USTUR Whole-Body Case 0212: Testing NCRP Wound Model

Maia Avtandilashvili, Stacey L. McComish and Sergei Y. Tolmachev

US Transuranium and Uranium Registries
College of Pharmacy, Washington State University
Richland, WA 99354

"Learning from Plutonium and Uranium Workers"

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Motivation

- ❑ **>2,000 contaminated wounds reported**
  - ➢ Commonly treated by tissue excision and chelation
- ❑ **NCRP 156 Wound Model (2007)**
  - ➢ Based exclusively on animal experiments
  - ➢ Important to test against human data
- ❑ **Effectiveness of chelation treatment**
  - ➢ Residual vs. projected dose
- ❑ **USTUR Whole Body donations:** *A total of 42 cases*
  - ➢ 10 cases with documented wound intakes: ^{239}Pu (9), ^{241}Am (1)
  - ➢ 4 cases with a single Pu wound as a major intake
 - ➢ Case 0212 selected for this study

USTUR Whole Body Case 0212

➢ Exposure: Wound (treated)

➢ Treatment: Tissue Excision & Ca-DTPA

➢ Donation Year: 1984

➢ Post-Intake: 17 y

➢ Cause of Death: Pulmonary Emphysema

➢ Age: 56 y

Contaminated Wound

- ❑ Left middle finger, anterior surface
- ❑ Cutting a pipe on the solvent extraction hood
- ❑ Material involved: $Pu(NO_3)_4$
- ❑ Initial survey meter reading: 10,000 dpm
  - ➤ Decontaminated to 500 dpm
- ❑ Initial wound count: 59 nCi (~2.2 kBq)
  - ➤ After wound excision: 11 nCi (~0.4 kBq)
  - ➤ Excised tissue count: 122 nCi (~4.5 kBq)
- ❑ Chelation treatment: 6 months – bi-weekly
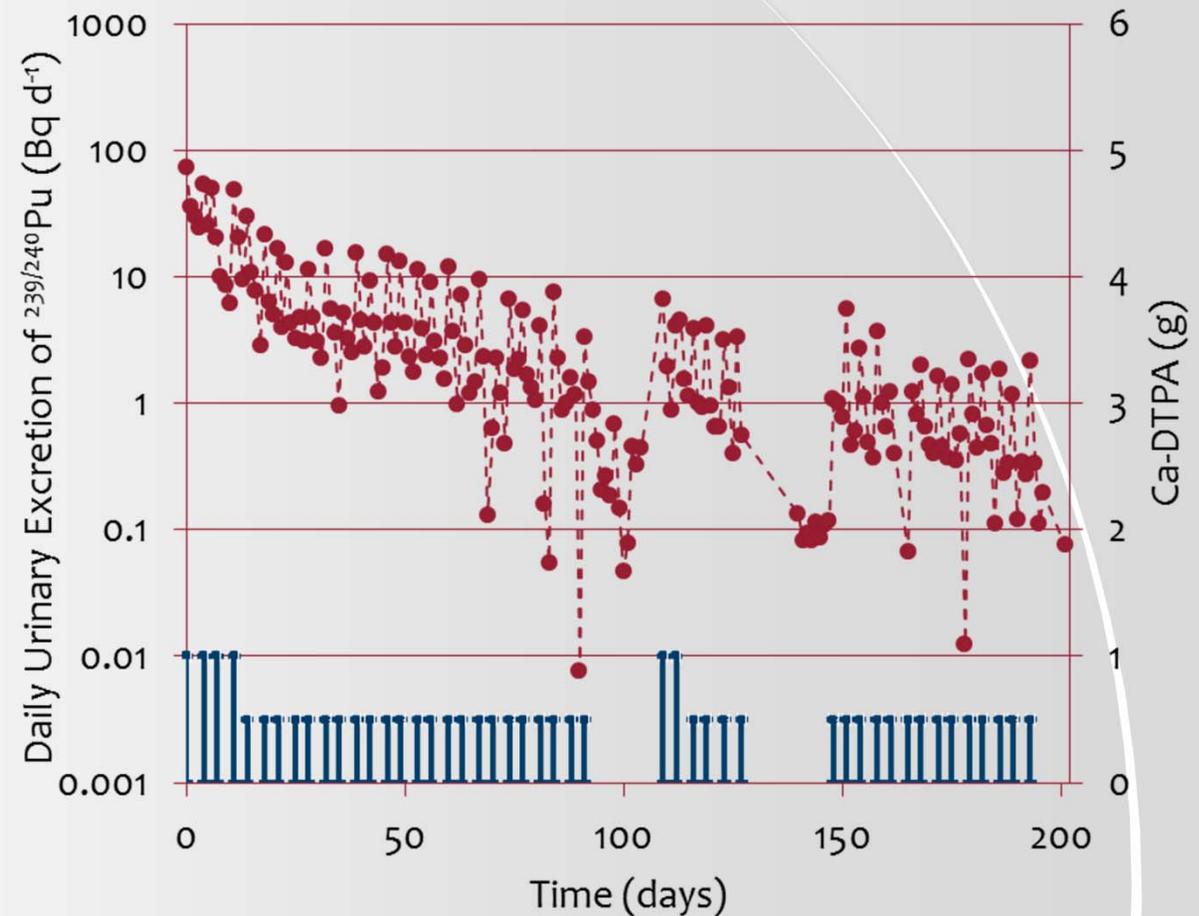 - ➤ A total of 26.5 g Ca-DTPA
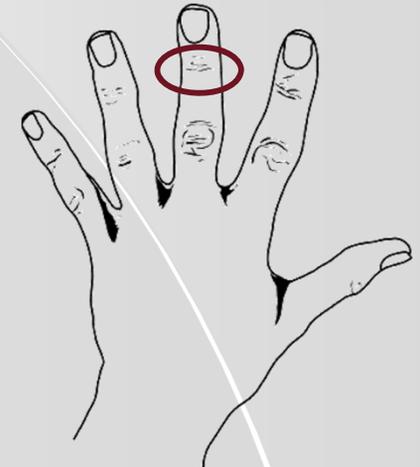
Urinalysis Data

➢ **Analysis Method:**
  ✓ Autoradiography

➢ **MDA: ~0.001 Bq d^{-1}**
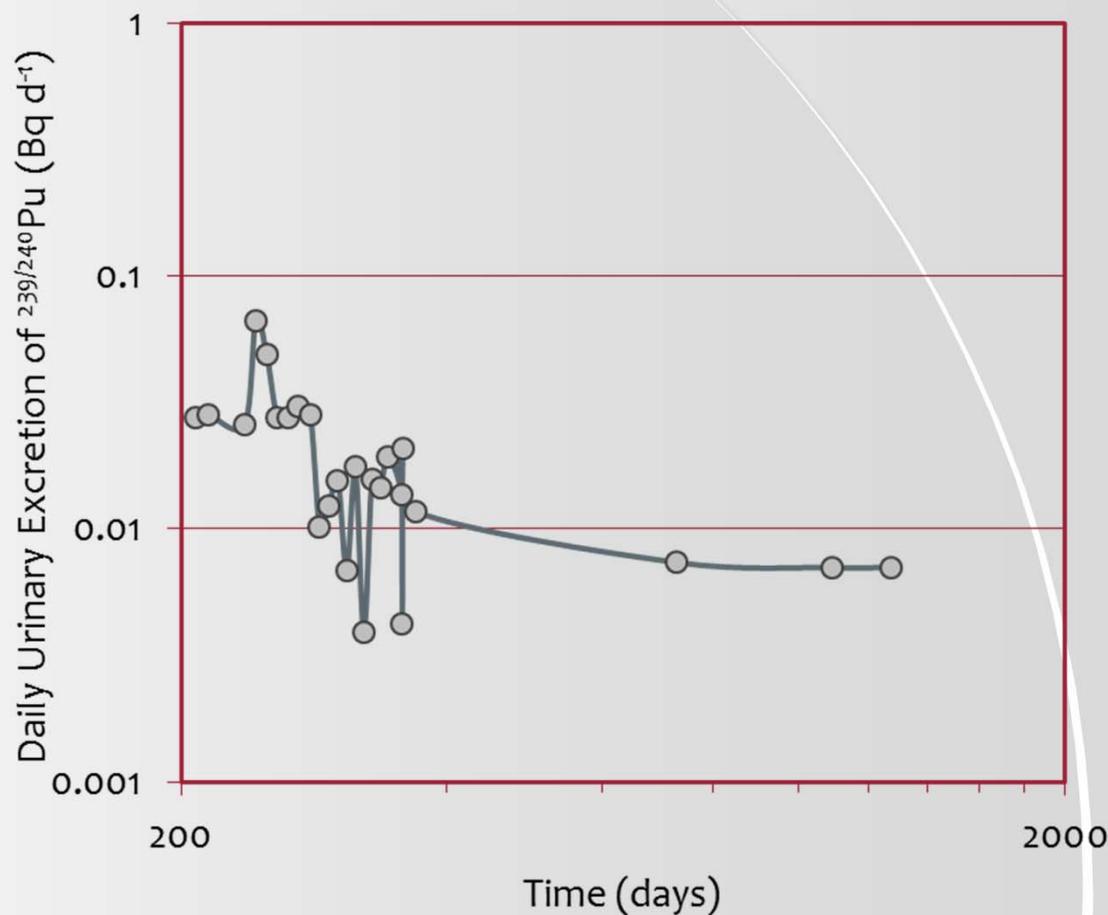
➢ **A total of 205 samples**
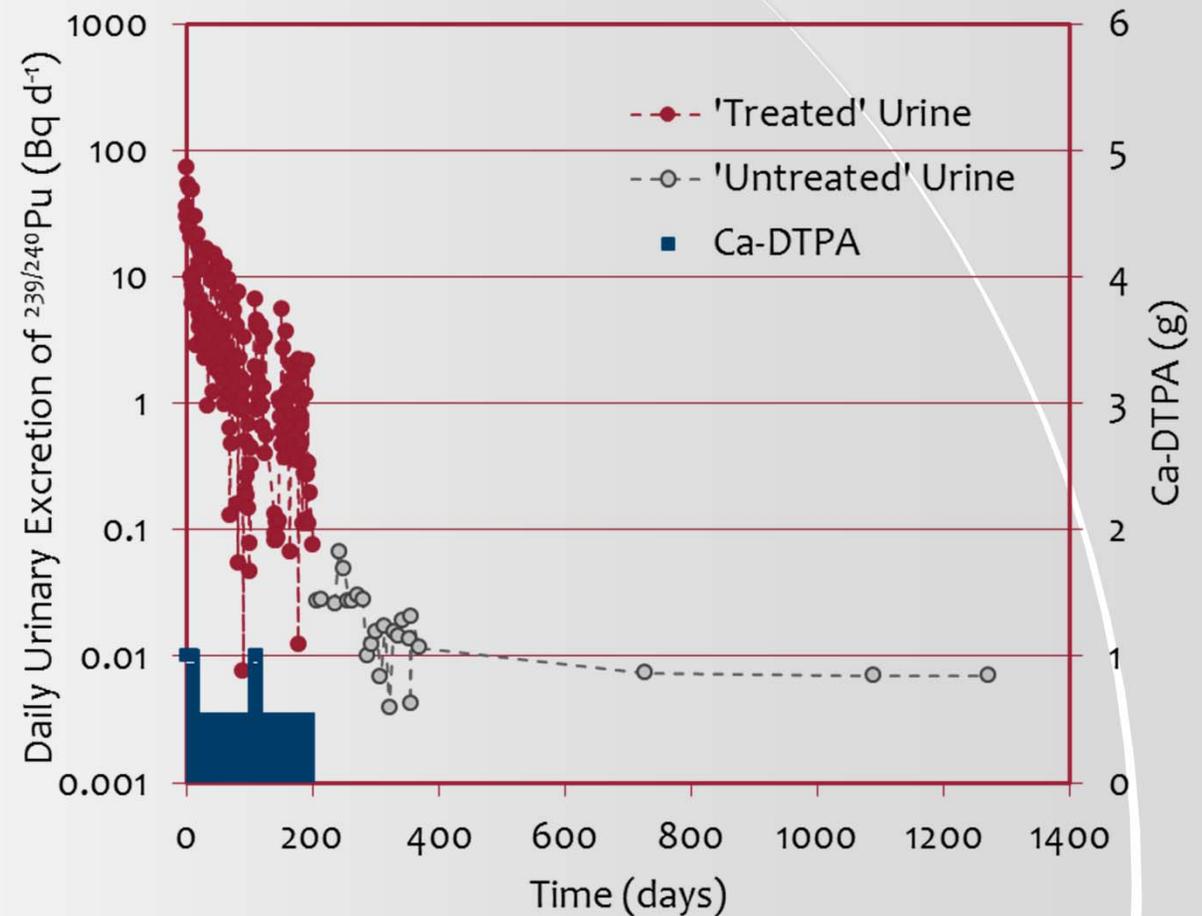
Urinalysis Data: 'Treated'

- ➢ **Analysis Method:**
  - ✓ Autoradiography

- ➢ **MDA: ~0.001 Bq d^{-1}**

- ➢ **A total of 205 samples**

- ➢ **180 samples**
  - ✓ affected by DTPA
  - ✓ 201 days post-intake

- ➢ **~ 916 Bq Pu excreted during treatment**
  - ✓ Max rate: 73 Bq d^{-1}

Urinalysis Data: 'Untreated'

➤ **Analysis Method:**
  ✓ Autoradiography

➤ **MDA:** ~0.001 Bq d^{-1}

➤ **A total of 205 samples**

➤ **25 samples**
  ✓ not affected by DTPA

➤ **Ave. post-DTPA rate:**
  ✓ 0.02 ± 0.01 Bq d^{-1}

Figure axes: Daily Urinary Excretion of $^{239/240}$Pu (Bq d^{-1}) vs. Time (days)

Autopsy Tissue Sample Analysis

➤ Total of 264 tissue samples

➤ Analysis Method: *Alpha Spectrometry*

| Tissue	Concentration, Bq kg^{-1}	Activity, Bq
Wound (*muscle & skin*)	**40.2 ± 0.7**	**14.3 ± 0.3**
Lungs including LNTH	0.48 ± 0.07	0.82 ± 0.12
Skeleton (*174 samples*)	11.0 ± 0.1	114.5 ± 0.5
Liver	33.8 ± 1.1	80.5 ± 2.6
Kidneys	0.37 ± 0.01	0.172 ± 0.005
Soft Tissues (*56 samples*)	0.0004 ± 0.0001	34.2 ± 0.6
Total Systemic	**n/a**	**229.2 ± 2.7**

Methods

❑ **Internal Dosimetry Software**

➤ IMBA Professional Plus®

❑ **Maximum likelihood fitting of:**

➤ 'Baseline' (post-treatment) urine data

❑ **Models applied:**

➤ ICRP 67 Pu Systemic Model

➤ NCRP Wound Model
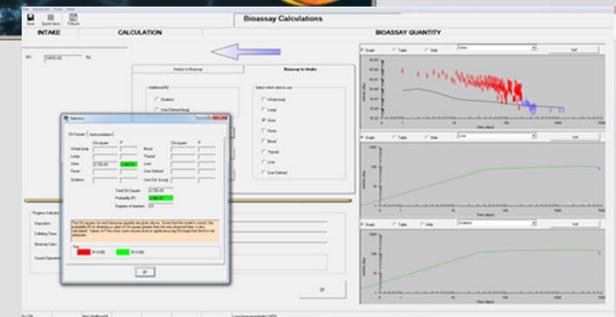
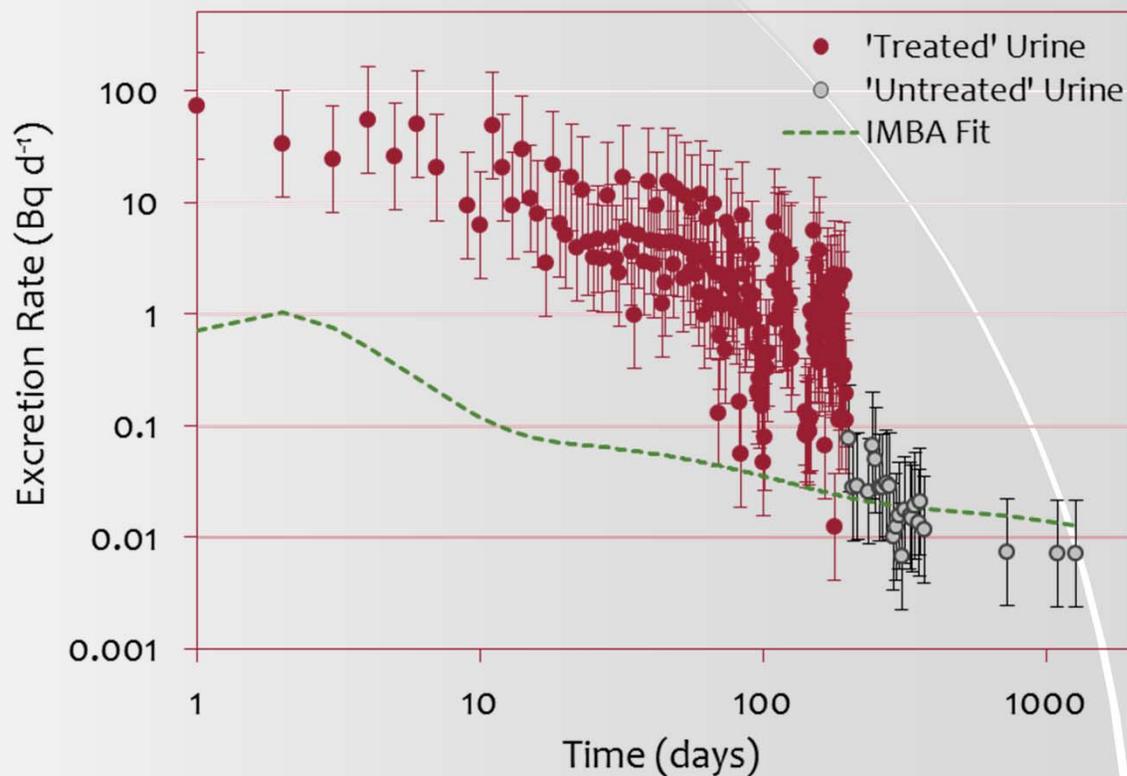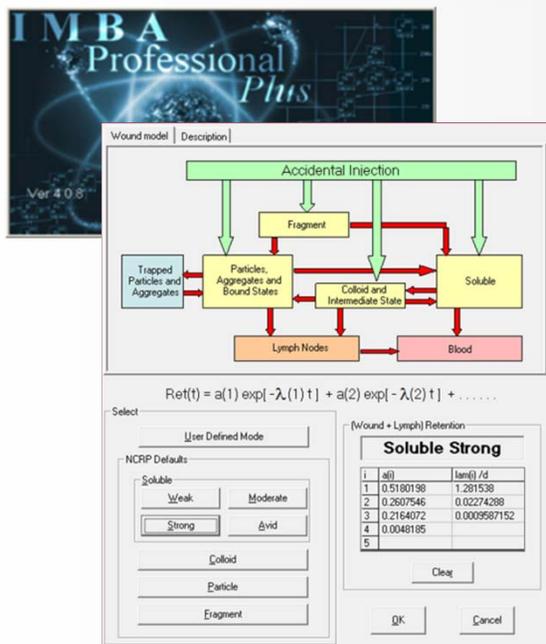# NCRP Wound Model
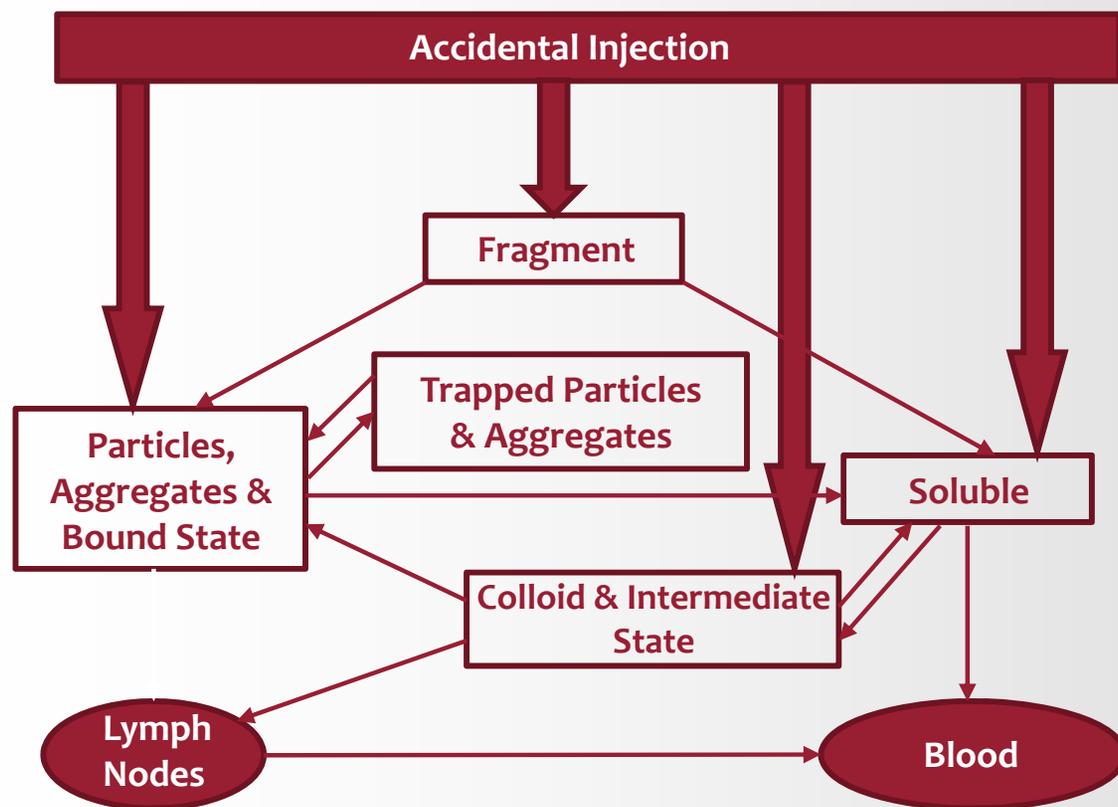
- ☐ Default material types:
  - ➢ Soluble
    - ✓ Weak
    - ✓ Moderate
    - ✓ Strong ⬅ $Pu(NO_3)_4$
    - ✓ Avid
  - ➢ Colloid
  - ➢ Particle
  - ➢ Fragment

Diagram labels: Accidental Injection, Fragment, Trapped Particles & Aggregates, Particles, Aggregates & Bound State, Soluble, Colloid & Intermediate State, Lymph Nodes, Blood

Results: Excretion

❑ Credible fit:

➤ $\chi 2$ alpha = 0.246

Results: Retention
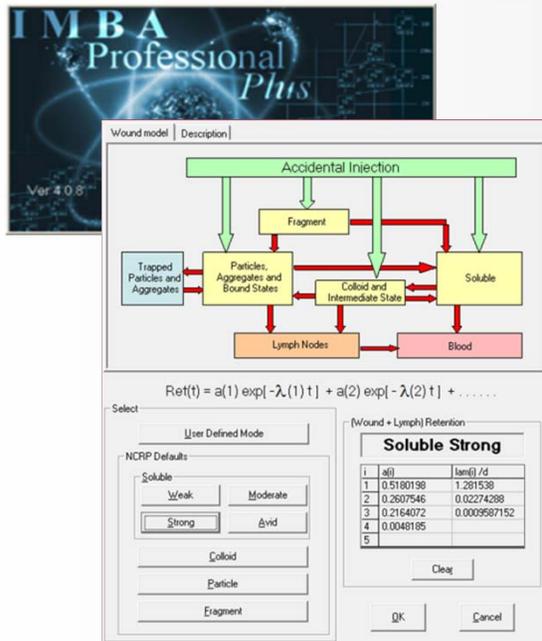
Pu Retention at Time of Death, Bq		
Organ	*Predicted*	*Measured*
Liver	97.3	80.5
Skeleton	147.4	114.5
Wound	6.8	14.3

Model predicted:

❑ Pu in liver and skeleton
  ➢ within ~25%

❑ Pu in wound
  ➢ by a factor of 2
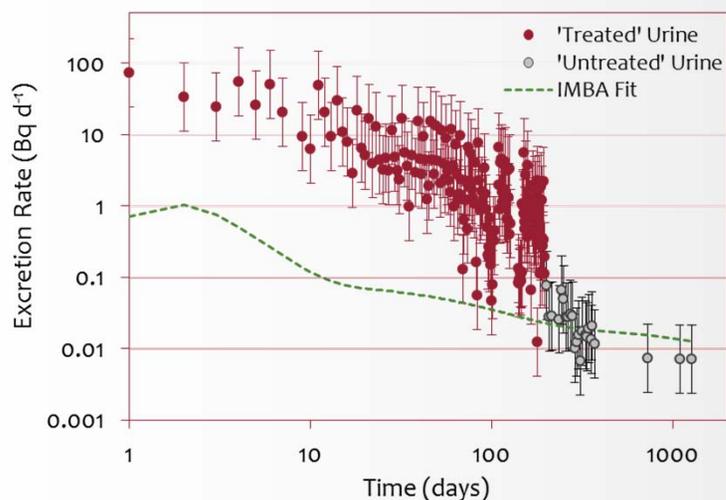
Results: Intake and Dose

❑ Intake

➢ IMBA estimate: 364 Bq

➢ Pu excreted with DTPA: 916 Bq

+ } **1,280 Bq**

❑ Committed Effective Dose

➢ Residual CED: 177 mSv

vs.

➢ Projected CED: 622 mSv

Future Work

❑ Apply Bayesian analysis methods:

➢ Define suitable priors for wound model parameters

➢ Use Monte Carlo simulation (WeLMoS, MCMC) to:

✓ derive best estimate of intake

✓ calculate uncertainties in wound retention parameters

✓ quantify effectiveness of DTPA treatment

Questions?