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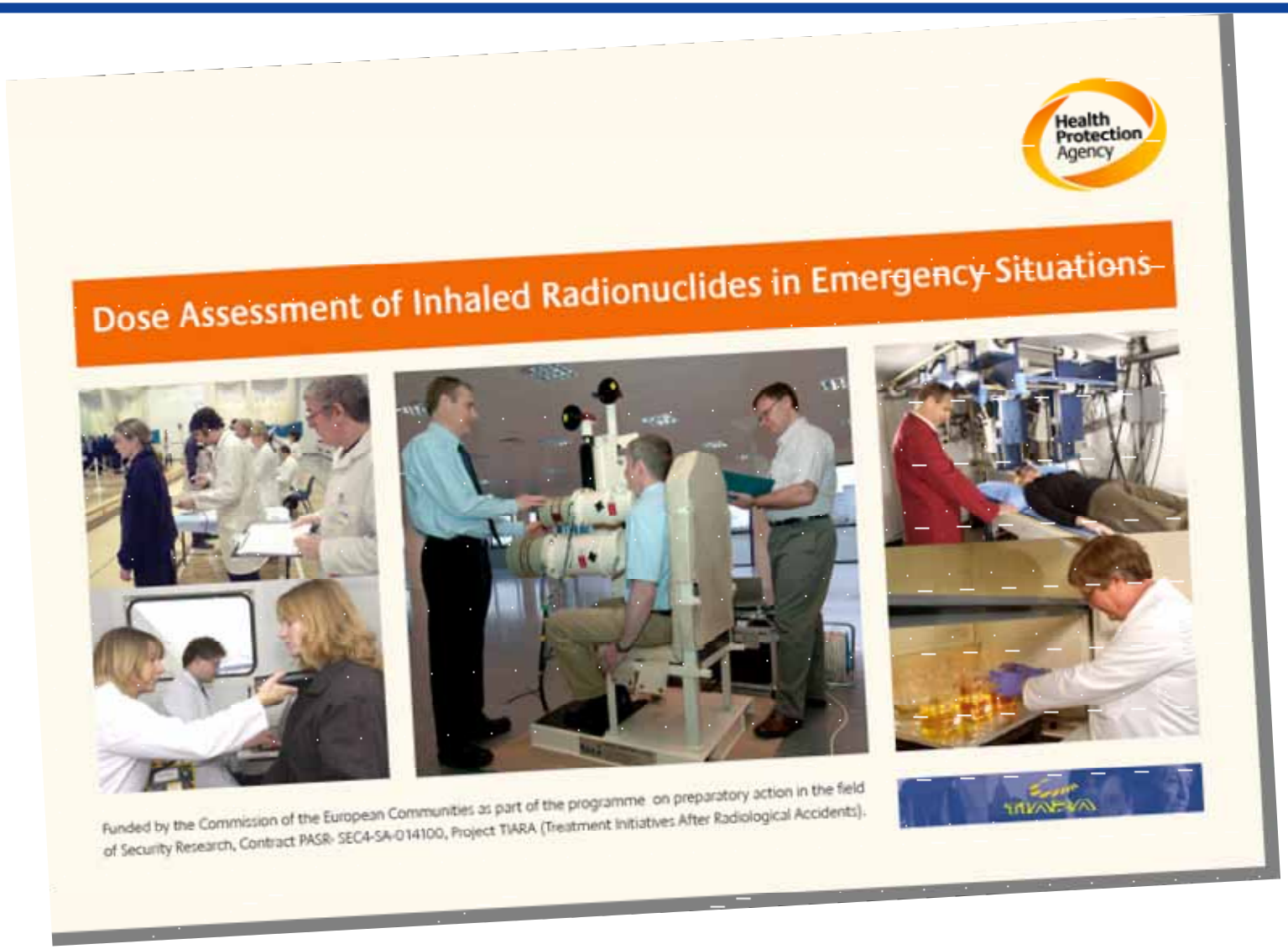
Rapid application of models in internal dosimetry, from monitoring data to dose

4th EURADOS Winter School
Radiological emergencies – Internal exposures
Rome, 3 February 2010

TIARA project



TIARA project

Treatment Initiatives After Radiological Accidents

Objectives

- Provide guidance on dose assessment and efficacy of treatment
- Foresee the operational needs for treating mass casualties
- Monitor and pursue development of new treatments

TIARA project

Treatment Initiatives After Radiological Accidents

Participants (Medics)

CEA, France – Florence Menetrier (Chair), Phillipe Berard

CIEMAT, Spain – Miguel-Angel Morcillo, David Cebrian

FZK, Germany – Volker List

STUK, Finland – Wendla Paile

INM, UK – David Holt

Karolinska Institute, Sweden – Siegfried Joussineau

SRV, Sweden – Tore Eriksson, Jan-Anders Holmlund

HPA, UK – Alan Hodgson, Neil Stradling

ICRP biokinetic models (www.icrp.org)

Human Respiratory Tract Model (HRTM)

Publication 66 (1994)

Clearance – competition between absorption and particle transport

Radionuclide specific Systemic models

Publications 56 (1990), 67 (1994), 69 (1995)

Gut uptake model

Publication 30 (1979)

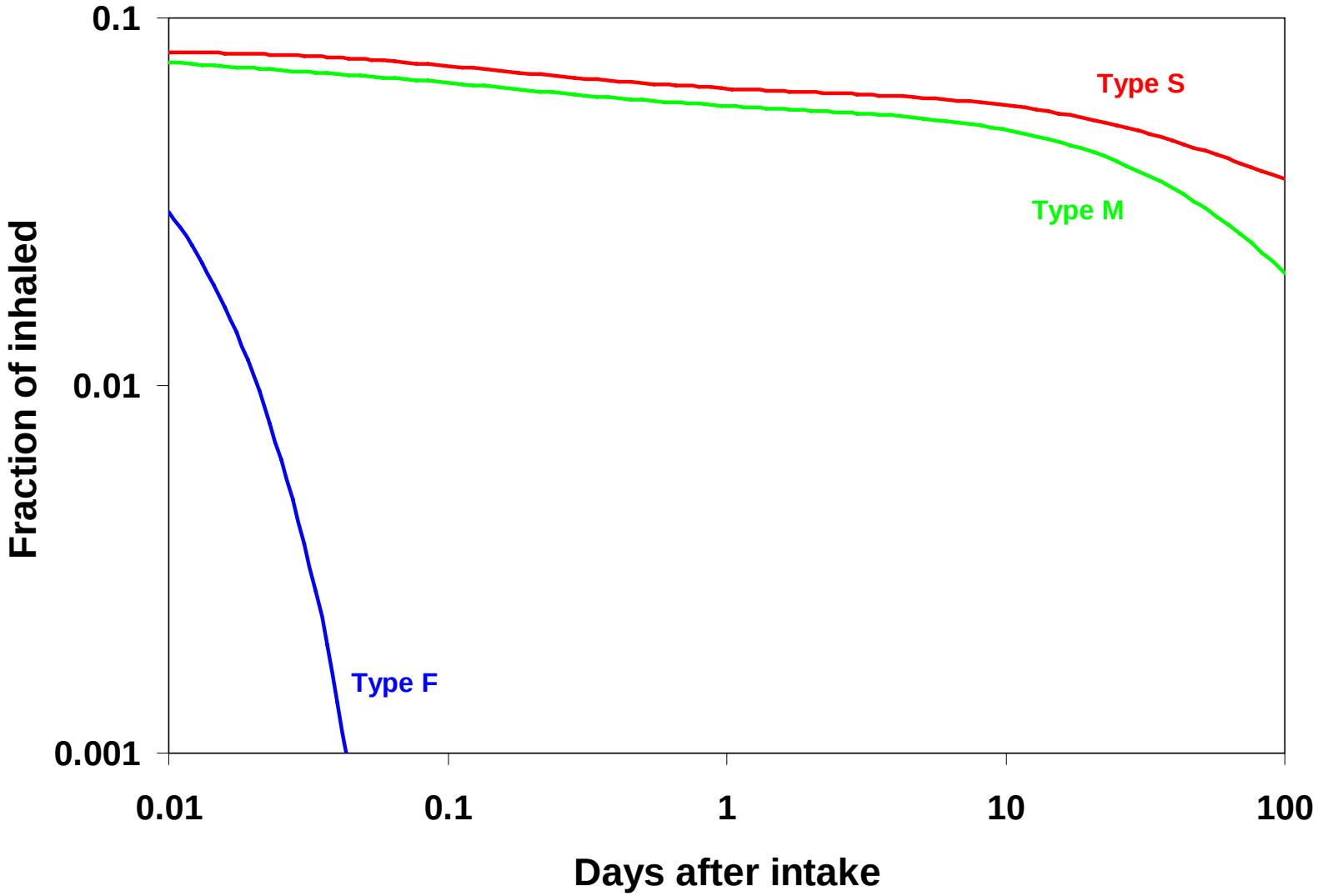
Human Alimentary Tract (HAT) model

Publication 100 (2007)

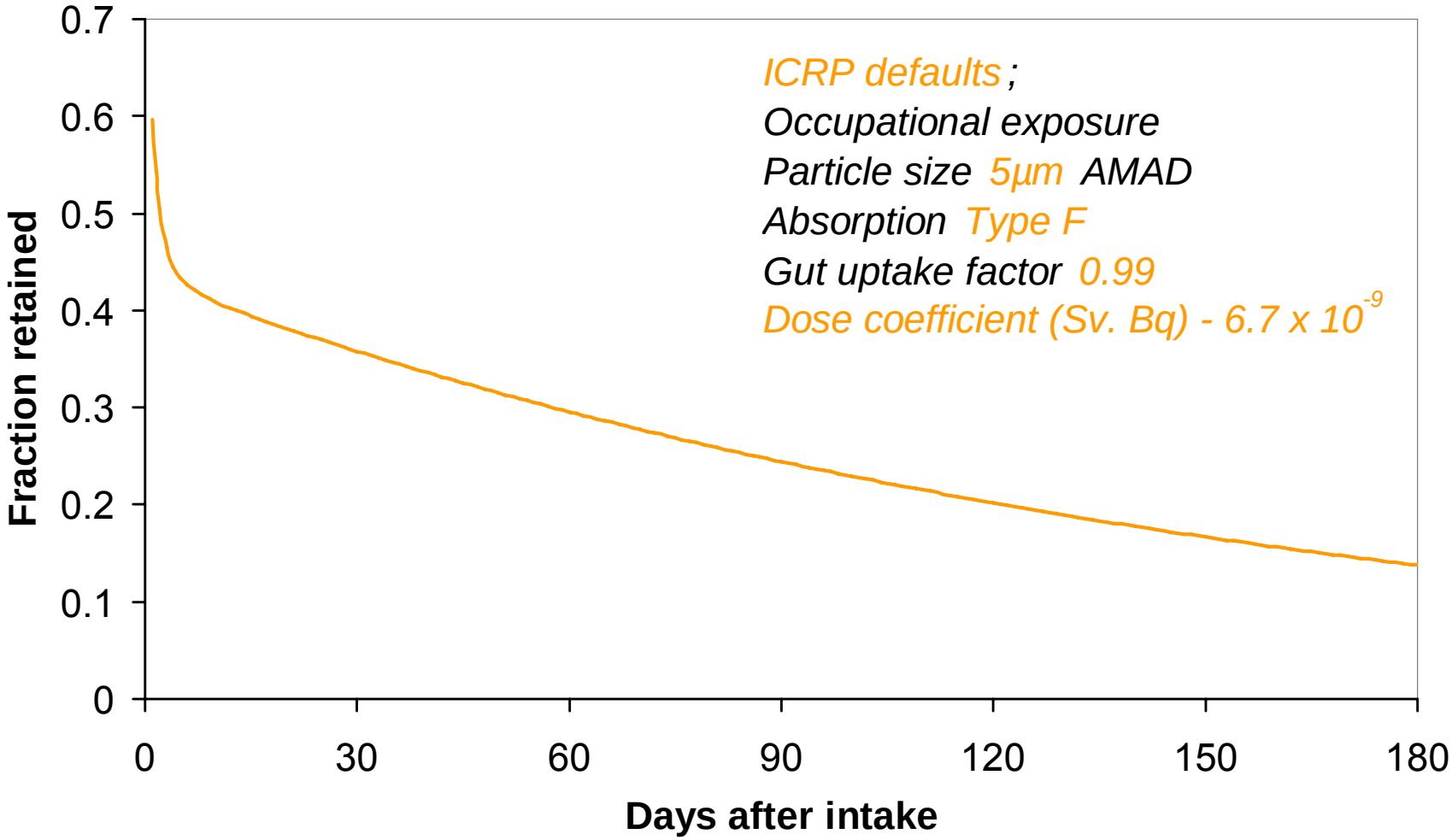
ICRP Absorption Types

ICRP Type	Rapid		Slow	
	Fraction (f_r)	Rate (s_r)	Fraction ($1-f_r$)	Rate (s_s)
Fast	1 (100%)	100 (*t/2* ~10 mins)	-	-
Moderate	0.1 (10%)	100 (*t/2* ~10 mins)	0.9 90%	5×10^{-3} *t/2* ~140 days
Slow	0.001 (0.1%)	100 (*t/2* ~10 mins)	0.999 (99.9%)	1×10^{-4} (*t/2* ~7000 days)

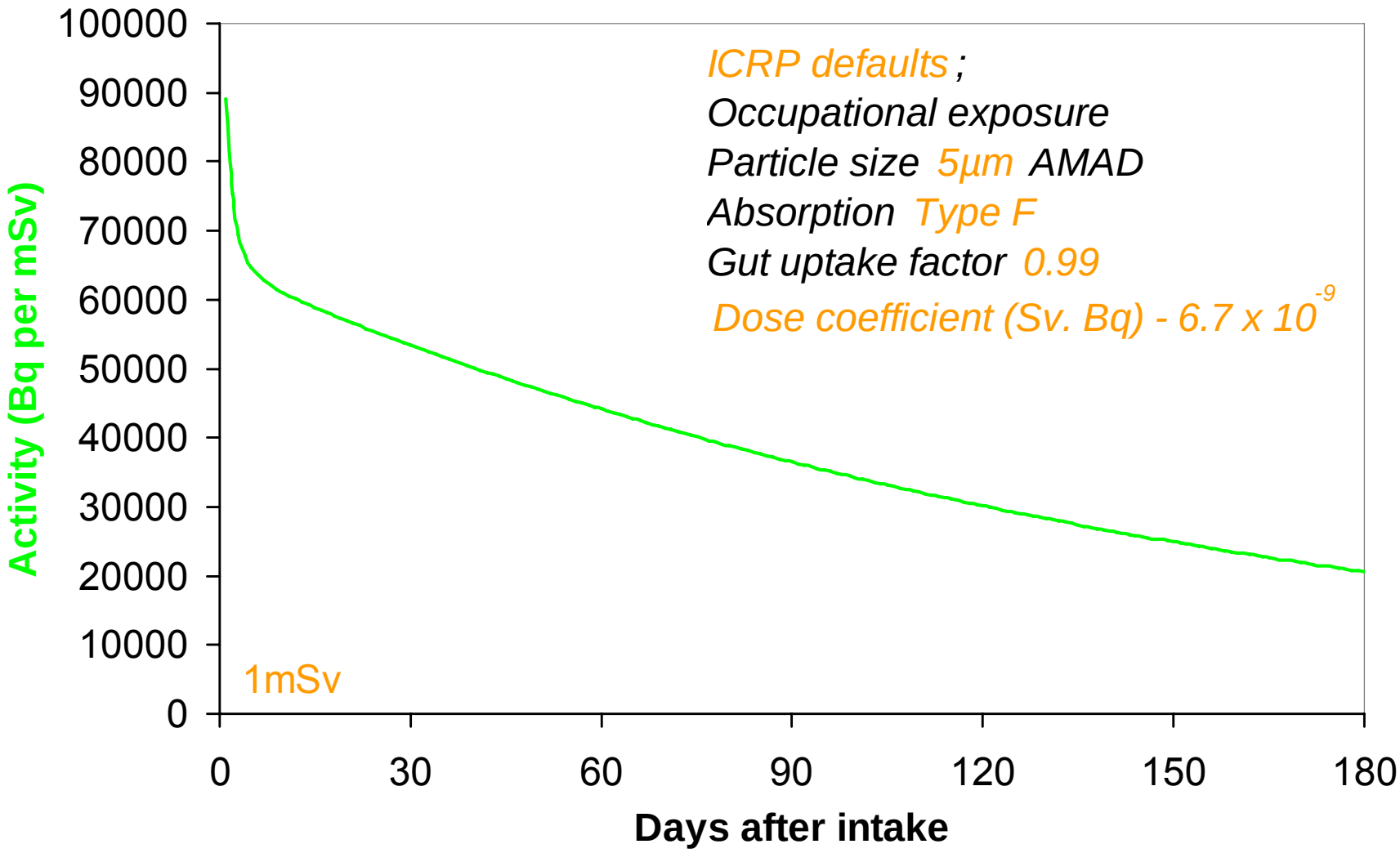
ICRP Absorption Types – 5 µm aerosol



Whole body retention of ^{137}Cs – *default*



Whole body retention of ^{137}Cs



Simple example – ^{137}Cs Whole Body Retention

Known *unknowns* at time of exposure

Particle size? 1, 5, 10 µm AMAD (ICRP default)

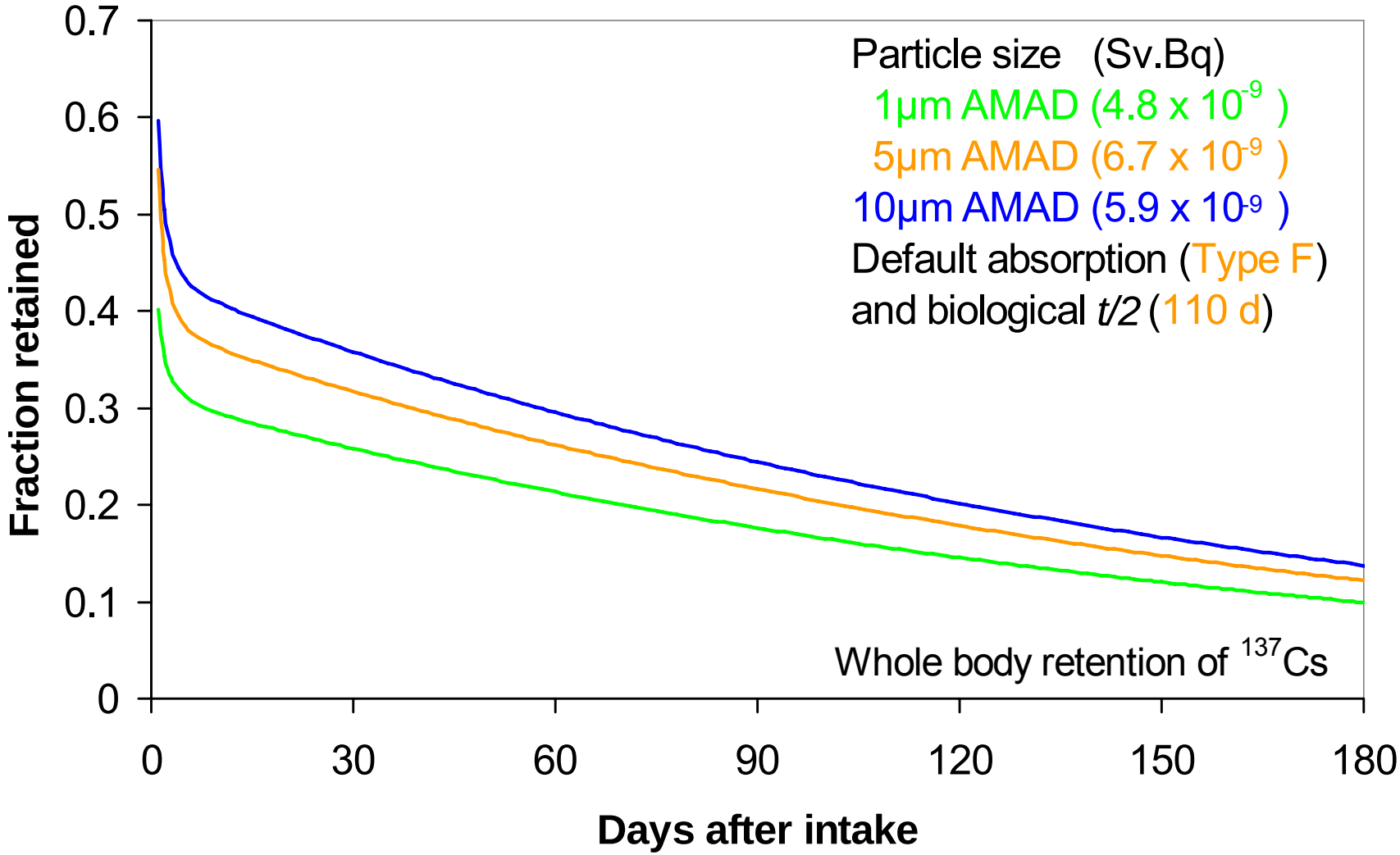
ICRP Absorption Type? Type M, Type F

Gut uptake (f_1)? 0.1 (Type M) and 0.99 (Type F)

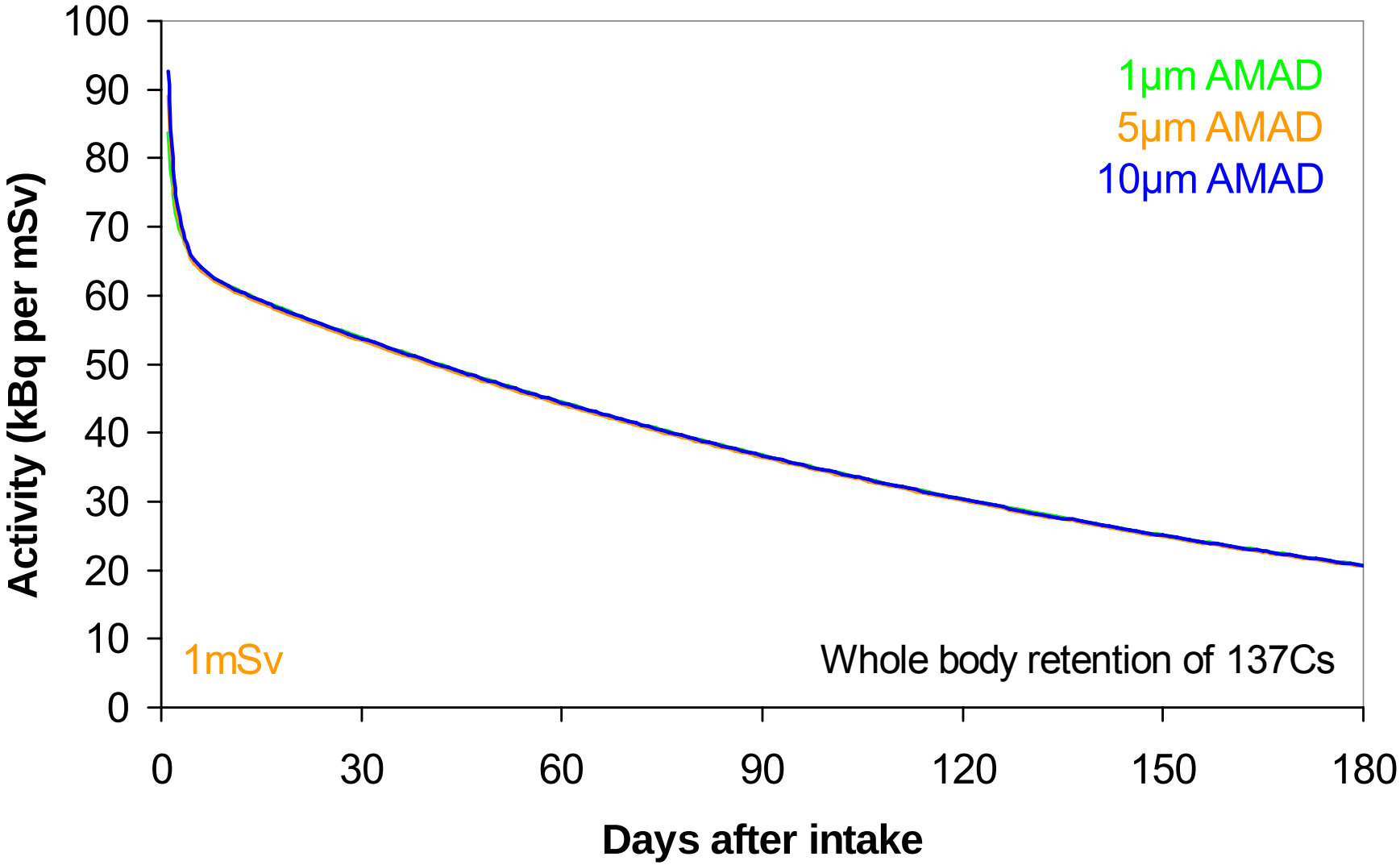
Long term biological $t/_2$ in body? 50, 110, 150 days

Number of combinations to consider……18

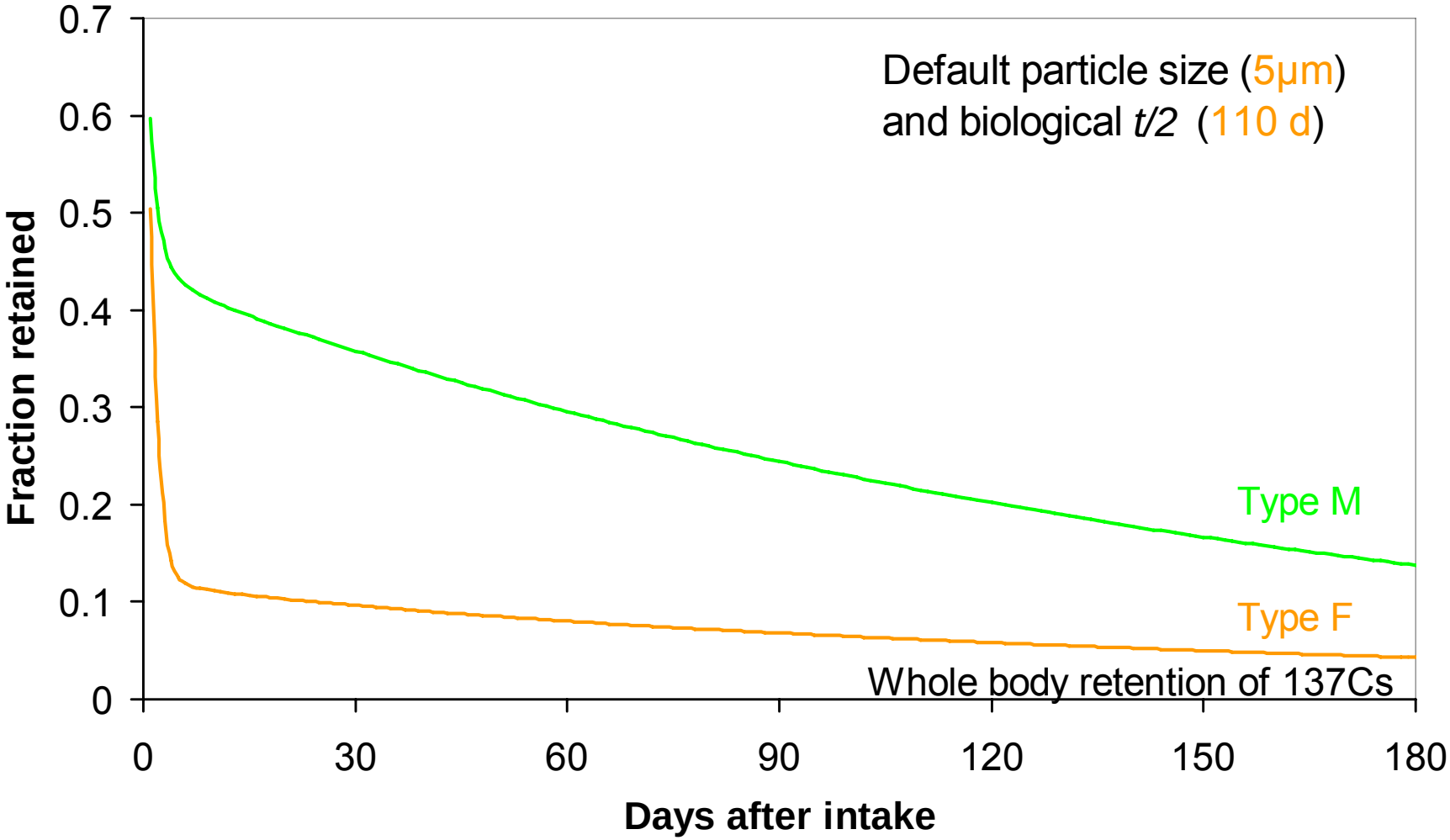
Effect of particle size – retention curves



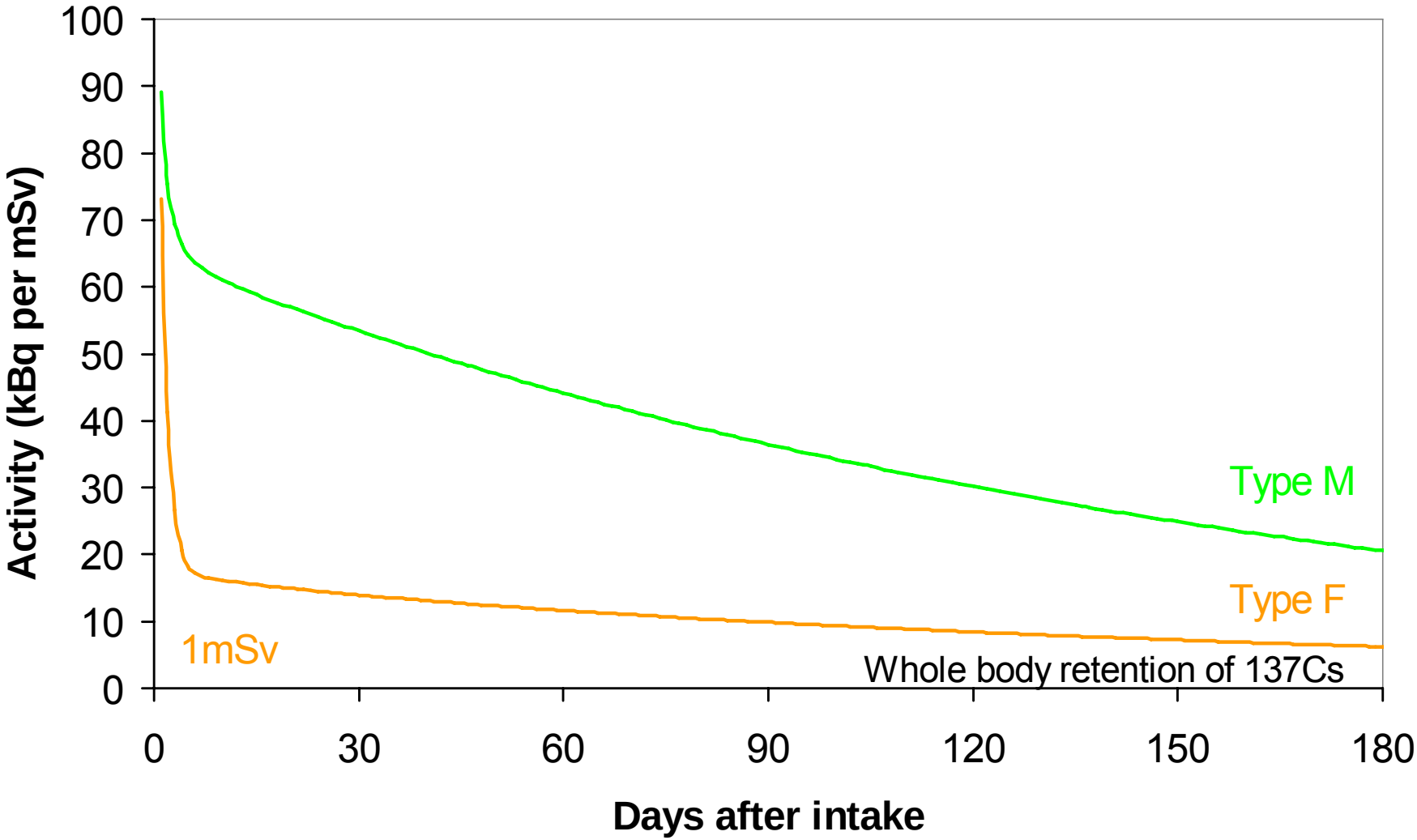
Effect of particle size – dose curves



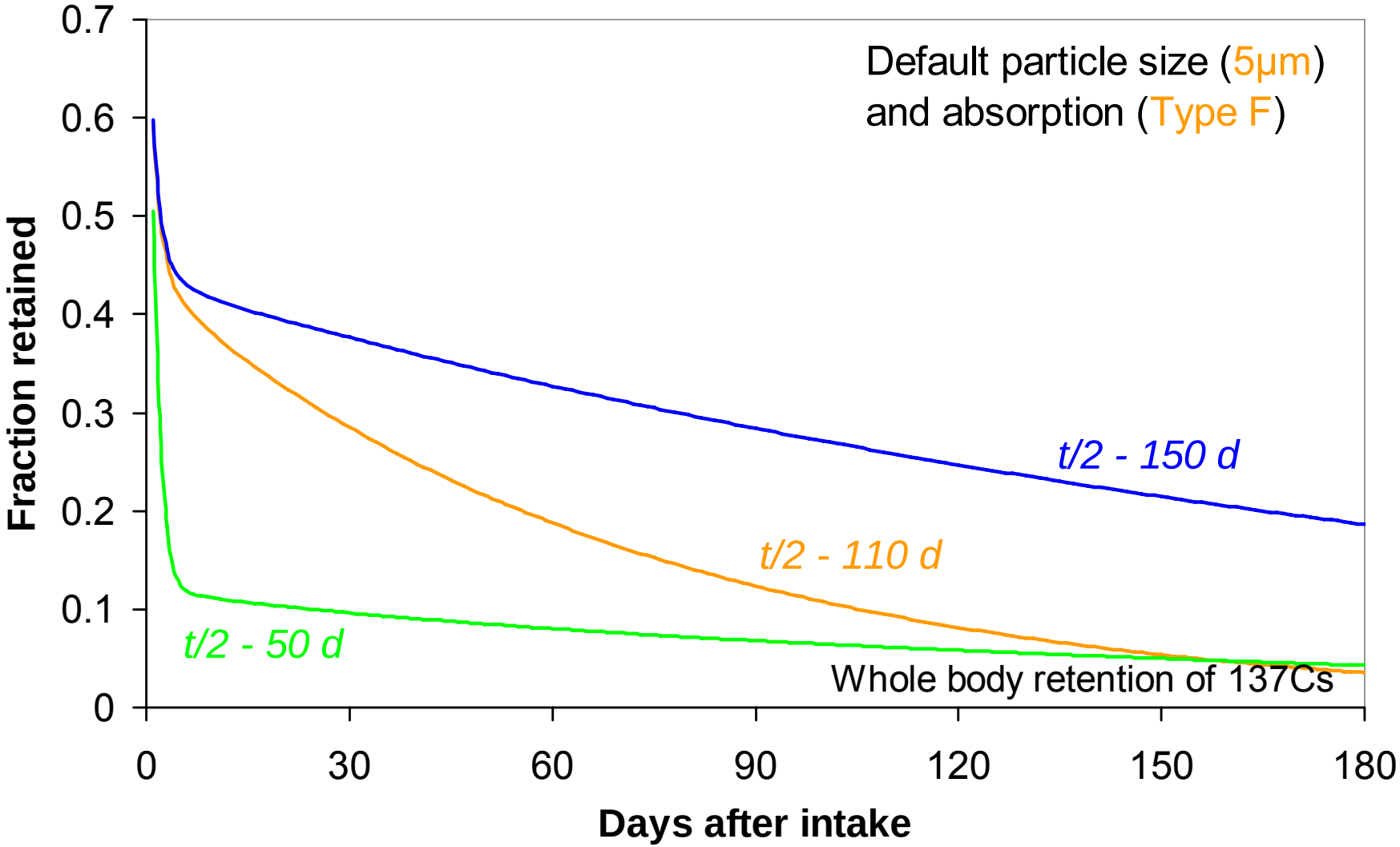
Effect of Absorption type – retention curves



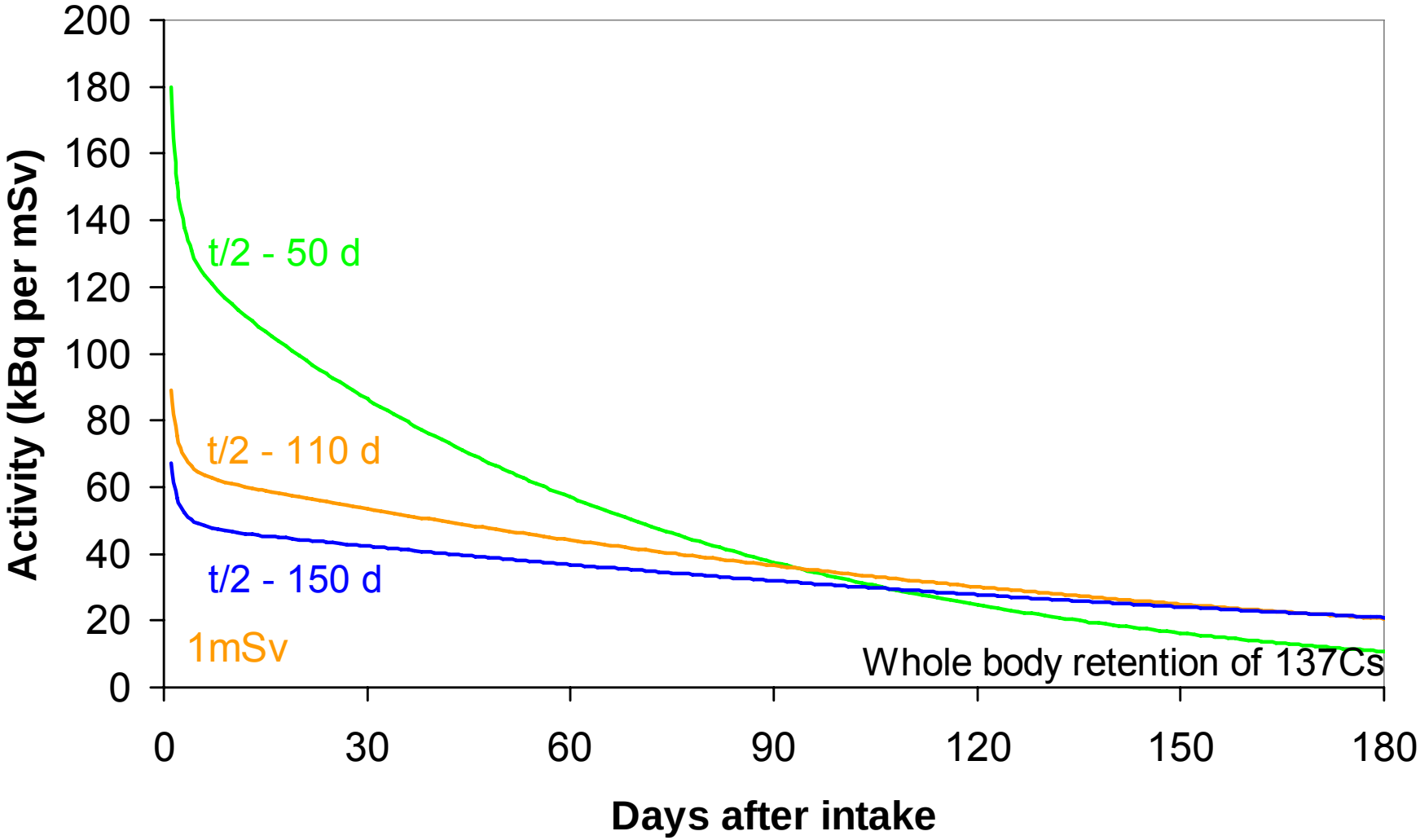
Effect of Absorption Type – dose curves



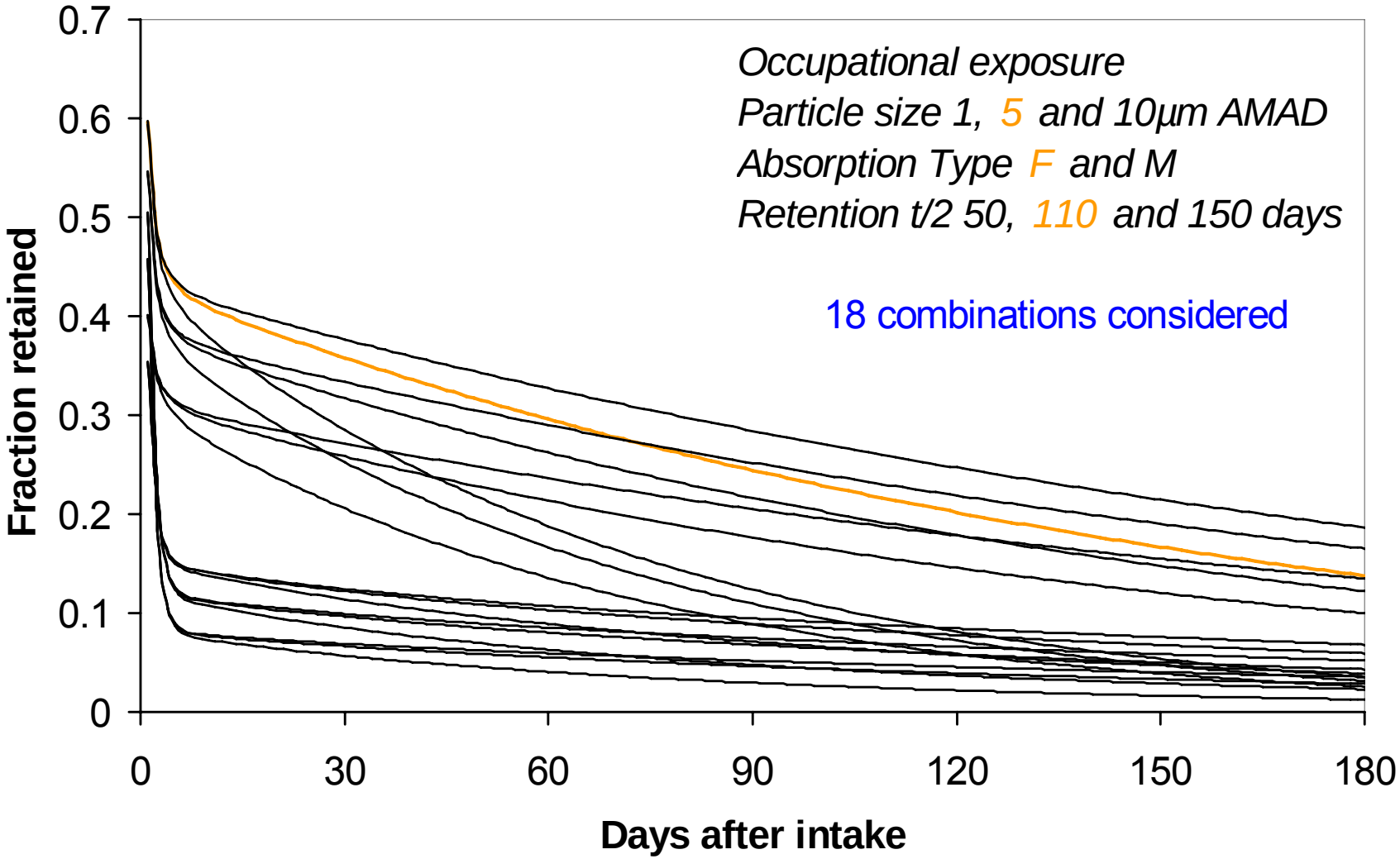
Effect of biological *t/2* – retention curves



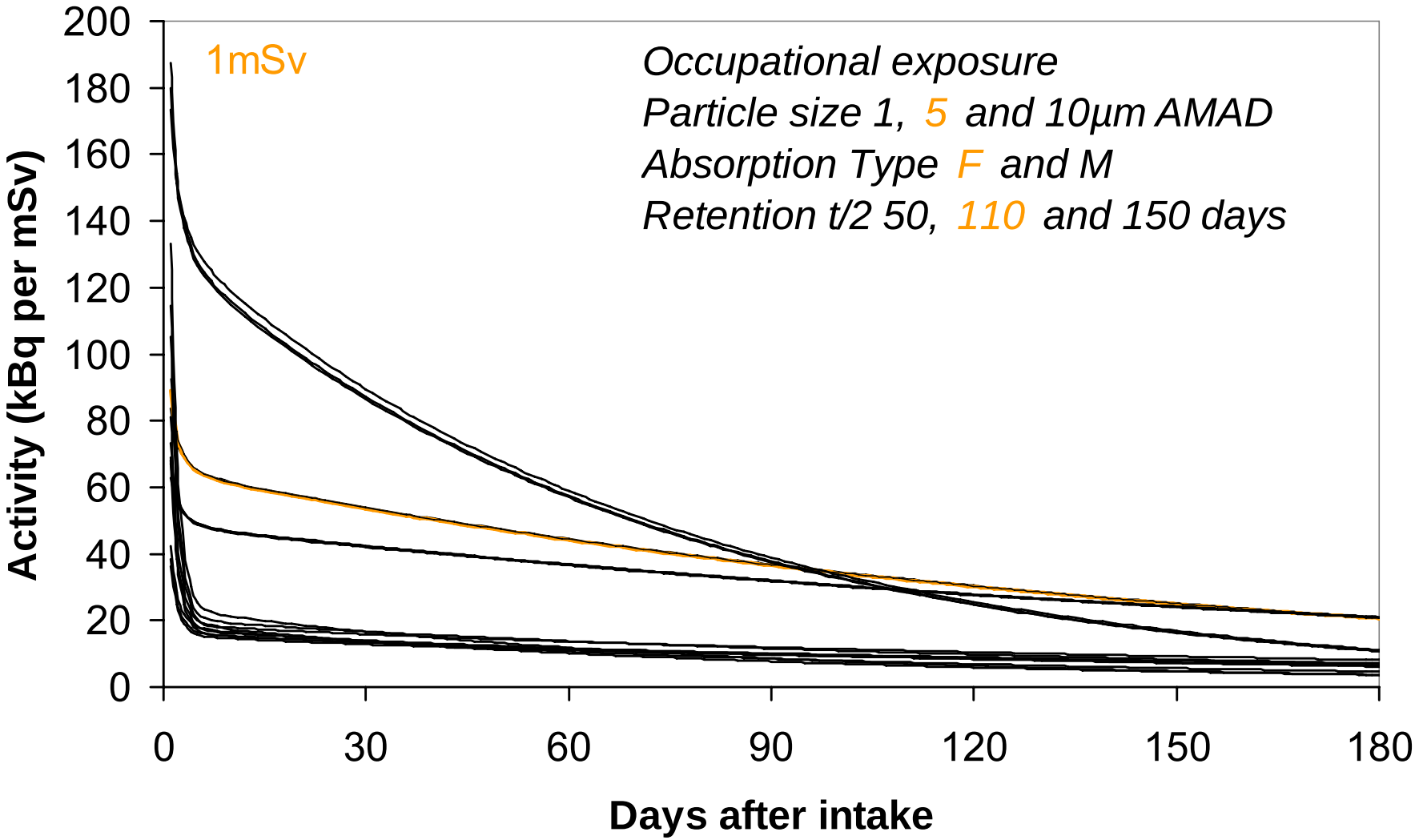
Effect of biological *t/2* – dose curves



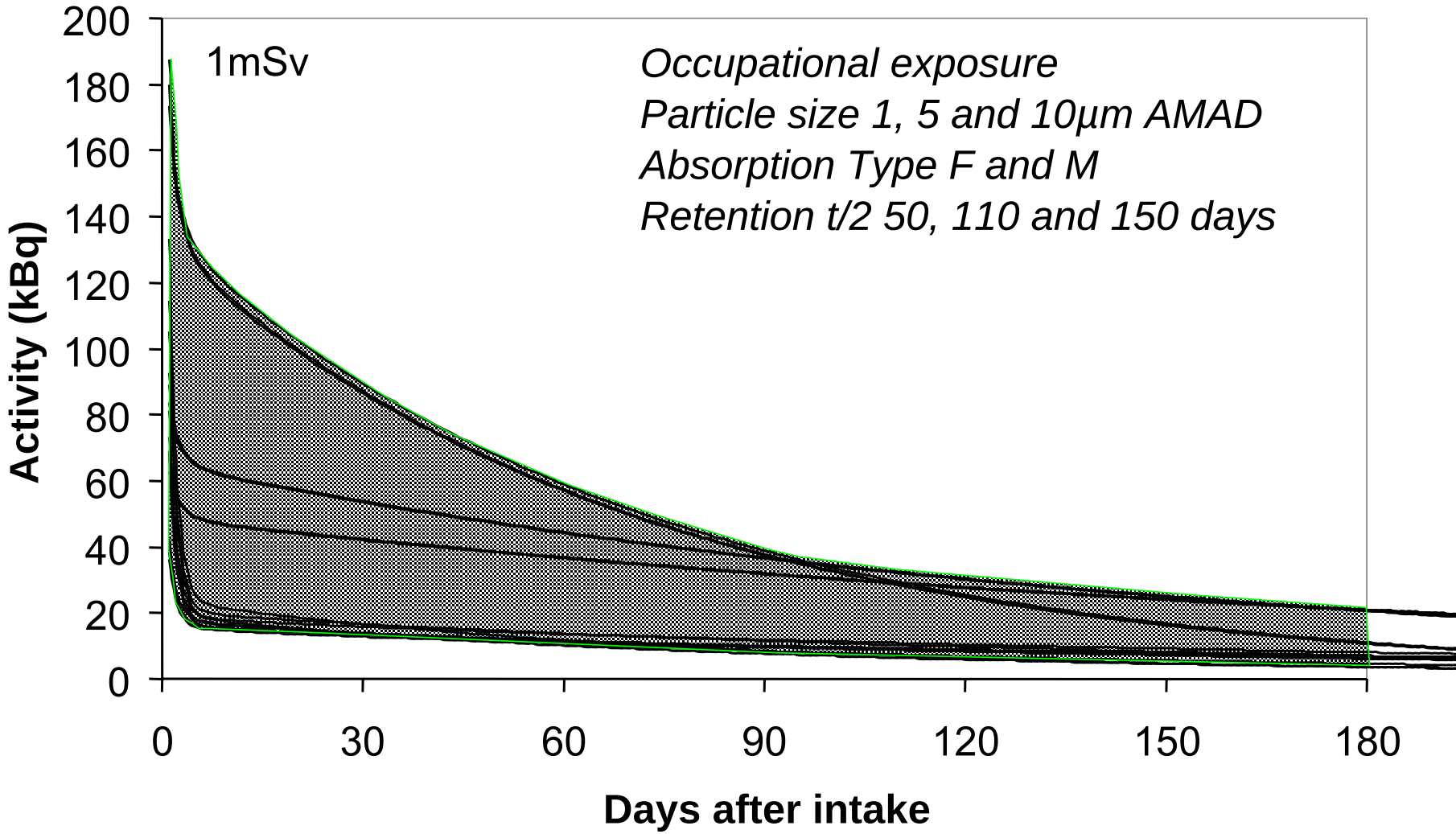
^{137}Cs – 'known' unknowns retention curves



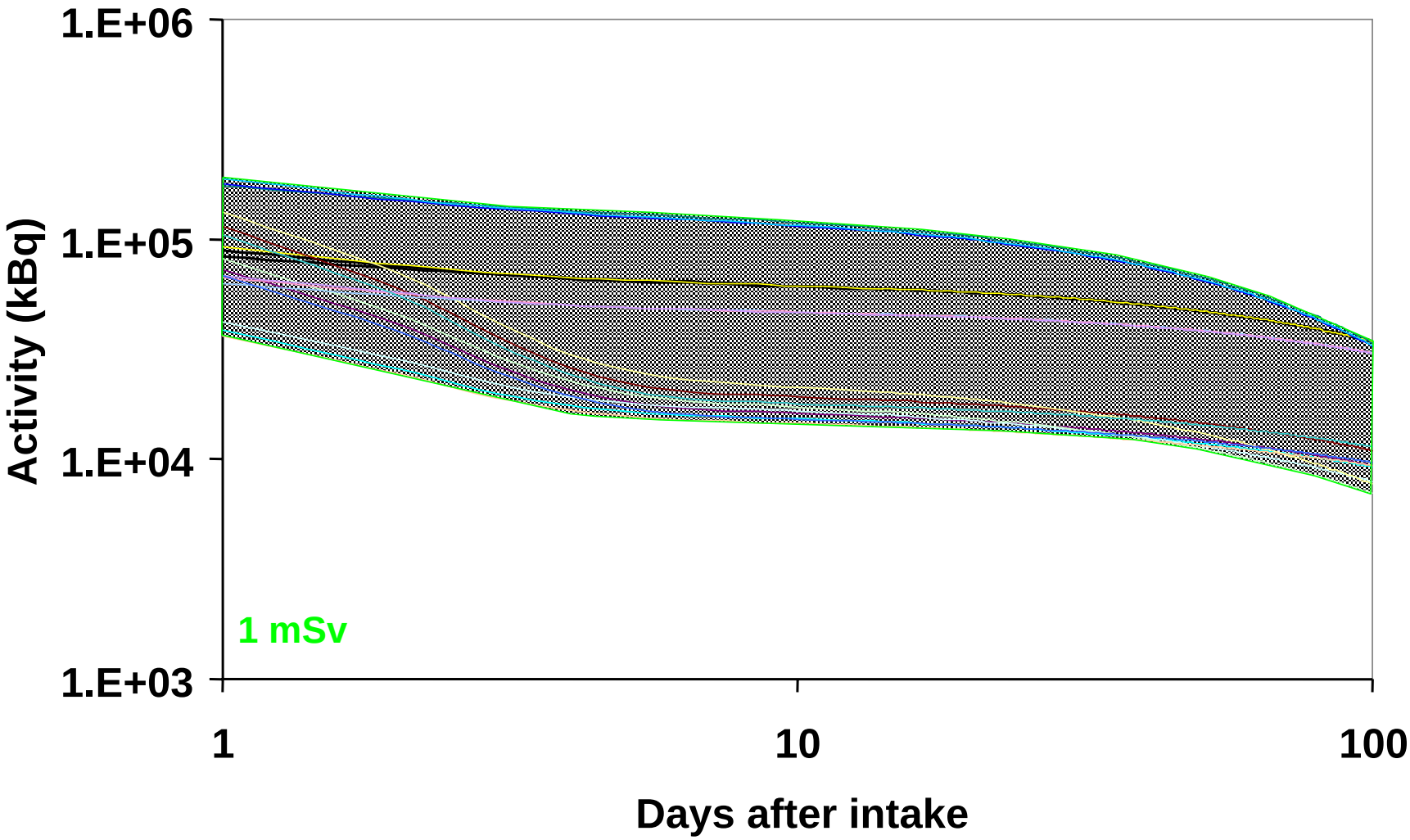
^{137}Cs – 'known' unknowns dose curves



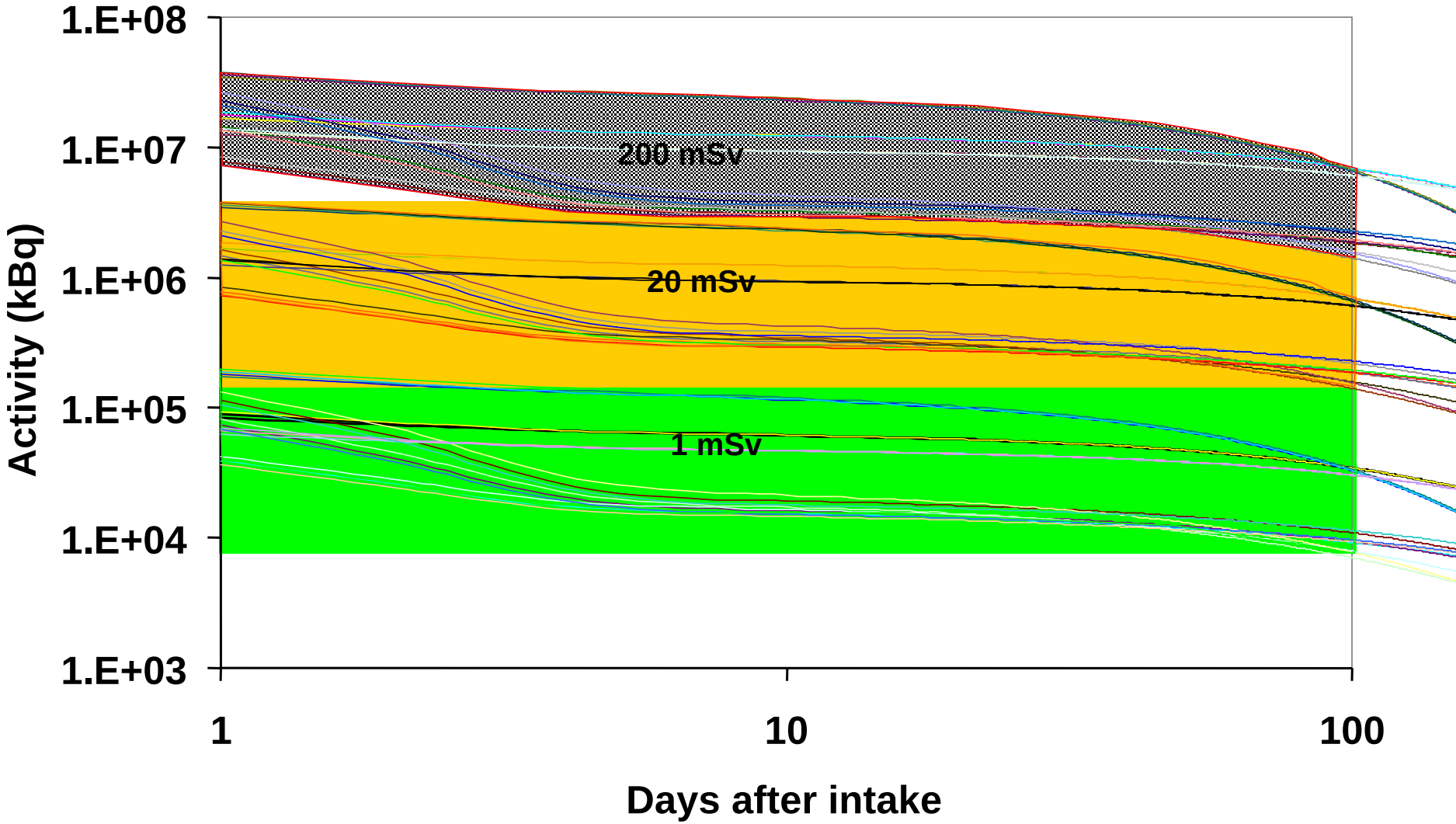
TIARA approach



Whole body retention of ^{137}Cs – log axis



Whole body retention of ^{137}Cs - scaled



TIARA - Proposed Action Levels

DEFINITELY >200 mSv - Treatment implemented

Could be >200 mSv - More accurate dose assessment/medical judgement

Could be >20 mSv but DEFINITELY <200 mSv - More accurate dose assessment/medical judgement

Could be >1 mSv but DEFINITELY <20 mSv - Public reassurance/more accurate dose assessment

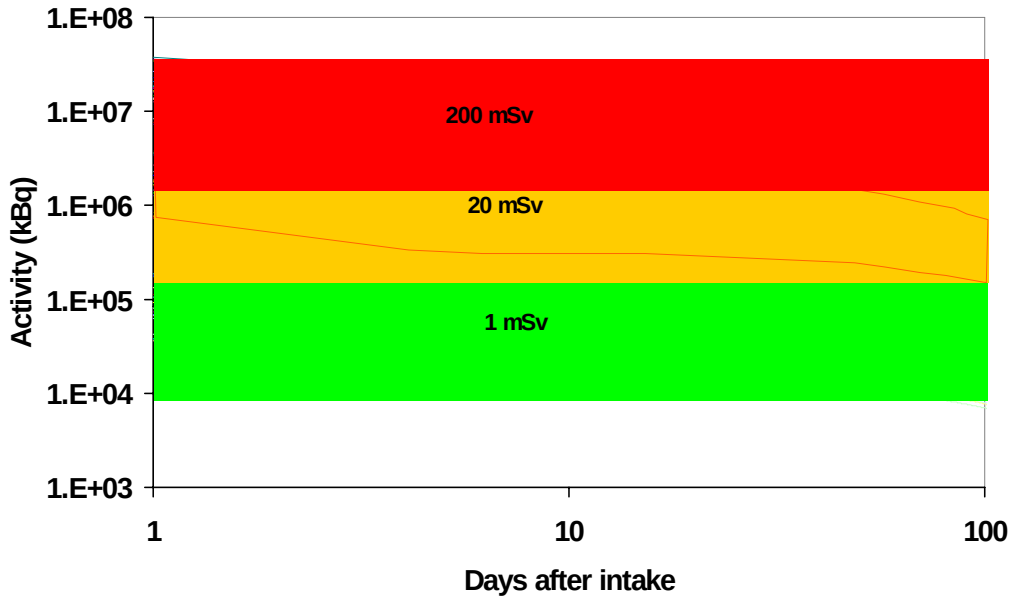
DEFINITELY <1 mSv - Public reassurance, no further action

Based on adults - lower levels considered for children?

Information available

Decision aiding

- Doses acceptably low (<1 mSv)
- Follow up assessment (<20 mSv)
- Treatment unnecessary (<200 mSv)
- Consider implementing treatment (≥200 mSv)



Optimise monitoring procedure

- Is the MDA of monitoring procedure sufficiently low to assess the specified dose?
- Can measurement times reduced?
- Is uncertainty in the assessed dose acceptable?
- Optimal monitoring procedure?

Examples of TIARA figures

Acute inhalation exposure

^{137}Cs

Monitoring procedure – Whole Body measurement

Acute inhalation exposure

^{239}Pu

Monitoring procedure – Bioassay (urinary and faecal excretion)

TIARA– ^{137}Cs unknown exposure parameters

Particle size - 0.1, 1, 5, 10, 100 µm AMAD

ICRP Absorption Type - Type M, Type F

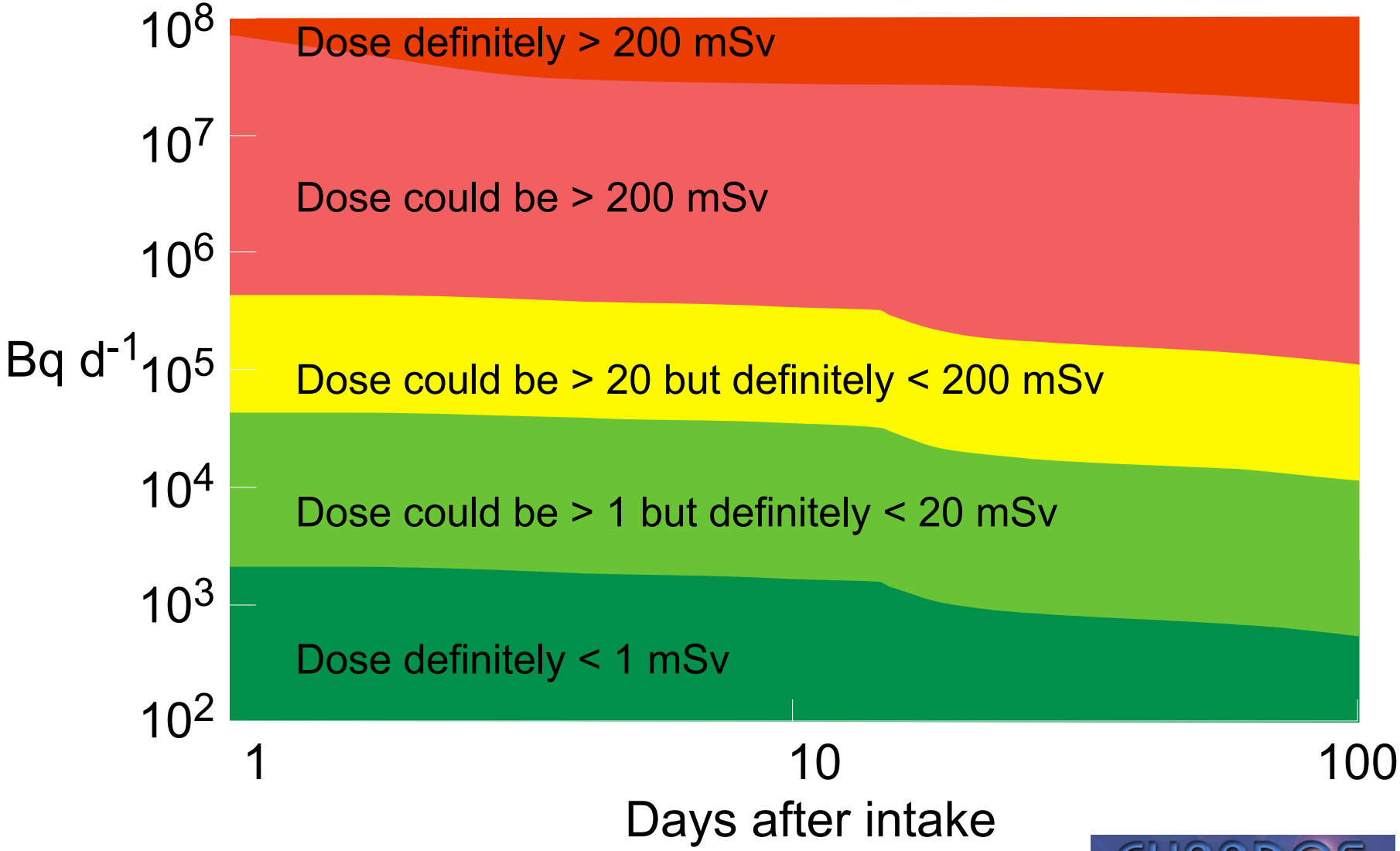
Long term retention $t/_2$ in body - 50, 110, 150 d

Breathing rate - 0.45, 1.2, 3.0 m^3/h

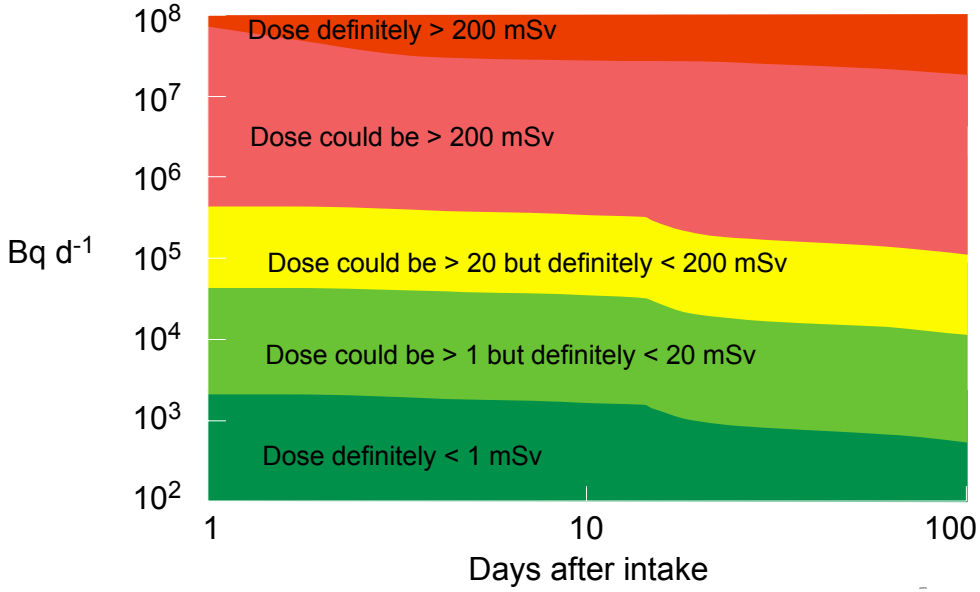
Particle transport rate - Default /1.7, Default, Default x 1.7

Number of combinations considered……270!

TIARA - ^{137}Cs Whole Body Measurement



TIARA - ^{137}Cs Whole Body Measurement



With a MDA of 100 Bq

- Doses below 1 mSv can be confirmed at long times after exposure
- Counting times can be considerably shorter than used routinely
- Lower sensitivity equipment (MDA 2-3 kBq) can be used

TIARA - ^{239}Pu unknown exposure parameters

Particle size - 0.1, 1, 5, 10, 100 µm AMAD

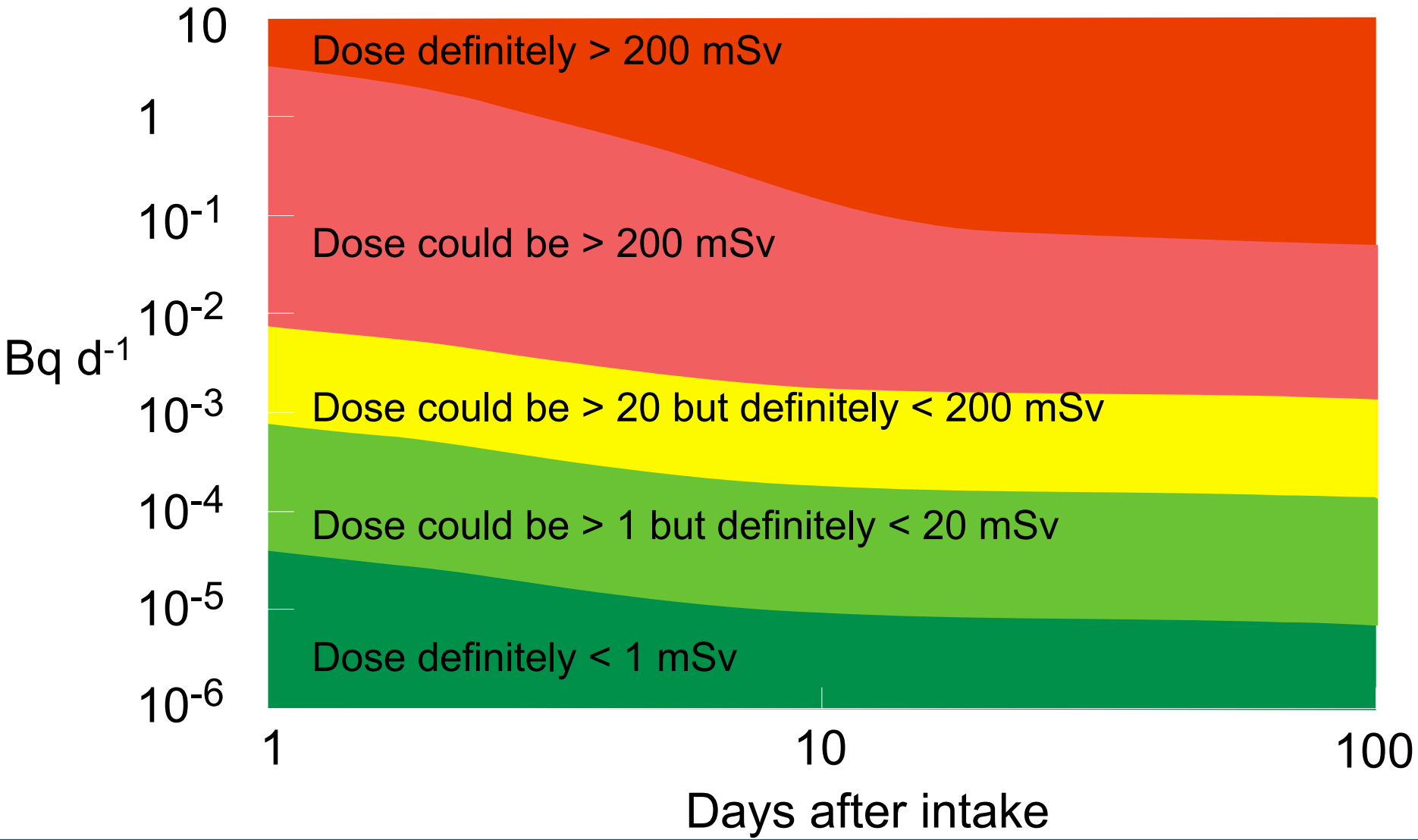
ICRP Absorption Type - Type S, Type M, Type F

Breathing rate - 0.45, 1.2, 3.0 m^3/h

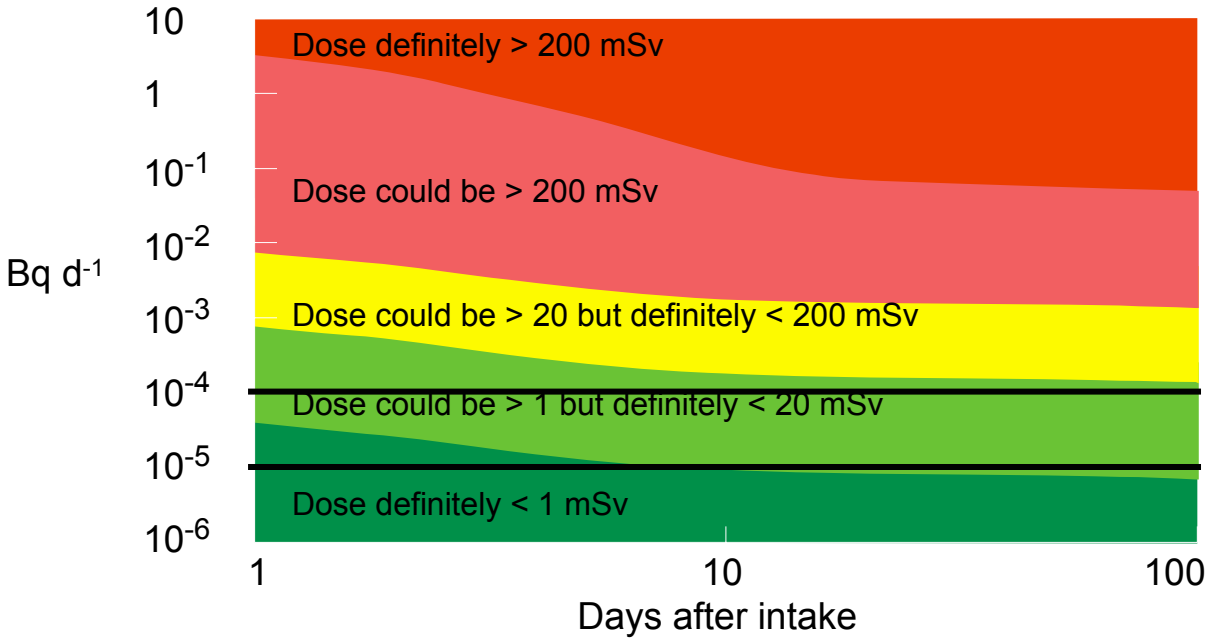
Particle transport rate - Default /1.7, Default, Default x 1.7

Number of combinations considered……135

Urinary excretion of ^{239}Pu



Urinary excretion of ^{239}Pu



With a MDA of 10^{-4} Bq d^{-1} (alpha spectrometry)

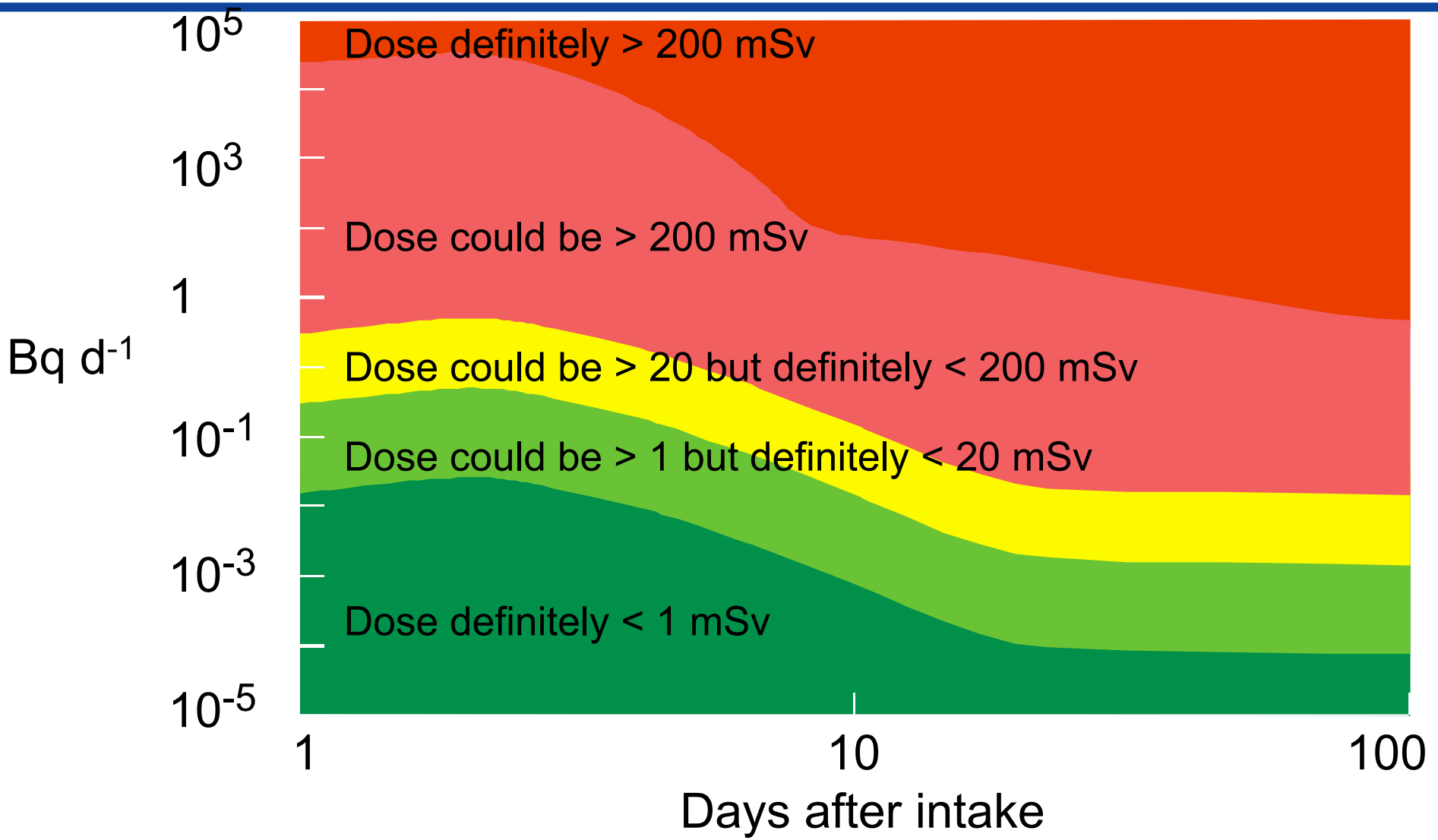
Doses below 1 mSv cannot be confirmed

Doses below 20 mSv can be confirmed up to and beyond 100 days after exposure

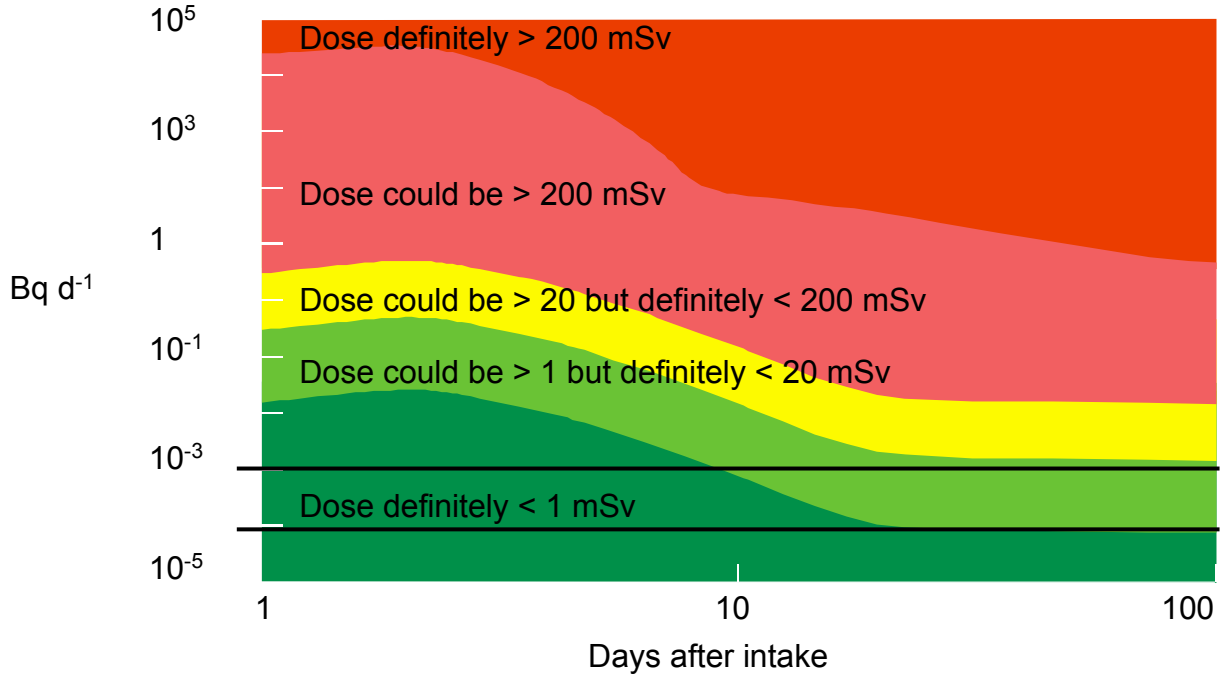
With a MDA of $<10^{-4}$ Bq d^{-1} (mass spectrometry)

Doses below 1 mSv can be confirmed for about 1 week after exposure

Faecal excretion of ^{239}Pu



Faecal excretion of ^{239}Pu



With a MDA of 10^{-3} Bq d^{-1} (alpha spectrometry)

Doses below 1 mSv can be confirmed for about 10 days after exposure

Doses below 20 mSv can be confirmed up to and beyond 100 days after exposure

With a MDA of $<10^{-4}$ Bq d^{-1} (mass spectrometry)

Doses below 1 mSv can be confirmed for about 3 weeks after exposure

Summary of TIARA approach

Figures are intuitive - Simple and easy to interpret

Uses

- Confirm that doses are acceptably low eg <1 mSv
- Treatment - unnecessary/considered/implemented
- Uncertainty in the assessed dose/procedure acceptable
- Optimise monitoring procedure
- Identify monitoring procedure - MDA of monitoring procedure sufficiently low to assess the specified dose
- Can measurement times be reduced

TIARA booklet - radionuclides of interest

Element	Isotope	Half life	Emission
Amercium	Am-241	432 y	$\alpha\gamma$
Caesium	Cs-137	30 y	γ
Cobalt	Co-60	5.2 y	γ
Iodine	I-131	8 d	γ
Iridium	Ir-192	74 d	γ
Molybdenum/Technicium	Mo-99/Tc-99^{m}	66 h/6 h	γ
Plutonium	Pu-238	88 y	α
	Pu-239	2.4 10^4 y	α
Polonium	Po-210	138 d	α
Radium	Ra-226+	1600 y	α, β, γ
Selenium	Se-75	120 d	γ
Strontium	Sr-89	51 d	β
	Sr-90/Y-90	29.1 y/64 h	β
Uranium	Depleted (DU)		α, β, γ
	Natural		α, β, γ
Ytterbium	Yb-169	32 d	γ

Source of TIARA booklet

Download pdf of the booklet at;

http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1240472270226?p=1229070382559

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Thank you for your attention