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HANFORD WHOLE BODY COUNTER 1982 ACTIVITIES

by

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INTRODUCTION

This report describes the routine whole body counting measurement program for the Hanford project personnel during 1982. Special studies and development work performed in conjunction with the whole body counting facilities are also described. Similar reports have been written annually since 1978. The first report described all of the major facilities and equipment at the whole body counter, and subsequent reports have described additions or changes which have occurred since 1978. This report describes the activity and changes for 1982. These reports have been intentionally brief to reduce the time needed for reading and preparation. A comprehensive manual for the whole body counting operations is planned and will be distributed in 1984.

ROUTINE COUNTING OF DOE CONTRACTOR PERSONNEL

Figure 1 shows the *in vivo* measurements made at the whole body counting facility since 1972. The total measurements for 1982 were 8113 which is only slightly higher than the 8081 performed in 1981. The whole body counting section of each bar includes all types of measurements except lung counts. These totaled 6454 which was about 3% higher than the 6283 measurements in 1981. The 1659 lung counts for 1982 is about 8% lower than in 1981. Table 1 shows the number and type of measurements made on personnel for each Hanford contractor, DOE, and private industries, which include Exxon Nuclear, U.S. Ecology, the Washington Public Power Supply System and Allied Nuclear. The work is performed for private industry only when it does not impact on the service to DOE Contractors. This private work does contribute $20K to $30K per year towards the support of the whole body counting services which in turn reduces the cost to the DOE Contractors.

The requests for whole body counting service are usually heaviest in the summer, and 1982 was no exception. We had monthly measurements of over 800 per month in June and July as compared to approximately 500 per month in October, November and December.

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TABLE 1. *In Vivo* Measurements Made in 1982

Contractor	Whole Body Counts	Lung Counts	Thyroid	Wound	Other
BSC	2	1			
DOE	5	2			
RHO	2091	316		5	6
UNI	1768	11			59
HEDL	1011	836	1		5
HEHF	1	1			
JAJ	240	71			1
PNL	1038	327	1	4	5
Kaiser	9	1			
Private Industries	197	93		3	2
TOTALS	6362	1659	2	12	78

GRAND TOTAL = 8113

In the 1982 routine counting program, 107 workers showed positive amounts of gamma-emitting radionuclides. Eighty-eight were less than 10 nCi and 19 were above this level. In addition, there were two cases where workers had received medically administered radionuclides of ^{131}I or $^{201-202}Tl$. There were 25 positive lung counts for ^{239}Pu and ^{241}Am, but these were from previously known internal depositions.

IN VIVO MEASUREMENT INCIDENT CASES

The number of Hanford DOE Contractor employees measured as a result of radioactive contamination incidents during 1982 was 81. Table 2 shows a comparison of the number of incident measurements to that in previous years.

TABLE 2. Number of Incidents Requiring *In Vivo* Measurements

Year	Number
1978	85
1979	196
1980	73
1981	90
1982	81

The types of measurements made and the magnitude of the internal contamination for the 1982 incidents is shown in Table 3.

TABLE 3. 1982 Incident Cases

Type of Count	Less than MDA*	MDA* to 10 nCi	Greater than 10 nCi
Whole body -- gamma ray	7	8	18
Lung -- Pu or Am	36	4	1
Wound	6	1	
Thyroid	--	--	—
TOTALS	49	13	19

* Minimum detectable amount

FACILITIES AND EQUIPMENT

New Intrinsic Germanium Detector - A major change is being made in the detector system for measuring low-energy gamma and x-ray emitters in the lung. The 9.5-mm-thick NaI(Tl) and the phoswich detectors will be replaced by multiple 20 cm^2 by 13-mm-thick intrinsic germanium (IG) detectors. The first set of three IG detectors were received in 1982 and were installed in the lead-shielded room for testing, calibration, and use on special incidents of internal contamination.

The resolution of the IG detection is about 650 eV full width at half maximum for the L x-rays emitted from ^{239}Pu and the 59.5-keV gamma ray from ^{241}Am. Although the total area of the three IG detectors is less than half that of a 5-in.-diameter NaI(Tl) or phoswich detector, the much lower background under the narrow photopeak of the IG detector provides better sensitivity. The resolution of the IG detector is demonstrated in Figure 2 which shows a one-hour measurement of ^{238}Pu accidentally inhaled by a radiation worker. The L x-rays of 13.4, 17 and 20.4 keV are clearly resolved and the 43-keV gamma ray is evident. The summation of 13.9 hrs of measurements shown in Figure 3 shows the resolution of the IG detectors more clearly. The ratios of the L x-ray probe are very useful in determining if the distribution in the lung is abnormal or if some external activity exists on the body.

The IG detectors have been very useful in identifying and quantifying ^{238}Pu, ^{239}Pu, ^{241}Am, ^{154}Eu, ^{235}U, Nat U, ^{210}Pb, ^{226}Ra and daughters. When they are put into routine use in 1983, they will also be useful in measuring ^{144}Ce and ^{239}Np. They are especially useful for gamma-ray energies below 300 keV and have some limited usefulness at higher energies. The second set of detectors will be delivered in the early part of 1982. At that time, the NaI(Tl) and phoswich lung counters will be replaced by the two IG systems.

Design of New Shielded Facilities - The capacity of the present shielded facilities in the 747A Building is presently being exceeded, and the overflow is being handled in the mobile whole body counters located across the parking lot. The 747A building was originally designed to accommodate a second shielded room. A shielded room has been designed and the preliminary engineering study report and the cost estimates have been completed. The room will be fabricated with an inner layer of pre-World War II steel plate (2-1/2 inches thick), a layer of lead brick (4 inches thick) and an outer shell of carbon steel (1/2 inch thick) utilizing all welded construction. The steel is available from the Nevada test site operations for just the shipping costs. The total cost of the shielded facility has been estimated at $140,000.

The justification for this facility has been written and included a survey of information from whole body counting operations at other DOE laboratories throughout the United States. A summary of this survey in Table 4 shows that the labor, facilities and overall costs per measurement are significantly lower at the PNL facilities because of the large number of measurements. A source of funding and priority for this shielded room has not been established, and it may be a few years before it can be built.

To avoid routine whole body counting in the mobile counters until the new shielded room can be built, a shielded facility was also designed that can be economically constructed with materials and equipment available at the whole body counter. This facility would be a small walk-in maze-type and would contain five large NaI(Tl) detectors having a thickness of 4 inches and ranging in diameter from 9-3/8 to 11-1/2 inches. A two-minute count of an employee in this counter would give a count rate from a radionuclide in the body that would be 2.6 times that for the person in a 10-minute count in the routine shadow shield counter.

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This new counter would not quantify the radionuclide content as accurately, but it would have greater sensitivity for detecting radioactivity in the body. The short counting time of two or three minutes would allow all people to be measured in the counter and eliminate the need for people to walk across the parking lot to the mobile counters. Those few people who show positive internal radionuclide content would then be measured on the standard shadow shield counter for an accurate determination of amount present. This facility would postpone the need for a large shielded room facility for several years. If approved, this walk-in maze-type facility will be constructed by July 1983.

Improved Data Processing for the Mobile Counter - An Apple II computer was purchased for each of the two, mobile, whole body counter units. These computers replace the function of the paper tape punches, which were old, worn out and exhibiting a high rate of malfunction. The computers store spectra on magnetic (floppy) discs and are programmed to calculate and print the results immediately after the count. At the present time, the spectra and computations are transferred to the Nova 4 main whole body computer from the floppy disc which is carried to the whole body counter at the end of each day. Work is continuing in interfacing the Apple II computer to the multichannel analyzer and to the Nova 4 computer by modem transmission.

NEW PROCEDURES

For 17-keV x-rays, the transmission through fat is significantly different than through muscle. A change in fat composition from 20% to 33% in the average chest wall thickness will result in a 27% increase in the transmission of a 17-keV x-ray. The percent fat is an important parameter in estimating the content of Pu or U in the lungs. During regular chest wall thickness measurements, the ultrasound instrumentation is adjusted to optimize the definition of the chestwall-lung interface. However, the instrumentation response can be tuned to give more detail near the skin surface. When this is done, an image of the fat-muscle interface near the chest wall can be made made. (see Figure 5). The thickness of the fat layer is easily seen as the space between the chest surface and the fat-muscle interface and can be determined and expressed as a percentage of the chest wall thickness.

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The tissue equivalent torso phantom has three sets of chest plates of different fat composition. The three compositions are 1) all muscle, 2) 50% fat-50% muscle, and 3) 87% fat-13% muscle. By measuring standard ^{239}Pu lungs in the phantom with the various chest wall compositions, a family of curves can be generated so that a calibration factor can be obtained for a person with any chest wall thickness and any percent fat value.

RESEARCH AND DEVELOPMENT ACTIVITIES

Gas Scintillation Proportional Counters - A Teflon-body, 10-inch-diameter gas scintillation proportional (GSP) counter with a "Kapton" plastic window was tested to determine if the xenon gas would remain pure enough to maintain good resolution. By using a hot calcium purifier with convection gas flow, the counter was operated in the laboratory for six months with only a slight degradation of the resolution. The Teflon construction material is essentially free from radioactivity and does not contribute to the background of the counter.

Further development was made on the photoionization chamber which is used as a scintillation light detector. The chamber has multiple concentric anode sections which can be independently adjusted for gain. This type of chamber significantly improved the resolution for broad beam radiation, but the resolution was not as good as that for a collimated beam of radioactivity. Further work is needed on this uniform light-collection problem.

Our experience this past year with the new IG detector described in a previous section has shown that the performance of these detectors is superior to that expected from the GSP counter in every way except that of large areas. However, our experience with the ^{238}Pu inhalation case, which was described previously in this report, indicates that large area detectors are not as advantageous as previously thought. Therefore, it is doubtful that the GSP counter would provide a sensitivity that would be lower than the IG detectors, and further expenditure of time and money cannot be justified from the whole body counting programs. The GSP counter is still very attractive for improved neutron spectroscopy and environmental monitoring, and it will be developed for these purposes as outside funding becomes available.

Interlaboratory Comparison of ^{92m}Nb in the Lungs of Humans and in Tissue Equivalent Torso Phantom - Work was completed on the certification of the tissue equivalent torso phantom as an international standard for lung calibration for adult male humans. This work was sponsored by the IAEA and involved eight male adults who inhaled small quantities of ^{92m}Nb on one-micron-size microspheres. The ^{92}Nb emits a 15.8-keV x-ray which is similar in energy to the x-rays from ^{239}Pu and it also emits a 934-keV gamma-ray which allows the quantity in the lung to be easily determined. By knowing the amount in the lung a calibration factor can be determined for the measurement of the 15.8-keV x-ray. The inhalation was done at Harwell, England. After stabilization of the ^{92m}Nb in the lung, these subjects were measured at several whole body counting laboratories in the United States and Great Britain. The ^{92m}Nb activity was also uniformly incorporated in the lungs of the phantom and measured with several different chest wall thicknesses. The calibration factors obtained from the human subjects for the 15.8-keV x-rays are shown in Figure 5 along with the calibration factors obtained from the phantom. Since the human subjects had varying amounts of fat in their chest wall thickness, all the factors of both human subjects and the phantom were normalized to 100% muscle. This was possible from data obtained using phantom chest plates ranging from 13% to 100% muscle equivalency. The agreement between the human subjects and the phantom is quite good and demonstrates that at least for one-micron particle size, the activity uniformly distributed in the phantom lung gives the same detector response as that normally distributed in human lungs. Further studies are planned in which several female subjects will inhale ^{92m}Nb to determine the effects of thicker chest walls.

Whole Body Counting Staff

H. E. Palmer	Staff Scientist and Technical Leader
G. A. Rieksts	Development Engineer, Routine Operations
H. B. Spitz	Senior Research Scientist, part time, Research Studies
M. C. Rhoads	Senior Technician
J. M. Mackliet	Technician
B. W. Perkins	Electronic Technician (assigned from Craft and Operation Services Department)

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PRESENTATIONS AND PUBLICATIONS DURING 1982

H. E. Palmer, "A Large-Area, Low-Background Gas Scintillation Proportional Counter." Presented at the 1982 Nuclear Science Symposium, Washington, D.C., October 20-22, 1982.

Table 4

Department of Energy Laboratories
Whole Body Counter Survey (1)

Lab., Person in Charge	FTS Phone #	Number of Shielded Rooms	Number of Shadow Shields	Number of Personnel (2)	Measurement Per Year (3)	Relative Labor Cost Cost per Measurement (4)
Argonne Nat. Lab Dick Tookey	972-4132	3	2	3	100 (350)	Not applicable
Brookhaven Nat. Lab. Stan Cohn	666-3591	5	-	8	100 (500)	Not applicable
Los Alamos Nat. Lab. Dennis Vasilik	843-2724	2	-	2	1600	$ 75.00
Lawrence Livermore Nat. Lab. Larry Anderson	532-5181	1	-	2	600	$200.00
Oak Ridge Nat. Lab. Carol Berger	624-6662 (Research) 624-6662 (Y-12)	1 1+1 planned	1	5 4	1000 3500	$300.00 $ 69.00
Rocky Flats Plant Roger Falk	320-4212	3	-	4.5	4400	$ 61.00
Savannah River Plant Ken Krase	239-1384	1 (count 2 shifts/day)		3	2900	$ 62.00
Hanford Earl Palmer	444-6257	2	2	4	8000 (50)	$ 30.00

1. Telephone survey of April 12 and 13, 1982 by Earl Palmer of Hanford.
2. Number of personnel does not include instrument maintenance support.
3. The number of measurements are for Health Physics purposes. The values in parentheses are measurements made for research purposes, such as the radium dial painter studies and Nuclear Medicine studies, etc.
4. Relative labor cost calculated assuming an average of $60K per year for each person working at the whole body counting facility.

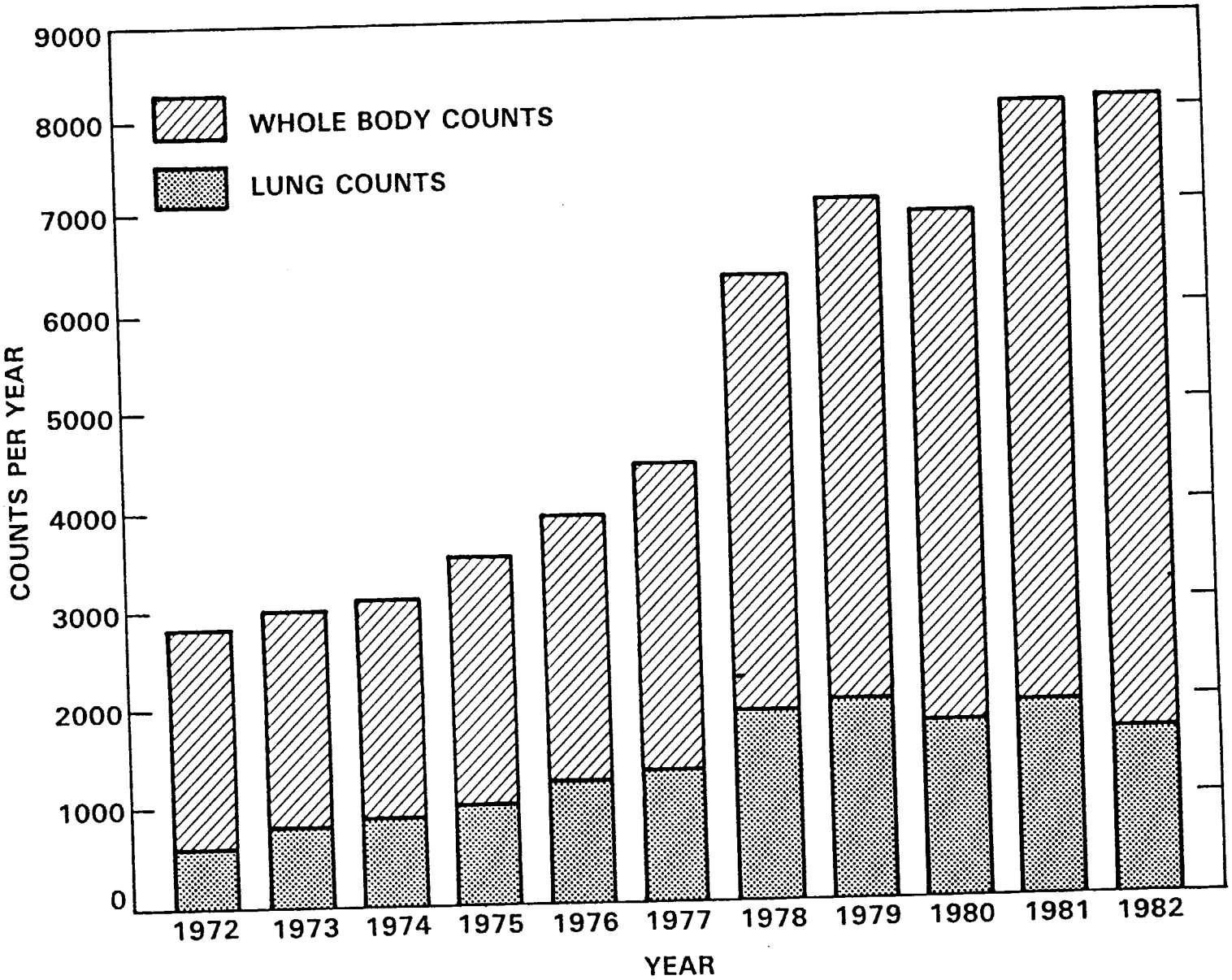

FIGURE 1. IN VIVO MEASUREMENTS AT THE HAN D WHOLE BODY COUNTER FACILITIES

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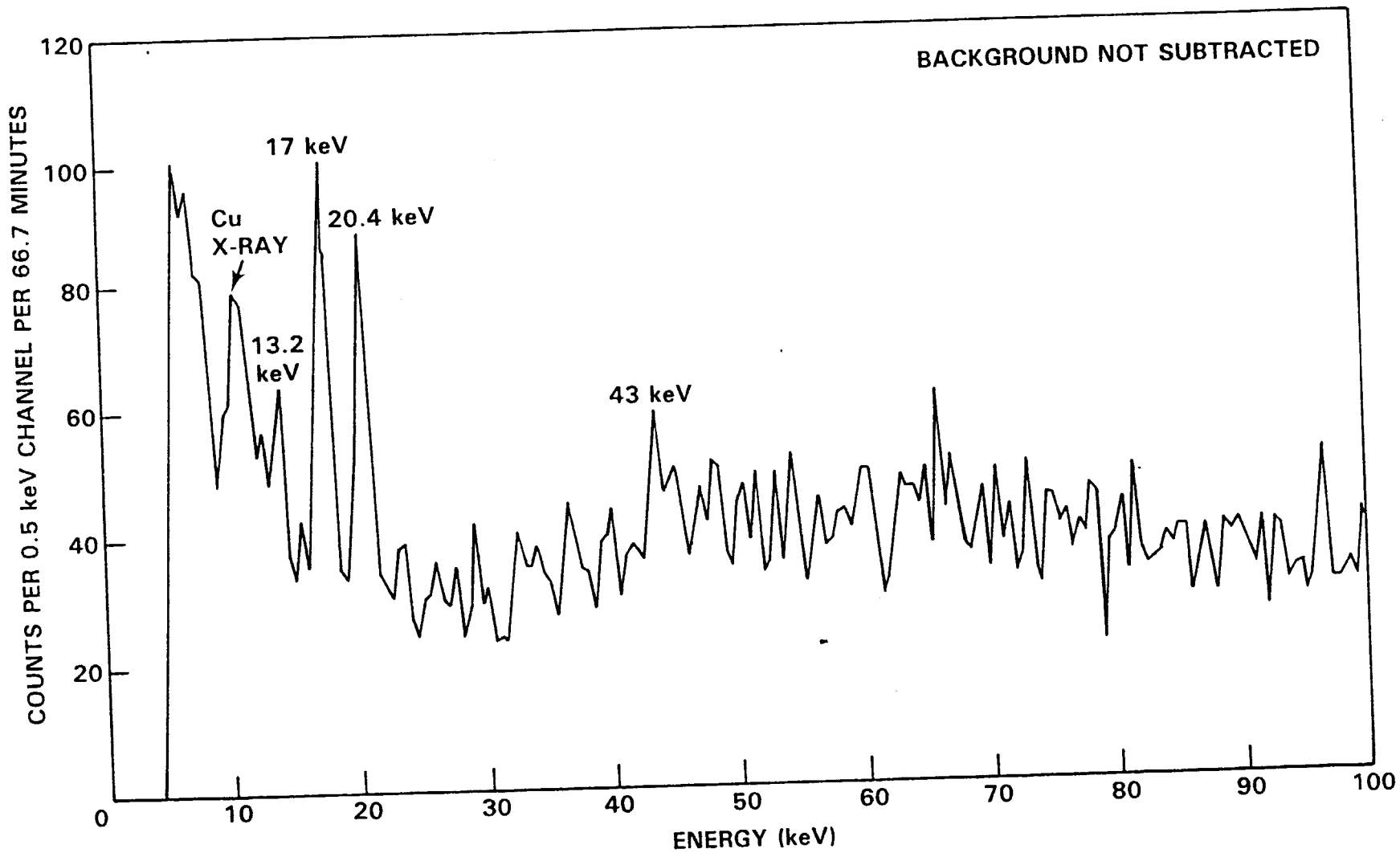

FIGURE 2. 4000 SECOND COUNT OF 50 nCi OF ^{238}Pu IN THE LUNG

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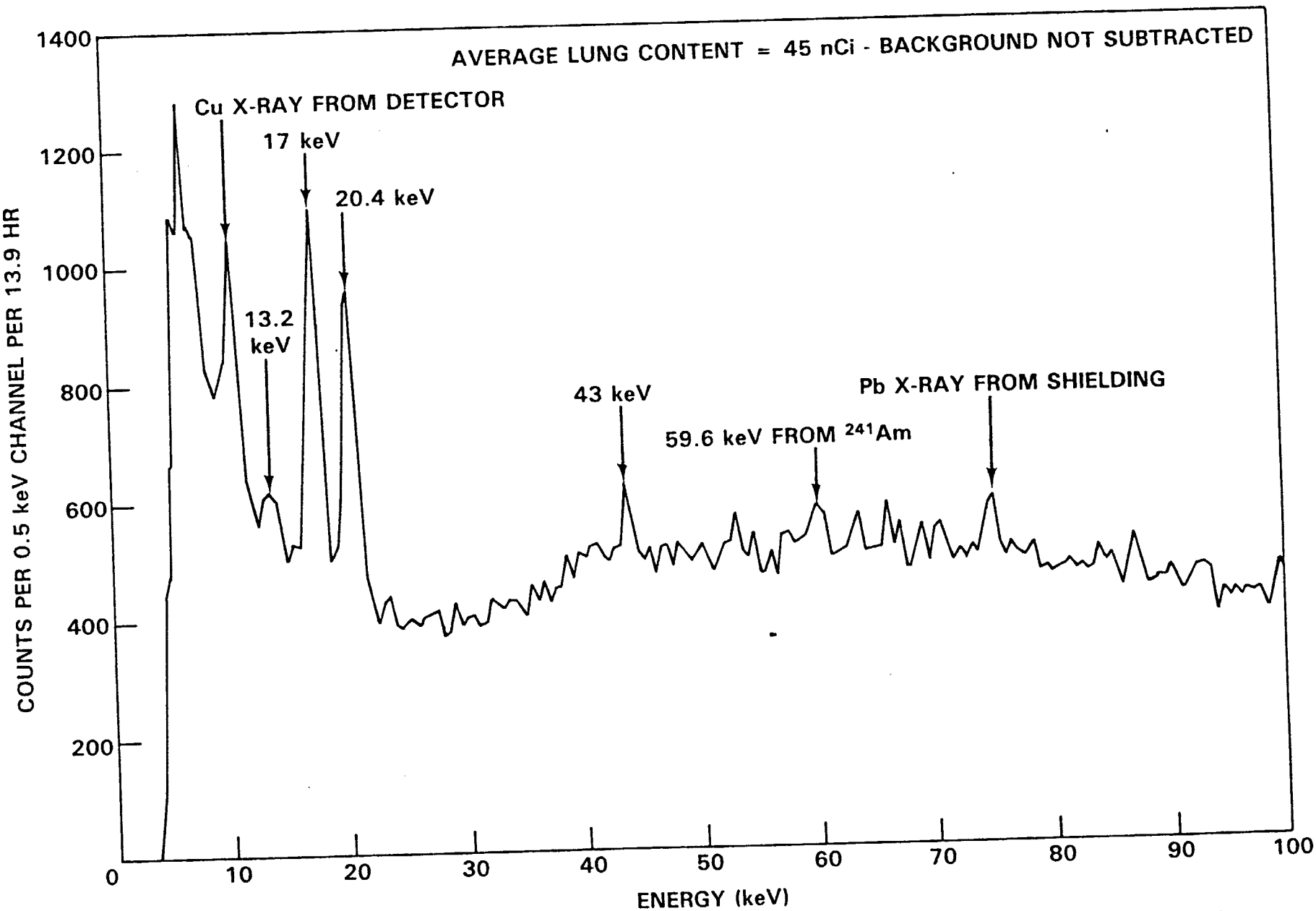

FIGURE 3. A SUMMATION OF 13 MEASUREMENTS OF INHALED ^{9}Pu

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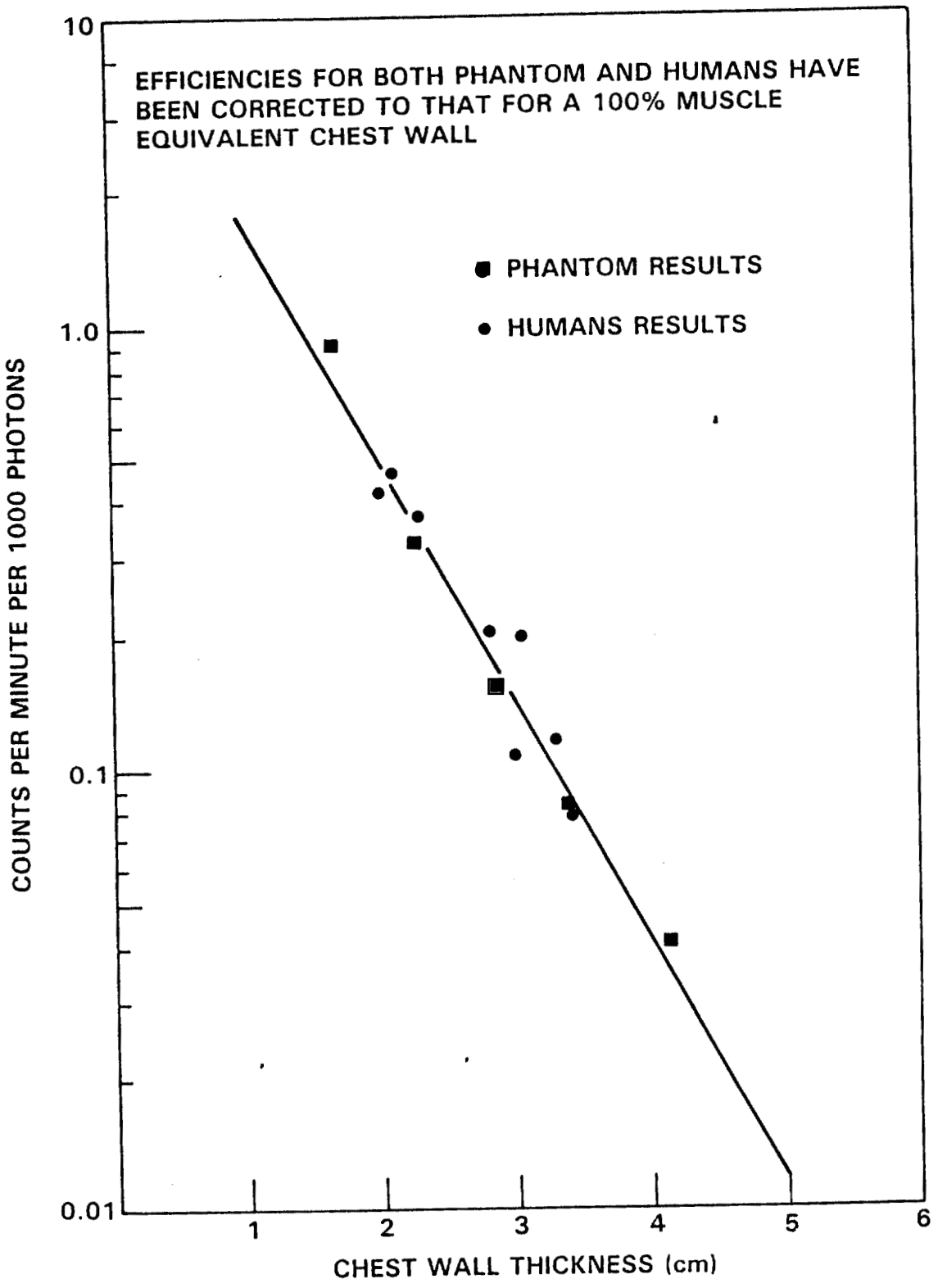

FIGURE 4. PNL TWIN PHOSWICH LUNG COUNTER DETECTOR EFFICIENCY FOR ^{92m}Nb

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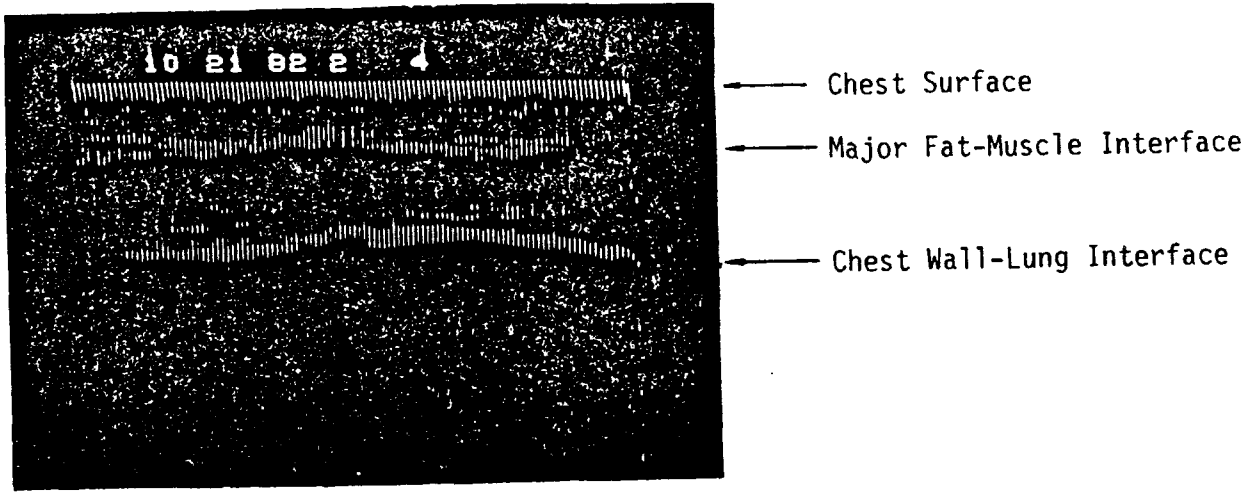

FIGURE 5. DISPLAY OF ULTRASOUND IMAGE OF FAT-MUSCLE AND CHEST WALL-LUNG INTERFACES.