S factors for small animal dosimetry based on Monte Carlo simulations of an anatomical realistic mouse phantom

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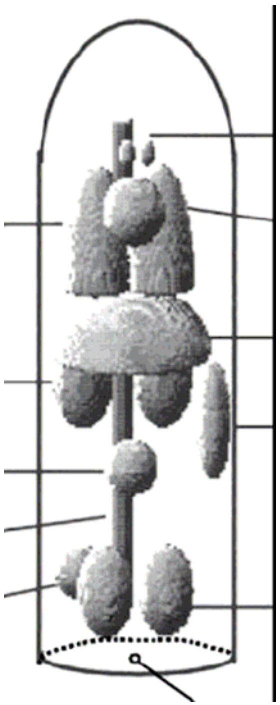
Introduction

- Biokinetic and dosimetry studies in small animals often precedes clinical Radionuclide Therapies.

- Electron range large compared to organ sizes in e.g. mice's.
  - Absorbed fractions less than unity
  - Cross-doses need to be considered

  - → A realistic phantom is required for good dosimetry

Examples of mouse phantoms

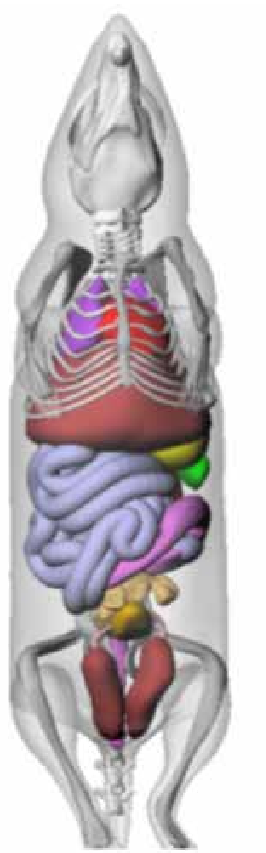


Hindorf et al.

(JNM 2004)

Stabin et al.

(JNM 2006)

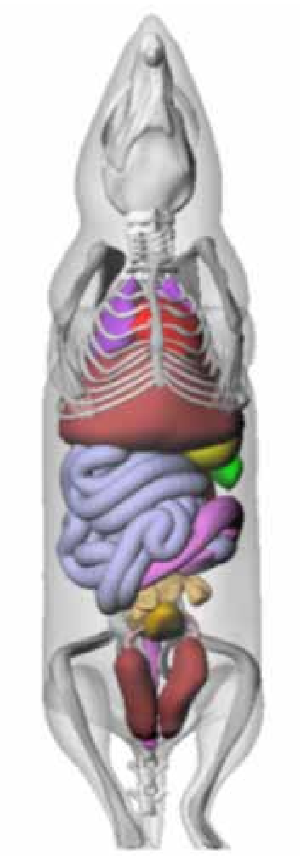


Segars et al.

(Mol Imaging Biol 2004)
(Moby)

The ”Moby” phantom

- Developed by *Segars et al (2004)* for evaluation and optimization of small animal imaging.
- Based on NURBS surfaces and is similar to the well-known NCAT computer phantom.
- Allows for flexibility, e.g. heart motion and respiratory motions
- Generates a voxel-based phantom of desired size.
- 35 segmented regions (8 heart regions and 7 brain regions)



Aims of this work

- Calculate absorbed fractions and S factors from Moby by **EGS4** and **MCNPX 2.6a** Monte Carlo simulation.
- Investigate differences in results from **EGS4** and **MCNPX 2.6a**
- Compare Moby used as a dosimetry model to previous published models.

Materials and Methods

- Moby phantom – general settings used
- 128*128*432 voxels, 0.25 mm voxels.
- 25 source- and target-organs used.
    - Heart regions combined into one organ
    - Brain regions combined into one organ
- In addition, kidneys, lungs, testes and thyroid divided into left and right.

Materials and Methods …cont'd

- Monte Carlo simulations with **EGS4** and **MCNPX 2.6a.**
- Simulations for mono-energetic photons and electrons and for ^{18}F, ^{124}I, ^{131}I, ^{111}In, ^{177}Lu and ^{90}Y.
- Composition for tissue, lung and skeleton taken from NIST (ICRP).

Materials and Methods – MCNPX

- Own constructed IDL-program creates the input files.
- Lattice model.
- Each organ represented by one universe.
- Lattice elements with X number of descendent same universes comprimized as Xr for faster initialization.
- Source sampling – most efficent with list mode.

Materials and Methods – MCNPX...

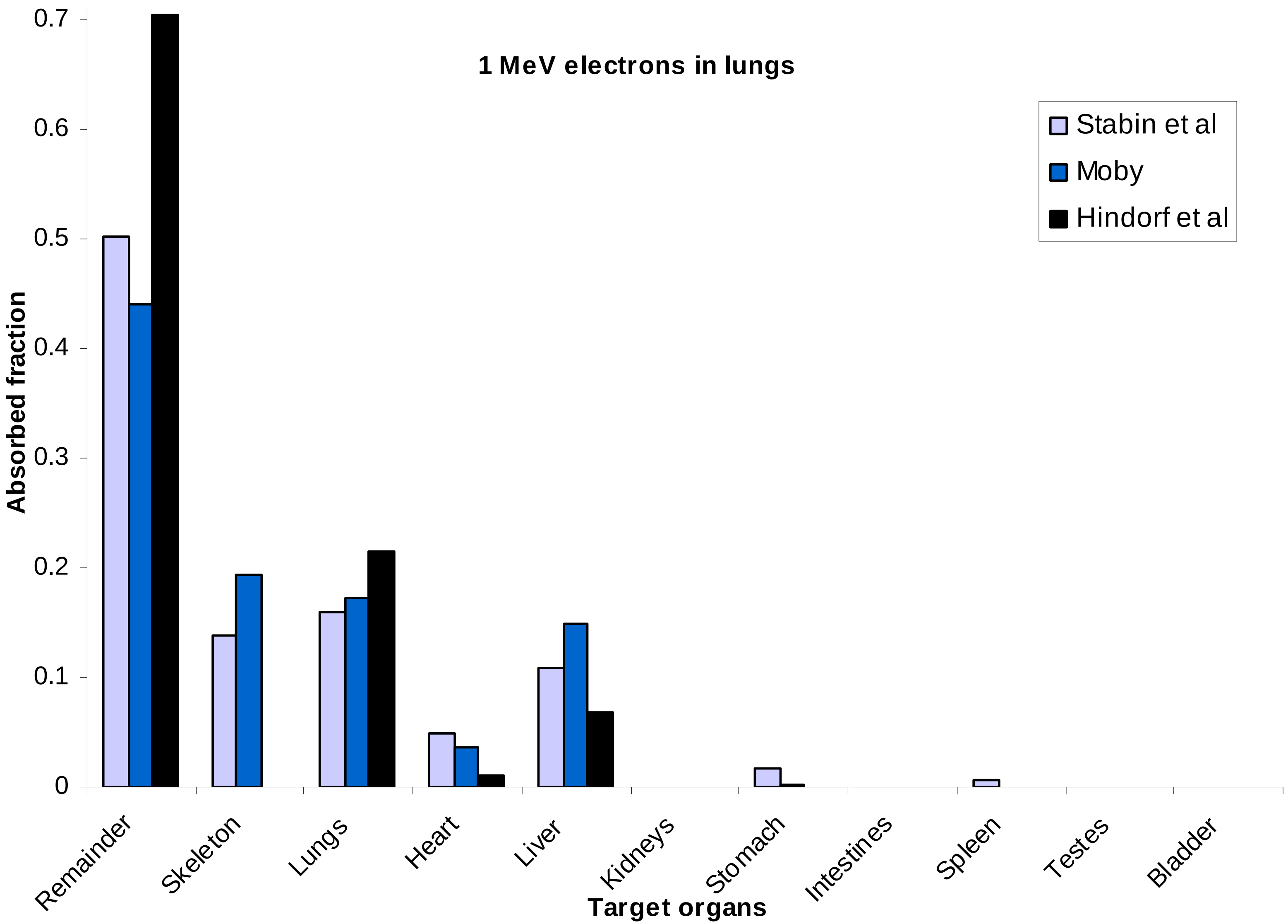
- Physics
  - ITS indexing algorithm (dbcn 17j 1).
  - ESTEP = default – No impact on the results because of isotropically emitting sources.
  - emax - Set to highest electron/photon energy in the problem.
  - E:cut 10 keV (default 1 keV) - Speeds up the simulation.
- *f8-tally for organ dosimetry. Not useful for voxel dosimetry.

Results: EGS4 vs. MCNPX

- Photons
  - Self doses: ~1% higher in **MCNPX**
  - Cross doses: < 2%
- Electrons
  - Self doses: <2% difference, except for E > 1 MeV for Lung (3%).
  - Cross doses: < 3% (except for bremsstrahlung only)
- Simulation times – 1 million 1 MeV electrons
  AMD Athlon 2200GHz + 1GB RAM
  - MCNPX 0.27 min initialization+ 11.69 min simulation
  - EGS4 15.5 min simulation

Absorbed Fractions from EGS4

1 MeV electrons from Lungs



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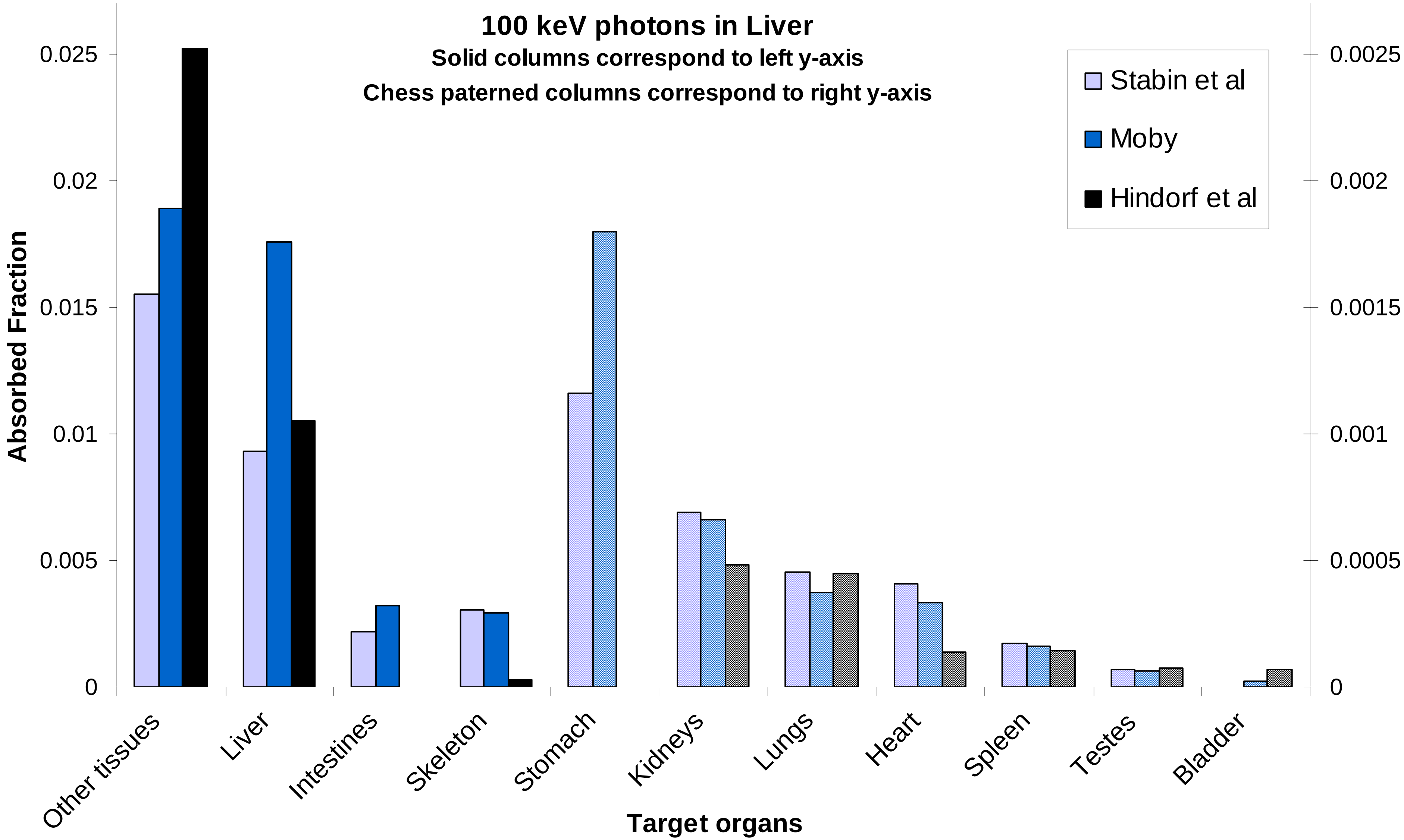
Absorbed Fractions from EGS4

100 keV photons from Liver



Conclusions

- Absorbed fractions from **MCNPX** and **EGS4** corresponds well for most organs.
- WIP: Implementation of **EGSnrc** (more accurate physics)
- The Moby phantom is useful for dosimetry studies because
  - Anatomically realistic
  - Has more segmented organs than previously published models.
- The phantom can to some extent be altered to model anatomical variations of the mice.

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