Quantum Key Distribution over Telecom Networks

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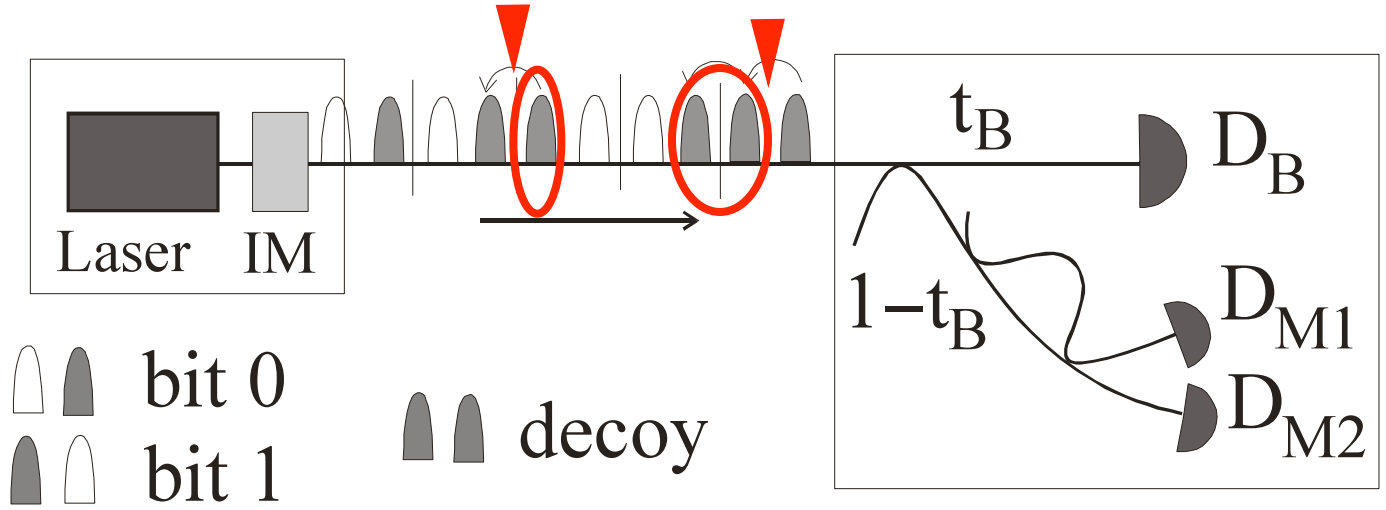
- Long-distance high speed QKD
- Commercial QKD and Data Encryption over a single optical fibre using WDM

Coherent one-way (COW) scheme



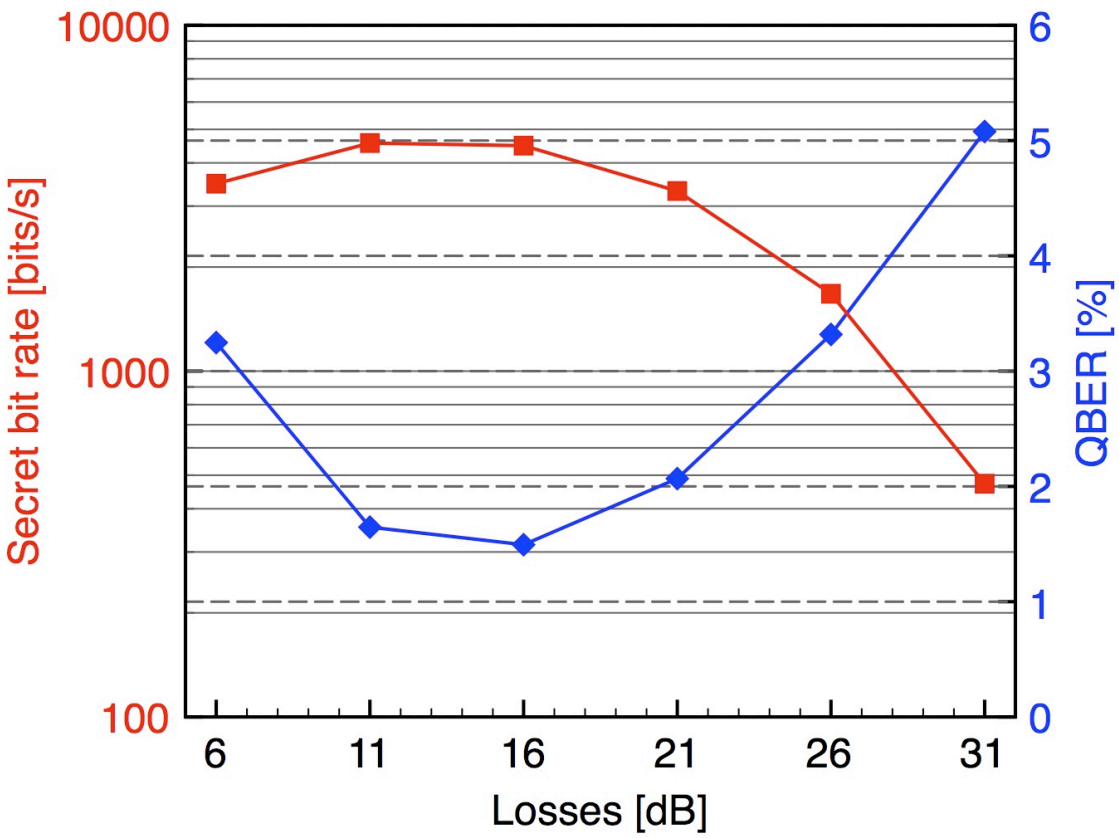
Advantages:

- Simple optical setup, no noise on the data line
- **Security:** check the coherence of successive pulses
Reduced interference visibility does not introduce errors
- Resistant to PNS attacks! ($\mu_{opt} \approx 0.5$)
(Note: Scheme does not work with single photons)

COW implementation (SECOQC)

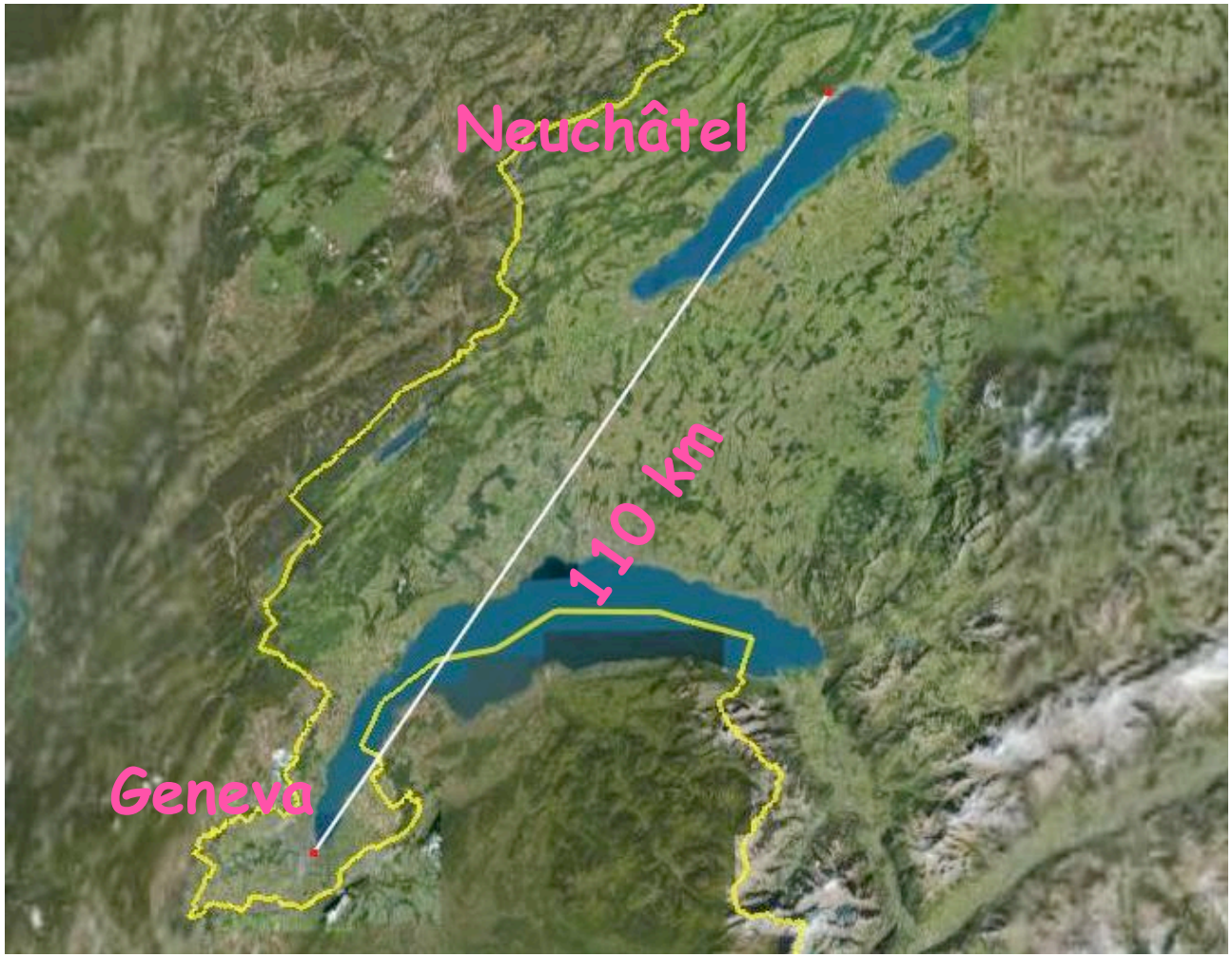
- Completely automated prototypes with integrated PC
- 2.5 GHz Xilinx Virtex II pro FPGA
- 625 MHz pulse rate (312.5 MHz logical)
- Real time distillation (cascade)

COW results (InGaAs lab, 25 km + x dB)



- Detector saturates at short distances
- Range ca. 150 km (0.2 dB/km)

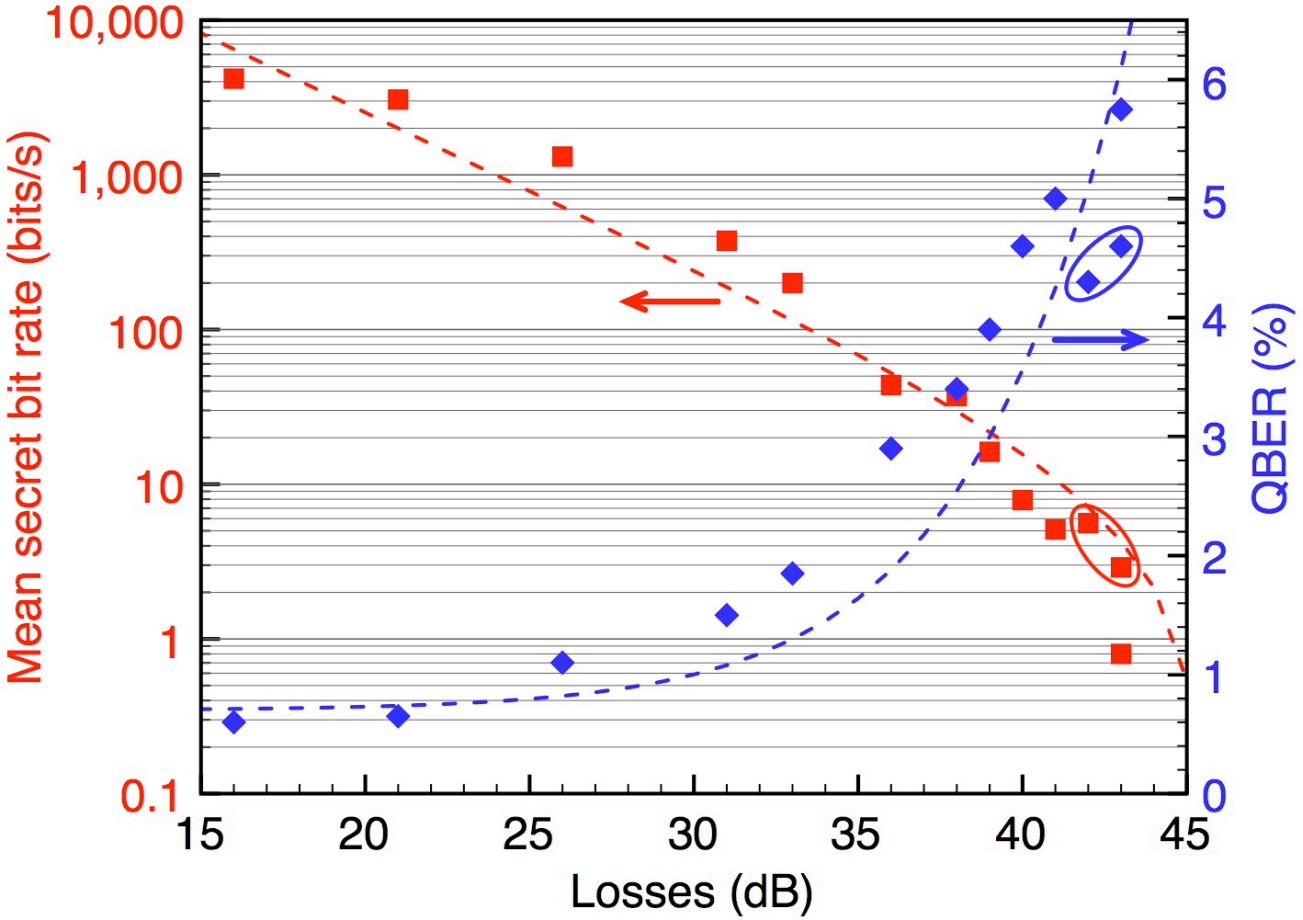
The COW in the Field



2 dark fibers
~150km
43 dB loss
(0.29dB/km)

Opt. Exp. **17** (16), 13326-13334 (2009)

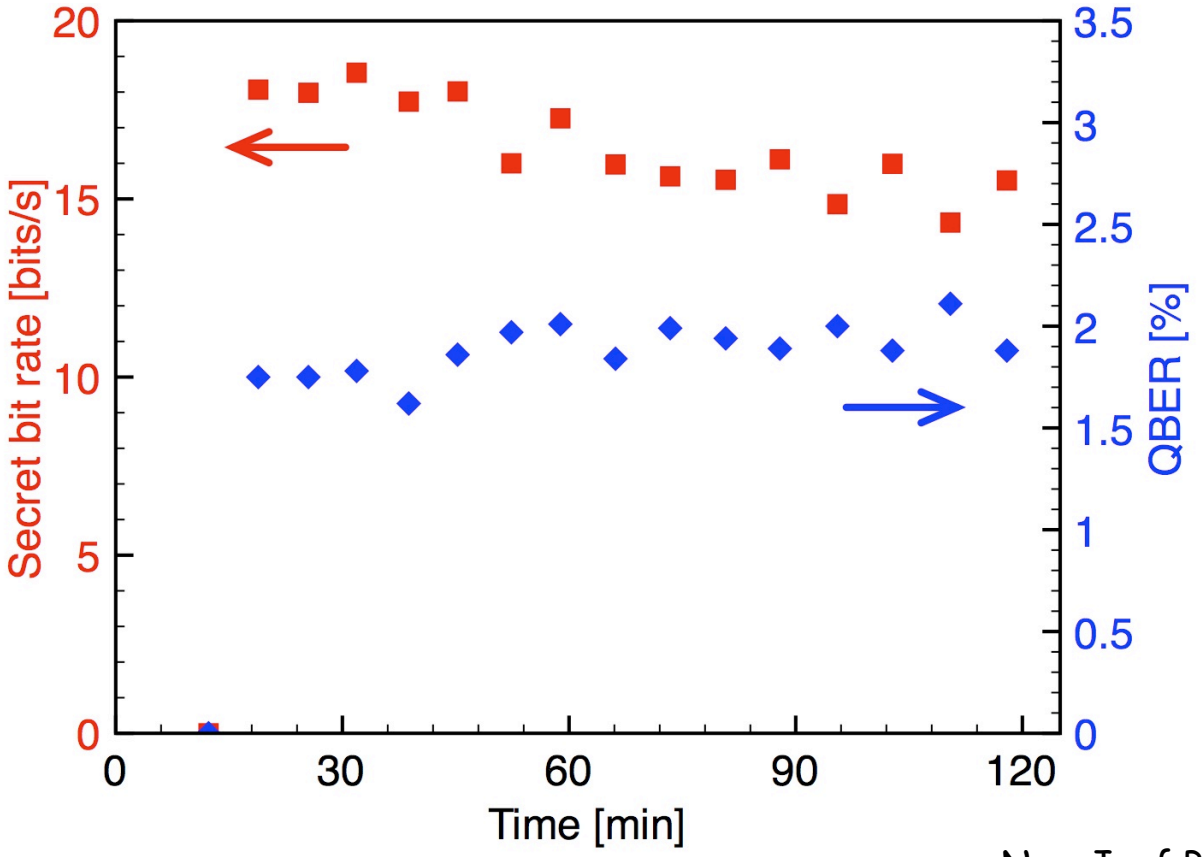
COW results (SSPD, 150 km - x dB)



- SSPDs at 2.7K
- variation of μ to simulate different losses (150 km of fibres)
- more than 2 secret bits/s over 43dB of losses

QKD over 250 km of ULL fibers

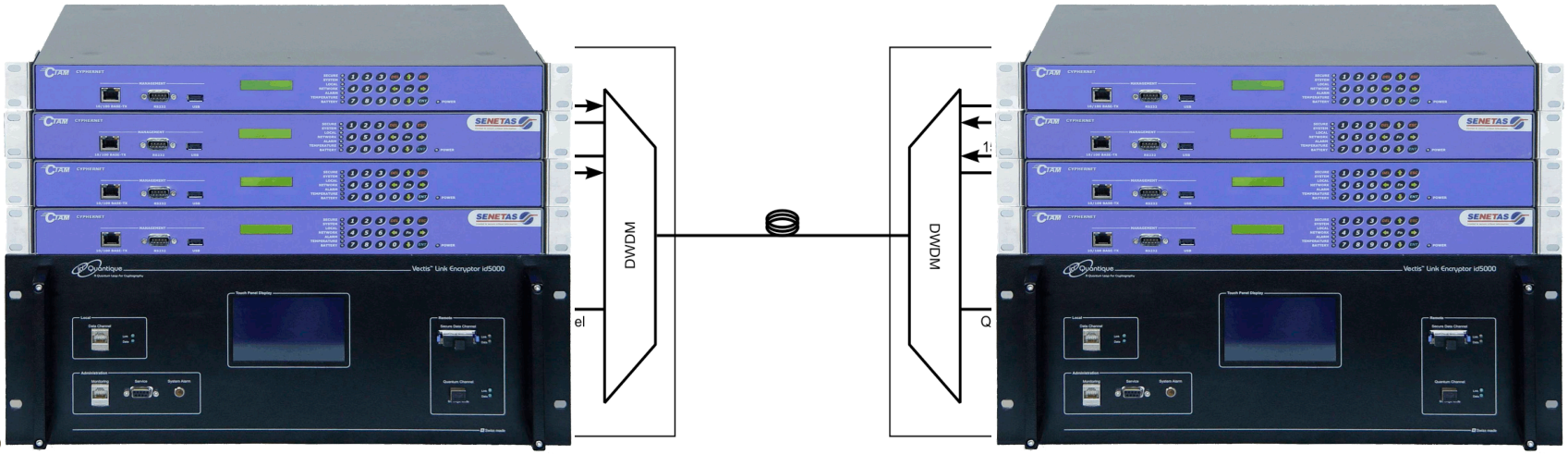
ITU G.652 compliant low loss fiber by Corning Inc.
Attenuation: 0.165 dB/km @ 1550nm

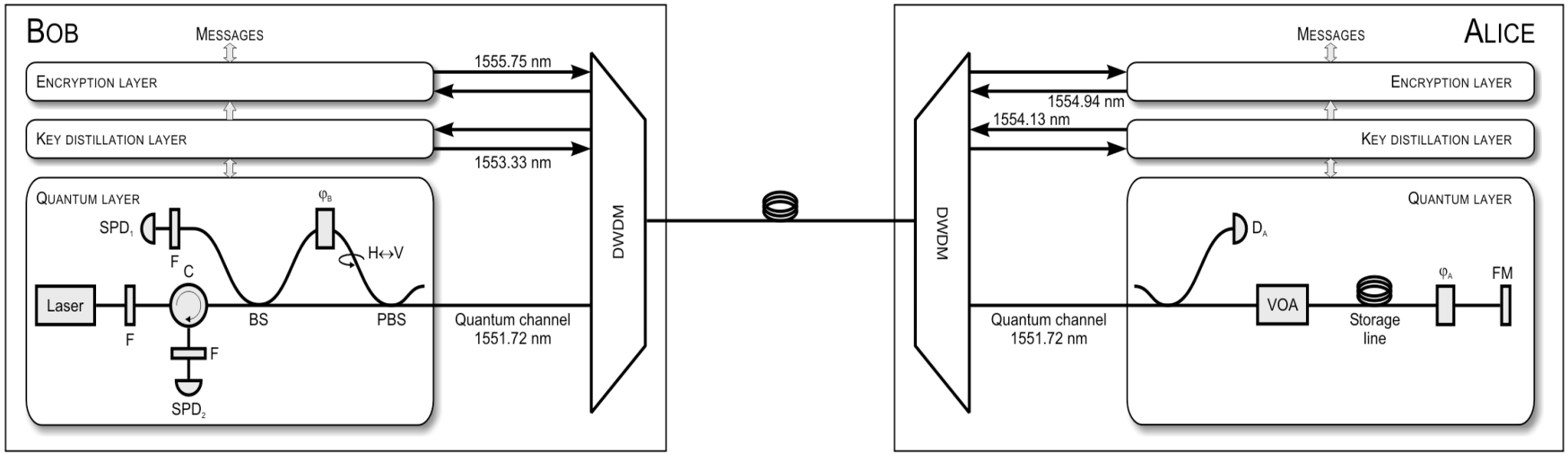


New J. of Phys **11**, 075003 (2009)

Quantum Key Distribution over Telecom Networks

- Goal: Key distribution and high speed data encryption over a single optical fibre
- Commercial QKD (plug & play) and AES-encryptors (256 bits keys, 1 Gbps rate)





$$QBER = QBER_{opt} + QBER_{det} + QBER_{noise/WDM}$$

What are the noise sources?

- Crosstalk of other wavelengths into quantum channel
- Generation of parasitic light at the wavelength of the quantum channel
  - by Raman scattering
  - by Four Wave Mixing (FWM)

Raman Scattering

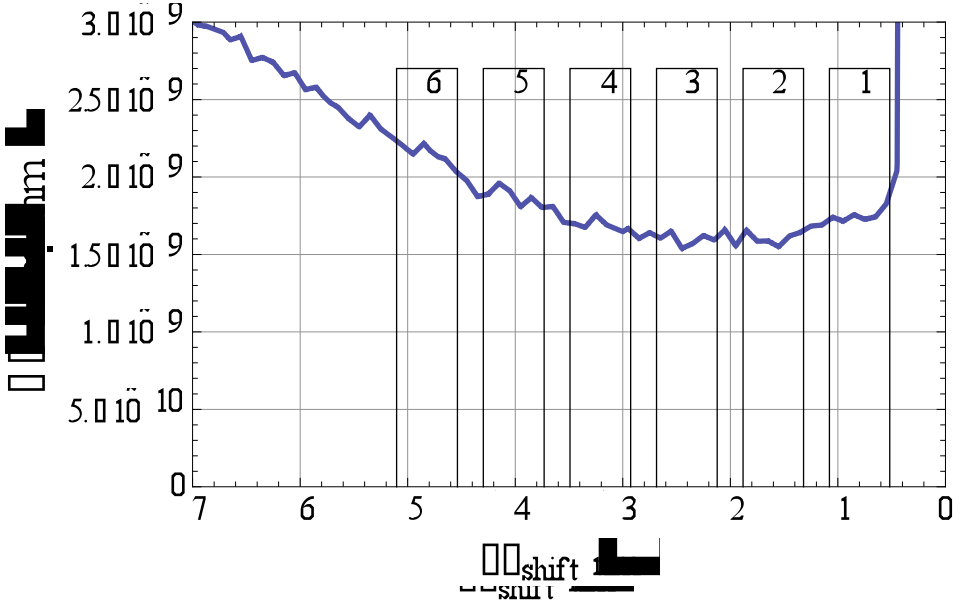
$$P_{forward} = P_{in}\, p(\lambda) L e^{-\alpha L}$$

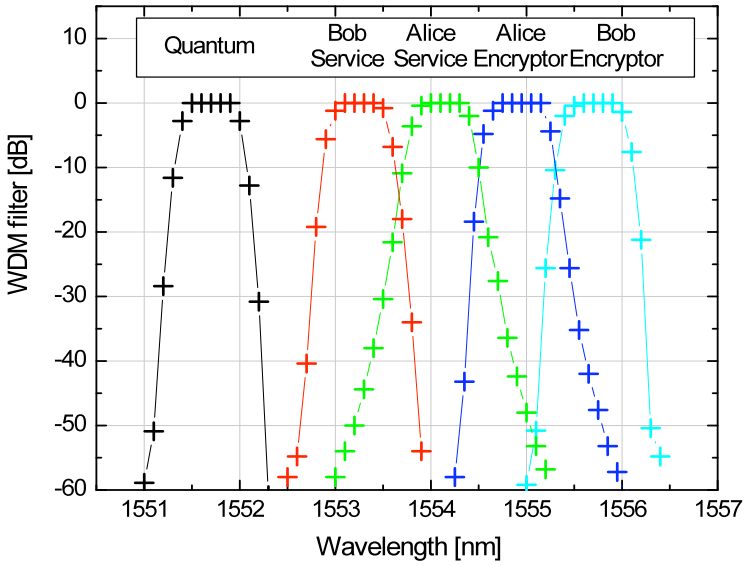
$$P_{backward} = P_{in}\, p(\lambda) \frac{1 - e^{-2\alpha L}}{2\alpha}$$

$$P_{forward} = P_{out}\, p(\lambda) L$$

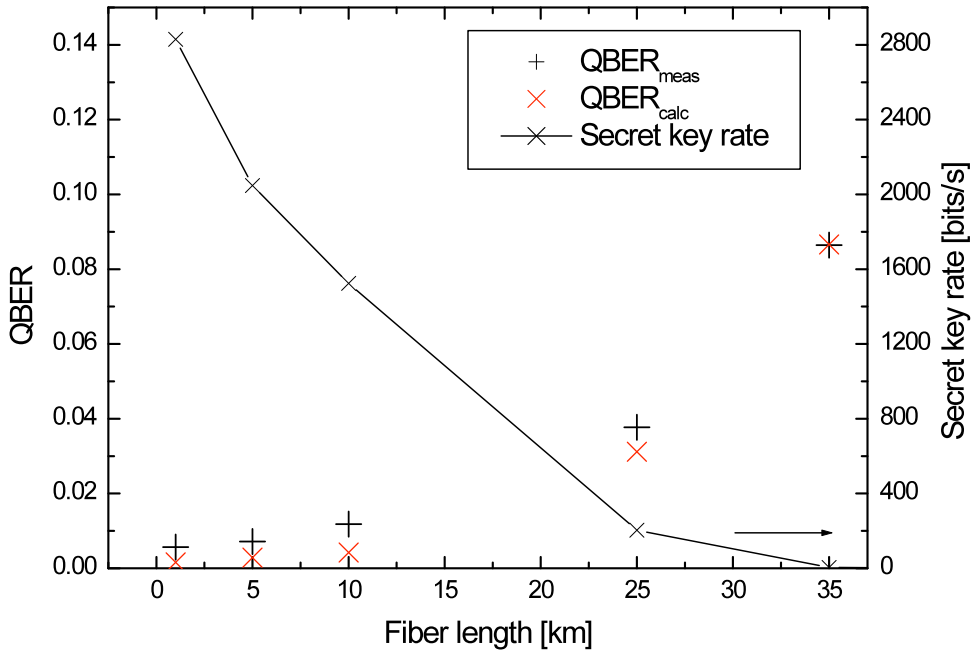
$$P_{backward} = P_{out}\, p(\lambda) \frac{e^{\alpha L} - e^{-\alpha L}}{2\alpha}$$

SFP receivers: -28dBm





Experimental Results



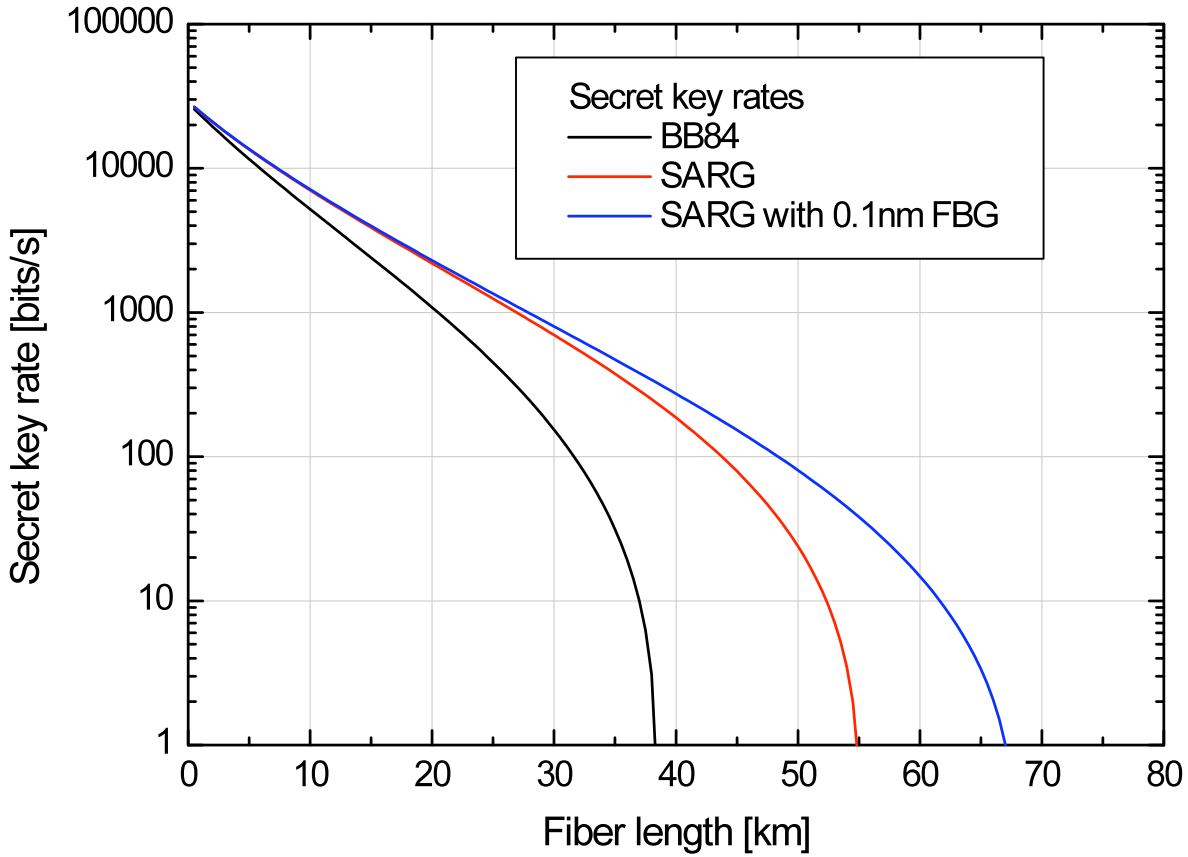
How can we increase the range?

$$S \propto \mu(L), e^{-\alpha L}$$

$$N \propto \Delta\lambda, e^{\alpha L}$$

BB84: $\mu=t$ SARG: $\mu=t^{1/2}$

Additional filter (FBG) : $\Delta\lambda$=0.8 nm $\rightarrow\Delta\lambda$=0.1 nm



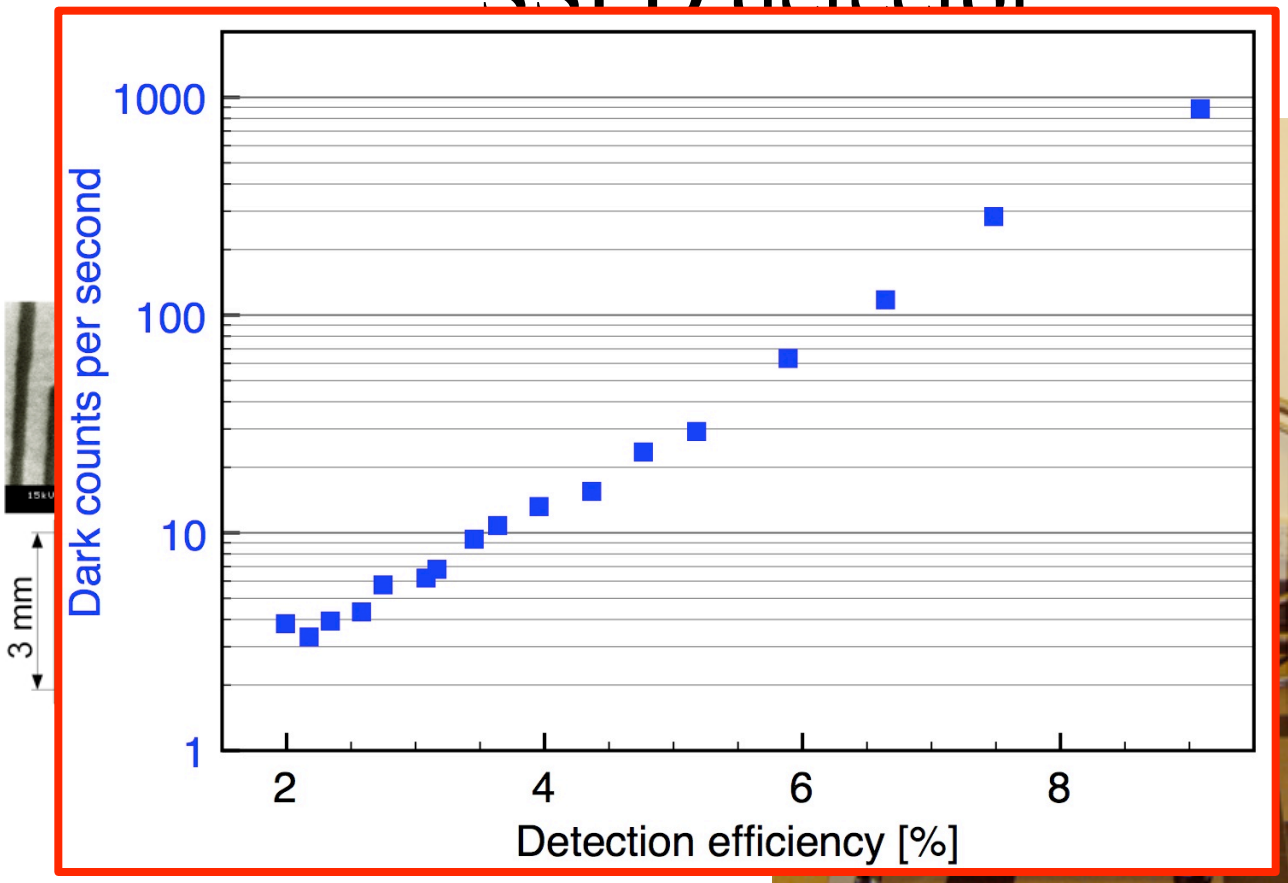
Conclusions

Limits of QKD

- Standard fibre and InGaAs detectors: 150 km
- With ULL fibre and SSPD detector: 250 km
- Key exchange and high speed encryption (1Gbps) using a single dark fibre: 60 km

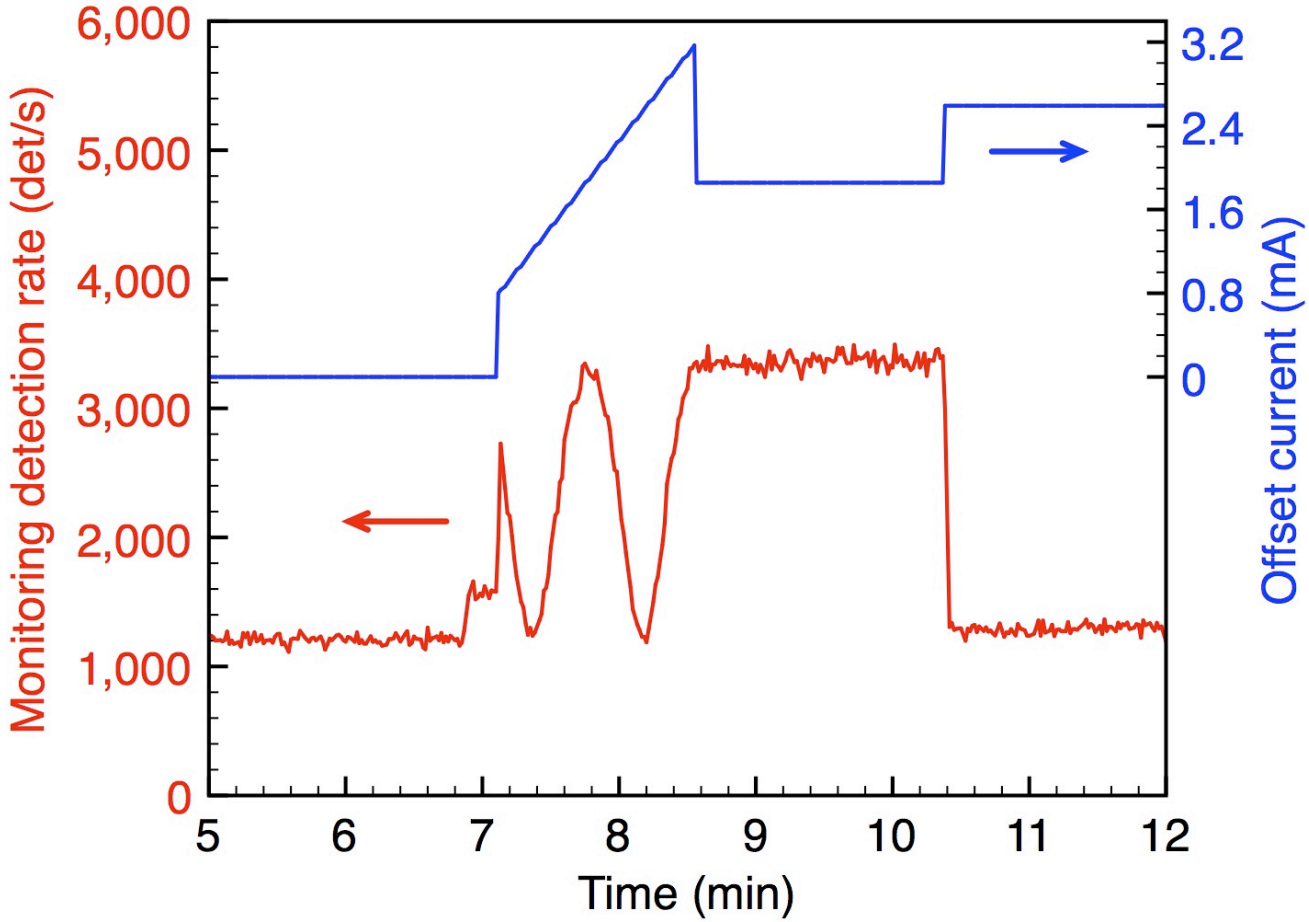
- Acknowledgments:
  Swisscom, University of Neuchâtel, Corning, NCCR quantum photonics, SINPHONIA

SSPD detector



- superconducting single photon detectors (SSPD) based on meandered NbN nano-wires
- cryogen-free, closed cycle, cryostat system
- temperature 2.5-2.8K

Monitoring



- Visibility larger than 95%
- InGaAs detector with 25km + 10dB