100Gb/s Ethernet Optics: Trends & Directions

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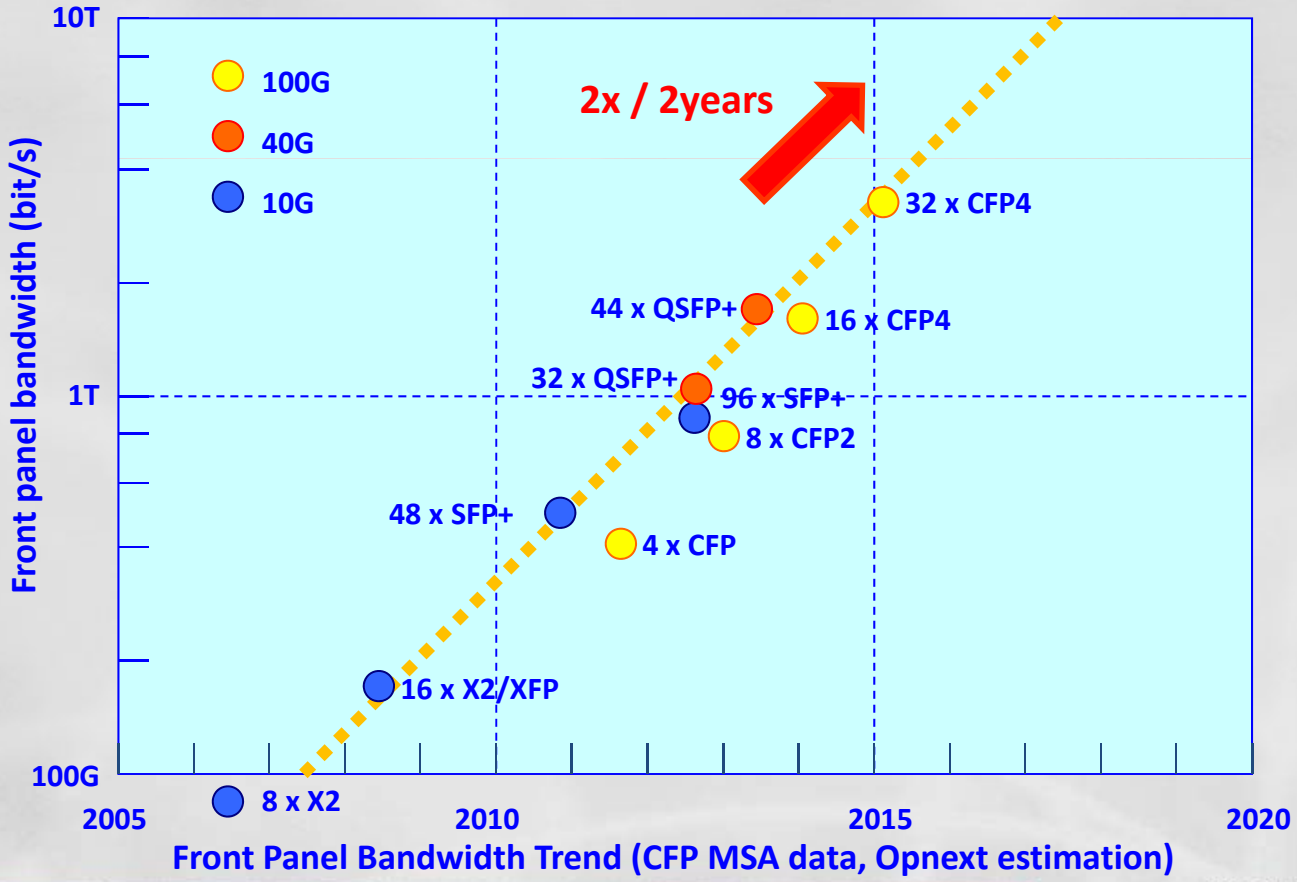
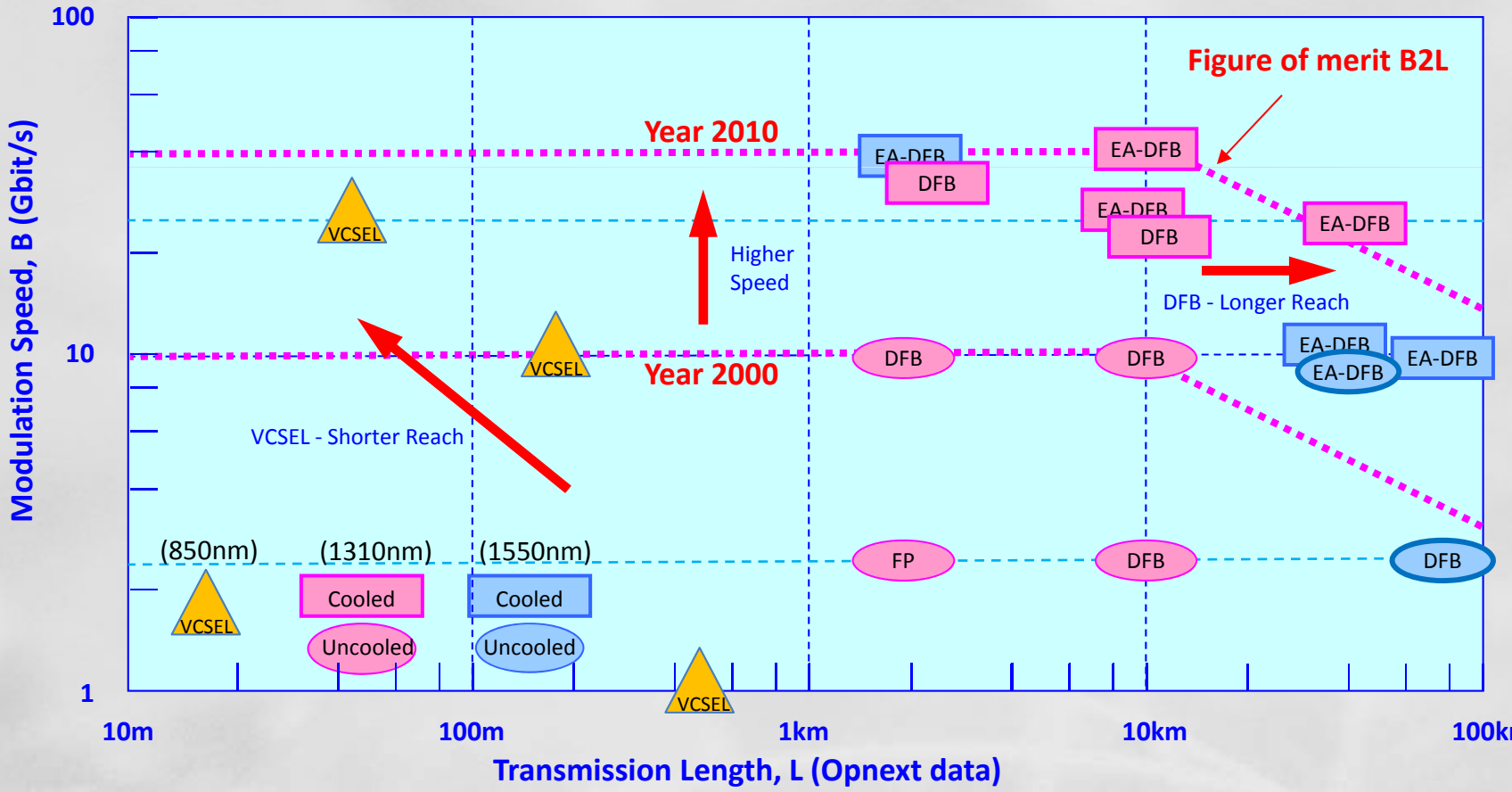
Ethernet Optical Port Density Trend

- Today: 4 ports CFP = 400Gb/s Front Panel BW
- Next Gen Target: 1Tb/s + Front Panel BW
- Challenges: reduced power consumption & cost

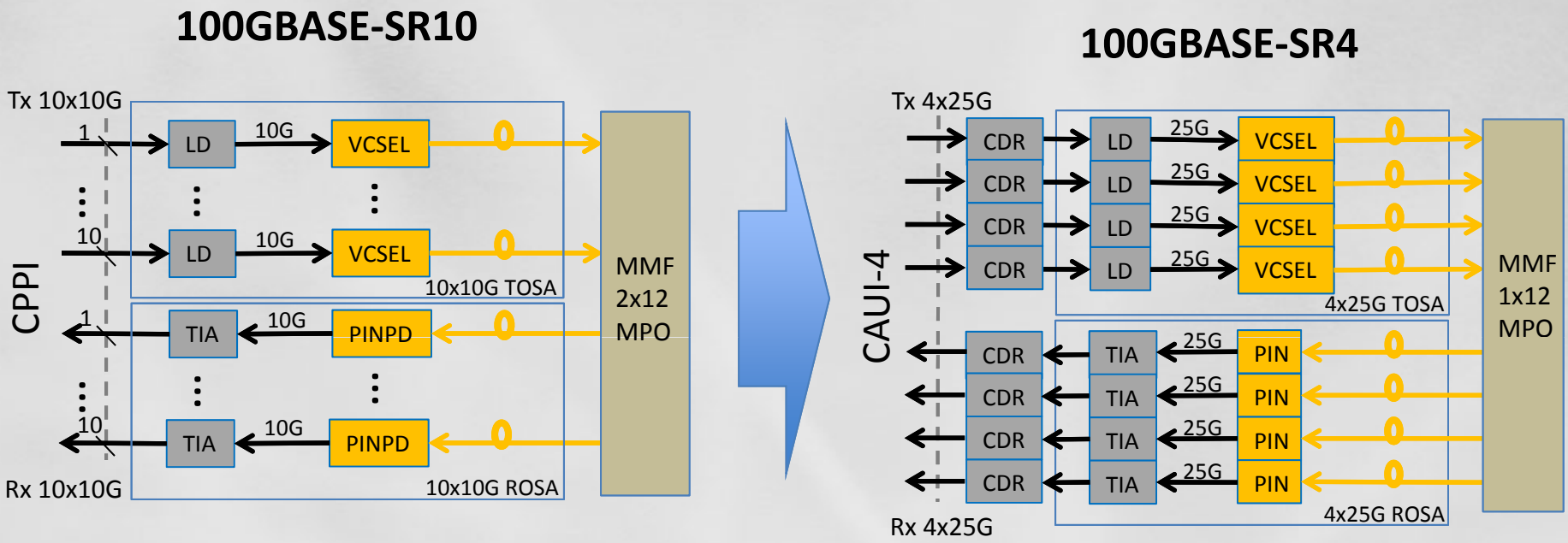


Laser Device Trends

- III-V DFB SM devices are increasing in speed and reach
- VCSEL MM devices are increasing in speed, but with reduced reach
- Hybrid DFB-Si Photonic devices are emerging with lower power consumption



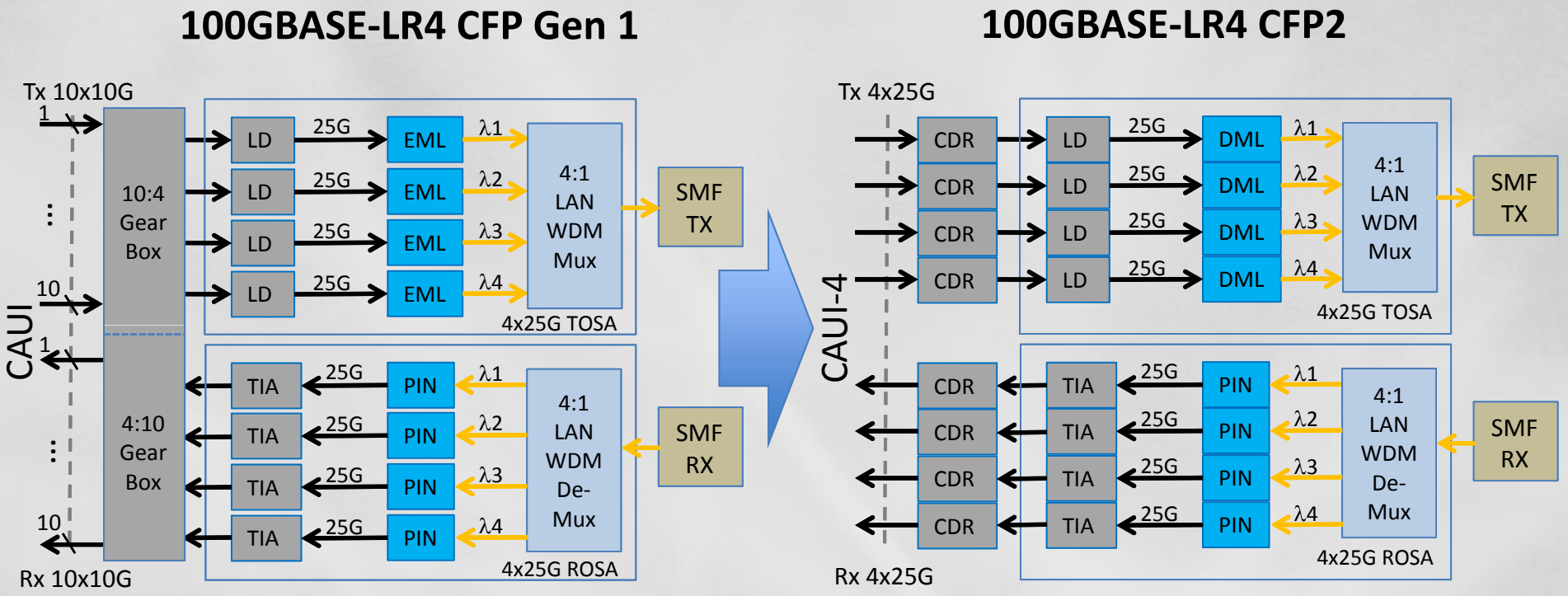
100GE Optical Interface Trend - MMF



- Reduced reach: < 100m OM3 MMF
- Increased complexity: CDR, host FEC, optical equalization
- Increased power consumption per lane 0.6W/10G -> 1.1W/25G
- Performance issues: ISI, MPN, link latency, MMF type BW dependency

Ref. Diagrams: IEEE 802.3 Next Gen 100G Optical Ethernet Study Group, cole_1a_0212_NG100GOPTX

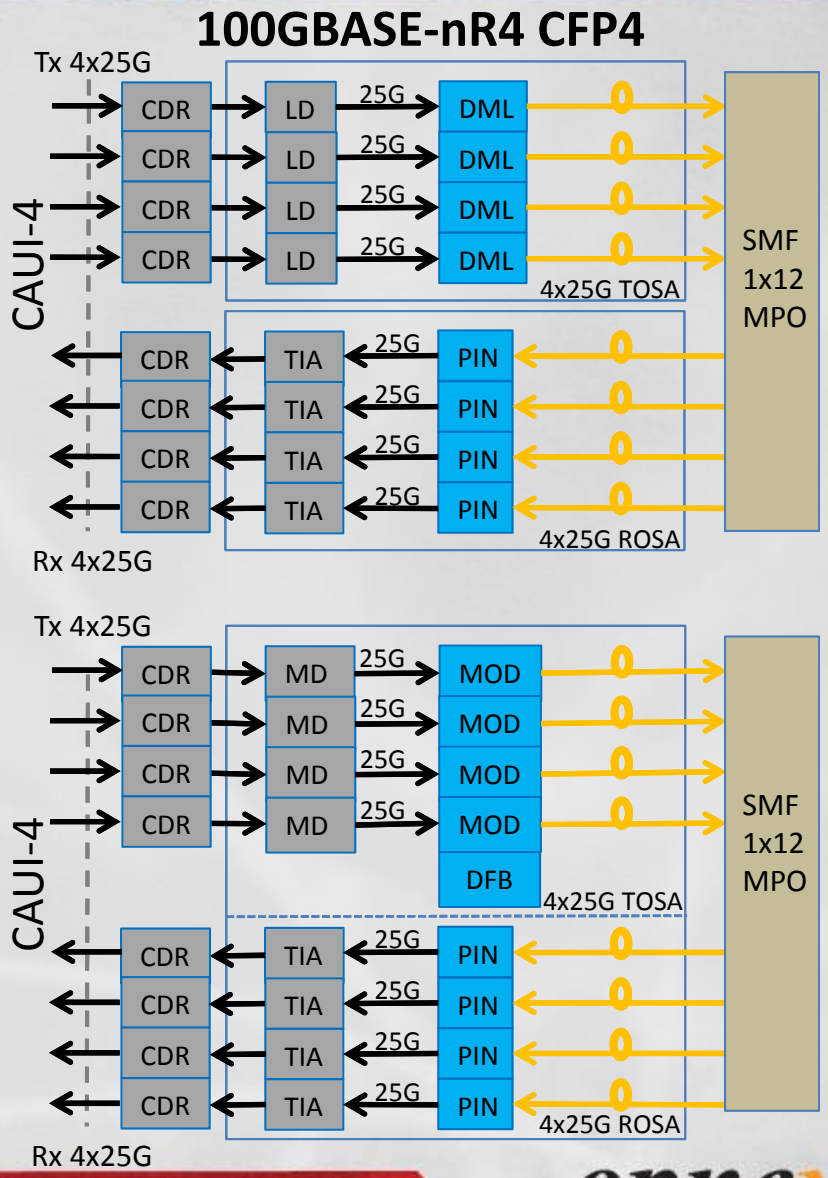
100GE Optical Interface Trend - SMF



- 28G EA-DFB -> 28G DML
- Optical-mux/de-mux TOSA/ROSA integration
- Host-Module I/F simplification: 10:4 gearbox (CAUI) –> 4x28G CDR (CAUI-4)
- Significant reductions in power consumption (20W -> 8W), form factor size (CFP -> CFP2, CFP4) and cost.

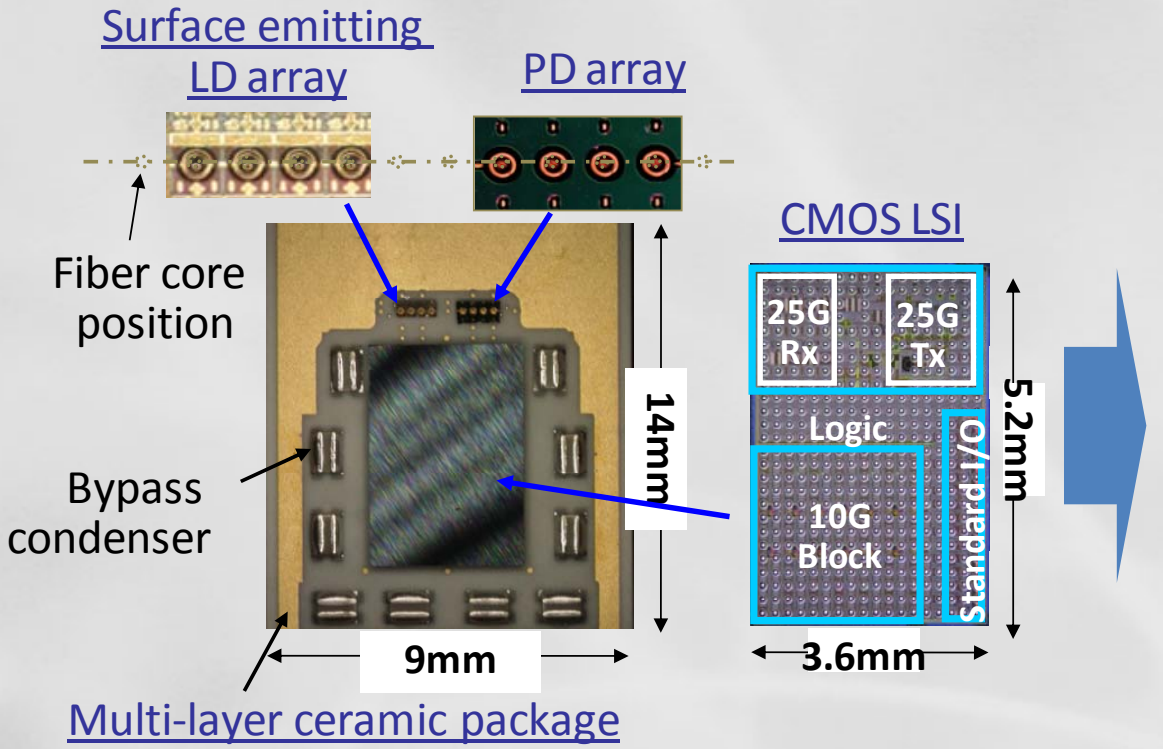
100GE Optical Interface Trend – Parallel SMF Solutions

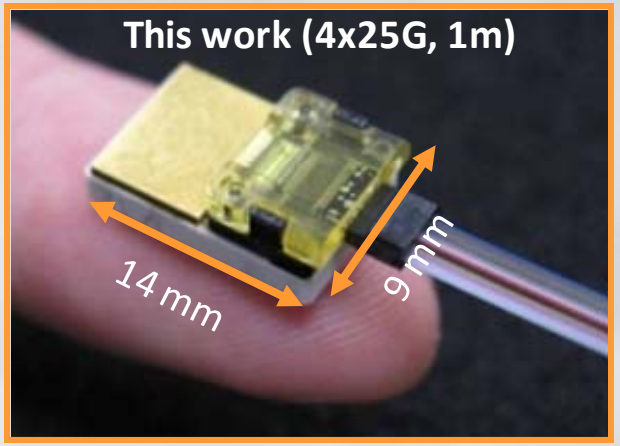
- Medium reach (< 1km) 4x25G parallel SMF optical interface understudy for data center apps
- O-mux/de-mux eliminated
- New technologies for optical engines, e.g. Lens-integrated DFB/PD arrays, SOI modulator array
- Advantages of lower power consumption, form factor size and cost compared to 100GBASE-LR4
- Is parallel SMF medium reach cabling in data center acceptable?



Prototype 4x25G Parallel SMF Transceiver

- Surface mount with passive alignment enables low cost module.
- Use of lens-integrated optical devices reduces components and assembly costs in transceiver design.





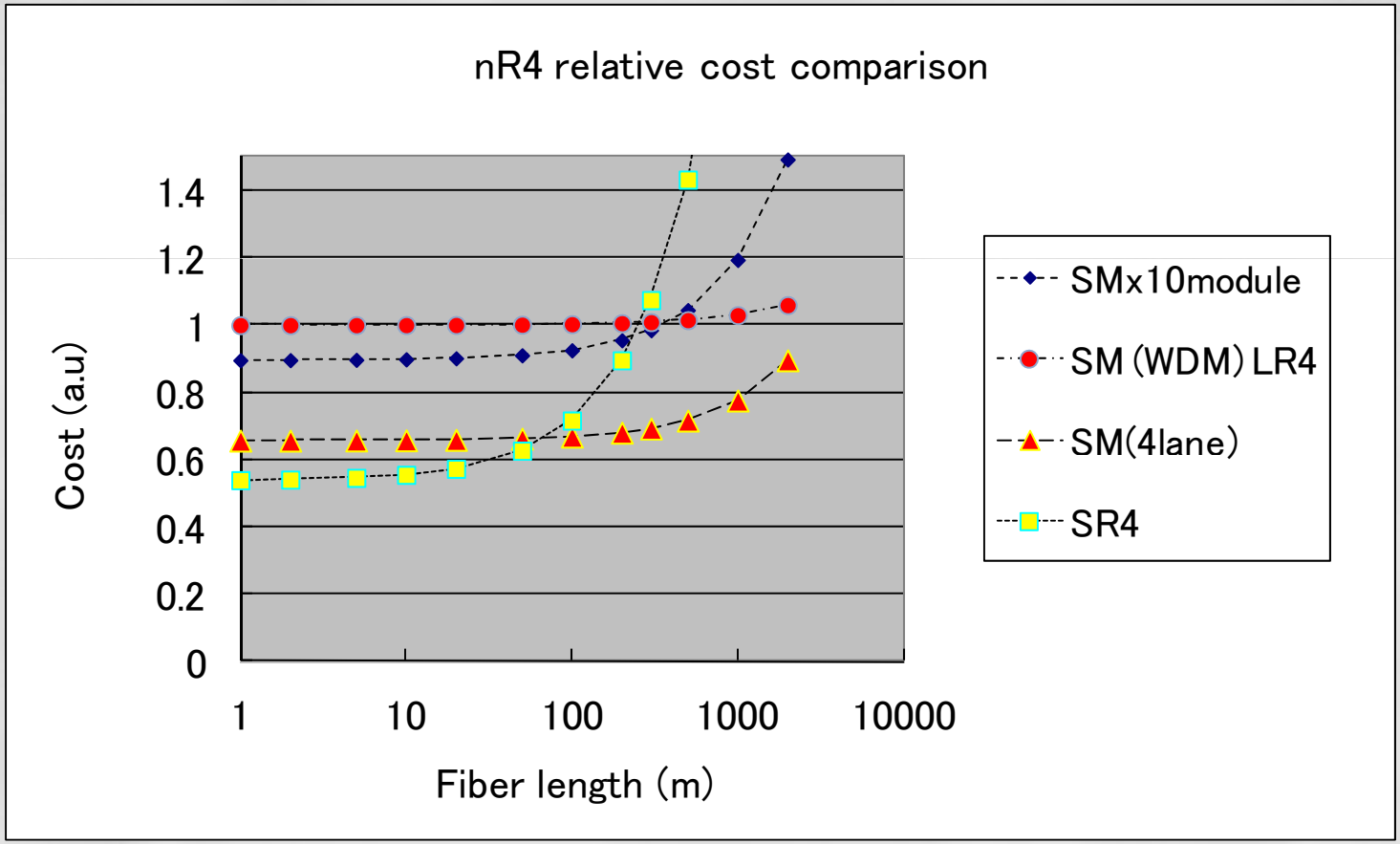
Foot print : 14 x 9 mm^2 (1/100)
Power: 2W (1/15)

Ref: T. Takemoto et al., ECOC 2011, Th.12.B.5 (2011).

A part of this work was performed under management of the PETRA supported by NEDO.

100GE Optics Relative Cost Trend

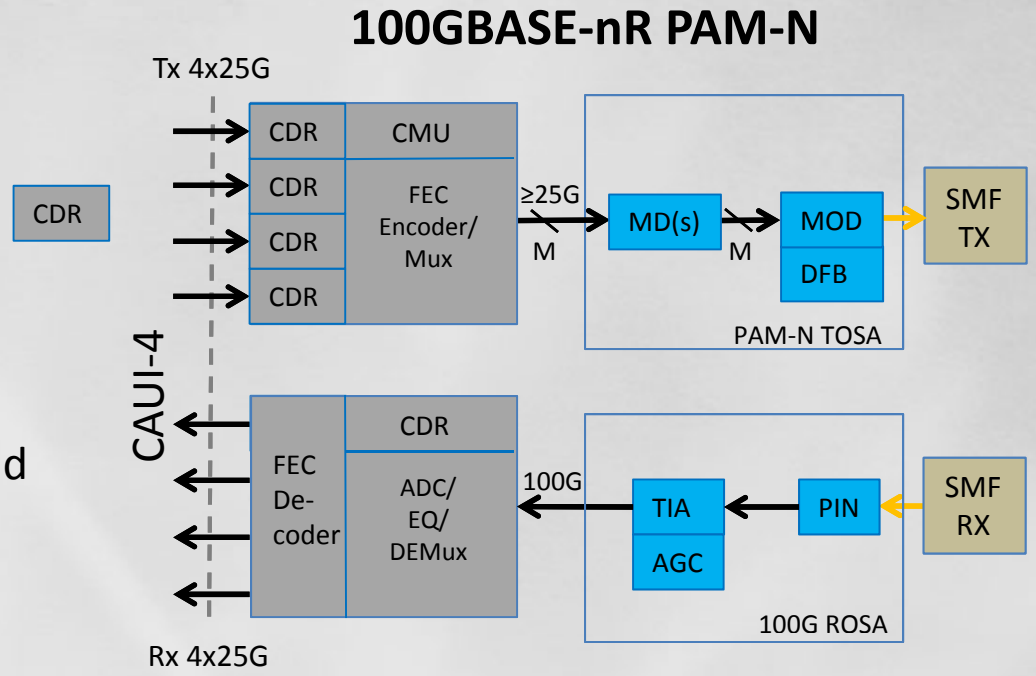
- Total cost includes module, connecter and fiber cable costs.
- Fiber + connecter cost does not contribute much in the case of SMF. It is module cost itself which matters.

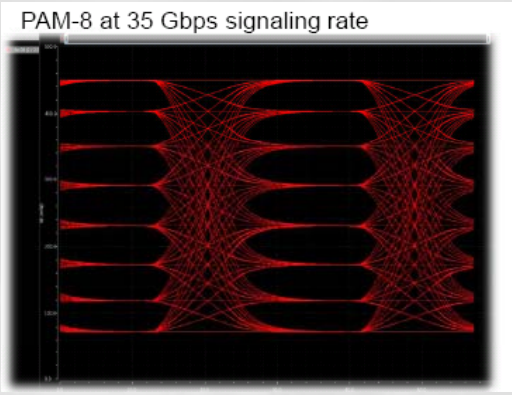


Source: IEEE 802.3 Next Gen 100G Optical Ethernet Study Group, anderson_0112_NG100GOPTX

100GE Optical Multi-level Modulation

- Leverage advances in DSP-based 100G coherent technologies for 100G single wavelength client applications.
- Variety of approaches being investigated, e.g. PAM-8, PAM-16, 16QAM
- Reduction in number of lasers leads to significant reductions in power, cost and improved reliability.
- Challenging requirements: Linearity, laser RIN, modulator r/f time, ER performances
- Mitigation of phase-noise converted RIN due to multiple reflections in the SMF link needs to be understood.
- Many technical challenges!
- Basis for 400G/1TB solutions.





See Ref: IEEE 802.3 Next Gen 100G Optical Ethernet Study Group, bhoja_0112_NG100GOPTX

Take-aways

- Expect increased use of SM optics for 100G short reach interconnects in the data center, due to reach limitations of high-speed MM VCSELs.
- Near term, 100G parallel SMF solutions have advantages over 100GBASE-LR4 in terms of cost, power consumption and form factor size for medium reach interconnects.
- Long term, solutions using single wavelength/multi-level modulation for 100GE client applications appears feasible, but many technical challenges to overcome.