```
======================================================================= Recent
                                                                        Recent
     PROGRAM RECENT                                                     Recent
     VERSION 79-1 (OCTOBER 1979)  CDC-7600                              Recent
     VERSION 80-1 (MAY 1980)      IBM, CDC AND CRAY VERSION             Recent
     VERSION 80-2 (DECEMBER 1980) IMPROVED TREATMENT OF UNRESOLVED      Recent
                                  REGION TO COMPUTE ALL REACTIONS AT    Recent
                                  THE SAME TIME.                        Recent
     VERSION 81-1 (MARCH 1981)  IMPROVED BASED ON USER COMMENTS.        Recent
     VERSION 81-2 (AUGUST 1981) ADDED MONITOR MODE. ADDED SPEED OPTION  Recent
                                TO BYPASS BACKWARDS THINNING IF FILE 3  Recent
                                ALLOWABLE ERROR = 0.0 (NOTE THIS OPTION Recent
                                WILL RESULT IN ALL TABULATED POINTS     Recent
                                FROM THE EVALUATION BEING KEPT IN THE   Recent
                                OUTPUT FROM THIS PROGRAM).              Recent
     VERSION 82-1 (JANUARY 1982) IMPROVED COMPUTER COMPATIBILITY.       Recent
     VERSION 83-1 (JANUARY 1983)*MAJOR RE-DESIGN.                       Recent
                                *PAGE SIZES INCREASED.                  Recent
                                *ELIMINATED COMPUTER DEPENDENT CODING.  Recent
                                *NEW, MORE COMPATIBLE I/O UNIT NUMBERS. Recent
                                *ADDED OPTION TO KEEP ALL RECONSTRUCTED Recent
                                 AND BACKGROUND ENERGY POINTS.          Recent
                                *ADDED STANDARD ALLOWABLE ERROR OPTIONS Recent
                                 (CURRENTLY 0.1 PER-CENT RECONSTRUCTION Recent
                                 AND 0.0 PER-CENT THINNING).            Recent
     VERSION 83-2 (OCTOBER 1983) IMPROVED BASED ON USER COMMENTS.       Recent
     VERSION 84-1 (JANUARY 1984) IMPROVED INTERVAL HALFING CONVERGENCE. Recent
     VERSION 85-1 (APRIL 1985)  *A BRAND NEW PROGRAM WHICH COMPLETELY   Recent
                                 SUPERCEDES ALL PREVIOUS VERSIONS OF    Recent
                                 THIS PROGRAM.                          Recent
                                *UPDATED FOR ENDF/B-VI FORMATS.         Recent
                                *ADDED GENERAL REICH-MOORE FORMALISM    Recent
                                 (WITH TWO FISSION CHANNELS).           Recent
                                *DECREASED RUNNING TIME.                Recent
                                *SPECIAL I/O ROUTINES TO GUARANTEE      Recent
                                 ACCURACY OF ENERGY.                    Recent
                                *DOUBLE PRECISION TREATMENT OF ENERGY   Recent
                                 (REQUIRED FOR NARROW RESONANCES).      Recent
     VERSION 85-2 (AUGUST 1985) *FORTRAN-77/H VERSION                   Recent
     VERSION 86-1 (JANUARY 1986)*ENERGY DEPENDENT SCATTERING RADIUS     Recent
     VERSION 86-2 (JUNE 1986)   *IF FIRST CHANCE FISSION (MT=19)        Recent
                                 BACKGROUND IS PRESENT ADD RESONANCE    Recent
                                 CONTRIBUTION OF FISSION TO IT.         Recent
     VERSION 86-3 (OCTOBER 1986)*MULTI-LEVEL OR REICH-MOORE..CORRECT    Recent
                                 POTENTIAL SCATTERING CROSS SECTION FOR Recent
                                 MISSING AND/OR FICTICIOUS (L,J)        Recent
                                 SEQUENCES.                             Recent
     VERSION 87-1 (JANUARY 1987)*IMPROVED COMBINING FILE 2+3            Recent
     VERSION 87-2 (MARCH 1987)  *CORRECTED ADLER-ADLER CALCULATIONS.    Recent
     VERSION 88-1 (JULY 1988)   *UPDATED REICH-MOORE ENDF/B-VI FORMAT   Recent
                                 TO BE THE SAME AS REICH-MOORE FORMAT   Recent
                                 IN EARLIER VERSIONS OF ENDF/B FORMAT.  Recent
                                *CHECK FOR PRELIMINARY ENDF/B-VI        Recent
                                 REICH-MOORE FORMAT (NOW ABANDONED)     Recent
                                 AND TERMINATE EXECUTION IF DATA IS     Recent
                                 IN THIS FORMAT.                        Recent
                                *CALCULATE CHANNEL RADIUS OR SET IT     Recent
                                 EQUAL TO THE SCATTERING RADIUS.        Recent
                                *IMPLEMENTED HYBRID R-FUNCTION WITH THE Recent
                                 FOLLOWING RESTRICTIONS                 Recent
                                 - ONLY INELASTIC COMPETITION (NO       Recent
                                   CHARGED PARTICLES)                   Recent
                                 - NO TABULATED FILE 2 BACKGROUND       Recent
```

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                            - NO TABULATED OPTICAL MODEL PHASE     Recent
                              SHIFT                                Recent
                           *PROGRAM EXIT IF GENERAL R-MATRIX IN    Recent
                            THE EVALUATION (THIS FORMALISM WILL    Recent
                            BE IMPLEMENTED ONLY AFTER THE AUTHOR   Recent
                            RECEIVES REAL EVALUATIONS WHICH USE    Recent
                            THIS FORMALISM...UNTIL THEN IT IS      Recent
                            IMPOSSIBLE TO ADEQUATELY TEST THAT     Recent
                            THE CODING FOR THIS FORMALISM IS       Recent
                            CORRECT).                              Recent
                           *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                            FROM 1002 TO 4008.                     Recent
                           *DOUBLE PRECISION RESONANCE REGION      Recent
                            LIMITS.                                Recent
                           *FILE 2 AND FILE 3 ENERGIES WHICH ARE   Recent
                            NEARLY EQUAL ARE TREATED AS EQUAL      Recent
                            (I.E., SAME TO ABOUT 9 DIGITS).        Recent
                           *CHECK FILE 3 BACKGROUND CROSS SECTIONS Recent
                            IN EDIT MODE.                          Recent
                           *OPTION...INTERNALLY DEFINE FILENAMES   Recent
                            (SEE SUBROUTINE FILEIO FOR DETAILS).   Recent
VERSION 89-1 (JANUARY 1989)*PSYCHOANALYZED BY PROGRAM FREUD TO     Recent
                            INSURE PROGRAM WILL NOT DO ANYTHING    Recent
                            CRAZY.                                 Recent
                           *UPDATED TO USE NEW PROGRAM CONVERT     Recent
                            KEYWORDS.                              Recent
                           *CORRECTED MULTILEVEL, REICH-MOORE AND  Recent
                            HYBRID R-FUNCTION POTENTIAL SCATTER    Recent
                            TO ACCOUNT FOR REPEATED J-VALUES FOR   Recent
                            THE SAME TARGET SPIN AND L-VALUE.      Recent
                           *ADDED LIVERMORE CIVIC COMPILER         Recent
                            CONVENTIONS.                           Recent
                           *UPDATED TO USE NEW ENDF/B-VI           Recent
                            CONVENTION TO ALLOW UNRESOLVED         Recent
                            RESONANCE CONTRIBUTION TO ALREADY      Recent
                            BE INCLUDED IN THE FILE 3 CROSS        Recent
                            SECTIONS (INFINITELY DIULUTE           Recent
                            CONTRIBUTION).                         Recent
VERSION 90-1 (JUNE 1990)   *UPDATED BASED ON USER COMMENTS         Recent
                           *ADDED FORTRAN SAVE OPTION              Recent
                           *NEW MORE CONSISTENT ENERGY OUTPUT      Recent
                            ROUTINE                                Recent
VERSION 91-1 (JULY 1991)   *NEW UNIFORM TREATMENT OF ALL RESONANCE Recent
                            FORMALISMS (SEE, COMMENTS BELOW)       Recent
                           *NEW REICH-MOORE ALGORITHM              Recent
                           *MORE EXTENSIVE ERROR CHECKING AND      Recent
                            ERROR MESSAGE EXPLANATIONS             Recent
VERSION 92-1 (JANUARY 1992)*MAJOR RESTRUCTING TO IMPROVE ACCURACY  Recent
                            AND COMPUTER INDEPENDENCE.             Recent
                           *INCREASED ENERGY POINT PAGE SIZE FROM  Recent
                            1002 TO 4008.                          Recent
                           *NO MORE THAN 2 ENERGY POINTS WHERE     Recent
                            CROSS SECTION IS ZERO AT BEGINNING     Recent
                            OF A SECTION FOR EACH REACTION,E.G.,   Recent
                            THRESHOLD FISSION.                     Recent
                           *PROCESS ONLY A PORTION OF RESONANCE    Recent
                            REGION - SEE EXPLANATION BELOW         Recent
                           *ALL ENERGIES INTERNALLY ROUNDED PRIOR  Recent
                            TO CALCULATIONS.                       Recent
                           *COMPLETELY CONSISTENT I/O AND ROUNDING Recent
                            ROUTINES - TO MINIMIZE COMPUTER        Recent
                            DEPENDENCE.                            Recent
VERSION 93-1 (MARCH 1993)  *UPDATED REICH-MOORE TREATMENT TO USE   Recent
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                            L DEPENDENT SCATTERING RADIUS (APL)    Recent
                            RATHER THAN SCATTERING RADIUS (AP)     Recent
                            (SEE, ENDF/B-VI FORMATS AND            Recent
                             PROCEDURES MANUAL, PAGE 2.6)          Recent
                           *INCREASED PAGE SIZE FROM 4008 TO       Recent
                            20040 DATA POINTS.                     Recent
                           *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                            FROM 4008 TO 20040.                    Recent
VERSION 94-1 (JANUARY 1994)*VARIABLE ENDF/B DATA FILENAMES         Recent
                            TO ALLOW ACCESS TO FILE STRUCTURES     Recent
                            (WARNING - INPUT PARAMETER FORMAT      Recent
                            HAS BEEN CHANGED).                     Recent
                           *CLOSE ALL FILES BEFORE TERMINATING     Recent
                            (SEE, SUBROUTINE ENDIT)                Recent
VERSION 94-2 (AUGUST 1994) *CORRECTED ADDJ FOR ENERGY DEPENDENT    Recent
                            (TABULATED) SCATTERING RADIUS CASE.    Recent
VERSION 96-1 (JANUARY 1996) *COMPLETE RE-WRITE                     Recent
                            *IMPROVED COMPUTER INDEPENDENCE        Recent
                            *ALL DOUBLE PRECISION                  Recent
                            *ON SCREEN OUTPUT                      Recent
                            *UNIFORM TREATMENT OF ENDF/B I/O       Recent
                            *IMPROVED OUTPUT PRECISION             Recent
                            *ALWAYS INCLUDE THERMAL VALUE          Recent
                            *DEFINED SCRATCH FILE NAMES            Recent
VERSION 97-1 (APRIL 1997)   *OPTIONAL MAKE NEGATIVE CROSS          Recent
                             SECTION = 0 FOR OUTPUT                Recent
                           *INCREASED PAGE SIZE FROM 20040 TO      Recent
                            120000 DATA POINTS.                    Recent
                           *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                            FROM 20040 TO 120000.                  Recent
VERSION 99-1 (MARCH 1999)   *CORRECTED CHARACTER TO FLOATING       Recent
                             POINT READ FOR MORE DIGITS            Recent
                            *UPDATED TEST FOR ENDF/B FORMAT        Recent
                             VERSION BASED ON RECENT FORMAT CHANGE Recent
                            *UPDATED CONSTANTS BASED ON CSEWG      Recent
                             SUBCOMMITTEE RECOMMENDATIONS          Recent
                            *GENERAL IMPROVEMENTS BASED ON         Recent
                             USER FEEDBACK                         Recent
VERSION 99-2 (JUNE 1999)    *IMPLEMENTED NEW REICH-MOORE FORMALISM Recent
                             TO ALLOW DEFINITION OF (L,J,S) FOR    Recent
                             EACH SEQUENCE.                        Recent
                            *ASSUME ENDF/B-VI, NOT V, IF MISSING   Recent
                             MF=1, MT-451.                         Recent
VERS. 2000-1 (FEBRUARY 2000)*GENERAL IMPROVEMENTS BASED ON         Recent
                             USER FEEDBACK                         Recent
VERS. 2002-1 (MAY 2002)     *OPTIONAL INPUT PARAMETERS             Recent
             (SEPT. 2002)   *OUTPUT RESONANCE WITH 9 DIGITS        Recent
                            *TO BE C AND C++ COMPATIBLE OUTPUT     Recent
VERS. 2004-1 (JAN. 2004)    *ADDED INCLUDE 'recent.h'              Recent
                            *MADE ENDF/B-VII READY                 Recent
                            *UPDATED FOR NEW REICH-MOORE LRF=7     Recent
                             PARAMETERS WITH COMPETITION           Recent
                            *ADDED COULOMB PENETRATION FACTORS FOR Recent
                             LRF=7 COMPETITIVE CHANNELS.           Recent
                            *EXTENDED DEFINITIONS OF PENETRATION   Recent
                             FACTOR, LEVEL SHIFT FACTOR, AND       Recent
                             POTENTIAL SCATTERING PHASE SHIFT      Recent
                             ABOVE L = 5 TO INFINITY.              Recent
                            *ADDED QUICK CALCULATION - IF THE      Recent
                             INPUT ALLOWABLE ERROR IS 1.0 OR MORE  Recent
                             (100 % OR MORE) THERE IS NO ITERATION Recent
                             TO CONVERGENCE - CROSS SECTION ARE    Recent
                             QUICKLY CALCULATED ONLY AT A FIXED    Recent
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                            SET OF ENERGY POINTS, BASED ON THE    Recent
                            ENERGY AND WIDTH OF ALL RESONANCES.   Recent
                            THIS CAN BE USED TO QUICKLY "SEE"     Recent
                            NEW EVALUATIONS THAT MAY CONTAIN      Recent
                            ERRORS, THAT WOULD OTHERWISE CAUSE    Recent
                            THIS CODE TO RUN FOR AN EXCESSIVELY   Recent
                            LONG TIME.                            Recent
VERS. 2005-1 (JUNE 2005)    *ADDED ENERGY DEPENDENT SCATTERING    Recent
                            RADIUS FOR ALL RESONANCE TYPES        Recent
                            (EARLIER ONLY BREIT-WIGNER ALLOWED).  Recent
VERS. 2007-1 (JAN. 2007)    *CHECKED AGAINST ALL ENDF/B-VII.      Recent
                           *DECOUPLED PAGE SIZE FROM MAX. # OF    Recent
                            RESONANCES.                           Recent
                           *INCREASED PAGE SIZE FROM 120,000 TO   Recent
                            750,000 DATA POINTS.                  Recent
                           *KEPT MAX. # OF RESONANCE AT 120,000.  Recent
                           *CORRECTED ALL BACKGROUND = 0 CASE     Recent
                                                                  Recent
OWNED, MAINTAINED AND DISTRIBUTED BY                              Recent
-----------------------------------                               Recent
THE NUCLEAR DATA SECTION                                          Recent
INTERNATIONAL ATOMIC ENERGY AGENCY                                Recent
P.O. BOX 100                                                      Recent
A-1400, VIENNA, AUSTRIA                                           Recent
EUROPE                                                            Recent
                                                                  Recent
ORIGINALLY WRITTEN BY                                             Recent
-----------------------------------                               Recent
DERMOTT E. CULLEN                                                 Recent
UNIVERSITY OF CALIFORNIA                                          Recent

LAWRENCE LIVERMORE NATIONAL LABORATORY                            Recent
L-159                                                             Recent
P.O. BOX 808                                                      Recent
LIVERMORE, CA 94550                                               Recent
U.S.A.                                                            Recent
TELEPHONE  925-423-7359                                           Recent
E. MAIL    CULLEN1@LLNL.GOV                                       Recent
WEBSITE    HTTP://WWW.LLNL.GOV/CULLEN1                            Recent
                                                                  Recent
Acknowledgement (Version 2004-1)                                  Recent
================================================================= Recent
The author thanks Nancy Larson, ORNL, for providing her SAMRML    Recent
code for comparison to RECENT output for Reich-Moore evaluations, Recent
in particular to verify results for the new LFR=7 evaluations. I  Recent
also thank her for providing guidance to help me understand and   Recent
implement this new teatment for Reich-Moore parameters.           Recent
                                                                  Recent
ACKNOWLEDGEMENT (VERSION 92-1)                                    Recent
================================================================= Recent
THE AUTHOR THANKS SOL PEARLSTEIN (BROOKHAVEN NATIONAL LAB) FOR    Recent
SIGNIFICANTLY CONTRIBUTING TOWARD IMPROVING THE ACCURACY AND      Recent
COMPUTER INDEPENDENCE OF THIS CODE - THANKS, SOL                  Recent
================================================================= Recent
                                                                  Recent
AUTHORS MESSAGE                                                   Recent
================================================================= Recent
THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION  Recent
FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDERED Recent
THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASE Recent
READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY    Recent
THE COMMENTS CONCERNING MACHINE DEPENDENT CODING.                  Recent
                                                                  Recent
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AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER Recent
INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE Recent
OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT Recent
IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY Recent
COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO Recent
IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF Recent
THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR Recent
COMPUTER. Recent
Recent
PURPOSE Recent
================================================================ Recent
THIS PROGRAM IS DESIGNED TO RECONSTRUCT THE RESONANCE CONTRIBUTION Recent
TO THE CROSS SECTION IN LINEARLY INTERPOLABLE FORM, ADD IN ANY Recent
LINEARLY INTERPOLABLE BACKGROUND CROSS SECTION AND OUTPUT THE Recent
RESULT IN THE ENDF/B FORMAT. THE CROSS SECTIONS OUTPUT BY THIS Recent
PROGRAM WILL BE LINEARLY INTERPOLABLE OVER THE ENTIRE ENERGY RANGE Recent
Recent
THE RESONANCE CONTRIBUTION IS CALCULATED FOR TOTAL (MT=1), Recent
ELASTIC (MT=2), CAPTURE (MT=102) AND FISSION (MT=18), ADDED Recent
TO THE BACKGROUND (IF ANY) AND OUTPUT. IN ADDITION, IF THERE Recent
IS A FIRST CHANCE FISSION (MT=19) BACKGROUND PRESENT THE RESONANCE Recent
CONTRIBUTION OF FISSION WILL BE ADDED TO THE BACKGROUND AND Recent
OUTPUT. IF THERE IS NO FIRST CHANCE FISSION (MT=19) BACKGROUND Recent
PRESENT THE PROGRAM WILL NOT OUTPUT MT=19. Recent
Recent
IN THE FOLLOWING FOR SIMPLICITY THE ENDF/B TERMINOLOGY--ENDF/B Recent
TAPE--WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE TAPE, CARDS, Recent
DISK OR ANY OTHER MEDIUM. Recent
Recent
PROCESSING DATA IN THE ENDF/B-VI FORMAT Recent
================================================================ Recent
IT HAS NOW BEEN CONFIRMED (PRIVATE COMMUNICATION, CHARLES DUNFORD, Recent
APRIL, 1991) THAT THE PROPER PROCEDURE TO FOLLOW WHEN THERE ARE Recent
MISSING OR DUPLICATE J VALUES IS TO IN ALL CASES ADD A SEQUENCE Recent
WITH NO RESONANCES TO ACCOUNT FOR THE CONTRIBUTION OF THE SEQUENCE Recent
TO THE POTENTIAL SCATTERING CROSS SECTION. Recent
Recent
THIS IS THE PROCEDURE WHICH WAS FOLLOWED BY ALL VERSIONS OF RECENT Recent
SINCE 86-3 AND WILL CONTINUE TO BE THE PROCEDURE. Recent
Recent
INPUT ENDF/B FORMAT AND CONVENTIONS Recent
================================================================ Recent
ENDF/B FORMAT Recent
------------- Recent
THIS PROGRAM ONLY USES THE ENDF/B BCD OR LINE IMAGE FORMAT (AS Recent
OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION Recent
OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV, V OR VI FORMAT). Recent
Recent
IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B Recent
FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS Recent
ASSUMED THAT THE MAT, MF AND MT ON EACH LINE IS CORRECT. SEQUENCE Recent
NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE Recent
CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451 Recent
AND ALL SECTIONS OF MF=2 AND 3 MUST BE CORRECT. THE PROGRAM COPIES Recent
ALL OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE Recent
TO THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS. Recent
Recent
ENDF/B FORMAT VERSION Recent
--------------------- Recent
THE FORMATS AND CONVENTIONS FOR READING AND INTERPRETING THE DATA Recent
VARIES FROM ONE VERSION OF ENDF/B TO THE NEXT. HOWEVER, IF THE Recent
HOLLERITH SECTION (MF=1, MT=451) IS PRESENT IT IS POSSIBLE FOR Recent
THIS PROGRAM TO DISTINGUISH BETWEEN DATA IN THE ENDF/B-IV, V AND Recent

VI FORMATS AND TO USE THE APPROPRIATE CONVENTIONS FOR EACH ENDF/B VERSION (SEE, SUBROUTINE FILE1 FOR A DESCRIPTION OF HOW THIS IS DONE). IF THE HOLLERITH SECTION IS NOT PRESENT THE PROGRAM WILL ASSUME THE DATA IS IN THE ENDF/B-VI FORMAT AND USE ALL CONVENTIONS APPROPRIATE TO ENDF/B-V. USERS ARE ENCOURAGED TO INSURE THAT THE HOLLERITH SECTION (MF=1, MT=451) IS PRESENT IN ALL EVALUATIONS.

INPUT OF ENERGIES

ALL ENERGIES ARE READ IN DOUBLE PRECISION (BY SPECIAL FORTRAN I/O ROUTINES) AND ARE TREATED IN DOUBLE PRECISION IN ALL CALCULATIONS.

OUTPUT ENDF/B FORMAT AND CONVENTIONS

CONTENTS OF OUTPUT

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

DOCUMENTATION

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

********** RECENT (VERSION 2007-1) **********
RESONANCE CONTRIBUTION RECONSTRUCTED TO WITHIN 0.100 PER-CENT
COMBINED DATA NOT THINNED (ALL RESONANCE + BACKGROUND DATA KEPT)

THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR, SIGMA1 AND GROUPY) REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON THE DATA, INCLUDING WHICH VERSION OF EACH PROGRAM WAS USED.

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

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.

OUTPUT FORMAT OF ENERGIES

IN THIS VERSION OF RECENT 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 Recent
OUTPUT OPTION. HOWEVER USE OF THIS OPTION TO COMPARE THE RESULTS Recent
OF ENERGIES WRITTEN IN THE NORMAL ENDF/B CONVENTION OF 6 DIGITS Recent
TO THE 9 DIGIT OUTPUT FROM THIS PROGRAM DEMONSTRATED THAT FAILURE Recent
TO USE THE 9 DIGIT OUTPUT CAN LEAD TO LARGE ERRORS IN THE DATA Recent
JUST DUE TO TRANSLATION OF ENERGIES FROM THEIR INTERNAL (BINARY) Recent
REPRESENTATION TO THE ENDF/B FORMAT. Recent
Recent
ACCURACY OF ENERGY Recent
------------------ Recent
IN ORDER TO ALLOW ENERGIES TO BE ACCURATELY OUTPUT TO 9 DIGITS Recent
ON SHORT WORD LENGTH COMPUTERS (E.G. IBM) ALL ENERGIES AND Recent
ENERGY DEPENDENT TERMS ARE READ AND TREATED IN DOUBLE PRECISION. Recent
Recent
OUTPUT OF RESONANCE PARAMETERS Recent
------------------------------ Recent
A SPECIAL CONVENTION HAS BEEN INTRODUCED REGARDING RESONANCE Recent
PARAMETERS. IN ORDER TO ALLOW THE USER TO DOPPLER BROADEN AND/OR Recent
SELF-SHIELD CROSS SECTIONS THE RESONANCE PARAMETERS ARE ALSO Recent
INCLUDED IN THE OUTPUT WITH THE EVALUATION. IN ORDER TO AVOID THE Recent
POSSIBILITY OF ADDING THE RESONANCE CONTRIBUTION A SECOND TIME Recent
TWO CONVENTIONS HAVE BEEN ADOPTED TO INDICATE THAT THE RESONANCE Recent
CONTRIBUTION HAS ALREADY BEEN ADDED TO THE FILE 3 CROSS SECTIONS, Recent
Recent
(1) WHEN THE DATA IS PROCESSED BY THIS PROGRAM LRP (IN MF=1, Recent
MT=451) IS SET EQUAL TO 2. THIS IS A CONVENTION WHICH HAS BEEN Recent
ADOPTED AS A STANDARD CONVENTION IN ENDF/B-VI, BUT IS ONLY TO BE Recent
USED FOR PROCESSED DATA, AS OPPOSED TO THE ORIGINAL EVALUATIONS. Recent
IN EVALUATIONS WHICH CONTAIN MF=1, MT=451 LRP CAN BE USED TO Recent
DETERMINE IF THE MATERIAL HAS BEEN PROCESSED. Recent
Recent
(2) THE LRU FLAG IN EACH SECTION OF FILE 2 DATA IS CHANGED TO Recent
LRU=LRU+3. FOR EXAMPLE WHEN READING AN ENDF/B EVALUATION LRU=0 Recent
(NO RESONANCES), =1 (RESOLVED) OR =2 (UNRESOLVED) INDICATES THAT Recent
THE DATA IS IN THE ORIGINAL ENDF/B FORM. LRU=3 (NO RESONANCES), Recent
=4 (RESOLVED) OR =5 (UNRESOLVED) INDICATES THAT THE RESONANCE Recent
CONTRIBUTION HAS ALREADY BEEN ADDED TO THE FILE 3 DATA. THIS Recent
SECOND CONVENTION HAS BEEN ADOPTED AS INSURANCE THAT THE RESONANCE Recent
CONTRIBUTION WILL NOT BE ADDED TWICE, EVEN FOR EVALUATIONS WHICH Recent
DO NOT CONTAIN MF=1, MT=451 (EVALUATIONS WHICH CONTAIN MF=1, Recent
MT=451 ARE COVERED BY CONVENTION (1), DESCRIBED ABOVE). Recent
Recent
UNIFORM TREATMENT OF RESONANCE FORMALISMS Recent
========================================================================= Recent
NORMALIZATION Recent
============= Recent
ALL OF THE RESONANCE FORMALISMS INCLUDE A FACTOR OF, Recent
Recent
PI*(FRACTIONAL ABUNDANCE)/(K**2) Recent
Recent
THIS FACTOR HAS BEEN REMOVED FROM THE CALCULATION OF EACH TYPE Recent
OF RESONANCE FORMALISM AND IS APPLIED AS A FINAL NORMALIZATION Recent
AFTER THE CALCULATION, ONLY ONE PLACE IN THIS PROGRAM. Recent
Recent
FOR SIMPLICITY THIS TERM IS NOT INCLUDED IN THE FOLLOWING Recent
DERIVATIONS - IN ALL CASES THE ACTUAL CROSS SECTION IS A PRODUCT Recent
OF THE ABOVE FACTOR TIMES THE RESULTS PRESENTED BELOW. Recent
Recent
SIMILARITIES Recent
============ Recent
FOR THE RESOLVED RESONANCE REGION, EXCEPT FOR SINGLE LEVEL BREIT Recent
WIGNER, PARAMETERS ALL OF THE FORMALISMS DEFINE THE CROSS SECTIONS Recent
IN AN EQUIVALENT FORM, Recent

```
                                                                      Recent
TOTAL    = 2*GJ*REAL(1 - U)                                           Recent
         = 2*GJ*(1 - REAL(U))                                         Recent
ELASTIC  =   GJ*(1 - U)**2                                            Recent
         =   GJ*((1 - 2*REAL(U)) + (REAL(U)**2 + IM(U)**2))           Recent
         = 2*GJ*(1 - REAL(U)) - GJ*(1 - (REAL(U)**2 + IM(U)**2))      Recent
                                                                      Recent
SINCE THE FIRST TERM IS THE TOTAL, THE SECOND TERM MUST BE            Recent
ABSORPTION. SO WE FIND,                                               Recent
                                                                      Recent
ABSORPTION = GJ*(1 - (REAL(U)**2 + IM(U)**2))                         Recent
                                                                      Recent
IN ALL CASES U IS DEFINED IN THE FORM,                                Recent
                                                                      Recent
U        = EXP(-I*2*PS)*((1-X) - I*Y)                                 Recent
                                                                      Recent
WHERE (X) AND (Y) ARE RELATED TO THE SYMMETRIC AND ANTI-SYMMETRIC     Recent
CONTRIBUTIONS OF THE RESONANCES, RESPECTIVELY. ONLY THE DEFINITION    Recent
OF (X) AND (Y) WILL BE DIFFERENT FOR EACH RESONANCE FORMALISM.        Recent
BELOW WE WILL SHOW THAT WHAT MIGHT APPEAR TO BE A STRANGE CHOICE      Recent
OF DEFINITION OF THE SIGN OF (X) AND(Y) HAS BEEN SELECTED SO THAT     Recent
FOR BREIT-WIGNER PARAMETERS (X) AND (Y) CORRESPOND EXACTLY TO THE     Recent
SYMMETRIC AND ANTI-SYMMETRIC CONTRIBUTION OF THE RESONANCES.          Recent
                                                                      Recent
U        = (COS(2*PS) - I*SIN(2*PS))*((1-X) - I*Y)                    Recent
         =   ((1-X)*COS(2*PS) - Y*SIN(2*PS))                          Recent
         =-I*((1-X)*SIN(2*PS) + Y*COS(2*PS))                          Recent
                                                                      Recent
REAL(U)  = ((1-X)*COS(2*PS) - Y*SIN(2*PS))                           Recent
IM(U)    =-((1-X)*SIN(2*PS) + Y*COS(2*PS))                           Recent
                                                                      Recent
R(U)**2  =((1-X)*COS(2*PS))**2 + (Y*SIN(2*PS))**2                     Recent
          -2*(1-X)*Y*COS(2*PS)*SIN(2*PS)                              Recent
I(U)**2  =((1-X)*SIN(2*PS))**2 + (Y*COS(2*PS))**2                     Recent
          +2*(1-X)*Y*COS(2*PS)*SIN(2*PS)                              Recent

                                                                      Recent
THE TERMS 2*(1-X)*Y*COS(2*PS)*SIN(2*PS) CANCEL AND UPON USING         Recent
THE IDENTITY COS(2*PS)**2 + SIN(2*PS)**2 = 1,                         Recent
                                                                      Recent
SUM      = (1-X)**2 + (Y)**2                                          Recent
                                                                      Recent
WE NOW HAVE ALL THE QUANTITIES THAT WE NEED TO DEFINE THE CROSS       Recent
SECTIONS,                                                             Recent
                                                                      Recent
ELASTIC                                                               Recent
=======                                                               Recent
ELASTIC  =GJ*(1 - 2*REAL(U) + (REAL(U)**2 + IM(U)**2))                Recent
         =GJ*(1 - 2*((1-X)*COS(2*PS)-Y*SIN(2*PS))+(1-X)**2+(Y)**2)    Recent
                                                                      Recent
THIS CAN BE WRITTEN AS A SUM OF 2 SQUARES,                            Recent
                                                                      Recent
ELASTIC  =GJ*(COS(2*PS) - (1-X))**2 + (SIN(2*PS) + Y)**2)             Recent
                                                                      Recent
         =GJ*((COS(2*PS))**2 - 2*(1-X)*COS(2*PS) + (1-X)**2) +        Recent
              (SIN(2*PS))**2 + 2*Y*SIN(2*PS)    + (Y)**2)             Recent
                                                                      Recent
AGAIN USING THE IDENTITY COS(2*PS)**2 + SIN(2*PS)**2 = 1, WE CAN      Recent
SEE THAT THE DEFINITION AS THE SUM OF 2 SQUARES IS IDENTICAL TO       Recent
THE PRECEDING DEFINITION OF THE ELASTIC.                              Recent
                                                                      Recent
ELASTIC  =GJ*(COS(2*PS) - (1-X))**2 + (SIN(2*PS) + Y)**2)             Recent
         =GJ*((COS(2*PS)-1) + X)**2 + (SIN(2*PS) + Y)**2)             Recent
```

Recent

USING THE IDENTITY (1 - COS(2*PS))) = 2*SIN(PS)**2, WE OBTAIN Recent
THE FINAL FORM FOR THE ELASTIC, Recent

ELASTIC =GJ*(2*SIN(PS)**2 - X)**2 + (SIN(2*PS) + Y)**2) Recent

ABSORPTION Recent
========== Recent
ABSORPTION = GJ*(1 - (REAL(U)**2 + IM(U)**2)) Recent
= GJ*(1 - ((1-X)**2 + (Y)**2) Recent
= GJ*(1 - (1 - 2*X + (X)**2 + (Y)**2) Recent
= GJ*(2*X - (X)**2 + (Y)**2) Recent

SINCE PHYSICALLY THE ABSORPTION CANNOT BE NEGATIVE WE CAN SEE Recent
THAT (X) MUST BE POSITIVE AND 2*X MUST BE GREATER THAN Recent
(X)**2 + (Y)**2, FOR ALL OF THE FORMALISMS. Recent

TOTAL Recent
===== Recent
IN THIS PROGRAM THE TOTAL CROSS SECTION IS ALWAYS DEFINED TO BE Recent
THE SUM OF ITS PARTS - SO THE ABOVE DEFINITION IS NEVER EXPLICITLY Recent
USED. HOWEVER, WE CAN LEARN SOMETHING BY EXAMINING THE DEFINITION, Recent

TOTAL = 2*GJ*REAL(1 - U) Recent
= 2*GJ*(1 - (((1-X)*COS(2*PS) - Y*SIN(2*PS))) Recent
= 2*GJ*((1 - COS(2*PS))*(1-X) - (1-X) + Y*SIN(2*PS)) Recent
= 2*GJ*(2*SIN(PS)**2*(1-X) - (1-X) + Y*SIN(2*PS)) Recent

= 4*GJ*SIN(PS)**2 + Recent
2*GJ*((X-1) - 2*X*SIN(PS)**2 + Y*SIN(2*PS)) Recent

THE IMPORTANT POINT TO NOTE IS THAT THE DEFINITION OF THE TOTAL Recent
DOES NOT EXPLICITLY CONTAIN ANY DEPENDENCE ON X**2 AND Y**2 - Recent
THE LEVEL-LEVEL INTERFERENCE TERMS. Recent

THIS IMPLIES THAT IF A GIVEN SET OF RESONANCE PARAMETERS ARE USED Recent
WITH THIS DEFINITION THEY WILL PRODUCE EXACTLY THE SAME TOTAL Recent
CROSS SECTION - WHETHER WE CLAIM THE PARAMETERS HAVE BEEN Recent
PRODUCED USING A SINGLE OR MULTI-LEVEL FIT. THIS RESULT COULD Recent
BE VERY MISLEADING, IF THIS RESULT FOR THE TOTAL IS IMPLIED TO Recent
MEAN THAT ONE INTERPRETATION OR THE OTHER WILL NOT HAVE ANY Recent
EFFECT ON THE INDIVIDUAL CROSS SECTIONS. Recent

STARTING FROM EXACTLY THE SAME RESONANCE PARAMETERS, RELATIVE TO Recent
THE RESULTS OBTAINED USING THE SINGLE LEVEL FORMULA, MULTI-LEVEL Recent
RESULTS WILL TEND TO ALWAYS DECREASE THE ABSORPTION AND INCREASE Recent
THE ELASTIC. THIS CAN BE IMMEDIATELY SEEN FROM OUR GENERAL Recent
MULTI-LEVEL DEFINITION OF ABSORPTION, Recent

ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2)) Recent

THE SINGLE LEVEL ABSORPTION IS, Recent

ABSORPTION =GJ*(2*X) Recent

THE DIFFERENCE BETWEEN THE TWO IS -2*GJ*(X**2 + Y**2), SO THAT Recent
REGARDLESS OF HOW WE DEFINE (X) AND (Y) THE INCLUSION OF THIS Recent
TERM WILL ALWAYS DECREASE ABSORPTION. SINCE THE TOTAL CROSS Recent
SECTION IS THE SAME IN BOTH CASE, THIS MEANS THAT THE ELASTIC Recent
HAS BEEN INCREASED BY THIS AMOUNT. Recent

AGAIN, THESE RESULTS ARE BASED ON STARTING FROM EXACTLY THE SAME Recent
PARAMETERS - IN ANY ACTUAL CASE THE PARAMETERS BASED ON A SINGLE Recent

OR MULTI-LEVEL FIT WILL BE QUITE DIFFERENT - THE POINT THAT WE Recent
WANT TO STRESS HERE IS THAT YOU SHOULD NEVER USE PARAMETERS Recent
WHICH HAVE BEEN DEFINED BY A FIT USING ONE FORMALISM - IN THE Recent
EQUATIONS FOR A DIFFERENT FORMALISM - AND ASSUME THAT THE RESULTS Recent
WILL BE CONSISTENT - AND NEVER USE THE TOTAL CROSS SECTION TO Recent
SEE WHETHER OR NOT A SET OF SINGLE LEVEL PARAMETERS CAN BE USED Recent
WITH A MULTI-LEVEL FORMALISM. Recent
Recent
POTENTIAL CROSS SECTION Recent
======================== Recent
FAR FROM RESONANCES (X) AND (Y) WILL BE SMALL AND THE ELASTIC Recent
CROSS SECTION REDUCES TO, Recent
Recent
ELASTIC =GJ*(2*SIN(PS)**2)**2 + (SIN(2*PS))**2 Recent
=GJ*4*(SIN(PS)**4 + SIN(2*PS)**2 Recent
Recent
USING THE IDENTITY SIN(2*PS) = 2*SIN(PS)*COS(PS) Recent
Recent
=4*GJ*(SIN(PS)**4 + (SIN(PS)*COS(PS))**2) Recent
=4*GJ*SIN(PS)**2*(SIN(PS)**2 + COS(PS)**2) Recent
=4*GJ*SIN(PS)**2 Recent
Recent
WHICH IS THE POTENTIAL CROSS SECTION. NOTE THAT THIS RESULT IS Recent
INDEPENDENT OF THE FORMALISM USED, AS IT MUST PHYSICALLY BE, Recent
AND AS SUCH ALTHOUGH AS YET WE HAVE NOT DEFINED IT, WE CAN Recent
NOW SEE THAT IN ALL CASES (PS) MUST BE THE PHASE SHIFT AND FOR Recent
CONSISTENCY IT MUST BE DEFINED USING EXACTLY THE SAME DEFINITION Recent
IN ALL CASES. Recent
Recent
IN ADDITION SINCE PHYSICALLY FOR EACH L VALUE WE EXPECT TO OBTAIN Recent
A POTENTIAL CROSS SECTION, Recent
Recent
4*(2*L+1)*SIN(PS)**2 Recent
Recent
OBVIOUSLY FOR CONSISTENCY WE MUST HAVE, Recent
Recent
(2*L+1) = (SUM OVER J) GJ Recent
Recent
ONLY IN THIS CASE WILL THE RESULTS BE CONSISTENT - THIS POINT WILL Recent
BE DISCUSSED IN DETAIL BELOW. Recent
Recent
WHAT ARE THIS TERMS (X) AND (Y) Recent
============================== Recent
(X) AND (Y) CAN BE EASILY IDENTIFIED BY CONSIDERING THE SINGLE Recent
AND MULTI-LEVEL BREIT WIGNER FORMALISMS. IN THESE CASES WE WILL Recent
FIND THAT, Recent
Recent
X = GAM(N)*GAM(T)/2/DEN Recent
Y = GAM(N)*(E-ER)/DEN Recent
DEN = ((E-ER)**2 + (GAM(T)/2)**2) Recent
Recent
EXTREME CARE HAS TO BE USED TO PROPERLY DEFINE (Y) SUCH THAT IT Recent
IS NEGATIVE FOR E LESS THAN ER AND POSITIVE FOR E GREATER THAN Recent
ER. I WILL MERELY MENTION THAT THE EQUATIONS FOR ALL FORMALISMS Recent
IN ENDF-102 DO NOT CONSISTENTLY USE (E - ER) - IN SOME CASES Recent
THIS IS WRITTEN AS (ER - E), WHICH CAN LEAD TO AN INCORRECT Recent
SIGN IN THE DEFINITION OF THE (Y) THAT WE REQUIRE. Recent
Recent
THE INTERFERENCE TERMS CAN BE WRITTEN IN TERMS OF, Recent
1) LEVEL-SELF INTERFERENCE = THE CONTRIBUTION OF EACH LEVEL Recent
INTERFERRING WITH ITSELF Recent
2) LEVEL-LEVEL INTERFERENCE = THE CONTRIBUTION OF EACH LEVEL Recent
INTERFERRRING WITH ALL OTHER LEVELS Recent

WE WILL REFER TO THESE TWO AS (L-S) AND (L-L),

```
X**2     = (GAM(N)*(GAM(T)/2)**2/(DEN)**2      + (L-L)
         = (GAM(N)**2*((GAM(T)/2)**2)/(DEN)**2 + (L-L)
Y**2     = (GAM(N))**2*((E-ER))**2/(DEN)**2    + (L-L)

X**2+Y**2= GAM(N)**2*DEN/(DEN)**2 = GAM(N)**2/DEN + (L-L)
```

TO SEE THE EFFECT OF INCLUDING MULTI-LEVEL INTERFERENCE WE CAN CONSIDER OUR GENERAL EXPRESSION FOR ABSORPTION,

```
ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2))
```

AND NOTE THAT FOR BOTH SINGLE AND MULTI-LEVEL BREIT WIGNER THE ENDF-102 SAYS TO TREAT ABSORPTION IN A SINGLE LEVEL APPROXIMATION I.E., IGNORE LEVEL-LEVEL INTERFERENCE. IF ALL INTERFERENCE IS IGNORED THIS IS EQUIVALENT TO COMPLETELY IGNORING X**2 + Y**2 AND DEFINING,

```
ABSORPTION =GJ*2*X
           =2*GJ*GAM(N)*GAM(T)/DEN
```

WHICH IS INCORRECT - SINCE THIS SEEMS TO INDICATE EVERYTHING IS ABSORBED. IN ORDER TO OBTAIN THE CORRECT EXPRESSION WE CANNOT COMPLETELY IGNORE INTERFERENCE - WE CAN IGNORE LEVEL-LEVEL INTERFERENCE, BUT WE MUST INCLUDE LEVEL-SELF INTERFERENCE,

```
X**2+Y**2= GAM(N)**2/DEN

ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2))
           =GJ*GAM(N)*(GAM(T)-GAM(N))/DEN
           =GJ*GAM(N)*GAM(A)/DEN
```

## SUMMARY

AN IMPORTANT POINT TO NOTE IS THE DEFINITION OF (X) AND (Y) WHICH IN ALL CASES WILL CORRESPOND TO THE SYMMETRIC AND ANTI-SYMMETRIC CONTRIBUTION OF THE RESONANCES. IN PARTICULAR DEFINING (U) IN TERMS OF (1-X) INSTEAD OF (X) IS EXTREMELY IMPORTANT. NOTE, THAT THE DEFINITION OF THE ELASTIC AND ABSORPTION ONLY INVOLVE (X), NOT (1-X). FAR FROM RESONANCES (X) CAN BE EXTREMELY SMALL, THEREFORE (1-X) WILL BE VERY CLOSE TO (1). IF THE CALCULATION PROCEEDS BY FIRST CALCULATING (1-X) AND THEN DEFINING (X) BY SUBTRACTING (1), EXTREME ROUND-OFF PROBLEMS CAN RESULT. THESE PROBLEMS CAN BE AVOIDED BY IN ALL CASES DEFINING (X) DIRECTLY, WITHOUT ANY DIFFERENCES.

IN EACH FORMALISM THE DEFINITION OF (X) AND (Y) MAY BE DIFFERENT BUT ONCE WE HAVE DEFINED (X) AND (Y) WE CAN IMMEDIATELY WRITE THE CROSS SECTIONS USING A UNIFORM DEFINITION,

```
ELASTIC =GJ*(2*SIN(PS)**2 - X)**2 + (SIN(2*PS) + Y)**2)

ABSORPTION =-GJ*(2*X + (X)**2 + (Y)**2)
```

AND DEFINE THE TOTAL AS THE SUM OF THESE 2 PARTS.

## RELATIONSHIP TO SINGLE LEVEL

HOW DO THE SINGLE AND MULTI-LEVEL FORMALISMS COMPARE. TO SEE, STARTING FROM OUR GENERAL DEFINITION OF THE ELASTIC IN THE FORM,

```
ELASTIC =GJ*(2*SIN(PS)**2 + X)**2 + (SIN(2*PS) + Y)**2)
        =GJ*(4*SIN(PS)**4 - 4*X*SIN(PS)**2 + X**2
           + SIN(2*PS)**2 + 2*Y*SIN(2*PS)  + Y**2)

        =4*GJ*SIN(PS)**2 +
           GJ*(X**2 + Y**2
              -4*X*SIN(PS)**2
              +2*Y*SIN(2*PS))
```

AND OUR SPECIFIC DEFINITIONS OF (X) AND (Y) FOR MULTI-LEVEL BREIT-WIGNER PARAMETERS,

```
X        = GAM(N)*GAM(T)/2/DEN
Y        = GAM(N)*(E-ER)/DEN
DEN      = ((E-ER)**2 + (GAM(T)/2)**2)

X**2+Y**2= GAM(N)**2/DEN + (L-L)
```

WE CAN RECOGNIZE X**2 AND Y**2 AS THE INTERFERENCE - (L-S) + (L-L) TERMS IN THE MULTI-LEVEL FORMALISM. IN ORDER TO OBTAIN THE SINGLE LEVEL EQUATION WE CAN ASSUME THAT EACH LEVEL DOES NOT INTERFERE WITH ANY OTHER LEVEL - THEREFORE THE (L-L) CONTRIBUTION IS ZERO.

```
ELASTIC =4*GJ*SIN(PS)**2 +
          GJ*GAM(N)*(GAM(N)
                     -2*GAM(T)*SIN(PS)**2
                     +2*(E-ER)*SIN(2*PS))/DEN
```

WHICH IS THE FORM THAT IT APPEARS IN ENDF-102, EXCEPT FOR TWO TYPOGRAPHICAL ERRORS IN THE SECOND TERM,

```
-2*GAM(T)*SIN(PS)**2
```

WHICH IN ENDF-102 IS WRITTEN,

```
-2*(GAM(T)-GAM(N))*SIN(2*PS)**2
```

## PROGRAM CONVENTIONS

### MINIMUM INPUT DATA

FOR EACH MATERIAL TO BE PROCESSED THE MINIMUM INPUT DATA ARE THE RESONANCE PARAMETERS IN FILE 2. IF THERE ARE NO FILE 2 PARAMETERS IN A GIVEN MATERIAL THE ENTIRE MATERIAL WILL SIMPLY BE COPIED. NEITHER THE HOLLERITH SECTION (MF=1, MT=451) NOR THE BACKGROUND CROSS SECTION (SECTIONS OF MF=3) NEED BE PRESENT FOR THIS PROGRAM TO EXECUTE PROPERLY. HOWEVER, SINCE THE CONVENTIONS USED IN INTERPRETING THE RESONANCE PARAMETERS DEPENDS ON ENDF/B VERSION USERS ARE STRONGLY RECOMMENDED TO INSURE THAT MF=1, MT=451 IS PRESENT IN EACH MATERIAL TO ALLOW THE PROGRAM TO DETERMINE THE ENDF/B FORMAT VERSION.

### RESONANCE PARAMETERS

RESONANCE PARAMETERS MAY BE REPRESENTED USING ANY COMBINATION OF THE REPRESENTATIONS ALLOWED IN ENDF/B,

(1) RESOLVED DATA
    (A) SINGLE LEVEL BREIT-WIGNER
    (B) MULTI-LEVEL BREIT-WIGNER
    (C) ADLER-ADLER
    (D) REICH-MOORE
    (E) HYBRID R-FUNCTION

(2) UNRESOLVED DATA Recent
(A) ALL PARAMETERS ENERGY INDEPENDENT Recent
(B) FISSION PARAMETERS ENERGY DEPENDENT Recent
(C) ALL PARAMETERS ENERGY DEPENDENT Recent
Recent
THE FOLLOWING RESOLVED DATA FORMALISMS ARE NOT TREATED BY THIS Recent
VERSION OF THE CODE AND WILL ONLY BE IMPLEMENTED AFTER EVALUATIONS Recent
USING THESE FORMALISMS ARE AVAILABLE TO THE AUTHOR OF THIS CODE Recent
FOR TESTING IN ORDER TO INSURE THAT THEY CAN BE HANDLED PROPERLY Recent
(A) GENERAL R-MATRIX Recent
Recent
CALCULATED CROSS SECTIONS Recent
------------------------ Recent
THIS PROGRAM WILL USE THE RESONANCE PARAMETERS TO CALCULATE THE Recent
TOTAL, ELASTIC, CAPTURE AND POSSIBLY FISSION CROSS SECTIONS. THE Recent
COMPETITIVE WIDTH WILL BE USED IN THESE CALCULATIONS, BUT THE Recent
COMPETITIVE CROSS SECTION ITSELF WILL NOT BE CALCULATED. THE Recent
ENDF/B CONVENTION IS THAT ALTHOUGH A COMPETITIVE WIDTH MAY BE Recent
GIVEN, THE COMPETITIVE CROSS SECTION MUST BE SEPARATELY TABULATED Recent
AS A SECTION OF FILE 3 DATA. Recent
Recent
RESOLVED REGION Recent
--------------- Recent
IN THE RESOLVED REGION THE RESOLVED PARAMETERS ARE USED TO Recent
CALCULATE COLD (0 KELVIN), LINEARLY INTERPOLABLE, ENERGY DEPENDENT Recent
CROSS SECTIONS. Recent
Recent
SCATTERING RADIUS Recent
----------------- Recent
FOR SINGLE OR MULTI LEVEL BREIT-WIGNER PARAMETERS THE SCATTERING Recent
RADIUS MAY BE SPECIFIED IN EITHER ENERGY INDEPENDENT (CONSTANT) Recent
OR ENERGY DEPENDENT FORM (A TABLE OF ENERGY VS. RADIUS AND AN Recent
ASSOCIATED INTERPOLATION LAW). IN ALL OTHER CASE ONLY AN ENERGY Recent
INDEPENDENT SCATTERING RADIUS IS ALLOWED. Recent
Recent
FOR ANY ONE MATERIAL (I.E. MAT) IF ENERGY DEPENDENT SCATTERING Recent
RADII ARE GIVEN THE TOTAL NUMBER OF INTERPOLATION REGIONS AND Recent
TABULATED VALUES FOR THE ENTIRE MATERIAL CANNOT EXCEED, Recent
200 - INTERPOLATION REGIONS Recent
500 - TABULATED VALUES Recent
IF THESE LIMITS ARE EXCEEDED THE PROGRAM WILL PRINT AN ERROR Recent
MESSAGE AND TERMINATE. Recent
Recent
IF YOU REQUIRE A LARGER NUMBER OF INTERPOLATION REGION AND/OR Recent
TABULATED VALUES, Recent
(1) INTERPOLATION REGIONS - INCREASE THE DIMENSION OF NBTRHO AND Recent
INTRHO IN COMMON/TABRHO/ THROUGHOUT THE PROGRAM AND CHANGE MAXSEC Recent
IN SUBROUTINE RDAP (MAXSEC = MAXIMUM NUMBER OF INTERPOLATION Recent
REGIONS). Recent
(2) TABULATED VALUES - INCREASE THE DIMENSION OF ERHOTB, RHOTAB Recent
AND APTAB IN COMMON/TABRHO/ THROUGHOUT THE PROGRAM AND CHANGE Recent
MAXRHO IN SUBROUTINE RDAP (MAXRHO = MAXIMUM NUMBER OF TABULATED Recent
VALUES). Recent
Recent
RESOLVED REICH-MOORE AND MULTI-LEVEL BREIT-WIGNER PARAMETERS Recent
---------- Recent
CROSS SECTIONS FOR REICH-MOORE PARAMETERS ARE CALCULATED ACCORDING Recent
TO THE EQUATION (1) - (8) OF SECTION D.1.3 OF ENDF-102. IN ORDER Recent
TO CALCULATE CROSS SECTIONS FROM MULTI-LEVEL PARAMETERS IN A Recent
REASONABLE AMOUNT OF TIME THIS PROGRAM EXPRESSES THE CROSS SECTION Recent
IN TERMS OF A SINGLE SUM OVER RESONANCES (SEE, ENDF-102, SECTION Recent
D.1.2, EQUATIONS 6-7), RATHER THAN AS A DOUBLE SUM (SEE, ENDF-102 Recent
SECTION D.1.2, EQUATION 1-2). IN ORDER FOR THE ENDF-102 EQUATIONS Recent

TO BE CORRECT THE PARAMETERS MUST MEET THE FOLLOWING CONDITIONS, Recent

(1) FOR EACH L STATE ALL PHYSICALLY POSSIBLE J SEQUENCES MUST BE PRESENT. ONLY IN THIS CASE WILL THE CONTRIBUTIONS OF THE INDIVIDUAL J SEQUENCES ADD UP TO PRODUCE THE CORRECT POTENTIAL SCATTERING CONTRIBUTION FOR THE L STATE (SEE, ENDF-102, SECTION D.1.2, EQUATIONS 6-7). IF ANY J SEQUENCE IS MISSING THE PROGRAM WILL PRINT A WARNING AND ADD THE J SEQUENCE WITH NO RESONANCE PARAMETERS IN ORDER TO ALLOW THE POTENTIAL SCATTERING TO BE CALCULATED CORRECTLY (THIS IS EQUIVALENT TO ASSUMING THAT THE EVALUATOR REALIZES THAT ALL J SEQUENCES MUST BE AND ARE PRESENT AND THAT THE EVALUATION STATES THAT THERE ARE NO RESONANCES WITH CERTAIN PHYSICALLY POSSIBLE J VALUES... IN THIS CASE POTENTIAL CONTRIBUTION MUST STILL BE CONSIDERED).

EXAMPLE
=======
AN EXAMPLE OF WHERE THIS OCCURS AND IS IMPORTANT TO CONSIDER IS U-238 IN ENDF/B-IV AND V LIBRARIES WHERE FOR L=1 THERE IS ONLY A J=1/2 SEQUENCE. NOT INCLUDING THE J=3/2 SEQUENCE LEADS TO UNDERESTIMATING THE POTENTIAL SCATTERING AND PRODUCES MINIMA IN THE ELASTIC CROSS SECTION WHICH ARE AN ORDER OF MAGNITUDE LOWER THAN THE CROSS SECTIONS OBTAINED BE INCLUDING THE J=3/2 SEQUENCE.

(2) FOR A GIVEN TARGET SPIN AND L VALUE THERE MAY BE 2 POSSIBLE MEANS OF OBTAINING THE SAME J VALUE. WHEN THIS OCCURS IN ORDER TO CALCULATE THE CORRECT POTENTIAL SCATTERING CROSS SECTION IT IS IMPORTANT TO INCLUDE THE EFFECT OF BOTH POSSIBLE J SEQUENCES, EVEN THOUGH FROM THE ENDF/B DATA IT IS NOT POSSIBLE TO DETERMINE WHICH OF THE 2 POSSIBLE SEQUENCES ANY GIVEN RESONANCE BELONGS TO. IN THIS CASE THIS PROGRAM TREAT ALL RESONANCES WITH THE SAME J VALUE AS BELONGING TO THE SAME J SEQUENCE (TO ALLOW INTERFERENCE) AND WILL ADD AN ADDITIONAL J SEQUENCE WITH NO RESONANCES IN ORDER TO ALLOW THE POTENTIAL CROSS SECTION TO BE CALCULATED CORRECTLY. WHEN THIS OCCURS A WARNING MESSAGE IS PRINTED, BUT BASED ON THE ENDF/B DATA THERE IS NOTHING WRONG WITH THE DATA AND THERE IS NOTHING THAT THE USER CAN DO TO CORRECT OR IN ANY WAY MODIFY THE DATA TO ELIMINATE THE PROBLEM.

EXAMPLE
=======
FOR A TARGET SPIN =1 AND L=1 THE 2 RANGES OF PHYSICALLY POSSIBLE J ARE 1/2, 3/2, 5/2 AND 1/2, 3/2. BY CHECKING THE ENDF/B DATA IT IS POSSIBLE TO INSURE THAT THE 3 POSSIBLE J VALUES (1/2, 3/2, 5/2) ARE PRESENT AND TO INCLUDE ALL 3 J SEQUENCES IN THE CALCULATIONS. HOWEVER, UNLESS ALL 5 POSSIBLE J SEQUENCES ARE INCLUDED THE STATISTICAL WEIGHTS OF THE J SEQUENCES WILL NOT SUM UP TO 2*L+1 AND THE POTENTIAL CROSS SECTION WILL BE UNDERESTIMATED. IN THIS EXAMPLE THE SUM OF THE 3 J SEQUENCES 1/2, 3/2, 5/2 IS 2, RATHER THAN 3 AS IT SHOULD BE FOR L=1, AND THE CONTRIBUTION OF THE L=1 RESONANCES TO THE POTENTIAL SCATTERING CROSS SECTION WILL ONLY BE 2/3 OF WHAT IT SHOULD BE, UNLESS THE OTHER 2 J SEQUENCES (WITH DUPLICATE J VALUES) ARE INCLUDED IN THE CALCULATION.

(3) EACH RESONANCE MUST HAVE AN ASSIGNED, PHYSICALLY POSSIBLE J VALUE. PHYSICALLY IMPOSSIBLE OR AVERAGE J VALUES CANNOT BE UNIQUELY INTERPRETED USING THE EQUATIONS IN ENDF-102 AND THEIR USE WILL USUALLY RESULT IN PHYSICALLY UNRELIABLE CROSS SECTIONS. THIS PROGRAM WILL CHECK ALL J VALUES AND IF ANY ARE

ARE FOUND TO BE PHYSICALLY IMPOSSIBLE (BASED ON TARGET SPIN AND L VALUE) AN ERROR MESSAGE WILL BE PRINTED TO INDICATE THAT THE RECONSTRUCTED CROSS SECTIONS WILL BE UNRELIABLE AND THE PROGRAM WILL CONTINUE. IN AN ATTEMPT TO CALCULATE THE CORRECT POTENTIAL SCATTERING CROSS SECTION THIS PROGRAM WILL SUBTRACT THE POTENTIAL SCATTERING CONTRIBUTION DUE TO ALL FICTICIOUS J SEQUENCES AND ADD THE CONTRIBUTION OF ALL PHYSICALLY POSSIBLE J SEQUENCES (AS DESCRIBED ABOVE).

WARNING (LET THE USER BEWARE)
==========

(A) IT CANNOT BE STRESSED ENOUGH THAT CROSS SECTIONS OBTAINED USING PHYSICALLY IMPOSSIBLE J VALUES FOR REICH-MOORE AND MULTI-LEVEL BREIT-WIGNER RESONANCE PARAMETERS WILL RESULT IN UNRELIABLE CROSS SECTIONS. THE DECISION TO HAVE THIS PROGRAM CONTINUE TO PROCESS WHEN THIS CONDITION IS FOUND IS BASED ON AN ATTEMPT TO ALLOW THE USER TO AT LEAST HAVE SOME RESULTS (HOWEVER BAD THEY MAY BE) IF THERE IS NO OTHER EVALUATED DATA AVAILABLE.

(B) EVEN THOUGH THE REICH-MOORE AND MULTI-LEVEL EQUATIONS ARE DEFINED AS ABSOLUTE OR SQUARED CONTRIBUTIONS WHICH MUST ALL BE PHYSICALLY POSSIBLE, ATTEMPTING TO CORRECT THE POTENTIAL CROSS SECTION (AS DESCRIBED ABOVE) CAN LEAD TO NEGATIVE ELASTIC CROSS SECTIONS. THIS IS BECAUSE BASED ON THE INFORMATION AVAILABLE IN THE EVALUATION IT IS NOT NOT POSSIBLE TO CORRECTLY ACCOUNT FOR THE INTERFERENCE BETWEEN THE RESONANCE AND POTENTIAL CONTRIBUTIONS FOR EACH J SEQUENCE.

UNRESOLVED RESONANCE REGION
---

IN THE UNRESOLVED RESONANCE REGION THE UNRESOLVED PARAMETERS ARE USED TO CALCULATE INFINITELY DILUTE AVERAGE CROSS SECTIONS. NOTE, IT IS IMPORTANT TO UNDERSTAND THAT FROM THE DEFINITION OF THE UNRESOLVED PARAMETERS IT IS NOT POSSIBLE TO UNIQUELY CALCULATE ENERGY DEPENDENT CROSS SECTIONS. ONLY AVERAGES OR DISTRIBUTIONS MAY BE CALCULATED.

UNRESOLVED INTERPOLATION
---

IN THE UNRESOLVED RESONANCE REGION CROSS SECTIONS AT EACH ENERGY ARE CALCULATED BY INTERPOLATING PARAMETERS. THIS IS THE CONVENTION USED IN ENDF/B-IV AND EARLIER VERSIONS OF ENDF/B. THE ENDF/B-V CONVENTION OF INTERPOLATING CROSS SECTIONS, NOT PARAMETERS, HAS BEEN ABANDONED AS IMPRACTICAL SINCE IT CAN LEAD TO THE SITUATION WHERE EXACTLY THE SAME PHYSICAL DATA CAN LEAD TO DIFFERENT RESULTS DEPENDING ON WHICH OF THE THREE ENDF/B UNRESOLVED PARAMTER FORMATS IS USED. FOR EXAMPLE, GIVEN A SET OF ENERGY INDEPENDENT UNRESOLVED PARAMETERS IT IS POSSIBLE TO CODE THESE PARAMETERS IN EACH OF THE THREE ENDF/B UNRESOLVED PARAMETER FORMATS. SINCE PHYSICALLY WE ONLY HAVE ONE SET OF PARAMETERS WE WOULD EXPECT THE RESULTS TO BE INDEPENDENT OF HOW THEY ARE REPRESENTED IN ENDF/B. UNFORTUNATELY USING THE ENDF/B-V CONVENTION TO INTERPOLATE CROSS SECTIONS CAN LEAD TO THREE COMPLETELY DIFFERENT RESULTS. IN CONTRAST USING THE ENDF/B-IV AND EARLIER CONVENTION OF INTERPOLATING PARAMETERS LEADS TO COMPLETELY CONSISTENT RESULTS.

INTERNAL REPRESENTATION OF UNRESOLVED PARAMETERS
---

ANY OF THE THREE POSSIBLE REPRESENTATIONS OF UNRESOLVED PARAMETERS CAN BE UNIQUELY REPRESENTED IN THE ALL PARAMETERS ENERGY DEPENDENT REPRESENTATIONS WITH THE APPROPRIATE (ENDF/B VERSION DEPENDENT) INTERPOLATION LAW. THIS IS DONE BY THE PROGRAM WHILE READING THE

UNRESOLVED PARAMETERS AND ALL SUBSEQUENT CALCULATIONS NEED ONLY CONSIDER THE ALL PARAMETERS ENERGY DEPENDENT REPRESENTATION. Recent

RESONANCE RECONSTRUCTION STARTING ENERGY GRID Recent

---

AS IN ANY ITERATIVE METHOD THE WAY TO SPEED CONVERGENCE IS TO TRY TO START CLOSE TO THE ANSWER. THIS PROGRAM ATTEMPTS TO DO THIS BY STARTING FROM AN ENERGY GRID WHICH IS A GOOD APPROXIMATION TO A SIMPLE BREIT-WIGNER LINE SHAPE, Recent

SIGMA(X)=1.0/(1.0+X*X) Recent

WHERE X IS THE DISTANCE FROM THE PEAK IN HALF-WIDTHS Recent

SUBROUTINE SUBINT HAS A BUILT-IN TABLE OF NODES WHICH ARE THE HALF-WIDTH MULTIPLES TO APPROXIMATE THE SIMPLE BREIT-LINE SHAPE TO WITHIN 1 PER-CENT OVER THE ENTIRE INTERVAL 0 TO 500 HALF-WIDTHS Recent

BETWEEN ANY TWO RESOLVED RESONANCES THE STARTING GRID IS BASED ON THE HALF-WIDTHS OF THE TWO RESONANCES. FROM THE LOWER ENERGY RESONANCE UP TO THE MID-POINT BETWEEN THE RESONANCES (MID-POINT IS DEFINED HERE AS AN EQUAL NUMBER OF HALF-WIDTHS FROM EACH RESONANCE) THE HALF-WIDTH OF THE LOWER ENERGY RESONANCE IS USED. FROM THE MID-POINT UP TO THE HIGHER ENERGY RESONANCE THE HALF-WIDTH OF THE UPPER ENERGY RESONANCE IS USED. Recent

WITH THIS ALOGORITHM CLOSELY SPACED RESONANCES WILL HAVE ONLY A FEW STARTING NODES PER RESONANCE (E.G. U-235). WIDELY SPACED RESONANCES WILL HAVE MORE NODES PER RESONANCE (E.G. U-238). FOR A MIX OF S, P, D ETC. RESONANCES THIS ALOGORITHM GUARANTEES AN ADEQUTE DESCRIPTION OF THE PROFILE OF EVEN EXTREMELY NARROW RESONANCES (WHICH MAY IMMEDIATELY CONVERGENCE TO THE ACCURACY REQUESTED, THUS MINIMIZING ITERATION). Recent

BACKGROUND CROSS SECTIONS Recent

---

THE PROGRAM WILL SEARCH FOR BACKGROUND CROSS SECTIONS FOR TOTAL (MT=1), ELASTIC (MT=2), FISSION (MT=18), FIRST CHANCE FISSION (MT=19) AND CAPTURE (MT=102). Recent

(1) THE BACKGROUND CROSS SECTIONS (FILE 3) CAN BE PRESENT OR NOT PRESENT FOR EACH REACTION. Recent

(2) IF FOR A GIVEN REACTION THE BACKGROUND CROSS SECTION IS PRESENT, IT WILL BE ADDED TO THE RESONANCE CONTRIBUTION AND THE RESULT WILL BE OUTPUT. Recent

(3) IF FOR A GIVEN REACTION THE BACKGROUND IS NOT PRESENT THE PROGRAM WILL, Recent

- (A) IF THE INPUT TO THE PROGRAM SPECIFIES NO OUTPUT FOR REACTIONS WITH NO BACKGROUND THERE WILL BE NO OUTPUT. Recent
- (B) IF THE INPUT TO THE PROGRAM SPECIFIES OUTPUT FOR REACTIONS WITH NO BACKGROUND, Recent
  - (I) THE RESONANCE CONTRIBUTION TO TOTAL, ELASTIC OR CAPTURE WILL BE OUTPUT. Recent
  - (II) IF ALL FISSION RESONANCE PARAMETERS ARE ZERO THE FISSION CROSS SECTION (MT=18) WILL NOT BE OUTPUT. OTHERWISE THE RESONANCE CONTRIBUTION OF THE FISSION (MT=18) WILL BE OUTPUT. Recent
  - (III) THERE WILL BE NO OUTPUT FOR FIRST CHANCE FISSION (MT=19). Recent

COMBINING RESONANCES AND BACKGROUND CROSS SECTIONS Recent

---

IN ORDER TO BE COMBINED WITH THE RESONANCE CONTRIBUTION THE BACKGROUND CROSS SECTIONS MUST BE GIVEN AT 0 KELVIN TEMPERATURE AND MUST BE LINEARLY INTERPOLABLE. IF THESE CONDITIONS ARE MET THE RESONANCE AND BACKGROUND CONTRIBUTIONS WILL BE ADDED TOGETHER AND OUTPUT. IF THESE CONDITIONS ARE NOT MET THE BACKGROUND CROSS SECTION WILL BE IGNORED AND ONLY THE RESONANCE CONTRIBUTION WILL BE OUTPUT. IF THE BACKGROUND HAS NOT BEEN ADDED TO THE RESONANCE CONTRIBUTION AFTER THIS PROGRAM FINISHES THE USER CAN MAKE THE RESONANCE AND BACKGROUND CONTRIBUTIONS COMPATIBLE BY,

(1) IF THE BACKGROUND IS NOT LINEARLY INTERPOABLE, LINEARIZE THE BACKGROUND (E.G., USE PROGRAM LINEAR).
(2) IF THE BACKGROUND IS NOT GIVEN AT 0 KELVIN, DOPPLER BROADEN THE RESONANCE (NOT BACKGROUND) CONTRIBUTION TO THE SAME TEMPERATURE AS THE BACKGROUND (E.G., USE PROGRAM SIGMA1).

ONCE THE RESONANCE AND BACKGROUND CONTRIBUTIONS HAVE BEEN MADE COMPATIBLE THEY CAN BE ADDED TOGETHER (E.G., USE PROGRAM MIXER).

THE RECONSTRUCTION OF THE RESONANCE CONTRIBUTION TO THE CROSS SECTION CAN BE QUITE EXPENSIVE (IN TERMS OF COMPUTER TIME). SINCE THE RECONSTRUCTION IS PERFORMED BEFORE THE BACKGROUND CROSS SECTIONS ARE READ, THE ABOVE CONVENTIONS HAVE BEEN ADOPTED IN ORDER TO AVOID LOSE OF COMPUTER TIME INVOLVED IN RECONSTRUCTING THE RESONANCE CONTRIBUTION.

## COMMON ENERGY GRID

THIS PROGRAM WILL RECONSTRUCT THE RESONANCE CONTRIBUTION TO THE TOTAL, ELASTIC, FISSION AND CAPTURE CROSS SECTIONS ALL ON THE SAME ENERGY GRID. EACH REACTION WILL THEN BE COMBINED WITH ITS BACKGROUND CROSS SECTION (IF ANY) AND OUTPUT WITHOUT ANY FURTHER THINNING. IF THERE ARE NO BACKGROUND CROSS SECTIONS, OR IF THE BACKGROUND CROSS SECTION FOR ALL FOUR REACTIONS ARE GIVEN ON A COMMON ENERGY GRID, THE OUTPUT FROM THIS PROGRAM WILL BE ON A COMMON ENERGY GRID FOR ALL FOUR REACTIONS.

## THERMAL ENERGY

IF THE RESONANCE REGION SPANS THERMAL ENERGY (0.0253 EV) THIS POINT IS ALWAYS INCLUDED IN THE COMMON ENERGY GRID USED FOR ALL REACTIONS AND WILL ALWAYS APPEAR IN THE OUTPUT DATA.

## SECTION SIZE

SINCE THIS PROGRAM USES A LOGICAL PAGING SYSTEM THERE IS NO LIMIT TO THE NUMBER OF POINTS IN ANY SECTION, E.G., THE TOTAL CROSS SECTION MAY BE REPRESENTED BY 200,000 DATA POINTS.

## SELECTION OF DATA

THE PROGRAM SELECTS MATERIALS TO BE PROCESSED BASED EITHER ON MAT (ENDF/B MAT NO.) OR ZA. THE PROGRAM ALLOWS UP TO 100 MAT OR ZA RANGES TO BE SPECIFIED. THE PROGRAM WILL ASSUME THAT THE ENDF/B TAPE IS IN EITHER MAT OR ZA ORDER, WHICHEVER CRITERIA IS USED TO SELECT MATERIALS, AND WILL TERMINATE WHEN A MAT OR ZA IS FOUND THAT IS ABOVE THE RANGE OF ALL REQUESTS.

## ALLOWABLE ERROR

THE RECONSTRUCTION OF LINEARLY INTERPOLABLE CROSS SECTIONS FROM RESONANCE PARAMETERS CANNOT BE PERFORMED EXACTLY. HOWEVER IT CAN BE PERFORMED TO VIRTUALLY ANY REQUIRED ACCURACY AND MOST

IMPORTANTLY CAN BE PERFORMED TO A TOLERANCE THAT IS SMALL COMPARED TO THE UNCERTAINTY IN THE CROSS SECTIONS THEMSELVES. AS SUCH THE CONVERSION OF CROSS SECTIONS TO LINEARLY INTERPOLABLE FORM CAN BE PERFORMED WITH ESSENTIALLY NO LOSS OF INFORMATION.

THE ALLOWABLE ERROR MAY BE ENERGY INDEPENDENT (CONSTANT) OR ENERGY DEPENDENT. THE ALLOWABLE ERROR IS DESCRIBED BY A TABULATED FUNCTION OF UP TO 20 (ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATION 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, E.G., 0.1 PER-CENT FROM 0 UP TO THE LOW EV RANGE AND A LESS STRINGENT TOLERANCE AT HIGHER ENERGIES.

### DEFAULT ALLOWABLE ERROR

IN ORDER TO INSURE CONVERENCE OF THE RESONANCE RECONSTRUCTION THE ALLOWABLE ERROR MUST BE POSITIVE. IF THE USER INPUTS AN ERROR FOR RESONANCE RECONSTRUCTION THAT IS NOT POSITIVE IT WILL BE SET TO THE DEFAULT VALUE (CURRENTLY 0.1 PER-CENT) AND INDICATED AS SUCH IN THE OUTPUT LISTING.

### INTERVAL HALVING ALGORITHM

THIS PROGRAM WILL START BY CALCULATING THE CROSS SECTIONS AT THE ENERGIES CORRESPONDING TO THE PEAK OF EACH RESONANCE, AS WELL AS A FIXED NUMBER OF HALF-WIDTHS ON EACH SIDE OF EACH RESONANCE. STARTING FROM THIS BASIC GRID OF POINTS THE PROGRAM WILL CONTINUE TO HALF EACH INTERVAL UNTIL THE CROSS SECTIONS FOR ALL REACTIONS AT THE CENTER OF THE INTERVAL CAN BE DEFINED BY LINEAR INTERPOLATION FROM THE ENDS OF THE INTERVAL TO WITHIN THE USER SPECIFIED ACCURACY CRITERIA.

### DISTANT RESONANCE TREATMENT

THE OPTION TO TREAT DISTANT RESONANCES, WHICH WAS AVAILABLE IN EARLIER VERSIONS OF THIS PROGRAM, IS NO LONGER AVAILABLE, BECAUSE IT WAS FOUND TO PRODUCE UNRELIABLE RESULTS. IN THIS VERSION OF THE PROGRAM ALL RESONANCES ARE TREATED EXACTLY.

## PROGRAM OPERATION

### EDIT MODE

IT IS SUGGESTED THAT BEFORE RUNNING THIS PROGRAM TO RECONSTRUCT CROSS SECTIONS FROM RESONANCE PARAMETERS (WHICH CAN BE QUITE EXPENSIVE) THE USER FIRST RUN THE PROGRAM IN THE EDIT MODE (SEE, DESCRIPTION OF INPUT PARAMETERS BELOW). IN THE EDIT MODE THE PROGRAM WILL READ, LIST AND EXTENSIVELY CHECK THE CONSISTENCY OF ALL RESONANCE PARAMETERS AND ENDF/B DEFINED RESONANCE FLAGS. THIS IS A VERY INEXPENSIVE MEANS OF CHECKING ALL DATA BEFORE INVESTING A LARGE AMOUNT OF MONEY IN RECONSTRUCTING CROSS SECTIONS. ANY AND ALL DIGNOSTICS RECEIVED FROM THE EDIT WILL SUGGEST HOW TO CORRECT THE EVALUATED DATA TO MAKE IT CONSISTENT BEFORE RECONSTRUCTING CROSS SECTIONS. IN ORDER TO OBTAIN MEANINGFUL RESULTS FROM THE RECONSTRUCTION ALL SUGGESTED CHANGES TO THE EVALUATION SHOULD BE PERFORMED BEFORE TRYING RECONSTRUCTION (OTHERWISE THE RESULT OF RECONSTRUCTION WILL NOT BE RELIABLE).

### RECONSTRUCTION MODE

FOR EACH REQUESTED MATERIAL Recent
--- Recent
IF SECTION MF=1, MT=451 IS PRESENT COMMENTS WILL BE ADD TO Recent
DOCUMENT THAT THE MATERIAL HAS BEEN PROCESSED. MF=1, MT=451 WILL Recent
ALSO BE USED TO DETERMINE THE VERSION OF THE ENDF/B FORMAT WHICH Recent
WILL ALLOW THE PROGRAM TO USE THE APPROPRIATE CONVENTIONS. Recent
Recent
ALL OF THE FILE 2 RESONANCE PARAMETERS ARE FIRST READ AND THE Recent
LINEARLY INTERPOLABLE CONTRIBUTION OF THE RESONANCE PARAMETERS Recent
TO THE TOTAL, ELASTIC, CAPTURE AND FISSION CROSS SECTIONS IS Recent
CALCULATED SIMULTANEOUSLY USING A COMMON ENERGY GRID FOR ALL Recent
FOUR REACTIONS. Recent
Recent
AFTER THE RESONANCE CONTRIBUTION HAS BEEN RECONSTRUCTED EACH OF Recent
THE FIVE REACTIONS (MT=1, 2, 18, 19, 102) IS CONSIDERED SEPARATELY Recent
FOR COMBINATION WILL THE BACKGROUND CROSS SECTION, IF ANY, AS Recent
DESCRIBED ABOVE. Recent
Recent
OUTPUT WILL INCLUDE THE ENTIRE EVALUATION, INCLUDING RESONANCES Recent
PARAMETERS WITH LRU MODIFIED (AS DESCRIBED ABOVE) TO INDICATE Recent
THAT THE RESONANCE CONTRIBUTION HAS ALREADY BEEN ADDED TO THE Recent
FILE 3 CROSS SECTIONS. Recent
Recent
THE CYCLE OF RECONSTRUCTING THE RESONANCE CONTRIBUTION AND ADDING Recent
THE BACKGROUND WILL BE REPEATED FOR EACH MATERIAL REQUESTED. Recent
Recent
PROCESS ONLY A PORTION OF RESONANCE REGION Recent
========== Recent
MODERN EVALUATIONS MAY BE EXTREMELY LARGE AND IT MAY NOT BE Recent
POSSIBLE TO PROCESS AN ENTIRE EVALUATION (I.E., ADD THE RESONANCE Recent
CONTRIBUTION) DURING A SINGLE COMPUTER RUN. Recent
Recent
ALSO IN THE CASE WHERE YOU ARE ONLY INTERESTED IN THE CROSS Recent
SECTIONS OVER A SMALL ENERGY RANGE, YOU MAY NOT WANT TO PROCESS Recent
AN ENTIRE EVALUATION, E.G., IF YOU ONLY WANT TO KNOW WHAT THE Recent
CROSS SECTIONS ARE NEAR THERMAL ENERGY, 0.0253 EV. Recent
Recent
IN ORDER TO ALLOW AN EVALUATION TO BE PROCESSED USING A NUMBER OF Recent
SHORTER COMPUTER RUNS AN OPTION HAS BEEN ADDED TO THIS PROGRAM TO Recent
ALLOW THE USER TO SPECIFY THE ENERGY RANGE TO BE PROCESSED. Recent
Recent
USING THIS OPTION YOU MAY START AT THE LOWEST ENERGY (ZERO UP TO Recent
SOME ENERGY) AND USE THE RESULTS OF THIS RUN AS INPUT TO THE Recent
NEXT RUN, WHERE YOU CAN SPECIFY THE NEXT ENERGY RANGE. THIS Recent
CYCLE CAN BE REPEATED UNTIL YOU HAVE PROCESSED THE ENTIRE Recent
EVALUATION. Recent
Recent
WARNING - THIS OPTION SHOULD BE USED WITH EXTREME CARE - THIS Recent
OPTION HAS BEEN RELUCTANTLY ADDED - RELUCTANTLY BECAUSE IT CAN Recent
BE EXTREMELY DANGEROUS TO USE THIS OPTION UNLESS YOU CAREFULLY Recent
CHECKED WHAT YOU ARE DOING. Recent
Recent
THE OPTION SHOULD ONLY BE USED AS FOLLOWS, Recent
1) YOU MUST PROCESS USING ENERGY RANGES STARTING AT LOW ENERGY Recent
AND WORKING YOUR WAY TOWARD HIGH ENERGY, E.G., Recent
0.0 TO 3.0+3 Recent
3.0+3 TO 10.0+3 Recent
10.0+3 TO 80.0+3, ETC. Recent
2) FOR THE LAST ENERGY RANGE THE LOWER ENERGY LIMIT MUST BE Recent
NON-ZERO (WHERE TO START) AND THE UPPER ENERGY LIMIT MUST Recent
BE ZERO (NO LIMIT) Recent
80.0+3 TO 0.0 Recent
Recent

IF YOU ARE ONLY INTERESTED IN THE CROSS SECTION OVER A NARROW ENERGY INTERVAL AND DO NOT INTENT TO MAKE ANY OTHER USE OF THE RESULTS, YOU CAN IGNORE THESE WARNINGS AND MERELY SPECIFY ANY ENERGY INTERVAL OVER WHICH YOU WISH CALCULATIONS TO BE PERFORMED. Recent

NORMALLY WHEN THIS PROGRAM PROCESSES AN EVALUATION IT WILL SET FLAGS IN THE EVALUATION TO PREVENT THE SAME RESONANCE CONTRIBUTION FROM BEING ADDED TO THE CROSS SECTION MORE THAN ONCE, SHOULD YOU USE THE OUTPUT FROM THIS PROGRAM AS INPUT TO THE PROGRAM. Recent

WHEN PROCESSING ONLY PORTIONS OF THE RESONANCE REGION THIS PROGRAM CANNOT SET THESE FLAGS TO PROTECT AGAINST ADDING THE RESONANCE CONTRIBUTION MORE THAN ONCE - WHICH MAKES USE OF THIS OPTION EXTREMELY DANGEROUS. Recent

ONLY YOU CAN CHECK TO MAKE SURE THAT YOU HAVE CORRECTLY INCLUDED EACH ENERGY RANGE ONLY ONCE - SEE THE COMMENT LINES AT THE END OF SECTION, MF=1, MT=451, FOR A COMPLETE RECORD OF EACH RUN USING THIS PROGRAM. THIS SECTION WILL CONTAIN LINES OF THE FORM Recent

********** PROGRAM RECENT (VERSION 2007-1) **********
ONLY PROCESS  0.00000+ 0 TO  3.00000+ 3 EV
********** PROGRAM RECENT (VERSION 2007-1) **********
ONLY PROCESS  3.00000+ 3 TO  1.00000+ 4 EV
********** PROGRAM RECENT (VERSION 2007-1) **********
ONLY PROCESS  1.00000+ 4 TO  8.00000+ 4 EV
********** PROGRAM RECENT (VERSION 2007-1) **********
ONLY PROCESS  8.00000+ 4 TO  2.00000+ 7 EV Recent

YOU SHOULD CHECK TO INSURE THAT THERE ARE NO OVERLAPPING ENERGY RANGES OR MISSING ENERGY RANGES. Recent

WHEN YOU INDICATE BY INPUT THAT YOU ARE ABOUT TO PROCESS THE LAST ENERGY RANGE (SEE ABOVE, LOWER ENERGY LIMIT = NON-ZERO, UPPER ENERGY LIMIT = ZERO), THIS PROGRAM WILL ASSUME THAT YOU HAVE NOW COMPLETED ALL PROCESSING - AND ONLY THEN WILL IT SET FLAGS IN THE EVALUATION TO PREVENT THE RESONANCE CONTRIBUTION FROM BEING ADDED MORE THAN ONCE. FOR THIS REASON YOU CANNOT PROCESS STARTING WITH ENERGY INTERVALS AT HIGH ENERGY AND WORKING TOWARD LOW ENERGY - YOU MUST START AT LOW ENERGY AND WORK TOWARD HIGH ENERGY. Recent

I/O FILES Recent
========== Recent
INPUT FILES Recent
----------- Recent
UNIT  DESCRIPTION Recent

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

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

SCRATCH FILES Recent

```
-------------                                                        Recent
UNIT  DESCRIPTION                                                    Recent
----  -----------                                                    Recent
 12   SCRATCH FILE FOR DATA RECONSTRUCTED FROM RESONANCE             Recent
      PARAMETERS (BINARY - 100200 WORDS/RECORD)                      Recent
 14   SCRATCH FILE FOR COMBINED FILE 2 AND 3 DATA                    Recent
      (BINARY - 40080 WORDS/RECORD)                                  Recent
                                                                     Recent
OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILEIO)                 Recent
================================================================     Recent
UNIT  FILE NAME                                                      Recent
----  ----------                                                     Recent
  2   RECENT.INP                                                     Recent
  3   RECENT.LST                                                     Recent
 10   ENDFB.IN                                                       Recent
 11   ENDFB.OUT                                                      Recent
 12   (SCRATCH)                                                      Recent
 14   (SCRATCH)                                                      Recent
                                                                     Recent
INPUT CARDS                                                          Recent
================================================================     Recent
LINE  COLS.  FORMAT  DESCRIPTION                                     Recent
----  -----  ------  -----------                                     Recent
  1    1-11    I11   RETRIEVAL CRITERIA (0=MAT, 1=ZA)               Recent
                     THIS OPTION DEFINED WHETHER COLUMNS 1-22 OF     Recent
                     SUBSEQUENT INPUT CARDS SHOULD BE INTERPRETED    Recent
                     TO BE MAT OR ZA RANGES.                         Recent
      12-22   E11.4  FILE 2 MINIMUM ABSOLUTE CROSS SECTION           Recent
                     (IF 1.0E-10 OR LESS IS INPUT THE PROGRAM        Recent
                     WILL USE 1.0E-10)                               Recent
      23-33    I11   TREATMENT OF REACTIONS FOR WHICH BACKGROUND     Recent
                     CROSS SECTION IS NOT GIVEN.                     Recent
                     = 0 - IGNOR (I.E. NO OUTPUT)                    Recent
                     = 1 - OUTPUT RESONANCE CONTRIBUTION.            Recent
                     THIS OPTION IS USEFUL WITH PARTIAL EVALUATION   Recent
                     (E.G. ENDF/B-V DOSIMETRY LIBRARY) WHERE ONLY    Recent
                     ONE OR MORE OF THE REACTIONS ARE OF ACTUAL      Recent
                     INTEREST.                                       Recent
                     WARNING...THE USE OF THIS FIELD HAS BEEN        Recent
                     CHANGED. THIS FIELD WAS PREVIOUSLY USED TO      Recent
                     DEFINE THE PRECISION OF THE CALCULATION AND     Recent
                     OUTPUT. THE FORMER DEFINITION OF THIS FIELD     Recent
                     WAS...                                          Recent
                     MINIMUM ENERGY SPACING FLAG                     Recent
                     = 0 - 6 DIGIT MINIMUM ENERGY SPACING.           Recent
                           STANDARD 6 DIGIT E11.4 OUTPUT.            Recent
                     = 1 - 9 DIGIT MINIMUM ENERGY SPACING.           Recent
                           STANDARD 6 DIGIT E11.4 OUTPUT.            Recent
                     = 2 - 9 DIGIT MINIMUM ENERGY SPACING.           Recent
                           VARIABLE 9 DIGIT F FORMAT OUTPUT.         Recent
                     FROM EXPERIENCE IT HAS BEEN FOUND THAT          Recent
                     FAILURE TO SET THIS OPTION TO 2 CAN RESULT      Recent
                     IN LARGE ERRORS IN THE FINAL DATA. THEREFORE    Recent
                     INTERNALLY THIS OPTION IS SET TO 2.             Recent
      34-44    I11   OPERATING MODE                                  Recent
                     = 0 - CACULATE. MINIMUM OUTPUT LISTING          Recent
                     = 1 - CACULATE. LIST ALL RESONANCE PARAMETERS   Recent
                     = 2 - EDIT MODE. NO CALCULATION. LIST ALL       Recent
                           RESONANCE PARAMETERS.                     Recent
                     NOTE, THE EDIT MODE (=2) IS THE SUGGESTED       Recent
                     MODE TO FIRST TEST THE CONSISTENCY OF THE       Recent
                     EVALUATED DATA, BEFORE RECONSTRUCTING CROSS     Recent
                     SECTIONS (SEE, COMMENTS ABOVE).                 Recent
```

| | | | | |
|---|---|---|---|---|
| | 45-55 | I11 | NEGATIVE CROSS SECTIOIN TREATMENT | Recent |
| | | | = 0 - O.K. - NO CHANGE | Recent |
| | | | = 1 - SET = 0 | Recent |
| | 56-66 | I11 | MONITOR MODE SELECTOR | Recent |
| | | | = 0 - NORMAL OPERATION | Recent |
| | | | = 1 - MONITOR PROGRESS OF RECONSTRUCTION OF | Recent |
| | | | FILE 2 DATA AND COMBINING FILE 2 AND | Recent |
| | | | FILE 3 DATA. EACH TIME A PAGE OF DATA | Recent |
| | | | POINTS IS WRITTEN TO A SCRATCH FILE | Recent |
| | | | PRINT OUT THE TOTAL NUMBER OF POINTS | Recent |
| | | | ON SCRATCH AND THE LOWER AND UPPER | Recent |
| | | | ENERGY LIMITS OF THE PAGE (THIS OPTION | Recent |
| | | | MAY BE USED IN ORDER TO MONITOR THE | Recent |
| | | | EXECUTION SPEED OF LONG RUNNING JOBS). | Recent |
| 2 | 1-60 | A60 | ENDF/B INPUT DATA FILENAME | Recent |
| | | | (STANDARD OPTION = ENDFB.IN) | Recent |
| 3 | 1-60 | A60 | ENDF/B OUTPUT DATA FILENAME | Recent |
| | | | (STANDARD OPTION = ENDFB.OUT) | Recent |
| 4-N | 1-11 | I11 | MINIMUM MAT OR ZA (SEE COLS. 1-11, LINE 1) | Recent |
| | 12-22 | I11 | MAXIMUM MAT OR ZA (SEE COLS. 1-11, LINE 1) | Recent |
| | | | UP TO 100 MAT OR ZA RANGES MAY BE SPECIFIED, | Recent |
| | | | ONE RANGE PER LINE. THE LIST IS TERMINATED | Recent |
| | | | BY A BLANK LINE. IF THE THE UPPER LIMIT OF | Recent |
| | | | ANY REQUEST IS LESS THAN THE LOWER LIMIT THE | Recent |
| | | | UPPER LIMIT WILL BE SET EQUAL TO THE LOWER | Recent |
| | | | LIMIT. IF THE FIRST REQUEST LINE IS BLANK IT | Recent |
| | | | WILL TERMINATE THE REQUEST LIST AND CAUSE ALL | Recent |
| | | | DATA TO BE RETRIEVED (SEE EXAMPLE INPUT). | Recent |
| | 23-33 | E11.4 | LOWER ENERGY LIMIT FOR PROCESSING. | Recent |
| | 34-44 | E11.4 | UPPER ENERGY LIMIT FOR PROCESSING. | Recent |
| | | | *THE LOWER AND UPPER ENERGY LIMITS MUST BE | Recent |
| | | | ZERO, OR BLANK, UNLESS YOU WISH TO ONLY | Recent |
| | | | PROCESS A PORTION OF RESONANCE REGIONS. | Recent |
| | | | *THESE ENERGY LIMITS ARE ONLY READ FROM THE | Recent |
| | | | FIRST MAT/ZA REQUEST LINE | Recent |
| | | | *IF BOTH ARE ZERO (OR BLANK) THE ENTIRE | Recent |
| | | | RESONANCE REGION FOR EACH MATERIAL WILL BE | Recent |
| | | | PROCESSED | Recent |
| | | | *IF LIMITS ARE INPUT ONLY THAT PORTION OF THE | Recent |
| | | | RESONANCE REGION FOR EACH MATERIAL WHICH | Recent |
| | | | LIES BETWEEN THESE LIMITS WILL BE PROCESSED | Recent |
| | | | *SEE INSTRUCTIONS ABOVE BEFORE USING THIS | Recent |
| | | | OPTION. | Recent |
| VARY | 1-11 | E11.4 | ENERGY FOR FILE 2 ERROR LAW ( SEE ) | Recent |
| | 12-22 | E11.4 | ERROR FOR FILE 2 ERROR LAW (COMMENTS) | Recent |
| | | | ( BELOW ) | Recent |
| | | | | Recent |

NOTE, THIS VERSION OF THE PROGRAM DOES NOT THIN THE COMBINED FILE FILE 2 + 3 DATA. AS SUCH THE ERROR LAW FOR COMBINING FILE 2 + 3 WHICH WAS REQUIRED IN EARLIER VERSIONS OF THIS CODE ARE NO LONGER REQUIRED.

THE FILE 2 ERROR LAW MAY BE ENERGY INDEPENDENT (DEFINED BY A SINGLE ERROR) OR ENERGY DEPENDENT (DEFINED BY UP TO 20 ENERGY, ERROR PAIRS). FOR THE ENERGY DEPENDENT CASE LINEAR INTERPOLATION WILL BE USED TO DEFINE THE ERROR AT ENERGIES BETWEEN THOSE AT WHICH THE ERROR IS TABULATED. THE ERROR LAW IS TERMINATED BY A BLANK LINE. IF ONLY ONE ENERGY, ERROR PAIR IS GIVEN THE LAW WILL BE CONSIDERED TO BE ENERGY INDEPENDENT. IF MORE THAN ONE PAIR IS GIVEN IT BE CONSIDERED TO BE ENERGY DEPENDENT (NOTE, THAT FOR A CONSTANT ERROR THE ENERGY INDEPENDENT FORM WILL RUN FASTER. HOWEVER, FOR SPECIFIC APPLICATIONS AN ENERGY DEPENDENT ERROR MAY BY USED TO MAKE THE PROGRAM RUN CONSIDERABLE FASTER).

ALL ENERGIES MUST BE IN ASCENDING ENERGY ORDER. FOR CONVERGENCE OF THE FILE 2 RECONSTRUCTION ALGORITHM ALL THE ERRORS MUST BE POSITIVE. IF ERROR IS NOT POSITIVE IT WILL BE SET EQUAL TO THE STANDARD OPTION (CURRENTLY 0.001, CORRRESPONDING TO 0.1 PER-CENT). IF THE FIRST LINE OF THE ERROR LAW IS BLANK IT WILL TERMINATE THE ERROR LAW AND THE ERROR WILL BE TREATED AS ENERGY INDEPENDENT, EQUAL TO THE STANDARD OPTION (CURRENTLY, 0.1 PER-CENT). SEE, EXAMPLE INPUT 4.

EXAMPLE INPUT NO. 1

CONSIDER ALL URANIUM ISOTOPES AND TH-232. CONSIDER CROSS SECTIONS WHICH ARE LARGER THAN 1.0E-8 BARNS IN ABSOLUTE VALUE. ONLY OUTPUT REACTIONS FOR WHICH A BACKGROUND IS GIVEN. LIST ALL PARAMETERS AND CALCULATE CROSS SECTIONS. MONITOR THE EXECUTION PROGRESS OF THE PROGRAM. BETWEEN 0 AND 100 EV USE 0.1 PER-CENT ACCURACY. BETWEEN 100 EV AND 1 KEV VARY THE ACCURACY FROM 0.1 TO 1 PER-CENT. ABOVE 1 KEV USE 1 PER-CENT ACCURACY.

EXPLICITLY SPECIFY THE STANDARD FILENAMES.

THE FOLLOWING 11 INPUT CARDS ARE REQUIRED.

```
        1 1.00000-08          0          1          0         1
ENDFB.IN
ENDFB.OUT
     92000      92999
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232)
                            (END REQUEST LIST)
0.00000+ 0 1.00000-03
1.00000+02 1.00000-03
1.00000+03 1.00000-02
1.00000+09 1.00000-02
                            (END FILE 2 ERROR LAW)
```

EXAMPLE INPUT NO. 2

CONSIDER ALL URANIUM ISOTOPES AND TH-232. CONSIDER CROSS SECTIONS WHICH ARE LARGER THAN 1.0E-8 BARNS IN ABSOLUTE VALUE. ONLY OUTPUT REACTIONS FOR WHICH A BACKGROUND IS GIVEN. CROSS SECTIONS WILL BE CALCULATED, BUT PARAMETERS WILL NOT BE LISTED. THE PROGRESS OF THE PROGRAM WILL NOT BE MONITORED. USE 0.1 PER-CENT ACCURACY FOR ALL ENERGIES. SINCE 0.1 PER-CENT IS THE STANDARD OPTION FOR THE ERROR LAW THE FIRST ERROR LAW LINE MAY BE LEFT BLANK.

LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL THEN USE THE STANDARD FILENAMES.

THE FOLLOWING 7 INPUT CARDS ARE REQUIRED.

```
        1 1.00000-08          0          0          0         0


     92000      92999
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232)
                            (END REQUEST LIST)
                            (USE STANDARD OPTION FOR ERROR LAW)
```

EXAMPLE INPUT NO. 3

THE SAME AS EXAMPLE INPUT NO. 2, ONLY IN THIS CASE ONLY CALCULATE CROSS SECTIONS OVER THE ENERGY RANGE 0.01 TO 0.1 EV - ACROSS THE

```
    THERMAL ENERGY RANGE. NOTE, THE ONLY DIFFERENCE BETWEEN THE INPUT  Recent
    PARAMETERS IN THIS CASE AND IN EXAMPLE NO. 2, IS THAT ON THE       Recent
    SECOND INPUT LINE WE HAVE ADDED THE ENERGY RANGE 0.01 TO 0.1 EV.   Recent
    USE \PREPRO94\LINEAR\ENDFB.OUT AS INPUT AND ENDFB.OUT AS OUTPUT -  Recent
    SINCE ENDFB.OUT IS THE STANDARD OUTPUT FILENAME THE NAME CAN BE    Recent
    EITHER INCLUDED IN THE INPUT OR LEFT BLANK.                        Recent
                                                                       Recent
    THE FOLLOWING 7 INPUT CARDS ARE REQUIRED.                          Recent
                                                                       Recent
         1 1.00000-08          0          0          0         0       Recent
\PREPRO94\LINEAR\ENDFB.OUT                                             Recent
ENDFB.OUT                                                              Recent
     92000      92999 1.00000- 2 1.00000- 1                            Recent
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232)   Recent
                            (END REQUEST LIST)                         Recent
                            (USE STANDARD OPTION FOR ERROR LAW)        Recent
                                                                       Recent
    EXAMPLE INPUT NO. 4                                                Recent
    -------------------                                                Recent
    RECONSTRUCT ALL DATA. OUTPUT ALL REACTIONS, REGARDING OF WHETHER   Recent
    OR NOT THERE IS A BACKGROUND CROSS SECTION. DO NOT MONITOR THE     Recent
    PROGRESS OF THE PROGRAM. RECONSTRUCT CROSS SECTIONS TO 1 PER-CENT  Recent
    ACCURACY. USE \ENDFB6\LINEAR\ZA092238 AS INPUT AND                 Recent
    \ENDFB6\RECENT\ZA092238 AS OUTPUT.                                 Recent
                                                                       Recent
    THE FOLLOWING 6 INPUT CARDS ARE REQUIRED.                          Recent
                                                                       Recent
         0 0.0                1          0          0         0       Recent
\ENDFB6\ZA092238                                                       Recent
\ENDFB6\RECENT\ZA092238                                                Recent
                       (RETRIEVE ALL DATA, END REQUEST LIST)           Recent
           1.00000- 2                                                  Recent
                       (END FILE 2 ERROR LAW)                          Recent
                                                                       Recent
    EXAMPLE INPUT NO. 5                                                Recent
    -------------------                                                Recent
    RECONSTRUCT ALL DATA. ONLY OUTPUT REACTIONS FOR WHICH A BACKGROUND Recent
    CROSS SECTION IS GIVEN. DO NOT MONITOR THE PROGRESS OF THE PROGRAM Recent
    RECONSTRUCT CROSS SECTIONS TO 0.1 PER-CENT ACCURACY. USE ENDFB.IN  Recent
    AS INPUT AND ENDFB.OUT AS OUTPUT.                                  Recent
                                                                       Recent
    THIS CORRESPONDS TO USING ALL OF THE STANDARD OPTONS BUILT-IN TO   Recent
    THE PROGRAM AND ALL INPUT CARDS MAY BE BLANK.                      Recent
                                                                       Recent
    IN THIS CASE THE FOLLOWING 5 INPUT CARDS ARE REQUIRED.             Recent
    (ZEROES ARE INDICATED ON THE FIRST LINE, BELOW, ONLY TO INDICATE   Recent
    WHERE THE LINE IS. THE ACTUAL INPUT LINE CAN BE COMPLETELY BLANK). Recent
                                                                       Recent
         0 0.0                0          0          0         0       Recent
                       (USE STANDARD INPUT FILENAME = ENDFB.IN)        Recent
                       (USE STANDARD OUTPUT FILENAME = ENDFB.OUT)      Recent
                       (RETRIEVE ALL DATA, END REQUEST LIST)           Recent
                       (0.1 ERROR, END FILE 2 ERROR LAW)               Recent
                                                                       Recent
====================================================================== Recent
```