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Charge sharing measurements for digital algorithms achieving subpixel resolution in hybrid pixel detectors.

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Hybrid pixel detectors are segmented devices used for X-ray detection, consisting of a sensor attached to readout electronics. Detectors working in single-photon counting mode process each incoming photon individually, have essentially infinite dynamic range and by applying energy discrimination they provide noiseless imaging [1].
To improve the resolution of the detector and allow operation with high-intensity photon fluxes, the pixel size is reduced. However, with decreasing pixel size, a charge sharing effect is more significant. This leads to false events registration or omitting the event and degradation of the energy resolution of the detector. The algorithms aiming at reducing the influence of charge sharing are already implemented on-chip [1]. However, the spatial resolution of the detector can be increased beyond the physical pixel size if charge proportions collected by neighboring pixels are analyzed. Today's technology allows the implementation of an ADC in each readout channel [2], which makes the implementation of a digital algorithm achieving subpixel resolution possible.
The simulations show that charge cloud size referred to pixel size and noise are the key parameters that determine the subpixel algorithm accuracy and final detector resolution [3]. Therefore, two chips attached to the sensors of different materials and different thicknesses were tested to observe and quantify the charge sharing effect. Devices under test were the LNPIX IC, consisting 128 x 256 pixels of 75 um pitch, attached to 320 µm Si detector, and MPIX IC, consisting 96 × 192 pixels of 100 µm pitch, attached to 0.75 mm and 1.5 mm CdTe detector [4]. The spectral response was measured for each device and the Edge Spread Function (ESF) was calculated.

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[2] P. Kmon et al., "Spectrum1k —integrated circuit for medical imaging designed in CMOS 40 nm,"Journal of Instrumentation, vol. 17, no. 03, p. C03023, Mar. 2022, doi: 10.1088/1748-0221/17/03/C03023.
[3] A. Krzyżanowska and R. Szczygieł, "Simulation study on improving the spatial resolution of photon-counting hybrid pixel X-ray detectors,"Opto-Electronics Review, vol. 29, no. 4, pp. 187–191, 2021, doi: 10.24425/OPELRE.2021.139756.
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