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DETERMINATION OF P^{32} IN VIVO

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ABSTRACT

A transmission proportional counter and a NaI(Tl) scintillator, operated in coincidence for detection of P^{32} beta rays emitted from the head, is better for in vivo measurements than a bremsstrahlung counter. The background is lower and is much less variable from person to person. Relatively little shielding is required. The P^{32} body burdens of people who eat whitefish from the Columbia River near Hanford can be measured by this method.

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Fish and waterfowl that feed in the Columbia River downstream from the Hanford reactors acquire some radionuclides that enter the river with the reactor effluent water.(1) P^{32} and Zn^{65} are the principal nuclides found, and suckers and whitefish usually contain the greatest concentration of these nuclides. Since sportsmen obtain and eat the waterfowl and fish from the Columbia River below Hanford, a method of measuring the low level body burden of these nuclides in humans is needed. Since Zn^{65} is a gamma emitter, body burdens down to 1 nCi can easily be measured in a whole body counter. Foster(2) has described an experiment in which a subject ate a weekly meal of whitefish and the accumulation of the Zn^{65} in the body was studied. P^{32} does not emit a gamma ray and it is much more difficult to measure. This paper describes a method by which body burdens of P^{32} down to 40 nCi can be measured.

Several reports have described the determination of P^{32} in the human body by detection of bremsstrahlung.(3,4,5) The bremsstrahlung counter we have used is a $4\frac{1}{2}$ inch diameter by 3 mm thick NaI(Tl) scintillator with a 0.001 inch thick aluminum window. Body burdens of

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P^{32} down to 200 nCi can be detected with it. The principal problem which prevents reliable measurements of lower body burdens is that it is impossible to distinguish between a bremsstrahlung photon and a low energy gamma ray or secondary photon. Therefore, the backgrounds of different people depend on their size, which influences the scattering of surrounding background radiation, and their body burden of gamma emitting isotopes. Although significant improvement can be made by applying corrections for these two variables, the accuracy with which the individual subject background can be estimated is still the greatest limitation in low level bremsstrahlung measurement.

A typical spectrum obtained with this bremsstrahlung counter placed at the head of a subject containing about 1 mCi of P^{32} is shown in Curve A of Figure 1. Some of this spectrum, however, is not due to bremsstrahlung. An absorber that absorbs beta rays but does not significantly absorb the bremsstrahlung produces Curve B of Figure 1 when placed between the counter and the subject's head. Curve B is the true bremsstrahlung spectrum. The difference between A and B, Curve C, is the spectrum due to beta rays emitted from the surface of the head. The areas under curves B and C are nearly equal, i.e. about the same number of counts are obtained from beta rays as from bremsstrahlung. This indicated that counting of only the beta rays should be investigated. If the background could be reduced sufficiently, the minimum detectable amount of P^{32} might be even lower than for bremsstrahlung counting.

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Counting the beta rays emitted through the skin may not work for other pure beta-ray emitters which are metabolized differently than phosphorus. Although phosphorus, like calcium, is associated with bone growth, it is also an essential component of all cells. The blood contains several different compounds of phosphorus. Much of the P^{32} in the body is circulated in the blood stream and reaches the surface of the body. However, deposits of Sr^{90} on the outside of the skull could be measured since the skin and tissue covering the skull is thinner than the range of Y^{90} beta rays.

To reduce the background during the detection of beta rays, I placed a transmission type proportional counter in front of the bremsstrahlung counter. This proportional counter was 1 x 6 x 6 inches and was divided into six small counters, each having a cross section of 1 in^2 and a length of 6 inches, by means of ground wires. The thin windows were 0.008 inch Mylar plastic. The counter was operated as a flow counter using 90% argon - 10% methane. The six anodes were connected together and in coincidence with the NaI scintillator. Figure 2 shows a sketch of the counter. With this arrangement a pulse in the NaI counter would be analyzed only when the radiation produced a pulse in the proportional counter at the same time. This discriminates against gamma and X rays and counts every charged particle that enters both counters. Inside a good lead shield a large share of the background in the bremsstrahlung counter alone is due to relatively high energy gamma rays that scatter so as to leave only a little energy

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in the scintillator. The coincidence requirement eliminates this kind of background. Beta rays from the skin can go through the proportional counter with little trouble and are counted nearly as well as before in the NaI scintillator. A NaI scintillator is used rather than a plastic scintillator because the better resolution provides easy energy calibration with low energy photon sources.

The background of this coincidence counter, for 40 to 1000 KeV pulses in the NaI, was 12 counts per minute when operated in the Hanford iron room with a phantom head made of sugar. With the coincidence circuit turned off it was 130 counts per minute. Typically, the coincidence rate was 20 counts per minute when counting a subject containing only normal amounts of K^{40} and Cs^{137}. A pressed-wood beta absorber 3/16 inch thick placed between the head and the counter reduced the rate to 15 per minute, which is 3 counts per minute above that of the phantom head. This indicates normal beta background from the head is about 5 counts per minute, probably from K^{40} beta rays. The other 3 counts per minute are probably due to Compton recoil electrons produced by gamma rays emitted from the body. The background due to higher than normal gamma radiation in a subject can be determined with the beta ray absorber over the counter. All normal subjects counted so far have had about the same beta ray counting rate, 4 to 5 counts per minute.

The counter was calibrated with five subjects containing known amounts of P^{32}. The average counting rate at the side of the head is

1.0 counts per 20 minutes per nanocurie of P^{32} in the body. The range of rates was ± 15% for the five subjects. Figure 2 shows the counts obtained for two subjects. They were studied for several weeks and one of the subjects was reinjected after 28 days. The effective half-life for P^{32} was about 10 days; this agrees with previous results obtained with the bremsstrahlung counter at higher activity levels of P^{32}. A detailed study of the influence of body size, excess fat, and different head shapes on the counting rate has not been made. The range of ± 15% in counting rate was obtained from the five subjects who ranged in weight from 160 to 210 pounds and in height from 60 to 69 inches. For very small or very large people the counting rate per nCi of P^{32} in the body may vary more than 15%. The detection limit for the counter is about 40 nanocuries of P^{32} at the 95% confidence level. This is much better than the bremsstrahlung counter because the background is lower, shows much less variation from person to person, and can be more accurately measured.

The coincidence counter has a higher counting rate over the head than over any other body extremity. In order to stay as far as possible from organs such as the liver, which concentrates potentially interfering isotopes such as Zn^{65}, it is not used over the torso. Another advantage of using an extremity such as the head is that only that extremity and the counter need be shielded; an iron room is not needed. I found that the counting rate with the head and counter shielded with lead two inches thick (total weight 1000 pounds) was the same as in the

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iron room. Such small and light-weight shielding requirements make it feasible to add such a counter to the Hanford Mobile Whole Body Counter facility.(7)

One reason for developing a sensitive, in vivo counter for P^{32} was to measure people who eat Columbia River fish. Whitefish contain the most P^{32} and during the fall often reach 2 nanocuries per gram, wet weight.(1) A person eating half a pound of such whitefish and absorbing 75% of the P^{32} would acquire a body burden of 350 nanocuries. Five subjects ate 3/4 pound each of whitefish which had been caught in the Columbia River. After allowing one day for absorption of the P^{32}, the subjects were measured for 20 minutes with the coincidence counter and showed body burdens of 70, 110, 89, 72, and 93 nCi. The amount of P^{32} in the whitefish ingested by the first two subjects was not known but the last three ingested 110 nCi, and the standard deviation for the measured in vivo burdens was about 25 nCi. This counter is in use at the Battelle-Northwest whole body counting facility and has been used in other experiments on P^{32} uptake from fish conducted there.

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ACKNOWLEDGEMENTS

We are indebted to Dr. Osgood of the University of Oregon Medical School and to the Swedish Hospital in Seattle for allowing us to make measurements on people with known body burdens of P^{32}.

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FIGURE LEGENDS

1. Bremsstrahlung Counter Spectra
2. Beta Coincidence Counter
3. Retention of Low Level Burdens of P^{32}

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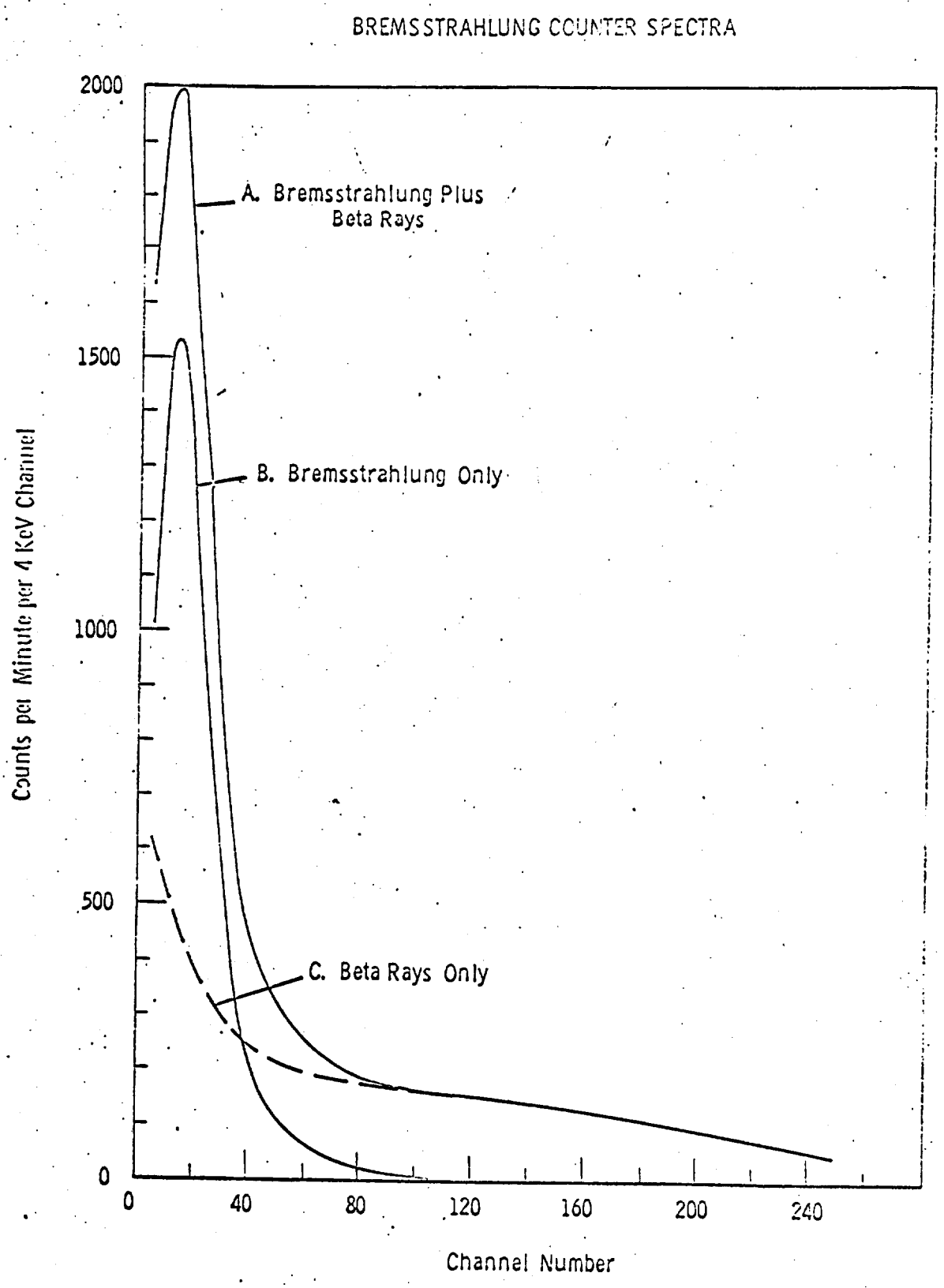

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Figure 1

BETA COINCIDENCE COUNTER

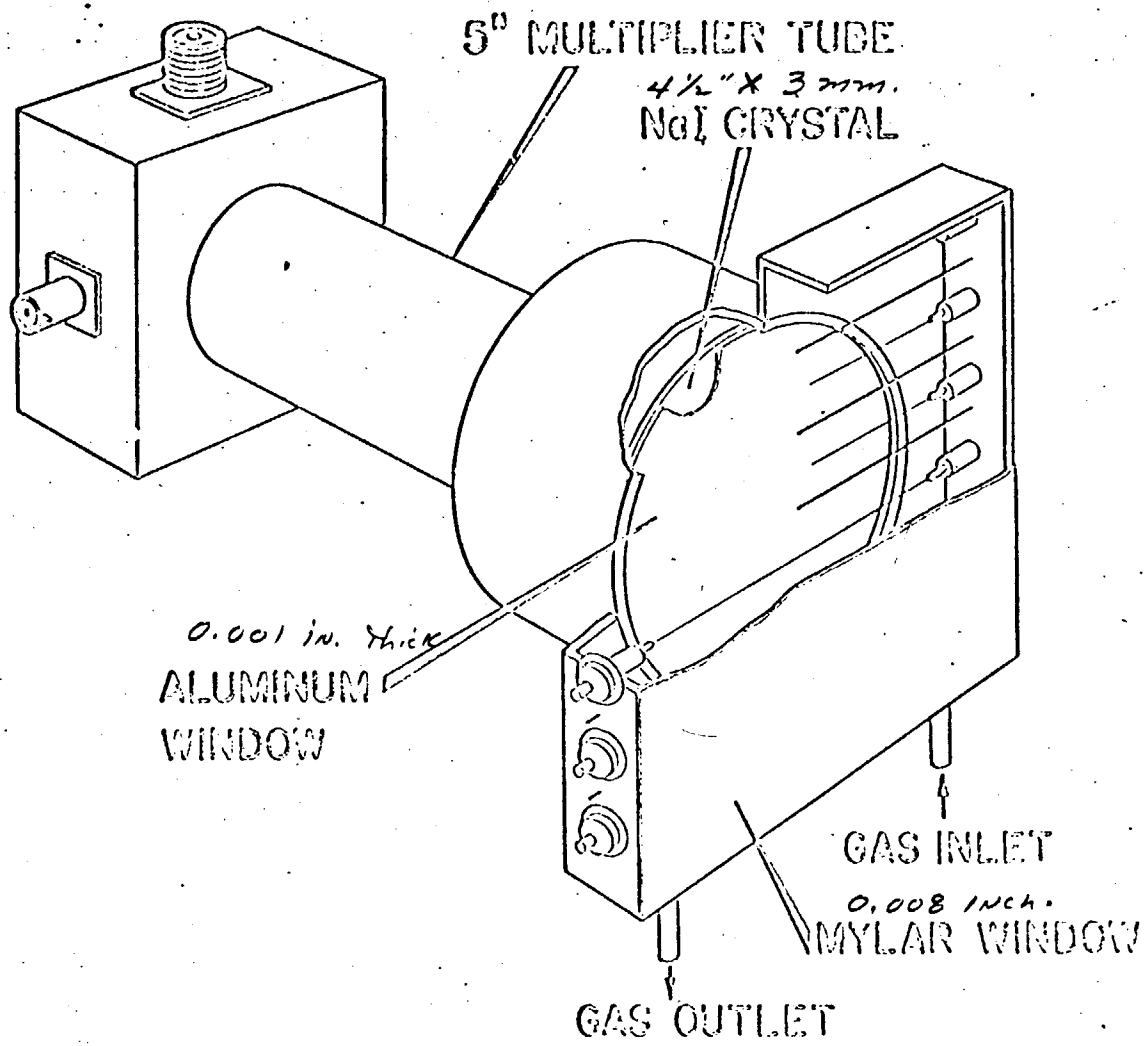

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Figure 2

RETENTION OF LOW LEVEL BURDENS OF P^{32}

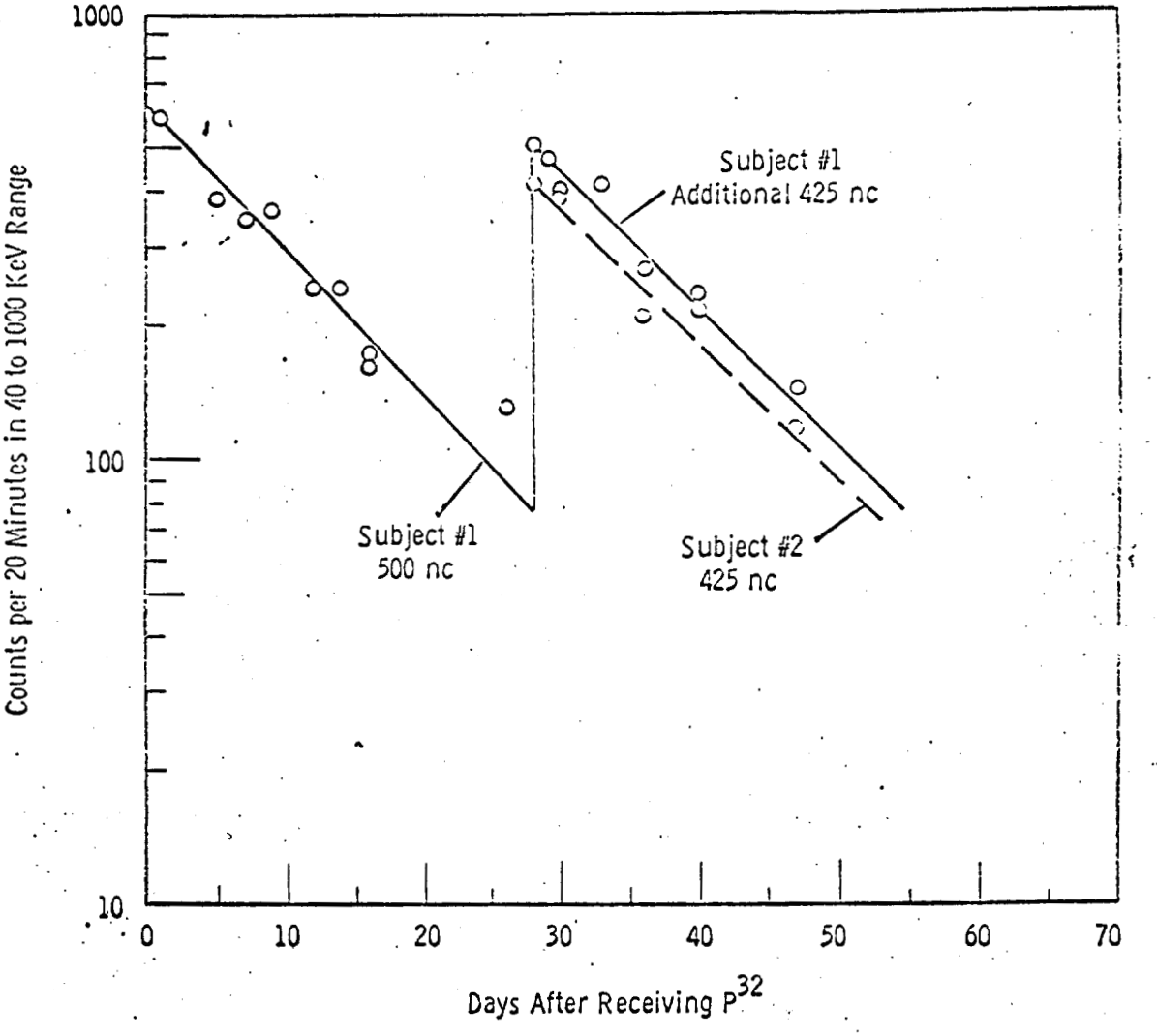

Figure 3

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HUMAN SUBJECTS RESEARCH
DOCUMENTS READY TO BE RELEASED

PNL NO.	TITLE/SUBJECT	DOC.DATE	PAGE COUNT
PNL-9120	Memo to H.M. Parker from K.L. Swinth Information on 103 Pd-51Cr Inhalation Experiment	11/18/77	2
PNL-9121	Memo to H.M. Parker from K.L. Swinth Human Subjects Review for 103Pd-51Cr Inhalation Experiment	08/17/77	2
PNL-9122-DEL	Memo to H.M. Parker from K.L. Swinth Human Subjects Review for 103Pd-51Cr Inhalation Experiment	08/29/77	59
PNL-9123	Memo to H.M. Parker from R.C. Free HSC 77-16 - Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters	12/21/77	1
PNL-9124	HSC Member Review of HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters Signed by J.A. Figg	12/15/77	2
PNL-9125	HSC Member Review of HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters Signed by E.B. Harkins	12/15/77	2
PNL-9126	HSC Member Review of HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters Signed by A.L. Judy	12/15/77	2
PNL-9127	HSC Member Review of HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters Signed by S. Marks	12/15/77	2
PNL-9128	HSC Member Review of HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters Signed by D. Newton	12/15/77	2
PNL-9129	DSI to H. Parker from K. Swinth	07/21/78	1
PNL-9130	DSI to H. Parker from K. Swinth	06/19/78	1
PNL-9131-DEL	Letter to K.L. Swinth from D. Newton	06/06/78	1
PNL-9132	Memo to H.M. Parker from K.L. Swinth Visit of Pd-Cr Subject	05/05/78	1
PNL-9133	Memo to H.M. Parker from K.L. Swinth Harwell's Phanton Plans	04/04/78	1
PNL-9134	Memo to H.M. Parker from K.L. Swinth Intercalibration via Phanton and 51Cr-103Pd	04/03/78	4
PNL-9135	Memo to DHSC 77-16 from H.M. Parker HSC-7716 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters	12/02/77	1

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PNL NO.	TITLE/SUBJECT	DOC.DATE	PAGE COUNT
PNL-9136	Memo to K.L. Swinth from H.M. Parker HSC 77-16 Interlaboratory Comparison of Techniques for Measuring Lung Burdens of Low Energy X-Ray Emitters (103-Pd-51Cr Inhalation Experiment)	12/21/77	1
PNL-9137-DEL	Memo to H.M.Parker from K.R. Kalkwarf Request to Consider the Proposed Study: Urinary Excretion of Metals and DTPA	04/17/78	5
PNL-9138	Handwritten Note from J.A. Figg and HSC Member Review of Urinary Excretion of Metals and DTPA Sheet	05/15/78	3
PNL-9139	HSC Member Review of Urinary Excretion of Metals and DTPA Signed by W.D. Norwood	05/15/78	2
PNL-9140	HSC Member Review of Urinary Excretion of Metals and DTPA Signed by A.L. Judy	05/15/78	2
PNL-9141-DEL	Memo to H.M. Parker from C.E. Newton HSC-78-4, and Member Review of Urinary Excretion of Metals and DTPA Signed by C.E. Newton	05/12/78	3
PNL-9142	HSC Member Review of Urinary Excretion of Metals and DTPA Form Signed by Michael Mill.....	05/15/78	2
PNL-9143-DEL	HSC Member Review of Urinary Excretion of Metal and DTPA Signed by (illegile)	05/15/78	2
PNL-9144-DEL	Memo to H.M. Parker from S. Marks HSC-78-4, Urinary Excretion of Metals and DTPA	06/07/78	1
PNL-9145-DEL	Memo to D.R.Kalkwarf from H.M. Parker HSC-78-4, Urinary Excretion of Metals and DTPA	06/01/78	1
PNL-9146-DEL	Unconditional Release and Agreement	10/31/77	7
PNL-9147-DEL	Memo to DHSC 78-4 from H.M. Parker Urinary Excretion of Metals and DTPA (189 for GK-01-02-01-1) PNL ID #34 HSC 78-4	05/04/78	1
PNL-9148-DEL	Memo to H. Parker from A.C. Rither Research Involving Urine Samples of Harold R. McCluskey	03/10/78	1
PNL-9151	Memo to H.M. Parker from J.J. Fuquay Human Subjects Committee Review	03/05/68	22
PNL-9152	Memo to C.A. Bennett from H.M. Parker No Subject	04/23/70	1
PNL-9153	Memo to C.A. Bennett from H.M. Parker No Subject	04/09/70	2
PNL-9154	Note to H.M. Parker from H.A. Kornberg No Subject	/ /	2

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PNL-9155	Memo to R&D Division Managers from H.M. Parker Reports That Need to Come to the Attention of the Human Subjects Committee	01/05/70	1
PNL-9156	Memo to H.M. Parker from W.J. Bair Human Subjects Committee	01/05/70	1
PNL-9157	Note to W.J. Bair from M.F. Sullivan No Subject	12/17/69	2
PNL-9158	Request for Proposal Information and Evaluation (File #F41609-70-R-0015) Determining Skin Hazards Associated with Exposure to Laser Radiation	09/18/69	4
PNL-9159	Letter to W.G. Harris from F.W. Albaugh Investigation of Laser Skin Hazards (F41609-70-R-0015)	12/16/69	5
PNL-9160	Letter to W.S. Guttman from F.W. Albaugh (RFP F41609-70-R-0016) A Study Relating to Dose Levels from Laser Radiation to Threshold Effects in Skin 211B00170	12/10/69	5
PNL-9161	Contact Memo to Distribution from D.D. Mahlum Request for Further Details About Experimental Protocol on Proposal 211B00170	12/10/69	1
PNL-9162	Memo to H.M. Parker from C.E. Newton, Jr. Human Subjects Committe Meeting	12/09/69	1
PNL-9163	Memo to H.M. Parker from C.E. Newton, Jr. Human Subjects Committee Meeting - November 19, 1969	11/20/69	3
PNL-9164	Letter to W.S. Guttman from F.W. Albaugh A Study Relating to Dose Levels from Laser Radiation to Threshold Effects in Skin 211B00170	11/11/69	2
PNL-9165-DEL	Suggested Research Program - A Study Relating Dose Levels from Laser Radiations to Threshold Effects in Skin (RFP F41609-70-R-0015) (211B00170)	11/11/69	33
PNL-9166	Time and Cost Proposal - A Study Relating Dose Levels from Laser Radiation to Threshold Effects in Skin 211B00170	11/11/69	13
PNL-9167	Memo to H.M. Parker from F.P. Hungate Study of Laser Effects on Skin	11/10/69	1
PNL-9216	Handwritten Notes - 147Pm via 143Pm	/ /	1
PNL-9217	Retention and Translocation of Inhaled Calcined Promethium Oxide in Beagle Dogs Annual Report No. 13 (B.O. Stewart and J.C. Gaven)	01/27/67	4

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PNL-9234-DEL	Memo to H.E. Palmer from H.M. Parker Lung Counting of Foreign Volunteers Who Have Inhaled Radioactive Material	06/16/83	3
PNL-9236	Evaluation of Radionuclides in Man (189-78-RK-128) (F.T. Cross)	05/04/77	6
PNL-9237	Approval Prep Sheet with Risk Assessment Evaluation of Radionuclides in Man (F.T. Cross)	04/21/77	15
PNL-9238	Memo to H.M. Parker from R.C. Free Research Involving Human Tissues, Etc. from Corpses	04/29/77	1
PNL-9239	Summary of Comments Evaluation of Radionuclides in Man HSC 77-5	/ /	1
PNL-9240	Comments from J.A. Figg for DHSC 77-5	05/05/77	2
PNL-9241	Note to R.C. Free from A.L. Judy Evaluation of Radionuclides in Man Proposal 189-78-RK-128 (HSC 77-5)	05/02/77	1
PNL-9242	Review Sheet for Evaluation of Radionuclides in Man Signed by EB Harkins	05/02/77	2
PNL-9243	Memo to R. Free from S. Marks Review of Evaluation of Radionuclides in Man Proposal 189-78-RK-128	04/29/77	1
PNL-9244	Review Sheet for Evaluation of Radionuclides in Man Signed by RE Shippert	05/06/77	2
PNL-9245	Memo to Distribution from I.C. Nelson Evaluation of Radionuclides in Man	10/25/76	2
PNL-9246	Memo to F.T. Cross from R.C. Free Evaluation of Radionuclides in Man Proposal 189-78-RK-128 (HSC 77-5)	05/12/77	1
PNL-9248	Memo to DHSC 77-5 from H.M. Parker Evaluation of Radionuclides in Man	05/05/77	1
PNL-9249	Memo to DHSC 77-5 from H.M. Parker Evaluation of Radionuclides in Man Proposal 189-78-RK-128 (HSC 77-5)	04/25/77	1
PNL-9250	Review Sheet for Evaluation of Radionuclides in Man (189-78-RK-128)	/ /	2
PNL-9251	DSI to H.M. Palmer from A.R. Adeline No Title	05/26/67	3
PNL-9252	Letter to S.L. Fawcett from P.G. Holsted Agreement with Human Volunteers in Research Programs	06/24/66	4
PNL-9254	Memo to File from PTS Human Subjects Committee Meeting, Thursday, November 16, 1967	11/04/68	2

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PNL-9272	Letter to F.W. Albaugh from C.L. Robinson FY 1968 Financial Plan No. 2 for Operations (Change in 06 Program)	12/01/67	1
PNL-9275	Greenie Article Volunteers Needed	08/04/67	1
PNL-9276	Letter to C.L. Robinson from D.S. Cameron Study of Promethium Metabolism in Humans	11/28/67	3
PNL-9277	Letter to P.A. Fuqua from C.E. Newton, Jr. No Title	07/18/67	2
PNL-9278	Minutes of HOHFI Radioisotope Committee Meeting (P.A. Fuqua)	06/28/67	2
PNL-9279	Letter to Radioisotope Committee from W.D. Norwood, M.D. No Title	06/02/67	1
PNL-9280	Memo to R.S. Paul from P.A. Fuqua, M.D. No Title	05/25/67	1
PNL-9281	Memo to P.A. Fuqua from R.S. Paul No Title	05/25/67	1
PNL-9282	Letter to P.A. Fuqua from R.S. Paul No Title	05/25/67	2
PNL-9283	Memo to J.J. Fuquay from P.T. Santilli Study of Promethium Metabolism in Humans	05/15/67	1
PNL-9287	Justification, Internal Depositions of Radionuclides in Man	02/01/67	7
PNL-9290	Letter to C.L. Robinson from S.L. Fawcett Agreement with Human Volunteers in Research Programs	11/22/66	2
PNL-9291	Minutes of Meeting Research Program - Administration of Radioisotopes (E.J. Quigley)	11/14/66	2
PNL-9293	Justification Whole Body Counting	03/01/66	6
PNL-9294	Justification, Excretion Rates vs. Lung Burdens in Man	04/01/66	7
PNL-9295	Memo to P.T. Santilli from R.S. Paul Agreement with Human Volunteers in Research Programs	07/26/66	2
PNL-9299	Letter to Director from M.W. Tiernan Radiation Workers' Followup	07/07/78	2
PNL-9300	Memo to H.M. Parker from B. Robinson Special Study - Plutonium Urinalysis	08/30/78	1
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PNL-9308-DEL	Memo to H.E. Palmer from H.M. Parker Lung Counting of Foreign Volunteers Who Have Inhaled Radioactive Material	01/23/80	1
PNL-9309-DEL	Memo to H.M. Parker from H.E. Palmer Lung Counting of Foreign Volunteers Who Have Inhaled Radioactive Material	01/18/80	1
PNL-9312	Memo to S.J. Farmer from H.M. Parker Are Convened Meetings of Institutional Review Boards Mandatory for Special Assurances?	09/06/79	3
PNL-9313	Memo to J.J. Fuquay from A.C. Rither Battelle-Columbua Policies for Operation of Their Human Subjects Committee	09/04/79	2
PNL-9315	Case No. 3	11/17/67	2
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PNL-9348	Memo to J.J. Fuquay from S. Marks Health Effects, FYI	11/01/84	6
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PNL-9352	Note to J.J. Fuquay from S. Marks	04/23/85	3
PNL-9355	Letter to Fitzsimmons from R.P. Marshall Hanford Health and Mortality Study	06/05/85	3
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PNL-9359	Letter to T.R. Fitzsimmons from W.R. Wiley Epidemiology Studies: Report and Workshop	10/16/85	3
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PNL-9361	Memo to Distribution from S. Marks Response to Fitzsimmons' Letter of August 2	09/05/85	6
PNL-9364	Memo to Distribution from S. Marks Comments on the Alvarez Report	08/29/94	29
PNL-9470	Accumulation of Zinc-65 from Prolonged Consumption of Columbia River Fish - Article (R.F. Foster and J.F. Honstead)	/ /	5
PNL-9471	Uptake and Retention of 32P and 65ZN From Fish (J.F. Honstead and D.N. Brady	05/13/66	9
PNL-9472	Letter to R.F. Foster from P.G. Holsted High-Alum Water Treatment	09/01/65	1
PNL-9473	Memo to H.B. Spitz from S. Marks DHSC 81-8 (Formerly DHSC 78-2) Translocation of Yellowcake from the Respiratory Tract TD 1070 300A01198	08/10/81	1
PNL-9474	Memo to B. Wiley from J. Fuquay Dick Emery's Paper for Pacific Search	09/29/80	1
PNL-9475-DEL	Letter to M.W. Tiernan from J.J. Fuquay Request for Environmental Evaluation	09/07/80	0
PNL-9476	Memo to Distribution from W.J. Bair Administration of 85Sr to Human Volunteers (74-5)	02/11/74	18
PNL-9477	Letter to W.T. Doran from P.A. Fuqua HEHF & Battelle 143Pm Study	09/12/68	27
PNL-9478	Listing of Contents	/ /	1
PNL-9479	Memo of Expenses for Walla Walla Project	/ /	1
PNL-9480	Letter to K.L. Swinth from C.A. Paulsen Seminar	02/03/66	1
PNL-9481	Radiation and Human Spermatogenesis - An In-Progress Program Review	12/02/65	5
PNL-9482	Appendix I Panel Discussion (C.A. Paulsen)	/ /	3
PNL-9485	Appendix V Table VIII - Shielding Survey Results	/ /	7
PNL-9487	Memo to Distribution from W.J. Bair Expansion of Autopsy Program	12/16/74	3
PNL-9498	Letter to H.M. Parker from P.G. Barnard DHSC 78-8	11/30/78	1
PNL-9499	Memo to H.M. Parker from C.E. Newton Development of a Portable Blood Irradiator	11/30/78	1
PNL-9500	Review Sheet for DHSC 78-8 Development of a Portable Blood Irradiator Signed by W.D. Norwood	11/24/78	2

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DOCUMENTS READY TO BE RELEASED

PNL NO.	TITLE/SUBJECT	DOC.DATE	PAGE COUNT
PNL-9501	Letter to H.M. Parker from A.L. Judy DHSC 78-8 Development of a Portable Blood Irradiator	11/27/78	1
PNL-9502	Review Sheet DHSC 78-8 Development of a Portable Blood Irradiator Signed by E.B. Harkins	11/29/78	2
PNL-9503	Review Sheet DHSC 78-8 Development of a Portable Blood Irradiator Signed by A. Schilly	12/04/78	2
PNL-9504	Memo to F.P. Hungate from H.M. Parker Information Required for Blood Irradiator Program	07/10/79	2
PNL-9505	Letter to R.O. Baukol from F.P. Hungate Portable Blood Irradiator	03/13/79	1
PNL-9506	Letter to C. Bieber from F.P. Hungate Blood Irradiator	02/14/79	1
PNL-9507	170Tm in Vitreous Carbon as a Fully Portable Extracorporeal Blood Irradiator (L.R. Bunnell, F.P. Hungate, W.F. Riemath and M.F. Gillis)	/ /	12
PNL-9508	Memo to H.M. Parker from A.C. Rither Human Subjects Committee Review of Blood Irradiator Program	02/14/79	1
PNL-9509	Memo to H.M. Parker from F.P. Hungate Human Subjects Committee Review of Blood Irradiator Program	01/22/79	1
PNL-9510	Memo to F.P. Hungate from H.M. Parker Development of a Portable Blood Irradiator	12/11/78	1
PNL-9511	Memo to Distribution from H.M. Parker Development of a Portable Blood Irradiator	11/17/78	3
PNL-9512	Memo to H.M. Parker from F.P. Hungate Development of a Portable Blood Irradiator	10/13/78	3
PNL-9513	HSC 74-6 Reviews and Comments (Handwritten)	/ /	2
PNL-9514	Review Sheet Semi-Portable Blood Irradiator Signed by R.C. Free	05/01/74	2
PNL-9639	Proposal Measurement of Muscular-Skeletal Changes Which Occur During Space Flight (H.E. Palmer)	10/25/76	8
PNL-9640	Memo to H.M. Parker from C.E. Newton Proposal HSC 77-2	02/11/77	1
PNL-9641	Review Sheet Signed by W.R. Wiley	02/08/77	2
PNL-9642	Memo to H.M. Parker from A.L. Judy Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	01/20/77	1
PNL-9643	Memo to H.M. Parker from S. Marks Proposal Involving Administration of Strontium-85 to Volunteer Patients and Normal Subjects	01/18/77	2

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DOCUMENTS READY TO BE RELEASED

PNL NO.	TITLE/SUBJECT	DOC.DATE	PAGE COUNT
PNL-9644	Memo to H.M. Parker from C.E. Newton Comments - DHSC 77-2	01/20/77	3
PNL-9645	Memo to DHSC 77-2 from H.M. Parker Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts HSC 77-2	03/28/77	1
PNL-9646	Memo to H.M. Parker from H.E. Palmer The Need for an IND for 85Sr Use in Studying Methods for Measuring Bone Mineral Loss During Space Flight	03/11/77	1
PNL-9647	Memo to H.M. Parker from H.E. Palmer 85Sr Study in Human Subjects	03/24/77	1
PNL-9648	Memo to H.E. Palmer from H.M. Parker HSC 77-2 - Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	03/10/77	1
PNL-9649	Memo to H.M. Parker from H.E. Palmer Additional Information Regardin HSC 77-2, Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	03/03/77	6
PNL-9650	Memo to Distribution from H.M. Parker Human Subjects Committee Meeting, February 14, 1977	02/16/77	4
PNL-9651	Memo to H.E. Palmer from H.M. Parker Provision of Information	02/15/77	1
PNL-9652	Memo to H.M. Parker from H.E. Palmer Reply to HSC Review of HSC 77-2, Investigate Methods for Measuring Muscle Mass and Bone Mass in Astronauts	02/10/77	5
PNL-9653	Memo to W.R. Wiley from H.M. Parker HSC 77-2 Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	01/28/77	1
PNL-9654	Memo to H.E. Palmer from H.M. Parker HSC 77-2 Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	01/28/77	2
PNL-9655	Memo to C.E. Newton from H.M. Parker Membership on DHSC 77-2	01/17/77	2
PNL-9656	Memo to DHSC 77-2 from H.M. Parker Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	01/11/77	2
PNL-9657	Blank Review Sheet for Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts	01/11/77	2
PNL-9658	Proposal Proposed Research Program Investigate Methods for Measuring Muscle and Bone Mass Changes in Astronauts 2311102245, Amendment 4	11/05/76	10

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DOCUMENTS READY TO BE RELEASED

PNL NO.	TITLE/SUBJECT	DOC.DATE	PAGE COUNT
PNL-9659	Memo to H.M. Parker from H.E. Palmer Administration of 85Sr to Volunteer Patients and Normal Subjects	10/22/76	10
PNL-9660	Handwritten Notes on Prostate	/ /	1
PNL-9661	Letter to R.M. Baltzo from W.E. Wilson Regarding Questions of May 28, 1968	06/10/68	5
PNL-9662	Letter to R.M. Baltzo from C.E. Newton Response to Letter Dated May 28	05/31/68	1
PNL-9663	Letter to F.L. Rising from K.L. Swinth Walla Walla Project	12/12/67	1
PNL-9664	Report to N.S. Porter from K.L. Swinth Biomedical Electronics Memorandum Report BME-5-67 Irradiation Vessel Temperature Control	12/12/67	4
PNL-9666	Letter to W.E. Wilson from C.A. Paulsen Dosimetry Data for the Neutrons	10/18/67	1
PNL-9667	Tentative Plan of Presentation to the Parker Committee	09/25/67	2
PNL-9668	Memo to K.K. Leeser from C.E. Newton Personal Liabilities Associated with Medical Research	07/12/67	1
PNL-9669	Memo to W.E. Wilson from K.L. Swinth Fast Neutron Medical Research Facility Dosimetry for 2.5 MeV Neutrons	04/11/67	7
PNL-9670	Handwritten Notes - Inclusion on CAP's Report	/ /	3
PNL-9671	DSI to P. Santilli from K.L. Swinth Neutron Source	03/17/67	1
PNL-9672	Letter to K. Swinth from E.B. Harvey Date and Time for Review of Contract	03/08/67	2
PNL-9673	Letter to C.A. Paulsen from K.L. Swinth Budget Information	03/06/67	1
PNL-9674	Handwritten Notes	09/06/66	4
PNL-9675	History of Spermatogenesis Project (W.C. Roesch)	12/15/66	1
PNL-9676	DSI To Walt from K.L. Swinth Meeting	10/26/66	2
PNL-9677	Memo to Distribution from W.B. Nelp Review of Clinical Research and Investigation Involving Human Subjects	12/15/66	2
PNL-9678	Effects of Neutron Irradiation of Spermatogenesis in Man	/ /	4
PNL-9679	Review Schedule, AEC, Dr. Paulsen's Group	/ /	2
PNL-9680	Sperm Concentration Post-Irradiation	/ /	1
PNL-9681	Determination of P32 In Vivo (H.E. Palmer)	05/26/65	12

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