Fast time-gated superconducting nanowire single-photon detectors (SNSPDs)

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Abstract

SNSPDs are renowned for their single-photon sensitivity, low jitter, and high efficiency. However, their dynamic range is typically binary - either no photon or a single photon - posing challenges in experiments with high number of photons. To mitigate saturation and latching, on-off time-gating is essential. Rapid transition times will enhance sensitivity, filter intense excitations, and suppress dark counts.
We present our work on time-gated SNSPDs, where the detection current is dynamically switched to prevent saturation. Starting with a basic square-wave scheme achieving ~50 ns transition times, we introduce a novel method (Figure 1) that reduces it to the sub-ns range (Figure 2). We report on the latest measurements, and demonstrate that even a light pulse with 100'000 photons over 500 ns, just before the on-transition, does not compromise performance.

By gating an SNSPD one can precisely determine when it becomes sensitive and unsensitive to light allowing one to set a detection window useful for a range of experiments. For example, a user can choose to synchronize the measurement with a pulsed laser and only detect photons at a certain time after excitation. This can be beneficial for experiments in the field of quantum memories [1], [2]. Another interesting use is to obtain time resolution by repeating the experiment several times and detecting at consequent time windows to reconstruct a time-resolved curve.
Finally, gating can act as an active quenching strategy to increase count-rate and speed by fighting the intrinsic dead-time. This can be useful in QKD and Laser Communication [3],[4].

References

[1] Johnston, A., Felix-Rendon, U., Wong, YE. *et al. Nat Commun* **15**, 2350 (2024).

[2] H. Song, X. Zhang, Y. Zhi, L. Komza, and A. Sipahigil in *CLEO 2024*, Technical Digest Series (Optica) 2024, paper FTu3I.2.

[3] J. Wang, B. J. Rollick, Z. Jia and B. A. Huberman in *Journal of Lightwave Technology*, vol. 42, no. 11, pp. 4086-4095, 1 June1, 2024

[4] Phys. Rev. Applied 20, 044052 – 19 October, 2023

Figures

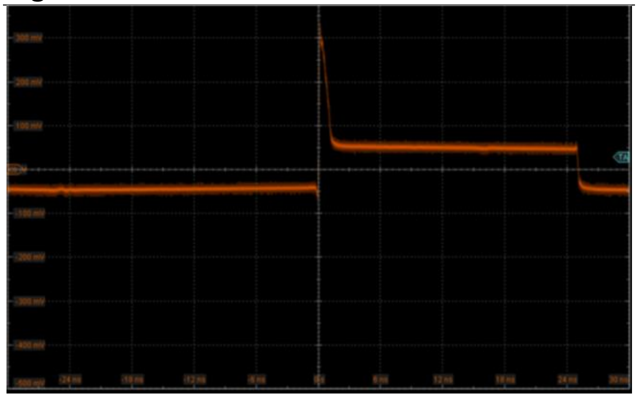

Figure 1: Oscilloscope trace of the gating signal with a kick. The first sharp peak allows to overcome the intrinsic inductance limitation.

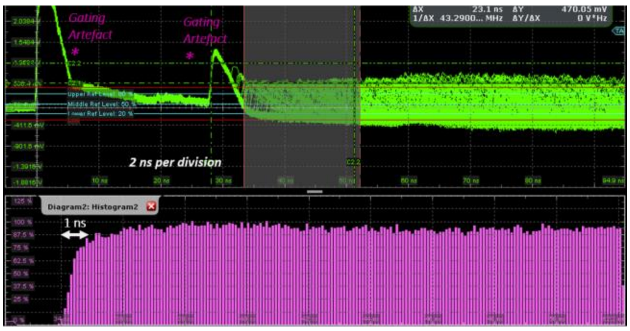

Figure 2: (Top) SNSPD output trace under CW illumination. (Bottom) Efficiency recovery histogram from gate start. 10-90% transition within 1 ns.