Contribution ID: **7** Type: **Contribution type**

Advances in hybrid detector development for synchrotrons and XFELs at PSI

Wednesday, 9 June 2021 15:55 (20 minutes)

Hybrid detectors developed at PSI are used worldwide for synchrotron and XFEL applications. They consist in a sensor absorbing the X-ray radiation, usually silicon, connected to the CMOS readout electronics, that processes the signal generated by the sensor signal on a pixel by pixel basis. This gives the advantage that both components can be optimized separately.
Single photon counting detectors are well established at synchrotrons for diffraction applications, but they also have several drawbacks. They cannot work at low energies (about 2 keV), the minimum pixel pitch is technology-limited and they require major improvements in order to sustain the high intensities provided by fourth generation synchrotron sources.
Charge integrating detectors with dynamic gain switching can provide an extended dynamic range and find applications at X-ray Free Electron Lasers as well as at synchrotrons for high flux experiments as an alternative to single photon counters, despite the challenges given by their high data throughput and their complex calibration. In low illumination conditions, analog detectors also provide information on the X-ray energy.
Moreover, despite being limited in the pixel size by the bump-bonding, it is possible to exploit charge diffusion to interpolate the photon position at the level of a few microns, combined with an energy resolution of about 1keV FWHM.
In parallel to the advances in the readout electronics, sensors with improved quantum efficiency are under development, optimizing a shallow entrance window for soft X-rays or exploiting heavier material than silicon for higher energies (e.g, GaAs, CdTe or CdZnTe).
Additionally, sensors with internal amplification (LGADs) can improve the signal-to-noise ratio of low energy photons and allow single photon counting detectors to be operated also in the soft X-ray energy range.
This presentation discusses recent advances in detector development at PSI and the challenges that we are facing due to the new X-ray sources.

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Session Classification: Session