Consensus Proposal Supporting 200GEL Copper Cable Objectives

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Agenda

Usage of Copper Cables in Networking

Motivations for 200 Gbps Copper Cabling

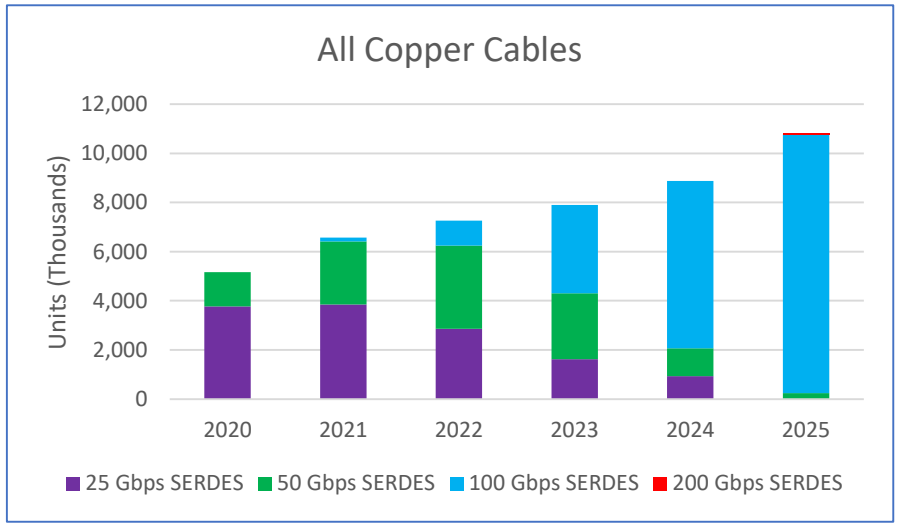
Cable Length Requirements

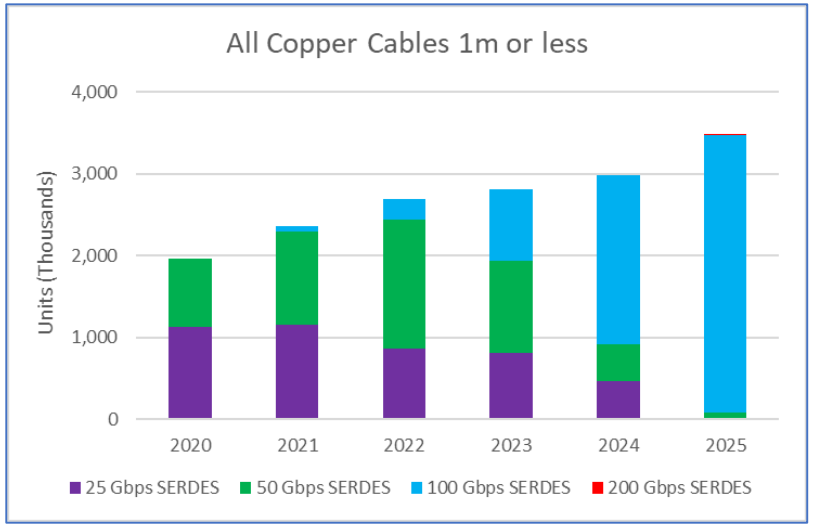
Enabling Factors

- Possible budget
- PCB loss
- Cable Investigations
- Existing Industry Activity

Proposed Objectives

Copper cables are a key enabler of cost-effective cloud architectures – especially at higher data rates





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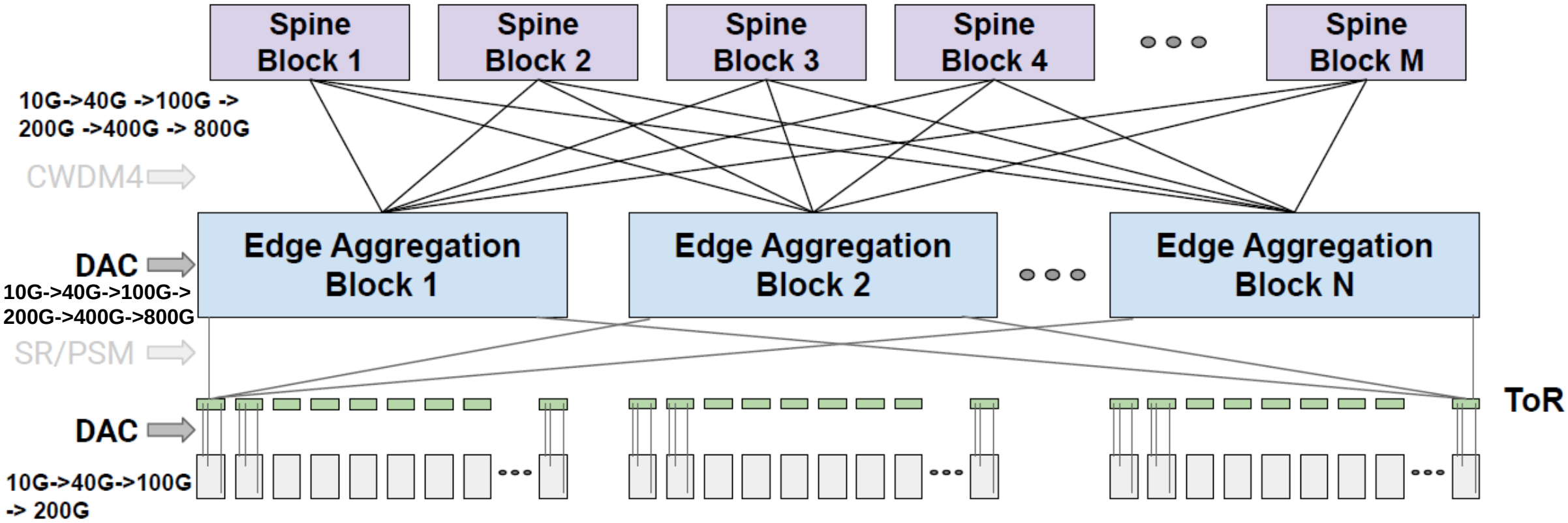
Copper Cables Are A Growing Critical Building Block Of Cloud Architectures

IEEE

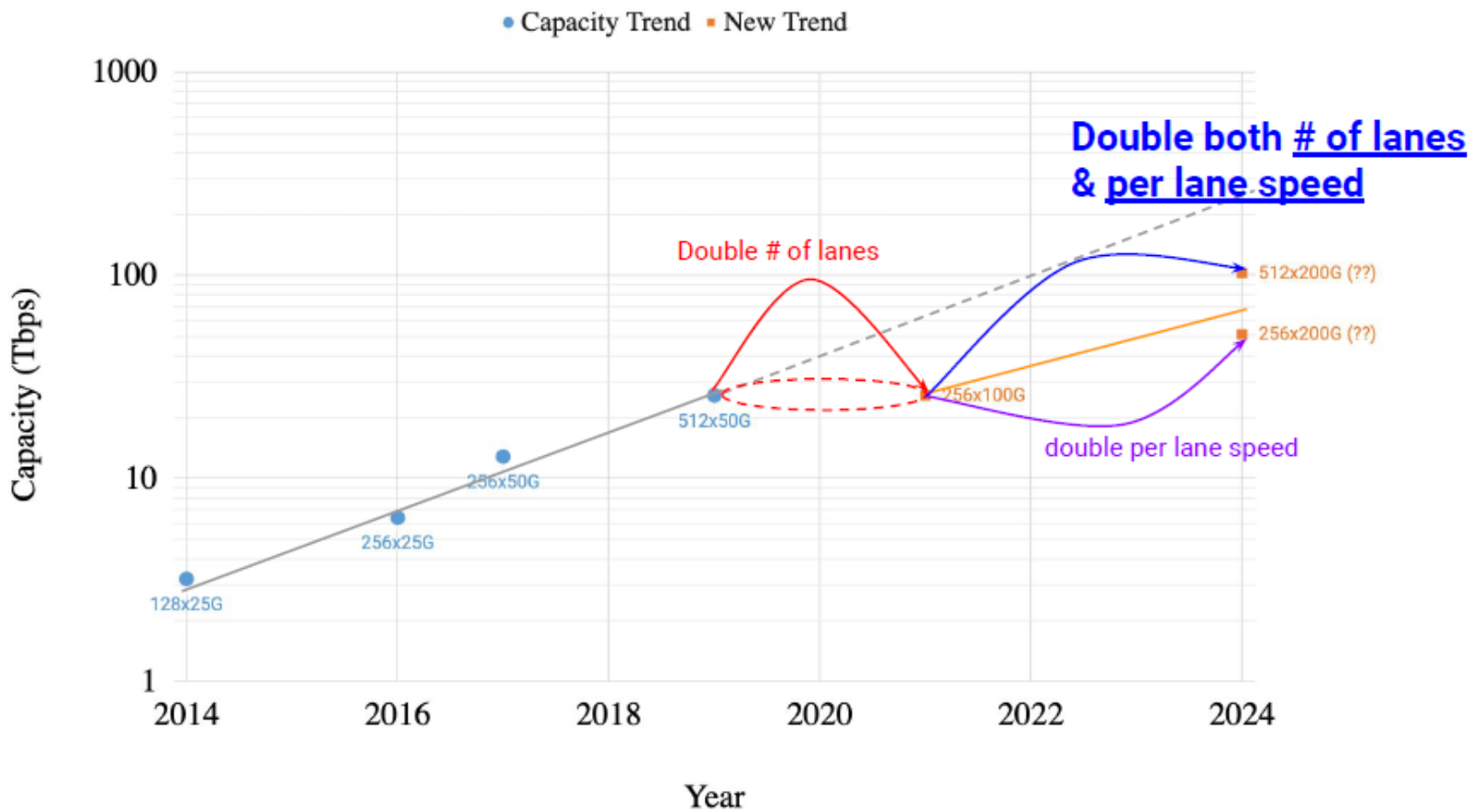
>400G will be needed in Datacenter Network fabrics



- DAC (Direct Attach Copper) is efficient interconnect for aggregation block and server racks

https://www.ieee802.org/3/B400G/public/21_03/lam_b400g_01a_210329.pdf

Motivations for 200Gbps/lane



- Switch capacity growth slowed down due to limitation of power, SI and # of packaging pins
- 200Gbps/lane is critical to scale the switch bandwidth and efficiency of networking fabric.

https://www.ieee802.org/3/B400G/public/21_03/lam_b400g_01a_210329.pdf

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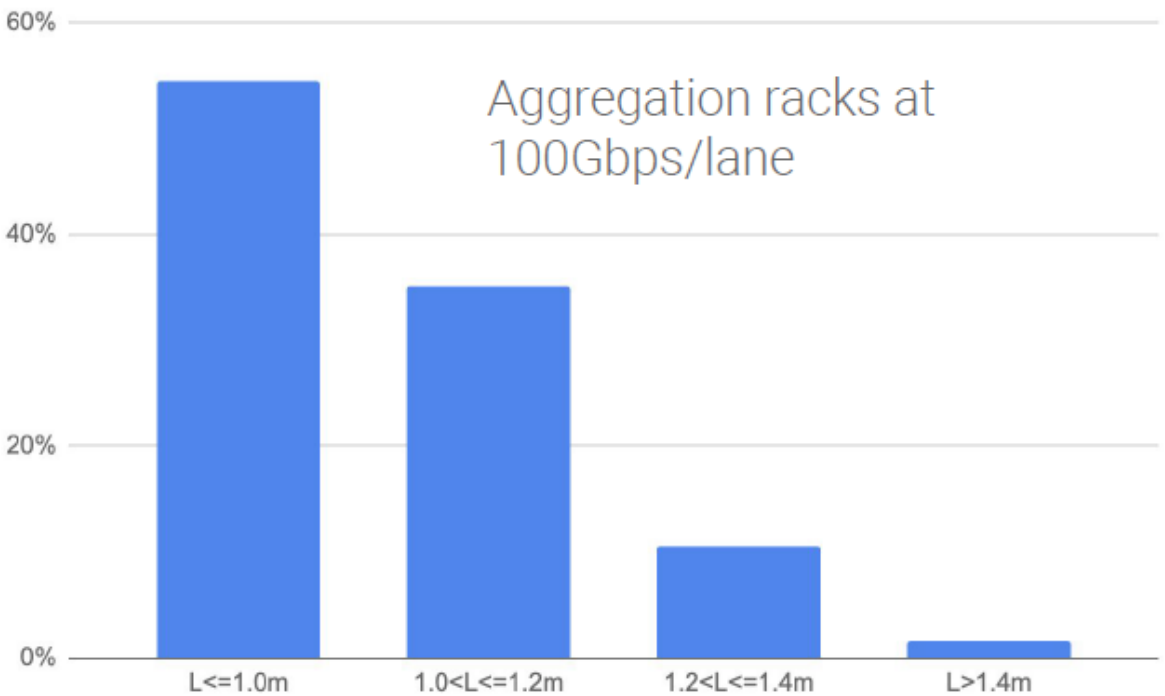
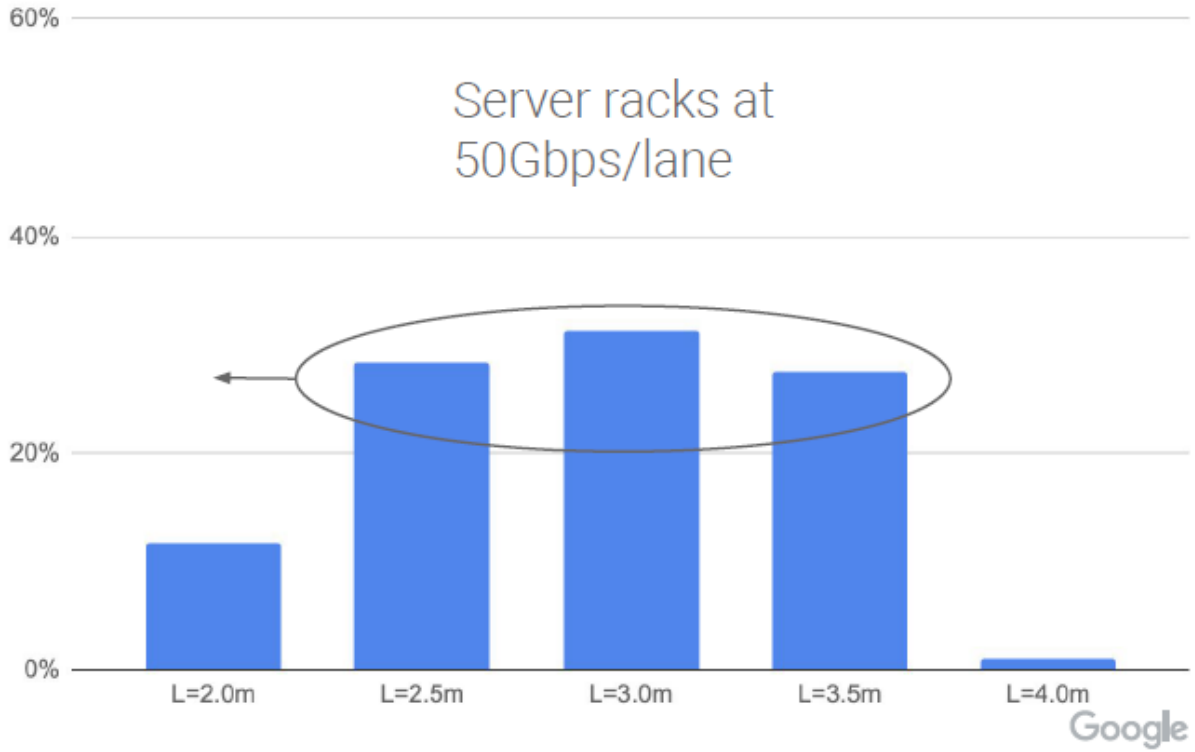
Cable length distributions

Aggregation racks: 1m prevalant at 100GEL, justifies 1m 200GEL development.
Server racks evolving from 50GEL architectures:

- Rackifications re-engineered to reduce lengths
- Asymmetric link budgets: short PCBs with long cables
- Active cables (optical, copper) where cost effective





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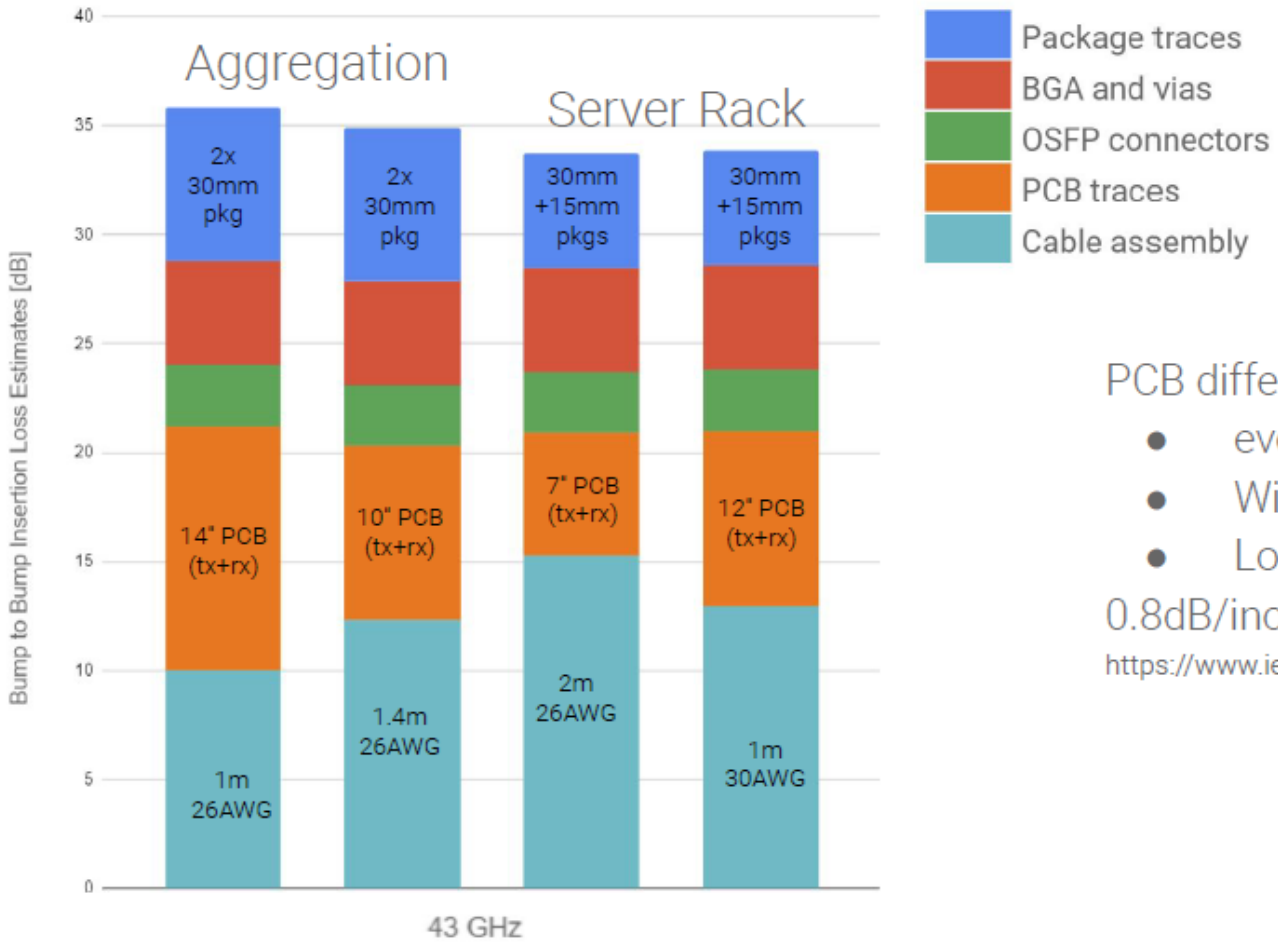
Example Links for <36dB bump2bump

Wide range of implementations covering both aggregation and server racks:



PCB differential pair loss improvements:

- evolutionary (no exotic materials)
- Wide trace with improved surface roughness
- Low dielectric loss

0.8dB/inch: lab measurements on prototype switchcards.

https://www.ieee802.org/3/B400G/public/21_05/noujeim_b400g_01_210517.pdf

Retrospective: 100GEL budget

50GEL

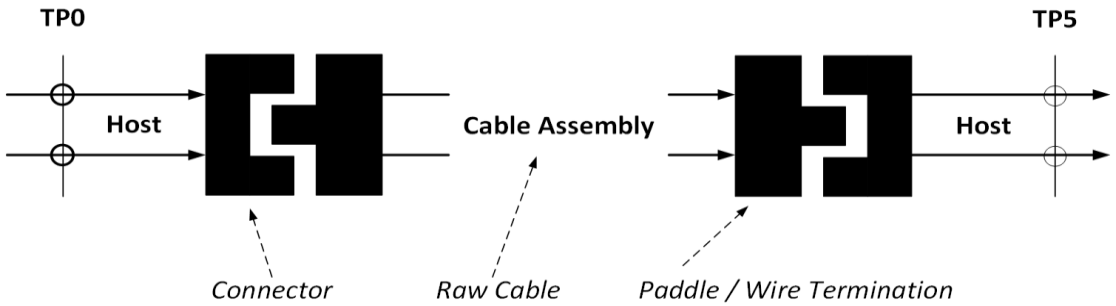
Parameter	IL@fn (dB)
Raw cable	9.0
Paddle card + wire termination	1.5 (x2)
Host PCB (x2)	7.3 (x2)
Connector (x2)	1.2 (x2)
Total loss TP0-TP5	29.0

100GEL – Study Group*

Parameter	IL@fn (dB)
Raw cable	10.0
Paddle card + wire termination	2.0 (x2)
Host PCB (x2)	14.0 (x2)
Connector (x2)	2.0 (x2)
Total loss TP0-TP5	46.0

100GEL – D2p1

Parameter	IL@fn (dB)	
Raw cable	8.85	-12.5%
Paddle card + wire termination	1.35 (x2)	-32.5%
Host PCB (x2)	6.875 (x2)	-50.9%
Connector (x2)	1.6 (x2)	-20%
Total loss TP0-TP5	28.5	-38.1%



- 100GEL budgets changed dramatically over the course of the project
- 200GEL budgets need to take advantage of advances in technology and implementation

* https://www.ieee802.org/3/100GEL/public/18_01/palkert_100GEL_02_0118.pdf

Starting Point for 200GEL budget

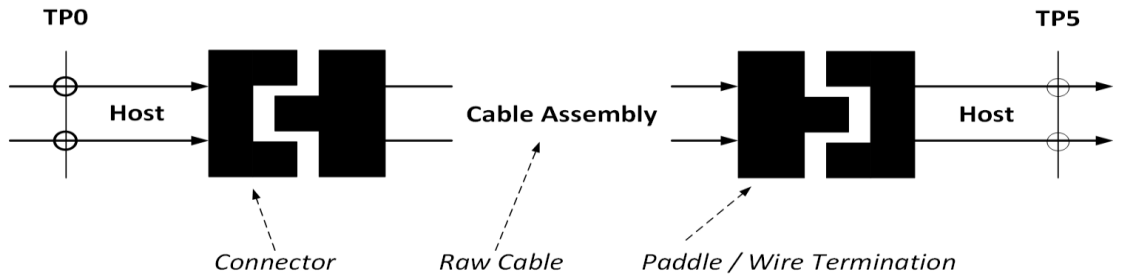
- Multiple modulation solutions are being considered at this time, none of which should limit support of the objective
- PAM-6 modulation shows promising IL for an end-to-end link using a present reference topology
- PAM-4 modulation requires continued development of components, materials, and manufacturing techniques and implementation options

B400G – 42.5 GHz

Parameter	IL@fn (dB)
Raw cable (1m)	6.0
Paddle card + wire termination	2.5 (x2)
Host PCB (x2)	8.85 (x2)
Connector (x2)	1.2 (x2)
Total loss TP0-TP5	31.1

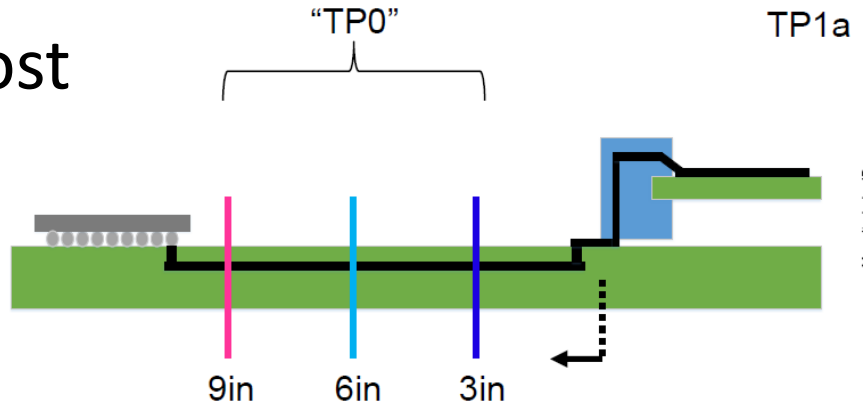
B400G – 53.125 GHz

Parameter	IL@fn (dB)
Raw cable (1m)	7.0
Paddle card + wire termination	3.2 (x2)
Host PCB (x2)	10.3 (x2)
Connector (x2)	2.0 (x2)
Total loss TP0-TP5	38.0

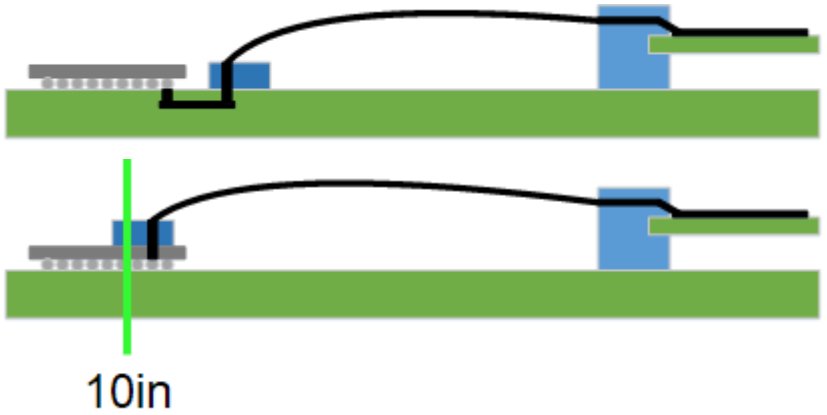


Host PCB options + OSFP 200GEL connector performance

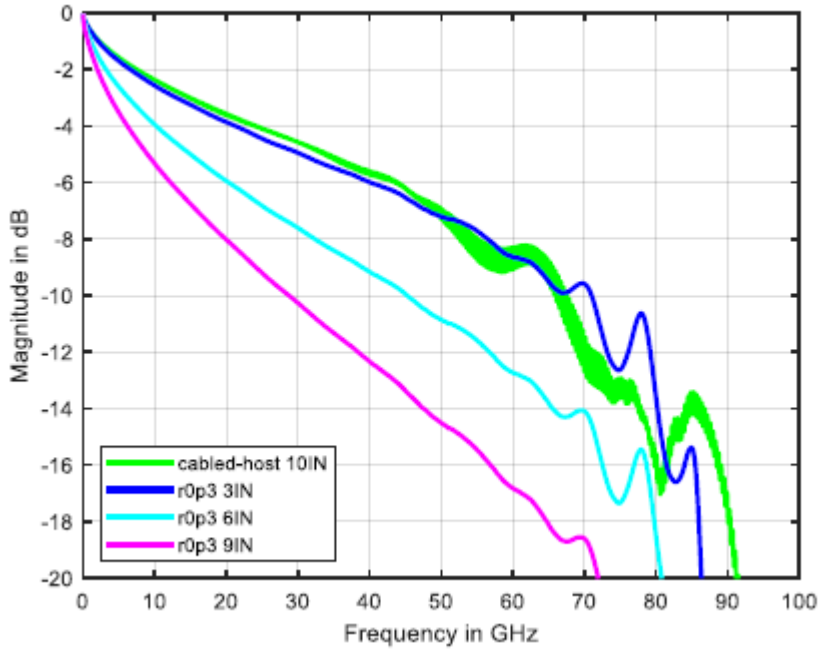
- PCB host



- Cabled host

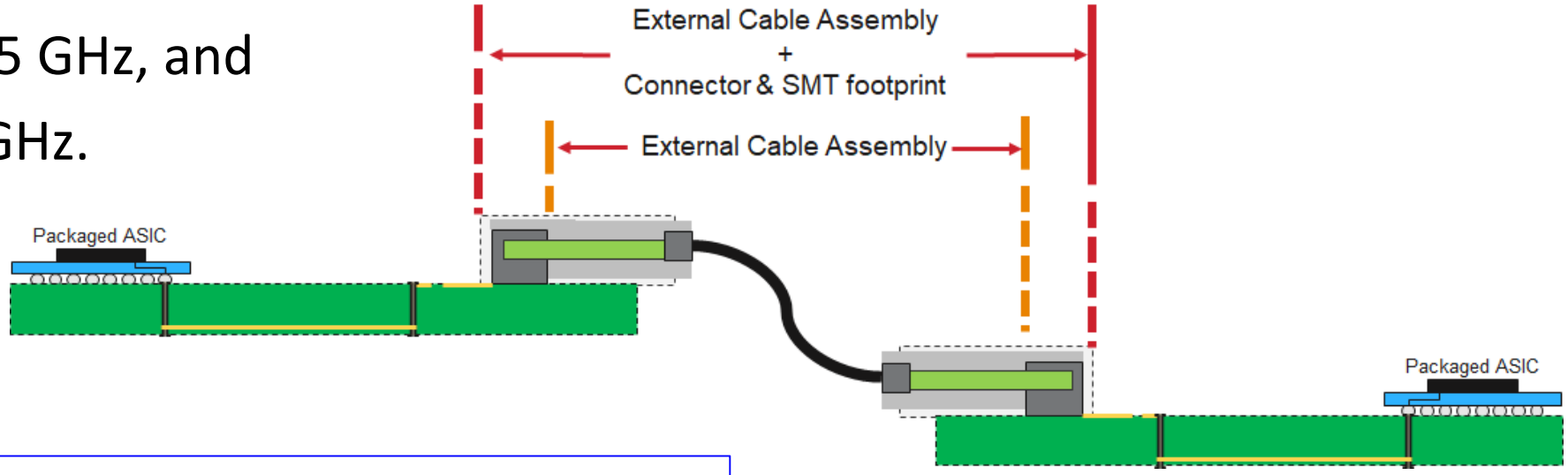


- Significant progress has been made in the last six months to improve component performance estimates from 100GEL and develop confidence for 200GEL pluggable interfaces.
- Data presented from the OSFP 200GEL ad-hoc:
  - OSFP 200GEL connector
  - PCB trace models
    - ~1.10 dB/inch (42.5 GHz), ~1.25 dB/inch (53.125 GHz)



System topology

- Opportunity: enable CR DAC solutions for 200GEL with cable length up to at least 1 meter
- Status: current bulk cable solution for 100GEL applications can achieve approximately
  - 7 dB/m at 53.125 GHz, and
  - 6 dB/m at 42.5 GHz.

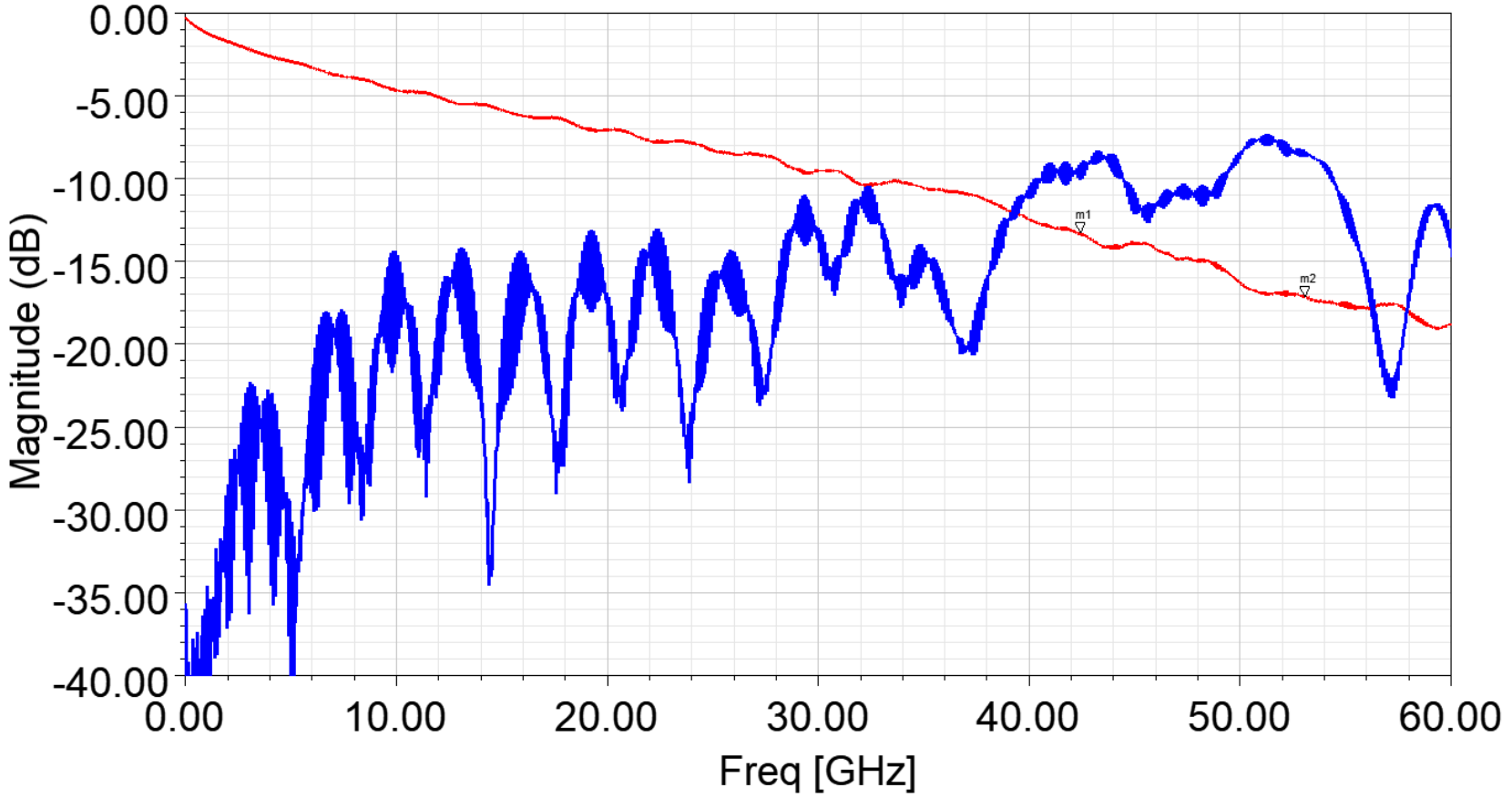


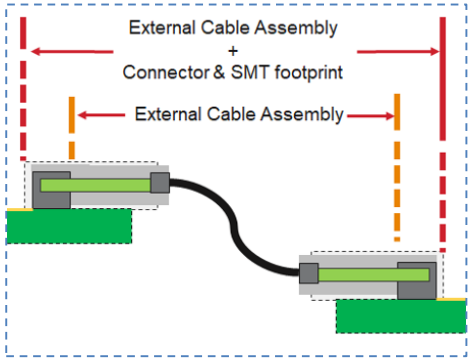
Multiple Modulation Solutions Are Viable

System topology (2)

Modulation	
PAM-6 (42.5 GHz)	PAM-4 (53.125 GHz)
13.3 dB	17.2 dB

External cable assembly (connector and SMT footprint included)





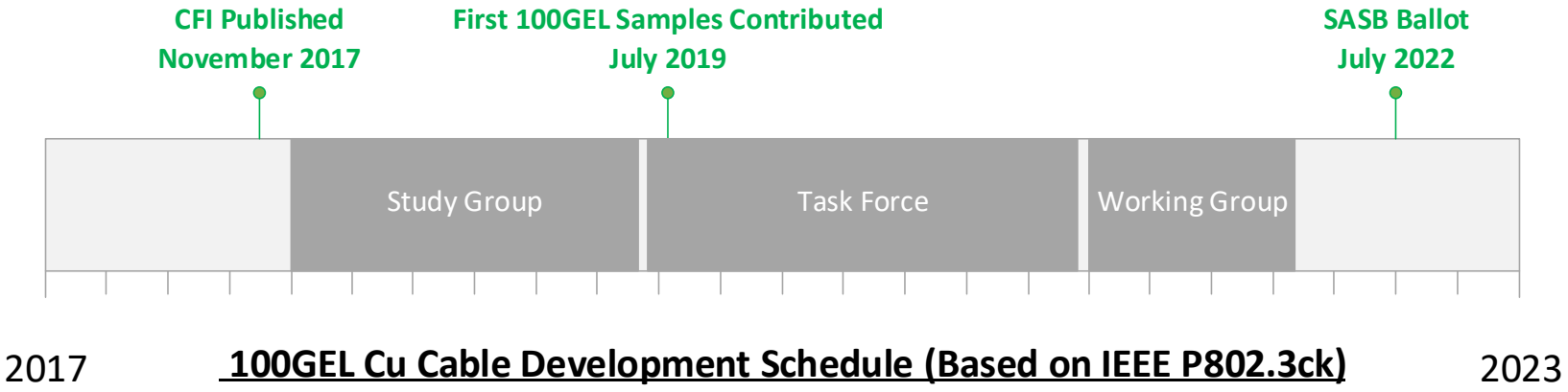
Cable, Termination, Paddlecard, Connector and Conn Footprint Projections Give a Good Start

Other enablers for passive copper cable

- Modulation decisions
- Asymmetric link definitions such as being discussed in IEEE P802.3ck
- Industry 200+ Gb/s efforts already underway enable data early in the W/G process
- Retimed links based on the July 13 adopted chip to chip objectives

Many “Tools in the Toolbox” Exist to Enable A Solution

Past, present and future



- Assuming a similar overall timeline for the 200GEL project, development is on, or ahead of schedule compared to the 100GEL project work
- Multiple interconnect suppliers are committed to sampling 200GEL conn and cables by Q2 ‘22

Industry Activities for 200G Are Ahead of What Happened In IEEE P802.3ck

Retrospective

IEEE Project	IEEE P802.3bj	IEEE P802.3cd	IEEE P802.3ck	TBD
Ethernet Rate	100G	50/100/200G	100/200/400G	200/400/800/1600G
Timeline	2011-2014	2016-2018	2018-2021	2021-
Per-lane rate & modulation	25G NRZ	50G PAM4	100G PAM4	200G PAM-N (TBD)
Insertion loss & Reach objectives	35dB @12.89GHz	30dB @13.89GHz	28.5dB @26.56GHz	TBD
	5m Cu Cable	3m Cu Cable	2m Cu Cable	1m Cu Cable
Host Silicon Transceiver architecture	Analog	Analog	Analog/DSP	Enhanced DSP

One meter Copper Cable reach is extremely useful for the data center

Proposed “Beyond 400G” objectives to enable copper cable implementations based on 200GEL

1. 800 Gb/s related
   - Define a physical layer specification that supports 800 Gb/s operation over four pairs of copper twinax cable in each direction with a reach of up to at least 1 meter
2. 1.6 Tb/s related
   - Define a physical layer specification that supports 1.6 Tb/s operation over eight pairs of copper twinax cable in each direction with a reach of up to at least 1 meter
3. 200 Gb/s related
   - Define a physical layer specification that supports 200 Gb/s operation over one pair of copper twinax cable in each direction with a reach of up to at least 1 meter
4. 400 Gb/s related
   - Define a physical layer specification that supports 400 Gb/s operation over two pairs of copper twinax cable in each direction with a reach of up to at least 1 meter

Additional proposed “Beyond 400G” objective to enable copper cable implementations based on 100GEL

- 800 Gb/s related
  - Define a physical layer specification that supports 800 Gb/s operation over eight pairs of copper twinax cable in each direction with a reach of up to at least 2 meter (not included in ck)