Second announcement and call for registration

EURADOS Annual Meeting 2017

AM2017

Karlsruhe, 27th February to 2nd March 2017

EURADOS European Radiation Dosimetry Group e.V.

KIT Karlsruhe Institute of Technology

10th EURADOS Winter School

"Internal dosimetry for radiation protection and medicine"

Uncertainties on internal dosimetry

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2 March 2017

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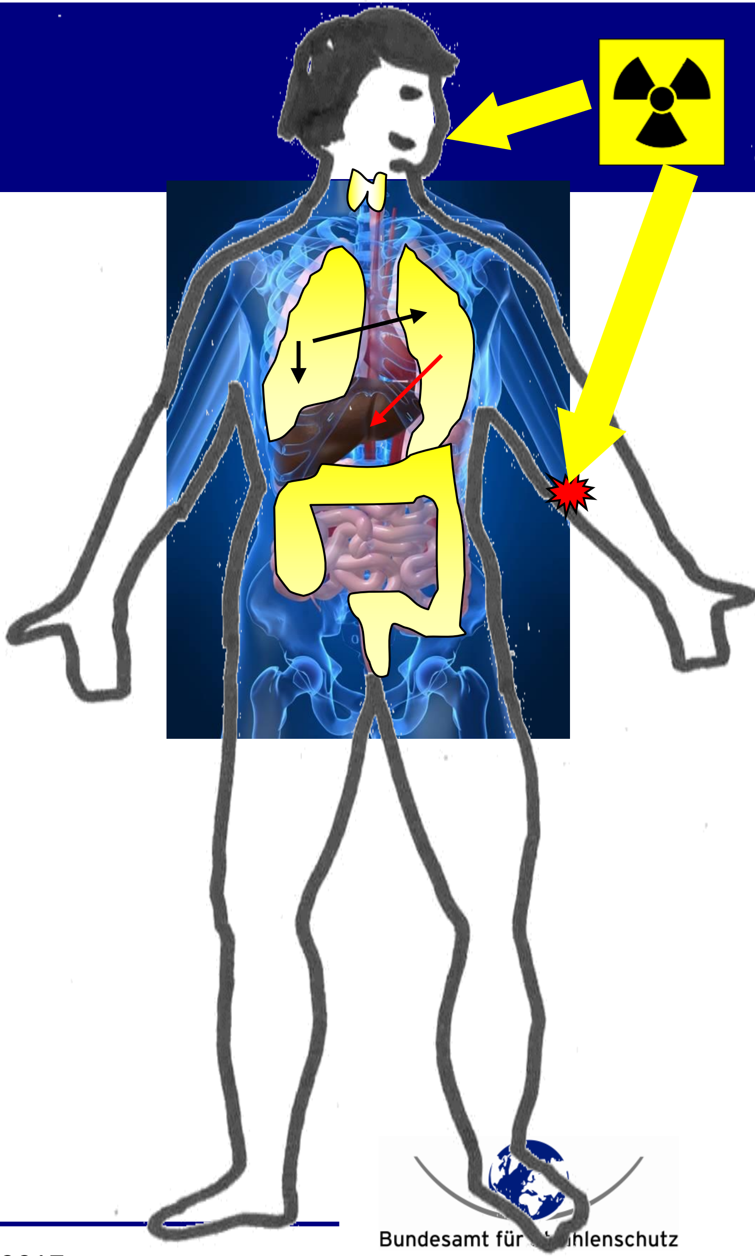
| Verantwortung für Mensch und Umwelt |

Bundesamt für Strahlenschutz

Internal dosimetry



Internal dose is evaluated with mathematical models

Intake

↓

Time-activity curves in the source regions

➡ Number of nuclear transformations

↓ Nuclear data, phantoms and particle transport

Tissue absorbed dose (mGy)

↓ Radiation weighting factors w_R

Tissue equivalent dose (mSv)

↓ Tissue weighting factors w_T

Effective dose (mSv)

Biokinetic Model

Dosimetric Model

For regulatory purposes ICRP publications give dose coefficients

Intake

i = 1 Bq

Biokinetic Model

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Dosimetric Model

Tissue weighting factors w_T

Effective dose (mSv)

DOSE COEFFICIENTS

Internal dose assessment for regulatory purposes

In order to assess radiation doses, models are necessary to simulate the geometry of the external exposure, the biokinetics of incorporated radionuclides, and the human body. The reference models and necessary reference parameter values are established and selected from a range of experimental investigations and human studies through judgements. For regulatory purposes, these models and parameter values are fixed by convention and are not subject to uncertainty. The Commission is aware of uncertainties and lack of precision of the models and parameter values. Efforts are undertaken to critically evaluate and to reduce the uncertainties. For individual retrospective dose and risk assessments, individual parameters and uncertainties have to be taken into account.

ICRP Publ. 103, Executive Summary, (l) – page 13
ICRP Publ. 130, Paragraph (303) – page 121

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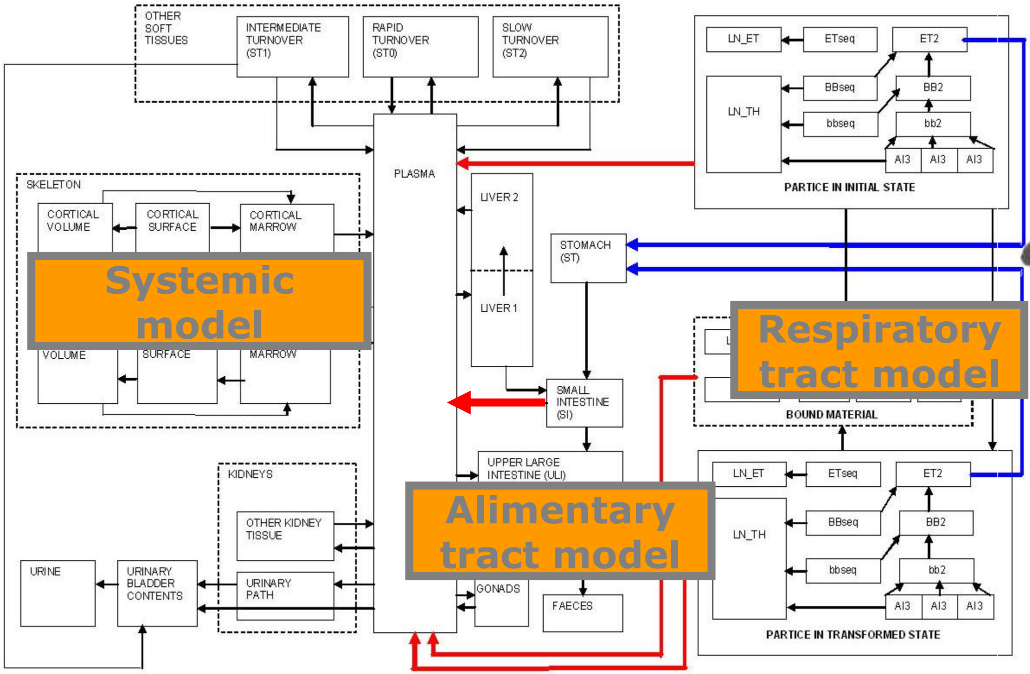
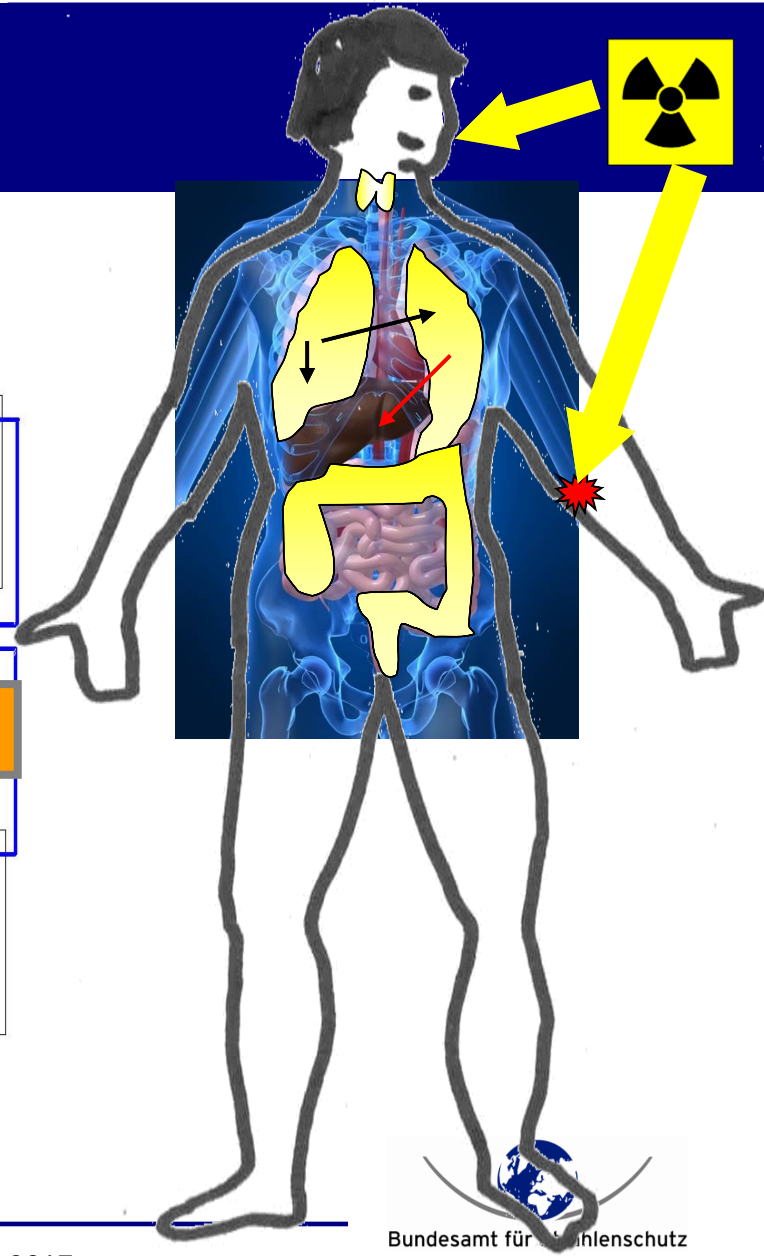
DOSE COEFFICIENTS

Biokinetic models





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Bundesamt für Strahlenschutz

Sources of uncertainties from the biokinetic models

- Adequacy of the model structure
- Uncertainties in model parameter values
  - Source data
- Human studies (H1)
- Other mammalian species (A1)
- Human studies - Chemical analogues (H2)
- Other mammalian species - Chemical analogue in (A2)
- Basic physiological data (P)
  - Correlations
- Physical half-lives are known to a very good degree of accuracy

For regulatory purposes ICRP publications give dose coefficients

Intake

$i = 1$ Bq

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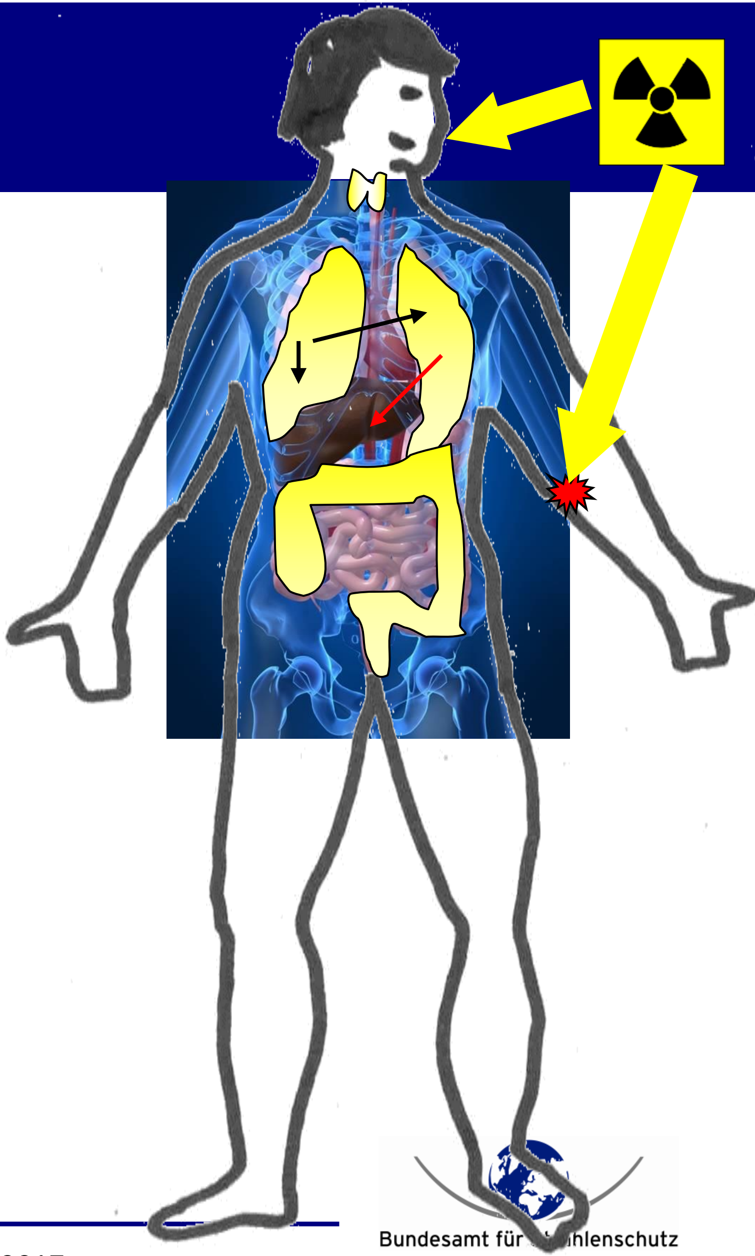
DOSE COEFFICIENTS

Dosimetric models

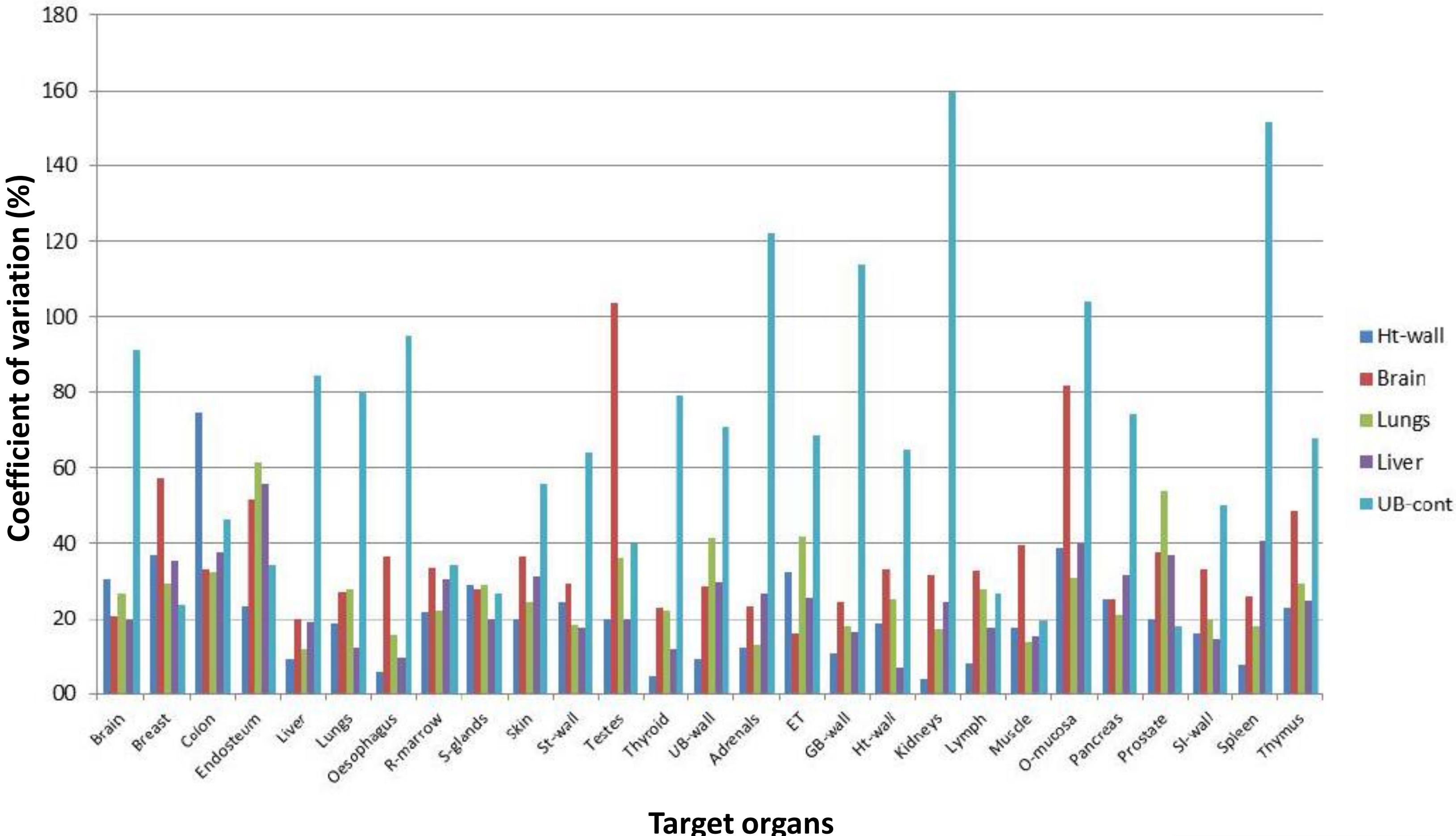


Sources of uncertainties from the dosimetric models

- Physical properties (energy and spectra of the emitted radiation) are known to a very good degree of precision
- A number of different voxel phantoms are currently available: intraindividual variabilities can be easily assessed and quantified
- Significant contributions to the uncertainty can be due to inhomogeneous activity distributions and simplifying assumptions on the location of radiosensitive cells (particularly important for high LET radiation and for walled hollow organs)

Uncertainties on the S-values for ^{18}F-FDG

V. Spielmann and W. Li, HMGU



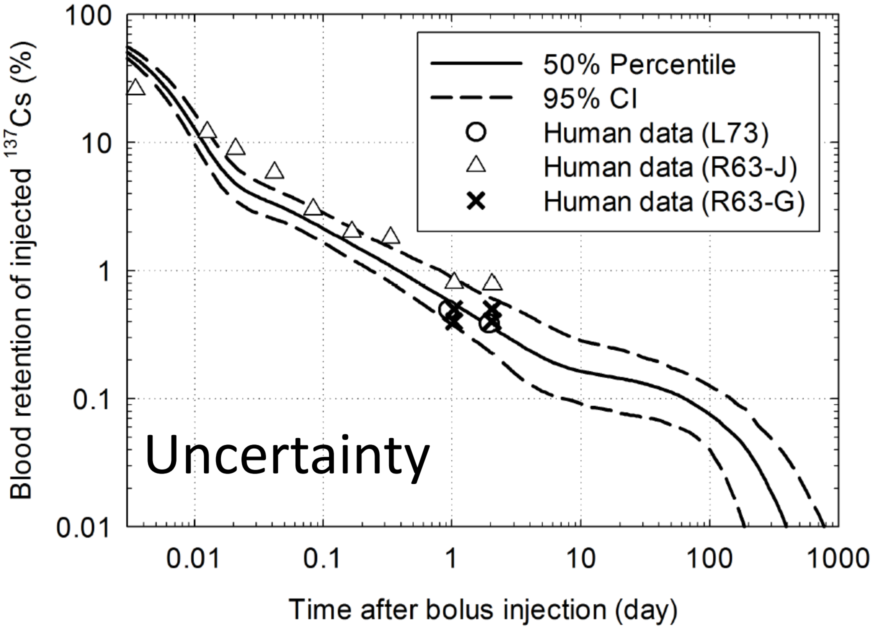
Uncertainties in the biokinetic model.

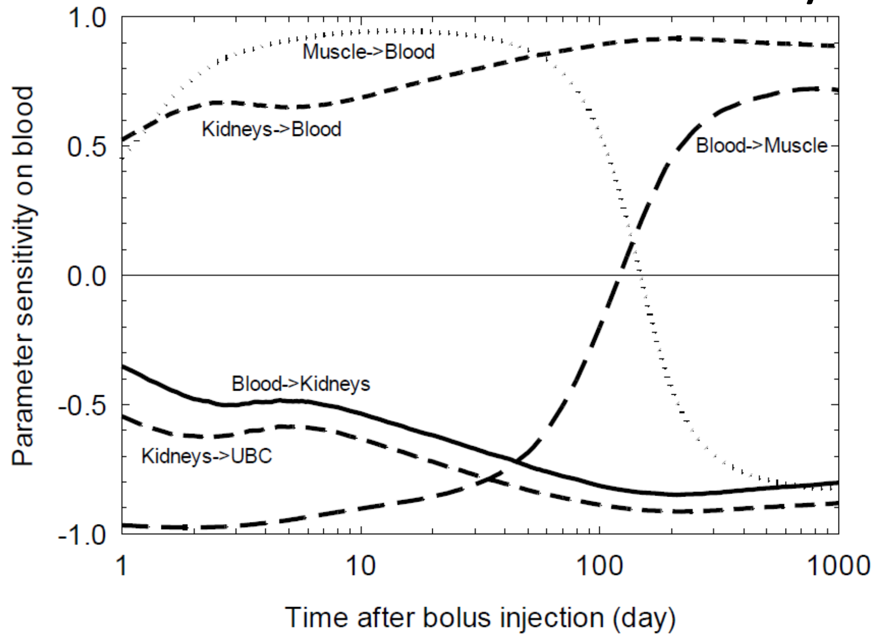
Radiation Protection Dosimetry (2015), Vol. 163, No. 1, pp. 37–57
Advance Access publication 17 April 2014
doi:10.1093/rpd/ncu055

PARAMETER UNCERTAINTY ANALYSIS OF A BIOKINETIC MODEL OF CAESIUM

W. B. Li[1,*], W. Klein[2], E. Blanchardon[3], M. Puncher[4], R. W. Leggett[5], U. Oeh[1], B. Breustedt[6], D. Noßke[7] and M. A. Lopez[8]

Sensitivity





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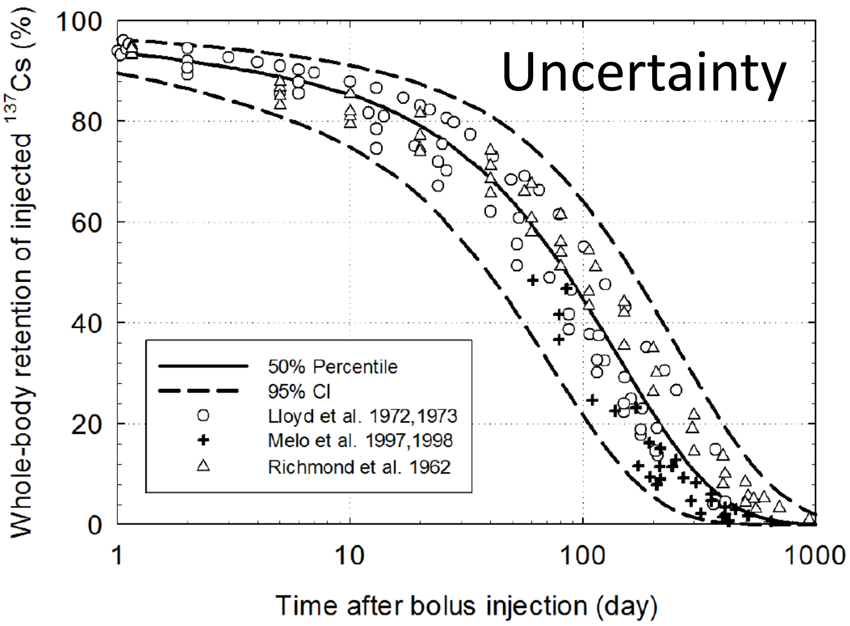

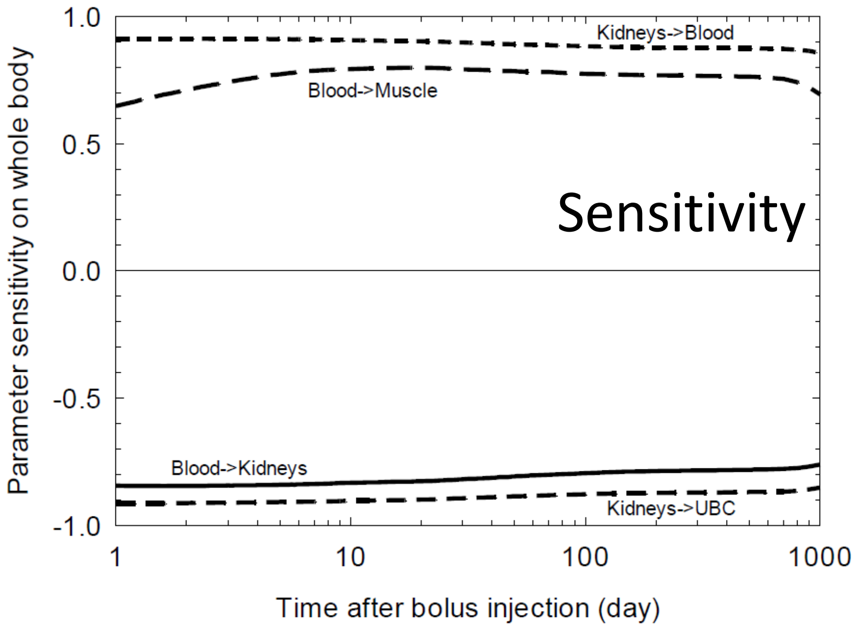

Estimating intake from bioassay measurements

Intake

$i = 1$ Bq

Biokinetic Model

Time-activity curves in the source regions

➡ Number of nuclear transformations

Measurement(s) M

➡ $m(t)$ ➡ $M/m(t) = I$

Nuclear data, phantoms and particle transport

Tissue absorbed dose (mGy)

Radiation weighting factors w_R

Tissue equivalent dose (mSv)

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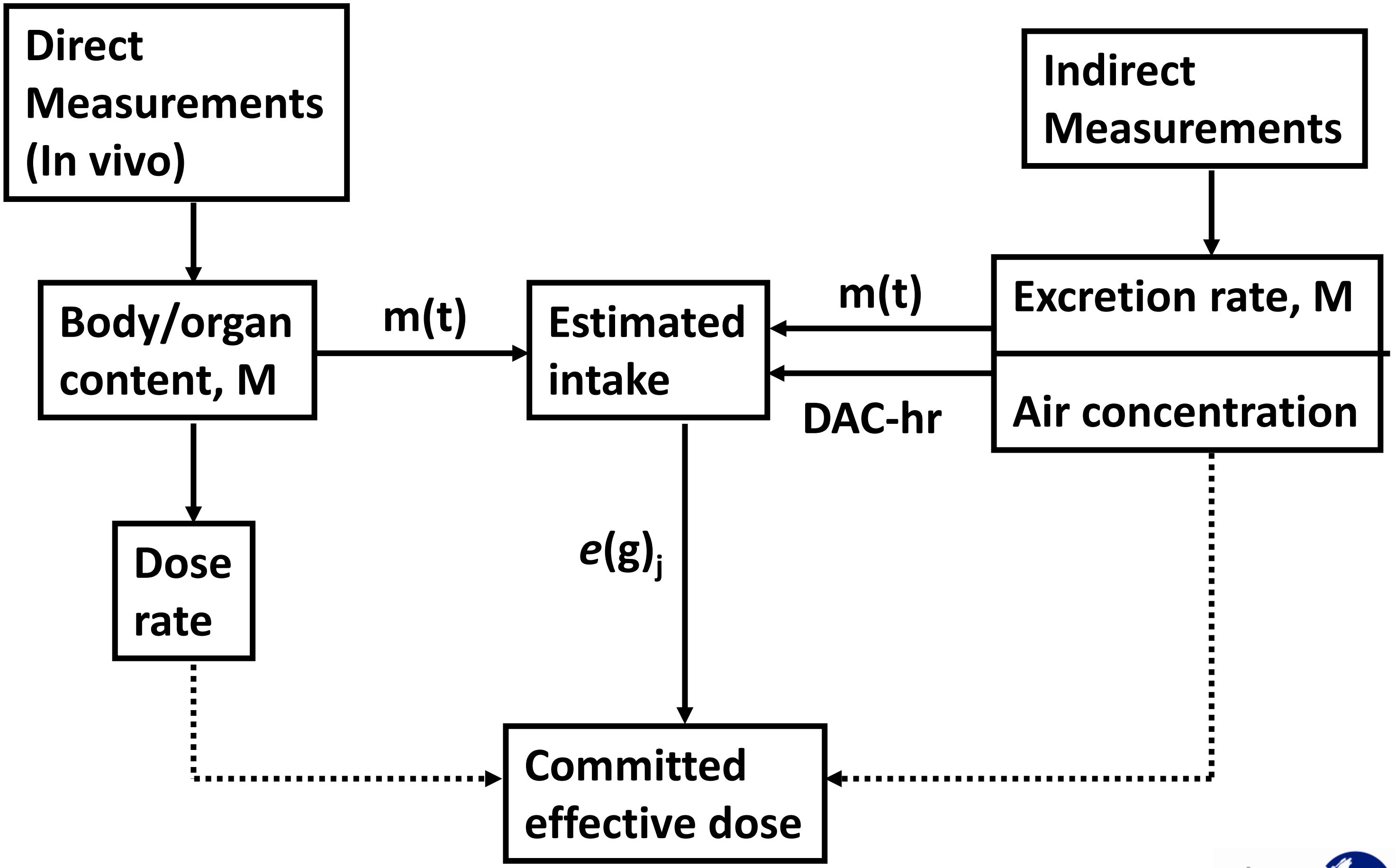
Effective dose (mSv)

Dosimetric Model

DOSE COEFFICIENTS

Estimating intake from bioassay measurements



Estimating intake from bioassay measurements

Intake

I

Biokinetic Model

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➡ Number of nuclear transformations

Measurement(s) M

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Nuclear data, phantoms and particle transport

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Radiation weighting factors w_R

Tissue equivalent dose (mSv)

Dosimetric Model

Tissue weighting factors w_T

Effective dose (mSv)

DOSE VALUES

The biokinetic model is used twice.

Intake

I

Biokinetic Model

Time-activity curves in the source regions

➡ Number of nuclear transformations

Measurement(s) M

➡ m(t) ➡ M/m(t) = I

Nuclear data, phantoms and particle transport

Tissue absorbed dose (mGy)

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Effective dose (mSv)

Dosimetric Model

DOSE VALUES

Uncertainty sources in dose assessment based on bioassay data.

- uncertainties associated with measurements used to determine the activity of a radionuclide in vivo or in a biological sample;
- uncertainties in the exposure scenario used to interpret the bioassay results:
  - route of intake,
  - time pattern of intake
  - specific radionuclide(s) taken into the body
  - chemical and physical form of the deposited radionuclide(s).

EURADOS exercise on dose reconstruction

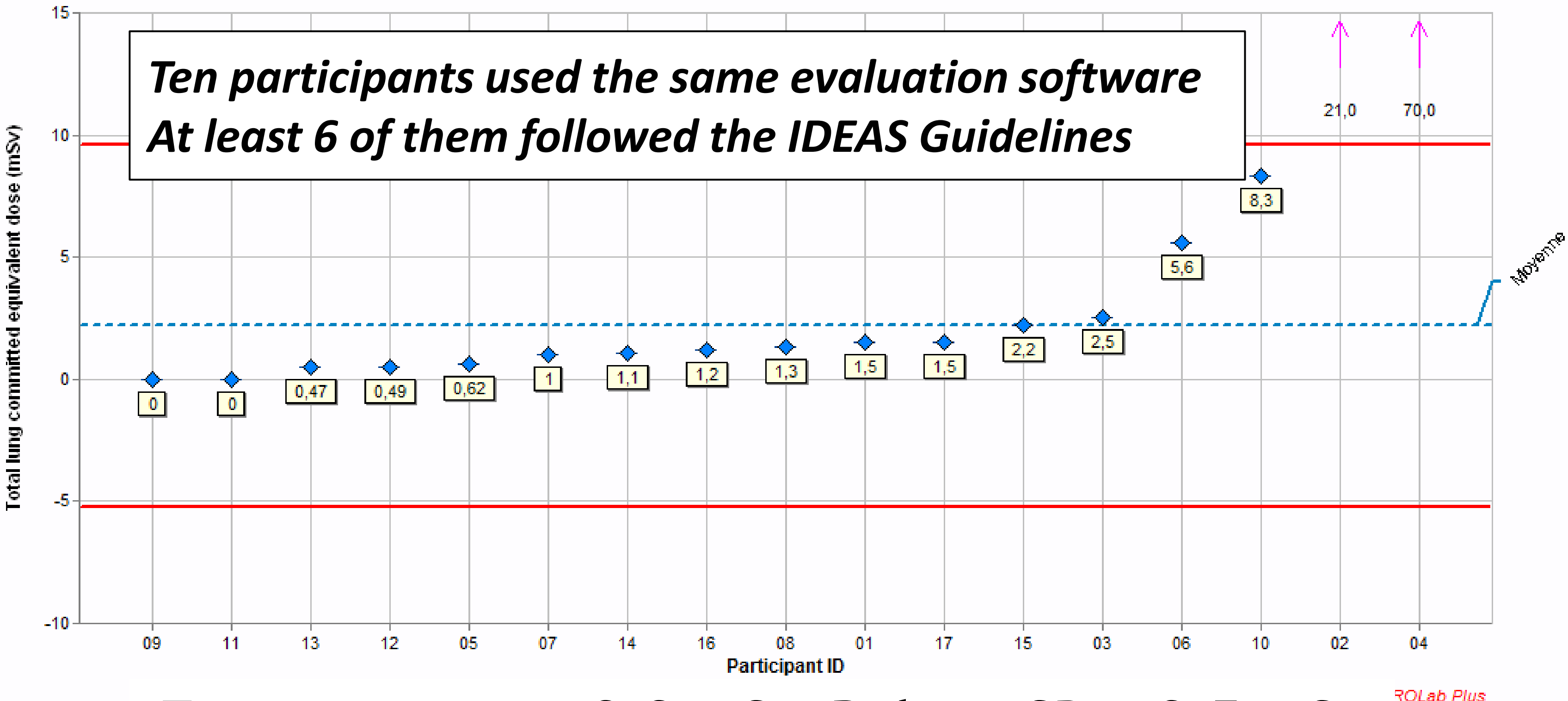
Courtesy of E.Davesne, IRSN

- No faeces bioassay
- 47 urine bioassay from 1968 to 1981
  - all values below LOD
  - No indication of sampling period
  - 28 urine samples measured by both mass and activity techniques
  - 15 samples measured only by activity
  - 4 samples measured only by mass
- Exposure from JEM
  - Potential exposure to Type F natural U between 1965 and 1981
  - No identified incidents

EURADOS exercise on dose reconstruction

Courtesy of E.Davesne, IRSN

Total committed lung doses



- Robust mean = 2.2 mSv, Robust SD = 2.5 mSv
- Relative SD > 1

EURADOS exercise on dose reconstruction

Courtesy of E.Davesne, IRSN

- **Definition of intake pattern for daily exposure: acute at the middle of the internal vs chronic**
- **Definition of exposure time: from bioassay? from JEM?**
- **Treatment of data below LOD: to be integrated in dose assessment? to be imputed? Which value?**
- **Absorption into blood: reference Type? Mixture? Specific?**

➚ **All hypotheses are reasonable. Which influence of each hypothesis on dose estimates?**

Estimating intake from Job-Exposure-Matrix

Intake

I

Biokinetic Model

Time-activity curves in the source regions

➡ Number of nuclear transformations

Nuclear data, phantoms and particle transport

Tissue absorbed dose (mGy)

Radiation weighting factors w_R

Tissue equivalent dose (mSv)

Dosimetric Model

Tissue weighting factors w_T

Effective dose (mSv)

DOSE VALUES

Exposure ot uranium miners (CURE Project)

Concerted Uranium Research

- Radon gas (Bq·m^{-3})

  Radon progeny
  F = equilibrium factor
  (e.g., ventilation)
  f_p = unattached fraction
  Aerosol characteristics
  (e.g., use of diesel motors)

- Uranium ore dust
  (Long lived radionuclides)

Sources of exposure for the miners

Concerted Uranium Research

Gamma (low LET):
External (radionuclides in the ores)
~ homogeneous exposure of all organs
Internal (radon progeny, LLR in the ore dust)

Alfa and beta (high/low LET):
Internal (radon gas, radon progeny, LLR in the ore dust)
Very inhomogeneous, depending on the deposition pattern

Setting up the Job-Exposure-Matrix: characterization of the intake

Concerted Uranium Research

- **Individual exposure data**
  - **Radon progeny (h.J.m^{-3} or WLM)**
  - **Radon gas (h.Bq.m^{-3})**
  - **Long-lived radionuclides including uranium (h.Bq.m^{-3})**
  - **External gamma radiation (mGy)**
- **Parameters of exposure**
  - **Breathing rate (m^3.h^{-1})**
  - **Radon progeny : equilibrium factor F, unattached fraction f_p**
  - **Long-lived radionuclides: isotopic composition**
  - **Particles sizes: median diameter AMTD/AMAD and standard deviation σ_g**
  - **Absorption in lung (f_r, s_r, s_s)**
- **Job types**
  - **Wet/dry drilling, ventilation, diesel, physical activity**

Setting up the Job-Exposure-Matrix: definition of job types.

Concerted Uranium Research

- 0: Hewer + wet drilling + diesel + good ventilation
- 1: Hewer + wet drilling + no diesel + good ventilation
- 2: Hewer + wet drilling + no diesel + medium ventilation
- 3: Hewer + wet drilling+ no diesel + bad ventilation
- 4: Hewer + dry drilling + no diesel + bad ventilation
- 5: Other (underground) + diesel+ good ventilation
- 6: Other (underground) + no diesel + good ventilation
- 7: Other (underground) + no diesel + medium ventilation
- 8: Other (underground) + no diesel + bad ventilation
- 9: Other (surface)
- 10: Miller (ore) + good ventilation
- 11: Miller (ore) + medium ventilation
- 12: Miller (ore) + bad ventilation
- 13: Miller (non-calcined samples) + good ventilation
- 14: Miller (non-calcined samples) + medium ventilation
- 15: Miller (non-calcined samples) + bad ventilation
- 16: Miller (ore and non-calcined samples) + good ventilation
- 17: Miller (ore and non-calcined samples) + medium ventilation
- 18: Miller (ore and non-calcined samples) + bad ventilation
- 19: Miller (calcined samples) + good ventilation
- 20: Miller (calcined samples) + medium ventilation
- 21: Miller (calcined samples) + bad ventilation
- 19: Miller (calcined and non-calcined samples) + good ventilation
- 20: Miller (calcined and non-calcined samples) + medium ventilation
- 21: Miller (calcined and non-calcined samples) + bad ventilation
- 22: Miller (ore and calcined samples) + good ventilation
- 23: Miller (ore and calcined samples) + medium ventilation
- 24: Miller (ore and calcined samples) + bad ventilation
- 25: Miller (ore, calcined and non-calcined samples) + good ventilation
- 26: Miller (ore, calcined and non-calcined samples) + medium ventilation
- 27: Miller (ore, calcined and non-calcined samples) + bad ventilation

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