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HANFORD WHOLE BODY COUNTER 1985 ACTIVITIES

by

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INTRODUCTION

This report describes the routine whole body counting measurement program for Hanford project personnel during 1985 and includes special studies and development work performed in conjunction with the whole body counting facilities. Similar annual reports have been written since 1978. The first report described the major facilities and equipment at the whole body counter; subsequent reports have described additions and changes. These reports are informal summaries and are distributed only to DOE-RL and the Hanford contractors.

ROUTINE COUNTING PROGRAM

Figure 1 shows a bar graph of the in vivo measurements made at the whole body counting facility since 1975 (figures begin on page 13). The total number of measurements for 1985 was 10,518, which is 6 percent higher than the total in 1984. The whole body counting section of each bar, which includes all types of measurements except lung counts, totaled 8,646, which was about 6 percent higher than in 1984. Lung counts for 1985 totaled 1,872 (6 percent higher than in 1984), which almost equals a previous high level of 1,879 in 1979.

Table 1 shows the number and type of measurements made on personnel for each Hanford contractor, DOE, and local private industries, which include Exxon Nuclear, U.S. Ecology, Pacific Nuclear, and Allied Nuclear. A new category this year is special requests, which includes measurements solicited by Argonne National Laboratories, Mound Laboratory, National Lead of Ohio, Precision Cast Parts, U.S. Bureau of Mines, University of Washington School of Medicine, and 89 members of Ringold farm families (requested by DOE). The private work, which is performed for private industry only to the extent that it does not affect the service to DOE contractors, contributed about $40K toward the support of the whole body counting services in 1985, thereby reducing the cost to DOE contractors.

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Figure 2 shows the trends and usage of the whole body counting facilities over the past six years. The usage by Rockwell Hanford Operations (RHO) and UNC Nuclear Industries (UNC) has increased significantly, whereas usage by all other customers has remained at the same level or decreased.

Table 1. In Vivo Measurements Made in 1985

Contractor	Whole Body Counts	Lung Counts	Thyroid	Wound	Other	Total
BCSR	11					11
DOE	2	2			1	5
RHO	3,005	591	1	7	40	3,644
UNC	2,937	116			2	3,055
WHC	764	515			1	1,280
HEHF						
JAJ	333	13				346
PNL	1,067	317		3	5	1,392
KEH	256	1				257
Private Industries	99	297				396
Special Requests	110	20			2	132
TOTAL	8,584	1,872	1	10	51	10,518

In the 1985 routine counting program, 71 workers showed positive amounts of gamma-emitting radionuclides. Twelve results were higher than 10 nCi, and 59 were below this level but greater than 2 nCi. In addition, there were 8 cases where workers had received medically administered radionuclides of ^{131}I, $^{201,202}Th$, ^{67}Ga, or ^{57}Co. There were 70 positive lung counts for ^{239}Pu and ^{241}Am, but most of these were from previously known internal depositions.

IN VIVO MEASUREMENT INCIDENT CASES

Fifty-two Hanford DOE contractor employees were measured as a result of radioactive contamination incidents during 1985. Table 2 compares the number of employees measured who were involved in incident cases to that of previous years.

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Table 2. Number of Employees Measured as a Result of Contamination Incidents

Year	Number
1978	85
1979	196
1980	73
1981	90
1982	81
1983	88
1984	62
1985	52

The types of measurements made and the magnitude of the internal contamination for the 1985 incidents are shown in Table 3.

Table 3. 1985 Incident Cases

Type of Count	Less than MDA[a]	MDA to 10 nCi	Greater than 10 nCi
Whole Body--Gamma Ray	16	1	11
Lung--Pu or Am	9	6	1
Wound	5	1	2
TOTAL	30	8	14

[a]Minimum detectable amount.

FACILITIES AND EQUIPMENT

The major facility change in 1985 was the construction of a new front entrance to the 747A Building. The entrance is now easily identified and gives a much more professional appearance to the building. The double glass doors provide a more pleasant environment for the waiting and reception room. Other changes in facilities and equipment are:

Central Liquid Nitrogen Supply - A 500-gallon liquid nitrogen tank was installed behind the 747A Building and insulated lines have been run into each of the shielded rooms. This eliminates the need

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for twice-weekly deliveries from Central Stores and allows automatic filling procedures to be used in keeping germanium detector Dewars full of liquid nitrogen. This is a much safer procedure than the hand-filling done previously. The liquid nitrogen consumption is greater, but the actual overall cost is about the same because the bulk price is much less than that for purchasing small quantities.

New Computer - A Hewlett-Packard 9000 Series 500 computer system was purchased, installed, and interfaced to the several multichannel analyzers used for in vivo measurements. The main advantages of this new system are a twenty-fold increase in disk storage space and multi-user capability. This will allow computer storage of spectra from whole body counting measurements for about 15 months compared to a maximum of one week with the old system. This increased storage capacity is especially helpful since spectra are not going to be saved on the ORE data base after December 31, 1985. The main controlling program used for data acquisition was redesigned and rewritten. One of the major improvements is multi-user simultaneous access to all measurement records and spectra for the last 15 months. In addition, the users have access to extensive word processing programs and document maintenance features. Greater use of this new system will occur in the next few months as graphics capability and automated verification of records with the ORE data base will be incorporated.

New Shielded Room - The conceptual design report was reviewed and amended in March 1985. The project cost estimate was increased from $180,000 to $255,000. This increase was one of the factors that delayed allocation of the construction funds. The project is now 15 months behind schedule. The shielded room is still necessary to adequately conduct the more than 10,000 measurements done annually at the whole body counting facilities.

Dental Chair for Lung Count Positioning - As a result of the ^{92m}Nb lung calibration studies in females, which were described in the 1984 activities report and further discussed in the next section of this report, the horizontal bed mounted on a hydraulic dental chair lift was replaced by a modern dental chair. This dental chair allows a

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lung count to be made with the person in either the supine position or with the torso of the body tilted up at an angle of approximately 45 degrees. The new dental chair is lifted and positioned electromechanically rather than by the hand-operated hydraulic lift used with the old bed. Redundant electrical switching was added to the new dental chair to chair to prevent injury in case one switch malfunctions.

SPECIAL STUDIES

Whole Body Counting of Farm Families Downwind from the Hanford Project - During the month of November, Mobile Whole Body Counter B was moved to the Chiawana Grange Building on Taylor Flats Road for measuring any possible internal radioactive contamination in the local residents. Over a period of 7 working days, 89 people were measured. No unusual radionuclides were measured in any of these people. Normal amounts of ^{40}K were measured in everyone.

Radon decay products were measured on the clothing of a few of the residents. This study was done at the request of DOE and under the direction of the Internal Dosimetry program of the Personnel Dosimetry section.

Special In Vivo Measurement Requests - For the past few years, the Hanford whole body counter has had a greater capability for measuring low-energy photon emitters in the body than other counting facilities in the world. This has resulted in requests for whole body counting services from other DOE laboratories and government agencies. At the request of NIOSH, two groups of workers from the National Lead of Ohio Fernald Plant were measured for uranium in the lung. The U.S. Bureau of Mines at Albany, Oregon, requested that two of their employees be measured for thorium uptake in the body. Argonne National Laboratory requested that we measure one of their employees for ^{239}Pu and other transuranic radionuclides. Precision Cast Parts

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Company of Portland requested that several of their employees be measured for thorium content. The University of Washington School of Medicine requested a ^{239}Pu measurement on one of their patients who had previously worked on the cleanup of the ^{239}Pu contamination of soil in Spain.

Measurement of ^{239}Pu and ^{241}Am in Axillary Lymph Nodes - A wound severely contaminated with ^{239}Pu and associated ^{241}Am resulted in some of the insoluble material entering the lymph fluids of the hand and being filtered out by the lymph nodes located near the axilla (armpit). A count over these axillary lymph nodes with a germanium planar detector showed ^{241}Am activity to be only .10 nCi, but still easily measured as shown in Figure 3a. The position of the detector for this count is shown in Figure 3b. This is the first time activity has been measured in the axillary lymph nodes at Hanford. The only other reported measurement of this type occurred at the Atomic Weapons Research Establishment at Aldermaston, England, a few years ago. It is possible that in previous Hanford wound cases, axillary lymph node uptake has gone undetected. When these people return to the whole body counter for routine measurements, appropriate axillary lymph node counts will be performed.

Continuing Studies on Harold McCluskey - Although the results of the many in vivo measurements on Mr. McCluskey have not been presented in these annual reports in the past, it should be noted that regular monthly measurements have been made on him since the accident which happened almost ten years ago. For the most part, these measurements have consisted of monitoring the levels of ^{241}Am in the liver, skeleton, and facial skin and underlying tissue. A summary of these levels plotted against time out to 3,430 days (9.4 years) is given in Figure 4 which shows the current levels to be 0.6, 8, and 3 μCi in the liver, bone, and facial tissue, respectively. The DTPA treatment frequency is also shown at the bottom of Figure 4. The count rate over the liver between day 400 and day 933 was probably due to ^{241}Am in the ribs and

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vertebrae, not the liver. Therefore after day 933, about 200 nCi should be subtracted from the plotted liver data to determine the amount actually in the liver.

A measurement on day 984 showed a sudden unexplained increase to 0.97 μCi in the liver, after which it has stayed within the range of 0.2 to 0.6 μCi. In general, it appears that since the termination of DTPA treatment, the loss of facial activity has been accompanied by a translocation to the liver and bone. All of the loss from the facial tissue cannot be accounted for in the liver and bone uptake nor in the urine and fecal excretion. Gradual loss from the surface of the skin may account for the difference. The liver seems to have reached an equilibrium over the past few years, where the amount depositing in the liver from the face is equal to the amount translocating from the liver to the bone.

RESEARCH AND DEVELOPMENT ACTIVITIES

Determination of ^{241}Am in Tracheobronchial Lymph Nodes - Radioactivity in the tracheobronchial lymph nodes is difficult to detect and quantify because it is not easily distinguishable from lung-deposited activity. Through the efforts of a summer NORCUS appointment graduate student, significant progress was made in our ability to detect and roughly quantify ^{241}Am in these lymph nodes. This was done by making lateral scans of both lung and pulmonary lymph nodes containing ^{241}Am with a collimated set of two germanium planar detectors. The results are shown in Figure 5. The response of the collimated detector scan for activity in the lungs is very different from that in the lymph nodes. When the activity is deposited in both the lymph nodes and lung, the percentage of deposition in each can also be estimated from the peak-to-valley ratios of the scans. A Hanford worker who has had a lung burden of insoluble ^{239}Pu for several years was measured by this technique; the resulting curve (also in Figure 4) shows that essentially all the activity resides in the lungs. This technique will be used for all future cases where there is a question about the amount of activity in the lymph nodes.

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The Construction of Calibration Phantoms from Skeletal Parts of Whole Body Donations to the Transuranium Registry - The skull and the arm bones have been selected as the first bones of Whole Body Donation Case #1 (see previous Whole Body Counter Activity Reports for 1979, 1981, 1983, and 1984) to be incorporated into realistic tissue-equivalent calibration phantoms. Because of the lack of funding for this work at PNL, the half skull was sent to New York University Medical Center because they had a nonradioactive matching skull of the same size, half of which could be combined with our half skull. They also had some funding, experience, and interested graduate students to do this type of work. Their finished product is shown in Figure 6. The phantom closely represents a human head; half of the skull contains ^{241}Am representative of a person with a skeletal content of 119 nCi. The tissue-equivalent plastic filling and encapsulating the skull is polyurethane with calcium carbonate added to closely simulate the absorption characteristics for low energy- photons. The skull still belongs to the Transuranium Registry, but PNL is the custodian of the phantom. The phantom is available to any whole body counting laboratory for calibration purposes.

The arm bones are being incorporated into a tissue-equivalent arm phantom. This work is being done by a graduate student who is using this project for his master's research and thesis. This phantom should be completed in 1986.

The Sensitivity for Measuring ^{239}Pu in the Lung - A question often arises concerning the minimum detectable amount (MDA) of radioactivity that can be measured in an organ or distributed throughout the total body. The most frequent question concerns the MDA for ^{239}Pu in the lungs. Determining the answer is not easy because the MDA for ^{239}Pu in the lungs depends on the chest wall thickness and the size of the person being measured.

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These questions of sensitivity could be answered by studies using a subject's background count to which very short counts made on the phantom are added. This provides random additions of spectral counts equivalent to low quantities of a radionuclide in the lung and does it without significantly perturbing the original background spectra of the subject.

An example of this process of adding counts is given in Figures 7 and 8, where counts equivalent to 3.1, 6.2, 16, 32, 48, 96, and 192 nCi in the lung of the phantom are added to a 2000-sec (33.3 min) background count of an uncontaminated person. The basic phantom has a chest wall thickness of 1.63 cm (Figure 7). In Figure 8, the phantom with one chest plate overlay represents a chest wall thickness of 2.3 cm. In Figure 7, the 17-keV peak can be clearly seen above the background continuum for 16 nCi of ^{239}Pu in the lungs (this is the maximum permissible lung burden). However, in the 200 people we have measured for chest wall thickness during the past five years, the lowest chest wall thickness was 1.9 cm. Figure 8 shows that for a 2.26-cm chest wall thickness the least amount that produces a definite peak above the background continuum is 32 nCi. From the data in Figures 7 and 8, we can predict that about 25 nCi of ^{239}Pu could be detected in the person whose chest wall thickness was 1.9 cm. Measurements with thicker chest plates representing chest wall thickness up to 4.3 cm show that, in a person with a chest wall thickness of 4 cm or more, more than 100 nCi of ^{239}Pu in the lungs is necessary before it can be measured.

This technique should be used to conduct a series of statistically valid measurements to determine the defined measurement capability of a lung counting system. This should be done at least for a germanium detector array and for a Phoswich system. It needs to be done for ^{239}Pu, ^{241}Am, ^{238}U, and ^{235}U. The measurements can be done very easily and rapidly. The statistical design, data processing, and computer summing analysis of spectra will require the major portion of the effort. When completed, sensitivity curves

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could be generated for each lung counting system and each radionuclide. This type of information is needed to define the capability of counting systems and to find ways to obtain better sensitivity.

An Improved Geometry for Lung Counting - The ^{92m}Nb (mock ^{239}Pu) studies described in previous annual Whole Body Counter Activity Reports have provided some additional results that have improved the sensitivity for measuring ^{239}Pu in the lung. As we began the female study, it became obvious that the count rates of the 15.8- and 17.7-keV x-rays over the upper chest wall were significantly higher when the subject was in a reclining position than in the horizontal supine position. In the reclining position, the torso is about 45 degrees from horizontal.

Figure 9 shows the difference in the count rate of the x-rays between the two counting geometries for one female subject. This subject exhibits a typical, but not the highest, difference observed between the reclining and supine positions. A more complete description of this study will be published later in a journal article. The increase in counting rate in the reclining position is due to the reduction in chest wall thickness as the breast tissue drops lower. This same effect can also be observed, but to a much lesser degree, with male subjects, especially those who are overweight.

As a result of these studies, we will change our routine lung counting geometry in early 1986 from a horizontal bed to a reclining position in a commercial dental chair as shown in Figure 10. Chest wall thickness measurements made with ultrasound instrumentation are made with the subject in the reclining position. Further studies are needed to ensure that the Lawrence Livermore tissue-equivalent phantom is still a good reference standard for the reclining as well as the supine position.

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PUBLISHED PAPERS

Newton, D., A. C. Wells, S. Mizushita, R. E. Toohey, J. Y. Sha, R. Jones, S. J. Jeffries, H. E. Palmer, G. A. Rieksts, A. L. Anderson, and G. W. Campbell. 1985. "The Livermore Phantom as a Calibration Standard in Assessment of Plutonium in Lungs." Proceedings of IAEA Symposium on the Assessment of Radioactive Contamination in Man; Paris, France; November 19-23, 1984; pp 189-199; IAEA-SM-276/01; International Atomic Energy Agency; Vienna, Austria.

Palmer, H. E., B. D. Breitenstein, P. W. Durbin, K. R. Heid, and J. F. McInroy. 1985. "Calibration of Whole-Body Counters for Transuranic Radionuclides by Using Total-Body Donations to the United States Transuranium Registry. Proceedings of Symposium on the Assessment of Radioactive Contamination in Man; Paris, France; November 19-23, 1984; pp 201-209; IAEA-SM-276/01; International Atomic Energy Agency; Vienna, Austria.

Palmer, H. E., and G. A. Rieksts. 1985. "High Purity Planar Germanium Detector for In Vivo Measurement of Uranium and Transuranic Radionuclides." Proceedings of IAEA Symposium on the Assessment of Radioactive Contamination in Man; Paris, France; November 19-23, 1984; pp 93-106; IAEA-SM-276/01; International Atomic Energy Agency; Vienna, Austria.

Palmer, H. E., H. B. Spitz, and G. A. Rieksts. 1985. "The U.S. Transuranium Registry Report on the ^{241}Am Content of a Whole Body, Part III: Gamma Ray Measurements," Health Physics 49, pp 577-586.

Spitz, H. B., R. L. Buschbom, G. A. Rieksts, and H. E. Palmer. 1985. "A New Method for Analyzing High Resolution Spectra from Whole Body Counter In Vivo Measurements." Health Physics 49, pp 1085-1096.

PAPERS PRESENTED AT MEETINGS

Rieksts, G. A., H. E. Palmer, and H. B. Spitz. "Design Calibration and Implementation of the Hanford Rapid Measurement Whole Body Counter." Annual Meeting of the Health Physics Society; Chicago, Illinois; May 26-31, 1985. Also presented at the Columbia Chapter Health Physics Society Symposium on Quality Assurance In Ionizing Radiation Measurement in 1985.

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WHOLE BODY COUNTING STAFF

H. E. Palmer	Staff Scientist and Technical Leader
G. A. Rieksts	Development Engineer, Routine Operations
M. C. Rhoads	Senior Technician
J. M. Mackliet	Technician
D. P. Mielke	Technician
B. W. Perkins	Electronics Technician (assigned from Craft Services Section)

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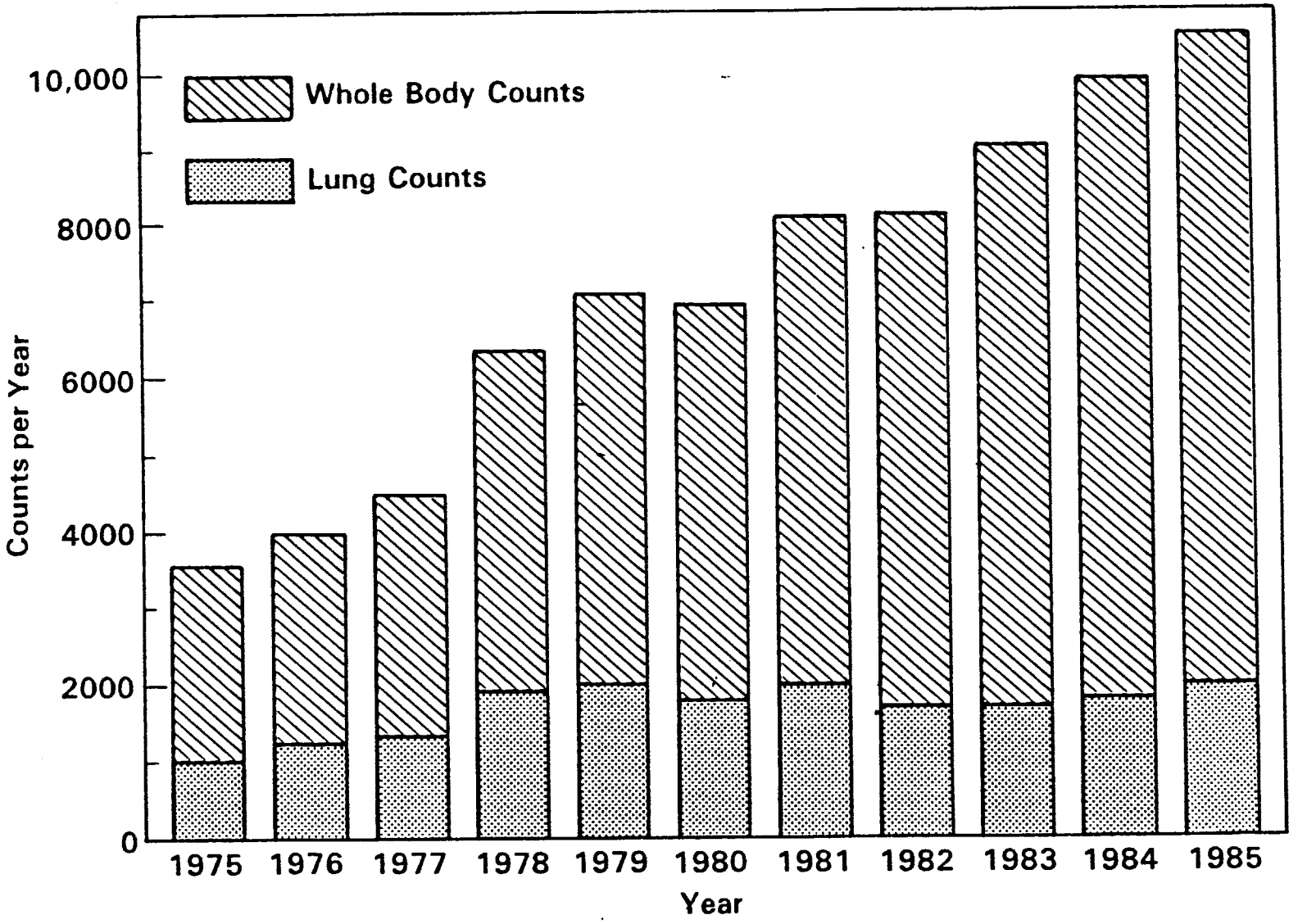

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Figure 1. In Vivo Measurements at the Hanford Whole Body Counter Facilities

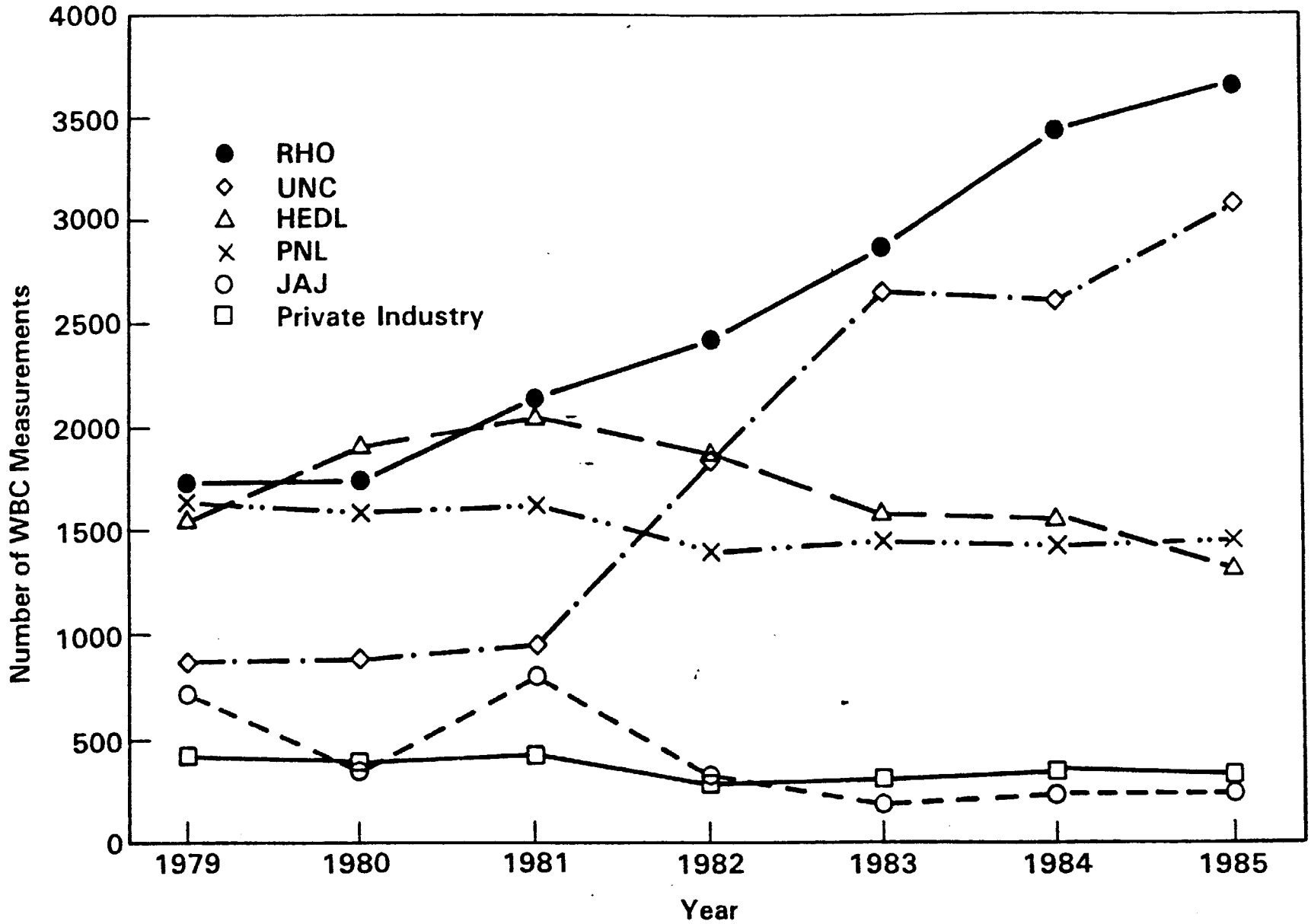

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Figure 2. Whole Body Counter Usage During the Last 7 Years

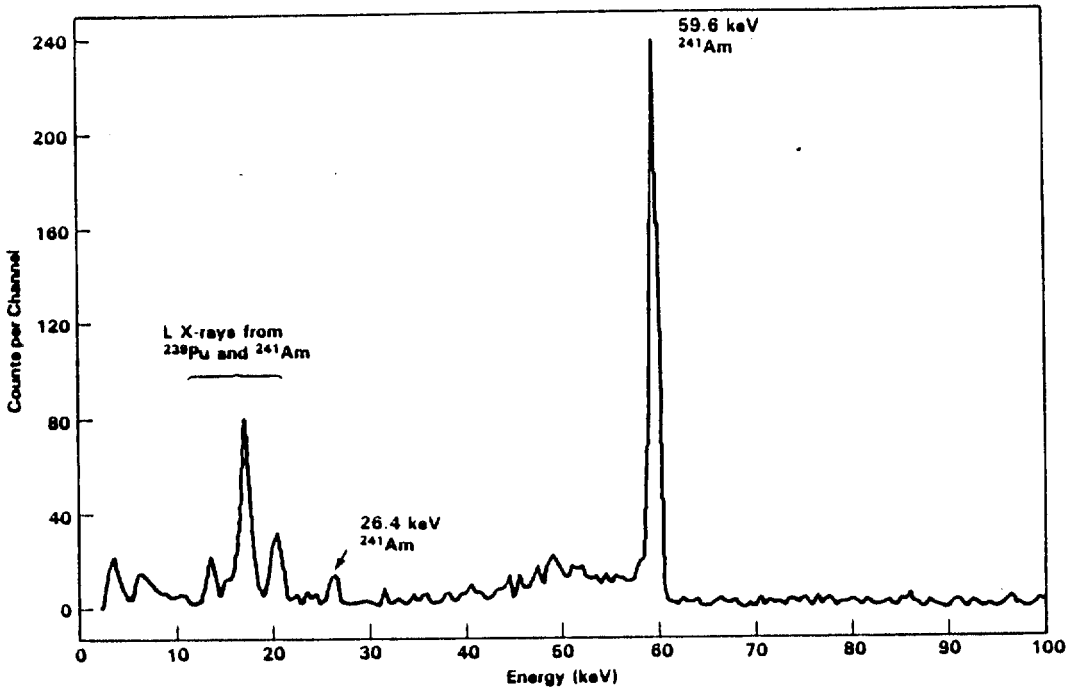

Figure 3a. Photon Energy Spectrum from a Measurement of ^{239}Pu and ^{241}Am in Axillary Lymph Nodes

Figure 3b. Position of Detector for Count in Figure 3a

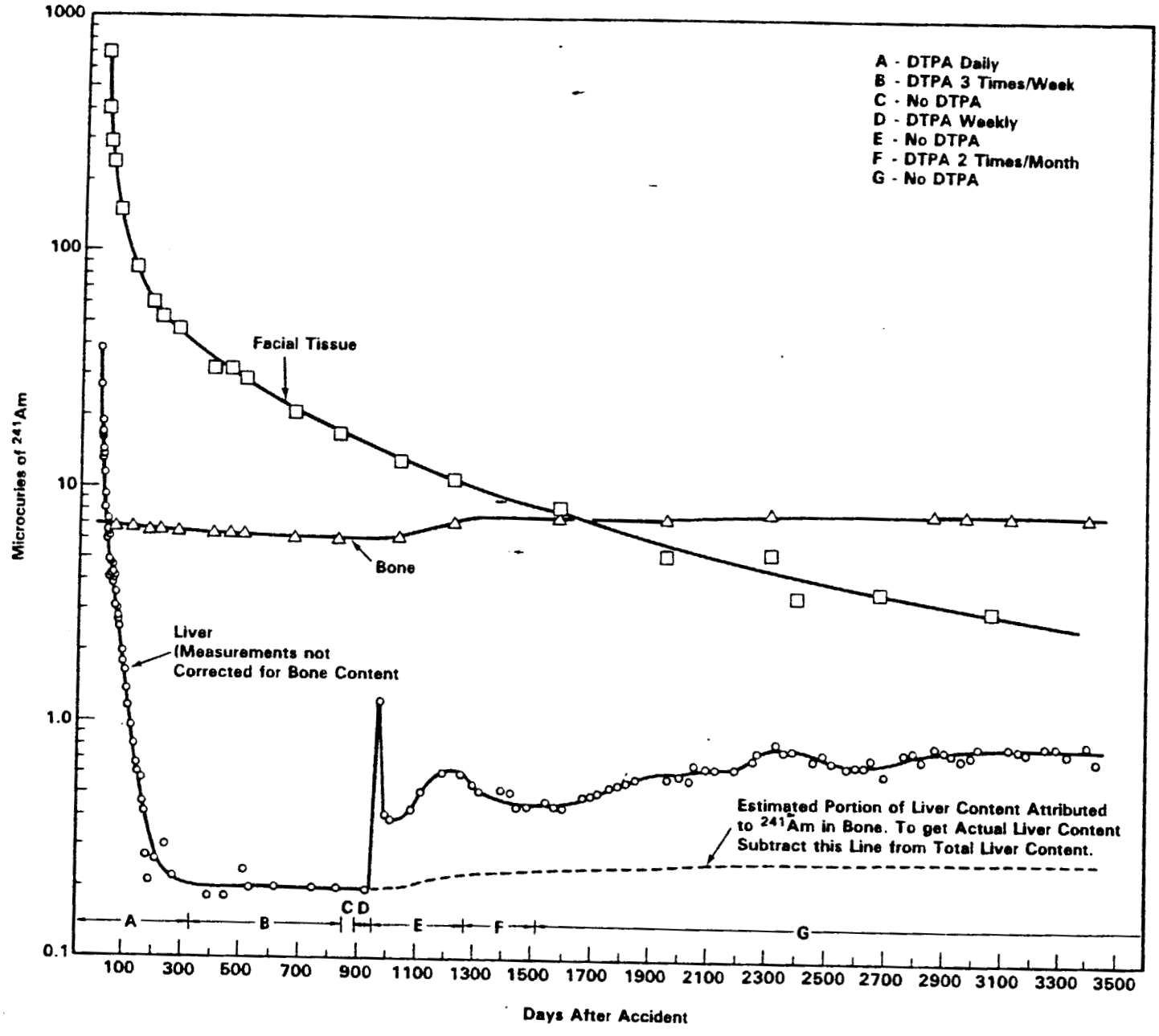

Figure 4. Measurement of Liver, Bone, and Facial Tissue on ^{241}Am Accident Subject Over 9.4-year Period

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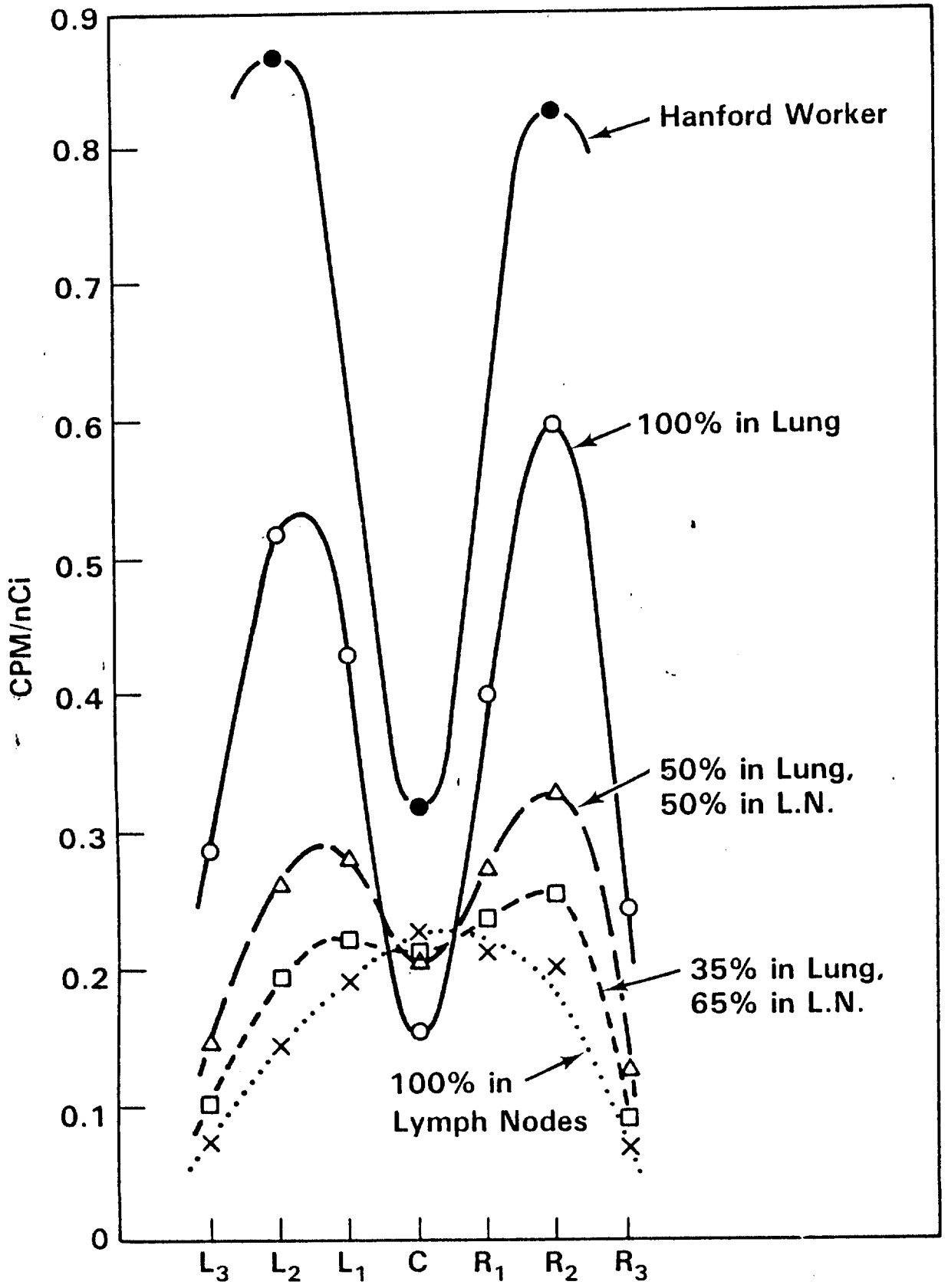

Figure 5. Results of Lateral Scans with a Collimated Set of Germanium Planar Detectors

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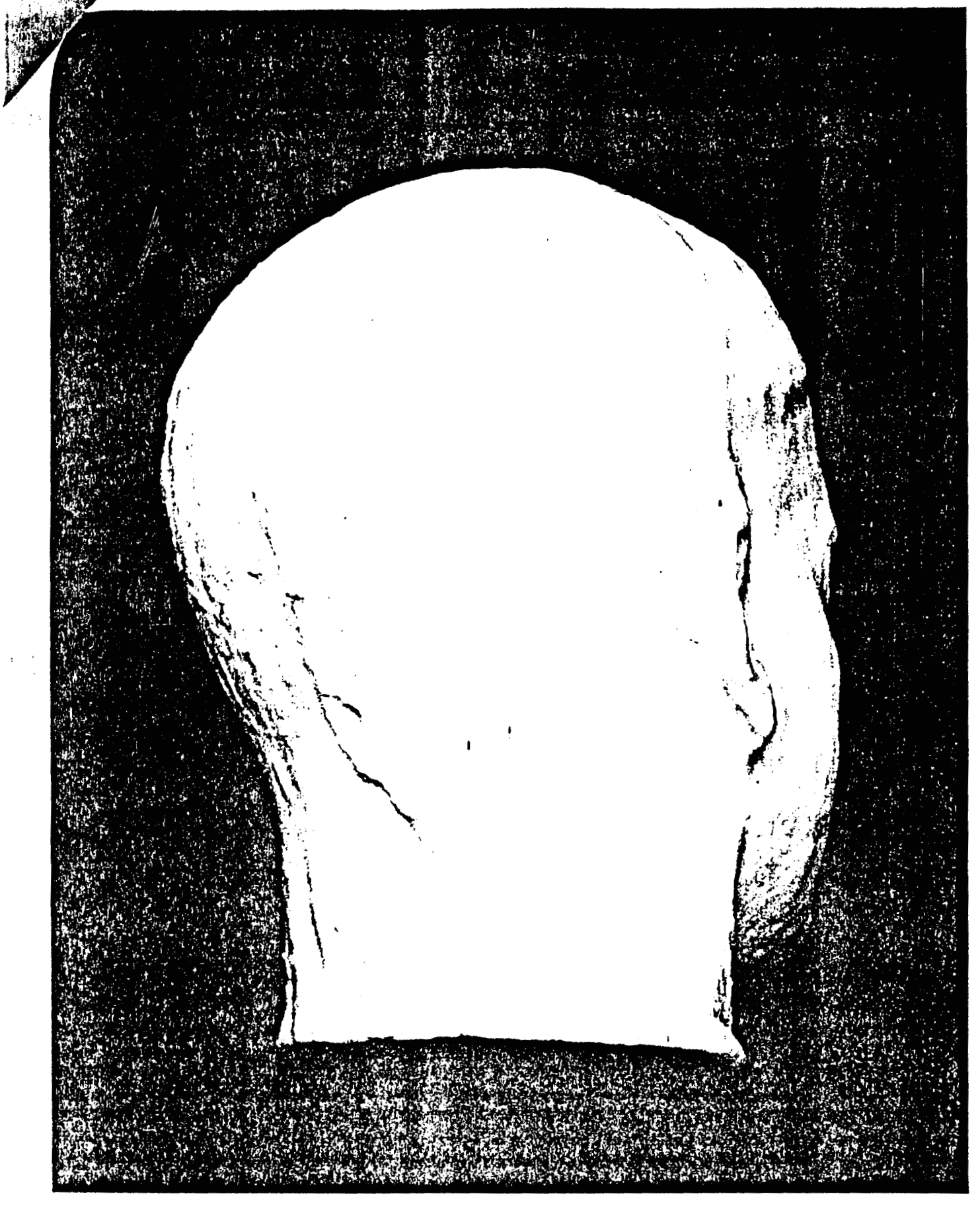

Figure 6. Tissue-Equivalent Skull Calibration Phantom

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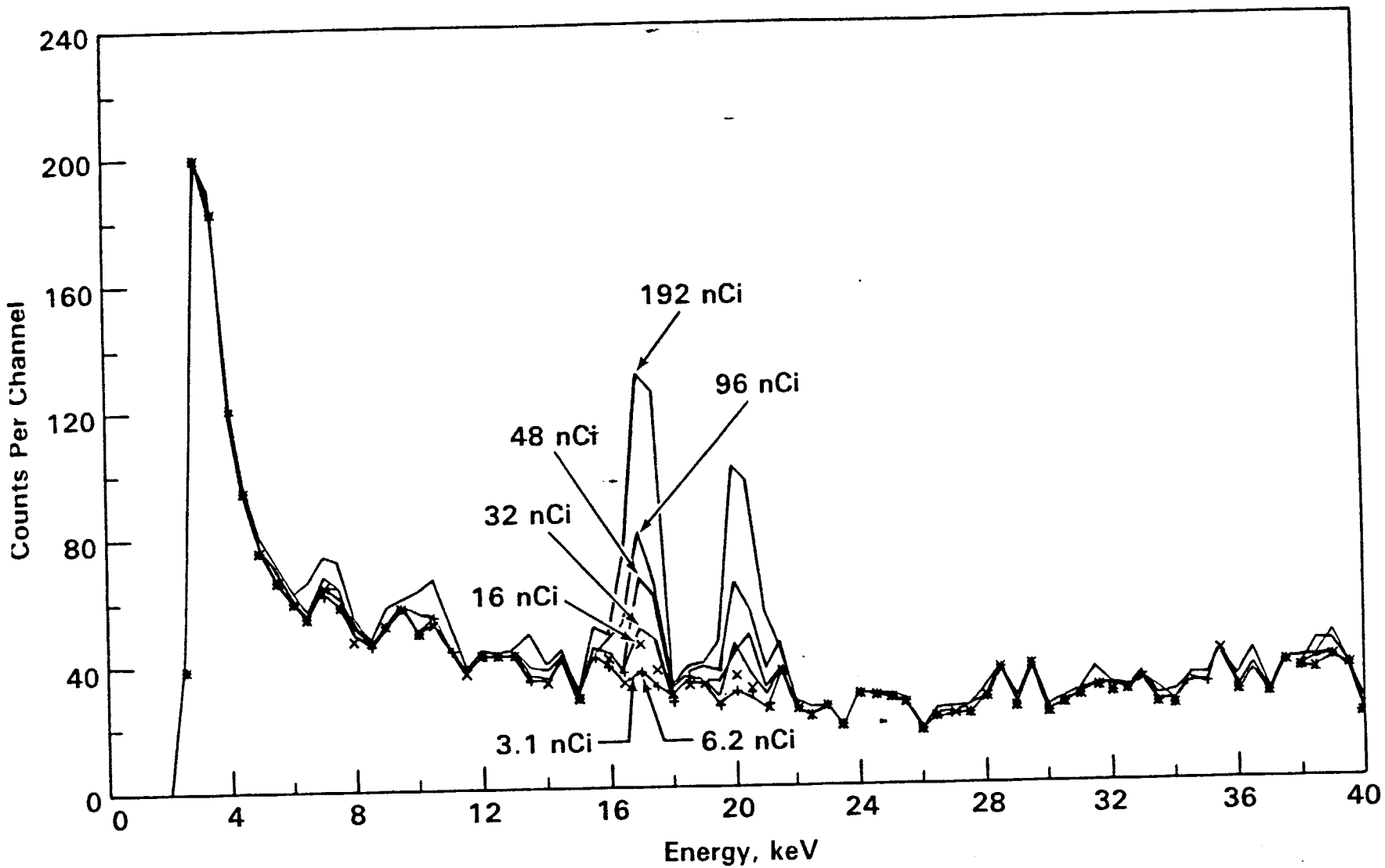

Figure 7. Spectra of Various Amounts of ^{239}Pu in the Lung, 1.6-cm Chest Wall Thickness

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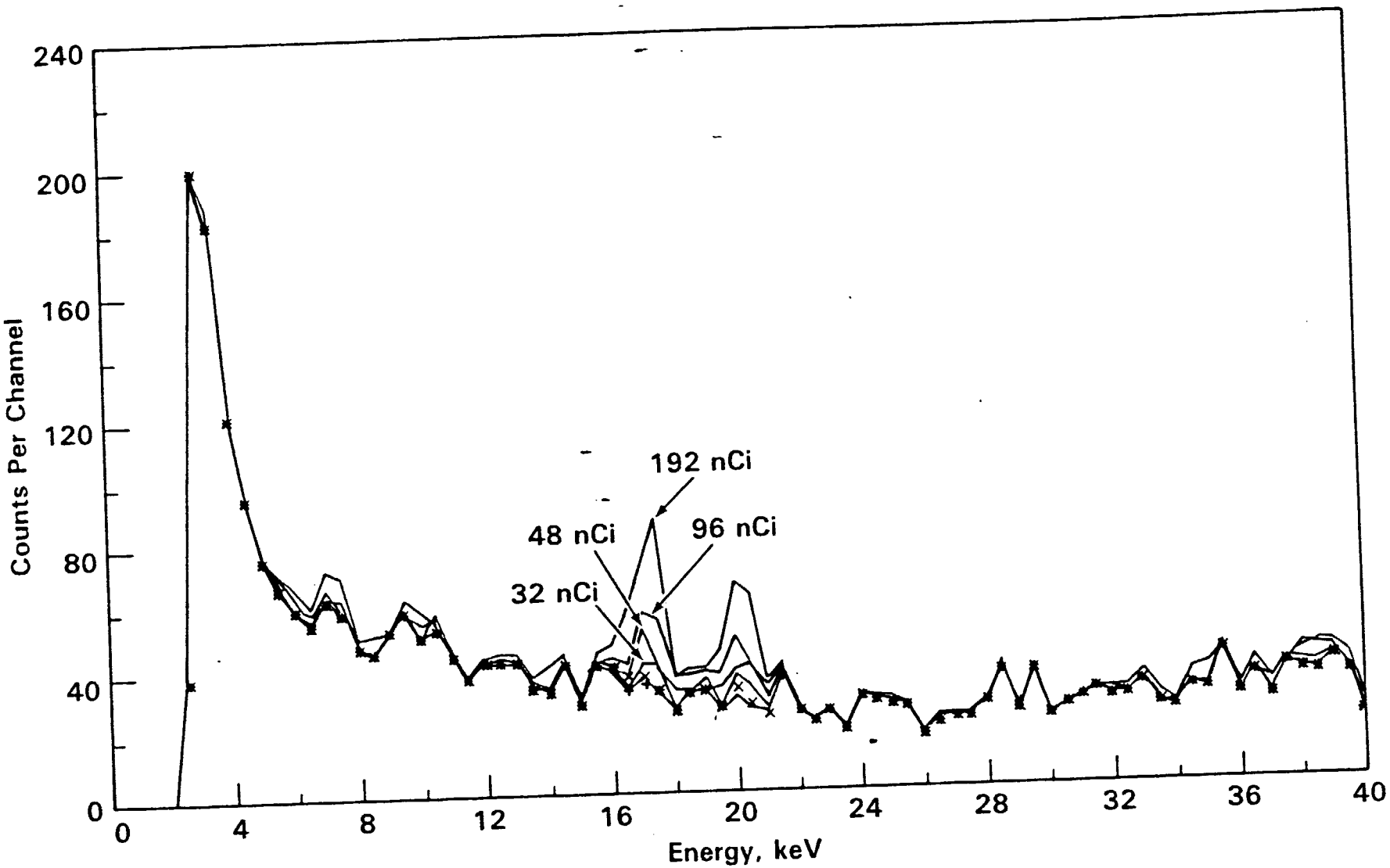

Figure 8. Spectra of Various Amounts of ^{239}Pu in the Lung, 2.3-cm Chest Wall Thickness

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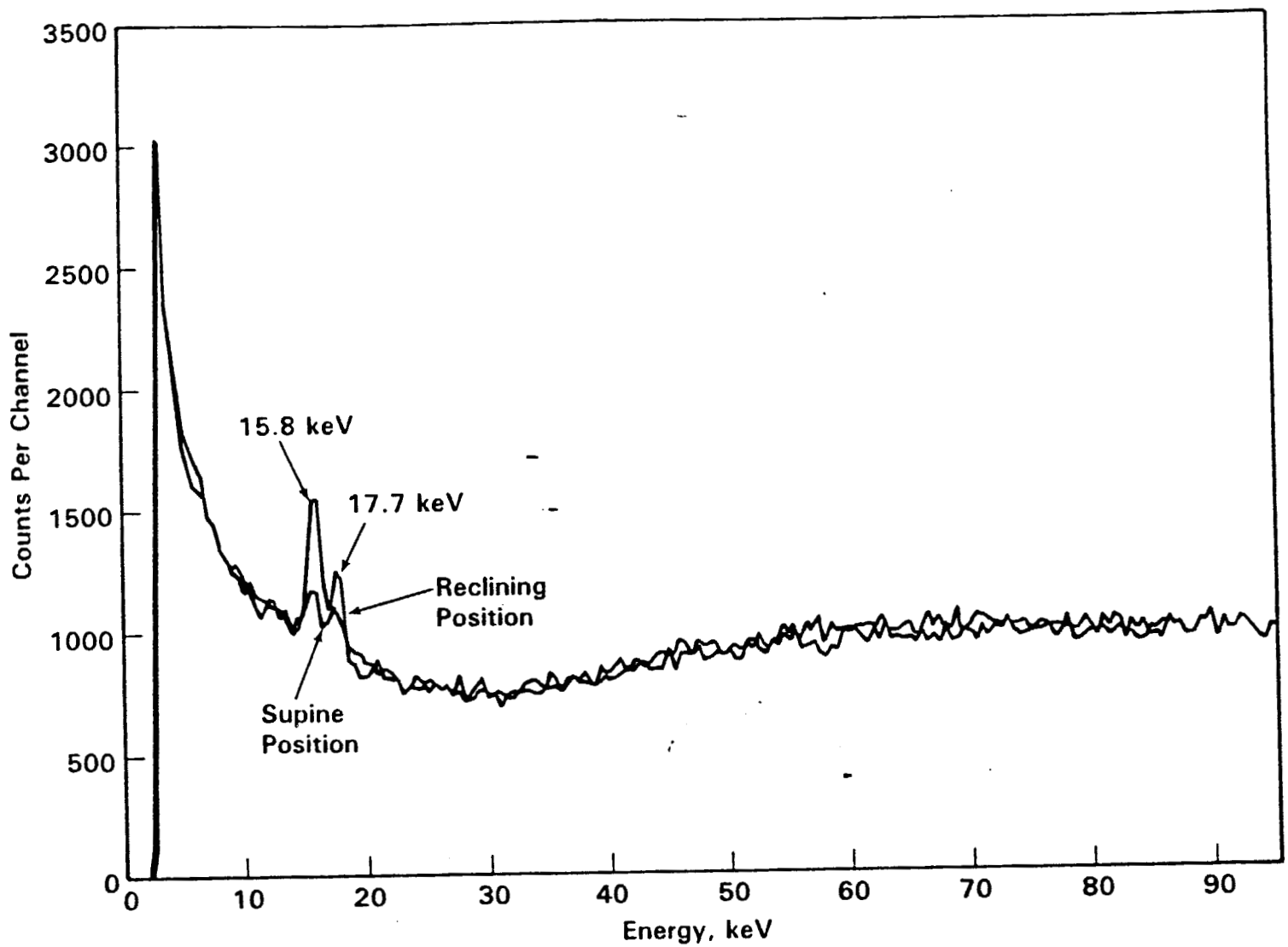

Figure 9. Comparison of ^{92m}Nb Measurement in the Lung of a Female in the Supine and Reclining Positions

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