Ross Saunders
GM, Next-gen Transport
Opnext Subsystems Inc.

100G Cost/Performance Optimization

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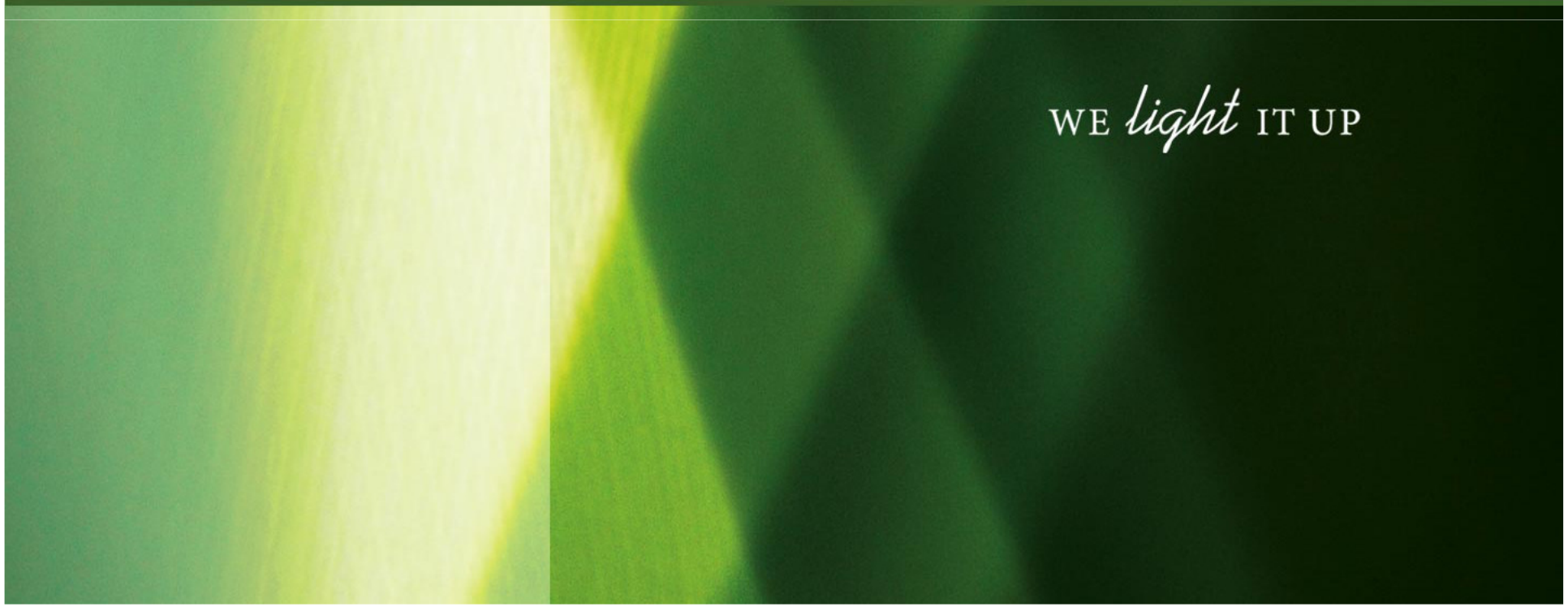

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Optical Transport Historical Perspective

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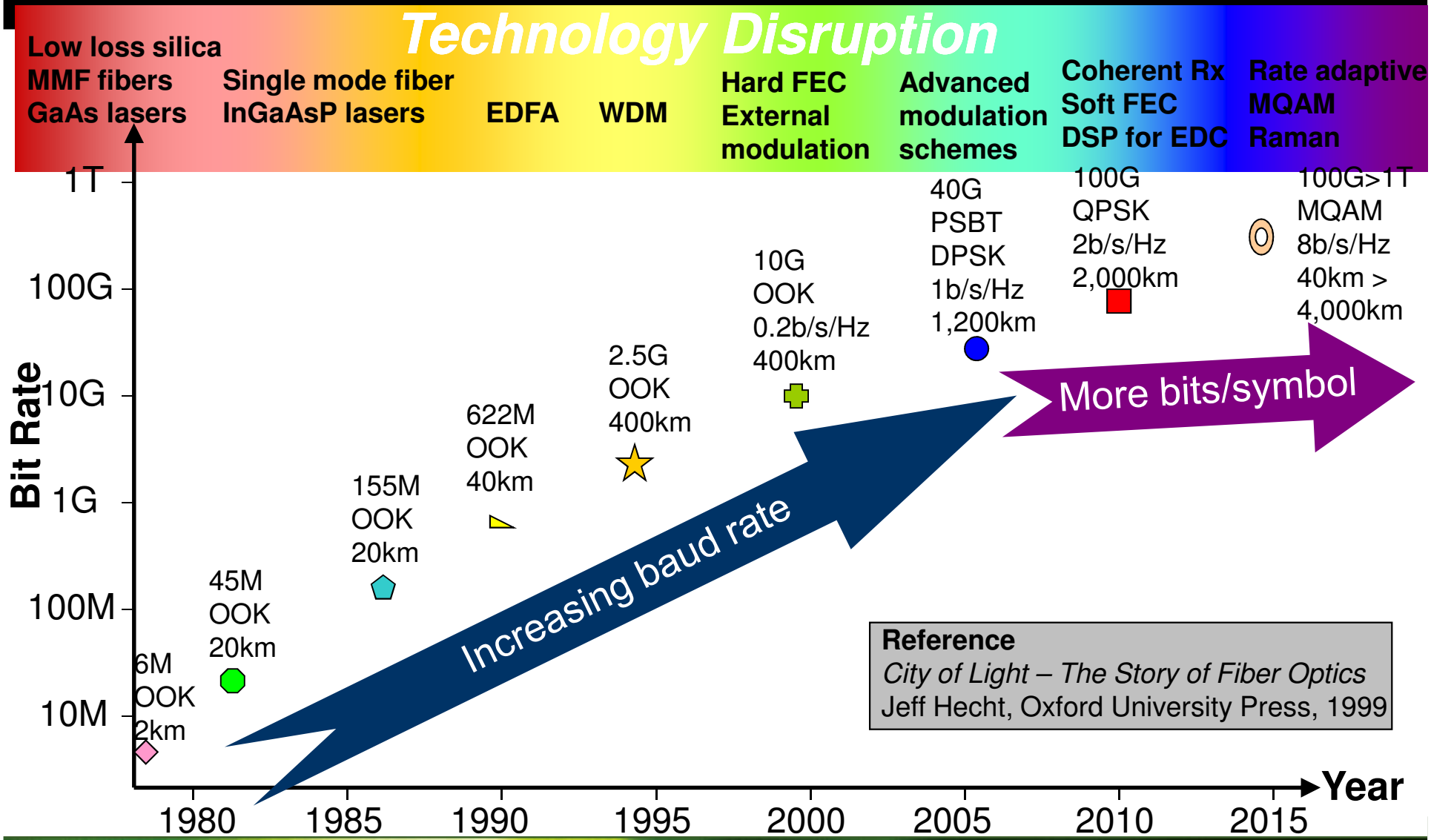

Reference
City of Light – The Story of Fiber Optics
Jeff Hecht, Oxford University Press, 1999

40G – Lessons Learned

- 40G market drivers were OC-768 PoS ports on IP routers and the need for spectral efficiency in the core
  - Good business but did not meet cost points for deployment “en masse”
- Two phased 40G deployments irritated carriers
  - CS-RZ/PSBT 1st gen 40G, followed by CO/A-DPSK
- On line side, start-ups led the commercialization, a worry for large OEMs and carriers
  - Mintera, Optium, CoreOptics and StrataLight
- Supply chain has been pretty fragmented chasing many modulation formats
  - CS-RZ, PSBT, DPSK, DQPSK, PM-QPSK, OFDM

100G PM-QPSK Implementation

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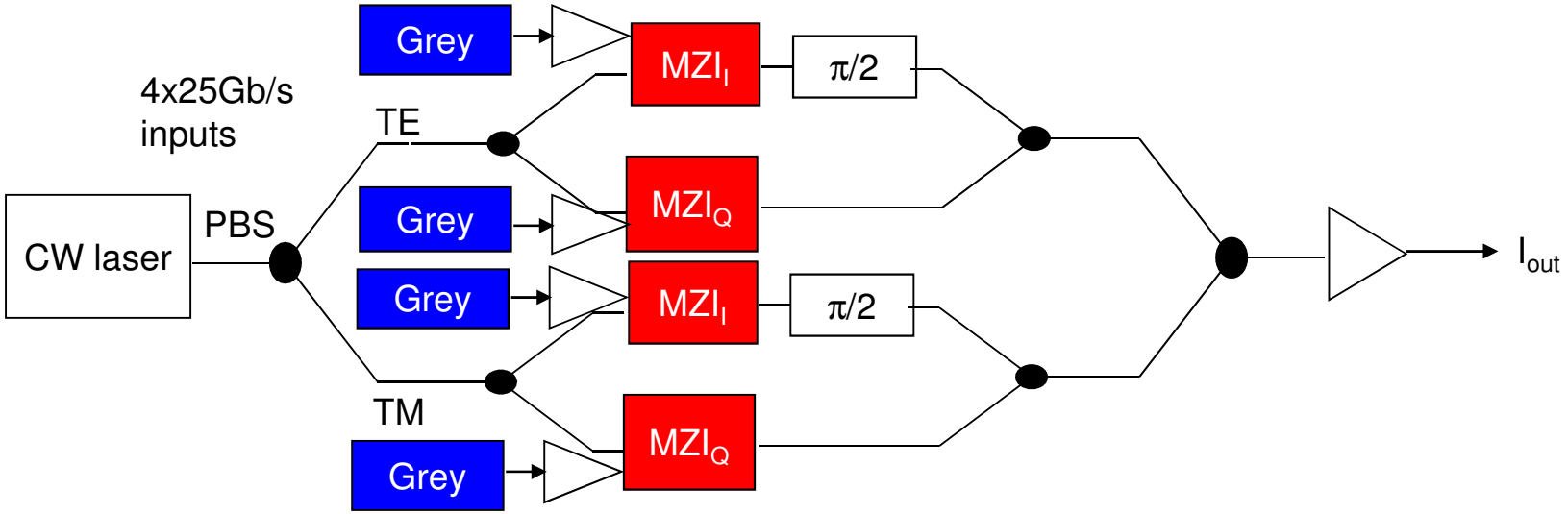
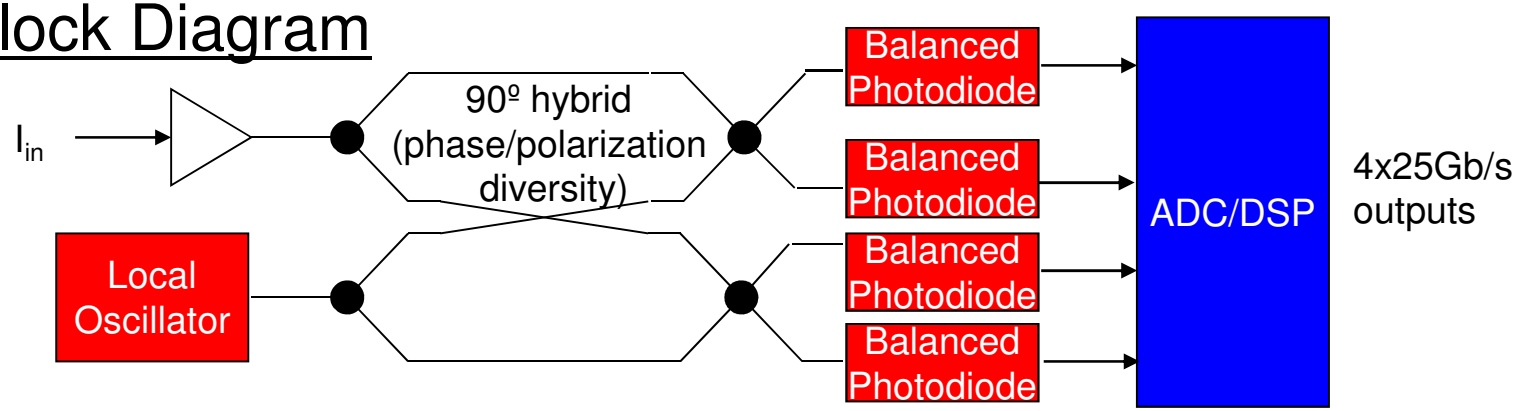
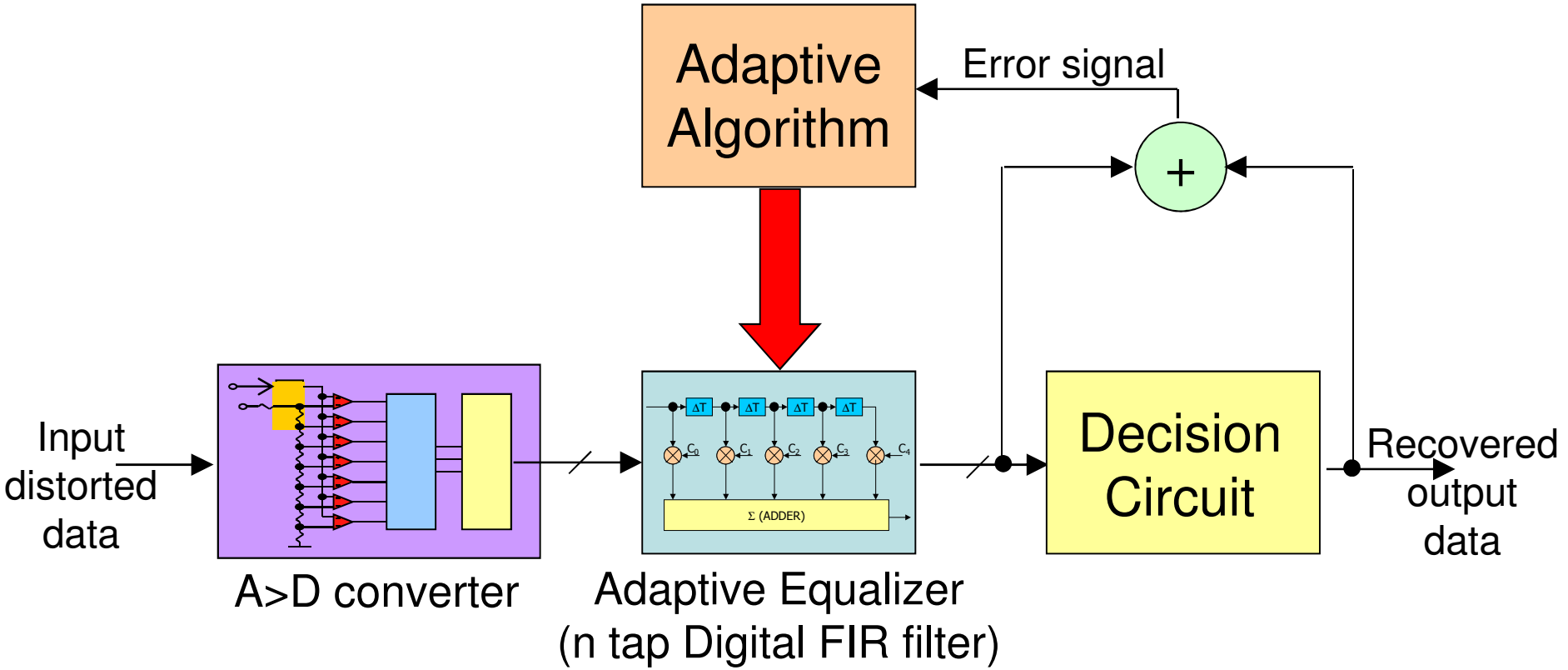
Tx Block Diagram



Rx Block Diagram



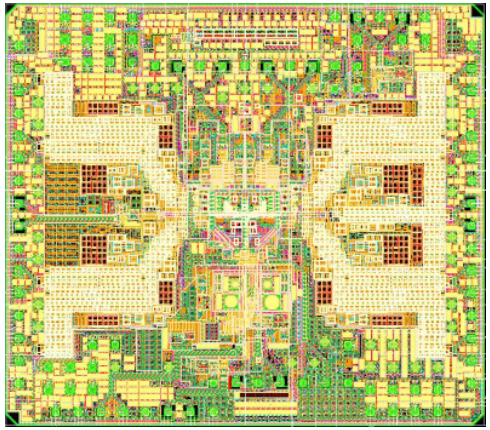
Key Technology - Digital Coherent Receiver

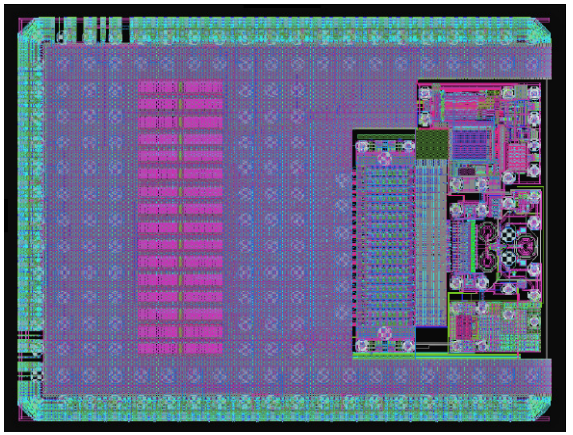


Electronic Integration

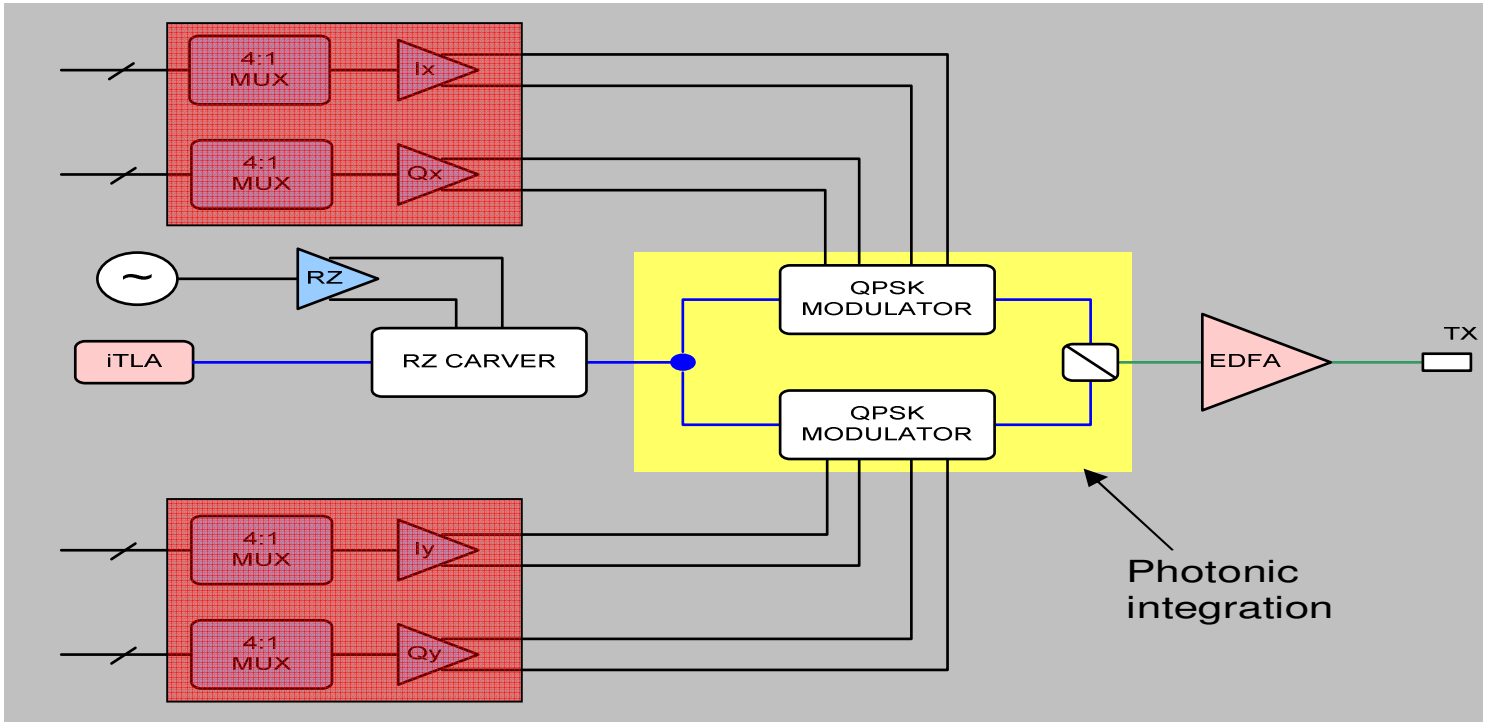
- 130nm SiGe for high speed mux'ing and TIAs
  - 132Gb/s (4x 32Gb/s) MUX speed
- 65nm CMOS for ADC/DSP/FEC modem system-on-a-chip
  - >1Tb/s internal bus speed
- High development cost
- Low manufacturing cost

High Speed SiGe MUX **+** ***High Density CMOS modem***



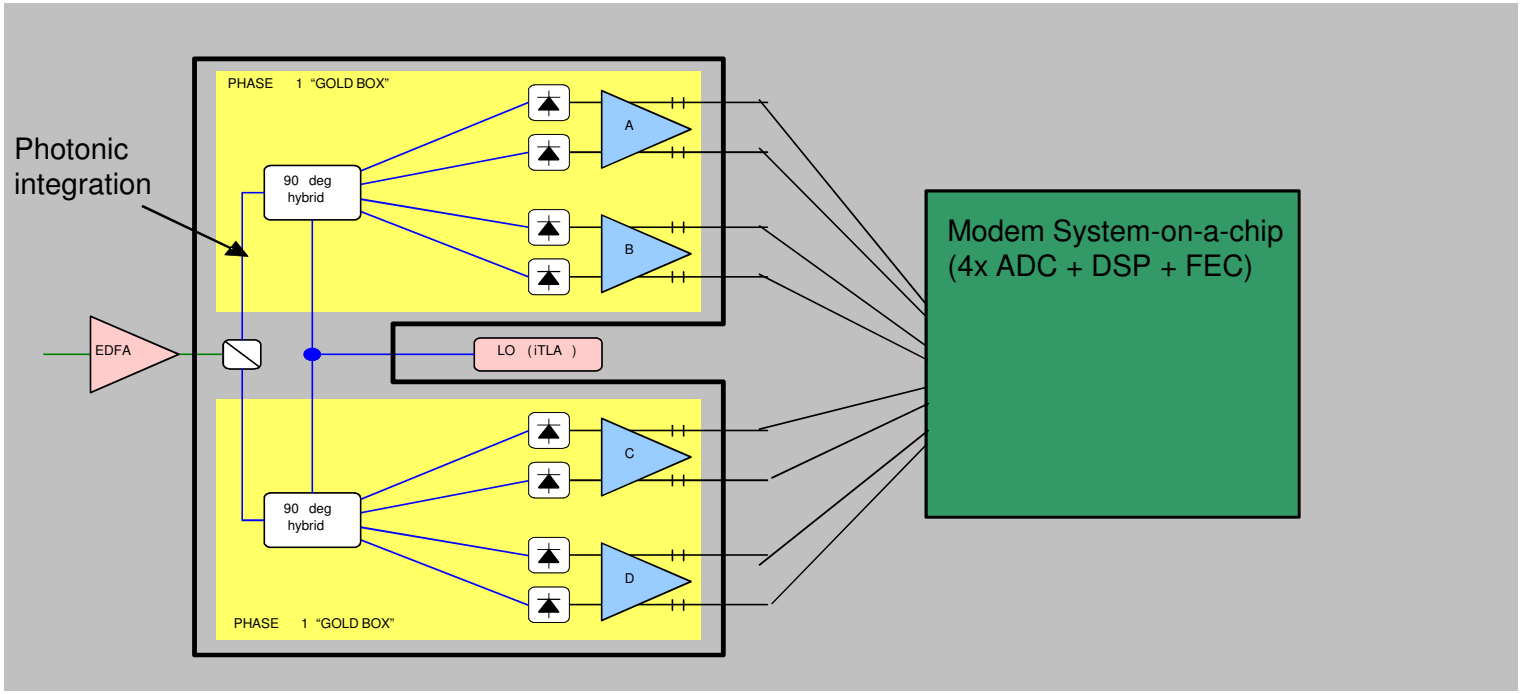


100G Transmit Side Photonic Integration



- Opnext developed Mux
- OIF defined integrated transmit photonics

100G Receive Side Photonic Integration



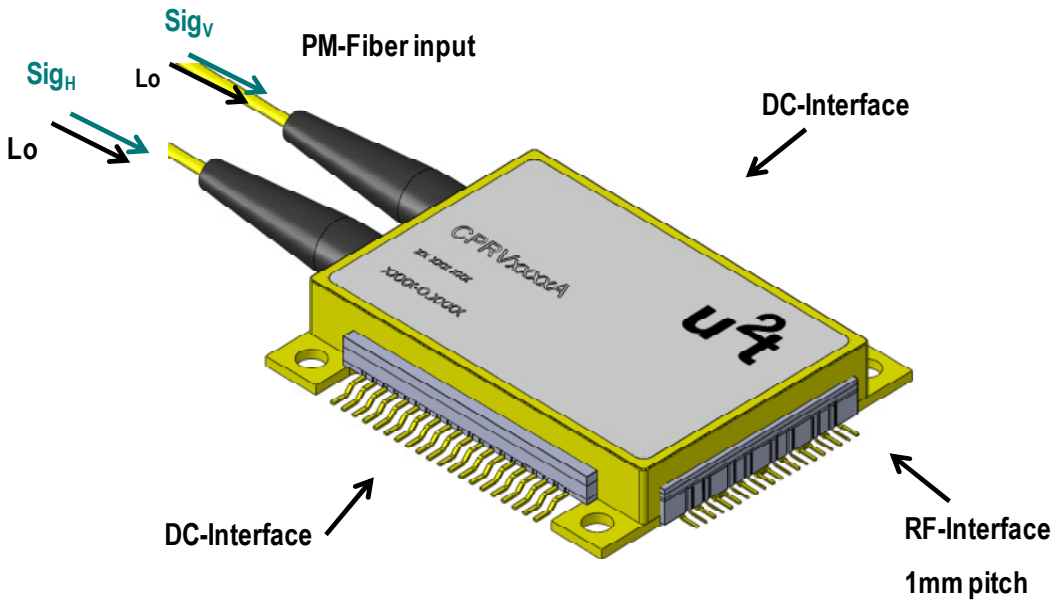
- Opnext developed ADC/DSP/FEC ASIC
- OIF defined integrated receive photonics

1st Generation Rx by U²T

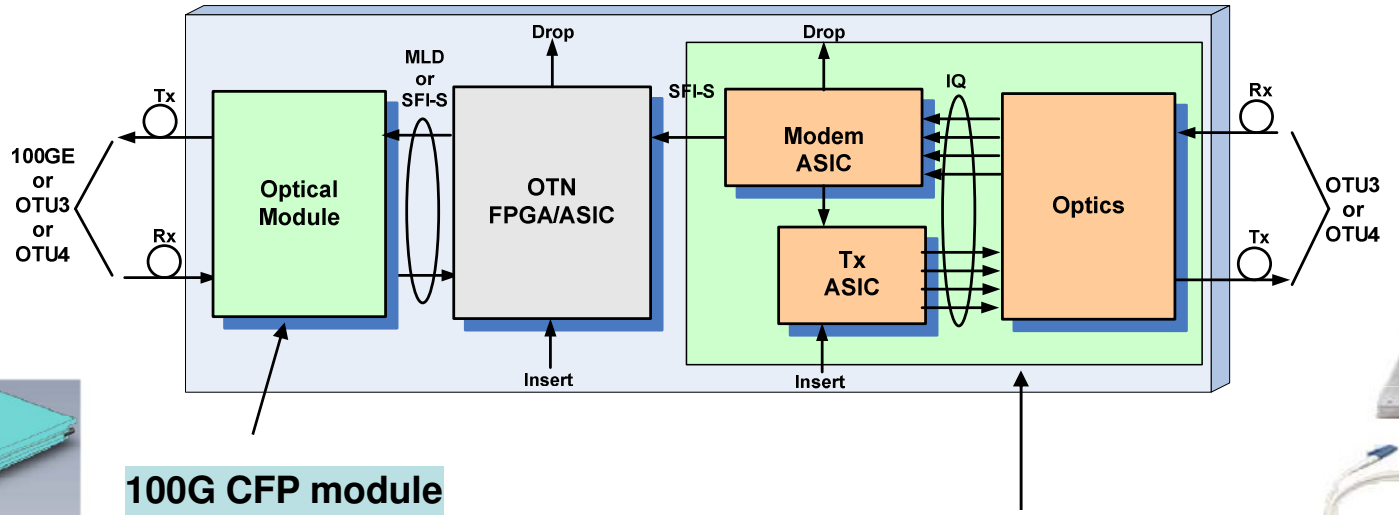
u²t photonics opnext

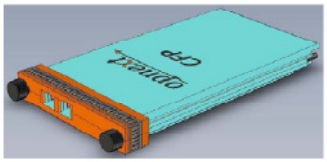
Coherent Detector Features:

- **Symbol rate up to 32 GBaud/s**
- **Optimized for 100G DP-QPSK**
- **Full surface mount design with coplanar waveguide interface**
- **Integrated 90°Hybrids with linear balanced receiver technology**
- **Very low package footprint 37mm x 40mm x 6.6mm**
- **External SIG-PBS**
- **External LO-PBS**



100G Module Leadership





100G CFP module

- P802.3ba compliant
- 4x25G LAN WDM optical interface
- Power < 20W
- Footprint 125 x 86 mm
- Compliant to CFP MSA

100G DWDM module

- Must retrofit into existing DWDM infrastructure
- Power/footprint same as current 40G
- Price 2x current 40G
- Compliant to OIF 100G MSA

Opnext leads the market in both 100G line and client modules

Summary

- 40G market fragmentation chasing too many modulation formats, should be avoided for 100G
- Carriers and OEMs don't want phased introduction – 100G must meet the market requirements in 1st design
- 100G coherent PM-QPSK format chosen and standardized at OIF to help focus supply chain and enable multi-sourcing
  - Meets requirements but is a complex design
  - Pushes the limit on electronics speed/complexity for ADC/DSP
  - More complex optical design – need photonic integration for cost/manufacturability/footprint reasons
- OIF standardization is helping create an eco-system and focusing investment capital
- Will see 100G component/module availability next year