Third MAXIMA training school

Breast Model Validation for Monte Carlo Evaluation of Normalized Glandular Dose Coefficients in Mammography

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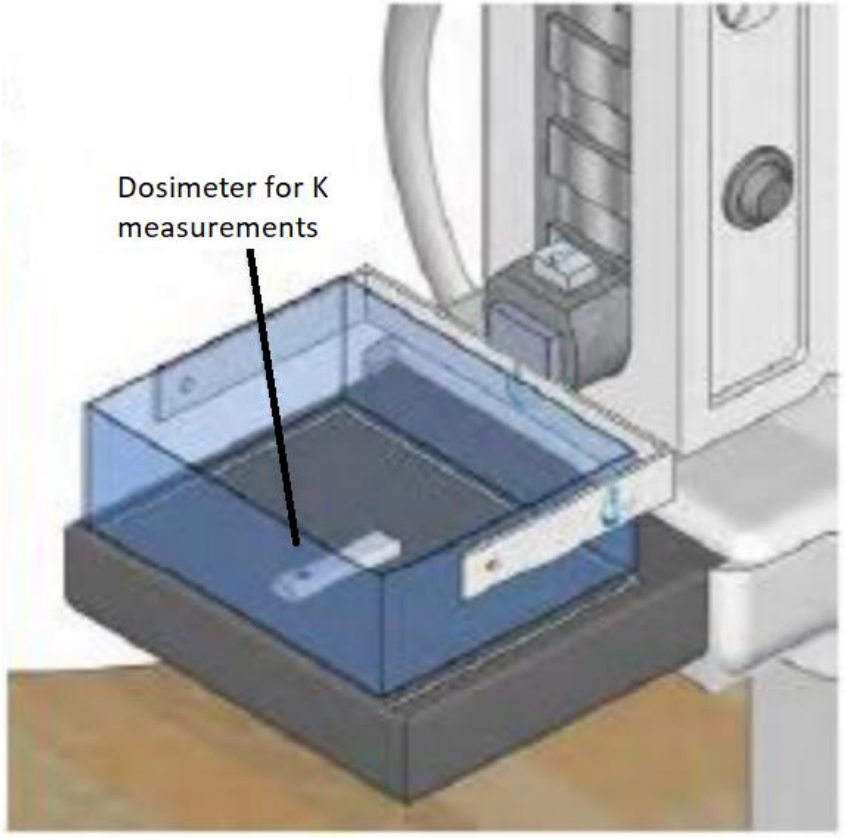
Dosimetry in mammography

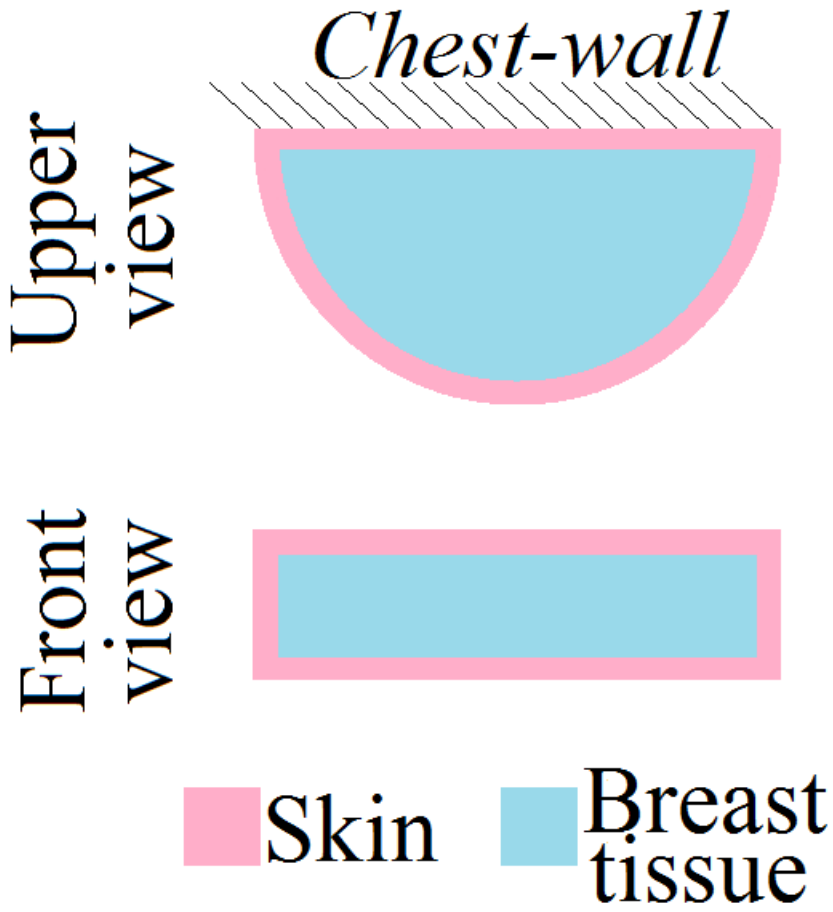
Mean Glandular Dose (MGD) = DgN (or c·g·s) · K

Air kerma at the breast surface

Coefficients calculated **via MC simulations**



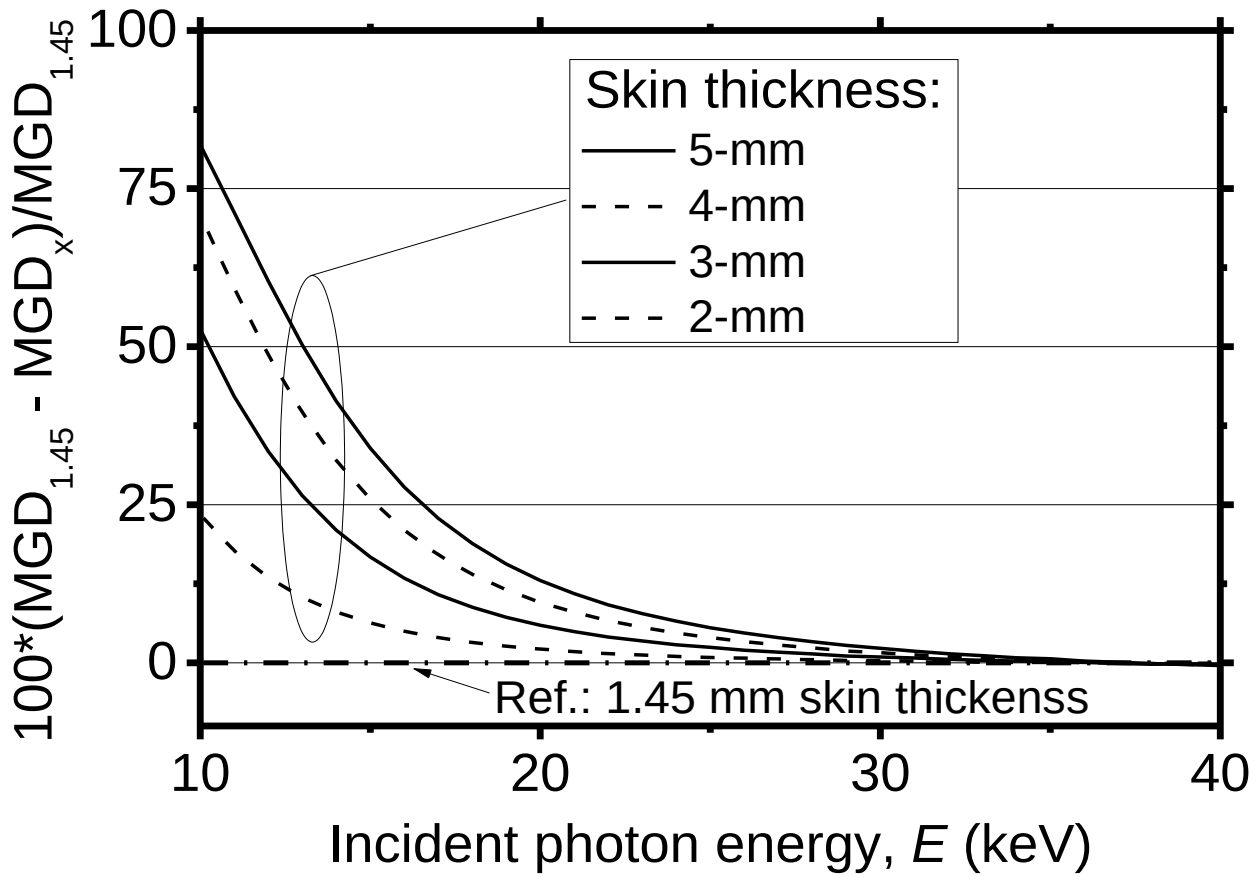
Breast model assumptions: skin thickness



Model from	Skin layer (mm)	Adipose layer (mm)
Dance (1990)	0.00	5.00
Wu et al (1991)	4.00	0.00
BCT experiments	1.45	0.00
Histology	1.45	2.00

Skin thickness influence on the MGD

Compressed breast thickness = 5 cm; glandular fraction = 20%



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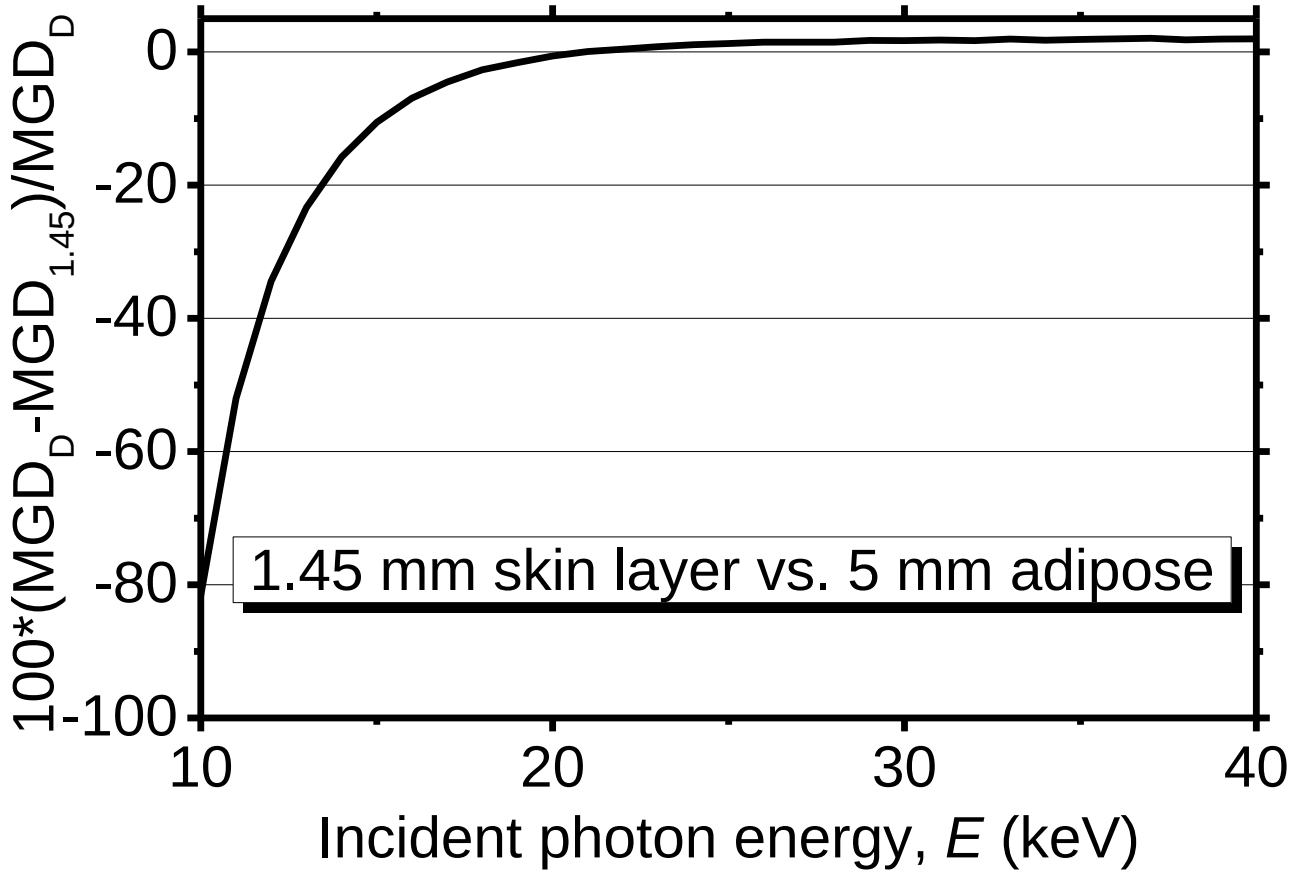
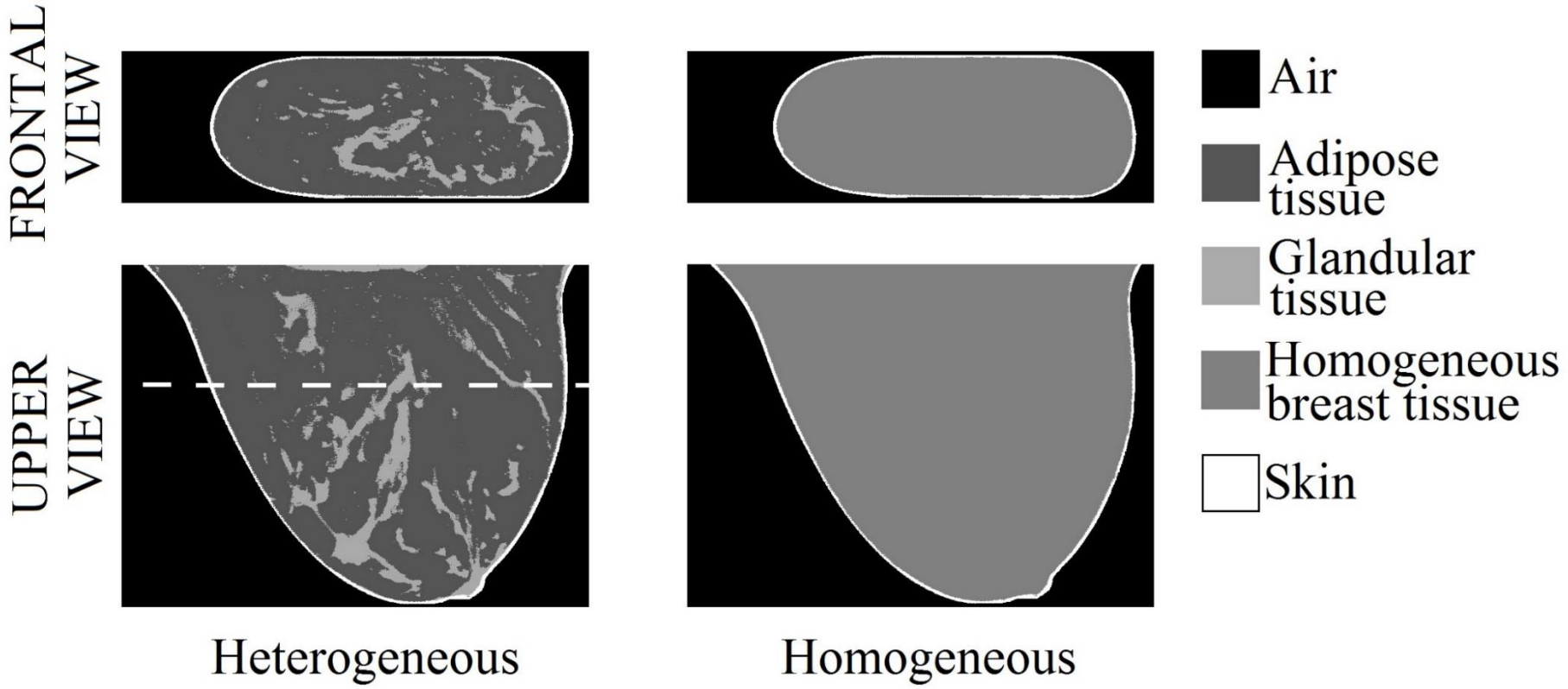
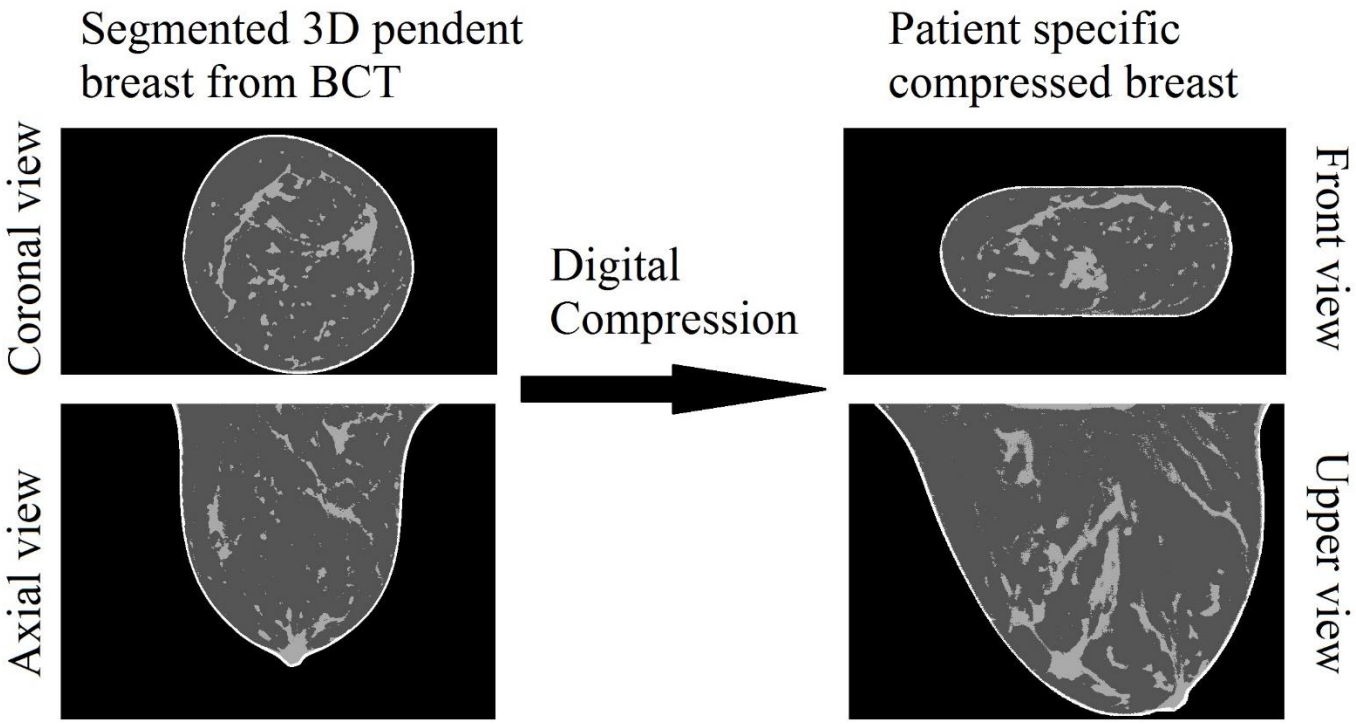


Breast model assumptions: glandular distribution



$$Probability\ of\ dose\ absorbtion\ in\ the\ gland = \frac{f_g \times \frac{\mu_{en}}{\rho}(E)_g}{f_g \times \frac{\mu_{en}}{\rho}(E)_g + (1 - f_g) \times \frac{\mu_{en}}{\rho}(E)_a}$$

20 voxelized patient specific breast phantoms from 3D breast images



	Mean	StdDev	Min	Max
Glandular fraction (%)	23.1	15.3	5.0	54.3
Compressed thickness (cm)	5.9	1.5	2.9	7.8

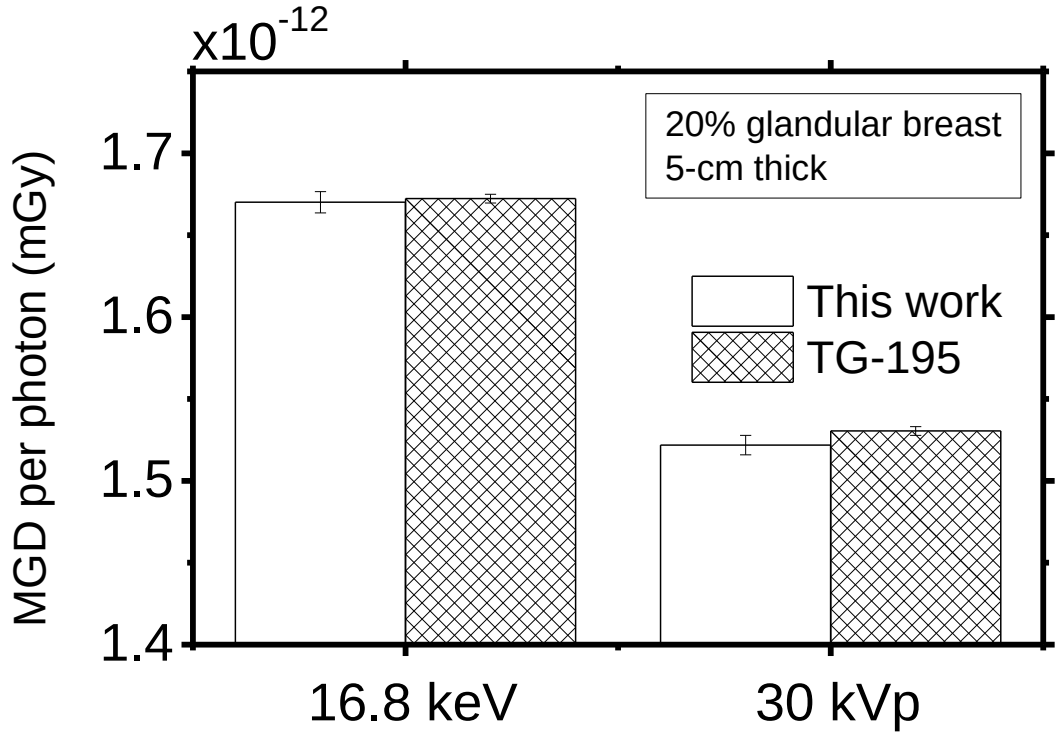
*Sechopoulos et al 2012, "Characterization of the homogeneous tissue mixture approximation in breast imaging dosimetry." *Med. Phys.* 39 5050-5059.

MC code for breast dosimetry

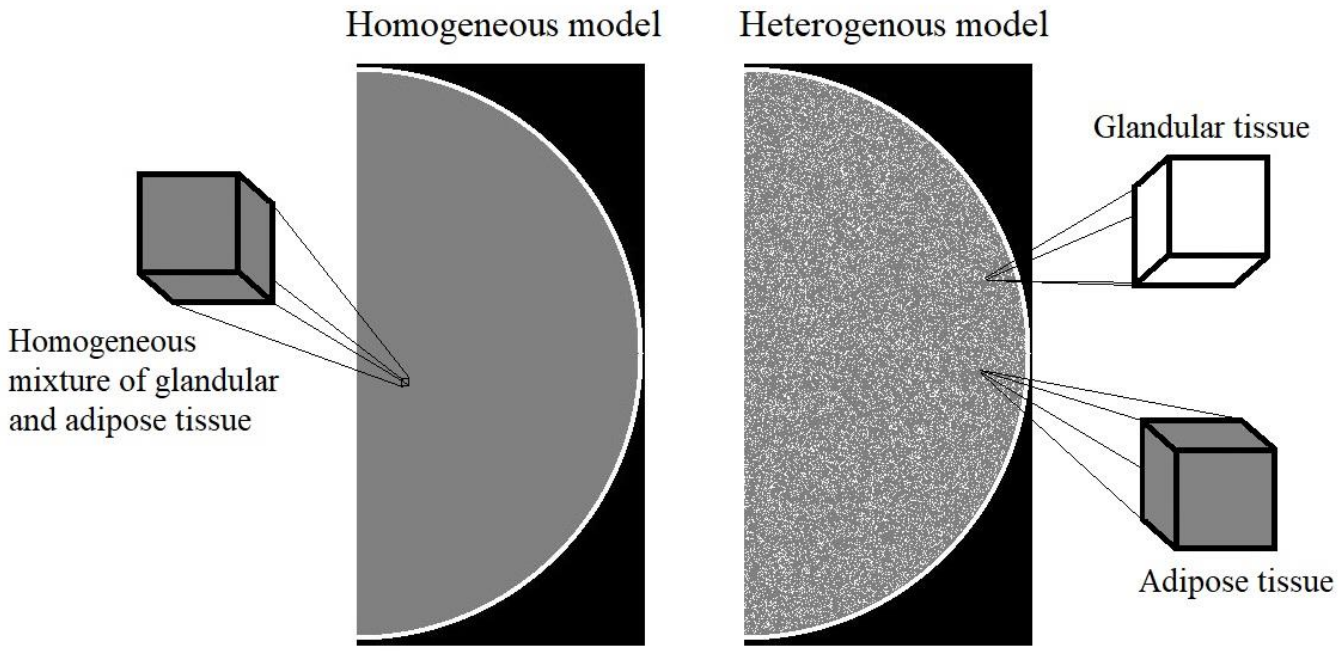
Code based on GEANT4 toolkit

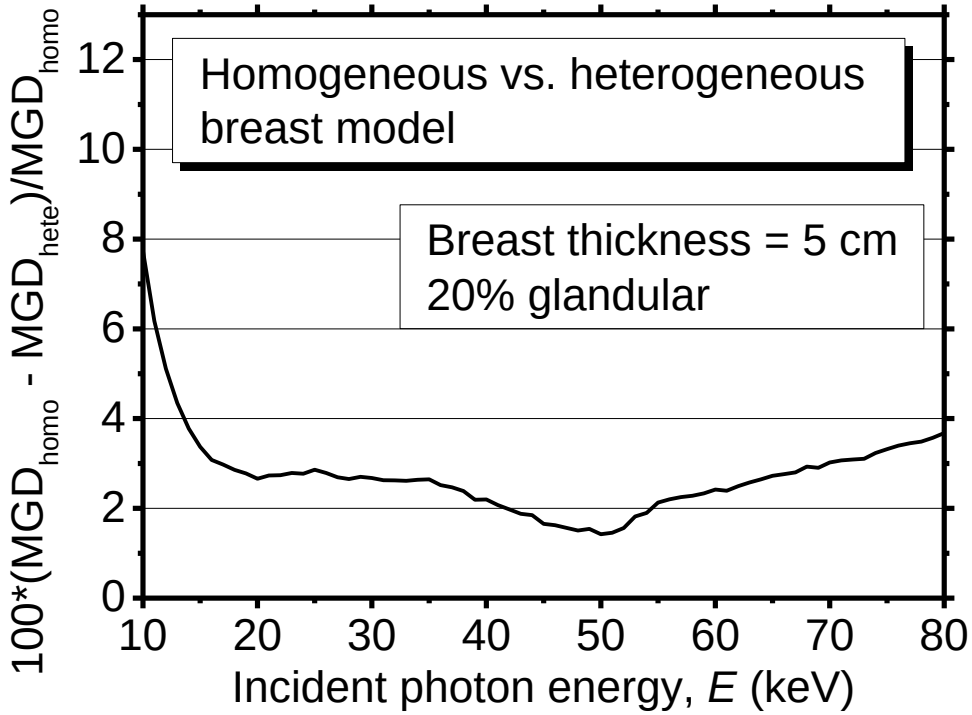
Physics list: Option4

Code validated vs AAPM TG195 data



MC validation for the heterogeneous model

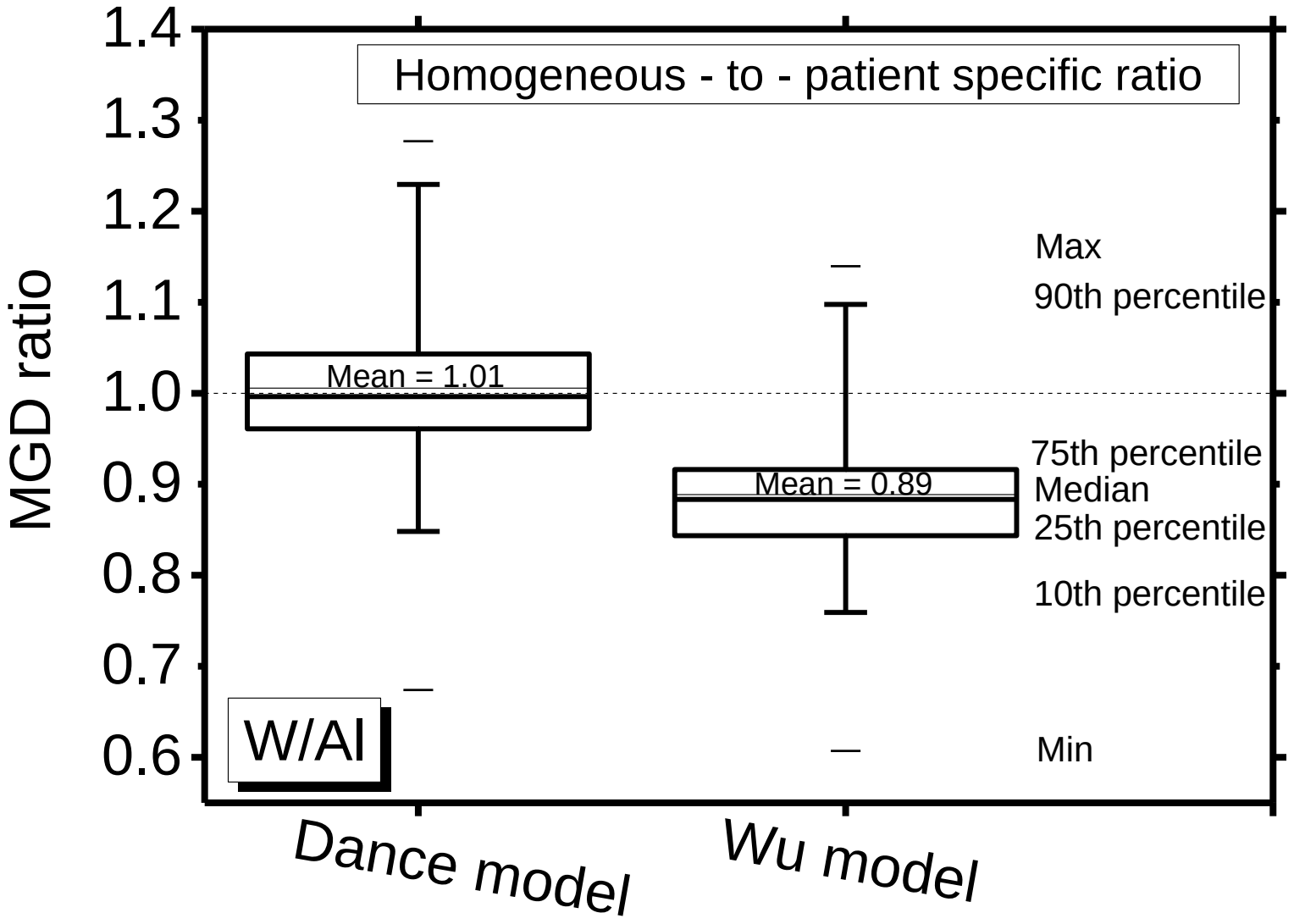




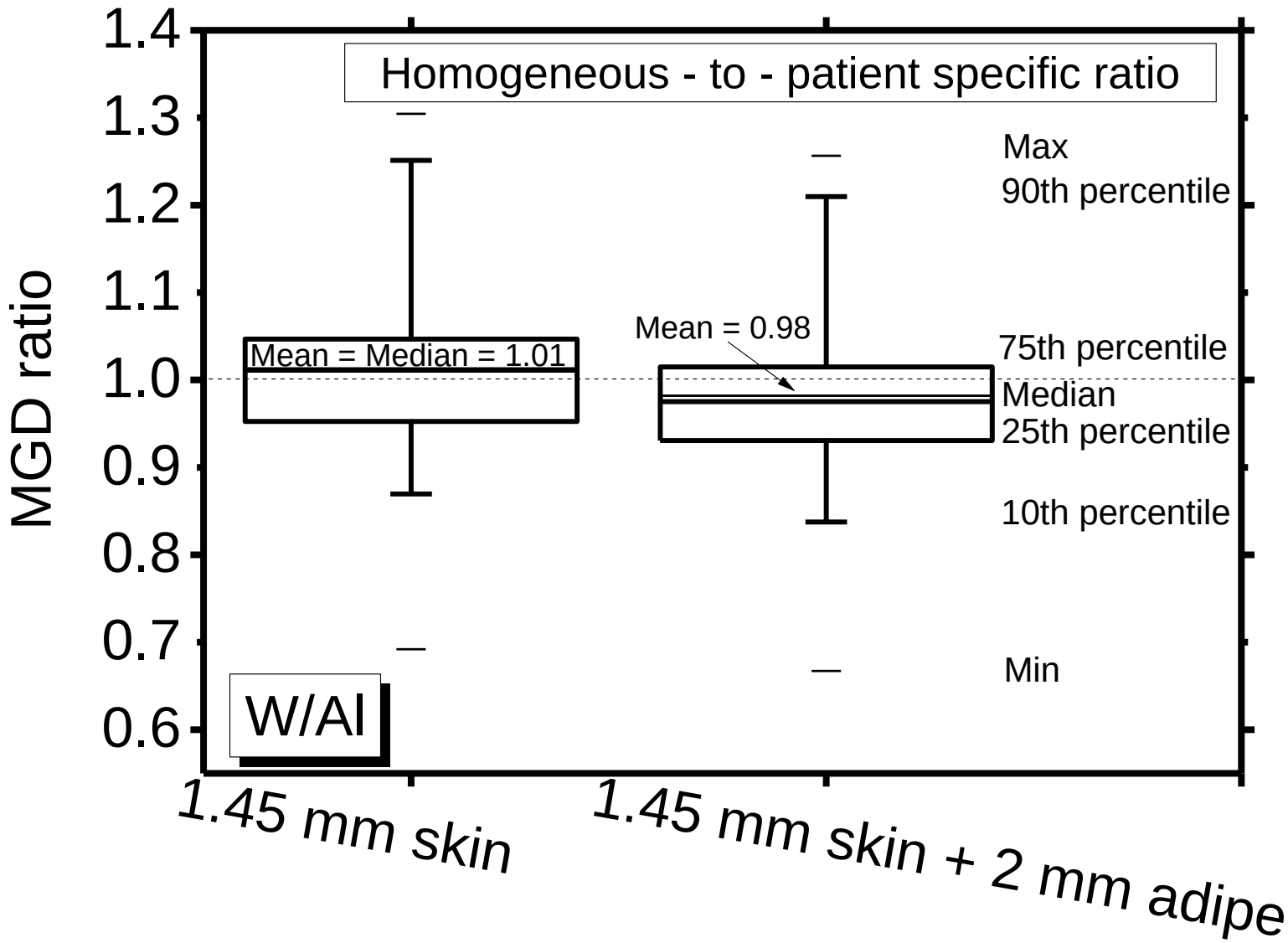
Technique factors

Technique factors					
Breast thickness range (cm)	Tube voltage (kV)	W/0.700 mm Al		W/0.050 mm Rh	
		Simulated HVL (mmAl)	Calculated HVL below the compression paddle (mmAl)	Simulated HVL (mmAl)	Calculated HVL below the compression paddle (mmAl)
2–3	26	0.399	0.440	0.460	0.488
3–4	27	0.420	0.464	0.471	0.501
4–5	28	0.440	0.486	0.482	0.511
5–6	29	0.459	0.508	0.491	0.521
6–7	30	0.479	0.530	0.499	0.530
7–8	31	0.498	0.552	0.508	0.538

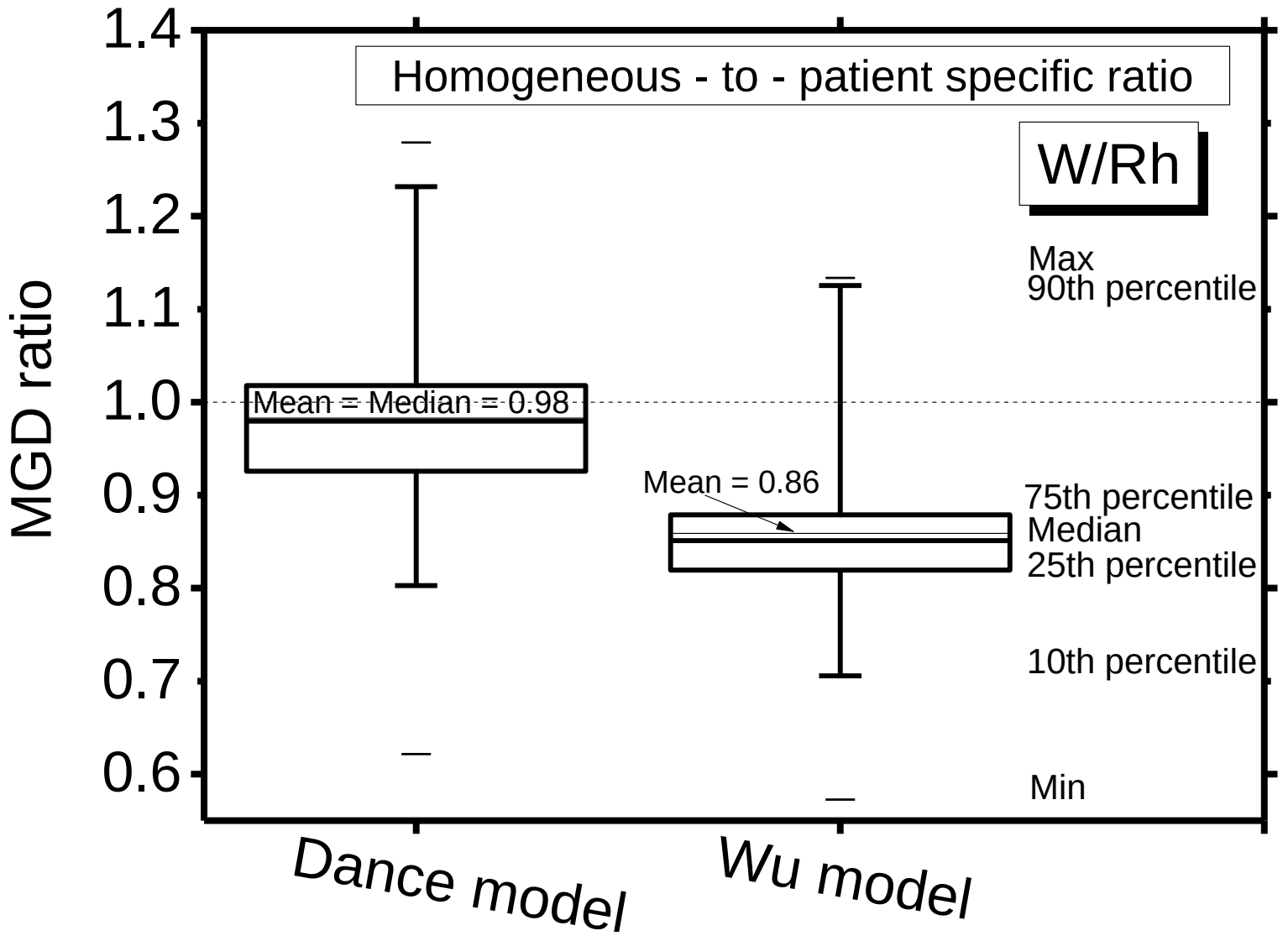
Standard models vs. patient specific phantoms



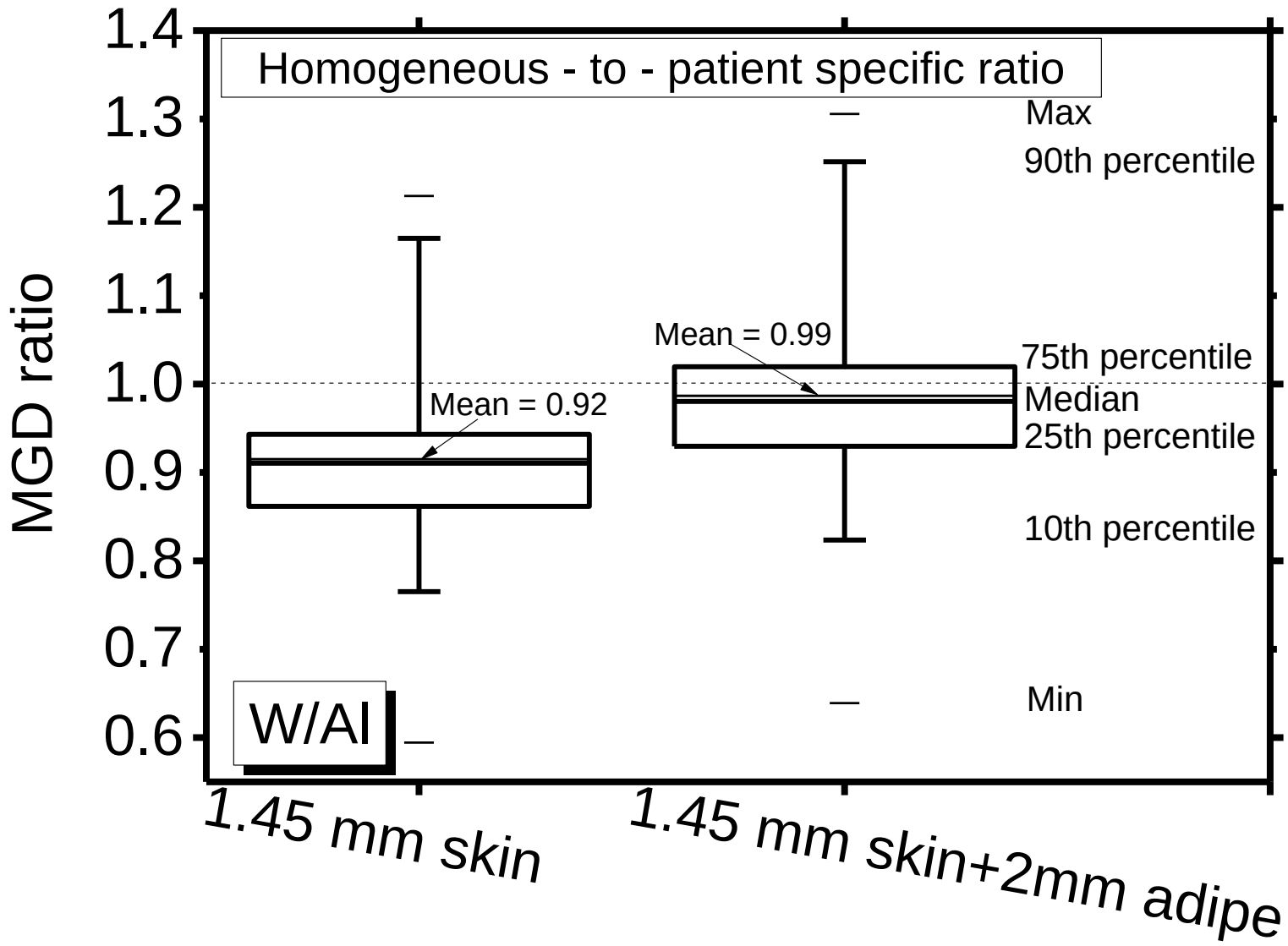
New models vs. patient specific phantoms



Standard models vs. patient specific phantoms



New models vs. patient specific phantoms



Conclusions

- The skin model in MC simulations presents a large influence on MGD estimates;
- A simple breast model can produce MGD underestimation up to about 42% when compared to the dose estimates via patient specific breast phantoms;
- The model proposed by Wu et al (1991) led to the lowest dose overestimation (16%) combined with the highest MGD underestimation (-42%) for a specific breast (W/Rh spectra);
- Breast model with a 1.45 mm skin thickness and the Dance's model led to the lowest differences (1%), on average, when compared to patient specific breast phantoms, with respect to Wu's model (-11%).

Thank you!!!

Any questions?

Third MAXIMA Training school - *Napoli 17th- 19th September 2018*

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