

Clinical and Pre-clinical applications spectral x-ray detectors



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Disclosure

MARS Bioimaging Ltd has been granted exclusive rights to commercialise Medipix3 technology in the field of small animal and human computed tomography

Overview

- Goal
- Significance
 - Improved use of radiographic pharmaceuticals
 - Improved intrinsic tissue contrast
- Method
 - People
 - Medipix3
 - MARS scanner
 - Challenges in extending to human CT

Goal

Improved diagnostic accuracy of medical x-ray systems by using spectral x-ray detectors

X-ray Detector
Technology



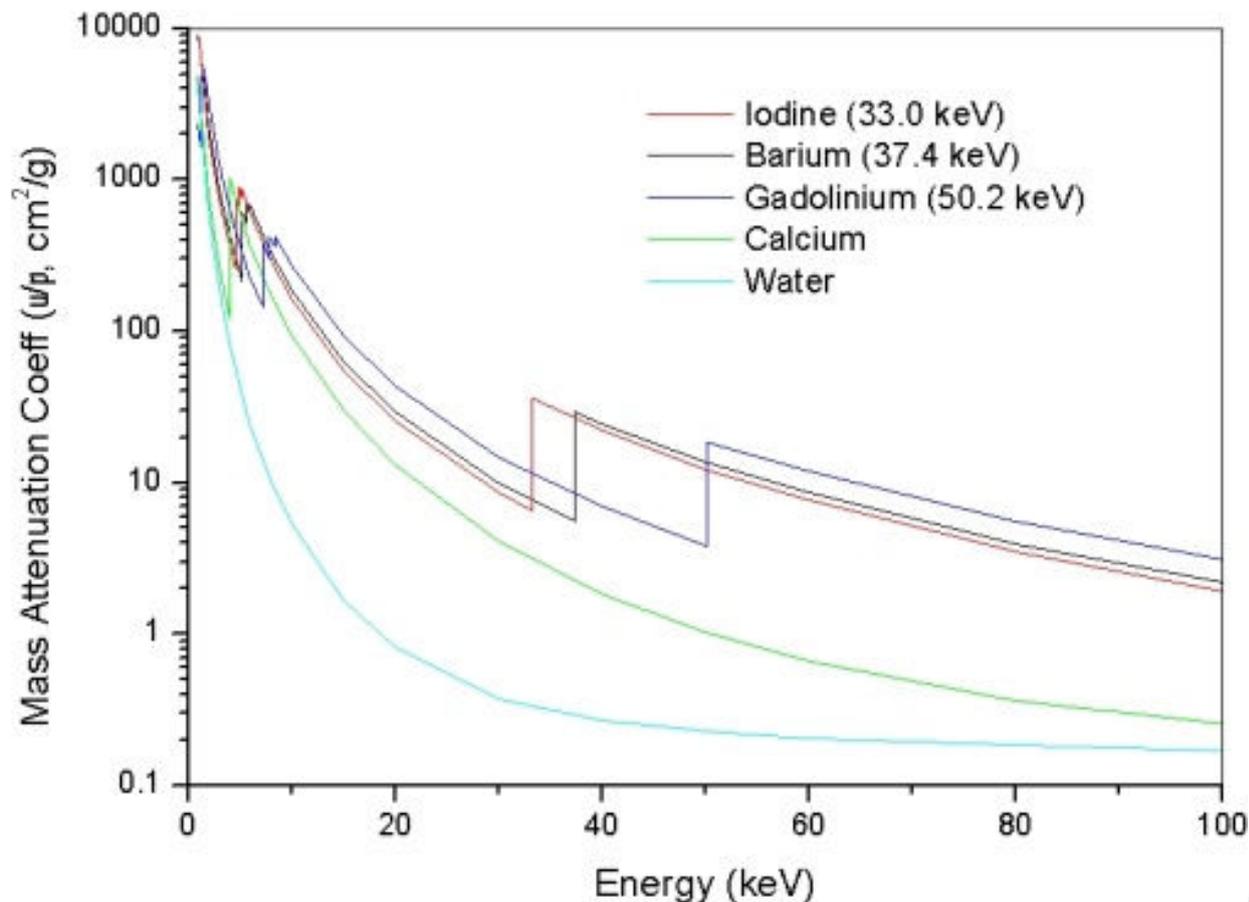
Clinical
Application

We are bridging this gap

Spectral x-ray systems

Goal: “Measure the curve”

Traditional x-ray: “Area under the curve”

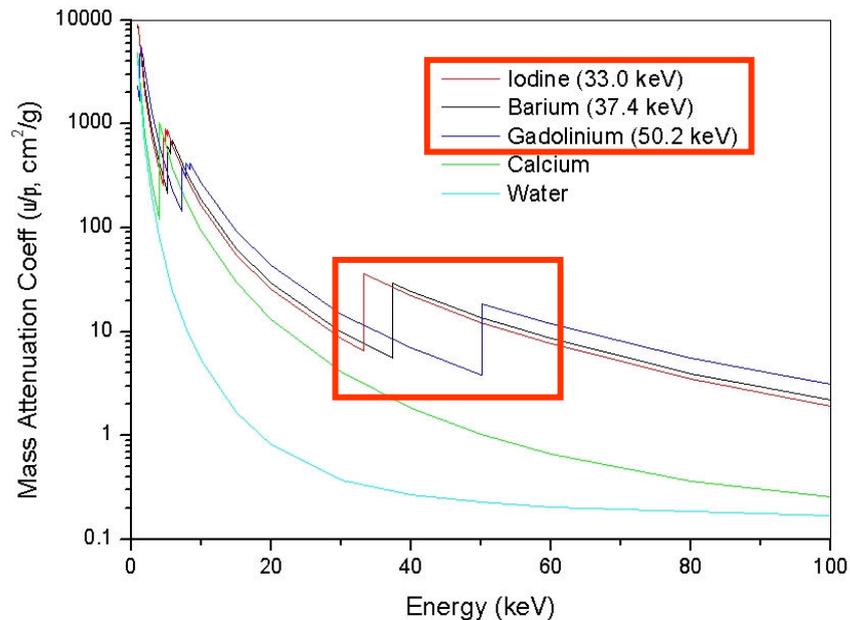


Significance

Radiographic pharmaceuticals

Pharmaceuticals often have heavy elements

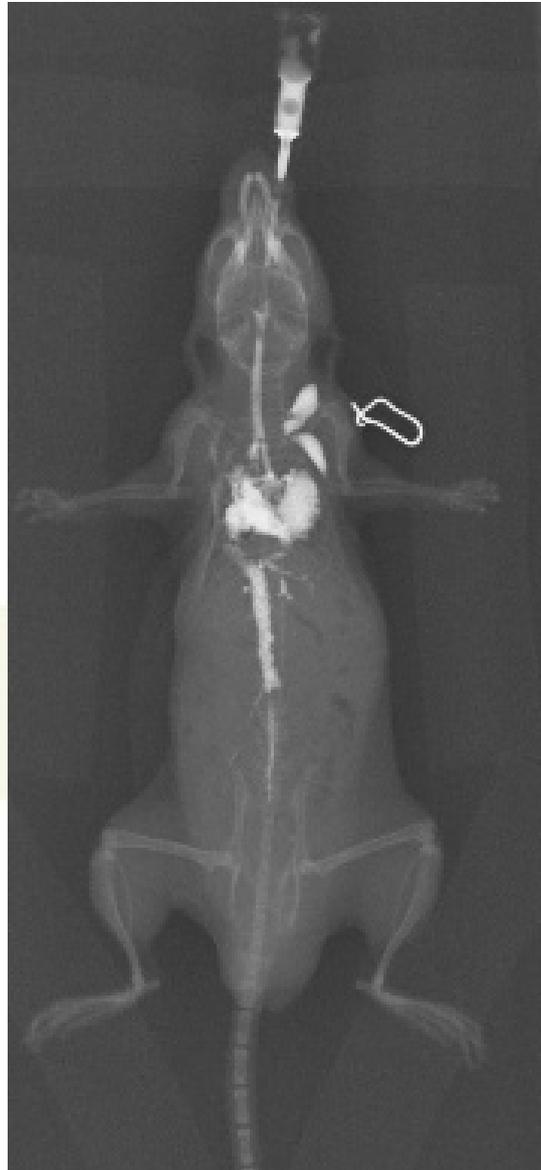
(K-edge in diagnostic range)



Better diagnosis because

- can use in combination
- can have new pharmaceuticals

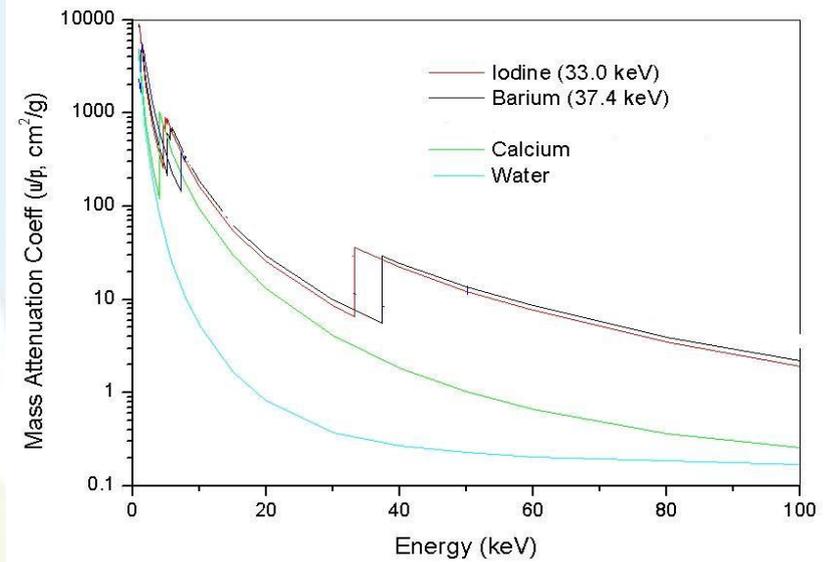
Multiple pharmaceuticals



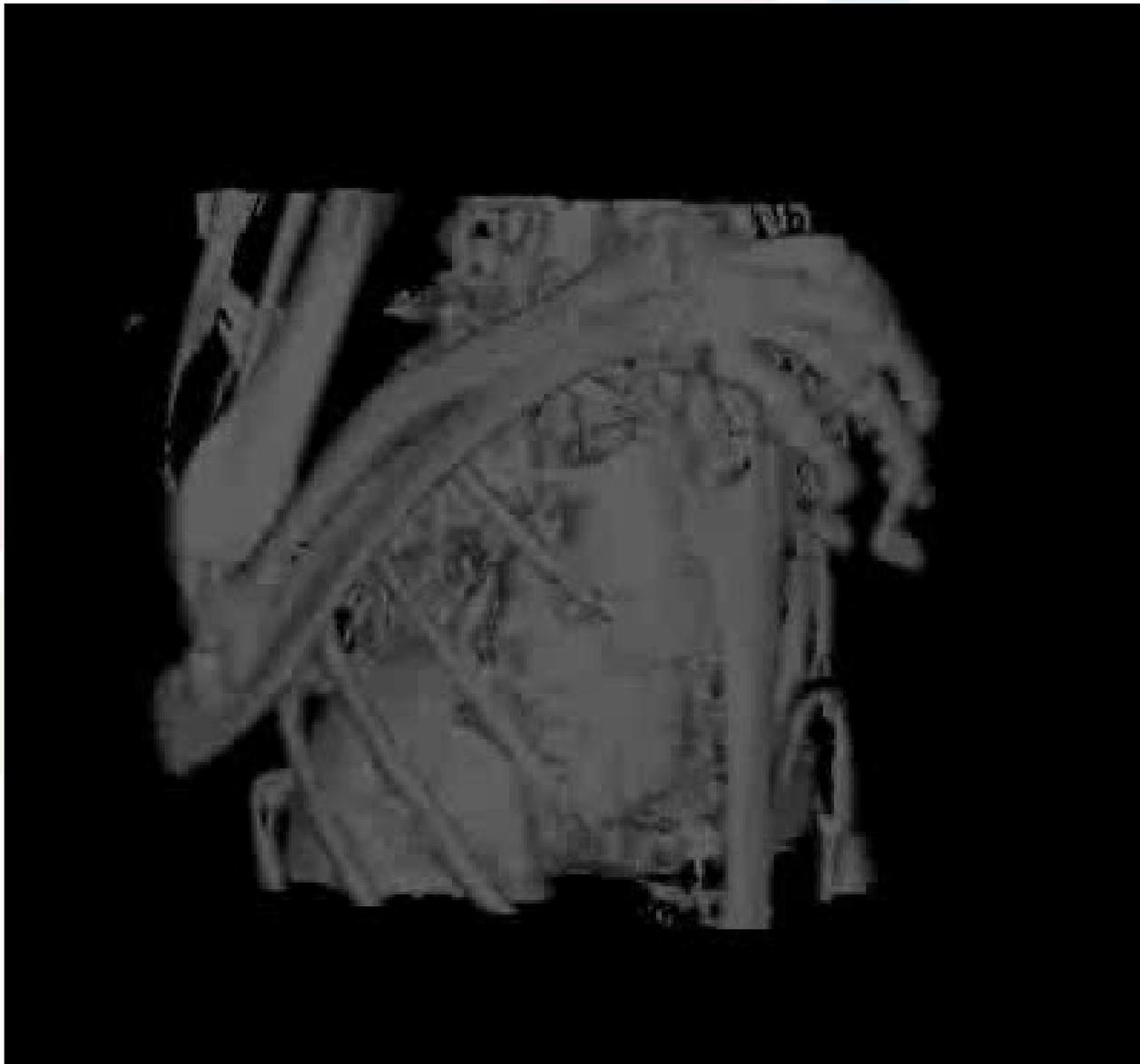
Iodine: Pulmonary circulation

Barium: Lung

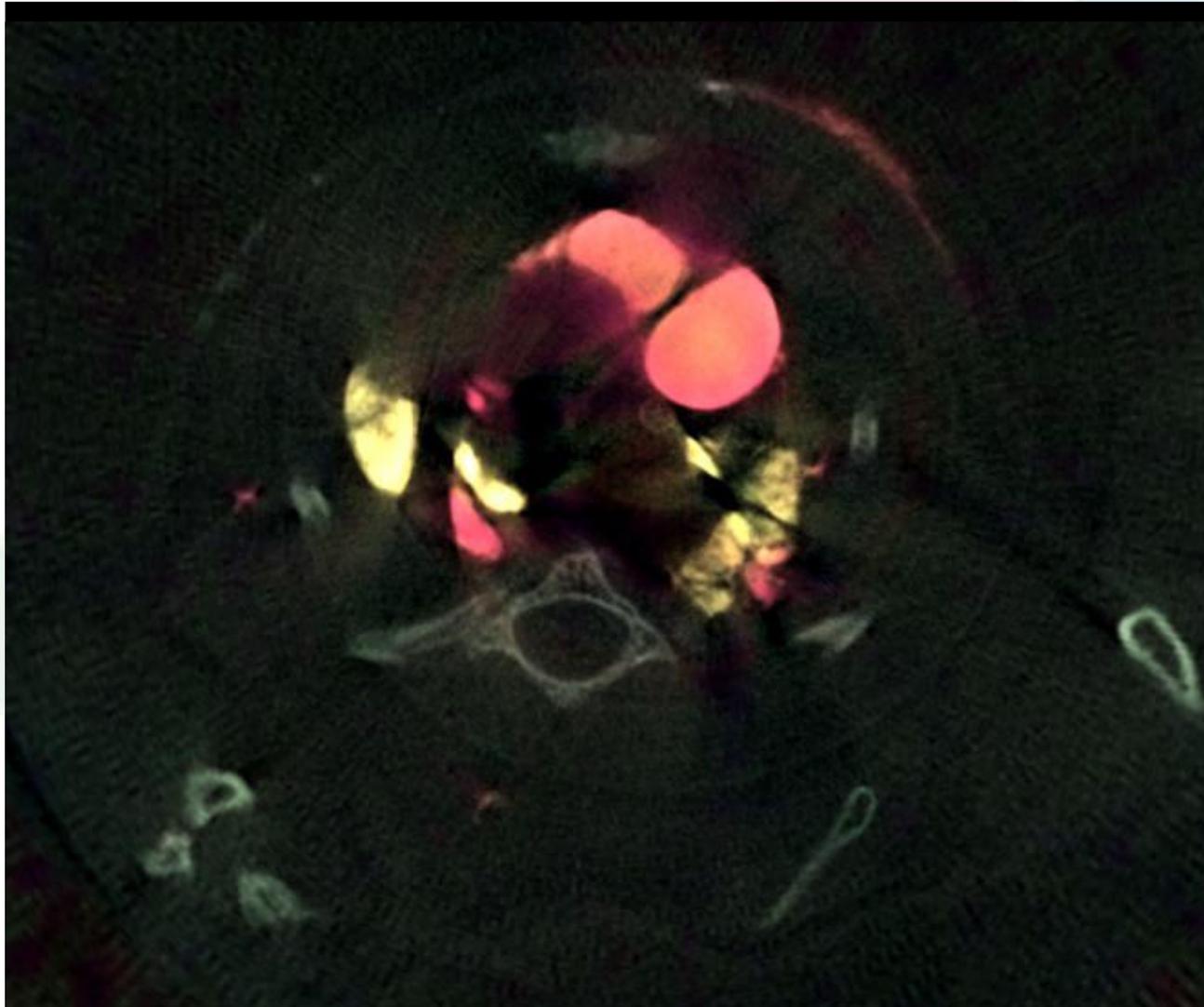
Calcium: normal bone



Traditional “broad spectrum” CT



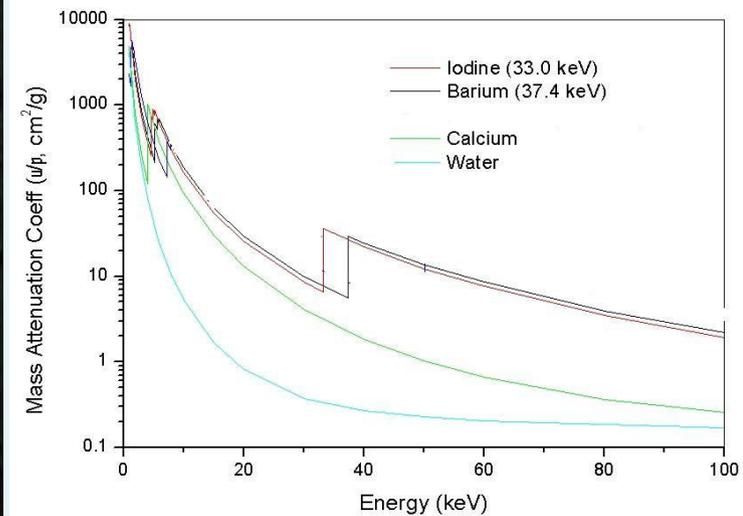
Pharmaceuticals identified by spectral information



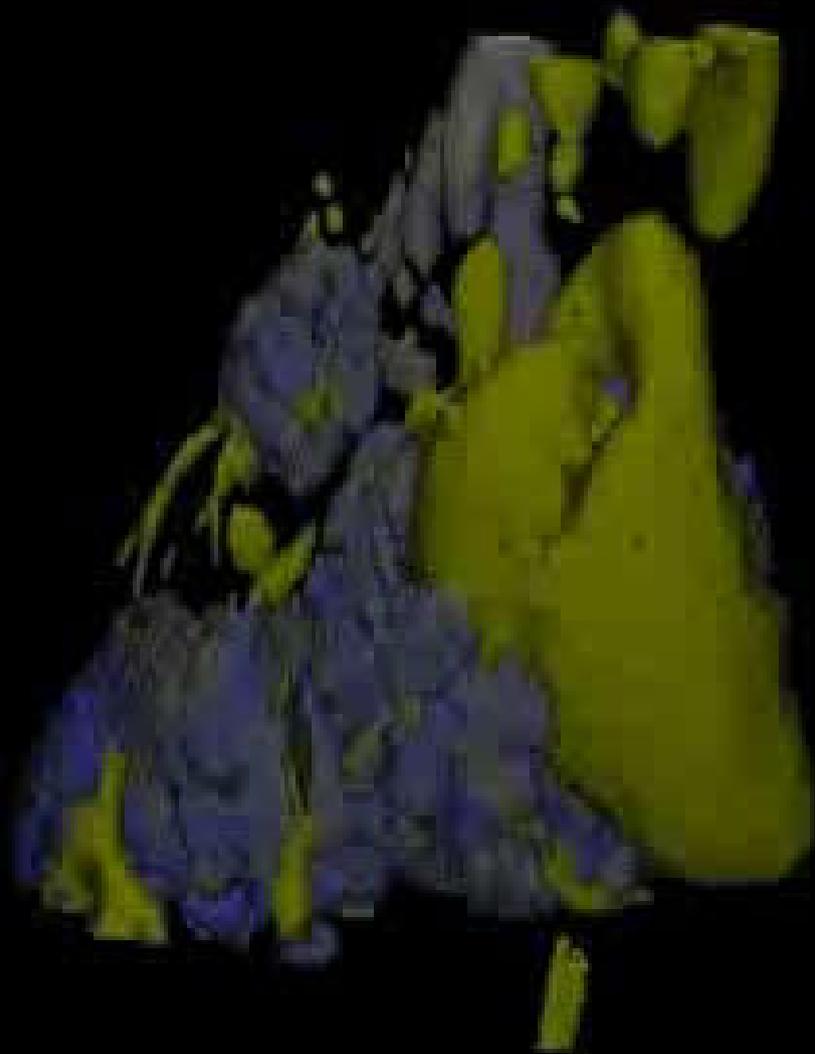
Iodine: Pulmonary circulation

Barium: Lung

Calcium: normal bone



Quantative system developed by Universität Erlangen–Nürnberg



Multiple pharmaceuticals

Pre-clinical applications:

Simultaneous :

- Metabolic marker of myocardial viability (K^+ / Rb^+)
- Routine vascular contrast agents (eg iodine)

Rubidium (k-edge 15 keV)

→ K^+ analogue

Iodine (k-edge 33 keV)

→ Vascular pool

19	20
K	Ca
37	38
Rb	Sr
55	56
Cs	Ba
87	88
Fr	Ra



Work in partnership with Mayo Clinic

Multiple pharmaceuticals

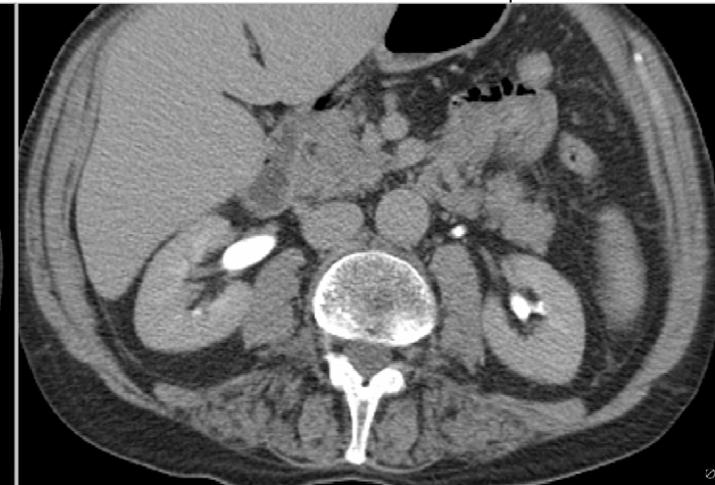
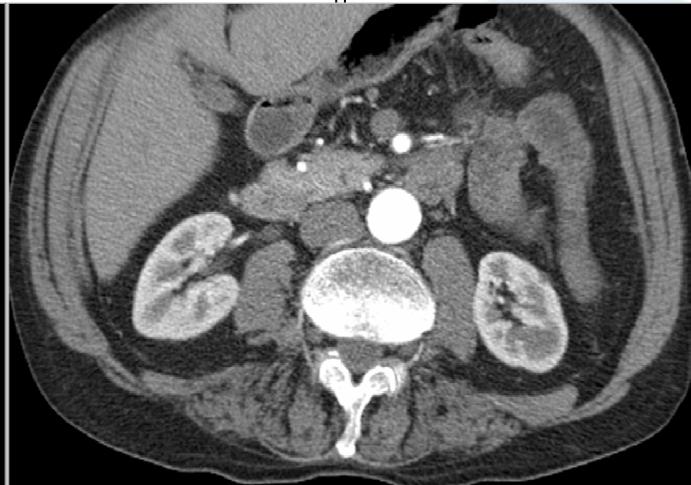
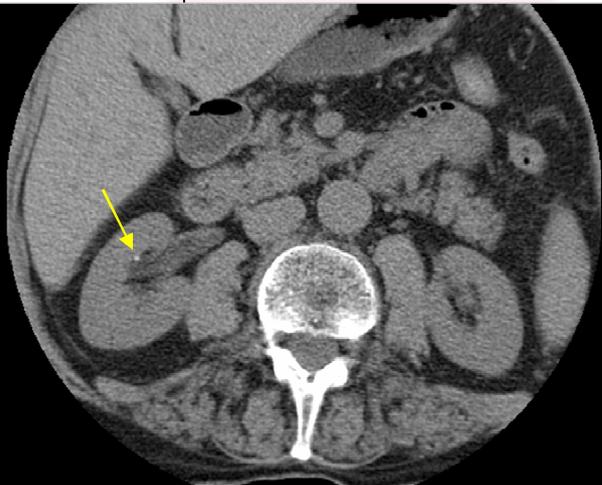
Clinical applications:

- **CT**

- Non-contrast scan
- Contrast scan
- Delayed scan

- **Spectral-CT**

- Contrast₁ outside room
- Contrast₂ on scanner
- Scan

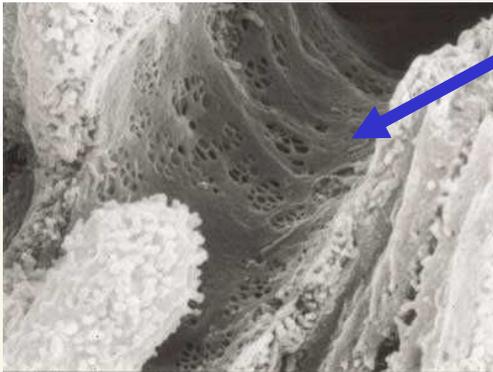


- **3 scans**
- Twice on table

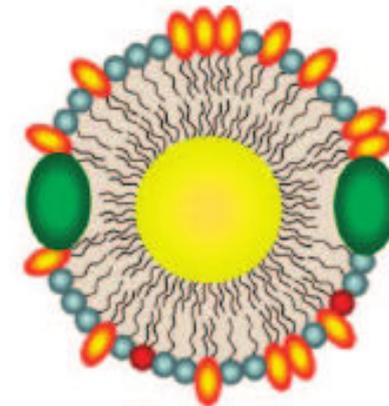
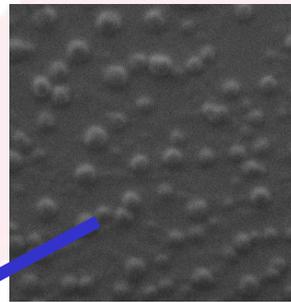
- **1 scan**
- Once on table

New pharmaceuticals

Functional agents: eg. nano-particles



Liver sieve porosity with
labelled lipid spheres



Au-HDL

HDL labelling
(*Memorial Sloan Kettering
Cancer Centre*)

Improved soft tissue contrast

Aim to distinguish intrinsic materials in the body

eg. Ca vs. Fe

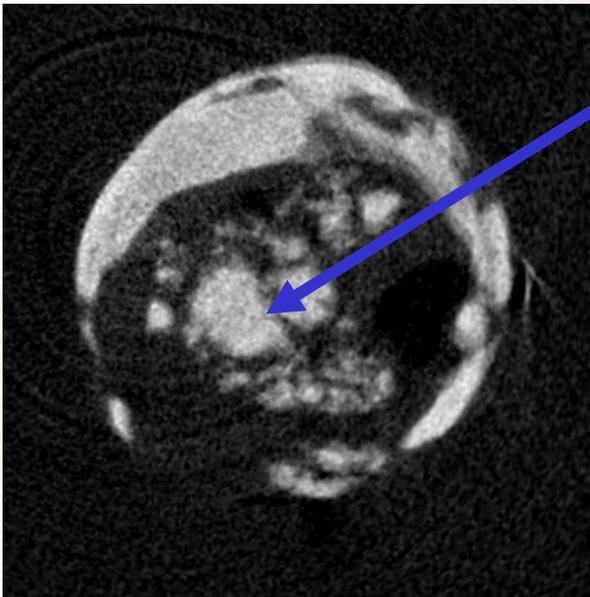
Often “just doable” with dual energy systems but,

- Optimum energy varies for each material
- Dual energy systems have high noise

Work in partnership with Mayo Clinic

Improved soft tissue contrast

Aim to distinguish intrinsic materials in the body



Ca or Fe?

- Atheroma plaque stability
- Important for vascular imaging

Work in partnership with Mayo Clinic

Method

People: Medipix 2/3 Collaborations

Transferring photon counting technology to medicine

18+ institutes for 15+ years



Lead designer: Michael Campbell, CERN



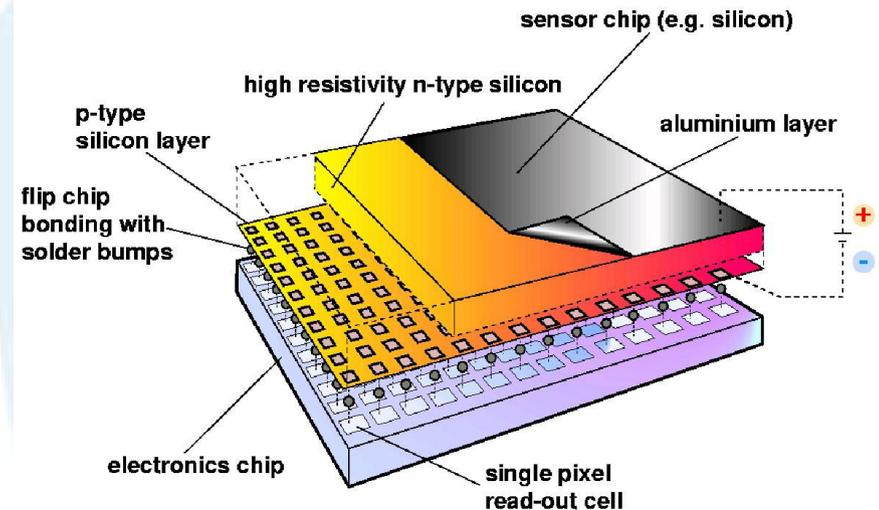
Medipix3

8 Simultaneous energies

55 μm isometric resolution

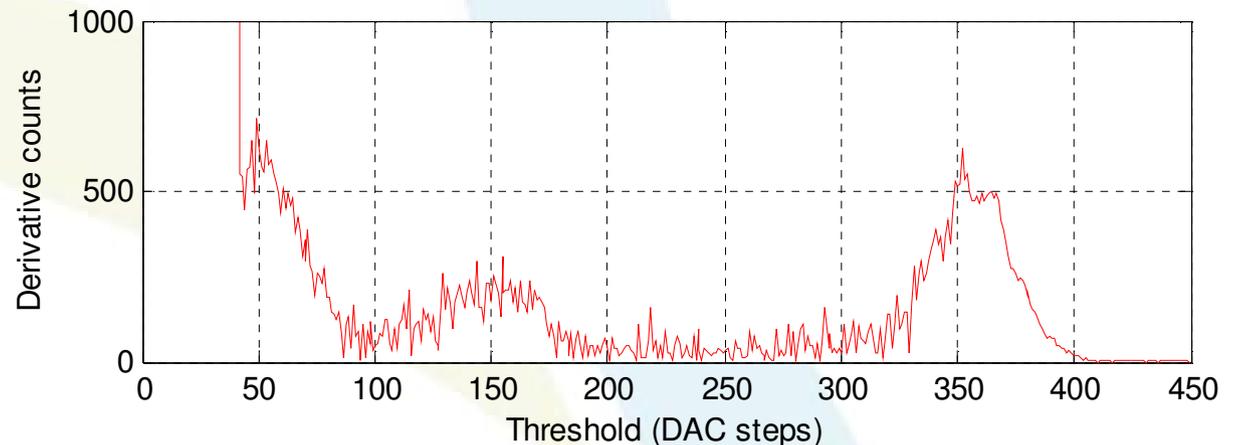
Excellent energy resolution

10^8 photons per second per mm^2
(approx)

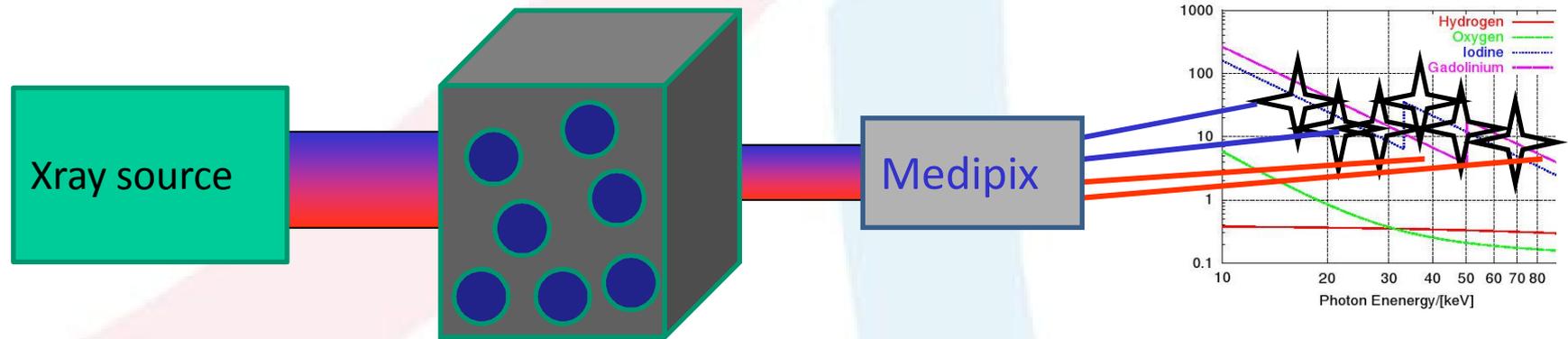


^{241}Am source

keV	Intensity
13.9	0.42
26.34	0.024
33.19	0.00126
59.54	0.359



Medipix All Resolution System

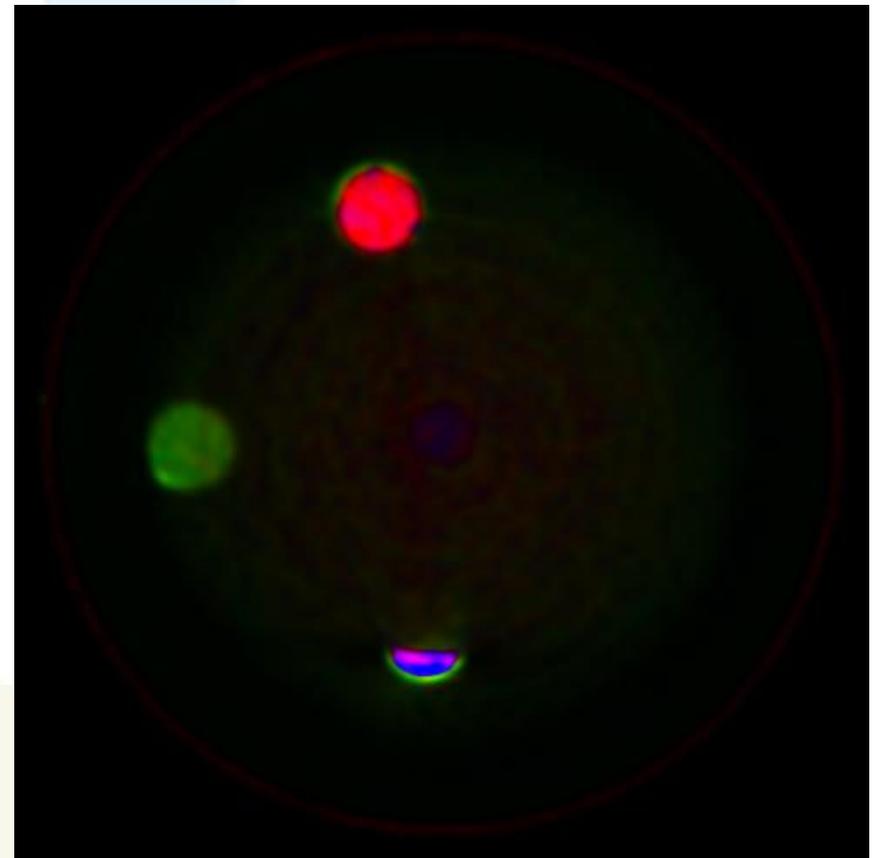
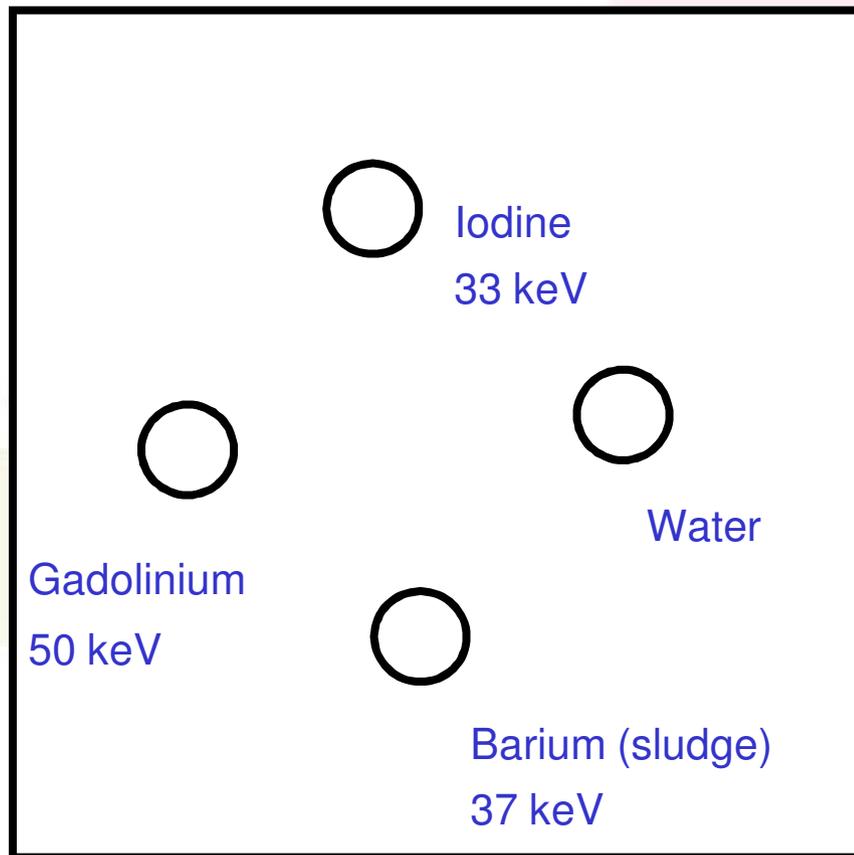


Energy resolution
Spatial resolution
Temporal resolution



Medipix3 works in energy range suitable for humans imaging

CdTe sensor efficient up to 100 keV x-rays

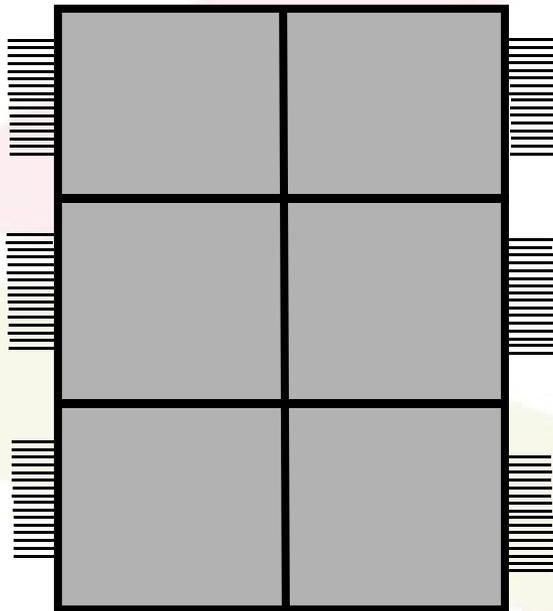


3 pharmaceuticals perspex phantom

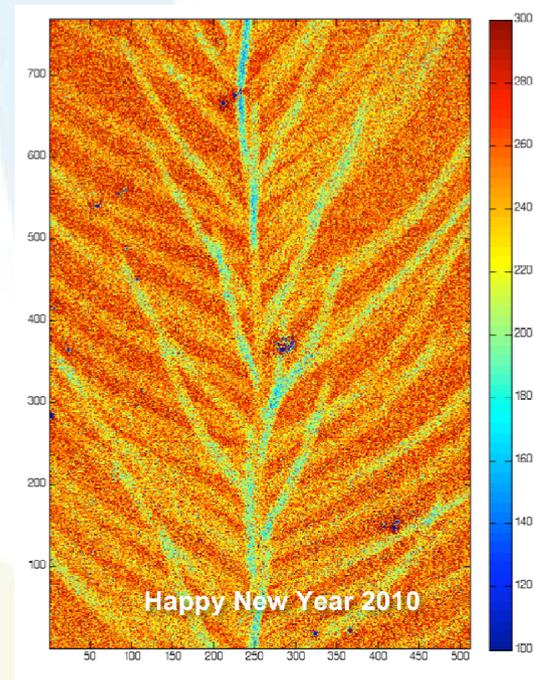
Medipix tileable for human CT

Can do “2 x N” arrays

eg. 100cm x 28mm for human CT



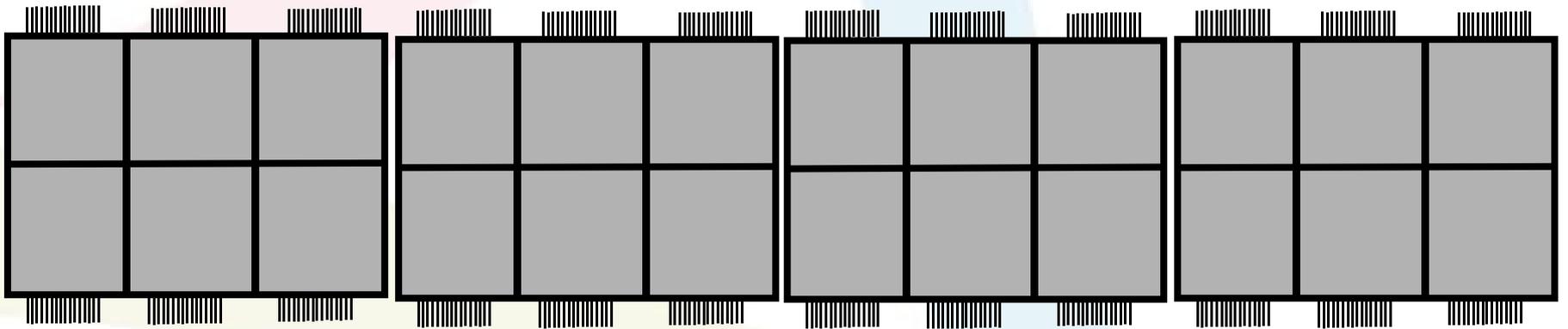
Basic unit 2x3 CdTe array



Medipix tileable for human CT

Can do “2 x N” arrays

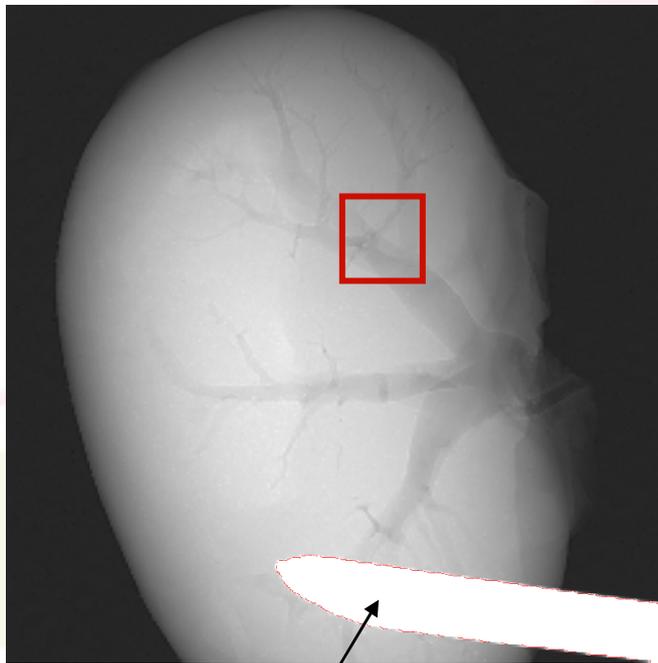
eg. 100cm x 28mm for human CT



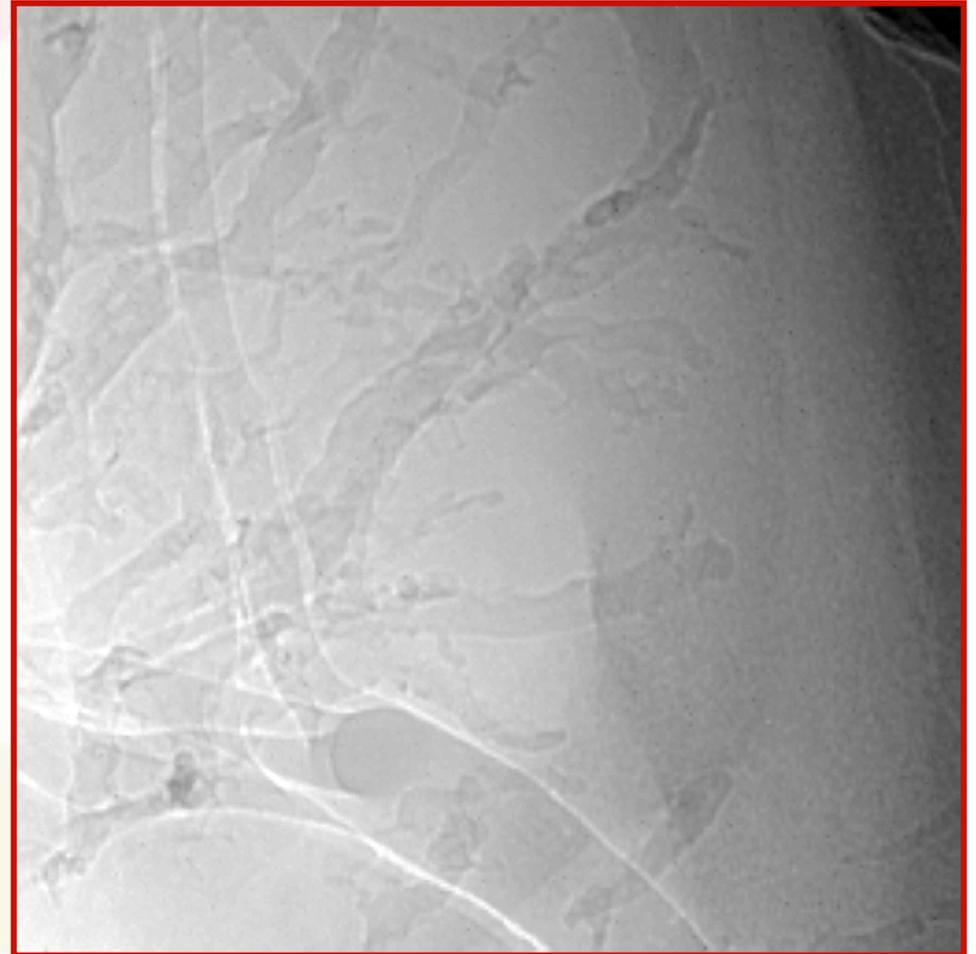
Basic unit 2x3 CdTe array

Medipix enables phase contrast imaging

Mouse kidney



Needle holding the sample



Summary

Spectral x-ray imaging:

- Benefit for both preclinical and clinical imaging
- Medipix3 makes it possible now

Thank You

Anthony Butler¹

Michael Campbell²

Michael Fiederle³

Jan Jakubek⁴

Thilo Michel⁵

Thanks to:

Medipix2 and Medipix3
Collaborations

1 University of Canterbury

2 CERN

3 Albert-Ludwigs-Universität Freiburg

4 Czech Technical University

5 Universität Erlangen–Nürnberg