Clinical Photon-Counting CT: The Small Pixel Effect and its Implications for Dose Reduction

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Aim

To assess the potential dose reduction achievable with the first clinical photon-counting CT (PCCT) in ultra-high resolution mode (UHR) compared to acquisitions using standard (Std) mode.

Alpha Detector Modes

Naeotom Alpha at University Hospital Mannheim

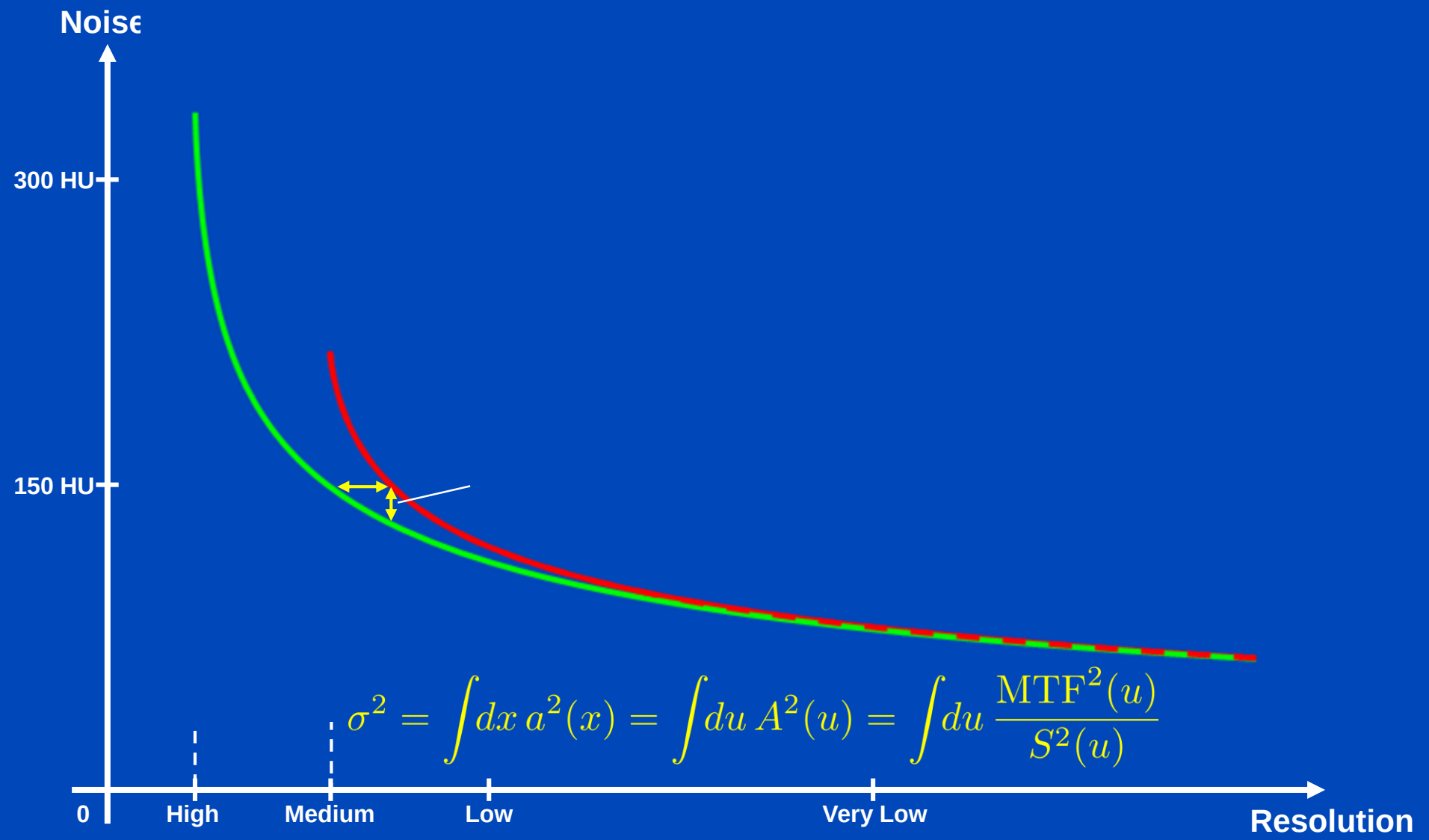
Standard Mode

M4	M4
M4	M4
M4	M4

UHR Mode

S1	S1	S1	S1
S1	S1	S1	S1
S1	S1	S1	S1
S1	S1	S1	S1
S1	S1	S1	S1
S1	S1	S1	S1

The “Small Pixel Effect”



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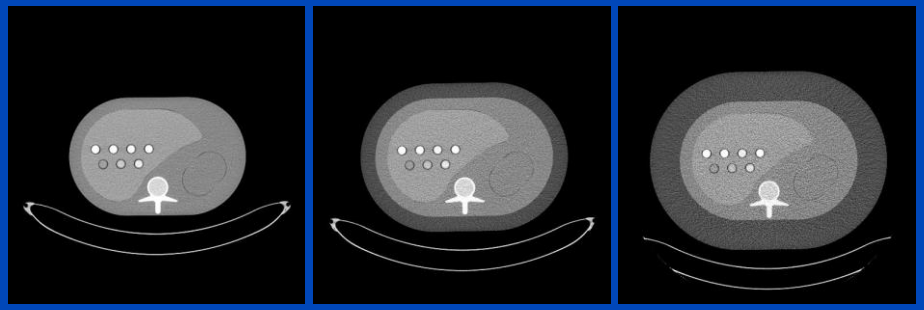
Materials and Methods

- Abdomen phantoms of three different sizes (S, M, L)
  - Small: 20 cm × 30 cm
  - Medium: 25 cm × 35 cm
  - Large: 30 cm × 40 cm



- Tube voltage: 120 kV
- Slice thickness: 1 mm
  - Small pixel effect only laterally observable
- $CTDI_{32}$ at 4 mGy, 8 mGy, 12 mGy
- Collimation:
  - UHR : Acq. 120 × 0.2 mm
  - Std : Acq. 144 × 0.4 mm
- Image reconstruction:
  - Same target spatial resolution
  - Use of all 10 available body kernels
  - Only filtered backprojection (FBP)

C = 20 HU, *W* = 600 HU

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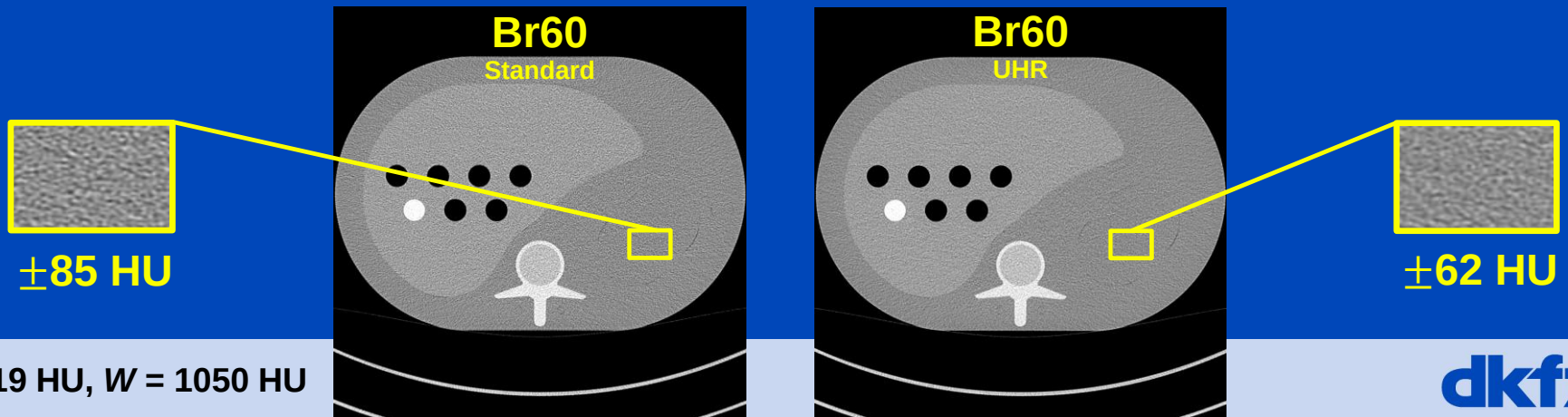
Noise and Dose Reduction

- Noise is calculated from the standard deviation in an ROI in the spleen.
- The small pixel effect is the noise ratio of the two acquisition modes:

$$R = \frac{\sigma_{\mathrm{Std}}}{\sigma_{\mathrm{UHR}}}$$

- The potential x-ray dose reduction is estimated as:

$$\mathrm{DoseReduction} = 1 - \frac{\sigma^2_{\mathrm{UHR}}}{\sigma^2_{\mathrm{Std}}}$$



C = 19 HU, *W* = 1050 HU

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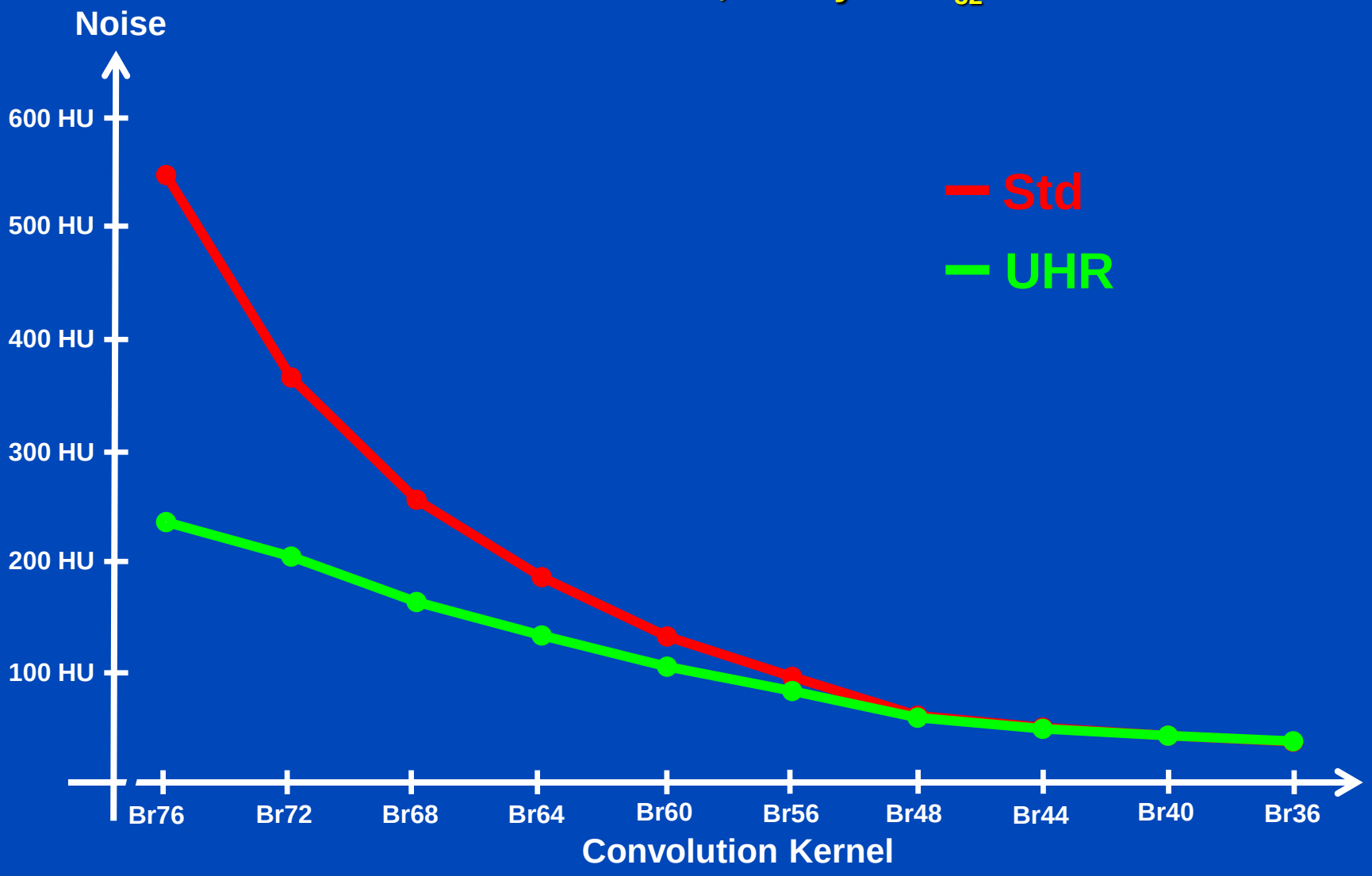
Small Pixel Effect at Naeotom Alpha

Medium Phantom, 4 mGy $CTDI_{32}$



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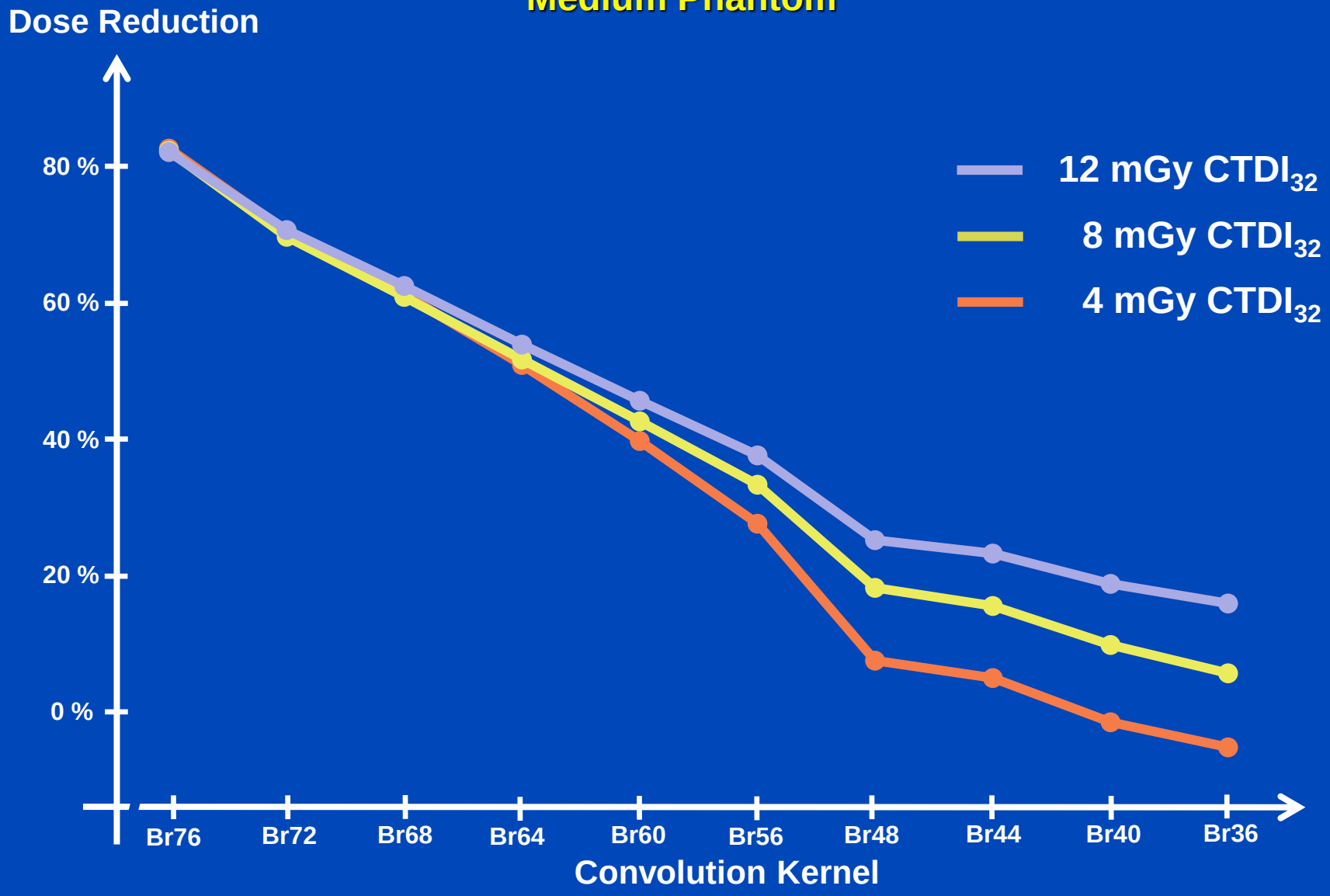
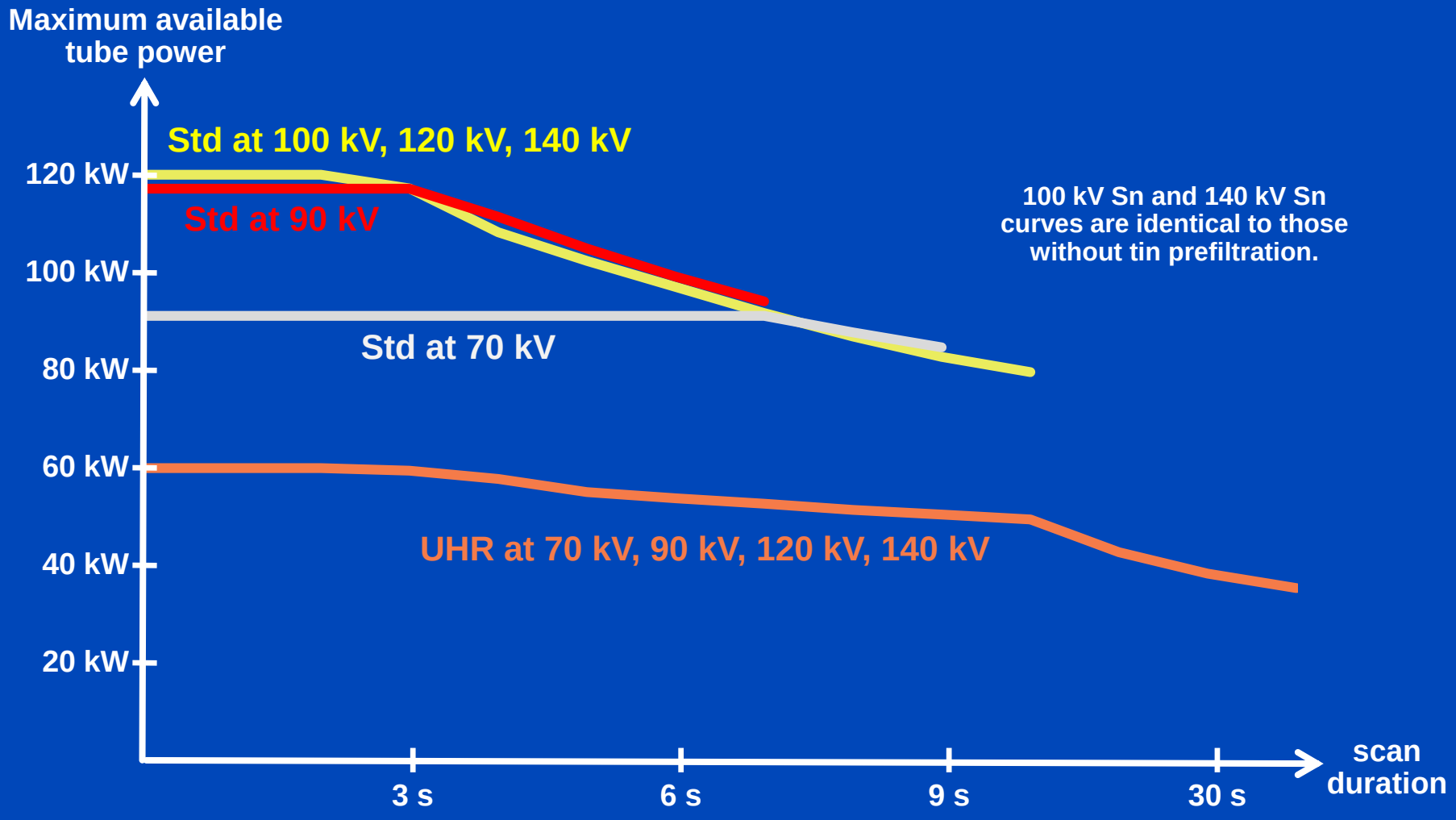
Potential Dose Reduction

Medium Phantom



Drawbacks of UHR?

Power of Vectron X-Ray tube in Naeotom Alpha



Conclusions

- At sharp convolution kernels, UHR acquisitions allow for significant dose reduction compared to Std mode.
- Dose reduction curves diverge for smooth kernels:
  - Dose-dependent filter?
- Disadvantages of UHR acquisitions:
  - Lower tube power
  - Lower collimation
- Still, this study encourages the use of UHR mode, even if high resolution is not of interest, since the potential dose reduction is very prominent.

Thank You!

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

Job opportunities through DKFZ's international Fellowship programs (marc.kachelriess@dkfz.de).

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