Characterizing SNSPD Performance via High-Resolution and High-Throughput Multichannel Time Tagging

Andreas Lehr*, Torsten Langer, Torsten Krause, Nicolai Adelhöfer, Tino Röhlicke, Hans-Jürgen Rahn, Michael Wahl

PicoQuant GmbH, Rudower Chaussee 29, 12489 Berlin, Germany

Modern quantum optics experiments increasingly rely on large-scale Superconducting Nanowire Single-Photon Detector (SNSPD) arrays, yet the resulting data volumes often create significant bottlenecks in acquisition and real-time analysis. We present the HydraHarp 500 L, an extendable time-tagging system with up to 65 input channels specifically optimized for the demands of multi-pixel detector characterization. The instrument achieves a digital timing resolution of 1 ps and a timing uncertainty of 2 ps RMS, paired with an exceptionally short dead time of 680 ps per channel.

To manage the massive throughput generated by high-count-rate arrays, the system features a high-speed host interface for data streaming over USB 3.2 Gen 2x2, supporting sustained rates exceeding 200 Mcps, while an external FPGA interface enables massive data transfer up to 1680 Mcps. A critical hardware advancement is the integration of Constant Fraction Discriminators (CFDs), which mitigate time-walk effects and significantly improve jitter compared to traditional level triggers – essential for precision characterization at high count rates. [1] Furthermore, we demonstrate a specialized software workflow based on our software UniHarp and Python-based programming interface snAPI. This ecosystem allows for advanced Photon Number Resolving (PNR) analysis and the study of detector pulse shapes [2] through slope-based projections and recovery time corrections.

Fig. 1: *Preliminary design of HydraHarp 500 L main unit together with PNR analysis and correction tools implemented in UniHarp software.*

References

[1] A. Mueller et al., Appl. Phys. Lett. 122, 044001 (2023).

[2] T. Schapeler et al., Proc. SPIE 13448, APCT XIX, 134480C (2025).