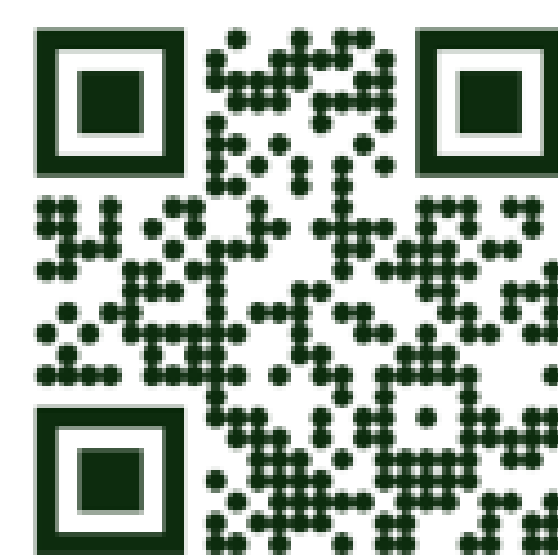




ALL-SILICON QUANTUM KEY DISTRIBUTION CIRCUITS FOR MONOLITHIC DATACENTER ENGINES

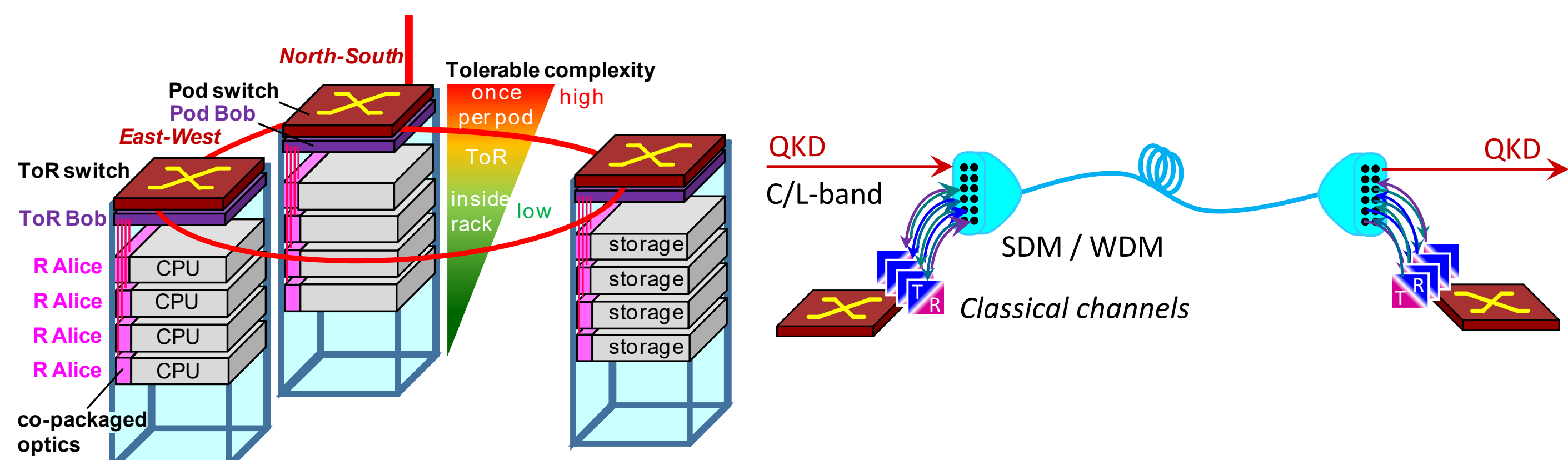


<https://qiss-me.eu>

Commodity QKD

Intra-Datcenter

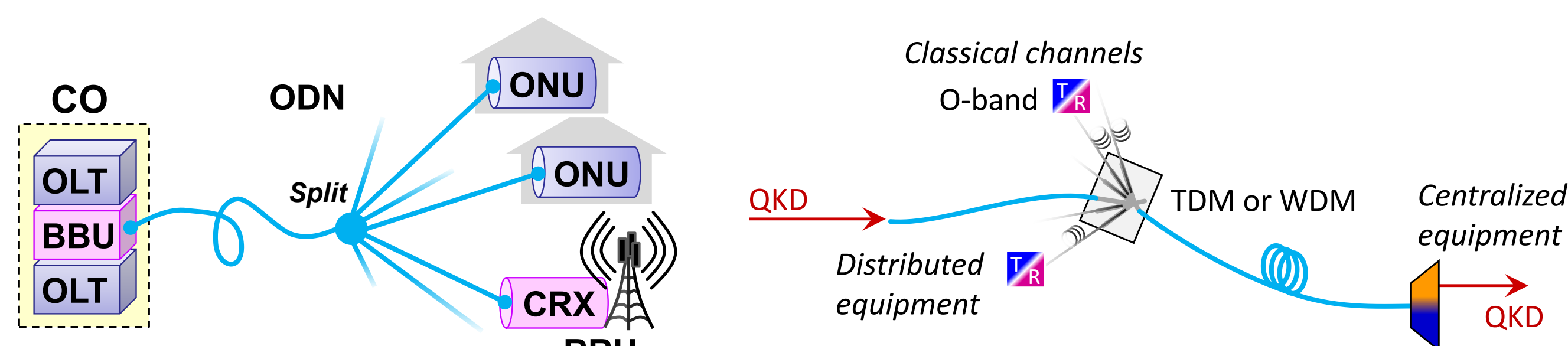
Traditional perimeter security is insufficient:
"No resource can be inherently trusted."



Access / 6G

Finally, a low-cost / best-effort QKD solution for taxpayers.

TLS 1.3 limit: one new 256-bit AES key every 375 GB of data



Chips made of "star dust"

Silicon Photonics as a "dirt effect" of the universe



Silicon

Group IV
Elemental semiconductor

GaAs

Group III/V
Compound semiconductor

5	6	7	8	9
B	C	N	O	F
Boron	Carbon	Nitrogen	Oxygen	Fluorine
13	14	15	16	17
Al	Si	P	S	Cl
Aluminum	Silicon	Phosphorus	Sulfur	Chlorine
31	32	33	34	35
Ga	Ge	As	Se	Br
Gallium	Germanium	Arsenic	Selenium	Bromine
49	50	51	52	53
In	Sn	Sb	Te	I
Indium	Tin	Antimony	Tellurium	Iodine
81	82	83		
Tl	Pb	Bi		
Thallium	Lead	Bismuth		

InP

Group III/V
Compound semiconductor

Critical raw materials

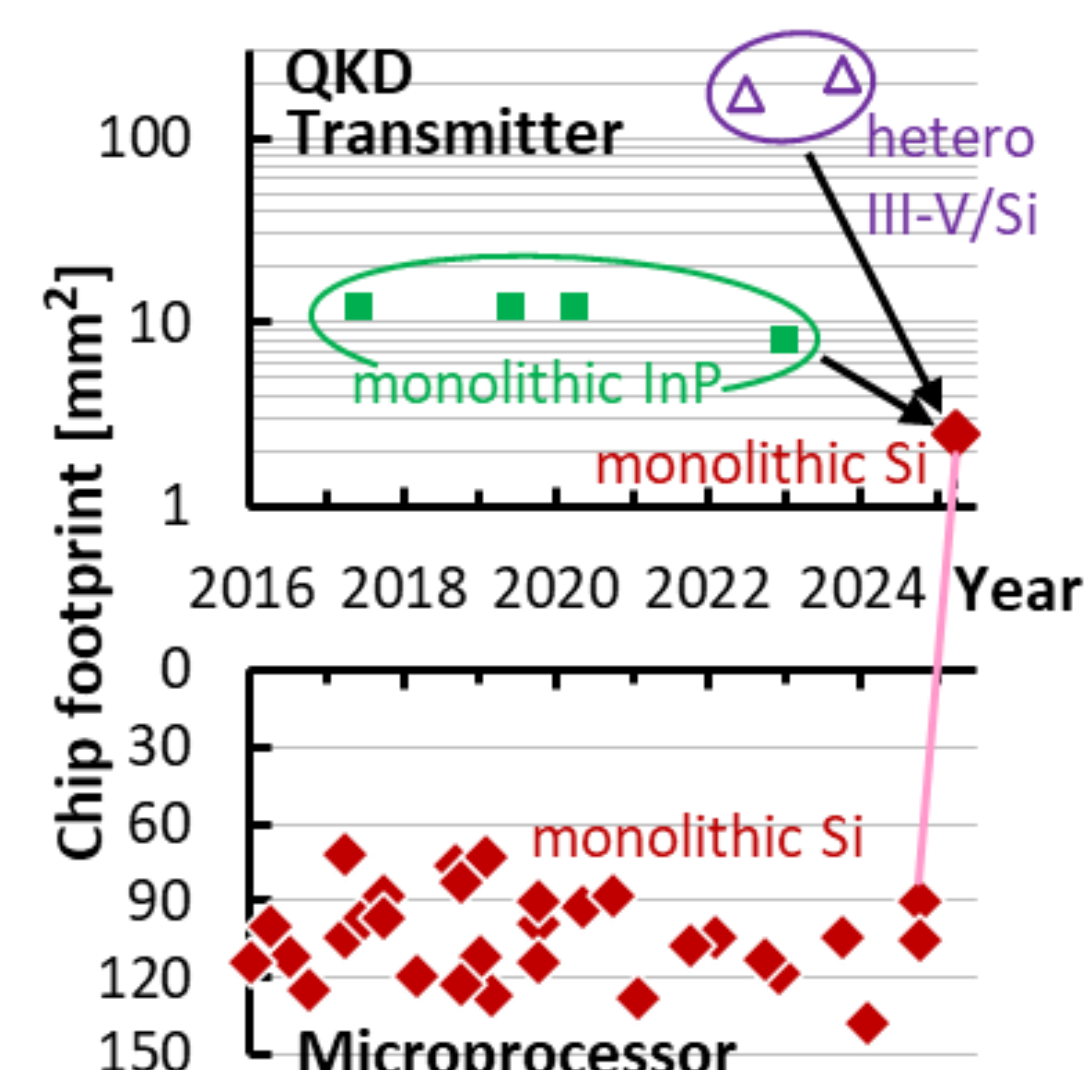
- ✓ Costly material
- ✓ Complex assembly
- ✓ Hermetic packaging

Commodity

- ✓ Low-cost material
- ✓ CMOS foundries
- ✓ Established integration lines (microelectronics)

BUT

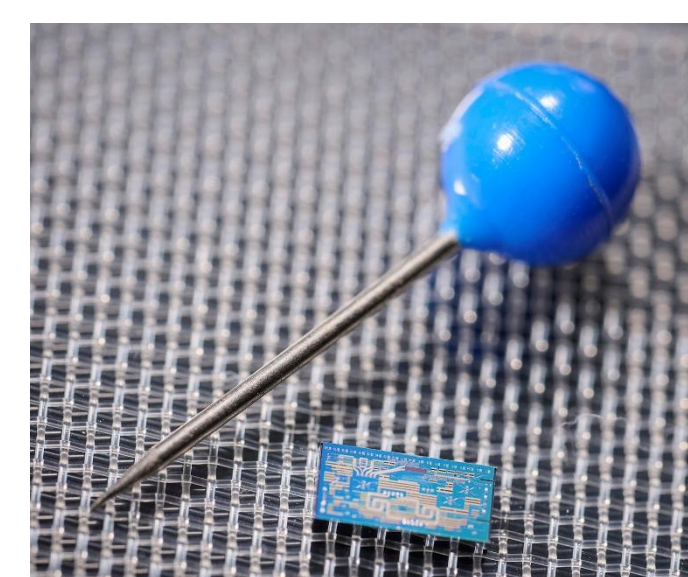
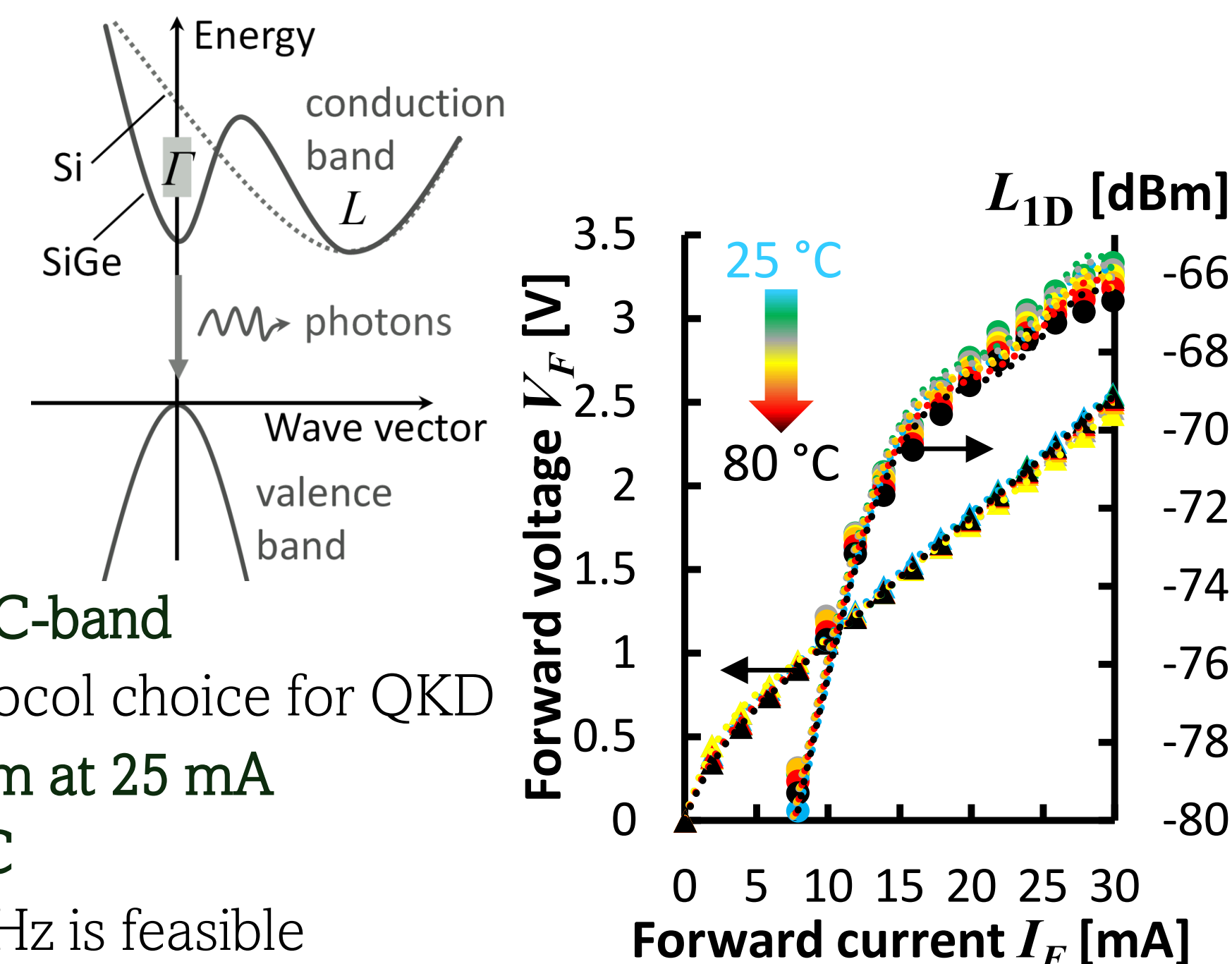
No optical gain on silicon
→ No laser on silicon



How much light can be sourced?

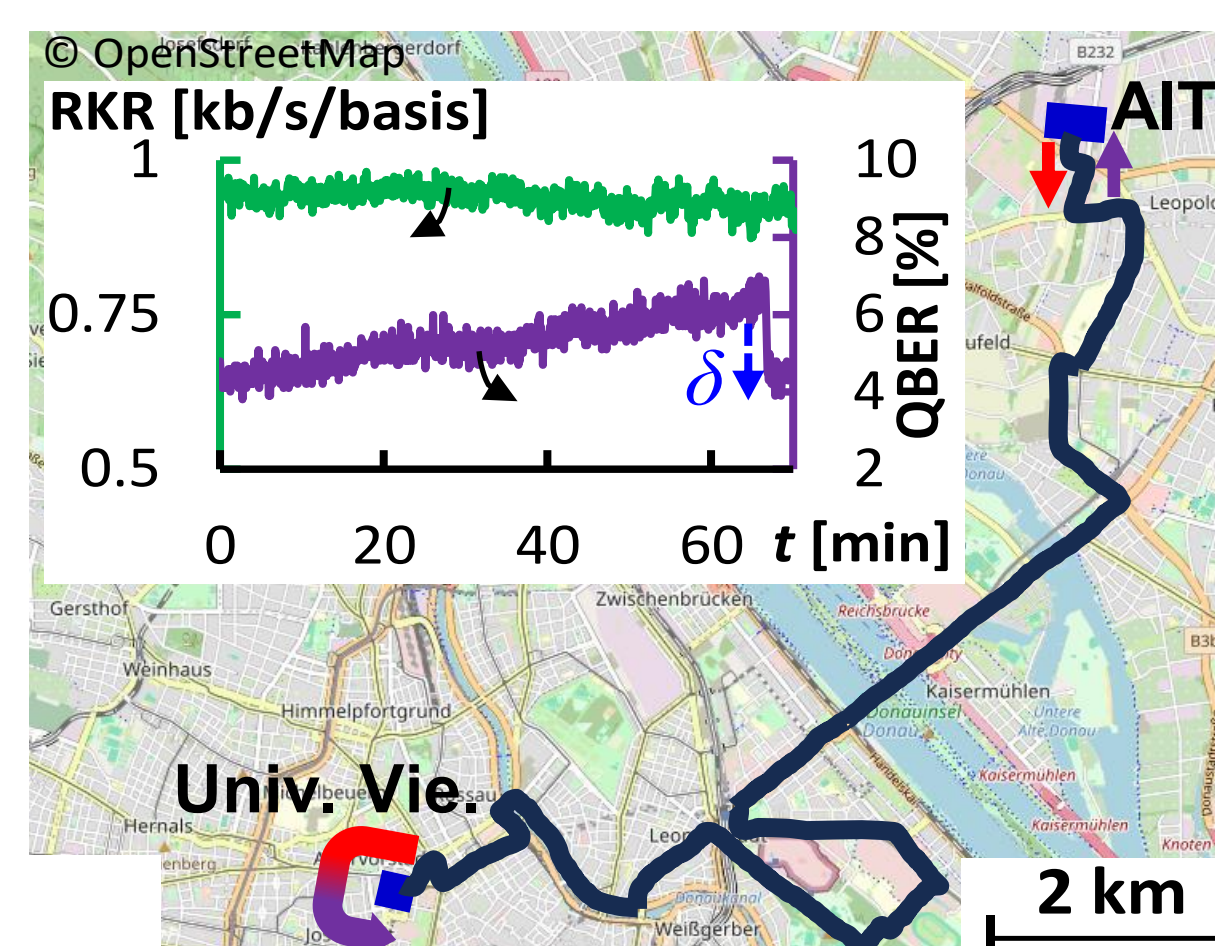
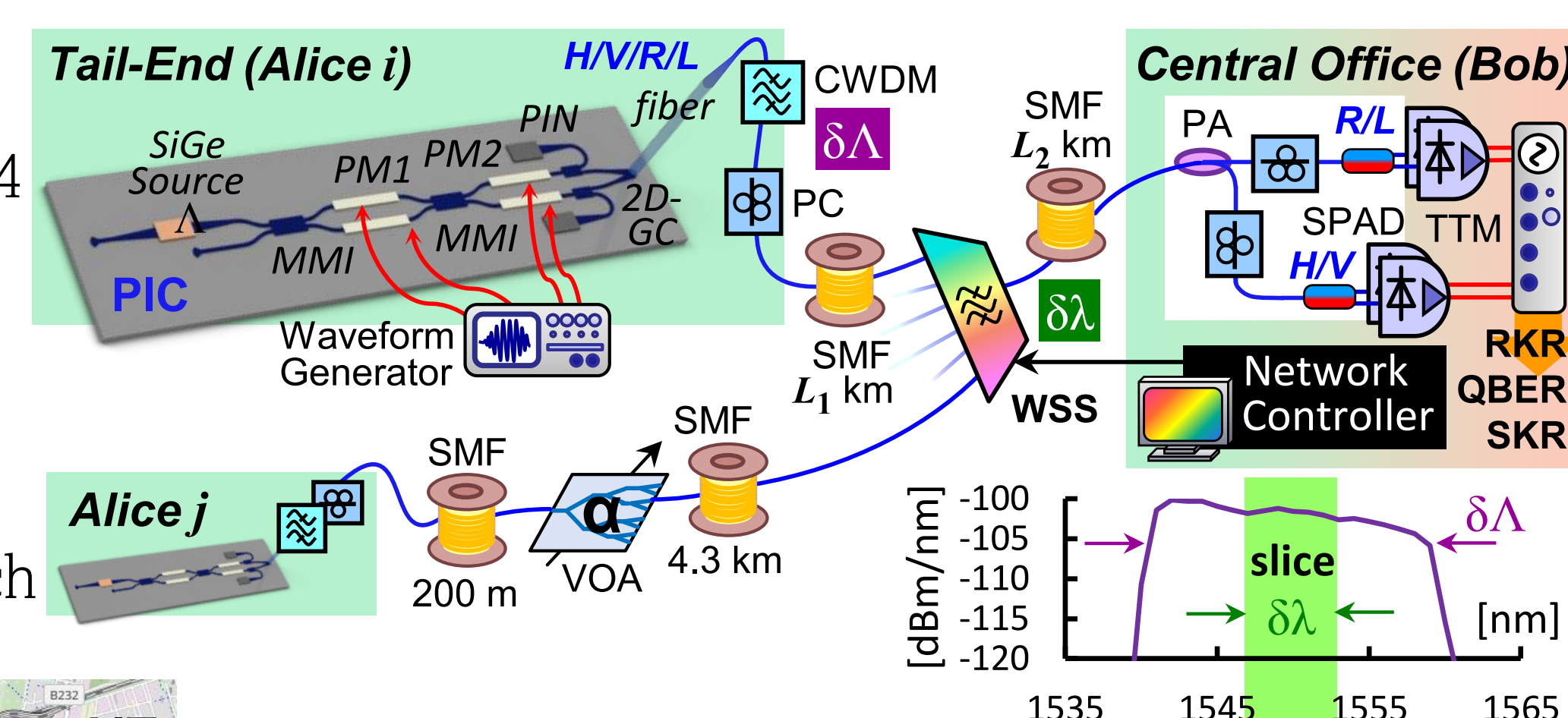
Forward-biased SiGe PIN junction on silicon-on-insulator platform

- ▶ Waveguide coupled light emission
- ▶ Bias current 10...30 mA
- ▶ LED-like emission
- ✓ FWHM bandwidth covers entire C-band
- ✗ Incoherent light, limiting the protocol choice for QKD
- ▶ Aggregated light output of -66.9 dBm at 25 mA
- ▶ Stable emission from 25 °C to 80 °C
- ▶ Direct source modulation at 200 MHz is feasible
- ✓ Carving and decoy state transmission



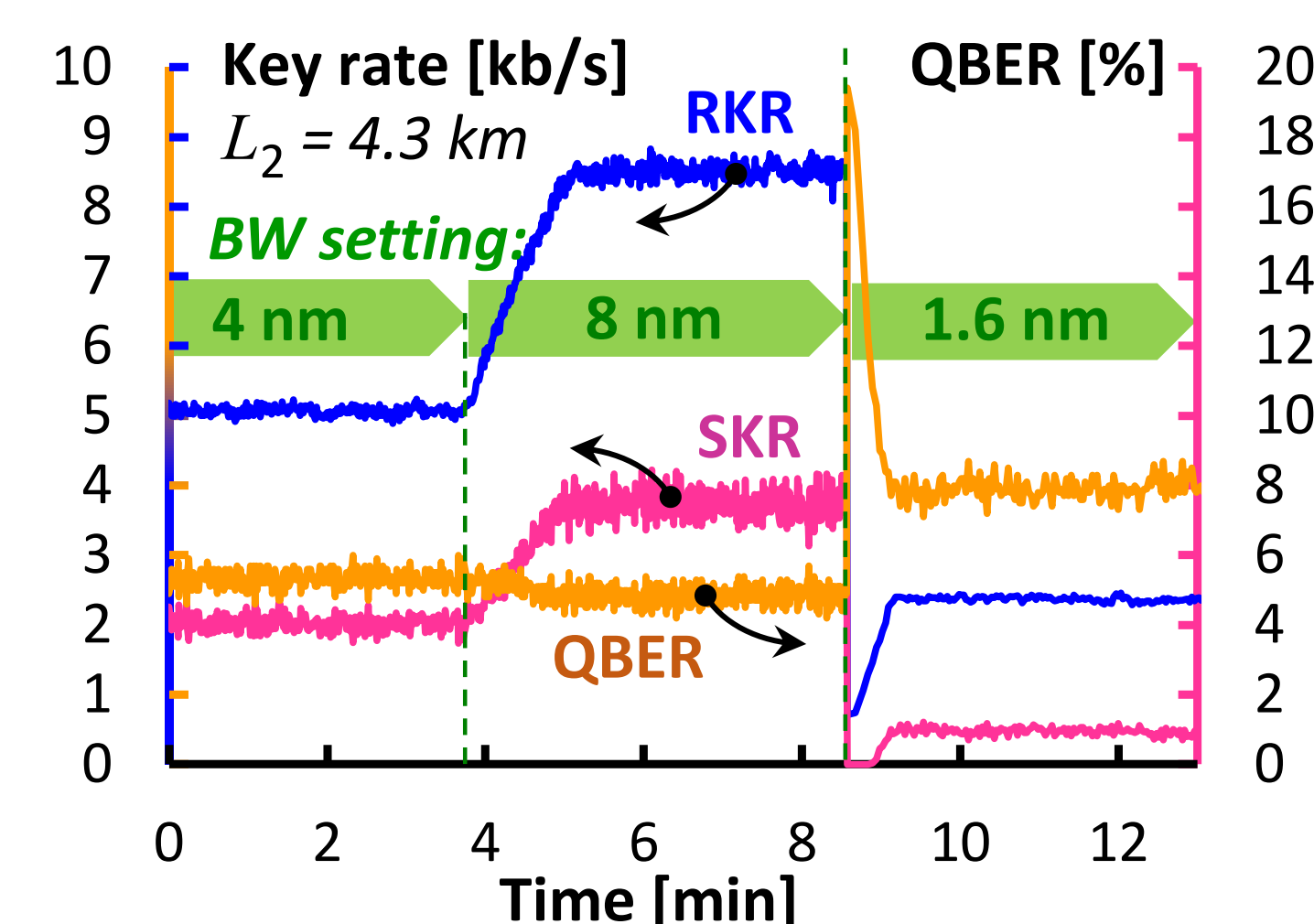
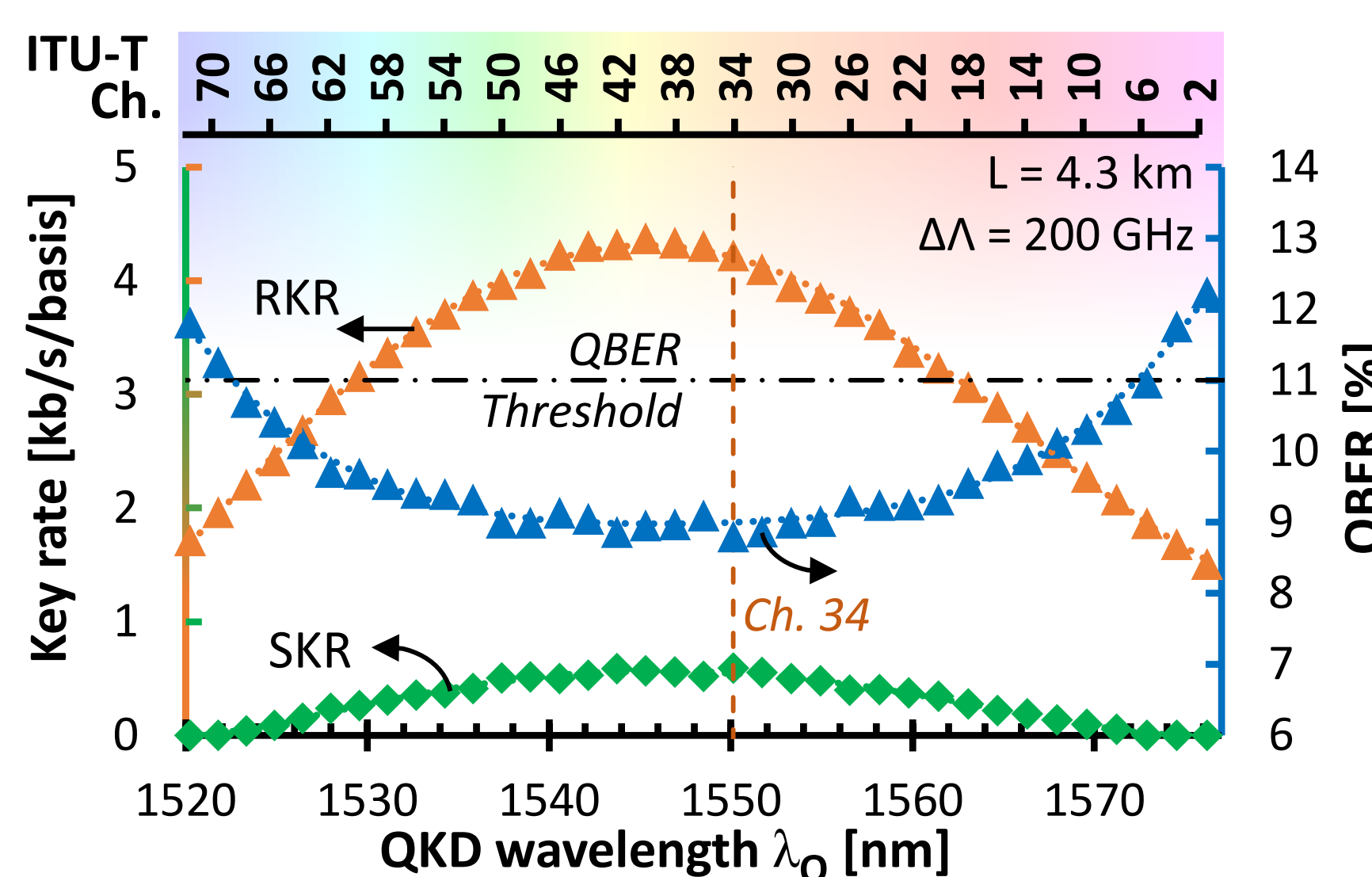
SiGe QKD transmitter

- ▶ Polarization-encoded BB84
- ▶ $R_{\text{Sym}} = 100$ Mbaud
- ▶ $\mu = 0.1$ photons/symbol
- ▶ Channel definition through WDM filtering and wavelength-selective switch



- ▶ SiGe sourced QKD transmitter shows no performance penalty compared to traditional laser-sourced QKD transmitter
- ▶ Min. QBER of 1.51 % is comparable to state-of-the-art systems employing QKD symbol rates in the GHz range

- ▶ Secure-key rate of 655 b/s over 46 km of deployed fiber
- ▶ Multi-wavelength support for 32 200-GHz ITU-T DWDM channels, without SiGe source redesign



- ▶ Dynamic key allocation according to user demands via spectral slice tuning
- ▶ 18.7 dB dynamic secure-key rate adjustment through fine-tuned detector class and slice assignment
- ▶ 30.9 dB supported optical end-to-end budget, compatible with XGS-PON class-N1 budget

Publications

- [1] Honz, W. Boxleitner, M. Ferreira-Ramos, M. Hentschel, P. Walther, H. Hübel and B. Schrenk, "Monolithic Multi-Channel SiGe Quantum Key Distribution Transmitter Chip," Journal of Lightwave Technology, vol. 44, no. 3, pp. 1151-1158, 2026
- [2] F. Honz, V. Pezelj, T. Strobl, F. Kutschera, V. Saggio, P. Walther, H. Hübel, and B. Schrenk, "Implementing QKD over Multi-Fiber Ribbon Cables: How Dark is the "Dark Fiber"?", in Proc. Opt. Fiber Comm. Conf. (OFC'26), Los Angeles, United States, Mar. 26, W3K.1
- [3] F. Honz, V. Pezelj, V. Saggio, W. Boxleitner, M. Hentschel, P. Walther, H. Hübel, and B. Schrenk, "Programmable Quantum Key Distribution Network for Dynamic and Multi-Granular Key Allocation," in Proc. Opt. Fiber Comm. Conf. (OFC'26), Los Angeles, United States, Mar. 26, Tu3K.1
- [4] B. Schrenk, F. Honz, W. Boxleitner, and V. Saggio, "Quantum-Optic Silicon Integration for "Commodity" Quantum Key Distribution Applications," in Proc. 2026 IEEE Photonics Soc. Summer Top. Meet. Ser. (SUM), Tulum, Mexico, July 26, WD2.2

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Leibniz Institute
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NVIDIA