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Towards ps and fs diffraction with the XPAD detector

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Short (ps) or ultra-short (fs) synchrotron X-ray pulses enable to probe the dynamics of photo-induced molecular states, collective movements in solids, or the course of chemical reactions. In so-called 'pump-probe' experiments, the system being studied is excited by a fs or ps laser pulse and probed after a certain delay by a pulse of synchrotron X-rays. This procedure must be repeated many times, in a stroboscopic way, to generate the necessary statistics for a reliable measurement.
Experiments of this kind are already being carried out in synchrotron radiation centres, where the beam delivered is naturally pulsed thanks to the 'bunch'structure of the electron beam in the storage ring. Nevertheless, to perform time-resolved experiments, only the X-ray pulse immediately following the laser pulse should be counted. In SOLEIL's'eight-bunch'mode for example, the counting of diffracted photons must be enabled for no longer than twice the bunch spacing, 2x147ns ˜300 ns.The 2D detectors normally used in diffraction, CCD cameras or image plates cannot switch that quickly. This is the reason why the selection of the X-ray pulse to be measured is usually performed by a mechanical selector, or 'chopper'. Unfortunately, choppers are limited to a maximum frequency of 1 kHz, cannot be fully frequency-tuned, and involve a complex mechanical design.
In collaboration with the CCPM and the CRG D2AM beamline at ESRF, the Detector group of SOLEIL is developing a hybrid pixel detector: XPAD. The version 3.2 of this detector has been optimised to be able to count on a duration specified by the width of a logic gate, at any frequency. The rest of the time, the counting of photons is disabled.
The feasibility of pump probe experiments with XPAD3.2 was proven on SOLEIL's CRISTAL diffraction beamline, where a single chip was synchronized to one of the eight bunches circulating in the storage ring, at up to 100 kHz. A module consisting of 7 chips hybridized to a Si sensor (7×1.5 cm2) will be used this spring, to study the structural dynamics of molecular spin-crossover crystals induced by a laser pulse. The preliminary results, from the detector point of view, of this experiment will be presented. The full detector (8 modules, 56 chips, 7×12 cm2, Si sensor) will be available for pump probe experiments at SOLEIL by the end of this year.

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