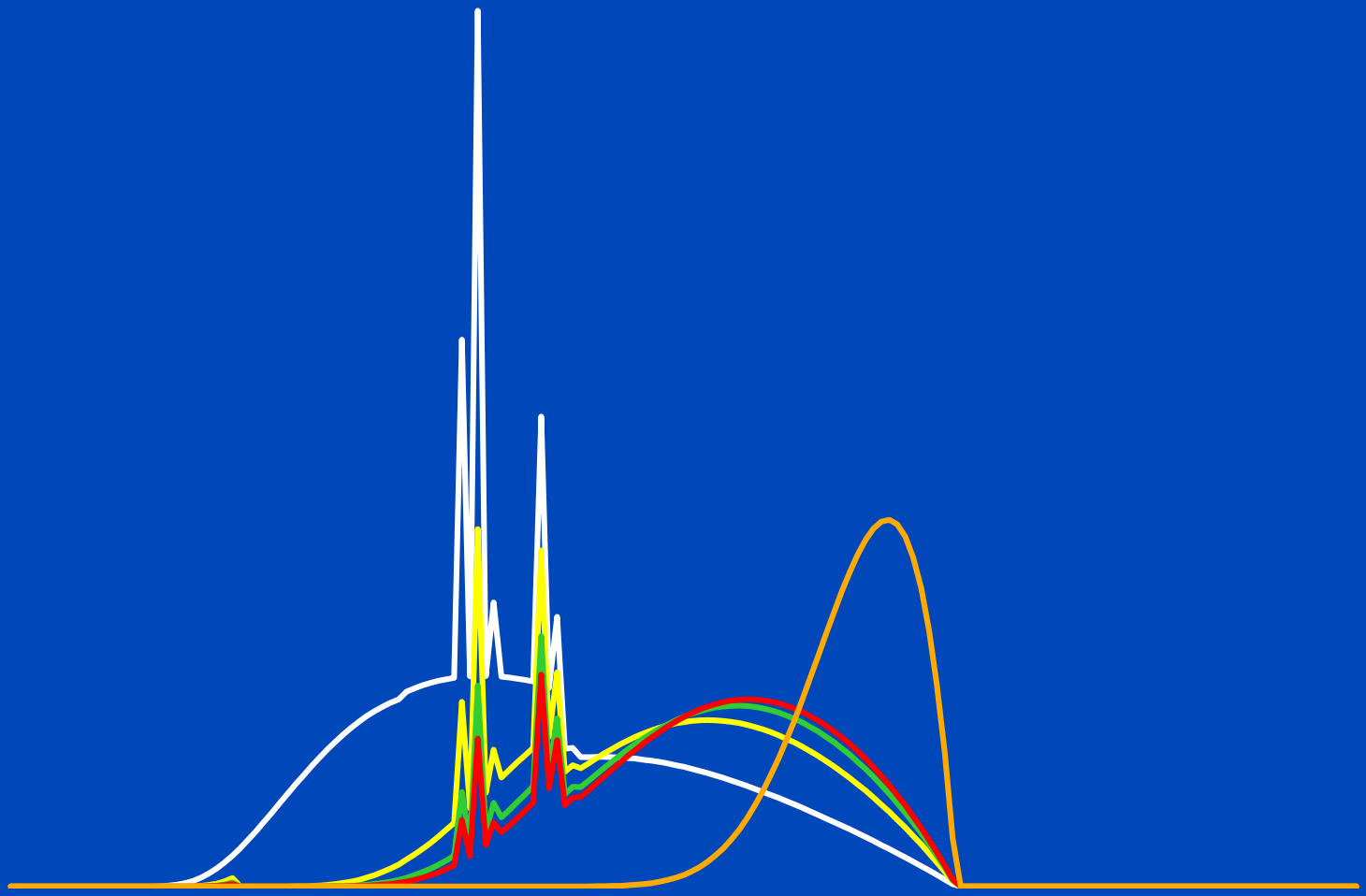
Dose Reduction Potential of Patient-Specific Prefilters with Current Diagnostic Single Energy CT

Jörg Steidel, Laura Klein, Joscha Maier, Stefan Sawall, and Marc Kachelrieß

German Cancer Research Center (DKFZ)
Heidelberg, Germany
www.dkfz.de/ct

dkfz. DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

120 kV Spectra



No tin filter
- 100% dose
- 100 mA

0.4 mm Sn
- 70.5% dose
- 287 mA

0.6 mm Sn
- 66.3% dose
- 429 mA

0.7 mm Sn
- 64.8% dose
- 515 mA

5.0 mm Sn
- 56.6% dose
- 95935 mA

Same detector SNR in all 5 cases!

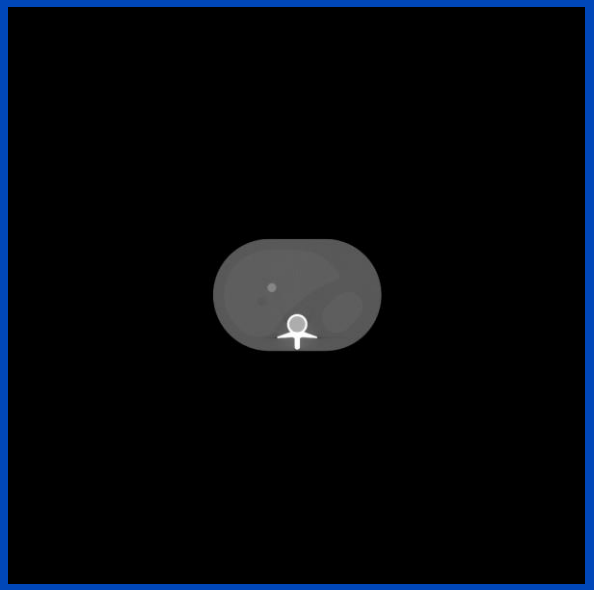
Current CT System

- Tube voltage range: 70 – 150 kV in 10 kV steps
- Maximum tube current time product (assuming 1 s exposure per z-position): 1000 mAs
- Tube current modulation

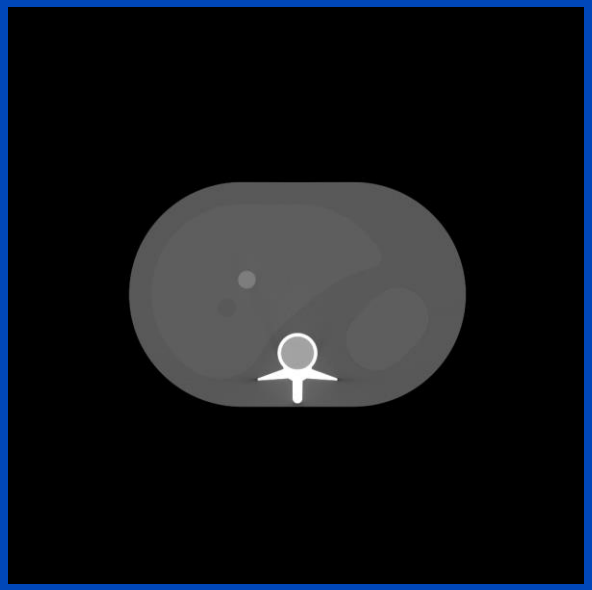
Simulations

- Prefilter materials: tin and copper
- Prefilter thickness: 0.0 – 5.0 mm in 0.1 mm steps
- Tube voltage: 35 – 150 kV in 5 kV steps
- 3 phantoms:

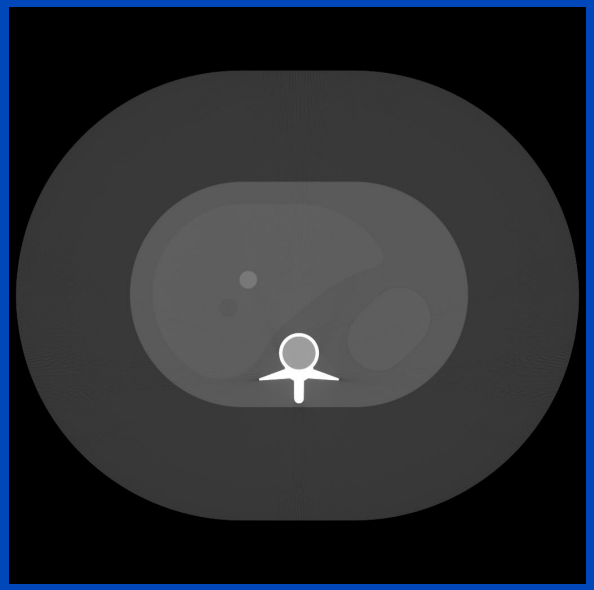
Child (15 × 10 cm)



Adult (30 × 20 cm)



Obese (50 × 40 cm)



C = 200 HU, *W* = 1000 HU, *U* = 100 kV, no prefilter

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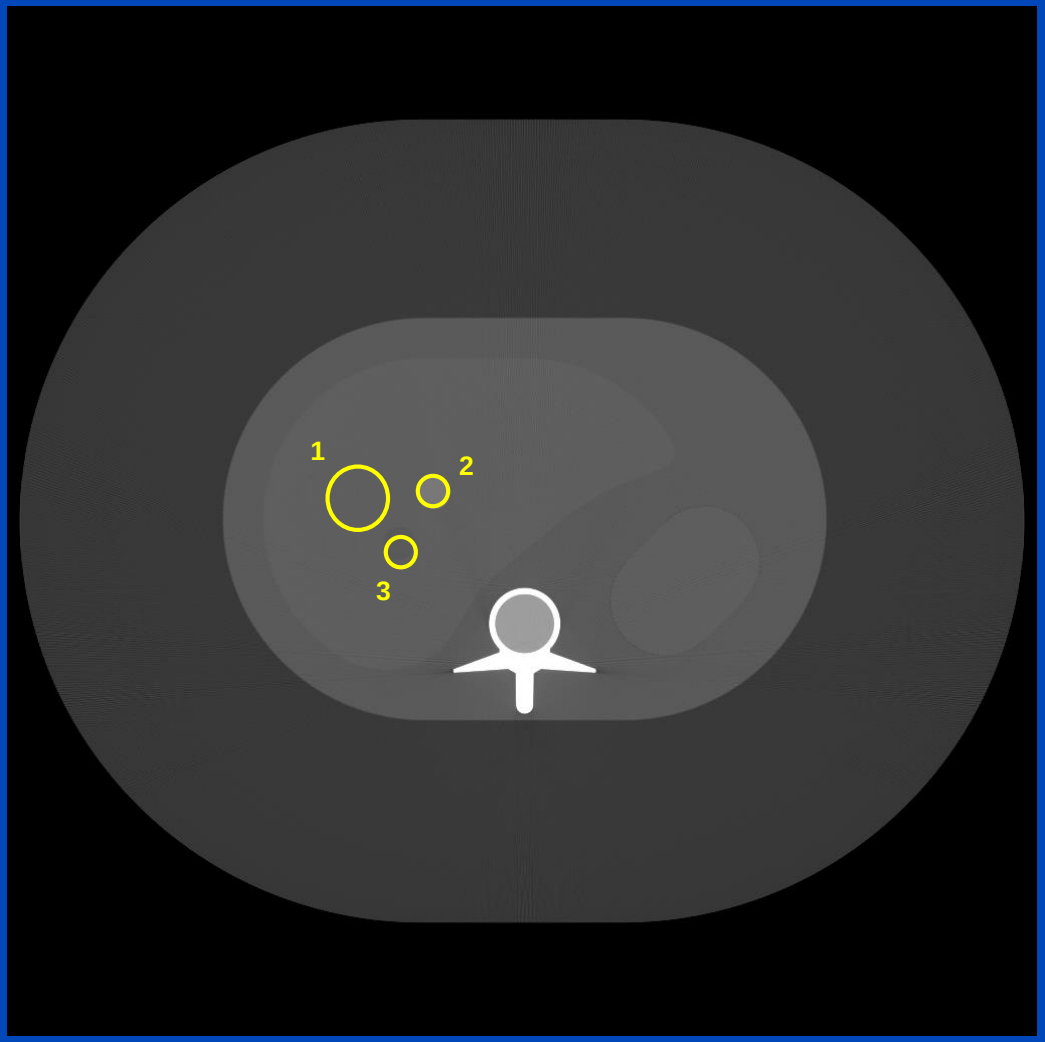
Image Quality Assessment



$$\mathrm{CNRD} = \frac{|\mu_1 - \mu_2|}{\sqrt{\sigma_1^2 + \sigma_2^2}\sqrt{D}}$$

- **Regions of interest**
  1. **Liver**
  2. **Iodine insert**
  3. **Soft tissue insert**
- **Dose: Monte Carlo[2] simulations of a 32 cm CTDI phantom**
- **Spatial resolution identical for all simulations**

[2] M. Baer and M. Kachelrieß, Hybrid Scatter Correction for CT Imaging, Phys. Med. Biol. 57, 6849-6867 (2012).

***C* = 200 HU, *W* = 1000 HU, *U* = 100 kV, no prefilter**

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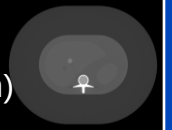
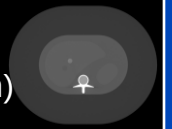
Dose Reduction by Patient-Specific Tin or Copper Prefilters 1000 mAs Limit

	Child (15 cm × 10 cm) 	**Adult** (30 cm × 20 cm) 	**Obese** (50 cm × 40 cm) 
Soft tissue (basis)	30 mAs, 90 kV	100 mAs, 130 kV	600 mAs, 150 kV
Soft tissue, Sn	0.6 mm, 1000 mAs, 75 kV **15%**	1.0 mm, 1000 mAs, 120 kV **32%**	0.2 mm, 1000 mAs, 150 kV **25%**
Soft tissue, Cu	1.6 mm, 1000 mAs, 70 kV **17%**	3.4 mm, 1000 mAs, 125 kV **31%**	0.8 mm, 1000 mAs, 150 kV **29%**
Iodine (basis)	50 mAs, 70 kV	120 mAs, 90 kV	720 mAs, 120 kV
Iodine, Sn	0 mm, 210 mAs, 50 kV **39%**	0.1 mm, 1000 mAs, 70 kV **40%**	0.0 mm, 1000 mAs, 105 kV **39%**
Iodine, Cu	0.4 mm, 1000 mAs, 50 kV **57%**	0.2 mm, 1000 mAs, 65 kV **49%**	0.0 mm, 1000 mAs, 105 kV **39%**

Dose Reduction by Patient-Specific Tin or Copper Prefilters 1000 mAs Limit, 70-150 kV, 10 kV steps

	Child (15 cm × 10 cm) 	**Adult** (30 cm × 20 cm) 	**Obese** (50 cm × 40 cm) 
Soft tissue (basis)	30 mAs, 90 kV	100 mAs, 130 kV	600 mAs, 150 kV
Soft tissue, Sn	0.6 mm, 1000 mAs, 80 kV **14%**	1.0 mm, 1000 mAs, 120 kV **32%**	0.2 mm, 870 mAs, 150 kV **25%**
Soft tissue, Cu	1.6 mm, 1000 mAs, 70 kV **17%**	3.1 mm, 1000 mAs, 120 kV **31%**	0.8 mm, 1000 mAs, 150 kV **29%**
Iodine (basis)	50 mAs, 70 kV	120 mAs, 90 kV	720 mAs, 120 kV
Iodine, Sn	0 mm, 50 mAs, 70 kV **0%**	0.1 mm, 1000 mAs, 70 kV **40%**	0.0 mm, 1000 mAs, 110 kV **26%**
Iodine, Cu	0.1 mm, 58 mAs, 70 kV **3%**	0.4 mm, 1000 mAs, 70 kV **44%**	0.1 mm, 1000 mAs, 110 kV **28%**

Conclusions

- 12% – 31% dose reduction for soft tissue contrast depending on patient size through prefiltration
  - Sn filter with thickness range of 0.0 – 1.0 mm or
  - Cu filter with thickness range of 0.0 – 3.1 mm
  - Fine gradations to optimally adapt to the patient (0.1 mm / 0.3 mm steps for Sn/Cu)
- No significant dose reduction for iodine contrast through prefiltration with current CT systems.
- If tube voltages below 70 kV were available copper prefiltration would significantly outperform tin for iodine contrast.
- 0% – 40% dose reduction for iodine contrast can be achieved through lower tube voltages depending on patient size.

Thank You!

This presentation is available at www.dkfz.de/ct

Job opportunities through DKFZ's international PhD or Postdoctoral Fellowship programs (www.dkfz.de) or directly through Prof. Dr. Marc Kachelrieß (marc.kachelriess@dkfz.de).

Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.