Context-Sensitive Ultra High Resolution Bone Imaging in Whole-Body Photon-Counting CT

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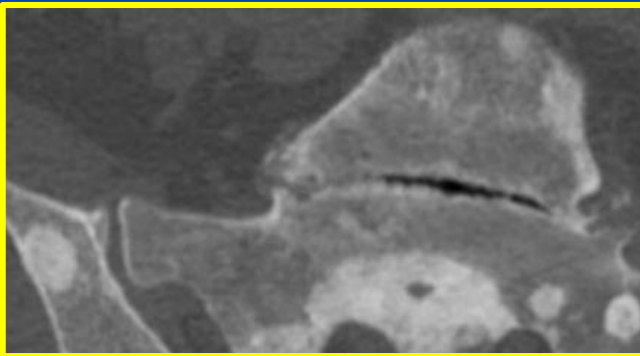
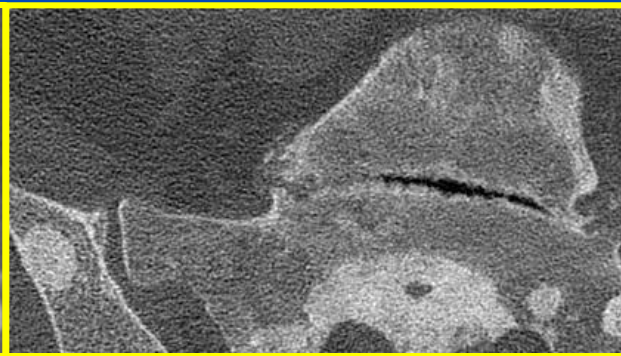**dkfz.** DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

Aim

To provide organ-specific, context-sensitive images in PC CT showing osseous structures at ultra high resolution and soft tissue at standard resolution with reduced noise in a single image.
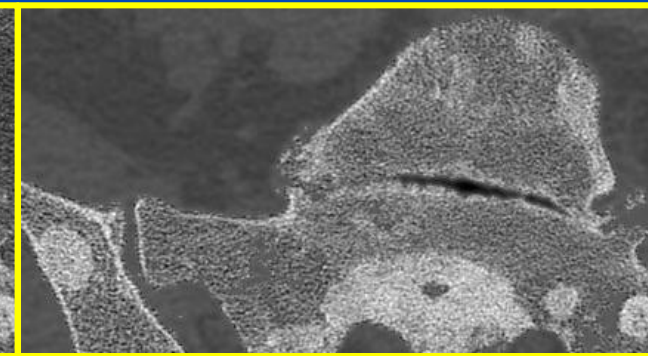

Reconstruction with a smooth kernel
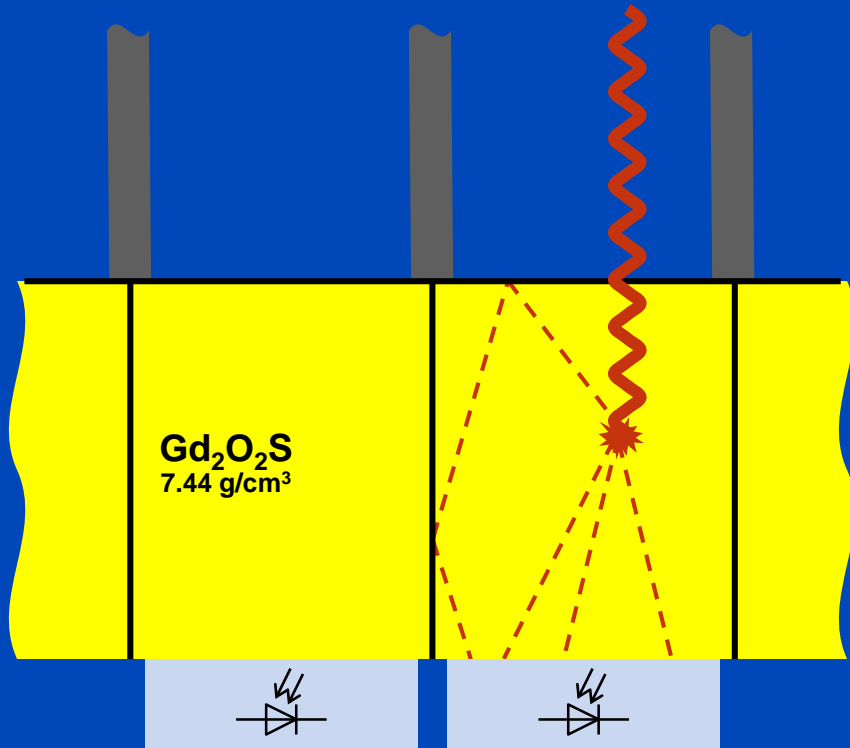
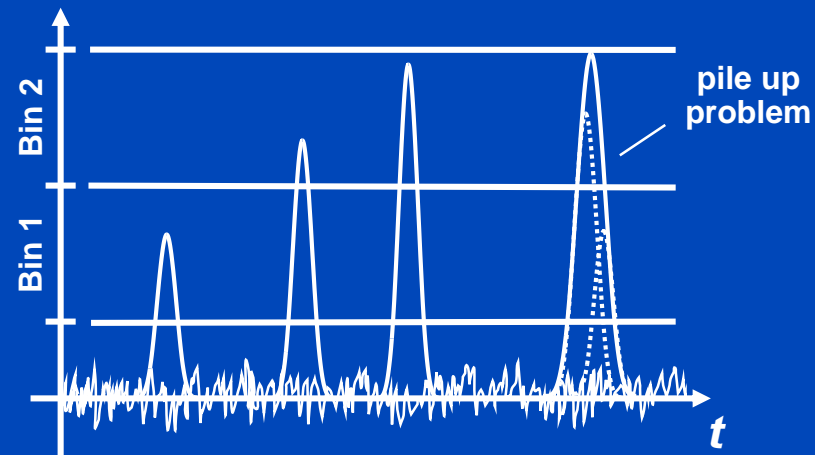**Reconstruction with a UHR kernel**

Context-sensitive image

C = 500 HU, W = 2500 HU

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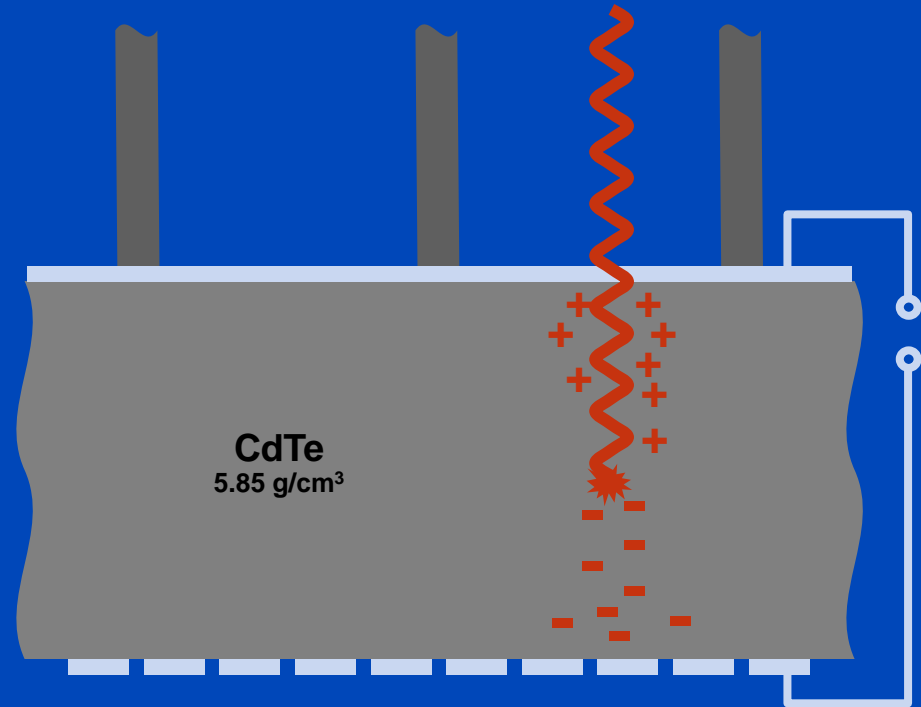
Energy integrating detector

Gd$_2$O$_2$S
7.44 g/cm^3

pile up
only

t

Photon counting detector

CdTe
5.85 g/cm^3

Bin 2

Bin 1

pile up
problem

t

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Context-Sensitive Imaging

D40f

Low resolution f^{D40f}

$$f_{\text{VNC}} = \alpha_1 f_{\text{Bin1}}^{\text{D40f}} + \alpha_2 f_{\text{Bin2}}^{\text{D40f}}$$

Soft Tissue Mask M_S

VNC

Bin 1

Bin 2

α

Threshold

Bone Mask M_B

Context-Sensitive Image f_{CS}

W

$$f_{\text{CS}} = W\left(M_B \circ f^{\text{U70f}} + M_S \circ f^{\text{D40f}} \right)$$

High resolution f^{U70f}

U70f

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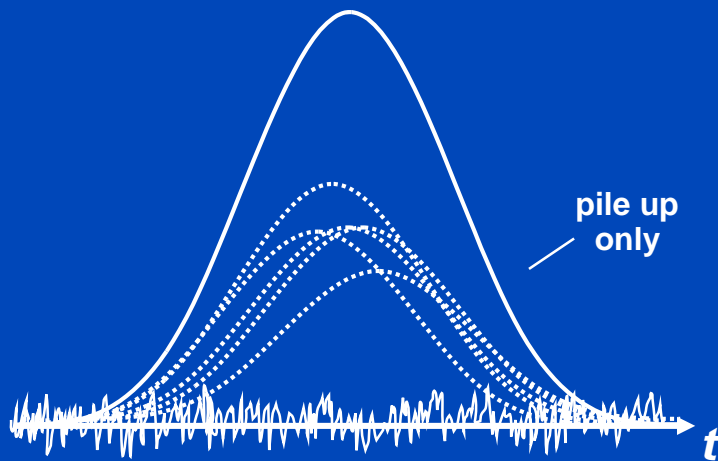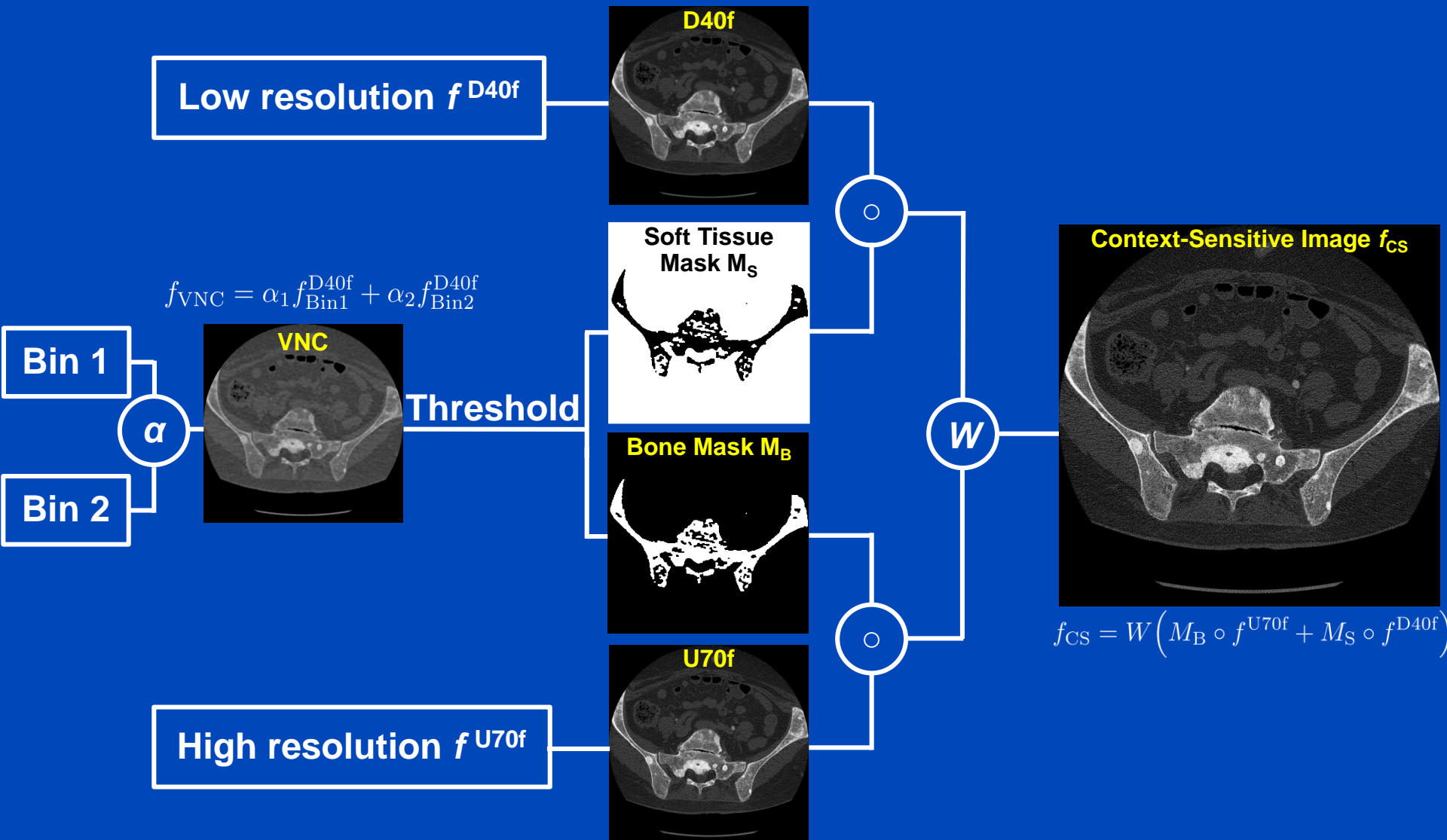
Materials and Methods

Measurements:

- **A set of 30 measurements**
  - **12 patient measurements**
  - **18 cadaver measurements**

- **Ultra high resolution (UHR) mode**

- **Effective tube current of 300 mAs**

- **Tube voltage of 120 kV**
  - **Threshold setting:**
    - **Bin 1: 25 keV – 70 keV**
    - **Bin 2: 70 keV – 120 keV**

Reconstruction:

- **UHR kernel (U70f, $MTF_{10\%}$= 17.7 lp/cm) for osseous structures**
  - **slice thickness 0.25 mm / position increment 0.25 mm**

- **Smooth kernel (D40f, $MTF_{10\%}$= 7.4 lp/cm) for soft tissue and contrast agent if present**
  - **slice thickness 0.75 mm / position increment 0.25 mm**
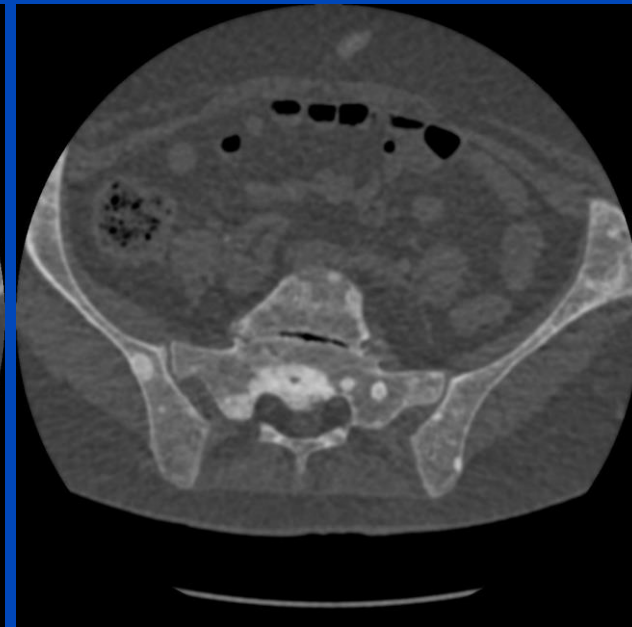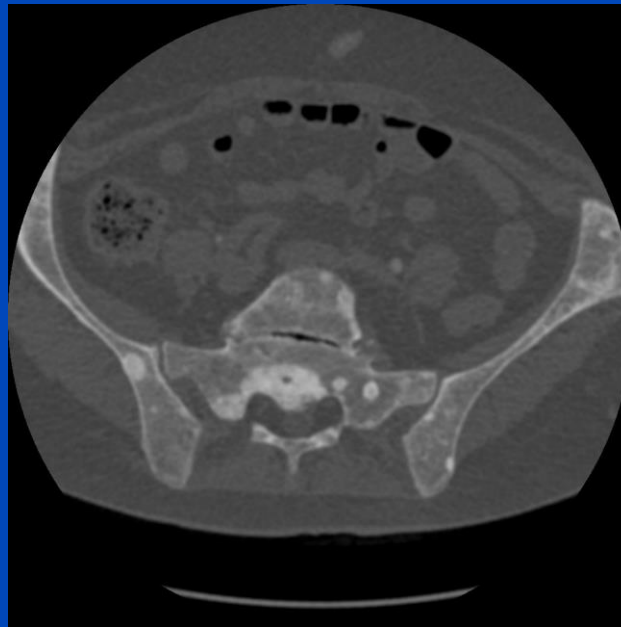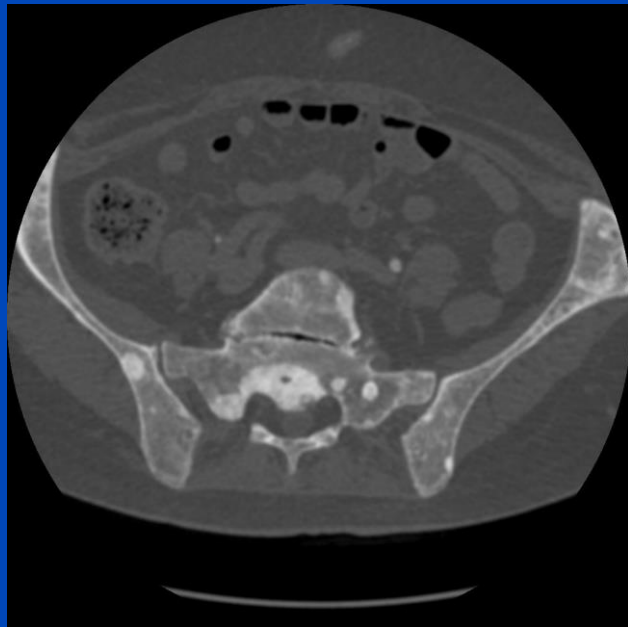
Results

D40f, 1 mm slice thickness, 0.25 mm increment

Weighting factors:

$$\alpha_1 f_{\text{Bin1,ST}}^{\text{D40f}} + \alpha_2 f_{\text{Bin2,ST}}^{\text{D40f}} = 1$$
$$\alpha_1 f_{\text{Bin1,CA}}^{\text{D40f}} + \alpha_2 f_{\text{Bin2,CA}}^{\text{D40f}} = 1$$

$$\Rightarrow \quad f_{\text{VNC}} = \alpha_1 f_{\text{Bin1}}^{\text{D40f}} + \alpha_2 f_{\text{Bin2}}^{\text{D40f}}$$

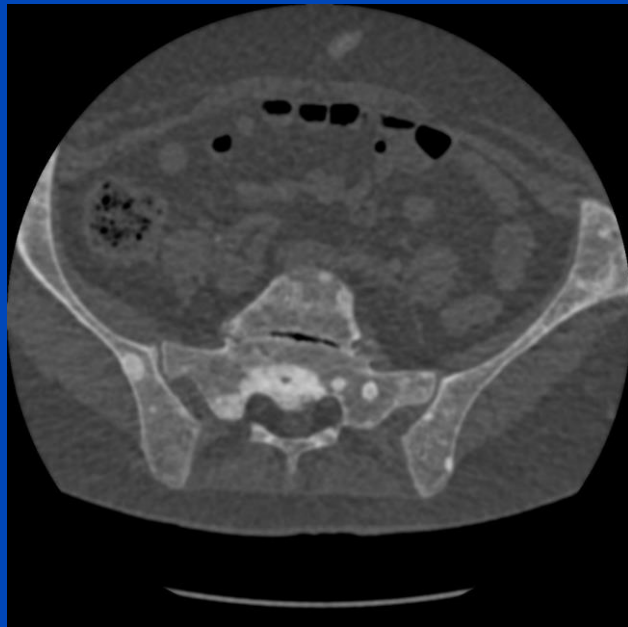| Bin 1 [25 keV, 70 keV]	Bin 2 [70 keV, 120 keV]	VNC

C = 500 HU, W = 2500 HU C = 500 HU, W = 2500 HU

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Results

D40f, 1 mm slice thickness, 0.25 mm increment

VNC

Bone Mask M_B

Soft Tissue Mask M_S

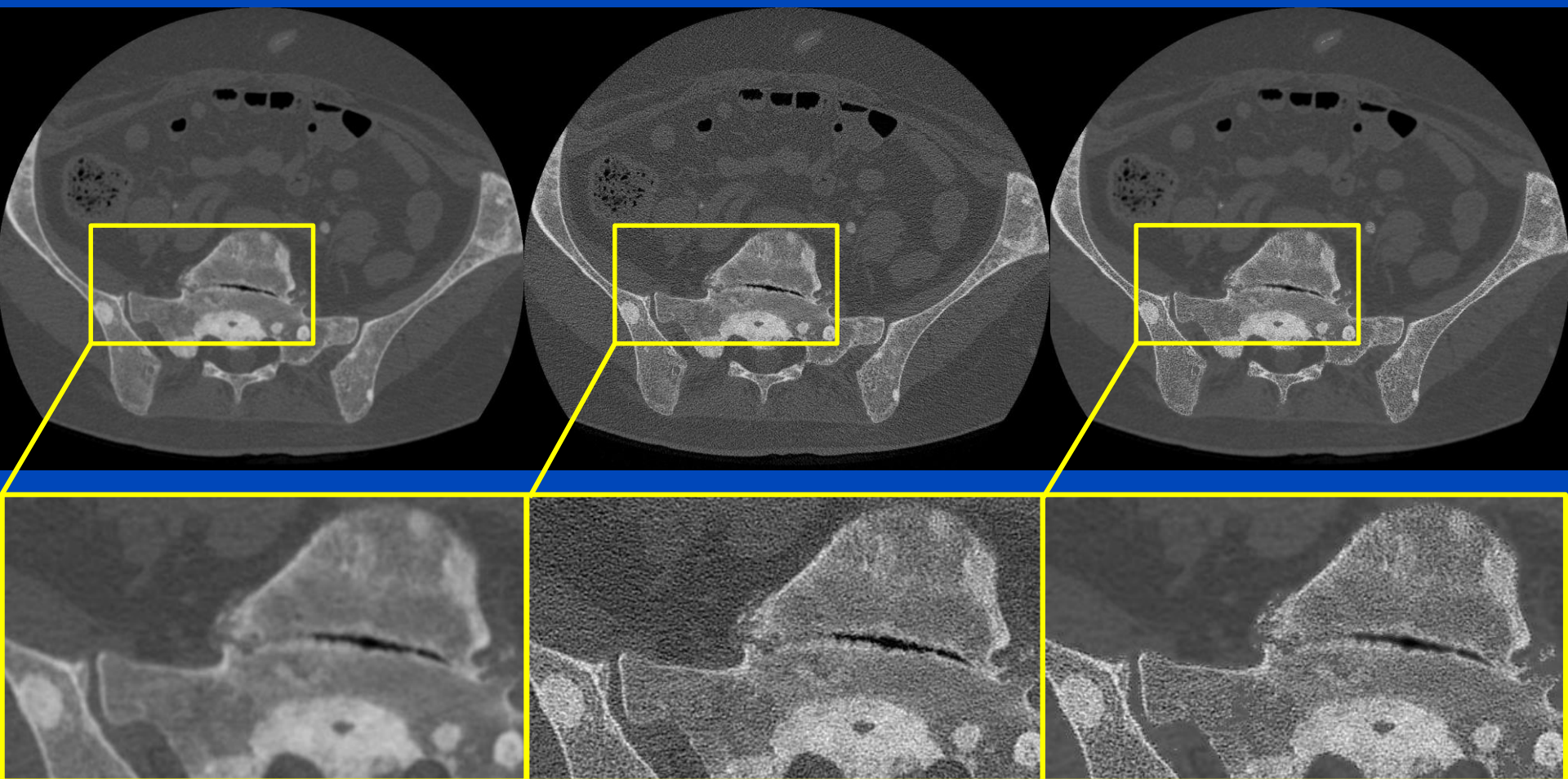

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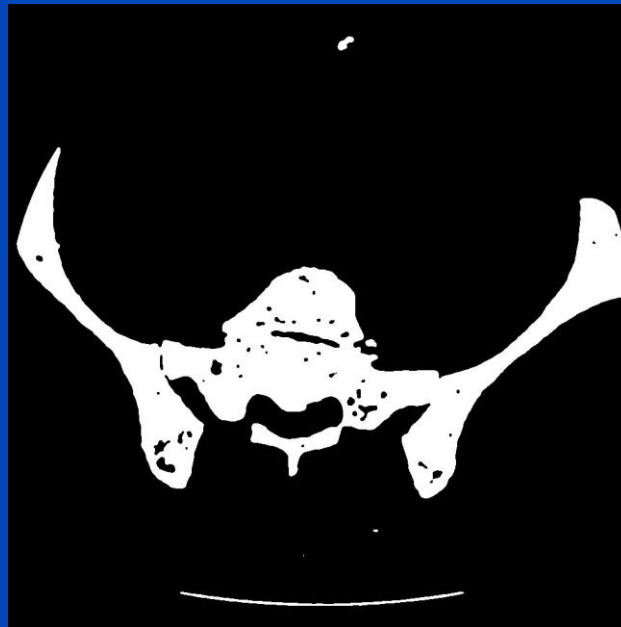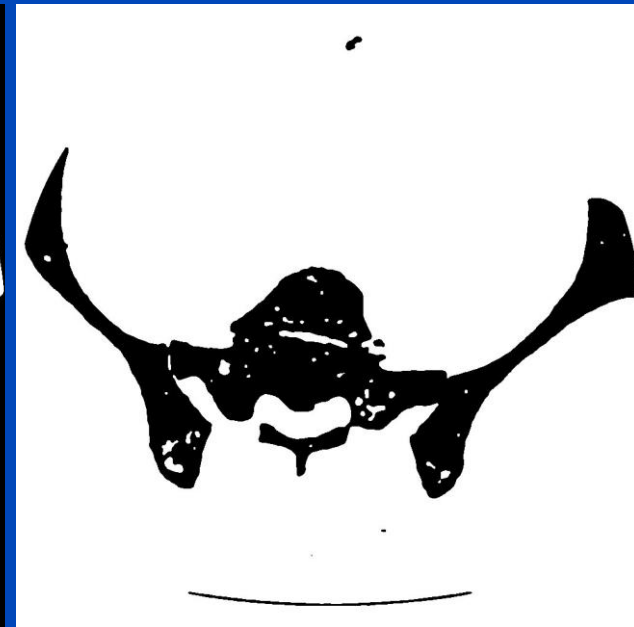
Results

57-year-old patient with bone metastases

Reconstruction with D40f   **Reconstruction with U70f**   **Context-sensitive image**
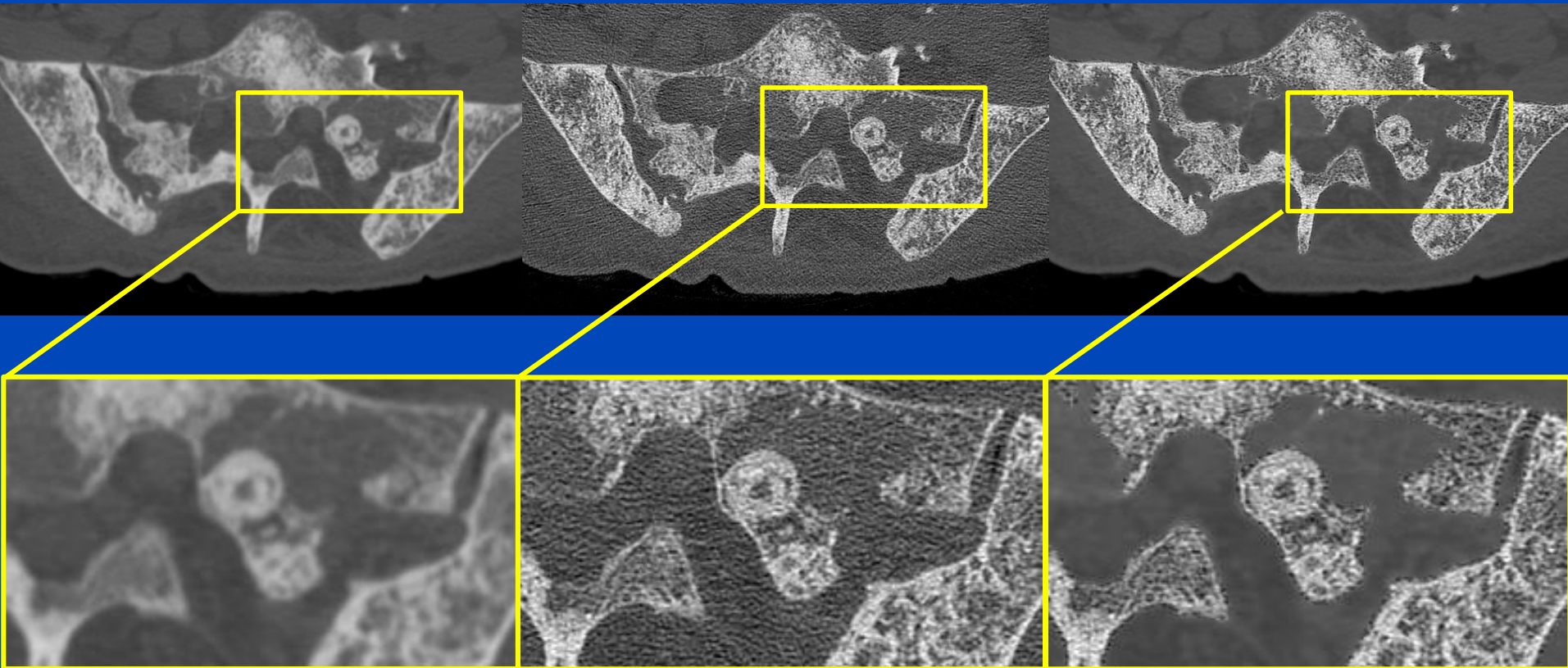
$C = 500$ HU, $W = 2500$ HU

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Results
68-year-old patient with bone metastases

Reconstruction with D40f **Reconstruction with U70f** **Context-sensitive image**

C = 500 HU, W = 2500 HU
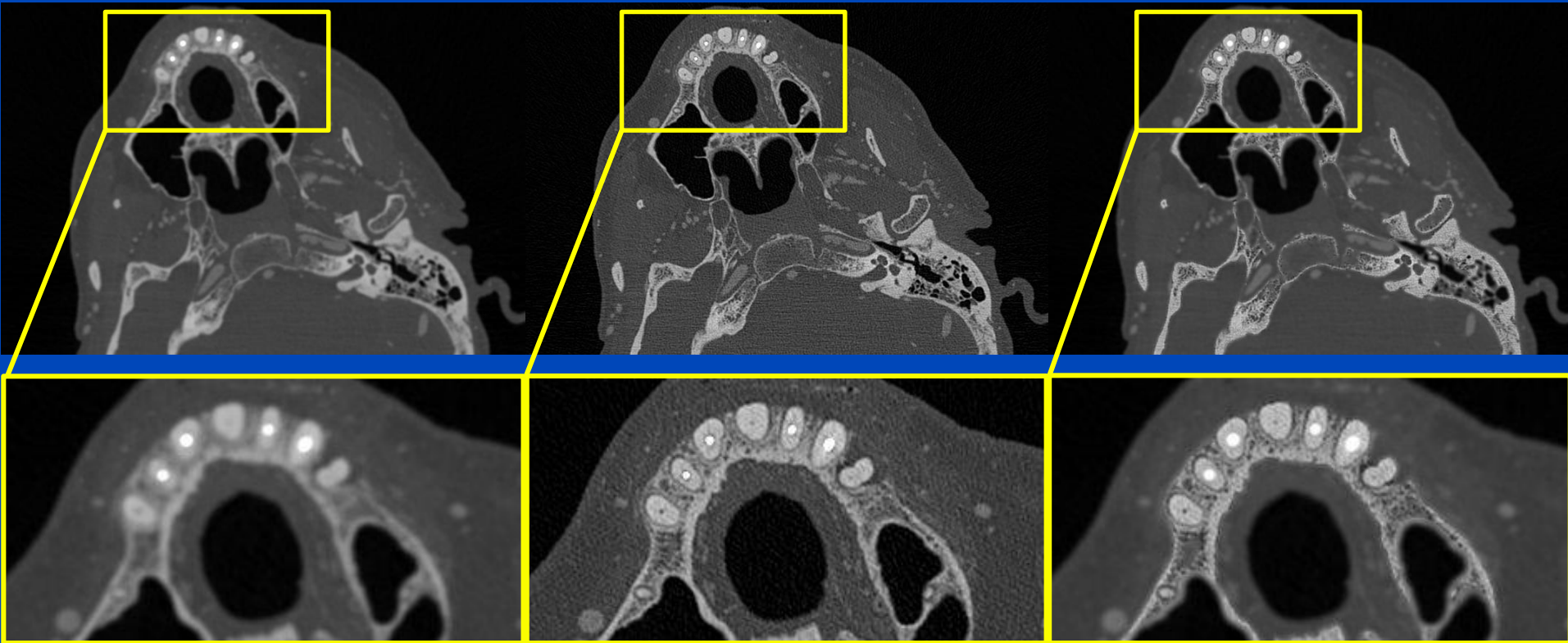
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Results
Cadaver Measurement

Reconstruction with D40f   **Reconstruction with U70f**   **Context-sensitive image**

$C = 500$ HU, $W = 2500$ HU

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Conclusions

- Context-sensitive images including UHR data potentially improve clinical workflow by presenting mutually exclusive image properties within a single image.

- Context-sensitive imaging may also increase the chance of incidental findings.

- The spectral data intrinsically provided by the PC detector can be used to automatically separate for bones, soft tissue and contrast agents.

- Quantification of iodine is still possible since the proposed algorithm ensures iodine to be reconstructed using a quantitative kernel.

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Thank You!

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