mm-Wave hybrid photonic wireless links for ultra-high speed wireless transmissions

mm-Wave Hybrid Photonic Wireless Links for Ultra-High Speed Wireless Transmissions

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Introduction & Motivation

Hybrid *photonic-wireless transmission* schemes in the mm-wave frequency range are promising candidates to enable the *multi-gigabit per second data communications* required from *wireless and mobile networks* of the 5th and future generations. Large FCC *spectrum allocations* for wireless transmission at 71–76GHz and 81–86GHz allow high-bandwidth, *long and medium distance* point-to-point links.

Photonic integration may pave the way to practical applicability of such hybrid links by *reduction* in complexity, size and – most important – *cost*.

Silicon Photonic Integrated Circuits

Motivation

Silicon-on-insulator (SOI) photonic integrated circuits (PICs) are a prime candidate for photonic integration, due to a number of factors:

- Compatible to CMOS technology and fabrication infrastructure
  - Highly accurate, high-yield and mature technology
  - Hybrid photonic and electronic integration
- Operation in the 1.3μm and 1.55μm telecommunications windows
- Large selection of photonic components available
  - Filters
  - (De-)Multiplexers
  - Splitters
  - Modulators
  - Mach-Zehnder
  - Photodetectors
- Active components with heterogeneous integration (III/V, InP etc)

Integration of mm-Wave Transmitter

Silicon photonic integrated circuits allow integration of the mm-wave generation setup, including generation of a wavelength comb or two appropriately spaced spectral lines and the modulation for data transmission or sensing.

mm-Wave Hybrid Photonic Wireless Setup

(I) Optical Line Termination
- SFP+ for signal generation
- PRBS15 NRZ from PPG

Fiber Trasmission:
10km SMF & 5km BIF

(II) Radio Access Unit
- Free running LO
- Controlled power on PD
- 8dB RF Amplifier
- 48dBi Antenna Gain

(III) Wireless Receiver
- 40dB Low-Noise Amplifier
- Schottky Diode based Envelope Detector
- Signal Recovery and Analysis

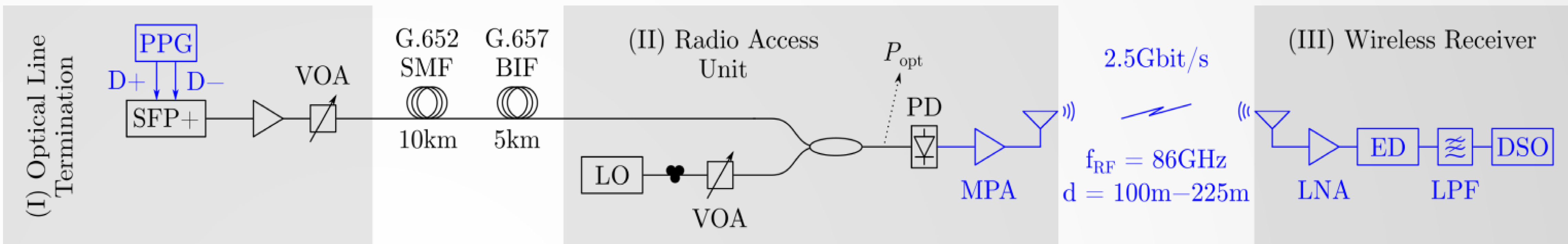

Figure 1. Experimental setup for radio-over-fiber transmission. SFP+: enhanced small form-factor pluggable, PPG: pulse pattern generator, VOA: variable optical attenuator, LO: local oscillator, PD: photodiode, MPA: medium power amplifier, LNA: low noise amplifier, ED: envelope detector, LPF: Lowpass filter, DSO: digital storage oscilloscope

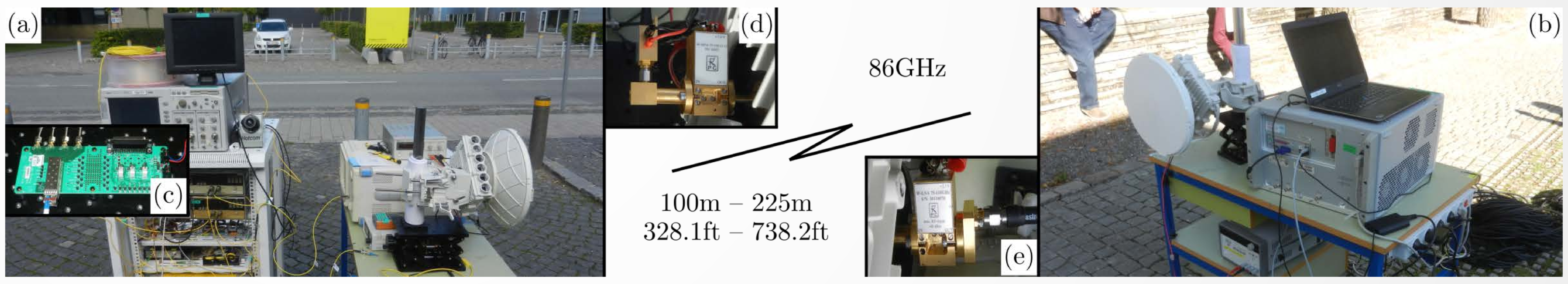

Figure 2. Outdoor experimental setup: (a) transmitter station, (b) receiver station, (c) evaluation board with SFP+, (d) PD and MPA mounted on transmit antenna, (e) LNA and ED mounted on receive antenna

millimeter Wave Silicon Photonics for Remote Sensing and Wireless Links

mmW-SPRAWL

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225m Outdoor Wireless Transmission

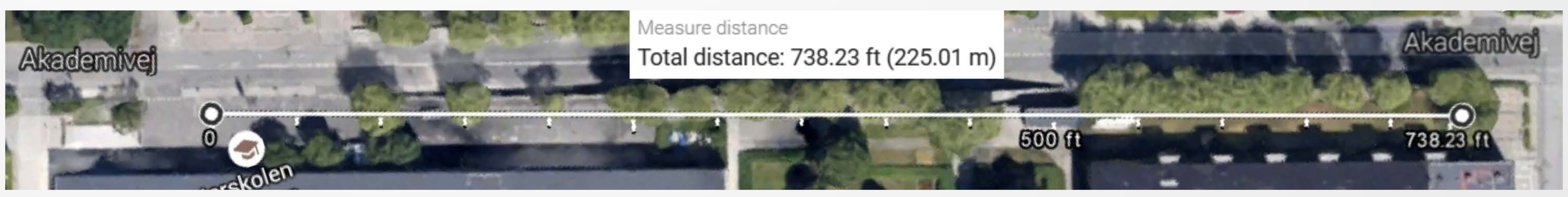

Figure 4. Outdoor transmission path on the DTU university campus

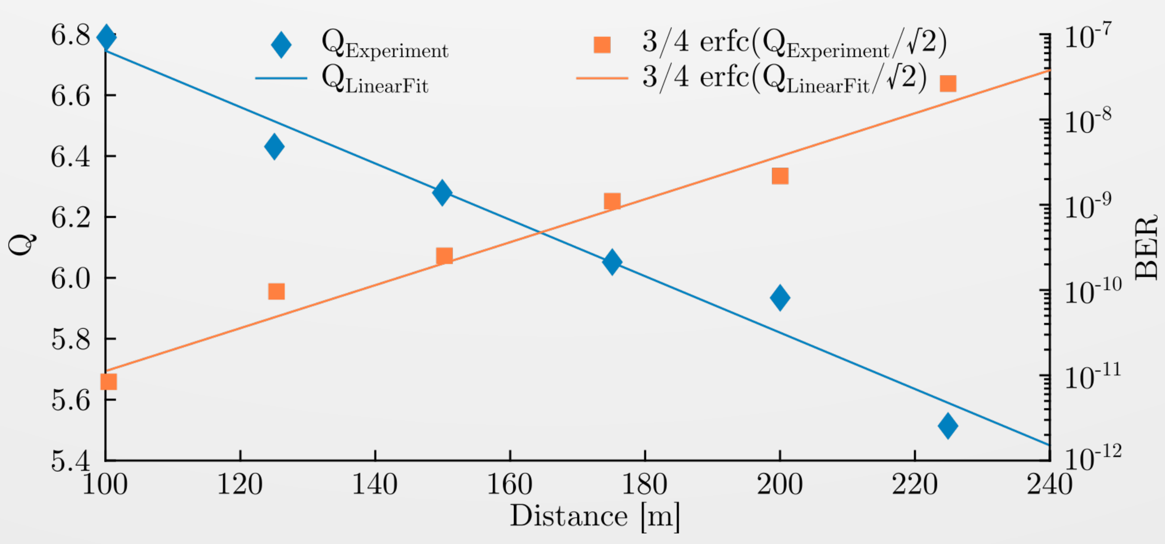

Figure 5. Q factor and BER over transmission distance

- ✓ BER < 10^{-7} at all distances
- ✓ linear relation between BER and distance

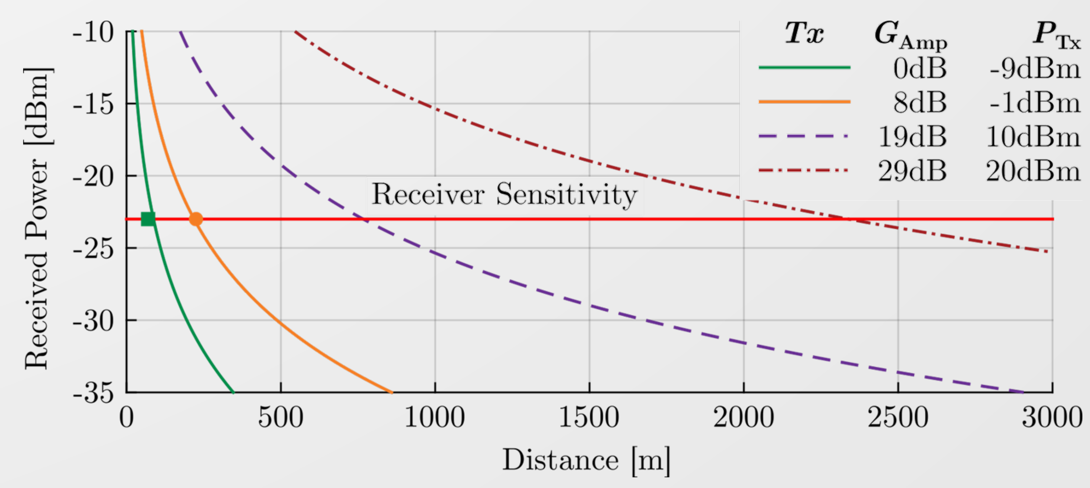

Figure 6. Calculated maximum wireless reach of the hybrid photonic wireless link

- ✓ up to 2340m wireless transmission with readily available RF equipment
- ✓ experiments agree well with Friis' model

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