Resolving Photon Numbers Using a Single Superconducting Strip Single-Photon Detector

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Efficient and precise photon-number-resolving detectors are essential for the advancement of optical quantum information science. Despite this, very few detectors have been able to distinguish photon numbers with both high fidelity and a large dynamic range, all while maintaining high speed and high timing precision. Superconducting nanostrip-based detectors excel at counting single photons efficiently and rapidly, but face challenges in balancing dynamic range and fidelity for photon number resolving. Here, we have pioneered the demonstration of high-fidelity and large-dynamic-range photon number resolution using a single superconducting microstrip [1]. Remarkably, even without cryogenic amplifiers, a large-inductance meandering superconducting microstrip can successfully distinguish up to 10 photons through the rising-edge time of response pulses, with readout fidelity reaching an impressive 98% and 90% for 4-photon and 6-photon events respectively. Furthermore, our proposed dual-channel timing setup enables real-time photon number readout. Our solution boasts high fidelity, a large dynamic range, and real-time characterization for photon number resolution and simplicity with respect to device structure, fabrication, and readout, which may provide a promising avenue towards optical quantum information science, including quantum computation and quantum metrology.

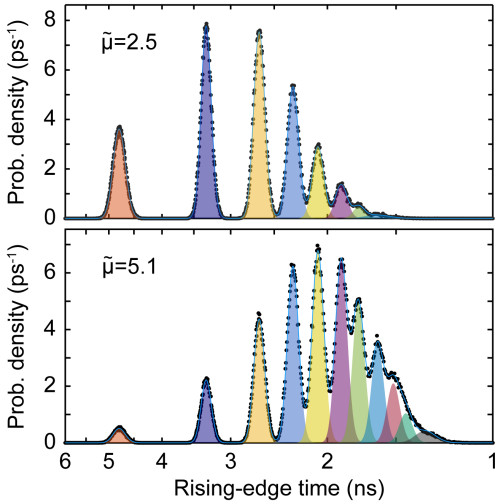

Fig. 1: *Photon-number resolution in an SSPD. Histograms (dots) and Gaussian fitting (lines) of the rising-edge time of response pulses under pulsed laser illumination with an effective mean photon number $\tilde{\mu}$ at 2.5 and 5.1. Color areas represent the decomposed Gaussian functions.*

References

[1] L.-D. Kong et al., Advanced Photonics 6, 016004 (2024).