION OF 6 DIGITS TO THE 9 DIGIT OUTPUT FROM THIS PROGRAM DEMONSTRATED THAT FAILURE TO USE THE 9 DIGIT OUTPUT CAN LEAD TO LARGE ERRORS IN THE DATA JUST DUE TO TRANSLATION OF THE ENERGIES TO THE ENDF/B FORMAT.

CONTENTS OF OUTPUT  
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ENTIRE EVALUATIONS ARE OUTPUT, NOT JUST THE BROADENED FILE 3 CROSS SECTIONS, E.G. ANGULAR AND ENERGY DISTRIBUTIONS ARE ALSO INCLUDED.

DOCUMENTATION  
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THE FACT THAT THIS PROGRAM HAS OPERATED ON THE DATA IS DOCUMENTED BY THE ADDITION OF THREE COMMENTS CARDS AT THE END OF EACH HOLLERITH SECTION IN THE FORM

\*\*\*\*\* PROGRAM SIGMA1 (2015-1) \*\*\*\*\*  
 DATA DOPPLER BROADENED TO 300.0 KELVIN AND  
 DATA THINNED TO WITHIN AN ACCURACY OF 0.1 PER-CENT

THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR, RECENT AND GROUPY) REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON THE DATA.

THESE COMMENT CARDS ARE ONLY ADDED TO EXISTING HOLLERITH SECTIONS, I.E., THIS PROGRAM WILL NOT CREATE A HOLLERITH SECTION. THE FORMAT OF THE HOLLERITH SECTION IN ENDF/B-V DIFFERS FROM THE THAT OF EARLIER VERSIONS OF ENDF/B. BY READING AN EXISTING MF=1, MT=451 IT IS POSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN. WITHOUT HAVING A SECTION OF MF=1, MT=451 PRESENT IT IS IMPOSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN, AND AS SUCH IT IS IMPOSSIBLE FOR THE PROGRAM TO DETERMINE WHAT FORMAT SHOULD BE USED TO CREATE A HOLLERITH SECTION.

REACTION INDEX  
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THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN SECTION MF=1, MT=451 OF EACH EVALUATION.

THIS PROGRAM DOES NOT UPDATE THE REACTION INDEX IN MF=1, MT=451. THIS CONVENTION HAS BEEN ADOPTED BECAUSE MOST USERS DO NOT REQUIRE A CORRECT REACTION INDEX FOR THEIR APPLICATIONS AND IT WAS NOT CONSIDERED WORTHWHILE TO INCLUDE THE OVERHEAD OF CONSTRUCTING A CORRECT REACTION INDEX IN THIS PROGRAM. HOWEVER, IF YOU REQUIRE A REACTION INDEX FOR YOUR APPLICATIONS, AFTER RUNNING THIS PROGRAM YOU MAY USE PROGRAM DICTIN TO CREATE A CORRECT REACTION INDEX.

SECTION SIZE	Sigma1
-----	Sigma1
SINCE THIS PROGRAM USES A LOGICAL PAGING SYSTEM THERE IS NO LIMIT	Sigma1
TO THE NUMBER OF POINTS IN ANY SECTION, E.G., THE TOTAL CROSS	Sigma1
SECTION MAY BE REPRESENTED BY 200,000 DATA POINTS.	Sigma1
SELECTION OF DATA	Sigma1
-----	Sigma1
THE PROGRAM SELECTS MATERIALS TO BE BROADENED BASED EITHER ON	Sigma1
MAT (ENDF/B MAT NO.) OR ZA. THE PROGRAM ALLOWS UP TO 100 MAT OR	Sigma1
ZA RANGES TO BE SPECIFIED. THE PROGRAM WILL ASSUME THAT THE	Sigma1
ENDF/B TAPE IS IN EITHER MAT OR ZA ORDER, WHICHEVER CRITERIA IS	Sigma1
USED TO SELECT MATERIALS, AND WILL TERMINATE WHEN A MAT OR ZA	Sigma1
IS FOUND THAT IS ABOVE THE RANGE OF ALL REQUESTS.	Sigma1
ENERGY GRID OF BROADENED DATA	Sigma1
-----	Sigma1
THE ENERGY GRID FOR THE DOPPLER BROADENED CROSS SECTIONS IS	Sigma1
SELECTED TO INSURE THAT THE BROADENED DATA IS LINEAR-LINEAR	Sigma1
INTERPOLABLE. AS SUCH THE ENERGY GRID FOR THE BROADENED DATA	Sigma1
MAY NOT BE THE SAME AS THE ENERGY GRID FOR THE ORIGINAL	Sigma1
UNBROADENED DATA. GENERALLY AFTER BROADENING THERE WILL BE	Sigma1
FEWER DATA POINTS IN THE RESONANCE REGION, BUT AT LOW ENERGY	Sigma1
THERE MAY BE MORE POINTS, DUE TO THE 1/V LOW ENERGY EFFECT	Sigma1
CREATED BY DOPPLER BROADENING.	Sigma1
EFFECTIVE TEMPERATURE INCREASE	Sigma1
-----	Sigma1
IF THE ORIGINAL DATA IS NOT AT ZERO KELVIN THE PROGRAM WILL	Sigma1
BROADEN THE DATA BY THE EFFECTIVE TEMPERATURE DIFFERENCE TO THE	Sigma1
FINAL TEMPERATURE. IF THE DATA IS ALREADY AT A TEMPERATURE THAT	Sigma1
IS HIGHER THAN THE FINAL TEMPERATURE DOPPLER BROADENING IS	Sigma1
NATURALLY NOT PERFORMED AND THE TEMPERATURE IN THE SECTION IS LEFT	Sigma1
AT ITS ORIGINAL VALUE.	Sigma1
MULTIPLE FINAL TEMPERATURES	Sigma1
-----	Sigma1
THE PRESENT VERSION ONLY DOPPLER BROADENS TO ONE FINAL TEMPERATURE	Sigma1
(IF THERE IS SUFFICIENT INTEREST EXPRESSED BY USERS FUTURE	Sigma1
VERSION MAY BROADEN TO MULTIPLE TEMPERATURES. PLEASE	Sigma1
CONTACT THE AUTHOR IF YOU ARE INTERESTED IN A MULTIPLE	Sigma1
TEMPERATURE OPTION).	Sigma1
PROGRAM OPERATION	Sigma1
-----	Sigma1
EACH SECTION OF FILE 3 DATA IS CONSIDERED SEPARATELY. THE DATA	Sigma1
IS READ AND DOPPLER BROADENED A PAGE AT A TIME (ONE PAGE IS	Sigma1
60000 DATA POINTS). UP TO THREE PAGES OF DATA MAY BE IN THE CORE	Sigma1
AT ANY GIVEN TIME, THE PAGE BEING BROADENED, THE PAGE BELOW IT	Sigma1
IN ENERGY AND THE PAGE ABOVE IT IN ENERGY. AFTER A PAGE HAS BEEN	Sigma1
BROADENED IT IS THINNED, IF THE ENTIRE SECTION CONTAINS ONLY	Sigma1
ONE PAGE OR LESS, IT WILL STILL BE CORE RESIDENT AND WILL BE	Sigma1
WRITTEN DIRECTLY FROM CORE TO THE OUTPUT TAPE. IF THE BROADENED,	Sigma1
THINNED SECTION IS LARGER THAN A PAGE, AFTER A PAGE HAS BEEN	Sigma1
BROADENED AND THINNED IT IS WRITTEN TO A SCRATCH FILE. AFTER THE	Sigma1
ENTIRE SECTION HAS BEEN BROADENED AND THINNED THE DATA IS READ	Sigma1
FROM SCRATCH TO CORE, ONE PAGE AT A TIME, THE OUTPUT TO THE OUTPUT	Sigma1
TAPE.	Sigma1
ALLOWABLE ERROR	Sigma1
-----	Sigma1
AFTER DOPPLER BROADENING THE CROSS SECTION IN THE RESONANCE REGION	Sigma1
WILL GENERALLY BE MUCH SMOOTHER THAN THE UNBROADENED DATA AND CAN	Sigma1
BE REPRESENTED TO THE SAME ACCURACY BY A SMALLER NUMBER OF ENERGY	Sigma1
POINTS. THEREFORE AFTER DOPPLER BROADENING THE DATA CAN BE THINNED	Sigma1
WITH ESSENTIALLY NO LOSE OF INFORMATION.	Sigma1
THE ALLOWABLE ERROR MAY BE ENERGY INDEPENDENT (CONSTANT) OR ENERGY	Sigma1
DEPENDENT. THE ALLOWABLE ERROR IS DESCRIBED BY A TABULATED	Sigma1
FUNCTION OF UP TO 20 (ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATION	Sigma1

BETWEEN TABULATED POINTS. IF ONLY ONE TABULATED POINT IS GIVEN THE ERROR WILL BE CONSIDERED CONSTANT OVER THE ENTIRE ENERGY RANGE. WITH THIS ENERGY DEPENDENT ERROR ONE MAY OPTIMIZE THE OUTPUT FOR ANY GIVEN APPLICATION BY USING A SMALL ERROR IN THE ENERGY RANGE OF INTEREST AND A LESS STRINGENT ERROR IN OTHER ENERGY RANGES.

INPUT FILES

UNIT DESCRIPTION

2 INPUT CARDS (BCD - 80 CHARACTERS/RECORD)  
10 ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)

OUTPUT FILES

UNIT DESCRIPTION

3 OUTPUT REPORT (BCD - 120 CHARACTERS/RECORD)  
11 FINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)

SCRATCH FILES

UNIT DESCRIPTION

12 SCRATCH FILE FOR BROADENED DATA  
(BINARY - 180000 WORDS/RECORD - DOUBLE PRECISION/  
42000 WORDS/RECORD - SINLGE PRECISION)

OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILEIO)

UNIT FILE NAME

2 SIGMA1.INP  
3 SIGMA1.LST  
10 ENDFB.IN  
11 ENDFB.OUT  
12 (SCRATCH)

INPUT CARDS

CARD COLS. DESCRIPTION

1 1-11 SELECTION CRITERIA (0=MAT, 1=ZA)  
12-22 MONITOR MODE SELECTOR  
= 0 - NORMAL OPERATION  
= 1 - MONITOR PROGRESS OF DOPPLER BROADENING OF DATA.  
EACH TIME A PAGE OF DATA POINTS IS WRITTEN TO  
THE SCRATCH FILE PRINT OUT THE TOTAL NUMBER OF  
POINTS ON SCRATCH AND THE LOWER AND UPPER  
ENERGY LIMITS OF THE PAGE (THIS OPTION MAY BE  
USED IN ORDER TO MONITOR THE EXECUTION SPEED  
OF LONG RUNNING JOBS).  
23-33 KELVIN TEMPERATURE  
34-44 MINIMUM CROSS SECTION OF INTEREST  
(DEFAULT VALUE = 1.0E-10 BARNS).  
45-55 NEGATIVE CROSS SECTION TREATMENT  
= 0 - O.K.  
= 1 - SET = 0  
56-66 UNRESOLVED RESONANCE REGION TREATMENT  
= 0 - COPY (NO BROADENING)  
= 1 - IGNORE (BROADEN)  
2 1-72 ENDF/B INPUT DATA FILENAME  
(STANDARD OPTION = ENDFB.IN)  
3 1-72 ENDF/B OUTPUT DATA FILENAME  
(STANDARD OPTION = ENDFB.OUT)  
4-N 1-11 LOWER MAT OR ZA LIMIT  
12-22 UPPER MAT OR ZA LIMIT  
UP TO 100 MAT OR ZA RANGES MAY BE SPECIFIED, ONE  
RANGE PER CARD. THE LIST OF RANGES IS TERMINATED BY  
A BLANK CARD. IF THE UPPER LIMIT IS LESS THAN THE  
LOWER LIMIT THE UPPER LIMIT WILL BE SET EQUAL TO THE

	LOWER LIMIT. IF THE FIRST REQUEST CARD IS BLANK IT	Sigma1
	WILL TERMINATE THE LIST OF REQUESTS AND CAUSE ALL	Sigma1
	DATA TO BE RETRIEVED (SEE EXAMPLE INPUT).	Sigma1
VARY 1-11	ENERGY FOR ERROR LAW	Sigma1
12-22	ERROR FOR ERROR LAW	Sigma1
	THE ACCEPTABLE LINEARIZING ERROR CAN BE GIVEN AS AN	Sigma1
	ENERGY DEPENDENT FUNCTION SPECIFIED BY UP TO 20	Sigma1
	(ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATION	Sigma1
	TABULATE POINTS. ENERGIES MUST BE IN ASCENDING ORDER.	Sigma1
	THE ERROR LAW IS TERMINATED BY A BLANK CARD. IF THE	Sigma1
	FIRST ERROR LAW CARD IS BLANK IT WILL TERMINATE THE	Sigma1
	ERROR LAW AND THE ERROR WILL BE TREATED AS ENERGY	Sigma1
	INDEPENDENT, EQUAL TO ZERO, WHICH INDICATES THAT THE	Sigma1
	BROADENED DATA SHOULD NOT BE THINNED.	Sigma1
		Sigma1
	EXAMPLE INPUT NO. 1	Sigma1
	-----	Sigma1
	BROADEN ALL URANIUM ISOTOPES AND THORIUM-232 TO 300 KELVIN. FROM	Sigma1
	0 TO 100 EV THIN OUTPUT DATA TO 0.1 PER-CENT ACCURACY. FROM 100 EV	Sigma1
	TO 1 KEV VARY THE ERROR BETWEEN 0.1 AND 1 PER-CENT. ABOVE 1 KEV	Sigma1
	USE 1 PER-CENT ACCURACY.	Sigma1
		Sigma1
	EXPLICITLY SPECIFY THE STANDARD FILENAMES.	Sigma1
		Sigma1
	THE FOLLOWING 11 CARDS ARE REQUIRED	Sigma1
		Sigma1
	1 0 3.00000+ 2	Sigma1
ENDFB.IN		Sigma1
ENDFB.OUT		Sigma1
92000 92999		Sigma1
90232	(UPPER LIMIT WILL AUTOMATICALLY BE DEFINED)	Sigma1
	(BLANK CARD INDICATES END OF REQUEST LIST)	Sigma1
0.00000+ 0 1.00000-03		Sigma1
1.00000+ 2 1.00000-03		Sigma1
1.00000+ 3 1.00000-02		Sigma1
1.00000+ 9 1.00000-02		Sigma1
	(BLANK CARD INDICATES END OF ERROR LAW)	Sigma1
		Sigma1
	EXAMPLE INPUT NO. 2	Sigma1
	-----	Sigma1
	BROADEN ALL DATA TO 300 KELVIN AND DO NOT THIN THE BROADEN DATA.	Sigma1
	ALL OF THE STANDARD OPTION MAY BE INVOKED MERELY BY SPECIFYING	Sigma1
	THE KELVIN TEMPERATURE ON THE FIRST CARD. ALL OTHER FIELDS MAY	Sigma1
	BE LEFT BLANK.	Sigma1
		Sigma1
	LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL	Sigma1
	THEN USE STANDARD FILENAMES.	Sigma1
		Sigma1
	THE FOLLOWING 5 CARDS ARE REQUIRED	Sigma1
		Sigma1
	3.00000+ 2	Sigma1
	(USE STANDARD FILENAME = ENDFB.IN)	Sigma1
	(USE STANDARD FILENAME = ENDFB.OUT)	Sigma1
	(RETRIEVE ALL DATA, TERMINATE REQUEST LIST)	Sigma1
	(0.0 ALLOWABLE ERROR, TERMINATE ERROR LAW)	Sigma1
		Sigma1
	EXAMPLE INPUT NO. 3	Sigma1
	-----	Sigma1
	THE SAME AS ABOVE, ONLY DEFINE THE MINIMUM CROSS SECTION OF	Sigma1
	INTEREST TO BE 1.0E-30 BARNS (INSTEAD OF THE DEFAULT VALUE OF	Sigma1
	1.0E-10).	Sigma1
		Sigma1
	READ ENDF/B DATA FROM \ENDFB6\RECENT\ZA092238 AND WRITE ENDF/B	Sigma1
	DATA TO \ENDFB\SIGMA1\ZA092238	Sigma1
		Sigma1
	THE FOLLOWING 5 CARDS ARE REQUIRED	Sigma1
		Sigma1
	3.00000+ 2 1.00000-30	Sigma1
\ENDFB6\RECENT\ZA092238		Sigma1
\ENDFB6\SIGMA1\ZA092238		Sigma1
	(RETRIEVE ALL DATA, TERMINATE REQUEST LIST)	Sigma1

(0.0 ALLOWABLE ERROR, TERMINATE ERROR LAW)

Sigma1

Sigma1

===== Sigma1