

End-to-end deep learning for high-precision 2D hit reconstruction in AC-LGAD sensors

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Abstract

The progressive development of particle detectors toward four-dimensional (4D) tracking imposes increasing demands on both timing and spatial resolution. While resistive AC-coupled Low Gain Avalanche Diode (AC-LGAD) sensors exhibit excellent timing performance, high-precision position reconstruction remains challenging due to complex charge sharing signals across multiple read-out pads. In this work, we present an end-to-end deep learning framework for high-precision two-dimensional (2D) hit reconstruction in AC-LGADs, consisting of a one-dimensional convolutional neural network (1D-CNN) backbone and a fully connected (FC) regression head, that directly reconstructs 2D hit coordinates from multi-channel waveforms, without relying on hand-crafted features or explicit physical models. With data acquired from high-resolution transient current technique (TCT) scans, the proposed method achieves position resolutions of about 5.4 micron near the center of the square region bounded by four neighboring electrodes, and of about 8.6 micron near the edges where charge sharing is reduced, representing a substantial improvement over the conventional amplitude-based reconstruction method used as a baseline. Furthermore, the model demonstrates robustness under reduced sampling rates compatible with realistic front-end electronics, maintaining stable performance at 5 GS/s or above, with only slight deterioration observed at lower sampling rates. These results establish the 1D-CNN-based method as a powerful and flexible tool for high-precision 2D hit reconstruction in AC-LGADs and highlight the promise of deep learning approaches in advancing silicon detector technology.

Note: Figure translations are in progress. See original paper for figures.

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