SEGMENTATION AND USE OF THE VISIBLE FEMALE DATASET FOR INDIVIDUAL EFFICIENCY CALIBRATION AND DOSIMETRY IN IONISING RADIATION RESEARCH

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Introduction: Currently, individual suitable physical phantoms are not available for in vivo calibration and dosimetry. Simulations with computational phantoms (voxel models) of real persons represent a promising support for individual monitoring of ionising radiation.

Segmentation of the Visible Female: The torso of the Visible Female dataset was pre-processed. With aid of region growing and interactively deformable triangle meshes it was segmented into four tissue classes: bones, lungs, liver and other tissue. The resolution of the data (Fig. 1, left) is 1 x 1 x 1 mm. This model is the first of its kind to be used in calculations of radiation transport for lower energy photons and interindividual comparison with the MEET-Man [1] dataset.

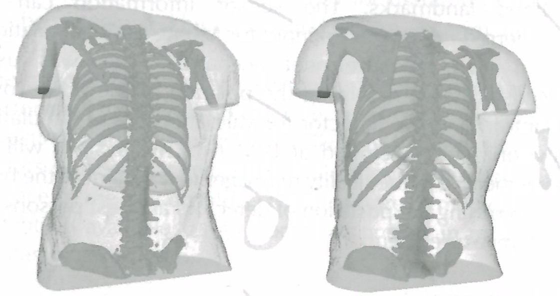

Figure 1: Segmented Visible Female (left) and MEET-Man (right) with bones, lungs and liver.

Monte Carlo calculations: Detector spectra and radiation transport of particles were calculated using Monte Carlo N-Particle eXtended (MCNPX) and Voxel2MCNP as described earlier [2]. For realistic anatomic geometries, two digital human voxel models, the Visible Female and the MEET-Man dataset were used as torsos, cubed in 1 x 1 x 1 mm resolution. Lung, liver or skeleton were assumed as Am-241 source in the simulations.

Efficiency calibration: The radiation measurable outside the body was simulated in form of energy spectra for two phoswich detectors, positioned left and right over the center of the respective organ or tissue. The simulations were performed for each source organ and used for the determination of efficiency factors (Fig. 2).

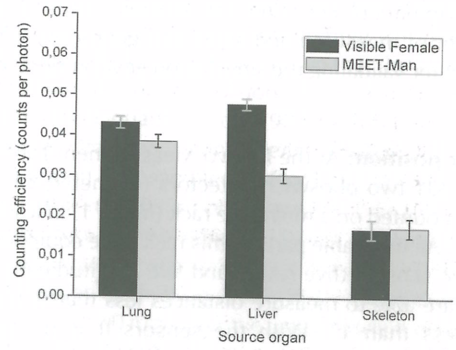

Figure 2: Counting efficiencies (sum of left and right detector, 107 histories each) for Am-241 (ROI 20-80 keV) calculated from simulations with MCNPX, three source organs and the torso datasets of the Visible Female and the MEET-Man.

The liver of the Visible female was determined to 167% of the weight of the Reference Woman´s and to 118% of the MEET-Man´s liver. The individual differences led to higher counting efficiencies compared to that of the MEET-Man (+ 35% at the right and +124% at the left detector).

Dosimetry: The large female liver obtained 108% of the liver dose of the MEET-Man (1.17 x 10-12 mSv per photon) in case of simulating Am 241 incorporation in the liver. Further results as the distribution of absorbed dose within the human body will be presented at this conference.

References:

1. Sachse F. B., Werner C., Müller M., and Meyer-Waarden K. Preprocessing of the visible man dataset for the generation of macroscopic anatomical models. In Proc. First Users Conference of the National Library of Medicine's Visible Human Project, 123–124 (1996).
2. Hegenbart L., Na Y. H., Zhang J. Y., Urban M., and Xu X. G. A Monte Carlo study of lung counting efficiency for female workers of different breast sizes using deformable phantoms. Phys Med Biol, 53(19), 5527–5538 (2008).

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