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USTUR Whole-Body Case 0212: Testing NCRP Wound Model

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*“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 Resources

- ❑ Whole Body donations: *A total of 42 cases*
 - 10 cases with documented wound intakes
 - ✓ ^{239}Pu : 9 cases, ^{241}Am : 1 case
 - 4 cases with a single Pu wound as a major intake
 - Case 0212 selected for this study

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United States Transuranium & Uranium Registries

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NIHTR
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NSA
National Radiobiology Institute

LEARNING FROM PLUTONIUM & URANIUM WORKERS

Pathology Database: Download ICD-9 and 10 causes of death

Visitors

4,439	127
281	85
226	67
178	64
161	60
156	36

You: [Country] Newest: [Country] (since May 17, 2010)

Public Outreach

- USTUR in the Community
- Educational Portal

Graduate Education

Sharing the USTUR dataset with students to provide meaningful data

Advisory Committee Conferences/Symposia Publications Faculty/Staff



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



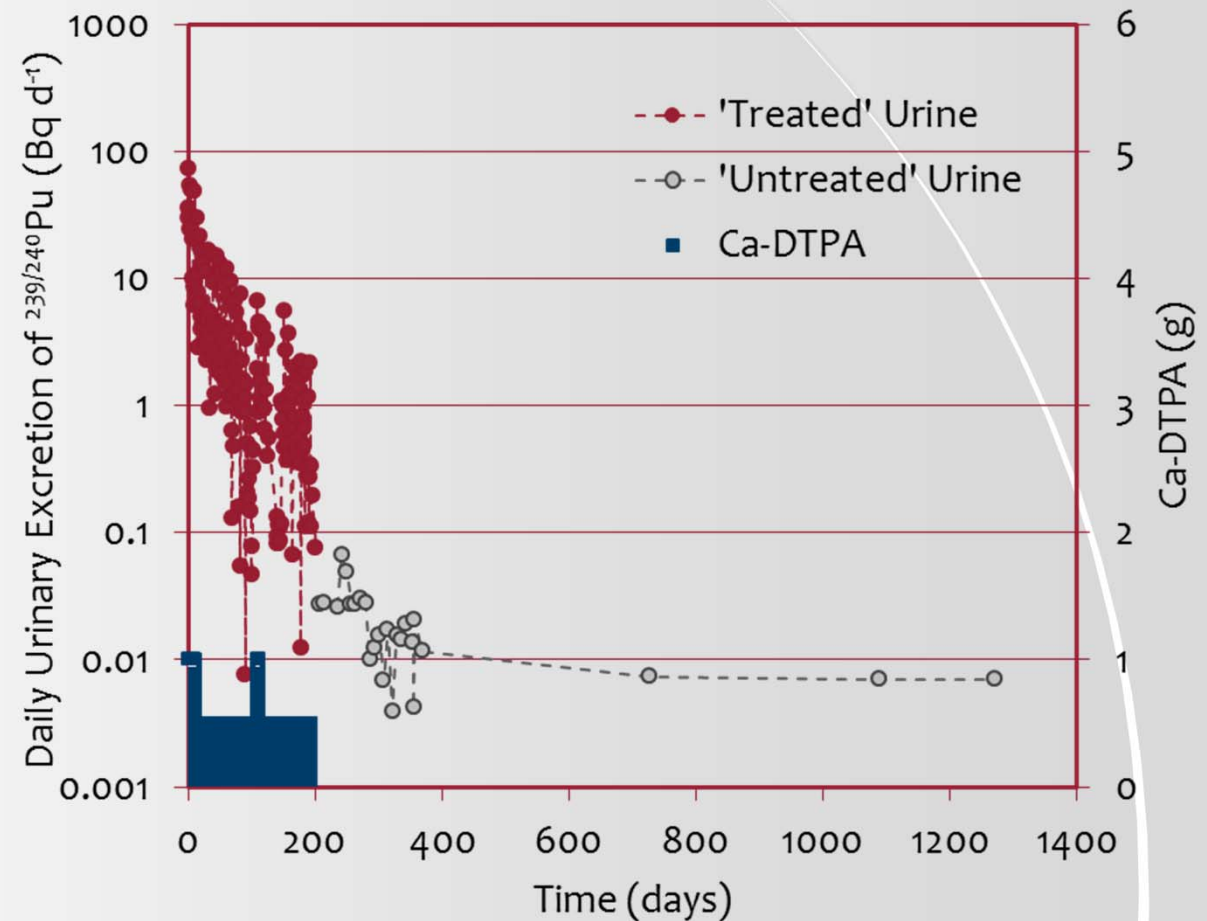
Contaminated Wound

- ❑ Left middle finger, anterior surface
- ❑ Material involved: $\text{Pu}(\text{NO}_3)_4$
- ❑ 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



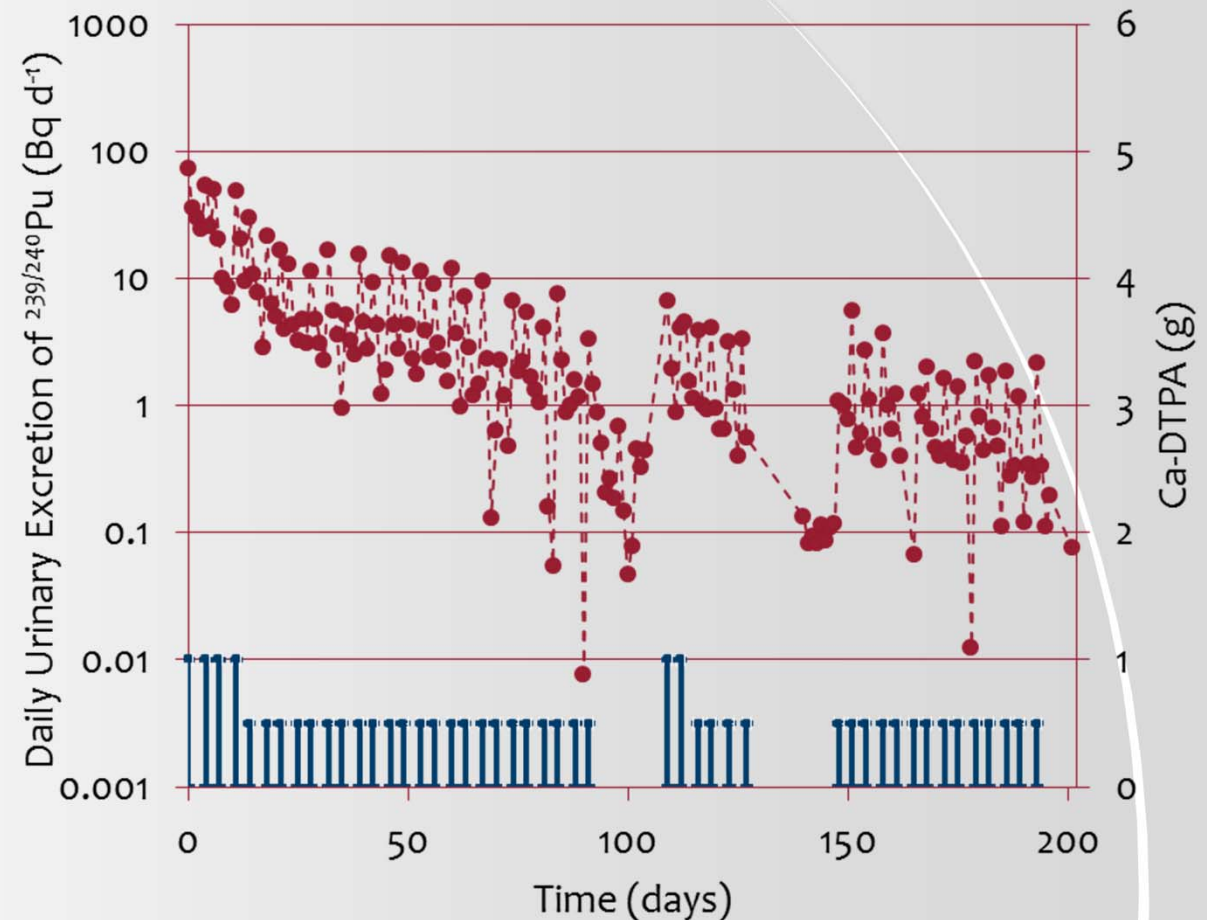
Urinalysis Data

- Analysis Method:
 - ✓ Track Analysis
- MDA: $\sim 0.001 \text{ Bq d}^{-1}$
- A total of 205 samples



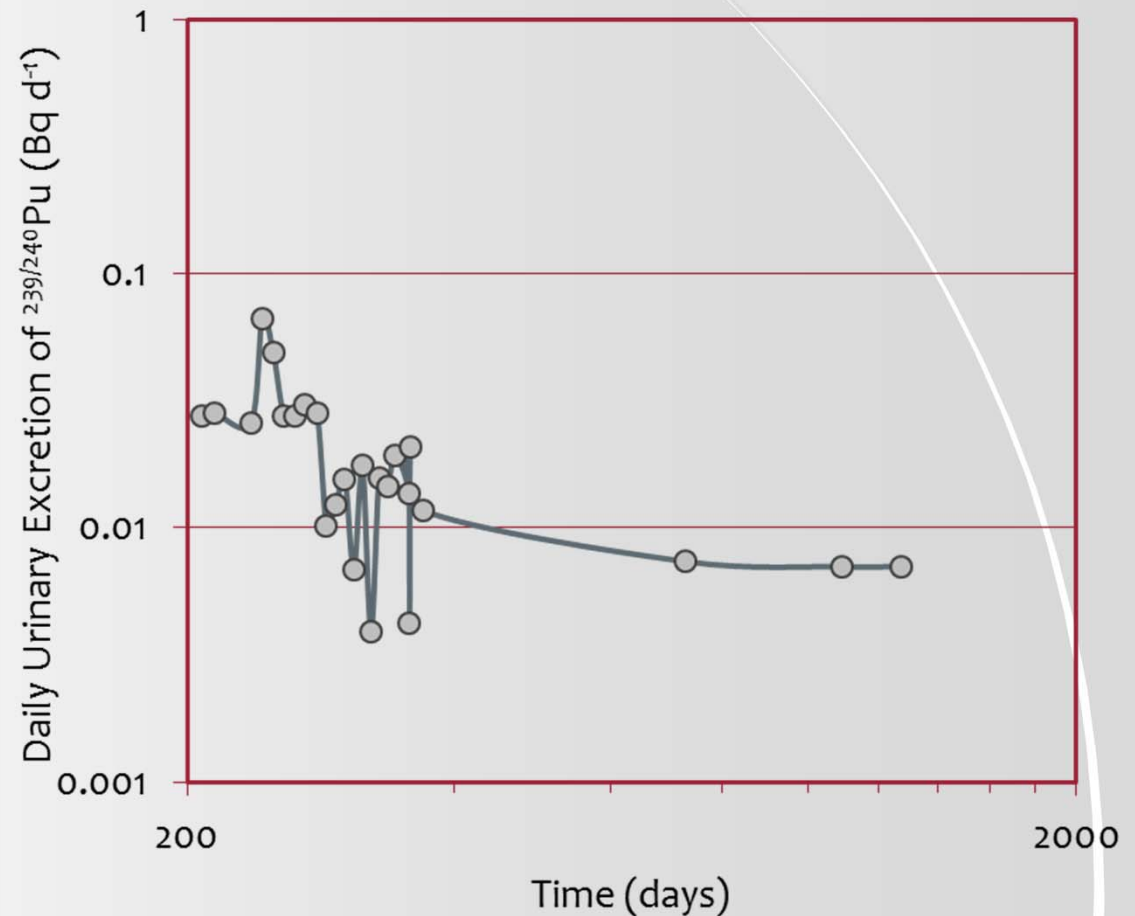
Urinalysis Data: 'Treated'

- Analysis Method:
 - ✓ Track Analysis
- MDA: $\sim 0.001 \text{ Bq d}^{-1}$
- A total of 205 samples
- 180 samples
 - ✓ affected by DTPA
 - ✓ 201 days post-intake
- $\sim 916 \text{ Bq Pu}$ excreted during treatment
 - ✓ Max rate: 73 Bq d^{-1}



Urinalysis Data: 'Untreated'

- Analysis Method:
 - ✓ Track Analysis
- MDA: $\sim 0.001 \text{ Bq d}^{-1}$
- A total of 205 samples
- 25 samples
 - ✓ not affected by DTPA
- Ave. post-DTPA rate:
 - ✓ $0.02 \pm 0.01 \text{ Bq d}^{-1}$



Autopsy Tissue Sample Analysis

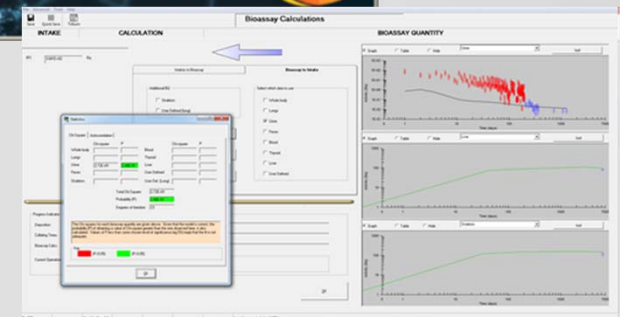
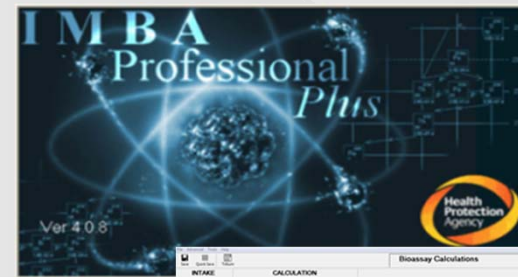
- Total of 264 tissue samples
- Analysis Method: *Alpha Spectrometry*

Tissue	Concentration, Bq kg ⁻¹	Activity, Bq
Wound (<i>muscle & skin</i>)	40.2 ± 0.7	14.3 ± 0.3
Lungs including LNTH	0.48 ± 0.07	0.82 ± 0.12
Skeleton (<i>174 samples</i>)	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 (<i>56 samples</i>)	0.0004 ± 0.0001	34.2 ± 0.6
Total Systemic	n/a	229.2 ± 2.7

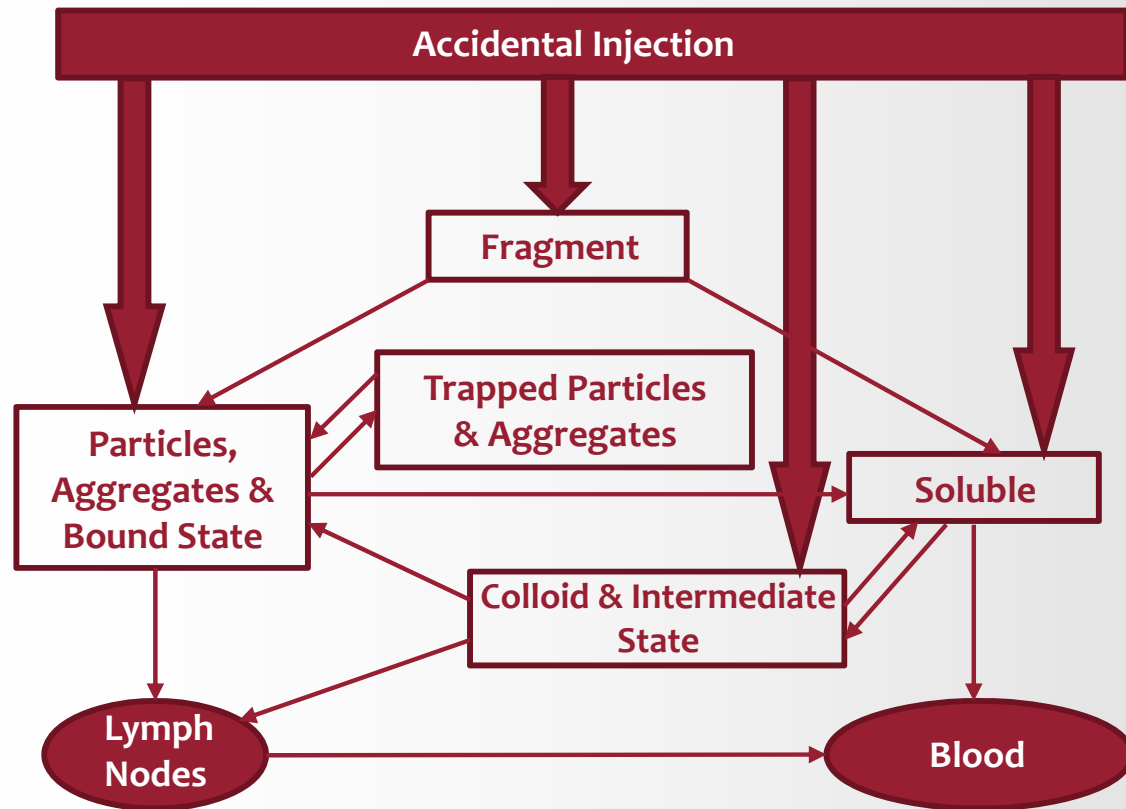


Methods

- ❑ 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

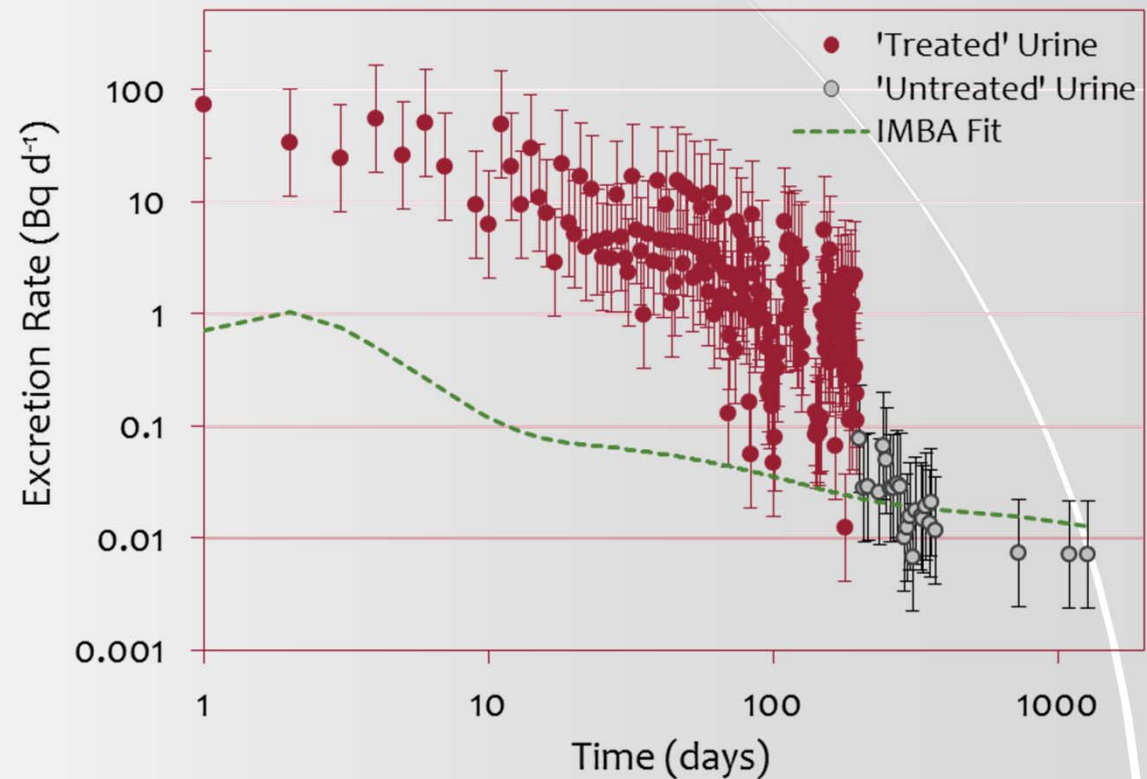
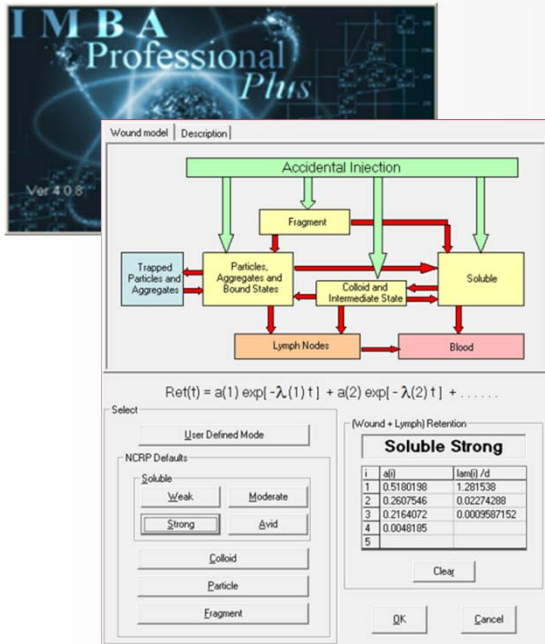


☐ Default material types:

- Soluble
 - ✓ Weak
 - ✓ Moderate
 - ✓ Strong ← $\text{Pu}(\text{NO}_3)_4$
 - ✓ Avid
- Colloid
- Particle
- Fragment



Results: Excretion

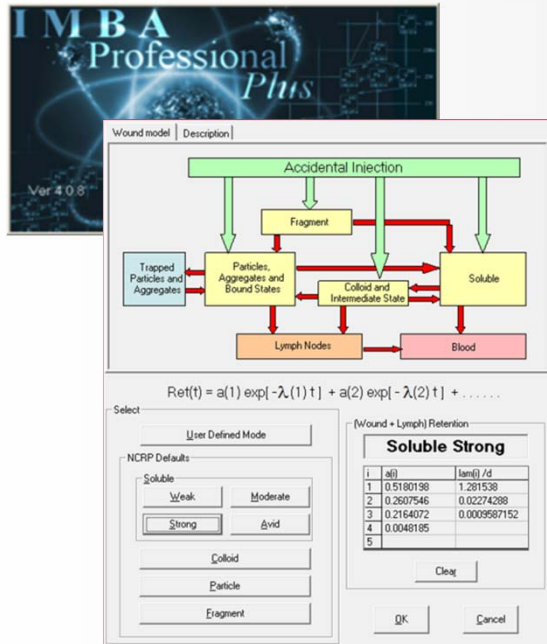


☐ Credible fit:

➤ χ^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:

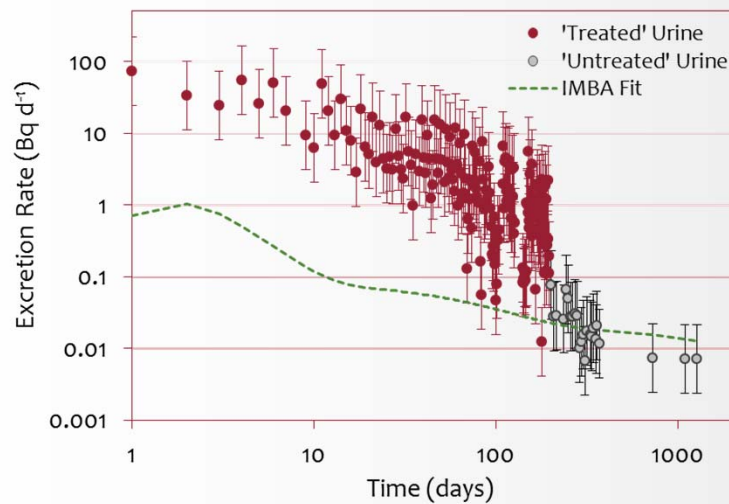
- Pu in liver and skeleton
 - within ~25%
- Pu in wound
 - by a factor of 2



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
 - Projected CED: 622 mSv
- vs.**



Conclusions

❑ Data support NCRP Wound Model

➤ $\text{Pu}(\text{NO}_3)_4 \Leftrightarrow \text{Soluble: Strong}$

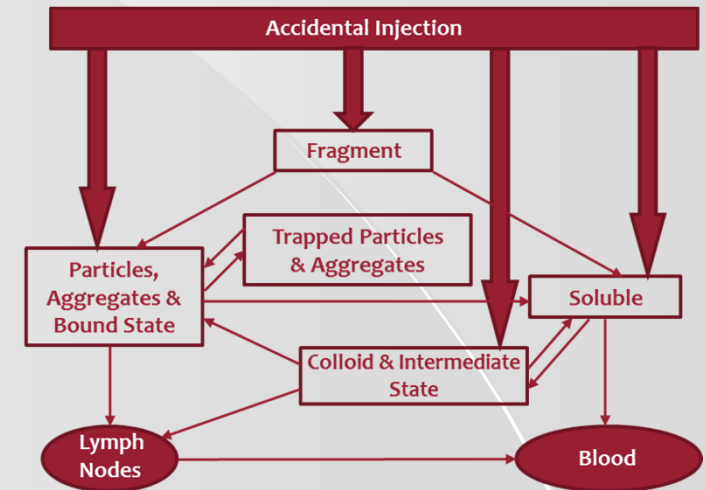
❑ Wound Treatment Effectiveness

➤ *Chelation:*

▪ Projected Dose / Residual Dose: ~ 3.5

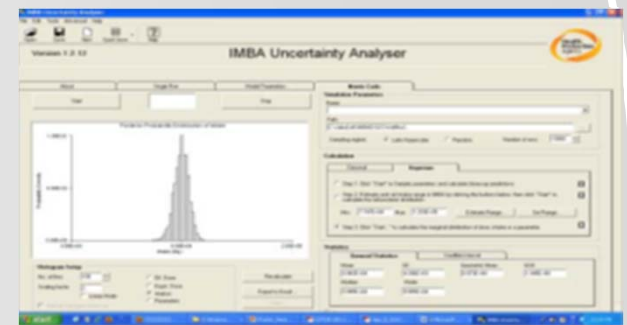
➤ *Chelation + Tissue Excision:*

▪ Projected Dose / Residual Dose: ~ 16



Future Work

- ❑ Apply Bayesian analysis methods:
 - Define suitable priors for wound model parameters
 - Use Markov Chain Monte Carlo (MCMC) to:
 - ✓ derive best estimate of intake
 - ✓ calculate uncertainties in wound retention parameters
 - ✓ quantify effectiveness of DTPA treatment



Questions?

