An integrated heterogeneous superconducting-silicon-photonic platform for measurement-device-independent quantum key distribution

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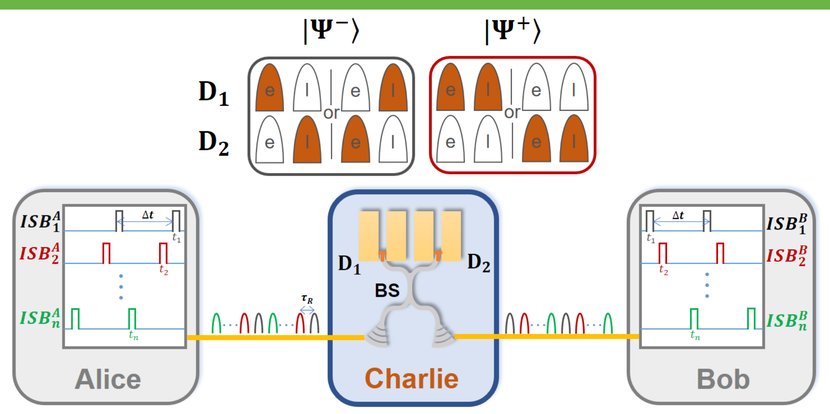
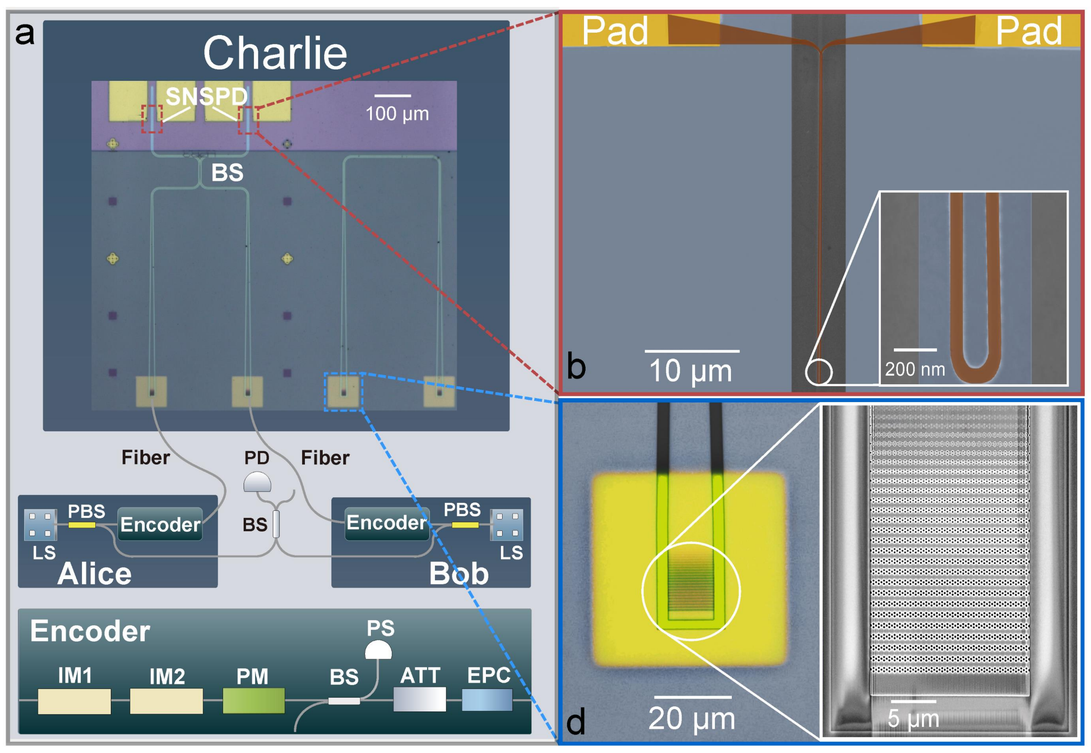
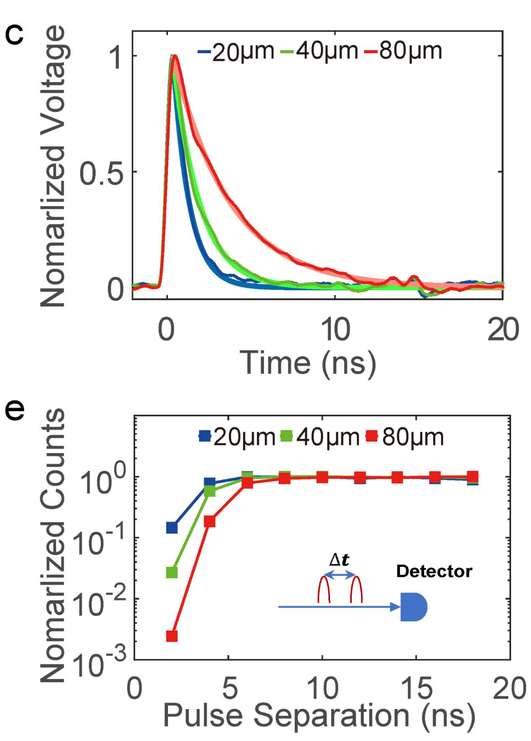
Introduction

Measurement-device-independent quantum key distribution (MDI-QKD) removes all detector side attacks. Here we realize a server for MDI-QKD based on a heterogeneous superconducting-silicon-photonics. The unique design of the waveguide integrated superconducting nanowire single-photon detector enables an ultra-short recovery time, allowing us to perform time-bin-encoded two-outcome Bell state measurements (BSM). Together with the time multiplexing, we obtain a secure key rate of 6.166 kbps over 24.0 dB loss with a 125 MHz clock rate, which is comparable to the state-of-the-art MDI-QKD experimental results with GHz clock rate.



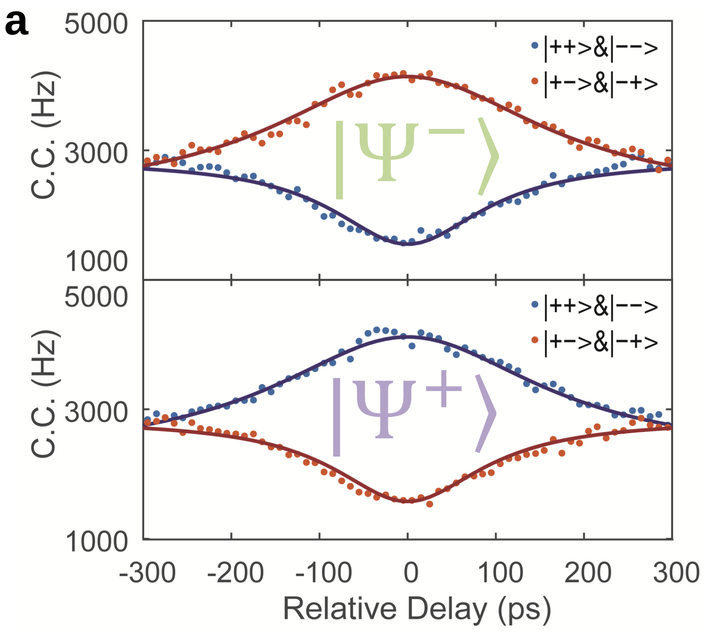
Experiment



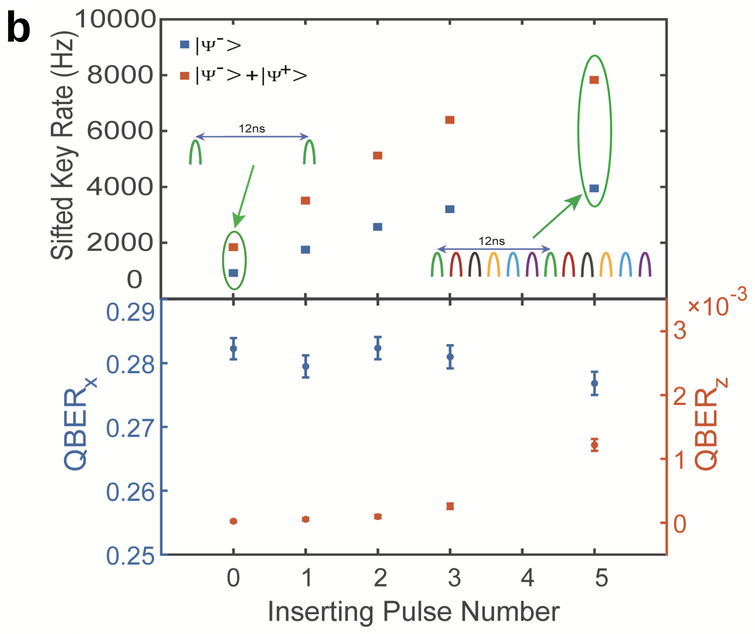


a. Schematic of the experimental setup. **b.** Scanning electron micrograph of the SNSPD with a 80 nm-wide, 80 um-long U-shaped nanowire which is connected with two golden pads and integrated on 500 nm-wide silicon waveguide. **c.** Response pulses of the SNSPD with same width but different length. **d.** Optical microscopy and scanning electron microscopy (SEM) pictures for the high-efficiency photonic-crystal grating coupler with back-reflected mirror. **e.** Normalized counts of the event that detector can detect both early and late pulse continuously as a function of time separation.

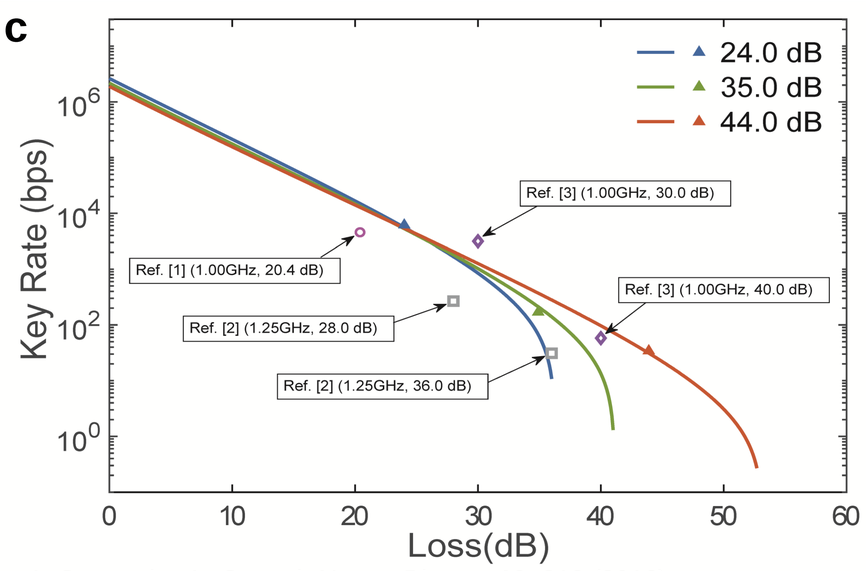
Results



a. The two-photon coincidence counts with BSM as a function of relative electronic delays between Alice's and Bob's pulse sequence.



b. Sifted key rate with only Ψ^- measurement or two Bell state measurement versus inserting pulse number and the measured QBER in X-basis or Z-basis versus inserting pulse number.



1. Comandar, L. C. et al. *Nature Photon.* **10**, 312 (2016).
2. Wei, K. et al. *Phys. Rev. X* **10**, 031030 (2020).
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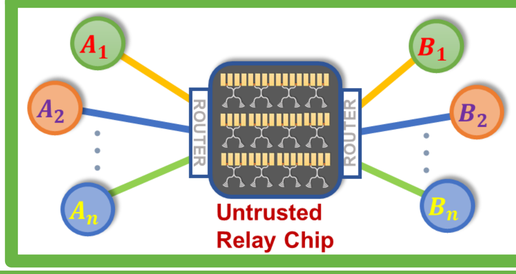
c. Finite-key secret rate versus different channel loss with 125 MHz system frequency and the comparison with the state of the art MDI-QKD experiments.

Outlook



By using more advanced waveguide-integrated SNSPDs, one can further scale the integrated server. Combined with transmitter chip, a fully chip-based, scalable and high-key-rate MDI-QKD metropolitan quantum network should be realized in the near future.

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