



# Radiochemistry Program at U.S. Transuranium and Uranium Registries - An Overview-

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***“Learning from Plutonium  
and Uranium Workers”***

# This Presentation

- USTUR: Who We Are and What We Do
  - ✓ History/Mission/Registrants
- Radiochemistry at USTUR: Past/Present/Future
  - ✓ Actinide measurement and separation techniques
  - ✓ Recent development in actinide separation
  - ✓ ICP-MS for actinide determination in human tissue
  - ✓ LA-ICP-MS for actinide elemental bio-imaging
- <http://www.ustur.wsu.edu/>



# Pre-USTUR: History

- 1949: Hanford Autopsy Study
- 1968: founded National Plutonium Registry, at the Hanford Occupational Health Foundation
- 1970: name changed to the U.S. Transuranium Registry (USTR)
- 1978: founded the U.S. Uranium Registry (USUR)
- 1979: Stuart Gunn – first whole body donation
- 1983: Harold McCluskey – dedicated issue of Health Physics Journal (October)



# USTUR: History

- **1992: USTR and USUR merge into USTUR** - a 3-y DOE grant to Washington State University for the management and operation of the Registries
- 1992: USTUR expansion - creation of National Human Radiobiological Tissue Repository (NHRTR)
- 1996: the U.S. National Radiobiology Archives (NRA) transferred from Pacific Northwest National Laboratory (PNNL) to USTUR
- 2009: Laboratory Facilities moved to Richland, WA



# USTUR: Mission

...to follow up occupationally exposed workers, from exposure through full lifespan, by studying the biokinetics (uptake, translocation and retention), and tissue dosimetry of the actinides (Pu, Am and U).

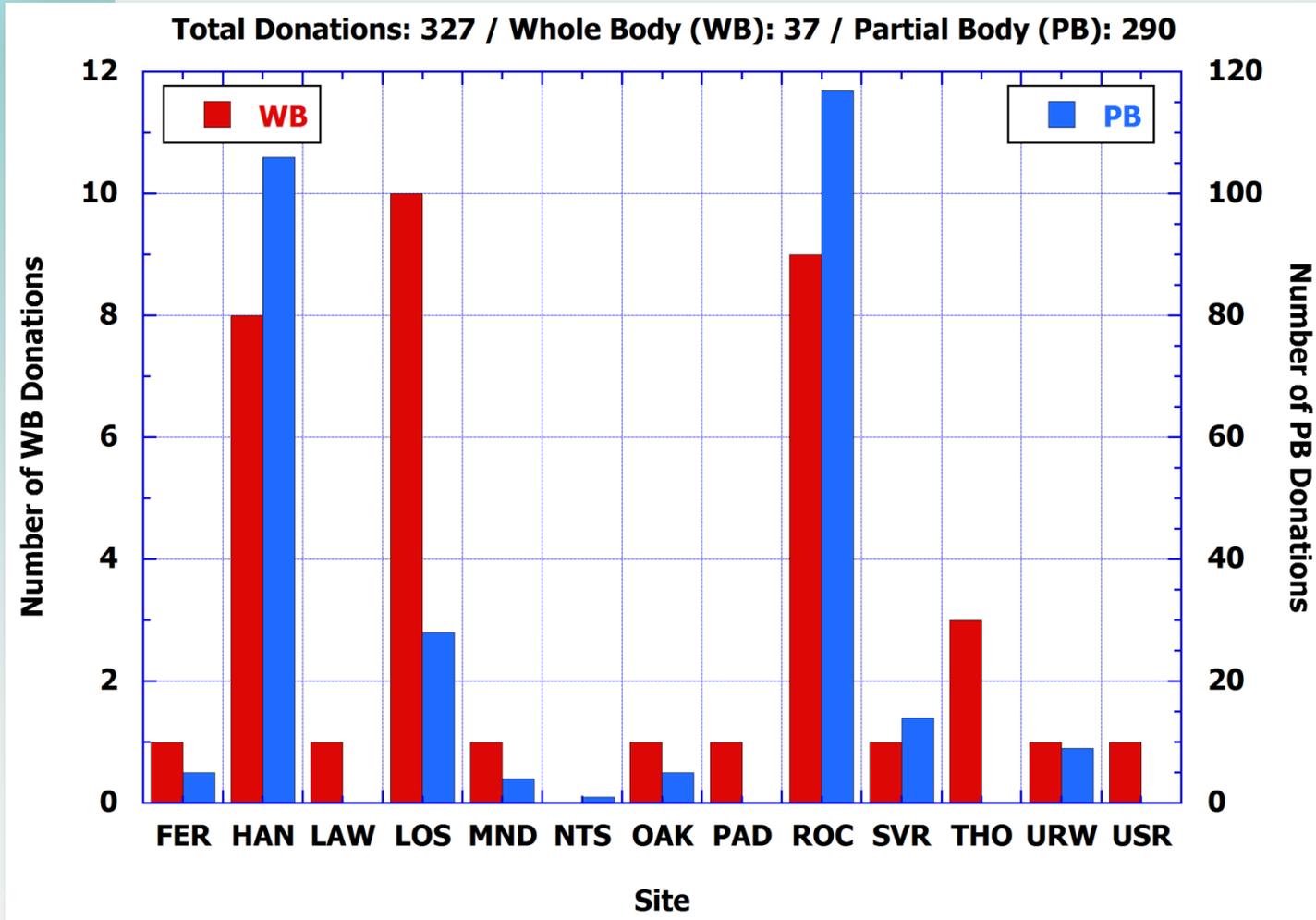


# USTUR: Registrants

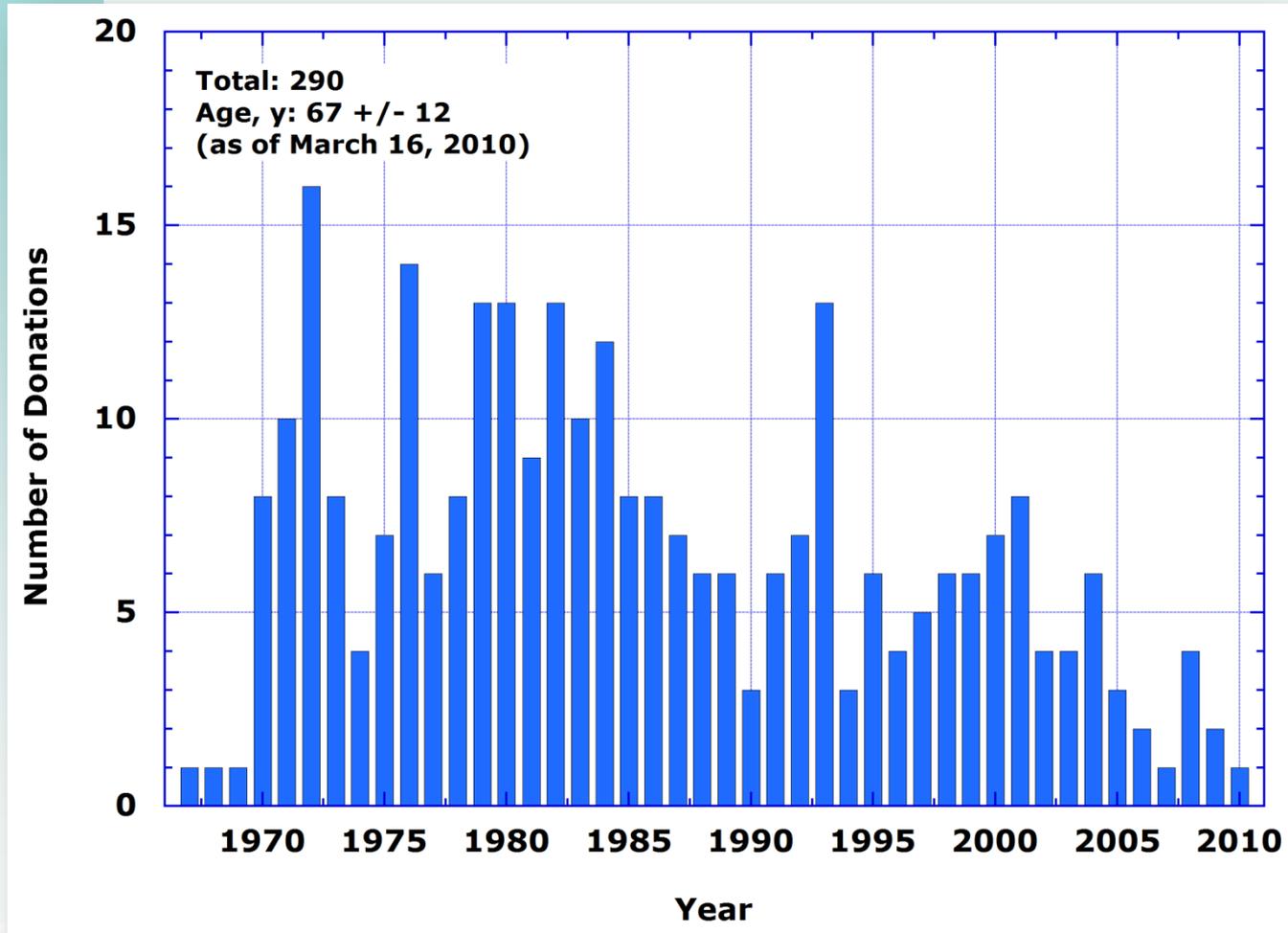
...to date, **327 former workers** from various U.S. weapons or other sites with known history of exposure to actinides **voluntarily donated** their tissues (290) or entire bodies (37) for **scientific research**.



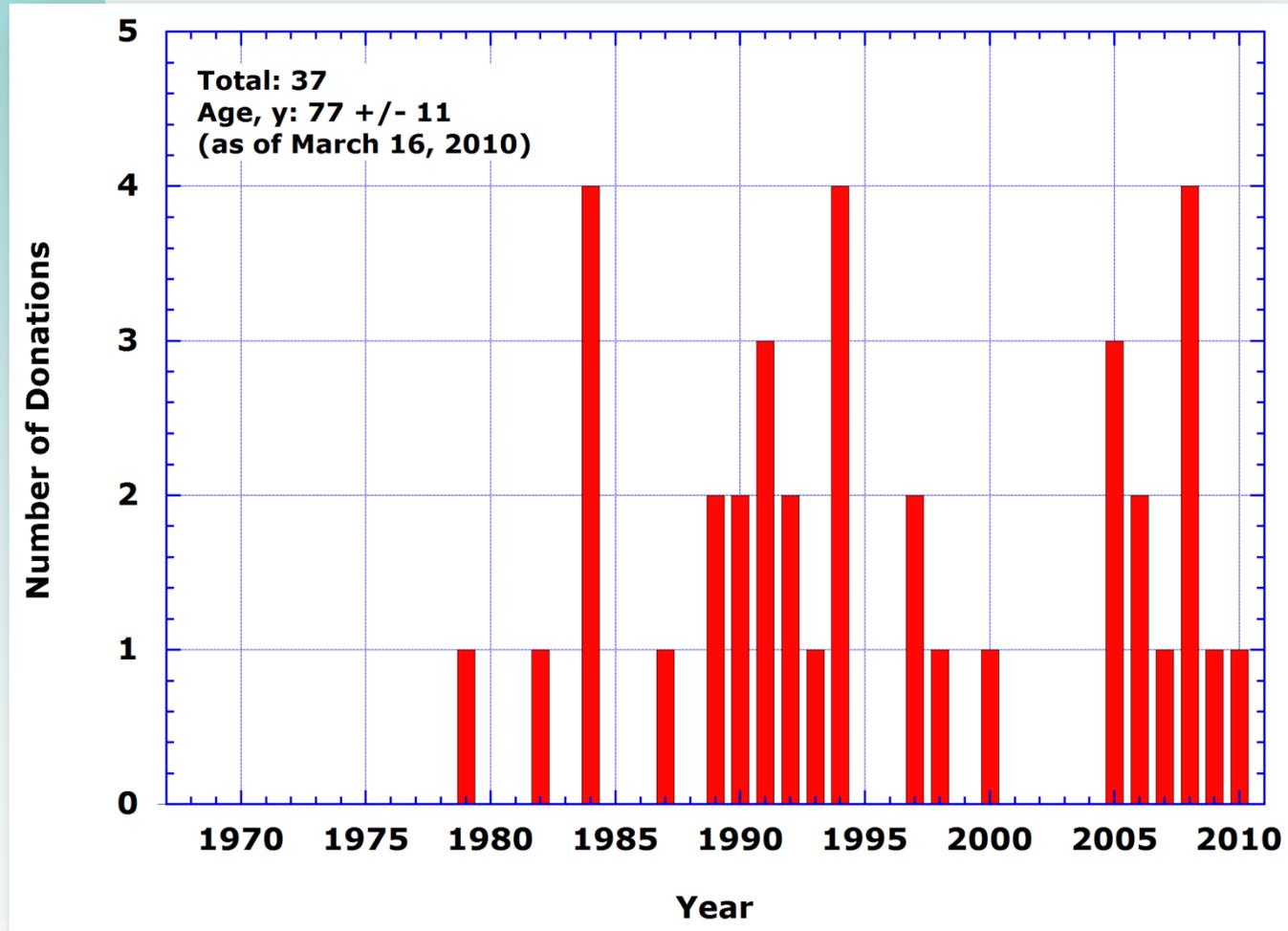
# USTUR Donations by Site



# USTUR: Partial Body Donations



# USTUR: Whole Body Donations



# Radiochemistry Program at USTUR

## - Human Tissue Analyses -



# Actinide Radionuclides

- $^{239+240}\text{Pu}$ ,  $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ ,  $^{241}\text{Pu}$
- $^{241}\text{Am}$
- $^{234}\text{U}$ ,  $^{235}\text{U}$  and  $^{238}\text{U}$ ,  $^{236}\text{U}$
- $^{232}\text{Th}$



# $^{239+240}\text{Pu}$ : USTUR vs. General Public

Tissue	$^{239+240}\text{Pu}$ concentration, Bq kg <sup>-1</sup> of wet tissue				Typical activity ratio, USTUR:GP	
	e.g. Case 0209		General public (GP)		USTUR:GP	
	Value	±SD	Average†	±SD	Value	±SD
<u>Soft Tissues:</u>						
Lung	1.34E+00	3.00E-02	3.75E-03	3.01E-03	356	287
Lymph Node	7.37E+01	2.23E+00	3.11E-03	1.36E-03	23,729	10,412
Liver	1.59E+00	3.47E-02	1.91E-02	3.89E-03	83.3	17.1
Kidney	1.61E-02	1.83E-03	1.48E-03	5.23E-04	10.9	4.1
Spleen	9.45E-02	7.59E-03	2.96E-03		31.9	2.6
<u>Bones:</u>						
Vertebrae	2.04E-01	3.59E-02	6.26E-03	2.72E-03	32.7	15.3
Rib	3.29E-01	5.55E-02	2.70E-03		122.0	20.5
Sternum	2.17E-01	1.54E-02	2.96E-03		73.2	5.2

† - from 4 studies in Japan, USA, Germany and Kazakhstan



# Analytical Support

- ✓ 1967 – 1987: DOW/Rockwell (Rocky Flats Plant)
- ✓ 1968 – 1978: PNL-Battelle (Hanford)
- ✓ 1971 – 1993: Los Alamos Scientific Laboratory
- ✓ 1992 – 2005: USTUR/NRC (WSU, Pullman)
- ✓ 2006 – 2008: USTUR/CLS (RJ Lee, Pasco)
- ✓ 2007 – 2008: STL-TestAmerica (Richland)
- ✓ 2010: USTUR Laboratory Facility (Richland)



# Analytical Measurement Techniques

- Alpha Spectrometry (AS):  $^{239+240}\text{Pu}$ ,  $^{238}\text{Pu}$ ,  $^{241}\text{Am}$ ,  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{232}\text{Th}$
- Autoradiography (AR): total  $\alpha$ -Pu
- Kinetic Phosphorescence Analysis (KPA): total U
- Neutron Activation Analysis (NAA):  $^{228}\text{Th}$ ,  $^{232}\text{Th}$
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS):  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ ,  $^{240}\text{Pu}/^{239}\text{Pu}$ , ( $^{241}\text{Pu}$ ,  $^{241}\text{Am}$ ),  $^{234}\text{U}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{236}\text{U}$



# USTUR: Human Tissue Analysis

- 1) Tissue sample dry/wet ashing / dissolution
- 2) Actinide separation from selected dissolved tissue sample aliquot
- 3) Counting source preparation: electrodeposition
- 4) Counting:  $\alpha$ -spectrometry



# LASL Methods

*Health Physics* Vol. 37 (July), pp. 1-136  
Pergamon Press Ltd., 1979. Printed in U.S.A.

## PLUTONIUM IN AUTOPSY TISSUE: A REVISION AND UPDATING OF DATA REPORTED IN LA-4875\*

J. F. McINROY, E. E. CAMPBELL, W. D. MOSS, G. L. TIETJEN,  
B. C. EUTSLER and H. A. BOYD

Los Alamos Scientific Laboratory, University of California, Los Alamos, NM 87545

*(Received 13 October 1978; accepted 5 December 1978)*

**Abstract**—Human tissues, obtained at autopsy in several geographical locations in the United States exposed primarily to atmospheric fallout from weapons testing and those from individuals who formerly worked with plutonium, have been analyzed quantitatively for plutonium in a continuing study at the Los Alamos Scientific Laboratory. This article contains additional data accumulated since publication of LASL report LA-4875, "Plutonium in Autopsy Tissue", in 1973 and includes some reanalyses of questionable results included in that report.

The primary objectives of the present study are to determine the baseline concentrations of plutonium in the general population and to monitor for changes that may be related to growth of the nuclear industry; obtain data on the long-range time dependence of fallout plutonium incorporation into the body; determine plutonium distribution in the body from various routes of intake; and provide a means for evaluating the validity of *in vivo* estimates of plutonium body burdens in occupationally exposed workers.



# LASL Methods

*Health Physics* Vol. 49, No. 4 (October), pp. 587-621, 1985  
Printed in the U.S.A.

0017-9078/85 \$3.00 + .00  
© 1985 Health Physics Society  
Pergamon Press Ltd.

## PART IV: PREPARATION AND ANALYSIS OF THE TISSUES AND BONES†

**JAMES F. MCINROY, HOWARD A. BOYD, BERNARD C. EUTSLER and DANIEL ROMERO**  
Los Alamos National Laboratory, University of California, Los Alamos, NM 87545

### INTRODUCTION

THE LOS Alamos National Laboratory has been analyzing the radionuclide content of human organs and tissues since 1959. Most early analyses were specifically for Pu isotopes, but analyses have also been performed for Am, U, and Th. Since 1978, Los Alamos has performed all the analyses of human tissue for the U.S. Transuranium Registry (USTR) except for those done by the Rocky Flats Plant (Rockwell International) chemistry group on their own former

total skeletal content must be based on analyses of only 100-300 g of bones which are not necessarily representative of the whole skeleton. The concentration of radionuclide measured in the fresh (wet) bone samples has been extrapolated, assuming a uniform distribution, to the entire anatomical skeleton (10,000 g for a 70 kg Reference Man) (ICRP75). Until now, there were no data (for any time after intake) on the total content or distribution of any actinide element in each bone of the human skeleton



# USTUR Methods

*Journal of Radioanalytical and Nuclear Chemistry, Vol. 234, Nos 1–2 (1998) 175–181*

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## **Preconcentration of plutonium and americium using the Actinide-CU™ Resin for human tissue analysis**

**H. Qu,<sup>1\*</sup> D. Stuit,<sup>1</sup> S. E Glover,<sup>1</sup> S. F. Love,<sup>2</sup> R. H. Filby<sup>1,2</sup>**

<sup>1</sup>*U.S. Transuranium and Uranium Registries,*

<sup>2</sup>*Department of Chemistry, Washington State University, Pullman, WA 99164, USA*

(Received February 5, 1998)

A method for the preconcentration of Am and Pu from human tissue solutions (liver, lung, bone etc) using the Actinide-CU Resin (EiChroM Industries) has been developed for their alpha-spectrometric determination. With near 100% recoveries were obtained by preconcentration, subsequent decomposition methods for eluent were developed. Good agreement for Pu and Am determination with the USTUR anion-exchange/solvent extraction method was demonstrated using previously analyzed human tissue solutions and NIST SRMs. The advantages of the preconcentration method applied to human tissue analysis are simplicity of operation, shorter analysis time compared to anion exchange/solvent extraction methods, and capacity to analyze large tissue samples (up to 15 g bone ash per analysis and 500 g soft tissue).

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# USTUR Methods

*Journal of Radioanalytical and Nuclear Chemistry, Vol. 234, Nos 1–2 (1998) 183–187*

## **Pre-concentration and separation of thorium, uranium, plutonium and americium in human soft tissues by extraction chromatography**

**C. A. Moody,<sup>1\*†</sup> S. E. Glover,<sup>1,2</sup> D. B. Stuit,<sup>2</sup> R. H. Filby<sup>1,2\*</sup>**

<sup>1</sup>*Department of Chemistry, Oregon State University, Corvallis, OR 97331, USA*

<sup>2</sup>*Department of Chemistry, Washington State University, Pullman, WA 99163, USA*

<sup>3</sup>*United States Transuranium and Uranium Registries, Washington State University, Pullman, WA 99163, USA*

(Received February 5, 1998)

An extraction chromatographic method is described for the pre-concentration and separation of thorium, uranium, plutonium and americium in human soft tissues. Tissues such as lung and liver are oven dried at 120 °C, ashed at 450 °C and the ashed sample is alternately wet ( $\text{HNO}_3/\text{H}_2\text{O}_2$ ) and dry ashed, and then dissolved in 8M HCl. Because of the complex matrix and large sample samples (up to 1500 g), the actinides were pre-concentrated from the tissue solution using the TRU™ resin (EICHROM) prior to elemental separation by extraction chromatography and determination of americium, plutonium, uranium and thorium by alpha spectrometry. The actinides were eluted from the preconcentration column and each actinide was individually eluted on TEVA™ and TRU™ resin columns in a tandem configuration. Actinide activities were then determined by alpha spectrometry after electrodeposition from a sulfate medium. The method was validated by analyzing human tissue samples previously analyzed for americium, plutonium, uranium and thorium in the United States Transuranium and Uranium Registries (USTUR). Two National Institute of Standards and Technology (NIST) Standard Reference Materials, SRM 4351-Human Lung and SRM 4352-Human Liver were also analyzed.

# Primary USTUR Methods

## Tissue ashing/dissolution

USTUR-100: dry ( $550^{\circ}$  C @ 5 – 30 days)

USTUR-110: wet ( $\text{HNO}_3\text{-H}_2\text{O}_2$ @hot plate /HCl)

## Pu/Am Separation

USTUR-150: actinide pre-concentration

USTUR-220: Pu isolation/purification

USTUR-310: Am purification

## Alpha Spectrometry

USTUR-510: electrodeposition

USTUR-600: measurements (150,000 sec)



# USTUR-150 Method

- Extraction Chromatography on Actinide Resin (Eichrom)
- 2-ml pre-packed column; 100-150  $\mu\text{m}$ 
  - ✓ DIPEX<sup>®</sup> extractant
    - High  $K_d$  for actinides @ 2M HCl
    - Low  $K_d$  for Fe (II) , Ca @ 2M HCl

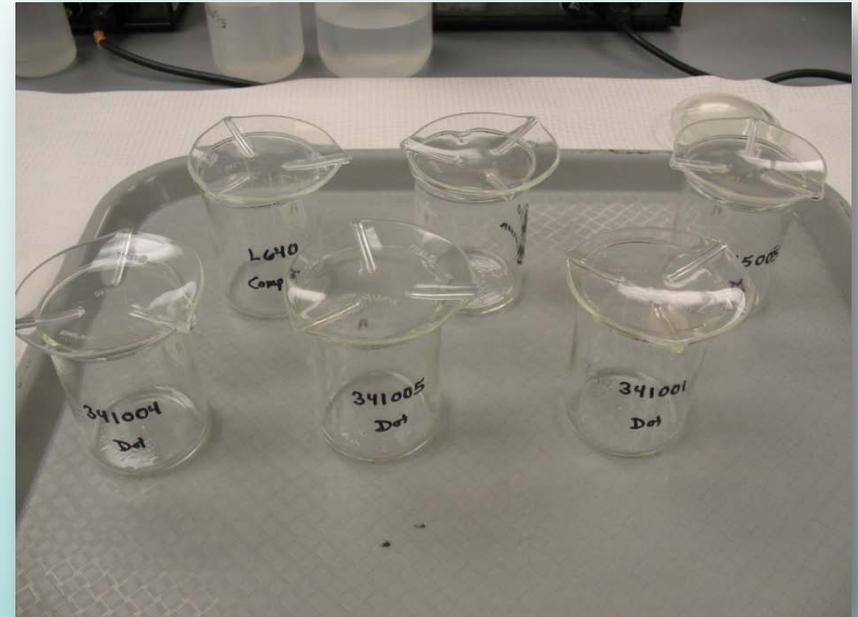


Actinide “pure” fraction

# USTUR-150 Method: Results



Before



After

**注意!**

70-90 min to complete separation  
DIPEX<sup>®</sup> digestion takes 1+ day!

# USTUR-220 Method

- Ion-Exchange on AG 1 × 4 (Bio-RAD)
  - ✓ Anion exchanger:  $\text{NO}_3^-$ ; 100-200 mesh
    - High  $K_d$  for Pu (IV): 8 M  $\text{HNO}_3$
    - Low  $K_d$  for Am (III) and U (VI)
    - Low  $K_d$  for Pu(III): 0.1M HCl-0.05M HF -0.1M  $\text{NH}_4\text{I}$

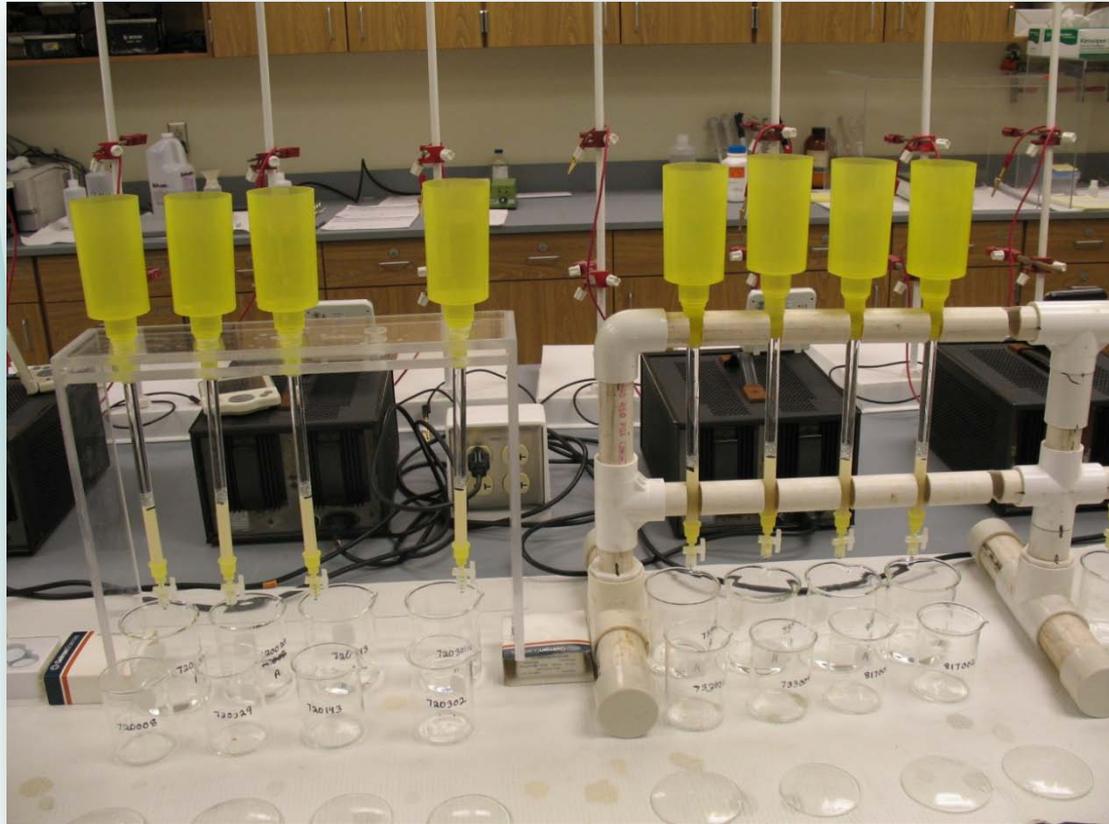


Plutonium “pure” fraction



Americium fraction

# USTUR-220: Experimental Setup



**注!**

**意** High acid waste production - 150 ml per sample

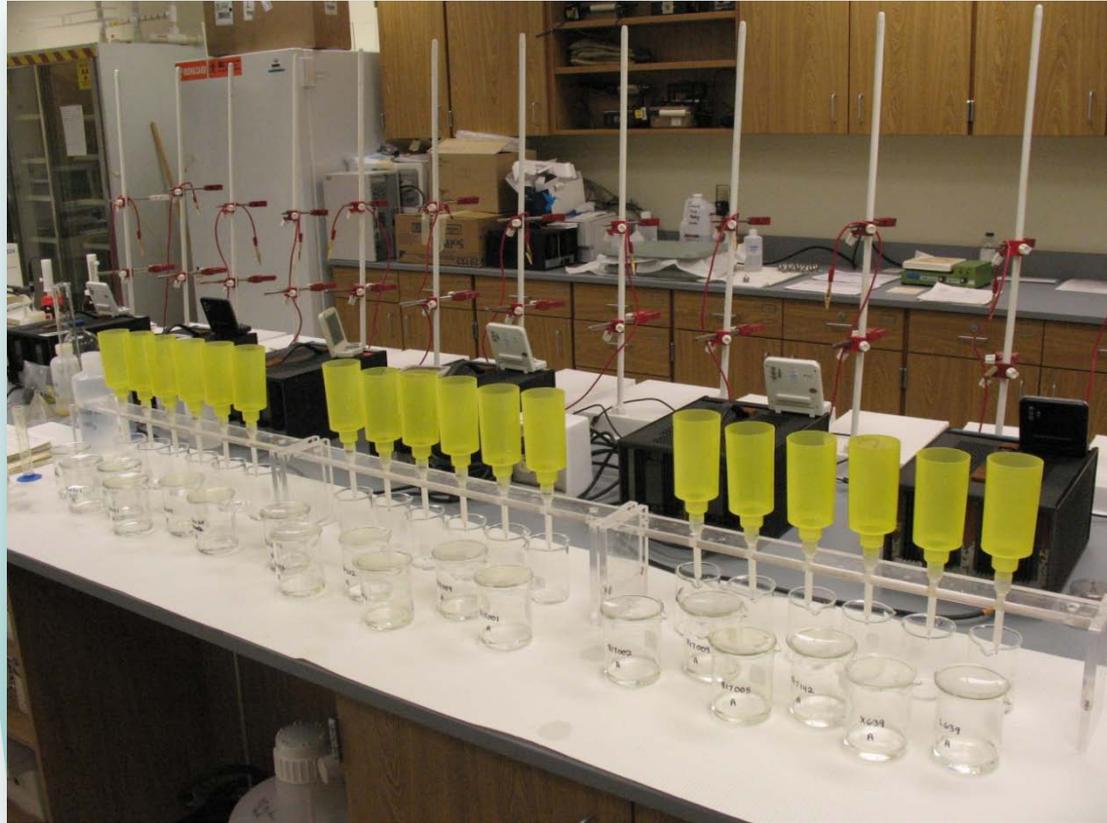
# USTUR-310 Method

- Extraction Chromatography on TRU<sup>®</sup> Resin (Eichrom)
- 2-ml pre-packed column; 100-150  $\mu\text{m}$
- ✓ CMPO-TBP extractant
  - High  $K_d$  for actinides @ 3M  $\text{HNO}_3$
  - Low  $K_d$  for Am (III) @ 0.025 M  $\text{HNO}_3$



Americium “pure” fraction

# USTUR-310: Experimental Setup



**注意**

Tracers of organic in Am-fraction – extra digestion step is needed

# USTUR-510: Experimental Setup



Electrodeposition: 1h @ 0.75 A ; pH 2.3 (initial)

# USTUR-600: Instrumentation

- *Octête™* PC system
- 4MCB: 32 detectors
- Software: Maestro v6.06 + Alpha Vision v5.30
- Sample/Background Counting: 150,000 sec / 300,000 sec
- Efficiency: 25 – 28%



# Actinide Separation (I): Summary

- Combination of extraction chromatography and ion-exchange
- Sample loading: **3 times**
- Number of samples: **18**
- Acid waste production: **345 mL per sample**
- Time for Am/Pu separation: **5+ days**
- Recovery: **75% ( $^{242}\text{Pu}$ ) and 85% ( $^{243}\text{Am}$ )**



<http://www.ustur.wsu.edu/PolicyProcedures/RadChemProcedures.html>



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Case Narratives

Radiochemistry

Health Physics

Pathology

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NHRTR

National Human Radiobiological Tissue Repository

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NRA

National Radiobiology Archives

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Links

## Radiochemistry Policies & Procedures Manual

"The ability of man to understand the world is limited, it follows that the world is not to be understood in terms of the world as it is, but in terms of the world as it is needed and limited. There is nothing limited. Thus, it is a respect job."

**Disclaimer of Responsibility:**

The following material is intended for research purposes only. Neither Washington State University nor the United States Transuranium and Uranium Registries may be held responsible for unauthorized changes and/or use of this material.

**Forward**

The United States Transuranium and Uranium Registries (USTUR) began with the establishment of the National Plutonium Registry in 1968 by the Atomic Energy Commission. The program name was changed in 1970 to reflect a broader interest in transuranic elements. A similar program was created in 1978 to study the uranium decay series and was named the United States Uranium Registry. Analytical support for the registries was provided by Rocky Flats from 1968 until 1987, Pacific Northwest Laboratory from 1968 until 1978, and Los Alamos National Laboratory from 1971 until 1993. Responsibility for the Registries was transferred to Washington State University in February 1992 at which time the two registries were joined as the USTUR.

Authorship of these procedures is listed as USTUR Radiochemistry Staff. Appropriate citation of original LANL methods is included in each section. Modification and additions to LANL procedures and new procedures/methods were written by Jim Elliston, Roy Filby, Sam Glover, Cathy Grimm, Suzanne Love, Hongguo Qu, Dorothy Stuit and Gail Deckert.

This manual represents the third edition of the USTUR Radiochemical Analysis Procedures Manual. All previous editions shall be immediately superseded by this edition.

**Table of Contents**

Procedure #	Title
USTUR001	Forward
USTUR010	Chain of Custody, Sample Number Assignment, and Sample Storage
USTUR020	Handling Biohazardous Material
USTUR025	Radiation Safety Authorization
USTUR030	Document Control and Record Storage
USTUR050	Radiochemical Analysis Form Description
USTUR070	Preparation of Tracers and Tracking Standard Solutions
USTUR080	Cleaning of Labware
USTUR100	Tissue Ashing, Sample Dissolution, Sample Aliquot Selection, and Tracer Addition for Anion Exchange Isolation of Radionuclides
USTUR105	Dry Ashing of Tissues
USTUR110	Wet Ashing of Tissues
USTUR115	Disposal of Radiochemicals



# Can We Do Better? - Yes

## (1) Separation technology improvement:

- extraction chromatography vs. ion-exchange
- vacuum assisted separation vs. gravity fed
- stack cartridges vs. single column

## (2) Development of new products:

- UTEVA<sup>®</sup> vs. TEVA<sup>®</sup> resin for U
- DGA<sup>®</sup> vs. TRU<sup>®</sup> resin for Am



# Actinides in Fish and Animal Tissues



## Actinides and Sr-89/90 in Animal Tissue



Sherrod L. Maxwell  
Washington Savannah River Co.  
52<sup>nd</sup> Radiobioassay and Radiochemical  
Measurements Conference

October 23, 2006



# Actinides in Fish and Animal Tissues



## Recent Improvements in Column Extraction Methods at SRS



Sherrod L. Maxwell  
Washington Savannah River Co.  
53<sup>rd</sup> Radiobioassay and Radiochemical  
Measurements Conference  
Eichrom Workshop

October 30, 2007



# Actinides in Fish and Animal Tissues

DOI: 10.1007/s10967-007-7120-4

*Journal of Radioanalytical and Nuclear Chemistry, Vol. 275, No.3 (2008) 605–612*

## Rapid column extraction method for actinides and strontium in fish and other animal tissue samples

S. L. Maxwell III,\* D. M. Faison

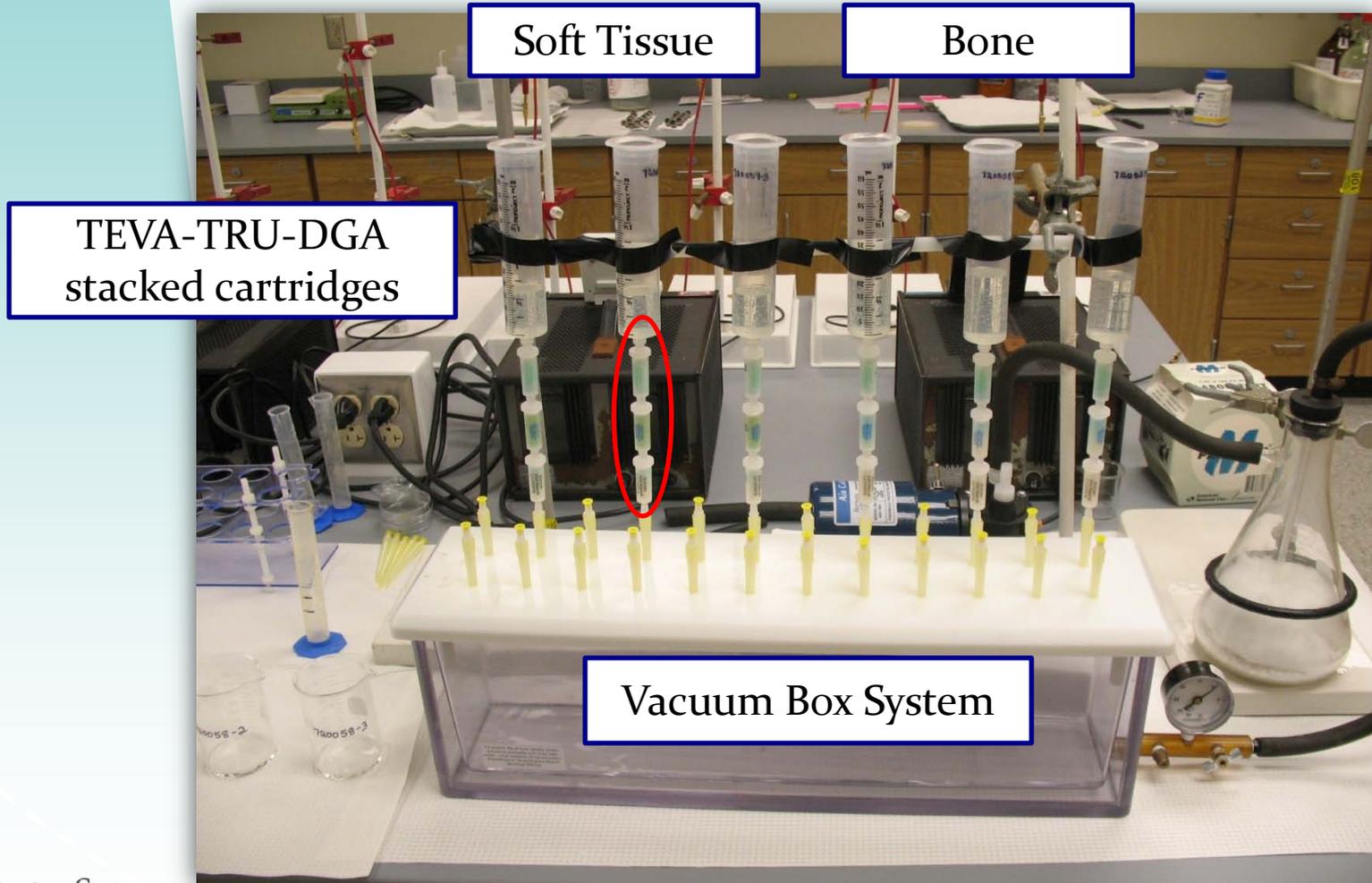
*Washington Savannah River Company, Building 735-B, Aiken, SC 29808, USA*

(Received June 12, 2007)

The analysis of actinides and radiostrontium in animal tissue samples is very important for environmental monitoring. There is a need to measure actinide isotopes and strontium with very low detection limits in animal tissue samples, including fish, deer, hogs, beef and shellfish. A new, rapid separation method has been developed that allows the measurement of plutonium, neptunium, uranium, americium, curium and strontium isotopes in large animal tissue samples (100–200 g) with high chemical recoveries and effective removal of matrix interferences. This method uses stacked TEVA Resin<sup>®</sup>, TRU Resin<sup>®</sup> and DGA Resin<sup>®</sup> cartridges from Eichrom Technologies (Darien, IL, USA) that allows the rapid separation of plutonium (Pu), neptunium (Np), uranium (U), americium (Am), and curium (Cm) using a single multi-stage column combined with alpha-spectrometry. Strontium is collected on Sr Resin<sup>®</sup> from Eichrom Technologies (Darien, IL, USA). After acid digestion and furnace heating of the animal tissue samples, the actinides and <sup>89/90</sup>Sr are separated using column extraction chromatography. This method has been shown to be effective over a wide range of animal tissue matrices. Vacuum box cartridge technology with rapid flow rates is used to minimize sample preparation time.



# Vacuum Assisted Extraction Chromatography



# Actinide Column Separation (II)

- 1) Sample in 12 mL warm 6M  $\text{HNO}_3$  and 12mL 2M  $\text{Al}(\text{NO}_3)_3$
- 2) Add 0.75 mL 1.5M Sulfamic Acid + 3 mL 1.5M Ascorbic Acid
- 3) Add 2.5 mL 3.5 M Sodium Nitrite
- 4) Sample loading (1 drop sec<sup>-1</sup>)

5) Beaker rinse: 5 mL 6M  $\text{HNO}_3$   
 6) **Separate cartridges**  
 7) TEVA rinse: 15 mL 3M  $\text{HNO}_3$

8) Rinse: 25 mL 9M HCl (Th)

9) Pu Elution: 30 mL  
 0.1M HCl - 0.05M HF - 0.04M rongalite

2 mL TEVA Resin  
 (50-100  $\mu\text{m}$ )

(6)

2 mL TRU-Resin  
 (50-100  $\mu\text{m}$ )

2 mL DGA-Resin  
 (50-100  $\mu\text{m}$ )

DGA resin not affected by  $\text{Fe}^{3+}$

Electrodeposition  
 (USTUR-510)



Alpha spectrometry  
 (USTUR-600)

Waste 4 - 8

# Actinide Column Separation (II)

## TRU - DGA cartridges from Step 6

**10) Am to DGA: 15 mL 4M HCl**  
**11) Separate cartridges**

2 mL TRU-Resin  
(50-100  $\mu\text{m}$ )

(11)

2 mL DGA-Resin  
(50-100  $\mu\text{m}$ )

Waste 10

**12) Rinse: 3 mL 1M HNO<sub>3</sub>**  
**13) Rinse: 10 mL 0.1M HNO<sub>3</sub> (U)**

**14) Am Elution: 10 mL 0.25M HCl**

Waste 12,13

Electrodeposition  
(USTUR-510)

Alpha spectrometry  
(USTUR-600)

# Actinide Separation (II): Summary

- Sequential vacuum-assisted extraction chromatography
- Sample loading: **once**
- Number of samples: **24**
- Acid waste production: **135mL per sample**
- Time for Am/Pu fraction separation: **6 h**
- Recovery: **>90% for both  $^{242}\text{Pu}$  and  $^{243}\text{Am}$**



# Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for Actinides and Isotopic Ratio Measurements

## *Collaboration with Northern Arizona University*



*Dr. Michael E. Ketterer*

Professor, Department of Chemistry and  
Biochemistry, Northern Arizona University  
Flagstaff, AZ, USA

# ICP-MS Benefits

- **Sufficient sensitivity** to determine actinides at fg-levels ( $10^{-15}$  g)
- **Rapid, low cost** analysis
- **Isotopic (atom ratio) information** for source identification and confirmation
- **Accurate** determinations by isotope dilution method ( $^{233,236}\text{U}$ ,  $^{242,244}\text{Pu}$ ,  $^{243}\text{Am}$ )

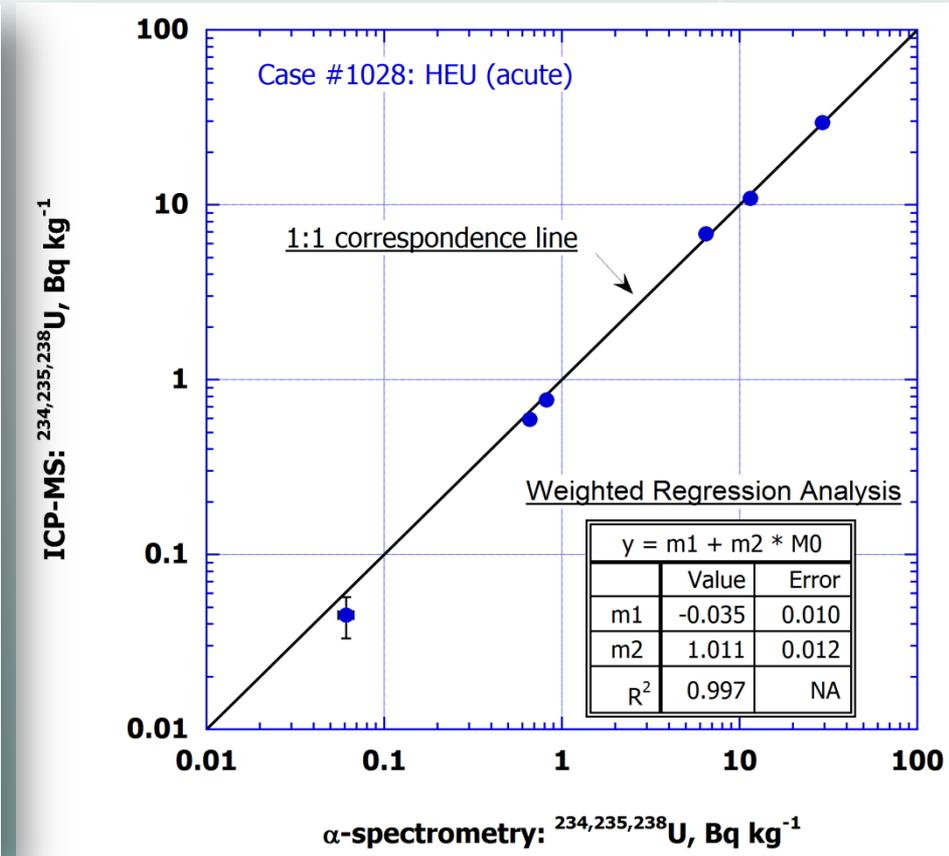
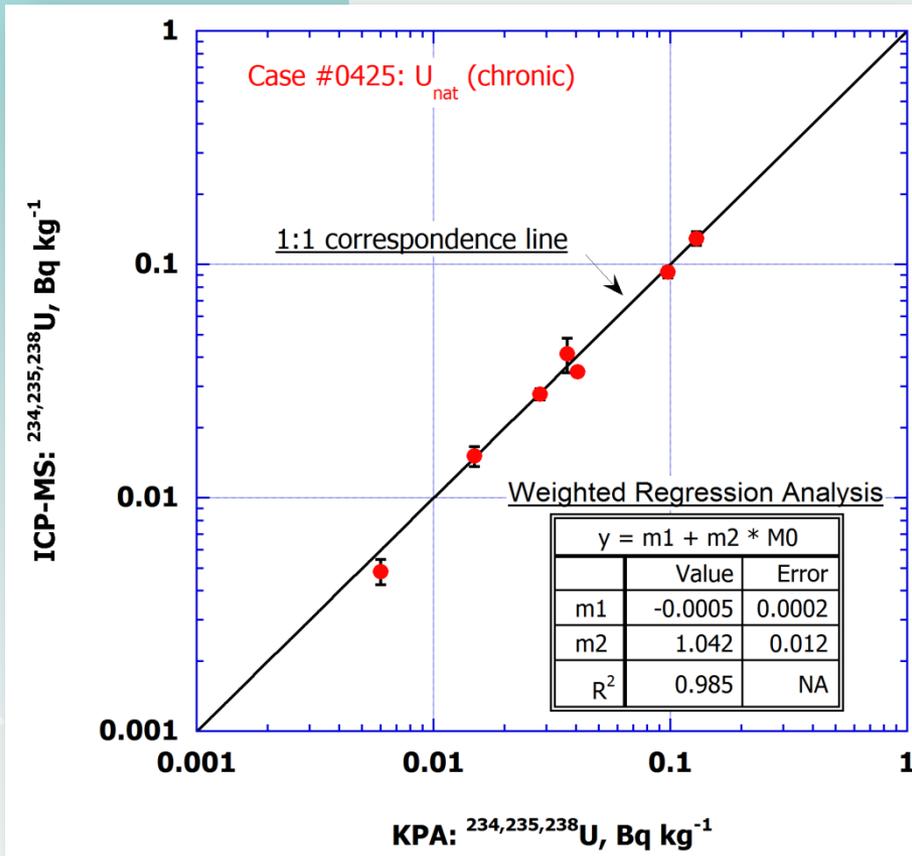


# Samples: SF-ICP-MS vs. AS & KPA

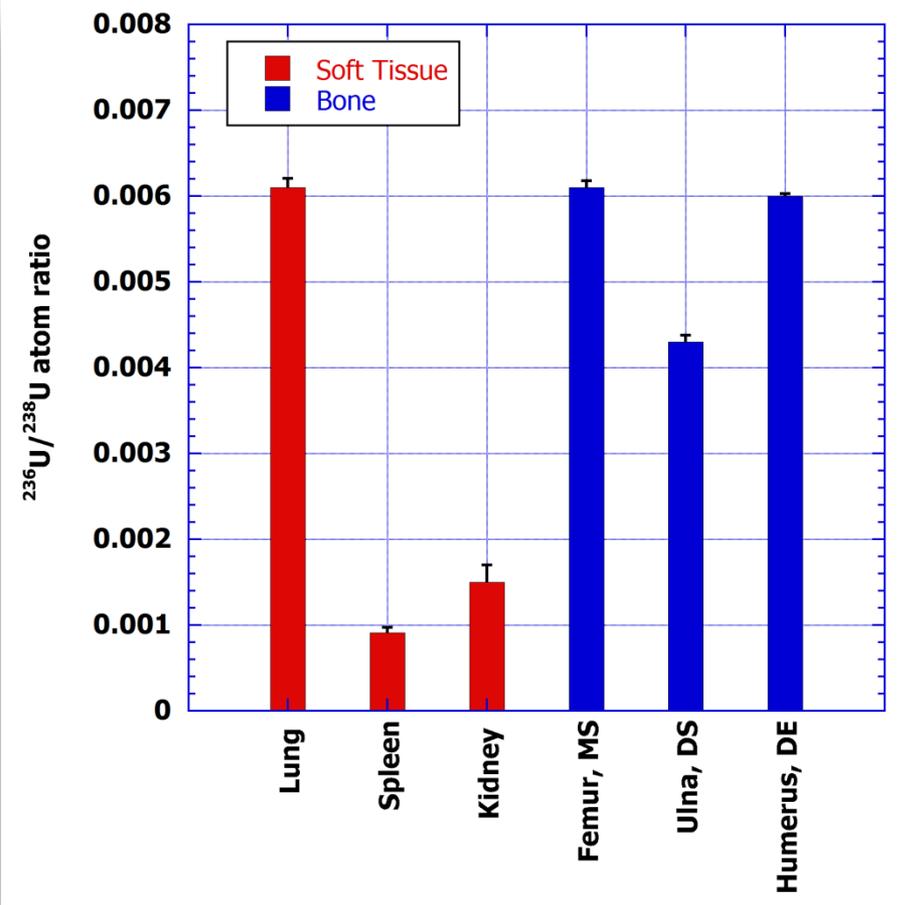
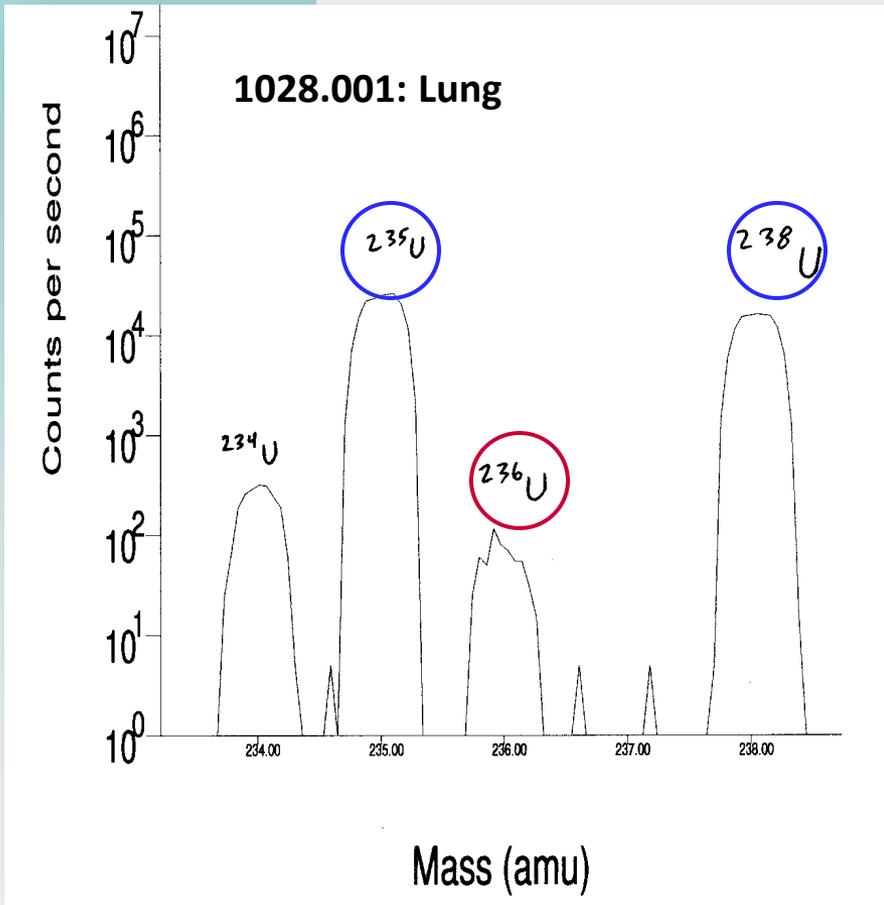
- 0269: Hanford – 1956 Acute Inhalation – Soluble  $^{239}\text{Pu}$  – Chelated
- 0425: Rocky Flats – 1965 Acute Inhalation (Fire) – Refractory  $^{239}\text{Pu}$
- 0720: Rocky Flats – 1965 Acute Inhalation (Fire) – Refractory  $^{239}\text{Pu}$
- 1028: Oak Ridge – 1954 Acute Inhalation – Highly Enriched Uranium

Case # (Age, y)	Follow-up (y)	# of Samples (Bone)	USTUR (AS, KPA)		
			U	Pu	Am
0269 (79)	38	4 (2)	x	o	o
0425 (83)	29	7 (3)	o	o	o
0720 (83)	40	2 (0)	x	o	o
1028 (86)	39	6 (3)	o	x	x

# Uranium: SF-ICP-MS vs. KPA & AS



# SF-ICP-MS: Anthropogenic $^{236}\text{U}$



## Measurement of $^{236}\text{U}$ in human tissue samples using solid phase extraction coupled to ICP-MS

Chunsheng Li,<sup>\*a</sup> Karima Benkhedda,<sup>a</sup> Sergei Tolmachev,<sup>b</sup> Lisa Carty,<sup>c</sup> Raymond Ko,<sup>a</sup> Deborah Moir,<sup>a</sup> Jack Cornett<sup>a</sup> and Gary Kramer<sup>a</sup>

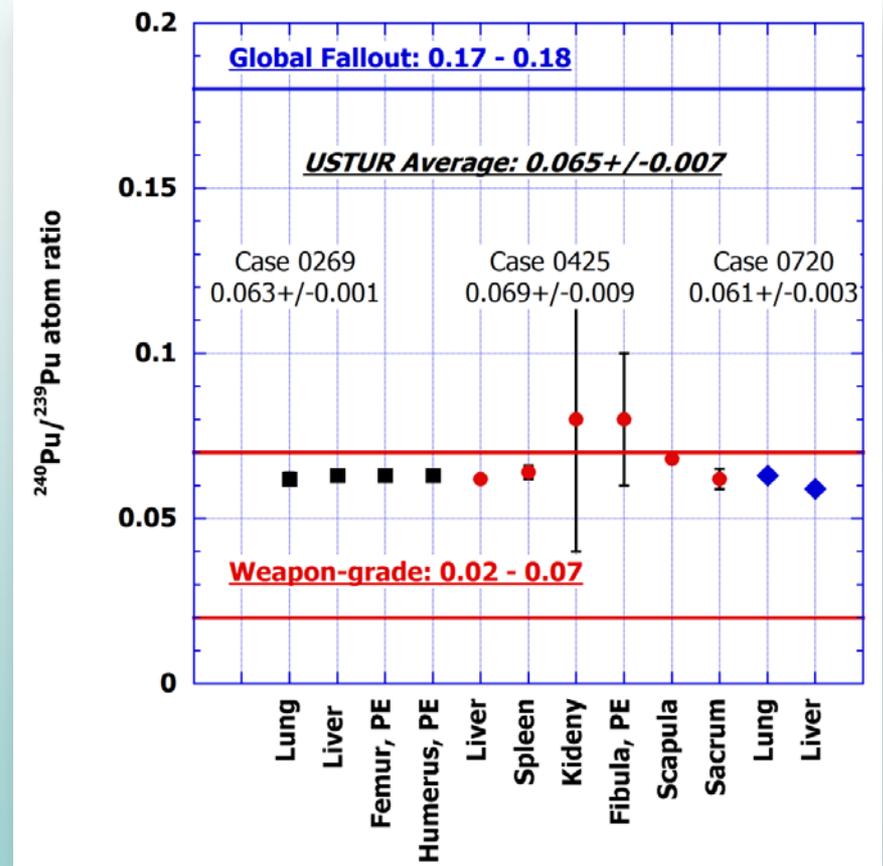
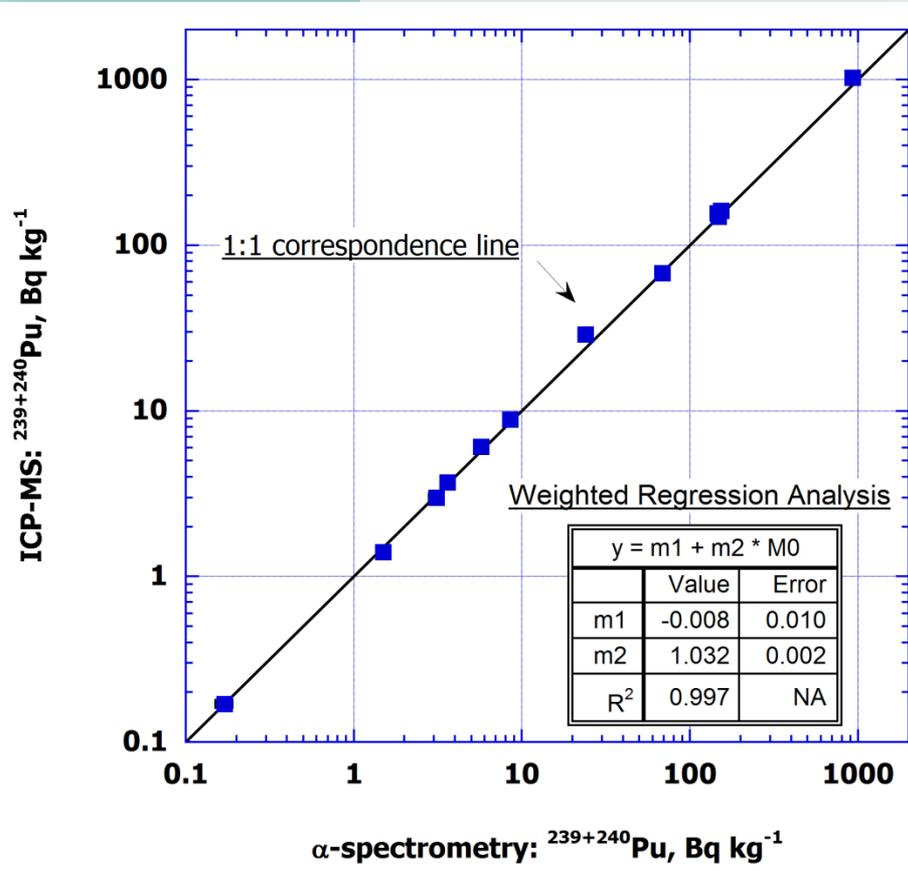
*Received 13th November 2009, Accepted 26th January 2010*

*First published as an Advance Article on the web ?????*

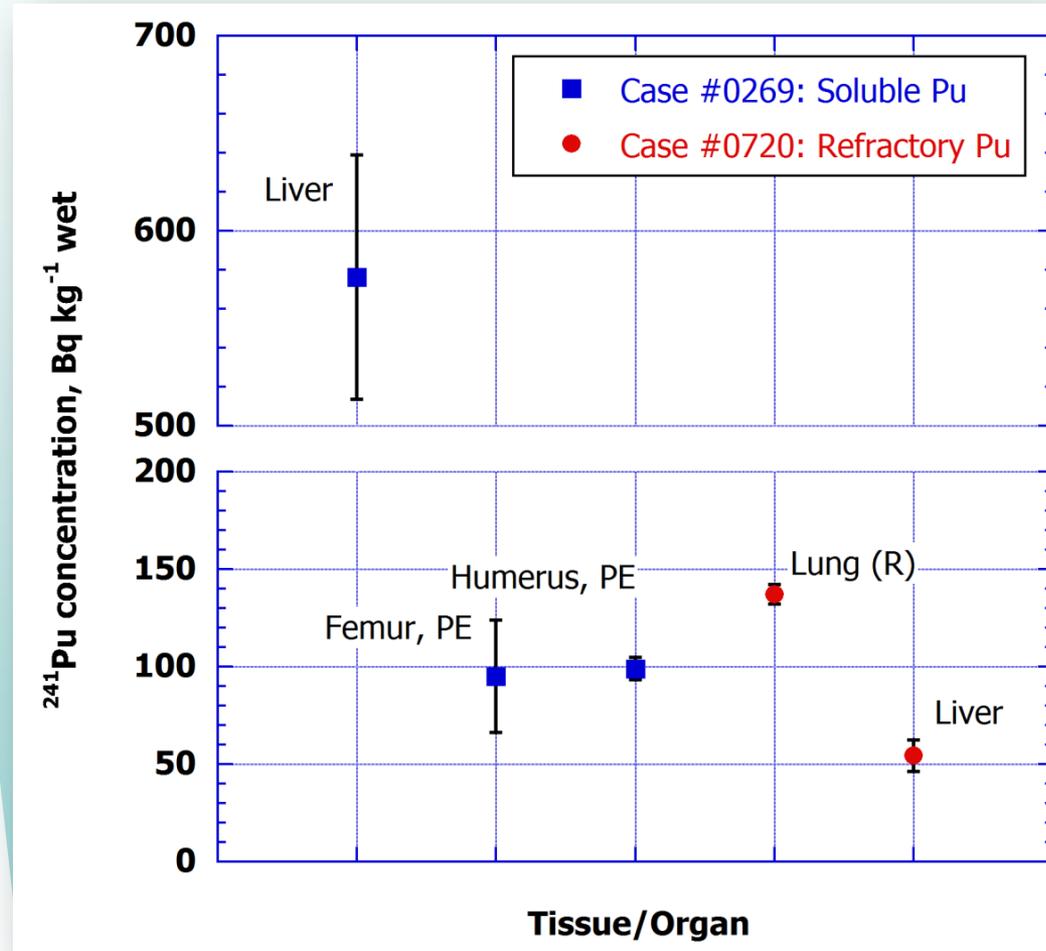
DOI: 10.1039/b923909j

$^{236}\text{U}$  is present at ultra-trace levels in typical environmental and biological samples. Typically, it has been measured by highly sensitive techniques, such as accelerator mass spectrometry. This paper reports the measurement of  $^{236}\text{U}$  in 20 human tissue samples using a sector field ICP-MS following automated SPE separation. The tissue samples were selected from one USTUR case, representing tissues/organs that are important for internal radiation assessment. Another uranium isotope,  $^{235}\text{U}$ , was also measured in the samples. The results for  $^{235}\text{U}$  were compared with those obtained by alpha spectrometry. For most cases, results from the two methods were comparable, indicating that the measurement of  $^{236}\text{U}$  in the samples is reliable.

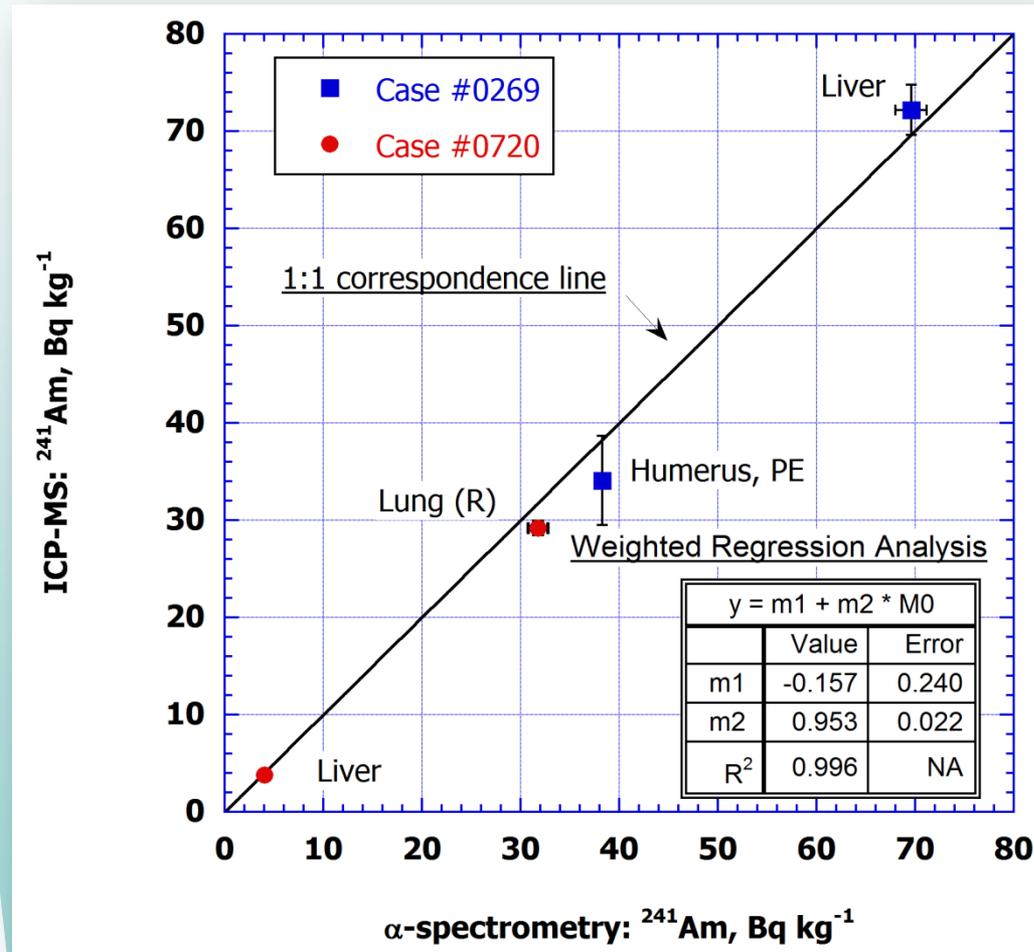
# Plutonium: SF-ICP-MS vs. AS



# SF-ICP-MS: $^{241}\text{Pu}$ ( $\beta$ -emitter)



# Americium: SF-ICP-MS vs. AS



# Laser-Ablation ICP-MS for Elemental Bio-Imaging of Actinides

*Collaboration with University of Technology  
Sydney, Australia*



*Dr. Philip Doble*

Professor, Department of Chemistry and  
Forensic Science, University of Technology  
Sydney, Australia

Director, Elemental Bio-imaging Facility



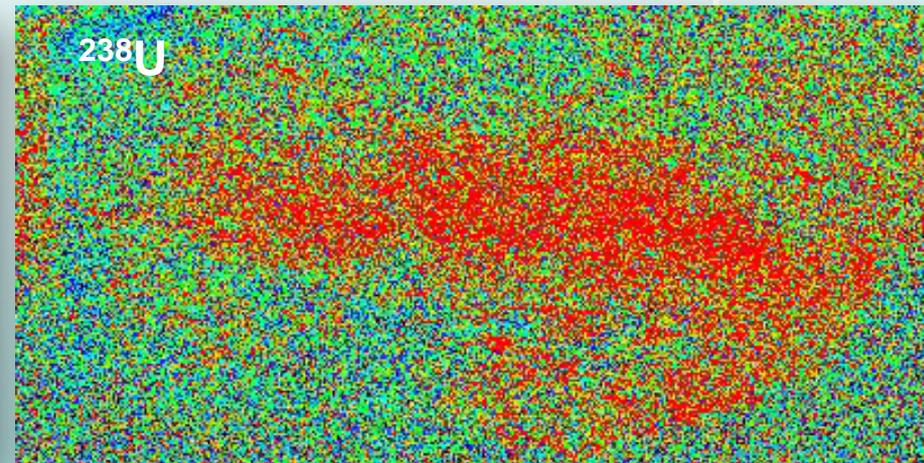
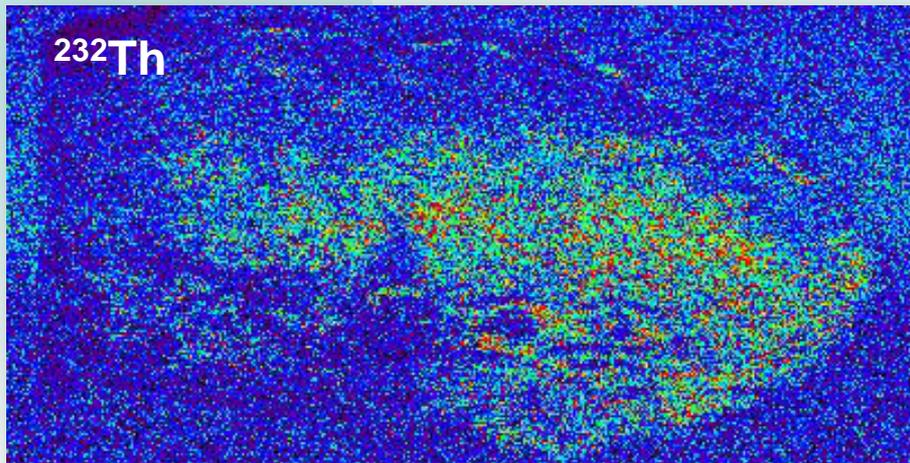
# Elemental Bio-Imaging (EBI)

- Imaging mass spectrometry using LA-ICP-MS
- Quantitative, isotope-specific determination and visualization of the spatial distribution of trace elements in thin tissue sections
- Technology transfer from analysis of geological samples

# Case 0846: Americium Exposure

- U.S. Radium Corp. – 1964-7 Chronic Inhalation –  $^{241}\text{AmO}_2$
- Chelated – Intravenous Injection of Ca-DTPA
- Died 2008 at age 72 – Atherosclerotic Heart Disease

[http://www.ustur.wsu.edu/Case\\_Studies/Narratives/0846\\_Narrative.php](http://www.ustur.wsu.edu/Case_Studies/Narratives/0846_Narrative.php)

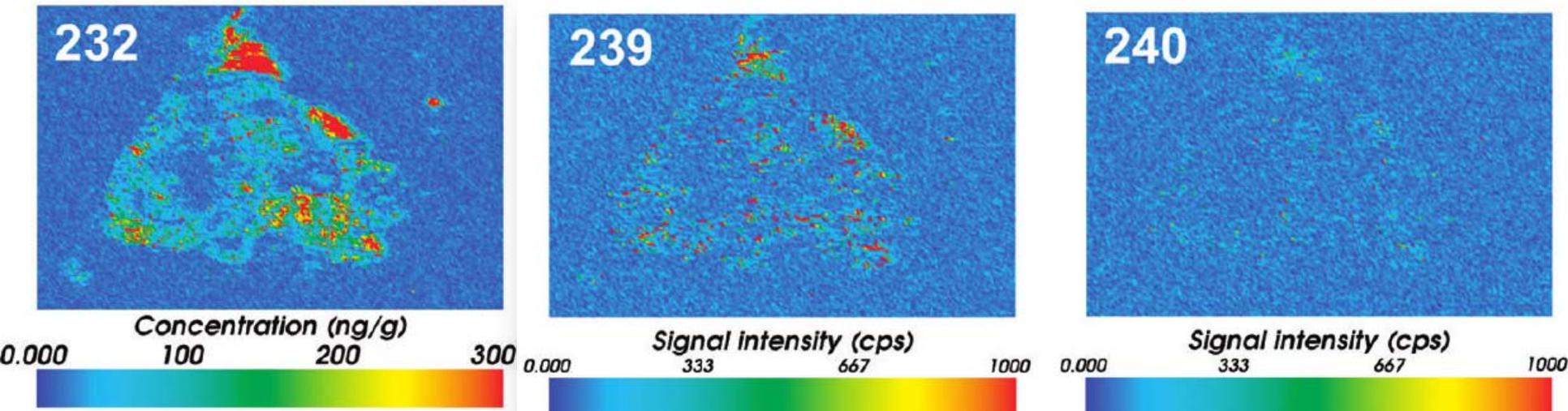


$^{232}\text{Th}$  and  $^{238}\text{U}$  concentration distributions in pulmonary lymph node from chronic environmental exposure

# Case 0407: Plutonium Exposure

- Rocky Flats – 1965 Acute (Fire) –  $^{239}\text{Pu}$  (refractory)
- Chelated – Intravenous Injection of Ca-DTPA
- Died 2008 at age 90+ – Atherosclerotic Heart Disease

[http://www.ustur.wsu.edu/Case\\_Studies/Narratives/0407\\_Narrative.php](http://www.ustur.wsu.edu/Case_Studies/Narratives/0407_Narrative.php)

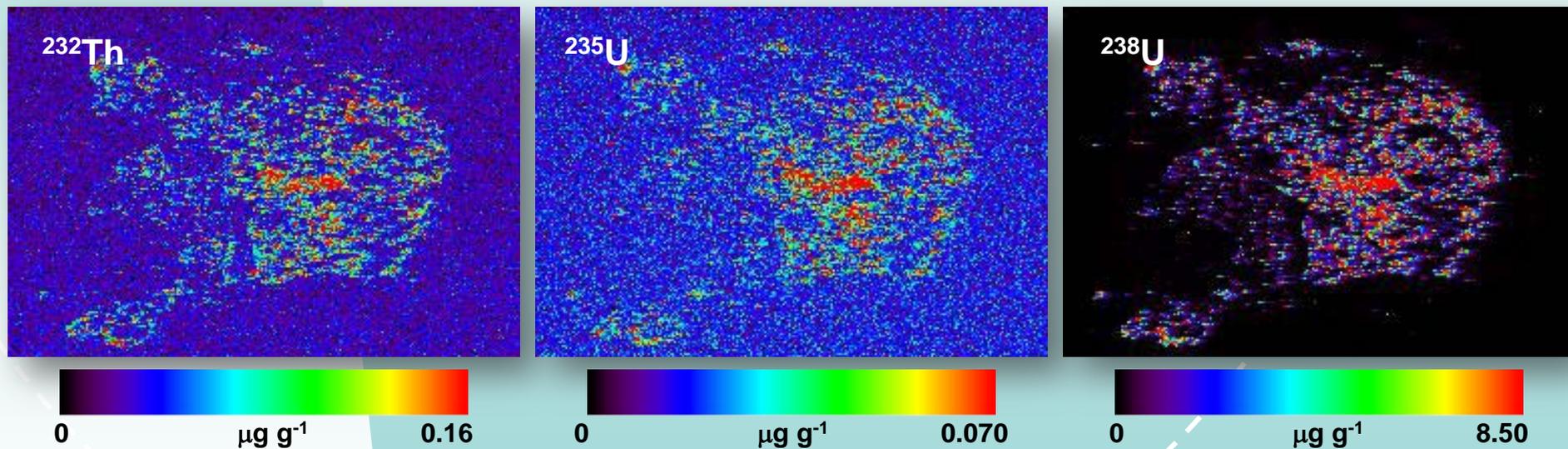


$^{232}\text{Th}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$  and  $^{240}\text{Pu}$  distributions in paratracheal lymph node from chronic natural background (Th, U) and occupational exposures (Pu)

# Case 1060: Uranium Exposure

- Hanford – late 1940s Chronic/Acute Inhalation –  $U_3O_8$  (likely fume)
- Urinary excretion – **316  $\mu\text{g}$  of U per day** (1<sup>st</sup> day after exposure)
- Died 2008 at age 83 – Cerebral Infarct

[http://www.ustur.wsu.edu/Case\\_Studies/Narratives/1060\\_Narrative.php](http://www.ustur.wsu.edu/Case_Studies/Narratives/1060_Narrative.php)



$^{232}\text{Th}$ ,  $^{235}\text{U}$  and  $^{238}\text{U}$  concentration distributions in parabranchial lymph node from occupational exposure (U)

# EBI : Summary

...new research in actinide spatial distribution studies and quantification in human tissues with application to internal dosimetry

## Elemental Bio-imaging of Thorium, Uranium, and Plutonium in Tissues from Occupationally Exposed Former Nuclear Workers

Dominic Hare,<sup>†</sup> Sergei Tolmachev,<sup>‡</sup> Anthony James,<sup>‡</sup> David Bishop,<sup>†</sup> Christine Austin,<sup>†</sup> Fred Fryer,<sup>§</sup> and Philip Doble<sup>\*\*†</sup>

*Elemental Bio-imaging Facility, University of Technology, Sydney, Broadway, New South Wales, Australia, United States Transuranium & Uranium Registries, College of Pharmacy, Washington State University, Richland, Washington, and Agilent Technologies Australia, North Ryde, New South Wales, Australia*

Internal exposure from naturally occurring radionuclides (including the inhaled long-lived actinides  $^{232}\text{Th}$  and  $^{238}\text{U}$ ) is a component of the ubiquitous background radiation dose (National Council on Radiation Protection and Measurements. *Ionizing radiation exposure of the population of the United States*; NCRP Report No. 160; NCRP: Bethesda, MD, 2009). It is of interest to compare the concentration distribution of these natural  $\alpha$ -emitters in the lungs and respiratory lymph nodes with those

sure) ranged up to 400 and 375 ng/g, respectively. In lung samples of occupationally nonexposed to thorium and uranium workers,  $^{232}\text{Th}$  and  $^{238}\text{U}$  concentrations ranged up to 200 and 170 ng/g, respectively. In a person occupationally exposed to air-oxidized uranium metal (Adley, F. E.; Gill, W. E.; Scott, R. H. *Study of atmospheric contamination in the melk plant building. HW-23352(Rev.)*; United States Atomic Energy Commission: Oakridge, TN, 1952, p 1–97), the maximum  $^{235}\text{U}$  and

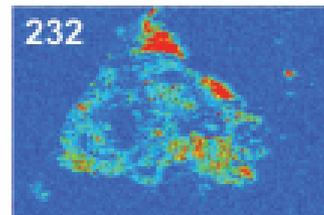
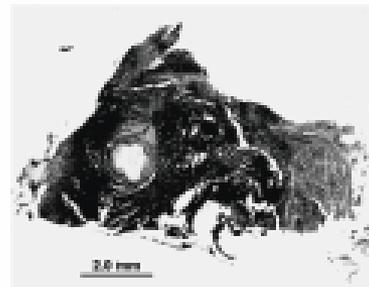


# EBI : Summary

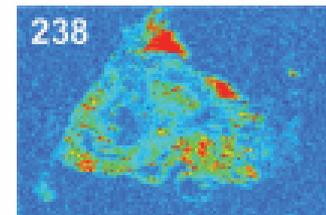
## RESEARCH PROFILE

### MS maps actinides in exposed workers

To understand and quantify human exposure to radioactive elements, scientists have traditionally faced a conundrum: methods that would allow them to visualize radioactive distribution within tissue have not allowed them to simultaneously pinpoint the identities and concentrations of the elements involved. An autoradiograph shows a visual distribution of alpha particle decay but does not reveal the identity of the element causing it. Radiochemical methods identify and quantify elements by dissolving the sample, but this eliminates information about the distribution of the elements.



Concentration (ng/g)  
0.000 100 200 300 400 500



Concentration (ng/g)  
0.0 44.7 133 200

first case, the worker had contact with insoluble Pu in a fire in 1965, and localized regions of a lymph node and lung tissue indicated mass peaks of 239 and 240 in relative concentrations that were consistent with weapons grade Pu. In another case, a worker had a skin wound that was contaminated with soluble

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**LEARNING FROM PLUTONIUM & URANIUM WORKERS**

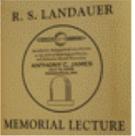
ISU/USTUR Graduate Student Auto-Segments Case 0102 Head Phantom  
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- » View Dr. James presentation to NIAID/NIH entitled "What We Should Learn from Lifetime Follow-up of U.S. Former Plutonium Workers".
- » Run streaming video presentation "USTUR: The Fifth Decade of Worker Follow-up"
- » USTUR director talks to Hanford Advisory Board (HAB) about plutonium toxicity
- » WSU/USTUR receives commendation from DOE's Chief Health Safety and Security Officer

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**USTUR Lab Manager Appointed Editor of JHPH**  
 Dr. Sergei Tolmachev has been appointed to serve on the Editorial Board for the Japanese Journal of Health Physics.  
  
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**Landauer Memorial Lecture**  
 USTUR Director receives honor of delivering the R.S. Landauer Sr. Memorial Lecture at the Health Physics Society's 54<sup>th</sup> Annual Meeting.  
  
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0102	0193	0205	0208
0212	0213	0242	0259 »
0262	0269 »	0303	0391
0407	0425 »	0456	0503
0635	0679 »	0680	0682 »
0706 »	0720 »	0740	0744
0745	0769	0834	0846
0990	1001	1002	1007
1010	1028	1053	1054
1060			

### Partial Body Donations

0001	0002	0003	0004
0005	0006	0007	0008
0009	0010	0011	0012
0013 »	0014	0015	0016
0017	0018	0019	0020
0021	0022	0023	0024 »
0025	0026	0027	0028

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 USTUR 0425: Radiochemistry. United States Transuranium and Uranium Registries. 10 November 2009. Washington State University: College of Pharmacy. Accessed 22 March 2010. Available at: [http://www.ustur.wsu.edu/Case\\_Studies/Radiochemistry/xls/0425\\_RadChem\\_Rev.2.xls](http://www.ustur.wsu.edu/Case_Studies/Radiochemistry/xls/0425_RadChem_Rev.2.xls)

This page was last updated on November 10, 2009. [usturwebmaster@tricity.wsu.edu](mailto:usturwebmaster@tricity.wsu.edu)

USTUR, Washington State University, 1845 Terminal Dr. Suite 201, Richland, WA 99354-4959 USA, 1-509-946-6870 or 1-800-375-9317

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# Radiochemistry Results: Summary

AP12																			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	
1	USTUR Case #0425 (WB)																		
2	Analized by:	α-spectrometry (1998, 2000)			Analyses performed:			<sup>239+240</sup> Pu,	<sup>238</sup> Pu,	<sup>241</sup> Am	Sample count time, s:		150,000		Background count time, s:		300,000		
3		ICP-MS (2007)																	
4																			
5																			
6	USTUR Sample #	Tissue description	Weight, g					Fraction, %		Tracer, dpm		Isotopic activity per sample, Bq						Tracer recovery, %	
7			Autopsy	Sample	Ash	Solution	Aliquot	Ash	Aliquot	<sup>242</sup> Pu	<sup>243</sup> Am	<sup>239+240</sup> Pu		<sup>238</sup> Pu		<sup>241</sup> Am		<sup>242</sup> Pu	<sup>243</sup> Am
8											Value	±SD	Value	±SD	Value	±SD			
9	425001	Lung R	1600.00	111.41	1.3	243.00	60.00	1.2%	24.7%	9.19	11.19	1.29E+01	3.35E-01	2.25E-01	1.10E-02	2.93E+00	6.17E-02	52.1%	79.5%
10	425002	LN Mediastinal Hilar	9.65	6.53	0.1	177.06	40.00	1.5%	22.6%	9.19		1.26E+01	2.66E-01	2.31E-01	9.28E-03				
11	425002	LN Mediastinal Hilar	9.65	6.53	0.1	177.06	40.00	1.5%	22.6%		11.19					2.81E+00	7.02E-02		56.1%
12	425002	LN Mediastinal Hilar	9.65	6.53	0.10	177.06	40.00	1.5%	22.6%	9.19	11.19	1.26E+01	2.66E-01	2.31E-01	9.28E-03	2.81E+00	7.02E-02	79.1%	56.1%
13	425003 (UTR)	Liver R	1600.00	187.32	2.2	227.02	50.00	1.2%	22.0%	9.19	11.19	1.59E+00	4.14E-02	3.06E-02	3.26E-03	1.66E-01	7.52E-03	71.1%	81.4%
14	425003 (GEL)	Liver R	1600.00	187.32	2.2	227.02		1.2%		2.00	2.00	1.61E+00	5.59E-02	2.72E-02	7.27E-03	1.89E-01	9.52E-03	98.0%	41.0%
15	425003 (NAU)	Liver R	1600.00	187.32	2.2	227.02		1.2%				1.69E+00	3.00E-02						
16	425003	Liver R	1600.00	187.32	2.20	227.02	50.00	1.2%	22.0%	9.19	11.19	1.63E+00	2.53E-02	2.89E-02	2.39E-03	1.77E-01	1.64E-02	98.0%	41.0%
17	425004	Bladder Gall	17.00	13.10	0.06	450.00	150.00	0.5%	33.3%	8.40	11.19	1.99E-03	5.64E-04	-6.88E-05	2.48E-04	7.91E-04	4.91E-04	58.9%	72.8%
18	425005	Thyroid	11.00	6.60	0.06	310.00	100.00	0.9%	32.3%	8.40	11.19	2.57E-03	5.55E-04	-1.68E-04	2.56E-04	-3.97E-04	5.49E-04	75.3%	49.3%
19	425006	Testis R	34.00	6.10	0.05	140.00	45.00	0.8%	32.1%	8.40	11.19	2.80E-03	6.20E-04	-2.55E-04	2.55E-04	1.55E-03	5.76E-04	67.7%	77.2%
20	425007	Spleen	170.00	40.70	0.47	280.54	90.00	1.2%	32.1%	8.40	11.19	2.34E-01	5.00E-03	4.93E-03	6.88E-04	4.78E-02	3.32E-03	63.4%	83.9%
21	425008	Aortic Arch	71.00	59.80	1.66	260.00	80.00	2.9%	30.8%	8.40	11.19	6.62E-02	2.17E-03	1.47E-03	3.35E-04	1.59E-02	1.45E-03	71.6%	77.5%
22	425009	Kidney R	120.00	80.10	0.73	450.00	150.00	0.9%	33.3%		11.19					8.10E-03	1.22E-03		59.3%
23	425009	Kidney R	120.00	80.10	0.73	450.00	150.00	0.9%	33.3%	8.40		1.40E-02	1.55E-03	4.86E-04	2.81E-04				51.1%
24	425009	Kidney R	120.00	80.10	0.73	450.00	150.00	0.9%	33.3%	8.40	11.19	1.40E-02	9.23E-04	4.86E-04	2.81E-04	8.10E-03	1.22E-03	51.1%	59.3%
25	425010	Brain	1350.00	151.00	2.08	1000.00	150.00	1.4%	15.0%	8.40		7.58E-03	1.45E-03	2.99E-19	3.15E-04				71.9%
26	425010	Brain	1350.00	151.00	2.08	1000.00	50.00	1.4%	5.0%		11.19					-6.63E-04	3.56E-03		43.1%
27	425010	Brain	1350.00	151.00	2.08	1000.00	100.00	1.4%	10.0%	8.40	11.19	7.58E-03	1.45E-03	2.99E-19	3.15E-04	-6.63E-04	3.56E-03	71.9%	43.1%
28	425011	Larynx	72.00	74.20	3.82	250.43	80.00	5.1%	31.9%	8.40	11.19	7.18E-02	5.95E-03	6.37E-19	1.92E-03	2.50E-02	1.65E-03	10.4%	87.6%
29	425011	Larynx	72.00	74.20	3.82	250.43	60.00	5.1%	24.0%	8.40		7.16E-02	6.17E-03	7.02E-04	1.22E-03				24.7%
30	425011	Larynx	72.00	74.20	3.82	250.43	40.00	5.1%	16.0%	8.40		6.40E-02	3.87E-03	2.48E-03	8.00E-04				79.3%
31	425011	Larynx	72.00	74.20	3.82	250.43	60.00	5.1%	24.0%	8.40	11.19	6.91E-02	3.13E-03	1.59E-03	7.28E-04	2.50E-02	1.65E-03	38.1%	87.6%
32	425012	Trachea	36.00	29.30	0.58	401.00	130.00	2.0%	32.4%	8.40	11.19	2.35E+00	4.03E-02	4.24E-02	2.20E-03	5.10E-01	1.14E-02	80.9%	64.2%
33	425013	Esophagus	62.00	48.50	0.32	325.00	100.00	0.7%	30.8%	8.40	11.19	1.07E+00	2.30E-02	2.28E-02	1.91E-03	2.32E-01	6.47E-03	60.8%	70.9%
34	425015	Heart	550.00	108.60	0.92	774.99	180.00	0.8%	23.2%	8.40	11.19	7.16E-03	1.46E-03	9.46E-04	8.00E-04	1.44E-03	8.57E-04	43.0%	60.6%
35	425016	Musc Thigh Front R	28.00	24.60	0.21	160.00	50.00	0.9%	31.3%	8.40	11.19	1.13E-03	3.86E-04	-5.40E-05	3.00E-04	1.14E-03	7.04E-04	80.5%	59.1%
36	425017	Bladder Urinary	65.00	46.00	0.24	200.99	60.00	0.5%	29.9%	8.40		2.39E-03	5.89E-04	-3.22E-04	1.44E-04				70.7%
37	425017	Bladder Urinary	65.00	46.00	0.24	200.99	30.00	0.5%	14.9%		11.19					3.77E-03	1.19E-03		81.8%
38	425017	Bladder Urinary	65.00	46.00	0.24	200.99	45.00	0.5%	22.4%	8.40	11.19	2.39E-03	5.89E-04	-3.22E-04	1.44E-04	3.77E-03	1.19E-03	70.7%	81.8%
39	425019	Stomach	145.00	101.10	0.49	350.00	100.00	0.5%	28.6%	8.40	11.19	1.27E-02	8.64E-04	3.89E-04	2.55E-04	3.66E-03	7.99E-04	85.3%	82.4%
40	425020	Intestine Small	775.00	114.80	0.69	425.02	125.00	0.6%	29.4%	8.40	11.19	5.65E-03	8.08E-04	1.16E-03	4.19E-04	3.38E-03	9.05E-04	85.1%	57.4%
41	425021	Intestine Large	1050.00	153.30	0.75	525.01	150.00	0.5%	28.6%		11.19					3.42E-03	8.18E-04		79.1%
42	425021	Intestine Large	1050.00	153.30	0.75	525.01	50.00	0.5%	9.5%	8.40		9.14E-03	2.49E-03	1.18E-03	1.67E-03	0.00E+00	0.00E+00	48.6%	
43	425021	Intestine Large	1050.00	153.30	0.75	525.01	100.00	0.5%	19.0%	8.40	11.19	9.14E-03	2.49E-03	1.18E-03	1.67E-03	3.42E-03	8.18E-04	48.6%	79.1%
44	425022	Testis Epididymus R	8.50	7.70	0.06	389.99	120.00	0.8%	30.8%	8.40	11.19	1.44E-03	4.21E-04	5.77E-05	1.29E-04	1.02E-03	6.33E-04	77.8%	71.8%
45	425023	Prostate	110.00	59.40	0.4	425.00	125.00	0.7%	29.4%	8.40	11.19	7.77E-03	1.05E-03	1.00E-03	4.79E-04	4.66E-03	9.25E-04	70.3%	73.4%
46	425026	Skel Femur PE	0.00	229.88	63.1	619.85	80.00	27.4%	12.9%		11.19					2.65E-01	1.35E-02		67.0%
47	425026	Skel Femur PE	0.00	229.88	63.1	619.85	100.00	27.4%	12.9%		11.19								76.4%

[http://www.ustur.wsu.edu/Case\\_Studies/Radiochemistry/xls/0425\\_RadChem\\_Rev.2.xls](http://www.ustur.wsu.edu/Case_Studies/Radiochemistry/xls/0425_RadChem_Rev.2.xls)



# Radiochemistry Results: Summary

	D	E	F	G	H	I	J	K	L	M	N	O	P
1	USTUR Case 0425 - Derived Whole Body Pu/Am Contents												
2					Age, y:	83							
3		Body Weight, kg:	74.9		DOD:	1994							
4		Body Height, cm:	168		Autopsy:	1994							
5		IC89 Predicted Skeletal Weight, kg:	9.2		Radiochemistry:	1998, 2000							
6													
7													
8													
9													
10													
11													
12													
13													
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Conference Contributions

Seminar/Symposium Presentations »

**2009**

- » Asia-Pacific Symposium on Radiochemistry, Napa, CA, November 29 - December 4, 2009.
- » Fall 2009 Beryllium Health and Safety Committee Meeting, Las Vegas, NV, November 3-5, 2009.
- » 54<sup>th</sup> Annual Meeting of the Health Physics Society, Minneapolis, MN, July 12-16.

**2008**

- » Third International Symposium on Beryllium Particulates and Their Detection, Albuquerque, New Mexico, November 17-19, 2008.
- » IRPA 12: 12<sup>th</sup> International Congress of the International Radiation Protection Association, Buenos Aires, Argentina, October 19-24, 2008.
- » Council on Ionizing Radiation Measurements and Standards (CIRMS) Annual Meeting, Gaithersburg, MD, October 6-8, 2008.
- » Second Annual College of Pharmacy Research Day, Pullman, Washington, August 20, 2008.
- » 53<sup>rd</sup> Annual Meeting of the Health Physics Society, Pittsburgh, PA, July 13-17, 2008.
- » JHPS 42: 42<sup>nd</sup> Annual Meeting of the Health Physics Society of Japan, Okinawa, JP, June 26-27, 2008.
- » Winter Conference on Plasma Spectrochemistry for Trace Element, Stable Isotope, and Elemental Speciation Analysis, Temecula, California, January 7-12, 2008.

**2007**

- » Radiobioassay & Radiochemical Measurements Conference (RRMC), Jackson Hole, Wyoming, October 29 - November 2, 2007.
- » 52<sup>nd</sup> Annual Health Physics Society Meeting, Portland, Oregon, July 8-12, 2007.

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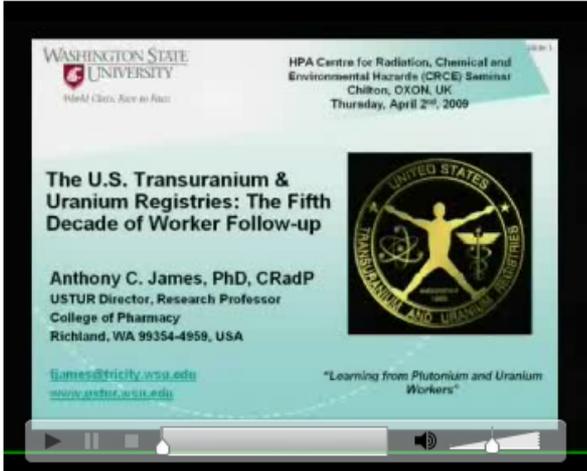
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## The U.S. Transuranium & Uranium Registries: The Fifth Decade of Worker Follow-up



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HPA Centre for Radiation, Chemical and Environmental Hazards (CRCE) Seminar  
Chilton, OXON, UK  
Thursday, April 2<sup>nd</sup>, 2009

**The U.S. Transuranium & Uranium Registries: The Fifth Decade of Worker Follow-up**

Anthony C. James, PhD, CRadP  
USTUR Director, Research Professor  
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"Learning from Plutonium and Uranium Workers"

This page was last updated on July 30, 2009. [usturwebmaster@tricity.wsu.edu](mailto:usturwebmaster@tricity.wsu.edu)



# USTUR Contributions



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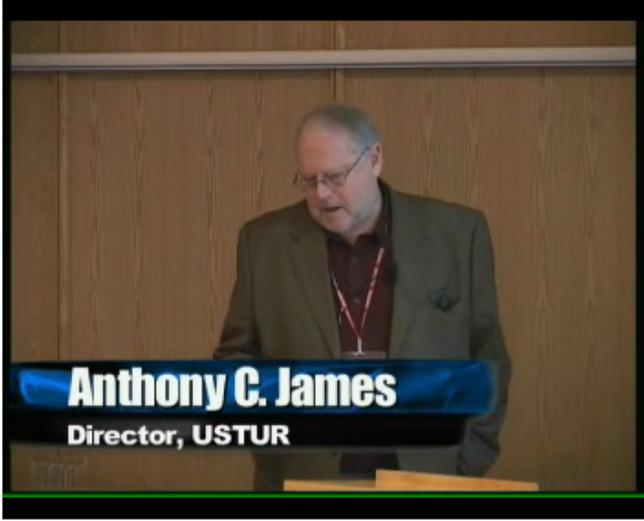
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## The U.S. Transuranium & Uranium Registries: The Fifth Decade of Worker Follow-up



Anthony C. James

Director, USTUR

This page was last updated on July 30, 2009. [usturwebmaster@tricity.wsu.edu](mailto:usturwebmaster@tricity.wsu.edu)

# National Human Radiobiological Tissue Repository

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## The National Human Radiobiological Tissue Repository

### Resources for Radiation Dosimetry and Biological Research



**The National Human Radiobiological Tissue Repository**

The NHRTR is one component of the United States Transuranium and Uranium Registries (USTUR). It contains frozen solutions, microscope slides, blocks that were collected at the autopsy of workers with high intakes of plutonium, americium, and thorium.

**The NHRTR is a Gr...**

The samples in the NHRTR are handled by qualified scientists who are conducting studies of low-dose studies of micro-distribution of elements, or studies of molecular changes.

**The NHRTR archives thousands of solutions containing acid dissolved tissues from each USTUR case. These solutions are available to qualified scientists for further research.**

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## Radium Studies

### Radium Dial Painters

The radium dial painting industry began in the United States in the early 1900's when it was found that objects painted with radioluminous material were visible in the dark. Several dial painting plants were established to capitalize on this discovery, including the U.S. Radium Corporation in Orange, New Jersey (initially located in Newark, New Jersey) and the Radium Dial Company in Ottawa, Illinois (previously located in Chicago and Peru, Illinois). These plants employed several hundred women to paint watch dials and military instruments with radium paint. Many of these women ingested Ra-226 and Ra-228 (mesothorium) as they 'tipped' brushes between their lips to obtain a finer point.<sup>(1)</sup>



**Radium Dial Painters.** (photo from Stannard, J. N. *Radioactivity and Health: A History.*)

A New York dentist, Theodore Blum, was one of the first to note the biological effects of radium when he observed what he termed "radium jaw" in a woman who had worked at a New Jersey dial painting plant. Such early cases exhibited "acute necrosis of the jaw, usually involving infection and severe leukopenia and anemia."<sup>(2)</sup> Within a few years osteogenic sarcomas began to appear. The practice of tipping brushes was prohibited in the late 1920s.

### Medical Exposures

In addition to those occupationally exposed in the dial painting industry, numerous people ingested radium or received injections for therapeutic purposes. Physicians prescribed radium to treat a variety of ailments such as acne, arthritis, and high blood pressure. Individuals also self-medicated themselves using publicly available "remedies" such as the radium spiked water, Radithor, which was certified to contain 1  $\mu\text{Ci}$  of  $^{226}\text{Ra}$  and 1  $\mu\text{Ci}$  of  $^{228}\text{Ra}$ .<sup>(2)</sup>



### Radium Research

Several radium research programs were initiated to study the effects of radium in

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S. Tolmachev : April 6, 2010; KEEA, Fukuoka, Japan



# National Radiobiology Archives

## Animal Tissue Archives :

- Argonne National Laboratory
- Brookhaven National Laboratory
- Colorado State University
- Pacific Northwest National Laboratory
- Lawrence Berkeley Laboratory
- Oak Ridge National Laboratory
- University of Utah

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## National Radiobiology Archives

by Charles R. Watson

### Introduction

The U.S. National Radiobiology Archives (NRA) is an archival program that was started in 1989 to collect, organize, and catalog data, laboratory notebooks, and animal tissue specimens from government (i.e. DOE and its predecessor agencies) sponsored radiobiology life-span studies performed at various National Laboratories and universities since the 1940's. These archived records and specimens that are stored and maintained in a centralized facility and are available for additional future research or analyses.



The NRA houses paraffin embedded tissue blocks, histopathology slides, and clinical notes for various animal life-span studies performed at National Laboratories and universities.

The NRA is part of a greater international program that includes the European Radiobiology Archives (ERA) and the Japanese Radiobiology Archives (JRA)<sup>1</sup>. Dr. Chuck Watson (NRA Database Consultant) served as the U.S. representative on the ERA Advisory Board. The board is overseeing the development of an internet version of the ERA to be called ERA-PRO. This activity is funded by European Community and managed by the German Federal Office for Radiation Protection.

[ERA Advisory Board »](#)  
[ERA-PRO »](#)

### Radiobiological Studies

#### Rodent and Nonhuman Primate Studies

Results from some 30,000 mice from studies comparing various strains have been transferred from Oak Ridge National Laboratory and Brookhaven National Laboratory. In addition, records, data, and many microscope slides from life-span studies on some 4,000 rats that were used for plutonium inhalation studies at Pacific Northwest National Laboratory and biokinetic and pathological data from experiments on more than 300 nonhuman primates have been added to the archive collection.

#### Life-Span Studies Using Beagle Dogs

The major thrust of the early studies was to determine the level, rate, and extent of the radiological and toxicological effects induced by ingested or inhaled radionuclides, including plutonium and other transuranics. Over several decades, a variety of life-span studies using

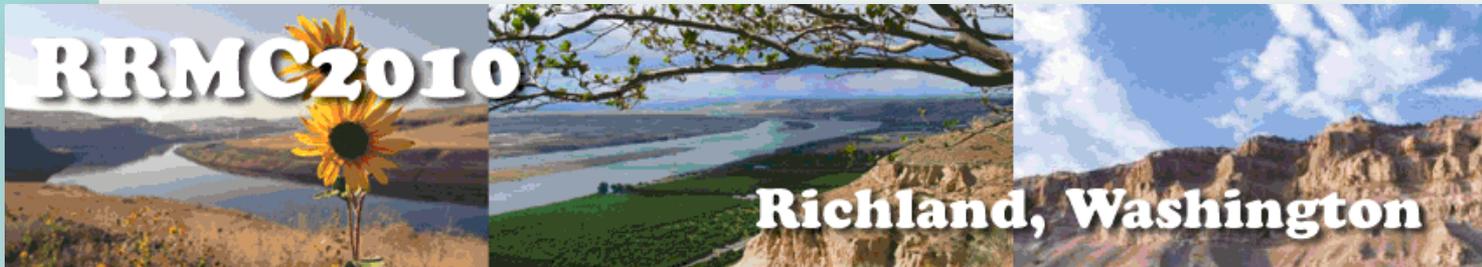


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**Thank you for your attention!**



# See you in Richland: Oct 25 – 29, 2010



## 56th Annual Radiobioassay & Radiochemical Measurement Conference

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### Objectives

In 1955, the First Annual Bioassay and Analytical Chemistry Conference drafted five objectives: (1) To bring everyone up-to-date on some of the latest developments in the field of bioassay (as well as analytical and environmental radiochemistry); (2) to enable all persons actively engaged in the field of bioassay, analytical (and environmental) radiochemistry to discuss mutual problems; (3) to standardize some of the procedures commonly used by the various laboratories; (4) to enable each laboratory to become familiar with procedures used elsewhere; and, (5) to plan for the future. When those objectives were drafted, the relatively new and exciting field of radiochemistry and radiobioassay was only emerging. Fifty-four years later, the objectives remain constant. The applications may have changed and the perspective of the goal has moderated, but the fervor and passion remain, as can be seen during the defense and discussion of any presentation.

The ideas, active research, and proposals presented here are unique. The Conference provides a forum for discussion. Many distinctive studies involving radiochemistry are first described during these sessions. The Conference also provides a fertile environment in which to conduct workshops and committee meetings. In all areas the participants are encouraged to become involved in exploring and expanding those concepts, ideas, and hypotheses; and in so doing, to challenge the average in the development of solutions to the technical barriers of the past.

The results of the Conferences are obvious. After fifty-four years we are still here and the original objectives remain as significant and vital as in 1955. The fundamental benefits for the participants are the application of the concepts and ideas learned and directly applied in their own work.