24th Meeting of the Conference on Radiation and Health
Chicago, IL, September 23 – 25, 2018

The United States Transuranium and Uranium Registries: Fifty Years of Contributions to Understanding of Plutonium in Humans

Sergei Y. Tolmachev, Director
stolmachev@wsu.edu

United States Transuranium and Uranium Registries
College of Pharmacy and Pharmaceutical Sciences
Washington State University

1845 Terminal Drive, Suite 201, Richland, WA 99354
www.ustur.wsu.edu

College of
Pharmacy and
Pharmaceutical Sciences
WASHINGTON STATE UNIVERSITY

Disclaimer

United States Transuranium and Uranium Registries (USTUR):

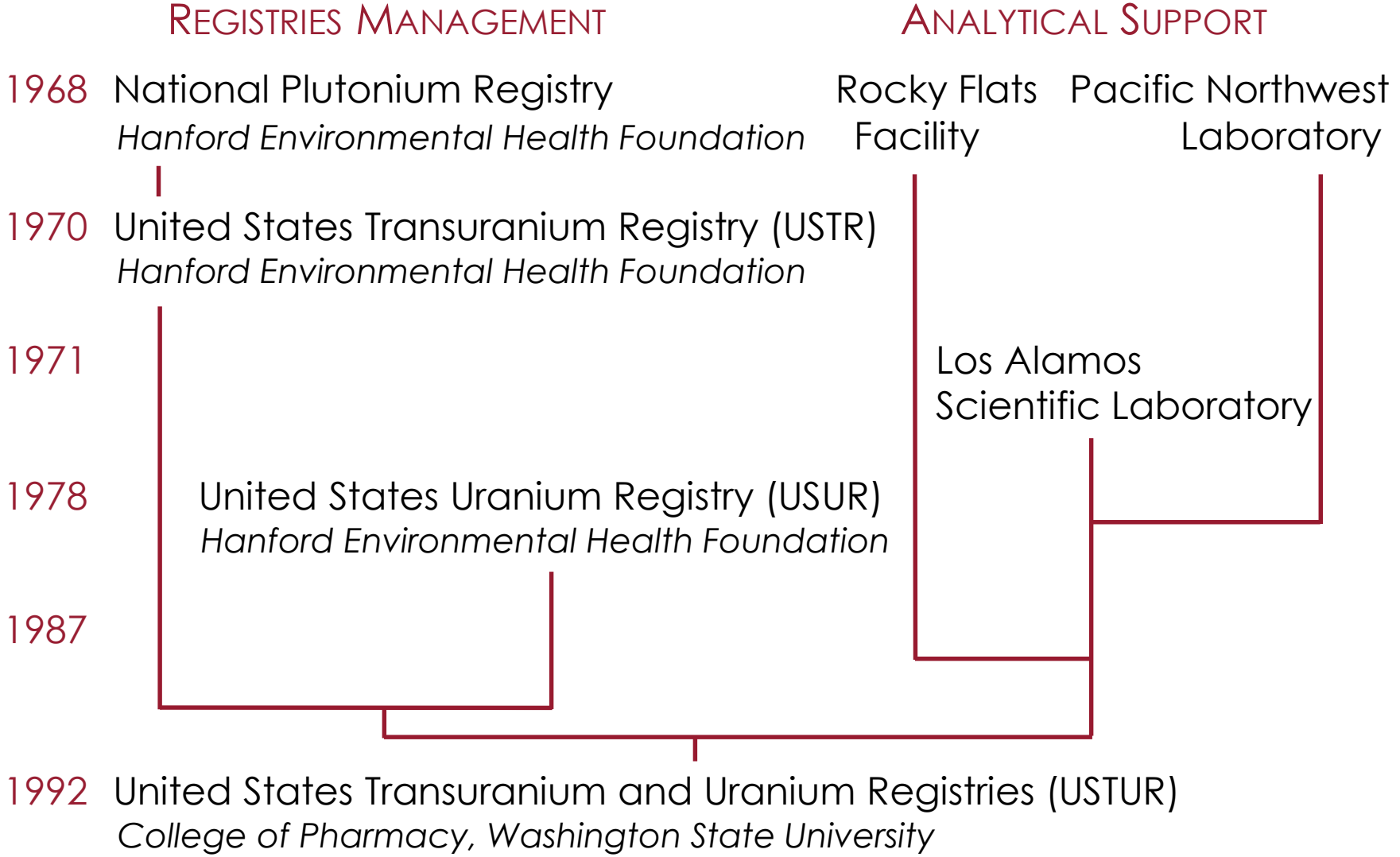
- is not an epidemiological study
- focuses on actinide biokinetics for radiation protection and dosimetry
- supports radiation epidemiology through the improvement of biokinetic models for more accurate dose reconstruction

U.S. AEC 1966 Meeting on Plutonium Contamination in Man (Rocky Flats Plant)

National Plutonium Registry: *1968 Advisory Committee Meeting*

Standing left to right: Carlos E. Newton, Jr., W. Daggett Norwood, H.D. Bruner, Philip A. Fuqua
Seated left to right: Thomas F. Mancuso, J.H. Sterner, Robley D. Evans, Herbert M. Parker
Not photographed: Clarence C. Lushbaugh, Lloyd M. Joshel

Genealogy of the USTUR



USTUR Today

- The United State Transuranium and Uranium Registries (USTUR) is a federal-grant program funded by the U.S. DOE Office of Domestic and International Health Studies (AU-13)
- Operated by College of Pharmacy and Pharmaceutical Sciences at Washington State University under Central DOE Institutional Review Boards
- DOE Program Manager: Dr. Joey Zhou
- Faculty and staff:

- Budget: $5,500,000 (April 1, 2017 – March 31, 2022)
- Location: Richland, WA
- Website: www.ustur.wsu.edu

Current Mission

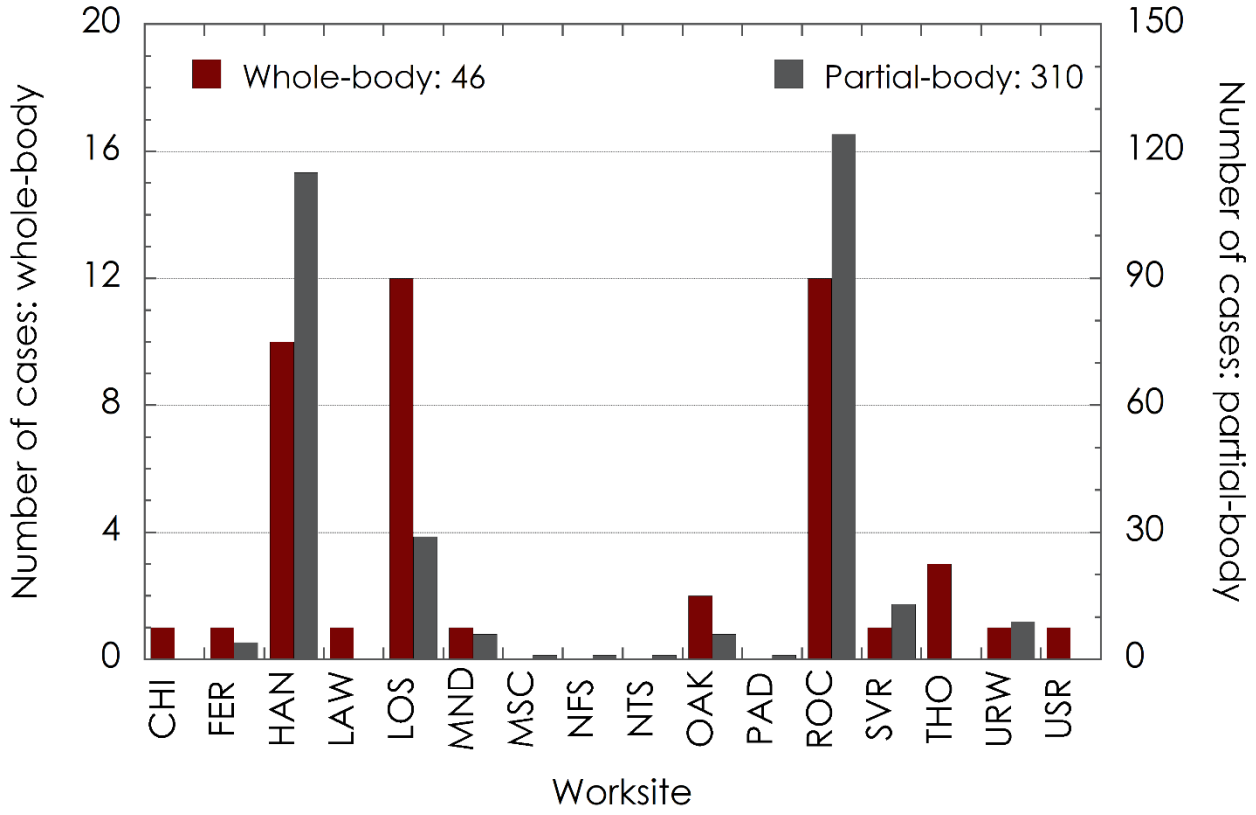
- Follow up occupationally-exposed individuals (volunteer Registrants) by studying the biokinetics (deposition, translocation, retention, and excretion) and tissue dosimetry of uranium and transuranium elements, such as plutonium, americium, curium, and neptunium
- Obtain, analyze, preserve, and make available for future research, materials from individuals who had documented intakes of uranium and transuranium elements
- Apply USTUR data to refine dose assessment methods in support of reliable epidemiological studies, radiation risk assessment, and regulatory standards for radiological protection of workers and general public

USTUR Registrants (I)

- Voluntary tissue donors (posthumous):

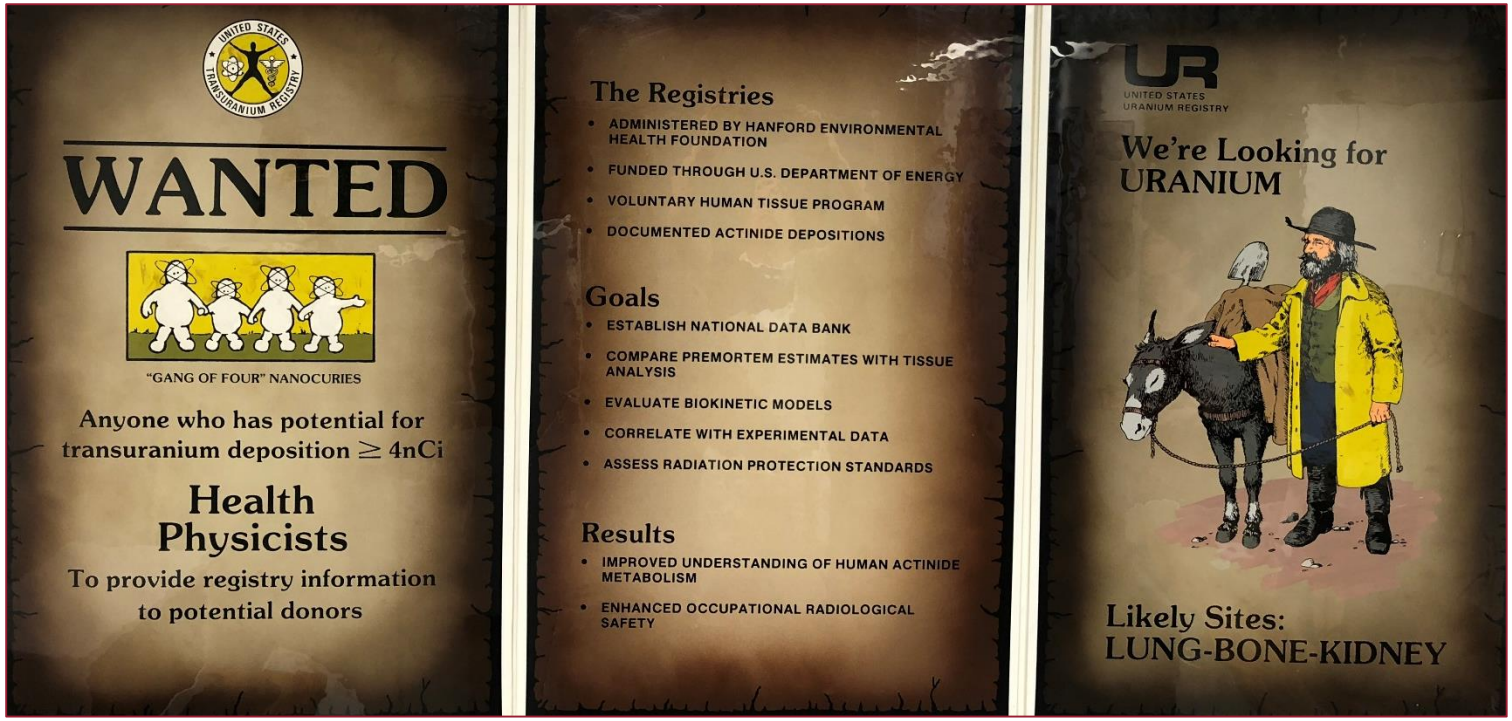
whole- (46) and/or partial-body (310) donations

- Former nuclear workers from DOE sites

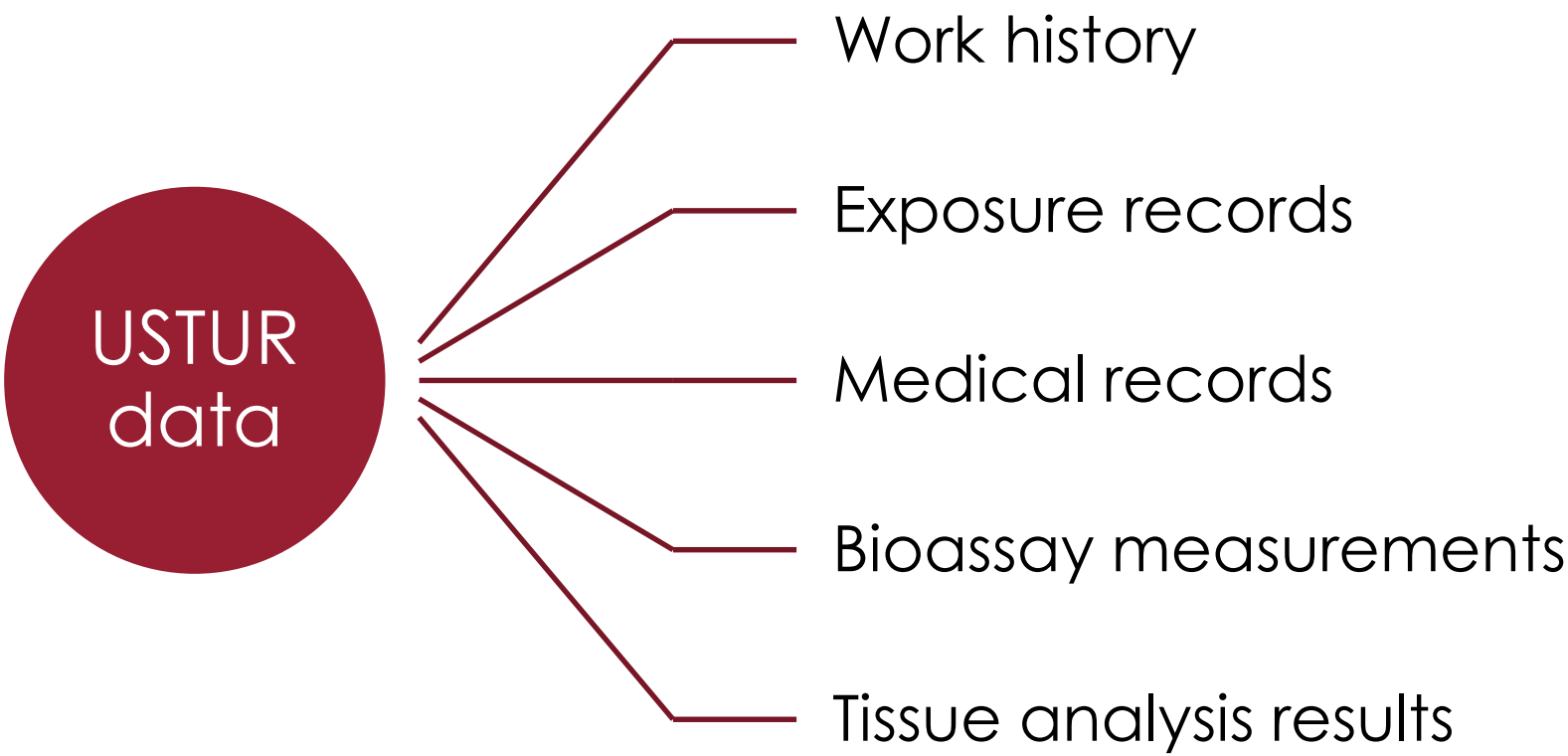


USTUR Registrants (II)

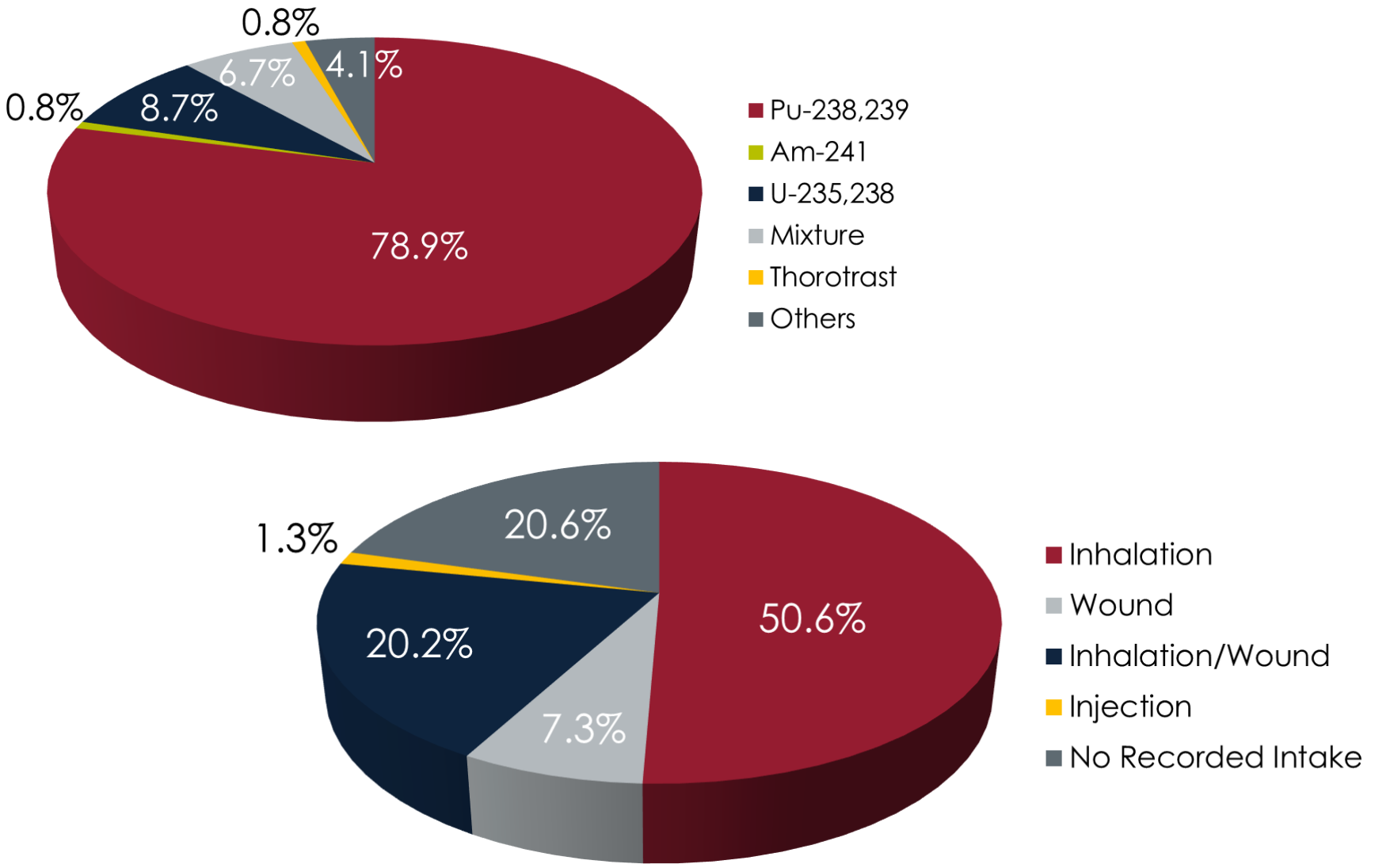
- Documented radiation exposure and work history
- Acceptance criteria:
  i. actinide internal deposition of ≥74 Bq (2 nCi)
  ii. external dose to whole body ≥0.1 Sv (10 rem)



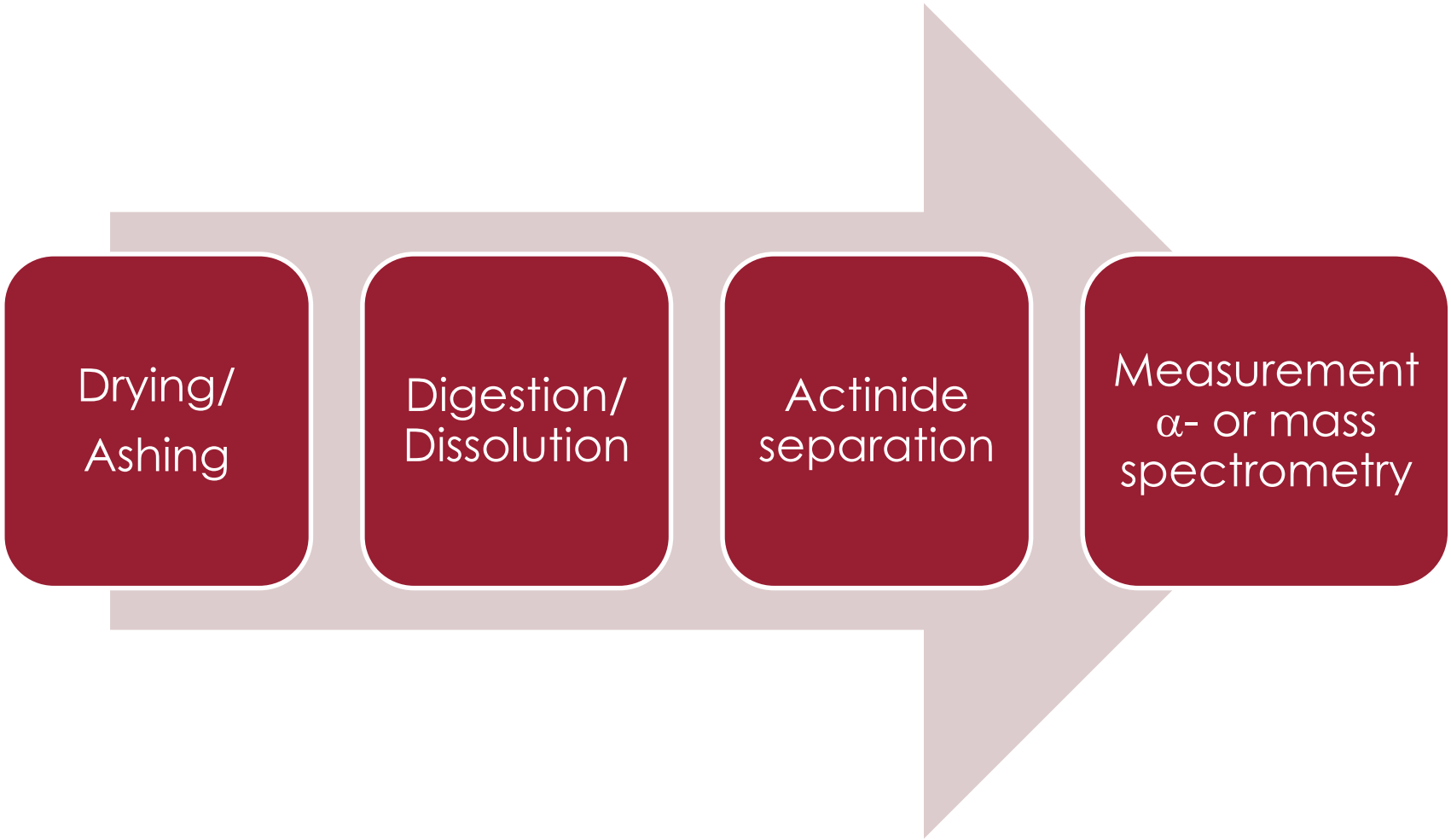
Unique Data Resource



Primary Intakes

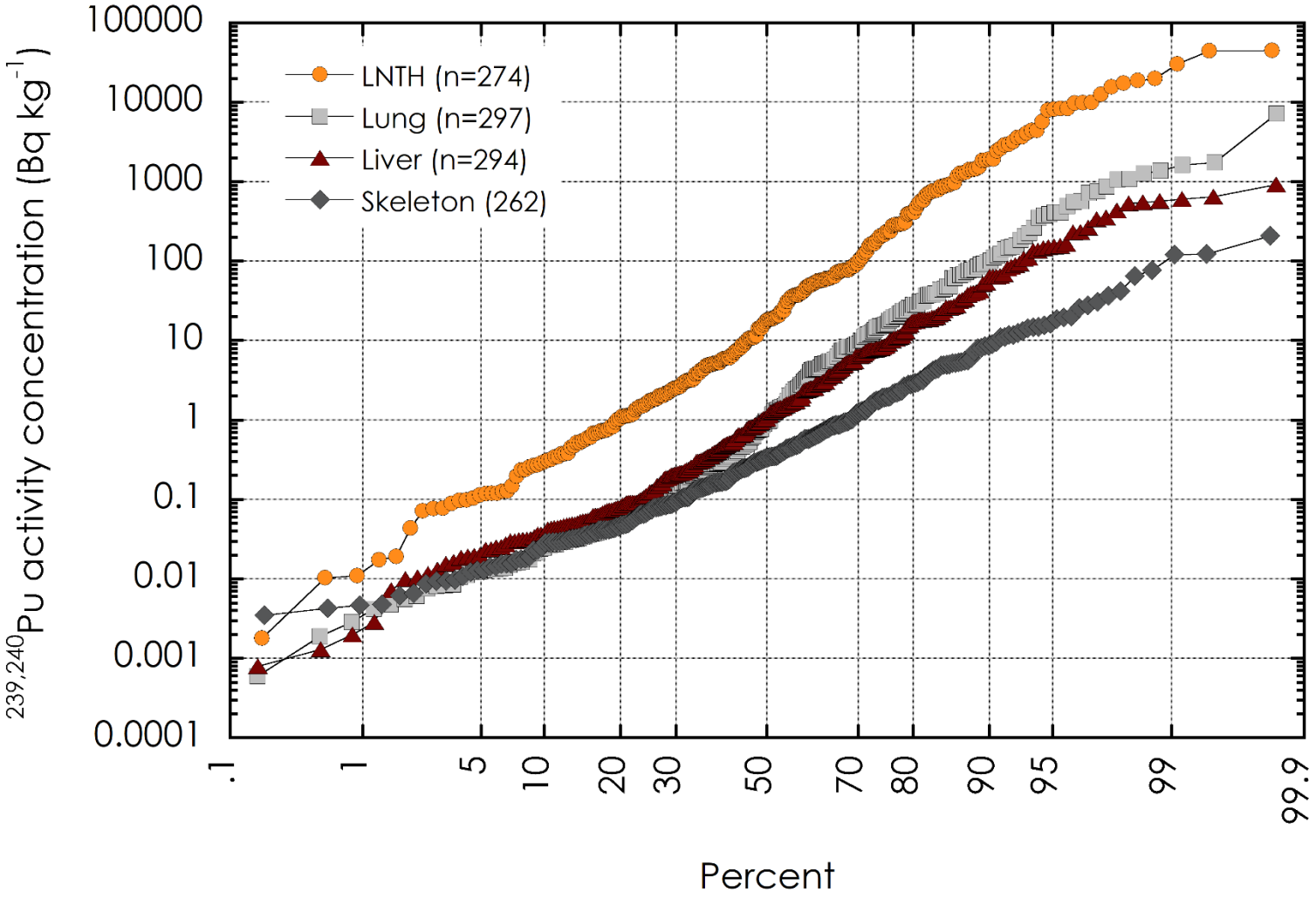


Tissue Analysis: *Backbone of the USTUR*



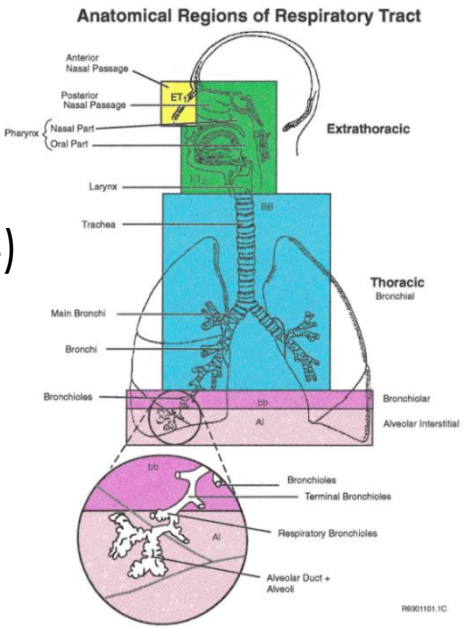
- 300 – 400 tissue analysis for Pu/Am and U per year

Plutonium in Tissues of USTUR Donors



Primary Research: *Biokinetic Modeling and Internal Dosimetry of Actinides*

- Testing, improving and parameterizing biokinetic models for radiological protection
  - ✓ Human Respiratory Tract Model (ICRP 130)
  - ✓ Wound Model (NCRP 156)
  - ✓ Systemic models for U, Pu, Am (ICRP OIR3 & OIR4)
- Evaluating uncertainties in internal radiation dose assessment
- Modeling actinide decorporation



Courtesy of W.J. Bair

CRH and RRS Posters

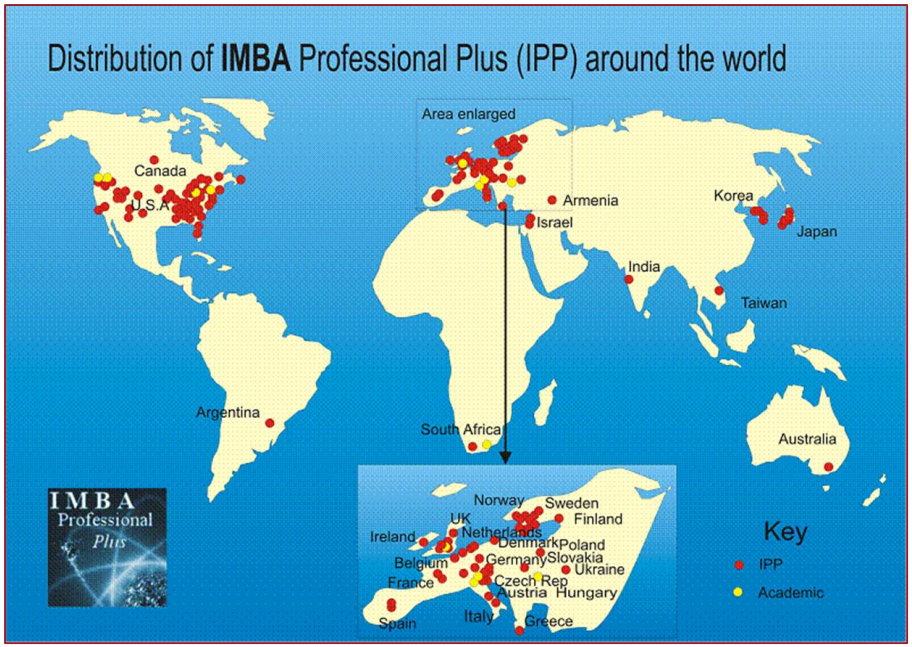
a. Avtandilashvili *et al*. Four-decade follow-up of plutonium-contaminated puncture wound treated with Ca-DTPA
b. Dumit *et al*. New compartmental model for plutonium decorporation therapy
c. Zhou *et al*. Update on Causes of Death among 354 Former Nuclear Workers in the United States Transuranium and Uranium Registries

IMBA Professional Plus® Software

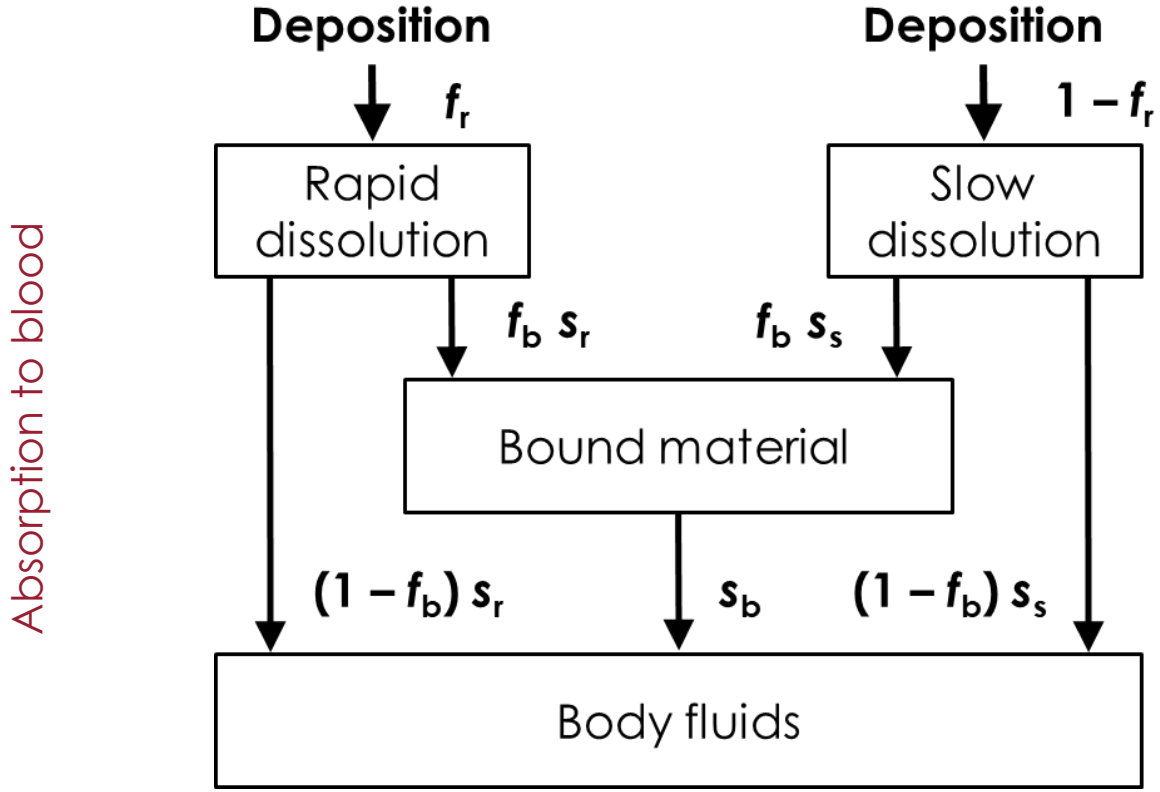
- Developed: ACJ & Associates (USA) and Health Protection Agency (UK)
- Funded: U.S. DOE, COG, and NIOSH

Dr. Anthony James
WSU/USTUR, Research Professor & Director

Dr. Alan Birchall
WSU/USTUR
Adjunct Professor

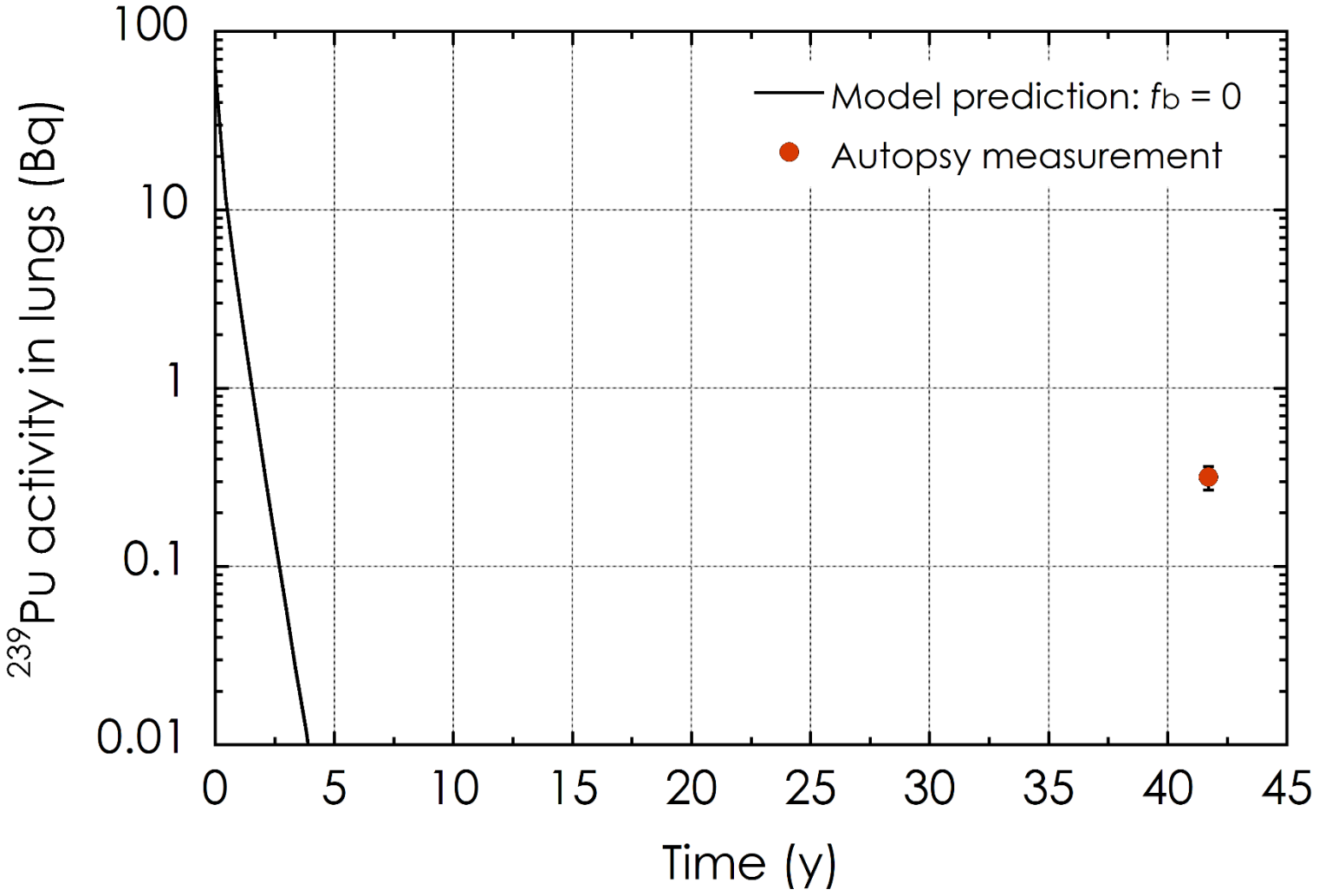


Human Respiratory Tract Model: *Plutonium Bound Fraction*

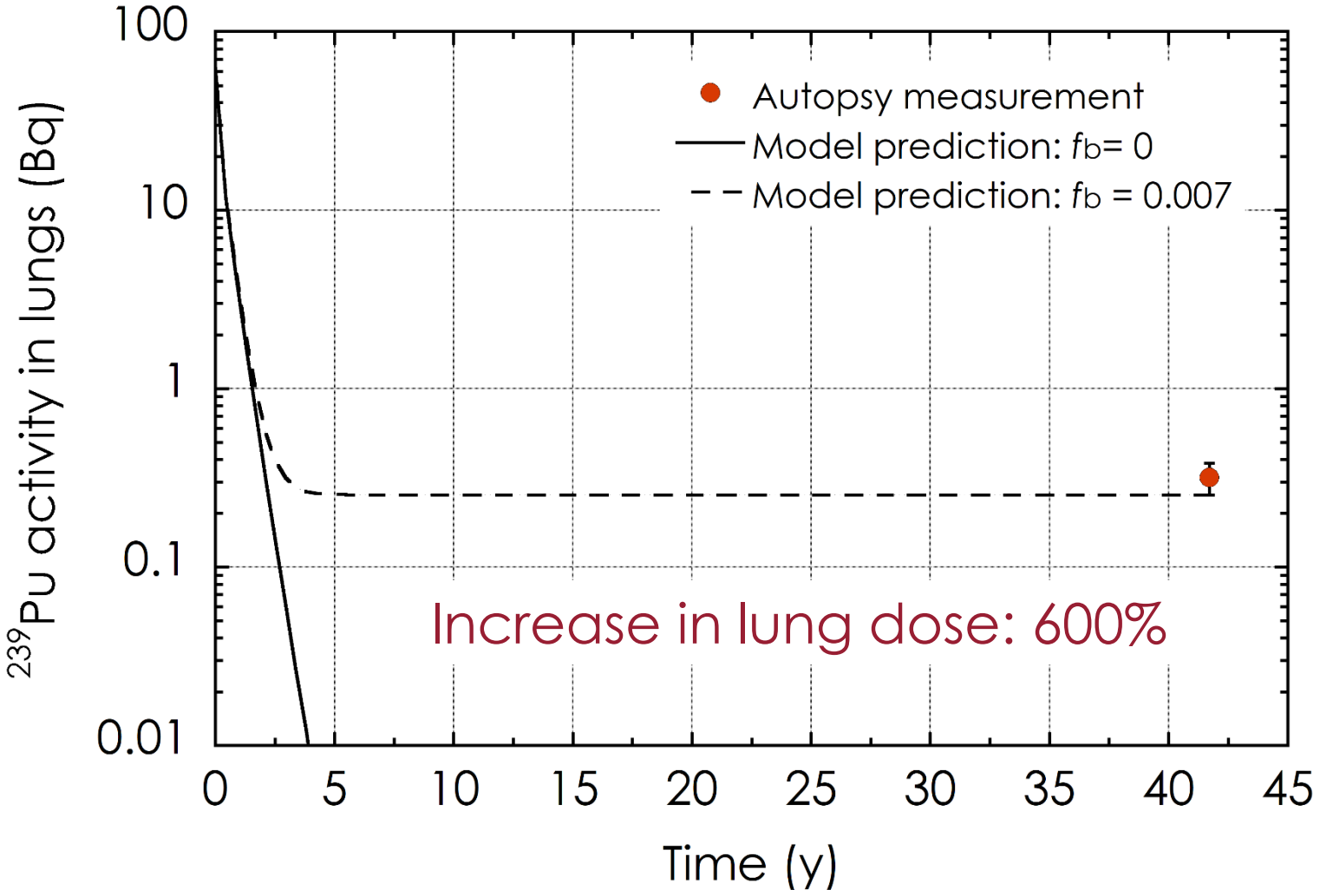


- Bound material fraction: f_b
- ICRP 66, ICRP130 HRTM: $f_b = 0$
- OIR Part 4 (upcoming): $f_b = 0.002$

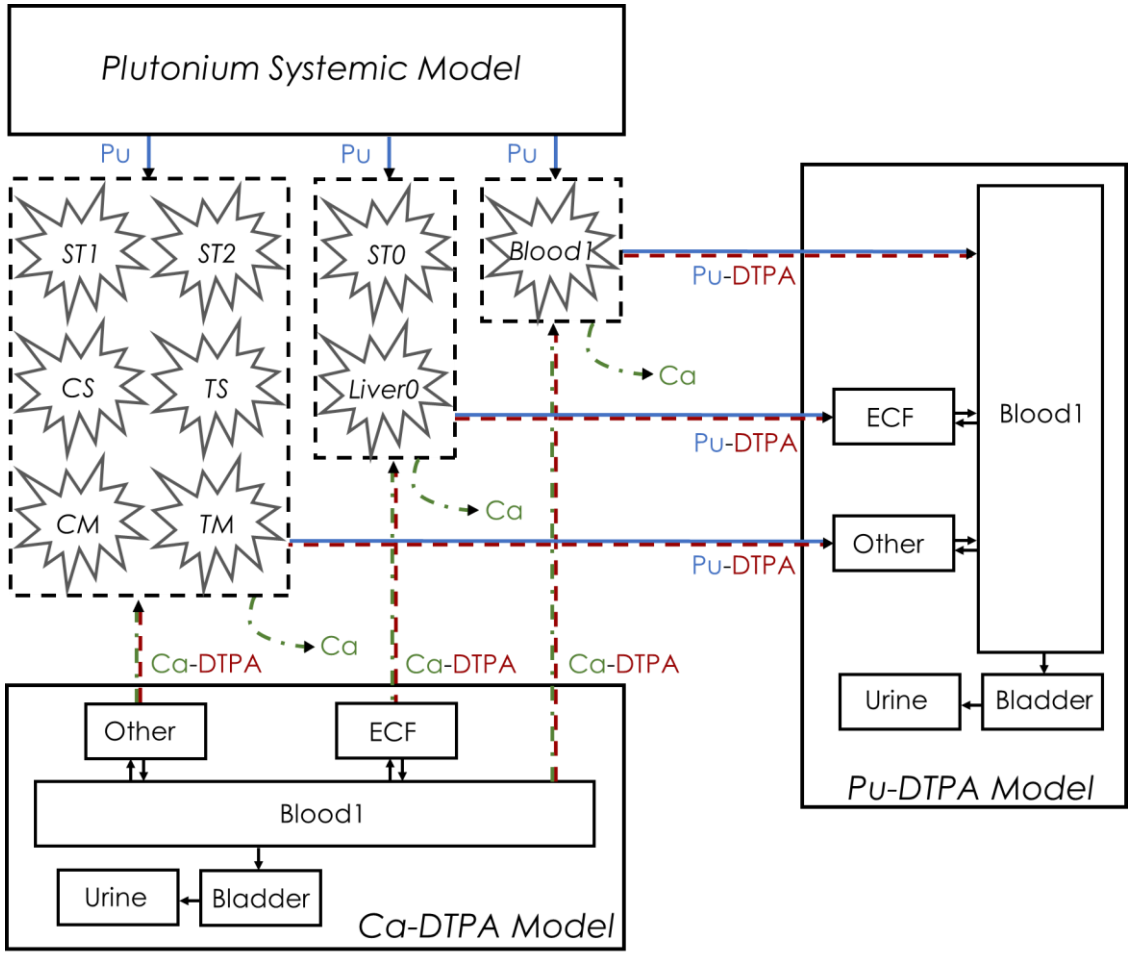
Soluble ^{239}Pu Retention in Lungs: $f_b = 0$



Soluble ^{239}Pu Retention in Lungs: $f_b = 0.007$



New System of Models for Plutonium Decorporation



Assumptions

- Chelation in extra-cellular fluid, liver, and skeleton in addition to chelation in blood
- Same model structure for the injected Ca-DTPA and Pu-DTPA chelate
- Different kinetics for Ca-DTPA and Pu-DTPA

RRS Poster: Dumit *et al*. *New compartmental model for plutonium decorporation therapy*

Collaborative Research Network

- Actinide biokinetic modeling and dosimetry
- Chelation therapy modeling
- Radiation biomarkers
- Nuclear forensics
- Actinide nanoparticles
- Beryllium and zirconium

EURADOS

MURR MISSOURI

一般財団法人 九州環境管理協会

OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

Los Alamos NATIONAL LABORATORY EST.1943

react/ts

Health Canada

Northwestern University

NCRP National Council on Radiation Protection and Measurements

KIT Karlsruhe Institute of Technology

UNIVERSITÉ LAVAL

ЮУрИБФ

Public Health England

USTUR and Russian Health Study

Radiation Protection Dosimetry (2017), Vol. 176, No. 1-2, pp. 45–49
Advance Access publication 10 June 2016
doi:10.1093/rpd/ncw136

THE MAYAK WORKER DOSIMETRY SYSTEM (MWDS 2013): SOLUBLE PLUTONIUM RETENTION IN THE LUNGS OF AN OCCUPATIONALLY EXPOSED USTUR CASE

S. Y. Tolmachev[1,*], C. E. Nielsen[2], M. Avtan… F. L. Miller[1], W. F. Morgan[4,5] and A. Birchal…
[1]US Transuranium and Uranium Registries, … Terminal Drive, Suite 201, Richland, WA 993…
[2]Mission Support Alliance, Richland, WA 99…
[3]Department of Toxicology, Centre for Radiat… England, Chilton, Didcot OX11 0RQ, UK
[4]Pacific Northwest National Laboratory, Rich…
[5]Global Dosimetry, Didcot, Oxon, UK

*Corresponding author: stolmachev@wsu.edu

For the first time, plutonium retention in human u… human respiratory tract proposed by the Internation… analytical work methodology, case selection criter… plutonium distribution in the lungs of a former nuc… Thirty-eight years post-intake, plutonium was found … alveolar–interstitial (AI) dosimetric compartments as… activity was estimated to be 2333 ± 23 and 42.1 ± … the extent of plutonium binding in the upper airways

Radiation Protection Dosimetry (2017), Vol. 176, No. 1-2, pp. 117–131
Advance Access publication 19 August 2016
doi:10.1093/rpd/ncw239

THE MAYAK WORKER DOSIMETRY SYSTEM (MWDS-2013): ESTIMATION OF PLUTONIUM SKELETAL BURDEN FROM LIMITED AUTOPSY BONE SAMPLES FROM MAYAK PA WORKERS

K. G. Suslova[1,*], A. B. Sokolova[1], S. Yu… Tolmachev[2] and S. C. Miller[3]
[1]Southern Urals Biophysics Institute (SU…
[2]United States Transuranium and Uraniu… University, Richland, WA, USA
[3]Division of Radiobiology, Department … City, UT, USA

*Corresponding author: suslova@subi.su

The method to estimate total skeleton plutoniu… ited bone samples obtained at autopsy is desc… from the mid-1950s to 2013. Plutonium was … The method was validated using data from … Registries (USTUR). The developed algorithm … conservative estimation. Late-in-life liver disea… ciated with significant differences in plutonium… ties are discussed and future studies will addr… data in support of the development of biokineti…

Radiation Protection Dosimetry (2017), Vol. 176, No. 1-2, pp. 50–61
Advance Access publication 24 April 2016
doi:10.1093/rpd/ncw083

THE MAYAK WORKER DOSIMETRY SYSTEM (MWDS 2013): A RE-ANALYSIS OF USTUR CASE 0269 TO DETERMINE WHETHER PLUTONIUM BINDS TO THE LUNGS

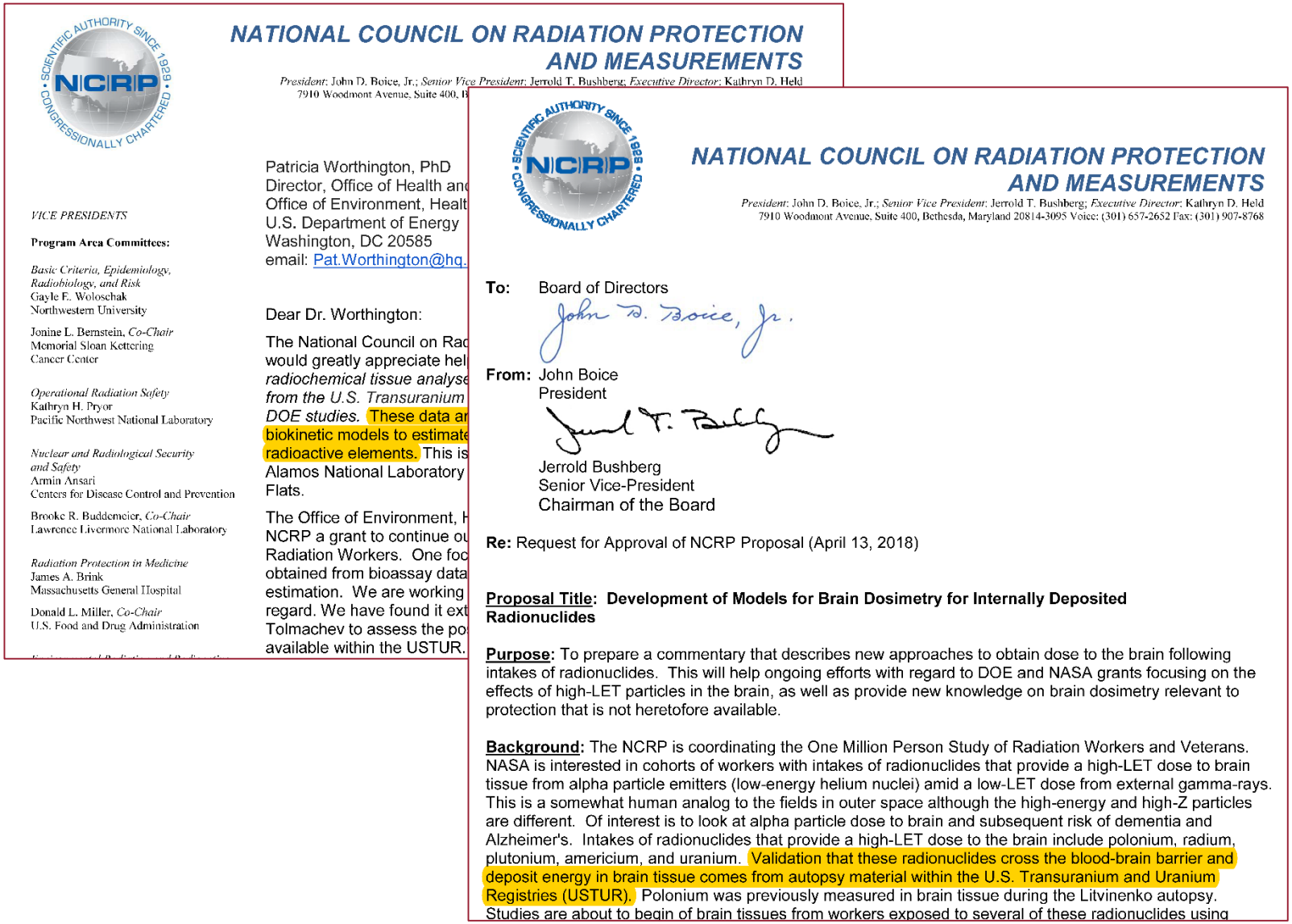
M. Puncher[1,*], A. Birchall[2] and S. Y. Tolmachev[3]
[1]Department of Toxicology, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot OX11 0RQ, UK
[2]Global Dosimetry, Didcot, Oxon, UK
[3]US Transuranium and Uranium Registries, College of Pharmacy, Washington State University, 1845 Terminal Drive, Suite 201, Richland, WA 99354, USA

*Corresponding author: matthew.puncher@phe.gov.uk

Received 9 February 2016; revised 9 February 2016; accepted 28 February 2016

Radionuclides in ionic form can become chemically bound in the airways of the lungs following dissolution of inhaled particulates in lung fluid. The presence of long-term binding can greatly increase lung doses from inhaled plutonium, particularly if it occurs in the bronchial and bronchiolar regions. However, the only published evidence that plutonium binding occurs in humans comes from an analysis of the autopsy and bioassay data of United States Transuranium and Uranium Registries Case 0269, a plutonium worker who experienced a very high (58 kBq) acute inhalation of plutonium nitrate. This analysis suggested a bound fraction of around 8 %, inferred from an unexpectedly low ratio of estimated total thoracic lymph node activity:total lung activity, at the time of death. However, there are some limitations with this study, the most significant being that measurements of the regional distribution of plutonium activity in the lungs, which provide more direct evidence of binding, were not available when the analysis was performed. The present work describes the analysis of new data, which includes measurements of plutonium activity in the alveolar–interstitial (AI) region, bronchial (BB) and bronchiolar (bb) regions, and extra-thoracic (ET) regions, at the time of death. A Bayesian approach is used that accounts for uncertainties in model parameter values, including particle transport clearance, which were not considered in the original analysis. The results indicate that a long-term bound fraction between 0.4 and 0.7 % is required to explain this data, largely because plutonium activity is present in the extra-thoracic (ET_2), bronchial and bronchiolar airways at the time of death.

USTUR and Million Person Study



NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS

President: John D. Boice, Jr.; *Senior Vice President*: Jerrold T. Bushberg; *Executive Director*: Kathryn D. Held
7910 Woodmont Avenue, Suite 400, Bethesda, Maryland 20814-3095 Voice: (301) 657-2652 Fax: (301) 907-8768

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Patricia Worthington, PhD
Director, Office of Health and
Office of Environment, Healt
U.S. Department of Energy
Washington, DC 20585
email: Pat.Worthington@hq.

Dear Dr. Worthington:

The National Council on Rad
would greatly appreciate hel
radiochemical tissue analyse
from the U.S. Transuranium
DOE studies. These data ar
biokinetic models to estimate
radioactive elements. This is
Alamos National Laboratory
Flats.

The Office of Environment, H
NCRP a grant to continue ou
Radiation Workers. One foc
obtained from bioassay data
estimation. We are working
regard. We have found it ext
Tolmachev to assess the po
available within the USTUR.

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7910 Woodmont Avenue, Suite 400, Bethesda, Maryland 20814-3095 Voice: (301) 657-2652 Fax: (301) 907-8768

To: Board of Directors

John D. Boice, Jr.

From: John Boice
President

Jerrold T. Bushberg

Jerrold Bushberg
Senior Vice-President
Chairman of the Board

Re: Request for Approval of NCRP Proposal (April 13, 2018)

Proposal Title: Development of Models for Brain Dosimetry for Internally Deposited Radionuclides

Purpose: To prepare a commentary that describes new approaches to obtain dose to the brain following intakes of radionuclides. This will help ongoing efforts with regard to DOE and NASA grants focusing on the effects of high-LET particles in the brain, as well as provide new knowledge on brain dosimetry relevant to protection that is not heretofore available.

Background: The NCRP is coordinating the One Million Person Study of Radiation Workers and Veterans. NASA is interested in cohorts of workers with intakes of radionuclides that provide a high-LET dose to brain tissue from alpha particle emitters (low-energy helium nuclei) amid a low-LET dose from external gamma-rays. This is a somewhat human analog to the fields in outer space although the high-energy and high-Z particles are different. Of interest is to look at alpha particle dose to brain and subsequent risk of dementia and Alzheimer's. Intakes of radionuclides that provide a high-LET dose to the brain include polonium, radium, plutonium, americium, and uranium. Validation that these radionuclides cross the blood-brain barrier and deposit energy in brain tissue comes from autopsy material within the U.S. Transuranium and Uranium Registries (USTUR). Polonium was previously measured in brain tissue during the Litvinenko autopsy. Studies are about to begin of brain tissues from workers exposed to several of these radionuclides using

Contribution to National Council on Radiation Protection and Measurements

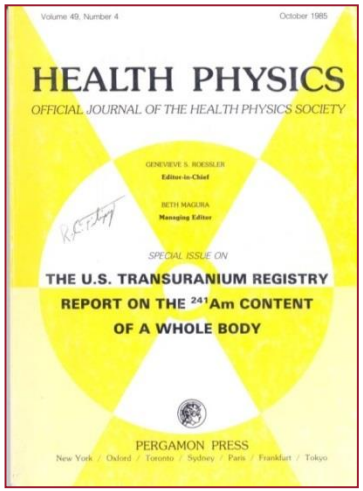
- Report 164: Uncertainties in Internal Radiation Dose Assessment (2009)
- Report 163: Radiation Dose Reconstruction Principles and Practices (2009)
- Report 156: Development of a Biokinetic Model for Radionuclide-Contaminated Wounds for Their Assessment, Dosimetry and Treatment (2006)
- Report 135: Liver Cancer Risk from Internally-Deposited Radionuclides (2001)
- Report 128: Radionuclide Exposure of the Embryo/Fetus (1998)

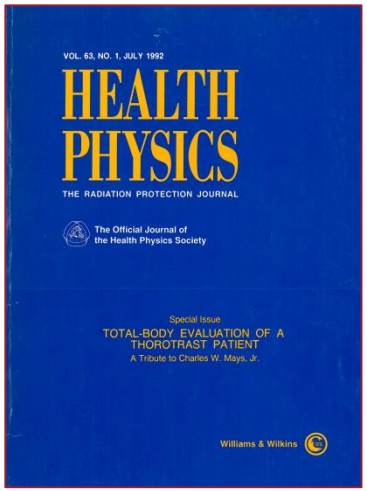
Contribution to International Commission on Radiological Protection

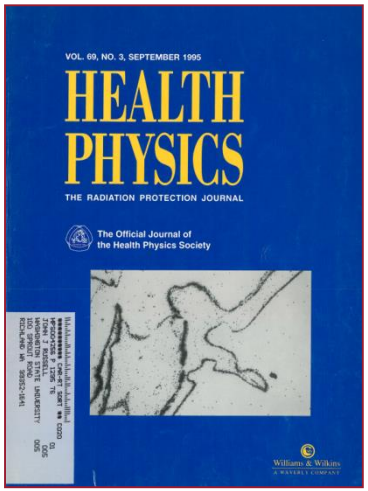
- Occupational Intakes of Radionuclides - Part 4 (upcoming)
- Publication 137: Occupational Intakes of Radionuclides - Part 3 (2017)
- Publication 70: Basic Anatomical & Physiological Data for Use in Radiological Protection - The Skeleton (1995)
- Publication 69: Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 3 Ingestion Dose Coefficients (1995)
- Publication 66: Human Respiratory Tract Model for Radiological Protection (1994)
- Publication 67: Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 2 Ingestion Dose Coefficients (1993)
- Publication 56: Age-dependent Doses to Members of the Public from Intake of Radionuclides - Part 1 (1989)
- Publication 48: The Metabolism of Plutonium and Related Elements (1986)

Health Physics Journal Special Issues

- 2019, upcoming: *The United States Transuranium and Uranium Registries (USTUR): Five Decade Follow-up of Plutonium and Uranium Workers*
- 1995, 69 (3): *1976 Hanford Americium Exposure Incident: Update*
- 1992, 63 (1): *Total-body Evaluation of a Thorotrast Patient*
- 1985, 49 (4): *The U.S. Transuranium Registry Report on the ^{241}Am Content of a Whole Body*







USTUR Special Issues: *HPJ PAP*

MODELING THE SKELETON WEIGHT OF AN ADULT CAUCASIAN MAN

THE IMPORTANCE AND QUANTIFICATION OF PLUTONIUM BINDING IN HUMAN LUNGS

Alan Bi

EVALUATING PLUTONIUM INTAKE AND RADIATION DOSE FOLLOWING EXTENSIVE CHELATION TREATMENT

Sara Dumit, Maia Avtandilashvili, and Sergei Y. Tolmachev[1]

THE PSEUDO-PELGER HUËT CELL AS A RETROSPECTIVE DOSIMETER: ANALYSIS OF A RADIUM DIAL PAINTER COHORT

Ronald E. Goans,[1] Richard E. Toohey,[2] Carol J. Iddins,[3] Stacey L. McComish,[4] Sergei Y. Tolmachev,[4] and Nicholas Dainiak[3,5]

INTRODUCTION

50 years of the USTUR: 1968 to 2018

USTUR: *Take Home Message*

- In-depth study of actinide biokinetics and tissue dosimetry
- Unique resource of data and preserved tissue materials from former nuclear workers
- Significant contributor to national and international radiation protection advisory bodies
- 50 years of research funded by U.S. DOE

Acknowledgment

USTUR Special Session at 61st Annual Meeting of the Health Physics Society, July 19, 2016, Spokane, WA

Questions?

stolmachev@wsu.edu

www.ustur.wsu.edu