======================================================================= Sixpak

Sixpak

PROGRAM SIXPAK Sixpak

============== Sixpak

VERSION 92-1 (JANUARY 1992) Sixpak

VERSION 92-2 (FEBRUARY 1992)\*INCREASED CORE ALLOCATION TO Sixpak

ACCOMMODATE JEF AND EFF EVALUATIONS. Sixpak

VERSION 92-3 (APRIL 1992) \*ADDED ADDITIONAL DATA TESTS. Sixpak

VERSION 92-4 (SEPT. 1992) \*CORRECTED KALBACH-MANN CALCULATIONS. Sixpak

\*FOR PHOTON PRODUCTION OUTPUT MF=12 Sixpak

(MULTIPLICITY), MF=14 (ISOTROPIC Sixpak

ANGULAR DISTRIBUTIONS) AND MF=15 Sixpak

(SPECTRA) - PREVIOUSLY ONLY MF=15. Sixpak

\*FIRST ORDER CORRECTIONS TRANSFORMING Sixpak

CENTER-OF-MASS SPECTRA TO LAB SYSTEM Sixpak

FOR OUTPUT IN MF=5 Sixpak

\*CORRECTED ISOTROPIC ANGULAR Sixpak

DISTRIBUTION FLAG (LI) Sixpak

VERSION 94-1 (JANUARY 1994) \*VARIABLE ENDF/B INPUT DATA FILENAME Sixpak

TO ALLOW ACCESS TO FILE STRUCTURES Sixpak

(WARNING - INPUT PARAMETER FORMAT Sixpak

HAS BEEN CHANGED) Sixpak

\*CLOSE ALL FILES BEFORE TERMINATING Sixpak

(SEE, SUBROUTINE ENDIT) Sixpak

\*INCREASED MAXIMUM TABLE SIZE FROM Sixpak

2000 TO 6000. Sixpak

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

\*IMPROVED COMPUTER INDEPENDENCE Sixpak

\*ALL DOUBLE PRECISION Sixpak

\*ON SCREEN OUTPUT Sixpak

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

\*IMPROVED OUTPUT PRECISION Sixpak

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

POINT READ FOR MORE DIGITS Sixpak

\*UPDATED TEST FOR ENDF/B FORMAT Sixpak

VERSION BASED ON RECENT FORMAT CHANGE Sixpak

\*GENERAL IMPROVEMENTS BASED ON Sixpak

USER FEEDBACK Sixpak

VERSION 99-2 (JUNE 1999) \*ASSUME ENDF/B-VI, NOT V, IF MISSING Sixpak

MF=1, MT-451. Sixpak

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

USER FEEDBACK Sixpak

VERS. 2002-1 (JANUARY 2002) \*CORRECTED ANGULAR DISTRIBUTION (MF=4) Sixpak

OUTPUT TO INSURE USED FIELDS ARE 0 Sixpak

(MAY 2002) \*OPTIONAL INPUT PARAMETERS Sixpak

(NOV. 2002) \*EXTENDED TO ALLOW CHARGED PARTICLE Sixpak

ANGULAR DISTRIBUTION IN MF=4 - Sixpak

WARNING - STRICTLY SPEAKING THIS IS Sixpak

NOT LEGAL, SINCE MF=4 IS SUPPOSED TO Sixpak

BE USED ONLY FOR NEUTRON ANGULAR Sixpak

DISTRIBUTIONS - BUT WHERE MT MAKES Sixpak

IT OBVIOUS THAT THE OUTGOING PARTICLE Sixpak

IS NOT A NEUTRON HOPEFULLY IT WILL Sixpak

NOT CAUSE A PROBLEM IF MF=4 IS USED Sixpak

FOR CHARGED PARTICLES. Sixpak

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

\*INCREASED MAXIMUM TABLE SIZE FROM Sixpak

6,000 TO 12,000. Sixpak

\*ADDED DUMMY A FOR ELEMENTS Sixpak

\*CORRECTED OUTPUT INTERPOLATON LAWS Sixpak

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

\*INCREASED MAXIMUM TABLE SIZE FROM Sixpak

12,000 TO 120,000. Sixpak

VERS. 2007-2 (DEC. 2007) \*72 CHARACTER FILE NAMES. Sixpak

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

VERS. 2011-1 (May 2011) \*Added MF/MT=9/5 yield output starting Sixpak

from MF/MT=6/5 distributions. Sixpak

\*Increased maximum Legendre order from Sixpak

30 to 1,000 - WARNING - using more Sixpak

than 30 results in NONSENSE = NOISE!! Sixpak

VERS. 2012-1 (Oct. 2012) \*Increased max. point count to 500,000 Sixpak

\*Added CODENAME Sixpak

\*32 and 64 bit Compatible Sixpak

\*Added ERROR stop Sixpak

\*For photons, combine discrete and Sixpak

continuum into tabulated increasing Sixpak

energy order. Sixpak

\*Check energy output order increasing. Sixpak

Print WARNING if not increasing - do Sixpak

not STOP- stopping would prevent ALL Sixpak

output - the user may not be at all Sixpak

interested in the BAD data, but may Sixpak

be interested in other output data Sixpak

that is o.k. Sixpak

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

\*Replaced ALL 3 way IF Statements. Sixpak

\*Deleted unused coding. Sixpak

Sixpak

OWNED, MAINTAINED AND DISTRIBUTED BY Sixpak

------------------------------------ Sixpak

THE NUCLEAR DATA SECTION Sixpak

INTERNATIONAL ATOMIC ENERGY AGENCY Sixpak

P.O. BOX 100 Sixpak

A-1400, VIENNA, AUSTRIA Sixpak

EUROPE Sixpak

Sixpak

ORIGINALLY WRITTEN BY Sixpak

------------------------------------ Sixpak

Dermott E. Cullen Sixpak

Sixpak

PRESENT CONTACT INFORMATION Sixpak

--------------------------- Sixpak

Dermott E. Cullen Sixpak

1466 Hudson Way Sixpak

Livermore, CA 94550 Sixpak

U.S.A. Sixpak

Telephone 925-443-1911 Sixpak

E. Mail RedCullen1@Comcast.net Sixpak

Website http://home.comcast.net/~redcullen1 Sixpak

Sixpak

COLLABORATION Sixpak

================================================================== Sixpak

DEVELOPED IN COLLABORATION WITH, Sixpak

Sixpak

\*THE NATIONAL NUCLEAR DATA CENTER, BROOKHAVEN NATIONAL LAB Sixpak

Sixpak

\*THE NUCLEAR DATA SECTION, IAEA, VIENNA, AUSTRIA Sixpak

Sixpak

\*CENTRO TECNICO AEROSPACIAL, SAO JOSE DOS CAMPOS, BRAZIL Sixpak

Sixpak

AS A PART OF AN INTERNATIONAL PROJECT ON THE EXCHANGE OF Sixpak

NUCLEAR DATA Sixpak

Sixpak

ACKNOWLEDGEMENT (VERSION 92-1) Sixpak

================================================================== Sixpak

THE AUTHOR THANKS SOL PEARLSTEIN (BROOKHAVEN NATIONAL LAB) FOR Sixpak

SIGNIFICANTLY CONTRIBUTING TOWARD IMPROVING THE ACCURACY AND Sixpak

COMPUTER INDEPENDENCE OF THIS CODE - THANKS, SOL Sixpak

Sixpak

ACKNOWLEDGEMENT (VERSION 92-4) Sixpak

================================================================== Sixpak

THE AUTHOR THANKS BOB MACFARLANE (LOS ALAMOS) FOR SUGGESTING HOW Sixpak

TO PROPERLY OUTPUT THE PHOTON PRODUCTION DATA TO PUT IT INTO Sixpak

EXACTLY THE FORM NEEDED FOR USE IN PROCESSING CODES. Sixpak

Sixpak

THE AUTHOR THANKS CHRIS DEAN (WINFRITH) FOR POINTING OUT ERRORS Sixpak

IN THE EARLIER TREATMENT OF THE KALBACH-MANN FORMALISM AND IN Sixpak

THE DEFINITION OF THE ISOTROPIC ANGULAR DISTRIBUTION FLAG (LI). Sixpak

Sixpak

AUTHORS MESSAGE Sixpak

================================================================== Sixpak

THE COMMENTS BELOW SHOULD BE CONSIDERED THE LATEST DOCUMENTATION Sixpak

INCLUDING ALL RECENT IMPROVEMENTS. PLEASE READ ALL OF THESE Sixpak

COMMENTS BEFORE IMPLEMENTING AND USING THESE CODES. Sixpak

Sixpak

AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER Sixpak

INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE Sixpak

OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT Sixpak

IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY Sixpak

COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO Sixpak

IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF Sixpak

THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR Sixpak

COMPUTER. Sixpak

Sixpak

PURPOSE Sixpak

================================================================== Sixpak

1) CHECK ALL DOUBLE-DIFFERENTIAL DATA (MF=6) Sixpak

Sixpak

2) OUTPUT EQUIVALENT MF = 4, 5, 12, 14 AND 15 DATA. Sixpak

Sixpak

DATA CHECKING Sixpak

================================================================== Sixpak

ALL OF THE ENDF/B-VI MF=6 DATA IS CHECKED - FOR DETAILS SEE BELOW. Sixpak

Sixpak

THE MF=6 DATA IS NOT CORRECTED AND OUTPUT IN THE ENDF/B FORMAT. Sixpak

IT IS MERELY CHECKED. IF ERRORS ARE FOUND IT IS UP TO THE USER Sixpak

TO TAKE CORRECTIVE ACTION ON THE MF=6 DATA. Sixpak

Sixpak

IN CONTRAST WHEN PROBLEMS ARE FOUND IN DATA WHICH WILL BE OUTPUT Sixpak

IN THE ENDF/B FORMAT (MF=4, 5, 12, 14 AND 15), WHENEVER POSSIBLE Sixpak

CORRECTIVE ACTION WILL BE TAKEN. Sixpak

Sixpak

FURTHER CHECKS AND CORRECTIONS Sixpak

================================================================== Sixpak

ONCE THE DATA HAS BEEN OUTPUT IN MF = 4, 5, 12, 14 AND 15 FORMATS Sixpak

FURTHER CORRECTIVE ACTION CAN BE TAKEN AS FOLLOWS, Sixpak

Sixpak

PROGRAM LEGEND Sixpak

============== Sixpak

CAN BE USED TO CORRECT ANGULAR DISTRIBUTIONS WHICH ARE NEGATIVE, Sixpak

TO CONVERT FROM LEGENDRE COEFFICIENTS TO TABULATED ANGULAR Sixpak

DISTRIBUTIONS AND GENERALLY PERFORM MORE EXTENSIVE TESTS OF Sixpak

ALL MF=4 DATA. Sixpak

Sixpak

PROGRAM EVALPLOT Sixpak

================ Sixpak

VERSION 92-1 AND LATER VERSIONS CAN PLOT ALL OF THE MF=4, 5 AND 15 Sixpak

DATA OUTPUT BY THIS CODE. EARLIER VERSIONS CAN PLOT MF=4 AND 5. Sixpak

GRAPHICS IS AN EXCELLENT WAY TO CHECK THIS DATA. Sixpak

Sixpak

PROGRAM PLOTTAB Sixpak

=============== Sixpak

THIS IS A GENERAL PLOTTING PROGRAM AND THERE IS AN INTERFACE IN Sixpak

THIS CODE TO PRODUCE OUTPUT FOR ANY MF=6 DATA IN THE PLOTTAB Sixpak

INPUT FORMAT. THIS PROGRAM CAN BE USED TO CHECK ALL OF THE MF=6 Sixpak

DATA AS WELL AS THE EQUIVALENT MF=4, 5, 12, 14 AND 15 DATA - AS Sixpak

WELL AS COMPARING THE ORIGINAL MF=6 AND EQUIVALENT DATA. Sixpak

Sixpak

DATA OUTPUT Sixpak

================================================================== Sixpak

THE ENDF/B MF=4, 5, 12, 14 AND 15 FORMATS ONLY ALLOW FOR NEUTRONS Sixpak

INCIDENTS Sixpak

Sixpak

THE ENDF/B MF=4 AND 5 FORMATS ONLY ALLOW FOR NEUTRONS OUTGOING. Sixpak

Sixpak

THE ENDF/B MF=12, 14 AND 15 ONLY ALLOWS FOR PHOTONS OUTGOING. Sixpak

Sixpak

THESE ARE THE ONLY COMBINATIONS OF DATA OUTPUT BY THIS CODE. Sixpak

Sixpak

ALL OTHER COMBINATIONS OF INCIDENT AND OUTGOING PARTICLES ARE Sixpak

CHECKED, BUT THE RESULTS CANNOT BE OUTPUT IN THE ENDF/B FORMAT. Sixpak

HOWEVER, USING THE PLOTTAB INTERFACE BUILT INTO THIS CODE THIS Sixpak

DATA CAN, AND HAS BEEN, OUTPUT AND CHECKED. Sixpak

Sixpak

THE NEUTRON DATA IN MF=4 CAN BE IN THE FORM OF EITHER TABULATED Sixpak

ANGULAR DISTRIBUTIONS OR LEGENDRE COEFFICIENTS. Sixpak

Sixpak

THE NEUTRON (MF=5) OR PHOTON (MF=15) SPECTRA ARE BOTH IN EXACTLY Sixpak

THE SAME FORMAT = ARBITRARY TABULATED FUNCTIONS - ENDF/B OPTION Sixpak

LF=1. Sixpak

Sixpak

ENDF/B DATA OUTPUT ORDER Sixpak

================================================================== Sixpak

ENDF/B DATA IS OUTPUT IN ASCENDING MAT, MF, MT ORDER. IN ORDER TO Sixpak

ALLOW THIS PROGRAM TO PRODUCE ALL OUTPUT IN A SINGLE PASS THROUGH Sixpak

THE MF=6 DATA, OUTPUT FOR EACH (MAT, MT) IS OUTPUT TO SEPERATE Sixpak

FILES FOR MF=4, 5, 12, 14 AND 15. Sixpak

Sixpak

FOR SUBSEQUENT USE THE ENDF/B FORMATTED DATA OUTPUT BY THIS CODE Sixpak

CAN BE MERGED TOGETHER USING PROGRAM MERGER (CONTAIN THE AUTHOR Sixpak

OF THIS CODE FOR A COPY OF MERGER), E.G., MERGE MF=12, 14 AND 15 Sixpak

DATA IN ORDER TO THEN CALCULATE PHOTON PRODUCTION DATA OR MF=4 Sixpak

AND 5 CAN BE MERGED TOGETHER TO CALCULATE NEUTRON TRANSFER - OR Sixpak

ALL OF THEM CAN BE MERGED TOGETHER TO PERFORM NEUTRON AND PHOTON Sixpak

CALCULATIONS. Sixpak

Sixpak

CORRELATED (MF=6) VS. UNCORRELATED (MF=4 AND 5) DATA Sixpak

================================================================== Sixpak

THE ENDF/B DOUBLE DIFFERENTAL = CORRELATED - DATA IN MF=6 Sixpak

REPRESENTS DATA IN THE FORM, Sixpak

Sixpak

F(E,EP,COS) = SIG(E)\*Y(E)\*G0(E,EP)\*F(E,EP,COS) Sixpak

Sixpak

SIG(E) = MF=3 CROSS SECTIONS Sixpak

Y(E) = YIELD (MULTIPLICITY) Sixpak

G0(E,EP) = ENERGY SPECTRUM Sixpak

F(E,EP,COS) = ANGULAR DISTRIBUTION Sixpak

Sixpak

IN A SITUATION WHERE YOU HAVE MONOENERGETIC AND MONODIRECTIONAL Sixpak

NEUTRONS INCIDENT YOU WILL BE ABLE TO OBSERVE CORRELATION EFFECTS Sixpak

IN THE NEUTRON SPECTRUM AND ANGULAR DISTRIBUTION. Sixpak

Sixpak

EVEN IN SITUATIONS WHERE YOU HAVE A NARROW SPECTRUM OF NEUTRONS Sixpak

THAT ARE HIGHLY DIRECTIONALLY ORIENTED YOU MAY BE ABLE TO OBSERVE Sixpak

THESE CORRELATION EFFECTS, E.G., A NARROW 14 MEV FUSION SOURCE Sixpak

INCIDENT ON THE FIRST WALL OF A CTR DEVICE. Sixpak

Sixpak

FOR SUCH SITUATIONS USE OF THE CORRELATED (MF=6) DATA IS REQUIRED Sixpak

IN CALCULATIONS. Sixpak

Sixpak

HOWEVER, IN MANY APPLICATIONS WHERE THERE IS A BROAD SPECTRUM OF Sixpak

NEUTRONS AND THE NEUTRON FLUX IS NOT HIGHLY DIRECTIONALLY Sixpak

ORIENTED, THE NEUTRON MULTIPLICATION, SPECTRUM AND ORIENTATION Sixpak

CAN BE FAIRLY ACCURATELY CALCULATED WITHOUT CONSIDERING Sixpak

CORRELATION EFFECTS. Sixpak

Sixpak

THE UNCORRELATED DATA PRODUCED BY THIS CODE REPLACES THE Sixpak

CORRELATED DATA, Sixpak

Sixpak

F(E,EP,COS) = SIG(E)\*Y(E)\*G0(E,EP)\*F(E,EP,COS) Sixpak

Sixpak

BY THE UNCORRELATED DATA, Sixpak

Sixpak

F(E,EP,COS) = SIG(E)\*Y(E)\*G0(E,EP)\*F0(E,COS) Sixpak

Sixpak

BY INTEGRATING G0(E,EP)\*F(E,EP,COS) OVER SECONDARY ENERGY (EP) Sixpak

TO DEFINE AN AVERAGE ANGULAR DISTRIBUTION, F0(E,COS). Sixpak

Sixpak

WHAT IS LOST IN THIS PROCESS IS THE CORRELATION BETWEEN EP AND COS Sixpak

SO THAT IN A TRANSPORT CALCULATION ALL MOMENTS OF THE FLUX WILL Sixpak

HAVE THE SAME SPECTRUM, G0(E,EP) AND EACH WILL BE EFFECTED BY THE Sixpak

AVERAGE ANGULAR DISTRIBUTION. Sixpak

Sixpak

FOR APPLICATIONS TO HIGH ENERGY FUSION APPLICATIONS CORRELATED Sixpak

DATA SHOULD BE USED. HOWEVER, FOR LOWER ENERGY APPLICATIONS, Sixpak

SUCH AS FISSION REACTORS, IT SHOULD BE ADEQUATE TO USE THE Sixpak

UNCORRELATED DATA - IN THIS CASE THE MOST IMPORTANT EFFECT Sixpak

WILL BE THE OVERALL NEUTRON MULTIPLICATION AND SPECTRUM. Sixpak

Sixpak

AN IMPORTANT CONSIDERATION IN DESIGNING THIS PROGRAM IS THAT Sixpak

MANY COMPUTER CODES - DATA PROCESSING AND TRANSPORT CODES - Sixpak

CANNOT USE THE CORRELATED (MF=6) DATA - NOR ARE THEY INTENDED Sixpak

FOR HIGH ENERGY USE. FOR THESE CODES THE UNCORRELATED DATA Sixpak

PRODUCED BY THIS CODE SHOULD BE ADEQUATE TO MEET THEIR NEEDS. Sixpak

Sixpak

WARNING - IT CANNOT BE STRESSED ENOUGH THAT THE OUTPUT OF THIS Sixpak

CODE SHOULD ONLY BE USED FOR LOW ENERGY APPLICATIONS - FAILURE Sixpak

TO HEED THIS WARNING CAN LEAD TO COMPLETELY UNRELIABLE RESULTS. Sixpak

Sixpak

ENDF/B FORMAT Sixpak

================================================================== Sixpak

THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS Sixpak

OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION Sixpak

OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV, V OR VI FORMAT). Sixpak

Sixpak

IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B Sixpak

FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS Sixpak

ASSUMED THAT THE MAT, MF AND MT ON EACH LINE IS CORRECT. SEQUENCE Sixpak

NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE Sixpak

CORRECTLY OUTPUT ON ALL LINES. THE FORMAT OF SECTION MF=1, MT=451 Sixpak

AND ALL SECTIONS OF MF=6 MUST BE CORRECT. THE PROGRAM SKIPS ALL Sixpak

OTHER SECTIONS OF DATA AND AS SUCH IS INSENSITIVE TO THE FORMAT Sixpak

OF ALL OTHER SECTIONS. Sixpak

Sixpak

CONTENTS OF OUTPUT Sixpak

================================================================== Sixpak

5 ENDF/B FORMATTED OUTPUT FILES ARE PRODUCED FOR NEUTRON INCIDENT Sixpak

DATA, Sixpak

Sixpak

1) ENDFB.MF4 - ANGULAR DISTRIBUTIONS AND LEGENDRE COEFFICIENTS Sixpak

FOR NEUTRONS Sixpak

2) ENDFB.MF5 - TABULATED NEUTRON ENERGY SPECTRA Sixpak

3) ENDFB.M12 - PHOTON EMISSION MULTIPLICITY Sixpak

4) ENDFB.M14 - PHOTON EMISSION ANGULAR DISTRIBUTIONS (ALWAYS Sixpak

ISOTROPIC) Sixpak

5) ENDFB.M15 - TABULATED PHOTON EMISSION SPECTRA Sixpak

Sixpak

EMITTED PARTICLE YIELD Sixpak

================================================================== Sixpak

NEUTRONS Sixpak

======== Sixpak

IN MF=6 THE YIELD FOR EACH REACTION IS THE ACTUAL MULTIPLICITY OF Sixpak

THE REACTION, E.G., (N,2N) = 2. IN USING MF=4 AND 5 DATA THE Sixpak

ENDF/B CONVENTION IS THAT THE MULTIPLICITY IS IMPLIED BY THE Sixpak

MT NUMBER, E.G., MT=16 = (N,2N) = 2. Sixpak

Sixpak

THE ONLY EXCEPT IN ENDF/B-VI IS MT=201 = TOTAL NEUTRON PRODUCTION Sixpak

WHERE AN ACTUAL ENERGY DEPENDENT YIELD IS INCLUDED IN MF=6. Sixpak

HOWEVER, IN THIS CASE THE MF=3 CROSS SECTION INCLUDES THE Sixpak

MULTIPLICITY (S. PEARLSTEIN, PRIVATE COMMUNICATION, JAN. 1992), Sixpak

SIG(MT=201) = 2\*SIG(N,2N)+3\*SIG(N,3N).....ETC. Sixpak

Sixpak

SO THAT FOR ALL ENDF/B-VI DATA AS OF JANUARY 1992 THE MF=4 AND 5 Sixpak

DATA OUTPUT BY THIS CODE CAN BE USED IN CONJUNCTION WITH THE MF=3 Sixpak

CROSS SECTIONS - WITHOUT ANY REFERENCE TO THE MF=6 YIELD. Sixpak

Sixpak

PHOTONS Sixpak

======= Sixpak

UNLIKE THE NEUTRONS WHERE WITH ONLY ONE EXCEPTION (MT=201) THE Sixpak

MF=6 YIELD IS ENERGY INDEPENDENT, IN THE CASE OF PHOTON EMISSION Sixpak

ALMOST ALL OF THE PHOTONS HAVE AN ENERGY DEPENDENT YIELD. Sixpak

Sixpak

THIS PROGRAM WILL OUTPUT THE PHOTON MULTIPLICITY IN MF=12 AND Sixpak

INDICATE THAT THERE IS A NORMALIZED DISTRIBUTION IN MF=15 Sixpak

(LF=1 IN MF=12). Sixpak

Sixpak

THIS PROGRAM WILL OUTPUT THE NORMALIZED PHOTON SPECTRA IN MF=15. Sixpak

CONTINUOUS ENERGY SPECTRA AND DISCRETE PHOTONS WILL ALL BE OUTPUT Sixpak

AS NORMALIZED SPECTRA. Sixpak

Sixpak

THIS PROGRAM WILL ALSO OUTPUT MF=14 PHOTON ANGULAR DISTRIBUTION Sixpak

DATA, ALWAYS USING THE ISOTROPIC FLAG TO MINIMIZE OUTPUT. Sixpak

Sixpak

WARNING OF ENERGY DEPENDENT YIELD Sixpak

================================= Sixpak

THIS PROGRAM WILL PRINT A WARNING MESSAGE IF A SECTION OF DATA Sixpak

BEING OUTPUT IN THE ENDF/B FORMAT HAS AN ENERGY DEPENDENT MF=6 Sixpak

YIELD AND THE EMITTED PARTICLE IS A NEUTRON - SINCE THE ENDF/B Sixpak

CONVENTION IS THAT FOR EACH MT NUMBER THE MULTIPLICITY IS IMPLIED Sixpak

WE DO NOT EXPECT AN ENERGY DEPENDENT MULTIPLICITY FOR NEUTRON Sixpak

EMISSION. Sixpak

Sixpak

USING THE OUTPUT Sixpak

================================================================== Sixpak

NOTE, THAT IN USING THIS DATA, STARTING FROM THE RELATIONSHIP, Sixpak

Sixpak

F(E,EP,COS) = SIG(E)\*Y(E)\*G0(E,EP)\*F0(E,COS) Sixpak

Sixpak

USING THE ENDF/B CONVENTION THAT THE MULTIPLICITY IS EITHER Sixpak

IMPLIED BY THE MT NUMBER (E.G., MT=16 = N,2N - MULTIPLICITY = 2) Sixpak

OR INCLUDED IN THE CROSS SECTION (E.G., MT=201 = TOTAL NEUTRON Sixpak

PRODUCTION) ALL THE INFORMATION REQUIRED FOR A CALCULATION IS Sixpak

AVAILABLE IN, Sixpak

Sixpak

MF=3 - SIG(E) Sixpak

MF=4 - F0(E,COS) - FOR OUTGOING NEUTRONS Sixpak

MF=5 - G0(E,EP) - FOR OUTGOING NEUTRONS Sixpak

MF=12 - Y(E) - FOR OUTGOING PHOTONS Sixpak

MF=14 - F0(E,COS) - FOR OUTGOING PHOTONS (ALWAYS ISOTROPIC) Sixpak

MF=15 - G0(E,EP) - FOR OUTGOING PHOTONS Sixpak

Sixpak

DOCUMENTATION Sixpak

================================================================== Sixpak

ONLY SECTIONS OF MF=4, 5, 12, 14, 15 ARE OUTPUT ON A ENDF/B FILE. Sixpak

THE ONLY DOCUMENTATION IS THE ENDF/B TAPE LABEL (FIRST RECORD OF Sixpak

EACH FILE) WHICH IDENTIFIES THE DATA AS SIXPAK OUTPUT. Sixpak

Sixpak

REACTION INDEX Sixpak

================================================================== Sixpak

THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN Sixpak

SECTION MF=1, MT=451 OF EACH EVALUATION. Sixpak

Sixpak

SECTION SIZE Sixpak

================================================================== Sixpak

ALL OF THE DATA IN ENDF/B-VI, MF=6 ARE QUITE SMALL TABLES. AS SUCH Sixpak

THIS PROGRAM ONLY ALLOWS TABLES OF UP TO 12000 POINTS (12,000 X, Sixpak

Y VALUES). THIS SIZE IS MORE THAN ADEQUATE TO HANDLE ALL OF THE Sixpak

CURRENT ENDF/B-VI DATA, AND IT CAN BE EASILY INCREASED TO HANDLE Sixpak

ANY NEWER DATA AS IT BECOMES AVAILABLE. Sixpak

Sixpak

PLEASE CONTACT THE AUTHOR IF YOU HAVE AN EVALUATION WHICH EXCEEDS Sixpak

THIS LIMIT. Sixpak

Sixpak

SELECTION OF DATA Sixpak

================================================================== Sixpak

THE PROGRAM SELECTS DATA TO BE PROCESSED BASED ON MAT/MT RANGES Sixpak

(MF=6 ASSUMED). THIS PROGRAM ALLOWS UP TO 100 MAT/MT RANGES TO BE Sixpak

SPECIFIED BY INPUT PARAMETERS. THE PROGRAM WILL ASSUME THAT THE Sixpak

ENDF/B TAPE IS IN MAT ORDER. THE PROGRAM WILL TERMINATE EXECUTION Sixpak

WHEN A MAT IS FOUND THAT IS ABOVE ALL REQUESTED MAT RANGES. Sixpak

Sixpak

PROGRAM OPERATION Sixpak

================================================================== Sixpak

EACH SECTION (MT) OF MF=6 DATA IS SUBDIVIDED INTO SUBSECTIONS - Sixpak

ONE SUBSECTION FOR EACH EMITTED PARTICLE. Sixpak

Sixpak

EACH SUBSECTION OF DATA IS CONSIDERED SEPARATELY. EACH SUBSECTION Sixpak

OF ENDF/B MF=6 DATA TO PROCESS IS IN THE FORM, Sixpak

Sixpak

F(E,EP,COS) = SIG(E)\*Y(E)\*G0(E,EP)\*F(E,EP,COS) Sixpak

Sixpak

SIG(E) = MF=3 CROSS SECTIONS Sixpak

Y(E) = YIELD (MULTIPLICITY) Sixpak

G0(E,EP) = ENERGY SPECTRUM Sixpak

F(E,EP,COS) = ANGULAR DISTRIBUTION Sixpak

Sixpak

G0(E,EP) = 1 WHEN INTEGRATED OVER EP (SECONDARY ENERGY) Sixpak

G0(E,EP)\*F(E,EP,COS) = 1 WHEN INTEGRATED OVER EP AND COS Sixpak

Sixpak

THIS PROGRAM WILL DEFINE THE ZEROTH ORDER MOMENTS OF THE Sixpak

ENERGY AND ANGULAR DISTRIBUTIONS, Sixpak

Sixpak

G0(E,EP) = G0(E,EP)\*F(E,EP,COS) INTEGRATED OVER COS Sixpak

F0(E,COS) = G0(E,EP)\*F(E,EP,COS) INTEGRATED OVER EP Sixpak

Sixpak

FOR NEUTRON INDUCED REACTIONS THE ENDF/B FORMATTED OUTPUT WILL BE Sixpak

Sixpak

F0(E,COS)- IN ENDFB.MF4 FOR NEUTRONS OUT OF A REACTION Sixpak

G0(E,EP) - IN ENDFB.MF5 FOR NEUTRONS OUT OF A REACTION Sixpak

- IN ENDFB.M15 FOR PHOTONS OUT OF A REACTION Sixpak

Sixpak

FOR NEUTRONS INCIDENT AND NEUTRONS EMITTED THIS DATA WILL BE Sixpak

OUTPUT IN MF=4 AND 5 FORMATS. Sixpak

Sixpak

FOR NEUTRONS INCIDENT AND PHOTONS EMITTED THIS DATA WILL BE Sixpak

OUTPUT IN MF=15 FORMAT - THE SPECTRA ARE OUTPUT AND THE Sixpak

ANGULAR DISTRIBUTION IS IGNORED. Sixpak

Sixpak

ALL PHOTON EMISSION IN THE ENDF/B-VI LIBRARY AS OF JANUARY 1992 Sixpak

IS ISOTROPIC AND AS SUCH NO DISTRIBUTION OF PHOTON ANGULAR Sixpak

DISTRIBUTIONS NEED BE OUTPUT - IT IS ALWAYS ISOTROPIC. Sixpak

Sixpak

FOR ALL OTHER COMBINATIONS INCIDENT AND EMITTED PARTICLES Sixpak

THERE WILL BE NO ENDF/B FORMATTED OUTPUT. Sixpak

Sixpak

VARIATIONS FROM ENDF/B MANUAL Sixpak

================================================================== Sixpak

LAW=1, LANG=2 = KALBACH-MANN Sixpak

============================ Sixpak

FOR THE DISTRIBUTIONS, Sixpak

Sixpak

F(MU,E,EP) = G0(E,EP)\*A\*(COSH(MU\*A)+R(E,EP)\*SINH(MU\*A)) Sixpak

Sixpak

G0(E,EP) = 1 - WHEN INTEGRATED OVER EP. Sixpak

Sixpak

A\*(COSH(MU\*A)+R(E,EP)\*SINH(MU\*A)) = 2 - WHEN INTEGRATD OVER MU Sixpak

Sixpak

THIS MEANS AS DEFINED IN THE ENDF/B MANUAL THE DISTRIBUTIONS Sixpak

ARE NORMALIZED TO 2, INSTEAD OF 1. IN ORDER TO OBTAIN CORRECTLY Sixpak

NORMALIZED DISTRIBUTIONS THE DISTRIBUTION SHOULD BE DEFINED Sixpak

TO INCLUDE A FACTOR OF 1/2 MULTIPLYING THE ANGULAR PART OF Sixpak

THE DISTRIBUTION. Sixpak

Sixpak

F(MU,E,EP) = G0(E,EP)\*0.5\*A\*(COSH(MU\*A)+R(E,EP)\*SINH(MU\*A)) Sixpak

Sixpak

THIS IS THE FORM USED IN THIS CODE Sixpak

Sixpak

LAW=1, ND NOT 0 = DISCRETE SECONDARY ENERGY DISTRIBUTION Sixpak

======================================================== Sixpak

THE ENDF/B MANUAL SAYS THESE ARE FLAGGED WITH NEGATIVE ENERGIES. Sixpak

IN ENDF/B-VI ALL OF THESE HAVE POSITIVE ENERGY. THIS CODE DOES Sixpak

NOT CONSIDER THE ENDF/B-VI DATA TO BE IN ERROR. Sixpak

Sixpak

WITH THE CONVENTION ACTUALLY USED IN ENDF/B-VI ALL SECONDARY Sixpak

ENERGIES SHOULD BE NON-NEGATIVE AND IN ASCENDING ENERGY ORDER Sixpak

FOR EACH INCIDENT ENERGY. Sixpak

Sixpak

FROM THE ENDF/B MANUAL IT IS NOT OBVIOUS WHAT G0(E,EP) SHOULD BE Sixpak

FOR DISCRETE PHOTONS - PHYSICALLY THIS IS A DELTA FUNCTION. IN Sixpak

ENDF/B-VI IT IS ENTERED AS 1.0 = INTERPRETING IT AS INTEGRATED Sixpak

OVER SECONDARY ENERGY - IN WHICH CASE THE DELTA FUNCTION = 1.0. Sixpak

Sixpak

LIMITATIONS Sixpak

================================================================== Sixpak

CHECKING DATA Sixpak

================================================================== Sixpak

THIS PROGRAM CHECKS ALL ENDF/B-VI MF=6 DATA. THE FOLLOWING CHECKS Sixpak

ARE PERFORMED. Sixpak

Sixpak

PARAMETERS Sixpak

========== Sixpak

ALL PARAMETERS ARE CHECKED FOR CONSISTENCY. IF PARAMETERS ARE Sixpak

NOT CONSISTENT THE PROGRAM MAY NOT BE ABLE TO PERFORM THE Sixpak

FOLLOWING TESTS AND WILL MERELY SKIP A SECTION OF DATA. Sixpak

Sixpak

INTERPOLATION LAWS Sixpak

================== Sixpak

ALL INTEGRATIONS ARE PERFORMED USING THE INTERPOLATION LAW GIVEN Sixpak

FOR SECONDARY ENERGY AND/OR COSINE. INTEGRATIONS ARE NOT Sixpak

PERFORMED OVER INCIDENT - ONLY INTEGRATION OVER SECONDARY ENERGY Sixpak

AND/OR COSINE ARE PERFORMED AT EACH INCIDENT ENERGY. THEREFORE Sixpak

THE INTERPOLATION LAW FOR INCIDENT ENERGY IS NOT USED BY THIS Sixpak

CODE. Sixpak

Sixpak

ALL INTERPOLATION LAWS ARE CHECKED. ALL DATA ASSOCIATED WITH Sixpak

INTERPOLATION LAWS ARE CHECKED, E.G., NO NON-NEGATIVE VALUES Sixpak

REQUIRING LOG INTERPOLATION. IN ORDER TO PERFORM REQUIRED Sixpak

INTEGRALS OVER COS AND EP IT IS IMPERATIVE THAT THE INTERPOLATION Sixpak

LAWS BE COMPATIBLE WITH THE DATA. Sixpak

Sixpak

ENDF/B-VI ALLOWS NEW INTERPOLATION LAWS FOR CORRESPONDING POINT Sixpak

AND UNIT BASE TRANSFORMATION INTERPOLATION. NONE OF THESE NEW Sixpak

INTERPOLATION LAWS ARE USED IN THE ENDF/B-VI LIBRARY AS OF Sixpak

JANUARY 1992 TO INTERPOLATE IN SECONDARY ENERGY OR COSINE. Sixpak

THEREFORE THIS PROGRAM CAN PERFORM ALL OF THE REQUIRED INTEGRALS Sixpak

OVER SECONDARY ENERGY AND/OR COSINE USING ONLY THE OLDER Sixpak

INTERPOLATION CODES. THIS PROGRAM ONLY PERFORMS INTEGRALS FOR Sixpak

EACH INCIDENT ENERGY, SO THAT INTERPOLATION IN INCIDENT ENERGY Sixpak

IS NOT PERFORMED BY THIS PROGRAM. Sixpak

Sixpak

NEW INTERPOLATION SCHEMES ARE USED FOR INCIDENT ENERGY - FOR Sixpak

EXAMPLE, CORRESPONDING POINT INTERPOLATION IS SPECIFIED TO ALLOW Sixpak

INTERPOLATION IN G0(E,EP) TO SIMULATE CASES WHERE THE INPUT ENERGY Sixpak

LIMIT IS DEFINED BY E-EP = A DIAGONAL CURVE ACROSS (E,EP) SPACE. Sixpak

THIS INTERPOLATION CODE CANNOT BE SPECIFIED IN THE MF=5 OUTPUT Sixpak

OF THIS CODE - MF=5 ONLY ALLOWS THE OLDER INTERPOLATION LAWS Sixpak

INT=1 THROUGH 5. THEREFORE THIS PROGRAM WILL USE THE CLOSEST Sixpak

CORRESPONDING INTERPOLATION CODE FOR OUTPUT TO MF=5. FOR USE Sixpak

WHERE THE OUTPUT OF THIS CODE = LOW ENERGY APPLICATIONS - THIS Sixpak

SHOULD HAVE LITTLE EFFECT ON RESULTS. Sixpak

Sixpak

FOR CONSISTENCY WITH EARLIER VERSIONS OF ENDF/B IN CREATING THE Sixpak

ENDF/B OUTPUT, IF ANY INPUT INTERPOLATION LAW IS NOT IN THE Sixpak

RANGE 1-5, IT WILL FIRST BE TESTED TO SEE IF MOD(10) IT IS Sixpak

IN THIS RANGE, FINALLY IF EVEN THIS DOESN'T WORK IT IS SET Sixpak

EQUAL TO 2 (LINEARLY INTERPOLATION). THIS METHOD WILL EFFECTIVELY Sixpak

REPLACE CORRESPONDING POINT AND UNIT BASE TRANSFORMATION BY THE Sixpak

CLOSEST RELATED INTERPOLATION LAW 1 THROUGH 5 - AGAIN NOTE, AS Sixpak

OF JANUARY 1992 NONE OF THESE NEW LAWS ARE USED IN ENDF/B-VI. IF Sixpak

THIS MUST BE DONE FOR INTERPOLATION IN SECONDARY ENERGY OR COSINE Sixpak

AN ERROR MESSAGE WILL BE PRINTED - SINCE THIS WOULD EFFECT THE Sixpak

ACCURACY OF THE INTEGRALS PERFORMED BY THIS PROGRAM. IF THIS MUST Sixpak

BE DONE FOR INCIDENT ENERGY NO MESSAGE IS PRINTED - SINCE THIS Sixpak

WILL NOT EFFECT THE ACCURACY OF THE INTEGRALS PERFORMED BY THIS Sixpak

PROGRAM. Sixpak

Sixpak

SPECTRA AND ANGULAR DISTRIBUTIONS Sixpak

================================= Sixpak

ALL SPECTRA AND ANGULAR DISTRIBUTIONS ARE CHECKED TO INSURE Sixpak

THEY ARE NORMALIZED AND DO NOT INCLUDE ANY NEGATIVE VALUES. Sixpak

Sixpak

LEGENDRE COEFFICIENTS Sixpak

===================== Sixpak

THE NORMALIZATION, F0, CANNOT BE NEGATIVE. Sixpak

Sixpak

LEGENDRE COEFFICIENTS IN NORMAL FORM ARE CHECKED TO INSURE Sixpak

THEY ARE IN THE RANGE -1 TO +1 = THE LEGENDRE EXPANSION OF A Sixpak

DELTA FUNCTION AT COS=+1 OR -1 - COEFFICIENTS SHOULD NOT Sixpak

EXCEED WHAT YOU GET FROM A DELTA FUNCTION. Sixpak

Sixpak

ANGULAR DISTRIBUTIONS ARE CHECKED AT COS = -1, 0 AND +1. Sixpak

Sixpak

CREATING ENDF/B OUTPUT Sixpak

================================================================== Sixpak

THIS PROGRAM CAN CREATE EQUIVALENT MF =4, 5, 12, 14, 15 DATA FOR Sixpak

ALL OF THE DATA INCLUDED IN ENDF/B-VI AS OF JANUARY 1992, EXCEPT Sixpak

FOR 1 SECTION OF LAW=6 DATA (SEE DETAILS BELOW). Sixpak

Sixpak

THIS PROGRAM HAS NOT BEEN TESTED ON OTHER DATA LIBRARIES, E.G., Sixpak

JEF, JENDL, ETC. Sixpak

Sixpak

THE PROGRAM HAS THE FOLLOWING LIMITATION AS FAR AS CREATING Sixpak

ENDF/B FORMATTED OUTPUT. Sixpak

Sixpak

ISOTROPIC PHOTON EMISSION Sixpak

========================= Sixpak

FOR PHOTON EMISSION THE DISTRIBUTIONS ARE ASSUMED TO BE ISOTROPIC Sixpak

AND ONLY THE MULTIPLICITY IS OUTPUT IN MF=12, ISOTROPIC ANGULAR Sixpak

DISTRIBUTIONS IN MF=14 AND THE SPECTRA IN MF=15. ALL ENDF/B-VI Sixpak

MF=6 DATA AS OF JANUARY 1992 INCLUDE ONLY ISOTROPIC PHOTON Sixpak

EMISSION - SO THAT THIS IS NOT A LIMITATION ON TRANSLATING Sixpak

ENDF/B-VI DATA. Sixpak

Sixpak

EITHER TABULATED OR LEGENDRE COEFFICIENTS Sixpak

========================================= Sixpak

FOR LAW=2 THE REPRESENTATION, EITHER TABULATED OR LEGENDRE Sixpak

COEFFICIENTS, CAN BE SPECIFIED FOR EACH INCIDENT ENERGY. Sixpak

Sixpak

IN ORDER TO OBTAIN CORRECT ENDF/B OUTPUT THE REPRESENTATION Sixpak

MUST BE THE SAME FOR ALL INCIDENT ENERGIES = MF=4 DATA CAN ONLY Sixpak

BE TABULATED OR LEGENDRE OVER THE ENTIRE ENERGY RANGE. Sixpak

Sixpak

YIELD AND OUTPUT NORMALIZATION Sixpak

============================== Sixpak

THE YIELD INCLUDED WITH EACH SECTION OF DATA IS NOT USED FOR Sixpak

OUTPUT FOR NEUTRONS, BUT IS INCLUDED IN THE OUTPUT FOR PHOTONS. Sixpak

IN ALL CASES THE ANGULAR DISTRIBUTIONS AND SPECTRA OUTPUT ARE Sixpak

NORMALIZED TO UNITY. Sixpak

Sixpak

LAW=0 Sixpak

===== Sixpak

NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON Sixpak

REACTIONS ARE NOT EXPECTED. Sixpak

Sixpak

LAW=1 Sixpak

===== Sixpak

FOR EACH INCIDENT ENERGY DISCRETE AND CONTINUOUS EMISSION SPECTRA Sixpak

CANNOT BE MIXED TOGETHER - THEY MUST BE ALL EITHER DISCRETE OR Sixpak

CONTINUOUS. IF DISCRETE EMISSION IS GIVEN ONLY 1 SECONDARY Sixpak

ENERGY (NEP=1) MAY BE GIVEN = A NORMALIZED DISTRIBUTION FOR A Sixpak

SINGLE DISCRETE EMISSION ENERGY. ALL OF THE ENDF/B-VI DATA AS Sixpak

OF JANUARY 1992 CONFORM TO THESE LIMITATIONS. Sixpak

Sixpak

SINCE THE FLAG NA, TO INDICATE ISOTROPIC DISTRIBUTIONS, IS ONLY Sixpak

GIVEN FOR EACH SECONDARY ENERGY (EP) THE PROGRAM CANNOT DECIDE Sixpak

IN ADVANCE WHETHER OR NOT THE DISTRIBUTION WILL BE ISOTROPIC Sixpak

AT ALL INCIDENT ENERGIES. THEREFORE ISOTROPIC DISTRIBUTIONS Sixpak

WILL BE OUTPUT EITHER: LANG = 1 - AS 1 LEGENDRE COEFFICIENT = 0.0 Sixpak

OR LANG = NOT 1 - AS A 2 POINT ANGULAR DISTRIBUTION AT COS = -1.0 Sixpak

AND +1.0 WITH BOTH VALUES EQUAL TO 0.5 (A NORMALIZED ISOTROPIC Sixpak

DISTRIBUTION). Sixpak

Sixpak

DISCRETE PHOTONS ARE OUTPUT IN MF=15 AS 3 POINT DISTRIBUTIONS Sixpak

WITH SECONDARY ENERGY POINTS AT EP-DEP, EP, EP+DEP, WHERE Sixpak

DEP=0.001\*EP. THE VALUES AT EP-DEP AND EP+DEP ARE 0.0, AND Sixpak

AT EP THE VALUE IS 1000.0/EP TO NORMALIZE THE DISTRIBUTION. Sixpak

Sixpak

LAW=2 Sixpak

===== Sixpak

NO LIMITATION ON REPRESENTATIONS. Sixpak

Sixpak

LAW=3 Sixpak

===== Sixpak

NO LIMITATION ON REPRESENTATIONS. Sixpak

Sixpak

LAW=4 Sixpak

===== Sixpak

NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON Sixpak

REACTIONS ARE NOT EXPECTED. Sixpak

Sixpak

LAW=5 Sixpak

===== Sixpak

NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON Sixpak

REACTIONS ARE NOT EXPECTED. Sixpak

Sixpak

LAW=6 Sixpak

===== Sixpak

NO OUTPUT - ENDF/B-VI ONLY INCLUDES 1 SECTION OF THIS TYPE OF DATA Sixpak

FOR (N,D) 2N,P. Sixpak

Sixpak

LAW=7 Sixpak

===== Sixpak

FOR EACH INCIDENT ENERGY THE REPRESENTATION MUST BE EITHER, Sixpak

Sixpak

1) SQUARE = FOR EACH INCIDENT COSINE EXACTLY THE SAME SECONDARY Sixpak

ENERGIES. Sixpak

Sixpak

2) LINEAR = FOR EACH INCIDENT COSINE THE INTERPOLATION LAW Sixpak

BETWEEN SECONDARY ENERGIES MUST BE LINEAR. Sixpak

Sixpak

THESE 2 PRESENTATIONS ARE THE ONLY ONES PRESENTED IN ENDF/B-VI Sixpak

AS OF JANUARY 1992 - SO THIS PROGRAM CAN TRANSLATED ALL LAW=7 Sixpak

DATA FOR ENDF/B-VI. Sixpak

Sixpak

LABORATORY VS. CENTER-OF-MASS SYSTEM Sixpak

================================================================== Sixpak

IN MANY CASES PEOPLE ASSUME THAT FOR HEAVY (HIGH ATOMIC WEIGHT) Sixpak

MATERIALS THE CENTER-OF-MASS AND LAB SYSTEMS ARE ALMOST IDENTICAL, Sixpak

SINCE IN THIS CASE THE CENTER-OF-MASS ENERGY WILL BE MUCH SMALLER Sixpak

THAN THE INCIDENT ENERGY. FOR A PROCESS SUCH AS ELASTIC SCATTERING Sixpak

WHERE FOR HEAVY MATERIALS THE SECONDARY ENERGY, EP, WILL ALWAYS Sixpak

BE A LARGE FRACTION OF THE INCIDENT ENERGY, THIS ASSUMPTION IS Sixpak

VALID. HOWEVER, FOR THE TYPICAL REACTIONS INCLUDED IN MF=6 THIS Sixpak

IS NOT ALWAYS TRUE - IN MANY OF THESE CASES THE SECONDARY ENERGY Sixpak

CAN EXTEND ALL THE WAY DOWN TO ZERO, AND IN PARTICULAR IT CAN Sixpak

BE SMALL COMPARED TO THE CENTER-OF-MASS ENERGY - WHICH MAKES THE Sixpak

TRANSFORMATION FROM CENTER-OF-MASS TO LAB IMPORTANT. THEREFORE Sixpak

GENERALLY TO TREAT MF=6 DATA WE MUST CONSIDER THIS TRANSFORMATION. Sixpak

Sixpak

THE FOLLOWING DISCUSSING ONLY APPLIES TO SPECTRA THAT MAY BE Sixpak

OUTPUT IN MF=5 = ONLY DATA FOR NEUTRONS INCIDENT AND EMITTED - Sixpak

IN PARTICULAR THE FOLLOWING DEFINITIONS ARE NOT GENERAL - THEY Sixpak

ARE ONLY VALID FOR INCIDENT AND EMITTED NEUTRONS. Sixpak

Sixpak

DOUBLE DIFFERENTIAL DATA IN MF=6 MAY BE GIVEN IN EITHER THE LAB Sixpak

OR C.M. SYSTEM. SIMILARLY ANGULAR DISTRIBUTIONS IN MF=4 MAY BE Sixpak

GIVEN IN EITHER THE LAB OR C.M. SYSTEM. IN CONTRAST ENERGY Sixpak

SPECTRA IN MF=5 CAN ONLY BE GIVEN IN THE LABORATORY SYSTEM. Sixpak

Sixpak

THE ANGULAR DISTRIBUTIONS OUTPUT BY THIS CODE IN MF=4 ARE IN THE Sixpak

SAME SYSTEM IN WHICH THEY ARE GIVEN IN MF=6 - EITHER LAB OR Sixpak

CENTER-OF-MASS SYSTEM. Sixpak

Sixpak

THE ENERGY SPECTRA OUTPUT BY THIS CODE IN MF=5 MUST BE IN THE LAB Sixpak

SYSTEM - THIS IS THE ONLY ALLOWED FORM FOR MF=5 DATA. Sixpak

Sixpak

FOR MF=6 SPECTRA GIVEN IN THE LAB SYSTEM THIS MERELY REQUIRES Sixpak

COPYING THE GIVEN SPECTRA TO MF=5 OUTPUT. Sixpak

Sixpak

FOR MF=6 SPECTRA GIVEN IN THE CENTER-OF-MASS SYSTEM ONLY FIRST Sixpak

ORDER CORRECTIONS IN THE SPECTRA AND USED AND THEY ARE THEN Sixpak

OUTPUT IN MF=5 AS IN THE LAB SYSTEM - THE FIRST ORDER CORRECTIONS Sixpak

ARE DESCRIBED BELOW. Sixpak

Sixpak

DEFINING, Sixpak

MM = CENTER OF MASS MOTION Sixpak

CM = OUTGOING (EMITTED) PARTICLE IN CENTER OF MASS Sixpak

LAB = OUTGOING (EMITTED) PARTICLE IN LAB Sixpak

THETA = CM SCATTERING ANGLE RELATIVE TO INCIDENT DIRECTION Sixpak

COS(CM) = COSINE OF THE CM SCATTERING ANGLE Sixpak

Sixpak

FOR NEUTRONS INCIDENT WITH AN ENERGY, E, AND THEREFORE A SPEED, Sixpak

Sixpak

VN(E) = 2\*SQRT(E)/MASS(IN) Sixpak

Sixpak

THE CENTER-OF-MASS SPEED IS GIVEN BY, Sixpak

Sixpak

V(MM) = VN(E)/(1 + A) Sixpak

Sixpak

AND THE CENTER OF MASS ENERGY BY, Sixpak

Sixpak

E(MM) = 1/2\*MASS(IN)\*V(MM)\*\*2 Sixpak

= 1/2\*MASS(IN)\*VN(E)\*\*2/(1 + A)\*\*2 Sixpak

= E/(1 + A)\*\*2 Sixpak

Sixpak

FOR DISTRIBUTIONS GIVEN IN MF=6 IN THE CM, THE SPEED, V(CM), Sixpak

SHOULD BE VECTORIALLY ADDED TO THAT OF OUTGOING PARTICLES TO Sixpak

DEFINE THE OUTGOING PARTICLES LAB VELOCITY, AND IN TURN IT'S Sixpak

ENERGY, Sixpak

Sixpak

V(LAB)\*COS(LAB) = V(MM) + V(CM)\*COS(CM) Sixpak

V(LAB)\*SIN(LAB) = V(CM)\*SIN(CM) Sixpak

Sixpak

V(LAB)\*\*2 = V(MM)\*\*2 + V(CM)\*\*2 + 2\*COS(CM)\*V(MM)\*V(CM) Sixpak

Sixpak

EP(LAB) = 0.5\*MASS(OUT)\*V(LAB)\*\*2 Sixpak

Sixpak

= E(MM) + EP(CM) + 2\*COS(CM)\*SQRT(E(MM)\*EP(CM)) Sixpak

Sixpak

WE CAN ALSO DEFINE THE REVERSE TRANSFORMATION USING, Sixpak

Sixpak

V(CM)\*COS(CM) = V(LAB)\*COS(LAB) - V(MM) Sixpak

V(CM)\*SIN(CM) = V(LAB)\*SIN(LAB) Sixpak

Sixpak

V(CM)\*\*2 = V(MM)\*\*2 + V(LAB)\*\*2 - 2\*COS(LAB)\*V(MM)\*V(LAB) Sixpak

Sixpak

EP(CM) = 0.5\*MASS(OUT)\*V(CM)\*\*2 Sixpak

Sixpak

= E(MM) + EP(LAB) - 2\*COS(LAB)\*SQRT(E(MM)\*EP(LAB)) Sixpak

Sixpak

WE CAN DEFINE COS(LAB) FROM THE RELATIONSHIP, Sixpak

Sixpak

V(LAB)\*COS(LAB) = V(MM) + V(CM)\*COS(CM) Sixpak

Sixpak

COS(LAB) =[V(MM) + V(CM)\*COS(CM)]/V(LAB) Sixpak

Sixpak

[V(MM) + V(CM)\*COS(CM)] Sixpak

COS(LAB) =--------------------------------------------- Sixpak

SQRT[V(MM)\*\*2+V(CM)\*\*2+2\*COS(CM)\*V(MM)\*V(CM)] Sixpak

Sixpak

OR COS(CM) FROM THE RELATIONSHIP, Sixpak

Sixpak

V(CM)\*COS(CM) = V(LAB)\*COS(LAB) - V(MM) Sixpak

Sixpak

COS(CM) =[V(LAB)\*COS(LAB) - V(MM)]/V(CM) Sixpak

Sixpak

[V(LAB)\*COS(LAB) - V(MM)] Sixpak

COS(CM) =------------------------------------------------ Sixpak

SQRT[V(LAB)\*\*2+V(CM)\*\*2-2\*COS(LAB)\*V(LAB)\*V(MM)] Sixpak

Sixpak

THE JACOBIAN CAN BE DEFINED FROM, Sixpak

Sixpak

V(LAB)\*COS(LAB) = V(MM) + V(CM)\*COS(CM) Sixpak

Sixpak

J = D[COS(CM)]/D[COS(LAB)] = V(LAB)/V(CM) Sixpak

= SQRT[EP(LAB)/EP(CM)] Sixpak

Sixpak

WITH THESE DEFINITIONS OF EP(LAB) AND COS(LAB) IN TERMS OF E(MM), Sixpak

EP(CM) AND COS(CM) IT IS POSSIBLE TO PERFORM A POINT-BY-POINT Sixpak

TRANSFORMATION OF DISTRIBUTIONS FROM THE CM TO LAB SYSTEM USING Sixpak

THESE DEFINITIONS - OR IF WE WISHED WE COULD PERFORM THE REVERSE Sixpak

TRANSFORMATION USING THE ABOVE RELATIONSHIPS AND THE IDENTITY, Sixpak

Sixpak

F(E,EP(LAB),COS(LAB))\*D(COS(LAB))=F(E,EP(CM),COS(CM))\*D(COS(CM)) Sixpak

Sixpak

THIS IS NOT WHAT WILL BE DONE HERE, SINCE WE WILL ONLY BE Sixpak

INTERESTED IN THE ZEROTH ORDER MOMENTS OF THESE DISTRIBUTIONS, Sixpak

BUT WE WILL BE INTERESTED IN DEFINING THOSE MOMENTS IN THE Sixpak

LAB SYSTEM IN TERMS OF MF=6 SPECTRA GIVEN IN THE CM SYSTEM USING, Sixpak

Sixpak

F(E,EP(LAB),COS(LAB)) = F(E,EP(CM),COS(CM))\*J Sixpak

Sixpak

THE LIMITS OF EP(LAB) ARE DEFINED BY SETTING COS(CM) = +1 OR -1, Sixpak

Sixpak

EP(LAB) = (SQRT(EP(CM)) + SQRT(E(MM)))\*\*2 FOR COS(CM) = +1 Sixpak

= (SQRT(EP(CM)) - SQRT(E(MM)))\*\*2 FOR COS(CM) = -1 Sixpak

Sixpak

IN THIS FORM WE CAN SEE THAT AS LONG AS THE SECONDARY ENERGY IN Sixpak

THE CENTER-OF-MASS SYSTEM, EP(CM), IS MUCH LARGER THAN THE Sixpak

ENERGY OF THE CENTER-OF-MASS, E(MM), THE CENTER-OF-MASS AND LAB Sixpak

ENERGIES WILL BE ALMOST EQUAL - SIMILARLY FOR THE COSINE, IN Sixpak

THIS CASE COS(LAB) AND COS(CM) WILL BE ALMOST EQUAL - HOWEVER, Sixpak

FOR THE MF=6 DATA WE CANNOT ASSUME THAT THIS IS TRUE. Sixpak

Sixpak

TO FIRST ORDER THE ANGULAR DEPENDENCE CAN BE IGNORED, Sixpak

Sixpak

EP(LAB) = E(MM) + EP(CM) Sixpak

Sixpak

ALL THIS SAYS IS THAT TO FIRST ORDER THE EFFECT OF TRANSFORMING Sixpak

FROM THE CM TO LAB SYSTEM IS TO INCREASE THE ENERGY OF THE Sixpak

EMITTED PARTICLE IN THE CENTER-OF-MASS SYSTEM BY THE ENERGY OF Sixpak

THE CENTER-OF-MASS TO DEFINE THE LAB ENERGY. Sixpak

Sixpak

NOT ONLY THE ENERGY, BUT ALSO THE SPECTRA MUST BE TRANSFORMED. Sixpak

STARTING FROM THE DOUBLE DIFFERENTIAL DATA IN THE LAB SYSTEM, Sixpak

F(E,EP,COS(LAB)), WE CAN DEFINE THE LAB SCALAR SPECTRUM AS, Sixpak

Sixpak

G0(E,EP) = INTEGRAL F(E,EP,COS(LAB))\*D(COS(LAB)) Sixpak

Sixpak

THIS IS THE NORMAL CALCULATION DEFINED ABOVE AND USED FOR DATA Sixpak

GIVEN IN THE LAB SYSTEM. Sixpak

Sixpak

STARTING FROM DATA IN THE CENTER OF MASS SYSTEM F(E,EP,COS(CM)), Sixpak

WE CAN USE THE RELATIONSHIP, Sixpak

Sixpak

F(E,EP,COS(LAB))\*D(COS(LAB)) = F(E,EP,COS(CM))\*J\*D(COS(LAB)) Sixpak

Sixpak

J = SQRT(EP(LAB)/EP(CM)) - THE JACOBIAN Sixpak

Sixpak

= E(MM)/EP(CM) + 1 + 2\*COS(CM)\*SQRT(E(MM)/EP(CM)) Sixpak

Sixpak

AS IN THE CASE OF THE ENERGY, IN THIS FORM WE CAN SEE THAT AS Sixpak

LONG AS THE SECONDARY ENERGY IN THE CENTER-OF-MASS SYSTEM, Sixpak

EP(CM), IS LARGE COMPARED TO THE CENTER-OF-MASS ENERGY, E(MM), Sixpak

THE JACOBIAN IS ESSENTIALLY UNITY AND THE CENTER-OF-MASS AND LAB Sixpak

SPECTRA WILL BE VERY SIMILAR - AGAIN, GENERALLY WE CANNOT Sixpak

ASSUME THAT THIS IS TRUE FOR THE MF=6 SPECTRA. Sixpak

Sixpak

THEREFORE WE CAN ALSO DEFINE THE LAB SCALAR SPECTRUM IN TERMS OF Sixpak

THE CM SPECTRUM IN THE FORM, Sixpak

Sixpak

G0(E,EP) = INTEGRAL F(E,EP,COS(CM))\*J\*D(COS(LAB)) Sixpak

Sixpak

CONSISTENT WITH THE ABOVE ASSUMPTION THAT THE ANGULAR DEPENDENCE Sixpak

OF EP(LAB) CAN BE IGNORED THE JACOBIAN WILL NOT BE USED IN Sixpak

PERFORMING THESE INTEGRALS - IN WHICH CASE THE INTEGRAL REDUCES Sixpak

TO EXACTLY THE SAME FORM AS IF THE DATA WERE IN THE LAB SYSTEM. Sixpak

Sixpak

IT SHOULD BE NOTED THAT SINCE IN THIS CASE THE MF=4 ANGULAR Sixpak

DISTRIBUTIONS ARE GIVEN IN THE CM SYSTEM AND WHEN USED IN ANY Sixpak

APPLICATION THEY WILL BE TRANSFORMED TO THE LAB SYSTEM - WHEN Sixpak

THIS IS DONE THE JACOBIAN WILL BE APPLIED. Sixpak

Sixpak

IN THIS CODE WHERE WE ARE MOSTLY CONCERNED WITH CONSERVING THE Sixpak

NUMBER OF EMITTED PARTICLES AND AVERAGE ENERGIES THE NEUTRON Sixpak

SPECTRA OUTPUT IN MF=5 WILL NOT BE COMPLETELY CONVERTED TO THE Sixpak

LAB SYSTEM - ONLY FIRST ORDER CORRECTIONS WILL BE INCLUDED BY Sixpak

INCREASING THE EMITTED PARTICLE ENERGY BY THE CENTER OF MASS Sixpak

ENERGY, I.E., FOR A CENTER OF MASS SPECTRUM TABULATED AT CENTER Sixpak

OF MASS ENERGIES EP(CM) THESE WILL ALL BE UNIFORMLY INCREASED Sixpak

BY E(MM) TO ACCOUNT FOR THE CENTER OF MASS MOTION - THE SPECTRA Sixpak

WILL NOT BE MODIFIED BY THE JACOBIAN FACTOR SQRT(EP(LAB)/EP(CM)) Sixpak

SINCE THIS WOULD REQUIRE A DETAILED TRANSFORMATION IN ENERGY AND Sixpak

COS(THETA) SPACE - WHICH IS JUDGED NOT TO BE WORTH PERFORMING Sixpak

WITHIN THE LIMITS OF WHERE THE OUTPUT FROM THIS CODE IS INTENDED Sixpak

TO BE USED. Sixpak

Sixpak

SINCE THE ANGULAR DISTRIBUTION IS ALWAYS OUTPUT IN THE SAME Sixpak

SYSTEM AS WHICH IT IS GIVEN IN MF=6, NO TRANSFORMATION IS Sixpak

REQUIRED FOR THE MF=4 OUTPUT. Sixpak

Sixpak

WHEN USED IN LOW ENERGY APPLICATIONS (E.G., FISSION REACTORS) THE Sixpak

HIGH ENERGY SPECTRA PRESENTED IN MF=6 WILL BE MOSTLY IMPORTANT Sixpak

SIMPLY IN CONSERVING PARTICLES, (E.G., AS IN (N,2N)) AND ENERGY Sixpak

AND THE DETAILS OF THE CORRELATION AND GROSS ENERGY SPECTRA WILL Sixpak

NOTE PLAY THAT IMPORTANT A ROLE. IN THIS CASE THE SPECTRA OUTPUT Sixpak

BY THIS PROGRAM IN MF=5 SHOULD BE ADEQUATE. Sixpak

Sixpak

PLOTTAB FORMATTED OUTPUT Sixpak

================================================================== Sixpak

THIS PROGRAM CONTAINS ROUTINES TO PRODUCE OUTPUT THAT CAN BE USED Sixpak

AS INPUT TO THE PLOTTAB CODE TO OBTAIN GRAPHIC RESULTS. Sixpak

Sixpak

THESE ROUTINES ARE DESIGNED ONLY FOR USE BY THE AUTHOR TO CHECK Sixpak

THIS CODE. USERS ARE ASKED NOT TO ACTIVATE OR TRY TO USE THESE Sixpak

ROUTINES. UNLESS YOU COMPLETELY UNDERSTAND THIS CODE THE RESULTS Sixpak

CAN BE UNRELIABLE IF YOU ACTIVATE THESE ROUTINES. Sixpak

Sixpak

INPUT FILES Sixpak

================================================================== Sixpak

UNIT DESCRIPTION Sixpak

---- ----------- Sixpak

2 INPUT LINES (BCD - 80 CHARACTERS/RECORD) Sixpak

10 ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD) Sixpak

Sixpak

OUTPUT FILES Sixpak

================================================================== Sixpak

UNIT DESCRIPTION Sixpak

---- ----------- Sixpak

3 OUTPUT REPORT (BCD - 120 CHARACTERS/RECORD) Sixpak

11 ENDF/B DATA MF=4 (BCD - 80 CHARACTERS/RECORD) Sixpak

12 ENDF/B DATA MF=5 (BCD - 80 CHARACTERS/RECORD) Sixpak

14 ENDF/B DATA MF=15 (BCD - 80 CHARACTERS/RECORD) Sixpak

17 ENDF/B DATA MF=12 (BCD - 80 CHARACTERS/RECORD) Sixpak

18 ENDF/B DATA MF=14 (BCD - 80 CHARACTERS/RECORD) Sixpak

15 PLOTTAB INPUT PARAMETERS (BCD - 80 CHARACTERS/RECORD) Sixpak

16 PLOTTAB FORMATTED OUTPUT (BCD - 80 CHARACTERS/RECORD) Sixpak

Sixpak

SCRATCH FILES Sixpak

================================================================== Sixpak

NONE Sixpak

Sixpak

OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILIO1 AND FILIO2) Sixpak

================================================================== Sixpak

UNIT FILE NAME Sixpak

---- ---------- Sixpak

2 SIXPAK.INP Sixpak

3 SIXPAK.LST Sixpak

10 ENDFB.IN Sixpak

11 ENDFB.MF4 Sixpak

12 ENDFB.MF5 Sixpak

14 ENDFB.M15 Sixpak

17 ENDFB.M12 Sixpak

18 ENDFB.M14 Sixpak

15 PLOTTAB.INP Sixpak

16 PLOTTAB.CUR Sixpak

Sixpak

Sixpak

INPUT PARAMETERS Sixpak

================================================================== Sixpak

LINE COLS. DESCRIPTION Sixpak

---- ----- ----------- Sixpak

1 1-72 ENDF/B INPUT DATA FILENAME Sixpak

(STANDARD OPTION = ENDFB.IN) Sixpak

2-N 1-6 MINIMUM MAT FOR REQUESTED RANGE Sixpak

9-11 MINIMUM MT FOR REQUESTED RANGE Sixpak

12-17 MAXIMUM MAT FOR REQUESTED RANGE Sixpak

20-22 MAXIMUM MT FOR REQUESTED RANGE Sixpak

Sixpak

LEAVE THE DEFINITION OF THE FILENAME BLANK - THE PROGRAM WILL Sixpak

THEN USE THE STANDARD FILENAME (ENDFB.IN). Sixpak

Sixpak

UP TO 100 MAT/MT RANGES MAY BE SPECIFIED. THE LIST OF RANGES IS Sixpak

TERMINATED BY A BLANK LINE. IF THE FIRST INPUT LINE IS COMPLETELY Sixpak

BLANK ALL DATA WILL BE PROCESSED. Sixpak

Sixpak

EXAMPLE INPUT NO. 1 Sixpak

------------------- Sixpak

PROCESS ALL MF=6 DATA ON AN ENDF/B TAPE. USE THE STANDARD INPUT Sixpak

DATA FILENAME ENDFB.IN IN THIS CASE THE USER CAN EITHER EXPLICITLY Sixpak

SPECIFY THE FILENAME AND MAT/MT RANGE BY THE FOLLOWING 2 INPUT Sixpak

LINES, Sixpak

Sixpak

ENDFB.IN Sixpak

1 1 9999 999 Sixpak

(BLANK LINE, TERMINATES REQUEST LIST) Sixpak

Sixpak

OR BY INPUTTING 2 BLANK LINE = PROCESS EVERYTHING. Sixpak

Sixpak

EXAMPLE INPUT NO. 2 Sixpak

------------------- Sixpak

PROCESS BE-9, MAT=425, MT=16. READ THE DATA FROM ENDFB6\BE9. Sixpak

IN THIS CASE THE FOLLOWING 3 INPUT LINES ARE REQUIRED, Sixpak

Sixpak

ENDFBB6\BE9 Sixpak

425 16 425 16 Sixpak

(BLANK LINE, TERMINATES REQUEST LIST) Sixpak

Sixpak

EXAMPLE INPUT NO. 3 Sixpak

------------------- Sixpak

PROCESS ALL MT=16 (N,2N) DATA. THIS CAN BE DONE BY SPECIFYING THE Sixpak

MAXIMUM MAT RANGE = 1 TO 9999, AND MT=16 FOR THE MINIMUM AND Sixpak

MAXIMUM MT RANGE. READ THE DATA FROM ENDFB6\K300. IN THIS CASE Sixpak

CASE THE FOLLOWING 3 INPUT LINES ARE REQUIRED, Sixpak

Sixpak

ENDFB6\K300 Sixpak

1 16 9999 16 Sixpak

(BLANK LINE, TERMINATES REQUEST LIST) Sixpak

Sixpak

======================================================================= Sixpak