Possible Consequences of Inhomogeneous Suborgan Distribution of Dose and the Linear No-Threshold Dose-Effect Relationship

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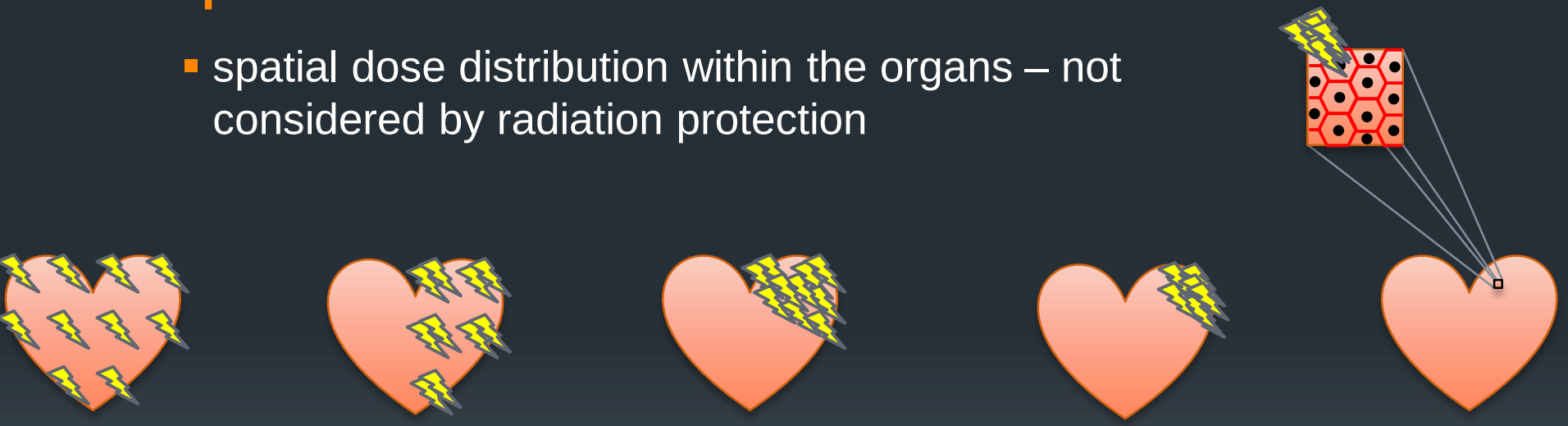
Introduction – a theoretical question

- spatial dose distribution within the organs – not considered by radiation protection



- very different exposure scenarios – the same effective dose and nominal risk

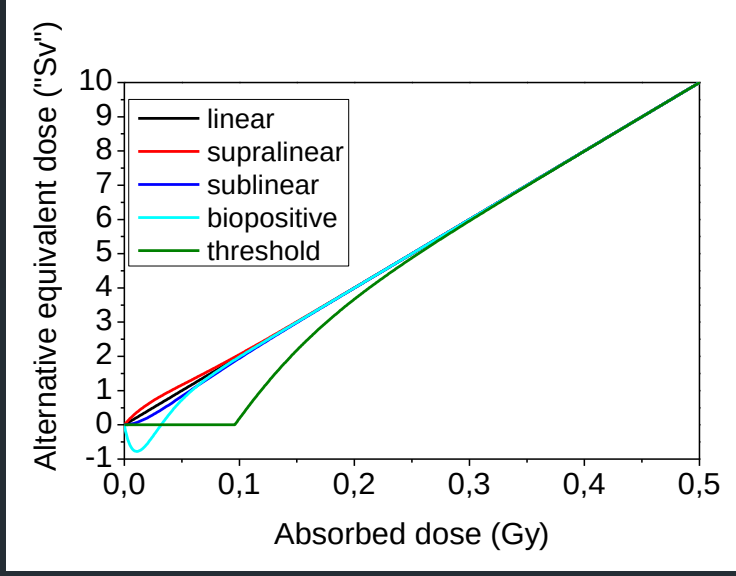
A practical issue – radon inhalation

- radon progeny – inhomogeneous deposition in the lungs
- significant issue in radiation protection
  - contribution to natural radiation burden of the public
  - second most important cause of lung cancer

Objective

- What consequences have the inhomogeneous dose-distribution,
  - if nominal risk is linear function of absorbed dose?
  - if nominal risk is non-linear function of absorbed dose?

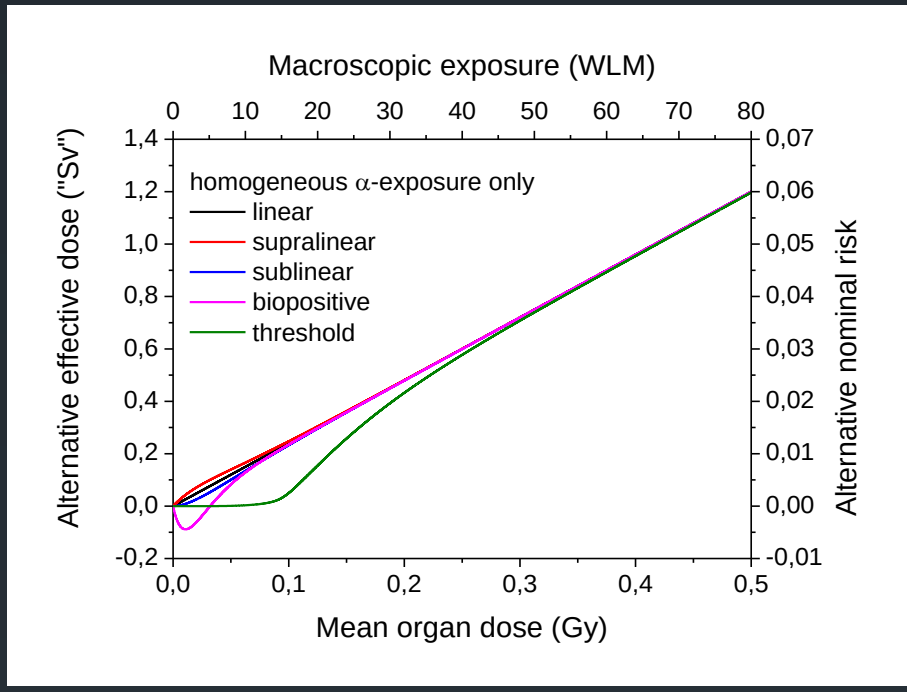
Methods

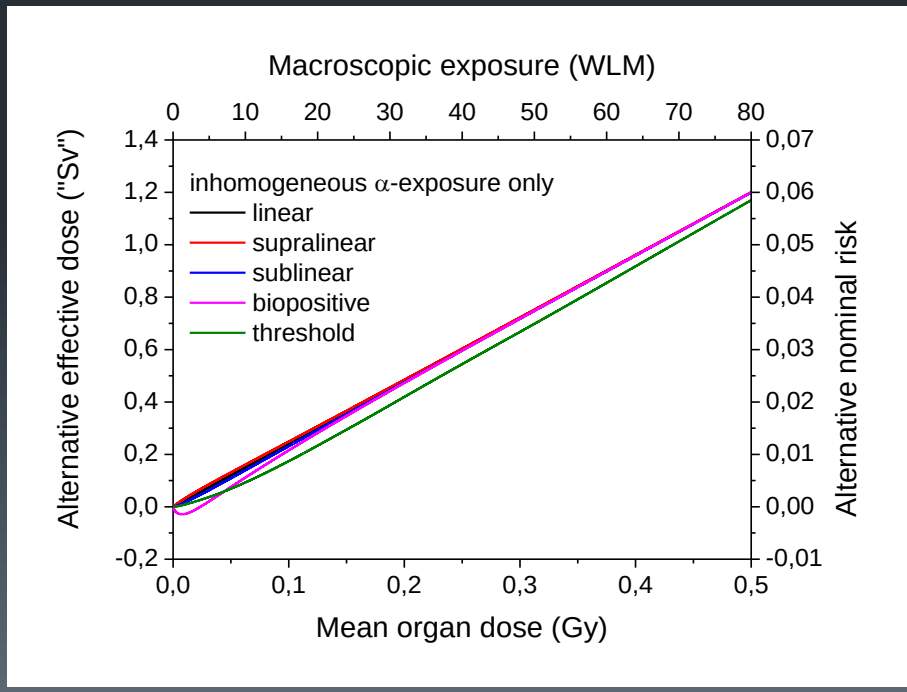


- introduction of tissue units (TUs) with an approximate size of 250 μm × 250 μm × 60 μm, where absorbed dose is computed
- introduction of alternative equivalent dose (H_T^*) as the function of dose absorbed by TUs $(D_{TU,i})$
- introduction of alternative effective dose (E^*) considering the suborgan dose distribution with the following expression:
  - $E^* = \sum_i w_{TU,i} \cdot H_T^*(D_{TU,i})$, where $w_{TU,i} = \frac{m_{TU,i}}{m_T} \cdot w_T$
- the dose distribution in the lungs is identical with the dose distribution in the central airways

Results

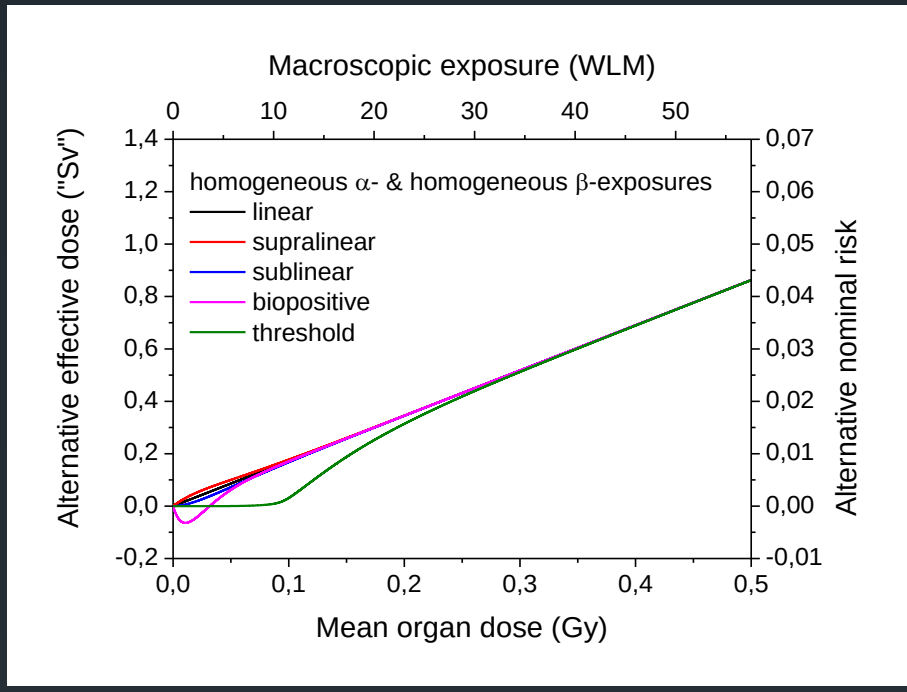
- only α-exposure
- the linear function independent on the dose-distribution
- the non-linear functions are much closer to the linear one in case of inhomogeneous exposure

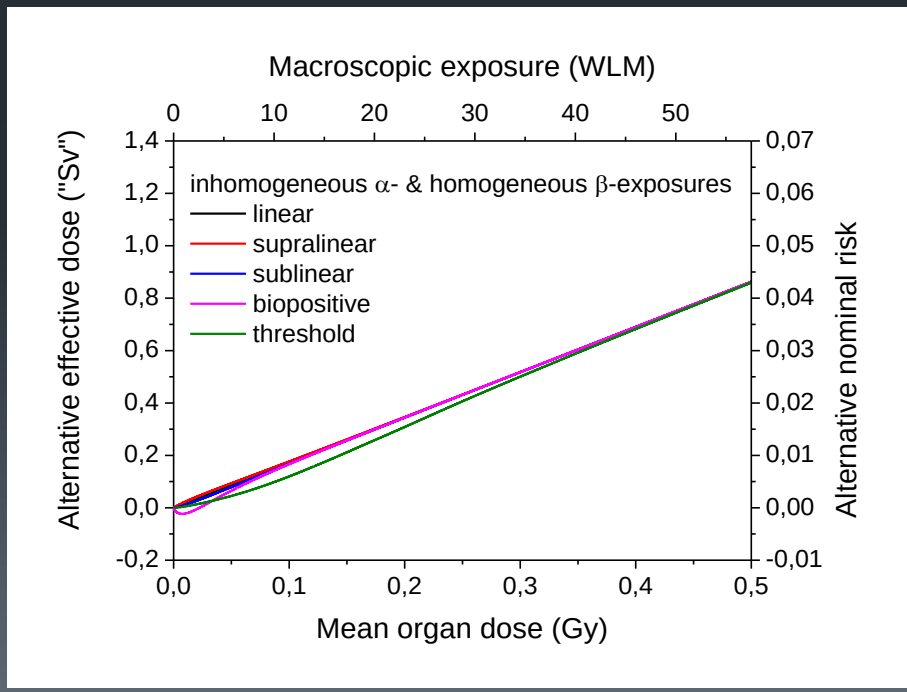




Results

- an inhomogeneous α- & a homogeneous β-exposure
- the linear function independent on the dose-distribution
- the non-linear functions are much closer to the linear one in case of inhomogeneous exposure





Conclusions

- Spatial distribution of dose cannot be considered, if the relationship between nominal risk and absorbed dose is linear.
- If there are any low dose nonlinearity in risk, it is probably less significant in case of inhaled radon progeny, than in case of radiation sources causing homogeneous exposures.
  - Proved linear relationship in case of radon does not necessarily mean linear relationship in the low dose range in general.
  - Proved low dose nonlinearity in case of homogeneous exposures does not necesseraly mean nonlinear risk-exposure relationship in case of radon progeny.

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