Deep Learning-Based Delay-Line Detector Evaluation for Spatiotemporal Correlation Measurements of Ultrafast Electron Events

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In strong-field and attosecond physics, the observation of electron correlations has recently gained increasing interest. However, the precise reconstruction of electron events using delay-line detectors presents a significant challenge, especially when multiple electrons arrive closely confined in space and time. Novel deep learning-based reconstruction approaches for two-electron events have been shown to significantly outperform classical algorithms, reducing the dead radius by a factor of 8 while improving overall resolution [1]. Nevertheless, this approach was still limited in terms of precision and evaluation speed due to the necessity to include classical algorithms into the reconstruction pipeline. Here we present an improved approach that overcomes these limitations by enabling the direct reconstruction of the electron's spatiotemporal positions from the analog input signals. We achieve further improvements in spatial reconstruction and strong enhancements in temporal resolution for spatially confined two-electron events. We showcase that our deep learning approach enables the simultaneous investigation of temporal and spatial electron correlations for ultrafast emitted two-electron events while also improving number statistics measurements through robust detection of the event's hit multiplicity.

References

[1] M Knipfer, S Meier, T Volk, J Heimerl, P Hommelhoff and S Gleyzer, Mach. Learn.: Sci. Technol. **5**, 025019 (2024)