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FITPULS

**A Code for Obtaining Analytic Fits to Aggregate
Fission-Product Decay-Energy Spectra**

University of California



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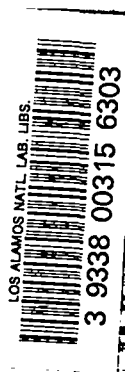
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A Code for Obtaining Analytic Fits to Aggregate Fission-Product Decay-Energy Spectra

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FITPULS
A CODE FOR OBTAINING ANALYTIC FITS TO AGGREGATE
FISSION-PRODUCT DECAY-ENERGY SPECTRA

by

R. J. LaBauve, D. C. George, and T. R. England

ABSTRACT

This report describes the operation and input to the FITPULS code, recently updated to utilize interactive graphics. The code is designed to retrieve data from a library containing aggregate fine-group spectra (150 energy groups) from fission products, collapse the data to few groups (up to 25), and fit the resulting spectra along the cooling time axis with a linear combination of exponential functions. Also given in this report are useful results for aggregate gamma and beta spectra from the decay of fission products released from ^{235}U irradiated with a pulse (10^{-4} s irradiation time) of thermal neutrons. These fits are given in 22 energy groups that are the first 22 groups of the LASL 25-group decay-energy group structure, and the data are expressed both as MeV per fission second and particles per fission second; these pulse functions are readily folded into finite fission histories.

I. INTRODUCTION

Aggregate fission-product beta and gamma spectra in 150 energy groups (the PEFPYD library)¹ have been generated from ENDF/B-IV using the CINDER-10 summation code and other Los Alamos Scientific Laboratory (LASL) processing codes as described in Ref. 1. The FITPULS code is designed to collapse the 150 energy-group fission-product spectra to few groups (up to 25) and fit the resulting spectra along the cooling time axis with a linear combination of exponential functions. An earlier version of FITPULS is described in Ref. 1, including 11-group fits, but recently the code has been updated to improve resulting fits by using

interactive graphics. It is the purpose of this report to describe the operation of and input to this version of FITPULS and to provide specific 22-group spectrum fits for the ^{235}U thermal fission products. Familiarity with Ref. 1 may be of help to the reader, particularly in definition of units and utility of the fitted data. The energy boundaries of the 11 groups used in Ref. 1 correspond to boundaries of the 22-group structure used in this report. Reference 1, however, provides fits for several fissioning nuclides.

The PEFPYD library contains data generated for a pulse, that is, for an irradiation time of 10^{-4} s using ENDF/B-IV data. (NOTE: 10^{-4} s is arbitrary but is small compared to fission-product lifetimes, hence adequate for defining a pulse.) Analytic fits to this pulse data are very convenient for design applications, as these functions can be folded with a reactor power history, for example, so that decay spectra for irradiated fuel can be calculated as a function of cooling time. Simple approximations can be added to account for neutron absorption.¹⁻³ Such fitted functions have been provided for the American Nuclear Society standard for decay-heat power in light water reactors.⁴

II. OPERATION OF FITPULS

The FITPULS code can either take the aggregate of data for various cooling times t after a pulse irradiation and fit it with a linear combination of functions $fc(t)$,

$$fc(t) = \sum_{i=1}^n \alpha_i e^{-\lambda_i t} \quad , \quad (\text{MeV /fission-second}) \quad (1)$$

where the α_i and λ_i are determined by the code, or the code can take data following one or more finite irradiation times, reduce these to a single equivalent pulse, and obtain the α_i and λ_i for the result. [By an equivalent pulse we mean a function, as in Eq. (1), that will duplicate to great accuracy the initial input values when folded into the finite fission history. The function is not unique even for the case of a single input experiment.] Pulse fits are usually done for calculated data, as from the CINDER-10 code, whereas fits for experimental data generally require the finite irradiation time option. In fact, data from several experiments with different irradiation times can be entered into the code together; the resulting fit will converge to a minimum chi-square, and

percent deviations from the use of the pulse will be obtained for each experimental point.

Normally, experimental decay data are for relatively large energy bins or even for a single total summed over all energies, so that rebinning is unnecessary. For the calculated data, however, the 150-group energy bins (in equal widths of 0.05 MeV) need to be reduced to 25 or less by rebinning into wider bins in order to make the fits useful. Routines for doing this are contained in FITPULS in which the bounds of the subset groups need not coincide with those for the 150 fine groups. An option is also available for expressing the re-grouped data in either MeV per fission-second or numbers of particles per fission-second.

FITPULS contains three options for obtaining the parameters for the fits to the rebinned decay-energy spectra. In the first option, both the α_i 's and λ_i 's are obtained by a simple stripping method beginning at the long cooling time end. Semi-log slopes ($\Delta \log FX / \Delta t$) where (t, FX) are the points to be fitted, and coefficients are calculated for pairs of points beginning with the two extreme cooling times. The contributions of the α and λ from a particular pair of points are removed from the remaining points before proceeding to the next pair. If a particular point is within 5% of the value calculated by using the current α and λ , it is considered to be "on the same slope" and is not used in a subsequent α , λ calculation. This stripping process continues automatically in the code until the data points are exhausted, but regions of data requiring negative coefficients as, for example, regions where the slope reverses, are skipped. These regions are subsequently handled with interactive graphics in another routine in the code as described in the example problem below.

The first fitting option does not require initial guesses for either α_i or λ_i , but input values for the λ_i are required for the second option. The method used in this single-parameter fit, that is, a least-squares fit of the α_i 's given adequately chosen λ_i 's, is described in Ref. 5. The λ_i 's can be taken from previously obtained fits for a similar problem; gamma-decay energy spectra for a different set of yields, for example; or the reciprocals of a number of cooling times taken over the range of interest can be used for input λ_i 's. The second option must be used if the data to be fit is for a finite irradiation time, as the first option only works for a pulse. Note that option 2 is not too efficient; and, as a matter of fact, this option should only be used if it is impossible to use either options 1 or 3.

In the third and final option, a non-linear least-squares routine⁶ is used. This routine requires fairly good guesses for both the α_i 's and λ_i 's in order to get good results. These can be obtained either from previous fits with similar shapes or from first running options one or perhaps two. As would be expected, running time for this option is an order of magnitude or more greater than the running time for options one and two, incurring that much greater expense. It is necessary, however, to exercise this option if fits to within a few per cent over large cooling time ranges (over about ten decades) are desired.

III. INPUT AND SAMPLE PROBLEMS

A description of the overlay structure and a listing of the FITPULS code is contained in Appendix A. A description of the FITPULS input specifications is given in Table I. Note that the input description given in Ref. 1 is now obsolete, as also is the description of running a sample problem.

As the first sample problem, consider a multigroup collapse of the PEFPYD data for the aggregate decay-energy gamma spectra of fission products produced by a pulse (10^{-4} s irradiation time) of thermal neutrons on ^{235}U . (MAT = 1261, MF=80, MT=803, see Table II for definition of MAT, MF, and MT numbers in PEFPYD.) The PEFPYD data used in this problem were processed from a CINDER-10 output run for a cooling time range from 0.0 to 10^{10} s in six time steps per decade. We shall specify a cooling time range of 0.1 to 10^9 s for this example and a broad-group structure containing groups 1-22 of the LASL decay energy-group structure shown in Table III.⁷ The group structure is truncated at group 22 since the PEFPYD library contains insufficient spectral data above 7 MeV to obtain realistic fits.

In this first example, we choose the units of MeV per fission-second and choose to use the first fitting option for the first pass, which calls for the use of interactive graphics. This is done by setting the input as follows.

Input to Program FITPULS

```
Card 1      NPUN = 20
            IRAD = 0
            NCORS = 0
            NIAPL = 1
```

Input to Subroutine CORSBIN

```
Card 1A     MAT1 = 1261
            MF1 = 80
            MT1 = 803
            MEVU = 0
```

TABLE I

FITPULS INPUT SPECIFICATIONS

<u>Card No.</u>	<u>Format</u>	<u>Variable</u>	<u>Comment</u>
1	12I6	NPUN	Set NPUN = 7 if rebinned data file wanted; otherwise set to 20.
		IRAD	Set IRAD = 0 for regular pulse fit. Set IRAD = 1 to reduce finite irradiation data to pulse.
		NCORS	Set NCORS = 0 to call subroutine CORSBIN. Set NCORS = 1 for no call, i.e., if input data is not to be rebinned, which is usually the case for fitting experimental data (IRAD = 1).
		NIAPL	Set NIAPL = 1 if first fitting option using interactive graphics is desired. Set NIAPL = 0 if second or third option using file 7 output from previous problem is desired. Otherwise, set NIAPL = -1.
(Input continued in OVLAY1)			
2	8A10	TITL(I)	80 character title, if TITL(1) = SELECT, subroutine SELECT is called and this input goes here (see SELECT input). If TITL(1) = DO NOT GO, program stops.
3	12I6	IPROB	Problem No. Make negative if fit is to be made in segments. See conditional input below.
		NTOTER	Option to read experimental data. See subroutine RUNTOTS.
		NPUN	Flag for file 7 output. Set equal to 7 if file 7 output is desired, equal to 20 if file 7 output is not desired. In general file 7 output is needed for subsequent runs.
		NSTEP	Flag to call subroutine DHFIT, which calls the routine STEPIT that performs a non-linear least-squares fit. Routine usually not called until a couple of passes are made to get a coarse adjustment of the parameters using more rapid options. Set equal to zero if DHFIT is not desired,

otherwise set to 1. Also note below option for calling DHFIT by group.

		NFINL	Flag for option to read all parameters for all groups from previous problem. Used when striving for final convergence. Set equal to 1 to activate, otherwise set equal to zero. See conditional input below.
4	6E12.5	DIFLIM	Maximum per cent deviation allowed in STEPIT. Set high on initial passes and tighten up as desired convergence is approached.
		RUNTIM	Running time. Make fraction of second less than execution time to get file 7 for subsequent run.
		TMIN	Minimum cooling time desired. If set to zero, code will choose minimum cooling time available on data file.
		TMAX	Maximum cooling time desired. If set to zero, code will choose maximum cooling time available on data file.
		CXMIN	Minimum allowed value of decay energy. Set so fit is limited to about 15 decades.
5	12 I6	KKN(I)	Flags for calling for fits by group. If call for a particular group, say Group IG, is desired, set KKN(IG) = IG. If call is not desired, set KKN(IG) = zero.

FITPULS Conditional Input

(Input for subroutine CORSBIN, after card 1 if NCORS = 0)

1A	6I11	MAT1	MAT-No. of desired fissioning nuclide.
		MF1	MF desired (incident energy type).
		MT1	MT desired (particle/photon data type).
		MEVU	MEVU = 0, units are in MeV/fiss-s. MEVU = 1, units are in particles/fiss-s.
2A	6I11	NE	No. of desired broad groups + 1.
3A	6E11.4	EB(I)	Energy bounds in MeV, including lower and upper bounds. Read low to high energy.

(Input for subroutine SELECT, after card 2 if TITL(1) = SELECT)

1B	12I6	ITS,ITP	No. of time steps desired, indexes of desired time steps. SELECT used if one wishes to fit a subset of particular data file, and this input follows the title card.
----	------	---------	---

(Input for subroutine RUNTOTS, after card 2 if NTOTER = 1)

The read statements in this subroutine should be changed to conform with format in which data is received. See subroutine.

If NIAPL = 0 or NFIN = 1, file 7 output from a previous problem must be attached after card 5. This file, in an ENDF-like format, contains alphas and lambdas for all groups.

(Input for subroutine TRMSEE, after file 7 output and for each group IG where KKN(IG) = -IG)

1C	12I6	MLT	Number of parameters to be changed.
2C	I6	L	Time step number of parameters to be changed.
	E12.5	ALF(K,L)	New value of alpha
	E12.5	ALAM(K,L)	New value of lambda
3C	12I6	LT	No. of terms to be removed.
		LTM(I)	Term nos. of terms removed.

IPROB set negative allows the data for the groups to be fitted in several segments, and card 6 is read after card 5.

6	12I6	NSEG	No. of segments plus 1.
		NS(I)	Breakpoints of segments.

(Input for subroutine PULSFIT, after card 5 or 6 if NIAPL = -1.)

1D	12I6	LWT	Weight function desired in single parameter fit. If LWT = 0, weight function = 1. If LWT = 2, weight function = 1/FX. If LWT = 2, weight function = $1/FX^2$. If LWT = 3, weight function = $1/FX^{1.5}$. (Here, FX = MeV/fiss-s values to be fitted,)
		KTRM	No. of lambdas to be read in,
		IPRT	Print flag; if IPRT = 1, print A matrix. If IPRT = 0, no print.

2D

12I6

IWANT

Select lambdas wanted by position number.
If all are to be retained, as in a first
pass, set equal to zero.

KCAL(L)

Position nos. of lambdas to be kept. Do
not enter if IWANT = 0.

TABLE II

DEFINITION OF MAT, MF, MT NUMBERS USED IN PEPYD

- MAT: Mat-No. of target nucleus, same as in ENDF/B.
- MF: File No., used to identify energy type of incident neutron, defined as follows:
- MF=80 - fission induced by thermal neutrons.
 - MF=81 - fission induced by fast neutrons.
 - MF=82 - fission induced by high-energy (14-MeV) neutrons.
- MT: Section number used to describe data contents of the sections. MT numbers are as follows:
- MT=801 - delayed energy/fission for $\beta^- + \gamma$ summed over all fission products.
 - MT=802 - delayed energy/fission for β^- summed over all fission products.
 - MT=803 - delayed energy/fission for γ summed over all fission products.
 - MT=811 - delayed energy/fission for $\beta^- + \gamma$ summed over all gaseous fission products (halogens plus noble gases).
 - MT=812 - delayed energy/fission for β^- summed over all gaseous fission products.
 - MT=813 - delayed energy/fission for γ summed over all gaseous fission products.
 - MT=821 - delayed energy/fission for $\beta^- + \gamma$ summed over the noble gas fission products.
 - MT=822 - delayed energy/fission for β^- summed over noble gas fission products.
 - MT=823 - delayed energy/fission for γ summed over noble gas fission products.
 - MT=831 - delayed energy/fission for $\beta^- + \gamma$ summed over halogen fission products.
 - MT=832 - delayed energy/fission for β^- summed over halogen fission products.
 - MT=833 - delayed energy/fission for γ summed over halogen fission products.

TABLE III

LASL GROUP STRUCTURE FOR DECAY ENERGY

<u>Group No.</u>	<u>E-Low (MeV)</u>	<u>E-High (MeV)</u>	<u>Delta-E (MeV)</u>
1	0.00000	0.01000	0.01000
2	0.01000	0.10000	0.09000
3	0.10000	0.30000	0.20000
4	0.30000	0.40000	0.10000
5	0.40000	0.50000	0.10000
6	0.50000	0.70000	0.20000
7	0.70000	0.90000	0.20000
8	0.90000	1.00000	0.10000
9	1.00000	1.12500	0.12500
10	1.12500	1.33000	0.20500
11	1.33000	1.50000	0.17000
12	1.50000	1.66000	0.16000
13	1.66000	1.87500	0.21500
14	1.87500	2.00000	0.12500
15	2.00000	2.33300	0.33300
16	2.33300	2.66600	0.33300
17	2.66600	3.00000	0.33400
18	3.00000	3.50000	0.50000
19	3.50000	4.00000	0.50000
20	4.00000	5.00000	1.00000
21	5.00000	6.00000	1.00000
22	6.00000	7.00000	1.00000
23	7.00000	8.00000	1.00000
24	8.00000	9.00000	1.00000
25	9.00000	10.00000	1.00000

Card 2A NE = 23

Card 3A (Group bounds from Table III)

Input to OVLAY1

Card 2 Title Card

Card 3 IPROB = 1
 NTOTER = 0
 NPUN = 7
 NSTEP = 0
 NFINL = 0

Card 4 DIFLIM = 5.0 (used in second pass)
 RUNTIM = 295.0 (used in second pass)
 TMIN = 0.1
 TMAX = 1.0E+9
 GXMAX = 1.0E-21

Card 5 KKN(K) = group numbers, 1-22

If the first fitting option is specified as in this example (NIAPL=1), the code must be run from a graphics terminal so that displayed intermediate results can be viewed and acted upon. Although all groups are treated interactively, for purposes of illustration we will discuss the interactive graphics operation for only two groups, namely 12 and 16.

First, consider the fitting for group 12. Figure 1 shows the result of a fit in which only positive coefficients are allowed, which can be done by not entering data points requested from interactive graphics. In the figure, six point per decade data from the PEFPYD library are represented by asterisks; the curve computed from the calculated parameters is represented by a solid line. Note that the fit overshoots in the region 6×10^4 to 4×10^5 s cooling time. As is evident from the figure, negative coefficients are needed in this region to correctly represent the reverse in slope. Table IV, taken from the code output File 20, shows the actual numerical values plotted in Fig. 1, and in addition, the per-cent difference between the computed and original values. As can be seen from this table, the difference exceeds 100% at a cooling time of 1×10^5 s. Note also in Table IV that the first three points overshoot by more than 10%. Parameters calculated using the first fitting option but bypassing the interactive graphics feature are the first 12 in Table V under the heading "Option I" values.

The first figure that appears on the graphics terminal screen for this group (12) is reproduced as Fig. 2. This is for the first "region" that contains at least three contiguous points for which differences between computed and original values exceed 10%, and these differences are plotted on a log scale against the representative cooling times on a linear scale. A vector is drawn between the last two points to aid the eye in selecting those points to be used in computing the parameters. Note in Fig. 2 that points 1 and 3 were selected. The code then computes the slope $[\Delta(\log FX)/\Delta t]$ between the selected points (1 and 3), and using this slope next computes the coefficients for the selected points (1,3) and each point in between (2). Finally, an average coefficient is calculated for this set by simply averaging the coefficients. The resulting α and λ are number 13 in Table V.

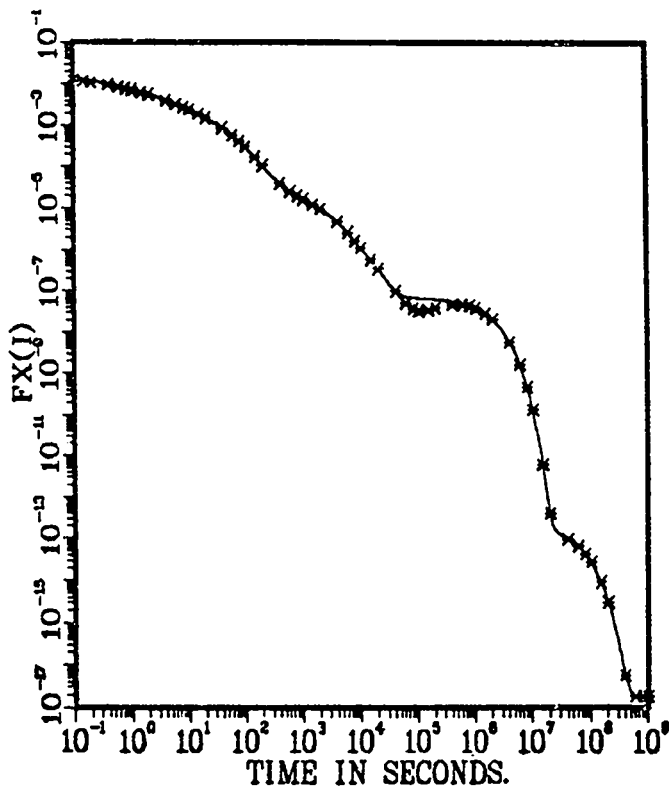


Fig. 1.

Fit without interactively generated parameters for group 12.

GROUP, 12 SET, 1
 enter pair of points to calculate parameters
 1,3

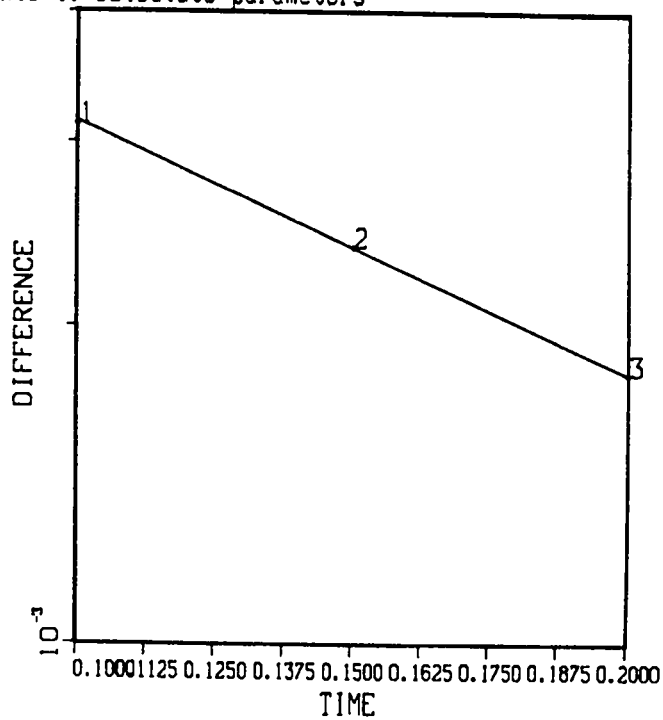


Fig. 2.

First display for group 12.

TABLE IV

GROUP 12 RESULTS WITH INTERACTIVE GRAPHICS BYPASSED

Step No.	Time	Original Value	Computed Value	Per cent Difference
1	1.00000E-01	1.18510E-02	1.49678E-02	-2.63002E+01
2	1.50000E-01	1.13322E-02	1.37127E-02	-2.10069E+01
3	2.00000E-01	1.08687E-02	1.26723E-02	-1.65949E+01
4	4.00000E-01	9.43458E-03	9.96329E-03	-5.60400E+00
5	6.00000E-01	8.45178E-03	8.55738E-03	-1.24948E+00
6	8.00000E-01	7.73742E-03	7.73742E-03	0.
7	1.00000E+00	7.18978E-03	7.18978E-03	0.
8	1.50000E+00	6.22239E-03	6.28343E-03	-9.80949E-01
9	2.00000E+00	5.55506E-03	5.63502E-03	-1.43944E+00
10	4.00000E+00	4.02138E-03	4.04420E-03	-5.67343E-01
11	6.00000E+00	3.22970E-03	3.22970E-03	-3.93727E-09
12	8.00000E+00	2.73656E-03	2.73656E-03	-5.07125E-13
13	1.00000E+01	2.39237E-03	2.39485E-03	-1.03424E-01
14	1.50000E+01	1.84014E-03	1.84179E-03	-8.93647E-02
15	2.00000E+01	1.49834E-03	1.49846E-03	-7.90612E-03
16	4.00000E+01	8.43702E-04	8.46443E-04	-3.24903E-01
17	6.00000E+01	5.63688E-04	5.64056E-04	-6.52599E-02
18	8.00000E+01	4.04582E-04	4.04602E-04	-4.90849E-03
19	1.00000E+02	3.03230E-04	3.04000E-04	-2.53772E-01
20	1.50000E+02	1.67961E-04	1.68900E-04	-5.58601E-01
21	2.00000E+02	1.06700E-04	1.06783E-04	-7.76052E-02
22	4.00000E+02	3.86301E-05	3.92374E-05	-1.57219E+00
23	6.00000E+02	2.47972E-05	2.50615E-05	-1.06582E+00
24	8.00000E+02	1.91685E-05	1.91705E-05	-1.04180E-02
25	1.00000E+03	1.60403E-05	1.60404E-05	-4.68689E-04
26	1.50000E+03	1.18872E-05	1.19483E-05	-5.14086E-01
27	2.00000E+03	9.51152E-06	9.51636E-06	-5.09075E-02
28	4.00000E+03	4.62256E-06	4.57756E-06	9.73388E-01
29	6.00000E+03	2.57195E-06	2.56523E-06	2.61617E-01
30	8.00000E+03	1.61457E-06	1.61471E-06	-8.79782E-03
31	1.00000E+04	1.11886E-06	1.11887E-06	-7.91176E-04
32	1.50000E+04	5.72884E-07	5.76982E-07	-7.15375E-01
33	2.00000E+04	3.46863E-07	3.49321E-07	-7.08610E-01
34	4.00000E+04	9.85013E-08	9.85017E-08	-3.75236E-04
35	6.00000E+04	5.10354E-08	7.12370E-08	-3.95835E+01
36	8.00000E+04	3.71013E-08	6.75729E-08	-8.21309E+01
37	1.00000E+05	3.30575E-08	6.64363E-08	-1.00972E+02 a
38	1.50000E+05	3.42913E-08	6.43559E-08	-8.76739E+01
39	2.00000E+05	3.85599E-08	6.23740E-08	-6.17589E+01
40	4.00000E+05	4.80559E-08	5.50389E-08	-1.45310E+01
41	6.00000E+05	4.75911E-08	4.85664E-08	-2.04917E+00
42	8.00000E+05	4.37704E-08	4.28550E-08	2.09144E+00
43	1.00000E+06	3.91830E-08	3.78153E-08	3.49055E+00
44	1.50000E+06	2.87345E-08	2.76587E-08	3.74380E+00
45	2.00000E+06	2.09018E-08	2.02301E-08	3.21381E+00
46	4.00000E+06	5.90419E-09	5.78983E-09	1.93694E+00
47	6.00000E+06	1.67887E-09	1.65715E-09	1.29384E+00
48	8.00000E+06	4.78413E-10	4.74402E-10	8.38398E-01
49	1.00000E+07	1.36585E-10	1.35904E-10	4.98015E-01
50	1.50000E+07	6.11894E-12	6.11894E-12	-1.68979E-12
51	2.00000E+07	4.15253E-13	4.15253E-13	-3.89061E-12
52	4.00000E+07	9.67216E-14	1.00144E-13	-3.53809E+00
53	6.00000E+07	6.55882E-14	6.48295E-14	1.15672E+00
54	8.00000E+07	4.28427E-14	4.19710E-14	2.03464E+00
55	1.00000E+08	2.75448E-14	2.71745E-14	1.34410E+00
56	1.50000E+08	9.19704E-15	9.17292E-15	2.62293E-01
57	2.00000E+08	3.10432E-15	3.10432E-15	-4.06587E-13
58	4.00000E+08	5.79643E-17	5.79643E-17	0.
59	6.00000E+08	1.85988E-17	1.86113E-17	-6.73276E-02
60	8.00000E+08	1.80882E-17	1.80948E-17	-3.67576E-02
61	1.00000E+09	1.80799E-17	1.80800E-17	-4.74956E-04

a - maximum difference

TABLE V

EXAMPLE 1: FIT TO SIX PT/DECADE DATA

	Parameters from Option I		Parameters from Option III	
	<u>Alpha</u>	<u>Lambda</u>	<u>Alpha</u>	<u>Lambda</u>
1	1.8122E-17	2.3004E-12	1.8116E-17	2.2465E-12
2	2.3896E-13	2.1747E-08	2.3935E-13	2.1747E-08
3	7.0687E-08	6.2555E-07	7.1024E-08	6.2555E-07
4	2.5966E-06	1.1189E-04	2.0730E-06	1.1517E-04
5	1.6345E-05	4.4012E-04	1.6952E-05	4.3706E-04
6	9.4182E-06	1.3878E-03	8.3936E-06	1.3878E-03
7	1.2285E-04	5.0707E-03	1.2247E-04	5.0707E-03
8	9.9422E-04	1.6398E-02	9.9433E-04	1.6398E-02
9	1.3648E-03	4.8550E-02	1.3623E-03	4.8550E-02
10	2.3382E-03	1.4595E-01	2.3394E-03	1.4595E-01
11	4.3989E-03	5.2611E-01	4.4170E-03	5.3718E-01
12	9.0820E-03	4.1653E+00	9.1106E-03	4.1350E+00
13	-5.3861E-03	5.4701E+00	-5.4596E-03	5.5756E+00
14	-6.0494E-08	4.6613E-06	-6.0839E-08	4.7414E-06
15	3.0316E-07	4.1238E-05	3.0316E-07	4.1238E-05

Since the first region contained only three points, the next picture displayed on the graphics terminal for group 12 is for "region" or "set" number 2, which is shown in Fig. 3. This set contains five points from 6×10^4 to 2×10^5 s cooling time. Note that points 4 and 5 were selected for the calculation, and the resulting α and λ are numbered 14 in Table V under Option I values.

In the next picture displayed, the remaining three points from set 2 are plotted after removal of the contributions from the α and λ computed from points 4 and 5. This display is reproduced as Fig. 4. Although not evident from the figure, the negative coefficient calculated from points 4 and 5 will cause the fit to undershoot, so the coefficient calculated from points selected in Fig. 4 will be positive. Note that points 1 and 2 were selected, and the resulting parameters are numbered 15 in Table V under Option I values.

When in the interactive graphics mode, the code will automatically display the results of the fit compared with the original input data. This graphical comparison is shown in Fig. 5, and numerical values as well as per-cent differences are given in Table VI. Note that the maximum difference has been reduced from 101 to 23%, and that it now occurs at 2×10^4 s cooling time. These results are accurate enough to proceed to the second pass in which the third option, that for a non-linear least-squares fit, is specified.

Only minor input changes are needed to run the second pass for the non-linear least-squares fit, namely, set NIAPL=0, NSTEP=1, and NFINL=1. Also File 7 from the first pass must be attached to the input after card 5. Note that for this pass DIFLIM = 5.0 was specified. This means that the non-linear least-squares routine STEPIT will attempt to adjust the α_i and λ_i for a particular group until no calculated point differs from the input data point by more than 5% before proceeding to the next group. If the input guesses for α_i and λ_i supplied by the user are inadequate, STEPIT will continue to adjust the parameters until a minimum chi-square is reached, after which the calculation will proceed to the next group.

Figure 6 shows the per-cent deviation of the fitted data from the original input data. Note that it is within the input specification of 5% over the whole of the fitted cooling-time range. Figure 7 is a final plot of the fit for group 12.

GROUP, 12 SET, 2
enter pair of points to calculate parameters
? 4,5

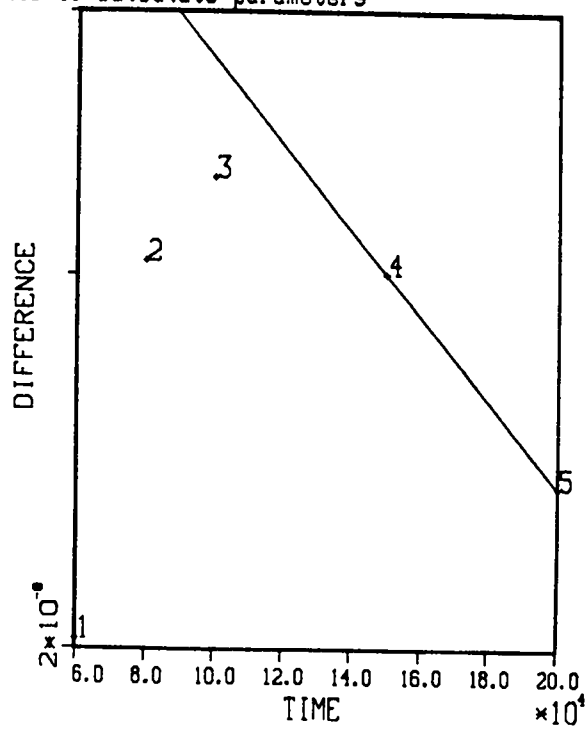


Fig. 3.
Second display for group 12.

GROUP, 12 SET, 2
enter pair of points to calculate parameters
? 1,2

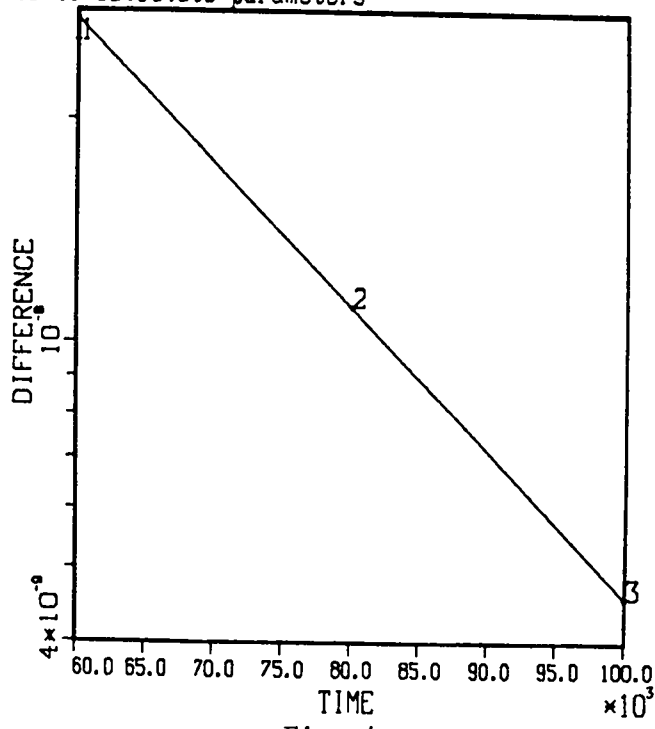


Fig. 4.
Third display for group 12.

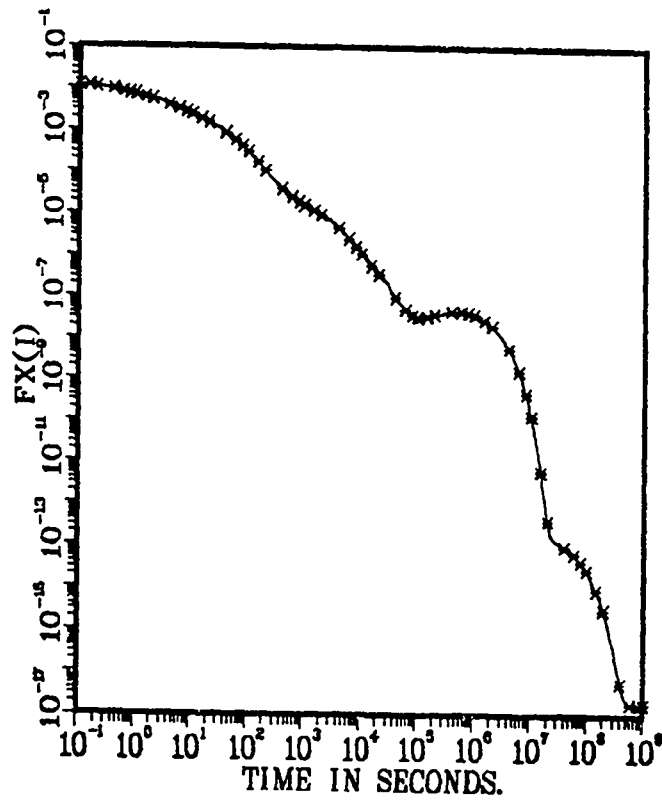


Fig. 5.
First pass fit for group 12.

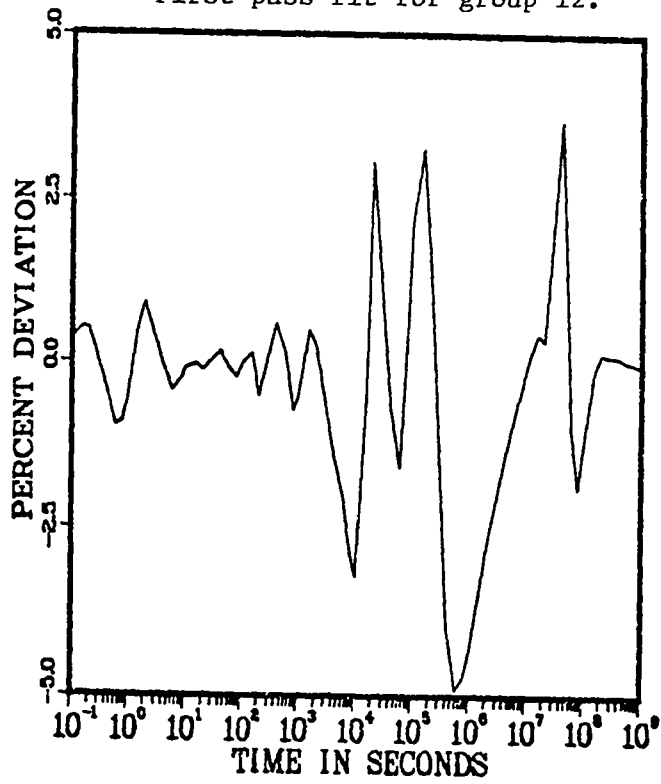


Fig. 6.
Deviation from input for group 12.

TABLE VI

GROUP 12 RESULTS AFTER USING INTERACTIVE GRAPHICS

Step No.	Time	Original Value	Computed Value	Per cent Difference
1	1.00000E-01	1.18510E-02	1.18512E-02	-2.04759E-03
2	1.50000E-01	1.13322E-02	1.13420E-02	-8.63541E-02
3	2.00000E-01	1.08687E-02	1.08689E-02	-2.23264E-03
4	4.00000E-01	9.43458E-03	9.35955E-03	7.95284E-01
5	6.00000E-01	8.45178E-03	8.35537E-03	1.14073E+00
6	8.00000E-01	7.73742E-03	7.66993E-03	8.72224E-01
7	1.00000E+00	7.18978E-03	7.16734E-03	3.12085E-01
8	1.50000E+00	6.22239E-03	6.28220E-03	-9.61195E-01
9	2.00000E+00	5.55506E-03	5.63517E-03	-1.44209E+00
10	4.00000E+00	4.02138E-03	4.04444E-03	-5.73376E-01
11	6.00000E+00	3.22970E-03	3.22994E-03	-7.51114E-03
12	8.00000E+00	2.73656E-03	2.73680E-03	-8.86378E-03
13	1.00000E+01	2.39237E-03	2.39509E-03	-1.13562E-01
14	1.50000E+01	1.84014E-03	1.84203E-03	-1.02542E-01
15	2.00000E+01	1.49834E-03	1.49870E-03	-2.40851E-02
16	4.00000E+01	8.43702E-04	8.46685E-04	-3.53606E-01
17	6.00000E+01	5.63688E-04	5.64298E-04	-1.08179E-01
18	8.00000E+01	4.04582E-04	4.04843E-04	-6.46454E-02
19	1.00000E+02	3.03230E-04	3.04241E-04	-3.33395E-01
20	1.50000E+02	1.67961E-04	1.69140E-04	-7.01988E-01
21	2.00000E+02	1.06700E-04	1.07023E-04	-3.02747E-01
22	4.00000E+02	3.86301E-05	3.94753E-05	-2.18780E+00
23	6.00000E+02	2.47972E-05	2.52969E-05	-2.01520E+00
24	8.00000E+02	1.91685E-05	1.94035E-05	-1.22620E+00
25	1.00000E+03	1.60403E-05	1.62711E-05	-1.43869E+00
26	1.50000E+03	1.18872E-05	1.21732E-05	-2.40603E+00
27	2.00000E+03	9.51152E-06	9.73558E-06	-2.35572E+00
28	4.00000E+03	4.62256E-06	4.77524E-06	-3.30301E+00
29	6.00000E+03	2.57195E-06	2.74311E-06	-6.65453E+00
30	8.00000E+03	1.61457E-06	1.77440E-06	-9.89917E+00
31	1.00000E+04	1.11886E-06	1.26184E-06	-1.27792E+01
32	1.50000E+04	5.72884E-07	6.83888E-07	-1.93764E+01
33	2.00000E+04	3.46863E-07	4.27098E-07	-2.31315E+01 ^a
34	4.00000E+04	9.85013E-08	1.06548E-07	-8.16881E+00
35	6.00000E+04	5.10354E-08	5.10354E-08	0.
36	8.00000E+04	3.71013E-08	3.71013E-08	0.
37	1.00000E+05	3.30575E-08	3.33870E-08	-9.96824E-01
38	1.50000E+05	3.42913E-08	3.49155E-08	-1.82011E+00
39	2.00000E+05	3.85599E-08	3.86393E-08	-2.05913E-01
40	4.00000E+05	4.80559E-08	4.56642E-08	4.97680E+00
41	6.00000E+05	4.75911E-08	4.48759E-08	5.70529E+00
42	8.00000E+05	4.37704E-08	4.14022E-08	5.41053E+00
43	1.00000E+06	3.91830E-08	3.72434E-08	4.95012E+00
44	1.50000E+06	2.87345E-08	2.76031E-08	3.93732E+00
45	2.00000E+06	2.09018E-08	2.02247E-08	3.23968E+00
46	4.00000E+06	5.90419E-09	5.78983E-09	1.93694E+00
47	6.00000E+06	1.67887E-09	1.65715E-09	1.29384E+00
48	8.00000E+06	4.78413E-10	4.74402E-10	8.38398E-01
49	1.00000E+07	1.36585E-10	1.35904E-10	4.98015E-01
50	1.50000E+07	6.11894E-12	6.11894E-12	-1.68979E-12
51	2.00000E+07	4.15253E-13	4.15253E-13	-3.89061E-13
52	4.00000E+07	9.67216E-14	1.00144E-13	-3.53809E+00
53	6.00000E+07	6.55882E-14	6.48295E-14	1.15672E+00
54	8.00000E+07	4.28427E-14	4.19710E-14	2.03464E+00
55	1.00000E+08	2.75448E-14	2.71745E-14	1.34410E+00
56	1.50000E+08	9.19704E-15	9.17292E-15	2.62293E-01
57	2.00000E+08	3.10432E-15	3.10432E-15	-4.06587E-13
58	4.00000E+08	5.79643E-17	5.79643E-17	0.
59	6.00000E+08	1.85988E-17	1.86113E-17	-6.73276E-02
60	8.00000E+08	1.80882E-17	1.80948E-17	-3.67576E-02
61	1.00000E+09	1.80799E-17	1.80800E-17	-4.74956E-04

a - maximum difference

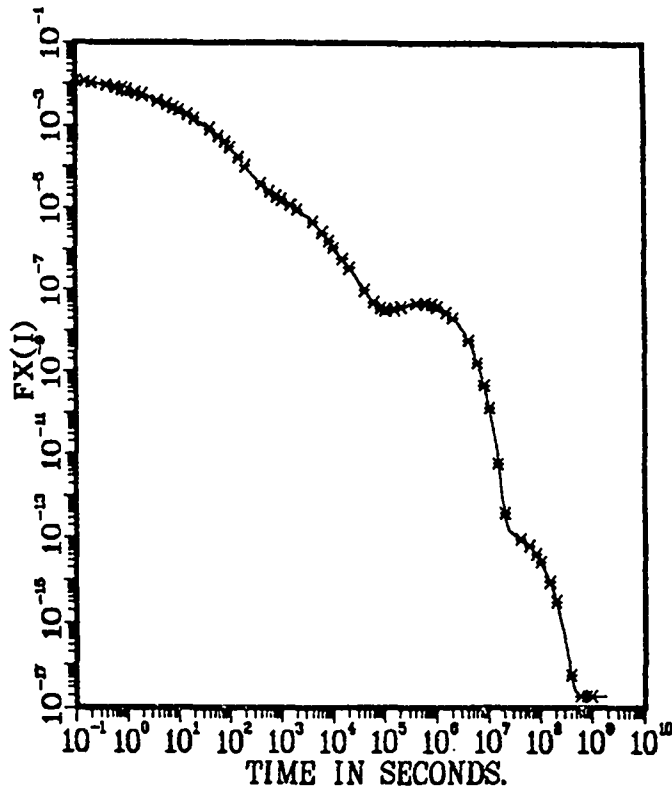


Fig. 7.
Five percent fit for group 12.

It would seem that from the above description of the fitting for group 12 that interactive graphics are not needed and that the whole process could be easily automated. The example of the fitting for group 16, however, makes the need for the interactive graphics much clearer. Figure 8 shows the fit with the interactive graphics bypassed. At first sight, it appears that the fitting in the region 10^5 to 10^7 s cooling time would be similar to that for group 12 except that the set contains 13 rather than 5 points. If we proceed as we did in the fitting for group 5, we would choose the last two points for the parameter calculation that appear in each display of the set (Fig. 9-12). The result is seen in Fig. 13, which could not be fit with sufficient accuracy in STEPIT before this routine converged to minimum (high) chi-square.

Now consider a second attempt at obtaining a fit for group 16 (Fig. 14-17). Instead of choosing points 12 and 13 in the first display, we choose points 11 and 12. As a result, we obtain a first pass fit (Fig. 18) that can easily be brought to within the desired 5% accuracy by the non-linear least-squares routine (Figs. 19 and 20).

The parameters for the fits obtained for all 22 groups are given in Appendix B. The parameters for fits obtained for MAT 1261, MF=80, MT=802 (betas) are also given in Appendix B.

As a second example to illustrate the operation of the FITPULS code, consider an Oak Ridge National Laboratory (ORNL) irradiation experiment,⁸ the data for which are shown in Table VII. These experiments, in which ^{239}Pu was irradiated with thermal neutrons, were performed for three irradiation times, namely, 1, 5, and 100 s, and beta and gamma fission-product decay energy were measured. Note that other experiments at other laboratories could also be included in generating a combined pulse function in this example. The input routine RUNTOTS, which was altered to conform to the format in which the experimental data were received, is given in the listing of the code in Appendix A. The formats in the routine are for reading the data as shown in Table VII. Generally, it is more convenient to change the data formats in RUNTOTS than to change the data.

For this particular example, the total decay energy (sum of beta plus gamma) is to be fit and the non-linear least-squares option was chosen on the first pass since a very good guess for the input parameters is available. This is the fit for total decay energy from ^{239}Pu irradiated with a pulse of thermal neutrons as calculated for the ANS standard. These parameters are given in Table VIII under the column labeled "ANS Standard".

The input for this second example is as follows:

Input to Program FITPULS:

Card 1 NPUN = 20
 IRAD = 1
 NCORS = 1
 NIAPL = 0

Input to OVLAY1

Card 2 Title Card

Card 3 IPROB = 1
 NTOTER = 1
 NPUN = 7
 NSTEP = 1
 NFINL = 1

Input to Subroutine RUNTOTS

Card 1A (Data from Table VII)

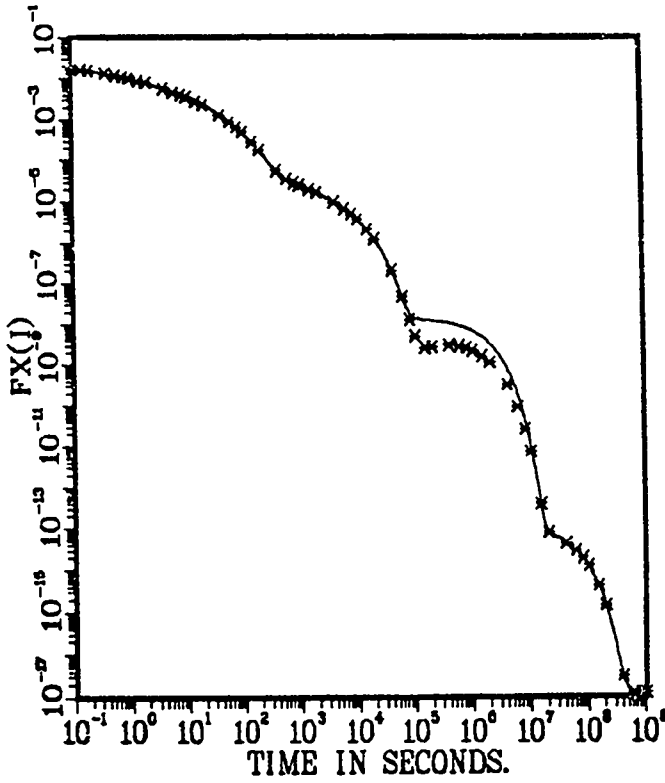


Fig. 8.

Fit without interactive generated parameters for group 16.

GROUP 16 SET, 2

enter pair of points to calculate parameters
? 12,13

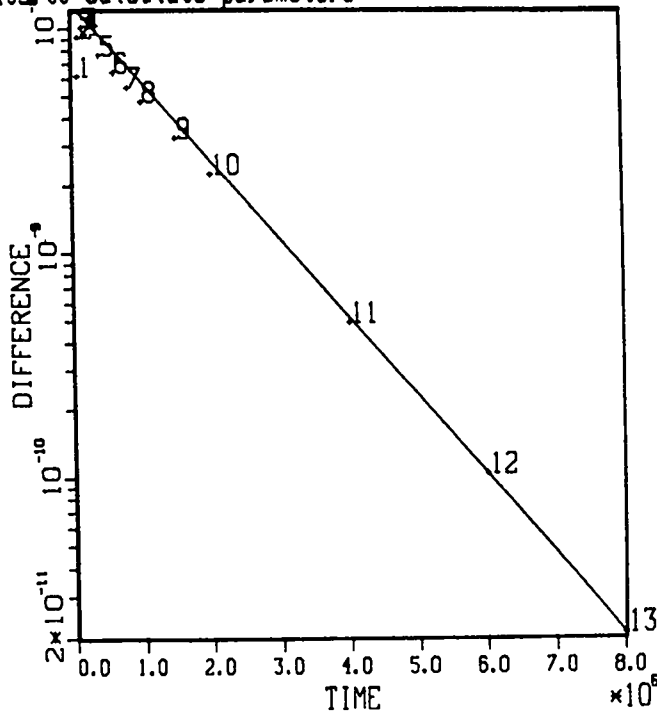


Fig. 9.

First display, first attempt at group 16 fit.

GROUP 16 SET, 2
 enter pair of points to calculate parameters
 ? 10,11

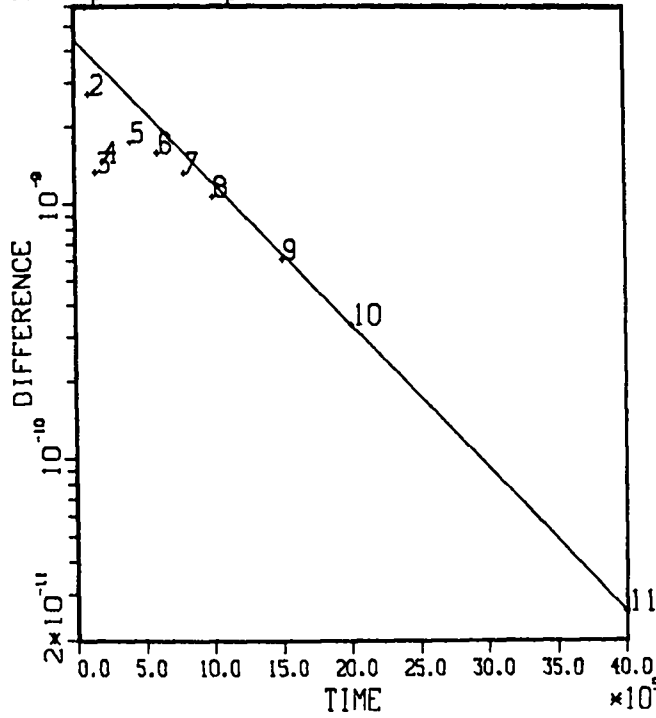


Fig. 10.

Second display, first attempt at group 16 fit.

GROUP 16 SET, 2
 enter pair of points to calculate parameters
 ? 7,8

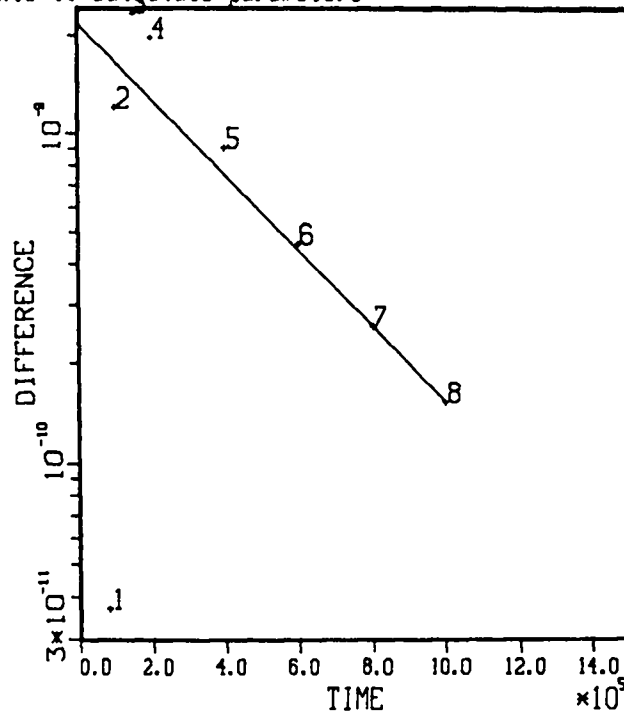


Fig. 11.

Third display, first attempt at group 16 fit.

GROUP 16 SET, 2
 enter pair of points to calculate parameters
 ? 3,4

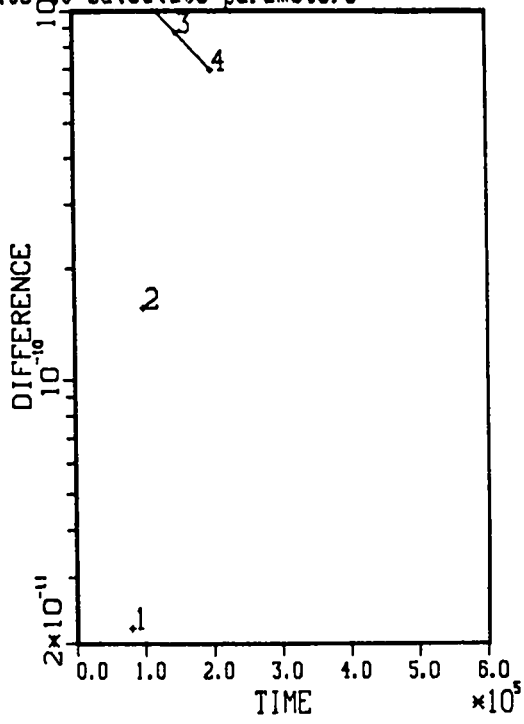


Fig. 12.
 Fourth display, first attempt at group 16 fit.

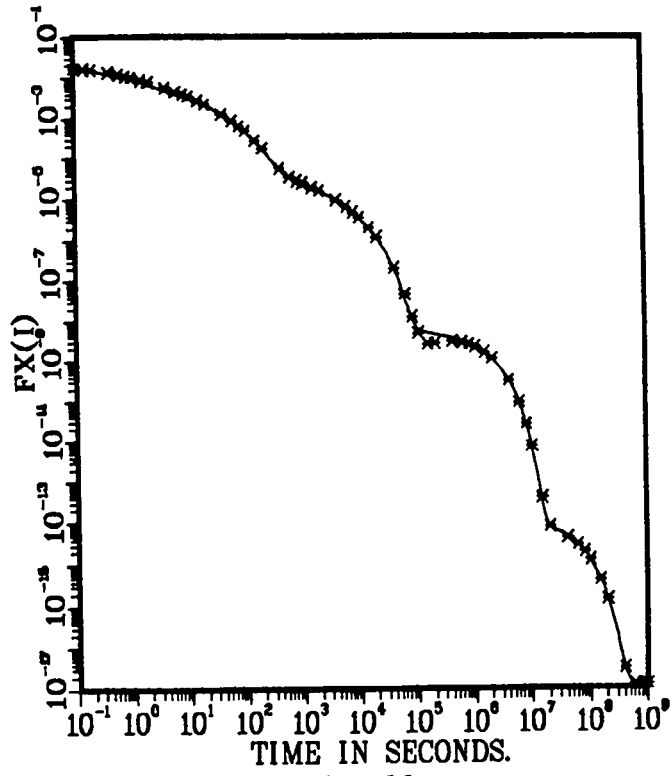


Fig. 13.
 Unsuccessful first attempt at group 16 fit.

GROUP 16 SET, 2
 enter pair of points to calculate parameters
 ? 11,12

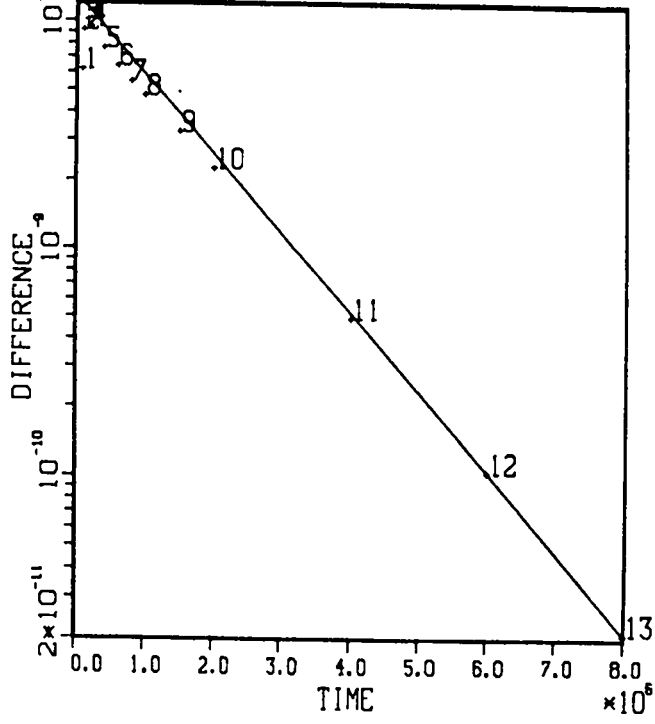


Fig. 14.
 First display, second attempt at group 16 fit.

GROUP 16 SET, 2
 enter pair of points to calculate parameters
 ? 7,8

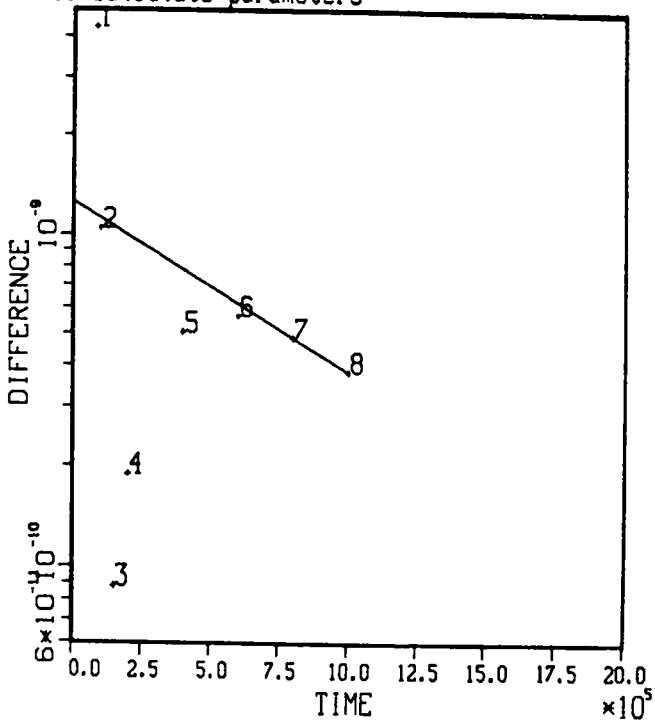


Fig. 15.
 Second display, second attempt at group 16 fit.

GROUP, 16 SET, 2
 enter pair of points to calculate parameters
 ? 4,5

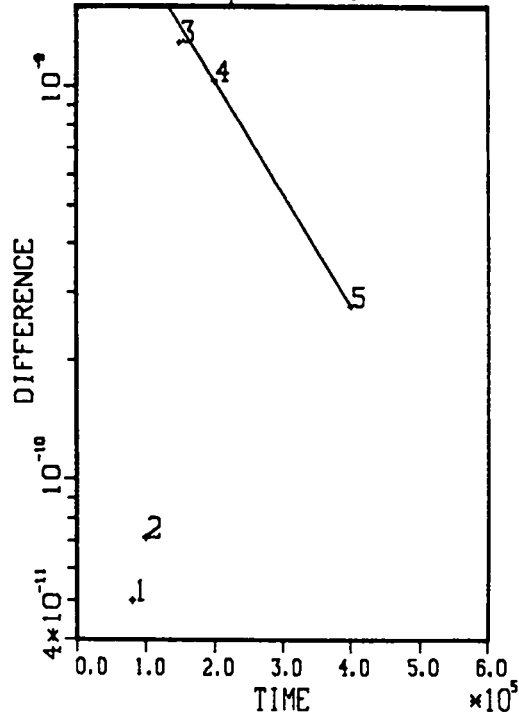


Fig. 16.

Third display, second attempt at group 16 fit.

GROUP, 16 SET, 2
 enter pair of points to calculate parameters
 ? 1,3

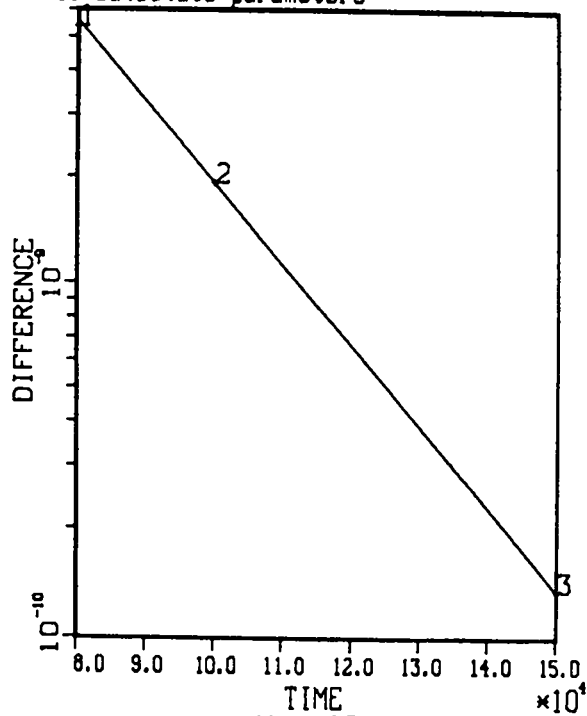


Fig. 17.

Fourth display, second attempt at group 16 fit.

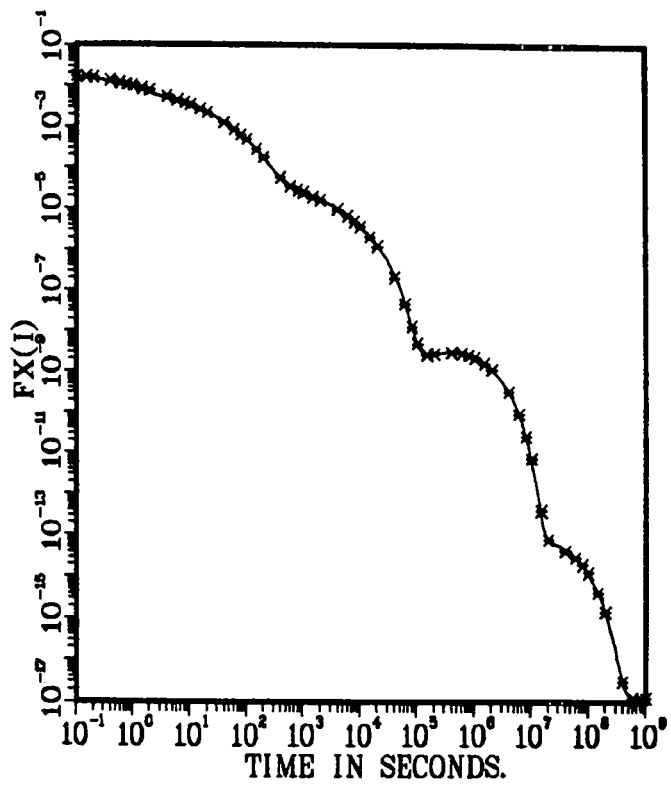


Fig. 18.
Successful first pass group 16 fit.

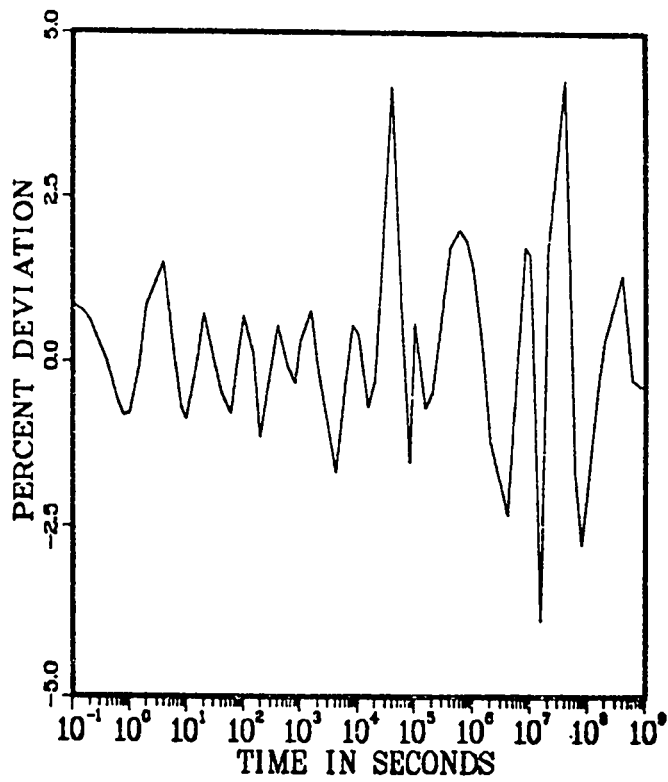


Fig. 19.
Deviation from input for group 16.

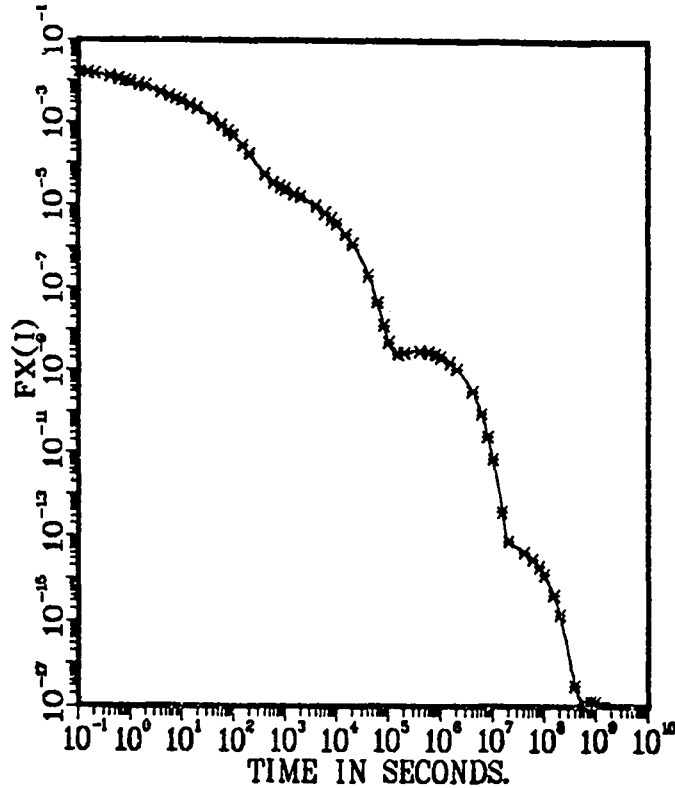


Fig. 20.

Five percent fit for group 16.

Input to OVLAY1 cont'd.

```
Card 4      DIFLIM = 1.0
            RUNTIM = 295.0
            TMIN  = 2.2
            TMAX  = 1.195+4
            GXMAX = 0.
```

```
Card 5      KKN(1) = 1
```

The parameters for the ANS standard shown in Table VIII were placed in an ENDF-like format and attached after card 5.

The problem ran to a minimum chi-square convergence of 0.00175 before the input accuracy of 1% could be achieved. The results are given in Table IX, and, as can be seen from this table, the largest per-cent difference is 1.37% occurring at a cooling time of 20.2 s, so the experiment seems to be self-consistent to within at least this amount. The resulting parameters are given in Table VIII under the column labeled "ORNL Exp."

It is interesting to compare these results with the 1978-79 ANS 5.1 standard. It should be noted that the ORNL experiment used as Example 2 was one

of three experiments, along with calculated values, considered in formulating the ANS standard. The comparison is shown in Fig. 21. Note that the ORNL experiment lies well within the uncertainty band of the standard.

IV. SUMMARY

This report describes the FITPULS code, and examples are given in which the use of interactive graphics is illustrated. Useful fits for gamma and beta fission-product decay energy spectra in 22 neutron energy groups for ^{235}U fuel irradiated with a pulse of thermal neutrons are given in Appendix B. The fits are given for both units of MeV per fission-second and particles per fission-second.

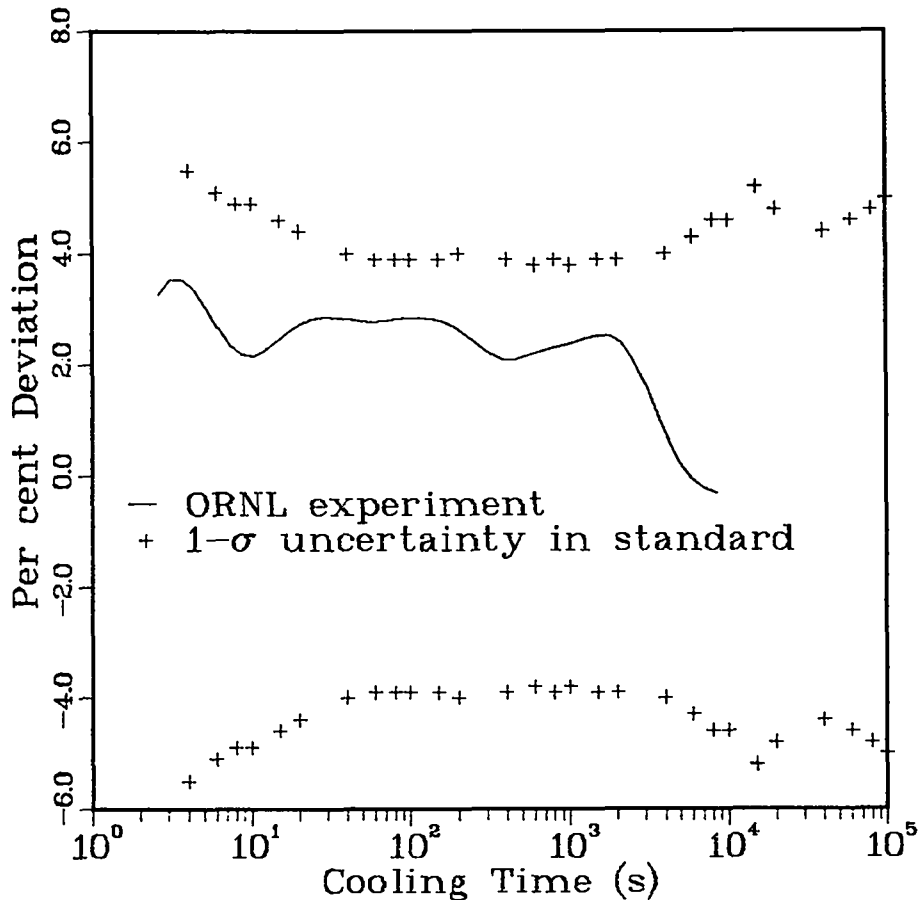


Fig. 21.
ORNL experiment compared to standard.

TABLE VII

ORNL DATA FOR THREE IRRADIATION TIMES OF ^{239}Pu WITH THERMAL NEUTRONS

Irrad Time(s)	Waiting Time(s)	Counting Time(s)	MeV/fiss ^a	
			β	γ
1.0	1.7	1.0	0.1811	0.1346
1.0	2.7	1.0	0.1470	0.1044
1.0	3.7	1.0	0.1211	0.0865
1.0	4.7	2.0	0.1945	0.1380
1.0	6.7	3.0	0.2152	0.1537
1.0	9.7	5.0	0.2438	0.1848
1.0	14.7	5.0	0.1680	0.1362
1.0	19.7	5.0	0.1288	0.1094
1.0	24.7	10.0	0.1905	0.1713
1.0	34.7	10.0	0.1406	0.1321
1.0	44.7	15.0	0.1580	0.1558
1.0	59.7	15.0	0.1208	0.1217
1.0	74.7	15.0	0.0980	0.0986
1.0	90.0	20.0	0.1062	0.1056
1.0	110.0	20.0	0.0849	0.0844
5.0	17.7	5.0	0.1258	0.1086
5.0	22.7	10.0	0.1852	0.1698
5.0	32.7	10.0	0.1363	0.1324
5.0	42.7	15.0	0.1545	0.1550
5.0	57.7	15.0	0.1185	0.1208
5.0	72.7	15.0	0.0949	0.0976
5.0	88.0	20.0	0.1028	0.1049
5.0	108.0	20.0	0.0827	0.0846
5.0	128.0	40.0	0.1279	0.1291
5.0	168.0	60.0	0.1366	0.1375
5.0	228.0	70.0	0.1157	0.1163
5.0	298.0	100.0	0.1210	0.1252
5.0	398.0	200.0	0.1703	0.1805
5.0	598.0	200.0	0.1225	0.1347
5.0	798.0	400.0	0.1741	0.1969
100.0	250.0	100.0	0.1218	0.1272
100.0	350.0	200.0	0.1706	0.1823
100.0	550.0	200.0	0.1232	0.1348
100.0	750.0	400.0	0.1766	0.1984
100.0	1150.0	400.0	0.1228	0.1436
100.0	1550.0	400.0	0.0922	0.1112
100.0	1950.0	500.0	0.0867	0.1089
100.0	2450.0	500.0	0.0653	0.0860
100.0	2950.0	1000.0	0.0917	0.1287
100.0	3950.0	2000.0	0.1071	0.1607
100.0	5950.0	2000.0	0.0631	0.0983
100.0	7950.0	2000.0	0.0439	0.0677
100.0	9950.0	4000.0	0.0617	0.0872

^aSee Ref. 8 for a clarification of this unit.

TABLE VIII

EXAMPLE 2: FIT TO EXPERIMENTAL DATA (^{239}Pu THERMAL FISSION)

Parameters from ANS Standard		Fit to ORNL Exp.	
<u>Alpha</u>	<u>Lambda</u>	<u>Alpha</u>	<u>Lambda</u>
2.0830E-01	1.0020E+01	3.5696E+00	3.5491E+00
3.8530E-01	6.4330E-01	4.1004E-01	7.2551E-01
2.2130E-01	2.1860E-01	2.2288E-01	2.2181E-01
9.4600E-02	1.0040E-01	9.5227E-02	1.0367E-01
3.5310E-02	3.7280E-02	3.4997E-02	3.88334E-02
2.2920E-02	1.4350E-02	2.2816E-02	1.4790E-02
3.9460E-03	4.5490E-03	4.0597E-03	4.7821E-03
1.3170E-03	1.3280E-03	1.3783E-03	1.4102E-03
7.0520E-04	5.3560E-04	7.0010E-04	5.3448E-04
1.4320E-04	1.7300E-04	1.4553E-04	1.7380E-04
1.7650E-05	4.8810E-05	1.7797E-05	4.7344E-05
7.3470E-06	2.0060E-05	7.1997E-06	1.8562E-05
1.7470E-06	8.3190E-06	1.6824E-06	1.9636E-06
5.4810E-07	2.3580E-06	4.3891E-07	2.9475E-07
1.6710E-07	6.4500E-07	1.4408E-07	8.0625E-08
2.1120E-08	1.2780E-07	1.2289E-08	1.5975E-08
2.9960E-09	2.4660E-08	2.8362E-09	3.1109E-09
5.1070E-11	9.3780E-09	3.4834E-11	1.3855E-09
5.7300E-11	7.4500E-10	5.4918E-11	1.5831E-09
4.1380E-14	2.4260E-10	1.1226E-14	3.5460E-10
1.0880E-15	2.2100E-13	9.6156E-13	1.1673E-13
2.4540E-15	2.6400E-14	3.1984E-17	4.0494E-14
7.5570E-17	1.3800E-14	1.7054E-16	9.6888E-15

TABLE IX

FINAL FIT OF ORNL EXPERIMENT

Time	Original Value	Computed Value	Per cent Difference
.2200E+01	.3157E+00	.3158E+00	.2457E-01
.3200E+01	.2514E+00	.2509E+00	-.1963E+00
.4200E+01	.2076E+00	.2083E+00	.3527E+00
.5700E+01	.1663E+00	.1660E+00	-.1213E+00
.8200E+01	.1230E+00	.1232E+00	.1942E+00
.1220E+02	.8572E-01	.8543E-01	-.3377E+00
.1720E+02	.6084E-01	.6089E-01	.7794E-01
.2220E+02	.4764E-01	.4733E-01	-.6593E+00
.2970E+02	.3618E-01	.3573E-01	-.1248E+01
.3970E+02	.2727E-01	.2710E-01	-.6221E+00
.5220E+02	.2092E-01	.2080E-01	-.5785E+00
.6720E+02	.1617E-01	.1612E-01	-.3180E+00
.8220E+02	.1311E-01	.1300E-01	-.7953E+00
.1000E+03	.1059E-01	.1045E-01	-.1362E+01
.1200E+03	.8465E-02	.8454E-02	-.1269E+00
.2020E+02	.2344E+00	.2376E+00	.1368E+01 ^a
.2770E+02	.1775E+00	.1790E+00	.8632E+00
.3770E+02	.1344E+00	.1357E+00	.9736E+00
.5020E+02	.1032E+00	.1041E+00	.8689E+00
.6520E+02	.7977E-01	.8061E-01	.1057E+01
.8020E+02	.6417E-01	.6503E-01	.1348E+01
.9800E+02	.5193E-01	.5224E-01	.6079E+00
.1180E+03	.4183E-01	.4228E-01	.1084E+01
.1480E+03	.3213E-01	.3239E-01	.8367E+00
.1980E+03	.2284E-01	.2292E-01	.3217E+00
.2630E+03	.1657E-01	.1656E-01	-.7113E-01
.3480E+03	.1231E-01	.1236E-01	.3955E+00
.4980E+03	.8770E-02	.8801E-02	.3504E+00
.6980E+03	.6430E-02	.6462E-02	.4997E+00
.9980E+03	.4638E-02	.4640E-02	.5759E-01
.3000E+03	.2490E+00	.2495E+00	.2156E+00
.4500E+03	.1765E+00	.1767E+00	.1560E+00
.6500E+03	.1290E+00	.1295E+00	.4021E+00
.9500E+03	.9375E-01	.9291E-01	-.8932E+00
.1350E+04	.6660E-01	.6672E-01	.1783E+00
.1750E+04	.5085E-01	.5085E-01	.7817E-02
.2200E+04	.3912E-01	.3911E-01	-.1785E-01
.2700E+04	.3026E-01	.3039E-01	.4360E+00
.3450E+04	.2204E-01	.2205E-01	.5006E-01
.4950E+04	.1339E-01	.1330E-01	-.6353E+00
.6950E+04	.8070E-02	.8085E-02	.1868E+00
.8950E+04	.5580E-02	.5591E-02	.2058E+00
.1195E+05	.3723E-02	.3719E-02	-.9974E-01

a - maximum difference

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APPENDIX A

ORGANIZATION AND LISTING OF FITPULS CODE

The FITPULS code is organized into a main program (FITPULS) and three overlays (subroutine OVLAY1, subroutine OVLAY2, and subroutine OVLAY3). The purpose of the main program is to read initial input and to call desired overlays.

The purpose of OVLAY1 is to read additional input data and to rebin decay-energy input data if desired. This is done in subroutines CORSBIN and REBIN. OVLAY1 also contains a subroutine, SELECT, for selecting a subset of the decay-energy input data to be fit and a subroutine, TRMSEE, used to aid the user in

adjusting parameters to improve the fit. Finally, the subroutine RUNTOTS in OVRLAY1 is used for reading in experimental data.

OVRLAY2 contains subroutines for fitting options 1 and 2. These include the routines PULSFIT, PDIF, and SEEFIT. This overlay also contains subroutines for placing the final output (the parameters for the fit) in an ENDF-like format, routines PCHOUT and CXFP, and the subroutines used in the interactive graphics, routines SETUP, YMMX, DECBND, PTLPT, and PICTUR.

OVRLAY3 contains the subroutines used for fitting option 3, the non-linear least-squares option. These include DHFIT, FUNK, and STEPIT. This overlay also contains the subroutine FINECHK for graphically examining the accuracy of the fit.

Users of FITPULS should be warned that the version of the code for which the listing below is given is dependent upon the Los Alamos Scientific Laboratory operating system and that some changes would be necessary if the code is used at another installation. In particular, a local linear equation solver and local plotting routines are used in this version.

```

PROGRAM FITPULS (TAPE5,TAPE6,TAPE7,TAPE10,TAPE20,OUTPUT,TTY,TAPE11)FITP 10
1 =TTY)FITP 20
C FITP 30
C THIS PROGRAM ACCEPTS FISSION-PRODUCT DATA (BETA AND GAMMA) IN FITP 40
C UNITS OF ENERGY /FISSION WHICH HAVE BEEN ENERGY BINNED INTO FINE FITP 50
C GROUPS(150)FOR A NUMBER OF COOLING TIME STEPS DERIVED AS FOLLOWS- FITP 60
C YIELD DATA FROM ENDF WERE FIRST PROCESSED BY THE FPCYS CODE TO FITP 70
C SUPPLY FINE GROUP INPUT FOR THE FPSPEC CODE. FPSPEC ALSO FITP 80
C REQUIRES OUTPUT FROM THE CINDER-10 CODE. FINALLY THE OUTPUT OF FITP 90
C FPSPEC WAS PROCESSED BY THE FOTOELF CODE WHICH PUTS THE DATA IN FITP 100
C AN ENDF-LIKE FORMAT WHICH IS THE INPUT DATA LIBRARY FOR THIS FITP 110
C CODE(FITPULS).FITP 120
C FITP 130
C FITPULS REBINS THIS DATA INTO A USER CHOSEN BROAD GROUP STRUCTURE FITP 140
C (NOTE THAT THIS REBINNING CHANGES UNITS TO ENERGY/FISSION-SEC. FITP 150
C OR,OPTIONALLY,TO UNITS OF NUMBER OF PARTICLES PER FISSION) FITP 160
C AND FITS THE DATA FOR EACH GROUP WITH A LINEAR COMBINATION OF FITP 170
C FUNCTIONS AS FOLLOWS -- FITP 180
C FITP 190
C GXC(I ,K)=SUM+ALF(L,K)*(EXP(-ALAM(L,K)*T(I)),SUM OVER L=1,KTRM, FITP 200
C WHERE KTRM IS THE NUMBER OF PAIRS OF PARAMETERS (ALF, FITP 210
C ALAM) FOR GROUP K. FITP 220
C FITP 230
C GXC(I ,K)=ENERGY(MEV)/FISS-SEC FOR GROUP K AND COOLING TIME T(I). FITP 240
C GXC(I ,K) CAN ALSO BE EXPRESSED AS PARTICLES/FISS BY SETTING THE FITP 250
C FLAG MEVU=1. FITP 260
C MAX.ALLOWED VALUE FOR KTRM(KTR(K)),NO. OF PARAM. PAIRS/GP=50. FITP 270
C MAX.ALLOWED NO. OF BROAD GROUPS,NERG=25. FITP 280
C MAX. ALLOWED NO. OF INPUT COOLING TIME STEPS,ITSP=70. FITP 290
C FITP 300
C THE CODE ALSO HAS AN OPTION OF REDUCING EXPERIMENTAL DATA FOR FITP 310
C A FINITE IRRADIATION TIME TO A PULSE AND OBTAINING A FIT FOR THE FITP 320
C EQUIVALENT PULSE. FOR THIS OPTION SET IRAD=1. FITP 330
C FITP 340
C THERE ARE THREE FITTING OPTIONS AVAILABLE IN FITPULS. THE FIRST FITP 350
C TWO RUN VERY FAST WHEREAS THE THIRD, A NON-LINEAR LEAST FITP 360
C SQUARES FITTING OPTION IS TIME CONSUMING. THESE OPTIONS ARE FITP 370
C SELECTED BY THE FLAG NIAPL AS FOLLOWS- FITP 380
C NIAPL=1 THE FIRST OPTION SELECTED. BEGINNING WITH LONGEST FITP 390
C COOLING TIME PARAMETERS ARE COMPUTED FOR PAIRS OF FITP 400
C USER SELECTED POINTS. INTERACTIVE GRAPHICS AID IN FITP 410
C POINT SELECTION. CANNOT BE USED FOR FINITE FITP 420
C IRRADIATION FIT. GOOD FOR PULSE FIT ONLY. FITP 430
C NIAPL=-1 THE SECOND OPTION IS SELECTED. ALAM VALUES MUST BE FITP 440
C INPUT AS THIS OPTION ONLY COMPUTES ALF VALUES GIVEN FITP 450
C ALAM VALUES. METHOD DESCRIBED IN LA-6684-MS. USE FITP 460
C THIS METHOD FOR FINITE IRRADIATION FITTING. FITP 470
C NIAPL=0 THE THIRD OPTION SELECTED. GOOD GUESSES FOR BOTH FITP 480
C ALF AND ALAM VALUES MUST BE INPUT AS THIS IS THE FITP 490
C NON-LINEAR LEAST-SQUARES FITTING OPTION. GUESSES FITP 500
C ARE OBTAINED BY FIRST RUNNING ONE OF THE FIRST TWO FITP 510
C OPTIONS. FITP 520
COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB, FITP 530
1 NIN, NOUT FITP 540
COMMON /PULSDAT/ NDT, EB(25), GX(25,400), NERG, ALF(25,50), ALAM(2FITP 550
1 5,50) FITP 560
LEVEL 2, A, B FITP 570
COMMON /PULSCAL/ A(50,50), B(50,1) FITP 580
COMMON /PULSOUT/ ALPHA(50), FXC(100), PCT(100) FITP 590
COMMON /MANI/ WX(100), TITL(8), KTR(50), NS(10), KKN(25), DIFLIM FITP 600
COMMON /ENDF/MEVU, MAT, MF, MT, RUNTIM, NPUN FITP 610
COMMON /TRMOT/ TL(10), LTM(50), LT FITP 620
COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200) FITP 630
COMMON /COMO/ NP, TMIN, TMAX, NSTEP, GXMIN, TC(100), LXX(20), FITP 640
1 NFINL FITP 650
DATA NIN, NOUT, NDT /5,6,10/ FITP 660
C FITP 670
CALL FILEREP FITP 680
READ (NIN,20) NPUN,IRAD,NCORS,NIAPL FITP 690
C FITP 700
C SET NPUN=7 HERE IF REBINNED DATA FILE WANTED,OTHERWISE NPUN=20. FITP 710
C IRAD=0,REGULAR PULSE FIT REQUESTED, =1,FIT FOR FINITE IRRADIATION FITP 720
C TIME DATA WANTED. FITP 730
C NCOR=0,CALL CORSBIN, =1,NO CALL. FITP 740
C NIAPL=1 FIT OPTION 1; NIAPL=-1 FIT OPTION 2; NIAPL=0 FIT OPTION 3 FITP 750

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C	NIAPL=1 INTERACTIVE POINT SELECTION	FITP 760
	IF (NIAPL.EQ.1) CALL GTEKT (1HU,4H4014,960)	FITP 770
	IF (NIAPL.NE.1) CALL GLOT (1HU,7HFITPULS,7)	FITP 780
	CALL OVERLAY (5HOVLY1,1,0,0)	FITP 790
	IF (NFINL.EQ.1) GO TO 10	FITP 800
	CALL OVERLAY (5HOVLY2,2,0,0)	FITP 810
10	CONTINUE	FITP 820
	CALL OVERLAY (5HOVLY3,3,0,0)	FITP 830
	IF (NPUN.EQ.7) CALL PCHOUT (LXX)	FITP 840
	CALL DONEPL	FITP 850
	STOP	FITP 860
C		FITP 870
20	FORMAT (12I 6)	FITP 880
	END	FITP 890

	SUBROUTINE OVRLAY1	OVR1 10
C		OVR1 20
C	OVRLAY 1 READS INPUT AND REBINS DATA	OVR1 30
C		OVR1 40
	COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB,	OVR1 50
	1 NIN, NOUT	OVR1 60
	COMMON /PULSDAT/ NDT, EB(25), GX(25,400), NERG, ALF(25,50), ALAM(20	OVR1 70
	1 5,50)	OVR1 80
	LEVEL 2, A, B	OVR1 90
	COMMON /PULSCAL/ A(50,50), B(50,1)	OVR1 100
	COMMON /PULSOUT/ ALPHA(50), FXC(100), PCT(100)	OVR1 110
	COMMON /MANI/ WX(100), TITL(8), KTR(50), NS(10), KKN(25), DIF LIM	OVR1 120
	COMMON /ENDF/MEVU, MAT, MF, MT, RUNTIM, NPUN	OVR1 130
	COMMON /TRMOT/ TL(10), LTM(50), LT	OVR1 140
	COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200)	OVR1 150
	COMMON /COMO/ NP, TMIN, TMAX, NSTEP, GXMIN, TC(100), LXX(20),	OVR1 160
	1 NFINL	OVR1 170
	REAL TMN(20), TMX(20)	OVR1 180
C		OVR1 190
C	IF (NCORS.LE.0) CALL CORSBIN	OVR1 200
C		OVR1 210
C	SEE CORSBIN FOR MAT1,MF1,MT1 INPUT.	OVR1 220
C		OVR1 230
C	READ (NIN,40) (TITL(I),I=1,8)	OVR1 240
C		OVR1 250
C	TITL=EIGHTY CHARACTER(HOLLERITH) TITLE.	OVR1 260
C		OVR1 270
C	TITL(1)=CHARACTER FOR CALLING SUBROUTINE SELECT TO CHOOSE DATA	OVR1 280
C	TO BE USED IN FIT. IF TITL(1)= SELECT ,SEE SUBROUTINE	OVR1 290
C	SELECT FOR INPUT.	OVR1 300
C	IF TITL(1)= DO NOT GO,PROGRAM STOPS. USED WHEN JUST	OVR1 310
C	REBINNED DATA DESIRED.	OVR1 320
C		OVR1 330
C	IF (TITL(1).EQ.10H SELECT) CALL SELECT	OVR1 340
C	WRITE (NOUT,50) (TITL(I),I=1,8)	OVR1 350
C	IF (TITL(1).EQ.10H DO NOT GO) STOP	OVR1 360
C	REWIND NPUN	OVR1 370
C	READ (NIN,60) IPROB,NTOTER,NPUN,NSTEP,NFINL	OVR1 380
C		OVR1 390
C	IPROB = PROBLEM NO. MAKE NEGATIVE IF FIT IS MADE IN SEGMENTS.	OVR1 400
C	NTOTER = FLAG TO DENOTE SPEC. OR TOTAL CALC.=0, CODE READS SPECT.	OVR1 410
C	DATA FROM TAPE FILE.=1, CODE READS DATA FROM INPUT FILE.	OVR1 420
C	NPUN = FLAG FOR PARAMETERS OUTPUT IN ENDF-LIKE FORMAT.=7, OUTPUT,	OVR1 430
C	=20 NO OUTPUT.	OVR1 440
C	NSTEP = FLAG TO CALL NON-LINEAR LEAST SQUARES ROUTINE.=0, ROUTINE	OVR1 450
C	NOT CALLED.=1, ROUTINE CALLED.	OVR1 460
C	NFINL = FLAG FOR READING ALL PARAMATERS FROM PREVIOUS PROB.I.E.,	OVR1 470
C	PULSFIT WILL NOT BE CALLED FOR ANY GROUP.=0, NO EFFECT.=1,	OVR1 480
C	SEE READ, STATEMENTS BELOW.	OVR1 490
C		OVR1 500
C	IF (NTOTER.GT.0) CALL RUNTOTS	OVR1 510
C	READ (NIN,70) DIF LIM, RUNTIM, TMIN, TMAX, GXMIN	OVR1 520
C		OVR1 530
C	DIF LIM = MAX. PERCENT POINTWISE DEVIATION ALLOWED IN STEPIT.	OVR1 540
C	USUALLY SET HIGH ON INITIAL PASSES AND TIGHTENED UP IN	OVR1 550
C	SUBSEQUENT PASSES.	OVR1 560
C	RUNTIM = RUNNING TIME. MAKE FRACT. OF SECOND LESS THAN THAT USED	OVR1 570
C	ON CONTROL CARD TO GET OUTPUT FILE FOR SUBSEQUENT RUN.	OVR1 580

	GX(K,I)=A(K,I)	SELE 270
	T(I)=ALAMDA(I)	SELE 280
30	CONTINUE	SELE 290
	WRITE (NOUT,60) (I,T(I),GX(K,I),I=1,ITS)	SELE 300
40	CONTINUE	SELE 310
	ITSP=ITS	SELE 320
	RETURN	SELE 330
C		SELE 340
	50 FORMAT (12I 6)	SELE 350
	60 FORMAT (4H I=,I 3,3H T=.1E12.5,4H GX=,1E12.5)	SELE 360
	END	SELE 370
	SUBROUTINE TRMSEE (LK,KKX)	TRMS 10
C		TRMS 20
C	THIS ROUTINE IS CALLED IF KKN IS SET NEGATIVE FOR A GROUP.	TRMS 30
C	ROUTINE PRINTS OUT TERM BY TERM CALCULATION OF FX FOR USE IN	TRMS 40
C	ADJUSTING FITTING PARAMETERS. THIS DONE BY CHANGING AND/OR	TRMS 50
C	REMOVING PARAMETERS.	TRMS 60
C		TRMS 70
	COMMON /MANI/ WX(100), TITL(8), KTR(50), NS(10), KKN(25), DIF LIM	TRMS 80
	COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB,	TRMS 90
	1 NIN, NOUT	TRMS 100
	COMMON /PULSDAT/ NDT, EB(25), GX(25,400), NERG, ALF(25,50), ALAM(2	TRMS 110
	1 5,50)	TRMS 120
	LEVEL 2, TRM, TPRT	TRMS 130
	COMMON /PULSCAL/ TRM(50,50), TPRT(50)	TRMS 140
	COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200)	TRMS 150
	COMMON /TRMOT/ TL(10), LTM(50), LT	TRMS 160
C		TRMS 170
	K=LK	TRMS 180
	KTRM=KTR(K)	TRMS 190
	TL(1)=10HORIGINAL P	TRMS 200
	TL(2)=10HARAMATRS F	TRMS 210
	TL(3)=10HOR GROUP	TRMS 220
	IF (KKX.EQ.0) GO TO 10	TRMS 230
	WRITE (NOUT,150) (TL(I),I=1,3),K	TRMS 240
	WRITE (NOUT,160) (L,ALF(K,L),ALAM(K,L),L=1,KTRM)	TRMS 250
10	IF (KKX.GT.0) GO TO 90	TRMS 260
	DO 40 I=1,ITSP	TRMS 270
	FX(I)=0.	TRMS 280
	DO 30 L=1,KTRM	TRMS 290
	TRM(I,L)=ALF(K,L)*EXP(-ALAM(K,L)*T(I))	TRMS 300
	IF (IRAD.LE.0) GO TO 20	TRMS 310
	IF (TRM(I,L).LT.0.) TRM(I,L)=0.	TRMS 320
	COFF=ALF(K,L)/DELT(I)/ALAM(K,L)**2	TRMS 330
	XPO1=1.-EXP(-ALAM(K,L)*RADT(I))	TRMS 340
	XPO2=1.-EXP(-ALAM(K,L)*DELT(I))	TRMS 350
	XPO3=EXP(-ALAM(K,L)*(T(I)-DELT(I)/2.))	TRMS 360
20	CONTINUE	TRMS 370
	IF (IRAD.EQ.1) TRM(I,L)=COFF*XPO1*XPO2*XPO3	TRMS 380
	LTM(L)=L	TRMS 390
	FX(I)=FX(I)+TRM(I,L)	TRMS 400
30	CONTINUE	TRMS 410
40	CONTINUE	TRMS 420
	K1=1	TRMS 430
50	K2=K1+4	TRMS 440
	IF (K2.GT.KTRM) K2=KTRM	TRMS 450
	WRITE (NOUT,170) (LTM(L),L=K1,K2)	TRMS 460
	DO 60 I=1,ITSP	TRMS 470
	WRITE (NOUT,180) T(I),GX(K,I),(TRM(I,L),L=K1,K2)	TRMS 480
60	CONTINUE	TRMS 490
	K1=K2+1	TRMS 500
	IF (K1.LE.KTRM) GO TO 50	TRMS 510
	DO 80 I=1,ITSP	TRMS 520
	PCTDIF=0.	TRMS 530
	IF (GX(K,I).LE.0.) GO TO 70	TRMS 540
	PCTDIF=(GX(K,I)-FX(I))/GX(K,I)*100.	TRMS 550
70	CONTINUE	TRMS 560
	WRITE (NOUT,190) I,T(I),GX(K,I),FX(I),PCTDIF	TRMS 570
80	CONTINUE	TRMS 580
	IF (KKX.LE.0) RETURN	TRMS 590
90	CONTINUE	TRMS 600
	READ (NIN,210) MLT	TRMS 610

	IF (MLT.EQ.0) GO TO 110	TRMS 620
	DO 100 MM=1,MLT	TRMS 630
	READ (NIN,200) L,ALF(K,L),ALAM(K,L)	TRMS 640
100	CONTINUE	TRMS 650
110	CONTINUE	TRMS 660
	READ (NIN,210) LT,(LTM(JJ),JJ=1,LT)	TRMS 670
C		TRMS 680
C	MLT=NO OF PARAMETERS TO BE CHANGED	TRMS 690
C	LT = NUMBER OF TERMS TO BE REMOVED.	TRMS 700
C	LTM(L) = TERM NOS. OF TERMS TO BE REMOVED.	TRMS 710
	IF (LT.EQ.0) RETURN	TRMS 720
	LTX=0	TRMS 730
	LL=1	TRMS 740
	KTRM=KTR(K)	TRMS 750
	DO 130 L=1,KTRM	TRMS 760
	IF (LTM(LL).EQ.L) GO TO 120	TRMS 770
	LTX=LTX+1	TRMS 780
	TRM(1,LTX)=ALF(K,L)	TRMS 790
	TRM(2,LTX)=ALAM(K,L)	TRMS 800
	GO TO 130	TRMS 810
120	CONTINUE	TRMS 820
	LL=LL+1	TRMS 830
130	CONTINUE	TRMS 840
	KTRM=LTX	TRMS 850
	DO 140 L=1,KTRM	TRMS 860
	ALF(K,L)=TRM(1,L)	TRMS 870
	ALAM(K,L)=TRM(2,L)	TRMS 880
140	CONTINUE	TRMS 890
	TL(1)=10HREVISED PA	TRMS 900
	TL(2)=10HRAMETERS F	TRMS 910
	KTR(K)=KTRM	TRMS 920
	TL(3)=10HOR GROUP	TRMS 930
	WRITE (NOUT,150) (TL(I),I=1,3),K	TRMS 940
	WRITE (NOUT,160) (L,ALF(K,L),ALAM(K,L),L=1,KTRM)	TRMS 950
	RETURN	TRMS 960
C		TRMS 970
		TRMS 980
150	FORMAT (1H1,5X,3A10,13)	TRMS 990
160	FORMAT (1H0,3H L=,13,10H ALF(K,L)=,1PE11.4,11H ALAM(K,L)=,1PE11.4)	TRMS1000
170	FORMAT (1H0,25H COOL TIME GX,5I 15)	TRMS1010
180	FORMAT (1P7E15.5)	TRMS1020
190	FORMAT (1H0,3H I=,13,3H T=,1E12.5,4H GX=,1E12.5,4H FX=,1E12.5,8H PTRMS1030	
	1CTDIF=,1E12.5)	TRMS1040
200	FORMAT (16,2E12.5)	TRMS1050
210	FORMAT (12I 6)	TRMS1060
	END	TRMS1070

	SUBROUTINE CORSBIN	CORS 10
C		CORS 20
C	ROUTINE FORMS COARSE GROUPS FROM FINE GROUP DATA IN ENDF-LIKE	CORS 30
C	FORMAT.	CORS 40
C		CORS 50
	COMMON /PULSIN/ AO(50), FX(200), T(401), KE, ITSP, IPROB, NIN,	CORS 60
	1 NOUT	CORS 70
	COMMON /PULSDAT/ NDF, EB(25), GB(25,400), NERG, EO(200), DUM(70),	CORS 80
	1 TOT(50)	CORS 90
	COMMON /ENDF/MEVU, MAT1, MF1, MT1, RUNTIM, NPUN	CORS 100
C	READ INPUT	CORS 110
	READ (NIN,90) MAT1,MF1,MT1,MEVU	CORS 120
C		CORS 130
C	MAT1=MAT NO. OF FISSIONING NUCLIDE DESIRED.	CORS 140
C	MF1=DATA TYPE DESIRED,MF1=80=F.P.DATA FOR THERMAL PULSE,MF1=81=	CORS 150
C	F.P. DATA FOR FAST PULSE,ETC.	CORS 160
C	MT1=TYPE OF F.P. WANTED,MT1=801=DATA FOR BETA- PLUS GAMMA,MT1=802=	CORS 170
C	DATA FOR GAMMA ONLY,MT1=803=DATA FOR BETA- ONLY,ETC.	CORS 180
C	MEVU=0,UNITS ARE MEV/FISS, =1,UNITS ARE PARTICLE/FISS.	CORS 190
C	SEARCH ENDF TAPE FOR DESIRED DATA.	CORS 200
C		CORS 210
10	CONTINUE	CORS 220
	READ (NDF,100) (AO(I),I=1,7),MAT,MF,MT,NSEQ	CORS 230
	IF (MF.EQ.-0) MF=80	CORS 240
	IF (MAT.EQ.-1) WRITE (NOUT,110) MAT,NDF	CORS 250
	IF (MAT.EQ.-1) STOP	CORS 260

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IF (MAT.LT.MAT1) GO TO 10
IF (MAT.EQ.MAT1) GO TO 20
WRITE (NOUT,110) MAT1,NDF
STOP
20 CONTINUE
IF (MF.LT.MF1) GO TO 10
IF (MF.EQ.MF1) GO TO 30
WRITE (NOUT,120) MF1,NDF
STOP
30 CONTINUE
IF (MT.LT.MT1) GO TO 10
IF (MT.EQ.MT1) GO TO 40
WRITE (NOUT,130) MT1,NDF
STOP
40 CONTINUE
READ (NDF,140) NT
READ (NDF,90) NICHT
ITSP=NT
C
C READ BROAD GROUP STRUCTURE
C
READ (NIN,90) NE
READ (NIN,150) (EB(N),N=1,NE)
C
C NE=NO OF BROAD GROUPS PLUS ONE.
C EB=ENERGY BOUNDS INCLUDING UPPER AND LOWER BOUNDS IN MEV
C NE=NE-1
C NERG=NE
C DO 70 IT=1,NT
C READ (NDF,160) T(IT),KE
C READ (NDF,90) NICHT
C READ (NDF,150) (EO(K),FX(K),K=1,KE)
C KE1=KE+1
C EO(KE1)=(EO(KE)-EO(KE-1))+EO(KE)
C
C THE FOLLOWING LOOP SELECTS THE CORRECT UNITS.
C DO 50 K=1,KE
C IF (MEVU.EQ.1) FX(K)=FX(K)/((EO(K)+EO(K+1))/2.0)+1.E+4
C IF (MEVU.EQ.0) FX(K)=FX(K)*1.E+4
50 CONTINUE
CALL REBIN
DO 60 IE=1,NE
GB(IE,IT)=DUM(IE)
60 CONTINUE
70 CONTINUE
DO 80 IE=1,NE
WRITE (NOUT,170) IE,EB(IE),EB(IE+1)
WRITE (NOUT,180) (IT,T(IT),GB(IE,IT)),IT=1,NT)
WRITE (NPUN,90) MAT1,MF1,MT1
WRITE (NPUN,90) NE,NT
WRITE (NPUN,190) IE,EB(IE),EB(IE+1)
WRITE (NPUN,190) (IT,T(IT),GB(IE,IT)),IT=1,NT)
80 CONTINUE
REWIND 10
RETURN
C
90 FORMAT (6I11)
100 FORMAT (6A10,A6,I4,I2,I3,I5)
110 FORMAT (1H1,15H SORRY, MAT = ,I4,13H NOT ON TAPE ,I3)
120 FORMAT (1H1,14H SORRY, MF = ,I4,13H NOT ON TAPE ,I3)
130 FORMAT (1H1,14H SORRY, MT = ,I4,13H NOT ON TAPE ,I3)
140 FORMAT (55X,I11)
150 FORMAT (6E11.4)
160 FORMAT (11X,1E11.4,33X,I11)
170 FORMAT (1H0,17H ENERGY BIN NO. ,I3,6H FROM ,1PE12.5,8H MEV TO ,1PCORS
1 E12.5,5H MEV.)
180 FORMAT (1H ,13H TIME STEP = ,I3,16H COOLING TIME = ,1PE12.5,6H FX
1= ,1PE12.5)
190 FORMAT (2(I5,2E15.8))
END

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CORS 270
CORS 280
CORS 290
CORS 300
CORS 310
CORS 320
CORS 330
CORS 340
CORS 350
CORS 360
CORS 370
CORS 380
CORS 390
CORS 400
CORS 410
CORS 420
CORS 430
CORS 440
CORS 450
CORS 460
CORS 470
CORS 480
CORS 490
CORS 500
CORS 510
CORS 520
CORS 530
CORS 540
CORS 550
CORS 560
CORS 570
CORS 580
CORS 590
CORS 600
CORS 610
CORS 620
CORS 630
CORS 640
CORS 650
CORS 660
CORS 670
CORS 680
CORS 690
CORS 700
CORS 710
CORS 720
CORS 730
CORS 740
CORS 750
CORS 760
CORS 770
CORS 780
CORS 790
CORS 800
CORS 810
CORS 820
CORS 830
CORS 840
CORS 850
CORS 860
CORS 870
CORS 880
CORS 890
CORS 900
CORS 910
CORS 920
CORS 930
CORS 940
CORS 950
CORS 960

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C SUBROUTINE REBIN REBI 10
REBI 20

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C      ROUTINE FOR BROAD GROUP BINNING. BOUNDARIES DO NOT HAVE TO      REBI 30
C      COINCIDE WITH FINE GROUP BOUNDARIES. WRITTEN BY GRAHAM          REBI 40
C      FOSTER,LASL,1975.                                               REBI 50
C      CHANGED OCT, 1977. LASL, D. GEORGE                             REBI 60
C                                                                 REBI 70
C      COMMON /PULSIN/ AO(50), Y(200), T(401), NX, ITSP, IPROB, NIN, NOUTREBI 80
C      COMMON /PULSDAT/ NDT, U(25), GB(25,400), NU, X(200), V(70), TOT(50REBI 90
C      )                                                                 REBI 100
C      SUM1=SUM2=0.                                                    REBI 110
C      NU1=NU+1                                                         REBI 120
C      NX1=NX+1                                                         REBI 130
C      DO 10 IU=1,NU1                                                  REBI 140
C      V(IU)=0.                                                         REBI 150
10    DO 20 IX=1,NX                                                    REBI 160
C      IF (X(IX).LT.U(1)) GO TO 20                                     REBI 170
C      IF (X(IX).GT.U(NU1)) GO TO 20                                  REBI 180
C      SUM1=SUM1+Y(IX)                                                 REBI 190
C      20 CONTINUE                                                    REBI 200
C      FIND THE FIRST BIN                                             REBI 210
C      DO 30 IX=1,NX                                                  REBI 220
C      IF (X(IX).EQ.U(1)) GO TO 50                                     REBI 230
30    IF (X(IX).GT.U(1)) GO TO 40                                     REBI 240
C      WRITE (NOUT,110)                                               REBI 250
C      RETURN                                                         REBI 260
40    V(1)=Y(IX-1)*(X(IX)-U(1))/(X(IX)-X(IX-1))                     REBI 270
50    IX=IX+1                                                         REBI 280
C      DO 80 IU=1,NU                                                  REBI 290
60    IF (X(IX).GT.(U(IU+1)*1.0001)) GO TO 70                       REBI 300
C      V(IU)=V(IU)+Y(IX-1)                                           REBI 310
C      IF (IX.GT.NX) GO TO 90                                         REBI 320
C      IX=IX+1                                                         REBI 330
C      GO TO 60                                                       REBI 340
70    CRIN=Y(IX-1)*(U(IU+1)-X(IX-1))/(X(IX)-X(IX-1))               REBI 350
C      V(IU)=V(IU)+CRIN                                              REBI 360
C      Y(IX-1)=Y(IX-1)-CRIN                                          REBI 370
80    CONTINUE                                                       REBI 380
90    IF (X(NX1).GT.U(NU1)) WRITE (NOUT,120) X(NX1),U(NU1)         REBI 390
C      DO 100 IU=1,NU                                                 REBI 400
100   SUM2=SUM2+V(IU)                                                 REBI 410
C      ERRD=0.001                                                    REBI 420
C      IF (ABS(SUM2-SUM1).GT.ERRD*SUM1) WRITE (NOUT,130) SUM1,SUM2   REBI 430
C      IF (SUM2.GT.SUM1) WRITE (NOUT,101) (I,X(I),Y(I),I=1,NX)      REBI 440
C      IF (SUM2.GT.SUM1) WRITE (NOUT,102) (N,U(N),V(N),N=1,NU)      REBI 450
C      RETURN                                                         REBI 460
C                                                                 REBI 470
C      110 FORMAT (29H CANT FIND FIRST ENERGY BOUND)                REBI 480
120   FORMAT (17H0***** LAST DATUME10.3,27H EXTENDS BEYOND END OF GRID E1REBI 490
C      1 0.3,6H *****/)                                             REBI 500
130   FORMAT (32H0***** INTEGRAL BEFORE REBINNING E10.3,41H DOES NOT EQUAREBI 510
C      1L INTEGRAL AFTER REBINNING E10.3,6H *****/)                 REBI 520
C      END                                                            REBI 530

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C      SUBROUTINE RUNTOTS                                             RUNT 10
C                                                                 RUNT 20
C      ROUTINE TO READ TOTALS, I.E.,GX(K,I) SUMMED OVER ENERGY.    RUNT 30
C                                                                 RUNT 40
C      COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB, RUNT 50
C      1 NIN, NOUT                                                    RUNT 60
C      COMMON /PULSDAT/ NDT, EB(25), GX(25,400), NERG, ALF(25,50), ALAM(2RUNT 70
C      1 5,50)                                                        RUNT 80
C      COMMON /PULSOUT/ ALPHA(50), FXC(100), PCT(100)                RUNT 90
C      COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200)     RUNT 100
C                                                                 RUNT 110
C      THIS SUBROUTINE IS USED FOR READING EXPERIMENTAL DATA.      RUNT 120
C      UNFORTUNATELY, THIS CAN BE RECEIVED IN A VARIETY OF FORMATS,SO RUNT 130
C      THIS ROUTINE MUST BE CONTINUALLY CHANGED TO ACCOMADATE WHATEVER RUNT 140
C      FORMAT THS DATA IS IN. THE FUNNY LOOKING STATEMENTS BELOW ARE RUNT 150
C      FOR READING SOME ORNL DATA IN THE WHITTEMORE JUNK FORMAT.   RUNT 160
C                                                                 RUNT 170
C      DIMENSION HDR(8)                                              RUNT 180
C      READ (NIN,30) NP,NE,NHD                                       RUNT 190
C      DO 10 L=1,NHD                                                 RUNT 200
C      READ (NIN,50) (HDR(I),I=1,8)                                  RUNT 210

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	WRITE (NOUT,50) (HDR(I),I=1,8)	RUNT 220
10	CONTINUE	RUNT 230
	DO 20 I=1, NP	RUNT 240
	IF (I.LE.NE) EB(I)=0.0	RUNT 250
	READ (NIN,40) (GX(K,I),K=10,15)	RUNT 260
	WRITE (NOUT,40) (GX(K,I),K=10,15)	RUNT 270
	RADT(I)=GX(10,I)	RUNT 280
	T(I)=GX(11,I)+GX(12,I)/2.0	RUNT 290
	DELT(I)=1.0	RUNT 300
	GX(1,I)=(GX(13,I)+GX(14,I))*GX(10,I)/GX(12,I)	RUNT 310
20	CONTINUE	RUNT 320
	ITSP=NP	RUNT 330
	NE=1	RUNT 340
	NERG=1	RUNT 350
	RETURN	RUNT 360
C		RUNT 370
	30 FORMAT (12I6)	RUNT 380
	40 FORMAT (6E12.5)	RUNT 390
	50 FORMAT (8A10)	RUNT 400
	END	RUNT 410
	SUBROUTINE OVLAY2	OVR2 10
C		OVR2 20
C	OVLAY2 IS ROUTINE FOR FITTING OPTIONS 1 AND 2	OVR2 30
C		OVR2 40
	COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB,	OVR2 50
	1 NIN, NOUT	OVR2 60
	COMMON /PULSDAT/ NDT, EB(25), GX(25,400), NERG, ALF(25,50), ALAM(20	OVR2 70
	1 5,50)	OVR2 80
	LEVEL 2, A, B	OVR2 90
	COMMON /PULSCAL/ A(50,50), B(50,1)	OVR2 100
	COMMON /PULSOUT/ ALPHA(50), FXC(100), PCT(100)	OVR2 110
	COMMON /MANI/ WX(100), TITL(8), KTR(50), NS(10), KKN(25), DIF LIM	OVR2 120
	COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200)	OVR2 130
	COMMON /COMO/ NP, TMIN, TMAX, NSTEP, GXMIN, TC(100), LXX(20),	OVR2 140
	1 NFINL	OVR2 150
	COMMON /CLWT/ LWTR	OVR2 160
	LWTR=0	OVR2 170
	DO 70 K=1, NERG	OVR2 180
	IF (KKN(K).NE.K) GO TO 70	OVR2 190
		OVR2 200
C	THIS PORTION OF ROUTINE ALLOWS FIT IN SEVERAL SEGMENTS. TO	OVR2 210
C	ACTIVATE, SET IPROB NEGATIVE. NOTE - INPUT NEEDED FOR EA. GROUP.	OVR2 220
C		OVR2 230
C	NSEG = NUMBER OF SEGMENTS + 1	OVR2 240
C	NS = BREAKPOINTS OF SEGMENTS.	OVR2 250
C		OVR2 260
	NSEG=2	OVR2 270
	NS(1)=1	OVR2 280
	IF (IPROB.LT.0) READ (NIN,80) NSEG,(NS(LX),LX=2,NSEG)	OVR2 290
C		OVR2 300
	IF (NSEG.LE.2) NS(2)=NP	OVR2 310
	NSEG1=NSEG-1	OVR2 320
	LTRM=0	OVR2 330
	KTR(K)=0	OVR2 340
	DO 40 N=1, NSEG1	OVR2 350
	N1=NS(N)	OVR2 360
	N2=NS(N+1)	OVR2 370
	ITP=N2-N1+1	OVR2 380
	ITSP=0	OVR2 390
	IX=0	OVR2 400
	IF (TMIN.LT.TC(1)) TMIN=TC(1)	OVR2 410
	IF (TMAX.LE.0.0) TMAX=TC(NP)	OVR2 420
	IF (TMAX.GT.TC(NP)) TMAX=TC(NP)	OVR2 430
	DO 10 I=1, ITP	OVR2 440
	NN=N1+I-1	OVR2 450
	IF (GX(K,NN).LT.GXMIN) GO TO 10	OVR2 460
	IF (TC(NN).LT.TMIN) GO TO 10	OVR2 470
	IF (TC(NN).GT.TMAX) GO TO 10	OVR2 480
	IX=IX+1	OVR2 490
	ITSP=IX	OVR2 500
	LXX(K)=IX	OVR2 510
	FX(IX)=GX(K,NN)	OVR2 520

	T(I X)=TC(NN)	OVR2 530
10	CONTINUE	OVR2 540
	CALL PULSFIT (K)	OVR2 550
	IF (N.NE.NSEGI) KTRM=KTRM-1	OVR2 560
	IX=0	OVR2 570
	DO 20 I=1,ITP	OVR2 580
	NN=N1+I-1	OVR2 590
	IF (GX(K,NN).LT.GXMIN) GO TO 20	OVR2 600
	IF (TC(NN).LT.TMIN) GO TO 20	OVR2 610
	IF (TC(NN).GT.TMAX) GO TO 20	OVR2 620
	IX=IX+1	OVR2 630
	ITSP=IX	OVR2 640
	LXX(K)=IX	OVR2 650
	FX(I X)=GX(K,NN)	OVR2 660
	T(I X)=TC(NN)	OVR2 670
20	CONTINUE	OVR2 680
	IF (N1A PL.EQ.1) CALL SEEFIT (K)	OVR2 690
	DO 30 J=1,KTRM	OVR2 700
	LTRM=LTRM+1	OVR2 710
	ALF(K,LTRM)=B(J,1)	OVR2 720
	ALAM(K,LTRM)=ALAMDA(J)	OVR2 730
30	CONTINUE	OVR2 740
	KTR(K)=KTR(K)+KTRM	OVR2 750
40	CONTINUE	OVR2 760
	KTRM=KTR(K)	OVR2 770
	DO 50 J=1,KTRM	OVR2 780
	ALAMDA(J)=ALAM(K,J)	OVR2 790
	B(J,1)=ALF(K,J)	OVR2 800
50	CONTINUE	OVR2 810
	WRITE (NOUT,90) K,EB(K),EB(K+1)	OVR2 820
	DO 60 J=1,KTRM	OVR2 830
	WRITE (NOUT,100) J,ALAMDA(J),B(J,1)	OVR2 840
60	CONTINUE	OVR2 850
70	CONTINUE	OVR2 860
	RETURN	OVR2 870
C		OVR2 880
	80 FORMAT (12I6)	OVR2 890
	90 FORMAT (1H1,24H RESULTS FOR GROUP NO. ,I3,11H E-LOWER = ,1PE12.5,	OVR2 900
	1 17H MEV. E-UPPER = ,1PE12.5,5H MEV.)	OVR2 910
100	FORMAT (1H0,4H J =,I3,9H ALAMDA =,1PE12.5,4H B =,1PE12.5)	OVR2 920
	END	OVR2 930

	SUBROUTINE PULSFIT (KKF)	PULS 10
C		PULS 20
C	THIS ROUTINE PROVIDES 1 AND 2 PARAMETER FITS FOR A COMBINATION	PULS 30
C	OF LINEAR FUNCTIONS OF THE FORM --	PULS 40
C		PULS 50
C	FX(I)=SUM+ALPHA(K)*EXP(-ALAMDA(K)*T(I)),SUM OVER K=1,KTRM,	PULS 60
C	THE NUMBER OF TERMS USED TO REPRESENT FX.	PULS 70
		PULS 80
	COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB,	PULS 90
	1 NIN, NOUT	PULS 100
	LEVEL 2, A, B	PULS 110
	COMMON /PULSCAL/ A(50,50), B(50,1)	PULS 120
	COMMON /PULSOUT/ ALPHA(50), FXC(100), PCT(100)	PULS 130
	COMMON /MANI/ W(100), TITL(8), KTR(50), NS(10), KKN(25), DIF LIM	PULS 140
	COMMON /FINRAD/ N1A PL, IRAD, NCORS, RADT(200), DELT(200)	PULS 150
	COMMON /CLWT/ LWTR	PULS 160
	DIMENSION KCAL(71), IPVT(50)	PULS 170
	ITS=1	PULS 180
	IPRO=KKF	PULS 190
	IF (N1A PL.EQ.1) GO TO 10	PULS 200
	IF (N1A PL.EQ.0) RETURN	PULS 210
C	INPUT TO THIS SUBROUTINE NEEDED ONLY IF N1A PL=-1.	PULS 220
	READ (NIN,220) LWT,KTRM,IPRT	PULS 230
	READ (NIN,230) (ALAMDA(K),K=1,KTRM)	PULS 240
C		PULS 250
C	LWT=WT FCN DESIRED,=0,W=1,=1,W=1/FX,=2,W=1/FX**2,=3,W=1/FX**1.5.	PULS 260
C	KTRM=NO. OF ALAMDAS USED IN FIT.	PULS 270
C	IPRT=1,PRINT A-MATRIX.=0,NO PRINT.	PULS 280
C	ALAMDA(K) = LAMDAS PROVIDED BY USER, AS THIS OPTION ONLY FITS	PULS 290
C	COEFFICIENTS.	PULS 300
C	GO TO 50	PULS 310

10	CONTINUE	PULS 320
	I 1=IT SP	PULS 330
	KK=1	PULS 340
20	I 2=I 1-1	PULS 350
C	IF ((FX(I 2)/FX(I 1)).LT.5.0) I 2=I 1-2	PULS 360
	ALAMDA(KK)=ALOG(FX(I 2)/FX(I 1))/(T(I 1)-T(I 2))	PULS 370
	B(KK,1)=FX(I 1)/EXP(-ALAMDA(KK)*T(I 1))	PULS 380
	IT 1=I 2-1	PULS 390
	FT 1=FX(IT 1)-(B(KK,1)*EXP(-ALAMDA(KK)*T(IT 1)))	PULS 400
	IF (-FT 1.LT.FX(IT 1)) GO TO 30	PULS 410
	IF (KGFL.NE.IPRO) GO TO 30	PULS 420
	I 1=I 2	PULS 430
	GO TO 20	PULS 440
30	CONTINUE	PULS 450
	I 3=I 2-1	PULS 460
	IF LG=0	PULS 470
	DO 40 I =1,I 3	PULS 480
	FT=FX(I)	PULS 490
	FX(I)=FX(I)-(B(KK,1)*EXP(-ALAMDA(KK)*T(I)))	PULS 500
	ATST=FX(I)/FT	PULS 510
	IF (ATST.GT.0.05) GO TO 40	PULS 520
	IF LG=IF LG+1	PULS 530
	WRITE (NOUT,180) I,FT,FX(I)	PULS 540
40	CONTINUE	PULS 550
	I 1=I 3-IF LG	PULS 560
	KK=KK+1	PULS 570
	IF (I 1.GE.2) GO TO 20	PULS 580
	KTRM=KK-1	PULS 590
	RETURN	PULS 600
50	CONTINUE	PULS 610
C		PULS 620
C	WRITE OUT INPUT FOR DEBUG	PULS 630
	WRITE (NOUT,240) (K,ALAMDA(K),K=1,KTRM)	PULS 640
	WRITE (NOUT,250) (I,T(I),FX(I),I=1,IT SP)	PULS 650
	DO 60 I =1,IT SP	PULS 660
	W(I)=1./FX(I)**2	PULS 670
	IF (LWT.EQ.3) W(I)=1./FX(I)**1.5	PULS 680
	IF (LWT.EQ.1) W(I)=1./FX(I)	PULS 690
	IF (LWT.LE.0) W(I)=1.	PULS 700
60	CONTINUE	PULS 710
	WRITE (NOUT,260) LWT	PULS 720
C		PULS 730
C	REORDER ALAMDAS HI TO LO	PULS 740
C		PULS 750
	CALL QQSORT (KTRM,ALAMDA,PCT(1),PCT(50),PCT(50))	PULS 760
	NTRM=KTRM/2	PULS 770
	DO 70 K=1,NTRM	PULS 780
	TEMP=ALAMDA(K)	PULS 790
	ALAMDA(K)=ALAMDA(KTRM-K+1)	PULS 800
70	ALAMDA(KTRM-K+1)=TEMP	PULS 810
C		PULS 820
C	CALCULATE B MATRIX	PULS 830
C		PULS 840
	DO 100 K=1,KTRM	PULS 850
	B(K,1)=0.	PULS 860
	DO 90 I =1,IT SP	PULS 870
	IF (IRAD.LE.0) GO TO 80	PULS 880
	XP1=EXP(-ALAMDA(K)*RADT(I))	PULS 890
	XP2=EXP(-ALAMDA(K)*DELT(I))	PULS 900
	XP3=EXP(-ALAMDA(K)*(T(I)-DELT(I)/2.))	PULS 910
	B(K,1)=B(K,1)+FX(I)*1./DELT(I)/ALAMDA(K)**2*(1.-XP1)*(1.-XP2)*XP3	PULS 920
	I *W(I)	PULS 930
	GO TO 90	PULS 940
80	CONTINUE	PULS 950
	B(K,1)=B(K,1)+FX(I)*EXP(-ALAMDA(K)*T(I))*W(I)	PULS 960
90	CONTINUE	PULS 970
100	CONTINUE	PULS 980
C		PULS 990
C	CALCULATE A MATRIX	PULS1000
C		PULS1010
	DO 110 I =1,KTRM	PULS1020
	DO 110 J =1,KTRM	PULS1030
	A(I,J)=0.	PULS1040
110	CONTINUE	PULS1050
	DO 150 K=1,KTRM	PULS1060

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ALAM=ALAMDA(K)
DO 140 L=1,KTRM
DO 130 I=1,ITSP
IF (IRAD.LE.0) GO TO 120
XPO1=1.-EXP(-ALAMDA(K)*RADT(I))
XPO2=1.-EXP(-ALAMDA(L)*RADT(I))
XPO3=1.-EXP(-ALAMDA(K)*DELT(I))
XPO4=1.-EXP(-ALAMDA(L)*DELT(I))
XPO5=EXP(-ALAMDA(K)*(T(I)-DELT(I))/2.)
XPO6=EXP(-ALAMDA(L)*(T(I)-DELT(I))/2.)
COFF=1./DELT(I)/ALAMDA(K)**2
COFT=1./DELT(I)/ALAMDA(L)**2
A(K,L)=A(K,L)+COFF*COFT*XPO1*XPO2*XPO3*XPO4*XPO5*XPO6*W(I)
GO TO 130
120 CONTINUE
A(K,L)=EXP(-(ALAM+ALAMDA(L))*T(I))*W(I)+A(K,L)
130 CONTINUE
140 CONTINUE
150 CONTINUE
C
C PRINT A MATRIX
C
IF (IPRT.LT.1) GO TO 170
WRITE (NOUT,270) IPRO
DO 160 K=1,KTRM
WRITE (NOUT,280) (A(K,L),L=1,KTRM)
160 CONTINUE
170 CONTINUE
WRITE (NOUT,290) IPRO
WRITE (NOUT,280) (B(K,1),K=1,KTRM)
C SUBROUTINE LCMLSS SOLVES THE SET OF LINEAR EQUATIONS AX=B
CALL LCMLSS (KTRM,1,A,50,B,50,IPVT,DET,PCT(1),PCT(50))
WRITE (NOUT,290) IPRO
WRITE (NOUT,280) (B(K,1),K=1,KTRM)
CALL PDIF
WRITE (NOUT,190) IPRO
WRITE (NOUT,200) (I,T(I),FX(I),FXC(I),PCT(I),I=1,ITSP)
RETURN
WRITE (NOUT,210)
STOP
C
180 FORMAT (1H0,14H POINT AT I =,13,14H ON SLOPE FT =.E12.6,5H FX =
1.E12.6)
190 FORMAT (109H1 STEP NO. TIME ORIGINAL VALUE COMPUTED VALUE PERCENT DIFFERENCE IPROB=,13)
200 FORMAT (16,1P4E18.5)
210 FORMAT (16H SINGULAR SYSTEM)
220 FORMAT (12I6)
230 FORMAT (3(11X,E11.4))
240 FORMAT (3H K=,13,11H ALAMDA(K)=,1PE12.5)
250 FORMAT (4H I=,13,6H T(I)=,1PE12.5,7H FX(I)=,1PE12.5)
260 FORMAT (1H0,6H LWT=,13)
270 FORMAT (16H0 A-MATRIX FOR,16)
280 FORMAT (2X,10E12.3)
290 FORMAT (15H0 B-MATRIX FOR,16)
END
C
SUBROUTINE PDIF PDIF 10
C
C ROUTINE CALCULATES PER CENT DIFFERENCES BETWEEN CALCULATED AND INPUT DATA. PDIF 20
C PDIF 30
C PDIF 40
C PDIF 50
COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB, PDIF 60
1 NIN, NOOT PDIF 70
LEVEL 2, A, B PDIF 80
COMMON /PULSCAL/ A(50,50), B(50,1) PDIF 90
COMMON /PULSOUT/ ALPHA(50), FXC(100), PCTDIF(100) PDIF 100
COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200) PDIF 110
DO 30 I=1,ITSP PDIF 120
PCTDIF(I)=0. PDIF 130
FXC(I)=0. PDIF 140
DO 20 K=1,KTRM PDIF 150
IF ((-ALAMDA(K)*T(I)).GT.300.) ALAMDA(K)=-300.0/T(I) PDIF 160

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	IF (IRAD.LE.0) GO TO 10	PDIF 170
	COFF=B(K)/DELT(I)/ALAMDA(K)*.2	PDIF 180
	XPO1=1.-EXP(-ALAMDA(K)*RADT(I))	PDIF 190
	XPO2=1.-EXP(-ALAMDA(K)*DELT(I))	PDIF 200
	XPO3=EXP(-ALAMDA(K)*(T(I)-DELT(I)/2.))	PDIF 210
	FXC(I)=FXC(I)+COFF*XPO1*XPO2*XPO3	PDIF 220
	GO TO 20	PDIF 230
10	CONTINUE	PDIF 240
	FXC(I)=FXC(I)+B(K)*EXP(-ALAMDA(K)*T(I))	PDIF 250
	ALPHA(K)=B(K)*EXP(-ALAMDA(K)*T(I))	PDIF 260
20	CONTINUE	PDIF 270
30	PCTDIF(I)=(FX(I)-FXC(I))/FX(I)*100.	PDIF 280
	RETURN	PDIF 290
	END	PDIF 300

	SUBROUTINE SEEFIT (IP)	SEEF 10
C	ROUTINE DOES INTERACTIVE GRAPHICS.	SEEF 20
C		SEEF 30
	COMMON /PULSIN/ ALAMDA(50), FX(200), T(401), KTRM, ITSP, IPROB,	SEEF 40
	1 NIN, NOOT	SEEF 50
	LEVEL 2, A, B	SEEF 60
	COMMON /PULSCAL/ A(50,50), B(50,1)	SEEF 70
	COMMON /PULSOUT/ ALPHA(50), FXC(100), PCTDIF(100)	SEEF 80
	COMMON /FINRAD/ NIAPL, IRAD, NCORS, RADT(200), DELT(200)	SEEF 90
	DIMENSION TI(10), XL(10), YL(10)	SEEF 100
	DIMENSION FNG(7,20), TNG(7,20), NS(20), YP(20), XP(20)	SEEF 110
	NOUT=20	SEEF 120
	M=1	SEEF 130
	N=0	SEEF 140
	DO 10 JJX=1,5	SEEF 150
	NS(JJX)=1	SEEF 160
10	CONTINUE	SEEF 170
	CALL PDIF	SEEF 180
	DO 40 I=1,ITSP	SEEF 190
	IF (ABS(PCTDIF(I)).LT.10.) GO TO 40	SEEF 200
	DIF F=FX(I)-FXC(I)	SEEF 210
	TXT=ABS(PCTDIF(I))	SEEF 220
C	IF (TXT.LT.20) GO TO 220	SEEF 230
	IF (N.LT.20) N=N+1	SEEF 240
	NS(M)=N	SEEF 250
	IF (N.LE.1) GO TO 30	SEEF 260
	IF (I.EQ.(I-1)) GO TO 30	SEEF 270
	IF (N.LE.3) GO TO 20	SEEF 280
	M=M+1	SEEF 290
20	N=1	SEEF 300
30	CONTINUE	SEEF 310
	WRITE (NOUT,190) IP,I,PCTDIF(I),DIF F	SEEF 320
	I I=I	SEEF 330
	TNG(M,N)=T(I)	SEEF 340
	FNG(M,N)=DIF F	SEEF 350
	MM=M	SEEF 360
40	CONTINUE	SEEF 370
	IF (MM.EQ.0) GO TO 140	SEEF 380
	MJM=KTRM	SEEF 390
	DO 130 M=1,MM	SEEF 400
	NN=NS(M)-1	SEEF 410
	WRITE (NOUT,200) (M,N,TNG(M,N),FNG(M,N),N=1,NN)	SEEF 420
	IF (NN.LE.2) GO TO 130	SEEF 430
C	FIND MINS AND MAXS	SEEF 440
50	FNGMX=FNG(M,1)	SEEF 450
	TMX=TNG(M,1)	SEEF 460
	FNGMN=FNG(M,1)	SEEF 470
	TMN=TNG(M,1)	SEEF 480
	DO 60 N=1,NN	SEEF 490
	IF (TNG(M,N).GT.TMX) TMX=TNG(M,N)	SEEF 500
	IF (TNG(M,N).LT.TMN) TMN=TNG(M,N)	SEEF 510
	IF (FNG(M,N).GT.FNGMX) FNGMX=FNG(M,N)	SEEF 520
	IF (FNG(M,N).LT.FNGMN) FNGMN=FNG(M,N)	SEEF 530
	XP(N)=TNG(M,N)	SEEF 540
	YP(N)=FNG(M,N)	SEEF 550
60	CONTINUE	SEEF 560
C	DRAW PICTURE	SEEF 570
		SEEF 580

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