

L'évolution des systèmes de transmission optique très haut débit et l'impact de la photonique sur silicium

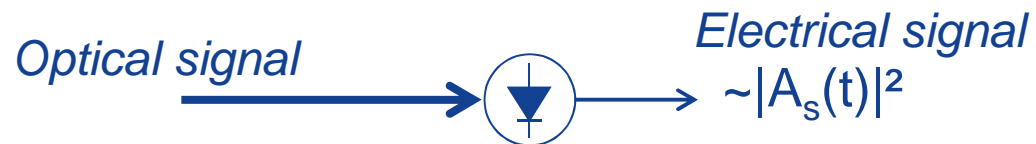
- G. Charlet
- 27-November-2017

Introduction

- Evolution of long distance transmission systems: from direct detection to coherent
- Modulation format and receiver description
- Toward high baudrate systems
- Silicon photonic integration

Evolution of transmission systems: from direct detection to coherent

- **Direct detection** was the conventional way to detect optical signal.
= QUADRATIC detection of electric field

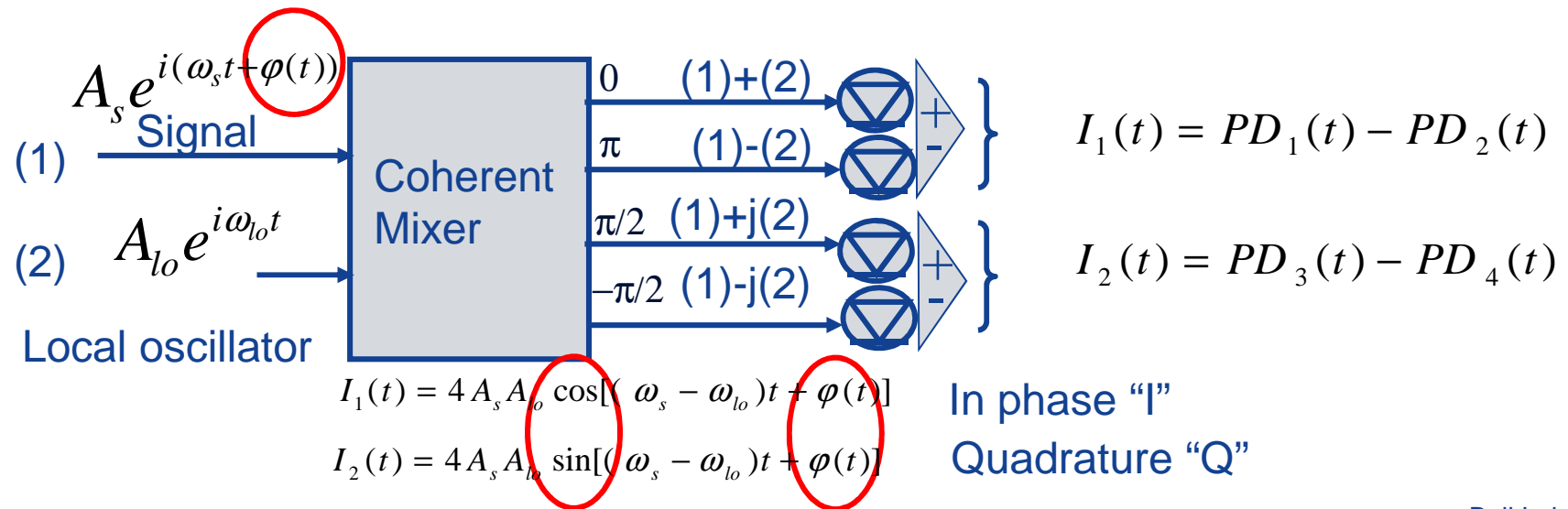


- Limitations for higher bit rate because of
 - Chromatic dispersion
 - Polarization mode dispersion (PMD)
- Limited spectral efficiency

Evolution of transmission systems: from direct detection to coherent

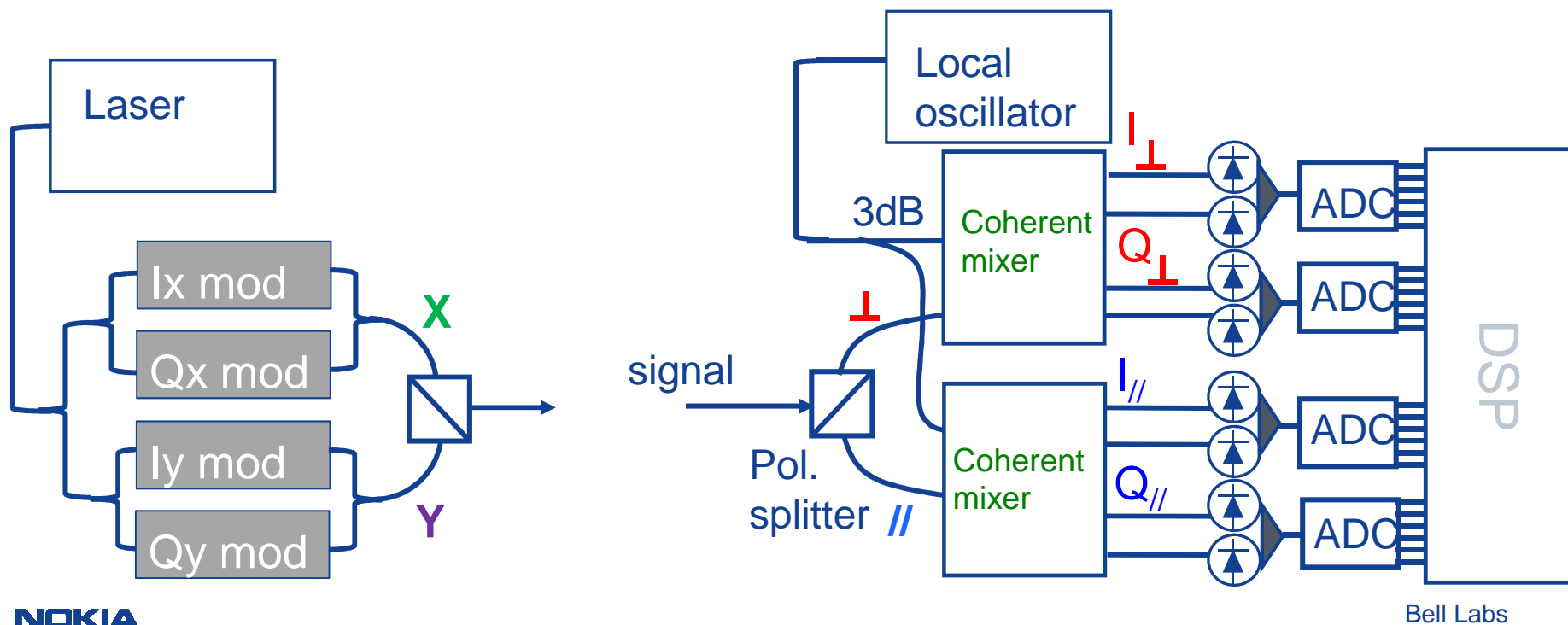
Coherent detection

= LINEAR detection of the electric field, by beating with local oscillator (LO)



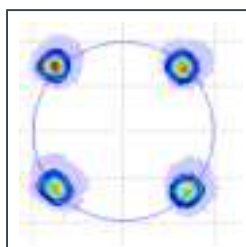
Evolution of transmission systems: from direct detection to coherent

Modulation and detection of 4 dimensions

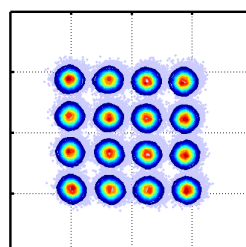


Modulation

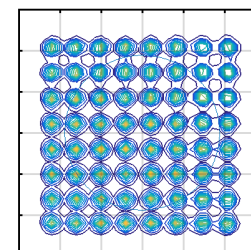
From QPSK to 16QAM and 64QAM



QPSK
100Gb/s



16QAM
200Gb/s



64QAM
300Gb/s

@32Gbaud
25% FEC

- Higher signal integrity required for 16/64QAM
- Shorter reach (reduction by factor of ~5 between each format)

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Baudrate and bandwidth requirements

From 32Gbaud to 64Gbaud

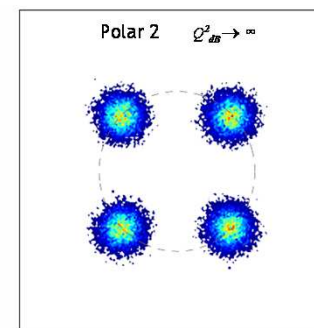
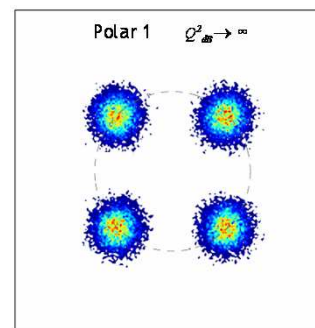
- First generation of coherent systems (2010-2013) designed around 30Gbaud
- Current highest speed systems operates at 44 to 56Gbaud
- 64Gbaud seen as the next step, to continue to reduce cost per bit.

- Bandwidth requirement \sim baudrate / 2
- Bandwidth $>$ 32GHz for all components (DAC, drivers, modulator, photodiode, TIA, ADC)

Silicon photonic for coherent system

Receiver integration and ANR MICROS project

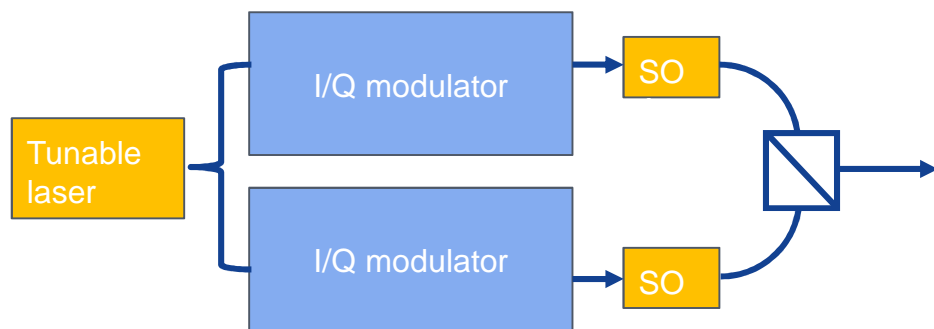
- Goal: integration of tunable laser with polarization diversity coherent receiver.



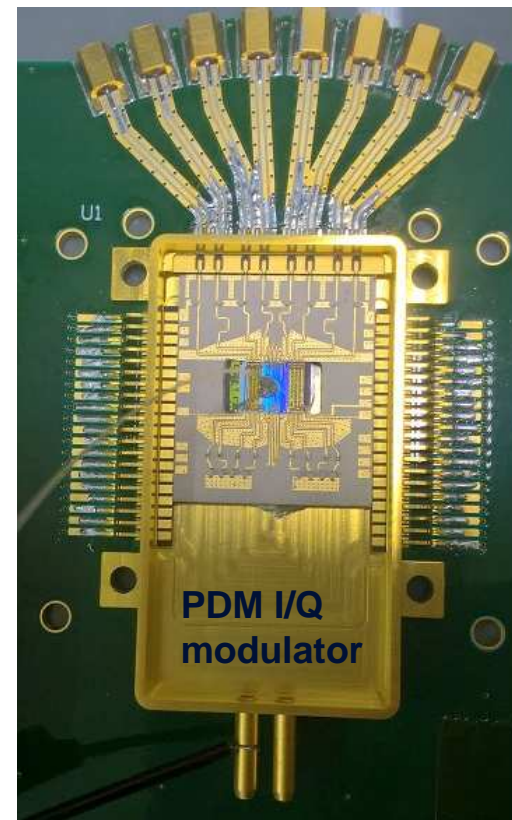
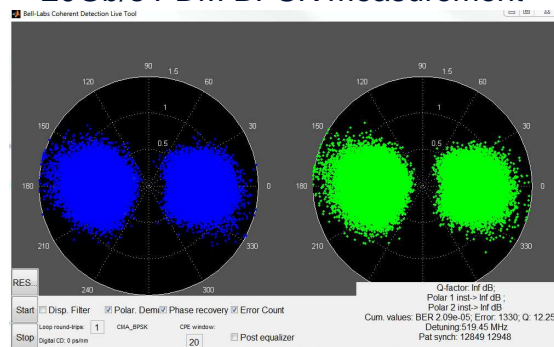
- Functional device and packaging
 - But too large loss... (8 to 17dB excess loss depending on polarization)
 - Laser integration planned, but not integrated in the packaged device...

Silicon photonic for coherent system

Transmitter integration and ANR ULTIMATE project

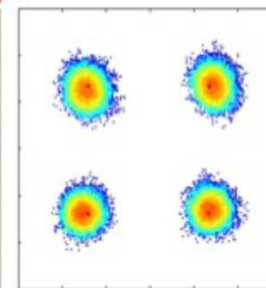
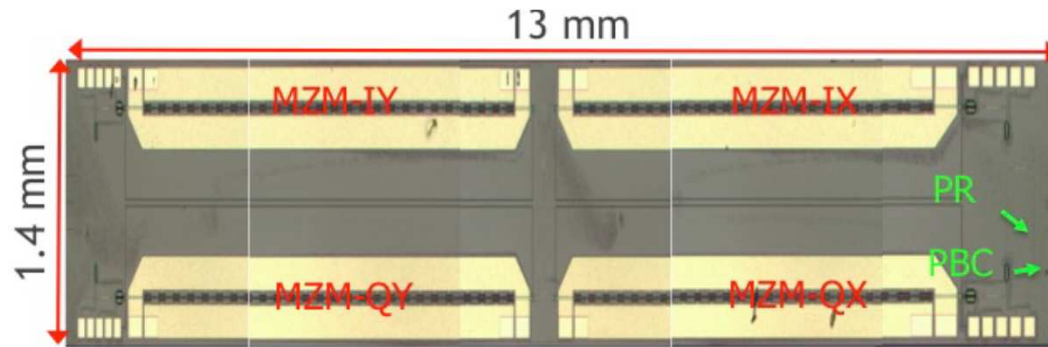


20Gb/s PDM BPSK measurement

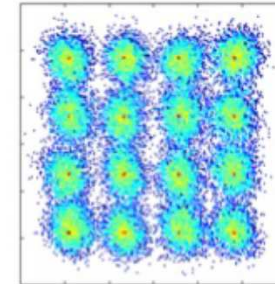


PDM I/Q Modulator and coherent receiver

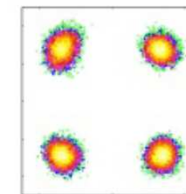
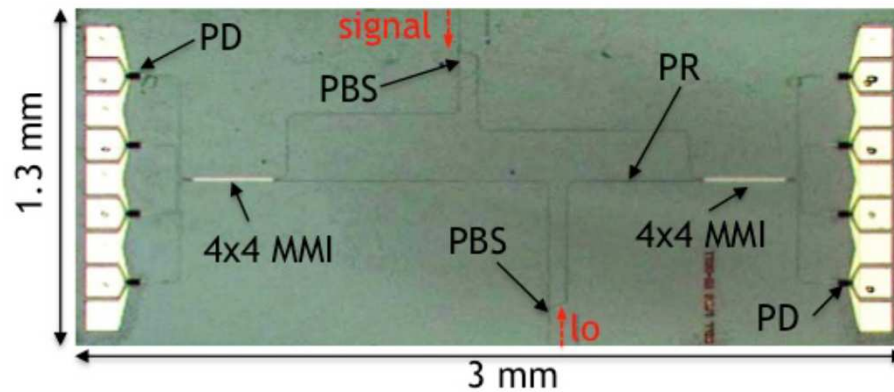
Courtesy of Po Dong



112-Gb/s PDM-QPSK



224-Gb/s PDM-16-QAM

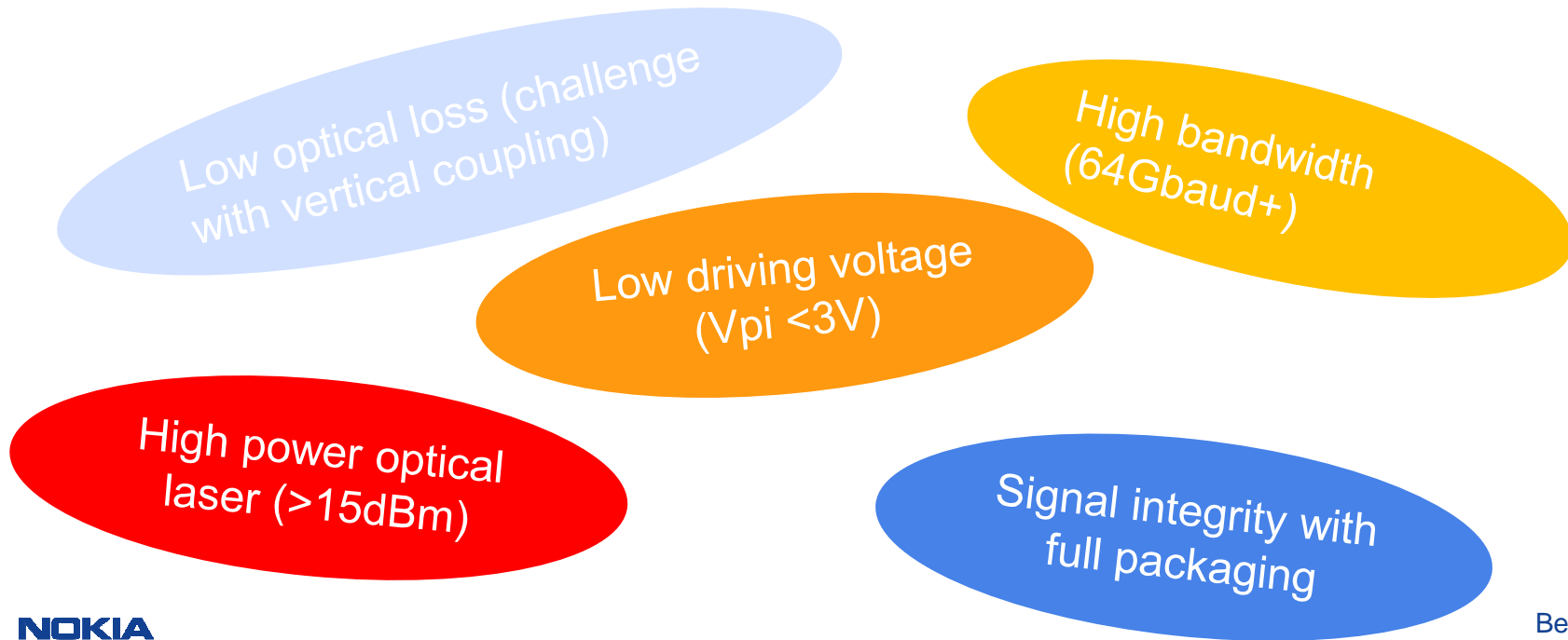


Monolithic polarization diversity coherent receiver using on-chip polarization rotators (PR)

OFC2013 PDP 5C6, Po Dong

Expectations from WDM industry

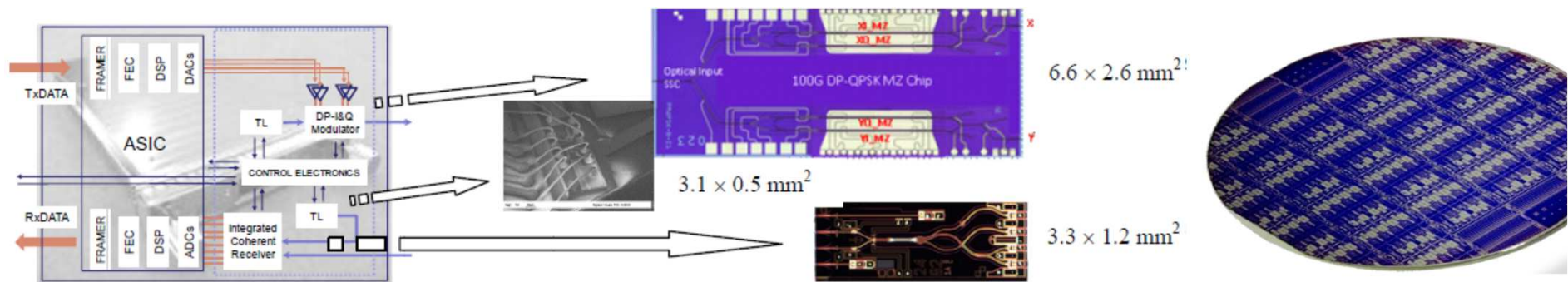
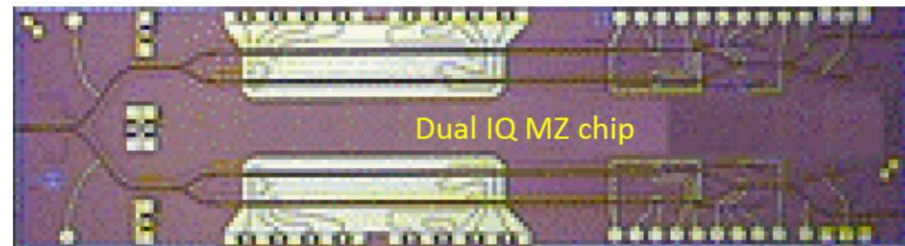
- Large numbers of key parameters to be met simultaneously



Competition from InP integration

- Large variety of material used in WDM industry
 - LiNbO3 modulator
 - PLC (Silica)
 - Free space optics
 - InP for modulator, receiver, laser...

Coherent mixer



Conclusion

- Silicon photonic integration is a promising technology for future WDM systems.
- All key building block demonstrated.
- Acacia successful in producing PDM I/Q modulator and coherent receiver.
- Pure InP manufacturers have today mature technology and high performance products.
- InP integration with Silicon photonic is an attractive path.
- Reducing cycle duration (from design to chip to packaging) might be important.
- I am counting on you to build a strong and performing Silicon photonic industry in Europe