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ANN on-chip and in-pixel implementation towards pulse amplitude measurement

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We present the design and simulation results of an intelligent pixel consisting of an analogue front-end, Analog-to-Digital Converter (ADC) and an Artificial Neural Network (ANN) for in-pixel data pre-processing. The source of signals is a silicon X-ray sensor connected to the front-end optimized for 4 keV - 12 keV. The low-noise operation in the order of 60 el. rms. allows for precise signal representation before digitizing with 6-bit and 5 MHz –10 MHz sampling rate ADC. 6-bit samples are buffered and further processed by an ANN, which main goal is to give the precise estimation of the pulse amplitude with the resolution exceeding 6 bits. With the presented approach we overcome the traditional photon energy measurement, where analogue blocks are used for keeping the pulse amplitude information and then digitizing it with more precise ADC. The state-of-the-art solutions that offer the highest accuracy are Medipix3RX [1] with up to 8 energy discrimination levels, Timepix3 [2] with the implementation of time-over-threshold (ToT) functionality and Flora [3] with successive approximation ADC.

In this work, we present novel approach with on-chip implementation of an ANN together with simulation results explaining the idea, providing the information about achievable accuracy, and an optimization procedure. The design is being prepared utilizing deep sub-micron technology of CMOS 28 nm, which allows for dense logic synthetizing and therefore gives an opportunity for ANN placing as close to the signal as possible.

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