

# **Next Generation 100G Client Optics**

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100G and Beyond in ITU-T and IEEE  
Workshop 13, ECOC 2011  
Geneva, Switzerland  
18 September 2011  
Chris Cole

# Outline

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- **ITU-T & IEEE 100G Client Optics**
  - 100m High Density Data Center Optics
  - 1000m Structured Data Center Optics
  - 10km General Data Center Optics
  - FEC
  - Summary
  - Appendix: Non ITU-T & IEEE 100G Client Optics

# ITU-T & IEEE 100G Client Optics

Optics designation	100m	1000m	2km to 10km
primary application(s)	high density data center	structured data center	telecom & general data center
~loss budget	2dB	2.5dB	6dB*
~link budget = loss + penalties	8dB	3dB	8dB
bit/sec cost & power target	~10GE-SR	~10GE-SR	~10GE-LR
volume laser technology	VCSEL PIC	TBD	DFB PIC
fiber	parallel MMF	duplex SMF	duplex SMF
Existing standard	100GE-SR10	none	G.959.1 100GE-LR4
Next Gen standard	100GE-SR4	100GE-nR4 ???	none ???

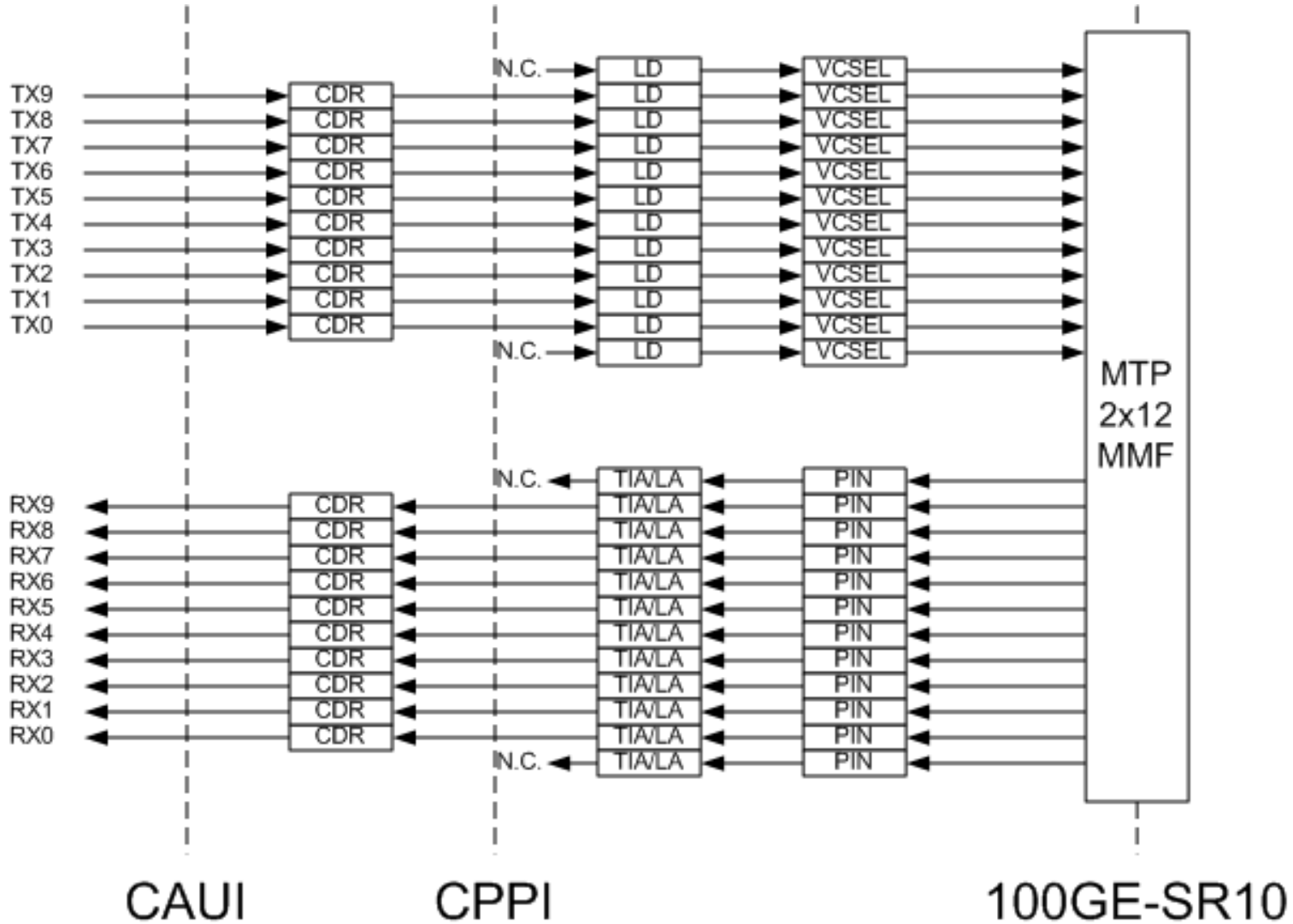
\* 2km telecom optics min loss budget is 4dB

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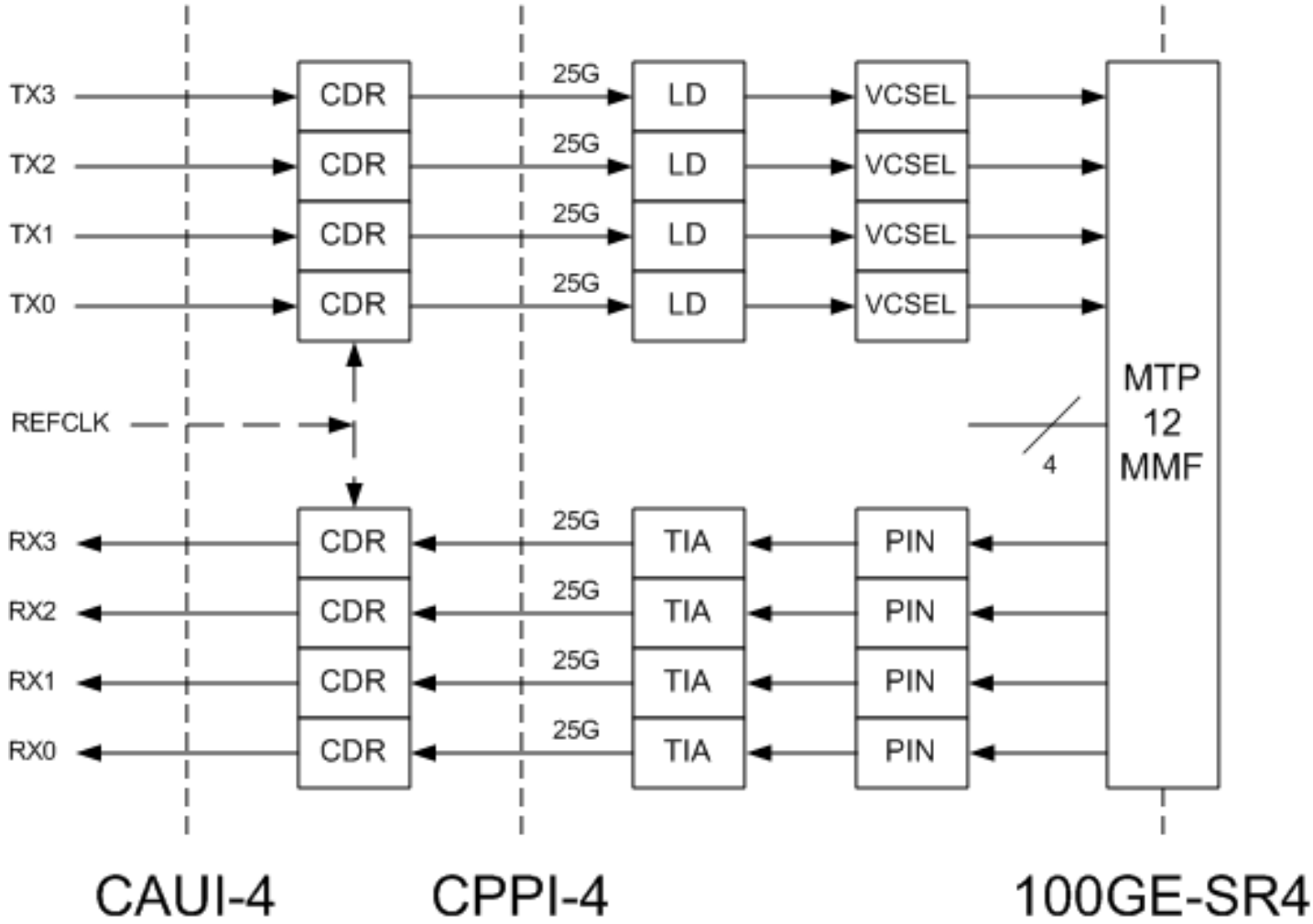
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# 100G Parallel MMF Existing Optics



# 100G Parallel MMF Next Gen Optics



Long term, high volume architecture

# 100G Parallel MMF Key Technology

- High yield Photonic Integrated Circuit (PIC\*) parallel quad VCSEL array
- Ex. monolithic GaAs quad 850nm VCSEL array, 0.25mm x 1.0mm PIC, Finisar Corp.



\* The "C" in PIC is a stretch since there are no optical connections.

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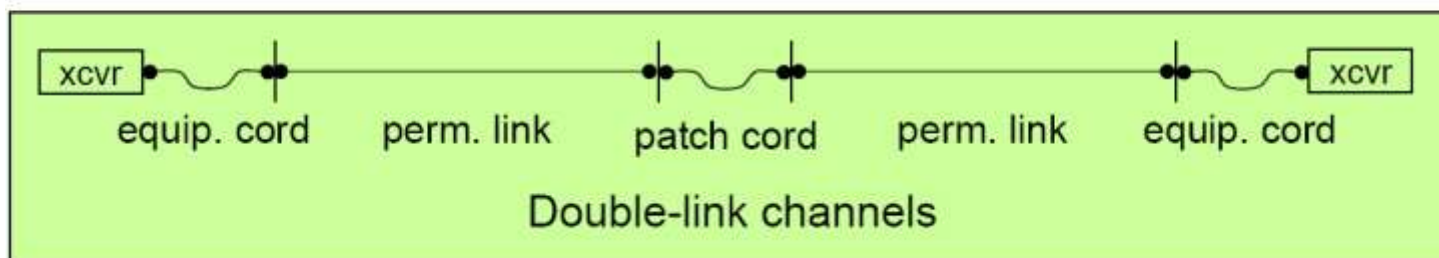
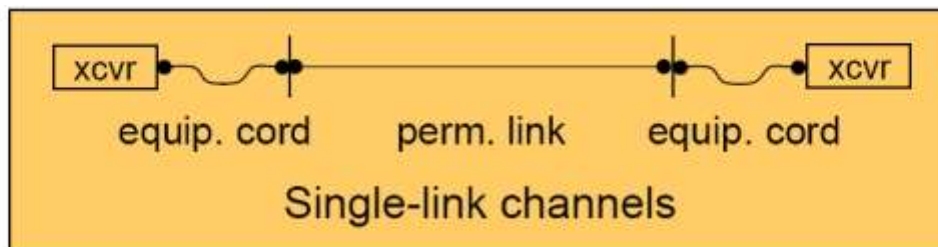


# 1000m Structured Optical Link Application

- Majority of 10G data center optics are 10GE-SR
- 10GE-SR VCSEL technology has significantly lower cost & power than 10GE-LR DFB laser technology
- 10GE-SR 300m reach covered 99% of data center links when adopted in 2002, and still covers majority of links today
- Since 2002, the appearance of Internet Data Centers (IDCs) with link reach requirements >300m created a need for new 10G optics:
  - structured link reach up to 1000m @ ~10GE-SR bit/sec cost
- Similar 40G and 100G structured optics are needed or will be needed
- 100GE-SR10 and 100GE-SR4, using parallel VCSEL Arrays and MTP connectors, are not practical for >300m links
- 100GE-LR4, using DFB PICs, exceeds 10GE-SR bit/sec cost & power
- Large difference between 1000m structured and 10km general optics link budgets (>6dB) offers opportunities for new technologies

# 1000m Structured Optical Link Definition

- What is a 1000m structured data center optical link?
- 1000m or shorter duplex SMF link with a pre-defined fixed number of connectors; similar to structured duplex or parallel MMF links
- Does not support large number of connectors or optical loss elements like passive cross-connect or power splitters
- Example structured links from presentation by Paul Kolesar (CommScope), “Fiber Cabling Trends in Data Centers” during 802.3 Next Gen 100G PMD Study Group, Chicago, IL, 14 Sept. 2011



# 1000m Structured Optical Link Next Steps

- Optics technologies TBD
  - 100GE-LR4 WDM cooled 4x25G DFB PIC (reference baseline)
  - un-cooled CWDM 4x25G DFB PIC (unlikely to be compelling)
  - Si 4x25G modulator PIC
  - InP 4x25G modulator PIC
  - Long Wave 4x25G VCSEL PIC
  - other
- Market potential and volume timeline TBD
- Exact reach TBD
- IEEE may not find sufficient justification for a 1000m structured optics standard (100GE-nR4), either because of insufficient market volume or immature optics technology

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# 2km Telecom Optics Use

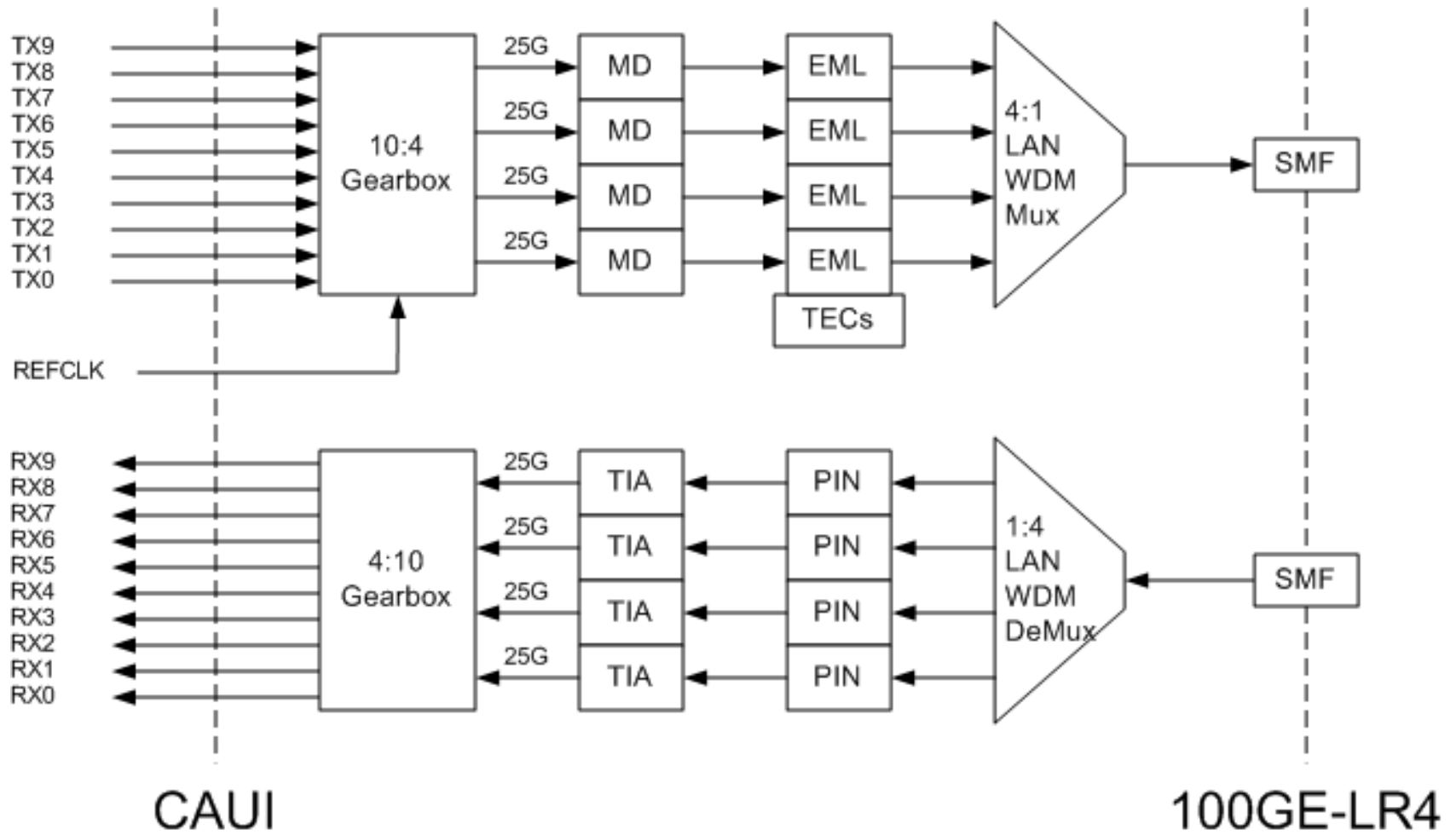
40G 2km telecom optics link budget	ATT	China Telecom	Deutsche Telekom	NTT	Sprint	Verizon
6dB deployed (4dB loss budget)	Yes	Yes	Yes	Yes	Yes	Yes
7dB preferable (5dB loss budget)	Yes	Yes	Yes	Yes	Yes	Yes
4dB sufficient for all links	No	No	No	No	No	No

- Source: “100Gb/s SMF Client Reach Specs” presentation during Next Gen Optical PMD CFI Discussion, 11/8/10, Dallas, TX
- All deployed 10G & 40G 2km telecom optics have 4dB min loss budget
- 100G 2km telecom optics application is the same as 40G application
- 100G 2km telecom optics cost target: ~10GE-LR bit/sec

# 2km Telecom Optics Implementation

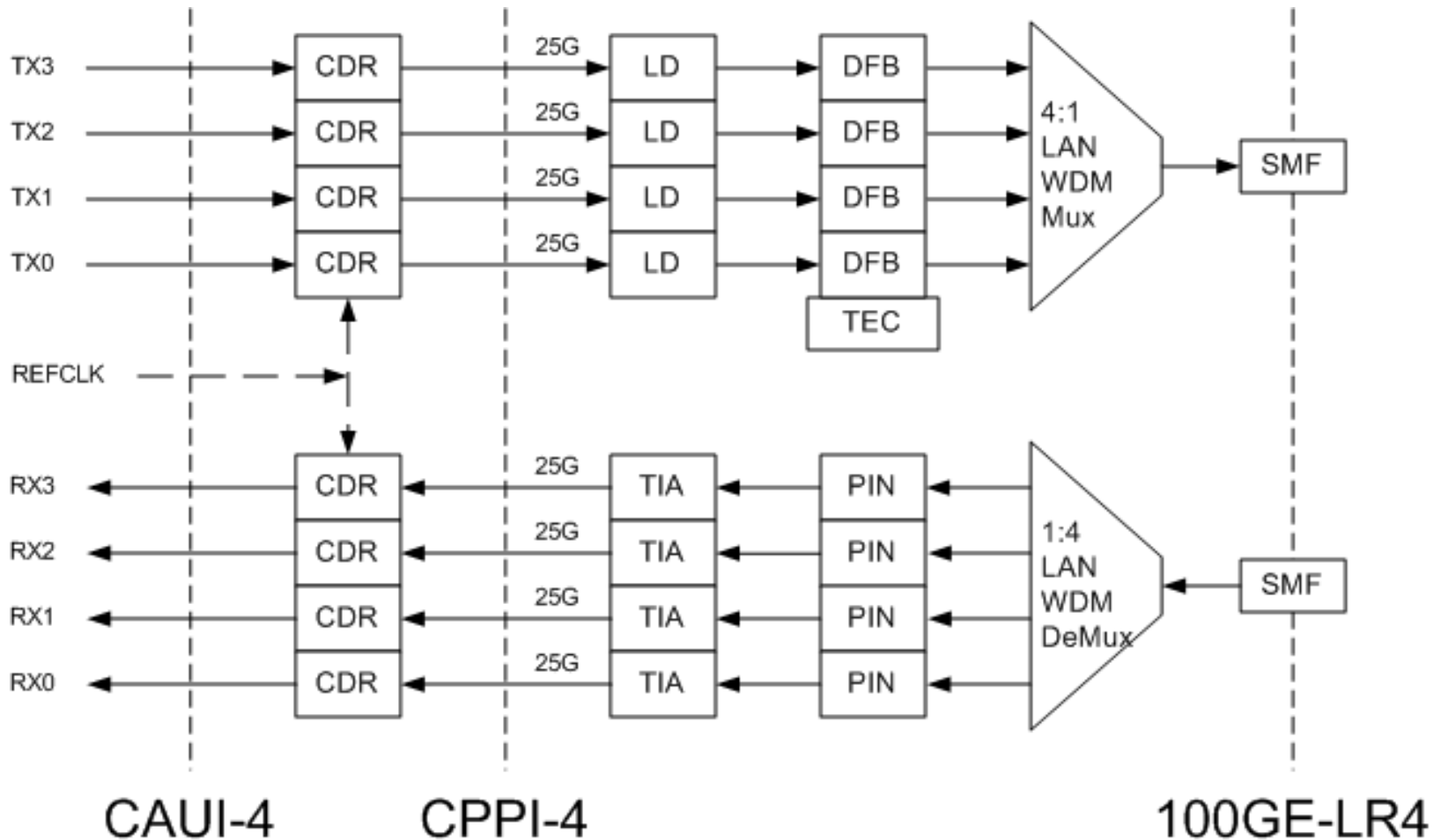
- 10GE-LR 10km general optics have 6.2dB loss and 9.4dB link budgets
- OC-192 SR-1 2km telecom optics have 4dB loss and 5dB link budgets
- Volume of the two 10G applications is similar
- Early SR-1 single rate 300-pin modules have been replaced by pluggable dual rate modules which meet both specifications
- Despite large link budget difference, lower cost of 2km telecom optics does not justify dedicated SR-1 single rate 10G pluggable modules
- 40G is now the same; 40GE-LR4 WDM tri-rate modules are the lowest cost 40GBASE, STM-256 and OTU3 client optics
- 100G is also the same; 100GE-LR4 WDM dual-rate modules will be the lowest cost 100GBASE and OTU4 client optics
- IEEE is not likely to find justification for a 100G 2km 4dB loss optics standard, because it splits volume and increases OpEx support cost

# 100G WDM Duplex SMF Existing Optics



G.959.1 4I1-9D1F is corresponding ITU-T optical specification

# 100G WDM Duplex SMF Next Gen Optics

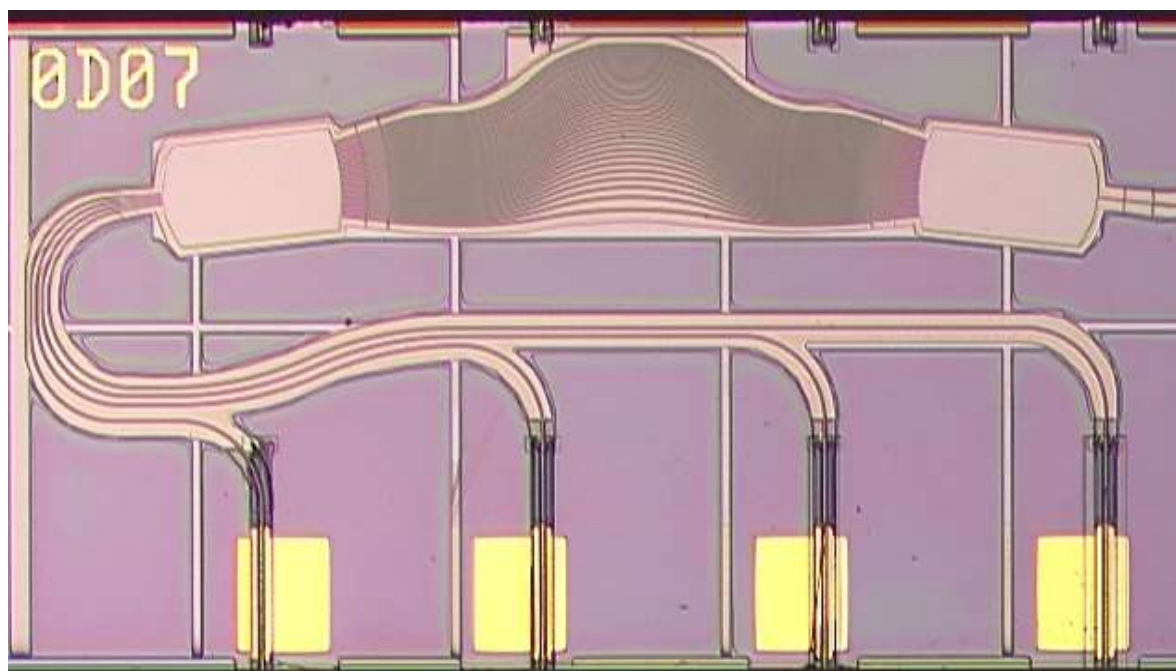


G.959.1 4I1-9D1F is corresponding ITU-T optical specification



# 100G WDM Duplex SMF Key Technology

- High yield Photonic Integrated Circuit (PIC) WDM quad DFB array
- Ex. monolithic InP quad 1310nm band DFB laser array with AWG, 1.1mm x 2.4mm PIC, CyOptics Inc.



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# FEC in Next Gen 100G Client Optics

- IEEE 802.3 Next Generation 100G Study Group is investigating using FEC for 100G Client Optics
- Baseline I/O to support standard specifications
- Extended I/O with FEC to support enhanced specifications:
  - extended electrical or optical performance such as reach
  - reduced cost through simplified design and testing (ex. no low BER specifications and measurements)
- Auto Negotiation can be used to revert to baseline

Electrical I/O	MMF optics	SMF optics
baseline (ex. CAUI-4)	100GE-SR4	100GE-LR4
extended w/ FEC (ex. CAUI-4f)	100GE-SR4f	100GE-LR4f

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- IEEE 802.3 Next Generation 100G Study Group is investigating the following new 4x25G optics:
  - 100m parallel MMF (100GE-SR4) high density data center optics standard
  - 1000m duplex SMF (100GE-nR4) structured data center optics standard
  - 10km duplex SMF general data center optics lower cost & power alternative to existing 100GE-LR4 DFB based standard
- IEEE 802.3 Next Generation 100G Study Group is investigating the following new 4x25G electrical I/O:
  - CAUI-4; w/ & w/o FEC standard
  - CPPI-4; w/ & w/o FEC, w/ & w/o EDC standard

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# Non ITU-T & IEEE 100G Client Optics

	“2km” 10x10G MSA Rev2.2 Spec	“10km” 10x10G MSA Rev2.2 Spec
rate Gb/s	100	100
reach km	“2”	“10”
fiber	duplex SMF	duplex SMF
$\lambda$ nm	1550	1550
penalties dB	2.5	<b>3.0</b>
loss budget dB	<b>2.6</b>	<b>5.0</b>
link budget dB	5.1	8.0

- 10x10G MSA “2km” spec is not per ITU-T and IEEE methodology:
  - loss is below widely deployed 4dB min
- 10x10G MSA “10km” spec is not per ITU-T and IEEE methodology:
  - loss is below widely deployed 6dB min
  - 1550nm  $\lambda$  penalties are too low and not interoperable
- 10x10G MSA client specs created:
  - end user confusion
  - need for translation to ITU-T and IEEE methodology designations to prevent improper deployment

# Non ITU-T & IEEE 100G Optics Use Chart

	10x10G MSA Rev2.2 Spec	ITU-T & IEEE methodology
<b>Optics designation &amp; reach</b>	<b>2km</b>	<b>1000m</b>
claimed application(s)	telecom central office & structured data center	structured data center
2.6dB loss budget supports claimed apps ?	no	yes
2.5dB penalties interoperable over claimed reach ?	yes	yes
<b>Optics designation &amp; reach</b>	<b>10km</b>	<b>2km</b>
claimed application(s)	general data center	telecom central office & structured data center
5dB loss budget supports claimed apps ?	no	yes
3dB penalties interoperable over claimed reach ?	no	yes