Optical Integration and the Role of DSP in Coherent Optics Modules

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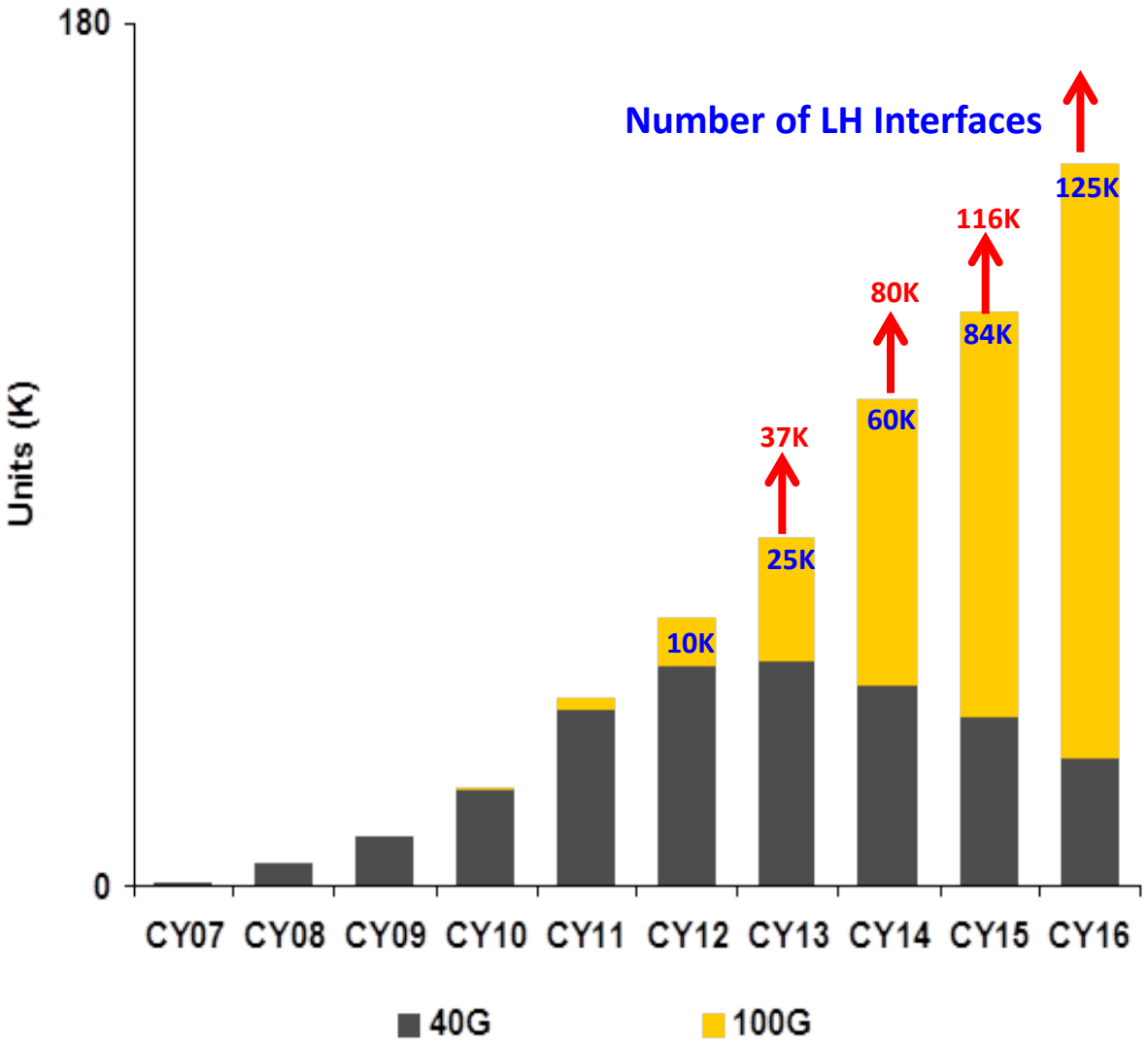
Market Watch OFC 2014

Outline

- 100G Deployment
  - Rapid Growth in Long Haul
  - Role of Modules
- 100G Module Standards and their Applications
  - Gen1 5x7 MSA
  - Gen2 4x5 MSA
  - Pluggable Modules (CFP, CFP2…)
- Challenges for DSP and Optical Components
  - Lower Power Dissipation
  - Smaller Size
  - Packaging
- Discussion

Long Haul 100G Growth

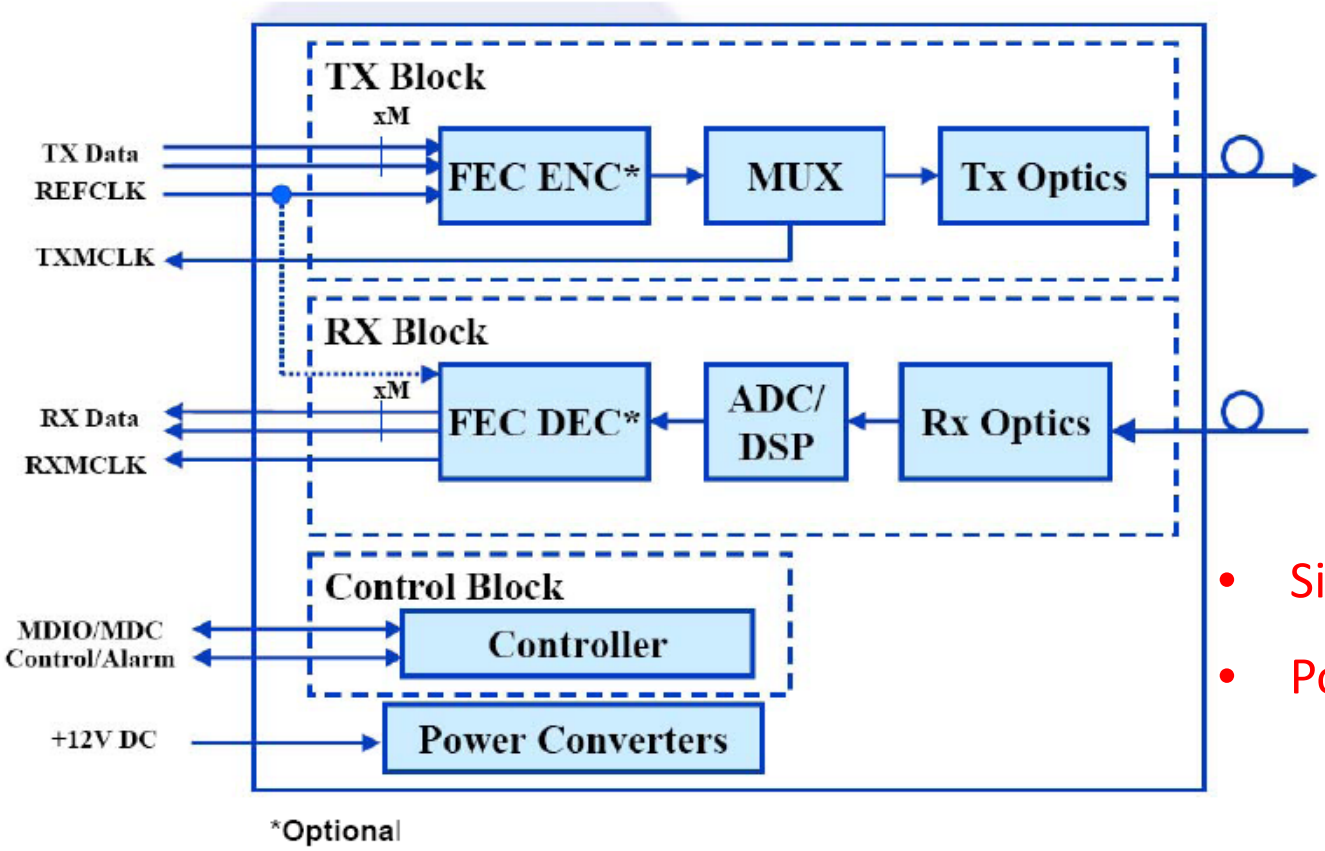


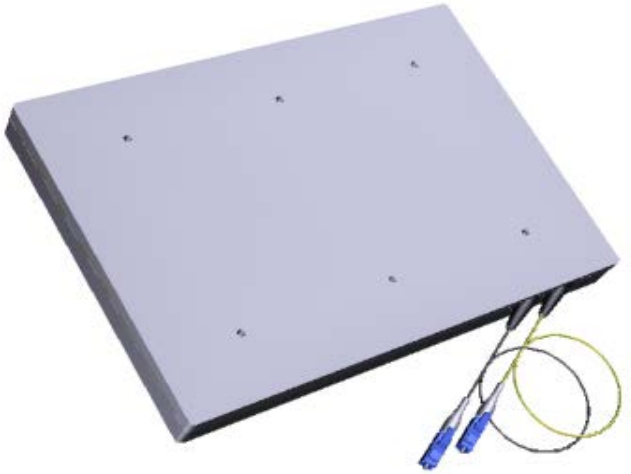
- 2015: >100K LH Interfaces
- Only 15-20% modules

Ref: A. Schmitt, Infonetics, OIF meeting Jan. 2013

Source: Infonetics Nov 2012

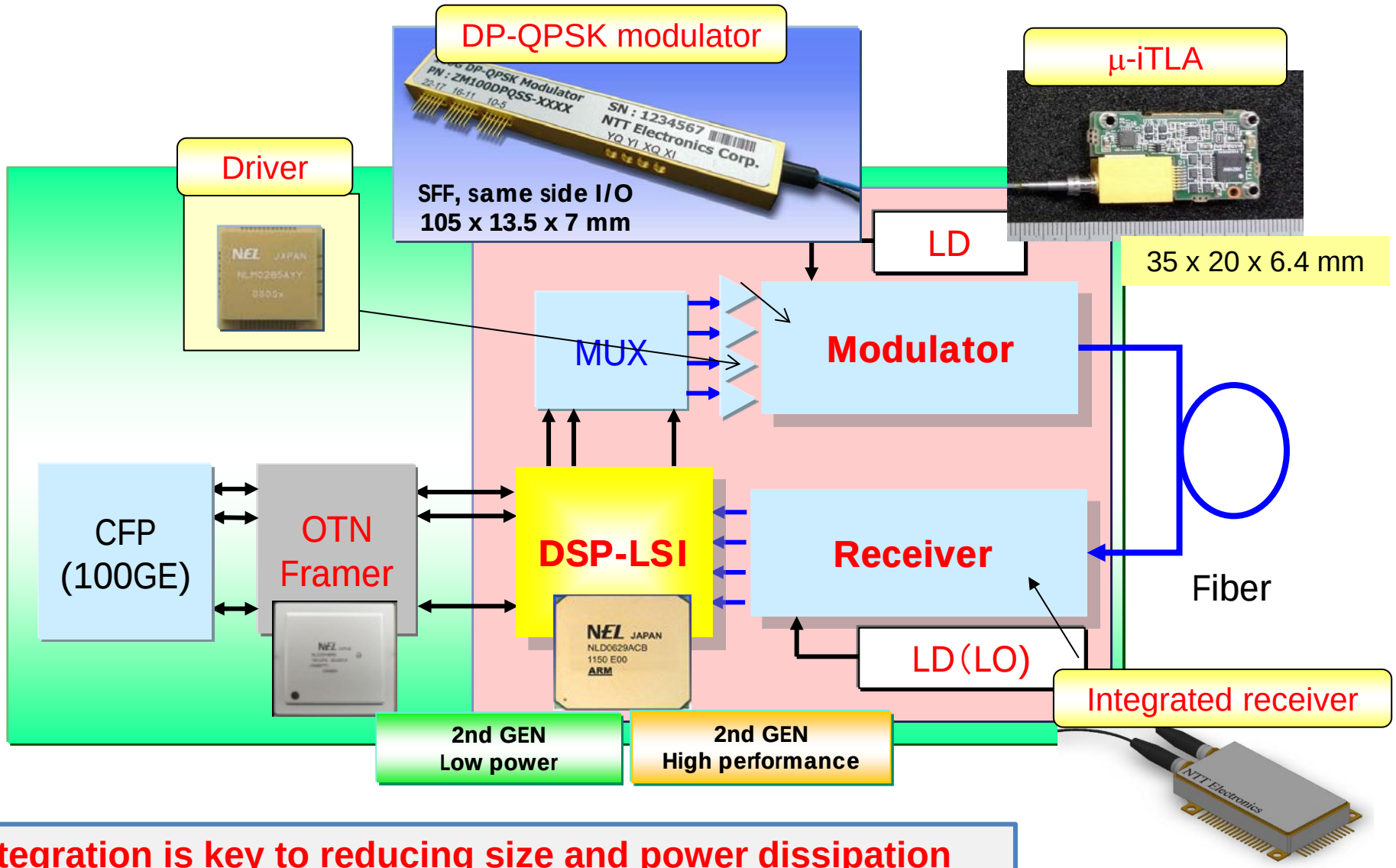
Current OIF LH 100G MSA module:





- Size: 5 in. x 7 in.
- Power Dissipation: 80 W

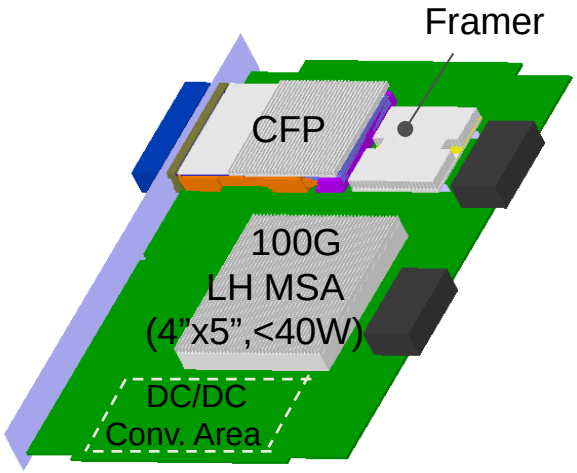
NEL product lineup for 100G linecard



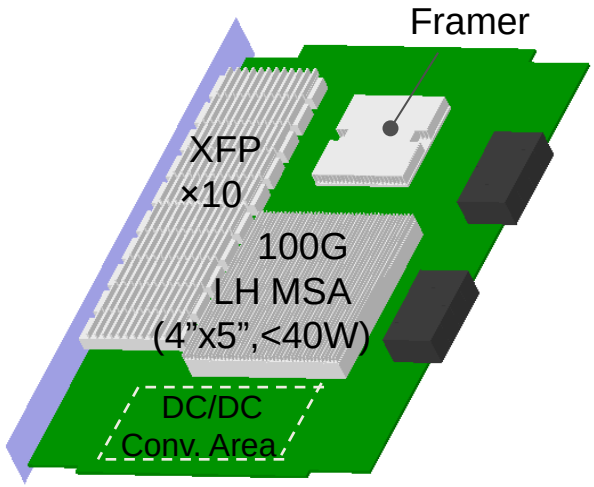
Integration is key to reducing size and power dissipation

Example of Module Layout in the 100G Transmission Line Card

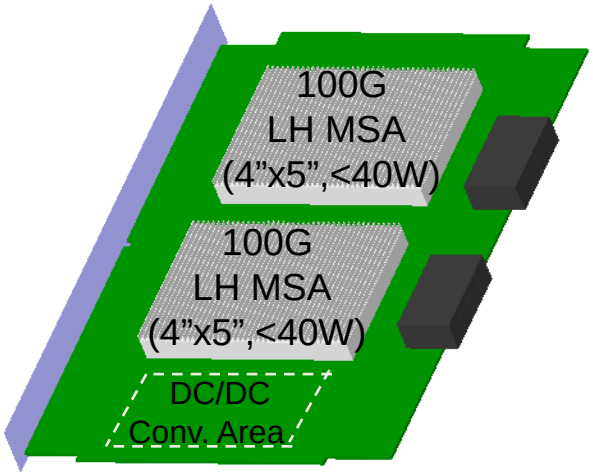
a) Transponder



b) Muxponder



c) Regenerator



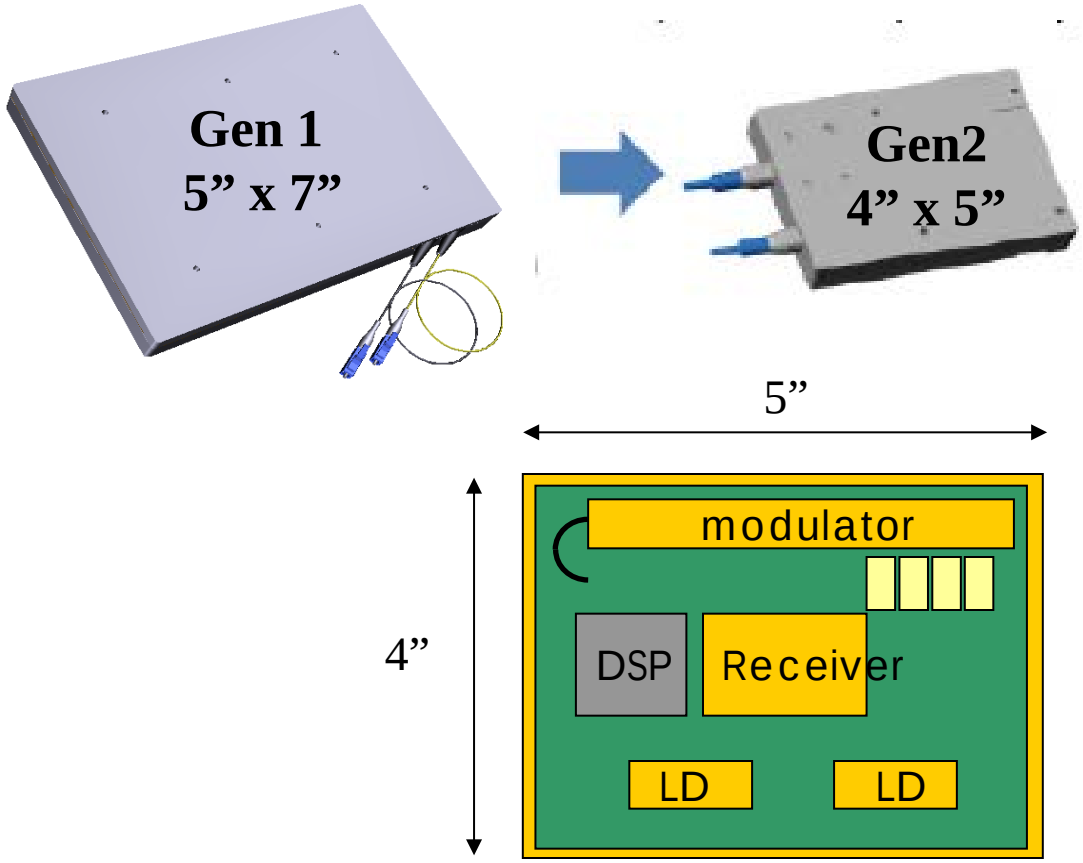
Module size required for the line card

	a) Transponder	b) Muxponder	c) Regenerator
5"x7"(Gen.1)	✓		
4"x5"(Gen.2)	✓	✓	✓

The module with the size of 4"x5" can enable three kinds of the line cards

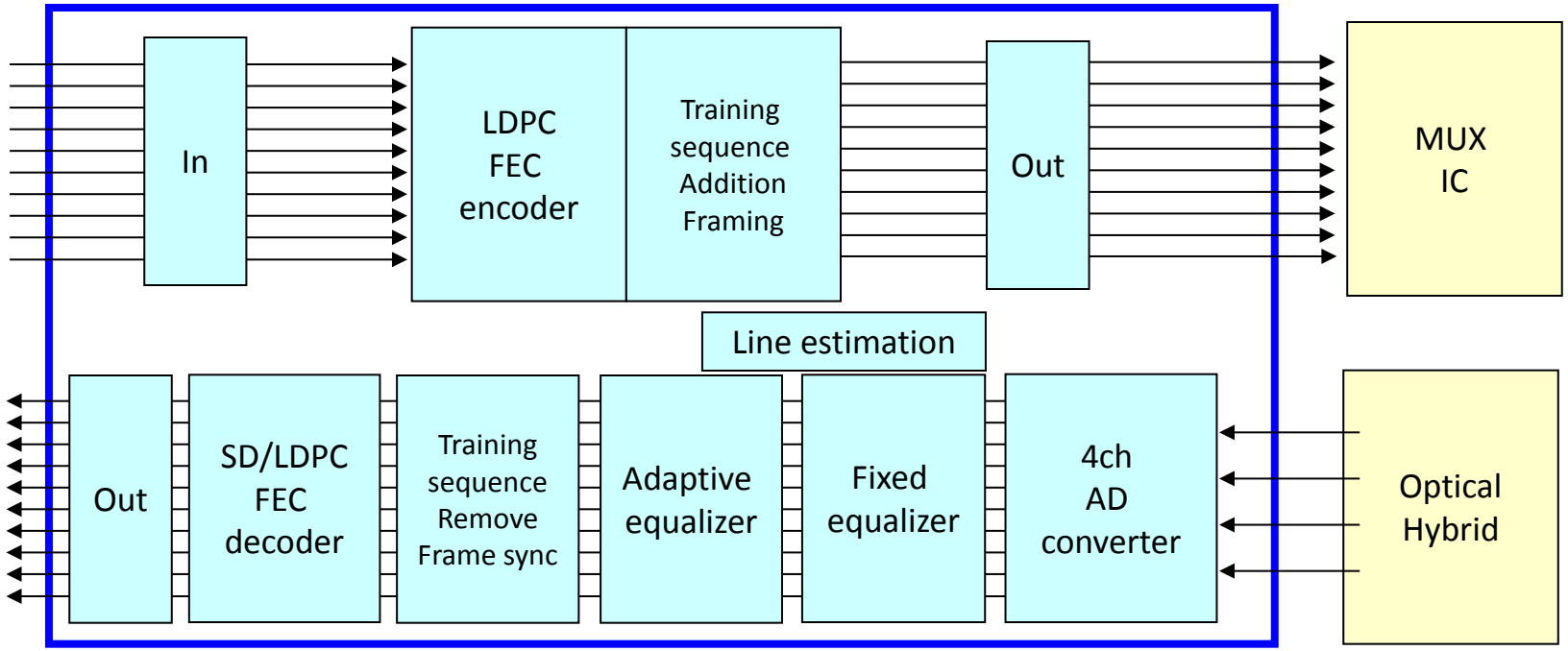
Courtesy: Onaka, Fujitsu

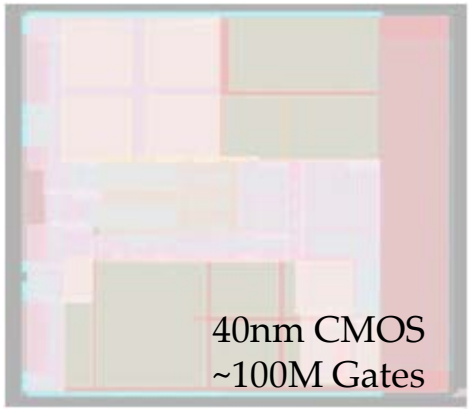
Evolution of 100G modules: LH Applications



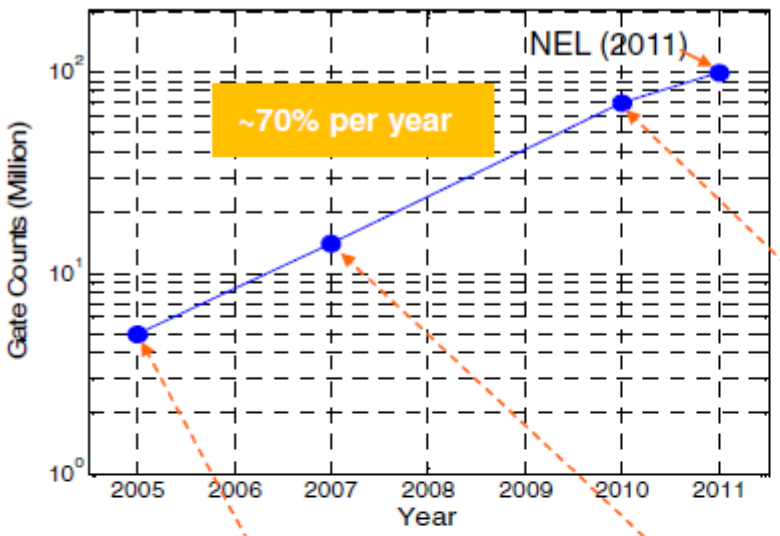
- **Module Power dissipation dominated by electronic components such as DSP and MUX**
- **Module Size (width, depth, height) determined by optical components such as Tx and Rx**

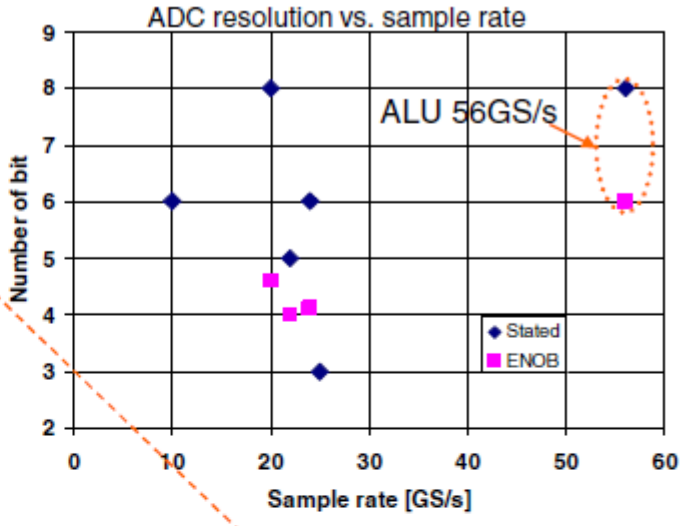
Block Diagram of 100G Coherent DSP

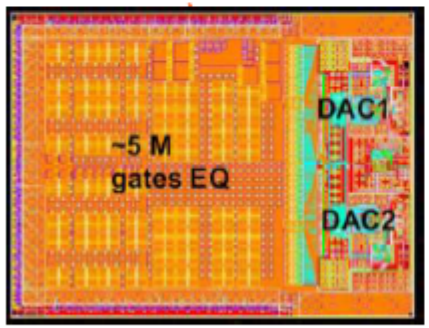




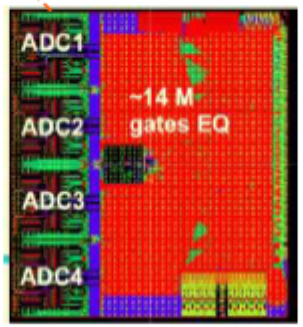
DSP ASIC Milestones



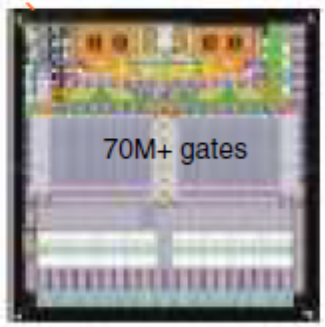




Nortel electronic pre-EDC 10G Tx (2005)
20GS/s DAC



Nortel 40Gb/s PDM-QPSK (2007)
20GS/s ADC/DSP



Alcatel-Lucent 112Gb/s (2010)
56GS/s ADC/DSP

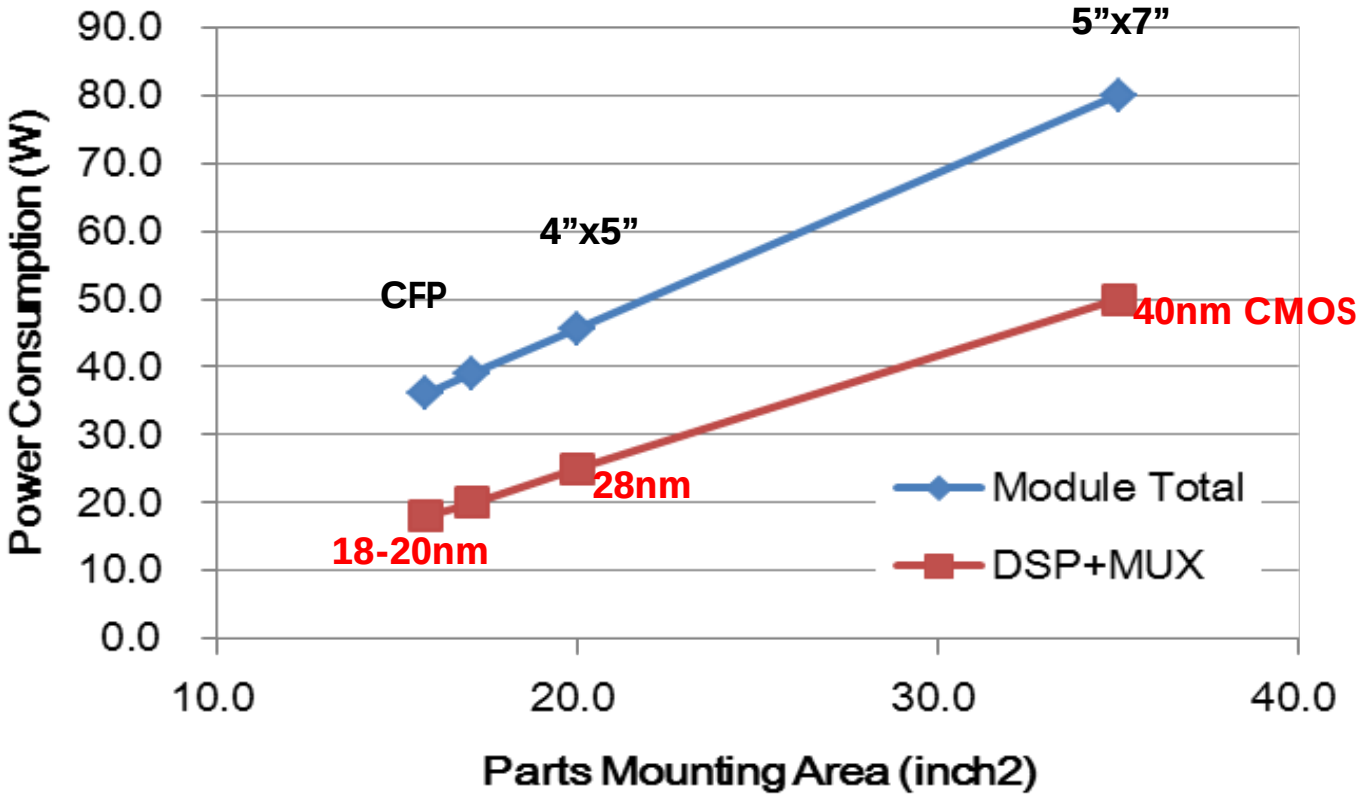
Alcatel·Lucent

Xiang Liu and S. Chandrasekhar, OFC 2014 Tutorial W1H.5 37

Breakdown of 100G module power dissipation

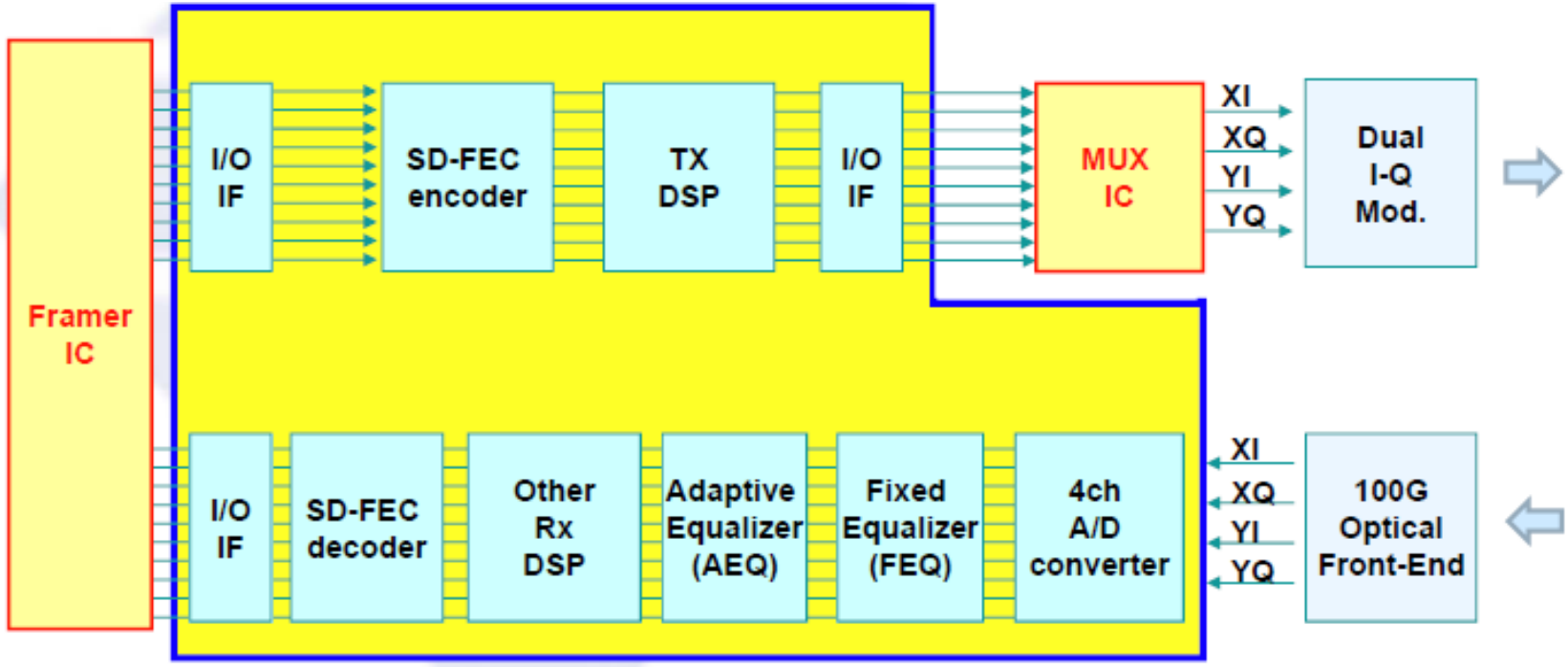
	Gen1 MSA	4”x5” Gen2 MSA
DSP	35.0	20.0
MUX	6.5	0.0
Modulator(TEC)	0	0
Driver	10.0	7.0
ITLA(Tx&LO)	6.0	8.0
Receiver FE	3.5	1.5
MISC	2.0	1.0
DD-conv.	16.0	2.5
Total	79.0 W	40.0 W

100G Transceiver Module/DSP Power Dissipation



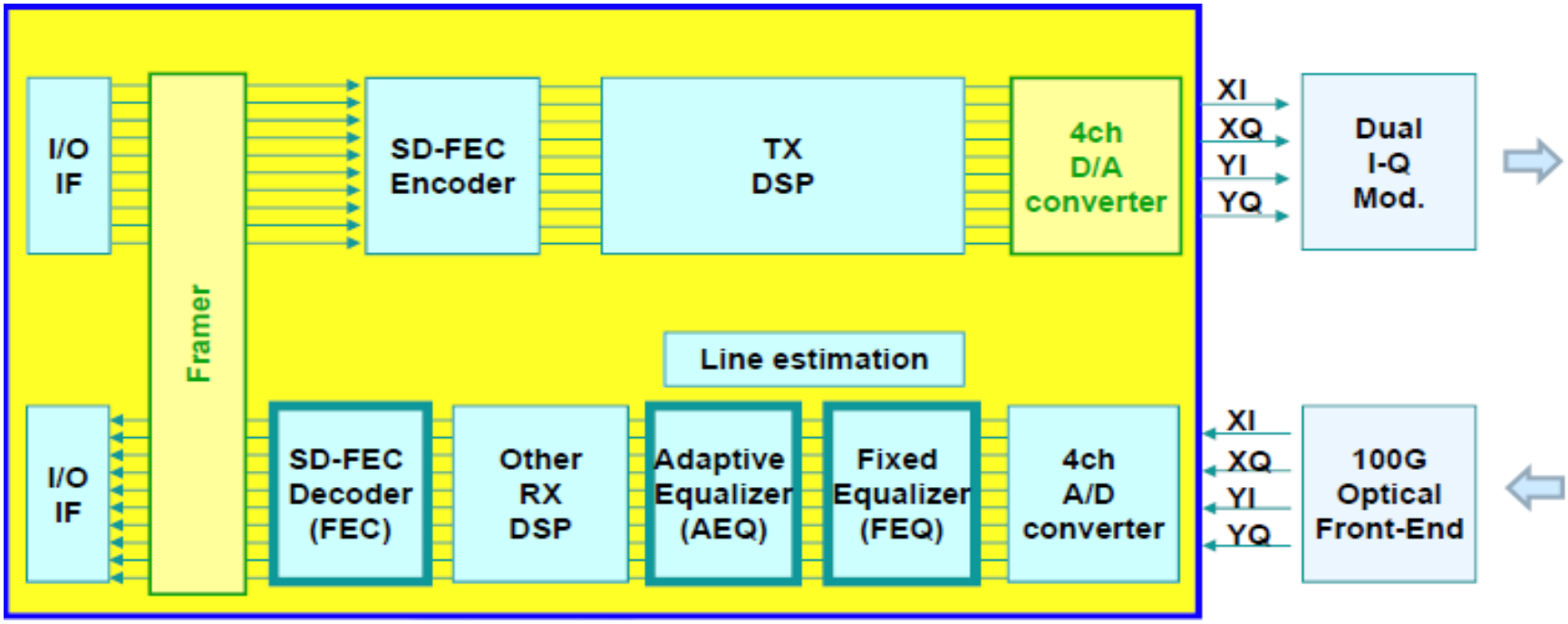
100G Cohernet DSP ASIC Gen -1

- 40nm CMOS with External Functions
  - External Framer ASIC
  - External Transmit Mux

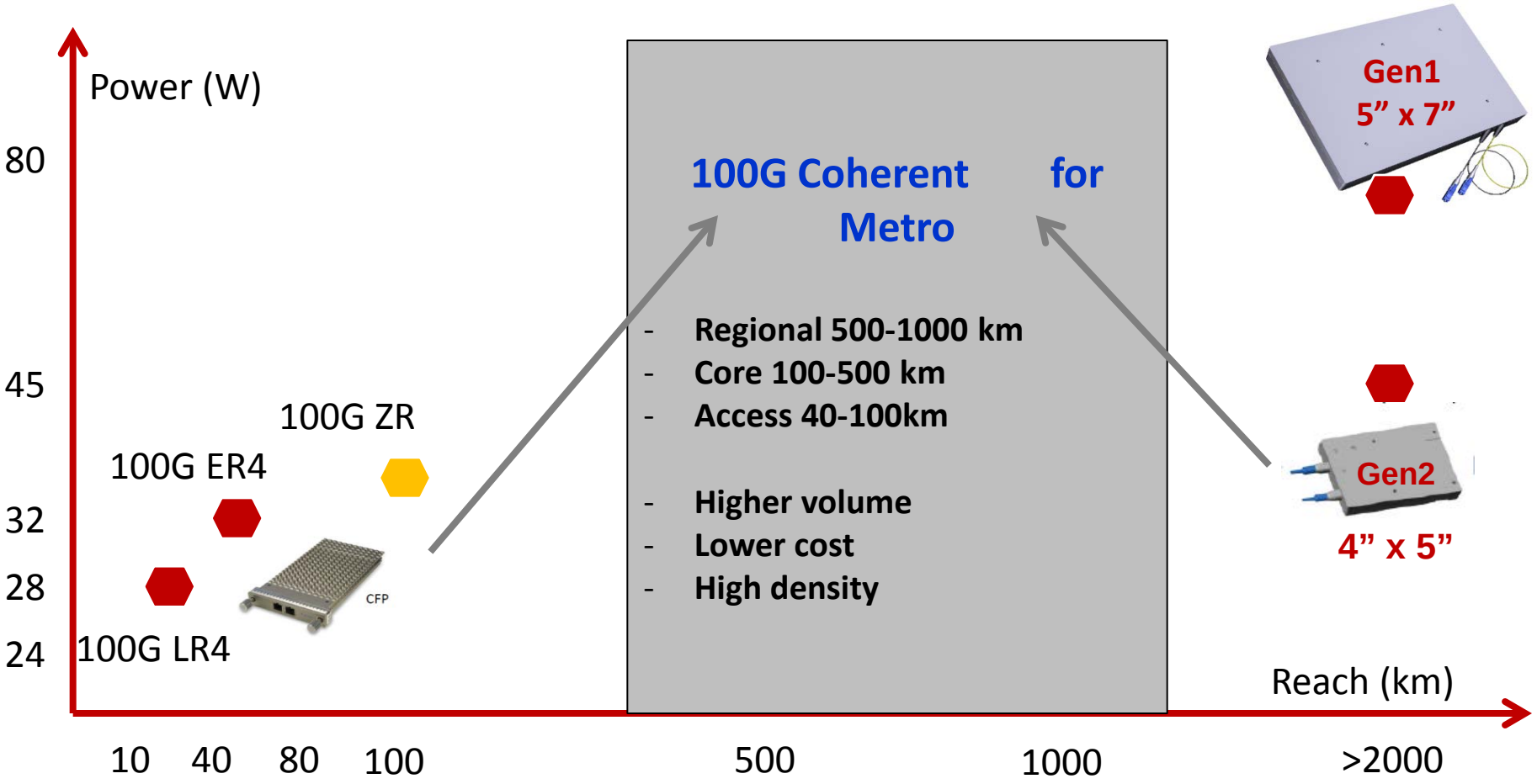


100G Cohernet DSP ASIC Gen -2

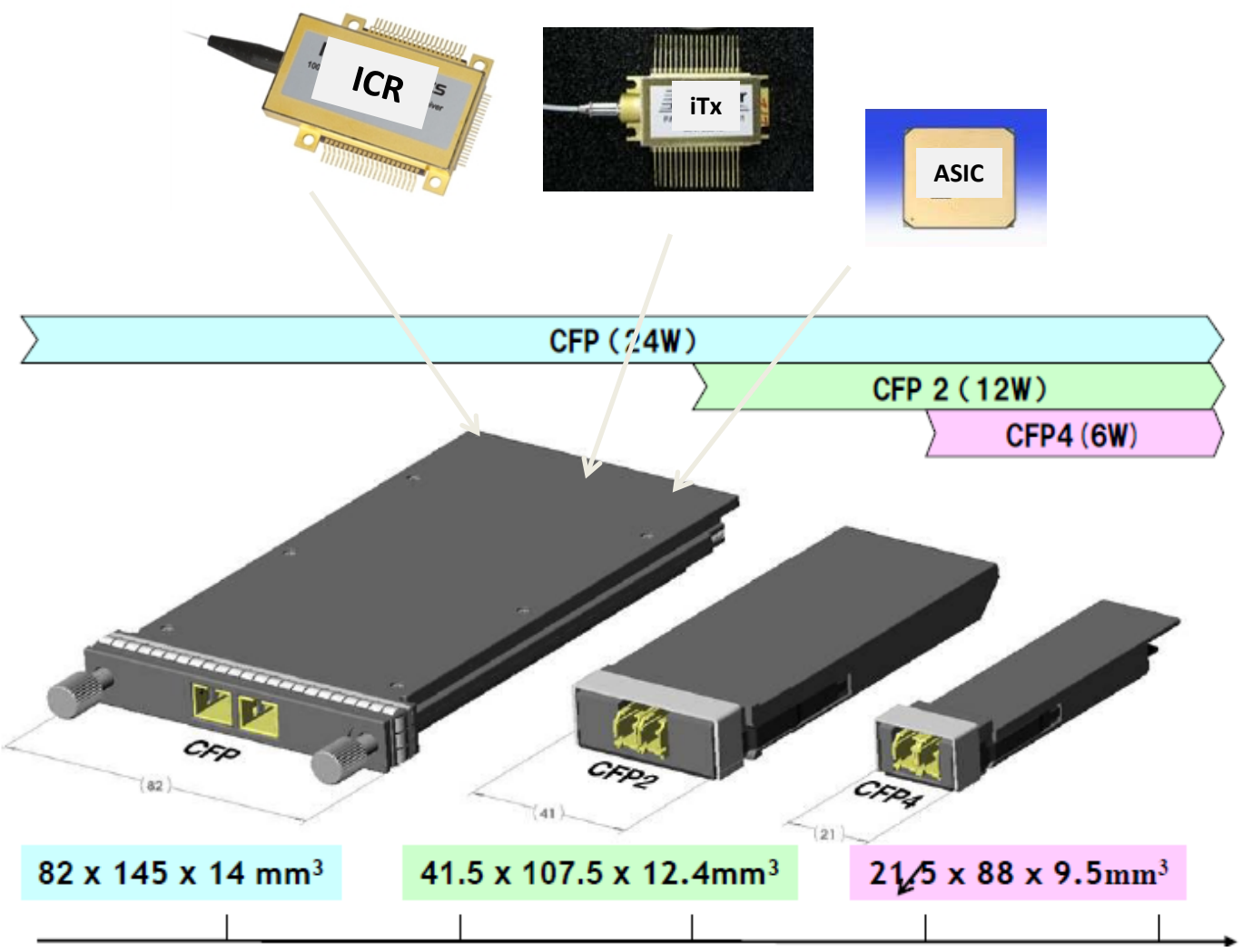
- **Next Gen CMOS with Additional Functionality**
  - **Internal Framer**
  - **Internal 4x DAC**



100G Transceiver Module Landscape

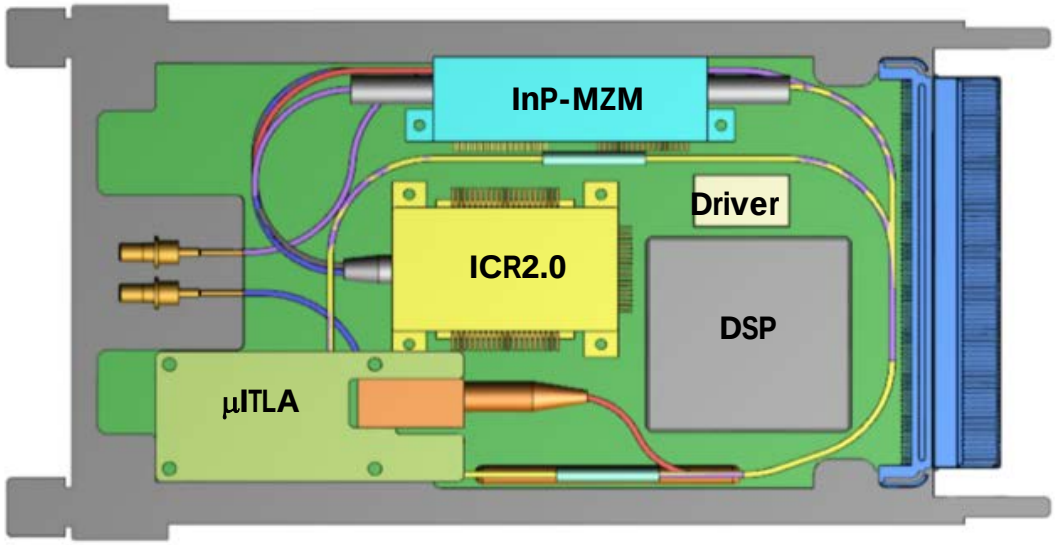


Integrated Components for smaller pluggable modules



Integrated Components for Coherent CFP module

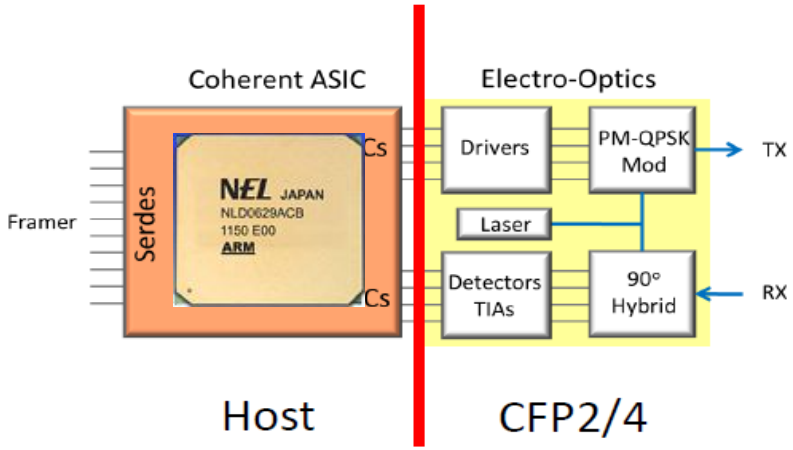
Size 82 x 145 x 14 mm



Power dissipation 24 W

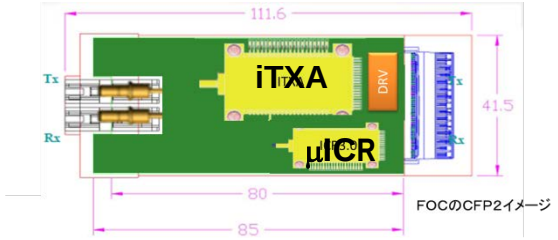
	CFP target
DSP	12.0
MUX	0
Modulator(TEC)	1.0
Driver	3.0
ITLA(Tx&LO)	4.0
Receiver FE	1.5
MISC	1.0
DD-conv.	1.5
Total	24.0 W

100G CFP2 Analog Coherent Optics module



DSP on Host Board

CFP2 ACO



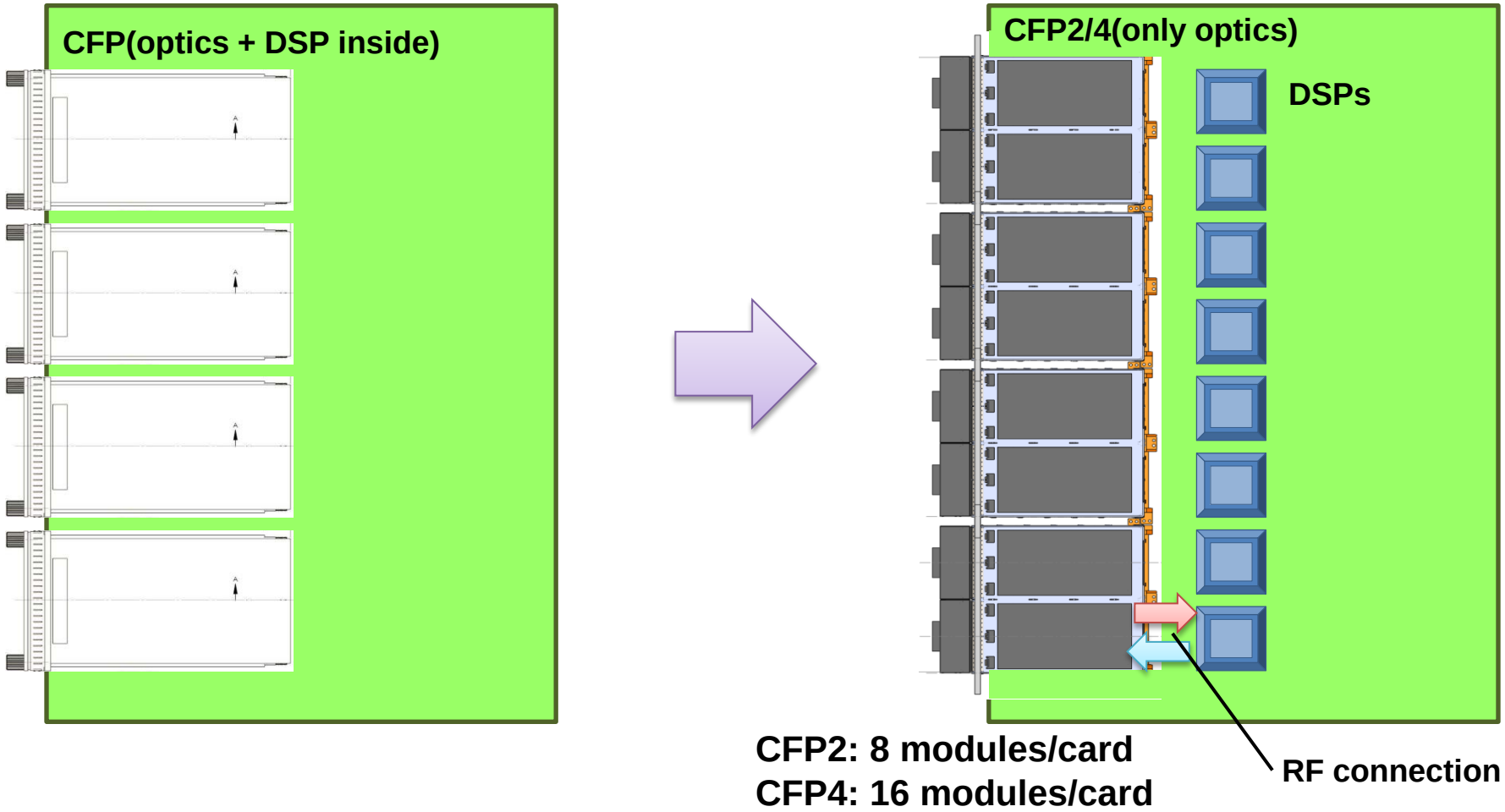
Size: 42 x 106 x 12 mm

Power 12W

CFP2 ACO IA currently under discussion in OIF

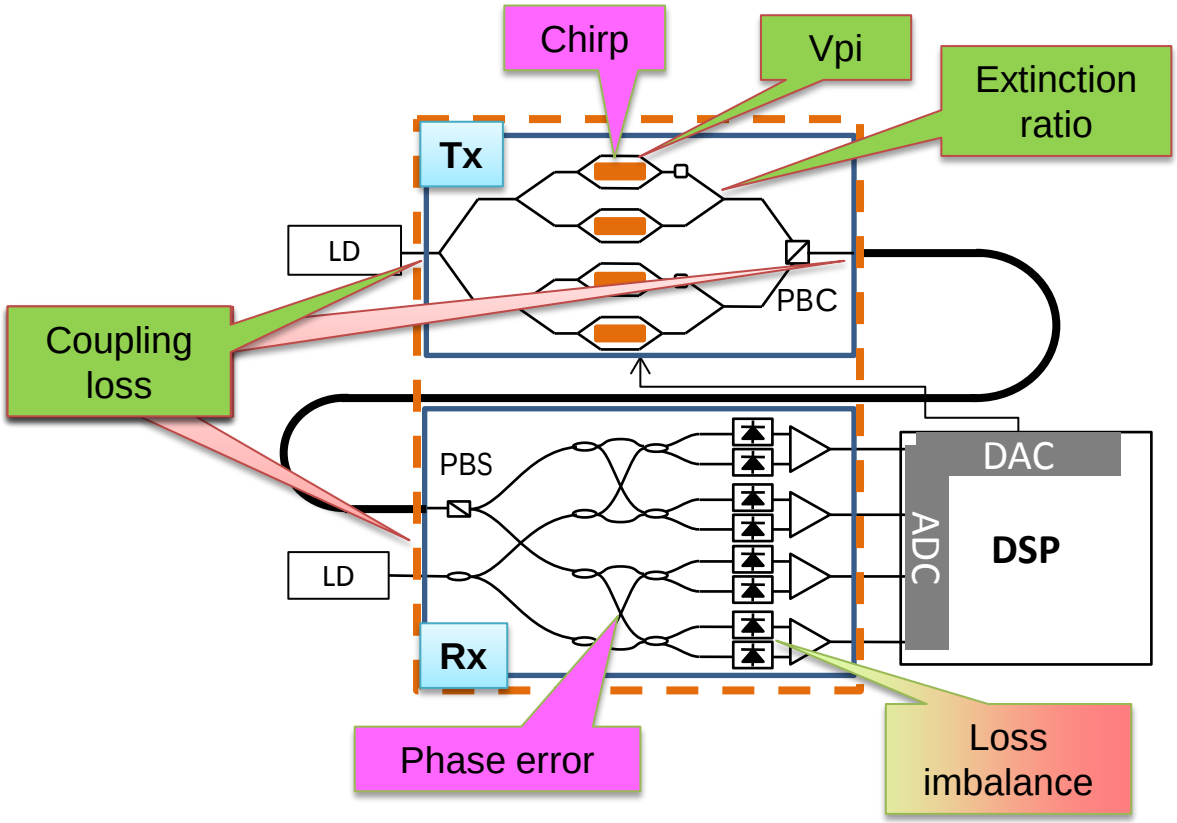
Pluggable Digital Coherent TRx

Line card



- Optics part will be separated from DSP
- CFP2 will be no more than single optical component

Compact Optical Tx and Rx …DSP Assist



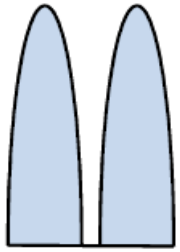
Future Higher Performance DSP-ASICs

- **Higher FEC**
- **Non-linear Compensation**
- **Cycle Slip Control**

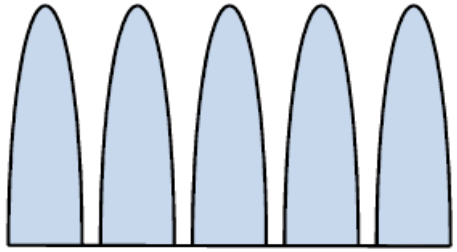
Performance enhancement by DSP

Multi carrier options for 400G and 1T systems

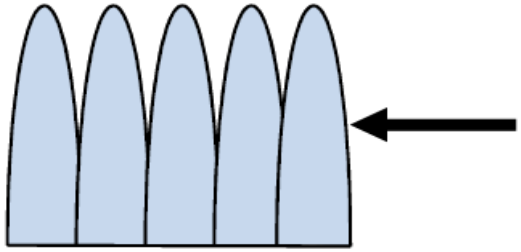
- **Dual carrier 2x200G for 400G switching to DP- 16QAM**
- **Additional carriers can be added to make a 4 X 100G, or 10 X 100G, or 5 X 200G superchannel**



2 X 200G Channels @ 50GHz

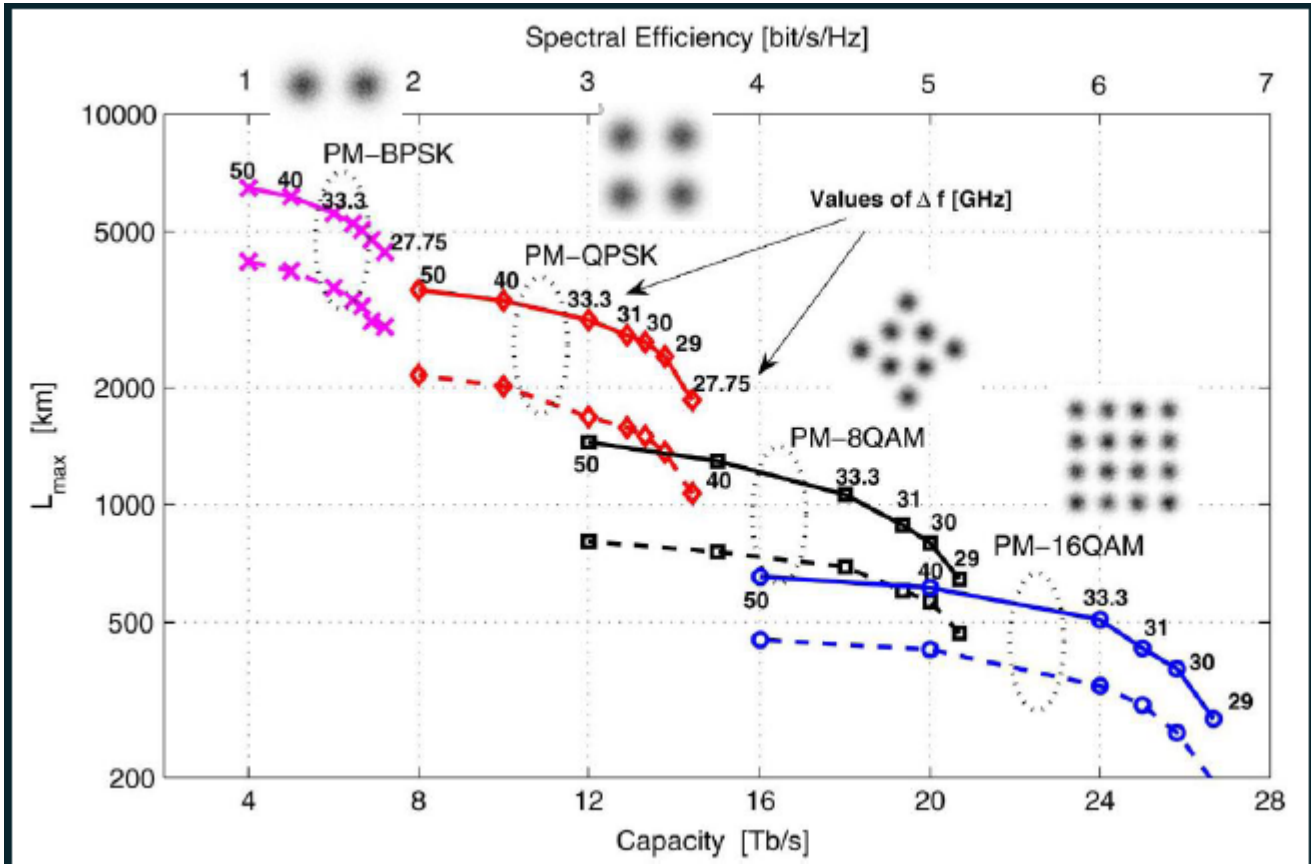


5 X 200G Channels @ 50GHz



1T Superchannel with Flexgrid

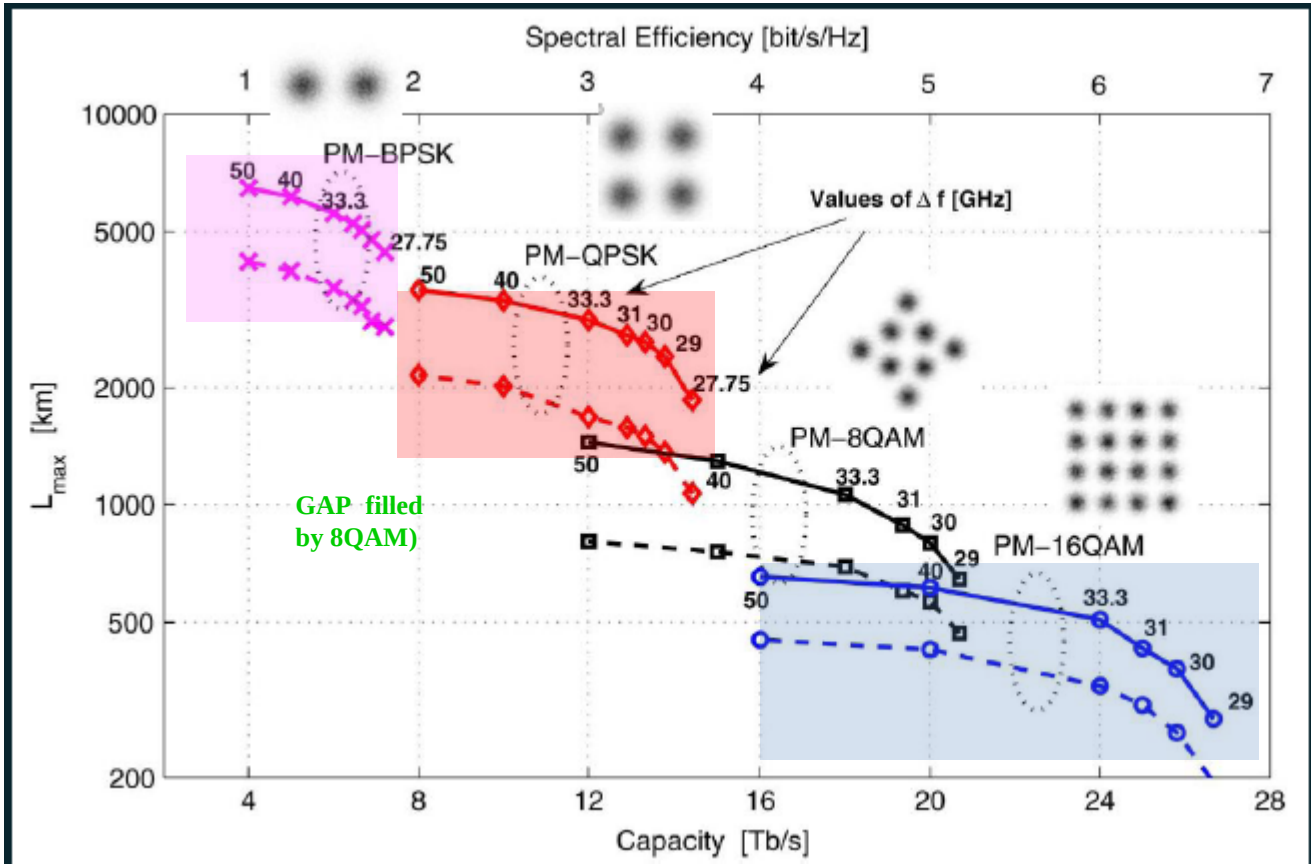
Reach and Capacity Tradeoff



- Solid lines SMF, Dashed ELEAF, no Raman
- 90 km and 25 dB per span
- Symbol-rate 27.75 Gbaud
- BER 4E-3

G. Bosco et al., JLT, vol.29, No.1, p.53, 2011

Reach and Capacity Tradeoff



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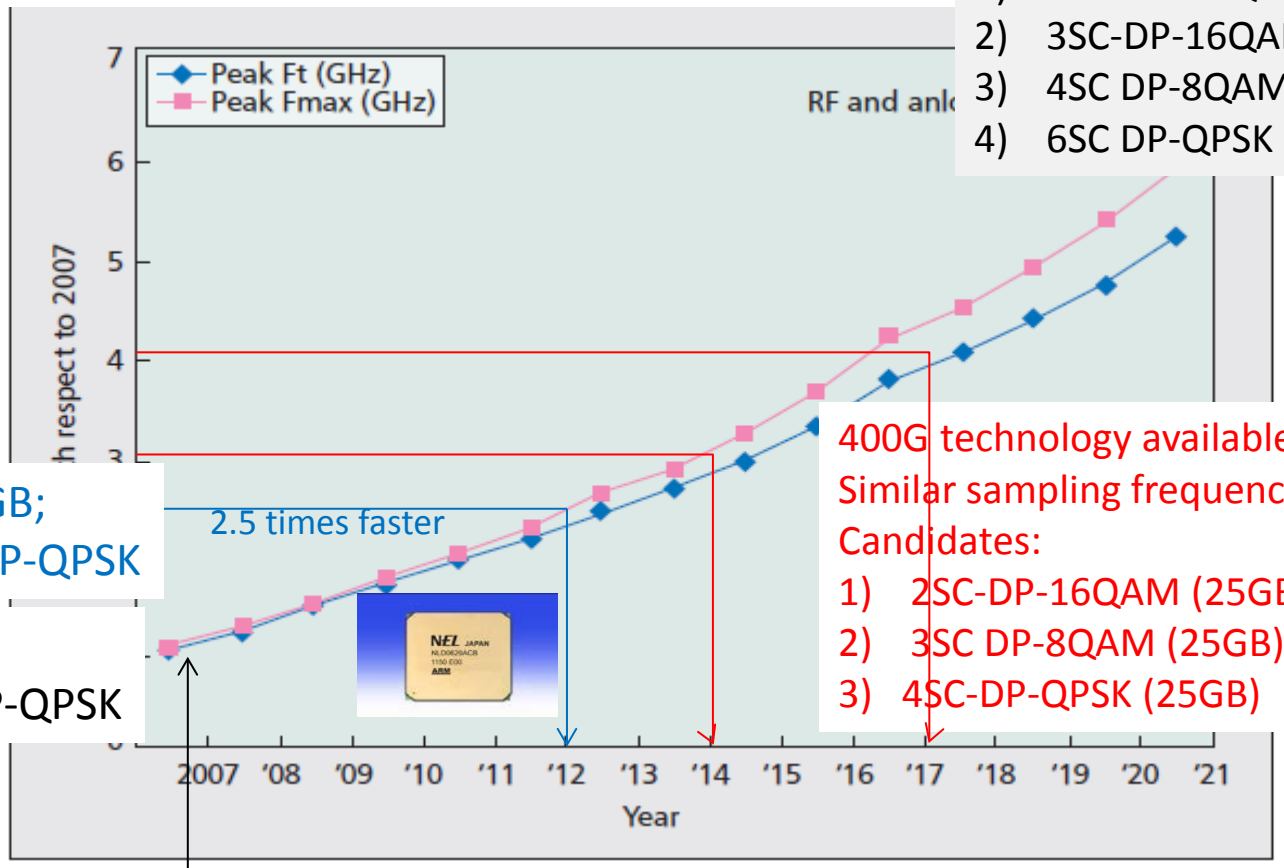
G. Bosco et al., JLT, vol.29, No.1, p.53, 2011

ADC in CMOS for 400G and 1T

1Tbit/s/ch in 2017, the baud-rate 40GB.
Modulation format may be,
1) 2SC-DP-64QAM (40GB)
2) 3SC-DP-16QAM (40GB)
3) 4SC DP-8QAM (40GB)
4) 6SC DP-QPSK (40GB)

International Technology Roadmap for Semiconduc



25-32GB;
100GDP-QPSK

10GB;
40GDP-QPSK

400G technology available in 2014
Similar sampling frequency of 100G DP-QPSK
Candidates:
1) 2SC-DP-16QAM (25GB)
2) 3SC DP-8QAM (25GB)
3) 4SC-DP-QPSK (25GB)

40G coherent was realized in maturity. ɔrietary

Thank You !!

Questions?