Monochromatic Imaging in Dual Energy CT (DECT): Metal Artifact Reduction with Acceptable Image Quality?

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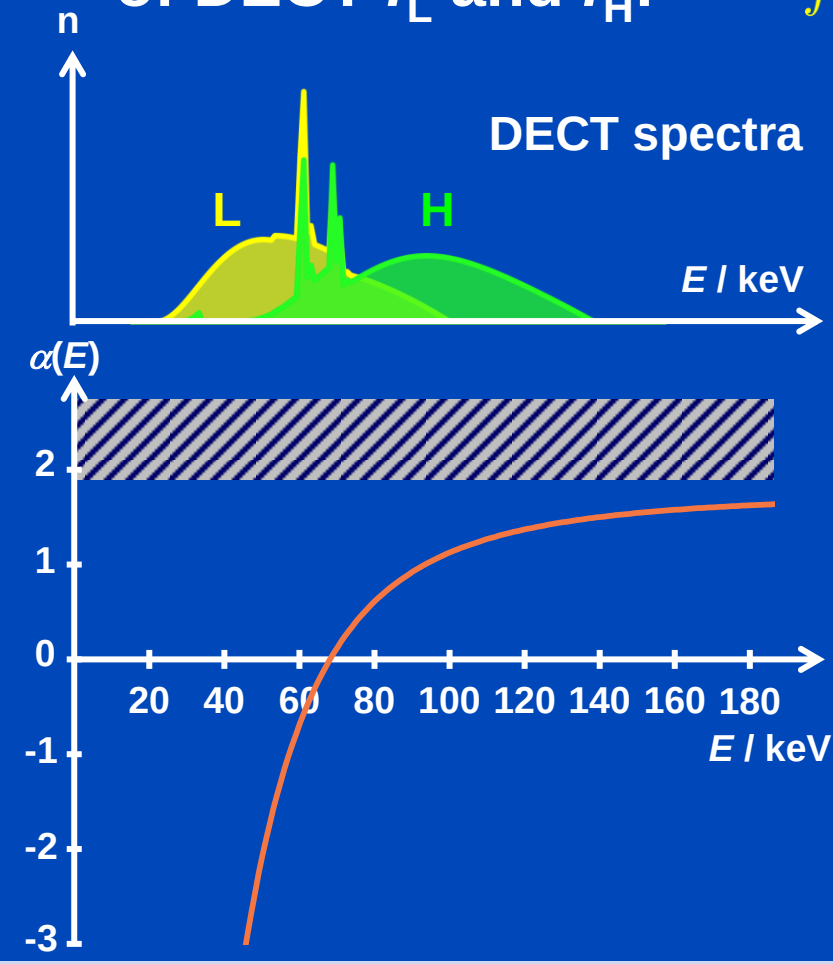
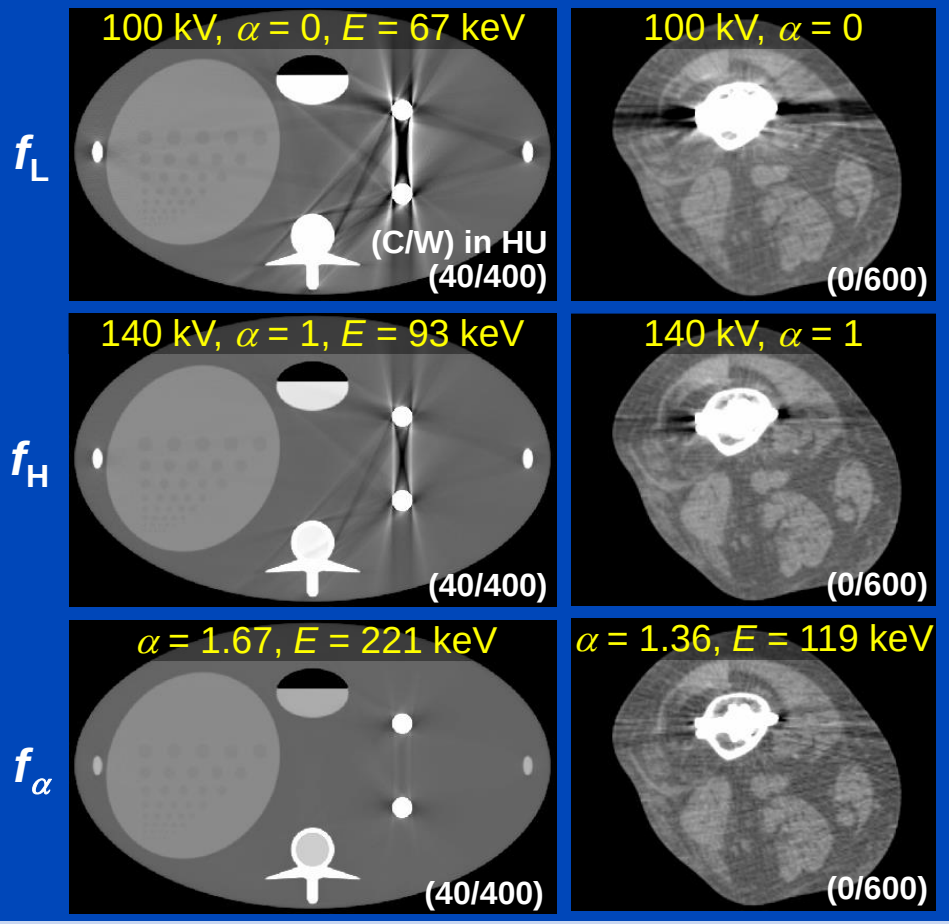
DECT and Pseudo Monochromatic Imaging

Pseudo monochromatic imaging is a linear combination of DECT f_L and f_H: $f_\alpha = (1-\alpha)\, f_L + \alpha\, f_H$





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Monochromatic Imaging

- **Pseudo monochromatic imaging** $f_\alpha = (1-\alpha)\, f_\mathrm{L} + \alpha\, f_\mathrm{H}$
  - **Image-based postprocessing**
  - **Provided in clinical DECT scanners**
- **Virtual monochromatic imaging** $g_\alpha = (1-\alpha)\, g_\mathrm{L} + \alpha\, g_\mathrm{H}$
  - **Rawdata-based preprocessing**
  - **Constraint on consistent rawdata**
- **True monochromatic imaging**
  - **Would require monochromatic x-rays – not applicable here**

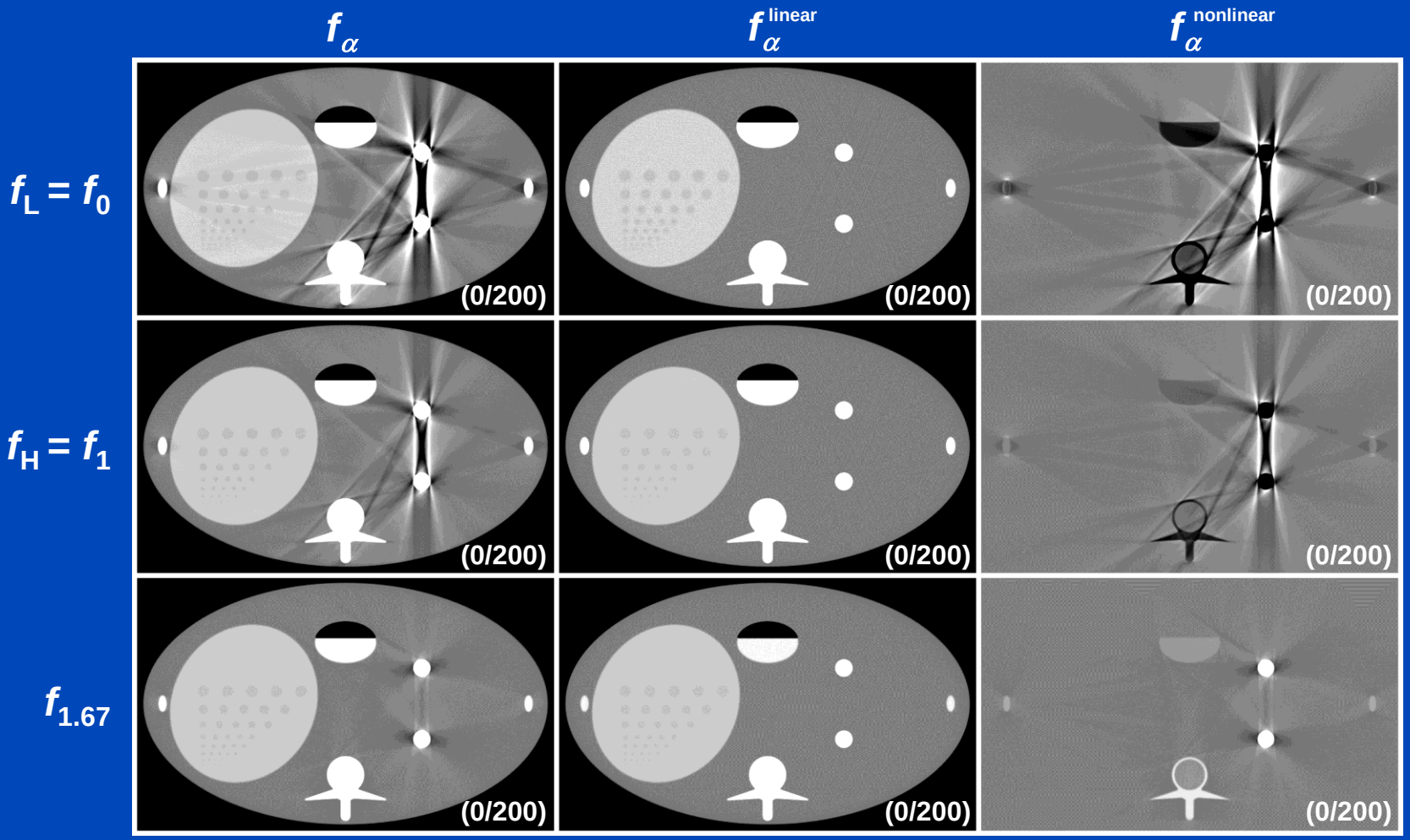
$$q_\mathrm{L} = -\ln \int dE\, w_\mathrm{L}(E)\, e^{-p_\mathrm{W}\mu_\mathrm{W}(E) - p_\mathrm{B}\mu_\mathrm{B}(E)}$$

$$q_\mathrm{H} = -\ln \int dE\, w_\mathrm{H}(E)\, e^{-p_\mathrm{W}\mu_\mathrm{W}(E) - p_\mathrm{B}\mu_\mathrm{B}(E)}$$

Series Expansion

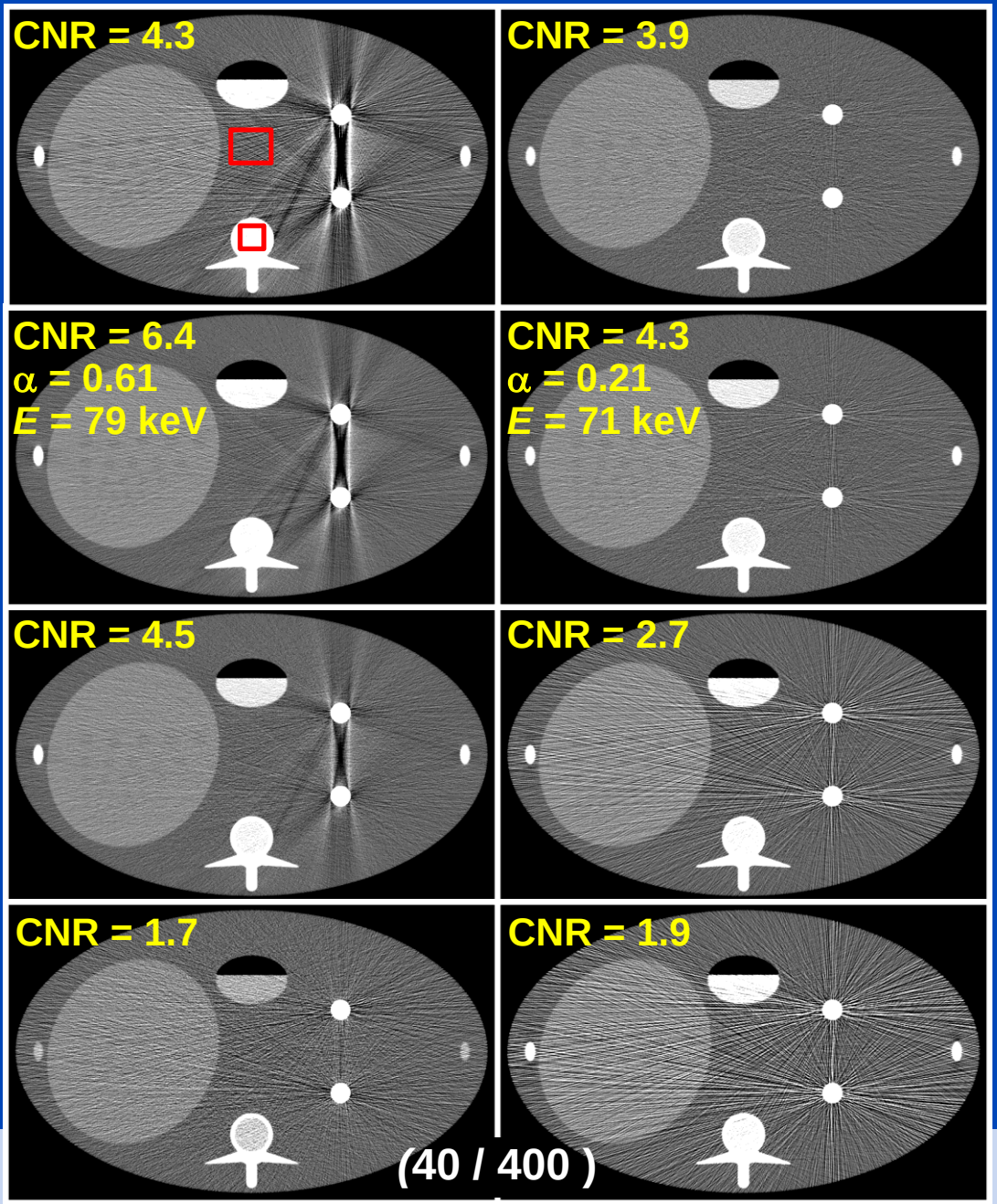
- **Series expansion of the polychromatic attenuation:**

$$q_j = -\ln \int dE\, w_j(E)\, e^{-p_{\mathrm{W}}\mu_{\mathrm{W}}(E) - p_{\mathrm{B}}\mu_{\mathrm{B}}(E)} = \sum\nolimits_{kl} c_{jkl} p_{\mathrm{W}}^{k} p_{\mathrm{B}}^{l}$$



pseudo monochromatic
image-based processing

virtual monochromatic
rawdata-based processing



$f_L = f_0$ (E = 67 keV)

maximum CNR

$f_H = f_1$ (E = 93 keV)

$f_{1.67}$ (E = 221 keV)

g_0 (E = 67 keV)

maximum CNR

g_1 (E = 93 keV)

$g_{1.67}$ (E = 221 keV)

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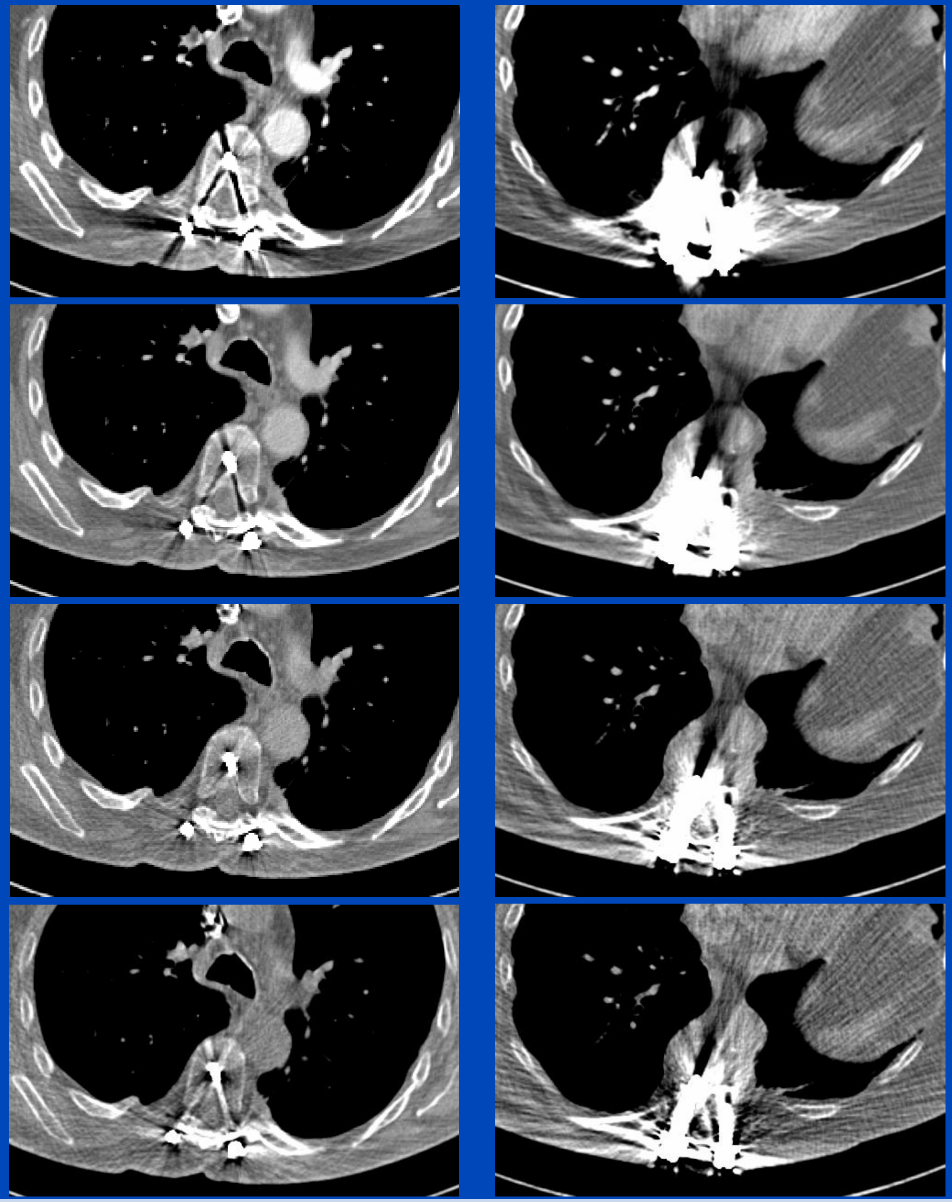
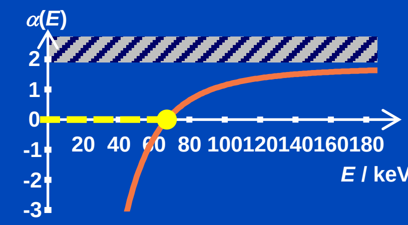
Patient Data Set – Pseudo Monochromatic Imaging

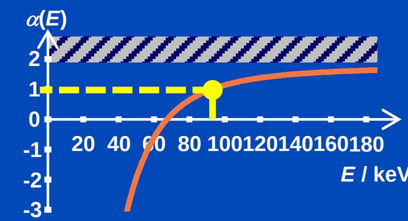
z = -178 mm | z = -264 mm



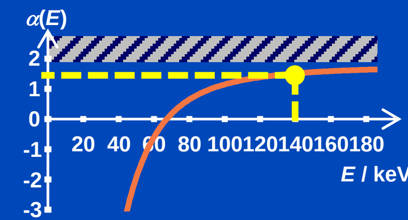
$f_L = f_0$
(E = 67 keV)



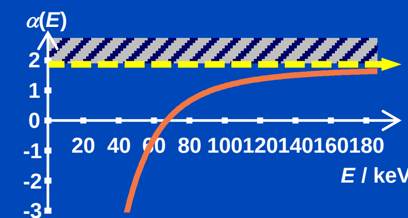
$f_H = f_1$
(E = 93 keV)



$f_{1.50}$
(E = 140 keV)



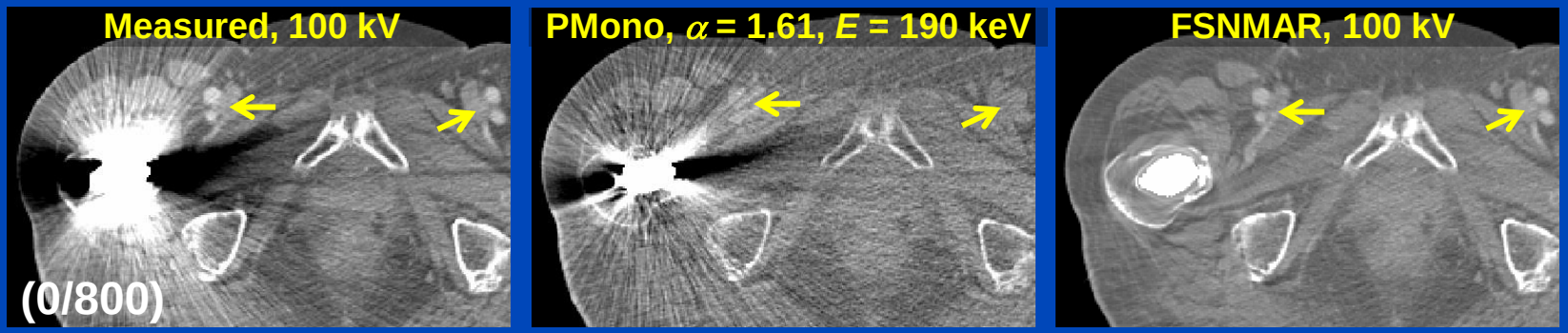
$f_{1.90}$
(E = --- keV)



C = 0 HU, W = 800 HU

Conclusion

- **Pseudo monochromatic imaging**
  - **cannot completely remove metal artifacts,**
  - **can sometimes reduce metal artifacts,**
  - **reduces CNR, if used for metal artifact reduction.**
- **Rawdata-based DECT decomposition is to be preferred.**
- **Rawdata-based MAR methods such as FSNMAR[1,2] should be preferred.**
- **The additional information available in DECT should be used for spectral imaging rather than for artifact reduction.**



[1]E. Meyer, R. Raupach, M. Lell, B. Schmidt, and M. Kachelrieß. Normalized metal artifact reduction (NMAR) in computed tomography. Med. Phys. 37(10):5482-5493, October 2010. [2]E. Meyer, R. Raupach, M. Lell, B. Schmidt, and M. Kachelrieß. Frequency split metal artifact reduction (FSMAR) in CT. Med. Phys. 39(4):1904-1916, April 2012.

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This presentation will soon be available at www.dkfz.de/ct.