

# 100Gb/s SMF PMDs

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40Gb/s and 100Gb/s Fiber Optic Task Force  
SMF Ad-Hoc  
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# Outline

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- Client Optics Overview
- LR4 Generations
- PMD Power
- PMD Relative Costs
- Total Link Cost Ratios
- Appendix: PSM Applications

# Client Optics Overview

Client optics application & media type(s)	High density data center duplex or parallel MMF	Structured data center duplex or parallel SMF	data center & central office duplex (or parallel) SMF	General data center duplex SMF	Metro inter-data center duplex SMF
nominal reach (determines min. penalty)	100m	500m	2km	10km	20, 30, 40km
minimum loss budget	2dB	2.5dB*	4dB	6dB	11 to 21dB
bits/sec cost baseline	10G VCSEL MMF	10G VCSEL MMF	10G DFB laser SMF	10G DFB laser SMF	10G EML SMF
10G standard	10GE-SR	none	OC-192 SR-1 G.693 10G	10GE-LR	10GE-ER G.959.1 10G
40G standard	40GE-SR4	none	40GE-FR G.693 40G	40GE-LR4 G.695 10G	40GE-ER4
100G standard	100GE-SR10 100GE-SR4	100GE-nR4?	100GE-FR4?	100GE-LR4 G.959.1 25G	100GE-ER4 G.959.1 25G

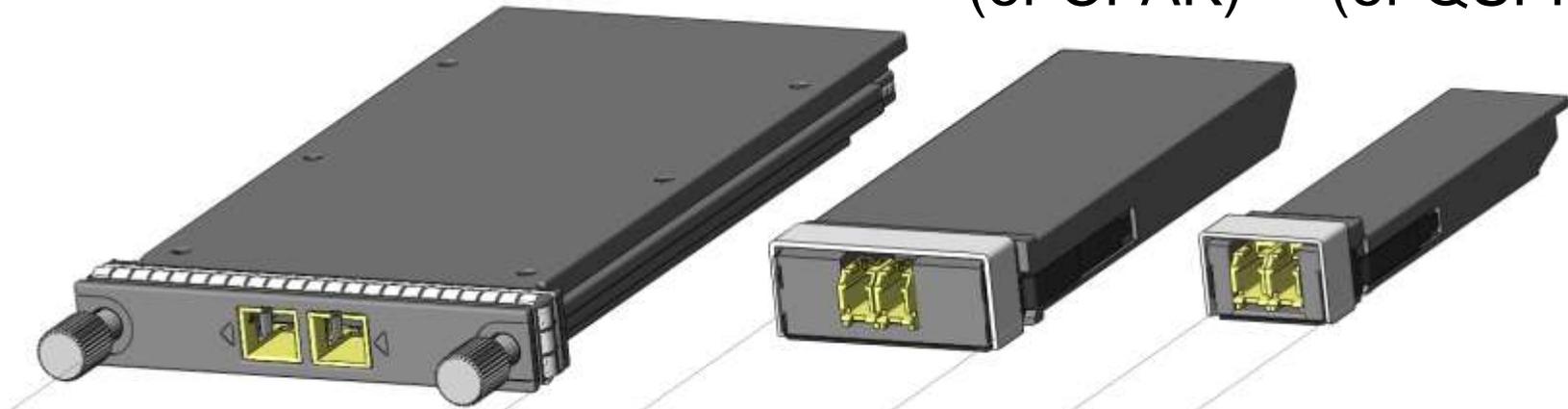
\* Updated partly to reflect kolesar\_01\_0213, which proposes 2.9dB minimum

# 100GE-LR4 Generations

Gen1: CFP

Gen2: CFP2  
(or CPAK)

Gen3: CFP4  
(or QSFP28)



	Gen1	Gen2	Gen3
1 <sup>st</sup> ship	2010	2013	2014/15
TOSA	4 discrete EMLs	Quad DFB laser PIC or Si Mod PIC	Quad DFB laser PIC or Si Mod PIC
ROSA	Quad PIN PIC or 4 discrete PINs	Quad PIN PIC	Quad PIN PIC

PIC (Photonic Integrated Circuit)

# 100GE PMD Power

Power (W)	SR4	PSM4	LR4 Gen1	LR4 Gen2	LR4 Gen3
Form-factor	CFP4/ QSFP28	CFP4/ QSFP28	CFP	CFP2/ CPAK	CFP4/ QSFP28
Cole	2.6		22	7 <sup>1</sup>	4.5
petrilla_03a_0113 <sup>2</sup>	2.64	3.76		7.00	
Cisco 2012 <sup>3</sup>			<24	<7.5	

<sup>1</sup> Measured power of CFP2s now in the field

<sup>2</sup> Confirmed in anderson\_01\_0213

<sup>3</sup> Public customer presentations

# 100GE PMD Relative Cost

SR10 CXP = 1x	SR4	PSM4	LR4 Gen2	LR4 Gen3
Form-factor	CFP4/ QSFP28	CFP4/ QSFP28	CFP2/ CPAK	CFP4/ QSFP28
petrilla_02a_0112 <sup>1</sup>	1.2x	3x to 4x		
cole_02a_0312 <sup>2, 3</sup>	1.2x	3x to 4x	8x <sup>4</sup>	5x to 6x
anderson_01_0113 <sup>5</sup>	<4x	4x <sup>6</sup>	9.3x	<div style="border: 2px solid red; padding: 5px; text-align: center;"> <b>Wow!!! LR4 will be dirt cheap</b> </div> 
petrilla_03a_0113 <sup>5</sup>	1.1x	4x	12x	
welch_01a_0113 <sup>5</sup>		0.82x		3.5x

<sup>1</sup> Anderson and Petrilla numbers only

<sup>2</sup> Based on 9/20/10 ECOC study

<sup>3</sup> LR4 Gen1 CFP = 16x

<sup>4</sup> Confirmed by CFP2s now in the field

<sup>5</sup> Confirmed in anderson\_01\_0213

<sup>6</sup> From petrilla\_02a\_0112

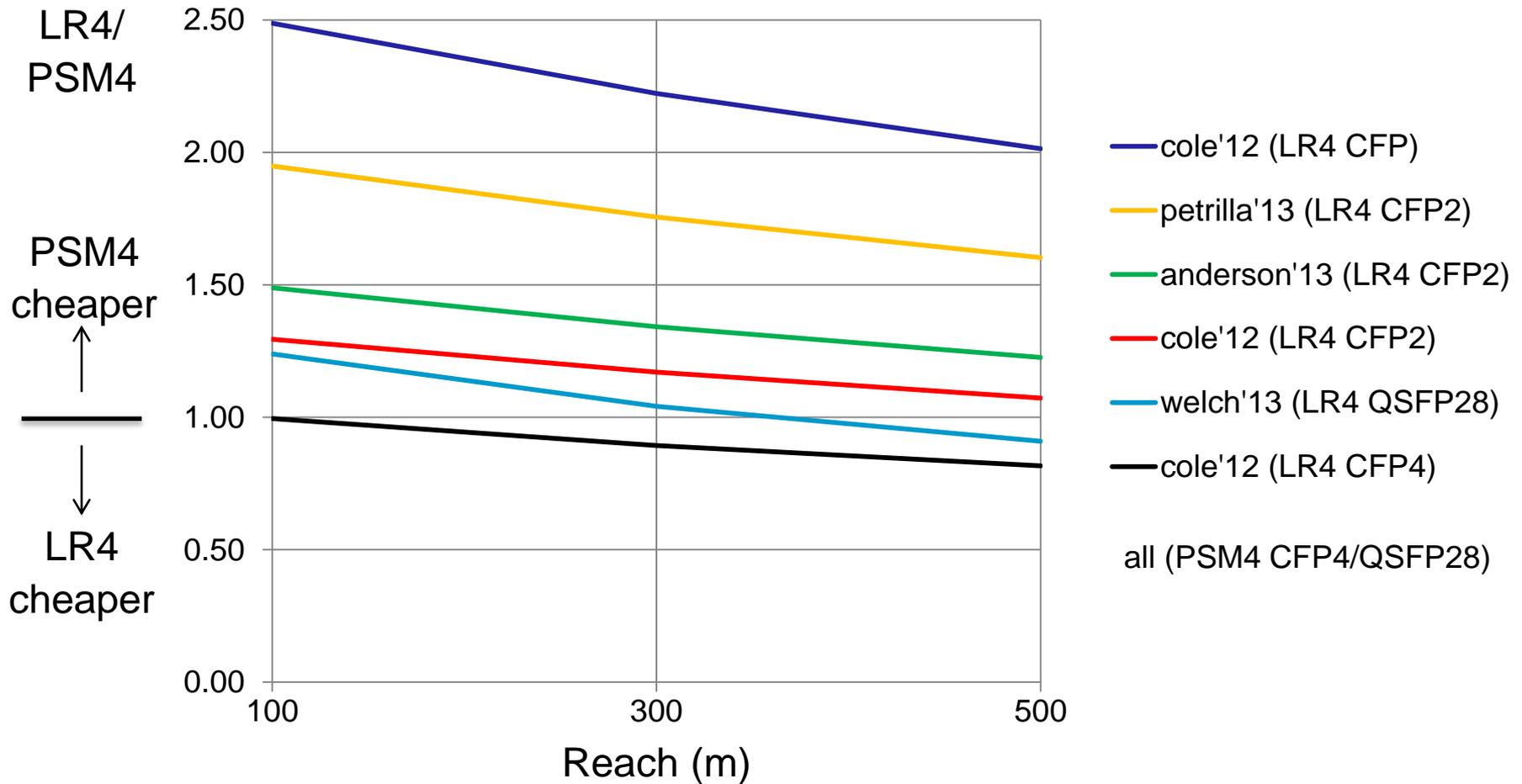
# Cabled Fiber Link Relative Cost

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Channel Type	Double-Link (DL)		
Fiber Type	100m	300m	500m
2f OS2 SMF	1.5	2	2.5
8f OS2 SMF	6	8	10

Fiber connectivity cost ratios only (no transceivers) from [cole\\_01\\_0512](#) (Abbott, Cole, Coleman, Kolesar, Swanson)

# 100GE LR4/PSM4 Total Link Cost Ratio



$$\text{LR4/PSM4} = (2 \cdot \text{LR4} + \text{SMF}_{\text{DL } 2\text{f OS2}}) / (2 \cdot \text{PSM4} + \text{SMF}_{\text{DL } 8\text{f OS2}})$$

# 100GE LR4 Total Link Relative Cost

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- LR4 Gen1 total link cost is higher than PSM4
- LR4 Gen2 total link cost is moderately higher than PSM4
- LR4 Gen3 total link cost will be similar or lower than PSM4
- Beyond Gen3, LR4 module cost will drop by 1.5x to 2x through low cost optical packaging, for example as described by Bhatt, Martin, Vlasov, Welch, and others

# Appendix: PSM Applications

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- App. 1: Gen1 SMF PMD
  - 100GE Gen1 design-in window is closed
  - 400GE Gen1 is a good opportunity
- App. 2: SMF-only Datacenter
  - PSM4 + LR4 instead of SR4 + LR4
  - <100m parallel SMF CapEx > parallel MMF CapEx
    - SMF-only datacenter OpEx is lower?  
(analogous to 40GE-FR justification)
    - SMF cabling is sunk cost or not fully accounted for?
- App. 3: High Density SMF PMD
  - 4x10GE-LR QSFP+
  - 10x10GE-LR CFP2 & MLG CFP4
  - 5x40GE-LR4 MLG CFP2