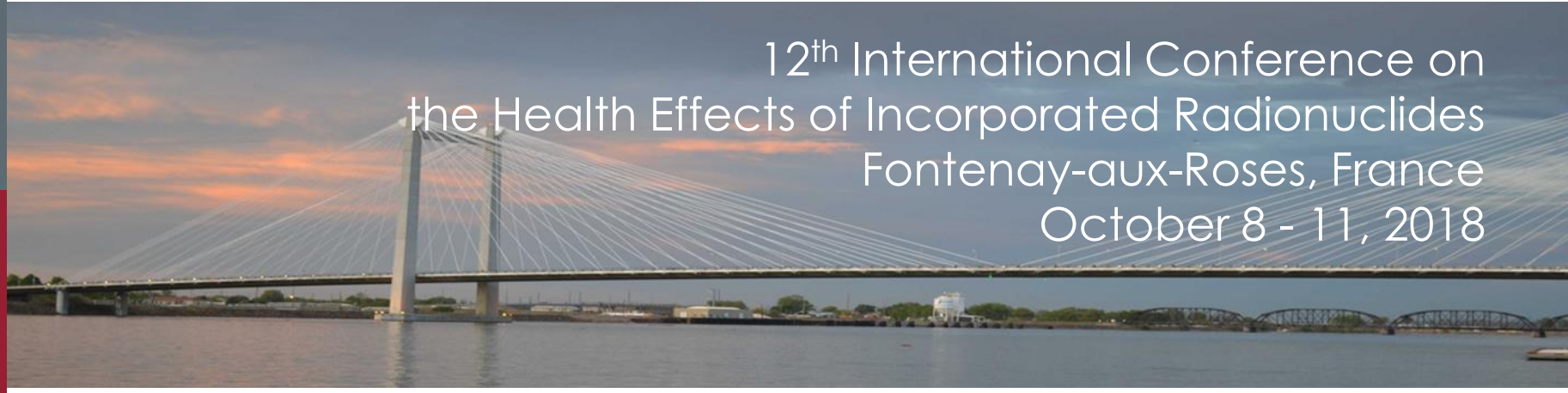


12th International Conference on
the Health Effects of Incorporated Radionuclides
Fontenay-aux-Roses, France
October 8 - 11, 2018

Biokinetics of Soluble Plutonium after Wound Injury Treated with Ca-DTPA

Maia Avtandilashvili, Sergei Y.Tolmachev

US Transuranium and Uranium Registries
College of Pharmacy and Pharmaceutical Sciences,
Washington State University, Richland, WA, USA
www.ustur.wsu.edu

"Learning from Plutonium and Uranium Workers"

US Transuranium and Uranium Registries

- 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)

Oct 9, 13:50 pm

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

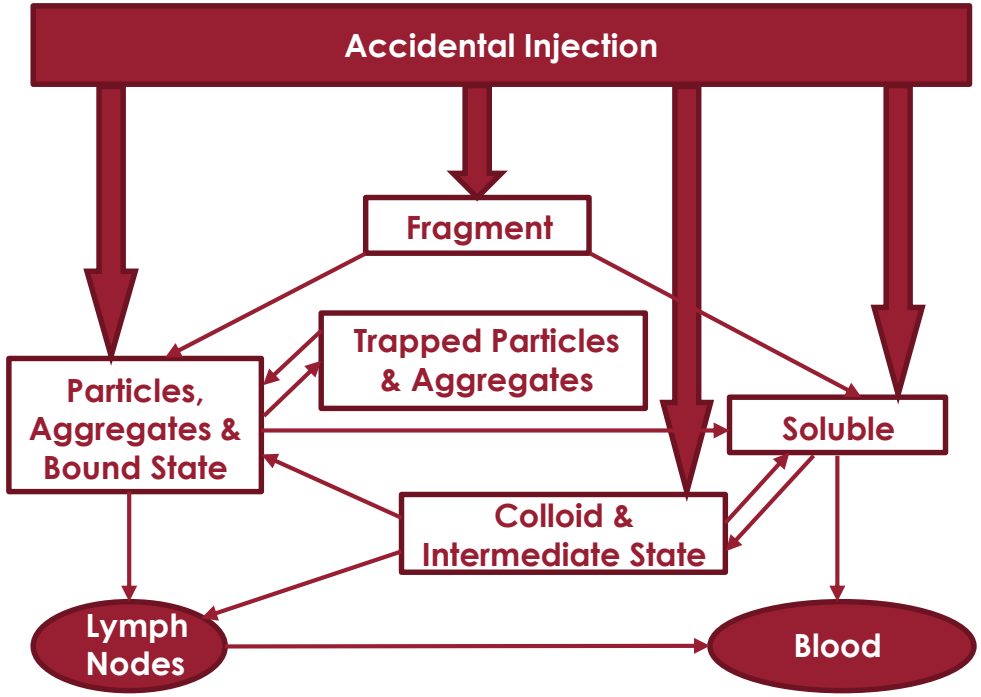
Motivation

- >2,000 contaminated wounds reported

  Commonly treated by tissue excision and chelation

- NCRP 156 Wound Model (2007)

  Based exclusively on animal experiments



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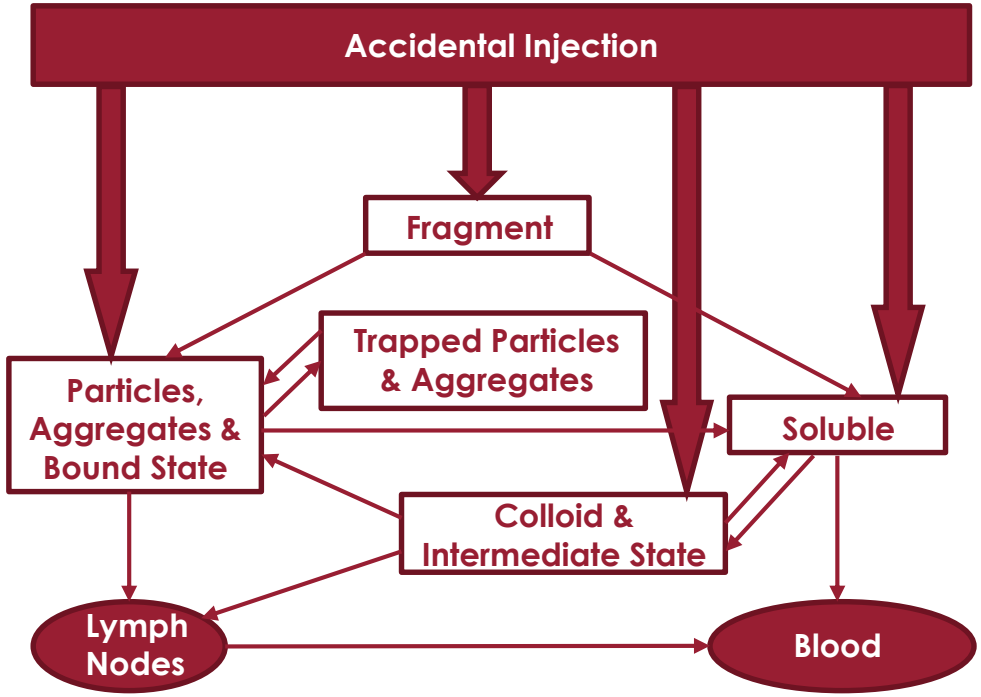
Soluble material:
- Weak
- Moderate
- Strong
- Avid



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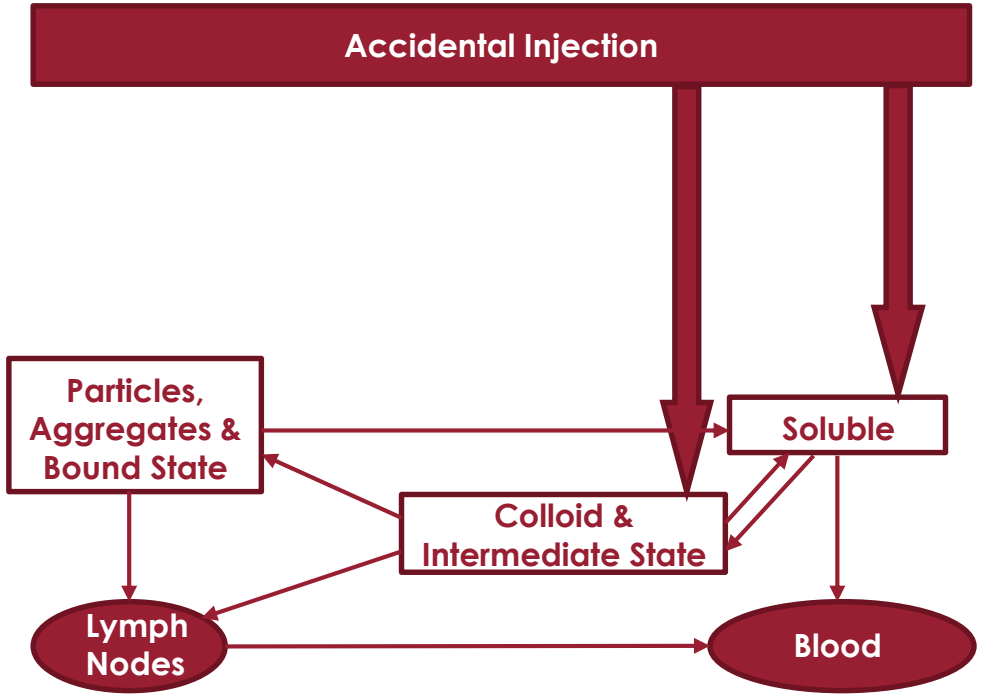
Colloid



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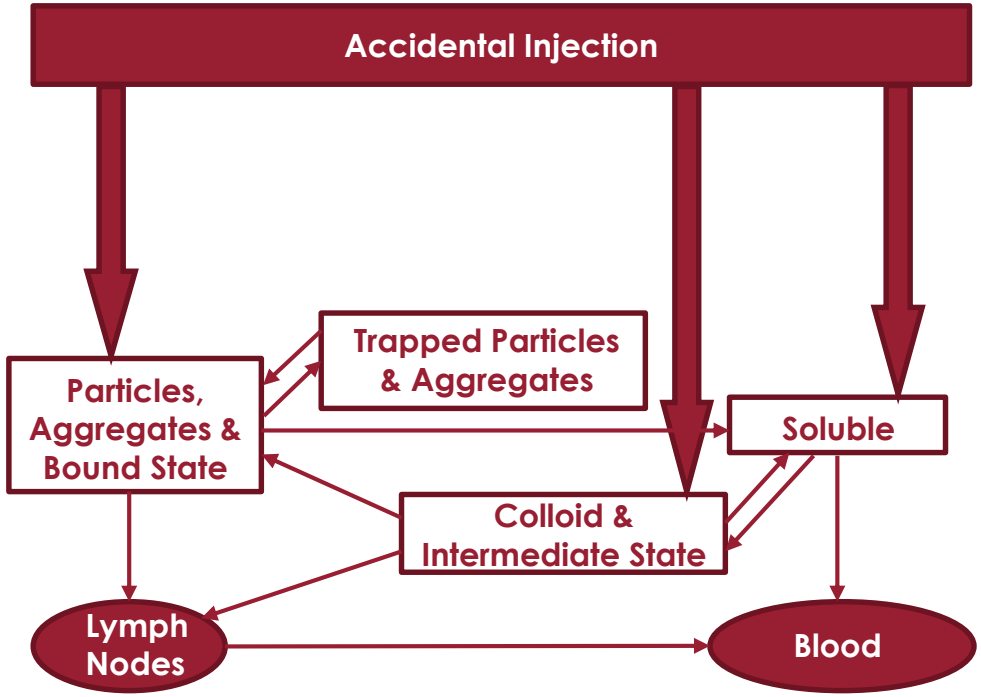
Particle



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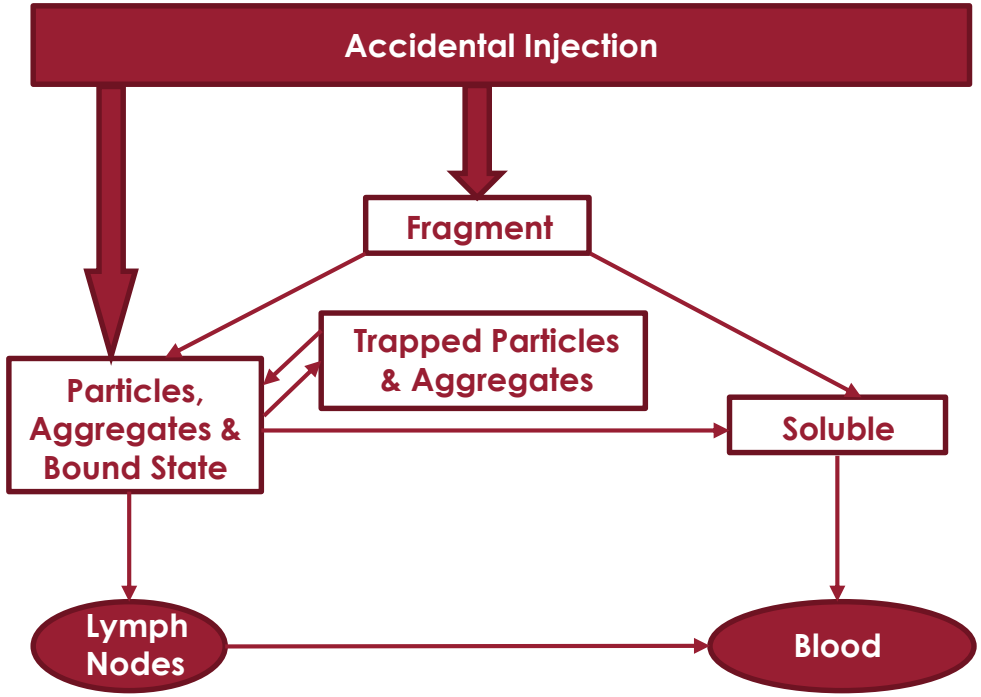
Fragment



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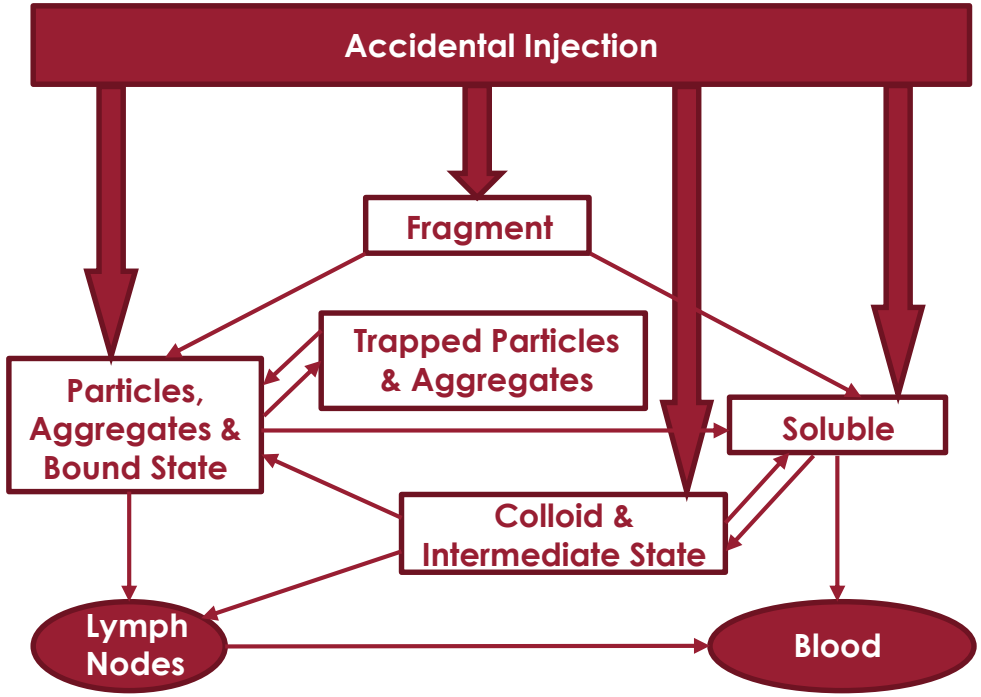


USTUR Data

- 19 cases with ^{239}Pu wound(s) as major intake route

  8 whole-body, 11 partial-body
- Chelation treatment administered: 5
- Follow-up bioassay

  Urine analyses, wound counts
- Post-mortem tissue analyses

  Liver, skeleton, wound

USTUR Whole-body Donor

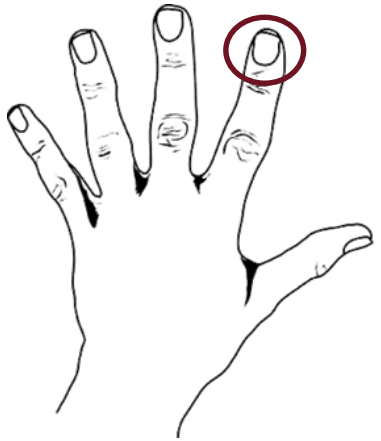
- Worked with actinides for 30 years
- ^{239}Pu intake due to contaminated wound
- Treated with Ca-DTPA
- No other significant internal contamination
- Died 40 years post intake at age 87

Accident

- Working in glove box on Pu separation
- Punctured finger on contaminated equipment
- Chemical form reported: $Pu(NO_3)_4$
- Hood glove contaminated to > 40,000 dpm
- Initial survey meter reading on finger: 20,000 dpm

  Decontaminated to ~5,000 dpm
- Estimated initial ^{239}Pu activity in wound: ~4.1 kBq

Treatment

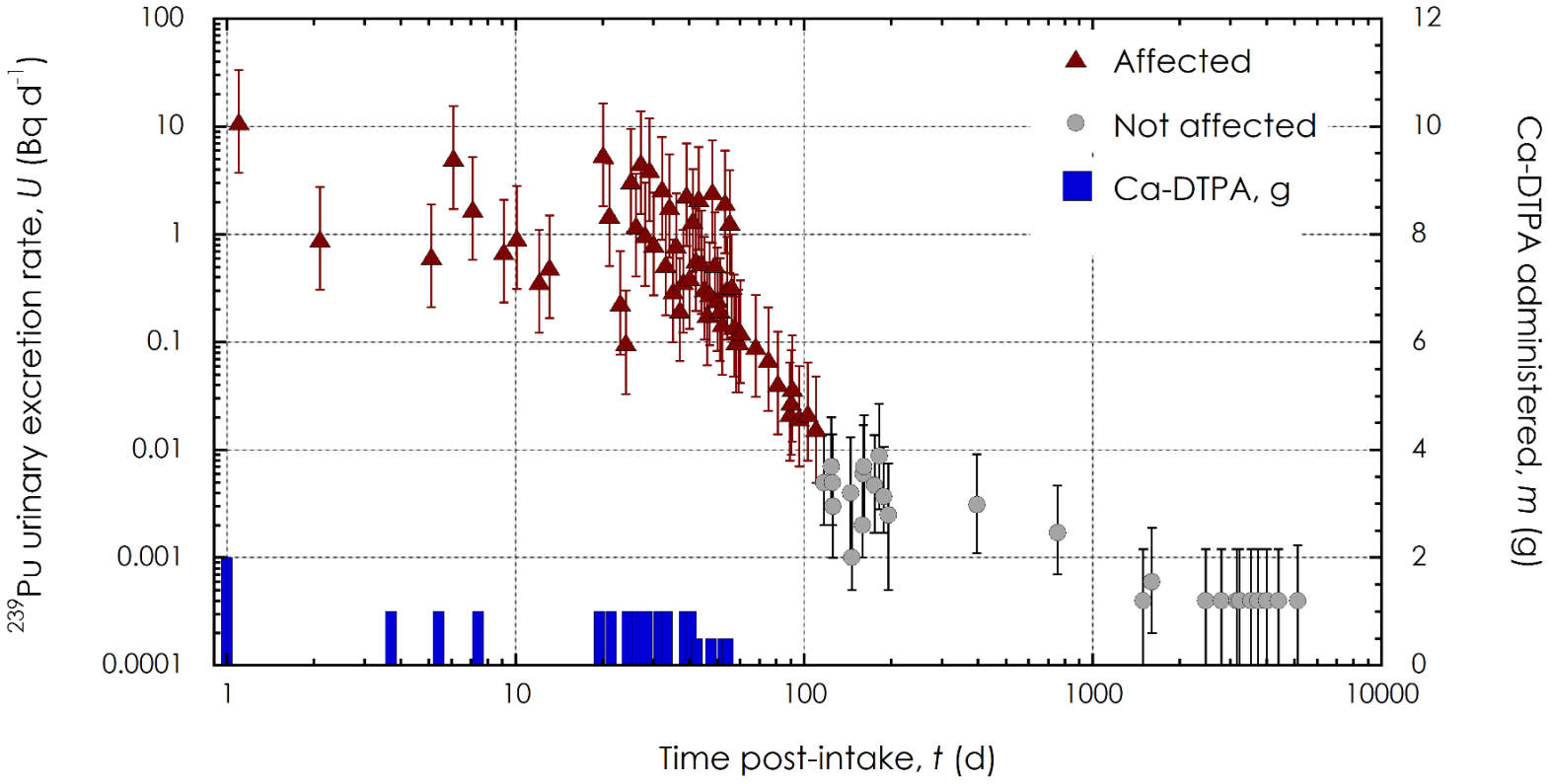


- Contaminated tissue excised twice
  - A total of 2.3 kBq removed
  - 59 Bq measured in wound a month later

- Chelation therapy with Ca-DTPA
  - Twice a week over two months
  - A total of 16 g Ca-DTPA in 18 i.v. injections

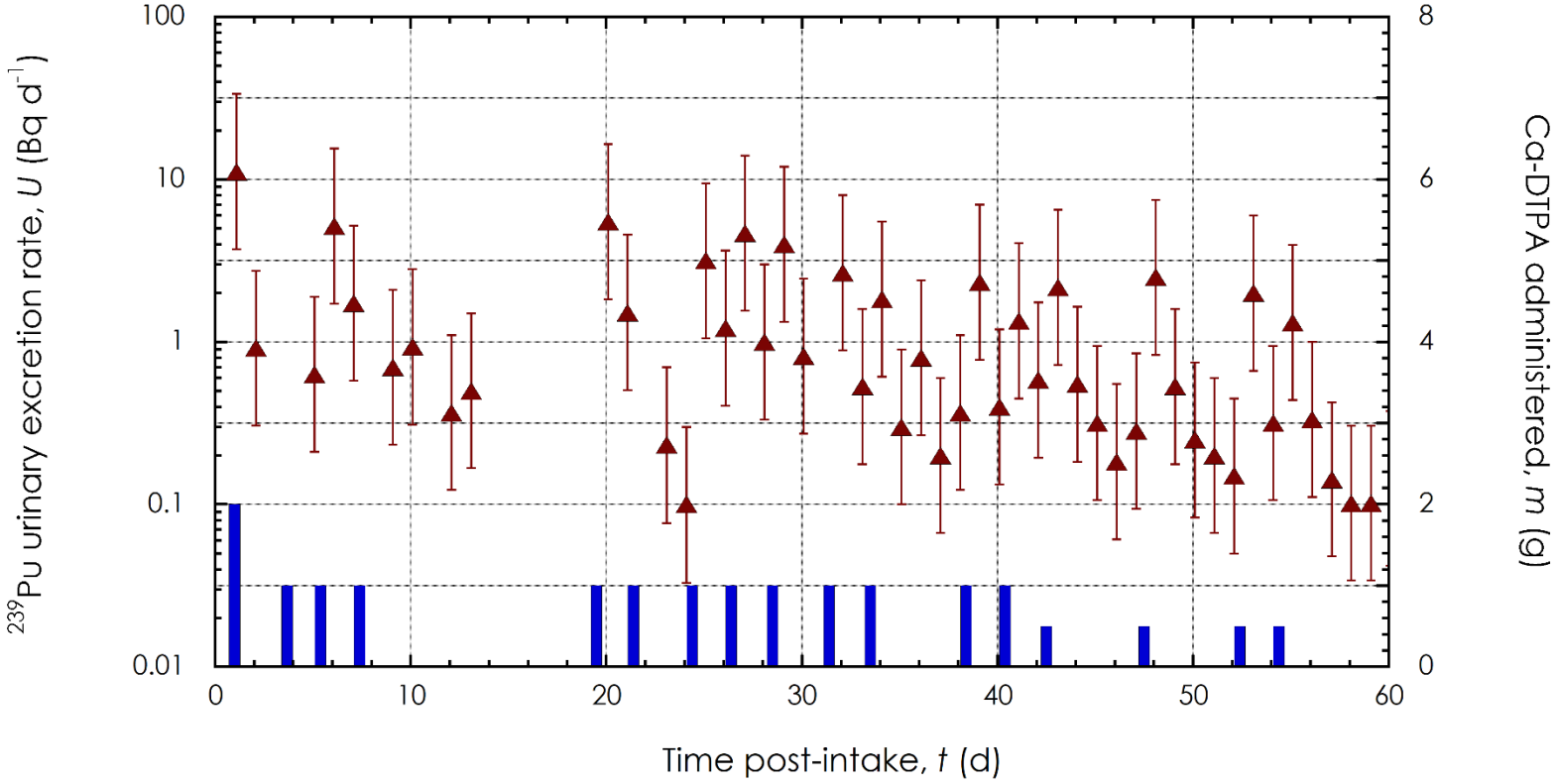
Urinalysis Data

- Analysis method: Autoradiography
- MDA: ~0.8 mBq
- Valid urine measurements: 83



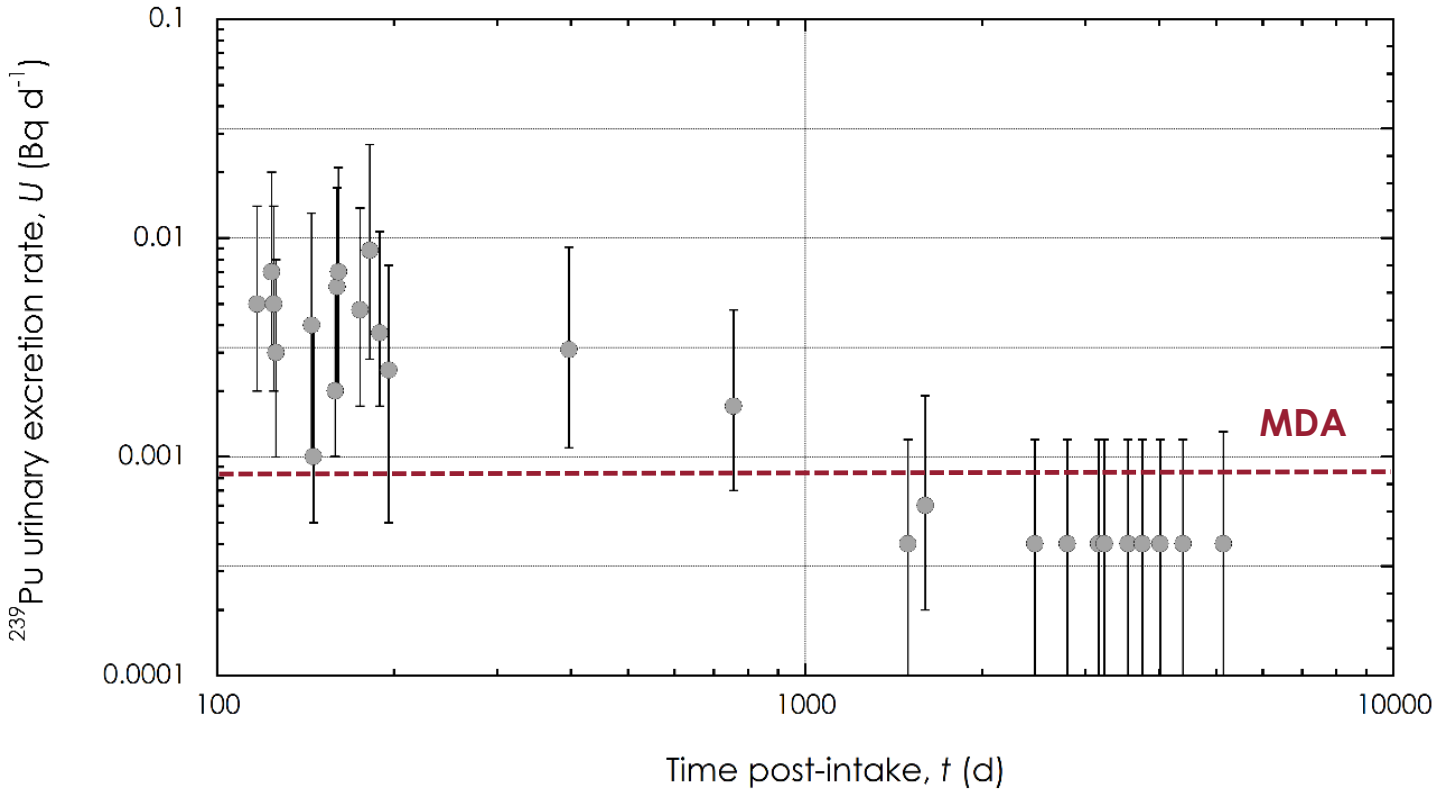
Urinalysis Data

- Measurements affected by DTPA: 57
- Max excretion rate: 11.2 Bq d^{-1} on day 1
- Pu activity in urine during treatment: ~~70.5 Bq~~ 77.8 Bq



Urinalysis Data

- Urine measurements not affected by DTPA: 26
- Average excretion rate: 3.0 ± 2.5 mBq d^{-1}
- < MDA after 1,000 days post-intake



Post-mortem Tissue Analysis

Tissue	Concentration, Bq kg^{-1}	Activity, Bq
Wound		
Right 2nd finger	n/a	1.35 ± 0.03
Right axillary LN	0.39 ± 0.14	0.0018 ± 0.0006
Skeleton (*7 samples*)	1.58 ± 0.06	17.5 ± 0.7
Liver	8.5 ± 0.2	12.2 ± 0.3
Lungs	0.088 ± 0.004	0.136 ± 0.007
Thoracic LN	0.18 ± 0.07	0.006 ± 0.002
Other soft tissues		
Kidneys	0.15 ± 0.01	0.041 ± 0.003
Heart	0.20 ± 0.01	0.23 ± 0.01
Brain	0.094 ± 0.005	0.112 ± 0.007

Observations

- Concentration in axillary lymph nodes comparable with other soft tissues

  Consistent with intake of soluble material

- Lungs to liver activity ratio << 1

  No significant inhalation intake

- Liver to skeleton activity ratio: 1 : 1.4

  Consistent with Leggett et al. Pu systemic model

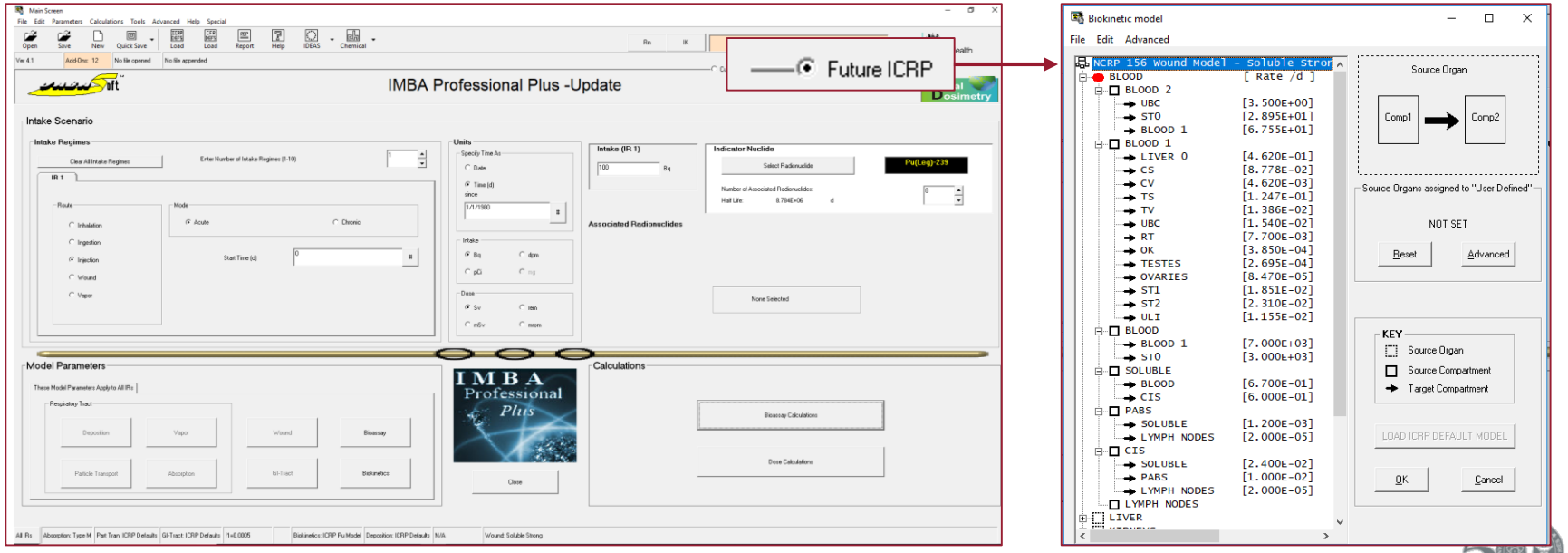
Methods

- Internal Dosimetry Software IMBA Professional Plus®
  Special academic edition

  Allows to build and solve the systemic models

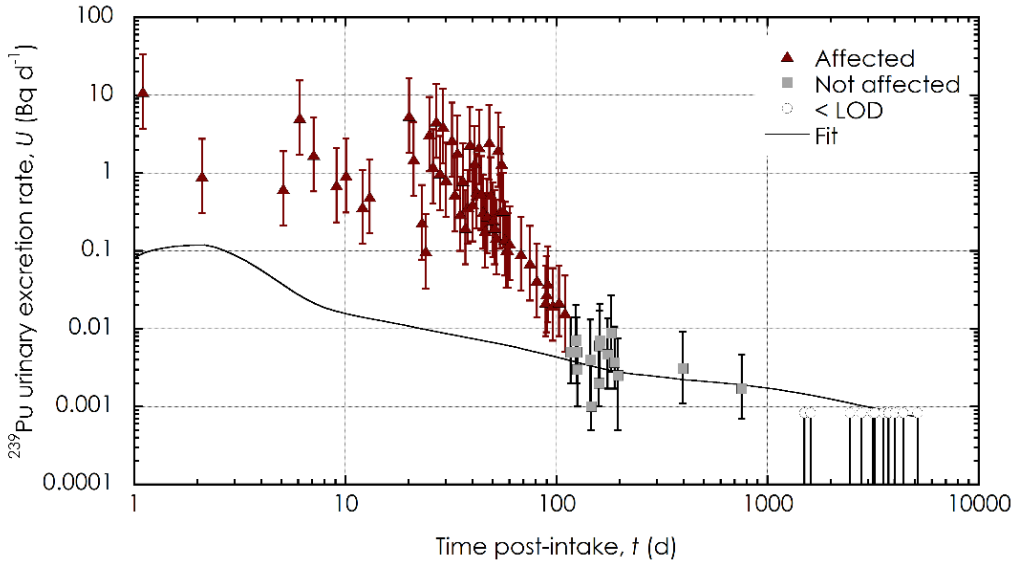
- Models applied:
  Leggett et al. (2005) Pu Systemic Model

  NCRP Wound Model: Strongly retained soluble material



Results: Fit and Predictions

- Maximum likelihood fit of 'baseline' urine data
- χ^2 alpha > 0.05



Pu Retention at Time of Death, Bq		
Organ	*Predicted*	*Measured*
Liver	10.9	12.2
Skeleton	15.4	17.5
Wound	0	1.4

Bound Pu in wound ??

Results: Intake and Dose

- Intake

  IMBA estimate: 47.6 Bq

  Pu excreted with DTPA: 77.8 Bq

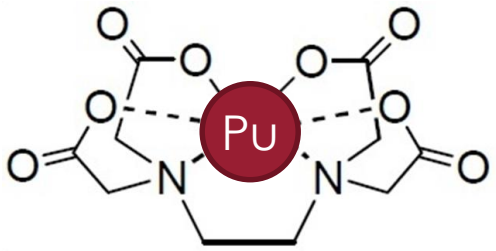
  \+ } 125 Bq

- Committed effective dose

  Residual: 24.1 mSv

  vs.

  Projected: 63.3 mSv



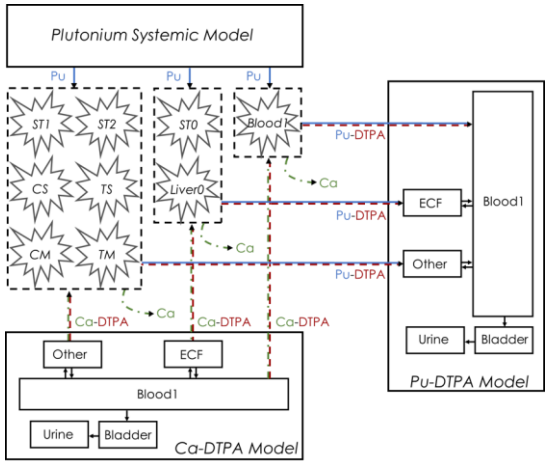
Conclusions

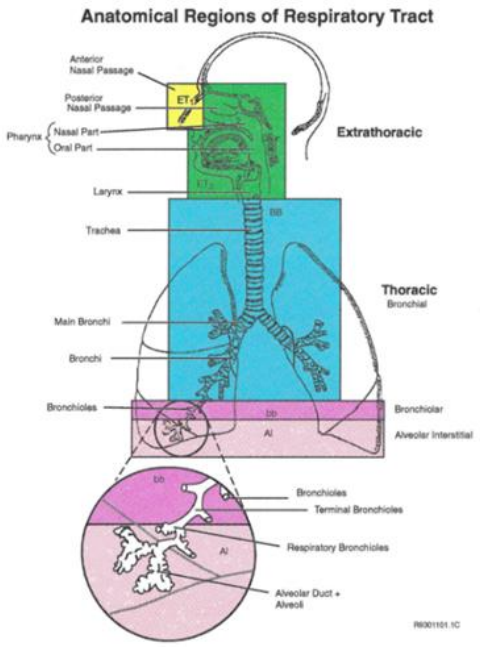
- Data from USTUR whole-body donor used to evaluate wound intake of soluble plutonium
- Forty years post-intake, 12.2 Bq, 17.5 Bq and 1.35 Bq were still retained in this individual's liver, skeleton and wound, respectively
- Initial deposition in wound was estimated to be ~125 Bq of ^{239}Pu; ~78 Bq was excreted due to Ca-DTPA therapy
- Therapy reduced the effective dose by a factor of 2.6

Future Work

Pu decorporation modeling

- Model DTPA-affected urine data from this case
- Validate and optimize system of models proposed by Dumit *et al*. 2018





Courtesy of W.J. Bair

Pu bound fraction

- Dissect left lung based on ICRP HRTM compartments: BB, bb, AI
- Measure ^{239}Pu concentrations to evaluate bound Pu in upper airways

Questions?

m.avtandilashvili@wsu.edu
www.ustur.wsu.edu