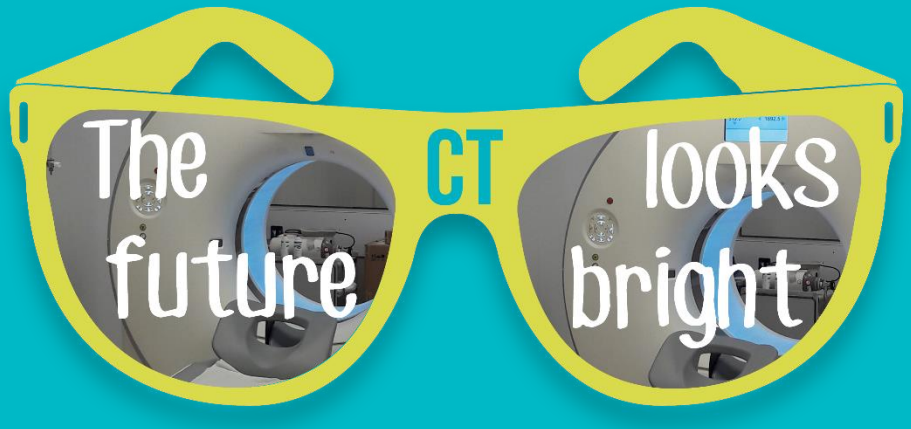


Dual energy CT

Dr. Pieter Marchal

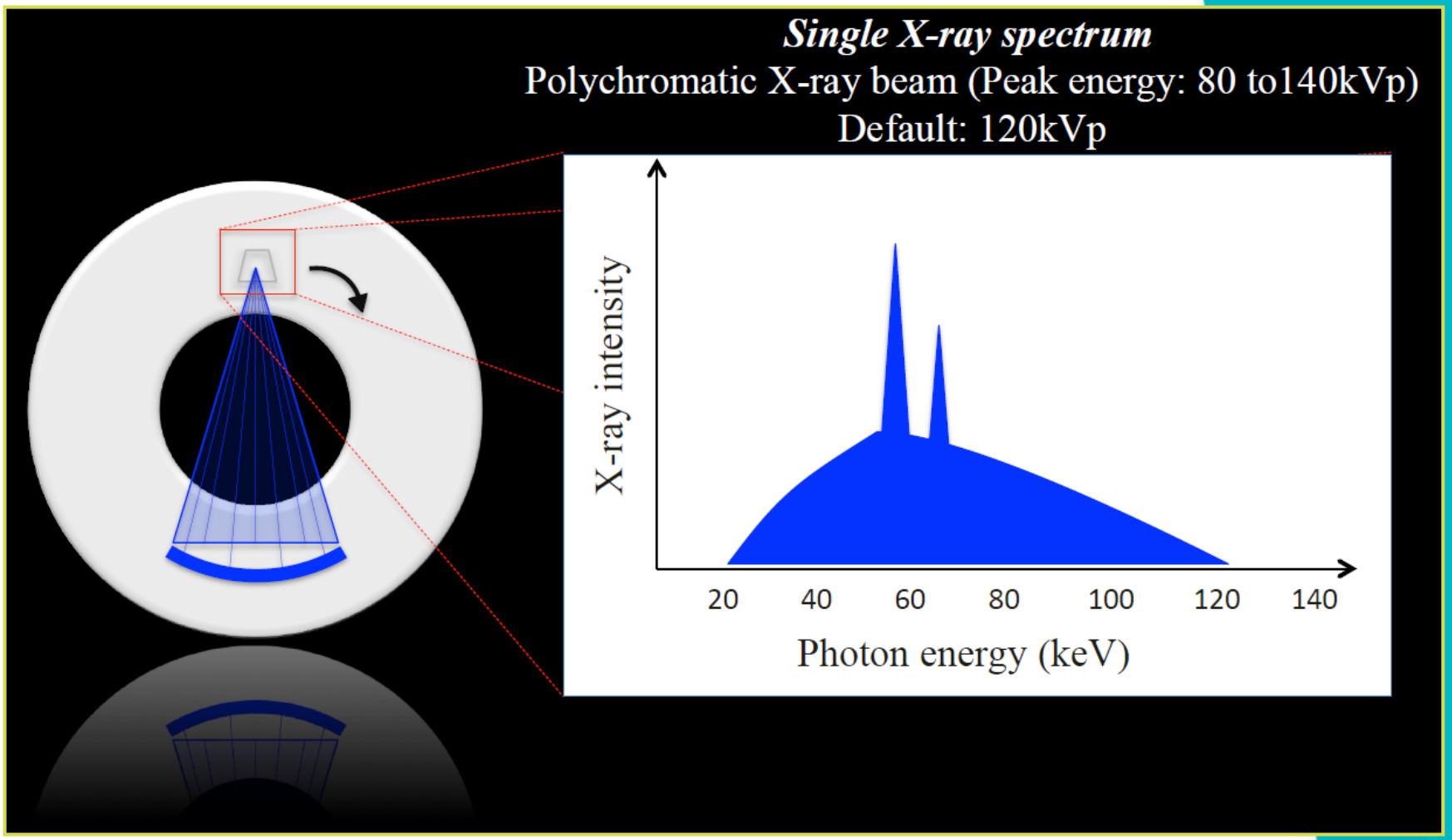
Medische Beeldvorming ZOL

Overzicht

- Inleiding
- Fysica 101
- Applicaties
- Voorbeelden

Conventional (single energy) CT imaging

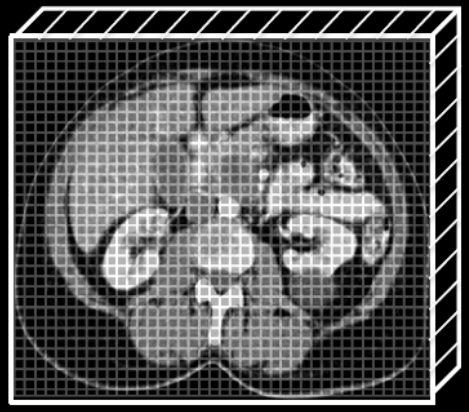
Scan acquisition



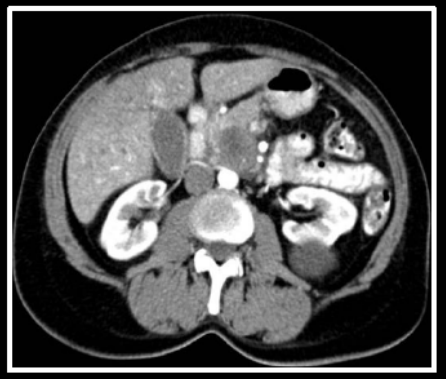
Conventional (single energy) CT imaging

Image reconstruction

CT scan data
(Voxel)

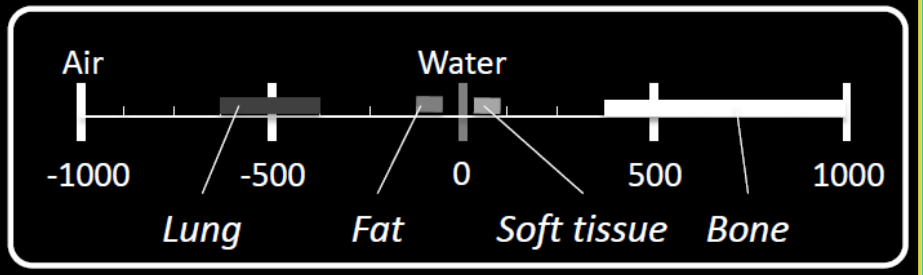


Digital image
(Pixel)



$$\text{CT number (HU)} = \frac{\mu - \mu_{(water)}}{\mu_{(water)}} \times 1000$$

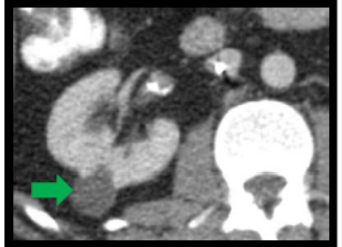
Map of tissue's X-ray attenuation expressed in HU



Attenuation measurements (HU)

Clinical Diagnosis

Simple renal cyst



8HU

Adrenal adenoma

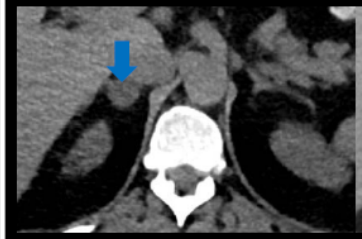
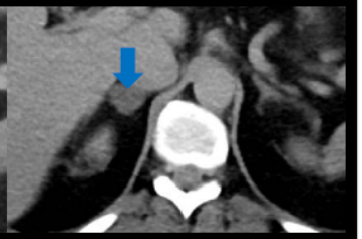
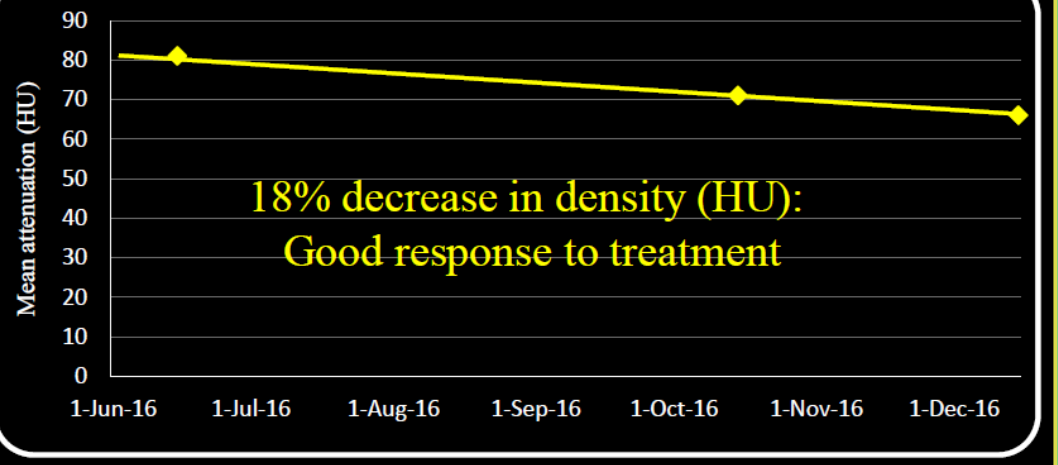
Non-contrast	PVP	Delayed
		
1HU	29HU	10HU

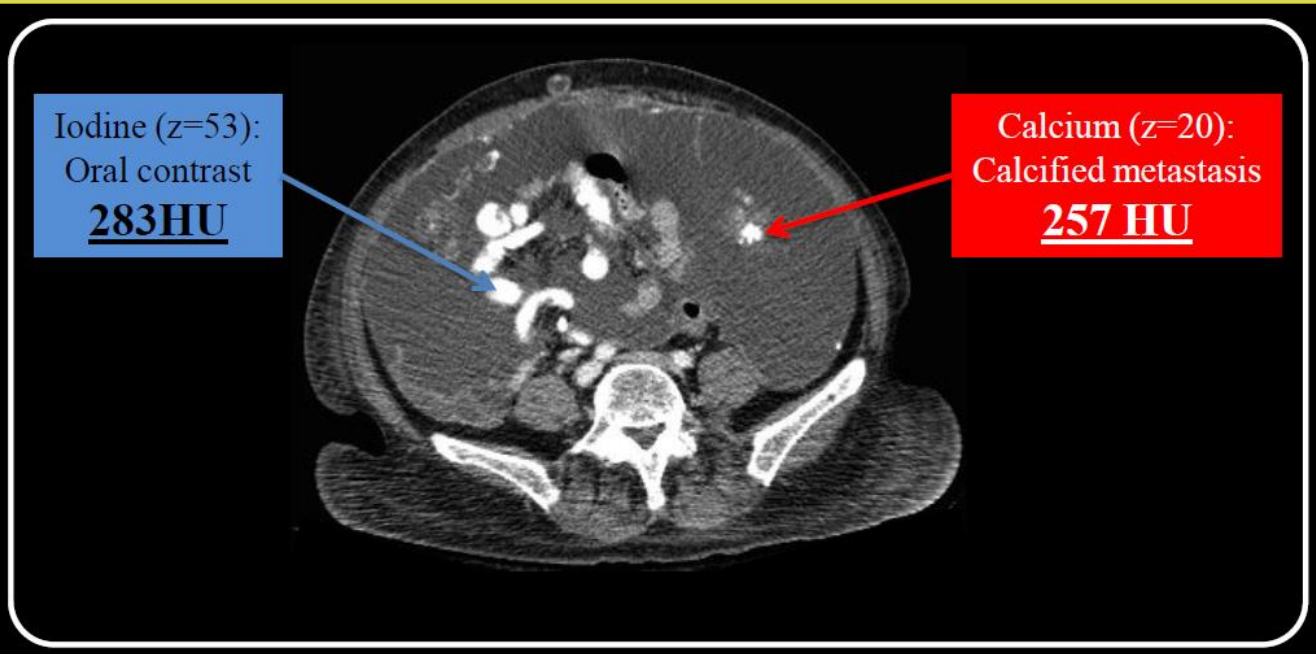
Image Biomarker

Tumor response (Revised CT evaluation criteria) *Choi criteria*	
Partial response	A decrease in size of >10%
	A decrease in **tumor density (HU)** >15% on CT



Limitations of attenuation measurements

Material Differentiation

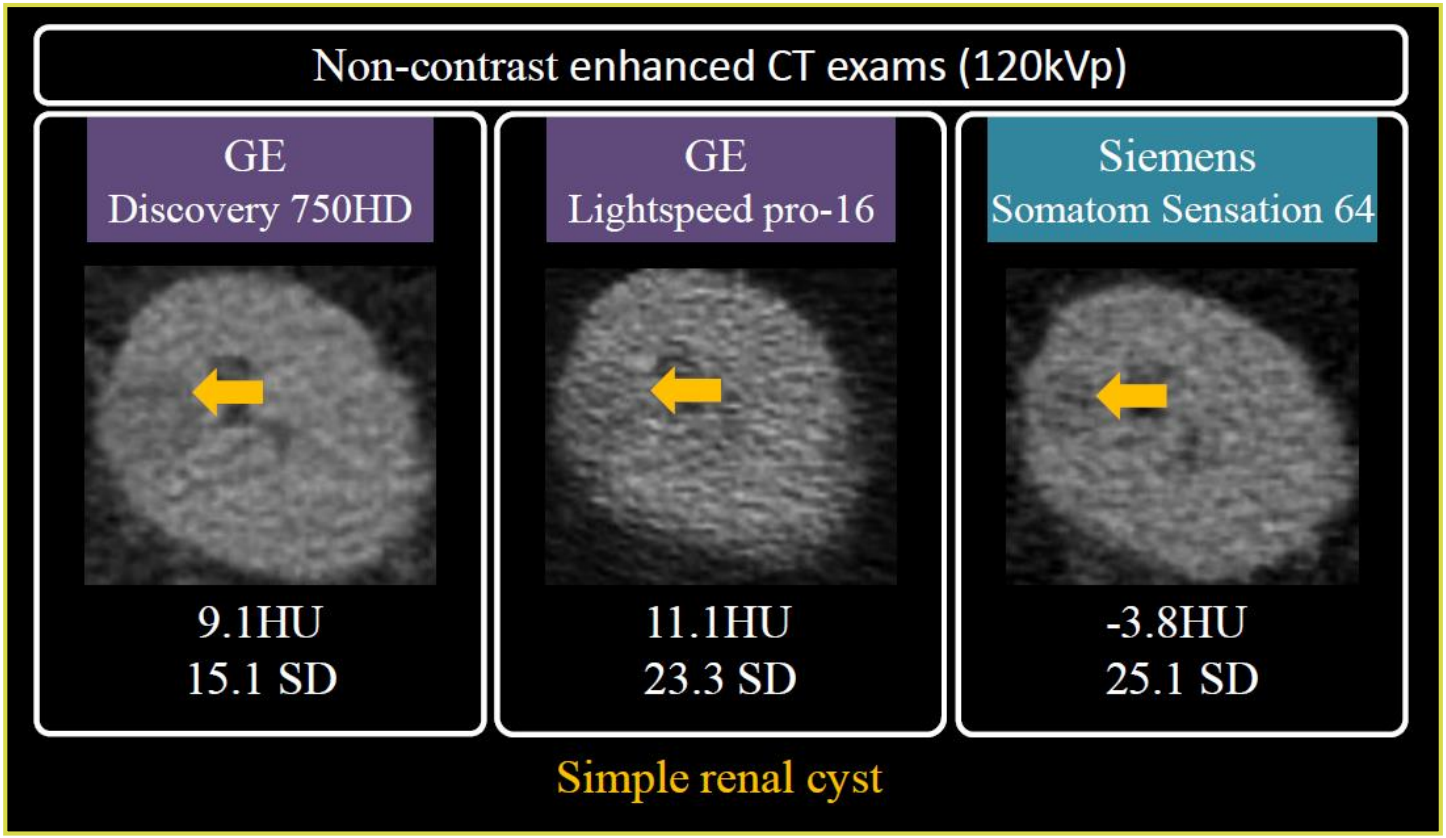


Material Quantification Accuracy

Attenuation on contrast-enhanced CT (HU) = Inherent tissue attenuation (HU) + Contrast enhancement (HU)

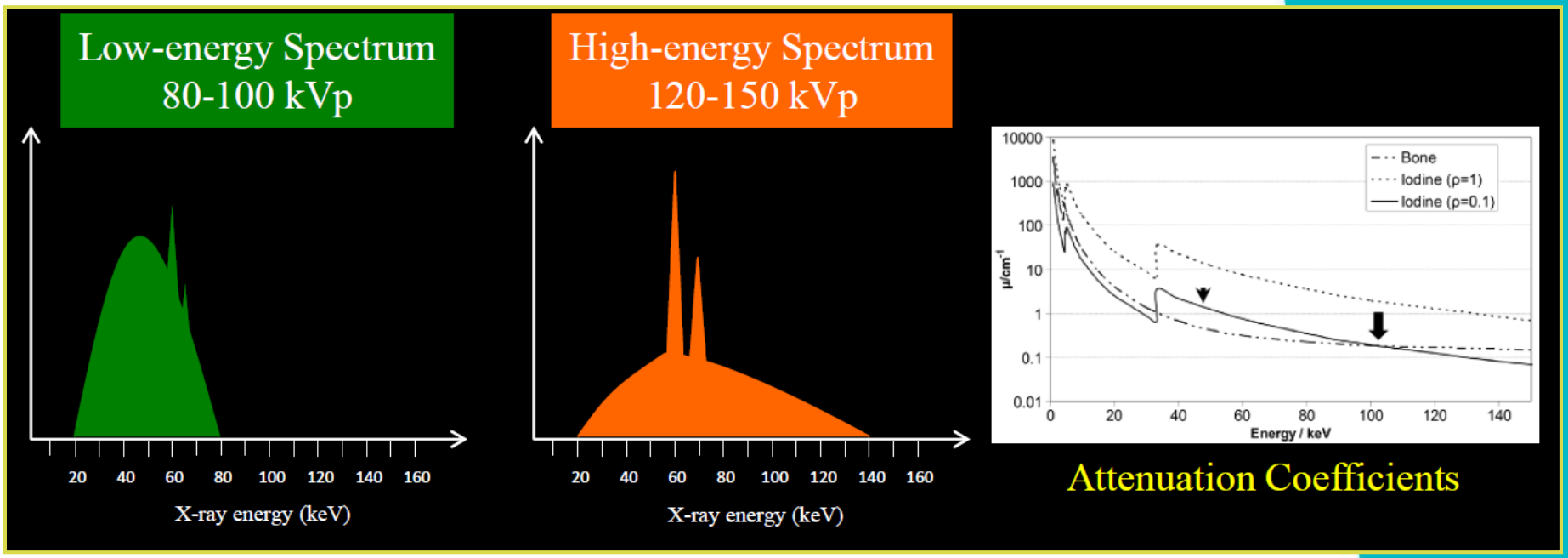
Limitations of attenuation measurements

Variability in attenuation (HU) among SECT scanners: <u>10-25 HU</u>

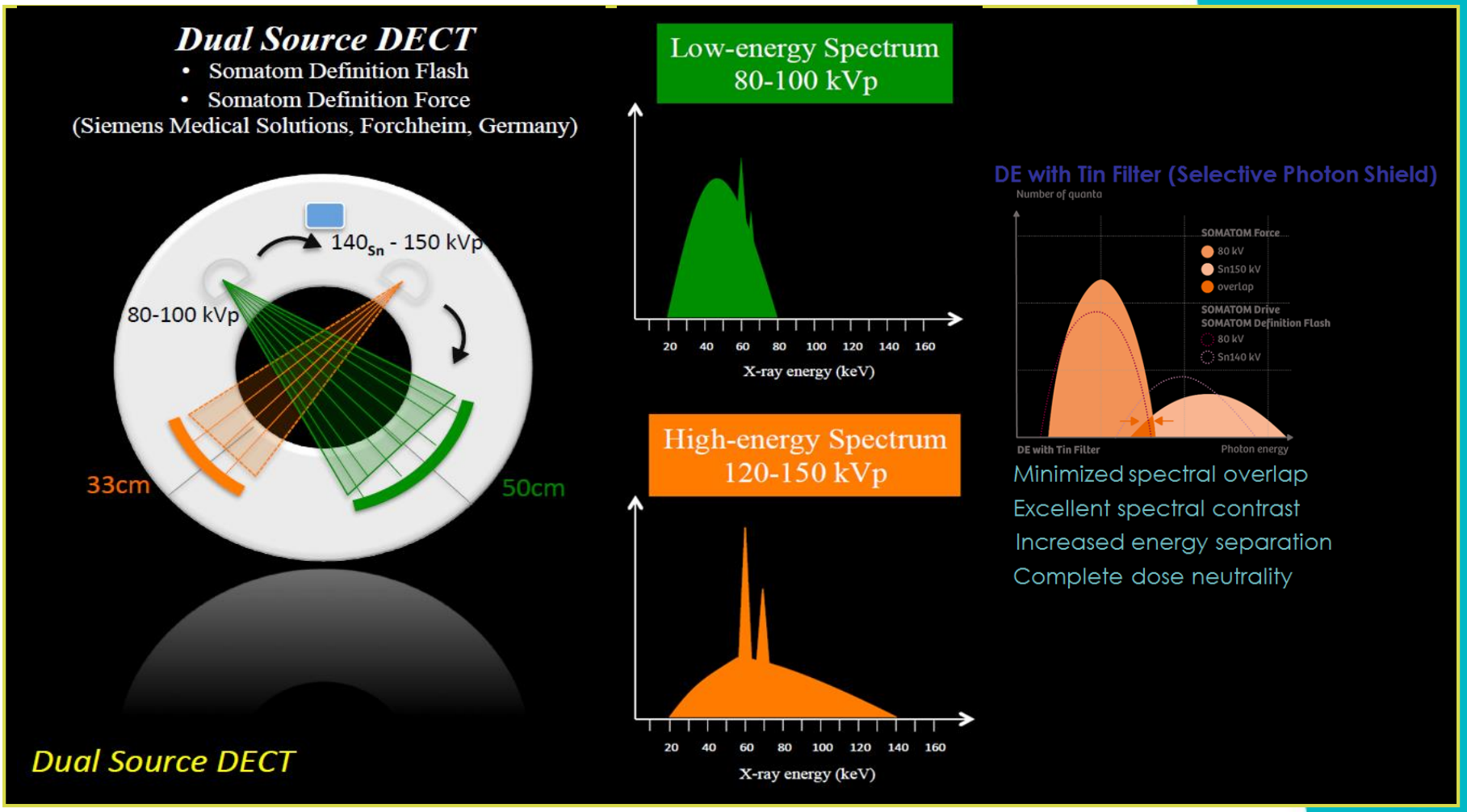


Dual-energy CT

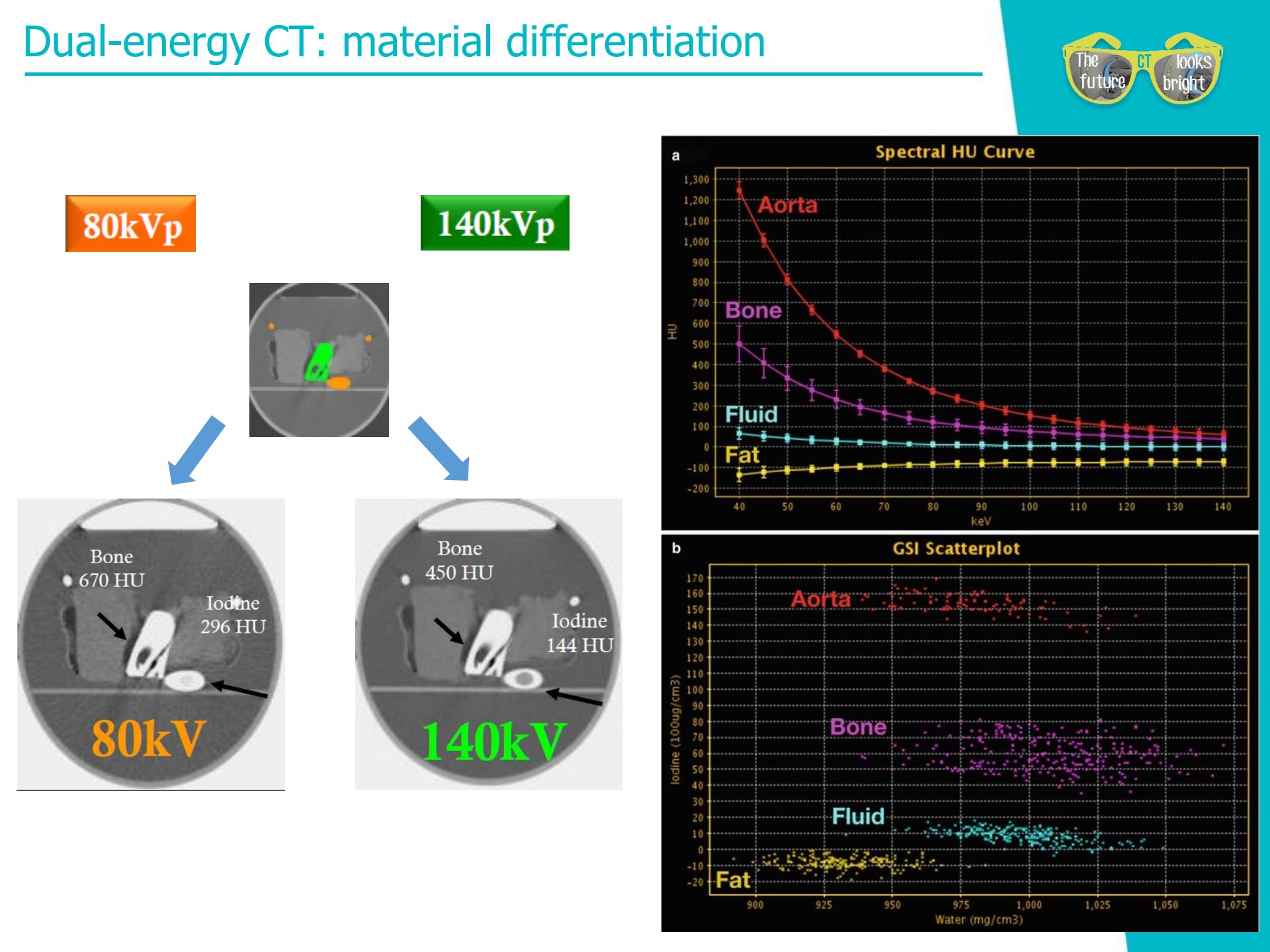
More information about tissues



Dual-energy/spectral CT systems



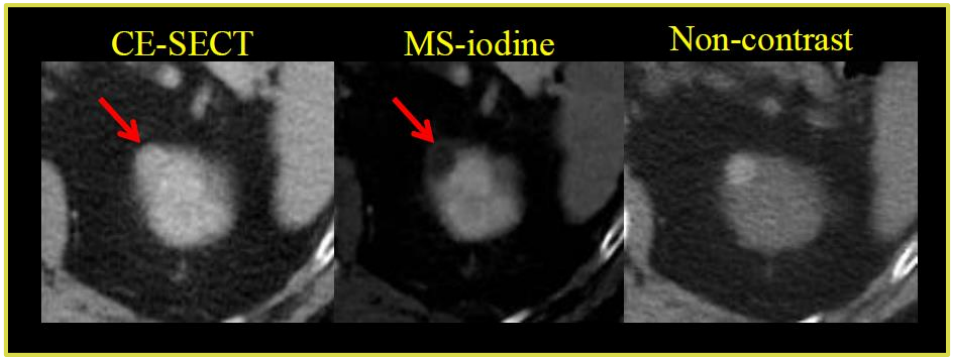
Dual-energy CT: material differentiation



Material specific iodine images

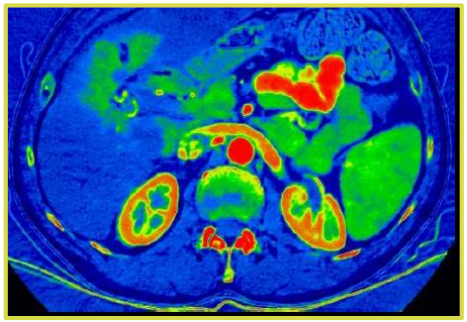
Qualitative

- Specific measurement of tissue enhancement
- Increased tissue contrast
  - Amplify subtle differences in attenuation between normal and abnormal tissues
  - Regardless of the acquisition time

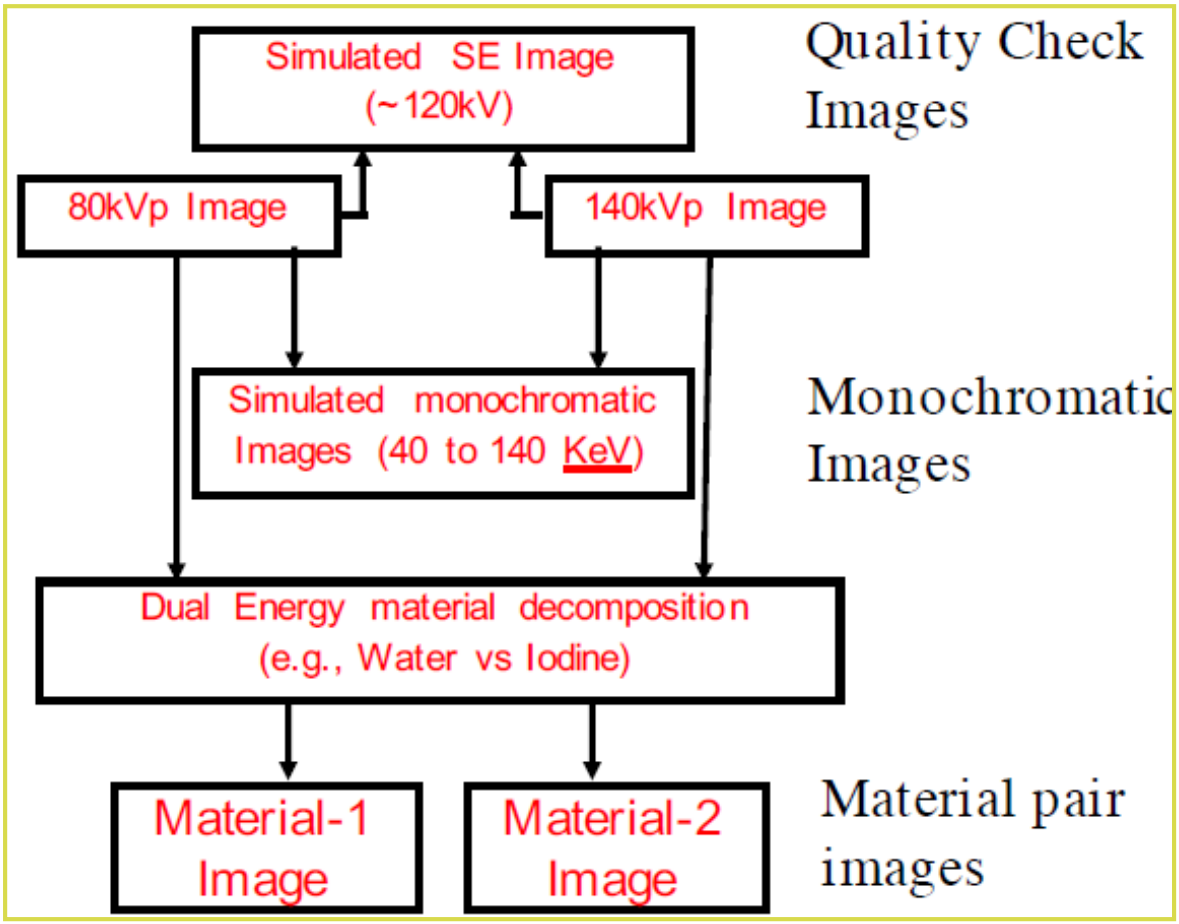


Iodine quantification

- Images represent the mass density (concentration)
- Opportunities
  - Diagnosis
  - Treatment planning
  - Follow-up



Processing


Simulated SE Image
(~120kV)
Quality Check
Images
80kVp Image
140kVp Image
Simulated monochromatic
Images (40 to 140 KeV)
Monochromatic
Images
Dual Energy material decomposition
(e.g., Water vs Iodine)
Material-1
Image
Material-2
Image
Material pair
images

DECT data sets

Virtual mono-chromatic images

- Simulated CT data sets resembling CT images generated from mono-chromatic CT beam
- VMC images of lower energy (50-65 keV)
  - Improve contrast between different tissues
  - Enhance visualization of vessels and hyper vascular lesions
  - Higher image noise and artifacts
- VMC images of higher energy
  - Lower artifacts and reduced contrast between tissues
  - Useful for reduction of metal artifacts

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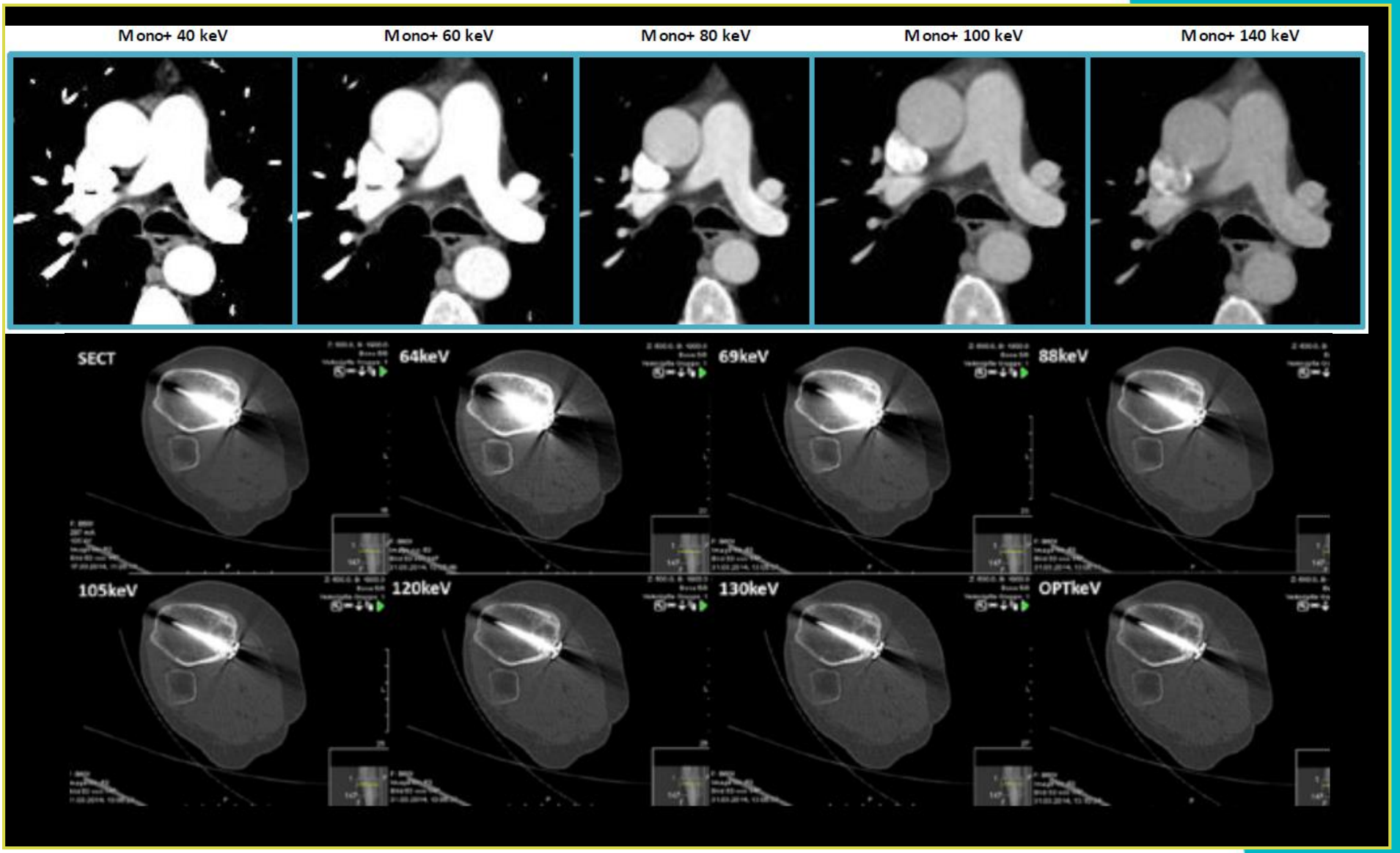
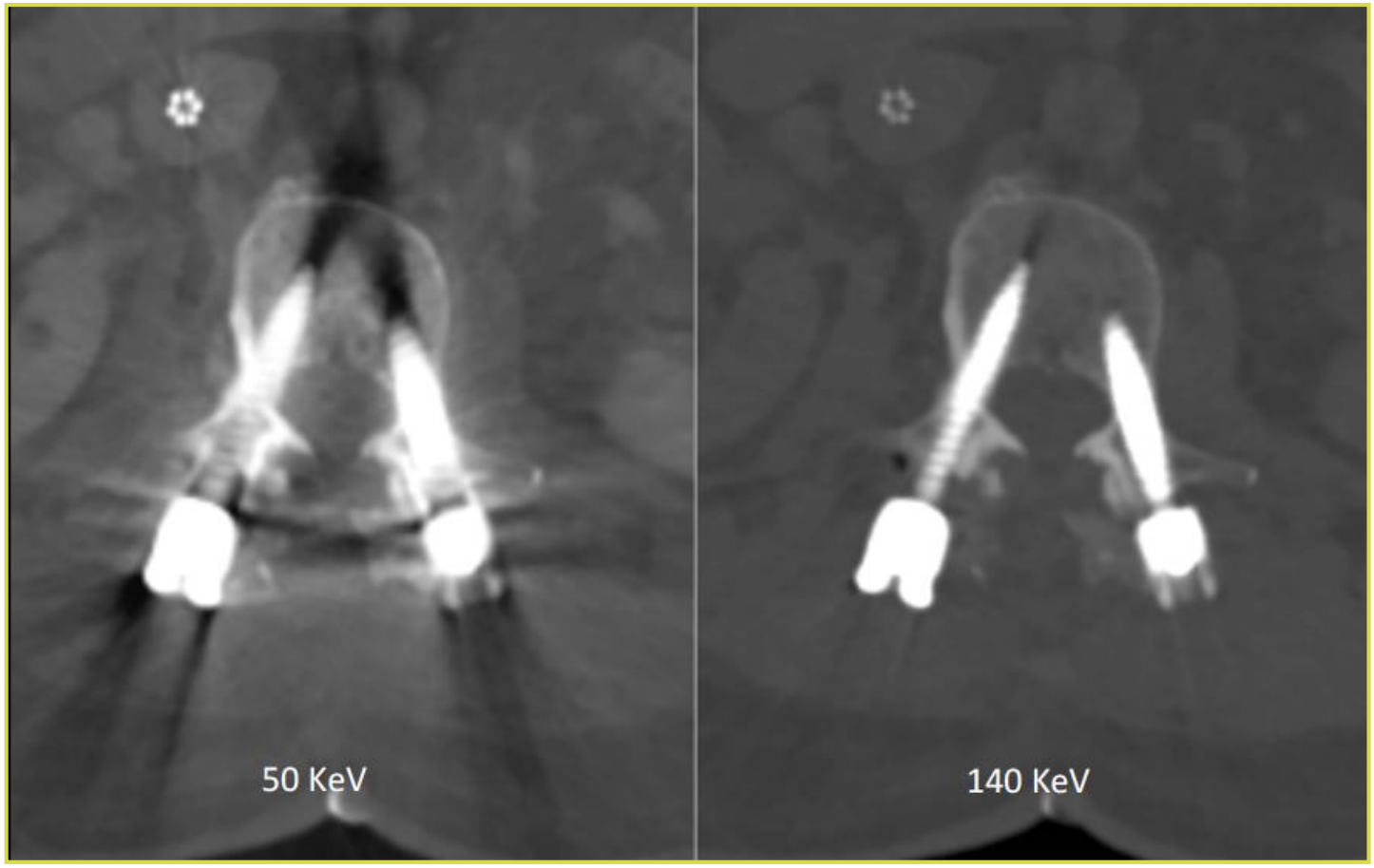
Monochromatic images



Monochromatic images



DECT data sets

Virtual unenhanced images

- Image data sets are equivalent to non-contrast CT images
- Eliminate the need for true unenhanced acquisition thereby reducing radiation dose

Material specific iodine images

- Image data sets show distribution of iodine in tissues independent of background attenuation
- Provide a reliable representation of tissue enhancement
- Improved detection of lesion enhancement compared to HU measurements

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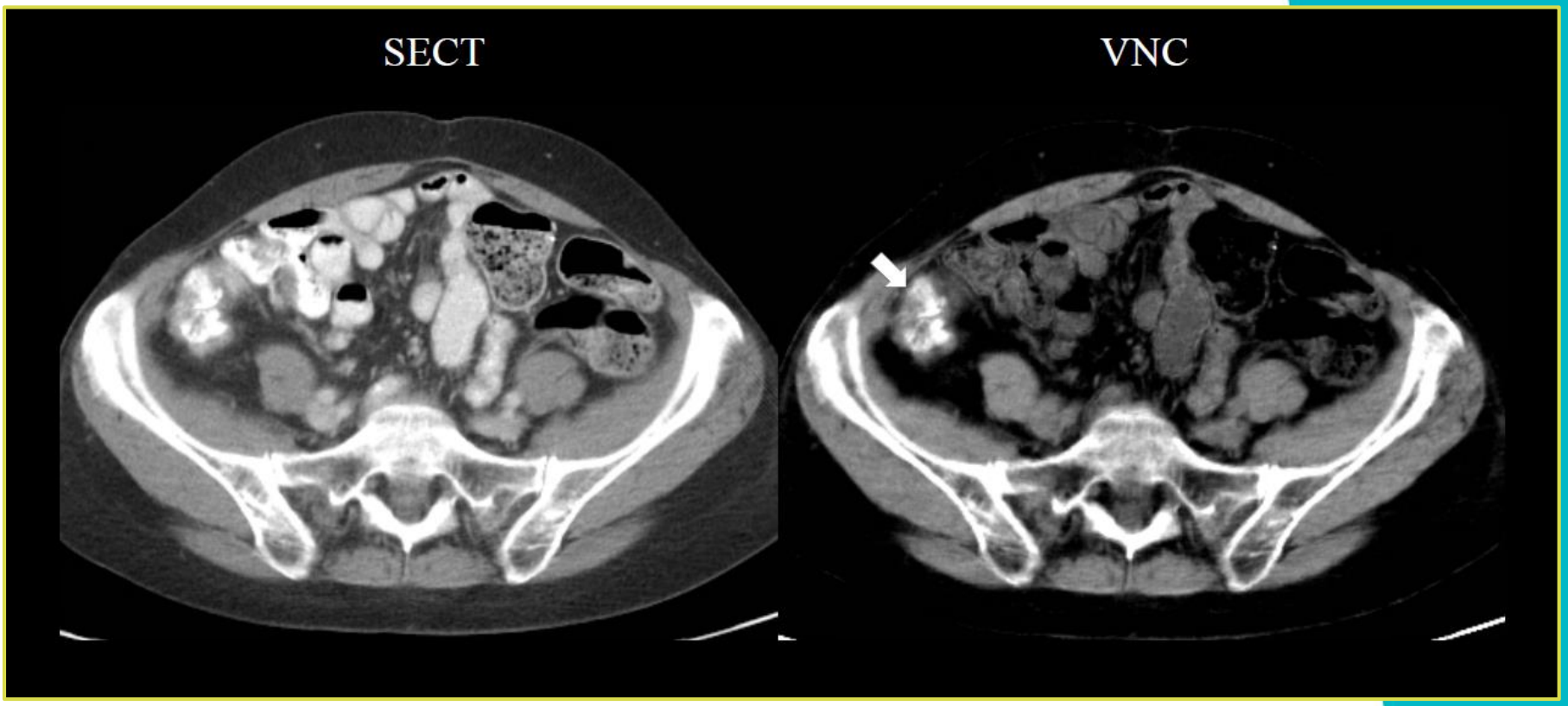
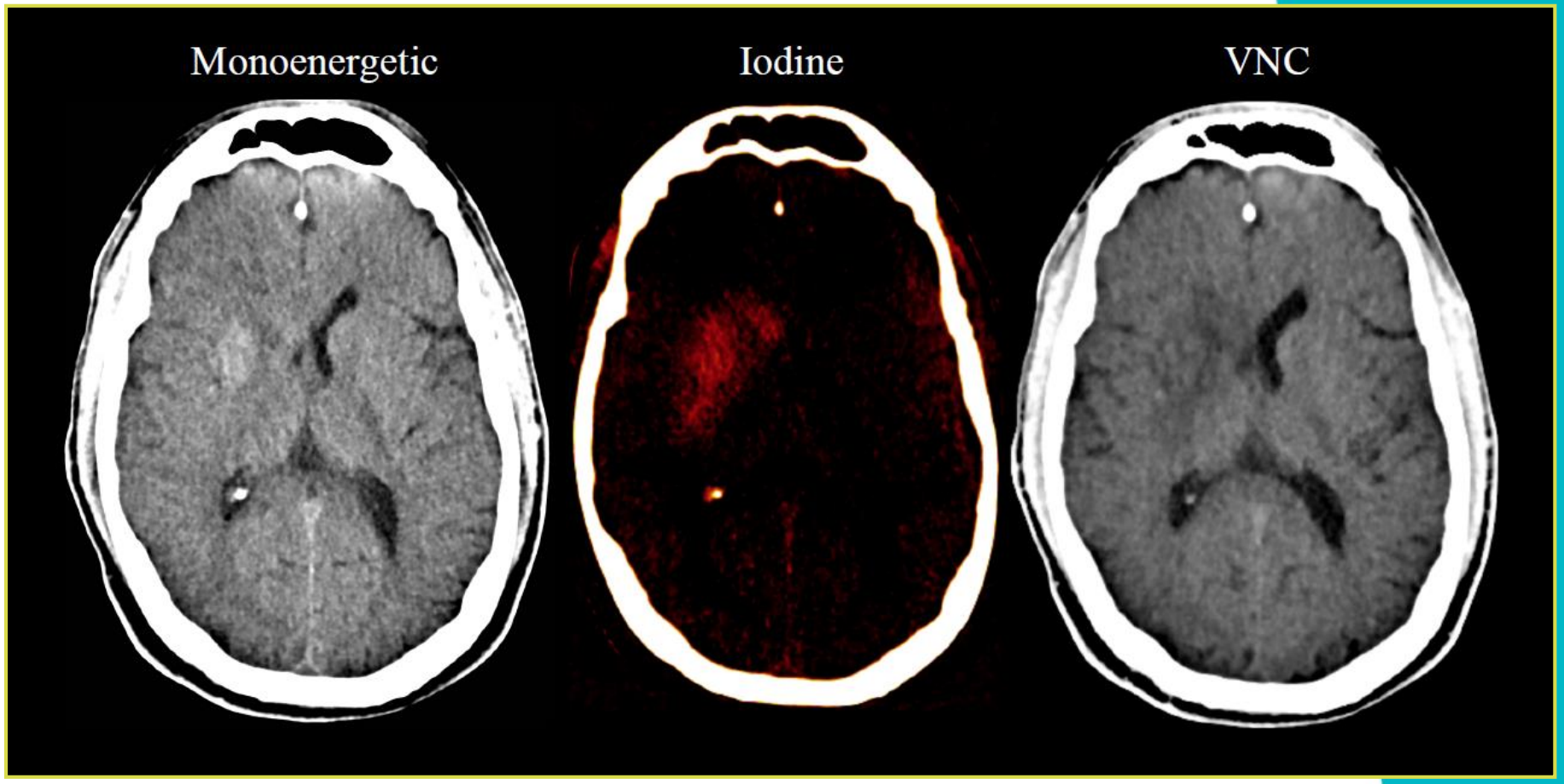
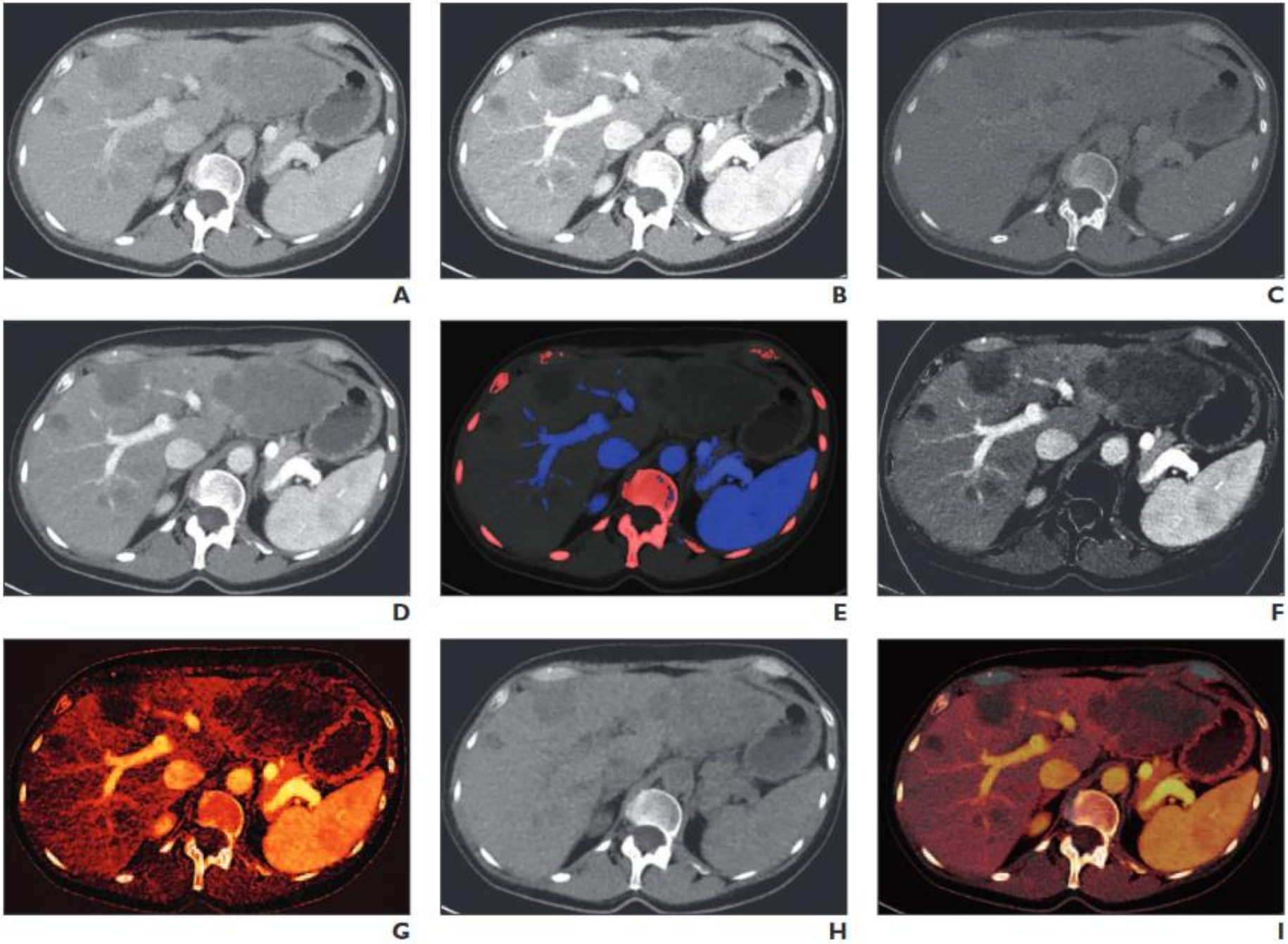
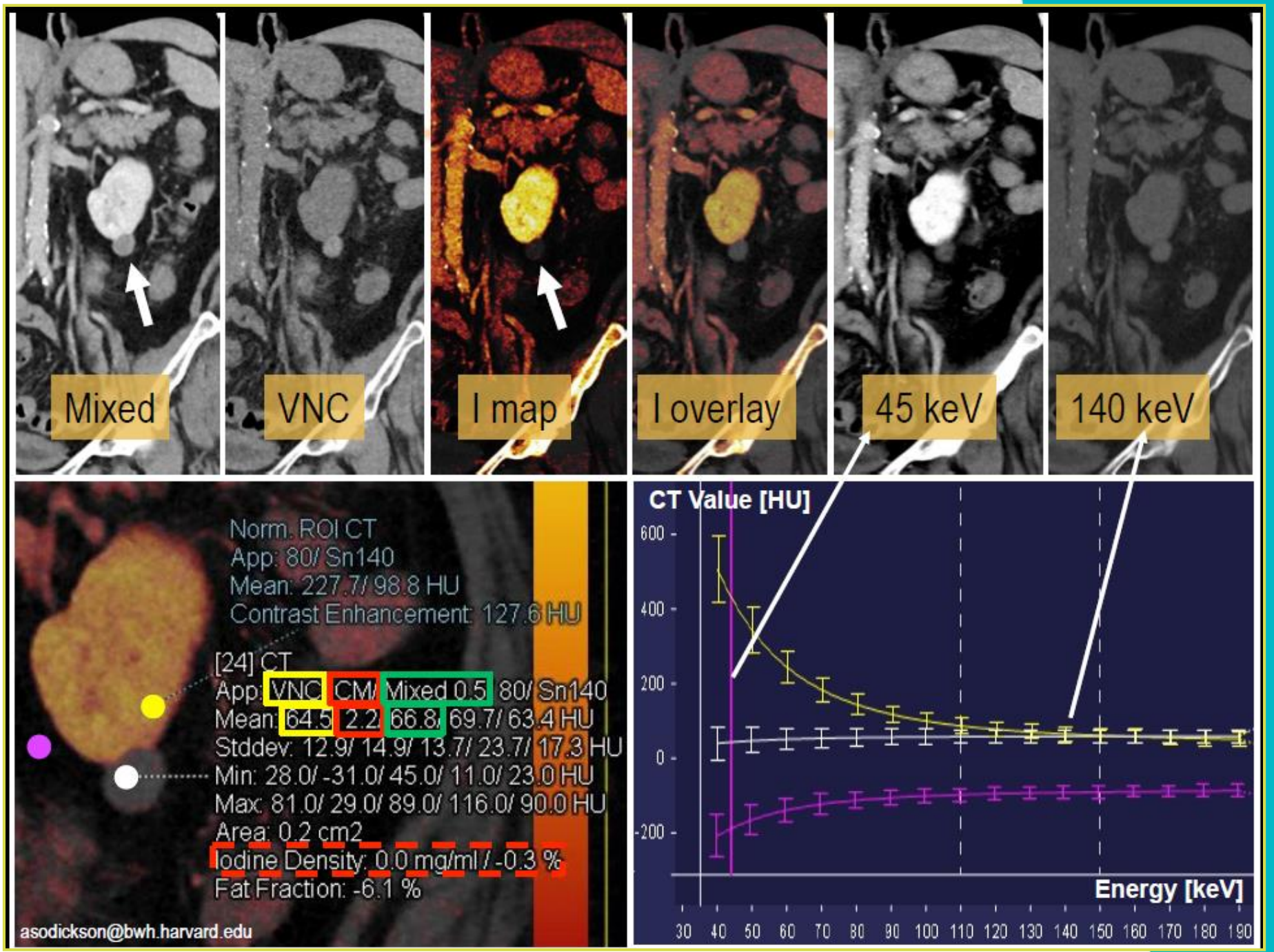
VNC images



Material specific iodine




A
B
C
D
E
F
G
H
I


Mixed
VNC
I map
I overlay
45 keV
140 keV
Norm. ROI CT
App: 80/ Sn140
Mean: 227.7/ 98.8 HU
Contrast Enhancement: 127.6 HU
[24] CT
App: VNC CM/ Mixed 0.5 80/ Sn140
Mean: 64.5 2.2 66.8 69.7/ 63.4 HU
Stddev: 12.9/ 14.9/ 13.7/ 23.7/ 17.3 HU
Min: 28.0/ -31.0/ 45.0/ 11.0/ 23.0 HU
Max: 81.0/ 29.0/ 89.0/ 116.0/ 90.0 HU
Area: 0.2 cm2
Iodine Density: 0.0 mg/ml / -0.3 %
Fat Fraction: -6.1 %
asodickson@bwh.harvard.edu
CT Value [HU]
600
400
200
0
-200
Energy [keV]
30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190

All cakes and ale?

Dose?

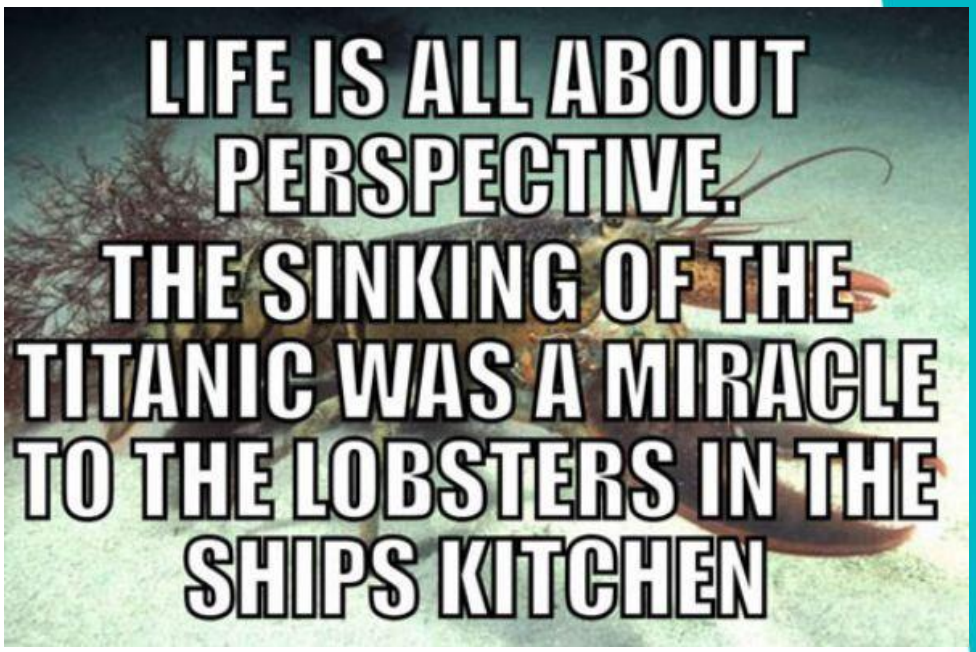
Metal artifacts?

Size?

Exam time?

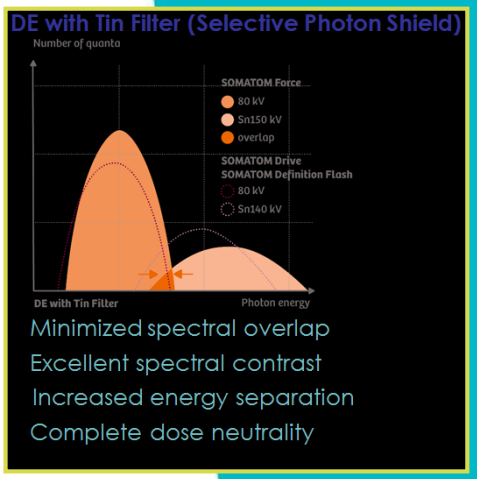
Transmission time?

Education?



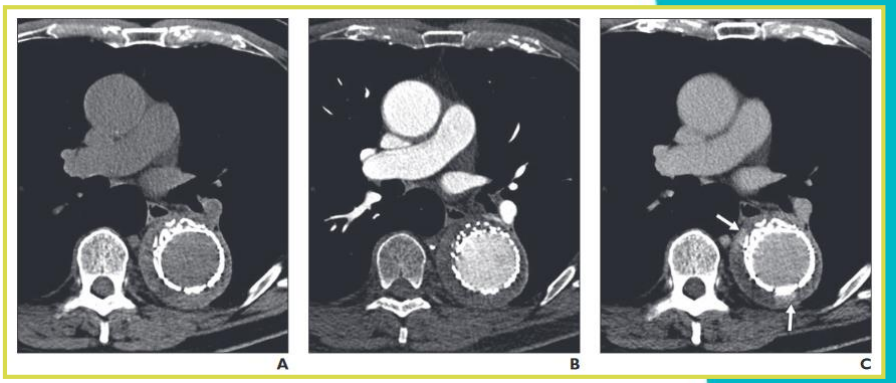
Dose

- The radiation exposure required for DECT depends on the technology used (dual source < single source)
- The aim is to use the same dose as would be used for a single-energy examination

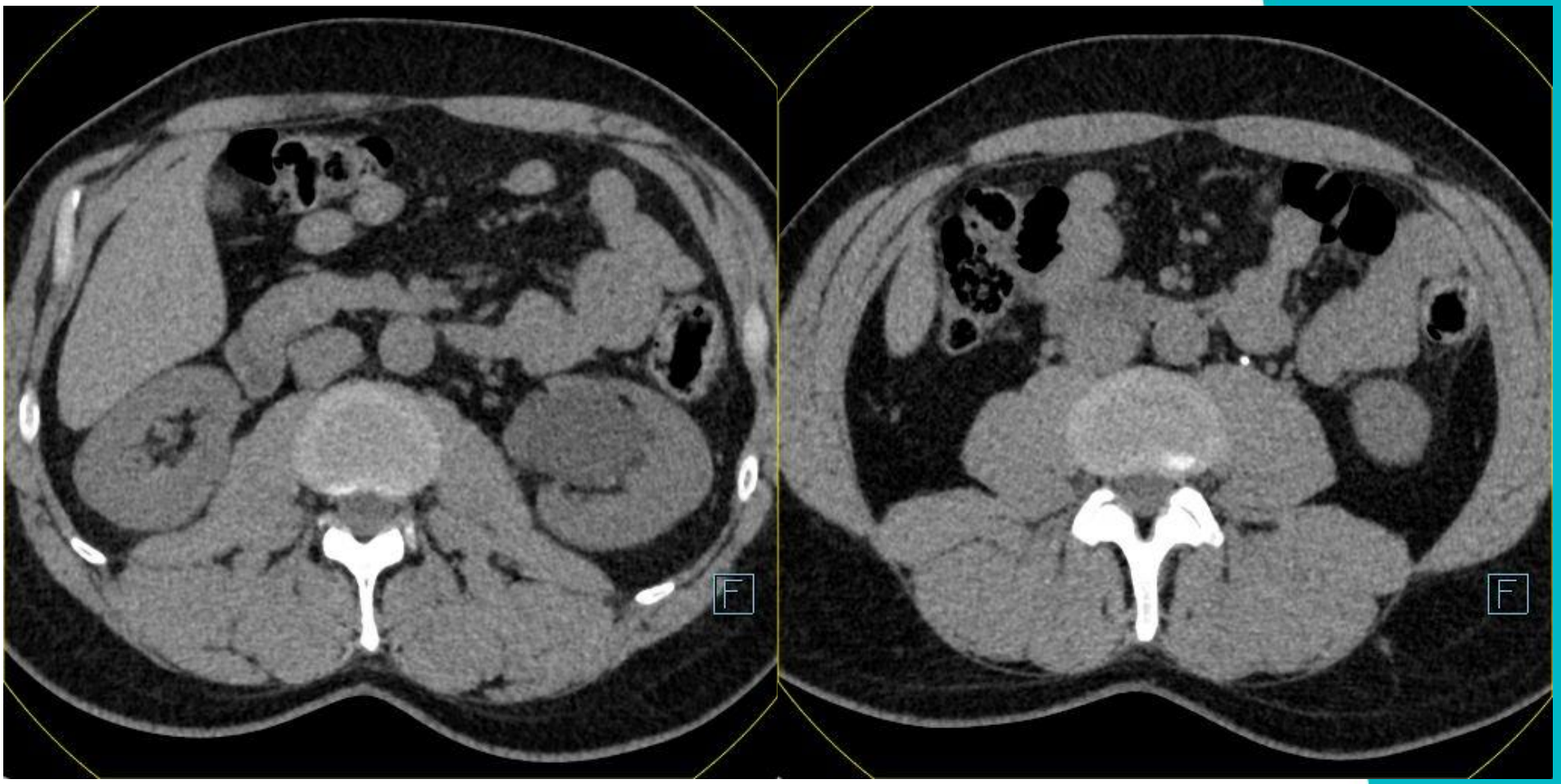


- Less number of scan phases

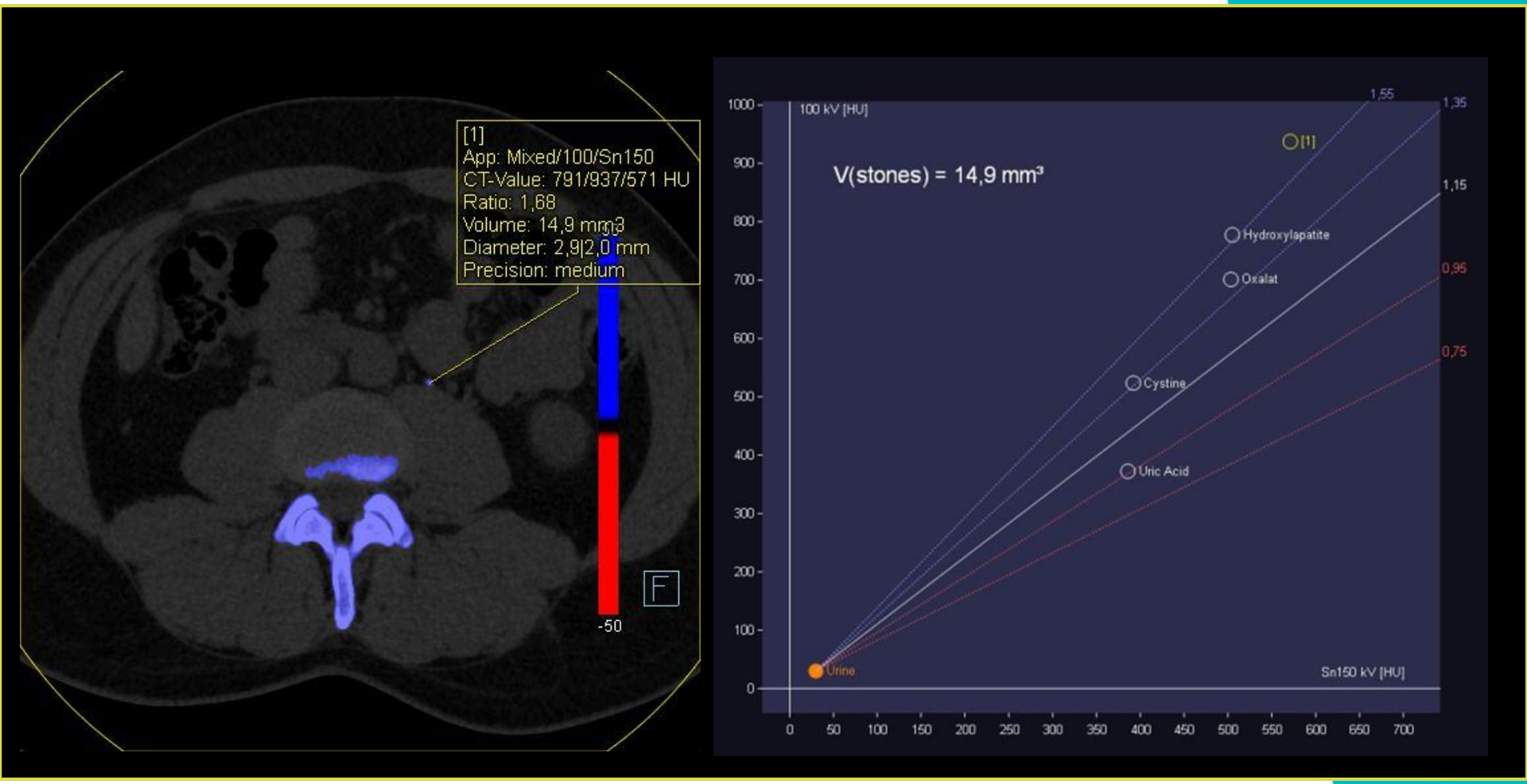
- Elimination of true non-contrast with VNC: -20%
- Elimination of true non-contrast and arterial phase: -64%



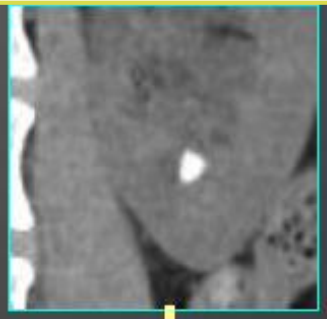
Examples



Kidney stones



Kidney stones



Uric Acid Stone

Medical Management
Allopurinol
Treatment of Hyperuricemia

<1000 HU
(Struvite)

ESWL

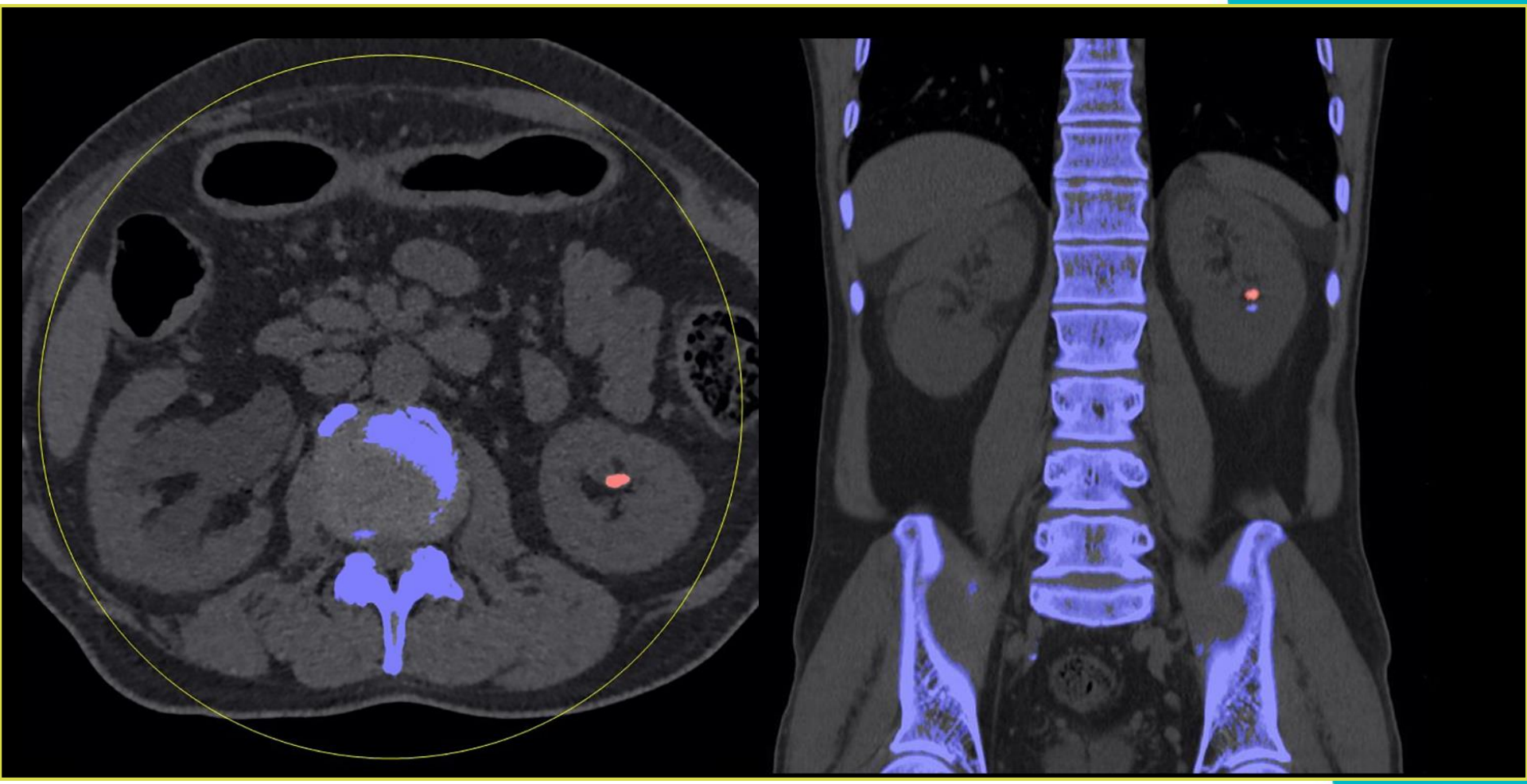
>1000HU
(Brushite, Cystine, COM)

Ureteroscopy
PCNL

Stone composition also effects the efficacy of ESWL

- Brushite, cystine and COM stones are hard and resistant
- Struvite stones usually fragment easily

Kidney stones



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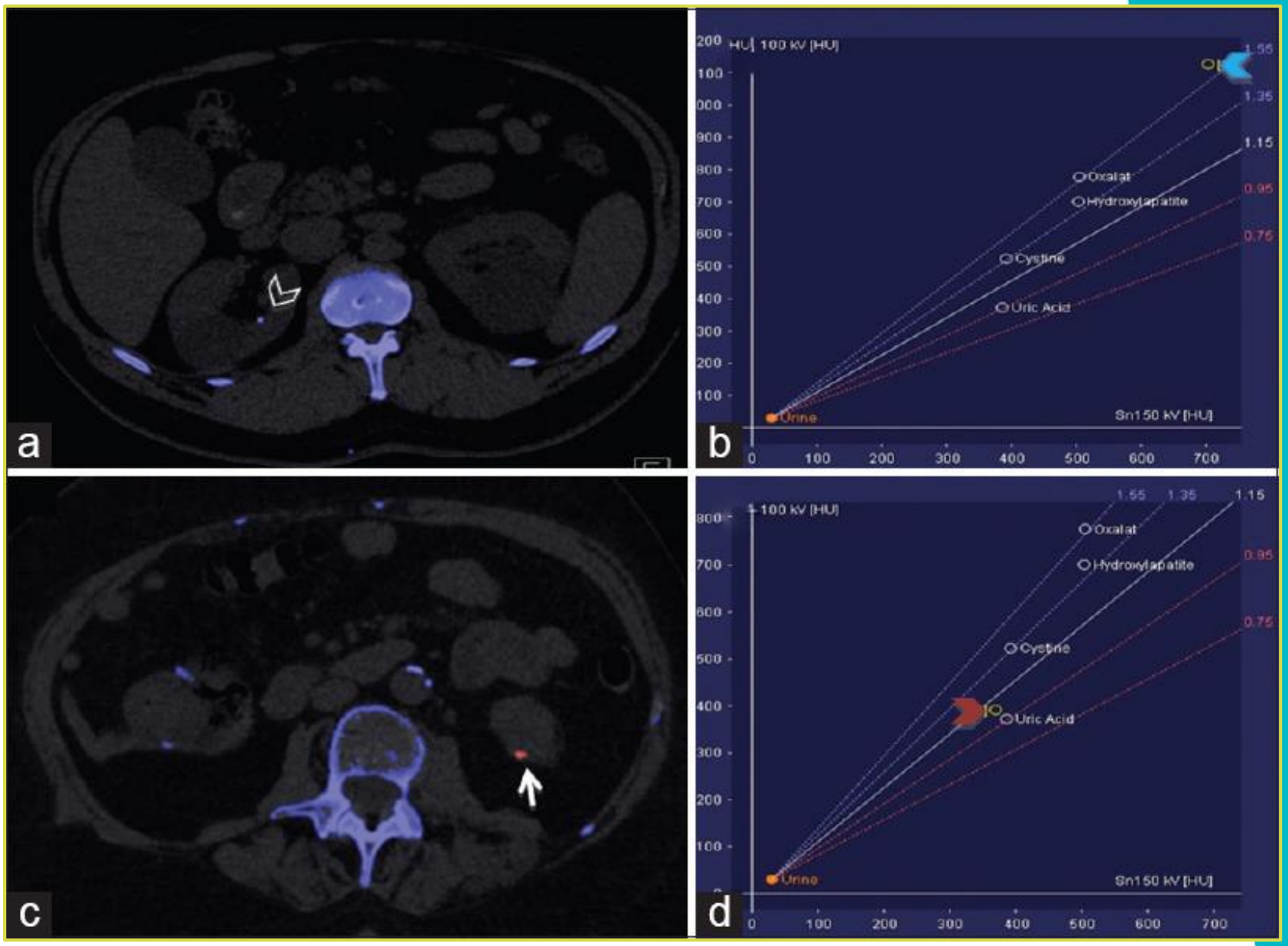
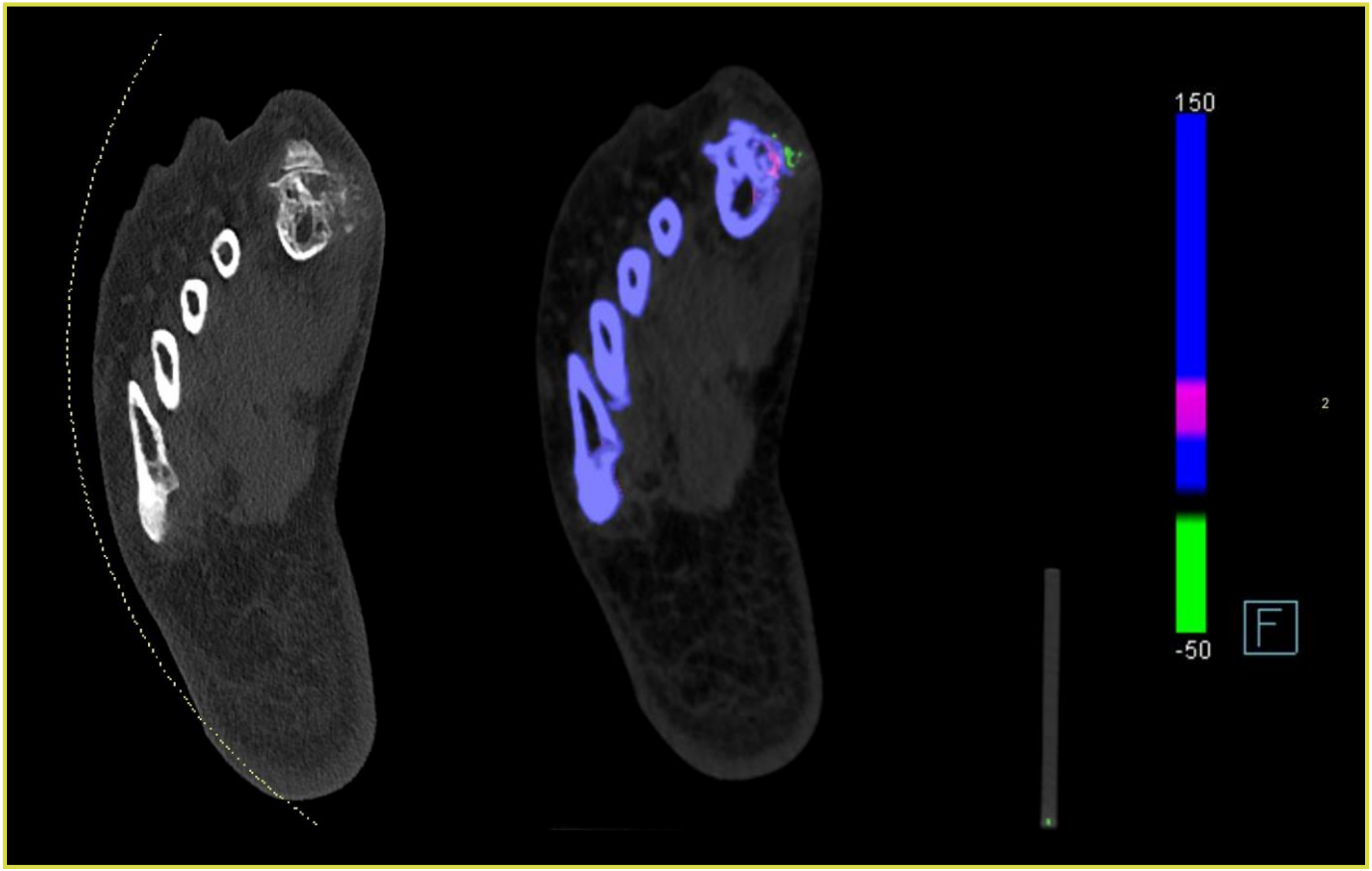
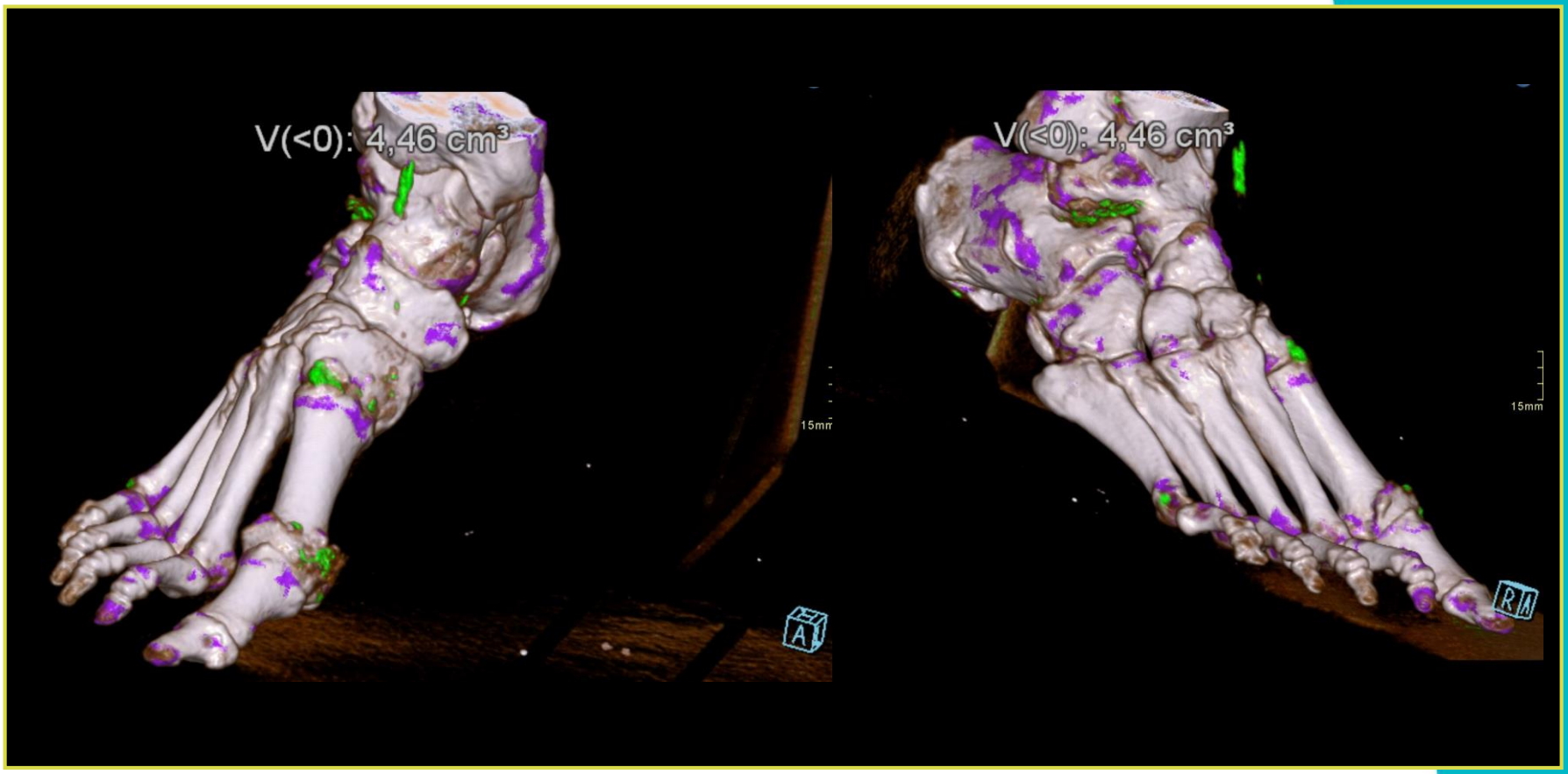
Kidney stones



Gout

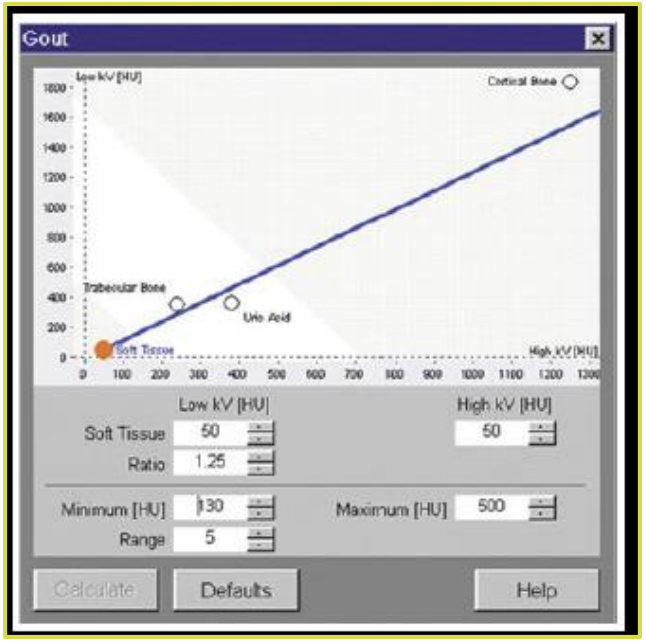


Gout

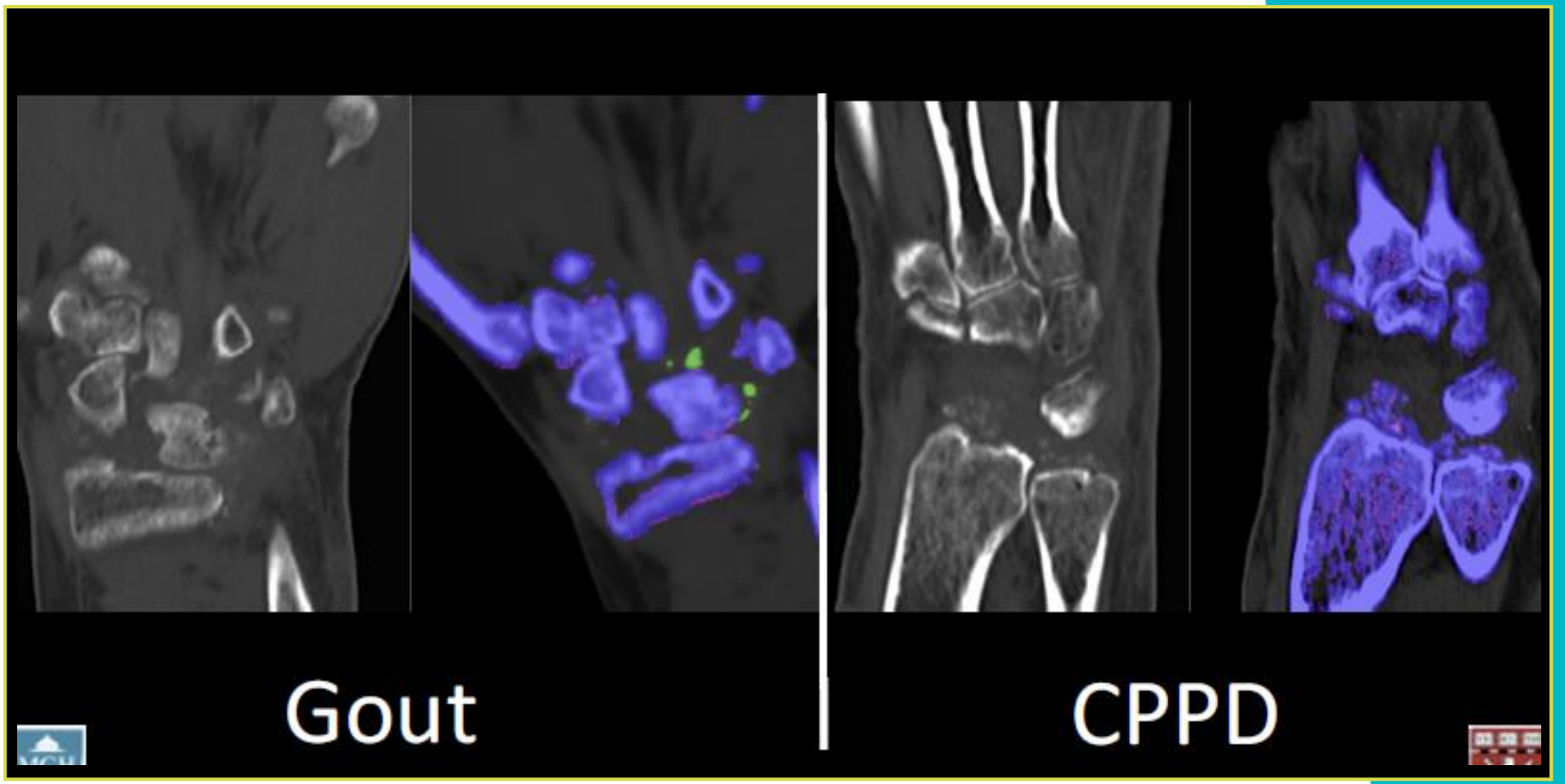


Gout

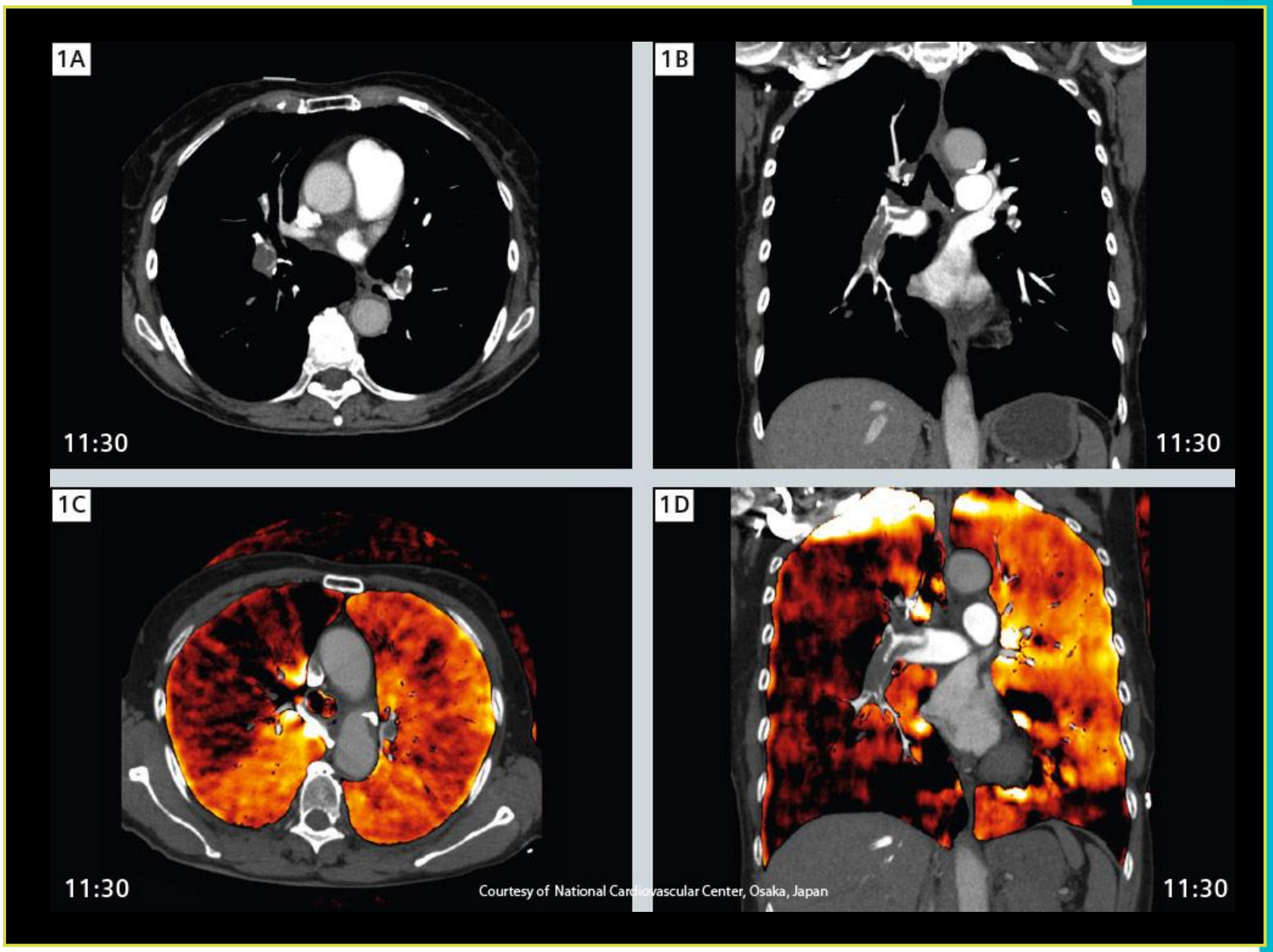
- Calcium and urate: marked difference in photoelectric absorption
  - Sensitivity: 78-100%
  - Specificity: 89-100%
- Can calculate tophi volume



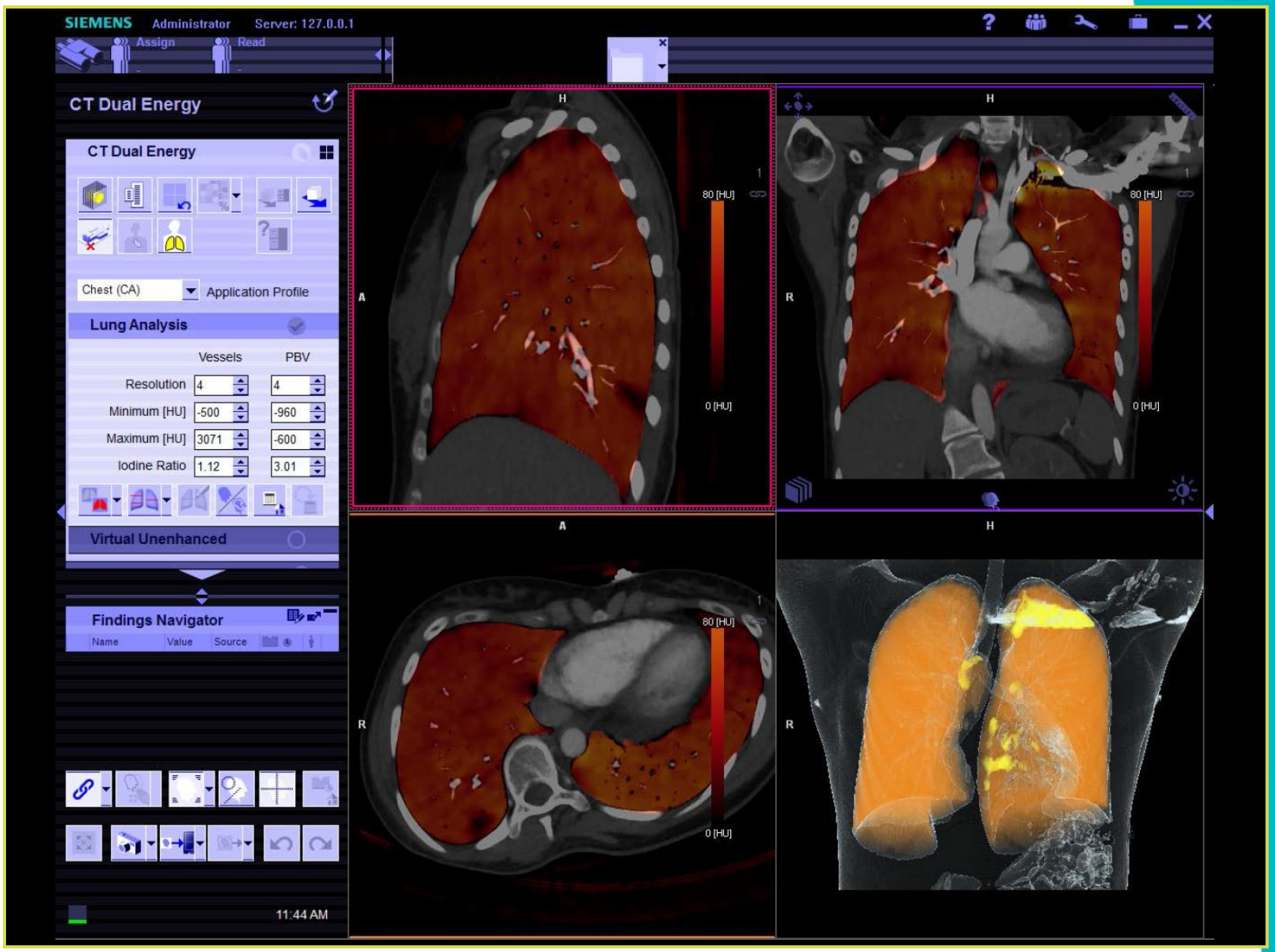
Gout



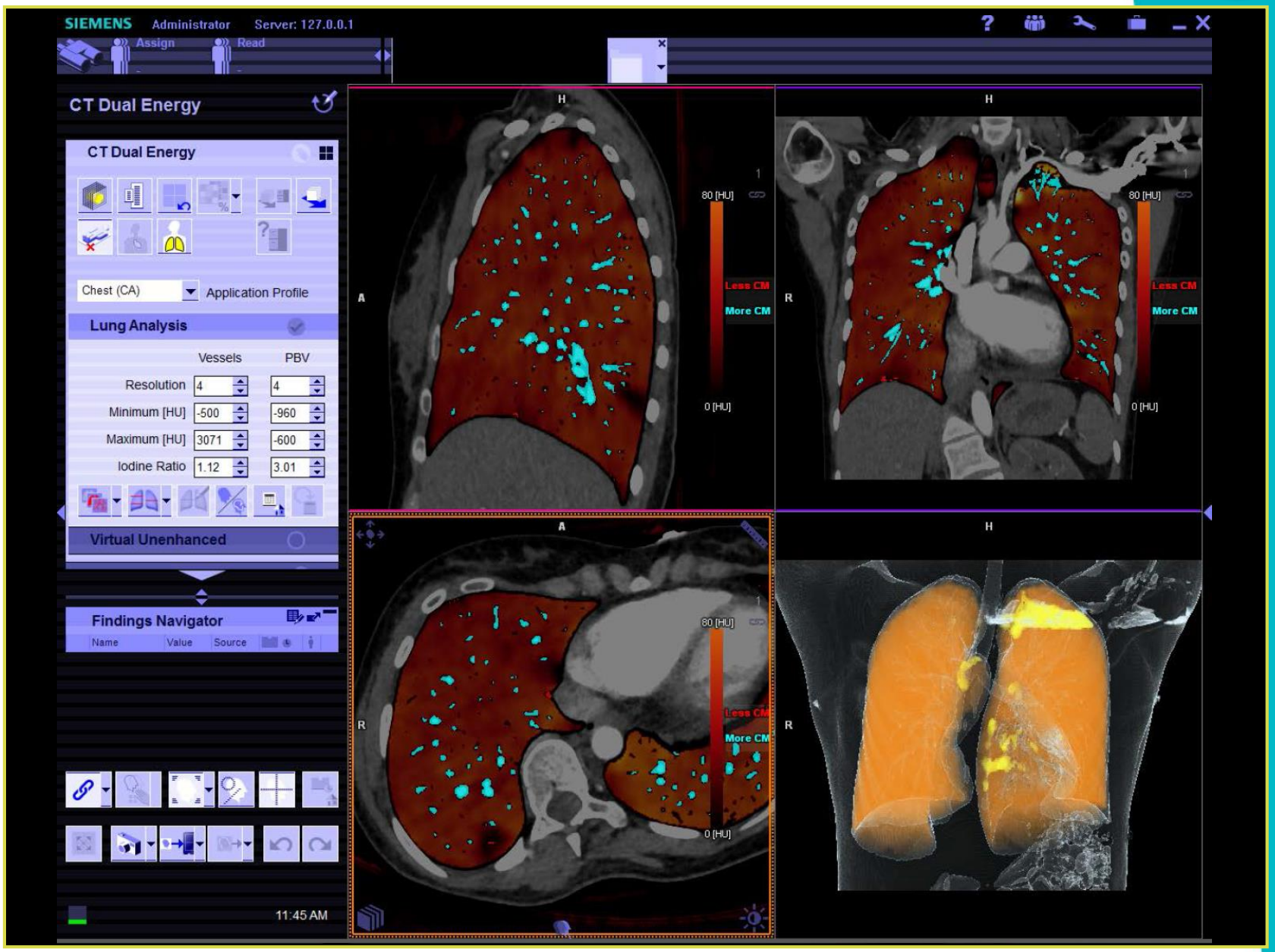
Lung embolism



Lung embolism



Lung embolism



Conclusion

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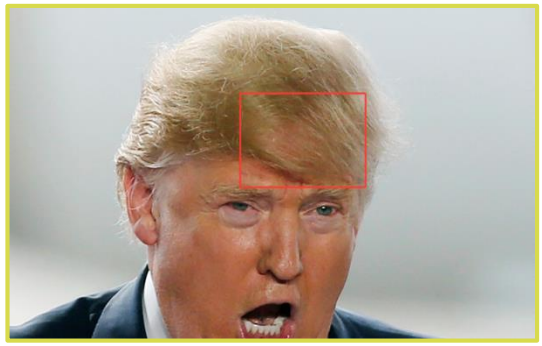
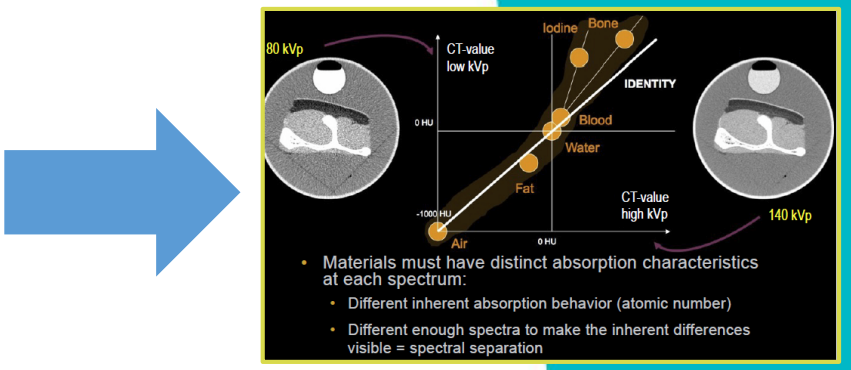
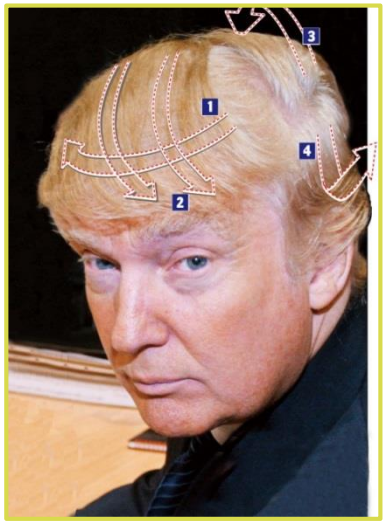
Real?




80 kVp
CT-value low kVp
Iodine
Bone
IDENTITY
0 HU
Blood
Water
Fat
-1000 HU
Air
0 HU
CT-value high kVp
140 kVp
• Materials must have distinct absorption characteristics at each spectrum:
• Different inherent absorption behavior (atomic number)
• Different enough spectra to make the inherent differences visible = spectral separation


1
2
3
4

Dank u voor uw aandacht

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