ICRP Systemic Biokinetic Models

Learning Objectives

- Describe the parameters and uses of systemic biokinetic models
- Identify sources for various models
- Explain differences between the ICRP and NRC models for uranium

Systemic biokinetic models

- **Element-specific**
- **Available in ICRP 78 (1997) for H, Fe, Co, Sr, Ru, I, Cs, Ra, Th, U, Np, Pu, Am, Cm, Cf, and in earlier reports for other elements**
- **Give the systemic deposition of activity into each organ from the transfer compartment (blood and lymph)**
- **Give the transfer coefficients between the organs and the bloodstream**
- **Give excretion pathways and fractions**

Uptake

- The fraction of an intake entering the systemic circulation is referred to as the ***uptake***
- ICRP models for radionuclides in systemic circulation are used to calculate dose coefficients
- Following review of data behavior of radionuclides in the body, a number of elemental models have been revised
- Revised models were also used to calculate dose coefficients for workers

Revision of systemic models

- Models for several elements have been revised, particularly to account for recycling of radionuclides between compartments (so they are more complicated!)

- The models are more physiologically oriented, can be applied to calculate bioassay quantities, and evaluate dose to the general population not only to workers.

- Previously, a number of radionuclides (e.g. ^{239}Pu) were assumed to be retained on bone surfaces - a conservative assumption

- Evidence indicates a fraction of plutonium is buried as a result of bone growth and turnover

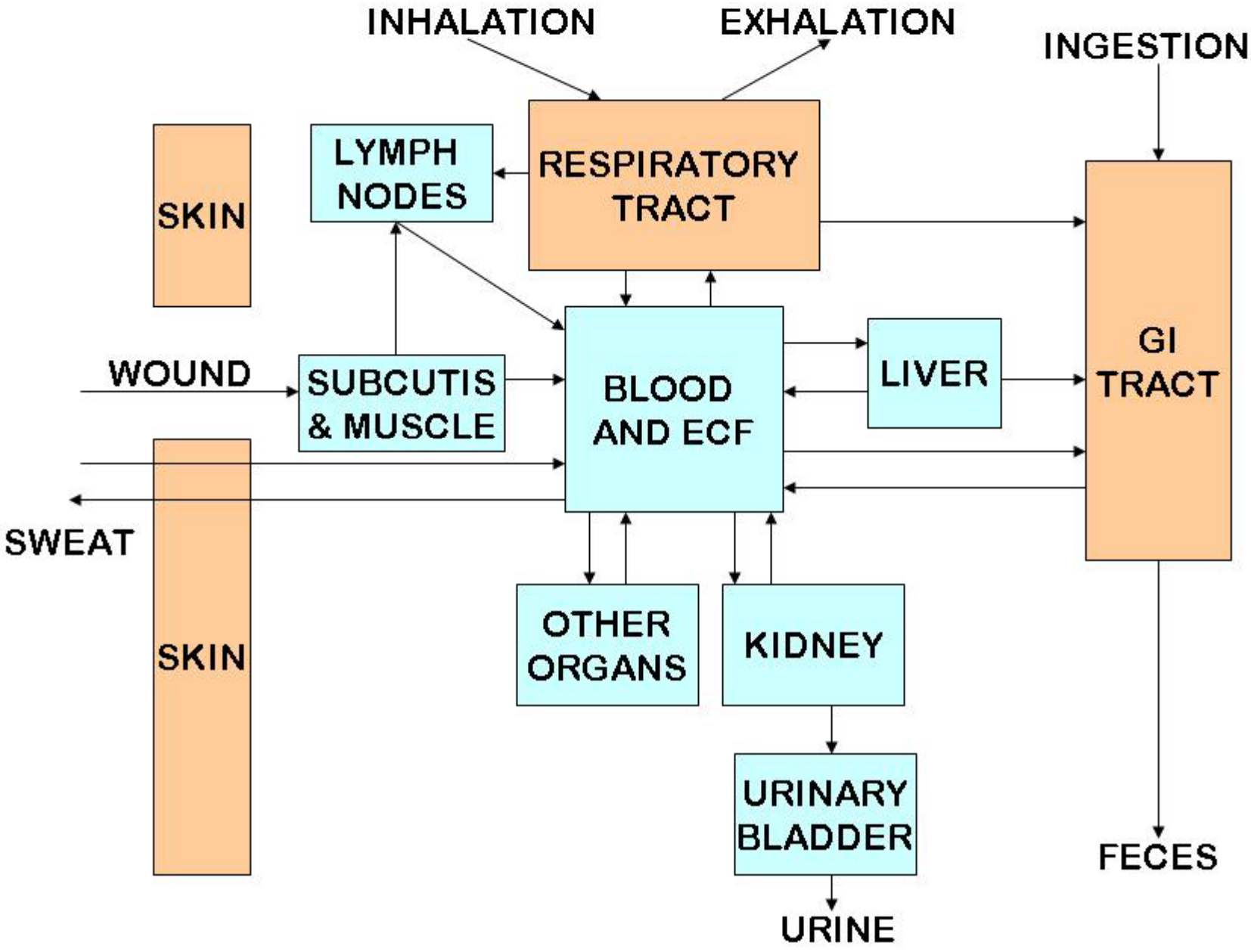
Revision of systemic models, con't.

- Another fraction is desorbed and re-enters the blood
- Some may be re-deposited in the skeleton and liver or be excreted
- In contrast, 'bone volume seeking' nuclides, such as ^{90}Sr and ^{226}Ra, have been assumed to instantaneously distribute in bone volume

Revision of systemic models, con't.

- The process is actually progressive
- Generic models for plutonium, other actinides, and for the alkaline earth metals have been developed to:
  - Allow for the known radionuclide behavior
  - Account for knowledge of bone physiology
- The model for alkaline earth metals has also been applied, with some modifications, to lead and to uranium.

GENERIC BIOKINETIC MODEL



Iodine **(from ICRP 67)**

- Of iodine that reaches the blood :
  - 30% is accumulated into the thyroid gland,
  - 70% is excreted directly in urine.
- Iodide incorporated into thyroid hormones leaves the gland with an half time of 80 d and enters other tissues where it is retained with a half-time of 12 d.
- Most iodide (80%) is subsequently released and is available in the circulation for uptake in the gland and urinary excretion.
- The remainder (20%) is excreted in faeces in organic form.

Iodine

- Model :

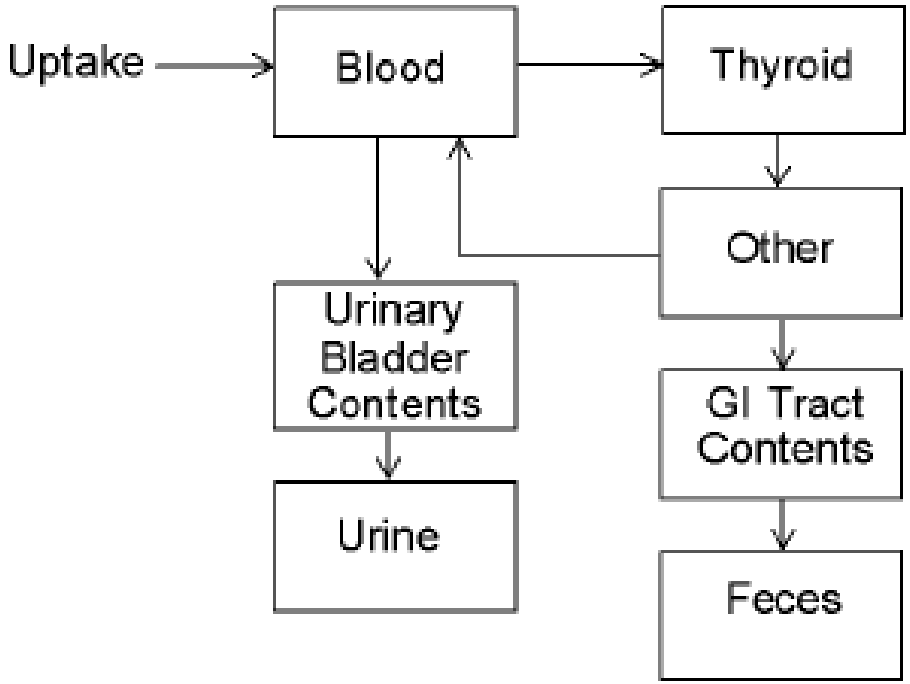


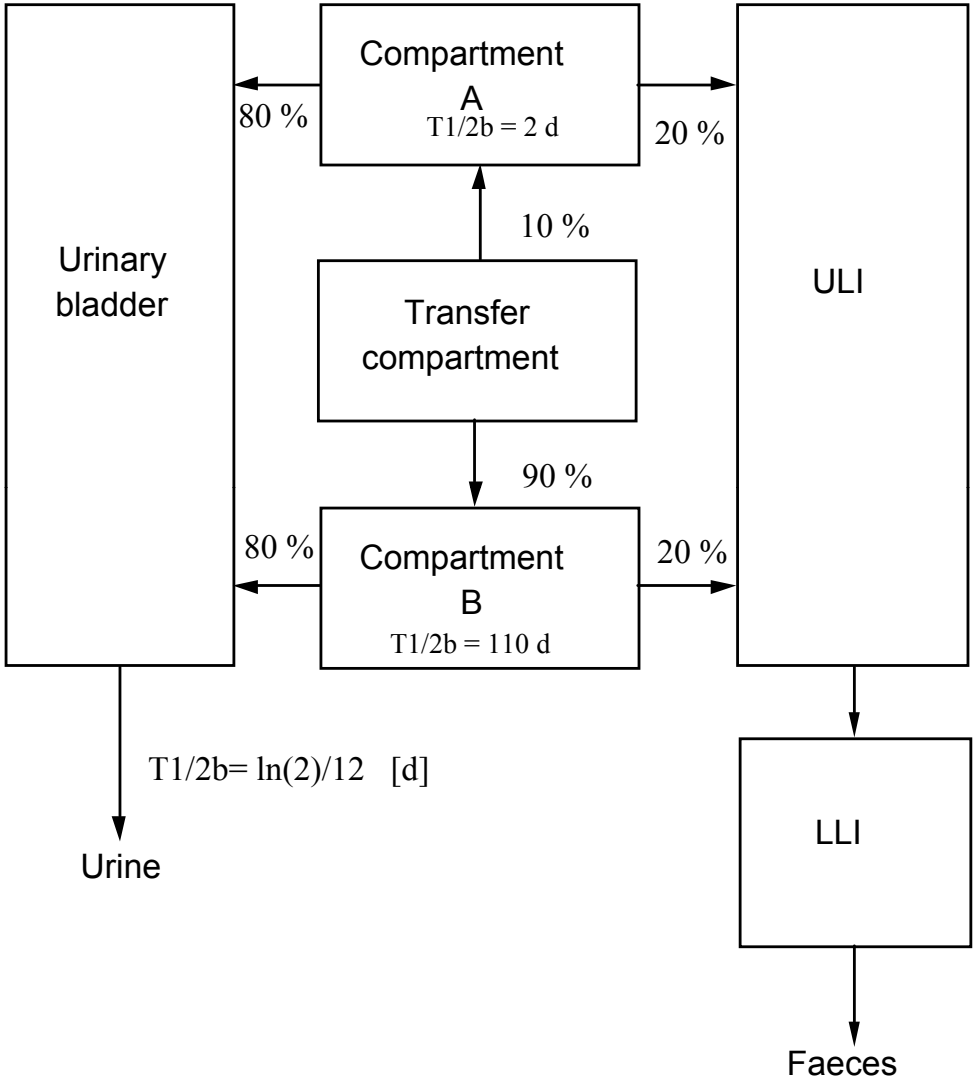
Figure 5.1. Structure of the model for iodine used in ICRP Publication 30 (1979) and current ICRP documents.

Cesium **(from ICRP 67)**

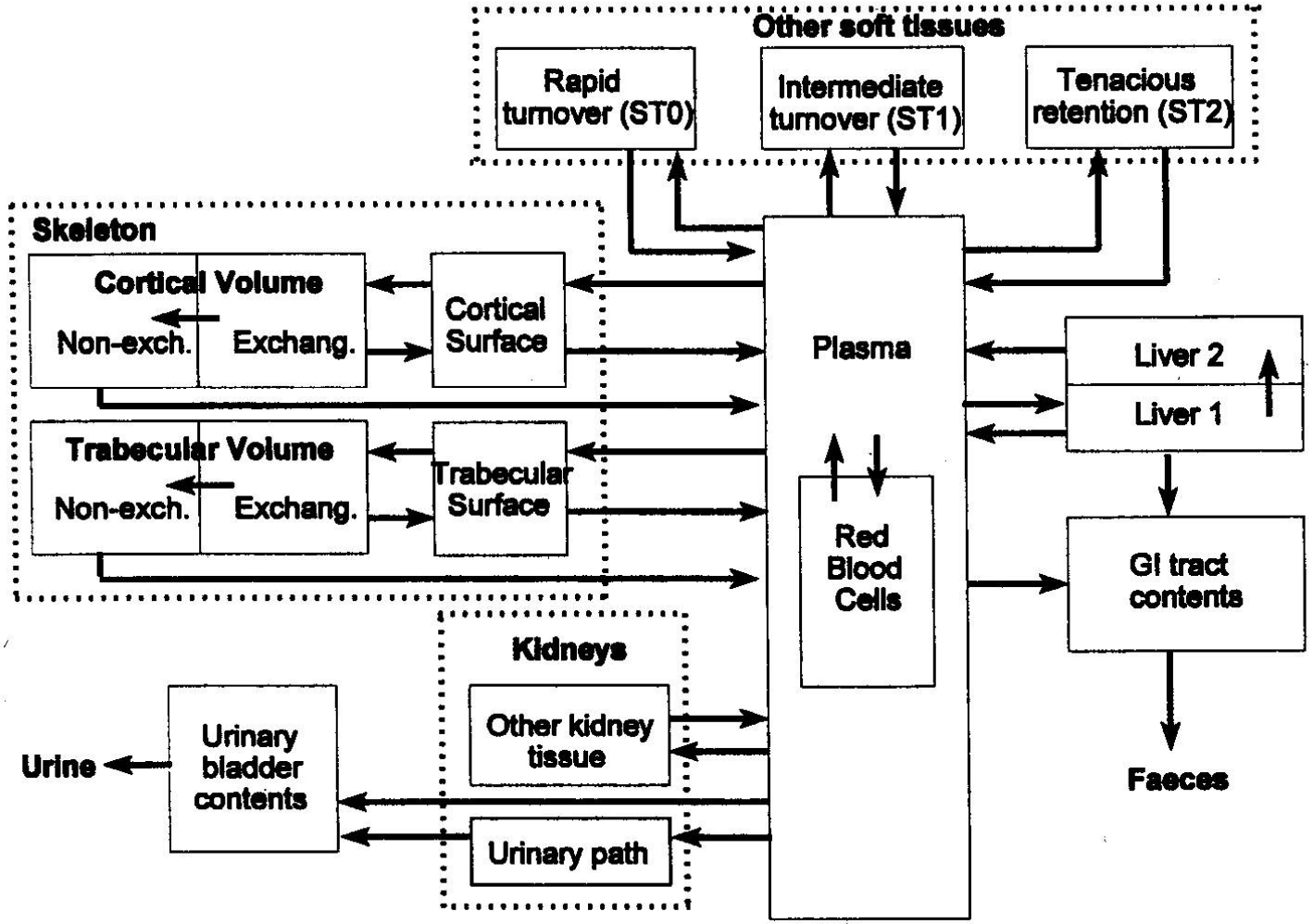
- Systemic caesium is taken to be distributed uniformly throughout all body tissues
- 10% of activity is assumed to be retained with a biological half life of 2 days (A)
- 90% of activity is assumed to be retained with a biological half life of 110 days (A)
- For female the half time of compartment B is significantly less than for males.
- In some countries there is also evidence of mean biological half time for adult males shorter than 110 d.
- Urinary to faecal excretion ratio of 4:1 is recommended.

Cesium

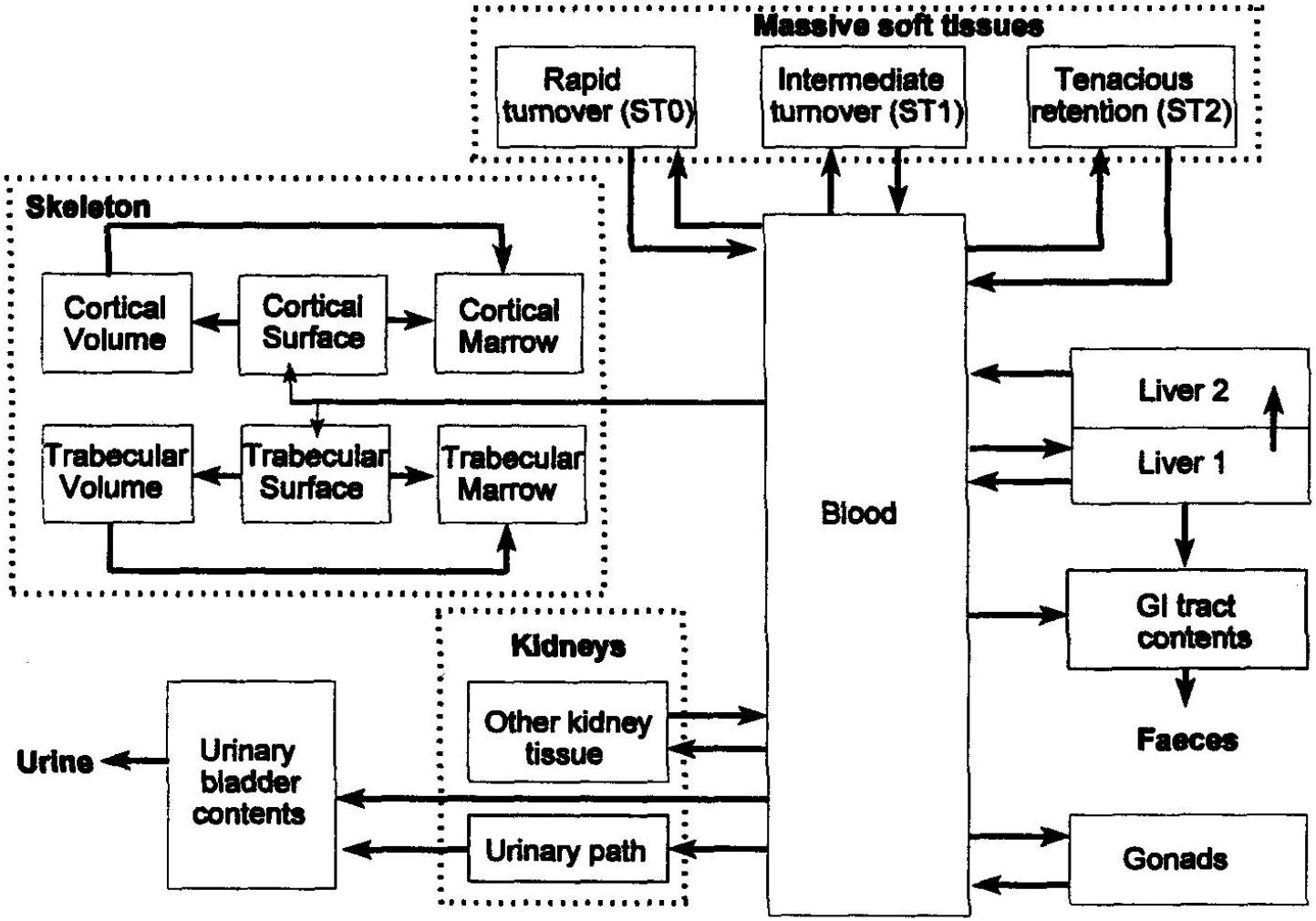
- Model :



Model for Sr, Ra and U



Model for Th, Np, Pu, Am and Cm



Radioactive progeny

- A number of radionuclides decay to nuclides that are themselves radioactive
- It has been assumed that the decay products would follow the biokinetics of their parents
- A few exceptions made for decay products which are isotopes of noble gases or iodine
- The revised biokinetic models apply separate systemic biokinetics to the parent and its decay products for intakes of radioisotopes of lead, radium, thorium and uranium.

Excretion

- Urinary bladder and colon are given w_T values
- Specific information is given on excretion pathways in the urine and feces in revised biokinetic models for workers.
- GI tract model is used to assess doses from systemic activity lost into the feces.
- Secretion of radionuclides from the blood into the upper large intestine is assumed (e.g. for bone-seeking radionuclides)
- A urinary bladder model has been adapted for calculating doses to the bladder wall

$$\lambda = 12\ d^{-1} \Rightarrow [\ 6\ \text{voids}\ d^{-1}]$$