

57th HPS Annual Meeting
July 25, 2012, Sacramento, CA

Maximum Likelihood Analysis of Bioassay Data from Long-term Follow-up of Two Refractory PuO₂ Inhalation Cases

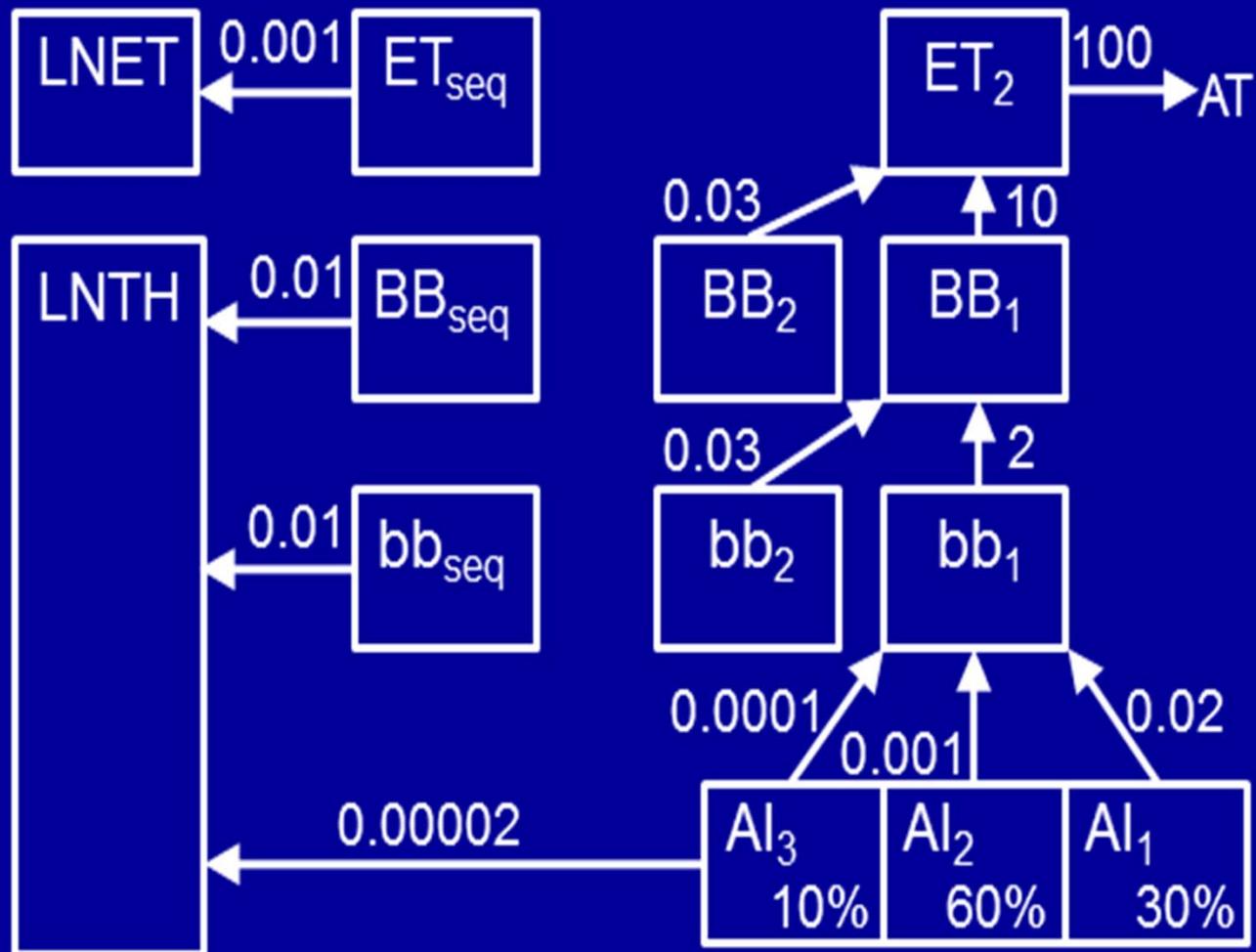
Maia Avtandilashvili^{†‡}, Richard R Brey[‡], Anthony C James[†]

[†]USTUR, Washington State University

[‡]Idaho State University

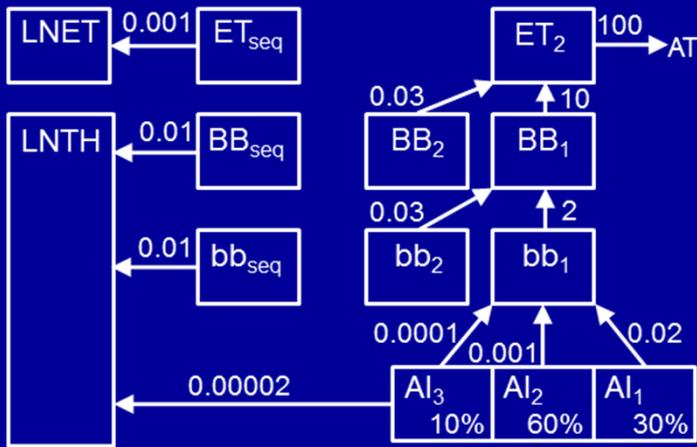
Introduction: Review of HRTM

ICRP Publication 66 (1994)

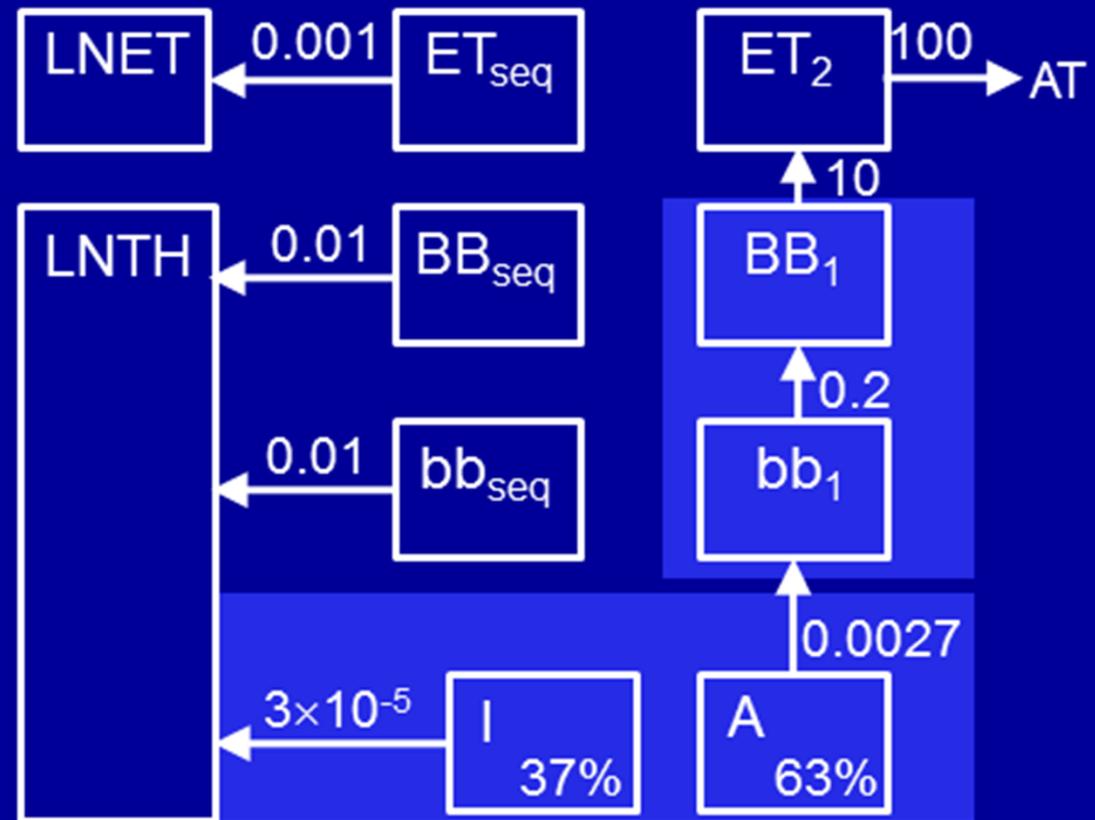


Introduction: Review of HRTM

ICRP Publication 66 (1994)

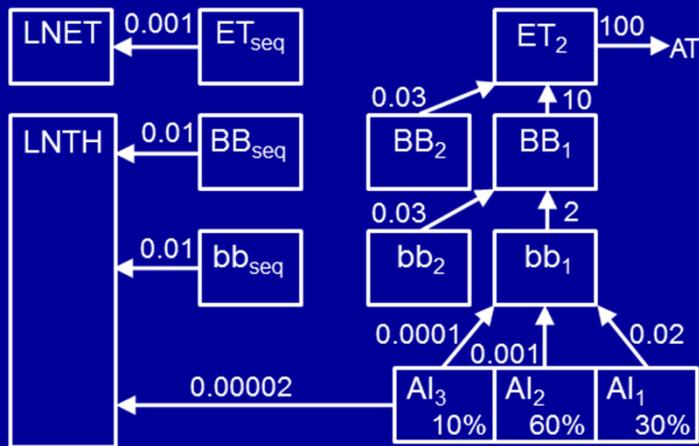


Gregoratto et al. (2010)



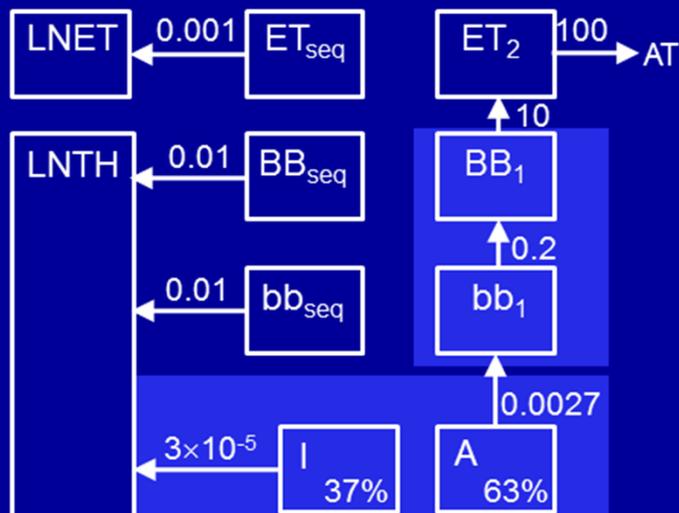
Introduction: Objectives

ICRP Publication 66 (1994)



- Test the models
- Derive the case-specific parameters

Gregoratto et al. (2010)



- Estimate Intake and target tissue doses

Materials and Methods: Accident

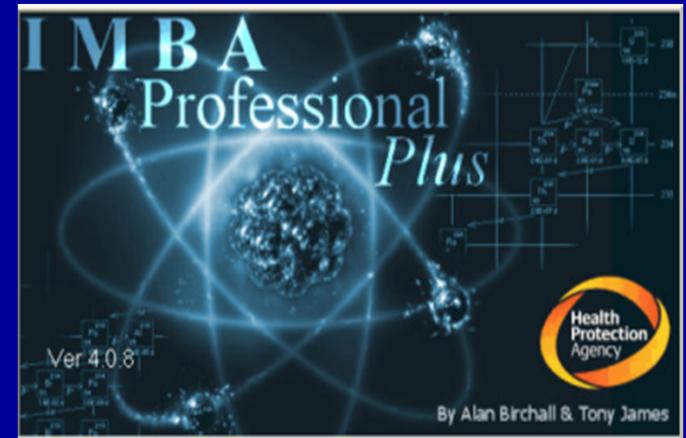
- 1965 Pu fire: Contamination over 6,500 m²
 - Pu-in-Air: ~ 37 mBq m⁻³ to ~ 37 kBq m⁻³
 - Highly refractory PuO₂
 - 0.32-μm MMD ⇒ 1-μm AMAD
 - Initial Am / Pu Mass Ratio: 1,830 ppm
 - *Mann JR, Kirchner RA, Health Phys 13:877-882; 1967*
- USTUR Cases 0202 and 0407
 - Highest exposed of 18 USTUR donors involved
 - Ca-DTPA Treatment: *Ineffective!*
 - Follow-up: Lung Counts, Urine, Feces
 - Post-mortem tissue analyses: Case 0202 only

Materials and Methods: Case Summary

	Case 0202	Case 0407
Lung Burden:	16 kBq	15 kBq
Cause of Death:	Myocardial Infarction	Subarachnoid Hemorrhage
Post-Intake:	18 y	43 y
Smoking History:	1 pack per day	Non-smoker
Lung Pathology:	Exposure to Coal Dust; COPD	None reported

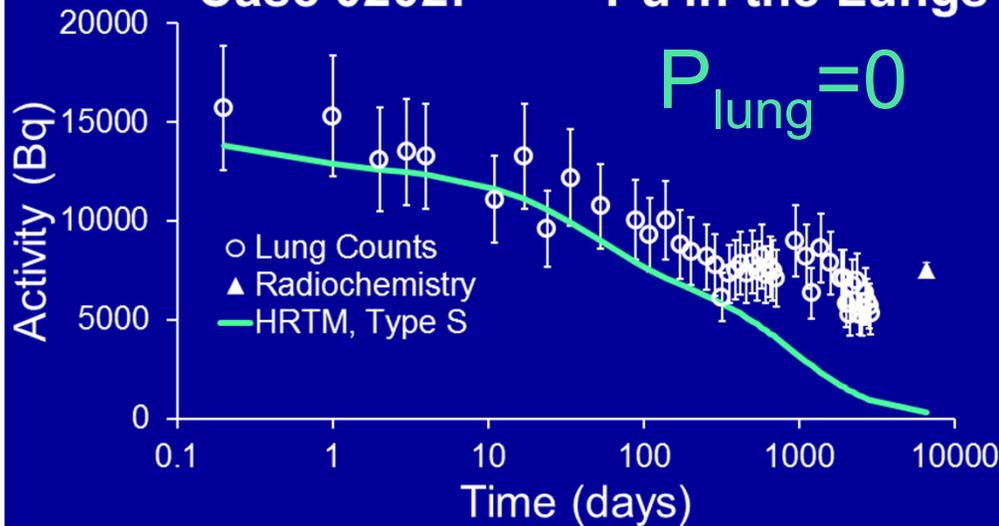
Materials and Methods: Data Analysis

- Internal Dosimetry Software
 - IMBA Professional Plus (IPP)
- Maximum Likelihood Fitting
 - Examine the applicability of a model
 - χ^2 test statistic
 - Optimize the model parameters
 - Estimate the intake and doses

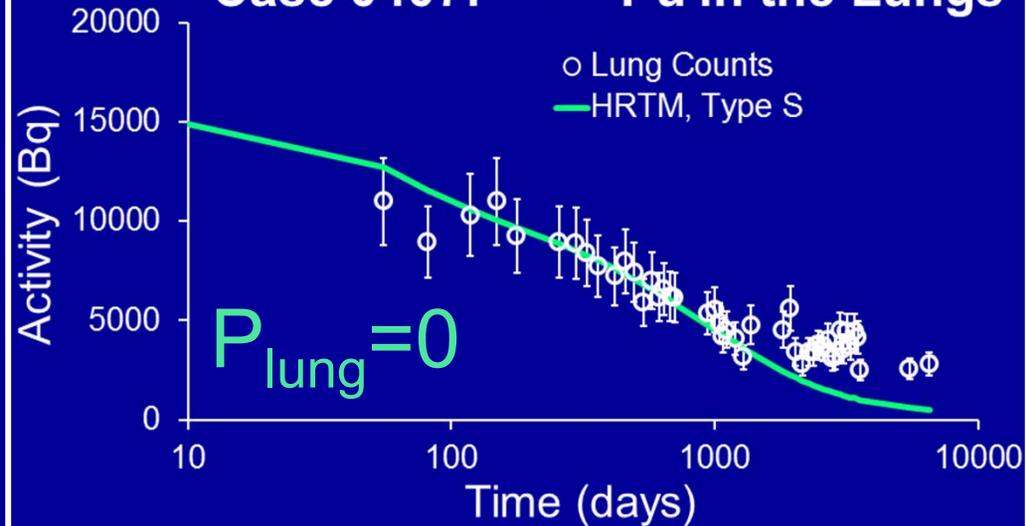


Results: Testing HRTM

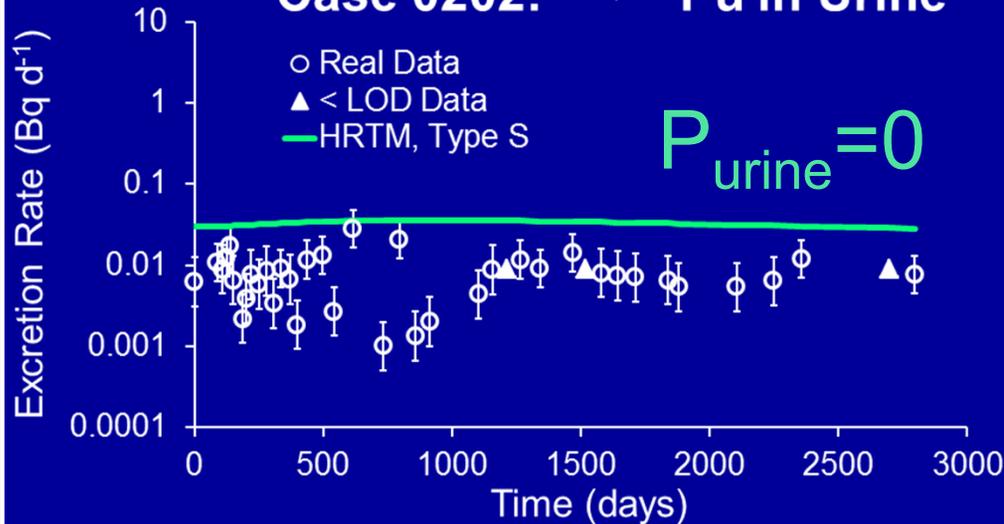
Case 0202: $^{239,240}\text{Pu}$ in the Lungs



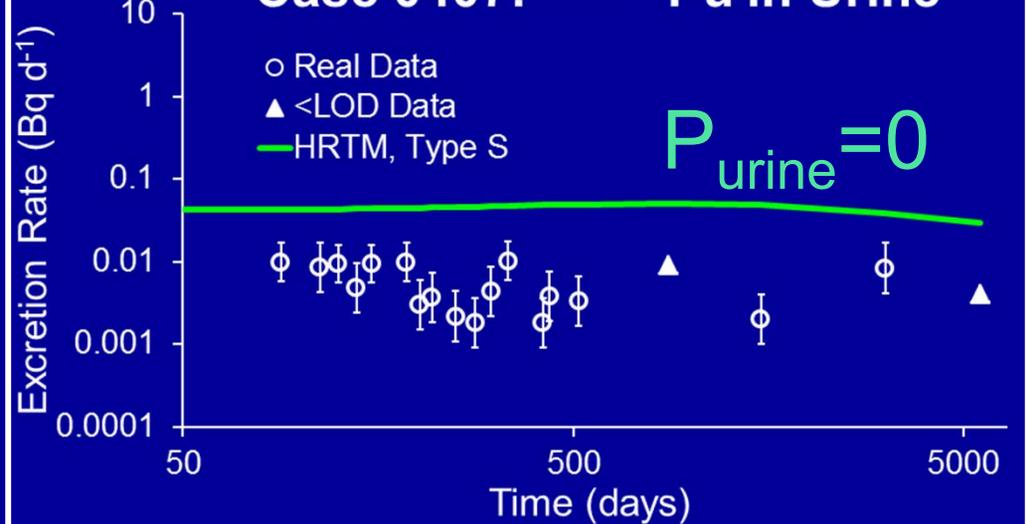
Case 0407: $^{239,240}\text{Pu}$ in the Lungs



Case 0202: $^{239,240}\text{Pu}$ in Urine

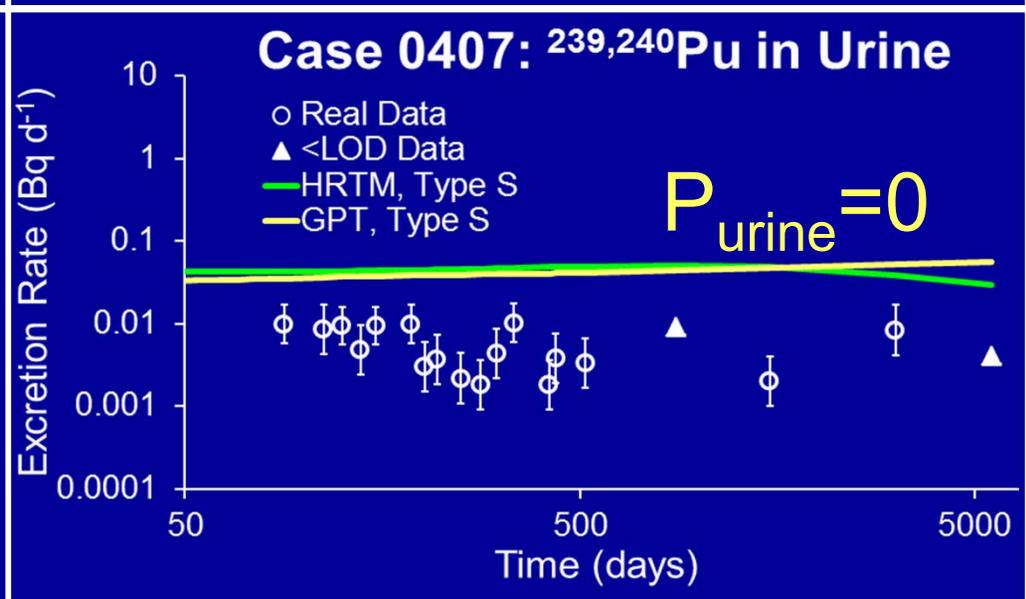
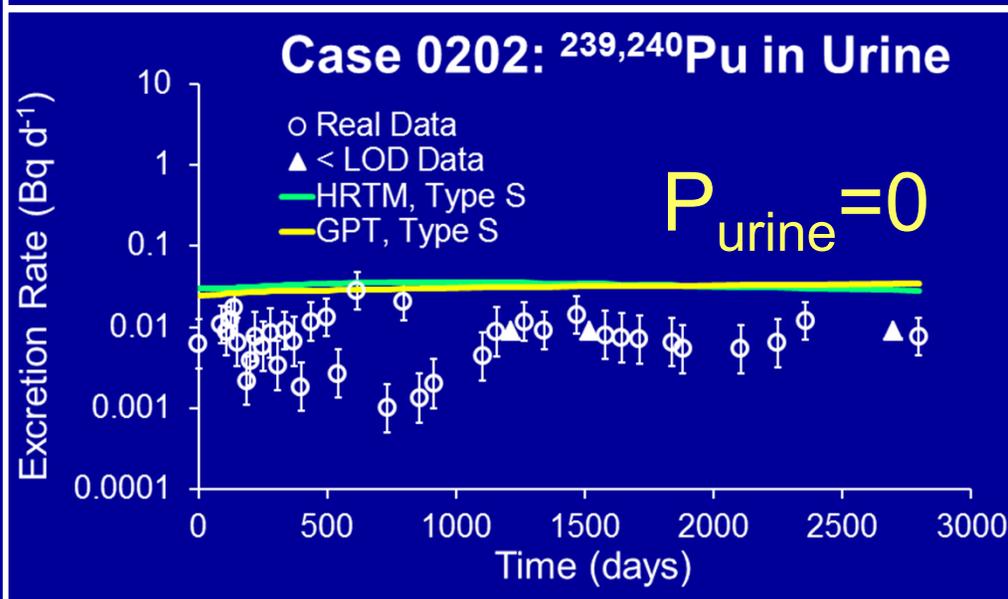
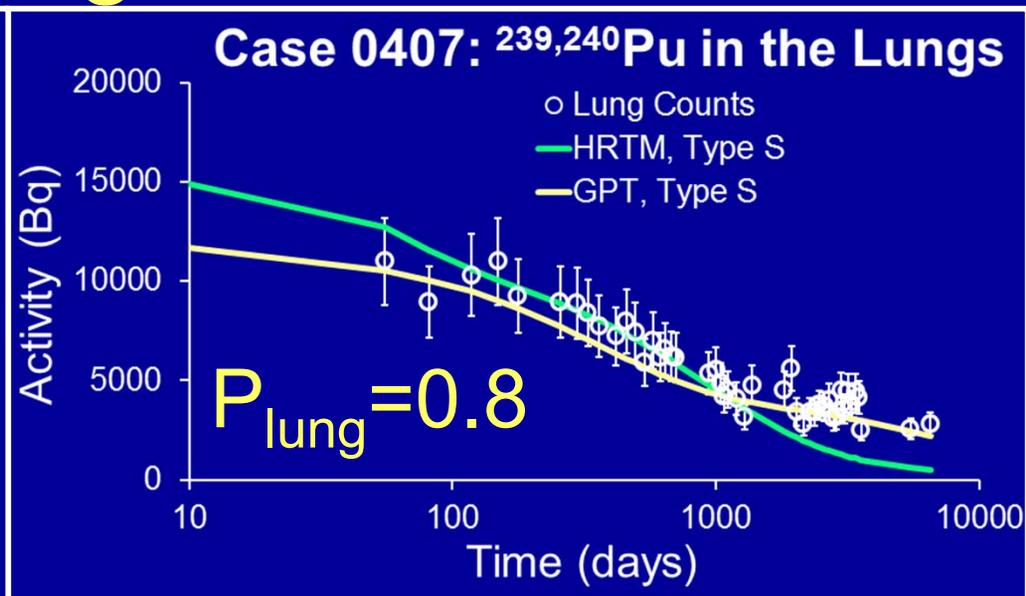
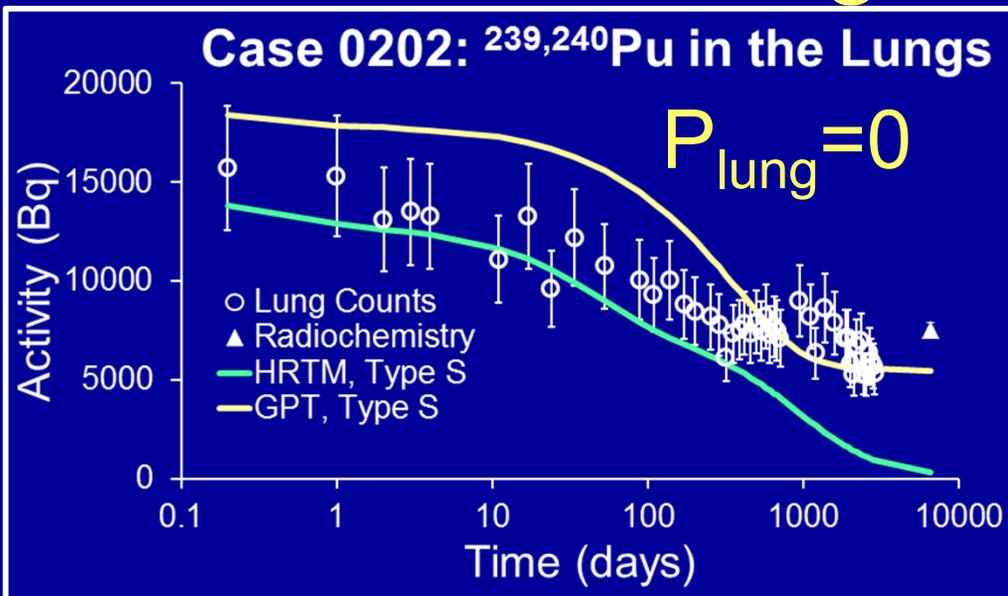


Case 0407: $^{239,240}\text{Pu}$ in Urine



$$P_{\text{liver}}=0; P_{\text{skel}}=0.07$$

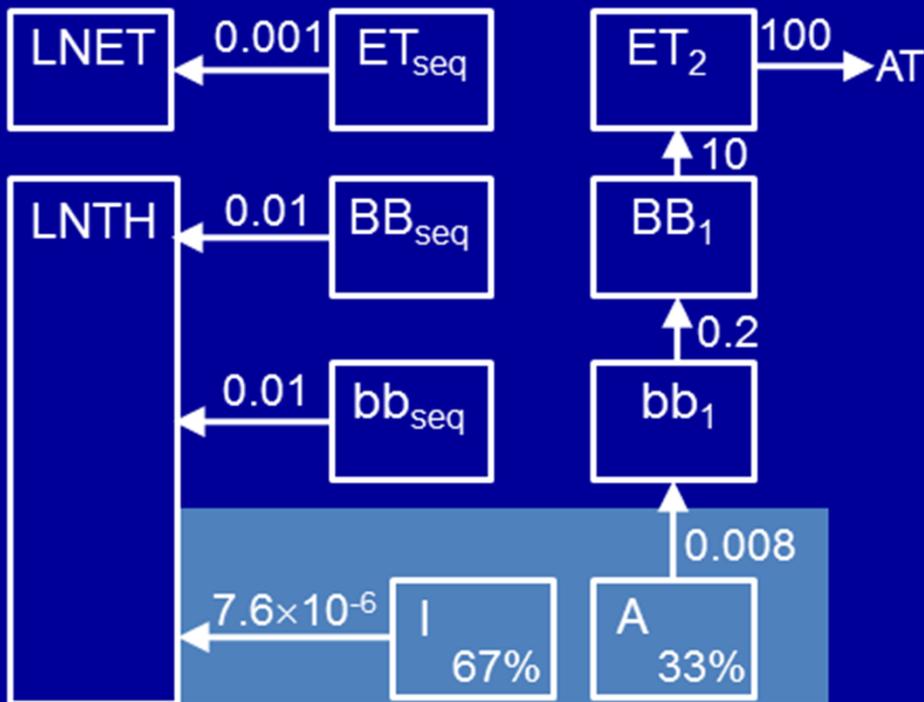
Results: Testing Gregoratto et al. PT



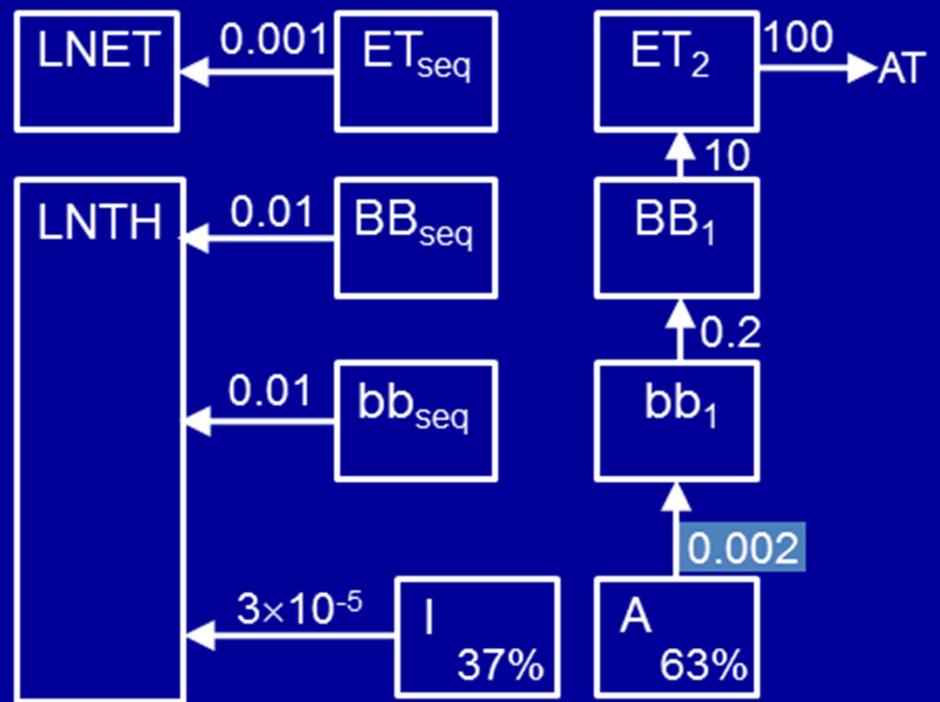
$$P_{\text{liver}}=0; P_{\text{skel}}=0$$

Results: Optimized GPT Models

OGPT - 0202



OGPT - 0407



<i>Parameter</i>	<i>Default</i>	<i>68% CI</i>
Fraction Deposited in Interstitium	0.37	0.2 – 0.7
$A \rightarrow bb, d^{-1}$	0.0027	0.0008 – 0.009
$I \rightarrow LN_{TH}, d^{-1}$	0.00003	n/a

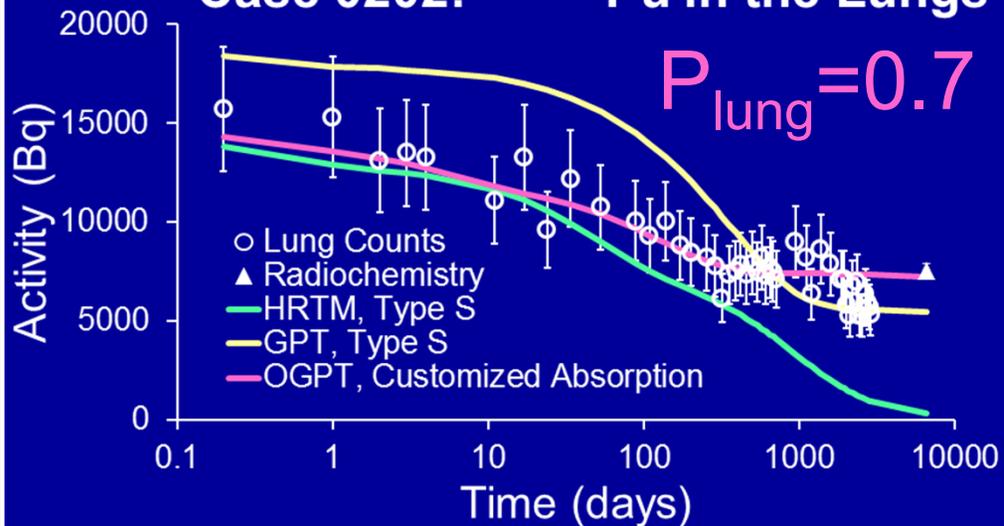
Results: Customized Absorption

Parameter	Type S	Case 0202	Case 0407
f_r	0.001	0.01	0.007
s_r, d^{-1}	100	1.0	1.98
s_s, d^{-1}	1.0×10^{-4}	4.5×10^{-6}	5.3×10^{-6}

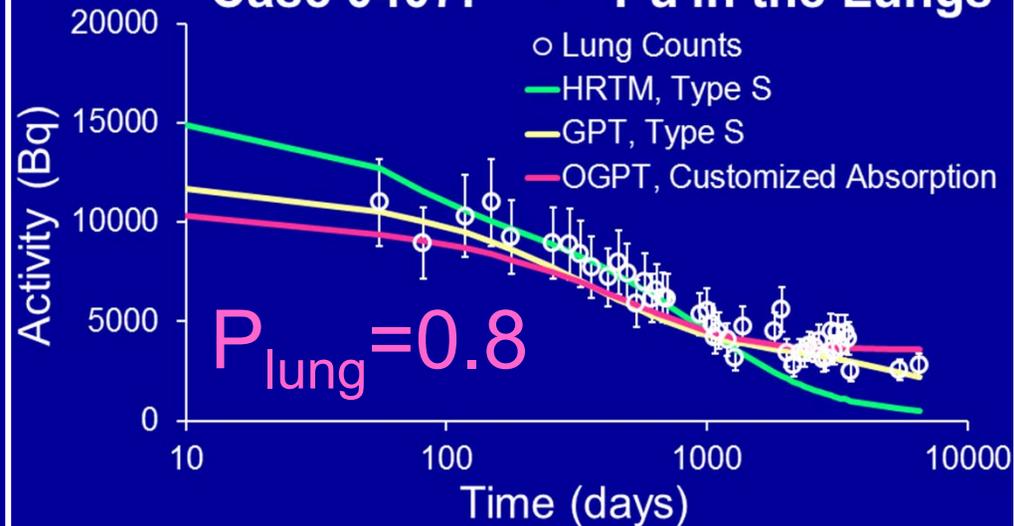
- ✓ PuO₂ particles extremely insoluble
 - ~99% absorbed with a half-life of up to 400 y

Results: Application of Optimized Models

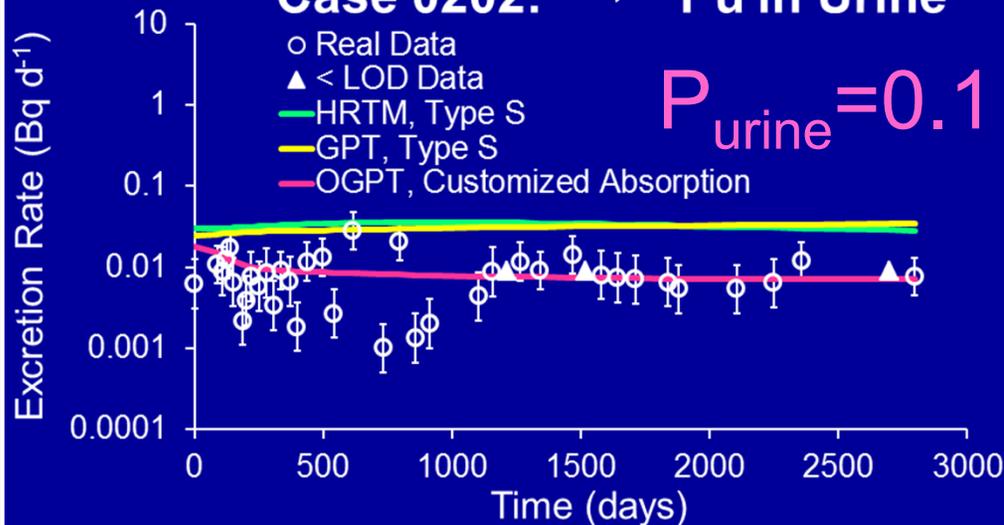
Case 0202: $^{239,240}\text{Pu}$ in the Lungs



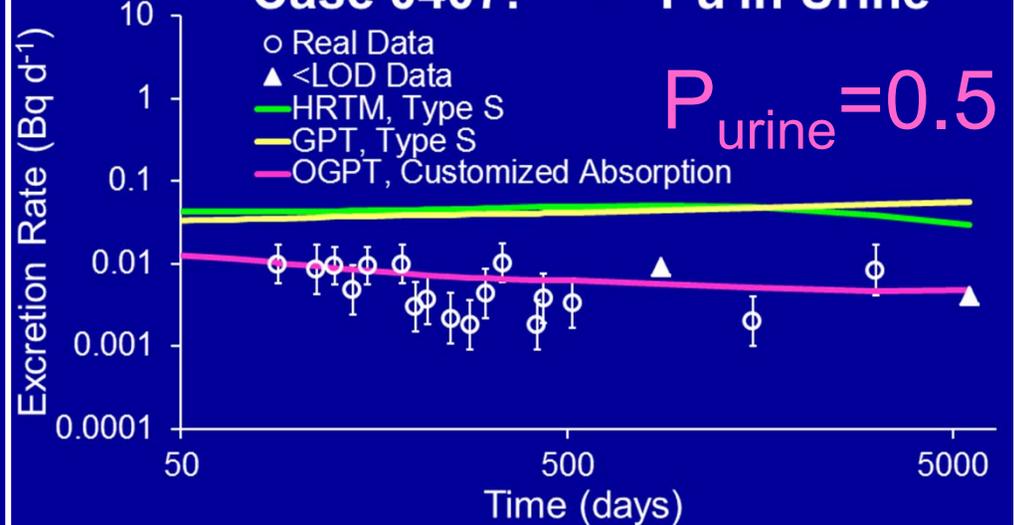
Case 0407: $^{239,240}\text{Pu}$ in the Lungs



Case 0202: $^{239,240}\text{Pu}$ in Urine



Case 0407: $^{239,240}\text{Pu}$ in Urine



$P_{\text{liver}} = 0.9$; $P_{\text{skel}} = 0.8$

Results: Intake and Dose Estimate

- Intake, kBq: 81 (Case 0202); 73 (Case 0407)
- Total Effective Dose, Sv:
 - 7.3 (Case 0202); 3.5 (Case 0407)
- Lung contribution to the total effective dose:
 - Up to ~ 97%
- Liver, bone surface and red bone marrow contribution to the total effective dose:
 - 1.5% or less
- The committed effective dose per unit intake from inhaled $^{239,240}\text{Pu}$, Sv Bq⁻¹:
 - $\sim 9 \times 10^{-5}$ (Case 0202); $\sim 4 \times 10^{-5}$ (Case 0407)
- ICRP DCC for Type S Pu: 8.3×10^{-6} Sv Bq⁻¹

Acknowledgement

- Dedicated to the memory of:



Anthony C James

- Special Thanks to:

Alan Birchall and Matthew Puncher
Health Protection Agency, UK

Thank you for your attention

Questions?

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