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**GRPAUT: A Program for Pu
Isotopic Analysis (A User's Guide)**

ISPO TASK A.76

John G. Fleissner

January 30, 1981

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TECHNICAL ASSISTANCE
TO IAEA SAFEGUARDS

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Monsanto

MOUND FACILITY
Miamisburg, Ohio 45342

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MONSANTO RESEARCH CORPORATION
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Introduction

GRPAUT is a modular program for performing automated Pu isotopic analysis supplied to the International Atomic Energy Agency (IAEA) per ISPO Task A.76. Section I of this user's guide for GRPAUT presents an overview of the various programs and disk files that are used in performing a Pu isotopic analysis. Section II describes the program GRFEDT which is used in creating and editing the analysis parameter file that contains all the spectroscopic information needed at runtime by GRPAUT. An example of the dialog and output of GRFEDT is shown in Appendix B. Section III describes the operation of the various GRPAUT modules: GRPNL2, the peak stripping module; EFFCH2, the efficiency calculation module; and ISOAUT, the isotopic calculation module. (A description of the peak fitting methodology employed by GRPNL2 is presented in Appendix A.) Finally, Section IV outlines the procedure for determining the peak shape constants for a detector system and describes the operation of the program used to create and edit the peak shape parameter files. An output of GRPAUT, showing an example of a complete isotopic analysis, is presented in Appendix C. Source listings of all the Fortran programs supplied to the Agency under ISPO Task A.76 are contained in Appendix E.

I. Program overview

The program GRPAUT is designed to perform isotopic analysis of Pu or Pu-U spectra with minimal operator intervention. Disk files are used to supply the spectral information required to perform the analysis. Parameters such as peak energies, amplifier gain, ADC zero offset, etc., are contained in an "analysis parameter" file which is created and edited by the program GRFEDT. A different analysis parameter file is required for each energy range to be analyzed. The element name for each file is derived from the spectral type (either Pu or Pu-U) and from the energy range to be analyzed. For example, for isotopic analysis of a Pu spectrum (P), having gamma-ray energies up to 413 keV, the analysis parameter file would have an element name of P413. Similarly, the file for mixed Pu-U analysis (U), with an energy range to 270 keV, would have an element name of U270.

The peak shape response for each detector or detector system is also supplied via a disk file at runtime. The constants which parameterize the peak shape response are determined from calibration spectra with the aid of the program PKANAL. These peak shape constants are stored on a disk file with the program DETFIL. Each detector system is assigned a two digit "ID" number which is used in the element name for the peak shape parameter file. This "ID" is entered into the spectral header along with the other header information using the Nuclear Data supplied program PARS. (For a description of PARS, see the ND 6620 User Manual and ISPO Report 115: "Task A.29, NDA/Computer Data Processing.") The detector "ID" must be the first two characters of the header variable DE (detector type) and can be followed by twelve additional characters of information. For example, the DE entry for detector "30," a 15 cc coaxial detector, might be: 30 COAX 15 CC.

The logical unit definitions are transparent to the user since they are assigned within the various programs. The only exception is the "results" file, which is used to pass data between the modules of GRPAUT. The

user must assign this file to logical unit one (1). The spectrum and spectral header are assigned to logical units 12 and 8, respectively, by the job stream that transfers the spectrum from the Silena to the ND6620. These assignments follow the Nuclear Data convention. Table 1 lists the files and their logical unit assignments as used by the programs described in this volume.

A job stream format is used to execute the various modules of GRPAUT in program sequence. The job stream can also be used to define the logical unit for the "results" file. The commands required for an isotopic analysis sequence are as follows (where <CR> indicates a carriage return entry):

```
RES DATA.RES,BLK=10
DEF 1,DATA.RES          (logical unit def. for results file)
R GRPNL2
P208                    (analysis file element name)
NO                       (short form opt., yes for long form)
R EFFCH2
<CR>
R ISOAUT
<CR>
DEL DATA.RES
PAC DATA
ENDJOB
```

If this job stream has the element name GRPAUT, then to run the isotopic analysis program via the job stream, the user types:

```
JOB AUTO.GRPAUT,,,TTY
```

Upon completion of the analysis, the message "JOB STREAM COMPLETED" will appear on the ND6620 display.

TABLE I - Logical unit assignments for GRPAUT, PKANAL, and file maintenance programs.

<u>Logical Unit #</u>	<u>File Assignment</u>	<u>File Name</u>	<u>Associated Program(s)</u>
1	RESULTS FILE	OPTIONAL	GRPAUT
2	UNUSED	-	-
3	UNUSED	-	-
4	SCRATCH FILE	DATA.MTRX	GRPAUT
5	TTY	-	-
6	LP	-	-
7	UNUSED	-	-
8	SPECTRUM HEADER	OPTIONAL	GRPAUT, PKANAL
9	ANALYSIS FILE	ANALFL. <u>XXXX</u> *	GRPAUT, GRFEDT
10	DETECTOR FILE	DET. <u>EZZ</u> **	GRPAUT, DETFIL
11	UNUSED	-	-
12	SPECTRUM	OPTIONAL	GRPAUT, PKANAL

*ANALYSIS FILE ELEMENT NAME = XXXX

**DETECTOR "ID" NUMBER = ZZ

II. GRFEDT

The program GRFEDT creates and edits the analysis parameter file which contains the input parameters for the spectral regions to be fit by the program module GRPNL2. The files created by GRFEDT are identified within the programs GRFEDT and GRPNL2 by the four letter alphanumeric element name for that file; e.g., P208. The file name for the analysis files is ANALFL; thus, the above file is stored on the disk as: ANALFL.P208. The assignment of the logical unit for the analysis files is performed automatically by both programs and is, therefore, transparent to the user. Logical unit 9 is used for the analysis file.

GRFEDT will accept from one to twenty "regions of interest." Each region can contain up to 16 peaks. The various parameters for a region are entered by answering the prompting questions of the program.

To run the program the user types:

```
RUN GRFEDT
```

to which the program responds:

```
PROGRAM GRFEDT
USED FOR EDITING ANALYSIS FILES FOR GRPNL2
TYPE FOLLOWING:
FILENAME:
```

The four letter element name for the disk file is now entered, e.g., P208. The program then attempts to verify that the file exists on the disk. If the file is not present on the disk, the program asks the user whether he wishes to create a new file with the element name that was entered. If the user responds "YES," a blank file is created on the disk which can then be edited. If the user responds "NO," the program restarts.

After entering the filename (or creating a new file), the program is ready to accept the input data. The regions are edited one at a time and may be done in any order. The prompting commands in program sequence and a brief description of each follow. An entry of zero or carriage return in response to any prompting question does not change the previous value for that parameter.

INDEX OF REGION TO BE EDITED (1-20):

Index number of the region to be edited (1-20). If a zero is entered or no entry is made, the program prompts with:

INDEX OF REGION TO BE ZEROED (1-20):

A region index entry here will completely zero all the parameters for that particular region. This is useful for deleting a region of interest.

NUMBER OF LOW ENERGY BACKGROUND CHANNELS:

The number of channels prior to the START CHANNEL to be used in calculating the background on the low energy side of the region of interest.

START CHANNEL:

The first channel in the region of interest.

END CHANNEL:

The last channel in the region of interest. The number of channels between START CHANNEL and END CHANNEL cannot exceed 150 channels. After the END CHANNEL has been entered, the program checks the number of channels in the ROI. If the limit of 150 channels has been exceeded, the message:

MAXIMUM NUMBER (150) OF CHANNELS EXCEEDED, REENTER:

is printed, and the program loops back to the prompt for the START CHANNEL.

NUMBER OF HIGH ENERGY BACKGROUND CHANNELS:

The number of channels after the END CHANNEL to be used in calculating the background on the high energy side of the region of interest.

LOW ENERGY REFERENCE ENERGY:

HIGH ENERGY REFERENCE ENERGY:

The energies of two well defined peaks in the spectrum or region of interest can be entered here. If the input to the GAIN prompt question (see below) is a positive number, these two peaks are then used by the program GRPNL2 as calibration points for a two point determination of the gain.

LOW ENERGY BACKGROUND SLOPE:

HIGH ENERGY BACKGROUND SLOPE:

Slopes for the background before and after the peak grouping may be entered for peaks which lie in a region where the Compton background has a non-zero slope. The slope is expressed as the counts change per channel. To enter a value of zero (0.0), type -9999.

ENERGY OF CHANNEL ZERO:

The energy that corresponds to channel zero. Also known as zero intercept. To enter a value of zero (0.0), type -9999.

ENERGY OF CHANNEL ZERO:

The energy that corresponds to channel zero. Also known as zero intercept. To enter a value of zero (0.0), type -9999.

GAIN:

The gain is expressed in keV/channel. Entering the gain as a negative number signifies absolute gain; i.e., the gain and zero intercept are used by GRPNL2 to locate peaks and determine energies. If the gain is entered as a positive number, it is used as an "approximate" gain to locate the reference peaks (see above). The reference peaks are then used to determine the gain and zero intercept.

TYPE PEAK INDEX-FLAG-PEAK ENERGY XXX,X,XXXX.XX 1/LINE
NEGATIVE INDEX SPECIFIES ENERGY AND/OR HEIGHT RATIOED
FLAG=1 SPECIFIES UNCERTAIN ENERGY (-ENERGY FOR XRAY)

The energies for the peaks in the region of interest (up to a limit of 16) are entered, one per line. On each line are entered the peak index (positive or negative), a flag (0 or 1), and the peak energy in keV (positive or negative) separated by commas. A negative value for the energy indicates that the peak is an x-ray and will be fit as such by GRPNL2. In this case the program prompts with:

INTRINSIC WIDTH (eV):

and waits for the user to input the intrinsic width [1] of the x-ray line. A flag value of 1 indicates the energy is "uncertain," that is the peak centroid position will be a variable in the fitting process. A value of zero fixes the centroid to the channel corresponding to the energy of the peak entered by the user; i.e., $\text{centroid} = (\text{PEAK ENERGY} - \text{ZERO INTERCEPT}) / \text{GAIN}$. Entering the peak index as a negative number indicates that the peak energy or the peak height will be fixed relative to another peak in the region of interest. GRFEDT in this case prompts with:

ENERGY FIXED RELATIVE TO PEAK #:

and the user inputs the index of the peak to which the current peak is to be fixed. GRPNL2 will then vary the centroid of the current peak as the centroid of the peak to which it has been fixed varies. This is useful for splitting close members of a multiplet or for fixing the position of weak peaks. If a zero is entered or no entry made, the centroid is varied per the flag parameter discussed above. The user is then prompted for the peak height relationship:

PEAK HGHT. (ZERO FOR UNKNOWN, NEG. FOR RATIOED):

An entry of zero or no entry allows the peak height to be a variable in the fitting routine. A positive entry fixes the peak height to that value, while a negative entry indicates the peak height is to be ratioed to another peak in the region of interest. The height ratio is then the absolute value of the entry, where the height ratio is defined as the current peak's height divided by the height of the reference peak. This allows the height to be varied in proportion to a second peak, which is useful when both peaks are from the same isotope and their branching ratios are well known. In the case of a negative entry for the peak height, the user is then prompted for the peak index of the reference peak:

INDEX OF PEAK RATIOED TO:

The program then loops back for the next "peak index, flag, energy" entry. An entry of zero or no entry for the peak index exits this loop. Typing -9999. in place of the peak energy zeroes the parameters discussed above that are associated with that peak index.

DO YOU WANT TO FREE PARAMETER: (ENTER YES OR NO)
FWHM ?

An entry of YES allows the FWHM to be a free parameter. An entry of NO fixes the FWHM to the value determined from the peak shape parameter file.

TAIL AMPLITUDE (A) ?

An entry of YES allows the amplitude, A, of the tailing function to be a free parameter. An entry of NO fixes A to the value determined from the peak shape parameter file.

TAIL SLOPE (B) ?

An entry of YES allows the slope, B, of the tailing function to be a free parameter. An entry of NO fixes B to the value determined from the peak shape parameter file.

The program will now loop back for the index of the next region to be edited. A carriage return in response to "INDEX OF REGION TO BE EDITED:" and "INDEX OF REGION TO BE ZEROED:" exits the editing loop. The program then writes the edited file on the disk and prints out a summary of the data file before terminating execution. A sample output for GRFEDT is presented in Appendix B. A flowchart showing the overall organization of GRFEDT is shown in Figure 1.

Figure 1 - Flow chart illustrating organization of computer program GRFEDT.

III. GRPAUT

GRPAUT is an "automated" code, written in modular form, for Pu or Pu-U isotopic analysis. The first module, GRPNL2, performs the peak stripping using the GRPANL formalism [2]. (For a discussion of the peak fitting methodology of GRPNL2 see Appendix A.) The second module, EFFCH2, calculates the efficiency correction factors using an intrinsic calibration technique. ISOAUT, the final module, computes isotopic ratios from the peak areas and the efficiency correction factors. It also performs the error propagation calculations. A disk file is used to pass the data between the individual modules.

To perform a complete isotopic analysis, from spectrum stripping to isotopic abundance calculation, the three modules are run consecutively using a job stream format. The user responses to the program prompts are contained in the job stream dialog. (See Sec. I for a description of this job stream.) However, each of the individual modules: GRPNL2, EFFCH2, and ISOAUT, can be run as a stand-alone program, for which the user responses would be entered via the keyboard at runtime.

A. GRPNL2

GRPNL2 is the general purpose, automatic peak-stripping program for multiplet (or singlet) analysis. The functional form used is that of an asymmetric Gaussian with a diffused step background. It is written in Fortran and occupies approximately 21k words of memory on the ND6620 computer. The input data for the program is contained on three disk files: the peak shape parameter file, the analysis parameter file, and the spectral data file; all of these must be present on the disk at runtime.

The peak shape parameter file contains the constants necessary to determine the FWHM and the tailing parameters for a particular detector. Each detector is assigned a two-digit identification number. This detector "ID" is contained in the header information for the pulse height data

file and, therefore, the proper detector parameters are called in automatically by GRPNL2 for each spectrum to be analyzed. The detector parameter file is created and edited by the program DETFIL (discussed in Section IV).

The analysis parameter file contains data describing the spectral regions to be fit such as: start channel, end channel, gain, etc. These files are created and edited by the program GRFEDT. A four-letter alphanumeric element name is used to designate the file in the program GRPNL2. (See Sec. II. for a complete description of the analysis parameter file.)

The spectral data file contains the pulse height data plus an identification header for the spectrum. The spectral file is obtained prior to run time by reading the appropriate spectrum into the Silena analyzer and then transferring it to the ND6620. The programs GRPNL2 and PKANAL (see Sec. IV) observe the Nuclear Data convention of using logical unit 12 for the spectral file.

To run the program the user types:

```
RUN GRPNL2
```

At this point the program attempts to verify that the spectral data file exists on the disk. If an error occurs in attempting to open the file, the message:

```
SPECTRUM FILE OPEN ERROR
```

is printed and the program halts. Once the specified file is found on the disk, the program responds with:

```
TYPE NAME OF ANALYSIS PARAMETER FILE
```

The four-letter element name for the analysis parameter file is now entered; e.g., P208. The program then attempts to verify the existence of the file on the disk. If the file is not found, the message:

ANALYSIS FILE OPEN ERROR

is printed and the program halts. Once the program verifies the existence of both the spectral and analysis parameter files, the operator is prompted with:

COMPLETE PRINTOUT?

An answer of "yes" designates the "long form" of the output. If the user responds with anything else, then the "short form" of the output is designated. Sample outputs for the "short" and "long" form are shown in Appendices C and D respectively. Having answered these three questions, GRPNL2 begins fitting the first "region of interest."

The maximum number of channels in each "region of interest" (ROI) is limited to 150 channels exclusive of the background channels. The maximum number of free parameters that are allowed for each multiplet fit is 16. The parameters that can be freed for each peak of the multiplet are the height (area) and the centroid. The parameters that can be freed for the entire multiplet are the FWHM and the tailing parameters (A and B). Thus, up to a 16 peak multiplet can be fit if only the peak height (area) for each peak is allowed to be a free parameter. A six peak multiplet can be fit if all parameters are allowed to vary; however, this should only be attempted with spectra having good statistics. Occasionally, an ill-condition matrix or a non-convergent fit occurs in the fitting process when too many parameters have been freed than can be warranted by the counting statistics. When this situation arises, GRPNL2 fixes the multiplet parameters: BTAIL, ATAIL, and FWHM, in order, one at a time (if they have been freed), and retries the fit until a convergent fitting sequence is attained.

As with the number of free parameters for the multiplet, some tolerance has been built into GRPNL2 for the specification of the start and stop channels for a region of interest and also for the specification of the

background slope. If an "approximate" gain (see Section II) has been specified in the analysis file, the exact gain and intercept are calculated using the reference peaks. This new gain and intercept are then used to shift the start and stop channels such that the energy window for that region of interest is preserved. Thus, the user does not need to change the analysis file if the gain and/or intercept in the spectrum to be analyzed differs slightly from that specified in the analysis file. In like manner, if a zero or negative sloping background has been specified in the analysis parameter file, and a positive sloping background is identified by GRPNL2 for a region of interest, the program inserts a straight-line positive sloping background for the multiplet. Although positive sloping backgrounds are not routinely encountered in gamma-ray spectra taken with germanium detectors, they can occur due to such phenomena as the presence of backscatter peaks, x-ray tails, etc. Upon insertion of a positive sloping background by the program, the message:

WARNING: POSITIVE SLOPING BACKGROUND

is printed along with the computed positive slope and the average background above and below the peak prior to the data summary for that ROI.

The output form for GRPNL2 first lists the final results of the fit for each individual region of interest. In the "long form" output, iteration-by-iteration results are included in the printout such that after each iteration the values for the parameters: peak centroid, energy, peak height, FWHM, ATAIL, and BTAIL are listed for each peak in the ROI.

If the fitting sequence should not converge (as discussed above), one of the following applicable messages will be printed before GRPNL2 fixes a free parameter and the fit is retried:

SUM OF THE SQUARES OF R > THAN THOSE OF Y
FIT RETRIED WITH ONE LESS FREE PARAMETER

MATRIX IS SINGULAR

FIT RETRIED WITH ONE LESS PARAMETER

MAXIMUM NUMBER OF ITERATIONS EXCEEDED

FIT RETRIED WITH ONE LESS FREE PARAMETER

Once a convergent fit is achieved, the header information from the spectral file is printed followed by a summary of the input data from the analysis parameter file. The results for the analysis of that particular region of interest are then listed. The QFIT value (reduced χ^2) along with the final values for the FWHM, gain (keV/channel), ATAIL and BTAIL parameters for the multiplet are printed. Next, the final values for the peak centroid, energy, area, and per cent error of the area measurement are printed for each peak of the multiplet. Finally, a statistic [3,4], FOM (figure-of-merit), for the fit is printed.

Many times the reduced χ^2 value (QFIT) does not convey enough information by itself for a reliable judgment to be made on the goodness of fit. Normally, the experimenter would use plots of the fit to the data and/or a scan of the residuals in order to make this determination. However, a comparison of the QFIT and FOM values allows some conclusions to be drawn that aid the user in assessing the goodness-of-fit. Table II presents combinations of QFIT and FOM values and generalizations that can be drawn from them.

If the "short form" of the output has been selected, the FOM completes the ROI printout. For the "long form," the ROI printout is completed by a channel-by-channel summary of the following parameters: net counts (YNET), the residuals, and the weighted residuals. When the data for each ROI have been listed, a final tabulation of the centroids, energies, areas, and errors for all the peaks contained in the analysis parameter file is printed. These energies, areas, and area errors are then written to a "results" file on the disk. This "results" file is accessed via logical unit 1 (see Sec. I for a description of the logical unit assignments).

TABLE II - Combinations of QFIT and FOM values and generalizations concerning goodness-of-fit that can be drawn from them. Fits have been characterized as: good, fair (small flaws), and poor (major flaws). Counting statistics (STATS) have been characterized as: good ($\leq 1\%$) or poor ($\geq 10\%$).

FOM Value	QFIT VALUE		
	≈ 1	2-10	> 10
$< 2.5\%$	Good Fit	Good Fit Good Stats	Fair Fit Good Stats
2.5%-3.5%	Good Fit Poor Stats	Fair Fit	Fair-Poor Fit
$> 3.5\%$	Good Fit Poor Stats	Fair-Poor Fit	Poor Fit

B. EFFCH2

The second module of GRPAUT, EFFCH2, performs the efficiency correction calculations. An intrinsic calibration technique is used to obtain relative efficiency corrections which are a function of the detector response, the absorbers used (including the containment package), and the self-absorption of the sample. Areas for Pu-239, Pu-241, and Am-241 peaks are corrected for the gamma-ray branching intensities and are fit using a weighted least squares technique to the functional form:

$$\ln \epsilon_i = a_0 + \sum_{j=1}^2 a_j / E_i^j + \sum_{j=1}^3 a_{j+2} (\ln E_i)^j + a_6 \delta_6 + a_7 \delta_7$$

The terms containing the coefficients a_6 and a_7 are used to normalize the Pu-241 and the Am-241 data points to the Pu-239 data points. These normalization coefficients also provide an isotopic concentration measurement for Pu-241 and Am-241 relative to Pu-239.

EFFCH2 obtains the raw peak areas and errors from the "results" file. When a complete isotopic analysis is being performed via the job stream method described in Sec. I, the use of this program module is transparent to the user. However, the program can be run in a stand-alone mode. To run the program in this fashion, the user types:

RUN EFFCH2

to which the program responds:

ENTER RESULT FILE.ELEMENT NAME

The user enters the file and element name for the appropriate "results" file to be analyzed. Whether run in the stand-alone mode or the job stream sequence, the execution of the program is identical.

The output of the program consists of a line-by-line summary of the peak energies, areas, area errors, and relative gamma-ray branching intensities of the peaks to be used in the least-squares fit. Each entry is labeled with a peak index, which indicates the isotope to which the peak belongs: 1 for Pu-239, 2 for Pu-241, and 3 for Am-241. A normalized listing of the data is then printed, where now the peak areas have been divided by the gamma-ray branching intensities. These normalized peak areas are the experimental relative efficiency values to be fitted.

Following the normalized listing, the coefficients and their associated errors are printed along with the reduced chi-square statistic for the fit. Finally, a tabulation of relative efficiencies and relative efficiency errors for all the peaks in the "results" file is printed. These efficiency factors and their uncertainties are written to the original "results" file.

C. ISOAUT

ISOAUT, the final module of the program GRPAUT, computes the isotopic ratios using the raw areas and the efficiency factors contained in the "results" file. It also performs the error propagation calculations. When ISOAUT is invoked via the job stream format, its use is transparent to the user. However, like EFFCH2, it can be run in a stand-alone mode. To run ISOAUT in this fashion (assuming EFFCH2 has been run previously such that the efficiency corrections have been calculated), the user would enter:

```
RUN ISOAUT
```

to which the program responds:

```
ENTER RESULT FILE.ELEMENT NAME
```

The user then enters the file and element name for the appropriate results file. Whether run in the job stream or stand-alone mode, the operation of the program is identical.

The output of ISOAUT consists of a data summary and a listing of the calculated isotopic ratios. The data summary lists the gamma-ray energy, the peak area and uncertainty, and the efficiency correction factor and its uncertainty, for each gamma-ray line used in the isotopic analysis. Isotopic ratios and their uncertainties in per cent are then listed for various peak pairs; first, relative to Pu-239 and then relative to Pu-241. Finally, the isotopic abundances of Pu-241 and Am-241 relative to Pu-239 are listed as determined from the normalization constants of the relative efficiency curve fit (see EFFCH2 discussion). An example of a complete isotopic analysis output is shown in Appendix C.

IV. Peak shape parameter determination

The peak shape algorithm employed in GRPNL2 describes the peak as a Gaussian plus a low-energy side tailing term (Cf Eq A-1 and Figure 2). This tailing term is further subdivided into short-term tailing and long-term tailing. While the short-term tailing is thought to be mainly detector (and gamma-ray energy) dependent, the long-term tailing may depend upon the scattering within the sample and hence is sample dependent. Any tailing on the high energy side of the peak is usually due to signal distortion in the pulse shaping electronics and should be eliminated if possible.

The Gaussian portion of the peak can be described by three parameters: 1) x_0 - the peak centroid, 2) y_0 - the peak height at x_0 , and 3) σ - the peak width parameter. The first two parameters x_0 and y_0 usually are the unknowns of interest to be determined in a gamma-ray measurement. The peak width parameter, however, is proportional to the full width at half maximum (FWHM) of the peak and thus is a measure of the resolution of the detector system. This parameter can be determined a priori through a calibration of the detector system's resolution as a function of energy. As noted in Appendix A, σ^2 can be written in terms of the gamma-ray energy as:

$$\sigma^2 = k_1 + k_2 \cdot E \quad \text{A-3}$$

The short-term tailing is described by the exponential form:

$$T(x_i)_{S.T.} \propto A \exp B(x_i - x_0) \quad \text{IV-1}$$

where it has been determined empirically that B is essentially a constant for a detector system. The parameter A , however, is a function of the detector and the gamma-ray energy and can be described by the functional form:

Figure 2 - Gamma-ray photopeak obtained with Ge(Li) detector showing:
 1) Gaussian, 2) short-term tailing, 3) long-term tailing, and 4) dif-
 fused-step background contributions to spectral peak shape.

$$\ln A = k_3 + k_4 \cdot E$$

IV-2

Thus, the short-term tailing contribution to the peak can also be obtained by an empirical determination of B, k_3 , and k_4 . The long-term tailing component has the same functional form as the short-term tailing, that is:

$$T(x_i)_{L.T.} \propto C \exp D(x_i - x_0)$$

IV-3

Thus, all the peak shape constants, σ , A, B, C, and D can be determined from peaks in calibration spectra by measurement of the parameters FWHM, k_1 , k_2 , k_3 , k_4 , B, C, and D.

Some care must be exercised in choosing the calibration sources and in obtaining the spectra used for the peak shape parameter determination. The gamma-ray peaks to be used as calibration points should be well isolated and span the energy range of interest. The background continuum on either side of the peaks should be flat and free from interfering peaks. Count times should be long enough to ensure that the peaks to be used as calibration points have good counting statistics. However, high count rates should be avoided and/or pile-up rejection used to avoid peak shape distortion.

Once the calibration spectra have been obtained, the peaks are fit using the same shape algorithm employed in GRPNL2. The program PKANAL employs the peak shape algorithm of GRPNL2 and is used only for fitting singlets, hence it is well suited for determining the peak shape constants.

Unlike GRPNL2, PKANAL is an interactive program and the user must supply the relevant spectral data at runtime. PKANAL, like GRPNL2, uses logical unit 12 for the spectral data file.

To run PKANAL the user types:

RUN PKANAL

to which the program responds with a list of five options for running PKANAL. These options, listed in Table III, allow the user to choose a simple peak integration (option 0) or a choice of four combinations of free parameters for a fit to the data (options 1-4). Options 2, 3, and 4 are used in determining the peak shape constants.

After the options list, the user is prompted for the following spectral data information:

TYPE PEAK START AND END CHANNEL

The start and stop channels for the peak have the same definitions as in the program GRFEDT.

TYPE LOW AND HIGH ENERGY BACKGROUND CHANNELS

Again, the same definitions as in GRFEDT apply.

TYPE OPTION NUMBER

The user enters the relevant option number (0-4) for the present fit.

TYPE GAIN AND FWHM IN KEV

The GAIN (keV/channel) and the value of the FWHM (keV) are entered. For options 2 through 4, the FWHM is used as the starting value in the iterative fitting process.

TYPE ATAIL-BTAIL (SHORT-TERM)

The short-term tailing amplitude and slope are entered. They will be fixed or freed in the fitting process depending on the option selected.

TYPE ATAIL-BTAIL (LONG-TERM)

TABLE III - Free parameter options for singlet-fitting program PKANAL.

<u>Option #</u>	<u>FREE PARAMETER</u>			
	<u>Peak Height</u> <u>Peak Centroid</u>	<u>FWHM</u>	<u>A-Tail</u>	<u>B-Tail</u>
0	--- Peak Integration ---			
1	Yes	No	No	No
2	Yes	Yes	No	No
3	Yes	Yes	Yes	No
4	Yes	Yes	Yes	Yes

The long-term tailing amplitude and slope are entered. These values are fixed during the fitting process.

Once the above spectral information has been entered, the iterative fitting process is begun. The values for the peak centroid, peak height, FWHM, ATAIL, BTAIL (short-term) and QFIT are printed after each iteration. Upon convergence the message:

ENTER NEW ATAIL-BTAIL (LONG-TERM):(CR TO END)

is printed. The user may now enter new values for the long-term tailing amplitude and slope in order to obtain a better fit. If the user enters new values for the long-term tailing, the iterative process is restarted with the current values for the peak centroid and peak height as the new starting values. The values for the parameters FWHM, ATAIL, and BTAIL, however, are reset to the original values entered by the user since they can be more sensitive to a change in the long-term tailing. A comparison of the QFIT values for the different values of the long-term tailing constants allows the user to select the set of long-term tailing constants that produce the best fit. When the user is satisfied with the fit, an entry of zero or a carriage return, in response to the prompt for new long-term tailing constants concludes the fit. The final values for the various parameters are then printed followed by a channel-by-channel summary that is identical to the "long-form" of GRPNL2 (See Sec. III).

The peak shape constant determination process uses a high energy peak as the starting point since tailing is more severe at the higher energies. The peak selected should be well isolated and have good counting statistics. The start channel should be chosen far enough below the peak to include the long-term tailing contribution. The extent of the long-term tailing contribution below the photopeak is illustrated in Figures 2 and 3. Even though the effects of long-term tailing can be ignored (i.e., $C=0$) for many applications and the area under the long-term tail is not counted in the peak area, it should be included when determining the

Figure 3 - Gamma-ray photopeak of Figure 2 with background continuum removed. Long-term tailing contribution to peak shape is apparent on low-energy side of peak.

peak shape constants since it allows a more accurate determination of the short-term tailing constants. A step-by-step procedure for determining all the necessary peak shape constants follows.

STEP 1: Use PKANAL option 3 to fit the tailed high-energy peak. Set the long-term tailing constants, C and D, equal to zero; i.e., no long-term tailing contribution. Use a moderate value for the short-term tailing slope, $B = 3.0$. The peak will be fit with the Gaussian and short-term tailing components. A scan of the residuals will reveal the long-term tailing component. The log of the residuals is then plotted versus channel number and a straight line is fit to the linear portion of the log plot of the residuals. The long-term tailing slope, D, is the slope of this line divided by the gain. The tailing amplitude C can be determined by extrapolating the fitted line to the peak centroid channel, x_0 . The intercept, y_c , of the line at $x = x_0$, divided by the peak height y_0 , yields C; i.e. $C = y_c/y_0$. (See Figure 4.)

STEP 2: The high energy peak is now refit using the values of C and D determined in step 1. Option 4 is now used in order to free the short-term tailing constants, A and B. Since it has been empirically determined that B is essentially a constant for a given detector system, then the value of B obtained in this fit will be used for all succeeding fits. The value of B is typically between 1.0 and 5.0.

STEP 3: The remaining calibration peaks are now fit in decreasing order of energy. The values of B and D determined in Steps 1 and 2 are used. Since B is not to be varied, PKANAL option 3 is used for the remaining fits. The value of A chosen for the initial estimate should be slightly smaller than the preceding final value. For each of the remaining calibration peaks, the value of C can be adjusted to give the lowest QFIT value.

STEP 4: Only the peak shape parameters k_1 , k_2 , k_3 , and k_4 remain to be determined. The values of the FWHM (in keV) for the calibration peaks

Figure 4 - Gamma-ray photopeak of Figure 2 with background continuum, Gaussian and short-term tailing contributions removed. Slope and intercept of line through log plot of residuals used to determine long-term tailing constants C and D (see text).

are used to determine the parameters k_1 and k_2 . Equation A-3 can be written as:

$$[\text{FWHM(keV)}]^2 - 0.46(\text{GAIN})^2 = k_1 + k_2 \cdot E \quad \text{IV-4}$$

where the value 0.46 is Sheppard's correction constant [7]. A linear regression can be used to fit the data points $[E_i, \text{FWHM}_i^2]$ to a straight line to determine k_1 and k_2 (See Figure 5). Finally, the values of A obtained from the fits of the calibration peaks can be used to determine k_3 and k_4 . The relationship between gamma-ray energy and the slope constant A is given in Equation (A-4) as:

$$\ln A = k_3 + k_4 \cdot E \quad \text{A-4}$$

Again a linear regression can be used to fit the data points $[E_i, \ln A_i]$ to a straight line to determine the parameters k_3 and k_4 . (See Figure 5.)

Once the peak shape parameters have been determined, they are stored on a disk file that can be accessed by GRPNL2. Each detector system is assigned a two-digit identification number. (This "ID" number is entered into the spectral header with the ND program PARS. See Sec. I for details.) The detector parameter file is then stored on the disk using the file name DET. The two-digit "ID" number is appended to the letter "E" to form the element name. Thus, the peak shape parameter file for detector system "30" would be stored on the disk as: DET.E30. The detector parameter file is created and edited by the program DETFIL, which automatically assigns the file to logical unit 10.

To run the program DETFIL the user types:

```
RUN DETFIL
```

to which the program responds:

Figure 5 - $(FWHM)^2$ and $\ln A$ plotted as function of gamma-ray energy. Fits used to determine peak shape parameters: k_1 , k_2 , k_3 , and k_4 (see text).

PROGRAM DETFIL

PREPARES DISK FILES OF SHAPE CONSTANTS USED BY GRPNL2

TYPE DETECTOR NUMBER FOR CONSTANT FILE:

the user then enters the two-digit identification number for the relevant detector. The program then responds with:

IS THIS A NEW FILE? (YES OR NO):

If the user wishes to create a completely new file YES is entered. If he wishes to edit a previously created file, an answer of NO is entered. In either case the user is prompted with:

DO YOU WISH TO EDIT PEAK SHAPE CONSTANTS

OR ENTER ENTIRE LIST OF CONSTANTS? (0=EDIT,1=ENTER LIST):

If the user is creating a new file or wants to change all the constants for a particular detector an entry of 1 (ENTER LIST) is made. The user is then prompted to enter the seven peak shape parameters: k(1), k(2), k(3), k(4), B, C, and D. After these parameters are entered, they are listed for the user in case further editing is necessary.

If the user wishes to edit only the values of a few peak shape parameters from an existing file, an entry of 0 (EDIT) is made in response to the above prompt. A list of the current values is printed and the program types:

ENTER INDEX, VALUE (ENTER 0 TO END):

The index from the listing and the peak shape constant to be edited are entered, one per line. When the user wishes to exit the edit loop, a zero is entered and the program types an updated listing of the peak shape constants.

Whether the user has entered an entire list of constants or only edited a few values, after the updated listing is printed the program types:

DO YOU WISH TO EDIT OR END? (1=EDIT, 0=END):

At this point the user may enter (or reenter) the editing loop by typing a 1 or may exit the program by typing a 0. When the user chooses to exit, the new or revised data are written onto the designated disk file. The program then prints the last date the file was edited and the current date.

If the program fails to open the output file, then the message:

FILE OPEN FAILED

will be printed and program execution will be halted. If the user attempts to create a new shape parameter file with an existing element name, the program responds:

OUTPUT FILE ALREADY EXISTS

and program execution will be halted.

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Appendix A

GRPNL2 FITTING ALGORITHM

The program called GRPANL (GRouP ANalysis) evolved over a number of years as an interactive, general purpose program for use on minicomputers to analyze designated peak groupings of gamma- and x-rays in spectra taken with germanium detectors [2]. Its purpose is to calculate peak positions, or energies, and peak intensities while allowing the operator control with respect to the initial parameters for analysis of the peak grouping. Recently [5], the program has been adapted to perform automatic analysis of spectra, thus minimizing operator intervention. This type of automatic analysis is particularly useful when large numbers of similar spectra must be analyzed. The spectral parameters that would normally require decisions by a trained gamma-ray spectroscopist are stored on a disk file prior to run time, thus, eliminating the need for the operator to have any formal training in gamma-ray spectroscopy. This automated version of GRPANL is called GRPNL2. It employs the identical methodology of GRPANL and is intended for the user who requires spectral analysis yielding accurate energies and peak areas with a minimum of operator intervention.

Although the program GRPANL was originally written for use on a PDP-8 computer [6], and later adapted to the PDP-11 series, the version of GRPNL2 listed in this report operates on a ND6620 under the MIDAS PLUS operating system of Nuclear Data Incorporated. It is capable of analyzing a peak grouping spanning a region of up to 150 channels and allows up to 16 parameters to be freed (i.e., 16 degrees of freedom with respect to any combination of peak heights, positions, and peak shape parameters). In addition, the peak position and/or intensity of any peak can be fixed relative to that of any other designated peak within the grouping. X-rays, whose shapes are different from gamma rays, can also be fitted. The peak energies are determined by either specifying the exact gain and zero intercept or by allowing the program to calculate the energy scaling, using specified internal reference peaks.

FITTING METHODOLOGY

Accurate determination of peak positions and areas is one of the most important aspects of analyzing complex x- and gamma-ray spectra obtained with solid-state detectors. These measurements usually require a fitting procedure, particularly when two or more peaks overlap severely. Several methods of fitting have been developed [7-11]. Each fitting technique is based on a supporting model or methodology. The methodology frequently grows out of such factors as experience, intended use of the analysis program, size and speed of the computer used, and accuracy that is required. In this section, the methodology used in the GRPANL/GRPNL2 program will be discussed.

A. PEAK SHAPE ALGORITHM

The most obvious and intense portion of a gamma-ray peak is described by a Gaussian function. However, deviations from Gaussian, known as tailing, occur on the low- and sometimes also on the high-energy side of the peak. The low side tailing is due to incomplete charge collection in the detector, though low angle scattering in the sample source or in surrounding materials can also contribute to low side tailing. Tailing on the high energy side arises from signal distortion by the pulse-shaping electronic modules. This high-side tailing should be eliminated or reduced as much as possible.

The tailing portion of a peak can generally be described using one or more terms of exponential form. Some programs divide each peak into fitting regions and apply a separate function to each region [9]. The boundary conditions are chosen so that the calculated response and, in most cases its first derivative, form a smooth curve. The analytical expression for the shape function used in GRPANL is adapted from Sanders and Holmes [12] and treats the entire peak region with a single expression. This expression is given by:

$$y_i = y_0 [\exp \alpha (x_i - x_0)^2 + T(x)] \quad (A-1)$$

where

y_i = net counts in channel x_i for a single peak

y_0 = peak height at $x_i = x_0$

$\alpha = -4 \ln 2 / (\text{FWHM})^2 = -1/2\sigma^2$ (σ = peak width parameter)

x_0 = peak centroid position

$T(x)$ = tailing function

The tailing function is given by:

$$T(x) = [A \exp B(x_i - x_0) + C \exp D(x_i - x_0)] \cdot [1 - \exp 0.4 \alpha (x_i - x_0)^2]^\delta \quad (\text{A-2})$$

where

A and C = the short-and long-term tailing amplitudes

B and D = the tailing slopes

$\delta = 1$ for $x_i < x_0$; $\delta = 0$ for $x_i \geq x_0$.

The expression in the right-hand bracket of the tailing function causes the tailing contribution to be brought smoothly to zero as the peak centroid is approached (see Figure 2). The long-term tailing component can be disregarded ($C = 0$) for many applications. However, inclusion of this component is desirable in order to obtain a more accurate fit of a large peak multiplet having good counting statistics.

The peak shape parameters in the above expressions are y_0 , x_0 , α , A, B, and sometimes C and D. Peak positions and heights are generally the measurements of interest, thus x_0 and y_0 are the principal parameters in

the fitting process. The other parameters may be treated as fixed or free parameters depending on whether their values have been predetermined via a calibration. The values of α , A, B can be determined from rather simple expressions in terms of the gamma-ray energy. For example, the peak width σ can be expressed as a function of the gamma-ray energy (E) by:

$$\sigma^2 = \sigma_N^2 + \sigma_S^2 = k_1 + k_2 E \quad (A-3)$$

where σ_N is related to the system "noise" and σ_S is a term related to the statistical nature of the charge collection process. Once k_1 and k_2 are determined (see Section IV), the above expression can subsequently be used to calculate the width parameter for a peak of any other energy.

Empirically, it has been found that the tailing slope, B, can generally be treated as a constant for a given detector system. To determine B accurately, a high energy peak where the short-term tailing is most severe should be used. Once B is determined and held constant, the tailing amplitude (A) can be expressed by:

$$\ln A = k_3 + k_4 E \quad (A-4)$$

(The determination of parameters A and B is discussed in Section IV).

There are now five basic peak-shape constants (i.e., k_1 , k_2 , k_3 , k_4 , and B) plus the two long-term tailing constants, C and D, which are required only in special cases. These shape constants are stored in a "detector" file that is accessed by GRPNL2. The "analysis parameter file" (discussed in Sec. II) has control over how the program is to use the information in the "detector" file; that is, whether the parameters calculated using these shape constants will be fixed in the fitting process or are only to be used as the starting estimates in the iteration process.

Although long-term tailing can be included in the fitting process, GRPNL2 does not include the area under the long-term tail as part of the reported peak area; however, the area under the short-term tail will be

included. A short-term tailing slope of $B=1$ should be used to distinguish the two forms of tailing, with values for B generally between 1.0 and 5.0. The tailing amplitude varies according to the slope value with high amplitudes occurring with higher slope values. It also varies according to the severity of the peak tailing with low energy peaks of good detectors exhibiting rather low values (0.01 - 0.1) and higher energy peaks exhibiting tailing amplitude values that may be greater than 1.0.

The peak shapes of x-rays differ from those of gamma rays of the same energy because atomic transitions have much shorter lifetimes than nuclear transitions. This difference becomes more pronounced with increasing energy. The intrinsic radiative width of heavy element x-rays at 100 keV is about 100 eV; whereas, gamma-ray widths are typically a small fraction of an electron volt. Furthermore, the intrinsic x-ray distribution is Lorentzian in shape. When the broadened x-ray distribution is convoluted with the nearly Gaussian instrumental response, the result is a more complex peak shape than that produced by gamma rays. The necessary modification to the peak shape algorithm needed to fit this new distribution (shown in Figure 6) is discussed in an earlier report [13]. This algorithm is incorporated into GRPNL2.

B. DELINEATION OF THE BACKGROUND

The peaks of any x- or gamma-ray spectrum lie on top of a background distribution resulting from the Compton scattering process. In GRPNL2, this distribution must be removed before the peaks can be fit. The "analysis parameter file" (discussed in Section II) specifies regions on either side of the peak groupings that establish the corresponding background levels. The slopes of the background continuum preceding and following the peak grouping can also be specified if a peak grouping rests on a sloping background.

An explicit function [8] is used to calculate the interpolated background between the start and stop channels which define the region of interest

Figure 6 - X-ray photopeak showing convolution of instrumental Gaussian shape and intrinsic Lorentzian distribution.

(ROI). This function can be written in the following form:

$$B_i = b_m + (b_n - b_m) \left(\frac{\sum_{j=m}^i y_j}{\sum_{k=m}^n y_k} \right) \quad (A-5)$$

where

m = start channel of ROI,

n = stop channel of ROI,

B_i = computed background at channel i ,

y_i = spectrum count of channel i ,

b_m = background level of the low-energy side of the peak,

b_n = background level of the high-energy side of the peak.

This procedure works equally well for single peaks and for complex peak groupings (Figure 7). An examination of Equation A-5 shows that it is essentially equivalent to the error-function form [10] for describing the background continuum. However, in GRPNL2 the background is removed per Equation A-5 before the fitting process commences; whereas, the error function method includes it in the fitting process. The latter method, therefore, requires more fitting parameters and greater calculation time.

If a background continuum slope has been specified, the steps in the background centered at the peak positions are superimposed on the specified

Figure 7 - Background continuum shape, generated using Eq. A-5, under a complex multiplet containing contributions from 14 gamma-ray peaks.

slope, and the size of the steps depends on the sign and magnitude of the slope. If the two input slopes are different, the background continuum will make a gradual change from one to the other, with steps occurring at the positions of greatest peak intensity.

The selection of the start and stop channels for a ROI is usually a matter of judgment, and it is frequently difficult to determine or define where a peak should start or end. This is particularly true if one is to include long-term tailing and/or x-rays in the fitting process, since these distributions extend to considerable distances from the peak, as previously illustrated in Figures 2 and 6. Depending on where the boundaries are chosen, the channel regions selected for measuring the background levels may contain small contributions from the peaks to be fit. GRPNL2 handles this problem by automatically adjusting the measured levels according to the current computed contribution of the peaks to the two background regions. The adjustment is refined after each iteration of the least-squares fitting process.

C. FITTING PROCESS

Following the removal of the background continuum, the new channel counts of a multiplet are considered as a set of data values Y_i that have been measured with respect to an independent variable x_i and to which overlapping single peaks may be contributing according to:

$$i = \sum_{j=1}^n y_{ji} \quad (A-6)$$

The solution to the fit is determined by finding a response function that, when evaluated point by point, most closely approximates the original data values (Y_0). This evaluation is done by minimizing chi square (χ^2). However, because the equations describing the peak shape are not of linear form, an iterative procedure is used to arrive at a solution to the fit. The method used in GRPNL2 is a non-linear least squares technique based on linearizing the equations by performing a first order, Taylor's series expansion about the trial values of the free

parameters. (The method is also variously known as the Gauss-Seidel or Newton-Raphson method). From Equations A-1 and A-2, we see that y_i is related to several peak parameters (N) which we will here designate simply as p_k , that is:

$$y_{ij} = f(p_1, p_2, \dots, p_N) \quad (A-7)$$

By retaining only the first term in the Taylor's expansion of this equation, we derive:

$$y_{ij} - f(p_1^0, p_2^0, \dots, p_N^0) = \sum_{k=1}^N \frac{\delta f}{\delta p_k} \Delta p_k \quad (A-8)$$

where

y_{ij} = the contribution of the j th peak to channel i ,

p_k^0 = current best estimate in the k th peak parameter,

Δp_k = the change in the current best estimate of the k th parameter required to obtain a better fit to the data.

The current "free" parameter values are updated following each iteration, and the process continued until the current indicated change in each parameter is less than the prescribed amount.

The speed at which convergence is achieved is dependent upon a number of factors. Among these are the complexity of the grouping, the number of free parameters, the convergence criteria, and the accuracy of the initial parameter estimates. In addition to slow convergence, poor parameter estimates or statistically poor data may lead to an ill condition matrix or a fitting sequence that does not converge. GRPNL2 precludes or rectifies these conditions by including boundary constraints, damping or limiting the estimated changes to be made in the free parameters, automatically reducing the number of free parameters and limiting the allowable number of iterations to 15.

Convergence is determined by comparing the magnitude of the last changes made in each of the parameters being determined with internally specified convergence criteria. Each convergence criterion value has a fixed and a variable component, the latter being related to the error associated with the parameter being determined. The use of the error component allows early convergence because the specification arising only from the fixed component would be needlessly tight when applied to statistically poor data.

Once convergence has been attained, calculations are made to determine the final peak energies, intensities, and the respective errors. The latter are based on counting statistics and the goodness of fit and are calculated using the formula:

$$\text{ERROR}(j) = (\text{DM}(j) * \text{QFIT})^{1/2} \quad (\text{A-9})$$

where

$\text{DM}(j)$ = diagonal error matrix element of parameter j

and

$$\text{QFIT} = \left(\sum_{i=1}^N R_i^2 \right) / \text{DOF} \quad (\text{A-10})$$

R_i = the weighted residual of the fit to channel i

and

DOF = degrees of freedom.

Appendix B

Example of output for program GRFEDT (user responses are indicated by underscoring; symbol **↵** indicates insertion of a carriage return)

.RUN GRFEDT

PROGRAM GRFEDT

USED FOR EDITING ANALYSIS FILES FOR GRFNL2

TYPE FOLLOWING:

FILE NAME: RFAN

INDEX OF REGION TO BE EDITED (1-20) : 8

NUMBER OF LOW ENERGY BACKGROUND CHANNELS: 7

START CHANNEL: 1688

END CHANNEL: 1735

NUMBER OF HIGH ENERGY BACKGROUND CHANNELS: 7

LOW ENERGY REFERENCE ENERGY: 148.57

HIGH ENERGY REFERENCE ENERGY: 208.00

BACKGROUND SLOPE: ?

ENERGY OF CHANNEL ZERO: ?

GAIN: .115

TYPE PEAK INDEX-FLAG-PEAK ENERGY XXX,X,XXXX.XX 1/LINE

NEGATIVE INDEX SPECIFIES ENERGY AND/OR HEIGHT RATIOED

FLAG = 1 SPECIFIES UNCERTAIN ENERGY (- ENERGY FOR X-RAY)

1,1,195.66

-2,1,196.87

ENERGY FIXED RELATIVE TO PEAK #: 1

PEAK HGHT.(ZERO FOR UNKNOWN,NEG. FOR RATIOED) : -0.0348

INDEX OF PEAK RATIOED TO : 1

-3,1,198.02

ENERGY FIXED RELATIVE TO PEAK #: 1

PEAK HGHT.(ZERO FOR UNKNOWN,NEG. FOR RATIOED) : ?

DO YOU WANT TO FREE PARAMETER: (ENTER YES OR NO)

FWHM ? YES

TAIL AMPLITUDE (A) ? NO

TAIL SLOPE (B) ? N

INDEX OF REGION TO BE EDITED (1-20) : 2

NUMBER OF LOW ENERGY BACKGROUND CHANNELS: ?

START CHANNEL: ?

END CHANNEL: ?

NUMBER OF HIGH ENERGY BACKGROUND CHANNELS: ?

LOW ENERGY REFERENCE ENERGY: ?

HIGH ENERGY REFERENCE ENERGY: ?

BACKGROUND SLOPE: -9999.

ENERGY OF CHANNEL ZERO: -9999.

GAIN: ?

TYPE PEAK INDEX-FLAG-PEAK ENERGY XXX,X,XXXX.XX 1/LINE

NEGATIVE INDEX SPECIFIES ENERGY AND/OR HEIGHT RATIOED

FLAG = 1 SPECIFIES UNCERTAIN ENERGY (- ENERGY FOR X-RAY)

DO YOU WANT TO FREE PARAMETER: (ENTER YES OR NO)

FWHM ? ?

TAIL AMPLITUDE (A) ? YES

TAIL SLOPE (B) ? ?

INDEX OF REGION TO BE EDITED (1-20) : ?

INDEX OF REGION TO BE ZEROED (1-20) : 20

INDEX OF REGION TO BE EDITED (1-20) : 2
 INDEX OF REGION TO BE ZEROED (1-20) : 2

FILE NAME : GRFANP.ANL

16-JAN-81

REGION	LOW E BKGD	START CHAN	END CHAN	HIGH E BKGD	LOW E REF.	HIGH E REF.	ZERO CHAN	BKGD SLOPE	GAIN	FWHM	A	B
1	3	1068	1138	7	129.3	148.6	0.0	0.0	0.1150	1	1	0
2	7	1109	1138	7	129.3	148.6	0.0	0.0	0.1150	1	1	0
3	7	1223	1314	5	129.3	148.6	0.0	0.0	0.1150	1	1	0
4	5	1317	1339	7	129.3	148.6	0.0	0.0	0.1150	0	0	0
5	7	1377	1445	7	148.6	208.0	0.0	0.0	0.1150	1	1	0
7	7	1463	1504	7	148.6	208.0	0.0	0.0	0.1150	1	0	0
8	7	1688	1735	7	148.6	208.0	0.0	0.0	0.1150	1	0	0
9	7	1752	1830	7	148.6	208.0	0.0	0.0	0.1150	1	1	0
10	3	2208	2234	3	148.6	208.0	0.0	0.0	0.1150	1	0	0
11	7	2313	2340	7	148.6	208.0	0.0	0.0	0.1150	1	1	0
12	7	1548	1569	7	148.6	208.0	0.0	0.0	0.1150	1	0	0
13	7	1628	1659	7	148.6	208.0	0.0	0.0	0.1150	1	0	0
15	7	3175	3286	5	208.0	413.7	0.0	0.0	0.1150	1	1	0
16	7	3394	3436	7	208.0	413.7	0.0	0.0	0.1150	1	1	0
17	7	3562	3628	7	208.0	413.7	0.0	0.0	0.1150	1	1	0
18	7	3908	3942	7	208.0	413.7	0.0	0.0	0.1150	1	1	0
19	7	2874	3019	7	208.0	413.7	0.0	0.0	0.1150	1	0	0

REGION	INDEX	ENERGY	EFLAG	HEIGHT	HTFLAG	GAMMA
1	1					
	1	124.51	-4	-0.970E-02	-4	0.0
	2	125.21	-4	-0.114E-01	-4	0.0
	3	125.29	-4	0.000E+00	0	0.0
	4	129.29	1	0.000E+00	0	0.0
	5	122.99	-4	-0.245E+00	-3	0.0
	6	123.62	-4	0.000E+00	0	0.0
2	1	129.29	1	0.000E+00	0	0.0
3	1	143.35	-5	-0.610E-01	-2	0.0
	2	144.21	1	0.000E+00	0	0.0
	3	146.08	-5	-0.421E+00	-2	0.0
	4	146.56	-5	0.000E+00	0	0.0
	5	148.57	1	0.000E+00	0	0.0
	6	150.11	-5	-0.160E+00	-4	0.0
	7	141.66	-5	-0.113E+00	-2	0.0
4	1	152.68	1	0.000E+00	0	0.0

REGION 5

1	159.96	-5	0.000E+00	0	0.0
2	160.19	-5	-0.517E-01	-4	0.0
3	160.28	-5	0.000E+00	0	0.0
4	161.45	1	0.000E+00	0	0.0
5	164.58	1	0.000E+00	0	0.0
6	165.93	-5	0.000E+00	0	0.0

REGION 7

1	169.56	-2	0.000E+00	0	0.0
2	171.34	1	0.000E+00	0	0.0

REGION 8

1	195.66	1	0.000E+00	0	0.0
2	196.87	-1	-0.340E-01	-1	0.0
3	198.02	-1	0.000E+00	0	0.0

REGION 9

1	203.54	1	0.000E+00	0	0.0
2	208.00	1	0.000E+00	0	0.0

REGION 10

1	255.38	1	0.000E+00	0	0.0
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REGION 11

1	267.54	1	0.000E+00	0	0.0
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REGION 12

1	179.20	1	0.000E+00	0	0.0
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REGION 13

1	189.32	1	0.000E+00	0	0.0
2	187.96	-1	0.000E+00	0	0.0

REGION 15

1	367.05	-5	0.000E+00	0	0.0
2	368.55	-5	-0.575E-01	-5	0.0
3	368.61	-5	0.000E+00	0	0.0
4	370.93	-5	0.000E+00	0	0.0
5	375.04	1	0.000E+00	0	0.0
6	376.60	1	0.000E+00	0	0.0
7	372.45	-5	0.000E+00	0	0.0

REGION 16

1	392.53	-2	0.000E+00	0	0.0
2	393.14	1	0.000E+00	0	0.0

REGION 17

1	413.71	1	0.000E+00	0	0.0
2	411.15	-1	0.000E+00	0	0.0
3	416.00	-1	0.000E+00	0	0.0

REGION 18

1	451.41	1	0.000E+00	0	0.0
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REGION 19

1	332.39	-6	0.000E+00	0	0.0
2	332.86	-6	0.000E+00	0	0.0
3	335.42	-6	0.000E+00	0	0.0
4	336.11	-6	0.000E+00	0	0.0
5	341.51	-6	0.000E+00	0	0.0
6	345.01	1	0.000E+00	0	0.0
7	337.70	-6	0.000E+00	0	0.0
8	334.10	-6	0.000E+00	0	0.0

Appendix C

Sample of isotopic analysis output of program GRPAUT
("Short Form" of GRPNL2 included)

RUN GRPAUT
PROGRAM GRPNL2

TYPE FILE NAME AND SEQUENCE NUMBER OF SPECTRUM TO BE CALCULATED SALM,11
TYPE NAME OF CALCULATION PARAMETER FILE RFAN
COMPLETE PRINT OUT ? NO
PROGRAM GRPNL2 VERSION 1A 04-DEC-80 15:33

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1067
GROUP ENDS AT CHANNEL 1137
BACKGROUND LOW ENERGY 3
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	124.510	0.00	NO	4	NO	4	-0.00970
2	125.210	0.00	NO	4	NO	4	-0.01140
3	125.290	0.00	NO	4	YES	0	0.00000
4	129.290	0.00	YES	0	YES	0	0.00000
5	122.990	0.00	NO	4	NO	3	-0.24510
6	123.620	0.00	NO	4	YES	0	0.00000

ANALYSIS RESULTS

QFIT 124.4 FWHM 0.58160 KEV/CHANNEL 0.11460 ATAIL 0.00076 BTAIL 1.11386

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1081.717	124.478	6653.	0.0000E+00	0.0
2 1087.825	125.178	7834.	0.0000E+00	0.0
3 1088.523	125.258	205956.	0.0000E+00	3.2
4 1123.426	129.258	694325.	0.0000E+00	1.8
5 1068.453	122.958	41223.	0.0000E+00	0.0
6 1073.951	123.588	-12018.	0.0000E+00	-25.1

FOM(%) = 7.38

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DKOGRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1108
GROUP ENDS AT CHANNEL 1137
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	129.290	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.3 FWHM 0.58501 KEV/CHANNEL 0.11460 ATAIL 0.00669 BTAIL 1.11386

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1123.451	129.261	696426.	0.0000E+00	0.2

FOM(%) = 0.59

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1222
 GROUP ENDS AT CHANNEL 1314
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 5
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE YES
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	143.350	0.00	NO	5	NO	2	-0.06100
2	144.210	0.00	YES	0	YES	0	0.00000
3	146.080	0.00	NO	5	NO	2	-0.42100
4	146.560	0.00	NO	5	YES	0	0.00000
5	148.570	0.00	YES	0	YES	0	0.00000
6	150.110	0.00	NO	5	NO	4	-0.16000
7	141.660	0.00	NO	5	NO	2	-0.11300

ANALYSIS RESULTS

QFIT 1.7 FWHM 0.60891 KEV/CHANNEL 0.11460 ATAIL 0.01383 BTAIL 1.11386

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1245.488	143.247	2656.	0.0000E+00	0.0
2 1253.183	144.128	43652.	0.0000E+00	0.8
3 1269.309	145.977	18460.	0.0000E+00	0.0
4 1273.498	146.457	41891.	0.0000E+00	0.9
5 1291.037	148.467	725521.	0.0000E+00	0.2
6 1304.474	150.007	6756.	0.0000E+00	0.0
7 1230.741	141.557	4878.	0.0000E+00	0.0

FOM(%) = 1.18

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1317
GROUP ENDS AT CHANNEL 1339
BACKGROUND LOW ENERGY 5
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM NO
TAIL AMPLITUDE NO
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	152.680	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.1 FWHM 0.60549 KEV/CHANNEL 0.11460 ATAIL 0.00465 BTAIL 1.11386

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1327.157	152.606	26188.	0.0000E+00	1.2

FOM(%) = 6.80

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1377
 GROUP ENDS AT CHANNEL 1445
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE YES
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	159.960	0.00	NO	5	YES	0	0.00000
2	160.190	0.00	NO	5	NO	4	-0.05170
3	160.280	0.00	NO	5	YES	0	0.00000
4	161.450	0.00	YES	0	YES	0	0.00000
5	164.580	0.00	YES	0	YES	0	0.00000
6	165.930	0.00	NO	5	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.2 FWHM 0.63158 KEV/CHANNEL 0.11500 ATAIL 0.00113 BTAIL 1.10995

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1390.244	159.875	28043.	0.0000E+00	1.6
2 1392.244	160.105	1173.	0.0000E+00	0.0
3 1393.026	160.195	37344.	0.0000E+00	1.2
4 1403.247	161.371	22762.	0.0000E+00	1.3
5 1430.416	164.495	217446.	0.0000E+00	0.3
6 1442.154	165.845	2140.	0.0000E+00	10.0

FOM(%) = 1.89

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANFANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1463
GROUP ENDS AT CHANNEL 1504
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE NO
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	169.560	0.00	NO	2	YES	0	0.000000
2	171.340	0.00	YES	0	YES	0	0.000000

ANALYSIS RESULTS

QFIT 2.0 FWHM 0.62492 KEV/CHANNEL 0.11500 ATAIL 0.00531 BTAIL 1.10995

	CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1	1473.893	169.496	19023.	0.0000E+00	2.2
2	1489.371	171.276	21789.	0.0000E+00	2.0

FOM(%) = 9.73

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1547
GROUP ENDS AT CHANNEL 1568
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE NO
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIDED TO	RATIO
1	179.200	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.8 FWHM 0.65961 KEV/CHANNEL 0.11478 ATAIL 0.00566 BTAIL 1.11210

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1557.485	179.165	13965.	0.0000E+00	3.1

FOM(%) = 12.12

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1627
 GROUP ENDS AT CHANNEL 1658
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE NO
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	189.320	0.00	YES	0	YES	0	0.00000
2	187.960	0.00	NO	1	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.1 FWHM 0.66086 KEV/CHANNEL 0.11478 ATAIL 0.00609 BTAIL 1.11210

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1645.777	189.299	16996.	0.0000E+00	1.9
2 1633.929	187.939	1539.	0.0000E+00	15.3

FOM(%) = 11.09

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DKOGRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1688
 GROUP ENDS AT CHANNEL 1735
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE NO
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	195.660	0.00	YES	0	YES	0	0.00000
2	196.870	0.00	NO	1	NO	1	-0.03480
3	198.020	0.00	NO	1	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.5 FWHM 0.69680 KEV/CHANNEL 0.11500 ATAIL 0.00645 BTAIL 1.10995

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1700.860	195.598	24657.	0.0000E+00	1.6
2 1711.381	196.808	861.	0.0000E+00	0.0
3 1721.380	197.958	4132.	0.0000E+00	6.7

FOM(%) = 10.72

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANFANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 1752
GROUP ENDS AT CHANNEL 1830
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	203.540	0.00	YES	0	YES	0	0.00000
2	208.000	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 3.9 FWHM 0.69120 KEV/CHANNEL 0.11500 ATAIL 0.01285 BTAIL 1.10995

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1769.289	203.468	127892.	0.0000E+00	0.3
2 1808.008	207.920	2918084.	0.0000E+00	0.1

FOM(%) = 0.49

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DKOGRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 2207
GROUP ENDS AT CHANNEL 2233
BACKGROUND LOW ENERGY 3
BACKGROUND HIGH ENERGY 3
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE NO
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	255.380	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.6 FWHM 0.72826 KEV/CHANNEL 0.11500 ATAIL 0.00995 BTAIL 1.10995

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 2220.118	255.315	15972.	0.0000E+00	1.7

FOM(%) = 6.64

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 2312
GROUP ENDS AT CHANNEL 2339
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	267.540	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.3 FWHM 0.77120 KEV/CHANNEL 0.11500 ATAIL 0.00484 BTAIL 1.10995

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 2325.854	267.475	85521.	0.0000E+00	0.5

FOM(%) = 1.41

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 2874
 GROUP ENDS AT CHANNEL 3019
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE NO
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	332.390	0.00	NO	6	YES	0	0.00000
2	332.860	0.00	NO	6	YES	0	0.00000
3	335.420	0.00	NO	6	YES	0	0.00000
4	336.110	0.00	NO	6	YES	0	0.00000
5	341.510	0.00	NO	6	YES	0	0.00000
6	345.010	0.00	YES	0	YES	0	0.00000
7	337.700	0.00	NO	6	YES	0	0.00000
8	334.100	0.00	NO	6	YES	0	0.00000

ANALYSIS RESULTS

QFIT 2.0 FWHM 0.84295 KEV/CHANNEL 0.11498 ATAIL 0.01845 BTAIL 1.11024

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 2889.903	332.312	120394.	0.0000E+00	0.4
2 2893.990	332.782	70312.	0.0000E+00	0.7
3 2916.256	335.342	47785.	0.0000E+00	0.6
4 2922.257	336.032	16682.	0.0000E+00	1.2
5 2969.224	341.432	9682.	0.0000E+00	1.3
6 2999.665	344.932	78613.	0.0000E+00	0.4
7 2936.086	337.622	1086.	0.0000E+00	6.8
8 2904.775	334.022	128.	0.0000E+00	61.9

FOM(%) = 1.67

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 3175
 GROUP ENDS AT CHANNEL 3286
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 5
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE YES
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIDED TO	RATIO
1	367.050	0.00	NO	5	YES	0	0.00000
2	368.550	0.00	NO	5	NO	5	-0.05750
3	368.610	0.00	NO	5	YES	0	0.00000
4	370.930	0.00	NO	5	YES	0	0.00000
5	375.040	0.00	YES	0	YES	0	0.00000
6	376.600	0.00	YES	0	YES	0	0.00000
7	372.450	0.00	NO	5	YES	0	0.00000

ANALYSIS RESULTS

QFIT 0.9 FWHM 0.87758 KEV/CHANNEL 0.11498 ATAIL 0.02255 BTAIL 1.11024

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 3191.531	366.992	10814.	0.0000E+00	1.2
2 3204.578	368.492	11078.	0.0000E+00	0.0
3 3205.100	368.552	19022.	0.0000E+00	1.0
4 3225.278	370.872	11770.	0.0000E+00	1.1
5 3261.025	374.982	194119.	0.0000E+00	0.3
6 3274.483	376.529	9315.	0.0000E+00	1.3
7 3238.498	372.392	415.	0.0000E+00	16.7

FOM(%) = 1.07

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 3394
GROUP ENDS AT CHANNEL 3436
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	392.530	0.00	NO	2	YES	0	0.00000
2	393.140	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 2.0 FWHM 0.88714 KEV/CHANNEL 0.11498 ATAIL 0.02416 BTAIL 1.11024

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 3413.008	392.456	22580.	0.0000E+00	2.6
2 3418.314	393.066	40160.	0.0000E+00	0.8

FOM(%) = 1.97

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
 DETECTOR 10 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
 COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 3562
 GROUP ENDS AT CHANNEL 3628
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE YES
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	413.710	0.00	YES	0	YES	0	0.00000
2	411.150	0.00	NO	1	YES	0	0.00000
3	416.000	0.00	NO	1	YES	0	0.00000

ANALYSIS RESULTS

QFIT 6.5 FWHM 0.93594 KEV/CHANNEL 0.11498 ATAIL 0.01851 BTAIL 1.11024

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 3597.407	413.658	157182.	0.00000E+00	0.3
2 3575.142	411.098	391.	0.00000E+00	15.4
3 3617.325	415.948	396.	0.00000E+00	12.7

FOM(%) = 2.22

WARNING: POSITIVE SLOPING BACKGROUND
AVBG1= 122. AVBG2= 131.

SLP= 0.243

PROGRAM GRPNL2 VERSION 1A 04-DEC-80 15:49

ANALYSIS 3802. LIVE TIME 50000.0 SECONDS
DETECTOR 10 ELAPSED TIME 0.0 SECONDS
GEOMETRY 1 START DAY 4-15-80 MO-DY-YR
KEV/CHANNEL 0.1150 FILES DK1SSALM1011 DK0GRFANPANL
COMMENTS: SALE #03802

GROUP STARTS AT CHANNEL 3908
GROUP ENDS AT CHANNEL 3942
BACKGROUND LOW ENERGY 7
BACKGROUND HIGH ENERGY 7
ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
FWHM YES
TAIL AMPLITUDE YES
TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	451.410	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 0.7 FWHM 0.95243 KEV/CHANNEL 0.11498 ATAIL 0.07882 BTAIL 1.11024

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 3926.034	451.442	17634.	0.0000E+00	1.0

FOM(%) = 2.28

ANALYSIS 3802.
 DETECTOR 10
 GEOMETRY 1
 KEV/CHANNEL 0.1150
 COMMENTS: SALE #03802

LIVE TIME 50000.0 SECONDS
 ELAPSED TIME 0.0 SECONDS
 START DAY 4-15-80 MD-DY-YR
 FILE DK1SSALM1011

KEV/CHANNEL 0.1150

INDEX	CHANNEL NUMBER	ENERGY KEV	TOTAL COUNTS	COUNTS PER SEC	GAMMAS PER SEC	PER CENT ERROR
1	1082.3	124.48	6652.7	0.1331	0.13	0.00
2	1088.4	125.18	7833.6	0.1567	0.16	0.00
3	1089.1	125.26	205956.3	4.1191	4.12	3.17
4	1123.8	129.26	694325.1	13.8865	13.89	1.76
5	1069.0	122.96	41222.5	0.8245	0.82	0.00
6	1074.5	123.59	-12018.4	-0.2404	-0.24	-25.09
7	1123.9	129.26	696425.8	13.9285	13.93	0.16
8	1245.5	143.25	2656.0	0.0531	0.05	0.00
9	1253.2	144.13	43652.5	0.8730	0.87	0.77
10	1269.3	145.98	18460.3	0.3692	0.37	0.00
11	1273.4	146.46	41891.3	0.8378	0.84	0.86
12	1290.9	148.47	725521.1	14.5104	14.51	0.16
13	1304.3	150.01	6756.1	0.1351	0.14	0.00
14	1230.8	141.56	4877.5	0.0976	0.10	0.00
15	1326.9	152.61	26187.7	0.5238	0.52	1.19
16	1390.1	159.88	28043.2	0.5609	0.56	1.61
17	1392.1	160.11	1173.3	0.0235	0.02	0.00
18	1392.9	160.20	37344.0	0.7469	0.75	1.23
19	1403.1	161.37	22762.1	0.4552	0.46	1.27
20	1430.3	164.50	217446.3	4.3489	4.35	0.31
21	1442.1	165.85	2140.4	0.0428	0.04	10.04
22	1473.8	169.50	19023.1	0.3805	0.38	2.23
23	1489.3	171.28	21789.2	0.4358	0.44	2.05
24	1700.8	195.60	24656.6	0.4931	0.49	1.64
25	1711.4	196.81	860.8	0.0172	0.02	0.00
26	1721.4	197.96	4132.0	0.0826	0.08	6.74
27	1769.3	203.47	127891.6	2.5578	2.56	0.33
28	1808.0	207.92	2918083.5	58.3617	58.36	0.07
29	2220.2	255.32	15971.8	0.3194	0.32	1.72
30	2326.0	267.48	85521.3	1.7104	1.71	0.47
31	1557.9	179.16	13964.7	0.2793	0.28	3.06
32	1646.1	189.30	16996.5	0.3399	0.34	1.94
33	1634.2	187.94	1539.1	0.0308	0.03	15.27
34	3191.5	366.99	10813.7	0.2163	0.22	1.16
35	3204.6	368.49	11078.0	0.2216	0.22	0.00
36	3205.1	368.55	19021.9	0.3804	0.38	1.01
37	3225.3	370.87	11769.7	0.2354	0.24	1.08
38	3261.0	374.98	194118.7	3.8824	3.88	0.28
39	3274.5	376.53	9315.3	0.1863	0.19	1.33
40	3238.5	372.39	415.5	0.0083	0.01	16.73
41	3413.0	392.46	22579.7	0.4516	0.45	2.58
42	3418.3	393.07	40160.3	0.8032	0.80	0.79
43	3597.4	413.66	157182.0	3.1436	3.14	0.32
44	3575.1	411.10	390.6	0.0078	0.01	15.45
45	3617.3	415.95	395.9	0.0079	0.01	12.68
46	3926.0	451.44	17634.5	0.3527	0.35	1.02
47	2889.9	332.31	120394.2	2.4079	2.41	0.43
48	2894.0	332.78	70312.1	1.4062	1.41	0.66

49	2916.3	335.34	47785.4	0.9557	0.96	0.56
50	2922.3	336.03	16681.7	0.3336	0.33	1.19
51	2969.2	341.43	9681.5	0.1936	0.19	1.26
52	2999.7	344.93	78612.6	1.5723	1.57	0.41
53	2936.1	337.62	1086.0	0.0217	0.02	6.75
54	2904.8	334.02	127.8	0.0026	0.00	61.86

NO.	X	Y	ERROR	INTENSITY	ERROR	INDEX
1)	0.12926E+03	0.69643E+06	0.11252E+04	0.626E+03	0.000E+00	1
2)	0.14413E+03	0.43652E+05	0.33515E+03	0.283E+02	0.000E+00	1
3)	0.16137E+03	0.22762E+05	0.28927E+03	0.120E+02	0.000E+00	1
4)	0.17128E+03	0.21789E+05	0.44637E+03	0.107E+02	0.000E+00	1
5)	0.17916E+03	0.13965E+05	0.42693E+03	0.616E+01	0.000E+00	1
6)	0.18930E+03	0.16996E+05	0.32930E+03	0.774E+01	0.000E+00	1
7)	0.19560E+03	0.24657E+05	0.40462E+03	0.108E+02	0.000E+00	1
8)	0.20347E+03	0.12789E+06	0.42213E+03	0.560E+02	0.000E+00	1
9)	0.25532E+03	0.15972E+05	0.27459E+03	0.805E+01	0.000E+00	1
10)	0.34493E+03	0.78613E+05	0.32341E+03	0.559E+02	0.000E+00	1
11)	0.37498E+03	0.19412E+06	0.54886E+03	0.157E+03	0.000E+00	1
12)	0.39280E+03	0.62740E+05	0.66241E+03	0.553E+02	0.000E+00	1
13)	0.41366E+03	0.15718E+06	0.50704E+03	0.149E+03	0.000E+00	1
14)	0.45144E+03	0.17634E+05	0.18008E+03	0.189E+02	0.000E+00	1
15)	0.14847E+03	0.72552E+06	0.11407E+04	0.187E+03	0.000E+00	2
16)	0.15988E+03	0.28043E+05	0.45149E+03	0.634E+01	0.000E+00	2
17)	0.16450E+03	0.21745E+06	0.66540E+03	0.453E+02	0.000E+00	2
18)	0.20792E+03	0.29181E+07	0.21618E+04	0.533E+03	0.000E+00	2
19)	0.26748E+03	0.85521E+05	0.39820E+03	0.182E+02	0.000E+00	2
20)	0.12526E+03	0.20596E+06	0.65293E+04	0.408E+03	0.000E+00	3
21)	0.14646E+03	0.41891E+05	0.36174E+03	0.553E+02	0.000E+00	3
22)	0.16950E+03	0.19023E+05	0.42450E+03	0.173E+02	0.000E+00	3

NO.	X	Y	ERROR	INTENSITY	ERROR	INDEX
1)	0.12926E+03	0.11125E+04	0.17974E+01	0.626E+03	0.000E+00	1
2)	0.14413E+03	0.15425E+04	0.11843E+02	0.283E+02	0.000E+00	1
3)	0.16137E+03	0.18968E+04	0.24106E+02	0.120E+02	0.000E+00	1
4)	0.17128E+03	0.20383E+04	0.41756E+02	0.107E+02	0.000E+00	1
5)	0.17916E+03	0.22670E+04	0.69306E+02	0.616E+01	0.000E+00	1
6)	0.18930E+03	0.21959E+04	0.42545E+02	0.774E+01	0.000E+00	1
7)	0.19560E+03	0.22767E+04	0.37361E+02	0.108E+02	0.000E+00	1
8)	0.20347E+03	0.22838E+04	0.75380E+01	0.560E+02	0.000E+00	1
9)	0.25532E+03	0.19841E+04	0.34111E+02	0.805E+01	0.000E+00	1
10)	0.34493E+03	0.14058E+04	0.57834E+01	0.559E+02	0.000E+00	1
11)	0.37498E+03	0.12364E+04	0.34959E+01	0.157E+03	0.000E+00	1
12)	0.39280E+03	0.11352E+04	0.11985E+02	0.553E+02	0.000E+00	1
13)	0.41366E+03	0.10556E+04	0.34052E+01	0.149E+03	0.000E+00	1
14)	0.45144E+03	0.93304E+03	0.95280E+01	0.189E+02	0.000E+00	1
15)	0.14847E+03	0.38798E+04	0.61002E+01	0.187E+03	0.000E+00	2
16)	0.15988E+03	0.44232E+04	0.71214E+02	0.634E+01	0.000E+00	2
17)	0.16450E+03	0.48001E+04	0.14689E+02	0.453E+02	0.000E+00	2
18)	0.20792E+03	0.54748E+04	0.40559E+01	0.533E+03	0.000E+00	2
19)	0.26748E+03	0.46990E+04	0.21879E+02	0.182E+02	0.000E+00	2
20)	0.12526E+03	0.50479E+03	0.16003E+02	0.408E+03	0.000E+00	3
21)	0.14646E+03	0.75753E+03	0.65414E+01	0.553E+02	0.000E+00	3
22)	0.16950E+03	0.10996E+04	0.24538E+02	0.173E+02	0.000E+00	3

AMERICIUM CORRECTION FACTOR= 0.9719

	COEFFICIENT	ERROR
A(0)=	0.6199364E+01	+/- 0.1700090E+00
A(2)=	-0.3233572E-01	+/- 0.4238126E-02
A(3)=	0.3030380E+00	+/- 0.4479052E+00
A(4)=	0.2146235E+01	+/- 0.3692964E+00
A(5)=	0.6554843E+00	+/- 0.1218668E+00
A(6)=	0.8494591E+00	+/- 0.2633061E-02
A(7)=	-0.7329421E+00	+/- 0.8170692E-02

RELIABILITY FACTOR 0.17602E+01

ENERGY	EFFICIENCY	ERROR
124.478	0.96236E+03	0.27
125.178	0.98439E+03	0.25
125.258	0.98691E+03	0.25
129.258	0.11124E+04	0.16
122.958	0.91457E+03	0.32
123.588	0.93437E+03	0.30
129.261	0.11125E+04	0.16
143.247	0.15242E+04	0.23
144.128	0.15478E+04	0.24
145.977	0.15963E+04	0.25
146.457	0.16086E+04	0.26
148.467	0.16591E+04	0.27
150.007	0.16965E+04	0.28
141.557	0.14779E+04	0.22
152.606	0.17568E+04	0.29
159.875	0.19071E+04	0.31
160.105	0.19114E+04	0.31
160.195	0.19131E+04	0.31
161.371	0.19346E+04	0.31
164.495	0.19882E+04	0.32
165.845	0.20098E+04	0.32
169.496	0.20634E+04	0.32
171.276	0.20871E+04	0.32
195.598	0.22672E+04	0.28
196.808	0.22701E+04	0.28
197.958	0.22724E+04	0.28
203.468	0.22779E+04	0.27
207.920	0.22760E+04	0.26
255.315	0.20426E+04	0.23
267.475	0.19526E+04	0.24
179.165	0.21736E+04	0.31
189.299	0.22438E+04	0.30
187.939	0.22368E+04	0.30
366.992	0.12765E+04	0.21
368.492	0.12685E+04	0.21
368.552	0.12682E+04	0.21
370.872	0.12559E+04	0.21
374.982	0.12346E+04	0.20
376.529	0.12267E+04	0.20
372.392	0.12480E+04	0.20
392.456	0.11497E+04	0.19
393.066	0.11469E+04	0.19
413.658	0.10582E+04	0.26
411.098	0.10687E+04	0.24
415.948	0.10491E+04	0.27
451.442	0.92286E+03	0.58
332.312	0.14820E+04	0.27
332.782	0.14789E+04	0.27
335.342	0.14625E+04	0.26
336.032	0.14581E+04	0.26
341.432	0.14242E+04	0.26
344.932	0.14027E+04	0.25
337.622	0.14480E+04	0.26
334.022	0.14709E+04	0.27

DATA SUMMARY:

INDEX	ENERGY	AREA	ERROR	EFFIC	EFF ERROR
1	125	206788.69	3.17	986.91	0.25
2	129	696425.81	0.16	1112.46	0.16
3	144	43652.47	0.77	1547.85	0.24
4	148	725521.06	0.16	1659.11	0.27
5	153	26187.67	1.19	1756.82	0.29
6	160	37343.97	1.23	1913.10	0.31
7	161	22762.08	1.27	1934.60	0.31
8	165	217446.34	0.31	1988.20	0.32
9	203	127891.59	0.33	2277.88	0.27
10	208	2918083.50	0.07	2275.99	0.26
11	335	47785.44	0.56	1462.48	0.26
12	345	78612.63	0.41	1402.71	0.25
13	369	19021.90	1.01	1268.16	0.21
14	375	194118.72	0.28	1234.59	0.20

ISOTOPIC RATIOS FROM PEAK PAIRS (XXX/YYY):

238PU/239PU=	587.47	PPM	+/-	1.50%	(153/144)	BIAS COR. = 1.030
240PU/239PU=	136308.70	PPM	+/-	1.88%	(160/161)	BIAS COR. = 1.014
241PU/239PU=	13968.48	PPM	+/-	0.69%	(208/203)	BIAS COR. = 1.010
	13934.94	PPM	+/-	0.93%	(148/144)	BIAS COR. = 0.996
	14205.69	PPM	+/-	1.52%	(165/161)	BIAS COR. = 0.998
	14199.01	PPM	+/-	0.93%	(148/129)	BIAS COR. = 1.019
241AM/239PU=	9256.51	PPM	+/-	3.20%	(125/129)	BIAS COR. = 1.000
	9798.65	PPM	+/-	0.79%	(335/345)	BIAS COR. = 1.000
	10386.58	PPM	+/-	1.09%	(369/375)	BIAS COR. = 1.000

XXXPU/241PU RATIOS:

238PU/241PU=	0.0421	+/-	1.30%	(153/148)	BIAS COR. = 1.033
240PU/241PU=	9.6381	+/-	2.22%	(160/165)	BIAS COR. = 1.024
	9.6291	+/-	1.31%	(160/148)	BIAS COR. = 1.018

ISOTOPIC RATIOS FROM NORMALIZATION CONSTANTS:

241PU/239PU=	14009.25	PPM	+/-	0.46%
241AM/239PU=	8647.92	PPM	+/-	1.44%

STOP -- ISOAUT FINISHED

Appendix D

Sample of GRPNL2 "Long Form" output

.R GRPNL2
PROGRAM GRPNL2

TYPE FILE NAME AND SEQUENCE NUMBER OF SPECTRUM TO BE CALCULATED METL,25
TYPE NAME OF CALCULATION PARAMETER FILE PUAN
COMPLETE PRINT OUT ? YES

WARNING: POSITIVE SLOPING BACKGROUND
AVBG1= 38255. AVBG2= 39529.

SLP= 55.372

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1327.36	152.68	2980.340	0.6280	0.1025	2.6572	1

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1326.74	152.61	3209.255	0.6280	0.1025	2.6572	2

PROGRAM GRPNL2 VERSION 1A 26-SEP-80 15:54

ANALYSIS	2.	LIVE TIME	50000.0 SECONDS
DETECTOR	50	ELAPSED TIME	0.0 SECONDS
GEOMETRY	2	START DAY	6-24-80 MO-DY-YR
KEV/CHANNEL	0.1150	FILES	DK1SMETL1025 DKOGPUANPANL
COMMENTS: JUNE '80 METAL XCHG., #2			

GROUP STARTS AT CHANNEL	1316
GROUP ENDS AT CHANNEL	1338
BACKGROUND LOW ENERGY	5
BACKGROUND HIGH ENERGY	7
ZERO-CHANNEL ENERGY	0

PARAMETER TABLE	FREE
FWHM	NO
TAIL AMPLITUDE	NO
TAIL SLOPE	NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	152.680	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.4 FWHM 0.62971 KEV/CHANNEL 0.11469 ATAIL 0.10253 BTAIL 2.65717

CHANNEL ENERGY COUNTS GAMMAS/MIN PCTERR
 1 1326.774 152.613 19059. 0.0000E+00 3.7

FOM(%) = 19.73

CHANNEL	ENERGY	INDEX	YNET	RESIDUALS	STD DEV
1316	151.38	1	-118.31	-130.68	-0.66
1317	151.49	2	143.19	126.35	0.64
1318	151.61	3	244.77	220.46	1.11
1319	151.72	4	61.49	21.10	0.11
1320	151.84	5	459.93	377.54	1.90
1321	151.95	6	256.65	63.97	0.32
1322	152.07	7	479.18	33.75	0.17
1323	152.18	8	977.57	53.78	0.27
1324	152.29	9	1705.86	61.97	0.31
1325	152.41	10	2296.21	-169.53	-0.84
1326	152.52	11	3305.37	208.61	1.02
1327	152.64	12	2988.15	-264.49	-1.29
1328	152.75	13	2890.82	42.85	0.21
1329	152.87	14	2172.79	96.53	0.48
1330	152.98	15	1503.73	242.27	1.21
1331	153.10	16	436.85	-203.66	-1.03
1332	153.21	17	142.62	-131.36	-0.66
1333	153.33	18	-116.63	-218.26	-1.11
1334	153.44	19	20.93	-15.08	-0.08
1335	153.56	20	-11.43	-27.11	-0.14
1336	153.67	21	-556.55	-567.05	-2.90
1337	153.79	22	564.56	555.40	2.80

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1390.48	159.96	15704.855	0.6396	0.1047	2.6476	1
1392.48	160.19	828.146	0.6396	0.1047	2.6476	
1393.26	160.28	15044.539	0.6396	0.1047	2.6476	
1403.42	161.45	16018.303	0.6396	0.1047	2.6476	
1430.62	164.58	59279.234	0.6396	0.1047	2.6476	
1442.34	165.93	348.469	0.6396	0.1047	2.6476	

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1389.73	159.87	12343.317	0.6664	0.1047	2.6476	2
1391.73	160.10	770.703	0.6664	0.1047	2.6476	
1392.51	160.19	7522.270	0.6664	0.1047	2.6476	
1402.88	161.39	14907.221	0.6664	0.1047	2.6476	
1429.86	164.49	62634.379	0.6664	0.1047	2.6476	
1441.59	165.84	174.234	0.6664	0.1047	2.6476	

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1389.76	159.88	8777.603	0.6459	0.1423	2.6476	3
1391.76	160.11	804.048	0.6459	0.1423	2.6476	
1392.54	160.20	11029.456	0.6459	0.1423	2.6476	
1402.79	161.38	15552.184	0.6459	0.1423	2.6476	
1429.90	164.50	65203.562	0.6459	0.1423	2.6476	
1441.63	165.85	199.516	0.6459	0.1423	2.6476	

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1389.76	159.88	8999.558	0.6443	0.1539	2.6476	4
1391.76	160.11	805.442	0.6443	0.1539	2.6476	
1392.54	160.20	10752.546	0.6443	0.1539	2.6476	
1402.79	161.38	15579.149	0.6443	0.1539	2.6476	
1429.90	164.50	65243.539	0.6443	0.1539	2.6476	
1441.63	165.85	195.577	0.6443	0.1539	2.6476	

PROGRAM GRPNL2 VERSION 1A 26-SEP-80 15:56

ANALYSIS 2. LIVE TIME 50000.0 SECONDS
 DETECTOR 50 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 2 START DAY 6-24-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SMETL1025 DK06PUANPANL
 COMMENTS: JUNE '80 METAL XCHG., #2

GROUP STARTS AT CHANNEL 1376
 GROUP ENDS AT CHANNEL 1444
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE YES
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	159.960	0.00	NO	5	YES	0	0.00000
2	160.190	0.00	NO	5	NO	4	-0.05170
3	160.280	0.00	NO	5	YES	0	0.00000
4	161.450	0.00	YES	0	YES	0	0.00000
5	164.580	0.00	YES	0	YES	0	0.00000
6	165.930	0.00	NO	5	YES	0	0.00000

ANALYSIS RESULTS

QFIT 2.0 FWHM 0.64937 KEV/CHANNEL 0.11510 ATAIL 0.15538 BTAIL 2.64759

CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1 1389.764	159.878	55131.	0.0000E+00	2.5
2 1391.763	160.108	4939.	0.0000E+00	0.0
3 1392.544	160.198	65951.	0.0000E+00	2.1
4 1402.794	161.378	95817.	0.0000E+00	1.0
5 1429.902	164.498	403700.	0.0000E+00	0.4
6 1441.630	165.848	956.	0.0000E+00	75.7

FOM(%) = 2.64

CHANNEL	ENERGY	INDEX	YNET	RESIDUALS	STD DEV
1376	158.29	1	-33.66	-67.23	-0.34
1377	158.41	2	52.76	7.29	0.04
1378	158.52	3	272.65	211.12	1.06
1379	158.64	4	194.37	111.15	0.56
1380	158.75	5	41.75	-71.35	-0.36
1381	158.87	6	-16.01	-173.80	-0.87
1382	158.98	7	-108.98	-346.55	-1.74
1383	159.10	8	245.80	-163.78	-0.82
1384	159.21	9	961.15	155.39	0.77
1385	159.33	10	1798.33	138.08	0.68
1386	159.44	11	3503.23	236.85	1.14
1387	159.56	12	5878.33	62.40	0.29
1388	159.67	13	9454.25	273.78	1.24
1389	159.79	14	13054.07	243.01	1.06
1390	159.90	15	15728.77	-151.47	-0.64
1391	160.02	16	17312.93	-201.22	-0.84
1392	160.14	17	16521.34	-664.97	-2.81
1393	160.25	18	15068.48	95.80	0.41
1394	160.37	19	11511.76	30.85	0.14
1395	160.48	20	8060.35	320.03	1.47
1396	160.60	21	5392.96	638.59	3.01
1397	160.71	22	3543.42	379.14	1.83
1398	160.83	23	3477.65	231.90	1.12
1399	160.94	24	5396.01	367.75	1.73
1400	161.06	25	8033.14	-183.68	-0.84
1401	161.17	26	12060.08	119.53	0.53
1402	161.29	27	14104.54	-696.60	-3.01

1403	161.40	28	16042.22	508.30	2.16
1404	161.52	29	13554.49	-177.76	-0.77
1405	161.63	30	10337.61	141.29	0.63
1406	161.75	31	6485.18	123.93	0.58
1407	161.86	32	3110.24	-228.38	-1.11
1408	161.98	33	1773.24	292.79	1.44
1409	162.09	34	580.59	16.26	0.08
1410	162.21	35	277.23	78.21	0.39
1411	162.32	36	365.03	280.99	1.41
1412	162.44	37	-258.51	-320.05	-1.61
1413	162.55	38	341.21	271.99	1.36
1414	162.67	39	124.49	35.80	0.18
1415	162.78	40	50.59	-66.23	-0.33
1416	162.90	41	273.17	118.01	0.59
1417	163.01	42	377.97	171.02	0.86
1418	163.13	43	91.15	-185.57	-0.93
1419	163.24	44	366.92	-3.84	-0.02
1420	163.36	45	100.11	-401.72	-2.02
1421	163.47	46	120.33	-587.61	-2.95
1422	163.59	47	1058.57	-55.52	-0.28
1423	163.70	48	1898.68	-179.65	-0.88
1424	163.82	49	4772.04	356.54	1.69
1425	163.93	50	9729.25	227.10	1.02
1426	164.05	51	18768.22	-49.51	-0.21
1427	164.16	52	32264.75	-358.50	-1.34
1428	164.28	53	47845.48	-592.74	-2.00
1429	164.39	54	61751.77	697.29	2.19
1430	164.51	55	65032.43	-177.01	-0.55
1431	164.62	56	59301.45	483.69	1.54
1432	164.74	57	44903.69	254.63	0.88
1433	164.85	58	28275.05	-252.87	-0.97
1434	164.97	59	14636.00	-711.33	-3.06
1435	165.08	60	6934.64	-26.33	-0.12
1436	165.20	61	2906.19	227.89	1.11
1437	165.31	62	1143.74	239.56	1.19
1438	165.43	63	395.60	76.58	0.38
1439	165.55	64	256.12	69.01	0.35
1440	165.66	65	-1.93	-193.67	-0.97
1441	165.78	66	545.21	329.69	1.65
1442	165.89	67	372.98	154.90	0.78
1443	166.01	68	-299.71	-490.77	-2.48

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1473.88	169.56	527.387	0.6528	0.1067	2.6476	1
1489.34	171.34	15062.367	0.6528	0.1067	2.6476	1

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1473.42	169.51	451.378	0.6624	0.1067	2.6476	2
1488.88	171.29	14885.747	0.6624	0.1067	2.6476	2

CHANNEL	KEV	PEAK HEIGHT	FWHM	ATAIL	BTAIL	ITERATION #
1473.41	169.51	469.931	0.6485	0.1067	2.6476	3
1488.88	171.29	15209.813	0.6485	0.1067	2.6476	3

PROGRAM GRPNL2 VERSION 1A 26-SEP-80 15:59

ANALYSIS 2. LIVE TIME 50000.0 SECONDS
 DETECTOR 50 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 2 START DAY 6-24-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILES DK1SMETL1025 DKOGPUANPANL
 COMMENTS: JUNE '80 METAL XCHG., #2

GROUP STARTS AT CHANNEL 1462
 GROUP ENDS AT CHANNEL 1503
 BACKGROUND LOW ENERGY 7
 BACKGROUND HIGH ENERGY 7
 ZERO-CHANNEL ENERGY 0

PARAMETER TABLE FREE
 FWHM YES
 TAIL AMPLITUDE NO
 TAIL SLOPE NO

REGION BACKGROUND SLOPE 0.0000

PEAK NUMBER	ENERGY KEV	WIDTH EV	UNCERTAIN ENERGY	FIXED TO	UNCERTAIN INTENSITY	RATIOED TO	RATIO
1	169.560	0.00	NO	2	YES	0	0.00000
2	171.340	0.00	YES	0	YES	0	0.00000

ANALYSIS RESULTS

QFIT 1.6 FWHM 0.65117 KEV/CHANNEL 0.11510 ATAIL 0.10668 BTAIL 2.64759

	CHANNEL	ENERGY	COUNTS	GAMMAS/MIN	PCTERR
1	1473.413	169.506	2871.	0.0000E+00	25.4
2	1488.878	171.286	93403.	0.0000E+00	1.1

FOM(%) = 7.93

CHANNEL	ENERGY	INDEX	YNET	RESIDUALS	STD DEV
1462	168.19	1	74.34	72.36	0.37
1463	168.31	2	-215.28	-217.98	-1.12
1464	168.42	3	234.99	231.24	1.18
1465	168.54	4	167.58	161.92	0.83
1466	168.65	5	-55.90	-65.86	-0.34
1467	168.77	6	239.14	218.45	1.12
1468	168.88	7	-414.67	-460.61	-2.38
1469	169.00	8	146.41	49.27	0.25
1470	169.11	9	-58.40	-241.12	-1.24
1471	169.23	10	618.69	322.37	1.64
1472	169.34	11	405.78	-3.31	-0.02
1473	169.46	12	419.89	-59.06	-0.30
1474	169.57	13	528.85	52.57	0.27
1475	169.69	14	524.66	121.22	0.62
1476	169.80	15	217.66	-78.53	-0.40
1477	169.92	16	160.05	-37.66	-0.19
1478	170.03	17	-338.03	-472.47	-2.43
1479	170.15	18	-166.65	-278.56	-1.43
1480	170.26	19	-583.00	-712.07	-3.68
1481	170.38	20	297.39	92.75	0.47
1482	170.49	21	35.39	-382.00	-1.96
1483	170.61	22	593.22	-365.71	-1.86
1484	170.72	23	1810.69	-344.54	-1.73
1485	170.84	24	4622.74	269.23	1.30
1486	170.96	25	7761.07	153.49	0.72
1487	171.07	26	11350.42	28.73	0.13
1488	171.19	27	14261.53	-0.42	-0.00
1489	171.30	28	15063.60	-124.76	-0.54
1490	171.42	29	13555.18	-85.83	-0.38
1491	171.53	30	10493.68	185.12	0.84
1492	171.65	31	6355.83	-199.22	-0.95
1493	171.76	32	3681.85	174.26	0.85
1494	171.88	33	1580.01	0.27	0.00
1495	171.99	34	878.84	279.58	1.42
1496	172.11	35	-71.79	-263.77	-1.35
1497	172.22	36	196.93	144.38	0.74
1498	172.34	37	-29.34	-42.34	-0.22
1499	172.45	38	12.75	9.09	0.05
1500	172.57	39	276.17	274.34	1.40
1501	172.68	40	-180.46	-181.99	-0.94

ANALYSIS 2. LIVE TIME 50000.0 SECONDS
 DETECTOR 50 ELAPSED TIME 0.0 SECONDS
 GEOMETRY 2 START DAY 6-24-80 MO-DY-YR
 KEV/CHANNEL 0.1150 FILE DK1SMETL1025
 COMMENTS: JUNE '80 METAL XCHG., #2

KEV/CHANNEL 0.1150

INDEX	CHANNEL NUMBER	ENERGY KEV	TOTAL COUNTS	COUNTS PER SEC	GAMMAS PER SEC	PER CENT ERROR
1	1326.6	152.61	19059.4	0.3812	0.38	3.68
2	1389.8	159.88	55131.1	1.1026	1.10	2.52
3	1391.8	160.11	4938.7	0.0988	0.10	0.00
4	1392.5	160.20	65950.6	1.3190	1.32	2.11
5	1402.8	161.38	95816.8	1.9163	1.92	1.04
6	1429.9	164.50	403699.8	8.0740	8.07	0.39
7	1441.6	165.85	955.6	0.0191	0.02	75.66
8	1473.4	169.51	2871.5	0.0574	0.06	25.41
9	1488.9	171.29	93402.7	1.8681	1.87	1.11

NO.

Appendix E

Fortran Source Listings

Programs:

DETFIL

EFFCH2

GRFEDT

GRPNL2

ISOAUT

PKANAL

DETFIL Listing

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C PROGRAM DETFIL
C SAVES CONSTANTS FOR GRPNL2 BY DETECTOR NUMBER
C WRITTEN BY J. G. FLEISSNER, MOUND LAB., 29-APR-80
C ND SYSTEM VERSION 7/80
  LOGICAL*1 DNEW(24),DOLD(24)
  LOGICAL*1 RESBUF(20),DEFBUF(16),IDT(2)
  COMMON/DAT/ M,ARY(100)
  EQUIVALENCE(DEFBUF(14),IDT(1))
  DATA DOLD/24*' '//
  DATA RESBUF/'@','R','E','S',' ',' ','D','E','T',' ',' ','E',
1' ',' ',' ',' ','R','L','K',' '=' ,'2',' ',' ','@'/
  DATA DEFBUF/'@','D','E','F',' ',' ','1','0',' ',' ','D','E',
1'T',' ',' ','E',' ',' ',' ','@'/
  DATA YES/1HY/
  M=0
  DO 90 I=1,24
  DNEW(I)=0
90    CONTINUE
100   DO 110 I=1,100
  ARY(I)=0.
110   CONTINUE
  CALL ATIME(DNEW)
  TYPE 9010
9010  FORMAT(' PROGRAM DETFIL'/
1' PREPARES DISK FILES OF SHAPE CONSTANTS USED BY GRPNL2'//
1' TYPE DETECTOR NUMBER FOR CONSTANT FILE: ',*)
  ACCEPT 9020,IDT
9020  FORMAT(2A1)
  TYPE 9035
9035  FORMAT(' IS THIS A NEW FILE? (YES OR NO): ',*)
  ACCEPT 9036,ANS
9036  FORMAT(A1)
  CALL MCLI(DEFBUF)
  IF(ANS.EQ.YES) GO TO 150
  READ(10) M,DOLD
  READ(10) (ARY(I),I=1,M)
  ENDFILE 10
150   CONTINUE
  TYPE 300
300   FORMAT(/,1X,'DO YOU WISH TO EDIT PEAK SHAPE CONSTANTS',/,
1' OR ENTER ENTIRE LIST OF CONSTANTS? (0=EDIT,1=ENTER LIST): ',*)
  ACCEPT 310,LOP
310   FORMAT(I2)
  IF(LOP.LT.1) GO TO 305
  DO 320 I=1,4
  TYPE 330,I
330   FORMAT(1X,'ENTER K(''I1,''): ',*)
  ACCEPT 340,ARY(I)
340   FORMAT(E10.1)

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DETFIL Listing...

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320  CONTINUE
      TYPE 350
350  FORMAT(1X,'ENTER SHORT-TERM SLOPE B: ',%)
      ACCEPT 340,ARY(5)
      TYPE 355
355  FORMAT(1X,'ENTER LONG-TERM AMPLITUDE C: ',%)
      ACCEPT 340,ARY(8)
      TYPE 360
360  FORMAT(1X,'ENTER LONG TERM SLOPE D: ',%)
      ACCEPT 340,ARY(9)
505  TYPE 490
490  FORMAT(/,1X,'INDEX',2X,'CONST.',7X,'VALUE')
      DO 510 I=1,4
      TYPE 515,I,I,ARY(I)
515  FORMAT(1X,I1,'')      K('I1','') = ',1PE14.4)
510  CONTINUE
      TYPE 520,ARY(5)
520  FORMAT(1X,'5')      B = ',1PE14.4)
525  FORMAT(1X,'6')      C = ',1PE14.4)
530  FORMAT(1X,'7')      D = ',1PE14.4)
      TYPE 525,ARY(8)
      TYPE 530,ARY(9)
      IF(LOP.EQ.0) GO TO 545
535  TYPE 540
540  FORMAT(/,1X,'DO YOU WISH TO EDIT OR END? (1=EDIT,0=END): ',%)
      ACCEPT 310,LED
      IF(LED.EQ.0)GO TO 600
545  TYPE 550
550  FORMAT(/,1X,'ENTER INDEX, VALUE (ENTER 0 TO END):')
555  ACCEPT 560,IX,VAL
560  FORMAT(I2,E10.1)
      LOP=1
      IF(IX.LE.0) GO TO 505
      IF(IX.LT.6) ARY(IX)=VAL
      IF(IX.GT.5) ARY(IX+2)=VAL
      GO TO 555
600  IF(ANS.NE.YES) GO TO 700
      CALL OANDC(10,IERR,ID,ID,ID,ID,ID,ID,ID)
      IF(IERR.NE.0) GO TO 620
      TYPE 610
610  FORMAT(1X,'OUTPUT FILE ALREADY EXISTS')
      STOP
620  RESBUF(11)=IDT(1)
      RESBUF(12)=IDT(2)
      CALL MCLI(RESBUF,IERR)
      IF(IERR.EQ.1) GO TO 700
      TYPE 650
650  FORMAT(1X,'FILE OPEN FAILED')
      STOP
700  CONTINUE
      IF(M.LT.10) M=10
      WRITE(10) M,DNEW
      WRITE(10) (ARY(I),I=1,M)
      ENDFILE 10
      CALL MCLI('@DEF 6,TTY@')

```

DETFIL Listing...

```
          WRITE(6,9070) IDT,(DNEW(J),J=1,12),(DOLD(JJ),JJ=1,12)
9070      FORMAT(/,' CONSTANT DATA FILE ',2A1,/,
             1' CURRENT      ',12A1,/,
             1' LAST UPDATE ',12A1)
          WRITE(6,9090)
9090      FORMAT(1H1)
          STOP 'END OF JOB'
          END
```

EFFCH2 Listing

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C      EFFCH.FOR EFFICIENCY CHAIN PROGRAM
C      PERFORMS EFFICIENCY FITS TO RAW PU AREAS
C      239-PU AREAS HAVE INDEX 1
C      241-PU AREAS HAVE INDEX 2
C      241-AM AREAS HAVE INDEX 3
C      CORRECTIONS FOR AM CONTRIBUTIONS TO 241-PU PEAKS ARE
C      APPLIED AUTOMATICALLY
C      WRITTEN BY J. G. FLEISSNER, MOUND LABORATORY.
C      CONTAINS BIAS CORRECTIONS OF 7/1/80 FOR 171,179,189,196 PEAKS J.G.F.
      DIMENSION IY(22),IDATA(1009)
      COMMON /COM1/Y(40),E(40),REL(40),ER(40)
      COMMON /COM2/L(11),M,MEFF,INDEXY(40),INDEXX(40)
      COMMON /REST/RENG(100),RCTS(100),RER(100),REFF(100),REFER(100),
      106,ED6,D7,ED7,MRX
      DOUBLE PRECISION X(40),Y,E,A(11,24),XX,YR,Z,F,YY,V,W,REL,ER,ZZ
      COMMON X,ZZ,AP(8),A,N,NPTS
      LOGICAL*1 DEFBUF(24),FILE(14)
      EQUIVALENCE (FILE(1),DEFBUF(8))
      EQUIVALENCE (IDATA(1),RENG(1))
      DATA DEFBUF/'@','D','E','F',' ',' ','1',' ',' ',' '
      1' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' '
      2' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' '
      DATA AP/8*0./
      DATA END/'E',RESTT/'R',ALIST/'L',ALEGE/'L',STAND/'S',EFF/'A'
      DATA COR/'C',AIN/'I',OPT/'O',ID/-9999,ANORM/'N',DUMP/'D'
      DATA PLOTT/'P'
      DATA IY/7,9,19,23,31,32,24,27,29,52,38,41,43,46,
      112,16,20,28,30,3,11,22/
      DATA REL/626.D0,28.3D0,12.0D0,10.69D0,6.16D0,7.74D0,10.83D0,56.D0,
      18.05D0,55.92D0,157.D0,55.27D0,148.9D0,18.9D0,
      2187.D0,6.34D0,45.3D0,533.D0,18.2D0,408.D0,55.3D0,17.3D0,
      318*1.D0/
C      SET UP LU'S5& DEFINE LU1 BASED ON OPTIONAL INPUT
      CALL MCLI('@DEF 5,TTY;6,LP@')
      WRITE (7,12)
12     FORMAT(' ENTER RESULT FILE,ELEMENT NAME')
      READ(5,14)I,FILE
14     FORMAT(Q,14A1)
      IF(I.LE.1) GOTO 16
      CALL MCLI(DEFBUF)
C      CHECK LU1
16     CALL QANDC(1,IERR,ID,ID,ID,ID,ID,ID,ID)
      IF(IERR.EQ.0) GOTO 17
      WRITE(7,9917) FILE
9917   FORMAT(' FILE ',14A1,' COULD NOT BE OPENED')
      STOP
17     CONTINUE
      READ (1) IDATA
      ENDFILE 1

```

```

C      DO 18 K=1,MRX
C      WRITE(6,20) RENG(K),RCTS(K),RGAM(K),RER(K)
C 20   FORMAT(1X,4F10.5)
C 18   CONTINUE
140   NPTS=22
      MEFF=3
      NFLG=0
      D6=0.0
      D7=0.0
      DO 200 K=1,40
      ER(K)=0.0
      INDEXX(K)=0
      IF(K.GT.NPTS) INDEXX(K)=1
200   CONTINUE
      DO 10 I=1,NPTS
      IIY=IY(I)
      Y(I)=RCTS(IIY)
      E(I)=RER(IIY)*Y(I)*.01
      X(I)=RENG(IIY)
      INDEXY(I)=1
      IF(I.GT.14) INDEXY(I)=2
      IF(I.GT.19) INDEXY(I)=3
      IF(Y(I).GT.0.)GO TO 10
      INDEXX(I)=1
      IF(INDEXY(I).EQ.3) NFLG=NFLG+1
C      WRITE(6,5) Y(I),RCTS(IIY),E(I),RER(IIY),X(I),RENG(IIY)
C 5    FORMAT(6F12.5)
10    CONTINUE
      Y(12)=Y(12)+RCTS(42)
      E(12)=(E(12)**2.+(RER(42)*RCTS(42)*.01)**2.)**0.5
      X(12)=392.8
11    DO 591 LL=1,2
      WRITE(5,480)
      WRITE(6,480)
480   FORMAT(/2X,'NO.',7X,'X',12X,'Y',10X,'ERROR',5X,'INTENSITY'
1,4X,'ERROR',3X,'INDEX'/)
      DO 590 J0=1,NPTS
      J=J0
      IF(INDEXX(J).EQ.1) GO TO 590
      IF(LL.EQ.2) GO TO 560
      WRITE(6,600) J,X(J),Y(J),E(J),REL(J),ER(J),INDEXY(J)
      WRITE(5,600) J,X(J),Y(J),E(J),REL(J),ER(J),INDEXY(J)
      GO TO 590
560   V=YY(J,1,3)
      W=YY(J,0,4)
      WRITE(6,600) J,X(J),V,W,REL(J),ER(J),INDEXY(J)
      WRITE(5,600) J,X(J),V,W,REL(J),ER(J),INDEXY(J)
590   CONTINUE
      WRITE(6,99)
99    FORMAT('1')
591   CONTINUE
      GO TO 950
640   TYPE 650
650   FORMAT(/1X,'CHANGE=NO.,DELETE=-NO.,LIST,RESTART,END')
      CALL CONVRT(XX,YR,Z,V,W,ALPHA)

```

```

      IF(ALPHA.EQ.RESTT) GO TO 140
      IF(ALPHA.EQ.ALIST) GO TO 11
      IF(ALPHA.EQ.END) GO TO 950
750    IF(XX) 770,950,810
770    J=XX-.5
      INDEXX(-J)=1
      GO TO 640
810    J=XX+.5
      IF(J.GT.NPTS) NPTS=J
      TYPE 180
180    FORMAT(1X,'X Y ERROR INTENSITY. END')
840    CALL CONVRT(X(J),Y(J),E(J),REL(J),ER(J),ALPHA)
      INDEXY(J)=MEFF
      IF(ALPHA.NE.EFF) GO TO 890
      MEFF=X(J)+1
      GO TO 840
890    INDEXX(J)=0
      GO TO 640
600    FORMAT(1X,I3,' '),3(2X,E11.5),2(2X,E9.3),3X,I1)
950    AMCOR=(1.0-2.167*Y(20)*Y(8)/(Y(1)*Y(18)))
      IF(Y(20).LE.0.0) AMCOR=1.0
      WRITE(6,949) AMCOR
949    FORMAT(1X,'AMERICIUM CORRECTION FACTOR= ',F6.4, '//)
      Y(17)=Y(17)*AMCOR
      Y(18)=Y(18)*AMCOR
      Y(19)=Y(19)*AMCOR
      L(1)=0
      DO 960 J=2,11
960    L(J)=J
1070   N=7
      IF(NFLG.EQ.3) N=6
1220   DO 1250 K=1,11
      DO 1250 KK=1,24
      A(K,KK)=0
1250   A(K,N+K)=1
      DO 1320 J2=1,NPTS
      J=J2
      IF(INDEXX(J).EQ.1) GO TO 1320
      DO 1321 K3=1,N
      K=K3
      A(K,23)=A(K,23)+YY(J,1,1)*F(X(J),K,J)/YY(J,0,2)**2
      DO 1322 KK2=1,N
      KK=KK2
      A(K,KK)=A(K,KK)+F(X(J),K,J)*F(X(J),KK,J)/YY(J,0,2)**2
1322   CONTINUE
1321   CONTINUE
1320   CONTINUE
      DO 1490 K=1,N
      XX=A(K,K)
      DO 1390 KK=K,N
      IF(DABS(A(KK,K)).GE.DABS(XX)) MAX=KK
      XX=A(MAX,K)
1390   N2=2*N
      DO 1440 KK=K,N2
      Z=A(K,KK)

```



```

      A(K, KK)=A(MAX, KK)
      A(MAX, KK)=Z
1440   A(K, KK)=A(K, KK)/XX
      DO 1490 J=1, N
      IF(J.EQ.K) GO TO 1490
      DO 1480 KK=K, N2
1480   A(J, N2+K-KK)=A(J, N2+K-KK)-A(K, N2+K-KK)*A(J, K)
1490   YR=0
      WRITE(5, 1570)
      WRITE(6, 1570)
      DO 1560 K=1, N
      DO 1540 KK=1, N
1540   A(K, 24)=A(K, 24)+A(K, KK+N)*A(KK, 23)
      XX=DSQRT(DABS(A(K, K+N)))
      WRITE(6, 1580) L(K), A(K, 24), XX
      IF(L(K).LT.8) AP(L(K)+1)=A(K, 24)
      IF(L(K).NE.6) GO TO 1550
      D7=A(K, 24)
      ED7=XX
1550   IF(L(K).NE.7) GO TO 1560
      D6=A(K, 24)
      ED6=XX
1560   WRITE(5, 1580) L(K), A(K, 24), XX
1570   FORMAT(/11X, 'COEFFICIENT', 9X, 'ERROR'/)
1580   FORMAT(1X, 'A(', I3, ')=' , 3X, E14.7, 2X, '+/-', 2X, E14.7)
      DO 1660 KO=1, NPTS
      K=KO
      IF(INDEXX(K).EQ.1) GO TO 1660
      Z=0
      DO 1640 J3=1, N
      J=J3
1640   Z=Z+A(J, 24)*F(X(K), J, K)
      YR=YR+(YY(K, 1, 1)-Z)**2/YY(K, 0, 2)**2
1660   CONTINUE
      ZZ=0
      NFREE=0
      DO 1700 JJ=1, NPTS
1700   IF(INDEXX(JJ).EQ.0) NFREE=NFREE+1
      IF(NFREE-N.LE.0) GO TO 1730
      ZZ=DSQRT(YR/(NFREE-N))
1730   WRITE(5, 1740) ZZ
      WRITE(6, 1740) ZZ
1740   FORMAT(/1X, 'RELIABILITY FACTOR', 4X, E11.5, ///)
      WRITE(6, 99)
      ED6=ED6*ZZ
      ED7=ED7*ZZ
      DO 2010 LM=1, MRX
      Z=0.
      YR=0.
      XX=RENG(LM)
      DO 1880 K2=1, N
      K=K2
      Z=Z+A(K, 24)*F(XX, K, 0)
      DO 1880 KK0=1, N
      KK=KK0

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EFFCH2 Listing...

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      YR=YR+A(K, KK+N)*F(XX, K, 0)*F(XX, KK, 0)
1880  CONTINUE
      YR=DSQRT(DABS(YR))
      Z=DEXP(Z)
      YR=Z*YR
      REFF(LM)=Z
      REFER(LM)=YR/Z*100.
2010  CONTINUE
      WRITE(6, 2020)
2020  FORMAT(///, 10X, 'ENERGY', 10X, 'EFFICIENCY', 5X, 'ERROR', ///)
      DO 2040 LN=1, MRX
      WRITE(6, 2030) RENG(LN), REFF(LN), REFER(LN)
2030  FORMAT(10X, F7.3, 9X, E11.5, 5X, F5.2)
2040  CONTINUE
      WRITE(6, 99)
C 2000 CALL PLOTS(0., 0., 0.)
C      CALL PLOTF
      WRITE (1) IDATA
C      TYPE 993, IERR
C 993  FORMAT(3X, I2)
      ENDFILE 6
      STOP
      END

```

```

C      SUBROUTINE CONVRT
      SUBROUTINE CONVRT(V,W,X,Y,Z,ALPHA)
      DOUBLE PRECISION V,W,X,Y,Z,XX(5),XIND,XMULT,XMULT1
      DIMENSION A(72),CHAR(31)
      DATA CHAR /'0','1','2','3','4','5','6','7','8','9',
1'.,','+',','-','D','E','S','L','C','R','Y','N','O','I',
2940 1'T','P','A','G','U','M',' ',' ',' '/
      DO 2950 I=1,5
2950  XX(I)=0
      ALPHA=CHAR(30)
      ACCEPT 2980,A
2980  FORMAT(72A1)
      NUM=1
      IPOSIT=0
3010  XMULT=1
      XMULT1=1
      MULT1=1
      INDEX=1
      NEXP=0
3060  IPOSIT=IPOSIT+1
      IF(IPOSIT.GT.72) GO TO 3580
      DO 3130 J=1,31
      IF(A(IPOSIT).NE.CHAR(J)) GO TO 3130
      IND=J
      XIND=IND
      GO TO(3170,3250,3250,3420,3470,3480,3480,3140,3060),INDEX
3130  CONTINUE
3140  TYPE 3150
3150  FORMAT(1X,'READ ERROR. REENTER')
      GO TO 2940
3170  IF(IND.GT.29)GO TO 3060
      IF(IND.GT.13) GO TO 3550
      IF(NUM.GT.5) GO TO 3060
      INDEX=2
      IF(IND.EQ.12) GO TO 3060
      IF(IND.NE.13) GO TO 3250
      XMULT=-XMULT
      GO TO 3060
3250  IF(IND.GT.29) GO TO 3370
      IF((IND.NE.14).AND.(IND.NE.15)) GO TO 3290
      INDEX=4
      GO TO 3060
3290  IF((IND.EQ.11).AND.(INDEX.EQ.3)) GO TO 3140
      IF(IND.NE.11) GO TO 3330
      INDEX=3
      GO TO 3060
3330  IF(IND.GT.10) GO TO 3140
      IF(INDEX.EQ.3) XMULT=XMULT*(1D1)
      XX(NUM)=(1D1)*XX(NUM)+XIND-(1D0)
      GO TO 3060
3370  XX(NUM)=XX(NUM)/XMULT
      IF(MULT1.GT.0) XX(NUM)=XX(NUM)*XMULT1
      IF(MULT1.LT.0) XX(NUM)=XX(NUM)/XMULT1
      NUM=NUM+1
      GO TO 3010

```

```
3420 INDEX=INDEX+1
      IF(IND.EQ.12) GO TO 3060
      IF(IND.NE.13) GO TO 3470
      MULT1=-MULT1
      GO TO 3060
3470 IF(IND.GT.10) GO TO 3140
3480 IF(IND.GT.29) GO TO 3530
      IF(IND.GT.10) GO TO 3140
      INDEX=INDEX+1
      NEXP=10*NEXP+IND-1
      GO TO 3060
3530 XMULT1=(1D1)**(NEXP)
      GO TO 3370
3550 ALPHA=CHAR(IND)
      INDEX=9
      GO TO 3060
3580 V=XX(1)
      W=XX(2)
      X=XX(3)*XX(2)/100
      Y=XX(4)
      Z=XX(5)
      RETURN
      END
```

```

C      FUNCTION FUNC
      DOUBLE PRECISION FUNCTION F(X,N,I)
      COMMON /COM1/ Y(40),E(40),REL(40),ER(40)
      COMMON /COM2/ L(11),M,MEFF,INDEXY(40)
      DOUBLE PRECISION X,P(25),Y,REL,ER,E
      IF(MEFF.GT.0) GO TO 2790
      P(1)=1
      IF(L(N).EQ.0) GOTO 2770
      F=X**L(N)
      IF(M.EQ.0) GO TO 2780
2730   P(2)=X
      K=L(N)+1
      DO 2760 J=3,K
2760   P(J)=((2*J-3)*X*P(J-1)-(J-2)*P(J-2))/(J-1)
2770   F=P(L(N)+1)
2780   RETURN
2790   F=0
      IF(L(N).LE.2) F=1./((X/1000.）**L(N))
      IF((L(N).GT.2).AND.(L(N).LE.5)) F=(DLOG(X/1000.))**L(N)-2)
      IF(I.EQ.0) GO TO 2780
      IF((L(N).EQ.6).AND.(INDEXY(I).EQ.2)) F=1.0
      IF((L(N).EQ.7).AND.(INDEXY(I).EQ.3)) F=1.0
      RETURN
      END

```

```

DOUBLE PRECISION FUNCTION YY(I,J,K)
COMMON /COM1/ Y(40),E(40),REL(40),ER(40)
COMMON /COM2/L(11),M,MEFF
DOUBLE PRECISION Y,E,YY,REL,ER
IF(MEFF.EQ.0) GO TO 3780
IF (K.EQ.1) YY=DLOG(Y(I)/REL(I))
IF(K.EQ.1) RETURN
YY=DSQRT((E(I)/Y(I))**2+(ER(I)/REL(I))**2)
IF(K.EQ.2) RETURN
IF(K.EQ.3) YY=Y(I)/REL(I)
IF(K.EQ.4) YY=YY*Y(I)/REL(I)
RETURN
3780 IF(K.EQ.1) YY=Y(I)
      IF(K.EQ.2) YY=E(I)
      RETURN
      END

```

GRFEDT Listing

```

C PROGRAM GRFEDT.FOR
C FOR EDITING ANALYSIS PARAMETER FILES FOR GRPNL2
C MODIFIED FOR GRPNL2 BY J.G.FLEISSNER (MRC) 8/78
C ND SYSTEM VERSION 7/80
  LOGICAL*1 ATE(24),ELMT(4)
  LOGICAL*1 DEFBUF(20),RESBUF(24)
  EQUIVALENCE (DEFBUF(15),ELMT(1))
  DATA DEFBUF/'@','D','E','F',' ',' ','9',' ',' ','A','N','A','L','F','L',' ',
  1',' ',' ',' ',' ',' ',' ','@',' ',' /
  DATA RESBUF/'@','R','E','S',' ',' ','A','N','A','L','F','L',' ',' ',
  1',' ',' ',' ',' ',' ',' ','B','L','K',' ','='','3',' ','0',' ','@',' /
  INTEGER*2 INDATA(2900)
  EQUIVALENCE(MREG(1,1),INDATA(1))
  COMMON/DAT/ MREG(20,4),REF(20,5),PEAK(20,16),
  IMCERT(20,16),MSHAP(20,3),GAMA(20,16),HIGH(20,16),MHGT(20,16)
  DATA SSS/1H*/
  DATA Y/1HY/
  DATA YN/1HN/
  CALL ATIME(ATE)
  CALL MCLI('@DEF 6,LP@')
  ZER=-9990.
  DO 70 KK=1,20
  DO 60 LK=1,4
  MREG(KK,LK)=0
60  CONTINUE
70  CONTINUE
  DO 73 KK=1,20
  DO 72 LK=1,5
  REF(KK,LK)=0.
72  CONTINUE
73  CONTINUE
  DO 75 KK=1,20
  DO 74 LK=1,16
  PEAK(KK,LK)=0.
  MCERT(KK,LK)=0
  GAMA(KK,LK)=0.0
  HIGH(KK,LK)=0.0
  MHGT(KK,LK)=0
74  CONTINUE
75  CONTINUE
  DO 78 KK=1,20
  DO 77 LK=1,3
  MSHAP(KK,LK)=0
77  CONTINUE
78  CONTINUE
100  TYPE 9020
9020  FORMAT(' PROGRAM GRFEDT',/,
  1' USED FOR EDITING ANALYSIS FILES FOR GRPNL2',/,
  1' TYPE FOLLOWING:',/, ' FILE NAME: ', $)

```

```

          ACCEPT 9030,ELMT
9030      FORMAT(4A1)
          CALL MCLI(DEFBUF)
          CALL DANDC(9,IERR,ID,ID,ID,ID,ID,ID)
          IF(IERR.EQ.0) GO TO 112  !FILE FOUND
          TYPE 9040,ELMT  !FILE NOT FOUND
9040      FORMAT(' FILE NOT FOUND DO YOU WANT TO START A NEW FILE',/,
1' WITH NAME: ANALFL.',4A1,' (ENTER YES OR NO): ',2X,$)
          ACCEPT 9050,ANS
9050      FORMAT(A1)
          IF(ANS.NE.Y) GO TO 100  !TYPE NEW FILE NAME
          DO 108 I=1,4
          RESBUF(I+12)=ELMT(I)
108       CONTINUE
          CALL MCLI(RESBUF,IERR)
          IF(IERR.NE.1) STOP 'FILE CREATION ERROR'
          GO TO 113
112       READ (9) INDATA
          ENDFILE 9
113       TYPE 9060
9060      FORMAT(' +INDEX OF REGION TO BE EDITED (1-20) : ', $)
          ACCEPT 9070,N
9070      FORMAT(I2)
          IF(N.EQ.0) GO TO 115
          GO TO 120
115       TYPE 9071
9071      FORMAT(' +INDEX OF REGION TO BE ZEROED (1-20) : ', $)
          ACCEPT 9072,N
9072      FORMAT(I2)
          IF(N.EQ.0) GO TO 135
          DO 116 LI=1,16
          PEAK(N,LI)=0
          MCERT(N,LI)=0
116       CONTINUE
          DO 117 LI=1,5
          REF(N,LI)=0
117       CONTINUE
          DO 118 LI=1,4
          MREG(N,LI)=0
118       CONTINUE
          DO 119 LI=1,3
          MSHAP(N,LI)=0
119       CONTINUE
          GO TO 136
120       TYPE 9080
9080      FORMAT(' +NUMBER OF LOW ENERGY BACKGROUND CHANNELS: ', $)
          ACCEPT 9090,ILO
9090      FORMAT(I3)
          IF(ILO.NE.0) MREG(N,1)=ILO
9095      TYPE 9100
9100      FORMAT(' +START CHANNEL: ', $)
          ACCEPT 9110,IST
9110      FORMAT(I4)
          IF(IST.NE.0) MREG(N,2)=IST
          TYPE 9120

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```

9120  FORMAT('END CHANNEL: ',%)
      ACCEPT 9110,IED
      IF(IED.NE.0) MREG(N,3)=IED
      IF((MREG(N,3)-MREG(N,2)+1).LE.150) GO TO 9125
      TYPE 9121
9121  FORMAT(1X,'MAXIMUM NUMBER (150) OF CHANNELS EXCEEDED,
REENTER:',/)
      GO TO 9095
9125  TYPE 9130
9130  FORMAT('NUMBER OF HIGH ENERGY BACKGROUND CHANNELS: ',%)
      ACCEPT 9090,IHI
      IF(IHI.NE.0) MREG(N,4)=IHI
      TYPE 9140
9140  FORMAT('LOW ENERGY REFERENCE ENERGY: ',%)
      ACCEPT 9150,ENL
9150  FORMAT(F6.1)
      IF(ENL.NE.0.) REF(N,1)=ENL
      TYPE 9160
9160  FORMAT('HIGH ENERGY REFERENCE ENERGY: ',%)
      ACCEPT 9150,HEN
      IF(HEN.NE.0.) REF(N,2)=HEN
      TYPE 9180
9180  FORMAT('BACKGROUND SLOPE: ',%)
      ACCEPT 9150,BKS
      IF(BKS.NE.0.) REF(N,4)=BKS
      IF(BKS.LT.ZER) REF(N,4)=0.0
      TYPE 9170
9170  FORMAT('ENERGY OF CHANNEL ZERO: ',%)
      ACCEPT 9150,ZCH
      IF(ZCH.NE.0.) REF(N,3)=ZCH
      IF(ZCH.LT.ZER) REF(N,3)=0.0
      TYPE 9185
9185  FORMAT('GAIN: ',%)
      ACCEPT 9187,GN
9187  FORMAT(F7.5)
      IF(GN.NE.0) REF(N,5)=GN
      TYPE 9190
9190  FORMAT(' TYPE PEAK INDEX-FLAG-PEAK ENERGY XXX,X,XXXX.XX
1/LINE',/,
1' NEGATIVE INDEX SPECIFIES ENERGY AND/OR HEIGHT RATIOED',/,
1' FLAG = 1 SPECIFIES UNCERTAIN ENERGY (- ENERGY FOR X-RAY)')
DO 121 J=1,16
ACCEPT 9195,IP11,ISTR,PKV
9195  FORMAT(I4,I2,F7.0)
      IF(IP11.EQ.0) GO TO 130
      IF(PKV.GT.ZER) GO TO 202
      ISTR=0
      PEAK(N,-IP11)=0.0
      GAMA(N,-IP11)=0.0
      MCERT(N,-IP11)=0
      HIGH(N,-IP11)=0.0
      MHGT(N,-IP11)=0
      GO TO 121
202   IP1=IABS(IP11)
      IF(IP1.NE.0) PEAK(N,IP1)=PKV

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IF(PKV) 200,200,201
200 TYPE 299
299 FORMAT(' + INTRINSIC WIDTH (EV): ',*)
ACCEPT 298,GAMA(N,IFI)
298 FORMAT(F6.1)
201 MCERT(N,IFI)=ISTR
IF(IFI1.GT.0) GO TO 121
TYPE 297
297 FORMAT(' + ENERGY FIXED RELATIVE TO PEAK : ',*)
ACCEPT 296,M
296 FORMAT(I2)
IF (M.GT.0) MCERT(N,IFI)=-M
TYPE 295
295 FORMAT(' + PEAK HGHT.(ZERO FOR UNKNOWN,NEG. FOR RATIOED) :',*)
ACCEPT 294,HIGH(N,IFI)
MHGT(N,IFI)=0
IF(HIGH(N,IFI).GT.0.0) MHGT(N,IFI)=-IFI
IF (HIGH(N,IFI).GE.0.0)GO TO 121
293 FORMAT(' + INDEX OF PEAK RATIOED TO :',*)
294 FORMAT(F6.1)
TYPE 293
ACCEPT 291 , IN
291 FORMAT(I2)
MHGT(N,IFI)=-IN
121 CONTINUE
130 TYPE 9200
9200 FORMAT(' DO YOU WANT TO FREE PARAMETER: (ENTER YES OR NO) ',/,
1' FWHM ? ',*)
ACCEPT 9210,ANT
9210 FORMAT(A1)
IF(ANT.EQ.Y) MSHAP(N,1)=1
IF(ANT.EQ.YN) MSHAP(N,1)=0
TYPE 9220
9220 FORMAT(' +TAIL AMPLITUDE (A) ? ',*)
ACCEPT 9210,ANST
IF(ANST.EQ.Y) MSHAP(N,2)=1
IF(ANST.EQ.YN) MSHAP(N,2)=0
TYPE 9230
9230 FORMAT(' +TAIL SLOPE (B) ? ',*)
ACCEPT 9210,ASN
IF(ASN.EQ.Y) MSHAP(N,3)=1
IF(ASN.EQ.YN) MSHAP(N,3)=0
136 WRITE(9) INDATA
ENDFILE 9
GO TO 113
135 WRITE(6,9240) ELMT,(ATE(K),K=1,11)
9240 FORMAT(4X,' FILE NAME : ANALFL.',4A1,20X,11A1)
WRITE(6,9250)
9250 FORMAT(/,X,'REGION',X,'LOW E START END',3X,
1' HIGH E LOW E HIGH E',
12X,'ZERO BKGD GAIN FWHM A',
1' B',/,8X,'BKGD CHAN',
1' CHAN BKGD REF. ',
1' REF. CHAN SLOPE',/)
DO 170 MM=1,20

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GRFEDT Listing...

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      IF (PEAK(MM,1)) 170,170,400
400   WRITE(6,9270) MM,MREG(MM,1),MREG(MM,2),
      1MREG(MM,3),MREG(MM,4),REF(MM,1),
      1REF(MM,2),REF(MM,3),REF(MM,4),REF(MM,5),MSHAP(MM,1),
      1MSHAP(MM,2),MSHAP(MM,3)
9270  FORMAT(3X,I2,4X,I2,4X,I4,2X,I4,4X,I2,2X,F6.1,2X,
      1F6.1,F6.1,2X,F5.1,1X,F7.4,3X,I1,3X,I1,
      12X,I1)
170   CONTINUE
      WRITE(6,330)
      DO 300 LL=1,20
      IF(PEAK(LL,1)) 300,300,310
310   WRITE(6,320) LL
320   FORMAT(/,1X,'REGION',2X,I2,/)
330   FORMAT(///,13X,'INDEX',2X,'ENERGY',2X,'EFLAG',4X,'HEIGHT',
      15X,'HTFLAG',2X,'GAMMA',)
      DO 390 LT=1,16
      IF(PEAK(LL,LT)) 390,390,340
340   WRITE(6,350) LT,PEAK(LL,LT),MCERT(LL,LT),HIGH(LL,LT),MHGT(LL,LT),
      1GAMA(LL,LT)
350   FORMAT(15X,I2,1X,F8.2,3X,I3,3X,E10.3,5X,I3,2X,F6.1)
390   CONTINUE
300   CONTINUE
      WRITE(6,9400)
9400  FORMAT(1H1)
      ENDFILE 9
      STOP
      END

```

11

```

20      STOP
      CONTINUE
      TYPE 9015
9015    FORMAT(' TYPE NAME OF CALCULATION PARAMETER FILE ',%)
      ACCEPT 9016,ELMT
9016    FORMAT(4A1)
      CALL MCLI(DEFBUF)
      CALL QANDC(9,IERR,ID,ID,ID,ID,ID,ID,ID)
      IF(IERR.EQ.0) GO TO 9014
      TYPE 9013
9013    FORMAT(1X,'ANALYSIS FILE OPEN ERROR')
      STOP
9014    TYPE 9017
9017    FORMAT(' COMPLETE PRINT OUT ? ',%)
      ACCEPT 9018,AAS
9018    FORMAT(A1)
      LISTFG=1
      IF(AAS.EQ.YES) LISTFG=0
      DO 400 IREG=1,20
56      IREGG=IREG
      READ (9) INDATA
      ENDFILE 9
      IF(PEAK(IREG,1).LE.0) GO TO 400
      IST=MREG(IREG,2) !START CHANNEL
      ST=MREG(IREG,2)
      IEND=MREG(IREG,3) !END CHANNEL
      END=MREG(IREG,3)
      NUMS=MREG(IREG,1) !LOW BACKGROUND
      NUMSJ=MREG(IREG,1)
      NUME=MREG(IREG,4) !HIGH BACKGROUND
      NUMEJ=MREG(IREG,4)
      GAIN=REF(IREG,5) !GAIN
      GAINJ=REF(IREG,5)
      RKEV=ABS(GAIN)
      JZERO=0
      ST1J=0.
      ST2J=0.
      ZERO=REF(IREG,3) !ZERO CHANNEL
      JZERO=ZERO
      ZER1=ZERO
      IF(GAIN.GT.0.) GO TO 30 !-GAIN = ABSOLUTE VALUE FOR GAIN
      NGAIN=1 !ABSOLUTE GAIN
      GAIN=-GAIN
      GO TO 40
30      CONTINUE !CALCULATE GAIN
      STD(1)=REF(IREG,1) !LOW ENERGY REFERENCE
      ST1J=REF(IREG,1)
      STD(2)=REF(IREG,2) !HIGH ENERGY REFERENCE
      ST2J=REF(IREG,2)
      NGAIN=0
40      CONTINUE
      NP=0
      DO 50 I=1,16
      IF(PEAK(IREG,I).EQ.0) GO TO 55
      NP=I

```

```

VAL=PEAK(IREG,I)
NXFLG(I)=0      !CERTAIN ENERGY
GAMA(I)=GAMB(IREG,I)
NXFLG(I)=MCERT(IREG,I)
NYFLG(I)=1      !GAMMA LINE
GAMA(I)=GAMA(I)*.001/GAIN
IF(MHGT(IREG,I).NE.0) NYFLG(I)=MHGT(IREG,I)
HIGHT(I)=HIGH(IREG,I)
EN(I)=ABS(VAL)
ENJ(I)=VAL
STRJ(I)=AND
IF(MCERT(IREG,I).EQ.1) STRJ(I)=AYES
50  CONTINUE
55  CONTINUE
NENUM=NP
IF(ITER.EQ.999) GO TO 61
DO 60 I=1,3      !SHAPE PARAMETERS
60  NFLG(I)=MSHAP(IREG,I)
61  CONTINUE
ALPJ=AND
TAMP=AND
TSLP=AND
IF(NFLG(1).EQ.1) ALPJ=AYES
IF(NFLG(2).EQ.1) TAMP=AYES
IF(NFLG(3).EQ.1) TSLP=AYES
SLP=REF(IREG,4)  !BACKGROUND SLOPE
BKGSPL=REF(IREG,4)
II=2840
CALL ZGNL(II)
ITER=1
CALL GRPNL3
CALL LOAD2
110 CALL FIT2
CALL RETRN2
IF(ITER.LT.990) GO TO 114
DO 112 II=1,3
ITEST=NFLG(4-II)
IF(NFLG(4-II).GT.0) NFLG(4-II)=0
IF((NFLG(4-II)-ITEST).NE.0) GO TO 56
IF(II.LT.3) GO TO 112
STOP ' RETRN2 10 '
112 CONTINUE
114 IF(ITER.LT.16) GO TO 110
CALL OUT2
400 CONTINUE
WRITE(1) IOUTD
ENDFILE 1
CALL DAYMON(IDAY,IYEAR,JDAY,JMON)
CALL ATIME(DTE)
WRITE(6,9200)(DTE(J),J=1,24),ID,ELTIME,DET,RTTIME,
1GEOM,JMON,JDAY,IYEAR,AKEV,TYPE,TITLE
9200 FORMAT(1X,' PROGRAM GRPNL2  VERSION 1A',10X,24A1,/,
1' SAMPLE ID',1X,16A1,2X,'LIVE TIME',7X,F8.1,1X,'SECONDS',/,
2' DETECTOR',2X,16A1,2X,'ELAPSED TIME',4X,F8.1,1X,'SECONDS',/

```

```

      3' GEOMETRY',2X,16A1,2X,'START
DAY',4X,2(I2,'-'),I4,1X,'MO-DA-YR',/
      4' KEV/CHANNEL',2X,F7.4,8X,'SAMPLE TYPE',2X,16A1,/
      5' COMMENTS:',1X,64A1,/)
      WRITE(6,9210) RKEV
9210  FORMAT(/,' KEV/CHANNEL ',F8.4,/)
      1' INDEX  CHANNEL ENERGY  TOTAL    COUNTS  GAMMAS  PER CENT',/
      1'      NUMBER  KEV      COUNTS  PER SEC  PER SEC  ERROR',/)
      DO 410 I=1,MRX
      RCHAN=(RENG(I)-ZER1)/GAIN
      WRITE(6,9220) I,RCHAN,RENG(I),RCTS(I),(RCTS(I)/ELTIME),
      1(RCTS(I)/ELTIME),RER(I)
9220  FORMAT(I4,F10.1,F8.2,1X,F9.1,F10.4,F8.2,F9.2)
410   CONTINUE
      WRITE(6,9230)
9230  FORMAT(1H1)
      END

```

```

SUBROUTINE GRPNL3
C   GETSHP,READP,MAXVAL,MINVAL,AVE,GFIT
C   MODIFIED FOR PDP11/05 JE FAGER 9/76
C   THIS PROGRAM IS A GENERAL PURPOSE PROGRAM FOR FITTING MULTIPLETS.
C   IT WILL ACCOMODATE UP TO 16 FREE PARAMETERS. THE PEAK HEIGHT
C   PARAMETERS (AREAS) ARE AUTOMATICALLY FREED. THE OTHERS CAN BE
C   SELECTED.
      REAL*8 DBLK
      DIMENSION NWRDS(5),NFLG(16),NYFLG(16),NXFLG(16),EN(16),SHAPC(5)
      DIMENSION STD(2),CLIN(5),Y(60),XC(2),REFCH(2),HIGHT(16),GAMA(16)
      COMMON/GNL/ NUMS,NUME,NDPTS,NP,ITER,NWRDS,NFLG,NYFLG,NXFLG,FNAME,
      1ST,END,
1  GAIN,ZERO,START,ALPHA,FWHM,ATAIL,BTAIL,STD,C1,C2,AVEBG,
2  SLP,EN,SHAPC,HIGHT,GAMA,Y
      COMMON/PASS/ENJ(16),IST,IEND,NUMSJ,NUMEJ,GAINJ,JZERO,ST1J,ST2J,
      1STRJ(16),NENUM,ALPJ,TAMP,TSLP,BKGSJP,FILE(3),SSS,YES,BK1,NGAIN,
      1IREGG,LISTFG,PAME(3),ZER1
      CALL GETSHP
22  AVECH = 0.5 * (ST + END)
      GSQ = GAIN * GAIN
      SG = SHAPC(1) / GSQ + SHAPC(2) * (ST / GAIN + ZERO/GSQ) + .462
      FWHM = SQRT (SG)
      ALPHA = -2.7726 / SG
      AVEN = AVECH * GAIN + ZERO
      ATAIL = EXP (SHAPC(3) + AVEN * SHAPC(4))
      BTAIL = SHAPC(5) * GAIN
      IF(NGAIN) 29,29,54
29  DO 50 J=1,2
      REFCH(J)=0.
      XC(J)=0.
      IF(STD(J)) 32,50,32
32  REF=(STD(J)-ZERO)/GAIN
      ST1=REF-30.
      IST1=REF-30.
      CALL READGP(IST1,60)
      CALL MAXVAL (20,40,JPK,YMAX,Y)
      CALL MINVAL (1,JPK,MS,BG1,Y)
      CALL MINVAL (JPK,60,ME,BG2,Y)
      CALL AVE (MS,ME,SUM,AV,Y)
      YS = 0.0
      DBG = BG2 - BG1
      DO 35 I = MS,ME
      YS = YS + Y(I)
      Y(I) = Y(I) - BG1 - DBG * YS/SUM
35  CONTINUE
      GSQ = GAIN * GAIN
      SG = SHAPC(1) / GSQ + SHAPC(2) * ST1 / GAIN + .462
      ALFA = -2.7726 / SG
      EXP1 = EXP (SHAPC(3) + STD(J) * SHAPC(4))
      NUM = 9
      IF (ALFA +.2) 36,36,37
36  NUM = 7
37  CALL GFIT (JPK,PKPOS,PHT,NUM,ALFA,EXP1,BTAIL,Y)
      REFCH(J) = ST1 + PKPOS - 1.
      PP = REFCH(J)

```


GRPNL2 Listing...

```

      PKP = PP
C      DO 38 I = 1,4
C      PKP = PKP * REFCH(J)
C38    PP = PP + CLIN(I) * PKP
      XC(J) = PP
50     CONTINUE
      GAIN = (STD(2) - STD(1)) / (XC(2) - XC(1))
      ZERO = STD(1) - GAIN * XC(1)
      IST=((ST*GAINJ+ZER1)-ZERO)/GAIN
      IEND=((END*GAINJ+ZER1)-ZERO)/GAIN
      ST=IST
      END=IEND
      JZERO=ZERO
      ZER1=ZERO
54     PP = AVECH
      PKP = PP
C      DO 52 I = 1,4
C      PKP = PKP * AVECH
C52    PP = PP + CLIN(I) * PKP
      STD(1) = ZERO + GAIN * PP
      STD(2) = AVECH
      RETURN
      END

```

GRPNL2 Listing...

C SUBROUTINE READGP J G FLEISSNER 7/21/80
C READGP

 SUBROUTINE READGP(IST1,NUMPTS)

C IST1 =FIRST CHANNEL

C NUMPTS =NUMBER OF CHANNELS

C Y =ARRAY

 COMMON/GNL/ NUMS,NUME,NDPTS,NP,ITER,NWRDS,NFLG,NYFLG,
 INXFLG,FNAME,

1 ST,END,GAIN,ZERO,START,ALPHA,FWHM,ATAIL,BTAIL,REFEN,REFCH,

2 C1,C2,AVEBG,SLP,EN,SHAPC,HIGHT,GAMA,Y,PKPOS,PKHT,DUM

 DIMENSION NWRDS(5),NFLG(16),NYFLG(16),NXFLG(16),EN(16),

1 SHAPC(5),Y(150),PKPOS(16),PKHT(16),DUM(512),HIGHT(16),GAMA(16)

 LOGICAL*1 SPECHD(512)

 COMMON /SIDENT/SPECHD

 EQUIVALENCE(ICHAN,SPECHD(37)),(NBYTES,SPECHD(25))

 DEFINE FILE 12(0,2,U,IREC)

 NOFSET=(NBYTES/4)

 DO 1000 I=1,NUMPTS

 IREC=I+IST1+NOFSET-1

 READ(12,IREC) Y(I)

 CALL CHOP(Y(I),Y(I))

 CALL SFLOAT(Y(I),Y(I))

1000 CONTINUE

 ENDFILE 12

 II=561

 CALL ZGNL(II)

 RETURN

 END

GRPNL2 Listing...

```
C      AVE
C      THIS ROUTINE DETERMINES THE AVERAGE COUNT OF A GROUP OF DATA
C      VALUES FROM NS TO NE INCLUSIVE.  IT ALSO RETURNS THE SUM.
      SUBROUTINE AVE (NS,NE,SUM,AV,Y)
      DIMENSION Y(2)
      SUM = 0.0
      SM = NE - NS + 1
      DO 2 I = NS,NE
2      SUM = SUM + Y(I)
      AV = SUM / SM
      RETURN
      END
```

GRPNL2 Listing...

```
SUBROUTINE DAYMON(IDAY,IYEAR,JDAY,JMON)
  DIMENSION NDAT(12)
  DATA NDAT/0,31,59,90,120,151,181,212,243,273,304,334/
  JMON=0
  IL=0
  IF(IDAY.LE.59) GO TO 150
  TST=IYEAR-(IYEAR/4)*4
  IF(TST.LE.0) IL=1
150  DO 200 K=1,12
      IC=IDAY-NDAT(13-K)-IL
      IF(IC.GT.0) JMON=13-K
      IF(JMON.GT.0) GO TO 300
200  CONTINUE
300  JDAY=IDAY-NDAT(JMON)-IL
      RETURN
      END
```

```
C ZERO GNL COMMON ARRAY FOR PROGRAM PUIISO.FOR
SUBROUTINE ZGNL(IK)
COMMON/GNL/I(6056)
DO 100 II=IK,6056
100  I(II)=0
RETURN
STOP
END
```

```
C      MAXVAL
C      THIS ROUTINE RETURNS THE POSITION AND VALUE OF THE MAXIMUM VALUE
C      IN A GROUP OF DATA POINTS FROM NS TO NE INCLUSIVE.
      SUBROUTINE MAXVAL (NS,NE,JMAX,YMAX,Y)
      DIMENSION Y(2)
      YMAX = 0.0
      DO 2 I = NS,NE
      IF (Y(I) - YMAX) 2,2,4
4      YMAX = Y(I)
      JMAX = I
2      CONTINUE
      RETURN
      END
```

```

C      MINVAL
C      THIS ROUTINE RETURNS THE POSITION AND VALUE OF THE MINIMUM VALUE
C      IN A GROUP OF DATA POINTS FROM NS TO NE INCLUSIVE.
      SUBROUTINE MINVAL (NS,NE,JMIN,YMIN,Y)
      DIMENSION Y(2)
      YMIN=1.0E38
      DO 4 I=NS,NE
      IF (Y(I)-YMIN)2,4,4
2      JMIN=I
      YMIN=Y(I)
4      CONTINUE
      RETURN
      END

```

C SUBROUTINE GETSHP GET SHAPE PARAMETERS

```

SUBROUTINE GETSHP
  LOGICAL*1 DNEW(24),SPECHD(512),DEFBUF(16),DET(16)
  DIMENSION NWRDS(6),NFLG(16),NYFLG(16),NXFLG(16),EN(16),SHAPC(5)
  DIMENSION STD(2),CLIN(5),Y(60),XC(2),REFCH(2),HIGHT(16),GAMA(16)
  COMMON /SIDENT/ SPECHD
  COMMON/GNL/ NUMS,NUME,NDPTS,NF,NWRDS,NFLG,NYFLG,NXFLG,FNAME,
  1ST,END,
1  GAIN,ZERO,START,ALPHA,FWHM,ATAIL,BTAIL,STD,C1,C2,AVEBG,
2  SLP,EN,SHAPC,HIGHT,GAMA,Y
  EQUIVALENCE (DET(1),SPECHD(477))
  DATA DEFBUF/'@','D','E','F',' ','1','0',' ',' ','D','E',
  1'T',' ','E',' ',' ','@'/
  CALL RIDENT
  DEFBUF(14)=DET(1)
  DEFBUF(15)=DET(2)
  CALL MCLI(DEFBUF)
  READ(10) M,DNEW
  READ(10) (SHAPC(I),I=1,5)
  ENDFILE 10
  RETURN
  END

```



```

C      GFIT
C      THIS ROUTINE PERFORMS A GAUSSIAN FIT TO 5, 7, OR 9 POINTS
C      SURROUNDING THE L TH CHANNEL AND RETURNS THE EXACT PEAK POSITION
C      AND THE PEAK HEIGHT.
      SUBROUTINE GFIT (L,PKPOS,PKHT,NC,ALFA,EXP1,EXP2,Y)
      DIMENSION Y(2)
      SY = 0.0
      SXY = 0.0
      SXXY = 0.0
      LX = - NC / 2
      Y1 = Y(L+1)
      Y2 = Y(L-1)
      TPOS = .5 * (Y2-Y1) / (Y1 - 2. * Y(L) + Y2)
      Y0 = Y(L)
      DO 2 I = 1,NC
      K = L + LX
      XL = LX
      DLX = XL - TPOS
      Y1 = Y(K)
      IF (DLX) 1,7,7
1      Y1 =Y1-Y0 * EXP1* EXP(EXP2 * DLX) * (1. -EXP(.4*ALFA*DLX*DLX))
7      IF (Y1) 5,5,3
5      Y1 = 1.0
3      YLOG = ALOG (Y1)
      YX = XL * YLOG
      SXY = SXY + YX
      SY = SY + YLOG
      SXXY = SXXY + XL * YX
      LX = LX + 1
2      CONTINUE
      PKP = L
      IF (NC - 7) 4,6,8
4      PKPOS = SXY / (2.8571 * SY - 1.4286 * SXXY)
      PKHT = 0.485714 * SY - 0.142857 * SXXY +0.05*SXY*PKPOS
      GO TO 10
6      PKPOS = SXY / (2.6666 * SY - 0.6666 * SXXY)
      PKHT = 0.3333 * SY - 0.04762 * SXXY + .017857*SXY*PKPOS
      GO TO 10
8      PKPOS = SXY / (2.597 * SY - 0.3896 * SXXY)
      PKHT = 0.2554 * SY - 0.021645 * SXXY + .0083333*SXY*PKPOS
10     PKHT = EXP (PKHT)
      PKPOS=PKP+PKPOS
      RETURN
      END

```

```

      SUBROUTINE LOAD2
C LOAD2(BKGRD,AVE,READGP)
C      THIS SUBPROGRAM IS THE SECOND LINK TO THE PROGRAM "GRPNL2".
      COMMON/GNL/ NUMS,NUME,NDPTS,NP,ITER,NWRDS,NFLG,NYFLG,
      INXFLG,FNAME,
      1 ST,END,GAIN,ZERO,START,ALPHA,FWHM,ATAIL,BTAIL,REFEN,REFCH,
      2 C1,C2,AVEBG,SLP,EN,SHAPC,HIGHT,GAMA,Y,PKPOS,PKHT,DUM
      DIMENSION NWRDS(5),NFLG(16),NYFLG(16),NXFLG(16),EN(16),
      1 SHAPC(5),Y(150),PKPOS(16),PKHT(16),DUM(512),HIGHT(16),GAMA(16)
      NDPTS = END - ST + 1.
      NDATA = NDPTS + NUMS + NUME
      XNUMS = NUMS
      ST2 = ST - XNUMS
      IST2=ST2
      CALL READGP(IST2,NDATA)
      START = ST - 1.
40      NE1 = NDPTS + NUMS
      CALL AVE (1,NUMS,BGD,AVBG1,Y)
      CALL AVE (NE1,NDATA,YSUM,AVBG2,Y)
      SRB=(AVBG1**0.5)/XNUMS
      TSB=AVBG1+2.0*SRB
      IF(TSB.GT.AVBG2) GO TO 523
      WRITE(6,522)
522      FORMAT(1X,/)
      DO 300 JJ=1,2
      DO 200 II=1,30
      WRITE(6,400)
400      FORMAT(' + * ',1X,$)
200      CONTINUE
      IF(JJ.EQ.2) GO TO 300
      WRITE(6,522)
      WRITE(6,500)AVBG1,AVBG2
500      FORMAT(1X,'WARNING: POSITIVE SLOPING BACKGROUND',/,10X,
      1'AVBG1=',F7.0,5X,'AVBG2=',F7.0)
      WRITE(6,522)
      SLP=(AVBG2-AVBG1)/NDPTS
      WRITE(6,501)SLP
501      FORMAT(1X,' SLP= ',F6.3)
      WRITE(6,522)
300      CONTINUE
      WRITE(6,522)
523      BGD = BGD - YSUM
      K = NUMS + 1
      KK = NE1 - 1
      CALL AVE (K,KK,YSUM,XDUM,Y)
      CALL BKGRD (NUMS,NE1,AVBG1,AVBG2,SLP,SLP,YSUM,NDPTS,Y)
      IF (NDPTS - 150) 44,44,43
43      CONTINUE
      WRITE (6,100) NDPTS
100      FORMAT ('TOO MANY CHANNELS.  NDPTS = ',I4)
      STOP
44      AVEBG = 0.5 * (AVBG1 + AVBG2)
      DO 42 J = 1,NP
      PKPOS(J) = (EN(J) - REFEN)/ GAIN + REFCH - START
      NPK = PKPOS(J) + 0.5

```

GRPNL2 Listing...

```

42      PKHT(J) = Y(NPK)
        DO 55 J=1,NP
          IF(NYFLG(J)) 51,53,53
51      PKHT(J)=HIGHT(J)
          IF(HIGHT(J)) 52,53,53
52      L=-NYFLG(J)
          DX=PKPOS(J)-PKPOS(L)
          FCT=-HIGHT(J) *EXP(ALPHA*DX*DX)
          PKHT(L)=PKHT(L)* (1.-FCT/(1.+FCT))
          PKHT(J)=-HIGHT(J)*PKHT(L)
53      IF(NXFLG(J)) 54,55,55
54      L=-NXFLG(J)
          PKPOS(J)=PKPOS(L) - (EN(L) -EN(J))/GAIN
55      CONTINUE
          ITER = 1
          SLP = SHAPC(2) / GAIN
          NFLG(4) = 0
          RETURN
        END

```

```

SUBROUTINE BKGRD(NS,NE,AVBG1,AVBG2,SLP1,SLP2,SUM,L,Y)
DIMENSION Y(150)
XPTS = NE - NS
DBG = (AVBG2 - AVBG1) - 0.5 * (SLP1 + SLP2) * XPTS
XPTS = XPTS - 1.0
NS = NS + 1
NE = NE - 1
BG2 = AVBG2
SM = 0.0
DO 2 I = NS,NE
2 SM = SM + Y(I)
SM = SM - BG2 * XPTS
XS = 0.0
YS = 0.0
YSUM=0.0
RT2 = 0.0
FDY = 0.0
DD = 0.
L = 0
XBG =AVBG1
DSLFP =( SLP2 - SLP1)/XPTS
S1 = SLP1
DO 10 I = NS,NE
L = L + 1
DY = Y(I) - BG2
HDY = 0.5 * DY
YS = YS + HDY + FDY
YSUM = YSUM + DY
RT1 = YS/SM
BG = AVBG1 +DBG * YSUM/SM
DD = DD + (L * DSLFP + S1)
XBG = DD + BG
C
FDY=HDY
C
Y(L) = Y(I) - XBG
10 XS = XS + Y(L)
SUM = XS
RETURN
END

```

```

      SUBROUTINE FIT2
C      FIT2
C      THIS SUBPROGRAM PERFORMS A TAYLOR'S EXPANSION ABOUT THE TRIAL
C      VALUES TO OBTAIN A SET OF LINEAR EQUATIONS. IT IS THE THIRD LINK
C      TO THE PROGRAM "GRPNL2".
      COMMON/GNL/ K, KK, NDPTS, NP, ITER, LFLG, NWRDS, NFLG1, NFLG2, NFLG3,
      1 NXF, MWRDS,
1      NYFLG, NXFLG, FNAME, EXP1, EXP2, GAIN, ALFA, START, ALPHA, FWHM,
2      ATAIL, BTAIL, R1, R2, BG, AVEBG, ASLF, BWRDS, GAMA, YNET, PKPOS, PKHT, DELY,
3      DEL, RM, VM, ACOEF, WM
      DIMENSION NWRDS(4), MWRDS(12), NYFLG(16), NXFLG(16), BWRDS(37),
1      YNET(150), PKPOS(16), PKHT(16), DELY(150), DEL(16), RM(150), VM(16),
2      ACOEF(150,16), BG(2), GAMA(16), WM(16), SUM(16)
      COMMON/PASS/ ENJ(16), IST, IEND, NUMSJ, NUMEJ, GAINJ, JZERO,
      1ST1J, ST2J, STRJ(16), NENUM, ALPJ, TAMP, TSLF, BKGSFLF,
      1FILE(3), SSS, YES, BK1, NGAIN, IREGG, LISTFG, PAME(3), ZER1, SUM
      LOGICAL*1 RESBUF(22), DEFBUF(18)
      DATA RESBUF/'@','R','E','S',' ',' ','D','A','T','A',' ',' ','M','T',
      1'R','X',' ',' ','B','L','K',' ','=' ,'3','8','@'/
      DATA DEFBUF/'@','D','E','F',' ',' ','4',' ',' ','D','A','T','A',' ',' ','
      1'M','T','R','X','@',' ',' '/
      IF (ITER - 1) 2,1,2
1      EXP1 = ATAIL
      EXP2 = BTAIL
      KK = NFLG1 + NFLG2 + NFLG3
2      SG = -2.7726 / ALPHA
      CX = SQRT(-ALPHA)
      XPTS = NDPTS
      BG(1) = 0.0
      BG(2) = 0.0
      DO 400 J = 1, NP
      SUM(J) = 0.
      AMP = EXP1
      XI = PKPOS(J)
      DO 300 L = 1, 2
      CC = CX * XI
      IF (GAMA(J)) 201, 201, 100
100      CALL BWF(CC)
201      BG(L) = BG(L) + PKHT(J) * (.6366 * GAMA(J) * CX * CC + AMP * EXP(-EXP2 * XI))
      AMP = 0.0
      XI = XPTS - PKPOS(J)
300      CONTINUE
400      CONTINUE
      DBG = BG(2) - BG(1)
      CALL AVE(1, NDPTS, YSUM, AV, YNET)
      YF = 0.0
      GSQ = GAIN * GAIN
      DO 30 I = 1, NDPTS
      XI = I
      FX = 0.0
      DALFA = 0.0
      DBETA = 0.0
      DGAMA = 0.0
      WT = 1.0 / SQRT (YNET(I) + AVEBG)
      K = KK

```

```

DO 20 J = 1,NP
DLTAX = XI - PKPOS(J)
DX = DLTAX
DLX = DLTAX
DLXSQ = DLTAX * DLTAX
EXPNI = 0.0
PHT = PKHT(J)
ALFA = -2.7726 / (ASLP * PKPOS(J) + SG)
EXPNT = ALFA * DLXSQ
EXPNI = 0.
IF (EXPNT + 14.) 4,3,3
3 EXPNI = EXP (EXPNT)
4 IF(DLTAX) 53,54,54
53 EXPNI=EXP(0.4*EXPNT)
54 FXX=EXPNI
IF(GAMA(J)) 52,52,51
51 WL=GAMA(J)*CX
CX=SQRT(-ALFA)
CD=CX*DLTAX
CALL CBWF (WL,EXPNT,EXPNI,CD)
FXX=CD
52 IF (NFLG1) 6,6,5
5 DALFA = DALFA + PHT * DLXSQ * EXPNI
6 IF (DLTAX) 7,14,14
7 EXPN = EXP2 * DLTAX
IF (EXPN + 10.) 14,8,8
8 EXPN2 = EXP (EXPN)
CB = EXPN2 * (1.0 - EXPNI)
FXX = FXX + EXP1 * CB
IF (NFLG3) 10,10,9
9 DGAMA = DGAMA + DLTAX * EXP1 * PHT * CB
10 IF (NFLG2) 14,14,11
11 DBETA = DBETA + CB * PHT
14 IF(NYFLG(J)) 16,16,15
15 K = K + 1
ACOE(I,K) = EXPNI * WT
16 IF (NXFLG(J)) 19,19,17
17 K = K + 1
ACOE(I,K) = -2. *ALFA *PHT * DX *EXPNI * WT
19 FX = FX + FXX * PHT
SUM(J)=SUM(J)+FXX*PHT
20 CONTINUE
L = 0
IF (NFLG1) 22,22,21
21 L = L + 1
ACOE(I,L) = DALFA * WT
22 IF (NFLG2) 24,24,23
23 L = L + 1
ACOE(I,L) = DBETA * WT
24 IF (NFLG3) 26,26,25
25 L = L + 1
ACOE(I,L) = DGAMA * WT
26 YP=YP+YNET(I)
DELY(I) = (YNET(I) +BG(1) +YP*DBG/YSUM - FX ) * WT
30 CONTINUE

```

```

      CALL MCLI(DEFBUF)
      CALL QANDC(4,IERR,ID,ID,ID,ID,ID,ID)
      IF(IERR.EQ.0) GO TO 550
      CALL MCLI(RESBUF)
      CALL QANDC(4,IERR,ID,ID,ID,ID,ID,ID)
      IF(IERR.EQ.0) GO TO 550
      STOP 'FILE DATA.MTRX CREATION ERROR'
550   CONTINUE
      DO 101 J=1,K
      WRITE(4) (ACDEF(I,J), I=1,150)
101   CONTINUE
      ENDFILE 4
      LFLG=1
      CALL MLR
      IF(LFLG.EQ.2) GOTO 102
      CALL MLRA
102   CONTINUE
      IF(LISTFG.EQ.1) RETURN
      TYPE 9010,ITER
9010  FORMAT(/,' CHANNEL KEV      PEAK HEIGHT FWHM  ATAIL BTAIL
      1  ITERATION ',I3)
      DO 200 J=1,NP
      PKP=PKPOS(J)+START
      FWHM1=GAIN*SQRT(SG)
      EXP22=EXP2/GAIN
      PKE=PKP*GAIN+ZER1
      TYPE 9020,PKP,PKE,PKHT(J),FWHM1,EXP1,EXP22
9020  FORMAT(2F9.2,F12.3,1X,3F7.4)
200   CONTINUE
      RETURN
      END

```

GRPNL2 Listing...

C CBWF
SUBROUTINE CBWF (WL,EXPNT,EXPN1,CD)
C1=1.-0.5642*WL
C2=.15915*WL
C3=.25*WL*WL
C4=0.6366*WL
RT=C1+C3
CC=ABS(CD)
CALL BWF (CC)
AA=(C1-C2*EXPNT+C3*(1.+2.*EXPNT))*EXPN1+C4*CC
CD=AA/RT
RETURN
END


```

C      BWF
      SUBROUTINE BWF (X)
      DIMENSION CA(5),CB(6)
      CA(1) = .729281
      CA(2) = .0344557
      CA(3) = .127639
      CA(4) = -.0325239
      CA(5) = .00642257
      CB(1) = .933301
      CB(2) = -4.45603
      CB(3) = 1.16191
      CB(4) = -.141124
      CB(5) = -.0352464
      CB(6) = .00744387
      IF (X - 2.2) 2,10,10
2      XX = X * X
      AX = 1.
      SUM = 0.0
      DO 4 I = 1,5
      AX = AX * XX
4      SUM = SUM + CA(I) * AX
      X = SUM * EXP (-XX)
      GO TO 20
10     XLOG = ALOG (X)
      SUM = CB(1)
      DO 12 I = 2,6
12     SUM = SUM + CB(I) * XLOG ** (I-1)
      X = EXP (SUM)
20     RETURN
      END

```

```

C      MLR
C      THIS IS THE FIRST PART OF A LEAST-SQUARES PROGRAM WHICH WAS
C      ADAPTED FROM THE "MLR" PROGRAM WRITTEN BY R. E. VON HOLDT,LLL.
C      THE SEQUEL IS MLRA OR MLRS.
      SUBROUTINE MLR
      COMMON/GNL/ N, KK, M, NP, ITER, NFLG, NWRDS, NFLG1, NFLG2, NFLG3,
      1NXF, MWRDS,
      1 NYFLG, NXFLG, FNAME, EXP1, EXP2, GAIN, ALFA, START, ALPHA, FWHM,
      2 ATAIL, BTAIL, R1, R2, BG, AVEBG, ASLP, BWRDS, GAMA, YNET, PKPOS, PKHT, Y,
      3 X, R, V, B, W
      DIMENSION NWRDS(4), MWRDS(12), NYFLG(16), NXFLG(16), BWRDS(37),
      1 YNET(150), PKPOS(16), PKHT(16), Y(150), X(16), R(150), V(16),
      2 B(2400), BG(2), GAMA(16), W(16)
      IB = 150
      DO 70 I = 1, N
      T = 0.
      IK = (I-1) * IB
      DO 20 K = I, M
      LL = IK + K
      T = T + B(LL) * B(LL)
20    CONTINUE
      IF (T) 30, 29, 30
29    NFLG = 2
      GO TO 75
30    ST = SQRT (T)
      LL = IK + I
      W(I) = ST
      IF (B(LL)) 31, 32, 32
31    W(I) = -ST
32    B(LL) = B(LL) + W(I)
      V(I) = -B(LL) * W(I)
      IF (I-N) 35, 75, 35
35    IP = I + 1
      IF (IP, GT, N) GO TO 70
      DO 60 J = IP, N
      T = 0.
      JK = (J-1) * IB
      DO 40 K = I, M
      LL = IK + K
      LLL = JK + K
40    T = T + B(LL) * B(LL)
      T = T / V(I)
      DO 50 L = I, M
      LL = JK + L
      LLL = IK + L
50    B(LL) = B(LL) + T * B(LL)
60    CONTINUE
70    CONTINUE
75    CONTINUE
      RETURN
      END

```

```

C      MLRA
C      THIS IS A SEQUEL TO THE MLR PROGRAM.  IT REQUIRES MORE CORE THAN
C      THIS IS A SEQUEL TO THE MLR PROGRAM.
C      (ADAPTED FROM THE MLR PROGRAM WRITTEN BY R. H. VON HOLDT,LLL)
      SUBROUTINE MLRA
      COMMON/GNL/ N, KK, M, NP, ITER, NFLG, NWRDS, NFLG1, NFLG2, NFLG3,
      1NXF, MWRDS,
1  NYFLG, NXFLG, FNAME, EXP1, EXP2, GAIN, ALFA, START, ALPHA, FWHM,
2  ATAIL, BTAIL, R1, R2, BG, AVEBG, ASLP, BWRDS, GAMA, YNET, PKPOS, PKHT, Y,
3  X, R, V, B, W
      DIMENSION NWRDS(4), MWRDS(12), NYFLG(16), NXFLG(16), BWRDS(37),
1  YNET(150), PKPOS(16), PKHT(16), Y(150), X(16), R(150), V(16),
2  B(2400), BG(2), GAMA(16), W(16)
      DIMENSION A(150)
      LOGICAL*1 DEFBUF(18)
      DATA DEFBUF/'@','D','E','F',' ','4',' ',' ','D','A','T','A',
1',','M','T','R','X','@',' ' /
      IB = 150
      DO 80 I = 1, M
80    R(I) = Y(I)
      DO 90 I = 1, N
90    X(I) = 0.
      S = 0.
      DO 100 L = 1, M
100   S = S + R(L) * R(L)
      YE = S
105   DO 130 I = 1, N
      T = 0.
      LK = (I-1) * IB
      DO 110 K = 1, M
      LL = LK + K
110   T = T + B(LL) * R(K)
      T = T/V(I)
      DO 120 L = 1, M
      LL = LK + L
120   R(L) = R(L) + T * B(LL)
130   CONTINUE
      IN = N
140   R(IN) = R(IN)/W(IN)
150   J = IN
155   J = J - 1
      IF (J) 190, 190, 160
160   LL = (IN-1) * IB + J
      R(J) = R(J) + R(IN) * B(LL)
      GO TO 155
190   IN = IN - 1
      IF (IN) 200, 200, 140
200   DO 210 I = 1, N
      SC = X(I)
      SD = R(I)
      XD = SC - SD
210   X(I) = XD
      DO 215 I = 1, M
215   R(I) = Y(I)
C      READ SECTIONS OF "A" MATRIX FOM PREVIOUSLY STORED "AMTRX" FILES

```

```

C      STORED ON RK0
      CALL MCLI(DEFBUF)
      CALL QANDC(4,IERR,ID,ID,ID,ID,ID,ID)
      IF(IERR,EQ,0) GO TO 216
      STOP 'OPEN ERROR MLRA'
216    CONTINUE
      DO 220 J = 1,N
      READ (4) (A(I) , I = 1,IB)
      XD = X(J)
      DO 230 I = 1,M
230    R(I) = R(I) - A(I) * XD
      220 CONTINUE
      ENDFILE 4
      RE = 0.
      DO 240 I = 1,M
240    RE = RE + R(I) * R(I)
      IF (RE - S) 250,270,270
250    S = RE
      GO TO 105
270    IF (RE - YE) 280,290,290
290    NFLG = 3
280    RETURN
      END

```

```

      SUBROUTINE RETRN2
C     RETRN2 (LMLRE)
C     THIS SUBPROGRAM IS THE FOURTH LINK TO THE PROGRAM "GRPNL2".
      COMMON/GNL/ K, KK, NDPTS, NP, ITER, NERR, NWRDS, NFLG1, NFLG2,
      1NFLG3, MWRDS,
      1 NYFLG, NXFLG, FNAME, EXP1, EXP2, GAIN, ALFA, START, ALPHA, FWHM, ATAIL,
      2 BTAIL, REFEN, REFCH, C1, C2, AVEBG, SLP, EN, SHAPC, HIGHT, GAMA, Y,
      3 PKPOS, PKHT, DELY, DEL, RM, DM, ACOEF, WM
      DIMENSION NWRDS(4), MWRDS(13), NYFLG(16), NXFLG(16), EN(16), SHAPC(5),
      1 PKPOS(16), PKHT(16), DELY(150), DEL(16), RM(150), ACOEF(2400),
      2 WM(16), DM(16), GAMA(16), Y(150), HIGHT(16)
      GO TO (1,2,3) NERR
      2  WRITE (6,101)
        WRITE(6,106)
      106 FORMAT(1X, 'FIT RETRIED WITH ONE LESS FREE PARAMETER')
      101 FORMAT(1X, 'MATRIX IS SINGULAR')
      GO TO 10
      3  WRITE (6,102)
        WRITE (6,106)
      102 FORMAT (1X, 'SUM OF SQUARES OF R > THAN THOSE OF Y')
      10  ITER=999
        RETURN
C     INCREMENT THE TRIAL VALUES AND CHECK FOR COMPLETION OF ITERATIVE
C     PROCESS.
      1  L = 0
        CALL MLRE
        DO 4 J=1,16
      4  DM(J)=SQRT(DM(J))
        LFLG = 0
        IF (NFLG1) 43,43,41
      41  L = L + 1
        ADEL=ABS(DEL(L))
C     ALPHA=ALPHA + DEL(L) * (1. + ADEL/(ALPHA - ADEL))
        DP=DEL(L)/ALPHA
        IF(ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
        ALPHA=ALPHA*(1.+DP)
        IF (ADEL + .01*ALFA) 43,43,42
      42  LFLG = 1
      43  IF (NFLG2) 46,46,44
      44  L = L + 1
        IF(ITER-NFLG1) 45,45,15
      15  IF (EXP1 + DEL(L)) 16,16,17
      16  DEL(L) = - .5 * EXP1
      17  ADEL=ABS(DEL(L))
        EXP1=EXP1 +DEL(L) * (1.- ADEL / (EXP1 + ADEL))
        IF (ADEL -DM(L) - .01 * EXP1) 46,46,45
      45  LFLG = 1
      46  IF (NFLG3) 49,49,47
      47  L = L + 1
        IF (ITER-NFLG1-NFLG2) 48,48,19
      19  IF (EXP2 + DEL(L)) 20,20,21
      20  DEL(L) = .5 * EXP2
      21  ADEL = ABS(DEL(L))
        EXP2 = EXP2 + DEL(L) * (1. -ADEL / (EXP2 + ADEL ))
        IF (ADEL - DM(L) - .02 * EXP2) 49,49,48

```

GRPNL2 Listings...

```

48      LFLG = 1
49      K = L
        DO 60 J = 1,NP
        IF (NYFLG(J)) 52,52,50
50      K = K + 1
        ADEL = ABS( DEL(K))
        DP=DEL(K)/PKHT(J)
        IF(ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
        PKHT(J)=PKHT(J)*(1.+DP)
        IF(PKHT(J).LT.1.0) GOTO 52
        IF (ADEL - DM(K) -.001 * PKHT(J)) 52,52,51
51      LFLG = 1
52      IF (NXFLG(J)) 60,60,53
53      K = K + 1
        ADEL = ABS (DEL(K))
        IF(ADEL - 1.) 56,55,55
55      DEL(K) = 0.5 * DEL(K)/ADEL
56      PKPOS(J) = PKPOS(J) + DEL(K)
        IF(ABS(ADEL)-DM(K) -.01*PKPOS(J)) 60,60,54
54      LFLG = 1
60      CONTINUE
        DO 65 J=1,NP
        IF(NYFLG(J)) 61,63,63
61      PKHT(J)=HIGHT(J)
        IF(HIGHT(J)) 62,63,63
62      L=-NYFLG(J)
        PKHT(J)=-HIGHT(J)*PKHT(L)
63      IF(NXFLG(J)) 64,65,65
64      L=-NXFLG(J)
        PKPOS(J)=PKPOS(L)-(EN(L)-EN(J))/GAIN
65      CONTINUE
        IF(LFLG) 70,79,70
70      ITER = ITER + 1
        IF (ITER - 15)78,78,77
78      RETURN
77      WRITE (6,105)
        WRITE(6,106)
105     FORMAT (1X,'MAXIMUM ITERATIONS EXCEEDED.')
```

ITER=999
RETURN

79 CONTINUE
ITER=99
RETURN
END

```

C      MLRE
C      THIS ROUTINE OBTAINS THE DIAGONAL MATRIX ELEMENTS FOLLOWING A
C      LEAST-SQUARES CALCULATION.  THESE CAN BE USED FOR ERROR ANALYSIS.
      SUBROUTINE MLRE
      COMMON/GNL/ NN, KK, NDPTS, NF, ITER, NERR, NWRDS, NFLG1, NFLG2,
      1NFLG3, MWRDS,
      1 NYFLG, NXFLG, FNAME, EXP1, EXP2, GAIN, ALFA, START, ALPHA, FWHM, ATAIL,
      2 BTAIL, REFEN, REFCH, C1, C2, AVEBG, SLP, EN, SHAPC, HIGHT, GAMA, Y,
      3 PKPOS, PKHT, DELY, DEL, RM, D, B, W
      DIMENSION NWRDS(4), MWRDS(13), NYFLG(16), NXFLG(16), EN(16), SHAPC(5),
      1 PKPOS(16), PKHT(16), DELY(150), DEL(16), RM(150), B(2400),
      2 W(16), D(16), GAMA(16), Y(150), HIGHT(16)
      N = NN
      IA=150
      DO 6 I = 1, N
      IF(W(I).EQ.0.)GOTO 6
      D(I) = -1. / W(I)
      IF (N - 1) 4,4,1
      1 JJ = I + 1
      IF(JJ.GT.N) GO TO 4
      DO 3 J = JJ, N
      S = 0.
      KJ = J - 1
      DO 2 K = I, KJ
      LL = (J - 1) * IA + K
      S = S + D(K) * B(LL)
      2 CONTINUE
      D(J)=0.
      IF(W(J).EQ.0) GO TO 3
      D(J) = S / W(J)
      3 CONTINUE
      4 S = 0.
      DO 5 L = I, N
      S = S + D(L) **2
      5 CONTINUE
      D(I) = S
      6 CONTINUE
      RETURN
      END

```

SUBROUTINE OUT2

C SUBROUTINE OUT2 MODIFIED FOR PDF-9 JE FAGER 9/76

C THIS SUBPROGRAM IS THE FIFTH LINK TO THE PROGRAM "GRFANL".

LOGICAL*1 DTE(24),SPECHD(512),ID(16),DET(16),GEOM(16)

LOGICAL*1 TYPE(16),TITLE(64)

DIMENSION NWRDS(22),NYFLG(16),NXFLG(16),BWRDS(21),

1 YNET(150),PKPOS(16),PKHT(16),RES(150),DEL(16),RM(150),

2 DM(16),NSMBL(20),EDGE(20),COFMU(8,20),MTLZ(5),CMPOS(5),NABS(5),

3 ABS1(5),DCNST(15),BG(2),HIGHT(16),GAMA(16),YSUM(16)

COMMON/PASS/ENJ(16),IST,IEND,NUMSJ,NUMEJ,GAINJ,JZERO,ST1J,ST2J,

1STRJ(16),NENUM,ALPJ,TAMP,TSLP,BKGSFP,FILE(3),SSS,YES,BK1,

1NGAIN,IREGG,LISTFG,PAME(3),ZER1,YSUM

COMMON/REST/RENG(100),RCTS(100),RER(100),REFF(204),MRX

COMMON/GNL/ K,KK,NDPTS,NP,NWRDS,NYFLG,NXFLG,FNAME,EXP1,EXP2,

1 GAIN,ALFA,START,ALPHA,FWHM,ATAIL,BTAIL,REFEN,REFCH,BG,

2 AVEBG,ASLP,BWRDS,HIGHT,GAMA,YNET,PKPOS, PKHT,RES,DEL,RM,DM

COMMON/SIDENT/SPECHD

EQUIVALENCE (ID(1),SPECHD(397)),(ELTIME,SPECHD(49))

EQUIVALENCE (DET(1),SPECHD(477)),(RTTIME,SPECHD(57))

EQUIVALENCE (GEOM(1),SPECHD(445)),(AKEV,SPECHD(113))

EQUIVALENCE (TYPE,SPECHD(429)),(TITLE,SPECHD(333))

EQUIVALENCE (IDAY,SPECHD(81)),(IYEAR,SPECHD(83))

DATA Y/4HYES /

DATA AND/4HNO /

DATA BL/4H /

CALL ATIME(DTE)

CALL SFLOAT(ELTIME,ELTIME)

CALL SFLOAT(RTTIME,RTTIME)

CALL DAYMON(IDAY,IYEAR,JDAY,JMON)

NOUT = 3

SUM = 0.0

SUM2=0.0

CTS2=0.0

DO 1 I = 1,NDPTS

RES(I) = RM(I) * SQRT (YNET(I) + AVEBG)

SUM2=SUM2+ABS(RES(I))

1 SUM = SUM + RM(I) **2

DOF = NDPTS - KK - NP

QFIT = SUM / DOF

SG = -2.7726 / ALPHA + ASLP * 0.5 * FLOAT(NDPTS)

ALFA=-2.7726/SG

FWHM = SQRT (SG)

BTAIL = EXP2 / GAIN

CA=0.4*ALFA

AR = 0.0

XX=.25

CT=.5

DO 13 I=1,NDPTS

XSQ=XX*XX*CA

DELA=EXP(-EXP2*XX+XSQ*CT)

AR=AR+DELA*CT

XX=I

CT=1.

IF(DELA*200.-AR) 14,13,13

CONTINUE


```

14   TAIL=EXP1*(1./EXP2-AR)
      FWHM = FWHM * GAIN
      WRITE(6,9010)(DTE(J),J=1,24),ID,ELTIME,DET,RTIME,
1GEOM,JMON,JDAY,IYEAR,AKEV,TYPE,TITLE
9010  FORMAT(1X,' PROGRAM GRPNL2  VERSION 1A',10X,24A1,//
1'SAMPLE ID',1X,16A1,2X,'LIVE TIME',7X,F8.1,1X,'SECONDS',/
2'DETECTOR',2X,16A1,2X,'ELAPSED TIME',4X,F8.1,1X,'SECONDS',/
3'GEOMETRY',2X,16A1,2X,'START
DAY',4X,2(I2,'-'),I4,1X,'MO-DA-YR',/
4'KEV/CHANNEL',2X,F7.4,8X,'SAMPLE TYPE',2X,16A1,/
5'COMMENTS:',1X,64A1,/)
      WRITE(6,9020)IST,IEND,NUMSJ,NUMEJ,JZERO,ALPJ,TAMP,TSLP,BKGSFP
9020  FORMAT(/
1' GROUP STARTS AT CHANNEL      ',I5/
1' GROUP ENDS AT CHANNEL        ',I5/
1' BACKGROUND LOW ENERGY      ',I5/
1' BACKGROUND HIGH ENERGY     ',I5/
1' ZERO-CHANNEL ENERGY'6X,I5//
1' PARAMETER TABLE      FREE'//
1' FWHM                    ',6X,A4/
1' TAIL AMPLITUDE'6X,A4/
1' TAIL SLOPE              '6X,A4//
1' REGION BACKGROUND SLOPE  'F8.4/)
      WRITE (6,9030)
9030  FORMAT(/
1' PEAK      ENERGY  WIDTH  UNCERTAIN  FIXED  UNCERTAIN  RATIOED
1'          RATIO'//
1' NUMBER    KEV      EV    ENERGY    TO      INTENSITY  TO'//)
      DO 500 I=1,NENUM
      GAMA(I)=GAMA(I)*GAINJ/.001
      IF(GAMA(I).EQ.0.) GAMA(I)= BL
      NX=BL
      IF(NXFLG(I).LT.0)NX= - NXFLG(I)
      ANY=Y
      NYY=BL
      IF(NYFLG(I).LT.0) ANY=AND
      IF(NYFLG(I).LT.0) NYY=-NYFLG(I)
      IF(HIGHT(I).EQ.0)HIGHT(I)=BL
      WRITE(6,9040) I,ENJ(I),GAMA(I),STRJ(I),NX,ANY,NYY,HIGHT(I)
9040  FORMAT(I6,F9.3,F7.2,5X,A4,3X,I4,9X,A4,3X,I4,9X,F8.5)
500   CONTINUE
      WRITE(6,9050) QFIT,FWHM,GAIN,EXP1,BTAIL
9050  FORMAT(/// ANALYSIS RESULTS',//
1' QFIT',F6.1,' FWHM',F8.5,' KEV/CHANNEL',F8.5,
1' ATAIL',F9.5,' BTAIL',F10.5,/)
C     READ (1,110)MN
C110  FORMAT ('DO YOU WANT PHOTON EMISSION RATES CALCULATED? ',A2)
C     IF (MN - 1632) 29,20,29
C20   READ (1,111) DFILE
C111  FORMAT ('FILE NAME FOR DETECTOR CONSTANTS IS ',A6)
C     WRITE (3,111) DFILE
C     CALL IOPEN ('SYS',DFILE)
C     READ (4,112) DUM
C     READ (4,112) (DCNST(I), I = 1,15)
C112  FORMAT (A6)

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GRPNL2 Listings...

```

C      READ (1,113) GEOM
C113   FORMAT ('SAMPLE DISTANCE FROM DETECTOR =',F6.2)
C      WRITE (3,113) GEOM
C      GEOM = GEOM + DCNST(15)
C      READ (1,114) SURFC
C114   FORMAT ('SAMPLE AREA =',F6.2)
C      WRITE (3,114) SURFC
C      IF (SURFC) 21,22,21
C21    READ (1,115) SMPWT
C      WRITE (3,115) SMPWT
C115   FORMAT ('SAMPLE WEIGHT =',F8.3)
C22    DEPTH = .00001
C      N1 = 0
C      IF (SMPWT) 24,25,24
C24    READ (1,116) DEPTH
C      WRITE (3,116) DEPTH
C116   FORMAT ('SAMPLE DEPTH =',F6.3)
C      WRITE (1,117)
C      WRITE (3,117)
C117   FORMAT ('SPECIFY SAMPLE COMPOSITION (TERMINATE WITH 0 AMOUNT)'
C      1 /'ELEMENT AMOUNT(%)')
C      K = 0
C26    K = K + 1
C      READ (1,118) MTLZ(K),CMPOS(K)
C      WRITE (3,118) MTLZ(K),CMPOS(K)
C118   FORMAT (' ',A2,F10.2)
C      CMPOS(K) = 0.005 * CMPOS(K) * SMPWT / SURFC
C      IF (CMPOS(K)) 26,27,26
C27    N1 = K - 1
C25    WRITE (1,119)
C      WRITE (3,119)
C119   FORMAT (' SPECIFY ABSORBERS USED',/'ELEMENT AMOUNT (G/SQ-CM)')
C      K = 0
C28    K = K + 1
C      READ (1,118) NABS(K),ABS1(K)
C      WRITE (3,118) NABS(K),ABS1(K)
C      IF (ABS1(K)) 28,29,28
C29    N2 = K - 1
C      IF (N1 + N2) 37,38,37
C37    CALL SEEK( 1,FABS)
C      READ(2) NSMBL,EDGE,COFMU
38     L = KK
        WRITE (6,121)
121    FORMAT (/3X,' CHANNEL      ENERGY  COUNTS  GAMMAS/MIN  PCTERR')
        DO 555 J = 1,NP
          SG=-2.7726/ALPHA+ASLP*PKPOS(J)
          ALFA=-2.7726/SG
          CTS=PKHT(J)*(1.7724*SQRT(-1/ALFA)+TAIL)
555    CTS2=CTS2+CTS
          FOM=SUM2*100./CTS2
          DO 122 J = 1,NP
            SG=-2.7726/ALPHA+ASLP*PKPOS(J)
            ALFA=-2.7726/SG
            FRACT1=0.
            FRACT2=0.

```

```

      GAMA(J)=GAMA(J)*.001/GAIN
      IF(GAMA(J))28,28,30
30     FRAC1=ATAN(2.*PKPOS(J)/GAMA(J))
      FRACT1=1.-.6366*FRAC1
      DELT=NDPTS-PKPOS(J)
      FRAC2=ATAN(2.*DELT/GAMA(J))
      FRACT2=1.-.6366*FRAC2
28     CTS=YSUM(J)+YSUM(J)*(FRACT1+FRACT2)
      ERR=0.0
      IF(NYFLG(J)) 36,36,31
31     L = L + 1
      IF(QFIT.LT.1.0) QFIT=1.0
      IF(FOM.LT.2.6) QFIT=1.0
      ERR = (100.*DM(L) *SQRT (QFIT ))/ PKHT(J)
36     CHAN = PKPOS(J) + START
      EPK = REFEN + (CHAN - REFCH) * GAIN
      GAMAS = 0.0
C      IF (MN - 1632) 40,30,40
C30     ELOG = ALOG (.001 * EPK)
C      SMU = 0.0
C      IF (N1) 33,33,32
C32     CALL CALMU (N1,SMU,EPK,ELOG,MTLZ,CMPOS,NSMBL,EDGE,COFMU)
C33     CALL GPM (EPK,ELOG,GEOM,SURFC,DEPTH,SMU,CTS,GAMAS,DCNST)
      TIME=ELTIME/60.
      GAMAS = GAMAS / TIME
C      IF (N2) 34,40,34
C34     ATN = 0.0
C      CALL CALMU (N2,AMU,EPK,ELOG,NABS,ABS1,NSMBL,EDGE,COFMU)
C      IF (AMU - 6.9) 35,39,39
C35     ATN = EXP (AMU)
C39     GAMAS = GAMAS * ATN
40     WRITE (6,102) J,CHAN,EPK,CTS,GAMAS,ERR
102     FORMAT (1X,I2,F9.3,F10.3,F9.0,E11.4,F6.1)
      MRX=MRX+1
      RENG(MRX)=EPK
      RCTS(MRX)=CTS
      RER(MRX)=ERR
      IF (NXFLG(J)) 122,122,9
9      L = L + 1
122     CONTINUE
      WRITE(6,123) FOM
123     FORMAT(/,1X,'FOM(%) = ',F10.2,/)
      IF(LISTFG.EQ.0) GO TO 9005
      WRITE(6,9001)
9001     FORMAT(1H1)
      RETURN
9005     WRITE(6,9100)
9100     FORMAT(' CHANNEL   ENERGY   INDEX   YNET   RESIDUALS   STD DEV')
      DO 103 I=1,NDPTS
      YP=0.
      DBG=BG(2)-BG(1)
      CALL AVE(1,NDPTS,TAREA,AV,YNET)
      IICH=I+START
      EENG=(FLOAT(IICH) - REFCH)*GAIN+REFEN
      YP=YP+YNET(I)

```

GRFNL2 Listings...

```
YNET(I)=YNET(I) + BG(1) + DBG * YP/TAREA  
WRITE(6,9110) IICH,EENG,I,YNET(I),RES(I),RM(I)  
9110  FORMAT(I5,F11.2,I5,3F10.2)  
103   CONTINUE  
      WRITE(6,9001)  
      RETURN  
      END
```

ISOAUT Listing

```

C PROGRAM ISOAUT
C PERFORMS PU ISOTOPIC RATIO CALCULATIONS
C DATA IS READ FROM DISK FILE
C PROGRAM WRITTEN BY J. G. FLEISSNER, MOUND LABRATORY.
  INTEGER PKS(19)
  DIMENSION A(19),DA(19),BR2(19),R(15),EF(19),DR(15),DBR2(19),DE(19)
  DIMENSION IY(14),FPEAK(3),CF(15),IDATA(1009)
  LOGICAL*1 DEFBUF(24),FILE(14)
  REAL*8 AA,B,C,D,FRAT
  COMMON /REST/RENG(100),RCTS(100),RER(100),REFF(100),REFER(100),
  ID6,ED6,D7,ED7,MRX
  EQUIVALENCE (FILE(1),DEFBUF(8))
  EQUIVALENCE (IDATA(1),RENG(1))
  DATA DEFBUF /'0','D','E','F',' ',' ','1',' ',' ',' ',
  1' ' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',
  2' ' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',' ',
  DATA IY/3,7,9,12,15,18,19,20,27,28,49,52,36,38/
  DATA PKS / 125,129,144,148,153,160,161,165,203,208,335,345,369,
  1375,642,646,662,717,722/
  DATA BR2 / 1079.1,324992.,625.5,1.4125,902.3,736.5,27656.,1.197,
  1251.98,81026.,1580.,0.558,19948.0,51.11,211.9,20285.,
  27.136E-6,130218.,1.116E-6/
  DATA DBR2 / 2.89,2.51,4.71,4.89,3.43,2.42,2.81,2.81,2.50,4.39,6.3,
  18.5,8.42,17.6,0.0,0.0,0.0,0.0,0.0/
  DATA CF /1.03,.981,1.014,1.010,.996,.998,1.019,1.003,1.0,
  10.974,1.033,1.024,1.018,1.,1./
C
  SET UP LU'S 56,DEFINE LU1 BASED ON OPTIONAL INPUT
  CALL MCLI('DEF 5,TTY:6,LP0')
  WRITE(7,12)
12  FORMAT(' ENTER RESULT FILE,ELEMENT NAME')
  READ(5,14)I,FILE
14  FORMAT(Q,14A1)
  IF(I.LE. 1) GOTO 16
  CALL MCLI(DEFBUF)
C
  CHECK LU1
16  CALL QANDC(1,IERR,ID,ID,ID,ID,ID,ID,ID)
  IF (IERR.EQ.0) GOTO 17
  WRITE (7,9917) FILE
9917 FORMAT(' FILE',14A1,' COULD NOT BE OPENED')
  STOP
17  CONTINUE
  READ(1) IDATA
  ENDFILE 1
C
  DO 18 K=1,MRX
C
  WRITE(6,20) RENGL(K),RCTS(K),RER(K),REFF(K),REFER(K)
C 20  FORMAT(1X,5(E11.5,4X))
C 18  CONTINUE
C
  PRINT 100
C
  100 FORMAT (' ENTER SAMPLE ID: ',*)

```

```

C      ACCEPT 200,AA,B,C,D
C 200  FORMAT (4A5)
      DO 50 MM=15,19
      A(MM)=1.0
      DA(MM)=1.0
      EF(MM)=1.0
      50  CONTINUE
      DO 4550 I=1,19
4550   DE(I)=1.0
      MS=14
      DO 300 IZ=1,MS
      IYY=IY(IZ)
      A(IZ)=RCTS(IYY)
      DA(IZ)=RER(IYY)
      EF(IZ)=REFF(IYY)
      DE(IZ)=REFER(IYY)
      300  CONTINUE
      A(1)=(RCTS(2)+RCTS(3))- .01136*A(2)*REFF(2)/REFF(4)
C      PRINT 4000
C 4000  FORMAT (' DO YOU WISH TO INCLUDE ERRORS IN EFFICIENCY?'
C        1,' (1=YES,2=NO) ',#)
C      ACCEPT 500,NERFLG
C      IF ( NERFLG .EQ. 1 .OR. NERFLG .EQ. 2 ) GO TO 4050
C      PRINT 600
C      GO TO 150
C 4050  CONTINUE
      550  PRINT 1500
1500   FORMAT(1X,'DATA SUMMARY:',//
      1' INDEX ENERGY',7X,'AREA',13X,'ERROR',10X,'EFFIC',5X,
      1'EFF ERROR')
      DO 950 I=1,MS
      PRINT 1600,I,PKS(I),A(I),DA(I),EF(I),DE(I)
1600   FORMAT (3X,I2,5X,I3,4(5X,F10.2))
      950  CONTINUE
      DO 1450 I=1,MS
      DA(I)=DA(I)*0.01
1450   CONTINUE
      DO 2250 I=1,19
      DE(I)=DE(I)*0.01
      DBR2(I)=DBR2(I)*0.001
2250   CONTINUE
1750   DO 1850 LM=1,MS
1850   A(LM)=A(LM)/EF(LM)
      AM1=1.534*A(1)/A(2)
C      AM2=0.04093*A(13)/A(12)
      COR=AM1
      PPM241=5991.*EXP(D7)
      PPMAM=17998.*EXP(D6)
C      IF ( NTST .EQ. 1 ) COR=AM2
C      PRINT 2500,AA,B,C,D
C 2500  FORMAT (' SAMPLE ID: ',4A5///)
      DO 550 I=1,15
      R(I)=0.0
      550  CONTINUE
      IF(A(3).GT.0.0) R(1)=BR2(1)*A(5)/A(3)

```

```

IF(A(12).GT.0.0) R(2)=BR2(2)*A(11)/A(12)
IF(A(7).GT.0.0) R(3)=BR2(10)*A(6)/A(7)
IF(A(9).GT.0.0) R(4)=BR2(3)*(A(10)/A(9)-BR2(4)*COR)
IF(A(3).GT.0.0) R(5)=BR2(5)*A(4)/A(3)
ZET=(A(8)-COR*BR2(12)*A(7))
IF(A(7).GT.0.0) R(6)=BR2(11)*ZET/A(7)
IF(A(2).GT.0.0) R(7)=BR2(13)*A(4)/A(2)
IF(A(12).GT.0.0) R(8)=BR2(6)*A(13)/A(12)
IF(A(2).GT.0.0) R(9)=BR2(7)*(A(1)/A(2))
IF(A(14).GT.0.0) R(10)=BR2(9)*A(15)/A(14)
IF(A(4).GT.0.0) R(11)=BR2(8)*A(5)/A(4)
IF(A(8).GT.0.0) R(12)=BR2(14)*A(6)/ZET
IF(A(4).GT.0.0) R(13)=BR2(15)*A(6)/A(4)
IF(A(12).GT.0.0) R(14)=BR2(16)*(A(11)/A(12)-PFM241*BR2(17))
IF(A(14).GT.0.0) R(15)=BR2(18)*(A(13)/A(14)-PFM241*BR2(19))
DO 600 I=1,15
R(I)=R(I)*CF(I)
600 CONTINUE
DR(1)=SQRT(DBR2(1)**2+DA(5)**2+DA(3)**2)
DR(2)=SQRT(DBR2(2)**2+DA(11)**2+DA(12)**2)
DR(3)=SQRT(DBR2(10)**2+DA(7)**2+DA(6)**2)
DR(4)=SQRT(DBR2(3)**2+DA(10)**2+DA(9)**2)
DR(5)=SQRT(DBR2(5)**2+DA(4)**2+DA(3)**2)
DR(6)=SQRT(DBR2(11)**2+DA(8)**2+DA(7)**2)
DR(7)=SQRT(DBR2(13)**2+DA(4)**2+DA(2)**2)
DR(8)=SQRT(DBR2(6)**2+DA(13)**2+DA(12)**2)
DR(9)=SQRT(DBR2(7)**2+DA(1)**2+DA(2)**2)
DR(10)=SQRT(DBR2(9)**2+DA(15)**2+DA(14)**2)
DR(11)=SQRT(DBR2(8)**2+DA(5)**2+DA(4)**2)
DR(12)=SQRT(DBR2(14)**2+DA(6)**2+DA(8)**2)
DR(13)=SQRT(DBR2(15)**2+DA(6)**2+DA(4)**2)
DR(14)=SQRT(DBR2(16)**2+DA(11)**2+DA(12)**2)
DR(15)=SQRT(DBR2(17)**2+DA(13)**2+DA(14)**2)
C IF (NERFLG.EQ.0) GO TO 4450
DR(1)=SQRT(DR(1)**2+DE(5)**2+DE(3)**2)
DR(2)=SQRT(DR(2)**2+DE(11)**2+DE(12)**2)
DR(3)=SQRT(DR(3)**2+DE(7)**2+DE(6)**2)
DR(4)=SQRT(DR(4)**2+DE(10)**2+DE(9)**2)
DR(5)=SQRT(DR(5)**2+DE(4)**2+DE(3)**2)
DR(6)=SQRT(DR(6)**2+DE(8)**2+DE(7)**2)
DR(7)=SQRT(DR(7)**2+DE(4)**2+DE(2)**2)
DR(8)=SQRT(DR(8)**2+DE(13)**2+DE(12)**2)
DR(9)=SQRT(DR(9)**2+DE(1)**2+DE(2)**2)
DR(10)=SQRT(DR(10)**2+DE(15)**2+DE(14)**2)
DR(11)=SQRT(DR(11)**2+DE(5)**2+DE(4)**2)
DR(12)=SQRT(DR(12)**2+DE(6)**2+DE(8)**2)
DR(13)=SQRT(DR(13)**2+DE(6)**2+DE(4)**2)
DR(14)=SQRT(DR(14)**2+DE(11)**2+DE(12)**2)
DR(15)=SQRT(DR(15)**2+DE(13)**2+DE(14)**2)
C 4450 CONTINUE
DO 1950 LL=1,15
1950 DR(LL)=DR(LL)*100.0
WRITE(6,5030)
5030 FORMAT(////,1X,'ISOTOPIC RATIOS FROM PEAK PAIRS (XXX/YYY):',/,/)
PRINT 2600,R(1),DR(1),CF(1)

```

```

2600  FORMAT (' 238PU/239PU= ',F10.2,' PPM +/- ',F6.2,
1'Z (153/144) BIAS COR. = ',F5.3)
PRINT 2700,R(3),DR(3),CF(3)
2700  FORMAT (' 240PU/239PU= ',F10.2,' PPM +/- ',F6.2,
1'Z (160/161) BIAS COR. = ',F5.3)
C    IF ( ICH .EQ. 2 ) GO TO 2050
C    PRINT 2800,R(2),DR(2),PKS(11),PKS(12)
2800  FORMAT (15X,F10.2,' PPM +/- ',F6.2,'Z (' ,
1I3,'/',I3,' ) BIAS COR. = ',F5.3)
2050  PRINT 2900,R(4),DR(4),CF(4)
2900  FORMAT (' 241PU/239PU= ',F10.2,' PPM +/- ',F6.2,
1'Z (208/203) BIAS COR. = ',F5.3)
PRINT 2800,R(5),DR(5),PKS(4),PKS(3),CF(5)
PRINT 2800,R(6),DR(6),PKS(8),PKS(7),CF(6)
PRINT 2800,R(7),DR(7),PKS(4),PKS(2),CF(7)
PRINT 3000,R(9),DR(9),CF(9) .
3000  FORMAT (' 241AM/239PU= ',F10.2,' PPM +/- ',F6.2,
1'Z (125/129) BIAS COR. = ',F5.3)
PRINT 2800,R(14),DR(14),PKS(11),PKS(12),CF(14)
PRINT 2800,R(15),DR(15),PKS(13),PKS(14),CF(15)
C    IF ( ICH .EQ. 2 ) GO TO 2150
C    PRINT 2800,R(8),DR(8),PKS(13),PKS(12)
C    PRINT 2800,R(10),DR(10),PKS(15),PKS(14)
2150  PRINT 3100 .
3100  FORMAT (////' XXXPU/241PU RATIOS: '///)
PRINT 3200,R(11),DR(11),CF(11)
3200  FORMAT (' 238PU/241PU= ',F7.4,' +/- ',F6.2,
1'Z (153/148) BIAS COR. = ',F5.3)
PRINT 3300,R(12),DR(12),CF(12)
3300  FORMAT (' 240PU/241PU= ',F7.4,' +/- ',F6.2,
1'Z (160/165) BIAS COR. = ',F5.3)
PRINT 3400,R(13),DR(13),CF(13)
3400  FORMAT (15X,F7.4,' +/- ',F6.2,
1'Z (160/148) BIAS COR. = ',F5.3)
WRITE(6,5000)
5000  FORMAT(///,1X,' ISOTOPIC RATIOS FROM NORMALIZATION CONSTANTS:')
WRITE(6,5010) PPM241,ED7*100.
5010  FORMAT(//,1X,' 241PU/239PU=',F10.2,' PPM +/- ',F6.2,'Z')
WRITE(6,5020) PPMAM,ED6*100.
5020  FORMAT(1X,' 241AM/239PU=',F10.2,' PPM +/- ',F6.2,'Z')
WRITE(6,99)
99    FORMAT('1')
STOP 'ISOAUT FINISHED'
END

```


PKANAL Listing

```

C ROUTINE GETDAT
C GET DATA FOR PKANAL FROM PDP-11 FILE
C LINK 1 OF PKANAL
  LOGICAL*1 ANS,C,S
  DATA C/'C'//,S/'S'//
100  TYPE 9010
9010  FORMAT(' PROGRAM PKANAL'//
  1' OPTION  FUNCTION'//
  1'  0    SIMPLE INTEGRATION'//
  1'  1    POSITION AND HEIGHT PARAMETER FREE'//
  1'  2    1+ FWHM FREE'//
  1'  3    1,2+ SHORT TERM TAILING AMPLITUDE FREE'//
  1'  4    1,2,3+ SHORT TERM TAILING SLOPE FREE'//)
  CALL DANDC(12,IERR,ID,ID,ID,ID,ID,ID,ID)
  IF(IERR,EQ.0) GO TO 110
  WRITE(7,105)
105  FORMAT(1X,'SPECTRUM FILE OPEN ERROR')
  STOP
110  CALL RIDENT
  CALL PKANAL
150  WRITE(7,200)
200  FORMAT(1X,'STOP (S) OR CONTINUE (C) ? ',%)
  READ (5,250) ANS
250  FORMAT(A1)
  IF(ANS,EQ.C) GO TO 100
  IF(ANS,NE.S) GO TO 150
  STOP
  END

```

PKANAL Listing...

```

SUBROUTINE PKANAL
C   PKANAL (MAXVAL,CHFIT,NCTS,AVE)
C   THIS IS GENERAL PURPOSE PROGRAM FOR FITTING A SINGLE PEAK.
C   ALL INITIAL PARAMETERS ARE FROM THE TELETYPE.
C   OPTIONS:
C   0 = SIMPLE INTEGRATION. IE. NO FITTING.
C   1 = POSITION AND HEIGHT PARAMETERS FREE.
C   2 = WIDTH PARAMETER ALSO FREE.
C   3 = TAILING AMPLITUDE PARAMETER ALSO FREE.
C   4 = TAILING SLOPE PARAMETER ALSO FREE.
C   MODIFIED TO RUN ON A PDP-11
C   JE FAGER 3/28/77
C   MODIFIED FOR 200 CHANNELS, LONG TERM TAILING, CONVERGENCE
C   CRITERIA, AND DAMPING CONDITIONS ON PEAK PARAMETERS
C   BY J.G.FLEISSNER, MOUND FACILITY 8/14/78
C   LOGICAL*1 DTE(24),DET(16)
C   DIMENSION NWRDS(6),NFLG(10),NXFLG(10),NYFLG(10),AWRDS(3),
1  Y(200),PKPOS(2),PKHT(2)
C   LOGICAL*1 SPECHD(512)
C   COMMON/SIDENT/SPECHD
C   COMMON/HEP2/NS1,NE1,NDPTS,NWRDS,IFLG,NFLG,NXFLG,NYFLG,AVEBG,
1  PCTERR,START,GAIN,TIME,AWRDS,ALPHA,ATAIL,BTAIL,EXP3,EXP4,Y,
1  PKPOS,PKHT
C   GEOMETRY CODE (6600 GEOMETRY)
C   LOGICAL*1 GEOM(16)
C   EQUIVALENCE(GEOM(1),SPECHD(445))
C   DETECTOR NUMBER (6600 CONFIGURATION)
C   EQUIVALENCE(DET(1),SPECHD(477))
C   ANALYSIS NUMBER (6600 ID)
C   LOGICAL*1 ID(16)
C   EQUIVALENCE(ID(1),SPECHD(397))
C   ACQUISITION DATE (6600 DATE)
C   EQUIVALENCE(IDAY,SPECHD(81)),(IYEAR,SPECHD(83))
C   ELAPSED TIME
C   EQUIVALENCE(ELTIME,SPECHD(49))
C   COMMENT (6600 TITLE)
C   LOGICAL*1 TITLE(64)
C   EQUIVALENCE(TITLE(1),SPECHD(333))
C   TRANSLATE ELAPSED TIME
C   CALL SFLOAT(ELTIME,ELTIME)
C   TRANSLATE DAY OF YEAR TO DAY-MON
C   CALL DAYMON(IDAY,IYEAR,JDAY,JMON)
C   CALL ATIME(DTE)
C   TYPE 9050
9050  FORMAT(' +TYPE PEAK START AND END CHANNEL      ',%)
C   ACCEPT 9060,IST,IEN
9060  FORMAT(2I5)
C   ST=IST
C   EN=IEN
C   TYPE 9070
9070  FORMAT(' +TYPE LOW AND HIGH ENERGY BKG CHANNELS    ',%)
C   ACCEPT 9060,NUMS,NUME
C   TYPE 9080
9080  FORMAT(' +TYPE OPTION NUMBER      ',%)
C   ACCEPT 9090,IFLG

```

PKANAL Listing...

```

9090  FORMAT(I1)
      IF(IFLG.EQ.0) GO TO 11
      TYPE 9100
9100  FORMAT(' +TYPE GAIN AND FWHM IN KEV      ', $)
      ACCEPT 9110, GAIN, FWHM
9110  FORMAT(F10.0, F10.0)
      TYPE 9120
9120  FORMAT(' +TYPE  ATAIL-BTAIL (SHORT TERM)  ', $)
      ACCEPT 9110, ATAIL, BTAIL
      TYPE 9130
9130  FORMAT(' +TYPE  ATAIL-BTAIL (LONG TERM)   ', $)
      ACCEPT 9110, EXP3, EXP4
      WRITE(6, 9200) (DTE(I), I=1, 11), ID, GEOM, DET,
      1JDAY, JMON, IYEAR, ELTIME, TITLE
      WRITE(6, 9201) IST, IEN, NUMS, NUME, IFLG, GAIN, FWHM, ATAIL, BTAIL,
      1EXP3, EXP4
9200  FORMAT(' 1PROGRAM PKANAL', 20X, 11A1, '///
1' ANALYSIS', 16A1, '/',
1' GEOMETRY', 16A1, '/',
1' DETECTOR', 16A1, '/',
1' DATE      ', I2, ':', I2, ':', I4, '/',
1' TIME      ', F8.0, '/',
118X, 64A1)
9201  FORMAT(' PEAK STARTS AT CHANNEL ', I4/
1' PEAK ENDS AT CHANNEL      ', I4/
1' BACKGROUND LOW ENERGY   ', I4/
1' BACKGROUND HIGH ENERGY  ', I4/
1' OPTION NUMBER            ', I4/
1' GAIN (KEV/CHANNEL)       ', F11.4/
1' FWHM (KEV)               ', F11.4/
1' A-TAIL                   ', F11.4/
1' B-TAIL                   ', F11.4/
1' EXP3                     ', F11.4/
1' EXP4                     ', F11.4//)
2     IF (FWHM) 6, 4, 6
4     FWHM = 0.6
6     ALPHA = -2.7707 * GAIN * GAIN / (FWHM * FWHM)
      IF (BTAIL) 10, 8, 10
8     BTAIL = 3.
10    BTAIL = BTAIL * GAIN
11    IF (NUMS) 15, 14, 15
14    NUMS = 5
15    IF (NUME) 17, 16, 17
16    NUME = 5
17    XNUMS = NUMS
      NWRDS(2) = 0
      ST1 = ST - XNUMS + 1.
      START = ST1 - 1.
      NS1 = ST - START
      NE1 = EN - START
      NDPTS = NE1 + NUME
      IST1 = ST1
      CALL READCH(IST1, 200)
      IY = IST1
      CALL NCNTS (1, NS1, NE1, NDPTS, NDPTS, BGD, YSUM, ER, AVEBG, Y, Y)

```

PKANAL Listing...

```

CALL MAXVAL (1,NDPTS,JPK,BIGST,Y)
CALL CHFIT (JPK,REFPK,Y)
PKPOS(1) = REFPK
PKHT(1) = BIGST
START = START + XNUMS
PCTERR = 100.*ER / YSUM
NFLG(1) = 0
NFLG(2) = 0
NFLG(3) = 0
IF (IFLG - 1) 24,29,25
24  CONTINUE
    TIME=ELTIME/60.
    CPM = YSUM / TIME
    WRITE (6,111) REFPK,YSUM,TIME,CPM,PCTERR
111  FORMAT (' PEAK POSITION = ',F8.3,'/' AREA = ',F10.1,' COUNTS ',
1     'COUNT TIME =',F6.1,' MIN'/' CPM =',F8.2,' +/-',F5.2,' %',//,5X,
2     'NET COUNTS')
    WRITE (6,112) (Y(I), I = 1,NDPTS)
112  FORMAT (10F8.0)
    RETURN
25  IF (IFLG - 3) 28,27,26
26  NFLG(3) = 1
27  NFLG(2) = 1
28  NFLG(1) = 1
29  NYFLG(1) = 1
    NXFLG(1) = 1
    NFLG(4) = 1
    NFLG(7) = 1
    CALL FIT
    RETURN
END

```

```

      SUBROUTINE FIT
C      FIT (MLR,MLRS)
C      THIS SUBPROGRAM IS THE SECOND LINK TO THE PROGRAM "PKANAL".
C      IT PERFORMS A TAYLOR'S EXPANSION ABOUT THE TRIAL VALUES TO
C      OBTAIN A SET OF LINEAR EQUATIONS.
      DIMENSION NWRDS(6),MWRDS(3),NXFLG(10),NYFLG(10),
1  YNET(200),PKPOS(2),PKHT(2),DELY(200),DEL(5),RM(200),
2  ACOEF(200,5),WM(5),VM(5),BCOEF(200,5)
      COMMON/HEP2/ NS1,NE1,NDPTS,KK,NWRDS,NFLG1,NFLG2,NFLG3,ITER,KL,
1  NERR,NP,MWRDS,NXFLG,NYFLG,AVEBG,PCTERR,START,GAIN,TIME,ALFA,
1EXP1,EXP2,ALPHA,ATAIL,
2  BTAIL,EXP3,EXP4,YNET,PKPOS,PKHT,DELY,DEL,RM,ACOE,WM,VM
776  QFIT=0.0
      ITER=0
      ALFA = ALPHA
      EXP1 = ATAIL
      EXP2 = BTAIL
      EXP4=EXP4*GAIN
      KK = NFLG1 + NFLG2 + NFLG3
      WRITE(6,800)
800  FORMAT(3X,'PKPOS',7X,'PKHT',8X,'ALPHA',7X,'ATAIL',
17X,'EXP2',8X,'QFIT',/)
2  DO 30 I = 1,NDPTS
      XI = I
      DY = YNET(I)
      DALFA = 0.0
      DBETA = 0.0
      DGAMA = 0.0
      WT = 1.0 / SQRT (ABS(YNET(I)) + AVEBG)
      K = KK
      DO 20 J = 1,NP
      DLTAX = XI - PKPOS(J)
      DLXSQ = DLTAX * DLTAX
      EXPN1 = 0.0
      PHT = PKHT(J)
      EXPNT = ALFA * DLXSQ
      IF (EXPNT + 14.) 4,3,3
3  EXPN1 = EXP (EXPNT)
      DY = DY - EXPN1 * PHT
4  IF (NFLG1) 6,6,5
5  DALFA = DALFA + PHT * DLXSQ * EXPN1
6  IF (DLTAX) 7,14,14
7  EXPN = EXP2 * DLTAX
      IF(EXP3) 72,72,71
71  DY=DY-PHT*EXP3*(EXP(EXP4*DLTAX))*(1.-EXP(0.4*EXPNT))
72  IF (EXPN + 10.) 14,8,8
8  EXPN2 = EXP (EXPN)
      EXPN3 = 0.0
      IF (EXPN1) 12,13,12
12  EXPN3 = EXP (0.4 * EXPNT)
13  CA = EXP1
      CB = EXPN2 * (1. - EXPN3)
      CY = CA * PHT
      DY = DY - CY * CB
      IF (NFLG2) 10,10,9

```

PKANAL Listing...

```

9      DBETA = DBETA + CB * PHT
10     IF (NFLG3) 14,14,11
11     DGAMA = DGAMA + DLTAX * CY * CB
14     IF (NYFLG(J)) 16,16,15
15     K = K + 1
      ACOEF(I,K) = EXPN1 * WT
16     IF (NXFLG(J)) 20,20,17
17     K = K + 1
      ACOEF(I,K) = -2. *ALFA *PHT* DLTAX *EXPN1 *WT
20     CONTINUE
      L = 0
      IF (NFLG1) 22,22,21
21     L = L + 1
      ACOEF(I,L) = DALFA * WT
22     IF (NFLG2) 24,24,23
23     L = L + 1
      ACOEF(I,L) = DBETA * WT
24     IF (NFLG3) 26,26,25
25     L = L + 1
      ACOEF(I,L) = DGAMA * WT
26     DELY(I) = DY * WT
30     CONTINUE
      KL = K
      DO 34 I = 1,NDPTS
      DO 32 J = 1,KL
32     BCOEF(I,J) = ACOEF(I,J)
34     CONTINUE
      WRITE(6,9010) PKPOS(1),PKHT(1),ALFA,EXP1,EXP2,QFIT
9010   FORMAT(6(1PE12.3))
      ENDFILE 6
      NERR = 1
      CALL MLR (BCOEF)
      CALL MLRS (BCOEF)
      GO TO (35,36,37), NERR
36     WRITE (6,101)
101    FORMAT ('MATRIX IS SINGULAR')
      GO TO 38
37     WRITE (6,102)
102    FORMAT ('SUM OF SQUARES OF R > THAN THOSE OF Y')
38     STOP 'END OF JOB'
35     L = 0
      LFLG = 0
      IF (NFLG1) 43,43,41
41     L = L + 1
      DP=DEL(L)/ALFA
      IF(ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
      ALFA=ALFA*(1.+DP)
      IF (ABS (DEL(L)) + .01*ALFA) 43,43,42
42     LFLG = 1
43     IF (NFLG2) 46,46,44
44     L=L+1
      DP=DEL(L)/EXP1
      IF(ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
      EXP1=EXP1*(1.+DP)
      IF (ABS (DEL(L)) - .02 * EXP1) 46,46,45

```

```

45      LFLG = 1
46      IF (NFLG3) 49,49,47
47      L = L + 1
         DP=DEL(L)/EXP2
         IF (ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
         EXP2=EXP2*(1.+DP)
         IF (ABS (DEL(L)) - .05 * EXP2) 49,49,48
48      LFLG = 1
49      K = L
         DO 60 J = 1,NP
         IF (NYFLG(J)) 52,52,50
50      K = K + 1
         DP=DEL(K)/PKHT(J)
         IF (ABS(DP).GT.0.5) DP=SIGN(0.5,DP)
         PKHT(J)=PKHT(J)*(1+DP)
         IF (ABS (DEL(K)) - .002 * PKHT(J)) 52,52,51
51      LFLG = 1
52      IF (NXFLG(J)) 60,60,53
53      K=K+1
         IF (ABS(DEL(K)).GT.0.5) DEL(K)=SIGN(0.5,DEL(K))
         PKPOS(J) = PKPOS(J) + DEL(K)
         IF (ABS (DEL(K)) - .02 * PKPOS(J)) 60,60,54
54      LFLG = 1
60      CONTINUE
         IF (LFLG) 70,797,70
70      ITER = ITER + 1
         DOF=NDPTS-KK-3
         SUM=0.0
         DO 777 II=1,NDPTS
777      SUM=SUM+RM(II)*RM(II)
         QFIT=SUM/DOF
         IF (ITER - 15) 2,2,77
77      WRITE (6,105)
105      FORMAT ('MAXIMUM ITERATIONS EXCEEDED.')
```

797 TYPE 778

778 FORMAT ('OENTER NEW ATAIL, BTAIL (LONG TERM) : (CR TO END) ', \$)

ACCEPT 779,EXP3,EXP4

779 FORMAT(F10.0,F10.0)

IF (EXP3) 79,79,776

79 CALL OUTO

RETURN

END

```
C READ IDENTIFICATION TO SPECTRA FILE
SUBROUTINE RIDENT
LOGICAL*1 SPECHD(512)
COMMON /SIDENT/SPECHD
DEFINE FILE 12(0,256,U,IREF)
CALL RONLY(12)
IREF=1
READ(12,IREF) SPECHD
ENDFILE 12
RETURN
END
```



```
SUBROUTINE DAYMON(IDAY,IYEAR,JDAY,JMON)
DIMENSION NDAT(12)
DATA NDAT/0,31,59,90,120,151,181,212,243,273,304,334/
JMON=0
IL=0
IF(IDAY.LE.59) GO TO 150
TST=IYEAR-(IYEAR/4)*4
IF(TST.LE.0) IL=1
150 DO 200 K=1,12
IC=IDAY-NDAT(13-K)-IL
IF(IC.GT.0) JMON=13-K
IF(JMON.GT.0) GO TO 300
200 CONTINUE
300 JDAY=IDAY-NDAT(JMON)-IL
RETURN
END
```

```

      SUBROUTINE OUTO
C     OUTO
C     THIS SUBPROGRAM IS THE THIRD LINK TO THE PROGRAM "PKANAL".
      DIMENSION NWRDS(35),
1     BWRDS(5),YNET(200),PKPOS(2),PKHT(2),DELY(200),DEL(5),RM(200)
      COMMON/HEP2/NS1,NE1,NDPTS,KK,IJ,NWRDS,AVEBG,PCTERR,START,GAIN,
1     TIME,ALFA,EXP1,EXP2,BWRDS,YNET,PKPOS,
2     PKHT,DELY,DEL,RM
      CA = 0.4 * ALFA
      SUM2=0.
      FOM=0.
      AR = 0.0
      XX = 0.25
      CT = 0.5
      DO 80 I = 1,NDPTS
      XSQ = XX * XX * CA
      DELA = EXP (-EXP2 * XX + XSQ * CT)
      AR = AR + DELA * CT
      XX = I
      CT = 1.0
      IF (DELA * 200. - AR) 81,80,80
80     CONTINUE
81     RALFA = SQRT (-1. / ALFA)
      ARATO = 1.7724 * RALFA + EXP1 *(1./ EXP2 - AR)
      AREA = PKHT(1) * ARATO
      SUM = 0.0
      DO 84 I = 1,NDPTS
      DELY(I) = RM(I) * SQRT (YNET(I) + AVEBG)
      SUM2=SUM2+ABS(DELY(I))
84     SUM = SUM + RM(I) * RM(I)
      DOF = NDPTS - KK - 3
      FOM=100.*SUM2/AREA
      QFIT = SUM / DOF
      RA = 1.6645 * RALFA
      F12M = GAIN * RA
      BTAIL = EXP2 / GAIN
      WRITE (6,106) START,PKPOS(1),PKHT(1),AREA,PCTERR,QFIT,F12M,EXP1,
1     BTAIL,FOM
106    FORMAT (//,5X,'ANALYSIS RESULTS OF PEAK STARTING AT ',F8.0/
1'   PKPOS    PKHT    NETCTS    PCTERR ',
1'   QFIT    FWHM    ATAIL    BTAIL    FOM(%)'
2     / F8.3,F9.0,F11.0,F8.2,F7.2,F8.4,F9.5,F8.4,F8.2 /)
      WRITE(6,9005)
9005   FORMAT(' CHANNEL ENERGY INDEX    YNET ',
1'   RESIDUALS    STD.DEV. '//
111X,'(KEV)')
      DO 200 I=1,NDPTS
      ICH=I+START
      ENG=FLOAT(ICH)*GAIN
      WRITE(6,9010) ICH,ENG,I,YNET(I),DELY(I),RM(I)
9010   FORMAT(I6,F11.4,I5,3F10.2)
200    CONTINUE
      RETURN
      END

```

PKANAL Listing...

```

C      NCTS
C      THIS ROUTINE RETURNS THE NET CHANNEL COUNTS IN A PEAK, THE SUM OF
C      THE NET COUNTS, THE AVERAGE BACKGROUND LEVELS IN FRONT AND IN
C      BACK OF A PEAK GROUPING, AND THE NUMBER OF DATA POINTS IN THE NET
C      COUNT ARRAY.
      SUBROUTINE NCTS (N1,N2,M1,M2,ND,S1,S2,AV1,AV2,Y1,Y2)
      DIMENSION Y1(2),Y2(2)
      NAD=0
      IF(N2) 12,13,13
12     N2=-N2
      NAD=N2
13     CALL AVE (N1,N2,S1,AV1,Y1)
      CALL AVE (M1,M2,S2,AV2,Y1)
      S1 = S1 + S2
      K = N2 + 1
      KK = M1 - 1
      CALL AVE (K,KK,S2,DUM,Y1)
      DBG = AV2 - AV1
      L =NAD
      YS = 0.0
      XS = 0.0
      YSS = 0.0
      ITER = 0
      CHANS = KK - K + 1
      S2 = S2 - AV2 * CHANS
3     IF (DBG) 1,4,4
1     DO 2 I = K,KK
      YS = YS + Y1(I) - AV2
      BG = AV1 + DBG * YS / S2
      IF (ITER) 9,9,7
7     YSS = YSS + Y1(I) - BG
      BG = AV1 + DBG * YSS / S3
9     CNET = Y1(I) - BG
      IF (ITER) 2,2,11
11    L = L + 1
      Y2(L) = CNET
2     XS = XS + CNET
      IF (ITER) 5,5,8
5     S3 = XS
      XS = 0.0
      YS = 0.0
      ITER = 1
      GO TO 1
4     XK = KK - K + 1
      YS = AV1
      DBG = DBG / XK
      DO 6 I = K,KK
      L = L + 1
      YS=YS + DBG
      CNET = Y1(I) - YS
      Y2(L) = CNET
6     XS = XS + CNET
8     S2 = XS
      ND = L
      RETURN

```

PKANAL Listing...

END

```
C      NCNTS
C      THIS ROUTINE IS SIMILAR TO "NCTS" ROUTINE EXCEPT THAT IT RETURNS
C      AN AVERAGE BACKGROUND AND THE ERROR ASSOCIATED WITH THE TOTAL NET
C      COUNT.
      SUBROUTINE NCNTS (N1,N2,M1,M2,ND,S1,S2,ER,AVEBG,Y1,Y2)
      DIMENSION Y1(2),Y2(2)
      CHANS = M1 - N2 + 1
      XPTS = M2 + N2 - M1 - N1 + 1
      CALL NCTS (N1,N2,M1,M2,ND,S1,S2,AV1,AV2,Y1,Y2)
      AVEBG = 0.5 * (AV1 + AV2)
      IF (S2) 1,2,2
1      S2 = 0.0
2      ER = SQRT (S2 + AVEBG * CHANS * (1. + CHANS / XPTS))
      RETURN
      END
```

PKANAL Listing...

```
C      MAXVAL
C      THIS ROUTINE RETURNS THE POSITION AND VALUE OF THE MAXIMUM VALUE
C      IN A GROUP OF DATA POINTS FROM NS TO NE INCLUSIVE.
      SUBROUTINE MAXVAL (NS,NE,JMAX,YMAX,Y)
      DIMENSION Y(2)
      YMAX = 0.0
      DO 2 I = NS,NE
      IF (Y(I) - YMAX) 2,2,4
4      YMAX = Y(I)
      JMAX = I
2      CONTINUE
      RETURN
      END
```

PKANAL Listing...

```
C      CHFIT
C      THIS ROUTINE LOCATES THE CENTROID OF A PEAK BASED ON A 7 POINT
C      PARABOLA FIT.
      SUBROUTINE CHFIT (L,PKPOS,Y)
      DIMENSION Y(2)
      A1 = Y(L-3)
      A2 = Y(L-2)
      A3 = Y(L-1)
      A4 = Y(L)
      A5 = Y(L+1)
      A6 = Y(L+2)
      A7 = Y(L+3)
      PKPOS = L
      PKPOS = PKPOS+(4.5*(A7-A1)+3.*(A6-A2)+1.5*(A5-A3))/
1  (4.*A4 + 3.*(A3+A5) - 5.*(A1 + A7))
      RETURN
      END
```

```
C      AVE
C      THIS ROUTINE DETERMINES THE AVERAGE COUNT OF A GROUP OF DATA
C      VALUES FROM NS TO NE INCLUSIVE.  IT ALSO RETURNS THE SUM.
      SUBROUTINE AVE (NS,NE,SUM,AV,Y)
      DIMENSION Y(2)
      SUM = 0.0
      SM = NE - NS + 1
      DO 2 I = NS,NE
2      SUM = SUM + Y(I)
      AV = SUM / SM
      RETURN
      END
```


PKANAL Listing...

```

C      MLR
C      THIS IS THE FIRST PART OF A LEAST-SQUARES PROGRAM WHICH WAS
C      ADAPTED FROM THE "MLR" PROGRAM WRITTEN BY R. E. VON HOLDT,LLL.
C      THE SEQUEL IS MLRA OR MLRS.
      SUBROUTINE MLR (B)
      DIMENSION NWRDS(6),MWRDS(3),NXFLG(10),NYFLG(10),
1  YNET(200),PKPOS(2),PKHT(2),Y(200),X(5),R(200),
2  ACOEF(200,5),W(5),V(5),B(1000)
      COMMON/HEP2/ NS1,NE1,M,KK,NWRDS,NFLG1,NFLG2,NFLG3,ITER,N,
1  NFLG,NP,MWRDS,NXFLG,NYFLG,AVEBG,PCTERR,START,GAIN,TIME,ALFA,
1EXP1,EXP2,ALPHA,ATAIL,
2  BTAIL,EXP3,EXP4,YNET,PKPOS,PKHT,Y,X,R,ACOEf,W,V
      LB=200
      IB = LB
      DO 70 I = 1,N
      T = 0.
      IK = (I-1) * IB
      DO 20 K = I,M
      LL = IK + K
      T = T + B(LL) * B(LL)
20  CONTINUE
      IF (T) 30,29,30
29  NFLG = 2
      GO TO 75
30  ST = SQRT (T)
      LL = IK + I
      W(I) = ST
      IF (B(LL)) 31,32,32
31  W(I) = -ST
32  B(LL) = B(LL) + W(I)
      V(I) = -B(LL) * W(I)
      IF (I-N) 35,75,35
35  IP = I + 1
      DO 60 J = IP,N
      T = 0.
      JK = (J-1) * IB
      DO 40 K = I,M
      LL = IK + K
      LLL = JK + K
40  T = T + B(LL) * B(LLL)
      T = T / V(I)
      DO 50 L = I,M
      LL = JK + L
      LLL = IK + L
50  B(LL) = B(LL) + T * B(LLL)
60  CONTINUE
70  CONTINUE
75  RETURN
      END

```

```

C      MLRS
C      THIS IS A SEQUEL TO THE MLR PROGRAM.  IT REQUIRES MORE CORE THAN
C      DOES "MLRA" BECAUSE THE "A" MATRIX IS RESIDENT AT ALL TIMES.
C      (ADAPTED FROM THE MLR PROGRAM WRITTEN BY R. H. VON HOLDT,LLL)
      SUBROUTINE MLRS (B)
        DIMENSION NWRDS(6),MWRDS(3),NXFLG(10),NYFLG(10),
1       YNET(200),PKPOS(2),PKHT(2),Y(200),X(5),R(200),
2       A(1000),W(5),V(5),B(1000)
        COMMON/HEP2/ NS1,NE1,M,KK,NWRDS,NFLG1,NFLG2,NFLG3,ITER,N,
1       NFLG,NP,MWRDS,NXFLG,NYFLG,AVEBG,PCTERR,START,GAIN,TIME,ALFA,
1       IEXP1,EXP2,ALPHA,ATAIL,
2       BTAIL,EXP3,EXP4,YNET,PKPOS,PKHT,Y,X,R,A,W,V
        LB=200
        IB = LB
        DO 80 I = 1,M
90       R(I) = Y(I)
        DO 90 I = 1,N
90       X(I) = 0.
        S = 0.
        DO 100 L = 1,M
100      S = S + R(L) * R(L)
        YE = S
105      DO 130 I = 1,N
        T = 0.
        LK = (I-1) * IB
        DO 110 K = 1,M
        LL = LK + K
110      T = T + B(LL) * R(K)
        T = T/V(I)
        DO 120 L = 1,M
        LL = LK + L
120      R(L) = R(L) + T * B(LL)
130      CONTINUE
        IN = N
140      R(IN) = R(IN)/W(IN)
150      J = IN
155      J = J -1
        IF (J) 190,190,160
160      LL = (IN-1) * IB + J
        R(J) = R(J) + R(IN) * B(LL)
        GO TO 155
190      IN = IN - 1
        IF (IN) 200,200,140
200      DO 210 I = 1,N
        SC = X(I)
        SD = R(I)
        XD = SC - SD
210      X(I) = XD
        DO 230 I = 1,M
        RD = Y(I)
        DO 220 J = 1,N
        LL = (J - 1) * IB + I
        AD = A(LL)
        XD = X(J)
        RD = RD - AD * XD

```

PKANAL Listing...

```
220  CONTINUE
      R(I) = RD
230  CONTINUE
      RE = 0.
      DO 240 I = 1,M
240    RE = RE + R(I) * R(I)
      IF (RE - S) 250,270,270
250    S = RE
      GO TO 105
270    IF (RE - YE) 280,290,290
290    NFLG = 3
280  RETURN
      END
```

PKANAL Listing...

C SUBROUTINE READCH J G FLEISSNER 7/21/80

```

C
      SUBROUTINE READCH(IST1,NUMPTS)
C IST1   =FIRST CHANNEL
C NUMPTS =NUMBER OF CHANNELS
C Y      =ARRAY
      DIMENSION NWRDS(6),MWRDS(3),NXFLG(10),NYFLG(10),
1  YNET(200),PKPOS(2),PKHT(2),DELY(200),DEL(5),RM(200)
      LOGICAL*1 SPECHD(512)
      COMMON /SIDENT/ SPECHD
      COMMON/HEP2/ NSI,NE1,NDPTS,KK,NWRDS,NFLG1,NFLG2,NFLG3,ITER,KL,
1  NERR,NP,MWRDS,NXFLG,NYFLG,AVEBG,PCTERR,START,GAIN,TIME,ALFA,
      1EXP1,EXP2,ALPHA,ATAIL,
2  BTAIL,EXP3,EXP4,YNET,PKPOS,PKHT,DELY,DEL,RM
      EQUIVALENCE (ICHAN,SPECHD(37))
      EQUIVALENCE (NBYTES,SPECHD(25))
      DEFINE FILE 12(0,2,U,IREC)
C      CALCULATE NUMBER OF HEADER RECORDS
      NOFSET=(NBYTES/4)
C      READ AND TRANSLATE EACH CHANNEL
      DO 1000 I=1,NUMPTS
      IREC=I+NOFSET+IST1-1
      READ (12,IREC) YNET(I)
      CALL CHOP(YNET(I),YNET(I))
      CALL SFLOAT(YNET(I),YNET(I))
1000  CONTINUE
      ENDFILE 12
      RETURN
      END

```

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