Ultra-thin scCVD Diamond as XBPM at SOLEIL

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Synchrotron SOLEIL

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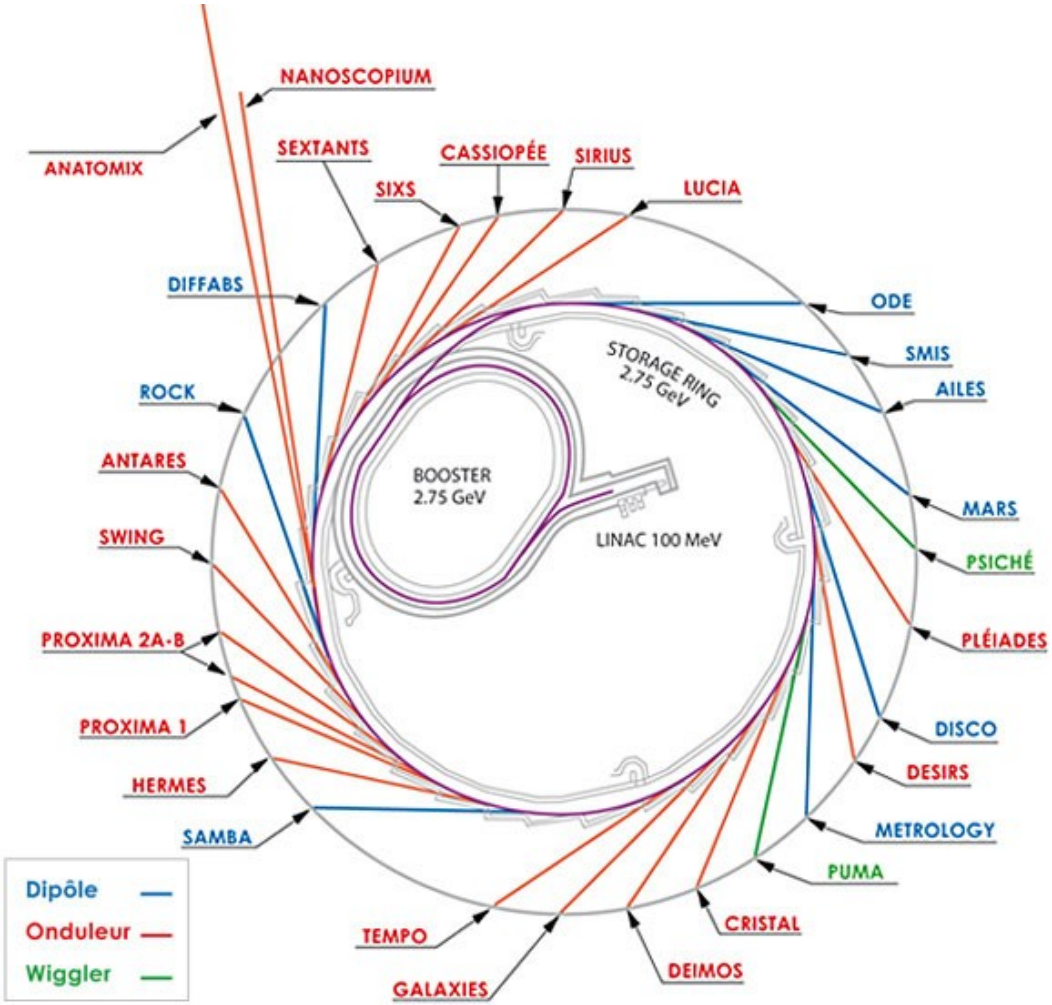
Outline

- Introduction
- Why XBPM ? First diamond XBPM results
- Ultra thin XBPM Measurements and Results
    - X-ray Beam Intensity Monitoring
    - X-ray Beam Position resolution
- Summary

SOLEIL synchrotron

IR – visible – soft X-ray - hard X-ray



29 beamlines

« Plateau de Saclay »
Close to Paris

>3000 users in 2013

Diagnostic Detector

Intensity monitoring (I0)

Sensitivity (Small variation)
Homogeneity
Beam absorption

Position monitoring (XBPM)

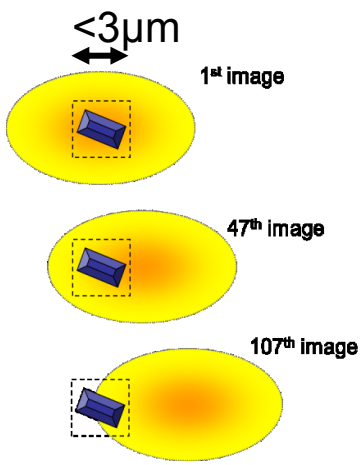
Sensitivity (Small displacement)
Linearity & homogeneity
Speed
Beam absorption

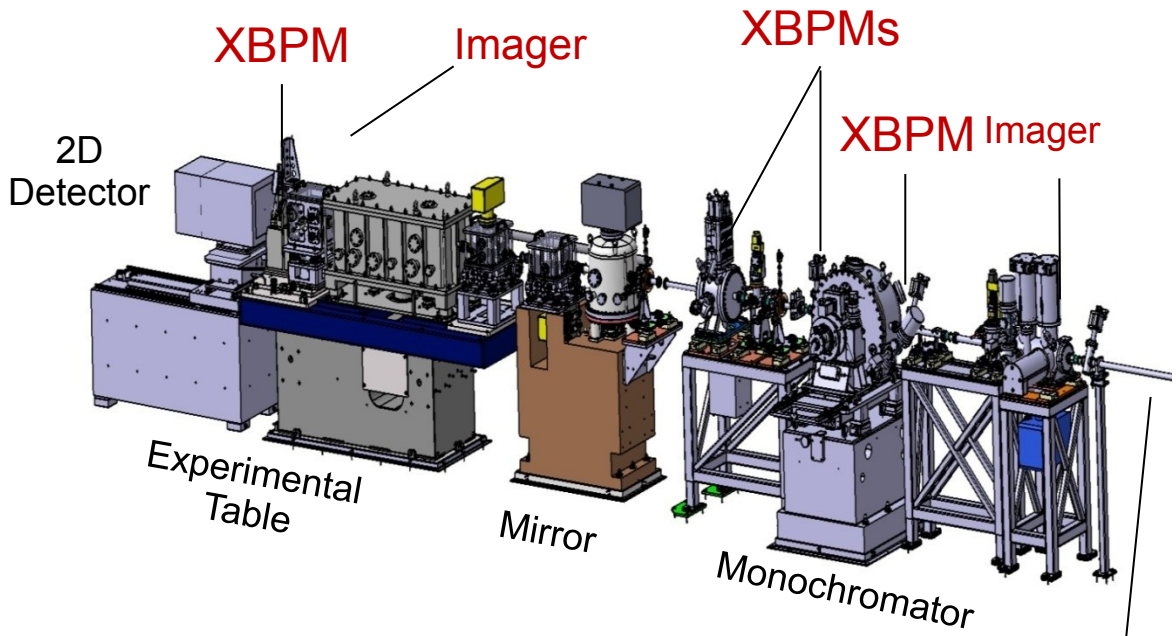
Highest Requirements depending on the beamline and working energy

- **Intensity precision : within 1%**
- **Position Resolution < 1µm**
- **Acquisition speed 1ms**
- **Transparency : maxi 10% absorption**
- **Vacuum compatibility & radiation hardness**

Why XBPMs for MX ?

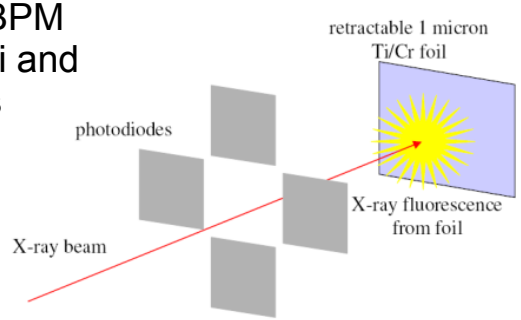
PROXIMA 2 5 – 15 keV (Dedicated to micro-crystallography)





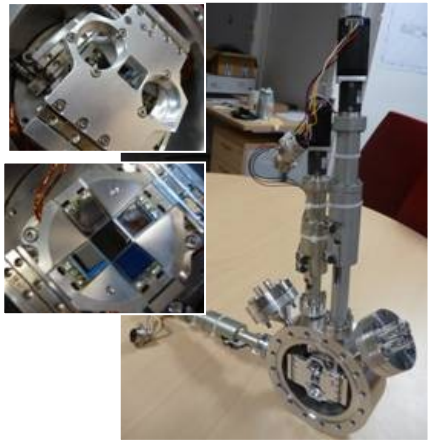
Keeping the beam on the crystal!

Indirect foil XBPM
With 0.5 µm Ti and
4 photodiodes



The principle of the Alkire XBPM design.

Home made indirect XBPM



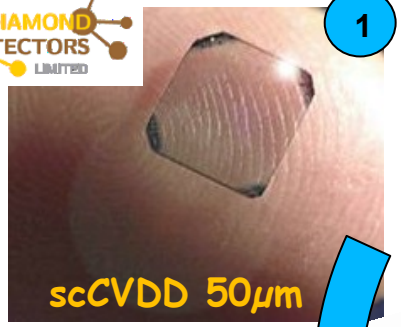
- Compact UVH design
- Good Intensity monitor
- Good position linearity

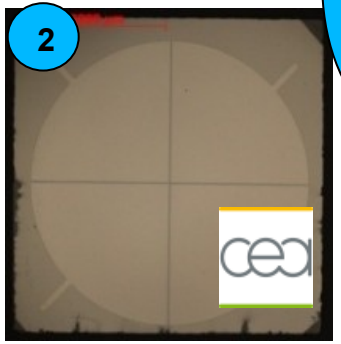
- **10µm resolution @1kHz**
- fragile thin foil

XBPM Diamond at SOLEIL

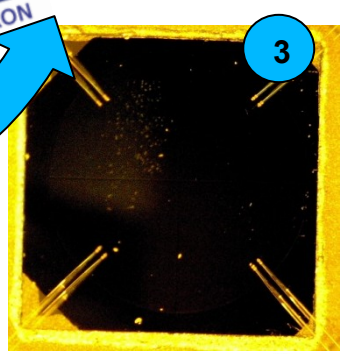
Quadrant Detector
Diamond supplier = Diamond Detector Limited
sc-CVD Electronic Grade Diamond **~50µm**

(out of business)



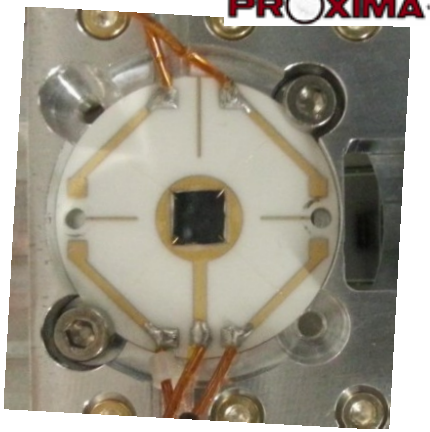


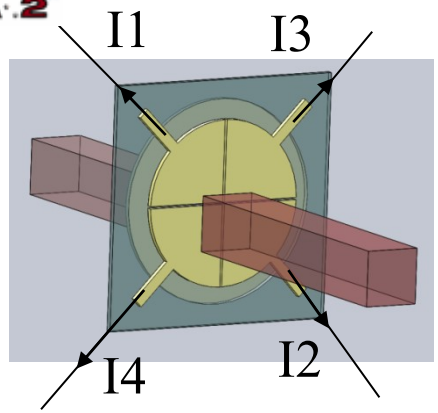
M. Pomorski,



PCB
& connexions

First detector installed on





Beam intensity I0

$$I0 = I1 + I2 + I3 + I4$$

Beam position
by 'center-of-mass'

$$X = Kx\frac{(I2 + I3) - (I1 + I4)}{I0}$$

$$Z = Kz\frac{(I1 + I3) - (I4 + I2)}{I0}$$

XBPM scCVD 50µm - results

Time scan XBPM monitor

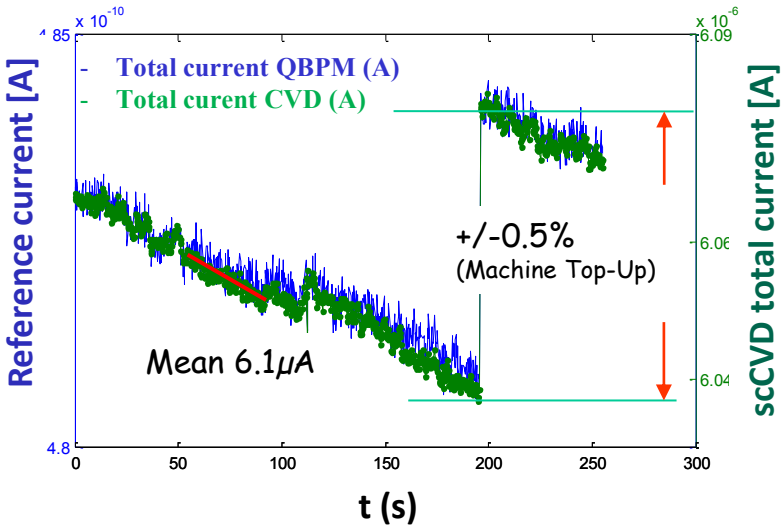
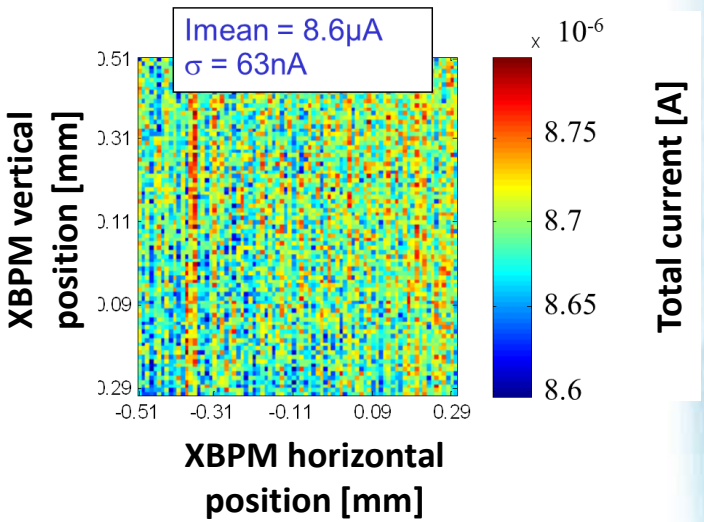
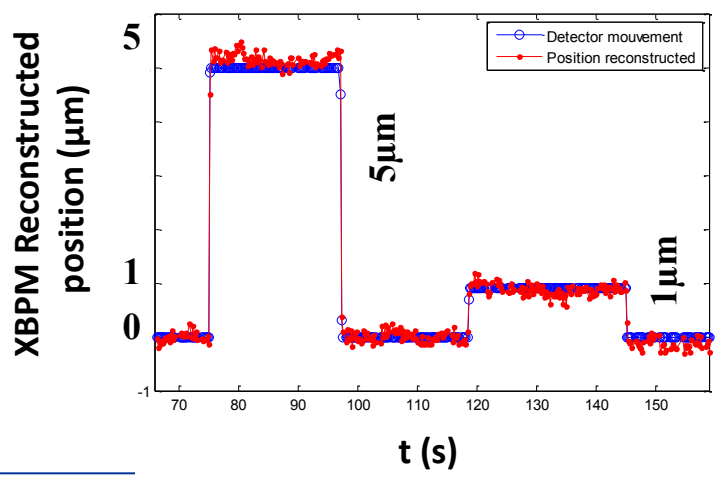


Image of I_0 vs. XBPM position

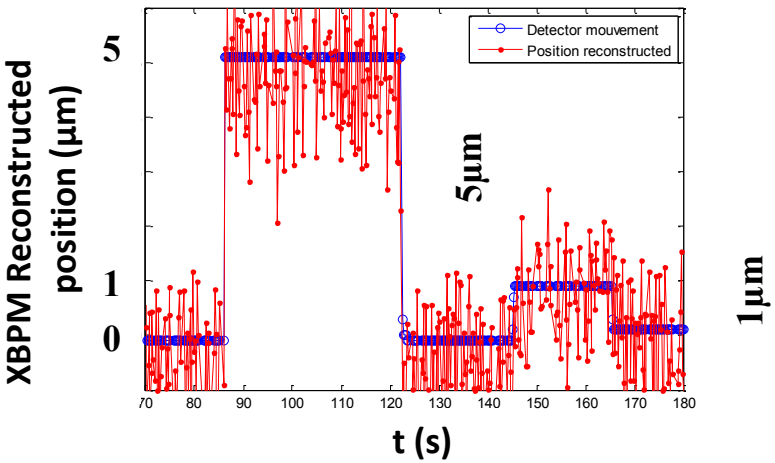


XBPM reconstruction vs. XBPM displacement

100ms ADC integration time

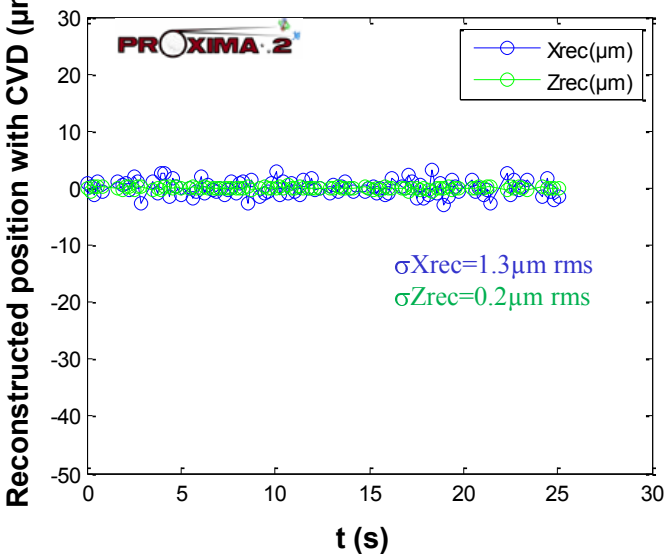


1ms ADC integration time



XBPM scCVD 50µm – QBPM comparison

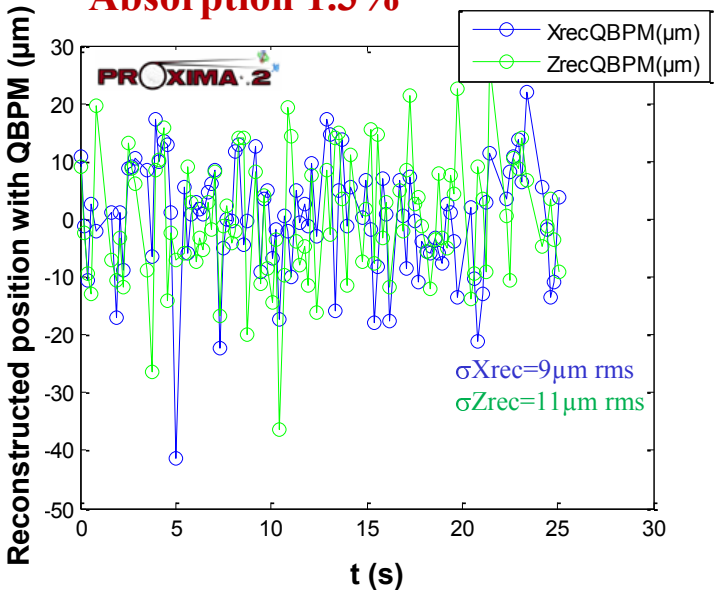
scCVD Diamond 50µm, Absorption 2%



ADC Int. Time (ms)	Z recons (rms)
100	20 nm
10	100nm
1	200 nm

Total current 6,50µA
std current = 475pA rms (5Hz)
=> **0.007%** of intensity fluctuation

Alkyre Type (Ti_{foil}=0.5µm), Absorption 1.3%



ADC Int. Time (ms)	Z recons (rms)
100	1µm
10	5 µm
1	11 µm

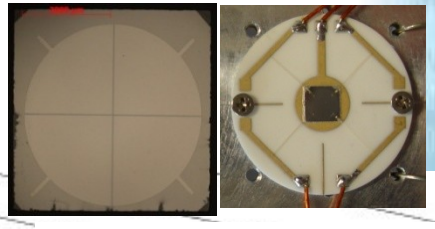
Total current 0,45µA
std current = 480pA rms (5Hz)
=> **0.1%** of intensity fluctuation

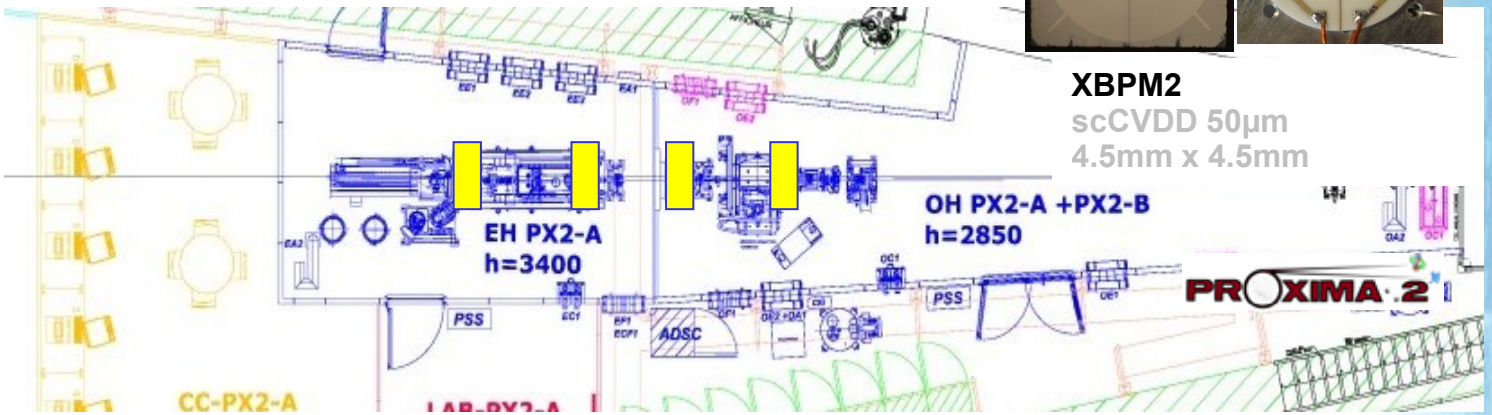
Status

Several 'thick' EG scCVD XBPMs already installed at Soleil for permament in-beam monitoring (>5keV):

- submicron position resolution @ kHz
- beam intensity monitoring at ‰ level
- stable operation, radiation hard

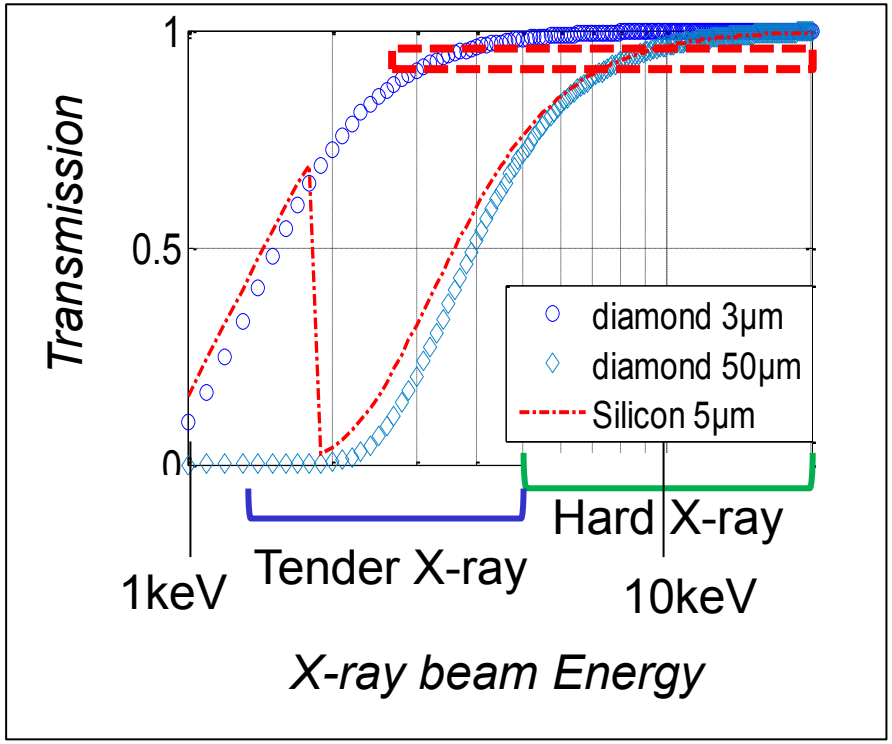
Characterisation of CVD Diamond devices as XBPMs at SOLEIL
Kewin Desjardins *et al* 2013 *Journal of Physics: Conference Series 425 (2013) 212004*





but…..transmission issue for low energy beamlines (1-5keV)

Utra-thin XBPM - Motivation

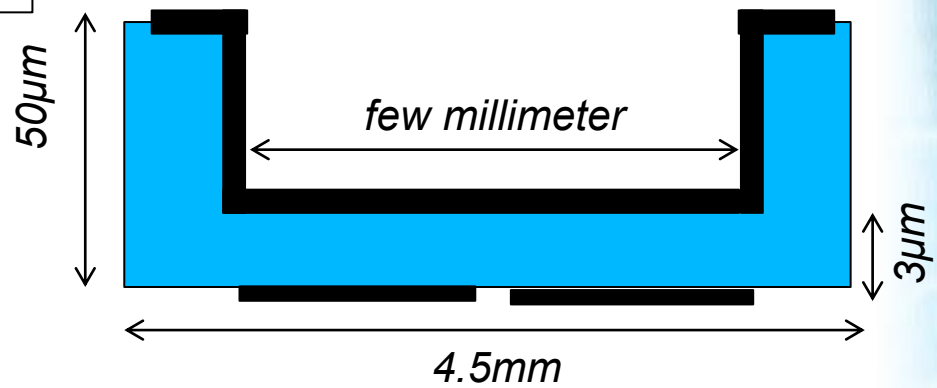


Challenging X-ray beamline working between 1.4keV to 11keV

Need to reduce thickness down to 3µm of Diamond

Deep etching in magnetron sputtering PVD

- Ar/0 plasma
- simple shadow masks
- currently about 1.2µm/h max

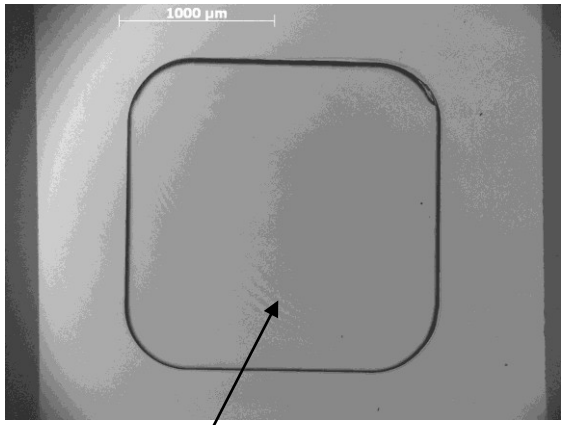


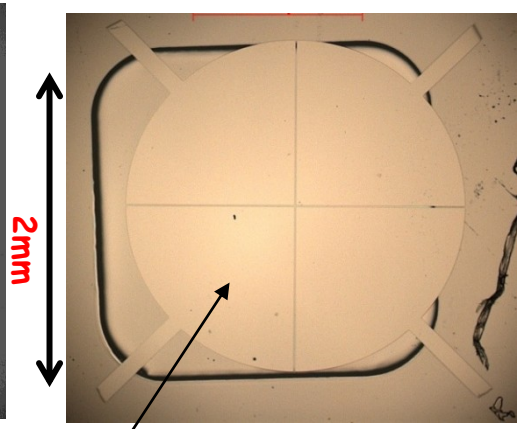
See M. Pomorski talk 1rst ADAMAS in 2012

Ultra thin XBPM

First prototype

Etching and electrode fabrication





3 µm thick membrane 2mm x 2mm

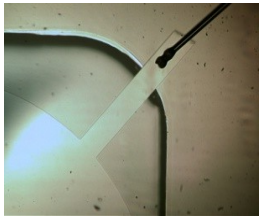
Quadrant Al photolithography

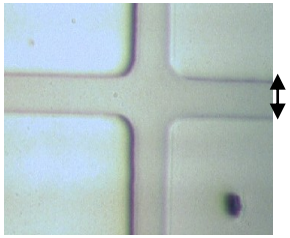
Using a Optical Grade plate e6 (5ppb<[N]<1ppm)
pre-thinned to ~60µm by polishing (DDK)

selected by J.Morse ESRF, France

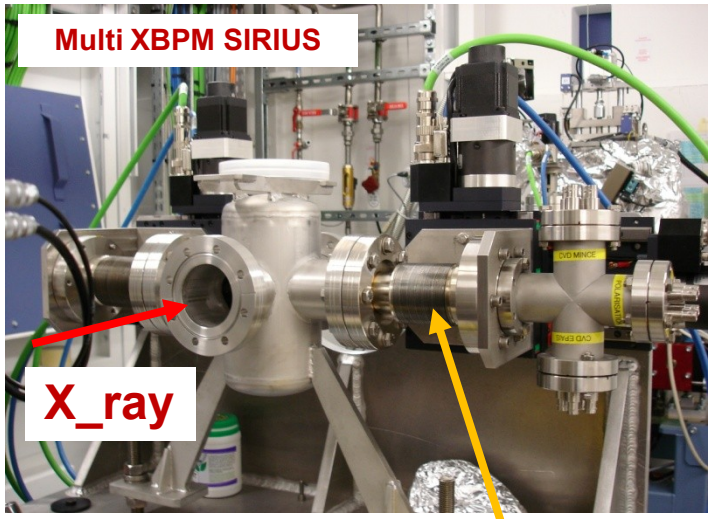
M. Pomorski, Diamond sensors Laboratory, CEA LIST, France

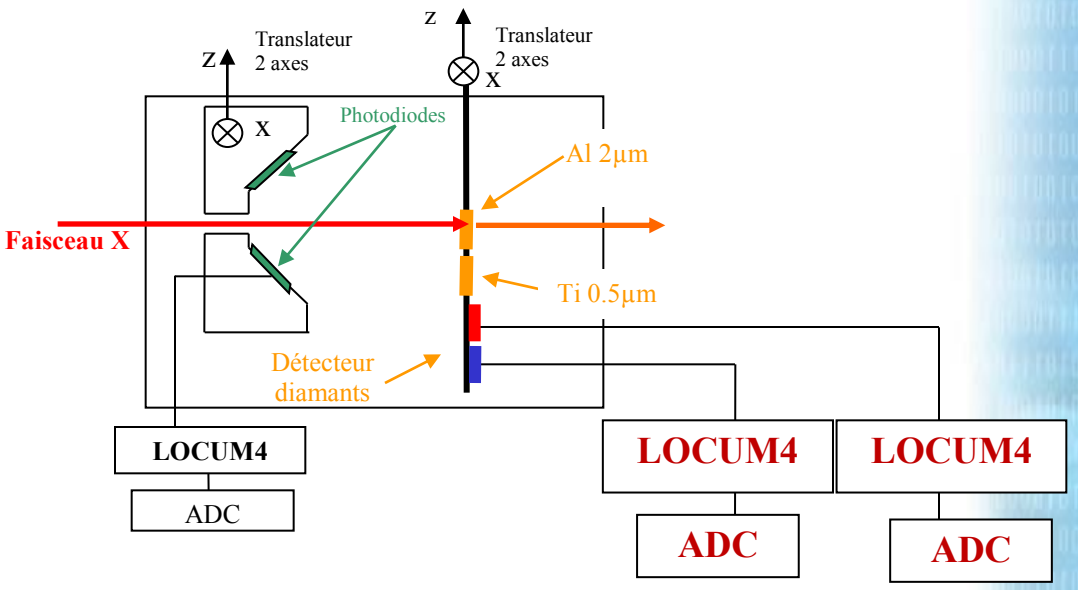
[XBPM 3µm OG-scCVD Diamond]

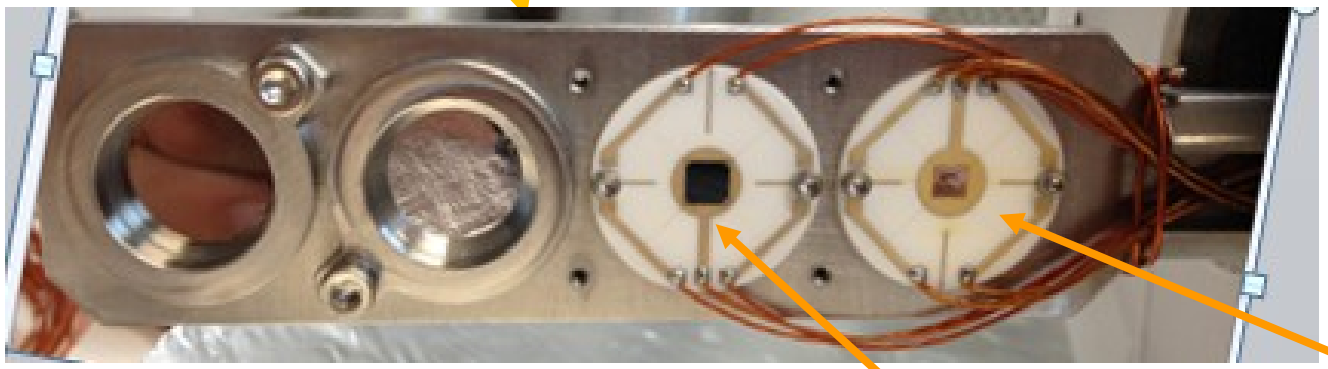




Multi XBPM on SIRIUS beamline







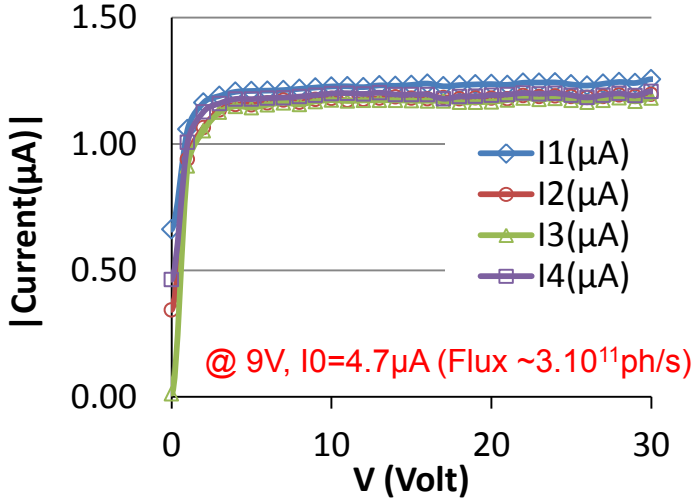
4Q scCVD 3µm

4Q scCVD 50µm

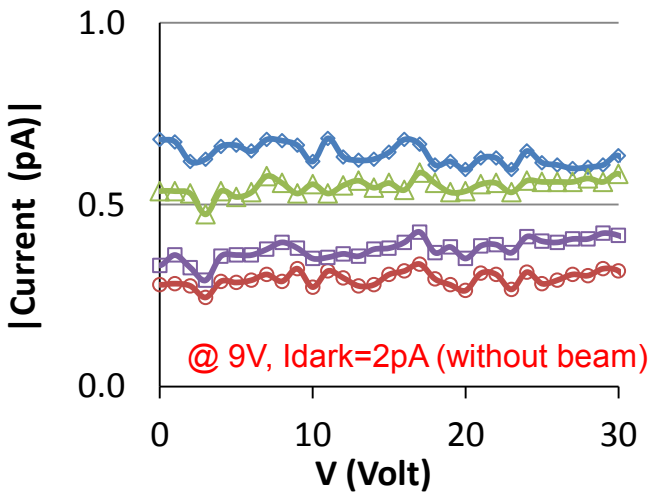
XBPM 3µm – Intensity monitoring

X-ray beam induced current (XBIC)

[100% of CCE for 2V/µm]

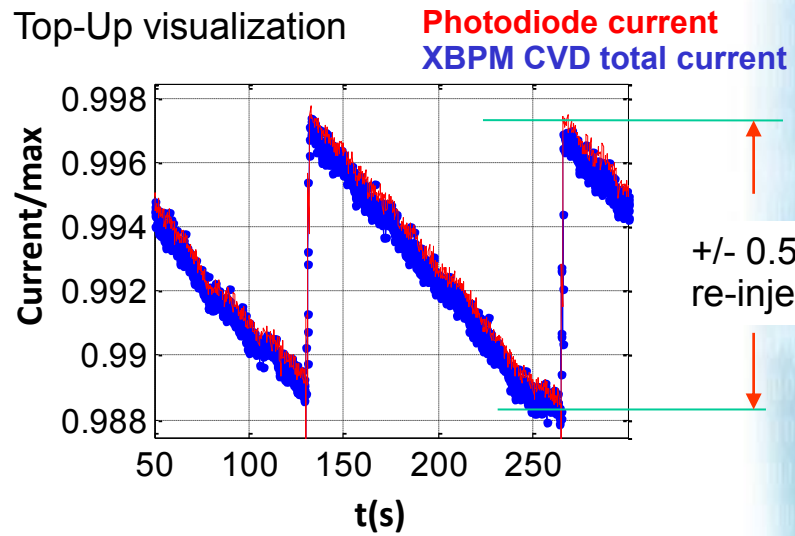


Leakage current



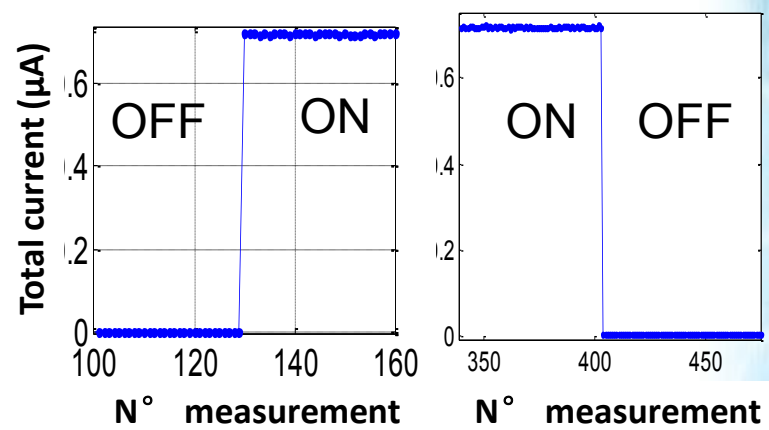
Intensity Monitoring (I0)

[Sensitivity at ‰ level]



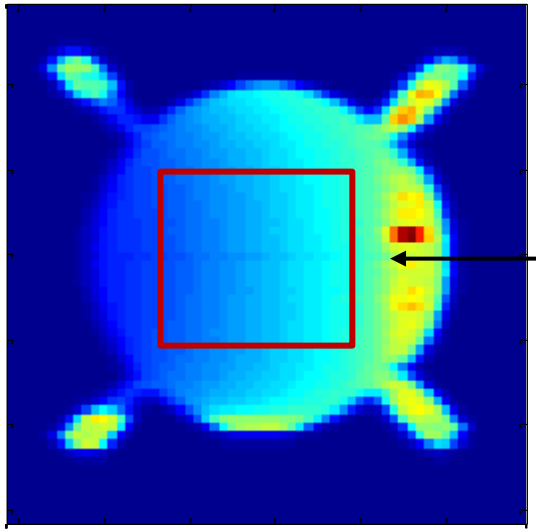
XBIC (ON/OFF)

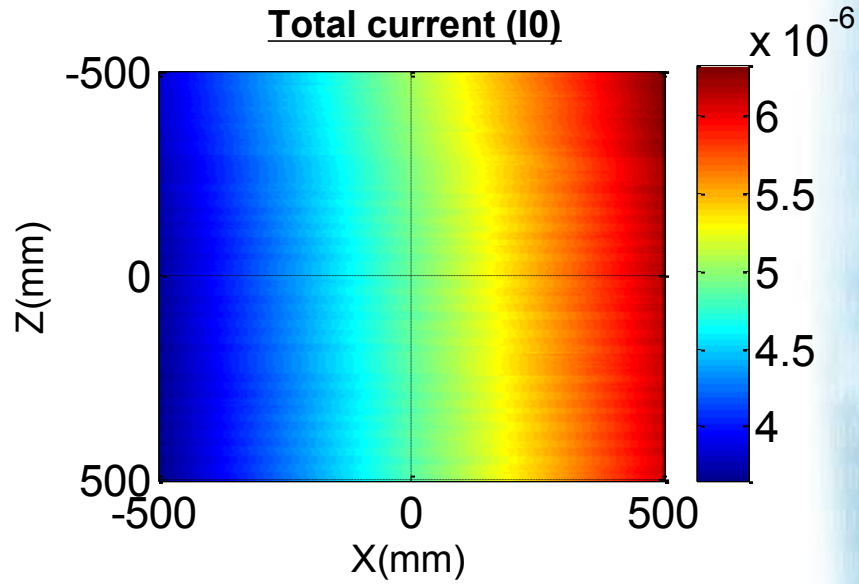
[no priming, no persistence]



XBPM 3µm – Homogeneity

2D scan total current (I0)



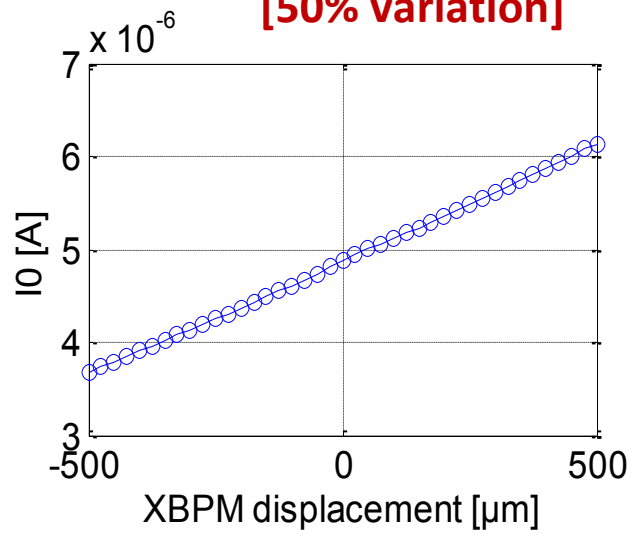


Intensity inhomogeneous response compared to 50µm XBPM

Signal change by a factor of 2 due to

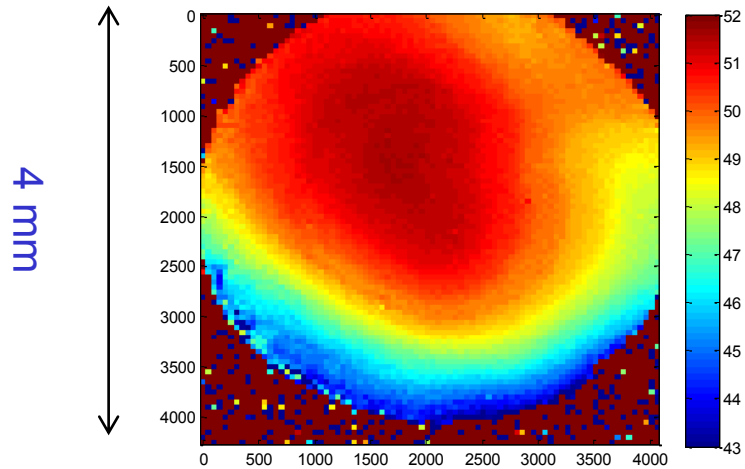
the sample wedge (polishing)

[50% variation]

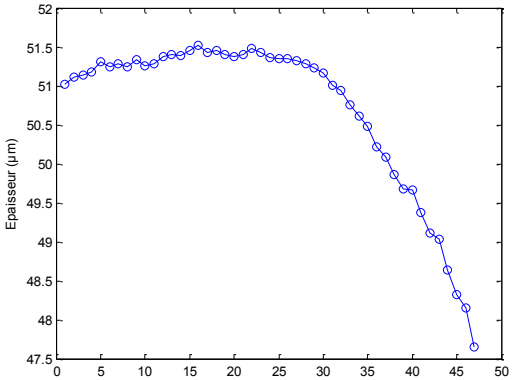


Wedge problem

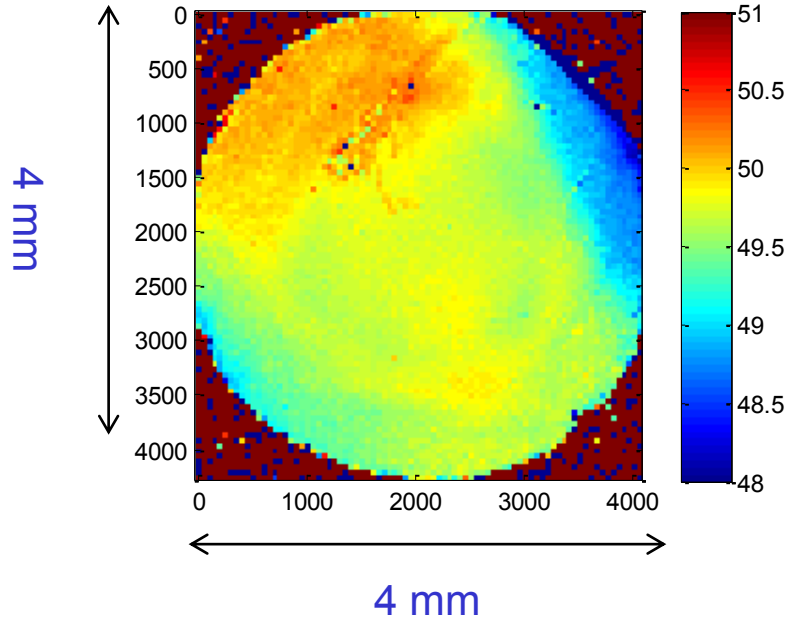
mean = 50.3µm



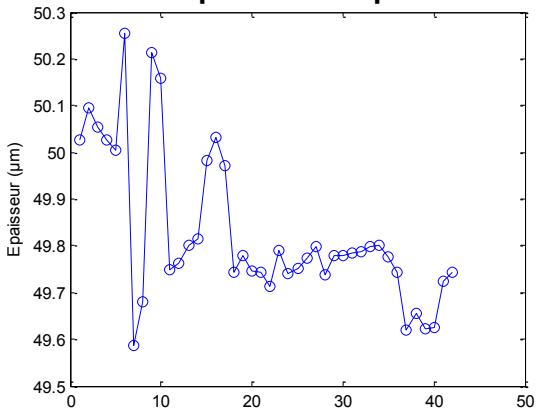
Pp = 6.3µm



mean = 49.75µm



Pp = 1.1µm



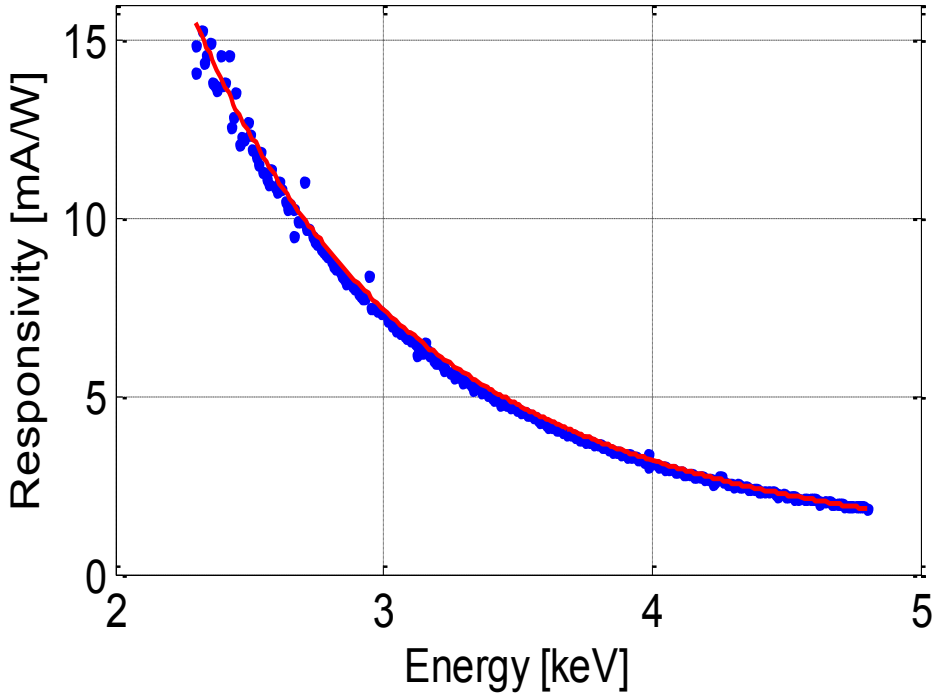
XBPM 3µm – Responsivity

XBPM Total current → Φ Flux

Responsivity (A/W)

$$I = \eta \frac{E_{ph}}{\varepsilon_r} A\Phi \quad CE$$

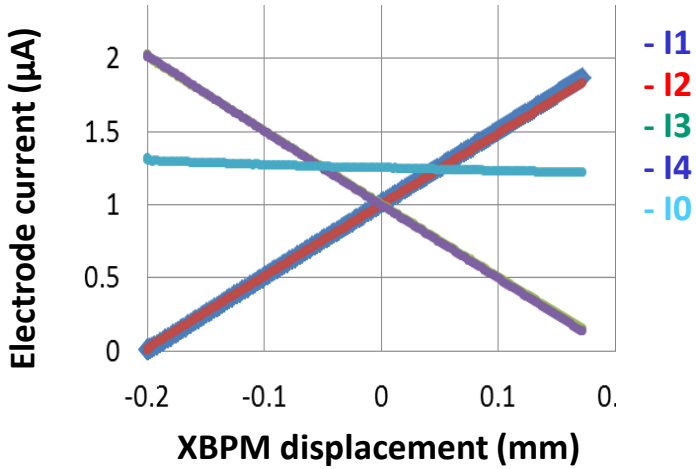
[Absolute flux detector]

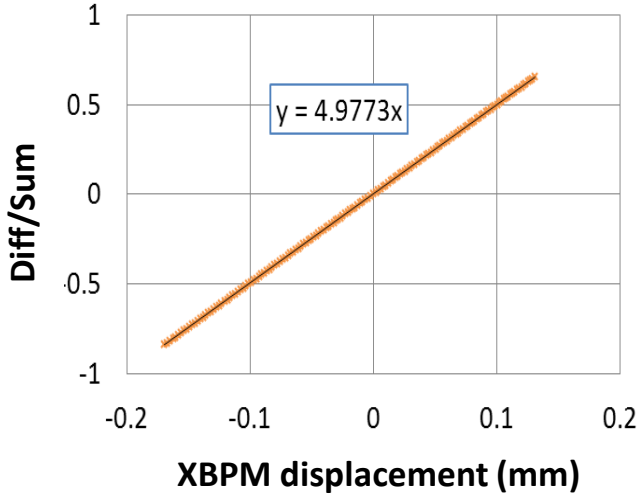


XBPM 3µm - Position Calibration

1D scan

[Horizontal & Vertical scale factor (mm^{-1})]

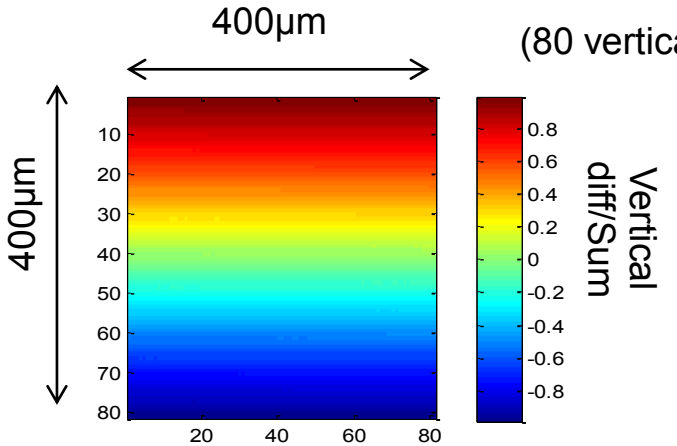




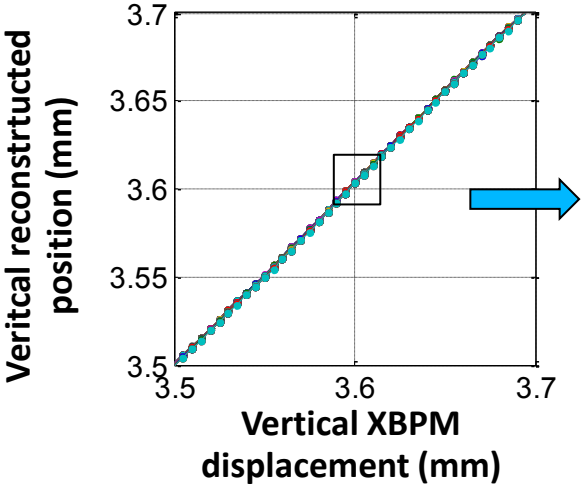
Kx = 0.3 mm and Kz = 0.2 mm

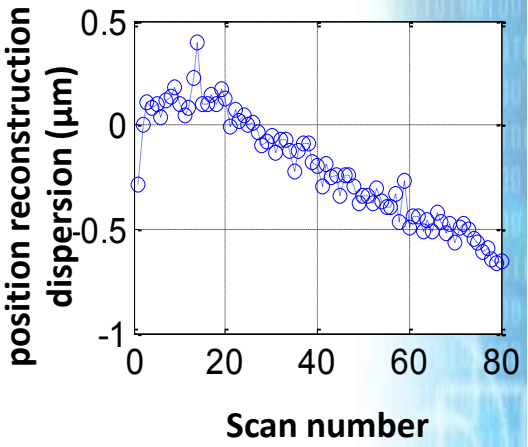
2D scan

(80 vertical scans)



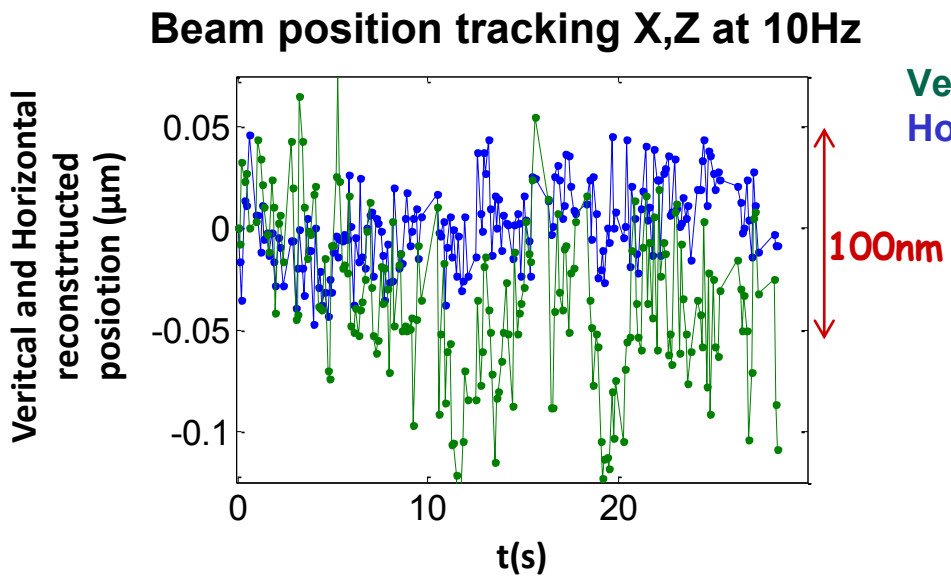
[homogenous position calibration]



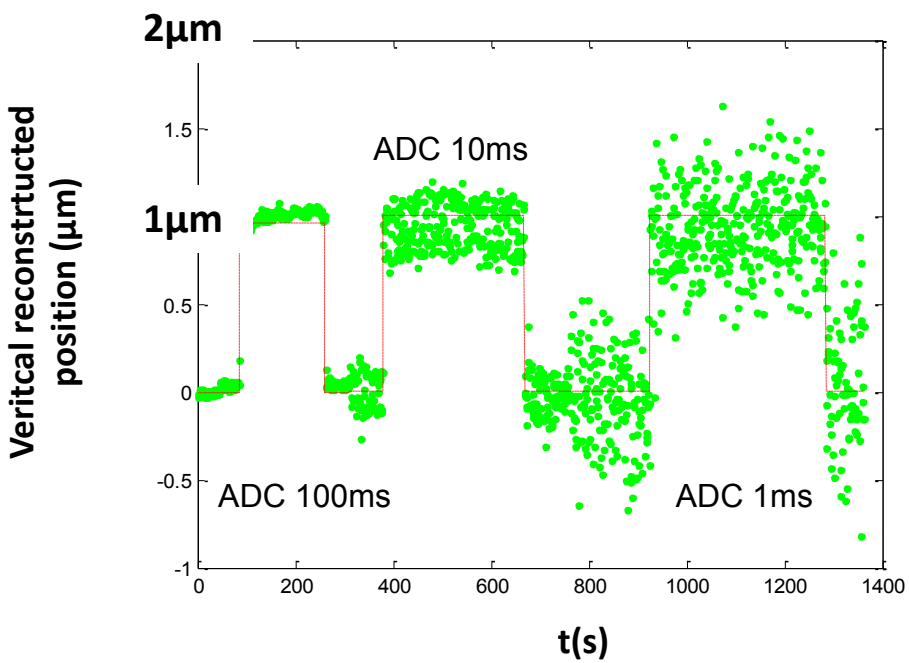


σZrec = 0.27 µm
ppZrec = 1.13 µm

XBPM 3µm - Position resolution



Vertical reconstructed position
Horizontal reconstructed position



[Submicron position resolution for 1kHZ]

(identical to thick EG)

BW [Hz]	Resolution measurement	
	X [rms]	Z [rms]
10	20 nm	40 nm
100	120 nm	250 nm
1000	250 nm	800nm

XBPM 3µm - Summary

We managed to produce **super-thin XBPM on OG scCVD** membranes:

- auto-supported and robust
- Low absorption for tender X-ray, 3% for 4keV
- 100% CCE

- submicron position resolution
- X-ray beam intensity monitoring at ‰ level
- Absolute flux detector

'the wedge' is current limiting factor for few micron thick large area membranes

The diamond have to select (wedge, polishing, structural defects, …)

Next devices

PSD for Hard X-ray beamline 25µm
new XBPM 3µm

Thank you for your attention

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