27

A Research Report for Westinghouse Hanford Company

**In-Situ Determination of
Radionuclide Levels in
Facilities to be Decommissioned
Using the Allowable Residual
Contamination Level Method**

**R. J. Arthur
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July 1989

**Prepared for the U.S. Department of Energy
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SUMMARY

This feasibility study resulted in verification of a direct and two alternate indirect techniques for making in-situ determinations of ^{90}Sr and other radionuclide levels in a Hanford facility to be decommissioned that was evaluated using the Allowable Residual Contamination Level (ARCL) method. The ARCL method is used to determine the extent of decontamination that will be required before a facility can be decommissioned.

A sump in the 1608F Building was chosen for the feasibility study. Hanford decommissioning personnel had previously taken 79 concrete and surface scale samples from the building to be analyzed by radiochemical analysis. The results of the radiochemical analyses compare favorably with the values derived by the in-situ methods presented in this report. Results obtained using a portable spectrometer and thermoluminescent dosimeters (TLDs) were both very close to the radiochemistry results.

Surface ^{90}Sr levels detected on the sump floor were 550 pCi/cm² using the spectrometer system and 780 pCi/cm² using the TLD data. This compares favorably with the levels determined by radiochemical analyses (i.e., 230 to 730 pCi/cm²). Surface ^{90}Sr levels detected on the sump wall ranged between 10 and 80 pCi/cm² using the spectrometer system, compared with a conservative 200 pCi/cm² using the TLD data. The radiochemical results ranged between 19 and 77 pCi/cm² for the four samples taken from the wall at indeterminate locations.

In-situ radionuclide levels determined in this feasibility study agree well with the values determined by radiochemical methods, which were used to calculate a dose rate of 4.3 mrem/yr using the ARCL method. The 4.3 mrem/yr value is below the allowable limit of 25 mrem/yr for decommissioning facilities in place at Hanford. Therefore, since the in-situ methods used in this feasibility study were able to detect levels of radionuclides, especially ^{90}Sr , which resulted in potential dose estimates that were below

the 25 mrem/yr limit, the methods presented in this report may provide time and cost savings to decommissioning operations.

CONTENTS

SUMMARY	iii
INTRODUCTION	1
TECHNICAL APPROACH	3
METHODOLOGY AND INSTRUMENTATION	5
DIRECT ASSAY	5
METHODOLOGY OF SPECTRAL ANALYSIS	6
GAMMA-RAY SPECTROMETER	7
THERMOLUMINESCENT DOSIMETERS	12
WISE AND SIMPLE COMPUTER CODES	14
EXPERIMENTAL	15
ANALYSIS BY SPECTRAL STRIPPING	23
ANALYSIS BY ENERGY WINDOW SUBTRACTION	29
RESULTS AND DISCUSSION	31
DIRECT ASSAY RESULTS	31
CORRELATION RATIO RESULTS	32
THERMOLUMINESCENT DOSIMETER RESULTS	32
REFERENCES	37
APPENDIX A	A.1
APPENDIX B	B.1
APPENDIX C	C.1

FIGURES

1	Schematic of Setup for in situ Gamma-Ray Spectrometer for Measuring Surficial Wall Contamination	8
2	Photograph of Setup for in situ Gamma-Ray Spectrometer for Measuring Surficial Floor Contamination	9
3	Detail of the in situ Gamma-Ray Spectrometer Setup for Measuring Surficial Wall Contamination	11
4	TLD Locations in the 1608F Building and 105F Lunchroom	13
5	Dose Rate Profile (+) as Measured by TLD's	16
6	Cesium-137 Library Standard Reference Spectrum, Partially Smoothed for Clarity	17
7	Cobalt-60 Library Standard Reference Spectrum, Partially Smoothed for Clarity	18
8	Europium-152 and -154 Library Standard Reference Spectrum, Partially Smoothed for Clarity	19
9	Strontium-90 Library Standard Reference Spectrum, Partially Smoothed for Clarity	20
10	Detector Response for a Cesium-137 Point Source	21
11	Relative Response for a Cesium-137 Point Source Convolved with the Area Viewed by the Detector	22
12	Efficiency Curve for Gamma-Ray Analysis of the 1608F Building Sump Floor	24
13	Flowchart of the Steps Used in Analyzing a Field Spectrum	27
14	WISE and SIMPLE Output for Calculated Response from Floor Only (o) and Wall Only (+)	34
15	Measured Dose Rate (+) and WISE and SIMPLE Calculated (Fitted) Values	36

TABLES

1	Concentrations of Radionuclides Found in the 1608F-Building Sump as Determined by In-Situ Counting with a Tungsten-Collimated Intrinsic-Germanium Gamma-Ray Spectrometer	25
2	Radionuclide Concentrations Determined by WISE and SIMPLE Calculations and TLD Dose Rate Data	26
3	Cesium-137 and Strontium-90 Levels as Determined by Direct-Assay and Alternative Methods	33
4	Summary of Energy Window and Count Rate Data for ⁹⁰ Sr Standard Used to Determine the ⁹⁰ Sr Concentration in the 1608F Building 102 Sump	B.1
5	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration on the Floor of the 1608F Building 102 Sump	B.2
6	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 1-Foot Level of the 1608F Building 102 Sump	B.3
7	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 3-Foot Level of the 1608F Building 102 Sump	B.4
8	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 9-Foot Level of the 1608F Building 102 Sump	B.5
9	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 11-Foot Level of the 1608F Building 102 Sump	B.6
10	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 13-Foot Level of the 1608F Building 102 Sump	B.7
11	Summary of Energy Window and Count Rate Data for Determination of ⁹⁰ Sr Concentration at the 18-Foot Level of the 1608F Building 102 Sump	B.8

INTRODUCTION

One of the most expensive parts of decommissioning a facility is determining the inventories of radionuclides present. The usual method involves collecting samples of concrete, paint, piping, sediment, etc., in a statistically valid manner for laboratory-based radiochemical analysis (Denham, Baines and Jaquish 1983; Holoway et al. 1981; West, Umbarger and Dempsey 1978). An in-situ method for determining the inventories of radionuclides may provide quicker turnaround on sample analyses, at a reduced cost, and with the potential for providing more accurate determinations of contamination levels.

Discussions between decommissioning personnel at Hanford and Pacific Northwest Laboratory(a) (PNL) staff were conducted in May of 1987 to determine a suitable facility in which to conduct a feasibility study for measuring surface contamination of radioactive materials. Two facilities were chosen for review. One of these, in the 100B Area, was considered undesirable because of congestion due to piping and ductwork. The other, various rooms in the 1608F Building, offered a variety of scenarios for decontamination and decommissioning (D&D) purposes and was subsequently chosen.

Hanford decommissioning personnel provided drawings, radiological survey data, and some preliminary gamma-ray spectral data. This information was reviewed so that appropriate equipment could be chosen. Decommissioning personnel had previously taken 79 concrete and surface-scale samples to be analyzed by radiochemical methods. The results of these radiochemical analyses provide the values for comparison with those derived from the in-situ feasibility study presented herein.

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TECHNICAL APPROACH

Three different approaches were used during this feasibility study. The first method, the direct-assay technique, uses a high-resolution germanium diode fitted with a tungsten collimator to directly measure the floor and wall surfaces. This procedure measures the radiations, both gamma-ray and bremsstrahlung, emitted by all radionuclides present. Spectral stripping techniques eventually yield the bremsstrahlung component attributed to the $^{90}\text{Sr}/^{90}\text{Y}$ radionuclide pair.

The second approach uses ^{137}Cs levels obtained from the direct-assay results and a correlation ratio for ^{90}Sr levels versus ^{137}Cs levels obtained empirically from previous Hanford decommissioning studies (Beckstrom 1985; Beckstrom 1984; Dorian and Richards 1978) to estimate corresponding ^{90}Sr levels.

The third approach uses a combination of thermoluminescent dosimeters (TLD's) to determine radiation profiles, gamma-ray spectral data to identify contributing gamma-ray emitters to the TLD profile, and the WISE and SIMPLE shielding computer codes (Reece et al. 1989). By matching the measured dose rates and profiles with the calculated values, a source-term level is obtained for the radionuclides.

METHODOLOGY AND INSTRUMENTATION

Three approaches were used during the course of the feasibility study. The main approach involved a direct-assay analysis in which energetic radiation, emitted as a result of radiocontamination, are detected by a high-resolution germanium-diode gamma-ray detector. The level of ^{90}Sr contamination was established by the intensity of bremsstrahlung radiation present in the gamma-ray spectra. Two approaches were used for determining the bremsstrahlung intensities: spectral stripping and energy-window subtraction.

The second approach indirectly established the ^{90}Sr levels by using a correlation ratio for ^{90}Sr versus ^{137}Cs which had been established previously for other building that were decontaminated on the Hanford Nuclear Reservation.

The third approach used thermoluminescent dosimeters to directly measure radiation levels. The direct-assay gamma-ray spectral data was used to identify levels of gamma-ray emitters in the TLD profile. The WISE and SIMPLE computer codes were used to establish the dose rates and to establish the source term.

DIRECT ASSAY

The fundamental approach in this procedure is to use high-resolution germanium-diode spectroscopy to measure photons emitted by radionuclides. The majority of radionuclides of concern in decontamination efforts usually emit some form of photon radiation. The few that don't can usually be inferred from the presence or absence of accompanying radionuclides that do emit photons. The characteristic energy of photons emitted by such activation and fission products can be used to identify and quantify most of the various radioisotopes.

Two of the major radionuclides of interest are ^{90}Sr and its daughter product, ^{90}Y , which emit only beta particles. However, the deceleration of the

energetic beta particles which penetrate into the surficially contaminated matrix material produces a significant intensity of bremsstrahlung radiation, which can be used to quantify the extent of surficial ⁹⁰Sr contamination.

The general approach undertaken with direct assay in this study is to measure the gross contamination level of a floor or wall by observing large surface areas. The average values obtained are then used to determine if additional counting may be required, such as when a given level of contamination is exceeded. Future use of direct assay might identify localized areas of high radioactivity that contribute to an elevated contamination level. One approach might be to place a collimated gamma-ray spectrometer directly adjacent to predetermined grid points. The resulting data would be used by a computer program that maps contours of radiation levels. Because the detector is placed very close to the sample in such a detailed grid scenario, the detection limit is greatly enhanced and shorter counting times are feasible.

Another benefit of the direct assay approach is the potential for determining the degree of contaminant penetration into the matrix. Specifically, the peak-to-Compton ratio is higher for a gamma-ray-emitting radionuclide located on a surface than the corresponding ratio for the same radionuclide located within a given matrix. Conversely, the peak-to-Compton ratio is even lower if the radioactivity has been covered over with uncontaminated material. Appropriate calibrations would then provide quantitative measures of these peak-to-Compton ratios and, hence, identify the depth penetration of a radiocontamination (Brodzinski 1983).

METHODOLOGY OF SPECTRAL ANALYSIS

The steps used to quantitatively determine the level of surficial ⁹⁰Sr contamination using data from the gamma-ray spectrometer are described in detail in previous reports (Brodzinski 1983; Nielson et al. 1976; Brodzinski and Nielson 1980) and are further discussed in this report.

The determination of the ^{90}Sr levels on a contaminated surface is complicated by two phenomena which must be accounted for in any in-situ quantitative analysis: the spectrum generated by the bremsstrahlung radiation due to ^{90}Sr and ^{90}Y beta particles is a continuum of photon energies with no distinguishing monoenergetic photopeaks, and other fission products may be present which also emit energetic beta particles that contribute to the total bremsstrahlung spectrum. The most accurate approach to quantitative determination of ^{90}Sr , one which accounts for both of these difficulties, is to "strip out" each identifiable component of an unknown spectrum using a library of standard spectra. The remaining spectrum represents the component due to $^{90}\text{Sr}/^{90}\text{Y}$ bremsstrahlung. Such an approach, however, necessitates a standard spectrum for each radionuclide likely to be encountered, for each detector to be used, and for each matrix material to be examined.

An equivalent approach to spectral stripping, and one which is also described in this report, is to identify regions of the gamma-ray spectrum which represent continuum data (i.e., regions that are relatively free of major gamma-ray peaks) and which contain identifiable portions of the $^{90}\text{Sr}/^{90}\text{Y}$ bremsstrahlung continuum. The integrated number of counts in these regions is corrected for the contributions from the appropriate library spectra, and the net remaining number of counts corresponds to the level of ^{90}Sr .

GAMMA-RAY SPECTROMETER

The germanium-diode spectrometer used for in-situ analysis is specifically designed to be a portable unit capable of measuring gamma rays and bremsstrahlung radiation. This detector is a large-volume intrinsic-germanium coaxial diode with a full-width-at-half-maximum (FWHM) resolution of 1.82 keV at the 1332-keV line of ^{60}Co and a relative efficiency of 32.8%. It is mounted in a 12-inch-long end cap and attached to a portable liquid-nitrogen cryostat, which has a minimum holding time of 16 hours.

The relative positioning of the down-looking spectrometer is illustrated in Figure 1. The spectrometer itself, as shown in Figure 2, is held within a custom mounting jig which also supports a variety of collimators that can be

FIGURE 1. Schematic of Setup for In-Situ Gamma-Ray Spectrometer for Measuring Surficial Wall Contamination

FIGURE 2. Photograph of Setup for In-Situ Gamma-Ray Spectrometer for Measuring Surficial Floor Contamination

positioned at any point along the end cap. The frame also contains the liquid nitrogen dewar and allows the spectrometer and collimators to be suspended by cabling and a winch.

The collimators used in this study are 14-cm-diameter tungsten right-circular cylinders with a 7.15-cm-diameter hole through the center. Two of the collimators, one of depth 8.20 cm and one of 7.00 cm, have the center hole machined entirely through the collimator, resulting in a toroidal shape. A third collimator, of depth 7.00 cm, has the center hole machined only 3.8 cm into the cylinder, resulting in a well shape. The two toroid-shaped collimators were used to shield the circumference of the diode when the contaminated floor was being counted through the bottom end of the suspended spectrometer. When the contaminated sump walls were counted, the 8.20-cm toroidal and the 7.00-cm well-shaped collimator were used with a 0.635-cm-wide (0.25-in.) slit maintained between them by two lucite spacer disks. The slit was centered at the midpoint of the coaxial diode. Figure 3 shows the spectrometer setup for counting a contaminated wall. One of the two lucite spacers is visible, centered in the slit.

Data were accumulated on a Davidson TM Model 4106A multichannel analyzer (MCA) and transferred to a Tektronix TM 4923 tape unit for subsequent computer reduction and analysis. Recent advances in personal computer technologies, however, would allow data acquisition, storage, and analysis to also be performed in situ. Although power for the system used in this study was derived from electric lines available at the site, power may be supplied in remote locations by a portable gasoline generator or by self-contained battery units. Data reduction for the present study was performed on both an IBM-PC [®] desktop computer and a PDP TM 11/44 minicomputer. Identification and quantitation of radioisotopes were accomplished using the RAYGUN gamma-ray analysis code (Hensley et al. 1988; Gunnink and Niday 1972; Gunnink and Ruhter 1980). Quantification of bremsstrahlung radiation was performed by region-of-interest integration.

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FIGURE 3. Detail of the In-Situ Gamma-Ray Spectrometer Setup for Measuring Surficial Wall Contamination

THERMOLUMINESCENT DOSIMETERS

The sump in room 102 of the 1608F Building measured 10 feet wide by 16 feet long by 31 feet deep. The opening to the sump was centered on the width and was 6.25 feet from the north wall. The dose rate within the sump was measured using three TLD-400 chips loaded into small gelatin capsules that were attached to a nylon line at 1-foot intervals. High sensitivity TLD-400 material was chosen because the radiological survey data provided by decommissioning personnel showed dose rates to be less than 1 mR/h.

Five TLD strings were placed in and around the 1608F Building, as seen in Figure 4. Three strings were placed into the sump on July 1, 1987. These strings were identified as A, B, and C. The two remaining strings, identified as B1 and B2, were used to monitor background levels. String B1 was placed in room 106 of the 1608F Building, and string B2 was placed in the 105F lunchroom located approximately 100 yards to the north of the 1608F Building.

String A was located in the center of the sump opening (room 102) and extended from contact at floor level up approximately 31 feet to the sump opening. String B was approximately 18 inches from the west wall at the top and about 6 inches from the wall near the floor. String C was on the floor and extended from the west wall to within 3 feet of the east wall.

The five TLD strings were removed on August 5, 1987. Exposure time was 838.5 hours. The maximum dose received, 1692.8 mrad, was on string C-0. Capsule C-0 was in the corner formed by the west wall and the floor of the sump. Maximum doses on strings A and B were 634.9 and 962.5 mrad, respectively. Dose rates in mrad/h are determined by dividing the total dose received by the hours of irradiation. The profile described by plotting the TLD data is the first parameter in determining the surface contamination. See Figure 5 for the dose rate and dose profile as determined by the TLD method.

FIGURE 4. TLD Locations in the 1608F Building and 105F Lunchroom

WISE AND SIMPLE COMPUTER CODES

The dose rates from the TLDs and the relative levels of radionuclide contamination determined by the gamma-ray spectrometer provide sufficient information for analysis and interpretation. The data were run through IBM-PC versions of the WISE and SIMPLE shielding codes. These codes have the advantage of taking into account all geometry and shielding parameters, which were straightforward for the sump.

Input data included the sump dimensions, the relative source terms for the floor and walls, and the measured TLD dose points. The source-term concentrations are varied until the actual dose rates are matched. The initial relative radionuclide ratio is determined by efficiency correction of the gamma-ray full-energy peaks measured by the high-purity germanium detector.

EXPERIMENTAL

Fission products observed in the 1608F sump were ^{60}Co , ^{90}Sr , ^{137}Cs , ^{152}Eu , and ^{154}Eu . Potassium-40 and other naturally occurring radioisotopes were also present. Europium-155 was not observed.

Standard library spectra for the individual species present in the 1608F sump were obtained by placing a point source of known intensity against a concrete floor and/or wall and counting for a length of time sufficient to give better than 5% statistical uncertainty in the resulting photopeaks or integrated spectral regions. The standard library net spectra for the floor analysis, partially smoothed for clarity, are shown in Figures 6 through 9.

The normalized background spectrum for the concrete floor and/or wall has been subtracted from the gross spectra to give these standard library spectra. Monte Carlo programs (Wielopolski 1977) written in Pascal code were used to correlate the expected spectrum from a single point source on a wall to that expected for a uniformly contaminated large surface, and the resulting minor corrections were applied to the experimentally obtained calibration data.

The calibration for the floor analysis was accomplished by using point sources of gamma-ray emitting standards distributed across an "infinite" plane divided into a large number of concentric rings having equal area. The germanium diode was placed at the center of these concentric rings at an elevation equivalent to that used in the 1608F sump (3 feet 8 inches). The detector response for a ^{137}Cs point source at various distances is shown in Figure 10. The relative response curve which results from dividing the detector response by the area of the corresponding concentric ring is shown in Figure 11. Previous work has shown (Brodzinski 1983) that the overall spectrum obtained by summing the spectra of concentric rings can be duplicated by a single measurement taken at a specific horizontal distance. For the detector used in this study, the specific horizontal distance is 1.7 feet and corresponds to the "average" or median position on the distribution shown in Figure 11, i.e., the position on the curve where the area under the

1608F SUMP - TLD STRING 'A'

FIGURE 5. Dose Rate Profile (+) as Measured by TLDs

FIGURE 6. Cesium-137 Library Standard Reference Spectrum, Partially Smoothed for Clarity

FIGURE 7. Cobalt-60 Library Standard Reference Spectrum, Partially Smoothed for Clarity

FIGURE 8. Europium-152 and -154 Library Standard Reference Spectrum, Smoothed for Clarity

FIGURE 9. Strontium-90 Library Standard Reference Spectrum, Partially Smoothed for Clarity

FIGURE 10. Detector Response for a Cesium-137 Point Source

FIGURE 11. Relative Response for a Cesium-137 Point Source Convolved with the Area Viewed by the Detector

curve above and below the point are equal. The efficiency curve for determination of levels of surficial floor contamination by the gamma-ray-emitting radionuclides is shown in Figure 12. Table 1 lists the corresponding radionuclide concentrations for the 1608F sump floor and walls. The direct analysis compares favorably with the values estimated by the WISE-and-SIMPLE analysis presented in Table 2. The RAYGUN-generated outputs for peak and area identification of the pertinent spectra are contained in Appendix A.

It should be noted that, although the point source at small horizontal distance gives a high response in the detector (Figure 10), the area viewed by the detector is small, resulting in a small net contribution (Figure 11) to the overall system response. Points at a greater horizontal distance register a smaller response, but the area viewed is much larger. Points at the edge of the horizontal distance have a response which is too low to compensate for the large area viewed, so that only a small contribution is made by these points to the overall system response. Further collimation of the detector would increase the response of the system, but would decrease the area viewed at any one time.

Another item to note is that a very intense point source (such as a particle of a disintegrated fuel pellet), when located at an optimal horizontal distance from the detector, would yield a disproportionately high contamination level for the area viewed. The effect of such a "hot spot" is somewhat mitigated by the large area viewed. Further collimation of the detector would help identify the presence of such a particle, but standard monitoring of the area with a handheld proportional counter would also provide clear indication of a particle's presence.

ANALYSIS BY SPECTRAL STRIPPING

Figure 13 is a flowchart of the steps used in analyzing a field data set. After data collection, each spectrum is gain-shifted to 1 keV/channel. The gain-shifting is performed to correct for any zero or gain drift during the course of data acquisition, or for variable instrument calibration. Shifting

FIGURE 12. Efficiency Curve for Gamma-Ray Analysis of the 1608F Building Sump Floor

Table 1. Concentrations of radionuclides found in the 1608F sump as determined by in situ counting with a tungsten-collimated intrinsic-germanium gamma-ray spectrometer.

<u>Depth</u>	<u>^{137}Cs</u>	<u>^{60}Co</u>	<u>^{152}Eu</u>	<u>^{154}Eu</u>
Floor	2200 ± 50	830 ± 46	4490 ± 320	713 ± 65
1 Ft.	646 ± 50	557 ± 53	2750 ± 320	439 ± 80
3 Ft.	396 ± 39	338 ± 49	1340 ± 273	226 ± 61
9 Ft.	521 ± 18	428 ± 22	1710 ± 200	212 ± 32
11 Ft.	360 ± 12	237 ± 14	1430 ± 110	187 ± 21
13 Ft.	47 ± 6	44 ± 7	287 ± 107	56 ± 12
18 Ft.	0 ± 8	0 ± 11	53 ± 78	9 ± 16

Table 2. Radionuclide Concentrations Determined by WISE and SIMPLE Calculations and TLD Dose Rate Data.

<u>Radionuclide</u>	<u>% Activity</u>	<u>Source Term</u>	<u>Coefficient</u>	<u>Concentration (pCi/cm²) Floor</u>
⁶⁰ Co	2.21	3.67E-6 *	7.25E-5	= 266.
¹³⁷ Cs	61.99	1.03E-4 *	7.25E-5	= 7470.
¹⁵² Eu	32.59	5.43E-5 *	7.25E-5	= 3940.
¹⁵⁴ Eu	3.21	5.33E-6 *	7.25E-5	= 386.
				<u>Wall</u>
⁶⁰ Co	4.23	4.10E-6 *	3.89E-5	= 160.
¹³⁷ Cs	50.33	4.99E-5 *	3.89E-5	= 1940.
¹⁵² Eu	41.60	4.24E-5 *	3.89E-5	= 1650.
¹⁵⁴ Eu	3.70	3.60E-6 *	3.89E-5	= 140.

Figure 13. Flowchart of the Steps Used in Analyzing a Field Spectrum.

is performed by the program GAINSHF, listed in Appendix C, on a PDP-11/44 minicomputer. The operator inputs the approximate location of three known peaks and their exact energies. The GAINSHF program then computes the zero, gain, and non-linearity for the given spectrum, shifts the data into corresponding channels proportionately, and produces a new spectrum that is precisely 1 keV/channel. This data manipulation technique does not correct for loss of resolution due to field use of the instrumentation, but this shortcoming does not affect the accuracy of the reduced data.

The operator then subtracts the gain-normalized background spectrum from the unknown spectrum based on the ratio of the live counting times for the two spectra.

Each radioisotope present in the unknown spectrum is then identified on the basis of its characteristic full-energy photopeaks and the corresponding library spectrum is stripped out proportional to the photopeak intensities. (The intensity of the photopeak is also used to determine the level of surficial contamination for the particular radioisotope.)

The spectrum that remains after stripping represents the continuum due to ^{90}Sr bremsstrahlung radiation and is compared to the library ^{90}Sr spectrum to determine contamination level. Several integrated regions of the residual ^{90}Sr spectrum can be compared to the library ^{90}Sr spectrum to ensure the correct bremsstrahlung shape, and each region should yield the same value for the level of ^{90}Sr . When no ^{90}Sr is present, the final spectrum should be merely a straight line with only a statistical fluctuation of data above and below the zero line.

Smoothing can be applied to the resulting spectra to render them more attractive but is not necessary for accurate data analysis.

ANALYSIS BY ENERGY WINDOW SUBTRACTION

As mentioned previously, an equivalent approach to spectral stripping is to identify regions of the gamma-ray spectrum that represent continuum data (i.e., which are relatively free of major gamma-ray peaks) and which correspond to significant portions of the ^{90}Sr bremsstrahlung continuum. The integrated number of counts in these regions is corrected for contributions from the appropriate normalized library spectra (the same spectra that are used in the spectral stripping approach). The net remaining number of counts corresponds to the level of ^{90}Sr contamination.

as mentioned previously, an equivalent approach to spectral stripping is to identify regions of the gamma-ray spectrum that represent continuum data (i.e., which are relatively free of major gamma-ray peaks) and which correspond to significant portions of the ^{22}Na bremsstrahlung continuum. The integrated number of counts in these regions is corrected for contributions from the appropriate correlated therapy spectra (the same spectra that are used in the spectral stripping process) to the net remaining number of counts corresponds to the level of ^{22}Na emission.

RESULTS AND DISCUSSION

Background data for this study were obtained from similar matrices in close proximity of the sampling site. The gamma-ray background spectrum intended for direct-assay analysis of the 1608F sump was obtained from walls where no significant contamination was detected, at a height of 24 feet or greater above the floor. Background data for the TLD analysis came from placing a series of TLD capsules on concrete surfaces known to be contamination free.

DIRECT ASSAY RESULTS

The radionuclides and selected photopeaks used for analyzing spectra in this study were: ^{137}Cs (662 keV), ^{60}Co (1172 and 1332 keV), ^{152}Eu (964, 1086, 1112, and 1408 keV), and ^{154}Eu (1275 keV).

The residual sample spectrum, after stripping, represents only ^{90}Sr bremsstrahlung radiation and is compared to the library ^{90}Sr reference spectrum on the basis of intensity to determine contamination levels. Three different energy regions were compared in this study to ensure the correct bremsstrahlung shape and to confirm the contamination level obtained by the stripping approach. The energy regions selected were 250 to 329 keV (80 keV wide), 351 to 415 keV (65 keV wide), and 455 to 649 keV (195 keV wide). The results from the energy-window analysis for the floor and the walls at various sump depths is given in Tables B.1 through B.8 of Appendix B.

The ^{90}Sr level determined for a given sump depth is reported based on the sum of the counts in the three energy windows. The associated standard deviation is based on the observed variation among energy windows, since this variability exceeded the uncertainty expected using standard counting statistics (Bevington 1969; Knoll 1979; Krugers 1973). Net counts in a given energy window are divided by the window width to give a normalized count value expressed in counts/keV. A relative standard deviation is computed for the three resulting normalized values. The resulting relative standard deviation, when multiplied by the ^{90}Sr level, gives the standard deviation listed in the tables.

Analysis of the floor spectrum gave an average ^{90}Sr level of 550 ± 400 pCi/cm² (1800 s count time). Similar analyses gave average wall contamination levels of 69 ± 39 pCi/cm² (2000 s count time) at the 1-foot level (some of the floor was viewed by the diode at this level, which undoubtedly contributed to the reading), 39 ± 35 pCi/cm² (2130 s count time) at the 3-foot level, 30 ± 19 pCi/cm² (2040 s count time) at the 9-foot level, 44 ± 11 pCi/cm² (2000 s count time) at the 11-foot level, 28 ± 7 pCi/cm² (4000 s count time) at the 13-foot level (close to the water line), and 8 ± 3 pCi/cm² (10000 s count time) at the 18-foot level. The uncertainties associated with these values are standard deviations and are predominantly due to relatively short counting times (half-hour to one-hour counts). These uncertainties can be reduced by lengthening the time of count, which also has the effect of reducing the lower limit of detection.

CORRELATION RATIO RESULTS

The second approach to measuring ^{90}Sr levels uses ^{137}Cs levels obtained from the direct-assay results and a correlation ratio for ^{90}Sr levels versus ^{137}Cs levels obtained empirically from previous Hanford decommissioning studies (Beckstrom 1985; Beckstrom 1984; Dorian and Richards 1978) to estimate corresponding ^{90}Sr levels. A correlation ratio of 1:9.6 for [^{90}Sr]:[^{137}Cs] was used. The resulting levels, presented in Table 3, generally show good agreement when compared to levels estimated using the direct-assay method.

THERMOLUMINESCENT DOSIMETER RESULTS

During actual operation of the sump, the level of water pumped from the core was maintained at a minimum of 7 ft and a maximum of 13 ft 3 in. As noted in Figure 5, a fairly sharp decrease in dose rate is seen at around 12 ft. This correspondence to the operating water level, as well as to the water-stain mark on the walls below this level, indicate a reduction in the source-term.

Figure 14 illustrates the contribution to the dose rate if the dose was from floor only, illustrated by the 'o' symbol, or from the four walls only,

Table 3. Cesium-137 and Strontium-90 Levels as Determined by Direct Assay and Alternate Methods.

Direct Assay and Correlation Ratio Results

<u>Distance Above Floor (ft)</u>	<u>¹³⁷Cs Concentration (pCi/cm²)</u>	<u>⁹⁰Sr Concentration (pCi/cm²)</u>	
	<u>Direct</u>	<u>Direct</u>	<u>Correlation Ratio</u>
1	646	69	67
3	396	39	41
9	521	30	54
11	360	44	37
13	47	28	5
18	0	8	0

Thermoluminescent Dosimeter Results Produced by WISE and SIMPLE (W&S)

	<u>¹³⁷Cs Concentration (pCi/cm²)</u>		<u>⁹⁰Sr Concentration (pCi/cm²)</u>		
	<u>Direct</u>	<u>W&S</u>	<u>Direct</u>	<u>Correlation Ratio</u>	<u>W&S</u>
Total Wall	1970	1940	191	204	202
Total Floor	2200	7470	550	228	777

Radiochemical Assay Results

Wall	10-80
Floor	231-732

1608F SUMP FLOOR AND WALL PROFILE

FIGURE 14. WISE and SIMPLE Output for Calculated Response from Floor Only (o) and Wall Only (+)

illustrated by the '+' symbol. This is presented to show the effects of source geometry. Figure 15, shows the measured data, indicated by the '+' symbol, plotted with the WISE-and-SIMPLE fitted data, represented by the solid line. The accuracy of the fitted data is dependent upon the identification and relative percentage concentration of each radionuclide.

When the measured and calculated dose rates and profile are matched, the radionuclide source-term concentration has been determined and corresponds to the current values of the source-term input.

The concentrations presented previously in Table 2 were determined from the least-squares fit of the measured and calculated data by the WISE and SIMPLE codes. Table 3 lists the ^{90}Sr levels determined by the various assay methods used in this report. If the destructive assay results by radiochemical analysis are presumed to be accurate, then comparing the values determined by other methods is also valid.

The ^{90}Sr levels determined by the other methods fall within the range of radiochemical values or error slightly on the conservative (high) side and are equally as valid as the radiochemical technique. Most importantly, the comparison between the direct assay and the radiochemical analysis has validated the direct assay method for in-situ evaluation of radioactive contamination levels.

1608F SUMP

FIGURE 15. Measured Dose Rate (+) and WISE and SIMPLE Calculated (Fitted) Values

REFERENCES

- Beckstrom, J. F. 1984. ARCL Calculations for Decommissioning the 117-H Filter Building. UNC-3001, United Nuclear Industries, Inc., Richland, Washington.
- Beckstrom, J. F. 1985. ARCL Calculations from Decommissioning the 117-C Filter Building. UNC-3415 REV1, United Nuclear Industries, Inc., Richland, Washington.
- Bevington, P. R. 1969. Data Reduction and Error Analysis for the Physical Sciences. McGraw-Hill Book Co., New York.
- Brodzinski, R. L. and H. L. Nielson. 1980. "A Well-Logging Technique for the In Situ Determination of ⁹⁰Sr." Nucl. Instrum. Methods 173: 299.
- Brodzinski, R. L. 1983. Portable Instrumentation for Quantitatively Measuring Radioactive Contamination Levels and for Monitoring the Effectiveness of Decontamination and Decommissioning Activities. PNL-4744, Pacific Northwest Laboratory, Richland, Washington.
- Denham, D. H., M. G. Baines and R. E. Jaquish. 1983. A Guide for Radiological Characterization and Measurement for Decommissioning of U.S. Department of Energy Surplus Facilities. DOE/EP-0100, U. S. Department of Energy, Washington, D.C.
- Dorian, J. J. and V. R. Richards. 1978. Radiological Characterization of the Retired 100 Areas. UNC-3001, United Nuclear Industries, Inc., Richland, Washington.
- Gunnink, R. and J. B. Niday. 1972. Computerized Quantitative Analysis by Gamma-Ray Spectrometry. Vol. 1, UCRL-51061, Lawrence Livermore National Laboratory, Livermore, California.
- Gunnink, R. and W. Ruhter. 1980. GRPANL: A Program for Fitting Complex Peak Groupings for Gamma and X-Ray Energies and Intensities. UCRL-52917, Lawrence Livermore National Laboratory, Livermore, California.
- Hensley W.K., E. A. Lepel, M. E. Yuly, and K. H. Abel. 1988. "Adaptation and Implementation of the RAYGUN Gamma-Ray Analysis Code on the IBM PC," J. Radioanal. Nucl. Chem. Art. 124(2):481-499.
- Holoway, C. F., J. P. Witherspoon, H. W. Dickson, P. M. Lautz and T. Wright. 1981. Monitoring for Compliance with Decommissioning Termination Survey Criteria. NUREG/CR-2082, ORNL/HASRD-95, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Knoll, G. F. 1979. Radiation Detection and Measurement. John Wiley & Sons, New York.

Kruger, J. 1973. Instrumentation in Applied Nuclear Chemistry. Plenum Press, New York. 1973.

Nielson, K. K., C. W. Thomas, N. A. Wogman, and R. L. Brodzinski. 1976. "Development of a Plutonium-Americium Monitor for In Situ Soil Surface and Pond Bottom Analysis." Nucl. Instrum. Methods 138: 227.

Reece, W. D., S. D. Miller, L. A. Sigalla and L. F. Munson. 1989. Development of the WISE and SIMPLE Codes for Estimating Radioactive Waste Inventory and Shielding: User's Manual. EPRI NP-6226-CCML, Project 2412-7, Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, California.

West, L., C. J. Umbarger, and T. Dempsey. 1978. "A Germanium-Diode Detector System for the Detection of Transuranics at Low-Activity Concentrations in Soil". Proceedings of the Health Physics Society Eleventh Mid-Year Topical Symposium on Radiation Instrumentation, W. W. Wadman III, ed.

Wielopolski, L. 1977. "The Monte Carlo Calculation of the Average Solid Angle Subtended by a Right Circular Cylinder from Distributed Sources." Nucl. Instrum. Methods 143: 577.

APPENDIX A

Computer Output from the RAYGUN
Gamma-Ray Analysis Program

Analysis performed by: RJ Arthur

Sample: Sump floor: Detector looking at bottom, elevation 3' 8"

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 30.00m (1800.0000 seconds)
 LIVE TIME 30.00m (1800.0000 seconds)

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID1.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	53. 60.	28947.	10497.	57.74	1.024E+06	2.1	0
2	66.9	63. 69.	23179.	5459.	65.84	5.296E+05	3.7	0
3	86.2	79. 106.	105355.	11770.	85.11	1.129E+06	3.9	0
4	121.8	119. 124.	53069.	33132.	120.78	3.131E+06	0.8	0
5	245.2	244. 247.	11063.	5960.	244.43	5.465E+05	3.1	0
6	248.2	247. 249.	4750.	73.	247.44	3.274E+04	100.0	0
7	344.2	340. 346.	18833.	14164.	343.61	1.280E+06	1.1	0
8	367.9	367. 369.	2188.	435.	367.36	3.923E+04	14.4	0
9	411.1	410. 412.	2539.	975.	410.63	8.740E+04	6.6	0
10	444.0	442. 445.	3286.	1416.	443.61	1.265E+05	5.1	0
11	586.1	584. 587.	1427.	160.	585.94	1.553E+04	100.0	0
12	591.9	591. 596.	2119.	292.	591.79	2.577E+04	21.5	0
13	661.7	658. 664.	11684.	9862.	661.65	8.662E+05	2.4	0
14	678.8	678. 679.	698.	185.	678.78	1.622E+04	18.8	0
15	688.7	687. 691.	1521.	295.	688.74	2.589E+04	19.4	0
16	723.1	722. 724.	1702.	906.	723.23	7.929E+04	5.5	0
17	756.9	753. 761.	2535.	409.	757.06	3.573E+04	16.7	0
18	778.9	777. 782.	5265.	3923.	779.07	3.422E+05	2.1	0
19	867.0	865. 869.	2248.	1152.	867.42	1.000E+05	5.0	0
20	873.0	871. 875.	1615.	490.	873.35	4.250E+04	10.7	0
21	963.8	961. 965.	4767.	3876.	964.29	3.350E+05	1.9	0
22	995.9	992. 997.	1374.	450.	996.48	3.883E+04	10.7	0
23	1004.4	1002. 1008.	1994.	1002.	1005.03	8.645E+04	5.5	0
24	1085.2	1080. 1088.	3873.	2987.	1085.92	2.568E+05	4.9	0
25	1089.8	1088. 1091.	973.	188.	1090.54	1.615E+04	26.4	0
26	1111.4	1108. 1115.	4477.	3482.	1112.22	2.990E+05	2.2	0
27	1172.5	1169. 1175.	5646.	5049.	1173.37	4.327E+05	1.6	0
28	1212.1	1210. 1214.	624.	373.	1213.04	3.253E+04	8.5	0
29	1273.4	1270. 1278.	1692.	1390.	1274.55	1.247E+05	3.2	0
30	1298.0	1296. 1301.	588.	443.	1299.18	4.015E+04	6.1	0
31	1331.3	1328. 1335.	4947.	4829.	1332.51	4.441E+05	1.5	0
32	1406.8	1402. 1409.	5185.	5125.	1408.12	4.860E+05	1.4	0
33	1459.2	1452. 1462.	465.	443.	1460.67	4.283E+04	5.0	0
34	1492.8	1491. 1495.	42.	36.	1494.25	3.548E+03	19.1	0
35	1526.9	1525. 1528.	64.	58.	1528.47	5.743E+03	14.5	0
36	1594.4	1593. 1597.	73.	56.	1596.12	5.738E+03	16.8	0
37	1762.3	1760. 1764.	26.	26.	1764.28	2.774E+03	22.6	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 3' Level: W Collim. + 2" Pb, No Slit (Bkgd.)

Count date: 07-Aug-1987 at 0:00:00

Count times: REAL TIME 6.67m (400.00000 seconds)
 LIVE TIME 6.67m (400.00000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID22.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gamma /sec	Err % SD	System bkg
1	58.7	53. 60.	5556.	2154.	57.82	1.179E+07	4.4	0
2	66.9	64. 69.	3851.	828.	65.95	3.933E+06	10.0	0
3	121.4	120. 124.	4168.	1418.	120.55	3.515E+06	5.9	0
4	244.8	244. 246.	777.	191.	244.08	2.214E+05	19.3	0
5	344.2	343. 346.	1069.	711.	343.67	5.693E+05	5.3	0
6	661.8	659. 665.	764.	504.	661.65	1.994E+05	6.6	0
7	723.3	722. 724.	177.	66.	723.18	2.613E+04	25.6	0
8	779.0	777. 780.	378.	238.	778.97	9.338E+04	9.6	0
9	867.1	863. 868.	298.	134.	867.14	5.228E+04	16.1	0
10	964.0	962. 967.	458.	330.	964.18	1.283E+05	7.3	0
11	1004.4	1003. 1007.	195.	92.	1004.70	3.556E+04	20.2	0
12	1085.6	1082. 1088.	400.	277.	1085.92	1.072E+05	8.3	0
13	1111.8	1110. 1114.	378.	293.	1112.24	1.133E+05	7.3	0
14	1172.9	1169. 1176.	622.	529.	1173.40	2.039E+05	5.1	0
15	1212.0	1211. 1214.	69.	44.	1212.50	1.722E+04	22.1	0
16	1273.8	1270. 1276.	164.	135.	1274.41	5.442E+04	10.3	0
17	1298.2	1295. 1300.	64.	44.	1298.84	1.793E+04	20.9	0
18	1331.8	1326. 1334.	538.	515.	1332.51	2.131E+05	4.6	0
19	1407.0	1403. 1410.	546.	535.	1407.82	2.282E+05	4.4	0
20	1459.8	1455. 1462.	79.	68.	1460.67	2.950E+04	14.6	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec .

Analysis performed by: RJ Arthur

Sample: 1' Level: W Collim., 1/4" Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 33.33m (2000.0000 seconds)
 LIVE TIME 33.33m (2000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID3.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	51. 60.	37709.	13219.	57.71	1.450E+07	2.0	0
2	66.8	63. 69.	25168.	5156.	65.80	4.911E+06	4.1	0
3	121.3	117. 123.	34887.	10684.	120.42	5.303E+06	2.4	0
4	244.6	244. 247.	7721.	2053.	243.90	4.760E+05	5.6	0
5	344.1	342. 346.	10119.	6167.	343.58	9.883E+05	2.0	0
6	411.0	410. 413.	3033.	512.	410.63	6.776E+04	14.5	0
7	443.9	440. 447.	5406.	710.	443.60	8.638E+04	15.0	0
8	510.7	509. 514.	3433.	287.	510.48	3.001E+04	28.3	0
9	661.6	659. 666.	9480.	6385.	661.65	5.048E+05	1.8	0
10	688.6	687. 691.	2000.	162.	688.66	1.531E+04	100.0	0
11	723.1	717. 724.	3787.	985.	723.25	7.756E+04	8.2	0
12	756.7	756. 759.	1654.	250.	756.97	1.969E+04	22.1	0
13	778.8	777. 782.	5344.	3392.	779.09	2.663E+05	2.5	0
14	867.0	861. 869.	3790.	1037.	867.47	8.100E+04	7.8	0
15	872.9	872. 875.	1698.	475.	873.35	3.713E+04	11.4	0
16	963.7	961. 965.	5299.	4027.	964.27	3.132E+05	2.0	0
17	995.8	995. 997.	1105.	466.	996.49	3.617E+04	9.0	0
18	1004.3	1001. 1006.	2206.	973.	1005.03	7.553E+04	6.4	0
19	1085.0	1081. 1088.	4412.	2996.	1085.87	2.318E+05	4.8	0
20	1089.6	1088. 1091.	1240.	424.	1090.44	3.281E+04	12.5	0
21	1111.3	1107. 1115.	5517.	4047.	1112.14	3.129E+05	2.1	0
22	1172.3	1168. 1176.	7017.	5946.	1173.34	4.586E+05	1.5	0
23	1212.0	1208. 1214.	970.	403.	1213.06	3.169E+04	9.7	0
24	1273.3	1271. 1276.	1978.	1680.	1274.49	1.356E+05	2.8	0
25	1298.0	1296. 1300.	674.	490.	1299.18	4.000E+04	6.0	0
26	1331.2	1327. 1334.	6335.	6166.	1332.51	5.103E+05	1.3	0
27	1406.7	1400. 1409.	6657.	6527.	1408.08	5.570E+05	1.3	0
28	1459.1	1453. 1463.	483.	457.	1460.63	3.980E+04	4.9	0
29	1492.3	1491. 1495.	48.	36.	1493.88	3.198E+03	21.3	0
30	1526.1	1525. 1530.	76.	62.	1527.70	5.547E+03	15.3	0
31	1594.6	1589. 1596.	105.	93.	1596.33	8.533E+03	11.6	0
32	1762.2	1760. 1764.	32.	29.	1764.24	2.819E+03	21.4	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 1' Level: W Collim. + 2" Pb, No Slit (Bkgd.)

Count date: 07-Aug-1987 at 0:00:00

Count times: REAL TIME 6.67m (400.00000 seconds)
 LIVE TIME 6.67m (400.00000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID23.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkgd
1	58.7	53. 60.	6701.	2668.	57.77	1.462E+07	4.1	0
2	66.8	65. 69.	3991.	998.	65.82	4.751E+06	8.4	0
3	121.3	119. 123.	5365.	1966.	120.40	4.881E+06	5.1	0
4	244.7	244. 245.	842.	314.	243.98	3.637E+05	11.8	0
5	344.1	343. 345.	1375.	982.	343.53	7.871E+05	4.3	0
6	661.8	660. 664.	1082.	782.	661.65	3.092E+05	4.8	0
7	723.7	722. 726.	382.	106.	723.59	4.165E+04	24.3	0
8	778.9	775. 783.	836.	390.	778.91	1.532E+05	9.5	0
9	867.3	866. 870.	383.	184.	867.39	7.189E+04	13.1	0
10	873.6	872. 875.	238.	82.	873.75	3.193E+04	24.3	0
11	964.0	961. 966.	694.	480.	964.20	1.866E+05	6.3	0
12	1004.8	1003. 1008.	324.	132.	1005.12	5.119E+04	17.2	0
13	1085.3	1083. 1089.	578.	370.	1085.71	1.430E+05	7.9	0
14	1111.8	1109. 1115.	694.	540.	1112.25	2.086E+05	5.4	0
15	1172.8	1171. 1175.	867.	780.	1173.30	3.010E+05	4.0	0
16	1212.7	1211. 1214.	101.	53.	1213.26	2.086E+04	23.0	0
17	1273.7	1269. 1277.	301.	229.	1274.36	9.241E+04	8.4	0
18	1298.2	1297. 1300.	71.	46.	1298.91	1.895E+04	21.0	0
19	1331.8	1328. 1335.	896.	870.	1332.51	3.598E+05	3.5	0
20	1406.9	1405. 1410.	915.	901.	1407.76	3.843E+05	3.4	0
21	1459.9	1455. 1462.	67.	59.	1460.76	2.557E+04	14.8	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 3' Level: W Collim., 1/4" Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 35.50m (2130.0000 seconds)
 LIVE TIME 35.50m (2130.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID5.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	56. 60.	22920.	11170.	57.59	1.153E+07	1.7	0
2	67.0	64. 69.	19896.	4843.	65.75	4.334E+06	3.9	0
3	121.8	119. 123.	24146.	8943.	120.69	4.158E+06	2.4	0
4	244.9	244. 247.	6328.	1810.	244.01	3.940E+05	5.8	0
5	344.2	343. 346.	7166.	4764.	343.54	7.170E+05	2.1	0
6	411.1	408. 413.	3197.	452.	410.59	5.610E+04	17.1	0
7	444.0	443. 448.	3237.	519.	443.55	5.929E+04	14.9	0
8	511.3	510. 516.	2942.	307.	510.96	3.009E+04	24.3	0
9	661.7	659. 663.	5614.	4202.	661.65	3.119E+05	2.0	0
10	688.6	685. 691.	1949.	170.	688.65	1.256E+04	36.0	0
11	723.1	720. 724.	1766.	541.	723.23	4.004E+04	11.0	0
12	778.9	777. 781.	3160.	1994.	779.07	1.470E+05	3.3	0
13	867.1	863. 870.	2472.	780.	867.48	5.726E+04	8.3	0
14	872.9	872. 876.	1351.	283.	873.25	2.072E+04	17.4	0
15	963.7	962. 966.	3339.	2504.	964.25	1.829E+05	2.6	0
16	995.9	994. 997.	819.	222.	996.48	1.617E+04	18.8	0
17	1004.3	1003. 1006.	1186.	613.	1004.91	4.466E+04	6.8	0
18	1085.1	1082. 1088.	2749.	1792.	1085.91	1.302E+05	3.4	0
19	1089.1	1088. 1090.	654.	249.	1089.92	1.807E+04	13.1	0
20	1111.4	1109. 1113.	3154.	2559.	1112.20	1.858E+05	2.4	0
21	1172.3	1167. 1175.	4801.	4022.	1173.31	2.913E+05	1.9	0
22	1212.0	1210. 1213.	452.	229.	1213.01	1.687E+04	11.4	0
23	1273.4	1269. 1275.	1341.	1103.	1274.52	8.366E+04	3.6	0
24	1298.0	1296. 1301.	480.	322.	1299.25	2.468E+04	7.8	0
25	1331.2	1327. 1335.	4314.	4141.	1332.51	3.218E+05	1.6	0
26	1406.6	1402. 1409.	4048.	3984.	1408.06	3.193E+05	1.6	0
27	1459.2	1455. 1463.	430.	403.	1460.71	3.299E+04	5.3	0
28	1526.4	1524. 1528.	61.	52.	1528.01	4.377E+03	16.0	0
29	1594.9	1593. 1599.	76.	66.	1596.66	5.687E+03	14.0	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 3' Level: W Collim., No Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 6.67m (400.00000 seconds)
 LIVE TIME 6.67m (400.00000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID15.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	52. 60.	6003.	2252.	57.88	1.231E+07	4.6	0
2	66.9	66. 70.	3504.	864.	65.96	4.104E+06	9.1	0
3	121.7	119. 124.	4884.	1520.	120.88	3.756E+06	6.4	0
4	244.9	242. 247.	1436.	240.	244.18	2.777E+05	21.4	0
5	344.4	343. 345.	882.	591.	343.75	4.736E+05	5.8	0
6	444.2	443. 445.	306.	104.	443.71	6.335E+04	21.6	0
7	661.9	659. 663.	686.	486.	661.65	1.921E+05	6.1	0
8	723.4	722. 725.	219.	74.	723.22	2.926E+04	25.7	0
9	779.1	776. 783.	554.	301.	778.98	1.181E+05	9.4	0
10	867.8	867. 869.	187.	95.	867.75	3.713E+04	17.6	0
11	964.0	962. 968.	513.	333.	964.13	1.296E+05	7.9	0
12	1004.9	1003. 1006.	200.	117.	1005.01	4.543E+04	14.4	0
13	1085.7	1084. 1087.	278.	212.	1085.97	8.198E+04	8.8	0
14	1111.8	1110. 1116.	449.	330.	1112.07	1.275E+05	7.2	0
15	1173.0	1170. 1177.	629.	533.	1173.31	2.054E+05	5.1	0
16	1274.0	1272. 1276.	175.	152.	1274.45	6.146E+04	9.2	0
17	1298.5	1298. 1301.	65.	43.	1298.98	1.757E+04	21.7	0
18	1332.0	1328. 1336.	559.	533.	1332.51	2.204E+05	4.6	0
19	1407.3	1404. 1410.	584.	578.	1407.94	2.465E+05	4.2	0
20	1456.8	1454. 1458.	27.	24.	1457.46	1.059E+04	22.4	0
21	1459.8	1458. 1461.	59.	57.	1460.51	2.466E+04	13.8	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 9' Level: W Collim., 1/4" Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 34.00m (2040.0000 seconds)
 LIVE TIME 34.00m (2040.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID10.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	55. 61.	14489.	5655.	57.70	6.084E+06	2.7	0
2	66.9	63. 69.	12352.	2282.	65.82	2.131E+06	6.6	0
3	121.5	120. 124.	13416.	5203.	120.47	2.531E+06	2.8	0
4	244.7	244. 247.	3342.	944.	243.99	2.146E+05	8.0	0
5	344.1	343. 345.	3696.	2759.	343.56	4.335E+05	2.5	0
6	411.1	410. 412.	920.	188.	410.66	2.434E+04	21.7	0
7	443.9	441. 446.	1710.	346.	443.56	4.129E+04	16.0	0
8	511.2	509. 513.	1157.	186.	510.95	1.903E+04	27.2	0
9	661.6	659. 663.	3281.	2458.	661.65	1.905E+05	2.6	0
10	723.1	721. 725.	1013.	309.	723.25	2.388E+04	26.5	0
11	778.8	777. 781.	1875.	1204.	779.06	9.266E+04	4.2	0
12	867.0	866. 868.	792.	380.	867.42	2.908E+04	9.1	0
13	872.9	872. 874.	590.	172.	873.31	1.314E+04	18.5	0
14	963.7	962. 966.	2012.	1524.	964.26	1.162E+05	3.3	0
15	995.3	994. 997.	548.	191.	995.97	1.451E+04	15.8	0
16	1004.2	1003. 1007.	810.	361.	1004.87	2.750E+04	9.8	0
17	1085.0	1083. 1088.	1619.	1073.	1085.81	8.140E+04	8.8	0
18	1089.1	1088. 1091.	511.	239.	1089.87	1.816E+04	17.2	0
19	1111.3	1107. 1113.	2008.	1467.	1112.14	1.112E+05	3.4	0
20	1172.4	1169. 1175.	2881.	2522.	1173.39	1.907E+05	2.3	0
21	1212.0	1209. 1217.	478.	155.	1213.03	1.195E+04	18.2	0
22	1273.3	1272. 1275.	699.	612.	1274.50	4.841E+04	4.6	0
23	1298.0	1296. 1299.	251.	173.	1299.22	1.385E+04	10.5	0
24	1331.2	1326. 1334.	2773.	2681.	1332.51	2.175E+05	2.0	0
25	1406.7	1402. 1409.	2597.	2558.	1408.10	2.140E+05	2.0	0
26	1459.2	1452. 1462.	427.	402.	1460.68	3.434E+04	5.3	0
27	1594.9	1592. 1597.	44.	38.	1596.64	3.416E+03	44.8	0
28	1762.2	1758. 1765.	41.	35.	1764.25	3.328E+03	19.5	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 9' Level: W Collim., No Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 16.67m (1000.0000 seconds)
 LIVE TIME 16.67m (1000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID16.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gamma /sec	Err % SD	System bkg
1	58.8	53. 60.	7432.	2689.	57.69	5.904E+06	4.1	0
2	66.9	65. 69.	4701.	1108.	65.78	2.111E+06	8.2	0
3	84.7	80. 87.	7713.	685.	83.63	1.007E+06	18.8	0
4	661.9	660. 664.	431.	207.	661.65	3.277E+04	13.3	0
5	779.0	777. 781.	341.	124.	778.88	1.952E+04	19.0	0
6	867.3	865. 870.	295.	74.	867.32	1.161E+04	30.6	0
7	964.1	962. 967.	418.	232.	964.20	3.607E+04	10.6	0
8	1004.9	1003. 1006.	162.	55.	1005.09	8.786E+03	100.0	0
9	1085.9	1083. 1087.	316.	226.	1086.18	3.496E+04	8.9	0
10	1111.9	1109. 1114.	452.	326.	1112.27	5.038E+04	7.4	0
11	1172.9	1167. 1176.	632.	464.	1173.36	7.162E+04	6.1	0
12	1212.3	1208. 1217.	167.	81.	1212.82	1.271E+04	19.7	0
13	1273.8	1269. 1276.	219.	171.	1274.36	2.761E+04	9.8	0
14	1298.9	1297. 1301.	74.	55.	1299.44	8.913E+03	20.2	0
15	1331.9	1328. 1334.	636.	601.	1332.51	9.948E+04	4.3	0
16	1407.1	1404. 1410.	604.	587.	1407.80	1.002E+05	4.2	0
17	1460.0	1454. 1462.	177.	171.	1460.84	2.978E+04	7.9	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 11' Level: W Collim. + 2" Pb, 1/4" Slit

Count date: 11-Aug-1987 at 0:00:00

Count times: REAL TIME 33.33m (2000.0000 seconds)
 LIVE TIME 33.33m (2000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID24.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkgr
1	58.8	52. 62.	10487.	3548.	57.41	1.074E+03	3.9	0
2	67.3	62. 70.	8190.	5893.	65.92	1.529E+03	12.3	0
3	88.0	70. 104.	35911.	4192.	86.67	8.012E+02	14.7	0
4	105.1	104. 107.	3949.	366.	103.82	5.723E+01	23.7	0
5	121.9	120. 124.	8846.	4299.	120.61	5.678E+02	2.9	0
6	244.9	243. 247.	2672.	952.	243.90	6.033E+01	7.0	0
7	344.3	343. 346.	3062.	2368.	343.49	1.149E+02	2.6	0
8	411.2	410. 413.	764.	228.	410.53	9.184E+00	17.8	0
9	444.0	443. 445.	659.	285.	443.41	1.079E+01	11.3	0
10	512.2	509. 514.	799.	164.	511.75	5.547E+00	23.1	0
11	661.8	660. 664.	1935.	1485.	661.65	4.194E+01	3.3	0
12	723.1	718. 728.	1247.	327.	723.10	8.721E+00	14.3	0
13	778.9	777. 780.	1178.	870.	779.01	2.214E+01	4.4	0
14	867.2	863. 871.	997.	294.	867.47	7.057E+00	14.0	0
15	963.8	962. 965.	1298.	1060.	964.28	2.413E+01	3.7	0
16	995.8	995. 997.	254.	110.	996.33	2.461E+00	18.2	0
17	1004.4	999. 1007.	780.	326.	1004.87	7.279E+00	10.8	0
18	1085.3	1083. 1088.	975.	720.	1085.97	1.565E+01	4.9	0
19	1089.2	1088. 1092.	344.	133.	1089.87	2.878E+00	17.8	0
20	1111.4	1107. 1114.	1366.	999.	1112.14	2.153E+01	4.2	0
21	1172.6	1171. 1177.	1538.	1319.	1173.47	2.788E+01	3.2	0
22	1212.1	1207. 1216.	360.	156.	1212.99	3.252E+00	15.3	0
23	1273.4	1271. 1275.	443.	381.	1274.48	7.821E+00	6.1	0
24	1298.1	1296. 1300.	156.	112.	1299.24	2.281E+00	12.6	0
25	1331.3	1329. 1335.	1449.	1398.	1332.51	2.823E+01	2.8	0
26	1406.8	1404. 1410.	1594.	1575.	1408.12	3.119E+01	2.5	0
27	1459.4	1454. 1462.	327.	317.	1460.81	6.192E+00	5.8	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 11' Level: W Collim. + 2" Pb, No Slit (Bkgd.)

Count date: 11-Aug-1987 at 0:00:00

Count times: REAL TIME 33.33m (2000.0000 seconds)
 LIVE TIME 33.33m (2000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID31.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.7	53. 60.	7699.	3295.	57.10	1.004E+03	3.3	0
2	66.8	64. 71.	6801.	1417.	65.21	3.721E+02	8.2	0
3	510.1	509. 511.	258.	103.	509.65	3.490E+00	23.4	0
4	661.8	660. 663.	306.	107.	661.65	3.032E+00	20.9	0
5	778.3	777. 781.	314.	92.	778.40	2.348E+00	25.1	0
6	963.6	962. 966.	367.	195.	964.18	4.449E+00	11.9	0
7	1000.2	999. 1003.	215.	87.	1000.86	1.944E+00	21.3	0
8	1004.3	1003. 1006.	160.	61.	1004.94	1.356E+00	26.5	0
9	1085.0	1083. 1088.	354.	214.	1085.89	4.646E+00	10.4	0
10	1111.1	1110. 1113.	327.	239.	1112.05	5.150E+00	8.5	0
11	1172.1	1170. 1175.	582.	481.	1173.17	1.016E+01	5.4	0
12	1211.9	1208. 1213.	109.	51.	1213.06	1.067E+00	26.9	0
13	1273.1	1271. 1276.	205.	153.	1274.45	3.133E+00	10.5	0
14	1297.7	1294. 1299.	81.	42.	1299.09	8.610E-01	25.9	0
15	1331.0	1329. 1334.	623.	596.	1332.51	1.204E+01	4.3	0
16	1406.2	1403. 1410.	634.	608.	1407.84	1.205E+01	4.2	0
17	1459.1	1453. 1462.	220.	208.	1460.84	4.069E+00	7.3	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec .

Analysis performed by: RJ ARTHUR

Sample: 13' Level: W Collim. + 2" Pb, 1/4" Slit

Count date: 11-Aug-1987 at 0:00:00

Count times: REAL TIME 66.67m (4000.0000 seconds)
 LIVE TIME 66.67m (4000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:effloor.tst

Spectrum from file : DAVID25.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	58.8	52. 60.	12809.	4866.	57.36	7.374E+02	3.0	0
2	66.9	65. 69.	7568.	2013.	65.52	2.630E+02	5.7	0
3	121.8	119. 123.	6869.	651.	120.48	4.304E+01	19.2	0
4	344.1	343. 345.	904.	368.	343.32	8.939E+00	10.3	0
5	510.7	508. 513.	917.	220.	510.22	3.735E+00	18.3	0
6	661.8	656. 663.	1282.	529.	661.65	7.474E+00	8.5	0
7	778.9	777. 780.	693.	367.	778.99	4.665E+00	8.7	0
8	963.5	962. 967.	919.	618.	964.02	7.040E+00	5.7	0
9	1000.7	999. 1003.	341.	93.	1001.34	1.036E+00	26.2	0
10	1004.5	1003. 1005.	273.	128.	1005.07	1.428E+00	16.0	0
11	1085.1	1082. 1088.	755.	468.	1085.89	5.087E+00	6.9	0
12	1111.2	1109. 1113.	801.	594.	1112.08	6.405E+00	5.3	0
13	1172.3	1170. 1174.	946.	785.	1173.24	8.300E+00	4.2	0
14	1273.3	1271. 1275.	366.	291.	1274.52	2.986E+00	7.2	0
15	1297.9	1296. 1301.	176.	105.	1299.18	1.066E+00	15.0	0
16	1331.2	1329. 1334.	966.	907.	1332.51	9.161E+00	3.5	0
17	1406.6	1401. 1409.	1231.	1189.	1408.11	1.177E+01	3.0	0
18	1459.3	1453. 1462.	545.	514.	1460.87	5.026E+00	4.7	0
19	1761.3	1760. 1765.	46.	40.	1763.59	3.619E-01	18.1	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ ARTHUR

Sample: 13' Level: W Collim. + 2" Pb, No Slit (Bkgd.)

Count date: 11-Aug-1987 at 0:00:00

Count times: REAL TIME 33.33m (2000.0000 seconds)
 LIVE TIME 33.33m (2000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID32.ray;0

Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkgd
1	58.8 53. 60.	6070.	2643.	58.23	7.879E+02	3.8	0
2	66.8 66. 69.	3071.	894.	66.25	2.306E+02	8.1	0
3	84.2 82. 88.	5184.	344.	83.70	6.836E+01	29.1	0
4	661.3 660. 664.	241.	83.	661.65	2.334E+00	24.2	0
5	963.3 962. 965.	180.	90.	964.14	2.045E+00	18.3	0
6	1085.0 1084. 1086.	135.	88.	1086.00	1.916E+00	15.3	0
7	1111.0 1109. 1113.	267.	201.	1112.12	4.335E+00	9.1	0
8	1172.2 1171. 1174.	289.	231.	1173.39	4.882E+00	8.1	0
9	1273.0 1269. 1276.	117.	77.	1274.34	1.583E+00	17.2	0
10	1331.1 1329. 1334.	337.	310.	1332.51	6.266E+00	6.1	0
11	1406.3 1404. 1409.	333.	321.	1407.80	6.361E+00	5.8	0
12	1459.0 1453. 1463.	212.	208.	1460.62	4.068E+00	7.1	0

 ++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 18' Level: W Collim., 1/4" Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 2.78h (10000.000 seconds)
 LIVE TIME 2.78h (10000.000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:efffloor.tst

Spectrum from file : DAVID4.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkgc
1	58.7	54. 59.	21857.	8802.	57.82	1.927E+06	2.1	0
2	66.8	63. 69.	21966.	3869.	65.87	7.360E+05	5.2	0
3	84.1	82. 87.	21681.	746.	83.23	1.104E+05	27.7	0
4	344.6	344. 345.	876.	175.	344.09	5.610E+03	22.6	0
5	352.0	351. 355.	1943.	314.	351.51	9.829E+03	19.0	0
6	510.9	507. 514.	2738.	600.	510.58	1.255E+04	11.6	0
7	583.2	582. 585.	1205.	215.	582.94	3.899E+03	21.8	0
8	609.2	607. 613.	1895.	306.	609.01	5.290E+03	19.3	0
9	661.8	659. 663.	2388.	1289.	661.65	2.037E+04	4.6	0
10	723.3	721. 725.	1265.	224.	723.23	3.529E+03	21.4	0
11	778.9	776. 781.	2025.	893.	778.98	1.402E+04	6.3	0
12	867.2	866. 868.	836.	275.	867.39	4.304E+03	13.6	0
13	911.0	910. 913.	810.	176.	911.27	2.748E+03	21.6	0
14	963.9	959. 965.	2417.	1389.	964.15	2.161E+04	4.4	0
15	968.6	968. 969.	387.	104.	968.90	1.990E+03	100.0	0
16	1000.8	1000. 1003.	727.	244.	1001.15	3.790E+03	14.3	0
17	1004.5	1003. 1006.	873.	392.	1004.82	6.087E+03	9.4	0
18	1085.3	1083. 1088.	1876.	1197.	1085.81	1.852E+04	4.2	0
19	1089.3	1088. 1091.	639.	200.	1089.72	3.093E+03	16.4	0
20	1111.7	1109. 1115.	2268.	1540.	1112.20	2.381E+04	3.6	0
21	1119.9	1117. 1121.	620.	144.	1120.42	2.223E+03	23.0	0
22	1172.7	1170. 1175.	2864.	2366.	1173.31	3.649E+04	2.5	0
23	1212.3	1210. 1215.	581.	179.	1212.88	2.810E+03	18.8	0
24	1273.7	1272. 1275.	926.	755.	1274.42	1.219E+04	4.4	0
25	1298.2	1297. 1300.	329.	208.	1298.93	3.397E+03	10.2	0
26	1331.7	1327. 1334.	2848.	2652.	1332.51	4.390E+04	2.1	0
27	1407.0	1403. 1412.	2929.	2819.	1407.89	4.810E+04	2.0	0
28	1459.8	1455. 1462.	1719.	1643.	1460.74	2.862E+04	2.6	0
29	1594.4	1589. 1599.	143.	77.	1595.56	1.407E+03	18.8	0
30	1762.8	1761. 1765.	153.	135.	1764.12	2.605E+03	9.7	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

Analysis performed by: RJ Arthur

Sample: 18' Level: W Collim., No Slit

Count date: 05-Aug-1987 at 0:00:00

Count times: REAL TIME 16.67m (1000.0000 seconds)
 LIVE TIME 16.67m (1000.0000 seconds)

Detector: tst Pos # 0 geometry factor 1.000

Efficiencies and shape parameters from file: vel:effloor.tst

Spectrum from file : DAVID17.ray;0

	Peak channel	Region start end	Gross counts	Net area ++	Energy (keV)	Gammas /sec	Err % SD	System bkg
1	8.3	5. 11.	0.	831.	7.23	1.714E+07	10.9	0
2	58.8	55. 61.	2693.	950.	57.83	2.080E+06	7.0	0
3	67.0	66. 69.	1589.	347.	66.01	6.587E+05	15.3	0
4	83.4	80. 87.	3261.	314.	82.50	4.687E+05	26.6	0
5	661.9	660. 663.	213.	128.	661.65	2.031E+04	13.4	0
6	779.0	776. 781.	193.	89.	778.97	1.392E+04	20.7	0
7	963.9	963. 965.	169.	129.	964.07	2.010E+04	11.2	0
8	1085.3	1083. 1088.	149.	82.	1085.57	1.276E+04	17.8	0
9	1111.8	1109. 1114.	186.	127.	1112.12	1.971E+04	12.3	0
10	1172.8	1170. 1175.	296.	254.	1173.22	3.924E+04	7.2	0
11	1273.8	1272. 1277.	86.	70.	1274.36	1.134E+04	14.4	0
12	1331.9	1330. 1334.	285.	273.	1332.51	4.520E+04	6.3	0
13	1407.1	1404. 1412.	295.	286.	1407.82	4.881E+04	6.1	0
14	1460.0	1455. 1462.	133.	123.	1460.80	2.141E+04	9.7	0

++ Net Peak Area above the Compton Continuum before correction for system background. Values flagged with a * are subsequently corrected for system background before calculation of absolute emission rate (gams/sec).

APPENDIX B

Compilation of Summaries of Data for
Energy-Window and Count Rates for ^{90}Sr Determinations

Table 4. Summary of energy window and count rate data for the ^{90}Sr standard used to determine ^{90}Sr levels in the 1608F building 102 sump. The sum of the net counts in each case is used to provide the ultimate ^{90}Sr level, expressed in pCi/cm². Differences in geometry and counting efficiency between the two counting setups, for floor versus walls, account for the difference in corresponding conversion factors.

Energy Window (keV)	Net Count (3600 s)
250-329 (80 wide)	2591.8
351-415 (65 wide)	837.8
455-649 (195 wide)	904.2
Sum	4333.8

Conversion factor for floor value:

$$[^{90}\text{Sr}] = (67.95 \text{ s-pCi/count/cm}^2) \cdot (\text{Observed net count/s})$$

Conversion factor for wall values:

$$[^{90}\text{Sr}] = (9.63 \text{ s-pCi/count/cm}^2) \cdot (\text{Observed net count/s})$$

Table 5. Summary of energy window and count rate data for determination of ^{90}Sr levels on the floor of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

<u>Energy Window (keV)</u>	<u>Gross Counts (1800 s)</u>	<u>Backgrd Counts</u>	<u>Counts: ^{137}Cs Region</u>	<u>Counts: ^{60}Co Regions</u>	<u>Counts: Eu Regions</u>	<u>Net Counts</u>
250-329 (80 wide)	77889	49622	6857	7260	6359	7792
351-415 (65 wide)	37834	22901	3941	2353	4404	4235
455-649 (195 wide)	69450	46544	5518	5688	9156	2545
Sum	185173	119066	16316	15301	19919	14572

<u>Energy Window (keV)</u>	<u>Net Count (1800 s)</u>	<u>Normalized Net Counts (counts/keV)</u>
250-329 (80 wide)	7792	97.40
351-415 (65 wide)	4235	65.15
455-649 (195 wide)	2545	13.05

Average net counts: 58.54 ± 42.56 count/keV

Relative Standard Deviation = $42.56 / 58.54 = 0.7271$

Absolute ^{90}Sr Level = $(67.95) \cdot (14572 / 1800) = 550$

Absolute Standard Deviation = $0.7271 \cdot 550 = 400$

$$[^{90}\text{Sr}] = 550 \text{ pCi/cm}^2 \pm 400$$

Table 6. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 1-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

Energy Window (keV)	Gross Counts (2000 s)	Backgrd Counts	Counts: ^{137}Cs Region	Counts: ^{60}Co Regions	Counts: Eu Regions	Net Counts
250-329 (80 wide)	86477	73260	2211	5518	4373	1115
351-415 (65 wide)	44594	35850	1271	1789	3029	2656
455-649 (195 wide)	93930	70935	1779	4323	6296	10596
Sum	225001	180045	5261	11630	13698	14367

Energy Window (keV)	Net Count (2000 s)	Normalized Net Counts (counts/keV)
250-329 (80 wide)	1115	13.94
351-415 (65 wide)	2656	40.86
455-649 (195 wide)	10596	54.34

Average net counts: 36.38 ± 20.57 count/keV

Relative Standard Deviation = $20.57 / 36.38 = 0.5654$

Absolute ^{90}Sr Level = $(9.63) \cdot (14367 / 2000) = 69$

Absolute Standard Deviation = $0.5654 \cdot 69 = 39$

$$[^{90}\text{Sr}] = 69 \text{ pCi/cm}^2 \pm 39$$

Table 7. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 3-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

<u>Energy Window (keV)</u>	<u>Gross Counts (2130 s)</u>	<u>Backgrd Counts</u>	<u>Counts: ^{137}Cs Region</u>	<u>Counts: ^{60}Co Regions</u>	<u>Counts: ^{152}Eu Regions</u>	<u>Net Counts</u>
250-329 (80 wide)	65883	58719	1442	3553	2208	-39
351-415 (65 wide)	33213	27099	829	1152	1529	2604
455-649 (195 wide)	68207	55076	1160	2784	3180	6006
Sum	167303	140894	3431	7489	6917	8571

<u>Energy Window (keV)</u>	<u>Net Count (2130 s)</u>	<u>Normalized Net Counts (counts/keV)</u>
250-329 (80 wide)	-39	-0.49
351-415 (65 wide)	2604	40.06
455-649 (195 wide)	6006	30.80

Average net counts: 23.46 ± 21.25 count/keV

Relative Standard Deviation = $21.25 / 23.46 = 0.9057$

Absolute ^{90}Sr Level = $(9.63) \cdot (8571 / 2130) = 39$

Absolute Standard Deviation = $0.9057 \cdot 39 = 35$

$$[^{90}\text{Sr}] = 39 \text{ pCi/cm}^2 \pm 35$$

Table 8. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 9-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

<u>Energy Window (keV)</u>	<u>Gross Counts (2040 s)</u>	<u>Backgrd Counts</u>	<u>Counts: ^{137}Cs Region</u>	<u>Counts: ^{60}Co Regions</u>	<u>Counts: Eu Regions</u>	<u>Net Counts</u>
250-329 (80 wide)	34134	23146	2011	5912	2723	341
351-415 (65 wide)	17389	11004	1156	1917	1886	1427
455-649 (195 wide)	37134	22371	1618	4632	3921	4591
Sum	88657	56520	4785	12461	8531	6359

<u>Energy Window (keV)</u>	<u>Net Count (2040 s)</u>	<u>Normalized Net Counts (counts/keV)</u>
250-329 (80 wide)	341	4.26
351-415 (65 wide)	1427	21.95
455-649 (195 wide)	4591	23.54

Average net counts: 16.59 ± 10.70 count/keV

Relative Standard Deviation = $10.70 / 16.59 = 0.6451$

Absolute ^{90}Sr Level = $(9.63) \cdot (6359 / 2040) = 30$.

Absolute Standard Deviation = $0.6451 \cdot 30 = 19$

$$[^{90}\text{Sr}] = 30 \text{ pCi/cm}^2 \pm 19$$

Table 9. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 11-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

Energy Window (keV)	Gross Counts (2000 s)	Backgrd Counts	Counts: ^{137}Cs Region	Counts: ^{60}Co Regions	Counts: Eu Regions	Net Counts
250-329 (80 wide)	20165	11481	1231	2343	2206	2904
351-415 (65 wide)	10046	5040	708	760	1528	2011
455-649 (195 wide)	21238	11054	991	1836	3176	4182
Sum	51449	27575	2929	4939	6909	9097

Energy Window (keV)	Net Count (2000 s)	Normalized Net Counts (counts/keV)
250-329 (80 wide)	2904	36.30
351-415 (65 wide)	2011	30.94
455-649 (195 wide)	4182	21.45

Average net counts: 29.56 ± 7.52 count/keV

Relative Standard Deviation = $7.52 / 29.56 = 0.2545$

Absolute ^{90}Sr Level = $(9.63) \cdot (9097 / 2000) = 44$

Absolute Standard Deviation = $0.2545 \cdot 44 = 11$

$$[^{90}\text{Sr}] = 44 \text{ pCi/cm}^2 \pm 11$$

Table 10. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 13-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

Energy Window (keV)	Gross Counts (4000 s)	Backgrd Counts	Counts: ^{137}Cs Region	Counts: ^{60}Co Regions	Counts: Eu Regions	Net Counts
250-329 (80 wide)	21182	15188	324	872	1046	3752
351-415 (65 wide)	9756	6146	186	283	724	2417
455-649 (195 wide)	21653	13894	261	683	1506	5309
Sum	52591	35228	772	1837	3276	11478

Energy Window (keV)	Net Count (4000 s)	Normalized Net Counts (counts/keV)
250-329 (80 wide)	3752	46.90
351-415 (65 wide)	2417	37.18
455-649 (195 wide)	5309	27.23

Average net counts: 37.10 ± 9.84 count/keV

Relative Standard Deviation = $9.84 / 37.10 = 0.2651$

Absolute ^{90}Sr Level = $(9.63) \cdot (11478 / 4000) = 28$

Absolute Standard Deviation = $0.2651 \cdot 28 = 7$

$$[^{90}\text{Sr}] = 28 \text{ pCi/cm}^2 \pm 7$$

Table 11. Summary of energy window and count rate data for determination of ^{90}Sr levels at the 18-foot level of the 1608F Building 102 sump. The sum of the net counts is used to provide the ultimate ^{90}Sr levels. The standard deviation associated with the level is based on the variation observed in the net counts in the three energy windows which make up the sum. The background count and the gamma-ray regions are normalized to equal the gross count live time, given in parentheses.

Energy Window (keV)	Gross Counts (10000 s)	Backgrd Counts	Counts: ^{137}Cs Region	Counts: ^{60}Co Regions	Counts: Eu Regions	Net Counts
250-329 (80 wide)	38898	35220	8	1	502	3167
351-415 (65 wide)	20853	18640	5	0	348	1860
455-649 (195 wide)	50453	46260	6	1	723	3463
Sum	110204	100120	19	3	1572	8490

Energy Window (keV)	Net Count (10000 s)	Normalized Net Counts (counts/keV)
250-329 (80 wide)	3167	39.59
351-415 (65 wide)	1860	28.62
455-649 (195 wide)	3463	17.76

Average net counts: 28.65 ± 10.91 count/keV

Relative Standard Deviation = $10.91 / 28.65 = 0.3809$

Absolute ^{90}Sr Level = $(9.63) \pm (8490 / 10000) = 8.2$

Absolute Standard Deviation = $0.3809 \pm 8.2 = 3.1$

$$[^{90}\text{Sr}] = 8.2 \text{ pCi/cm}^2 \pm 3.1$$

APPENDIX C

Archived Listing of GAINSHF Program
and Necessary Compilation Command Files

The following is a listing of the GAINSHF program in archived format. The program itself is written in RATFOR and FORTRAN 77, suitable for processing on a Digital Equipment Corporation (DEC) PDP-11 series minicomputer. The particular archiving program (AR) and the RATFOR preprocessor (RT4) were obtained at little or no charge from the DECUS Program Library (Fall '83 RSX SIG tape), 219 Boston Post Road, BPO2, Marlboro, MA, 01752 (Hensley et al. 1988, reference 3).

The user should note that the '#' symbol is used by both AR and RT4 to precede a string of comment characters on any given line. The '#-h- ' sequence marks a program-module header for the AR archiving program and is followed by various pieces of information, such as number of bytes in the module, date and time of creation, and disk-space usage identifiers. The '%' symbol is used by the RATFOR preprocessor to identify a string that should not be translated by the preprocessor.

The command for unarchiving the modules is, using the AR program installed as ...ARC:

```
ARC -XV GAINSHF.W
```

The executable task image is then created through use of a command file:

```
@GAINSHF.CMD
```

Following creation of the executable image, the directory can be purged of unnecessary files using the following command file:

```
@CLEANUP.CMD
```

```
#-h- gainshf.cad      385 asc 18-aug-88 16:19:25 arthur (richard arthur)
```

```
      Create the GAINS.TSK image from the file in the GAINS.W archive
```

```
      .ENABLE SUBSTITUTION
```

```
      .ENABLE LOWERCASE
```

```
      gainshf.cad
```

```
RATFOR -n gainshf.r >gainshf.for
```

```
F77 gainshf=gainshf
```

```
RATFOR -n tiread.r >tiread.for
```

```
F77 tiread=tiread
```

```
RATFOR -n iosubs.r >iosubs.for
```

```
F77 iosubs=iosubs
```

```
RATFOR -n rddm.r >rddm.for
```

```
F77 rddm=rddm
```

```
F77 rdpol=rdpol
```

```
RATFOR -n ingam.r >ingam.for
```

```
F77 ingam=ingam
```

```
RATFOR -n getnam.r >getnam.for
```

```
F77 getnam=getnam
```

```
RATFOR -n pkfit.r >pkfit.for
```

```
F77 pkfit=pkfit
```

```
RATFOR -n maxval.r >maxval.for
```

```
F77 maxval=maxval
```

```
RATFOR -n gfit.r >gfit.for
```

```
F77 gfit=gfit
```

```
RATFOR -n dnmfit.r >dnmfit.for
```

```
F77 dnmfit=dnmfit
```

```
RATFOR -n linfit.r >linfit.for
```

```
F77 linfit=linfit
```

```
RATFOR -n matinv.r >matinv.for
```

```
F77 matinv=matinv
```

```
RATFOR -n shift.r >shift.for
```

```
F77 shift=shift
```

```
RATFOR -n ratsubs.r >ratsubs.for
```

```
F77 ratsubs=ratsubs
```

```
RATFOR -n output.r >output.for
```

```
F77 output=output
```

```
F77 todm=todm
```

```
F77 wtpol=wtpol
```

```
MCR MAC redund=redund
```

```
TKB @gainshf.bld
```

```
;
```

```
.STOP
```

```
#-h- gainshf.bld      56 asc 17-aug-88 15:21:37 arthur (richard arthur)
```

```
gainshf/id,gainshf/-ap,gainshf=gainshf/ap
```

```
saxbuf=512
```

```
//
```

```
#-h- gainshf.odl      252 asc 17-aug-88 14:49:23 arthur (richard arthur)
```

```
      .ROOT      GAINSHF-REDUND-A-LB: [1,1]SYSLIB/LB:$SHORT-*(C,D,E,F,G,H)
```

```
A:      .FCTR      TIREAD
```

```
C:      .FCTR      IOSUBS-(RDPOL,RDDMN)
```

```
D:      .FCTR      INGAM-GETNAM
```

```
E:      .FCTR      LINFIT-MATINV
```

```
F:      .FCTR      PKFIT-MAXVAL-(GFIT,DMNFIT)
```

```
G:      .FCTR      SHIFT-RATSUBS
```

```
H:      .FCTR      OUTPUT-(TODM,WTPOL)
```

```
      .END
```

```
#-h- gainshf.r      4455 asc 18-aug-88 18:17:57 arthur (richard arthur)
```

```
      Research Scientists initiating code usage:
```

```
      Walter King HENSLEY
```

```
      Richard James ARTHUR
```

```
PROGRAM GAINS
```

```

# This program computes the non-linear gain present in a calibration
# spectrum using a 2-degree (quadratic) polynomial fit.

COMMON/DWN/ ic(8282)
COMMON/OVER/ iovtab(2040)

COMMON /INFO/ nPk, nTerms, Energy(20), PkPos(20,3), dPkPos(20)

COMMON /fittyp/ DMN, POLACK
LOGICAL DMN, POLACK

##
##
VIRTUAL vnorm(8192)
##
##
DIMENSION data(4096)
EQUIVALENCE(data,ic(181))
EQUIVALENCE(gain,ic(39))
EQUIVALENCE(iSplit,ic(93))

### REAL Energy(20), PkPos(20,3)
LOGICAL STD, FIT, OUTCAL

### REAL dPkPos(20)
REAL Z(20)
REAL A(5), dA(5)

BYTE CHAR(8)
LOGICAL iND, iEr

### call TIUNIT
nCalib= 0

repeat
{
# Get the name of the DMN or POLACK spectrum and read in the data
call DATAIN

# Find out if this spectrum is a standard
call TIWRI(' ')
call TIREAD(' Is this a gain-shift calibration standard? (y/n) ',Value,CHAR,nCHAR,iND,iEr)
if (iND) GOTO 999
if (Value .EQ. 1.) # User said 'yes'
{
STD= .TRUE.
nCalib= nCalib +1
}

# Get an idea of where the Std. peaks are and their associated energies
call INQAM(nPk,Energy,Z)

# Get from the user the degree of the fit
call DEGREE( nTerms )

# Estimate the peak centers by fitting a Gaussian through five (5) data pts.
if (nCalib .GT. 2) # Only 2 calibration spectra at any one time
{
Do i=1, nPk
{
PkPos(i,1)= PkPos(i,2)
PkPos(i,2)= 0.
}
}
nCalib= 2 # Reset the counter
}
}

```



```

call TIWRI(' ')
call PKFIT(nPk,Energy,Z)
Do i=1, nPk
{
PkPos(i,nCalib)= Z(i)
dPkPos(i)= 1.
}
}
else
{
# This is NOT a calibration STD
STD= .FALSE.

call TIWRI(' ')
call TIREAD(' Are there internal standard peaks to shift with? ',Value,CHAR,nCHAR,iND,iEr)

if (iND) GOTO 999
if (Value .EQ. 1.) # User said 'yes'
{
# Does the user want to force a fit through given peak-centers?
call TIWRI(' ')
call TIREAD(' Force a calibration fit? (y/n) [Default=N] ',Value,CHAR,nCHAR,iND,iEr)
if (iND) GOTO 999
if (Value .EQ. 1. )
{
call TIWRI(' ')
call INGAM(nPk,Energy,Z)

Do i=1, nPk # Reset calibration peak storage
{
PkPos(i,1)= Z(i)
PkPos(i,2)= 0.
PkPos(i,3)= 0.
dPkPos(i)= 1.
}
nTerms= nPk
}
else # Not a forced calibration fit
{
call TIWRI(' ')
# Get the Std. peaks and their associated energies
call INGAM(nPk,Energy,Z)

# Get from the user the degree of the fit
call DEGREE( nTerms )

call PKFIT(nPk,Energy,Z)
}
}
else # User said NO internal STD, so use calibration STD's to shift with
{
# If (nCalib = 2) we may assume that the user wishes to use
# the averaged value of the calibration spectra peak
# positions.
# Otherwise, us data in CALIB.DAT which has the information
# from the last calibration STD processed.
if (nCalib .EQ. 2) # Use the calibration spectra already processed
{
# Get rid of the oldest calibration STD
Do i=1, nPk
{
PkPos(i,3)= ( PkPos(i,1) +PkPos(i,2) ) /2.
}
nCalib= 3
}
}
}

```

```

    }

# Only one calibration standard was processed previously
else if (nCalib .EQ. 1)
{
    call TIWRI(' ')
    call TIWRI(' Only one standard was processed so it will be used to shift
the data')

    call INCALB( A )
}

# Use an old calibration set since the user has not
# processed a calibration STD.
else if (nCalib .LE. 0)
{
    call TIWRI(' ')
    call TIWRI(' You did not process any calibration standards, so you')
    call TIWRI(' must want to use an old set of calibration results.')
    call TIWRI(' The calibration results used are found in 'CALIB.DAT')

    call INCALB( A )
}

}

# The routine LINFIT will return the coefficients 'A(i)' which will allow
# the RATSUBS routine DAC to convert the spectrum to 1 Kev/chan.

call LINFIT(nPk,Energy,PkPos(1,nCalib),dPkPos,nTerms,A,dA,ChiSq,RSq)

# Set up a file called 'CALIB.DAT' in a form acceptable to the
# program [38,3]PLT to plot residuals vs. gamma-ray energy
if(1STD & (nCalib /= 0))
call RESULT(nPk,Energy,PkPos(1,nCalib),dPkPos,nTerms,A,dA,ChiSq,RSq)

# Now shift the spectrum using the coefficients 'A'
call SHIFT(A,vnorm)

# If we are setting up a calibration curve using a standard, we don't
# need to shift the spectrum
if (STD)
    NEXT

# Now write out the shifted spectrum as a DMN or POLACK spectrum
call OUTPUT

}

999 continue
call EXIT
end

#-h- tired.r 3811 sec 03-jun-85 15:42:22 system
# Research Scientist initiating code usage:
# Richard James ARTHUR

# =====
SUBROUTINE TIUNIT

# This subroutine allows the user to specify an indirect command file
# for input of answers and values to the calling program.

# Usage: RUN xxxxxxxx /COMMAND:'LUN=3 &filename.com'
# where:
# xxxxxxxx = name of task image

```

```

#           LUN = logical unit number to use for indirect command file
#           filename.com = name of file containing indirect commands

COMMON/UNIT/ LUN

BYTE LINE(80)
BYTE FILNAM(30)

LOGICAL LUNOPN

DATA LUNOPN /.FALSE./

# Ignore the rest if a file is already open
if (LUNOPN) GOTO 999

# Get MCR command line of nCHAR characters
call GETMCR(LINE,nCHAR)

# '=' must precede the logical unit no.
# '@' must precede the indirect command filename
iLUN= 0
iFIL= 0
Do i=1, nCHAR
{
if (LINE(i) .EQ. '=') iLUN= i+1
if (LINE(i) .EQ. '@') iFIL= i+1
}

# If we have both pieces of information passed to the program, then use them
if ((iLUN .NE. 0) .AND. (iFIL .NE. 0))
{
100  DECODE(1,100,LINE(iLUN)) LUN
format(i1)

j= 0
Do i=iFIL, nCHAR
{
j= j +1
FILNAM(j)= LINE(i)
}

# OPEN(UNIT=LUN,NAME=FILNAM,STATUS='old')
}

# If no information was passed, then assume default value of LUN=5
if (LUN .EQ. 0)
LUN= 5

LUNOPN= .TRUE.

999  continue

RETURN
END

# =====
#
SUBROUTINE TIREAD(STRING,Value,CHAR,nCHAR,iEnd,iErr)

COMMON/UNIT/ LUN

LOGICAL iEnd, iErr
BYTE STRING(1)
BYTE CHAR(1)

```

```

iEnd= .FALSE.
iErr= .FALSE.
Value= 0.

call TIOUT(STRING)      # print the message

call TIUNIT             # Which UNIT to read from?

READ(LUN,400,end=888) nCHAR,(CHAR(i),i=1,nCHAR)
%400 FORMAT(Q,<nCHAR>A1)

if (LUN .NE. 6)
  {
    WRITE(5,401) (CHAR(i),i=1,nCHAR)
%401   format(' ',<nCHAR>A1)
  }

if (nCHAR .GT. 0)      # was anything typed in?
  {
    call UPPCAS(CHAR,nCHAR)
    if (CHAR(1) .EQ. 'A') Value= 1.      # Affirmative resp.
    if (CHAR(1) .EQ. 'T') Value= 1.      # True response
    if (CHAR(1) .EQ. 'Y') Value= 1.      # Yes response

    Do i=1,nCHAR
      {
        if ((CHAR(i) .GE. '0') .AND. (CHAR(i) .LE. '9')) # Is it a number?
          NEXT
        if (CHAR(i) .EQ. ' ')
          NEXT
        if (CHAR(i) .EQ. '-')
          NEXT
        if (CHAR(i) .EQ. '+')
          NEXT
        if (CHAR(i) .EQ. 'E')
          NEXT
        else GOTO 777      # Not a valid number
      }
    DECODE(nCHAR,500,CHAR,err=777) Value
%500   FORMAT(G<nCHAR>.0)
  }
  GOTO 999

777  iErr = .TRUE.
      RETURN
888  iEnd= .TRUE.

999  RETURN
      END

# =====
#
SUBROUTINE TIWRI(STRING)
  BYTE STRING(1)

  call TIOUT(STRING)      # Write the STRING on the terminal

  WRITE(5,1)              # Skip to the next line on the screen
%1   FORMAT(' ')

  RETURN
  END

# =====
#
SUBROUTINE TIOUT(STRING)
  BYTE STRING(1)

  nCHAR= 0

```

```

repeat      # must be an ASCII string
{
  nCHAR= nCHAR +1
  if (STRING(nCHAR) .EQ. 7) NEXT      # let BELLS thru
  if (STRING(nCHAR) .EQ. 9) NEXT      # let TABs ('11) thru
  if (STRING(nCHAR) .LT. ' ') BREAK
  if (STRING(nCHAR) .GT. ' ') BREAK
}
nCHAR= nCHAR -1

if (nCHAR .GT. 0)      # print anything?
{
  WRITE(6,200) (STRING(i),i=1,nCHAR)
%200  FORMAT('8',<nCHAR>A1)
}

RETURN
END

```

```

# =====
#

```

```

SUBROUTINE UPPCAS(Char,nChar)

BYTE Char(1)

% UpLo= %840      ! Bit pattern converts lower case to upper.

Do i=1,nChar
{
  if ((Char(i).GE.97) .AND. (Char(i).LE.122))
  {
    Char(i)= Char(i) -UpLo
  }
}

RETURN
END

```

```

#-h- iosubs.r      2850  asc 19-aug-88 11:36:02  arthur (richard arthur)

```

```

# =====

```

```

SUBROUTINE DATAIN

```

```

COMMON /fityp/ DMN, POLACK
LOGICAL DMN, POLACK

```

```

BYTE file(30)
LOGICAL gotit

```

```

LOGICAL iND, iEr

```

```

DMN= .FALSE.
POLACK= .FALSE.

```

```

repeat      # get the name of the spectrum & read in the data
{
  call TIWRI(' ')
  call TIREAD(' Enter the name of the spectrum to be gain shifted: ',Value,file,num,iND,iEr)

  if (iND) GOTO 999
  file(num+1) = 0
  if(num .LT. 2) GOTO 999

  call RDPOL(file,gotit)      # try to read in the data
  if (gotit)
  {
    POLACK= .TRUE.
    BREAK
  }
}

```

```

        call RDOMN(file, gotit)
        if (gotit)
        {
            DMN= .TRUE.
            BREAK
        }
        write(5,1400) file
1400      format(' Something is wrong with ',30a1)
    }
until (gotit)

RETURN

999  continue
    call EXIT
    END

# =====

SUBROUTINE RESULT(nDATA,X,Y,dY,nExpon,A,dA,ChiSq,RSq)

REAL A(1), dA(1), X(1), Y(1), dY(1)

%   OPEN(UNIT=2,FILE='calib.dat',STATUS='new')

WRITE(2,1) (A(i),i=1,nExpon), (dA(i),i=1,nExpon)
%1   FORMAT(' ',1P(nExpon)E13.8, 15X, 1P(nExpon)E13.8)

WRITE(2,2) ChiSq, RSq
%2   FORMAT(' CHISQ=',F9.6,' R*2=',F10.7,
%       1      15X,'Energy, Resid., Obsvd., Calcd.')

WRITE(2,3)
%3   FORMAT('          ENERGY (KEV)')

WRITE(2,4)
%4   FORMAT('          RESIDUAL')

    Do i=1, nDATA
    {
        Calcd= A(1) +X(i)*(A(2) +X(i)*A(3))      # Quadratic fit
        Calcd= A(nExpon)
        Do j=(nExpon-1), 1, -1
        {
            Calcd= Calcd+X(i) +A(j)
        }
        Obsvd= Y(i)
        Resid= Obsvd -Calcd
        WRITE(2,5) X(i), Resid, Obsvd, Calcd
%5       FORMAT(' ',4F12.4)
    }

%   CLOSE(UNIT=2,DISPOSE='save')

RETURN
END

# =====

SUBROUTINE INCALB( A )

BYTE CHAR(30)
LOGICAL iND, iER

REAL A(1)

# Read in the last calibration
1  continue

%   OPEN(unit=2,name='calib.dat',type='unknown',

```



```

%      1      form='formatted',access='sequential')

      READ(2,5,end=888) (A(i),i=1,3)
%6      format(1X,3E13.8)

      if (ABS(A(2)) .LT. 1.E-7)
         GOTO 888

      CLOSE(unit=2)

      WRITE(6,7) (A(i),i=1,3)
%7      format(' Calibration parameters used: ',3E17.8)

      RETURN

888      continue
      CLOSE(unit=2)
      call TIWRI(' ')
      call TIWRI(' There are no old calibration data! You must run a')
      call TIWRI(' calibration spectrum first !')
      call EXIT

      call TIWRI(' Enter the desired calibration parameters:')
      call TIREAD(' Zero : ',Value,CHAR,nCHAR,iND,iER)
      if (iND) GOTO 999
      A(1) = Value
      call TIREAD(' Gain : ',Value,CHAR,nCHAR,iND,iER)
      if (iND) GOTO 999
      A(2) = Value
      call TIREAD(' Non-Linearity : ',Value,CHAR,nCHAR,iND,iER)
      if (iND) GOTO 999
      A(3) = Value

      RETURN

999      continue
      call EXIT
      END

$-h- rdpol.ftn      1786 nsc 17-aug-84 09:57:23 system
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C ROUTINE NAME:
C
C      SUBROUTINE RDPOL(FILNAM,GOTIT)
C
C PURPOSE:
C      READS A SPECTRUM IN POLACK FORMAT
C
C CALLED BY
C ROUTINES:
C      598
C
C ROUTINES
C CALLED:
C      NONE
C
C COMMON:
C
C      COMMON/DMM/IC(8292)
C
C ARGUMENTS:
C
C      FILNAM = THE NAME OF THE FILE TO OPEN
C      GOTIT = .TRUE. IF THE SPECTRUM WAS IN POLACK FORMAT
C             ELSE .FALSE.
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C      INTEGER HEADER
C      DIMENSION REL(4998),DATA(128),HEADER(100)
C      EQUIVALENCE( REL(1) , IC(101) )
C      EQUIVALENCE( HEADER,DATA )
C      LOGICAL*1 FILNAM(38)
C      LOGICAL GOTIT
C
C      DON'T COUNT, OR LOG BAD OPENS WHEN DETERMINING WHICH

```

```

C      TYPE OF FILE THE DATA IS IN (POLACK OR DMN)
C
C      CALL ERRSET(44, .FALSE., .FALSE.)
C
C      INITIALIZE GOTIT
C
C      GOTIT = .FALSE.
C
C
C      TRY TO OPEN THE FILE AS POLACK FORMATTED DATA
C
C
C      OPEN UP A 'RAYGUN' TYPE FILE TO READ REAL COUNTS FROM
C      A RANDOM ACCESS FILE, 128 CHANNELS PER RECORD
C
C      OPEN(UNIT=1, NAME=FILNAM, TYPE='OLD', ACCESS='DIRECT', READONLY,
C      1 FORM='UNFORMATTED', RECORDSIZE=128, MAXREC=35, ERR=100,
C      2 BLOCKSIZE=512)
C
C      GOTIT = .TRUE.
C
C      READ(1, ERR=400) DATA      ! THE FIRST RECORD IS THE HEADER
C
C      SAVE THE HEADER SO IT DOESN'T GET CLOBBERED
C
C      DO 50 I=1,100
C          IC(I) = HEADER(I)
50      CONTINUE
C
C      NCHAN = HEADER(4)
C
C      WRITE(6,*) NCHAN
C
C      NREC = NCHAN / 128
C
C      DO 70 I=1, NREC
C          IREC=I + 1              !ADD ONE FOR THE HEADER
C          READ(1, IREC, ERR=400) DATA
C          J = (I - 1) * 128
C          DO 60 K=1, 128
C              REL(J+K) = DATA(K)
60          CONTINUE
70      CONTINUE
C
C      CLOSE(UNIT=1)
100     RETURN
C
C      HAD PROBLEMS READING THE FILE
C
C      WRITE (6,410) FILNAM
400     FORMAT (' CAN'T READ ',30A1, ' AS A POLACK FILE')
410     CALL CLOSE (1)
C      STOP
C      END
#-h- rddmn.r      2972 asc 07-jan-85 13:54:09 system
SUBROUTINE RDDMN(FILE, GOTIT)

COMMON/DMN/ IC(8292)      # named common block for the DMN Format data
COMMON/OVER/ iovtab(2048) # for the overflow table

BYTE FILE(30)            # for the file name
REAL real(4096)
LOGICAL gotit

EQUIVALENCE (real(1), ic(101)) # use the same storage locations

gotit = .FALSE.

```

```

#..... associate logical unit 1 with the file ...

%      OPEN(unit=1,name=file,type='OLD',form='UNFORMATTED',
%      1 access='SEQUENTIAL',err=2000,READONLY)

#..... read the header (it's always 100 integer words long)

      READ(1) (ic(i),i=1,100)
      number = ic(4)      # header(4) is the number of channels
      nover = ic(100)     # header(100) is the number of overflows

#..... close the file

      Close(unit=1)

#..... now reopen it and read the header and the data
#.....      (it's all one record).

%      OPEN(unit=1,name=file,type='OLD',form='UNFORMATTED',
%      1 access='SEQUENTIAL',err=2000,READONLY)

      READ(1) (ic(i),i=1,number+100)

#..... now read any overflows

      if (nover .le. 0) goto 250
      READ(1) (icvtab(i),i=1,nover)

250    call CLOSE(1)

#..... convert to reals

      Do i=number,1,-1
      {
        real(i) = SCOUNT(i+100)
      }

      gotit = .true.

2000   RETURN
      END

# =====

FUNCTION SCOUNT(I)

#
# FUNCTION SUBPROGRAM TO CONVERT INTEGER COUNTS TO REAL COUNTS
#
# INTEGER DATA EXISTS IN TWO CLASSES
#
# CLASS 1: OLD DMN TYPE DATA
#   IF THE SIGN BIT IS SET THEN THE NUMBER MUST BE
#   MULTIPLIED BY -4096 TO GET THE PROPER FLOATING
#   POINT VALUE.
#   IF THE SPECTRUM IS AN OLD TYPE SPECTRUM THEN
#   B(100) WILL BE EQUAL TO ZERO.
# CLASS 2: MOST RECENT TYPE DATA
#   THE DATA IN ARRAY B REPRESENTS POSITIVE COUNTS
#   RANGING FROM 0 TO 65536.
#   IF B(100)=-1 THEN THERE WERE NO CHANNELS WITH
#   MORE THAN 65536 COUNTS.
#   IF B(100) IS GREATER THAN ZERO THEN B(100) IS
#   THE NUMBER OF CHANNELS THAT OVERFLOWED.
#   THE NUMBER OF OVERFLOWS IS IN THE LEFT FOUR BITS
#   AND THE CHANNEL NUMBER OF THE OVERFLOWED CHANNEL
#   IS IN THE RIGHT 12 BITS OF WORDS FOLLOWING THE
#   DATA IN FILE WITH NAME 'DMNSAV.TMP;1'

```

```

INTEGER B

COMMON /DMN/ B(8292)
COMMON /OVER/ IOVTAB(2048)

INTEGER KC(2048)
EQUIVALENCE (KC(1),IOVTAB(1))

SCOUNT=0.                                #INITIALIZE RESULT TO ZERO
IF (B(100).EQ.0)                          #IF OLD DMN DATA CHECK FOR -
{
  X=B(I)                                  #OLD DMN DATA
  IF (X.LT.0.) X=-40.*X                  #IF SIGN BIT ON MULTIPLY BY -40.
  SCOUNT=X                               #SET COUNTS=RESULT AND GO HOME
}
else
{
  YY=B(I)                                #GET LEAST SIGNIFICANT 16 BITS
  IF (B(I).LT.0) YY=32768.-(B(I).AND.*7777) #CONVERT TO POSITIVE No.
  IF (B(100).EQ.-1) GOTO 2000           #IF NO OVERFLOWS FINISH UP
  K=0                                    #SET OVERFLOW COUNTER TO 0
  1010 K=K+1                             #BUMP OVERFLOW
  IF (K.GT.B(100)) GOTO 2000            #SEE IF # OVERFLOW CHANNELS TOO BIG
  JCH=(KC(K).AND.*7777)+101             #FORM THE CHANNEL # +101
  IF (JCH-1) 1010,1020,2000             #IS THIS THE ONE WE NEED?
  1020 YY=65536.+ISHFT(KC(K),-12)+YY    #YES CALCULATE NEW RESULT
  2000 SCOUNT=YY                         #SET COUNTS=RESULT AND GO HOME
}
9999 RETURN
END
#-h- ingam.r      2439 asc 17-aug-88 13:24:08 arthur (richard arthur)
# Research Scientist Initiating code usage:
# Richard James ARTHUR

```

=====

```

SUBROUTINE INGAM(nPts,X,Y)

REAL X(1),Y(1)

BYTE FILNAM(31), Dummy
LOGICAL IND, iEr

call TIWRI(' ')
call TIWRI(' If you already have a file containing the approximate')
call TIWRI(' peak center and the exact gamma-ray energy,')
call TIWRI(' then enter the name of the file. Otherwise, hit')
call TIWRI(' <RETURN> and the program will ask you for the')
call TIWRI(' information.')
call TIWRI(' ')

LUN= 6                                # Read filename from terminal
call GETNAM(FILNAM,LUN,iErr)
if (iErr .EQ. 0)
{
  X
  1 OPEN(UNIT=2,FILE=FILNAM,STATUS='old',READONLY,
        ACCESS='sequential')
  READ(2,10) Dummy
  100 FORMAT(A1)
  Do i=1, 400
  {
    READ(2,*,END=100) X(i), Y(i)
  }
  100 CLOSE(UNIT=2,DISPOSE='save')
  nPts= i-1
}

```

```

else
{
  Do i=1, 488
  {
    call TIWRI(' ')
    call TIREAD(' Approximate channel of peak center? ',Value,FILNAM,nCHAR,iND,iEr)
    if (iND) GOTO 999
    if (nCHAR .EQ. 0) GOTO 888
    Y(i)= Value

    call TIREAD(' Energy of the gamma ray? ',Value,FILNAM,nCHAR,iND,iEr)
    if (iND) GOTO 999
    if (nCHAR .EQ. 0)
    {
      X(i)= Y(i)
    }
    else
    {
      X(i)= Value
    }

    call TIWRI(' ')
  }
888  continue
     nPts= i-1

     call TIWRI(' ')
     call TIREAD(' Do you want to save this data? (Y/N) ',Value,FILNAM,nCHAR,iND,iEr)
     if (iND) GOTO 999
     if (Value .EQ. 1.)
288   {
        continue
        call TIWRI(' ')

        LUN= 5          # Read filename from terminal
        call GETNAM(FILNAM,LUN,iErr)

X      OPEN(UNIT=2,FILE=FILNAM,STATUS='new',
X      1      ACCESS='sequential')

        WRITE(2,1)
X1      FORMAT(' Expected Energy    Obs.Channel')

        WRITE(2,2) (X(j),Y(j),j=1,nPts)
X2      FORMAT(' ',2F15.4)

        ENDFILE 2
X      CLOSE(UNIT=2,DISPOSE='save')
        }

    RETURN

999  continue
     CLOSE(UNIT=6)
     call EXIT
     END

# =====

SUBROUTINE DEGREE( nTerms )

  BYTE CHAR(8)
  LOGICAL iND, iEr

  call TIWRI(' ')
  call TIWRI(' How many terms do you wish to use for the calibrated shift?')
  call TIREAD(' [Default=3, i.e., a zero, a gain, & a non-linearity term] --
',Value,CHAR,nCHAR,iND,iEr)
  if (iND) GOTO 999

```

```

        if (nCHAR .EQ. 0)
            {
                nTerms= 3
            }
        else
            {
                if (Value .LT. 2.) Value= 2.  # Fitting curve must at least be linear (degree of 1)
                nTerms= IFIX(Value)
            }

        RETURN

999  continue
      call EXIT
      END

#-h- getnam.r      5594  asc 17-aug-84 09:58:34  system
#      Research Scientist initiating code usage:
#      Richard James ARTHUR

# N.B.: This code is a modification of one originally written by
#      Gayle S. McNeece

#CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
#
# ROUTINE NAME:
#      SUBROUTINE GETNAM(iFNAME,LUN,iErr)

# PURPOSE:      Gets a FILENAME from terminal (LUN=0 or 5) or
#               some other logical unit (LUN <> 5)

#
# ROUTINES
# CALLED:      NONE
#
# ARGUMENTS:
#
#       {BYTE iFNAME(31)}
#       BYTE iFNAME(1)
#           iFNAME = ARRAY TO STORE RESULTANT FILE NAME IN
#           LUN     = Logical unit no. to get filename from ...
#                   = 0 gets it from TI:
#                   = 5 IF ALL WENT WELL
#                   = 1 IF BLEW IT AND WANT TO MENU
#
#CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      LOGICAL iND, iEr

      BYTE IUC(2),iNAME(40)
      INTEGER iBUF(16)
      EQUIVALENCE (iNAME,iBUF)
      EQUIVALENCE (iBUF(8),IUC(1))

      iErr= 0      #ASSUME A-OK

# TO FORM DEFAULT FILENAME (OR EVEN INPUT FILENAME)
# MUST FIGURE OUT WHICH UIC HE'S WORKING IN
      call GETTSK(iBUF,IDS)

# WORD 7 = Default LOGIN UIC (GROUP, MEMBER)
      IUCM=IUC(2)
      IUCG=IUC(1)
100  ENCODE(30,110,iFNAME) IUCM,IUCG
110  FORMAT('SY0: ',03,' ',03,' ')
      iFNAME(31)=0      #TERMINATING NULL FOR DEFAULT

      if (LUN .EQ. 0) LUN= 5
      if (LUN .EQ. 5)      # Read name from terminal if LUN = 5
          {
              call TIREAD(' File name? ',Value,iNAME,nCHAR,iND,iEr)
              if (iND) GOTO 600      # ^Z ?
          }

```



```

    }
    else
    {
        READ(LUN,1,END=888) nCHAR, (iNAME(i), i=1, nCHAR)
%1      format(4,31A1)
    }

    iPos=1                                #PLACE IN iNAME CURRENTLY SCANNING
    iPosF=31

    # SCAN iNAME FOR PARTS NOT ENTERED
    if (nCHAR .LE. 0) GOTO 200             # goto DEFAULT FILENAME

    # Look for : to see if he entered DEVICE
    DO iLoop=1, nCHAR
    {
        if (iNAME(iLoop) .EQ. ':')        #HAVE UIC
        {
            # The user entered a DEVICE name, so copy it into the FILENAME
            i1B= iLoop                     # Remember where the ':' occurred
            iPos= iPos + iLoop             # Remember where we're pointing
            iPosF= 5                       # Move pointer to end of device space
            if ((iNAME(3) .LT. '0') .OR. (iNAME(3) .GT. '9')) iNAME(3)= '0'
            DO i=1,3
            {
                iFNAME(i)= iNAME(i)
            }
            iFNAME(4)= ':'
            GOTO 130
        }
    }
    GOTO 150                               # no DEVICE so look for UIC.

    # LOOK FOR [ TO SEE IF ENTERED UIC
130    continue
    DO iLoop=1, nCHAR
    {
        if (iNAME(iLoop) .EQ. '[') GOTO 150    #HAVE UIC
    }
    GOTO 200                                #NO UIC

    # FOUND UIC [ -- MAKE SURE ] IS THERE TOO--IF NOT --ERROR
    # ALSO CLEAR OUT iFNAME(5-12) TO REFILL WITH ENTERED UIC
150    continue
    i1B= iLoop +1
    DO i=0,12
    {
        iFNAME(i)= ' '
    }

    # SEARCH FOR ] AND WORK BACKWARDS FROM ] POSITION
    DO iLoop=i1B, nCHAR
    {
        if (iNAME(iLoop) .EQ. ']') GOTO 160
    }

    # IF GOT HERE NO ] -- ERROR
    GOTO 500

160    continue
    iPos= iLoop +1                          #SO KNOW WHERE TO START SCANNING AGAIN
    i2B= iLoop -1                          #WHERE LAST CHAR. WAS BEFORE ]
    iPosF= 12                              #WHERE WORKING IN iFNAME
    DO i=i2B, i1B, -1
    {
        if ((iNAME(i) .LT. '0' .OR. iNAME(i) .GT. '9') .AND. iNAME(i) .NE. ',') GOTO 500
    }
    #ERROR
    if (iNAME(i) .EQ. ',') iPosF= 9
    iFNAME(iPosF)= iNAME(i)
    iPosF= iPosF -1                        #REMEMBER WE'RE WORKING BACKWARDS

```

```

    }

260  CONTINUE
# GOT HERE BY NO UIC OR BY PROCESSING AN ENTERED UIC SO HAVE UIC
  if (iPos .GT. nCHAR)          #STILL MORE CHARACTERS
  {

# RAN OUT OF CHARACTERS--DEFAULT REST OF NAME TO FILE.DAT;1
#   ENCODE(17,285,iFNAME(14))
%285  FORMAT('FILE   .DAT   ')
      iPosF=91
      iErr= 1          # Flag no file name
      GOTO 400
  }

# IF NEXT CHARACTER IS . SAVE 'FILE' AS THE ROOT FILENAME
  iPosF=23
  if (iNAME(iPos) .EQ. '.') GOTO 260

# IF NEXT CHARACTER IS ; SAVE 'FILE.DAT' AS THE ROOT AND EXTENSION
  iPosF=27
  if (iNAME(iPos) .EQ. ';') GOTO 300

# ASSUME HAVE A ROOT OF THE FILENAME
  iPosF=14
  while (iPos .LE. nCHAR)
  {
    if (iNAME(iPos) .EQ. '.' .OR. iNAME(iPos) .EQ. ';') GO TO 230
    if (iNAME(iPos) .NE. ' ')
    {
      iFNAME(iPosF)= iNAME(iPos)
      iPosF= iPosF +1
    }
    iPos= iPos +1
  }

# GOT HERE BECAUSE RAN OUT OF CHARACTERS OR HIT A . OR ;
230  CONTINUE

# IF RAN OUT OF CHARACTERS, STICK ON EXTENSION AND VERSION
  if (nCHAR .GE. iPos) GOTO 260          #STILL CHARACTERS LEFT
  iPosF= 23
  ENCODE(8,240,iFNAME(iPosF))
%240  FORMAT(' .DAT   ')
      iPosF= iPosF +8
      GOTO 400

# HIT HERE IF GOT A . OR ;
250  CONTINUE
  if (iNAME(iPos) .EQ. '.') GOTO 300

# HIT ; -- DEFAULT EXTENSION
  iPosF= 23
  ENCODE(4,260,iFNAME(iPosF))
%260  FORMAT(' .DAT   ')
      iPosF= iPosF +4
      GOTO 350

# HAVE A . -- GET EXTENSION
300  CONTINUE
  iPosF= 23
  while (iPos .LE. nCHAR)
  {
    if (iNAME(iPos) .EQ. ';') GO TO 350          #INTO VERSION
    if (iNAME(iPos) .NE. ' ')          # Remove apaces
    {
      iFNAME(iPosF)= iNAME(iPos)
      iPosF= iPosF +1
    }
  }

```

```

        iPos= iPos +1
    }

# IF HIT HERE RAN OUT OF CHARACTERS -- ADD VERSION
    iPosF= 27
    ENCODE(4,320,iFNAME(iPosF))
%320  FORMAT(' ',iPosF)
    iPosF= iPosF +4
    GOTO 400

# HAVE EXTENSION -- INTO VERSION
350  CONTINUE
    iPosF= 27
    iFNAME(iPosF)=', '
    iPos= iPos +1
    iPosF= iPosF +1
360  if (iFNAME(iPos) .LT. '0' .OR. iFNAME(iPos) .GT. '9') GOTO 500
    iFNAME(iPosF)= iFNAME(iPos)
    iPos= iPos +1
    iPosF= iPosF +1
    if (iPos .LE. nCHAR) GOTO 360
    GOTO 400                                #HAVE IT

# CHECK TO MAKE SURE THIS IS A LEGAL FILENAME--OPEN IT WITH TYPE
# UNKNOWN, DISPOSE=DELETE
400  CONTINUE

# NULL FILL LEFT OVER PART OF NAME
    if (iPosF .EQ. 31) GOTO 420
    DO 410 i= iPosF,31
%410  iFNAME(i)= ' '
420  CONTINUE
    iFNAME(31)= #

# Convert all characters in filename to UPPER CASE
    call UPPCAS(iFNAME,30)
#% OPEN(UNIT=1,NAME=iFNAME,TYPE='old',DISPOSE='save',
#% 1      ERR=500)      !ERROR DOESNT WORK--GET INSTR TRAP--BOO
# CLOSE(UNIT=1)      #ASSUME A-OK
    RETURN

# ERROR ON FILENAME
500  CONTINUE
    WRITE(5,510)
510  FORMAT(' BAD FILENAME--TRY AGAIN')
    GOTO 100

# HIT END OF FILE ON NAME
600  CONTINUE
    CLOSE(UNIT=5)
    call EXIT

```

END

#-h- pkfit.r 1119 asc 18-aug-88 18:19:22 arthur (richard arthur)

= = = = =

SUBROUTINE PKFIT(nPk,Energy,Z)

COMMON/DWN/ ic(8202)

DIMENSION data(4000)

EQUIVALENCE(data,ic(101))

LOGICAL RLB

Flag if the user is R.L. Brodzinski

DIMENSION iBuf(10)

```

        BYTE IUC(2)
        EQUIVALENCE (IBUF(16),IUC(1))

        REAL Energy(1)
        REAL Z(1)

# Must figure out which UIC user is working in
    call GETTSK(iBuf,ids)

# WORD 17 = login UIC (group,member)
    RLB=.FALSE.
# if (IUC(2) .EQ. '136') RLB=.TRUE.      ! User Ron L. Brodzinski!

### if (.NOT.RLB) call TIWRI(' User is NOT R.L. Brodzinski!')
### if (RLB) call TIWRI(' User IS R.L. Brodzinski!')

    Do i=1, nPk
    {
        ns = IFIX(Z(i)) -15
        ne = ns + 38
        call MAXVAL(ns,ne,jmax,ymax,data)

        if (RLB)      # Use GFIT if R.L. Brodzinski
        {
            call GFIT(jmax,Z(i),pkht,5,data)
            call GFIT(jmax,Z(i),pkht,Pkwid,5,data)
            Z(i)= Z(i) +1 # Correct for data starting in channel 0
        }

        else
        {
            fmax= jmax
            call DMFIT(fmax)
            Z(i)= fmax
        }

        write(5,2888) Energy(i), Z(i)
2888      format(' The centroid of the ',f10.4,' keV peak is at ',f10.4)
###      dZ(i)= 1.
    }

    RETURN
    END

#-h- maxval.r      783 sec 29-aug-84 16:58:08 system
    subroutine maxval(ns,ne,jmax,ymax,y)

# this routine returns the position and value of the maximum
# value in a group of data points from ns to ne inclusive.

    dimension y(1)

    ymax = 0.
    do i = ns,ne
    {
        if (y(i) > ymax)
        {
            ymax = y(i)
            jmax = i
        }
    }

# This algorithm uses a weighted average to estimate the peak center.
# (This particular method is more accurate for broad peaks which
# are suffering from poor counting statistics.)

    Sum= 0.
    Wtotal= 0.
    Do i=ns+10, ns+10

```

```

    {
      Wt= y(i)
      Sum= Sum +Wt *FLOAT( i )
      WTotal= WTotal +Wt
    }

    if (jmax .LE. 16)      # Does poor counting statistics justify using weighted average?
    {
      jmax= IFIX( 0.5 +Sum /WTotal )
    }

    RETURN
  END
#-h- gfit.r      1889  sec 28-aug-84 19:03:36  system
      subroutine gfit(l,pkpos,pkht,nch,y)
###      subroutine gfit(l,pkpos,pkht,pkwid,nch,y)

#      fit the channel location and determine
#      peak height by fitting the top of the
#      peak to a gaussian.

      dimension y(2),t(9)

      nChan= nch
      nLoop= 0      # if we have to try extra pts.
50      continue

      sy = 0.
      sxy = 0.
      lx = -nChan/2-1
      is = 1+lx
      do i = 1,nChan
      {
        tv = y(is+i)
        ylog = 0.
        if (tv > 1.)
          ylog = alog(tv)
        sy = sy+ylog
        sxy = sxy+(lx+i)*ylog
        t(i) = ylog
      }
      a0 = sy/nChan
      if (nChan < 7)      # use the 5 point fitting routine
      {
        a1 = sxy/10
        a2 = (2*(t(1)-t(3)+t(5))-t(2)-t(4))/14
        c = 2
      }
      else if (nChan == 7)  # use the 7 point fitting routine
      {
        a1 = sxy/28
        a2 = (5*(t(1)+t(7))-3*(t(3)+t(5))-4*t(4))/84
        c = 4
      }
      else      # use the 9 point fitting routine
      {
        a1 = sxy/60
        a2 = 28*(t(1)+t(9))+7*(t(2)+t(8))-8*(t(3)+t(7))
        a2 = (a2-17*(t(4)+t(6))-28*t(5))/924
        c = 28./3
      }
      v = a1/a2/2      # Take derivative of quadratic, set equal to zero, and solve for x (pkpos)
      pkpos = 1-v
      pkht = exp(a0-c*a2-a1*v/2)

      if ((v .GT. 2.) .OR. (a2 .GE. 0.))      # pkpos too far off or parabola is not peak shaped
      {
        if ((nLoop .EQ. 0) .AND. (nChan .LT. 9))      # Try more pts.
        {
          nLoop= nLoop +1

```

```

        nChan= nChan +2
        sy= 0.
        if (sy .EQ. 0.) GOTO 50      # Dummy 'if' to satisfy FORTRAN77
    }
else      # Use weighted ave. for peak center
    {
        Sum= 0.
        WTotal= 0.
        Do i=(1-nChan/2), (1+nChan/2)
            {
                Wt= y(i)
                Sum= Sum +Wt *FLOAT( i )
                WTotal= WTotal +Wt
            }
        pkpos= IFIX( 0.5 +Sum /WTotal )
    }
}

#### Zimmerman transform to determine width of fitted peak
#### y1= a0 -a1*(v-2.) +a2*(v-2.)**2
#### y2= a0 -a1*(v) +a2*(v)**2
#### y3= a0 -a1*(v+2.) +a2*(v+2.)**2

#### pkwid= SQRT( 4./(y2/y3 -y1/y2) )
#### pkwid= SQRT(8. *ALOG(2.)) *pkwid      # Return width as FWHM

return
end

```

#-h- denfit.r 1094 mac 04-apr-85 14:35:00 arthur (richard arthur)

= = = = =

```

SUBROUTINE DMNFIT(PkPos)
#
# This subroutine uses the DMN algorithm for fitting a parabola to
# the LOG of 5 data points to determine a value for the peak center
#
COMMON /DMN/ ic(6292)      # spectral data

REAL counts(4096)
EQUIVALENCE (counts,ic(101))

REAL t(5)

iCHAN = IFIX( PkPos ) -2
Do indx=1, 5
    {
        t(indx)= 1.
        test= counts( iCHAN +indx )
        if (test .GT. 1.) t(indx) = ALOG(test)
    }

sy = t(1) + t(2) + t(3) + t(4) + t(5)
sxy = t(1) + 2.*t(2) + 3.*t(3) + 4.*t(4) + 5.*t(5)
sx2y = t(1) + 4.*t(2) + 9.*t(3) + 16.*t(4) + 25.*t(5)
a1 = -3.*sy + 2.671428571*sxy - 0.4285714286*sx2y
a2 = 0.5*sy - 0.4285715286*sxy + 0.071428571*sx2y

# if (ABS(a2*500.) .GE. ABS(a1)) cen = -a1/(2.*a2)

# Value for 'cen' must stay within the channels examined, i.e.,
# 0. <= (cen===-a1/(2*a2) <= 5.
#
# which is equivalent to { a1/a2 (= 0. ) .AND. (a1 <=|10*a2|)

```



```

EXTERNAL F

FLAG= .FALSE.

DO i=1, nMODEL
  {
    A(i)= 0.
    dA(i)= 0.
  }

CHISQR= 0.
RSQ= 0.

if (nDATA .LE. 0)
  RETURN

if (nDATA .EQ. 0)
  {
    A(1)= Y(1)
    RETURN
  }

#.....Accumulate weighted sums

WMean= 0.D0
DO i=1, nDATA
  {
    WMean= WMean +WEIGHT(dY(i))
  }
WMean= WMean /DFLDAT( nDATA )

#.....Calculate the G vector

DO K=1, NMODEL
  {
    G(K) = 0.D0
    DO I=1, NDATA
      {
        Wt = WEIGHT(dY(i)) /WMean
        G(K) = G(K) + Wt *DBLE(Y(I)) *F(K,X(I))
      }
    }
}

#.....Calculate the H matrix

DO K=1, NMODEL
  {
    KK = (K-1)*NMODEL
    DO J=1, NMODEL
      {
        JK = J+KK
        H(JK) = 0.D0
        DO I=1, NDATA
          {
            Wt = WEIGHT(dY(i)) /WMean
            H(JK) = H(JK) + Wt *F(J,X(I)) *F(K,X(I))
          }
        }
      }
    }
}

#.....Invert H in place

call MATINV (H, NMODEL, DET)

#.....Compute parameter values

DO K=1, NMODEL
  {
    DUMMY = 0.D0
    KK = (K-1)*NMODEL

```

```

        DO J=1, NMODEL
        {
        DUMMY = DUMMY + G(J) *H(J*KK)
        }
        P(K) = DUMMY
    }

#.....Compute parameter uncertainties

    CHISQ = 0.
    DO I=1, NDATA
    {
        FIT = 0.
        DO J=1, NMODEL
        {
            FIT = FIT + SNGL( P(J) *F(J,X(I)) )
        }
        Wt = WEIGHT(dY(i)) /WMean
        CHISQ = CHISQ + SNGL( Wt ) *(Y(I)-FIT)**2
    }

#.....Compute chi-squared per degree of freedom

    if (nMODEL .LT. nDATA)
        CHISQR = CHISQ *WMean /FLOAT(NDATA-NMODEL)
    else
        CHISQR= 0.      # Perfect fit if nDATA = nMODEL

    DO i=1, nDATA
    {
        if (dY(i) .NE. 1.) FLAG= .TRUE.
    }

    if (FLAG)
    {
        Varnc= 1.D0 /WMean
    }
    else
    {
        Varnc= DBLE( CHISQR )
    }

    DO K=1, NMODEL
    {
        sX= 0.D0
        sXX= 0.D0
        DO i=1, nDATA
        {
            Wt = WEIGHT(dY(i)) /WMean
            sX= sX +Wt *F(k,X(i))
            sXX= sXX +Wt *F(k,X(i))
        }
        SigmaX= sXX -sX*sX/DFLOAT(nDATA)
        if (SigmaX .LT. 0.D0) SigmaX= 0.D0
        SigmaX= DSQRT( SigmaX /DFLOAT( nDATA-1 ) )
        if (SigmaX .EQ. 0.D0) SigmaX= 1.D0

        dA(K) = SQRT( SNGL( DABS( H(K*(K-1)+NMODEL) *Varnc ) /DFLOAT(nDATA-1) /SigmaX**2 ) )
    }

#.....Compute coefficient of multiple determination

    sY= 0.D0
    sYY= 0.D0
    DO i=1, nDATA
    {
        Tmp= DBLE( Y(i) )
        sY= sY +Tmp
        sYY= sYY +Tmp*Tmp
    }

```

```

      AG= 0.D0
      DO j=1, nMODEL
      {
        AG= AG +P(j) *Q(j)
      }

      Pts= DFL0AT( nDATA )
      denom= sYY -sY*sY/Pts
      if (denom .EQ. 0.)
      {
        RSQ= 1.
      }
      else
      {
        RSQ= (AG -sY*sY/Pts) /denom
      }

      DO j=1, nMODEL
      {
        A(j)= SNGL( P(j) )
      }

      RETURN
      END

# =====
      DOUBLE PRECISION FUNCTION WEIGHT(dY)

# This FUNCTION returns the value to use for weighting based on the
# uncertainty which the user has specified in dY

      if (dY .EQ. 0.) dY= 1.

      WEIGHT= 1.D0/ DBLE( dY**2 )

      RETURN
      END

# =====
      DOUBLE PRECISION FUNCTION F(i,x)

# This is a user-defined function as required by the [30,1]FIT.W package
# for the fit of a linear model.

# This particular function is general for a polynomial fit to the data.

# F= x**(i-1)          # Single precision statement

      F= 1.D0
      if (i .EQ. 1) RETURN

      Do j=1, (i-1)
      {
        F= F *DBLE(x)
      }

      RETURN
      END

#-h- matinv.r      3737 asc 17-aug-84 09:59:24 system
      SUBROUTINE MATINV (ARRAY, NORDER, DET)

#
#*****
#      Inverts the symmetric double precision matrix ARRAY of degree *
#      NORDER and calculates its determinant DET *
#*****

```

```

#
# DESCRIPTION OF PARAMETERS
#   ARRAY - Input matrix which is replaced by its inverse.
#           Note: original matrix is lost.
#   NORDER - Degree of matrix (order of determinant).
#   DET - Determinant of input matrix.
#
# RESTRICTIONS
#   To use this routine for matrices of degree > 20, the
#   of the variables IK and JK below must be increased to
#   the desired degree.
#
# PROGRAMMER
#   Robert Walraven
#   Department of Applied Science
#   University of California
#   Davis, CA 95616
#   (916) 752-8388
#
#*****
#
#   INTEGER*2 IK(20), JK(20)
#   DOUBLE PRECISION ARRAY(1), AMAX, SAVE
#
#-----
#
#   DET = 1.
#
#----- Main loop begins here -----
#
#   DO 130 K=1, NORDER
#       AMAX = 0D0
#       KK = (K-1)*NORDER
#
#----- Find the largest element ARRAY(I,J) in the rest of the matrix --
#
#   10   CONTINUE
#
#       DO 30 I=K, NORDER
#           DO 20 J=K, NORDER
#               JJ = (J-1)*NORDER
#               IF (DABS(AMAX) .GT. DABS(ARRAY(I+JJ))) GO TO 20
#               AMAX = ARRAY(I+JJ)
#               IK(K) = I
#               JK(K) = J
#           20   CONTINUE
#       30   CONTINUE
#
#----- Interchange the rows and columns to put AMAX in ARRAY(K,K) -----
#
#       IF (AMAX .NE. 0D0) GO TO 40
#       DET = 0.
#       RETURN
#
#   40   I = IK(K)
#       IF (I .LT. K) GO TO 10
#       IF (I .EQ. K) GO TO 60
#
#       DO 50 J=1, NORDER
#           JJ = (J-1)*NORDER
#           SAVE = ARRAY(K+JJ)
#           ARRAY(K+JJ) = ARRAY(I+JJ)
#           ARRAY(I+JJ) = -SAVE
#       50   CONTINUE
#
#   60   J = JK(K)
#       IF (J .LT. K) GO TO 10
#       IF (J .EQ. K) GO TO 80
#
#       JJ = (J-1)*NORDER

```

```

DO 70 I=1, NORDER
  SAVE = ARRAY(I+KK)
  ARRAY(I+KK) = ARRAY(I+JJ)
  ARRAY(I+JJ) = -SAVE
70 CONTINUE
#
80 CONTINUE
#
----- Accumulate the elements of the inverse matrix in ARRAY -----
#
DO 90 I=1, NORDER
  IF (I .NE. K) ARRAY(I+KK) = -ARRAY(I+KK) / AMAX
90 CONTINUE
#
DO 110 I=1, NORDER
  DO 100 J=1, NORDER
    IF (I.EQ.K .OR. J.EQ.K) GO TO 100
    JJ = (J-1)*NORDER
    ARRAY(I+JJ) = ARRAY(I+JJ)
    * ARRAY(I+KK)*ARRAY(K+JJ)
100 CONTINUE
110 CONTINUE
#
DO 120 J=1, NORDER
  JJ = (J-1)*NORDER
  IF (J .NE. K) ARRAY(K+JJ) = ARRAY(K+JJ) / AMAX
120 CONTINUE
#
  ARRAY(K+KK) = 1./AMAX
  DET = DET * AMAX
130 CONTINUE
#
===== End of main loop =====
#
----- Restore the ordering of the matrix -----
#
DO 170 L=1, NORDER
  K = NORDER - L + 1
  KK = (K-1)*NORDER
  J = IK(K)
  IF (J .LE. K) GO TO 150
#
  JJ = (J-1)*NORDER
  DO 140 I=1, NORDER
    SAVE = ARRAY(I+KK)
    ARRAY(I+KK) = -ARRAY(I+JJ)
    ARRAY(I+JJ) = SAVE
140 CONTINUE
#
150 CONTINUE
#
  I = JK(K)
  IF (I .LE. K) GO TO 170
#
  DO 160 J=1, NORDER
    JJ = (J-1)*NORDER
    SAVE = ARRAY(K+JJ)
    ARRAY(K+JJ) = -ARRAY(I+JJ)
    ARRAY(I+JJ) = SAVE
160 CONTINUE
#
170 CONTINUE
#
-----
#
  RETURN
END
#-b- shift.r      1055 aac 10-aug-88 11:30:55 arthur (richard arthur)
# = = = = =

```

```

SUBROUTINE SHIFT(A,vnorm)
COMMON/DMM/ ic(8192)

##
##
VIRTUAL vnorm(1)
##
##
DIMENSION data(4096)
EQUIVALENCE(data,ic(101))
EQUIVALENCE(gain,ic(39))

REAL A(1)

BYTE CHAR(8)
LOGICAL ind, iEr

# Save the observed GAIN and ZERO
### fGAIN= 1. /A(2)
### fZERO= -A(1) /A(2)

# See what gain the user wants to shift to
call TIWRI(' ')
call TIREAD(' Use a gain other than 1.0 ? (y/n) ',Value,CHAR,nCHAR,ind,iEr)
if (ind) GOTO 999
if (Value .EQ. 1.)      # got the value of the new gain
{
  call TIWRI(' ')
  call TIREAD(' Gain: ',Value,CHAR,nCHAR,ind,iEr)
  if (ind) GOTO 999
  if (Value .GT. 0.) gain= Value

  call TIREAD(' Zero: ',Value,CHAR,nCHAR,ind,iEr)
  if (ind) GOTO 999
  zero = Value
}

# Adjust the coefficients to give us the appropriate gain
factor= 1. /gain      # Adjust the observed GAIN to give the desired gain
Do i=2, 6
{
  A(i)= A(i) /factor**(i-1)
}
}

# Make sure we don't exceed the bounds of our data storage array
nchan = ic(4)
Emax = ENRGY(FLDAT(nchan),A) -1.

if (Emax .GT. 8192.) Emax = 8192.      # limit the range to 8 MeV

# Now we're ready to call the digital to analog converter
# and then write the data out to a scratch array

vnorm(1) = data(1)      # channel zero = live time
vnorm(2) = data(2)      # channel one = real time

Do i=3, 8192
{
  jj=i-1      # Skip CHAN 0 and CHAN 1; start at 2 kev
  call DAC(data,jj,value,A,Emax)
  vnorm(i) = value
}

# Copy the shifted spectrum to the output array
gain1= 1.      # Allow only the zero to change now
call ADC(gain1,zero,vnorm,data,nchan)

```

```

999  continue
      RETURN
      END
#-h- ratsubs.r      4894  asc  19-aug-88 11:37:38  arthur (richard arthur)
# =====

```

```

      subroutine ADC(gain,zero,data,chan,Nchan)

```

```

#       Provides variable gain and zero for normalized
#       gamma ray spectra
#       Input data is in the DATA array
#       Output data is in the CHAN array

```

```

      virtual data(1)

```

```

      dimension chan(1)

```

```

      Emax= (zero +0.5) +gain *(FLOAT(Nchan) +0.5)

```

```

      zsave= zero

```

```

      zero= zero -0.5

```

```

      for(ich=3; ich<Nchan; ich=ich+1)

```

```

#       {
#       E= (zero -0.5) +gain *(FLOAT(ich) +0.5)
#       E= (zero +0.5) +gain *(FLOAT(ich) +0.5)
#       E= zero +gain *(FLOAT(ich) +0.5)
#       Elo= E -0.5*gain
#       if(Elo <1) next
#       Ehi= E +0.5*gain
#       if(Ehi > Emax)
#       {
#         chan(ich)= 0.
#         next
#       }
#       intE= int(Elo)
#       if(Ehi <= intE +1)
#         chan(ich)= gain *data(intE)
#       else
#       {
#         fract= 1. - (Elo - intE)
#         chan(ich)= fract *data(intE)
#         intE= intE +1
#         fract= Ehi - intE
#         while(fract > 1.)
#         {
#           chan(ich)= chan(ich) +data(intE)
#           intE= intE +1
#           fract= Ehi -intE
#         }
#         chan(ich)= chan(ich) +fract *data(intE)
#       }
#     }
      zero= zsave

      return
      end

```

```

# =====

```

```

      subroutine DAC(chan,ien,data,A,Emax)

```

```

#       Normalize spectra with arbitrary gain A zero
#       to 1.0 keV/ch w/zero offset

```

```

      dimension chan(1)

```

```

      REAL A(1)      # Calibration coefficients

```

```

      Energy= FLOAT( ien ) +1.0

```



```

ene= Energy
if(en > Emax)
{
    data= 0.
    return
}

Clo= A(1) +ene*(A(2) +ene*A(3))
if(Clo < 3.)
{
    data= 0.
    return
}
ene= Energy +1.
Chi= A(1) +ene*(A(2) +ene*A(3))

intClo= int(Clo)
intChi= int(Chi)
data= 0.

# For the case where a fraction of the previous channel is within the energy window
if((intChi -intClo) .GE. 1)
{
    Ef= ENRGY(FLOAT(intClo+1),A)
    Ei= ENRGY(FLOAT(intClo),A)
    Ebar= (Ef +Ei) /2.
    delE= Ef -Ei
    delC= (A(2) +2.*A(3)*Ebar)*delE
    Densty= delC *chan(intClo)
    Densty= chan(intClo)
    fract= FLOAT(intClo+1) -Clo
    data= fract *Densty
    Clo= intClo +1
    intClo= Clo
}

# For the case where one (or more) entire channel is within the energy window
while((intChi -intClo) .GE. 1)
{
    Ef= ENRGY(FLOAT(intClo+1),A)
    Ei= ENRGY(FLOAT(intClo),A)
    Ebar= (Ef +Ei) /2.
    delE= Ef -Ei
    delC= (A(2) +2.*A(3)*Ebar)*delE
    Densty= delC *chan(intClo)
    Densty= chan(intClo)
    fract= 1.
    data= data +fract *Densty
    Clo= intClo +1
    intClo= Clo
}

# For the case where only a fraction of the higher channel is within the energy window
if((intChi -intClo) .EQ. 0)
{
    Ef= ENRGY(FLOAT(intChi+1),A)
    Ei= ENRGY(FLOAT(intChi),A)
    Ebar= (Ef +Ei) /2.
    delE= Ef -Ei
    delC= (A(2) +2.*A(3)*Ebar)*delE
    Densty= delC *chan(intChi)
    Densty= chan(intChi)
    fract= Chi -Clo
    data= data +fract *Densty
}

return
end

```

```

# = = = = =

```

```

FUNCTION ENRGY(Channl,P)
# This function is used to solve for energy in a quadratic equation
# when given the channel number.

REAL P(3)
DOUBLE PRECISION A, B, C, DISCRM, Y

A= DBLE( P(3) )
B= DBLE( P(2) )
C= DBLE( P(1) )
Y= DBLE( Channl )

if (P(3) .EQ. 0.)          # Linear or quadratic?
{
  ENRGY= SNGL( (Y -C) /B )      # Linear function
}
else
{
  DISCRM= DSQRT( B*B -4.00*A*(C-Y) )
  ENRGY= SNGL( (DISCRM -B) /(2.00*A) )
}

RETURN
END

# = * * * * *

subroutine parse(line,length,n,args)

implicit integer(a-z)
byte line
real args
logical delim,inarg

dimension line(1),args(1)

narg= 0
inarg= .false.

# make sure the line ends with a blank

eol= length +1
line(eol)= ' '

# find the delimiters & decode the line

for(j=1; j .le. eol; j=j+1)
{
  if(delim(line,j) .and. .not. inarg) next
  else if(.not. delim(line,j) .and. .not. inarg)
  {
    inarg= .true.
    start= j
    number= 1
  }
  else if(.not. delim(line,j) .and. inarg)
    number= number +1
  else
  {
    narg= narg +1
    decode(number,1000,line(start),err=600) args(narg)
    inarg= .false.
  }
}
if(narg .ne. n)
{

```

```

        write(5,1100) narg,n
        write(5,1200) (line(i),i=1,length)
        n= -narg
    }
    return

500  write(5,1200) (line(i),i=1,length)
    n= -1
    return

1000 format(f7.0)
1100 format(//,' found',i3,' arguments insted of the',i3,' expected')
1200 format(' problems decoding the line ',/,1x,132a1)
    end

# = = = = =

    logical function delim(line,index)

    implicit integer(a-z)
    byte line
    dimension line(1)

    delim= .false.

    if(line(index) .eq. ' ') delim= .true.           # space
    else if(line(index) .eq. ',') delim= .true.       # comma
    else if(line(index) .eq. 9) delim= .true.          # tab
    else if(line(index) .eq. ':') delim= .true.        # colon
    else if(line(index) .eq. '/') delim= .true.        # slash

    return
end
#-h- output.r      559 asc 18-aug-88 18:28:58 arthur (richard arthur)

# = = = = =

    SUBROUTINE OUTPUT(A,vnorm)

    COMMON/DMM/ ic(8292)

    ##
    ##
    VIRTUAL vnorm(1)
    ##
    ##
    DIMENSION data(4096)
    EQUIVALENCE(data,ic(101))

    BYTE CHAR(8)
    LOGICAL iND, iEr

    # Go write it out

    call TIWRI(' ')
    call TIREAD(' Write the data in POLACK format ? (y/n) ',Value,CHAR,nCHAR,iND,iEr)
    if (iND) GOTO 999
    call TIWRI(' ')
    if (Value .EQ. 1.)
        call WTPOL
    else
        {
            nchan= ic(4)
            Do i=3, nchan
                {
                    data(i)= ANINT( data(i) )
                }
            }
        call TODMM
    }

```

```

    }
999  continue
    RETURN
    END
#-h- wtpol.ftn      1572  msc  03-jun-85 15:38:09  system
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C  ROUTINE NAME:
C
C      SUBROUTINE WTPOL
C
C  PURPOSE:
C      CONVERT SPECTRAL DATA IN REAL FORMAT TO THE
C      POLACK'S FORMAT INORDER TO HANDLE NEGITIVE NUMBERS
C
C  COMMON:
C
C      COMMON/DWN/IC(8202)
C
C  ARGUMENTS:
C      NONE
C
C  FILES:
C      NONE
C
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
CCC  DIMENSION REL(4096),FILE(27),DATA(128)
      DIMENSION REL(4096),DATA(128)
      INTEGER HEADER(100)
      EQUIVALENCE (REL(1),IC(101))
      EQUIVALENCE (HEADER,DATA)
C
      BYTE FILE(27)
      LOGICAL ind,ier
C
C
C      THE FIRST STEP IS TO GET THE DATA TO BE CONVERTED
C
C
C      THE DATA IS ALREADY IN COMMON *IC(8202)* HA HA
C
C
C
C      GET THE FILE NAME AND
C      WRITE THE DATA OUT IN "POLISH" FORMAT
C
C
      call TIREAD(' Enter filename for the POLACK output: ',
1         Value,FILE,nCHAR,ind,ier)
      if (ind) GOTO 1100
      FILE(nCHAR+1) = 0
      if (nCHAR .EQ. 0) GOTO 1000
C
C
C      OPEN UP RAYGUN TYPE FILE TO WRITE REAL COUNTS TO
C      RANDOM ACCESS FILE, 128 CHANNELS PER RECORD
C
C
      OPEN(UNIT=1,NAME=FILE,TYPE='new',ACCESS='direct',
1 FORM='unformatted',RECORDSIZE=128,MAXREC=33,ERR=2000)
C
C
      DO 850 I=1,100
          HEADER(I) =IC(I)
850  CONTINUE
C
C
      WRITE(1'1)DATA      !WRITE THE DATA AS THE FIRST RECORD
C
      NCHAN = HEADER(4)
      NREC = NCHAN / 128

```

```

C      DO 1000 I=1,NREC
          J = (I - 1) * 128
          DO 900 K=1,128
              DATA(K) = REL(J+K)
900      CONTINUE
          IREC=I + 1          !ADD ONE FOR THE HEADER
          WRITE(1'REC) DATA
1000     CONTINUE
C      CLOSE(UNIT=1)

1100     CONTINUE

        CLOSE(UNIT=5)

C      RETURN
C
C
2000     WRITE(5,2050) FILE
2050     FORMAT(' Can't open ',27A1)
        STOP
        END
#-h- todm.ftn      2164  asc 17-aug-88 13:27:38 arthur (richard arthur)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C  ROUTINE NAME:          SUBROUTINE TODMN
C
C  PURPOSE:              CONVERT REAL DATA TO THE DMN
C                        FORMAT OF 16-BIT UNSIGNED INTERGERS
C                        WITH AN OVERFLOW TABLE
C
C  COMMON:
C                        COMMON/DMN/IC(8292)
C                        COMMON/OVER/OVYTAB(2048)
C
C  ARGUMENTS:            NONE
C
C  FILES:
C                        NONE
C
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

        DIMENSION REL(4096),FILE(27)
        EQUIVALENCE (FILE(1),IC(87))
        EQUIVALENCE (REL(1),IC(101))
        LOGICAL*1 FILE
        LOGICAL ind, ier

1      NOV = 0              !INITIAL NUMBER OF OVERFLOWS
        IC(100) = -1        !START WITH NO OVERFLOWS

C      THE FIRST STEP IS TO GET THE DATA TO BE CONVERTED
C
C      EASY, IT WAS IN COMMON
C
C      NOW CONVERT THE DATA TO DMN FORMAT

        NCHAM = IC(4)

        DO 400 I=1,NCHAM
            C = REL(I)
            IF (C .LT. 0) C = 0
100         IF (C .GE. 32768.) GOTO 200
            IC(I+100) = C
            GOTO 400
            !TEMPORARY COUNTS
            !MUST NOT HAVE NEG #'S
            !WE MUST DO A CONVERSION
            !TRIVIAL CASE
            !ALL DONE
200

```

```

200 IF (C .GE. 65536.) GOTO 300          !WILL HAVE OVERFLOWS
C = C - 32768.                          !GET THE FIRST 16-BITS
IC(I+100) = C                          !PUT THEM IN IC
IC(I+100) = IC(I+100) .OR. '100000    !SET BIT-16
GOTO 400                                !ALL DONE

300 JOV = C/65536.                      !# OF TIMES WE OVERFLOWED
NOV = NOV + 1                          !DUMP THE OVERFLOW COUNTER
IOVTAB(NOV) = ISHFT(JOV,12) .OR. (I-1) !FOR THE SHIFTED TIMES AND
C = C - FLOAT(JOV) * 65536.            !THE CHANNEL NUMBER
GOTO 100                                !REMOVE THE OVERAGE
!AND GO CHECK THE REST

400 CONTINUE

C NOW TO PUT THE OVERFLOWS WHERE THEY BELONG

DO 500 I=1,NOV
IC(4196+I) = IOVTAB(I)                !OVERFLOWS START AT 4197
500 CONTINUE

C NOW TO FIX UP THE HEADER

IF(NOV .GT. 0) IC(100) = NOV           !CORRECT NUMBER OF OVERFLOWS

C AND WRITE THE DATA OUT

```

```

700 continue
call TIREAD('Enter filename for the DMN spectrum: ',Value,
1 FILE,nCHR,iND,iER)
if (iND) GOTO 999
if (nCHR .EQ. 0) GOTO 999
FILE(nCHR+1) = #

```

```

OPEN(UNIT=1,FORM='unformatted',NAME=file,ERR=999,
1 ACCESS='sequential',TYPE='new')

```

```

write(1) (IC(J),J=1,NCHAN+100)
IF (NOV .GT. 0) WRITE(1) (IC(J),J=4197,4196+NOV)
close(unit=1)

```

```

999 continue
RETURN

```

```

900 WRITE(6,950) FILE
950 FORMAT(' Can''t open ',Z7A1)
1000 CLOSE(UNIT=5)
RETURN
END

```

```

#-h- redund.sac      268 sac 17-aug-84 18:05:30 system
.TITLE REDUND

```

```

;
; THIS WILL REMOVE SOME REDUNDANT CODE
; BY HAVING THE SEQUENTIAL I/O ROUTINES
; GETSQ AND PUTSQ PASS CONTROL DIRECTLY
; TO THE RANDOM ROUTINES GET AND PUT.
;

```

```

.GETSQ:: JMP .GET          ;PASS CONTROL TO .GET
.PUTSQ:: JMP .PUT          ;PASS CONTROL TO .PUT
.END

```

```

#-h- cleanup.csd     1345 sac 17-aug-88 14:57:55 arthur (richard arthur)

```

```

; Cleanup after creating the GAINSHF.TSK image
;

```

```

PIP gainshf.r;#/DE
.;PIP gainshf.ftn;#/DE

```

```

PIP gainhf.obj;*/DE
;;
PIP tiread.r;*/DE
.;PIP tiread.ftn;*/DE
PIP tiread.obj;*/DE
;;
PIP iosubs.r;*/DE
.;PIP iosubs.ftn;*/DE
PIP iosubs.obj;*/DE
;;
PIP rddan.r;*/DE
.;PIP rddan.ftn;*/DE
PIP rddan.obj;*/DE
;;
PIP rdpol.ftn;*/DE
PIP rdpol.obj;*/DE
;;
PIP degree.r;*/DE
.;PIP degree.ftn;*/DE
PIP degree.obj;*/DE
;;
PIP ingam.r;*/DE
.;PIP ingam.ftn;*/DE
PIP ingam.obj;*/DE
;;
PIP getnam.r;*/DE
.;PIP getnam.ftn;*/DE
PIP getnam.obj;*/DE
;;
PIP pkfit.r;*/DE
.;PIP pkfit.ftn;*/DE
PIP pkfit.obj;*/DE
;;
PIP maxval.r;*/DE
.;PIP maxval.ftn;*/DE
PIP maxval.obj;*/DE
;;
PIP gfit.r;*/DE
.;PIP gfit.ftn;*/DE
PIP gfit.obj;*/DE
;;
PIP dmfitt.r;*/DE
.;PIP dmfitt.ftn;*/DE
PIP dmfitt.obj;*/DE
;;
PIP linfit.r;*/DE
.;PIP linfit.ftn;*/DE
PIP linfit.obj;*/DE
;;
PIP matinv.r;*/DE
.;PIP matinv.ftn;*/DE
PIP matinv.obj;*/DE
;;
PIP shift.r;*/DE
.;PIP shift.ftn;*/DE
PIP shift.obj;*/DE
;;
PIP ratsubs.r;*/DE
.;PIP ratsubs.ftn;*/DE
PIP ratsubs.obj;*/DE
;;
PIP output.r;*/DE
.;PIP output.ftn;*/DE
PIP output.obj;*/DE
;;
PIP todan.ftn;*/DE
PIP todan.obj;*/DE
;;
PIP wtpol.ftn;*/DE
PIP wtpol.obj;*/DE

```



```
PIP redund.sac;*/DE
PIP redund.obj;*/DE
PIP gainshf.cmd;*/DE
PIP gainshf.bld;*/DE
PIP gainshf.odl;*/DE
PIP gainshf.wsp;*/DE
PIP gainshf.stb;*/DE
PIP cleanup.cmd;*/DE
```


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