Fitting bioassay data and biokinetic models to estimate the intake of people exposed to random and irregular intake of radioactive particles.

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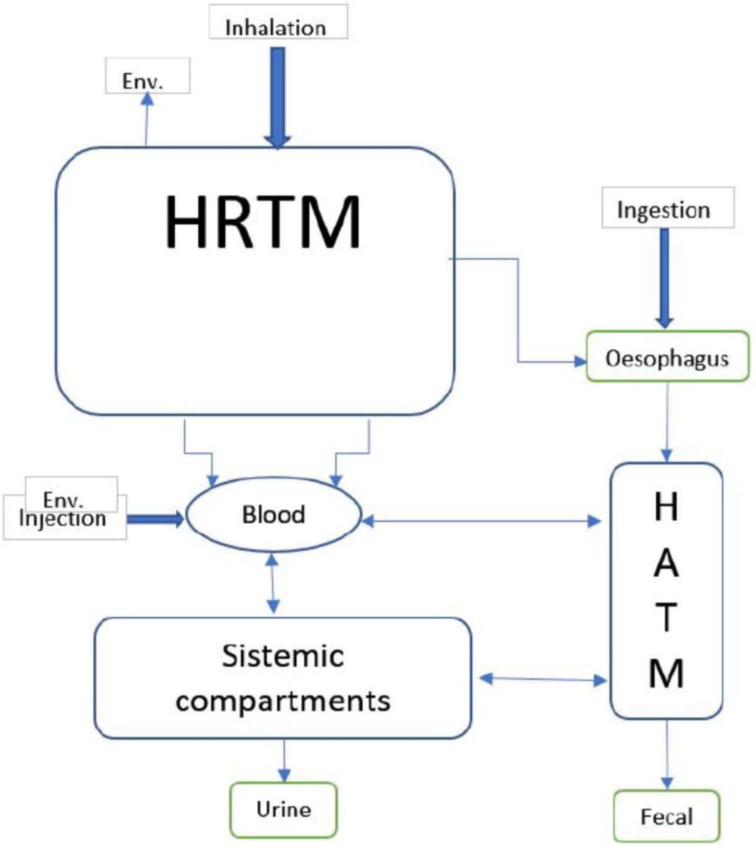
- Workers routinely exposed to radioactive particles, in order to estimate the radioactive particle intake, are monitored taken bioassay measuring the activity y_i, in Bq, of a specific isotope in the urine excretion or the lung retention.

- Biokinetic models - supplied by ICRP- of the distribution of isotope are used: the human body is divided in compartments and the time-dependent activity of radionuclide in each compartment is represented as a function of time after intake.
- Solving these models are obtained the called the response functions that represents, for an specific isotope, the predicted activity of a radionuclide in the body, organ, tissue or daily excreta at a particular time t after the intake.

$$r(t) = \sum_j \theta_j e^{-\beta_j t}$$



The ICRP divides the human body in subsystems: The alimentary tract model (HATM), the respiratory tracts model (HRTM) and specific subsystems of each compartment

- Thus, if we take sample (i.e. the accumulated 24 hour urinary excretion) on the day *t*, observing a value y(*t*) for an isotope, then we can estimate the intake quantity b(*t*)

$$\hat{b}_1 = y(t)/r(t)$$

Real situations are more complex. We have analysed the case where the worker is exposed to a multiple constant intake, this means that during some periods intakes occurs followed by periods without intakes.

Let us assume k intervals (s_1, T_1), (s_2, $s_2 + T_2$), … , (s_k, $s_k + T_k$), with k constant and positive continuous intakes b_i, i = 1, 2, … , k respectively. The quantity y(t) retained in the body at time t can be modeled as:

$$y(t) \quad = \quad b_1 q_1(t) + b_2 q_2(t) + \cdots + b_k q_k(t) + \varepsilon(t), \;\; t \in [1, s_{k+1}],$$

where

$$q_i(t) = \begin{cases} 0 & \text{if } t \leq s_i, \\ \int_0^{t-s_i} r(s)ds & \text{if } s_i < t < s_i + T_i, \\ \int_{t-s_i-T_i}^{t-s_i} r(s)ds & \text{if } t \geq s_i + T_i. \end{cases}$$

Example.- We consider a worker that has been exposed to a constant intake of UO2 radioactive aerosols during the following periods: from 06/01/1998 to 10/29/2016, from 01/16/2017 to 03/26/2017, from 01/10/2018 to 03/21/2018. During this time urine samples (Bq of alpha-U accumulated in 24h) were taken from the worker with results shown in Table. We wish to estimate the activity incorporated in the different periods.

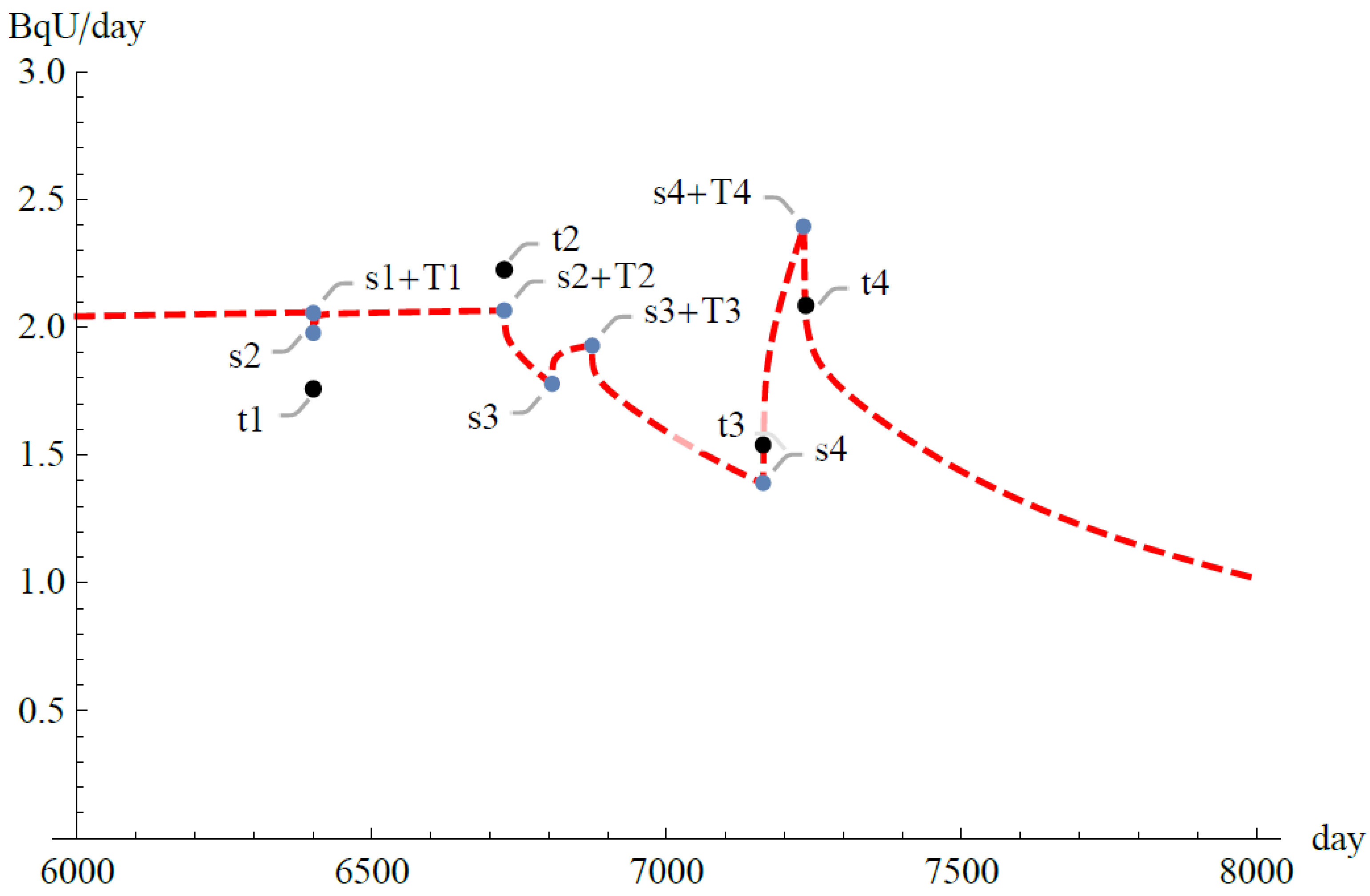
s_1	T_1	t_1	s_2	T_2	t_2	s_3	T_3	$t_3 = s_4$	T_4	t_4
1	6400	6401	6402	323	6726	6804	69	7163	70	7235
		y_1			y_2			y_3		y_4
		1.76			2.23			1.54		2.09
		σ_1			σ_2			σ_3		σ_4
		0.26			0.32			0.27		0.31

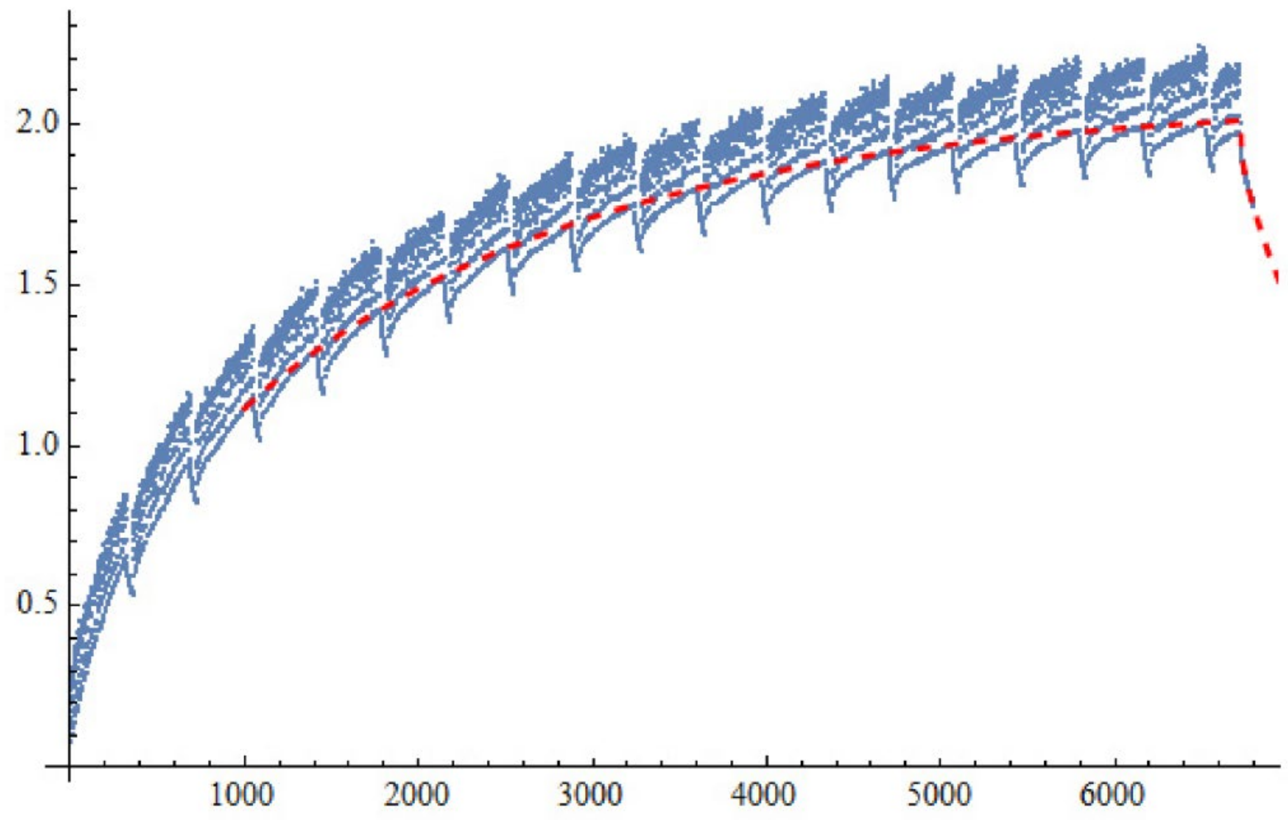
$$r_{urine24-h}(t) = 0004769e^{-1.2t} + 0.001358e^{-1.003t} + 0.000689e^{-1.0t} + 0.000007971e^{-0.3436t} + 0.00000312e^{-0.2005t} + 0.0000088e^{-0.1388t} + 0.000001544e^{-0.099t} + 0.0000393e^{-0.09728t} + 0.0000038e^{-0.03219t} - 9.2 \times 10^{-8}e^{-0.01258t} + 0.0000173e^{-0.0035t} + 0.0000033e^{-0.0005t} + 0.0000052e^{-0.0004822t} + 2.25 \times 10^{-8}e^{-0.0003797t} + 9.1 \times 10^{-9}e^{-0.0001897t} + 4.04 \times 10^{-8}e^{-0.00008067t} + 1.896 \times 10^{-9}e^{-0.00001892t}$$

Fitting the model

{B1, B2, B3} are unknown

$$\hat{B} = (X^T \Sigma^{-1} X)^{-1} X^T \Sigma^{-1} Y$$





It has been found that in practical situations the random intake can approach to the case of a constant intake or multiple constant intake.

The figure represents the daily urine excretion of U. It can be observed that two days after the intake stops both solutions are practically equal. This can be explained because part of the elimination by the urine excretion happens faster after the intake happens, then after that it is more stable.

Thank you for your attention.
The presentation can be downloaded from:
http://diarium.usual.es/guillermo

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