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USTUR Case 0846: Modeling Americium Biokinetics after Intensive Decorporation Therapy

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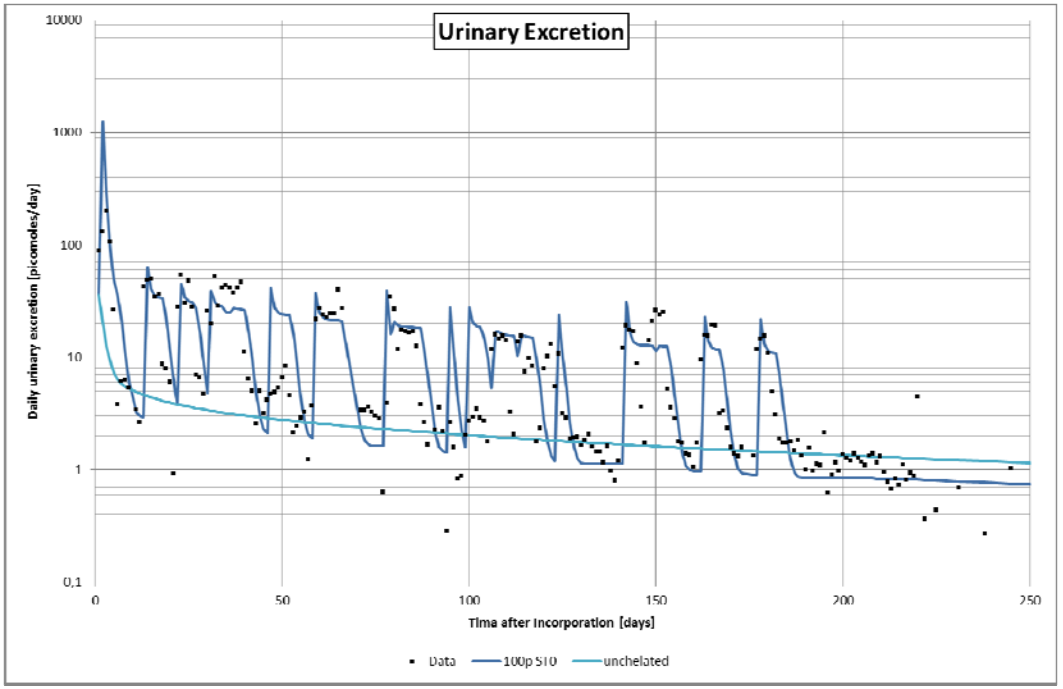
"Learning from Plutonium and Uranium Workers"

Why using USTUR data for chelation therapy modeling?

- DTPA chelation therapy removes "accessible" ^{241}Am in extracellular fluids
  - ✓ How are extracellular fluids in ICRP models represented?

- Example (USTUR Case 0269)
  - ✓ ST0 compartment



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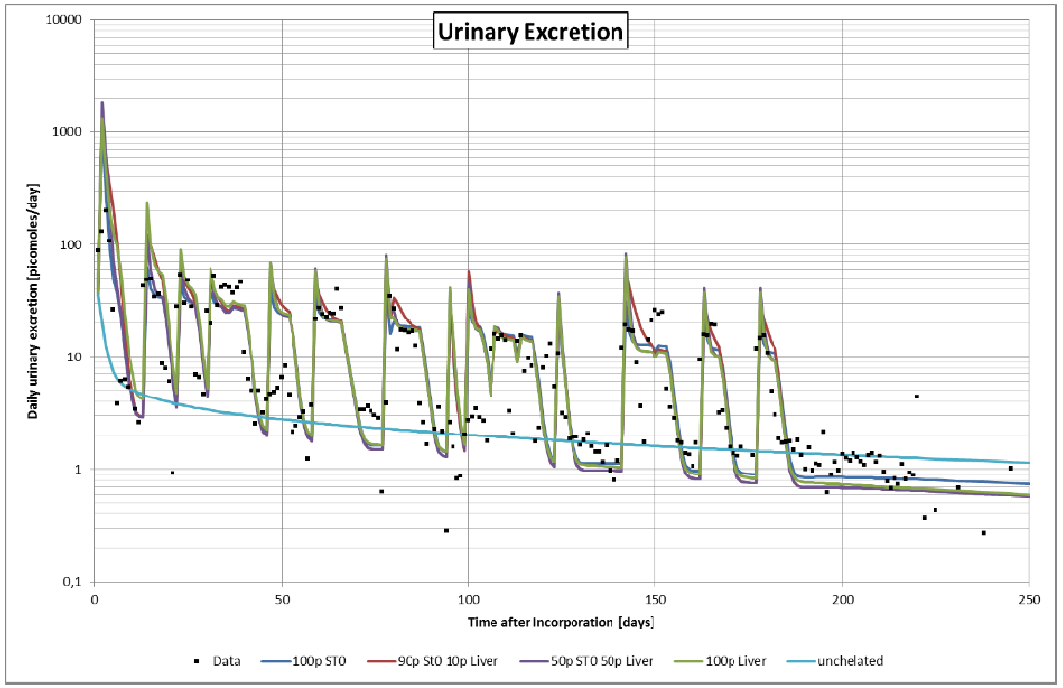
  - ✓ ST0 + liver (x %)
- Fit to urine data possible for several assumptions



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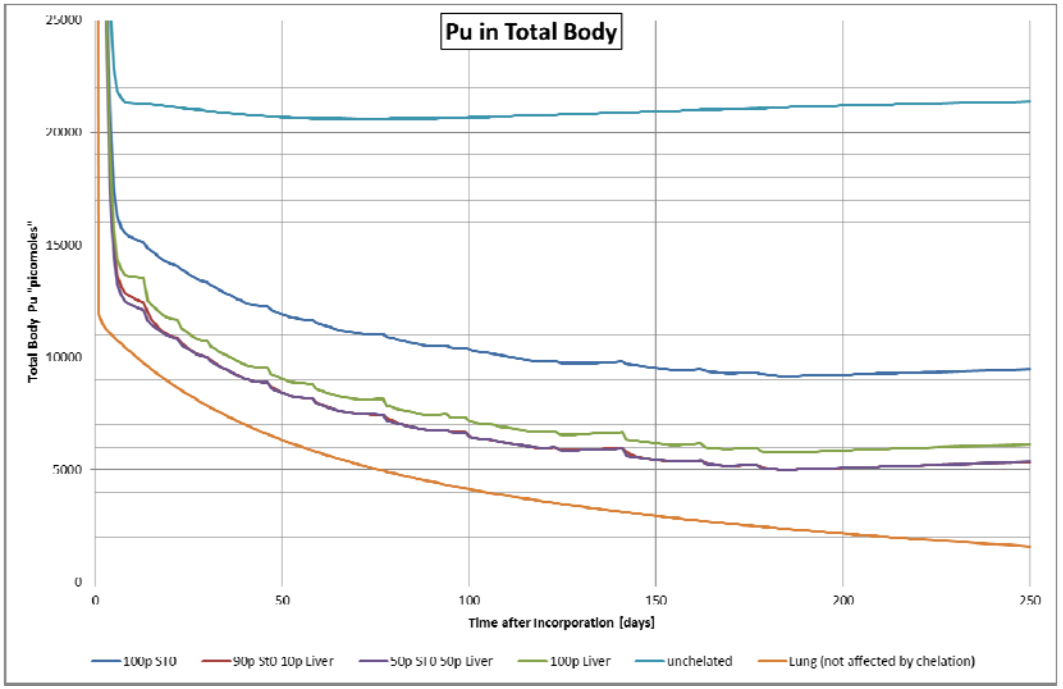
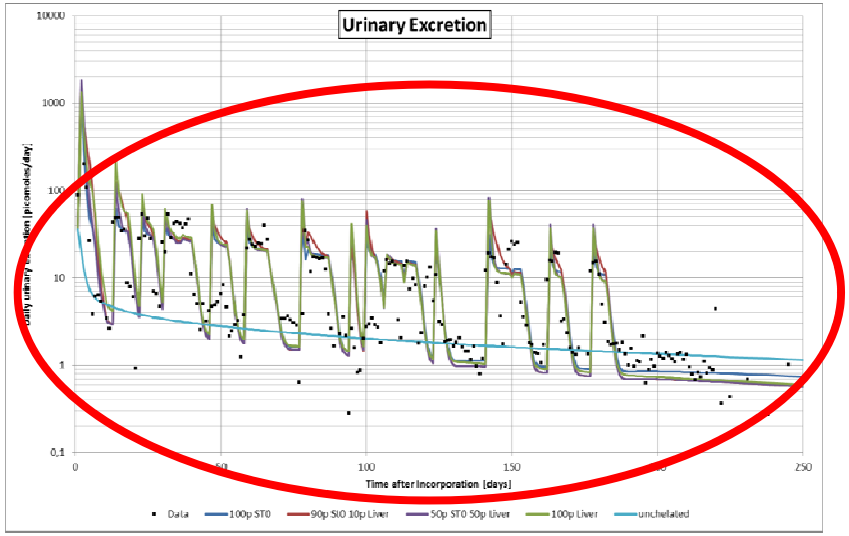
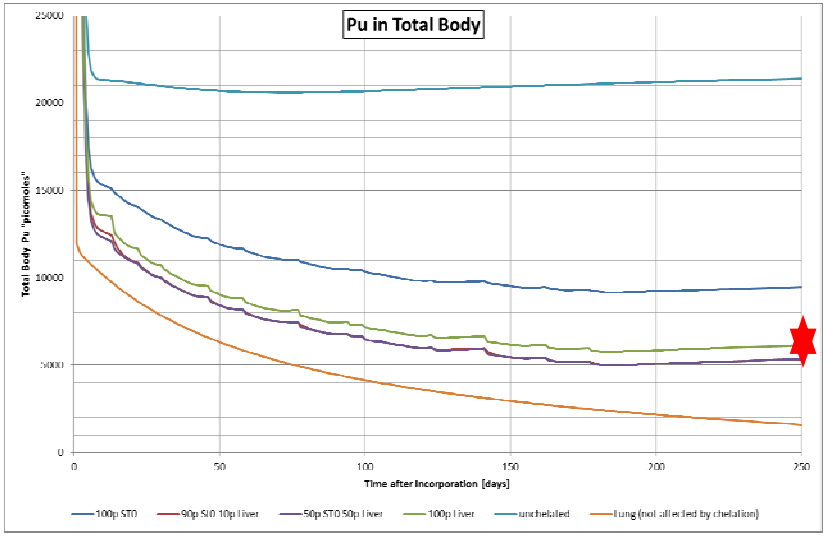
- Different predictions of effect of therapy



Why using USTUR data for chelation therapy modeling?

- USTUR has a large collection of data of chelated cases
  - ✓ Health Physics Database
    - Urinary and Fecal excretion
    - In-vivo counting (mainly for ^{241}Am)
  - ✓ Autopsy data
    - Provides insight at distribution after therapy





Case 0846 – Scenario

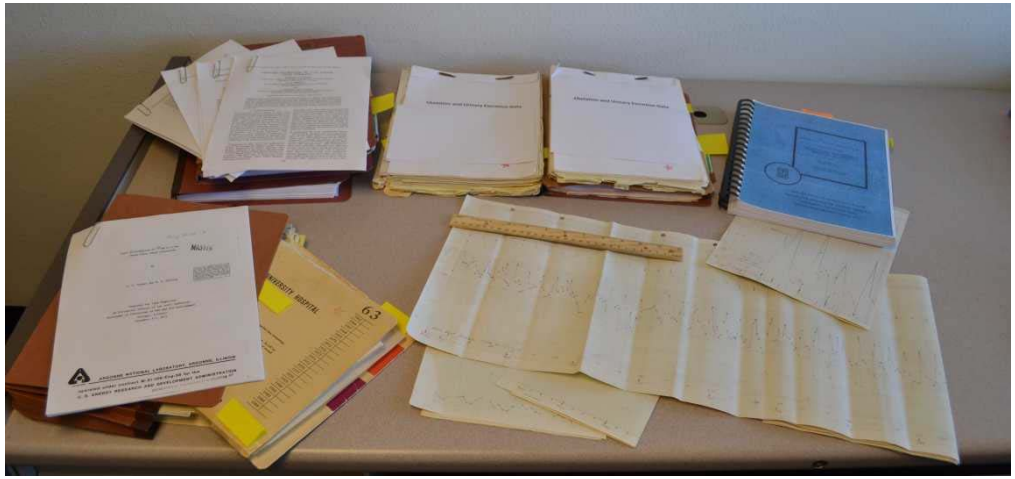
- Manufacturing sources containing $^{241}AmO_2$
  - ✓ 50 compacts manufactured over 3 years
- Compacting/pressing of pellet in pressing hood
  - ✓ Half-mask respirator worn for transfer and compacting
  - ✓ A "small" amount of visible dust was sometimes released during the pressing operation in the hood
- Alpha activity was detected in urine samples
  - ✓ Worker was sent to WBC
  - ✓ Estimated body burden = 1.8 mCi = 66,7 kBq (36 times the Maximum Permissible Body Burden)

Case 0846 – Therapy and Bioassay

- Removed from work and chelation therapy started
- 380 week therapy
  - ✓ total administration of 313.5g Ca-DTPA
    - 330 i.v. of 1g Ca-DTPA: once a week
    - 57 i.v. of 0.5g Ca-DTPA: twice per week
    - 43 weeks without treatment
- Extensive Bioassay Measurements under Treatment
  - ✓ Weekly body counts until week 60 of therapy
  - ✓ Fecal collection until week 80
  - ✓ Virtually all urine has been collected under therapy
    - Daily collection in the first two years of therapy
    - Weekly collection in the following 5 years
    - One week per month in the last year

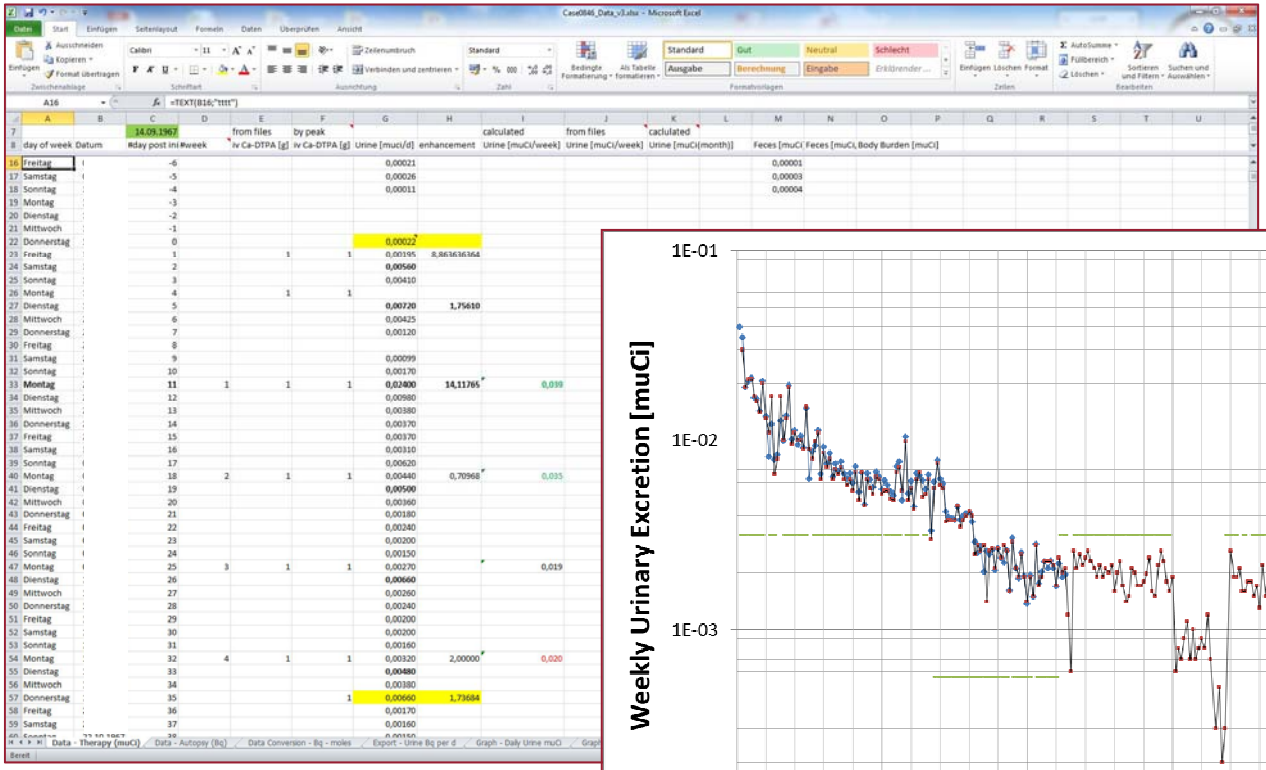
Case 0846 – Materials

- The case has been studied intensively (in 1960s - 1970s)
  - ✓ Several reports and papers in Health Physics Journal
  - ✓ Chapter in book for HPS Summer School 2004
- Bioassay data, exposure and medical records are available at USTUR



Case 0846 – The Dataset

- Data were collected and standardized in MS Excel file



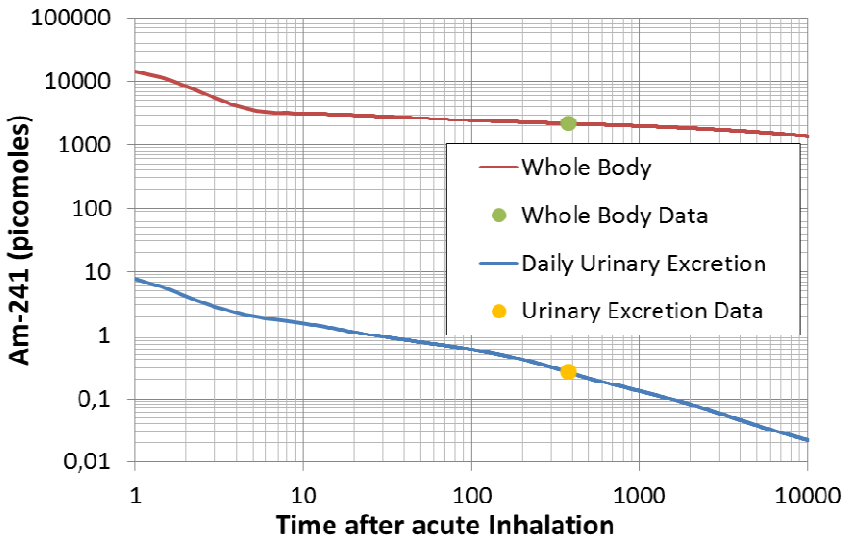
Case 0846 – Original Analysis

- Pre ICRP Publication 30 era
  - ✓ Empirical equations, no compartmental models
- Assumptions
  - ✓ average intake 2 years before therapy
  - ✓ "DTPA complexes americium and plutonium as soon as it leaves bone surfaces and transports the complex to urine for excretion"
- Conclusions
  - ✓ Half of the body burden removed is by action of DTPA
  - ✓ 7 years post therapy "the body burden was 0.72mCi with most of remaining burden in bones"

Quotes taken from: Allen Brodsky and Niel Wald @ HPS SummerSchool 2004

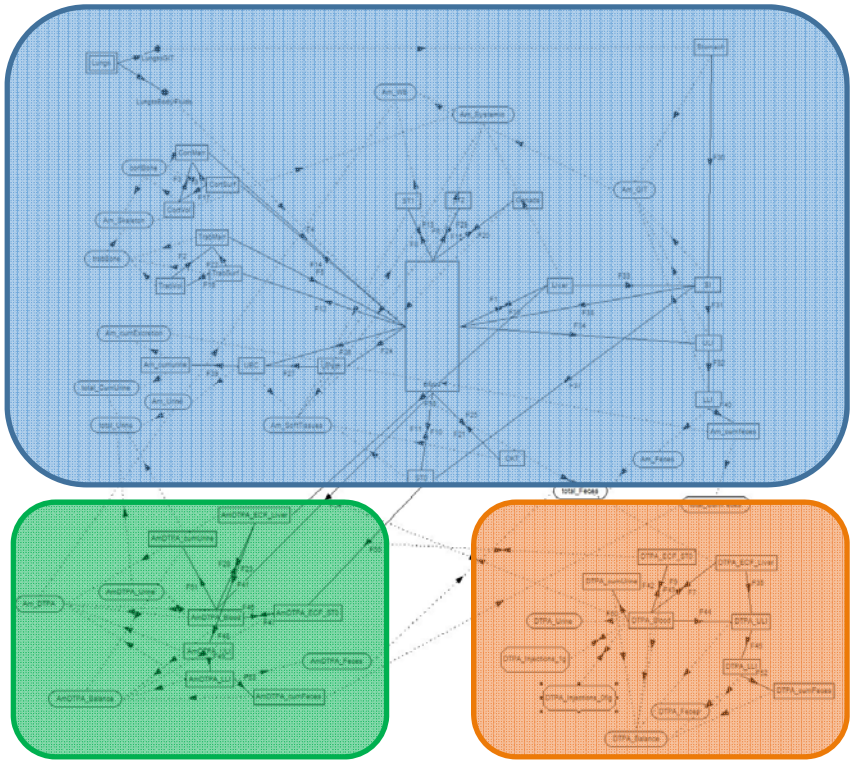
Case 0846 – New Analysis

- ICRP compartmental models and reference values
  - ✓ Lung (ICRP 66, Class M)
  - ✓ Americium systemic (ICRP 67)
  - ✓ GIT (ICRP30, f_1=0.005)
- Definition of initial scenario using pre-therapeutic data and information
  - ✓ Urine: 8.14 Bq/d
  - ✓ Whole body 66.7 kBq
- Acute intake
  - ✓ 1.2 MBq ^{241}Am
  - ✓ 380 days before therapy



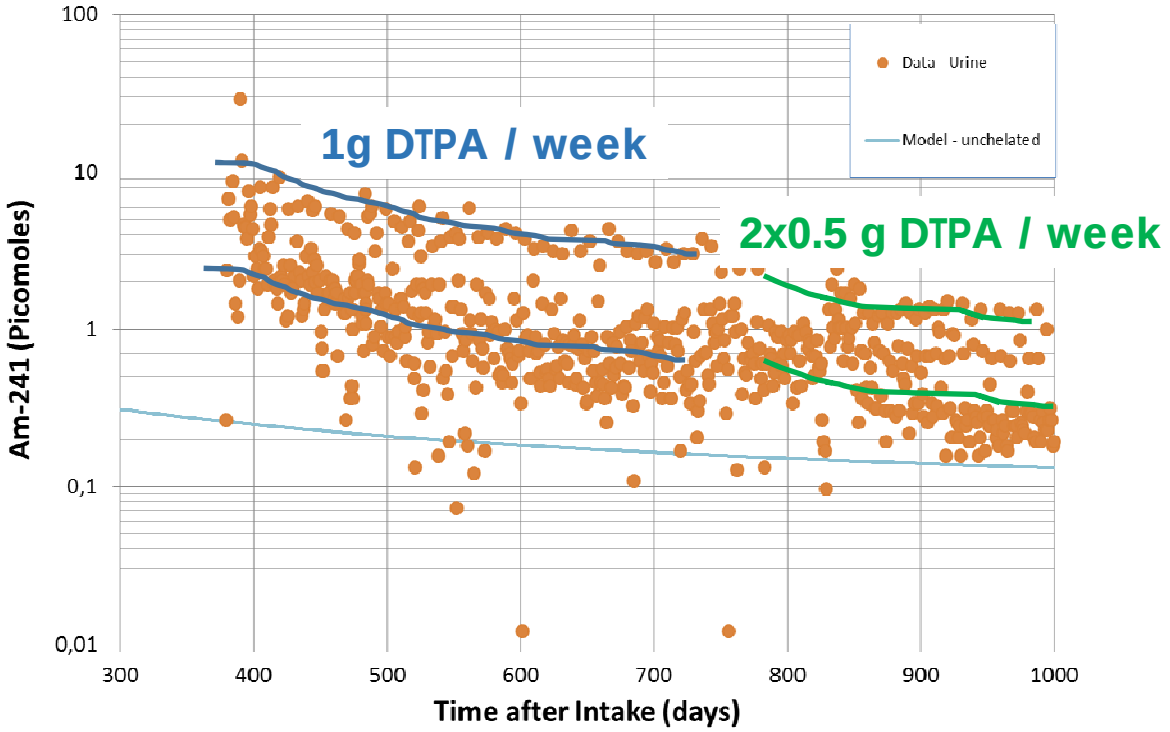
Case 0846 – New Analysis

- CONRAD Model of DTPA therapy
  - ✓ 3 compartmental systems
    - ^{241}Am
    - DTPA (injected)
    - ^{241}Am-DTPA (chelates)
  - ✓ Coupling (2nd order kinetics)
    - Parameter K_c
- Original CONRAD Model
  - ✓ Chelation only in ST0 compartment
- Modified EURADOS Model
  - ✓ Chelation also in other compartments



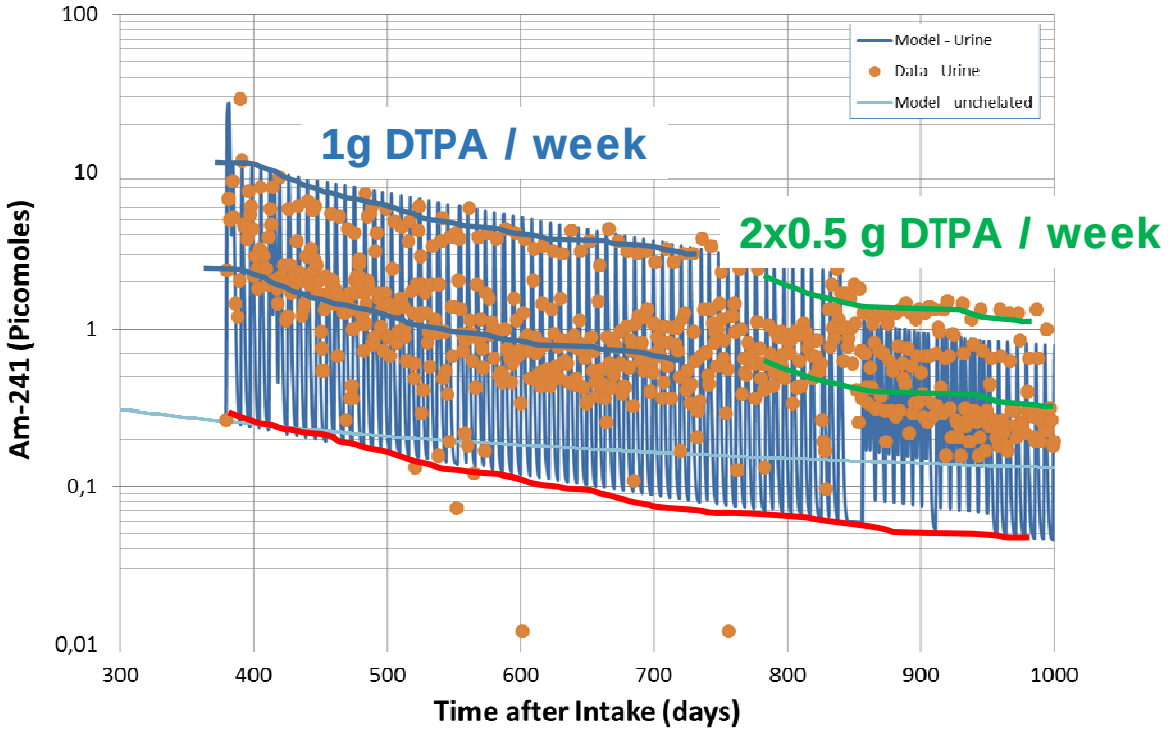
Case 0846 – New Analysis (Cont'd)

- Daily urinary excretion data
  - ✓ Effect of DTPA at day after injection
  - ✓ Elevated and steeper Baseline in between
  - ✓ Enhancement factor: ~5



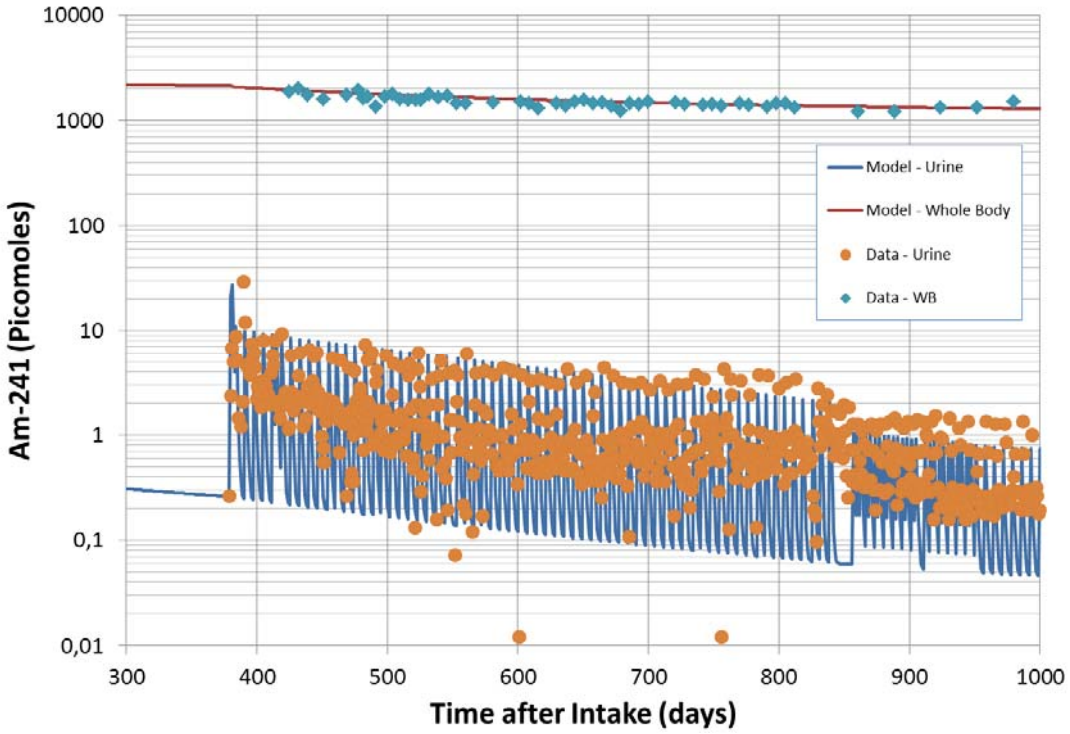
Case 0846 – New Analysis (Cont'd)

- Fitting daily urinary excretion data
  - ✓ Chelation constant K_C = 1E-10
  - ✓ 25% of chelation in liver
  - ✓ Model prediction is dropping below unchelated baseline



Case 0846 – New Analysis (Cont'd)

- Fitting daily urinary excretion and whole body data
  - ✓ K_C = 1E-10 and 25% of chelation in liver
    fit urinary excretion and whole body retention data



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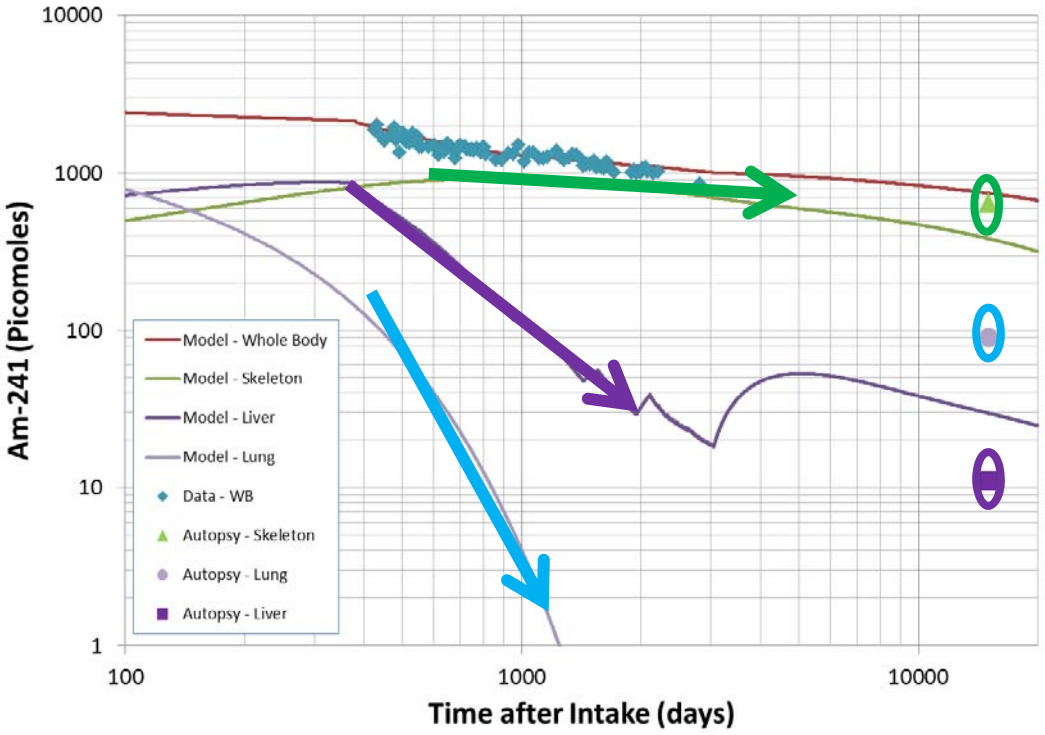
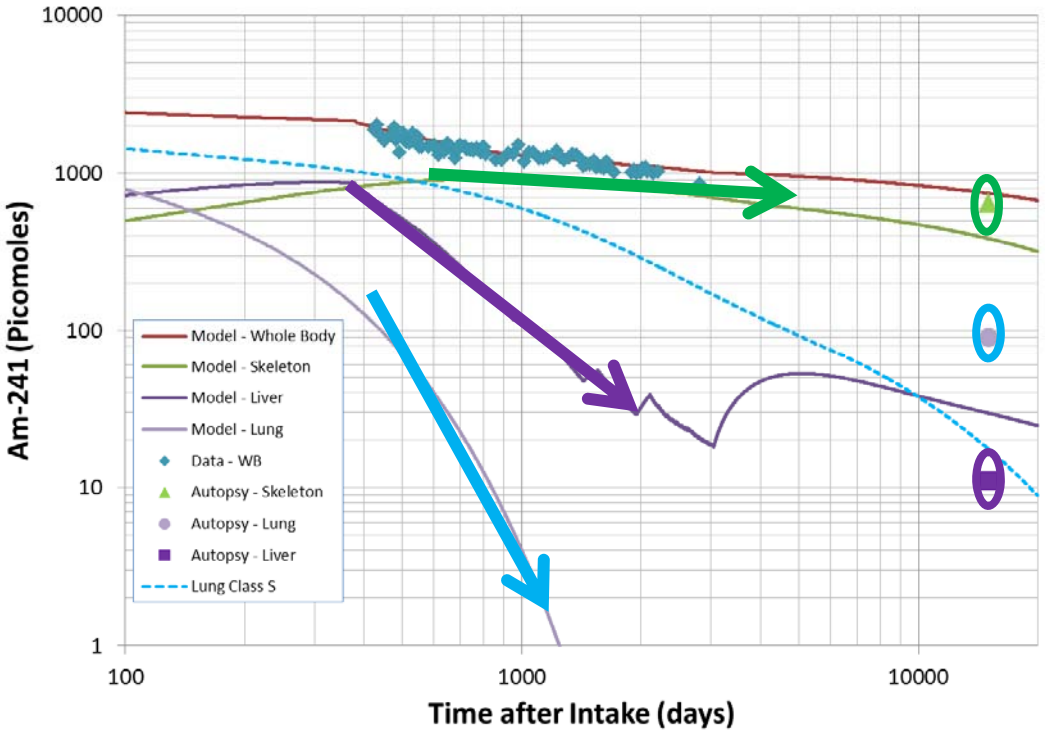
- Prediction of retention in organs
  - ✓ Predictions of retention in liver, skeleton and lungs
  - ✓ Acute inhalation of type M material is not a good choice



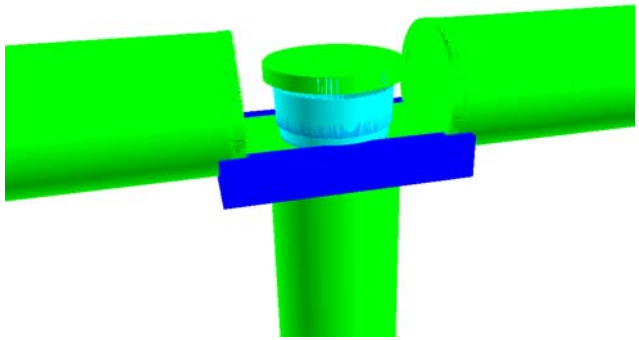
Case 0846 – New Analysis (Cont'd)

- Prediction of retention in organs
  - ✓ Predictions of retention in liver, skeleton and lungs
  - ✓ Acute inhalation of type M material is not a good choice
- The initial scenario needs to be refined



Summary

- The USTUR is unique resource for biokinetic modeling
- USTUR Case 0846
  - ✓ Extensive data set is available
  - ✓ Intake scenario is undefined
    - Many assumptions are required for modeling
  - ✓ Case 0846 contributed to education of students at KIT
    - γ-measurement of 241Am in lung tissue samples
    - MCNP simulations for HPGe detector calibration



Thank you for your Attention

Five Decade Follow-up of Plutonium and Uranium Workers and hopefully many more decades to come

Do you have any questions or suggestions on chelation therapy modeling?

Bastian.breustedt@kit.edu is happy to receive and discuss them