Some Aspects of DU Risks

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What is Depleted Uranium?

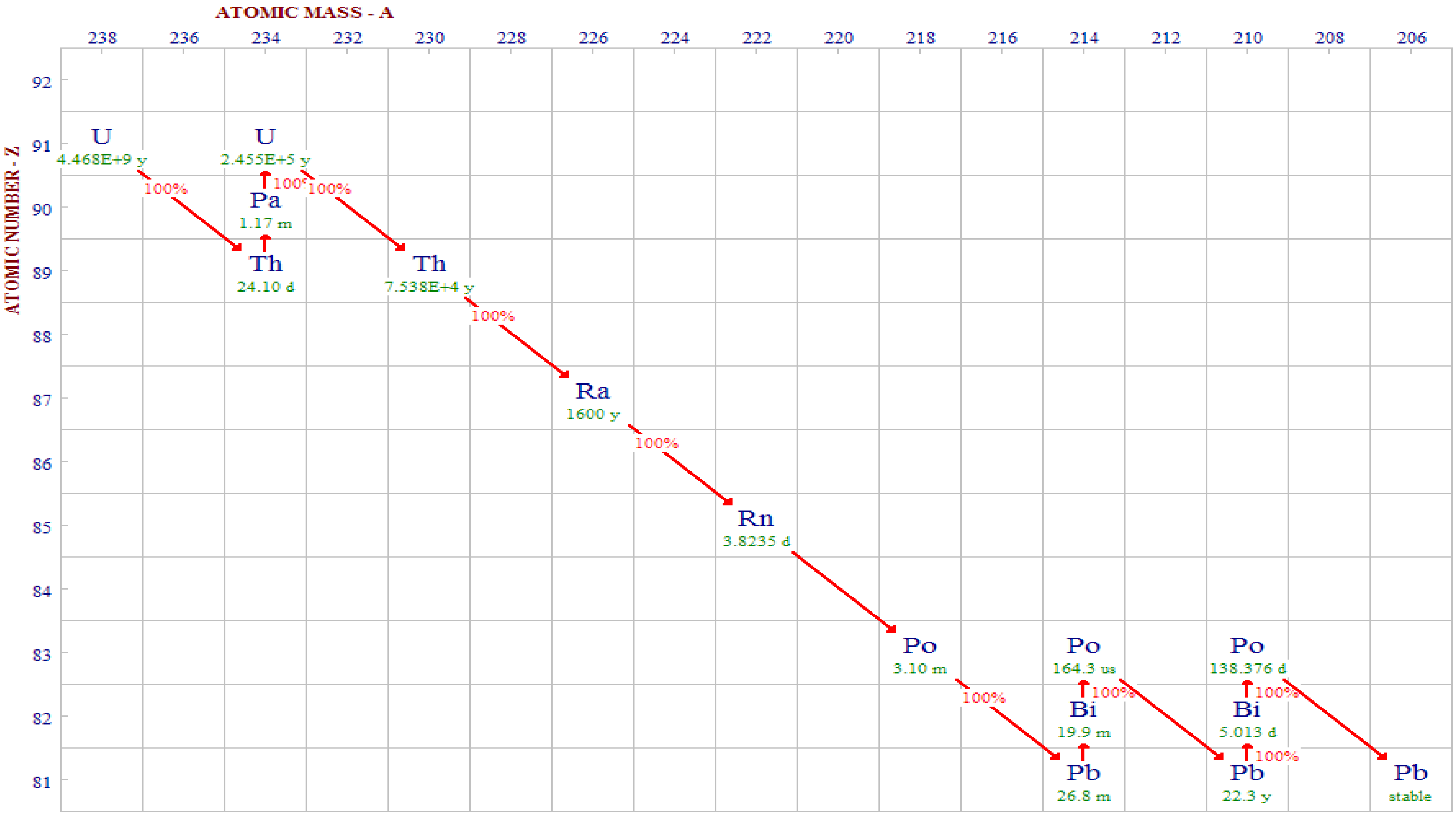
Composition of natural and depleted uranium

Radionuclide	Natural Uranium	Depleted Uranium
U-238	99.284%	99.7 to 99.8%
U-235	0.711%	0.2 to 0.3%
U-234	0.005 %	0.001%

Radiological Properties

Nuclide	Alpha particle energy - MeV	Half-life years
Uranium-238	4.1	4.46 billion
Uranium-235	4.4	0.7 billion
Uranium-234	4.8	245,000
Neptunium-237	4.8	2.14 million
Plutonium-238	5.5	87.7
Plutonium-239	5.1	24,110
Plutonium-240	5.1	6,537
Americium-241	5.5	432

Decay Series U-238



Decay Series U-235

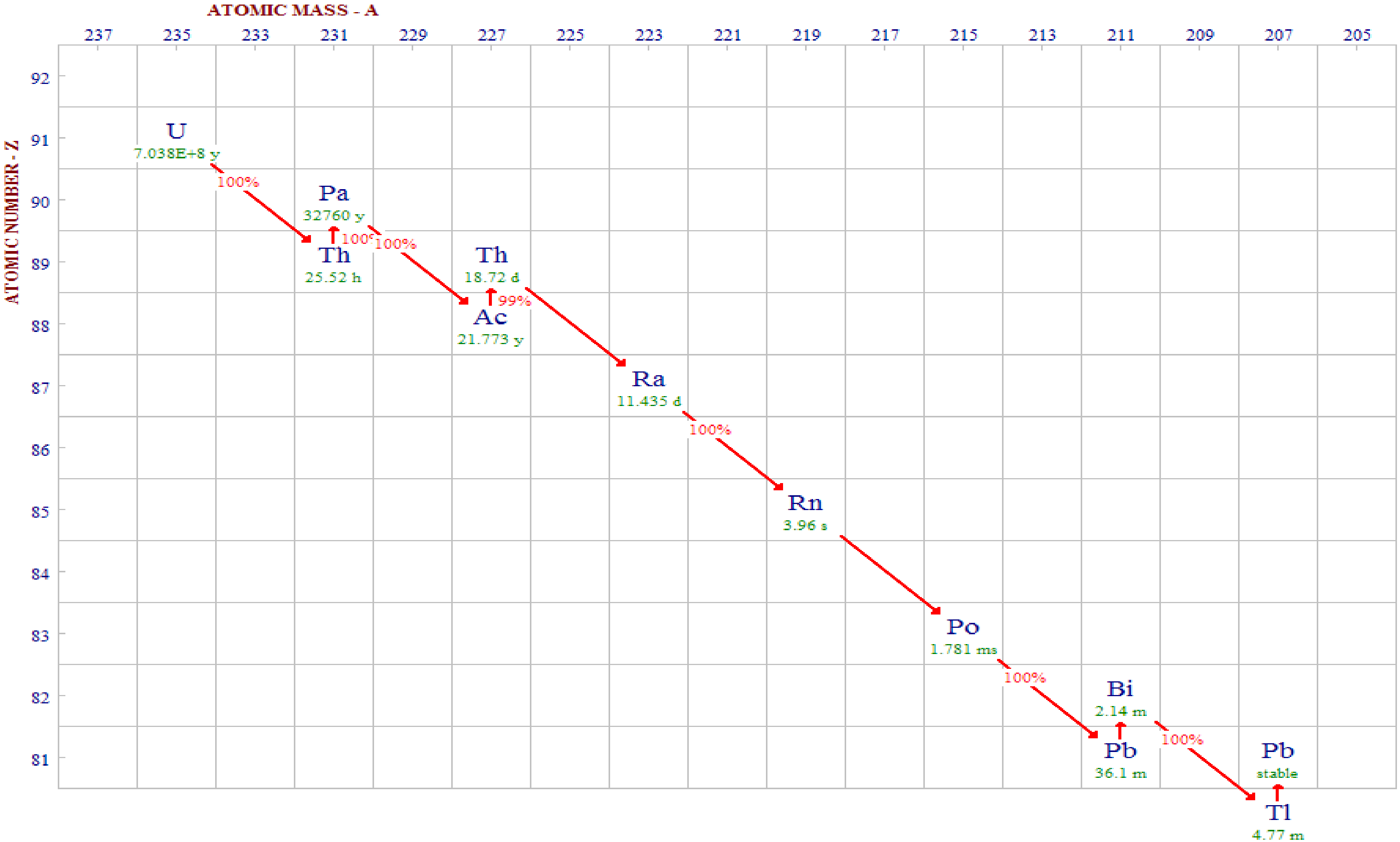
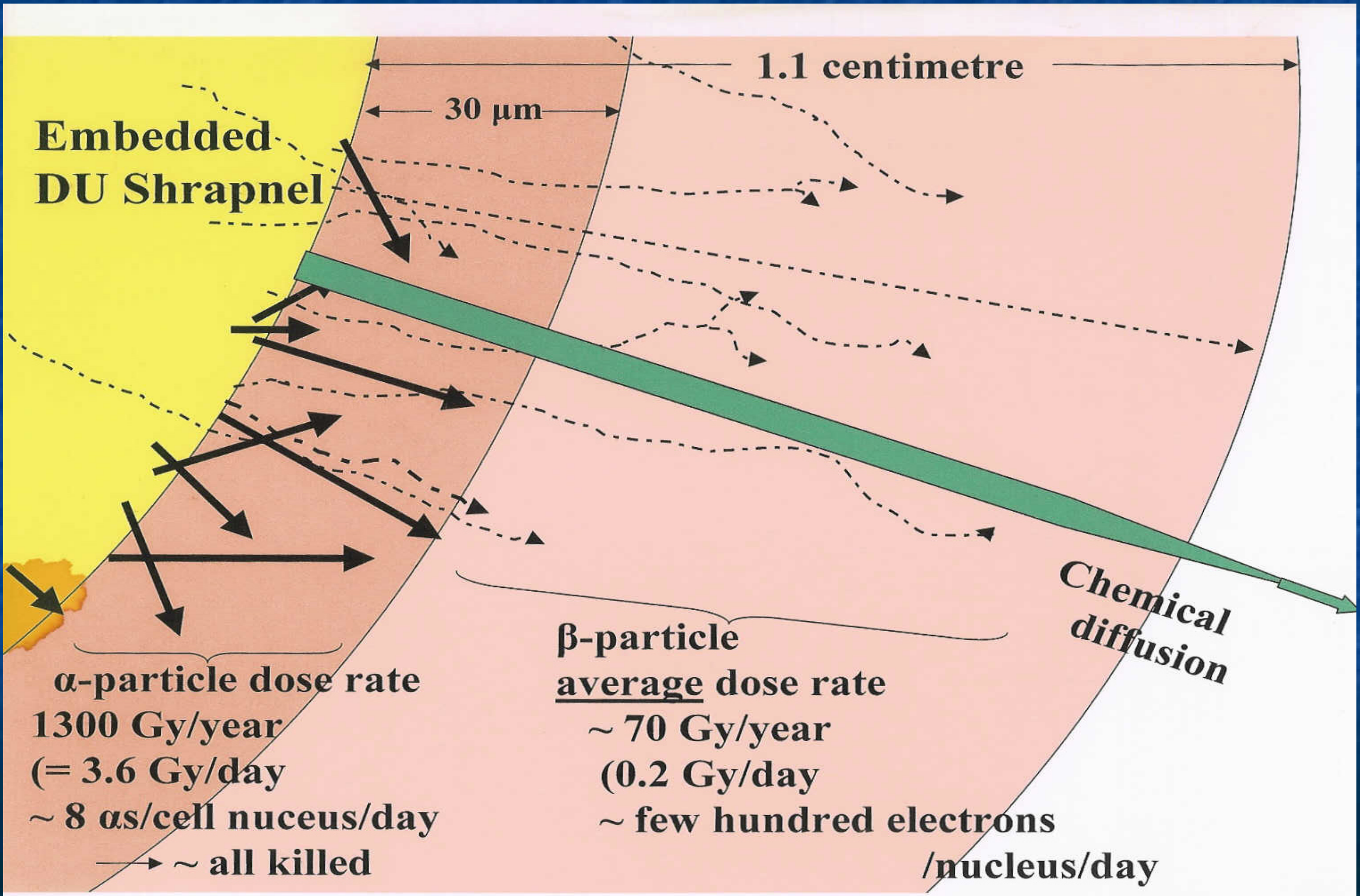


Diagram by Professor Dudley Goodhead



Specific Activities

form	Specific activity kBq/g
uranium metal (DU)	15
uranium oxide (DU_3O_8)	13
uranium mill tailings	>4
0.2% uranium ore	0.15

Uranium metabolism

- uranium concentrates in skeleton, liver, kidneys, testes and brain (WHO 2001 pp65-66)
- rats implanted with DU pellets show uranium concentrates in heart, lung tissue, ovaries and lymph nodes (Arfsten, Still & Ritchie 2001 p182)

Risks of Depleted Uranium

a. heavy metal (chemical oxidative stress)
b. radionuclide (ionisation of DNA)
c. addition (a+b)
or possible synergy (a x b)

Research indicates uranium is a

•Carcinogen	}	
•Mutagen	}	radiation
•Teratogen	}	effects
•Cytotoxin	}	
•Neurotoxin	}	chemical
•Nephrotoxin	}	effects
•Renotoxin	}	

Radiation and Chemical Effects

- DU is currently regulated primarily on its chemical hazard alone
- radiation hazard assumed to be of less concern
- what about additive or synergistic effects?

Possible Synergism between Chemical and Radiological Effects?

- synergistic response when cadmium exposures combined with gamma radiation Miller et al. 2002b p. 275
- bystander cells (ie not irradiated) vulnerable to both radiation-induced and chemical-induced effects

Miller et al 2002b, p. 277

Relative Roles Of Radiological/Chemical Hazards of DU -A Significant Issue

- DU caused increases in dicentric chromosome aberrations - not observed with heavy metals. Miller et al. 2002a p. 121-122
- Number of neoplastic transformations depended on activity not on the U isotope Miller et al. 2002b p. 275
- DU capable of inducing “oxidative DNA damage in the absence of significant decay.” Miller et al. 2002c p. 251
- U radiological and chemical effects might play tumour-initiating and tumour-promoting roles Miller et al 2004 p. 254

Dr Alexandra Miller

Armed Forces Radiobiology Research Institute, US

Alexandra C Miller, et al Transformation of human osteoblast cells to the tumorigenic phenotype by depleted uranium-uranyl chloride. Environmental Health Perspectives; v.106, no. 8 (1998 Aug). pp.465-471.	Alexandra C. Miller et al. “Depleted uranium-catalyzed oxidative DNA damage: absence of significant alpha particle decay.” Journal of inorganic biochemistry, v. 91 (2002). pp. 246-252.
Alexandra C. Miller, et al “Potential health effects of the heavy metals, depleted uranium and tungsten, used in armorpiercing munitions: comparison of neoplastic transformation, mutagenicity, genomic instability, and oncogenesis.” Metal Ions in Biology and Medicine, v. 6 (2000). pp. 209-211.	Alexandra C. Miller, et al. “Genomic instability in human osteoblast cells after exposure to depleted uranium: delayed lethality and micronuclei formation.” Journal Of Environmental Radioactivity, v. 64, nos. 2-3 (2003). pp. 247-259
Alexandra C. Miller, et al “Potential late health effects of depleted uranium and tungsten used in armor-piercing munitions: Comparison of neoplastic transformation and genotoxicity with the known carcinogen nickel.” Military medicine, v.167, Supplement 1 (Feb. 2002). pp. 120-122.	Alexandra C. Miller, et al “Effect of the militarily-relevant heavy metals, depleted uranium and heavy metal tungstenalloy on gene expression in human liver carcinoma cells (HepG2). Molecular and cellular biochemistry, v. 255 (2004). pp. 247-256.
Alexandra C. Miller, et al “Observation of radiation-specific damage in human cells exposed to depleted uranium: dicentric frequency and neoplastic transformation as endpoints.” Radiation protection dosimetry, v. 99, nos.1-4 (2002). pp. 275-278.	Alexandra C. Miller,et al. “Leukemic transformation of hematopoietic cells in mice internally exposed to depleted uranium” Molecular and Cellular Biochemistry, Volume 279, Numbers 1-2, November (2005) pp. 97-104(8).

Untargetted effects of radiation

- Bystander effect
- Genomic instability
- Minisatellite mutations

Completely different from classical theory of radiation’s effects – ie DNA damage

Not yet taken into account -re radiation risks

Uncertainties in Doses/Risks

- CERRIE Report found major uncertainties in internal emitters doses/risks www.cerrie.org
- Uncertainties in doses could be up to 100-1000 fold in some cases
- CERRIE pressed for Precautionary Approach to be used in assessing risks of from intakes of alpha and beta emitters

Uncertainties in Dose Coefficients

(Goossens et al, 1998)

Goossens LHJ, Harper FT, Harrison JD, Hora SC, Kraan BCP, Cooke RM (1998) Probabilistic Accident Consequence Uncertainty Analysis: Uncertainty Assessment for Internal Dosimetry: Main Report. Prepared for U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, USA. And for Commission of the European Communities, DG XII and XI, B-1049 Brussels Belgium. NUREG/CR-6571 EUR 16773.

Nuclide	**Intake**	**Organ**	**Range (95th / 5th percentiles)**
Cs-137	ingestion	red bone marrow	4
I-131	inhalation	thyroid	9
Sr-90	ingestion	red bone marrow	240
Sr-90	ingestion	bone surface	390
Pu-239	ingestion	red bone marrow	1,300
Sr-90	inhalation	lungs	5,300
Ce-144	inhalation	red bone marrow	8,500
Pu-239	ingestion	bone surface	20,000

Uncertainties in Biokinetic Parameters (adults)

Leggett RW (2001) Reliability of the ICRP's dose coefficients for members of the public. 1. Sources of uncertainty in biokinetic models. Radiation Protection Dosimetry Vol. 95, No 3, pp 199-213.

Biokinetic Parameter	Range (95th / 5th)
% Absorption of Cs oxides to blood from GI tract	2
% Ret'n of blood Pu- endosteal bone surfaces > 10 y	5
% Retention of blood Sr in liver and skeleton > 10 y	10
% Retention of insoluble particles (1 um AMAD) in pulmonary region after 10 y	100
% Absorption of Ru oxides (1 um AMAD) to blood from respiratory tract 10 y after deposition	200
% Retention insol particles (1 um AMAD) in TB > 1 y	1000
% Absorption of Pu oxides to blood from GI tract	2000
% Retention of blood Cs in whole body after 5 y	10,000,000
% Retention insol particles (1 um AMAD) in TB >10 y	100,000,000

Conclusions 2

- As we find out more from radiobiology - U toxicity increases
- New radiation effects are not being taken into account
- CERRIE – large uncertainties in doses of some alpha emitters
- Need to adopt Precautionary Principle

Conclusions 1

- DU and U essentially the same
- Betas as important as alphas
- Possible synergism/additive effects important
- Indicative evidence that U's radiological effects as great as chemical effects
- Because of lack of epidemiology, difficult to establish U risks with precision