

XPAD3

a fast hybrid pixel readout chip
for X-Ray synchrotron facilities

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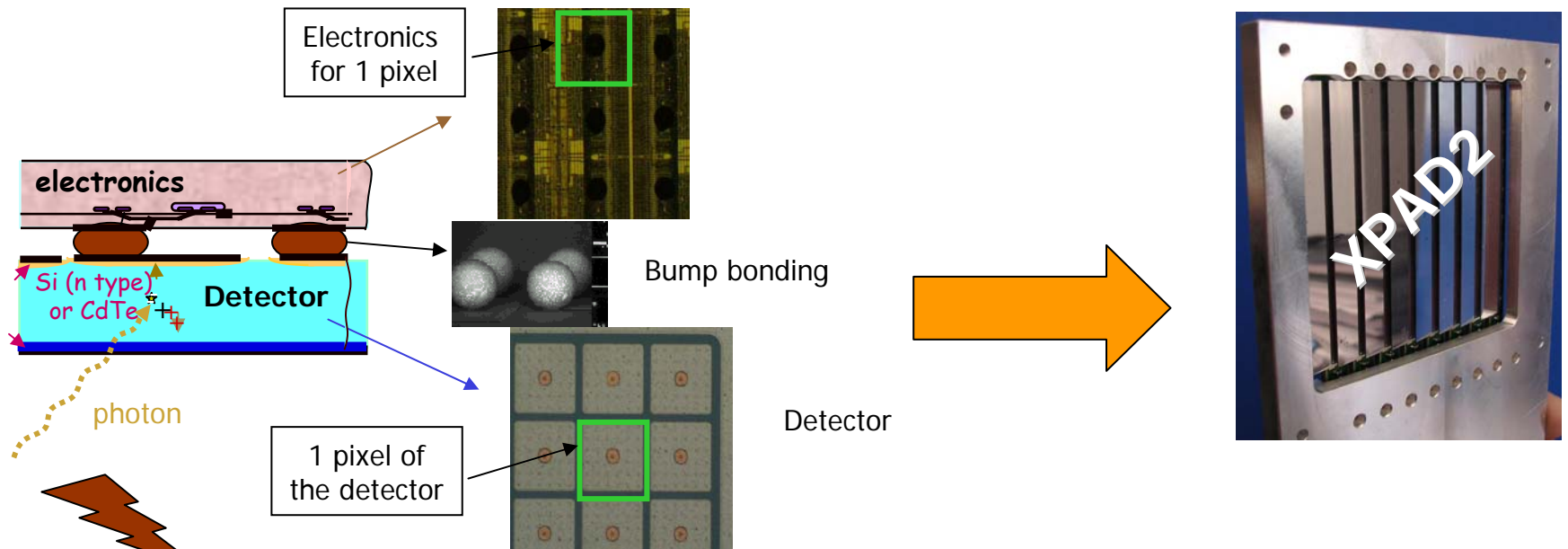




Outline

- Hybrid pixels
- Specifications
- Architecture
- Results
- XPIX : the Imager

Hybrid pixels

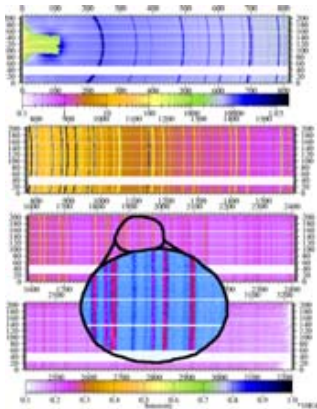


- choice of the sensor substrate (Si, CdTE, AsGa)
- Single photon counting (as opposed to charge integration)
- Noise suppression
 - ➔ Energy selection
 - ➔ Filling factor ~ 100%
 - ➔ High dynamic range

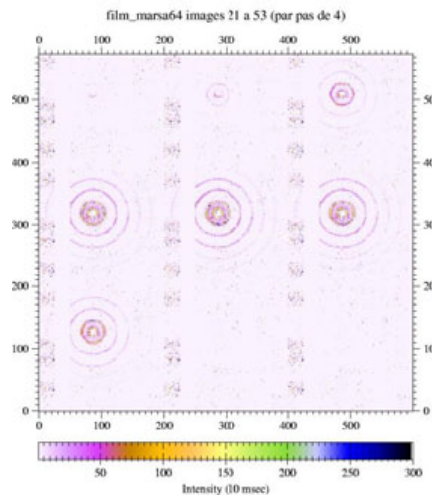
The XPAD projects

X-Rays synchrotron facilities

XPIX



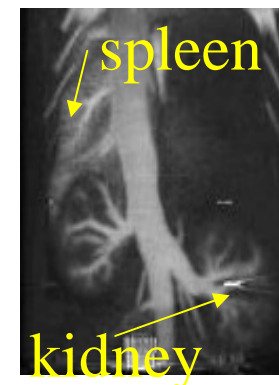
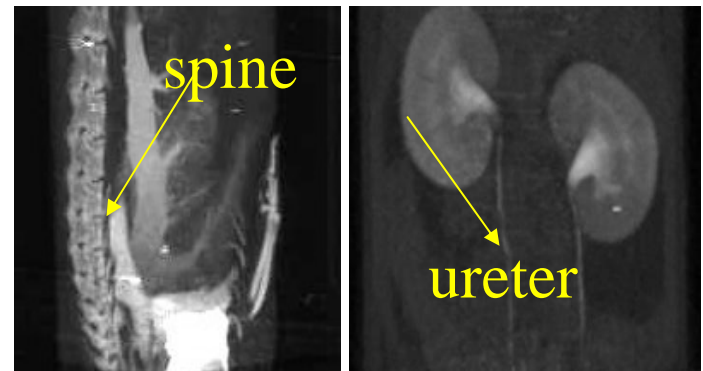
Powder diffraction



SAXS application
(sample moving
across the beam)

Small animal X-ray CT-scanner

PIXSCAN

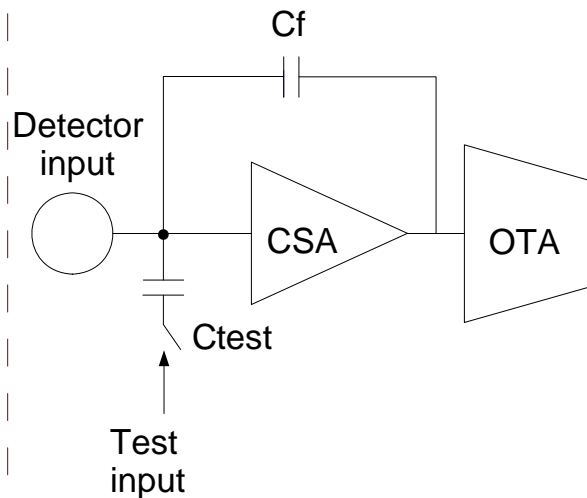


XPAD3 : the new version

Version	XPAD3S	
Number of pixels	9600 (80 x 120)	
Pixel size	130 μ m x 130 μ m	
Readout time	2ms	
Counting rate	2.10 ⁶ photons/pixel/second	
On the fly readout	YES	
Power	40 μ W/pixel	
Input polarity	Holes collection	
Gain	89 nA/keV to 35 keV	
Selectivity mode	Single threshold	
Non linearity	<4% over 35 keV	
Global Electronic noise	130e- rms	
Threshold adjustment resolution	50e- typ.	

Pixels Architecture of XPAD3S

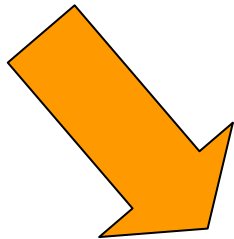
Charge Detection



Preamplifier And OTA chain

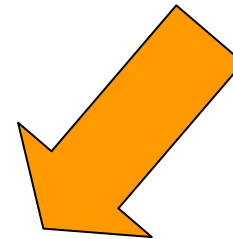
□ Classical Folded Cascode Preamplifier

- Single power Supply (2V)
- DC coupled
- Feedback capacitance = 10fF
- Gain 3.8 mV/ keV



□ Operational Transconductor Amplifier

- Single power Supply (2V)
- Wide band Architecture

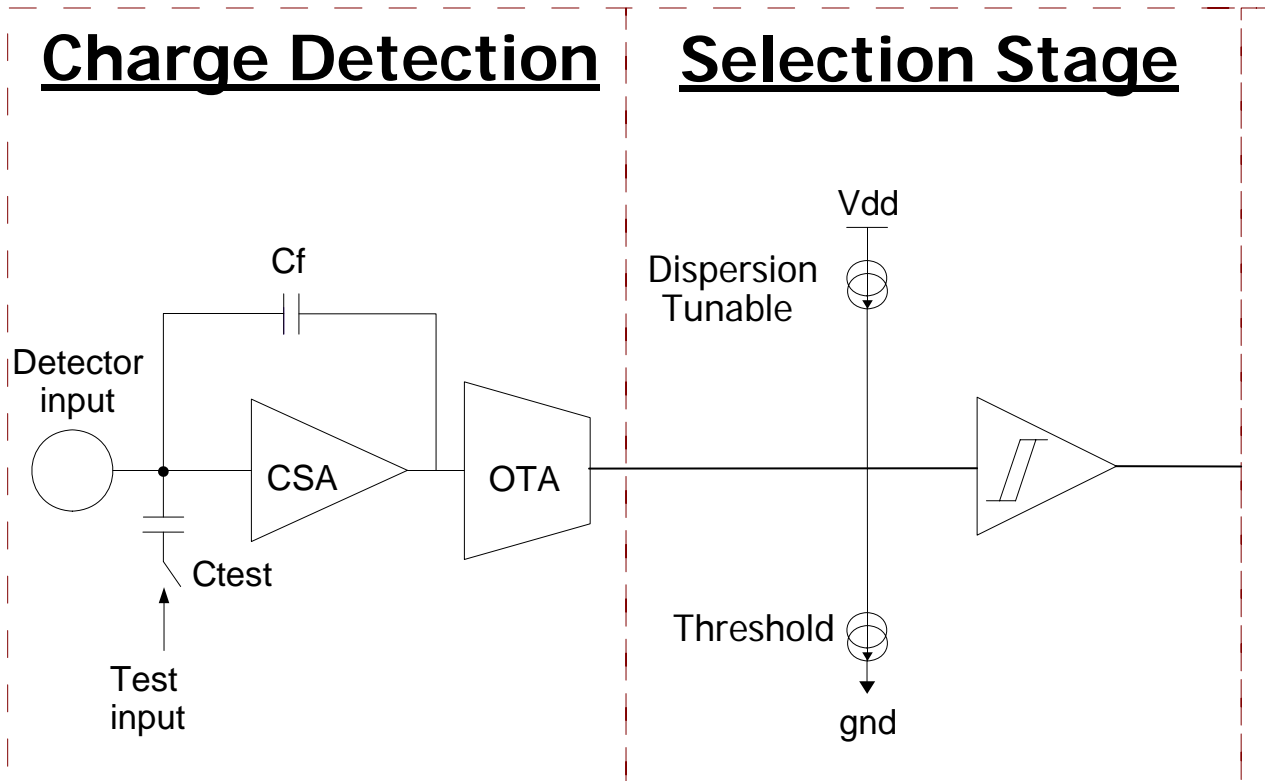


- Noise 100e- rms (load Cd = 200fF)
- Gain 89 nA/keV
- Non-Linearity <4% over 35keV

O'Connor, P.: 'CMOS preamplifier for low-capacitance detectors', NIM A, 1997, 390, pp. 241-245

Gilbert, B.: 'The Multi-tanh Principle: A Tutorial Overview', IEEE, JSSC, 1998, vol 33, n°1

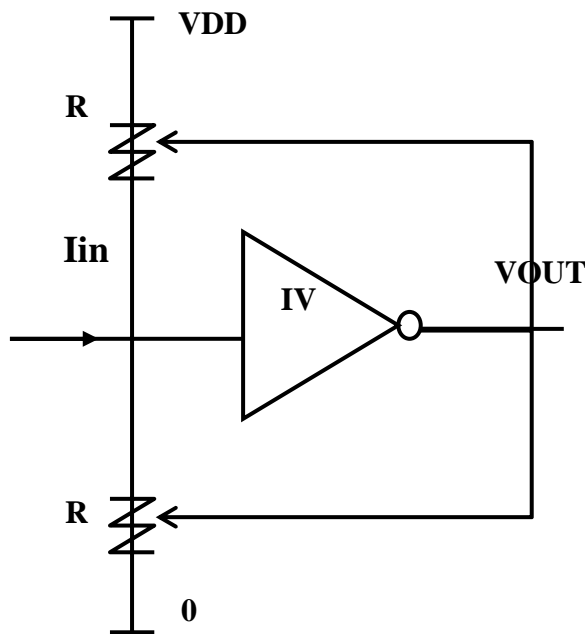
Pixels Architecture of XPAD3S



Comparator

a current mode approach

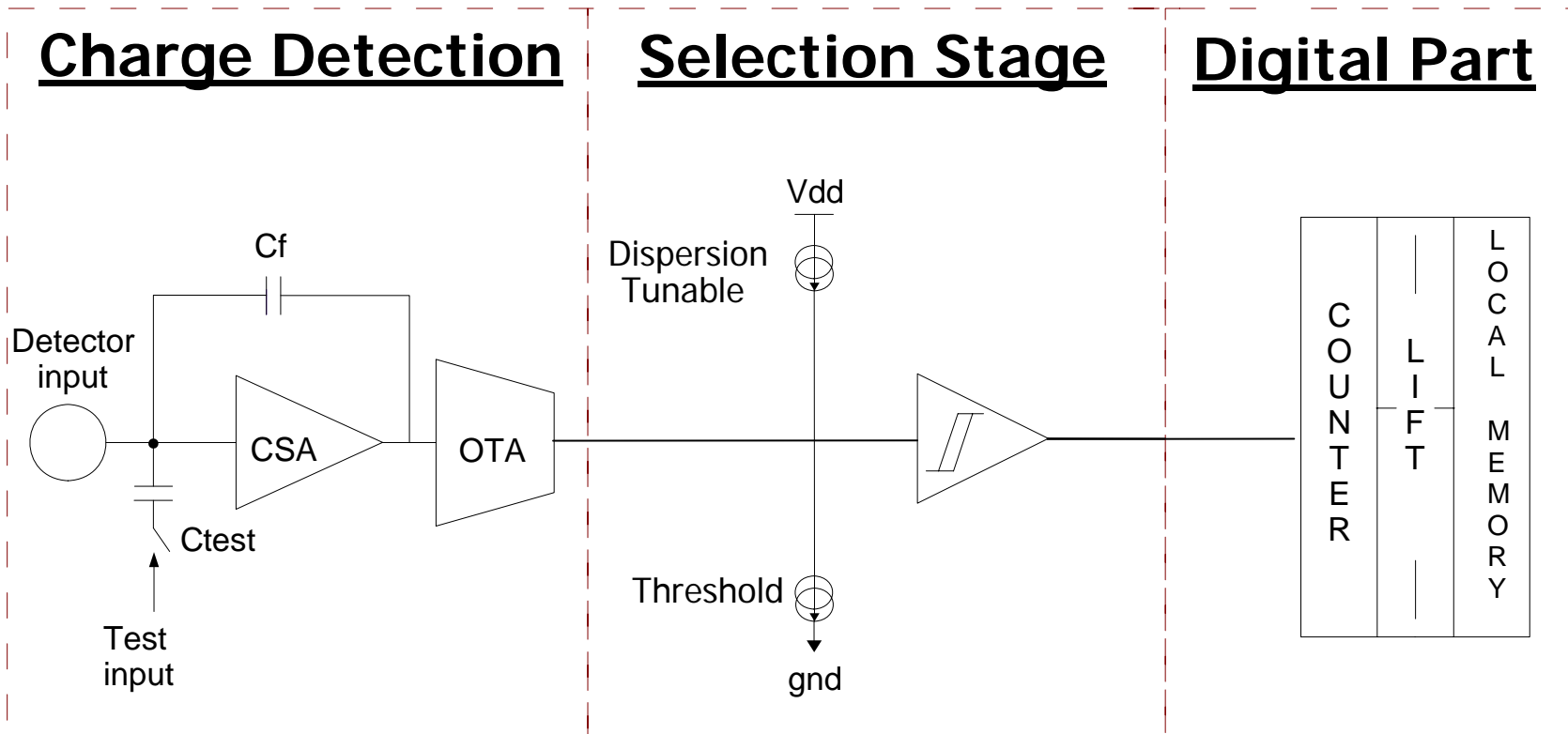
TRAFF, H.: 'Novel approach to high speed CMOS current comparators',
Electron. Lett., 1992, 28, (3), pp. 310–312



Threshold adjustment by current mode DAC

- A common nodal connection
 - Adjustable LSB : typical 15nA
- Speed (toggle in few ns)
 - High accuracy (1nA DC ; 10nA transient)
 - Low power (few μW) ; no biasing

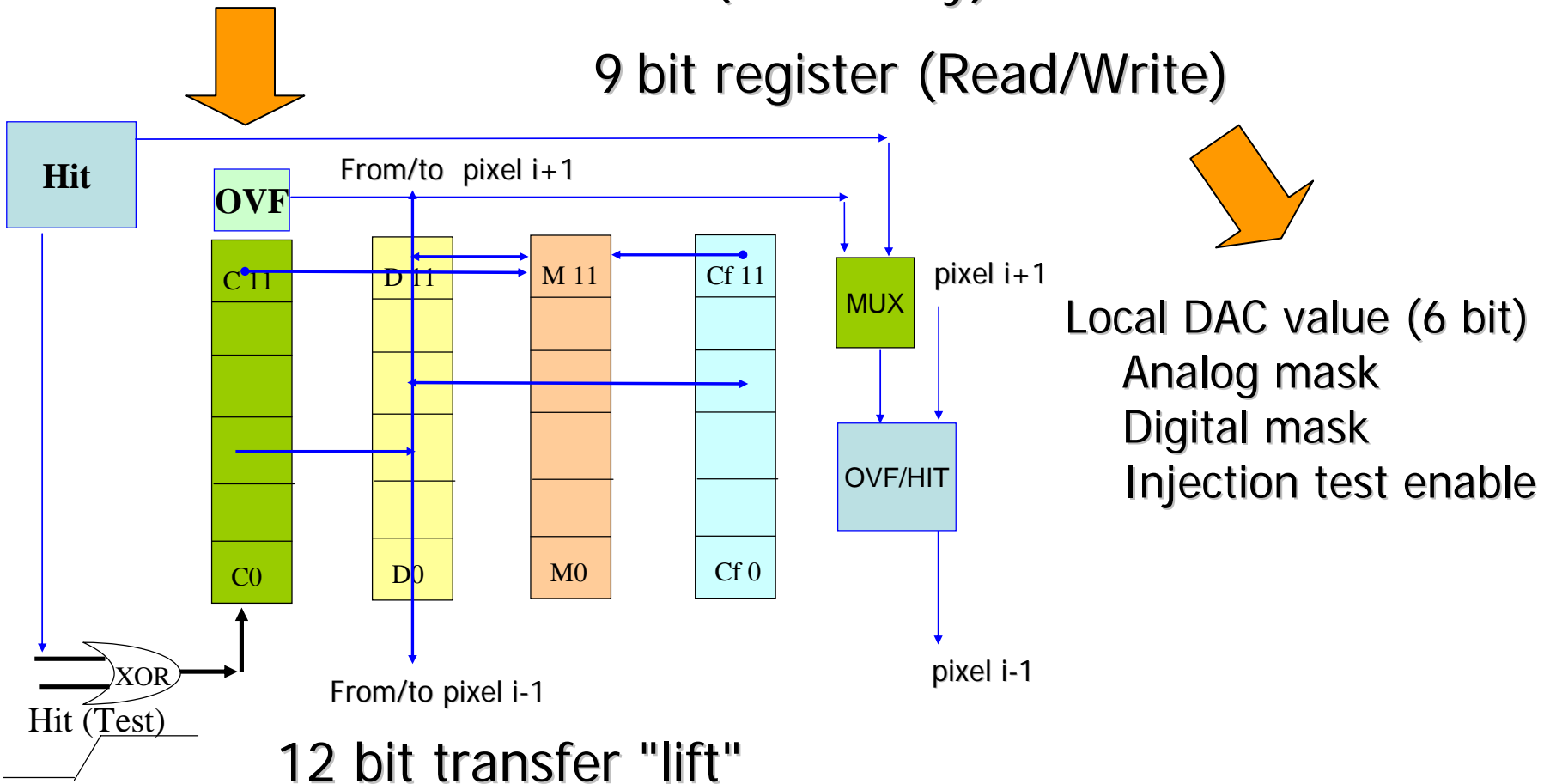
Pixels Architecture of XPAD3S



Digital part of pixels

12 bit counter + Overflow(Read only)

9 bit register (Read/Write)



Local DAC value (6 bit)
 Analog mask
 Digital mask
 Injection test enable

Pixel floorplan

A layout's state-of-art

Guard Rings+ shielding strategy

Readout logic

12 bit counter

Configuration registers

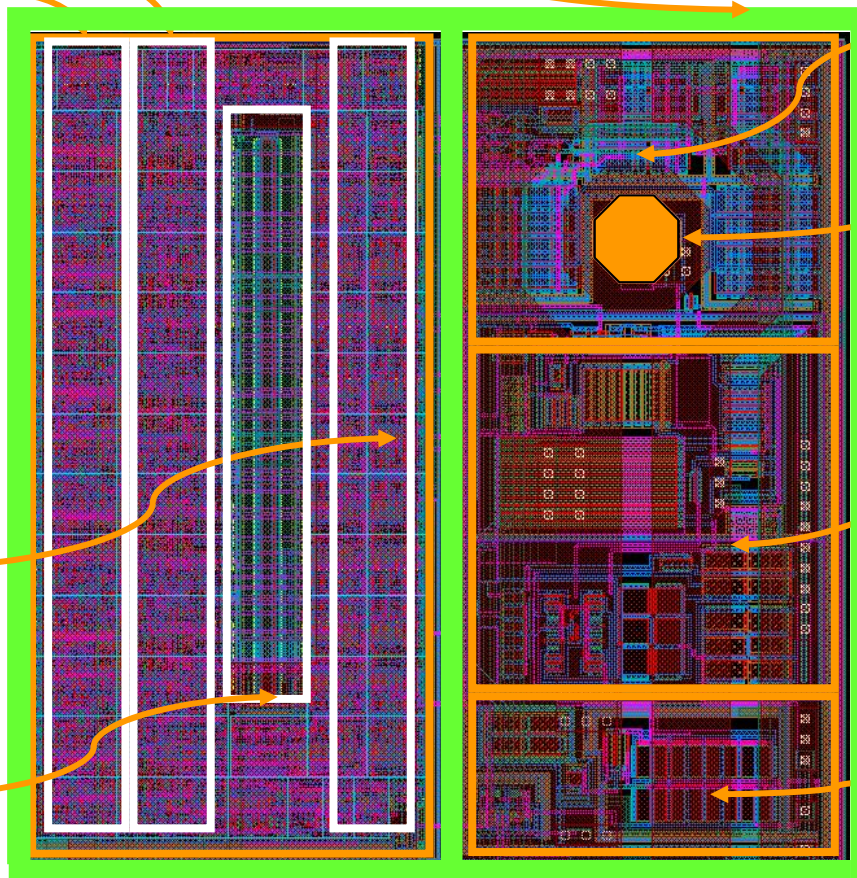
Decoupling Capacitors

Current mode DAC

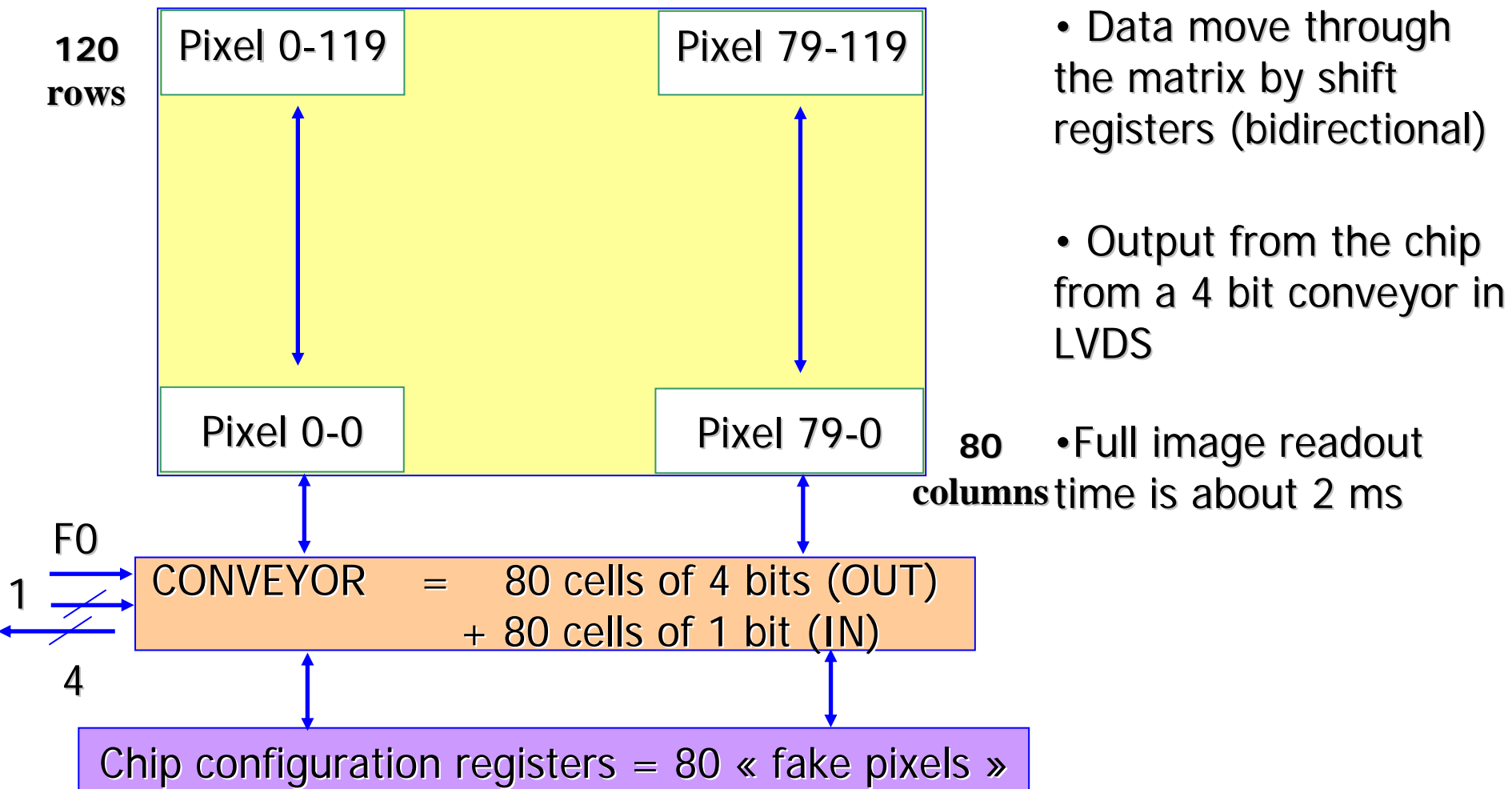
Bump Pad

CSA & OTA

Threshold ;
Current mode
Comparator

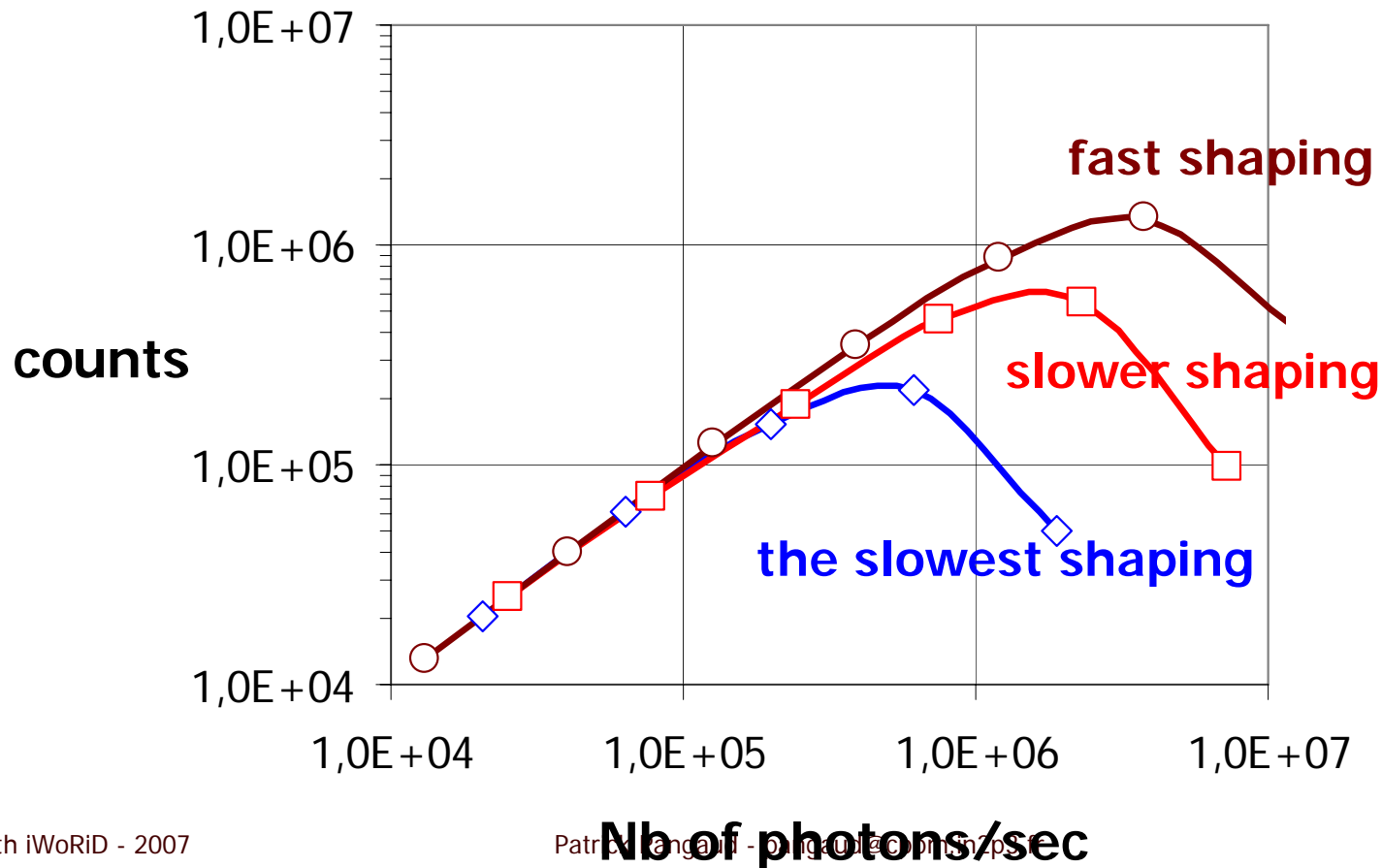


The Chip Readout



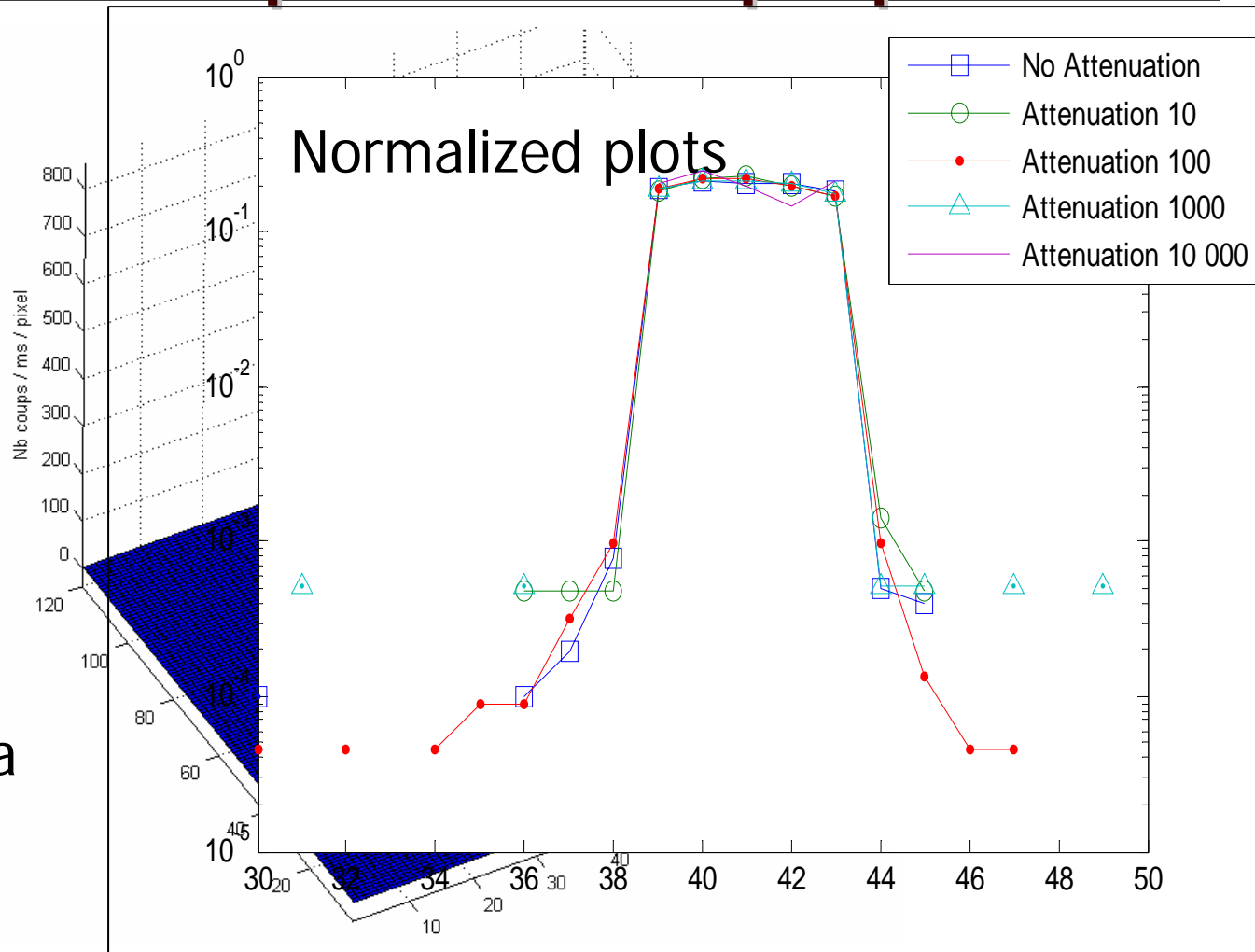
Up to 10^6 photons by second

Counts vs. incidents photons (5keV)
expected (ligne) ; measured (dots)



No Cross – Talk

Neighbor pixels keep quite !!



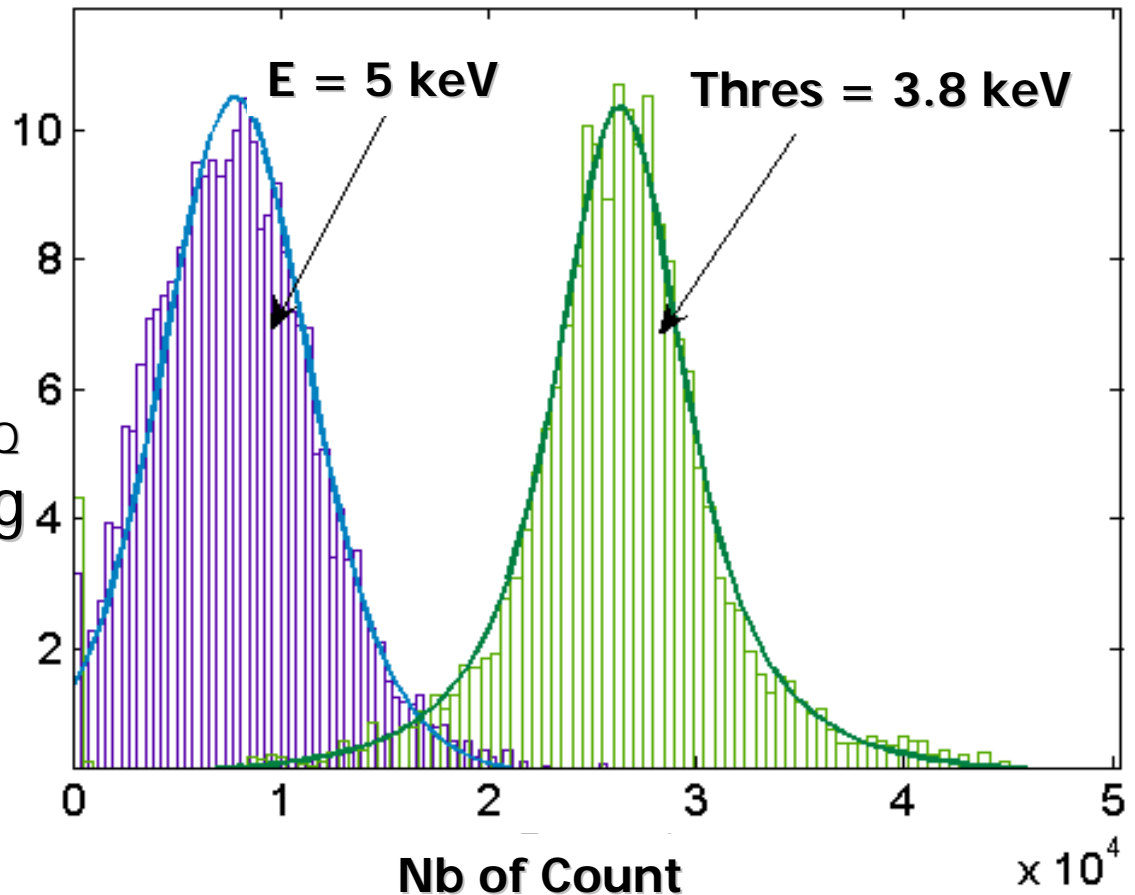
A 17 keV Beam passes through a controlled 6 X 5 pixels aperture

Minimum Energy threshold

Flat Field of 5keV

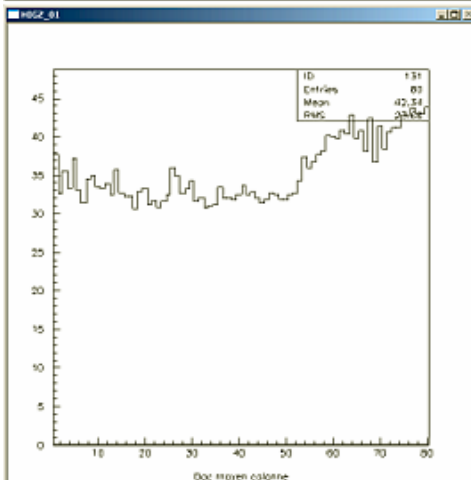
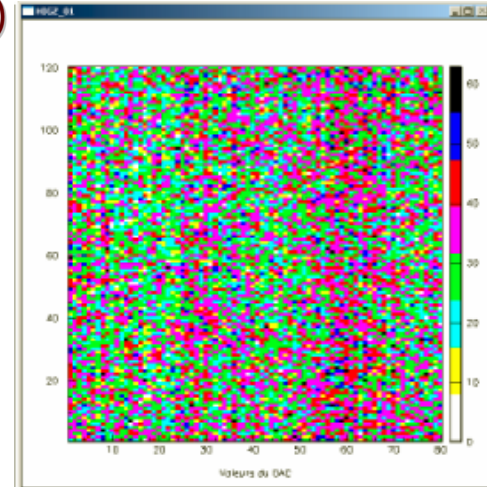
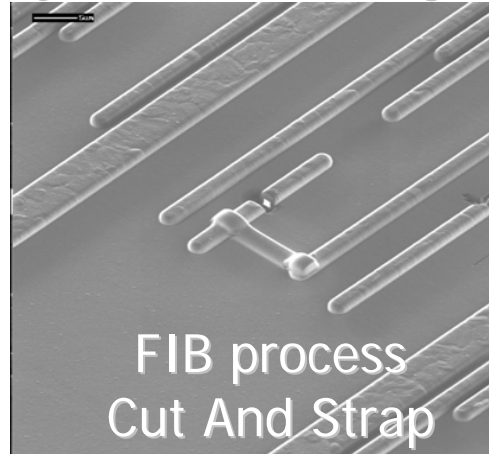
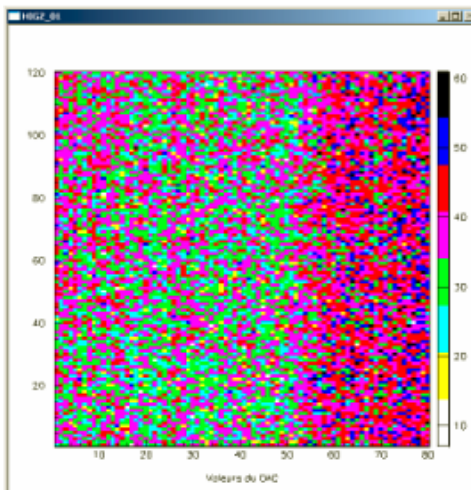
- On the fly readout
- Full speed readout
 - Limited by the present DAQ
- Full detector counting

Nb of Pixels



XPAD3's Surgery Repair by FIB (Focus Ion Beam)

(courtesy Serma Technologies, Grenoble)

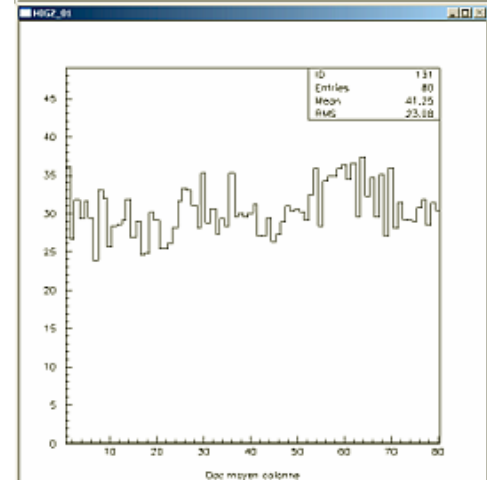


Problem :

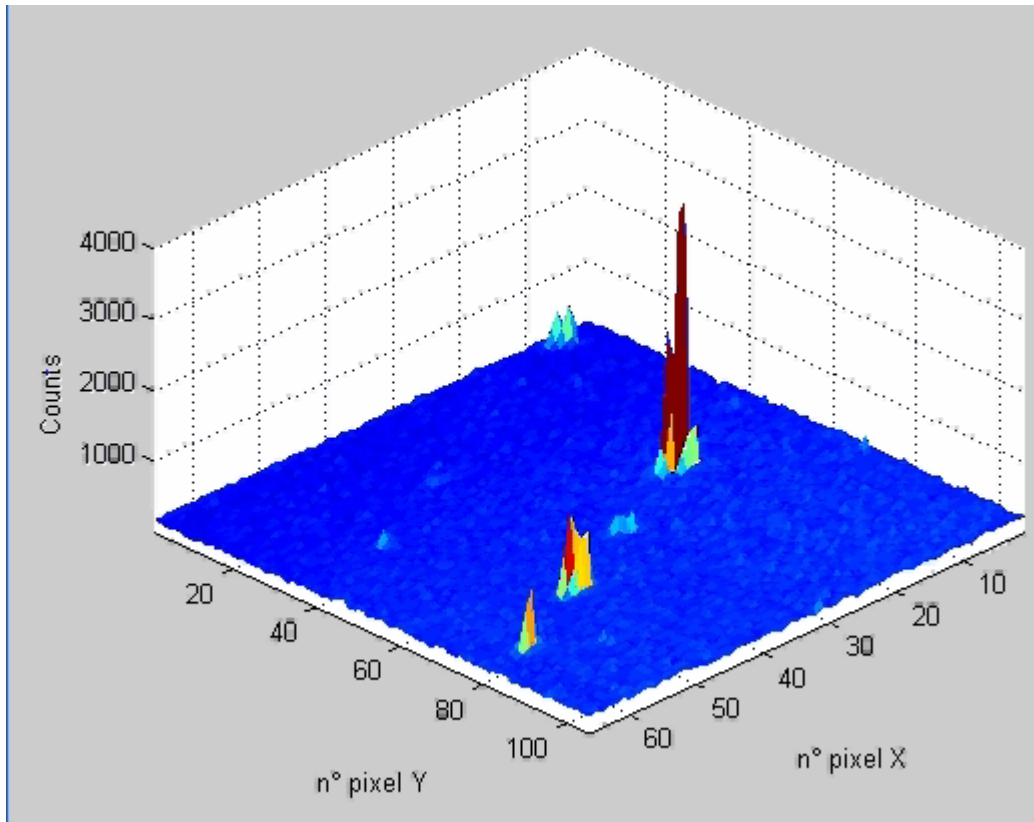
No regular power supplies tracks

Effect : Right-left dispersion deficiency

Uniform power supplies distribution after surgery



Very First X-rays diffraction experiment



Single XPAD3S with his
silicon detector

Diffraction of a Lysozyme's
protein

$E = 5,9 \text{ keV}$

PROXIMA1 line of SOLEIL
July 2007

XPIX : The new XPAD's imager receiving XPAD3

→
Fluid circulation
(cooling)

8 modules
per detector

7 chips
per module

←



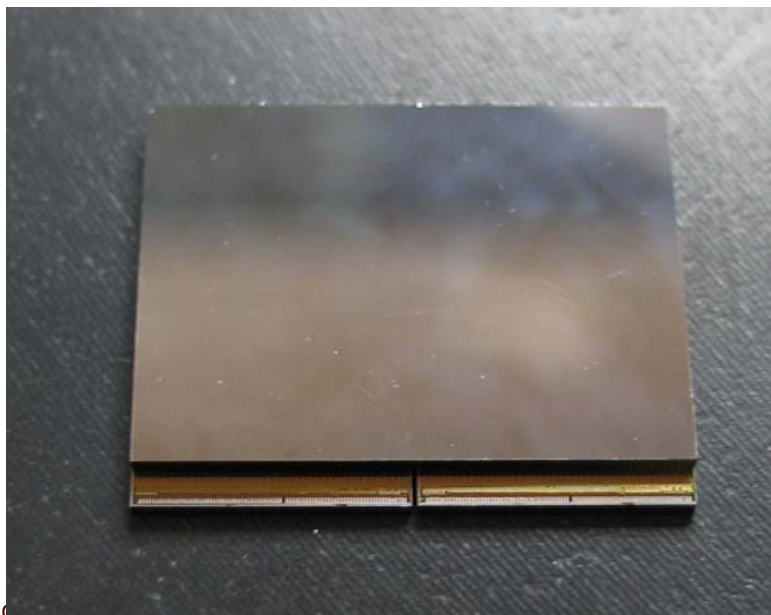
3 detectors to be
delivered in Fall
2007 to
ESRF, SOLEIL
and CPPM

XPAD3's Detector Module



Si Module
7 XPAD3 chips

CdTe Module
2 XPAD3 chips



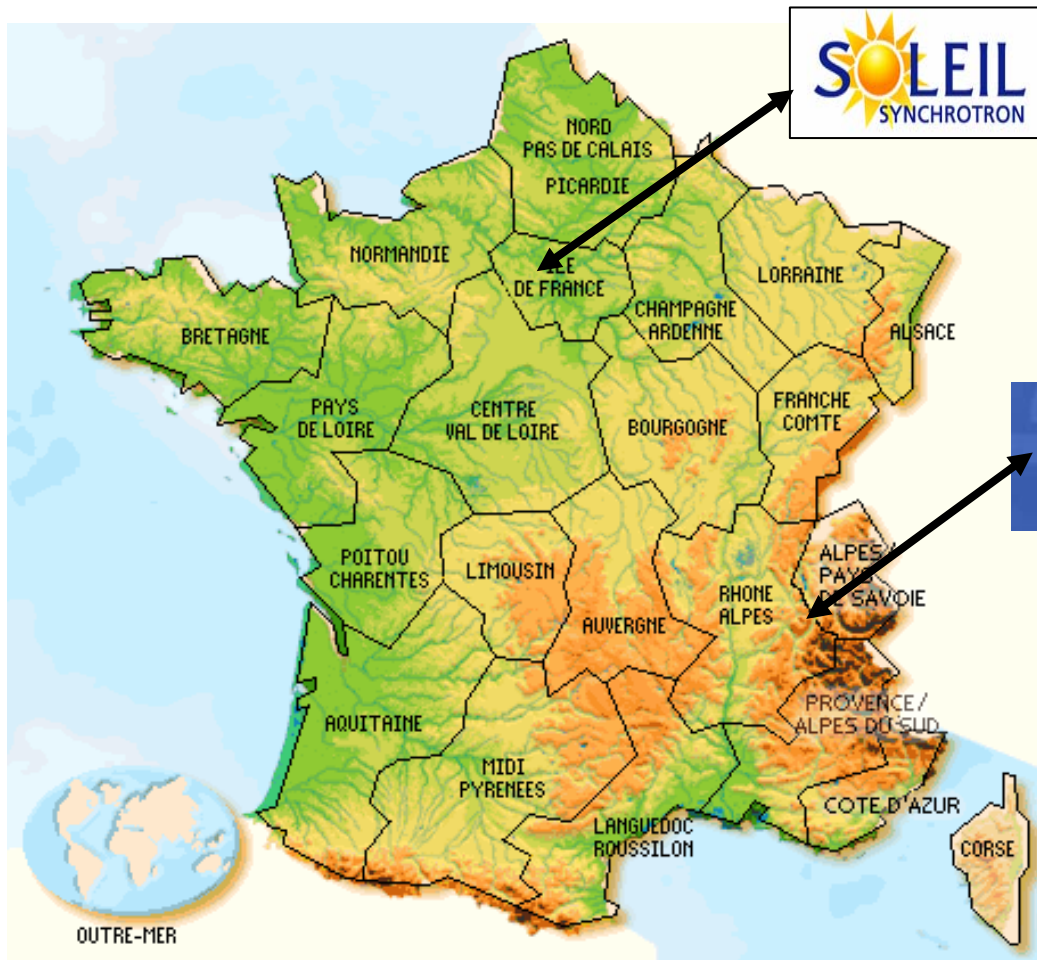
XPAD3S

is

- A single matrix of 9600 hybrid pixels of $130\mu\text{m}$ square
- High counting rate up to 10^6 ph/sec/px
- Fast readout data with no dead time
- Minimum Threshold ~ 4 keV
- High spatial accuracy : no cross-talk

And ready to form the XPIX project

French Synchrotrons' facilities greet XPAD3



St Aubin
DIFFABS
PROXIMA 1



Grenoble
D2AM

**And a special thanks
to
the D2AM's team and to the
detector's team of SOLEIL**



<http://imxgam.in2p3.fr>

The ImXgam Team

A CPPM's Group from Marseille