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Ultra-Fast Hybrid Pixel Detector for Synchrotron Time-Resolved Pump-Probe Diffraction Experiments

A time-resolved diffraction experiments at Synchrotron SOLEIL are based on a general pump-probe scheme developed and implemented on hard X-ray beamline. In such experiment, samples are excited with an ultra-short laser pulse (the pump) and their atomic structures changes are studied by measuring the diffraction pattern from a single pulse of synchrotron radiation (the probe) with a 2-D pixel detector with a precisely controlled delay. Recently, an improvement to the classical pump-probe scheme has been proposed at Synchrotron SOLEIL to study sample's response at two different delays after each laser excitation. For this purpose, a new pump-probe-probe scheme is proposed, based on a new detection which requires ultra-fast X-Ray hybrid pixel detector for photon counting. This new detector is under development. With this detector, the pump-probe-probe experiments can be carried out with a laser repetition rate up to 5 kHz and with time between two delays below 100 µs. Furthermore, the spatial resolution needed requires square pixels not larger than 75 µm, and a temporal resolution down to few tens of nanoseconds. Moreover, pile-up and cosmic events have to be rejected from the measurement thanks to two detection discriminators thresholds architecture. Despite nice performances principle already existing on small prototypes, large area detector for time resolved studies have still to be demonstrated and should overcome present limitations. Therefore, a new detector generation, dedicated for time resolved studies, is proposed in this project. Such device would be based on a hybrid pixel detector with a dedicated readout circuit working in photon counting mode. The detector would allow acquisition with at least four different delays after laser excitation and would be characterised by an excellent time resolution and temporal dispersion on the nanosecond scale. Together with capability to count for periods of maximum few tens of nanoseconds it would offer a unique possibility to carry out the experiments also on the filling modes of the synchrotron storage ring that today are not adapted for time resolved studies (i.e. uniform). Additionally, the detector would work in the energy windowing mode, to perform energy dispersive time resolved experiments.

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