Implementation of a Fast SiPM-Based Detection Chain for Quantum Communication

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High transmission rates represent a fundamental challenge in quantum communication, particularly for detectors operating in the photon-number-resolving (PNR) regime. While mature commercial solutions exist for single-photon detection, equivalent options for PNR detectors remain scarce. Silicon photomultipliers (SiPMs) constitute a valid candidate to fill this gap, provided their analog output is coupled to suitable signal processing electronics.

We present results from a fully digital readout and real-time processing system designed for SiPM-based PNR measurements. By characterizing both classical and quantum states of light, we demonstrate the system's ability to accurately reconstruct photon-number statistics and to measure quantum correlations.

Measurements on coherent states demonstrate a wide dynamic range, spanning mean photon numbers per pulse from 0.07 to beyond 30, at repetition rate of 1 MHz, which proves to be an interesting range for developing new quantum communication protocols [1]. In addition, measurements on twin-beam states [2] establish the system's sensibility to nonclassical correlations and reveal how detection performance scales with the quantum efficiency of the detector.

Compared to conventional NIM-based acquisition chains [3], the presented system achieves reduced electronic noise and higher maximum operating speeds, making it a strong platform for advancing high-rate quantum optical experiments and quantum communication protocols.

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References

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