Sensors for XPAD hybrid pixel detectors : Si (5-25keV), CdTe (8-40keV).

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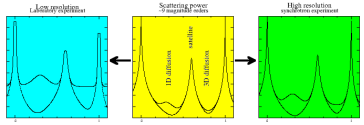
Material Science or Solid state physics

Exploration of reciprocal space, profile shape, diffuse scattering...
The Fourrier transform of the image is widely spread.



- resolution optimized during experiment by adjusting detector position

⇒ pixel size ≈ beam spot size ≈ 150μm

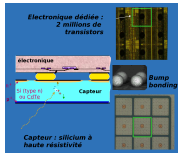
- detector has to be fixed on goniometer arm ⇒ mass, connection

XPAD project (BM02@ESRF, CPPM-IN2P3, NEEL-CNRS, SOLEIL)

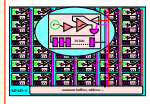
Berar, JSR 2001, Boudet NIM-B 2004, Basolo IEEE-TNS 2005

hybrid pixel detectors : "intelligent" pixels

Principe : associer une chaîne électronique complète à chaque pixel



XPAD1 : 24 × 25 pixel/circuit
Circuits : AMS CMOS 0.8 μm
Diodes : épaisseur 300μm



The XPAD project (XPAD1-2)		
dynamic range	$> 10^9 count/pixel$	⇒ 32 bits architecture
saturation rate	$> 10^7 \nu/s/pixel$	⇒ noise $< 0.1 \nu/s/pixel$
energy range	$5 \rightarrow 25\ keV$	from beamline energy range
pixel size	$330 \times 330 \mu m^2$	spot size (1995) : $250 \times 400\ \mu m^2$
exposure time	$1ms \rightarrow 1000\ s$	kinetics potentiality

Boudet *et al.*, NIM A510 (2003) 41-44. Berar *et al.*, J. Appl. Cryst. 35 (2002) 471-476

XPAD2 detector : 8 modules × 8 chips

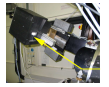
New diodes of 500μm Si thick → efficiency 78 % @15keV, 21% @25keV

Diode ⇌ 8 chips of 24 × 25 pixels
PCB card : drivers and regulators.
Modules ⇌ acquisition card
Alterra Nios kit + ethernet

Tiled as close as possible → reduce shading, dead zones.
Metallic holder → few μm.
Size : 200 × 192 pixels
Surface ≈ 68 × 68mm^2.

Interface software developed using LabWindows/CVI application software moves to Linux.

XPAD prototype on BM02 beamlinen.

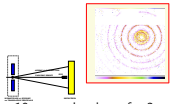


Basolo *et al.*, J.Synch. Rad.14 (2007) 151-157.

Kinetics potentiality of XPAD2

XPAD2 whole electronic designed to allow kinetics studies (ms range).

- chips register 16bits + overflow
- on-board memories 32 bits
- exposure time : $1ms \rightarrow 8300s$
- dead time for reading :
  - whole image $2ms$
  - overflow $16\mu s$ each $10ms$
- on-board storage :
  - 423 images $< 10ms$
  - 233 images $>= 10ms$



10 ms each taken of a 2s movies showing diffraction while the sample crosses the beam at D2AM SAXS camera.

The quench of $Al_{2x}Ca_yO_{3x+y}$ ceramics can lead to vitrous or crystalline oxides. The transition between the liquid state and the cristalline one occurs in less than 20ms and may exhibit some transient phases.

Data collection is limited by the cell aperture, which has been designed for linear detector, diagram reconstructed from a few frames of 20ms

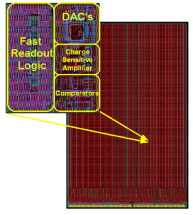
XPAD3 design

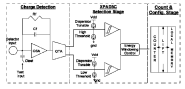
- Obsolescence of the AMS-CMOS 0.8 μm technology
- New XPAD3 using 0.25 μm technology with 25 μm bumps
- New analog and digital architecture

	XPAD2	XPAD3S	XPAD3C
polarization	both	e^+ (Si)	e^- (CdTe)
pixel size	$330 \times 330 \mu m^2$	$130 \times 130 \mu m^2$	
chip size	$8 \times 10\ mm^2$	$10 \times 15\ mm^2$	
frequency	$5.10^{-8} Hz$	$5.10^{-7} Hz$ (≡ count/surface)	
photons rate	$2.10^6 ph/s/pixel$	$2.10^5 ph/s/pixel$ (≡ count/surface)	
counters (bits)	$16 + 16\ ext$	$12 + 16\ ext$ (≡ count/surface)	
energy range	(5) 15 → $25keV$	5 → $32keV$	7 → $60keV$
energy edges	low level	low level	low and up levels
pixels/chip	$24 \times 25 = 600$	$80 \times 120 \approx 1.10^4$	
pixels/module	$8 \times 600 \approx 5.10^3$	$\approx 7.10^4$	
pixels/detector	$\approx 4.10^4$	$\approx 5.10^5$	
geometries	8×8 or 2×5	7×8 and ...	

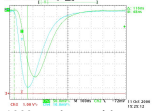
The chip layout and pixel chain in XPAD3S.

Power=40$\mu W/pixel$, electronic noise ≈ 100e rms





Time response of the preamplifier.

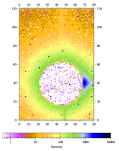


1500 transistors dans chaque pixel dont 1000 partie numérique et 500 partie analogique, soit environ 15 millions pour le circuit (le processeur Pentium III en techno 0,25um en contient environ 9 millions).

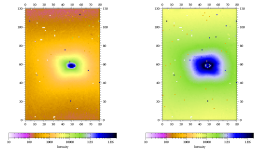
Pangaud *et al.*, NIM A571 (2007) 321-324

XPAD3S with Si sensor

The assembly of a wide XPAD3S detector is not yet finished (Nov. 2007) as the first chips have been received on January.
However, numerous tests have been carried out on small prototypes ... Results fullfilled the expected perfomances.

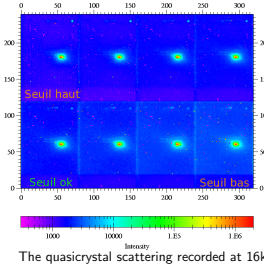


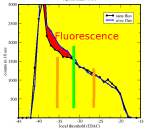
Aroud SAXS beam stop at 5keV



Diffuse scattering around a Bragg peak (with/without saturation)

XPAD3S Si bounded Energy resolution, removing fluorescence

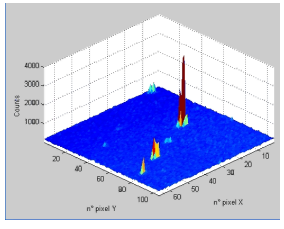




Threshold scan of one pixel

The quasicrystal scattering recorded at 16keV contains a continuous background due to Zn fluorescence. By shifting the common edge the fluorescence and then the signal itself are cutted (from bottom right to top left).

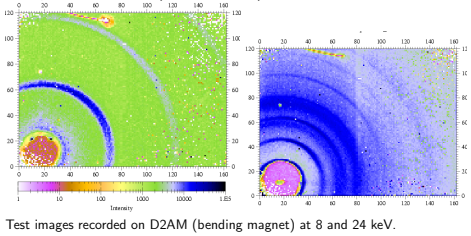
XPAD3S Si bounded at 5.9keV



Preliminary tests have been conducted on the PIX1 beamline at SOLEIL at low energy (5.9keV). On left, diffraction peaks of a lisozyme crystal observed while rotation the crystal by 0.05 deg. steps.

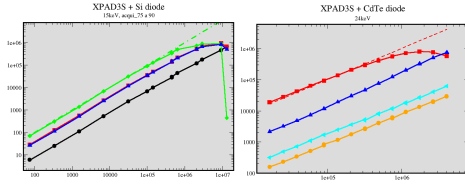
XPAD3S CdTe bounded : high energy becomes available

Such detector, limited by CdTe sensor size (2 XPAD3 chips), can be used at 40-60keV.



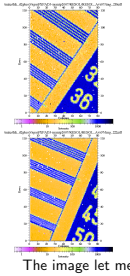
Test images recorded on D2AM (bending magnet) at 8 and 24 keV.
Pixel at chip borders are 2.5 wider, effect corrected on the view.

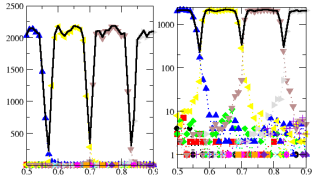
XPAD3S Si and CdTe hybrided : counting linearity



Intensities in adjacent pixel measured on D2AM beamline in 16 bunch modes.
At 15keV, with Si diode the saturation reach $9.10^5 \nu/s$, the linearity being good up to $3.10^5 \nu/s$, that is $2.10^7 \nu/s/mm^2$.
At 24 keV, quite the same limits are obtained even if the charge amount increase the time constant.

XPAD3S spatial resolution using 500μm Si sensor.

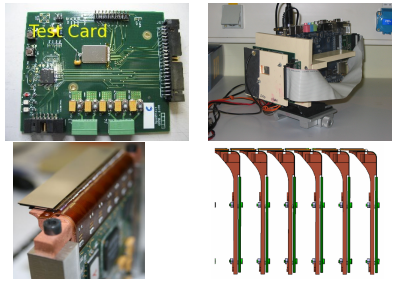




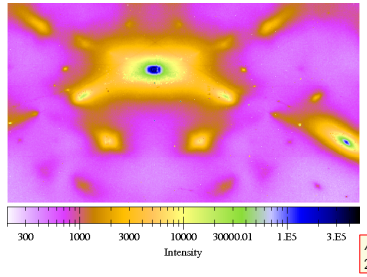
Scan of a narrow (10μm) beam along detector pixels at 17keV. Even on a log scale the cross-talk vanish on less than one pixel.

The image let measure about 40 lines pair / mm using a non perfect instrumental settings (source size 0.3mm at 270mm and detector at ≈ 15 mm of test chart.

From chips to modules



XPAD3S Si modules 1st images



AlPdMn 23 keV

XPAD Collaboration

Thanks to all participants

S. Arnaud [12], S. Basolo [3], P. Breugnon [3], B. Caillot [12], J.-C. Clemens [3], P. Delpierre [3], B. Dinkespiler [3], S. Hustache [4], I. Koudobine [3], K. Medjoubi [4], M. Menouni [3], P. Pangaud [3], R. Potheau [3], E. Vigeolas [3]

[1] D2AM/ESRF Grenoble [2] Inst. NEEL [3] CPPM-IN2P3 Marseille [4] Sync. SOLEIL St Aubin

and for your attention!