Contribution ID: **48** Type: **poster**

Digital implementation of the Inverse Error Function for subpixel resolution algorithms in hybrid pixel detectors.

Hybrid pixel detectors are segmented devices used for X-ray detection that consist of a sensor attached to the 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 severe. This leads to false event registration or omitting the event, and thus, degradation of the energy and position resolution of the detector. 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 [2], [3]. An alternative digital algorithm using approximation of the inverse error function can be implemented on-chip.

This work focuses on the core of the new digital algorithm, namely, the implementation of the Inverse Error Function (erf-1) in a 40nm CMOS technology. The design is modeled using SystemVerilog hardware description language (HDL) and verified through targeted and random simulations. A fixed-point arithmetic approach is employed to approximate the function. The impact of architectural trade-offs on power, precision, and area are evaluated. The design is optimized for the digital in-pixel algorithm allowing photon registration with subpixel resolution in photon counting detectors. However, the methodology of the approximation of the erf-1 function can be used for future research in efficient hardware computation of other complex mathematical functions.

[1] R. Ballabriga et al., "Photon Counting Detectors for X-Ray Imaging with Emphasis on CT,"IEEE Trans Radiat Plasma Med Sci, vol. 5, no. 4, pp. 422–440, Jul. 2021, doi: 10.1109/TRPMS.2020.3002949.
[2] P. Grybos, R. Kleczek, P. Kmon, P. Otfinowski, and P. Fajardo, "Small pixel high-spatial resolution photon-counting prototype IC for synchrotron applications,"Journal of Instrumentation, vol. 18, no. 1, Jan. 2023, doi: 10.1088/1748-0221/18/01/C01052.
[3] A. Krzyzanowska and P. Otfinowski, "Digital subpixel algorithm for small pixel photon counting devices," Opto-Electronics Review, ISSN 1896-3757. —2025 —vol. 33 no. 1 art no. e152768, s. 1–6.

Workshop topics

Front-end electronics and readout

Authors: Dr KRZYŻANOWSKA, Aleksandra (AGH University of Krakow); Dr OTFINOWSKI, Piotr (AGH University of Krakow); Mr LITWINEK, Tomasz (AGH University of Krakow)

Presenter: Mr LITWINEK, Tomasz (AGH University of Krakow)