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Machine Learning Applied to Active Collimation in Monolithic Arrays of SDDs

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Monolithic arrays of SDDs represent a promising solution for high-rate X-ray spectroscopy detectors at synchrotron beamlines. However, charge sharing near pixel boundaries represents an obstacle for multichannel X-ray fluorescence spectroscopy based on monolithic Silicon Drift Detector (SDD) arrays. While crosstalk is efficiently reduced by traditional mechanical collimation, active area and overall efficiency are compromised. In this work, we propose electronic collimation as a solution, and we will be presenting our research at the upcoming conference.

Experimental measurements were conducted using an ARDESIA-16 detection module, highlighting charge sharing effects through pulsed laser measurements and ^{55}Fe X-ray source experiments. Following a quantitative evaluation of the entity of charge sharing between neighboring channels, we developed a discrimination and reconstruction algorithm to identify these events and ultimately estimate their total energy by taking into account significant parameters such as rise time and coincidence of events on neighboring channels. This algorithm was effective in minimizing the background continuum while preserving overall efficiency.

Moreover, we integrated machine learning into our approach, aiming to enhance crosstalk mitigation. The combination of discrimination algorithms and machine learning utilizes the shape of step-like events at the output of the charge sensitive amplifier (CSA), their rise time, and the detector timing capabilities for effective charge sharing event identification. This integrated approach not only minimizes background but also recovers useful signals that might be discarded with simpler filters.

Our approach eliminates the need for custom-made mechanical collimators, simplifying the mounting process on SDDs, especially when dealing with narrow pixel pitches. We maximize the effective area beyond what mechanical collimation could achieve via electronic collimation and machine learning, offering an opportunity for improving the performance of SDD-based spectroscopy detectors. Moreover, we recover valuable events from the background and integrate them into the photopeak, restoring active area that is naturally lost as a result of charge sharing effects.

I plan to submit also conference proceedings

Yes

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