12th International Conference on
the Health Effects of Incorporated Radionuclides
Fontenay-aux-Roses, France
October 8 – 11, 2018

The United States Transuranium and Uranium Registries: Fifty-year History of Actinide Biokinetic Research

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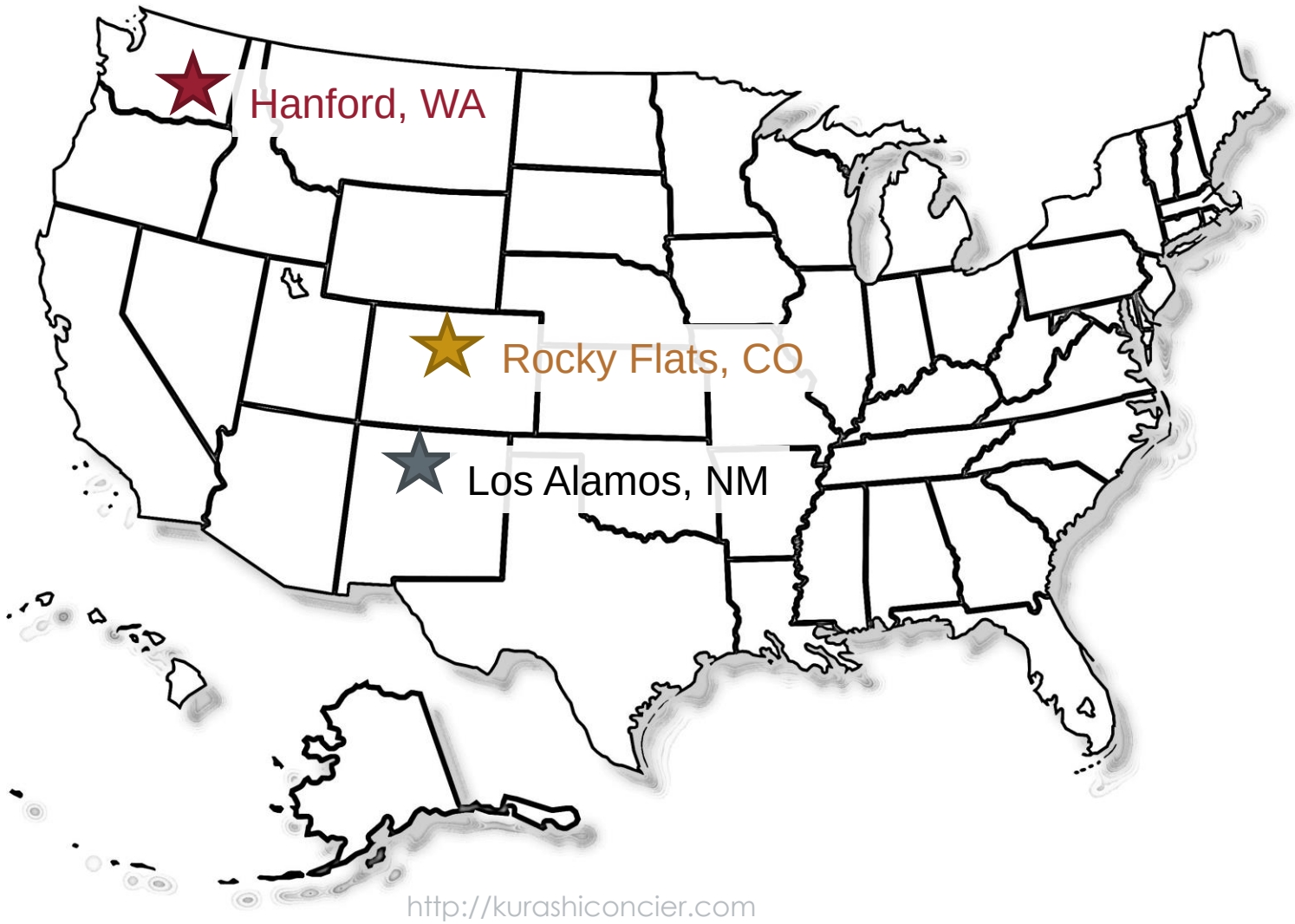
"Learning from Plutonium and Uranium Workers"

U.S. Transuranium and Uranium Registries: History and Mission

Early Autopsy Studies

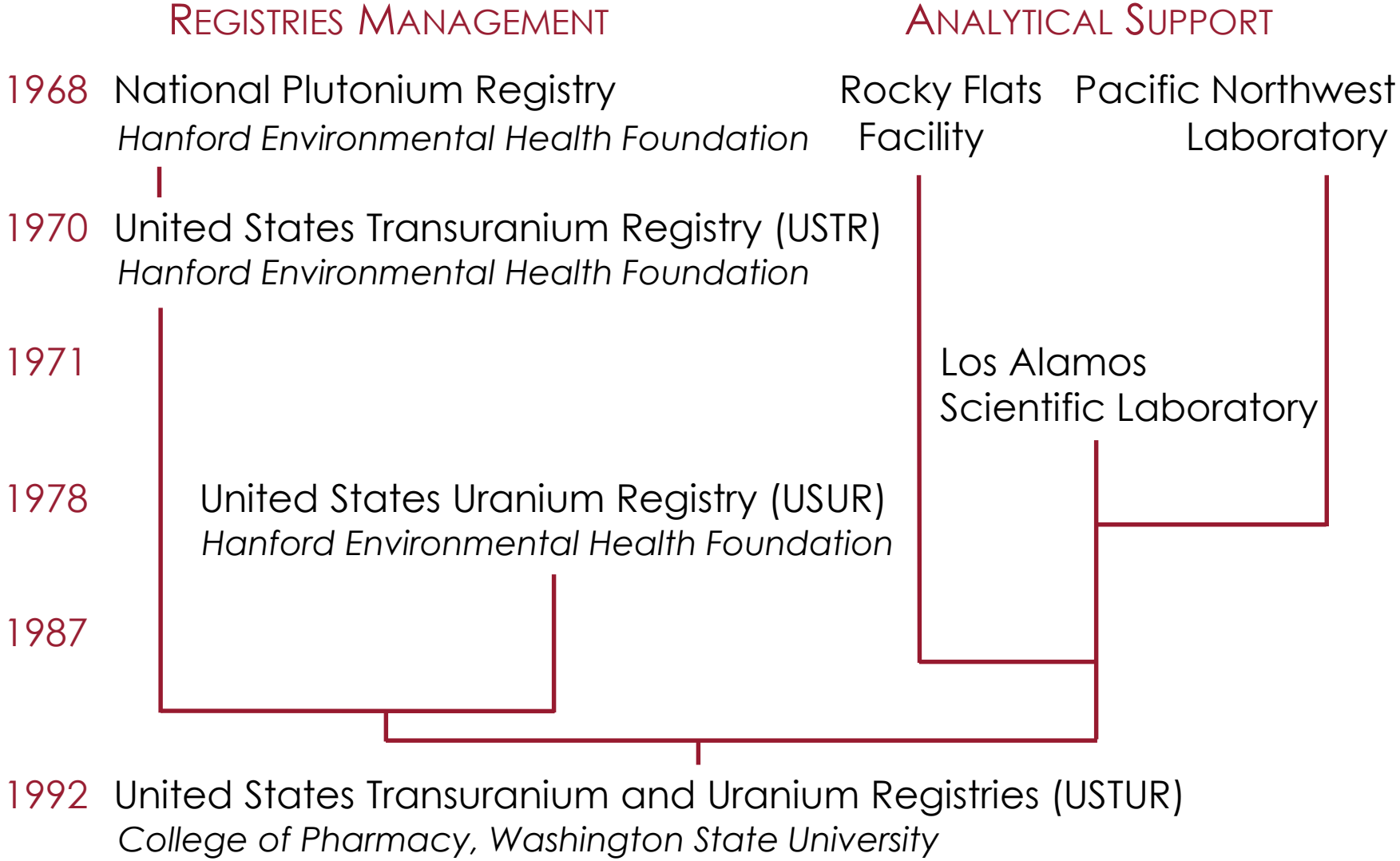


U.S. AEC 1966 Meeting on Plutonium Contamination in Man (Rocky Flats Plant)

National Plutonium Registry: *1968 Advisory Committee Meeting*

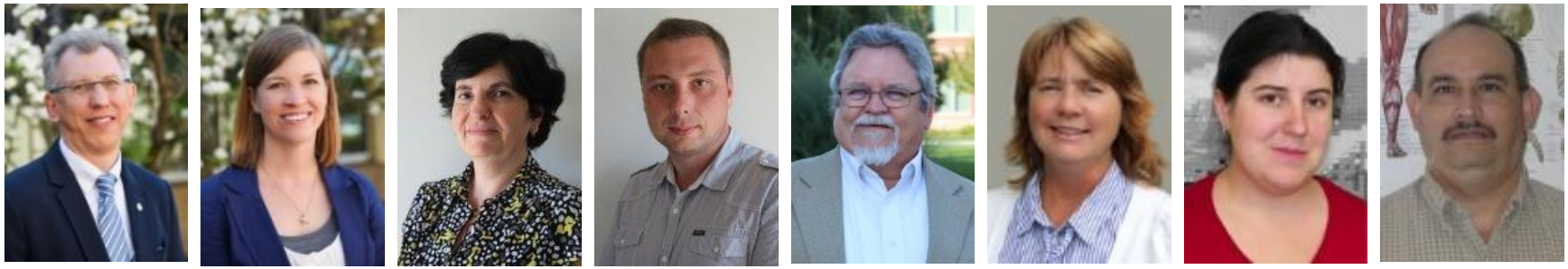
Standing left to right: Carlos E. Newton, Jr., W. Daggett Norwood, H.D. Bruner, Philip A. Fuqua
Seated left to right: Thomas F. Mancuso, J.H. Sterner, Robley D. Evans, Herbert M. Parker
Not photographed: Clarence C. Lushbaugh, Lloyd M. Joshel

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
- Budget: $5,500,000 (April 1, 2017 – March 31, 2022)
- Faculty and staff:



- Location: Richland, WA
- Website: www.ustur.wsu.edu

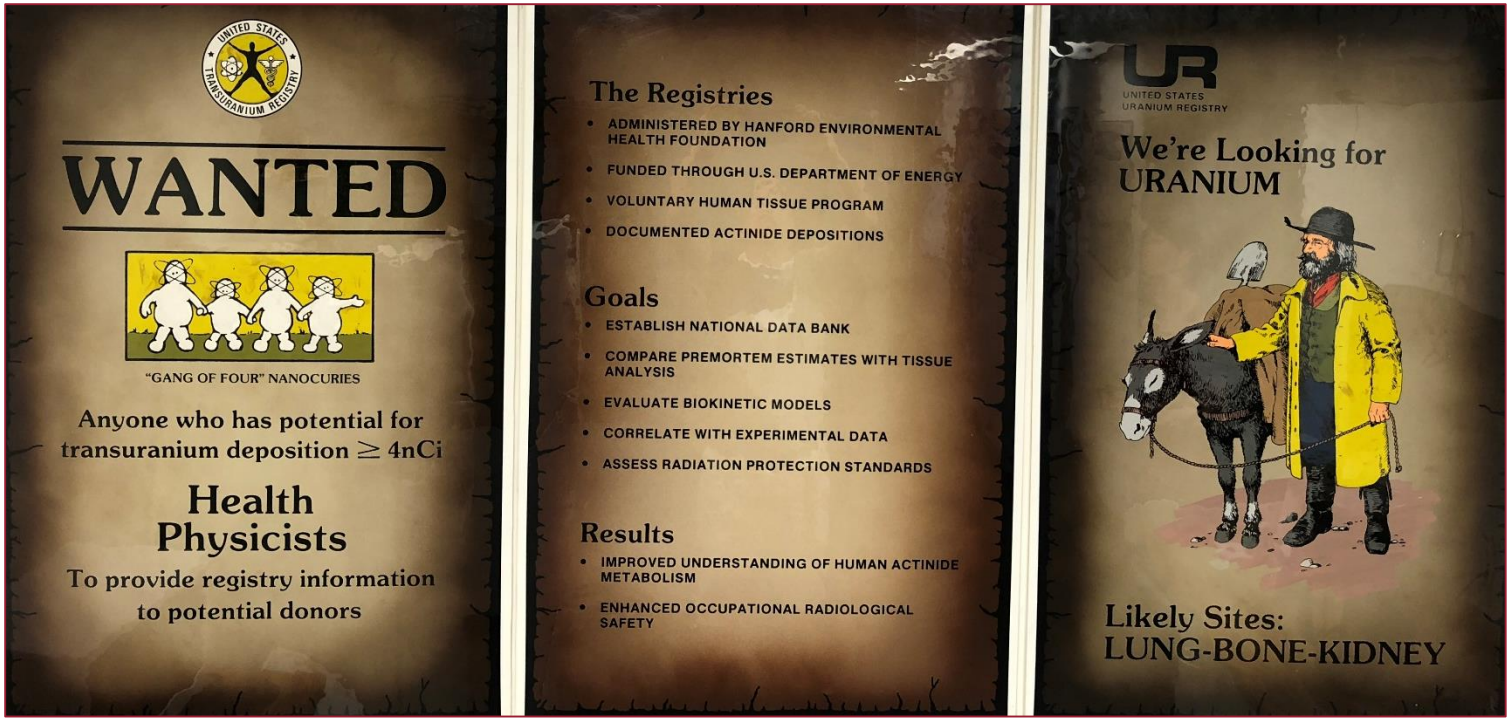
Current Mission

- 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

USTUR Registrants (I)

- Voluntary tissue donors (posthumous)
- 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)

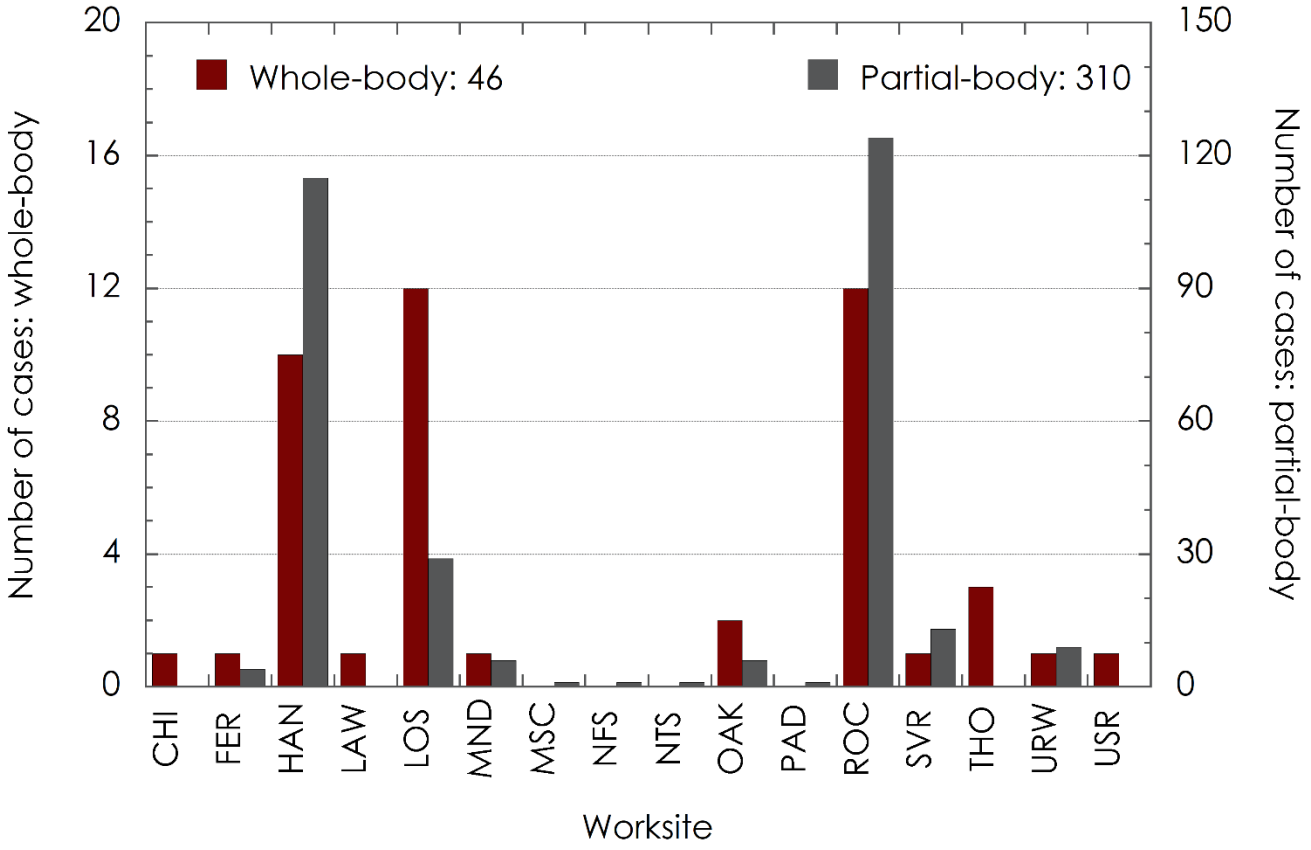


USTUR Registrants (II)

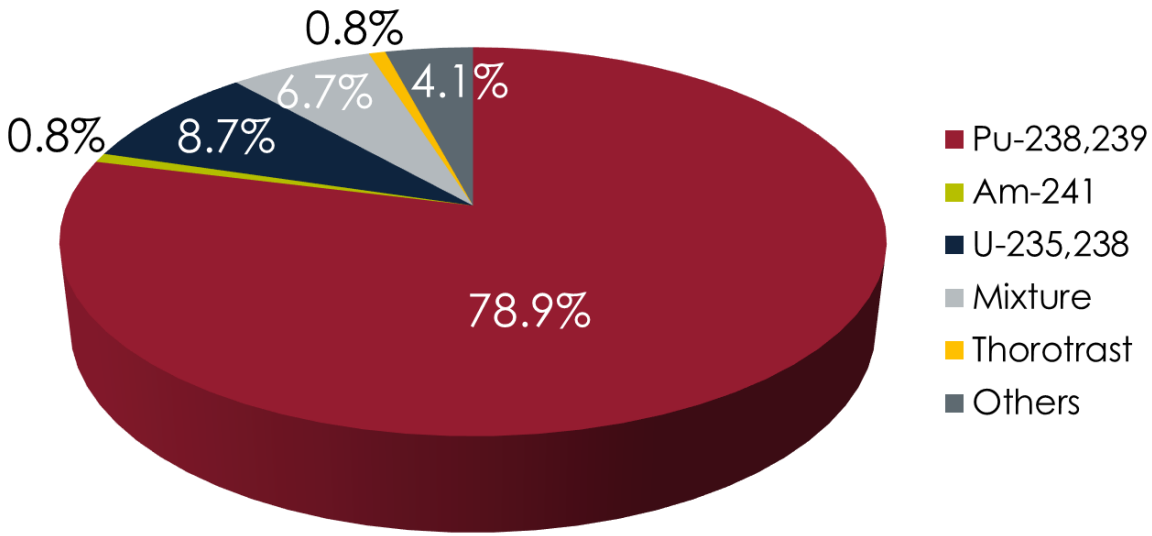
- Voluntary tissue donors (posthumous)

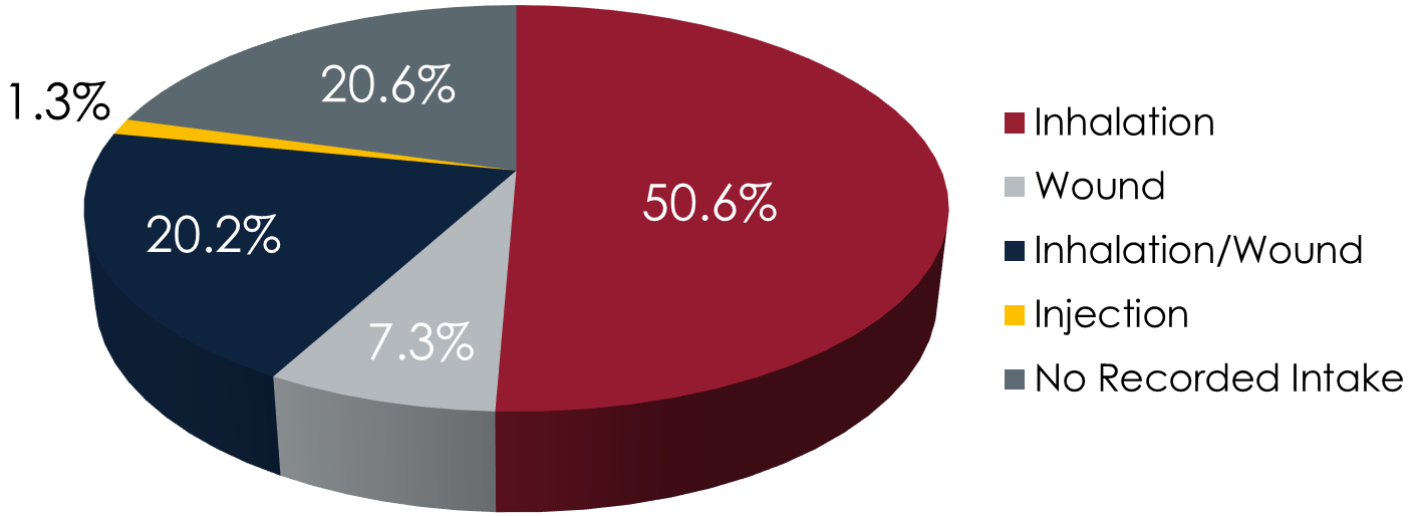
whole- (46) and/or partial-body (310) donation

- Former nuclear workers from DOE sites

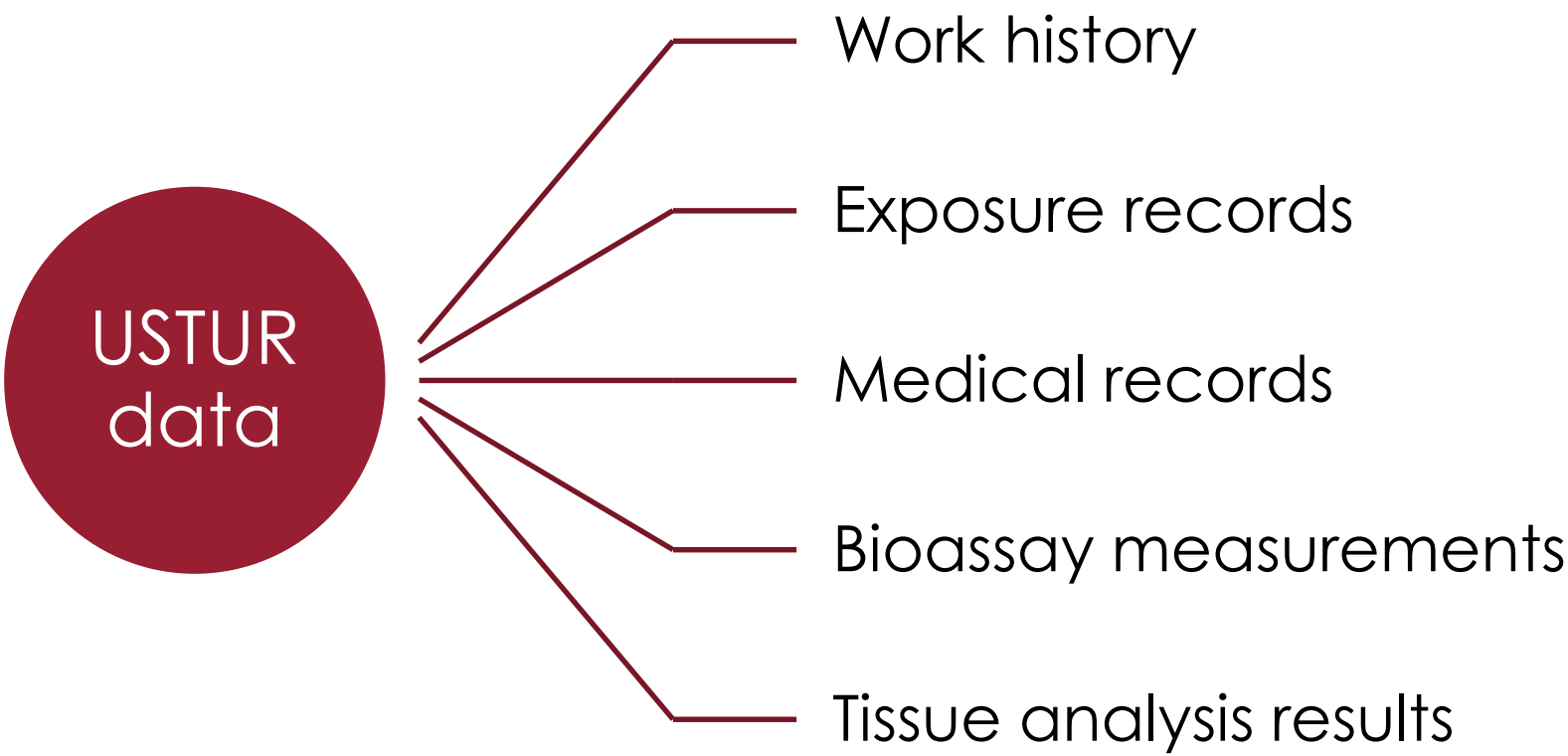


Primary Intakes

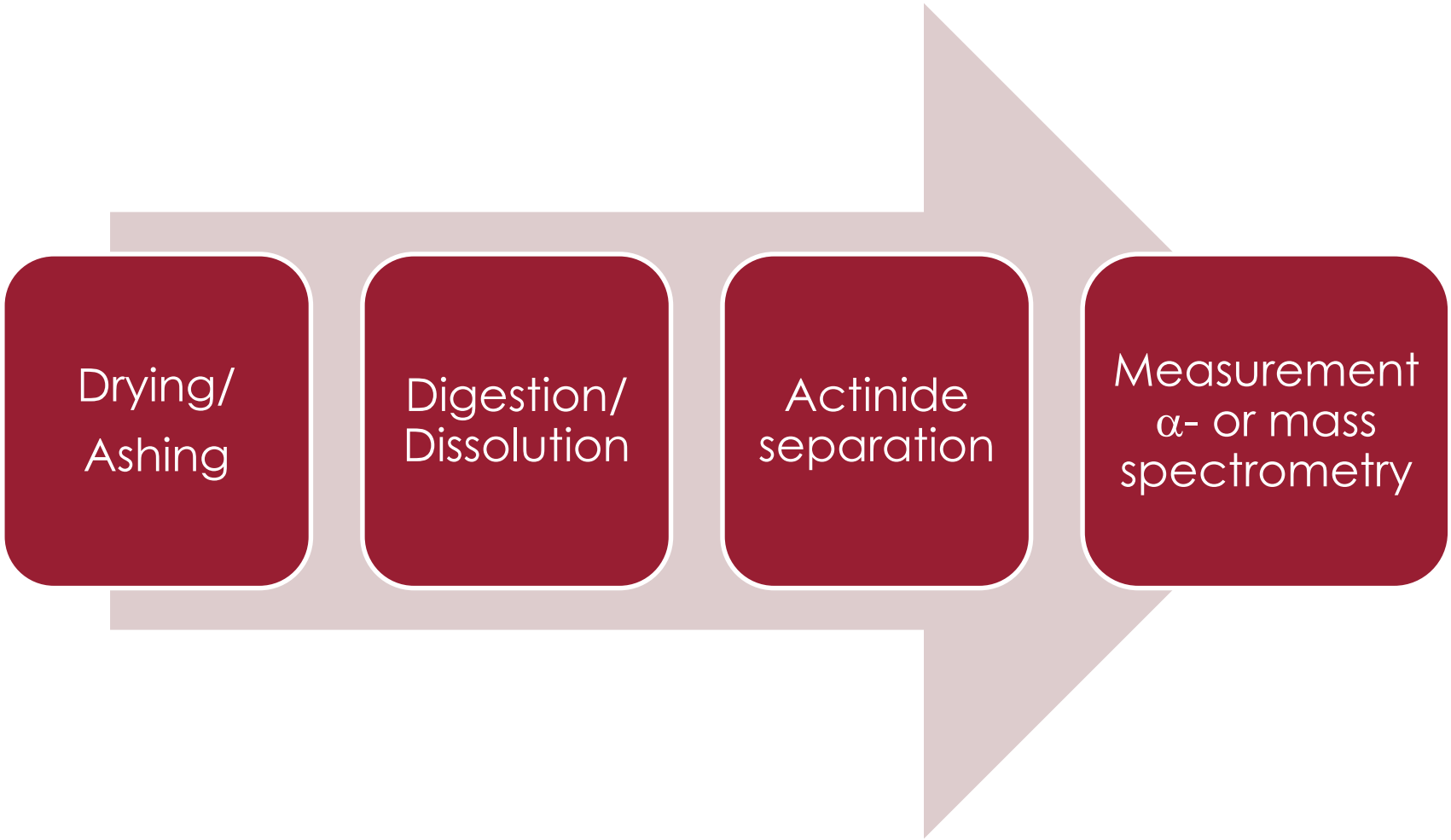




Unique Data Resource

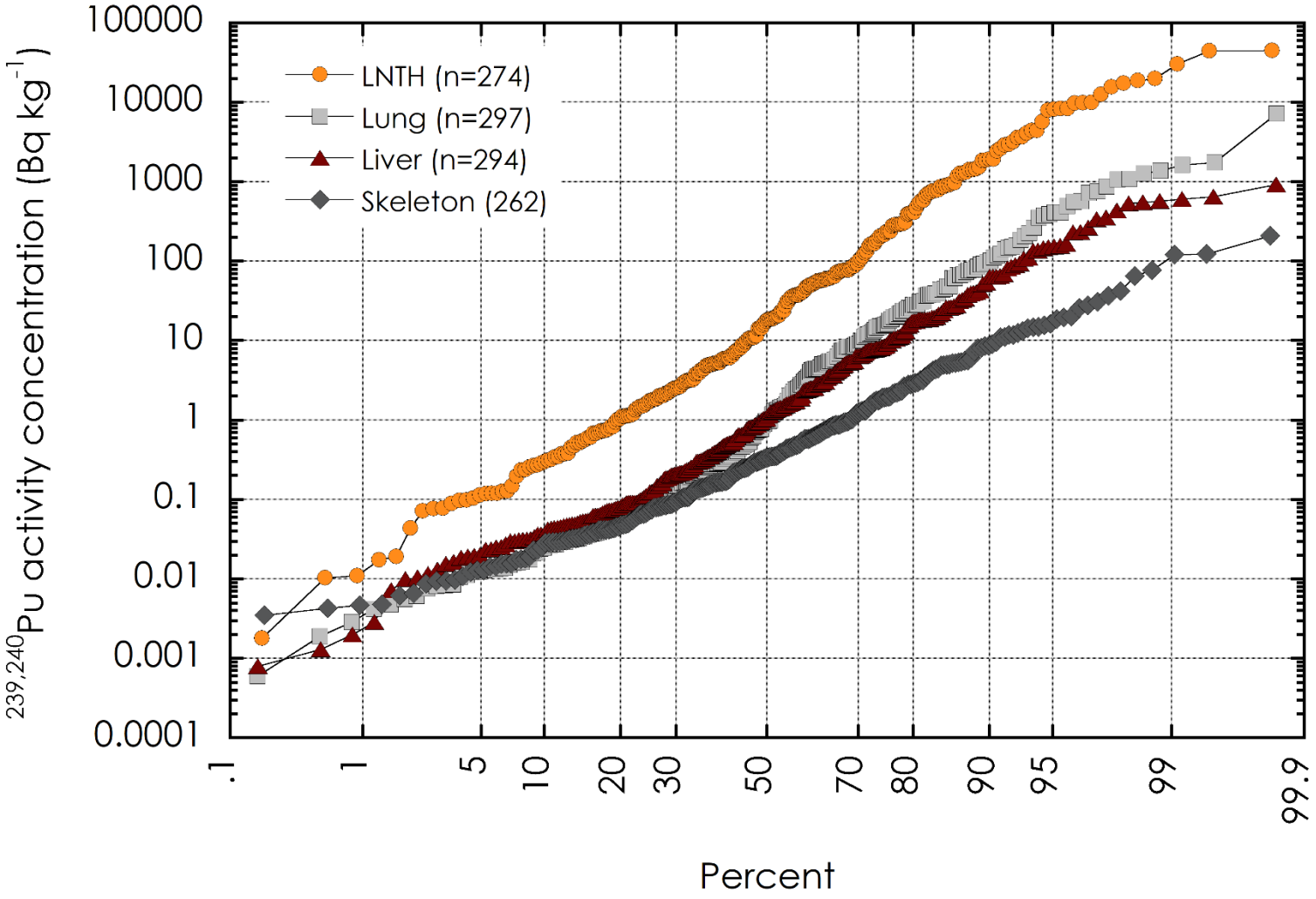


Tissue Analysis: *Backbone of the USTUR*



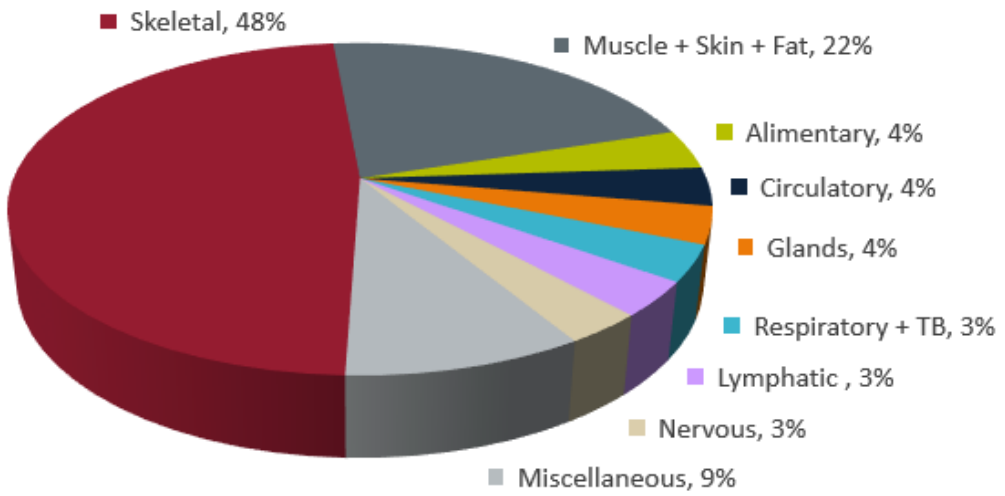
- 300 – 400 tissue analysis for Pu/Am and U per year

Plutonium in Tissues of USTUR Donors



National Human Radiobiology Tissue Repository (NHRTR)

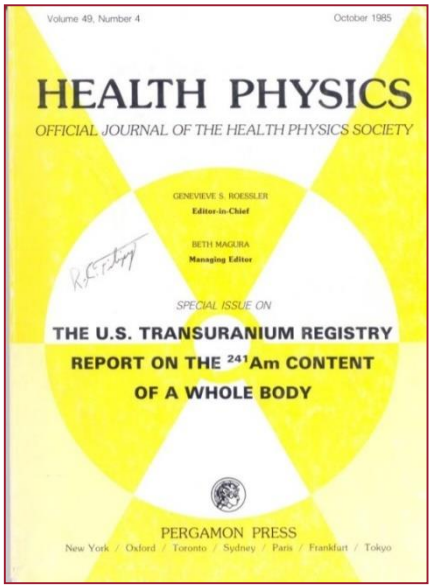
- USTUR tissue donations: 9,000+ frozen tissues
- Argonne National Laboratory (ANL) historical samples
  - ✓ Radium dial painters
  - ✓ Plutonium injection studies
- Los Alamos National Laboratory (LANL) population studies



Historical Landmarks

First Whole-Body Donation: Case 0102

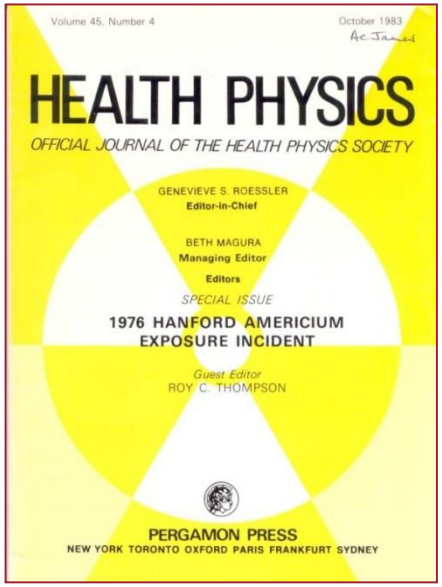
- Worked with unsealed ^{241}Am source for 2 years
- ^{241}Am was detected later in routine urine samples
- Contemporary estimate of intake: 8 – 40 kBq
- Systemic deposition: 82% skeleton, 6.3% liver; 11% other tissues
- *In vivo* calibration phantoms of skull, torso, arm and leg

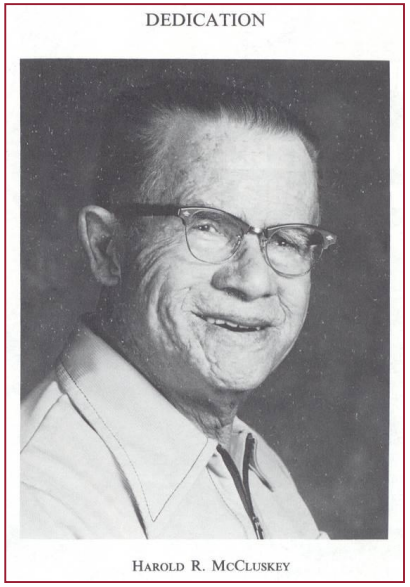


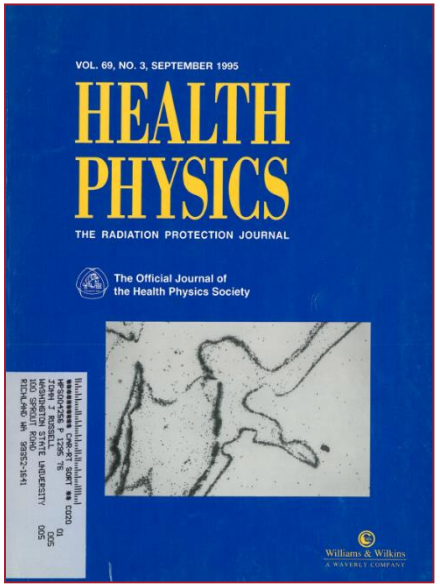
The Atomic Man: Case 0246

Largest recorded Am intake !!!

- Explosion of ion-exchange column with ~150 g of ^{241}Am
- Estimated uptake > 40 MBq
- Extensive Ca/Zn-DTPA chelation therapy
- Systemic deposition after treatment – 0.5 MBq

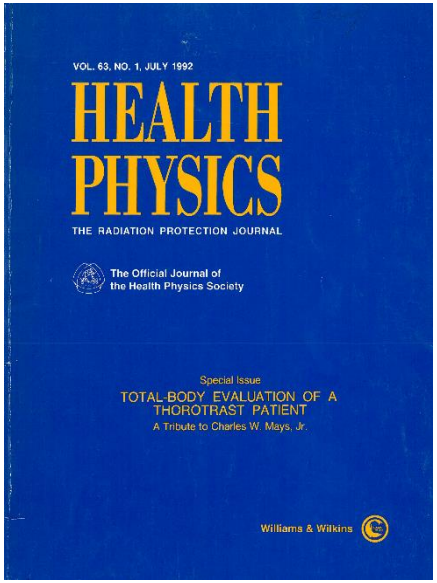






Thorotrast Study: Case 1001

- First study of thorium distribution in a human body
- Female whole-body donor
- Medical exposure to Thorotrast® ($^{232}ThO_2$ colloidal)

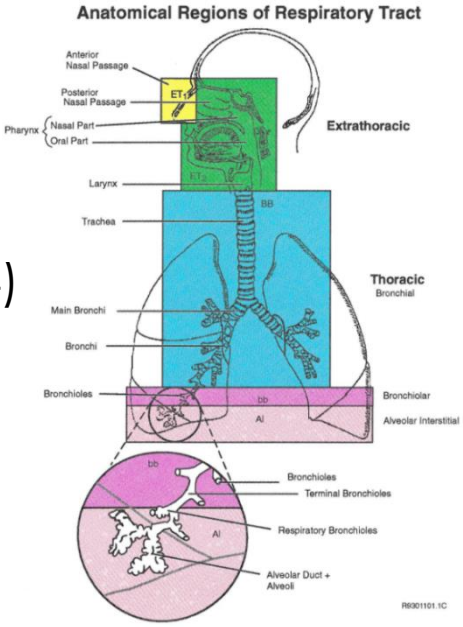


- Findings
  - ✓ Alpha risk coefficients for liver, skeleton, and leukemia
  - ✓ Spleen destruction
  - ✓ Clarified epidemiologic studies
  - ✓ DNA analysis: deleted region of *c-fms* gene, possibly radiation induced

Current Research and Collaborations

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

USTUR Presentations

I. Avtandilashvili and Tolmachev. Biokinetics of soluble plutonium after wound injury treated with Ca-DTPA

II. Leggett *et al*. Case studies in brain dosimetry for internal emitters: Is more detail needed for epidemiology?

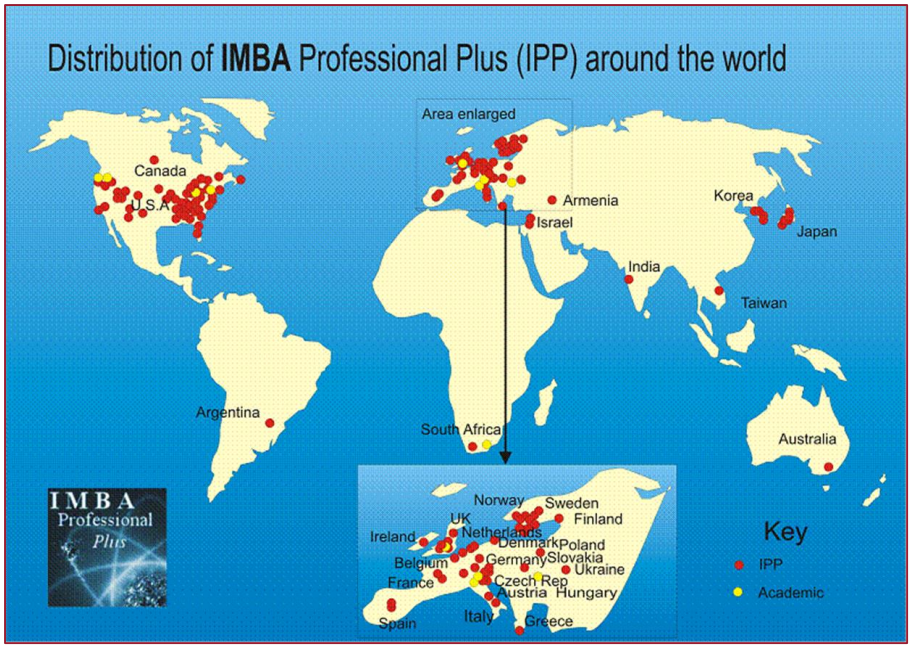
III. Tolmachev *et al*. USTUR: Expanding horizons for actinide biokinetics and dosimetry

IMBA Professional Plus® Software

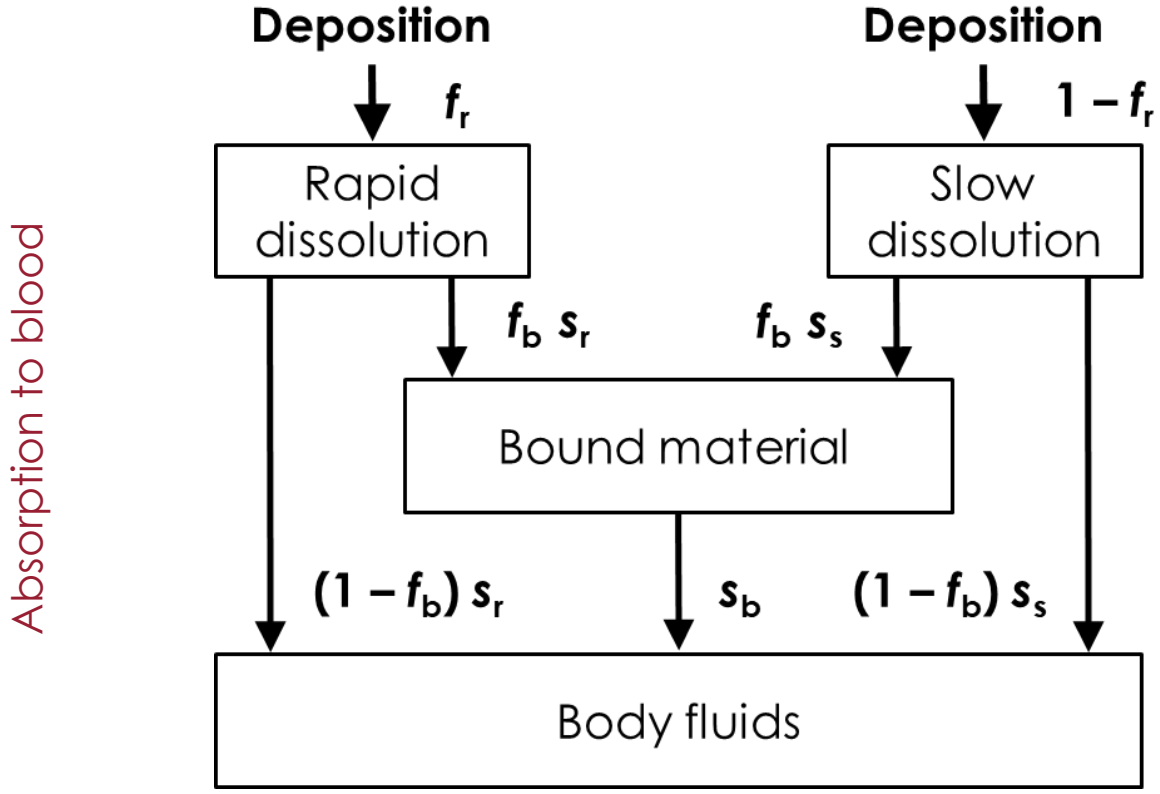
- Developed: ACJ & Associates (USA) and Health Protection Agency (UK)
- Funded: U.S. DOE, COG, and NIOSH

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

Dr. Alan Birchall
WSU/USTUR
Adjunct Professor

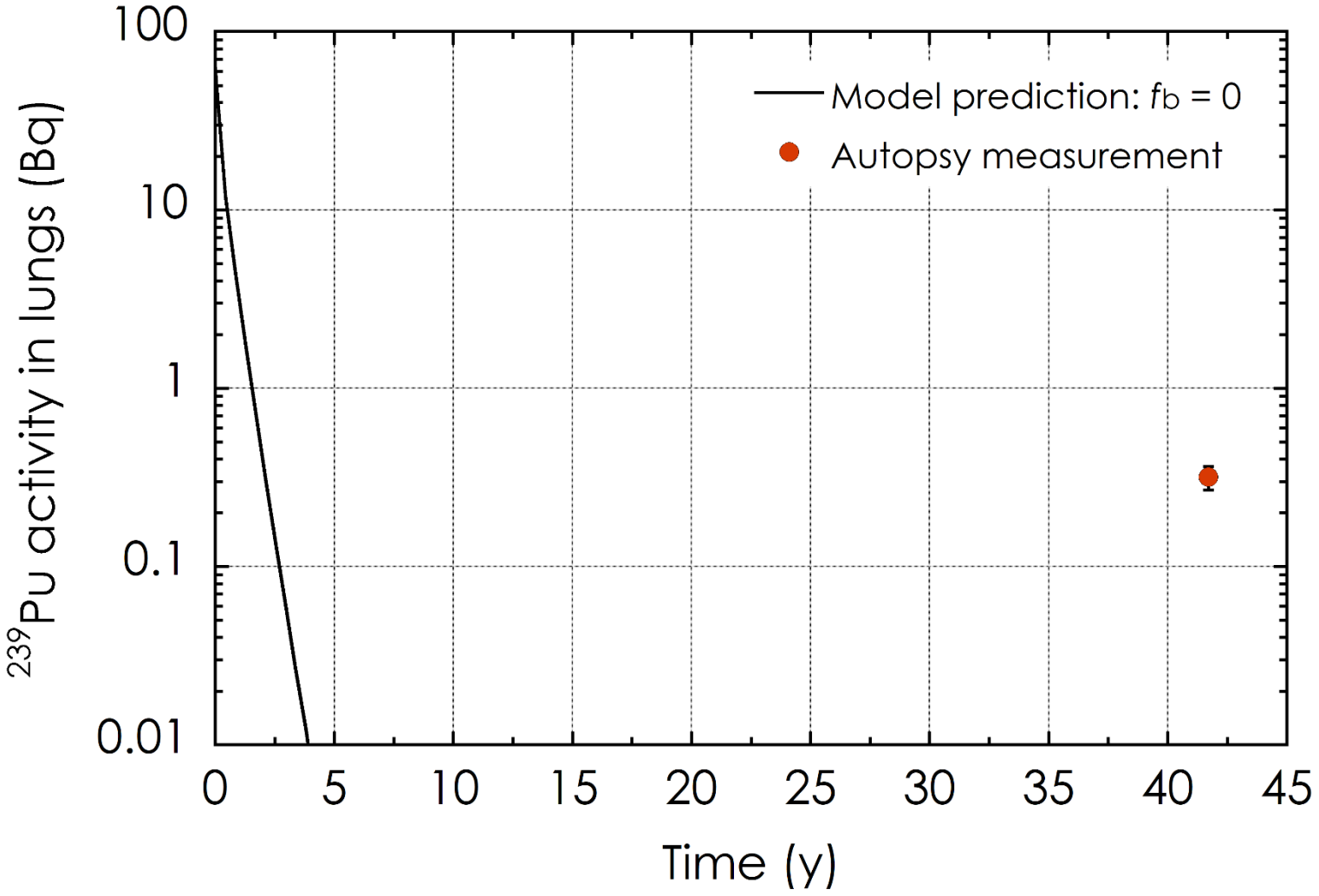


Human Respiratory Tract Model: *Plutonium Bound Fraction*

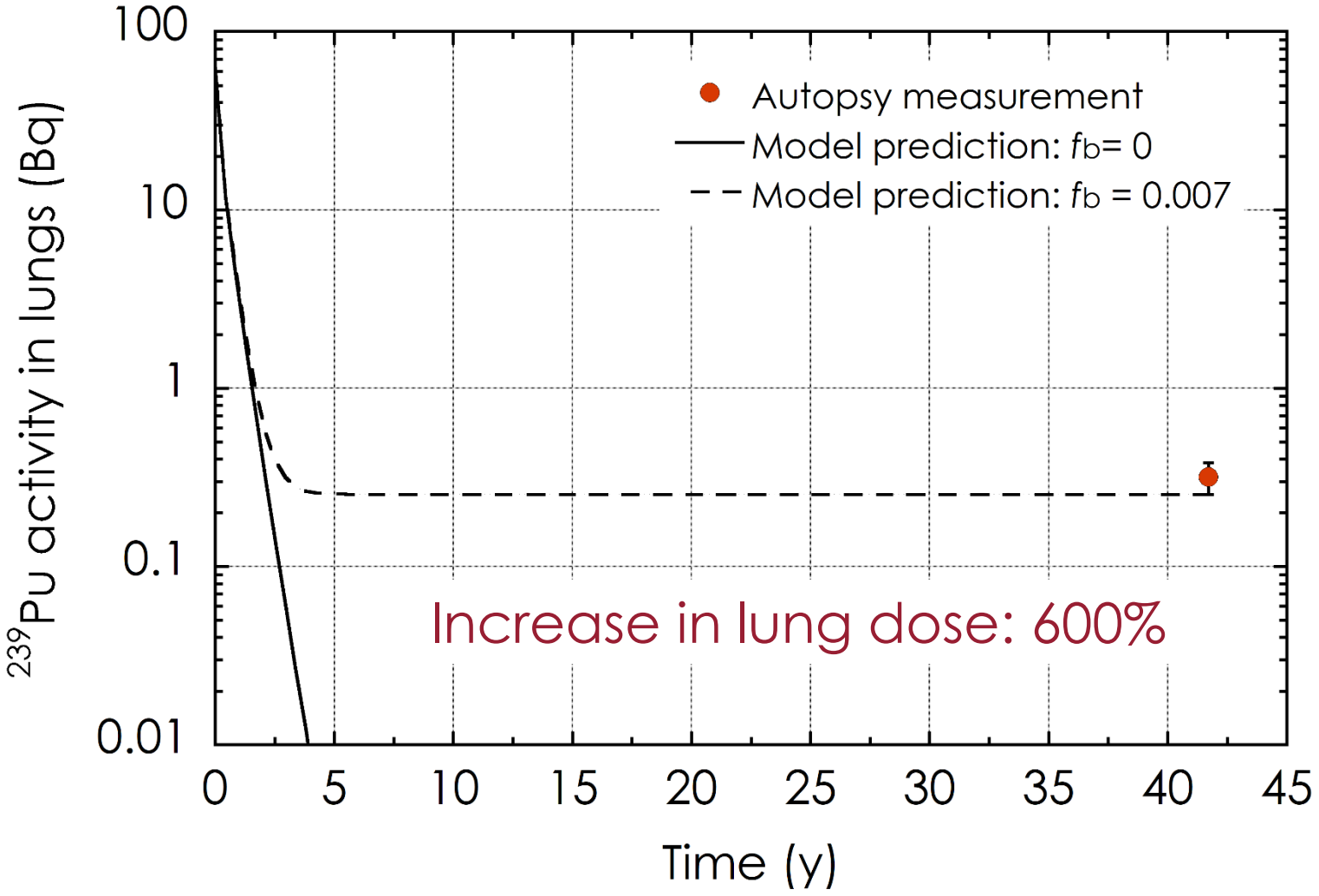


- Bound material fraction: f_b
- ICRP 66, ICRP130 HRTM: $f_b = 0$
- OIR Part 4 (*upcoming*): $f_b = 0.002$

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

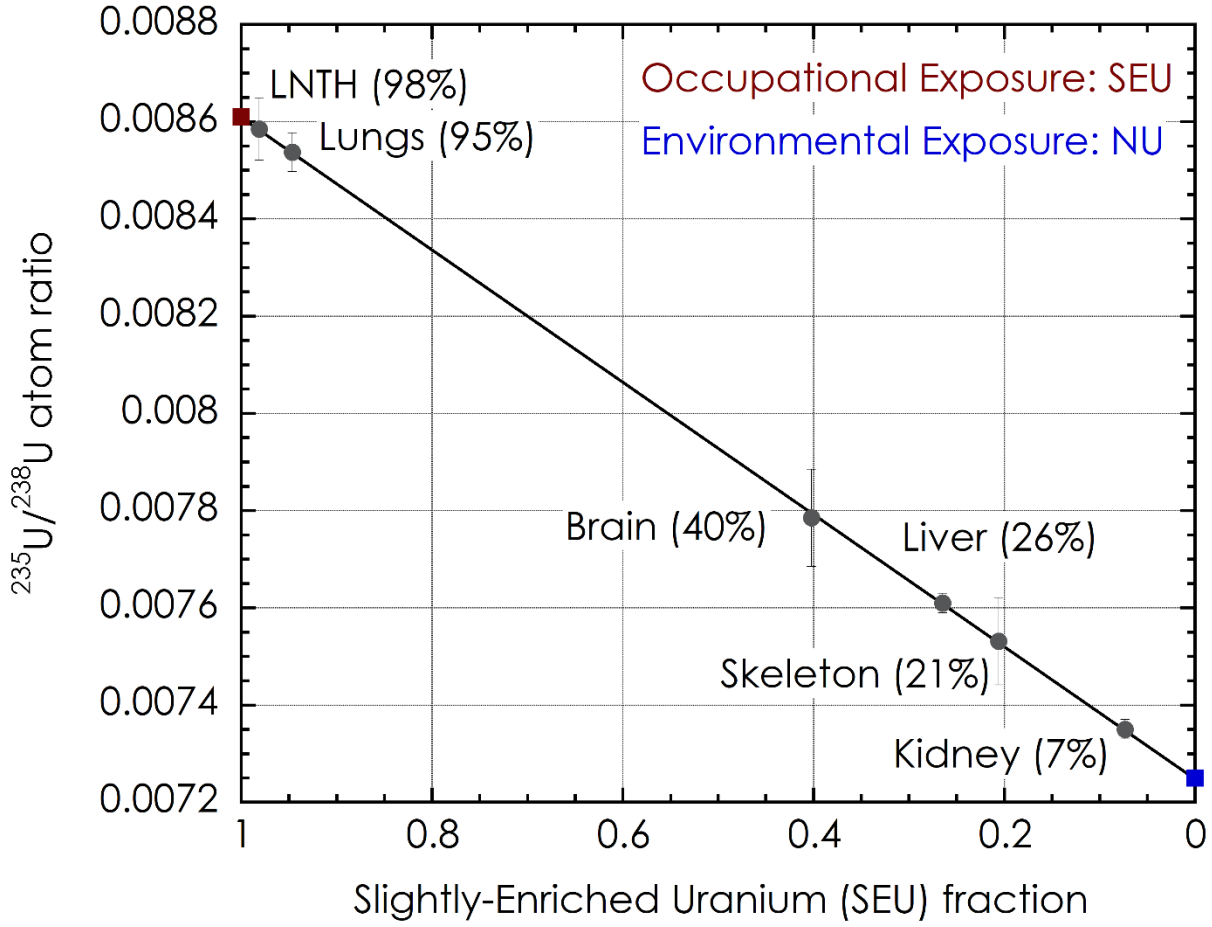


Soluble ^{239}Pu Retention in Lungs: $f_b = 0.007$



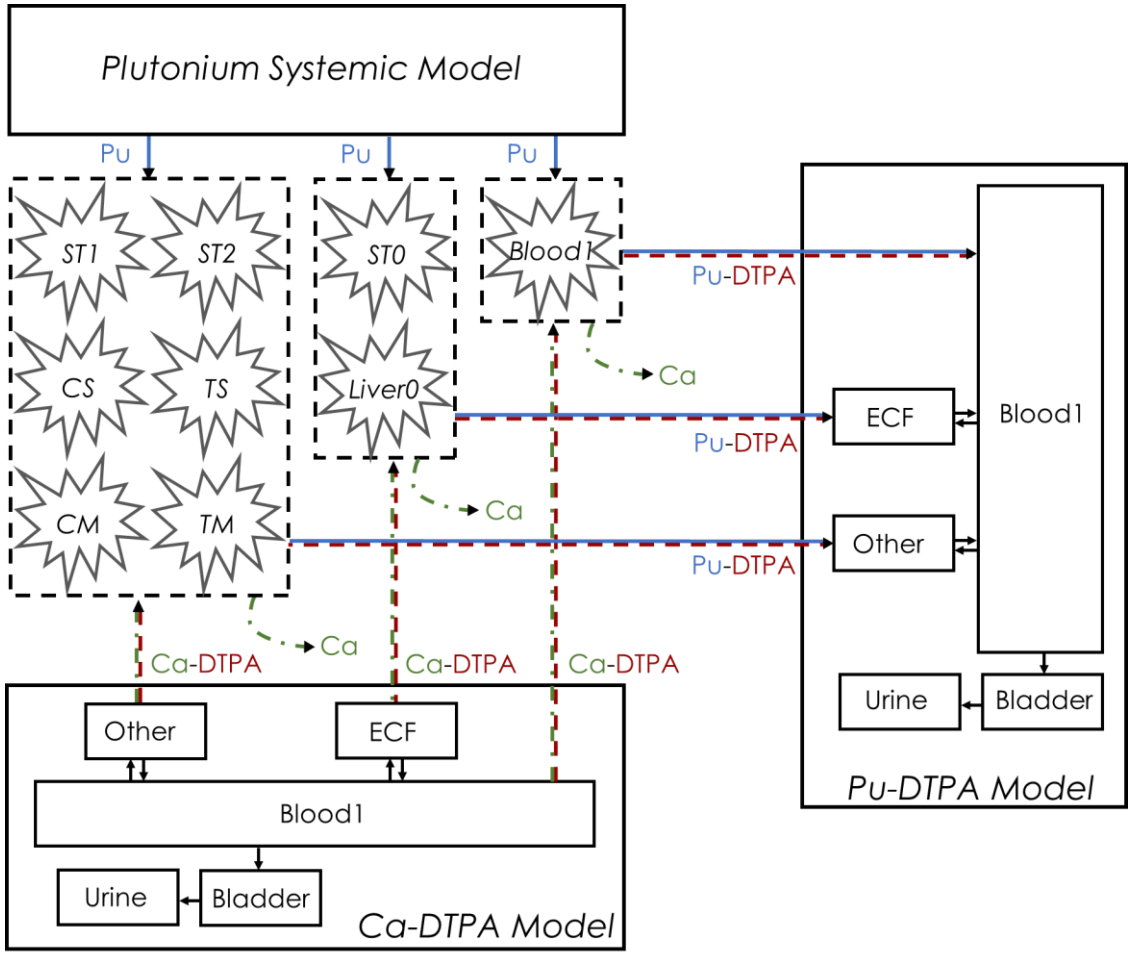
Uranium Hexafluoride Inhalation

- Acute inhalation due to massive explosion of UF_6 tank
- Slightly enriched U retained in lungs 65 y post-intake



Avtandilashvili *et al*. J. Radiol. Prot. 35: 129-151; 2015.

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

Dumit *et al*. Radiation Research (*submitted*); 2018.

Collaborative Research Network

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

EURADOS

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Health Canada

Northwestern University

NCRP National Council on Radiation Protection and Measurements

KIT Karlsruhe Institute of Technology

Université Laval

ЮУрИБФ

Public Health England

USTUR Scientific Contributions

Contribution to National Council on Radiation Protection and Measurements

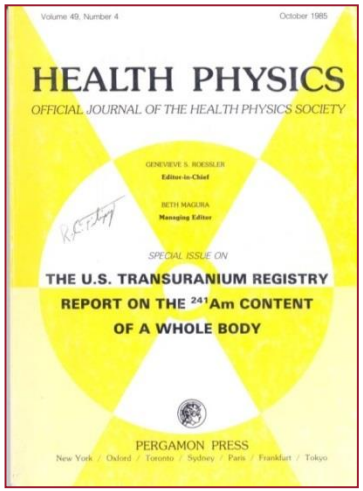
- Report 164: Uncertainties in Internal Radiation Dose Assessment (2009)
- Report 163: Radiation Dose Reconstruction Principles and Practices (2009)
- Report 156: Development of a Biokinetic Model for Radionuclide-Contaminated Wounds for Their Assessment, Dosimetry and Treatment (2006)
- Report 135: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

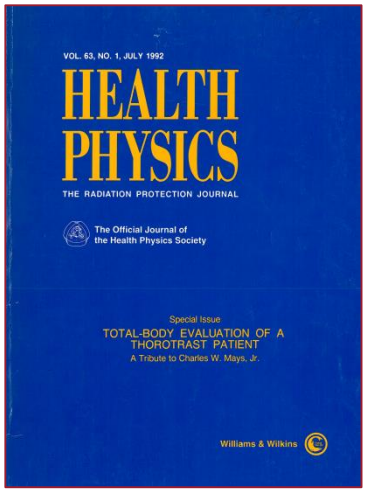
Contribution to International Commission on Radiological Protection

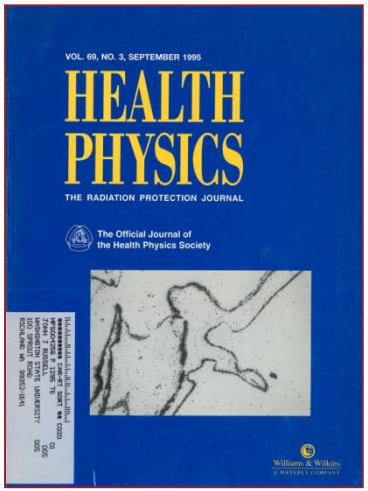
- Occupational Intakes of Radionuclides - Part 4 (upcoming)
- Publication 137: Occupational Intakes of Radionuclides - Part 3 (2017)
- Publication 70: Basic Anatomical & Physiological Data for Use in Radiological Protection - The Skeleton (1995)
- Publication 69: Age-dependent Doses to Members of the 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

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?

m.avtandilashvili@wsu.edu

www.ustur.wsu.edu