Opportunities of photon-number resolution with SNSPDs to enable photonic quantum processors

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The ability to resvole photon numbers is essential to enable boson sampling machines and linear optical quantum computing, but also for many quantum repeater protocols, for the generation and distribution of heralded multi-photon entanglement and to improve heralded single-photon sources. We will present a set performance-focused and practical-minded criteria to evaluate and compare different approaches for photon-number resolving (PNR). The properties concern the scaling of *n*-photon efficiencies, the assignment probability of number of clicks, the capability to operate as a PNR detector at high rate, how it imposes limitations on the duration of the input light pulses, and the overall scalability and operational simplicity.

We will present a novel SNSPD-based approach that performs very well on all the criteria [1] – see Fig. 1. This approach consists in parallel-SNSPD (P-SNSPD) devices that today enable very high *n*-photon efficiencies (see Fig. 2), as well as detection rates as high as 1 Gcps. This creates new possibilities for for high-speed quantum communication. It also used for research-level and commercial-level quantum computers such as the PT-2 of ORCA Computing [2].

We believe this analysis and our results have the potential to bring clarity and understanding of how well PNR detectors can perform in many photonic quantum technologies.

References

[1] L. Stasi *et al.*, ACS Photonics 12, 1 (2024) 320-329.

[2] https://www.idquantique.com/idq-supports-orca-computing-quantum-ai-computing-system/

Figures

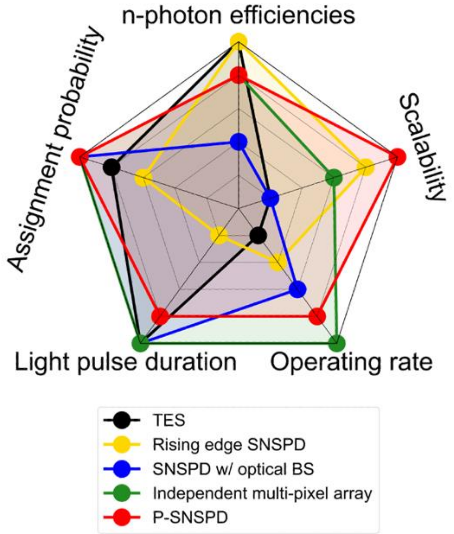

Figure 1: Radar map showing a comparison of different PNR approaches on the criteria.

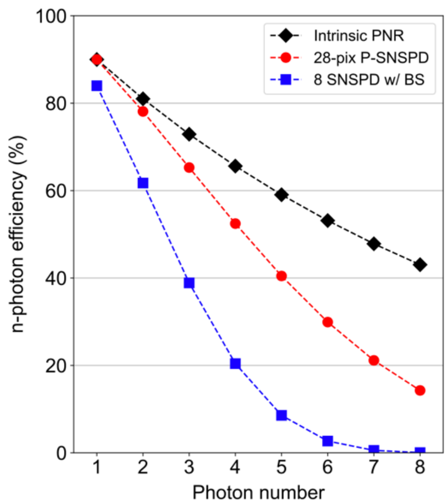

Figure 2: Scaling of *n*-photon efficiency of two – SNSPD-based PNR approaches with respect to a close-to-ideal PNR detector with intrinsic PNR scaling.