

I-ImaS: Intelligent Imaging Sensor Application to intelligent imaging

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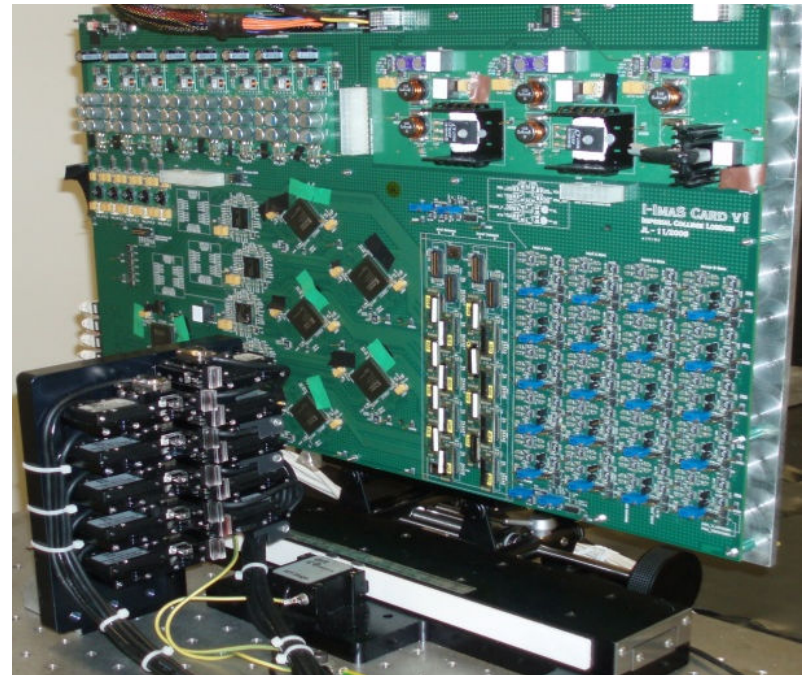
Imperial College London

R Turchetta

Rutherford Appleton Laboratory

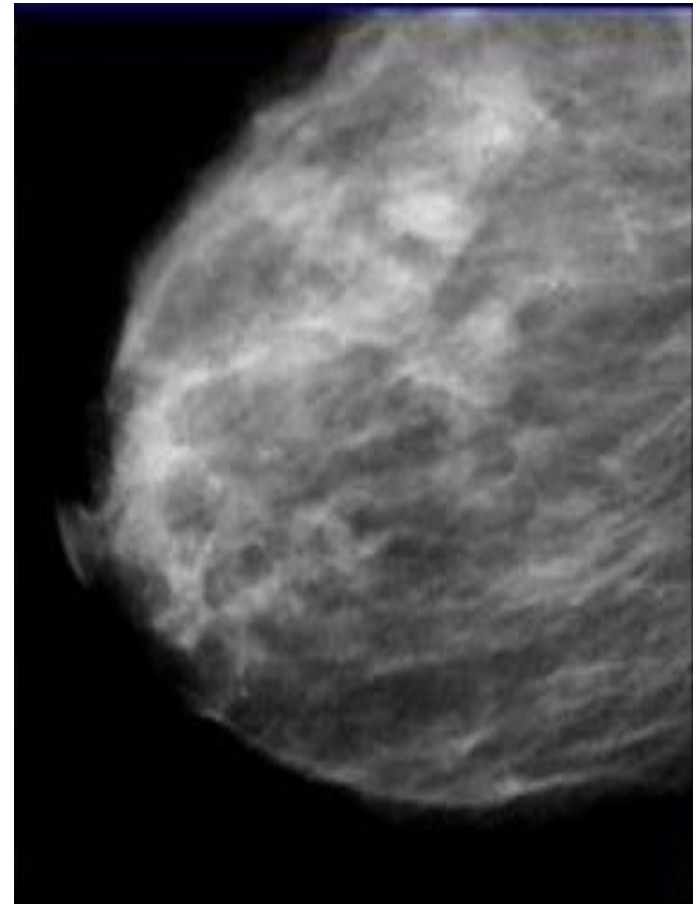
Overview

- Introduction
 - Diagnostic radiography
 - The I-ImaS concept
- I-ImaS system
 - Modelling
 - Components
- Results and conclusions



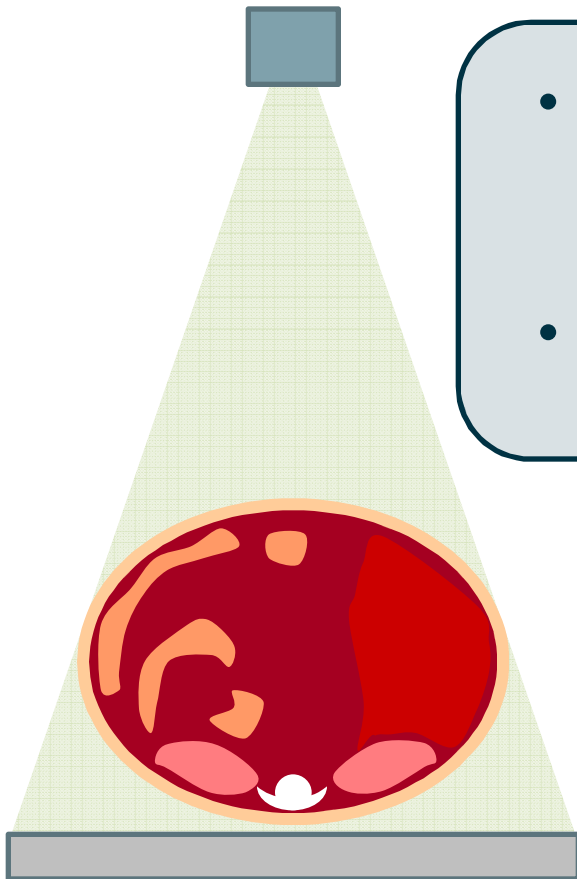
Diagnostic Radiography

- X-rays per year in USA
 - 70,000,000 chest x-rays
 - 35,000,000 mammograms
- Chest x-ray 0.02 mSv
 - 1 in a million risk
- Mammogram 1 mSv
- ‘If dose reduced by 20% in mammography, then 2000 lives saved per year in EU’



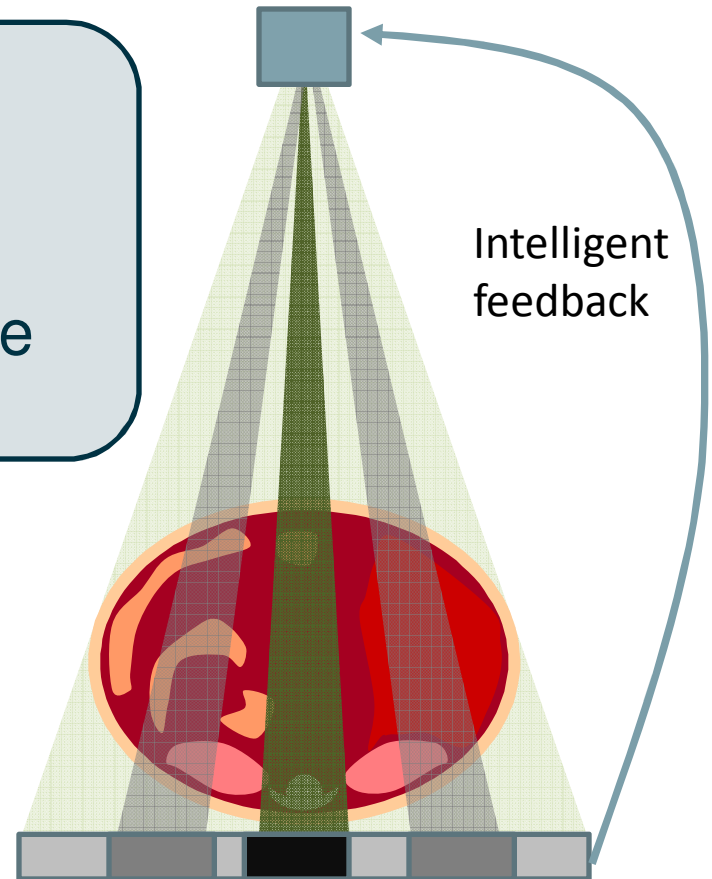
Redistributing dose

Global dose



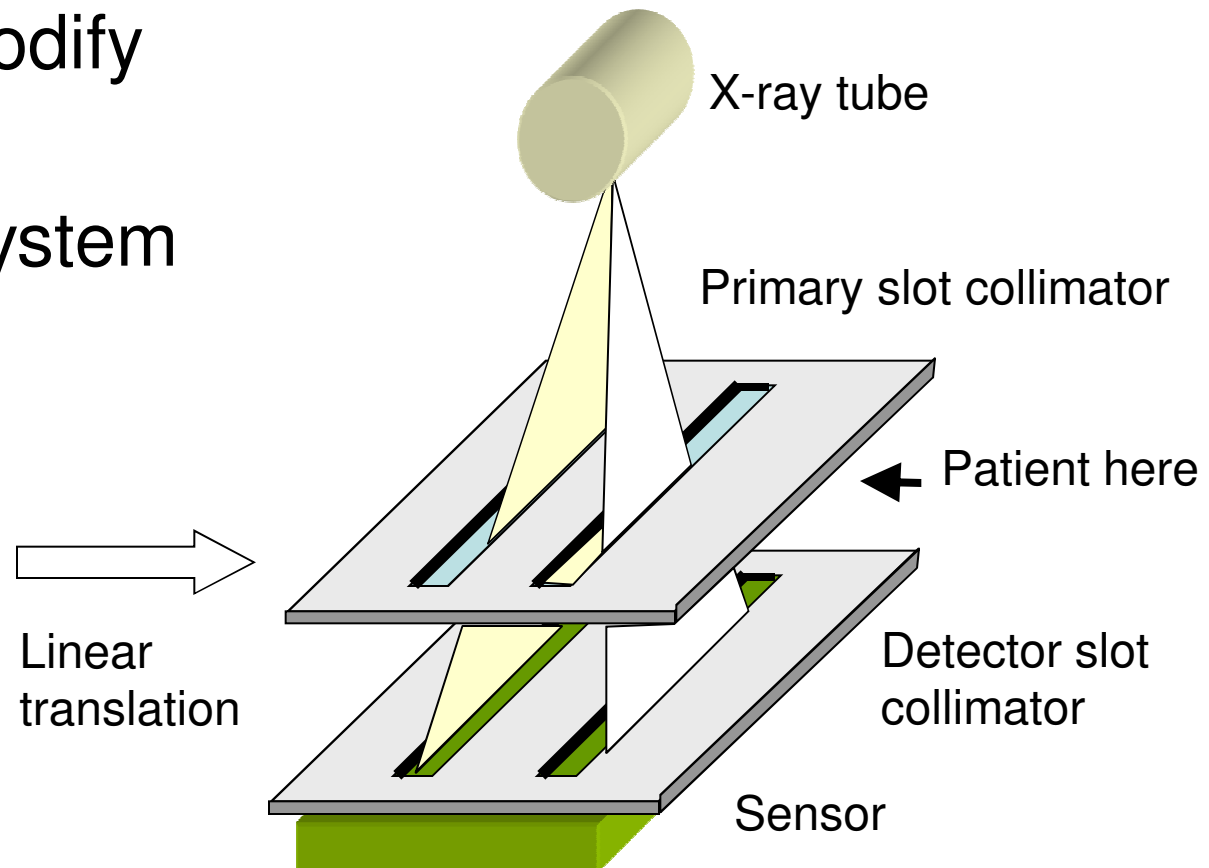
- lower patient dose
- increase image quality

Local dose

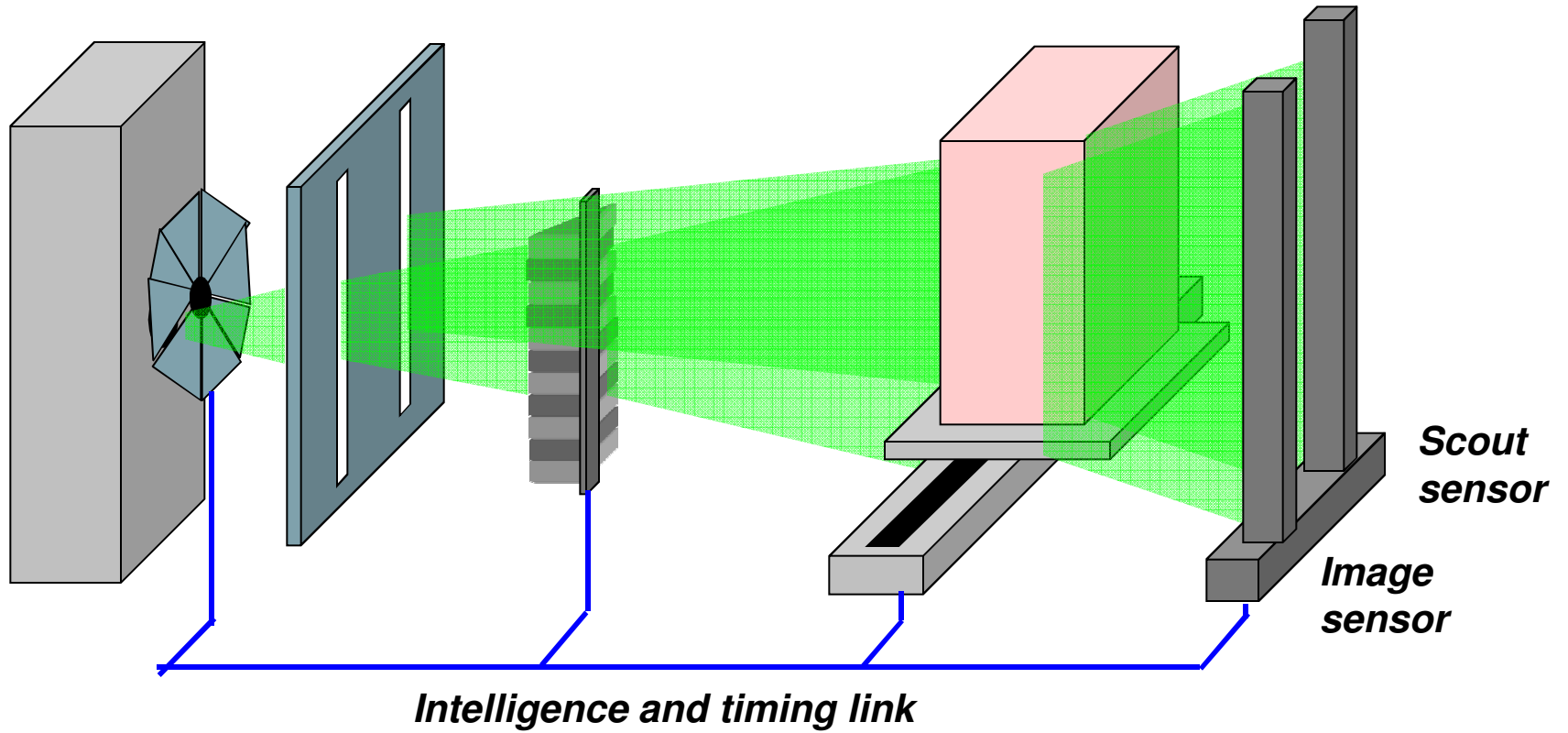


I-ImaS concept

- Use data gleaned locally to intelligently modify local exposure
- Dual line-scan system
 - Scout image
 - Intelligent image



5. Scout system and filters

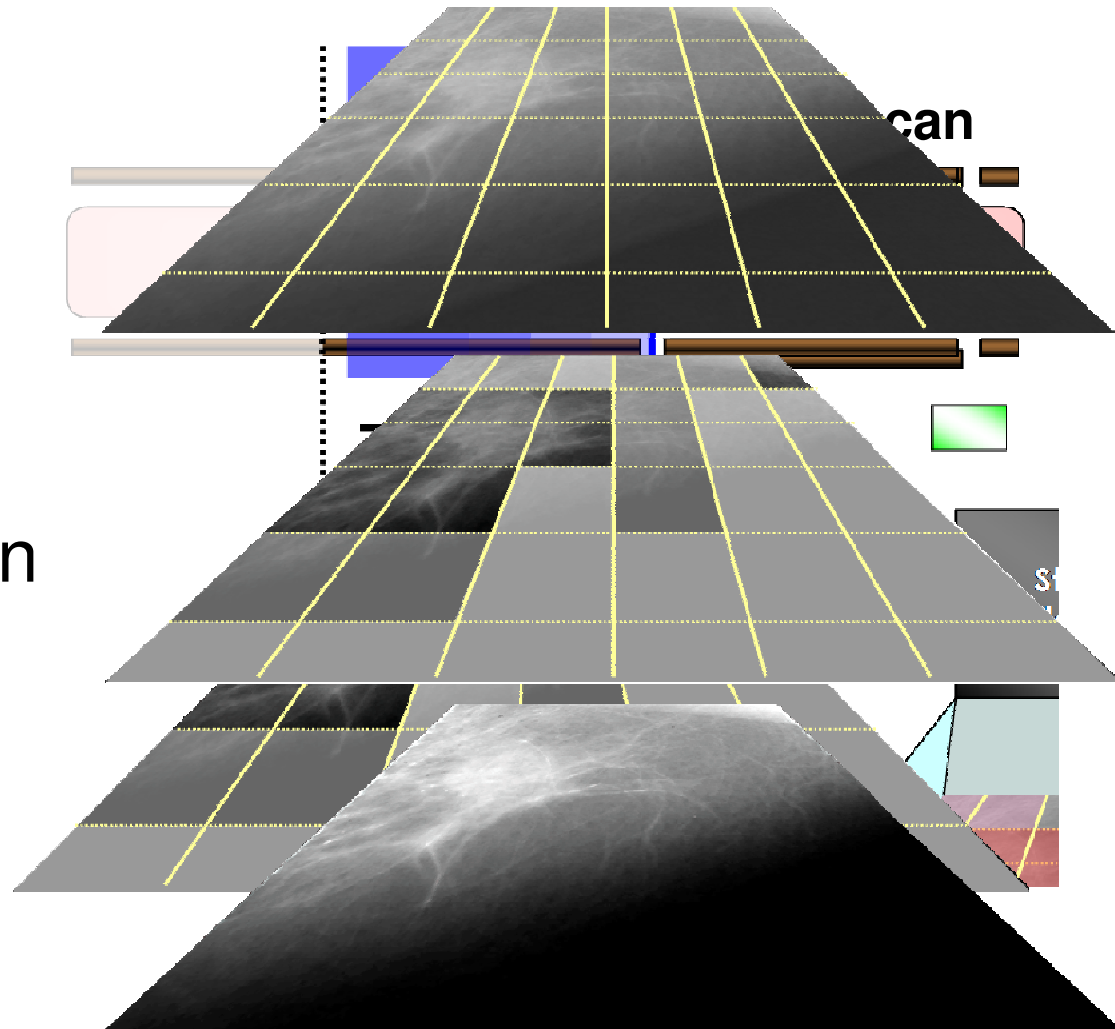


The scan

STEP 1: Measure local features

STEP 2: Adjust dose according to first scan

STEP 3: Image stitching

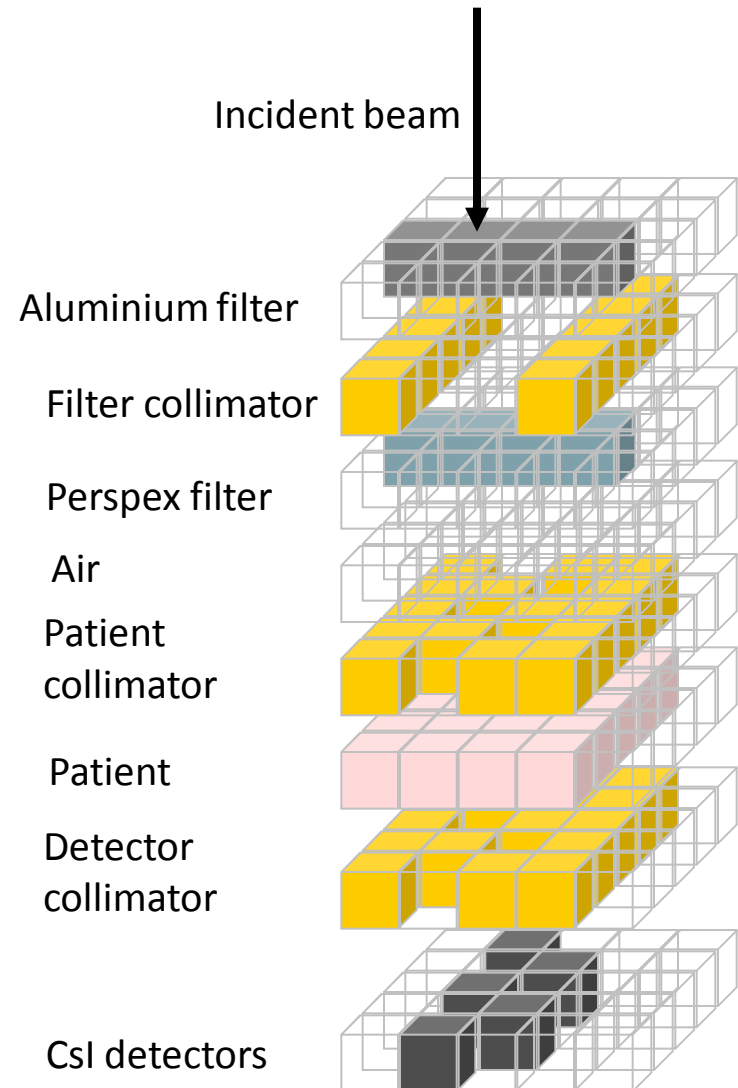


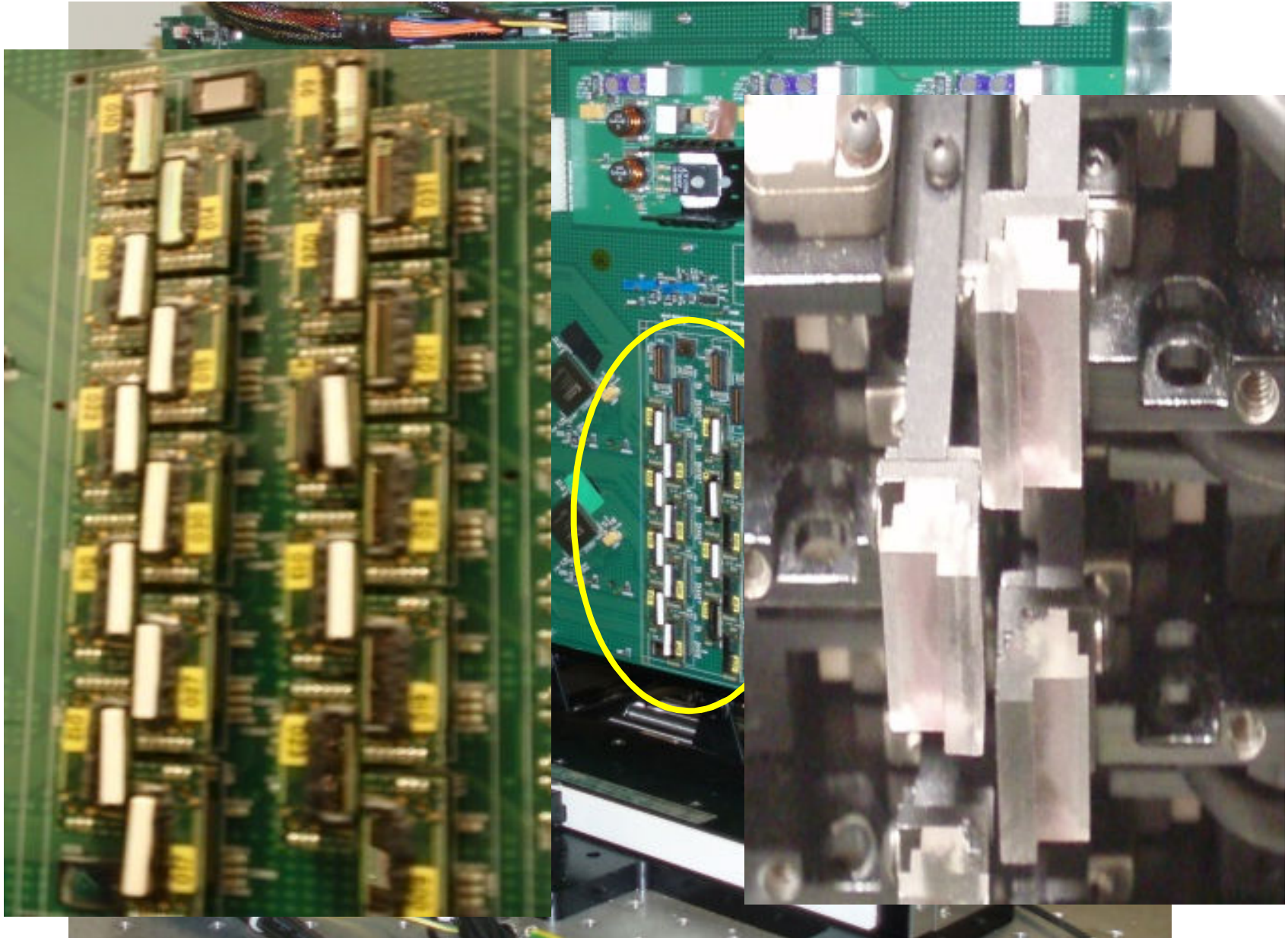
System design constraints

- X-ray fluence
 - Naked detector 10,000 photons per pixel
 - Attenuated beam 500
- Scan area
 - 18 x 24 cm
 - Intelligence ROI size 1 x 16 mm
- Time
 - Total scan time <10 seconds
 - Frame integration time 10 ms

System design

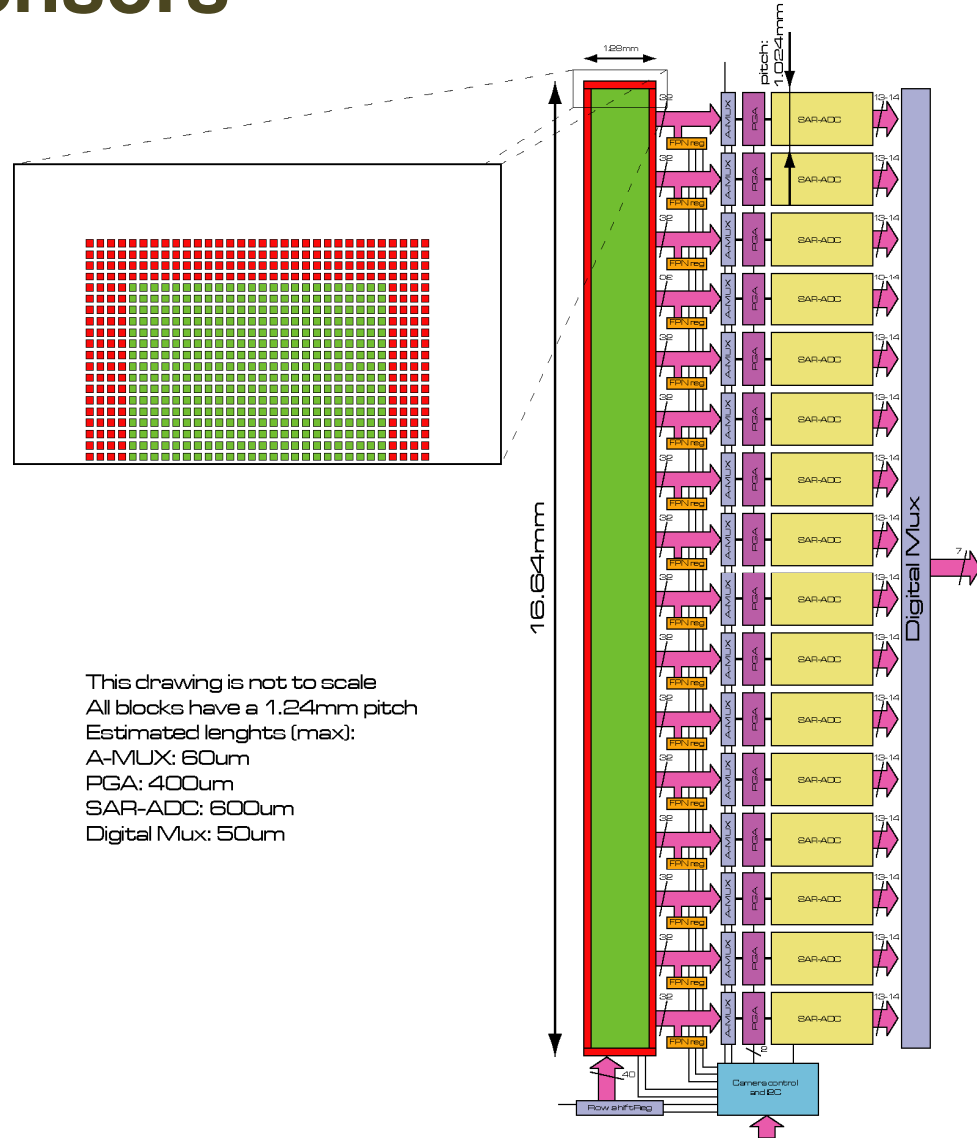
- EGS4
- 8 5x5 layers of voxels
- Perpendicular plane geometry
- X spacing is 3 mm
- Y spacing is 16 mm
- Includes any k-characteristics
- Disregards depositions <10 keV
- Pencil beam into centre of middle detector





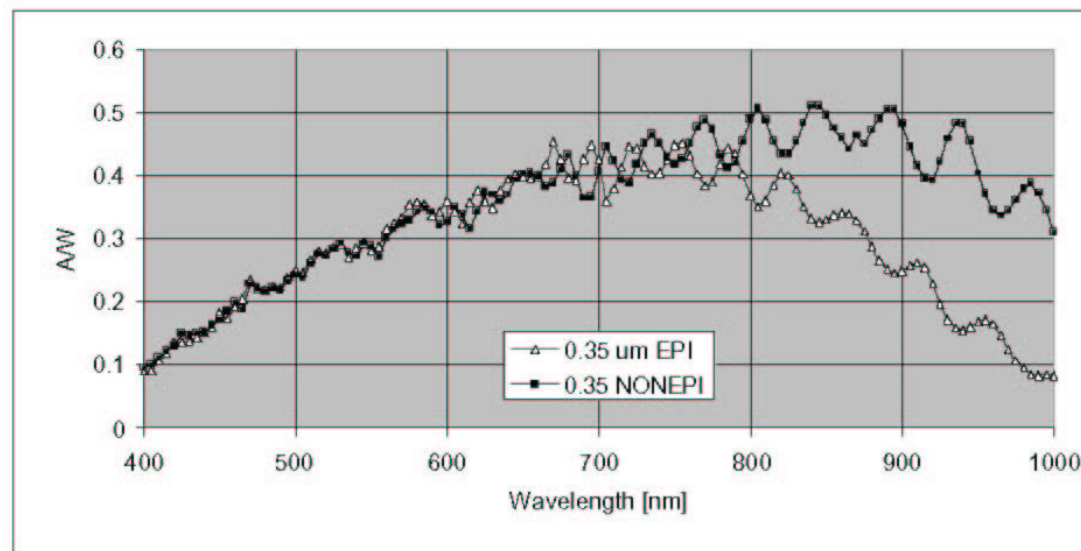
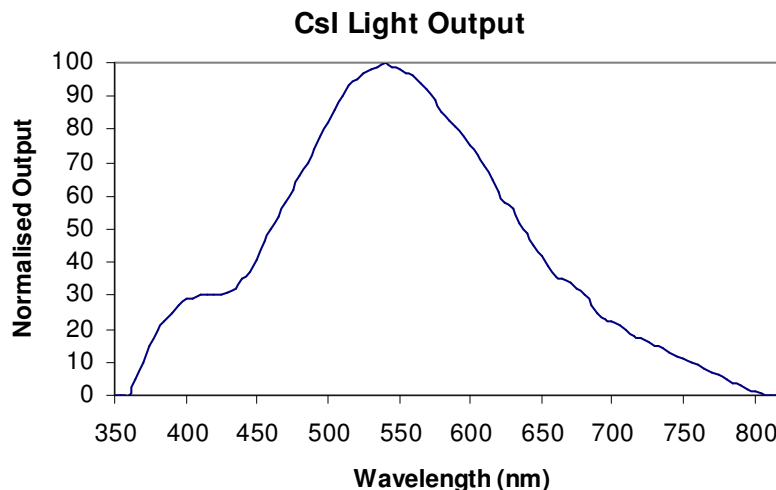
CMOS Active Pixel Sensors

- 0.35 μm CMOS
- 512 x 32 pixels
- 32 μm pitch
- 14 bit digital output
- Data throughput:
35 MB per second

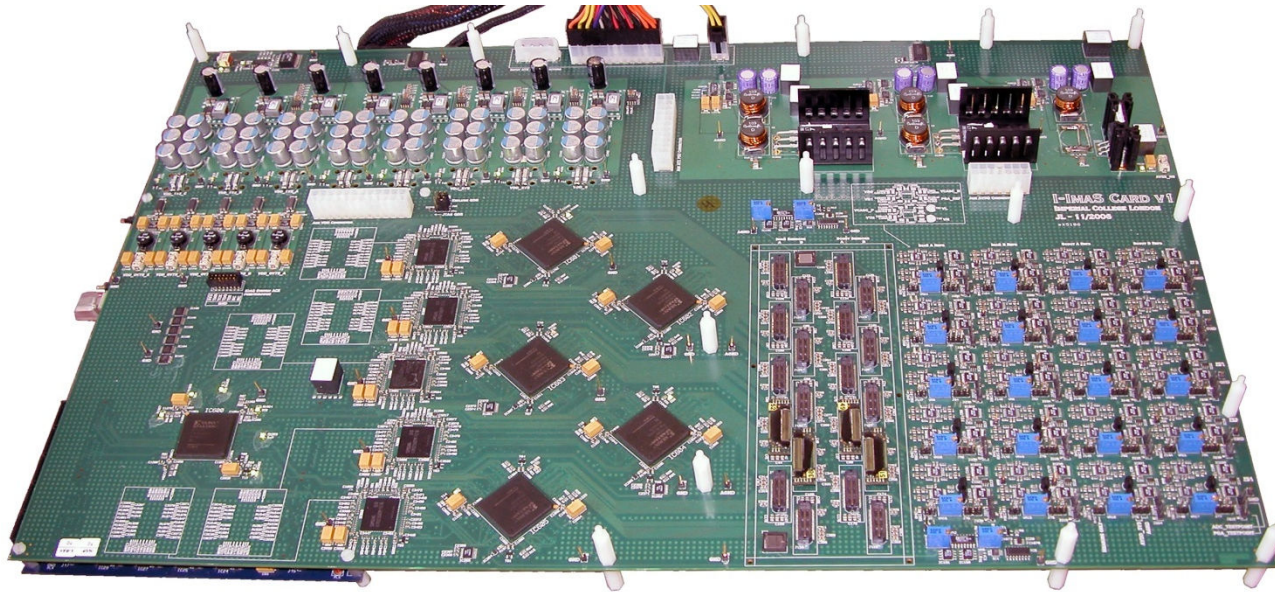


Scintillator Material

- 16.9 mm x 2 mm CsI(Tl)
 - Yield is 52000 photons MeV⁻¹
- Response of chips
- Structure of scintillator
 - Columnar
 - Grown onto fibre optic face plates
- Trade offs
 - Efficiency v spatial resolution



I-ImaS Card

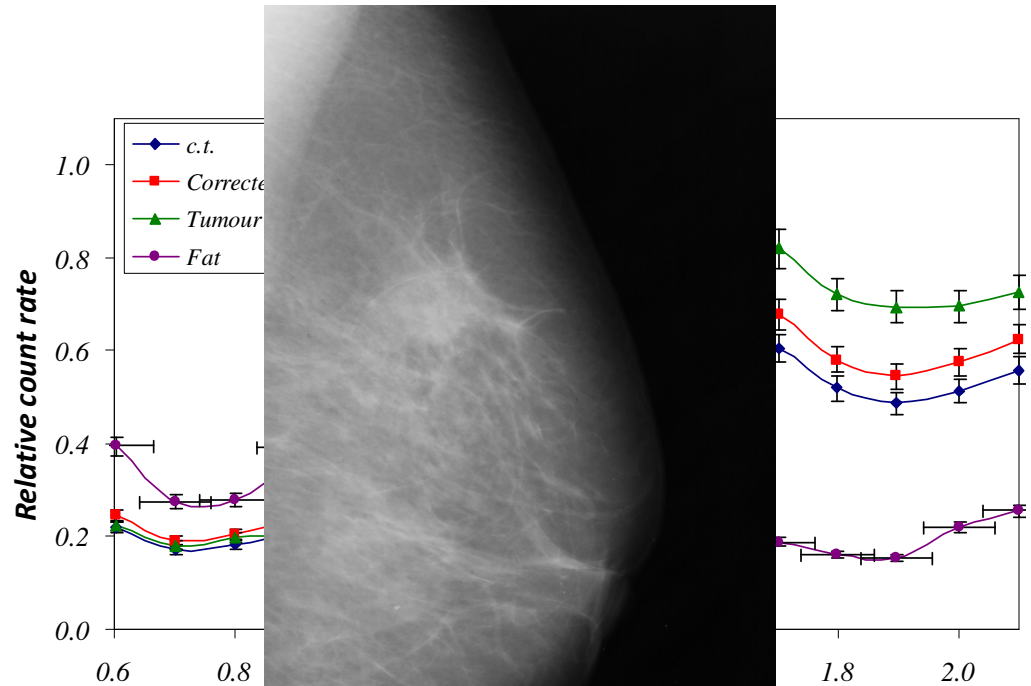


- I-ImaS Card controls & reads out 20 sensors (10 Scout, 10 I-ImaS)
- Real-time steering algorithm implemented in on-board FPGAs

Intelligence drivers

- Variance
- Maximum value
- Minimum value
- Alternative data
 - diffraction

$$\chi = \frac{E}{hc} \sin\left(\frac{\theta}{2}\right)$$

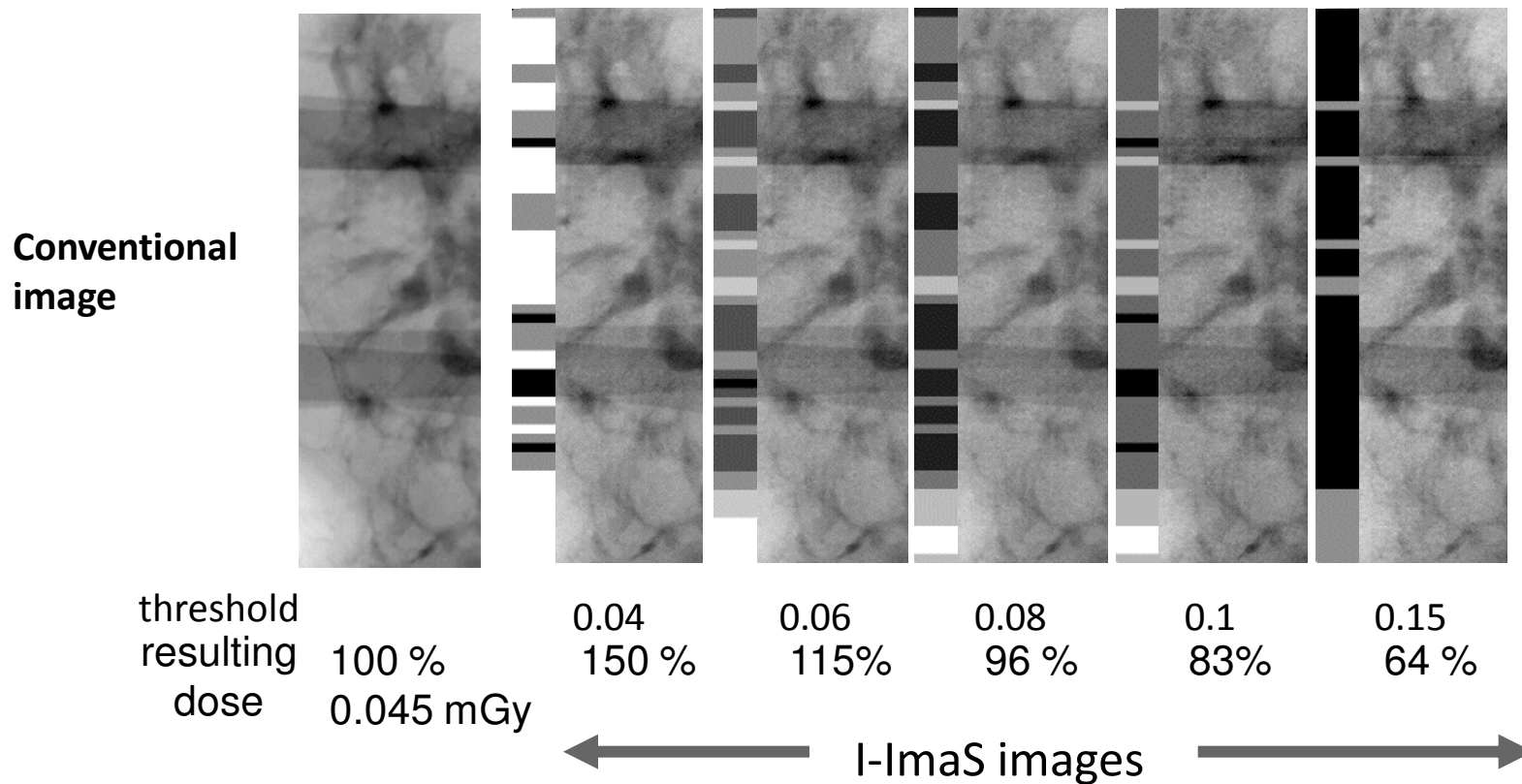


Normalised diffraction
connective tissue d

oma, 96% pure
d for volume of sample.

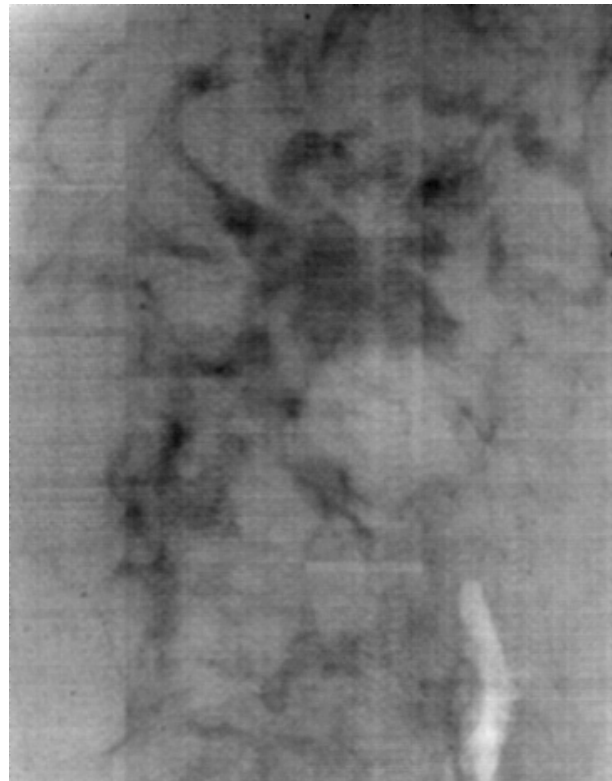
Breast tissue

- Implementation of six standard deviation thresholds



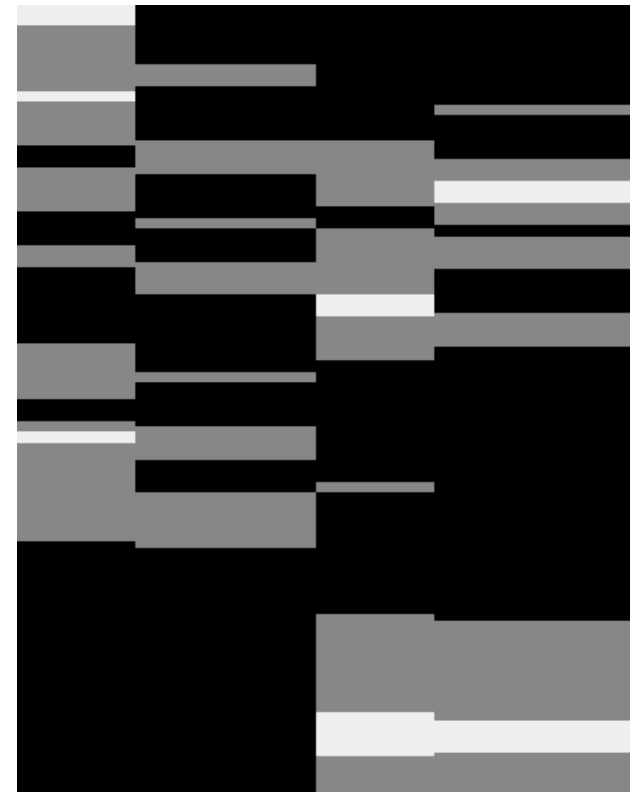


scout



I-ImaS

65% of conventional dose



dose distribution map

Dental

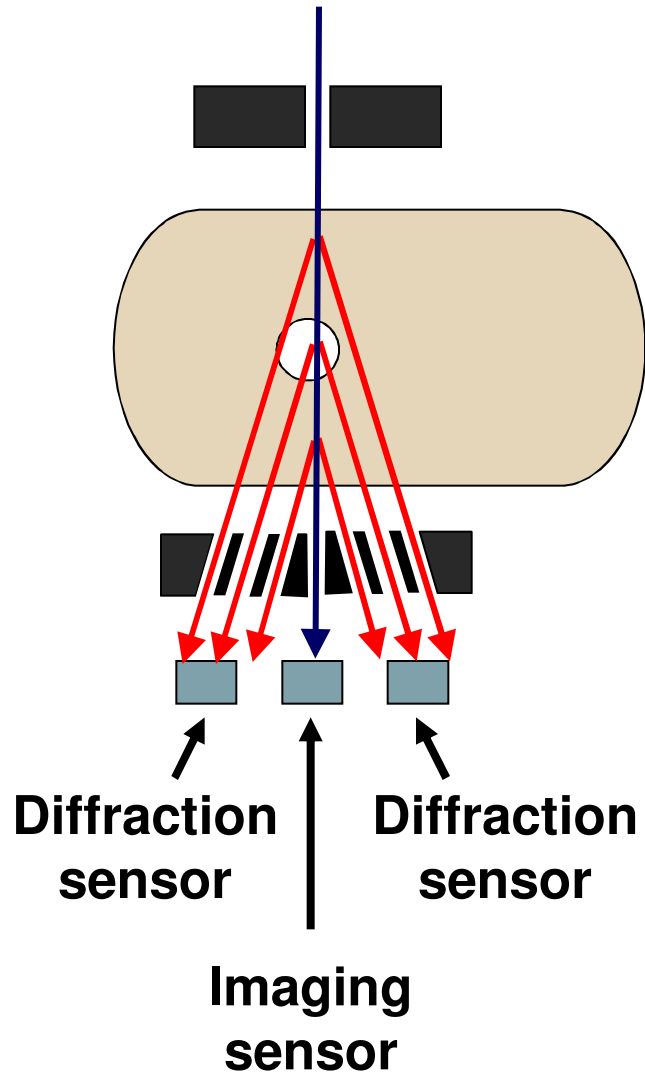


Conventional
image

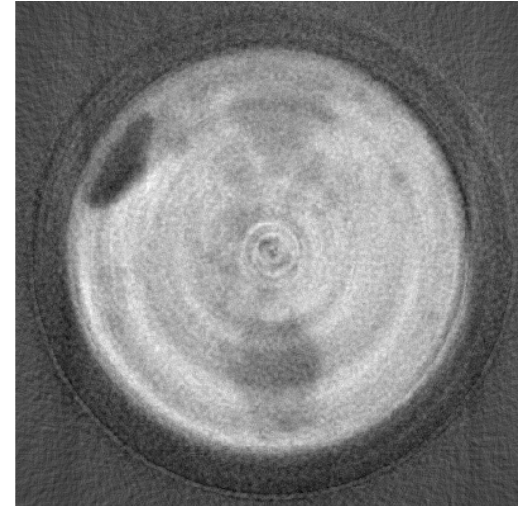
threshold		0.08	0.16	0.20	0.30	0.40
resulting dose	100 % (0.4 mGy)	145 %	120%	108 %	90%	75 %

← I-ImaS images →

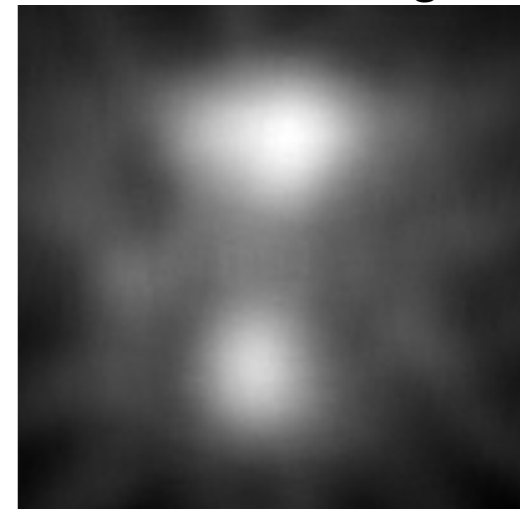
Diffraction



Conventional image



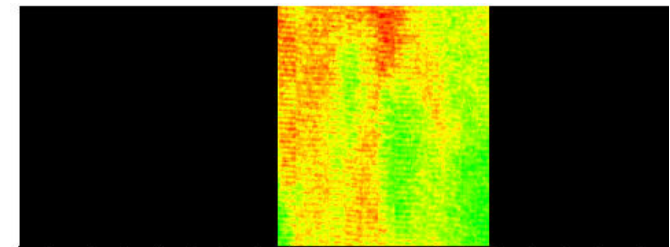
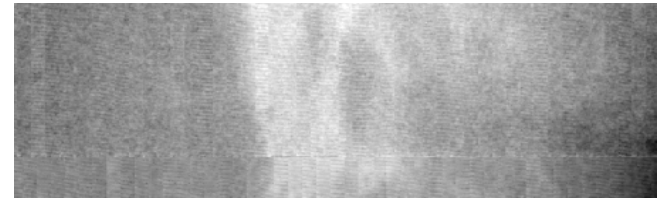
Diffraction image



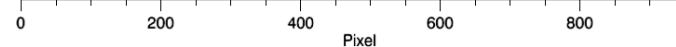
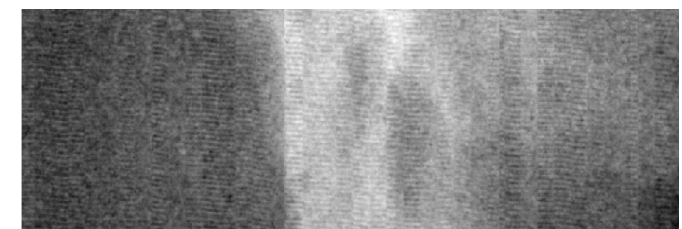
Diffraction results

- 46% incident exposure reduction to at least 58% of the total image area for all image
- Highlights at least 70% of the suspicious region in all instances

24.8 μGy

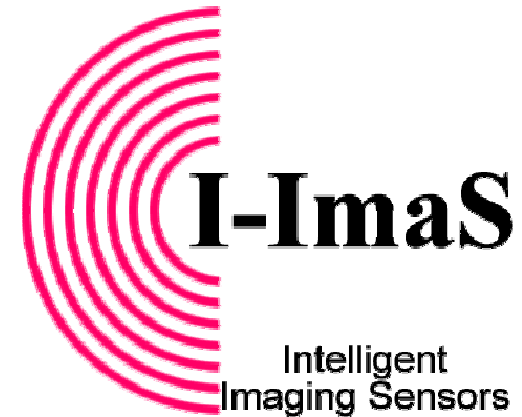


16.6 μGy



Conclusions

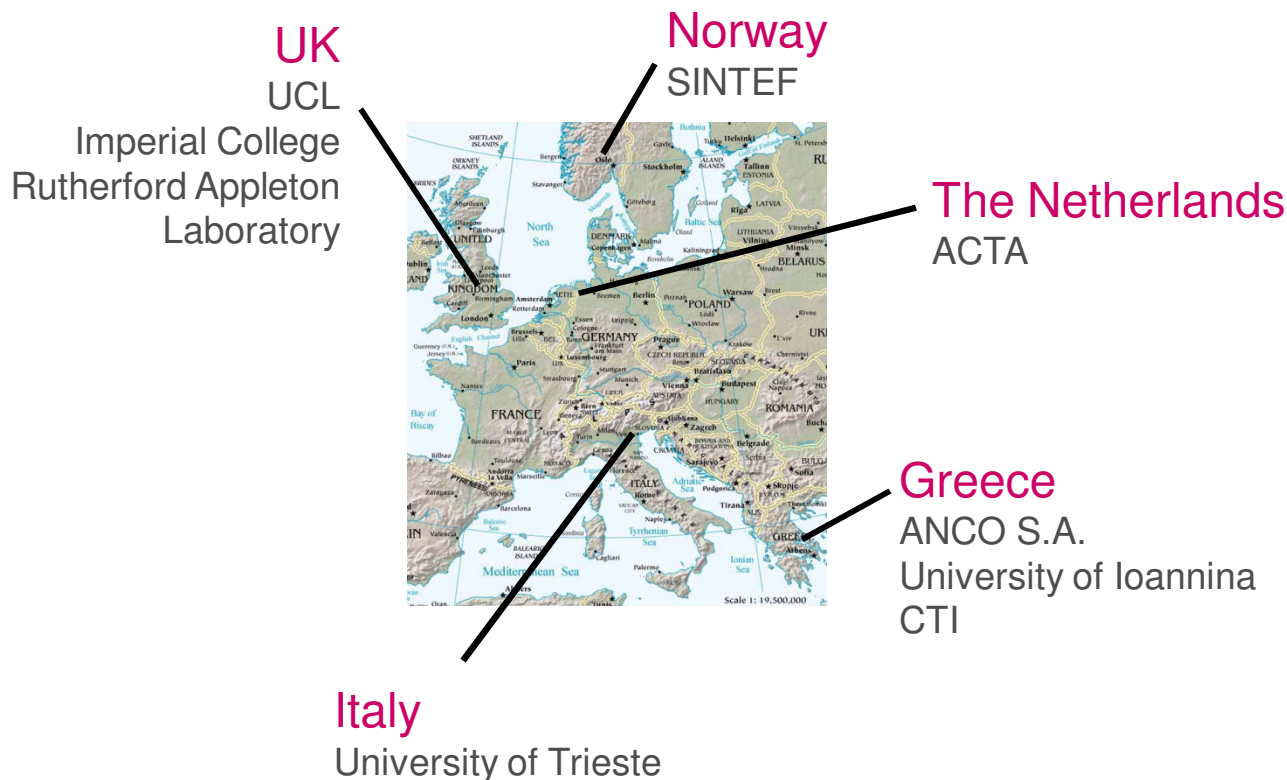
- Intelligent imaging system
 - Conceptualised and constructed
- Statistical intelligence
 - ‘better’ image for same dose
 - ‘same’ image for reduced dose
- Alternative data intelligence
 - Practical mechanism for using diffraction information, offering tissue discrimination



What next?

- Single pass optimised industrial imaging
 - Baggage scanners
- Security imaging
 - Distributed dose in full body images
 - Active dose modification/cut off
- Medical imaging
 - CT
 - Portal imaging for dosimetry

Acknowledgements



Funded under FP6: European Commission Priority 3: Nano-technologies and nano-sciences, knowledge-based multi-functional materials and new production processes and devices under Contract No. NMP-2-CT-2003-505593