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A Code to Unfold Bremsstrahlung Experimental Distributions

(September 1967)

NASA Contract
No.: NAS 5-10337

Prepared by

J.J. Steyn
Senior Technical Associate

For

Goddard Space Flight Center
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Approved: ______________________

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General Manager-Engineering Division

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SUMMARY

A FORTRAN IV code for the IBM-7094 computer has been developed to analyze multi-channel pulse-height analyzer gamma photon spectral distributions. The distributions for which the code was developed are those encountered in the measurement of the bremsstrahlung radiation field from volume beta sources, which may consist of a limited number of line spectra in association with the bremsstrahlung. The code generates the detector system response matrix function and applies it to the monoenergetic spectral components discretely and to the bremsstrahlung iteratively. It corrects for iodine K X-ray escape, detector non-linearity, system drift, source decay, background, and detection efficiency. The code presents digital results in the form of differential and integrated photon number and energy distributions, and exposure dose. The code optionally outputs spectral data for use as input to a Calcomp plotting program.

1. INTRODUCTION

This report presents a description of and the user requirements for code CUBED II - - - a digital computer Code to Unfold Bremsstrahlung Experimental Distributions developed under NASA-GSFC contract NAS5-10337. Code CUBED-II, written in the FORTRAN IV language for the IBM-7094 digital computer, is a much modified version of code CUBED which was developed under contract NAS5-10133 and previously reported in NUS-315 and -316 [1, 2]. The experimental continuous distributions to be analyzed and for which the code has been specifically developed, are those recorded by the right-cylindrical sodium-iodide (thallium activated) ---- NaI (Tl) ---- scintillation crystal, coupled to a multi-channel pulse-height analyzer and exposed to the bremsstrahlung and line energy photon field generated by right-cylindrical beta emitting isotopic sources.

The code can either read or generate the scintillation detector system response function matrix and apply it to unfold the pulse-height analyzer distributions to determine differential and integrated photon number and energy distributions, and exposure doses. The response maxtrix generation procedure relies on the spectra of standard radioisotopes such as Cd^{109}, Hg^{203}, Sr^{85}, Cs^{137}, Nb^{95}, Mn^{54} and Zn^{65}. The standard spectra are normalized with respect to photopeak pulse-height and area, their Gaussian photopeaks are subtracted and their Compton continua thus determined. The continua of the response matrix vectors are determined for the response matrix energies by quadratically interpolating the normalized continua of the standards and computing the appropriate associated Gaussian photopeaks. The thus interpolated vectors are redistributed in pulse-height to match detector system energy response and to satisfy the requirements of the bremsstrahlung spectra to be unfolded.

Code CUBED-II applies the response function matrix according to two distinct procedures to unfcid either bremsstrahlung spectra, complex spectra consisting of a limited number of photopeaks or spectra consisting of bremsstrahlung-plus-photopeaks. The code computes detector incident photon lines in the unknown spectra by the fitting of a Gaussian function to each photopeak. The photopeak associated Compton continua are determined by an interpolation of the response function continua. The thus determined photopeak-plus-continuum spectra are subtracted to leave, ideally, a continuous or zero residual spectrum. Continuous and residual spectra are iteratively unfolded according to the method of Scofield[2,3], to determine detector incident continuous photon spectra. Total incident spectra are calculated as the sum of line and continuous spectra.

The code corrects for partial photon energy deposition in the NaI(Tl) detector through the application of the response matrix. It corrects for the number of photon interactions in the detector crystal and for absorptions by the crystal cladding materials, interposed absorbers such as Lucite and the air medium between the source and the crystal. In addition, it corrects for primary source decay, iodine K X-ray escape, pulse-height drift and natural background. It corrects for system nonlinear energy response either inherently during unfolding or optionally when spectral unfolding is optionally not carried out.

Code CUBED-II is designed to optionally output spectral data in a form directly compatible with a Calcomp plotting code. A Calcomp plotting code has been developed under the present contract and is reported upon separately in a complementary report, NUS-397[4]. Since the present report is considered primarily as a code user's manual, a detailed description of the mathematics and the logic of the code is referred to report NUS-316[3].

2. CODE DESCRIPTION

2.1 INTRODUCTION

Code CUBED-II is written in the FORTRAN IV compiler language for a 32k memory IBM-7094 digital computer. It was designed to run under the IBSYS monitor system at NASA Goddard Space Flight Center. Input data are read from card-to-tape ---- TAPE 2, digital output is written on tape for print out ---- TAPE 3, and on tape-to-card ---- TAPE 4, for input to the CALCOMP plotting code[4]. The code calls only standard library subroutines, such as transcendental functions.

The code consists of a main control program and twenty-nine subprograms, numbered from 1 to 30. A subprogram glossary is given in Appendix I, in alphabetic name order; an input glossary of variables in Appendix II, in order of input; and a code FORTRAN punch card deck listing in Appendix III. Appendix IV consists of a sample input card deck listing and Appendix V of a program output listing corresponding to the input given in Appendix IV: the execution time for the sample data was approximately one minute.

The code is written in such a manner as to make it readily amenable to either modification or subprogram substitution and, thus suitable for analyzing scintillation spectra other than bremsstrahlung such as those originating in, for example, photon transmission or scattering experiments. The response matrix generation portion of the code may be separated from the overall code and used under the control of a substitute main program. Appendix VI gives a listing of such a substitute program and the code CUBED-II subprograms required. In addition a modified version of the response matrix generation portion of the code may be run under the control of a substitute program to normalize the continua resulting from many measurements of either a single or various sources. Appendix VI gives a brief description and FORTRAN listing of such a substitute program and the code CUBED-I subprograms required.

The logic and function of the main program -- MAIN -- and its subprograms are discussed in Section 2.2, in some detail. Those subprograms not discussed are considered as being adequately described in Appendix I. FORTRAN names and variables are shown capitalized in what follows, with 'zero' and 'oh' thus: 0, Ø. The constants required by the code are explained in Section 2.3. Reference to this Section will allow the user to make changes as necessary, in for example, the relationship of such as the detector system photopeak resolution and pulse-height with photon energy.

The code output is discussed in Section 2.4 with special reference to the intermediate output which may be requested as noted in Section 3.2, and to the interpretation of the data listed in Appendix V.

2.2 CODE LOGIC

2.2.1. MAIN PROGRAM

The main program was designed to execute data input and output operations, many of them under initially input option signals, and provide the control connectivity for the hierarchy of twenty-nine subprograms presented in Figure 1. Figure 2 shows a simplified flow diagram of the main program. Program MAIN calls ten subprograms, namely:

PHØFRA	ØMITS	DEC	GANE	SINGLE
SØLN	DECAY	GEØMTR	ENLIN	PULSE

Subprogram PHOFRA is called by MAIN to generate and return the detector system response matrix and the associated vectors relating pulse-height to photon energy. It also returns a vector of photopeak-area-to-total-spectrum-area ratios, i.e. experimental photofractions, for code check purposes. The generated response matrix may be optionally output on punch cards for either input to a Calcomp plotting program or to code CUBED-II at a later time. Since the matrix output data is multiplied by 10^4 for plot normalization reasons, the data must be divided by 10^4 if it is to be used as code CUBED-II input. Under control of an input option signal, the matrix and its associated vectors may be read as a card deck, instead of generated. For the analysis of many sets of unknown spectra one response matrix may be applicable, and thus the main program includes an option to bypass both the calling of PHOFRA and the input of a matrix card deck. For similar reasons an option is provided to call PHØFRA to generate a response matrix based on previously input standard spectra.

Code options allow either the execution of MAIN to continue, return to start or call EXIT after the calling of PHØFRA. Thus the code may be run only for the purpose of generating a response matrix.

The code takes advantage of the fact that certain input data cards for a set or block of unknown (beta) source spectra, vary in only one or two variables, and so need not be repeated, the unchanging variables being supplied through the automatic calling of subprogram ØMITS by MAIN.

Unknown spectra are input to the code in uninterrupted blocks of up to twenty spectra through the calling of subprogram DEC by MAIN. Since pulse-height analyzer background subtracted counts are recorded in a complement mode, i.e. as positive numbers, they are converted to true negative numbers by subprogram DEC. A count greater than 9×10^5 is assumed to be in the complement mode.

MAIN is coded to subtract background spectra from source-plus-background spectra under an input option control signal. This option allows the subtraction or addition, of a fraction or multiple of the background spectrum. It further allows the continued reuse, as desired, of a previously stored background spectrum, and of course the addition of similar spectra for special purposes.

The energy correspondence of the response function matrix to the unknown spectra is matched through MAIN calling subprogram GANE[2]. Subprogram GANE returns spectra to the main program which are normalized to pulse-height analyzer true zero pulse-height and gain changed such that their channel width corresponds to that of the response matrix.

The code corrects unknown spectra for the non-linear energy response of NaI(Tl) during the unfolding process or if according to an input option this process is by-passed, by the calling of subprogram ENLIN. Subprogram ENLIN returns an energy linearized spectrum to MAIN which may be subsequently corrected for other phenomena but is not unfolded.

At this point in the main program on both the first and subsequent loops, the response matrix is stored, and an unknown pulse-height analyzer spectrum is prepared and ready for conversion to a photon number spectrum. According to an input option signal the code is instructed that the unknown spectrum is either a pure continuum or that instead, a given number of monoenergetic spectra are "superimposed" on a continuous spectra. If the input option indicates the presence of superimposed monoenergetic spectra and if their line energies are input, MAIN calls subprogram SINGLE prior to proceeding with the unfolding process.

Subprogram SINGLE is called by MAIN to determine the location of the photopeaks indicated by the input energies of the monoenergetic components of the unknown spectrum. Gaussian distributions are fitted to each photopeak and the associated Compton continua established, and the corresponding line photon numbers calculated. In this manner the monoenergetic spectral components are determined in turn and subtracted from the unknown spectrum to leave a residual continuum spectrum. The residual spectrum is returned to MAIN for subsequent unfolding. The line photon numbers are added to the residual photon number spectrum determined by unfolding to give the total photon number spectrum represented by the input pulse-height analyzer spectrum.

At this point in the main program on both the first and subsequent loops, the unknown spectra are considered as prepared for unfolding, and thus, they and the response matrix are communicated to subprogram SØLN. Subprogram SØLN is called by MAIN to control the unfolding process according to the Scofield method[3] and to apply efficiency corrections. Subprogram SØLN returns the corrected photon number spectrum to the main program.

The determined photon number spectrum is corrected for primary source decay after the main program calls function subprogram DECAY. Subprogram DECAY returns a correction factor by which the number spectrum is multiplied. The calling of subprogram DECAY may be optionally bypassed, in which case the multiplying factor is taken as unity.

Subprogram GEØMTR is called by the main program to apply the decay correction factor, carry out geometrical corrections, compute the distributions, and exposure dose.

Subprogram GEØMTR returns the final results to the main program for output, after which the code loops back along either paths 1, 2, or 3, as shown in Figure 2. The code loops back along path 1 primarily to read new data pertaining either to the response matrix or to the control options or both. The code loops back along path 2 to read new data pertaining either to the unknown source or if the maximum number of allowable passes (twenty) along path 3 have been equaled; the second reason is dictated by computer finite capacity. The code loops back along path 3 to read a new unknown spectrum.

The called subprograms PHØFRA, ENLIN, SINGLE, SØLN and GEØMTR are discussed further in Subsections 2.2.2 through 2.2.6.

2.2.2 RESPONSE FUNCTION MATRIX

2.2.2.1 Matrix Generation

The detector system response function matrix is generated under the control of subprogram PHØFRA. The subprograms called by PHØFRA are those shown in Figure 3, namely:

GANE	RESGEN	TA	TE
PULSE	RAXEL	PEAKS	PEEK

The main program supplies PHØFRA with a number of control parameters, and three variables. The variables are, namely:

a. the response function matrix size (FØRTRAN name N),

b. the desired energy worth of the upper edge of the matrix highest energy increment (ELIMIT) and,

c. a linear energy response coefficient (EM = 'N-floating point'/ELIMIT).

PHØFRA begins execution by input of a card deck of spectra of standard radioisotopes. The number of such spectra is equal to NSTAND, where NSTAND ≤ 9. This card deck is preceded by one parameter card containing information regarding the number of spectra in the deck (NSTAND); the number of "dead" or unused channels at the low energy end of each spectrum (NPHA); and the pulse-height analyzer reference coarse gain at which they were measured (UNGAIN). The parameter card is followed by a set of NSTAND cards, each pertaining to and in the same order as the spectra to which they refer. These cards contain the source identity, data regarding peak approximate locations and the deviation of the spectrum from true zero pulse-height and hence the ± normalizing spectrum shift required. A typical card deck is shown in Figure 4. (Further details are referred to Section 3)

The standard spectra allowed by the code must have been measured from the following radioisotope sources:

Cd^{109}	Sc^{47}	Hg^{203}	Au^{198}	Sr^{85}
Cs^{137}	Mn^{54}	Nb^{95}	Na^{22}	Zn^{65}

The order in which they are input to the code is immaterial excepting that Na^{22} and Zn^{65} must be input second-last and last, respectively. The user may employ sources not shown above by an obvious modification of the DATA Statement in subprogram PHØFRA (located at subprogram statement number 9095 + 5), so long as such sources are monoenergetic and do not contain an 0·51 MeV energy photon line. For example, suitable alternate spectra might be those originating from Cr^{51} & F^{18} sources, or even hand prepared.

According to an input option and after the first call, calling of PHØFRA allows the by-passing of input of standard spectra. This allows the code to generate a response matrix based on already stored standard spectra. Similarly subprogram SINGLE calls PHOFRA to determine Compton continua based on already stored current standard spectra.

After data input to PHØFRA, counts in the complement mode are converted to their true negative value. The spectra are shifted to true-zero pulse-height by the calling of subprogram GANE. Their order of input is established prior to the calling of subprogram RESGEN.

Subprogram RESGEN is called by subprogram PHØFRA to normalize the standard spectra with respect to photopeak area and pulse-height, and to subtract photopeaks and source-characteristic X-ray peaks. The residual spectra thus determined consist of Compton continua characteristic of the primary photon energy. The X-ray peaks are subtracted since they are not representative of the primary photon energy but rather of the source. The 0·51 MeV photopeaks and their Compton continua are subtracted for the same reason. Figure 5 shows a typical set of spectral continua as normalized by subprogram RESGEN for PHØFRA. The logic of subprogram RESGEN is described in section 2.2.2.2.

Subprogram RESGEN returns normalized differential standard spectra to subprogram PHØFRA. These spectra are transformed to cumulative distributions in the negative pulse-height direction, i.e. beginning at the highest channel number. The cumulative distributions are re-ordered with respect to the ascending order of primary photon energy, prior to interpolation. The energy ordered cumulative distributions are interpolated quadratically with respect to the energy axis of the desired response function matrix through subprogram PHØFRA calling subprogram TA and function subprogram TE. The results of interpolation consist of N (corresponding to matrix size) Compton continuum vectors, as cumulative distributions, which ideally, are normalized to unit photopeak area and pulse-height. The interpolated cumulative distributions are differentiated to yield the conventional differential continuum distributions. Subprogram SINGLE calls PHØFRA to interpolate normalized Compton continua at specific energies as described in this paragraph.

The Gaussian photopeaks and iodine K X-ray escape peaks of unit total area and at unit pulse-height (photopeak) are added to the differential Compton continua to yield N complete spectra. The peaks are computed through PHØFRA calling subprogram PEAKS. The Gaussian photopeak photon energy dependent standard deviation $\sigma(E)$, is computed from an expression of the type[2,5]

$$\sigma(E) = k \cdot E^n \qquad (1)$$

where

> k and n are determined by a fit to the photopeaks of the standard spectra, either by a regression analysis or by a plot of $\sigma(E)$ against E on log-log graph paper and the slope n and the intercept k (at E = 1.0 keV) obtained.

The energy dependent K X-ray escape fraction is determined through PHØFRA calling function subprogram RAXEL, which interpolates a stored table of escape fractions described in Section 2.3.

The N determined unit length differential spectra are redistributed in pulse-height according to the non-linear energy response of the detector system. The redistribution is obtained through PHØFRA calling subprogram GANE. The non-linear pulse-height is obtained through calling function subprogram PULSE.

At this point in the execution of subprogram PHØFRA a response function matrix has been determined. This matrix and its corresponding vectors of pulse-height, photon energy and photofraction are returned to the main program. Figure 6 shows the photofractions as determined by PHØFRA and the actual experimental values at standard source energies.

2.2.2.2 SPECTRUM NORMALIZATION

Subprogram RESGEN normalizes the standard spectra communicated to it through the calling of subprogram PHØFRA. A general flow diagram of its logic is given in Figure 7 . It begins execution by carrying out certain initializations. In the event that an 0.51 MeV spectrum and either Zn^{65} and/or Na^{22} have been included in the input standard spectra, it additionally stores then as dummy vectors for later 0.51 MeV spectral subtraction. It calls subprogram STDFIT to carry out a non-linear regression fit of a Gaussian-plus-straight-line function as coded in subprogram FUNUS, to the primary and 0.51 MeV (of Na^{22} and Zn^{65}) spectral photopeaks. Subprogram STDFIT calls subprogram GUESS to estimate suitable initial values of the five function parameters: straight-line slope and intercept; Gaussian photopeak standard deviation, area and mean pulse-height. Subprogram STDFIT returns the parameters of the fitted photopeaks to subprogram RESGEN.

Subprogram RESGEN uses the fitted parameters to subtract the primary photon energy photopeaks from the standard spectra. This operation is followed by a subtraction of the characteristic X-ray peaks in the case of those spectra where they occur. The 0.51 MeV photopeak and continuum of Sr^{85}, if it has been input, is employed to subtract the 0.51 MeV spectrum contribution of Na^{22} and/or Zn^{65}. This operation requires both count and pulse-height gain normalization, the gain normalization being carried out through the calling of subprogram GANE.

The Compton continua are gain normalized to a photopeak pulse-height of 100 channels by the calling of subprogram GANE and count normalized to unit photopeak area by a division operation. The iodine K X-ray escape peak is subtracted for the case of primary photon energies less than 300 keV. The resulting residual normalized continua are checked for negative count values, which are replaced by zero, and returned to the calling subprogram PHØFRA. The photopeak fitted parameters are also returned to subprogram PHØFRA.

Although the parameters of the Gaussian photopeaks were intended to be optionally least-squares fitted to an empirical expression by the calling of subprogram SVFIT[1,2], they are at present coded as program constants. At subprogram RESGEN statement 9096, SN and SCONST correspond to n and k of equation (1) and are coded as equal to 0.7677 and 0.3210, respectively. This encoding is based on the NASA-GSFC particular detector system; it is proposed to use subprogram SVFIT in a future version of code CUBED-II.

Code CUBED-II computes Gaussian photopeaks using the coded values of n and k in the noted subprograms and for the following reasons:

(a) Subprogram GUESS to estimate the initial value of photopeak parameters for the iterative regression analysis carried out by subprogram STDFIT.

(b) Subprogram RESGEN to compute the iodine K X-ray escape peak subtracted from standard source spectra. The actual values of n and k are those coded in subprogram RESGEN, or as generated by subprogram SVFIT if it is used.

(c) Subprogram PHØFRA to compute the photopeaks and escape peaks for response matrix generation. Actual values are those coded in RESGEN, or as generated by subprogram SVFIT, if used.

(d) Subprogram SINGLE to estimate the approximate fitting limits or channel numbers, bounding photopeaks or X-ray peaks to be analyzed discretely.

Subprogram SVFIT of code CUBED-I, may be employed in code CUBED-II after DIMENSION values coded as 40 are reduced to 30 or less.

2.2.3 ENERGY RESPONSE CORRECTION

Subprogram ENLIN is called by MAIN according to an input option to correct pulse-height analyzer spectra for the non-linear response of the NaI (Tl) scintillation spectrometer system to gamma photon energy. The logic of subprogram ENLIN is described in this section.

The main program supplies ENLIN with a number of control parameters and four variables. The variables are, namely:

a. The number of channels in the spectrum to be linearized (NX),

b. The counts in the spectrum to be linearized (FM (I)),

c. The energy at which the spectrum was calibrated (EG), and

d. The measured pulse-height corresponding to the calibration energy (VG).

For the sake of discussion in this section the above input to ENLIN will be referred to as n, C'_i, E_m and V'_m, respectively.

Subprogram ENLIN begins execution by defining the linear response slope, or channel energy worth Δ as

$$\Delta = E_m/V \tag{2}$$

where

$$V = V'_m / (1 + \partial V_m (E_m)) \tag{3}$$

and

$\partial V_m (E_m)$ is the fractional deviation of pulse-height from a linear response for energy E_m, as determined by ENLIN calling subprogram PULSE; ∂V is further discussed in Section 2.3. The linear response is normalized at energies $E = 0$ and 1.3325 MeV.

The non-linear channel energy worth of channel i, is determined as

$$\Delta'_i = V'_i - V'_{i-1} \qquad (4)$$

where

$$V'_i = V_i \, (1 + \partial V_i \, (E_i)) \qquad (5)$$

With the above relationships established the linear response count in channel i, C_i, may be determined as

$$C_i = C'_i \cdot \Delta'_i / \Delta_i \qquad (6)$$

Although the energy worth for C'_i varies from channel to channel it is equal for all channels for C_i. Again, the spectrum integrated counts for C_i and C'_i are equal. Appendices IV and V present a sample input and output for C'_i and C_i; C'_i was chosen such that C_i would be a straight line corresponding to a linear response curve.

2.2.4 ANALYSIS OF MONOENERGETIC SPECTRAL CONTRIBUTIONS

Subprogram SINGLE is called by MAIN according to an input option to carry out an analysis on indicated given energy monoenergetic spectral contributions. It was developed for those bremsstrahlung spectra where prominent Gaussian photopeaks are present. It was not intended for X-ray peaks which consist of more than one X-ray line and thus, not a simple Gaussian distribution. For those spectra containing X-ray peaks the iterative unfolding procedure may be applied, but the rate of convergence may depend on the prominence of the peak. An option allows X-ray peaks to be alternatively fitted with a single Gaussian distribution to give an approximate result. The degree of aproximation obtained has not been fully analyzed.

Subprogram SINGLE begins execution by estimating the channel locations of the photopeak fitting limits (NSS and NFNN) based on the peak input energies. It first establishes the approximate channel region of the photopeak. It than ascertains it more accurately by calling subprogram VECTMX for the approximated channel region to establish the channel of maximum count. The fitting limits are determined as a function of photon energy in terms of the standard deviation and the constants given in equation (1). The subprogram checks to ensure fitting limits are within the spectrum and not overlapping each other.

With the fitting limits established subprogram STDFIT is called to fit a Gaussian distribution to each photopeak in turn. Subprogram STDFIT returns the photopeak parameters to SINGLE.

The Compton continuum associated with each photopeak is determined by calling subprogram PHØFRA, which returns an interpolated continuum normalized with respect to a photopeak pulse-height of 100 channels and unit area. The continuum is then scaled and gain changed according to the peak area and pulse-height determined by STDFIT.

Gain changing is carried out through SINGLE calling subprogram GANE. The photopeak and Compton continuum are then subtracted from the unknown spectrum for each monoenergetic spectral component in turn to finally leave a bremsstrahlung continuum residual spectrum. If no bremsstrahlung or other continuous contribution was present in the unknown, then ideally a zero spectrum will result.

Prior to returning the residual continuum to MAIN for iterative unfolding SINGLE determines the photon number of each monoenergetic spectral component. It does this by computing the photofraction, P(E), the detector interaction efficiency, $\epsilon(E)$, and the attenuation term for detector cladding, air and lucite material interposed between the source and NaI (Tl) crystal, $\eta(E)$, all as outlined in reference (2). The photon number is then determined from the relationship:

$$N(E) = \frac{\text{Photopeak Area (or Counts)}}{P(E) \cdot \epsilon(E) \cdot \eta(E)}, \qquad (7)$$

The corrections noted are carried out by subprogram SINGLE calling function subprograms EFFIC, AIRABS, PERSPX and CLAD. N(E) is returned to MAIN to be added to the continuum number spectrum determined by iterative unfolding, and thus give the total number spectrum corresponding to the unknown pulse-height spectrum. Figure 8 shows a number spectrum for Cs^{137} and Mn^{54} as determined by code CUBED-II employing subprogram SINGLE.

2.2.5 SPECTRAL UNFOLDING

The reduction of pulse-height analyzer continuous spectra to photon number spectra and the application of efficiency corrections are carried out under the control of subprogram SØLN called by the main program. Subprogram SØLN begins execution by carrying out certain initializations after which it calls subprogram RESMAT to unfold the the pulse-height analyzer spectra according to the Scofield method[3]. The number spectra returned by subprogram RESMAT are corrected for efficiency. The thus corrected number spectra are returned to MAIN. The remainder of this section describes the logic of the unfolding subprogram RESMAT and of the efficiency vector subprograms EFFIC, AIRABS, PERSPX and CLAD.

Subprogram RESMAT unfolds the pulse-height analyzer spectra by solving the matrix equation (in matrix notation)

$$\vec{P} = \bar{\bar{R}}\ \vec{N}' \qquad (8)$$

where $\vec{P}$ and $\vec{N}'$ are the m-dimensional vectors of PHA spectrum and efficiency uncorrected photon number spectrum, respectively, and $\bar{\bar{R}}$

is the m x m square response function matrix. Equation (8) is formally solved as

$$\vec{N}' = \bar{\bar{R}}^{-1} \vec{P} \qquad (9)$$

where $\bar{\bar{R}}$ is non-singular and $\bar{\bar{R}}^{-1}$ is its inverse. Subprogram RESMAT executes equation (9) iteratively according to the Scofield method (3). Figure 9 shows a flow diagram of the iterative algorithm coded in subprogram RESMAT. Further details are referred to references (2) and (3).

The efficiency corrected photon number spectrum N, is determined from equation (9), as

$$\vec{N} = \bar{\bar{\eta}}^{-1} \vec{N}' \qquad (10)$$

where $\bar{\bar{\eta}}$ is a diagonal efficiency matrix accounting for interaction efficiency and photon attenuation by detector cladding, air and lucite materials interposed between the source and the crystal. Subprogram SØLN calls function subprograms EFFIC, CLAD, AIRABS and PERSPX to determine $\bar{\bar{\eta}}$ and then executes equation (10), returning the determined photon number spectrum to MAIN. Figure 10 shows a typical spectrum before ($\vec{P}$) and after ($\vec{N}$) unfolding.

2.2.6 ANALYSIS OF UNFOLDED SPECTRA

Subprogram GEØMTR is called by MAIN to carry out a final analysis on the unfolded photon number spectra. The spectra are corrected for primary source decay and converted by GEØMTR to differential photon number flux at the detector per unit time, $N_x(E)$, (coded as FNXTAL), as

$$N_x(E) = \frac{N(E)}{\pi R_x^2}, \quad \gamma/\text{cm}^2\ \text{sec} \qquad (11)$$

where

R_x = NaI (Tl) crystal radius, cm.

The differential energy flux incident on the crystal per unit time, $I_x(E)$, (coded as ENXTAL), is determined as

$$I_x(E) = N_x(E) \cdot E, \text{ MeV/cm}^2 \text{ sec} \qquad (12)$$

The energy integrated exposure dose rate at the crystal, D, (coded as DOSDET), is determined as

$$D = \int_{energy} N_x(E)\, E \mu_{air}(E)\, K\, dE, \text{ roentgens/hours} \qquad (13)$$

where

$\mu_{air}(E)$ = energy mass absorption coefficient of air, cm^2/gm

K = conversion constant
= $3600/5.24 \times 10^7$, (roentgens-second-gm air)/MeV-hour

The integration in equation (13) is carried out numerically by GEØMTR, as

$$D = \sum_{i=1}^{m} N(E_i)\, E_i\, \mu_{air}(E_i)\, K\, \Delta E_i \quad , \qquad (14)$$

The energy integrated photon number and photon energy flux at the crystal is determined by integrating $N_x(E)$ and $I_x(E)$ over E, (coded as SUMNUM and SUMENY); the units are γ/cm^2-sec and MeV/cm^2-sec. The following tabulated data are also determined by sub-program GEOMTR for output by the calling main program:

FORTRAN NAME	EQUAL TO	DEFINITION & UNITS
(AT THE CRYSTAL)		
AVENGY	$\frac{\Sigma N(E) . E . \Delta E}{\Sigma N(E) . \Delta E}$	average energy, Mev
PHNUBE	$\frac{\Sigma N(E) . \Delta E}{N_\beta}$	integrated photon number flux per beta source strength, $(\gamma/cm^2 - sec)/\beta/sec)/MeV$; ($N_\beta$ defined below)

ENBENY	$\frac{\Sigma N(E).E.\Delta E}{E_{\beta_{max}}}$	integrated energy flux per beta maximum energy, (MeV/cm^2 -sec)/MeV; ($E_{\beta_{max}}$ defined below)
PHENBE	$\frac{\Sigma N(E).\Delta E}{N_\beta}$	integrated energy flux per beta source strength, (MeV/cm^2 -sec)/(β/sec)
DOXBEX	D/N_β	dose rate per beta source strength, (r/hr)/(β/sec); (D defined in equation (13)).

(AT THE BETA SOURCE CYLINDER)

DOSCYL	$\frac{DOSBEX}{G}$	dose rate per beta source strength, (r/hr)/(β/sec); (G defined below)
DCYVOL	$\frac{DOSCYL}{\text{Source Volume}}$	dose rate per beta source strength per cm^3 of source volume, = DOSCYL/cm^3

where

$E_{\beta_{max}}$ = maximum beta energy in MeV

= EBMAX of card (7) of report section 3.2*

N_β = number of source emitted betas per unit time

= (SBETA of card (7) of report section 3.2) $\div$ 3.7 x 10^{10}.**

and $$G = \Omega_x/\Omega = 1/2(1 - r/(r^2 + R_x^2)^{1/2})$$

where

Ω_x = solid-angle subtended by the crystal at the source geometric center.

* if not meaningful to code user, then input as, EBMAX = 1.0

** if not meaningful to code user, then input as, SBETA = 1.0/(3.7 x 10^{10}).

Ω = total solid-angle at the source = 4π steradian

r = source to crystal distance

Subprogram GEOMTR returns all of the above data to the main program for output under option. The differential energy flux at the crystal $I_x(E)$, (ENXTAL) is output under option by MAIN on punch cards for input to a CALCOMP plotting program.

2.3 CODE CONSTANTS

In this section the origin and meaning of constants employed by code CUBED-II are discussed. All attenuation coefficients used were those given in references (6) and (7). The discussion is carried through in alphabetic order of subprograms, except for MAIN which is discussed first. Certain subprograms require no discussion.

MAIN: the constant 30.48 at program statement number 0 + 5 is source-to-crystal distance in cm. for use by the code in that instance where it is omitted from input. The constant 0.75 at statement number 0 + 18 is Lucite absorber thickness in cm^2/gm for use by the code; Lucite thickness is presently not coded for input, though it may easily be coded by the user. The constants ØN = 20.0, HITMAX = 50.0, EPS = .0001, RX = 3.81 and H = 7.62 at statement numbers 7708 to 11008 are used by the code if input left blank; they are discussed in Section 3.2. The constants associated with UT at statement numbers 40 to 47 are explained in section 3.2. The constant 3.7 E + 10 at statement number 128 + 1 is the conversion factor for Curies to disintegrations/second.

AIRABS: the mass absorption coefficients of air are given in the DATA statement in cm^2/gm. The coefficients include coherent scattering. They are multiplied by the density of air in gm/cc to give output units in cm^{-1}.

CLAD: The attenuation factors (a fraction) of the detector cladding material are given in the DATA statement. They were determined for the following material composition and thicknesses

Material	Density X Thickness mg /cm^2	Density gm/cm^3
Aluminum	130	2.70
Neoprene	43	1.30
Polythene	13	0.90
Aluminum Oxide	67	4.0

and the expression

$$\text{"Factor"} = e^{-\mu(E)\cdot \text{Thickness}}$$

where

$\mu(E)$ is the material weighied mass absorption coefficient.

DØSE: the energy mass absorption coefficients for air are given in the DATA statement in cm^2/gm. They are based at 20°C and a fractional weight composition of

Nitrogen	0.755
Oxygen	0.232
Argon	0.013

EFFIC: The energy of the K electron shell absorption edge of iodine in NaI(Tl) is coded as 0·03316 MeV. The density of NaI(Tl) as 3.667 gm/cc. The total mass absorption coefficients are given in the DATA statement in cm^2/gm; they do not include coherent scattering. EPS = 1.0E - 06, is the integrating accuracy required of code SIMPSN for evaluation of the interaction efficiency factor(2).

FUNUS: The constant 0.3989423 is unique to the normal or Gaussian distribution(8), ie. for a unit area Gaussian the maximum population, at the mean, is = 0.3989423/(Standard deviation) = $1/\sigma\sqrt{2\pi}$.

GEØMTR: The constant defined as CØNST has been already discussed for equation (13).

GUESS: The constants ·321 and ·7677 are k and n of equation (1). The constant 1·065 is unique to the Gaussian distribution, ie, the area of a Gaussian is given as[8]

$$= \text{(Width at half height)} \times \text{(Height)} \times 1.065$$

where

$$\frac{\sqrt{\pi}}{2\sqrt{\log_e 2}} \simeq 1.065$$

The values of 0.321 and .7677 correspond to a 7.1% detector resolution at E = 0.662 MeV.

PEEK: constant 0.3989423 explained for subprogram FUNUS.

PERSPX: the mass absorption coefficient for perspex (ie. Lucite) is given in the DATA statement in cm^2/gm.

PHØFRA: the isotopic names and photopeak energies in MeV of the allowed standard source spectra are given in the DATA statement located at subprogram statement number 9095 + 5. The energy of the iodine K X-ray, 0.0285 MeV, is given at statement numbers 825 and 59. The constant 2354.82 coded at statement numbers 59 + 2 and 5 + 2 is equal to 2.35482 times 1000.0 where 2.35482 is a unique Gaussian constant[8], i.e. Gaussian width at half height = 2 x 1.17741 x σ

PULSE: the fractional deviations of pulse height at specific energies are given in the DATA statement. They are based on an analysis of experimentally measured standard source spectra whose photopeak energies are well known. A step-by-step description of such an analysis can be found in reference (9). The deviation values coded in PULSE are typical of the spectrometer system and not just characteristic of NaI(Tl).

RESGEN: the constants 0.321, 0.7677, 2.354 and 0.0295 at statement numbers 9096, 9096 + 1, 9096 + 3 and 11005 + 4 have been explained for subprograms GUESS and PHØFRA.

SINGLE: the constants .321, .7677 and 2.354 at statement number 1870 + 1 have been discussed for subprogram GUESS and PHØFRA.

RAXEL: the iodine K X-ray escape fractions derived from the equations of Axel[10] for parallel beam geometry and as modified in reference (11) are given in the DATA statement for energies up to 0.150 MeV. For incident photon energies greater than 0.150 MeV, the fraction is computed by RAXEL as

$$F_k(E) = 5.0233 \times 10^{-5} \times E^{-2.787}$$

and for $E > 0.5$ MeV, as

$$F_k(E) = 0.0$$

3. INPUT DESCRIPTION

3.1 GENERAL

Figure 2 gives a simplified flow diagram of the main program, showing the flow path location of READ statements. Figure 11 gives a model of the input deck. The encircled card numbers in Figure 11 are referenced to locations similarly encircled in Figure 2. The Standard Source Spectra deck, encircled number (6A) is shown in more detail in Figure 4. The READ statement for (6A) is located in subprogram PHØFRA. Card deck (6A) is physically located between cards encircled (5) and (7), as shown in Figure 11. Spectral variables for (6A) are defined in Figure 12. The optional single card (9) is required only when intermediate iterating output from subprogram RESMAT is desired. The optional card deck (6B) is loaded instead of (6A) when the response matrix is to be READ, instead of generated. The control variables M (1) to M (18), except M (16) and M (17), are required for branching in MAIN. M (16) ≠ 0, is to allow the subprogram PHØFRA READ statement to be jumped in those instances when a new response matrix is to be computed using standard spectra previously stored and analyzed. M (17) ≠ 0, is to allow SØLN to jump the unfolding procedure, but apply efficiency corrections. Punched card output options for CALCOMP code input are defined by card (4); they are variables MPLØT (1) to MPLØT (5). The variables MPLØT (1) and MPLØT (2) are reserved for output to be CALCOMP plotted; variables MPLØT (5) defines the number of acutal CALCOMP plots; variables MPLØT (3) and MPLØT (4) are spare and thus available for additional output option.

The details, restrictions, order, formats and card locations of the code input are described below. Card numbers are encircled and defined in the order in which they are read by the code.

3.2 CARD INPUT DETAILS

Card (1) (one card; once only)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
SET	1-10	F10.5	Total number of spectra to be unfolded

Card (2) (single card)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
CASE	2-72 (column 1 for printer control)	A	User's problem description (alphanumeric)

Card (3) (single card)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
M (1)	1-4	I4	Signal for routing after response matrix generation < 0 CALL EXIT = 0 Continue > 0 Return to READ card (2)
M (2)	5-8	I4	If = 0, correct for source decay else no correction.
M (3)	9-12	I4	If = 0, call GANE for energy correspondence correction else no correction.
M (4)	13-16	I4	If = 0, output the spectral result of M (3) correction.
M (5)	17-20	I4	If = 0, unfold spectra else bypass.
M (6)	21-24	I4	If ≠ 0, output the unfolded, but otherwise uncorrected spectrum.
M (7)	25-28	I4	If ≠ 0, output the unfolding convergence differences.
M (8)	29-32	I4	If ≠ 0, write the decay corrected spectrum.
M (9)	33-36	I4	Output the final results: none < 0 all = 0 integrated only > 0
M (10)	37-40	I4	If = 0, output the response matrix.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
M (11)	41-44	I4	If ≠ 0, by-pass the final result computations, (i.e. by-pass GEØMTR).
M (12)	45-48	I4	If = 0, output the number and energy flux spectra, (i.e. final result spectra).
M (13)	49-52	I4	Spare option
M (14)	53-56	I4	Spare option
M (15)	57-60	I4	If ≠ 0, read card (10) and analyze complex-plus-continuous spectra.
M (16)	61-64	I4	If ≠ 0, used by PHØFRA to skip the input of standard spectra when previously input spectra can be reused for new response matrix.
M (17)	65-68	I4	If ≠ 0, analyze spectra, but do not unfold.
M (18)	69-72	I4	If ≠ 0, READ card (9).

NOTE: The choice of non-zero values required for M (I) is arbitrary, however, index values will aid in identity, e.g. if M (7) ≠ 0 then use as = 7.

Card (4)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
MPLØT (1)	1-4	I4	Signal to output on cards the generated response matrix individual vectors for CALCOMP plotting.
MPLØT (2)	518	I4	Signal to output on cards the code determined energy spectra for CALCOMP plotting.
MPLØT (3)	9-12	I4	Spare option signal
MPLØT (4)	13-16	I4	Spare option signal
MPLØT (5)	17-20	I4	The actual number of spectra (or figures) to be output on cards for input to the CALCOMP plotting code.

Card (5) (single card; last 5 variables usually blank)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
ELIMIT	1-10	F10.5	The energy of the upper edge of the response matrix highest channel, meV.
ØJSØ	11-20	F10.5	Loop limit; number of sets of source data (card (7)) before return to READ card (2).
ØMM	21-30	F10.5	If < 0 READ a response matrix, (card set (6B)), = 0 use already computed matrix, > 0 generate new matrix; CALL PHØFRA. Choice of values are arbitrary, eg. -1. and +1.
ØN	31-40	F10.5	The size of the response matrix, i.e. number of channels; also the size of final flux spectra, ≤40.0.
HITMAX	41-50	F10.5	The maximum number of unfolding iterations; an even number such as 50.0 unless iterating output per M (18) required. ≤ 100.0.
EPS	51-60	F10.5	Convergence tolerance at which iteration will cease. e.g. .0002.
RX	61-66	F6.4	Radius of NaI (Tl) crystal, cm.
H	67-72	F6.4	Cylindrical length of NaI (Tl) crystal, cm.

NOTE:	if ØN	zero	(or blank)	code	sets	=	20.
	if HITMAX	"	(" ")	"	"	=	50.
	if EPS	"	(" ")	"	"		.0001
	if RX	"	(" ")	"	"		3.81 cm. (= 1.5")
	if H	"	(" ")	"	"		7.62 cm. (= 3")

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE

Card (6)

Card (6) refers to a deck of cards of which two kinds are allowable, namely: (6A) or (6B).

Card set (6A) will be input, if ØMM < 0; read by subprogram PHØFRA.

Card set (6B) will be input if OMM > 0; read by program MAIN.

Neither set input if ØMM = 0

Card Set (6A) (NPHA, NSJ, NFNJ, NSXJ, NFXJ and SHIFT are defined in Figure 12).

Card (6A) - 1

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
NSTAND	1-5	I5	The number of standard source spectra.
NPHA	6-10	I5	The count in the first NPHA channels of each standard spectrum are replaced by the count in channel NPHA + 1.
UNGAIN	11-20	F10.5	The reference coarse gain of the pulse-height analyzer. Use 1.0, 2.0, 4.0, 8.0, 16.0 or 32.0 (for future code extension).

Card Set (6A) - 2 (I = to NSTAND cards)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
ALABFL (I)	216	A5	Standard source identity. Must be one of CD109, SC47, HG203, AU198, SR85, CS137, MN54, NB95, ZN65 or NA22, right-justified in card field.
NSJ (I)	11-15	I5	A Gaussian-plus-straight-line function is fitted to standard spectra from channel NSJ to NFNJ.
NFNJ (I)	16-20	I5	A Gaussian-plus-straight-line function is fitted to standard spectra from channel NSJ to NFNJ.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
NSXJ (I)	21 - 25	I5	X-ray peaks between channel NSXJ and NFXJ are subtracted from standard spectra; if NSXJ is negative the 0.51 meV spectra of Na^{22} and Zn^{65} are subtracted if they are present in the standard deck (-NSXJ and +NFXJ are .51 meV peak channels defining this fitting range).
NFXJ (I)	26 - 30	I5	X-ray peaks between channel NSXJ and NFXJ are subtracted from standard spectra; if NSXJ is negative the 0.51 meV spectra of Na^{22} and Zn^{65} are present in the standard deck (-NSXJ and +NFXJ are .51 meV peak channels defining this fitting range).
SHIFT (I)	31 - 40	F10.5	The channel location (±) of the standard spectrum true zero pulse-height. The code carries out a shift correction.

Card Set 6A - 3 (NSTAND times 20 cards); ((R (I, J) , I = 1,200) , J = 1 , NSTAND)

R (1, 1)	1 - 7	F7.1	The count in the first channel of the first input standard spectrum.
R (2, 1)	8 - 14	F7.1	The count in the second channel of the first input standard spectrum.
⋮			
R (10, 1)	63 - 70	F7.1	The count in the tenth channel of the first input standard spectrum.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
R (11, 1)	1-7	F7.1	The count in the eleventh channel of the first input standard spectrum.
⋮			
R (200, NSTAND)	63-70	F7.1	The count in the 200th channel of the NSTANDth input standard spectrum.

The above Card Set (6A) - 3 may be summarized as:

10 channels of information/card per 10F7.1 format
20 cards/spectrum
NSTAND spectra,

The spectrum input order must correspond with the order of card set (6A) - 2, Na^{22} (if input) must precede Zn^{65} (if input) and Zn^{65} must be last (if Zn^{65} not input, Na^{22} must be last). The order of the remaining spectra is immaterial.

Card Set (6B)

Card Set (6B) - 1 ((ØN x ØN/5) Cards); ((R (J, I), I=1, ØN), J = 1, ØN)

R (1, 1)	1-11	E11.4	Response Matrix Element 1,1
R (1, 2)	12-22	E11.4	" " " 1,2
R (1, 3)	23-33	E11.4	" " " 1,3
R (1, 4)	34-44	E11.4	" " " 1,4
R (1, 5)	45-55	E11.4	" " " 1,5
R (1, 6)	1-11 (second card)	E11.4	" " " 1,6
⋮			
R (ØN, ØN)	45-55 (last card)	E11.4	" " " ØN, ØN

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE

NOTE: The first ØN elements input represent the lowest energy matrix vector spectrum (analogous to a PHA spectrum); similarly, the second ØN elements, etc. The sum over each vector must = unity.

Card Set (6B) - 2 ((ØN/2) cards)

Q (1)	1-7	F7.4	Mid-increment energy of first energy interval of response of matrix.
Q (2)	8-14	F7.4	Mid-increment energy of second energy interval of response matrix.
.			
.			
.			
.			
Q (10)	64-70	F7.4	Mid-increment energy of tenth energy interval of response matrix.
Q (11)	1-7	F7.4	Mid-increment energy of eleventh energy interval of response matrix.
.			
.			
.			
.			
Q (ØN)	64-70	F7.4	Mid-increment energy of ØNth energy interval of response matrix.

Card Set (6B) - 3 ((ØN/2) cards)

PV (1)	1-7	F7.4	Mid-channel value of first channel of response matrix.
PV (2)	8-14		Mid-channel value of second channel of response matrix.
.			
.			
.			

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
PV (10)	64-70	F7.4	Mid-channel value of tenth channel of response matrix.
PV (11)	1-7	F7.4	Mid-channel value of eleventh channel of response matrix.
.			
.			
.			
PV (ØN)	64-70	F7.4	Mid-channel value of ØNth channel of response matrix.

Card (7) (Single Card)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
BTAG	2-6	A5	Unknown (beta) source identity (alphanumeric)
SBETA	11-20	F10.5	Unknown (beta) source strength, curies.
EBMAX	21-30	F10.5	Unknown (beta) source maximum beta energy, meV.
CYLDIA	31-40	F10.5	Unknown source cylindrical diameter, cm.
TH	41-50	F10.5	Unknown source half-life (optional units; see UT this card).
RUNS	51-60	F10.5	Number of spectra per unknown source data set, $\leq$ 20.0.
CHANLS	61-66	F6.0	Number of pulse-height analyzer channels per spectrum, $\leq$ 200.0.
UT	67-72	F6.0	Multiplier for TH: UT = 0.0; TH in years = 1.0; TH in seconds = 60.0; TH in minutes = 24.0; TH in hours = 365.0; TH in days (Values other than these will cause output of error flag followed by CALL EXIT)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE

NOTE: BTAG, SBETA and EBMAX may be 'blank', 1.0 and 1.0 if not known prior to analysis. Actual values are used only for normalizing in subprogram GEØMTR prior to output of analysis results.

Card Set (8)

"Number of cards in set (8)"= RUNS. Input of card I = 1 detailed below, cards 2 to RUNS similar. Card order must correspond to related pulse-height analyzer unknown (beta) spectra, I $\not>$ 20.0.

DOST (I)	1-7	F7.3	Distance from geometric center of unknown source to front face of NaI (Tl) cystal, cm.
TETA (I)	8-14	F7.3	Polar angle of NaI (Tl) crystal axis with respect to the unknown source, degrees (a dummy variable for future use).
FIE (I)	15-21	F7.3	Azimuth angle of NaI (Tl) crystal axis respect to the unknown source, degrees (a dummy variable for future use).
DELT (I)	22-28	F7.3	Live time counting duration of unknown spectrum, minutes.
TM1 (I)	29-35	F7.3	Time duration from reference time to start of counting, days.
COGAIN (I)	36-42	F7.3	Pulse-height analyzer coarse gain setting for unknown spectrum, $\geq$ 1.0.
VG (I)	43-49	F7.3	Monitor pulse-height corresponding to EG(I), channels.
EG (I)	50-56	F7.3	Monitor energy corresponding to VG(I), meV.
TTZ (I)	57-63	F7.3	Pulse-height analyzer channel location of true zero pulse-height, channels.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
BK (I)	64-70	F7.3	BK (I) times a background spectrum may be subtracted from the unknown spectrum (if BK (I) negative, then is added).
BNBK (I)	71-72	F2.0	Background spectrum signal: < 0 subtract previously stored background = 0 no background > 0 read and subtract background Background spectra are read following unknown spectra with which they are associated.

Card (9) (one card)

This card is input only when M (18) $\neq$ 0. It may contain up to 18 integer numbers, which are the indices of the iterating or unfolding loop at which intermediate output is desired. $\overline{<}$ eighteen indices may be input. The card format is 18I4

Example:

MN (1)	1-4	I4	Iterating loop index eg. 3
MN (2)	5-8	I4	" " " eg. 5
MN (3)	9-12	I4	" " " eg. 9

will give output on iterating loops 3, 5 and 9.

Card Set (10)

This card set is input only when M (15) $\neq$ 0. It must consist of RUNS cards corresponding to the number of unknown spectra in card set (11) . Each card contains the photon energies of the photopeaks in the corresponding unknown complex-plus-continuous spectrum to be analyzed. From one to four photopeaks may be analyzed

EUK (1, 1)	1-10	F10.5	Energy of the first photopeak in card set (11) first spectrum

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
EUK (2, 1)	11-20	F10.5	Energy of the second photo-peak in card set (11) first spectrum.
EUK (3, 1)	21-30	F10.5	Energy of the third photopeak in card set (11) first spectrum.
EUK (4, 1)	31-40	F10.5	Energy of the fourth photo-peak in card set (11) first spectrum.
EUK (5, 1)	41-50	F10.5	Channel defining lower energy side of an X-ray peak whose energy is EUK (1, 1), in card set (1 first spectrum; NSJ on card (6A)-2.
EUK (6, 1)	51-60	F10.5	Channel defining upper energy side of an X-ray peak whose energy is EUK (1, 1), in card set 11 first spectrum; c. f. NFNJ on card (6A)-2.
EUK (1, 2)	1-10	F10.5	
.			
.			
.			
EUK (6, RUNS)	51-60	F10.5	Channel defining upper energy side of an X-ray peak whose energy is EUK (1, RUNS), in card set 11 last spectrum; c. f. NFNJ on card (6A)-2.

NOTE: The first photopeak is that at the lowest energy with the remainder being in energy ascending order. If EUK (5, 1) and EUK (6, 1) are blank no X-ray is present.

Card Set (11)

The number of cards in this set = (CHANLS * RUNS/10.0. + the number of background cards if any). The cards will contain the unknown (eg. beta) source spectra to be unfolded. The number of spectra which may be input is limited by the DIMENSION (20) of card set (7) and defined as = RUNS. The spectra, corresponding to card sets (7) and (8), may be stacked together. A background spectrum if input must directly follow the unknown spectrum from which it is to be subtracted. Twenty unknown spectra each followed by a background spectrum are regarded as twenty spectra from the standpoint of 20 being the maximum number. Each spectrum contains CHANLS channels and background spectra must correspond. Each card contains 10 channels of information. Thus, the following is typical of card set (11) as read by subprogram DEC: -

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
S (1)	1-7	F6.0	Pulse-height analyzer count in channel 1.
S (2)	8-13	F6.0	Pulse-height analyzer count in channel 2.
S (3)	15-20	F6.0	Pulse-height analyzer count in channel 3.
.			
.			
.			
S (10)	64-70	F7.1	Pulse-height analyzer count in channel 10.
S (11)	1-7	F7.1	Pulse-height analyzer count in channel 11.
.			
.			
.			
S (CHANLS)	____	F7.1	Pulse-height analyzer count in channel CHANLS.
(last card in spectrum)			

3.3 CODE OUTPUT

Throughout the discussion in this section, reference to Appendix V, Sample Code Output Listing, is necessary and understood. Those outputs which are clearly defined by format headings are either not discussed or are mentioned only briefly. Output pages are referred to through the encircled letters A, B, C, etc. The minus signs in front of zeroes are a computer phenomenon and not meaningful.

A. The values on this page are output by MAIN, and are as input on card sets (1) to (5), with the exception of EM(=EN/ELIMIT) and the obvious modifications to NaI(Tl) crystal dimensions (note the units are output in inches).

B. The values on this page are output by PHØFRA, and correspond to those standard source spectral parameters input on card sets (6A) - 1 and - 2. Indicated channel numbers are those values after shifting with respect to true zero channel has been carried out.

C. The values on this and following similar pages are the standard source spectral counts corrected for input in the complement mode and true zero channel. This output by PHØFRA corresponds to card set (6A) - 3 input.

D. The results of the Gaussian function regression analysis by STDFIT for the standard spectra photopeaks are output on this page by RESGEN. The output is self-explanatory.

E. The output on this and the following similar pages, by PHØFRA, consists of the Compton continua of the standard source spectra normalized with respect to unit photopeak area and a pulse-height of 100 channels. Beginning at the first channel containing a negative count, the spectra are modified to contain zero counts.

F. The photofractions output on this page, by PHØFRA, are for the energies output on page H and correspond to the solid line in Figure 6.

G. This page presents the response matrix generated by PHØFRA and output by MAIN. It corresponds to that input which would be required for card set (6B)-1.

H. This page presents the energies (in MeV) and pulse-heights (in channels) corresponding to the generated response matrix, at increment midpoints, as determined by PHØFRA and output by MAIN. It corresponds to that input which would be required for card sets (6B)-2 and -3.

I. The output on this page, by MAIN, corresponds to the input specified for card sets (7) and (8), excepting that the units in some cases are modified before output.

J. Optional output by MAIN giving the indices for which unfolding iteration output has been requested by input of card (9).

K. Optional output by MAIN giving the energies (in MeV) of photopeaks at which discrete analysis by SINGLE has been requested through input of card (10).

L. The output on this page by MAIN corresponds to the (first) spectrum to be analyzed and as input on card set (11). Background spectrum subtraction and complement mode correction is carried out before output.

M. The output on this page by SINGLE is self-explanatory and refers to the fitting of an input specified monoenergetic spectral component of the unknown spectrum.

N. The optional output on this page by MAIN corresponds to the unknown spectrum after gain changing and before unfolding analysis.

O. The output on this page (and the following page) by RESMAT is that requested by input of card (9). It consists of the gain changed unknown spectrum normalized to unit integral count; output at loop IT, corresponding to that requested (per MN), of the determined photon number spectrum (PHI) and the iterated input spectrum (PP); the iterated spectrum and the iteration convergence loop (IT), the normalizing integral count (SU) and the final value of the iteration arresting criterion term (TERM = χ^2, Pearson's Chi Square).

P. The output on this page by SØLN is self-explanatory and consists of the components of the diagonal efficiency matrix, η, defined by equation (10) of section 2.2.5.

Q. The optional output on this page by MAIN, consists of the efficiency corrected and unfolded spectrum after post-normalization (scaling with SU); the rate of convergence during unfolding ($\Delta\chi^2$); and a repeat output of the gain-changed unknown spectrum.

R. The optional output on this page, by MAIN, is self-explanatory and consists of $N_x(E)$ and $I_x(E)$, as already discussed in section 2.2.6.

S. The output on this page, by MAIN, is self-explanatory and consists of SUMNUM, SUMENY, D (Equation 14), AVENGY, etc. in the order of, and as already discussed in, section 2.2.6.

T. The output on this page by MAIN consists of the diagonal of the efficiency matrix η, defined by equation (10) of section 2.2.5.

4.0 SUMMARY AND CONCLUSIONS

A FORTRAN IV IBM-7094 package code has been developed for the rapid analysis of bremsstrahlung spectra. The code is readily adaptable to the analysis of continuous scintillation spectra generated by other than pure beta emitting volumetric sources, such as are obtained in photon backscattering or forward scattering experiments. The response matrix generating portion of the code is suitable for use as a separate entity for analyzing spectral problems such as those encountered in the various fields of gamma spectrometry.

The code employs an iterative unfolding method which has been used successfully by its authors, N. E. Scofield(11) and R. Gold(12), by the present author(10), and others(13,14). While it is not suggested that this method is exact, it does obtain results which are approximately correct. It is suggested that degree of accuracy be the subject of future work, wherein the iterative method results would be compared with analytic results. The best value of the matrix size consistent with non-oscillatory good results and computer efficiency would be of interest here. Contract circumstances did not allow sufficient time to pursue such a study in detail during the development of code CUBED-II.

It is proposed that the response matrix generating portion of the code be made more versatile by allowing additional standard sources, such as Co^{60} and Na^{24}, to be input and thus allow the code upper energy range to extend from 1.28 MeV to 2.76 MeV. In this respect, it is mentioned that during the code development, considerable difficulty was experienced in using Na^{22} because of the relatively high intensity of the 1.28 MeV photopeak. Also in this regard, it is mentioned that spectra with prominent backscatter peaks presented difficulties, especially when associated with geometry that varied from standard source to standard source. This problem may be at least partially circumvented by a judicious choice of experiment shielding geometry and materials.

It is concluded that the developed code CU2ED-II is an operable and useful addition to the field of scintillation spectrometry. It allows the generation of the detector system response function matrix, the spectral unfolding process and the final analysis of unknown continuous spectra to be carried out in a single computer run.

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FIGURES

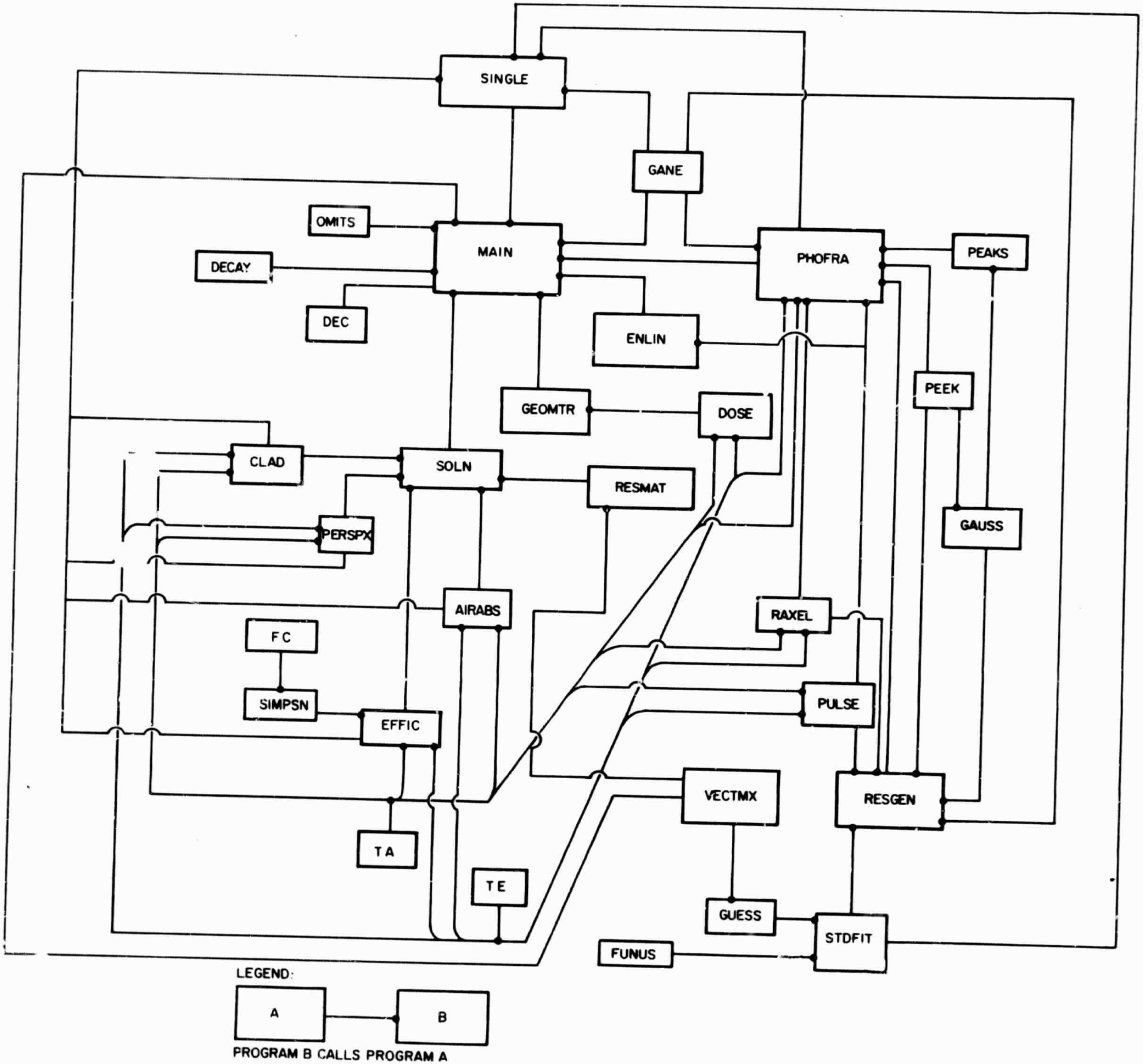


FIGURE 1 CODE CUBED II SUBPROGRAM CONNECTIVITY

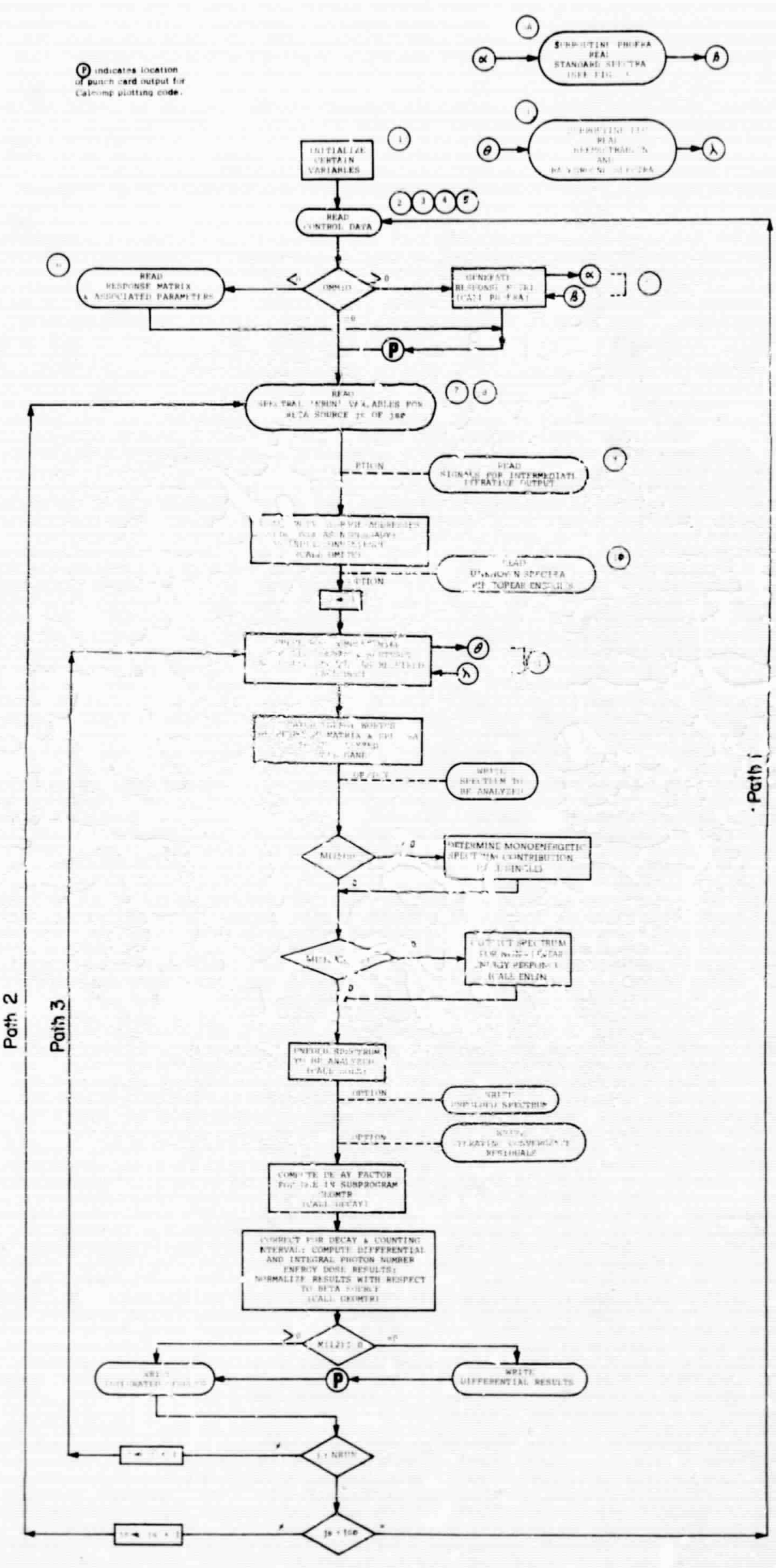


FIG.2
CODE CUBED-II MAIN PROGRAM
GENERAL FLOW DIAGRAM

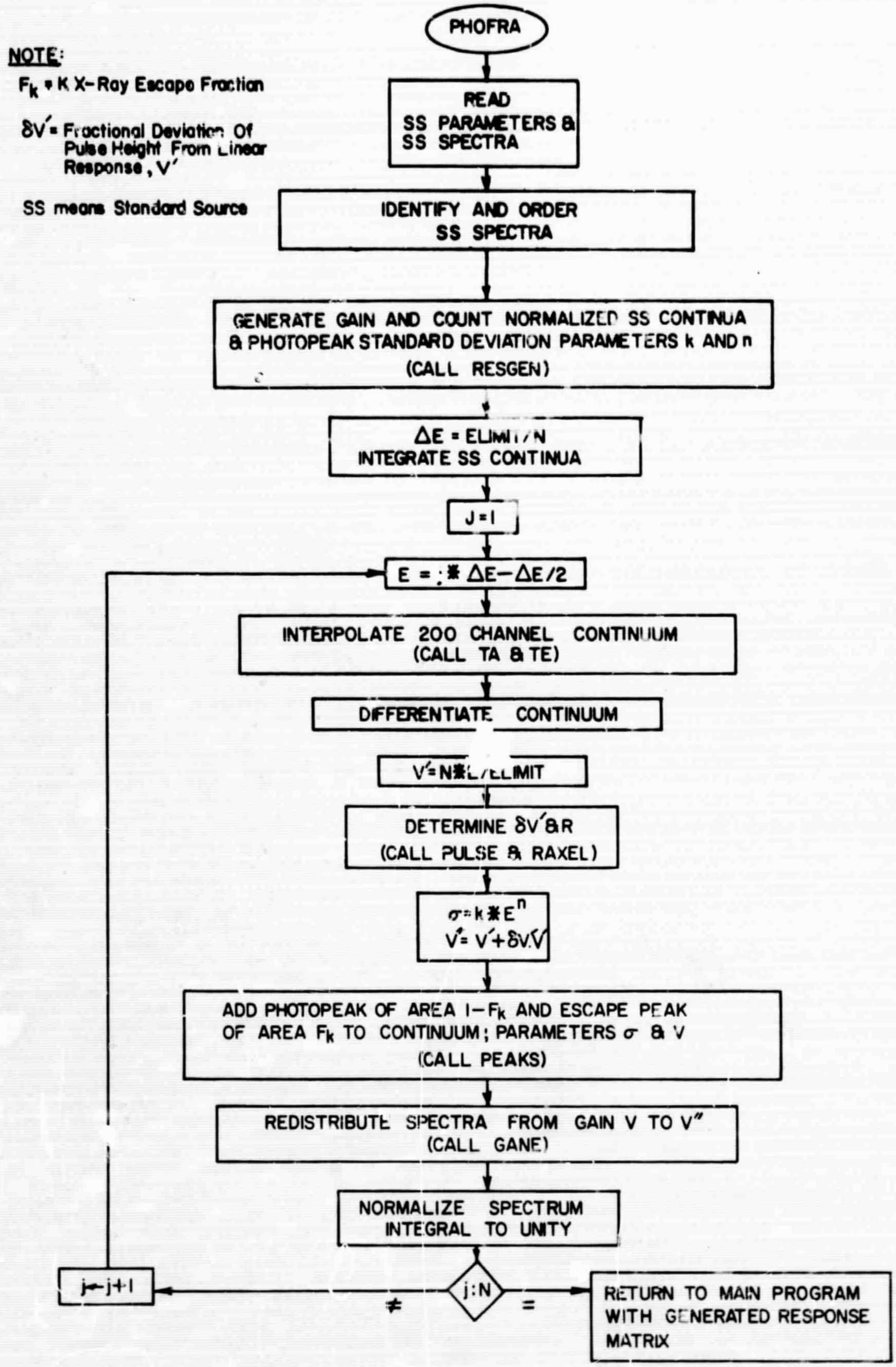


FIG. 3

FLOW DIAGRAM OF RESPONSE MATRIX GENERATING PROGRAM LOGIC; SUBPROGRAM PHOFRA

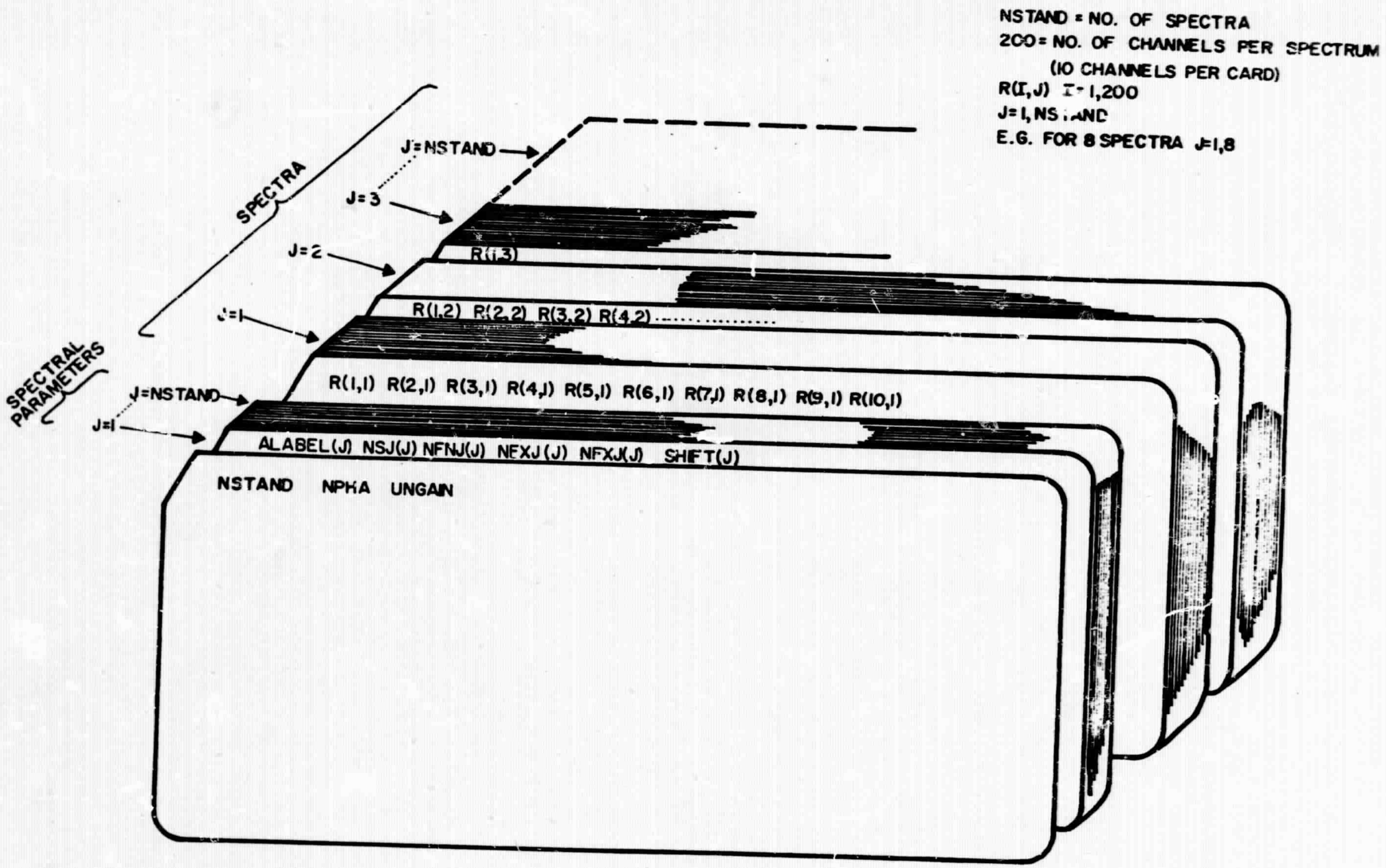


FIG. 4

STANDARD SOURCE SPECTRA LIBRARY DECK ARRANGEMENT

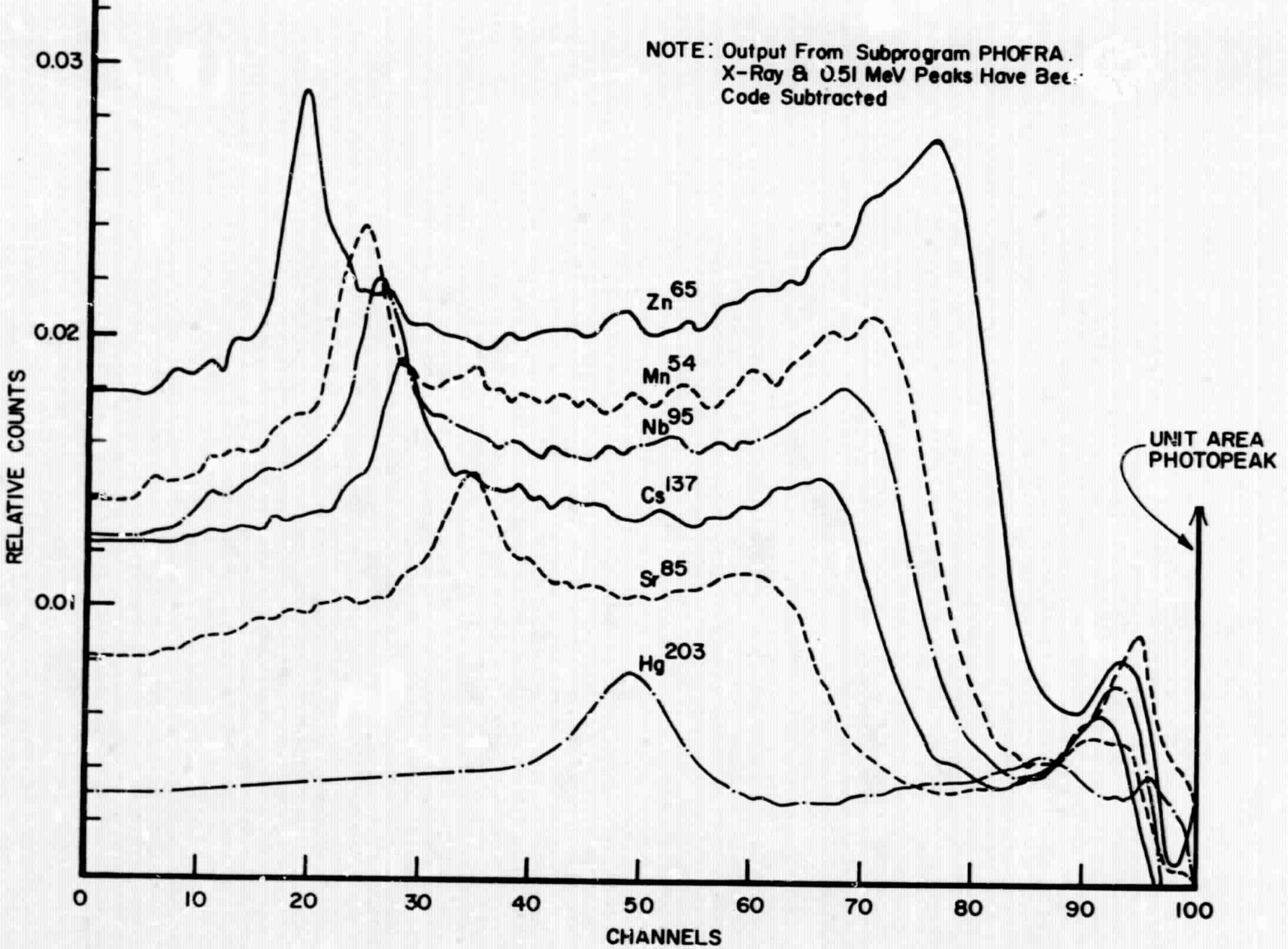


FIG. 5

COMPTON CONTINUA NORMALIZED TO UNIT AREA PHOTOPEAK IN CHANNEL 100

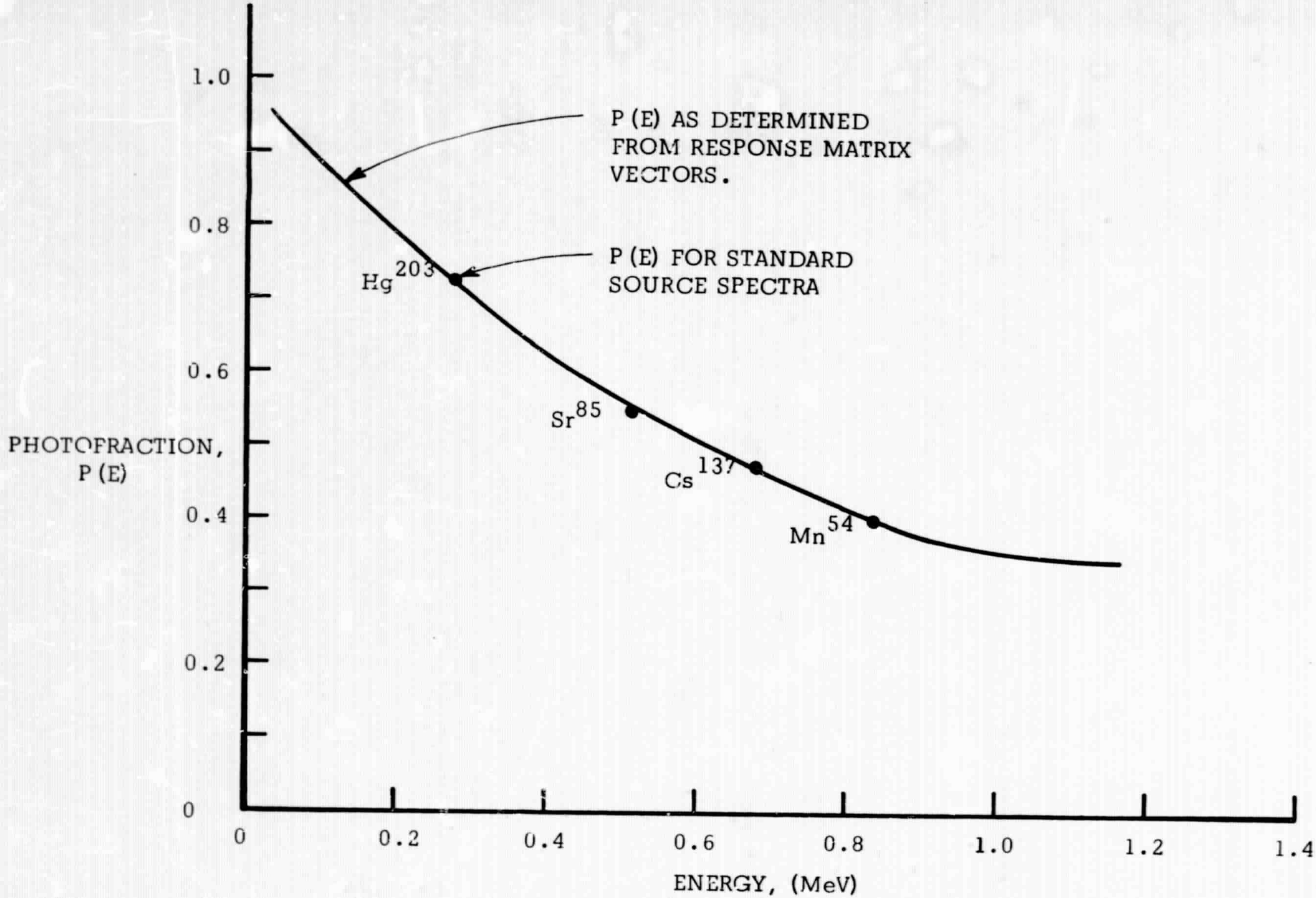


FIGURE 6

PHOTOFRACTIONS GENERATED BY CODE CUBED-II: SUBPROGRAM PHØFRA

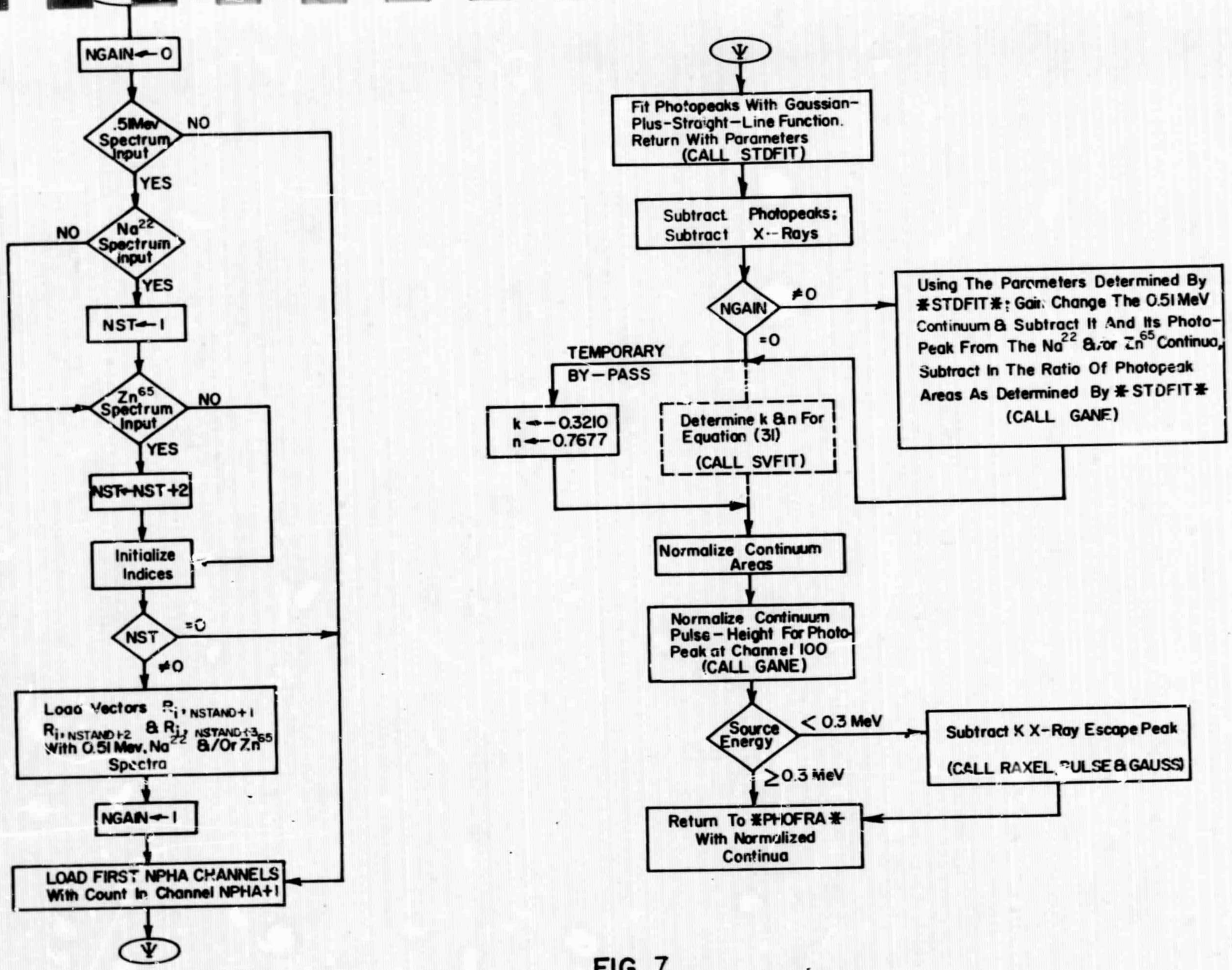


FIG. 7

GENERAL LOGIC FLOW DIAGRAM
FOR SUBPROGRAM RESGEN

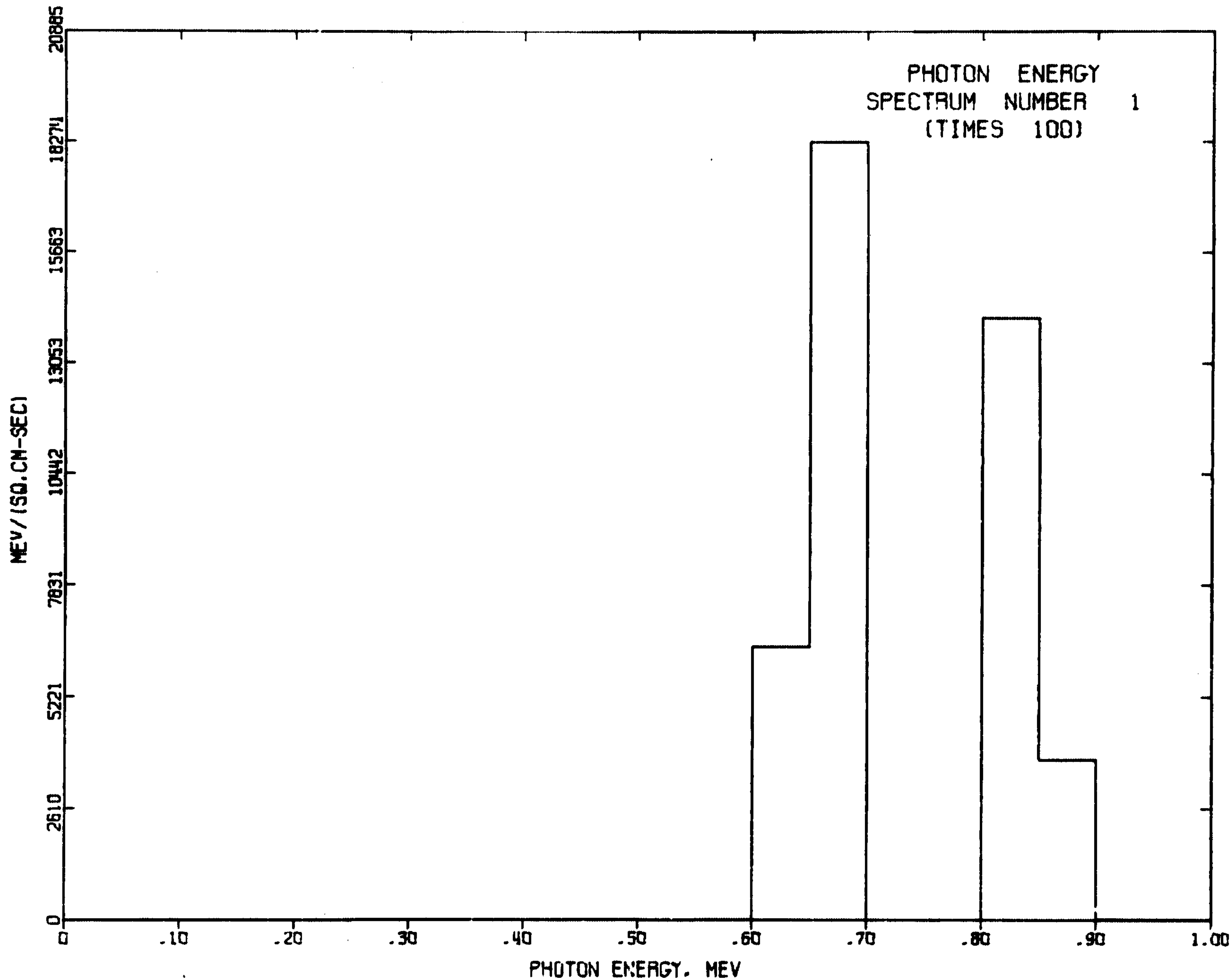


FIGURE 8

MONOENERGETIC ENERGY SPECTRUM OF Cs^{137} AND Mn^{54} AFTER ANALYSIS

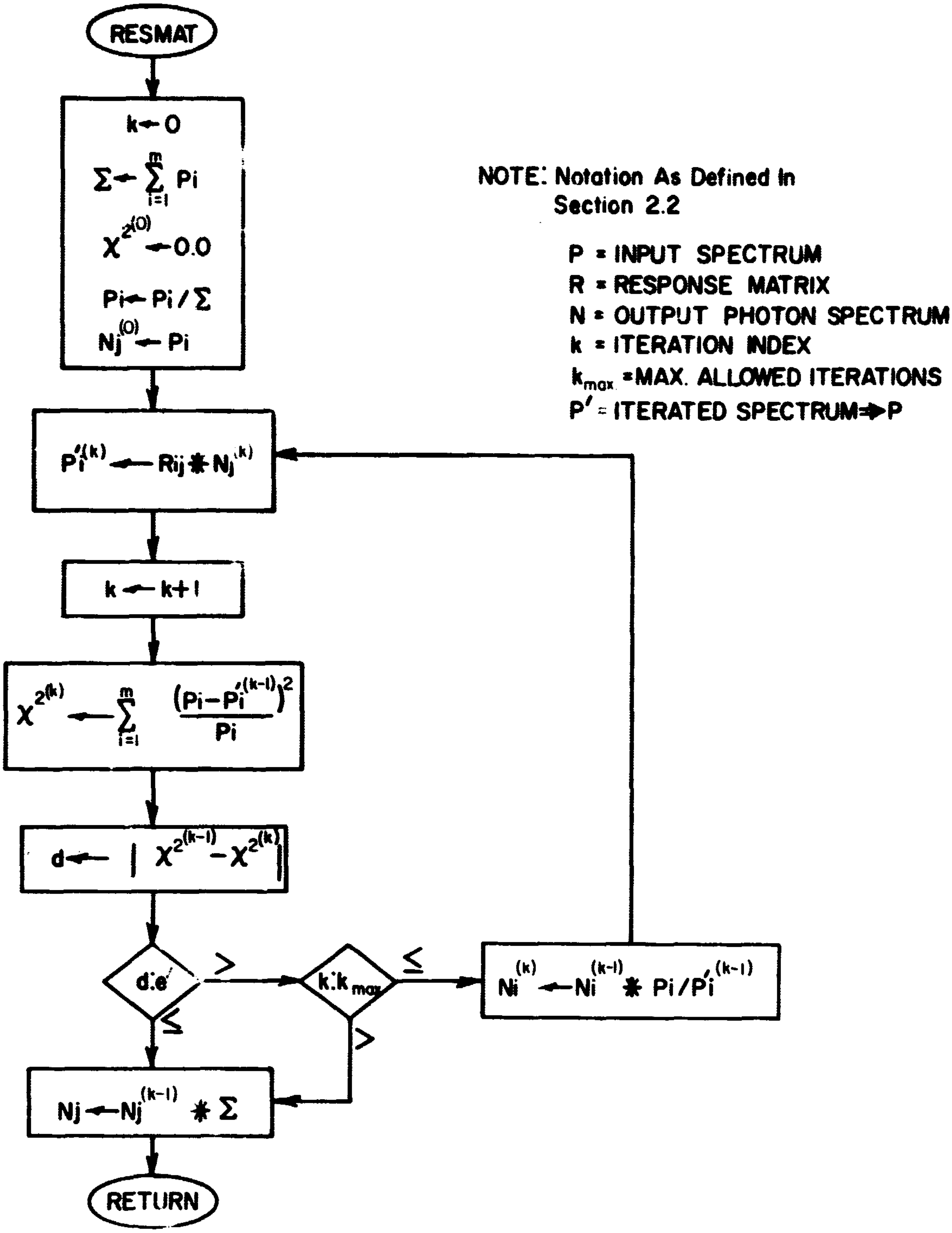
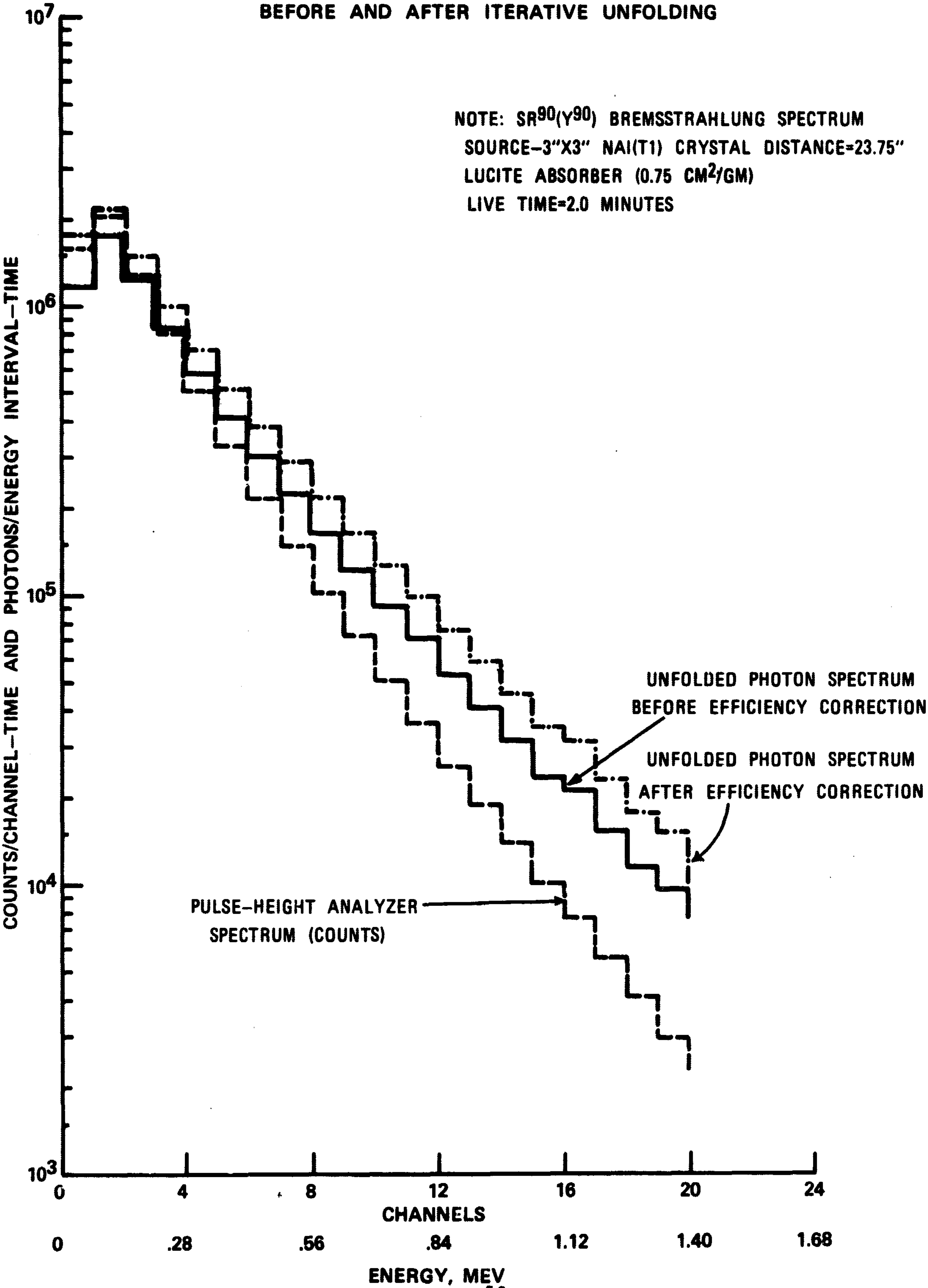


FIG. 9

FLOW DIAGRAM SHOWING THE GENERAL LOGIC OF SUBPROGRAM RESMAT

FIGURE 10 BREMSSTRAHLUNG SPECTRUM BEFORE AND AFTER ITERATIVE UNFOLDING



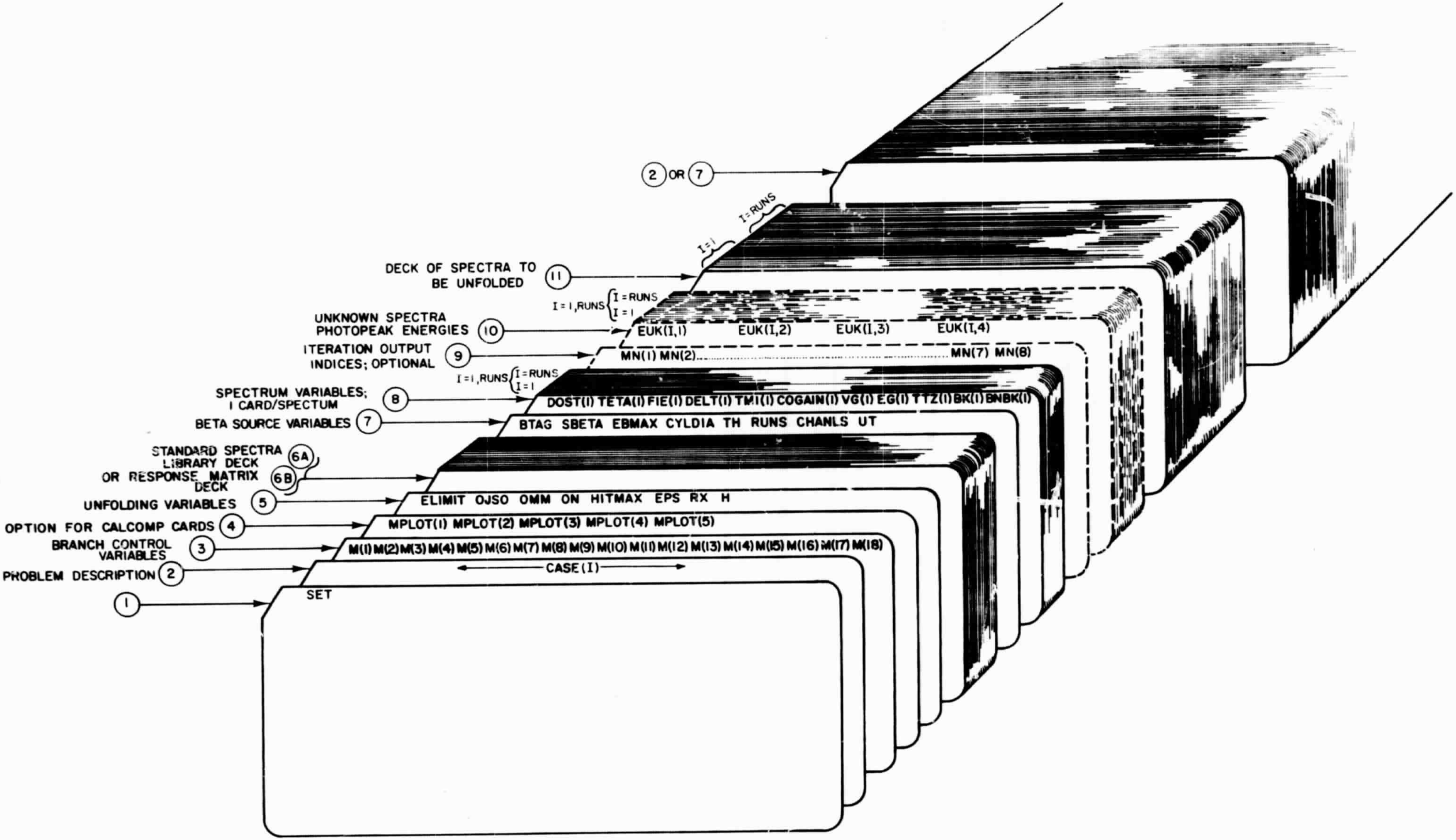


FIGURE 11
ARRANGEMENT FOR INPUT CARD DECK
FOR CODE CUBED-II

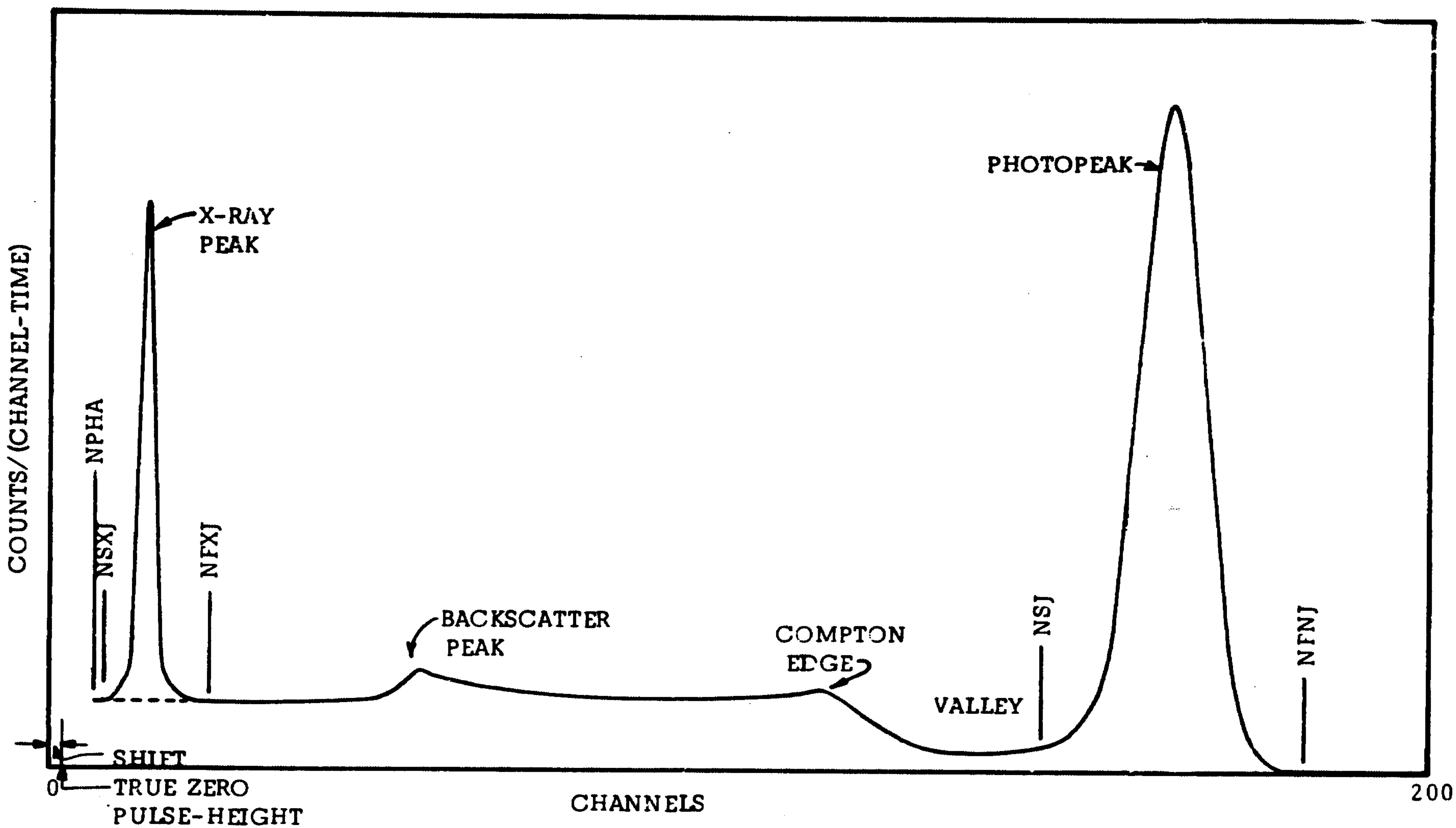


FIGURE 12
FIGURE DEFINING SPECTRAL VARIABLES FOR SUBPROGRAM PHØFRA INPUT

APPENDIX I

GLOSSARY OF PROGRAMS

APPENDIX 1

GLOSSARY OF PROGRAMS FOR CUBED-II

(In alphabetical order, except for MAIN)

NUMBER	NAME	FUNCTION or USE	
1	MAIN	Input, output and linking of subprograms.	
2	AIRABS	Computes air interaction factor.	(F)
3	CLAD	Computes detector cladding absorption factor.	(F)
4	DEC	Reads pulse-height analyzer spectra; checks for PHA-complemented counts	
5	DECAY	Computes decay correction factor.	(F)
6	DØSE	Computes gamma photon dose.	(F)
7	EFFIC	Computes elements of detection efficiency vector.	
8	ENLIN	Applies energy response non-linearity correction.	
9	FC	Crystal interaction efficiency function.	(F)
10	FUNUS	Photopeak function fitted by STDFIT (Gaussian distribution on straight line base).	
11	GANE	Gain changing program; also spectral shifting.	
12	GAUSS	Computes Gaussian photopeak for given parameters.	
13	GEØMTR	Computes geometry factors, integrates number and energy spectra and calculates normalized dose data for final code results.	
14	GUESS	Provides initial estimates of the photopeak function parameters for non-linear regression analysis in subprogram STDFIT.	

15	ØMITS	Code for insertion of repetitive variables omitted on all but first-card of set.	
16	PEAKS	Adds photopeaks and escape peaks and computes photofractions.	
17	PEEK	Computes Gaussian function.	(F)
18	PERSPX	Computes [illegible]spex absorption factor.	(F)
19	PHØFRA	Control program for response matrix generation.	
20	PULSE	Computes the detector system pulse-height for given energy.	
21	RAXEL	Computes NaI (Tl) iodine K X-ray escape fraction.	(F)
22	RESGEN	Orders and normalizes standard spectra for response matrix interpolation.	
23	RESMAT	Pulse-height analyzer spectrum unfolding according to the Scofield algorithm.	
24	SIMPSN	Simpson's rule integrating program for function FC.	(F)
25	SINGLE	Determines monoenergetic spectral contribution.	
26	SØLN	Determines and applies detector efficiency vector.	
27	STDFIT	Non-linear regression analysis of standard spectra photopeaks.	
28	TA	Binary table searching program.	
29	TE	n-degree Lagrangian interpolation program.	(F)
30	VECTMX	Determines the index and value of the maximum valued element in a vector of elements.	

FUNCTION subroutines are donoted by (F).

APPENDIX II

GLOSSARY OF INPUT VARIABLES

APPENDIX 2

GLOSSARY OF INPUT VARIABLES

In Order of FORTRAN Listing Appearance

NAME	DESCRIPTION, PURPOSE OR USE	PROGRAM AND FORMAT STATEMENT NO.
SET	Total number of spectra to be unfolded.	MAIN, 27000
CASE (12)	Seventy-one columns (characters) user remarks.	, 1001
M (18)	Eighteen branching controls	, 1001
MPLØT (5)	Five punch card output options	, 1001
ELIMIT	Energy in meV of upper edge of response matrix highest channel.	, 1001
ØJSØ	The number of spectra to be unfolded for a given set of unknown source data.	, 1001
ØMM	Signal to generate, read or assume as already stored: The system response matrix.	, 1001
ØN	Number of response matrix increments (matrix size: ØN).	, 1001
HITMAX	Maximum number of unfolding iterations desired; an even number unless intermediate unfolding output desired per M(18) and MN(I).	, 1001
EPS	Unfolding convergence tolerance.	, 1001
RX	NaI(Tl) crystal radius (cm.)	, 1001
H	NaI(Tl) crystal length (cm.)	, 1001
R (40,40)	Response matrix (READ when ØMM negative).	, 1966*
K	For low energy analysis the lowest response matrix vectors may be zero because of 10 keV energy cut-off; K is the cut-off index (READ when ØMM negative).	, 6691*
COGAIN(20)	Pulse-height analyzer coarse gain setting for unknown spectrum ($\geq$ 1.0).	, 12000
VG (20)	Monitored or calibrated spectrum; reference pulse-height corresponds to EG (channels).	, 12000

EG (20)	Monitor or calibrating spectrum: reference energy corresponds to VG (meV.).	,	12000
TTZ (20)	Positive or negative channel location of pulse-height analyzer true zero	,	12000
BK (20)	A multiplier applied to background spectra for subtraction operations (addition operations if negative).	,	12000
BNBK (20)	A background subtraction option signal (if zero, no background; if +, subtract existing background; if -, subtract new background).	,	12000
MN (18)	Iteration indices at which intermediate unfolding output desired per M(18) $\neq$ 0.	,	555*
EUK (6,20)	Monoenergetic photopeak energies and X-ray upper and lower channel limits.	,	700*
S(200)	Pulse-height analyzer unknown source and background spectra.	DEC,	3000
NSTAND	The number of spectra in the standard source library deck.	PHØFRA,	6
NPHA	The first NPHA analyzer channels are referred to as "dead" or redundant.	,	6
UNGAIN	Reference coarse gain for standard spectra; used for pulse-height energy relationship.	,	6
ALABEL (9)	Standard source identity	,	6**
NSJ (9)	Fit standard spectrum photopeak from channel NSJ to NFNJ.	,	6**
NFNJ (9)	Fit standard spectrum photopeak from channel NSJ to NFNJ.	,	6**
NSXJ (9)	Subtract-standard spectrum X-ray peak or fit 0.51 meV peak from channels NSXJ to NFXJ.	,	6**
NFXJ (9)	Subtract-standard spectrum X-ray peak or fit 0.51 meV peak from channels NSXJ to NFXJ.	,	6**
SHIFT (9)	True zero pulse-height channel location for standard spectrum: NSJ, NFNJ, NSXJ, and NFXJ adjusted accordingly.	,	6**

R (9, 200)	NSTAND standard radioisotope spectra: 200 channels each.	88**

Numbers in parentheses indicate DIMENSION reserved storage. If none indicated, (1) to be assumed.

*Input according to option signals.

**Numbers in parenthese are three (3) less than DIMENSION, but must not be exceeded.

APPENDIX III

FORTRAN PUNCH CARD DECK LISTING
(SUPERCEDES LISTING IN NUS-315[1])

```
$IBFTC MAIN     DECK,REF,LIST
C  NUS CORPORATION (J.J.STEYN) (1967)
C**********  PROGRAM NUMBER -  1   CUBED-2    ************
C                    *****MAIN PROGRAM*****
C                    **********************
C
C  CODE *CUBED VERSION-2* ....CODE TO UNFOLD BREMSSTRAHLUNG EXPERIMENTAL
C  DISTRIBUTIONS
C  CUBED REQUIRES  *TAPE 2-INPUT*  *TAPE 3-OUTPUT*  *TAPE 4-PUNCH CARDS CALCOMP*
C     CALLS  *DEC* - *DECAY* - *ENLIN* - *GANE* - *GEOMTR*
C     CALLS  *OMITS* - *PHOFRA* - *SINGLE* - *SOLN* - *VECTMX*
C
C  MAIN PROGRAM CONTROLS, INPUTS,OUTPUTS AND CONNECTS SUBPROGRAMS.
C
      COMMON /A/ DI,H,MF
      COMMON /C/ SUMNUM,SUMENY,DOSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
     1 DOSBEX,DOSCYL,DBXVOL,DCYVOL
      DIMENSION DOST(20),CASE(12),M(18),R(40,40),Q(200),TETA(20),FIE(20)
     1,          DELT(20),EG(20),VG(20),TM1(20),TTZ(20),COGAIN(20),
     2   FM(200),PHI(200),ETA(200),PFRACT(50),  PV(50), DIF(100),
     3MN(18),B(200),ENXTAL(200),BNBK(20),EUK(6,20),EU(6),ELG(4),
     4 PHOT(4),BK(20),PP(200)
     5           ,MPLOT(5),TITLE(12),TN(40),VEC(200),TITE(12)
      REWIND 4
      IG=1
      DATA (TITLE(I),I=1,12)/6H  RESP,6HONSE V,6HECTOR ,2H  ,3*6H      ,
     12H  ,3*6H      ,2H  /
      DATA (TN(I),I=1,40)/2H 1,2H 2,2H 3,2H 4,2H 5,2H 6,2H 7,2H 8,2H 9,
     12H10,2H11,2H12,2H13,2H14,2H15,2H16,2H17,2H18,2H19,2H20,2H21,2H22,
     22H23,2H24,2H25,2H26,2H27,2H28,2H29,2H30,2H31,2H32,2H33,2H34,2H35,
     32H36,2H37,2H38,2H39,2H40/
      DATA (TITE(I),I=1,12)/6H   PHO,6HTON  E,6HNERGY ,2H  ,6HSPECTR,
     16HUM  NU,6HMBER  ,2H  ,6H    (T,6HIMES  ,6H100)  ,2H  /
C
C
      MRPEAT=0
      MF=0
      DI=30.48
      MM=1
      NS=1
      KK=0
      NDEGRE=2
      NGU=1
      NGD=1
      NGE=1
```

```
      NGR=1
      NGC=1
      NGX=1
      NGA=1
      NGL=1
      TKLLC=0.750
      DIF(1)=0.0
C  SET =NUMBER OF TIMES PROGRAM WILL CALL *SOLN* (I.E. INVERSION)
      READ (2,27000)  SET
27000 FORMAT (F10.5)
C  CASE(I)=72 COLUMNS OF REMARKS FOR INPUT/OUTPUT PER EACH PASS THRU 1.
C  M(3) TO M(?8) NORMALLY ZERO (OR BLANK)
C  M(1)=SIGNAL TO EXIT/CONTINUE/LOOPBACK, AFTER *PHOTO*
C  M(2)=SIGNAL TO CORRECT FOR SOURCE DECAY IF =0 , ELSE FACTOR = 1.0
C  M(3)=SIGNAL TO CALL *GANE* IF =0  (FOR ENERGY CORRESPONDENCE)
C  M(4)=SIGNAL TO WRITE THE ENERGY-CORRESPONDING SPECTRUM IF = 0
C  M(5)=SIGNAL TO UNFOLD SPECTRA IF = 0 , ELSE BY-PASS
C  M(6)= SIGNAL TO WRITE PHI(I) AFTER *SOLN* IF NCT = 0 (NO DECAY CORRN)
C  M(7)=SIGNAL TO OUTPUT FITTING DIFFERENCES DIF(I) IF NCT = 0
C  M(8)=SIGNAL TO WRITE DECAY CORRECTED PHA SPECTRUM IF NCT = 0
C  M(9)=SIGNAL FOR FINAL RESULTS (SKIP/ALL/INTEG ONLY) PER (-/0/+)
C  M(10)=SIGNAL TO WRITE RESP. MATRIX R(I,J) AFTER *PHOTO* IF =0
C  M(11)=SIGNAL TO CALL *GEOMTR* IF =0
C  M(12)=SIGNAL TO WRITE NUMBER FLUX IF =0
C  M(13)=SPARE
C  M(14)=SPARE
C  M(15)=SIGNAL THAT UNKNOWNS CONTAIN BREMSS+PEAKS (IF NCT=0)
C  M(16)=SIGNAL TO RE-USE EXISTING STAND. SPECTRA FOR NEW RESP. MATRIX
C  M(17)=SIGNAL TO CALL *SOLN* FOR ETA(I) ONLY,.  (NO UNFOLDING)
C  M(18)=SIGNAL TO READ CARD OF MN(I) FOR INTERMED.ITER. OUTPUT IF NCT=0
C  MPLOT(1)=OUTPUT ON CARDS THE GENERATED RESPONSE MATRIX VECTORS CALCOMP PLOT
C  MPLOT(2)=OUTPUT ON CARDS THE CODE DETERMINED ENERGY SPECTRA FOR CALCOMP PLOT
C  MPLOT(3)=SPARE OPTION SIGNAL
C  MPLOT(4)=SPARE OPTION SIGNAL
C  MPLOT(5)=NUMBER OF SPECTRA OUTPUT ON CARDS FOR INPUT TO CALCOMP PLOTTING CODE
C  ELIMIT=ENERGY IN MEV OF UPPER LIMIT OF RESP. MATRIX HIGHEST CHANNEL
C  OJSO=NUMBER OF SIMILAR SETS OF DATA BEFORE LOOPING TO STATEMENT 1.
C  OMM=SIGNAL TO READ/ASSUME EXISTS/GENERATE RESPONSE MATRIX PER -/0/+
C  ON=NUMBER OF CHANNELS IN RESPONSE MATRIX, IF =0 CODE SETS TO 20
C  HITMAX=MAX NUMBER OF ITERATIONS FOR *RESMAT*.  ALSO A SIGNAL TO OUTPUT
C  IF HITMAX=0 CODE SETS TO 50.0
C  FITTING DATA WHILE ITERATING AT LOOP INDEX MN(I).... FOR ITMAX=ODD
C  NUMBER
C  EPS=CONVERGENCE TOLERANCE CHOSEN FOR ITERATIVE FITTING
C  IF EPS=0, CODE SETS TO 0.0001
```

```
C  RX=NAI(TL) CRYSTAL RADIUS, IF =0 CODE SETS TO 3.81 CM.
C  H= NAI(TL) CRYSTAL LENGTH, IF =0 CODE SETS TO 7.62 CM.
C  ON,HITMAX,EPS,RX,H NORMALLY BLANK
    1 READ    (2,1001)  (CASE(I),I=1,12),(M(I),I=1,18),(MPLOT(I),I=1,5),
     1ELIMIT,OJSC,OMM,ON,HITMAX,EPS,RX,H
 1001 FORMAT (12A6/18I4/5I4/6F10.5,2F6.4)
C  INPUT CHECKING
      JSC=OJSC
      MM=OMM
      IF(ON)7709,7708,7709
 7708 ON=20.0
 7709 N=ON
      IF(HITMAX)8809,8808,8809
 8808 HITMAX=50.0
 8809 IF(EPS)9909,9908,9909
 9908 EPS=.0001
 9909 ITMAX=HITMAX
      IF(RX)10009,10008,10009
10008 RX=3.81
10009 IF(H)11009,11008,11009
11008 H=7.62
11009 EN=N
      EM=EN/ELIMIT
      DXX=2.0*RX/2.54
      HXX=H/2.54
      WRITE   (3,4001) (CASE(I),I=1,12),(I,M(I),I=1,18)
 4001 FORMAT (1H1,30H BRIEF DESCRIPTION OF PHA RUNS   /1X,A5,11A6//
 400116H CONTROL NUMBERS    /(6(3H M(,I2,4H) = I2,1X)))
      WRITE(3,90)(I,MPLOT(I),I=1,5)
   90 FORMAT ( 41HOCALCOMP PLOTTING OPTION CONTROL NUMBERS  /5(7H MPLOT(
     1,I2,4H) = ,I2,1X))
      WRITE (4,5555) MPLOT(5)
 5555 FORMAT(1X,I2)
      WRITE   (3,4002) EM,ELIMIT,EPS,JSC,MM,ITMAX,N,DXX,HXX
 4002 FORMAT (    6HOEM =    ,F10.5,14H CHANNELS/MEV  /9HOELIMIT= ,F10.5/
 400213 3HOITERATIVE ERROR TOLERANCE,EPS = ,F10.5/36HONUMBER OF BETA SOUR
 40022CE SETS,OJSC =  I3,5X,5HMM = ,I3/33HOMAX NUMBER OF ITERATIONS,ITMA
 40023X= ,I3,5X/30HONUMBER OF CHANNELS INPUT, N =  ,I3/
 40024  25HONAI(TL) CRYSTAL SIZE =    F4.2,3H X ,F4.2,9H INCHES.   /1H1)
      JS=1
      IF(MM)120,21234,12
21234 IF(M(16))21244,2,21244
21244  MRPEAT=M(16)
      GO TO 12
C
```

```
C   IF OMM IS NEG. THEN READ RESP. MATRIX, R(I,J)
C   ALSO READ K,Q(I), AND PV(I)
C   K=INDEX OF RESP. MATRIX HIGHEST ZERO VECTOR
C   Q=INCREMENT MID-POINT ENERGIES IN MEV (CORRESP. TO PV)
C   PV=CHANNEL MID-POINT PULSE-HT. VALUES CORRESP. TO Q
C
  120 READ (2,1966) ((R(I,J),I=NS,N),J=NS,N)
 1966 FORMAT (1X,5E14.7                    )
      READ    (2,6691) K, (Q(I),I=1,N),(PV(I),I=1,N)
 6691 FORMAT (I5/(5F10.5))
      GO TO 121
C
   12 CALL PHOFRA (R,N,EM,ELIMIT,NGO,NGR,   NDEGRE,Q,PV,PFRACT,K,MRPEAT
   121,0.0,PP)
C
      NP=N
  121 META=8
      MSKIP=1
      IF( M(10) )14,13,14
   13 WRITE   (3,2001)((R(I,J),I=NS,N),J=NS,N)
 2001 FORMAT (//34H1SYSTEM RESPONSE FUNCTION MATRIX  //(10E11.4))
 2009 FORMAT (1H1)
      WRITE   (3,2009)
      IF(MPLOT(1))91,14,91
   91 NOV=N
      XZ=10.0
      IDX=1
      IDY=2
      EMAXE=0.0
      BIG=0.0
      DO 92 I=1,N
      DO 92 J=1,N
      VEC(J)=R(I,J)
   92 CALL VECTMX(VEC,1,NOV,JMAX,BIG)
      BIG=BIG*10000.0
      DO 93 I=1,N
      DO 97 J=1,N
      VEC(J)=R(I,J)*10000.0
   97 CONTINUE
      TITLE(4)=TN(I)
      WRITE (4,404)(TITLE(ICOM),ICOM=1,12),NOV,IDX,IDY,EMAXE,XZ,BIG,(VEC
     1(ICAL),ICAL=1,NOV)
  404 FORMAT(3A6,A2,3A6,A2,3A6,A2/1X,3I5,3E15.8/(1X,5E14.7))
      IG=IG+1
      IF(IG-MPLOT(5))4445,4446,4446
```

```
 4446 END FILE 4
      ENC FILL 4
      DC 7777 IR=1,4
 7777 MPLCT(IR)=C
      GC TC 14
 4445 CCNTINUE
   93 CONTINUE
   14 WRITE   (3,2C00) (Q(I),I=NS,N)
 2CCO FCRMAT(49H REPCNSE MATRIX ENERGY INTERVAL MICPCINTS IN MEV
 2CCC1  //(10F7.4))
      WRITE   (3,9876)  (PV(I),I=NS,N)
 9876 FCRMAT (/////37H PULSE-HEIGHT IN CHANNELS (MICPCINTS) //(1CF7.2))
      WRITE   (3,2C09)
      IF( M(1) )3CCC,16,15
   15 CALL EXIT
 3CCO GC TC 1
   16 MM=C
      NGE=1
C BTAG IS LABEL (EG. GA-7C) OF BETA SCLRCE
C  SBETA=NLMBER BETA/SEC CF ENERGY EBMAX (IN CURIES) FRCM SCURCE WITH
C  RESPECT TC A REFERENCE CATE ANC TIME.
C  EBMAX=SCLRCE MAXIUM BETA ENERGY (MEV)
C  CYLDIA=CIAMETER OF BETA SOLRCE CYLINDER(=LENGTH) IN CENTIMETERS
C  TH=BETA SOLRCE HALF-LIFE IN UNITS CF SECCNDS,MINUTES,HCURS,CAYS
C  ,YEARS MLLTIPLIED BY UT(BELOW)TC CCNVERT TC MINUTES.
C  RUNS=NLMBER OF PHA-RLNS PER SET (E.G. PER BETA SCLRCE)
C  CHANLS=NLMBER CF CHANNELS IN EACH SPECTRUM CF SET (=200 IF
C  NCT SPECIFIED)
C  UT=NLMBER CF TIME UNITS (EG. HCURS/CAY IF TH IN HCURS)
C  ,IE.MUST BE O.C (TH IN YEARS), 1.0 (TH IN SECCNDS), 6C.0 (TH IN
C  MINUTES), 24.C ( TH IN HCURS), 365.C (TH IN DAYS)
C  E.G. IF TH IS 64 HOURS THEN LT=24.0
    2 REAC    (2,2C000)BTAG,SBETA,EBMAX,CYLDIA,TH,RUNS,CHANLS,LT
2CCCO FCRMAT (A6,4X,5F1C.5,2F6.C)
      NX=CHANLS
      NRUN=RUNS
C  HALF-LIFE CHECK
      IF(LT)41,40,41
   40 UT=365.25*1440.
      TH=TH*UT
      GC TC 5C
   41 IF(LT-1.)43,42,43
   42 TH=TH/6C.
      GC TC 5C
   43 IF(LT-6C.)44,50,44
```

```
   44 IF(LT-24.)46,45,46
   45 TH=TH*6C.
      GC TC 5C
   46 IF(LT-365.)48,47,48
   47 TH=TH*1440.
      GC TC 5C
   48 WRITE   (3,49) LT
   49 FCRMAT (35H HALF-LIFE FACTCR ...ERRCR... UT =  F10.5, 6H EXIT  )
      GC TC 15
   5C CCNTINUE
      WRITE   (3,128)  BTAG,SBETA,EBMAX,CYLCIA,TH,NRUN,NX,UT
  128 FORMAT (1H1, 90H    BETA    SCURCE    MAX BETA    SCURCE    SCURCE
  1281NUMBER CF    NUMBER     HALF-LIFE              /90H    SCURCE STRENG
  1282TH   ENERGY   DIAMETER HALF-LIFE  PHA RUNS   CF CHANNELS  MULTIPLI
  1283ER            /80H             (CURIES)    (MEV)      (CM.)  (MINUTES)
  1284  THIS SET   PER SPECTRUM        //4X,A6,3F10.4,E11.4,I6,7X,I4,3X,
  1285  E11.4//////////)
      SBETA=SBETA*3.7E+10
C  INCEXEC INPUT (I=1 TO NRUN)
C  CODE INSERTS FCR INDEX I GREATER THAN 1 IF VALUE SAME AS FCR
C  I=1, FCR VARIABLES DELT, TM1, CCGAIN, VG, EG, TTZ.
C  DCST=DISTANCE FRCM SCURCE GEOMETRIC CENTRE TO CRYSTAL FRONT-FACE (CM.)
C  DELT=DURATION CF PHA-CCUNTING IN MINUTES
C  FIE=AZIMUTH ANGLE AT SCURCE,CF CRYSTAL-AXIS (DEGREES)
C  TETA=PCLAR ANGLE AT SOURCE,OF CRYSTAL AXIS (DEGREES)
C  TM1=TIME DURATICN FROM REFERENCE-TIME TC START CF CCUNTING IN DAYS
C  CCGAIN=CCARSE GAIN SETTING CF PHA (EG. 8.)
C  VG AND EG ARE PULSE-HT AND ENERGY CF REFERENCE MONITCR PHCTCPEAK
C  VG CHANNELS ANC EG MEV
C  TTZ=THE NUMBER CF CHANNELS FROM TRUE-ZERC TC LOWER EDGE CF CHAN 1.
C  BNBK ANC BK=NBK AND BKGD (SEE BELOW) (ARE BACKGROUND SIGNALS)
      DO 5CC7 I=1,20
      DCST(I)  =C.C
      TETA(I)  =C.C
      FIE(I)   =C.C
      DELT(I)  =0.0
      TM1(I)   =0.C
      CCGAIN(I)=C.C
      VG(I)    =C.C
      EG(I)    =0.C
      BK(I)    =C.C
      TTZ(I)   =C.C
 5CC7 BNBK(I)  =C.C
      READ   (2,12CC0)(DCST(I),TETA(I),FIE(I),DELT(I),TM1(I),CCGAIN(I),
     1 VG(I),EG(I),TTZ(I),BK(I),BNBK(I),I=1,NRUN)
```

```
12000 FORMAT (10F7.3,F2.0)
      IF(NRUN-1)5008,5008,5009
 5009 CALL CMITS(NRUN,DELT   )
      CALL CMITS(NRUN,TM1    )
      CALL CMITS(NRUN,COGAIN)
      CALL CMITS(NRUN,VG     )
      CALL CMITS(NRUN,EG     )
      CALL CMITS(NRUN,TTZ    )
 5008 CONTINUE
      WRITE   (3,127) (DIST(I),TETA(I),FIE(I),DELT(I),TM1(I),COGAIN(I),
     1 VG(I),EG(I),TTZ(I),BK(I),BNBK(I),I=1,NRUN)
  127 FORMAT (1H0,104H  SOURCE   CRYSTAL ANGLE  COUNTING  REFERENCE   PH
 1271A   MONITOR   MONITOR SPECTRA   BACKGROUND BACKGROUND
 1272/104H  CRYSTAL    AT SOURCE     DURATION    TIME     COARSE  PULSE-
 1273    ENERGY   ZERO       SIGNAL     MULTIPLIER
 1274/85H DISTANCE    (DEGREES)    (MINUTES)   (DAYS)    GAIN   HEIGHT
 1275   (MEV)     SHIFT                       /85H  (CM.)     POLAR  AZIMUTH
 1276                                  (CHANNELS)           (CHANNELS)
 1277///(2X,      4F8.3,2X,F8.2,3X,F5.2,1X,3F9.4,2F11.4))
      WRITE   (3,2009)
C
C  IF M(18) NOT=0,READ INDICES MN(I) OF ITERATION INTERMED. OUTPUT
C
      IF(M(18))333,444,333
  333 READ    (2,555)  (MN(I),I=1,18)
  555 FORMAT (18I4)
      WRITE   (3,556)  (MN(I),I=1,18)
  556 FORMAT (53H1ITERATING OUTPUT ON ITERATION LOOPS NUMBERED BELOW
 5561///(1X,5I10))
      WRITE   (3,2009)
  444 IF(NX)9111,1119,9111
 1119 NX=200
 9111 ROGAIN=EN
      IF(M(15))770,771,770
C
C EUK(I,1)=ONE TO 4 PEAK ENERGIES (MEV) FOR J=1
C EUK(I,2)=ONE TO 4 PEAK ENERGIES (MEV) FOR J=2
C EUK(I,3)=ONE TO 4 PEAK ENERGIES (MEV) FOR J=3
C          -------------------   ETC.  ------------------
C
  770 READ (2,700) ((EUK(I,J),I=1,6),J=1,NRUN)
  700 FORMAT (6F10.5)
      WRITE (3,701) ((EUK(I,J),I=1,4),J=1,NRUN)
  701 FORMAT (35H1 ENERGIES IN MEV OF UNKNOWN PEAKS   ///(1X,4F10.4))
  771 CONTINUE
```

```
C
C MAIN EXECUTION LOOP FROM HERE
C
      DO 500 J=1,NRUN
      GAIN=VG(J)*ELIMIT/EG(J)
      DIST=DOST(J)
      DT=DELT(J)
      TM=TM1(J)
      BKGD=BK(J)
      NBK=BNBK(J)
      N=NX
      JJ=J
      CLAMDA=ALOG(2.0)/TH
C
C  READ SPECTRA
C  BKGD=MULTIPLIER FOR BACKGROUND ADDITION/SUBTRACTION OPERATIONS
C  NBK=SIGNAL                  SUBT/NOT READ/ADD A BACKGROUND PER -/0/+
C  IF NBK =0 NEITHER READ NOR SUBTRACT A BACKGROUND.
C  IF NBK  NEG. THEN SUBTRACT THE CURRENT EXISTING BACKGROUND.
C  IF NBK  POS THEN READ AND SUBTRACT BKGD*BACKGROUND.
C
C  SPECTRA READ AND COMPLEMENTED BY *DEC*
C
      CALL DEC (NX,FM)
      IF(NBK)6,22222,11
   11 CALL DEC (NX,B)
    6 DO 3 I=1,NX
    3 FM(I)=FM(I)-BKGD*B(I)
22222 CONTINUE
      WRITE (3,25123) JJ,BTAG,(FM(I),I=1,200)
25123 FORMAT(1H1,17H SPECTRUM NUMBER    ,I3,5H FOR ,A6,8H SOURCE        //
25123133H  (AFTER BACKGROUND SUBTRACTION)    //(1X,10F8.0))
      IF(M(3))9,8,9
    8 TZ=TTZ(J)
      SM=0.0
      IF(M(15))773,778,773
  773 DO 774 I=1,6
  774 EL(I)=ELK(I,J)
      DO 775 I=1,4
      IF(EL(I))776,777,776
  777 IN=I-1
      GO TO 1778
  776 CONTINUE
  775 CONTINUE
 1778 CONTINUE
```

```
C  CALL *GANE* TC SHIFT FCR SPECTRAL ANALYSIS IN *SINGLE*.
C
      CALL GANE (TZ,N,1.0,1.0,SM,FM)
C
   32 CC 34 I=1,IN
      ELX=EL(I)
      CELV=PULSE(ELX,NGC,NDEGRE)
   34 ELG(I)=EL(I)*GAIN*(1.C+CELV)
C
C     WRITE(3,22333)N,NX,NGC,NGA,NGX,NGC,NGR,NDEGRE,K,NF,IN,
C    1(EL(I),I=1,IN),(ELG(I),I=1,IN),(FM(II),II=1,N)
C2233 FCRMAT(13H1MAIN/EL,FM  /1X,11I4/1X,4E14.7/(1X,10F8.C))
   36 CALL SINGLE (FM,ELG,EL,N,NGC,NGA,NGX,NGC,NGR,NCEGRE,TKLLC,EM,
   361  ELIMIT,G,PV,PFRACT,K, RX,   ENY,IN,NP,PHCT,NGE)
C  MAKE SPECTRUM CCMPATIBLE IN GAIN WITH RESP MATRIX
C
  778 CALL GANE (TZ,N,GAIN,RGGAIN,SM,FM)
C
      IF(M(4))8851,9,8851
 8851 WRITE   (3,8852) N,      GAIN,RGGAIN,(FM(I),I=1,N)
 8852 FCRMAT (1H1,32H INPUT SPECTRUM GAIN CHANGED TC     ,I5,9H CHANNELS
 88521/22H  GAIN CHANGE RATIO =   ,F10.5,1H/ ,F10.5     ///(1X,5E14.7))
    9 IF(M(5))124,1C,124
  124 IF(M(17))11C,21,110
  110 MF=1
      MSKIP=1
      CALL ENLIN (N,FM,EG,VG,NGL,JJ,NGC,C)
      WRITE (3,1CC)  N,(FM(I),I=1,N)
  1CC FCRMAT (24H1LINEARIZEC SPECTRUM CF  ,I4,2X,10H CHANNELS  //(1X,10F
  1C018.0))
   10 KK=KK+1
C
      CALL SOLN (R,EPS,N,IT,ITMAX,FM,PHI,Q,NS,NGE,NDEGRE,ETA,K,CIF,MN,
     1  DIST,RX,NGA,NGC,MSKIP,NGX,TKLLC,ELIMIT)
C
      WRITE (3,2CC9)
      MSKIP=0
      NSET=SET
      PRINT 9999,KK,NSET
 9999 FCRMAT (1H0,33H OPERATOR......FINISHING PROBLEM   I5, 3H CF,I5)
      IF(MF)122,79,122
  122 WRITE   (3,126)  (PHI(I),I=1,N)
  126 FCRMAT (1H1,40H PHA SPECTRUM CCRRECTED FCR EFFICIENCY  /(5(2X,E12.
  12615)))
      GC TC 21
```

```
   79 IF(M(15))179,125,179
  179 DO 70 JN=1,IN
      CY=EL(JN)*EM
      I=CY
      CIY=I
      IF((CY-CIY)-.5)71,71,72
   72 IF(I-N)76,77,75
   77 NJ=N
      GO TO 78
   76 I=I+1
      CIY=I
      GO TO 74
   71 IF(I)73,73,74
   73 NJ=1
   78 PHI(NJ)=PHI(NJ)+PHOT(JN)
      GO TO 75
   74 OIY=CIY-CY+0.5
      TWO=1.0-OIY
      PHI(I)=PHI(I)+PHOT(JN)*CIY
      PHI(I+1)=PHI(I+1)+PHOT(JN)*TWO
   75 CONTINUE
   70 CONTINUE
  125 IF( M( 6) )20,1421,20
   20 WRITE (3,2020) IT,
  201   (PHI(I),I=NS,N)
 2020 FORMAT ( 41H0DIFFERENTIAL FLUX AT ITERATION NUMBER =    ,I5/
 20201    (5(2X,E12.5)))
 1421 IF(M(7))1423,21,1423
 1423 WRITE    (3,1424) (DIF(I),I=1,IT)
 1424 FORMAT (30H FITTING DIFFERENCES              /(1X,5E14.7))
   21 IF(M(2))800,801,800
  800 DE=1.0
      GO TO 802
  801 DE=DECAY(    DT,TH,TM,CLAMDA)
  802 CONTINUE
10021 IF( M( 8) )81,99,81
   81 WRITE    (3,2025) N,(FM(I),I=NS,N)
 2025 FORMAT (1H1,16HSINGLE SPECTRUM        ,I5,10HCHANNELS  /(10F7.0))
   99 IF(M(11))500,24,500
C
   24 CALL GEOMTR (DIST,SBETA,DE,PHI,C,NS,N ,EBMAX,NGO,NDEGRE,RX,DT,VOL,
  241   CYLDIA,ENXTAL)
C
      IF(M(9))8888,25,500
   25 IF(M(12))8882,8881,8882
```

```
8881 WRITE(3,8890)(I,Q(I),PHI(I),ENXTAL(I),I=NS,N)
8890 FORMAT (44H1NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL        ///
88901 19H INCREMENT   ENERGY,13X,11HNUMBER FLUX,13X,11HENERGY FLUX/
88902 13X,5H(MEV),10X,19H(PHOTONS/CM**2-SEC),7X,15H(MEV/CM**2-SEC)//
88903 (1X,I6,3X,F10.5,10X,E14.7,10X,E14.7))
8882 CONTINUE
     IF(MPLOT(2))96,8888,96
  96 NCV=N
     XZ=10.0
     IDX=2
     IDY=4
     EMAXE=ELIMIT
     DO 197 I=1,200
 197 VEC(I)=0.0
     DO 98 I=1,NCV
  98 VEC(I)=ENXTAL(I)*100.0
     TITE(8)=TN(KK)
     WRITE(4,404)(TITE(ICOM),ICOM=1,12),NCV,IDX,IDY,EMAXE,XZ,BIG,(VEC(
    1ICAL),ICAL=1,NCV)
     IG=IG+1
     IF(IG-MPLOT(5))4447,4448,4448
4448 END FILE 4
     END FILE 4
     DO 6666 IR=1,4
6666 MPLOT(IR)=0
4447 CONTINUE
  94 CONTINUE
8888 WRITE (3,8892)
8892 FORMAT (42H1INTEGRATED RESULTS AT SOURCE AND CRYSTAL  ///
88921 58H ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL // )
     WRITE (3,8895)  SUMNUM,SUMENY,DOSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
    1 DOSBEX,DBXVOL
8895 FORMAT (37H0PHOTON NUMBER (PHOTONS/CM**2-SEC) = ,E14.7/37H PHOTON
88951ENERGY (MEV/CM**2-SEC)      = ,E14.7/37H PHOTON DOSE   (ROENTGENS/H
88952OUR)     = ,E14.7//24H AVERAGE ENERGY (MEV) = ,E14.7//77H PHOTON NU
88953MBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) =
88954 ,E14.7/77H PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2
88955-SEC)/MEV)           = ,E14.7/77H PHOTON ENERGY / SOURCE EMITTED BE
88956TA NUMBER (MEV/CM**2-SEC)/(BETA/SEC)      = ,E14.7/77H PHOTON DOSE
88957  / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)               = ,
88958 E14.7/92H PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE V
88959OLUME (((R/HR)/(BETA/SEC))/CM**3) = ,E14.7////)
     WRITE   (3,8891) DOSCYL,DCYVOL
8891 FORMAT (25H AT THE SOURCE CYLINDER      //
88911 77H PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)
```

```
 88912             = ,E14.7//92H PHCTCN DOSE    / SCLRCE EMITTEC BETA NUM
 8E913BER PER SCURCE VCLUME (((R/HR)/(BETA/SEC))/CM**3) = ,E14.7)
  5C0 CCNTINLE
      IF( META )129,60,129
  129 WRITE   (3,6C00)  (ETA(I),I=NS,N)
 6C00 FCRMAT (1H1,22H EFFICIENCY VECTCR ETA            /(1X,5E14.7))
      META=C
   60 IF(JS-JS0)61,1,61
   61 JS=JS+1
      GO TC 2
      END
$IBFTC AIRA     DECK,REF,LIST
      FLNCTION AIRABS (E,NGC,N,CIST)
C**********  PROGRAM NUMBER -  2   CUBED-2   ************
C
C     CALLED BY  *SOLN* - *SINGLE*
C     CALLS  *TA* - *TE*
C     CCMPLTES AIR INTERACTICN FACTCR.
C
      DIMENSICN X(22),R(22),Z(6),Y(6)
      GC TC (1,2),NGC
    1 NGO=2
      X(1)=.01
      DC 1C I=2,1C
   10 X(I)=X(I-1)+.C1
      DC 12 I=11,19
   12 X(I)=X(I-1)+.1
      X(2C)=1.5
      X(21)=2.0
      X(22)=3.C
      DATA(R(I),I=1,22)/4.97,.749,.347,.243,.2C3,.185,.174,.166,.16C,
     1.155,.123,.106,.0953,.0868,.0804,.C750,.C706,.C668,.C635,.C517,
     2.C445,.C357/
      M=22
      LCW=1
      DC 3 I=LCW,M
    3 R(I)=R(I)*.CC1293
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,R,N,L,C)
      NN=N+1
      AERMEW=TE (NN,Z,Y,E)
      AIRABS=EXP(-AERMEW*CIST)
      RETLRN
      END
$IBFTC CLAC     CECK,REF,LIST
      FLNCTICN CLAC (E,NGC,N)
```

```
C**********  PRUGRAM NLMBER -  3   CUBEC-2   ************
C
C      CALLEC BY  *SCLN* - *SINGLE*
C      CALLS  *TA* - *TE*
C      CCMPLTES DETECTCR CLACDING ABSCRPTICN FACTCR.
C
       DIMENSICN X(28),R(28),Z(6),Y(6)
       GC TC (1,2),NGC
     1 NGC=2
       X(1)=.01
       DC 10 I=2,9
    10 X(I)=X(I-1)+.C025
       DC 11 I=10,16
    11 X(I)=X(I-1)+.01
       DC 12 I=17,25
    12 X(I)=X(I-1)+.10
       X(26)=1.5
       X(27)=2.0
       X(28)=3.0
       DATA(R(I),I=1,28)/.C0396,.0590,.192,.355,.497,.6C5,.69C7,.748,
      1.7925,.8891,.9253,.941,.9495,.9542,.9572,.9598,.9694,.9736,.9763,
      2.9784,.9800,.9812,.9824,.9833,.9841,.9871,.9888,.9909/
       M=28
       LCW=1
     2 CALL TA (E,X,M,LCW,MOX,MUN,Z,Y,R,N,L,C)
       NN=N+1
       CLAC=TE (NN,Z,Y,E)
       RETLRN
       END
$IBFTC DEC     DECK,REF,LIST
       SUBRCLTINE DEC (NX,S)
C**********  PROGRAM NUMBER -  4   CUBEC-2   ************
C
C      CALLED BY  *MAIN*
C      READS PULSE-HEIGHT ANALYZER SPECTRA,  CHECKS FOR PHA-CCMPLEMENTED CCUNTS.
C
       DIMENSICN S(2CC)
       READ          (2,3COO)(S(I),I=1,NX)
  3CCO FCRMAT (10(F6.0,1X))
       DC 4 I=1,NX
       IF(S(I)-90CCCO.)5,5,6
     6 S(I)=S(I)-1CCCCCO.
     5 CONTINUE
     4 CCNTINUE
       RETLRN
```

```
      END
$IBFTC DECA    DECK,REF,LIST
      FLNCTICN DECAY (  DT,TH,T1,    CLAMCA )
C**********  PROGRAM NUMBER -  5   CLBED-2   ************
C
C     CALLED BY  *MAIN*
C     COMPLTES DECAY CORRECTICN FACTOR.
C
      T1=T1*1440.0
      IF( (CT/TH    )  - 0.0C1)2,2,1
    1 T2=T1 + CT
      TE=(-1.C/CLAMCA    )*ALOG ((EXP(-CLAMCA    *T1)-EXP(-CLAMCA    *T2))/
     1  (CLAMCA    *CT))
      GC TC 3
    2 TE=T1 + CT/2.C
    3 DECAY=EXP (CLAMCA    *TE)
      RETLRN
      END
$IBFTC DOSE    DECK,REF,LIST
      FUNCTION DCSE (E,NGC,N)
C**********  PROGRAM NUMBER -  6   CUBEC-2   ************
C
C     CALLED BY  *GECMTR*
C     CALLS  *TA* - *TE*
C     COMPLTES GAMMA PHCTCN DCSE.
C
      DIMENSICN X(20),R(2C),Z(6),Y(6)
      GC TC (1,2),NGD
    1 NGD=2
      X(1)=.010
      X(2)=.015
      X(3)=.02
      DC 7 I=4,7
    7 X(I)=X(I-1)+C.01
      X(8)=.08
      X(9)=.1
      X(1C)=.15
      X(11)=.2
      DC 8 I=12,15
    8 X(I)=X(I-1)+.1
      X(16)=0.8
      X(17)=1.0
      X(18)=1.5
      X(19)=2.0
      X(2C)=3.0
```

```
     1,.02364,.C2321,.02511,.C2681,.C2874,.C2954,.C2966,.C2959,.C2884,
     2.C2794,.02556,.02355,.02C71/
      M=2C
      LCW=1
    2 CALL TA(E,X,M,LCW,MCX,MLN,Z,Y,R,N,L,0)
      NN=N+1
      DCSE=TE (NN,Z,Y,E)*E
   10 RETURN
      END
$IBFTC EFFI    DECK,REF,LIST
      FUNCTION EFFIC (E,NGC,N,CAST,RCX,HH)
C**********  PROGRAM NUMBER -  7   CUBEC-2   ************
C
C     CALLEC BY  *SCLN* - *SINGLE*
C     CALLS  *SIMPSN* - *TA* - *TE*
C     COMPUTES ELEMENTS OF DETECTICN EFFICIENCY VECTCR.
C
      COMMCN /B/ XL,UEGAM,RX,CIST,H
      DIMENSICN X(32),R(32),Z(6),Y(6) ,W(32),V(6)
      DIST=CAST
      H=HH
      RX=RCX
      ARG=RX/(DIST+H)
      EPS=1.0E-06
      LCW=1
C     WRITE (3,1CC)CIST,H,RX,ARG
C 1C0 FORMAT(1X,4E14.7)
      GO TC (1,2),NGO
    1 IF(E-.03316)3,4,4
    4 NGC=2
      X(1)=.03316
      X(2)=.035
      X(3)=C.C40
      DC 6C I=4,14
   60 X(I)=X(I-1)+.010
      DC 7C I=15,27
   70 X(I)=X(I-1)+.C5C
      X(28)=0.90
      X(29)=1.C0
      X(3C)=1.5
      X(31)=2.0
      X(32)=3.0
      DATA(W(I),I=1,32)/3C.4,26.1,18.2,10.1,6.17,4.11,2.86,2.C6,1.57,
     11.23,.990,.814,.678,.568,.305,.2C7,.155,.1278,.111,.099C,.C9C1,
```

```
      2.0839,.C789,.C743,.C710,.C680,.0657,.0611,.0577,.0465,.C412,.0367/
      M=32
      DC 8C I=LCW,M
   80 R(I)=W(I)*3.667
C     WRITE (3,11C)(I,X(I),R(I),I=LCW,M)
C 110 FCRMAT(1X,I5,2E14.7)
      GC TC 2
    3 X(1)=.01
      X(2)=.015
      X(3)=.02C
      X(4)=.025
      X(5)=.030
      X(6)=.0331599
      DATA(V(I),I=1,6)/154.C,48.8C,22.10,11.75,7.310,5.580/
      DC 299 I=7,32
  299 R(I)=C.C
      M=6
      DC 8COI=LCW,M
  8C0 R(I)=V(I)*3.667
C     WRITE (3,11C)(I,X(I),R(I),I=LCW,M)
    2 CALL TA     (E,X,M,LCW,MCX,MUN,Z,Y,R,N,L,C)
      NN=N+1
      UEGAM=TE (NN,Z,Y,E)
C     WRITE (3,120) M,LCW,MCX,MUN,N,L,LEGAM,E
C 12C FCRMAT (1X,6I5,2E14.7)
      IF(ARG-C.C124)6,6,5
    5 A=0.C
      B=ATAN(ARG)
      KL=C
      CASE=SIMPSN(A,B,EPS)
      A=B
      B=ATAN(RX/DIST)
      KL=1
      UNUM=CASE + SIMPSN(A,B,EPS)
      DEN=        1.C-DIST/SQRT(DIST*DIST+RX*RX)
C     WRITE (3,13C) A,B,CASE,UNUM,DEN
C 130 FCRMAT (1X,5E14.7)
      EFFIC=UNUM/DEN
      RETURN
    6 EFFIC=1.C - EXP(-LEGAM*F)
      RETURN
      ENC
$IBFTC ENLI    DECK,REF,LIST
      SUBRCUTINE ENLIN (NX,FM,EG,VG,NGL,J,NGC,C)
C**********  PRCGRAM NUMBER -  8   CUBEC-2   ************
```

```
C
C     CALLED BY  *MAIN*
C     CALLS  *PULSE*
C     APPLIES ENERGY RESPONSE NON-LINEARITY CORRECTION.
C
      DIMENSION FM(200),EG(20),VG(20),C(200),Q(200)
      NDEGRE=2
      EGI=EG(J)
      DV=PULSE(EGI,NGC,2)
      EGVG=EG(J)*(1.0+DV)/VG(J)
C  DEFINE THE ENERGIES OF NON-LINEARITY, X(I).
C  TEMP. OUTPUT
C     WRITE(3,55)EGI,DV,EGVG,EG(J),VG(J),NGL,NGG,J,NX
C  55 FORMAT(10H ENLIN 1   ,5E14.7,4I5/)
    3 DO 6 I=1,NX
      EX=I
      EX=EX*EGVG
      IF(EX-0.015)3000,3001,3001
 3000 VP=EX
      C(I)=FM(I)
      GO TO 3002
 3001 VVP=EX*(1.0+PULSE(EX,NGC,2))
      C(I)=FM(I)*(VVP-VP)/EGVG
      VP=VVP
 3002 CONTINUE
      Q(I)=EX
    6 CONTINUE
      DO 7 I=1,NX
    7 FM(I)=C(I)
      NXX=NX+1
      DO 8 I=NXX,200
    8 FM(I)=0.0
      RETURN
      END
$IBFTC FC      DECK,REF,LIST
      FUNCTION FC(X)
C**********  PROGRAM NUMBER -  9   CUBEC-2   ************
C
C     CALLED BY  *SIMPSN*
C     CRYSTAL INTERACTION EFFICIENCY FUNCTION.
C
      COMMON /B/ KL,UEGAM,R ,DIST,H
      IF(KL)1,2,1
    1 IF(X)3,4,3
    3 FC=(1.0 - EXP(-UEGAM*(R/(SIN(X))-DIST/COS(X))))*SIN(X)
```

```
      RETURN
    4 FC=0.0
      RETURN
    2 FC=(1.0 - EXP(-LEGAM*H/COS(X)))*SIN(X)
      RETURN
      END
$IBFTC FUNL    DECK,REF,LIST
      SUBROUTINE FUNUS (FIT,FC,Y,B,P,A,NF,    NS,PP,ENY)
C**********  PROGRAM NUMBER - 10   CUBED-2   ************
C
C     CALLED BY  *STDFIT*
C     PHOTOPEAK FUNCTION FITTED BY -STDFIT-
C     (GAUSSIAN DISTRIBUTION ON STRAIGHT LINE BASE)
C
      DIMENSION FC(200),Y(200),B(5),P(200),A(200,5),          PP(200)
      FIT=0.0
      DO 50 I=1,200
      PP(I)=0.0
      P(I)=0.0
      DO 50 J=1,5
   50 A(I,J)=0.0
      PIE=3.14159265
      CONS=0.3989423*B(3)
C
C  COMPUTE STRAIGHT LINE BASE FOR PHOTOPEAK
C
  400 DO 402 I=NS,NF
      X=I
      X=X-0.5
      P(I)=B(4)*X + B(5)
      A(I,4)=X
  402 A(I,5)=1.0
C
C COMPUTE GAUSSIAN FUNCTION AND PARTIAL DERIVATIVES.
C
  403 DO 700 I=NS,NF
      X=I
      X=X-0.5
      PCN=(X-B(1))/B(2)
      ARG=EXP(-0.5*PCN*PCN)
      PP(I)=CONS*ARG/B(2)
      A(I,1)=PP(I)*PCN/B(2)
      A(I,2)=PP(I)*(PCN*PCN - 1.0)/B(2)
      A(I,3)=PP(I)/B(3)
      P(I)=P(I)+PP(I)
```

```
      FC(I)=Y(I)-P(I)
  7CO FIT=FIT+FC(I)*FC(I)/Y(I)
      RETLRN
      ENC
$IBFTC GANE    DECK,REF,LIST
      SUBRCLTINE GANE (TZ,NX,CAIN,RCGAIN,SPCCTH,C)
C**********  PROGRAM NUMBER - 11   CUBEC-2   ************
C
C     CALLED BY  *MAIN* - *SINGLE* - *RESGEN* - *PHCFRA*
C     GAIN CHANGING PROGRAM,  ALSC SPECTRAL SHIFTING.
C
      DIMENSICN  C(2CC),  FM(2CC)
      NLIMIT=2CC
      IF(TZ)1CCC,275,1CCO
 1CCO NZC=TZ
      NXC=NX-NZC
C
C INTEGER SHIFT IF *NZC* NCT ECLAL TC ZERC.
C
      IF(TZ )S13,S1C,S11
  S13 NZC=NZC-1
      NS=NZC*(-1) + 1
      NSX=NS-1
      NSXC=1
      NXO=NSX+NX
  S55 DC S56 I=NS,NXC
      K=I+NZC
  S56 FM(I)=C(K)
      DC S57 I=NS,NXC
  S57 C(I)=FM(I)
      GC TC 93
  S11 NS=1
      NSXC=NXC+1
      NSX=NX
  S45 DC S1 I=NS,NXC
      K=I+NZC
   91 C(I)=C(K)
   93 DC S2 I=NSXC,NSX
   92 C(I)=C.C
  S1C NX=NXC
C
C DECIMAL SHIFT.
C
  274 TNZC=NZC
      DIF=TZ-TNZC
```

```
      CCIF=1.C-CIF
      IF(CIF)271,272,271
  271 NXON=NX-2
      C(1)=C(1) + C(2)*CIF
      CC 27C I=2,NXCN
  270 C(I)=C(I)*CCIF + C(I+1)*DIF
      C(NXCN +1)=C(NXCN +1)*CCIF + C(NX)
      GC TC 273
  272 IF(NZC)273,275,275
  273 NX=NX-1
  275 TZ=C.
      L=1
      C=GAIN
      CC 5C I=1,NLIMIT
   50 FM(I)=0.C
      FMULT=GAIN/RCGAIN
C
C CEL=0.5 WHEN GAIN/RCGAIN=1./2. I.E. CCUBLING REQUIRED.
C CEL=2.0 WHEN GAIN/RCGAIN=2./1. I.E. HALVING REQUIRED.
C
    1 DEL=GAIN/RCGAIN
      IF(CEL-2.0)4C2, 204, 402
  4C2 IF(CEL-C.5)3, 3, 4
    3 L=L+1
      GAIN=GAIN*2.C
      GC TC 1
C
C  INITIALIZE FCR REDUCING ALGORITHM.
C
    4 I=1
      K=1
      X=0.
      XN=1.C
      DELT=C.
   6C DE=CEL
      IF(CEL-1.C)5,499 ,1C5
  499 IF(L-1)497,5C0,497
  497 CELT=RQGAIN/2.0
      L=L-1
  496 DC 498 I=1,NX
  498 FM(I)=C(I)
      GC TC 2C1
C
C  INCREASE.  ......  LCAC EVEN CHANNELS WITH QUACRATICALLY
C  INTERPCLATEC CCUNT.   SHIFT ENTIRE SPECTRUM UPWARC CNE*HALF CHAN.
```

```
C
    5 DELT=RGGAIN/2.0
      DEL=GAIN/DELT
      GC TC 6C
  3C3 NCX=J-4
      DC 3C5 J=1,NCX,2
      I=J+1
  305 C(I)= (3.0*C(J) + 6.0*C(J+2) - C(J+4))*.125
      C(I+2)= (3.C*C(I+3) + 6.0*C(I+1) - C(I-1))*.125
      NX=I+3
      DC 936 I=2,NX
  936 FM(I)=(C(I)+C(I-1))*0.5
      FM(1)=C(1)*0.5
      DC 935 I=1,NX
  935 C(I)=FM(I)
      GC TC 3C4
C
C  REDUCTICN ALGCRITHM.
C
  1C5 XK=DEL
      DEL=XN-X
      XKX=XK
  106 FM(K)=FM(K)+DEL*C(I)
      IF(I-NX)112,202,202
  112 X=X+DEL
      IF(X-XK+1.0E-9)108,107,107
  1C7 K=K+1
      XN=I
      DEL=XN-X
      XK=XK+XKX
      GC TC 1C6
  108 XN=XK
      DEL=XN-X
  109 IF(DEL-1.0)111,111,11C
  110 DIF=DEL-1.0
      DEL=DEL-DIF
      GC TC 1C9
  111 I=I+1
      GC TC 1C6
  2C2 DC 1599 INX=1,NLIMIT
 1599 C(INX)=C.C
      XNX=NX
      XNX=XNX/DE
      NX=XNX
C
```

```
C  LOAD ODD CHANNELS IF *DELT* EQUAL TO ZERO.
C
  201 IF(DELT) 300,301,300
  300 NC=2
      ND=1
      GO TO 302
  301 NC=1
      ND=0
  302 DO 200 I=1,NX
      J=NC*I - ND
  200 C(J)=FM(I)
      IF(DELT) 303,304,303
  304 IF(L-1)404, 500 ,404
  404 L=L-1
      GO TO 496
C
C  HALVING.
C
  204 I=1
      NCHECK=NX
      NX=NX/2
      NCK=NCHECK -(NX+NX)
      IF(NCK)555, 504, 555
  555 NX=NX+1
  504 K=2*I-1
      C(I)=C(K)+C(K+1)
      IF(I-NX)502,503,503
  502 I=I+1
      GO TO 504
  503 IF(L-1)525,525,205
C
C  SMOOTHING IF *SMOOTH* NOT EQUAL TO ZERO.
C
  525 IF(SMOOTH)526,500,526
  526 DELT=DEL
      SMOOTH=SMOOTH - 1.0
      FMULT=0.5
      GO TO 496
  205 L=L-1
      GO TO 204
C
C  COUNTS SCALED IN ACCORD WITH *FMULT* FOR INCREASED SPECTRA.
C
  500 KK=0
  915 CONTINUE
```

```
      IF(KK)1499,1500,1499
 1500 FAC=1.0
      GO TO 1501
 1499 FAC=1.0/2.0**KK
 1501 IF(FMULT-FAC)916,917,917
  916 KK=KK+1
      GO TO 915
  917 DO 920 I=1,NX
  920 C(I)=C(I)*FAC
      IF(SMOOTH)204,527,204
  527 GAIN=G
      RETURN
      END
$IBFTC GAUS     DECK,REF,LIST
      SUBROUTINE GAUSS (FM,V,S,PKAREA,SUM,NMAX)
C**********  PROGRAM NUMBER - 12   CUBED-2    ************
C
C     CALLED BY  *PEAKS* - *RESGEN*
C     CALLS  *PEEK*
C     COMPUTES GAUSSIAN PHOTOPEAK FOR GIVEN PARAMETERS.
C
      DIMENSION FM(200)
      SUM=0.0
      NMIN=V - 6.0*S
      IF(NMIN)7,7,8
    7 NMIN=1
    8 NMAX=V + 6.0*S + 1.0
      IF(NMAX-150)9,9,10
   10 NMAX=150
    9 DO 1 I=NMIN,NMAX
      X=I
      X=X-0.5
      G=PEEK(X,V,S,PKAREA)
      SUM=SUM+G
    1 FM(I)=FM(I)+G
C     WRITE (3,5) NMIN,NMAX,V,S,PKAREA,SUM,(FM(I),I=NMIN,NMAX)
C   5 FORMAT  (10H GAUSS      /1X,2I5,5X,4E14.7/(1X,5E14.7))
      RETURN
      END
$IBFTC GEOM     DECK,REF,LIST
      SUBROUTINE GEOMTR (RO,BETNUM,DE,PHI,E,NS,NX,   BETENY,NGD,N,RX,DT,
     1   VOL,CYLDIA,ENXTAL)
C**********  PROGRAM NUMBER - 13   CUBED-2    ************
C
C     CALLED BY  *MAIN*
```

```
C      CALLS  *DOSE*
C      COMPUTES GEOMETRY FACTORS.  INTEGRATES NUMBER AND ENERGY SPECTRA.
C      CALCULATES NORMALIZED DOSE DATA FOR FINAL CODE RESULTS.
C
       COMMON /C/ SUMNUM,SUMENY,DOSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
      1 DOSBEX,DOSCYL,DBXVCL,DCYVCL
       DIMENSION PHI(200),E(200),ENXTAL(200)
       PIE=3.14159265
       VCL=(PIE*CYLDIA**3)/4.0
       TIME=DT*60.0
       AREAXT=PIE*RX*RX
       CONST=3600./5.24E+07
       SOGEOM=0.5*(1.0-RC/SQRT(RC*RC+RX*RX))
       SUMNUM=0.0
       SUMENY=0.0
       DOSDET=0.0
C INTEGRATE.
       DO 2 I=NS,NX
       PHI(I)=CE*PHI(I)/(AREAXT*TIME)
       ENXTAL(I)=PHI(I)*E(I)
       EC=E(I)
       DOSXTL   =   PHI(I)*CONST*DOSE (EC,NGD,N)
       SUMNUM=SUMNUM+PHI(I)
       SUMENY=SUMENY+ENXTAL(I)
     2 DOSDET=DOSDET+DOSXTL
C
       AVENGY=SUMENY/SUMNUM
       PHNUBE=SUMNUM/BETNUM
       ENBENY=SUMENY/BETENY
       PHENBE=SUMENY/BETNUM
       DOSBEX=DOSDET/BETNUM
       DOSCYL=DOSBEX/SOGEOM
       DBXVCL=DOSBEX/VCL
       DCYVCL=DOSCYL/VCL
C
       RETURN
       END
$IBFTC GUES     DECK,REF,LIST
       SUBROUTINE GUESS (NS,NFN,Y,B,ENY)
C**********  PROGRAM NUMBER - 14   CUBED-2   ************
C
C      CALLED BY  *STDFIT*
C      CALLS  *VECTMX*
C      PROVIDES INITIAL ESTIMATES OF THE PHOTOPEAK FUNCTION PARAMETERS
C      FOR NONLINEAR REGRESSION ANALYSIS IN SUBPROGRAM -STDFIT-.
```

```
C
      DIMENSICN B( 5),Y(2C0)
      BIG=C.0
      CALL VECTMX (Y,NS,NFN,IEIG,BIG)
      B(1)=IBIG
      ANY=1COC.*ENY
      IF(B(3)-1.C)1,2,1
    2 W=NFN-NS
      W=0.45*W
      B(3)=C.C
      GC TC 3
    1 W=(.321*ANY**.7677)*B(1)/ANY
    3 B(2)=W/2.354
      B7   =Y(NFN)
      B(3)=       W*(BIG-B7   )*1.C65
      XNS=NS
      XNFN=NFN
      B(4)=(Y(NFN)-Y(NS))/(XNFN-XNS)
      B(5)=Y(NFN)-B(4)*XNFN
      RETLRN
      END
$IBFTC MITS    DECK,REF,LIST
      SUBRCLTINE CMITS(NRLN,X)
C**********  PROGRAM NUMBER - 15   CUBED-2   ************
C
C     CALLED BY  *MAIN*
C     INSERTICN CF REPETITIVE VARIABLES OMITTEC CN ALL BLT FIRST-CARD OF SET.
C
      DIMENSICN X(2C)
      NSTART=1
    1 NST=NSTART+1
      DO 2 I=NST,NRLN
      J=I
      IF(X(I))4,3,4
    3 X(I)=X(NSTART)
    2 CCNTINUE
    5 RETLRN
    4 IF(J-NRLN)6,5,6
    6 NSTART=J
      GC TC 1
      END
$IBFTC PEAK    DECK,REF,LIST
      SUBRCLTINE PEAKS (FM,V,E,R,VV,SI,SIG,NN,P,NMAX)
C**********  PROGRAM NLMBER - 16   CUBED-2   ************
C
```

```
C       CALLED BY  *PHCFRA*
C       CALLS  *GAUSS*
C       ADDS PHCTCPEAKS AND ESCAPE PEAKS AND CCMPUTES PHCTCFRACTICNS.
C
        DIMENSICN FM(2CC)
        NXN=V+1.0+6.C*SIG
        IF(NXN-NN)1CCC,1CCO,1CC1
 1CCO NNO=NXN
        GC TC 1CO2
 1CC1 NNC=NN
 1CO2 IF(R)9755,9755,9754
 9754 AREA=R
        GC TC 9756
 9755 SI=C.C
        AREA=C.C
 9756 PKAREA=1.C-R
        SUM=C.O
        CC 16 I=1,NNC
   16 SUM=SUM+FM(I)
        P=1.C/(SUM+1.C)
C ADD PHCTCPEAK
        CALL GAUSS (FM,V,SIG,PKAREA,SUM1,NMAX)
C
        IF(AREA)14,13,14
C ADD K-PEAK.
   14 CALL GAUSS (FM,VV,SI,AREA,SUM2,NM)
C
   13 CC 17 I=1,NNC
   17 FM(I)=FM(I)/(SUM+SUM1+SUM2)
        P=(SUM1+SUM2)/(SUM+SUM1+SUM2)
C
C FM(I) NCW ADDS UP TC UNIT AREA.
C
        RETURN
        END
$IBFTC PEEK     CECK,REF,LIST
        FUNCTICN PEEK(X,PAV,PAS,PAK)
C**********  PROGRAM NUMBER - 17   CUBED-2   ************
C
C       CALLED BY  *PHCFRA* - *GAUSS* - *RESGEN*
C       CCMPUTES GAUSSIAN FUNCTICN AT X.  (F)
C
        PCN=(X-PAV)/PAS
        ARG=C.5*PCN*PCN
        IF(ARG-20.0)2,2,3
```

```
    2 PEEK=C.3989423*PAK*EXP(-ARG)/PAS
      RETLRN
    3 PEEK=C.C
      RETLRN
      END
$IEFTC PERS    CECK,REF,LIST
      FLNCTICN PERSPX (E,NGX,N,TKLLC)
C**********  PROGRAM NUMBER - 18   CLBEC-2   ************
C
C     CALLEC BY  *SCLN* - *SINGLE*
C     CALLS  *TA* - *TE*
C     CCMPLTES PERSPEX ABSORPTICN FACTCR.  (F)
C
      DIMENSICN X(23),R(23),Z(6),Y(6)
      GC TC (1,2),NGX
    1 NGX=2
      X(1)=0.C1
      X(2)=C.C15
      X(3)=C.C20
      DC 7 I=4,11
    7 X(I)=X(I-1)+.01C
      DC 8 I=12,2C
    8 X(I)=X(I-1)+.1CC
      X(21)=1.5
      X(22)=2.0
      X(23)=3.0
      DATA(R(I),I=1,23)/3.04,.9586,.4953,.2729,.2176,.1966,.1851,.1780,
     1.17C7,.1660,.1603,.1320,.1148,.1C28,.C938,.0869,.C81C,.C763,.C72C,
     2.C687,.C559,.C478,.C384/
      LCW=1
      M=23
    2 CALL TA (E,X,M,LCW,MCX,MUN,Z,Y,R,N,L,0)
      NN=N+1
      P=TE (NN,Z,Y,E)
      PERSPX=EXP(-P*TKLLC)
      RETLRN
      END
$IBFTC PHCF    DECK,REF,LIST
      SUBRCLTINE PHCFRA (RM,N,EM,ELIMIT,NGC,NGR   ,NCEGRE,Q,PV,PFRACT,K,
     1 MRPEAT,ESING,FM)
C**********  PRCGRAM NUMBER - 19   CLBEC-2   ************
C
C     CALLEC BY  *MAIN* - *SINGLE*
C  CALLS  *GANE* - *PEAKS* - *PEEK* - *RESGEN* - *PULSE* - *RAXEL* - *TA* - *TE*
C     CCNTRCL PRCGRAM FCR RESPONSE MATRIX GENERATION.
```

```
C
      DIMENSION RM(40,40),R(200,15),FM(200),X(12)     ,PV(50),PFRACT(50),
     1 G(200),ALABEL(12),G(12),TAG(12),STDENY(12),STDEN(12),Z(6),Y(6)
     2 ,RR(16),NSJ(12),NFNJ(12),NSXJ(12),NFXJ(12), SHIFT(12),NCSUBT(12)
     3  ,NSM(12),DENY(12)
C
C READ IN ANY ORDER THE APPROPRIATLY LABELLED RESP. MATRIX LIBRY SPECTRA
C
C READ STANDARD LIBRARY SPECTRA.
C
      IF(ESING)815,816,815
  815 E=ESING
      V=E*EM
C     WRITE (3,818)   MRPEAT,NGC,NGR,E,V,EM
C 818 FORMAT (10H PHOFRA 1   /1X,3I10,5X,3E14.7)
      GO TO 817
  816 IF(MRPEAT)31234,21234,31234
21234 DO 9C52 J=1,12
      NFXJ(J)=0.0
 9C52 NSXJ(J)=0.0
C
C  NSTAND=NUMBER OF STANDARD SPECTRA IN THE LIBRARY DECK
C  NPHA=NUMBER OF DEAD CHANNEL IN BEGINNING OF STAND. SPECTRA
C  UNGAIN=REFERENCE COARSE GAIN (AS AT OCT19/66 IS A DUMMY)
C  ALABEL=STANDARD SOURCE IDENTITY (AS IN DATA STATEMENT BELOW)
C  FIT PE AKS FROM CHANNEL NSJ TO NFNJ
C  SUBTRACT PEAKS FROM CHANNEL NSXJ TO NFXJ (USE NEG VALUES IF .51 PEAKS
C    OF EITHER NA22 OR ZN65)
C  SHIFT=CHANNEL LOCATION OF TRUE ZERO PULSE-HEIGHT
C  R(1 TO 200,J)=SPECTRUM J        (J=1 TO NSTAND)
C
      READ (2,6)  NSTAND,NPHA,UNGAIN,
     1 (ALABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J), SHIFT(J), J=1,NSTAND)
    6 FORMAT (     2I5,F10.5/ (A6,4X,4I5,F10.5))
      READ    (2,88) ((R(I,J),I=1,200),J=1,NSTAND)
   88 FORMAT (10F7.1)
C
C  COMPLEMENT OVERSUBTRACTED COUNTS.
      DO 8000 J=1,NSTAND
      DO 8000 I=1,200
      IF(R(I,J)-800000.0)8001,8001,8002
 8002 R(I,J)=R(I,J)-1000000.0
 8001 CONTINUE
 8000 CONTINUE
C
```

```
C  SHIFT SPECTRA AN AMCLNT TZ IF TZ NCT =0
      NTZ=C
      DC SCCO J=1,NSTAND
      IF(NSXJ(J))9C15,9016,9016
 9C15 NSXJ(J)=-NSXJ(J)
      NCSLBT(J)=C
      GC TC 9C17
 9C16 NCSLBT(J)=1
 9C17 IF( SHIFT(J))9CC1,9C02,9CC1
 9C01 TZ= SHIFT(J)
      NTZ=TZ
      IF(NSXJ(J))9C18,9C19,9C18
 9C18 NSXJ(J)=NSXJ(J)-NTZ
      NFXJ(J)=NFXJ(J)-NTZ
 9C19 NSJ(J) =NSJ(J) -NTZ
      NFNJ(J)=NFNJ(J)-NTZ
      NX=2CC
      GAIN=1.C
      RCGAIN=1.0
      DC 9CC3 I=1,200
 9C03 FM(I)=R(I,J)
      CALL GANE (TZ,NX,GAIN,RCGAIN,C.0,FM)
      DC 9CC4 I=1,2CC
 9C04 R(I,J)=FM(I)
 9C02 CCNTINUE
 9CC0 CCNTINUE
      NPHA=NPHA-NTZ
      DC 9C95 I=1,NSTANC
 9C95 G(I)=C.C
      N5=5
      NA=1C
      NZ=9
      NTAG=12
      DATA (TAG(I),I=1,12) /6H CC109,6H  SC47,6H HG2C3,6H AU198,6H  SR85
     1  ,6H CS137,6H  MN54,6H  NB95,6H  ZN65,6H  NA22,6H  NA24,6H   K42/
     2 ,(STDEN(I),I=1,12)/.C8E,.155,.279,.4117,.515,.66162,.835,.764,
     3 1.114,1.28,2.76,1.51/
C
C IDENTIFY ENERGIES CF STANCARDS
      DC 1234 KK=1,NSTAND
      DC 3456 J=1,NTAG
      IF(ALABEL(KK).EC.TAG(J))GC TC 4321
 6543 CCNTINUE
 3456 CCNTINUE
      WRITE   (3,9) (ALABEL(JJ),JJ=1,NSTANC),(TAG(JJJ),JJJ=1,NTAG)
```

```
    9 FORMAT (1H1,23H ERROR FLAG FOR PHOFRA        /(1X,1H*,A6))
      CALL EXIT
 4321 STDENY(KK)=STDEN(J)
 1234 CONTINUE
C
C CALL RESGEN TO CALC GAUSSIAN PARAMETERS AND UNIT CONTINUA FOR STANDS.
C
      WRITE(3,7)  NSTAND,NPHA,UNGAIN,
     1 (ALABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J),SHIFT(J),STDENY(J),
     2 J=1,NSTAND)
    7  FORMAT(1H1,15X ,37H STANDARD SOURCE SPECTRAL PARAMETERS   ///
    71  14X,I5,33H SPECTRA IN STANDARD SOURCE DECK   //
    72  13X,16H CHANNELS ONE TO ,I4,22H ASSUMED AS REDUNDANT   //
    73  17X,25H REFERENCE COARSE GAIN =     ,F10.5////
    741X,72HSTANDARD          PHOTOPEAK     X-RAY OR .5 PEAK      SHIFT
    75 PHOTOPEAK     /71H  SOURCE       FROM        TO       FROM        TO
    76      SPECTRUM   ENERGY     //10X,60H   CHANNEL  CHANNEL   CHANNEL
    77 CHANNEL   CHANNELS      MEV      /(2X,A6,6X,I4,5X,I4,7X,I3,6X,I3,
    784X,F9.4,1X,F10.5))
      DO 27123 J=1,NSTAND
      WRITE   (3,8599) ALABEL(J),(R(I,J),I=1,200)
 8599 FORMAT (1H1,32X,25H STANDARD SOURCE SPECTRA    /////////  3X,A6,
 85991 8H SOURCE ////(1X,10F9.0))
27123 CONTINUE
      WRITE   (3,3)
    3 FORMAT (1H1)
      CALL RESGEN (R,ALABEL,TAG,G,SCONST,SN,ENPHO,UNGAIN,STDENY,NSTAND,
     1 NTAG,NA,NZ,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NCSUBT )
      DO 19123 J=1,NSTAND
      WRITE(3,3)
      WRITE   (3,81) ALABEL(J),(R(I,J),I=1,120)
   81 FORMAT (10X,42H NORMALIZED CONTINUUM OF STANDARD SPECTRA //////
   811 3X,A6,8H SOURCE ////(1X,5E14.7))
19123 CONTINUE
C
C INTEGRATE NORMALIZED STANDARD SPECTRA FOR INTERPOLATION EASE, HENCE
C DIFFERENTIATE INTERPOLATED SPECTRA LATER.
C
      DO 1000 J=1,NSTAND
      SUM=0.0
      DO 1000 I=1,200
      NDX=201-I
      SUM=SUM+R(NDX,J)
 1000 R(NDX,J)=SUM
C
```

```
C
      DC 5C49 J=1,NSTANC
 5C49 DENY(J)=STCENY(J)
      DC 5C53 K=1,NSTAND
      SMALL=1C.0
      DC 5C50 J=1,NSTAND
      IF(STDENY(J)-SMALL)5051,5C52,5C52
 5C51 NSMALL=J
      SMALL=STDENY(J)
 5C52 CCNTINUE
 5C50 CCNTINUE
      NSM(K)=NSMALL
      STDENY(NSMALL)=10.0
 5C53 CCNTINUE
C
C     NSM(K) NOW CCNTAINS THE CCRRECT INDEX CRCER
C
      DC 5C55 J=1,NSTAND
      NCRCER=NSM(J)
 5C55 STDENY(J)=CENY(NORDER)
      DO 5C57 I=1,2CC
      DO 5C56 KK=1,NSTAND
 5C56 CENY(KK)=R(I,KK)
      DO 5C58 J=1,NSTAND
      NCRDER=NSM(J)
 5C58 R(I,J)=CENY(NCRCER)
 5C57 CCNTINUE
C
C
C
C GENERATE RESPCNSE VECTORS
C INTERPCLATE THE RESPCNSE MATRIX CF SIZE N*N USING THE VECTCRS R(I,J).
C CETERMINE FCR CNE ENERGY, ALL CHANNELS, THEN INCREMENT ENERGY.
C
31234 K=0
      NC=2CC
      NMAX=NO
      P=0.C
      NS=1
      DC 1C I=NS,NC
   10 FM(I)=0.0
      DC 11 I=NS,N
      PFRACT(I)=C.C
      PV(I)=0.0
      CC 11 J=NS,N
```

```
   11 RM(I,J)=C.C
      EN=N
      CE=ELIMIT/EN
      DEL=CE/2.0
      MM=N
      WRITE(3,3)
C
      KJ=NS
  920 GAIN=1CC.
      E=KJ
      E=E*CE-CEL
C  INTERPCLATE FRCM ENERGY X(1) TC ENERGY X(NTCP)
  817 X(1)=C.C
      RR(1)=0.0
      LCW=1
      NTOP=NSTAND+1
      CC 1C05 I=1,100
      CC 1CC4 INCEX=2,NTOF
      X(INCEX)=STCENY(INDEX-1)
 1C04 RR(INCEX)=R(I,INCEX-1)
      CALL TA (E,X,NTCP,LCW,MCX,MLN,Z,Y,RR,NCEGRE,L,C)
      NN=NCEGRE+1
 1C05 FM(I)=TE (NN,Z,Y,E)
C
C CIFFERENTIATE FM(I)
      CC 1C50 I=1,101
      FM(I)=FM(I)-FM(I+1)
      IF(FM(I))3C33C,30331,30331
3C330 FM(I)=0.
3C331 CCNTINUE
 1C5C CCNTINUE
      CC 827 I=101,2CC
  827 FM(I)=0
      IF(ESING)821,822,821
  821 KJ=1
      IF(E-.5)823,824,824
  823 IF(E-.03316)824,825,825
  825 EK=E-.0285
      SCALE=1.0
      IF(EK-.C1)824,5,5
C
C SET ENERGY ANC PULSE-HEIGHT SCALES
  822 Q(KJ)=E
      V=E*EM
      IF(E-C.C10)6C,6C,59
```

```
   60 PV(KJ)=V
      K=K+1
      NMAX=N
      DC 30E8C I=1,2CC
30E80 FM(I)=0.0
      P=C.C
      GC TC 61
   59 EK=E-C.0285
      SCALE=GAIN/V
      SIG=(SCCNST*(E*1CCO.0)**SN)*SCALE*EM/2354.82
    8 NMA=GAIN+1.C+6.C*SIC
      IF(NMA-NC)123,123,124
  124 GN=GAIN
      GAIN=GAIN/2.C
      SIG=SIG/2.C
      SCALE=GAIN/V
C REDUCE VECTCR LENGTH TO ALLCW CCMPLETE PEAK TO BE FORMEC (I.E.LCW E)
      CALL GANE (C.C,NMAX,GN,GAIN,C.0,FM)
      GC TC 8
  123 V=E*EM
      V=V+V*PULSE (E,NGC,NDEGRE)
      PV(KJ)=V
      IF(E-.03316)4,4,5
    4 VV=C.C
      OR=C.C
      SI=C.0
      GC TC 14
    5 VK=EK*GAIN/E
      VV=VK+VK*PULSE (EK,NGC,NDEGRE)
      SI=(SCCNST*(EK*10CO.0)**SN)*SCALE*EM/2354.82
      CR=RAXEL(E,NGR,NDEGRE)
      IF(ESING)826,14,826
  E26 NBEGIN=VV-6.C*SI
      IF(NBEGIN)828,828,829
  E28 NBEGIN=1
  E29 DC E3C I=NBEGIN,1CO
      XI=I
      XI=XI-0.5
  E30 FM(I)=FM(I)+PEEK(XI,VV,SI,CR)
      GC TC 824
   14 CONTINUE
C     WRITE (3,12321) NMA,NC,K,NMAX,E,V,SIG,SCALE,GAIN,GN,VV,CR,SI,ESING
C2321 FCRMAT (1CH PHCFRA 2  ,4I5/(1X,5E14.7))
      CALL PEAKS (FM,GAIN,E,CR,VV,SI,SIG,NC,P,NMAX)
C
```

```
      CALL GANE (C.C,NMAX,GAIN,V,C.C,FM)
C
C     WRITE   (3,86) KJ,N,E, (FM(I),I=1,40)
C  86 FCRMAT(///////////
C  861        36H INTERPCLATED RESPCNSE MATRIX VECTOR,I3,4H CF ,I3,
C  86214H FCR ENERCY = ,F10.5,5H MEV      /(1X,5E14.7))
   61 M=NMAX
      IF(M- 40)9C,9C,91
   91 M=4C
   9C PFRACT(KJ)=P
      DC 2 I=NS,M
    2 RM(I,KJ)=FM(I)
      IF(KJ-MM)918,919,919
  918 KJ=KJ+1
      GC TC 920
  919 CONTINUE
      WRITE (3,3C770) (PFRACT(I),I=NS,N)
3C770 FCRMAT (///32H RESPCNSE MATRIX PHCTOFRACTICNS    //(1X,1CF7.4))
  E24 RETURN
      END
$IBFTC PULS     DECK,REF,LIST
      FUNCTICN PULSE (E,NGP,N)
C**********  PROGRAM NUMBER - 2C   CUBED-2   ************
C
C     CALLED BY  *PHCFRA* - *RESGEN* - *ENLIN*
C     CALLS  *TA* - *TE*
C     CCMPUTES THE DETECTCR SYSTIM PULSE-HEIGHT FOR GIVEN ENERGY.
C
      DIMENSICN X(45),R(45),Z(6),Y(6)
      IF(E - C.010)8,9,9
    8 WRITE (3,60) E
   60 FORMAT  (43H PULSE ENERCY LESS THAN 0.010 MEV.  ERRCR.  /E20.8)
      E=.C15
      GC TC 18
    9 IF(E - 3.C)18,18,12
   12 WRITE (3,61) E
   61 FCRMAT  (44H PULSE ENERCY GREATER THAN 3.0 MEV.  ERROR.  /E20.8)
      E=3.C
      GC TC 18
   18 GC TC (1,2),NGP
    1 NGP=2
      X(1)=0.C15
      DC 16 I=2,6
   16 X(I)=X(I-1)+.CC1
      DC 17 I=7,16
```

```
   17 X(I)=X(I-1)+.C02
      X(17)=.C425
      X(18)=.C45
      X(19)=.C5C
      X(2C)=.C55
      X(21)=.C60
      DC 19 I=22,25
   19 X(I)=X(I-1)+C.010
      DC 20 I=26,29
   20 X(I)=X(I-1)+.025
      DO 21 I=3C,35
   21 X(I)=X(I-1)+.05C
      DC 22 I=36,43
   22 X(I)=X(I-1)+.10C
      X(44)=1.3225
      DATA(R(I),I=1,44)/.C418C,.063C0,.07500,.08250,.0875C,.0885C,.086C0
     1,.079C0,.063CC,.039C0,.C3CCC,.029C0,.03300,.0430C,.05250,.06150,
     2.072C0,.081CC,.C851C,.0E450,.C8040,.06970,.06140,.05550,.05CC0,
     3.0382C,.03CCC,.C240C,.0186CC,.0115C,.00770,.00540,.C039C,.C0285,
     4.00215,.C011C,3*.C010C,.CC059,.CC060,.CC030,.00015,.C00C/
      M=44
      LCW=1
    2 CALL TA (E,X,M,LCW,MOX,MUN,Z,Y,R,N,L,C)
      NN=N+1
      PULSE=TE (NN,Z,Y,E)
   1C RETURN
      END
$IBFTC RAXE    DECK,REF,LIST
      FUNCTION RAXEL (E,NGR,N)
C**********  PROGRAM NUMBER - 21   CUBED-2   ************
C
C     CALLED BY  *RESGEN* - *PHCFRA*
C     CALLS  *TA* - *TE*
C     CCMPUTES NAI(T1) IOCINE K X-RAY ESCAPE FRACTICN.
C
      DIMENSICN X(14),R(14),Z(6),Y(6)
      IF(E-0.150)8,8,9
    8 IF(E-C.C3316)12,18,18
   18 GC TC (1,2),NGR
    1 NGR=2
      X(1)=C.C3316
      X(2)=0.C350
      X(3)=C.040
      DC 2C I=4,14
   20 X(I)=X(I-1)+C.010
```

```
      R( 1)=.27159
      R( 2)=.255CC
      R( 3)=.21001
      R( 4)=.14533
      R( 5)=.10157
      R( 6)=.C72CC
      R( 7)=.C5301
      R( 8)=.C395C
      R( 9)=.C3001
      R(1C)=.0233C
      R(11)=.C183C
      R(12)=.C148C
      R(13)=.C12C5
      R(14)=.C0994
      M=14
      LCW=1
    2 CALL TA    (E,X,M,LCW,MCX,MLN,Z,Y,R,N,L,O)
C     WRITE (3,100) M,LCW,MCX,MLN,L,N,NGR,Z(1),Z(2),Z(3),Y(1),Y(2),Y(3),
C    1 (I,X(I),R(I),I=1,14)
C 1C0 FCRMAT (10H RAXEL      ,7I5/1X,6E14.7//(1X,I5,5X,2E14.7))
      NN=N+1
      RAXEL= TE (NN,Z,Y,E)
   10 RETLRN
    9 IF(E-0.5)11,11,12
   11 RAXEL=(5.0233E-05)*E**(-2.7872)
      GC TC 1C
   12 RAXEL=0.0
      GC TC 1C
      END
$IBFTC RESG    DECK,REF,LIST
      SUBRCUTINE RESGEN (R,ALABEL,TAG,G,SCONST,SN,EM,UNGAIN,STCENY,
     1 NSTAND,NTAG,NA,NZ,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NCSUBT )
C**********  PROGRAM NUMBER - 22   CUBED-2   ************
C
C     CALLED BY  *PHCFRA*
C     CALLS  *STCFIT* - *PULSE* - *RAXEL* - *PEEK* - *GAUSS* - *GANE*
C     ORDERS AND NCRMALIZES STANCARC SPECTRA FOR RESPCNSE MATRIX INTERPCLATICN.
C
      DIMENSICN R(200,15),ALABEL(12),TAG(12),G(12),STDENY(12),NFNJ(12),
     1 NSJ(12),NFXJ(12),NSXJ(12),Y(2C0),PARAV(12),B(5),PARAS(12),
     2 PAREA(12),PP(2C0),         NCSLBT(12)
      NST=C
      NSTC1=0
      NSTC2=0
      NGAIN=0
```

```
      DC 2 I=1,NSTANC
      IF(ALABEL(I).NE.TAG(N5))GC TC 4
    3 I5=I
      NST=C
      GC TC 1C
    4 CCNTINUE
    2 CCNTINUE
      NAT=C
      EG=1.114
      IF(STCENY(NSTANC-1)-EG)50,51,50
   51 NAT=NAT+1
   50 EG=1.28
      NSTNAT=NSTANC-NAT-1
      IF(STCENY(   NSTNAT      )-EG)52,53,52
   53 NAT=NAT+1
   52 NSTANC=NSTANC-NAT
      NSTD3=NSTANC
      GC TC 2CC
C SEARCH FCR NA22.
   10 DC 2C I=1,NSTANC
      IF(ALABEL(I).NE.TAG(NA))GC TC 40
   30 INA=I
      NST=1
      GC TC 2C1
   40 CCNTINUE
   20 CCNTINUE
C SEARCH FCR ZN65.
  201 DC 2CCO I=1,NSTANC
      IF(ALABEL(I).NE.TAG(NZ))GC TC 40C
  300 INZ=I
      NST=NST+2
      GC TC 1111
  4CO CCNTINUE
 2COO CCNTINUE
C INITIAL LIMITS FCR START ANC STCP FITTING.
 1111 NSJ5=1
      NFN5=NFNJ(I5)
      NSTC1=NSTANC+1
      NSTC2=NSTD1+1
      NSTC3=NSTD2+1
C LOAC 3 EMPTY VECTCRS FOR TEMPCRARY USE.
      IF(NST)111,2CC,111
  111 NSJ(NSTC1)=NSJ(I5)
      NFNJ(NSTC1)=NFNJ(I5)
      STDENY(NSTD1)=STDENY(I5)
```

```
      DC 15C I=NSJ5,NFN5
  15C R(I,NSTC1)=R(I,I5)
      GC TC (159,17C,17C),NST
  170 NSJ(NSTC3)=NSXJ(INZ)
      NFNJ(NSTC3)=NFXJ(INZ)
      STDENY(NSTD3)=STDENY(INZ)
      NSJZ=NSJ(NSTC3)
      NFNZ=NFNJ(NSTC3)
      DC 18C I= 1   ,NFNZ
  180 R(I,NSTC3)=R(I,INZ)
      IF(NST-3)22C,160,22C
  159 NSTD3=NSTD2
  160 NSJ(NSTC2)=NSXJ(INA)
      NFNJ(NSTD2)=NFXJ(INA)
      STDENY(NSTD2)=STDENY(INA)
      NSJA=NSJ(NSTC2)
      NFNA=NFNJ(NSTC2)
      DO 19C I= 1   ,NFNA
  190 R(I,NSTC2)=R(I,INA)
  22C NGAIN=1
C
C NCN-LINEAR FIT NSTANC+3 SPECTRA, EXCLUDE EMPTY VECTCRS, FRCM NS TC NFN
C
C  INITIALIZE SUCH THAT THERE ARE NC FIXED PARAMETERS.
  200 CCNTINUE
      DC 5CCO J=1,NSTC3
      IF(NST-2)233,235,233
  235 JZ=J
      IF(JZ-NSTC2)233,5CO1,233
  233 NS=NSJ(J)
      NFN=NFNJ(J)
      ENY=STDENY(J)
 9CO2 DC 7CC2 I=1,NPHA
 7CO2 R(I,J)=R(NPHA+1,J)
      DC 2CO5 I=1,2CO
 2CO5 Y(I)=C.C
      DC 5CO2 I=NS,NFN
 5CO2 Y(I)=R(I,J)
      JJ=J
C
C CALL REGRESSION SUBPRCGRAM.
      CALL STCFIT (Y    ,NFN, E,                  NS,PP,ENY)
C
      PARAV(J)=B(1)
      PARAS(J)=B(2)
```

```
      PAREA(J)=B(3)
      PAV=PARAV(J)
      PAS=PARAS(J)
      PAK=PAREA(J)
C
C     WRITE (3,818) NS,NFN,J,ENY,B(1),B(2),B(3),B(4),B(5),(PP(II),II=NS,
C    1  NFN)
C 818 FORMAT (10H RESGEN 1   /1X,3I5,5X,6E14.7/(1X,5E14.7))
C SUBTRACT FITTED PEAK.
C
      NB1=B(1)
      DO 5010 I=NS ,NB1
 5010 R(I,J)=Y(I)-PP(I)
      NB3=B(1)-5.0*B(2)
      NB4=NS-1
      IF(NB3-NB4)30592,30593,30593
30592 DO 30591 I=NB3,NB4
      X=I
      X=X-0.5
30591 R(I,J)=R(I,J)-PEEK(X,PAV,PAS,PAK)
30593 NB2=NB1+1
      DO 5011 I=NB2,200
 5011 R(I,J)=0.0
      IF(NSXJ(J))5020,5001,5020
C
C SUBTRACT X-RAY PEAKS IF ANY.
C
 5020 IF(NCSUBT(J))5029,5001,5029
 5029 DEL=NFXJ(J)-NSXJ(J)
      NXX=NSXJ(J)
      NSX=NSXJ(J)+1
      NFXX=NFXJ(J)
      NFX=NFXJ(J)-1
      DO 5021 I=NSX,NFX
      X=I-NXX
 5021 R(I,J)=R(NXX,J)+X*(R(NFXX,J)-R(NXX,J))/DEL
 5001 CONTINUE
C  ZERO FROM THE FIRST NEGATIVE CHANNEL TO 200
      DO 9010 I=1,200
      IF(R(I,J))9011,9012,9012
 9011 INDIC=I
      GO TO 9014
 9012 CONTINUE
 9010 CONTINUE
      GO TO 9015
```

```
 9C14 DC 9C13 I=INCIC,2CO
 9C13 R(I,J)=C.0
 9C15 CCNTINUE
 5COO CCNTINUE
C
      IF(NGAIN)6CCC,7CCO,6OCO
C
C  IF(NGAIN=1) THEN SUBT C.51 PCRTICN FRCM NA AND/CR ZN, ELSE GC TC 7000
C
 6CCO NSP=NSTC2
 6CC1 GAIN=PARAV(I5 )
      GC TC (6011,6012,6012),NST
 6C11 N=INA
      GC TC 6014
 6C12 NSP=NSTC3
      N=INZ
 6C14 RCGAIN=PARAV(NSP)
      NF=NFNJ(NSTC1)
      DC 6C15 I=1,NF
 6C15 Y(I)=R(I,NSTC1)
C
C GAIN CHANGE NA AND ZN FCR .51 SUBTRACTICNS.
C
      CALL GANE (C.0,NF,GAIN,RCGAIN,0.C,Y)
C
      NAM=NFNJ(N)
      DC 6C16 I=1,NAM
 6C16 R(I,N)=R(I,N) - Y(I)*PAREA(NSP)/PAREA(I5 )
      NUS=PARAV(NSP)-6.0*PARAS(NSP)
      NAMLS=PARAV(NSP) + 6.C*PARAS(NSP)
      PAV=PARAV(NSP)
      PAS=PARAS(NSP)
      PAK=PAREA(NSP)
      DC 9C37 I=NUS,NAMLS
      X=I
      X=X-C.5
 9C37 R(I,N)=R(I,N)-PEEK(X,PAV,PAS,PAK)
      IF(NST-3)70CC,6009,70C0
 6CC9 NST=1
      NSP=NSP-1
      GC TC 6C01
C
C FIT PARAV(J) AND PARAS(J) AND RETURN WITH CCNSTANTS.
C
 7CCC IF(C(1))9C97,9C96,9C97
```

```
 9C96 SN=.7677
      SCCNST=.321
      SEK=1CCC.
      DIV=2.354
      GC TC 9098
C
 9C97 CCNTINUE
C9C97 CALL SVFIT (PARAV,PARAS,NSTANC,G,SCCNST,SN,STCENY,EM,LNGAIN)
      EM=1.C
C
      SEK=1.0
      DIV=1.0
C NCRMALIZE CCUNTS ANC GAINS.
C
 9C98 DC 7C10 J=1,NSTANC
      DO 7CC3 I=1,2CC
      Y(I)=R(I,J)/PAREA(J)
 7CC3 R(I,J)=C.0
      GAIN=PARAV(J)
      NX=2C0
      NF=GAIN+1.C
C     WRITE (3,818)NB1,NB3,NB4    ,GAIN,SEK,PAREA(J),G(1),PAV,R(1,J),
C    1  (Y(III),III=1,200)
C
      CALL GANE (C.C,NX,GAIN,1CC.C,C.0,Y)
C
      DC 3CCCC I=1,2CC
      IF(Y(I))30CC1,3CCC1,3COC2
30C01 NFNCRM=I-1
      NFNC=I
      GC TC 3CC03
30C02 CCNTINUE
3CCC0 CCNTINUE
C
C SUBTRACT K X-RAY ESCAPE PEAK IF ENERGY OF STANCARC LESS THAN 3CCKEV.
C
3CC03 IF(STCENY(J)-C.3C0)11C05,11CC4,11C04
11CC5 EN=STCENY(J)
      NN=1
      NC=2
      OR=RAXEL (EN,NN,NC)
      EK=EN-0.0285
      VK=EK*1C0.C/EN
      NN=1
      VV=VK+VK*PULSE (EK,NN,NC)
```

```
      EK=EK*SEK
      SI=(SCONST*EK**SN)*1CC.C/EK
      SI=SI/DIV
      PKAREA=-CR
C     WRITE (3,8  ) NFNCRM,NFNC,NX,VV,SI,PKAREA,EN,EK,VK,(Y(I),I=1,2C0)
C SUBTRACT K PEAK
      CALL GALSS (Y,VV,SI,PKAREA,SLM,NFNCRM)
C  ZERC FRCM THE FIRST NEGATIVE CHANNEL TO 2C0
11C04 DC 3C509I=NFNC,200
30509 Y(I)=C.C
      DC 7C04 I=1,NFNCRM
 7C04 R(I,J)=Y(I)
 7C10 CCNTINUE
      WRITE (3,82C)(J,ALABEL(J),PARAV(J),PARAS(J),PAREA(J),J=1,NSTAND)
  820 FCRMAT (1H1,45X,28HRESULTS CF PHCTOPEAK FITTING  ///
  8201  8X,5HINDEX,12X,15HSTANDARC SCLRCE,11X,12HPULSE-HEIGHT,1CX,
  8202 18HSTANDARC CEVIATION,14X,4HAREA/ 52X,1CH(CHANNELS),15X,
  8203 10H(CHANNELS),14X,13H(CCUNTS/TIME)//(9X,I3,18X,A6,3X,3E25.7))
      RETLRN
      END
$IBFTC RESM    DECK,REF,LIST
      SUBRCUTINE RESMAT (R,EPS,N,IT,ITMAX,P,PHI,K,DIF,MN)
C**********  PRCGRAM NUMBER - 23   CUBEC-2   ************
C
C     CALLEC BY  *SCLN*
C     CALLS  *VECTMX*
C  PULSE-HEIGHT ANALYZER SPECTRUM UNFCLCING ACCORCING TC THE SCCFIELD ALGCRITHM.
C
      DIMENSICN PP( 50),P(2C0),R( 4C, 4C),PHI(200) ,FIT(1C0),DIF(100)
     1  ,MN(18)
C
C  INITIALIZE
C
      NCHECK=ITMAX/2
      NCHECK=ITMAX-2*NCHECK
      SL=C.C
      DC 1599 I=K,N
 1599 SL=SL + P(I)
      DC 18C0 I=K,N
 18C0 P(I)=P(I)/SL
      YMAX=C.C
      CALL VECTMX (P,K,N,JMAX,YMAX)
      YLOW=YMAX*(1.CE-15)
      DC 1 I=1,N
      PP(I)=0.C
```

```
    1 PHI(I)=P(I)
C  WRITE IF ITMAX IS AN ODD-NUMBER.
      IF(NCHECK)8599,8000,8599
 8599 WRITE   (3,8589) (P(I),I=1,N)
 8589 FORMAT (30H1 NORMALIZED INPUT SPECTRUM            /(1X,10E11.4))
      INDEX=1
 8000 CONTINUE
      IT=1
      FIT(1)=0.
C
C  MATRIX MULTIPLICATION P=R.PHI
C
   10 DO 2 I=K,N
      PP(I)=0.0
      DO 2 J=K,N
      IF(R(I,J))2001,2000,2001
 2001 PP(I)=PP(I) + R(I,J)*PHI(J)
 2000 CONTINUE
    2 CONTINUE
      TERM = 0.0
C
C  ARRESTING CHECK WHEN  DIF(SUM(P-PP)**2/P) FOR LOOP(IT) AND LOOP(IT-1)
C  ARE LESS THAN EPS.... OR IT=ITMAX.
C
      DO 5 I=K,N
      IF(P(I))4,6,4
    4 TERM = ((P(I) - PP(I))**2)/P(I) + TERM
    6 CONTINUE
    5 CONTINUE
      IF(NCHECK)16000,15000,16000
16000 IF(MN(INDEX) - IT)15000,17000,15000
17000 WRITE (3,19000) IT,MN(INDEX),(PHI(I),I=K,N)
      WRITE (3,19005) IT,MN(INDEX),(PP(I) ,I=K,N)
      INDEX=INDEX+1
15000 CONTINUE
19000 FORMAT (51H INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I)) 2I5
190001/    (1X,10E11.4))
19005 FORMAT (51H INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))  2I5
190051/    (1X,10E11.4))
      IT=IT+1
      FIT(IT)=TERM
      DIF(IT)=ABS (FIT(IT-1) - FIT(IT) )
      IF(  DIF(IT)                      -EPS)7,7,29
   29 IF(IT-ITMAX)229,7,7
C
```

```
C  SCCFIELC CCRRECTICN FACTCR METHCC.
C
  229 DC 25 I=K,N
      IF(PP(I))125,52,125
  125 PHI(I)=PHI(I)*P(I)/FP(I)
   52 CCNTINUE
   25 CCNTINUE
      DC 1CCO I=K,N
      IF(ABS(PHI(I)) -   YLCW   )1CC1,1C02,1C02
 1CC1 PHI(I)=C.0
 1CC2 CCNTINUE
 1CCO CCNTINUE
      GC TC 1C
C
C  RESULTS.
C
    7 DC 6CC I=K,N
      P(I)=P(I)*SU
  6CC PHI(I)=PHI(I)*SL
C  WRITE IF ITMAX IS AN OCD-NUMBER.
      IF(NCHECK)9999,1CCOC,9999
 9999 WRITE   (3,9998) (PP(I),I=1,N)
 9998 FCRMAT (20H ITERATEC SPECTRUM             /(1X,10E11.4))
1CCCO CCNTINUE
   60 FCRMAT (20HC IT,SL,TERM              /I10,2E14.7)
      WRITE   (3,6C)  IT,SL,TERM
      RETURN
      END
$IBFTC SIMP    DECK,REF,LIST
      FUNCTICN SIMPSN (A,B,EPS)
C**********  PRCGRAM NUMBER - 24   CUBEC-2   ************
C
C     CALLEC BY  *EFFIC*
C     CALLS  *FC*
C     SIMPSCNS RULE INTEGRATING PRCGRAM FCR FUNCTICN -FC-.
C
      CCMMCN /B/ KL,UEGAM,RX,CIST,F
      TMAX=2048.
      AN=2.C
      FA=FC(A)
      FB=FC(B)
      FP=C.0
      SI=C.C
      DELT=B-A
  405 FCUR=C.C
```

```
      AK=1.0
      AKN=AN/2.0
  399 FFX=FC(A+(((2.0*AK-1.0)*DELT)/AN))
      FOUR=FOUR+FFX
      IF(AKN-AK)400,401,400
  400 AK=AK+1.0
      GO TO 399
  401 SIM=(DELT/(AN*3.0))*(FA+FB+4.0*FOUR+2.0*FP)
      IF(TMAX-AN)503,503,499
  499 DIFX=ABS(SIM-SI)
      IF(EPS-DIFX/SIM)402,403,403
  402 AN=AN+AN
      FP=FP+FOUR
      SI=SIM
      GO TO 405
  503 CONTINUE
  403 SIMPSN=SIM
      RETURN
      END
$IBFTC SING     DECK,REF,LIST
      SUBROUTINE SINGLE (FM,ELG,EL,NX,NGO,NGA,NGX,NGC,NGR,NDEGRE,TKLUC,
     1 EM,ELIMIT,C,PV,PFRACT,K,RX,     ENY,IN,NP,PHOT,NGE)
C**********  PROGRAM NUMBER - 25   CUBEC-2   ************
C
C       CALLED BY  *MAIN*
C  CALLS  *GANE* - *PHOFRA* - *STCFIT* - *EFFIC* - *CLAC* - *PERSPX* - *AIRABS*
C       DETERMINES MONOENERGETIC SPECTRAL CONTRIBUTION.
C
      DIMENSION FM(200),SLINE(200),EUG(4),EL(6),PP(200),RM(40,40),PV(50)
     1  ,PFRACT(50),C(200),PHOT(4),B(5),NSS(4),NFNN(4)
C
C  FM-IN IS  A BREMSS+LINE SPECTRUM.  FM-OUT IS A BREMSS ONLY, AND PHOT
C  CONTAINS THE LINE DATA TO BE ADDED TO PHI IN *MAIN*.
C
      COMMON/A/DI,H,MF
      NONE=1
      NOX=NX
      DIST=DI
      HH=H
      IF(EL(5))15000,1501,15000
15000 NSS(1)=EL(5)
      NFNN(1)=EU(6)
      NONE=2
      B(3)=1.0
      IF(IN-1)56,56,1501
```

```
 1501 CCNTINUE
C  ESTIMATE PHCTCPEAK FITTING LIMITS.
      DC 768 J=NCNE,IN
      DC 768 KCHECK =1,2
      IF(KCHECK-1)187C,1870,1871
 1871 BIG=C.0
      CALL VECTMX (FM,NS,NFN,IBIG,BIG)
      EUG(J)=IBIG
 187C ANY=1CCC.0*EL(J)
      SIG=((.321*ANY**.7677)*EUG(J)/ANY)/2.354
      IF(EL(J)-.2)771,772,772
  771 TNS=3.0
      TFN=4.0
      GC TC 775
  772 IF(EL(J)-.6)773,774,774
  773 TNS=3.0
      GC TC 776
  774 TNS=4.0
  776 TFN=3.0
  775 NSS(J)=EUG(J)-TNS*SIG
      NFNN(J)=EUG(J)+TFN*SIG+1.C
      NS=NSS(J)
      NFN=NFNN(J)
C     WRITE(3,19555) NSS(J),NFNN(J),ANY,SIG,EUG(J)
C9555 FCRMAT (10H SINGLE 1    /1X,2I10,3E14.7)
  768 CONTINUE
C  CHECK-CUT ESTIMATED FITTING LIMITS.
      IF(IN-1)56,56,766
  766 IIN=IN-1
      DC 769 J=1,IIN
      JNS=J+1
      IF(NFNN(J)-NSS(JNS))762,762,763
  763 MEAN=(NFNN(J)-NSS(JNS))/2
      NFNN(J)=NFNN(J)-MEAN
      NSS(JNS)=NFNN(J)+1
  762 CCNTINUE
      IF(NSS(J)-1)64,64,65
   64 NSS(J)=2
   65 IF(NFNN(J)-2CC)66,67,67
   67 NSS(J)=199
   66 CCNTINUE
  769 CCNTINUE
      IF(NFNN(IN)-200)56,57,57
   57 NSS(J)=2CC
```

```
C
      WRITE (3,1500)
 1500 FORMAT (1H1,43X,31HDI'CREIT PHOTOPEAK FITTING DATA   ///
 15001 6X,8HLOCATION,15X,7HCHANNEL,16X,12HPULSE-HEIGHT,10X,   18HSTANDARD
 15002 DEVIATION,14X,4HAREA/ 19H CHANNEL TO CHANNEL,10X,5H(MEV),18X,
 15003 10H(CHANNELS),15X,10H(CHANNELS),14X,13H(COUNTS/TIME)//)
      DO 100 J=1,IN
      NS=NSS(J)
      NFN=NFNN(J)
      ENY=EL(J)
      VENY=EUG(J)
C  STORE PEAK(J) OF SPECTRUM FM(I) IN SLINE(I).
      DO 760 I=1,200
  760 SLINE(I)=0.0
      DO 761 I=NS,NFN
  761 SLINE(I)=FM(I)
C
C  FIT PEAK FROM NS TO NFN.
C
      CALL STOFIT (SLINE,NFN,E,NS,PP,ENY)
C
C  SUBTRACT THE DETERMINED PEAK FROM NS TO NFN.
C
      DO 46 I=NS,NFN
      FM(I)=FM(I)-PP(I)
      IF(FM(I))47,48,48
   47 FM(I)=0.0
   48 CONTINUE
   46 CONTINUE
C
C  DETERMINE THE CONTINUUM ASSOCIATED WITH A PEAK OF AREA  = UNITY FOR
C  ENERGY = ENY, AND OF PULSE-HT. = 100 CHAN.    GAIN CHANGE PER B(1)
C  AND MULTIPLY BY B(3) AND FINALLY SUBTRACT IT FROM FM(I). ALSO DETERM.
C  THE PHOTOFRACTION TO CALC PHOTON FLUX.
C
      DO 99 I=1,200
   99 PP(I)=0.0
      WRITE (3,1600)  NS,NFN,ENY,B(1),B(2),B(3)
 1600 FORMAT (1H ,2X,I3,8X,I3,E22.7,3E25.7)
C
      CALL PHOFRA (RM,NP,EM,ELIMIT,NGC,NGR,NDEGRE,G,PV,PFRACT,K,C
     1 ,ENY,PP)
C
      DO 850 I=80,200
      IF(PP(I))851,851,852
```

```
  851 INDEX=I
      GC TC 853
  852 CCNTINUE
  850 CCNTINUE
  853 DC 854 I=INDEX,2C0
  854 PP(I)=C.C
      SUM=C.O
      DC 999 I=1,1C0
  999 SUM=SLM+PP(I)
      PHCT(J)=1.0/(1.C+SUM)
      NX=1CC
      GAINB1=B(1)
C     WRITE (3,19777) NP,EM,ELIMIT,SUM,PHOT(J),(PP(I),I=1,200)
C9777 FCRMAT (10H SINGLE 3    /1X,I10,4E14.7/(1X,5E14.7))
C
      CALL GANE(C.C,NX,10C.C,GAINB1,C.C,PP)
C
      IF(NX-2C0)18CC,1801,1801
 1801 NX=199
 18C0 DC 1100 I=1,NX
      FM(I)=FM(I)-PP(I)*B(3)
      IF(FM(I))1873,1874,1874
 1873 FM(I)=0.0
 1874 CCNTINUE
 11C0 CCNTINUE
C     WRITE (3,80C) NX,GAINB1,(FM(I),I=1,200),(PP(I),I=1,20C)
C 800 FCRMAT (10H SINGLE 3A     ,I1C,E14.7/(1X,5E14.7))
C
C  FM(I) NCW WITHCLT PEAK J AND ASSCC CCNTINLUM.  PHCT ABCVE IS PHCTCFRT
C  NCW IS LINE SPECTRLM AREA AT CHANNEL CCRRESPONDING TC ENY (CR EU(J))
C  AND VENY (CR EUC(J)).
C
      PHCT(J)=B(3)/PHCT(J)
C
      A=EFFIC(ENY,NGE,NDEGRE,DIST,RX,HH)
      BEE=AIRABS(ENY,NGA,NDEGRE,DIST)
      C=PERSPX(ENY,NGX,NDEGRE,TKLLC)
      D=CLAC(ENY,NGC,NDEGRE)
C     WRITE (3,19888) A,BEE,C,D,PHCT(J)
C9888 FCRMAT (10H SINGLE 4    /1X,5E14.7///)
      PHCT(J)=PHCT(J)/(A*BEE*C*D)
  1C0 CCNTINUE
      NGE=1
      NX=NCX
      RETLRN
```

```
      END
$IBFTC SCLN     DECK,REF,LIST
      SUBRCUTINE SCLN (R,EPS,N,IT,ITMAX,P,PHI,E,NS,NGC,NCEGRE,ETA,K,CIF,
     1 M,CIST,RX,NGA,NGC,MSKIF,NGX,TKLLC,ELIMIT)
C**********  PRCGRAM NUMBER - 26   CUBEC-2   ************
C
C     CALLED BY  *MAIN*
C     CALLS  *CLAC* - *RESMAT* - *AIRABS* - *EFFIC* - *PERSPX*
C     DETERMINES AND APPLIES CETECTCR EFFICIENCY VECTCR.
C
      CCMMCN /A/ CI,H,MF
      DIMENSICN P(2CO),R(40,4C),PHI(20C),ETA(2CO),E(2CO),CIF(1CC),M(18)
      IF(K)50,30,5C
   30 K=1
   50 KK=K-1
      IF(KK-1)601,6C2,6C2
  6C2 DC 6CC I=1,KK
  6CO P(I)=C.C
  601 CCNTINUE
      IF(MF)11,1,11
    1 CALL RESMAT (R,EPS,N,IT,ITMAX,P,PHI,K,CIF,M)
   11 IF(CIST-DI)3,40,3
   40 IF(MSKIP)3,4,3
    3 NGO=1
      WRITE (3,3CCC)
 3C00 FCRMAT (1H1,50X,18HEFFICIENCY FACTORS  /// 8X,5HINDEX,14X,
 3C001 6HENERGY,15X,3HAIR,15X,8HCLACDING,13X,6HLUCITE,13X,7HCRYSTAL/
 3C002 27X,5H(MEV),12X,11HATTENLATICN,9X,11HATTENUATICN,9X,
 3C003 11HATTENUATION,9X,10HEFFICIENCY//)
      DC 2 I=NS,N
      Q=E(I)
      ETA(I)=EFFIC (C,NGO,NCEGRE,CIST,RX,H)
      G=AIRABS (C,NGA,NCEGRE,CIST)
      ABSCRB=PERSPX(C,NGX,NCEGRE ,TKLLC)
      CAN=CLAC(Q,NCC,NDEGRE)
      WRITE   (3,1CCO) I,C,G,CAN,ABSCRB,ETA(I)
 1CCO FCRMAT (1H ,8X,I3,4X,5E2C.7)
    2 ETA(I)=ETA(I)*G*CAN                    *ABSCRB
      NGC=1
      DI=CIST
      IF(MF)99,4,99
    4 DC 22 I=NS,N
   22 PHI(I)=PHI(I)/ETA(I)
      MF=C
C  WRITE CIF(I) IF (IT=ITMAX)
```

```
      IF(IT-ITMAX)89,100,100
  100 WRITE   (3,105) (DIF(I),I=1,IT)
  105 FORMAT (1H1,36H FLUX FITTING DIFFERENCES (IT=ITMAX)/(1X,5E14.7))
      RETURN
   89 DO 9999 I=NS,N
 9999 PHI(I)=P(I)/ETA(I)
      RETURN
      END
$IBFTC STDF    DECK,REF,LIST
      SUBROUTINE STDFIT (Y,NFN,B                  ,NS,PP,ENY)
C**********  PROGRAM NUMBER - 27   CUBED-2   ************
C
C     CALLED BY  *RESGEN* - *SINGLE*
C     CALLS  *GUESS* - *FUNUS*
C     NON-LINEAR REGRESSION ANALYSIS OF STANDARD SPECTRA PHOTOPEAKS.
C
      DIMENSION FC(200),Y(200),B(5),P(200),A(200,5),G(6,6),PP(200)
      EPS=.00001
      L=B(3)
      DO 100 I=1,5
  100 B(I)=0.0
      B(3)=L
      KLM=5
      NBC=5
      PIE=3.14159265
      NB=KLM
      NF=NFN
      NI=10
      L=0
      FITLM1=0.0
C
C CALL GUESS TO INITIALIZE PARAMETERS.
C CALL FUNCTION TO BE FITTED.
      CALL GUESS (NS,NF,Y,B,ENY)
      FIT=0
    5 CALL FUNUS (FIT,FC,Y,B,F,A,NF,    NS,PP,ENY)
C CONSTRUCT THE NORMAL EQUATIONS.
      NN=NBC
      M=NN+1
      DO 21 I=1,NN
      G(I,M)=0.0
      DO 21 J=NS,NF
   21 G(I,M)=G(I,M)+A(J,I)*FC(J)/Y(J)
      DO 22 I=1,NN
      DO 22 K=1,NN
```

```
      G(I,K)=C.O
      DC 22 J=NS,NF
   22 G(I,K)=G(I,K)+A(J,I)*A(J,K)/Y(J)
C SCLVE NCRMAL ECLATICNS. FRCM HERE TC STATEMENT 11.
      DC 2 K=1,NN
      KK=K+1
      DC 1 J=KK,M
    1 G(K,J)=G(K,J)/G(K,K)
      DC 2 I=KK,NN
      DO 2 J=KK,M
    2 G(I,J)=G(I,J)-G(I,K)*G(K,J)
      K=NN
   15 IF(K-1)11,1C,10
   10 I=1
   14 IF(I-K)12,13,12
   12 G(I,M)=G(I,M)-G(I,K)*G(K,M)
      I=I+1
      GC TC 14
   13 K=K-1
      GC TC 15
   11 CCNTINUE
C
C FIT ARRESTING ..ECK.
      L=L+1
      IF(L-1)29,29,28
   28 IF(ABS(FITLM1-FIT)/FIT - EPS)42,42,29
   29 IF(L-NI)8,42,42
    8 DC 24 I=1,NBC
   24 B(I)=B(I)+G(I,M)
      FITLM1=FIT
C     WRITE (3,988) NF,NS,KLM,NFN,L,M,FIT,(B(I),I=1,5)
C 988 FORMAT (10H STDFIT      /1X,6I5,5X,E14.7//1X,5E14.7)
      GC TC 5
C FITTING CCMPLETE.  C. .CLLATE CCRRELATICN MATRIX.
   42 CCNTINUE
      RETLRN
      END
$IBFTC TA      DECK,REF,LIST
      SUBRCUTINE TA (E,X,M,MM,MCX,MLN,Z,Y,R,NCEGRE,L,LL)
C**********  PROGRAM NUMBER - 28   CLBEC-2   ************
C
C     CALLEC BY  *EFFIC* - *PERSPX* - *CLAD* - *AIRABS*
C     CALLEC BY  *CCSL* - *PULSE* - *RAXEL* - *PHCFRA*
C     BINARY TABLE SEARCHING FRCGRAM.
C
```

```
      DIMENSION X(45),Z( 6),Y( 6),R(45)
      MOX=M
      MLN=MM
    7 KDEL=(MOX-MLN)/2
    8 IF(KDEL)18,14,18
   18 KP=MLN+KDEL
      IF(X(KP)-E)12,12,11
   11 MOX=KP
      GO TO 7
   12 IF(E-X(KP))24,24,13
   13 MLN=KP
      GO TO 7
   24 MLN=KP
      MOX=KP+1
C
   14 IF(MOX-M)4,5,4
    5 L=MLN-2
      GO TO 6
    4 L=MLN-1
    6 NN=NDEGRE+1
      IF(LL)15,2,15
    2 DO 3 I=1,NN
      J=I+L
      Z(I)=X(J)
    3 Y(I)=R(J)
   15 RETURN
      END
$IBFTC TE       DECK,REF,LIST
      FUNCTION TE (N,X,Y,E)
C**********  PROGRAM NUMBER - 29   CUBED-2   ************
C
C     CALLED BY  *EFFIC* - *PERSPX* - *CLAD* - *AIRABS*
C     CALLED BY  *DOSE* - *PULSE*   *PAXEL* - *PHOFRA*
C     N-DEGREE LAGRANGIAN INTERPOLATION PROGRAM.
C
      DIMENSION X( 6),Y(6)
      S=0.
      I=1
   28 IF(I-N)21,21,22
   21 P=Y(I)
      J=1
   27 IF(J-N)23,23,24
   23 IF(I-J)25,26,25
   25 P=P*(E-X(J))/(X(I)-X(J))
   26 J=J+1
```

```
      GC TC 27
   24 S=S+P
      I=I+1
      GC TC 28
   22 TE =S
      RETURN
      END
$IBFTC VECT     DECK,REF,LIST
      SUBROUTINE VECTMX (Y,N1,N2,JMAX,YMAX)
C**********  PROGRAM NUMBER - 3C   CUBED-2   ************
C
C     CALLED BY  *MAIN* - *RESMAT* - *GUESS*
C     DETERMINES THE INDEX AND VALUE OF THE MAX ELEMENT IN A VECTOR OF ELEMENTS.
C
      DIMENSION Y(200)
      DO 1 I=N1,N2
      IF(Y(I)-YMAX)3,3,4
    4 YMAX=Y(I)
      JMAX=I
    3 CONTINUE
    1 CONTINUE
      RETURN
      END
```

APPENDIX IV
SAMPLE INPUT CARD DECK LISTING

```
$DATA
   4.0
 SAMPLE GSFC BREMSSTRAHLUNG SPECTRA     (SEPT 1967)
   0    0    0    4    0    6    7    8    0    0    0    0    0    0   15    0    0   18
   0    2              3
     .662         1.0          1.0          20.0          91.0
   7     7     4.
 HG203        110   143    12    48     1.7
  NB95        120   155     0     0     1.7
  MN54        130   165     0     0     1.7
 CD109        115   143     8    61     0.0
 CS137        110   143     0     0     0.0
  SR85        115   145     0     0     1.7
  ZN65        115   155   -51    68     1.7
000369 000668 001062 001063 001114 001087 001388 001418 001410 001439
001423 001447 001498 001605 001576 001742 001815 001955 002334 002707
002941 003015 002625 002309 002182 002252 002527 002699 002903 003151
004151 006060 008958 012654 016503 017683 016260 013286 009910 007915
006460 005457 004156 003105 002436 001947 001821 001822 001918 001937
001943 001947 002100 002245 002269 002410 002588 002734 002997 003276
003415 003476 003608 003589 003391 003191 002968 002707 002338 002190
001989 001764 001761 001693 001588 001420 001467 001443 001426 001304
001353 001366 001362 001310 001435 001395 001329 001460 001516 001547
001525 001529 001635 001651 001647 001703 001726 001699 001817 001785
001710 001639 001890 001874 002056 001969 002089 002254 002307 002364
002519 002687 003027 003557 004541 005928 008062 011030 014486 018876
024157 029507 034374 039219 042642 045461 046095 045349 043702 039797
035271 030541 024957 019769 015139 011064 007992 005387 003556 002233
001346 000651 000554 000370 000217 000200 000165 000159 000181 000134
000167 000146 000143 000127 000117 000149 000157 000155 000183 000147
000172 000099 000136 000135 000137 000119 000134 000124 000104 000127
000113 000104 000123 000093 000119 000106 000134 000077 000081 000088
000112 000130 000101 000114 000098 000104 000100 000110 000081 000074
000096 000104 000078 000122 000084 000121 000074 000075 000089 000184
000139 000562 002404 003697 003455 003240 003477 003602 003563 003610
003665 003520 003802 003744 003732 004127 003989 003979 003984 004100
004143 004154 004276 004304 004265 004356 004246 004522 004400 004567
004654 004765 004862 005277 005834 006162 006410 006153 006032 005558
005095 005003 004905 004824 004895 004848 004686 004718 004714 004647
004544 004525 004545 004647 004511 004513 004383 004467 004653 004413
004486 004429 004396 004596 004494 004605 004416 004560 004591 004576
004584 004632 004605 004709 004510 004493 004471 004645 004613 004621
004430 004766 004528 004697 004672 004791 004822 004870 004919 004922
005059 005061 005161 005260 005112 005133 005025 004924 004670 004310
004192 003762 003268 003053 002466 002188 001983 001816 001593 001493
001438 001331 001219 001167 001179 001075 001180 001169 001170 001269
```

001325	001479	001545	001672	001850	002285	002852	003557	004835	006572
009166	012655	017052	022417	028037	033729	037895	039725	039435	036506
031736	025678	019475	013934	009131	005454	003148	001721	000868	000505
000264	000204	000164	000155	000145	000115	000139	000125	000133	000107
000156	000142	000152	000131	000123	000125	000112	000128	000117	000113
000112	000134	000100	000109	000113	000105	000126	000116	000116	000091
000115	000112	000098	000099	000091	000089	000095	000090	000088	000069
000085	000067	000090	000093	000087	000071	000081	000081	000084	000017
000026	000155	001125	001216	001194	001168	001292	001331	001334	001475
001402	001355	001446	001422	001296	001538	001376	001435	001560	001453
001525	001515	001525	001504	001519	001489	001602	001569	001694	001586
001675	001624	001646	001707	001736	002015	002216	002116	002325	002363
002256	002168	002081	001907	001793	001823	001816	001728	001786	001703
001768	001765	001803	001757	001814	001850	001769	001676	001817	001623
001731	001722	001730	001690	001711	001667	001773	001686	001733	001655
001667	001752	001646	001669	001636	001747	001642	001797	001693	001691
001666	001753	001693	001772	001787	001744	001709	001721	001629	001725
001705	001763	001799	001769	001836	001771	001811	001732	001798	001873
001853	001695	001696	001950	001957	001976	001927	001924	001928	002040
001964	002020	001976	001943	001620	001813	[illegible]	001611	001434	001273
001193	001010	000869	000833	000794	000671	000635	000581	000501	000491
000466	000471	000441	000399	000436	000417	000450	000415	000503	000525
000552	000594	000566	000740	000849	001035	001309	001824	002491	003572
004496	006624	007646	009962	011630	013579	014509	015011	014993	013735
011931	010050	007555	005479	003701	002360	001470	000857	000450	000247
000134	000069	000054	000035	000044	000042	000039	000033	000016	000027
000025	000036	000027	000036	000012	000028	000015	000027	000013	000029
000022	000013	000016	000026	000023	000018	000001	000020	000019	000006
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000968	001549	002601	004331	007142	012068	018729	027125	035659	042891
047119	048134	045443	039657	033251	026442	019945	014365	009956	006651
004183	002512	001525	000816	000457	000234	000130	000116	000085	000109
000062	000040	000026	000015	000015	000015	000015	000015	000015	000015
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000015	000016	000030	000040	000050	000060	000070	000080	000090	000100
000110	000118	000125	000130	000132	000133	000131	000129	000123	000120
000115	000110	000105	000098	000092	000085	000078	000070	000065	000060
000055	000055	000055	000057	000060	000070	000082	000105	000130	000150
000180	000215	000250	000295	000332	000393	000538	000567	000752	000800
000919	001122	001310	001414	001549	001533	001573	001630	001771	001651
001630	001495	001405	001302	001211	001065	000831	000644	000560	000449
000350	000251	000162	000139	000069	000079	000042	000082	000112	999949
000041	000052	999989	999946	999995	999957	000017	999991	000026	999985
999971	000003	000001	999979	000002	999911	999975	000000	000024	000031
999998	000012	000014	000008	000050	999997	000040	000040	000030	999971

999986	999985	000031	000032	999976	000006	000013	000009	000050	999966
000015	000015	000045	000037	999920	000012	999954	999939	999993	000744
003200	003200	003200	003200	003200	003200	003200	003200	003200	003200
003145	003318	003230	003357	003145	003405	003267	003355	003396	003234
003313	003493	003363	003422	003442	003466	003543	003448	003522	003724
003793	003795	003991	004276	004509	004983	004952	004625	004519	004313
004139	004046	003865	003893	003929	003845	003721	003742	003724	003722
003790	003674	003650	003657	003547	003652	003736	003487	003651	003611
003565	003563	003422	003470	003447	003526	003567	003535	003502	003469
003361	003425	003501	003476	003491	003527	003589	003603	003610	003701
003778	003780	003761	003866	003825	003862	003834	003760	003637	003530
003075	002615	002602	002338	002072	001872	001624	001507	001353	001182
001161	001138	001124	001086	000965	000937	000940	000904	000937	000991
001000	001015	001034	001104	001257	001404	001518	001776	002033	002448
003059	004153	005519	007805	010762	014506	018734	023209	027615	031024
032593	033075	031246	027667	023137	017587	013084	008814	005726	003444
002031	001056	000559	000311	000150	000128	000108	000121	000132	000126
000160	000153	000153	000184	000171	000165	000159	000161	000161	000163
000155	000115	000095	000111	000086	000098	000078	000078	000067	000056
000059	000066	000062	000062	000076	000064	000073	000052	000065	000059
000067	000048	000045	000051	000067	000036	000056	000051	000057	000044
000065	000075	000062	000033	000048	000053	000041	000032	000032	000105
000182	000632	003613	011845	016213	006452	003215	003193	003400	003383
003401	003429	003460	003615	003563	003672	003667	003702	003709	003794
003863	003986	003823	003914	004031	004039	004026	003949	004214	004123
004293	004240	004124	004174	004276	004281	004266	004430	004725	004703
004850	004926	005427	005636	005908	006166	006169	005921	005656	005193
005019	004678	004821	004924	004600	004506	004515	004597	004357	004470
004522	004348	004400	004265	004227	004435	004281	004267	004368	004425
004452	004409	004410	004436	004612	004566	004708	004657	004576	004759
004594	004472	004400	004309	004134	003715	003268	003024	002788	002469
002172	002072	001963	001847	001802	001627	001565	001541	001544	001397
001391	001338	001396	001388	001401	001425	001430	001419	001409	001492
001528	001595	001574	001733	001791	001986	002208	002507	002973	003542
004551	006141	006489	011726	015719	020453	026002	031973	037932	042725
046713	048133	047657	044767	040347	034033	027069	020366	014561	009863
006404	003623	002315	001303	000636	000383	000264	000210	000173	000163
000172	000122	000122	000148	000142	000153	000150	000139	000149	000143
000140	000136	000133	000128	000145	000155	000133	000144	000138	000136
000128	000141	000142	000143	000130	000148	000116	000134	000127	000127
000124	000117	000116	000129	000126	000093	000112	000101	000112	000101
000079	000104	000092	000032	000109	000113	000106	000107	000084	000036
000000	000003	000261	003356	003366	003012	002911	002926	002901	003019
003020	003115	003017	003035	003171	003151	003015	003372	003304	003300
003461	003573	003954	004126	004514	004603	004566	003981	003903	003714
003757	003450	003560	003546	003529	003612	003454	003389	003384	003349

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003199 003134 003058 003069 002990 003010 002937 002974 003072 003040
002999 003055 003076 003110 003217 003363 003791 004494 005577 006747
007525 007245 006127 004819 003749 003225 003036 002940 002946 003011
002915 002927 003082 003069 003079 003104 003172 003138 003179 003130
003250 003128 003232 003346 003337 003456 003258 003518 003499 003697
003675 003614 003840 003724 003851 003912 003970 003976 003848 003794
003523 003233 002398 002507 002081 001860 001476 001330 001106 001103
000950 000943 000906 000886 000908 001008 001123 001252 001502 001917
002685 004143 006231 009409 013128 017420 021171 023243 023103 020691
016720 011957 007763 004446 002288 001026 000450 000213 000106 000075
000082 000071 000051 000072 000066 000058 000055 000047 000065 000054
000072 000062 000044 000057 000058 000054 000055 000048 000037 000045
000026 000037 000051 000074 000061 000011 000042 000039 000042 000048
000031 000042 000049 000047 000022 000023 000042 000039 000033 000033
000045 000023 000027 000041 000024 000032 000035 000026 000031 000018
000017 000009 000017 000007 000014 000035 000023 000017 000017 000000
 TL204            1.0        .766        2.54        3.9      1.0     130.0      0
121.29    -10.0    00.0     3.0 .001        2.0     130.   .662        0.0      0.0 0
   1   2   3   4   5   6   7   9  12  15  20  25  35  50  60  90
 .07                                       11.       20.
   169   11981   23233   21034   26210   33662   44035   55266   57394   63594
 78534  104450  173065  280727  282447  203239  139574   74726   38999   32312
 32283   33327   34359   35132   36090   36370   36442   36828   36845   36207
 35518   35326   34847   33857   33338   32839   32424   31857   31176   30617
 30389   29519   29154   28220   27856   26955   26294   25701   25151   24361
 23472   22436   22066   21278   20472   19681   18976   18283   17362   16909
 16037   15252   14748   14063   13466   12853   11914   11820   11009   10420
 10185    9495    9047    8466    7977    7586    7143    6627    6462    5988
  5529    5393    5106    4746    4509    4130    4043    3694    3472    3292
  3022    2735    2737    2419    2331    2213    1955    1916    1773    1606
  1471    1406    1279    1147    1103    1057     957     846     743     760
   689     573     564     555     467     467     444     352     366     331
   302     268     246     244     256     244     240     251     242     198
 SAMPLE GSFC BREMSSTRAHLUNG SPECTRA      (SEPT 1967)
   0   0   0   4   0   6   7   8   0   0   0   0   0   0  15  16   0  18
   0   2           1
       0.4         1.0         0.0         20.0        51.0
 PM147             1.0        .230         2.54        2.6      1.0     200.0      0
121.29    -10.0    00.0     20. .001         8.     140.   .279        0.0      0.0 0
   1   2   3   4   5   6   7   9  12  15  20  25  35
  .041                                     10.       29.
                                                                        15400
 18017   23245   29831   39446   49682   60195   71830   91941  118982  136702
131228  112195   90213   69246   49086   32591   22959   19988   19419   19768
 20328   20726   20775   20735   20849   20887   20886   21099   21174   21125
 20847   20538   19945   19605   19188   18764   18273   17763   17090   16528
```

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 16178  15001  15197  14760  14293  14019  14052  14014  14164  14362
 14773  14734  14167  12694  11536   9876   8522   7365   6619   5881
  5426   4957   4639   4313   3832   3585   3341   3019   2720   2531
  2132   2083   1769   1647   1464   1325   1151   1022    876    778
   709    590    526    445    311    313    347    194    207    161
   142     91     97     96     71     66     63     76     60     25
    35      4     44     44      0     33      6      9 999993     35
    40     40     36     50     38     27 999986      6 999997 999986
    17     29 999967     17     38 999979     21     37     27     35
    27     51      2     44     36 999990 999982 999990     36      6
     5     27     31     61      7     19 999972 999992 999998     15
999977     33      7 999990 999971      8 999982 999986     29     19
    22 999961 999957      1     30     16     19     14      6 999967
999969      9 999971      7 999990     13      7     24     21 999998
    17      7 999995 999981     30     18     17 999996     24      0
 SAMPLE GSFC BREMSSTRAHLUNG SPECTRA     (SEPT 1967)
   0   0   0   4   0   6   7   8   0   0   0   0   0   0   0  16   0  18
   0   2           4
       1.4         1.0         0.0        20.0        51.0
 SR90              1.0         .61        2.54        28.     1.0     100.0      0
60.325     10.0   -80.0     2.0 .001        1.0      95.0  1.33       0.0     1.0 1
   1   2   3   4   5   6   7   9  12  15  20  25  35
  1015 221423 455004 437028 449246 463573 452407 428854 355763 358381
322978 292968 263562 237246 213605 194254 175143 159934 145415 132203
121366 110587 100806  92620  84629  77309  71410  65375  60111  55333
 50803  47274  43601  40213  37710  34852  32328  29785  27651  25347
 23764  22008  20511  19232  17787  16615  15259  14463  13316  12710
 11480  10939  10096   9735   8868   8387   7883   7121   6890   6422
  5978   5549   5354   4930   4699   4320   4168   3700   3590   3454
  3240   2908   2821   2648   2499   2371   2202   2020   1825   1811
  1706   1677   1541   1546   1395   1333   1274   1089   1008    987
   964    864    870    779    741    738    656    573    588    513
     0    374    653   1036   1494   1097    989   1161   1194   1187
  1300   1206   1167   1137   1061    963    827    729    704    653
   593    466    462    403    323    289    265    242    208    166
   173    160    154    128    126    131    114    107     79     91
    97     93     93     82     65     46     53     29     41     41
    43     42     54     39     35     26     33     30     35     37
    27     25     33     40     26     40     31     26     31     26
    16     21     25     23     17     17     24     26     28     25
    21     23      7     19     20     19     16     14     15     15
    12     13     16      9      9     13     18     11     20     23
SAMPLE DATA FOR NASA-GSFC. NUS MODEL LINEAR TEST. (SEPT 11/67)
   0   2   3   4   5   6   0   8   0   0   0   0   0   0   0   0  17   0

       1.0         1.0         0.0        20.0        51.0
```

```
LINEAR        1.0        1.0        1.0      64.0     1.0     100.0       24
 100.     0.0     0.0     1.0     0.001  1.0  100.0     1.0     0.0     0.0 0
50.0    127.44 273.67 302.54 381.72 520.65 646.47 747.48 843.06 949.60
1057.1 1161.7 1263.0 1364.7 1467.9 1565.0 1671.6 1780.0 1886.2 1988.9
2085.0 2187.7 2289.6 2390.5 2490.1 2579.4 2680.9 2781.9 2882.4 2982.2
3076.3 3177.2 3277.8 3378.1 3477.9 3573.9 3674.6 3775.1 3875.4 3975.3
4073.8 4174.0 4273.9 4373.6 4472.8 4568.4 4669.2 4769.9 4870.5 4971.4
5077.3 5176.8 5276.1 5375.2 5474.1 5572.8 5671.3 5769.5 5867.5 5964.3
6048.7 6148.5 6248.2 6347.9 6447.6 6547.3 6646.9 6746.5 6846.1 6945.5
7043.0 7142.9 7242.8 7342.7 7442.6 7542.5 7642.4 7742.3 7842.2 7942.0
8041.7 8141.6 8241.6 8341.6 8441.5 8541.5 8641.5 8741.5 8841.4 8940.1
9028.0 9130.7 9233.5 9336.5 9439.7 9543.0 9646.6 9750.3 9854.3 9960.7
'
*      END TAPE
```

APPENDIX V

SAMPLE CODE OUTPUT LISTING

```
BRIEF DESCRIPTICN OF PHA RUNS
SAMPE GSFC BREMSSTRAHLUNG SPECTRA     (SEPT 1967)

CONTROL NUMBERS
M( 1) =  0  M( 2) =  0  M( 3) =  0  M( 4) =  4  M( 5) =  0  M( 6) =  6
M( 7) =  7  M( 8) =  8  M( 9) =  0  M(10) =  0  M(11) =  0  M(12) =  0
M(13) =  0  M(14) =  C  M(15) = 15  M(16) =  0  M(17) =  0  M(18) = 18

CALCOMP PLOTTING OPTICN CCNTROL NUMBERS
MPLOT( 1) =  C  MPLOT( 2) =  2  MPLOT( 3) = -0  MPLOT( 4) = -0  MPLOT( 5) =  3

EM =    30.21148 CHANNELS/MEV

ELIMIT=     C.66200

ITERATIVE ERROR TOLERANCE,EPS =     0.00010

NUMBER OF BETA SOURCE SETS,OJSC =    1     MM =   1

MAX NUMBER OF ITERATICNS,ITMAX=  91

NUMBER OF CHANNELS INPUT, N = 20

NAI(TL) CRYSTAL SIZE =  3.00 X 3.00 INCHES.
```

(A)

STANDARD SCURCE SPECTRAL PARAMETERS

7 SPECTRA IN STANDARD SCURCE DECK

CHANNELS CNE TO 6 ASSUMED AS REDUNDANT

REFERENCE COARSE GAIN = 4.00000

STANDARD SOURCE	PHOTOPEAK FROM	PHOTOPEAK TO	X-RAY OR .5 PEAK FROM	X-RAY OR .5 PEAK TO	SHIFT SPECTRUM	PHOTOPEAK ENERGY
	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNELS	MEV
HG203	109	142	11	47	1.7000	0.27900
NB95	119	152	0	0	1.7000	0.76400
MN54	135	164	0	0	1.7000	0.83500
CD109	115	143	8	61	0.	0.08800
CS137	110	143	0	0	0.	0.66162
SR85	114	144	0	0	1.7000	0.51500
ZN65	114	135	50	67	1.7000	1.11400

B

STANDARD SOURCE SPECTRA

HG203 SOURCE

1425.	1071.	1100.	1095.	1298.	1409.	1412.	1430.	1428.	1440.
1483.	1573.	1585.	1692.	1793.	1913.	2220.	2595.	2871.	2993.
2742.	2404.	2220.	2231.	2444.	2647.	2842.	3077.	3851.	5487.
8089.	11545.	15348.	17329.	16687.	14178.	10923.	8513.	6910.	5764.
4548.	3421.	2637.	2094.	1859.	1822.	1889.	1931.	1941.	1946.
2054.	2201.	2262.	2368.	2535.	2690.	2918.	3192.	3373.	3458.
3610.	3613.	3450.	3251.	3035.	2785.	2449.	2234.	2049.	1845.
1768.	1713.	1619.	1470.	1453.	1450.	1431.	1341.	1338.	1362.
1363.	1326.	1397.	1407.	1349.	1421.	1499.	1538.	1532.	1528.
1602.	1646.	1648.	1686.	1719.	1707.	1782.	1795.	1732.	1800.
1875.	1879.	2001.	1995.	2053.	2204.	2291.	2347.	2472.	2637.
2925.	3405.	4249.	5512.	7422.	10140.	13449.	17559.	22573.	27902.
32914.	37765.	41615.	44615.	45905.	45573.	44196.	40968.	36629.	31960.
26632.	21325.	16528.	12287.	8914.	6169.	4105.	2630.	1612.	1000.
629.	419.	263.	205.	175.	161.	174.	148.	157.	152.
144.	132.	120.	139.	155.	156.	175.	158.	164.	121.
125.	135.	136.	124.	129.	127.	110.	120.	117.	107.
117.	102.	111.	110.	126.	94.	80.	86.	105.	125.
110.	110.	103.	102.	101.	107.	90.	76.	89.	102.
86.	109.	95.	110.	88.	75.	85.	211.	184.	0.

NB95 SOURCE

2245.	3309.	3528.	3304.	3406.	3564.	3575.	3596.	3648.	3563.
3717.	3761.	3771.	4023.	4030.	3982.	3982.	4065.	4130.	4151.
4239.	4296.	4277.	4329.	4279.	4439.	4437.	4517.	4628.	4732.
4847.	5158.	5667.	6064.	6336.	6230.	6068.	5700.	5234.	5031.
4934.	4848.	4874.	4862.	4735.	4708.	4715.	4667.	4575.	4531.
4539.	4616.	4552.	4512.	4422.	4442.	4597.	4485.	4464.	4446.
4406.	4474.	4498.	4572.	4473.	4517.	4582.	4580.	4582.	4613.
4613.	4678.	4570.	4498.	4478.	4593.	4623.	4619.	4487.	4665.
4599.	4646.	4679.	4755.	4813.	4856.	4904.	4921.	5018.	5060.
5131.	5230.	5156.	5127.	5057.	4954.	4746.	4418.	4227.	3891.
3416.	3117.	2642.	2271.	2045.	1866.	1660.	1523.	1454.	1363.
1253.	1183.	1175.	1106.	1148.	1172.	1170.	1239.	1307.	1432.
1525.	1634.	1797.	2153.	2667.	3339.	4452.	6051.	8389.	11749.
15821.	20819.	26351.	32021.	36645.	39176.	39522.	37385.	33167.	27635.
21392.	15595.	10572.	6557.	3840.	2149.	1124.	[illegible]	336.	222.
176.	158.	149.	126.	133.	129.	131.	115.	141.	146.
135.	131.	125.	124.	116.	123.	120.	114.	112.	127.
110.	106.	112.	107.	120.	119.	116.	99.	106.	112.
102.	99.	93.	90.	93.	91.	89.	75.	79.	86.
89.	92.	89.	76.	78.	81.	83.	42.	17.	0.

STANDARD SOURCE SPECTRA

MN54 SOURCE

923.	1189.	1201.	1176.	1255.	1319.	1333.	1433.	1424.	1368.
1418.	1429.	1334.	1465.	1426.	1418.	1522.	1485.	1503.	1518.
1522.	1510.	1514.	1498.	1568.	1579.	1656.	1618.	1648.	1639.
1639.	1689.	1762.	1946.	2156.	2146.	2262.	2352.	2289.	2195.
2093.	1953.	1827.	1814.	1818.	1754.	1769.	1728.	1762.	1772.
1792.	1778.	1800.	1839.	1793.	1704.	1775.	1681.	1699.	1725.
1728.	1702.	1705.	1680.	1741.	1712.	1719.	1678.	1677.	1718.
1672.	1662.	1646.	1714.	1673.	1750.	1724.	1692.	1673.	1727.
1711.	1748.	1782.	1757.	1719.	1717.	1657.	1696.	1711.	1746.
1788.	1792.	1823.	1791.	1799.	1756.	1778.	1850.	1859.	1882.
1896.	1934.	1955.	1970.	1942.	1925.	1927.	2006.	2001.	2009.
1985.	1951.	1657.	1815.	1735.	1638.	1487.	1321.	1217.	1065.
911.	844.	806.	708.	646.	597.	525.	494.	475.	470.
450.	412.	425.	423.	440.	425.	477.	518.	544.	581.
584.	692.	816.	979.	1227.	1669.	2291.	3108.	4159.	5566.
7299.	9341.	11136.	12994.	14230.	14860.	14998.	14112.	12472.	10635.
8313.	6102.	4234.	2762.	1737.	1041.	572.	308.	168.	89.
59.	41.	41.	43.	40.	35.	21.	24.	26.	12.
21.	33.	19.	23.	19.	23.	17.	24.	24.	16.
16.	24.	24.	20.	6.	14.	19.	12.	6.	0.

STANDARD SOURCE SPECTRA

CD109 SOURCE

15.	15.	15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.	15.	15.
968.	1549.	2601.	4331.	7142.	12068.	18729.	27125.	35659.	42891.
47119.	48134.	45443.	39657.	33251.	26442.	19945.	14365.	9956.	6651.
4183.	2512.	1525.	816.	457.	234.	130.	116.	85.	109.
62.	40.	28.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.	15.	15.
15.	18.	30.	40.	50.	60.	70.	80.	90.	100.
110.	118.	125.	130.	132.	133.	131.	129.	123.	120.
115.	110.	105.	98.	92.	85.	78.	70.	65.	60.
55.	55.	55.	57.	60.	70.	82.	105.	130.	150.
180.	215.	250.	295.	332.	393.	538.	567.	752.	800.
919.	1122.	1310.	1414.	1549.	1533.	1573.	1630.	1771.	1651.
1630.	1455.	1405.	1302.	1211.	1065.	841.	644.	560.	449.
350.	231.	182.	139.	89.	79.	42.	82.	112.	-51.
41.	52.	-11.	-54.	-5.	-43.	17.	-9.	26.	-15.
-29.	3.	1.	-21.	2.	-89.	-25.	0.	24.	31.
-2.	12.	14.	8.	50.	-3.	40.	40.	30.	-29.
-14.	-12.	31.	32.	-22.	6.	13.	9.	50.	-34.
15.	15.	45.	37.	-80.	12.	-46.	-61.	-7.	744.

CS137 SOURCE

3200.	3200.	3200.	3200.	3200.	3200.	3200.	3200.	3200.	3200.
3145.	3318.	3230.	3357.	3145.	3405.	3267.	3355.	3396.	3234.
3313.	3493.	3383.	3422.	3442.	3466.	3543.	3448.	3522.	3724.
3793.	3795.	3991.	4276.	4509.	4988.	4952.	4825.	4519.	4313.
4139.	4048.	3836.	3893.	3929.	3845.	3721.	3742.	3724.	3722.
3790.	3674.	3650.	3657.	3547.	3652.	3736.	3487.	3651.	3611.
3565.	3563.	3422.	3470.	3447.	3526.	3567.	3535.	3502.	3469.
3361.	3425.	3501.	3478.	3491.	3527.	3589.	3603.	3610.	3701.
3778.	3780.	3761.	3866.	3825.	3862.	3834.	3760.	3637.	3530.
3075.	2815.	2602.	2338.	2072.	1872.	1624.	1507.	1353.	1182.
1161.	1138.	1124.	1086.	965.	937.	940.	904.	937.	991.
1000.	1015.	1034.	1104.	1257.	1404.	1518.	1776.	2033.	2448.
3059.	4158.	5519.	7805.	10762.	14506.	18734.	23209.	27615.	31024.
32593.	33075.	31246.	27667.	23137.	17537.	13084.	8814.	5726.	3444.
2031.	1056.	559.	311.	150.	128.	108.	121.	132.	126.
160.	153.	153.	184.	171.	165.	159.	161.	161.	163.
155.	115.	95.	111.	86.	98.	78.	78.	67.	56.
59.	66.	62.	62.	76.	64.	73.	52.	65.	59.
67.	48.	45.	51.	67.	36.	56.	51.	57.	44.
65.	75.	62.	33.	48.	53.	41.	32.	32.	105.

STANDARD SOURCE SPECTRA

SR 85 SOURCE

3501.	9435.	14903.	9380.	4186.	3200.	3338.	3388.	3396.	3421.
3451.	3568.	3579.	3639.	3668.	3691.	3707.	3768.	3856.	3955.
3872.	3887.	3996.	4037.	4030.	3972.	4134.	4150.	4242.	4256.
4159.	4159.	4247.	4280.	4270.	4381.	4636.	4710.	4806.	4903.
5277.	5608.	5841.	6089.	6168.	5995.	5735.	5332.	5071.	4920.
4838.	4893.	4697.	4534.	4512.	4572.	4429.	4436.	4506.	4400.
4384.	4305.	4238.	4373.	4327.	4271.	4338.	4408.	4444.	4422.
4410.	4428.	4559.	4580.	4665.	4672.	4600.	4704.	4643.	4509.
4422.	4336.	4186.	3841.	3402.	3097.	2859.	2565.	2261.	2102.
1954.	1864.	1815.	1680.	1584.	1548.	1543.	1441.	1393.	1354.
1380.	1391.	1397.	1418.	1428.	1422.	1412.	1467.	1517.	1575.
1580.	1685.	1774.	1927.	2141.	2417.	2833.	3371.	4248.	5664.
7785.	10755.	14521.	19033.	24337.	30182.	36144.	41287.	45517.	47752.
47819.	45634.	41673.	35927.	29158.	22377.	16302.	11272.	7442.	4597.
2767.	1607.	836.	459.	300.	226.	184.	166.	169.	137.
122.	140.	144.	150.	151.	142.	146.	145.	141.	137.
134.	130.	140.	152.	140.	141.	140.	137.	130.	137.
142.	143.	134.	143.	126.	129.	129.	127.	125.	119.
116.	125.	127.	103.	106.	104.	109.	104.	86.	96.
96.	85.	101.	112.	108.	107.	91.	61.	36.	0.

ZN65 SOURCE

186.	2427.	3377.	3124.	2941.	2921.	2908.	2984.	3020.	3087.
3047.	3065.	3145.	3157.	3056.	3265.	3324.	3301.	3427.	3545.
3840.	4074.	4398.	4716.	4637.	4157.	3926.	3771.	3744.	3542.
3541.	3556.	3534.	3537.	3501.	3408.	3385.	3359.	3244.	3167.
3087.	3066.	3014.	3004.	2959.	2963.	3043.	3050.	3011.	3038.
3070.	3100.	3185.	3319.	3663.	4283.	5252.	6466.	7322.	7329.
6462.	5211.	4070.	3382.	3093.	2969.	2944.	2991.	2944.	2923.
3035.	3073.	3076.	3096.	3152.	3148.	3167.	3145.	3214.	3162.
3200.	3312.	3340.	3420.	3317.	3440.	3505.	3638.	3682.	3632.
3772.	3759.	3813.	3894.	3953.	3974.	3886.	3810.	3604.	3320.
2998.	2624.	2209.	1926.	1591.	1374.	1173.	1104.	996.	945.
917.	892.	901.	978.	1088.	1213.	1427.	1792.	2455.	3706.
5605.	8456.	12012.	16132.	20046.	22621.	23145.	21415.	17911.	13386.
8979.	5425.	2936.	1405.	623.	284.	138.	84.	80.	74.
57.	66.	68.	60.	56.	49.	60.	57.	67.	65.
49.	53.	58.	55.	55.	50.	40.	43.	32.	34.
47.	67.	65.	26.	33.	40.	41.	46.	36.	39.
47.	48.	30.	23.	36.	40.	35.	33.	41.	30.
26.	37.	29.	30.	34.	29.	29.	22.	17.	11.
15.	10.	12.	29.	27.	19.	17.	5.	0.	0.

RESULTS OF PHOTOPEAK FITTING

INDEX	STANDARD SOURCE	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
1	HG203	0.1249653E 03	0.5170472E 01	0.5879692E 06
2	NB95	0.1359314E 03	0.3981012E 01	0.3561217E 06
3	MN54	0.1555815E 03	0.4208165E 01	0.1494891E 06
4	CD109	0.1283551E 03	0.7144329E 01	0.3034849E 05
5	CS137	0.1308002E 03	0.4192102E 01	0.3391116E 06
6	SR85	0.1298391E 03	0.4532[illegible]04E 01	0.5353141E 06
7	ZN65	0.1261401E 03	0.3203[illegible]9E 01	0.1815124E 06

(D)

NORMALIZED CONTINUUM OF STANDARD SPECTRA

HG203 SOURCE

0.3001899E-02	0.3001899E-02	0.3001899E-02	0.3001899E-02	0.3001899E-02
0.3017059E-02	0.3036764E-02	0.3054984E-02	0.3155860E-02	0.3184850E-02
0.3213644E-02	0.3242438E-02	0.3275949E-02	0.3304820E-02	0.3333614E-02
0.3362408E-02	0.3395893E-02	0.3424790E-02	0.3453584E-02	0.3482378E-02
0.3515837E-02	0.3544760E-02	0.3573554E-02	0.3602348E-02	0.3635781E-02
0.3664730E-02	0.3693523E-02	0.3722317E-02	0.3755725E-02	0.3784700E-02
0.3813493E-02	0.3842287E-02	0.3875669E-02	0.3904670E-02	0.3933463E-02
0.3962257E-02	0.3995613E-02	0.4050168E-02	0.4117169E-02	0.4133522E-02
0.4422487E-02	0.4728869E-02	0.4939677E-02	0.5311931E-02	0.5804819E-02
0.6428041E-02	0.7010880E-02	0.7310795E-02	0.7670214E-02	0.7545024E-02
0.7084918E-02	0.6548539E-02	0.5794387E-02	0.5028832E-02	0.4518692E-02
0.4015482E-02	0.3738571E-02	0.3564910E-02	0.3256920E-02	0.3096008E-02
0.3074876E-02	0.2967899E-02	0.2846444E-02	0.2884011E-02	0.2882702E-02
0.2875835E-02	0.2981982E-02	0.2893704E-02	0.3047006E-02	0.3217575E-02
0.3260675E-02	0.3248937E-02	0.3418178E-02	0.3499633E-02	0.3549884E-02
0.3638299E-02	0.3657016E-02	0.3796687E-02	0.3736783E-02	0.3791875E-02
0.3976453E-02	0.4077807E-02	0.4216124E-02	0.4273811E-02	0.4570131E-02
0.4621701E-02	0.4559818E-02	0.4409373E-02	0.4088770E-02	0.3727528E-02
0.3404116E-02	0.3187299E-02	0.3304224E-02	0.3194825E-02	0.3518175E-02
0.4008361E-02	0.3462729E-02	0.2897355E-02	0.2269576E-02	0.4884199E-03
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

E

NORMALIZED CONTINUUM OF STANDARD SPECTRA

NB95 SOURCE

0.1258448E-01	0.1258448E-01	0.1258448E-01	0.1258448E-01	0.1258448E-01
0.1266918E-01	0.1273087E-01	0.1289361E-01	0.1323301E-01	0.1366262E-01
0.1418147E-01	0.1402471E-01	0.1416334E-01	0.1448606E-01	0.1470177E-01
0.1503353E-01	0.1508269E-01	0.1517868E-01	0.1540702E-01	0.1565864E-01
0.1605827E-01	0.1653546E-01	0.1724803E-01	0.1898113E-01	0.2095970E-01
0.2219846E-01	0.2163867E-01	0.2027831E-01	0.1820437E-01	0.1751568E-01
0.1712665E-01	0.1714450E-01	0.1683396E-01	0.1658908E-01	0.1652777E-01
0.1620685E-01	0.1596374E-01	0.1611031E-01	0.1608083E-01	0.1579835E-01
0.1560486E-01	0.1604970E-01	0.1576473E-01	0.1567779E-01	0.1556046E-01
0.1578438E-01	0.1600458E-01	0.1580282E-01	0.1600299E-01	0.1612654E-01
0.1615940E-01	0.1624795E-01	0.1640275E-01	0.1601258E-01	0.1579477E-01
0.1610708E-01	0.1626855E-01	0.1597374E-01	0.1631588E-01	0.1625974E-01
0.1643591E-01	0.1676587E-01	0.1701351E-01	0.1721942E-01	0.1741331E-01
0.1774383E-01	0.1803020E-01	0.1832996E-01	0.1809176E-01	0.1780084E-01
0.1716569E-01	0.1596864E-01	0.1474581E-01	0.1297342E-01	0.1129270E-01
0.9069095E-02	0.7604239E-02	0.6709094E-02	0.5706770E-02	0.5229423E-02
0.4829141E-02	0.4325615E-02	0.4147911E-02	0.3945987E-02	0.4076497E-02
0.4120238E-02	0.4386453E-02	0.4784233E-02	0.5216551E-02	0.5632696E-02
0.6211657E-02	0.7047528E-02	0.7383105E-02	0.7097974E-02	0.5746579E-02
0.3536736E-02	0.7400135E-03	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

MN54 SOURCE

0.1387430E-01	0.1387430E-01	0.1387430E-01	0.1387430E-01	0.1439337E-01
0.1470641E-01	0.1453470E-01	0.1458139E-01	0.1476335E-01	0.1481092E-01
0.1550780E-01	0.1553824E-01	0.1577244E-01	0.1577912E-01	0.1571886E-01
0.1600927E-01	0.1665774E-01	0.1698497E-01	0.1712101E-01	0.1710019E-01
0.1790613E-01	0.2017187E-01	0.2238468E-01	0.2357957E-01	0.2410243E-01
0.2260315E-01	0.2083574E-01	0.1896697E-01	0.1885942E-01	0.1832306E-01
0.1812512E-01	0.1839272E-01	0.1858640E-01	0.1863524E-01	0.1897541E-01
0.1806465E-01	0.1811679E-01	0.1764875E-01	0.1796302E-01	0.1777319E-01
0.1761253E-01	0.1796826E-01	0.1785969E-01	0.1749205E-01	0.1773211E-01
0.1736250E-01	0.1723255E-01	0.1765278E-01	0.1801177E-01	0.1777224E-01
0.1756614E-01	0.1787680E-01	0.1827595E-01	0.1837430E-01	0.1788776E-01
0.1744938E-01	0.1772073E-01	0.1816126E-01	0.1863092E-01	0.1885759E-01
0.1868875E-01	0.1836944E-01	0.1899914E-01	0.1943717E-01	0.1972411E-01
0.2022261E-01	0.2042756E-01	0.2011893E-01	0.2023764E-01	0.2084771E-01
0.2083068E-01	0.2041624E-01	0.1916514E-01	0.1820286E-01	0.1635676E-01
0.1393092E-01	0.1185436E-01	0.9532646E-02	0.8550126E-02	0.7233603E-02
0.6379157E-02	0.5344354E-02	0.4992358E-02	0.4800023E-02	0.4385513E-02
0.4410387E-02	0.4521606E-02	0.4736372E-02	0.5429006E-02	0.5836931E-02
0.6143875E-02	0.7181540E-02	0.7961141E-02	0.8915246E-02	0.9235230E-02
0.7340014E-02	0.5313771E-02	0.4455170E-02	0.4178935E-02	0.3379702E-02
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

CD109 SOURCE

0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344058E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344058E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03	0.6344059E-03
0.6344058E-03	0.6344058E-03	0.6344057E-03	0.6344054E-03	0.6344045E-03
0.6344021E-03	0.6343960E-03	0.6343808E-03	0.6343441E-03	0.6342594E-03
0.6340702E-03	0.6336646E-03	0.6328262E-03	0.6311580E-03	0.6279634E-03
0.7089514E-03	0.1251649E-02	0.1798144E-02	0.2285387E-02	0.2760224E-02
0.3296507E-02	0.3712584E-02	0.4089715E-02	0.4379447E-02	0.4513634E-02
0.4417121E-02	0.4160981E-02	0.3712488E-02	0.3172480E-02	0.2603838E-02
0.2058413E-02	0.1557198E-02	0.1132871E-02	0.7940608E-03	0.4820779E-03
0.2991180E-03	0.2468021E-03	0.2950645E-03	0.4133116E-03	0.7314763E-03
0.1058456E-02	0.1429714E-02	0.1999748E-02	0.2750714E-02	0.3618357E-02
0.4037670E-02	0.4437828E-02	0.4439759E-02	0.3984411E-02	0.2805686E-02
0.3810343E-02	0.2064132E-02	0.3100582E-02	0.2860915E-03	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

CS137 SOURCE

0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01
0.1234286E-01	0.1234286E-01	0.1226760E-01	0.1252457E-01	0.1254770E-01
0.1270585E-01	0.1266437E-01	0.1272603E-01	0.1297844E-01	0.1280266E-01
0.1269020E-01	0.1335824E-01	0.1311128E-01	0.1324940E-01	0.1339473E-01
0.1353474E-01	0.1346878E-01	0.1424770E-01	0.1463246E-01	0.1504248E-01
0.1624659E-01	0.1793829E-01	0.1917318E-01	0.1875151E-01	0.1734591E-01
0.1635465E-01	0.1573499E-01	0.1491356E-01	0.1506597E-01	0.1496149E-01
0.1443830E-01	0.1441241E-01	0.1435985E-01	0.1455510E-01	0.1414849E-01
0.1409154E-01	0.1380193E-01	0.1412696E-01	0.1400490E-01	0.1386581E-01
0.1392185E-01	0.1374791E-01	0.1341698E-01	0.1334748E-01	0.1338878E-01
0.1368589E-01	0.1366057E-01	0.1347617E-01	0.1317911E-01	0.1314128E-01
0.1347360E-01	0.1343646E-01	0.1355702E-01	0.1382554E-01	0.1390719E-01
0.1413577E-01	0.1452474E-01	0.1455735E-01	0.1472721E-01	0.1479057E-01
0.1486919E-01	0.1464947E-01	0.1416041E-01	0.1329505E-01	0.1143125E-01
0.1031257E-01	0.8982497E-02	0.7706467E-02	0.6641262E-02	0.5838954E-02
0.5012905E-02	0.4514794E-02	0.4407683E-02	0.4298208E-02	0.3960443E-02
0.3643855E-02	0.3598062E-02	0.3541756E-02	0.3752818E-02	0.3860490E-02
0.3937022E-02	0.4133906E-02	0.4735435E-02	0.5328205E-02	0.5789937E-02
0.6134154E-02	0.6039807E-02	0.5566527E-02	0.4207013E-02	0.2515244E-02
0.7202175E-03	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

SR85 SOURCE

0.8095993E-02	0.8095993E-02	0.8095993E-02	0.8095993E-02	0.8095993E-02
0.8170109E-02	0.8237149E-02	0.8318347E-02	0.8520440E-02	0.8673871E-02
0.8840605E-02	0.8922804E-02	0.8978930E-02	0.9155596E-02	0.9441186E-02
0.9472658E-02	0.9435670E-02	0.9720164E-02	0.9782292E-02	0.9669921E-02
0.1002622E-01	0.1016316E-01	0.1031127E-01	0.1011198E-01	0.1016296E-01
0.1034767E-01	0.1037398E-01	0.1079506E-01	0.1133493E-01	0.1159423E-01
0.1205833E-01	0.1313828E-01	0.1397157E-01	0.1471862E-01	0.1481743E-01
0.1418141E-01	0.1310715E-01	0.1220455E-01	0.1183621E-01	0.1183082E-01
0.1134523E-01	0.1097581E-01	0.1103774E-01	0.1078946E-01	0.1081530E-01
0.1078613E-01	0.1063875E-01	0.1040242E-01	0.1043585E-01	0.1052764E-01
0.1039517E-01	0.1058869E-01	0.1074603E-01	0.1073024E-01	0.1070983E-01
0.1091420E-01	0.1109834E-01	0.1131976E-01	0.1125116E-01	0.1133309E-01
0.1122275E-01	0.1085419E-01	0.1059722E-01	0.1014793E-01	0.8991553E-02
0.7856541E-02	0.7070314E-02	0.6060113E-02	0.5309194E-02	0.4852520E-02
0.4522757E-02	0.4280451E-02	0.3933396E-02	0.3768729E-02	0.3670475E-02
0.3434204E-02	0.3307270E-02	0.3351628E-02	0.3380362E-02	0.3422320E-02
0.3460251E-02	0.3440674E-02	0.3503217E-02	0.3663348E-02	0.3816483E-02
0.3940254E-02	0.4181537E-02	0.4557590E-02	0.4939033E-02	0.5274551E-02
0.5358812E-02	0.5298631E-02	0.5225550E-02	0.5053199E-02	0.4082708E-02
0.2557951E-02	0.1204308E-02	0.4835844E-03	0.4639058E-03	0.3553561E-03
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

ZN65 SOURCE

0.1793414E-01	0.1793414E-01	0.1791549E-01	0.1787175E-01	0.1775530E-01
0.1793015E-01	0.1828956E-01	0.1871223E-01	0.1846417E-01	0.1877423E-01
0.1904528E-01	0.1858874E-01	0.1983496E-01	0.1981675E-01	0.2003138E-01
0.2084309E-01	0.2328266E-01	0.2605632E-01	0.2895549E-01	0.2854008E-01
0.2520712E-01	0.2363638E-01	0.2309797E-01	0.2166413E-01	0.2164889E-01
0.2157957E-01	0.2171026E-01	0.2100004E-01	0.2050687E-01	0.2052457E-01
0.2028508E-01	0.2010592E-01	0.2000138E-01	0.1986158E-01	0.1978861E-01
0.1961268E-01	0.1993937E-01	0.2021259E-01	0.1997858E-01	0.2010962E-01
0.2020123E-01	0.2031790E-01	0.2034332E-01	0.2027018E-01	0.2001698E-01
0.2038083E-01	0.2086786E-01	0.2111038E-01	0.2088110E-01	0.2031486E-01
0.2017827E-01	0.2033110E-01	0.2036707E-01	0.2070275E-01	0.2041394E-01
0.2071006E-01	0.2128030E-01	0.2139284E-01	0.2164711E-01	0.2188890E-01
0.2197445E-01	0.2193935E-01	0.2220069E-01	0.2212455E-01	0.2284791E-01
0.2331964E-01	0.2347769E-01	0.2357758E-01	0.2430230E-01	0.2535138E-01
0.2543293E-01	0.2587498E-01	0.2615913E-01	0.2665034E-01	0.2725521E-01
0.2757129E-01	0.2701902E-01	0.2603699E-01	0.2402853E-01	0.2145646E-01
0.1802136E-01	0.1467296E-01	0.1210114E-01	0.9910825E-02	0.8116126E-02
0.7385537E-02	0.6713137E-02	0.6411757E-02	0.6205117E-02	0.6448269E-02
0.7117865E-02	0.7739686E-02	0.8242260E-02	0.8133072E-02	0.7581476E-02
0.5694735E-02	0.2988543E-02	0.6928659E-03	0.1144649E-02	0.2718795E-02
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

RESPONSE MATRIX PHOTOFRACTIONS

```
0.9753 0.9306 0.8911 0.8609 0.8321 0.8034 0.7750 0.7472 0.7196 0.6902
0.6628 0.6373 0.6134 0.5910 0.5701 0.5505 0.5320 0.5146 0.4980 0.4823
```

SYS[illegible]SPO[illegible]FUNC[illegible] MATRIX

0.1000E 01	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1593E-00	0.8407E 00	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1967E-01	0.9261E-01	0.8845E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2145E-01	0.2897E-01	0.6558E-01	0.8701E 00	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2272E-01	0.2506E-01	0.4585E-01	0.5396E-01	0.8251E 00	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2378E-01	0.2551E-01	0.4519E-01	0.3703E-01	0.5089E-01	0.7774E 00	0.4022E-01	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2470E-01	0.2758E-01	0.3359E-01	0.4633E-01	0.3265E-01	0.5262E-01	0.7341E 00	0.4840E-01	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2548E-01	0.2849E-01	0.3092E-01	0.5274E-01	0.3014E-01	0.3105E-01	0.5557E-01	0.6884E 00	0.5722E-01	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2614E-01	0.2927E-01	0.3241E-01	0.4135E-01	0.4818E-01	0.2546E-01	0.3023E-01	0.5950E-01	0.6434E 00	0.6403E-01
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2687E-01	0.3101E-01	0.3334E-01	0.4263E-01	0.5103E-01	0.3671E-01	0.2207E-01	0.2615E-01	0.6408E-01	0.5942E 00
0.7137E-01	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.2732E-01	0.3179E-01	0.3348E-01	0.4588E-01	0.4467E-01	0.4600E-01	0.3304E-01	0.1758E-01	0.2324E-01	0.7095E-01
0.5490E 00	0.7704E-01	0.	0.	0.	0.	0.	0.	0.	0.
0.2764E-01	0.3188E-01	0.3494E-01	0.4288E-01	0.4607E-01	0.4555E-01	0.4140E-01	0.2571E-01	0.1615E-01	0.2098E-01
0.7722E-01	0.5077E 00	0.8178E-01	0.	0.	0.	0.	0.	0.	0.
0.2790E-01	0.3178E-01	0.3528E-01	0.3760E-01	0.5107E-01	0.4254E-01	0.4246E-01	0.3957E-01	0.1838E-01	0.1523E-01
0.1919E-01	0.8322E-01	0.4688E-00	0.8676E-01	0.[illegible]884E-03	0.	0.	0.	0.	0.
0.2815E-01	0.3133E-01	0.3500E-01	0.3586E-01	0.5096E-01	0.4259E-01	0.4086E-01	0.4093E-01	0.3433E-01	0.1483E-01
0.1425E-01	0.1776E-01	0.8678E-01	0.4359E-00	0.9015E-01	0.3410E-03	0.	0.	0.	0.
0.2837E-01	0.3088E-01	0.3425E-01	0.3591E-01	0.4583E-01	0.4607E-01	0.3939E-01	0.3897E-01	0.4025E-01	0.2727E-01
0.1395E-01	0.1315E-01	0.1686E-01	0.9146E-01	0.4043E-00	0.9250E-01	0.5399E-03	0.	0.	0.
0.2858E-01	0.3052E-01	0.3349E-01	0.3568E-01	0.4076E-01	0.4816E-01	0.3942E-01	0.2719E-01	0.3845E-01	0.3804E-01
0.2198E-01	0.1316E-01	0.1224E-01	0.1630E-01	0.9418E-01	0.3773E-00	0.9347E-01	0.9141E-03	0.	0.
0.3022E-01	0.3115E-01	0.3294E-01	0.3467E-01	0.4034E-01	0.4513E-01	0.3955E-01	0.3665E-01	0.3571E-01	0.3721E-01
0.3469E-01	0.2002E-01	0.1127E-01	0.1123E-01	0.1612E-01	0.9414E-01	0.3522E-00	0.9531E-01	0.1240E-02	0.
0.3089E-01	0.3128E-01	0.3234E-01	0.3372E-01	0.3913E-01	0.4283E-01	0.3958E-01	0.3628E-01	0.3455E-01	0.3447E-01
0.3624E-01	0.3255E-01	0.1726E-01	0.1039E-01	0.1044E-01	0.1615E-01	0.9369E-01	0.3296E-00	0.9662E-01	0.1825E-02
0.3072E-01	0.3089E-01	0.3154E-01	0.3277E-01	0.3638E-01	0.4313E-01	0.3820E-01	0.3566E-01	0.3418E-01	0.3325E-01
0.3368E-01	0.3550E-01	0.3033E-01	0.1503E-01	0.9885E-02	0.9906E-02	0.1617E-01	0.9474E-01	0.3076E-00	0.9795E-01
0.2988E-01	0.3002E-01	0.3074E-01	0.3178E-01	0.3439E-01	0.4291E-01	0.3685E-01	0.3475E-01	0.3366E-01	0.3248E-01
0.3214E-01	0.3340E-01	0.3507E-01	0.2766E-01	0.1378E-01	0.9510E-02	0.9473E-02	0.1633E-01	0.5515E-01	0.2881E-00

G

REPONSE MATRIX ENERGY INTERVAL MIDPOINTS IN MEV

0.0165	0.0496	0.0827	0.1158	0.1489	0.1820	0.2151	0.2482	0.2813	0.3144
0.3475	0.3806	0.4137	0.4468	0.4799	0.5130	0.5461	0.5792	0.6123	0.6454

PULSE-HEIGHT IN CHANNELS (MIDPOINTS)

0.54	1.63	2.65	3.65	4.64	5.62	6.60	7.59	8.58	9.57
10.56	11.55	12.54	13.54	14.54	15.53	16.53	17.52	18.52	19.52

SOURCE	S E STRENGTH (CURIES)	BET ENERGY (MEV)	SCCR DIAMETER (CM.)	S G HALF-LIFE (MINUTES)	N OF PHA RUNS THIS SET	N M OF CHANNELS PER SPECTRUM	MULTIPLIER
TL204	1.0000	0.7660	2.5400	0.2091E 07	1	130	0.5260E 06

SOURCE CRYSTAL DISTANCE (CM.)	CRYSTAL ANGLE AT SOURCE (DEGREES) POLAR	AZIMUTH	COUNTING DURATION (MINUTES)	REFERENCE TIME (DAYS)	PHA COARSE GAIN	MONITOR PULSE-HEIGHT (CHANNELS)	MONITOR ENERGY (MEV)	SPECTRA ZERO SHIFT (CHANNELS)	BACKGROUND SIGNAL	BACKGROUND MULTIPLIER
121.290	-10.000	0.	3.000	0.00	2.00	130.0000	0.6620	0.	0.	0.

ITERATING OUTPUT ON ITERATION LOOPS NUMBERED BELOW

1	2	3	4	5
6	7	9	12	15
20	25	35	50	60
90	-0	-0		

J

ENERGIES IN MEV OF UNKNOWN PEAKS

0.0700 -0. -0. -0.

SPECTRUM NUMBER 1 FOR TL204 SOURCE

(AFTER BACKGROUND SUBTRACTION)

169.	11981.	23233.	21034.	26210.	33662.	44035.	55266.	57394.	63594.
78534.	104450.	173066.	260727.	282447.	203239.	139574.	74726.	38999.	32312.
32283.	33327.	34339.	35132.	36090.	36370.	36442.	36823.	36845.	36207.
35513.	35326.	34847.	33857.	33338.	32839.	32424.	31857.	31176.	30617.
30339.	29519.	29134.	28220.	27856.	26955.	26294.	25701.	25151.	24361.
23472.	22436.	22086.	21278.	20472.	19681.	18976.	18283.	17362.	16909.
16037.	15252.	14748.	14063.	13466.	12858.	11914.	11820.	11009.	10420.
10185.	9495.	9047.	8468.	7977.	7586.	7143.	6627.	6462.	5988.
5529.	5393.	5108.	4746.	4509.	4130.	4043.	3694.	3472.	3292.
3022.	2735.	2737.	2419.	2331.	2213.	1955.	1916.	1773.	1606.
1471.	1406.	1279.	1147.	1103.	1057.	957.	846.	743.	760.
689.	573.	584.	555.	467.	467.	444.	352.	366.	331.
302.	268.	246.	244.	256.	244.	240.	251.	242.	198.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
11	20	0.7000000E-01	0.1429136E 02	0.1591510E 01	0.9400889E 06

```
INPUT SPECTRUM GAIN CHANGED TO     20 CHANNELS
GAIN CHANGE RATIO =  130.00000/  20.00000

0.1215001E 06 0.2769383E 06 0.2844746E 06 0.2231406E 06 0.2345895E 06
0.2129145E 06 0.1892125E 06 0.1608925E 06 0.1294570E 06 0.9915600E 05
0.7295350E 05 0.5159351E 05 0.3548051E 05 0.2390751E 05 0.1534801E 05
0.9640005E 04 0.5810504E 04 0.3434502E 04 0.1987002E 04 0.1553000E 04
```

```
NORMALIZED INPUT SPECTRUM
 0.5641E-01 0.1286E-00 0.1321E-00 0.1036E-00 0.1089E-00 0.9885E-01 0.8784E-01 0.7470E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7125E-02 0.4475E-02 0.2698E-02 0.1594E-02 0.9225E-03 0.7210E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     1     1
 0.5641E-01 0.1286E-00 0.1321E-00 0.1036E-00 0.1089E-00 0.9885E-01 0.8784E-01 0.7470E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7125E-02 0.4475E-02 0.2698E-02 0.1594E-02 0.9225E-03 0.7210E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     1     1
 0.9628E-01 0.1396E-00 0.1454E-00 0.1163E-00 0.1100E-00 0.9163E-01 0.7940E-01 0.6343E-01 0.4342E-01 0.3510E-01
 0.2463E-01 0.1665E-01 0.1093E-01 0.7072E-02 0.4385E-02 0.2647E-02 0.1543E-02 0.8859E-03 0.5098E-03 0.3010E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     2     2
 0.3305E-01 0.1164E-00 0.1200E-00 0.9224E-01 0.1078E-00 0.1066E-00 0.9719E-01 0.8797E-01 0.7461E-01 0.6037E-01
 0.4658E-01 0.3445E-01 0.2482E-01 0.1742E-01 0.1158E-01 0.7567E-02 0.4715E-02 0.2870E-02 0.1669E-02 0.1727E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     2     2
 0.7374E-01 0.1329E-00 0.1376E-00 0.1111E-00 0.1140E-00 0.1017E-00 0.9002E-01 0.7581E-01 0.6074E-01 0.4631E-01
 0.3400E-01 0.2401E-01 0.1647E-01 0.1108E-01 0.7115E-02 0.4455E-02 0.2686E-02 0.1589E-02 0.9610E-03 0.6663E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     3     3
 0.2528E-01 0.1146E-00 0.1151E-00 0.8605E-01 0.1030E-00 0.1036E-00 0.9483E-01 0.8668E-01 0.7383E-01 0.6001E-01
 0.4640E-01 0.3437E-01 0.2483E-01 0.1744E-01 0.1159E-01 0.7602E-02 0.4735E-02 0.2881E-02 0.1602E-02 0.1869E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     3     3
 0.6483E-01 0.1287E-00 0.1324E-00 0.1051E-00 0.1097E-00 0.9918E-01 0.8807E-01 0.7475E-01 0.6014E-01 0.4604E-01
 0.3387E-01 0.2396E-01 0.1647E-01 0.1110E-01 0.7127E-02 0.4472E-02 0.2698E-02 0.1590E-02 0.9549E-03 0.7006E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     4     4
 0.2200E-01 0.1145E-00 0.1148E-00 0.8484E-01 0.1023E-00 0.1032E-00 0.9459E-01 0.8661E-01 0.7378E-01 0.6001E-01
 0.4639E-01 0.3436E-01 0.2483E-01 0.1744E-01 0.1159E-01 0.7607E-02 0.4735E-02 0.2889E-02 0.1548E-02 0.1923E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     4     4
 0.6146E-01 0.1285E-00 0.1320E-00 0.1039E-00 0.1091E-00 0.9889E-01 0.8787E-01 0.7469E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7127E-02 0.4474E-02 0.2699E-02 0.1588E-02 0.9441E-03 0.7110E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     5     5
 0.2019E-01 0.1146E-00 0.1149E-00 0.8456E-01 0.1022E-00 0.1032E-00 0.9456E-01 0.8662E-01 0.7378E-01 0.6001E-01
 0.4639E-01 0.3436E-01 0.2483E-01 0.1744E-01 0.1158E-01 0.7610E-02 0.4733E-02 0.2900E-02 0.1512E-02 0.1950E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     5     5
 0.5965E-01 0.1285E-00 0.1320E-00 0.1037E-00 0.1089E-00 0.9885E-01 0.8785E-01 0.7469E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7126E-02 0.4474E-02 0.2699E-02 0.1589E-02 0.9369E-03 0.7153E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     6     6
 0.1909E-01 0.1146E-00 0.1149E-00 0.8448E-01 0.1021E-00 0.1032E-00 0.9456E-01 0.8662E-01 0.7378E-01 0.6001E-01
 0.4639E-01 0.3435E-01 0.2483E-01 0.1744E-01 0.1158E-01 0.7612E-02 0.4731E-02 0.2910E-02 0.1489E-02 0.1966E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     6     6
 0.5856E-01 0.1286E-00 0.1321E-00 0.1036E-00 0.1089E-00 0.9885E-01 0.8784E-01 0.7469E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7126E-02 0.4475E-02 0.2699E-02 0.1590E-02 0.9322E-03 0.7175E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     7     7
 0.1839E-01 0.1146E-00 0.1149E-00 0.8446E-01 0.1021E-00 0.1032E-00 0.9456E-01 0.8662E-01 0.7378E-01 0.6001E-01
 0.4639E-01 0.3435E-01 0.2483E-01 0.1744E-01 0.1158E-01 0.7613E-02 0.4728E-02 0.2918E-02 0.1474E-02 0.1975E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     7     7
 0.5786E-01 0.1286E-00 0.1321E-00 0.1036E-00 0.1089E-00 0.9885E-01 0.8784E-01 0.7470E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7126E-02 0.4475E-02 0.2699E-02 0.1591E-02 0.9291E-03 0.7186E-03
ITERATED SPECTRUM
 0.5786E-01 0.1286E-00 0.1321E-00 0.1036E-00 0.1089E-00 0.9885E-01 0.8784E-01 0.7470E-01 0.6010E-01 0.4603E-01
 0.3387E-01 0.2395E-01 0.1647E-01 0.1110E-01 0.7126E-02 0.4475E-02 0.2699E-02 0.1591E-02 0.9291E-03 0.7138E-03

IT,SU,TERM
        8 0.2153984E 07 0.3731386E-04
```

EFFICIENCY F[illegible]S

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY
1	0.1655000E-01	0.7571659E 00	0.2955338E-00	0.5529962E 00	0.9939932E 00
2	0.4965000E-01	0.9685091E 00	0.9243792E 00	0.8025338E 00	0.9995738E 00
3	0.8275000E-01	0.9745699E 00	0.9550648E 00	0.8606189E 00	0.9982922E 00
4	0.1158500E-00	0.9769145E 00	0.9616817E 00	0.8902031E 00	0.9958833E 00
5	0.1489500E-00	0.9786729E 00	0.9651739E 00	0.8969141E 00	0.9923365E 00
6	0.1820500E-00	0.9801816E 00	0.9680744E 00	0.9028518E 00	0.9883866E 00
7	0.2151500E-00	0.9813536E 00	0.9701327E 00	0.9077421E 00	0.9833461E 00
8	0.2482500E-00	0.9822788E 00	0.9716137E 00	0.9118417E 00	0.9767708E 00
9	0.2813500E-00	0.9830984E 00	0.9729305E 00	0.9155686E 00	0.9676356E 00
10	0.3144500E-00	0.9837731E 00	0.9740272E 00	0.9183243E 00	0.9560802E 00
11	0.3475500E-00	0.9843411E 00	0.9749586E 00	0.9216959E 00	0.9434851E 00
12	0.3806500E-00	0.9848721E 00	0.9758243E 00	0.9243487E 00	0.9310993E 00
13	0.4137500E-00	0.9853653E 00	0.9766184E 00	0.9267435E 00	0.9182310E 00
14	0.4468500E-00	0.9858213E 00	0.9773461E 00	0.9289118E 00	0.9052964E 00
15	0.4799500E-00	0.9862420E 00	0.9780190E 00	0.9309245E 00	0.8926530E 00
16	0.5130500E 00	0.9866176E 00	0.9786315E 00	0.9327369E 00	0.8811430E 00
17	0.5461500E 00	0.9869559E 00	0.9791881E 00	0.9343833E 00	0.8706743E 00
18	0.5792500E 00	0.9872773E 00	0.9797009E 00	0.9359557E 00	0.8609267E 00
19	0.6123500E 00	0.9875819E 00	0.9801482E 00	0.9374613E 00	0.8506797E 00
20	0.6454500E 00	0.9878696E 00	0.9805454E 00	0.9388944E 00	0.8405923E 00

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DIFFERENTIAL FLUX AT ITERATION NUMBER =      8
  0.32010E 06   0.81308E 06   0.10898E 07   0.21843E 06   0.26165E 06
  0.26248E 06   0.23966E 06   0.21950E 06   0.18753E 06   0.15357E 06
  0.11973E 06   0.89462E 05   0.65319E 05   0.46364E 05   0.31126E 05
  0.20664E 05   0.12954E 05   0.80649E 04   0.41121E 04   0.55655E 04
FITTING DIFFERENCES
 0.             0.5106540E-01 0.4442097E-01 0.5356342E-02 0.8328452E-03
 0.2680052E-03 0.1051516E-03 0.4476060E-04
```

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SINGLE SPECTRUM    20CHANNELS
21500.276538.284475.223141.234589.212914.189212.160892.129457. 99156.
72954. 51594. 35481. 23908. 15348.  9640.  5811.  3435.  1987.  1553.
```

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	0.01655	0.3899599E 02	0.6453836E 00
2	0.04965	0.9905104E 02	0.4917384E 01
3	0.08275	0.1327603E 03	0.1098592E 02
4	0.11585	0.2661009E 02	0.3082779E 01
5	0.14895	0.3187450E 02	0.4747707E 01
6	0.18205	0.3197623E 02	0.5821272E 01
7	0.21515	0.2919635E 02	0.6281595E 01
8	0.24825	0.2673969E 02	0.6638128E 01
9	0.28135	0.2284566E 02	0.6427626E 01
10	0.31445	0.1870827E 02	0.5882815E 01
11	0.34755	0.1458572E 02	0.5069267E 01
12	0.38065	0.1089856E 02	0.4148536E 01
13	0.41375	0.7957311E 01	0.3292337E 01
14	0.44685	0.5648142E 01	0.2523872E 01
15	0.47995	0.3791840E 01	0.1819893E 01
16	0.51305	0.2517348E 01	0.1291525E 01
17	0.54615	0.1578055E 01	0.8618547E 00
18	0.57925	0.9824851E 00	0.5691045E 00
19	0.61235	0.5009457E 00	0.3067541E-00
20	0.64545	0.6780022E 00	0.4376165E-00

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INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL

```
PHOTON NUMBER (PHOTONS/CM**2-SEC) =  0.5078965E 03
PHOTON ENERGY (MEV/CM**2-SEC)     =  0.7575186E 02
PHOTON DOSE   (ROENTGENS/HOUR)    =  0.1877103E-03

AVERAGE ENERGY (MEV) =  0.1491482E-00

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) =  0.1372693E-07
PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2-SEC)/MEV)         =  0.9889277E 02
PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC)    =  0.2047348E-08
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)             =  0.5073251E-14
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.3941807E-15
```

AT THE SOURCE CYLINDER

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PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)             =  0.2058125E-10

PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.1599118E-11
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EFFICIENCY VECTOR ETA
0.1237297E-CO C.7718713E 00 0.8182604E 00 0.8328859E CC 0.8407230E 00
0.8467567E 00 C.8498190E 00 0.8500423E 00 0.8473865E 00 0.8417688E 00
0.8345550E CC C.8271482E CO 0.8189052E 00 0.8102365E 00 0.8015450E 00
0.7935486E CO 0.7862209E CO 0.7793887E 00 0.7719412E 0C 0.7644863E 00
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Partial output only for the remainder of this Appendix.

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BRIEF DESCRIPTION OF PHA RUNS
SAMPE GSFC BREMSSTRAHLUNG SPECTRA     (SEPT 1967)

CONTROL NUMBERS
M( 1) =  0  M( 2) =  C  M( 3) =  0  M( 4) =  4  M( 5) =  0  M( 6) =  6
M( 7) =  7  M( 8) =  8  M( 9) =  0  M(10) =  0  M(11) =  0  M(12) =  0
M(13) =  0  M(14) =  C  M(15) = 15  M(16) = 16  M(17) =  0  M(18) = 18

CALCOMP PLOTTING OPTICN CCNTRCL NUMBERS
MPLOT( 1) =  C  MPLOT( 2) =  2  MPLOT( 3) = -0  MPLOT( 4) = -0  MPLOT( 5) =  1

EM =    50.CCCCO CHANNELS/MEV

ELIMIT=     0.40COC

ITERATIVE ERROR TOLERANCE,EPS =     0.00010

NUMBER OF BETA SOURCE SETS,OJSO =     1     MM =   0

MAX NUMBER OF ITERATICNS,ITMAX=  51

NUMBER OF CHANNELS INPUT, N = 20

NAI(TL) CRYSTAL SIZE =  3.00 X 3.00 INCHES.
```

SYSTEM RESPONSE FUNCTION MATRIX

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1836E-01	0.9813E 00	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1064E-01	0.1701E-00	0.7976E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1147E-01	0.1060E-01	0.1073E-00	0.7955E 00	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1213E-01	0.1216E-01	0.2613E-01	0.7290E-01	0.7609E 00	0.1159E-00	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1262E-01	0.1272E-01	0.1834E-01	0.3972E-01	0.5173E-01	0.7223E 00	0.1425E-00	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1306E-01	0.1377E-01	0.1512E-01	0.2515E-01	0.3562E-01	0.5099E-01	0.6899E 00	0.1563E-00	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1347E-01	0.1436E-01	0.1410E-01	0.2731E-01	0.2514E-01	0.2646E-01	0.5443E-01	0.6581E 00	0.1666E-00	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1383E-01	0.1479E-01	0.1499E-01	0.2023E-01	0.2916E-01	0.2539E-01	0.2219E-01	0.5837E-01	0.6279E 00	0.1730E-00
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.1417E-01	0.1521E-01	0.1612E-01	0.1659E-01	0.3282E-01	0.2114E-01	0.2308E-01	0.2257E-01	0.6436E-01	0.6009E 00
0.1727E-00	0.3530E-03	0.	0.	0.	0.	0.	0.	0.	0.
0.1449E-01	0.1556E-01	0.1666E-01	0.1656E-01	0.2517E-01	0.3172E-01	0.1843E-01	0.2068E-01	0.2402E-01	0.7151E-01
0.5736E 00	0.1710E-00	0.6732E-03	0.	0.	0.	0.	0.	0.	0.
0.1477E-01	0.1589E-01	0.1698E-01	0.1747E-01	0.2014E-01	0.3545E-01	0.2160E-01	0.1769E-01	0.1967E-01	0.2499E-01
0.7946E-01	0.5450E 00	0.1698E-00	0.1151E-02	0.	0.	0.	0.	0.	0.
0.1504E-01	0.1616E-01	0.1725E-01	0.1825E-01	0.1903E-01	0.2849E-01	0.3269E-01	0.1681E-01	0.1706E-01	0.1945E-01
0.2491E-01	0.8760E-01	0.5172E 00	0.1682E-00	0.1761E-02	0.	0.	0.	0.	0.
0.1532E-01	0.1638E-01	0.1749E-01	0.1859E-01	0.1949E-01	0.2294E-01	0.3600E-01	0.2312E-01	0.1533E-01	0.1670E-01
0.1938E-01	0.2402E-01	0.9691E-01	0.4875E-00	0.1634E-00	0.2465E-02	0.	0.	0.	0.
0.1558E-01	0.1673E-01	0.1808E-01	0.1891E-01	0.2096E-01	0.2267E-01	0.2989E-01	0.3208E-01	0.1906E-01	0.1483E-01
0.1564E-01	0.1829E-01	0.2240E-01	0.1049E-00	0.4593E-00	0.1670E-00	0.3631E-02	0.	0.	0.
0.1582E-01	0.1706E-01	0.1872E-01	0.1964E-01	0.2066E-01	0.2586E-01	0.2564E-01	0.3317E-01	0.2528E-01	0.1892E-01
0.1293E-01	0.1425E-01	0.1683E-01	0.2098E-01	0.1113E-00	0.4326E-00	0.1656E-00	0.4654E-02	0.7748E-05	0.
0.1602E-01	0.1727E-01	0.1909E-01	0.2030E-01	0.1987E-01	0.2793E-01	0.2565E-01	0.2912E-01	0.2989E-01	0.2295E-01
0.1754E-01	0.1094E-01	0.1329E-01	0.1564E-01	0.2010E-01	0.1181E-00	0.4065E-00	0.1637E-00	0.6152E-02	0.1724E-04
0.1621E-01	0.1738E-01	0.1924E-01	0.2076E-01	0.1984E-01	0.2662E-01	0.2850E-01	0.2642E-01	0.3005E-01	0.2597E-01
0.2254E-01	0.1433E-01	0.1008E-01	0.1239E-01	0.1471E-01	0.1953E-01	0.1229E-00	0.3834E-00	0.1618E-00	0.7206E-02
0.1637E-01	0.1743E-01	0.1938E-01	0.2077E-01	0.2063E-01	0.2360E-01	0.3151E-01	0.2616E-01	0.2770E-01	0.2786E-01
0.2466E-01	0.2131E-01	0.1083E-01	0.9872E-02	0.1162E-01	0.1379E-01	0.1982E-01	0.1255E-00	0.3629E-00	0.1591E-00
0.1652E-01	0.1744E-01	0.1934E-01	0.2073E-01	0.2141E-01	0.2143E-01	0.3197E-01	0.2778E-01	0.2600E-01	0.2748E-01
0.2569E-01	0.2450E-01	0.1823E-01	0.8929E-02	0.7608E-02	0.1098E-01	0.1298E-01	0.2004E-01	0.1275E-00	0.3441E-00

BETA SOURCE	SOURCE STRENGTH (CURIES)	MAX BETA ENERGY (MEV)	SOURCE DIAMETER (CM.)	SOURCE HALF-LIFE (MINUTES)	NUMBER OF PHA RUNS THIS SET	NUMBER OF CHANNELS PER SPECTRUM	HALF-LIFE MULTIPLIER
PM147	1.0000	0.2300	2.5400	0.1387E 07	1	200	0.5260E 06

SOURCE CRYSTAL DISTANCE (CM.)	CRYSTAL ANGLE AT SOURCE (DEGREES) POLAR	AZIMUTH	COUNTING DURATION (MINUTES)	REFERENCE TIME (DAYS)	PHA COARSE GAIN	MONITOR PULSE-HEIGHT (CHANNELS)	MONITOR ENERGY (MEV)	SPECTRA ZERO SHIFT (CHANNELS)	BACKGROUND SIGNAL	BACKGROUND MULTIPLIER
121.290	-10.000	0.	20.000	0.00	8.00	140.0000	0.2790	0.	0.	0.

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
10	29	0.41000000E-01	0.19732188E 02	0.30598198E 01	0.86015318E 06

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	0.01000	0.2148339E 04	0.2148339E 02
2	0.03000	0.1340527E 02	0.4021582E-00
3	0.05000	0.1644938E 02	0.8224688E 00
4	0.07000	0.5186748E 01	0.3630724E-00
5	0.09000	0.5107092E 01	0.4596382E-00
6	0.11000	0.3452089E 01	0.3797298E-00
7	0.13000	0.2521226E 01	0.3277594E-00
8	0.15000	0.6473899E 00	0.9710848E-01
9	0.17000	0.2866600E-00	0.4873220E-01
10	0.19000	0.5305847E-01	0.1008111E-01
11	0.21000	0.1024705E-01	0.2151881E-02
12	0.23000	0.3357649E-02	0.7722592E-03
13	0.25000	0.5620725E-02	0.1405181E-02
14	0.27000	0.5491782E-02	0.1482781E-02
15	0.29000	0.4243794E-02	0.1230700E-02
16	0.31000	0.3642839E-02	0.1129280E-02
17	0.33000	0.2973029E-03	0.9810996E-04
18	0.35000	0.3606712E-04	0.1262349E-04
19	0.37000	0.2424264E-02	0.8969775E-03

```
INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL

PHOTON NUMBER (PHOTONS/CM**2-SEC) =  0.2195493E 04
PHOTON ENERGY (MEV/CM**2-SEC)     =  0.2440332E 02
PHOTON DOSE   (ROENTGENS/HOUR)    =  0.6757475E-02

AVERAGE ENERGY (MEV) =  0.1111524E-01

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) =  0.5933738E-07
PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2-SEC)/MEV)          =  0.1061014E 03
PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC)     =  0.6595491E-09
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)              =  0.1826345E-12
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.1419030E-13

AT THE SOURCE CYLINDER

PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)              =  0.7409144E-09

PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.5756745E-10
```

```
EFFICIENCY VECTOR ETA
0.1857761E-C3 C.6112422E CO 0.7730908E 00 0.8075965E OC 0.8224220E 00
0.8312413E CC C.8365553E CO 0.8409227E 00 0.8448972E CO 0.8477449E 00
0.8494961E CC C.8503553E CO 0.8499492E 00 0.8487387E 00 0.8460431E 00
0.8425711E CC C.8386205E CO 0.8339581E 00 0.8296610E 00
```

```
BRIEF DESCRIPTION OF PHA RUNS
 SAMPE GSFC BREMSSTRAHLUNG SPECTRA     (SEPT 1967)

CONTROL NUMBERS
M( 1) =  0  M( 2) =  C  M( 3) =  0  M( 4) =  4  M( 5) =  0  M( 6) =  6
M( 7) =  7  M( 8) =  8  M( 9) =  0  M(10) =  0  M(11) =  0  M(12) =  0
M(13) =  0  M(14) =  C  M(15) =  0  M(16) = 16  M(17) =  0  M(18) = 18

CALCOMP PLOTTING OPTICN CCNTRCL NUMBERS
MPLOT( 1) =  C  MPLOT( 2) =  2  MPLOT( 3) = -0  MPLOT( 4) = -0  MPLOT( 5) =  4

EM =    14.28571 CHANNELS/MEV

ELIMIT=    1.40CCC

ITERATIVE ERROR TOLERANCE,EPS =     0.00010

NUMBER OF BETA SOURCE SETS,OJSC =    1     MM =   0

MAX NUMBER OF ITERATICNS,ITMAX=  51

NUMBER OF CHANNELS INPUT, N = 20

NAI(TL) CRYSTAL SIZE =  3.00 X 3.00 INCHES.
```

SYSTEM RESPONSE FUNCTION MATRIX

0.1000E 01	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6161E-01	0.9384E 00	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.5184E-01	0.8790E-01	0.8603E 00	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.5728E-01	0.8874E-01	0.8683E-01	0.7869E 00	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6175E-01	0.8224E-01	0.8672E-01	0.5422E-01	0.7137E 00	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6351E-01	0.8580E-01	0.9425E-01	0.6141E-01	0.4466E-01	0.6465E 00	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6332E-01	0.7620E-01	0.9761E-01	0.8568E-01	0.4293E-01	0.4067E-01	0.5854E 00	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6368E-01	0.7334E-01	0.9354E-01	0.7908E-01	0.7698E-01	0.3155E-01	0.4029E-01	0.5295E 00	0.1182E-01	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6568E-01	0.6957E-01	0.8676E-01	0.7714E-01	0.7183E-01	0.6357E-01	0.2468E-01	0.4046E-01	0.4789E-00	0.1614E-01
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.6160E-01	0.6519E-01	0.8155E-01	0.7249E-01	0.6555E-01	0.6893E-01	0.6125E-01	0.2181E-01	0.4251E-01	0.4352E-00
0.2073E-01	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.5261E-01	0.5972E-01	0.7567E-01	0.6875E-01	0.6427E-01	0.6500E-01	0.6802E-01	0.5713E-01	0.1945E-01	0.4569E-01
0.3974E-00	0.2592E-01	0.	0.	0.	0.	0.	0.	0.	0.
0.4865E-01	0.5432E-01	0.6597E-01	0.6606E-01	0.6113E-01	0.6061E-01	0.6216E-01	0.6741E-01	0.5241E-01	0.1813E-01
0.4941E-01	0.3612E-00	0.2937E-01	0.	0.	0.	0.	0.	0.	0.
0.4601E-01	0.4962E-01	0.6227E-01	0.6241E-01	0.5848E-01	0.5662E-01	0.5744E-01	0.5996E-01	0.6626E-01	0.4704E-01
0.1680E-01	0.5186E-01	0.3327E-00	0.3232E-01	0.	0.	0.	0.	0.	0.
0.4364E-01	0.4644E-01	0.5544E-01	0.6092E-01	0.5421E-01	0.5328E-01	0.5273E-01	0.5450E-01	0.5845E-01	0.6407E-01
0.4186E-01	0.1599E-01	0.5447E-01	0.3073E-00	0.3654E-01	0.	0.	0.	0.	0.
0.4154E-01	0.4388E-01	0.5217E-01	0.5782E-01	0.4924E-01	0.4957E-01	0.4942E-01	0.4989E-01	0.5181E-01	0.5602E-01
0.6181E-01	0.3841E-01	0.1547E-01	0.5628E-01	0.2868E-00	0.3962E-01	0.	0.	0.	0.
0.3974E-01	0.4180E-01	0.5006E-01	0.5378E-01	0.4603E-01	0.4536E-01	0.4570E-01	0.4616E-01	0.4679E-01	0.4966E-01
0.5436E-01	0.5883E-01	0.3000E-01	0.1504E-01	0.5630E-01	0.2710E-00	0.4200E-01	0.7136E-04	0.	0.
0.3819E-01	0.3977E-01	0.4765E-01	0.5193E-01	0.4435E-01	0.4073E-01	0.4162E-01	0.4295E-01	0.4236E-01	0.4455E-01
0.4638E-01	0.5174E-01	0.5868E-01	0.3473E-01	0.1537E-01	0.5373E-01	0.2600E-00	0.4449E-01	0.1058E-03	0.
0.3632E-01	0.3793E-01	0.4433E-01	0.5523E-01	0.3737E-01	0.3816E-01	0.3604E-01	0.3776E-01	0.4035E-01	0.3937E-01
0.4130E-01	0.4364E-01	0.4747E-01	0.6245E-01	0.3240E-01	0.1533E-01	0.5243E-01	0.2519E-00	0.4670E-01	0.2168E-03
0.3575E-01	0.3600E-01	0.4140E-01	0.6242E-01	0.2429E-01	0.4050E-01	0.2945E-01	0.3267E-01	0.3651E-01	0.3423E-01
0.3673E-01	0.3759E-01	0.4061E-01	0.4404E-01	0.6793E-01	0.3031E-01	0.1553E-01	0.5471E-01	0.2460E-00	0.5289E-01
0.3499E-01	0.3353E-01	0.3857E-01	0.6873E-01	0.1369E-01	0.4420E-01	0.2413E-01	0.2735E-01	0.2442E-01	0.3398E-01
0.3049E-01	0.3193E-01	0.3254E-01	0.3442E-01	0.4728E-01	0.7314E-01	0.2825E-01	0.1542E-01	0.5929E-01	0.2424E-00

```
REPONSE MATRIX ENERGY INTERVAL MIDPCINTS IN MEV

0.0350 0.1050 0.1750 0.2450 0.3150 0.3850 0.4550 0.5250 0.5950 0.6650
0.7350 0.8050 0.8750 0.9450 1.0150 1.0850 1.1550 1.2250 1.2950 1.3650


PULSE-HEIGHT IN CHANNELS (MIDPCINTS)

  0.52   1.57   2.56   3.54   4.53   5.52   6.52   7.51   8.51   9.51
 10.51  11.51  12.51  13.51  14.51  15.51  16.51  17.51  18.50  19.49
```

BETA SOURCE	SOURCE STRENGTH (CURIES)	MAX BETA ENERGY (MEV)	SOURCE DIAMETER (CM.)	SOURCE HALF-LIFE (MINUTES)	NUMBER OF PHA RUNS THIS SET	NUMBER OF CHANNELS PER SPECTRUM	HALF-LIFE MULTIPLIER
SR90	1.0000	0.6100	2.5400	0.1473E 08	1	100	0.5260E 06

SOURCE CRYSTAL DISTANCE (CM.)	CRYSTAL ANGLE AT SOURCE (DEGREES) POLAR	AZIMUTH	COUNTING DURATION (MINUTES)	REFERENCE TIME (DAYS)	PHA COARSE GAIN	MONITOR PULSE-HEIGHT (CHANNELS)	MONITOR ENERGY (MEV)	SPECTRA ZERO SHIFT (CHANNELS)	BACKGROUND SIGNAL	BACKGROUND MULTIPLIER
60.325	10.000	-30.000	2.000	0.00	1.00	95.0000	1.3300	0.	1.0000	1.0000

```
INPUT SPECTRUM GAIN CHANGED TO     20 CHANNELS
GAIN CHANGE RATIO =  100.00000/  20.00000

0.1560189E C7 0.2053350E C7 0.1324488E 07 0.8030730E 06 0.5077610E 06
0.3283680E C6 0.2188800E 06 0.1494410E 06 0.1028920E 06 0.7215300E 05
0.5090501E C5 0.3654200E C5 0.2636900E 05 0.1907800E 05 0.1401300E 05
0.1010900E C5 0.7775002E C4 0.5612002E 04 0.4179002E 04 0.2983002E C4
```

```
NORMALIZED INPUT SPECTRUM
 0.2138E-00 0.2814E-00 0.1815E-00 0.1100E-00 0.6957E-01 0.4499E-01 0.2999E-01 0.2048E-01 0.1410E-01 0.9886E-02
 0.6975E-02 0.5007E-02 0.3613E-02 0.2614E-02 0.1920E-02 0.1385E-02 0.1065E-02 0.7690E-03 0.5726E-03 0.4087E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))      1    1
 0.2138E-00 0.2814E-00 0.1815E-00 0.1100E-00 0.6957E-01 0.4499E-01 0.2999E-01 0.2048E-01 0.1410E-01 0.9886E-02
 0.6975E-02 0.5007E-02 0.3613E-02 0.2614E-02 0.1920E-02 0.1385E-02 0.1065E-02 0.7690E-03 0.5726E-03 0.4087E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))       1    1
 0.2598E-00 0.3060E-00 0.1822E-00 0.1007E-00 0.5758E-01 0.3397E-01 0.2074E-01 0.1299E-01 0.8478E-02 0.5564E-02
 0.3704E-02 0.2497E-02 0.1708E-02 0.1173E-02 0.8234E-03 0.5677E-03 0.3960E-03 0.2788E-03 0.2028E-03 0.1295E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))      2    2
 0.1759E-00 0.2587E-00 0.1808E-00 0.1203E-00 0.8407E-01 0.5959E-01 0.4337E-01 0.3228E-01 0.2344E-01 0.1757E-01
 0.1314E-01 0.1004E-01 0.7645E-02 0.5825E-02 0.4477E-02 0.3380E-02 0.2866E-02 0.2121E-02 0.1617E-02 0.1290E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))       2    2
 0.2269E-00 0.2924E-00 0.1904E-00 0.1155E-00 0.7276E-01 0.4702E-01 0.3128E-01 0.2130E-01 0.1468E-01 0.1027E-01
 0.7234E-02 0.5170E-02 0.3725E-02 0.2687E-02 0.1970E-02 0.1423E-02 0.1060E-02 0.7703E-03 0.5782E-03 0.3986E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))      3    3
 0.1657E-00 0.2489E-00 0.1723E-00 0.1146E-00 0.8039E-01 0.5701E-01 0.4158E-01 0.3104E-01 0.2252E-01 0.1692E-01
 0.1266E-01 0.9722E-02 0.7415E-02 0.5666E-02 0.4364E-02 0.3290E-02 0.2881E-02 0.2117E-02 0.1601E-02 0.1323E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))       3    3
 0.2146E-00 0.2810E-00 0.1817E-00 0.1102E-00 0.6965E-01 0.4506E-01 0.3004E-01 0.2051E-01 0.1413E-01 0.9911E-02
 0.6997E-02 0.5020E-02 0.3627E-02 0.2624E-02 0.1927E-02 0.1397E-02 0.1060E-02 0.7696E-03 0.5761E-03 0.4057E-03
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))      4    4
 0.1651E-00 0.2492E-00 0.1721E-00 0.1144E-00 0.8030E-01 0.5693E-01 0.4152E-01 0.3099E-01 0.2246E-01 0.1688E-01
 0.1263E-01 0.9696E-02 0.7387E-02 0.5645E-02 0.4348E-02 0.3262E-02 0.2894E-02 0.2115E-02 0.1591E-02 0.1332E-02
INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))       4    4
 0.2139E-00 0.2812E-00 0.1815E-00 0.1100E-00 0.6956E-01 0.4499E-01 0.2999E-01 0.2047E-01 0.1410E-01 0.9885E-02
 0.6976E-02 0.5007E-02 0.3615E-02 0.2615E-02 0.1920E-02 0.1390E-02 0.1063E-02 0.7694E-03 0.5742E-03 0.4076E-03
ITERATED SPECTRUM
 0.2139E-00 0.2812E-00 0.1815E-00 0.1100E-00 0.6956E-01 0.4499E-01 0.2999E-01 0.2047E-01 0.1410E-01 0.9885E-02
 0.6976E-02 0.5007E-02 0.3615E-02 0.2615E-02 0.1920E-02 0.1390E-02 0.1063E-02 0.7694E-03 0.5742E-03 0.4076E-03

IT,SU,TERM
       5 0.7298160E 07 0.2012618E-00
```

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY
1	0.3500000E-01	0.9778627E 00	0.8483500E 00	0.8346675E 00	0.9996538E 00
2	0.1050000E-00	0.9881335E 00	0.9604082E 00	0.8878380E 00	0.9935769E 00
3	0.1750000E-00	0.9899426E 00	0.9675062E 00	0.9016528E 00	0.9790306E 00
4	0.2450000E-00	0.9911033E 00	0.9714756E 00	0.9114556E 00	0.9586511E 00
5	0.3150000E-00	0.9919011E 00	0.9740432E 00	0.9188737E 00	0.9308467E 00
6	0.3850000E-00	0.9924308E 00	0.9759332E 00	0.9246809E 00	0.9007974E 00
7	0.4550000E-00	0.9929763E 00	0.9775168E 00	0.9294218E 00	0.8716931E 00
8	0.5250000E 00	0.9933837E 00	0.9788375E 00	0.9333398E 00	0.8459187E 00
9	0.5950000E 00	0.9937254E 00	0.9799295E 00	0.9366778E 00	0.8243131E 00
10	0.6650000E 00	0.9940293E 00	0.9807800E 00	0.9396983E 00	0.8034574E 00
11	0.7350000E 00	0.9942718E 00	0.9816541E 00	0.9422524E 00	0.7861139E 00
12	0.8050000E 00	0.9945240E 00	0.9824473E 00	0.9445507E 00	0.7715785E 00
13	0.8750000E 00	0.9947331E 00	0.9830844E 00	0.9467351E 00	0.7561375E 00
14	0.9450000E 00	0.9949214E 00	0.9836682E 00	0.9485096E 00	0.7429647E 00
15	0.1015000E 01	0.9950919E 00	0.9842089E 00	0.9501022E 00	0.7309423E 00
16	0.1085000E 01	0.9952401E 00	0.9847017E 00	0.9515678E 00	0.7202201E 00
17	0.1155000E 01	0.9953814E 00	0.9851690E 00	0.9529699E 00	0.7096657E 00
18	0.1225000E 01	0.9955157E 00	0.9856108E 00	0.9543080E 00	0.6993497E 00
19	0.1295000E 01	0.9956429E 00	0.9860272E 00	0.9555821E 00	0.6893441E 00
20	0.1365000E 01	0.9957632E 00	0.9864181E 00	0.9567917E 00	0.6797214E 00

```
DIFFERENTIAL FLUX AT ITERATION NUMBER =       5
  0.17407E 07   0.21723E 07   0.14857E 07   0.99241E 06   0.70933E 06
  0.51497E 06   0.38531E 06   0.29461E 06   0.21802E 06   0.16732E 06
  0.12745E 06   0.99376E 05   0.77008E 05   0.59731E 05   0.46653E 05
  0.35451E 05   0.31845E 05   0.23576E 05   0.17960E 05   0.15223E 05
FITTING DIFFERENCES
 0.             0.3423507E-01 0.3189259E-01 0.2337686E-02 0.4598432E-05

SINGLE SPECTRUM     20CHANNELS
60189.053350.324488.803073.507761.323368.218880.149441.102892. 72153.
50905. 36542. 26369. 19078. 14013. 10109.  7775.  5612.  4179.  2983.
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NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	0.03500	0.3180791E 03	0.1113277E 02
2	0.10500	0.3969569E 03	0.4168047E 02
3	0.17500	0.2714834E 03	0.4750960E 02
4	0.24500	0.1813473E 03	0.4443009E 02
5	0.31500	0.1296195E 03	0.4083014E 02
6	0.38500	0.9410255E 02	0.3622948E 02
7	0.45500	0.7040966E 02	0.3203640E 02
8	0.52500	0.5383459E 02	0.2826316E 02
9	0.59500	0.3983998E 02	0.2370479E 02
10	0.66500	0.3057576E 02	0.2033288E 02
11	0.73500	0.2329009E 02	0.1711822E 02
12	0.80500	0.1815944E 02	0.1461835E 02
13	0.87500	0.1407190E 02	0.1231291E 02
14	0.94500	0.1091489E 02	0.1031457E 02
15	1.01500	0.8525122E 01	0.8652998E 01
16	1.08500	0.6478028E 01	0.7028660E 01
17	1.15500	0.5819239E 01	0.6721221E 01
18	1.22500	0.4308070E 01	0.5277385E 01
19	1.29500	0.3281831E 01	0.4249970E 01
20	1.36500	0.2781687E 01	0.3797002E 01

```
INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL

PHOTON NUMBER (PHOTONS/CM**2-SEC) =  0.1683879E 04
PHOTON ENERGY (MEV/CM**2-SEC)     =  0.4162410E 03
PHOTON DOSE   (ROENTGENS/HOUR)    =  0.8507740E-03

AVERAGE ENERGY (MEV) =  0.2471918E-00

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) =  0.4551024E-07
PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2-SEC)/MEV)          =  0.6823623E 03
PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC)     =  0.1124976E-07
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)              =  0.2299389E-13
PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.1736576E-14


AT THE SOURCE CYLINDER

PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)              =  0.2312669E-10

PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) =  0.1796894E-11
```

```
EFFICIENCY VECTOR ETA
0.6921752E 00 0.83715€6E 00 0.8454723E 00 0.8412923E 00 0.8262040E 00
0.80679913E 00 0.7863929E 00 0.7677080E 00 0.7518716E 00 0.7360750E 00
0.7229326E 00 0.7120819E 00 0.7000461E 00 0.6896735E 00 0.6801488E 00
0.67164415E 00 0.6631829E 00 0.6548420E 00 0.6466907E 00 0.6383003E 00
```

```
BRIEF DESCRIPTION OF PHA RUNS
SAMPL DATA FOR NASA-GSFC. NUS MODEL LINEAR TEST. (SEPT 11/67)

CONTROL NUMBERS
M( 1) =  0  M( 2) =  2  M( 3) =  3  M( 4) =  4  M( 5) =  5  M( 6) =  6
M( 7) =  0  M( 8) =  8  M( 9) =  0  M(10) =  0  M(11) =  0  M(12) =  0
M(13) =  0  M(14) =  0  M(15) =  0  M(16) =  0  M(17) = 17  M(18) =  0

CALCOMP PLOTTING OPTION CONTROL NUMBERS
MPLOT( 1) = -0  MPLOT( 2) = -0  MPLOT( 3) = -0  MPLOT( 4) = -0  MPLOT( 5) = -0

EM =    20.00000 CHANNELS/MEV

ELIMIT=     1.00000

ITERATIVE ERROR TOLERANCE,EPS =     0.00010

NUMBER OF BETA SOURCE SETS,OJSC =     1     MN =    0

MAX NUMBER OF ITERATIONS,ITMAX=  51

NUMBER OF CHANNELS INPUT, N = 20

NAI(TL) CRYSTAL SIZE =  3.00 X 3.00 INCHES.
```

BETA SOURCE	SOURCE STRENGTH (CURIES)	MAX BETA ENERGY (MEV)	SOURCE DIAMETER (CM.)	SOURCE HALF-LIFE (MINUTES)	NUMBER OF PHA RUNS THIS SET	NUMBER OF CHANNELS PER SPECTRUM	HALF-LIFE MULTIPLIER
LINEAR	1.0000	1.0000	1.0000	0.3840E 04	1	100	0.2400E 02

SOURCE CRYSTAL DISTANCE (CM.)	CRYSTAL ANGLE AT SOURCE (DEGREES) POLAR	AZIMUTH	COUNTING DURATION (MINUTES)	REFERENCE TIME (DAYS)	PHA COARSE GAIN	MONITOR PULSE-HEIGHT (CHANNELS)	MONITOR ENERGY (MEV)	SPECTRA ZERO SHIFT (CHANNELS)	BACKGROUND SIGNAL	BACKGROUND MULTIPLIER
100.000	0.	0.	1.000	0.	01.00	100.0000	1.0000	0.	0.	0.

SPECTRUM NUMBER 1 FOR LINEAR SOURCE

(AFTER BACKGROUND SUBTRACTION)

50.	127.	274.	303.	382.	521.	646.	747.	843.	950.
1057.	1162.	1263.	1365.	1468.	1565.	1672.	1740.	1836.	1949.
2085.	2188.	2290.	2391.	2490.	2579.	2681.	2782.	2882.	2982.
3076.	3177.	3278.	3378.	3478.	3574.	3675.	3775.	3875.	3975.
4074.	4174.	4274.	4374.	4473.	4568.	4669.	4770.	4871.	4971.
5077.	5177.	5276.	5375.	5474.	5573.	5671.	5770.	5868.	5964.
6049.	6149.	6248.	6348.	6448.	6547.	6647.	6747.	6846.	6946.
7043.	7143.	7243.	7343.	7443.	7543.	7642.	7742.	7842.	7942.
8042.	8142.	8242.	8342.	8442.	8542.	8642.	8742.	8841.	8940.
9028.	9131.	9234.	9337.	9440.	9543.	9647.	9750.	9854.	9961.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

LINEARIZED SPECTRUM OF 100 CHANNELS

50.	150.	250.	350.	450.	550.	650.	750.	850.	950.
1050.	1150.	1250	1350.	1450.	1550.	1650.	1750.	1850.	1950.
2050.	2150.	2250.	2350.	2450.	2550.	2650.	2750.	2850.	2950.
3050.	3150.	3250.	3350.	3450.	3550.	3650.	3750.	3850.	3950.
4050.	4150.	4250.	4350.	4450.	4550.	4650.	4750.	4850.	4950.
5050.	5150.	5250.	5350.	5450.	5550.	5650.	5750.	5850.	5950.
6050.	6150.	6250.	6350.	6450.	6550.	6650.	6750.	6850.	6950.
7050.	7150.	7250.	7350.	745	7550.	7650.	7750.	7850.	7950.
8050.	8150.	8250.	8350.	8450.	8550.	8650.	8750.	8850.	8950.
9050.	9150.	9250.	9350.	9450.	9550.	9650.	9750.	9850.	9950.

PHA SPECTRUM CORRECTED FOR EFFICIENCY

0.22982E 06	0.43099E 03	0.40490E 03	0.47823E 03	0.57880E 03
0.63833E 03	0.80113E 03	0.91442E 03	0.10294E 04	0.11427E 04
0.12589E 04	0.13746E 04	0.14901E 04	0.16052E 04	0.17206E 04
0.18351E 04	0.19499E 04	0.20650E 04	0.21806E 04	0.22965E 04
0.24130E 04	0.25298E 04	0.26475E 04	0.27661E 04	0.28860E 04
0.30063E 04	0.31280E 04	0.32514E 04	0.33767E 04	0.35038E 04
0.36303E 04	0.37584E 04	0.38881E 04	0.40194E 04	0.41521E 04
0.42837E 04	0.44169E 04	0.45515E 04	0.46876E 04	0.48243E 04
0.49624E 04	0.51014E 04	0.52417E 04	0.53832E 04	0.55256E 04
0.56688E 04	0.58130E 04	0.59579E 04	0.61034E 04	0.62494E 04
0.63940E 04	0.65394E 04	0.66856E 04	0.68325E 04	0.69801E 04
0.71269E 04	0.72749E 04	0.74240E 04	0.75743E 04	0.77260E 04
0.78810E 04	0.80363E 04	0.81917E 04	0.83472E 04	0.85022E 04
0.86542E 04	0.88070E 04	0.89606E 04	0.91151E 04	0.92705E 04
0.94282E 04	0.95859E 04	0.97437E 04	0.99013E 04	0.10059E 05
0.10213E 05	0.10368E 05	0.10524E 05	0.10681E 05	0.10840E 05
0.11003E 05	0.11166E 05	0.11330E 05	0.11494E 05	0.11659E 05
0.11824E 05	0.11990E 05	0.12156E 05	0.12322E 05	0.12488E 05
0.12652E 05	0.12817E 05	0.12983E 05	0.13149E 05	0.13316E 05
0.13483E 05	0.13651E 05	0.13820E 05	0.13989E 05	0.14158E 05

SINGLE SPECTRUM 100CHANNELS

50.	150.	250.	350.	450.	550.	650.	750.	850.	950.
1050.	1150.	1250.	1350.	1450.	1550.	1650.	1750.	1850.	1950.
2050.	2150.	2250.	2350.	2450.	2550.	2650.	2750.	2850.	2950.
3050.	3150.	3250.	3350.	3450.	3550.	3650.	3750.	3850.	3950.
4050.	4150.	4250.	4350.	4450.	4550.	4650.	4750.	4850.	4950.
5050.	5150.	5250.	5350.	5450.	5550.	5650.	5750.	5850.	5950.
6050.	6150.	6250.	6350.	6450.	6550.	6650.	6750.	6850.	6950.
7050.	7150.	7250.	7350.	7450.	7550.	7650.	7750.	7850.	7950.
8050.	8150.	8250.	8350.	8450.	8550.	8650.	8750.	8850.	8950.
9050.	9150.	9250.	9350.	9450.	9550.	9650.	9750.	9850.	9950.

APPENDIX VI

RESPONSE MATRIX GENERATION PROGRAM

APPENDIX VI

RESPONSE MATRIX GENERATION PROGRAM

The response matrix generation portion of code CUBED-II may be used separately, if desired. For this purpose a substitute controlling program listing is presented in this appendix. The following code CUBED-II subprograms are required:

FUNUS	PEAK	STDFIT
GANE	PHØFRA	TA
GAUSS	PULSE	TE
GUESS	RAXEL	RESGEN

The input for this program is card set (6A) as given in Section 3.2 of the user's manual. Card Set (6A) must be preceded by one card containing three variables, namely:

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
N	1-10	I10	The size of the response matrix, channels; $\leq$ 40.
ELIMIT	11-20	F10.5	The energy of the upper edge of the response matrix highest channel, meV.
MRPEAT	21-30	I10	When $\neq$ 0, used by PHØFRA to skip the input of standard spectra when previously input spectra can be reused for new response matrix.

```
$IBFTC MAIN     DECK,REF.LIST
C
C CODE CUBED TEMPORARY MAIN PRCGRAM FOR              SUBP. *PHCFRA*.
C
      DIMENSION R(40,40),Q(5C),PV(50),PFRACT(50)
C
    1 READ     (2,2)  N,ELIMIT,MRPEAT
    2 FORMAT (I10,F10.5,I1C)
      EN=N
      EM=EN/ELIMIT
      NGO=1
      NGR=1
      NDEGRE=2
      WRITE (3,2030) N,NGC,NGR,NDEGRE,ELIMIT,EN,EM
      CALL PHOFRA (R,N,EM,ELIMIT,NGO,NGR,NDEGRE,C,PV,PFRACT,K,MRPEAT)
   13 WRITE (3,2001)((R(I,J),I= 1,N),J= 1,N)
      WRITE (3,2009)
      WRITE (3,2000)(Q(I),I= 1,N)
      WRITE (3,9876)(PV(I),I=1,N)
      WRITE (3,2009)
 2009 FORMAT (1H1)
      WRITE (3,202C)(PFRACT(I),I= 1,N)
 2001 FORMAT (//8H MATRIX      /(10E11.4))
 2000 FORMAT (17H RESPCNSE MATRIX  //34H ENERGY INTERVAL MIDPCINTS IN ME
 20001V     /(10F7.4))
 9876 FORMAT (/30H PULSE-HIEGHT IN CHANNELS       /(10F8.3))
 2020 FORMAT (////15H PHCTCFRACTIONS  /(10F10.5))
 2030 FORMAT (1H1,10H NEW SET   /13H INPUT PARAS  / 1X,4I5,3E13.6)
      GO TO 1
      END
```

APPENDIX VII

NORMALIZING PROGRAM FOR STANDARD SPECTRA

APPENDIX VII

NORMALIZING PROGRAM FOR STANDARD SPECTRA

This appendix presents a substitute main program and a modified version of code CUBED-I[1] subprograms, which may be used to normalize standard spectra. Such a normalizing code is desirable, for example, in mapping the radiation affects of laboratory geometry for a proposed experiment. This mapping will often result in the generation of a large number of similar spectra, originating from a standard source such as Cs^{137} or Mn^{54}. The purpose of the program presented in this appendix is to allow the rapid semi-automatic analysis of many similar spectra.

The normalizing program outputs fitted photopeak areas, pulse-heights and standard deviations; spectral peak-to-total ratios --- photofractions; and Compton continua normalized to photopeak unit area and pulse-height (100 channels). X-ray and annihilation peaks, etc. are not subtracted by this program.

The substitute main program and code CUBED-I subprograms are listed in this appendix. A sample input and output are also listed --- for two similar Mn^{54} spectra. The input for this program is exactly as described for card set (6A) in report Section 3.2, excepting in that the spectra may, or may not, be similar, i.e. may be mixed in kind.

```
$EXECUTE          IBJOB
$IBJOB            GO,SOURCE,MAP
$IBFTC MAIN       DECK,REF,LIST
C HUS CORPORATION (STEYN)
C CODE CHSEL TEMPORARY MAIN PROGRAM FOR DEBUGING SUBP. *PHOFRA*.
C
      DIMENSION K(40,40),Q(50),PV(50),PFRACT(50)
    1 CONTINUE
      MRPEAT=0
      ELIMIT=1.0
      N=20.0
      EN=N
      EM=EN/ELIMIT
      NGC=1
      NGR=1
      NDEGRE=2
      CALL PHOFRA (K,N,EM,ELIMIT,NGC,NGR,NDEGRE,Q,PV,PFRACT,K,MRPEAT)
      GO TO 1
      END
$IBFTC GANE       DECK,REF,LIST
      SUBROUTINE GANE (TZ,NX,GAIN,RGGAIN,SMOOTH,C)
C********** PROGRAM NUMBER GSFC-16 **********
C   PROG G.
C   GAIN CHANGING PROGRAM (JUNE 4/64 VERSION)     INCLUDES SMOOTHING.
      DIMENSION  C(200),  FM(200)
      NLIMIT=200
      IF(TZ)1000,275,1000
 1000 NZC=TZ
      NXC=NX-NZC
C
C INTEGER SHIFT IF *NZC* NOT EQUAL TO ZERO.
C
      IF(TZ )913,910,911
  913 NZC=NZC-1
      NS=NZC*(-1) + 1
      NSX=NS-1
      NSXU=1
      NXO=NSX+NX
  955 DO 956 I=NS,NXO
      K=I+NZC
  956 FM(I)=C(K)
      DO 957 I=NS,NXO
  957 C(I)=FM(I)
      GO TO 95
  911 NS=1
```

```
      [illegible]=[illegible]+1
      NSX=NX
  9[illegible] DO 91 I=1,[illegible]
      K=I+NZC
   91 C(I)=C(K)
   93 DO 92 I=NSXO,NSX
   92 C(I)=0.0
  910 NX=NXO
C
C  DECIMAL SHIFT.
C
  274 TNZC=NZC
      DIF=TZ-TNZC
      DDIF=1.0-DIF
      IF(DIF)271,272,271
  271 NXON=NX-2
      C(1)=C(1) + C(2)*DIF
      DO 270 I=2,NXON
  270 C(I)=C(I)*DDIF + C(I+1)*DIF
      C(NXON +1)=C(NXON +1)*DDIF + C(NX)
      GO TO 273
  272 IF(NZC)273,275,275
  273 NX=NX-1
  275 TZ=0.
      L=1
      G=GAIN
      DO 50 I=1,NLIMIT
   50 FR(I)=0.0
      FMULT=GAIN/RQGAIN
C
C DEL=0.5 WHEN GAIN/RQGAIN=1./2. I.E. DOUBLING REQUIRED.
C DEL=2.0 WHEN GAIN/RQGAIN=2./1. I.E. HALVING REQUIRED.
C
    1 DEL=GAIN/RQGAIN
      IF(DEL-2.0)402, 204, 402
  402 IF(DEL-0.5)3, 3, 4
    3 L=L+1
      GAIN=GAIN*2.0
      GO TO 1
C
C  INITIALIZE FOR REDUCING ALGORITHM.
C
    4 I=1
      K=1
      X=0.
```

```
      XN=1.0
      DELT=0.
   60 DEL=DEL
      IF(DEL-1.0)5,499,105
  499 IF(L-1)497,496,497
  497 DELT=ROGAIN/2.0
      L=L-1
  496 DO 498 I=1,NX
  498 FM(I)=C(I)
      GO TO 201
C
C  INCREASE.  ......  LOAD EVEN CHANNELS WITH QUADRATICALLY
C  INTERPOLATED COUNT.   SHIFT ENTIRE SPECTRUM UPWARD ONE'HALF CHAN.
C
    5 DELT=ROGAIN/2.0
      DEL=GAIN/DELT
      GO TO 60
  303 NOX=J-4
      DO 305 J=1,NOX,2
      I=J+1
  305 C(I)= (3.0*C(J) + 6.0*C(J+2) - C(J+4))*.125
      C(I+2)= (3.0*C(I+3) + 6.0*C(I+1) - C(I-1))*.125
      NX=I+3
      DO 936 I=2,NX
  936 FM(I)=(C(I)+C(I-1))*0.5
      FM(1)=C(1)*0.5
      DO 935 I=1,NX
  935 C(I)=FM(I)
      GO TO 304
C
C  REDUCTION ALGORITHM.
C
  105 XK=DEL
      DEL=XN-X
      XKX=XK
  106 FM(K)=FM(K)+DEL*C(I)
      IF(I-NX)112,202,202
  112 X=X+DEL
      IF(X-XK)106,107,108
  107 K=K+1
      XN=I
      DEL=XN-X
      XK=XK+XKX
      GO TO 106
  108 X=XK
```

```
      DEL=XN-X
  109 IF(DEL-1.0)111,111,110
  110 DIF=DEL-1.0
      DEL=DEL-DIF
      GO TO 109
  111 I=I+1
      GO TO 100
  202 DO 1999 INX=1,NLIMIT
 1999 C(INX)=0.0
      XNX=NX
      XNX=XNX/DL
      NX=XNX
C
C  LOAD ODD CHANNELS IF *DELT* EQUAL TO ZERO.
C
  201 IF(DELT) 300,301,300
  300 NC=2
      ND=1
      GO TO 302
  301 NC=1
      ND=0
  302 DO 200 I=1,NX
      J=NC*I - ND
  200 C(J)=FM(I)
      IF(DELT) 303,304,303
  304 IF(L-1)404, 500 ,404
  404 L=L-1
      GO TO 496
C
C  HALVING.
C
  204 I=1
      NCHECK=NX
      NX=NX/2
      NCK=NCHECK -(NX+NX)
      IF(NCK)555, 504, 555
  555 NX=NX+1
  504 K=2*I-1
      C(I)=C(K)+C(K+1)
      IF(I-NX)502,503,503
  502 I=I+1
      GO TO 504
  503 IF(L-1)205,205,205
C
C  SMOOTHING IF *SMOOTH* NOT EQUAL TO ZERO.
```

```
      ARG=0.5*((X-V)/G)**2
      IF(ARG-20.0)2,3,3
    3 G=0.0
      GO TO 4
    2 G=CONS*PKAREA*EXP (-ARG)
    4 SUM=SUM + G
    1 FM(I)=FM(I)+ G
      RETURN
      END
$IBFTC SVFI     DECK,REF,LIST
      SUBROUTINE SVFIT (V,S,N,CG,A1,A2,E,EM,COARSE)
C********** PROGRAM NUMBER GSFC-32 **********
      DIMENSION S(12),E(12),CG(12),V(12)
C FIT PULSE-HEIGHT AND PEAK SIGMA TO EQUATION TYPE   SI=A1*E**A2 AND
C E=V*EM.      THIS SUB CALLED BY *RESGEN*
      SY=0.
      SX=0.
      SX2=0.
      SXY=0.
      SLXY=0.
      SLX2=0.
      DO 2 J=1,N
      VV=V(J)*COARSE/CG(J)
      CG(J)=E(J)/V(J)
      SLXY=SLXY+VV*E(J)
      SLX2=SLX2+VV*VV
      Y=ALOG10(S(J)*CG(J))
      X=ALOG10(E(J))
      SY=SY+Y
      SX=SX+X
      SX2=SX2+X*X
    2 SXY=SXY+X*Y
      EN=N
      A1=(SXY*SX-SY*SX2)/(SX*SX-EN*SX2)
      A2=(SY-EN*A1)/SX
      EM=SLXY/SLX2
      WRITE    (3,3) N,A1,A2,EM,COARSE,(E(I),S(I),CG(I),V(I),I=1,12)
    3 FORMAT (1H1, 7H SVFIT  /1X,I10,4E14.7/(1X,4E14.7))
      RETURN
      END
$IBFTC SC        DECK,REF,LIST
      SUBROUTINE SC     (MOX,LOW,X,R)
C********** PROGRAM NUMBER GSFC-28 **********
C  CALLED BY *RAXEL*.
C  TABLE OF K'ESCAPE FRACTIONS.
```

```
      DIMENSION X(20),R(20)
      X(1)=0.03316
      X(2)=0.0350
      X(3)=0.040
      DO 1 I=4,14
    1 X(I)=X(I-1)+0.010
      R(1)= .27159
      R(2)= .25500
      R(3)= .21001
      R(4)= .14533
      R(5)= .10157
      R(6)= .07200
      R(7)= .05301
      R(8)= .03950
      R(9)= .03001
      R(10)=.02330
      R(11)=.01830
      R(12)=.01480
      R(13)=.01205
      R(14)=.00994
      MOX=14
      LOW=1
      RETURN
      END
$IBFTC PULS     DECK,REF,LIST
      FUNCTION PULSE (E,NGP,N)
C********** PROGRAM NUMBER GSFC-24 **********
C
C  CALLED BY *PHOTO*.   CALLS *ENERGY*,*TA* AND *TE*.
C  PROGRAM TO DETERMINE THE APROPRIATE FRACTIONAL DEVIATION OF PULSE'
C  HEIGHT FROM LINEAR'RESPONSE.
C
      DIMENSION X(45),R(45),Z(12),Y(12)
      IF(E - 0.010)8,9,9
    8 WRITE (3,60) E
   60 FORMAT  (43H PULSE ENERGY LESS THAN 0.015 MEV.  ERROR.  /E20.8)
      E=.015
      GO TO 18
    9 IF(E - 3.0)18,18,12
   12 WRITE (3,61) E
   61 FORMAT  (44H PULSE ENERGY GREATER THAN 3.0 MEV.  ERROR.  /E20.8)
      E=3.0
      GO TO 18
   18 GO TO (1,2),NGP
    1 NGP=2
```

```
      CALL ENERGY (M,LOW,X,R)
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,P,N,L,0)
      NN=N+1
      PULSE=TE (NN,Z,Y,E)
   10 RETURN
      END
$IBFTC ENER     DECK,REF,LIST
      SUBROUTINE ENERGY (MOX,LOW,E,V)
C********** PROGRAM NUMBER GSFC-13 **********
C
C   CALLED BY *PULSE*.
C   TABLE OF FRACTIONAL DEVIATION OF PULSE'HEIGHT FROM LINEAR'RESPONSE.
C
      DIMENSION E(45),V(45)
      E(1)=0.015
      DO 10 I=2,6
   10 E(I)=E(I-1)+0.001
      DO 11 I=7,16
   11 E(I)=E(I-1)+0.002
      E(17)= .0425
      E(18)= .0450
      E(19)= .0500
      E(20)= .0550
      E(21)= .0600
      DO 12 I=22,25
   12 E(I)=E(I-1)+0.010
      DO 13 I=26,29
   13 E(I)=E(I-1)+0.025
      DO 14 I=30,35
   14 E(I)=E(I-1)+0.050
      DO 15 I=36,43
   15 E(I)=E(I-1)+0.100
      E(44)=1.3325
      V( 1)=  .04180
      V( 2)=  .06300
      V( 3)=  .07500
      V( 4)=  .08250
      V( 5)=  .08750
      V( 6)=  .08850
      V( 7)=  .08600
      V( 8)=  .07900
      V( 9)=  .06300
      V(10)=  .03900
      V(11)=  .03000
      V(12)=  .02900
```

```
      V(13)=  .03300
      V(14)=  .04300
      V(15)=  .05250
      V(16)=  .06150
      V(17)=  .07200
      V(18)=  .08100
      V(19)=  .08510
      V(20)=  .08490
      V(21)=  .08040
      V(22)=  .06970
      V(23)=  .06140
      V(24)=  .05550
      V(25)=  .05000
      V(26)=  .03820
      V(27)=  .03000
      V(28)=  .02400
      V(29)=  .01860
      V(30)=  .01150
      V(31)=  .00770
      V(32)=  .00540
      V(33)=  .00390
      V(34)=  .00285
      V(35)=  .00215
      V(36)=  .00110
      V(37)=  .00100
      V(38)=  .00100
      V(39)=  .00100
      V(40)=  .00099
      V(41)=  .00060
      V(42)=  .00030
      V(43)=  .00015
      V(44)=  .00000
      MOX=44
      LOW=1
      RETURN
      END
$IBFTC RAXE     DECK,REF,LIST
      FUNCTION RAXEL (E,NGR,N)
C********** PROGRAM NUMBER GSFC-25 **********
C
C  CALLED BY *SHAPE*.   CALLS *SC*,*TA* AND *TE*.
C  PROGRAM TO COMPUTE K'ESCAPE FRACTION.
C
      DIMENSION X(20),R(20),Z(12),Y(12)
      IF(E-0.150)8,8,9
```

```
    8 IF(E-0.03316)12,18,18
   18 GO TO (1,2),NGR
    1 NGR=2
      CALL SC     (M,LOW,X,R)
    2 CALL TA     (E,X,M,LOW,MOX,MUN,Z,Y,R,N,L,0)
      NN=N+1
      RAXEL= TE (NN,Z,Y,E)
   10 RETURN
    9 IF(E-0.5)11,11,12
   11 RAXEL=(5.0233E-05)*E**(-2.7872)
      GO TO 10
   12 RAXEL=0.0
      GO TO 10
      END
$IBFTC TA       DECK,REF,LIST
      SUBROUTINE TA (E,X,M,MM,MOX,MUN,Z,Y,R,NDEGRE,L,LL)
C********** PROGRAM NUMBER GSFC-33 **********
C
C CALLED BY *RAXEL*,*EFFIC*,*PULSE*,*DOSE*,*AIRABS* AND *PHOFRA*.
C BINARY SEARCH. RETURNS WITH BOUNDING INDICES AND NDEGRE+1 X,Y ELEMENT
C
      DIMENSION X(45),Z(12),Y(12),R(45)
      MOX=M
      MUN=MM
    7 KDEL=(MOX-MUN)/2
    8 IF(KDEL)18,14,18
   18 KP=MUN+KDEL
      IF(X(KP)-E)12,12,11
   11 MOX=KP
      GO TO 7
   12 IF(E-X(KP))24,24,13
   13 MUN=KP
      GO TO 7
   24 MUN=KP
      MOX=KP+1
C
   14 IF(MOX-M)4,5,4
    5 L=MUN-2
      GO TO 6
    4 L=MUN-1
    6 NN=NDEGRE+1
      IF(LL)15,2,15
    2 DO 3 I=1,NN
      J=I+L
      Z(I)=X(J)
```

```
    3 Y(I)=R(J)
   15 RETURN
      END
$IBFTC TE       DECK,REF,LIST
      FUNCTION TE (N,X,Y,E)
C********** PROGRAM NUMBER GSFC-34 **********
C
C CALLED BY *RAXEL* OR *EFFIC* OR *PULSE* OR *DOSE*
C N-DEGREE LAGRANGIAN INTERPOLATION
C
      DIMENSION X(12),Y(12)
      S=0.
      I=1
   28 IF(I-N)21,21,22
   21 P=Y(I)
      J=1
   27 IF(J-N)23,23,24
   23 IF(I-J)25,26,25
   25 P=P*(E-X(J))/(X(I)-X(J))
   26 J=J+1
      GO TO 27
   24 S=S+P
      I=I+1
      GO TO 28
   22 TE =S
      RETURN
      END
$IBFTC GUES     DECK,REF,LIST
      SUBROUTINE GUESS (NS,NFN,Y,B,ENY)
C********** PROGRAM NUMBER GSFC-19 **********
C GUESS PARAMETERS FOR GAUSSIAN + STRAIGHT LINE + COSINE.
C B(1)=PEAK PULSE-HEIGHT=CHAN OF MAX COUNT IN UPPER 1/3 SPECTRUM.
C B(2)=PEAK STANDARD DEVIATION= WIDTH/2.354
C B(3)=PEAK AREA=1.065*WIDTH*HEIGHT.
C B(4)=HALF COSINE WAVE-LENGTH=0.7*(B(1)-B(5))
C B(5)=CHAN AT COS MAX AMP=B(1)-2.2*B(2)
C B(6)=MAX AMP OF COS=COUNT IN B(5) MINUS BASE COUNT B(7).
C B(7)=BASE COUNT=COUNT ABOVE PEAK.
C B(8)=SLOPE OF VALLEY STRAIGHT LINE.
C WIDTH=2*((CHAN OF HALF MAX PEAK COUNT FOR I GREATER THAN B(1))-B(1)).
      DIMENSION B( 8),Y(200)
      BIG=0.0
      DO 2000 I=NS,NFN
      IF(Y(I)-BIG)3000,3000,4000
 4000 BIG=Y(I)
```

```
      IBIG=I
 3000 CONTINUE
 2000 CONTINUE
      B(1)=IBIG
      ANY=1000.*ENY
      W=(.321*ANY**.7677)*B(1)/ANY
      B(2)=W/2.354
      B(7)=Y(NFN)
      B(3)=     W*(BIG-B(7))*1.065
      XNS=NS
      XNFN=NFN
      B(4)=(Y(NFN)-Y(NS))/(XNFN-XNS)
      B(5)=Y(NFN)-B(4)*XNFN
      B(7)=0.0
      RETURN
      END
$IBFTC PHOF     DECK,REF,LIST
      SUBROUTINE PHOFRA (RM,N,EM,ELIMIT,NGO,NGR    ,NDEGRE,Q,PV,PFRACT,K,
     1 MRPEAT)
C********** PROGRAM NUMBER GSFC-23 **********
C
C THIS PROGRAM COMPUTES THE RESPONSE MATRIX RM(I,J)
C CALLED BY MAIN PROGRAM. CALLS *DECLIB*,*SOLIBY*,*RESGEN*,*GANE*,
C *PEAKS*,*RAXEL*,*PULSE* AND *TE*.
C
      DIMENSION RM(40,40),R(200,15),FM(200),X(12)     ,PV(50),PFRACT(50),
     1 Q(50),ALABEL(12),G(12),TAG(12),STDENY(12),STDEN(12),Z(12),Y(12)
     2 ,RR(16),NSJ(12),NFNJ(12),NSXJ(12),NFXJ(12), SHIFT(12),NOSUBT(12)
     3  ,NSM(12),DENY(12)
C
C READ IN ANY ORDER THE APPROPRIATLY LABELLED RESP. MATRIX LIBRY SPECTRA
C
C READ STANDARD LIBRARY SPECTRA.
C
      IF(MRPEAT)31234,21234,31234
31234 CONTINUE
21234 DO 9052 J=1,12
      NFXJ(J)=0.0
 9052 NSXJ(J)=0.0
C
C  NSTAND=NUMBER OF STANDARD SPECTRA IN THE LIBRARY DECK
C  NPHA=NUMBER OF DEAD CHANNEL IN BEGINNING OF STAND. SPECTRA
C  UNGAIN=REFERENCE COARSE GAIN (AS AT OCT19/66 IS A DUMMY)
C  ALABEL=STANDARD SOURCE IDENTITY (AS IN DATA STATEMENT BELOW)
C  FIT PE AKS FROM CHANNEL NSJ TO NFNJ
```

```
C  SUBTRACT PEAKS FROM CHANNEL NSXJ TO NFXJ (USE NEG VALUES IF .51 PEAKS
C     OF EITHER NA22 OR ZN65)
C  SHIFT=CHANNEL LOCATION OF TRUE ZERO PULSE-HEIGHT
C  R(1 TO 200,J)=SPECTRUM J          (J=1 TO NSTAND)
C
      READ (2,6)  NSTAND,NPHA,UNGAIN,
     1 (ALABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J), SHIFT(J), J=1,NSTAND)
    6 FORMAT (      2I5,F10.5/ (A6,4X,4I5,F10.5))
      READ     (2,88) ((R(I,J),I=1,200),J=1,NSTAND)
   88 FORMAT (10F7.1)
C
C  COMPLEMENT OVERSUBTRACTED COUNTS.
      DO 8000 J=1,NSTAND
      DO 8000 I=1,200
      IF(R(I,J)-800000.0)8001,8001,8002
 8002 R(I,J)=R(I,J)-1000000.0
 8001 CONTINUE
 8000 CONTINUE
C
C  SHIFT SPECTRA AN AMOUNT TZ IF TZ NOT =0
      NTZ=0
      DO 9000 J=1,NSTAND
      IF(NSXJ(J))9015,9016,9016
 9015 NSXJ(J)=-NSXJ(J)
      NOSUBT(J)=0
      GO TO 9017
 9016 NOSUBT(J)=1
 9017 IF( SHIFT(J))9001,9002,9001
 9001 TZ= SHIFT(J)
      NTZ=TZ
      IF(NSXJ(J))9018,9019,9018
 9018 NSXJ(J)=NSXJ(J)-NTZ
      NFXJ(J)=NFXJ(J)-NTZ
 9019 NSJ(J) =NSJ(J) -NTZ
      NFNJ(J)=NFNJ(J)-NTZ
      NX=200
      GAIN=1.0
      ROGAIN=1.0
      DO 9003 I=1,200
 9003 FM(I)=R(I,J)
      CALL GANE (TZ,NX,GAIN,ROGAIN,0.0,FM)
      DO 9004 I=1,200
 9004 R(I,J)=FM(I)
 9002 CONTINUE
```

```
 9000 CONTINUE
      NPHA=NPHA-NTZ
      DO 9095 I=1,NSTAND
 9095 G(I)=0.0
      N5=5
      NA=10
      NZ=9
      NTAG=12
      DATA (TAG(I),I=1,12) /6H CD109,6H  SC47,6H HG203,6H AU198,6H  SR85
     1  ,6H CS137,6H  MN54,6H  NB95,6H  ZN65,6H  NA22,6H  NA24,6H   K42/
     2 ,(STDEN(1),I=1,12)/.088,.155,.279,.4117,.515,.66162,.835,.764,
     3 1.114,1.28,2.76,1.51/
C
C IDENTIFY ENERGIES OF STANDARDS
      DO 1234 KK=1,NSTAND
      DO 3456 J=1,NTAG
      IF(ALABEL(KK).EQ.TAG(J))GO TO 4321
 6543 CONTINUE
 3456 CONTINUE
      WRITE   (3,9) (ALABEL(JJ),JJ=1,NSTAND),(TAG(JJJ),JJJ=1,NTAG)
    9 FORMAT (1H1,23H ERROR FLAG FOR PHOFRA        /(1X,1H*,A6))
      CALL EXIT
 4321 STDENY(KK)=STDEN(J)
 1234 CONTINUE
C
C CALL RESGEN TO CALC GAUSSIAN PARAMETERS AND UNIT CONTINUA FOR STANDS.
C
      WRITE(3,7)  NSTAND,NPHA,UNGAIN,
     1 (ALABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J),SHIFT(J),STDENY(J),
     2 J=1,NSTAND)
    7  FORMAT(1H1,15X ,37H STANDARD SOURCE SPECTRAL PARAMETERS   ///
    71  14X,I5,33H SPECTRA IN STANDARD SOURCE DECK   //
    72  13X,16H CHANNELS ONE TO ,I4,22H ASSUMED AS REDUNDANT   //1
    73  17X,25H REFERENCE COARSE GAIN =      ,F10.5////
    741X,72HSTANDARD         PHOTOPEAK      X-RAY OR .5 PEAK      SHIFT
    75 PHOTOPEAK      /72H  SOURCE       FROM        TO       FROM       TO
    76    SPECTRUM    ENERGY       /10X,60H   CHANNEL  CHANNEL   CHANNEL
    77 CHANNEL    CHANNEL     MEV         /(2X,A6,6X,I4,5X,I4,7X,I3,6X,I3,
    784X,2F10.5))
      DO 27123 J=1,NSTAND
      WRITE    (3,8999) ALABEL(J),(R(I,J),I=1,200)
 8999 FORMAT (1H1,32X,25H STANDARD SOURCE SPECTRA    ////////
 89991          1X,A6/(1X,10F9.0))
27123 CONTINUE
      WRITE   (3,3)
```

```
    3 FORMAT (1H1)
      NTEMP=1
      CALL RESGEN (R,ALABEL,TAG,G,SCONST,SN,ENPHU,UNGAIN,STDENY,NSTAND,
     1 NTAG,NA,NZ,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NOSUBT,NTEMP)
C
C INTEGRATE NORMALIZED STANDARD SPECTRA FOR INTERPOLATION EASE, HENCE
C DIFFERENTIATE INTERPOLATED SPECTRA LATER.
C
      DO 30122 J=1,NSTAND
      SUM=0
      DO 25122 I=1,120
25122 SUM=SUM+R(I,J)
30122 PFRACT(J)=1.0/(1.0+SUM)
      DO 19123 J=1,NSTAND
      WRITE(3,3)
      WRITE   (3,81) ALABEL(J), PFRACT(J) ,(R(I,J),I=1,120)
   81 FORMAT (10X,42H NORMALIZED CONTINUUM OF STANDARD SPECTRA //////
     8111X,A6/18H PHOTOFRACTION =  E14.7/(1X,5E14.7))
19123 CONTINUE
      RETURN
      END
$IBFTC RESG     DECK,REF,LIST
      SUBROUTINE RESGEN (R,ALABEL,TAG,G,SCONST,SN,EM,UNGAIN,STDENY,
     1 NSTAND,NTAG,NA,NZ,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NOSUBT,NTEMP)
C********** PROGRAM NUMBER GSFC-26 **********
      DIMENSION R(200,15),ALABEL(12),TAG(12),G(12),STDENY(12),NFNJ(12),
     1 NSJ(12),NFXJ(12),NSXJ(12),Y(200),PARAV(12),B(8),PARAS(12),
     2 PAREA(12),PP(200),NPARA(8),NOSUBT(12)
C THIS PROGRAM ORDERS STANDARD SPECTRA FOR INTERPOLATION OF RESP. MATRIX
C CALLED BY *PHOFRA*. CALLS *STDFIT*, *GANE*, *GAUSS* AND *SVFIT*.
C
C SEARCH FOR .51 MEV SPECTRUM, IF FOUND SEARCH FOR NA22 AND ZN65.
C .51SEARCH FIRST
      NST=0
      NSTD1=0
      NSTD2=0
      NGAIN=0
      IF(NTEMP)30123,30122,30123
30122 DO 2 I=1,NSTAND
      IF(ALABEL(I).NE.TAG(N5))GO TO 4
    3 I5=I
      NST=6
      GO TO 10
    4 CONTINUE
    2 CONTINUE
```

```
      NAT=0
      EG=1.114
      IF(STDENY(NSTAND-1)-EG)50,51,50
   51 NAT=NAT+1
   50 EG=1.23
      NSTNAT=NSTAND-NAT-1
      IF(STDENY(   NSTNAT     )-EG)52,53,52
   53 NAT=NAT+1
   52 NSTAND=NSTAND-NAT
30123 NSTD3=NSTAND
      GO TO 200
C SEARCH FOR NA22.
   10 DO 20 I=1,NSTAND
      IF(ALABEL(I).NE.TAG(NA))GO TO 40
   30 INA=I
      NST=1
      GO TO 201
   40 CONTINUE
   20 CONTINUE
C SEARCH FOR ZN65.
  201 DO 2000 I=1,NSTAND
      IF(ALABEL(I).NE.TAG(NZ))GO TO 400
  300 INZ=I
      NST=NST+2
      GO TO 1111
  400 CONTINUE
 2000 CONTINUE
C INITIAL LIMITS FOR START AND STOP FITTING.
 1111 NSJ5=1
      NFN5=NFNJ(I5)
      NSTD1=NSTAND+1
      NSTD2=NSTD1+1
      NSTD3=NSTD2+1
C LOAD 3 EMPTY VECTORS FOR TEMPORARY USE.
      IF(NST)111,200,111
  111 NSJ(NSTD1)=NSJ(I5)
      NFNJ(NSTD1)=NFNJ(I5)
      STDENY(NSTD1)=STDENY(I5)
      DO 150 I=NSJ5,NFN5
  150 R(I,NSTD1)=R(I,I5)
      GO TO (159,170,170),NST
  170 NSJ(NSTD3)=NSXJ(INZ)
      NFNJ(NSTD3)=NFXJ(INZ)
      STDENY(NSTD3)=STDENY(INZ)
      NSJZ=NSJ(NSTD3)
```

```
      NFNZ=NFNJ(NSTD3)
      DO 180 I= 1   ,NFNZ
  180 R(I,NSTD3)=R(I,INZ)
      IF(NST-3)220,160,220
  159 NSTD3=NSTD2
  160 NSJ(NSTD2)=NSXJ(INA)
      NFNJ(NSTD2)=NFXJ(INA)
      STDENY(NSTD2)=STDENY(INA)
      NSJA=NSJ(NSTD2)
      NFNA=NFNJ(NSTD2)
      DO 190 I= 1   ,NFNA
  190 R(I,NSTD2)=R(I,INA)
  220 NGAIN=1
C
C NON-LINEAR FIT NSTAND+3 SPECTRA, EXCLUDE EMPTY VECTORS, FROM NS TO NFN
C
C  INITIALIZE SUCH THAT THERE ARE NO FIXED PARAMETERS.
  200 CONTINUE
      DO 5000 J=1,NSTD3
      IF(NST-2)233,235,233
  235 JZ=J
      IF(JZ-NSTD2)233,5001,233
  233 NS=NSJ(J)
      NFN=NFNJ(J)
      ENY=STDENY(J)
      IF(ENY-3.0)9000,9001,9001
 9000 KLM=5
      NBC=5
      GO TO 9002
 9001 KLM=8
      NBC=8
 9002 DO 7002 I=1,NPHA
 7002 R(I,J)=R(NPHA+1,J)
      DO 1945 KJ=1,NBC
 1945 NPARA(KJ)=KJ
      DO 2005 I=1,200
 2005 Y(I)=0.0
      DO 5002 I=NS,NFN
 5002 Y(I)=R(I,J)
      JJ=J
      DO 57 KB=1,8
   57 B(KB)=0.0
C
C CALL REGRESSION SUBPROGRAM.
      CALL STDFIT (Y    ,NFN, B,KLM,NPARA,NBC,NS,PP,ENY)
```

```
C
      PARAV(J)=B(1)
      PARAS(J)=B(2)
      PAREA(J)=B(3)
      WRITE(3,30015) B(1),B(2),B(3)
30015 FORMAT (24H PHOTOPEAK PULSE-HEIGHT   ,E14.7/30H PHOTOPEAK STANDARD
300151DEVIATION   ,E14.7/16H PHOTOPEAK AREA   ,E14.7//              )
C
C SUBTRACT FITTED PEAK.
C
      NB1=B(1)
      DO 5010 I=NS ,NB1
 5010 R(I,J)=Y(I)-PP(I)
      NB3=B(1)-5.0*B(2)
      NB4=NS-1
      IF(NB3-NB4)30592,30593,30593
30592 DO 30591 I=NB3,NB4
      XOX=I
      XOX=XOX-0.5
      PON=(XOX-B(1))/B(2)
      GNK= 0.3989423*B(3)*EXP(-0.5*PON**2)/B(2)
30591 R(I,J)=R(I,J)-GNK
30593 NB2=NB1+1
      DO 5011 I=NB2,200
 5011 R(I,J)=0.0
      IF(NSXJ(J))5020,5001,5020
C
C SUBTRACT X-RAY PEAKS IF ANY.
C
 5020 IF(NOSUBT(J))5029,5001,5029
 5029 DEL=NFXJ(J)-NSXJ(J)
      NXX=NSXJ(J)
      NSX=NSXJ(J)+1
      NFXX=NFXJ(J)
      NFX=NFXJ(J)-1
      DO 5021 I=NSX,NFX
      X=I-NXX
 5021 R(I,J)=R(NXX,J)+X*(R(NFXX,J)-R(NXX,J))/DEL
 5001 CONTINUE
C  ZERO FROM THE FIRST NEGATIVE CHANNEL TO 200
      DO 9010 I=1,200
      IF(R(I,J))9011,9012,9012
 9011 INDIC=I
      GO TO 9014
 9012 CONTINUE
```

```
 9010 CONTINUE
      GO TO 9015
 9014 DO 9013 I=INDIC,200
 9013 R(I,J)=0.0
 9015 CONTINUE
 5000 CONTINUE
C
      IF(NGAIN)6000,7000,6000
C
C  IF(NGAIN=1) THEN SUBT 0.51 PORTION FROM NA AND/OR ZN, ELSE GO TO 7000
C
 6000 NSP=NSTD2
 6001 GAIN=PARAV(I5 )
      GO TO (6011,6012,6012),NST
 6011 N=INA
      GO TO 6014
 6012 NSP=NSTD3
      N=INZ
 6014 RQGAIN=PARAV(NSP)
      NF=NFNJ(NSTD1)
      DO 6015 I=1,NF
 6015 Y(I)=R(I,NSTD1)
C
C GAIN CHANGE NA AND ZN FOR .51 SUBTRACTIONS.
C
      CALL GANE (0.0,NF,GAIN,RQGAIN,0.0,Y)
C
      NAM=NFNJ(N)
      DO 6016 I=1,NAM
 6016 R(I,N)=R(I,N) - Y(I)*PAREA(NSP)/PAREA(I5 )
      NUS=PARAV(NSP)-6.0*PARAS(NSP)
      NAMUS=PARAV(NSP) + 6.0*PARAS(NSP)
      DO 9037 I=NUS,NAMUS
      XX=I
      XX=XX-0.5
      PON=(XX-PARAV(NSP))/PARAS(NSP)
      GPK=0.3989423*PAREA(NSP)*EXP(-0.5*PON**2)/PARAS(NSP)
 9037 R(I,N)=R(I,N)-GPK
      IF(NST-3)7000,6009,7000
 6009 NST=1
      NSP=NSP-1
      GO TO 6001
C
C FIT PARAV(J) AND PARAS(J) AND RETURN WITH CONSTANTS.
C
```

```
 7000 IF(G(1))9097,9096,9097
 9096 SN=.7677
      SCONST=.321
      SEK=1000.
      DIV=2.354
      GO TO 9098
C
 9097 CALL SVFIT (PARAV,PARAS,NSTAND,G,SCONST,SN,STDENY,EM,UNGAIN)
C
      SEK=1.0
      DIV=1.0
C NORMALIZE COUNTS AND GAINS.
C
 9098 DO 7010 J=1,NSTAND
      DO 7003 I=1,200
      Y(I)=R(I,J)/PAREA(J)
 7003 R(I,J)=0.0
      GAIN=PARAV(J)
      NX=200
      NF=GAIN+1.0
C
      CALL GANE (0.0,NX,GAIN,100.0,0.0,Y)
C
      DO 30000 I=1,200
      IF(Y(I))30001,30001,30002
30001 NFNORM=I-1
      NFNO=1
      GO TO 30003
30002 CONTINUE
30000 CONTINUE
C
C SUBTRACT K X-RAY ESCAPE PEAK IF ENERGY OF STANDARD LESS THAN 300KEV.
C
30003 IF(STDENY(J)-0.300)11005,11004,11004
11005 EN=STDENY(J)
      NN=1
      ND=2
      OR=RAXLL (EN,NN,ND)
      EK=EN-0.0265
      VK=EK*100.0/EN
      NN=1
      VV=VK+VK*PULSE (EK,NN,ND)
      EK=EK*SEK
      SI=(SCONST*EK**SN)*100.0/EK
      SI=SI/DIV
```

```
      PKAREA=-UR
C SUBTRACT K PEAK
      CALL GAUSS (Y,VV,SI,PKAREA,SUM,NFNORM)
C   ZERO FROM THE FIRST NEGATIVE CHANNEL TO 200
      DO 29765 I=NFNO,200
29765 Y(I)=0.0
      GO TO 10104
11004 DO 30509I=NFNO,200
30509 Y(I)=0.0
10104 DO 7004 I=1,NFNORM
 7004 R(I,J)=Y(I)
 7010 CONTINUE
      RETURN
      END
$IBFTC STDF     DECK,REF,LIST
      SUBROUTINE STDFIT (Y,NFN,SB,KLM,NPARA,NBC,NS,PP,ENY)
C*********** PROGRAM NUMBER GSFC-31 **********
      DIMENSION FC(200),Y(200),B(8),P(200),A(200,8),G(8,9),SB(8),DIF(200
     1 ),PP(200),NPARA(8),U(8,8)
C NON-LINEAR REGRESSION PROGRAM.    CALLED BY *RESGEN*.  CALLS *GUESS*
C AND *FUNUS*.
      EPS=.00001
      PIE=3.14159265
      NB=KLM
      NF=NFN
      NI=10
      L=0
      FITLM1=0.0
C
C CALL GUESS TO INITIALIZE PARAMETERS.
C CALL FUNCTION TO BE FITTED.
      CALL GUESS (NS,NF,Y,SB,ENY)
      DO 1000 I=1,8
 1000 B(I)=0.0
      FIT=0.
    5 CALL FUNUS (FIT,FC,Y,SB,P,A,NF,DIF,NS,PP,ENY)
C RENAME TO ACCOUNT FOR FIXED PARAMETERS.  THERE ARE NBC FREE PARAMETERS
C INDEXED AS NPARA(J)


      DO 58 J=1,NBC
      NARP=NPARA(J)
      B(J)=SB(NARP)
      DO 58 K=1,NF
   58 A(K,J)=A(K,NARP)
```

```
C CONSTRUCT THE NORMAL EQUATIONS.
      NN=NBC
      M=NN+1
      DO 21 I=1,NN
      G(I,M)=0.0
      DO 21 J=NS,NF
   21 G(I,M)=G(I,M)+A(J,I)*FC(J)/Y(J)
      DO 22 I=1,NN
      DO 22 K=1,NN
      G(I,K)=0.0
      DO 22 J=NS,NF
   22 G(I,K)=G(I,K)+A(J,I)*A(J,K)/Y(J)
C SOLVE NORMAL EQUATIONS. FROM HERE TO STATEMENT 11.
      DO 2 K=1,NN
      KK=K+1
      DO 1 J=KK,M
    1 G(K,J)=G(K,J)/G(K,K)
      DO 2 I=KK,NN
      DO 2 J=KK,M
    2 G(I,J)=G(I,J)-G(I,K)*G(K,J)
      K=NN
   15 IF(K-1)11,10,10
   10 I=1
   14 IF(I-K)12,13,12
   12 G(I,M)=G(I,M)-G(I,K)*G(K,M)
      I=I+1
      GO TO 14
   13 K=K-1
      GO TO 15
   11 CONTINUE
C
C FIT ARRESTING CHECK.
      L=L+1
      IF(L-1)29,29,28
   28 IF(ABS(FITLM1-FIT)/FIT - EPS)42,42,29
   29 IF(L-NI)8,42,42
    8 DO 24 I=1,NBC
   24 B(I)=B(I)+G(I,M)
      FITLM1=FIT
C
C RENAME PARAMETERS FOR NEXT LOOP. STORE B IN SB
C
   89 DO 90 J=1,NBC
      NARP=NPARA(J)
   90 SB(NARP)=B(J)
```

```
      GO TO 5
C FITTING COMPLETE.  CALCULATE CORRELATION MATRIX.
   42 CONTINUE


      RETURN
      END
$IBFTC FUNU     DECK,REF,LIST
      SUBROUTINE FUNUS (FIT,FC,Y,B,P,A,NF,DIF,NS,PP,ENY)
C********** PROGRAM NUMBER GSFC-15 **********
      DIMENSION FC(200),Y(200),B(8),P(200),A(200,8),DIF(200),PP(200)
      FIT=0.0
      DO 50 I=1,200
      PP(I)=0.0
      P(I)=0.0
      DO 50 J=1,8
   50 A(I,J)=0.0
      PIE=3.14159265
      CONS=0.3989423*B(3)
C
C  COMPUTE STRAIGHT LINE BASE FOR PHOTOPEAK
C
  400 DO 402 I=NS,NF
      X=I
      X=X-0.5
      P(I)=B(4)*X + B(5)
      A(I,4)=X
  402 A(I,5)=1.0
C
C COMPUTE GAUSSIAN FUNCTION AND PARTIAL DERIVATIVES.
C
  403 DO 700 I=NS,NF
      X=I
      X=X-0.5
      PON=(X-B(1))/B(2)
      ARG=EXP(-0.5*PON*PON)
      PP(I)=CONS*ARG/B(2)
      A(I,1)=PP(I)*PON/B(2)
      A(I,2)=PP(I)*(PON*PON - 1.0)/B(2)
      A(I,3)=PP(I)/B(3)
      A(I,7)=1.0
      P(I)=P(I)+PP(I)+B(7)
      FC(I)=Y(I)-P(I)
      DIF(I)=FC(I)
  700 FIT=FIT+FC(I)*FC(I)/Y(I)
```

```
      RETURN
      END
$DATA
    7       5    1.0
   MN54          115   149     0     0    0.0
   MN54          115   149     0     0    0.0
   MN54          115   149     0     0    0.0
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   MN54          115   149     0     0    0.0
   MN54          115   149     0     0    0.0
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014475 014668 014905 014727 014736 014851 014745 015298 015077 016018   002
016881 018296 019678 019877 019044 017920 016656 015980 015436 015100   003
014401 014438 014254 014058 013812 013626 013202 013185 013250 012966   004
012720 012550 012846 012311 012346 012199 012242 012199 011805 012024   005
011888 011774 011700 011545 011754 011560 011630 011549 011488 011298   006
011525 011214 011406 011409 011275 011339 011278 011148 011258 011119   007
011404 011112 011289 011573 011542 011249 011844 011836 011744 011826   008
011870 011885 012161 012091 012092 012032 011779 011539 011154 010565   009
009952 009320 008609 007908 007317 006508 005827 005360 004738 004308   010
003904 003670 003221 003081 003069 002857 002764 002840 002868 002925   011
003011 003212 003425 003968 004580 005239 006358 008062 009897 012478   012
015260 019022 023193 027579 032766 037267 042001 046765 051090 053324   013
055160 056387 055791 054497 051911 048838 044806 040895 036099 031864   014
027769 023382 019402 016087 013203 010503 008289 006483 004645 003466   015
002482 001622 001183 000716 000450 000297 000195 000111 000120 000059   016
000075 000071 000099 000050 000049 000079 000057 000099 000072 000060   017
000048 000091 000062 000079 000070 000027 000030 000069 000050 000042   018
000021 000111 000066 000066 000063 000049 000076 000068 000061 000073   019
000107 000019 000073 000042 000049 000078 000058 000080 000046 998050   020
010620 021901 016589 014681 013694 013249 013180 015545 015918 015103   021
014973 015112 015038 015187 015218 015341 014932 015245 015126 016211   022
017027 018275 019857 020100 019243 018604 017186 016364 015956 015509   023
014974 014747 014950 014562 014025 013873 013547 013610 013227 013268   024
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011319 011444 011563 011617 011733 011906 011885 012016 011993 012122   028
012279 012399 012212 012414 012280 012348 012112 011881 011715 011229   029
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004297 003915 003632 003297 003194 003098 002930 002908 002836 002905   031
002905 003044 003218 003559 004008 004764 005555 006755 008387 010319   032
013116 016235 019854 024252 029070 034371 039241 044264 048582 052144   033
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```

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002474	001673	001121	000771	000495	000341	000191	000141	000143	000082	056
000097	000091	000090	000067	000067	000071	000120	000101	000099	000069	057
000077	000097	000082	000092	000093	000023	000096	000087	000070	000061	058
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END TAPE

STANDARD SOURCE SPECTRAL PARAMETERS

2 SPECTRA IN STANDARD SOURCE DECK

CHANNELS ONE TO 5 ASSUMED AS REDUNDANT

REFERENCE COARSE GAIN = 1.00000

STANDARD SOURCE	PHOTOPEAK FROM CHANNEL	PHOTOPEAK TO CHANNEL	X-RAY OR .5 PEAK FROM CHANNEL	X-RAY OR .5 PEAK TO CHANNEL	SHIFT SPECTRUM CHANNEL	PHOTOPEAK ENERGY MEV
MN54	115	149	0	0	0.	0.83500
MN54	115	149	0	0	0.	0.83500

MN54

14165.	20042.	15793.	14312.	13829.	13383.	13447.	15260.	15579.	14733.
14475.	14668.	14905.	14727.	14736.	14851.	14745.	15298.	15077.	16018.
16881.	18296.	19678.	19877.	19044.	17920.	16656.	15980.	15436.	15100.
14401.	14438.	14254.	14058.	13812.	13626.	13202.	13185.	13250.	12966.
12720.	12550.	12846.	12311.	12346.	12199.	12242.	12199.	11805.	12024.
11888.	11774.	11700.	11545.	11754.	11560.	11630.	11549.	11488.	11298.
11525.	11214.	11406.	11409.	11275.	11339.	11278.	11148.	11258.	11119.
11404.	11112.	11289.	11573.	11542.	11249.	11844.	11836.	11744.	11826.
11870.	11885.	12161.	12091.	12092.	12032.	11779.	11539.	11154.	10565.
9952.	9320.	8609.	7908.	7317.	6508.	5827.	5360.	4738.	4308.
3904.	3670.	3221.	3081.	3069.	2857.	2764.	2840.	2868.	2925.
3011.	3212.	3425.	3968.	4580.	5239.	6358.	8062.	9897.	12478.
15260.	19022.	23193.	27579.	32766.	37267.	42001.	46765.	51090.	53324.
55160.	56387.	55791.	54497.	51911.	48838.	44806.	40895.	36099.	31864.
27769.	23382.	19402.	16087.	13203.	10503.	8289.	6483.	4645.	3466.
2482.	1622.	1183.	716.	450.	297.	195.	111.	120.	59.
75.	71.	99.	50.	49.	79.	57.	99.	72.	60.
48.	91.	62.	79.	70.	27.	30.	69.	50.	42.
21.	111.	66.	66.	63.	49.	76.	68.	61.	73.
107.	19.	73.	42.	49.	78.	58.	80.	46.	-1950.

STANDARD SOURCE SPECTRA

MN54

10620.	21901.	16589.	14681.	13654.	13249.	13180.	15545.	15918.	15103.
14973.	15112.	15038.	15187.	15218.	15341.	14932.	15245.	15126.	16211.
17027.	18275.	19857.	20100.	19243.	18604.	17186.	16364.	15956.	15509.
14974.	14747.	14950.	14562.	14025.	13873.	13547.	13610.	13227.	13268.
12955.	13015.	12738.	12814.	12396.	12417.	12689.	12360.	12029.	12161.
12095.	12131.	11927.	11954.	11969.	11844.	11669.	11626.	11522.	11481.
11699.	11288.	11502.	11591.	11345.	11527.	11631.	11452.	11472.	11256.
11319.	11444.	11563.	11617.	11733.	11906.	11885.	12016.	11993.	12122.
12279.	12399.	12212.	12414.	12280.	12348.	12112.	11881.	11715.	11229.
10651.	10052.	9414.	8548.	7637.	7158.	6385.	5744.	5115.	4779.
4297.	3915.	3632.	3297.	3194.	3098.	2930.	2908.	2836.	2905.
2905.	3044.	3218.	3559.	4008.	4764.	5555.	6755.	8387.	10319.
13116.	16235.	19854.	24252.	29070.	34371.	39241.	44264.	48582.	52144.
54920.	56880.	57241.	56442.	54652.	52307.	48702.	44739.	40438.	35473.
31095.	27211.	23159.	19424.	15620.	12967.	10456.	8231.	6236.	4763.
3455.	2320.	1654.	969.	746.	450.	315.	206.	128.	100.
84.	146.	119.	92.	76.	120.	114.	95.	63.	62.
61.	113.	73.	52.	65.	29.	40.	39.	63.	74.
60.	120.	84.	56.	77.	72.	67.	44.	91.	60.
87.	53.	57.	45.	54.	84.	71.	100.	24.	-2024.

```
PHOTOPEAK PULSE-HEIGHT  0.1319775E 03
PHOTOPEAK STANDARD DEVIATION  0.6952584E 01
PHOTOPEAK AREA  0.9441370E 06

PHOTOPEAK PULSE-HEIGHT  0.1327175E 03
PHOTOPEAK STANDARD DEVIATION  0.6841865E 01
PHOTOPEAK AREA  0.9365501E 06
```

NORMALIZED CONTINUUM OF STANDARD SPECTRA

MN54

PHOTOFRACTION = 0.4149215E-00

0.1870761E-01	0.1870761E-01	0.1870761E-01	0.1870761E-01	0.1874820E-01
0.2056112E-01	0.2153619E-01	0.2044218E-01	0.2041355E-01	0.2076724E-01
0.2059127E-01	0.2070090E-01	0.2072176E-01	0.2127289E-01	0.2186955E-01
0.2358586E-01	0.2621375E-01	0.2766648E-01	0.2674610E-01	0.2452023E-01
0.2277068E-01	0.2172901E-01	0.2084505E-01	0.2015706E-01	0.1998856E-01
0.1957048E-01	0.1918240E-01	0.1861899E-01	0.1845048E-01	0.1834324E-01
0.1788680E-01	0.1763182E-01	0.1764384E-01	0.1724143E-01	0.1708116E-01
0.1708932E-01	0.1670547E-01	0.1674704E-01	0.1656090E-01	0.1639644E-01
0.1619716E-01	0.1634202E-01	0.1621492E-01	0.1616081E-01	0.1598020E-01
0.1596367E-01	0.1577726E-01	0.1594513E-01	0.1585327E-01	0.1582792E-01
0.1572334E-01	0.1565657E-01	0.1559756E-01	0.1584271E-01	0.1564320E-01
0.1605340E-01	0.1606668E-01	0.1606922E-01	0.1654894E-01	0.1644568E-01
0.1655471E-01	0.1660575E-01	0.1693773E-01	0.1690205E-01	0.1685304E-01
0.1649623E-01	0.1595668E-01	0.1512721E-01	0.1403421E-01	0.1273876E-01
0.1151152E-01	0.1039313E-01	0.8049474E-02	0.7817006E-02	0.6844293E-02
0.5898454E-02	0.5299129E-02	0.4673782E-02	0.4292456E-02	0.4118514E-02
0.3825069E-02	0.3802525E-02	0.3725554E-02	0.3607288E-02	0.3478625E-02
0.3306307E-02	0.3242127E-02	0.2791670E-02	0.2557864E-02	0.2405006E-02
0.2275939E-02	0.2045634E-02	0.2403089E-02	0.2571696E-02	0.32444[illegible]E-02
0.3112245E-02	0.3689185E-02	0.4304219E-02	0.3268952E-02	0.7958176E-03
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

MN54
PHOTOFRACTION = 0.4056248E-00

0.1877502E-01	0.1877501E-01	0.1877501E-01	0.1877501E-01	0.1872817E-01
0.2110915E-01	0.2228995E-01	0.2131660E-01	0.2135827E-01	0.2135780E-01
0.2154116E-01	0.2168689E-01	0.2127689E-01	0.2152977E-01	0.2248638E-01
0.2436117E-01	0.2684658E-01	0.2836984E-01	0.2722288E-01	0.2554063E-01
0.2358991E-01	0.2257293E-01	0.2167772E-01	0.2101294E-01	0.2107913E-01
0.2034520E-01	0.1973936E-01	0.1926600E-01	0.1908698E-01	0.1877952E-01
0.1842925E-01	0.1830452E-01	0.1811553E-01	0.1765972E-01	0.1772701E-01
0.1770803E-01	0.1713938E-01	0.1720273E-01	0.1716890E-01	0.1695644E-01
0.1694651E-01	0.1686219E-01	0.1658119E-01	0.1643113E-01	0.1629605E-01
0.1649205E-01	0.1608229E-01	0.1636629E-01	0.1616065E-01	0.1637461E-01
0.1635106E-01	0.1624711E-01	0.1597363E-01	0.1612910E-01	0.1634354E-01
0.1650186E-01	0.1674657E-01	0.1684997E-01	0.1701695E-01	0.1708198E-01
0.1733848E-01	0.1750818E-01	0.1743748E-01	0.1745736E-01	0.1742667E-01
0.1701738E-01	0.1667323E-01	0.1580066E-01	0.1472562E-01	0.1362996E-01
0.1198054E-01	0.1053764E-01	0.9414101E-02	0.8077517E-02	0.7054949E-02
0.6325973E-02	0.5542173E-02	0.4954941E-02	0.4565941E-02	0.4344909E-02
0.4076299E-02	0.3932666E-02	0.3854270E-02	0.3705955E-02	0.3618081E-02
0.3539671E-02	0.3460500E-02	0.3322130E-02	0.3065915E-02	0.2850277E-02
0.2779913E-02	0.2828576E-02	0.2882915E-02	0.3386979E-02	0.4205164E-02
0.4543088E-02	0.4856305E-02	0.4645608E-02	0.4409789E-02	0.2036781E-02
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.
0.	0.	0.	0.	0.