Karlsruhe Institute of Technology

Comparison of internal and external dose conversion factors using ICRP adult male and MEETMan voxel model phantoms

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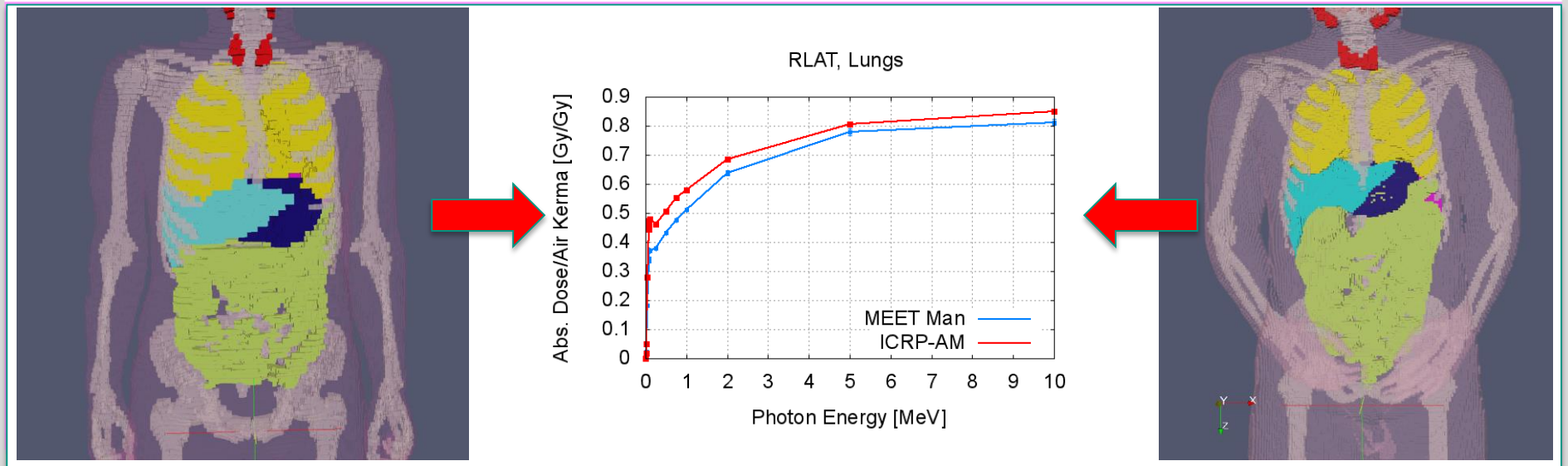
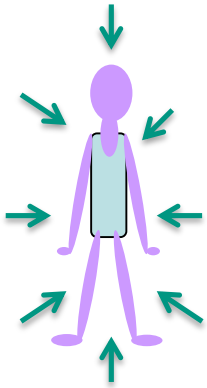
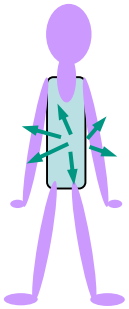


Motivation for this study

- Protection quantities (not measurable) ⟷ operational quantities (measurable)
  Dose conversion factors

- 

$$d.c.f = \frac{E_{Dep}}{KERMA \times M_{Organ}}$$



$$SAF = \frac{1}{M_T} \frac{Energy\ in\ T}{Energy\ from\ S}$$

- Evaluable only with Monte Carlo calculation and the use of voxel model phantoms

- Comparing different voxel model brings to the estimation of the possible difference between the calculated d.c.f. and its real value.

How we proceeded

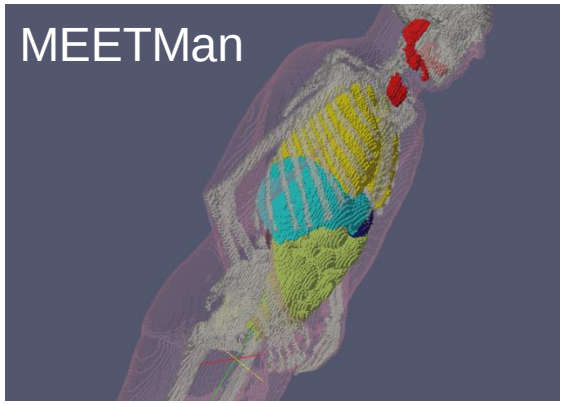
- Two voxel models employed.

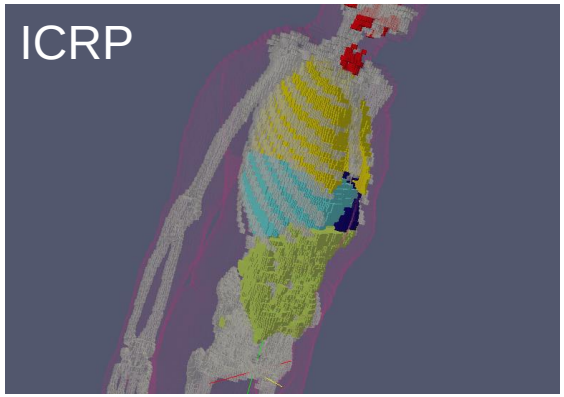
	ICRP adult male	MEET Man
Height	176 cm	180 cm
Weight	70 kg	92 kg
Voxel resolution	8 mm in height 2.08 mm^2 in-plan resolution	from 6 mm^3 down to 1 mm^3 (4 mm^3 used)

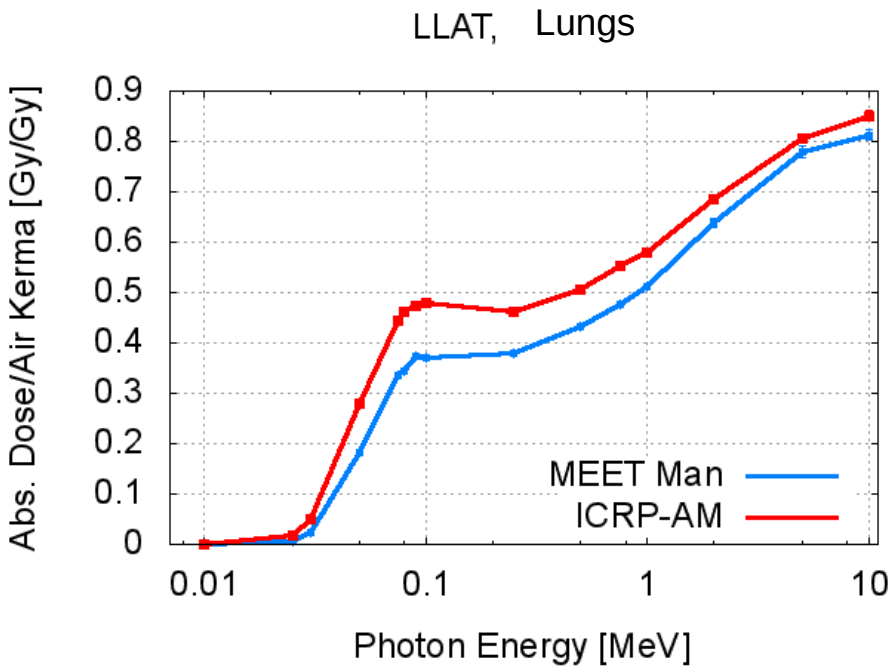
- Used Monte Carlo code: MCNPX (V.2.6.0).
  Phantom model converted into MCNPX voxel format via in-house software Voxel2MCNP.

External irradiation source [1/2]

- 4 scenarios: AP, PA, LLAT and RLAT.



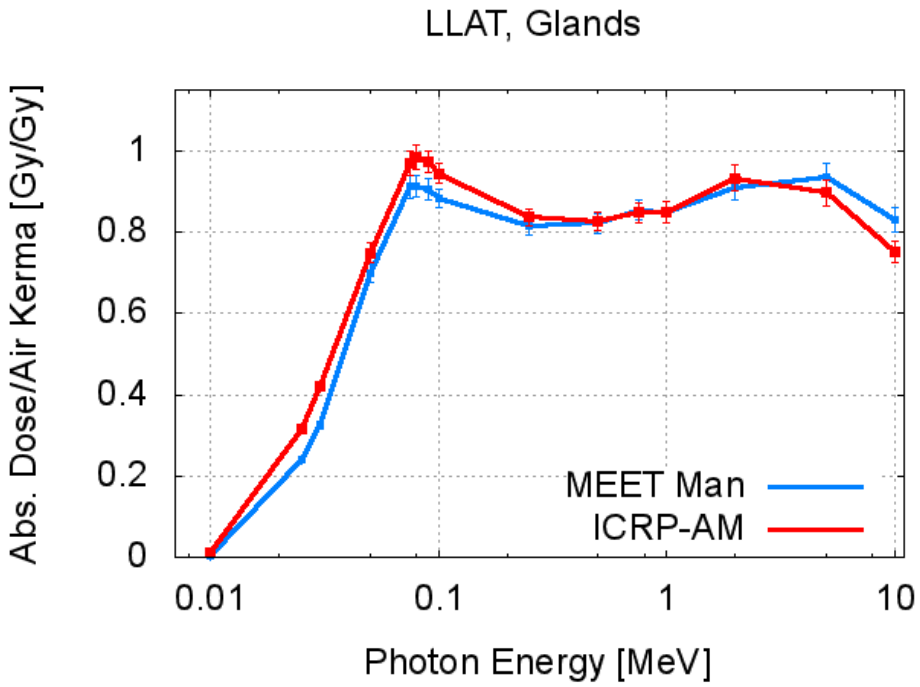




- Different position of the arms gives a different shielding on the side

External irradiation source [2/2]

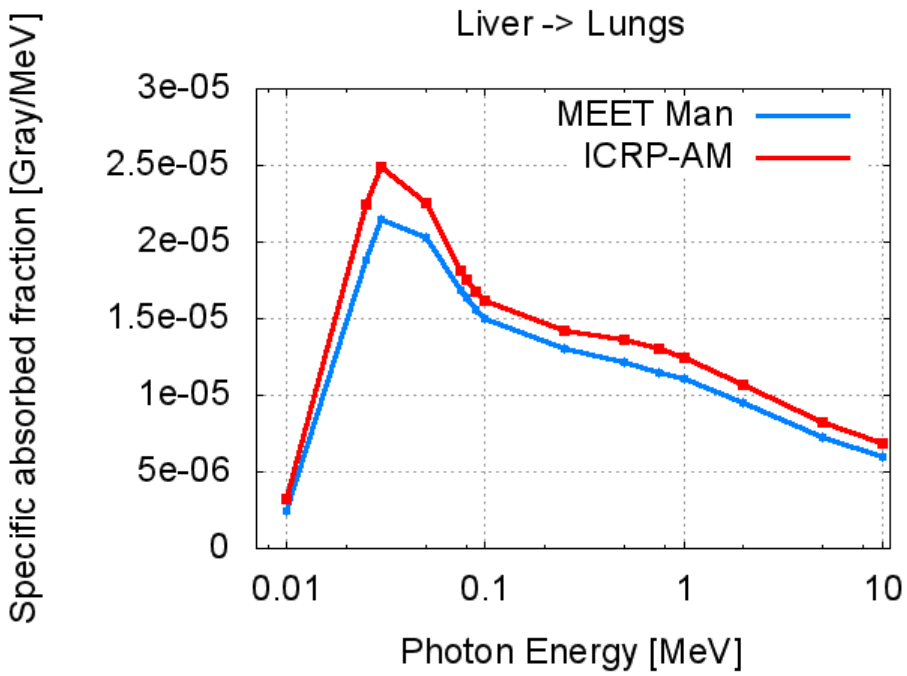
- Shielding from the adipose tissue: given the attenuation coefficient of the adipose tissue, a 100 keV photon beam is attenuated of 15% if crossing 1 cm of adipose.
- Evidence of shielding effect by looking at the thyroid and salivary glands.



Internal Contamination [1/2]

- More parameters play a role in the evaluation of the SAF.
- More difficult to give predictions on the effect of the anatomy on the SAF.
- One example where ICRP predicts higher value than MEET Man :

- Lungs in ICRP composed of blood and tissue:
  average density ρ=0.41 g•cm^{-3}
  MEET Man lungs ρ=0.32 g•cm^{-3}
  More energy deposited in ICRP
  ➔ higher values of SAF

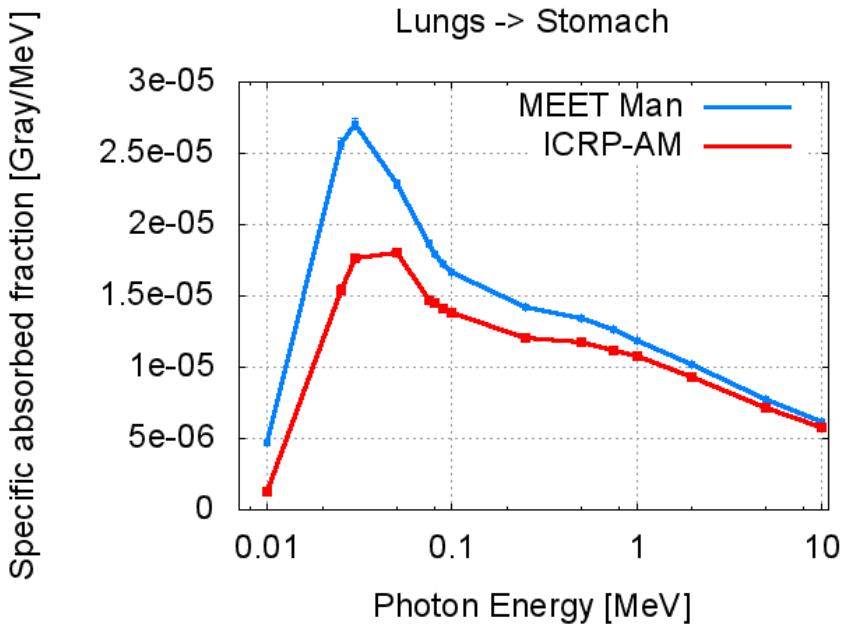


Internal Contamination [2/2]

- One example where ICRP gives lower value than MEET Man.
  If the organ with higher density is the source instead of the target, opposite effect:

  $\rho(\text{Lungs}_{\text{ICRP}}) > \rho(\text{Lungs}_{\text{MEET Man}})$

  ➔ more self-absorbtion in ICRP-Lungs
  ➔ lower SAF in ICRP-AM



Some more examples from external irradiation

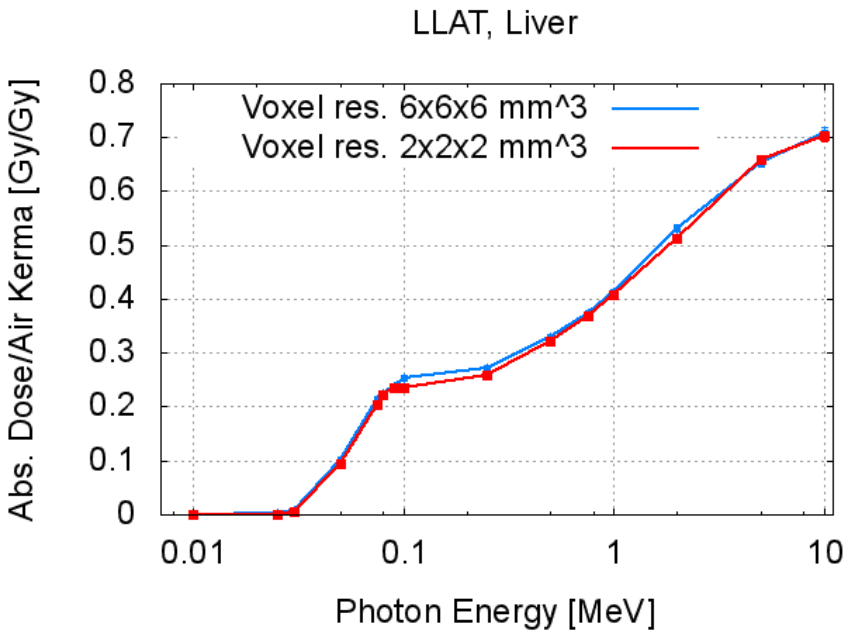
- For E=100 keV, ratio between d.c.f. from ICRP and MEET Man:

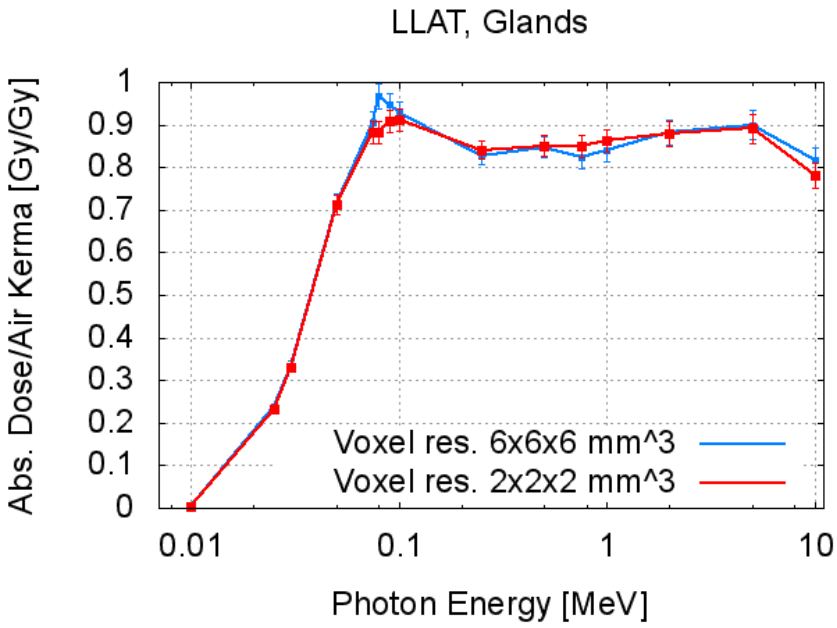
	Liver	Kidney	Lungs	St. Wall	Glands
AP	**11%**	-5%	7%	9%	0%
PA	0%	**22%**	-4%	3%	**35%**
RLAT	**37%**	**45%**	**29%**	0%	1%
LLAT	**27%**	**22%**	**11%**	**38%**	7%

- Dose calculated with ICRP is in the most of the cases over-estimated if the patient is bigger than ICRP model.

Effect of voxel resolution

- MEET Man available in several voxel resolution.
- No effect from different resolution expected for large organ i.e. on liver.
- Checked the effect on a small organ. Chosen glands (thyroid + salivary glands).





Conclusion and Outlook

- Considerable discrepancies among dose conversion factors calculated with different voxel model phantoms.
- ICRP gives conservative estimate of the organ effective dose, at least if the patient is bigger than ICRP-AM.
- Smaller reference voxel phantom exist.

- More scenarios of external irradiation and more couple source-organ will be calculated.
- Implementation of the dose conversion factors calculation in Voxel2MCNP.

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Thanks for your attention