Multipixel SNSPDs for GHz-Rate and High-Dynamic-Range Single-Photon Detection applications

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Abstract

The growing demand for single-photon detection have driven the development of a broad range of devices based on both semiconductor and superconducting platforms [1,2]. Quantum applications that rely on photon manipulation and transmission particularly favor the near-infrared (NIR) spectrum due to its excellent compatibility with standard optical fibers, continuously improving coupling and packaging techniques [3,4].
Superconducting Nanowire Single Photon Detectors (SNSPDs) stand out in this area thanks to a near-unity efficiency [5] and extremely high timing precision [6]. SNSPDs play a pivotal role in quantum applications, such as communications and computing [7], where enhanced performance in detection speed and Photon Number Resolution (PNR) is critical.
A strategy to boost SNSPDs performance is to subdivide its active area into multiple elements [8]. These designs reduce the recovery time per pixel, making the final detectors faster, and enabling PNR capabilities based on spatial multiplexing.
Here we present a comparative study of multipixel SNSPDs with different numbers of constitutive elements, highlighting the main differences in terms of high-count rate (HCR) limits, timing precision and photon number resolution. Fig 1(a) presents count rate limits from hundreds of MHz to few GHz in Continuous Wave (CW) illumination. The same analysis is shown at different pulsed illumination (PI) regimes. As seen in Fig. 1(b), paired with these performances single pixel jitter starting from 20 ps are achieved at low count rates. Concerning PNR, fidelities as a function of the photon number are shown for the same series of devices. To enhance PNR detection, time multiplexing schemes have also been investigated to mark clear trade-offs between highest fidelity and speed. Parallelly, a study of intrinsic PNR in individual pixels (Fig. 2(a)) is an alternative strategy that can be integrated with the previous approaches. As a final implementation, a signal combination design based on discrete amplitude multiplexing is shown to assess its possible utilizations (Fig. 2(b)).

References

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Figures

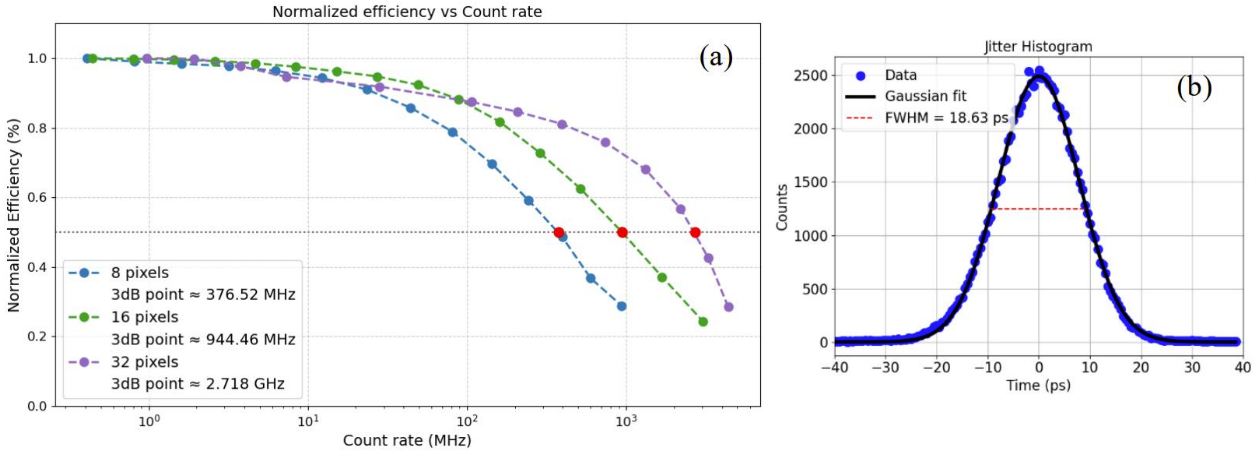

Figure 1: (a) HCR plot showing the normalized efficiency as a function of the count rate for different multipixel devices: red dots indicate the efficiency 3dB loss; (b) Jitter for an individual pixel at low count rates.

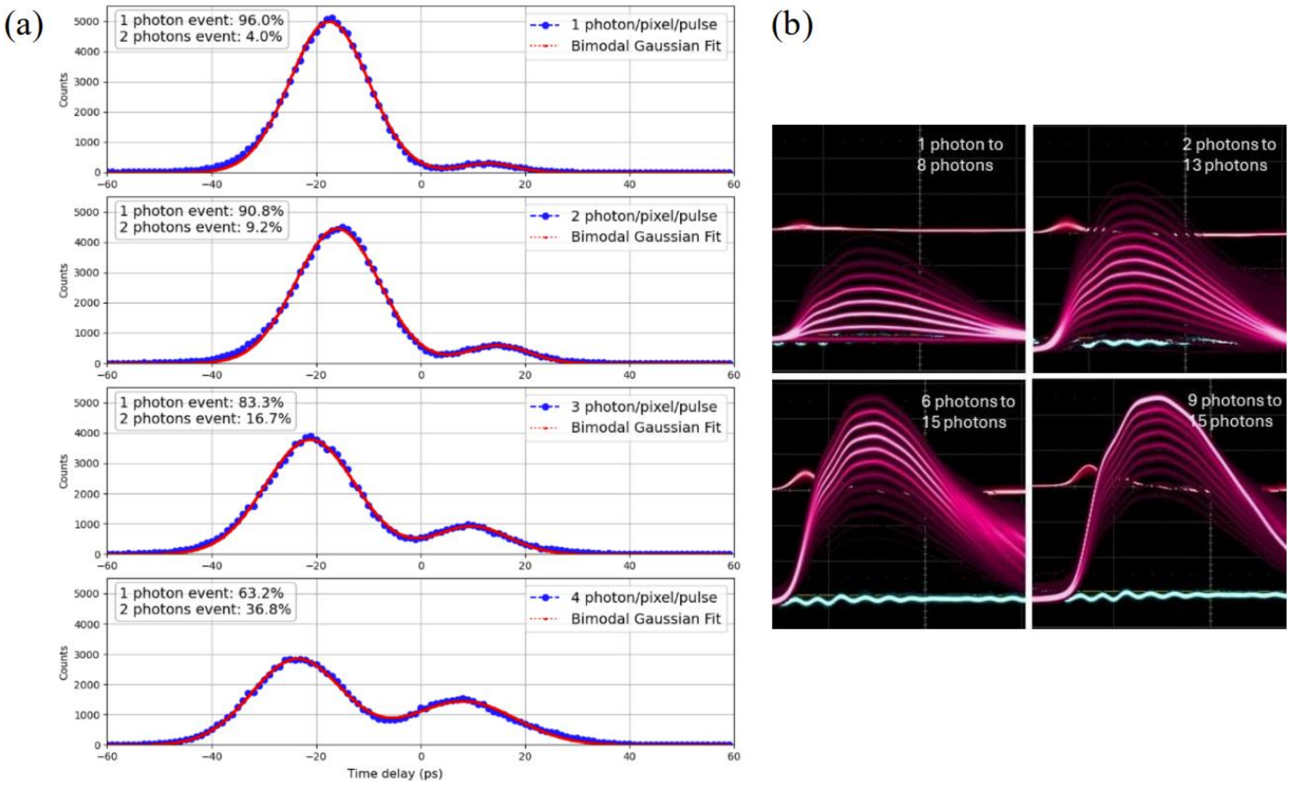

Figure 2: (a) Jitter of an individual pixel taken at four different photon fluxes: second peaks correspond to two-photons detection events; a bimodal gaussian fit is used to retrieve the fractional probabilities; (b) Persistence traces of a combined signal from a multipixel SNSPDs.