

Tytuł: Algorytmy cyfrowego przetwarzania danych w systemach detekcji promieniowania X. Projekt NCN, (2020-2022)

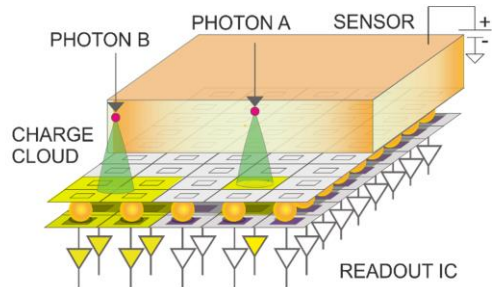
Title: Digital processing algorithms in X-ray detection systems. Project NCN, (2020-2022)

Principal Investigator

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Development of alternative solutions which can improve both spatial resolution and high count rate performance of hybrid pixel X-ray detectors using digital or analog signal processing.

Hybrid pixel detectors are segmented devices used for particles detection, consisting of a sensor and readout electronics. They are connected together in the final production step using bonding technique, which establish electrical and mechanical connection between each detection segment and its matching readout channel. To improve the resolution of a hybrid pixel detector and allow operation with high intensity photon fluxes, a pixel size is reduced. However, with decreasing pixel size, a charge sharing effect is more significant. The charge sharing effect occurs if charge generated during the photon-sensor interaction drifts towards pixel electrodes and spreads due to diffusion and repulsion. If the interaction occurs at the border between pixels, the charge may be collected not by a single electrode (like in case of photon A in Fig.1), but by two or more neighboring pixels (like in case of photon B). As a consequence, fractional signals are induced and processed in several readout channels instead of one. To detect a photon irrespectively of charge sharing effect, the total photon energy should be reconstructed from fractional signals. Therefore, the algorithms dealing with charge sharing are developed. Detailed studies and simulations of known solutions lead to the conclusion that even though anti-charge-sharing algorithms allow to reconstruct the initial photon energy and allocate the hit to the proper pixel, they have several disadvantages:

- the resolution of a detector is limited by the pixel size, which must be large enough to fit all the functionality required by the complex algorithms,
- the algorithms do not allow to work with bright photon sources, they require analog and digital interconnections between pixels which decrease effective maximum photon count rate registered per unit area.

The purpose of the project is development of alternative solutions which can improve both spatial resolution and the high count rate performance. The proposed new solutions include:

- improving spatial resolution. The algorithms using charge weighting or center of gravity calculation can be developed. In this approach, charge sharing becomes the desired effect, since the information on the proportions of charge collected by the pixels can be used to estimate the photon interaction position with subpixel resolution.
- using digital signal processing for charge summing which is much faster in comparison to analog summing algorithms and does not put additional constraints on the front-end readout channel processing speed.

All of the developed algorithms need evaluation if they can be implemented in a required pixel size. Deep submicron technologies, which are very area effective for digital logic implementation, will be used.

Journal / Conference Papers

- *Simulation study on improving the spatial resolution of photon-counting hybrid pixel X-ray detectors* / A. KRZYŻANOWSKA, R. SZCZYGIEŁ // *Opto-Electronics Review* / Stowarzyszenie Elektryków Polskich, Wojskowa Akademia Techniczna. Warszawa ; ISSN 1230-3402. — 2021
- Charge sharing simulations for new digital algorithms achieving subpixel resolution in hybrid pixel detectors / A. KRZYŻANOWSKA, A. Niedzielska, R. SZCZYGIEŁ // *Journal of Instrumentation* [Dokument elektroniczny]. — Czasopismo elektroniczne ; ISSN 1748-0221. — 2020 vol. 15 art. no. C02047,
- Measurements of charge sharing in a hybrid pixel photon counting CdTe detector / A. KRZYŻANOWSKA // *Journal of Instrumentation* [Dokument elektroniczny]. — Czasopismo elektroniczne ; ISSN 1748-0221. — 2021 vol. 16 art. no. C12027, s. [2],
- Charge sharing simulations and measurements for digital algorithms aiming at subpixel resolution in photon counting pixel detectors / A. KRZYŻANOWSKA, R. Szczygieł, P. Gryboś, J. Koczwarą, K. Cisło, A. Stasiak // *Journal of Instrumentation* [Dokument elektroniczny]. — Czasopismo elektroniczne, vol. 18 art. no. C02024

Presented research results:

- 21st International Workshop on Radiation Imaging Detectors, 7-12 July 2019. Kolympari, Chania, Crete, Greece
- 22nd International Workshop on Radiation Imaging Detectors, June 27- July 1, 2021 in Ghent, Belgium
- XX Krajowa Konferencja Elektroniki, 5-9.09.2021, Darłowo
- 2022 IEEE Nuclear Science Symposium, Medical Imaging Conference and Room Temperature Semiconductor Detector Conference', 05 – 12 November 2022, Milano, Italy
- The International Workshops on Radiation Imaging Detectors', 26–30 June 2022, Riva del Garda, Italy