# Concept, design and verification of components for an integrated on-detector silicon photonic multi-channel transmitter unit
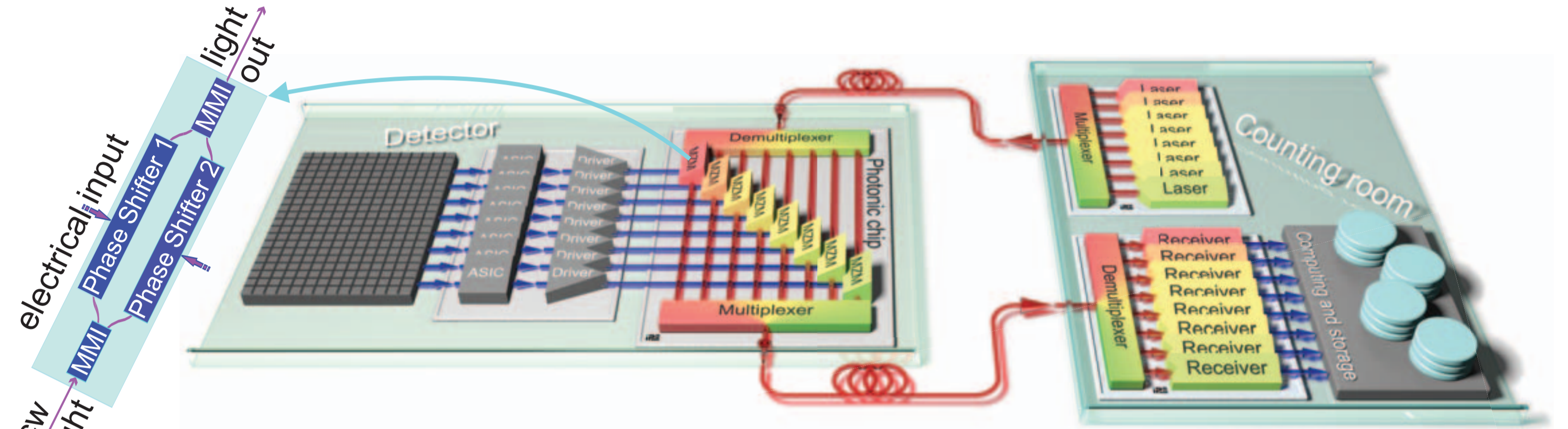
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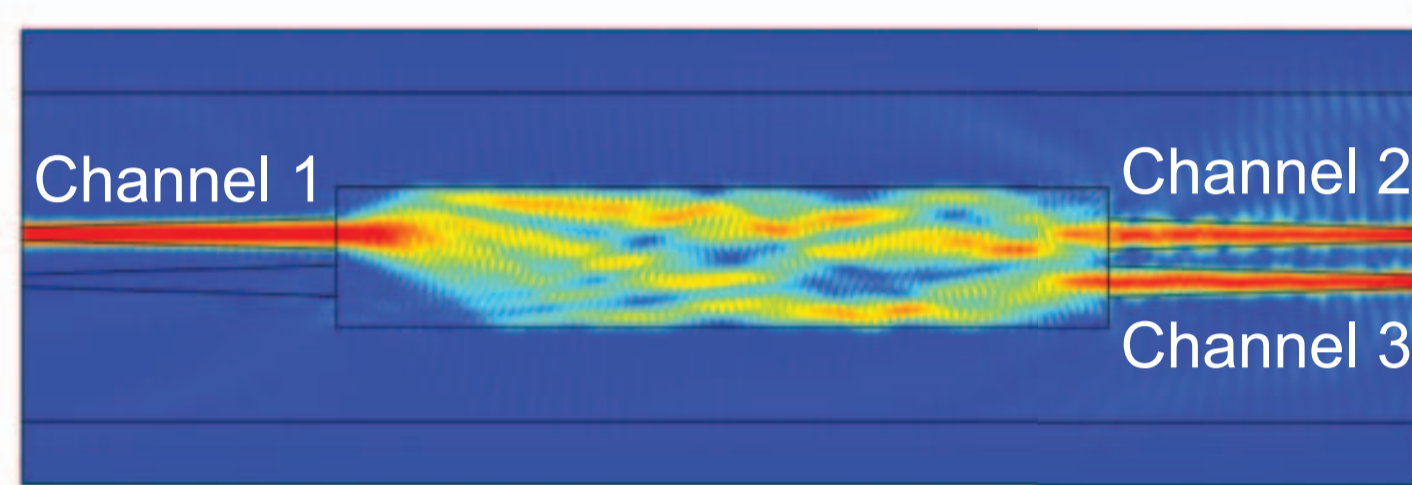
## Motivation

The data throughput of future detector readout systems is ever increasing. To satisfy the requirements of ultra-broad bandwidth, we propose a high-performance optical link utilizing wavelength-division multiplexing (WDM). The key components are monolithically integrated silicon photonic transmitter units, each with four parallel channels. With more parallel channels and more advanced modulation format, the bandwidth could achieve several Tbit/s potentially.
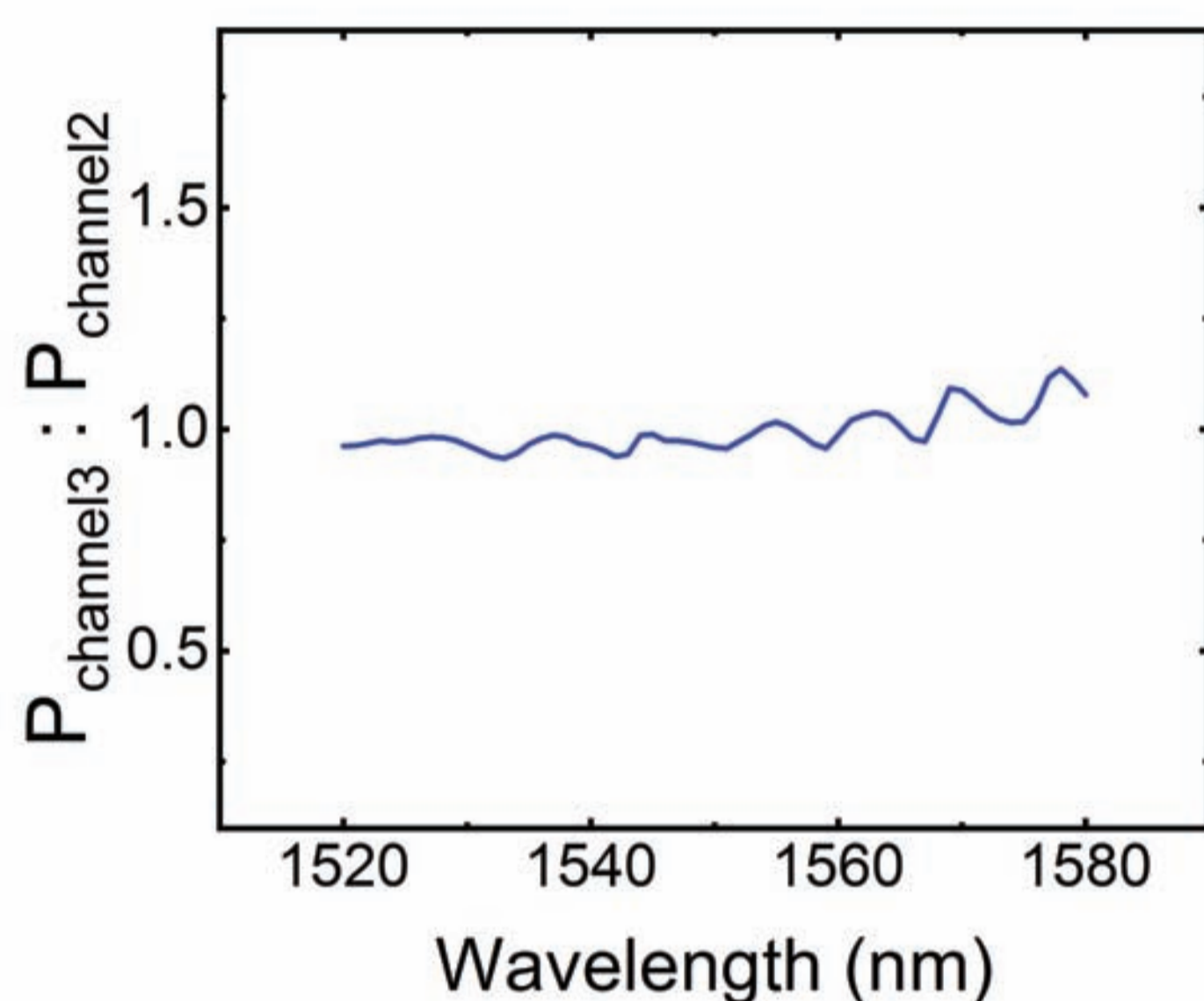
## System Schematic



Ultra-fast detector readout system for particle physics and photon science.
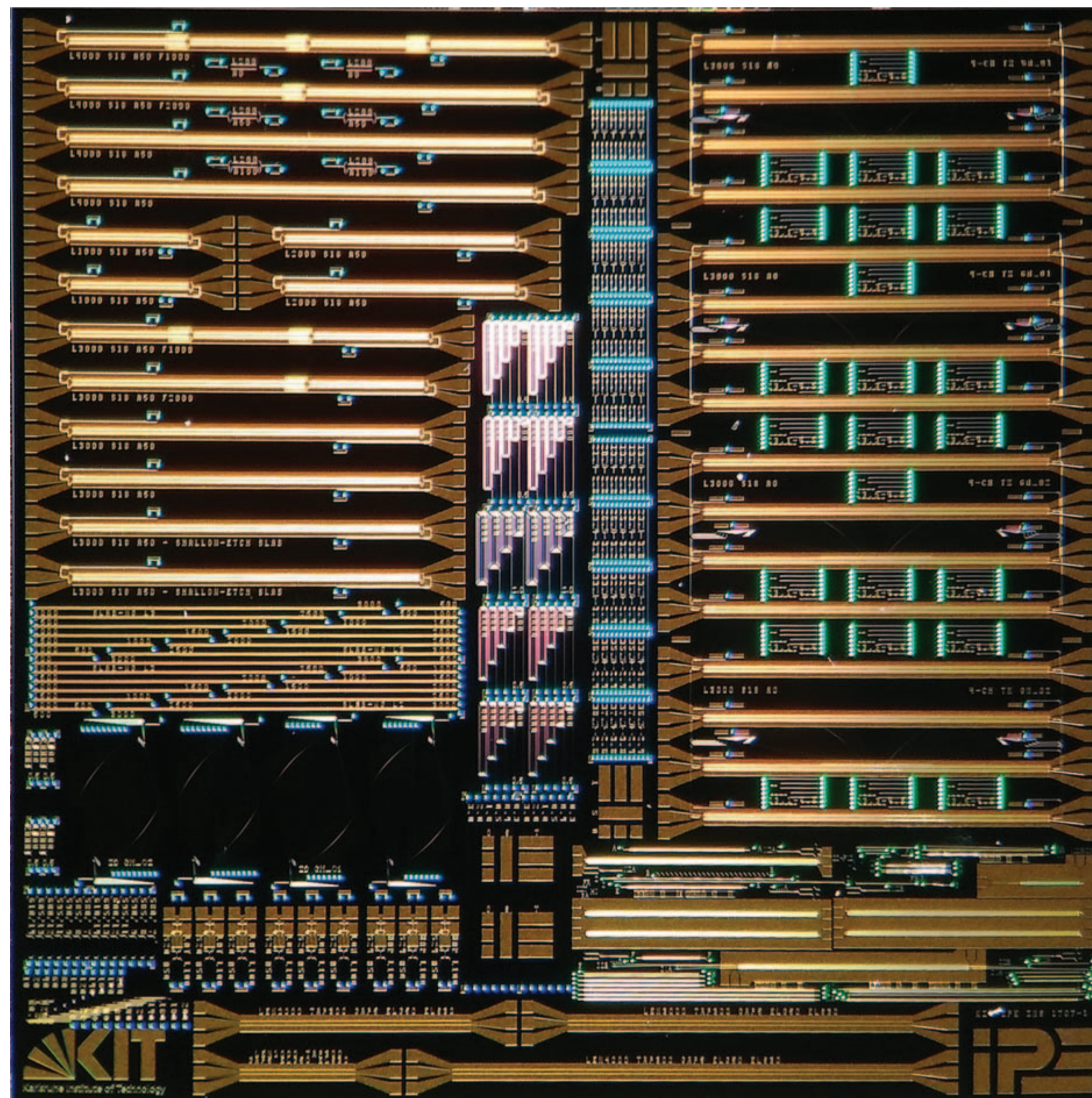
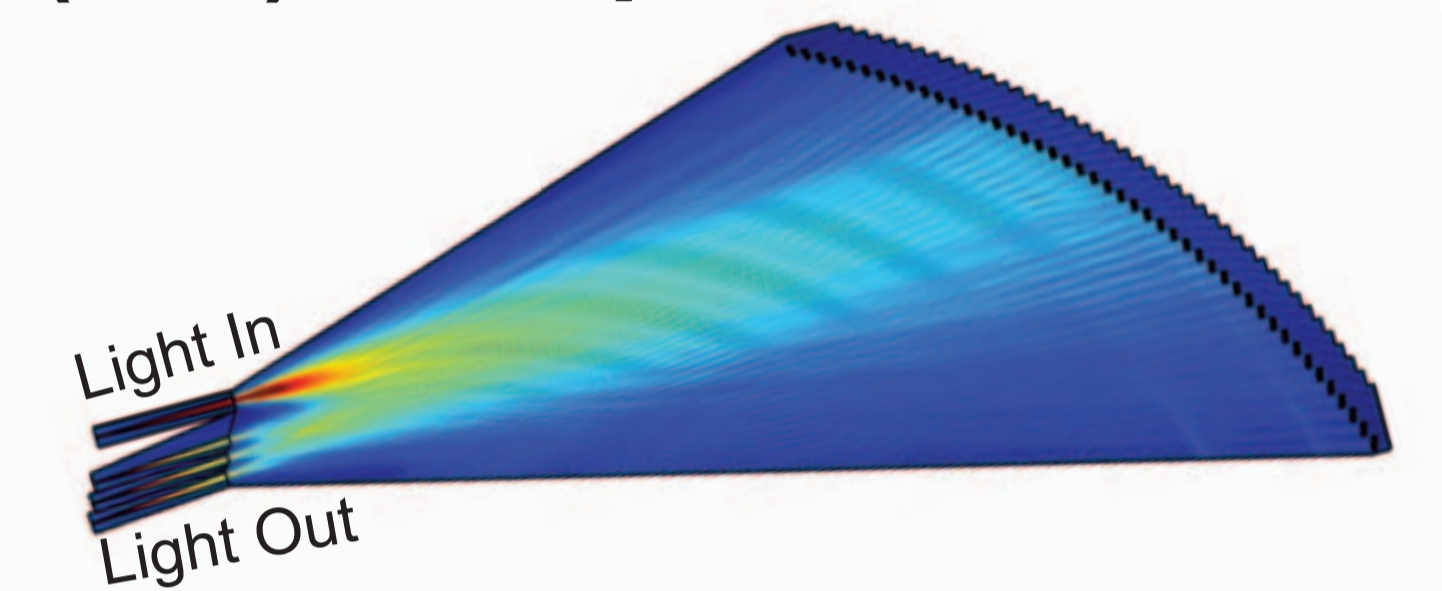## Multimode interferometers



Waveoptic simulation with COMSOL.



Simulated power ratio of output channels versus input wavelength, max. 0.6 dB loss in total.
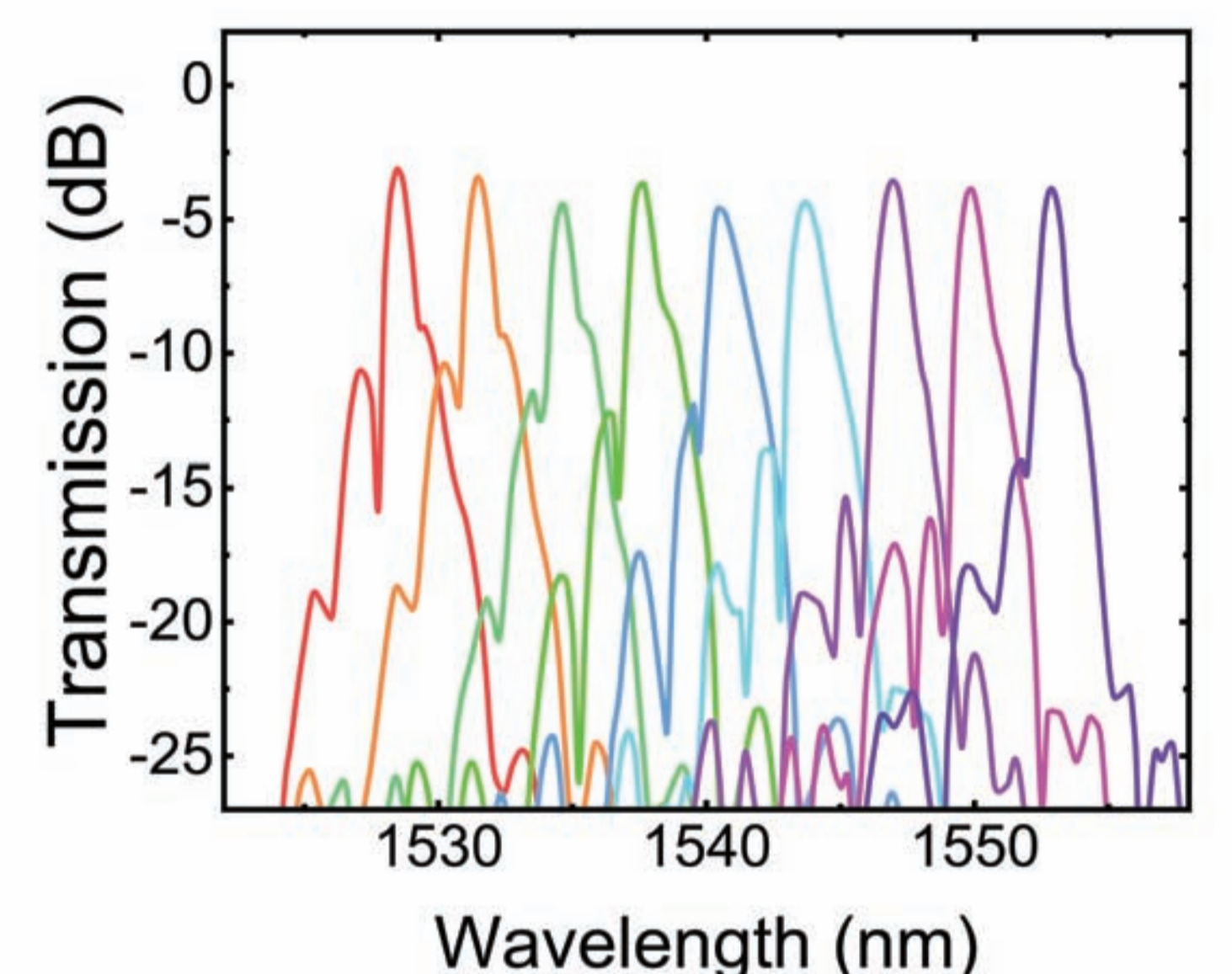


Photonic system chip (9.2 × 9.2 mm²) with 4-channel WDM transmitter units, individual pn-modulators, thermal modulators, Echelle grating (de-) multiplexers, and test structures.
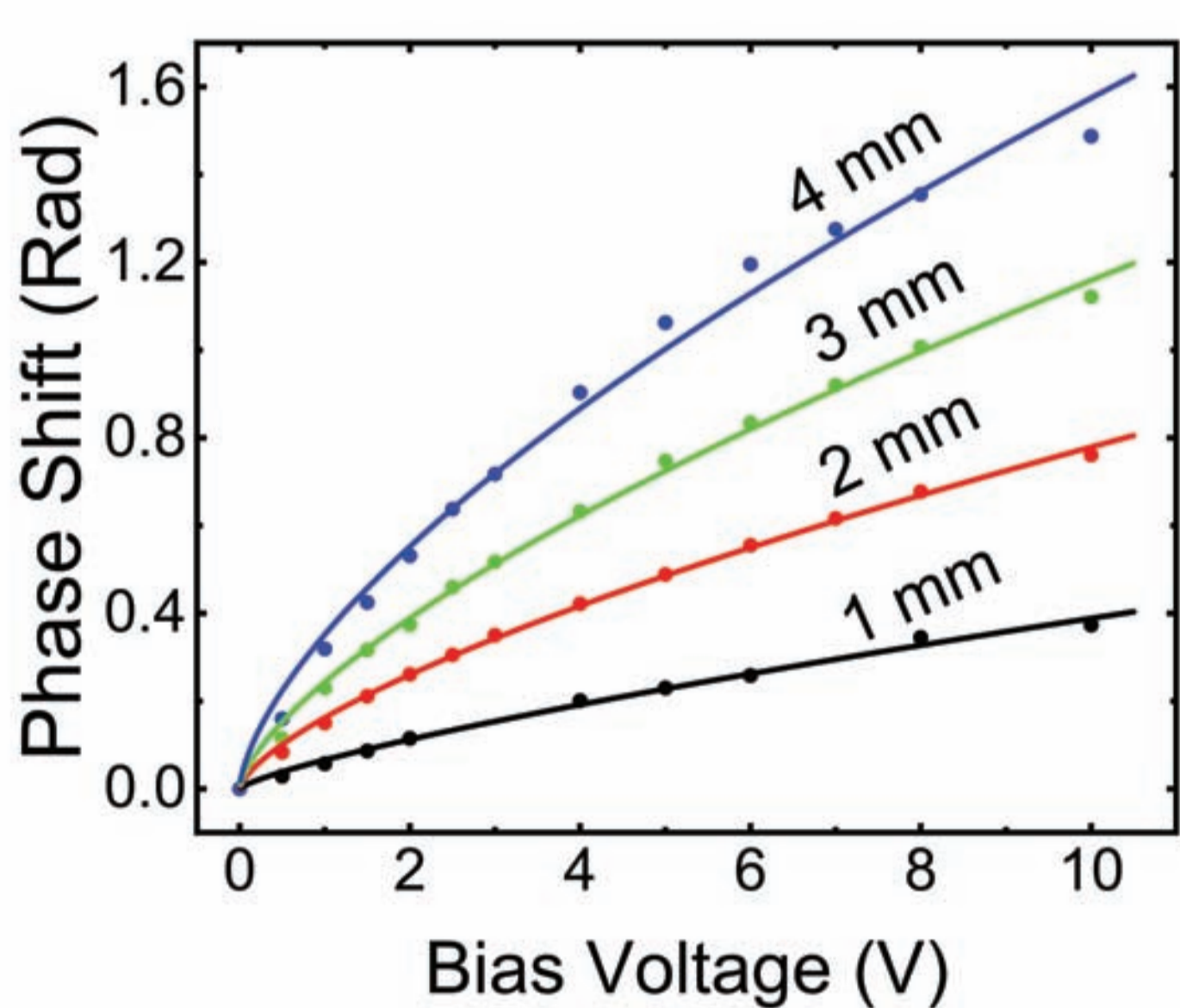
## (De-) Multiplexers



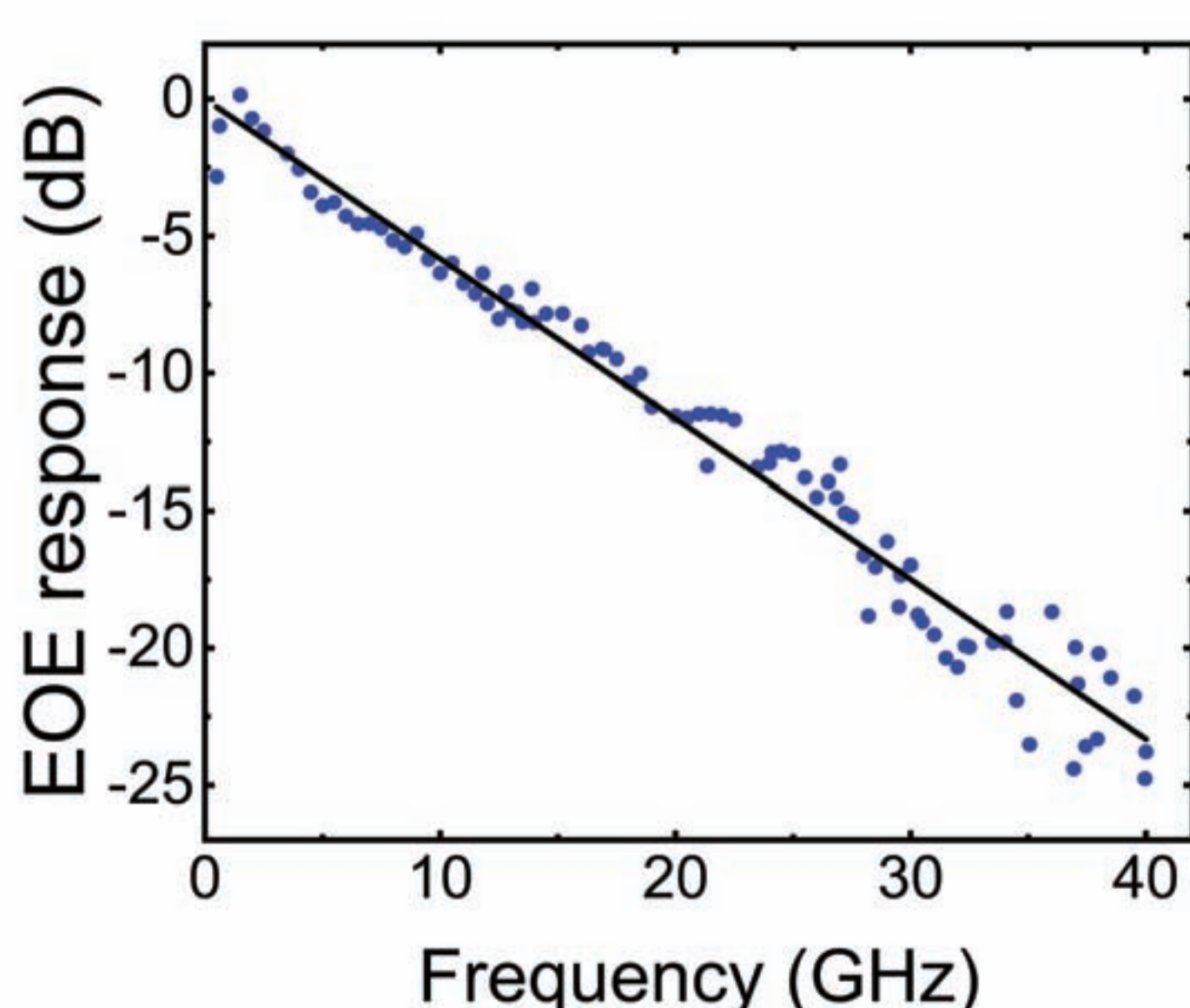Waveoptic simulation with COMSOL.



The transmission spectrum of a 1 × 9 demultiplexer of an on-chip integrated WDM transmitter unit.
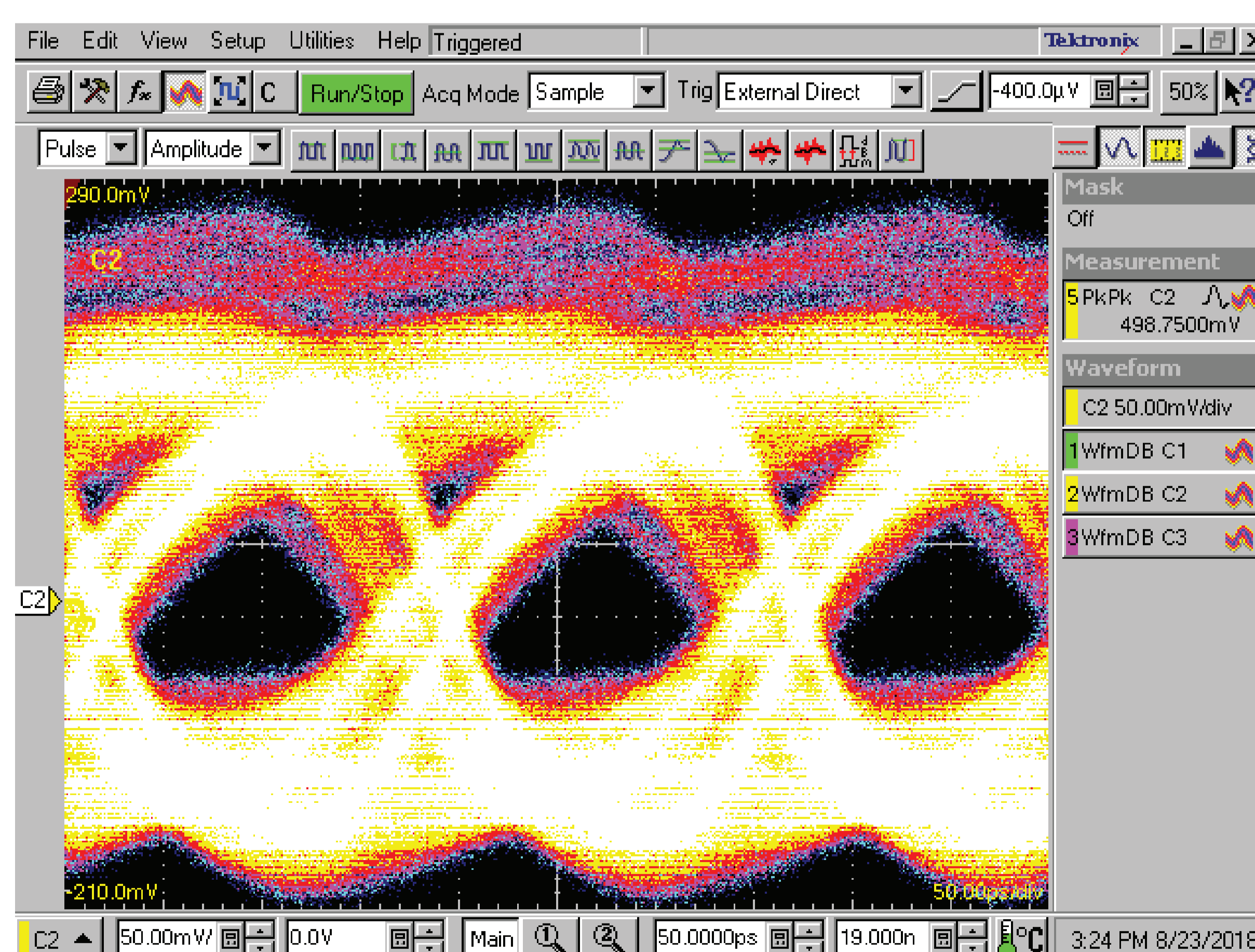
## Electro-optic modulators



The phase shift of an individual pn diode phase shifter versus the bias voltage for different shifter lengths.



Frequency response of a pn Mach Zehnder modulator of an integrated WDM transmitter unit.
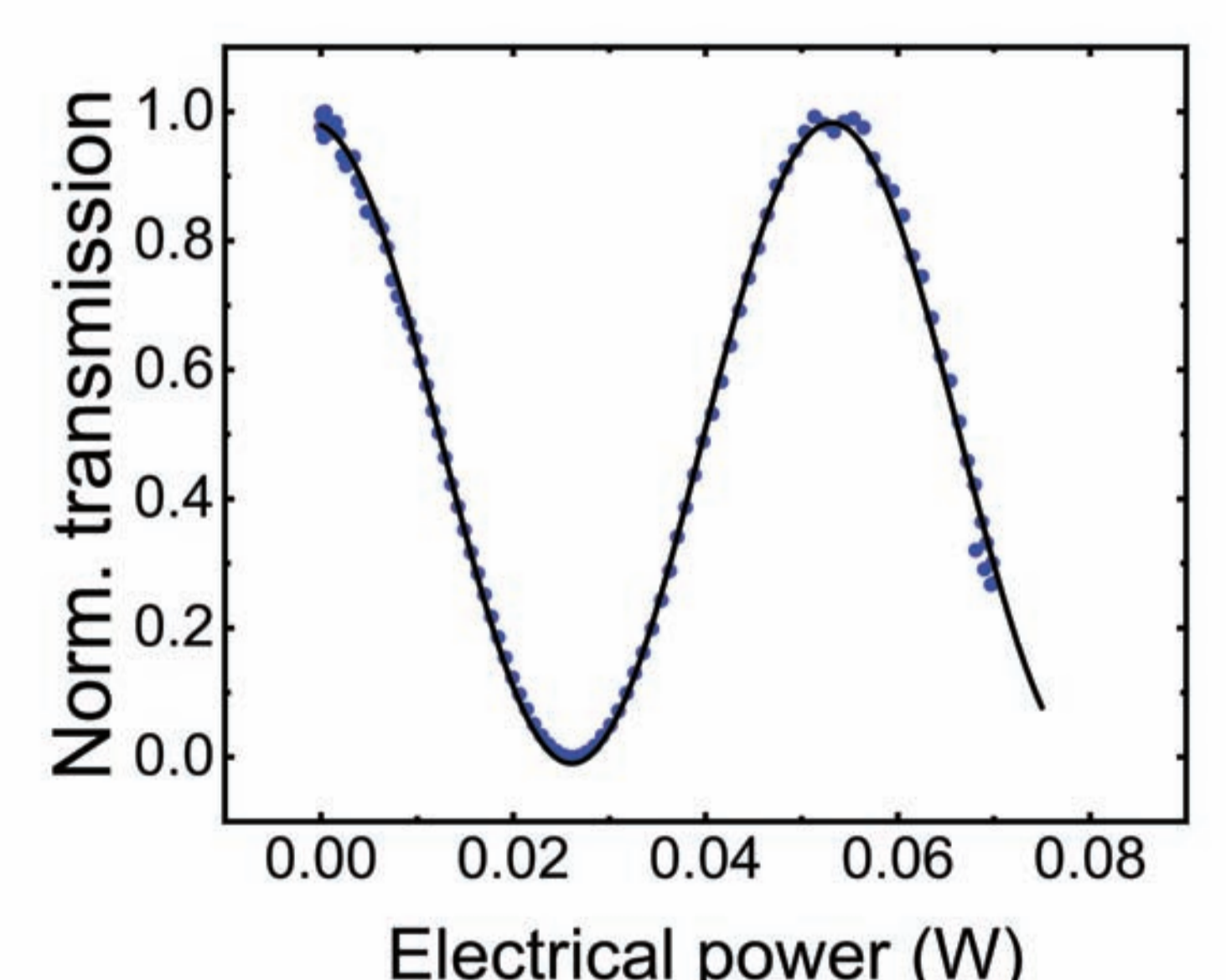


Eye diagram of one channel from a 4-channel integrated WDM transmitter unit at a bit rate of 5.65 Gbit/s. Measured bit error rate (BER) of $1.7 \times 10^{-9}$ over 45 minutes.

## Thermal modulators



Normalized transmission versus input electrical power.

## Outlook

- **Downlinks** with monolithically integrated Ge-photodiodes
- Dynamically **reconfigurable** Rx and Tx channels
- Advanced modulation formats for **higher bandwidth**
- **Working point** control
- **Monolithic integration** of sensors, ASICs, and photonics

## Partners

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