

# DynAMITe: a Wafer Scale Sensor for Biomedical Applications

M. Esposito<sup>1</sup>, T. Anaxagoras<sup>2</sup>, A. Fant<sup>2</sup>, K. Wells<sup>1</sup>,  
A. Kostantinidis<sup>3</sup>, J. Osmond<sup>4</sup>, P. Evans<sup>4</sup>,  
R. Speller<sup>3</sup> and N. Allinson<sup>2</sup>

<sup>1</sup>University of Surrey, Guildford, U.K.

<sup>2</sup>University of Lincoln, Lincoln, U.K.

<sup>3</sup>University College London, London, U.K.

<sup>4</sup>Institute for Cancer Research, Sutton, U.K.

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# Contents



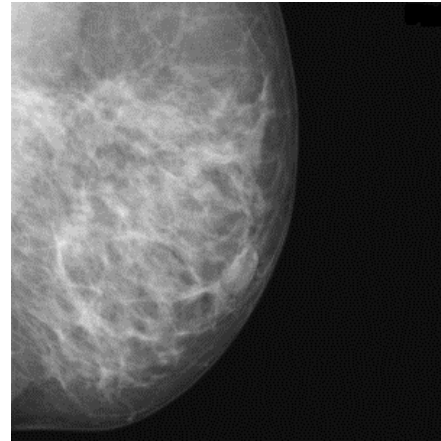
- **Biomedical imaging requirements**
- **Large area imaging detector with bimodal dynamic range and resolution**
- **Pixel structure and readout architecture**
- **Optical testing**
  - Conversion gain/ Read Noise/ Quantum efficiency/ FWC
  - Charge collection test
  - Non destructive readout- two separated readouts



# Large area imaging detectors

## Large Area Detectors

Near real time frame rate



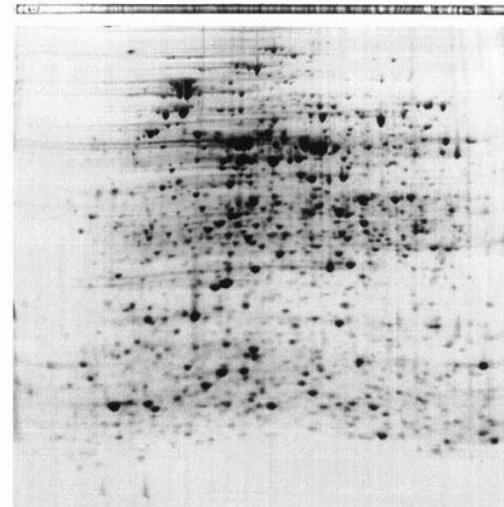
<http://lemur.cmp.uea.ac.uk/>

K. Lee et al.,  
*J. Bone Joint. Surg. Am.* 2010;92:2709-18.

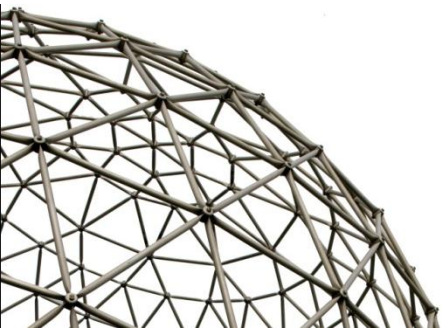
## Flat Panel Imagers

- Large pixels
- High noise
- Low frame rate
- Artefacts

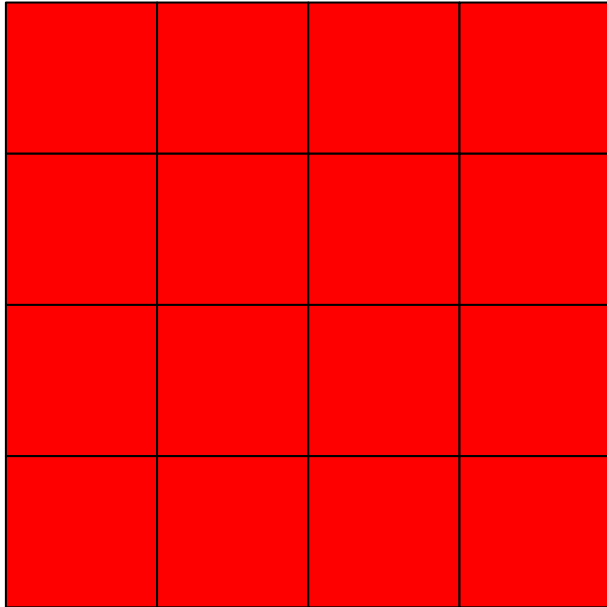
## CMOS APS



<http://www.aesociety.org/>



# Biomedical Imaging detectors



Large Pixels →  
High dynamic range



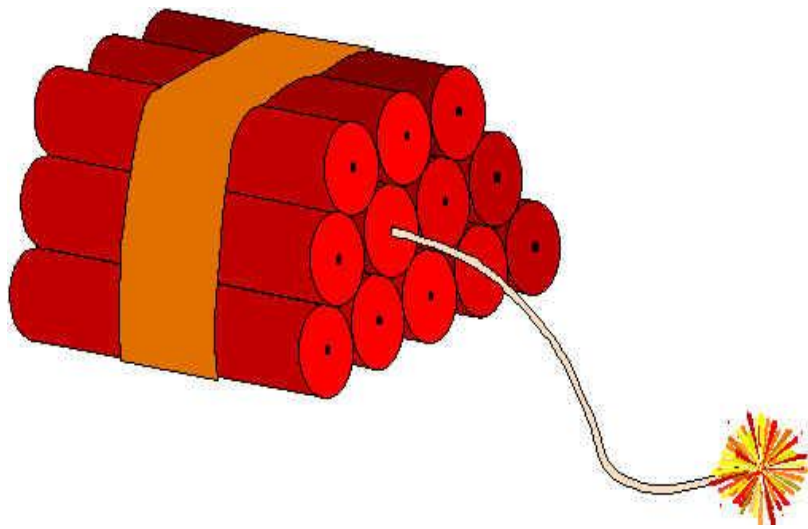
Low Noise  
High Spatial Resolution  
High Dynamic range

Small Pixels →  
Low Noise  
High Spatial Resolution

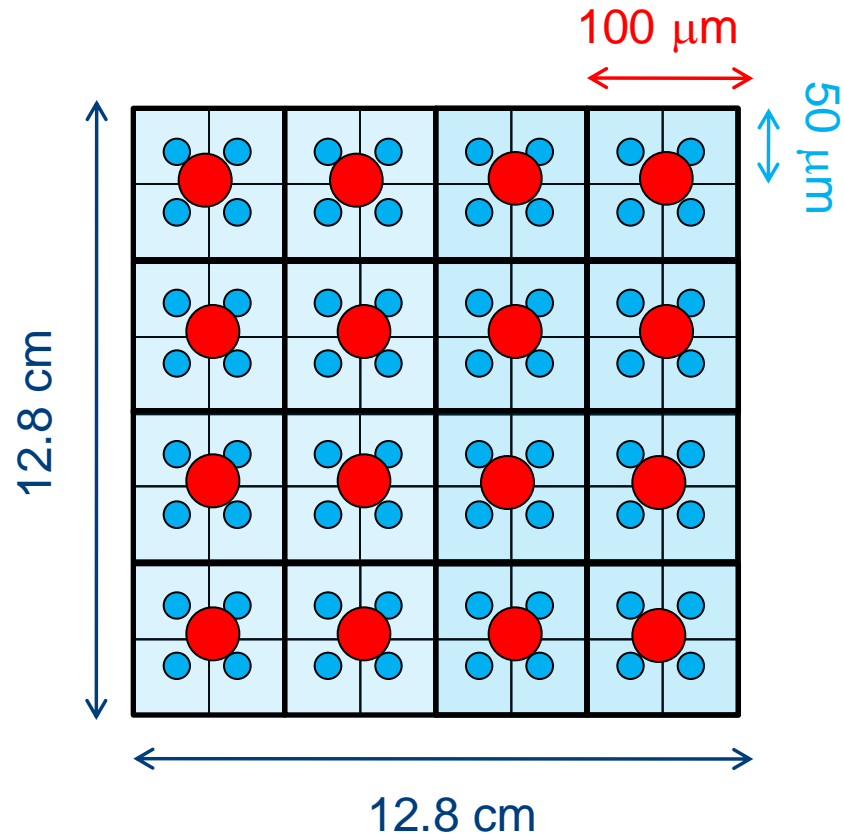




# The DynAMITe detector

12.8 cm × 12.8 cm  
2 side buttable



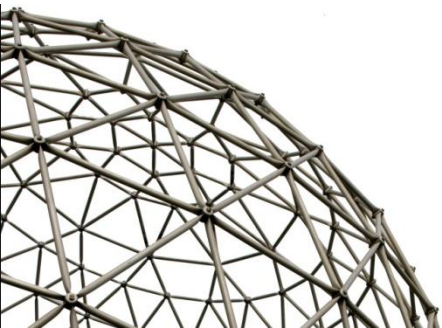
# DynAMITe: sensor architecture



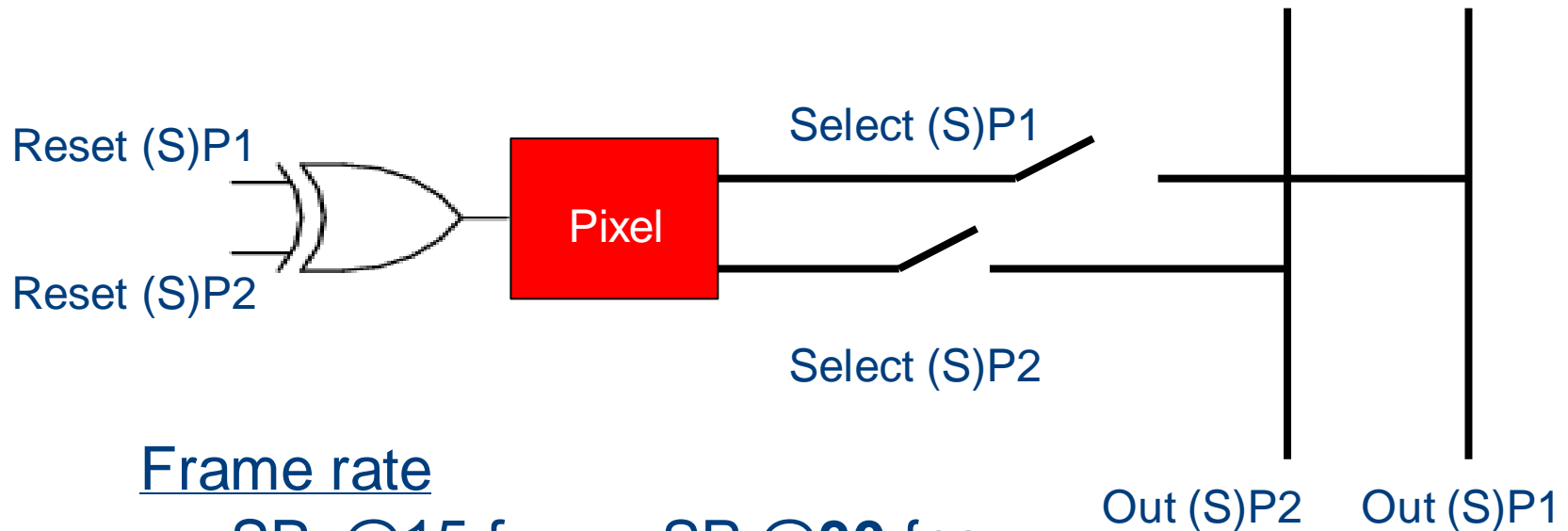
- 
 1260  $\times$  1280 Pixels (P)  
 100  $\mu\text{m}$  pitch
- 
 2520  $\times$  2560 Sub-Pixels (SP)  
 50  $\mu\text{m}$  pitch

Different reset voltages  $\rightarrow$

Different depletion widths



# Single Pixel readout



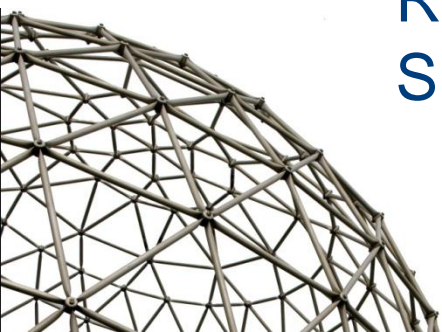
## Frame rate

$SP_i$  @15 fps  $\rightarrow$  SP @**30** fps

$P_i$  @45 fps  $\rightarrow$  P @**90** fps

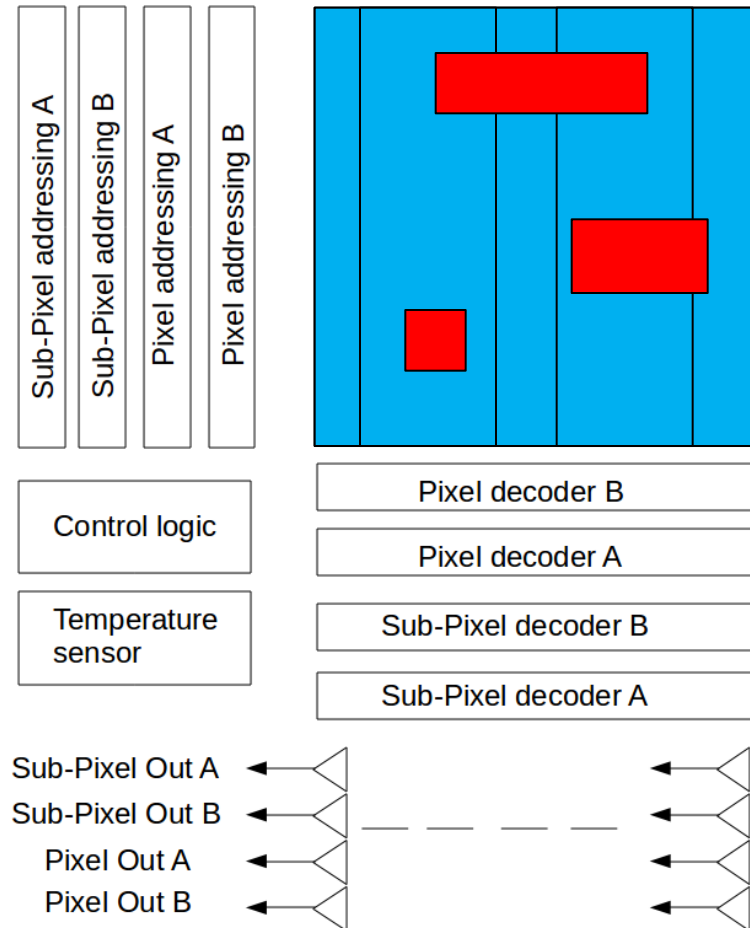
Region of interest ( $100 \times 100$ )

$SP_i$  @370fps  $\rightarrow$   $SP_i$  @**740** fps



# DynAMITe: readout

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



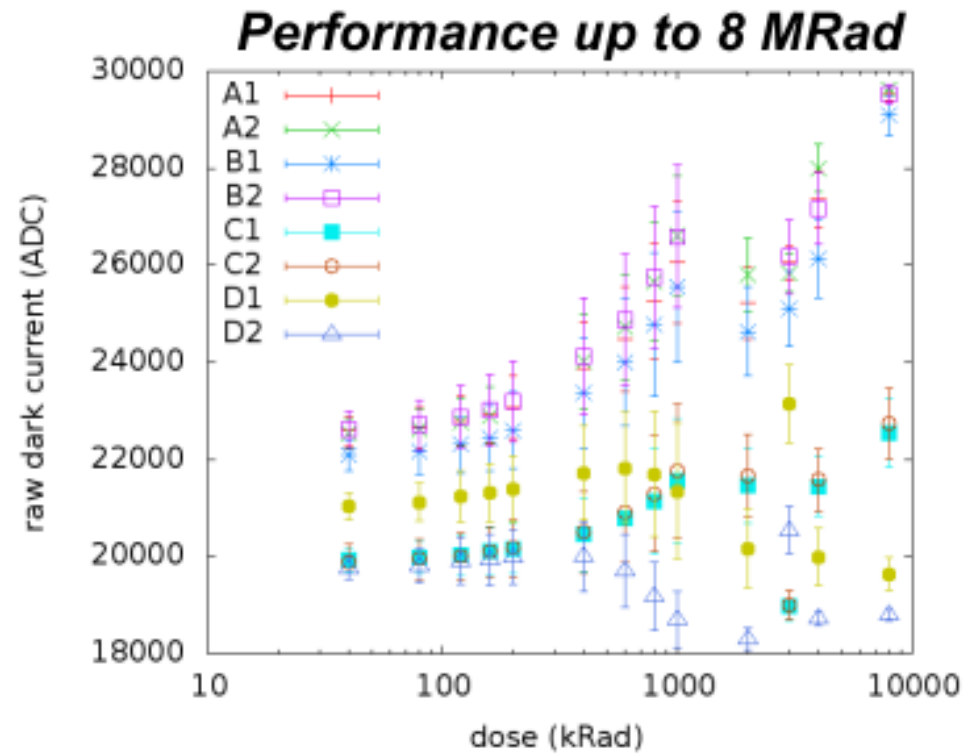
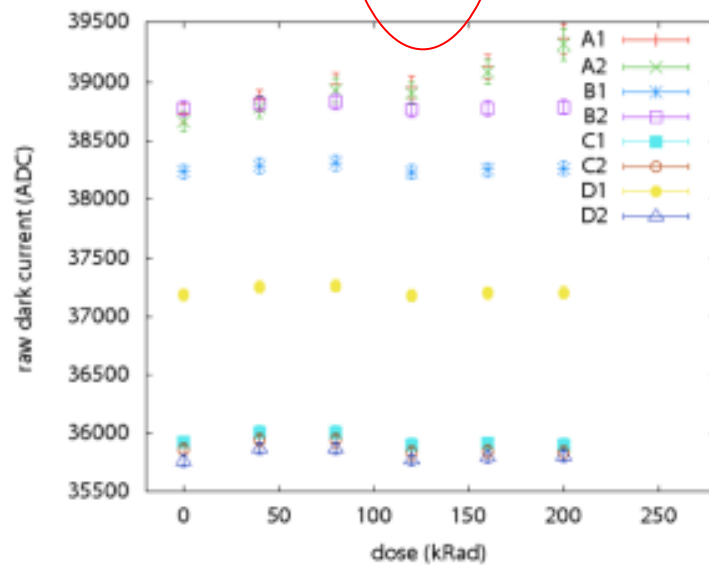
**Non destructive readout  
Online dose sensing**



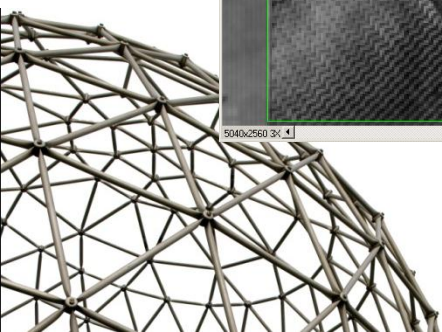


# Radiation hardness

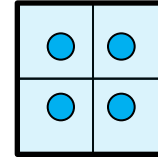
A1	B1	C1	D1
A2	B2	C2	D2



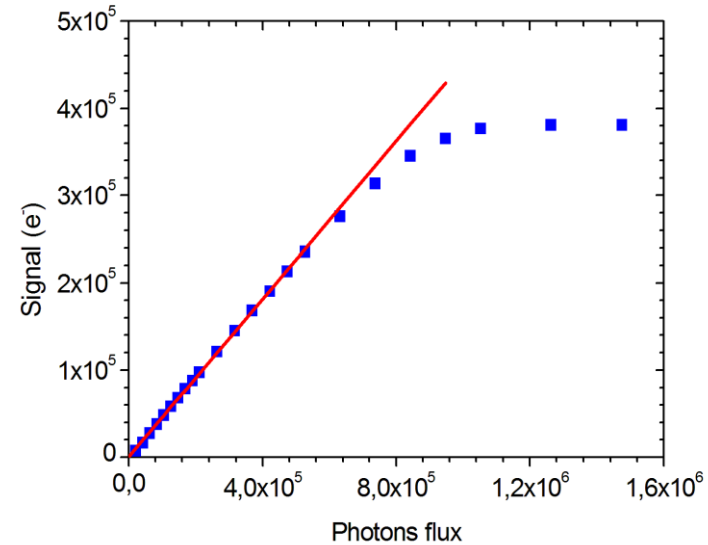
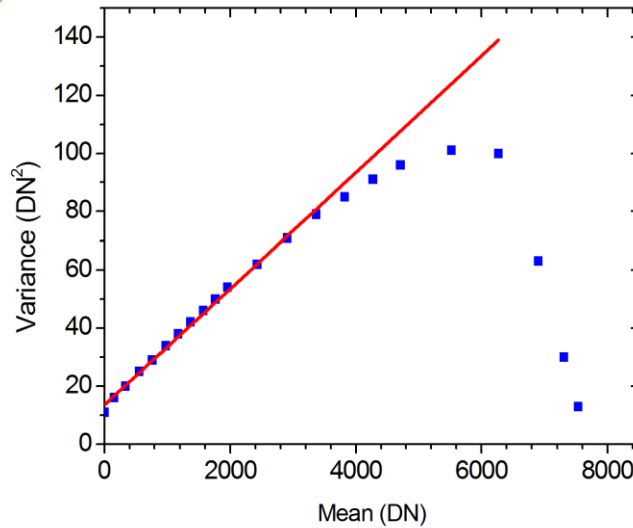
# First images with DynAMITe



# Optical performance (Sub-Pixels)

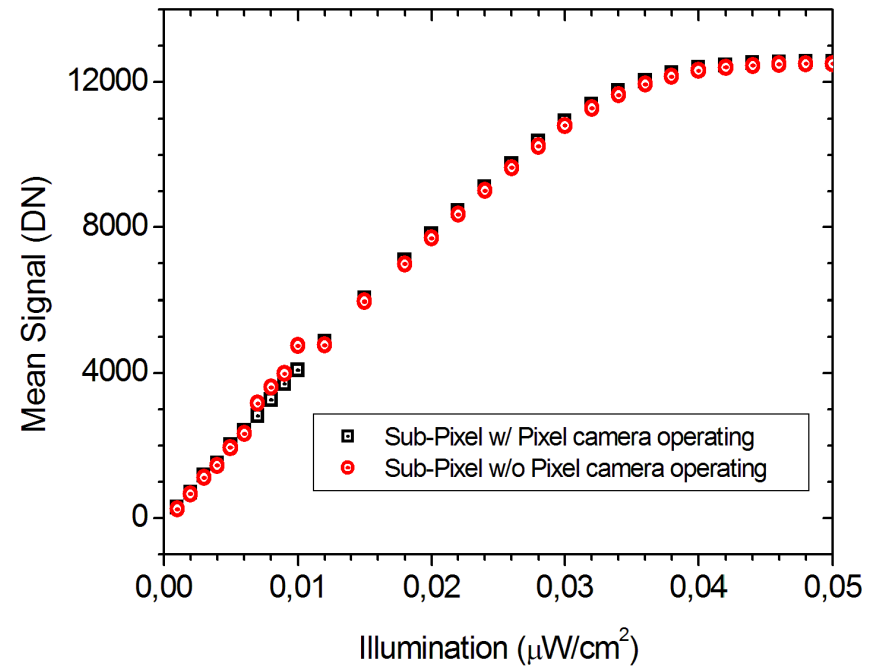
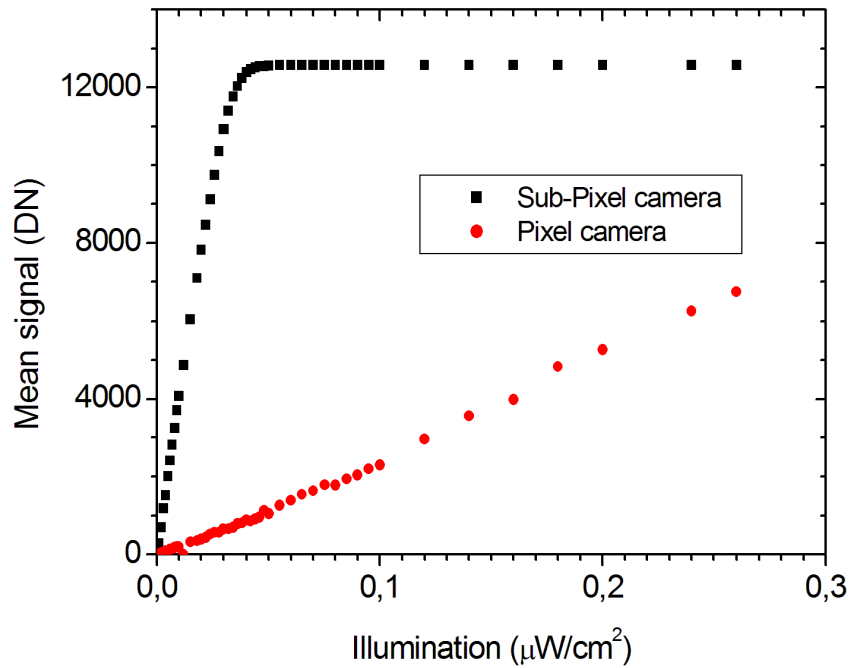
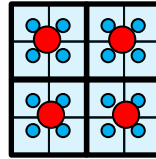


523 nm

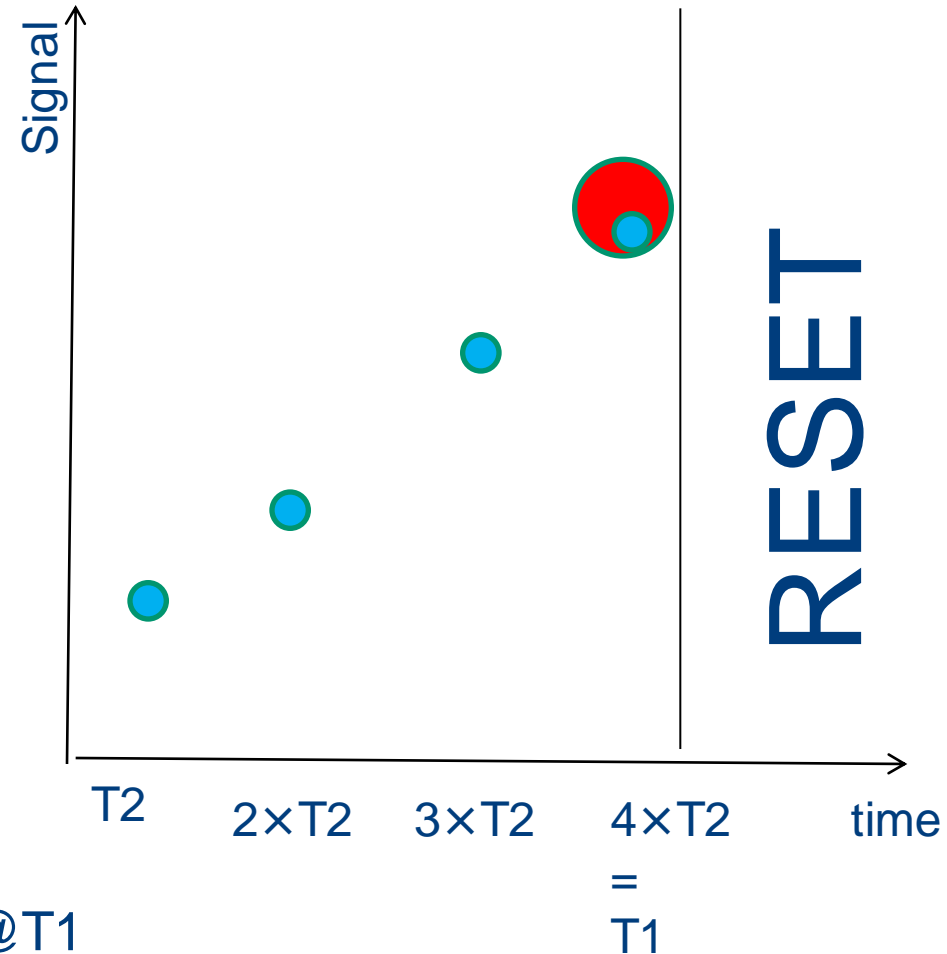
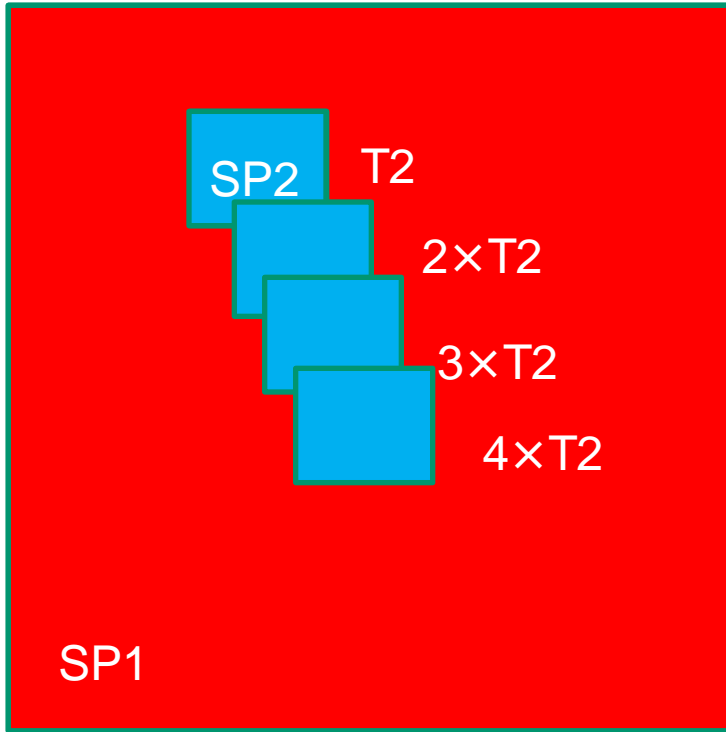


<b>Conversion Gain</b>	e-/DN	$50.0 \pm 0.2$
<b>Read Noise</b>	e-	$149.9 \pm 0.7$
<b>Full Well Capacity</b>	$10^5 e^-$	$2.8 \pm 0.2$
<b>Quantum Efficiency</b>	%	45.2
<b>Dynamic Range</b>	dB	65.3
<b>Linearity</b>	%	65.2
<b>Integral Non Linearity</b>	%	0.4

# Charge collection tests



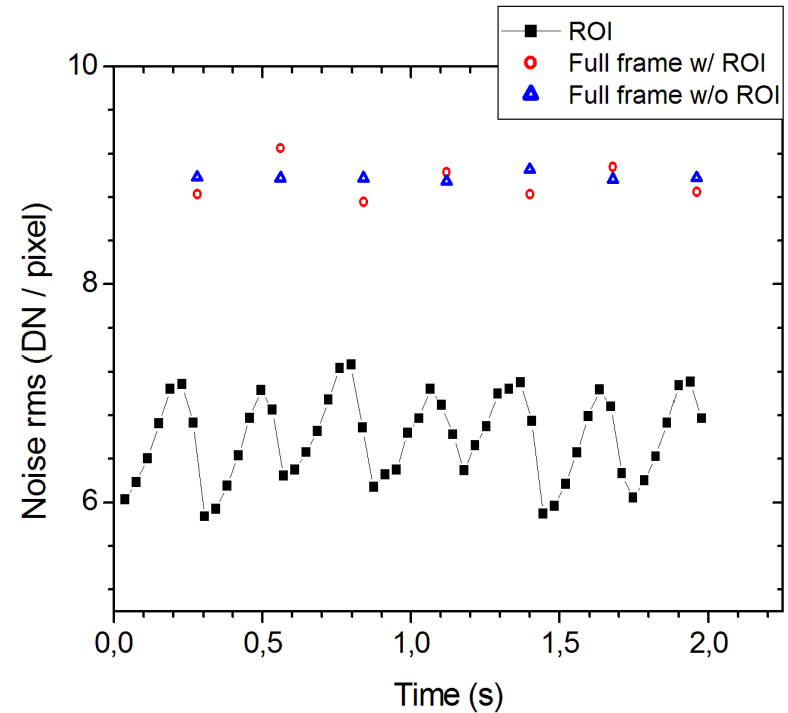
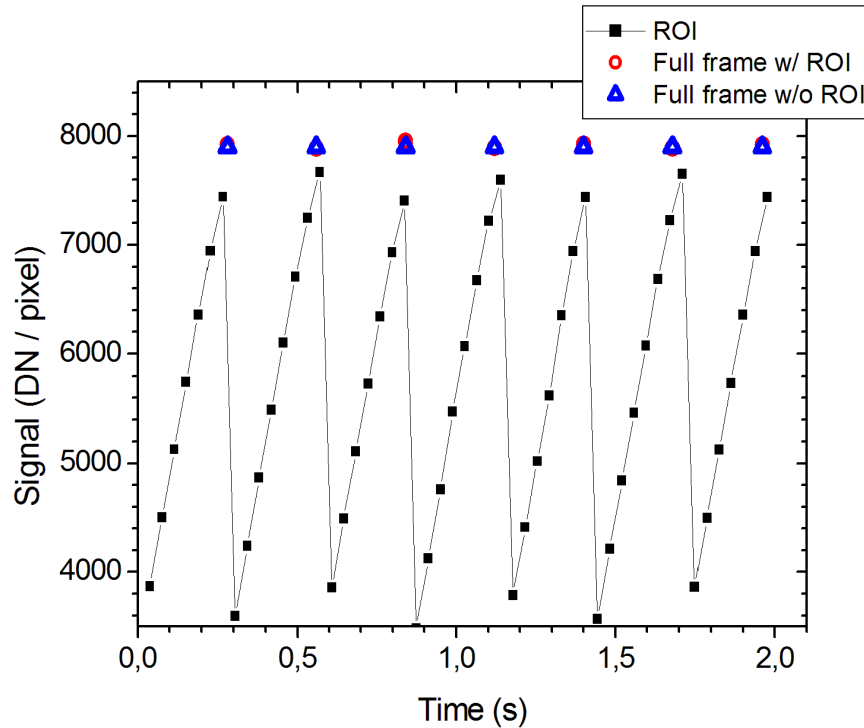
# Non destructive readout (I)



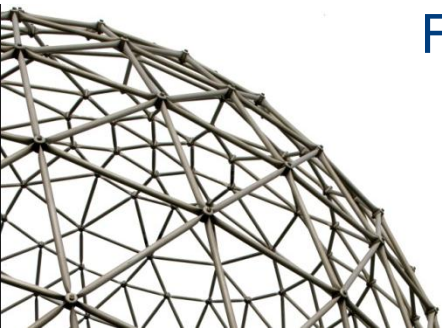
SP2 sampled @  $T_2$   
 SP1 sampled and reset @  $T_1$   
 $T_2 < T_1$



# Non destructive readout



ROI (SP2) sampled @ 26.3 fps  
Full frame (SP1) sampled and reset @ 3.6 fps



# Conclusions

- Dynamite sensor
  - High dynamic range
  - Low Noise
  - High Spatial Resolution
  - Several readout modalities
- Optical characterisation (Sub-Pixel camera)
  - 45% QE
  - 150 e<sup>-</sup> read noise
  - $2.8 \times 10^5$  e<sup>-</sup> FWC
- Charge collection tests / Non destructive readout
- Future applications:
  - Radiotherapy portal imaging
  - Breast mammography
  - Diffraction imaging
  - Electrophoresis



M<sup>3+</sup> Giving Science a New Image



shortlisted  
**BEA** 2011  
british engineering excellence awards