Contribution submission to the conference Erlangen 2026

Signal Processing and Machine Learning for Light Dark Matter Detection in DELight — •Dowling Wong for the DELight-Collaboration — KIT, Karlsruhe, DE

The parameter space for dark matter below a few hundred MeV remains largely unexplored, motivating detectors with ultra-low energy thresholds. The DELight experiment aims to directly detect light dark matter using superfluid helium-4 instrumented with about 60 large-area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology. Each LAMCAL achieves an eV-scale energy resolution, yielding a nuclear-recoil threshold around 10 eV. To further lower the threshold, robust and noise-aware reconstruction across the multi-channel readout is essential. I present a unified signal-processing and machine-learning framework developed for DELight. At the waveform level, we implement optimal filtering and principal component analysis estimators tuned to measured pulse shapes with noise spectra captured under preliminary operating conditions in the DELight LAMCALs. With physics-informed features, we develop a transformer-based attention architecture that captures inter-channel correlations to improve event reconstruction, while exploring data-driven filters to suppress non-stationary system noise and enhance sensitivity near threshold. I will discuss the architecture of the reconstruction pipeline and its performance on simulated and calibration R&D data, with a focus on trigger efficiency in offline scans. This work is supported by the Heidelberg Karlsruhe Strategic Partnership (HEiKA STAR), with personnel funded by the Alexander von Humboldt Foundation.

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