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Code CUBED-II

A Code to Unfold
Bremsstrahlung Experimental
Distributions

(September 1967)

NASA Contract
No.: NAS 5-10337

Prepared by
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Senior Technical Associate

For

Goddard Space Flight Center
Greenbelt, Maryland

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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 NAS5-10433 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 matrix generation procedure relies on the spectra of standard radioisotopes such as Cd¹⁰⁹, Hg²⁰³, Sr⁸⁵, Cs¹³⁷, Nb⁹⁵, Mn⁵⁴ and Zn⁶⁵. 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 unfold 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	GANÉ	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 PHOFRA 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 PHOFRA. 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 OMITTS 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	REGEN	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 (FORTRAN 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 \leq 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 Na²² and Zn⁶⁵ 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 9Ø95 + 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 Cr⁵¹ & F¹⁸ 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 PHØFRA 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)

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

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 Zn⁶⁵ and/or Na²² have been included in the input standard spectra, it additionally stores them 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 Na²² and Zn⁶⁵) 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 Sr⁸⁵, if it has been input, is employed to subtract the 0.51 MeV spectrum contribution of Na²² and/or Zn⁶⁵. 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'_1 , E'_m and V'_m , respectively.

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

$$\Delta = E'_m / V \quad (2)$$

where

$$V = V'_m / (1 + \partial V'_m (E'_m)) \quad (3)$$

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

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

where

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

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

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

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 approximation 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 then 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:

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

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 Cs¹³⁷ and Mn⁵⁴ 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)

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

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

is the $m \times m$ square response function matrix. Equation (8) is formally solved as

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

where \bar{R} is non-singular and \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

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

where $\bar{\eta}$ 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 $\bar{\eta}$ 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

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

where

$R_x = \text{NaI (Tl) crystal radius, cm.}$

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

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

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

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

where

$\mu_{\text{air}}(E)$ = 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 GEOMTR, as

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

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 $\gamma/\text{cm}^2\text{-sec}$ and $\text{MeV}/\text{cm}^2\text{-sec}$. The following tabulated data are also determined by sub-program GEOMTR for output by the calling main program:

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

ENBENY	$\frac{\sum N(E) \cdot E \cdot \Delta E}{E_{\beta \max}}$	integrated energy flux per beta maximum energy, (MeV/cm ² -sec)/MeV; (E _β _{max} defined below)
PHENBE	$\frac{\sum N(E) \cdot \Delta E}{N_{\beta}}$	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

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

$$= \text{EBMAX of card (7) of report section 3.2*}$$

$$N_{\beta} = \text{number of source emitted betas per unit time}$$

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

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

where

$$\Omega_x = \text{solid-angle subtended by the crystal at the source geometric center.}$$

* 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 10¹⁰).

Ω = total solid-angle at the source =
4 π 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 $\text{ON} = 20.0$, $\text{HITMAX} = 50.0$, $\text{EPS} = .0001$, $\text{RX} = 3.81$ and $\text{H} = 7.62$ 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 $3.7 \text{ E} + 10$ 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 weighted mass absorption coefficient.

DØSE: the energy mass absorption coefficients for air are given in the DATA statement in cm²/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 cm²/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

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

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 = $2 \times 1.17741 \times \sigma$

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).

REGEN: 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 actual 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)

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

Card ② (single card)

CASE	2-72 (column 1 for printer control)	A	User's problem description (alphanumeric)
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Card ③ (single card)

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.

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
M (11)	41-44	I4	If $\neq 0$, by-pass the final result computations, (i.e. by-pass GEOMTR).
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 $\neq 0$, read card ⑩ and analyze complex-plus-continuous spectra.
M (16)	61-64	I4	If $\neq 0$, 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 $\neq 0$, analyze spectra, but do not unfold.
M (18)	69-72	I4	If $\neq 0$, 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) $\neq 0$ then use as = 7.

Card ④

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)

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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 (T1) crystal, cm.
H	67-72	F6.4	Cylindrical length of NaI (T1) 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")

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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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 $\emptyset\text{MM} < 0$; read by subprogram PHØFRA.

Card set (6B) will be input if $\text{OMM} > 0$; read by program MAIN.

Neither set input if $\emptyset\text{MM} = 0$

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

Card (6A) - 1

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)

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.

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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 (\pm) of the standard spectrum true zero pulse-height. The code carries out a shift correction.
<u>Card Set 6A - 3 (NSTAND times 20 cards); ((R (I, J) , I = 1, 200) , J = 1 , NSTAND)</u>			
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.

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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, Na²² (if input) must precede Zn⁶⁵ (if input) and Zn⁶⁵ must be last (if Zn⁶⁵ not input, Na²² must be last).
 The order of the remaining spectra is immaterial.

Card Set (6B)

Card Set (6B) - 1 (($\emptyset N \times \emptyset N / 5$) Cards); ((R (J, I), I=1, $\emptyset N$), J = 1, $\emptyset N$)

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 ($\emptyset N$, $\emptyset N$)	45-55 (last card)	E11.4	" " "	$\emptyset N$, $\emptyset N$

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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NOTE: The first $\emptyset N$ elements input represent the lowest energy matrix vector spectrum (analogous to a PHA spectrum); similarly, the second $\emptyset N$ elements, etc. The sum over each vector must = unity.

Card Set (6B) - 2 ($\emptyset N/2$ 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 ($\emptyset N$)	64-70	F7.4	Mid-increment energy of $\emptyset N$ th energy interval of response matrix.

Card Set (6B) - 3 ($\emptyset N/2$ 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.
.			
.			
.			

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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)

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, ≤ 20.0 .
CHANLS	61-66	F6.0	Number of pulse-height analyzer channels per spectrum, ≤ 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)

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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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 GEOMTR 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 \leq 20.0.

DOST (I)	1-7	F7.3	Distance from geometric center of unknown source to front face of NaI (Tl) crystal, 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.

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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. \leq 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
------------	------	-------	---

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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 (11) 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: -

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
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 photo-peaks 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.

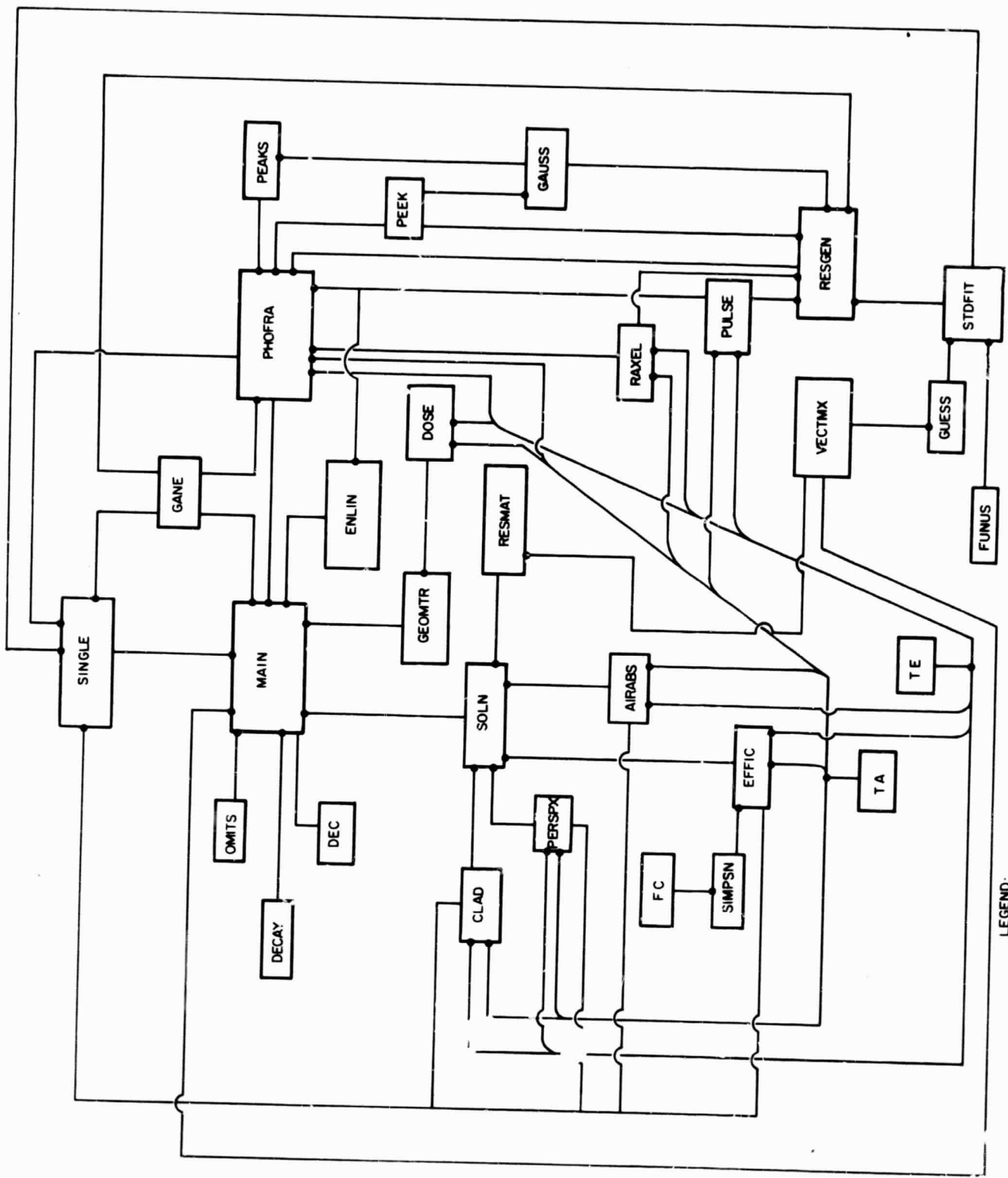
It is concluded that the developed code CU3ED-II is an operable and useful addition to the field of scintillation spectrometry. It allows the generation of the detector system response function matrix, the spectral unfolding process and the final analysis of unknown continuous spectra to be carried out in a single computer run.

REFERENCES

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FIGURES



LEGEND:



PROGRAM B CALLS PROGRAM A

FIGURE 1 CODE CUBED II SUBPROGRAM CONNECTIVITY

P indicates location of punch card output for program printing code.

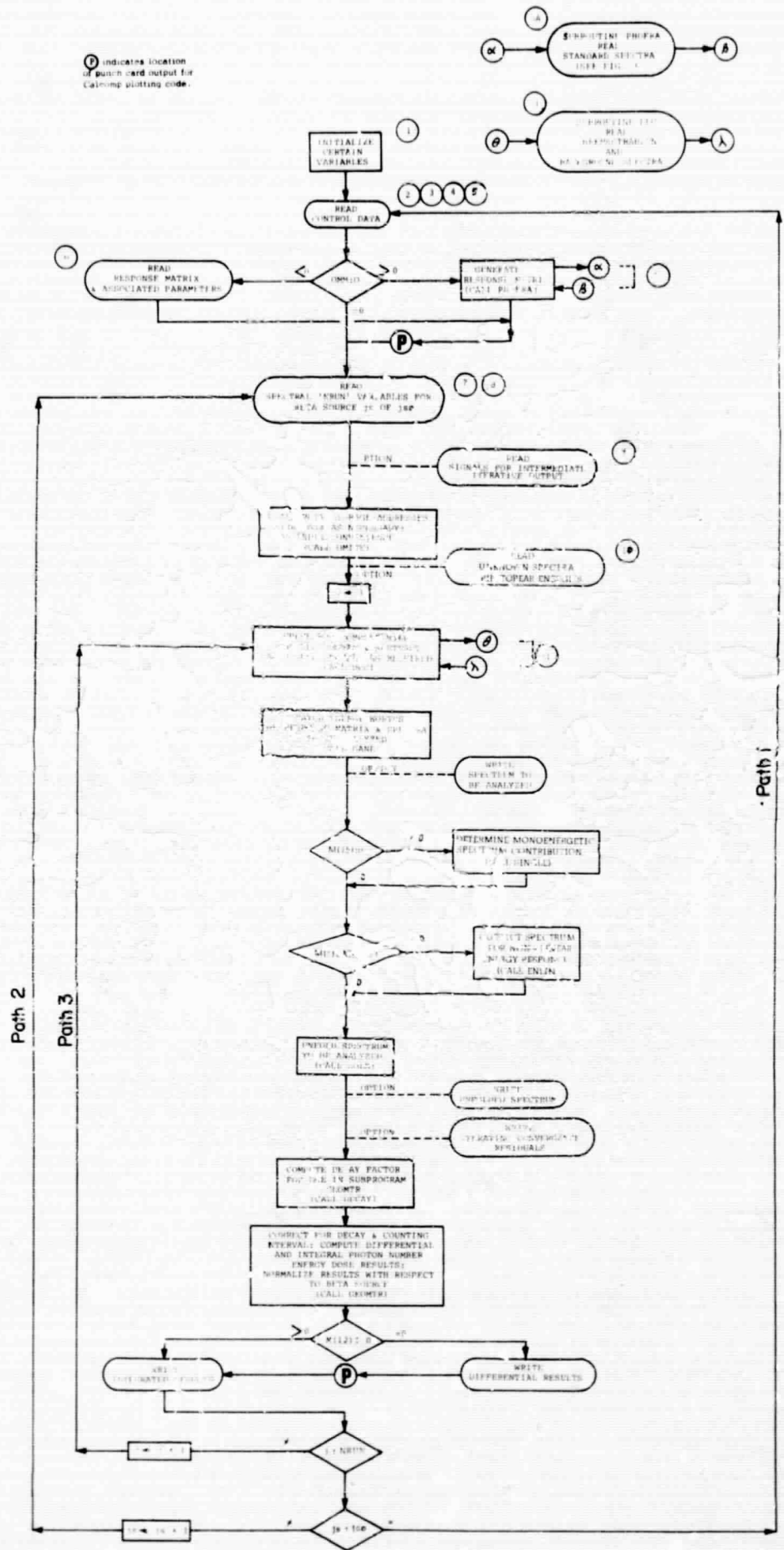


FIG 2
CODE CUBED-II MAIN PROGRAM
GENERAL FLOW DIAGRAM

NOTE:

F_k = K X-Ray Escape Fraction

δV = Fractional Deviation Of Pulse Height From Linear Response, V'

SS means Standard Source

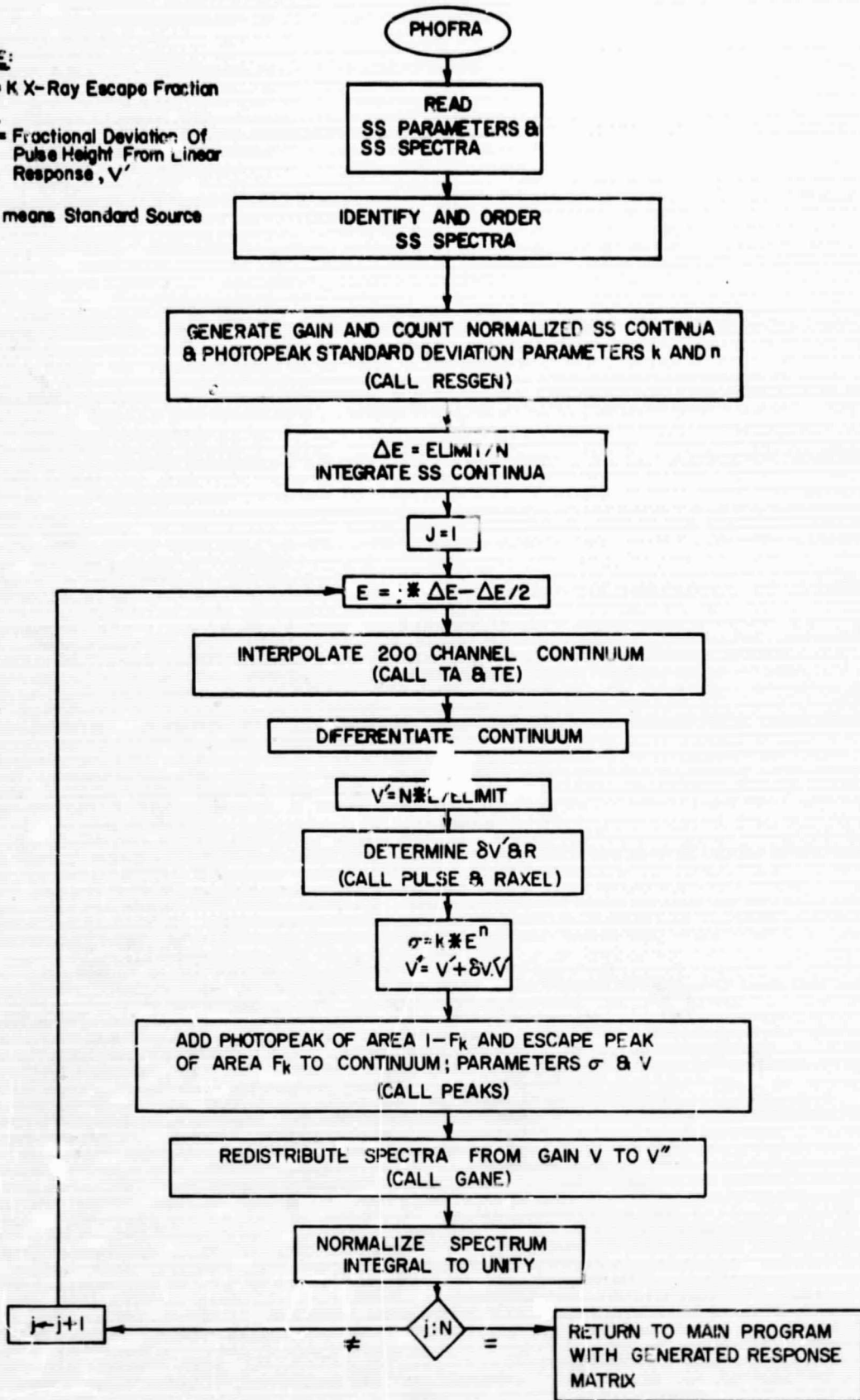


FIG. 3

FLOW DIAGRAM OF RESPONSE MATRIX GENERATING PROGRAM LOGIC; SUBPROGRAM PHOFRA

NSTAND = NO. OF SPECTRA
 ZCO = NO. OF CHANNELS PER SPECTRUM
 (10 CHANNELS PER CARD)
 $R(I, J) \quad I = 1, 200$
 $J = 1, NS, \dots, NC$
 E.G. FOR 8 SPECTRA $J=1, 8$

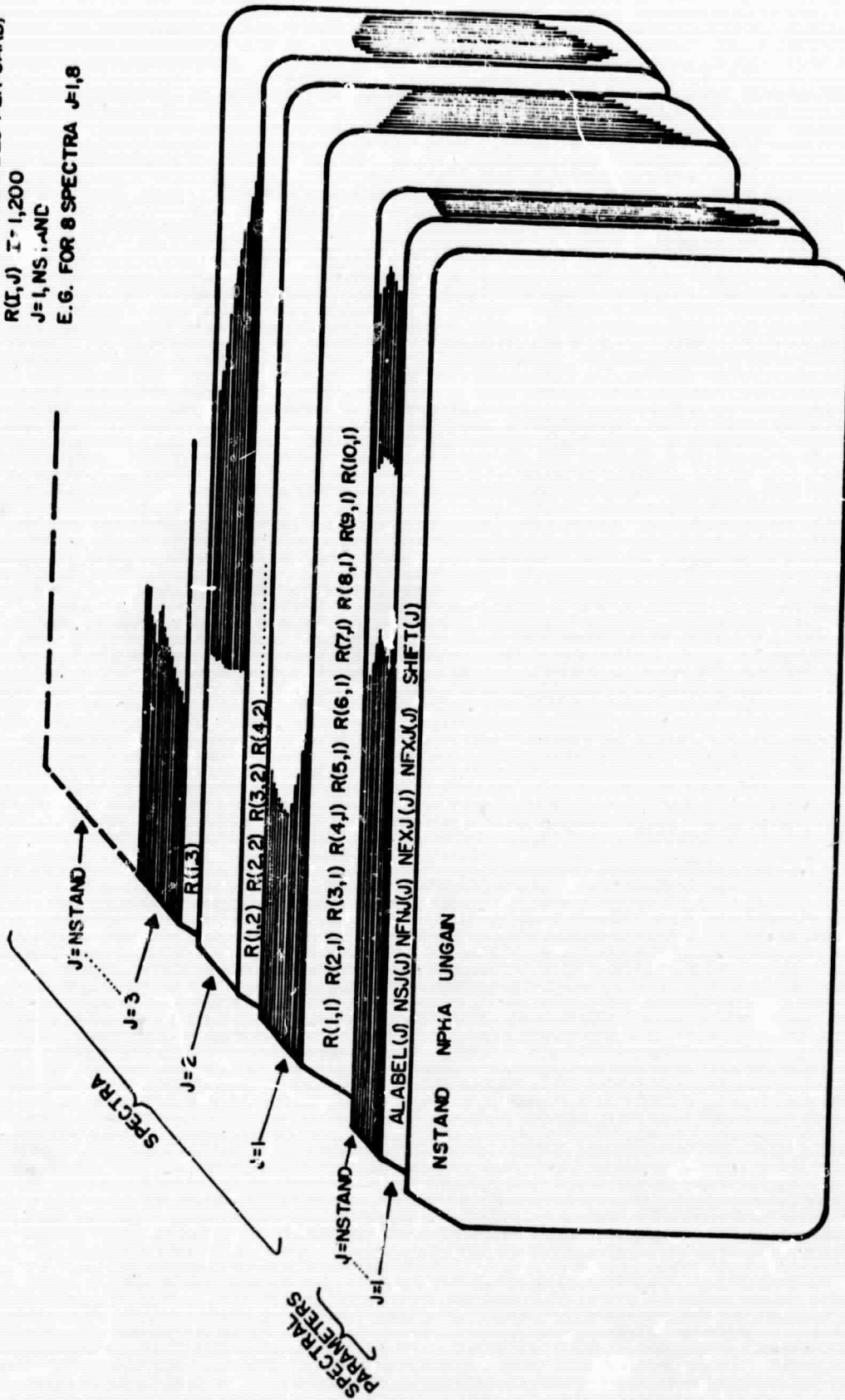


FIG. 4
 STANDARD SOURCE SPECTRA LIBRARY DECK ARRANGEMENT

NOTE: Output From Subprogram PHOFRA.
X-Ray & 0.51 MeV Peaks Have Been
Code Subtracted

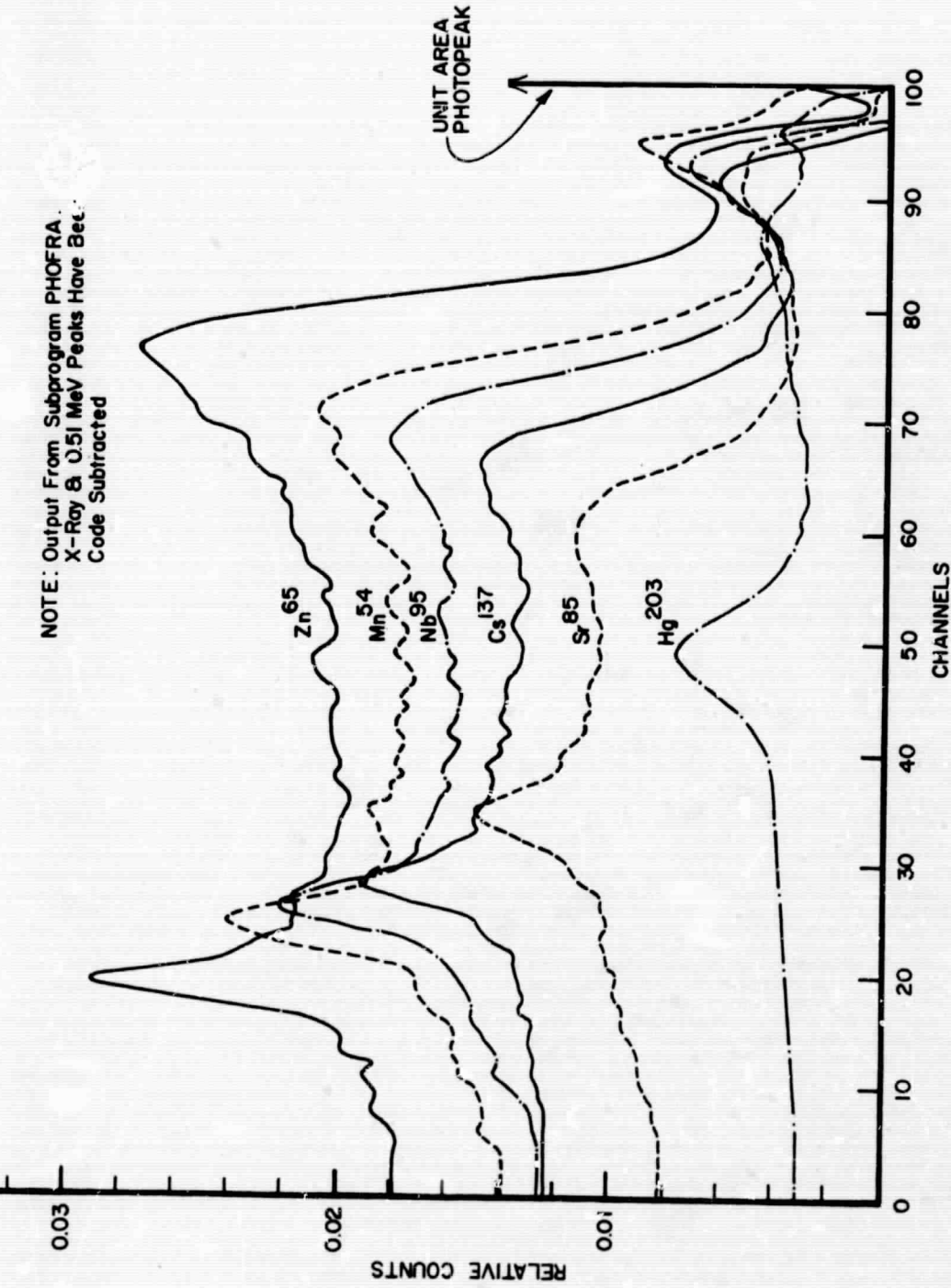


FIG. 5
COMPTON CONTINUA NORMALIZED TO UNIT
AREA PHOTOPEAK IN CHANNEL 100

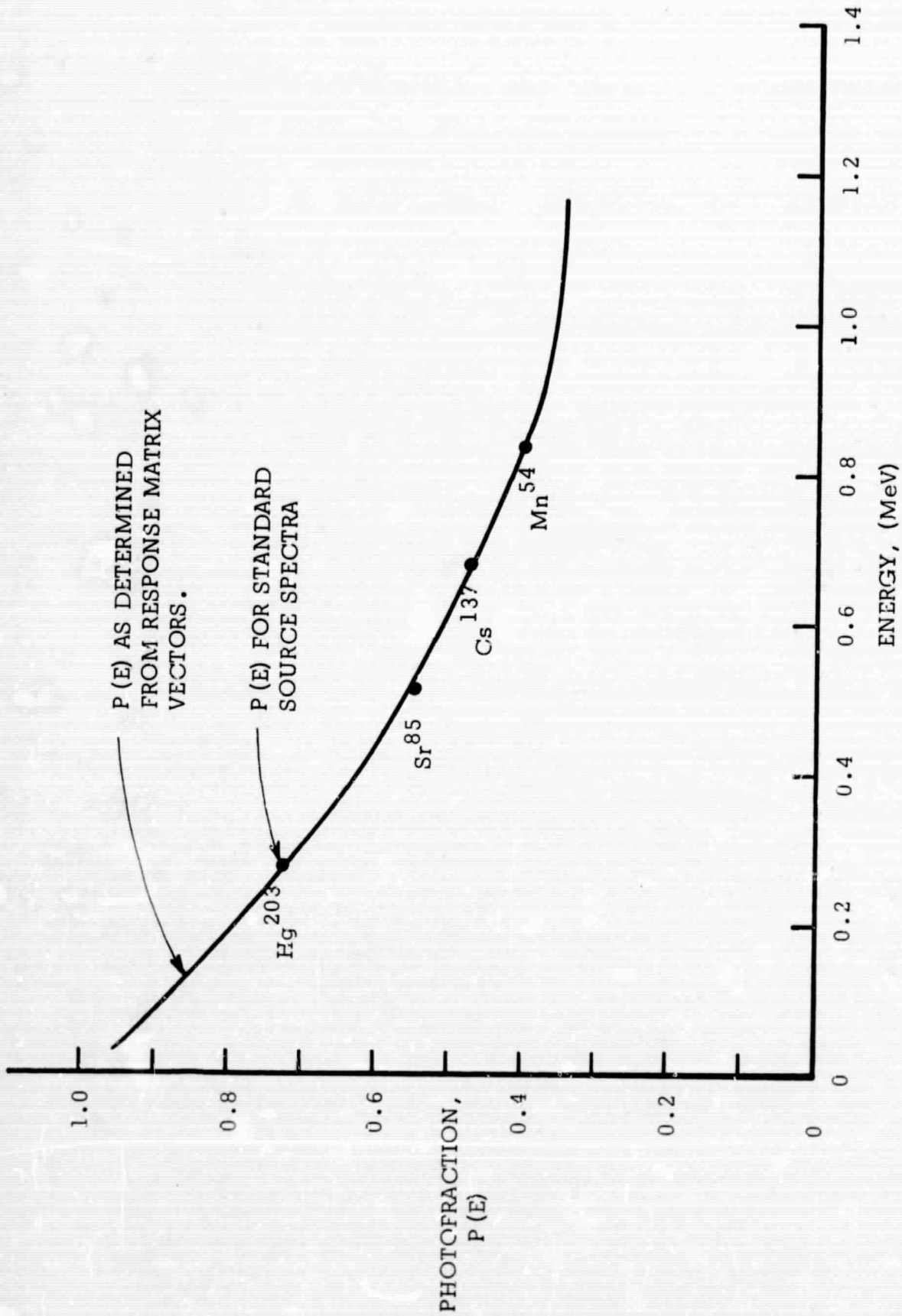


FIGURE 6

PHOTOFRACTIONS GENERATED BY CODE CUBED-II: SUBPROGRAM PHOFRA

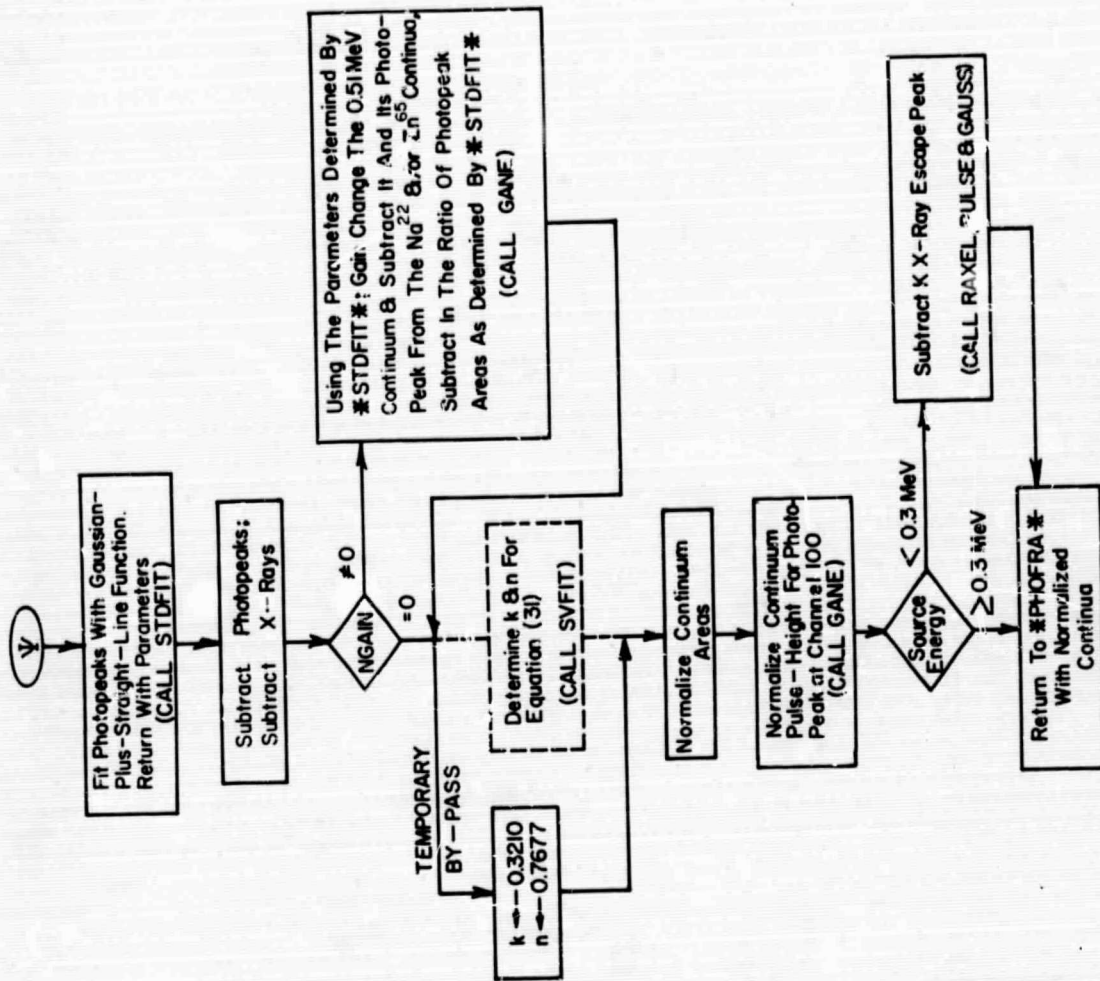
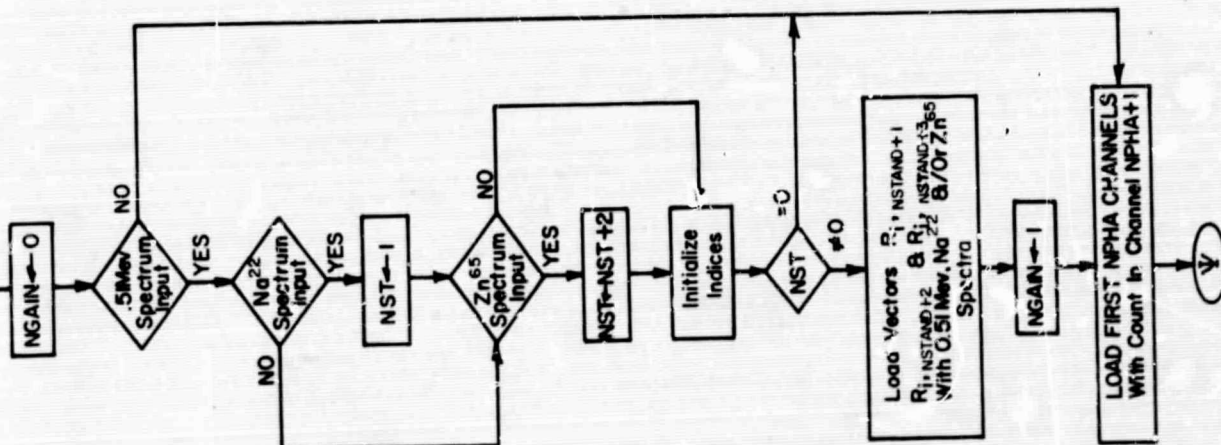


FIG. 7

GENERAL LOGIC FLOW DIAGRAM FOR SUBPROGRAM REGEN



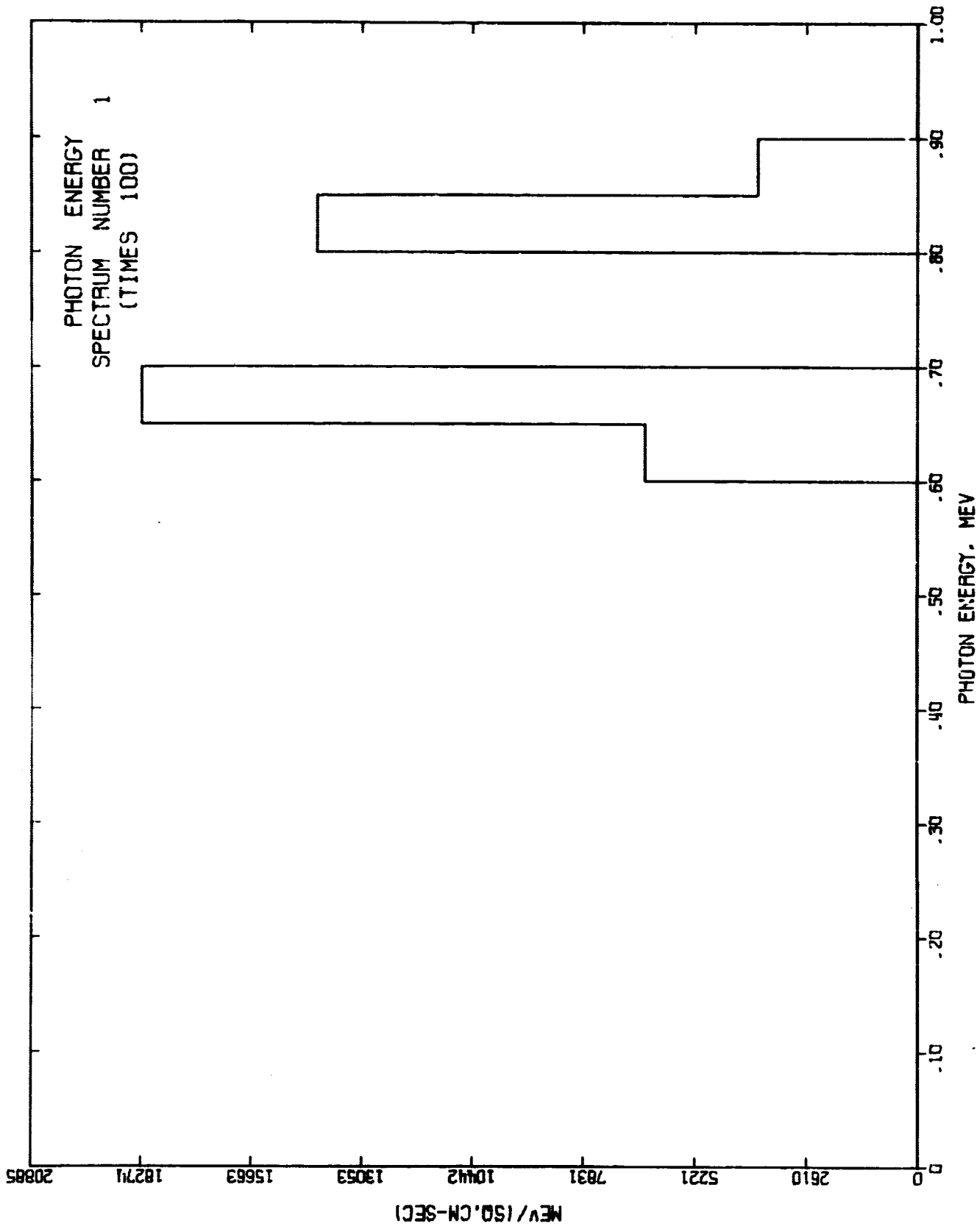


FIGURE 8
MONOENERGETIC ENERGY SPECTRUM OF Cs¹³⁷ AND Mn⁵⁴ AFTER ANALYSIS

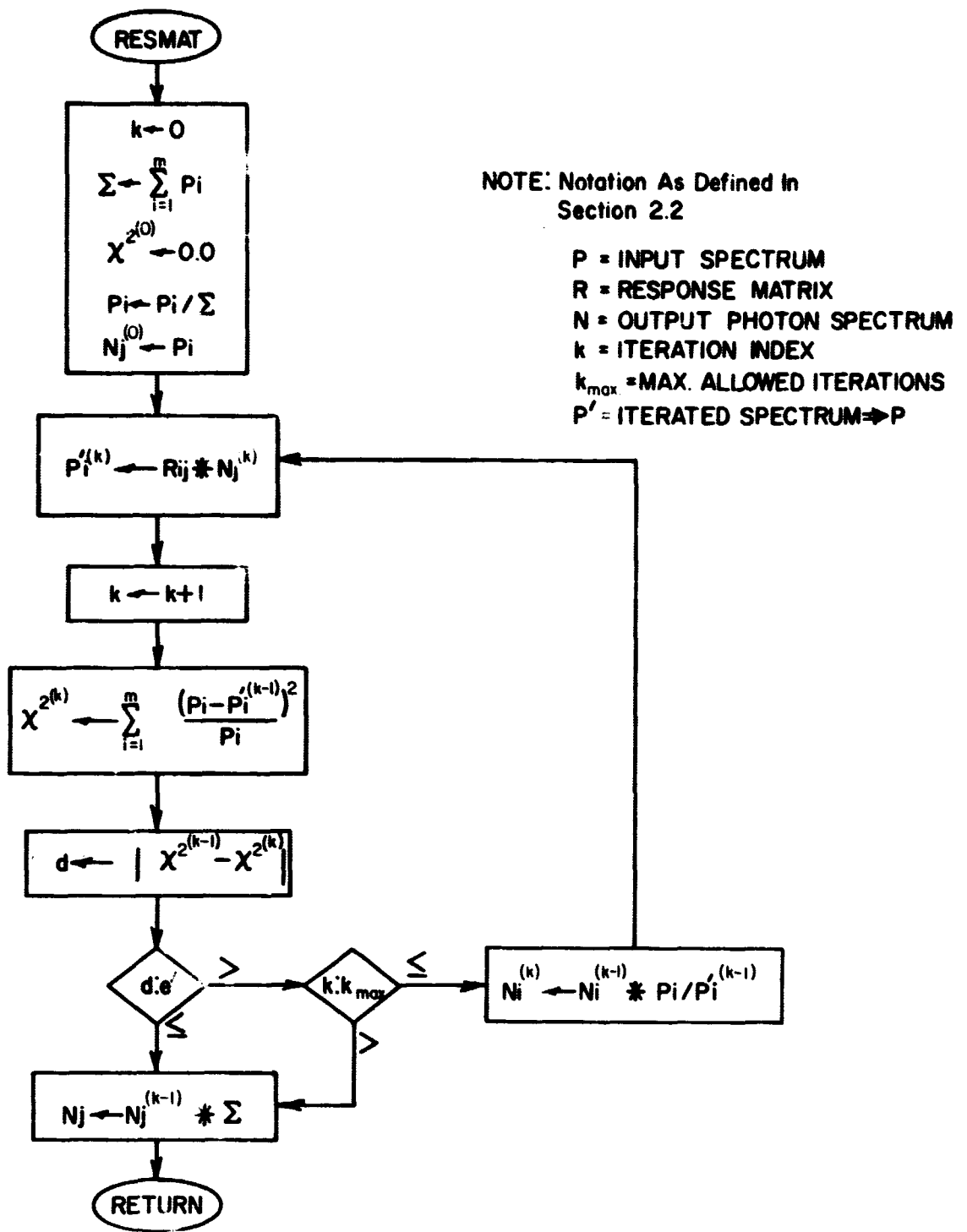
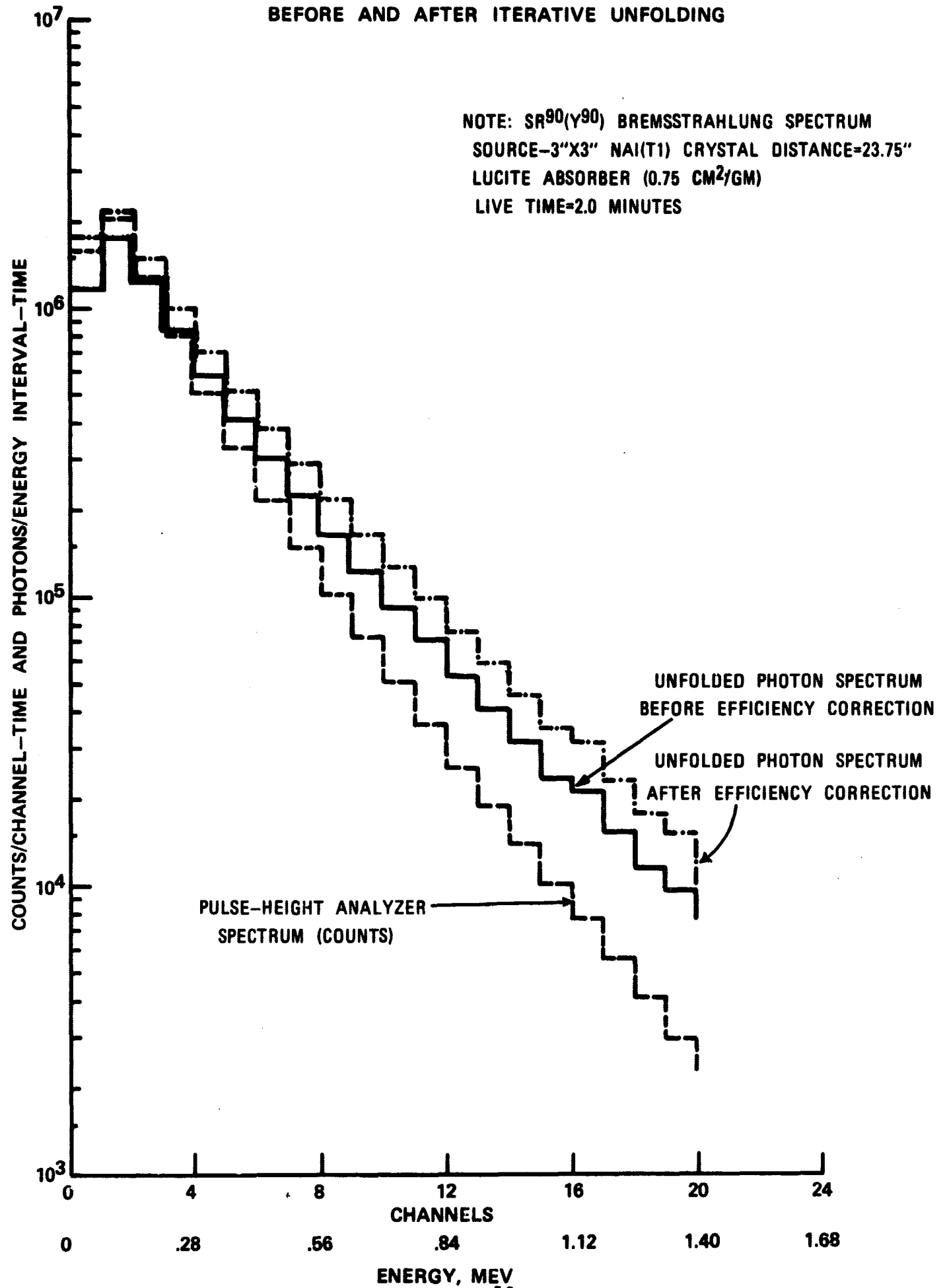


FIG. 9

FLOW DIAGRAM SHOWING
THE GENERAL LOGIC OF
SUBPROGRAM RESMAT

FIGURE 10 BREMSSTRAHLUNG SPECTRUM
BEFORE AND AFTER ITERATIVE UNFOLDING

NOTE: $\text{SR}^{90}(\text{Y}^{90})$ BREMSSTRAHLUNG SPECTRUM
SOURCE-3"X3" $\text{NAI}(\text{Tl})$ CRYSTAL DISTANCE=23.75"
LUCITE ABSORBER (0.75 CM^2/GM)
LIVE TIME=2.0 MINUTES



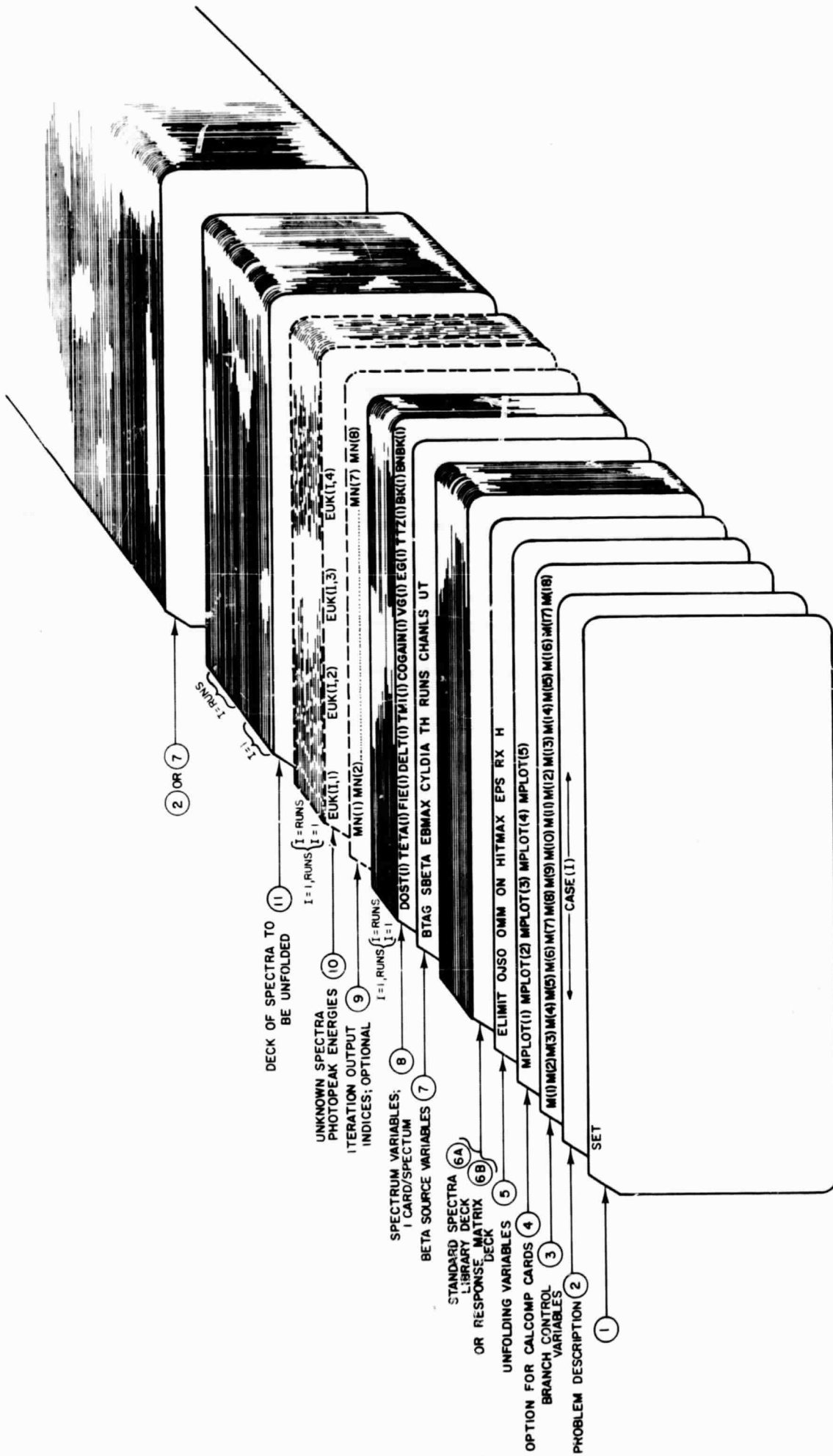


FIGURE 11
ARRANGEMENT FOR INPUT CARD DECK
FOR CODE CUBED-II

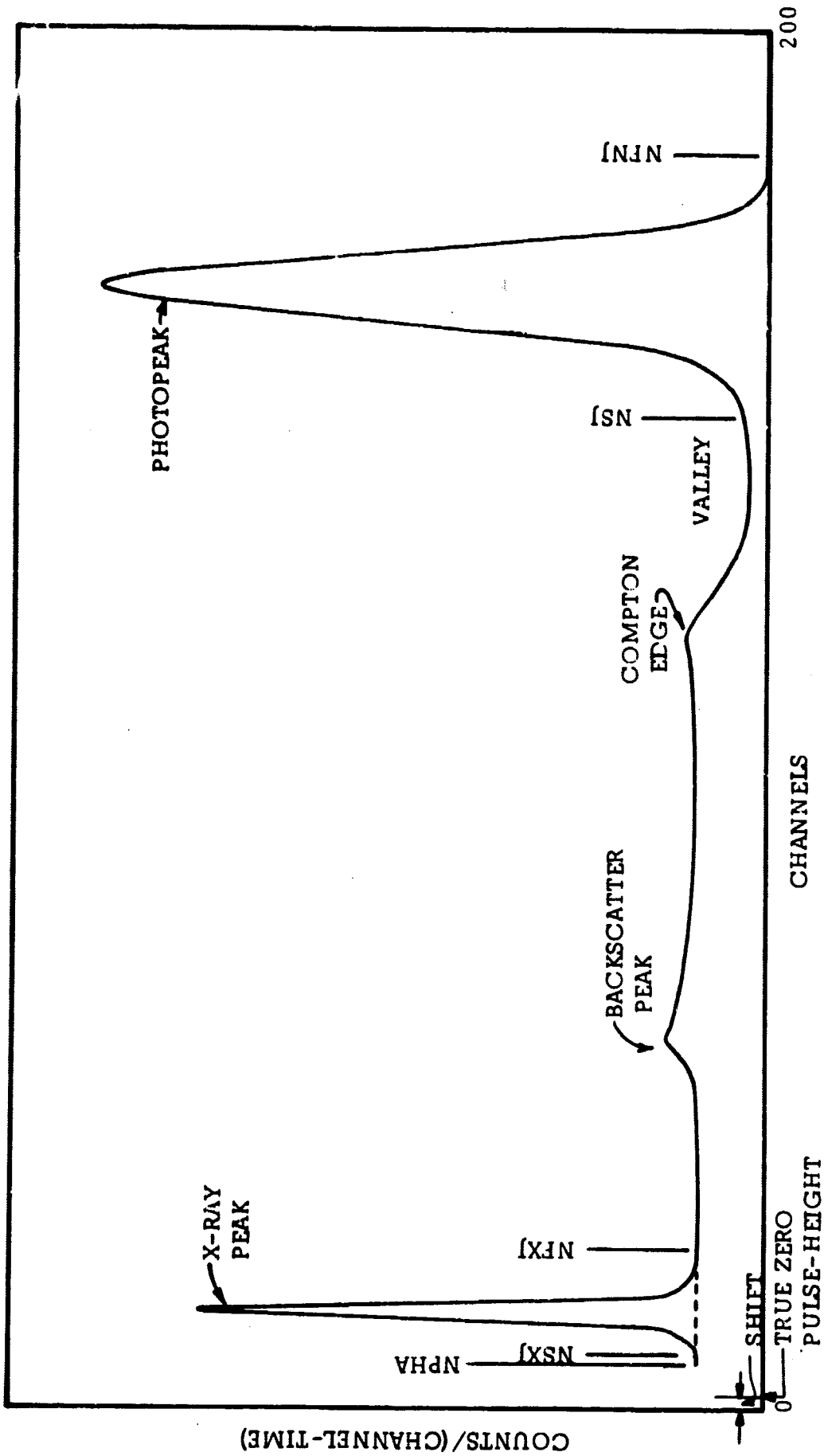


FIGURE 12
 FIGURE DEFINING SPECTRAL VARIABLES FOR SUBPROGRAM PHO FRA INPUT

APPENDIX I
GLOSSARY OF PROGRAMS

APPENDIX 1

GLOSSARY OF PROGRAMS FOR CUBED-II

(In alphabetical order, except for MAIN)

<u>NUMBER</u>	<u>NAME</u>	<u>FUNCTION or USE</u>
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	PCEK	Computes Gaussian function.	(F)
18	PERSPX	Computes μ_{apex} 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	SIMPSON	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 denoted by (F).

APPENDIX II
GLOSSARY OF INPUT VARIABLES

APPENDIX 2

GLOSSARY OF INPUT VARIABLES

<u>NAME</u>	<u>In Order of FORTRAN Listing Appearance</u> <u>DESCRIPTION, PURPOSE OR USE</u>	<u>PROGRAM AND</u> <u>FORMAT STATEMENT NO.</u>
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 (≥ 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, NEXJ, 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 parentheses are three (3) less than DIMENSION,
but must not be exceeded.

APPENDIX III

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

```

$IEFTC MAIN DECK,REF,LIST
C NLS CCRPRATION (J.J.STEYN) (1967)
C ***** PROGRAM NUMBER - 1 CUBEC-2 *****
C ***** MAIN PROGRAM*****
C *****
C
C CODE *CUBEC VERSION-2* ...CCODE IC UNFCLD BREMSSTRAHLUNG EXPERIMENTAL
C DISTRIBUTIONS
C CUBEC REQUIRES *TAPE 2-INPUT* *TAPE 3-CUIPUT* *TAPE 4-PUNCH CARDS CALCOMP*
C CALLS *DEC* - *DECAY* - *ENLIN* - *GANE* - *GECMTR*
C CALLS *OMITS* - *PPOFRA* - *SINGLE* - *SULN* - *VECTMX*
C
C MAIN PROGRAM CONTROLS, INPLTS,CUIPUTS AND CUNNECTS SUPPRCGRAMS.
C
COMMON /A/ DI,H,MF
COMMON /C/ SUMNUM,SUMENY,CCSDSET,AVENGY,PHNUBE,ENBENY,PHENPE,
1 CCSBEX,DCSCYL,CBXVCL,DCYVCL
DIMENSION DCST(20),CASE(12),M(18),R(40,40),C(200),TETA(20),FIE(20)
1, DELT(20),EG(20),VG(20),TMI(20),TTZ(20),CCGAIN(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),EUG(4),
4 PHCT(4),BK(20),PP(200)
5 ,MPLCT(5),TITILE(12),I,(40),VEC(200),TITE(12)
REWIND 4
IG=1
DATA (TITILE(I),I=1,12)/EH RESP,6PONSE V,6HECTOR ,2F ,3*6H ,
12H ,3*6H ,2F /
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)/6F PHC,6FICN E,6HNERGY ,2H ,6FSPECTR,
16HUM NL:SHMBER ,2F ,6H (T,6PIMES ,6HICG) ,2F /
C
C
MRPEAT=C
MF=C
DI=30.48
MM=1
NS=1
KK=C
NDEGRE=2
NGU=1
NGD=1
NGE=1

```

```

NGR=J
NGC=I
NGX=I
NGA=I
NGL=I
TKLLC=0.75C
DIF(I)=C.0
C SET =NUMBER OF TIMES PROGRAM WILL CALL *SCLN* (I.E. INVERSION)
  READ (2,270CC) SET
27000 FORMAT (F10.5)
C CASE(I)=72 COLUMNS OF REMARKS FOR INPUT/CUTPUT PER EACH PASS THRU I.
C M(3) TC M(8) NCRMALLY ZERC (GR BLANK)
C M(1)=SIGNAL TC EXIT/CONTINUE/LCCPBACK, AFTER *PHCTC*
C M(2)=SIGNAL TC CORRECT FOR SOURCE DECAY IF =0 , ELSE FACTOR = 1.0
C M(3)=SIGNAL TC CALL *GANE* IF =0 (FOR ENERGY CORRESPONDENCE)
C M(4)=SIGNAL TC WRITE THE ENERGY-CORRESPONDING SPECTRUM IF = 0
C M(5)=SIGNAL TC UNFOLD SPECTRA IF = 0 , ELSE BY-PASS
C M(6)= SIGNAL TC WRITE PHI(I) AFTER *SCLN* IF NCT = 0 (INC DECAY CORR)
C M(7)=SIGNAL TC CUTPUT FITTING DIFFERENCES DIF(I) IF NCT = 0
C M(8)=SIGNAL TC 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 TC WRITE RESP. MATRIX R(I,J) AFTER *PHCTC* IF = 0
C M(11)=SIGNAL TC CALL *GECMTR* IF =C
C M(12)=SIGNAL TC WRITE NUMBER FLUX IF =0
C M(13)=SPARE
C M(14)=SPARE
C M(15)=SIGNAL THAT UNKNOWNS CONTAIN BREMSS+PEAKS (IF NCT=C)
C M(16)=SIGNAL TC RE-USE EXISTING STAND. SPECTRA FOR NEW RESP. MATRIX
C M(17)=SIGNAL TC CALL *SOLN* FOR ETA(I) ONLY,.. (INC UNFOLDING)
C M(18)=SIGNAL TC READ CARD CF MN(I) FOR INTERMED.ITER. CUTPUT IF NCT=C
C MPLOT(1)=CUTPUT ON CARDS THE GENERATED RESPONSE MATRIX VECTORS CALCOMP PLOT
C MPLOT(2)=CUTPUT ON CARDS THE CCDE DETERMINED ENERGY SPECTRA FOR CALCOMP PLCT
C MPLOT(3)=SPARE OPTIGN SIGNAL
C MPLOT(4)=SPARE OPTIGN SIGNAL
C MPLOT(5)=NUMSER OF SPECTRA OUTPUT ON CARDS FOR INPUT TC CALCOMP PLOTTING CCDE
C ELIMIT=ENERGY IN MEV OF UPPER LIMIT CF RESP. MATRIX HIGHEST CHANNEL
C CJSO=NUMBER OF SIMILAR SETS CF DATA BEFORE LOOPING TC STATEMENT I.
C OPM=SIGNAL TC READ/ASSUME EXISTS/GENERATE RESPONSE MATRIX PER -/0/+
C CN=NUMBER CF CHANNELS IN RESPONSE MATRIX, IF =0 CCDE SETS TC 20
C HITMAX=MAX NUMBER CF ITERATIONS FOR *RESMAT*. ALSO A SIGNAL TC CUTPUT
C IF HITMAX=C CCDE SETS TO 5C.C
C FITTING DATA WHILE ITERATING AT LCCP INDEX MN(I).... FOR ITMAX=CCD
C NUMBER
C EPS=CCONVERGENCE TOLRANCE CHCSEN FOR ITERATIVE FITTING
C IF EPS=C, CCDE SETS TO 0.CCGI

```



```

C  RX=NAI(TL) CRYSTAL RADIUS, IF =C CCDE SETS TO 3.61 CM.
C  H= NAI(TL) CRYSTAL LENGTH, IF =C CCDE SETS TO 7.62 CM.
C  CN,HITMAX,EPS,RX,H NCRMALLY BLANK
   I REAC (2,ICCI) (CASE(I),I=1,12),(M(I),I=1,18),(MPLCT(I),I=1,5),
   IELIMIT,CJSC,CPM,ON,FITMAX,EPS,RX,H
1C01 FCRMAT (12A6/1814/514/6F1C.5,2F6.4)
C  INPUT CHECKING
   JSC=CJSC
   MM=CPM
   IF(CN)7709,7708,7705
7708 ON=2C.0
7709 N=ON
8808 HITMAX=50.0
8809 IF(EPS)9909,9908,99C9
9908 EPS=.COC1
9909 ITMAX=HITMAX
   IF(RX)1C009,10008,1C009
1C008 RX=3.81
10C09 IF(F)11C09,11008,11C09
11C08 H=7.62
11C09 EN=N
EM=EN/ELIMIT
DXX=2.0*RX/2.54
HXX=F/2.54
WRITE (3,4C01) (CASE(I),I=1,12),(I,M(I),I=1,18)
4C01 FCRMAT (IH1,30H BRIEF DESCRIPTION OF PHA RUNS /1X,A5,11A6//
4CC116H CONTROL NUMBERS /((3H M(,12,4H) = 12,1X)))
WRITE(3,90)(I,MPLCT(I),I=1,5)
90 FCRMAT ( 41HOCALCCMP PLCTTING OPTIGN CONTROL NUMBERS /5(7H MPLCTI
1,12,4H) = ,12,1X)
WRITE (4,5555) MPLOT(5)
5555 FCRMAT(1X,12)
WRITE (3,4C02) EM,ELIMIT,EPS,JSC,MM,ITMAX,N,CXX,FXX
4C02 FCRMAT ( 6HOEM = ,F1C.5,14H CHANNELS/MEV /9HOELIMIT= ,F10.5/
4C0213HOITERATIVE ERROR TOLERANCE,EPS = ,F10.5/36HONUMBER CF BETA SULR
4C022CE SETS,OJSC = 13,5X,5FMA = ,13/33HOMAX NUMBER CF ITERATIONS,ITMA
4C023X = ,13,5X/30HONUMBER CF CHANNELS INPUT, N = ,13/
4C024 25FONAI(TL) CRYSTAL SIZE = F4.2,3H X ,F4.2,9H INCHES. /IH1)
JS=1
IF(M)120,21234,12
21234 IF(M(16))21244,2,21244
21244 MRPEAT=M(16)
GC TC 12
C

```

```
C IF DM 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 ZERC VECTOR
C Q=INCREMENT MID-POINT ENERGIES IN PEV (CCRRESP. TC PV)
C PV=CHANNEL MID-POINT PULSE-HT. VALUES CORRESP. TC Q
C
120 READ (2,1966) ((R(I,J),I=NS,N),J=NS,N)
1966 FCRMAT (1X,5E14.7)
      READ (2,6691) K, (C(I),I=1,N),(PV(I),I=1,N)
6691 FCRMAT (15/(5F10.5))
      GC TC 121
C
12 CALL PHCFRA (R,N,EM,ELIPIT,NGC,NGR, NCEGRE,G,PV,PFRACT,K,MRPEAT
121,0.0,PP)
C
NP=N
121 META=8
      MSKIP=1
      IF( N(IC) )14,13,14
13 WRITE (3,2001)((R(I,J),I=NS,N),J=NS,N)
2001 FCRMAT (//34F1SYSTEM RESPENSE FUNCTION MATRIX //(ICELL.4))
2009 FORMAT (1H1)
      WRITE (3,2009)
      IF(MPLOT(1))91,14,91
91 NOV=N
      XZ=10.0
      ICX=1
      IDY=2
      EPAXE=0.0
      BIG=C.0
      DC 92 I=1,N
      DC 92 J=1,N
      VEC(J)=R(I,J)
92 CALL VECTMX(VEC,1,(CV,JPAX,BIG)
      BIG=BIG*10000.0
      DC 93 I=1,N
      DC 97 J=1,N
      VEC(J)=R(I,J)*10000.0
97 CCNTINUE
      TITLE(4)=IN(I)
      WRITE (4,404)(TITLE(ICCM),ICCM=1,12),NCV,IDX,ICY,LPAXE,XZ,BIG,(VEC
1(I,ICAL),ICAL=1,NCV)
404 FCRMAT(3A6,A2,3A6,A2,3A6,A2/1X,3I5,3E15.8/(1X,5E14.7))
      IG=IG+1
      IF(IC-MPLCT(5))4445,4446,4446
```

```

9446 END FILE 4
END FILL 4
DC 7777 IR=1,4
7777 MPLCT(IR)=C
GC TC 14
4445 CONTINUE
93 CONTINUE
14 WRITE (3,2C00) (Q(I),I=AS,N)
2C00 FCRMAT(49H REPCASE MATRIX ENERGY INTERVAL MIDPCINIS IN MEV
2CCC1 //(10F7.4))
9876 FCRMAT (///37H PULSE-HEIGHT IN CHANNELS (MIDPCINIS) //(1CF7.2))
WRITE (3,2C09)
IF( M(1) )3CCC,16,15
15 CALL EXIT
3CCC GC TC 1
16 MP=C
NGE=1
C BTAG IS LABEL (EG. GA-70) OF BETA SOURCE
C SBETA=NUMBER BETA/SEC CF ENERGY EBMAX (IN CURIES) FROM SOURCE WITH
C RESPECT TO A REFERENCE DATE AND TIME.
C EBMAX=SOURCE MAXIUM BETA ENERGY (MEV)
C CYLDIA=DIAMETER OF BETA SOURCE CYLINDER(=LENGTH) IN CENTIMETERS
C TH=BETA SOURCE HALF-LIFE IN UNITS CF SECCNDS,MINUTES,HCURS,DAYS
C ,YEARS MULTIPLIED BY UT(BELOW)TC CONVERT TC MINUTES.
C RUNS=NUMBER CF PHA-RUNS PER SET (E.G. PER BETA SOURCE)
C CHANLS=NUMBER CF CHANNELS IN EACH SPECTRUM CF SET (=200 IF
C NOT SPECIFIED)
C UT=NUMBER CF TIME UNITS (EG. HCURS/LAY IF TH IN HCURS)
C ,IE.MUST BE 0.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,UT
2CCC0 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

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44 IF(LT-24.)46,45,46
45 TF=TF*6C.
GC TC 5C
46 IF(LT-365.)48,47,48
47 TF=TF*1440.
GC TC 5C
48 WRITE (3,49) LT
49 FCRMAT (35H HALF-LIFE FACTOR ...ERRCR... UT = F10.5, 6F EXIT )
GC TC 15
5C CCNTINUE
WRITE (3,128) BTAG,SBETA,EBMAX,CYLCLIA,TH,NRLN,NX,UT
128 FCRMAT (1H1, 90H BETA SOURCE MAX BETA SOURCE SOURCE
1281NUMBER CF NUMBER HALF-LIFE /90F SOURCE 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//1111111111)
SBETA=SBETA*3.7E+10
C INDEXED INPUT (I=1 TO NRLN)
C CODE INSERTS FCR INDEX I GREATER THAN 1 IF VALUE SAME AS FCR
C I=1, FCR VARIABLES DELT, TPI, CCGAIN, VG, EG, TTZ.
C DCST=DISTANCE FROM SOURCE GEOMETRIC CENTRE TO CRYSTAL FRONT-FACE (CM.)
C DELT=DIRECTION CF PHA-COUNTING IN MINUTES
C FIE=AZIMUTH ANGLE AT SOURCE,CF CRYSTAL-AXIS (DEGREES)
C TETA=PLCLAR ANGLE AT SOURCE,OF CRYSTAL AXIS (DEGREES)
C TMI=TIME DURATION FROM REFERENCE-TIME TO START CF CCLNTING IN DAYS
C CCGAIN=CCARSE GAIN SETTING CF PHA (EG. 8.)
C VG AND EG ARE PULSE-PT AND ENERGY CF REFERENCE MONITOR PHOTICPEAK
C VG CHANNELS AND EG MEV
C TTZ=THE NUMBER CF CHANNELS FROM TRUE-ZERO TO LOWER EDGE CF CHAN 1.
C BNBK AND BK=NBK AND BKGD (SEE BELCN) (ARE BACKGROUND SIGNALS)
DC 5CC7 I=1,20
DCST(I) =C.C
TETA(I) =C.C
FIE(I) =C.C
DELT(I) =C.C
TPI(I) =C.C
CCGAIN(I)=C.C
VG(I) =C.C
EG(I) =C.C
BK(I) =C.C
TTZ(I) =C.C
5CC7 BNBK(I) =C.C
READ (2,12CCO)(DCST(I),TETA(I),FIE(I),DELT(I),TPI(I),CCGAIN(I),
1 VG(I),EG(I),TTZ(I),BNBK(I),I=1,NRLN)

```

```

12CCO FCRMAT (1CF7.3,F2.0)
IF(NRUN-1)5CC8,5CC8,5C0S
5C09 CALL CMTS(NRUN,DELT )
      CALL CMTS(NRUN,TM1 )
      CALL CMTS(NRUN,COGAIN)
      CALL CMTS(NRUN,VG )
      CALL CMTS(NRUN,EG )
      CALL CMTS(NRUN,TIZ )
5C08 CONTINUE
      WRITE (3,127) (COST(I),TETA(I),FIE(I),DELT(I),TM1(I),CCGAIN(I),
1  VG(I),EG(I),TIZ(I),BK(I),BNBK(I),I=1,NRUN)
127 FCRMAT (IHO,104H SCURCE CRYSTAL ANGLE COUNTING REFERENCE PH
127IA MONITCR MONITCR SPECTRA BACKGROND BACKGROUND
1272/104F CRYSTAL AT SCURCE CURATION TIME CCARSE PULSE-
1273 ENERGY ZERO SIGNAL MULTIPLIER
1274/85F DISTANCE (DEGREES) (MINUTES) (DAYS) GAIN HEIGHT
1275 (MEV) SHIFT /85F (CM.) PCLAR AZIMUTH
1276 (CHANNELS) (CHANNELS)
1277///(2X, 4F8.3,2X,F8.2,3X,F5.2,1X,3F9.4,2F11.4)
      WRITE (3,2C09)

```

```

C IF M(18) NCT=0,READ INDICES MN(I) OF ITERATION INTERMED. CUPUT
C
C IF(M(18))333,444,332
333 READ (2,555) (MN(I),I=1,18)
555 FCRMAT (18I4)
      WRITE (3,556) (MN(I),I=1,18)
556 FCRMAT (53H)ITERATING OUTPUT CN ITERATION LCCPS NUMBEREC BELOW
5561///(1X,5110)
      WRITE (3,2C09)
444 IF(NX)9111,1119,9111
1119 NX=2C
9111 RCGAIN=EN
      IF(M(15))770,771,770

```

```

C
C EUK(I,1)=ONE TC 4 PEAK ENERGIES (MEV) FOR J=1
C EUK(I,2)=CNE TC 4 PEAK ENERGIES (MEV) FOR J=2
C EUK(I,3)=CNE TC 4 PEAK ENERGIES (MEV) FOR J=3
C ----- ETC. -----
C
770 READ (2,7CC) ((ELK(I,J),I=1,6),J=1,NRUN)
700 FCRMAT (6F1C.5)
      WRITE (3,701) ((ELK(I,J),I=1,4),J=1,NRUN)
701 FCRMAT (35H) ENERGIES IN PEV CF LNKNCN PEAKS ///(1X,4F10.4)
771 CONTINUE

```

C MAIN EXECUTION LCCP FROM HERE
C
C

DC 500 J=1, NRUN
GAIN=VG(J)*ELIMIT/EG(J)
DIST=DOST(J)
CT=DELTA(J)
TP=TWI(J)
BKGD=BK(J)
NBK=BNBK(J)
N=NX
JJ=J
CLAMCA=ALCG(2.0)/TH

C READ SPECTRA
C BKGD=MULTIPLIER FOR BACKGROUND ADDITION/SUBTRACTION OPERATIONS
C NBK=SIGNAL SUBT/NCT READ/ACC A BACKGROUND PER -/0/+
C IF NBK =C 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*BKGD.

C SPECTRA READ AND COMPLEMENTED BY *DEC*

CALL CEC (NX,FM)
IF(NBK)6,2222,11
11 CALL CEC (NX,B)
6 DC 3 I=1,NX
3 FM(I)=FM(I)-BKGD*B(I)
2222 CONTINUE

WRITE (3,25123) JJ,RTAG,(FM(I),I=1,200)
25123 FORMAT(1H1,17H SPECTRLM NUMBER ,I3,5H FOR ,A6,8F SOURCE //
25123)33H (AFTER BACKGROUND SUBTRACTION) //(1X,1CF8.0))

IF(M(3))9,E,5
8 TZ=11Z(J)
SM=C.C
IF(M(15))773,778,772
773 DC 774 I=1,6
774 EL(I)=ELK(I,J)
DC 775 I=1,4
IF(EL(I))776,777,776
777 IN=I-1

GC 1C 1778
776 CCNTINUE
775 CCNTINUE
1778 CCNTINUE

```
C CALL *GANE* TC SHIFT FOR SPECTRAL ANALYSIS IN *SINGLE*.
C
C CALL GANE (IZ,N,1.0,1.0,SP,FM)
C
32 DC 34 I=1,IN
ELX=EL(I)
DELV=PULSE(ELX,NGC,NDEGRE)
34 ELG(I)=EL(I)*GAIN*(1.0+DELV)
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 FORMAT(13H1MAIN/EL,FM /1X,1114/1X,4E14.7/(1X,10F6.0))
36 CALL SINGLE (FM,ELG,EL,N,NGC,NGA,NGX,NGC,NGR,NDEGRE,TKLUC,EM,
361 ELIMIT,G,PV,PFRACT,K,RX, ENY,I,DP,PHGT,NGE)
C MAKE SPECTRUM COMPATIBLE IN GAIN WITH REF MATRIX
C
778 CALL GANE (IZ,N,GAIN,RGAIN,SP,FM)
C
IF(M(4))8851,9,8851
8851 WRITE (3,8852) N, GAIN,RGAIN,(FM(I),I=1,N)
8852 FORMAT (1H1,32H IMPLT SPECTRUM GAIN CHANGED TO ,15,9H CHANNELS
8852/22F GAIN CHANGE RATIO = ,F10.5,1H/ ,F10.5 //(1X,5E14.7))
9 IF(M(5))124,10,124
124 IF(M(17))11C,21,110
110 MF=1
MSKIP=1
CALL ENLIN (N,FM,EG,VG,NGL,JJ,NGC,C)
WRITE (3,100) N,(FM(I),I=1,N)
100 FORMAT (24HLINEARIZED SPECTRUM CF ,14,2X,10F CHANNELS //(1X,10F
10018.0))
10 KK=KK+1
C
CALL SOLN (R,EPS,N,IT,ITMAX,FM,PFI,Q,NS,NGE,NDEGRE,ETA,K,CIF,PN,
1 DIST,RX,NGA,NGC,MSKIP,NGX,TKLUC,ELIMIT)
C
WRITE (3,2005)
MSKIP=0
NSET=SET
PRINT 9599,KK,NSET
9599 FORMAT (1H0,33H OPERATOR.....FINISHING PROBLEM I5, 3H CF,I5)
IF(MF)122,75,122
122 WRITE (3,126) (PFI(I),I=1,N)
126 FORMAT (1H1,40H PFA SPECTRUM CORRECTED FOR EFFICIENCY /15(2X,E12.
12615))
GC TC 21
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79 IF(M(I5))179,125,179
179 DC 7C 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 TC 78
76 I=I+1
CIY=I
GO TC 74
71 IF(I)73,73,74
73 NJ=1
78 PHI(NJ)=PHI(NJ)+PHOT(JN)
GC TC 75
74 CIY=CIY-CY+C.5
TWO=1.0-OIY
PHI(I)=PHI(I)+PHOT(JN)*CIY
PHI(I+1)=PHI(I+1)+PPCT(JN)*TWC
75 CONTINUE
70 CONTINUE
125 IF( M( 6) )2C,1421,20
20 WRITE (3,2C2C) IT,
201 (PHI(I),I=NS,N)
2C20 FCRMAT ( 41HCDIFFERENTIAL FLUX AT ITERATION NUMBER = ,I5/
2C201 (5(2X,E12.5)))
1421 IF(M(7))1423,21,1423
1423 WRITE (3,1424) (DIF(I),I=1,IT)
1424 FCRMAT (30H FITTING DIFFERENCES
21 IF(M(2))80C,801,800
800 DE=1.0
GO TC 8C2
801 DE=DECAY( DT,TH,TM,CLAMCA)
802 CCNTINUE
1CC21 IF( M( 8) )81,99,81
81 WRITE (3,2C25) N,(FM(I),I=NS,N)
2C25 FCRMAT (1H1,16HSINGLE SPECTRUM
99 IF(M(1))50C,24,50C
C 24 CALL GECMTR (DIST,SEETA,DE,PHI,C,NS,N ,EBMAX,NGC,NCEGRE,RX,DT,VOL,
241 CYLCIA,ENXTAL)
C IF(M(9))888E,25,500
25 IF(M(12))888E2,8881,8882

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,15,1CHCHANNELS / (10F7.C)

/(1X,5E14.7))


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8881 WRITE(3,8890C)(I,Q(I),PHJ(I),ENXTAL(I),I=NS,N)
8890 FCRMAT (44HNUMBER AND ENERGY SPECTRUM AT THE CRYSTAL
8890C1 19F INCREMENT ENERGY,13X,11HNUMBER FLUX,13X,11FENERGY FLUX/
88902 13X,5H(MEV),10X,19F(PHCTCNS/CM**2-SEC),7X,15H(MEV/CM**2-SEC)//
88903 (1X,16,3X,F10.5,10X,E14.7,1CX,E14.7)
8882 CONTINUE
IF(MPLCT(2))96,8888,96
96 NCV=N
XZ=1C.0
IDX=2
ICY=4
EMAXE=ELIMIT
DC 197 I=1,2C0
197 VEC(I)=C.0
DC 98 I=1,NCV
98 VEC(I)=ENXTAL(I)*10C.0
TITE(8)=TN(KK)
WRITE(4,404)(TITE(ICOP),ICCM=1,12),NCV,ICX,ICY,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
DC 6666 IR=1,4
6666 MPLCT(IR)=0
4447 CONTINUE
94 CONTINUE
8888 WRITE (3,8892)
8892 FCRMAT (42F1 INTEGRATED RESULTS AT SOURCE AND CRYSTAL ///
88921 58F ENERGY INTEGRATED PHCTCN (BREMS.) VALUES AT THE CRYSTAL // )
WRITE (3,8895) SUMNUM, SUMENY,DCSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
1 DCSPBX,DBXVCL
8895 FCRMAT (37HCPHCTCN NUMBER (PHCTCNS/CM**2-SEC) = ,E14.7/37H PHOTON
88951ENERGY (MEV/CM**2-SEC) = ,E14.7/37H PHOTON DCSE (RCENTGENS/H
88952OUR) = ,E14.7//24H AVERAGE ENERGY (MEV) = ,E14.7//77H PHOTON NU
88953MBER / SOURCE EMITTED BETA NUMBER (PHCTCNS/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 PHCTCN DCSE
88957 / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)
88958 E14.7/92H PHCTCN DCSE / SOURCE EMITTED BETA NUMBER PER SOURCE V
88959OLUME ((R/HR)/(BETA/SEC))/(CM**3) = ,E14.7////)
WRITE (3,8891) DOSCYL,DCYVCL
8891 FCRMAT (25H AT THE SOURCE CYLINDER //
88911 77F PHCTCN DCSE / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)

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88912      = ,E14.7//52+ PHCTGN DOSE / SOURCE EMITTED BETA NUM
8E913BER PER SOURCE VOLUME ((R/FR)/(BETA/SEC))/CM**3) = ,E14.7)
500 CONTINUE
IF( META )125,60,125
129 WRITE (3,6CC0) (ETA(I),I=NS,N)
6CC0 FORMAT (1H1,22H EFFICIENCY VECTOR ETA / (1X,5E14.7))
      META=C
60 IF(JS-JSO)61,1,61
61 JS=JS+1
GO TC 2
END
$IRFTC AIRA DECK,REF,LIST
FUNCTION AIRABS (E,NGC,N,DIST)
C***** PROGRAM NUMBER - 2 CUBED-2 *****
C
C CALLED BY *SOLN* - *SINGLE*
C CALLS *TA* - *TE*
C COMPUTES AIR INTERACTION FACTOR.
C
DIMENSION X(22),R(22),Z(6),Y(6)
GO TC (1,2),NGC
1 NGO=2
X(1)=-.01
DC IC I=2,1C
10 X(I)=X(I-1)+.C1
DC 12 I=11,19
12 X(I)=X(I-1)+.1
X(20)=1.5
X(21)=2.0
X(22)=3.0
DATA(R(1),I=1,22)/4.97,.749,.347,.243,.203,.185,.174,.166,.160,
1.155,.123,.106,.0953,.0868,.0804,.0750,.0706,.0668,.0635,.0517,
2.0445,.0357/
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*DIST)
RETURN
END
$IRFTC CLAC DECK,REF,LIST
FUNCTION CLAC (E,NGC,N)

```

C***** PROGRAM NUMBER - 3 CUBEC-2 *****

C CALLED BY *SCLN* - *SINGLE*
C CALLS *TA* - *TE*
C CCMPLES DETECTCK CLADDING ABSORPTION FACTCK.
C

DIMENSION X(28),R(28),Z(6),Y(6)

GC TC (1,2),AGC

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,.457,.605,.6907,.748,
1.7925,.6891,.9253,.941,.9495,.9542,.9572,.9598,.9694,.9736,.9763,
2.9784,.5800,.5812,.5824,.5833,.9841,.9871,.9888,.9909/
M=28

LCW=1

2 CALL TA (E,X,M,LOH,MOX,MUN,Z,Y,R,N,L,C)

NN=N+1

CLAD=TE (NN,Z,Y,E)

RETURN

END

\$IBFTC DEC DECK,REF,LIST

SUBROUTINE DEC (NX,S)

C***** PROGRAM NUMBER - 4 CUBEC-2 *****

C

C CALLED BY *MAIN*

C READS PULSE-HEIGHT ANALYZER SPECTRA, CHECKS FOR PHA-COMPLEMENTED COUNTS.

C

DIMENSION S(200)

REAC (2,300)(S(I),I=1,NX)

3000 FCRRMAT (10(F6.0,1X))

DC 4 I=1,NX

IF(S(I)-90000.)5,5,6

6 S(I)=S(I)-100000.

5 CONTINUE

4 CCNTINUE

RETURN

```

END
$IBFTC DECA DECK,REF,LIST
FUNCTION DECAY ( DT,TH,T1, CLAMDA )
C***** PROGRAM NUMBER - 5 CUBED-2 *****
C
C CALLED BY *MAIN*
C CCMPLTES DECAY CORRECTION FACTOR.
C
T1=T1*1440.0
IF( (DT/TH ) - 0.001)2,2,1
1 T2=T1 + DT
TE=(-1.0/CLAMDA )*ALOG ((EXP(-CLAMDA *T1))-EXP(-CLAMDA *T2))/
1 (CLAMDA *DT))
GC TC 3
2 TE=T1 + DT/2.0
3 DECAY=EXP (CLAMDA *TE)
RETURN
END
$IBFTC DOSE DECK,REF,LIST
FUNCTION DCSE (E,NGC,N)
C***** PROGRAM NUMBER - 6 CUBED-2 *****
C
C CALLED BY *GEOMTR*
C CALLS *TA* - *TE*
C CCMPLTES GAMMA PHCTCN DCSE.
C
DIMENSION X(20),R(20),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(10)=-.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(20)=3.0

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1,.02364,.02321,.02511,.02681,.02874,.02954,.02956,.02959,.02884,
2.02794,.02556,.02355,.02071/
M=2C
LCW=1
2 CALL TA(E,X,M,LCW,MCX,MUN,Z,Y,R,N,L,O)
NN=N+1
DCSE=TE (NN,Z,Y,E)*E
10 RETURN
END
$IBFIC EFFI DECK,REF,LIST
FUNCTION EFFIC (E,NGC,N,CAS,RCX,PH)
C***** PROGRAM NUMBER - 7 CUBEC-2 *****
C
C CALLED BY *SCLN* - *SINGLE*
C CALLS *SIMPSN* - *TA* - *TE*
C COMPUTES ELEMENTS OF DETECTION EFFICIENCY VECTOR.
C
COMMON /B/ KL,UEGAM,RX,DIST,H
DIMENSION X(32),R(32),Z(6),Y(6),W(32),V(6)
DIST=CAST
H=HF
RX=RCX
ARG=RX/(DIST+H)
EPS=1.0E-06
LCW=1
WRITE (3,100)DIST,H,RX,ARG
C 100 FORMAT(1X,4E14.7)
GO TO (1,2),NGO
1 IF(E-.03316)3,4,4
4 NGC=2
X(1)=-.03316
X(2)=-.035
X(3)=C.C40
DO 6C I=4,14
60 X(I)=X(I-1)+.010
DO 7C I=15,27
70 X(I)=X(I-1)+.C5C
X(28)=0.90
X(29)=1.00
X(30)=1.5
X(31)=2.0
X(32)=3.0
DATA(W(1),I=1,32)/3C.4,26.1,18.2,10.1,6.17,4.11,2.86,2.06,1.57,
11.23,.990,.814,.678,.568,.305,.207,.155,.1278,.111,.099C,.C9C1,

```

```

2.0839,.C785,.C743,.C710,.C680,.0657,.0611,.0577,.0465,.C412,.0367/
M=32
DC 8C I=LCH,M
80 R(I)=W(I)*3.667
C WRITE (3,11C)(I,X(I),R(I),I=LCH,M)
C 110 FCRMAT(IX,IS,2E14.7)
GC IC 2
3 X(1)=-.01
X(2)=-.015
X(3)=-.02C
X(4)=-.025
X(5)=-.030
X(6)=-.0331559
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 8C0I=LCH,M
800 R(I)=V(I)*3.667
C WRITE (3,11C)(I,X(I),R(I),I=LCH,M)
2 CALL TA (E,X,M,LCH,MCX,MUN,Z,Y,R,N,L,C)
NN=N+1
UEGAM=TE (NN,Z,Y,E)
C WRITE (3,120) M,LCH,MCX,MUN,N,L,LEGAM,E
C 120 FCRMAT (IX,6I5,2E14.7)
5 A=0.C
B=ATAN(ARG)
KL=C
CASE=SIMPSON(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 (3,130) A,B,CASE,UNUM,DEN
C 130 FCRMAT (IX,5E14.7)
EFFIC=UNUM/DEN
RETURN
6 EFFIC=1.0 - EXP(-LEGAM*H)
RETURN
END
$IBFTC ENLI DECK,REF,LIST
SUBROUTINE ENLIN (NX,FM,EG,VG,NGL,J,NGC,C)
C***** PRGRAM NUMBER - E CUBEC-2 *****

```

```

C
C CALLED BY *MAIN*
C CALLS *PULSE*
C APPLIES ENERGY RESPONSE NCN-LINEARITY CORRECTION.
C
C DIMENSION FM(200),EG(20),VG(20),C(200),Q(200)
C NDEGRE=2
C EGI=EG(J)
C DV=PULSE(EGI,NGC,2)
C EGVG=EG(J)*(1.0+CV)/VG(J)
C DEFINE THE ENERGIES OF NCN-LINEARITY, X(I).
C TEMP. CLTPLT
C WRITE(3,55)EGI,CV,EGVG,EG(J),VG(J),NGL,NGD,J,NX
C 55 FORMAT(10H ENLIN I ,5E14.7,4I5/)
C 3 DC 6 I=1,NX
C EX=I
C EX=EX*EGVG
C IF(EX-0.015)3000,30C1,3C01
3000 VP=EX
C C(I)=FM(I)
C GC TC 3002
3001 VVP=EX*(1.0+PULSE(EX,NGC,2))
C C(I)=FM(I)*(VVP-VP)/EGVG
C VP=VVP
3002 CCNTINUE
C Q(I)=EX
6 CCNTINUE
C DC 7 I=1,NX
7 FM(I)=C(I)
C NXX=NX+1
C DC 8 I=NXX,200
8 FM(I)=C.0
C RETURN
C END
$IRFTC FC DECK,REF,LIST
FUNCTION FC(X)
C***** PROGRAM NUMBER - 9 CUBEC-2 *****
C
C CALLED BY *SIMPSN*
C CRYSTAL INTERACTION EFFICIENCY FUNCTION.
C
C COMMON /B/ KL,UEGAM,R ,DIST,H
C IF(KL)1,2,1
C 1 IF(X)3,4,3
C 3 FC=(1.0 - EXP(-UEGAM*(R/(SIN(X))-DIST/CGS(X))))*SIN(X)

```

```
RETURN
4 FC=C.C
RETURN
2 FC=(1.0 - EXP(-LEGAM**/(COS(X))))*SIN(X)
RETURN
END
$IEFIC FUNL DECK,REF,LIST
SUBROUTINE FUNUS (FIT,FC,Y,B,P,A,NF, AS,PP,ENY)
C***** PRGAM NUMBER - 1C CUBED-2 *****
C
C CALLED BY *STDFIT*
C PHTCPEAK FUNCTION FITTED BY -SICFIT-
C (GAUSSIAN DISTRIBUTION CN STRAIGHT LINE BASE)
C
C DIMENSION FC(200),Y(200),B(5),P(200),A(200,5), FP(200)
FIT=C.0
DC 50 I=1,200
PP(I)=0.C
P(I)=C.C
DC 50 J=1,5
50 A(I,J)=C.0
PIE=3.14159265
CONS=C.3989423*B(3)
C
C COMPUTE STRAIGHT LINE BASE FOR PHTCPEAK
C
400 DG 4C2 I=NS,NF
X=I
X=X-C.5
P(I)=B(4)*X + B(5)
A(I,4)=X
402 A(I,5)=1.C
C
C COMPUTE GAUSSIAN FUNCTION AND PARTIAL DERIVATIVES.
C
403 DC 7CC I=NS,NF
X=I
X=X-C.5
PCN=(X-B(1))/B(2)
ARG=EXP(-0.5*PCN*PCN)
PP(I)=CCNS*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)
700 FIT=FIT+FC(I)*FC(I)/Y(I)
RETURN
END
$IBFIC GANE DECK,REF,LIST
SUBROUTINE GANE (TZ,NX,GAIN,RCGAIN,SPCCTH,C)
C***** PROGRAM NUMBER - 11 CUBEL-2 *****
C
C CALLED BY *MAIN* - *SINGLE* - *REGEN* - *PHCFRA*
C GAIN CHANGING PROGRAM, ALSO SPECTRAL SHIFTING.
C
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
NSXC=1
NXO=NSX+NX
955 DC 956 I=NS,NXC
K=I+NZC
956 FM(I)=C(K)
DC 957 I=NS,NXC
957 C(I)=FM(I)
GC IC 93
911 NS=1
NSXC=NXC+1
NSX=NX
945 DC 91 I=NS,NXC
K=I+NZC
91 C(I)=C(K)
93 DC 92 I=NSXC,NSX
92 C(I)=C.C
910 NX=NXC
C
C DECIMAL SHIFT.
C
274 TNZC=NZC
DIF=TZ-TNZC

```

```
CCIF=1.C-DIF
IF(CIF)271,272,271
271 NXON=NX-2
C(I)=C(I) + C(2)*CIF
DC 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
G=GAIN
DC 5C I=1,NLIMIT
50 FM(I)=0.C
FMULT=GAIN/RCGAIN
C
C DEL=0.5 WHEN GAIN/RCGAIN=1./2. I.E. DOUBLING REQUIRED.
C DEL=2.0 WHEN GAIN/RCGAIN=2./1. I.E. HALVING REQUIRED.
C
1 DEL=GAIN/RCGAIN
IF(DEL-2.0)402, 204, 402
402 IF(DEL-C.5)3, 3, 4
3 L=L+1
GAIN=GAIN*2.C
GC TC 1
C
C INITIALIZE FOR REDUCING ALGORITHM.
4 I=1
K=1
X=0.
XN=1.C
DELT=0.
60 DE=DEL
IF(DEL-1.0)5,499,1C5
499 IF(L-1)497,500,497
497 DELT=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 QUADRATICALLY
C INTERPLATED COUNT. SHIFT ENTIRE SPECTRUM UPWARD ONE HALF CHAN.
```

C

```

5 DELT=RQGAIN/2.0
  DEL=GAIN/DELT
  GC TC 60
303 NCX=J-4
  DC 305 J=1,NCX,2
  I=J+1
305 C(I)=(3.0*C(J) + 6.0*C(J+2) - C(J+4))*0.125
  C(I+2)=(3.0*C(I+3) + 6.0*C(I+1) - C(I-1))*0.125
  NX=I+3
  DC 936 I=2,NX
536 FM(I)=(C(I)+C(I-1))*0.5
  FM(I)=C(I)*0.5
  DC 935 I=1,NX
535 C(I)=FM(I)
  GC TC 304

```

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+1.0E-9)108,107,107
107 K=K+1
  XN=I
  DEL=XN-X
  XK=XK+XKX
  GC TC 106
108 XN=XK
  DEL=XN-X
109 IF(DEL-1.0)111,111,111
110 DIF=DEL-1.0
  DEL=DEL-DIF
  GC TC 109
111 I=I+1
  GC TC 106
202 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

NC=1
GC TC 302

301 NC=1
NC=C

302 DC 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
GC TC 496

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
GC TC 504

503 IF(L-1)525,525,205

C

C SMOOTHING IF *SMCOTH* NOT EQUAL TO ZERO.

C

525 IF(SMCOTH)526,500,526
526 DELT=DEL

SMCOTH=SMCOTH - 1.0
FMULT=0.5

GC TC 496
205 L=L-1

GC TC 204

C

C COUNTS SCALED IN ACCRE WITH *FMULT* FOR INCREASED SPECTRA.

C

500 KK=C
915 CCNTINUE

```

IF(KK)1499,1500,1499
1500 FAC=1.0
GC TC 1501
1499 FAC=1.0/2.C**KK
1501 IF(FMULT-FAC)916,917,917
516 KK=KK+1
GC TC 915
917 DC 520 I=1,NX
520 C(I)=C(I)*FAC
IF(SMCOIH)2C4,527,2C4
527 GAIN=G
RETURN
END
$IRFTC GALS DECK,REF,LIST
SUBROUTINE GAUSS (FM,V,S,PKAREA,SLM,NMAX)
C***** PROGRAM NUMBER - 12 CUBED-2 *****
C
C CALLED BY *PEAKS* - *RESGEN*
C CALLS *PEEK*
C CCMPTES GAUSSIAN PHOTOPEAK FOR GIVEN PARAMETERS.
C
DIMENSION FM(200)
SUM=C.0
NMIN=V - 6.C*S
IF(NMIN)7,7,E
7 NMIN=1
8 NMAX=V + 6.C*S + 1.C
IF(NMAX-15C)9,9,1C
10 NMAX=15C
9 DC 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 (1CH GAUSS /1X,2I5,5X,4E14.7/(1X,5E14.7))
RETURN
END
$IRFTC GECM DECK,REF,LIST
SUBROUTINE GECMTR (RO,9ETNUM,DE,PHI,E,NS,NX, BETENY,NGD,N,RX,DT,
1 VCL,CYLCIA,ENXTAL)
C***** PROGRAM NUMBER - 13 CUBED-2 *****
C
C CALLED BY *MAIN*

```

```

C CALLS *DCSE*
C COMPLETES GEOMETRY FACTORS. INTEGRATES NUMBER AND ENERGY SPECTRA.
C CALCULATES NORMALIZED DCSE DATA FOR FINAL CODE RESULTS.
C

```

```

C CMCMCN /C/ SUMNUM,SUMENY,DCSDET,AVENGY,PHNURE,ENBENY,PHENBE,
1 DCSBEX,DCSCYL,DPXVCL,DCYVCL
DIMENSION PHI(200),E(200),ENXTAL(200)
PIE=3.14159265
VCL=(PIE*CYLPIA**3)/4.0
TIME=DT*60.0
AREAXT=PIE*RX*RX
CCNST=3600./5.24E+07
SGECM=C.5*(1.0-RC/SQRT(RC*RC+RX*RX))
SUMNUM=C.0
SUMENY=C.0
DCSDET=C.0
C INTEGRATE.

```

```

DC 2 I=NS,NX
PHI(I)=CE*PHI(I)/(AREAXT*TIME)
ENXTAL(I)=PHI(I)*E(I)
EC=E(I)
DCSXTL = PHI(I)*CCNST*DCSE (EC,NGD,N)
SUMNUM=SUMNUM+PHI(I)
SUMENY=SUMENY+ENXTAL(I)
2 DCSDET=DCSDET+DCSXTL

```

```

C
AVENGY=SUMENY/SUMNUM
PHNURE=SUMNUM/BETNUM
ENBENY=SUMENY/BETENY
PHENBE=SUMENY/BETNUM
DCSBEX=DCSDET/BETNUM
DCSCYL=DCSBEX/SGEOM
DPXVCL=DCSBEX/VCL
DCYVCL=DCSCYL/VCL

```

```

C RETURN
END

```

```

$IRFTC GUES DECK,REF,LIST
SUBROUTINE GLESS (NS,NFN,Y,B,ENY)
C***** PROGRAM NUMBER - 14 CUBEC-2 *****
C
C CALLED BY *STDFIT*
C CALLS *VECTMX*
C PROVIDES INITIAL ESTIMATES OF THE PHOTOCPEAK FUNCTION PARAMETERS
C FOR ACNLINER REGRESSION ANALYSIS IN SUBPRGRAM -SIDFIT-

```

C

```

DIMENSION B( 5),Y(2C0)
BIG=C.0
CALL VECTMX (Y,NS,NFN,IEIG,BIG)
B(1)=IBIG
ANY=ICOC.*ENY
IF(B(3)-1.0)1,2,1
2 W=NFN-NS
W=0.45*W
B(3)=C.C
GC TC 3
1 W=(.321*ANY**7.677)*B(1)/ANY
3 B(2)=W/2.354
B7 =Y(NFN)
B(3)= W*(BIG-B7 )*.C65
XNS=NS
XNFA=NFN
B(4)=(Y(NFN)-Y(NS))/(XNFN-XNS)
B(5)=Y(NFN)-B(4)*XNFN
RETURN
END

```

```

$IEFTC MITS DECK,REF,LIST
SUBROUTINE CMTS(NRNL,X)

```

```

C***** PROGRAM NUMBER - 15 CUBED-2 *****

```

C

```

CALLED BY *MAIN*
INSERTION CF REPETITIVE VARIABLES OMITTED ON ALL BUT FIRST-CARD OF SET.

```

C

```

DIMENSION X(2C)

```

```

NSTART=1
1 NST=NSTART+1
DO 2 I=NST,NRNL
J=1
IF(X(I))4,3,4
3 X(I)=X(NSTART)
2 CCNTINUE
5 RETURN
4 IF(J-NRNL)6,5,6
6 NSTART=J
GC TC 1
END

```

```

$IEFTC PEAK DECK,REF,LIST

```

```

SUBROUTINE PEAKS (FM,V,E,R,VV,SI,SIG,NN,P,NMAX)
C***** PROGRAM NUMBER - 16 CUBED-2 *****

```

C

```
C CALLED BY *PHCFRA*
C CALLS *GAUSS*
C ACDS PHCTICPEAKS AND ESCAPE PEAKS AND COMPUTES PHCTICFRACTIONS.
C
  DIMENSION FM(200)
  NXN=V+1.0+6.C*SIG
  IF(NXN-NN)ICCC,ICCO,ICG1
  IC00 NND=NXN
  GC TC IC02
  IC01 NNC=NN
  IC02 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
  DC 16 I=1,NNC
  16 SUM=SUM+FM(I)
  P=1.C/(SUM+1.C)
C ADD PHCTICPEAK
  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 DC 17 I=1,NNC
  17 FM(I)=FM(I)/(SUM+SUM1+SUM2)
  P=(SUM1+SUM2)/(SUM+SUM1+SUM2)
C
C FM(I) NCM ACDS LP TC UNIT AREA.
C
  RETURN
  END
$IBFTC PEEK DECK,REF,LIST
  FUNCTION PEEK(X,PAV,PAS,PAK)
C***** PROGRAM NUMBER - 17 CUBED-2 *****
C
C CALLED BY *PHCFRA* - *GAUSS* - *RESGEN*
C COMPLETES GAUSSIAN FUNCTION 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
  RETURN
3 PEEK=C.C
  RETURN
  END
$IEFTC PERS      DECK,REF,LIST
FUNCTION PERSPX (E,NGX,A,TKLUC)
C***** PROGRAM NUMBER - 18  CUBEC-2 *****
C
C   CALLED BY *SCLN* - *SINGLE*
C   CALLS *TA* - *TE*
C   CCMPUTES PERSPEX ABSORPTION FACTOR. (F)
C
  DIMENSION 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
  DO 7 I=4,11
  7 X(I)=X(I-1)+.01C
  DO 8 I=12,20
  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,
  1.1707,.1660,.1603,.1320,.1148,.1028,.0938,.0869,.0810,.0763,.0720,
  2.0687,.0559,.0478,.0384/
  LCW=1
  M=23
  2 CALL TA (E,X,M,LCW,MCX,PUN,Z,Y,R,N,L,O)
  NN=N+1
  P=TE (N,Z,Y,E)
  PERSPX=EXP(-P*TKLUC)
  RETURN
  END
$IEFTC PHCF      DECK,REF,LIST
SUBROUTINE PHCFRA (HM,N,EP,ELIMIT,NGD,NGR ,NDEGRE,Q,PV,PFRAC,T,K,
  1 MRPEAT,ESING,FM)
C***** PROGRAM NUMBER - 19  CUBEC-2 *****
C
C   CALLED BY *MAIN* - *SINGLE*
C   CALLS *GAME* - *PEAKS* - *PEEK* - *RESEGEN* - *PULSE* - *RAXEL* - *TA* - *TE*
C   CONTROL PROGRAM FOR RESPONSE MATRIX GENERATION.

```

```

C DIMENSION RM(40,40),R(200,15),FM(200),X(12),PV(50),PFRAC(50),
1 Q(200),ALABEL(12),G(12),TAG(12),STDENY(12),STDEN(12),Z(6),Y(6)
2 ,RR(16),NSJ(12),NFXJ(12),NSXJ(12),NFXJ(12),SHIFT(12),NCSUBT(12)
3 ,NSM(12),DENY(12)
C READ IN ANY ORDER THE APPROPRIATLY LABELLED RESP. MATRIX LIBRY SPECTRA
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 (1CH PHOFRA I /1X,3I10,5X,3E14.7)
GC TC 817
816 IF(MRPEAT)31234,21234,31234
21234 DO 5C52 J=1,12
NFXJ(J)=0.0
9C52 NSXJ(J)=0.0
C C N STAND=NUMBER CF STANDARD SPECTRA IN THE LIBRARY DECK
C NPFA=NUMBER CF DEAD CHANNEL IN BEGINNING CF STAND. SPECTRA
C UNGAIN=REFERENCE CCARSE GAIN (AS AT CCT19/66 IS A DUMMY)
C ALABEL=STANDARD SOURCE ICENTITY (AS IN DATA STATEMENT BELOW)
C FIT PE AKS FRCP CHANNEL NSJ TC NFNJ
C SUBTRACT PEAKS FRCP CHANNEL NSXJ TC NFXJ (USE NEG VALUES IF .51 PEAKS
C CF EITHER NA22 OR ZN65)
C SHIFT=CHANNEL LCCATION CF TRUE ZERC PULSE-HEIGHT
C R(1 TC 2CO,J)=SPECTRUM J (J=1 TC N STAND)
C READ (2,6) N STAND,NPFA,UNGAIN,
1 (ALABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J),SHIFT(J),J=1,N STAND)
6 FORMAT ( 2I5,F10.5/ (A6,4X,4I5,F10.5))
REAC (2,88) ((R(I,J),I=1,2CO),J=1,N STAND)
88 FORMAT (10F7.1)
C C CCMPLEMENT CVERSUBTRACTED CCLNTS.
DC 8CCO J=1,N STAND
DC 8CCO I=1,2CO
IF(R(I,J)-8CCCCC.C)8CC1,8CC1,8CC2
8CC2 R(I,J)=R(I,J)-1CCCCC.C
8CC1 CCNT INUE
8CCC CCNT INUE
C

```

C SHIFT SPECTRA AN AMCLNT TZ IF TZ NCT =0

```

NTZ=C
DC 5CC0 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))9CC1,9C02,5CC1
9C01 TZ= SHIFT(J)
NTZ=TZ
IF(NSXJ(J))9C18,9C15,9C18
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
RGGAIN=1.0
DC 5CC3 I=1,200
9C03 FM(I)=R(I,J)
CALL GANE (TZ,NX,GAIN,RCCAIN,C.O,FM)
DC 5CC4 I=1,2CC
9C04 R(I,J)=FM(I)
9C02 CCNTINUE
5CC0 CCNTINUE
NPHA=NPFA-NTZ
DC 9C95 I=1,NSTAND
9C95 G(I)=C.C
N5=5
NA=1C
NZ=9
NTAG=12
DATA (TAG(I),I=1,12) /6F CC109,6F SC47,6H HG2C3,6H AU198,6H SR85
1 ,6F CS137,6H MN54,6H NB95,6H ZN65,6H NA22,6F NA24,6F K42/
2 ,(STDEN(I),I=1,12)/.08E,.155,.279,.4117,.515,.66162,.835,.764,
3 1.114,1.28,2.76,1.51/
C IDENTIFY ENERGIES CF STANDARDS
DC 1234 KK=1,NSTAND
CC 3456 J=1,NTAG
IF(ALABEL(KK).EC.TAG(J))GC TC 4321
6543 CCNTINUE
3456 CCNTINUE
WRITE (3,9) (ALABEL(JJ),JJ=1,NSTAND),(TAG(JJJ),JJ=1,NTAG)

```

```

9 FCRMAT (IH1,23H ERRCR FLAG FOR PFCFRA / (IX,1H*,A6))
CALL EXIT
4221 STDENY(KK)=STDEN(J)
1234 CCNTINUE
C
C CALL RESGEN TO CALC GAUSSIAN PARAMETERS AND UNIT CCNTINLA FOR STANDS.
C
WRITE(3,7) NSTAND,NPHA,UNGAIN,
1 (ALABEL(J),NSJ(J),NFAJ(J),NSXJ(J),NFXJ(J),SHIFT(J),STDENY(J),
2 J=1,NSTAND)
7 FCRMAT(IH1,15X,37F STANDARD SOURCE SPECTRAL PARAMETERS ///
71 14X,15,33F SPECTRA IN STANDARD SOURCE DECK //
72 13X,16H CHANNELS ONE TO ,14,22F ASSUMED AS REDUNDANT //
73 17X,25H REFERENCE CCARSE GAIN = ,F10.5/////
74IX,72FSTANDARD PFCICPEAK X-RAY CR .5 PEAK SHIFT
75 PHCICPEAK /7IH SOURCE FROM TC FRCP TC
76 SPECTRUM ENERGY //10X,6CH CHANNEL CHANNEL CHANNEL
77 CHANNEL CHANNELS NEV / (2X,A6,6X,14,5X,14,7X,13,6X,13,
784X,F9.4,1X,F10.5))
DC 27123 J=1,NSTAND
WRITE (3,6599) ALABEL(J),(R(I,J),I=1,200)
8599 FCRMAT (IH1,32X,25H STANDARD SOURCE SPECTRA /////// 3X,A6,
8599I 8F SOURCE /// (1X,10F9.0))
27123 CCNTINUE
WRITE (3,3)
3 FCRMAT (IH1)
CALL RESGEN (R,ALABEL,TAG,G,SCCNST,SN,ENPHU,UNGAIN,STDENY,NSTAND,
1 NTAG,NA,NZ,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NCSUBT )
DC 19123 J=1,NSTAND
WRITE(3,3)
WRITE (3,81) ALABEL(J),(R(I,J),I=1,120)
81 FCRMAT (10X,42H NCRMALIZED CCNTINLUM CF STANDARD SPECTRA ///////
811 3X,A6,8H SOURCE /// (1X,5E14.7))
19123 CCNTINUE
C
C INTEGRATE NCRMALIZED STANDAND SPECTRA FOR INTERPLCLATION EASE, FENCE
C DIFFERENTIATE INTERPLCLATED SPECTRA LATER.
C
DC 1CCO J=1,NSTAND
SUM=C.0
DC 1CCO I=1,200
NDX=201-I
SUM=SUM+R(NDX,J)
1CCO R(NDX,J)=SUM
C

```

```
C
DC 5C49 J=1, NSTAND
5C49 DENY(J)=STDENY(J)
DC 5C53 K=1, NSTAND
SMALL=10.0
DC 5C50 J=1, NSTAND
IF (STDENY(J)-SMALL) 5051, 5C52, 5052
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 CORRECT INDEX ORDER
C
DC 5C55 J=1, NSTAND
NCRDRC=NSM(J)
5055 STDENY(J)=DENY(NCRDRC)
DO 5C57 I=1, 200
DO 5C56 KK=1, NSTAND
5C56 DENY(KK)=R(I, KK)
DO 5C58 J=1, NSTAND
NCRDRC=NSM(J)
5058 R(I, J)=DENY(NCRDRC)
5C57 CCNTINUE
C
C
C
C GENERATE RESPONSE VECTORS
C INTERPOLATE THE RESPONSE MATRIX OF SIZE N*N USING THE VECTORS R(I, J).
C DETERMINE FOR CNE ENERGY, ALL CHANNELS, THEN INCREMENT ENERGY.
C
31234 K=0
NC=2CC
NMAX=NO
P=0.0
NS=1
DC 10 I=NS, NC
10 FM(I)=0.0
DC 11 I=NS, N
PFRACT(I)=C.C
PV(I)=0.0
DC 11 J=NS, N
```

```

11 RM(I,J)=C.C
EN=N
DE=ELIMIT/EN
DEL=DE/2.0
MM=N
WRITE(3,3)
C
KJ=NS
920 GAIN=ICC.
E=KJ
E=E*DE-DEL
C INTERPLATE FRCP ENERGY X(I) TC ENERGY X(NTCP)
817 X(I)=C.C
RR(I)=0.0
LCh=1
NTOP=NSTAND+1
DC 1C05 I=1,100
DC 1C04 INDEX=2,NTOP
X(IINDEX)=STCENY(INDEX-1)
1C04 RR(INDEX)=R(I,INDEX-1)
CALL TA (E,X,NTCP,LCh,MCX,PLN,Z,Y,RR,NDEGRE,L,C)
NN=NDEGRE+1
1C05 FM(I)=TE (NN,Z,Y,E)
C
C DIFFERENTIATE FM(I)
DC 1C50 I=1,101
FM(I)=FM(I)-FM(I+1)
IF(FM(I))3C33C,30331,30331
30330 FM(I)=0.
30331 CCNTINUE
1C50 CCNTINUE
DC 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-.01)824,5,5
C
C SET ENERGY AND PULSE-HEIGHT SCALES
822 Q(KJ)=E
V=E*EM
IF(E-C.01)6C,6C,59

```

```

60 PV(KJ)=V
   K=K+1
   NMAX=N
   DC 3088C I=1,2CC
30880 FM(I)=0.0
   P=0.C
   GC TC 61
59 EK=E-C.0285
   SCALE=GAIN/V
   SIG=(SCCNST*(E*1000.0)**SN)*SCALE*EM/2354.82
8   NPA=GAIN+1.0+6.0*SIC
   IF(NPA-NC)123,123,124
124 GN=GAIN
   GAIN=GAIN/2.C
   SIG=SIG/2.C
   SCALE=GAIN/V
C REDUCE VECTOR LENGTH TO ALLCH COMPLETE PEAK TO BE FORMED (I.E.LCH E)
   CALL GANE (C.C,NMAX,GN,GAIN,C.O,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.C
   GC TC 14
5   VK=E*K*GAIN/E
   VV=VK+VK*PULSE (EK,NGC,NDEGRE)
   SI=(SCCNST*(EK*1000.0)**SN)*SCALE*EM/2354.82
   OR=RAXEL(E,NGR,NDEGRE)
   IF(ESING)826,14,826
826 NBEGIN=VV-6.C*SI
   IF(NBEGIN)828,828,829
828 NBEGIN=1
829 DC 83C I=NBEGIN,100
   XI=I
   XI=XI-0.5
830 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 FCRPAT (1CH PHCFRA 2 ,415/(1X,5E14.7))
   CALL PEAKS (FM,GAIN,E,CR,VV,SI,SIG,NC,P,NMAX)
C

```

```

C CALL GANE (C.C, NMAX, GAIN, V, C.C, C, FM)
C WRITE (3, 86) KJ, N, E, (FM(I), I=1, 40)
C 86 FORMAT(//////////)
C 861 36H INTERPLATED RESPONSE MATRIX VECTOR, I3, 4F, CF, I3,
C 86214H FCR ENERGY = , F10.5, 5F, MEV / (IX, 5E14.7)
C 61 M=NMAX
C IF(M- 4C) 9C, 9C, 9C
C 91 M=4C
C 9C PFRAC(T(KJ))=P
C DC 2 I=NS, M
C 2 RM(I, KJ)=FM(I)
C IF(KJ-M) 918, 919, 919
C 518 KJ=KJ+1
C GC IC 920
C 519 CONTINUE
C 30770 FCRMAT (///32H RESPONSE MATRIX PFCOFRAC(TIONS // (IX, 10CF7.4))
C 824 RETURN
C END
C $18FTC PUIS DECK, REF, LIST
C FUNCTION PULSE (E, NGP, N)
C ***** PROGRAM NUMBER - 2C CUBED-2 *****
C CALLED BY *PHCFRA* - *RESGEN* - *ENLIN*
C CALLS *TA* - *TE*
C COMPUTES THE DETECTOR SYSTEM PULSE-HEIGHT FOR GIVEN ENERGY.
C
C DIMENSION X(45), R(45), Z(6), Y(6)
C IF(E - C.010) 8, 9, 9
C 8 WRITE (3, 60) E
C 60 FORMAT (43F PULSE ENERGY LESS THAN 0.010 MEV. ERROR. /E20.8)
C E=C.15
C GC IC 18
C 9 IF(E - 3.C) 18, 18, 12
C 12 WRITE (3, 61) E
C 61 FCRMAT (44H PULSE ENERGY GREATER THAN 3.0 MEV. ERROR. /E20.8)
C E=3.C
C GC IC 18
C 18 GC IC (1, 2), NGP
C 1 NGP=2
C X(1)=0.C15
C DC 16 I=2, 6
C 16 X(I)=X(I-1)+.CC1
C DC 17 I=7, 16

```



```

17 X(I)=X(I-1)+.C02
   X(17)=.C425
   X(18)=.C45
   X(19)=.C50
   X(20)=.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=30,35
21 X(I)=X(I-1)+.050
   DC 22 I=36,43
22 X(I)=X(I-1)+.100
   X(44)=1.3225
   DATA(R(I),I=1,44)/.C418C,.063C0,.07500,.08250,.08750,.0885C,.086C0
   1,.079C0,.063C0,.039C0,.C3CC,.029C0,.033C0,.04300,.05250,.06150,
   2.072C0,.081C0,.C851C,.0E450,.C8040,.06970,.06140,.05550,.05C00,
   3.0382C,.03CC,.C240C,.0186C0,.0115C,.00770,.00540,.C0390,.C0285,
   4.00215,.C011C,3*.C010C,.CC099,.CC060,.CC030,.00015,.C00C/
M=44
LCM=1
2 CALL TA (E,X,M,LCh,MOX,PUN,Z,Y,R,N,L,C)
   NN=N+1
   PULSE=TE (NN,Z,Y,E)
10 RETURN
   END
$IRFTC RAXE DECK,REF,LIST
   FUNCTION RAXEL (E,NGR,N)
C***** PROGRAM NUMBER - 21 CUBED-2 *****
C
C CALLED BY *REGEN* - *PHCFRA*
C CALLS *TA* - *TE*
C CCMPLTES NAI(TI) IOCINE K X-RAY ESCAPE FRACTION.
C
   DIMENSION 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 20 I=4,14
20 X(I)=X(I-1)+C.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
M=14
LCW=1
2 CALL TA (E,X,M,LCW,MCX,MUN,Z,Y,R,N,L,0)
C WRITE (3,100) M,LCW,MCX,MUN,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 100 FCRMAT (10H RAXEL ,7I5/1X,6E14.7)/(1X,15,5X,2E14.7)
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 TC 10
12 RAXEL=0.0
GO TC 10
END
$1BFTC 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,NCSUBT )
C***** PROGRAM NUMBER - 22 CUBED-2 *****
C
C CALLED BY *PHCFRA*
C CALLS *STDFIT* - *PULSE* - *RAXEL* - *PEEK* - *GAUSS* - *GAME*
C ORDERS AND NORMALIZES STANDARD SPECTRA FOR RESPONSE MATRIX INTERPOLATION.
C
DIMENSICN R(200,15),ALAEEL(12),TAG(12),G(12),STDENY(12),NFNJ(12),
1 NSJ(12),NFXJ(12),NSXJ(12),Y(200),PARAV(12),B(5),PARAS(12),
2 PAREA(12),PP(200), NCSUBT(12)
NST=C
NSTC1=0
NSTC2=0
NGAIN=0

```

```
DC 2 I=1,NSTAND
IF(ALABEL(I).NE.TAG(NS))GC TC 4
3 I5=I
NST=C
GC TC 1C
4 CCNTINUE
2 CCNTINUE
NAT=C
EG=1.114
IF(STDENY(NSTAND-1))-EG)50,51,50
51 NAT=NAT+1
50 EG=1.28
NSTAAT=NSTAND-NAT-1
IF(STDENY( NSTAAT )-EG)52,53,52
53 NAT=NAT+1
52 NSTAND=NSTAND-NAT
NSTO3=NSTAND
GC TC 2C
C SEARCH FOR NA22.
10 DC 2C I=1,NSTAND
IF(ALABEL(I).NE.TAG(NA))GC TC 40
30 INA=I
NST=I
GC TC 2C1
40 CCNTINUE
20 CCNTINUE
C SEARCH FOR ZN65.
201 DC 2C00 I=1,NSTAND
IF(ALABEL(I).NE.TAG(NZ))GC TC 40C
300 INZ=I
NST=NST+2
GC TC 1111
400 CCNTINUE
2C00 CCNTINUE
C INITIAL LIMITS FOR START AND STEP FITTING.
1111 NSJ5=1
NFN5=NFNJ(I5)
NSTC1=NSTAND+1
NSTC2=NSTD1+1
NSTC3=NSTD2+1
C LOAD 3 EMPTY VECTORS FOR TEMPORARY USE.
111 NSJ(NSTC1)=NSJ(I5)
NFNJ(NSTC1)=NFNJ(I5)
STDENY(NSTD1)=STDENY(I5)
```

```

DC 150 I=NSJ5,NFN5
150 R(I,NSTC1)=R(I,I5)
GC TC (159,170,170),NST
170 NSJ(NSTC3)=NSXJ(INZ)
NFNJ(NSTC3)=NFXJ(INZ)
STDENY(NSTC3)=SIDENY(INZ)
NSJZ=NSJ(NSTC3)
NFNZ=NFNJ(NSTC3)
DC 160 I=1,NFNZ
180 R(I,NSTC3)=R(I,INZ)
IF(NST-3)22C,160,22C
159 NSTC3=NSID2
160 NSJ(NSTC2)=NSXJ(INA)
NFNJ(NSTC2)=NFXJ(INA)
STDENY(NSTC2)=SIDENY(INA)
NSJA=NSJ(NSTC2)
NFA=NFNJ(NSTC2)
DC 190 I=1,NFNA
190 R(I,NSTC2)=R(I,INA)
220 NGAIN=1

```

C CN-LINEAR FIT NSTAND+3 SPECTRA, EXCLUDE EMPTY VECTRS, FRM NS TO NFN

C INITIALIZE SUCH THAT THERE ARE NC FIXED PARAMETERS.

```

200 CCNTINUE
DC 500 J=1,NSTC3
IF(NST-2)233,235,233
235 JZ=J
233 NS=NSJ(J)
NFN=NFNJ(J)
ENY=STDENY(J)
9C02 DC 7CC2 I=1,NPHA
7C02 R(I,J)=R(NPT+A+1,J)
2C05 Y(I)=C.C
DC 500 I=NS,NFN
5C02 Y(I)=R(I,J)
JJ=J

```

C CALL REGRESSION SUBPRCGRAM.

CALL STCFIT (Y ,NFN, F,

NS,PP,ENY)

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(11),11=NS,
C 1 NFN)
C E18 FCRPAT (10H RESGEN 1 /1X,3I5,5X,6E14.7/(1X,5E14.7))
C SUBTRACT FITTED PEAK.
C

NB1=B(1)
DC 5C10 I=NS ,NB1
5C10 R(I,J)=Y(I)-PP(I)
NB3=B(1)-5.C*B(2)
NB4=NS-1
IF(NB3-NB4)3C592,30593,30593
30592 DC 3C591 I=NB3,NB4
X=I
X=X-C.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)=C.0
IF(NSXJ(J))5C20,5C01,5020
C
C SUBTRACT X-RAY PEAKS IF ANY.
C
5C20 IF(NCSUBT(J))5029,5C01,5029
5C29 DEL=NFJ(J)-NSXJ(J)
NXX=NSXJ(J)
NSX=NSXJ(J)+1
NFXX=NFJ(J)
NFJ=NFJ(J)-1
DC 5C21 I=NSX,NFX
X=I-NXX
5C21 R(I,J)=R(NXX,J)+X*(R(NFXX,J)-R(NXX,J))/DEL
5C01 CCNTINUE
C ZERO FRCPM THE FIRST NEGATIVE CHANNEL TO 2C0
DC 9C10 I=1,200
IF(R(I,J))9C11,9012,9C12
9C11 INDIC=I
GO TC 9C14
9C12 CCNTINUE
9C10 CCNTINUE
GC TC 9C15

```

```
SC14 DC 9C13 I=INCIC,2C0
9C13 R(I,J)=C.0
9C15 CONTINUE
5C00 CONTINUE
C
C IF(NGAIN)60CC,7C00,60C0
C
C IF(NGAIN=1) THEN SUBT C.51 PCRTICN FRM NA AND/OR ZN, ELSE GC IC 7000
C
6C00 NSP=NSTD2
6C01 GAIN=PARAV(15 )
6C11 N=INA
GC IC 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 SUBTRACTIONS.
C
CALL GANE (C.0,NF,GAIN,RQGAN,0.0,C,Y)
C
NAM=NFNJ(N)
DC 6C16 I=1,NAM
6C16 R(I,N)=R(I,N) - Y(I)*PAREA(NSP)/PAREA(15 )
NUS=PARAV(NSP)-6.0*PARAS(NSP)
NAMLS=PARAV(NSP) + 6.0*PARAS(NSP)
PAV=PARAV(NSP)
PAS=PARAS(NSP)
PAK=PAREA(NSP)
DC 9C37 I=NLS,NAMLS
X=1
X=X-C.5
9C37 R(I,N)=R(I,N)-PEEK(X,PAV,PAS,PAK)
IF(NST-3)70CC,6009,70C0
6C09 NST=1
NSP=NSP-1
GC IC 6C01
C
C FIT PARAV(J) AND PARAS(J) AND RETURN WITH CCNSTANTS.
C
7C00 IF(G(1))9C97,9C96,9C97
```

```
9C96 SN=.7677
SCONST=.321
SEK=1CCC.
DIV=2.354
GC TC 9098

C
9C97 CONTINUE
C9C97 CALL SVFIT (PARAV,PARAS,NSTANC,G,SCONST,SN,STIDENY,EM,LNGAIN)
EM=1.C

C
SEK=1.0
DIV=1.0
C NCRMALIZE CCUNTS AND GAINS.
C
9C98 DC 7C10 J=1,NSTANC
DG 7CC3 I=1,2CC
Y(I)=R(I,J)/PAREA(J)
7CC3 R(I,J)=C.0
GAIN=PARAV(J)
NX=2CC
NF=GAIN+1.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,ICC.C,C.O,Y)
C
DC 3CCC I=1,2CC
IF(Y(I))3CCC1,3CCC1,3CCC2
30C01 NFNCRP=I-1
NFNC=I
GC TC 3CC03
30C02 CONTINUE
30C00 CCNTINUE
C
C SUBTRACT K X-RAY ESCAPE PEAK IF ENERGY OF STANDARC LESS THAN 30C0EV.
C
30C03 IF(STIDENY(J)-C.3C0)11C05,11C04,11C04
11C05 EN=STIDENY(J)
NN=1
ND=2
OR=RAXEL (EN,NN,ND)
EK=EN-0.0285
VK=EK*1C0.C/EN
NN=1
VV=VK+VK*PULSE (EK,NN,ND)
```

```

EK=EK*SEK
SI=(SCONST*EK**SN)*ICC.C/EK
SI=SI/DIV
PKAREA=-CR
WRITE (3,8) NFNCRM,NFNC,NX,VV,SI,PKAREA,EN,EK,VK,(Y(I),I=1,200)
C SUBTRACT K PEAK
CALL GAUSS (Y,VV,SI,PKAREA,SUM,NFNCRM)
C ZERO FROM THE FIRST NEGATIVE CHANNEL TO 200
11004 DC 30509I=NFNC,200
30509 Y(I)=0.C
DC 7004 I=1,NFNCRM
7004 R(I,J)=Y(I)
7010 CCNTINUE
WRITE (3,82C)(J,ALABEL(J),PARAV(J),PARAS(J),PAREA(J),J=1,NSTAND)
E20 FCRMAT (1H1,45X,28HRESULTS CF PHCTOPEAK FITTING ///
E201 8X,5HINDEX,12X,15FSTANDARD SOURCE,11X,12HPULSE-HEIGHT,10X,
E202 18FSTANDARD DEVIATION,14X,4HAREA/ 52X,1CH(CHANNELS),15X,
E203 10H(CHANNELS),14X,13H(COUNTS/TIME)//(9X,13,19X,A6,3X,3E25.7))
RETURN
END
$IRFTC RESM DECK,REF,LIST
SUBCLTYNE RESMAT (R,EPS,N,IT,ITMAX,P,PHI,K,DIF,MN)
C***** PRGGRAM NUMBER - 23 CUBED-2 *****
C CALLED BY *SCLN*
C CALLS *VECTMX*
C PULSE-HEIGHT ANALYZER SPECTRUM UNFOLDING ACCORDING TO THE SCCFIELD ALGORITHM.
C DIMENSION PPI(50),P(200),R(4C,4C),PHI(200),FIT(100),CIF(100)
1 ,MN(18)
C INITIALIZE
NCHECK=ITMAX/2
NCFECK=ITMAX-2*NCHECK
SL=C.C
DC 1599 I=K,N
1599 SU=SL + P(I)
DC 1800 I=K,N
1800 P(I)=P(I)/SL
YMAX=0.C
CALL VECTMX (P,K,N,JMAX,YMAX)
YLOX=YMAX*(1.CE-15)
DC 1 I=1,N
PP(I)=0.C

```


/(IX,IOE(11.4))

```

1 PP(I)=P(I)
C WRITE IF ITMAX IS AN ODU-NUMBER.
  IF(NCHECK)8599,6000,8595
8599 WRITE (3,8589) (P(I),I=1,N)
8589 FORMAT (30H1 NCRMALIZED INPUT SPECTRUM
INDEX=1
8000 CONTINUE
IT=1
FIT(I)=C.

```

```

C C MATRIX MULTIPLICATION P=R.PHI
C
10 DC 2 I=K,N
  PP(I)=0.0
  DC 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 = C.0

```

```

C C ARRESTING CHECK WHEN CIF(SUM(P-PP)**2/P) FOR LCCP(IT) AND LCCP(IT-1)
C ARE LESS THAN EPS.... CR IT=ITMAX.
C

```

```

DC 5 I=K,N
IF(P(I))4,6,4
4 TLN = ((P(I) - PP(I))**2)/P(I) + TERM
6 CONTINUE
5 CONTINUE
  IF(NCHECK)1600,1500,1600
1600 IF(MN(INDEX) - IT)1500,1700,1500
1700 WRITE (3,1500) IT,MN(INDEX),(PHI(I),I=K,N)
  WRITE (3,1500) IT,MN(INDEX),(PP(I),I=K,N)
  INDEX=INDEX+1
1500 CONTINUE
15000 FCRMAT (51H INTERMEDIATE ITERATING CUIPUT (IT, MN, AND PHI(I)) 215
150001/ (1X,1CE11.4))
15005 FCRMAT (51H INTERMEDIATE ITERATING CUIPUT (IT, MN, AND PP(I)) 215
150051/ (1X,1CE11.4))
  IT=IT+1
  FIT(IT)=TERM
  CIF(IT)=ABS (FIT(IT-1) - FIT(IT) )
  IF( CIF(IT)
29 IF(IT-ITMAX)229,7,7

```

-EPS)7,7,29

C

C SCGFIELD CORRECTION FACTOR METHOD.

```

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 ICCO I=K,N
   IF(ABS(PHI(I)) - YLCM )IC01,IC02,IC02
IC01 PHI(I)=C.0
IC02 CCNTINUE
IC00 CCNTINUE
GC TC IC

```

C RESULTS.

```

C
7 DC 600 I=K,N
   P(I)=P(I)*SU
600 PHI(I)=PHI(I)*SU
C WRITE IF ITMAX IS AN OLD-NUMBER.
   IF(INCHECK)5599,IC00C,9999
5599 WRITE (3,9998) (PP(I),I=1,N)
9998 FORMAT (20H ITERATED SPECTRUM
10000 CCNTINUE
60 FCRMAT (20HC IT,SL,TERM
   WRITE (3,90) IT,SL,TERM
RETURN
END

```

/(IX,10E11.4))
/110,2E14.7)

```

$IRFTC SIMP DECK,REF,LIST
FUNCTION SIMPSN (A,B,EPS)
C***** PROGRAM NUMBER - 24 CUBED-2 *****
C
C CALLED BY *EFFIC*
C CALLS *FC*
C SIMPSCNS RULE INTEGRATING PROGRAM FOR FUNCTION -FC-.
C
CCMNCN /8/ KL,UEGAM,RX,LIST,F
TPAX=2048.
AN=2.0
FA=FC(A)
FB=FC(B)
FP=C.0
SI=C.0
DELT=B-A
FCUR=C.0

```

```

AK=1.0
AKN=AN/2.0
399 FFX=FC(A+((2.0*AK-1.0)*DELTA)/AN)
FCUR=FOLR+FFX
IF(AKN-AK)4CC,4C1,4C0
400 AK=AK+1.0
GC TC 399
401 SIM=(DELTA/(AN*3.0))*(FA+FE+4.0*FCUR+2.0*FP)
IF(TMAX-AN)5C3,503,495
499 DIFX=ABS(SIM-SI)
IF(EPS-DIFX/SIM)402,4C3,4C3
402 AN=AN+AN
FP=FP+FCUR
SI=SIM
GC TC 405
503 CONTINUE
403 SIMPSN=SIM
RETURN
END

```

```

$IRFTC SING DECK,REF,LIST
SUBROUTINE SINGLE (FM,ELG,EL,NX,NGO,NGA,NGX,NGC,NGR,NDEGRE,TKLUC,
1 EM,ELIMIT,C,PV,PFRAC,T,K,RX, ENY,IN,NP,PHOT,NGE)
C***** PROGRAM NUMBER - 25 CUBEC-2 *****

```

```

C CALLED BY *MAIN*
C CALLS *GANE* - *PHCFRA* - *STCFIT* - *EFFIC* - *CLAD* - *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 ,PFRAC(50),C(200),PHCT(4),B(5),NSS(4),NFNN(4)
C FM-IN IS A BREMSS+LINE SPECTRUM. FM-CLT IS A BREMSS ONLY, AND PHCT
C CONTAINS THE LINE DATA TO BE ADDED TO PHI IN *MAIN*.

```

```

COMMON/A/DI,P,MF
NCNE=1
NCX=NX
DIST=CI
HT=F
IF(EL(5))15000,1501,15010
15000 NSS(1)=EL(5)
NFNN(1)=EU(6)
NCNE=2
B(3)=1.0
IF(IN-1)56,56,1501

```

1501 CCNTINUE
C ESTIMATE PCTCPEAK FITTING LIMITS.
DC 768 J=NCAE,IN
DC 768 KCHECK =1,2
IF(KCHECK-1)187C,1870,1871
1871 BIG=C.0
CALL VECTMX (FM,NS,NFA,IBIG,BIG)
ELG(J)=IBIG
187C ANY=100C.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)=ELG(J)-TNS*SIG
NFNN(J)=ELG(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 /IX,2110,3E14.7)
768 CCNTINUE
C CHECK-CUT ESTIMATED FITTING LIMITS.
IF(IN-1)56,56,766
766 IIN=IN-1
DC 765 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 (3,15CC)
1500 FCRPAT (IH1,43X,31HCL'CREPT PHTCPEAK FITTING DATA ///
15001 6X,8FLCCAT1CN,15X,3P'N'CU,16X,12P'ULSE-HEIGHT,10X, 18H'STANDARD
15002 DEVIATION,14X,4H'AREA, 19F CHANNEL TC CHANNEL,10X,5F(MEV),18X,
15003 10F(CHANNELS),15X,10H(CHANNELS),14X,13H(CCOUNTS/TIME)///
DC 100 J=1,IN
NS=ASS(J)
NFN=NFNN(J)
ENY=EL(J)
VENY=EUG(J)
C STORE PEAK(J) CF SPECTRUM FM(I) IN SLINE(I).
DC 760 I=1,200
760 SLINE(I)=0.C
DC 761 I=NS,NFN
761 SLINE(I)=FM(I)
C
C FIT PEAK FROM NS TC NFN.
C
CALL STCFIT (SLINE,NFN,E,NS,PP,ENY)
C
SUBTRACT THE DETERMINEE PEAK FROM NS TO NFN.
DC 46 I=NS,NFN
FM(I)=FM(I)-PP(I)
IF(FM(I))47,48,48
47 FM(I)=0.0
48 CCNTINUE
46 CCNTINUE
C
C DETERMINE THE CCNTINUUM ASSOCIATED WITH A PEAK OF AREA = UNITY FOR
C ENERGY = ENY, AND CF PULSE-HT. = ICC CHAN. GAIN CHANGE PER B(1)
C AND MULTIPLY BY B(3) AND FINALLY SUBTRACT IT FROM FM(I). ALSO DETERM.
C THE PHTCFRACTION TC CALC PHTCN FLUX.
DC 99 I=1,200
99 PP(I)=0.0
WRITE (3,16CC) NS,NFN,ENY,B(1),B(2),B(3)
1600 FCRPAT (IH ,2X,13,8X,13,E22.7,3E25.7)
C
CALL PHCFRA (RM,NP,EM,ELIMIT,NGC,NGR,NDEGRE,G,PV,PFRACT,K,C
1,ENY,PP)
C
DC 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,200
854 PP(I)=C.C
SUM=C.0
DC 959 I=1,100
599 SUM=SUM+PP(I)
PHCT(J)=1.0/(1.0+SUM)
NX=1CC
GAINB1=8(1)
C WRITE (3,19777) NP,EM,ELIMIT,SUM,PHOT(J),(PP(I),I=1,200)
C9777 FCRPAT (10H SINGLE 3 /IX,110,4E14.7/(IX,5E14.7))
C
C CALL GANE(C.C,NX,IOC.C,GAINB1,C.C,PP)
C
IF(NX-200)18CC,1801,1801
1801 NX=199
1800 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
1100 CCNTINUE
C WRITE (3,800) NX,GAINB1,(FM(I),I=1,200),(PP(I),I=1,200)
C 800 FCRPAT (10H SINGLE 3A ,110,4E14.7/(IX,5E14.7))
C
C FM(I) NCH WITHCLT PEAK J AND ASSCC CCNTINLUM. PHCT ABCVE IS PHCTCFRT
C NCH IS LINE SPECTRUM AREA AT CHANNEL CORRESPONDING TC ENY (CR EU(J))
C AND VENV (CR EUG(J)).
C
PHCT(J)=B(3)/PHCT(J)
C
A=EFFIC(ENY,NGE,NDEGRE,IIST,RX,HT)
BEE=AIRABS(ENY,NGA,NDEGRE,DIST)
C=PERSPX(ENY,NGX,NDEGRE,TKLUC)
D=CLAC(ENY,NGC,NDEGRE)
C WRITE (3,19888) A,BEE,C,D,PHCT(J)
C9888 FCRPAT (10H SINGLE 4 /IX,5E14.7///)
100 CCNTINUE
NGE=1
NX=NCX
RETURN

```

```

E'D
$1EFTC SCLN      DECK,REF,LIST
SUBROUTINE SCLN (R,EPS,N,IT,ITMAX,P,PHI,E,NS,NGC,NDEGRE,ETA,K,CIF,
1 M,DCIST,RX,NGA,NGC,MSKIF,NGX,TKLUC,ELIMIT)
C***** PRGGRAM NUMBER - 26   CUBEC-2 *****
C
C CALLED BY *MAIN*
C CALLS *CLAC* - *RESMAT* - *AIRABS* - *EFFIC* - *PERSPX*
C DETERMINES AND APPLIES DETECTOR EFFICIENCY VECTOR.
C
CCMCMN /A/ CI,H,MF
DIMENSION P(200),R(40,4C),PHI(20C),ETA(20C),E(200),CIF(100),M(18)
IF(K)50,30,5C
30 K=1
50 KK=K-1
IF(KK-1)601,6C2,6C2
602 DC 600 I=1,KK
600 P(I)=C.C
601 CONTINUE
IF(MF)11,1,11
1 CALL RESMAT (R,EPS,N,IT,ITMAX,P,PHI,K,CIF,M)
11 IF(DIST-DI)3,40,3
40 IF(MSKIP)3,4,3
3 NGO=1
WRITE (3,3CCC)
3000 FCRMAT (1H1,50X,18HEFFICIENCY FACTORS /// 8X,5HINDEX,14X,
30001 6HENERGY,15X,3FAIR,15X,8FCLAIDING,13X,6HLUCITE,13X,7HCRYSTAL/
30002 27X,5H(MEV),12X,11FATTENLATICN,9X,11HATTENUATICN,9X,
30003 11FATTENUATION,9X,10FEFFICIENCY//)
DC 2 I=NS,N
Q=E(I)
ETA(I)=EFFIC (Q,NGC,NDEGRE,DCIST,RX,H)
G=AIRABS (Q,NGA,NDEGRE,DCIST)
ABSCR= PERSPX(Q,NGX,NDEGRE ,TKLUC)
CAN=CLAC(Q,NGC,NDEGRE)
WRITE (3,1000) I,G,G,CAN,ABSCR,ETA(I)
1000 FORMAT (1H ,8X,I3,4X,5E2C.7)
2 ETA(I)=ETA(I)*CAN
NGC=1
DI=DCIST
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)99,100,10C
100 WRITE (3,105) (CIF(I),I=1,IT)
105 FORMAT (1H1,36H FLUX FITTING DIFFERENCES (IT=ITMAX)/(1X,5E14.7))
RETURN
99 DC 9599 I=NS,N
5599 PHI(I)=P(I)/ETA(I)
RETURN
END
$IRFTC STDF DECK,REF,LIST
SUBROUTINE STDFIT (Y,NFA,B ,NS,PP,ENY)
C***** PROGRAM NUMBER - 27 CUBED-2 *****
C
C CALLED BY *REGEN* - *SINGLE*
C CALLS *GUESS* - *FUNUS*
C NCN-LINEAR REGRESSION ANALYSIS OF STANDARD SPECTRA PHOTOCPEAKS.
C
DIMENSION FC(200),Y(200),B(5),P(200),A(200,5),G(6,6),PP(200)
EPS=.00001
L=B(3)
DC 100 I=1,5
100 B(I)=C.C
B(3)=L
KLM=5
NBC=5
PIE=3.14159265
NB=KLM
NF=NFN
NI=1C
L=0
FITLM1=C.0
C
C CALL GUESS TO INITIALIZE PARAMETERS.
C CALL FUNCTION TO BE FITTED.
CALL GUESS (NS,NF,Y,B,ENY)
FIT=C
5 CALL FUNUS (FIT,FC,Y,B,F,A,NF, NS,PP,ENY)
C CONSTRUCT THE NORMAL EQUATIONS.
NN=NBC
M=NN+1
DC 21 I=1,NN
G(I,M)=C.C
DC 21 J=NS,NF
21 G(I,M)=G(I,M)+A(J,I)*FC(J)/Y(J)
DC 22 I=1,NN
DC 22 K=1,NN
```



```

G(I,K)=C.C
DC 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.
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,1C
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 CONTINUE

C FIT ARRESTING CHECK.
L=L+1
IF(L-1)29,29,28
26 IF(ABS(FITL1-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)
FITL1=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 COMPLETE. C. COLLATE CORRELATION MATRIX.
42 CONTINUE
RETURN
END

$IEFTC TA DECK,REF,LIST
SUBROUTINE TA (E,X,M,MM,MCX,MLN,Z,Y,R,NDEGRE,L,LL)
C***** PROGRAM NUMBER - 28 CUBED-2 *****
C
C CALLED BY *EFFIC* - *PERSPX* - *CLAD* - *AIRABS*
C CALLED BY *DCSE* - *PULSE* - *RAXEL* - *PHCFRA*
C BINARY TABLE SEARCHING PROGRAM.

```

```

DIMENSION X(45),Z( 6),Y( 6),R(45)
MCX=M
MLN=MM
7 KDEL=(MCX-MLN)/2
8 IF(KDEL)18,14,18
18 KP=MLN+KDEL
IF(X(KP)-E)12,12,11
11 MCX=KP
GC TC 7
12 IF(E-X(KP))24,24,13
13 MLN=KP
GC TC 7
24 MLN=KP
MCX=KP+1

```

C

```

14 IF(MCX-1)4,5,4
5 L=MLN-2
GC TC 6
4 L=MLN-1
6 NN=NDEGRE+1
IF(LL)15,2,15
2 DC 3 I=1,NN
J=I+L
Z(I)=X(J)
3 Y(I)=R(J)
15 RETURN
END

```

```

$IRFTC 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 *CCSE* - *PULSE* *AXEL* - *PHCFRA*

C N-DEGREE LAGRANGIAN INTERPLAICN PROGRAM.

C

```

DIMENSION X( 6),Y(6)
S=0.
I=1

```

I=1

```

28 IF(I-N)21,21,22
21 P=Y(I)
J=1

```

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

```

J=1

```

28 IF(I-N)21,21,22
21 P=Y(I)
J=1

```

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

```

J=1

GC TC 27
24 S=S+P
I=I+1
GC TC 28
22 TE =S
RETURN
END

\$IBFTC VECT DFCK,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)

DC 1 I=N1,N2

IF(Y(I)-YMAX)3,3,4

4 YMAX=Y(I)

JMAX=I

3 CONTINUE

1 CCNTINUE

RETURN

END

APPENDIX IV
SAMPLE INPUT CARD DECK LISTING

DATA
 SAMPLE GSFC REF SPECTRA TO SPECTRA (SEPT 1967)
 0 0 0 0 7 8 0 0 0 0 0 0 0 15 0 0 18
 0 2 0 1.0 1.0 20.0 91.0
 .002 7
 7
 4.0
 110 1+3 12 48 1.7
 120 100 0 0 1.7
 130 105 0 0 1.7
 140 143 8 61 0.0
 110 143 0 0 0.0
 115 145 0 0 1.7
 115 150 -51 68 1.7

H6260	000608	001062	001000	001114	001087	001388	001418	001410	001439
M490	001447	001490	001605	001576	001742	001815	001955	002334	002707
M454	003015	002020	002309	002122	002252	002527	002699	002903	003151
C0109	000000	000900	012604	016503	017683	016260	013286	009910	007915
C5137	000400	004100	003105	002430	001947	001821	001822	001918	001937
SP67	001947	002100	002245	002269	002410	002588	002734	002997	003276
ZN65	003476	003600	003589	003391	003191	002962	002707	002338	002190
	001989	001701	001693	001580	001420	001467	001443	001426	001304
	001353	001300	001310	001435	001395	001329	001460	001516	001547
	001525	001529	001633	001647	001703	001726	001699	001817	001785
	001710	001639	001890	002056	001969	002089	002254	002307	002364
	002519	002087	003027	003557	004541	005928	008062	011030	014486
	024157	029507	034374	039219	042642	045461	046095	045349	043702
	030271	030541	024907	019769	015139	011064	007992	005387	003556
	001346	000851	000504	000370	000217	000200	000165	000159	000181
	000167	000140	000143	000127	000117	000149	000157	000155	000183
	000172	000099	000100	000135	000137	000119	000134	000124	000104
	000113	000104	000120	000093	000119	000106	000134	000077	000081
	000112	000130	000101	000114	000098	000104	000100	000110	000081
	000096	000104	000076	000122	000084	000121	000074	000075	000089
	000139	000502	002404	003697	003455	003240	003477	003602	003563
	003505	003520	003602	003744	003702	004127	003989	003979	003984
	004143	004154	004270	004304	004265	004350	004246	004522	004400
	004654	004705	004802	005277	005804	006162	006410	006153	006032
	005095	005003	004900	004824	004890	004845	004686	004718	004714
	004544	004525	004540	004647	004511	004513	004383	004467	004653
	004400	004429	004390	004596	004494	004605	004416	004560	004591
	004504	004502	004600	004709	004510	004493	004471	004645	004613
	004430	004700	004520	004697	004672	004791	004822	004870	004919
	005009	005001	005101	005200	005112	005133	005025	004924	004670
	004192	003702	003200	003053	002400	002188	001983	001816	001593
	001438	001501	001210	001107	001179	001075	001180	001169	001170

001323	001479	001343	001672	001850	002283	002832	003557	004833	006572
009166	012655	017922	022417	028037	033729	037895	039725	039435	036506
031730	025078	019470	013934	009131	005454	003148	001721	000868	000505
000264	000204	000104	000155	000140	000115	000139	000125	000133	000107
000150	000142	000122	000131	000123	000125	000112	000128	000117	000113
000112	000134	000100	000109	000113	000105	000126	000116	000116	000091
000110	000112	000098	000099	000091	000089	000095	000090	000088	000069
000085	000067	000090	000093	000087	000071	000081	000081	000084	000017
000020	000135	001120	001210	001194	001168	001292	001331	001334	001475
001402	001353	001440	001422	001290	001533	001378	001435	001560	001453
001525	001515	001520	001504	001519	001489	001602	001569	001694	001586
001575	001624	001640	001707	001730	002015	002216	002116	002325	002363
002250	002100	002001	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
001607	001732	001640	001659	001630	001747	001642	001797	001693	001691
001600	001753	001693	001772	001787	001744	001709	001721	001629	001725
001705	001703	001722	001709	001836	001771	001811	001732	001798	001873
001553	001620	001690	001950	001957	001970	001927	001924	001928	002040
001904	002020	001970	001943	001920	001813	001912	001611	001434	001273
001193	001010	000509	000833	000794	000671	000635	000581	000501	000491
000400	000471	000441	000399	000430	000417	000450	000415	000503	000525
000552	000594	000500	000740	000849	001035	001309	001824	002491	003372
004496	000524	007040	009982	011630	013579	014509	015011	014993	013735
011931	010030	007520	005479	003701	002360	001470	000857	000450	000247
000134	000009	000054	000035	000044	000042	000039	000033	000016	000027
000020	000030	000027	000036	000012	000028	000015	000027	000013	000029
000022	000013	000010	000026	000023	000018	000011	000020	000019	000006
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000908	001549	002001	004331	007142	012068	018729	027125	035659	042891
047119	048134	049440	053057	033251	026442	019945	014365	009956	006651
004183	002512	001320	000810	000457	000234	000130	000116	000085	000109
000062	000040	000020	000015	000015	000015	000015	000015	000015	000015
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000015	000015	000015	000015	000015	000015	000015	000015	000015	000015
000110	000118	000120	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
000100	000215	000250	000295	000332	000393	000538	000567	000752	000800
000919	001122	001310	001414	001549	001533	001573	001630	001771	001651
001030	001495	001405	001302	001211	001065	000831	000644	000560	000449
000350	000231	000102	000139	000069	000073	000042	000062	000112	999949
000041	000002	999905	999940	999950	999957	000017	999991	000026	999965
999971	000003	000001	999979	000002	999911	999975	000000	000024	000031
999998	000012	000014	000000	000050	999997	000040	000040	000030	999971

999900	999908	000031	000032	999970	000065	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	003357	003357	003145	003405	003267	003355	003396	003234
003313	003493	003365	003422	003442	003466	003543	003448	003522	003724
003795	003795	003991	004276	004509	004983	004952	004825	004519	004313
004159	004040	003833	003833	003929	003845	003721	003742	003724	003722
003790	003074	003050	003057	003547	003652	003736	003487	003651	003611
003505	003503	003422	003470	003447	003526	003567	003535	003502	003469
003361	003425	003501	003470	003491	003527	003589	003603	003610	003701
003778	003780	003761	003866	003825	003862	003834	003760	003637	003530
003075	002015	002602	002338	002072	001872	001624	001507	001353	001182
001161	001139	001124	001080	000965	000937	000940	000904	000937	000991
001000	001015	001004	001104	001257	001404	001518	001776	002033	002448
000059	004158	005519	007805	010762	014506	018734	023209	027615	031024
032593	030075	031240	027667	025137	017587	013084	008814	005726	003444
002031	001050	000559	000311	000150	000128	000108	000121	000132	000126
000160	000153	000155	000184	000171	000165	000159	000161	000161	000163
000155	000115	000095	000111	000080	000098	000078	000078	000067	000056
000059	000060	000062	000062	000070	000064	000073	000052	000065	000059
000067	000048	000045	000051	000067	000036	000056	000051	000057	000044
000065	000075	000062	000033	000040	000053	000041	000032	000032	000105
000182	000052	003013	011045	016213	006452	003215	003193	003400	003383
003401	003429	003480	003615	003563	003672	003667	003702	003709	003794
003883	003986	003323	003914	004031	004039	004026	003949	004214	004123
004293	004240	004124	004174	004270	004281	004266	004430	004725	004703
004850	004820	005427	005630	005908	006165	006169	005921	005656	005193
005019	004078	004821	004924	004000	004500	004515	004597	004357	004470
004522	004342	004400	004265	004227	004435	004281	004267	004368	004425
004452	004409	004410	004430	004612	004566	004708	004657	004576	004759
004594	004472	004400	004309	004134	003715	003268	003024	002788	002469
002172	002072	001903	001847	001802	001627	001565	001541	001544	001397
001391	001330	001370	001338	001401	001425	001430	001419	001409	001492
001528	001395	001374	001733	001791	001980	002208	002507	002973	003542
004551	000141	006489	011720	015719	020453	026002	031973	037932	042725
040713	048103	047057	044707	040347	034033	027069	020366	014561	009863
000404	003023	002315	001303	000050	000383	000264	000210	000173	000163
000172	000122	000122	000148	000142	000153	000150	000139	000149	000143
000140	000150	000155	000128	000145	000155	000133	000144	000138	000136
000120	000141	000142	000143	000130	000143	000116	000134	000127	000127
000124	000117	000110	000129	000120	000093	000112	000101	000112	000101
000079	000104	000092	000032	000109	000113	000106	000107	000084	000036
000000	000005	000201	003550	003300	003012	002911	002926	002901	003019
003020	003110	003017	003055	003171	003151	003015	003372	003304	003300
003451	003573	003594	004120	004514	004803	004566	003981	003903	003714
003757	003450	003500	003540	003529	003612	003454	003389	003384	003349

APPENDIX V
SAMPLE CODE OUTPUT LISTING

BRIEF DESCRIPTION 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) = 0 MPLOT(2) = 2 MPLOT(3) = -0 MPLOT(4) = -0 MPLOT(5) = 3

EM = 30.21148 CHANNELS/MEV

ELIMIT= 0.66200

ITERATIVE ERROR TOLERANCE, EPS = 0.00010

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

MAX NUMBER OF ITERATIONS, ITMAX= 91

NUMBER OF CHANNELS INPUT, N = 20

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



STANDARD SOURCE SPECTRAL PARAMETERS

7 SPECTRA IN STANDARD SOURCE DECK

CHANNELS ONE TO 6 ASSUMED AS REDUNDANT

REFERENCE COARSE GAIN = 4.00000

STANDARD SOURCE	PHOTOPEAK		X-RAY CR 0.5 PEAK		SHIFT SPECTRUM CHANNELS		PHOTOPEAK ENERGY
	FRCM	TO	FRCM	TO	SHIFT SPECTRUM 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	



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.	1546.
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.	1357.	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.	31560.
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.	55.	110.	88.	75.	85.	211.	184.	0.



STANDARD SOURCE SPECIFA

NB 95 SOURCE

2245.	3309.	3528.	3304.	3406.	3564.	3575.	3596.	3648.	3563.
3717.	3761.	3771.	4023.	4030.	3982.	3982.	4065.	4130.	4151.
4239.	4256.	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.	4557.	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.	4675.	4755.	4813.	4856.	4904.	4921.	5018.	5060.
5131.	5230.	5156.	5127.	5057.	4954.	4746.	4418.	4227.	3891.
3416.	3117.	2642.	2271.	2045.	1866.	1650.	1523.	1454.	1363.
1253.	1183.	1175.	1106.	1148.	1172.	1170.	1239.	1307.	1432.
1525.	1634.	1757.	2153.	2667.	3339.	4452.	6051.	8389.	11749.
15821.	20819.	26351.	32021.	36645.	39176.	39522.	37385.	33167.	27635.
21392.	15595.	10572.	6557.	3840.	2149.	1124.	64.	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.	53.	90.	93.	91.	89.	75.	79.	86.
89.	92.	85.	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.	1752.	1823.	1791.	1799.	1756.	1778.	1850.	1859.	1882.
1896.	1924.	1555.	1970.	1942.	1925.	1927.	2006.	2001.	2009.
1985.	1951.	1857.	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.	309.	168.	89.
59.	41.	41.	43.	40.	35.	21.	24.	26.	12.
21.	33.	15.	23.	19.	23.	17.	24.	24.	16.
16.	24.	24.	20.	6.	14.	19.	12.	6.	0.

STANDARD SOURCE SPECTRA

SR 85 SOURCE

3501.	9435.	14903.	5380.	4186.	3200.	3338.	3388.	3396.	3421.
3451.	3568.	3575.	3639.	3668.	3691.	3707.	3768.	3856.	3955.
3872.	3887.	3950.	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.	4657.	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.	1357.	1418.	1428.	1422.	1412.	1467.	1517.	1575.
1580.	1685.	1774.	1527.	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.	51.	61.	36.	0.

ZN65 SOURCE

186.	2427.	3377.	3124.	2941.	2921.	2908.	2584.	3020.	3087.
3047.	3065.	3145.	3157.	3056.	3265.	3324.	3301.	3427.	3545.
3840.	4074.	4358.	4716.	4637.	4157.	3926.	3771.	3744.	2542.
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.	2523.
3035.	3073.	3076.	3096.	3152.	3148.	3167.	3145.	3214.	3162.
3200.	3312.	3340.	3420.	3317.	3440.	3505.	3638.	3682.	3632.
3772.	3759.	3813.	3694.	3953.	3974.	3886.	3810.	3604.	3320.
2998.	2624.	2209.	1926.	1591.	1374.	1173.	1104.	996.	945.
917.	892.	901.	578.	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	0.124963E 03	0.517047E 01	0.5879692E 06
2	NB95	0.1359314E 03	0.3981012E 01	0.3861217E 06
3	MS4	0.1555815E 03	0.4208165E 01	0.1494891E 06
4	CD109	0.1283551E 03	0.714329E 01	0.3034849E 05
5	CS157	0.1308002E 03	0.4192102E 01	0.3391116E 06
6	SR85	0.1298391E 03	0.4522904E 01	0.5353141E 06
7	ZN65	0.1261401E 03	0.3202734E 01	0.145124E 06



NORMALIZED CONTINUUM CF STANDARD SPECTRA

HG203 SOURCE

0.3001899E-C2 0.3001899E-C2 0.3001899E-02 0.3001899E-02 0.3001899E-02 0.3001899E-02
 0.3017059E-C2 0.3036764E-02 0.3054984E-02 0.3155860E-02 0.3155860E-02 0.3184850E-02
 0.3213644E-C2 0.3224243E-C2 0.3275949E-02 0.3304820E-02 0.3333361E-02 0.3333361E-02
 0.3362408E-C2 0.3355853E-02 0.3424790E-02 0.3453584E-02 0.3482378E-02 0.3482378E-02
 0.3515837E-C2 0.3544760E-02 0.3573554E-02 0.3602348E-02 0.3635578E-02 0.3635578E-02
 0.3664730E-C2 0.3693523E-02 0.3722317E-02 0.3755725E-02 0.3784700E-02 0.3784700E-02
 0.3813493E-C2 0.3842287E-C2 0.3875669E-02 0.3904670E-02 0.3933463E-02 0.3933463E-02
 0.3962257E-C2 0.3955613E-02 0.4050168E-02 0.4117169E-02 0.4133522E-02 0.4133522E-02
 0.4422487E-C2 0.4725869E-02 0.4939677E-02 0.5311931E-02 0.5804819E-02 0.5804819E-02
 0.6428041E-C2 0.7010880E-02 0.7310795E-02 0.7670214E-02 0.7545024E-02 0.7545024E-02
 0.7084918E-C2 0.6548539E-02 0.5794387E-02 0.5028832E-02 0.4518692E-02 0.4518692E-02
 0.4015482E-C2 0.3738571E-C2 0.3564910E-02 0.3256520E-02 0.3096008E-02 0.3096008E-02
 0.3074876E-C2 0.2967855E-02 0.2846444E-02 0.2884011E-02 0.2882702E-02 0.2882702E-02
 0.2875835E-C2 0.2981582E-C2 0.2893704E-02 0.3047006E-02 0.3217575E-02 0.3217575E-02
 0.3260675E-C2 0.3248937E-C2 0.3418178E-02 0.3499633E-02 0.3549884E-02 0.3549884E-02
 0.3638299E-C2 0.3657016E-02 0.3796687E-02 0.3736783E-02 0.3791875E-02 0.3791875E-02
 0.3976453E-C2 0.4077807E-C2 0.4216124E-02 0.4273811E-02 0.4570131E-02 0.4570131E-02
 0.4621701E-C2 0.4555818E-02 0.4409373E-02 0.4088770E-02 0.3727528E-02 0.3727528E-02
 0.3404116E-C2 0.3187299E-02 0.3304224E-02 0.3194825E-02 0.3518175E-02 0.3518175E-02
 0.4008361E-C2 0.3462729E-02 0.2897355E-02 0.2269576E-02 0.4884199E-03 0.4884199E-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

NB95 SOURCE

0.1258448E-01	C.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	0.1366262E-01
0.1418147E-01	0.1402471E-01	0.1416334E-01	0.1448606E-01	0.1470177E-01	0.1470177E-01
0.1503353E-01	0.1508265E-01	0.1517868E-01	0.1540702E-01	0.1565864E-01	0.1565864E-01
0.1605827E-01	0.1653546E-01	0.1724803E-01	0.1898113E-01	0.2095970E-01	0.2095970E-01
0.2219846E-01	0.2163867E-01	0.2027831E-01	0.1820437E-01	0.1751568E-01	0.1751568E-01
0.1712665E-01	C.1714450E-01	0.1683336E-01	0.1658908E-01	0.1652777E-01	0.1652777E-01
0.1620685E-01	0.1556374E-01	0.1611031E-01	0.1608083E-01	0.1579835E-01	0.1579835E-01
0.1560486E-01	C.1604970E-01	0.1576473E-01	0.1567779E-01	0.1556046E-01	0.1556046E-01
0.1578438E-01	0.1600458E-01	0.1580282E-01	0.1600299E-01	0.1612654E-01	0.1612654E-01
0.1615940E-01	0.1624755E-01	0.1640275E-01	0.1601258E-01	0.1579477E-01	0.1579477E-01
0.1610708E-01	0.1626855E-01	0.1557374E-01	0.1631588E-01	0.1625974E-01	0.1625974E-01
0.1643591E-01	0.1676577E-01	0.1701351E-01	0.1721942E-01	0.1741331E-01	0.1741331E-01
0.1774383E-01	C.1803020E-01	0.1832996E-01	0.1809176E-01	0.1780084E-01	0.1780084E-01
0.1716569E-01	0.1596864E-01	0.1474581E-01	0.1297342E-01	0.1129270E-01	0.1129270E-01
0.9069095E-02	0.7604239E-02	0.6709094E-02	0.5706770E-02	0.5229423E-02	0.5229423E-02
0.4829141E-02	0.4325615E-02	0.4147911E-02	0.3945987E-02	0.4076497E-02	0.4076497E-02
0.4120238E-02	C.4386453E-02	0.4784233E-02	0.5216551E-02	0.5632656E-02	0.5632656E-02
0.6211657E-02	0.7047528E-02	0.7383105E-02	0.7097974E-02	0.5746579E-02	0.5746579E-02
0.3536736E-02	C.7400135E-03	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02
0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02
0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02
0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02	0.0000000E-02

NORMALIZED CONTINUUM OF STANDARD SPECTRA

MN54 SOURCE

0.1387430E-01	0.1287430E-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	0.1658497E-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	0.1932306E-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	0.1756826E-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	0.1836544E-01	0.1899914E-01	0.1943717E-01	0.1972411E-01
0.20222261E-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	0.5532646E-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	0.7561141E-02	0.8915246E-02	0.9235230E-02
0.7340014E-02	0.5213717E-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

CS137 SOURCE

0.1234286E-C1	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01	0.1234286E-01
0.1234286E-C1	0.1234286E-01	0.1226760E-01	0.1226760E-01	0.1252457E-01	0.1252457E-01	0.1254770E-01	0.1254770E-01	0.1254770E-01	0.1254770E-01
0.1270585E-C1	0.1266437E-01	0.1272603E-01	0.1272603E-01	0.1297844E-01	0.1297844E-01	0.1280266E-01	0.1280266E-01	0.1280266E-01	0.1280266E-01
0.1269020E-C1	0.1335824E-01	0.1311128E-01	0.1311128E-01	0.1324940E-01	0.1324940E-01	0.1339473E-01	0.1339473E-01	0.1339473E-01	0.1339473E-01
0.1353474E-C1	0.1346878E-01	0.1424770E-01	0.1424770E-01	0.1463246E-01	0.1463246E-01	0.1504248E-01	0.1504248E-01	0.1504248E-01	0.1504248E-01
0.1624653E-C1	0.1733829E-01	0.1917318E-01	0.1917318E-01	0.1875151E-01	0.1875151E-01	0.1734591E-01	0.1734591E-01	0.1734591E-01	0.1734591E-01
0.1635465E-C1	0.1573455E-01	0.1491356E-01	0.1491356E-01	0.1506597E-01	0.1506597E-01	0.1496149E-01	0.1496149E-01	0.1496149E-01	0.1496149E-01
0.1443830E-C1	0.1441241E-01	0.1435985E-01	0.1435985E-01	0.1455510E-01	0.1455510E-01	0.1414849E-01	0.1414849E-01	0.1414849E-01	0.1414849E-01
0.1409154E-C1	0.1380193E-01	0.1412696E-01	0.1412696E-01	0.1400490E-01	0.1400490E-01	0.1386581E-01	0.1386581E-01	0.1386581E-01	0.1386581E-01
0.1392185E-C1	0.1374791E-01	0.1341698E-01	0.1341698E-01	0.1334748E-01	0.1334748E-01	0.1338878E-01	0.1338878E-01	0.1338878E-01	0.1338878E-01
0.1368589E-C1	0.1366557E-01	0.1347617E-01	0.1347617E-01	0.1317911E-01	0.1317911E-01	0.1314128E-01	0.1314128E-01	0.1314128E-01	0.1314128E-01
0.1347360E-C1	0.1343646E-01	0.1355702E-01	0.1355702E-01	0.1382554E-01	0.1382554E-01	0.1390719E-01	0.1390719E-01	0.1390719E-01	0.1390719E-01
0.1413577E-C1	0.1452474E-01	0.1455735E-01	0.1455735E-01	0.1472721E-01	0.1472721E-01	0.1479057E-01	0.1479057E-01	0.1479057E-01	0.1479057E-01
0.1486919E-C1	0.1464547E-01	0.1416041E-01	0.1416041E-01	0.1329505E-01	0.1329505E-01	0.1143125E-01	0.1143125E-01	0.1143125E-01	0.1143125E-01
0.1031257E-C1	0.8582497E-02	0.7706467E-02	0.7706467E-02	0.6641262E-02	0.6641262E-02	0.5838954E-02	0.5838954E-02	0.5838954E-02	0.5838954E-02
0.5012905E-C2	0.4514754E-02	0.4407683E-02	0.4407683E-02	0.4298208E-02	0.4298208E-02	0.3960443E-02	0.3960443E-02	0.3960443E-02	0.3960443E-02
0.3643855E-C2	0.3598062E-02	0.3541756E-02	0.3541756E-02	0.3752818E-02	0.3752818E-02	0.3960443E-02	0.3960443E-02	0.3960443E-02	0.3960443E-02
0.3937022E-C2	0.4133906E-02	0.4735435E-02	0.4735435E-02	0.5328205E-02	0.5328205E-02	0.5789937E-02	0.5789937E-02	0.5789937E-02	0.5789937E-02
0.6134154E-C2	0.6039807E-02	0.5566527E-02	0.5566527E-02	0.4207013E-02	0.4207013E-02	0.2515244E-02	0.2515244E-02	0.2515244E-02	0.2515244E-02
0.7202175E-C3	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.

NORMALIZED CONTINUUM OF STANDARD SPECTRA

SR 85 SOURCE

0.8095993E-02	C.8095993E-02	0.8095993E-02	0.8095993E-02	0.8095993E-02	0.8095993E-02
0.8170109E-02	C.8237149E-02	0.8318347E-02	0.8520440E-02	0.8673871E-02	0.8673871E-02
0.8840605E-02	C.8922804E-02	0.8978930E-02	0.9155596E-02	0.9441186E-02	0.9441186E-02
0.9472658E-02	C.9435670E-02	0.9720164E-02	0.9782292E-02	0.9669921E-02	0.9669921E-02
0.1002622E-01	C.1016216E-01	0.1031127E-01	0.1011198E-01	0.1016296E-01	0.1016296E-01
0.1034767E-01	C.1037358E-01	0.1075506E-01	0.1133493E-01	0.1159423E-01	0.1159423E-01
0.1205833E-01	C.1213828E-01	0.1397157E-01	0.1471862E-01	0.1481743E-01	0.1481743E-01
0.1418141E-01	C.1310715E-01	0.1220455E-01	0.1183621E-01	0.1183082E-01	0.1183082E-01
0.1134523E-01	C.1097581E-01	0.1103774E-01	0.1078946E-01	0.1081530E-01	0.1081530E-01
0.1078613E-01	C.1063875E-01	0.1040242E-01	0.1043585E-01	0.1052764E-01	0.1052764E-01
0.1039517E-01	C.1058869E-01	0.1074603E-01	0.1073024E-01	0.1070983E-01	0.1070983E-01
0.1091420E-01	C.1109834E-01	0.1131976E-01	0.1125116E-01	0.1133309E-01	0.1133309E-01
0.1122275E-01	C.1085419E-01	0.1059722E-01	0.1014793E-01	0.8991553E-02	0.8991553E-02
0.7856541E-02	C.7070214E-02	0.6060113E-02	0.5309194E-02	0.4852520E-02	0.4852520E-02
0.4522757E-02	C.4280451E-02	0.3533396E-02	0.3768729E-02	0.3670475E-02	0.3670475E-02
0.3434204E-02	C.3307270E-02	0.3351628E-02	0.3380362E-02	0.3422320E-02	0.3422320E-02
0.3460251E-02	C.3440674E-02	0.3503217E-02	0.3663348E-02	0.3816483E-02	0.3816483E-02
0.3940254E-02	C.4181537E-02	0.4557590E-02	0.4539033E-02	0.5274551E-02	0.5274551E-02
0.5358812E-02	C.5288631E-02	0.5225550E-02	0.5353199E-02	0.4082708E-02	0.4082708E-02
0.2557951E-02	C.1204308E-02	0.4835844E-03	0.4639058E-03	0.3553561E-03	0.3553561E-03
0.	C.	0.	0.	0.	0.
0.	C.	0.	0.	0.	0.
0.	C.	0.	0.	0.	0.
0.	C.	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	0.1828556E-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	0.2228268E-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	0.2021255E-01	0.1997858E-01	0.2010962E-01
0.2020123E-01	0.2031750E-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	0.2193535E-01	0.2220069E-01	0.2212455E-01	0.2284791E-01
0.2331964E-01	0.2347165E-01	0.2357758E-01	0.2430230E-01	0.2535138E-01
0.2543293E-01	0.2587458E-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	0.1467256E-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	0.6928655E-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 0.5306 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

F

REPONSE MATRIX ENERGY INTERVAL MIDPOINTS IN MEV

0.0165 0.07656 0.0827 0.1190 0.1469 0.1820 0.2151 0.2432 0.2713 0.3144
0.3475 0.3806 0.4137 0.4408 0.4779 0.5130 0.5461 0.5792 0.6123 0.6454

PULSE-HEIGHT IN CHANNELS (MIDPOINTS)

0.54 1.62 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



LI
MULTIPLIER

OF CHANNELS
PER SPECTRUM

OF PULSES
PER SPECTRUM

OF HALF-LIFE
PER SPECTRUM

OF HALF-LIFE
PER SPECTRUM

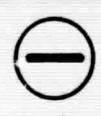
OF HALF-LIFE
PER SPECTRUM

OF HALF-LIFE
PER SPECTRUM

OF HALF-LIFE
PER SPECTRUM

TL204 1.0000 0.7060 2.5400 0.2051E 07 1 130 0.5263E 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 MULTIPLIER	BACKGROUND MULTIPLIER
121.290	-10.070 0.	3.000	0.00	2.00	130.000	0.6620	0.	0.	0.



ITERATING OUTPUT ON ITERATION LOOPS NUMBERED BELOW

1	2	3	4	5
6	7	4	12	15
20	25	35	50	60
30	-0	-0		



ENERGIES IN MPV OF UNKNOWN PEAKS

0.0700 -0. -0. -0.

-150-



FISCHER PHOTOPeAK FITTING DATA

LOCATION CHANNEL TO CHANNEL	ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
11 20	0.700000E-01	0.142513E 02	0.159101E 01	0.940088E 06



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

0.1215001E C6 C.2769383E 06 0.2844746E 06 0.2231406E C6 0.2345895E C6
0.2129145E C6 C.1892125E C6 0.1608925E 06 0.1294570E 06 0.9915600E C5
0.7295350E C5 C.5159351E C5 C.3548051E 05 0.2390751E 05 0.1534801E C5
0.9640005E C4 0.58105C4E 04 0.3434502E 04 0.1987002E 04 0.1553000E 04



NORMALIZED INPLT SPECTRLM

0.5641E-01	C.1286E-00	0.1341E-00	0.1036E-00	0.9355E-01	0.8744E-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	0.2693E-02	0.1594E-02	0.9225E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	1						
0.5641E-01	0.1286E-00	0.1341E-00	0.1036E-00	0.9355E-01	0.8744E-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	0.2693E-02	0.1594E-02	0.9225E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	1						
0.5628E-01	0.1356E-00	0.1424E-00	0.1163E-00	0.1103E-00	0.9153E-01	0.7940E-01	0.6343E-01	0.3510E-01
0.2463E-01	0.1665E-01	0.1095E-01	0.7072E-02	0.4385E-02	0.2647E-02	0.1543E-02	0.8859E-03	0.5058E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	2						
0.3305E-01	0.1184E-00	0.1205E-00	0.8224E-01	0.1078E-00	0.1066E-00	0.9719E-01	0.8757E-01	0.7461E-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
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	2						
0.7374E-01	0.1229E-00	0.1370E-00	0.1111E-00	0.1140E-00	0.1017E-00	0.9002E-01	0.7581E-01	0.6074E-01
0.3400E-01	0.2401E-01	0.1647E-01	0.1108E-01	0.7115E-02	0.4435E-02	0.2688E-02	0.1533E-02	0.9610E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	3						
0.2529E-01	0.1146E-00	0.1151E-00	0.8605E-01	0.1030E-00	0.1036E-00	0.9483E-01	0.8483E-01	0.7383E-01
0.4640E-01	0.3437E-01	0.2485E-01	0.1744E-01	0.1153E-01	0.7672E-02	0.4735E-02	0.2881E-02	0.1602E-02
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	3						
0.6483E-01	0.1287E-00	0.1324E-00	0.1051E-00	0.1097E-00	0.9914E-01	0.8807E-01	0.7475E-01	0.6014E-01
0.3387E-01	0.2395E-01	0.1647E-01	0.1110E-01	0.7125E-02	0.4472E-02	0.2656E-02	0.1590E-02	0.9545E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	4						
0.2200E-01	0.1145E-00	0.1149E-00	0.8464E-01	0.1023E-00	0.1032E-00	0.9459E-01	0.8661E-01	0.7378E-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
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	4						
0.6146E-01	0.1285E-00	0.1320E-00	0.1039E-00	0.1091E-00	0.9833E-01	0.8787E-01	0.7465E-01	0.6010E-01
0.3387E-01	0.2395E-01	0.1647E-01	0.1110E-01	0.7125E-02	0.4474E-02	0.2693E-02	0.1588E-02	0.9441E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	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
0.4639E-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
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	5						
0.5965E-01	0.1285E-00	0.1322E-00	0.1037E-00	0.1085E-00	0.9985E-01	0.8765E-01	0.7464E-01	0.6010E-01
0.3387E-01	0.2395E-01	0.1647E-01	0.1110E-01	0.7126E-02	0.4474E-02	0.2659E-02	0.1589E-02	0.9365E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	6						
0.4639E-01	0.1145E-00	0.1149E-00	0.8448E-01	0.1021E-00	0.1032E-00	0.9456E-01	0.8662E-01	0.7378E-01
0.5965E-01	0.1286E-00	0.1321E-00	0.1036E-00	0.1089E-00	0.9835E-01	0.8784E-01	0.7469E-01	0.6010E-01
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	7						
0.1330E-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
0.4639E-01	0.3435E-01	0.2483E-01	0.1744E-01	0.1154E-01	0.7613E-02	0.4728E-02	0.2918E-02	0.1474E-02
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	7						
0.5786E-01	0.1286E-00	0.1321E-00	0.1026E-00	0.1089E-00	0.9985E-01	0.8784E-01	0.7470E-01	0.6010E-01
0.3387E-01	0.2395E-01	0.1647E-01	0.1110E-01	0.7126E-02	0.4475E-02	0.2659E-02	0.1591E-02	0.9291E-03
INTERMEDIATE ITERATING	CLIPUT (IT, MN, AND PFI(1))	7						
0.5746E-01	0.1285E-00	0.1321E-00	0.1036E-00	0.1089E-00	0.9855E-01	0.8784E-01	0.7470E-01	0.6010E-01
0.3387E-01	0.2395E-01	0.1647E-01	0.1110E-01	0.7126E-02	0.4475E-02	0.2659E-02	0.1591E-02	0.9291E-03

IT, SU, TERM R C.2153954E C7 C.3731466E-C4



INDEX	ENERGY (MEV)	AIP ATTENUATION	GLASSING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY
1	C.165000E-01	0.757165E 00	0.295533E 00	0.536296E 00	0.953493E 00
2	C.496500E-01	C.665091E 00	0.324372E 00	0.362533E 00	0.959573E 00
3	C.827500E-01	C.574569E 00	C.555068E 00	0.305185E 00	C.598252E 00
4	C.115850E-00	C.578914E 00	0.461681E 00	0.450203E 00	0.795833E 00
5	C.148950E-00	C.578672E 00	0.465173E 00	0.466914E 00	0.792336E 00
6	C.182050E-00	0.480181E 00	C.463074E 00	0.502851E 00	0.958386E 00
7	C.215150E-00	C.481353E 00	C.470132E 00	C.507742E 00	C.983348E 00
8	C.248250E-00	0.582278E 00	0.571613E 00	0.511841E 00	0.976773E 00
9	C.281350E-00	C.483098E 00	0.475305E 00	0.515686E 00	0.967635E 00
10	C.314450E-00	0.583731E 00	0.474027E 00	0.518324E 00	0.956062E 00
11	C.347550E-00	0.584341E 00	0.474958E 00	0.521695E 00	0.943485E 00
12	C.380650E-00	0.584872E 00	0.475324E 00	0.524347E 00	0.931053E 00
13	C.413750E-00	0.495365E 00	0.576614E 00	0.526743E 00	C.918231E 00
14	C.446850E-00	0.485821E 00	0.577346E 00	0.528911E 00	C.905250E 00
15	C.475950E-00	0.582242E 00	0.478090E 00	C.493924E 00	0.892653E 00
16	C.513050E 00	0.586617E 00	0.478631E 00	0.532736E 00	0.881143E 00
17	C.546150E 00	C.585959E 00	C.479189E 00	0.534383E 00	0.870674E 00
18	C.579250E 00	0.487277E 00	0.479700E 00	0.535957E 00	0.860926E 00
19	C.612350E 00	0.487531E 00	0.480148E 00	C.537461E 00	C.850679E 00
20	C.645450E 00	0.487865E 00	0.480545E 00	0.538894E 00	0.840552E 00



DIFFERENTIAL FLUX AT ITERATION NUMBER = 8

0.32010E C6	0.81308E C6	C.1C898E 07	0.21843E 06	0.26165E 06
0.26243E C6	C.23966E C6	0.21950E 06	0.13753E 06	0.15357E 06
0.11973E C6	C.89462F C5	C.65319E 05	0.46364E 05	0.31126E 05
0.20664E C5	C.12954E C5	C.8C649E 04	0.41121E 04	0.55655E 04

FITTING DIFFERENCES

0. C.51C6540E-01 0.4442097F-01 0.5356342E-02 0.8328452E-03
 0.2680052E-03 0.1051516E-03 0.447606CE-04



SINGLE SPECTRUM 20CHANNELS

21500. 276538. 284475. 223141. 234589. 212914. 189212. 160892. 129457. 99156.
72954. 51594. 35461. 23908. 15346. 9640. 5811. 3435. 1987. 1553.

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHCT/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	C.01655	0.3859599E 02	0.6453836E 00
2	0.04965	0.9905104E 02	0.4917884E 01
3	C.08275	0.1427603E 03	0.1098592E 02
4	C.11585	0.2661009E 02	0.3082779E 01
5	C.14855	C.3187450E 02	0.4747707E 01
6	C.18205	C.3197623E 02	0.5821272E 01
7	C.21515	0.2919635F 02	0.6281595E 01
8	C.24825	0.2673969E 02	0.6638128E 01
9	C.28135	0.2284566F 02	0.6427626E 01
10	C.31445	0.1370827E 02	0.5882815E 01
11	C.34755	0.1458572E 02	0.5069267E 01
12	C.38065	0.1089856E 02	0.4148536E 01
13	C.41375	C.7957311E 01	0.3292337E 01
14	0.44685	0.5648142E 01	0.2523872E 01
15	C.47555	C.3751840E 01	0.1819893E 01
16	C.51305	0.2517348E 01	0.1291525E 01
17	C.54615	0.1578055E 01	0.8618547E 00
18	C.57925	0.9824851E 00	0.5691045E 00
19	0.61235	0.5009457E 00	0.3067541E-00
20	C.64545	0.6780022E 00	0.4376165E-00



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/FLUR) = 0.1677103E-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) = 0.2047346E-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) = 0.3941607E-15

AT THE SOURCE CYLINDER

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) = 0.1595118E-11



EFFICIENCY VECTOR ETA

0.1237297F-00 C.7718713E 00 0.8182604E 00 0.8328859E CC 0.8407230E 00
0.8467567E 00 C.8498150E 00 0.850423F 00 0.8473865E 00 0.8417688E 00
0.8345550E CC C.8271482E 00 0.8189052E 00 0.8102365E 00 0.8015450E 00
0.7935496E CC 0.7862209E CC 0.7753887E 00 0.7719412E CC 0.7644863E 00



Partial output only for the remainder of this Appendix.

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 CNTRL NUMBERS

MPL0T(1) = C MPL0T(2) = 2 MPL0T(3) = -0 MPL0T(4) = -0 MPL0T(5) = 1

EM = 50.00000 CHANNELS/MEV

ELIMIT= 0.40000

ITERATIVE ERROR TOLERANCE, EPS = 0.00010

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

MAX NUMBER OF ITERATIONS, IIMAX = 51

NUMBER OF CHANNELS INPLT, N = 20

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

BETA SOURCE STRENGTH (CURIES) 1.0000
 SOURCE MAX BETA ENERGY (MEV) 0.4300
 SOURCE DIAMETER (CM.) 2.5400
 SOURCE HALF-LIFE (MINUTES) 0.1307E 07
 NUMBER OF PHA PUMS THIS SET 1
 NUMBER OF CHANNELS PER SPECTRUM 200
 HALF-LIFE MULTIPLIER 0.5260E 06

SOURCE CRYSTAL ANGLE AT SOURCE (DEGREES) 0.
 POLAR ANGLE 0.
 COUNTING DURATION (MINUTES) 20.000
 PHA COARSE COUNTS (CHANNELS) 140.0000
 MONITOR ENERGY (MEV) 0.2750
 SPECTRA ZERO SHIFT (CHANNELS) 0.
 BACKGROUND SIGNAL MULTIPLIER 0.

121.290 -10.000 0. 20.000 0.00 8.00 140.0000 0.2750 0. 0.

DISCRETE PEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL	ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
10	0.410000E-01	3.197321E 02	0.3035549E 01	0.8601531E 06

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	C.01000	0.2148339E 04	0.2148339E 02
2	C.03000	0.1340527E 02	0.4021582E-00
3	C.05000	C.1644938E 02	0.8224688E 00
4	0.07000	0.5186748E 01	0.3630724E-00
5	0.09000	0.5107092E 01	0.4596382E-00
6	C.11000	0.3452089E 01	0.3797298E-00
7	C.13000	C.2521226E 01	C.3277594E-00
8	C.15000	C.6473859E 00	C.5710848E-01
9	C.17000	0.2866600E-00	0.4873220E-01
10	C.19000	0.5505847E-01	0.1008111E-01
11	C.21000	0.1024705E-01	0.2151381E-02
12	C.23000	C.3357649E-02	C.7722592E-03
13	C.25000	0.5620725E-02	C.1405181E-02
14	C.27000	0.5491782E-02	0.1482781E-02
15	C.29000	0.4243794E-02	0.1230700E-02
16	0.31000	0.3642839E-02	0.1129280E-02
17	C.33000	C.2973029E-03	0.5810996E-04
18	C.35000	C.3606712E-04	0.1262349E-04
19	C.37000	C.2424264E-02	0.8965775E-03

INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (BREMS.) VALUES AT THE CRYSTAL

PHOTON NUMBER (PHOTONS/CM**2-SEC) = 0.2155493E 04
 PHOTON ENERGY (MEV/CM**2-SEC) = 0.2447332E 02
 PHOTON DOSE (ROENTGENS/HR) = 0.6757475E-02

AVERAGE ENERGY (MEV) = 0.1111524E-01

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) = 0.593373E-07
 PHOTON ENERGY / SOURCE EMITTED BETA ENERGY (MEV/CM**2-SEC)/(MEV) = 0.1081014E 03
 PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC) = 0.6595451E-05
 PHOTON DOSE / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC) = 0.1926345E-12
 PHOTON DOSE / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME ((R/HR)/(BETA/SEC)/(CM**3)) = 0.141503E-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 C0 0.7730908E 00 0.8075965E 00 0.8224220E 00
0.8312413E CC C.8365553E C0 0.8409227E 00 0.8448972E C0 0.8477449E 00
0.8494961E CC C.8503553E C0 0.8455492E 00 0.8487387E 00 0.8460431E 00
0.8425711E CC C.8386205E C0 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) = 0 M(15) = 0 M(16) = 16 M(17) = 0 M(18) = 18

CALCOMP PLOTTING OPTION CONTROL 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, UJSC = 1 MV = 0

MAX NUMBER OF ITERATIONS, ITMAX= 51

NUMBER OF CHANNELS INPUT, N = 20

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

REPONSE MATRIX ENERGY INTERVAL MIDPOINTS 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 (MIDPOINTS)

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) PHA PULSES 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 ANGLE AT SOURCE DISTANCE (CM.) POLAR AZIMUTH COUNTING DURATION (MINUTES) REFERENCE TIME (DAYS) PHA GAIN MONITOR PULSE HEIGHT (CHANNELS) MONITOR ENERGY (MEV) SPECTRA ZERO SHIFT (CHANNELS) BACKGROUND SIGNAL MULTIPLIER

60.325 10.000 - 30.000 2.000 0.00 1.00 95.0000 1.3300 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 0.7775000E C4 0.5612000E 04 0.4179000E 04 0.2983000E C4

NORMALIZED INPLT SPECTRUM

0.2139E-00 C.2814E-00 0.1815E-00 0.1100F-00 0.6357E-01 0.4439E-01 0.2999E-01 0.2048E-01 C.1410E-01 C.9836E-02
0.5975E-02 0.5013E-02 0.3013E-02 0.2614F-02 0.1920F-02 0.1385E-02 0.1065E-02 0.7690E-03 0.5726E-03 C.4037E-03
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 1
0.2139E-00 C.2814E-00 0.1815E-00 0.1100F-00 0.6357E-01 0.4439E-01 0.2999E-01 0.2048E-01 C.1410E-01 C.9836E-02
0.5975E-02 0.5013E-02 0.3013E-02 0.2614F-02 0.1920F-02 0.1385E-02 0.1065E-02 0.7690E-03 0.5726E-03 C.4037E-03
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 1
0.2598E-00 C.3060E-00 0.1822E-00 0.1007E-00 0.5758E-01 0.3357E-01 0.2074E-01 0.1259E-01 C.6478E-02 C.5564E-02
0.3794E-02 0.2457E-02 0.1700E-02 0.1173F-02 0.8234F-03 0.5677E-03 0.3960E-03 0.2788E-03 C.2028E-03 C.1295E-03
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 2
0.1759E-00 C.2597E-00 0.1806E-00 0.1203E-00 0.8407E-01 0.5959E-01 0.4337E-01 0.3228E-01 C.2344E-01 C.1757E-01
0.1314E-01 C.1004E-01 0.7640E-01 0.5825E-02 0.4477E-02 0.3340E-02 0.2866E-02 0.2121E-02 0.1617E-02 C.1290E-02
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 2
0.2269E-00 C.2924E-00 0.1904E-00 0.1155E-00 0.7276E-01 0.4702E-01 0.3128E-01 0.2130E-01 C.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 CUTPUT (IT, MN, AND PH(I)) 3
0.1657E-00 C.2485E-00 0.1723E-00 0.1146F-00 0.8039F-01 0.5701E-01 0.4158E-01 0.3104E-01 0.2252E-01 C.1652E-01
0.1265E-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 CUTPUT (IT, MN, AND PH(I)) 3
0.2146E-00 C.2810E-00 0.1617E-00 0.1102E-00 0.6965E-01 0.4506E-01 0.3004E-01 0.2051E-01 C.1413E-01 C.9511E-02
0.5997E-02 0.5020E-02 0.3627E-02 0.2624F-02 0.1927E-02 0.1377E-02 0.1060E-02 0.7656E-03 0.5761E-03 0.4057E-03
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 4
0.1651E-00 C.2492E-00 0.1721E-00 0.1144E-00 0.8030E-01 0.5693E-01 0.4152E-01 0.3059E-01 C.2246E-01 C.1688E-01
0.1263E-01 0.9656E-02 0.7387E-02 0.5645F-02 0.4348E-02 0.3262E-02 0.2894E-02 0.2115E-02 0.1591E-02 0.1332E-02
INTERMEDIATE ITERATING CUTPUT (IT, MN, AND PH(I)) 4
0.2139E-00 C.2812E-00 0.1815E-00 0.1100E-00 0.6956E-01 0.4495E-01 0.2999E-01 0.2047E-01 C.1410E-01 C.9835E-02
0.5976E-02 0.5007E-02 0.3015E-02 0.2615E-02 0.1920E-02 0.1390E-02 0.1063E-02 0.7694E-03 0.5742E-03 C.4076E-03
ITERATED SPECTRUM
0.2139E-00 C.2812E-00 0.1815E-00 0.1100E-00 0.6956E-01 0.4495E-01 0.2999E-01 0.2047E-01 C.1410E-01 C.9835E-02
0.5976E-02 0.5007E-02 0.3015E-02 0.2615E-02 0.1920E-02 0.1390E-02 0.1063E-02 0.7694E-03 0.5742E-03 C.4076E-03

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCIF ATTENUATION	CRYSTAL EFFICIENCY
1	0.550000E-01	0.5778627E 00	0.8483500E 00	0.8346675E CC	0.9596538E 00
2	0.1050000E-00	0.6881335E 00	0.9604082E 00	0.6878380E CC	0.6935709E CC
3	0.1750000E-00	0.9979426E 00	0.9675062E 00	0.6015528E CC	0.9750306E CC
4	0.2450000E-00	0.6911033E 00	0.9714756E CC	0.9114556E CC	0.6586511E 00
5	0.3150000E-00	0.6919011E 00	0.9740432E CC	0.5188737E CC	0.9309467E 00
6	0.3850000E-00	0.9524308E 00	0.9759332E 00	0.5246805E CC	0.9507574E CC
7	0.4550000E-00	0.6929763E 00	0.9775168E 00	0.5294218E CC	0.3716531E 00
8	0.5250000E 00	0.6933837E 00	0.6786375E CC	0.5333358E CC	0.8459187E 00
9	0.5950000E 00	0.6937254E 00	0.9799295E 00	0.9366778E CC	0.8243131E 00
10	0.6650000E 00	0.6940293E 00	0.5807800E CC	0.5356583E CC	0.8024574E CC
11	0.7350000E 00	0.6942714E 00	0.6816541E 00	0.6422524E CC	0.7861135E 00
12	0.8050000E 00	0.6945240E 00	0.9824473E 00	0.5445507E CC	0.7715785E 00
13	0.8750000E 00	0.6947331E 00	0.9830844E 00	0.5467351E 00	0.7561375E 00
14	0.9450000E 00	0.6949214E 00	0.5836682E 00	0.545056E CC	0.7429647E 00
15	0.1015000E 01	0.6950919E 00	0.9842085E 00	0.5501022E 00	0.7309423E 00
16	0.1085000E 01	0.6952401E 00	0.6847017E 00	0.5515678E CC	0.7202201E CC
17	0.1155000E 01	0.6953814E 00	0.5851690E 00	0.5529655E CC	0.7056657E 00
18	0.1225000E 01	0.6955157E 00	0.6856138E 00	0.5545080E 00	0.6953497E 00
19	0.1295000E 01	0.6956429E 00	0.6860272E 00	0.5555821E 00	0.6853441E 00
20	0.1365000E 01	0.6957632E 00	0.9864181E 00	0.5567917E CC	0.6797214E 00

DIFFERENTIAL FLUX AT ITERATION NUMBER = 5

0.17407E C7	0.21723E C7	0.14857E 07	0.59241E 06	0.70933E 06
0.51437E 06	0.38521E 06	0.27461E 06	0.21902E 06	0.16732E 06
0.12745F 06	0.55376E C5	0.77008E 05	0.59731E 05	0.46653E 05
0.35451E C5	0.21845E C5	0.25276E 05	0.17562E 05	0.15223E 05

FITTING DIFFERENCES

0. 0.34235C7E-C1 0.318925CE-U1 0.2337686E-02 0.4598432E-05

SINGLE SPECTRUM 20CHANNELS

60189.05335C.3244EE.FC3C73.507761.J23368.218880.149441.102892. 72153.

50905. 36542. 26365. 19078. 14013. 10109. 7775. 5612. 4179. 2983.

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	C.03500	U.316C791E 03	0.1113277E 02
2	C.10500	C.3569569E 03	0.4168047E 02
3	C.17500	U.2714834E 03	0.4750560E 02
4	C.24500	U.1813473E 03	0.4443009E 02
5	C.31500	C.1296195E 03	0.4083014E 02
6	C.38500	C.9410255E 02	0.3622948E 02
7	C.45500	C.7040966E 02	0.3203640E 02
8	C.52500	U.5363459E 02	0.2826315E 02
9	C.59500	U.3563958E 02	0.2370479E 02
10	C.66500	U.3057576E 02	0.2033288E 02
11	C.73500	U.2329009E 02	0.1711822E 02
12	C.80500	C.1615944E 02	0.1461835E 02
13	C.87500	U.1407150E 02	0.1231291E 02
14	C.94500	U.1091489E 02	0.1031457E 02
15	1.01500	U.8525122E 01	C.8652998E 01
16	1.08500	U.6478028E 01	C.7028660E 01
17	1.15500	C.5619239E 01	C.6721221E 01
18	1.22500	U.4308070E 01	U.5277385E 01
19	1.29500	C.3281831E 01	U.4249970E 01
20	1.36500	U.2781687E 01	U.3797002E 01

INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (UNEMISS.) VALUES AT THE CRYSTAL

PHOTON NUMBER (PHOTONS/CM**2-SEC) = 0.1683679E 04
 PHOTON ENERGY (MEV/CM**2-SEC) = 0.4152410E 03
 PHOTON DOSE (ROENTGENS/FLUX) = 0.6507740E-03

AVERAGE ENERGY (MEV) = 0.2471918E-00

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SFC)/(BETA/SEC) = 0.4551024E-07
 PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2-SEC)/MEV) = 0.6F23623E 03
 PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC) = 0.1124576E-07
 PHOTON DOSE / SOURCE EMITTED BETA NUMBER (F/HR)/(BETA/SEC) = 0.2259385E-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 (F/HR)/(BETA/SEC) = 0.2312665E-10

PHOTON DOSE / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/(CM**3)) = 0.1756654E-11

EFFICIENCY VECTOR STA

0.6921752E	CC	C.6371566E	CC	C.6454723E	CC	C.8412923E	CC	J.3262049E	CC
0.8067913E	CC	C.7863925E	CC	C.767709CE	CC	C.7516716E	CC	J.7363757E	CC
0.7229326E	CC	C.7120815E	CC	C.7500461E	CC	C.6896735E	CC	J.6301483E	CC
0.6716415E	CC	C.6631824E	CC	C.654842CE	CC	C.64665C7E	CC	J.6363034E	CC

BRIEF DESCRIPTION OF PHA PLAS
SAMPLE DATA FOR NASA-3SEC. NUS MODEL LINEAR TEST. (SEPT 11/67)

CONTROL NUMBERS
M(1) = 0 M(2) = 2 M(3) = 0 M(4) = 4 M(5) = 0 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
MPLDT(1) = -0 MPLDT(2) = -0 MPLDT(3) = -0 MPLDT(4) = -0 MPLDT(5) = -0

EM = 20.00000 CHANNELS/MEV

ELIMIT= 1.00000

ITERATIVE PROC TOLERANCE, EPS = 0.00010

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

MAX NUMBER OF ITERATIONS, ILMAX= 51

NUMBER OF CHANNELS INPLT, N = 20

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

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

SOURCE CRYSTAL ANGLE AT SOURCE (DEGREES) 0.0
 POLAR AZIMUTH 0.0
 COUNTING DURATION (MINUTES) 1.000
 REFERENCE TIME (DAYS) 0.0
 PFA GAIN 91.00
 MCALIBR PULSE HEIGHT (CHANNELS) 100.0000
 MONITOR ENERGY (MEV) 1.0000
 SPECTRA ZERO SHIFT (CHANNELS) 0.0
 BACKGROUND SIGNAL MULTIPLIER 0.0

100.000 0.0 1.000 0.0 91.00 100.0000 1.0000 0.0

L INFRARED SPECTRUM OF LUG 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.	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.

PHA SPECTRUM	CORRECTED F	EFFICIENCY			
0.22982E 06	C.43059E 03	C.40490E 03	0.47423E 04	0.57880E 03	
0.63833E 03	0.50112E 03	0.91442E 03	0.10254E 04	0.11427E 04	
0.12584E 04	0.13746E 04	0.14901E 04	0.16352E 04	0.17206E 04	
0.18351E 04	0.19459E 04	0.20650E 04	0.21806E 04	0.22965E 04	
0.24130E 04	0.25258E 04	0.26475E 04	0.27661E 04	0.28863E 04	
0.30063E 04	0.31249E 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	0.44165E 04	0.45515E 04	0.46876E 04	0.48248E 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	0.65354E 04	0.66836E 04	0.68325E 04	0.69801E 04	
0.71269E 04	0.72745E 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	0.89070E 04	0.85606E 04	0.91151E 04	0.92705E 04	
0.94232E 04	0.95859E 04	0.97437E 04	0.99013E 04	0.10053E 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	REGEN

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:

<u>NAME</u>	<u>COLUMN</u>	<u>FORMAT</u>	<u>DESCRIPTION, PURPOSE OR USE</u>
N	1-10	I10	The size of the response matrix, channels; ≤ 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
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
N'GR=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 RESPENSE MATRIX //34H ENERGY INTERVAL MIDPCINTS IN ME
2000)V / (10F7.4))
9876 FORMAT (/30H PULSE-HIEGHT IN CHANNELS / (10F8.3))
2020 FORMAT (//17H PHCICFRACTIONS / (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 Cs¹³⁷ or Mn⁵⁴. 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 Mn⁵⁴ 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.

```

$EALCUTE 10000
$JBOOB 60, SOURCE, PAR
$IBFIC MAIN DECK, REF, LIST
C IUS COMPACTION (STEY P)
C COLLECTOR TEMPORARY MAIN PROGRAM FOR DEBUGING SUBP. *PHOFPA*.
C
      I=100, N(40,50), J(50), PV(50), PFRACT(50)
      1 COLLECTOR
      REPEAT=0
      ELIMIT=1.0
      RECO=0
      ENER=
      LABEL/ELIMIT
      HGC=1
      NOK=1
      NDCR=2
      CALL PHOFPA (M, H, E, ELIMIT, HGC, HGR, IDEGRE, O, PV, PFRACT, K, MRPEAT)
      GO TO 1
      END
$IBFIC GAIN, FREQ, REF, LIST
SOURCELINE GAIN (FZ, HX, GAIN, RCGAIN, SMOOTH, C)
C***** PROGRAM NUMBER 6SFC-10 *****
C PROG 6.
C GAIN CHANGE TO PROGRAM (JUNE 4/64 VERSION) INCLUDES SMOOTHING.
      DIMENSION C(200), FM(200)
      NLI=11200
      IF (I2) 1000, 275, 1000
      1000 NZC=I2
      NRC=NX-1026
C
C INTEGER SHIFT IF *NZC* NOT EQUAL TO ZERO.
C
      IF (I2) 215, 910, 911
      910 NZC=NZC-1
      NS=ZC*(-1) + 1
      NS=NS-1
      NSJ=1
      NAB=NSK+10
      905 DO 950 I=NS, NAB
      K=I+ZC
      950 FB(I)=C(K)
      957 C(I)=FB(I)
      958 DO 950 I=NS, NAB
      911 NS=1

```

900 I=1

901 I=1

902 I=1

903 I=1

904 I=1

905 I=1

906 I=1

C DECREMENT SHIFT.

274 TVC=IJC

275 IJ=IJC

276 IJ=IJC

277 (IJC)271,272,271

278 IJ=IJC

279 C(I)=C(I) + C(2)*IJC

280 I=2, NAXON

281 C(I)=C(I)+DIJF + C(I+1)*LIF

282 C(NAXON+1)=C(NAXON+1)*DIJF + C(NY)

283 I=273

284 IF(IJZC)273,275,275

285 IJZC=I-1

286 IZ=0.

287 L=1

288 G=0AIN

289 DO 30 I=1, IMLIMIT

30 FM(I)=0.0

FMULT=0AIN/RGGAIN

C

C DEL=0.5 WHEN GAIN/RGGAIN=1./2. I.E. DOUBLING REQUIRED.

C DEL=2.0 WHEN GAIN/RGGAIN=2./1. I.E. HALVING REQUIRED.

C

1 DEL=GAIN/RGGAIN

IF(DEL-2.0)402, 204, 402

402 IF(DEL-0.5)3, 3, 4

3 L=L+1

GAIN=0AIN.*2.0

30 TO 1

C

C INITIALIZE FOR REDUCING ALGORITHM.

C

4 I=1

K=1

X=0.

```

XN=1.0
DELF=0.
GO DEL=EL
IF (DEL-1.0) 5, 499, 105
499 IF (L-1) 497, 498, 497
497 DEL=ROJ/DL.0
L=L-1
498 DO 499 I=1, IX
498 F*(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=RGAIN/2.0
DEL=GAIN/DELT
GO TO 500
500 GOX=J-4
DO 505 J=1, N0X, 2
I=J+1
505 C(I) = (3.0*C(J) + 6.0*C(J+2) - C(J+4))*0.125
C(I+2) = (3.0*C(I+3) + 6.0*C(I+1) - C(I-1))*0.125
IX=I+3
DO 930 I=2, IX
930 FM(I) = (C(I)+C(I-1))*0.5
FM(I) = C(I)*0.5
DO 935 I=1, IX
935 C(I) = FM(I)
GO TO 304

C
C REDUCTION ALGORITHM.
C
105 XK=DEL
DEL=XN-X
XK=XK
100 F*(K)=FM(K)+DEL*C(I)
112 XEA=DEL
IF (A-XK) 100, 107, 108
107 K=K+1
XJ=1
DEL=XN-X
XK=XK+XEA
GO TO 100
110 X=KX

```

```

DEL=MAX
100 IF(DEL-1.0)110,111,110
110 MIF=DEL-1.0
DEL=FL-DEL
GO TO 109
111 I=I+1
GO TO 100
202 GO 1999 IAX=1,MLIMIT
1999 C(IAX)=0.0
IAX=IX
IX=IAX/UL
NX=IX

```

C C LOCAL MOD CORRECTIONS IF *DELTA* EQUAL TO ZERO.
C

```

201 IF(DELT) 300,301,300
300 NCF=2
NDEF1
GO TO 302
301 NCF=1
NDEF0
302 GO 200 I=1,IX
J=NC*I - ND
200 C(J)=FM(I)
304 IF(DELT) 303,304,303
304 IF(L-1)404, 500,404
404 L=L-1
GO TO 496

```

C HALVING.
C
C

```

204 I=1
NCHECK=IX
IX=IX/2
NCF=NCHECK - (IX+IX)
IF(NCF)555, 504, 555
555 IX=IX+1
504 K=2*I-1
C(I)=C(K)+C(K+1)
IF(L-IX)502,503,503
502 I=I+1
GO TO 504
503 IF(L-1)500,500,200

```

C STOPPING IF *S* GOING NOT EQUAL TO ZERO.
C


```

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
ENEN

```

```

A1=(SXY*SX-SY*SX2)/(SX*SX-EN*EN*SX2)
A2=(SY-EN*A1)/SX
EM=SLXY/SLX2
WRITE (3,3) N,A1,A2,E,EM,COARSE,(E(I),S(I),CG(I),V(I),I=1,12)
3 FORMAT (I11, 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-26 *****
C CALLED BY *RAXEL*.
C TABLE OF K ESCAPE FRACTIONS.

```

```

DIMENSION X(20),R(20)
X(1)=0.05316
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)=.01630
R(12)=.01480
R(13)=.01205
R(14)=.00994
MOX=14
LOW=1
RETURN
END

```

\$IBFC PULS DECK,REF,LIST

FUNCTION PULSE (E,NGP,N)

C***** PROGRAM NUMBER 65FC-24 *****

C CALLED BY *PHOTO* CALLS *ENERGY*,*TA* AND *TE*.
C PROGRAM TO DETERMINE THE APPROPRIATE 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)15,18,12

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, LG, X, R)
2 CALL TA (E, X, M, LOW, MOX, MUN, Z, Y, P, N, L, O)

NI=NI+1
PULSE=TE (NI, 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
- D0 10 I=2,6
- 10 E(I)=E(I-1)+0.001
- D0 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
- D0 12 I=22,25
- 12 E(I)=E(I-1)+0.010
- D0 13 I=26,29
- 13 E(I)=E(I-1)+0.025
- D0 14 I=30,35
- 14 E(I)=E(I-1)+0.050
- D0 15 I=36,45
- 15 E(I)=E(I-1)+0.100
- E(44)=1.3525
- V(1)=.04186
- 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)= .03620
 V(27)= .03000
 V(28)= .02400
 V(29)= .01800
 V(30)= .01150
 V(31)= .00770
 V(32)= .00540
 V(33)= .00390
 V(34)= .00265
 V(35)= .00215
 V(36)= .00110
 V(37)= .00100
 V(38)= .00100
 V(39)= .00100
 V(40)= .00099
 V(41)= .00080
 V(42)= .00050
 V(43)= .00015
 V(44)= .00000

NOX=44

LOW=1

RETURN

END

\$IBFTC RAXE DECK,REF,LISI

FUNCTION RAXEL (ENGR,N)

C***** PROGRAM NUMBER GSFC-25 *****

C CALLED BY *JHAPE* CALLS *SC**TA* AND *TE*.

C PROGRAM TO COMPUTE *ESCAPE FRACTION*.

C

DIFLISION X(20),Y(20),Z(12),Y(12)

IF(E-0.150)GOTO 9

```

6 IF(E-0.03316)12,13,18
18 GO TO (1,2),11GR
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

\$IBFIC 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=MM

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=1+L

Z(I)=X(J)

3 Y(I)=R(J)
15 RETURN
END

\$IBFC IE DECK,REF,LIST
FUNCTION IE (I,A,Y,E)

C***** PROGRAM NUMBER GSFC-34 *****

C CALLED BY *RAKEL* 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)25,25,25
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 IE =S
RETURN
END

\$IBFC 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 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,NFI
IF(Y(I)-JIG)3000,3000,4000
4000 BIG=Y(I)

```

1010=1
3000 CONTINUE
2000 CONTINUE
B(1)=1816
ANY=1000.*ENY
W=(.321*ANY**7.677)*B(1)/ANY
B(2)=W/2.354
B(7)=Y(NFN)
B(3)= W*(16-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
$IBFYC PHOF DECK,REF,LIST
SUBROUTINE PHOFRA (RM,N,EM,ELIMIT,NGO,NGR ,NDEGRE,Q,PV,PFRAC,T,K,
1 MRPEAT)
C***** PROGRAM NUMBER GSFC-23 *****
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),PFRAC(50),
1 Q(50),ALABEL(12),G(12),TAG(12),STDENY(12),STDEN(12),L(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 APPROPRIATELY LABELLED RESP. MATRIX LIBRY SPECTRA
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 LEAD CHANNEL IN BEGINNING OF STAND. SPECTRA
C UNGAIN=REFERENCE COURSE GAIN (AS AT OCT19/66 IS A DUMMY)
C ALABEL=STANDARD SOURCE IDENTITY (AS IN DATA STATEMENT BELOW)
C FIT PE AKS FROM CHANNEL IISJ TO NFNJ

```



```

C SUBTRACT PEAKS FROM CHANNEL NSXJ TO NFXJ (USE NEG VALUES IF .51 PEAKS
C OF EITHER HA22 OR ZH65)
C SHIFT CHANNEL LOCATION OF TRUE ZERO PULSE-HEIGHT
C R(1 TO 200,J)=SPECTRUM J (J=1 TO NSTAND)
C

```

```

      READ (2,0) NSTAND,PHI,PHI,UGAIN,
      1 (LABEL(J),NSJ(J),NFNJ(J),NSXJ(J),NFXJ(J), SHIFT(J), J=1,NSTAND)
      6 FORMAT ( 215,F10.57 (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 AMOUNT TZ IF TZ NOT =0
      NTZ=0

```

```

      DO 9000 J=1,NSTAND
      IF(.5XJ(J))9015,9016,9016
      9015 NSXJ(J)=-NSXJ(J)
      NSUBT(J)=0
      GO TO 9017
      9016 NSUBT(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)-I,TZ
      NFXJ(J)=NFXJ(J)-I,TZ
      9019 NSJ(J) =NSJ(J) -I,TZ
      NFNJ(J)=NFTJ(J)-I,TZ
      IX=200
      GAIN=1.0
      R/GAIN=1.0

```

```

      DO 9003 I=1,200
      9003 FM(I)=R(I,J)
      CALL GAINC (TZ,IX,GAIN,F0,GAIN,0.0,FM)
      DO 9004 I=1,200
      9004 R(I,J)=FM(I)
      9002 CONTINUE
C

```



```

3 FORMAT (1H1)
TEMP=1
CALL RESGEN (R,ALABEL,TAG,G,SCONST,SN,ENPHU,UNGAIN,STDENY,NSTAND,
1 NTAG,NA,NZ,N5,NFNJ,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 PFRAC(J)=1.0/(1.0+SUM)
DO 19123 J=1,NSTAND
WRITE(3,J)
WRITE (3,81) ALABEL(J), PFRAC(J), (R(I,J),I=1,120)
61 FORMAT (10X,42H NORMALIZED CONTINUUM OF STANDARD SPECTRA //)
6111X,46/10H PHOTOFRACTION = E14.77(1X,5E14.7)
19123 CONTINUE
RETURN
END

$IBFC RESG DECK,REF,LIST
SUBROUTINE RESGEN (R,ALABEL,TAG,G,SCONST,SN,EM,UNGAIN,STDENY,
1 NSTAND,NTAG,NA,I,Z,N5,NFNJ,NSJ,NFXJ,NSXJ,NPHA,NOSUBT,NTEMP)
C***** PROGRAM NUMBER 65FC-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),NPAPA(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
G5T=0
G5J1=0
NSTU2=0
I5614=0
IF(GTEMP)30123,30122,30123
30122 DO 2 I=1,NSTAND
IF(ALABEL(I).NE.TAG(N5))GO TO 4
3 I5=1
G5T=0
GO TO 10
4 CONTINUE
2 CONTINUE

```

```
NAF=0
LG=1,114
IF(STDENY(NSTAND-1)-EG)50,51,50
51 NAT=NAT+1
50 EG=1.23
NSINAT=NSTAND-NAT-1
IF(STDENY( NSTNAT )-EG)52,53,52
53 NAT=NAT+1
52 NSTANC=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 200 I=1,NSTAND
IF(ALABEL(I).NE.TAG(NZ))GO TO 400
300 INZ=I
NST=NST+2
GO TO 1111
400 CONTINUE
200 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)=NFXXJ(INZ)
STDENY(NSTD3)=STDENY(INZ)
NSJ2=NSJ(NSTD3)
```



```

IFNZ=NFJ(NSTD3)
DO 180 I=1,NFIZ
180 R(I,NSTD3)=R(I,INZ)
IF(NST-3)220,160,220
159 NSTD3=NSTD2
160 NSJ(NSTD2)=NSXJ(I,IA)
NFJ(NSTD2)=NF XJ(INA)
STDEY(NSTD2)=STDEY(INA)
NSJA=NSJ(NSTD2)
NFJA=NFJ(NSTD2)
DO 190 I=1,NFNA
190 R(I,NSTD2)=R(I,INA)
220 NGAIN=1

```

C NON-LINEAR FIT NSTD+3 SPECTRA, EXCLUDE EMPTY VECTORS, FROM NS TO NFN

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=NFJ(J)
ENY=STDEY(J)
IF(LNY-3.0)9000,9001,9001

```

9000 KLM=5

NBC=5

GO TO 9002

9001 KLM=8

NBC=8

5002 DO 7002 I=1,NPHA

7002 R(I,J)=R(UPHA+1,J)

DO 1945 NJ=1,NJBC

1945 NPARA(KJ)=KJ

DO 2005 I=1,200

2005 Y(I)=0.0

DO 5002 I=N5,MFN

5002 Y(I)=R(I,J)

JJ=J

DO 57 KB=1,8

57 B(KB)=0.0

C CALL RESOLUTION SUBPROGRAM.

CALL STAFF (I ,J,FJ, H,KLM,I,PARA,JBC,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
30015 DEVIATION ,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)=I(I)-PP(I)
NB3=B(1)-5.0*B(2)
NB4=NS-1
IF(NB3-NB4)30592,30593,30593
30592 DO 50591 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(NSAJ(J))5020,5001,5020
C
C SUBTRACT X-RAY PEAKS IF ANY.
C
5020 IF(NOSUBT(J))5029,5001,5029
5029 DEL=NFXX(J)-NSXJ(J)
IXX=NSXJ(J)
NSX=NSXJ(J)+1
NFXX=NFXXJ(J)
NFX=NFXXJ(J)-1
DO 5021 I=NSX,IFX
X=I-IXX
5021 R(I,J)=R(IXX,J)+X*(R(NFX,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
9012 CONTINUE

```

```

9010 CONTINUE
GO TO 9015
9014 DO 9015 I=INDIC,200
9013 R(I,J)=0.0
9015 CONTINUE
75000 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 RGAIN=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 GAIN (0.0,IF,GAIN,RGAIN,0.0,Y)
C
NAME=NFNJ(I)
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(6(-))9097,9096,9097
9096 SN=.7677
SCONST=.321
SEK=1000.
DIV=2.324
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 GAIN (0.0,NX,GAIN,100.0,0.0,0,Y)
C

```

```

DO 30000 I=1,200
IF(Y(I))30001,30001,30002
30001 NFORM=I-1
NFORM=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)
NFI=1
NFI=2
OR=RAALL (EM,I,J,FD)
EK=EM-0.0265
VK=EK+100.0/EN
NFI=1
VV=VK+VK*PULSE (EK,FI,FD)
EK=EK*5EN
SI=(SCONST*EK**SI)*100.0/EK
SI=SI/DIV

```



```

PKAREA=-JR
C SUBTRACT N PEAK
CALL GAUSS (Y,VV,SI,PKAREA,SUM,NFNORM)
C ZERO FROM THE FIRST NEGATIVE CHANNEL TO 200
DO 29765 I=NF10,200
29765 Y(I)=0.0
GO TO 10104
11004 DO 30509 I=NF10,200
30509 Y(I)=0.0
10104 DO 7004 I=1,NFNORM
7004 R(I,J)=Y(I)
7010 CONTINUE
RETURN
END
$IDFTC STUF CHECK,REF,LIST
SUBROUTINE STUF11 (Y,NFN,SB,KLM,NPARA,NBC,NS,PP,ENY)
C***** PROGRAM NUMBER 65FC-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=NF1
NI=10
LE=0
FITLM=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 F(I)=0.0
FIT=0.
5 CALL FUNUS (FIT,FC,Y,SB,PP,A,NF,DIF,NS,PP,ENY)
C REWIND TO ACCOUNT FOR FIXED PARAMETERS. THESE ARE NBC FREE PARAMETERS
C INDEXED AS NPARA(J)
DO 55 J=1,NBC
NAPP=NPARA(J)
B(J)=SB(NAPP)
DO 56 K=1,NF
56 A(K,J)=A(K,NAPP)

```

C CONSTRUCT THE NORMAL EQUATIONS.

NI=NBC

M=NIN+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=I+1

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(FITM1-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)

FITM1=FIT

C

C RENAME PARAMETERS FOR NEXT LOOP. STORE B IN SB

C

89 DO 90 J=1,NBC

PARP=PARA(J)

90 SB(PARP)=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=0.3939423*B(3)

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 COMPUTE GAUSSIAN FUNCTION AND PARTIAL DERIVATIVES.
C

403 DO 706 I=IS,IF
X=I
A=X-0.5
PON=(X-B(1))/B(2)
ARG=EXP(-0.5*PON*PON)
PP(I)=CONS*ARG/H(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)+U(7)
FC(I)=Y(I)-P(I)
DIF(I)=FC(I)
706 FIT=FIT+FC(I)*FC(I)/Y(I)

RETURN
LHD

\$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
MN54 115 149 0 0 0.0
MN54 115 149 0 0 0.0
MN54 115 149 0 0 0.0

014165	020042	015793	014312	013829	013383	013447	015260	015579	014733	001
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	050387	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
010520	021901	016589	014681	013694	013249	013180	015545	015918	015103	021
014973	015112	015038	015187	015218	015341	014932	015245	015126	016211	022
017027	016275	019857	020100	019243	018604	017186	016364	015956	015509	023
014974	014747	014950	014562	014025	013873	013547	013610	013227	013268	024
012955	013015	012736	012814	012396	012417	012689	012360	012029	012161	025
012095	012131	011927	011954	011969	011844	011669	011626	011522	011481	026
011699	011288	011502	011591	011345	011527	011631	011452	011472	011256	027
011319	011444	011503	011617	011733	011906	011885	012016	011993	012122	028
012279	012399	012212	012414	012280	012348	012112	011881	011715	011229	029
010651	010052	009414	008548	007637	007153	006385	005744	005115	004779	030
004297	003915	003632	003297	003194	003098	002930	002908	002836	002905	031
002905	003044	003218	003559	004008	004764	005555	006755	008387	010319	032
013116	010235	019854	024252	029070	034371	039241	044264	048582	052144	033
054920	050600	057241	050442	054652	052307	048702	044739	040438	035473	034

031095	027211	023159	019424	015620	012967	010456	008231	006236	004763	035
003455	002320	001654	000969	000746	000450	000315	000206	000128	000100	036
000084	000145	000112	000092	000076	000120	000114	000095	000063	000062	037
000061	000113	000073	000052	000065	000029	000040	000039	000063	000074	038
000060	000120	000064	000056	000077	000072	000067	000044	000091	000060	039
000067	000053	000057	000045	000054	000084	000071	000100	000024	997976	040
006075	023039	016836	014718	014030	013563	013515	015970	016289	015419	041
014998	015134	015510	015397	015762	015246	015164	015561	015578	016515	042
017708	018682	019970	020692	019728	018585	017474	016740	015976	015481	043
015293	015056	014536	014366	014116	014266	013626	013308	013344	013223	044
013095	013245	012826	012858	012655	012347	012373	012437	012316	012269	045
012126	011979	011983	011876	011930	011989	011722	011768	011732	011524	046
011741	011230	011520	011672	011452	011507	011553	011465	011607	011382	047
011566	011462	011813	011589	012022	011883	011932	012128	012274	012362	048
012348	012391	012350	012609	012244	012218	011961	011985	011414	010965	049
010269	009785	009055	008363	007569	006865	006191	005560	004733	004670	050
004080	003788	003488	003352	003096	003066	002928	002926	002913	002881	051
003141	003241	003499	003815	004512	005280	006451	007805	009860	012310	052
015435	019162	023249	028060	033553	038895	043858	048432	052385	055583	053
057035	057671	057168	055716	052938	050051	045567	041618	036887	032918	054
027902	023863	019918	016618	013506	010718	008230	006423	004820	003590	055
002474	001673	001121	000771	000495	000341	000191	000141	000143	000082	056
000097	000091	000090	000067	000071	000120	000101	000099	000069	000069	057
000077	000097	000082	000092	000093	000023	000096	000087	000070	000061	058
000081	000124	000093	000068	000075	000069	000067	000071	000093	000089	059
000068	000041	000058	000018	000046	000084	000038	000107	000052	997956	060
001551	004213	002731	002584	002313	002251	002540	004877	005561	004645	061
004306	004476	004201	004372	004301	004410	004009	004204	004375	004798	062
005286	005941	006497	006240	005834	004737	004048	003382	002907	002793	063
002611	002430	002187	002139	002172	002254	001909	001947	001974	001768	064
001808	001840	001771	001736	001715	001624	001705	001668	001618	001572	065
001680	001608	001750	001579	001750	001692	001687	001559	001567	001441	066
001657	001483	001556	001548	001422	001537	001545	001491	001544	001564	067
001675	001428	001728	001641	001712	001650	001663	001697	001602	001562	068
001700	001661	001583	001668	001603	001448	001389	001391	001416	001407	069
001280	001209	001220	001090	001018	000992	000887	000886	000733	000778	070
000684	000692	000547	000531	000580	000557	000528	000577	000499	000484	071
000474	000499	000497	000518	000624	000662	000884	001027	001303	001604	072
001896	002397	002936	003387	004020	004733	005137	005751	006188	006613	073
006719	006713	006901	006315	006160	005881	005337	004988	004334	003745	074
003589	002609	002364	001905	001562	001337	001040	000813	000595	000499	075
000343	000215	000147	000089	000055	000062	000078	000038	000064	000027	076
000003	000072	000028	000037	000006	000016	000024	000031	000033	000001	077
000017	000010	000010	000015	000013	000005	000016	000023	999997	000047	078
000026	000046	000039	000030	000002	000023	000053	000017	000063	000024	079

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 FROM CHANNEL	.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

STANDARD SOURCE SPECTRA

MN54	14165.	20042.	15793.	14312.	13829.	13383.	13447.	15260.	15579.	14733.
	14475.	14668.	14905.	14727.	14736.	14851.	14745.	15298.	15077.	16018.
	16881.	16296.	19679.	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.	12088.	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.	15018.	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	C.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
0.2277C68E-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	C.1724143E-01	0.1708116E-01
0.1708932E-01	0.1670547E-01	0.1674704E-01	C.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	C.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	C.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	0.3244471E-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.	C.	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
0.2358591E-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.