	Experiment title: Resolution below physical pixelation – Energy dependant characterisation of sub-pixel performance of an energy-dispersive 2D pnCCD detector	**Experiment number**: MI-1332
Beamline: ID13	**Date of experiment**: from: 26.4.2018 to: 29.4.2018	**Date of report**: 25.2.2020
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Report

Summary

The aim of this experiment was to characterize the sub-pixel resolution capabilities of an energy-dispersive pnCCD detector. Sub-pixel resolution can be achieved by localizing the centroid of the charge cloud created by the x-ray photon in the sensor substrate with very high accuracy. As the charge creation and migration process is energy dependent, this experiment was intended to add energy-dependent information on the charge cloud creation and the sub-pixel resolution performance of the detector at normal and oblique angle-of-incidence. Unfortunately, the limits of the employed setup, in particular the beam hardening during the attenuation, heaviliy deteriorated our data quality and we could thus only gain partial datasets with insufficient statistics.

Samples and Setup

The experiment was carried out at the micro branch (EH2) of ID13 while the storage ring was operated with a four bunch filling pattern as the experiment required very little photon intensity at an energy of 8 and 12 keV. The detector was operated in a dedicated vacuum vessel that was placed on the detector stage of ID13. A micro beam was created with a fresnel zone plate and focused on the pnCCD sensor, with a Pt/Ir order separation aperture. The beam intensity was controlled by inserting absorbers (Fe and Al) into the beam path to be able to operate the detector in single photon counting mode. In addition to the absorbers, the U35 undulator was detuned to further reduce the beam intensity.

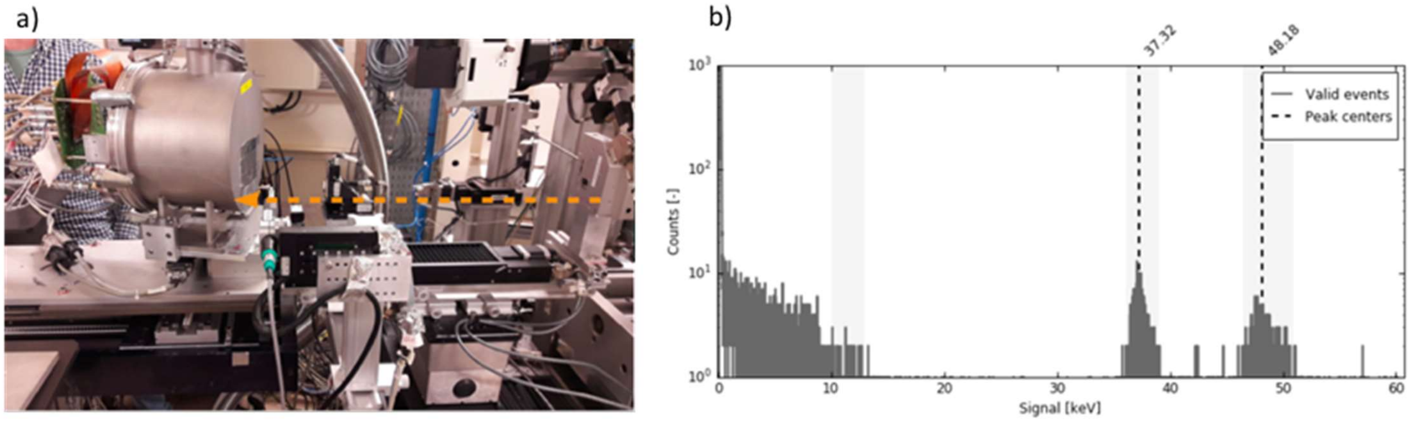

Figure 1 a) Experimental setup showing the vacuum vessle of the detector and the beam path b) Histogram of the detected events (incident beam 12 keV) close to the focal spot. The shaded areas indicate the signal intervals of the 1^{st} harmonic at 12keV, the 3^{rd} harmonic at 36 keV as well as the pile-up peak at 48 keV

Principal outcome

In total, we were able to obtain six data sets at 8 and 12 keV. The data acquisition process comprised a 2D map across the crossing point of 2x2 neighbouring pixels under normal incidence as well as two 1D line scans under a beam-detector incidence angle of 20 and 40 degrees. Further experiments for the detector and beam characterization were carried out as well. Fig 1a) gives an overview over the experimental setup and Fig 1b) shows the spectral composition of the photon energy in the focal spot at an incident beam energy of 12 keV It is directly evident that very little 12 keV photons can be detected in the spot and just 36 and 48 keV photons are present. We found this behaviour systematically in all our scans and after having verified our detector energy calibration, we are certain that the 36 keV signal is indeed 36 keV photons and not just pile-up of 12 keV photons due to the absence of double pile up. Our interpretation for this finding is the beam hardening effect during inserting the absorbers. As ID13 is supressing higher harmonics by attenuation them with a CRL prefocusing system instead of rejecting them with a mirror for stability reasons, the attenuation of the primary x-ray beam with absorbers obviously has allowed the 36 keV photons coming from bending magnet radiation of neighbouring bends and the general radiation background in the storage ring. Furthermore, the Fresnel zone plate can focus 36 keV photons in the same way as 12 keV photons.

Conclusions and further proceedings

In conclusion, this experiment was degraded by the spectral composition of the incident x-ray beam. Unfortunately, this was only realized after the experiment as the online data analysis was only possible to a very limited extend due to problems of concurrent data transfer and acquisition. The analysis of a dedicated dataset with sufficiently low gain and fast data acquisition helped us to evidence the presence of this high energy contamination. Most of the data sets were however acquired with a gain setting that didn't allow to detect 36 keV photons and hence overloading the ADC. The combination of all these factors led to the acquisition of non-contiguous datasets which could only be analysed to a certain extend and will not be able to give us the desired answer to the sub-pixel resolution of the pnCCD at these intermediate x-ray energies. Another point is that in hindsight another focusing optics would have been more suited for the experiment, like a KB mirror.

We would however acknowledge the strong support of the beamline to accommodate this experiment despite the invasive nature of the experiment and furthermore thank for the help of the PSCM labs with 3D printing of components in the preparation of this experiment.