

KNN-Based Position Reconstruction Algorithm for AC-Coupled Low Gain Avalanche Detector

To meet the particle detection requirements of next-generation high-energy physics experiments, the AC-Coupled Low Gain Avalanche Diodes (AC-LGADs) have emerged as a breakthrough technology. While retaining the exceptional temporal resolution of standard Low Gain Avalanche Diodes (LGADs), it ingeniously incorporates position sensitivity through its unique resistive n+ layer and capacitively coupled metal pad structure, enabling the precise spatial measurement. To address the position reconstruction challenge in pixel-type AC-LGADs, this study employs the K-Nearest Neighbors (KNN) algorithm by establishing a systematic methodological framework. Based on a simplified 2D charge diffusion model derived from Ohm's law and current conservation, the position-dependent signal distributions were simulated for circular, square, and cross-shaped metal pads using MATLAB's PDE Toolbox, providing scanned datasets. By expanding the feature space and selecting the optimal number of nearest neighbors (K-value), the optimized K-Nearest Neighbors (KNN) algorithm achieved satisfactory reconstruction accuracy on the simulated datasets for circular and square metal pad configurations. Finally, experimental validation was performed using laser-scan data. With neighboring metal pads spaced 3000 μm center to center, the optimized KNN algorithm achieved positional Root Mean Square Error (RMSE) of 11.16 μm .

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