

IMBL: X-ray characteristics & general imaging



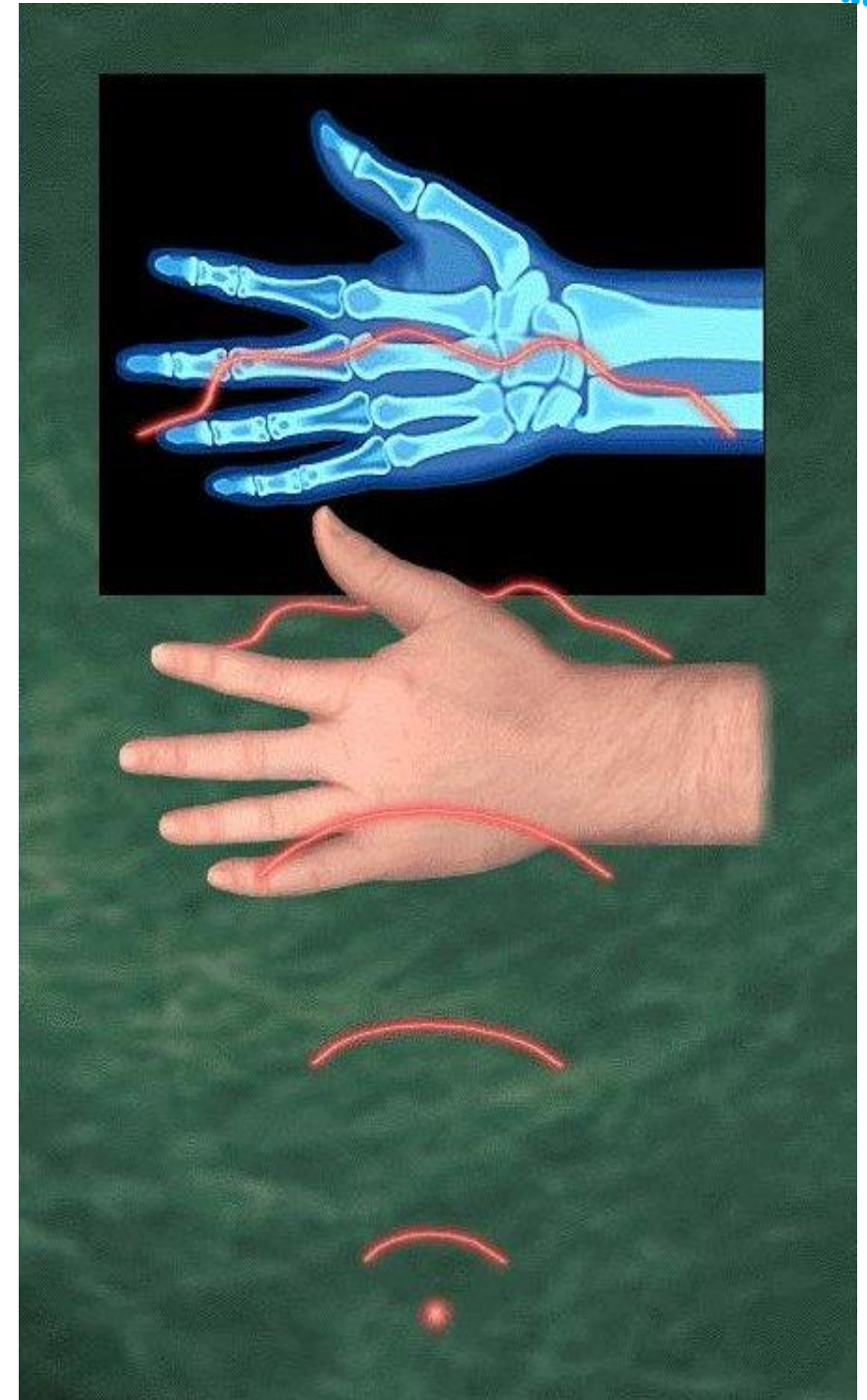
Australian Synchrotron

Andrew Stevenson
IMBL/ MCT, Australian Synchrotron
& CSIRO Manufacturing



CT@IMBL workshop – 23rd October, 2017

The “first” X-ray image

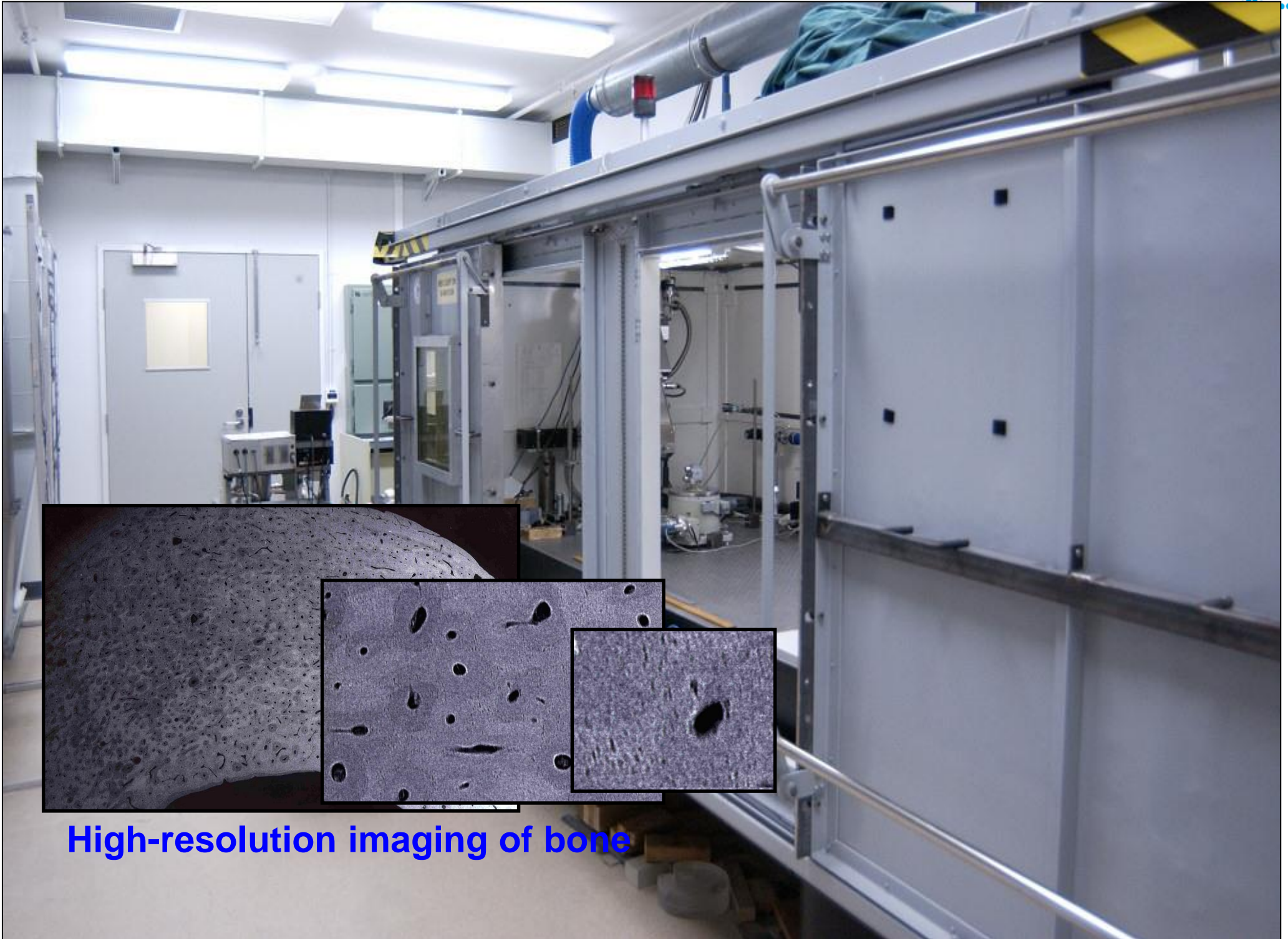


basic assumptions of conventional radiography



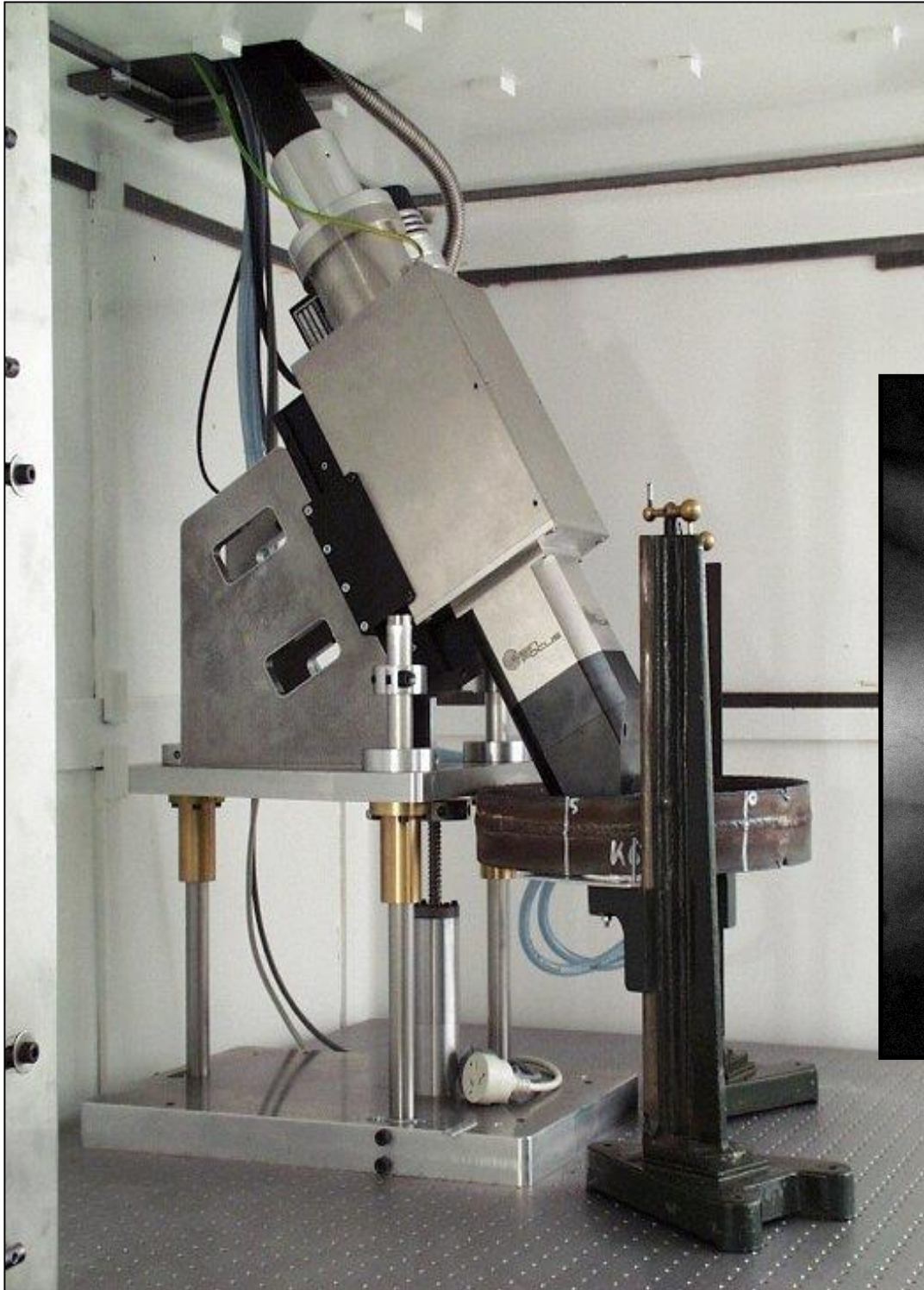
- 1. Contrast is produced purely by absorption in the object.**
- 2. Ray (or geometrical) optics is sufficient to describe image structure.**
- 3. It is not (usually) necessary to attempt to extract quantitative information from images.**

laboratory-based PCX imaging system

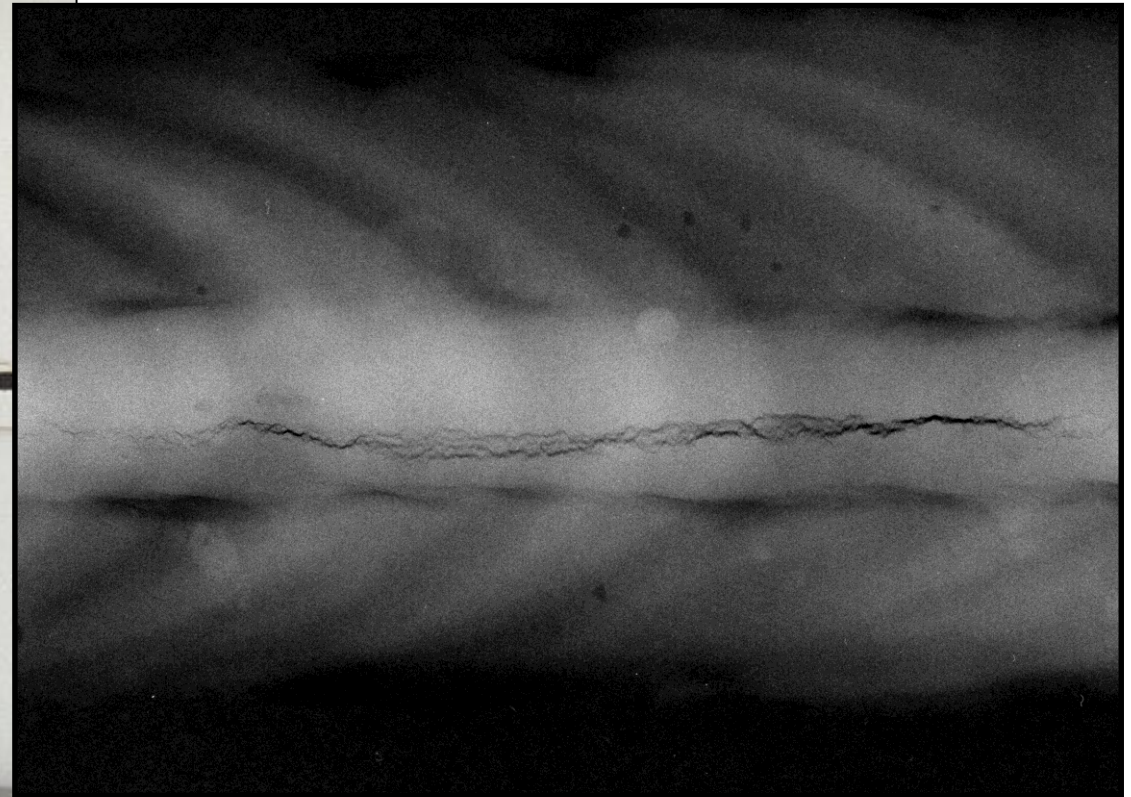


High-resolution imaging of bone

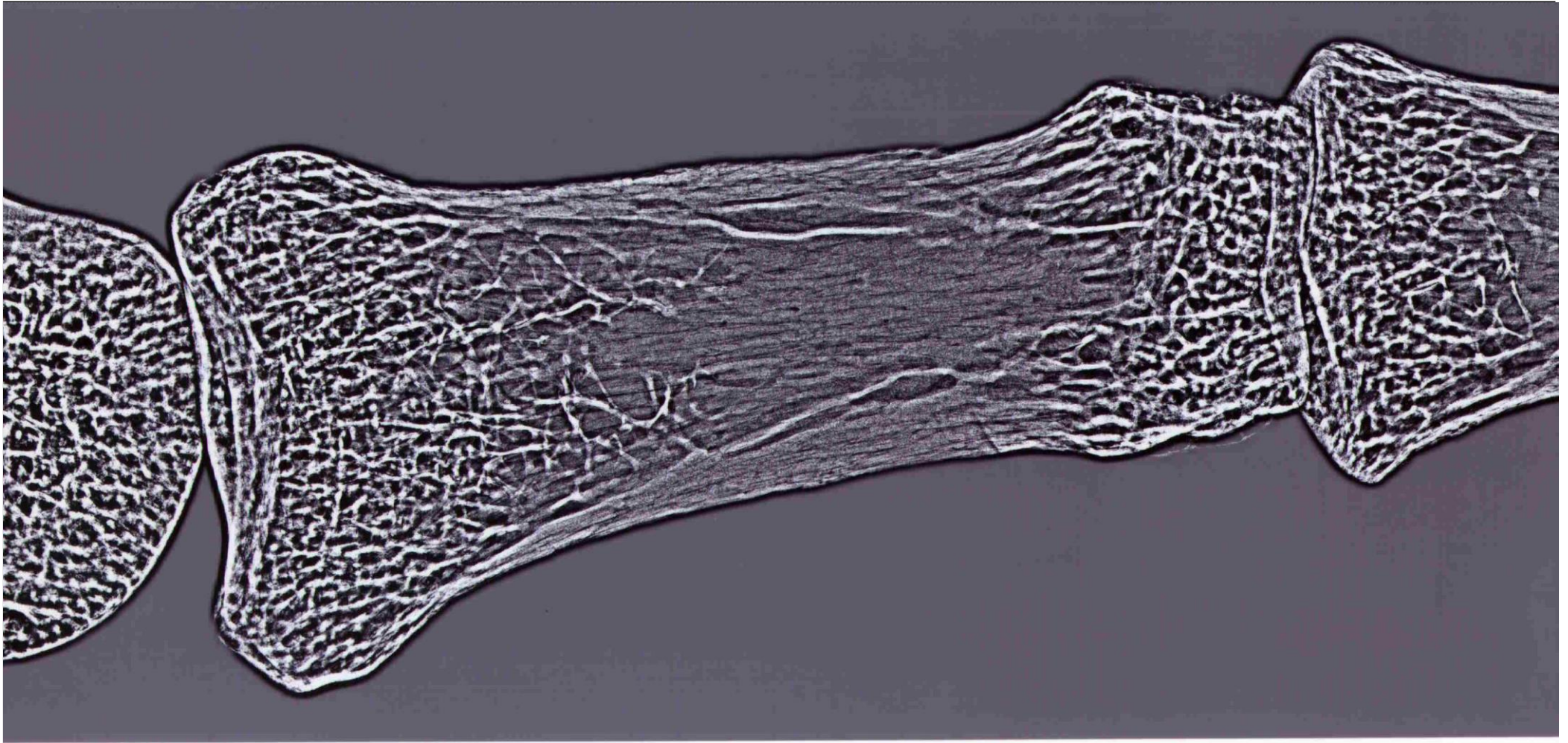
Feinfocus microfocus X-ray source - imaging and microtomography



**hot tear in girth weld for
9mm steel pressure pipe**

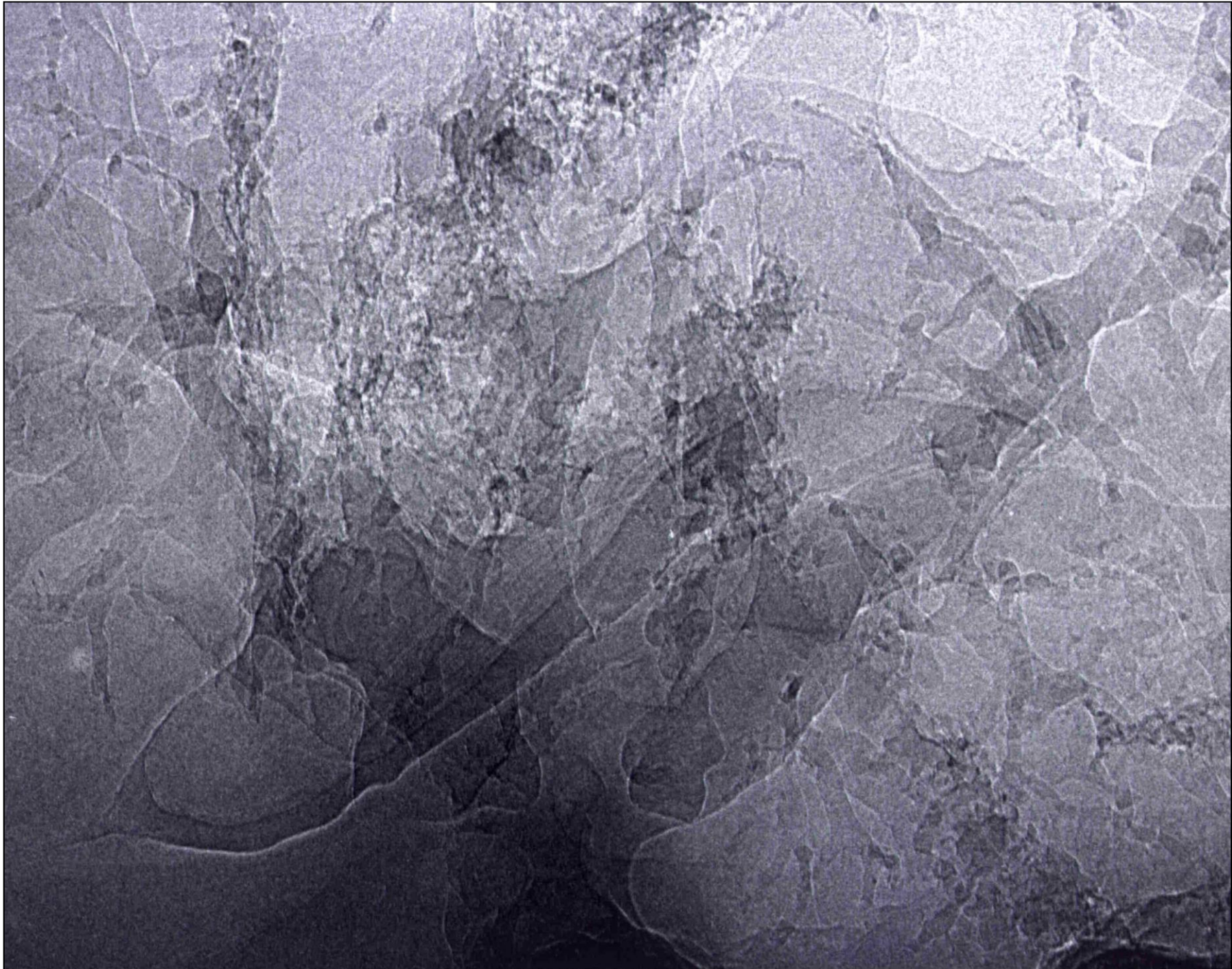


human finger (proximal phalanx)

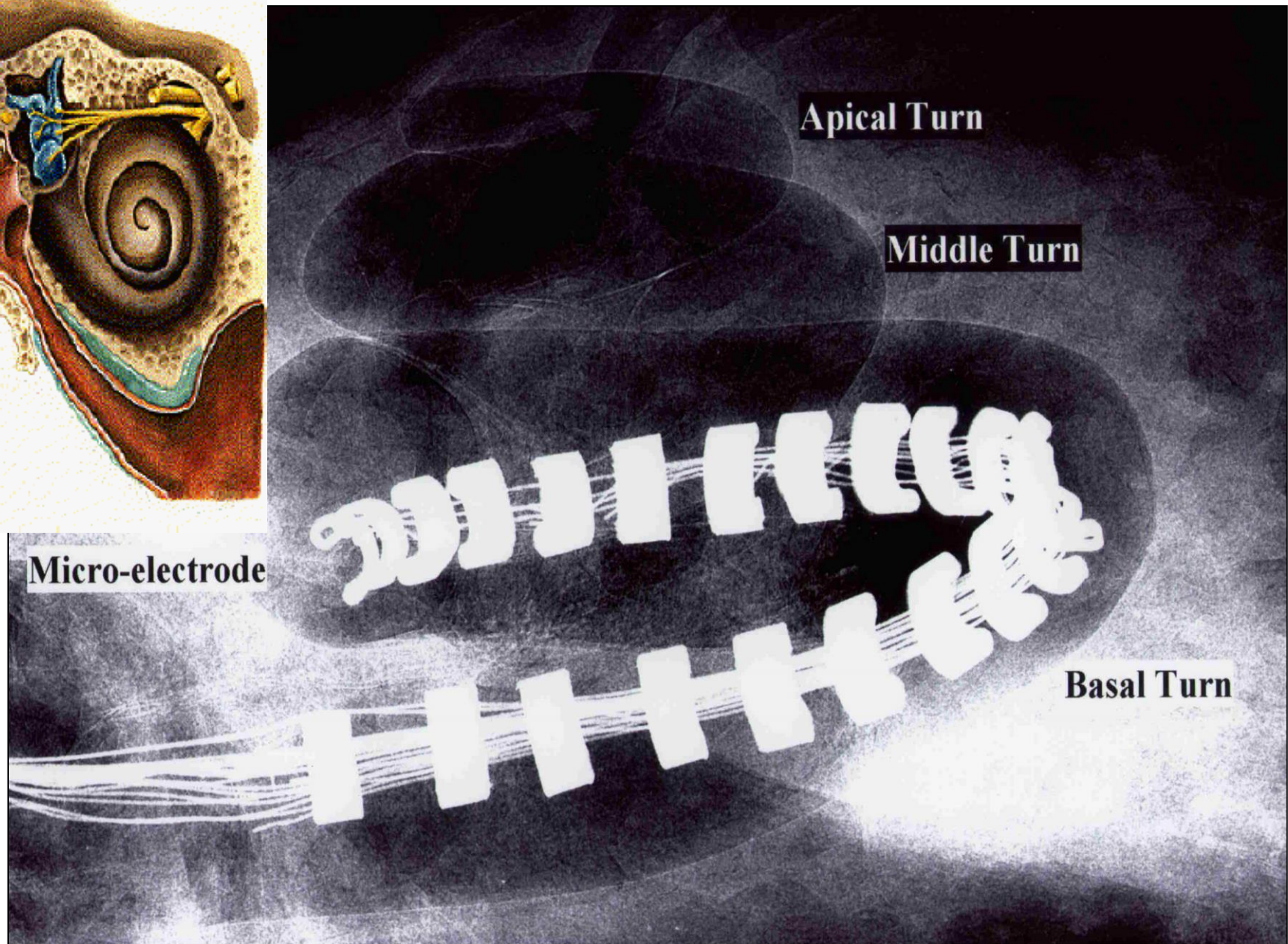
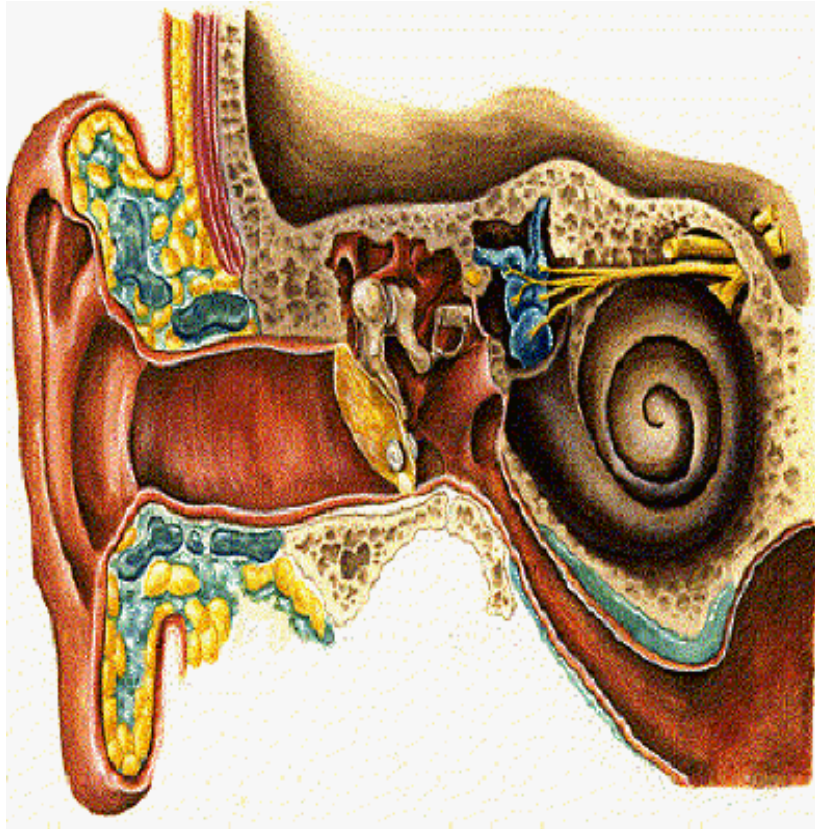


“unsharp masking”

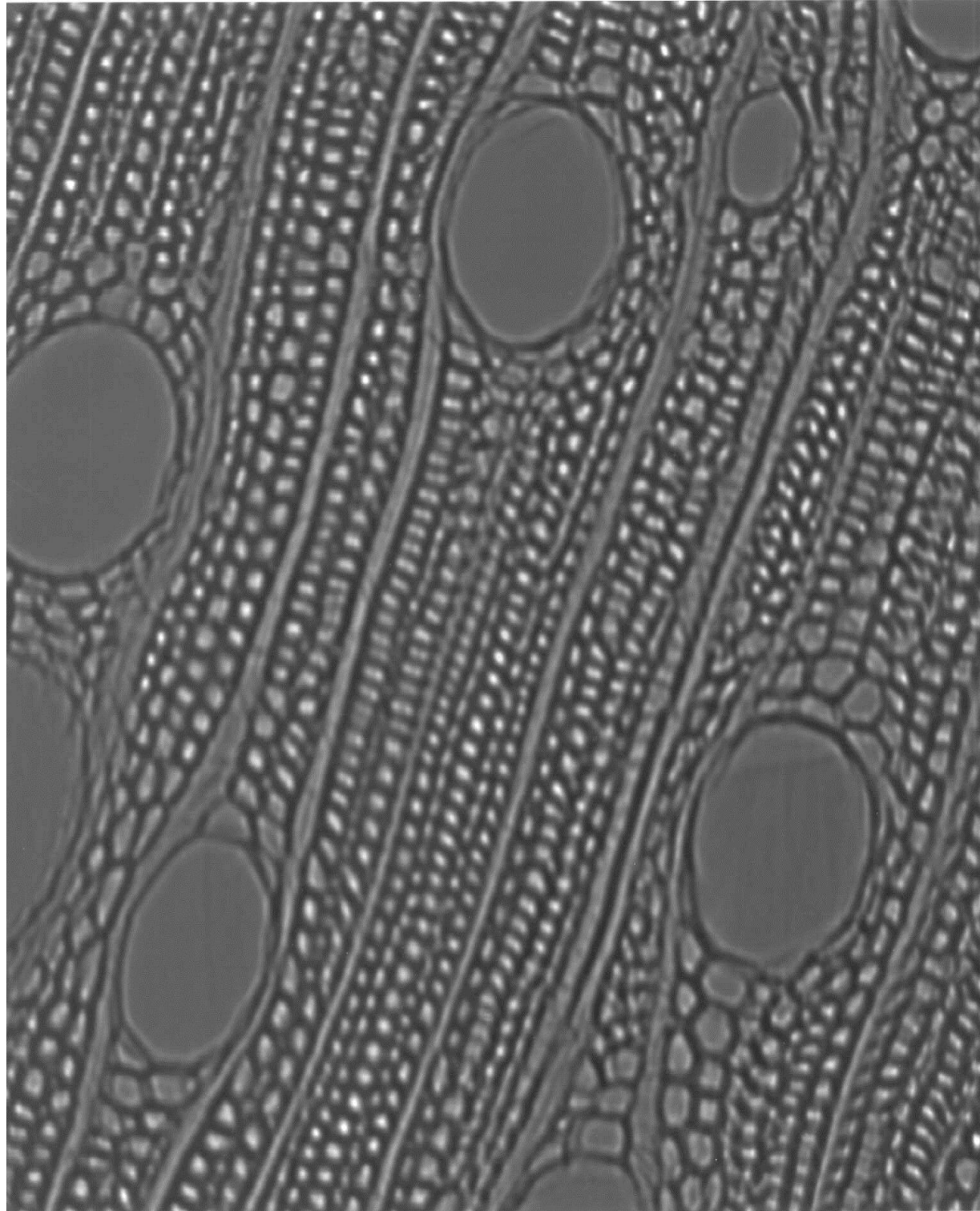
excised mouse kidney



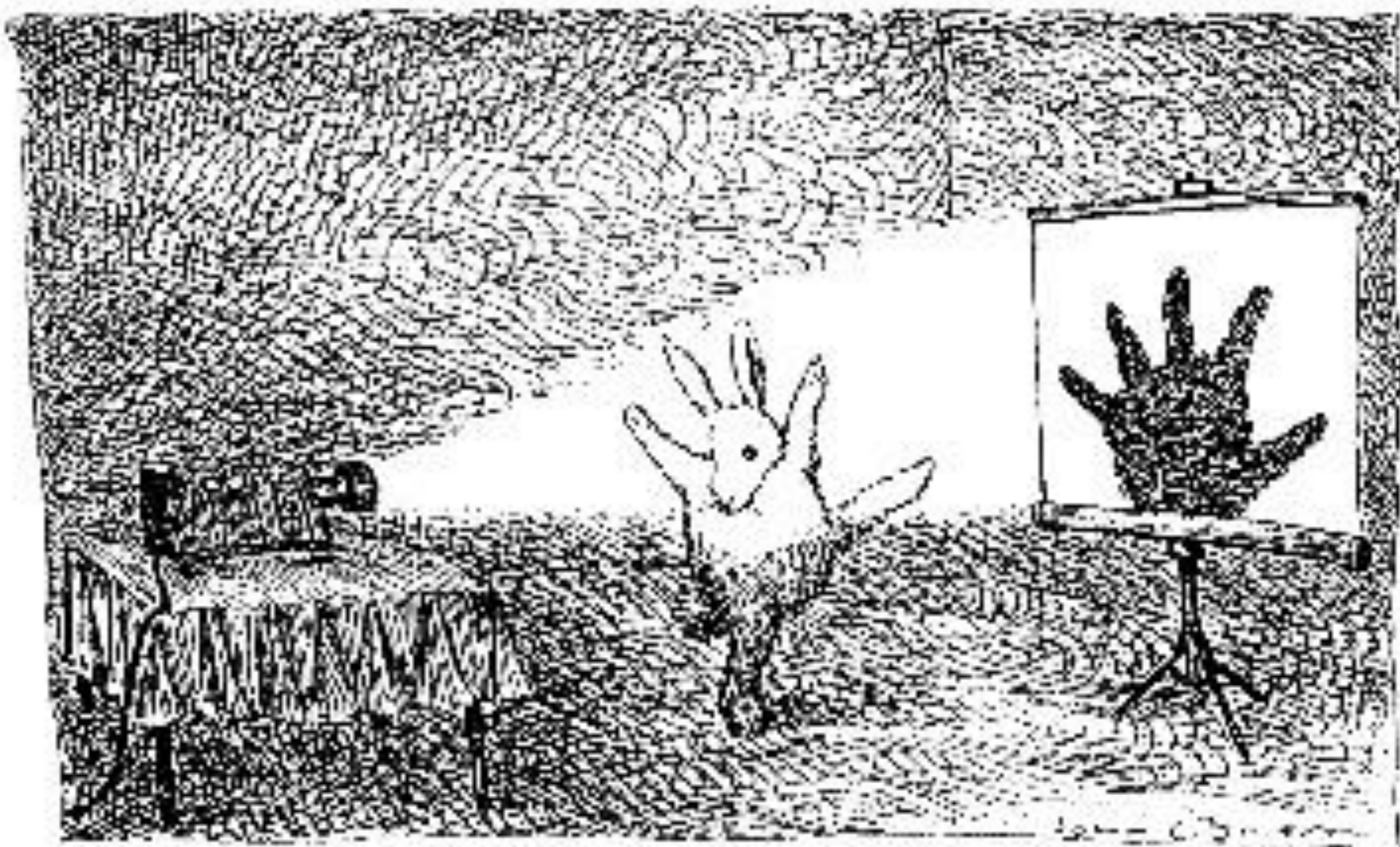
cochlear implant



thin wood cross-section



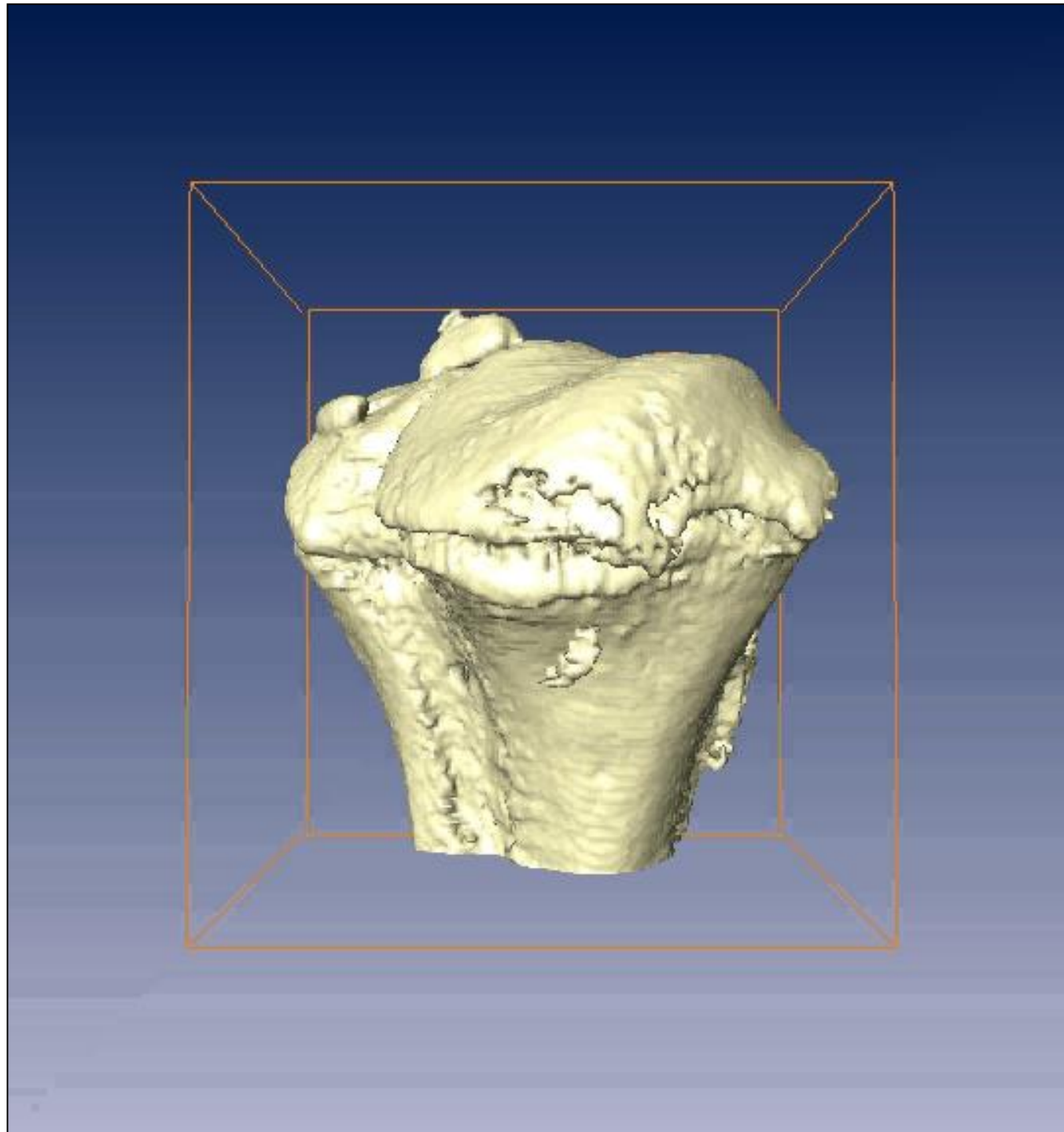
CT - motivation



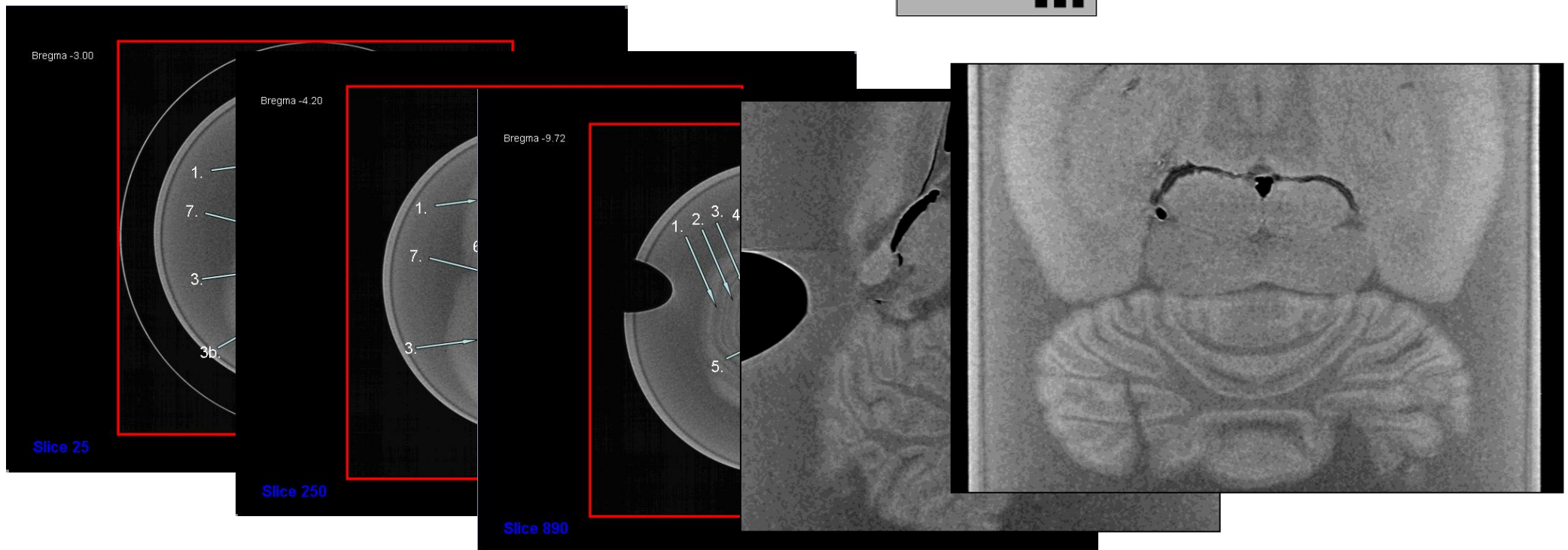
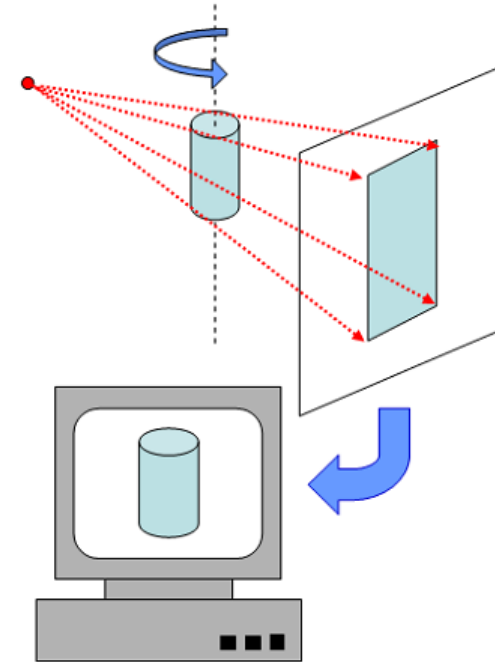
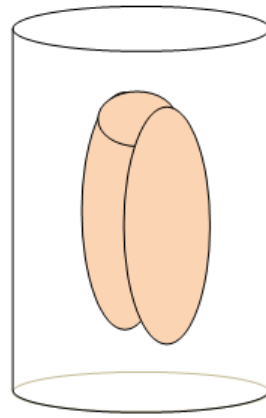
A single projection image is plainly insufficient to infer the structure of an object.

John O'Brien; © 1991 The New Yorker Magazine

mouse tibia - X-ray tomography



X-ray tomography on fixed & embedded rat brains



Imaging and Medical Beamline (IMBL)



Monash Biomedical Imaging (MBI)
– Monash/CSIRO

IMBL end station
at 140m

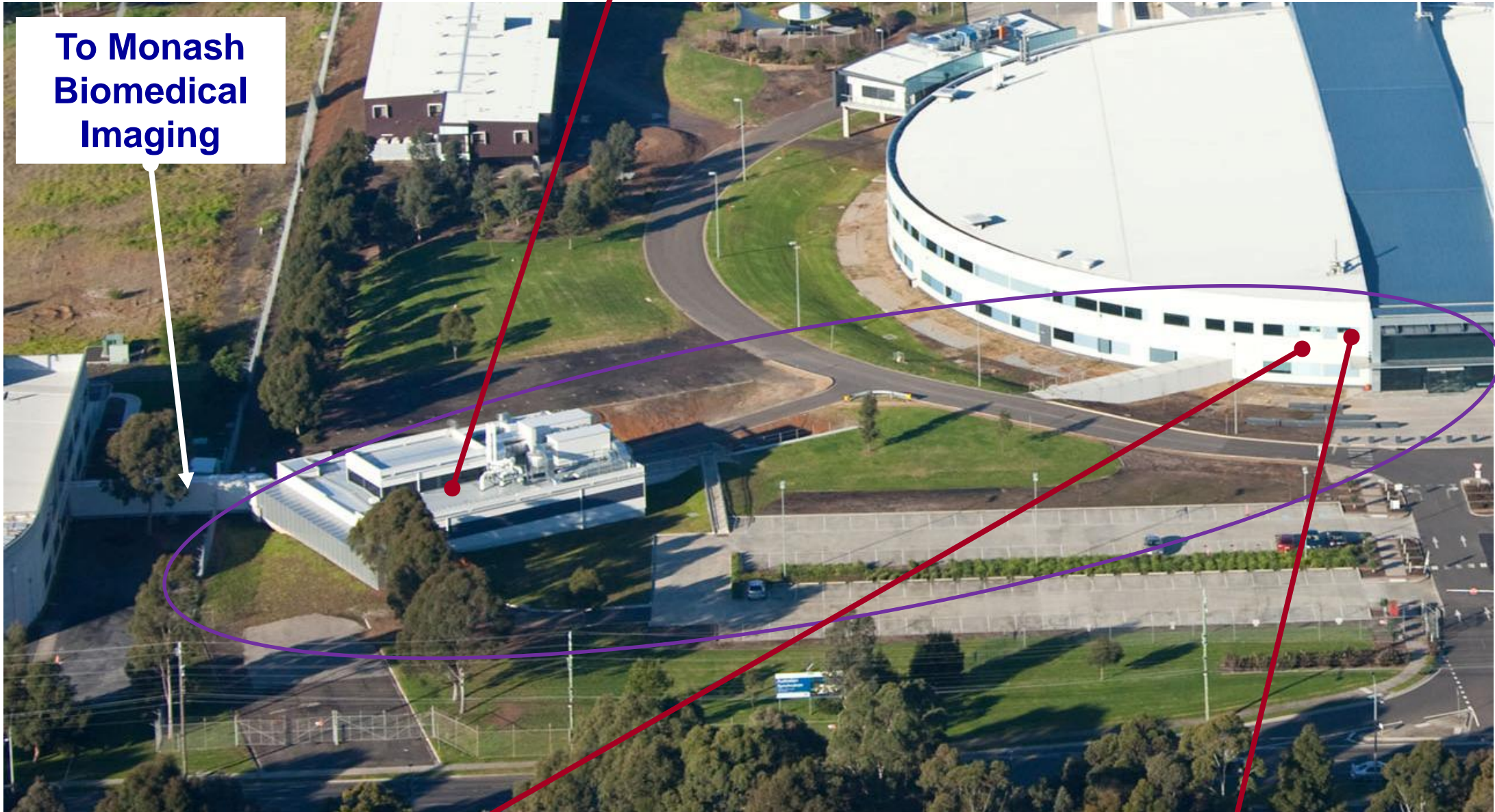
transfer tunnel



**~140m - mode 3: high-resolution
imaging (incl PCI) & (slower) CT**

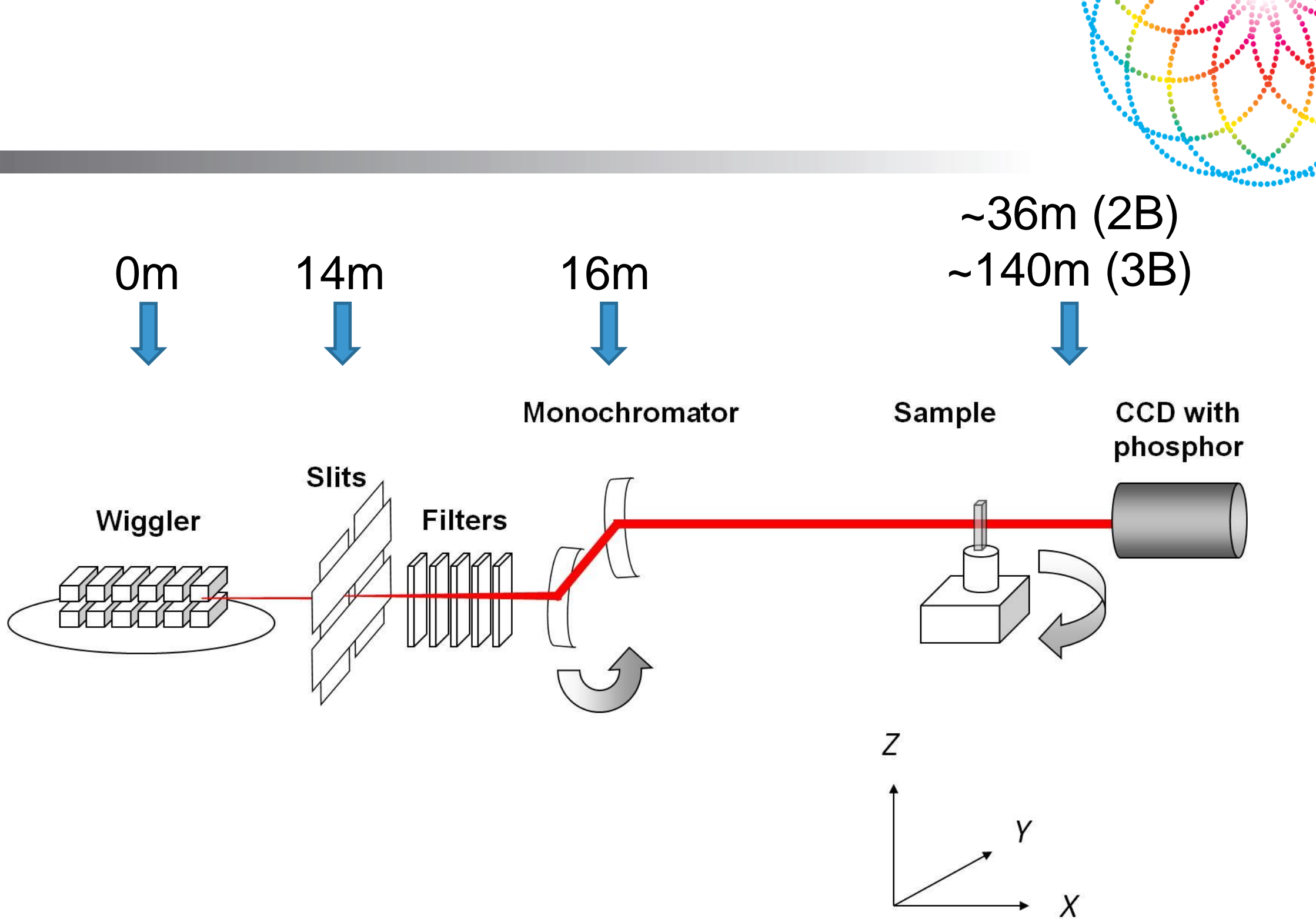


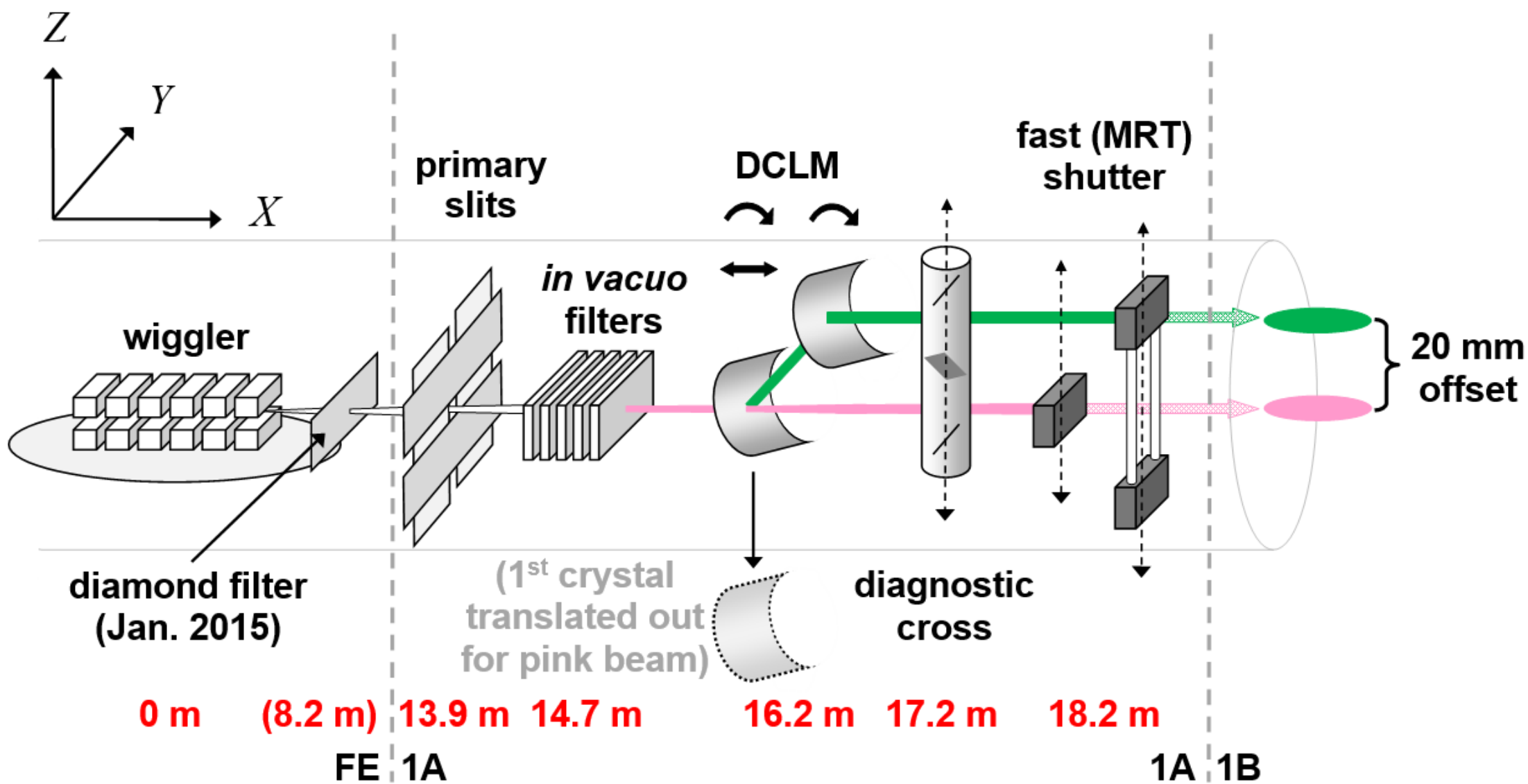
**To Monash
Biomedical
Imaging**

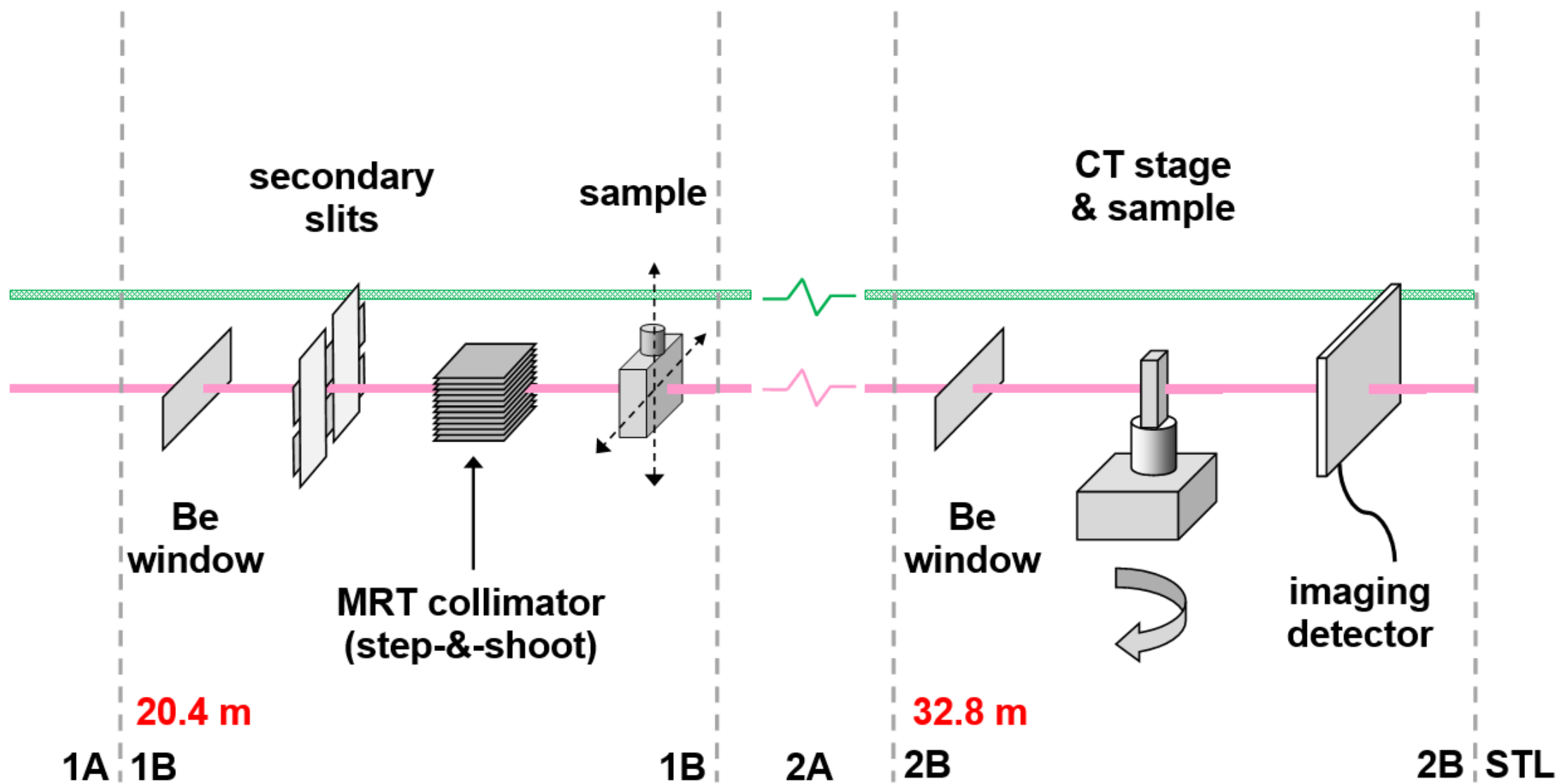


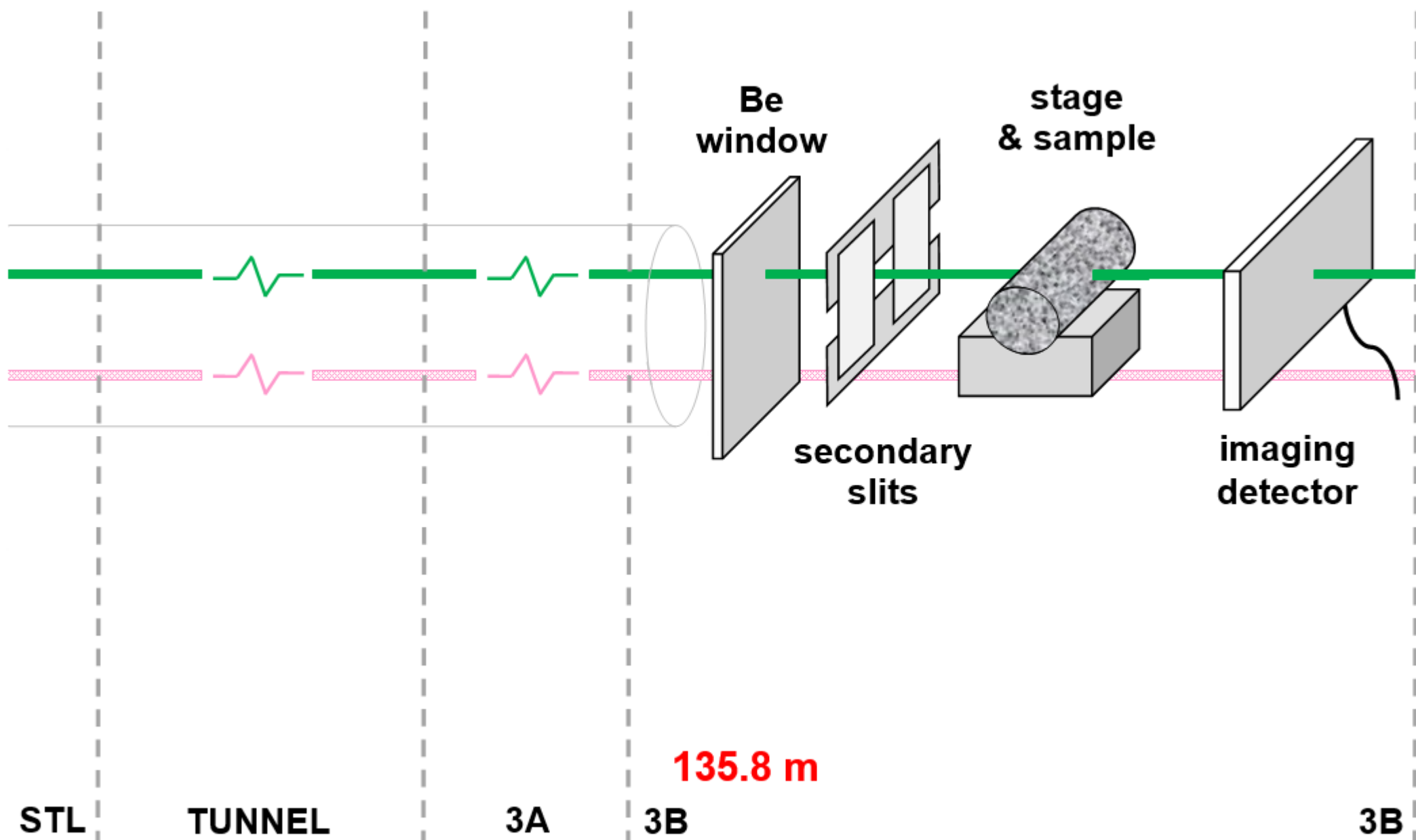
**~36m – mode 2: fast imaging &
CT, lower-dose radiotherapy**

**~22m - mode 1: high-
dose radiotherapy**





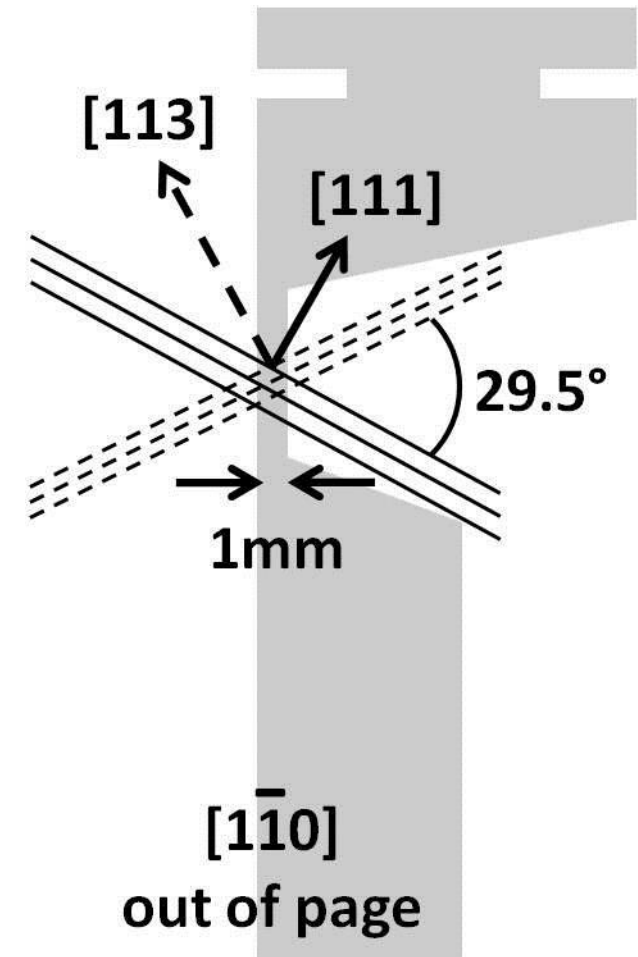
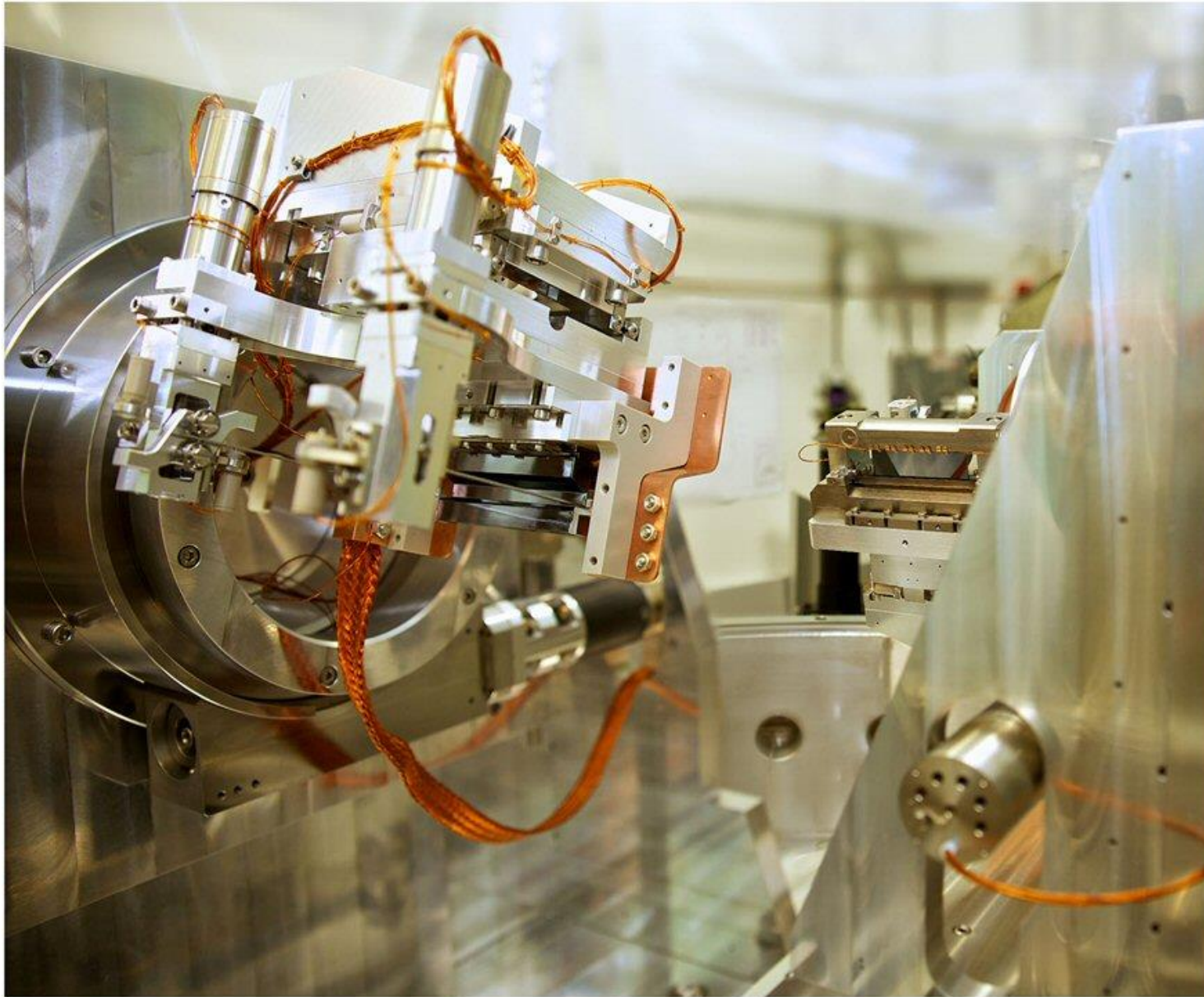




SCMPW



DCLM

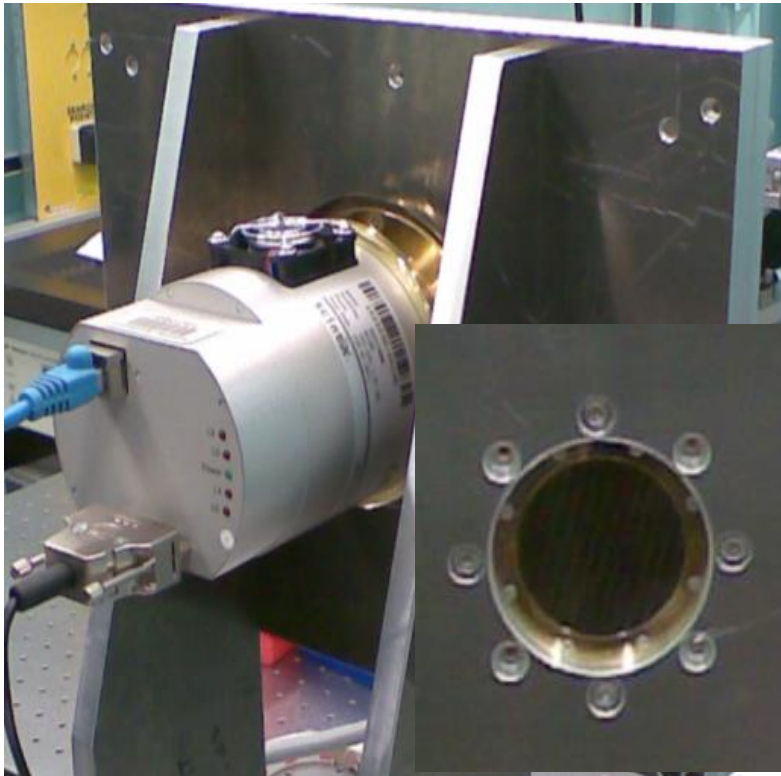


imaging detector details

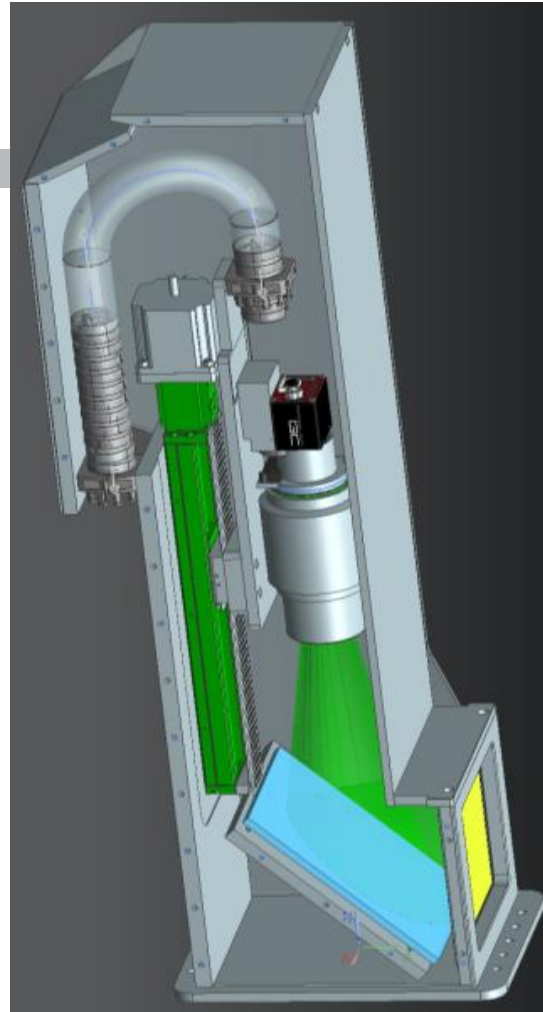


| detector | FOV (mm ²) | no. of pixels | pixel size (μm) | max. full fps | likely use |
|---|------------------------|---------------|-----------------|---------------|---|
| Diamond Optique Peter X-ray microscope with PCO.edge sensor | min: 1.66 x 1.40 | 2560 x 2160 | 0.64 | 50 | high resolution imaging & CT of small objects |
| | max: 13.46 x 11.36 | 2560 x 2160 | 5.3 | 50 | |
| Amethyst Scint-X DXI-11000 | 36.18 x 24.12 | 4024 x 2680 | 9 | 3 | medium resolution imaging at higher energies |
| Ruby Single PCO.edge sensor, lens coupled to scintillator | min: 16.25 x 13.72 | 2560 x 2160 | 6.35 | 50 | medium resolution imaging & CT at fast frame rates |
| | max: 57.1 x 48.2 | 2560 x 2160 | 22.3 | 50 | |
| Amber Photonic Science Dual VHR Imager | 100.14 x 33.48 | 8769 x 2923 | 11.4 | 1.2 | medium resolution, large area imaging |
| Quartz Hamamatsu C9252DK-14 flat panel imager | min: 243.2 x 100 | 2432 x 100 | 100 | 146 | therapy sample positioning, fast frame imaging & CT |
| | max: 243.2 x 123.2 | 1216 x 616 | 200 | 30 | |
| Opal Teledyne Dalsa, Argus Pan | current: 220 x 6.9 | 8160 x 256 | 27 | 7.8 | wide, medium resolution, for high energy imaging |
| | future: 440 x 6.9 | 16320 x 256 | 27 | 7.8 | |
| Mica modular version of Ruby (In development) | min: 380 x 32.4 | 25600 x 2160 | 15 | 50 | very large area, medium resolution imaging & CT |
| | max: 760 x 64.8 | 25600 x 2160 | 30 | 50 | |

detectors



Amethyst – Csl

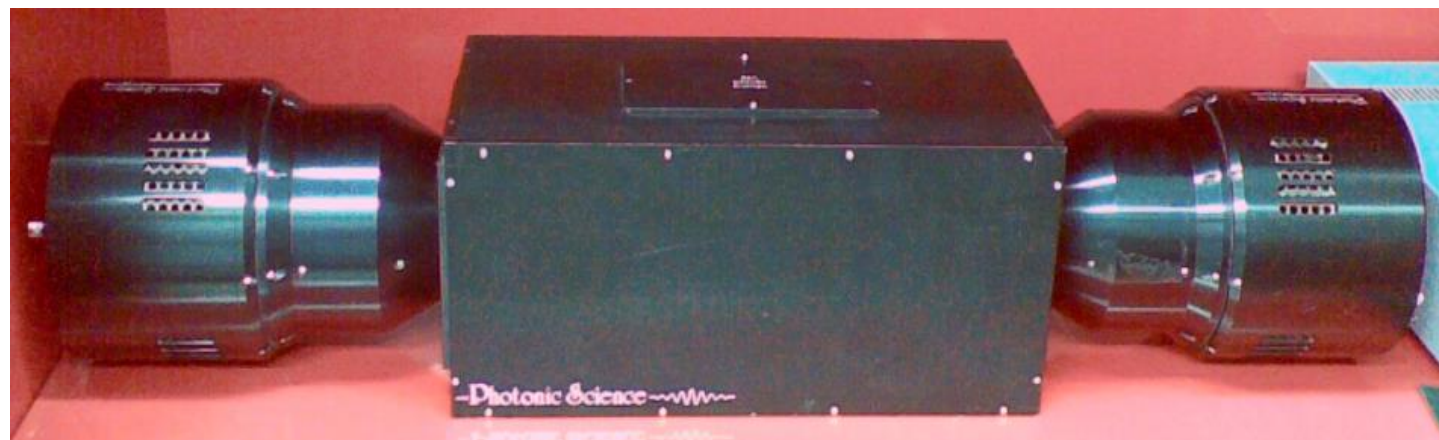


Ruby



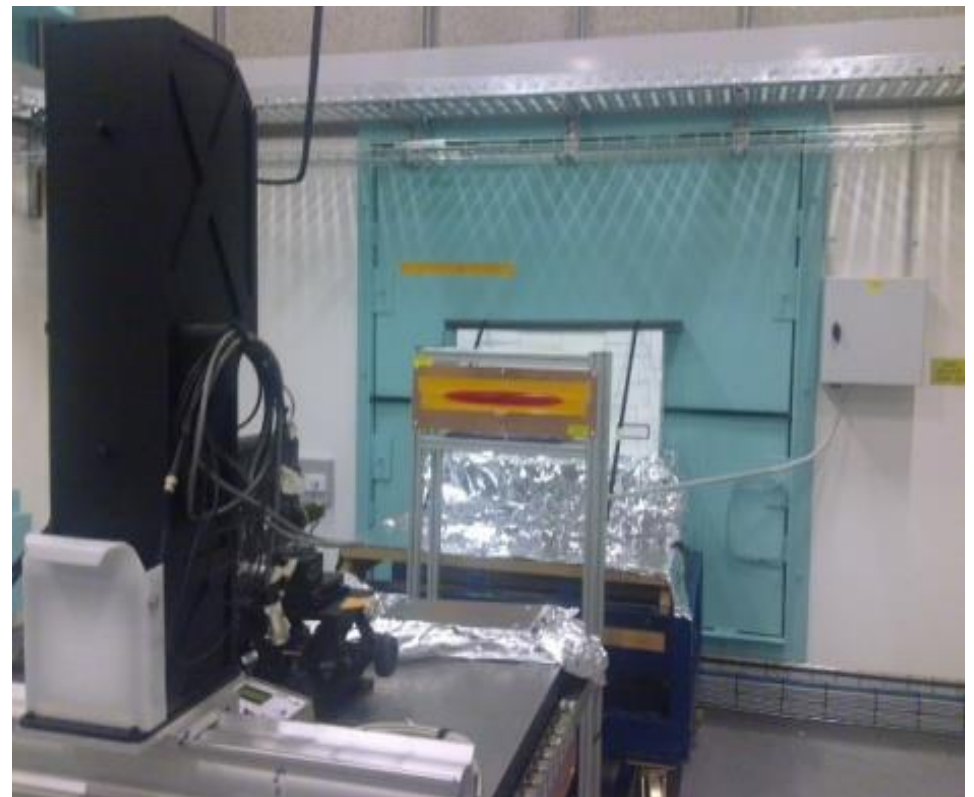
Diamond

Amber – Dual CCD Gadox

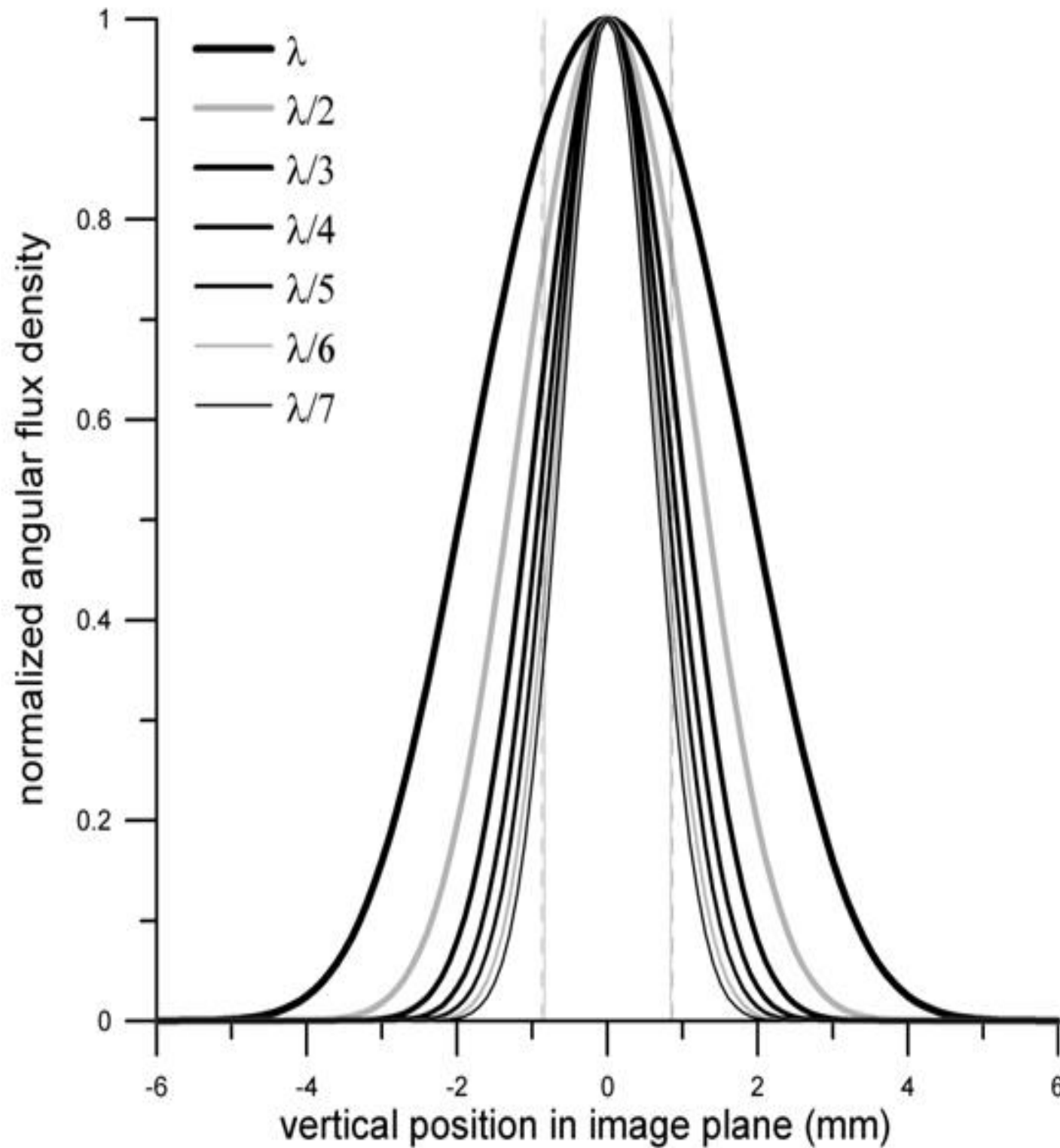


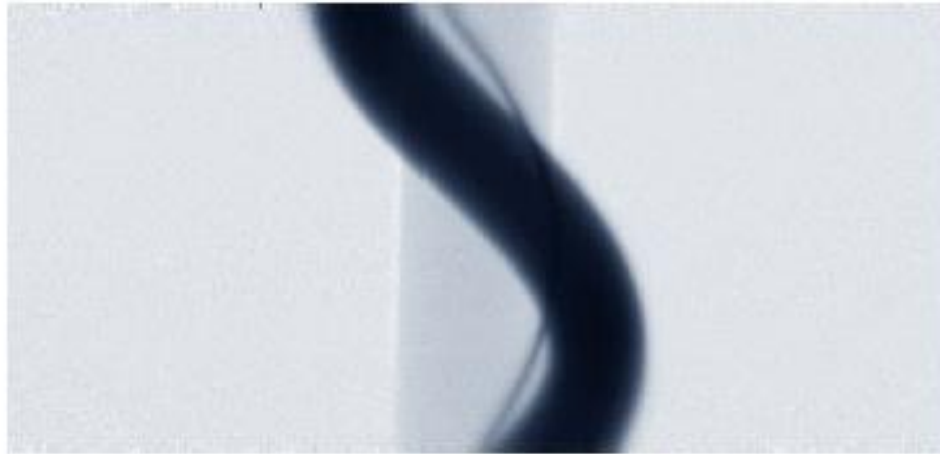
Flat-panel CMOS imager – Csl

3B for imaging/ tomography users



“roll-off” – vertical direction





(a)



(b)

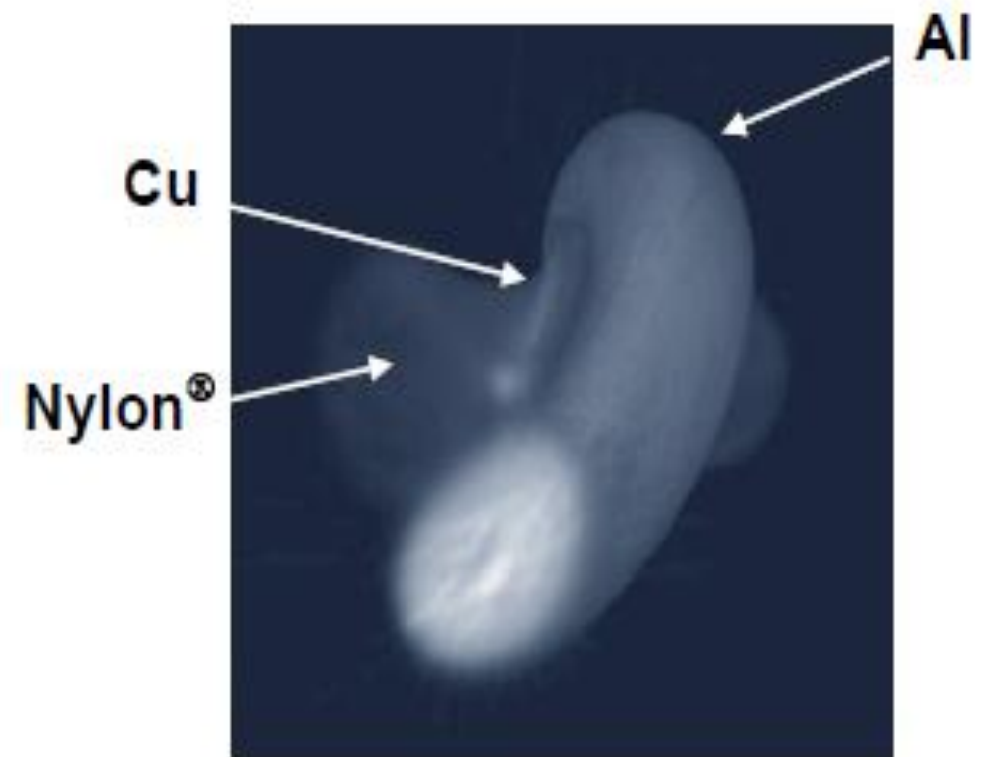


(c)

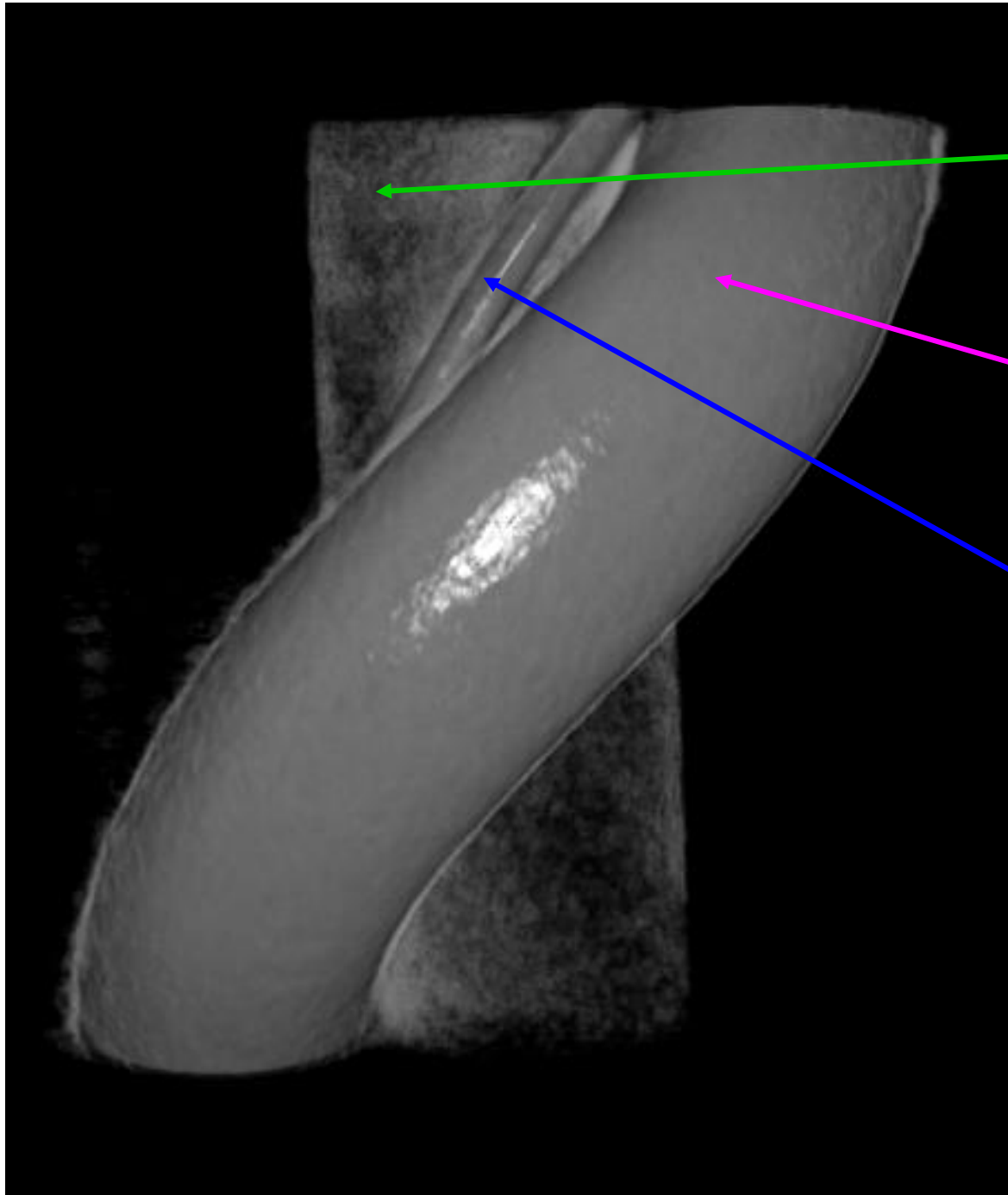


(d)

(a) 12.66 keV
(b) 18.00 keV
(c) 25.52 keV
(d) 30.49 keV



volume-rendered 12.66keV data



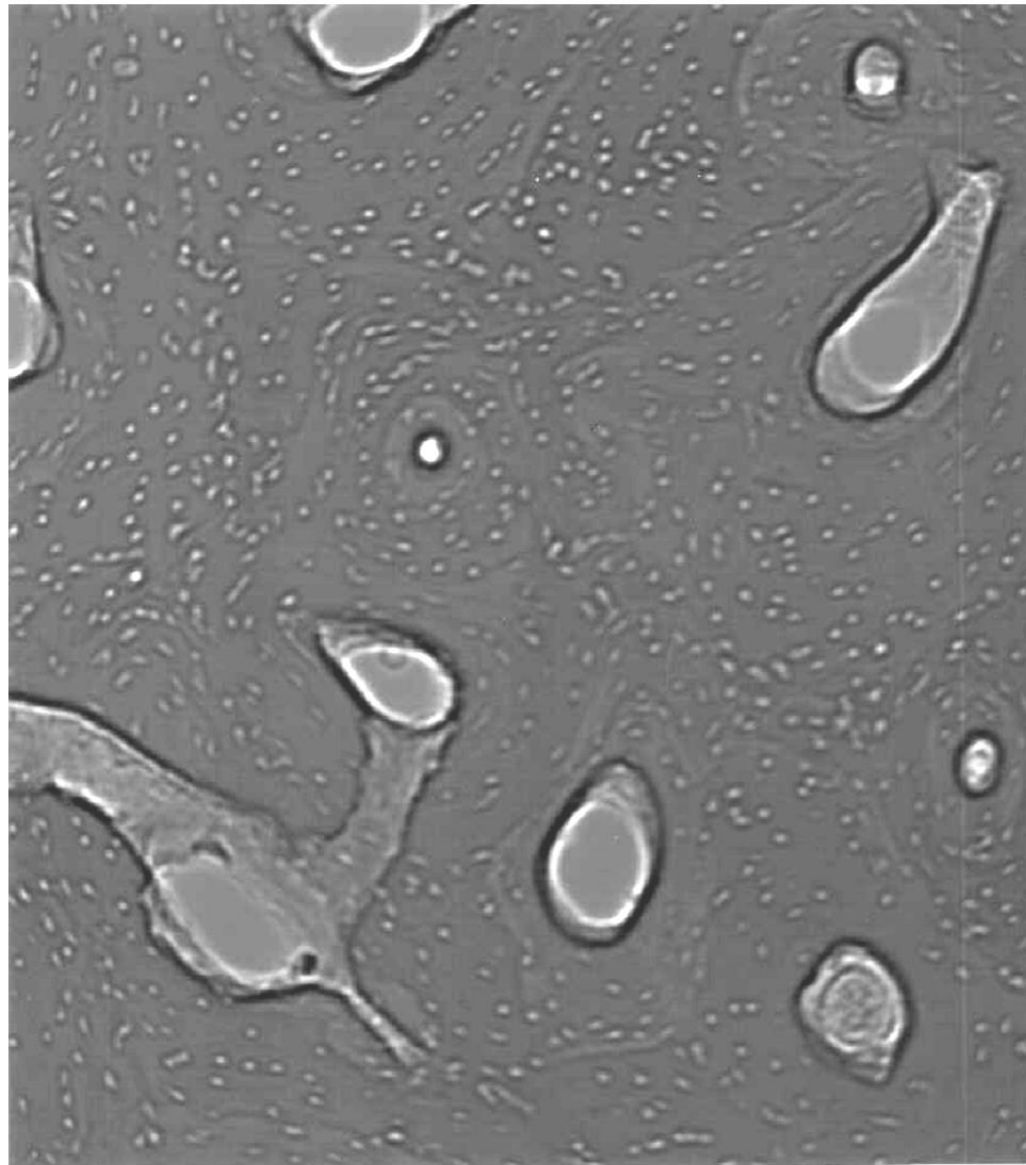
Nylon

Al

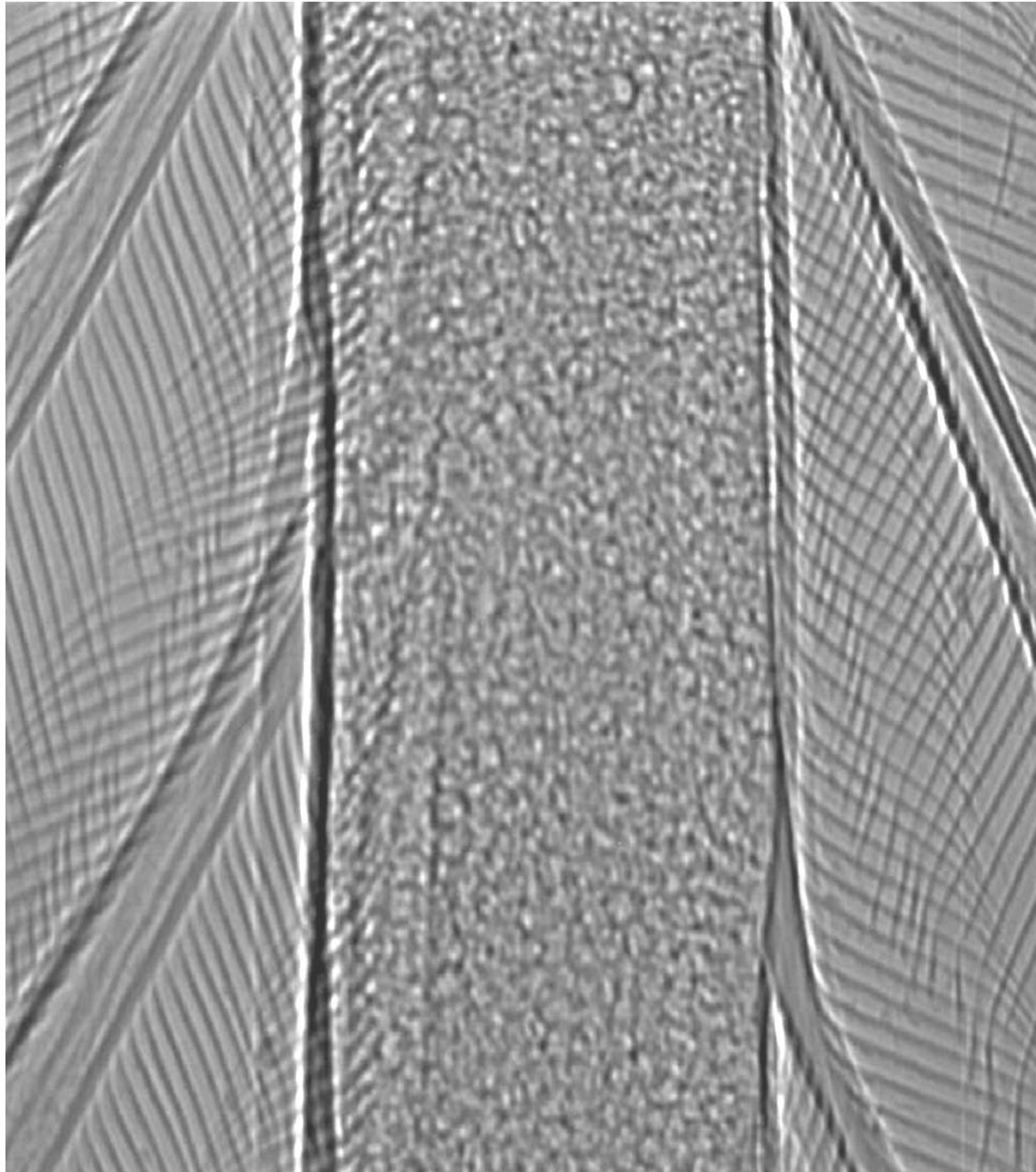
Cu

cross-section of human femur - data collected at ESRF in Grenoble, France

smallest features are osteocytes (of order $5\mu\text{m}$)

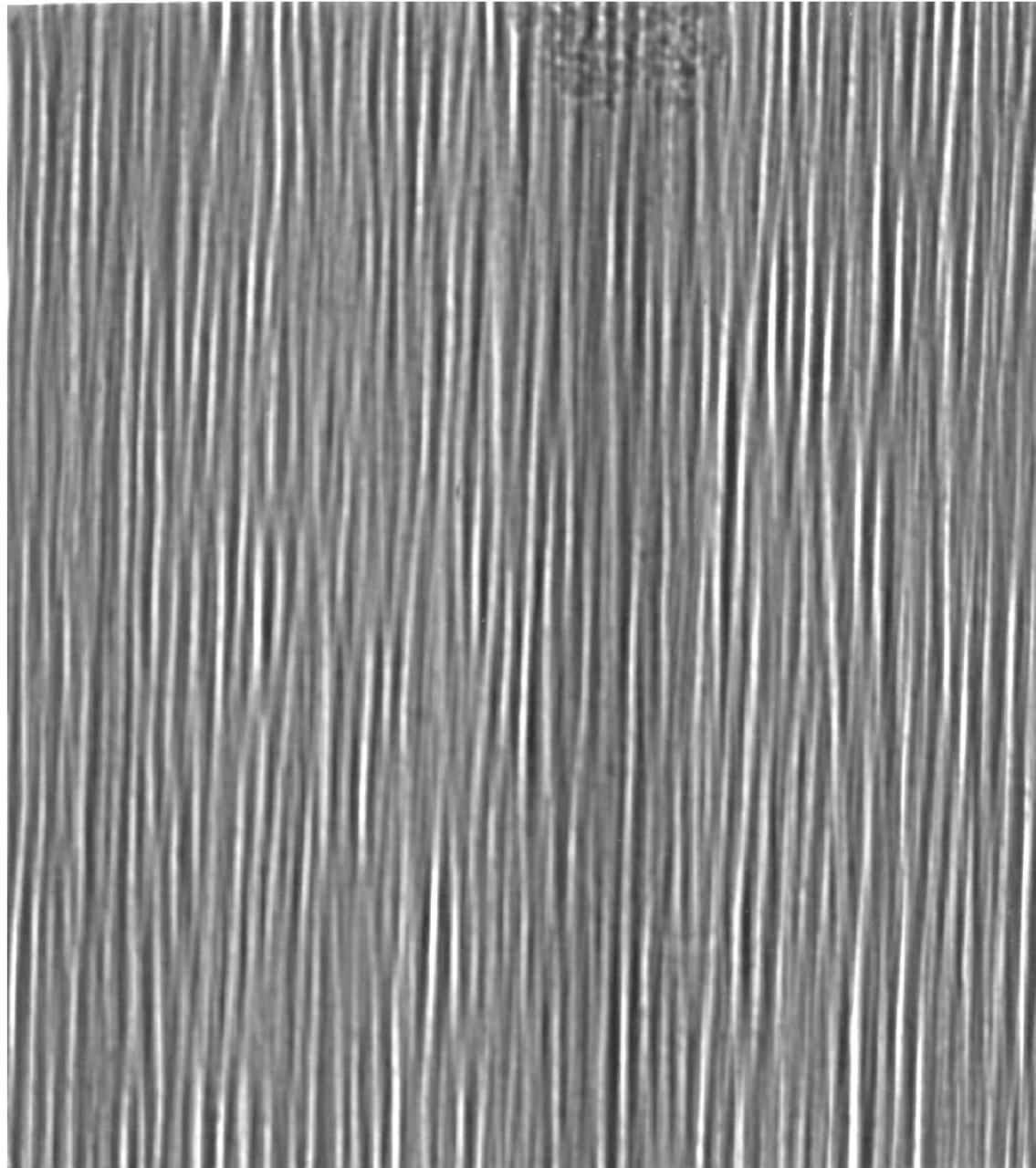


central section of a feather

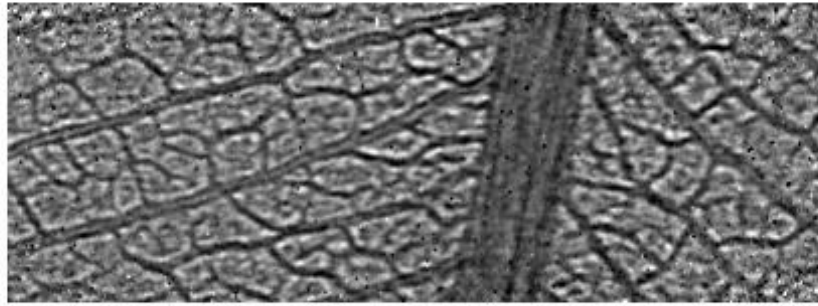


Graphite fibres ($\sim 10\mu\text{m}$) in Aluminium

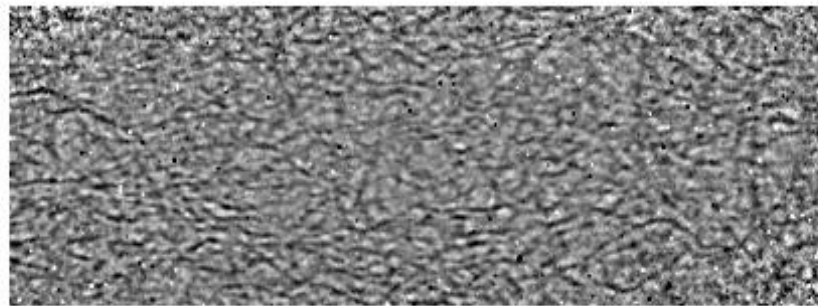
- data collected at ESRF



first X-ray images from IMBL (polychromatic) - December, 2008

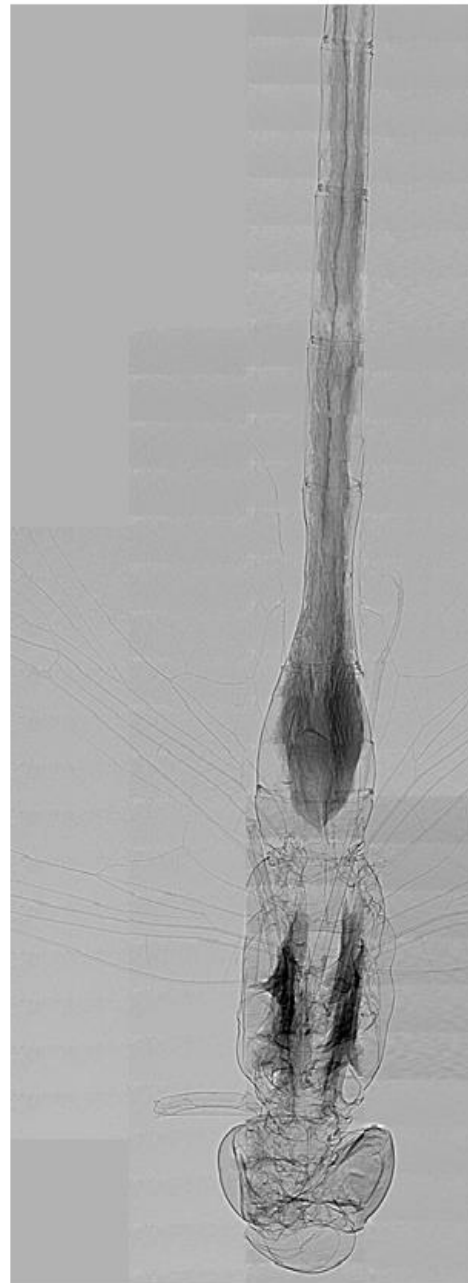


(a)

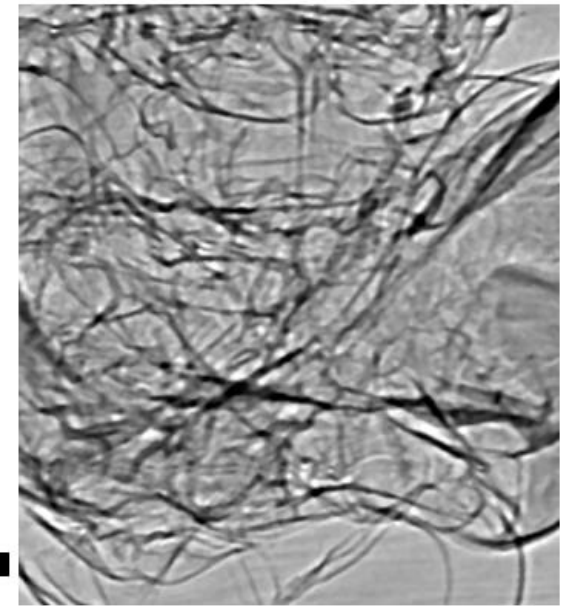


(b)

← ~6.2 mm →

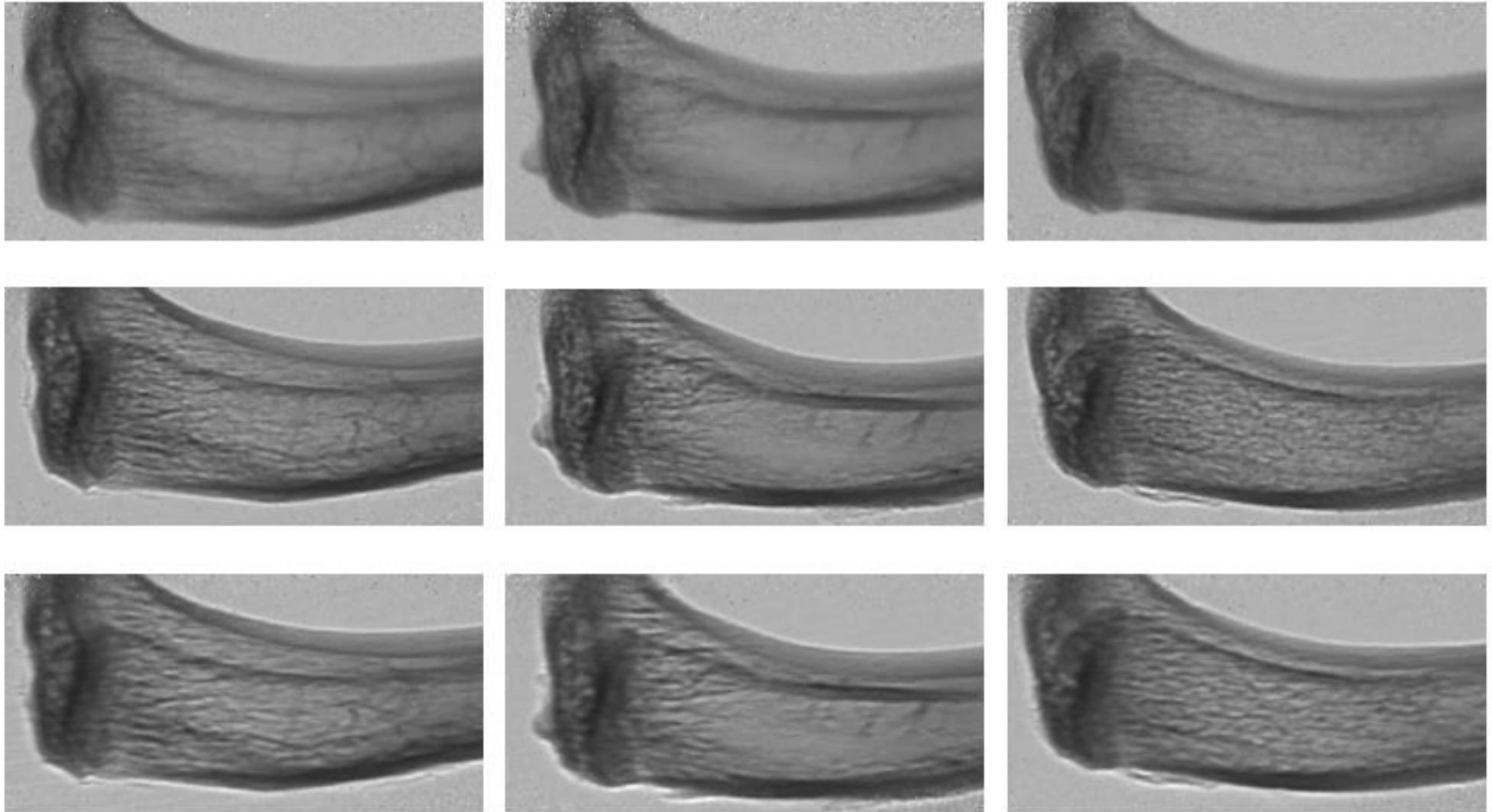


← ~26.5 mm →



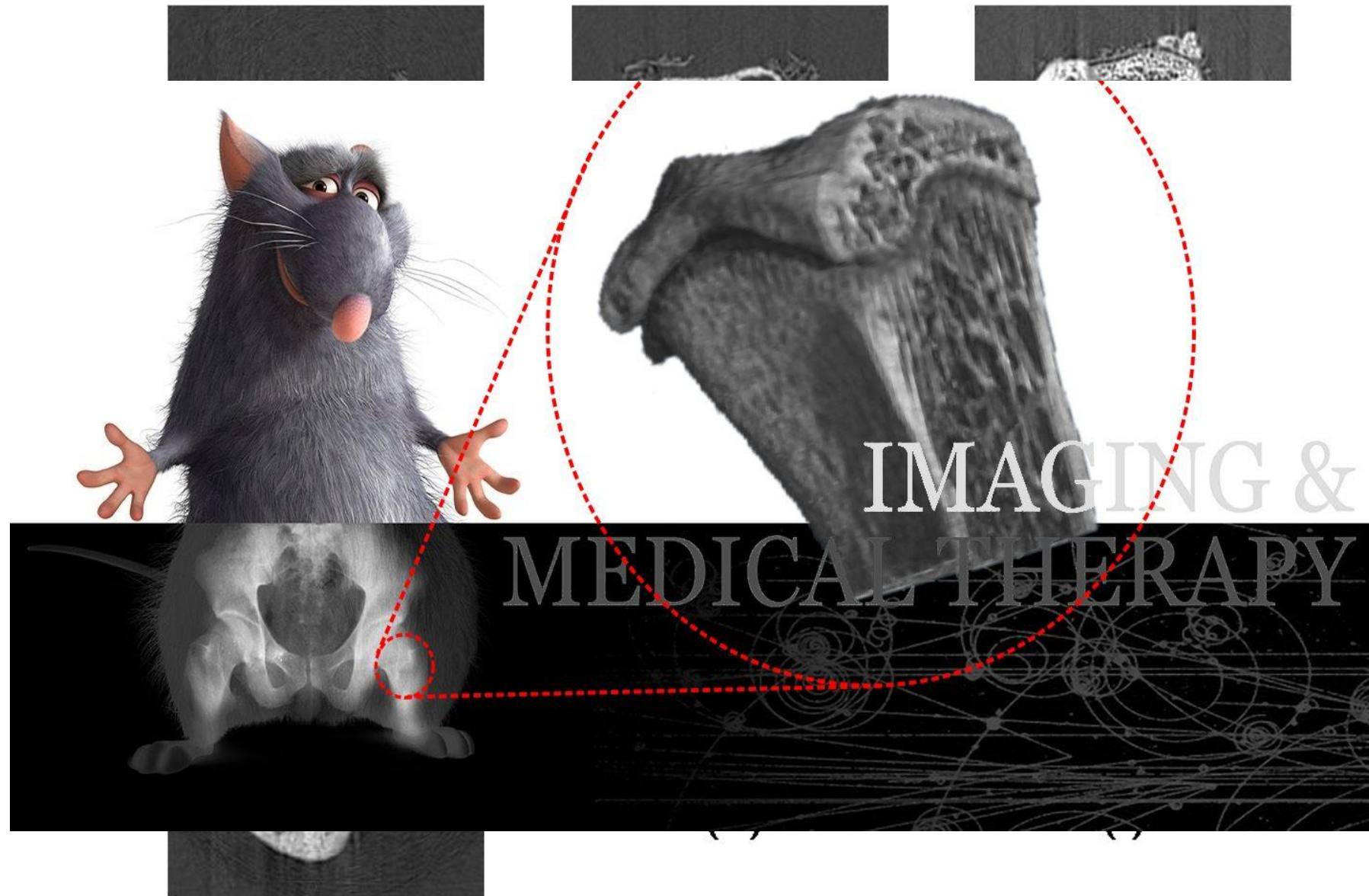
← ~6.5 mm →

first X-ray images from IMBL - mouse tibiae (different treatments & distances)



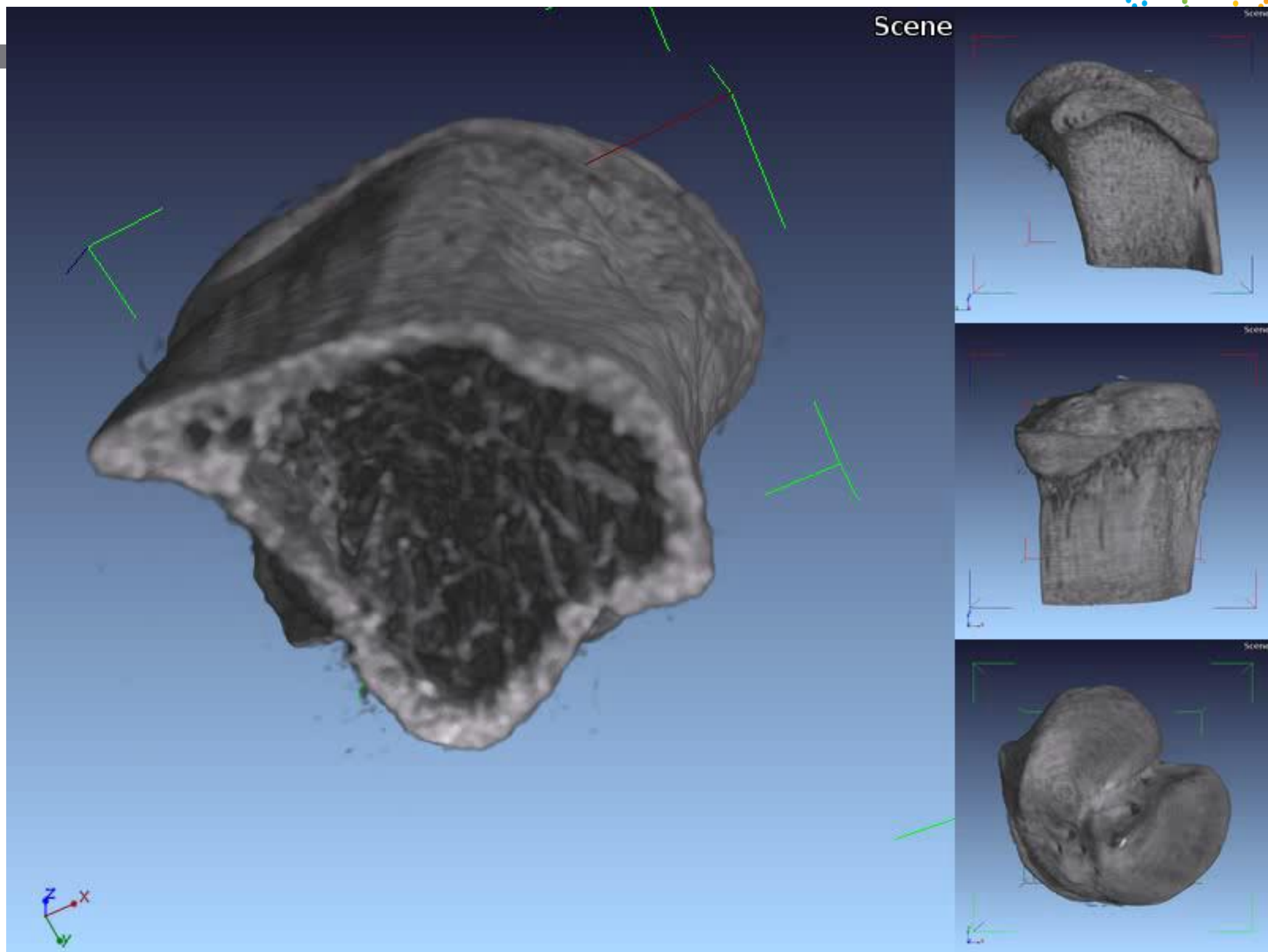
←~6.3 mm→

reconstructed tomography slices for leptin-treated mouse tibia



(d)

←~3.8mm→





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Thank you for your attention



Australian Synchrotron





“25keV.avi”, “50keV.avi” & “100keV.avi”

- **1024 μm \times 1024 μm**
- **Cu**
- **$R_1 = 21 \text{ m}$ & $R_2 = 1 \text{ cm}$**
- **$\sigma_d = 6.3 \mu\text{m}$**



“detector_resolution.avi”

- **1024 μm \times 1024 μm**
- **Ge 0.5 mm**
- **$R_1 = 21 \text{ m}$ & $R_2 = 1 \text{ cm}$**
- **50 keV**



“signal_to_noise.avi”

- **1024 μm \times 1024 μm**
- **Ge 0.5 mm**
- **$R_1 = 21 \text{ m}$ & $R_2 = 1 \text{ cm}$**
- **$\sigma_d = 5 \mu\text{m}$**
- **50 keV**



“Z.avi”

- **1024 μm \times 1024 μm**
- **0.5 mm**
- **$R_1 = 21 \text{ m}$ & $R_2 = 1 \text{ cm}$**
- **$\sigma_d = 6.3 \mu\text{m}$**
- **50 keV**



“K_abs_edge.avi”

- **1024 μm \times 1024 μm**
- **I (“IM”) & Ba (“BL”) 0.1 mm**
- **$R_1 = 21 \text{ m}$ & $R_2 = 1 \text{ cm}$**
- **$\sigma_d = 6.3 \mu\text{m}$**



“1B_PC.avi”, “2B_PC.avi” & “3B_PC.avi”

- **1024 μm \times 1024 μm**
- **Al 0.1 mm**
- **$R_1 = 20$ m (1B), 34 m (2B) & 138 m (3B)**
- **$\sigma_d = 5$ μm , $\sigma_{s,h} = 320$ μm & $\sigma_{s,v} = 16$ μm**
- **25 keV**