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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

USTUR Whole Body Case 0212

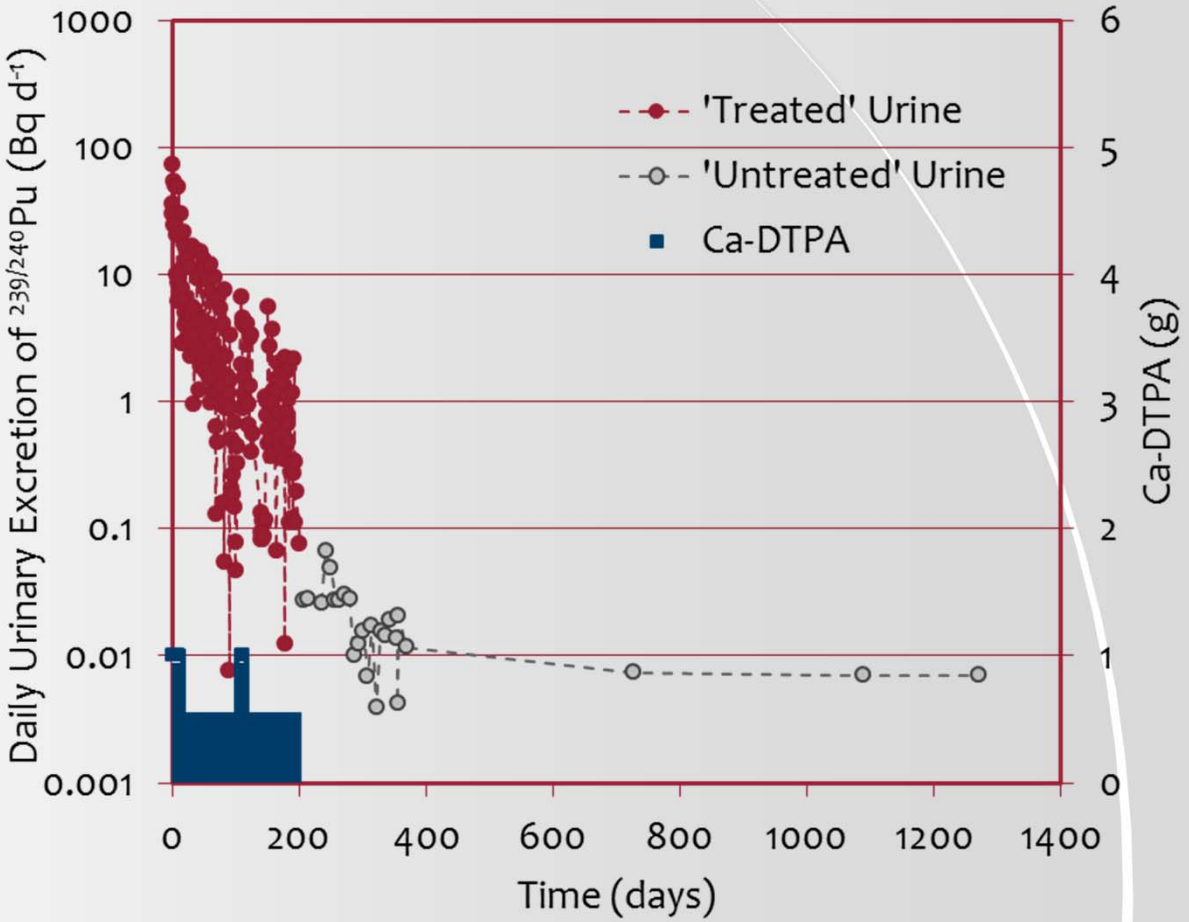
- Exposure: Wound (treated)
- Treatment: Tissue Excision & Ca-DTPA
- Donation Year: 1984
- Post-Intake: 17 y
- Cause of Death: Pulmonary Emphysema
- Age: 56 y

Contaminated Wound

- Left middle finger, anterior surface
- Material involved: $Pu(NO_3)_4$
- 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

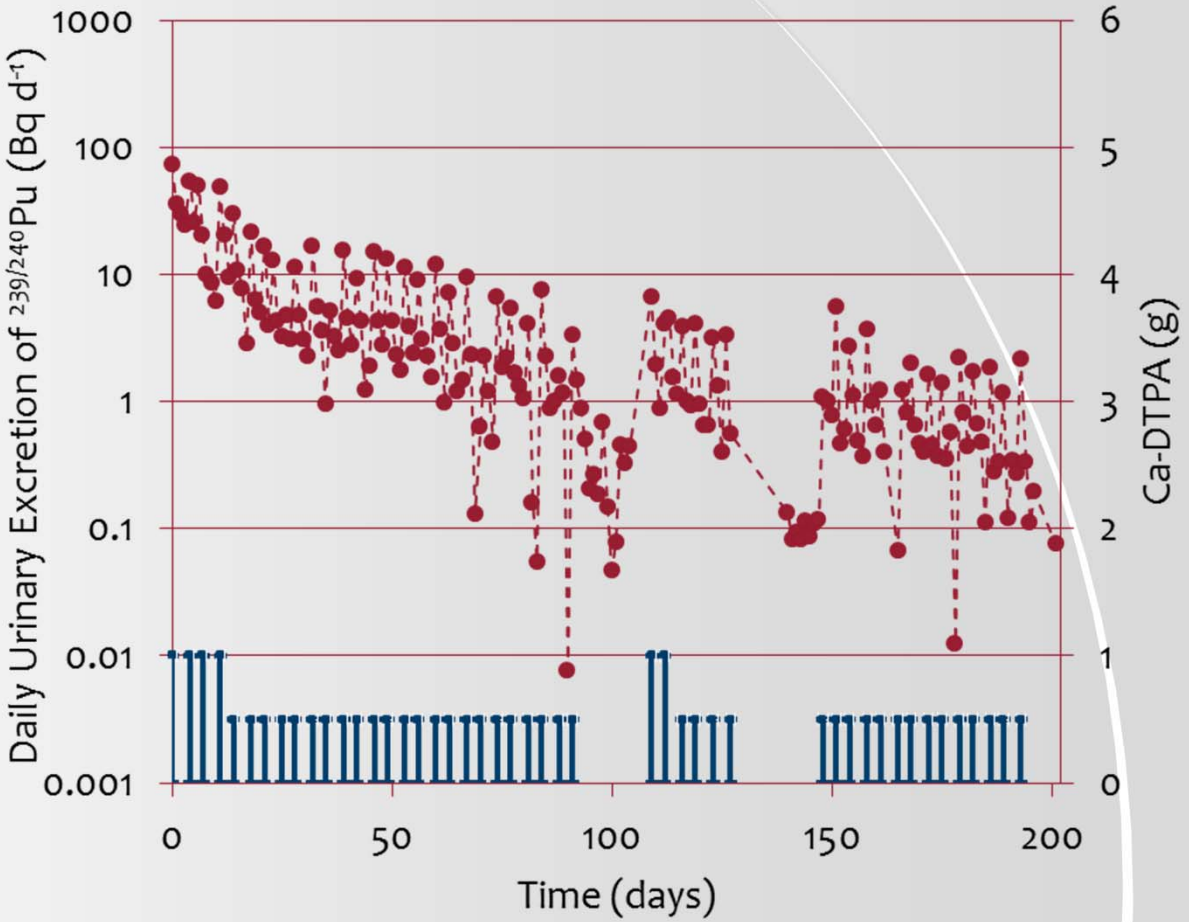
Urinalysis Data

- Analysis Method:
  - ✓ Track Analysis
- MDA: ~0.001 Bq d^{-1}
- A total of 205 samples



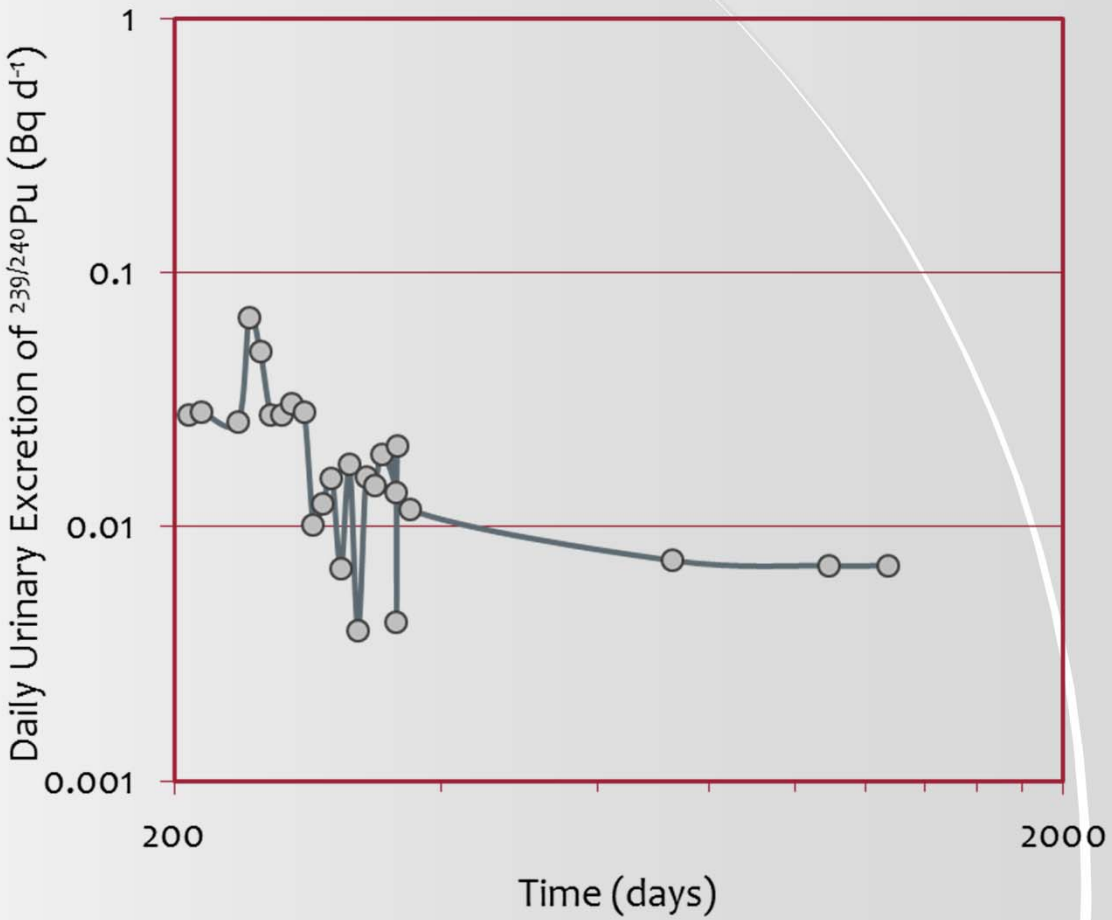
Urinalysis Data: 'Treated'

- Analysis Method:
  - ✓ Track Analysis
- 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:
  - ✓ Track Analysis
- 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}



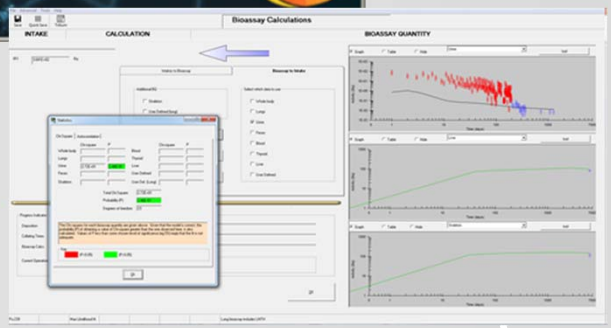
Autopsy Tissue Sample Analysis

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

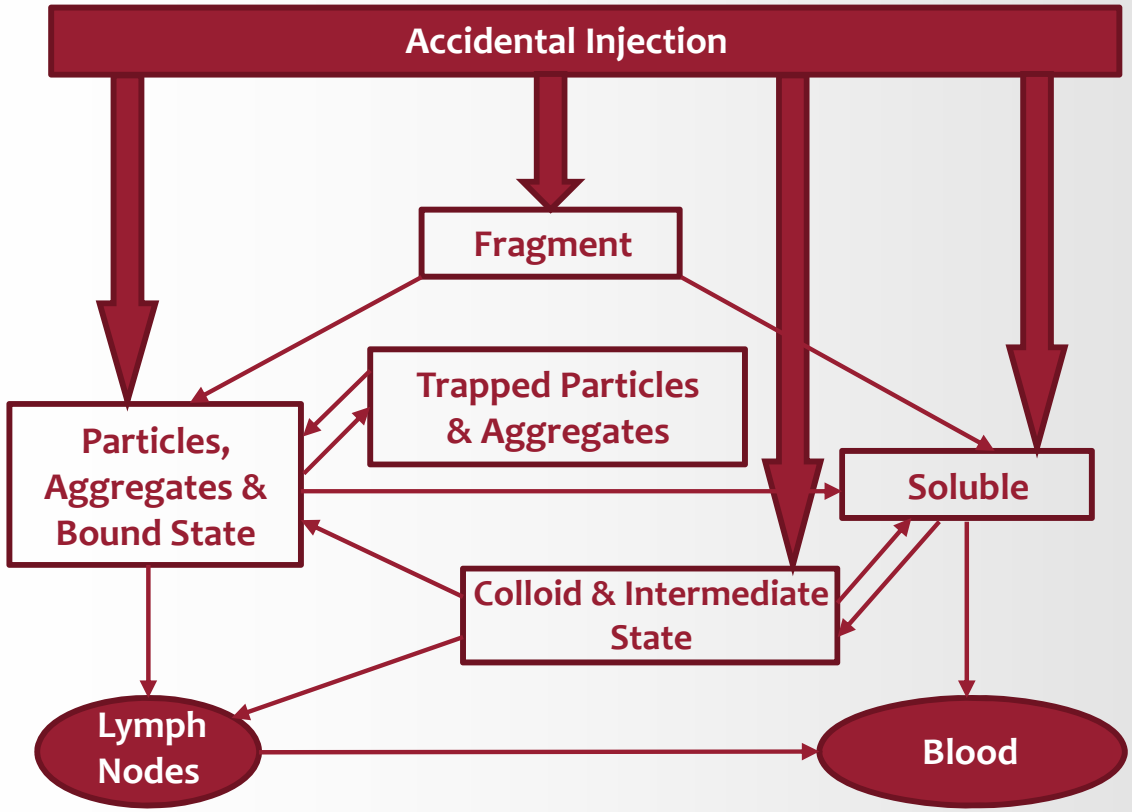
Tissue	Concentration, Bq kg^{-1}	Activity, Bq
Wound (*muscle & skin*)	**40.2 ± 0.7**	**14.3 ± 0.3**
Lungs including LNTH	0.48 ± 0.07	0.82 ± 0.12
Skeleton (*174 samples*)	11.0 ± 0.1	114.5 ± 0.5
Liver	33.8 ± 1.1	80.5 ± 2.6
Kidneys	0.37 ± 0.01	0.172 ± 0.005
Soft Tissues (*56 samples*)	0.0004 ± 0.0001	34.2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

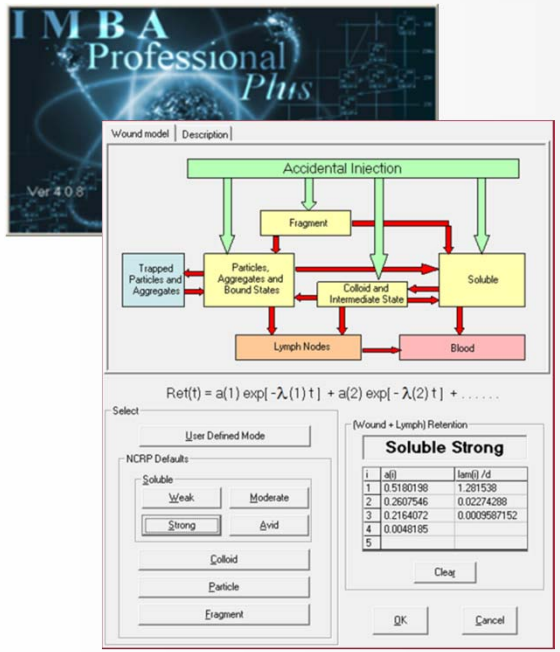


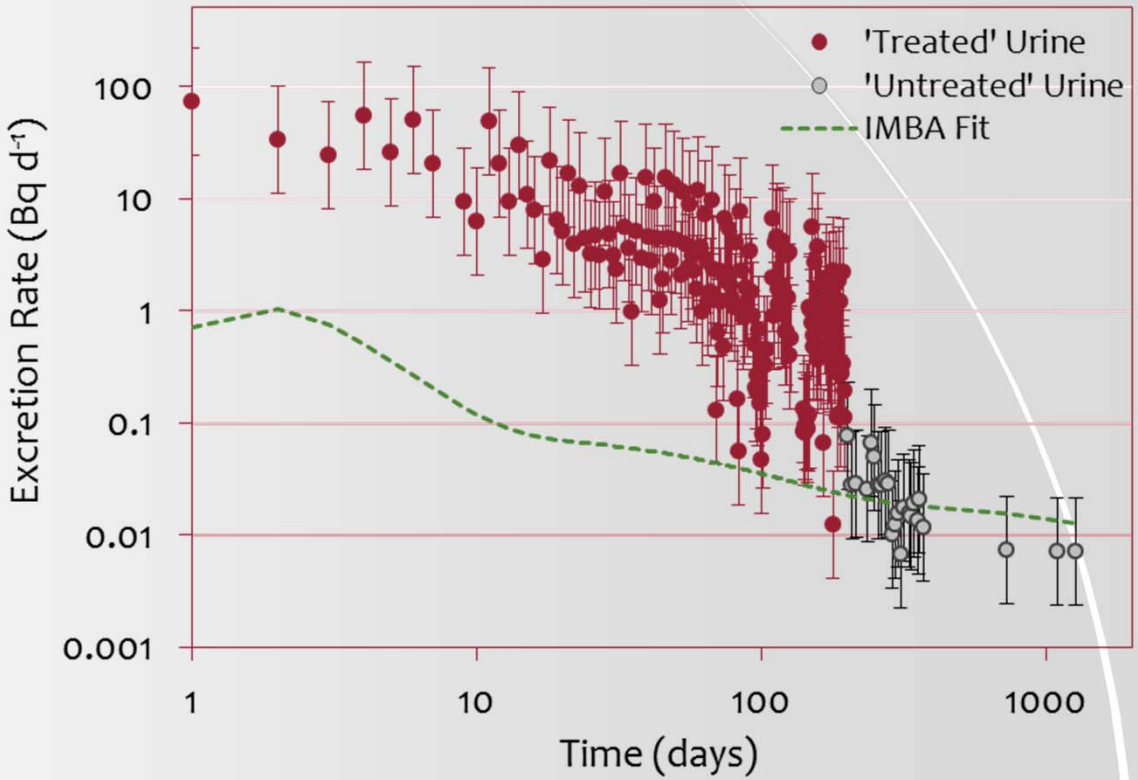
NCRP Wound Model



- Default material types:
  - Soluble
    - ✓ Weak
    - ✓ Moderate
    - ✓ Strong ← $Pu(NO_3)_4$
    - ✓ Avid
  - Colloid
  - Particle
  - Fragment

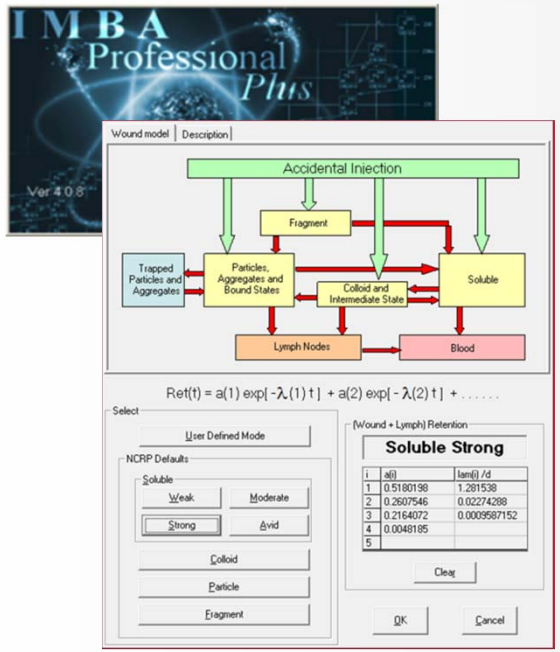
Results: Excretion





- 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:

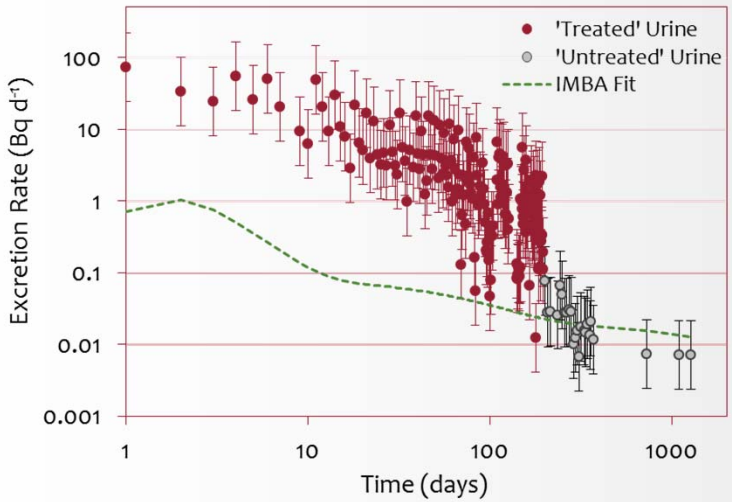
- Pu in liver and skeleton
  - within ~25%
- Pu in wound
  - by a factor of 2

Results: Intake and Dose

❑ Intake

- IMBA estimate: 364 Bq
- Pu excreted with DTPA: 916 Bq

+ → **1,280 Bq**



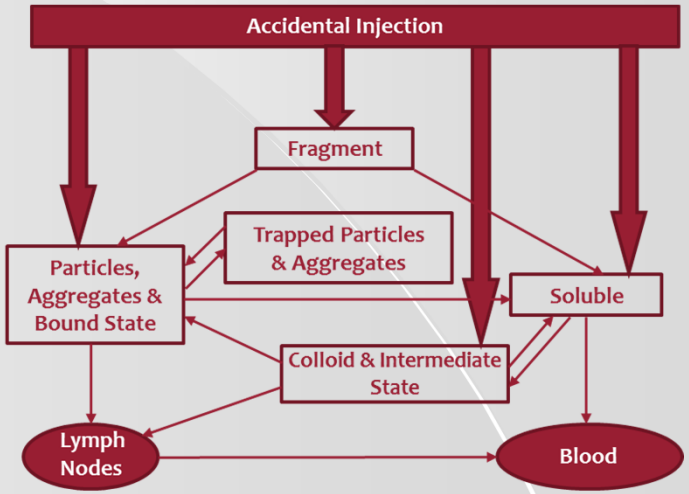
❑ Committed Effective Dose

- Residual CED: 177 mSv

vs.

- Projected CED: 622 mSv

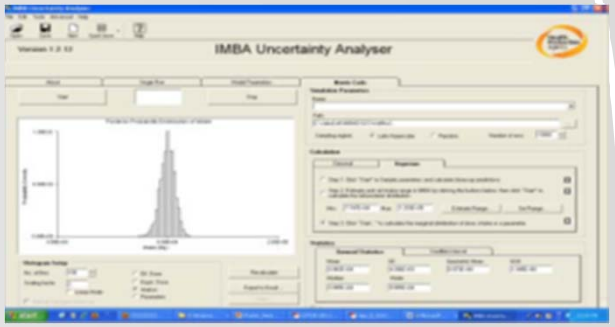
Conclusions



- Data support NCRP Wound Model
  - $Pu(NO_3)_4 \Leftrightarrow$ *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?