Code CUPED

A Code to Unfold Scintillation Spectrometer Polyenergetic Gamma Photon Experimental Distributions

September 1969

NASA Contract:
NAS 5-10337

Prepared by

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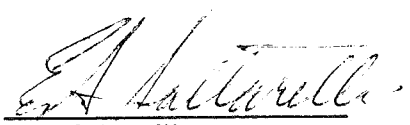
Approved: 
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SUMMARY

A FORTRAN code has been developed for the IBM-360 digital computer to unfold sodium-iodide (thallium-activated) scintillation spectrometer polyenergetic gamma photon experimental distributions. It was specifically designed to analyze the combination bremsstrahlung and monoenergetic gamma radiation field of cylindrical radioisotope power generators. 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. Results are presented in digital form for differential and integrated photon number and energy distributions, and exposure dose.

1. INTRODUCTION

This report presents a description of and the user requirements for code CUPED --- a digital computer code to unfold scintillation spectrometer polyenergetic gamma photon experimental distributions developed under NASA-GSFC contract NAS5-10337. Code CUPED, written in the FORTRAN IV language for the GSFC IBM-360/91 digital computer, is a much modified version of code CUBED which was developed under contracts NAS5-10133 and NAS5-10337 and previously reported in NUS-315, -316, and -395[1,2,3]. The experimental distributions which the code has been specifically developed to analyze, 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 photons emitted by right-cylindrical radioisotope power generators fuelled with such as either plutonium, thallium or strontium oxides.

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 dose. The response matrix generation procedure relies on the spectra of standard radioisotopes such as Cd^{109}, Hg^{203}, Sr^{85}, Cs^{137}, Nb^{95}, Mn^{54}, Zn^{65}, Co^{60} and Na^{24}. The standard spectra are normalized with respect to photopeak pulse-height and area, and their photopeaks subtracted to obtain normalized Compton continua. The response matrix vectors are determined at each energy by interpolating the normalized continua and computing the associated Gaussian photopeaks. The thus interpolated vectors are redistributed in pulse-height to correspond to the detector system energy response and to satisfy the requirements of the spectra to be unfolded. Quadratic interpolation of the normalized continua is carried out either

directly for gamma photon energies ≤ 0.6616 MeV or by a method of parts , described in this report, for energies > 0.6616 MeV.

Code CUPED applies the response function matrix according to two distinct procedures to unfold either bremsstrahlung spectra or complex spectra consisting of a limited number of photopeaks or spectra consisting of bremsstrahlung-plus-photopeaks. The code determines the detector incident photon lines in the unknown spectra through the fitting of a Gaussian-plus-straight-line function to each photopeak. The corresponding photopeak associated Compton continua are determined by an interpolation of the standard Compton continua. The thus determined photopeak-plus-continuum spectra are then subtracted to leave, ideally, either a continuous or zero residual spectrum. Continuous and residual spectra are iteratively unfolded according to the matrix inversion technique of Scofield[4-7], to determine detector-incident continuous photon spectra. The total incident gamma photon spectrum is determined as the sum of the line and continuous components.

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 detection system nonlinear energy response either inherently during unfolding or directly before unfolding according to option.

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[2] and NUS-395[3].

2. CODE DESCRIPTION

2.1 INTRODUCTION

Code CUPED is written in the FORTRAN IV compiler language for the GSFC IBM-360/91 digital computer. It was designed to run under the System 360 monitor system at NASA Goddard Space Flight Center. Input data are read from card-to-tape ---- TAPE 5, digital output is written on tape for print out ---- TAPE 6. The code calls only standard library subroutines, such as transcendental functions.

The code consists of a main control program and thirty-seven subprograms, numbered from 1 to 38. A subprogram glossary is given in Appendix I, in alphabetic name order, and a code FORTRAN punch card deck listing in Appendix II. Appendix III consists of a sample input card deck listing and Appendix IV of a program output listing corresponding to the input given in Appendix III: the execution time for the sample data was approximately five seconds (360/91) with compile and loading time being approximately 28 seconds.

Although CUPED is written for the -360/91 it may be run on smaller 360 machines, down to a -360/50. It has total byte length of less $\sim 2.05 \times 10^5$ (the -360 is 32 bit word third generation computer with 8 bits per byte) and thus a 'word' size of about 62k in the vernacular of second generation computers.

The logic and function of the main program, referred to as MAIN, and its subprograms are discussed in Section 2.2, in some detail. Those subprograms not discussed are considered as being adequately described in either Appendix I or references (1), (2) and (3). The user is also referred to those

same references for the theoretical bases of code CUPED. 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 operation is discussed in Section 3.1 with special reference to the various options available. The code input is detailed in Section 3.2, and the output is defined in Section 3.3. FORTRAN names and variables are shown capitalized in what follows, with 'zero' and 'oh' thus: 0,Ø.

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 thirty-eight subprograms presented in Figure 1. Figure 2 shows a simplified flow diagram of the main program. Program MAIN calls subprograms:

SHAPE	ØMITS	DEC	GANE	SINGLE
SØLN	DECAY	GEØMTR	ENLIN	XTAL

Subprogram SHAPE 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. 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 SHAPE and the input of a matrix card deck. For similar reasons an option is provided to call SHAPE to generate a response matrix based on previously input standard spectra.

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

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

Unknown spectra may be 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 normally recorded in a complement mode, i. e. as positive numbers, the code converts them to true negative numbers in 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 a background spectrum. It further allows the continued reuse, as desired, of a previously stored background spectrum, and of course the addition of similar spectra if this is the requirement of the user.

The energy correspondence of an unknown spectrum to the response function matrix is matched through MAIN calling subprogram GANE[1,2,8]. Subprogram GANE returns the unknown spectrum to the main program after normalization to pulse-height analyzer true zero pulse-height and gain changing such that channel width corresponds to that of the response matrix.

Additional automated modification of an unknown spectrum may be optionally carried out by the code, namely:

(a) the counts in the first n 'dead' channels of the spectrum may be replaced with either the count stored in channel n + 1 or counts determined by a straight line function of specified slope; and/or

(b) the counts between specified limiting channels may be replaced by counts determined by a straight line function of specified slope.

Item (a) allows the user to make judgments with respect to the first few percent of the spectrum which is often either suspect or actually electronically distorted. Item (b) allows the removal of a known spurious peak, etc. in order to allow more meaningful subsequent analysis.

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 ready for analysis and 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 a specified number of monoenergetic spectra "super-imposed" on a continuous spectrum. If the input option indicates the presence of superimposed monoenergetic spectra and if either their line energies and/or photopeak tail channel limits are input, MAIN calls subprogram SINGLE prior to calling subprogram SØLN to carry out iterative unfolding of the continuum.

Subprogram SINGLE is called by MAIN to analyze the photopeaks indicated by the input options for the monoenergetic components of the unknown spectrum. Gaussian distributions are fitted to each photopeak and the associated Compton continua are determined by SINGLE calling subprogram SHAPE and the corresponding line photon numbers calculated. In this manner the monoenergetic spectral components are established in turn and subtracted, i.e. stripped, from the unknown spectrum to leave a residual continuum spectrum. The residual spectrum is returned to MAIN for subsequent analysis and unfolding. The monoenergetic photon numbers thus obtained are added to the residual photon number spectrum determined later by unfolding, to give the total photon number spectrum corresponding to the input pulse-height analyzer spectrum.

Before calling subprogram SØLN the code tests certain input options (M(10), M(11), (M(12), to determine the users special requirements, three of these are, namely:

(a) is unknown spectrum to be corrected for non-linear energy response by calling subprogram ENLIN prior to or during unfolding?;

(b) is unknown spectrum to be corrected for detection efficiency by calling subprogram XTAL prior to gain changing, (eg. from 200 to 30 channels) and before unfolding or after?; or

(c) is unknown spectrum to be actually unfolded?

Item (a) allows the user to make decisions with respect to the effects of the linearity correction. Item (b) allows the user to make decisions with respect to efficiency correction effects and accuracies. Item (c) allows the user to make decisions with respect to such as the significance of actually carrying out the unfolding procedure on a low energy spectrum such as that of Pm^{147}. The optional linearizing of unknown spectra causes the code (subprogram SHAPE) to automatically linearize standard spectra and generate a linear response matrix. The above options and all others, are defined in more detail in Section 3.2. The called subprograms SHAPE, ENLIN, SINGLE, XTAL, SØLN

and GEØMTR are discussed further in Subsections 2.2.2 through 2.2.7. The code corrects unknown spectra for the non-linear energy response of NaI(Tl) either during the unfolding process or if according to an input option this process is by-passed, by the calling of subprogram ENLIN prior to unfolding. Subprogram ENLIN returns an energy linearized spectrum to MAIN which may be subsequently corrected for other phenomena.

At this point in the main program on both the first and subsequent loops, unknown spectra are considered as prepared for unfolding, and thus, they and the response matrix are communicated to subprogram SØLN. This subprogram is called by MAIN to control the iterative unfolding process according to the Scofield method[2,4,5] and to apply efficiency corrections. It returns the corrected photon number spectrum to the main program.

The main program calls subprogram DECAY to determine the primary source decay factor. Subprogram DECAY returns a correction factor by which the number spectrum is later multiplied. The calling of subprogram DECAY may be optionally bypassed, in which case the multiplying factor is assumed as unity.

Subprogram GEØMTR is called by the main program to apply the decay correction factor, carry out geometrical corrections, compute the final differential and integral photon number and energy 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 either code DIMENSION or computer finite capacity. The code loops back along path 3 to read a new unknown spectrum.

2.2.2 RESPONSE FUNCTION MATRIX

2.2.2.1 Response Matrix Generation

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

GANE	RESGEN	TA	TE	PØLATE	VETCMX
PULSE	RAXEL	PEAKS	PEEK	CØMPLX	ENLIN

The main program supplies SHAPE with a number of control parameters, and three variables. SHAPE begins execution by input of a card deck of spectra of standard radioisotopes. The number of such spectra is equal to NSTAND, where NSTAND ≤ 9. This card deck is preceded by one parameter card containing information regarding the number of spectra in the deck (NSTAND); the number of "dead" or unused channels at the low energy end of each spectrum (NPHA); the number of channels in the input standards (NXLIM); 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, i.e. the $\pm$ 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}	Cr^{51}	Sr^{85}	Cs^{137}
Mn^{54}	Nb^{95}	Na^{22}	Zn^{65}	Co^{60}	Na^{24}

The order in which they are input to the code is immaterial excepting that Na^{22}, Zn^{65}, Co^{60} and Na^{24} must be input in the above order. The user may employ

sources not shown above by an obvious modification of the DATA statements in subprogram SHAPE (located at subprogram statement numbers 9000 + 7 and +8), 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 either those originating from Au^{198} and F^{18} sources, or as hand prepared. Multipeak potential standard spectra may be prepared by treating them first as an unknown and using CUPED to determine components.

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

After spectral data is input to SHAPE, 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 for spectral normalization. The standard spectra may also be corrected for non-linear energy response in accord with an input-option (M(14)) if the unknown is to be similarly treated; this is as described in Sections 2.2.1 and 3.2.

Subprogram RESGEN is called by subprogram SHAPE to normalize the single-photopeak and Na^{22} and Zn^{65} standard spectra with respect to photopeak area and pulse-height; photopeaks and source-characteristic X-ray peaks are subtracted. The multipeak spectra of Co^{60} and Na^{24} are normalized later by the calling of subprogram CØMPLX. The residual spectra thus determined by RESGEN 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 component 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 SHAPE; the 1.17 MeV continuum determined by CØMPLX is included in this figure. The logic of subprogram RESGEN is described in section 2.2.2.2.

Subprogram RESGEN returns the normalized differential standard Compton distributions to subprogram SHAPE. These distributions are re-ordered with respect to the ascending order of primary photon energy, prior to the normalization of the multipeak standard spectra by CØMPLX. Subprogram SHAPE calls subprogram CØMPLX to determine normalized standard continua at either 1.33 and/or 2.76 MeV using the Co^{60} and Na^{24} standards, as described in section 2.2.2; the already described normalized Compton continua are required by CØMPLX for this analysis. The energy ordered normalized continua are interpolated quadratically with respect to the energy axis of the desired response function matrix through subprogram SHAPE calling subprogram PØLATE. The result of this interpolation consists of N(corresponding to matrix size) Compton continuum vectors normalized to unit photopeak area and pulse-height. Subprogram SINGLE calls SHAPE to obtain interpolated normalized Compton continua at specific energies as described in this paragraph.

The Gaussian photopeaks plus iodine K X-ray escape peaks of unit (total) area and at unit pulse-height (photopeak) are added to the differential Compton continua to give N (matrix size) complete spectra. The peaks are computed through SHAPE calling subprogram PEAKS which in turn calls GAUSS, which calls PEEK. The Gaussian photopeak photon energy dependent standard deviation $\sigma(E)$, is computed here from an expression of the type

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

where

> k and n are (presently) user-determined either by a regression analysis or by a plot of $\sigma(E)$ on log-log graph paper to obtain the slope n and the intercept k (at E = 1.0 keV).

The energy dependent K X-ray escape fraction is computed by calling function 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 linearly or non-linearly in accord with the option chosen. The redistribution is obtained through SHAPE calling subprogram GANE. The non-linear pulse-heights are obtained by the calling of function subprogram PULSE. Linear pulse-heights are determined if the standards were linearized by subprogram ENLIN.

At this point in the subprogram SHAPE execution, a response function matrix has been determined. This matrix and its corresponding vectors for pulse-height, photon energy and photofraction are returned to the main program. Figure 6 compares the photofractions of the response matrix vectors determined by SHAPE with actual experimental values separately determined for the standard source spectra.

2.2.2.2 Spectrum Normalization

Subprogram RESGEN normalizes the standard spectra input to SHAPE. This subprogram begins execution by carrying out necessary intializations. In the event that an 0.51 MeV spectrum and either Zn^{65} and/or Na^{22} have been included in the input standard spectra, they are also stored in dummy vectors for later 0.51 MeV component subtraction. SHAPE calls control subprogram CØBALT, which in turn calls subprogram STDFIT, to carry out a Gaussian fit to the primary and 0.51 MeV (of Na^{22} and Zn^{65}) spectral photopeaks. Subprogram STDFIT calls subprogram GUESS to estimate the necessary 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 determined photopeak parameters to carry out normalization and to subtract the photopeaks from the standard spectra. In

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

The residual 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 by the calling of RAXEL. The resulting residual normalized continua are checked for negative count values, which are replaced by zero, and returned to the calling subprogram SHAPE. The fitted photopeak parameters are also returned to subprogram SHAPE.

2.2.2.3 Multipeak Standard Spectrum Analysis

Subprogram CØMPLX, called by SHAPE, separates the components of the multipeak spectra of Co^{60} and Na^{24}. It calls subprogram CØBALT to determine the photopeak parameters and to subtract the photopeaks. It calls subprogram PØLATE to either interpolate or extrapolate a normalized Compton continuum from the already prepared monoenergetic standards for the 1.17 MeV energy component in the case of Co^{60} and the 1.368 MeV component in the case of Na^{24}. If the standards included Na^{22} then an extrapolation is only required for the Na^{24} analysis. The interpolated or extrapolated continuum is modified using the photopeak fitted parameters to determine a continuum which is subtracted from the Co^{60} or Na^{24} continua, as the case may be, to leave a residual 1.33 MeV or 2.754 MeV continuum. The residual continua so found are then normalized and included as additional members of the previously determined set of standards. Figure 6 shows an example 1.33 MeV photofaction

obtained by the code. Na^{24} standard spectra measured in the geometry of the other standards were not available for similar comparison.

2.2.2.4 Compton Continuum Interpolation

Subprogram PØLATE quadratically interpolates or extrapolates normalized Compton continua. It is called by SHAPE for response matrix vector generation purposes and by CØMPLX for multipeak standard spectrum analysis. Actual interpolation is performed in function subprogram TE.

For energies less than 0.6616 MeV, the interpolation is carried out directly on the differential standard continua. The interpolation assumes reasonably that at zero energy, the channel counts are also zero. For energies greater than 0.6616 MeV, a 'method of parts' was developed. This method divides the continuum into three characteristic regions: A) zero energy to backscatter peak, B) backscatter peak to Compton edge, and C) Compton edge to photopeak mean pulse-height. The mutual boundary of each region is overlapped for continuity reasons. The dashed curves in Figure 5 indicates the regional boundaries.

Prior to interpolation (or extrapolation) the three regions are aligned such that the regional boundaries on which the backscatter peaks and Compton edges lie would be vertical and straight if shown in Figure 5 , e.g. backscatter peaks normalized with respect to pulse-height. Alignment is carried out with respect to the continuum of highest energy in the set of three standards in the quadratic, and by the calling of subprogram GANE. The three interpolated components, A, B, and C, are unaligned by gain changing to obtain the desired continuum. The pulse-height axis direction of Region C is reversed for convenience during the whole operation, i.e. zero pulse-height is taken at the photopeak mean pulse-height. The central portion of Region B is determined by a direct interpolation of the standard continua. An empirically modified form of

the Compton angular-energy equation is used to aid in automatically locating the Compton edges and backscatter peaks.

PØLATE returns the interpolated Compton continuum to the calling program.

2.2.3 Energy Response Correction

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

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

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

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

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

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

For the sake of discussion in this section the above input to ENLIN will be referred to as n, C_i', E_m and V_m', respectively.

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

$$\Delta = E_m/V \qquad (2)$$

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 $V'_i - V'_{i-1}$

where

$$V' = V (1+\partial V (E)) \quad (4)$$

and

$$V = E/\Delta \quad (5)$$

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

$$C_i = C'_i \cdot (V'_i - V'_{i-1})/(V_i - V_{i-1}) \quad (6)$$

where the denominator is equal to one channel.

2.2.4 Analysis of Monoenergetic Spectral Contributions

Subprogram SINGLE is called by MAIN according to an input option to analyze photopeaks and their associated Compton continua, in complex spectral distributions. Subprogram SINGLE will fit a 'single or double Gaussian plus

straight line' function to the photopeaks of a multipeak PHA spectrum. It will subtract the fitted photopeaks and their associated continua to leave a residual continuous spectrum. In the case of a 'no-bremsstrahlung' complex PHA spectrum the residual will, ideally, have zero intensity.

The code CUPED user may input either the energy of the photopeaks to be fitted in SINGLE or alternately the photopeak fitting limits (channel numbers). In the event that the energies of only certain peaks are known they may be input, while the remainder may be defined by fitting limits. The choice of energy order of monoenergetic peak analysis and spectral stripping is left to the user; the code permits a mixed order to be chosen.

In addition to fitting and subtracting the monoenergetic components of an unknown spectrum, SINGLE determines their corresponding efficiency-corrected detector-incident photon number. The thus determined photon number may be optionally, either added to the bremsstrahlung photon number determined by later unfolding or diverted for separate output. In this way the separated radiations can be studied, eg. bremsstrahlung analyses may be carried out even though the subject source emits monoenergetic photons.

Although SINGLE is designed primarily for single or double (merged) photopeaks, it may be applied to x-ray peaks with a reasonable degree of accuracy. For x-ray peak analysis a single Gaussian will give an approximate result. The fitting of a double Gaussian requires that the peak have good counting statistics and thus be 'well' formed. Alternately, an x-ray peak may be analyzed approximately by the iterative unfolding procedure under the control of subprogram SØLN. It is noted that the iterative unfolding convergence rate is generally slower in spectra containing prominent residual peaks.

Subprogram SINGLE begins execution by determining whether the photopeak fitting limits have been input to MAIN by the user or whether they are to be determined. In the event that they are to be determined, SINGLE begins execution by estimating their channel locations based on the peak input energies. It first establishes the approximate channel region of the photopeak. It then ascertains it more accurately for the approximated channel region by calling subprogram VECTMX to establish the channel of maximum count. The fitting limits are determined as a function of the photon energy dependent standard deviation. A check is made to ensure that the limits are within the spectrum and that their domains to not overlap each other.

With the fitting limits established, a single or double Gaussian distribution is fitted to each photopeak in turn. Actual photopeak function fitting is carried out by the calling of subprogram STDFIT for single peaks and STDFT2 for double peaks. Although subprogram STDFT2 is capable of carrying out the fitting of a single peak and so leaving STDFIT redundant, it is not required to do so because of the other code CUPED changes that would be necessary. It is proposed that those modifications be considered as future work. Subprograms STDFIT and STDFT2 return fitted photopeak parameters to SINGLE.

The Compton continuum associated with each photopeak is determined by calling subprogram SHAPE, which returns an interpolated continuum normalized with respect to a photopeak of unit area and pulse-height (100 channels). The continuum is then scaled and gain changed according to the peak area and pulse-height determined by STDFIT or (STDFT2).

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 continua to MAIN for iterative unfolding, SINGLE determines the photon number corresponding to each monoenergetic spectral component. This is done 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:

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

The corrections noted are carried out by subprogram SINGLE calling subprogram XTAL. N(E) is returned to MAIN either to be added to the iteratively unfolded continuum number spectrum or to be output separately.

Figure 7 shows a PHA spectrum of PuO_2 before and after analysis by 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 pulse-height analyzer spectra according to the Scofield method [4,5]. The number spectra returned by subprogram RESMAT are corrected for efficiency by SØLN calling XTAL. 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 subprogram XTAL, EFFIC, AIRABS, PERSPX and CLAD.

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

$$\vec{P} = \overline{\overline{R}}\,\vec{N'} \tag{8}$$

where $\vec{P}$ and $\vec{N'}$ are the m-dimensional vectors of the PHA spectrum and the efficiency uncorrected photon number spectrum, respectively, and $\overline{\overline{R}}$ is the m x m square response function matrix. Equation (8) is formally solved as

$$\vec{N'} = \overline{\overline{R}}^{-1}\,\vec{P} \tag{9}$$

where $\overline{\overline{R}}$ is non-singular and $\overline{\overline{R}}^{-1}$ is its inverse. Subprogram RESMAT executes equation (9) iteratively according to the Scofield method [4,5]. Figure 8 shows a flow diagram of the iterative algorithm coded in subprogram RESMAT. Further details are referred to references (1-3).

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

$$\vec{N} = \overline{\overline{\eta}}^{-1}\,\vec{N}' \tag{10}$$

where $\overline{\overline{\eta}}$ 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 subprogram XTAL which in turn calls function subprograms EFFIC, CLAD, AIRABS and PERSPX, to determine $\overline{\overline{\eta}}$. SØLN then executes equation (10) and returns the determined photon number spectrum to MAIN. Figure 9 shows a typical spectrum before ($\vec{P}$) and after ($\vec{N}$) unfolding.

2.2.6 Analysis of Unfolded Spectra

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

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

where

R_x = NaI(Tl) crystal radius, cm.

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

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

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

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

where

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

K = conversion constant

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

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

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

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

FORTRAN NAME	EQUAL TO	DEFINITION & UNITS
(AT THE CRYSTAL)		
AVENGY	$\frac{\Sigma N(E).E\Delta E}{\Sigma N(E).\Delta E}$	average energy, MeV
PHNUBE	$\frac{\Sigma N(E).\Delta E}{N_\beta}$	integrated photon number flux per beta source strength, $(\gamma/cm^2\text{-sec})/\beta/sec)/MeV$; ($N_\beta$ defined below) *
ENBENY	$\frac{\Sigma N(E).E.\Delta E}{E_{\beta_{max}}}$	integrated energy flux per beta maximum energy, (MeV/cm^2-sec)/MeV; ($E_{\beta_{max}}$ defined below)
PHENBE	$\frac{\Sigma N(E).\Delta E}{N_\beta}$	integrated energy flux per beta source strength, (MeV/cm^2-sec)/(β/sec)
DOXBEX	D/N_β	dose rate per beta source strength, (r/hr)/(β/sec); (D defined in equation (13)).
(AT THE BETA SOURCE CYLINDER)		
DOSCYL	$\frac{DOSBEX}{G}$	dose rate per beta source strength, (r/hr)/(β/sec); (G defined below)

*Beta, N_{β_A} and $E_{\beta_{max}}$ are used in this section because of earlier bremsstrahling analyses; gamma (γ) may be conceptually substituted.

DCYVOL	DOSCYL Source Volume	dose rate per beta source strength per cm^3 of source volume, = DOSCYL/cm^3

where

$E_{\beta_{max}}$ = maximum beta (or chosen γ) energy in MeV

= EBMAX of card (6) of report section 3.2*

N_{β} = number of source emitted betas or γ's per unit time

= (SBETA of card (6) of report section 3.2) $\div$ 3.7×10^{10}.**

and

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

where

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

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

r = source to crystal distance

Subprogram GEØMTR returns all of the above data to the main program for output.

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

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

2.3 Code Constants

In this section the origin and meaning of certain constants coded into CUPED, are discussed. All attenuation coefficients used were those given in references (9-13). The discussion is carried through in alphabetic order of subprograms, except for General Discussion and MAIN which are presented first. Certain subprograms require no discussion.

General Discussion: Certain constant values appear periodically throughout CUPED. The values 2.35482, 2354.82, 0.3989423 and 1.065 are Gaussian or normal distribution constants[14]. The value 2.54 is for conversion from cm to inches. The values 60 (minutes/hr and seconds/min) and 1440 (minutes/day) are clock time conversion constants. The values 0.51097, 0.514, 1.173, 1.332, 1.368, and 2.754 are radioisotope peak energy values[15] in MeV, for β^+, Sr^{85}, Co^{60}, Co^{60}, Na^{24}, Na^{24}. Other values are either obvious or constants unique to code logic except as explained below.

MAIN: Certain constants required by CUPED subprograms are coded in MAIN and communicated by CØMMØN/CNSTNT/. The constant T 30 = 30.48 is source-to-crystal distance in cm for use by the code in instances where it (DOST(I)) is omitted from input. The constant T 75 = 0.75 is the coded thickness of Lucite absorber in cm^2/gm; presently not coded for input, though it may easily be. The constants T 20 = 20.0, T 50 = 50.0, T 01 = .0001, T 38 = 3.81 and T 76 = 7.62 are used by the code if input (ØN, HITMAX,EPS,RX,H) left blank; this is discussed in Section 3.2. The constant T 1293 = 0.001293 is the density of air coded for subprogram AIRABS. The constants T 90 = 900000. and T 1000000. are used by subprograms DEC and SHAPE for checking for spectral counts in the complement mode. The constant, T 366 = 3.671 is the density of NaI(Tl) in gm/cc. The constant, T 3316 = 0.03316, is the energy of the K electron shell absorption edge for

iodine in NaI(Tl), in MeV. The constant T 06 = 10^{-6} is an integration criterion for subprogram SIMPSN. The constants T 321 = .321 and T 7677 = .7677 are k and n of Equation (1). The constant T 285 = 0.0285 is the energy of the NaI(Tl) iodine k x-ray in MeV. The constants associated with UT at statement numbers 40 to 47 are explained in Section 3.2. The constant 3.7 E + 10 at statement number 128 + 1 is the conversion factor for Curies to disintegrations/second.

AIRABS: The mass absorption coefficients of air are given in the DATA statement in cm^2/gm. The coefficients include coherent scattering. They are multiplied by the density of air (T 1293) 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 thickness

Material	Density X Thickness gm/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 cm^2/gm. They are based at 20^o C and a fractional weight composition of

Nitrogen	0.755
Oxygen	0.232
Argon	0.013

EFFIC: The total mass absorption coefficients are given in the DATA statement in cm^2/gm; they do not include coherent scattering.

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

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

SHAPE: 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.

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 (16). The deviation values coded in PULSE are typical of the spectrometer system and not just characteristic of NaI(Tl).

RAXEL: The iodine K X-ray escape fractions derived from the equations of Axel[17] for parallel beam geometry and as modified in reference (18) 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

$$F_k(E) = 0.0$$

SIMPSN: The constant TMAX = 2048.0 = 2^{11} (first execution statement) is a criterion to stop integration in the event of a non-convergence.

STDFIT: The constant EPS = .00001 (at statement 100 - 3), is the fitting criterion for the single peak non-linear regression. The constant NI = 10 is a stopping criterion for non-linear regression in the event of a non-convergence.

STDFT2: Constants EPS and NI (first and second statements) are as for STDFIT, for double peak fitting.

3. CODE OPERATING INFORMATION

3.1 GENERAL

Code CUPED is written in FORTRAN-IV for the IBM-360/91. It may be run on any IBM-360 with sufficient core size, ie. the present version requires 205,000 bytes, (4 bytes/word). There are no Sense Switch or special tape requirements. Input formats are standard FORTRAN-IV, as given in any IBM or CDC Fortran manual; the code has been designed with a view to ease of translation for use on other than IBM computers. Input/output tapes are presently coded as LI and LØ equal to 5 and 6, respectively, at the beginning of MAIN (statement 19181 + 2 and + 3). A code listing is given in Appendix II .

Figure 10 shows a general arrangement for the data input cards. Input card details, order, formats, restrictions and location are given in Section 2.3. Card numbers are encircled and defined in the order in which they are read by the code. A sample input listing is presented in Appendix III.

The code CUPED input data card deck consists of thirteen (13) types of cards, referred to as Card (1) , Card (2) , etc. If the type requires more than a single card the reference is made to Card Set ◯. Card (1) is a single card, input only once. Cards (2)(3) and (4) are single cards input at least once. Card set (5) ((5A) or (5B)) is input at least once in order to define the response matrix. If the user only wishes to generate a response matrix but not to apply it to any data, then no further input is required. If the matrix is to be applied to analyze unknown spectra, further input is required to define the spectral data and the required analysis.

Card set (6) consists of two cards which must be input to define parameters which are common to all PHA spectra in the PHA spectral data set (card set (13)), eg. source size, counting time, source strength, etc. Card set (7) must be input to define parameters unique to each PHA spectrum in the PHA spectral data set, eg. zero shift required, smoothing required or not, source-to-detector distance, energy calibration data, etc. Card (8) and card sets (9) through (12) are optional. Card set (13) consists of the unknown PHA-spectra to be analyzed and their PHA-background-spectra. The code will analyze spectra of up to 256 channels, although up to 512 channels may be input and code gain-changed to 256 for analysis.

The optional cards are as follows: Card (8) is a single card to allow the user to study the iterative unfolding convergence, ie. intermediate unfolding data is output. Card set (9) allows the user to replace undesirable peaks, prominences or spurious spectral counts with a straight-line shape. Card set (10) allows the user to load initial spectral channels with a straight-line shape. Card set (11) allows the user to input the energy of photopeaks to be analyzed. Card set (12) allows the user to input the channel region of photopeaks to be analyzed. The input of both card set (11) and (12) allows the user to give the energy of certain peaks and the channel region of others. Card set (12) allows the user to input energy as well as channel domain for peaks, in which case the code will use the input energy as opposed to the code determined energy for such as efficiency calculations. This last is useful in applications where a priori knowledge indicates that the energy which the code would determine would be too approximate.

The input of channel number values must be as recorded by the pulse-height analyzer. The code will change the input values in accord with requested shifts or gain changes. In Section 3.2, 'rounded-up' refers to the 'next highest integer value', i.e., 3.7 rounded-up is 4. The input order of card

sets (7), (9), (10), (11) and (12) must correspond to the spectra of card set (13).

The code output is reviewed in Section 3.3. Appendix IV is a sample output listing. It corresponds to sample input of Appendix III. Debug type output may be obtained by input of M(8) = 8 on card (3). The user is cautioned with respect to profusion of output under this option - - - a trial using sample data is recommended first.

3.2 Card Input Details

Card (1) (one card; once only)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
SET	1-10	F10.5	Total number of spectra to be unfolded by a code run (= RUNS * ØJSØ * number of times card (2) to (4) input)

Card (2) (single card)

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

Card (3) (single card)

M (1)	1-3	I3	Signal for routing after response matrix generation > 0 CALL EXIT = 0 Continue < 0 Return to READ card (2)
M (2)	4-6	I3	= 0, use existing response matrix ≠ 0, generate new response matrix using existing standard spectra
M (3)	7-9	I3	If ≠ 0, read card (8) (iterative unfolding output signal)
M (4)	10-12	I3	If ≠ 0, read card (9) (replace peak with straight line)
M (5)	13-15	I3	If ≠ 0, read card (10) (dead channel fill-in)
M (6)	16-18	I3	If ≠ 0, add photopeak contributions to iteratively unfolded continuous photon number, else separate
M (7)	19-21	I3	If ≠ 0, SINGLE called for peak analysis

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
M (8)	22-24	I3	Debugging output if ≠ 0
M (9)	25-27	I3	If ≠ 0, the peaks analyzed by SINGLE are corrected for source decay
M (10)	28-30	I3	See Table I (routing option)
M (11)	31-33	I3	See Table I (routing option)
M (12)	34-36	I3	See Table I (routing option)
M (13)	37-39	I3	If = 0, output the GANE reduced PHA spectrum prior to unfolding
M (14)	40-42	I3	If ≠ 0, ENLIN called before entry to SINGLE (subsequent ENLIN call by-passed)
M (15)	43-45	I3	If ≠ 0, output the iterative unfolding convergence differences
M (16)	46-48	I3	If ≠ 0, do not correct for source decay, i.e., assume decay factor = 1.0
M (17)	49-51	I3	If ≠ 0, output the PHA spectrum
M (18)	52-54	I3	If ≠ 0, by-pass final result computations, i.e., by-pass GEØMTR

NOTE: The choice of non-zero values required for M (1) is arbitrary, however, positive subscript index values will aid in identity, e.g., if M (7) ≠ 0 then input as = 7; the user is cautioned that arbitrary negative values are allowed for M (11) and M (12) in accord with Table I.

Card (4) (single card; last 5 variables usually blank)

ELIMIT	1-10	F10.5	The energy of the upper edge of the response matrix highest channel, (MeV) (CHANLS * EG(J)/VG(J); see cards (6) and card set (7)

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
ØJSØ	11-20	F10.5	Loop limit; number of sets of source data (card sets (7) through (12), except (8), before loopback to READ card (2) .
ØMM	21-30	F10.5	If < 0 READ a response matrix, (card set (5B)), = 0 use already computed matrix, > 0 generate new matrix; CALL SHAPE. Choice of values are arbitrary, eg. -1. and +1.
ØN	31-40	F10.5	The size of the response matrix, ie. 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 input per M (3) required. ≤100.0.
EPS	51-60	F10.5	Convergence tolerance at which iteration will cease. eg. .0002.
RX	61-66	F6.4	Radius of NaI(Tl) crystal, cm.
H	67-72	F6.4	Cylindrical length of NaI(Tl) crystal, cm.

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

Card (5)

Card (5) refers to a deck of cards of which two kinds are allowable, namely: (5A) or (5B) .

Card set (5A) will be input, if ØMM > 0; read by subprogram SHAPE and a response matrix generated.

Card set (5B) will be input if ØMM < 0; response matrix input to program MAIN.

Neither set input if ØMM = 0, ie. a correct response matrix assumed as existing in storage.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
Card Set (5A) (NPHA, NSJ, NFNJ, NSXJ, NFXJ and SHIFT are defined in Figure (11).			
Card (5A) - 1 (single card) (See Figure 4)			
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.
NXLIM	11-15	I5	Number of channels in a standard spectrum ($\leq$ 260).
UNGAIN	16-25	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 (5A) - 2 (I= 1 to NSTAND cards) (See Figure 4)			
ALABEL (I), BLABEL (I)	2-6	2A3	Standard source idenity. Must be one of CD109, SC47, HG203, CR51, SR85, CS137, MN54, NB95, ZN65, NA22, CØ60 or NA24 in card field; see Section 2.2.2.1
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.
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 providing Sr^{85} (or a substitute 0.51 spectrum) also exists (-NSXJ and +NFXJ are .51 MeV peak channels defining this fitting range).

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
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 subtracted if they are present in the standard deck providing Sr^{85} (or a substitute 0.51 spectrum) also exists (-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.

Card Set (5A) - 3 (NSTAND times NXLIM/10 (rounded-up) cards); ((R (I,J), I = 1, NXLIM), J=1, NSTAND); (See Figure 4)

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.
R (11, 1)	1-7	F7.1	The count in the eleventh channel of the first input standard spectrum.
.			
.			
.			
R (NXLIM, NSTAND)	63-70	F7.1	The count in the NXLIMth channel of the NSTANDth input standard spectrum.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE

The above Card Set (5A) - 3 may be summarized as:

10 channels of information/card per 10F7.1 format, NXLIM/10 (rounded-up) cards per spectrum; if NXLIM = 256 then 256/10 = 25.6 taken as 26, NSTAND spectra.

The spectrum input order must correspond with the order of card set (5A) - 2; Na^{22} precedes Zn^{65} precedes Co^{60} precedes Na^{24}. The order of the remaining spectra is immaterial. If either Zn^{65} and/or Na^{22} input then Sr^{85} must have been input.

Card Set (5B)

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

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

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

Card Set (5B) - 2 ((ØN/2) cards)

Q (1)	1-7	F7.4	Mid-increment energy of first energy interval of response of matrix.
Q (2)	8-14	F7.4	Mid-increment energy of second energy interval of response matrix.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
Q (10)	64-70	F7.4	Mid-increment energy of tenth energy interval of response matrix.
Q (11)	1-7	F7.4	Mid-increment energy of eleventh energy interval of response matrix.
Q (ØN)	64-70	F7.4	Mid-increment energy of ØNth energy interval of response matrix.
Card Set (5B) - 3 ((ØN/2) cards)			
PV (1)	1-7	F7.4	Mid-channel value of first channel of response matrix.
PV (2)	8-14	F7.4	Mid-channel value of second channel of response matrix.
.			
.			
.			
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 (6) (two cards)			
First Card:			
BTAG,BTAGA	2-6	A4,A2	Unknown source identity (alphanumeric)
SBETA	11-20	F10.5	Unknown source strength, curies; see page 23 footnote.
EBMAX	21-30	F10.5	Unknown source maximum or reference energy, MeV; see page 23 footnote.
CYLDIA	31-40	F10.5	Unknown source cylindrical diameter, cm.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
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	See footnote; ≤260
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)
Second Card:			
M222	1-5	I5	The number of peaks to be fitted with a Gaussian for which channel limits will be input (per card set (12)) ≤ 20-M66; See card set (12) note.
M66	6-10	I5	The number of peaks to be fitted with a Gaussian for which only the energy is to be input (per card set (11)); ≤ 20-M22.
MZ	11-15	I5	The number of channels, in each spectrum, to be loaded with zero counts (beginning at channel 1).
MNX	16-20	I5	See footnote; ≤512

Footnote: The code will expect unknown spectra of MNX channels (MBX for backgrounds) to be input; it will analyze as if CHANLS channels were input; if 257 ≤ MNX ≤512 then unknown spectra are reduced to 256 channels by DEC calling GANE and analysis carried out on CHANLS channels; if MNX = 0, then CHANLS channels are input and analyzed.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
MBX	21-25	I5	Same as MNX, except that it refers to background spectra; see footnote; ≤512
MSM	26-30	I5	If ≠ 0, smooth spectra before analysis; use 1.0 or 2.0 for single or double smoothing pass by subprogram GANE.

NOTE: BTAG/BTAGA, SBETA and EBMAX may be 'blank', 1.0 and 1.0 if not known prior to analysis. Actual values are used only for normalizing in subprogram GEØMTR prior to output of analysis results; see page 23 footnote.

Card Set (7)

"Number of cards in set (7) " = 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 ≤ 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, ≥ 1.0.
VG (I)	43-49	F7.3	Monitor pulse-height corresponding to EG(I), channels.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
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.
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 (8) (one card input of M (3) ± 0)

This card may contain up to 18 integer numbers, which are the iterating or unfolding loop at which intermediate output is desired. ≤ 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 cause subprogram RESMAT to output on iterating loops 3, 5 and 9.

Card Set (9) (1, 2, 3 or 4 cards input if M (4) ± 0) (See Figure 12)

N1X (1)	1-5	I5	Replace a peak (or other prominence in spectrum 1 of card set (13) with a straight line from channel N1X(1) to N2X(1); count rate in N1X(1) and N2X(1), used to determine slope and intercept of straight line.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
N2X (1)	6-10	I5	See Above
N1X (2)	11-15	I5	See Above
N2X (2)	16-20	I5	See Above
.			
.			
.			
N2X (5)	46-50	I5	See Above
N1X (6)	1-5	I5	See Above
.			
.			
.			
N1X (RUNS)	—	I5	Replace a peak (or other prominence in spectrum RUNS, card set (13), with a straight line from channel N1X(J) to N2X(J); count rate in N1X(J) and N2X(J), used to determine slope and intercept of straight line; J = RUNS.
N2X (RUNS)	—	I5	See Above

NOTE: N2X (5) would be the tenth and last field of first card; the number of cards($\leq$ 4) depends on RUNS.

Card Set (10) (1 to 5 cards input if M (5) $\neq$ 0) (See Figure 12)

NFILL (1)	1-5	I5	Replace in spectrum 1 of card set (13), channels 1 to NFILL (1) with a straight line of slope VAL (1) based on count in channel NFILL (1).
VAL (1)	6-15	F10.5	See Above
NFILL (2)	16-20	I5	See Above
VAL (2)	21-30	F10.5	See Above
.			
.			
.			
VAL (4)	51-60	F10.5	See Above
NFILL (5)	1-5	I5	See Above
.			
.			
.			
.			

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
NFILL (RUNS)	—	I5	See Above
VAL (RUNS)	—	F10.5	See Above

NOTE: VAL (4) would be the eighth and last field of first card; the number of cards ($\leq$ 5) depends on RUNS.

Card Set (11) (1 * RUNS to 4 * RUNS cards input if M66 $\neq$ 0) (See Figure 12)

This card set is input only when M66 $\neq$ 0. It must consist of RUNS * (M66/5 rounded up)' cards corresponding to the number of unknown energy-specified spectral peaks in card set (13). Each card contains $\leq$ 5 photopeak photon energies corresponding to the unknown complex-plus-continuous spectrum to be analyzed. From one to 20(= M222) photopeaks may be energy specified per spectrum ie. a maximum of 4 cards per spectrum.

EUK (1, 1)	1-10	F10.5	Energy (MeV) of the first energy specified photopeak in card set (13) first spectrum.
EUK (2, 1)	11-20	F10.5	Energy (MeV) of the second energy-specified photopeak in card set (13) first spectrum.
EUK (3, 1)	21-30	F10.5	Similar to above.
EUK (M66, 1)	—	F10.5	Similar to above.
EUK (1, 2)	1-10	F10.5	Similar to above.
.			
.			
.			
EUK (M66, RUNS)	—	F10.5	Similar to above.

NOTE: The first photopeak in each spectrum is that of lowest energy with the remainder being in energy ascending order. The user is cautioned that peak channels may also be input instead or in addition, per card set (12) if M222 $\neq$ 0; M222 + M66 $\leq$ 20.

Card Set (12) (1*RUNS to 7*RUNS cards input if M222 $\neq$ 0) (See Figure 12)

This card set is input only when M222 $\neq$ 0. It must consist of 'RUNS* (M222/3 rounded-up)' cards corresponding to the number of unknown channel-limit specified spectral photopeaks in card

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
			set (13) . Each card contains information for ≤ 3 photopeaks. The information advises code of whether peak is a single peak or is instead one of a pair, of the upper and lower fitting limits (channel) and of the energy if it is not known.
NJJ (1, 1)	1-4	I4	Signal for first channel-limit-specified peak of first card set (13) spectrum: = 1, if a single peak = 2, if one of two peaks in a pair.
NSSS (1, 1)	5-8	I4	Channel number defining fitting limit on low energy side of first channel-limit-specified peak, ie. fit peak from channel NSSS(1, 1) to NFNNN(1, 1).
NFNNN (1, 1)	9-12	I4	Channel number defining fitting limit on high energy side of first channel-limit-specified peak, ie. fit peak from channel NSSS(1, 1) to NFNNN(1, 1).
EXRAY (1, 1)	13-20	F8.4	Energy of first channel-limit-specified peak, MeV .
NJJ (2, 1)	21-24	I4	Similar to NJJ (1, 1).
.			
.			
.			
EXRAY (3, 1)	53-60	F8.4	Similar to EXRAY (1, 1).
NJJ (4, 1)	1-4	I4	Similar to NJJ (1, 1).
.			
.			
.			
EXRAY (M222, RUNS)—		F8.4	Similar to EXRAY (1, 1).

NOTE: The user is cautioned that peak energy data may also be input instead or in addition, per card set (11) if M66 ≠0; M222 + M66 ≤ 20. If M66 = 0 and M222 ≠0 then photopeaks data may be input in any energy order; if M66 ≠0 and M222 ≠0 then input is expected in energy ascending order. Where data is input for double peaks NJJ(I,J) and NJJ(I,J + 1) =

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE

2 and 0, respectively, then energy ascending order is expected if EXRAY (I,J) specified. An example of input data for double peak (I and I + 1), is given (indices omitted):

NJJ	NSSS	NFNNN	EXRAY	NJJ	NSSS	NFNNN	EXRAY
2	46	—	0.501	0	7	66	0.575

This specifies that the code shall carry out a double peak analysis between channels 46 and 66, that peak energies are 0.501 and 0.575 MeV and that the peaks are approximately 7 channels apart. The code analysis will determine the actual separation distance and thus 7 is given only as an estimate.

Card Set (13)

The number of cards in this set = (CHANLS (or MNX) * RUNS/10.0 + the number of background cards if any)*. The cards will contain the unknown source spectra to be unfolded. The number of spectra which may be input is limited by the DIMENSION (20) = RUNS. The spectra, corresponding to card sets (6) and (7), 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 (or MNX) channels and background spectra must correspond*. Each card contains 10 channels of information. Thus, the following is typical of card set (13) as read by subprogram DEC:

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.

NAME	COLUMN	FORMAT	DESCRIPTION, PURPOSE OR USE
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)

* For input purposes, if MNX > CHANLS then replace CHANLS above with MNX for unknown and MBX for backgrounds, ie. CUPED will read spectra up to 512 channels in size (per MNX and MBX) but will immediately reduce them to CHANLS = 256.

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.

A. The values on this page are output by MAIN, and are as input on card sets (1) to (4), 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 SHAPE, and correspond to those standard source spectral parameters input on card sets (5A) - 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 SHAPE corresponds to card set (5A) - 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 SHAPE, consists of the Compton continua of the standard source spectra normalized with respect to unit photopeak area and a pulse-height of 100 channels.

F. This page presents the response matrix generated by SHAPE and output by MAIN. It corresponds to that input which would be required for card set (5B) - 1.

G. This page presents the energies (MeV), pulse-heights (channels) and photofractions corresponding to the generated response matrix, at increment midpoints, as determined by SHAPE and output by MAIN. The energies and pulse-heights correspond to that input which would be required for card sets (5B) - 2 and - 3. The photofractions correspond to the solid curve in Figure 6.

H. The output on this page, by MAIN, corresponds to the input specified for card sets (6) and (7), excepting that the units in some cases are modified before output.

I. Optional output by MAIN giving the indices for which unfolding iteration output has been requested by input of card (8).

J. Output by MAIN of the options requested through input of card sets (9), (10), (11) and/or (12).

K. The output on this page by MAIN corresponds to the (first) spectrum to be analyzed and as input on card set (13). Background spectrum subtraction and complement mode correction is carried out before output.

L. Output of spectrum before entry to SINGLE; in the example the result of smoothing is demonstrated.

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 output gives the PHA spectrum after stripping of photopeaks and associated continua by SINGLE; gain parameters for subsequent unfolding are also output.

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

P. The output on this page by RESMAT is that requested by input of card (8). 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).

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

R. The optional output on this page by MAIN, consists of the efficiency corrected and unfolded spectrum after post-normalization and the rate of convergence or fitting differences, during unfolding ($\Delta\chi^2$).

S. 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.

T. 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.

4. SUMMARY AND CONCLUSIONS

A FORTRAN-IV IBM-360 package code has been developed for the rapid analysis of bremsstrahlung spectra. The code is readily applicable to the analysis of sodium-iodide scintillation detector complex continuous spectra. The response matrix generating portion of the code is suitable for use as a separate entity for problems in spectral analysis such as are 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 [4,5] and R. Gold [6], by the present author [1-3, 18], and others [7]. While this method is approximate because of the iterative technique used, it generally is the most suitable where continuous spectra are involved. It is suggested that degree of accuracy be the subject of future work, wherein the iterative method results would be compared with results obtained by other methods. The best value of the matrix size consistent with non-oscillatory good results and computer efficiency would be of interest here[18]. Contract circumstances did not allow for detail studies during the development of code CUPED.

It is proposed that the response matrix generating portion of the code be made more versatile by studying the use of additional standard sources. Contract circumstances did not allow a detailed debugging of the code in the energy range 1.4 to 3.0 MeV. 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 relative to that at 0.51 MeV, thus Zn^{65} is recommended instead. Further work is proposed with a respect to use of the Na^{22} spectrum above 0.6 MeV.

The 200 channel PuO_2 spectrum of Figure 7 represents only half of the experimentally measured spectrum. The complete 400 channel distribution is shown in Figure 13. This spectrum is repeated in Figure 14 with a non-linear pulse-height scale proportional to the detection system resolution [19]; the peaks in both figures are numbered for comparison purposes. The advantages of this form of representation are self-evident. Photopeaks are given equal importance throughout the energy range of measurement. It is proposed that the further incorporation of an energy non-linear analysis unfolding method be considered for code CUPED.

It is concluded that the developed code ,CUPED , is an operable and useful addition to the field of scintillation spectrometry. It allows the semi-automatic generation of detector system response function matrices , spectral unfolding process and final analysis of unknown complex-continuous spectra to be carried out in a single computer run, i.e., without human interfacing. It is very suited to on-line applications.

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FIGURES

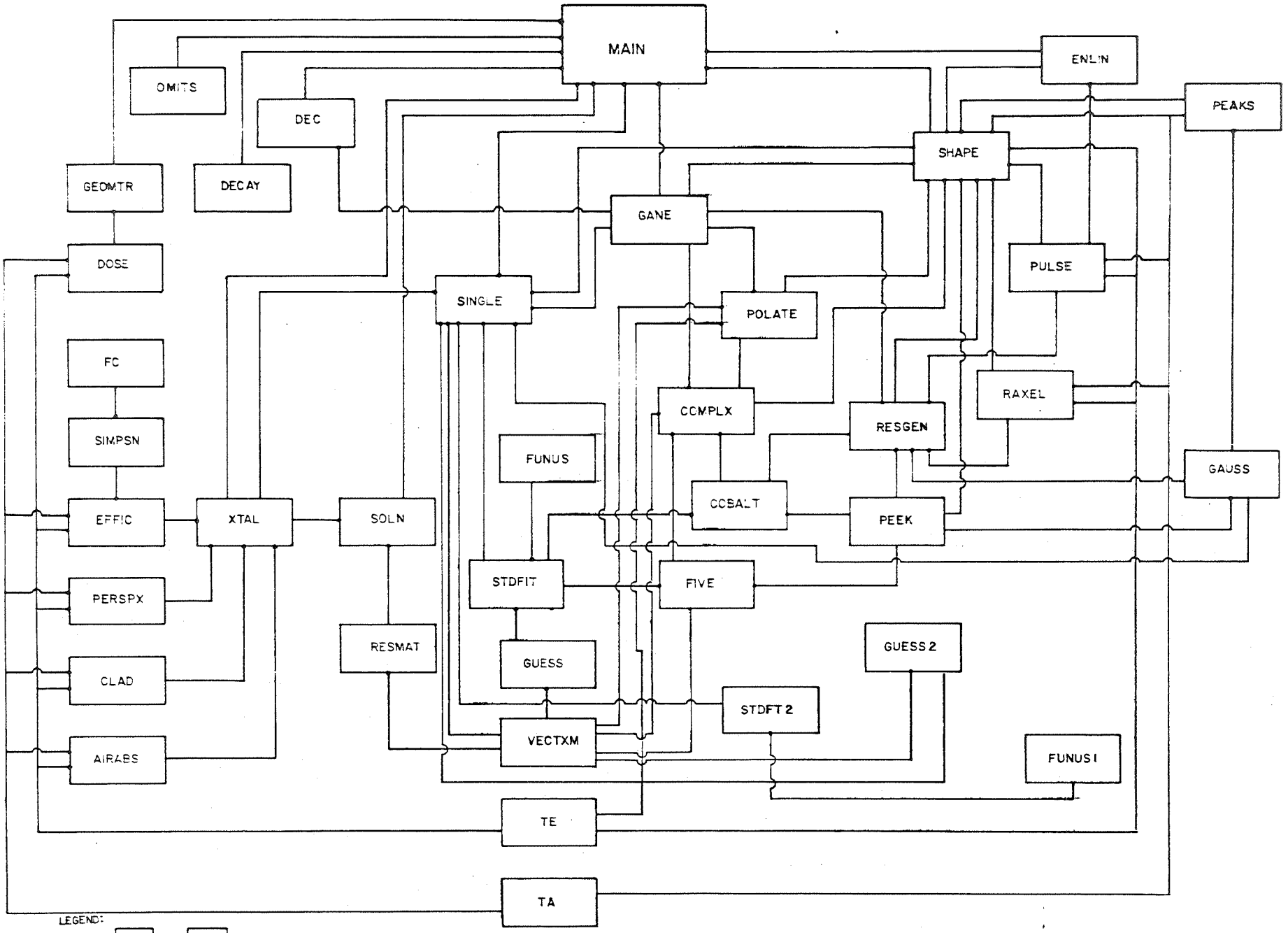


FIGURE 1

CODE CUPED SUBPROGRAM CONNECTIVITY

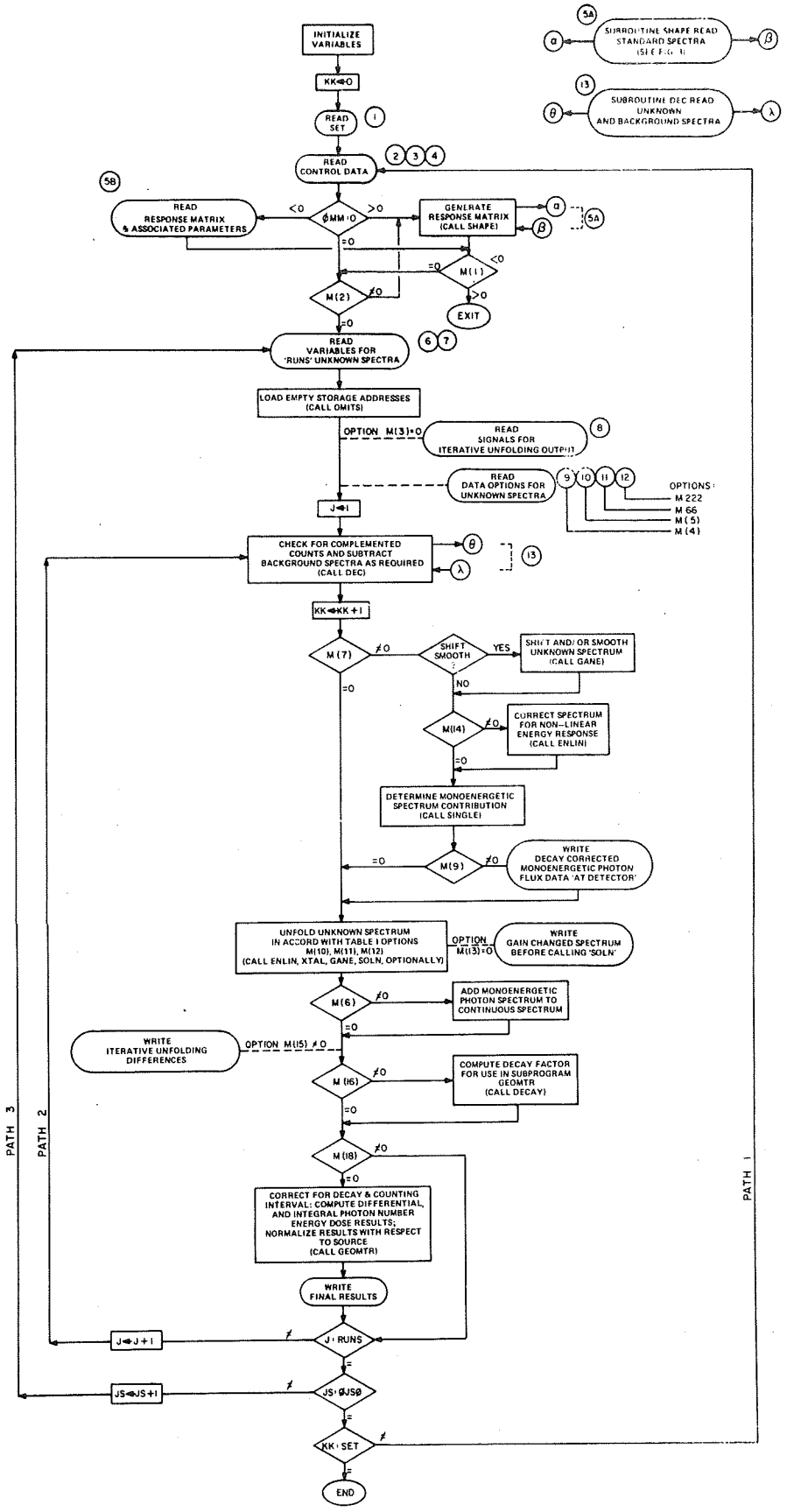


FIGURE 2

CODE CUPED SIMPLIFIED
FLOW DIAGRAM

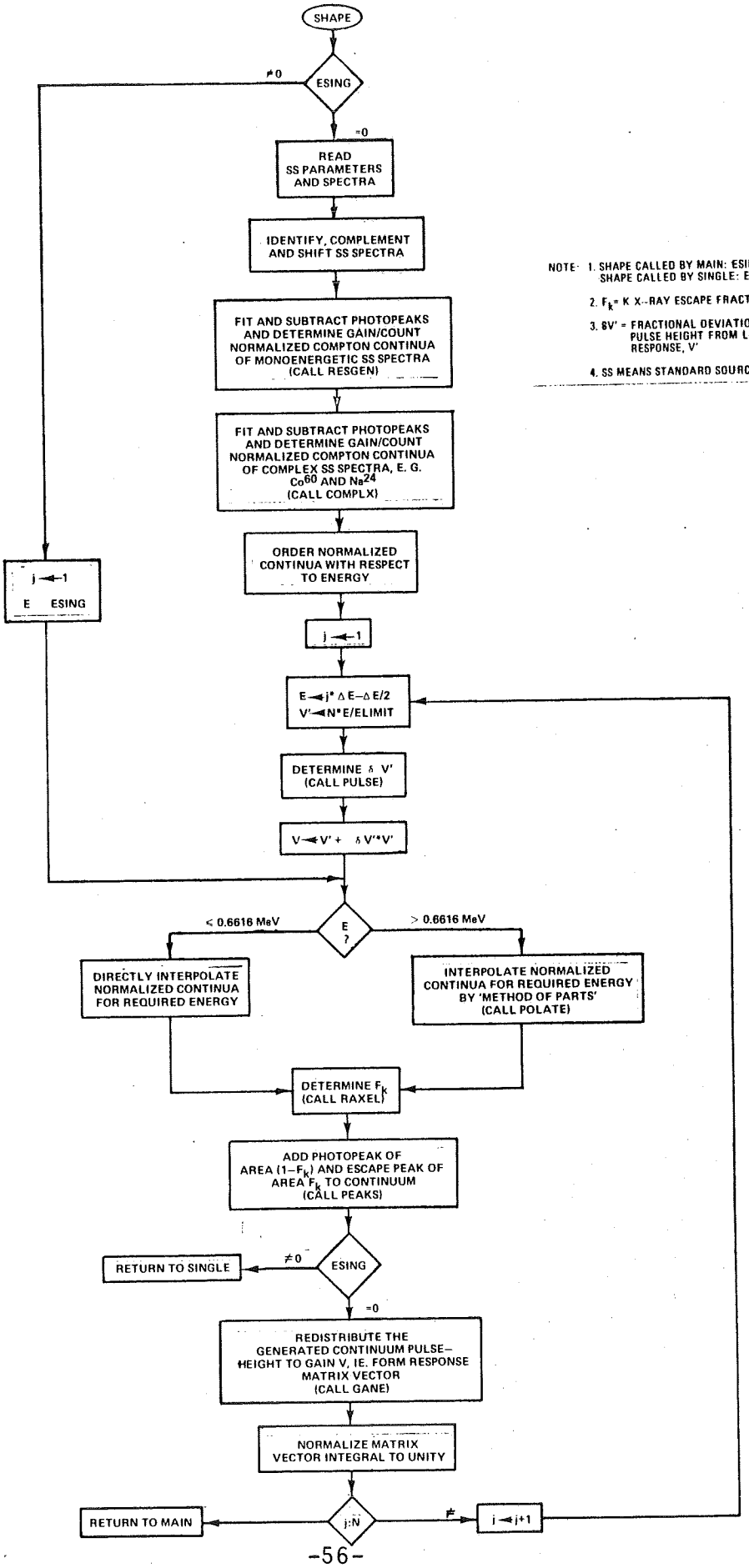


FIGURE 3

FLOW DIAGRAM OF RESPONSE MATRIX GENERATING PROGRAM LOGIC; SUBPROGRAM SHAPE

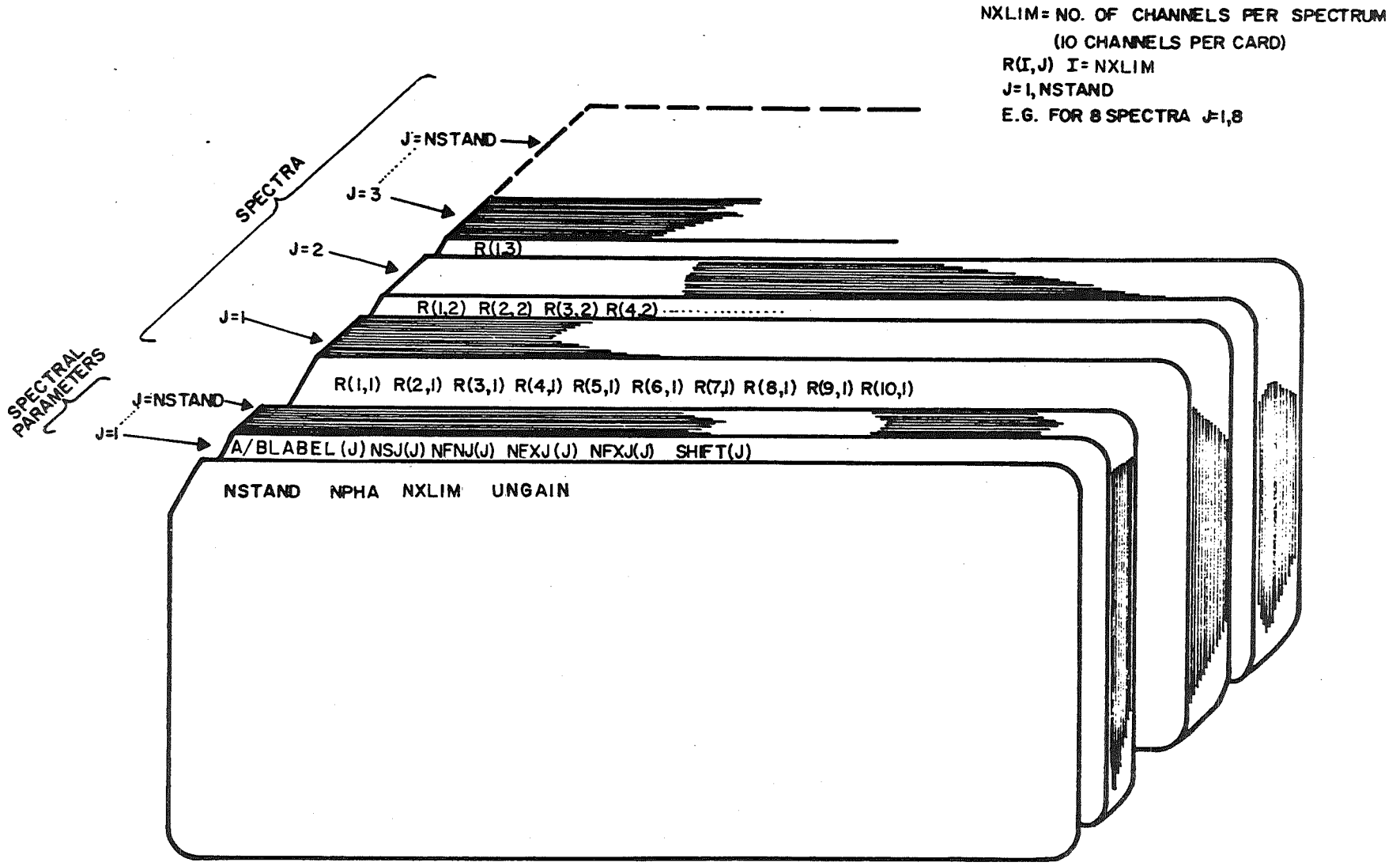


FIGURE 4

STANDARD SOURCE SPECTRA LIBRARY DECK ARRANGEMENT

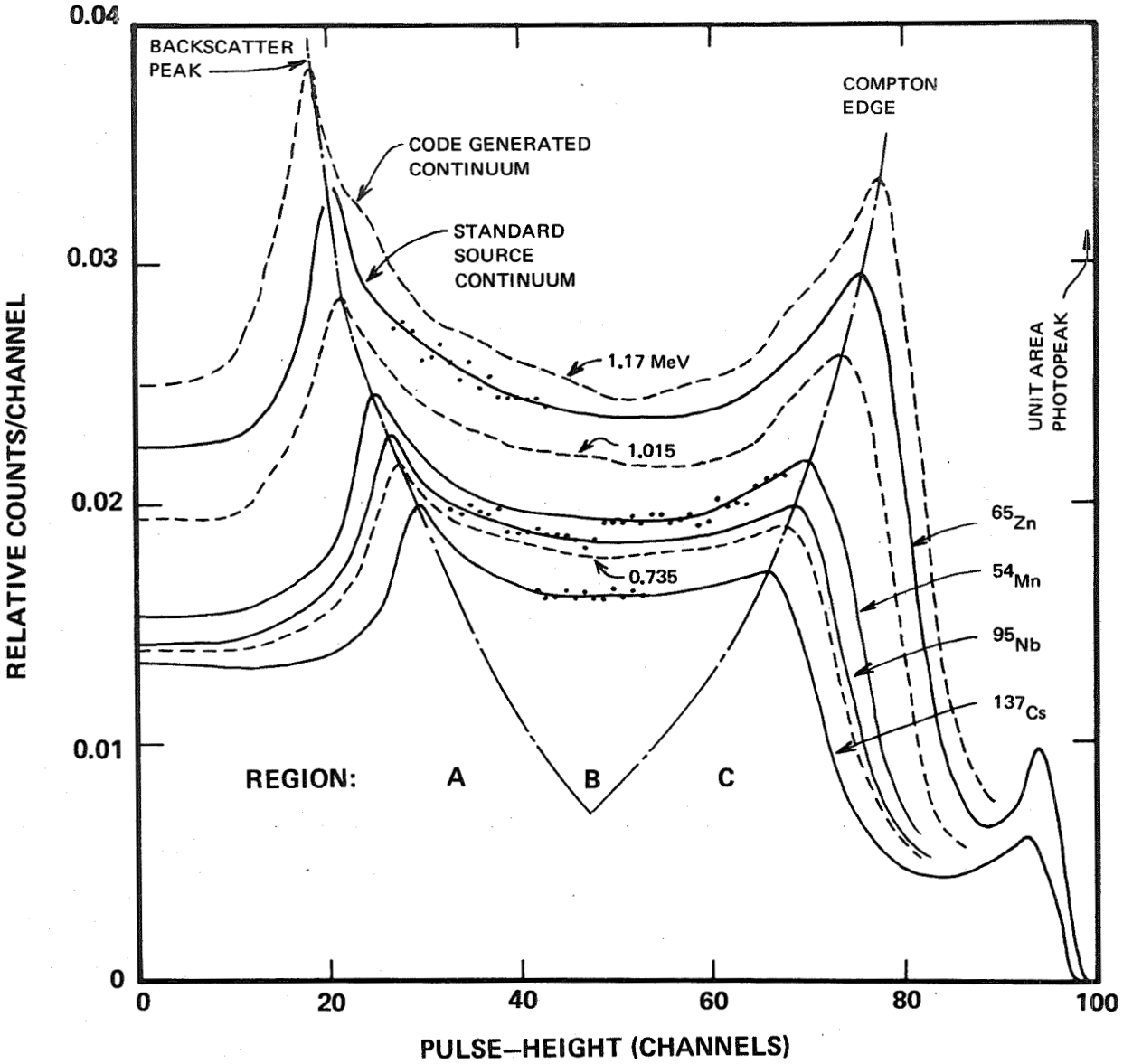


FIGURE 5

COMPARISON OF STANDARD SOURCE AND CODE GENERATED COMPTON CONTINUA PULSE–HEIGHT NORMALIZED TO UNIT AREA PHOTOPEAK

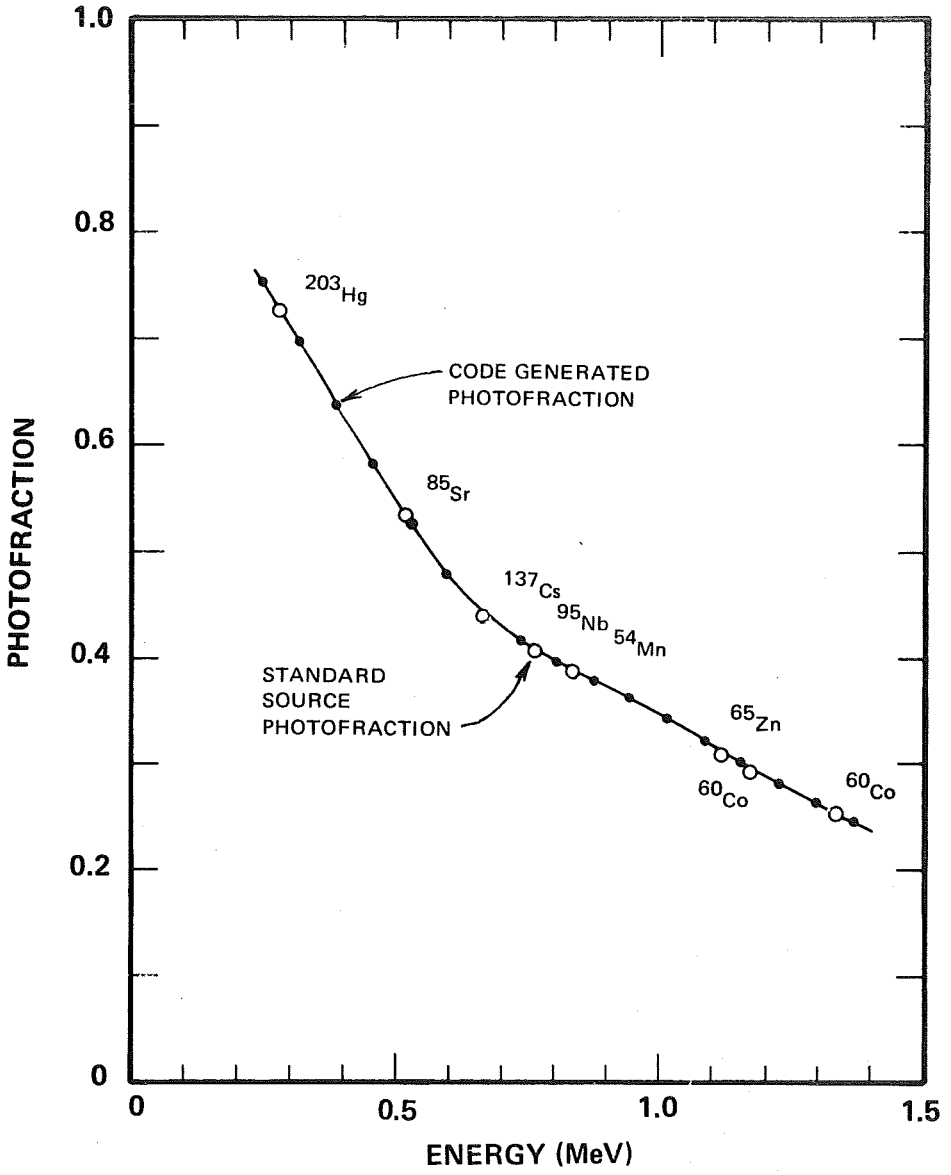


FIGURE 6

COMPARISON OF STANDARD SOURCE AND CODE GENERATED RESPONSE MATRIX PHOTOFRACTIONS

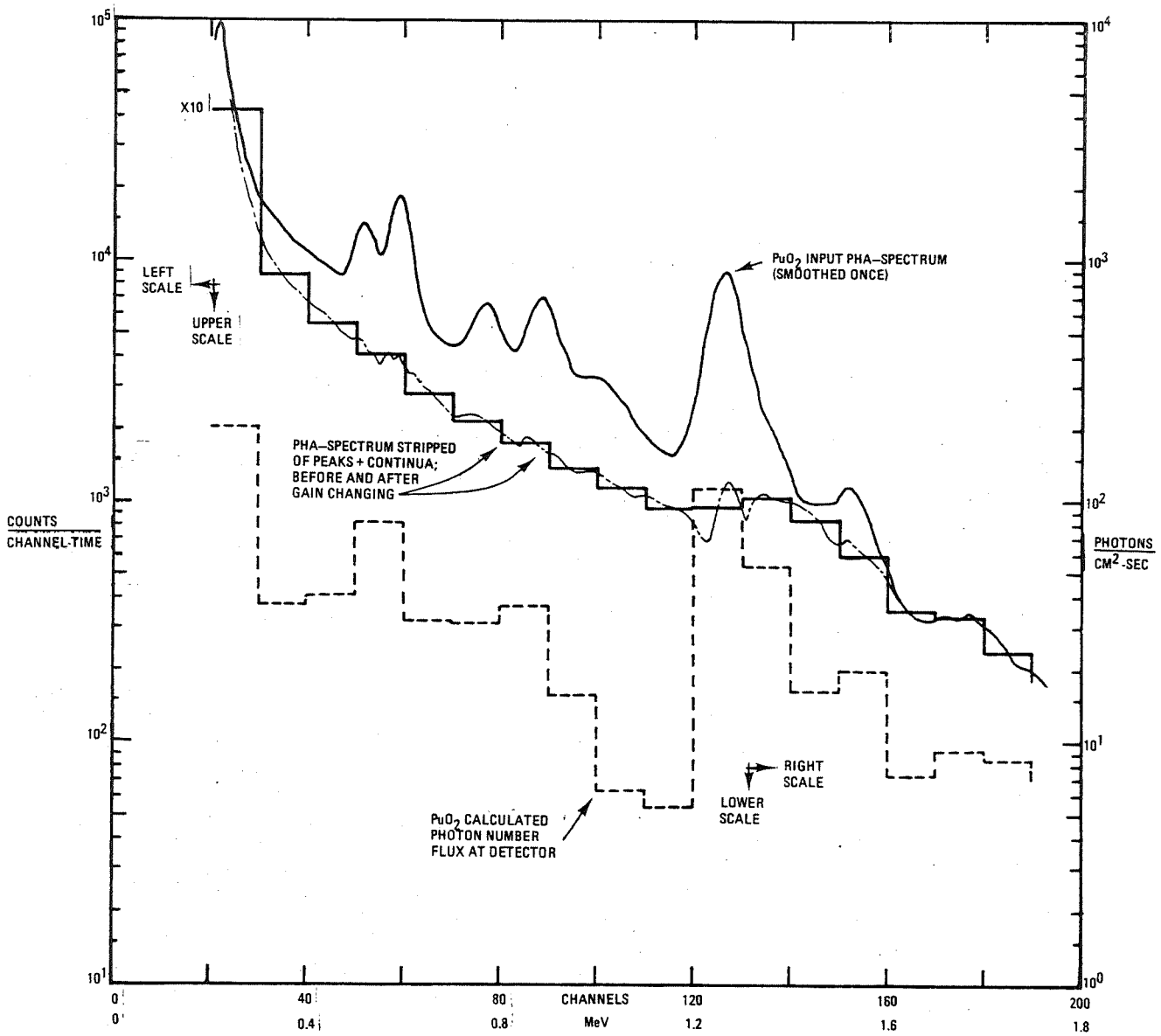


FIGURE 7

PLUTONIUM OXIDE SPECTRUM ANALYSIS

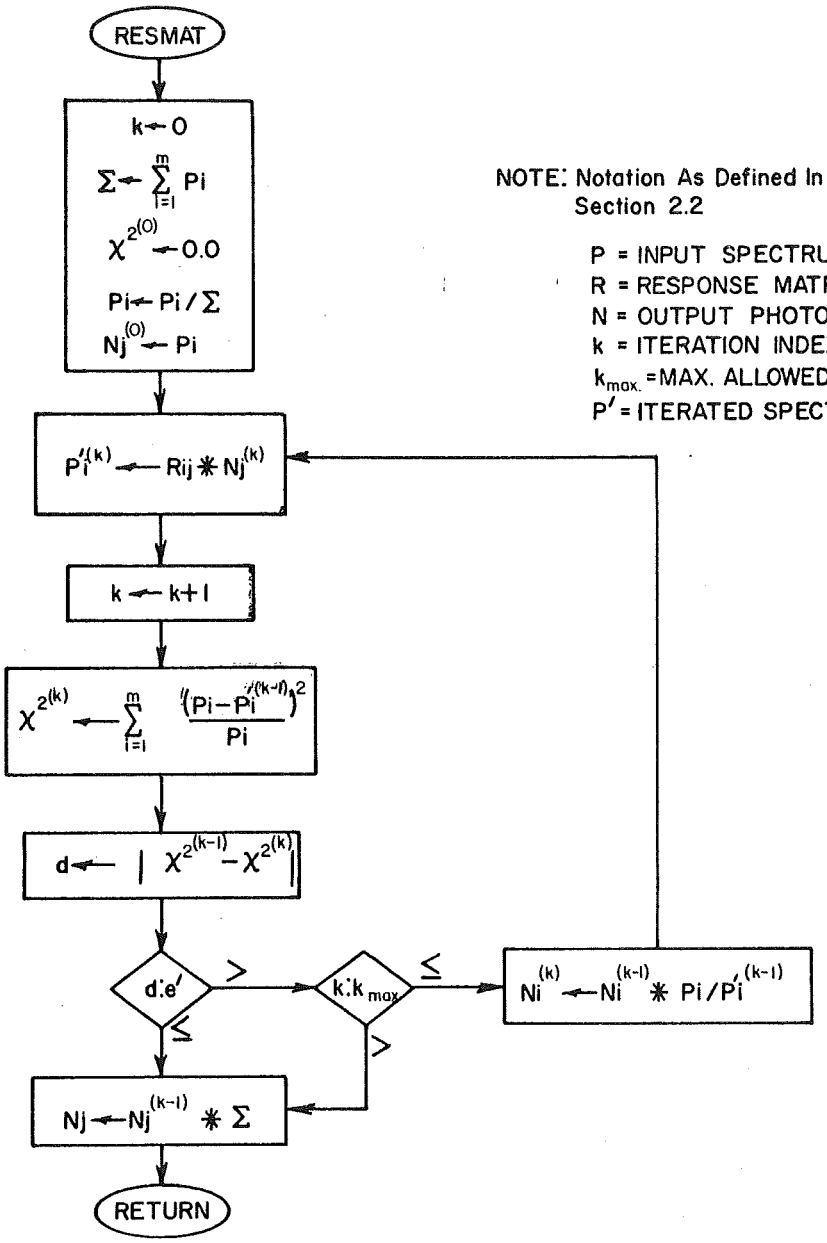
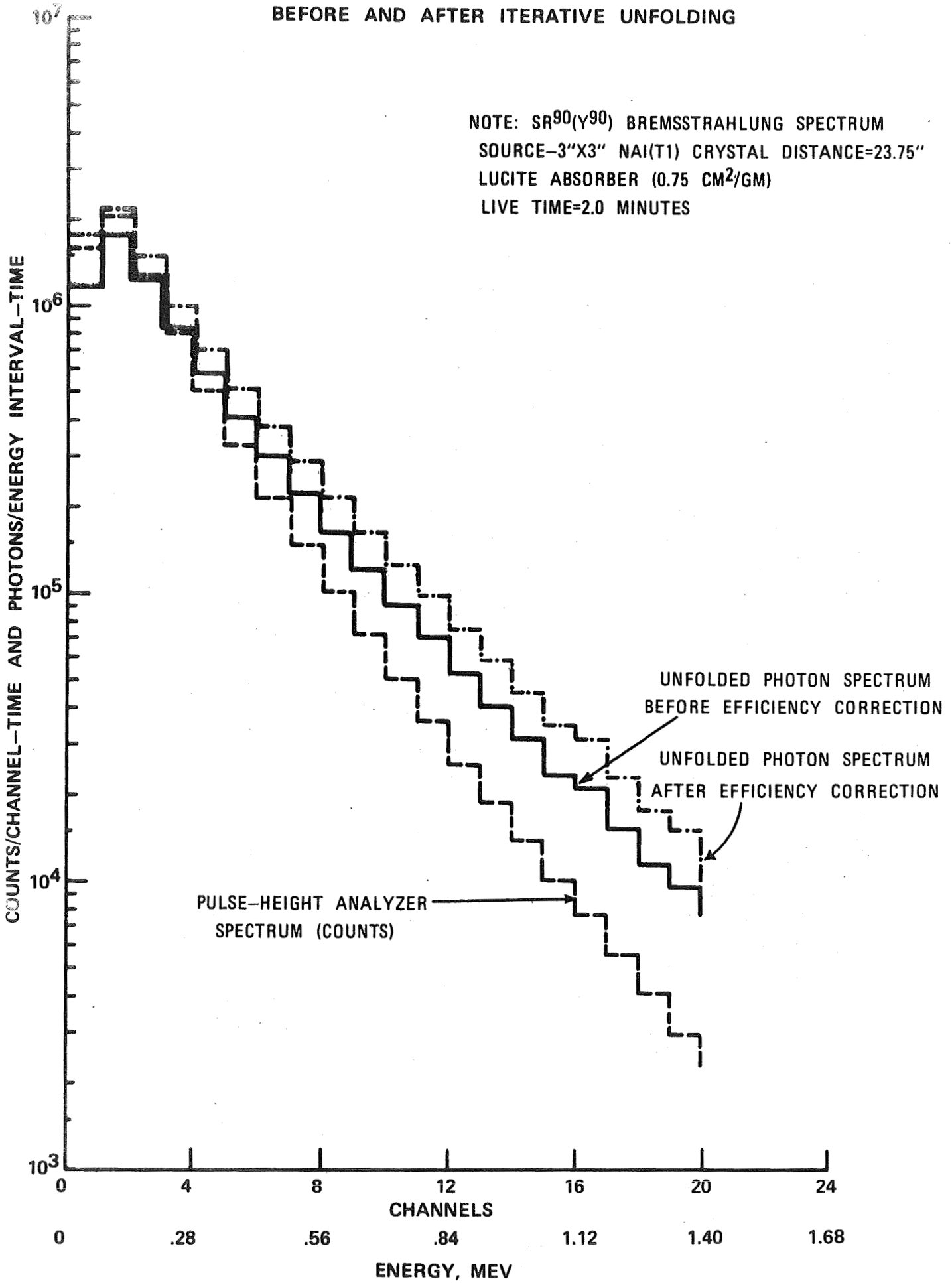


FIGURE 8

FLOW DIAGRAM SHOWING THE GENERAL LOGIC OF SUBPROGRAM RESMAT

FIGURE 9 BREMSSTRAHLUNG SPECTRUM
BEFORE AND AFTER ITERATIVE UNFOLDING



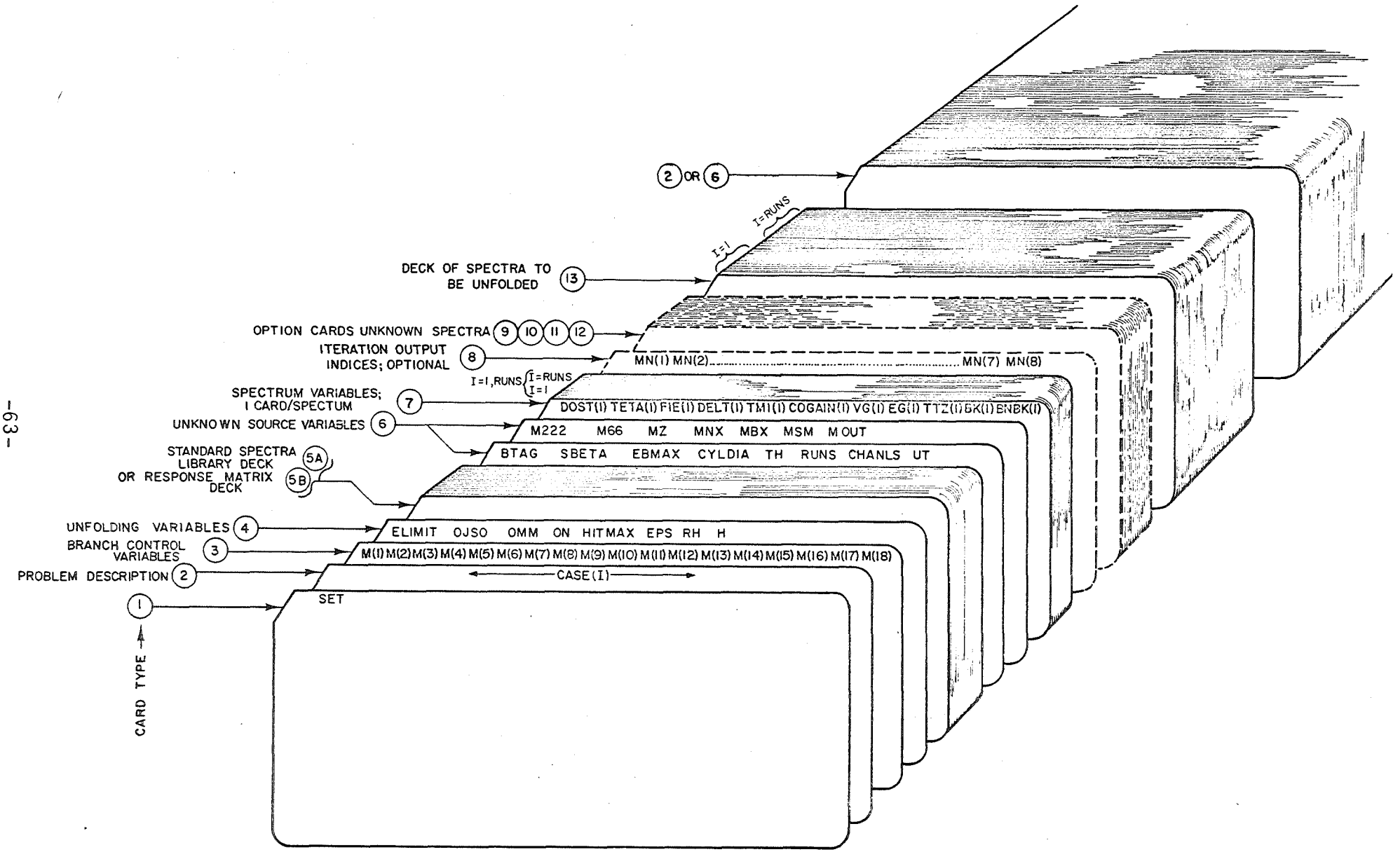


FIGURE 10
GENERAL ARRANGEMENT FOR INPUT CARD DATA DECK

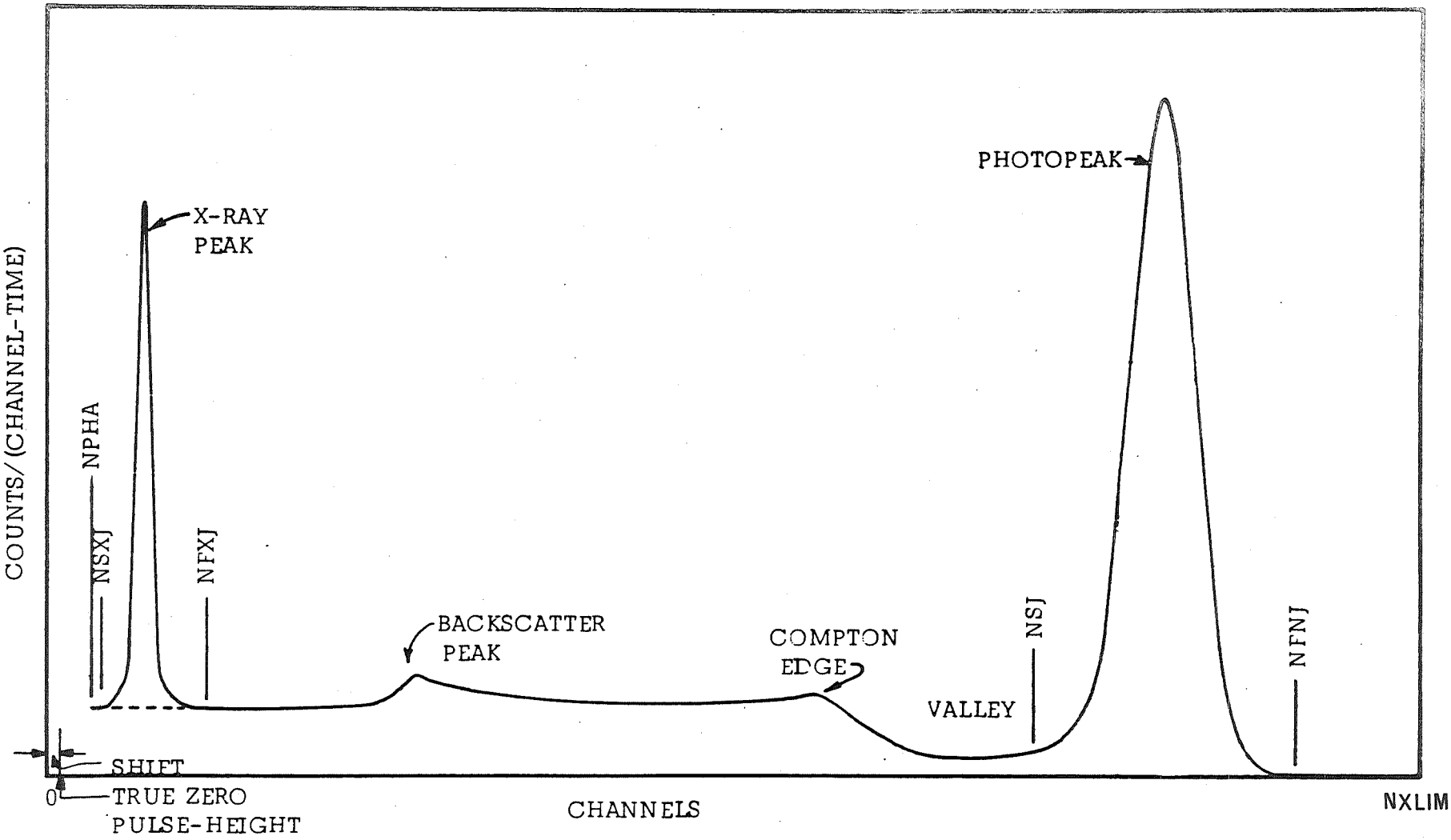
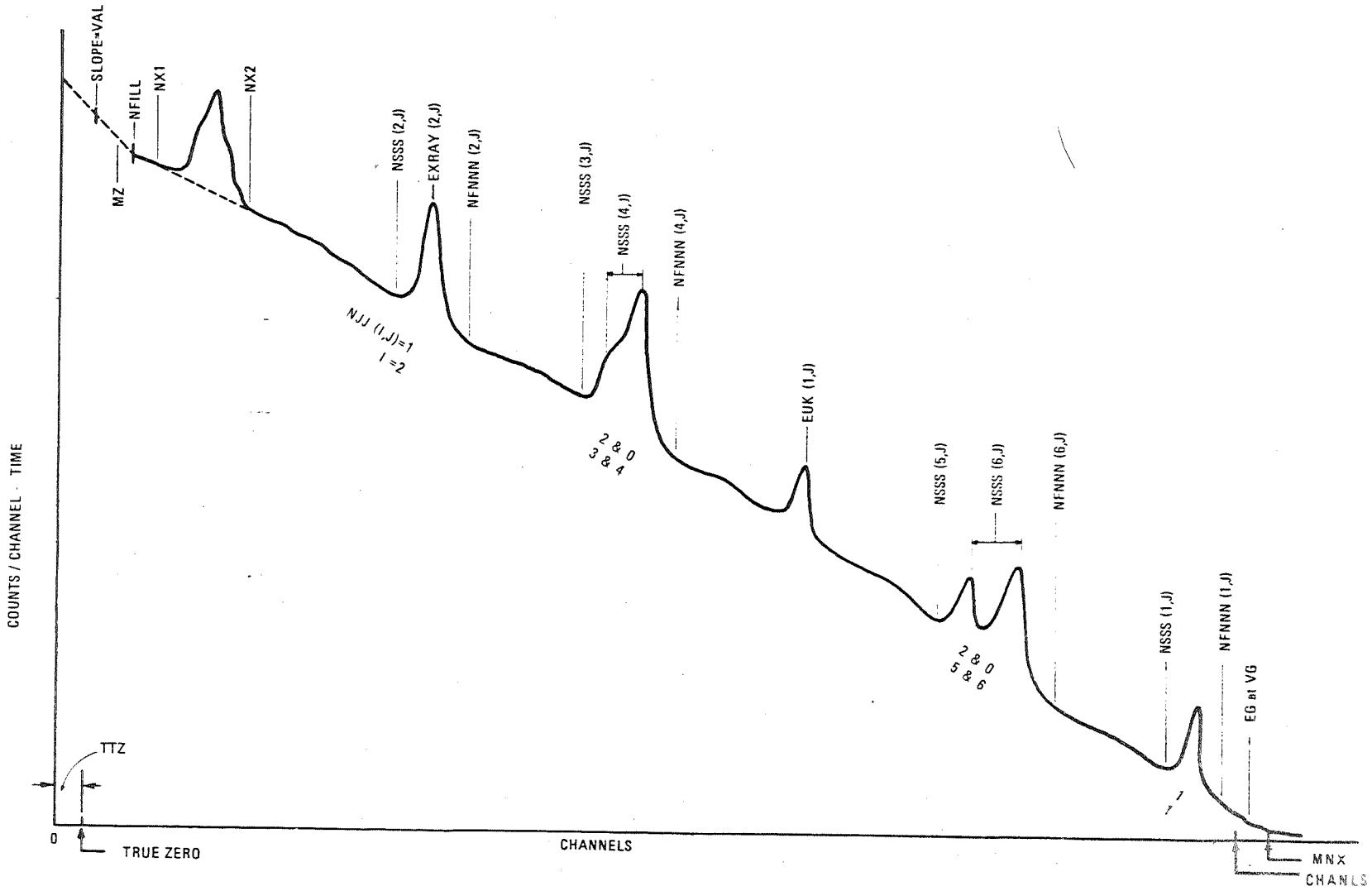


FIGURE 11

DEFINITION OF PARAMETERS FOR STANDARD SOURCE SPECTRA DATA INPUT



NOTE:

M222 = 6
M66 = 1
EXRAY (I,J) =0, EXCEPT EXRAY (2,J)

FIGURE 12

DEFINITION OF INPUT DATA PARAMETERS FOR UNKNOWN SPECTRA

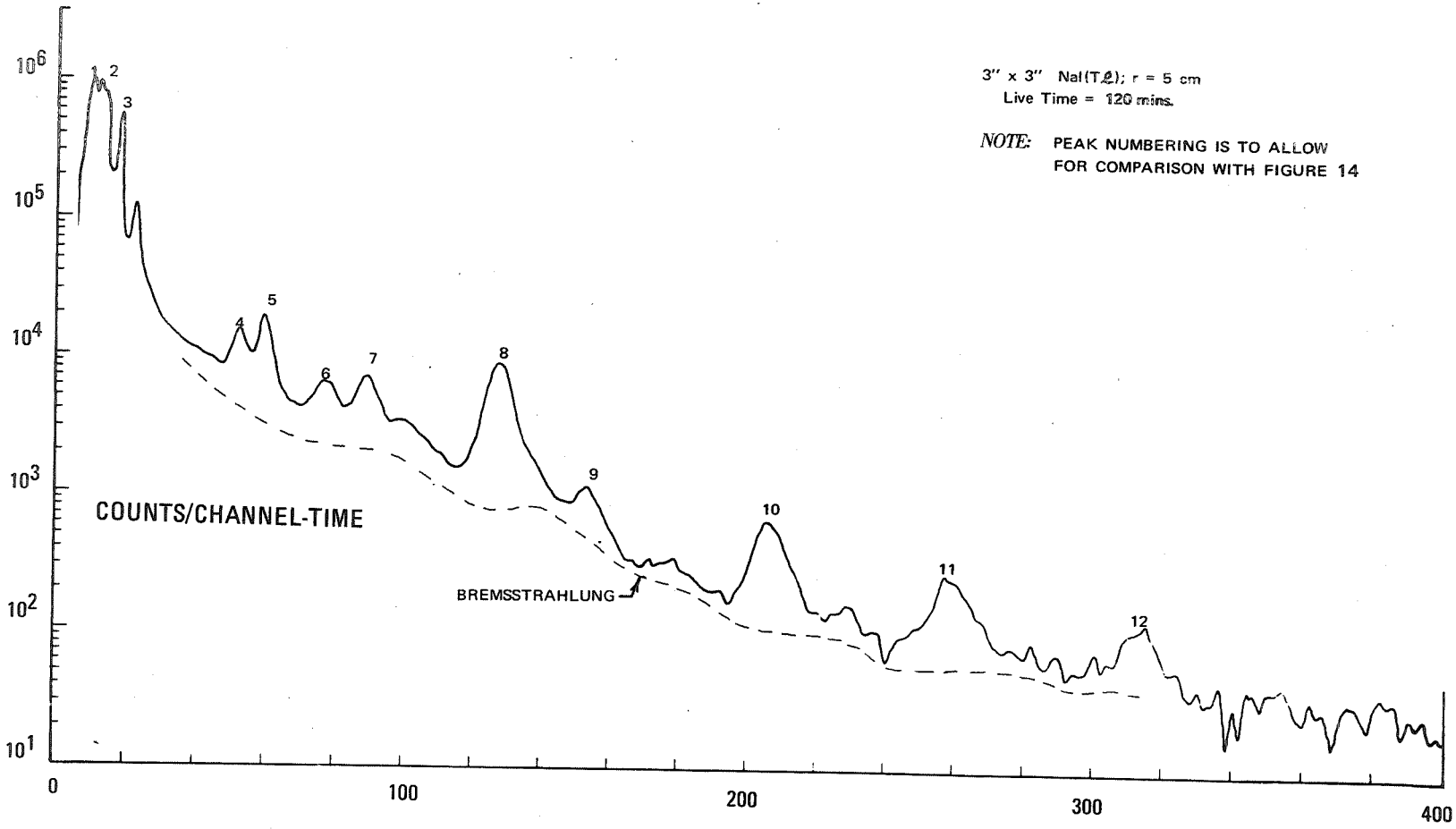
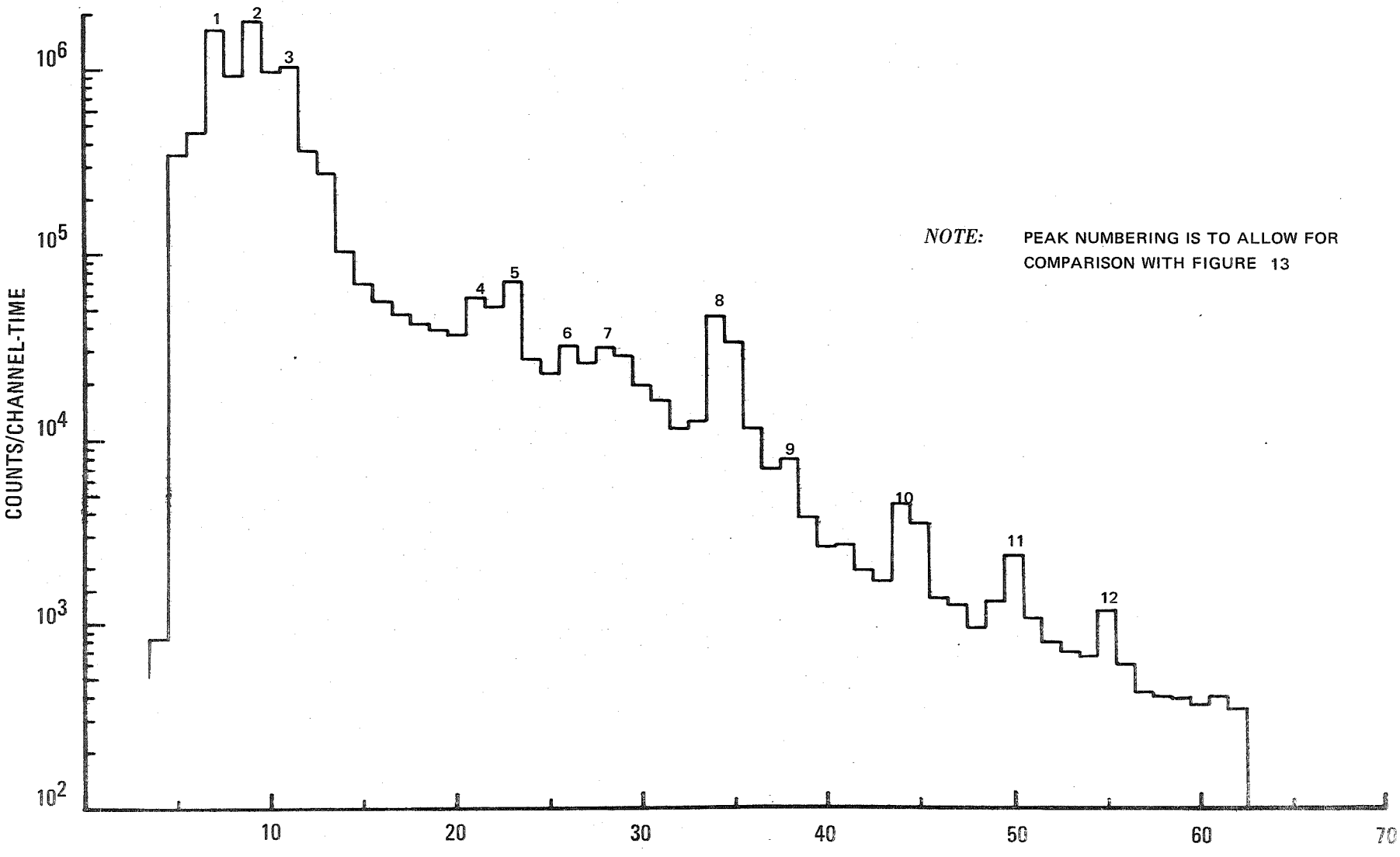


FIGURE 13

PLUTONIUM-OXIDE PHA SPECTRUM



NOTE: PEAK NUMBERING IS TO ALLOW FOR COMPARISON WITH FIGURE 13

FIGURE 14

NON-LINEAR ENERGY INTERVAL REPRESENTATION OF PuO_2 PHA SPECTRUM[19]

Table I

Allowable Values of Input
Options M(10), M(11) and M(12)

M(I)	Called Subprogram Operation Identifier (Defined Below)					
	1	2	3	4*	5*	6*
M(10)	0	0	0	10	0	10
M(11)	0	11	-11	11	11	11
M(12)	0	12	12	0	-12	12
Subprograms Called (See Appendix I for meaning)	GANE RESMAT XTAL	ENLIN XTAL GANE RESMAT	XTAL GANE RESMAT	ENLIN SØLN XTAL	ENLIN GANE RESMAT	ENLIN XTAL

Example: M(10), M(11), M(12) = 0, 11, 12 causes the code to correct an unknown spectrum for non-linear energy response, detection efficiency, gain change (e.g., from 200 to 30 channels) and then unfold. N. B. M(14) dictates whether ENLIN is to be called before or after entry to SINGLE.

* Not normally useful, i.e., for study or debugging purposes only.

APPENDIX I

GLOSSARY OF SUBPROGRAMS

APPENDIX 1

GLOSSARY OF PROGRAMS FOR CODE CUPED

(In alphabetical order, except for MAIN)

NUMBER	NAME	FUNCTION or USE
1	MAIN	Input, output and linking of subprograms.
2	AIRABS	Computes air attenuation factor. (F)
3	CLAD	Computes detector cladding attenuation factor. (F)
4	COBALT	Control program for photopeak fitting and subtraction.
5	CØMPLX	Analyzes Co^{60} and Na^{22} standard spectra for SHAPE.
6	DEC	Reads pulse-height analyzer spectra; checks for PHA-complemented counts.
7	DECAY	Computes source decay correction factor. (F)
8	DØSE	Converts gamma photon flux to dose. (F)
9	EFFIC	Computes elements of detector interaction efficiency vector. (F)
10	ENLIN	Applies non-linear energy response correction factor.
11	FC	Crystal interaction efficiency function. (F)
12	FIVE	Controls fitting and subtraction of Na^{22} escape and 0.51 MeV peaks.
13	FUNUS	Photopeak fitting function, partial derivatives and Chi-square term for STDFIT (one Gaussian plus straight line).

14	FUNUS II	Photopeak fitting function, partial derivatives and Chi-square term for STDFT 2 (two Gaussians plus straight line).
15	GANE	Gain changing program; also spectral shifting and smoothing.
16	GAUSS	Computes Gaussian photopeak for given parameters.
17	GEØMTR	Computes geometry factors, integrates number and energy spectra and calculates normalized dose data for final code results.
18	GUESS	Provides initial estimates of the photopeak function parameters for non-linear regression analysis in subprogram STDFIT.
19	GUESS 2	Provides initial estimates of the photopeak function parameter for non-linear regression analysis in subprogram STDFT 2.
20	ØMITS	Code for insertion of repetitive variables omitted on all but first-card of set.
21	PEAKS	Adds photopeaks and escape peaks; computes photofractions.
22	PEEK	Computes Gaussian function ordinate. (F)
23	PERSPX	Computes perspex absorption factor. (F)
24	PØLATE	Interpolates normalized Compton continua by the method of parts.
25	PULSE	Computes the detector system pulse-height at a given energy. (F)
26	RAXEL	Computes NaI(Tl) iodine K X-ray escape fraction. (F)
27	RESGEN	Orders and normalizes standard spectra for response matrix interpolation.
28	RESMAT	Pulse-height analyzer spectrum unfolding according to the Scofield algorithm.

29	SHAPE	Control program for response matrix generation.	
30	SIMPSN	Simpson's rule integrating program for function FC.	(F)
31	SINGLE	Determines monoenergetic spectral contribution.	
32	SØLN	Control program for unfolding and detector efficiency correction.	
33	STDFIT	Non-linear regression analysis of standard spectra single photopeaks.	
34	STDFT 2	Non-linear regression analysis of standard spectra photopeak pairs.	
35	TA	Binary table searching program.	
36	TE	n-degree Lagrangian interpolation program.	(F)
37	VECTMX	Determines the index and value of the maximum valued element in a vector of elements.	
38	XTAL	Controls computation of detector total efficiency.	

APPENDIX II

FORTRAN CARD DECK LISTING

```
  116 IF(M(12))111,112,111
//ZLJJSCUP JOB (M600111204,T,N00017,001001),045,MSGLEVEL=1,REGION=250K
// EXEC FORTRAN,PARM=BCD
//SOURCE.SYSLIN DD UNIT=2314,SPACE=(CYL,(10,5))
//SOURCE.SYSIN DD *
C   NUS CORPORATION (J.J.STEYN,H.BORN,J.T.STRAHL) (1969) REF NUS-557
C**********   PROGRAM NUMBER -  1    CUPED      ************
C                     *****MAIN PROGRAM*****
C                     **********************
C
C   CODE *CUPED*....CODE TO UNFOLD POLYENERGETIC EXPERIMENTAL DISTRIBUTIONS
C   CUPED REQUIRES  *TAPE 5-INPUT*  *TAPE 6-OUTPUT*
C      CALLS  *DEC* - *DECAY* - *EMLIN* - *GANE* - *GEOMTR*
C      CALLS  *OMITS* - *SHAPE*  - *SINGLE* - *SOLN* - *VECTMY*
C
C   MAIN PROGRAM CONTROLS. INPUTS.OUTPUTS AND CONNECTS SUBPROGRAMS.
C
      DIMENSION DOST(20),CASE(18),M(18),R(40,40),O(260),TETA(20),EIE(20)
     1,           DELT(20),EG(20),VG(20),TM1(20),TT7(20),COGAIN(20),
     2   EM(520),PHI(260),ETA(260),PERACT(50),  PV(50), DIF(100),
     3MN(18),B(260),ENXTAL(260),BNBK(20),EUK(20,20),EU(20),EUG(20),
     4 PHOT(20),BK(20),PP(260),NJJ(20,20),NSSS(20,20),NEMMM(20,20)
     5,N1X(20),N2X(20),NFILL(20),VAL(20),EXRAY(20,20)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON /A/ DI,H,MF
      COMMON /C/ SUMNUM,SUMENY,DOSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
     1 DOSBEX,DOSCYL,DBXVOL,DCYVOL
      COMMON/SHA/R,N,EM,ELIMIT,NGD,NGR,NDEGRE,O,PV,PERACT,K,MREPEAT,
     1  ESING,MEM
      COMMON/PLX/DUM1(3209),NDUM1(60),NX,NSTAND,NIR
      COMMON/POLT/DDUM(152),MUN1
      COMMON/GEN/DAM(29),NDAM(5)
      COMMON/SON/EM,EUG,EU,NP,NGA,NGX,NGC,TKLUC,RX,IN,PHOT,NGE,ETA,DIST
      COMMON/GEO/SBETA,DE,PHI,NS,EBMAX,NGD,DT,VOL,CYLDIA,ENXTAL
      COMMON/SOLRES/EPS,IT,ITMAX,DIF,MN,MSKIP,M14
      COMMON/SING/NA(20),NSS(20),NENN(20),EXR(20),M222,M66
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      COMMON/TMOUT/MOUT
      COMMON/OOORM/ORM,OORM
      ORM=100.0
      OORM=ORM-0.5
C
      NLIMIT=260
      DO 19181 I=1,3173
19181 DUM1(I)=0.0
      LP=7
      LI=5
      LO=6
      DI=30.48
      TKLUC=0.750
      T38=3.81
      T01=0.0001
      T20=20.0
      T50=50.0
      T76=7.62
      T1293=0.001293
      T90=900000.
      T100=1000000.
      T366=3.67
      T3316=0.03316
      T06=1.0E-06
      T321=.321
      T7677=.7677
      T285=0.0285
      MREPEAT=0
      MF=0
      MM=1
      MS=1
      KK=0
      K=0
      NDEGRE=2
      NGD=1
      NGD=1
      NGE=1
      NGR=1
      NGC=1
      NGX=1
      NGA=1
      NGL=1
      DIF(1)=0.0
C   SET =NUMBER OF TIMES PROGRAM WILL CALL *SOLN* (I.E. INVERSION)
      READ(LI,27000)  SET
27000 FORMAT (F10.5)
      NSET=SET
C   CASE(I)=72 COLUMNS OF REMARKS FOR INPUT/OUTPUT PER EACH PASS THRU 1.
C   M(I),I=1,30       18 CONTROL OPTIONS 20 TO 30 ARE SPARE
C   M(1)=LOOPBACT/CONTINUE/EXIT. AFTER *SHAPE* IF -/0/+
C   M(2)=RE-USE EXISTING STAND. SPECTRA FOR NEW RESP. MATRIX IF NOT =0
C   M(3)=READ CARD OF MN(I) FOR INTERMED.ITER. OUTPUT IF NOT =0.EG.IF=3
C   M(4)=READ CHANNELS FOR STR. LINE REPLACEMENT IF NOT = 0
C   M(5)=READ CHANNEL AND SCOPE FOR DEAD CHANNEL FILL-IN IF NOT = 0
C   M(6)=BY-PASS CONTROL-SEE NUS-557
C   M(7)=BY-PASS CONTROL-SEE NUS-557
C   M(8)=BY-PASS *SINGLE* IF = 0
C   M(9)=CORRECT *SINGLE* PEAKS FOR DECAY IF NOT = 0
C   M(10)=BY-PASS CONTROL-SEE NUS-557
C   M(11)=BY-PASS CONTROL---SEE NUS-557
C   M(12)=BY-PASS CONTROL-SEE NUS-557
C   M(13)=WRITE THE ENERGY-CORRESPONDING SPECTRUM IF NOT = 0
C   M(14)=CORRECT PHA SPECTRUM ENERGY LINEARITY FOR *SINGLE* IF NOT = 0
C   M(15)=SIGNAL TO OUTPUT FITTING DIFFERENCES DIF(I) IF NOT = 0
C   M(16)=CORRECT FOR SOURCE DECAY IF =0 . ELSE FACTOR = 1.0
C   M(17)=SIGNAL TO WRITE DECAY CORRECTED PHA SPECTRUM IF NOT = 0
C   M(18)=CALL *GEOMTR* IF =0 ELSE GO TO 500 FOR LOOPBACK
    1 READ    (LI,1001)  (CASE(I),I=1,18),(M(I),I=1,24),
     1ELIMIT,OJSO,OMM,OM,HITMAX,EPS,RX,H
 1001 FORMAT (18A4/24I3     /6F10.5,2F6.4)
C   ELIMIT=ENERGY IN MEV OF UPPER LIMIT OF RESP. MATRIX HIGHEST CHANNEL
C   OJSO=NUMBER OF SIMILAR SETS OF DATA BEFORE LOOPING TO STATEMENT 1.
C   OMM=SIGNAL TO READ/ASSUME EXISTS/GENERATE RESPONSE MATRIX PER -/0/+
C   OM=NUMBER OF CHANNELS IN RESPONSE MATRIX. IF =0 CODE SETS TO 20
C   HITMAX=MAX NUMBER OF ITERATIONS FOR *RESMAT*.  ALSO A SIGNAL TO OUTPUT
C   IF HITMAX=0 CODE SETS TO 50.0
C   FITTING DATA WHILE ITERATING AT LOOP INDEX MN(I).... FOR ITMAX=ODD
C   NUMBER
C   EPS=CONVERGENCE TOLERANCE CHOSEN FOR ITERATIVE FITTING
C   IF EPS=0. CODE SETS TO 0.0001
C   RX=MAT(II) CRYSTAL RADIUS. IF =0 CODE SETS TO 3.81 CM.
C   H= MAT(TL) CRYSTAL LENGTH. IF =0 CODE SETS TO 7.62 CM.
```

```
C  ON,HITMAX,EPS,RX,H NORMALLY BLANK
      MOUT=0
      IF(M(8).EQ.MOUT)MOUT=1
      M14=M(12)
      MEM=M(14)+M(11)
C  INPUT CHECKING AND FILLING BLANK OPTIONS
      JSO=0.1SO
      MM=0MM
      IF(ON)7709,7708,7709
 7708 ON=T20
 7709 N=ON
      IF(HITMAX)8809,8808,8809
 8808 HITMAX=T50
 8809 IF(EPS)9909,9908,9909
 9908 EPS=T01
 9909 ITMAX=HITMAX
      IF(RX)10009,10008,10009
10008 RX=T38
10009 IF(H)11009,11008,11009
11008 H=T76
11009 EN=N
      EM=EN/ELIMIT
      DXX=2.0*RX/2.54
      HXX=H/2.54
      WRITE  (LO,4001) (CASE(I),I=1,18),(I,M(I),I=1,24)
 4001 FORMAT (1HI,30H BRIEF DESCRIPTION OF PHA RUNS   /1X,1844//
 4001116H CONTROL NUMBERS     /(6(3H M(,I2,4H) = I3,1X)))
      WRITE  (LO,4002) EM,ELIMIT,EPS,JSO,MM,ITMAX,N,DXX,HXX
 4002 FORMAT (    6HOEM =   ,E10.5,14H CHANNELS/MEV  /9HOELIMIT= ,E10.5/
 4002133HOITERATIVE ERROR TOLERANCE,EPS = ,E10.5/36HONUMBER OF BETA SOUR
 40022CE SETS,OJSO =  I3,5X,5HMM = ,I3/33HOMAX NUMBER OF ITERATIONS,ITMA
 40023X= ,I3,5X/30HONUMBER OF CHANNELS INPUT, N =  ,I3/
 40024  25HOMAI(TL) CRYSTAL SIZE =    F4.2,3H X ,F4.2,9H INCHES.   /1H1)
      JS=1
      IF(MM)120,21234,12
21234 IF(M(2)) 21244,2,21244
21244  MREPAT=M(2)
      GO TO 12
C
C  IF MM IS NEG. THEN READ RESP. MATRIX, R(I,J)
C  ALSO READ K,O(I), AND PV(I)
C  K=INDEX OF RESP. MATRIX HIGHEST ZERO VECTOR
C  O=INCREMENT MID-POINT ENERGIES IN MEV (CORRESP. TO PV)
C  PV=CHANNEL MID-POINT PULSE-HT. VALUES CORRESP. TO O
C
  120 READ(LI,1966) ((R(I,J),I=NS,M),J=NS,M)
 1966 FORMAT (1X,5E14.7                )
      READ   (LI,6691) K, (O(I),I=1,M),(PV(I),I=1,M)
 6691 FORMAT (I5/(5E10.5))
      GO TO 121
   12 ESING=0.0
C
      CALL SHAPE
C
      MP=N
  121 META=R
      MSKIP=1
      WRITE  (LO,2001)((R(I,J),I=NS,M),J=NS,M)
 2001 FORMAT (//34H1SYSTEM RESPONSE FUNCTION MATRIX  //(10E11.4))
 2009 FORMAT (1H1)
      WRITE  (LO,2009)
      WRITE  (LO,2000) (O(I),I=NS,M)
 2000 FORMAT(49H RESPONSE MATRIX ENERGY INTERVAL MIDPOINTS IN MEV
 2000)  //(10E7.4))
      WRITE  (LO,9876)  (PV(I),I=NS,M)
 9876 FORMAT (/////37H PULSE-HEIGHT IN CHANNELS (MIDPOINTS) //(10E7.2))
      WRITE(LO,30770) (PERACT(I),I=NS,N)
30770 FORMAT (///32H RESPONSE MATRIX PHOTOREACTIONS   //(1X,10E7.4))
      WRITE  (LO,2009)
      IF( M(1) )3000,16,15
   15 CALL EXIT
 3000 GO TO 1
   16 MM=0
      NGE=1
C BTAG,BTAGA ARE LABELS (EG. GA-70) OF BETA SOURCE (IE. FIRST 4 COLS)
C  SBETA=NUMBER BETA/SEC OF 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 OF SECONDS,MINUTES,HOURS,DAYS
C  ,YEARS MULTIPLIED BY UT(BELOW)TO CONVERT TO MINUTES.
C  RUNS=NUMBER OF PHA-RUNS PER SET (E.G. PER BETA SOURCE)
C  CHANLS=NUMBER OF CHANNELS IN EACH SPECTRUM OF SET (=200 IF
C  NOT SPECIFIED)
C  UT=NUMBER OF TIME UNITS (EG. HOURS/DAY IF TH IN HOURS)
C  ,IF MUST BE 0.0 (TH IN YEARS), 1.0 (TH IN SECONDS), 60.0 (TH IN
C  MINUTES), 24.0 ( TH IN HOURS), 365.0 (TH IN DAYS)
C  E.G. IF TH IS 44 HOURS THEN UT=24.0
C  M222=NUMBER OF CHANNEL SPECIFIED PEAKS FOR *SINGLE* TO FIT
C  M66=NUMBER OF ENERGY SPECIFIED PEAKS FOR *SINGLE* TO FIT
C  M7=PUT ZERO COUNT IN FIRST M7 CHANNELS
C  MMX=NUMBER OF CHANNELS IN SPECTRUM OF SIZE 257 TO 512
C  MBX=NUMBER OF CHANNELS IN BKGRD OF SIZE 257 TO 512
C  MSM=SIGNAL TO SMOOTHEN UNKNOWN IF = 1 OR 2, ELSE = 0
    2 READ (LI,20000)BTAG,BTAGA,SBETA,EBMAX,CYLDIA,TH,RUNS,CHANLS,UT
     1,M222,M66,M7,MMX,MBX,MSM
20000 FORMAT (A4,A2,4X,5E10.5,2F6.0/4I5)
      MX=CHANLS
      NRUN=RUNS
C  HALF-LIFE CHECK
      IF(UT)4),40,41
   40 UT=365.25*1440.
      TH=TH*UT
      GO TO 50
   41 IF(UT-1.)43,42,43
   42 TH=TH/60.
      GO TO 50
   43 IF(UT-60.)44,50,44
   44 IF(UT-24.)45,45,46
   45 TH=TH*60.
      GO TO 50
   46 IF(UT-365.)48,47,48
   47 TH=TH*1440.
      GO TO 50
   48 WRITE  (LO,49) UT
   49 FORMAT (35H HALF-LIFE FACTOR ...ERROR... UT =  E10.5, 6H EXIT  )
      GO TO 15
   50 CONTINUE
      WRITE (LO,129) BTAG,BTAGA,SBETA,EBMAX,CYLDIA,TH,RUNS,MX,UT ,M222,
     7 M66,M7,MMX,MBX,MSM,MOUT
```

```
128 FORMAT (1H1, 90H    GAMMA    SOURCE    REFERENCE  SOURCE    SOURCE
1281NUMBER OF      NUMBER       HALF-LIFE                /90H     SOURCE STRENG
1282TH    ENERGY   DIAMETER HALF-LIFE  PHA RUNS   OF CHANNELS  MULTIPLI
1283ER              /80H                (CURIES)     (MEV)        (CM.)  (MINUTES)
1284  THIS SET    PER SPECTRUM              //3X,A4,A2,3F10.4,F11.4,I6,9X,I4,
12855X,F11.4///////8X,A5H M222             M66        M7            MNX         MRX
1286         MSM          MOUT //2X,7I10//////)
      SBETA=SBETA*3.7E+10
C   INDEXED INPUT (I=1 TO NRUN)
C   CODE INSERTS FOR INDEX I GREATER THAN 1 IF VALUE SAME AS FOR
C   I=1, FOR VARIABLES DELT, TM1, COGAIN, VG, FG, TTZ.
C   DOST=DISTANCE FROM SOURCE GEOMETRIC CENTRE TO CRYSTAL FRONT-FACE (CM.)
C   DELT=DURATION OF PHA-COUNTING IN MINUTES
C   FIF=AZIMUTH ANGLE AT SOURCE,OF CRYSTAL-AXIS (DEGREES)
C   TETA=POLAR ANGLE AT SOURCE,OF CRYSTAL AXIS (DEGREES)
C   TM1=TIME DURATION FROM REFERENCE-TIME TO START OF COUNTING IN DAYS
C   COGAIN=COARSE GAIN SETTING OF PHA (EG. 8.)
C   VG AND FG ARE PULSE-HT AND ENERGY OF REFERENCE MONITOR PHOTOPEAK
C   VG CHANNELS AND FG MEV
C   TTZ=THE NUMBER OF CHANNELS FROM TRUE-ZERO TO LOWER EDGE OF CHAN 1.
C   BNBK AND BK=NBK AND BKGD (SEE BELOW) (ARE BACKGROUND SIGNALS)
      DO 5007 I=1,20
      DOST(I)   =0.0
      TETA(I)   =0.0
      FIF(I)    =0.0
      DELT(I)   =0.0
      TM1(I)    =0.0
      COGAIN(I)=0.0
      VG(I)     =0.0
      FG(I)     =0.0
      BK(I)     =0.0
      TTZ(I)    =0.0
 5007 BNBK(I)   =0.0
      READ   (LI,12000)(DOST(I),TETA(I),FIF(I),DELT(I),TM1(I),COGAIN(I),
     1 VG(I),FG(I),TTZ(I),BK(I),BNBK(I),I=1,NRUN)
12000 FORMAT (10F7.3,F2.0)
      IF(MNX.LT.256) GO TO 5006
      XMNX=MNX
      FACTOR=CHANLS/XMNX
      DO 5005 I=1,NRUN
      VG(I)=VG(I)*FACTOR
 5005 TTZ(I)=TTZ(I)*FACTOR
 5006 IF(NRUN-1)5008,5008,5009
 5009 CALL  OMITS(NRUN,DELT   )
      CALL  OMITS(NRUN,TM1    )
      CALL  OMITS(NRUN,COGAIN)
      CALL  OMITS(NRUN,VG     )
      CALL  OMITS(NRUN,FG     )
      CALL  OMITS(NRUN,TTZ    )
 5008 CONTINUE
      DO 1521 J=1,NRUN
 1521 VG(J)=VG(J)-TTZ(J)
      WRITE   (LO,127) (DOST(I),TETA(I),FIF(I),DELT(I),TM1(I),COGAIN(I),
     1 VG(I),FG(I),TTZ(I),BK(I),BNBK(I),I=1,NRUN)
  127 FORMAT (1H0,104H   SOURCE     CRYSTAL ANGLE   COUNTING   REFERENCE    PH
  1271A     MONITOR     MONITOR SPECTRA    BACKGROUND BACKGROUND)
  1272/104H   CRYSTAL        AT SOURCE        DURATION     TIME        COARSE  PULSE-
  1273        ENERGY    ZERO           SIGNAL      MULTIPLIER
  1274/85H DISTANCE      (DEGREES)       (MINUTES)     (DAYS)        GAIN    HEIGHT
  1275     (MEV)       SHIFT                          /25H   (CM.)       POLAR   AZIMUTH
  1276                                          (CHANNELS)            (CHANNELS)
  1277///(2X,       4F8.3,2X,F8.2,3X,F5.2,1X,3F9.4,2F11.4))
      WRITE   (LO,2009)
C
C   IF M(3)  NOT=0,READ INDICES MM(I) OF ITERATION INTERMED. OUTPUT
C
      IF(M(3)) 333,444,333
  333 READ    (LI,555)   (MM(I),I=1,18)
  555 FORMAT  (18I4)
      WRITE   (LO,556)   (MM(I),I=1,18)
  556 FORMAT  (53H1ITERATING OUTPUT ON ITERATION LOOPS NUMBERED BELOW
  5561///(1X,5I10))
      WRITE   (LO,2009)
  444 IF(MX)9111,1119,9111
 1119 MX=256
 9111 ROGAIN=FN
      DO 3200 J=1,20
      DO 32000 I=1,20
      FUK(I,J)=0.0
      NJJ(I,K)=0
      NSSS(I,J)=0
      MENNW(I,J)=0
32000 FXRAY(I,J)=0.
      N1X(J)=0
      N2X(J)=0
      NFILL(J)=0
 3200 VAL(J)=0.0
      IN=M66+M222
      IF(M(4)) 3205,3206,3205
C   READ CHANNELS FOR STR. LINE REPLACEMENT
 3205 READ(LI,3240)(N1X(J),N2X(J),J=1,NRUN)
      IF(MNX.LT.256) GO TO 3204
      DO 3202 J=1,NRUN
      N1X(J)=N1X(J)*FACTOR
 3202 N2X(J)=N2X(J)*FACTOR
 3204 WRITE(LO,3241)(N1X(J),N2X(J),J=1,NRUN)
 3241 FORMAT(//35H CHANNELS FOR STR. LINE REPLACEMENT /(2X,10I5))
 3206 IF(M(5)) 3207,3208,3207
C   READ CHANNEL AND SLOPE FOR DEAD CHANNEL FILL-IN
 3207 READ(LI,3242) (NFILL(J),VAL(J),J=1,NRUN)
      IF(MNX.LT.256) GO TO 3201
      DO 3209 J=1,NRUN
      NFILL(J)=NFILL(J)*FACTOR
 3209 VAL(J)=VAL(J)/FACTOR
 3201 WRITE(LO,3243) (NFILL(J),VAL(J),J=1,NRUN)
 3243 FORMAT(//44H CHANNEL AND SLOPE FOR DEAD CHANNEL FILL-IN
     1/(4(2X,I5,F10.5)))
 3208 CONTINUE
 3240 FORMAT(10I5)
 3242 FORMAT(4( I5,F10.5))
      IF(M66 ) 770,771,770
C
C  FUK(I,1)=ONE TO M66 PEAK ENERGIES (MEV) FOR J=1
C  FUK(I,2)=ONE TO M66 PEAK ENERGIES (MEV) FOR J=2
C  FUK(I,3)=ONE TO M66 PEAK ENERGIES (MEV) FOR J=3
C            --------------------     ETC.    -------------------
C
  770 DO 1771 J=1,NRUN
      READ(LI,700) (FUK(I,J),I=1,M66)
  700 FORMAT(5F10.5)
```

```
      WRITE(LO,701) (EUK(I,J),I=1,MAA)
  701 FORMAT(35H1 ENERGIES IN MEV OF UNKNOWN PEAKS   ///(1X,4E10.5))
 1771 CONTINUE
  771 CONTINUE
      IF(M222) 1494,1495,1494
C  READ SINGLE OR DOUBLE SIGNAL AND PEAK LIMITS (3 PKS/CARD) FOR M222
C  PEAKS FOR *SINGLE* FITTING
 1494 DO 772 J=1,NRUN
      READ(LI,1496) (NJJ(JP,J),NSSS(JP,J),NENNN(JP,J),EXRAY(JP,J),JP=1,
     1M222)
 1496 FORMAT(3(3I4,F8.4))
      IF(MMX.LT.256) GO TO 772
      DO 702 JP=1,M222
      NSSS(JP,J)=NSSS(JP,J)*FACTOR
  702 NENNN(JP,J)=NENNN(JP,J)*FACTOR
  772 WRITE(LO,1490) (NJJ(JP,J),NSSS(JP,J),NENNN(JP,J),EXRAY(JP,J),JP=1,
     1M222)
 1490 FORMAT(//14H  CARD SET 12  //(2X,3(3I4,F10.4)))
 1495 CONTINUE
C
C MAIN EXECUTION LOOP FROM HERE
C
      DO 500 J=1,NRUN
      KK=KK+1
      MENLIN=0
      GAIN=VG(J)*ELIMIT/EG(J)
      DIST=DIST(J)
      DT=DELT(J)
      TM=TM1(J)
      BKGD=BK(J)
      NBK=NBBK(J)
      N=NX
      JJ=1
      CLAMDA=ALOG(2.0)/TH
C
C  READ SPECTRA
C  NOTE THAT SPECTRA AND BKGRDS OF SIZE 257 TO 512 CHANNELS MAY BE READ
C  BY *DECK, BUT ARE REDUCED TO SIZE NX WHERE NX LESS THAN 257.
C  BKGD=MULTIPLIER FOR BACKGROUND ADDITION/SUBTRACTION OPERATIONS
C  NBK=SIGNAL                    SUBT/NOT READ/ADD A BACKGROUND PER -/0/+
C  IF NBK =0 NEITHER READ NOR SUBTRACT A BACKGROUND.
C  IF NBK  NEG. THEN SUBTRACT THE CURRENT EXISTING BACKGROUND.
C  IF NBK  POS THEN READ AND SUBTRACT BKGD*BACKGROUND.
C
C  SPECTRA READ AND COMPLEMENTED BY *DEC*
C
      CALL DEC (NX,EM,MMX)
      IF(NBK)6,22222,11
C
   11 CALL DEC (NX,B,MBX)
C
    6 DO 3 I=1,NX
    3 EM(I)=EM(I)-BKGD*B(I)
22222 CONTINUE
      WRITE(LO,25123) JJ,BTAG,PTAGA,(EM(I),I=1,NX)
25123 FORMAT(1H1,17H SPECTRUM NUMBER   ,I3,5H FOR ,A4,A2,8H SOURCE     //
     1 25123H  (AFTER BACKGROUND SUBTRACTION)     //(1X,10E8.0))
      T7=TT7(J)
      NT7=T7
      SM=0.0
      IF(NIX(J)) 3230,3234,3230
 3230 NX1=NIX(J)
      NX2=NX2X(J)
      XMX1=NX1
      XMX2 = NX2
      SLP= (EM(NX2)-EM(NX1))/(XMX2-XMX1)
      NX11=NX1+1
      NX22=NX2-1
      DO 3231 I=NX11,NX22
      X=I-NX1
 3231 EM(I)=EM(NX1)+SLP*X
      WRITE(LO,3239)NX1,NX2
 3239 FORMAT(40H XRAY PEAK SUBTRACTED BETWEEN CHANNELS  I5,5H AND I5)
 3234 IF(NFILL(J))3232,3232,3232
 3232 IF(VAL(J))3235,3236,3235
 3235 NX2=NFILL(J)
      NX1=1
      FILL = NX2
      SLP = (EM(NX2)-VAL(J))/FILL
      NX11=NX1+1
      NX22 = NX2-1
      DO 3237 I= NX11,NX22
      X =I-NX1
 3237 EM(I) = VAL(J)+SLP*X
      WRITE(LO,7242)NX22,SLP,VAL(J)
 7242 FORMAT (6H FIRST,I4,2X,48H DEAD CHANNELS FILLED PER EM(I)=M*Y+C WH
     1ERE M = ,E14.7,9H AND C =     ,E14.7)
      GO TO 3233
 3236 NX2 = NFILL(J)-1
      NX1 = NFILL(J)
      DO 3238 I=1,NX2
 3238 EM(I) = EM(NX1)
      SLP=0.0
      WRITE(LO,7242)NX2,SLP,EM(NX1)
 3233 CONTINUE
      IF(M7)8881,25,8881
 8881 DO 8882 I=1,M7
 8882 EM(I)=0.0
   25 CONTINUE
      IF(M(7)) 773,9,773
  773 IF(MAA) 1497,777,1497
 1497 DO 774 I=1,MAA
  774 EU(I)=EUK(I,J)
  777 CONTINUE
11497 IF(M222) 1498,1499,1498
 1498 DO 775 I=1,20
      EXR(I)=0
      MA(I)=0
      MSS(I)=0
  775 MENN(I)=0
      DO 1489 I=1,M222
      EXR(I)=EXRAY(I,J)
      MA(I)=NJJ(I,J)
      MSS(I)=NSSS(I,J)-MT7
 1489 MENN(I)=NENNN(I,J)-NT7
 1499 CONTINUE
C
C  CALL *GAME* TO SUBT AND/OR SMOOTH FOR SPECTRAL ANALYSIS IN *SINGLE*.
      GG=GAIN
      AM=MSM
```

```
      IF(T7+DM)1492,32,1492
 1492 CALL GANE (T7,N,1.0,1.0,0.0,EM)
C
   32 IF(M66) 602,601,602
  602 DO 34 I=1,M66
   34 EUG(I)=EU(I)*GAIN/ELIMIT
  601 CONTINUE
      WRITE(LO,22333) (EM(II),II=1,N)
22333 FORMAT(40H1 UNKNOWN SPECTRUM BEFORE PEAK FITTING  //(4X,10E10.0))
      NSIM=N
   36 IF(M(14)) 60,129,60
C
   60 CALL ENLIN(N,EM,EG,VG,NGL,JJ,NGG,0,ELIMIT)
      MENLIN=1
  129 CALL SINGLE(NSIM,GG)
C
      WRITE(LO,22332)TZ,N,GAIN,ROGAIN,SM,(EM(I),I=1,N)
22332 FORMAT(1H1,43H GAIN PARAMETERS AFTER CALL SINGLE IN MAIN
     1/1X,E8.3,I5,3E10.4/(1X,10E12.6))
 1493 IF(M(9)) 300,306,300
  300 WRITE(LO,302)
  302 FORMAT(1H0,38X,43HSUBTRACTED DISCRETE PEAK PHOTON NUMBER FLUX //
     133X,5HINDEX,15X,6HENERGY,17X,11HNUMBER FLUX /
     253X,5H(MEV),14X,19H(PHOTONS/CM**2-SEC) //)
      DE=DECAY(DT,TH,TM,CLAMBA)
      DO 301 I=1,IN
      PHOT(I)=(DE*PHOT(I))/(DT*60.*3.14159265*RX*RX)
      WRITE(LO,303)I,EU(I),PHOT(I)
  303 FORMAT(1H ,34X,I1,2E25.7)
  301 CONTINUE
      DO 305 I=1,IN
  305 PHOT(I)=0.0
  306 CONTINUE
    9 DO 205 I=1,NLIMIT
  205 PHI(I)=Q(I)
      IF(M(10)) 124,10,124
  124 IF(M(11))110,21,110
  110 ME=1
      MSKIP=1
      GO TO 116
   10 IF(M(12))111,113,111
  116 IF(M(12))111,112,111
  111 M14=M(12)
      IF(M(11))209,113,112
  209 M17=M(11)
      GO TO 201
  112 M17=M(11)
      IF(MENLIN) 600,8888,600
C
8888  CALL ENLIN (N,EM,EG,VG,NGL,JJ,NGG,0,ELIMIT)
  600 MENLIN=0
C
      WRITE(LO,100)  N,(EM(I),I=1,N)
  100 FORMAT (24H1LINEARIZED SPECTRUM OF  ,I4,2Y,10H CHANNELS  //(1X,10E
     10018.0))
  201 IF(M(12))204,113,202
  202 NGE=1
C
      CALL XTAL(NS,N,0,H)
C
      DO 502 I=NS,N
  502 EM(I)=EM(I)/ETA(I)
      IF(ME)113,207,113
  207 DO 208 I=1,NLIMIT
  208 Q(I)=PHI(I)
      GO TO 113
  204 ME=0
  113 KK=KK+1
C
      IF(ME)206,778,206
C
C  MAKE SPECTRUM COMPATIBLE IN GAIN WITH RESP MATRIX
C
C
  778 CALL GANE (TZ,N,GAIN,ROGAIN,SM,EM)
C
  206 IF(M(13))114,8851,114
 8851 WRITE  (LO,8852) N,       GAIN,ROGAIN,(EM(I),I=1,N)
 8852 FORMAT (1H1,32H INPUT SPECTRUM GAIN CHANGED TO      ,I5,9H CHANNELS
     18852)/22H  GAIN CHANGE RATIO =    ,E10.5,1H/ ,E10.5      ///(1X,5E14.7))
C
  114 CALL SOLN
C
      WRITE(LO,2009)
      MSKIP=0
      IF(ME)122,79,122
  122 WRITE  (LO,126)  (PHI(I),I=1,N)
  126 FORMAT (1H1,40H PHA SPECTRUM CORRECTED FOR EFFICIENCY  //(5(2X,E12.
     12415)))
      GO TO 21
   79 IF(M(6)) 179,125,179
  179 DO 70 JN=1,IN
      DY=EU(JN)*EM
      I=DY
      DIY=I
      IF((DY-DIY)-.5)71,71,72
   72 IF(I-N)76,77,75
   77 NJ=N
      GO TO 78
   76 I=I+1
      DIY=I
      GO TO 74
   71 IF(I)73,73,74
   73 NJ=1
   78 PHI(NJ)=PHI(NJ)+PHOT(JN)
      GO TO 75
   74 DIY=DIY-DY+0.5
      TWO=1.0-DIY
      PHI(I)=PHI(I)+PHOT(JN)*DIY
      PHI(I+1)=PHI(I+1)+PHOT(JN)*TWO
   75 CONTINUE
   70 CONTINUE
  125 CONTINUE
   20 WRITE(LO,2020) IT,
  201   (PHI(I),I=NS,N)
 2020 FORMAT ( 41H0DIFFERENTIAL FLUX AT ITERATION NUMBER =   ,I5/
 20201    (5(2X,E12.5)))
 1421 IF(M(15))1423,21,1423
 1423 WRITE  (LO,1424) (DIF(I),I=1,IT)
 1424 FORMAT (30H FITTING DIFFERENCES              /(1X,5E14.7))
```

```
   21 IF(M(16))800,801,800
  800 DE=1.0
      GO TO 802
  801 DE=DECAY(   DT,TH,TM,CLAMDA)
  802 CONTINUE
10021 IF( M(17) )81,99,81
   81 WRITE  (LO,2025) N,(EM(I),I=NS,N)
 2025 FORMAT (1H1,17H SINGLE SPECTRUM ,I5,10HCHANNELS  /(1X,10E9.0))
   99 IF(M(18))500,24,500
C
   24 CALL GEOMTR
C
      WRITE(LO,8890)(I,O(I),PHI(I),ENXTAL(I),I=NS,N)
 8890 FORMAT (44H1NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL         ///
 88901 19H INCREMENT    ENERGY,13X,11HNUMBER FLUX,13X,11HENERGY FLUX/
 88902 13X,5H(MEV),10X,19H(PHOTONS/CM**2-SEC),7X,15H(MEV/CM**2-SEC)//
 88903 (1X,I6,3X,E10.5,10X,E14.7,10X,E14.7))
      WRITE(LO,8892)
 8892 FORMAT (42H1INTEGRATED RESULTS AT SOURCE AND CRYSTAL  ///
 88921 58H ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL // )
      WRITE(LO,8895)  SUMNUM,SUMENY,DOSDET,AVENGY,PHNUBE,ENBENY,PHENBE,
     1 DOSBEX,DAXVOL
 8895 FORMAT (37HOPHOTON NUMBER (PHOTONS/CM**2-SEC) = ,E14.7/37H PHOTON
 88951ENERGY (MEV/CM**2-SEC)     = ,E14.7/37H PHOTON DOSE   (ROENTGENS/H
 88952OUR)    = ,E14.7//24H AVERAGE ENERGY (MEV) = ,E14.7//77H PHOTON NU
 88953MBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) =
 88954 ,E14.7/77H PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2
 88955-SEC)/MEV)          = ,E14.7/77H PHOTON ENERGY / SOURCE EMITTED BE
 88956TA NUMBER (MEV/CM**2-SEC)/(BETA/SEC)     = ,E14.7/77H PHOTON DOSE
 88957  / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)                = ,
 88958 E14.7/92H PHOTON DOSE   / SOURCE EMITTED BETA NUMBER PER SOURCE V
 88959OLUME (((R/HR)/(BETA/SEC))/CM**3) = ,E14.7////)
      WRITE  (LO,8891) DOSCYL,DCYVOL
 8891 FORMAT (25H AT THE SOURCE CYLINDER     //
 88911 77H PHOTON DOSE   / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC)
 88912             = ,E14.7//92H PHOTON DOSE   / SOURCE EMITTED BETA NUM
 88913BER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) = ,E14.7)
  500 CONTINUE
      IF(JS-JSO)61,1111,61
   61 JS=JS+1
      GO TO 2
 1111 IF(KK.LT.NSET) GO TO 1
      END
      FUNCTION AIRABS (E,NGO,N,DIST)
C**********  PROGRAM NUMBER -  2   CUPED      ************
C
C     CALLED BY  *XTAL*
C     CALLS  *TA* - *TF*
C     COMPUTES AIR INTERACTION FACTOR.
C
      DIMENSION X(22),R(22),Z(6),Y(6),A(22)
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      GO TO (1,2),NGO
    1 NGO=2
      X(1)=.01
      DO 10 I=2,10
   10 X(I)=X(I-1)+.01
      DO 12 I=11,19
   12 X(I)=X(I-1)+.1
      X(20)=1.5
      X(21)=2.0
      X(22)=3.0
      DATA    A       /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
      LOW=1
      DO 3 I=LOW,M
    3 R(I)=A(I)*T1293
C
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,R,N,L,0)
C
      NN=N+1
      AERMEW=TE (NN,Z,Y,E)
      AIRABS=EXP(-AERMEW*DIST)
      RETURN
      END
      FUNCTION CLAD (E,NGC,N)
C**********  PROGRAM NUMBER -  3   CUPED      ************
C
C     CALLED BY  *XTAL*
C     CALLS  *TA* - *TF*
C     COMPUTES DETECTOR CLADDING ABSORPTION FACTOR.
C
      DIMENSION X(28),R(28),Z(6),Y(6)
      GO TO (1,2),NGC
    1 NGC=2
      X(1)=.01
      DO 10 I=2,9
   10 X(I)=X(I-1)+.0025
      DO 11 I=10,16
   11 X(I)=X(I-1)+.01
      DO 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       /.00396,.0590,.192,.355,.497,.605,.6907,.748,
     1.7925,.8891,.9253,.941,.9495,.9542,.9572,.9598,.9694,.9736,.9763,
     2.9784,.9800,.9812,.9824,.9833,.9841,.9871,.9888,.9909/
      M=28
      LOW=1
C
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,R,N,L,0)
C
      NN=N+1
      CLAD=TE (NN,Z,Y,E)
      RETURN
      END
      SUBROUTINE CORALT (N1,N2,MST,MSTD2)
C**********  PROGRAM NUMBER -  4   CUPED      ************
C
C     CALLED BY  *COMPLEX* - *REGGEN*
C     CALLS  *PEEK* - *STDETT*
C
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/PLX/P,STDENY,P,PARAV,PARAS,PAREA,DUM(3A),MSJ,MENJ,MSXJ,
     1  MEXJ,MSUBT,MY,MSTAND,MI4
      DIMENSION P(260,12),STDENY(12),MENJ(12),MSJ(12),MEXJ(12),MSXJ(12),
```

```
     1Y(260),PARAV(12),R(5),PARAS(12),PAREA(12), NOSUBT(12)
      NRA=0
C     WRITE(LO,99)N1,N2,NST,NSTD2
C  99 FORMAT(10H N1,N2,ETC ,4I10)
      IF(NIR)122,120,121
  122 ENCO=3.0
      GO TO 130
  120 ENCO=1.173
      GO TO 130
  121 ENCO=1.368
  130 DO 5000 J=N1,N2
      NRB=1
      INDIC=NLIMIT
      IF(NST-2)233,235,233
  235 JZ=J
      IF(JZ-NSTD2)233,5001,233
  233 NS=NSJ(J)
      NFN=NFNJ(J)
      ENY=STDENY(J)
      DO 2005 I=1,NLIMIT
 2005 Y(I)=0.0
      DO 5002 I=NS,NFN
 5002 Y(I)=R(I,J)
      JJ=J
      B(3)=0.0
C
C CALL REGRESSION SUBPROGRAM.
      CALL STDFIT (Y   ,NFN, B,              NS,   ENY)
C
      PARAV(J)=B(1)
      PARAS(J)=B(2)
      PAREA(J)=B(3)
      PAV=PARAV(J)
      PAS=PARAS(J)
      PAK=PAREA(J)
C
C SUBTRACT FITTED PEAK.
C
      NB1=B(1)
      DO 5010 I=NS ,NB1
      II=I
 5010 R(I,J)=Y(I)-PEEK(II,PAV,PAS,PAK)
      NB3=B(1)-6.0*B(2)
      NB4=NS-1
      IF(NB3-NB4)30592,30592,30593
30592 DO 30591 I=NB3,NB4
      II=I
30591 R(I,J)=R(I,J)-PEEK(II,PAV,PAS,PAK)
30593 IF(ENY-ENCO)100,101,100
  101 NB2=NRB
      NRA=NB1+1
      DO 104 I=NRA,NRB
      II=I
  104 R(I,J)=R(I,J)-PEEK(II,PAV,PAS,PAK)
      NB2=NB2+1
      GO TO 103
  100 NB2=NB1+1
  103 DO 5011 I=NB2,NLIMIT
 5011 R(I,J)=0.0
      IF(NSXJ(J))5020,5001,5020
C
C SUBTRACT X-RAY PEAKS IF ANY.
C
 5020 IF(NOSUBT(J))5029,5001,5029
 5029 DEL=NFXJ(J)-NSXJ(J)
      NXX=NSXJ(J)
      NSX=NSXJ(J)+1
      NFXX=NFXJ(J)
      NFX=NFXJ(J)-1
      DO 5021 I=NSX,NFX
      X=I-NXX
 5021 R(I,J)=R(NXX,J)+X*(R(NFXX,J)-R(NXX,J))/DEL
 5001 CONTINUE
C  ZERO FROM THE FIRST NEGATIVE CHANNEL TO 260
      DO 9010 I=NB3,NLIMIT
      IF(R(I,J))9011,9012,9012
 9011 INDIC=I
      GO TO 9014
 9012 CONTINUE
 9010 CONTINUE
      GO TO 9015
 9014 DO 9013 I=INDIC,NLIMIT
 9013 R(I,J)=0.0
 9015 CONTINUE
 5000 CONTINUE
      NRB=NB1
C     WRITE(LO,819)NRB,INDIC,NB1,NB2,NB3,NB4,NIR,NRA,ENCO
C 819 FORMAT(9H0 COR-1   ,8I5,E14.7/)
      RETURN
      END
      SUBROUTINE COMPLX (NST,NSTD2)
C**********  PROGRAM NUMBER -  5   CUPED      ************
C
C     CALLED BY  *SHAPE*
C     CALLS  *FIVE* - *GANE* - *POLATE* - *COBALT*
C
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/PLX/R,STDENY,B,PARAV,PARAS,PAREA,ALABEL,BLABEL,YS,Z,NSJ,
     1  NFNJ,NSXJ,NFXJ,NOSUBT,NX,NSTAND,NIR
      COMMON/POLT/PU,E,CEA,JMIN
      COMMON/OOORM/ORM,OORM
      DIMENSION NSJ(12),NFNJ(12),       STDENY(12),B(5),NSXJ(12),
     1NFXJ(12),NOSUBT(12),Z(6),YS(6),       R(260,12),ALABEL(12),
     2PU(50,3),          BLABEL(12),PARAV(12),PARAS(12),PAREA(12)
      DIMENSION SM0(520),FM(520),RV(520)
C     WRITE(LO,120)STDENY(NSTAND),NSJ(NSTAND),NFNJ(NSTAND),NSXJ(NSTAND),
C    1NOSUBT(NSTAND),NST,NSTD2,NIR,NX,NSTAND
C 120 FORMAT (1H1,E9.4,9I5)
      TAZ=0.0
      SM=0.0
      NTS=0
      NTS2=0
      NSTA1=NSTAND
      NSTA2=NSTAND
      IF(NIR)10,10,12
   12 NS=NSJ(NSTAND)
      NFN=NFNJ(NSTAND)
      DO 25 I=1,NLIMIT
   25 FM(I)=R(I,NSTAND)
      CALL FIVE (FM,NS,NFN,EYEMAX)
```

```
C     WRITE(LO,150) NS,NEN,(EM(I),I=1,NLIMIT)
C 150 FORMAT(1H1,2I5/(1X,10E9.0))
      DO 30 I=1,NLIMIT
   30 R(I,NSTAND)=EM(I)
C
   10 CALL COBALT(NSTA1,NSTA2,NTS,NTS2)
C
      WRITE(LO,9999)NSTAND,ALABEL(NSTAND),BLABEL(NSTAND),R(1),R(2),R(3)
 9999 FORMAT(9X,I3,18X,2A3,3X,3E25.7)
      ETEMP=STDENY(NSTAND)
      BB1=R(1)
      BB3=R(3)
      NSXJ(NSTAND)=0
      NEXJ(NSTAND)=0
      NOSUBT(NSTAND)=0
      IF(NIB)1,1,2
    1 STDENY(NSTAND)=1.173
      NSXJ(NSTAND)=NENJ(NSTAND)
      NENJ(NSTAND)=NSJ(NSTAND)
      NSJ(NSTAND)=NSJ(NSTAND)-(NSXJ(NSTAND)-NSJ(NSTAND))
      NSXJ(NSTAND)=0
C     WRITE(LO,2000)NIB,NSTAND,NSXJ(NSTAND),NENJ(NSTAND),NSJ(NSTAND),
C    1  BB1,BB3,ETEMP
C2000 FORMAT(10H COMPLEX   /5I10,3E14.7)
      GO TO 3
    2 STDENY(NSTAND)=1.368
      NSJ(NSTAND)=0.458*EYEMAX
      NENJ(NSTAND)=0.576*EYEMAX
C
    3 CALL COBALT(NSTA1,NSTA2,NTS,NTS2)
C
      WRITE(LO,9999)NSTAND,ALABEL(NSTAND),BLABEL(NSTAND),R(1),R(2),R(3)
  100 FORMAT(1H1,32X,25H STANDARD SOURCE SPECTRA  ////////3X,2A3,8
     1H SOURCE ////(1X,10E9.0))
      STDENY(NSTAND)=ETEMP
      BB=R(1)
      IF(NIB)14,14,15
   14 E=1.173
      GO TO 16
   15 E=1.368
   16 DO 40 I=1,NLIMIT
   40 EM(I)=0.0
      Z(1)=STDENY(NSTAND-3)
      Z(2)=STDENY(NSTAND-2)
      Z(3)=STDENY(NSTAND-1)
      JMIN=NSTAND-3
      DO 207 I=1,50
  207 RU(I,3)=0.0
      A=E
C
      CALL POLATE(EM)
C
      NCE=CEA
      WRITE(LO,130)ALABEL(NSTAND),BLABEL(NSTAND),A,(EM(I),I=1,110)
  130 FORMAT(1H1,12X,48H NORMALIZED CONTINUUM OF STANDARD SOURCE SPECTRA
     1301//////3X,2A3,8H SOURCE  //5X,8HENERGY= ,F10.4,5H MEV ///(1X,5E14.7
     1302))
      NX=102
      OG=DORM
      EM(101)=0.0
      EM(102)=0.0
      CALL GANE(TA7,NX,OG,BB,SM,EM)
      NX=BB
      DO 21 I=1,NX
   21 EM(I)=EM(I)*B(3)
      DO 8765 I=1,NLIMIT
 8765 SMO(I)=EM(I)
      SMM=1.0
      CALL GANE(TA7,NX,1.0,1.0,SMM,SMO)
      NBB1=0.3*BB1
      NBB2=0.7R*BB1
      DO 8764 I=NBB1,NBB2
 8764 EM(I)=SMO(I)
      DO 22 I=1,NLIMIT
   22 EM(I)=R(I,NSTAND)-EM(I)
      NX=NLIMIT
      ROG=DORM
      CALL GANE(TA7,NX,BB1,ROG,SM,EM)
      DO 23 I=1,NX
   23 R(I,NSTAND)=EM(I)/BB3
C     WRITE(LO,1120)BB1,BB3,CEA,E,BB
C1120 FORMAT(10H COMP-BB1  ,5E14.7)
C     WRITE(LO,130)ALABEL(NSTAND),BLABEL(NSTAND),(EM(I),I=1,NX)
      NXII=NX+1
      DO 24 I=NXII,NLIMIT
   24 R(I,NSTAND)=0.0
      IF(STDENY(NSTAND)-1.332)201,202,201
  202 DO 203 I=1,100
      EM(I)=0.0
  203 RV(I)=0.0
      M1=NCE
      M2=NCE+10
      DO 204 I=NCE,100
  204 EM(I)=R(I,NSTAND)
      JMAX=0
      YMAX=0.0
      CALL VECTMX (EM,M1,M2,JMAX,YMAX)
      GAIN=DORM-RU(1,1)
      MM=GAIN
      DO 205 I=1,MM
      II=MM-I+1
  205 RV(II)=RU(I,3)
      NX=MM+2
      ROGAIN=100-JMAX
      ROGAIN=ROGAIN-0.5
      CALL GANE(TA7,NX,GAIN,ROGAIN,SM,RV)
      DO 3000 I=1,MM
      JJ=100-I+1
      RV(JJ)=RV(I)
 3000 RV(I)=0.0
C     WRITE(LO,3010)(RV(I),I=1,100)
C3010 FORMAT(10H COMP END  /(1X,5E14.7))
      NB=82
      NE=95
      NDEL=82-NCE
      NA=NB
      ANORM=EM(NA)/RV(NA)
      DO 206 I=NB,NE
  206 R(I,NSTAND)=RV(I)*ANORM
      DO 8763 I=1,100
```

```
 8763 SMO(I)=R(I,NSTAND)
      SMM=2.0
      NXSM=100
      CALL GANE(TAZ,NXSM,1.0,1.0,SMM,SMO)
      DO 8762 I=30,78
 8762 R(I,NSTAND)=SMO(I)
C     WRITE(LO,1120)ANORM,GAIN,ROGAIN,BB1,BB3
C     WRITE(LO,120)YMAX,JMAX,NR,NX,NCE,N1,N2,NXU,II,NDEL
  201 WRITE(LO,130)ALABEL(NSTAND),BLABEL(NSTAND),STDEMY(NSTAND),(R(I,NST
     1AND),I=1,110)
C     WRITE(LO,120)STDEMY(NSTAND),NSJ(NSTAND),NENJ(NSTAND),NSXJ(NSTAND),
C    1NOSUBT(NSTAND),NST,NSTD2,NIR,NX,NSTAND
      RETURN
      END
      SUBROUTINE DEC (NX,S,MX)
C**********  PROGRAM NUMBER -  6   CUPED     ************
C
C     CALLED BY  *MAIN*
C     CALLS  *GANE*
C     READS PULSE-HEIGHT ANALYZER SPECTRA.  CHECKS FOR PHA-COMPLEMENTED COUNTS.
C
      DIMENSION S(260),FM(520)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1             T321,T7677,T285
      IF(MX-NX) 1,1,2
    2 READ(LI,3000)(FM(I),I=1,MX)
      MCX=MX
      GO TO 7
    1 READ           (LI,3000)(FM(I),I=1,NX)
      MCX=NX
 3000 FORMAT (10(F6.0,1X))
    7 DO 4 I=1,MCX
      IF(FM(I)-T90) 5,5,6
    6 FM(I)=FM(I)-T100
    5 CONTINUE
    4 CONTINUE
      IF(MX-NX)11,11,20
   20 IF(MX-NLIMIT)11,11,21
   21 ROGAIN=NX
      GAIN=MX
      MXX=MX
      CALL GANE(0.0,MXX,GAIN,ROGAIN,0.0,FM)
   11 DO 3 I=1,MX
    3 S(I)=FM(I)
      RETURN
      END
      FUNCTION DECAY (  DT,TH,T1,   CLAMDA )
C**********  PROGRAM NUMBER -  7   CUPED     ************
C
C     CALLED BY  *MAIN*
C     COMPUTES DECAY CORRECTION FACTOR.
C
      T1=T1*1440.0
      IF( (DT/TH    )  - 0.001)2,2,1
    1 T2=T1 + DT
      TF=(-1.0/CLAMDA    )*ALOG ((EXP(-CLAMDA    *T1)-EXP(-CLAMDA    *T2))/
     1  (CLAMDA    *DT))
      GO TO 3
    2 TF=T1 + DT/2.0
    3 DECAY=EXP (CLAMDA    *TF)
      RETURN
      END
      FUNCTION DOSE (E,NGD,N)
C**********  PROGRAM NUMBER -  8   CUPED     ************
C
C     CALLED BY  *GEOMTR*
C     CALLS  *TA* - *TF*
C     COMPUTES GAMMA PHOTON DOSE.
C
      DIMENSION X(20),P(20),Z(6),Y(6)
C
      GO TO (1,2),NGD
    1 NGD=2
      X(1)=.010
      X(2)=.015
      X(3)=.02
      DO 7 I=4,7
    7 X(I)=X(I-1)+0.01
      X(8)=.08
      X(9)=.1
      X(10)=.15
      X(11)=.2
      DO 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
      DATA     R        /4.5723,1.2532,.50292,.14456,.06216,.03767,.02864
     1,.02364,.02321,.02611,.02681,.02874,.02954,.02966,.02959,.02884,
     2.02794,.02556,.02355,.02071/
      N=20
      LOW=1
C
    2 CALL TA(E,X,M,LOW,MOX,MIN,Z,Y,R,N,L,0)
C
      NN=N+1
      DOSE=TF (NN,Z,Y,E)*E
   10 RETURN
      END
      FUNCTION EFFIC (E,NGD,N,DAST,ROX,HH)
C**********  PROGRAM NUMBER -  9   CUPED     ************
C
C     CALLED BY  *XTAL*
C     CALLS  *SIMPSM* - *TA* - *TF*
C     COMPUTES ELEMENTS OF DETECTION EFFICIENCY VECTOR.
C
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1             T321,T7677,T285
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON /B/ KL,OMEGAM,RX,DIST,H
      DIMENSION Y(32),P(32),Z(6),Y(6) ,W(32),V(6)
      DIST=DAST
C
      H=HH
      RX=ROX
      ARG=RX/(DIST+H)
      ERS=T06
```

```
      LOW=1
C     WRITE(LO,100)DIST,H,RX,ARG
C 100 FORMAT(1X,4E14.7)
      GO TO (1,2),NGO
    1 IF(E-T3316) 3,4,4
    4 NGO=2
      X(1)=T3316
      X(2)=.035
      X(3)=0.040
      DO 60 I=4,14
   60 X(I)=X(I-1)+.010
      DO 70 I=15,27
   70 X(I)=X(I-1)+.050
      X(28)=0.90
      X(29)=1.00
      X(30)=1.5
      X(31)=2.0
      X(32)=3.0
      DATA     W       /30.4,26.1,18.2,10.1,6.17,4.11,2.86,2.06,1.57,
     11.23,.990,.814,.678,.568,.305,.207,.155,.1278,.111,.0990,.0901,
     2.0839,.0789,.0743,.0710,.0680,.0657,.0611,.0577,.0445,.0412,.0367/
      M=32
      DO 80 I=LOW,M
   80 R(I)=W(I)*T366
C     WRITE(LO,110)(I,X(I),R(I),I=LOW,M)
C 110 FORMAT(1X,I5,2E14.7)
      GO TO 2
    3 X(1)=.01
      X(2)=.015
      X(3)=.020
      X(4)=.025
      X(5)=.030
      X(6)=T3316-.0000001
      DATA     V       /154.0,48.80,22.10,11.75,7.310,5.580/
      DO 299 I=7,32
  299 R(I)=0.0
      M=6
      DO 800I=LOW,M
  800 R(I)=V(I)*T366
C     WRITE(LO,110)(I,X(I),R(I),I=LOW,M)
C
    2 CALL TA     (E,X,M,LOW,MOX,MIN,Z,Y,R,N,L,0)
C
      NN=N+1
      UEGAM=TE  (NN,Z,Y,E)
C     WRITE(LO,120) M,LOW,MOX,MIN,N,L,UEGAM,E
C 120 FORMAT (1X,6I5,2E14.7)
      IF(ARG-0.0124)6,6,5
    5 A=0.0
      B=ATAN(ARG)
      KL=0
      CASE=SIMPSN(A,B,EPS)
      A=B
      B=ATAN(RX/DIST)
      KL=1
      UNUM=CASE + SIMPSN(A,B,EPS)
      DEN=          1.0-DIST/SQRT(DIST*DIST+RX*RX)
C     WRITE(LO,130) A,B,CASE,UNUM,DEN
C 130 FORMAT (1X,5E14.7)
      EFFIC=UNUM/DEN
      RETURN
    6 EFFIC=1.0 - EXP(-UEGAM*H)
      RETURN
      END
      SUBROUTINE ENLIN (MX,EM,EG,VG,NGL,J,NGO,O,ELIMIT)
C**********  PROGRAM NUMBER -  10  CUPED      **********
C
C     CALLED BY  *MAIN*  (TWICE)
C     CALLS  *PULSE*
C     APPLIES ENERGY RESPONSE NON-LINEARITY CORRECTION.
C
C
      DIMENSION EM(260),EG(20),VG(20),C(260),O(260),V(260)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      EGI=EG(J)
      DV=PULSE(EGI,NGO,2)
      EGVG=EG(J)*(1.0+DV)/VG(J)
C  DEFINE THE ENERGIES OF NON-LINEARITY, Y(I).
C  TEMP. OUTPUT
C  55 FORMAT(10H ENLIN 1   ,6E14.7,4I5/)
C     WRITE (LO,55) EGI,DV,EGVG,EG(J),VG(J),ELIMIT,NGL,NGO,J,MX
      OO=EGVG
      VP=0.0
    3 DO 6 I=1,MX
      V(I)=VP
      EX=I
      EX=EX*EGVG
C     WRITE(LO,50) I,EX
C  50 FORMAT (I5,5X,E14.7)
      MMX=I
      IF( (EX+((EX-OO)/2.))  - ELIMIT)100,100,105
  100 IF(EX-0.015)3000,3001,3001
 3000 VP=EX
      C(I)=EM(I)
      GO TO 3002
 3001 VVP=EX*(1.0+PULSE(EX,NGO,2))
      C(I)=EM(I)*(VVP-VP)/EGVG
      VP=VVP
 3002 CONTINUE
      O(I)=EX
      OO=O(I)
    6 CONTINUE
      I=I+1
      V(I)=VVP
  105 MX=MMX-1
C     WRITE (LO,40) (I,O(I),V(I),C(I),EM(I),I=1,100)
C  40 FORMAT (1HO,I5,5X,4E15.8)
      DO 7 I=1,MX
    7 EM(I)=C(I)
      MXX=MX+1
      DO 8 I=MXX,NLIMIT
    8 EM(I)=0.0
      RETURN
      END
      FUNCTION EC(X)
C**********  PROGRAM NUMBER -  11  CUPED      **********
C
C     CALLED BY  *SIMPSN*
C     CRYSTAL INTERACTION EFFICIENCY FUNCTION.
C
```

```
C
      COMMON /B/ KL,OMEGAM,R ,DIST,H
      IF(KL)1,2,1
    1 IF(X)3,4,3
    3 FC=(1.0 - EXP(-OMEGAM*(R/(SIN(X))-DIST/COS(X))))*SIN(X)
      RETURN
    4 FC=0.0
      RETURN
    2 FC=(1.0 - EXP(-OMEGAM*H/COS(X)))*SIN(X)
      RETURN
      END
      SUBROUTINE FIVE (Y,NS,NFN,EYEMAX)
C**********  PROGRAM NUMBER -  12  CUPED      ************
C
C     CALLED BY  *COMPLEX*
C     CALLS  *PEEK* - *STDFIT* - *VECTMX*
C
      DIMENSION Y(260),B(5)
      YMAX=0.0
      CALL VECTMX (Y,NS,NFN,JMAX,YMAX)
      EYEMAX=JMAX
      DO 4 I=1,3
      GO TO (1,2,3),I
C     SUBTRACT FIRST PAIR PEAK
    1 NSS=0.771*EYEMAX
      NFNN=0.883*EYEMAX
      ENY=2.244
      CALL STDFIT (Y,NFNN,B,NSS,   ENY)
      DO 10 II=NSS,NFNN
      J=II
   10 Y(II)=Y(II)-PEEK(J,B(1),B(2),B(3))
      GO TO 5
C     SUBTRACT SECOND PAIR PEAK
    2 NSS=0.587*EYEMAX
      NFNN=0.694*EYEMAX
      ENY=1.734
      CALL STDFIT (Y,NFNN,B,NSS,   ENY)
      DO 11 K=NSS,NFNN
      J=K
   11 Y(K)=Y(K)-PEEK(J,B(1),B(2),B(3))
      GO TO 5
C     SUBTRACT .51 PEAK
    3 NSS=0.162*EYEMAX
      NFNN=0.224*EYEMAX
      ENY=0.51
      EX=NFNN-NSS
      NOS=NSS
      EMX=(Y(NFNN)-Y(NOS))/EX
      DO 6 J=NSS,NFNN
      X=J
      X=X-0.5
    6 Y(J)=EMX*X+Y(NOS)
    5 CONTINUE
    4 CONTINUE
      RETURN
      END
      SUBROUTINE FUNIS(FIT,FC,Y,B,A,NF,NS)
C**********  PROGRAM NUMBER -  13  CUPED      ************
C
C     CALLED BY  *STDFIT*
C     PHOTOPEAK FUNCTION FITTED BY -STDFIT-
C     (GAUSSIAN DISTRIBUTION ON STRAIGHT LINE BASE)
C
      COMMON/TMOUT/MOUT
      COMMON/LIO/LI,LO,LP,NLIMIT
      DIMENSION FC(260),Y(260),B(5),A(260,5)
      FIT=0.0
      DO 50 J=1,5
      DO 50 I=1,NLIMIT
   50 A(I,J)=0.0
      CONS=.398423*B(3)/B(2)
C
C  COMPUTE STRAIGHT LINE BASE FOR PHOTOPEAK
C
C
C COMPUTE GAUSSIAN FUNCTION AND PARTIAL DERIVATIVES.
C
  403 DO 700 I=NS,NF
      X=I
      X=X-0.5
      P   =B(4)*X + B(5)
      A(I,4)=X
      A(I,5)=1.0
      PDN=(X-B(1))/B(2)
      PDN2=PDN*PDN
      ARG=EXP(-0.5*PDN2)
      PP=CONS*ARG
      A(I,1)=PP*PDN/B(2)
      A(I,2)=PP*(PDN2-1.0)/B(2)
      A(I,3)=PP/B(3)
      P=P+PP
      FC(I)=Y(I)-P
  700 FIT=FIT+FC(I)*FC(I)/Y(I)
      IF(MOUT)1,2,1
    2 WRITE(LO,710)NS,J,FIT,CONS,P,PP,PDN,PDN2,ARG,FC(NS),FC(NF),
     1  Y(NS),Y(NF),(B(I),I=1,5),(A(NS,I),I=1,5)
  710 FORMAT(12H FUNIS TEST   /2I5,5E15.7/10X,6E15.7/10X,5E15.7/
     1  10X,5E15.7)
    1 RETURN
      END
      SUBROUTINE FUNIS1(FIT,FC,Y,B,P,A,NFN,NS,KLM,NR,NFR)
C**********  PROGRAM NUMBER -  14  CUPED      ************
C
C     CALLED BY  *STDFT2*
C
      COMMON/TMOUT/MOUT
       COMMON/LIO/LI,LO,LP,NLIMIT
      DIMENSION FC(260),Y(260),B(8),P(260),A(260,8)
      FIT=0.0
      IF(NFR-5)1,2,1
    2 NM1=NFR-1
      NR=NFR
      NM2=NFR-2
      GO TO 3
    1 NM1=NR-1
      NM2=NR-2
    3 DO 50 I=NS,NFN
      P(I)=0.0
      DO 50 J=1,8
   50 A(I,J)=0.0
```

```
      CONR=0.398942*R(3)
      CONP=0.398942*R(NM2)
C     COMPUTE STRAIGHT LINE BASE FOR PHOTOPEAK
  400 DO 402 I=NS,NFN
      X=I-NS
      X=X-0.5
      P(I)=R(NM1)*X+R(NB)
      A(I,NM1)=X
  402 A(I,NB)=1.0
C     COMPUTE GAUSSIAM FUNCTIONS AND PARTIAL DERIVATIVES
      DO 700 I=NS,NFN
      X=I
      X=X-0.5
      PON1=(X-R(1))/R(2)
      IF(ABS(PON1)-7.0)99,999,999
   99 ARG1=EXP(-0.5*PON1*PON1)
      GO TO 299
  999 ARG1=0.0
  299 PP1=CONR*ARG1/R(2)
      A(I,1)=PP1*PON1/R(2)
      A(I,2)=PP1*(PON1*PON1-1.0)/R(2)
      A(I,3)=PP1/R(3)
      IF(NFB-5)4,5,4
    4 IF(R(4))500,500,510
  500 PP2=0.0
      GO TO 690
  510 IF(NB-8)512,514,700
  512 IF(NB-6)600,514,600
  600 BZ=R(2)
      GO TO 515
  514 BZ=R(5)
  515 PON2=(X-R(4))/BZ
      IF(ABS(PON2)-7.0)199,1999,1999
  199 ARG2=EXP(-0.5*PON2*PON2)
      GO TO 399
 1999 ARG2=0.0
  399 PP2=CONP*ARG2/BZ
      IF(NB-8)520,522,700
  520 IF(NB-6)620,522,620
  620 A(I,2)=A(I,2)+PP2*(PON2*PON2-1.0)/R(2)
      GO TO 550
  522 A(I,5)=PP2*(PON2*PON2-1.0)/R(5)
  550 A(I,4)=PP2*PON2/BZ
      A(I,NM2)=PP2/R(NM2)
      GO TO 690
    5 PP2=0.0
  690 P(I)=P(I)+PP1+PP2
      EC(I)=Y(I)-P(I)
  700 FIT=FIT+EC(I)*EC(I)/Y(I)
      IF(MOUT)15,100,15
   10 FORMAT(15H FUNDS R-VALUES   /(1X,8E14.4))
  100 WRITE(LO,10) (R(I),I=1,8)
      WRITE(LO,18)(EC(I),I=NS,NFN)
      WRITE(LO,19)(Y(I), I=NS,NFN)
      WRITE(LO,14)FIT,KLM,NM1,NM2,NB
   14 FORMAT(1H ,F11.4,4I6)
   18 FORMAT(16H FUNDS EC-VALUES  /(1X,10E10.2))
   19 FORMAT(16H FUNDS Y-VALUES  /(1X,10E10.2))
   15 RETURN
      END
```

```
      SUBROUTINE GAME (TZ,NX,GAIN,PDGAIN,SMOOTH,C)
C**********  PROGRAM NUMBER -  15  CODED      **********
C
C     REF. JR. NUC. SCI. AND ENG. VOL 35, MAR. 1969 STEVE AND ANDREWS
C     MARCH 1968 VERSION. I.F. DIMENSION CAPACITY CHECK
C     CALLED BY  *MAIN* - *SINGLE* - *RESCENE* - *SHAPE*
C     GAIN CHANGING PROGRAM.  ALSO SPECTRAL SHIFTING.
C
      DIMENSION C(520),FM(520)
      NLIMIT=520
      NONX=NX
      ONX=(PDGAIN/GAIN)*NONX
      NOMX=ONX
      IF(NONX-NLIMIT)620,620,621
  621 NX=NX-(NLIMIT-NONX)-1
  620 IF(TZ)600,601,601
  600 JTZ=ABS(TZ)
      NX=NX-JTZ
      IF(NX-NLIMIT)601,601,603
  603 NX=NLIMIT
  601 IF(TZ)1000,275,1000
 1000 NZC=TZ
      NXO=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
      NSXO=1
      NXO=NSX+NX
  955 DO 956 I=NS,NXO
      K=I+NZC
  956 FM(I)=C(K)
      DO 957 I=NS,NXO
  957 C(I)=FM(I)
      GO TO 93
  911 NS=1
      NSXO=NXO+1
      NSX=NX
  945 DO 91 I=NS,NXO
      K=I+NZC
   91 C(I)=C(K)
   93 DO 92 I=NSXO,NSX
   92 C(I)=0.0
  910 NX=NXO
C
C  DECIMAL SHIFT.
C
  274 TNZC=NZC
      DIF=TZ-TNZC
      DDIF=1.0-DIF
      IF(DIF)271,272,271
  271 NXON=NX-2
      C(1)=C(1) + C(2)*DIF
      DO 270 I=2,NXON
  270 C(I)=C(I)*DDIF + C(I+1)*DIF
      C(NXON +1)=C(NXON +1)*DDIF + C(NX)
      GO TO 273
```

```
  272 IF(NZC)273,275,275
  273 NX=NX-1
  275 TZ=0.
      L=1
      G=GAIN
      DO 50 I=1,NLIMIT
   50 FM(I)=0.0
      FMULT=GAIN/ROGAIN
C
C DEL=0.5 WHEN GAIN/ROGAIN=1./2. I.E. DOUBLING REQUIRED.
C DEL=2.0 WHEN GAIN/ROGAIN=2./1. I.E. HALVING REQUIRED.
C
    1 DEL=GAIN/ROGAIN
      IF(DEL-2.0)402, 204, 402
  402 IF(DEL-0.5)3, 3, 4
    3 L=L+1
      GAIN=GAIN*2.0
      GO TO 1
C
C  INITIALIZE FOR REDUCING ALGORITHM.
C
    4 I=1
      K=1
      X=0.
      XN=1.0
      DELT=0.
   60 DE=DEL
      IF(DEL-1.0)5,499 ,105
  499 IF(L-1)497,500,497
  497 DELT=ROGAIN/2.0
      L=L-1
  496 DO 498 I=1,NX
  498 FM(I)=C(I)
      GO TO 201
C
C  INCREASE.  ......  LOAD EVEN CHANNELS WITH QUADRATICALLY
C  INTERPOLATED COUNT.   SHIFT ENTIRE SPECTRUM UPWARD ONE-HALF CHAN.
C
    5 DELT=ROGAIN/2.0
      DEL=GAIN/DELT
      GO TO 60
  303 NNX=J-4
      DO 305 J=1,NNX,2
      I=J+1
  305 C(I)= (3.0*C(J) + 6.0*C(J+2) - C(J+4))*.125
      C(I+2)= (3.0*C(I+3) + 6.0*C(I+1) - C(I-1))*.125
      NX=I+3
      DO 936 I=2,NX
  936 FM(I)=(C(I)+C(I-1))*0.5
      FM(1)=C(1)*0.5
      DO 935 I=1,NX
  935 C(I)=FM(I)
      GO TO 304
C
C  REDUCTION ALGORITHM.
C
  105 XK=DEL
      DEL=XN-X
      XKX=XK
  106 FM(K)=FM(K)+DEL*C(I)
      IF(I-NX)112,202,202
  112 X=X+DEL
      IF(X-XK+1.0E-9)108,107,107
  107 K=K+1
      XN=I
      DEL=XN-X
      XK=XK+XKX
      GO TO 106
  108 XN=XK
      DEL=XN-X
  109 IF(DEL-1.0)111,111,110
  110 DIF=DEL-1.0
      DEL=DEL-DIF
      GO TO 109
  111 I=I+1
      GO TO 106
  202 DO 1999 INX=1,NLIMIT
 1999 C(INX)=0.0
      XNX=NX
      XNX=XNX/DE
      NX=XNX
C
C  LOAD ODD CHANNELS IF *DELT* EQUAL TO ZERO.
C
  201 IF(DELT) 300,301,300
  300 NC=2
      ND=1
      GO TO 302
  301 NC=1
      ND=0
  302 DO 200 I=1,NX
      J=NC*I - ND
  200 C(J)=FM(I)
      IF(DELT) 303,304,303
  304 IF(L-1)404, 500 ,404
  404 L=L-1
      GO TO 496
C
C  HALVING.
C
  204 I=1
      NCHECK=NX
      NX=NX/2
      NCK=NCHECK -(NX+NX)
      IF(NCK)555, 504, 555
  555 NX=NX+1
  504 K=2*I-1
      C(I)=C(K)+C(K+1)
      IF(I-NX)502,503,503
  502 I=I+1
      GO TO 504
  503 IF(L-1)525,525,205
C
C  SMOOTHING IF *SMOOTH* NOT EQUAL TO ZERO.
C
  525 IF(SMOOTH)526,500,526
  526 DELT=DEL
      SMOOTH=SMOOTH - 1.0
      FMULT=0.5
      GO TO 496
```

```
  205 L=L-1
      GO TO 204
C
C  COUNTS SCALED IN ACCORD WITH *EMULT* FOR INCREASED SPECTRA.
C
  500 KK=0
  915 CONTINUE
      IF(KK)1499,1500,1499
 1500 FAC=1.0
      GO TO 1501
 1499 FAC=1.0/2.0**KK
 1501 IF(EMULT-FAC)916,917,917
  916 KK=KK+1
      GO TO 915
  917 DO 920 I=1,NX
  920 C(I)=C(I)*FAC
      IF(SMOOTH)204,527,204
  527 GAIN=G
      RETURN
      END
      SUBROUTINE GAUSS (EM,V,S,PKAREA,SUM,NMAX)
C**********  PROGRAM NUMBER -  16  CUPED     ************
C
C     CALLED BY  *PEAKS* - *RESGEN*
C     CALLS  *PEEK*
C     COMPUTES GAUSSIAN PHOTOPEAK FOR GIVEN PARAMETERS.
C
      DIMENSION EM(260)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/TMOUT/MOUT
      SUM=0.0
      NMIN=V - 6.0*S
      IF(NMIN)7,7,8
    7 NMIN=1
    8 NMAX=V + 6.0*S + 1.0
      IF(NMAX-(NLIMIT-1))9,9,10
   10 NMAX=NLIMIT-1
    9 DO 1 I=NMIN,NMAX
      II=I
      G=PEEK(II,V,S,PKAREA)
      SUM=SUM+G
    1 EM(I)=EM(I)+G
      IF(MOUT)20,30,20
   30 WRITE(LO,5)NMIN,NMAX,V,S,PKAREA,SUM,(EM(I),I=NMIN,NMAX)
    5 FORMAT(10H GAUSS     /1X,2I5,5X,4F14.7/(1X,5E14.7))
   20 RETURN
      END
      SUBROUTINE GEOMTR
C**********  PROGRAM NUMBER -  17  CUPED     ************
C
C     CALLED BY  *MAIN*
C     CALLS  *DOSE*
C     COMPUTES GEOMETRY FACTORS.  INTEGRATES NUMBER AND ENERGY SPECTRA.
C     CALCULATES NORMALIZED DOSE DATA FOR FINAL CODE RESULTS.
C
      COMMON /C/ SUMNUM,SUMENY,DOSDET,AVENGY,PHNURE,ENRENY,PHENRE,
     1 DOSREX,DOSCYL,DRXVOL,DCYVOL
      COMMON/SHA/DUM1(1405),N,E,DUM2(104)
      COMMON/GEO/RETNUM,DF,PHI,NS,RETENY,NGO,DT,VOL,CYLDIA,ENXTAL
      COMMON/SOM/DUM3(560),NX,NDUM4(3),TKUC,RX,IN,PHOT(20),NCF,DUM5
     1(260),RO
      DIMENSION PHI(260),E(260),ENXTAL(260)
      PIE=3.14159265
      VOL=(PIE*CYLDIA**3)/4.0
      TIME=DT*60.0
      AREAXT=PIE*RX*PX
      CONST=3600./5.24E+07
      SUMNUM=0.0
      SUMENY=0.0
      SOGEOM=0.5*(1.0-RO/SQRT(RO*RO+RX*RX))
      DOSDET=0.0
C INTEGRATE.
      DO 2 I=NS,NX
      PHI(I)=DF*PHI(I)/(AREAXT*TIME)
      ENXTAL(I)=PHI(I)*E(I)
      EC=E(I)
      DOSXTL   =   PHI(I)*CONST*DOSE (EC,NGO,N)
      SUMNUM=SUMNUM+PHI(I)
      SUMENY=SUMENY+ENXTAL(I)
    2 DOSDET=DOSDET+DOSXTL
C
      AVENGY=SUMENY/SUMNUM
      PHNURE=SUMNUM/RETNUM
      ENRENY=SUMENY/RETENY
      PHENRE=SUMENY/RETNUM
      DOSREX=DOSDET/RETNUM
      DOSCYL=DOSREX/SOGEOM
      DRXVOL=DOSREX/VOL
      DCYVOL=DOSCYL/VOL
C
      RETURN
      END
      SUBROUTINE GUESS (NS,NEN,Y,B,ENY)
C**********  PROGRAM NUMBER -  18  CUPED     ************
C
C     CALLED BY  *STDFIT*
C     CALLS  *VECTMX*
C     PROVIDES INITIAL ESTIMATES OF THE PHOTOPEAK FUNCTION PARAMETERS
C     FOR NONLINEAR REGRESSION ANALYSIS IN SUBPROGRAM -STDFIT-.
C
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      COMMON/LIO/LI,LO,LP,NLIMIT
      COMMON/TMOUT/MOUT
      DIMENSION B( 5),Y(260)
      BIG=0.0
      CALL VECTMX (Y,NS,NEN,IBIG,BIG)
      B(1)=IBIG
      ANY=1000.*ENY
      IF(B(3)-1.0)1,2,1
    2 W=NEN-NS
      W=0.45*W
      B(3)=0.0
      GO TO 3
    1 W=(T321*ANY**T7677)*B(1)/ANY
    3 B(2)=W/2.354
      XNS=NS
      XNEN=NEN
      B(4)=(Y(NEN)-Y(NS))/(XNEN-XNS)
      B(5)=Y(NEN)-B(4)*XNEN
```

```
      B(3)=0.0
      DO 3000 I=NS,NFN
      X=I
      X=X-0.5
 3000 B(3)=B(3)+Y(I)-(B(5)+X*B(4))
      IF(MOUT)10,20,10
   20 WRITE(LO,3010)NS,NFN,IBIG,XNS,XNFN,BIG,ANY,FNY,N,Y(NFN),Y(NS),
     1  (B(I),I=1,5)
 3010 FORMAT(12H GUESS TEST  /3I5,4E20.7/15X,4E20.7/15X,5E20.7)
   10 RETURN
      END
      SUBROUTINE GUESS2(NS,NFN,Y,B,V1,V2)
C**********  PROGRAM NUMBER -  19  CUPED     ***********
C
C     CALLED BY  *SINGLE*
C
C     GUESS PARAMETERS FOR GAUSSIAN + STRAIGHT LINE
      COMMON/LIO/LI,LO,LP,NLIMIT
      COMMON/TMOUT/MOUT
      DIMENSION B(8),Y(260),VT(50)
      AREAT=0.
      A1=0.
      II=0
      B(1)=V1
      B(4)=V2
      XNS=NS
      XNF=NFN
      B(6)=(Y(NFN)-Y(NS))/(XNF-XNS)
      NT=NS
      IF(V2)25,26,25
   25 N1=1
      NV1=V1
      NV2=V2
      DO 100 I=NV1,NV2
      J=I-NV1+1
  100 VT(J)=1.0/Y(I)
      N2=J
      BIG=0.0
      CALL VECTMX (VT,N1,N2,JMAX,BIG)
      II=JMAX+NV1-1
      IF(II-NV1)105,105,106
  106 IF(II-NV2)26,105,105
  105 II=(V1+V2)/2.0+1.0
   26 DO 3000 I=NS,NFN
      X=I-NS
      AREAT=AREAT+Y(I)-(Y(NT)+X*B(6))
      IF(I-II)50,50,3000
   50 A1=AREAT
 3000 CONTINUE
      B(3)=A1
      B(5)=AREAT-A1
      AR=B(3)
      IF(B(3)-B(5))7,6,6
    7 AR=B(5)
      MX=B(4)
      XNX=B(4)-XNS
      GO TO 70
    6 CONTINUE
      MX=B(1)
      XMX=B(1)-XNS
   70 B(2)= AR /(2.497*(Y(MX)-(Y(NT)+XNX*B(6))))
      B(7)=Y(NS)
      IF(MOUT)2,1,2
    1 WRITE(LO,10)(B(I),I=1,7)
   10 FORMAT(17H GUESS B-VALUES   /(1X,5E14.7)///)
    2 RETURN
      END
      SUBROUTINE OMITS(NRUN,X)
C**********  PROGRAM NUMBER -  20  CUPED     ***********
C
C     CALLED BY  *MAIN*
C     INSERTION OF REPETITIVE VARIABLES OMITTED ON ALL BUT FIRST-CARD OF SET.
C
      DIMENSION X(20)
      NSTART=1
    1 NST=NSTART+1
      DO 2 I=NST,NRUN
      J=I
      IF(X(I))4,3,4
    3 X(I)=X(NSTART)
    2 CONTINUE
    5 RETURN
    4 IF(J-NRUN)6,5,6
    6 NSTART=J
      GO TO 1
      END
      SUBROUTINE PEAKS (EM,V,F,R,VV,SI,SIG,NN,P,NMAX)
C**********  PROGRAM NUMBER -  21  CUPED     ***********
C
C     CALLED BY  *SHAPE*
C     CALLS  *GAUSS*
C     ADDS PHOTOPEAKS AND ESCAPE PEAKS AND COMPUTES PHOTOREACTIONS.
C
      DIMENSION EM(260)
      NXN=V+1.0+6.0*SIG
      IF(NXN-NN)1000,1000,1001
 1000 NNO=NXN
      GO TO 1002
 1001 NNO=NN
 1002 IF(R)9755,9755,9754
 9754 AREA=R
      GO TO 9756
 9755 SI=0.0
      AREA=0.0
 9756 PKAREA=1.0-R
      SUM=0.0
      DO 16 I=1,NNO
   16 SUM=SUM+EM(I)
      P=1.0/(SUM+1.0)
C ADD PHOTOPEAK
      CALL GAUSS (EM,V,SIG,PKAREA,SUM1,NMAX)
C
      IF(AREA)14,13,14
C ADD K-PEAK.
   14 CALL GAUSS (EM,VV,SI,AREA,SUM2,NM)
C
   13 DO 17 I=1,NNO
   17 EM(I)=EM(I)/(SUM+SUM1+SUM2)
      P=(SUM1+SUM2)/(SUM+SUM1+SUM2)
C
```

```
C EM(I) NOW ADDS UP TO UNIT AREA.
C
      RETURN
      END
      FUNCTION PEEK(I,PAV,PAS,PAK)
C**********  PROGRAM NUMBER -  22  CUPED      ************
C
C     CALLED BY  *SHAPE* - *GAUSS* - *RESGEN* - *FIVE* - *SINGLE* -
C     *CORALT*
C     COMPUTES GAUSSIAN FUNCTION AT X.  (E)
C
      X=I
      X=X-0.5
      PON=(X-PAV)/PAS
      ARG=0.5*PON*PON
      IF(ARG-20.0)2,2,3
    2 PEEK=0.3989423*PAK*EXP(-ARG)/PAS
      RETURN
    3 PEEK=0.0
      RETURN
      END
      FUNCTION PERSPX (E,NGX,N,TKLUC)
C**********  PROGRAM NUMBER -  23  CUPED      ************
C
C     CALLED BY  *XTAL*
C     CALLS  *TA* - *TE*
C     COMPUTES PERSPEX ABSORPTION FACTOR.  (E)
C
      DIMENSION X(23),R(23),Z(6),Y(6)
      GO TO (1,2),NGX
    1 NGX=2
      X(1)=0.01
      X(2)=0.015
      X(3)=0.020
      DO 7 I=4,11
    7 X(I)=X(I-1)+.010
      DO 8 I=12,20
    8 X(I)=X(I-1)+.100
      X(21)=1.5
      X(22)=2.0
      X(23)=3.0
      DATA     R       /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/
      LOW=1
      M=23
C
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,R,N,I,0)
C
      NN=N+1
      P=TE (NN,Z,Y,E)
      PERSPX=EXP(-P*TKLUC)
      RETURN
      END
      SUBROUTINE POLATE(EOUT)
C**********  PROGRAM NUMBER -  24  CUPED      ************
C
C     CALLED BY  *SHAPE* - *COMPLEX*
C     CALLS  *VECTMX* - *GANE* - *TE*
C
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/PLX/R,STDENY(12),DUM(71),O(400M)(61),NSTAND,MIR
      COMMON/POLT/RU,E,GEA,JMIN
      COMMON/DOOPR/DOM,OOPR
      DIMENSION R(260,12),O(6),EOUT(520)     ,Y(6),EM(520),ERS(3),VRS(3),
     1 ECE(3),VCE(3),NRS(3),NCE(3),RV(260,3),VNRS(6),VNCE(6),EOM(520)
     2,NVX(3),NRX(3),EAM(520),RU(50,3),OO(6)
      NTREE=3
      SM=0.0
      TA7=0.0
      G1=1.0
      G2=1.0
      DO 3 I=1,NLIMIT
      EOUT(I)=0.0
      EOM(I)=0.0
      EAM(I)=0.0
    3 EM(I)=0.0
      DO 230 I=1,100
      Y(1)=R(I,JMIN)
      Y(2)=R(I,JMIN+1)
      Y(3)=R(I,JMIN+2)
  230 EOUT(I)=TE(NTREE,0.Y,E)
C     WRITE (LO,30) (EOUT(I),I=1,100)
      IF(E-.6616)240,100,100
C
C   DETERMINE COMPTON EDGE AND BS PEAK LOCATIONS
C
  100 J=3
      JN=J+JMIN-1
      DO 2 I=1,100
    2 EM(I)=R(I,JN)
      ERS(J)=O(J)/(1.0+(O(J)/0.511)*1.94)
      VRS(J)=ERS(J)*OOPR/O(J)
      ECE(J)=O(J)-ERS(J)
      VCE(J)=ECE(J)*OOPR/O(J)
      N1=VRS(J)-5.0
      N2=N1+10
      YMAX=0.0
      CALL VECTMX (EM,N1,N2,JMAX,YMAX)
      NRS(J)=JMAX
      N1=VCE(J)-15.0
      N2=N1+30
      YMAX=0.0
      CALL VECTMX (EM,N1,N2,JMAX,YMAX)
      NCE(J)=JMAX
      ENRS=NRS(3)
      ENRS=ENRS/VRS(3)
      ENCE=NCE(3)
      ENCE=ENCE/VCE(3)
      DO 70 J=1,2
      ERS(J)=O(J)/(1.0+(O(J)/0.511)*1.94)
      VRS(J)=ERS(J)*OOPR/O(J)
      ECE(J)=O(J)-ERS(J)
      VCE(J)=ECE(J)*OOPR/O(J)
      VNRS(J)=VRS(J)*ENRS
   70 VNCE(J)=VCE(J)*ENCE
      VNCE(3)=NCE(3)
      VNRS(3)=NRS(3)
      NRS(1)=VNRS(1)+0.5
      NRS(2)=VNRS(2)+0.5
```

```
      NCE(1)=VNCE(1)+0.5
      NCE(2)=VNCE(2)+0.5
C     WRITE (LO,60) ENBS,ENCE,(EBS(J),VBS(J),VNBS(J),VNCE(J),ECE(J),
C    1VCE(J),J=1,3)
C  60 FORMAT (1H1,20H LOCATION OF PEAKS   ///1X,2E10.5/(1X,6E10.5))
      DO 71 I=1,100
   71 FM(I)=0.0
C
C   RELOCATE 1ST HALF OF STANDARD CONTINUA
C
      DO 22 J=1,3
      DO 22 I=1,100
   22 RV(I,J)=0.0
      DO 222 J=1,3
      DO 222 I=1,50
  222 RU(I,J)=0.0
      DO 98 J=1,3
      NBX(J)=0.0
   98 NVX(J)=0.0
      NBX(3)=55
      DO 10 J=1,2
      GAIN=VNBS(J)
      ROGAIN=VNBS(3)
      NX=NBX(3)
      J1=J+JMIN-1
      DO 8 I=1,NX
    8 FM(I)=R(I,J1)
      CALL GANE (TAZ,NX,GAIN,ROGAIN,SM,FM)
      NBX(J)=NX
      DO 9 I=1,NX
    9 RV(I,J)=FM(I)
      DO 11 I=1,100
   11 FM(I)=0.0
C     WRITE(LO,61) NBX(1),NBX(2),NBX(3),NX,GAIN,ROGAIN,(RV(I,J),I=1,100)
C  61 FORMAT(1H1,20H MODIFIED SPECTRUM   ///1X,4I5,2E10.5/(1X,6E10.5))
   10 CONTINUE
C
C   RELOCATE 2ND HALF OF STANDARD CONTINUA
C
      DO 20 I=1,100
   20 FM(I)=0.0
      NVX(3)=45
      DO 18 J=1,2
      GAIN=OORM-VNCE(J)
      ROGAIN=OORM-VNCE(3)
      NX=NVX(3)
      J2=J+JMIN-1
      DO 19 I=1,NX
      II=101-I
   19 FM(I)=R(II,J2)
      CALL GANE (TAZ,NX,GAIN,ROGAIN,SM,FM)
      NVX(J)=NX
      DO 21 I=1,NX
      K=101-I
   21 RV(K,J)=FM(I)
      DO 23 I=1,100
   23 FM(I)=0.0
C     WRITE(LO,61)NVX(1),NVX(2),NVX(3),NX,GAIN,ROGAIN,(RV(I,J),I=1,100)
   18 CONTINUE
      DO 24 I=1,100
   24 RV(I,3)=R(I,JMIM+2)
C
C   REPLACE MIDDLE PART OF CONTINUA BY A STRAIGHT LINE
C
      DO 52 J=1,2
      NOX=NBX(J)-2
      NOXO=100-NVX(J)+2
      OX=NOX
      OXO=NOXO
      FM=(RV(NOXO,J)-RV(NOX,J))/(OXO-OX)
      NOXO=NOX
      DO 53 I=NOXO,NOXO
      X=I-NOX
   53 RV(I,J)=FM*X+RV(NOX,J)
C     WRITE (LO,66) (RV(I,J),I=1,100)
C  66 FORMAT (1H1,30H MODIFIED STANDARD CONTINUUM   ////(1X,5E14.7))
   52 CONTINUE
C     WRITE (LO,66) (RV(I,3),I=1,100)
C
C   INTERPOLATE
C
      DO 25 I=1,100
      Y(1)=RV(I,1)
      Y(2)=RV(I,2)
      Y(3)=RV(I,3)
      FM(I)=TE(NTREE,0.,Y,E)
      IF(FM(I))26,27,27
   26 FM(I)=0.0
   27 CONTINUE
   25 CONTINUE
C  30 FORMAT(1H0,25H INTERPOLATED CONTINUUM  ////(1X,5E14.7))
C     WRITE(LO,30)(FM(I),I=1,100)
      IF(E-1.173)111,121,111
  121 NN=NCE(3)
      NI=NN
      DO 112 JJ=1,2
      DO 112 I=NN,100
      II=I-NI+1
      J=JJ+1
  112 RU(II,JJ)=RV(I,J)
      DO 113 I=NN,100
      II=I-NI+1
  113 RU(II,3)=FM(I)
      QQ(1)=STDENY(NSTAND-2)
      QQ(2)=STDENY(NSTAND-1)
      QQ(3)=STDENY(NSTAND)
      E=1.332
      DO 131 I=1,II
      Y(1)=RU(I,1)
      Y(2)=RU(I,2)
      Y(3)=RU(I,3)
  131 RU(I,3)=TE(NTREE,QQ,Y,E)
C     WRITE(LO,2999)II,NN,NI,J,((RU(I,J),I=1,50),J=1,3)
C2999 FORMAT(5H POL  ,4I5/(1X,5E14.7))
C
C   RELOCATE 1ST HALF OF INTERPOLATED CONTINUA
C
  111 BSA=TE(NTREE,0.,VNBS,E)
C     WRITE (LO,67) BSA
C  67 FORMAT (1H1,22H LOCATION OF BS-PEAK   ////1X,E10.5)
```

```
C      WRITE (LO,60) EMRS,EMCE,(ERS(J),VRS(J),VNRS(J),VMCE(J),ECE(J),
C     1VCE(J),J=1,3)
C      WRITE(LO,9992)NTREE,E,(Q(I),Y(I),I=1,6)
C9992 FORMAT(1X,I5,E14.7/(1X,6E14.7))
       GAIN=VNRS(3)
       ROGAIN=RSA
       NX=NRX(3)
       DO 16 I=1,NX
   16 FDM(I)=FM(I)
       CALL GANE (TAZ,NX,GAIN,ROGAIN,SM,FDM)
C      WRITE (LO,63) NX,GAIN,ROGAIN,(FDM(I),I=1,100)
C  63 FORMAT (1H1,19H 2ND MODIFICATION   ///1X,I5,2E10.5/(1X,5E10.5))
       DO 47 I=56,100
   47 FDM(I)=0.0
C
C   RELOCATE 2ND HALF OF INTERPOLATED CONTINUA
C
       CEA=TF(NTREE,0,VNCE,E)
C      WRITE (LO,68) CEA
C  68 FORMAT (1H1,27H LOCATION OF COMPTON EDGE   ////1X,E10.5)
       GAIN=OORM-VNCE(3)
       ROGAIN=OORM-CEA
       NX=NVX(3)
       DO 28 I=1,NX
       K=101-I
   28 FAM(I)=FM(K)
       CALL GANE(TAZ,NX,GAIN,ROGAIN,SM,FAM)
       DO 17 I=NX,100
   17 FAM(I)=0.0
       DO 29 I=1,NX
       K=101-I
   29 FDM(K)=FAM(I)
       NXA=100
       SMOOTH=1.0
       CALL GANE (TAZ,NXA,G1,G2,SMOOTH,FOUT)
       MRS=RSA+12.
       MCE=CEA-10.0
       DO 80 I=MRS,MCE
   80 FDM(I)=FOUT(I)
C      WRITE (LO,63) NX,GAIN,ROGAIN,(FDM(I),I=1,100)
       DO 37 I=1,100
   37 FOUT(I)=FDM(I)
       FOUT(1)=FOUT(2)
       RU(1,1)=VNCE(3)
  240 CONTINUE
C 240 WRITE (LO,30) (FOUT(I),I=1,100)
       SUM=0.0
       DO 7483 I=1,100
 7483 SUM=SUM+FOUT(I)
C      WRITE(LO,7484) SUM
C7484 FORMAT(14H POLATE SUM =  ,E14.7//)
       RETURN
       END
       FUNCTION PULSE (E,NGP,N)
C**********  PROGRAM NUMBER -  25  CUPED      ***********
C
C      CALLED BY  *PHOERA* - *RESGEN* - *ENLINM*
C      CALLS  *TA* - *TF*
C      COMPUTES THE DETECTOR SYSTEM PULSE-HEIGHT FOR GIVEN ENERGY.
C
       COMMON /LTC/ LT,LO,LP,NLI*IT
       DIMENSION X(44),R(44),Z(6),Y(6)
       NZERO=0
       IF(E - 0.010)8,9,9
    8 WRITE(LO,60) E
   60 FORMAT  (43H PULSE ENERGY LESS THAN 0.010 MEV.  ERROR.  /E20.8)
       E=.015
       GO TO 18
    9 IF(E-1.3225)10,18,12
   12 PULSE=0.0
       GO TO 10
   18 GO TO (1,2),NGP
    1 NGP=2
       X(1)=0.015
       DO 16 I=2,6
   16 X(I)=X(I-1)+.001
       DO 17 I=7,16
   17 X(I)=X(I-1)+.002
       X(17)=.0425
       X(18)=.045
       X(19)=.050
       X(20)=.055
       X(21)=.060
       DO 19 I=22,25
   19 X(I)=X(I-1)+0.010
       DO 20 I=26,29
   20 X(I)=X(I-1)+.025
       DO 21 I=30,35
   21 X(I)=X(I-1)+.050
       DO 22 I=36,43
   22 X(I)=X(I-1)+.100
       X(44)=1.3225
       DATA      R        /.04180,.06300,.07500,.08250,.08750,.08850,.08600
      1,.07900,.06300,.03900,.03000,.02900,.03300,.04300,.05250,.06150,
      2.07200,.08100,.08510,.08490,.08040,.06970,.06140,.05550,.05000,
      3.03820,.03000,.02400,.01860,.01150,.00770,.00540,.00390,.00285,
      4.00215,.00110,3*.00100,.00099,.00060,.00030,.00015, 2*.000000/
       M=44
       LOW=1
    2 CALL TA (E,X,M,LOW,MOX,MIN,Z,Y,R,N,L,NZERO)
       NN=M+1
       PULSE=TF (NN,Z,Y,E)
   10 RETURN
       END
       FUNCTION RAXEL (E,NGP,N)
C**********  PROGRAM NUMBER -  26  CUPED      ***********
C
C      CALLED BY  *RESGEN* - *SHAPE*
C      CALLS  *TA* - *TF*
C      COMPUTES NAI(TL) IODINE K X-RAY ESCAPE FRACTION.
C
       COMMON /LTC/ LT,LO,LP,NLI*IT
       COMMON/CONSTNT/T3A,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
      1               T321,T767,T285
       DIMENSION X(14),R(14),Z(6),Y(6)
       NZERO=0
       IF(E-0.150)8,9,9
    9 IF(E-T331A) 12,18,18
   18 GO TO (1,2),NGP
    1 NGP=2
```

```
      X(1)=T3316
      X(2)=0.0350
      X(3)=0.040
      DO 20 I=4,14
   20 X(I)=X(I-1)+0.010
      R( 1)=.27159
      R( 2)=.25500
      R( 3)=.21001
      R( 4)=.14533
      R( 5)=.10157
      R( 6)=.07200
      R( 7)=.05301
      R( 8)=.03950
      R( 9)=.03001
      R(10)=.02330
      R(11)=.01830
      R(12)=.01480
      R(13)=.01205
      R(14)=.00994
      M=14
      LOW=1
    2 CALL TA (E,X,M,LOW,MOX,MUN,Z,Y,R,N,L,NZERO)
C     WRITE(LO,100) M,LOW,MOX,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 FORMAT (10H RAXEL       ,7I5/1X,6E14.7//(1X,I5,5X,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 TO 10
   12 RAXEL=0.0
      GO TO 10
      END
      SUBROUTINE RESGEN
C**********  PROGRAM NUMBER -  27  CUPED      ************
C
C     CALLED BY  *SHAPE*
C     CALLS  *STDFIT* - *PULSE* - *RAXEL* - *PEEK* - *GAUSS* - *GANE*
C     *COBALT*
C     ORDERS AND NORMALIZES STANDARD SPECTRA FOR RESPONSE MATRIX INTERPOLATION.
C
      DIMENSION R(260,12),ALABEL(12),TAG(24),      STDENY(12),NENJ(12),
     1 NSJ(12),NEXJ(12),NSXJ(12),Y(520),PARAV(12),B(5),PARAS(12),
     2 PAREA(12),NDSHRT(12),BLABEL(12)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/PLX/R,STDENY,B,PARAV,PARAS,PAREA,ALABEL,BLABEL,DUM1(12),
     1  NSJ,NENJ,NSXJ,NEXJ,NDSHRT,NX,NSTAND,NIB
      COMMON/GEN/ TAG,G,SCONST,SN,EM,UNGAIN,MTAG,NA,NZ,N5,NPHA
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      COMMON/SHA/SDUM(1969),MEM
      COMMON/DDORM/ORM,DORM
      NAT=0
C  INITIALIZE
      NST=0
      NSTD1=0
      NSTD2=0
      NGAIN=0
      N52=N5*2
      NA2=NA*2
      NZ2=NZ*2
      NENO=NLIMIT
      NENORM=NLIMIT-1
C  CHECK FOR AN 0.51 MEV SPECTRUM,E.G. SR-85
      DO 2 I=1,NSTAND
      IF(BLABEL(I).NE.TAG(N52))GO TO 4
    3 I5=I
      NST=0
      GO TO 10
    4 CONTINUE
    2 CONTINUE
      NAT=0
      EG=1.114
      IF(STDENY(NSTAND-1)-EG)50,51,50
   51 NAT=NAT+1
   50 EG=1.28
      NSTNAT=NSTAND-NAT-1
      IF(STDENY(  NSTNAT    )-EG)52,53,52
   53 NAT=NAT+1
   52 NSTAND=NSTAND-NAT
      NSTD3=NSTAND
      GO TO 200
C SEARCH FOR NA22.
   10 DO 20 I=1,NSTAND
      IF(BLABEL(I).NE.TAG(NA2))GO TO 40
   30 INA=I
      NST=1
      GO TO 201
   40 CONTINUE
   20 CONTINUE
C SEARCH FOR ZN65.
  201 DO 2000 I=1,NSTAND
      IF(BLABEL(I).NE.TAG(NZ2))GO TO 400
  300 INZ=I
      NST=NST+2
      GO TO 1111
  400 CONTINUE
 2000 CONTINUE
C INITIAL LIMITS FOR START AND STOP FITTING.
 1111 NSJ5=1
      NEN5=NENJ(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)
      NENJ(NSTD1)=NENJ(I5)
      STDENY(NSTD1)=STDENY(I5)
      DO 150 I=NSJ5,NEN5
  150 R(I,NSTD1)=R(I,I5)
      GO TO (159,170,170),NST
  170 NSJ(NSTD3)=NSXJ(INZ)
      NENJ(NSTD3)=NEXJ(INZ)
      STDENY(NSTD3)=STDENY(INZ)
      NSJZ=NSJ(NSTD3)
      NENZ=NENJ(NSTD3)
      DO 180 I= 1  ,NENZ
  180 R(I,NSTD3)=R(I,INZ)
```

```
      IF(NST-3)220,160,220
  159 NSTD3=NSTD2
  160 NSJ(NSTD2)=NSXJ(INA)
      NENJ(NSTD2)=NEXJ(INA)
      STDENY(NSTD2)=STDENY(INA)
      NSJA=NSJ(NSTD2)
      NENA=NENJ(NSTD2)
      DO 190 I= 1  ,NENA
  190 R(I,NSTD2)=R(I,INA)
  220 NGAIN=1
C     WRITE(LO,350)NST,NSJ5,NENS,NSTD1,NSTD2,NSTD3,NAT,N52,NA2,NZ2,
C    1  NSTAND,NSJZ,NENZ,I5,INZ,(R(10,J),J=1,12)
C 350 FORMAT(10H RESTEST   ,15I5/(1X,6E14.7))
C
C NON-LINEAR FIT NSTAND+3 SPECTRA, EXCLUDE EMPTY VECTORS, FROM NS TO NEN
C
  200 CONTINUE
      INIT=1
C
      CALL COBALT(INIT,NSTD3,NST,NSTD2)
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 ROGAIN=PARAV(NSP)
      NF=NENJ(NSTD1)
      DO 6015 I=1,NF
 6015 Y(I)=R(I,NSTD1)
C
C GAIN CHANGE NA AND ZN FOR .51 SUBTRACTIONS.
      SM=0.0
      TAZ=0.0
C
      CALL GANE (TAZ,NF,GAIN,ROGAIN,SM,Y)
C
      NAM=NENJ(N)
      DO 6016 I=1,NAM
 6016 R(I,N)=R(I,N) - Y(I)*PAREA(NSP)/PAREA(I5 )
      NUS=PARAV(NSP)-6.0*PARAS(NSP)
      NAMUS=PARAV(NSP) + 6.0*PARAS(NSP)
      PAV=PARAV(NSP)
      PAS=PARAS(NSP)
      PAK=PAREA(NSP)
      DO 9037 I=NUS,NAMUS
      II=I
 9037 R(I,N)=R(I,N)-PEEK(II,PAV,PAS,PAK)
      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 SN=1.7677
      SCONST=1.321
      SEK=1000.
      DIV=2.354
C
C NORMALIZE COUNTS AND GAINS.
      DO 7010 J=1,NSTAND
C
      DO 7003 I=1,NLIMIT
      Y(I)=R(I,J)/PAREA(J)
 7003 R(I,J)=0.0
      GAIN=PARAV(J)
      NX=NLIMIT
      IF(GAIN-100.0)9991,9992,9992
 9991 NX=(200.0*GAIN/100.0)-1.0
 9992 NF=GAIN+1.0
C     WRITE(LO,818)J,NX,NSP,GAIN,SEK,PAREA(J),G,PAV,R(10,J),(Y(III),
C    1  III=1,NLIMIT)
C 818 FORMAT (10H RESGEN 1   /1X,3I5,5X,6E14.7/(1X,5E14.7))
      TAZ=0.0
      SM=0.0
      ROG=NORM
C
      CALL GANE (TAZ,NX,GAIN,ROG,SM,Y)
C
      DO 30000 I=1,NLIMIT
      IF(Y(I))30001,30001,30002
30001 NENORM=I-1
      NEND=I
      GO TO 30003
30002 CONTINUE
30000 CONTINUE
C
C SUBTRACT K X-RAY ESCAPE PEAK IF ENERGY OF STANDARD LESS THAN 300KEV.
C
30003 IF(STDENY(J)-0.300)11005,11004,11004
11005 EN=STDENY(J)
      NN=1
      ND=2
      OR=RAXEL (EN,NN,ND)
      EK=EN-1.285
      VK=EK*NORM/EN
      NN=1
      VV=VK
      IF(MEM)2720,2720,2721
 2720 VV=VK+VK*PULSE (EK,NN,ND)
 2721 EK=EK*SEK
      SI=(SCONST*EK**SN)*NORM/EK
      SI=SI/DIV
      PKAREA=-OR
C     WRITE(LO,818)NENORM,NEND,NX,VV,SI,PKAREA,EN,EK,VK,(Y(I),I=1,NLIMIT
C    1)
C SUBTRACT K PEAK
      CALL GAUSS (Y,VV,SI,PKAREA,SUM,NENORM)
C  ZERO FROM THE FIRST NEGATIVE CHANNEL TO 260
11004 DO 30509I=NEND,NLIMIT
30509 Y(I)=0.0
      DO 7004 I=1,NENORM
 7004 R(I,J)=Y(I)
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 7010 CONTINUE
      WRITE(LO,820)(J,ALABEL(J),BLABEL(J),PARAV(J),PARAS(J),PAREA(J),
     1  J=1,NSTAND)
  820 FORMAT (1HI,45X,28HRESULTS OF PHOTOPEAK FITTING  ///
     8201  8X,5HINDEX,12X,15HSTANDARD SOURCE,11X,12HPULSE-HEIGHT,10X,
     8202 18HSTANDARD DEVIATION,14X,4HAREA/ 52X,10H(CHANNELS),15X,
     8203 10H(CHANNELS),14X,13H(COUNTS/TIME)//(9X,I3,18X,2A3,3X,3E25.7))
      RETURN
      END
      SUBROUTINE RESMAT
C**********  PROGRAM NUMBER -  28  CUPED      ************
C
C     CALLED BY  *SOLN*
C     CALLS  *VECTMX*
C  PULSE-HEIGHT ANALYZER SPECTRUM UNFOLDING ACCORDING TO THE SCOFIELD ALGORITHM.
C
      COMMON/SHA/R,N,DUM1(365),K,DUM2(3)
      COMMON/SOLRES/EPS,IT,ITMAX,DIF,MN,DUM3(2)
      COMMON/SON/P,DUM4(329)
      COMMON/GEO/DUM5(2),PHI,DUM6(266)
      COMMON/LIO/LI,LO,LP,NLIMIT
      DIMENSION PP( 50),P(520),R( 40, 40),PHI(260) ,FIT(100),DIF(100)
     1  ,MN(18)
C
C  INITIALIZE
C
      NCHECK=ITMAX/2
      NCHECK=ITMAX-2*NCHECK
      SU=0.0
      DO 1999 I=K,N
 1999 SU=SU + P(I)
      DO 1800 I=K,N
 1800 P(I)=P(I)/SU
      YMAX=0.0
C
      CALL VECTMX (P,K,N,JMAX,YMAX)
C
      YLOW=YMAX*(1.0E-15)
      DO 1 I=1,N
      PP(I)=0.0
    1 PHI(I)=P(I)
C  WRITE IF ITMAX IS AN ODD-NUMBER.
      IF(NCHECK)8999,8000,8999
 8999 WRITE  (LO,8989) (P(I),I=1,N)
 8989 FORMAT (30H1 NORMALIZED INPUT SPECTRUM             /(1X,10E11.4))
      INDEX=1
 8000 CONTINUE
      IT=1
      FIT(1)=0.
C
C  MATRIX MULTIPLICATION P=R.PHI
C
   10 DO 2 I=K,N
      PP(I)=0.0
      DO 2 J=K,N
      IF(R(I,J))2001,2000,2001
 2001 PP(I)=PP(I) + R(I,J)*PHI(J)
 2000 CONTINUE
    2 CONTINUE
      TERM = 0.0
C
C  ARRESTING CHECK WHEN  DIF(SUM(P-PP)**2/P) FOR LOOP(IT) AND LOOP(IT-1)
C  ARE LESS THAN EPS.... OR IT=ITMAX.
C
      DO 5 I=K,N
      IF(P(I))4,6,4
    4 TERM = ((P(I) - PP(I))**2)/P(I) + TERM
    6 CONTINUE
    5 CONTINUE
      IF(NCHECK)16000,15000,16000
16000 IF(MN(INDEX) - IT)15000,17000,15000
17000 WRITE(LO,19000) IT,MN(INDEX),(PHI(I),I=K,N)
      WRITE(LO,19005) IT,MN(INDEX),(PP(I) ,I=K,N)
      INDEX=INDEX+1
15000 CONTINUE
19000 FORMAT (51H INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I)) 215
190001/    (1X,10E11.4))
19005 FORMAT (51H INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))  215
190051/    (1X,10E11.4))
      IT=IT+1
      FIT(IT)=TERM
      DIF(IT)=ABS (FIT(IT-1) - FIT(IT) )
      IF(  DIF(IT)                                -EPS)7,7,29
   29 IF(IT-ITMAX)229,7,7
C
C  SCOFIELD CORRECTION FACTOR METHOD.
C
  229 DO 25 I=K,N
      IF(PP(I))125,52,125
  125 PHI(I)=PHI(I)*P(I)/PP(I)
   52 CONTINUE
   25 CONTINUE
      DO 1000 I=K,N
      IF(ABS(PHI(I)) -   YLOW   )1001,1002,1002
 1001 PHI(I)=0.0
 1002 CONTINUE
 1000 CONTINUE
      GO TO 10
C
C  RESULTS.
C
    7 DO 600 I=K,N
      P(I)=P(I)*SU
  600 PHI(I)=PHI(I)*SU
C  WRITE IF ITMAX IS AN ODD-NUMBER.
      IF(NCHECK)9999,10000,9999
 9999 WRITE  (LO,9998) (PP(I),I=1,N)
 9998 FORMAT (20H ITERATED SPECTRUM              /(1X,10E11.4))
10000 CONTINUE
   60 FORMAT (20H0 IT,SU,TERM                /I10,2E14.7)
      WRITE  (LO,60)  IT,SU,TERM
      RETURN
      END
      SUBROUTINE SHAPE
C**********  PROGRAM NUMBER -  29  CUPED      ************
C  CALLS  *GANE* - *PEAKS* - *PEEK* - *RESGEN* - *PULSE* - *PAXE* - *TA* - *TE*
C      - *POLATE* - *COMPLEX* - *VECTMX* - *ENLIN*
C      CONTROL PROGRAM FOR RESPONSE MATRIX GENERATION.
C
      DIMENSION RM(40,40),P(260,12),EM(520),X(12),PV(50),PERACT(50),
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     1 O(260),ALABEL(12),       TAG(24),STDENY(12),STDEN(12),Z(6),Y(6)
     2 ,RR(16),NSJ(12),NENJ(12),NSXJ(12),NEXJ(12), SHIFT(12),NOSUBT(12)
     3 ,NSM(12),DENY(12),R(5),PARAV(12),PARAS(12),PAREA(12) ,RU(50,3),
     4  BLABEL(12),ATAG(24),AEM(260),DM(260),VG(12)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/PLX/R,STDENY,B,PARAV,PARAS,PAREA,ALABEL,BLABEL,Y,Z,NSJ,
     1  NENJ,NSXJ,NEXJ,NOSUBT,NX,NSTAND,NIB
      COMMON/GEN/ TAG,G,SCONST,SM,ENPHO,UNGAIN,NTAG,NA,NZ,N5,NPHA
      COMMON/SHA/RM,N,EM,ELIMIT,NGO,NGR,NDEGRE,O,PV,PERACT,K,MRPEAT,
     1 ESING,MEM
      COMMON/POLT/PII,F,CFA,MIN
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      COMMON/SPCT/EM
C
      COMMON/TMOUT/MOUT
      COMMON/OOORM/ORM,OORM
C READ IN ANY ORDER THE APPROPRIATLY LABELLED RESP. MATRIX LIBRY SPECTRA
C
C READ STANDARD LIBRARY SPECTRA.
C
      SN=T7677
      SCONST=T321
      KKK=K
      NSJNIB=0
      STDNIB=0.0
      SM=0.0
      NL=0
      TAZ=0.0
      NIB=0
      N12=12
      IF(ESING)815,816,815
  815 E=ESING
      V=E*EM
C     WRITE(LO,818)   MRPEAT,NGO,NGR,E,V,EM
C 818 FORMAT (10H SHAPE 01   /1X,3I10,5X,3E14.7)
      KJ=1
      GAIN=OORM
      GO TO 718
  816 IF(MRPEAT)31234,21234,31234
21234 DO 9052 J=1,12
      NEXJ(J)=0.0
 9052 NSXJ(J)=0.0
C
C  NSTAND=NUMBER OF STANDARD SPECTRA IN THE LIBRARY DECK
C  NPHA=NUMBER OF DEAD CHANNEL IN BEGINNING OF STAND. SPECTRA
C  NXLIM=NUMBER OF CHANNELS IN A STANDARD SPECTRUM (260 MAX)
C  UNGAIN=REFERENCE COARSE GAIN (AS AT OCT19/66 IS A DUMMY)
C  ALABEL=STANDARD SOURCE IDENTITY (AS IN DATA STATEMENT BELOW)
C  FIT PE AKS FROM CHANNEL NSJ TO NENJ
C  SUBTRACT PEAKS FROM CHANNEL NSXJ TO NEXJ (USE NEG VALUES IF .51 PEAKS
C    OF EITHER NA22 OR ZN65)
C  SHIFT=CHANNEL LOCATION OF TRUE ZERO PULSE-HEIGHT
C  R(1 TO NXLIM,J)=SPECTRUM J      (J=1 TO NSTAND)
C
      DO 8081 J=1,12
      DO 8081 I=1,NLIMIT
 8081 R(I,J)=0.0
      READ(LI,6)  NSTAND,NPHA,NXLIM,UNGAIN,   (ALABEL(J),
     1  BLABEL(J),NSJ(J),NENJ(J),NSXJ(J),NEXJ(J), SHIFT(J), J=1,NSTAND)
    6 FORMAT (    3I5,F10.5/(2A3,4X,4I5,F10.5))
      DO 8080 J=1,NSTAND
      READ(LI,88) (R(I,J),I=1,NXLIM)
 8080 CONTINUE
   88 FORMAT (10F7.1)
C
C  COMPLEMENT OVERSUBTRACTED COUNTS.
      DO 8000 J=1,NSTAND
      DO 8000 I=1,NXLIM
      IF(R(I,J)-T90) 8001,8001,8002
 8002 R(I,J)=R(I,J)-T100
 8001 CONTINUE
 8000 CONTINUE
C     WRITE(LO,13456)N,NGO,NGR,MRPEAT,EM,ELIMIT,ESING
C3456 FORMAT(10H SHAPE-1    ,4I5,5X,3E14.7)
C
C  SHIFT SPECTRA AN AMOUNT TZ IF TZ NOT =0
      NTZ=0
      DO 9000 J=1,NSTAND
      IF(NSXJ(J))9015,9016,9016
 9015 NSXJ(J)=-NSXJ(J)
      NOSUBT(J)=0
      GO TO 9017
 9016 NOSUBT(J)=1
 9017 IF( SHIFT(J))9001,9002,9001
 9001 TZ= SHIFT(J)
      NTZ=TZ
      IF(NSXJ(J))9018,9019,9018
 9018 NSXJ(J)=NSXJ(J)-NTZ
      NEXJ(J)=NEXJ(J)-NTZ
 9019 NSJ(J) =NSJ(J) -NTZ
      NENJ(J)=NENJ(J)-NTZ
      NX=NXLIM
      GAIN=1.0
      ROGAIN=1.0
      DO 9003 I=1,NXLIM
      EM(I)=R(I,J)
 9003 R(I,J)=0.0
      CALL GANE (TZ,NX,GAIN,ROGAIN,SM,EM)
      DO 9004 I=1,NX
 9004 R(I,J)=EM(I)
 9002 CONTINUE
 9000 CONTINUE
      NPHA=NPHA-NTZ
      G=0.0
      N5=5
      NA=10
      NZ=9
      NTAG=12
C     WRITE(LO,13456)NTZ,NX,N5,NZ,TZ,GAIN,ROGAIN
      DATA ATAG    /3H CO,3H109,3H  S,3HC47,3H HG,3H203,3H  C,3H861,
     13H  S,3H885,3H CS,3H137,3H  M,3HN54,3H  N,3H895,3H  Z,3HN65,3H  N,
     23HA22,3H  C,3H060,3H  N,3HA24/
      DATA  STDEN  /.088,.155,.279,.323,.515,.66162,.835,.744,1.114,
     11.28,1.332,2.767/
      DO 19789 IJ=1,24
19789 TAG(IJ)=ATAG(IJ)
C
C IDENTIFY ENERGIES OF STANDARDS
      DO 1234 KK=1,NSTAND
```

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      DO 3456 J=1,NTAG
      JK=J*2
      IF(BLABEL(KK).EQ.TAG(JK))GO TO 4321
 6543 CONTINUE
 3456 CONTINUE
      WRITE (LO,9) (ALABEL(JJ),BLABEL(JJ),JJ=1,NSTAND), (TAG(JJJ),
     1  JJJ=1,24)
    9 FORMAT (1H1,23H ERROR FLAG FOR PHDFRA        /(1X,1H*,2A3))
      CALL EXIT
 4321 STDENY(KK)=STDEN(J)
 1234 CONTINUE
      IF(MEM)2720,2720,2721
 2721 NGC=1
      NGL=1
      DO 2722 J=1,NSTAND
      NXL=NXLIM
      JJ=J
      N1=NSJ(J)
      N2=NENJ(J)
      DO 2723 I=1,NXLIM
 2723 FM(I)=R(I,J)
      YM=0.0
      CALL VECTMX(FM,N1,N2,JM,YM)
      VG(J)=JM
      ELIM=STDENY(J)*1.5
      CALL ENLIN(NXL,FM,STDENY,VG,NGL,JJ,NGC,DM,ELIM)
      DO 2724 I=1,NXLIM
 2724 R(I,J)=FM(I)
 2722 CONTINUE
C     WRITE(LO,13456)JK,NSTAND,NTAG,NTZ,STDENY(1),STDENY(2),STDENY(8)
C
C CALL RESGEN TO CALC GAUSSIAN PARAMETERS AND UNIT CONTINUA FOR STANDS.
C
 2720 CONTINUE
      WRITE(LO,7) NSTAND,NPHA,INGAIN,  (ALABEL(J),
     1  BLABEL(J),NSJ(J),NENJ(J),NSXJ(J),NEXJ(J),SHIFT(J),STDENY(J),
     2 J=1,NSTAND)
    7  FORMAT(1H1,15X ,37H STANDARD SOURCE SPECTRAL PARAMETERS   ///
    71  14X,I5,33H SPECTRA IN STANDARD SOURCE DECK   //
    72  13X,16H CHANNELS ONE TO ,I4,22H ASSUMED AS REDUNDANT   //
    73  17X,25H REFERENCE COARSE GAIN =      ,F10.5////
    741X,72HSTANDARD         PHOTOPEAK      X-RAY OR .5 PEAK       SHIFT
    75 PHOTOPEAK      /71H  SOURCE       FROM        TO       FROM        TO
    76      SPECTRUM    ENERGY     //10X,60H   CHANNEL   CHANNEL   CHANNEL
    77 CHANNEL    CHANNELS       MEV      /(2X,2A3,6X,I4,5X,I4,7X,I3,6X,I3,
    784X,F9.4,1X,F10.5))
      DO 27123 J=1,NSTAND
      WRITE (LO,8999) ALABEL(J),BLABEL(J),(R(I,J),I=1,NXLIM)
 8999 FORMAT (1H1,32X,25H STANDARD SOURCE SPECTRA     ////////  3X,2A3,
 89991 8H SOURCE ////(1X,10F9.0))
27123 CONTINUE
      WRITE  (LO,3)
    3 FORMAT (1H1)
      NSTOOO=NSTAND
      IF(NPHA)7000,7000,9005
 9005 DO 7002 J=1,NSTAND
      DO 7002 I=1,NPHA
 7002 R(I,J)=R(NPHA+I,J)
 7000 NCOR=0
      IF(BLABEL(NSTAND).EQ.TAG(24))GO TO 4322
      GO TO 6200
 4322 NCOR=1
      NSTAND=NSTAND-NCOR
 6200 IF(BLABEL(NSTAND).EQ.TAG(22))GO TO 6201
      GO TO 6202
 6201 NCOR=NCOR+2
      NSTAND=NSTAND-1
 6202 IF(NCOR)6545,6545,6203
 6203 GO TO (6204,6204,6205),NCOR
 6204 NIR=NSTAND+1
      DO 6206 I=1,NXLIM
      AFM(I)=R(I,NIR)
 6206 R(I,NIR)=0.0
      NSJNIR=NSJ(NIR)
      NEJNIR=NENJ(NIR)
      STDNIR=STDENY(NIR)
      GO TO 6545
 6205 NIR=NSTAND+2
      DO 6207 I=1,NXLIM
      R(I,N12)=R(I,NIR)
 6207 R(I,NIR)=0.0
      NSJ(N12)=NSJ(NIR)
      NENJ(N12)=NENJ(NIR)
      STDENY(N12)=STDENY(NIR)
      GO TO 6204
 6545 CONTINUE
      NIR=-NIR
C     WRITE(LO,13456)NIR,NCOR,NSTAND,NSJNIR,STDNIR,STDENY(12),STDENY(8)
C
      CALL RESGEN
C
      NIR=-NIR
C     WRITE(LO,13456)NIR,NCOR,NSTAND,NSJNIR,STDNIR,STDENY(12),STDENY(8)
      NSTAM1=NSTAND
C
  350 FORMAT(10H FM,P,      /(1X,7E15.7))
44444 IF(NCOR)7500,7500,7501
 7501 GO TO (7502,7502,7503),NCOR
 7502 NSTAND=NSTOOO
      DO 7504 I=1,NXLIM
 7504 R(I,NIR)=AFM(I)
      NSJ(NIR)=NSJNIR
      NENJ(NIR)=NEJNIR
      STDENY(NIR)=STDNIR
      GO TO 7505
 7503 NSTAND=NSTOOO
      NIR=NSTAND
      DO 7506 I=1,NXLIM
 7506 R(I,NIR)=R(I,N12)
      NSJ(NIR)=NSJ(N12)
      NENJ(NIR)=NENJ(N12)
      STDENY(NIR)=STDENY(N12)
      NIR=NIR-1
      GO TO 7502
 7505 CONTINUE
 7500 DO 5049 J=1,NSTAND
 5049 DENY(J)=STDENY(J)
      DO 5053 JK=1,NSTAND
      SMALL=10.0
      DO 5050 J=1,NSTAND
```

```
      IF(STDENY(J)-SMALL)5051,5052,5052
 5051 NSMALL=J
      SMALL=STDENY(J)
 5052 CONTINUE
 5050 CONTINUE
      NSM(JK)=NSMALL
      STDENY(NSMALL)=10.0
 5053 CONTINUE
C
C     NSM(K) NOW CONTAINS THE CORRECT INDEX ORDER
C
      DO 5055 J=1,NSTAND
      NORDER=NSM(J)
 5055 STDENY(J)=DENY(NORDER)
      DO 5057 I=1,NXLIM
      DO 5056 KK=1,NSTAND
 5056 DENY(KK)=R(I,KK)
      DO 5058 J=1,NSTAND
      NORDER=NSM(J)
 5058 R(I,J)=DENY(NORDER)
 5057 CONTINUE
      K=KKK
      NS1=0
      NS2=0
      IF(NCOR)6544,31235,6544
 6544 GO TO (6211,6214,6213),NCOR
 6213 NSTAND=NSTAND-1
 6214 NIB=0
C     WRITE(LO,13456)NIB,NCOR,NSTAND,NSJNIB,STDNIB,STDENY(12),STDENY(8)
C     WRITE(LO,351)(STDENY(I),PARAV(I),PARAS(I),PAREA(I),DENY(I),
C    1  SHIFT(I),STDEN(I),I=1,12)
C 351 FORMAT(1X,7E12.5)
C     WRITE(LO,352)(NSJ(I),NENJ(I),NSXJ(I),NEXJ(I),NOSUBT(I),NSM(I),
C    1  I=1,12)
C 352 FORMAT(1X,6I10)
C     CALL COMPLX TO ANALYZE CO-SPECTRUM
C
      CALL COMPLX(NS1,NS2)
C
C     WRITE(LO,13456)NIB,NCOR,NSTAND,NSJNIB,STDNIB,STDENY(12),STDENY(8)
      IF(MOUT.NE.0) GO TO 44445
      WRITE(LO,81)ALABEL(NSTAND),BLABEL(NSTAND),(R(I,NSTAND),I=1,120)
44445 IF(NCOR-2)6216,31235,6216
 6216 NSTAND=NSTAND+1
 6211 NIB=1
C     CALL COMPLX TO ANALYZE NA-SPECTRUM
C
      CALL COMPLX(NS1,NS2)
C
C GENERATE RESPONSE VECTORS
C INTERPOLATE THE RESPONSE MATRIX OF SIZE N*N USING THE VECTORS R(I,J).
C DETERMINE FOR ONE ENERGY, ALL CHANNELS, THEN INCREMENT ENERGY.
C
31235 CONTINUE
      DO 19123 J=1,NSTAMI
      WRITE(LO,3)
      WRITE(LO,81) ALABEL(J),BLABEL(J),STDENY(J),(R(I,J),I=1,110)
   81 FORMAT (10X,42H NORMALIZED CONTINUUM OF STANDARD SPECTRA //////
     8113X,243,8H SOURCE ///5X,8HENERGY= ,F10.4,5H MEV ////(1X,5E14.7))
19123 CONTINUE
31234 K=0
      NO=NLIMIT
      NMAX=NO
      P=0.0
      NS=1
      DO 10 I=NS,NO
   10 EM(I)=0.0
      DO 11 I=NS,40
      PERACT(I)=0.0
      PV(I)=0.0
      DO 11 J=NS,40
   11 RM(I,J)=0.0
      EN=N
      DE=ELIMIT/EN
      DEL=DE/2.0
      MM=N
      WRITE(LO,3)
C
      KJ=NS
  920 GAIN=OORM
      F=KJ
      E=E+DE-DEL
C  INTERPOLATE FROM ENERGY X(1) TO ENERGY X(NTOP)
  718 IF(E-.6616)210,220,220
  210 RR(1)=0.0
      X(1)=0.0
      LOW=1
      NTOP=NSTAND+1
      DO 1005 I=1,100
      DO 1004 INDEX=2,NTOP
      X(INDEX)=STDENY(INDEX-1)
 1004 RR(INDEX)=R(I,INDEX-1)
      CALL TA (E,X,NTOP,LOW,MOX,MUN,Z,Y,RR,NDEGRE,L,NL)
      MM=NDEGRE+1
 1005 EM(I)=TE(MM,Z,Y,E)
      GO TO 211
  220 CONTINUE
  817 CONTINUE
      NTOP=NSTAND
      LOW=1
      DO 754 INDEX=1,NSTAND
      X(INDEX)=STDENY(INDEX)
  754 RR(INDEX)=1.0
      CALL TA (E,X,NTOP,LOW,MOX,MUN,Z,Y,RR,NDEGRE,L,NL)
      IF(MUN-(NSTAND-1))8171,8172,8172
 8172 MUN=NSTAND-2
C
 8171 CALL POLATE(EM)
C
      NCF=CFA
  211 CONTINUE
  950 FORMAT(10H SHAPE-1   /1X,7I5,F14.7/(1X,5E14.7))
C
      DO 827 I=101,NLIMIT
  827 EM(I)=0.0
C     WRITE(LO,951) KJ,NO,NMAX,N,NSTAND,MOX,MUN,E,(EM(I),I=1,110)
C     WRITE(LO,159)T331A,T285
C 159 FORMAT(13H SHAPE CHECK ,2E14.7/)
C 951 FORMAT(10H SHAPE-2   /1X,7I5,F14.7/(1X,5E14.7))
      IF(ESING)821,822,821
```

```
  821 KJ=1
      IF(E-.5)823,824,824
  823 IF(E-T3316) 824,825,825
  825 EK=E-T285
      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-0.010)60,60,59
   60 PV(KJ)=V
      K=K+1
      NMAX=N
      DO 30880 I=1,NLIMIT
30880 EM(I)=0.0
      P=0.0
      GO TO 61
   59 EK=E-T285
      SCALE=GAIN/V
      SIG=(SCONST*(E*1000.0)**SN)*SCALE*EM/2354.82
    8 NMA=GAIN+1.0+6.0*SIG
C     WRITE(LO,952) NMA,NO,SCALE,GAIN,V,SIG
C 952 FORMAT(10H SHAPE-1A   ,2I5,4E14.7)
      IF(NMA-NO)123,123,124
  124 GN=GAIN
      GAIN=GAIN/2.0
      SIG=SIG/2.0
      SCALE=GAIN/V
C REDUCE VECTOR LENGTH TO ALLOW COMPLETE PEAK TO BE FORMED (I.E.LOW E)
      CALL GANE (TAZ,NMAX,GN,GAIN,SM,EM)
      GO TO 8
  123 V=E*EM
      IF(MEM)1521,1521,1522
 1521 V=V+V*PULSE (E,NGO,NDEGRE)
 1522 PV(KJ)=V
      IF(E-T3316) 4,4,5
    4 VV=0.0
      DR=0.0
      SI=0.0
      GO TO 14
    5 VK=EK*GAIN/E
      IF(MEM)1523,1523,1524
 1524 VV=VK
      GO TO 1525
 1523 VV=VK+VK*PULSE (EK,NGO,NDEGRE)
 1525 SI=(SCONST*(EK*1000.0)**SN)*SCALE*EM/2354.82
      DR=RAXEL(E,NGR,NDEGRE)
      IF(ESING)826,14,826
  826 NBEGIN=VV-6.0*SI
      IF(NBEGIN)828,828,829
  828 NBEGIN=1
  829 DO 830 I=NBEGIN,100
      II=I
  830 EM(I)=EM(I)+PEEK(II,VV,SI,DR)
C     WRITE(LO,12321)NMA,NO,NBEGIN,NMAX,E,SN,SCONST,SCALE,GAIN,GN,VV,DR,
C    1SI,ESING
      GO TO 824
   14 CONTINUE
      CALL PEAKS (EM,GAIN,E,DR,VV,SI,SIG,NO,P,NMAX)
C
      NMXX=NO
C
      CALL GANE (TAZ,NMXX,GAIN,V,SM,EM)
      IF(MOUT.NE.0) GO TO 61
C     WRITE(LO,12321) NMA,NO,K,NMXX,E,V,SIG,SCALE,GAIN,GN,VV,DR,SI,ESING
C2321 FORMAT (10H PHOTRA 2   ,4I5/(1X,5E14.7))
      SUM=0.0
      DO 700 I=1,NMXX
  700 SUM=SUM+EM(I)
      WRITE(LO,500) SUM,NMXX
  500 FORMAT(/10H SUM,NMXX E15.8,I10)
      WRITE(LO,86) KJ,N,E,(EM(I),I=1,40)
   86 FORMAT(////////////
   861       36H INTERPOLATED RESPONSE MATRIX VECTOR,I3,4H OF ,I3,
   86214H FOR ENERGY = ,F10.5,5H MEV     /(1X,5E14.7))
   61 M=NMXX+2
      IF(M- 40)90,90,91
   91 M=40
   90 PERACT(KJ)=P
      DO 2 I=NS,M
    2 RM(I,KJ)=EM(I)
      IF(KJ-MM)918,919,919
  918 KJ=KJ+1
      GO TO 920
  919 CONTINUE
  824 RETURN
      END
      FUNCTION SIMPSN (A,B,EPS)
C**********  PROGRAM NUMBER -  30  CUPED     ************
C
C     CALLED BY  *EFFIC*
C     CALLS  *FC*
C     SIMPSONS RULE INTEGRATING PROGRAM FOR FUNCTION -FC-.
C
      COMMON /B/ KL,NEGAM,RX,DIST,H
      TMAX=2048.
      AN=2.0
      FA=FC(A)
      FB=FC(B)
      EP=0.0
      SI=0.0
      DELT=B-A
  405 FOUR=0.0
      AK=1.0
      AKN=AN/2.0
  399 FFX=FC(A+(((2.0*AK-1.0)*DELT)/AN))
      FOUR=FOUR+FFX
      IF(AKN-AK)400,401,400
  400 AK=AK+1.0
      GO TO 399
  401 SIM=(DELT/(AN*3.0))*(FA+FB+4.0*FOUR+2.0*EP)
      IF(TMAX-AN)503,503,499
  499 DIFX=ABS(SIM-SI)
      IF(EPS-DIFX/SIM)402,403,403
  402 AN=AN+AN
      EP=EP+FOUR
      SI=SIM
      GO TO 405
  503 CONTINUE
```

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  403 SIMPSN=SIM
      RETURN
      END
      SUBROUTINE SINGLE (NSIN,GG)
C**********  PROGRAM NUMBER -  31  CUPED      ***********
C
C     CALLED BY  *MAIN*
C     CALLS  *GANE* - *SHAPE* - *STDFIT* - *XTAL* - *STDFT2* - *GAUSS*
C     - *GUESS2* - *GANE* - *VECTMX*
C     DETERMINES MONOENERGETIC SPECTRAL CONTRIBUTION.
C
      DIMENSION EM(520),SLINE(260),EUG(20),EU(20),PP(520),RM(40,40),PV
     1(50),PERACT(50),Q(260),PHOT(20),R(5),NSS(20),NENN(20),ETA(260)
     2  ,EUGN(20),EUU(20),NAS(20),NAE(20),NAJ(20),RR(8),EXRY(20),NSM(20)
C
C  EM-IN IS  A BREMSS+LINE SPECTRUM.  EM-OUT IS A BREMSS ONLY, AND PHOT
C  CONTAINS THE LINE DATA TO BE ADDED TO PHI IN *MAIN*.
C
      COMMON/A/DI,H,MF
      COMMON/SHA/RM,N,EM,ELIMIT,NGO,NGR,NDEGRE,Q,PV,PERACT,K,MRPEAT,ENY,
     1  MEM
      COMMON/SON/FM,EUG,EU,NP,NGA,NGX,NGC,TKEUC,RX,IN,PHOT,NGF,ETA,D
      COMMON/LIO/LI,LO,LP,NLIMIT
      COMMON/SING/NJ(20),NSS,NENN,EXR(20),M22,M6
      COMMON/SPCT/PP
      COMMON/CNSTNT/T38,T01,T20,T50,T76,T1293,T90,T100,T366,T3316,T06,
     1              T321,T7677,T285
      COMMON/OORM/ORM,OORM
C     WRITE(6,1111)(EM(I),I=1,520)
C1111 FORMAT(10H SINGLE 00 /(1X10E12.6))
C     WRITE(6,1113)M22,M6,          (NJ(J),NSS(J),NENN(J),EXR(J),J=1,20)
C1113 FORMAT(10H M22, M6= ,2I10/(1X,3I10,E15.6))
      NONE=1
      NX=1
      NOX=NX
      DIST=0
      HH=H
      NON=NONE+M6
      IF(M6)8001,8000,8001
 8000 IF(M22) 8005,4567,8005
 4567 RETURN
 8001 IF(M22)8002,8003,8002
 8002 DO 8004 J=NON,IN
      JJ=J-M6
      EXR(J)=EXR(JJ)
      NSS(J)=NSS(JJ)
      NENN(J)=NENN(JJ)
 8004 NJ(J)=NJ(JJ)
C  ESTIMATE PHOTOPEAK FITTING LIMITS.
 8003 DO 1501 J=NONE,M6
      DO 768 KCHECK =1,2
      IF(KCHECK-1)1870,1870,1871
 1871 BIG=0.0
C
      CALL VECTMX (FM,NS,NEN,IRIG,BIG)
C
      EUG(J)=IRIG
 1870 ANY=1000.0*EU(J)
      SIG= (T321*ANY**T7677 *EUG(J)/ANY)/2.354
      IF(EU(J)-.2)771,772,772
  771 TNS=2.3
      TEN=3.1
      GO TO 775
  772 IF(EU(J)-.4)773,774,774
  773 TNS=3.0
      GO TO 776
  774 TNS=4.0
  776 TEN=3.0
  775 NSS(J)=EUG(J)-TNS*SIG
      NENN(J)=EUG(J)+TEN*SIG+1.0
      NS=NSS(J)
      NEN=NENN(J)
C     WRITE(LO,9555)NSS(J),NENN(J),ANY,SIG,EUG(J)
C9555 FORMAT(10H SINGLE 1    /1X,2I10,3E14.7)
  768 CONTINUE
      NJ(J)=1
 1501 CONTINUE
      IF(M22)8005,8007,8005
C  CHECK-OUT ESTIMATED FITTING LIMITS.
 8005 J=NON
  502 NS=NSS(J)
      NOJ=0
      IF(NJ(J)-2)504,503,504
  503 NEN=NENN(J+1)
      NOJ=2
      GO TO 506
  504 NEN=NENN(J)
  506 CONTINUE
C     WRITE(LO,1112)NS,NEN
C1112 FORMAT(9H NS, NEN  /(2I8))
      BIG=0.0
      CALL VECTMX(FM,NS,NEN,IRIG,BIG)
      EUG(J)=IRIG
  507 IF(EXR(J))5000,5000,5001
 5001 EU(J)=EXR(J)
      GO TO 5002
 5000 EU(J)=EUG(J)*ELIMIT/GG
 5002 CONTINUE
      IF(NOJ)509,8006,509
  509 NOJ=0
      JP1=J+1
  562 EUG(JP1)=IRIG+NSS(J+1)
      NEUG=EUG(JP1)
      IF(FM(NEUG)-FM(NS)) 560,560,561
  560 NSS(JP1)=-NSS(JP1)
      GO TO 562
  561 J=JP1
      GO TO 507
 8006 IF(J-JN)501,500,500
  501 J=J+1
      GO TO 502
  500 IF(M6) 56,56,4441
 4441 DO 5049 J=1,IN
      EUU(J)=EU(J)
      NAS(J)=NSS(J)
      NAE(J)=NENN(J)
      NAJ(J)=NJ(J)
      EXRY(J)=EXR(J)
 5049 EUGN(J)=EUG(J)
      DO 5008 J=1,20
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 5008 EXR(J)=0.0
      DO 5053 JK=1,IN
      SMALL=10000.
      DO 5050 J=1,IN
      IF(EUG(J)-SMALL)5051,5052,5052
 5051 NSMALL=J
      SMALL=EUG(J)
 5052 CONTINUE
 5050 CONTINUE
      NSM(JK)=NSMALL
      EUG(NSMALL)=10000.
 5053 CONTINUE
      DO 5057 J=1,IN
      NORDER=NSM(J)
      EUG(J)=EUGN(NORDER)
      EU(J)=EUU(NORDER)
      NSS(J)=NAS(NORDER)
      NFNN(J)=NAF(NORDER)
      EXR(J)=EXRY(NORDER)
 5057 NJ(J)=NAJ(NORDER)
 8007 IF(M6-1)56,56,766
  766 IIN=M6-1
      DO 769 J=1,IIN
      JNS=J+1
      IF(NFNN(J)-NSS(JNS))762,762,763
  763 MEAN=(NFNN(J)-NSS(JNS))/2
      NFNN(J)=NFNN(J)-MEAN
      NSS(JNS)=NFNN(J)+1
  762 CONTINUE
      IF(NSS(J)-1)64,64,65
   64 NSS(J)=2
   65 IF(NFNN(J)-NSIN)66,67,67
   67 NSS(J)=NSIN-1
   66 CONTINUE
  769 CONTINUE
      IF(NFNN(IN)-NSIN)56,57,57
   57 NSS(J)=NSIN
   56 CONTINUE
C     WRITE(6,1114) (FM(J),J=1,520)
C1114 FORMAT(' FM(J), IN SINGLE AFTER 56 '/(1X,10E12.5))
C
      ETAT=ETA(1)
      NGE=1
      J=1
 8015 NBS=0
      IF(NJ(J)-2)8011,8010,8011
 8010 NS=NSS(J)
      NFN=NFNN(J+1)
  577 V1=EUG(J)
      V2=EUG(J+1)
      IF(V1-V2) 575,575,576
  576 EUG(J)=V2
      EUG(J+1)=V1
      GO TO 577
  575 GO TO 8016
 8011 NS=NSS(J)
      NFN=NFNN(J)
      ENY=EU(J)
      VENY=EUG(J)
C  STORE PEAK(J) OF SPECTRUM FM(I) IN SLINE(I).
 8016 DO 760 I=1,NLIMIT
  760 SLINE(I)=0.0
      DO 761 I=NS,NFN
  761 SLINE(I)=FM(I)
C     WRITE(10,1115) (SLINE(I),I=1,260)
C1115 FORMAT(' SLINE(K), IN SINGLE '/(1X,10E12.5))
      IF(NJ(J)-2)8013,8012,8013
 8012 CALL GUESS2(NS,NFN,SLINE,BB,V1,V2)
      NFB=7
      CALL STDFT2(SLINE,NFN,BB,NS,NFB)
      IF(BB(1)-BB(4))516,515,515
  516 IF(EU(J)-EU(J+1)) 519,519,518
  518 AT=EU(J)
      EU(J)=EU(J+1)
      JP1=J+1
      EU(JP1)=AT
      AT=EXR(J)
      EXR(J)=EXR(JP1)
      EXR(JP1)=AT
      GO TO 519
  515 IF(EU(J)-EU(J+1))517,519,519
  517 AT=EU(J)
      EU(J)=EU(J+1)
      JP1=J+1
      EU(JP1)=AT
      AT=EXR(J)
      EXR(J)=EXR(JP1)
      EXR(JP1)=AT
  519 CONTINUE
      B3=-BB(3)
      B6=-BB(6)
      CALL GAUSS(FM,BB(1),BB(2),B3,SAM,NMAX)
      CALL GAUSS(FM,BB(4),BB(5),B6,SAM,NMAX)
      B(1)=BB(1)
      B(2)=BB(2)
      B(3)=BB(3)
      B(4)=BB(7)
      B(5)=BB(8)
      IF(EXR(J))530,530,540
  540 EU(J)=EXR(J)
      GO TO 531
  530 EU(J)=BB(1)*ELIMIT/GG
  531 VENY=BB(1)
      ENY=EU(J)
      NBS=1
      IF(NMAX-NFN)520,521,521
  520 NMAX=NFN
  521 GO TO 80014
C
C  FIT PEAK FROM NS TO NFN.
C
 8013 CALL STDFIT (SLINE,NFN,B,NS,ENY)
C
C  SUBTRACT THE DETERMINED PEAK FROM NS TO NFN.
C
      IF(EXR(J)) 5003,5003,5004
 5003 EU(J)=ENY
      GO TO 5005
 5004 ENY=EXR(J)
      EU(J)=ENY
```

```
 5005 CONTINUE
      B3=-B(3)
      CALL GAUSS(FM,B(),B(2),B3,SAM,NMAX)
80014 DO 46 I=NS,NMAX
      IF(FM(I))47,48,48
   47 FM(I)=0.0
   48 CONTINUE
   46 CONTINUE
C
C  DETERMINE THE CONTINUUM ASSOCIATED WITH A PEAK OF AREA  = UNITY FOR
C  ENERGY = ENY, AND OF PULSE-HT. = 100 CHAN.    GAIN CHANGE PER B(1)
C  AND MULTIPLY BY B(3) AND FINALLY SUBTRACT IT FROM FM(I). ALSO DETERM.
C  THE PHOTOREACTION TO CALC PHOTON FLUX.
C
 8020 DO 99 I=1,NLIMIT
   99 PP(I)=0.0
      MRPE=MRPEAT
      MEMY=MEM
      NNP=N
      N=NP
C
      CALL SHAPE
C
      N=NNP
      MRPEAT=MRPE
      MEM=MEMY
      DO 850 I=80,NLIMIT
      IF(PP(I))851,851,852
  851 INDEX=I
      GO TO 853
  852 CONTINUE
  850 CONTINUE
  853 DO 854 I=INDEX,NLIMIT
  854 PP(I)=0.0
      SUM=0.0
      DO 999 I=1,100
  999 SUM=SUM+PP(I)
      PHOT(J)=1.0/(1.0+SUM)
      NX=100
      GAINB1=B(1)
      PHO=PHOT(J)
C     WRITE(LO,19777) NP,EM,ELIMIT,SUM,PHOT(J),(PP(I),I=1,NLIMIT)
C9777 FORMAT (10H SINGLE 3    /1X,I10,4E14.7/(1X,5E14.7))
C
      CALL GANE(0.0,NX,DORM, GAINB1,0.0,PP)
C
      IF(NX-NLIMIT)1800,1801,1801
 1801 NX=NLIMIT-1
 1800 DO 1100 I=1,NX
      FM(I)=FM(I)-PP(I)*B(3)
      IF(FM(I))1873,1874,1874
 1873 FM(I)=0.0
 1874 CONTINUE
 1100 CONTINUE
C     WRITE(LO,800)NX,GAINB1,(FM(I),I=1,NLIMIT),(PP(I),I=1,NLIMIT)
C 800 FORMAT (10H SINGLE 3A    ,I10,E14.7/(1X,5E14.7))
C
C  FM(I) NOW WITHOUT PEAK J AND ASSOC CONTINUUM.  PHOT ABOVE IS PHOTOEFF
C  NOW IS LINE SPECTRUM AREA AT CHANNEL CORRESPONDING TO ENY (OR EIG(J))
C  AND VENY (OR EIG(J)).
C
      PHOT(J)=B(3)/PHOT(J)
C
      SLIME(1)=ENY
C
      CALL XTAL(1,J,SLIME,HH)
C
      PHOT(J)=PHOT(J)/ETA(1)
      WRITE(LO,555)PHOT(J),PHO
  555 FORMAT(1HO//69X,25HPHOTON NUMBER             =,F20.7/
     5551 69X,          25HPHOTOREACTION             =,F20.7////)
      WRITE(LO,1500)
 1500 FORMAT (1HO/43X,31HDISCRETE PHOTOPEAK FITTING DATA  ///
     15001 6X,8HLOCATION,15X,6HENERGY,16X,12HPULSE-HEIGHT,10X,    18HSTANDARD
     15002 DEVIATION,14X,4HAREA/ 19H CHANNEL TO CHANNEL,10X,5H(MEV),18X,
     15003 10H(CHANNELS),15X,10H(CHANNELS),14X,13H(COUNTS/TIME)//)
      WRITE(LO,1600) NS,NEN,ENY,B(1),B(2),B(3)
 1600 FORMAT (1H ,2X,I3,8X,I3,8X,F22.7,3E25.7)
  100 IF(J-IN)80200,8030,80200
80200 J=J+1
      IF(NRS)8040,8015,8040
 8040 NRS=0
      DO 8041 I=1,NLIMIT
 8041 SLIME(I)=0.0
      DO 8042 I=NS,NEN
 8042 SLIME(I)=FM(I)
      EIG(J)=BB(4)
      VENY=EIG(J)
      B(3)=BB(6)
      B(2)=BB(5)
      B(1)=BB(4)
      IF(EXR(J))532,532,534
  534 ENY=EXR(J)
      GO TO 533
  532 ENY=BB(4)*ELIMIT/GG
  533 GO TO 8020
 8030 NGE=1
      NX=NOX
      ETA(1)=ETAT
      RETURN
      END
      SUBROUTINE SOLN
C**********  PROGRAM NUMBER -  32  CUPED      ************
C
C      CALLED BY  *MAIN*
C      CALLS  *XTAL* - *RESMAT*
C      DETERMINES AND APPLIES DETECTOR EFFICIENCY VECTOR.
C
      COMMON /A/ DI,H,MF
      COMMON/SHA/R,N,DUM,ELIMIT,DUM1(21,NDEGRE,E,DUM2(100),K,DUM3(3)
      COMMON/SOH/P,DUM4(41),NGA,NGX,NGC,TKLUC,RX,DUM5(21),NGO,ETA,DIST
      COMMON/GEO/DUM6(2),PHI,NS,DUM7(245)
      COMMON/SOLRES/EPS,IT,ITMAX,DIF,M,MSKIP,M14
      COMMON/LIO/LI,LO,LP,NLIMIT
      DIMENSION P(520),P(40,40),PHI(260),ETA(260),E(260),DIF(100),M(18)
      IF(K)50,30,50
   30 K=1
   50 KK=K-1
      IF(KK-1)601,602,602
  602 DO 600 I=1,KK
```

```
  600 P(I)=0.0
  601 CONTINUE
      IF(MF)12,11,12
C
   11 CALL RESMAT
C
      MF=0
   12 IF(DIST-DI)3,40,3
   40 IF(MSKIP)3,4,3
    3 NGO=1
      IF(M14)2,13,2
C
   13 CALL XTAL(NS,N,F,H)
C
    2 NGO=1
      DI=DIST
      IF(MF)9,4,9
    4 IF(M14)54,44,54
   44 DO 22 I=NS,N
   22 PHI(I)=PHI(I)/ETA(I)
   54 MF=0
C  WRITE DIF(I) IF (IT=ITMAX)
      IF(IT-ITMAX)89,100,100
  100 WRITE(LO,105) (DIF(I),I=1,IT)
  105 FORMAT (1H1,36H FLUX FITTING DIFFERENCES (IT=ITMAX)/(1X,5E14.7))
   89 RETURN
    9 IF(M14)98,99,98
   98 DO 96 I=NS,N
   96 ETA(I)=1.0
   99 DO 9999 I=NS,N
 9999 PHI(I)=P(I)/ETA(I)
      RETURN
      END
      SUBROUTINE STDFIT (Y,MEN,B                ,NS,ENY)
C**********  PROGRAM NUMBER -  33  CUPED     **********
C
C     CALLED BY  *COBALT* - *SINGLE* - *FIVE*
C     CALLS  *GUESS* - *FUNDS*
C     NON-LINEAR REGRESSION ANALYSIS OF STANDARD SPECTRA SINGLE
C     PHOTOPEAKS
C
      DIMENSION EC(260),Y(260),B(5),A(260,5),G(6,6)
      COMMON /LIO/ LI,LO,LP,NLIMIT
      COMMON/TMOUT/MOUT
      EPS=0.00001
      L=B(3)
      DO 100 I=1,5
  100 B(I)=0.0
      B(3)=L
      NBC=5
      NF=MEN
      NI=10
      L=0
      FITLM1=0.0
      LL=0
C
C CALL GUESS TO INITIALIZE PARAMETERS.
C CALL FUNCTION TO BE FITTED.
      CALL GUESS (NS,MEN,Y,B,ENY)
      FIT=0.0
    5 CALL FUNDS (FIT,EC,Y,B,A,NF,NS)
C CONSTRUCT THE NORMAL EQUATIONS.
      NN=NBC
      M=NN+1
      DO 21 I=1,NN
      G(I,M)=0.0
      DO 21 J=NS,NF
   21 G(I,M)=G(I,M)+A(J,I)*EC(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.
      K=1
  109 IF(K-NN)2,2,18
    2 J=K+1
  101 IF(J-M)3,3,4
    3 G(K,J)=G(K,J)/G(K,K)
      J=J+1
      GO TO 101
    4 I=K+1
  102 IF(I-NN)7,7,6
    6 K=K+1
      GO TO 109
    7 J=K+1
  103 IF(J-M)17,17,16
   16 I=I+1
      GO TO 102
   17 G(I,J)=G(I,J)-G(I,K)*G(K,J)
      J=J+1
      GO TO 103
   18 K=NN
   15 IF(K-1)11,10,10
   10 I=1
   14 IF(I-K)12,13,12
   12 G(I,M)=G(I,M)-G(I,K)*G(K,M)
      I=I+1
      GO TO 14
   13 K=K-1
      GO TO 15
   11 CONTINUE
C
      L=L+1
      IF(L-1)29,29,28
   28 IF(ABS(FITLM1-FIT)/FIT - EPS)42,42,29
   29 IF(L-NI)8,42,42
    8 DO 24 I=1,NBC
   24 B(I)=B(I)+G(I,M)
      FITLM1=FIT
      IF(MOUT)5,9,5
    9 WRITE(LO,988)NF,NS,MEN,M,NBC,NN,NI,L,FIT,EPS,FITLM1,(B(I),I=1,5)
  988 FORMAT(10H STDFIT    /1X,8I5,5X,3E14.7//1X,5E14.7)
      GO TO 5
C FITTING COMPLETE.  CALCULATE CORRELATION MATRIX.
   42 CONTINUE
      RETURN
      END
      SUBROUTINE STDFT2 (Y,MEN,B,NS,NBR)
C**********  PROGRAM NUMBER -  34  CUPED     **********
```

```
C
C     CALLED BY  *SINGLE*
C     CALLS  *FUNDS1*
C
      DIMENSION Y(260),B(8),NPARA(8),A(260,8),G(9,9),EC(260),P(260)
       COMMON/LIO/LI,LO,LP,NLIMIT
      COMMON/TMOUT/MOUT
C     NON-LINEAR REGRESSION PROGRAM FOR STANDARD SPECTRA DOUBLE
C     PHOTOPEAKS
      EPS=0.0001
      NI=10
      KLM=5
      GO TO 1001
 1000 KLM=7
      GO TO 1001
 2000 KLM=6
      GO TO 1001
 2001 KLM=8
 1001 DO 1002 II=1,KLM
 1002 NPARA(II)=II
      L=0
      IF(KLM-5)1003,1003,1004
 1004 IF(KLM-6)1010,1010,1005
 1005 IF(KLM-7)1003,1003,1006
 1006 IF(KLM-8)1007,1007,1100
 1010 B(8)=B(7)
      B(7)=B(6)
      B(6)=B(5)
      B(5)=B(2)
 1007 NB=8
      GO TO 5
 1003 NB=7
    5 CALL FUNDS1(FIT,EC,Y,B,P,A,NFN,NS,KLM,NB,NER)
 1011 DO 58 J=1,KLM
      NARP=NPARA(J)
      B(J)=B(NARP)
      DO 58 K=1,NFN
   58 A(K,J)=A(K,NARP)
C     CONSTRUCT THE NORMAL EQUATIONS
      M=KLM+1
      DO 21 I=1,KLM
      G(I,M)=0.0
      DO 21 J=NS,NFN
   21 G(I,M)=G(I,M)+A(J,I)*EC(J)/Y(J)
      DO 22 I=1,KLM
      DO 22 K=1,KLM
      G(I,K)=0.0
      DO 22 J=NS,NFN
   22 G(I,K)=G(I,K)+A(J,I)*A(J,K)/Y(J)
C     SOLVE NORMAL EQUATIONS FROM HERE TO STATEMENT 11
      K=1
  100 IF(K-KLM)2,2,18
    2 J=K+1
  101 IF(J-M)3,3,4
    3 G(K,J)=G(K,J)/G(K,K)
      J=J+1
      GO TO 101
    4 I=K+1
  102 IF(I-KLM)7,7,6
    6 K=K+1
      GO TO 100
    7 J=K+1
  103 IF(J-M)17,17,16
   16 I=I+1
      GO TO 102
   17 G(I,J)=G(I,J)-G(I,K)*G(K,J)
      J=J+1
      GO TO 103
   18 K=KLM
   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     FIT ARRESTING CHECK
      L=L+1
      IF(L-1)29,29,28
   28 IF(ABS(FITLM1-FIT)/FIT-EPS)42,42,29
   29 IF(L-NI)8,42,42
    8 DO 24 I=1,KLM
   24 B(I)=B(I)+G(I,M)
      FITLM1=FIT
   89 DO 90 J=1,KLM
      NARP=NPARA(J)
   90 B(NARP)=B(J)
      IF(NER-5)30,42,30
   30 IF(KLM-5)1003,1003,3001
 3001 IF(KLM-6)1007,1007,3002
 3002 IF(KLM-7)1003,1003,3003
 3003 IF(KLM-8)1007,1007,1100
   42 FITLM1=0.0
      IF(NER-5)31,1111,31
   31 IF(KLM-5)1000,1000,1200
 1200 IF(KLM-6)2001,2001,1201
 1201 IF(KLM-7)2000,2000,1100
 1111 B(7)=B(4)
      B(8)=B(5)
      B(4)=0.0
      B(5)=0.0
      B(6)=0.0
 1100 CONTINUE
 3999 FORMAT(1H1,45HPARAMETERS FOR GAUSSIAN AND STRAIGHT LINE FIT ///
     11X,10HPEAK NO. 1  //1X,12HPULSE HEIGHT,7X,1H=,F15.4 /
     21X,20HSTANDARD DEVIATION =,F15.4 /1X,4HAREA,15X,1H=,F15.4 ///
     31X,10HPEAK NO. 2 //1X,12HPULSE HEIGHT,7X,1H=,F15.4 /
     41X,20HSTANDARD DEVIATION =,F15.4 /1X,4HAREA,15X,1H=,F15.4 ///
     51X,13HSTRAIGHT LINE  //1X,5HSLOPE,14X,1H=,F15.4 /
     61X,9HINTERCEPT,10X,1H=,F15.4 )
      IF(MOUT)99,98,99
   98 WRITE(LO,3999)(B(II),II=1,8)
   99 RETURN
      END
      SUBROUTINE FA (F,Y,M,MM,MDX,MIN,Z,Y,B,NDEGRE,L,II)
C**********  PROGRAM NUMBER -  35  CURED      **********
C
C     CALLED BY  *FEEIC* - *PERSPY* - *CLAD* - *AI2ARS*
```

```
C      CALLED BY  *DOSE* - *PULSE* - *RAXEL* - *SHAPE*
C      BINARY TABLE SEARCHING PROGRAM.
C
       DIMENSION X(45),Z( 6),Y( 6),R(45)
       MOX=M
       MIN=MM
     7 KDEL=(MOX-MIN)/2
     8 IF(KDEL)18,14,18
    18 KP=MIN+KDEL
       IF(X(KP)-E)12,12,11
    11 MOX=KP
       GO TO 7
    12 IF(E-X(KP))24,24,13
    13 MIN=KP
       GO TO 7
    24 MIN=KP
       MOX=KP+1
C
    14 IF(MOX-M)4,5,4
     5 L=MIN-2
       GO TO 6
     4 L=MIN-1
     6 NN=NDEGRE+1
       IF(LL)15,2,15
     2 DO 3 I=1,NN
       J=I+L
       Z(I)=X(J)
     3 Y(I)=R(J)
    15 RETURN
       END
       FUNCTION TE (N,X,Y,E)
C**********  PROGRAM NUMBER -  36  CUPED      **********
C
C      CALLED BY  *EFFIC* - *PERSPX* - *CLAD* - *AIRABS* - *POLATE*
C      CALLED BY  *DOSE* - *PULSE* - *RAXEL* - *SHAPE*
C      N-DEGREE LAGRANGIAN INTERPOLATION PROGRAM.
C
       DIMENSION X( 6),Y(6)
       S=0.
       I=1
    28 IF(I-N)21,21,22
    21 P=Y(I)
       J=1
    27 IF(J-N)23,23,24
    23 IF(I-J)25,26,25
    25 P=P*(E-X(J))/(X(I)-X(J))
    26 J=J+1
       GO TO 27
    24 S=S+P
       I=I+1
       GO TO 28
    22 TE =S
       RETURN
       END
       SUBROUTINE VECTMX (Y,N1,N2,JMAX,YMAX)
C**********  PROGRAM NUMBER -  37  CUPED      **********
C
C      CALLED BY  *MAIN* - *RESMAT* - *GUESS* - *FIVE* - *POLATE*
C      - *SINGLE*
C      DETERMINES THE INDEX AND VALUE OF THE MAX ELEMENT IN A VECTOR OF ELEMENTS.
C
       DIMENSION Y(260)
       DO 1 I=N1,N2
       IF(Y(I)-YMAX)3,3,4
     4 YMAX=Y(I)
       JMAX=I
     3 CONTINUE
     1 CONTINUE
       RETURN
       END
       SUBROUTINE XTAL(NS,NF,E,H)
C**********  PROGRAM NUMBER -  38  CUPED      **********
C
C      CALLED BY  *SOLN* - *SINGLE* - *MAIN*
C      CALLS  *EFFIC* - *PERSPX* - *CLAD* - *ABSORB*
C
       COMMON/LIO/LI,LO,LP,NLIMIT
       COMMON/SDN/DUM1(560),NDUM,NGA,NGX,NGC,TKLUC,RX,NDUM,DUM2(20),NGO,
      1ETA,DIST
       DIMENSION E(260),ETA(260)
C
       NGC=1
       NDEGRE=2
       WRITE(LO,3000)
 3000 FORMAT (1H1,50X,18HEFFICIENCY FACTORS  /// 8X,5HINDEX,10X,
 30001 6HENERGY,12X,3HAIR,12X,8HCLADDING,10X,6HLUCITE,10X,7HCRYSTAL,
 3000211X,5HTOTAL/
 30003 22X,5H(MEV), 9X,11HATTENUATION,6X,11HATTENUATION,6X,
 30004 11HATTENUATION,6X,10HEFFICIENCY,7X,10HEFFICIENCY///)
       DO 2 I=NS,NF
       NGA=1
       NGO=1
       E=E(I)
       ETA(I)=EFFIC (E,NGO,NDEGRE,DIST,RX,H)
       G=AIRABS (E,NGA,NDEGRE,DIST)
       ABSORB=PERSPX(E,NGX,NDEGRE ,TKLUC)
       CAN=CLAD(E,NGC,NDEGRE)
       A=ETA(I)*G* CAN*ABSORB
       WRITE(LO,1000) I,E,G,CAN,ABSORB,ETA(I),A
 1000 FORMAT (1H ,8X,I3,   6E17.5)
    2 ETA(I)=A
       RETURN
       END
/*
// EXEC LINKGO
//GO.FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),        *
//             SPACE=(CYL,(5,5))
//SYSABEND DD SYSOUT=A,SPACE=(TRK,(5))
//GO.DATA5 DD *
```

APPENDIX III

SAMPLE INPUT CARD DECK LISTING

```
  1.0
 TEST RUN RUN2 400 CH. TO 256.  6 PEAKS
 0  2  3  0  0  6  7  0  0  0  0  0  0  0  0 15 16  0  0
   2.0        1.0        1.0        0.0       51.0
    7     7  200     1.0
HG203       100   150    15    47        0.0
 SR85       110   145     0     0        0.0
CS137       110   147     0     0        0.0
 NB95       110   144     0     0        0.0
 MN54       110   144     0     0        0.0
 ZN65       115   143   -54    67        0.0
 CO60       122   142     0     0       -3.2
000000 000000 000670 000902 000760 000860 000860 000917 000966 000953  E0
001094 001047 001061 001110 001051 001223 001357 001532 001751 001874  E1
001734 001544 001324 001333 001421 001568 001576 001784 002047 002622  E2
003782 005941 008341 010705 011311 010229 007962 005928 004732 004017  E3
003306 002680 001962 001423 001101 000974 000991 000996 001005 001080  E4
001023 001074 001134 001123 001195 001317 001330 001399 001562 001654  E5
001829 001911 002048 001983 001963 001887 001860 001684 001578 001509  E6
001425 001269 001271 001175 001127 001095 001037 000993 000989 000948  E7
000929 000929 000924 000921 000953 000918 000950 001002 001035 001047  E8
001066 001071 001063 001107 001081 001168 001088 001182 001225 001201  E9
001237 001251 001260 001271 001262 001259 001324 001409 001415 001495  E10
001543 001513 001589 001833 001937 002295 002796 003525 004557 006194  E11
008118 010850 013584 017036 020230 023422 025834 028083 029117 029829  E12
028868 027557 025426 022621 019213 016047 012746 009898 007310 005393  E13
003635 002413 001524 000886 000551 000310 000175 000122 000082 000078  E14
000028 000044 000016 000056 000058 000027 000031 000033 000030 000032  E15
000035 000049 000041 000041 000044 000034 000031 000041 000046 000026  E16
000056 000031 000046 000031 000058 000025 000032 000034 000048 000045  E17
000041 000037 000037 000026 000031 000037 000047 000040 000043 000030  E18
000035 000032 000042 000027 000025 000037 000025 000025 000037 000000  E19
000000 000000 005224 006569 001895 001767 001724 001823 001898 001878  E0
001883 001920 001848 001959 001920 002024 002019 002127 002176 002129  E1
002062 002040 002057 002062 002055 002000 002098 002068 002098 002091  E2
002176 002119 002241 002225 002223 002306 002286 002353 002358 002509  E3
002685 002920 003039 003038 003208 003105 003044 002938 002938 002865  E4
002748 002842 002716 002742 002680 002655 002630 002516 002587 002642  E5
002564 002560 002540 002515 002439 002544 002676 002633 002775 002721  E6
002757 002896 002758 002823 002858 002774 002925 002688 002796 002611  E7
002416 002453 002258 002098 001959 001795 001564 001416 001343 001252  E8
001234 001206 001126 001096 001039 001080 001042 001041 000974 000941  E9
000927 000946 000887 000947 000917 000868 000859 000925 000971 000976  E10
000971 001016 001130 001235 001339 001477 001726 002310 002873 003943  E11
005346 007331 009907 012520 015779 018960 021819 024258 025505 026004  E12
024784 022676 019649 016234 012537 008971 006186 004058 002538 001402  E13
000813 000388 000177 000084 000025 000030 000003 000020 999985 000025  E14
000014 000001 000007 000013 000006 000011 000017 000015 000025 000004  E15
000010 000002 000030 000025 000001 000015 000006 000014 000018 000009  E16
999993 000008 000022 000020 000013 000013 000009 000011 000003 000013  E17
000023 000015 000021 000010 000028 000016 999999 000023 000013 000024  E18
000005 000017 000009 000018 000011 000005 000011 000000 000024 000000  E19
000000 000000 000391 002460 005458 018591 011156 003228 002239 002131  E0
002095 002090 002222 002348 002280 002286 002169 002125 002195 002189  E1
002165 002247 002251 002348 002320 002220 002275 002306 002362 002416  E2
002510 002501 002644 002764 003020 003204 003216 003312 003354 003103  E3
003190 002973 002987 002977 002892 002955 002883 002800 002866 002771  E4
002760 002691 002669 002735 002694 002665 002697 002740 002711 002620  E5
002745 002652 002655 002717 002757 002650 002744 002685 002668 002729  E6
002703 002839 002698 002754 002706 002745 002654 002885 002788 002761  E7
002807 002751 002857 002843 002865 002777 002744 002590 002476 002344  E8
002098 001902 001633 001487 001341 001231 001118 001086 000988 000906  E9
000923 000807 000809 000773 000746 000741 000752 000740 000730 000670  E10
000775 000761 000835 000873 001004 001102 001180 001388 001705 002272  E11
003062 004099 005760 007998 010583 013552 016386 019038 020885 022004  E12
021280 019441 016849 013395 010019 007096 004634 002866 001594 000843  E13
000415 000174 000102 000039 000040 000021 000015 000019 000007 000015  E14
000030 000050 000040 000046 000053 000053 000045 000044 000035 000032  E15
000043 000017 000021 000017 000008 000035 000013 000008 000021 000014  E16
000022 000012 000005 000007 000000 000017 000019 999993 000004 000011  E17
000005 000023 000003 000020 999993 000008 000022 000011 000007 000007  E18
000015 000014 000020 000018 000006 000004 000012 000011 000013 000000  E19
000000 000000 002668 003593 004041 003031 002654 002603 002671 002440  E0
002628 002845 002977 002937 002779 002771 002785 002791 002892 002917  E1
002862 002963 002932 002963 003174 003165 003140 003338 003366 003438  E2
003419 004031 004182 004344 004312 004197 004050 003867 003927 003858  E3
003830 003802 003733 003688 003796 003759 003705 003730 003813 003508  E4
003596 003546 003579 003637 003510 003618 003507 003536 003491 003526  E5
003356 003541 003482 003420 003469 003484 003378 003506 003541 003438  E6
003490 003518 003495 003629 003553 003542 003494 003442 003597 003519  E7
003444 003583 003649 003674 003688 003725 003784 003734 003776 003469  E8
003455 003375 003185 002884 002516 002245 002016 001728 001565 001518  E9
001335 001272 001110 001147 001034 000965 000925 000884 000871 000860  E10
000895 000821 000924 001004 001053 001184 001278 001445 001934 002381  E11
003356 004731 006401 009042 012312 016121 019855 023267 025337 026289  E12
025220 022348 018706 014126 009950 006597 003934 002183 001084 000475  E13
000246 000109 000039 000019 000023 000025 000002 000038 000014 000007  E14
000021 999990 000007 000003 000008 000028 000017 000016 000017 000013  E15
000017 000024 000004 000012 000006 000011 000012 999986 000020 999999  E16
000008 000015 000006 999996 000019 000017 000005 000006 000017 000004  E17
999998 000013 000010 000000 000013 000010 000002 000024 000006 000007  E18
000010 000006 000001 000008 000014 000011 000007 000000 000013 000000  E19
```

```
000000 000000 002100 002363 001965 002048 001976 002036 002016 002083        &0
002144 002218 002144 002132 002117 002067 002146 002203 002213 002165        &1
002148 002255 002308 002247 002291 002381 002408 002590 002727 003057        &2
003153 003230 003123 003163 003022 003054 002913 002931 002794 002878        &3
002709 002743 002679 002662 002569 002618 002586 002718 002588 002568        &4
002661 002587 002554 002487 002599 002576 002527 002574 002633 002585        &5
002593 002639 002531 002497 002583 002488 002545 002563 002480 002628        &6
002538 002523 002497 002573 002552 002493 002445 002605 002668 002589        &7
002648 002588 002629 002725 002762 002800 002762 002787 002850 002870        &8
002794 002678 002598 002535 002400 002257 001918 001742 001468 001229        &9
001109 001061 000892 000863 000789 000717 000704 000632 000578 000599        &10
000606 000596 000593 000676 000740 000784 000870 001018 001218 001528        &11
002012 002842 004116 005784 008124 010700 013782 016575 018092 018626        &12
018116 015873 013377 009948 006871 004508 002510 001388 000731 000327        &13
000138 000054 000012 000017 000016 999999 000016 000003 999997 000006        &14
000002 999993 999991 000011 000003 000006 000003 999997 000010 000010        &15
000016 999991 000018 000009 000003 000005 000017 000018 000016 000006        &16
000003 000001 000016 999989 000005 000034 000001 000008 000012 000000        &17
000010 000006 999997 999996 000010 000001 000007 999994 000011 000004        &18
000015 000019 999999 000007 000001 999991 000009 000020 000012 000000        &19
000000 000000 002845 003407 002638 002760 002868 002787 002915 002907        &0
002768 002879 002787 002863 003015 003074 003178 003027 003345 003365        &1
003602 003544 003710 004056 004125 004307 004297 003948 003932 003837        &2
003814 003670 003737 003552 003611 003608 003675 003406 003354 003322        &3
003397 003245 003196 003085 003222 003109 003014 003160 002995 002992        &4
003003 003018 002997 003078 003115 003340 003865 004377 005240 005726        &5
005888 005526 004689 003804 003085 002916 002856 002709 002795 002801        &6
002912 002737 002637 002780 002851 002909 002821 002806 002862 002844        &7
002884 002778 002963 002937 003039 002962 003066 003163 003070 003160        &8
003074 003329 003228 003319 003341 003498 003507 003427 003383 003438        &9
003133 002903 002565 002260 001985 001703 001326 001240 001073 001007        &10
000904 000830 000802 000749 000718 000849 000852 000845 000945 001219        &11
001512 001984 00283[illegible] 004206 006172 009050 012199 015770 018207 019904        &12
018875 016786 012846 009182 005920 003343 001815 000786 000404 000144        &13
000073 000007 000003 999992 999994 000023 000003 999982 000019 000025        &14
000019 000022 999986 000005 000012 000015 000022 000012 000007 999995        &15
000025 999996 000030 000019 000020 000052 999995 999971 999996 999970        &16
999962 999974 999983 999995 999986 999999 000017 000009 000017 000000        &17
999981 000010 000003 000006 999990 000006 000002 000010 000008 999997        &18
000007 000010 999997 000009 999995 000007 000009 999997 000008 000000        &19
000000 000008 000611 007029 007604 007866 008379 008611 008250 007996
008025 008414 008303 008515 008611 008729 009112 009505 010104 011167
012003 012483 011557 011543 010804 010737 010571 010423 010384 010211
009843 009641 009548 009353 009317 009121 009074 009125 008960 008970
008875 008908 008636 008753 008651 008562 008457 008458 008466 008488
008459 008482 008259 008219 008205 008171 008145 008249 008167 008136
007945 007977 008105 008164 008206 008265 008314 008312 008393 008356
008408 008236 008354 008500 008724 008722 008888 008726 008987 009183
009469 009606 009579 009625 009737 009762 009948 009782 009715 009312
008941 008555 008047 007599 007090 006856 006624 006585 006423 006415
006470 006320 006399 006341 006186 006054 006057 006670 008057 010847
015340 020879 027077 031373 032347 029421 023838 016855 010792 006544
004215 003436 003986 005727 008628 012771 017774 022343 025820 026541
024011 019373 013710 008721 004843 002534 001041 000432 000264 000164
000116 000092 000109 000107 000084 000086 000105 000098 000091 000102
000095 000102 000104 000104 000103 000102 000099 000095 000084 000100
000076 000075 000092 000081 000076 000088 000069 000067 000057 000076
000068 000066 000074 000075 000066 000059 000069 000073 000062 000080
000061 000059 000052 000069 000062 000063 000071 000055 000057 000063
000067 000034 000049 000048 000059 000048 000058 000068 000042 000000
  PH02        1.0        1.0        1.0        20.0        1.0     200.0  0.0
   7    0   20    0    0    I
  100.    0.     0.       1.0     1.0     1.0    127.0  1.27     0.      0.      0.
   1    2    3    4    5    7   10   15   20   30
   2 115    0   1.2700    0   10 144   1.36      2   46    0   0.50
   0    7   66   0.5750    2   69    0   0.7600    0   12   96   0.8750
   1 143 167   1.5400

100513 124001  81387  43872  33958  31632  26716  22787  20076  18482
 16846  16063  14977  14320  13427  12768  12231  11751  11418  11230
 10481   9918   9722   9510   9269   8743   8626   8950   9931  11764
 13968  15364  14202  11787   9944  10473  13311  17066  19334  18016
 14363  10043   7109   5740   5198   5078   4830   4574   4404   4342
  4327   4723   4915   5502   6167   6482   6663   6361   5726   4988
  4457   4222   4061   4420   4869   5758   6432   7025   7106   6655
  5809   5046   4196   3705   3371   3347   3318   3407   3304   3339
  3182   3124   2915   2730   2549   2501   2162   2095   1958   1937
  1744   1735   1676   1576   1508   1589   1638   1808   2116   2575
  3324   4313   5555   6977   8397   8992   9095   8633   7318   5924
  4551   3475   2854   2476   2244   2082   1960   1634   1485   1300
  1144   1050   1001    906    930    915    915    886    967   1051
  1124   1160   1148   1020    965    886    797    660    597    530
   433    425    375    345    333    334    333    306    315    327
   354    308    334    325    322    325    345    352    344    288
   293    277    282    253    221    221    203    206    199    207
   168    208    179    166    224    198    217    235    290    311
   293    277    282    253    221    221    203    206    199    207
   168    208    179    166    224    198    217    235    290    311
/*
/*
                                                                      4281 CARDS
```

APPENDIX IV

SAMPLE OUTPUT LISTING

BRIEF DESCRIPTION OF PHA RUNS

TEST RUN PUO2 400 CH. TO 256. 6 PEAKS

CONTROL NUMBERS

M(1) =	0	M(2) =	2	M(3) =	3	M(4) =	0	M(5) =	0	M(6) =	6
M(7) =	7	M(8) =	0	M(9) =	0	M(10) =	0	M(11) =	0	M(12) =	0
M(13) =	0	M(14) =	0	M(15) =	15	M(16) =	16	M(17) =	0	M(18) =	0
M(19) =	0	M(20) =	0	M(21) =	0	M(22) =	0	M(23) =	0	M(24) =	0

EM = 10.00000 CHANNELS/MEV

ELIMIT= 2.00000

ITERATIVE ERROR TOLERANCE,EPS = 0.00010

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

MAX NUMBER OF ITERATIONS,ITMAX= 51

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 8 ASSUMED AS REDUNDANT

REFERENCE COARSE GAIN = 1.00000

STANDARD SOURCE	PHOTOPEAK FROM	PHOTOPEAK TO	X-RAY OR .5 PEAK FROM	X-RAY OR .5 PEAK TO	SHIFT SPECTRUM	PHOTOPEAK ENERGY
	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNELS	MEV
HG203	110	150	15	47	0.0	0.27900
SR85	110	145	0	0	0.0	0.51500
CS137	110	147	0	0	0.0	0.66162
NB95	110	144	0	0	0.0	0.76400
MN54	110	144	0	0	0.0	0.83500
ZN65	115	143	54	67	0.0	1.11400
CO60	123	143	0	0	-1.2000	1.33200

Ⓑ

HG203 SOURCE

0.	0.	670.	902.	760.	860.	860.	917.	966.	953.
1094.	1047.	1061.	1110.	1051.	1223.	1357.	1532.	1751.	1874.
1734.	1544.	1324.	1333.	1421.	1568.	1576.	1784.	2047.	2622.
3782.	5941.	8361.	10705.	11311.	10229.	7962.	5928.	4732.	4017.
3306.	2680.	1962.	1423.	1101.	974.	891.	886.	1005.	1080.
1023.	1074.	1134.	1123.	1195.	1317.	1330.	1399.	1562.	1654.
1829.	1911.	2048.	1983.	1963.	1887.	1860.	1684.	1578.	1509.
1425.	1269.	1271.	1175.	1127.	1095.	1037.	993.	989.	948.
929.	929.	924.	921.	953.	918.	950.	1002.	1035.	1047.
1066.	1071.	1063.	1107.	1081.	1168.	1088.	1182.	1225.	1201.
1237.	1251.	1260.	1271.	1262.	1259.	1324.	1409.	1415.	1495.
1543.	1513.	1689.	1833.	1937.	2295.	2796.	3525.	4557.	6194.
8118.	10850.	13586.	17036.	20230.	23422.	25834.	28083.	29117.	29829.
28868.	27557.	25426.	22621.	19243.	16047.	12746.	9898.	7310.	5393.
3635.	2413.	1624.	889.	561.	310.	175.	122.	82.	78.
28.	44.	16.	56.	58.	27.	31.	33.	30.	32.
35.	49.	41.	41.	44.	34.	31.	41.	46.	26.
56.	31.	46.	31.	58.	25.	32.	34.	48.	45.
41.	37.	37.	26.	31.	37.	47.	40.	43.	30.
35.	32.	42.	27.	25.	37.	25.	25.	37.	0.

STANDARD SOURCE SPECTRA

SR85 SOURCE

0.	0.	5224.	6569.	1895.	1767.	1724.	1823.	1898.	1878.
1883.	1929.	1848.	1959.	1927.	2024.	2019.	2127.	2176.	2129.
2062.	2040.	2057.	2062.	2055.	2000.	2098.	2068.	2098.	2091.
2176.	2119.	2241.	2225.	2223.	2306.	2286.	2353.	2358.	2509.
2686.	2920.	3039.	3038.	3208.	3105.	3044.	2938.	2938.	2866.
2768.	2842.	2715.	2742.	2661.	2655.	2630.	2516.	2587.	2642.
2568.	2560.	2549.	2515.	2439.	2544.	2676.	2633.	2775.	2721.
2757.	2896.	2758.	2823.	2858.	2774.	2925.	2688.	2796.	2611.
2616.	2453.	2258.	2098.	1959.	1795.	1564.	1416.	1343.	1252.
1274.	1206.	1126.	1096.	1039.	1080.	1042.	1041.	974.	941.
927.	946.	887.	947.	917.	868.	859.	925.	971.	976.
971.	1016.	1130.	1235.	1339.	1477.	1726.	2310.	2873.	3943.
5346.	7331.	9937.	12520.	15779.	18960.	21819.	24258.	25505.	26034.
24794.	22676.	19649.	16234.	12537.	8971.	6186.	4058.	2538.	1402.
813.	388.	177.	84.	65.	30.	3.	20.	-15.	25.
14.	1.	7.	13.	6.	11.	17.	15.	25.	4.
10.	2.	30.	25.	1.	15.	4.	14.	18.	9.
-7.	8.	22.	21.	13.	13.	9.	11.	3.	13.
23.	15.	21.	10.	28.	16.	-1.	23.	13.	24.
5.	17.	9.	18.	11.	5.	11.	9.	24.	0.

CS137 SOURCE

0.	0.	391.	2460.	6468.	18691.	11156.	3228.	2239.	2131.
2095.	2090.	2222.	2348.	2250.	2286.	2169.	2125.	2195.	2189.
2166.	2247.	2251.	2348.	2340.	2225.	2275.	2399.	2362.	2416.
2510.	2501.	2643.	2764.	3020.	3204.	3216.	3312.	3354.	3103.
3190.	2973.	2987.	2977.	2892.	2955.	2881.	2800.	2866.	2771.
2760.	2691.	2669.	2735.	2694.	2665.	2697.	2740.	2711.	2620.
2745.	2652.	2665.	2717.	2757.	2650.	2746.	2685.	2668.	2729.
2703.	2839.	2698.	2754.	2706.	2745.	2654.	2885.	2788.	2761.
2807.	2751.	2857.	2843.	2865.	2777.	2744.	2580.	2476.	2344.
2098.	1902.	1633.	1487.	1341.	1231.	1118.	1086.	988.	916.
921.	847.	819.	773.	746.	741.	752.	740.	739.	670.
775.	761.	835.	873.	1004.	1102.	1187.	1388.	1705.	2272.
3062.	4099.	5740.	7998.	10583.	13552.	16386.	19138.	20885.	22004.
21289.	19441.	16849.	13395.	10019.	7096.	4634.	2866.	1594.	843.
415.	174.	112.	39.	40.	21.	15.	19.	7.	15.
30.	50.	40.	46.	53.	53.	45.	44.	35.	32.
43.	17.	21.	17.	8.	35.	13.	8.	21.	14.
22.	12.	5.	7.	0.	17.	19.	-7.	4.	11.
5.	23.	3.	20.	-7.	8.	22.	11.	7.	7.
15.	14.	20.	18.	6.	4.	12.	11.	13.	0.

STANDARD SOURCE SPECTRA

NB95 SOURCE

0.	0.	2668.	3593.	4041.	3031.	2654.	2603.	2671.	2640.
2629.	2845.	2977.	2937.	2779.	2771.	2785.	2791.	2892.	2917.
2862.	2963.	2932.	2963.	3174.	3165.	3140.	3338.	3366.	3438.
3819.	4031.	4132.	4364.	4312.	4197.	4080.	3867.	3937.	3858.
3830.	3802.	3733.	3688.	3796.	3769.	3705.	3739.	3813.	3598.
3505.	3546.	3579.	3637.	3510.	3618.	3517.	3535.	3491.	3525.
3356.	3561.	3432.	3420.	3499.	3484.	3379.	3506.	3541.	3638.
3495.	3518.	3495.	3529.	3353.	3542.	3494.	3462.	3597.	3519.
3565.	3588.	3649.	3674.	3588.	3725.	3784.	3734.	3776.	3669.
3655.	3375.	3135.	2884.	2516.	2245.	2016.	1728.	1565.	1518.
1335.	1272.	1113.	1147.	1034.	965.	925.	884.	871.	869.
895.	821.	924.	1004.	1053.	1184.	1278.	1445.	1934.	2381.
3364.	4731.	6491.	9042.	12312.	16121.	19855.	23267.	25337.	26389.
25220.	22348.	18706.	14126.	9950.	6597.	3934.	2183.	1084.	475.
246.	139.	39.	19.	23.	25.	2.	38.	14.	7.
21.	-10.	7.	3.	8.	28.	17.	16.	17.	13.
17.	24.	4.	12.	6.	11.	12.	-11.	20.	-1.
8.	15.	6.	-4.	18.	17.	5.	6.	17.	4.
-2.	13.	10.	1.	13.	10.	2.	24.	6.	7.
19.	6.	1.	8.	14.	11.	7.	0.	13.	1.

MN54 SOURCE

0.	0.	2100.	2363.	1985.	2048.	1976.	2036.	2016.	2083.
2144.	2218.	2144.	2132.	2117.	2067.	2146.	2203.	2213.	2165.
2148.	2255.	2378.	2247.	2291.	2381.	2408.	2590.	2727.	3057.
3153.	3230.	3123.	3163.	3062.	3054.	2913.	2931.	2794.	2878.
2709.	2743.	2679.	2662.	2569.	2618.	2586.	2718.	2588.	2568.
2661.	2587.	2554.	2487.	2599.	2576.	2527.	2574.	2633.	2585.
2593.	2639.	2531.	2497.	2583.	2489.	2545.	2563.	2480.	2628.
2538.	2523.	2497.	2573.	2552.	2491.	2445.	2605.	2668.	2589.
2648.	2588.	2639.	2725.	2762.	2800.	2762.	2787.	2850.	2870.
2754.	2678.	2598.	2535.	2403.	2257.	1918.	1742.	1468.	1229.
1109.	1061.	892.	863.	789.	717.	704.	632.	578.	599.
606.	596.	593.	676.	740.	784.	870.	1018.	1218.	1528.
2012.	2842.	4116.	5784.	8124.	10703.	13782.	16576.	18092.	18626.
18116.	15873.	13377.	9948.	6871.	4508.	2510.	1388.	731.	327.
138.	54.	12.	17.	16.	-1.	16.	3.	-3.	6.
2.	-7.	-9.	11.	3.	6.	3.	-3.	10.	10.
16.	-9.	18.	9.	3.	5.	17.	18.	16.	6.
3.	1.	16.	-11.	5.	34.	1.	8.	12.	0.
10.	6.	-3.	-4.	10.	1.	7.	-6.	11.	-4.
15.	19.	-1.	7.	1.	-9.	9.	20.	12.	0.

STANDARD SOURCE SPECTRA

ZN65 SOURCE

0.	0.	2845.	3407.	2638.	2760.	2868.	2787.	2915.	2907.
2768.	2879.	2787.	2863.	3015.	3074.	3178.	3027.	3345.	3365.
3502.	3544.	3710.	4056.	4125.	4307.	4297.	3948.	3932.	3837.
3814.	3670.	3737.	3552.	3611.	3608.	3675.	3406.	3354.	3322.
3307.	3245.	3196.	3085.	3222.	3109.	3014.	3160.	2995.	2992.
3033.	3018.	2997.	3078.	3115.	3341.	3865.	4377.	5240.	5726.
5888.	5526.	4689.	3804.	3085.	2916.	2856.	2709.	2795.	2801.
2912.	2737.	2637.	2781.	2851.	2909.	2821.	2806.	2862.	2844.
2884.	2778.	2963.	2937.	3039.	2962.	3166.	3163.	3078.	3160.
3174.	3329.	3228.	3319.	3341.	3498.	3507.	3427.	3383.	3438.
3133.	2933.	2565.	2260.	1965.	1703.	1326.	1240.	1073.	1007.
904.	830.	802.	749.	748.	849.	852.	845.	945.	1219.
1412.	1984.	2834.	4236.	6172.	9050.	12199.	15770.	18287.	19904.
19876.	16786.	12846.	9182.	5961.	3343.	1815.	786.	404.	144.
73.	7.	3.	-8.	-6.	23.	3.	-18.	19.	25.
19.	22.	-14.	5.	12.	15.	22.	12.	7.	-5.
25.	-4.	30.	19.	20.	52.	-5.	-29.	-4.	-30.
-18.	-26.	-17.	-5.	-14.	-1.	17.	9.	17.	0.
-19.	11.	3.	6.	-10.	6.	2.	10.	8.	-3.
7.	10.	-3.	9.	-5.	7.	9.	-3.	8.	0.

STANDARD SOURCE SPECTRA

CO60 SOURCE

0.	3.	6.	490.	5745.	7489.	7814.	8276.	8565.	8322.
8047.	8019.	8336.	8325.	9473.	8592.	8705.	9035.	9426.	9984.
10954.	11836.	12387.	12062.	11626.	10952.	10750.	10604.	10453.	10392.
10246.	9917.	9681.	9567.	9392.	9324.	9150.	9083.	9115.	8993.
8968.	8894.	8901.	8850.	8770.	8671.	8580.	8478.	8438.	8464.
8484.	8465.	8477.	8314.	8227.	8208.	8178.	8150.	8238.	8183.
8142.	7983.	7971.	8079.	8152.	8198.	8253.	8304.	8312.	8377.
8363.	8398.	8270.	8330.	8471.	8679.	8722.	8855.	8758.	8935.
9144.	9412.	9579.	9584.	9616.	9715.	9757.	9911.	9815.	9728.
9393.	9015.	8632.	8149.	7689.	7192.	6903.	6570.	6593.	6455.
6417.	6459.	6350.	6383.	6353.	6217.	6080.	6056.	6547.	7780.
10289.	14441.	19771.	25837.	31514.	32152.	30006.	24955.	18252.	12005.
7394.	4681.	3592.	3876.	5379.	8048.	11942.	16773.	21429.	25125.
26397.	24517.	20311.	14843.	9719.	5619.	2996.	1340.	554.	298.
184.	126.	97.	106.	107.	89.	86.	101.	99.	92.
100.	96.	101.	104.	104.	103.	102.	100.	96.	86.
97.	81.	75.	89.	83.	77.	86.	73.	67.	59.
73.	71.	66.	72.	75.	68.	60.	67.	72.	64.
76.	65.	59.	53.	66.	63.	63.	69.	58.	57.
62.	66.	41.	46.	48.	57.	50.	56.	66.	56.

RESULTS OF PHOTOPEAK FITTING

INDEX	STANDARD SOURCE	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
1	HG203	0.1293640E 03	0.5359105E 01	0.3901159E 06
2	SR85	0.1299154E 03	0.4466377E 01	0.2855384E 06
3	CS137	0.1293185E 03	0.4018573E 01	0.2157564E 06
4	NB95	0.1291098E 03	0.3796879E 01	0.2447787E 06
5	MN54	0.1292172E 03	0.3673845E 01	0.1693172E 06
6	ZN65	0.1294717E 03	0.3192249E 01	0.1531872E 06
7	CO60	0.1303343E 03	0.2804309E 01	0.1764731E 06
7	CO61	0.1134571E 03	0.2711362E 01	0.1925615E 06

NORMALIZED CONTINUUM OF STANDARD SOURCE SPECTRA

CO60 SOURCE

ENERGY= 1.1732 MEV

0.2646846E-01	0.2646846E-01	0.2547525E-01	0.2646874E-01	0.2503630E-01
0.2531807E-01	0.2512569E-01	0.2463023E-01	0.2434987E-01	0.2528646E-01
0.2717772E-01	0.2806072E-01	0.2855738E-01	0.3077833E-01	0.3115567E-01
0.3316684E-01	0.3587442E-01	0.3823366E-01	0.3713191E-01	0.3380536E-01
0.3354563E-01	0.3283470E-01	0.3208455E-01	0.3227669E-01	0.3342755E-01
0.3190130E-01	0.2949777E-01	0.3050300E-01	0.2772917E-01	0.2766851E-01
0.2787067E-01	0.2761759E-01	0.2722292E-01	0.2732985E-01	0.2759296E-01
0.2741951E-01	0.2655979E-01	0.2631678E-01	0.2572940E-01	0.2568012E-01
0.2590969E-01	0.2605839E-01	0.2616782E-01	0.2573343E-01	0.2528319E-01
0.2522488E-01	0.2526300E-01	0.2482699E-01	0.2423742E-01	0.2401549E-01
0.2478047E-01	0.2443208E-01	0.2482979E-01	0.2474272E-01	0.2450509E-01
0.2474865E-01	0.2520159E-01	0.2544264E-01	0.2549899E-01	0.2531078E-01
0.2507915E-01	0.2519117E-01	0.2547607E-01	0.2558392E-01	0.2572218E-01
0.2718165E-01	0.2894625E-01	0.2894846E-01	0.2844362E-01	0.2914467E-01
0.2962512E-01	0.2887173E-01	0.3033938E-01	0.3050105E-01	0.3124147E-01
0.3302990E-01	0.3357356E-01	0.3327994E-01	0.3156444E-01	0.2820840E-01
0.2482439E-01	0.2102492E-01	0.1684629E-01	0.1350956E-01	0.1125828E-01
0.1002641E-01	0.8908115E-02	0.8158270E-02	0.7496569E-02	0.8136358E-02
0.7983018E-02	0.8376796E-02	0.9859957E-02	0.1090555E-01	0.1092027E-01
0.8007824E-02	0.3478980E-02	0.4815639E-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 SOURCE SPECTRA

CO60 SOURCE

ENERGY= 1.3325 MEV

0.4341295E-01	0.3094905E-01	0.3101853E-01	0.3134372E-01	0.3194692E-01
0.3264210E-01	0.3295892E-01	0.3041316E-01	0.2796849E-01	0.2813519E-01
0.2708278E-01	0.2592969E-01	0.2646159E-01	0.2691513E-01	0.2834446E-01
0.3362410E-01	0.4400415E-01	0.4589734E-01	0.4649885E-01	0.4134053E-01
0.3941939E-01	0.3774905E-01	0.3776591E-01	0.3795122E-01	0.3678231E-01
0.3625144E-01	0.3527296E-01	0.3460725E-01	0.3376563E-01	0.3345424E-01
0.3307286E-01	0.3302681E-01	0.3318183E-01	0.3283355E-01	0.3238788E-01
0.3181666E-01	0.3129408E-01	0.3119950E-01	0.3129676E-01	0.3116640E-01
0.3093897E-01	0.3084192E-01	0.3031213E-01	0.3081194E-01	0.3072731E-01
0.3023370E-01	0.2963825E-01	0.2947183E-01	0.2969426E-01	0.2981533E-01
0.3029455E-01	0.3041202E-01	0.3069021E-01	0.3076787E-01	0.3073591E-01
0.3075473E-01	0.3077631E-01	0.3062458E-01	0.3050767E-01	0.3074014E-01
0.3131723E-01	0.3249104E-01	0.3376201E-01	0.3418598E-01	0.3404662E-01
0.3363177E-01	0.3299969E-01	0.3211054E-01	0.3122166E-01	0.3070489E-01
0.3058577E-01	0.3093324E-01	0.3167510E-01	0.3280288E-01	0.3411749E-01
0.3541201E-01	0.3650334E-01	0.3723139E-01	0.3755942E-01	0.3748723E-01
0.3566836E-01	0.3210821E-01	0.2939801E-01	0.2627845E-01	0.2104733E-01
0.1768945E-01	0.1368147E-01	0.1119411E-01	0.9771071E-02	0.8544035E-02
0.7739123E-02	0.7466565E-02	0.7829677E-02	0.7647868E-02	0.8917959E-02
0.1752238E-01	0.1566444E-01	0.1152772E-01	0.8399166E-02	0.2811144E-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

HG203 SOURCE

ENERGY= 0.2790 MEV

0.3187532E-02	0.3187532E-02	0.3187532E-02	0.3187532E-02	0.3187532E-02
0.3187532E-02	0.3184200E-02	0.3288179E-02	0.3526246E-02	0.3490566E-02
0.3617539E-02	0.3466146E-02	0.3437530E-02	0.3448964E-02	0.3440871E-02
0.3433256E-02	0.3425153E-02	0.3416597E-02	0.3408982E-02	0.3401353E-02
0.3392323E-02	0.3384768E-02	0.3377093E-02	0.3368510E-02	0.3360434E-02
0.3352819E-02	0.3344769E-02	0.3336160E-02	0.3328545E-02	0.3320919E-02
0.3311886E-02	0.3304270E-02	0.3296655E-02	0.3288065E-02	0.3279996E-02
0.3272391E-02	0.3264653E-02	0.3393376E-02	0.3461643E-02	0.3516635E-02
0.3733350E-02	0.3816306E-02	0.4223704E-02	0.4421636E-02	0.4825767E-02
0.5342465E-02	0.5971413E-02	0.6447189E-02	0.6641217E-02	0.6490875E-02
0.6205522E-02	0.5866211E-02	0.5312603E-02	0.4951231E-02	0.4501086E-02
0.4191447E-02	0.3910828E-02	0.3685640E-02	0.3508935E-02	0.3309116E-02
0.3231318E-02	0.3058784E-02	0.3065442E-02	0.3048509E-02	0.3380393E-02
0.3072749E-02	0.3133685E-02	0.3340623E-02	0.3436827E-02	0.3503629E-02
0.3527709E-02	0.3575736E-02	0.3592726E-02	0.3791534E-02	0.3711868E-02
0.3988657E-02	0.3984392E-02	0.4095737E-02	0.4142653E-02	0.4181981E-02
0.4153151E-02	0.4235953E-02	0.4524719E-02	0.4619278E-02	0.4801210E-02
0.4640743E-02	0.4734660E-02	0.4335018E-02	0.4071482E-02	0.3692162E-02
0.2941125E-02	0.2464349E-02	0.2133672E-02	0.2546392E-02	0.2432301E-02
0.2713073E-02	0.2489286E-02	0.1379860E-02	0.9845577E-03	0.1097073E-03
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

NORMALIZED CONTINUUM OF STANDARD SPECTRA

SR85 SOURCE

ENERGY= 0.5150 MEV

0.8613080E-02	0.8613080E-02	0.8613080E-02	0.8613080E-02	0.8613080E-02
0.8613080E-02	0.8608215E-02	0.8528713E-02	0.8630630E-02	0.8471753E-02
0.8838497E-02	0.8912381E-02	0.9170048E-02	0.9616729E-02	0.9803066E-02
0.9489968E-02	0.9279750E-02	0.9340199E-02	0.9342127E-02	0.9149693E-02
0.9468738E-02	0.9437423E-02	0.9501018E-02	0.9795993E-02	0.9782858E-02
0.1013109E-01	0.1009906E-01	0.1043982E-01	0.1050827E-01	0.1069311E-01
0.1141827E-01	0.1256599E-01	0.1356578E-01	0.1381770E-01	0.1443259E-01
0.1395316E-01	0.1346521E-01	0.1327272E-01	0.1278428E-01	0.1274193E-01
0.1241328E-01	0.1235266E-01	0.1209937E-01	0.1195763E-01	0.1149287E-01
0.1185523E-01	0.1175744E-01	0.1160683E-01	0.1148387E-01	0.1120498E-01
0.1149967E-01	0.1208745E-01	0.1228074E-01	0.1241053E-01	0.1253285E-01
0.1287364E-01	0.1270933E-01	0.1290813E-01	0.1282199E-01	0.1266139E-01
0.1256735E-01	0.1185435E-01	0.1151481E-01	0.1050323E-01	0.9460464E-02
0.8596171E-02	0.7492784E-02	0.6499633E-02	0.5967569E-02	0.5637776E-02
0.5502831E-02	0.5082760E-02	0.4857678E-02	0.4840765E-02	0.4744411E-02
0.4614311E-02	0.4331765E-02	0.4222203E-02	0.4219573E-02	0.4161753E-02
0.4198148E-02	0.3941504E-02	0.4021488E-02	0.4329156E-02	0.4414076E-02
0.4438423E-02	0.4797235E-02	0.5238943E-02	0.5440801E-02	0.5418684E-02
0.5867304E-02	0.5450126E-02	0.5084801E-02	0.4318312E-02	0.3620144E-02
0.1118185E-02	0.2926134E-03	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

NORMALIZED CONTINUUM OF STANDARD SPECTRA

CS137 SOURCE

ENERGY= 0.6615 MEV

0.1348738E-01	0.1348738E-01	0.1348738E-01	0.1348738E-01	0.1348737E-01
0.1348738E-01	0.1343843E-01	0.1277048E-01	0.1260379E-01	0.1319968E-01
0.1404867E-01	0.1375093E-01	0.1328469E-01	0.1288534E-01	0.1320856E-01
0.1309776E-01	0.1345938E-01	0.1373693E-01	0.1405391E-01	0.1351476E-01
0.1387120E-01	0.1434949E-01	0.1445173E-01	0.1506506E-01	0.1538948E-01
0.1636503E-01	0.1802287E-01	0.1932214E-01	0.1958003E-01	0.2014377E-01
0.1882005E-01	0.1862280E-01	0.1796659E-01	0.1786355E-01	0.1756370E-01
0.1752998E-01	0.1697312E-01	0.1709351E-01	0.1665710E-01	0.1631015E-01
0.1616671E-01	0.1636372E-01	0.1610909E-01	0.1626652E-01	0.1644033E-01
0.1599937E-01	0.1637444E-01	0.1598057E-01	0.1618997E-01	0.1654923E-01
0.1609733E-01	0.1637650E-01	0.1610442E-01	0.1638399E-01	0.1658661E-01
0.1659148E-01	0.1651491E-01	0.1636949E-01	0.1624810E-01	0.1703753E-01
0.1676790E-01	0.1675555E-01	0.1668051E-01	0.1713950E-01	0.1717465E-01
0.1694055E-01	0.1650336E-01	0.1535910E-01	0.1450016E-01	0.1310513E-01
0.1117158E-01	0.9446379E-02	0.8364104E-02	0.7385693E-02	0.6664019E-02
0.6189469E-02	0.5548727E-02	0.5358253E-02	0.4867494E-02	0.4710667E-02
0.4490603E-02	0.4492926E-02	0.4481297E-02	0.4396524E-02	0.4264932E-02
0.4613333E-02	0.4944768E-02	0.5413757E-02	0.6103054E-02	0.6305855E-02
0.6681945E-02	0.6975426E-02	0.6940488E-02	0.5243298E-02	0.3612872E-02
0.1719738E-02	0.1551420E-03	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

NORMALIZED CONTINUUM OF STANDARD SPECTRA

NB95 SOURCE

ENERGY= 0.7649 MEV

0.1415910E-01	0.1415910E-01	0.1415910E-01	0.1415910E-01	0.1415910E-01
0.1415910E-01	0.1414358E-01	0.1397611E-01	0.1453245E-01	0.1560773E-01
0.1539663E-01	0.1471295E-01	0.1473884E-01	0.1486048E-01	0.1537790E-01
0.1529199E-01	0.1560197E-01	0.1558772E-01	0.1627072E-01	0.1679443E-01
0.1685172E-01	0.1775734E-01	0.1809158E-01	0.2112529E-01	0.2163953E-01
0.2271691E-01	0.2289753E-01	0.2218954E-01	0.2108098E-01	0.2072535E-01
0.2044604E-01	0.2024311E-01	0.1992327E-01	0.1963515E-01	0.2005988E-01
0.1976925E-01	0.1978377E-01	0.1994222E-01	0.1996910E-01	0.1887265E-01
0.1900685E-01	0.1902123E-01	0.1895773E-01	0.1869390E-01	0.1866879E-01
0.1860431E-01	0.1830544E-01	0.1877378E-01	0.1831087E-01	0.1841314E-01
0.1838971E-01	0.1815475E-01	0.1869570E-01	0.1915274E-01	0.1854251E-01
0.1858554E-01	0.1905366E-01	0.1883454E-01	0.1866694E-01	0.1841001E-01
0.1893909E-01	0.1892444E-01	0.1919534E-01	0.1928506E-01	0.1949552E-01
0.1964691E-01	0.1907231E-01	0.1884709E-01	0.1978368E-01	0.1940193E-01
0.1738542E-01	0.1636132E-01	0.1420084E-01	0.1218775E-01	0.1031225E-01
0.8749984E-02	0.8120578E-02	0.7887164E-02	0.6496233E-02	0.6015935E-02
0.5541414E-02	0.5049977E-02	0.4786350E-02	0.4633125E-02	0.4637495E-02
0.4563745E-02	0.4718892E-02	0.5288213E-02	0.5706612E-02	0.5158017E-02
0.6429482E-02	0.7381929E-02	0.7223569E-02	0.6926479E-02	0.3655514E-02
0.1226191E-02	0.8027162E-05	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

MN54 SOURCE

ENERGY= 0.8359 MEV

0.1546274E-01	0.1546274E-01	0.1546274E-01	0.1546274E-01	0.1546273E-01
0.1546274E-01	0.1549861E-01	0.1611689E-01	0.1674518E-01	0.1658086E-01
0.1632813E-01	0.1606495E-01	0.1626572E-01	0.1686817E-01	0.1583760E-01
0.1652733E-01	0.1718810E-01	0.1756687E-01	0.1740975E-01	0.1808926E-01
0.1875734E-01	0.2132693E-01	0.2261020E-01	0.2418567E-01	0.2447919E-01
0.2413413E-01	0.2338626E-01	0.2312220E-01	0.2241294E-01	0.2170415E-01
0.2179635E-01	0.2088386E-01	0.2071525E-01	0.2034710E-01	0.1983532E-01
0.1993791E-01	0.2061477E-01	0.1980856E-01	0.2005233E-01	0.1999616E-01
0.1950256E-01	0.1943495E-01	0.1981984E-01	0.1946681E-01	0.1989577E-01
0.1998572E-01	0.1988598E-01	0.2002691E-01	0.1928532E-01	0.1962587E-01
0.1919847E-01	0.1957549E-01	0.1925175E-01	0.1993940E-01	0.1942864E-01
0.1924012E-01	0.1960856E-01	0.1946146E-01	0.1894521E-01	0.1962217E-01
0.2033175E-01	0.2003773E-01	0.2002167E-01	0.2018455E-01	0.2099034E-01
0.2134421E-01	0.2125172E-01	0.2149119E-01	0.2193122E-01	0.2160615E-01
0.2050758E-01	0.1973923E-01	0.1880374E-01	0.1727609E-01	0.1429547E-01
0.1223116E-01	0.9852346E-02	0.8424409E-02	0.7544734E-02	0.6688692E-02
0.6016973E-02	0.5461734E-02	0.5064208E-02	0.4511420E-02	0.4610132E-02
0.4606742E-02	0.4550177E-02	0.5261857E-02	0.5741943E-02	0.6178394E-02
0.6934442E-02	0.7381525E-02	0.7173019E-02	0.6324216E-02	0.4283320E-02
0.1376360E-02	0.1186633E-03	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0

NORMALIZED CONTINUUM OF STANDARD SPECTRA

ZN65 SOURCE

ENERGY= 1.1141 MEV

0.2270554E-01	0.2270554E-01	0.2270554E-01	0.2271953E-01	0.2269836E-01
0.2260320E-01	0.2245085E-01	0.2207366E-01	0.2181071E-01	0.2161495E-01
0.2234658E-01	0.2347405E-01	0.2428272E-01	0.2368174E-01	0.2556057E-01
0.2670835E-01	0.2686243E-01	0.2933428E-01	0.3176779E-01	0.3333212E-01
0.3258386E-01	0.3166966E-01	0.3010643E-01	0.2942329E-01	0.2847259E-01
0.2770959E-01	0.2783382E-01	0.2779615E-01	0.2705504E-01	0.2604914E-01
0.2639725E-01	0.2663109E-01	0.2592496E-01	0.2528101E-01	0.2584583E-01
0.2484092E-01	0.2554516E-01	0.2445731E-01	0.2448476E-01	0.2434481E-01
0.2431791E-01	0.2435781E-01	0.2423321E-01	0.2498269E-01	0.2448367E-01
0.2420341E-01	0.2424288E-01	0.2485366E-01	0.2406824E-01	0.2253740E-01
0.2341928E-01	0.2334866E-01	0.2351841E-01	0.2399490E-01	0.2410341E-01
0.2269716E-01	0.2358418E-01	0.2441110E-01	0.2428246E-01	0.2389934E-01
0.2428243E-01	0.2434974E-01	0.2383744E-01	0.2510896E-01	0.2534937E-01
0.2538831E-01	0.2609337E-01	0.2659136E-01	0.2655491E-01	0.2639098E-01
0.2804121E-01	0.2784570E-01	0.2835280E-01	0.2973722E-01	0.2950136E-01
0.2887340E-01	0.2379869E-01	0.2586716E-01	0.2291945E-01	0.1944315E-01
0.1613303E-01	0.1275336E-01	0.1070836E-01	0.8990251E-02	0.8153722E-02
0.7246811E-02	0.6763166E-02	0.6262356E-02	0.6785888E-02	0.7186878E-02
0.7212043E-02	0.8427655E-02	0.9583656E-02	0.9327102E-02	0.8329289E-02
0.5082455E-02	0.1722422E-02	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

SYSTEM RESPONSE FUNCTION MATRIX

0.1000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7850E-01	0.9214E 00	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
0.8247E-01	0.1086E 00	0.4190E 00	0.2967E-06	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
0.9137E-01	0.1294E 00	0.8230E-01	0.6969E 00	0.30396-04	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
0.9340E-01	0.1233E 00	0.1249E 00	0.5471E-01	0.6033E 00	0.3223E-33	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
0.9418E-01	0.1156E 00	0.1217E 00	0.1431E 00	0.4401E-01	0.5230E 00	0.1234E-02	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
0.9015E-01	0.1059E 00	0.1149E 00	0.1110E-00	0.8372E-01	0.3772E-01	0.4537E-00	0.2712E-02	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7772E-01	0.9404E-01	0.1090E 00	0.1300E 00	0.1020E 00	0.7023E-01	0.3430E-01	0.4074E 00	0.5052E-02	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7217E-01	0.8471E-01	0.9997E-01	0.9013E-01	0.8809E-01	0.9303E-01	0.5723E-01	0.3270E-01	0.3725E 00	0.8344E-02
0.4642E-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6768E-01	0.8091E-01	0.9247E-01	0.8148E-01	0.7902E-01	0.7801E-01	0.8788E-01	0.4774E-01	0.3393E-01	0.3404E 00
0.1183E-01	0.2631E-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6422E-01	0.7416E-01	0.8721E-01	0.7623E-01	0.7274E-01	0.6992E-01	0.7265E-01	0.8257E-01	0.4267E-01	0.3523E-01
0.3981E 00	0.1411E-01	0.3579E-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6280E-01	0.6723E-01	0.8339E-01	0.7254E-01	0.6753E-01	0.6534E-01	0.6529E-01	0.6934E-01	0.7692E-01	0.4059E-01
0.3576E-01	0.2769E 00	0.1631E-01	0.1810E-06	0.0	0.0	0.0	0.0	0.0	0.0
0.6233E-01	0.5952E-01	0.8032E-01	0.6956E-01	0.6396E-01	0.6151E-01	0.6023E-01	0.6253E-01	0.6527E-01	0.7157E-01
0.4070E-01	0.3634E-01	0.2478E 00	0.1823E-01	0.7076E-06	0.0	0.0	0.0	0.0	0.0
0.5997E-01	0.5136E-01	0.7805E-01	0.6758E-01	0.6137E-01	0.5839E-01	0.5642E-01	0.5787E-01	0.6219E-01	0.5886E-01
0.6779E-01	0.4137E-01	0.3579E-01	0.2244E 00	0.1864E-01	0.2163E-05	0.0	0.0	0.0	0.0
0.5884E-01	0.4388E-01	0.7480E-01	0.6511E-01	0.5925E-01	0.5576E-01	0.5330E-01	0.5477E-01	0.5600E-01	0.6019E-01
0.5299E-01	0.6444E-01	0.4225E-01	0.3458E-01	0.2036E 00	0.1914E-01	0.5179E-05	0.0	0.0	0.0
0.5751E-01	0.3732E-01	0.7022E-01	0.6501E-01	0.5711E-01	0.5436E-01	0.5208E-01	0.5217E-01	0.5365E-01	0.5760E-01
0.5334E-01	0.4791E-01	0.6241E-01	0.4247E-01	0.3425E-01	0.1843E 00	0.2011E-01	0.9323E-05	0.0	0.0
0.5596E-01	0.3329E-01	0.6310E-01	0.6439E-01	0.5614E-01	0.5247E-01	0.5020E-01	0.4710E-01	0.5113E-01	0.5135E-01
0.5958E-01	0.4613E-01	0.4365E-01	0.6190E-01	0.4972E-01	0.3445E-01	0.1680E 00	0.2035E-01	0.2164E-04	0.6471E-10
0.5345E-01	0.3167E-01	0.5242E-01	0.6405E-01	0.6511E-01	0.5148E-01	0.4854E-01	0.4698E-01	0.4582E-01	0.5108E-01
0.5212E-01	0.5567E-01	0.3984E-01	0.4153E-01	0.6359E-01	0.3665E-01	0.3549E-01	0.1544E 00	0.2016E-01	0.2846E-04
0.5913E-01	0.3291E-01	0.3627E-01	0.6608E-01	0.5474E-01	0.5062E-01	0.4768E-01	0.4642E-01	0.4260E-01	0.4861E-01
0.4873E-01	0.5729E-01	0.4561E-01	0.3437E-01	0.4116E-01	0.6711E-01	0.2913E-01	0.3809E-01	0.1427E 00	0.1968E-01
0.4611E-01	0.3593E-01	0.1726E-01	0.7117E-01	0.5422E-01	0.4924E-01	0.4729E-01	0.4532E-01	0.4339E-01	0.4289E-01
0.4954E-01	0.4746E-01	0.5319E-01	0.3765E-01	0.2744E-01	0.4331E-01	0.6853E-01	0.2074E-01	0.4208E-01	0.1325E 00

(F)

REPONSE MATRIX ENERGY INTERVAL MIDPOINTS IN MEV

0.0500	0.1500	0.2500	0.3500	0.4500	0.5500	0.6500	0.7500	0.8500	0.9500
1.0500	1.1500	1.2500	1.3500	1.4500	1.5500	1.6500	1.7500	1.8500	1.9500

PULSE-HEIGHT IN CHANNELS (MIDPOINTS)

0.54	1.54	2.53	3.52	4.51	5.51	6.51	7.51	8.51	9.51
10.51	11.50	12.50	13.50	14.50	15.50	16.50	17.50	18.50	19.50

RESPONSE MATRIX PHOTOFRACTIONS

0.9541	0.8567	0.7593	0.6669	0.5846	0.5094	0.4503	0.4114	0.3846	0.3599
0.3329	0.3046	0.2765	0.2504	0.2260	0.2044	0.1849	0.1679	0.1532	0.1405

(G)

GAMMA SOURCE	SOURCE STRENGTH (CURIES)	REFERENCE ENERGY (MEV)	SOURCE DIAMETER (CM.)	SOURCE HALF-LIFE (MINUTES)	NUMBER OF PHA RUNS THIS SET	NUMBER OF CHANNELS PER SPECTRUM	HALF-LIFE MULTIPLIER
PU02	1.0000	1.0000	1.0000	3.1053E 08	1	200	0.5260E 06

M222	M66	MZ	MNX	MPX	MSM
7	0	20	0	0	1

SOURCE CRYSTAL DISTANCE (CM.)	CRYSTAL AT SOURCE ANGLE (DEGREES) POLAR	AZIMUTH	COUNTING DURATION (MINUTES)	REFERENCE TIME (DAYS)	PHA COARSE GAIN	MONITOR PULSE HEIGHT (CHANNELS)	MONITOR ENERGY (MEV)	SPECTRA ZERO SHIFT (CHANNELS)	BACKGROUND SIGNAL	BACKGROUND MULTIPLIER
100.000	0.0	0.0	1.000	1.00	1.00	127.0000	1.2700	0.0	0.0	0.0

(H)

ITERATING OUTPUT ON ITERATION LOOPS NUMBERED BELOW

1	2	3	4	5
7	10	15	20	30
0	0	0	0	0
0	0	0		

(I)

CARD SET 12

2	115	0	1.2700	0	10	144	1.3600	2	46	0	0.5000
0	7	65	0.5750	2	69	0	0.7600	0	12	96	0.8760
1	143	167	1.5400								

(J)

SPECTRUM NUMBER 1 FOR PUO2 SOURCE

(AFTER BACKGROUND SUBTRACTION)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
100513.	124001.	81387.	43872.	33958.	31632.	26716.	22787.	20076.	18482.
16846.	16163.	14977.	14320.	13427.	12768.	12231.	11751.	11418.	11230.
10481.	9918.	9722.	9510.	9269.	8743.	8626.	8950.	9931.	11764.
13968.	15364.	14232.	11787.	9944.	10473.	13311.	17066.	19334.	18016.
14363.	10043.	7109.	5746.	5198.	5078.	4830.	4574.	4404.	4342.
4327.	4723.	4915.	5502.	6167.	6482.	6663.	6361.	5726.	4988.
4457.	4222.	4061.	4420.	4869.	5758.	6432.	7025.	7106.	6655.
5809.	5046.	4196.	3705.	3371.	3347.	3318.	3407.	3394.	3339.
3142.	3124.	2915.	2730.	2549.	2541.	2162.	2095.	1958.	1937.
1744.	1735.	1676.	1576.	1508.	1589.	1638.	1838.	2116.	2575.
3324.	4313.	5555.	6977.	8397.	8942.	9195.	8633.	7318.	5924.
4551.	3475.	2854.	2476.	2244.	2182.	1960.	1634.	1485.	1391.
1144.	1050.	1001.	906.	930.	915.	915.	886.	967.	1051.
1124.	1160.	1148.	1020.	965.	886.	797.	665.	597.	537.
433.	425.	375.	345.	333.	334.	333.	306.	316.	327.
354.	308.	334.	325.	322.	325.	345.	352.	344.	299.
293.	277.	282.	253.	221.	221.	243.	206.	190.	207.
168.	208.	179.	166.	224.	198.	217.	235.	230.	311.

(K)

UNKNOWN SPECTRUM BEFORE PEAK FITTING

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	-7216.	-7216.	38183.
94310.	98613.	73799.	53809.	38892.	30623.	26602.	23218.	20482.	18509.
17097.	15987.	15194.	14213.	13457.	12793.	12240.	11853.	11519.	11320.
10447.	10055.	9764.	9439.	9134.	8809.	8700.	9193.	10223.	12145.
14054.	14318.	13682.	11813.	10420.	11547.	14437.	16693.	18426.	17814.
13778.	11478.	7588.	5851.	5466.	5022.	4804.	4590.	4435.	4378.
4454.	4663.	5011.	5546.	6104.	6455.	6549.	6215.	5637.	5065.
4536.	4241.	4192.	4487.	5024.	5746.	6454.	6867.	6963.	6819.
5762.	5003.	4264.	3765.	3470.	3363.	3364.	3360.	3348.	3289.
3255.	3068.	2903.	2754.	2606.	2412.	2214.	2085.	1994.	1893.
1796.	1709.	1652.	1591.	1552.	1564.	1651.	1825.	2137.	2657.
3389.	4432.	5655.	7014.	8229.	8888.	8972.	8326.	7215.	5897.
4596.	3623.	2949.	2531.	2280.	2074.	1891.	1680.	1487.	1370.
1161.	1156.	982.	945.	930.	939.	898.	926.	980.	1154.
1121.	1134.	1105.	1047.	968.	974.	776.	685.	603.	526.
459.	400.	375.	353.	339.	329.	322.	319.	327.	326.
329.	331.	330.	326.	323.	333.	346.	341.	324.	317.
292.	283.	274.	254.	231.	216.	208.	205.	204.	199.
193.	181.	173.	194.	203.	211.	219.	241.	278.	

(L)

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.12700[illegible]E 01	0.99271E 00	0.98589E 00	0.95513E 00	0.71771E 00	0.67090E 00

PHOTON NUMBER = 0.3554195E 06
PHOTOFRACTION = 0.2709969E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
115	144	0.12700[illegible]E 01	0.12607[illegible]E 03	0.3371937E 01	0.5459844E 05

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.13[illegible]E 01	0.99297E 00	0.98639E 00	0.95671E 00	0.70503E 00	0.66065E 00

PHOTON NUMBER = 0.3619769E 05
PHOTOFRACTION = 0.2477741E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
115	144	0.13600[illegible]E 01	0.13525[illegible]E 03	0.2853853E 01	0.5925289E 04

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.5010006E 00	0.9888 4E 00	0.9784 3E 00	0.9320 7E 00	0.8787 0E 00	0.7924 5E 00

PHOTON NUMBER = 0.7474144E 06
PHOTOFRACTION = 0.5475301E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL-TO-CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
46	66	0.5000000E 00	0.5142572E 02	0.1918113E 01	0.3329754E 05

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.5750 5E 00	0.9894 7E 00	0.9796 4E 00	0.9357 6E 00	0.8566 3E 00	0.7760 0E 00

PHOTON NUMBER = 0.1643307E 06
PHOTOFRACTION = 0.4020494E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL-TO-CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
46	66	0.5750002E 00	0.5862791E 02	0.2184413E 01	0.6274670E 05

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.76100E 00	0.99070E 00	0.99196E 00	0.94309E 00	0.80624E 00	0.73970E 00

PHOTON NUMBER = 0.53118A2E 05
PHOTOFRACTION = 0.4080A24E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
69	96	0.76000000E 00	0.7622591E 02	0.25053235 01	0.16032705 05

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.87500E 00	0.99129E 00	0.98308E 00	0.94674E 00	0.78161E 00	0.72112E 00

PHOTON NUMBER = 0.8638912E 05
PHOTOFRACTION = 0.3784605E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
69	96	0.87500000E 00	0.8821091E 02	0.2543516E 01	0.2357678E 05

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.154[illegible]E 01	0.[illegible]342E 00	0.[illegible]725E 00	0.[illegible]67E 00	0.683128E 00	0.642816E 00

PHOTON NUMBER = 0.3776532E 05
PHOTOFRACTION = 0.2063627E 00

DISCRETE PHOTOPEAK FITTING DATA

LOCATION CHANNEL TO CHANNEL		ENERGY (MEV)	PULSE-HEIGHT (CHANNELS)	STANDARD DEVIATION (CHANNELS)	AREA (COUNTS/TIME)
143	167	0.1540[illegible]E 01	0.1824641E 03	0.3287717E 01	0.3683153E 04

GAIN PARAMETERS AFTER CALL SINGLE IN MAIN

0.0 193 200.0001 20.0000 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	0.3279355 05
0.867301E 05	0.929425E 05	0.680674E 05	0.481085E 05	0.332563E 05	0.251173E 05	0.211837E 05	0.178494E 05	0.151764E 05	0.132435E 05	
0.118218E 05	0.107606E 05	0.992093E 04	0.924902E 04	0.863018E 04	0.806643E 04	0.762730E 04	0.732439E 04	0.710338E 04	0.678067E 04	
0.643229E 04	0.625180E 04	0.615820E 04	0.589296E 04	0.561834E 04	0.526148E 04	0.497221E 04	0.481681E 04	0.479254E 04	0.478109E 04	
0.473046E 04	0.414605E 04	0.412800E 04	0.407157E 04	0.360746E 04	0.395829E 04	0.405895E 04	0.390607E 04	0.405958E 04	0.361266E 04	
0.337623E 04	0.346939E 04	0.311383E 04	0.295737E 04	0.283680E 04	0.272786E 04	0.260395E 04	0.248017E 04	0.232340E 04	0.226867E 04	
0.226278E 04	0.226935E 04	0.226527E 04	0.223711E 04	0.226968E 04	0.217980E 04	0.216763E 04	0.208694E 04	0.201734E 04	0.197847E 04	
0.189358E 04	0.181372E 04	0.174588E 04	0.178153E 04	0.181895E 04	0.183026E 04	0.180312E 04	0.168139E 04	0.165001E 04	0.159166E 04	
0.155650E 04	0.134274E 04	0.145613E 04	0.133954E 04	0.132249E 04	0.133948E 04	0.133748E 04	0.133591E 04	0.132423E 04	0.131257E 04	
0.129492E 04	0.124755E 04	0.119266E 04	0.117795E 04	0.117411E 04	0.111736E 04	0.104728E 04	0.103997E 04	0.106196E 04	0.105781E 04	
0.103747E 04	0.101912E 04	0.100172E 04	0.965867E 03	0.934905E 03	0.923278E 03	0.920271E 03	0.914670E 03	0.880360E 03	0.930087E 03	
0.736523E 03	0.731684E 03	0.669448E 03	0.759703E 03	0.944509E 03	0.110593E 04	0.133373E 04	0.116076E 04	0.108766E 04	0.104437E 04	
0.971052E 03	0.101394E 04	0.104540E 04	0.111552E 04	0.109198E 04	0.105219E 04	0.103733E 04	0.102729E 04	0.102131E 04	0.101382E 04	
0.990973E 03	0.964652E 03	0.935738E 03	0.912064E 03	0.885291E 03	0.821262E 03	0.780938E 03	0.761376E 03	0.678214E 03	0.675331E 03	
0.679759E 03	0.735652E 03	0.657882E 03	0.521501E 03	0.598565E 03	0.682459E 03	0.556371E 03	0.547065E 03	0.519987E 03	0.480636E 03	
0.435902E 03	0.398861E 03	0.370359E 03	0.359996E 03	0.338794E 03	0.328859E 03	0.321982E 03	0.319331E 03	0.320091E 03	0.324218E 03	
0.329219E 03	0.313976E 03	0.311156E 03	0.326003E 03	0.323163E 03	0.333344E 03	0.345844E 03	0.340281E 03	0.324031E 03	0.327496E 03	
0.291906E 03	0.282437E 03	0.273685E 03	0.254300E 03	0.236750E 03	0.215937E 03	0.206787E 03	0.204569E 03	0.204210E 03	0.199281E 03	
0.191781E 03	0.187504E 03	0.173000E 03	0.183694E 03	0.202844E 03	0.211031E 03	0.218631E 03	0.240906E 03	0.278156E 03		

```
 INPUT SPECTRUM GAIN CHANGED TO     19 CHANNELS
 GAIN CHANGE RATIO =  2.0000000E+ 00

 0.0             0.3279345E 05 0.4236717E 06 0.8729356E 05 0.5499171E 05
 0.2014493E 05 0.2319927E 05 0.2177730E 05 0.1760173E 05 0.1388685E 05
 0.1141115E 05 0.9435738E 04 0.9538375E 04 0.1037918E 05 0.8397889E 04
 0.5958785E 04 0.3509482E 04 0.3290312E 04 0.2364875E 04
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(O)

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 NORMALIZED INPUT SPECTRUM
 0.0          0.4180E-01 0.5400E 00 0.1113E 00 0.7039E-01 0.5119E-01 0.3593E-01 0.2776E-01 0.2243E-01 0.1770E-01
 0.1454E-01 0.1203E-01 0.1216E-01 0.1323E-01 0.1059E-01 0.7595E-02 0.4473E-02 0.4194E-02 0.3014E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     1     1
 0.0          0.4180E-01 0.5400E 00 0.1113E 00 0.7039E-01 0.5119E-01 0.3593E-01 0.2776E-01 0.2243E-01 0.1770E-01
 0.1454E-01 0.1203E-01 0.1216E-01 0.1323E-01 0.1059E-01 0.7595E-02 0.4473E-02 0.4194E-02 0.3014E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     1     1
 0.9248E-01 0.1403E 00 0.4782E 00 0.1026E 00 0.5893E-01 0.3836E-01 0.2561E-01 0.1806E-01 0.1381E-01 0.1053E-01
 0.8111E-02 0.6182E-02 0.5104E-02 0.4434E-02 0.3236E-02 0.2112E-02 0.1141E-02 0.8533E-03 0.5148E-03
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     2     2
 0.0          0.1246E-01 0.4698E 00 0.1207E 00 0.8337E-01 0.6832E-01 0.5162E-01 0.4267E-01 0.3645E-01 0.2976E-01
 0.2608E-01 0.2340E-01 0.2896E-01 0.3947E-01 0.3466E-01 0.2731E-01 0.1754E-01 0.2061E-01 0.1765E-01
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     2     2
 0.1030E 00 0.1381E 00 0.5559E 00 0.1276E 00 0.8200E-01 0.5996E-01 0.4305E-01 0.3383E-01 0.2806E-01 0.2317E-01
 0.1935E-01 0.1604E-01 0.1453E-01 0.1439E-01 0.1148E-01 0.8239E-02 0.4741E-02 0.4211E-02 0.2935E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     3     3
 0.0          0.3772E-02 0.5924E 00 0.1053E 00 0.7126E-01 0.5833E-01 0.4368E-01 0.3494E-01 0.2914E-01 0.2274E-01
 0.1960E-01 0.1755E-01 0.2423E-01 0.3654E-01 0.3198E-01 0.2518E-01 0.1654E-01 0.2053E-01 0.1813E-01
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     3     3
 0.9347E-01 0.1192E 00 0.5325E 00 0.1103E 00 0.6999E-01 0.5127E-01 0.3628E-01 0.2846E-01 0.2354E-01 0.1942E-01
 0.1638E-01 0.1373E-01 0.1289E-01 0.1331E-01 0.1078E-01 0.7789E-02 0.4543E-02 0.4196E-02 0.3001E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     4     4
 0.0          0.1323E-02 0.6027E 00 0.1062E 00 0.7147E-01 0.5847E-01 0.4267E-01 0.3408E-01 0.2777E-01 0.2072E-01
 0.1741E-01 0.1537E-01 0.2286E-01 0.3630E-01 0.3142E-01 0.2455E-01 0.1629E-01 0.2051E-01 0.1821E-01
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     4     4
 0.9328E-01 0.1171E 00 0.5383E 00 0.1100E 00 0.6913E-01 0.5031E-01 0.3533E-01 0.2746E-01 0.2252E-01 0.1837E-01
 0.1545E-01 0.1297E-01 0.1243E-01 0.1318E-01 0.1063E-01 0.7659E-02 0.4489E-02 0.4192E-02 0.3012E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     5     5
 0.0          0.4726E-03 0.6026E 00 0.1074E 00 0.7247E-01 0.5953E-01 0.4338E-01 0.3443E-01 0.2767E-01 0.1997E-01
 0.1630E-01 0.1426E-01 0.2235E-01 0.3644E-01 0.3130E-01 0.2435E-01 0.1623E-01 0.2052E-01 0.1822E-01
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     5     5
 0.9353E-01 0.1168E 00 0.5400E 00 0.1109E 00 0.6961E-01 0.5064E-01 0.3541E-01 0.2737E-01 0.2229E-01 0.1798E-01
 0.1506E-01 0.1261E-01 0.1227E-01 0.1318E-01 0.1060E-01 0.7618E-02 0.4476E-02 0.4193E-02 0.3014E-02
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PHI(I))     7     7
 0.0          0.6049E-04 0.6024E 00 0.1078E 00 0.7313E-01 0.6045E-01 0.4441E-01 0.3531E-01 0.2807E-01 0.1953E-01
 0.1550E-01 0.1317E-01 0.2264E-01 0.3664E-01 0.3126E-01 0.2425E-01 0.1622E-01 0.2053E-01 0.1822E-01
 INTERMEDIATE ITERATING OUTPUT (IT, MN, AND PP(I))     7     7
 0.9369E-01 0.1167E 00 0.5401E 00 0.1113E 00 0.7007E-01 0.5109E-01 0.3575E-01 0.2758E-01 0.2229E-01 0.1774E-01
 0.1473E-01 0.1229E-01 0.1218E-01 0.1322E-01 0.1059E-01 0.7598E-02 0.4473E-02 0.4194E-02 0.3014E-02
 ITERATED SPECTRUM
 0.9370E-01 0.1167E 00 0.5401E 00 0.1113E 00 0.7011E-01 0.5116E-01 0.3583E-01 0.2763E-01 0.2232E-01 0.1771E-01
 0.1466E-01 0.1221E-01 0.1217E-01 0.1322E-01 0.1059E-01 0.7596E-02 0.4473E-02 0.4194E-02 0.3014E-02

 IT,SU,TERM
         9 0.7845656E 06 0.1341255E 00
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(P)

EFFICIENCY FACTORS

INDEX	ENERGY (MEV)	AIR ATTENUATION	CLADDING ATTENUATION	LUCITE ATTENUATION	CRYSTAL EFFICIENCY	TOTAL EFFICIENCY
1	0.500000E-01	0.97449E 00	0.92536E 00	0.86291E 00	0.99959E 00	0.77744E 00
2	0.150000E 00	0.98243E 00	0.95527E 00	0.89711E 00	0.99969E 00	0.84282E 00
3	0.250000E 00	0.98547E 00	0.97169E 00	0.91205E 00	0.99727E 00	0.84995E 00
4	0.350000E 00	0.98711E 00	0.97502E 00	0.92190E 00	0.93679E 00	0.83123E 00
5	0.450000E 00	0.98833E 00	0.97741E 00	0.92911E 00	0.89770E 00	0.80573E 00
6	0.550000E 00	0.98926E 00	0.97925E 00	0.93457E 00	0.86285E 00	0.78119E 00
7	0.650000E 00	0.99002E 00	0.98060E 00	0.93908E 00	0.83258E 00	0.75904E 00
8	0.750000E 00	0.99064E 00	0.98184E 00	0.94275E 00	0.80620E 00	0.74109E 00
9	0.850000E 00	0.99116E 00	0.98286E 00	0.94599E 00	0.78697E 00	0.72525E 00
10	0.950000E 00	0.99162E 00	0.98371E 00	0.94863E 00	0.76746E 00	0.71017E 00
11	0.105000E 01	0.99200E 00	0.98446E 00	0.95084E 00	0.75080E 00	0.69716E 00
12	0.115000E 01	0.99234E 00	0.98514E 00	0.95287E 00	0.73548E 00	0.68511E 00
13	0.125000E 01	0.99265E 00	0.98576E 00	0.95477E 00	0.72061E 00	0.67324E 00
14	0.135000E 01	0.99294E 00	0.98634E 00	0.95654E 00	0.70641E 00	0.66177E 00
15	0.145000E 01	0.99321E 00	0.98686E 00	0.95817E 00	0.69330E 00	0.65093E 00
16	0.155000E 01	0.99344E 00	0.98729E 00	0.95960E 00	0.68219E 00	0.64207E 00
17	0.165000E 01	0.99364E 00	0.98765E 00	0.96084E 00	0.67315E 00	0.63476E 00
18	0.175000E 01	0.99383E 00	0.98800E 00	0.96206E 00	0.66447E 00	0.62771E 00
19	0.185000E 01	0.99401E 00	0.98834E 00	0.96320E 00	0.65621E 00	0.62094E 00

DIFFERENTIAL FLUX AT ITERATION NUMBER = 9

0.0	0.20172E 02	0.55051E 06	0.11173E 06	0.11962E 06
0.22245E 06	0.87224E 05	0.85465E 05	0.10047E 06	0.43128E 05
0.17225E 05	0.14755E 05	0.30998E 06	0.14714E 06	0.44562E 05
0.54603E 05	0.20053E 05	0.25661E 05	0.23020E 05	

FITTING DIFFERENCES

0.0 0.29940E 00 0.51983E-01 0.93339E-01 0.81797E-02

0.13316E-02 0.34457E-03 0.12856E-03 0.58829E-04

NUMBER AND ENERGY SPECTRUM AT THE CRYSTAL

INCREMENT	ENERGY (MEV)	NUMBER FLUX (PHOTONS/CM**2-SEC)	ENERGY FLUX (MEV/CM**2-SEC)
1	0.05000	0.0	0.0
2	0.15000	0.7371602E-02	0.1105722E-02
3	0.25000	0.2035860E-03	0.5084695E-02
4	0.35000	0.3717918E 02	0.1301271E 02
5	0.45000	0.4006533E 02	0.1802940E 02
6	0.55000	0.8129715E 02	0.4471341E 02
7	0.65000	0.3107755E 02	0.2072840E 02
8	0.75000	0.3123466E 02	0.2342598E 02
9	0.85001	0.3679332E 02	0.3127431E 02
10	0.95000	0.1578904E 02	0.1497108E 02
11	1.05000	0.6293264E 01	0.6607986E 01
12	1.15000	0.3396131E 01	0.6205543E 01
13	1.25000	0.1132077E 03	0.1416398E 03
14	1.35001	0.5377463E 02	0.7259586E 02
15	1.45000	0.1610333E 02	0.2334981E 02
16	1.55000	0.1995564E 02	0.3093123E 02
17	1.65000	0.7328831E 01	0.1209386E 02
18	1.75001	0.9378304E 01	0.1641272E 02
19	1.85000	0.8412994E 01	0.1556403E 02

INTEGRATED RESULTS AT SOURCE AND CRYSTAL

ENERGY INTEGRATED PHOTON (BREMSS.) VALUES AT THE CRYSTAL

PHOTON NUMBER (PHOTONS/CM**2-SEC) = 0.7175212E 03
PHOTON ENERGY (MEV/CM**2-SEC) = 0.5423594E 03
PHOTON DOSE (ROENTGENS/HOUR) = 0.1014621E-02

AVERAGE ENERGY (MEV) = 0.75587928 00

PHOTON NUMBER / SOURCE EMITTED BETA NUMBER (PHOTONS/CM**2-SEC)/(BETA/SEC) = 0.1339246E-07
PHOTON ENERGY / SOURCE EMITTED BETA ENERGY ((MEV/CM**2-SEC)/MEV) = 0.5423594E 03
PHOTON ENERGY / SOURCE EMITTED BETA NUMBER (MEV/CM**2-SEC)/(BETA/SEC) = 0.1465936E-07
PHOTON DOSE / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC) = 0.2742219E-13
PHOTON DOSE / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) = 0.3491502E-13

AT THE SOURCE CYLINDER

PHOTON DOSE / SOURCE EMITTED BETA NUMBER (R/HR)/(BETA/SEC) = 0.7565362E-13

PHOTON DOSE / SOURCE EMITTED BETA NUMBER PER SOURCE VOLUME (((R/HR)/(BETA/SEC))/CM**3) = 0.9632901E-13