Dose and photon counts statistics

	ESRF Bending Magnet 05 characteristics
Transverse Coherence	~ 9 µm x 25 µm
Energy resolution	ΔE/E~ $3.7\ 10^{-2}$ using double multilayer monochromator ΔE/E~ $2.1\ 10^{-4}$ using double crystal Si(111) monochromator
Photons	$3\ 10^{12}$ ph/s/mm^2 with double multilayer monochromator $2.4\ 10^{10}$ ph/s/mm^2 with double Si(111) monochromator
Detection	16-bit, indirect-illumination, 2-dimensional Frelon camera (dynamic: from 100 (noise) up to 26000 counts)

Minimum counts per pixel to ensure trustable cross-correlation with Frelon CCD camera: 300 (SNR ~ 3)

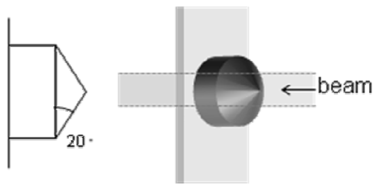
Minimum flux with detector pixel size 0.8 µm^2: ~ 1.10^{11} ph/mm^2

Minimum flux with detector pixel size 5.8 µm^2: ~ 2.10^{9} ph/mm^2

Some currently used quantitative methods for hard X-Rays phase sensing

Instrument	Sensitivity	Absorption in the device at 12 keV	sampling resolution	Few Comments
Grating interferometer	~ 0.1 µrad	> 50%	~ 1 µm	(+) suitable for large field of view (-) high absorption in gratings at lower energies (-) several exposures required to measure the phase shift accurately
Hartmann sensor	~ 0.1 µrad	Not applicable	~ 20 µm (resolution of the holes grid)	(+) single shot measurement (-) low spatial resolution (-) delicate calibration
XST technique	< 0.1 µrad	~ 0 %	< 1 µm	(+) high sensitivity, high sampling resolution (+) simple arrangement (+) single exposure for differential measurement
TIE based methods		0 %	~ 1 µm	(+) simple arrangement (-) complex numerical methods (-) multiple exposures required (-) restricted to non absorbing samples

Phase imaging of a PMMA cone



PMMA Cone sample

Detector field of view: 1.6 mm x 1.6 mm
Pixel size: 0.8 µm
Speckle size: ~10 pixels

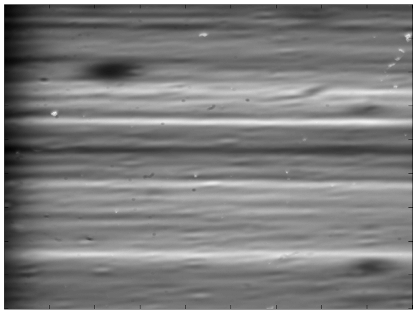
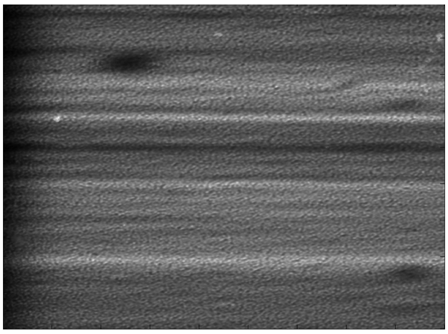
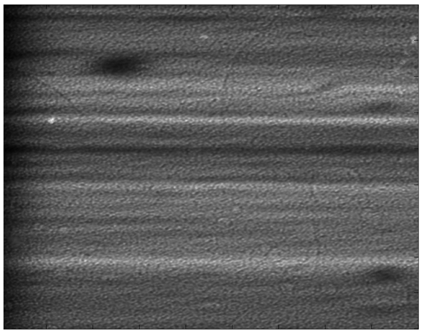


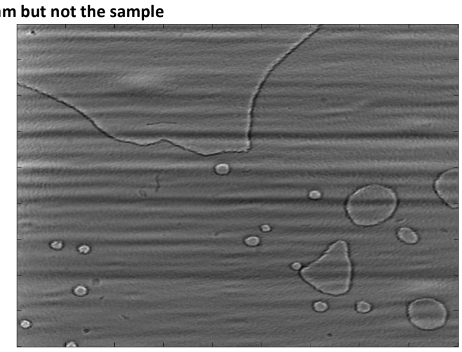
Image of the direct beam, without sample and without membrane



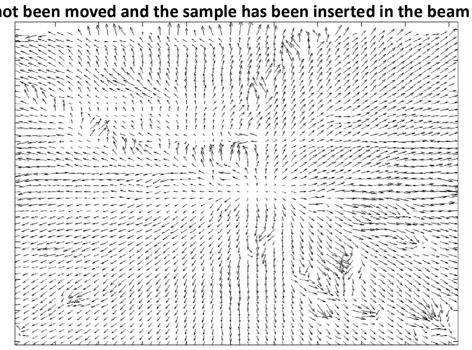
Aquisition 1 – image of the speckle pattern: the membrane is in the beam but not the sample



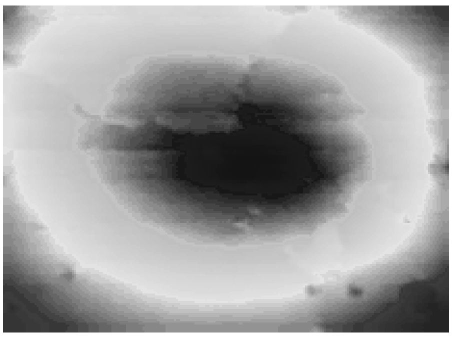
Aquisition 2 – image of the distorted speckle pattern: the membrane as not been moved and the sample has been inserted in the beam



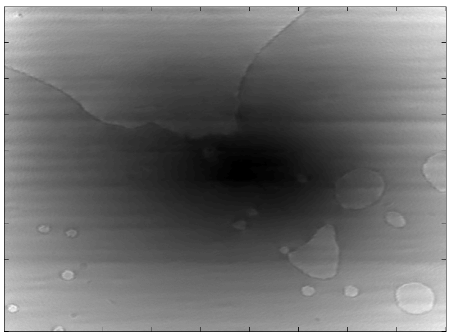
Absorption image calculated by dividing acquisition 2 by acquisition 1. As we are in the Fresnel regime but not at zero distance from the sample, edges of phase objects (air bubbles in the glue) are emphasized. Here the phase gradient information is not recovered and the cone shape of our sample remains invisible.



Speckle displacement vectorfield calculated using a Digital image correlation algorithm.

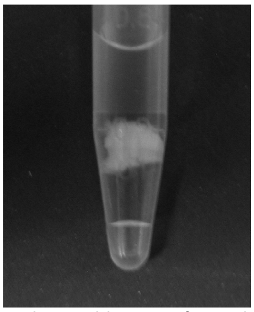


Phase reconstruction using the XST technique: the cone is fully recovered in a quantitative way as well as the phase accidents caused by the presence of air bubbles in the glue of the sample holder.



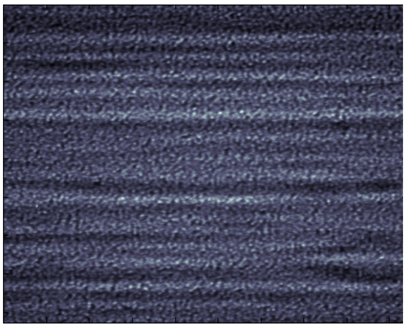
Phase map reconstruction and edges enhancement using the absorption image.

Cartilage differential phase imaging

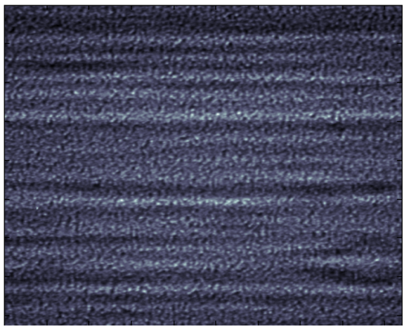


Sample made of cartilage and bone cut from a human finger. The sample is floating in a formaline solution

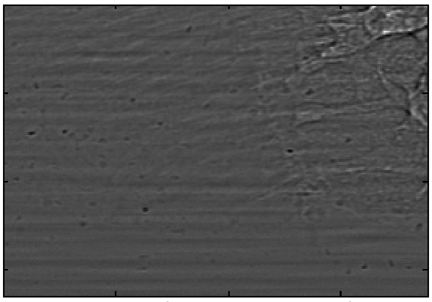
Energy: 12 keV
Detector field of view: 1.6 mm x 1.6 mm
Pixel size: 0.8 µm



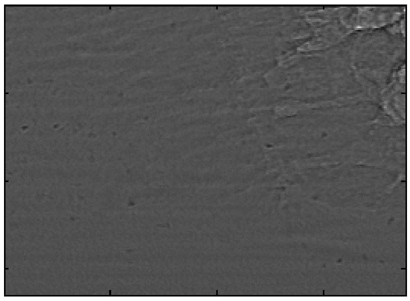
Acquisition 1 – image of the speckle pattern: the membrane is in the beam but not the sample



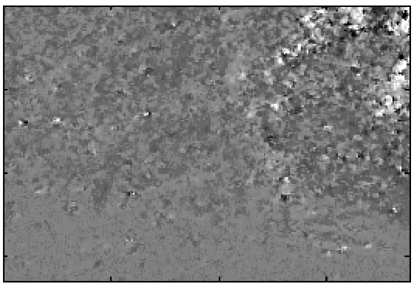
Acquisition 2 – image of the distorted speckle pattern: the membrane as not been moved and the sample has been inserted into the beam



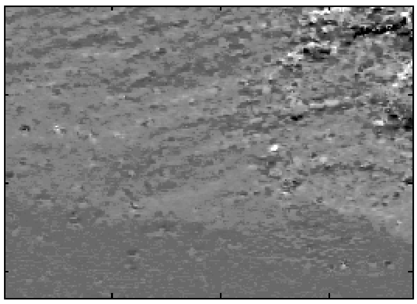
Standard absorption image (without any membrane): while the bone on the right hand side of the image is easily recognizable, the cartilage on the left hand side is barely visible. No sample is present at the bottom of the image.



Absorption image with speckle image: Acquisition2/Acquisition1
The shift of the speckle is so small that the resulting absorption image is highly comparable with the absorption image obtained without the membrane in the beam



Horizontal differential phase image
The cartilage and its structure are clearly visible.



Vertical differential phase image