Giving Science a New Image

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^{14}C autoradiography with a novel wafer scale CMOS Active Pixel Sensor

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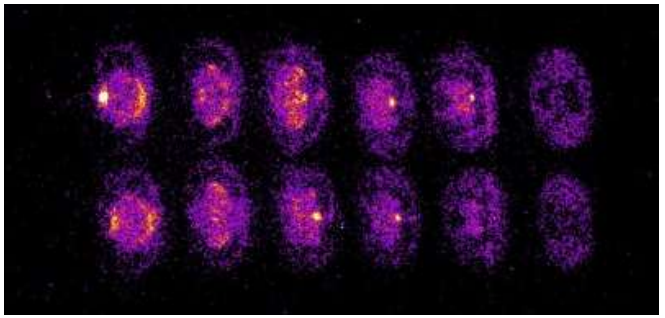
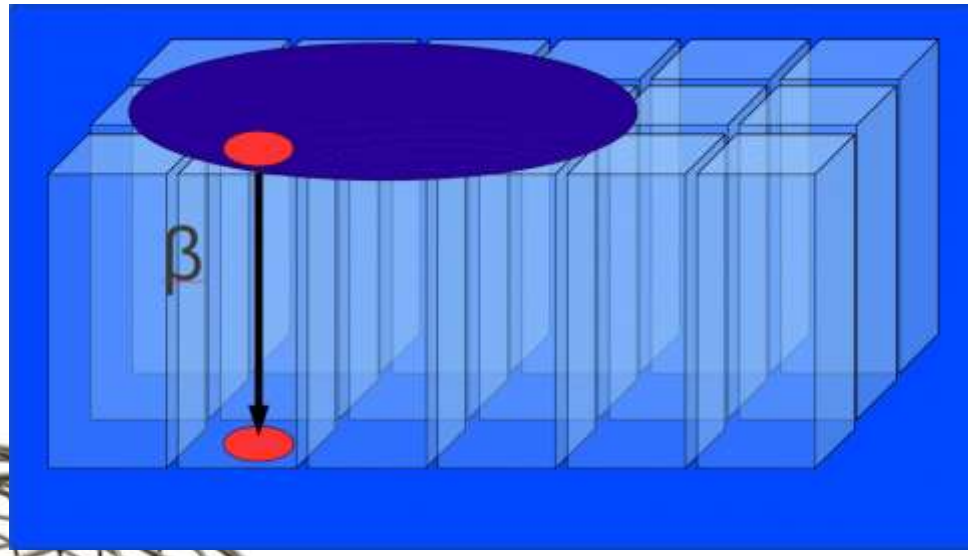
14TH INTERNATIONAL WORKSHOP
ON RADIATION IMAGING DETECTORS
1-5 JULY 2012
Figueira da Foz, Coimbra, PORTUGAL

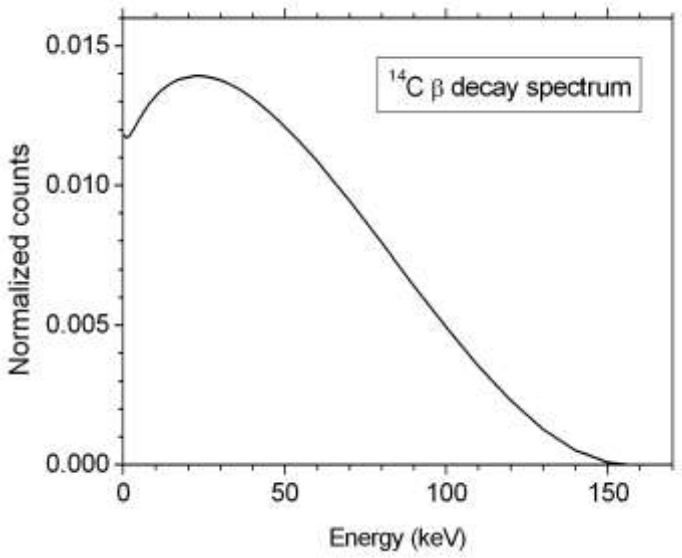
Contents

- Autoradiography in pre-clinical sciences
- Conventional detection medium
- Digital systems for autoradiography
- The DynAMITe detector for digital autoradiography
- Dark correction & cluster analysis
- Sensitivity
- ^{14}C labeled tissue imaging

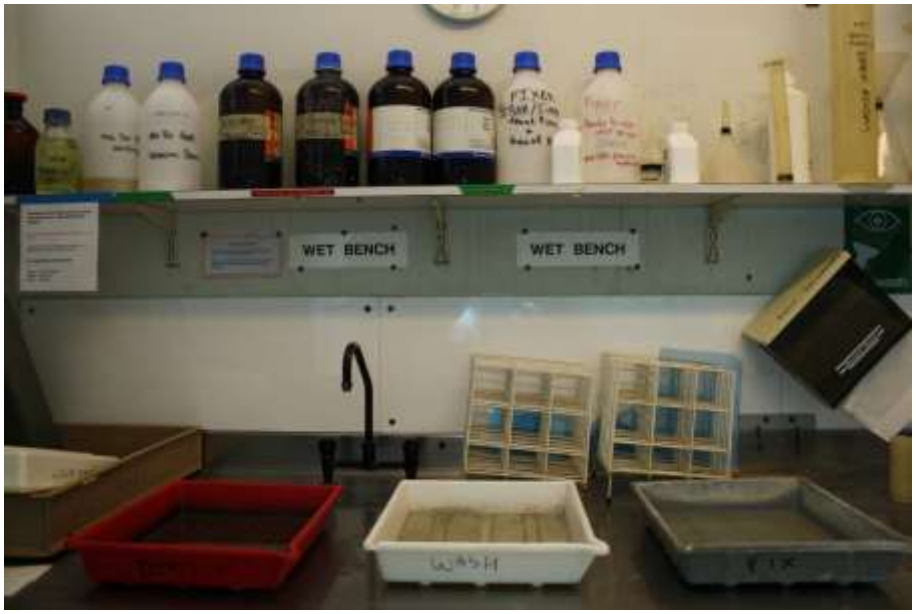
Autoradiography in pre-clinical sciences







Film emulsion



- Limited dynamic range
- Poor linearity
- Low sensitivity
- Need for lengthy exposures (up to several weeks)

Digital detectors for autoradiography

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DEPFET BIOSCOPE

J. Ulrici et al.
NIMA 465 2001

0.3 × 0.3 cm^2

MEDIPIX2

Mettivier et al.
IEEE IEEE TNS 52 (2005)

1.4 × 1.4 cm^2

Vanilla

Cabello et al. Proc. SPIE 7258 (2009)

1.3× 1.3 cm^2

Timepix

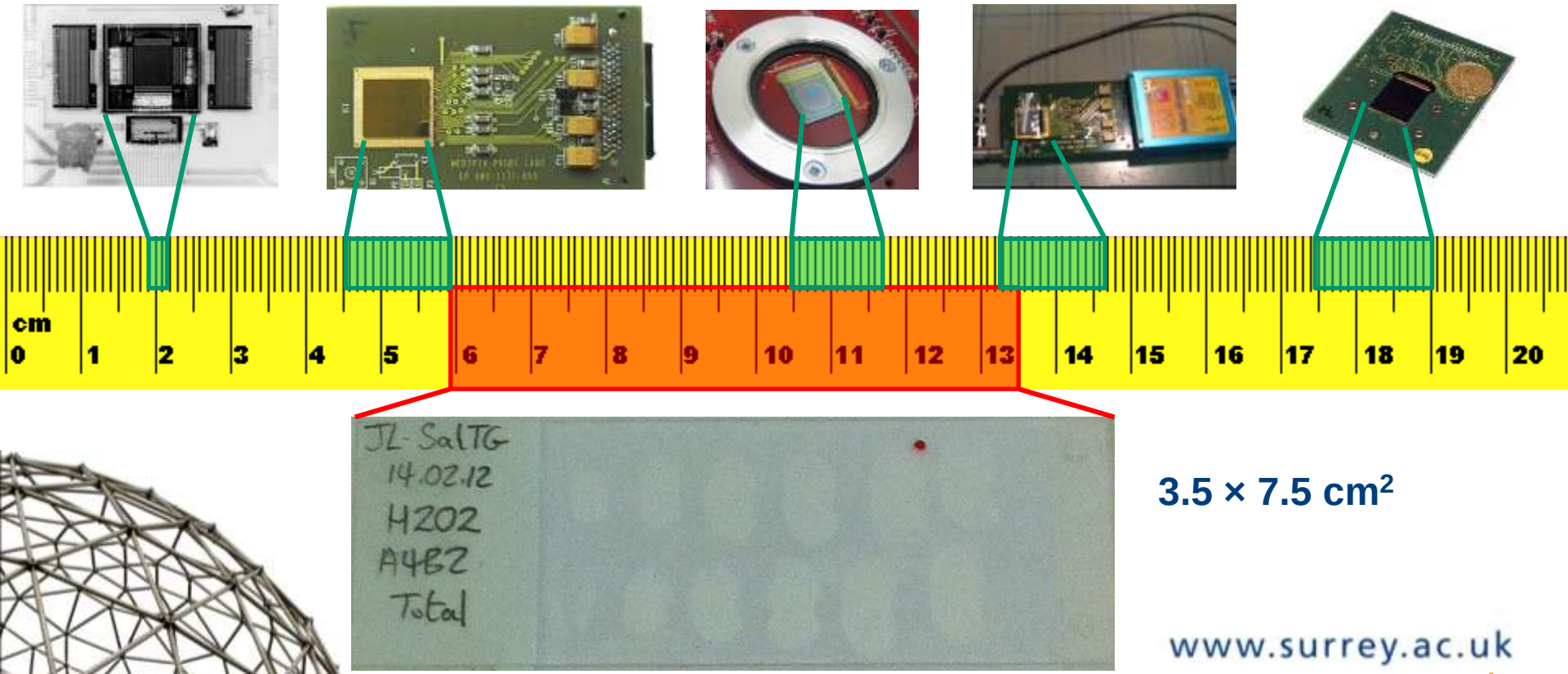
Esposito et al.
PMB 56 (2011)

1.4× 1.4 cm^2

MIMOSA V

Deputch et al
NIMA .543 (2005)

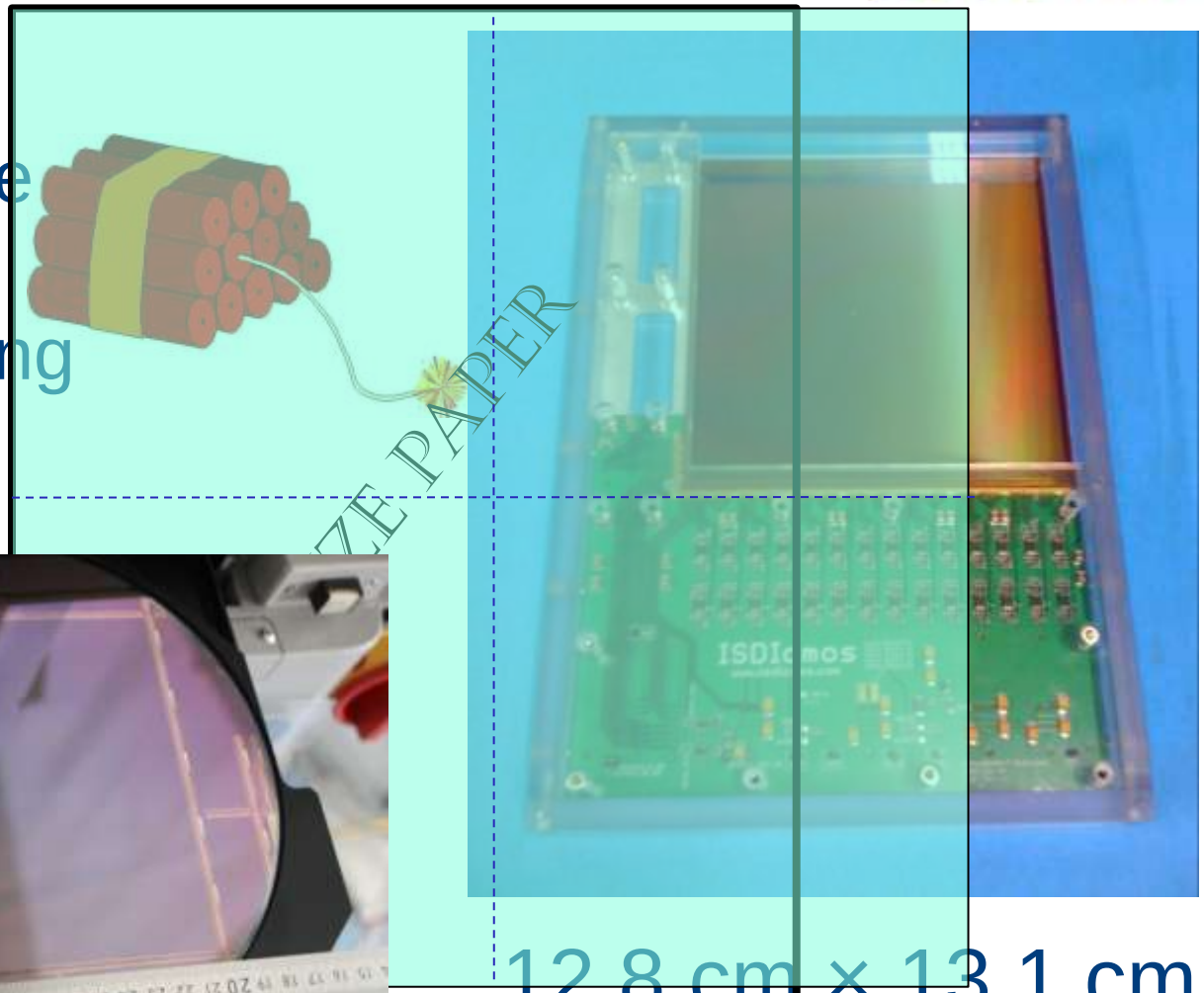
1.7 × 1.7 cm^2

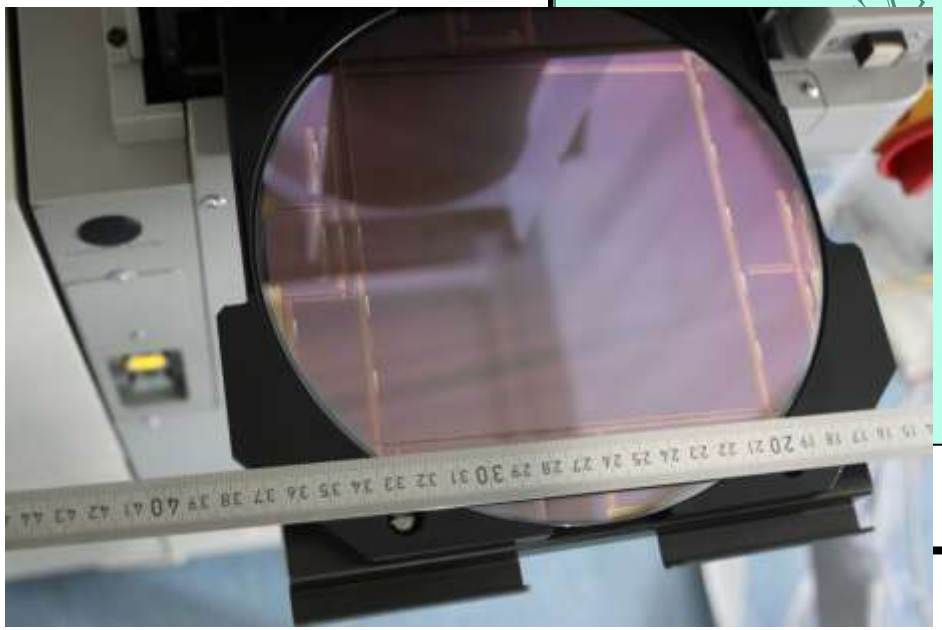


3.5 × 7.5 cm^2

The DynAMITe CMOS Active Pixel Sensor

Dynamic range
Adjustable for
Medical Imaging
Technology





12.8 cm × 13.1 cm
2 side buttable

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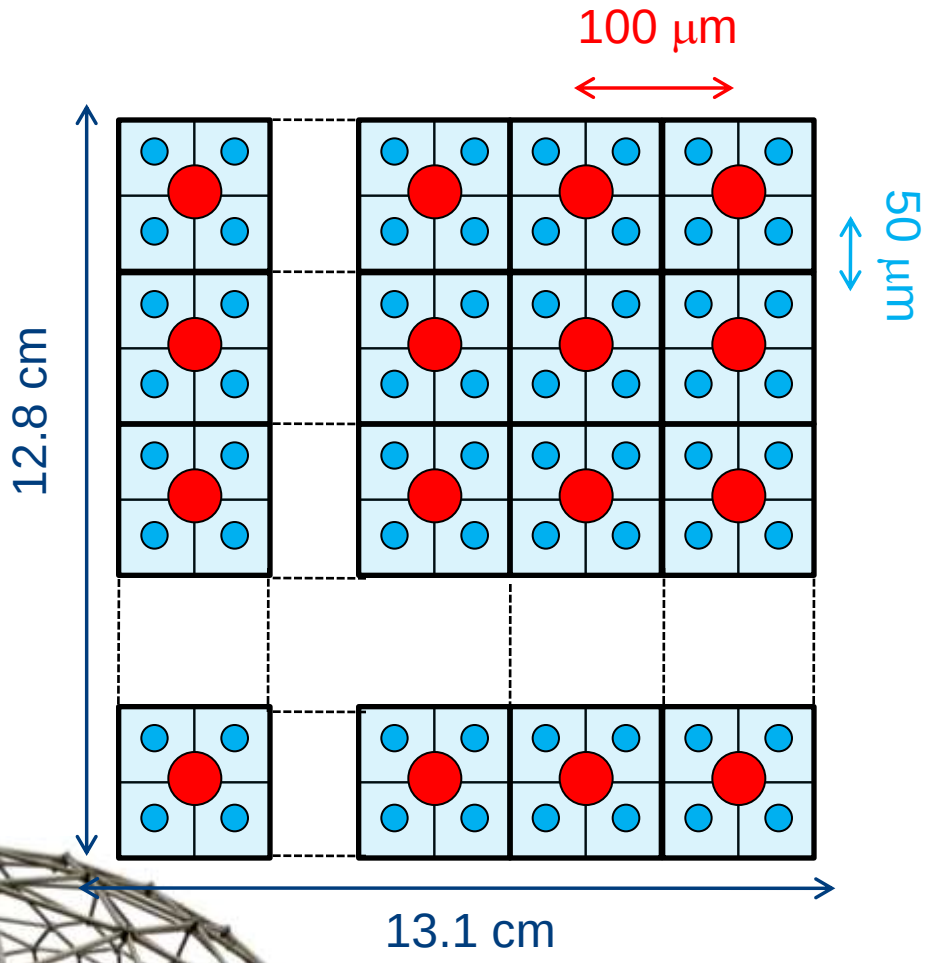
The DynAMITe concept: two detectors in one



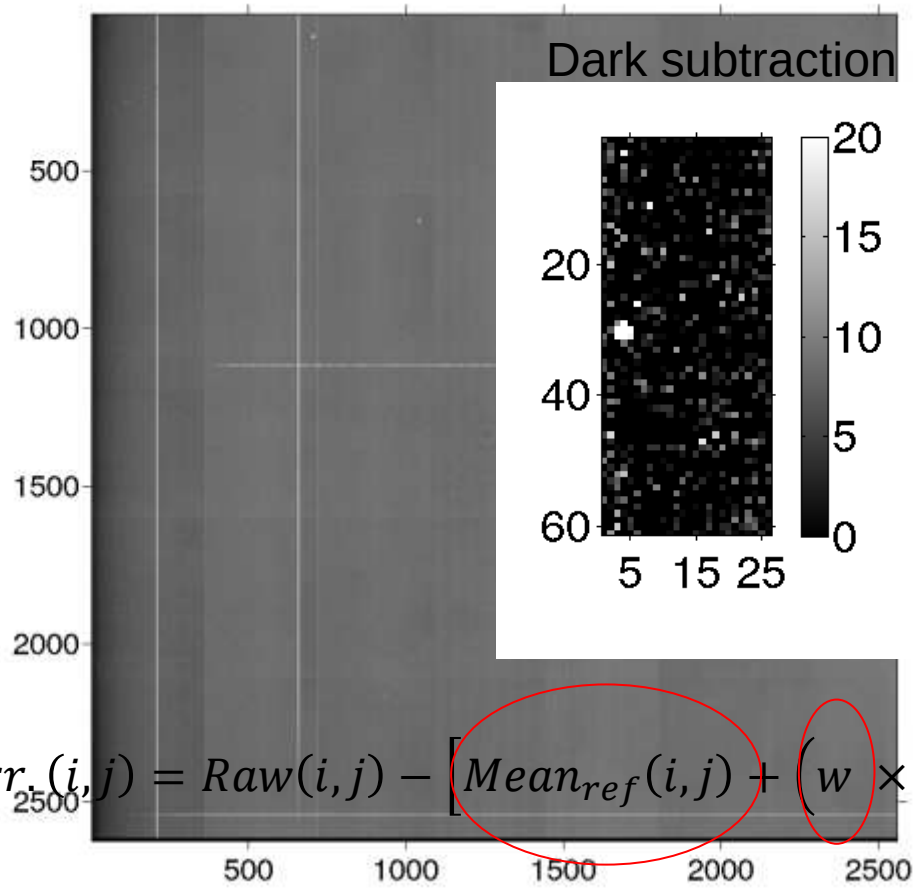
1280×1312 Pixels (P)
100 μm pitch

2560×2624 Sub-Pixels (SP)
50 μm pitch

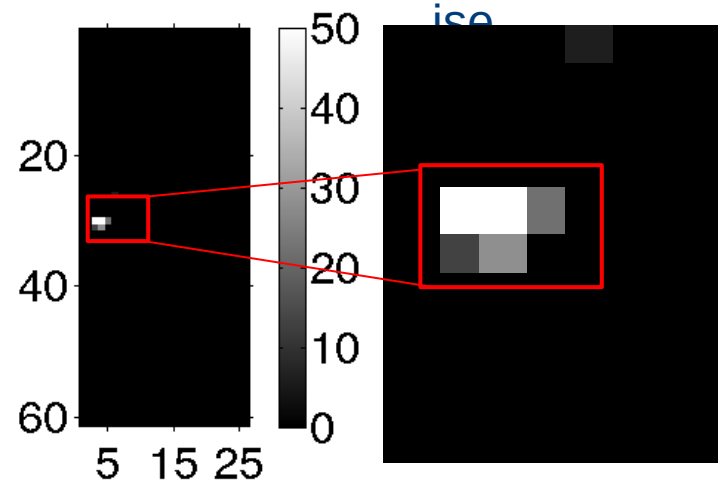
- Non destructive readout (CDS)
- Online dose sensing

Radiation hard

Dark correction



Adaptive dark correction



Flickering pixels

$$Corr.(i,j) = Raw(i,j) - \left[Mean_{ref}(i,j) + \left(w \times Mean_{ref}(i,j)\right) + 3 \times Sdev_{ref}(i,j)\right]$$

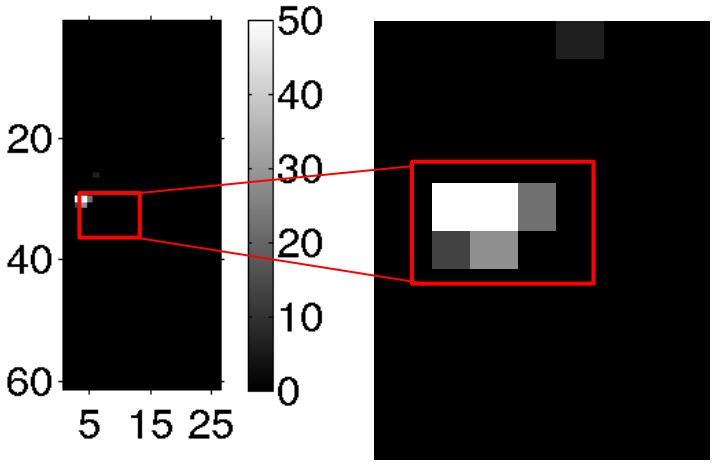
Offset

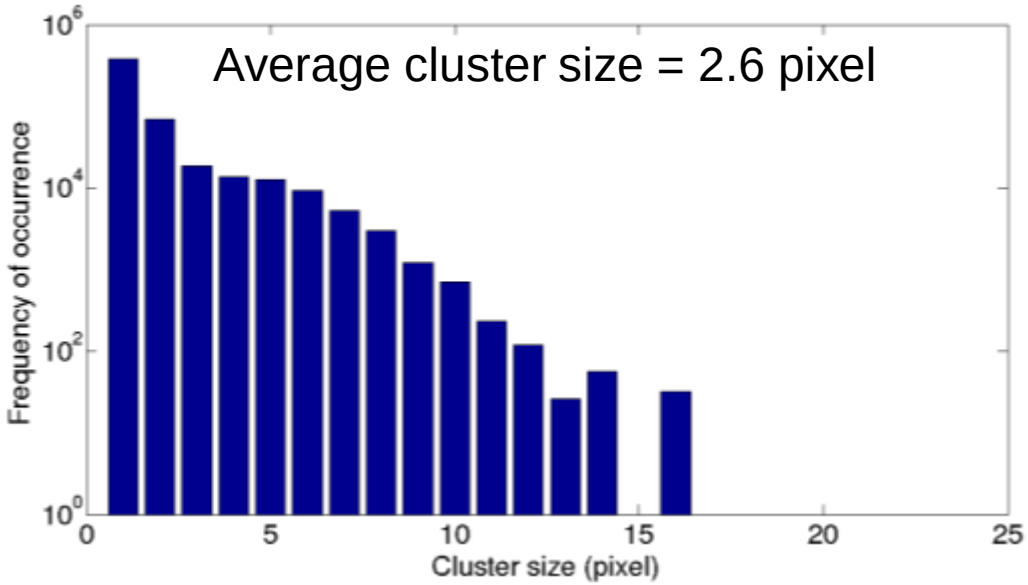
Temperature drift

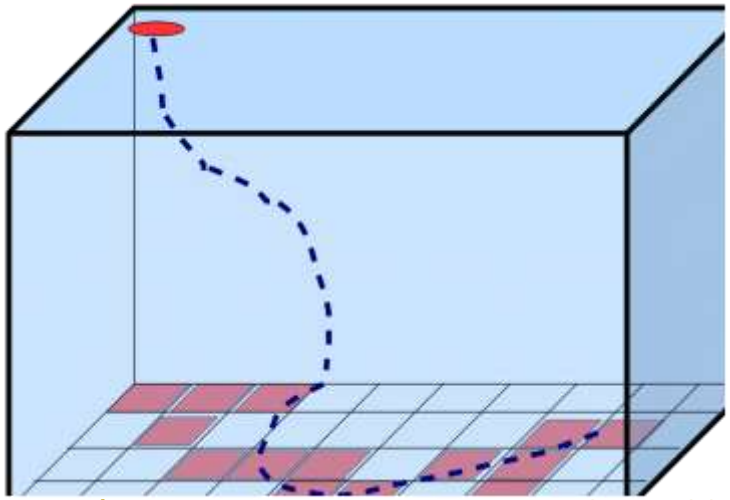
Temporal noise

$$w = \frac{\overline{Mean_{ref}} - \overline{Mean_{curr}}}{\overline{Mean_{ref}}}$$

Cluster analysis

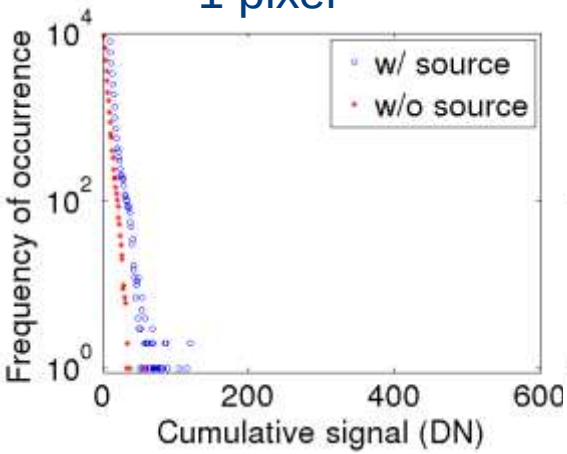




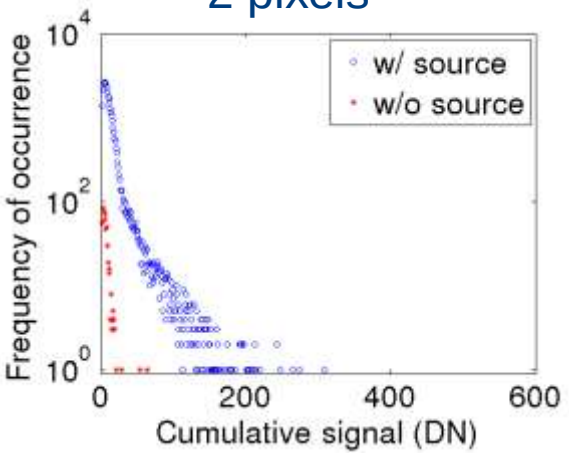


Cluster analysis

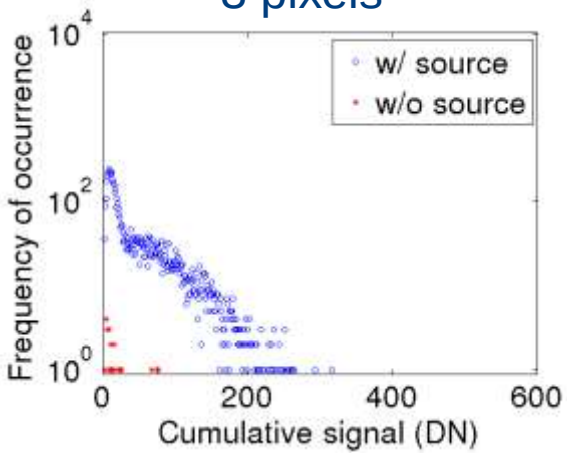
1 pixel



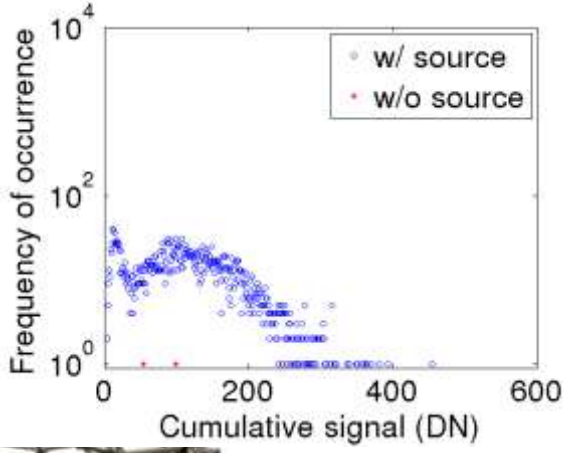
2 pixels



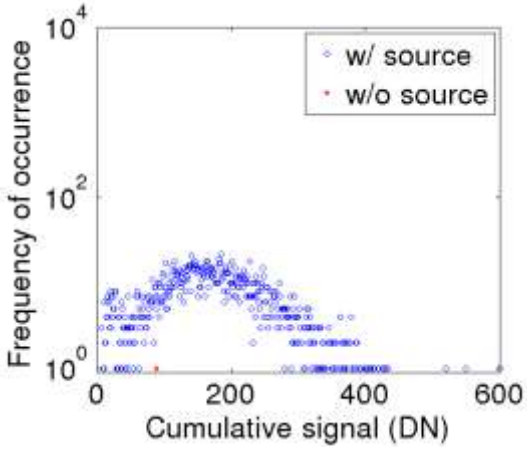
3 pixels



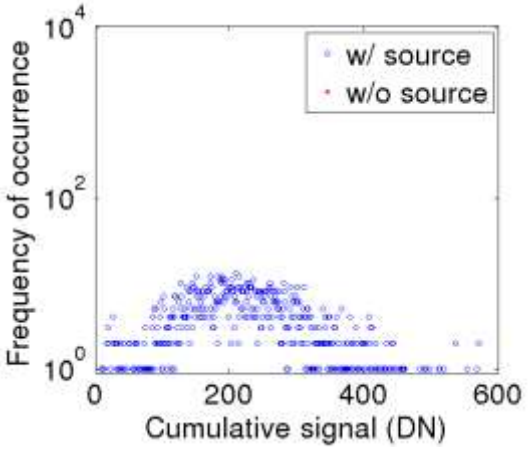
4 pixels



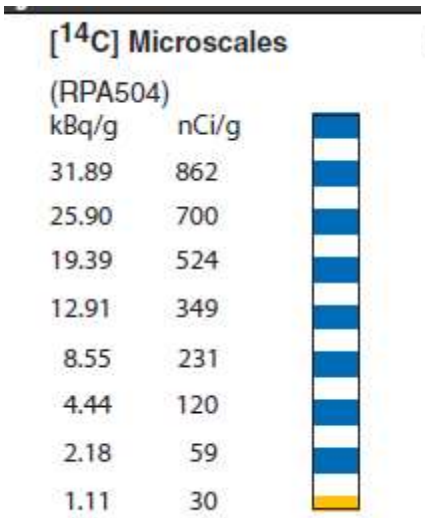
5 pixels

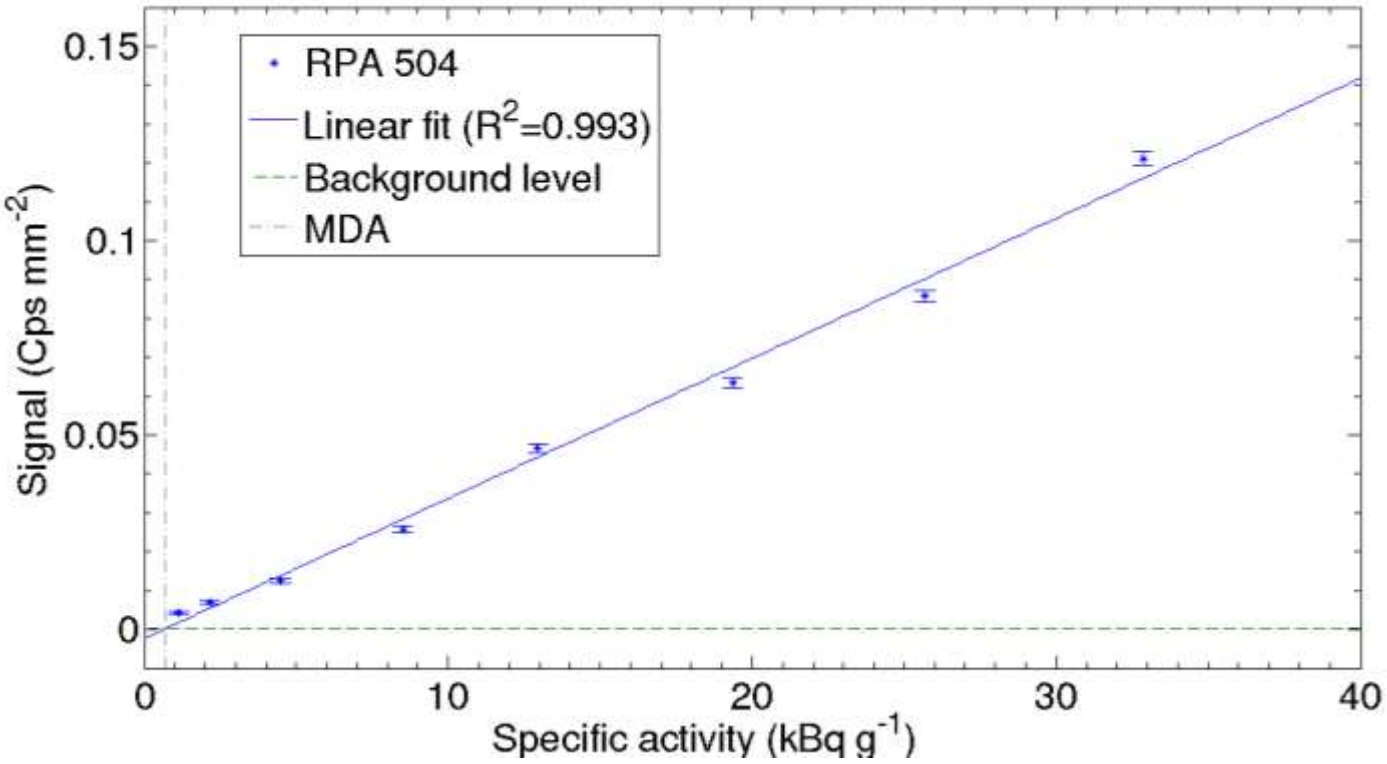


6 pixels



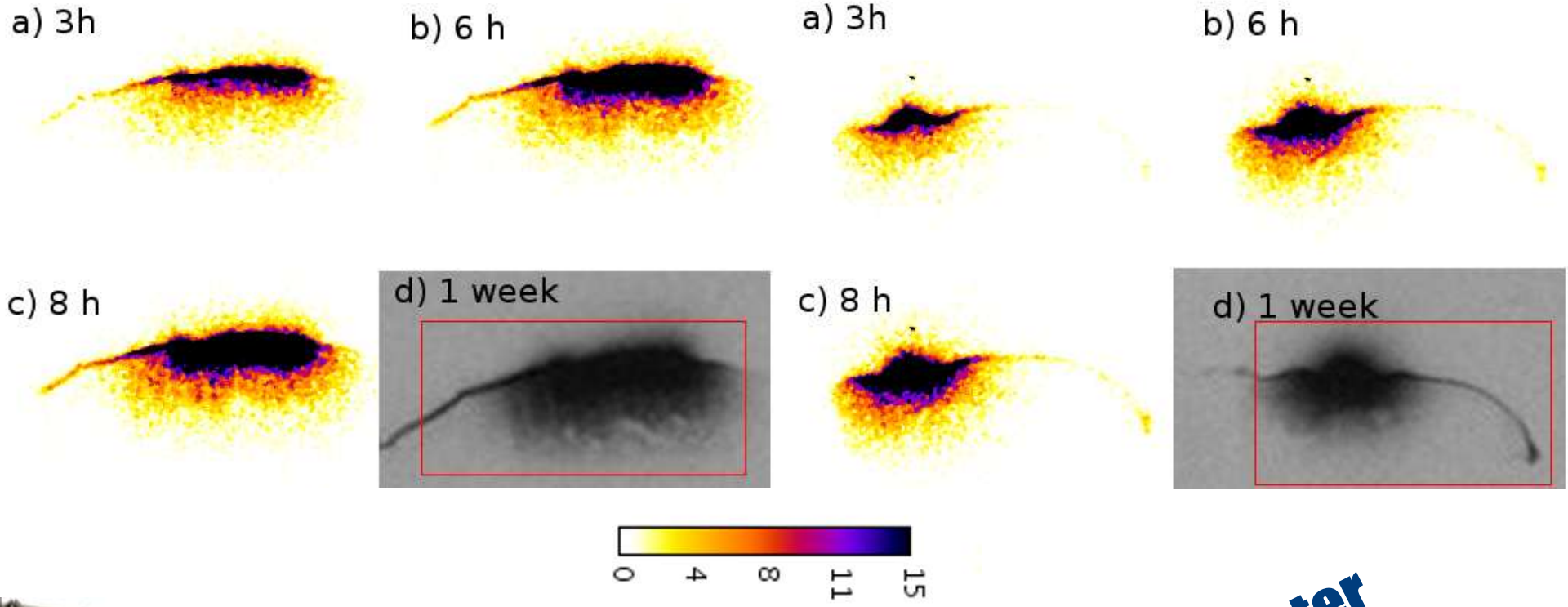
Sensitivity





Sensitivity (cps g kBq^{-1} mm^{-2})	Exp. Time (h)	Background (cps mm^{-2})	MDA (Bq)
3.6 × 10^{-3}	2	2.18× 10^{-4}	0.06

Tissue imaging

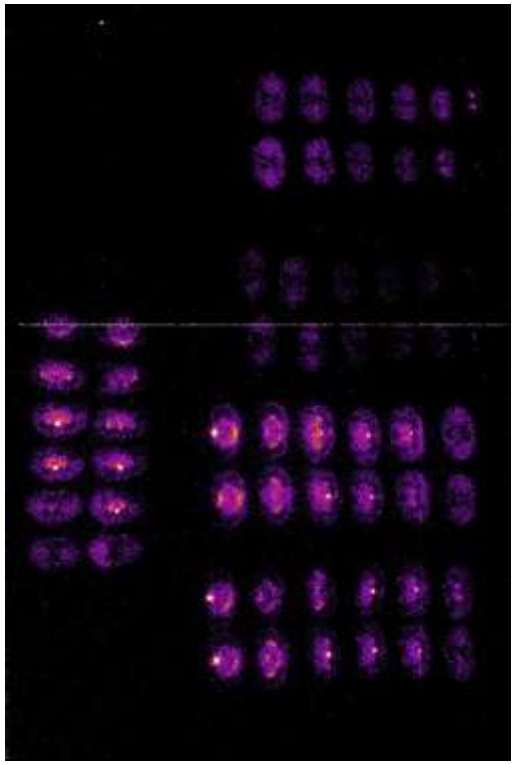


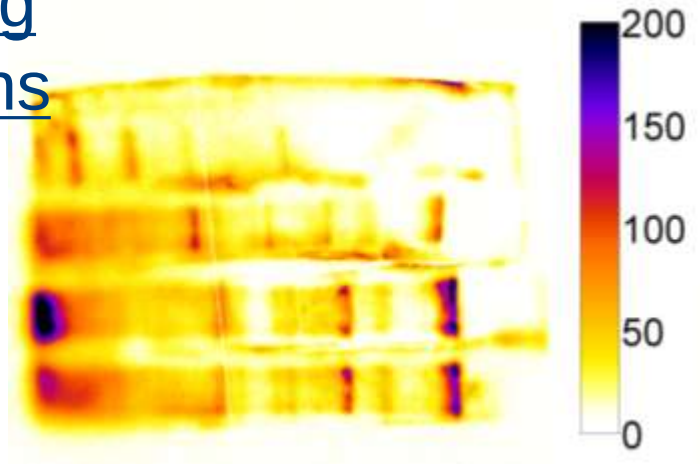
Porcine snout tissue sections labeled with ^{14}C- sulphur mustard

30 times faster

Conclusions

- The DynAMIte CMOS APS has been characterised as suitable system for digital autoradiography
- Dark correction & cluster analysis
- Tissue imaging and comparison with film images
- Single platform technology to be used across a range of pre-clinical ionizing and non-ionizing imaging applications





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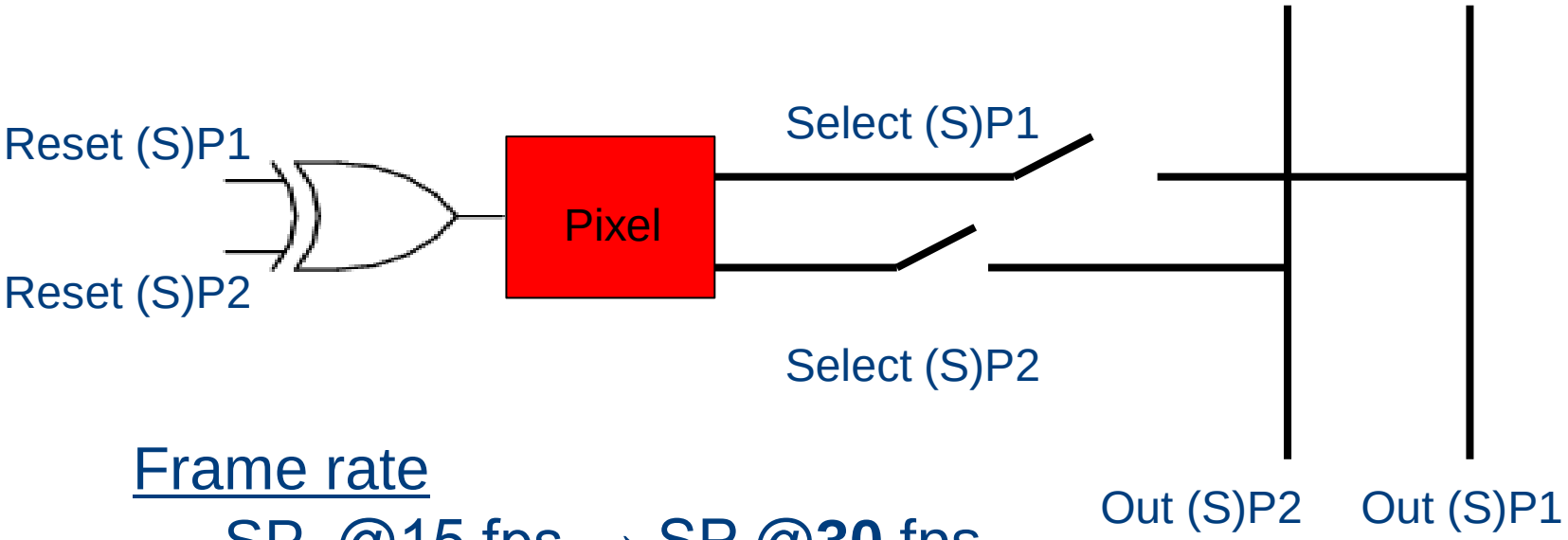
Single Pixel readout



Frame rate

SP_i @15 fps → SP @**30** fps

P_i @45 fps → P @**90** fps

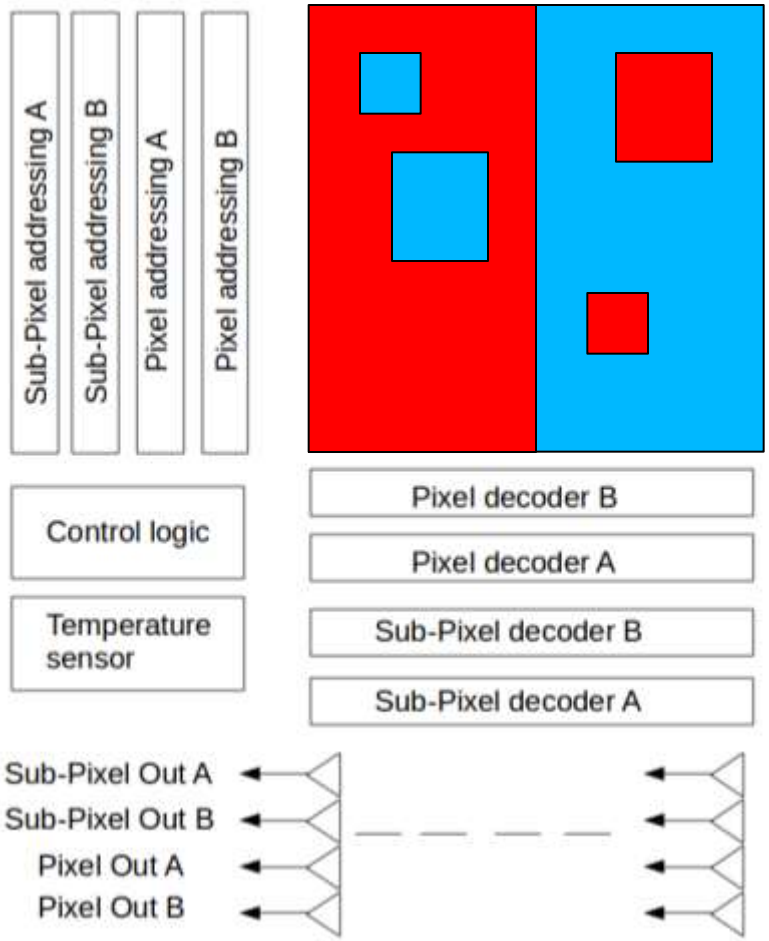
Region of interest (100×100)

SP_i @370fps → SP_i @**740** fps

DynAMITe: readout

- Pixels
- Sub-Pixels
- Pixels & Sub-Pixels
- Pixels & Sub-Pixels (ROI)
- Sub-Pixels & Pixels (ROI)

Non destructive readout
Correlate double sampling
Online dose sensing



PTC

523 nm

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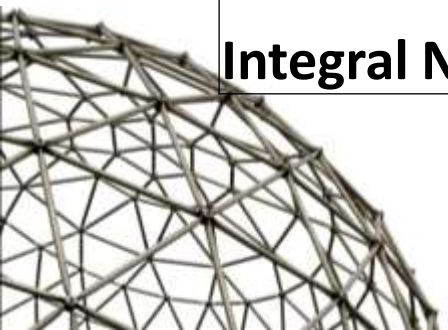
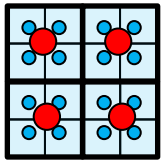
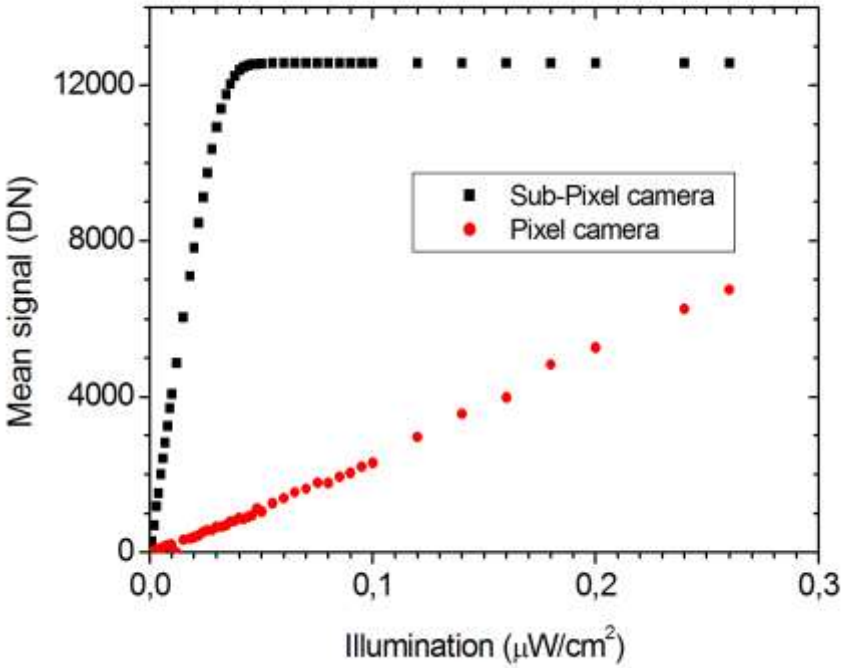
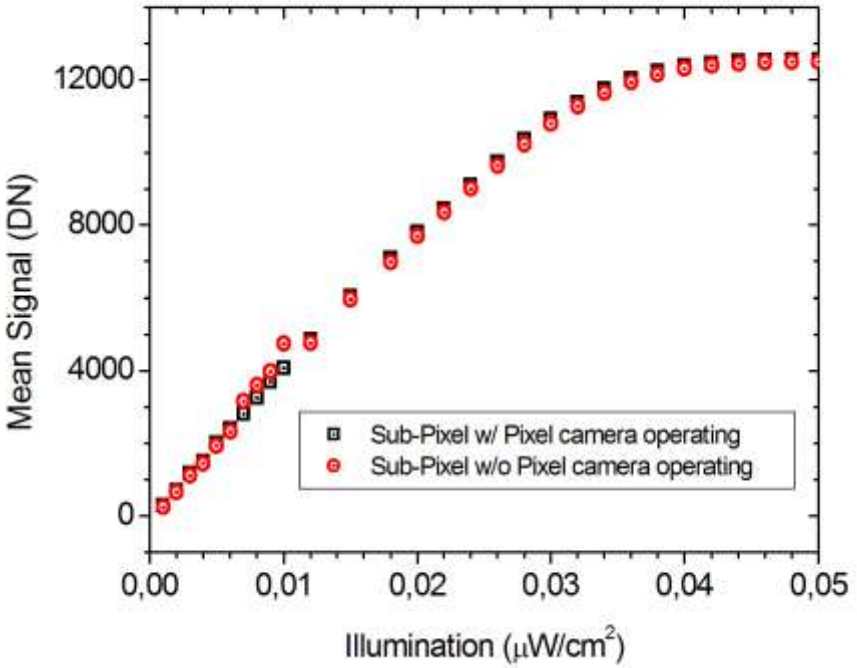
		Sub-Pixels	Pixels
Conversion Gain	e-/DN	50.0	293.3
Read Noise	e-	149.9	780.1
Full Well Capacity	10^5e-	2.8	1.9
Quantum Efficiency	%	45.2	38
Dynamic Range	dB	65.3	68
Linearity	%	65.2	67
Integral Non Linearity	%	0.4	2



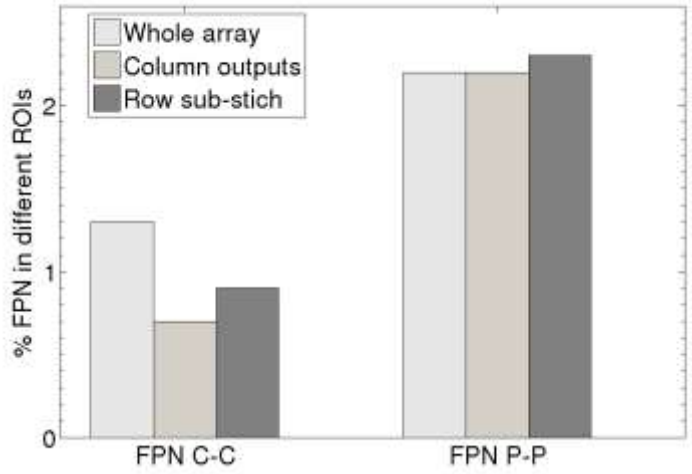
Charge collection tests





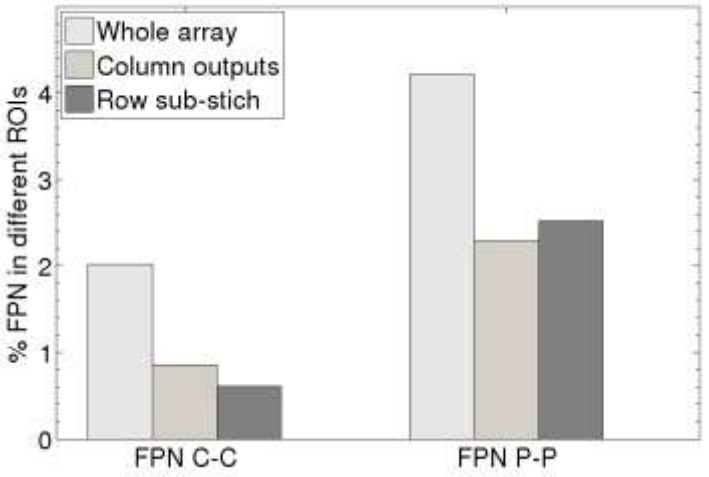


P camera: FPN



P camera

SP camera



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