IMBL: X-ray characteristics & general imaging

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The “first” X-ray image
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
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
Monash Biomedical Imaging (MBI) – Monash/CSIRO

IMBL end station at 140m

transfer tunnel

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

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

~22m - mode 1: high-dose radiotherapy
### imaging detector details

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

Amethyst – CsI

Ruby

Diamond

Amber – Dual CCD Gadox

Flat-panel CMOS imager – CsI
3B for imaging/ tomography users
“roll-off” – vertical direction
(a) 12.66 keV
(b) 18.00 keV
(c) 25.52 keV
(d) 30.49 keV
volume-rendered 12.66keV data
cross-section of human femur - data collected at ESRF in Grenoble, France

smallest features are osteocytes (of order 5μm)
central section of a feather
Graphite fibres (~10μm) 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)
reconstructed tomography slices for leptin-treated mouse tibia
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Thank you for your attention
“25keV.avi”, “50keV.avi” & “100keV.avi”

- 1024 μm × 1024 μm
- Cu
- $R_1 = 21$ m & $R_2 = 1$ cm
- $\sigma_d = 6.3$ μm
“detector_resolution.avi”

- 1024 μm × 1024 μm
- Ge 0.5 mm
- $R_1 = 21$ m & $R_2 = 1$ cm
- 50 keV
“signal_to_noise.avi”
• 1024 μm × 1024 μm
• Ge 0.5 mm
• R₁ = 21 m & R₂ = 1 cm
• σ₃ = 5 μm
• 50 keV
“Z.avi”
• 1024 μm × 1024 μm
• 0.5 mm
• $R_1 = 21$ m & $R_2 = 1$ cm
• $σ_d = 6.3$ μm
• 50 keV
“K_abs_edge.avi”

- $1024 \, \mu m \times 1024 \, \mu m$
- $I \ (“IM”)$ & $Ba \ (“BL”)$ 0.1 mm
- $R_1 = 21 \, m \ & \ R_2 = 1 \, cm$
- $\sigma_d = 6.3 \, \mu m$
“1B_PC.avi”, “2B_PC.avi” & “3B_PC.avi”

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