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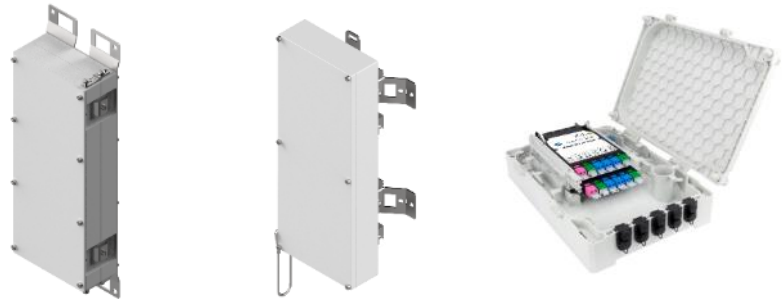
Some things to consider with 400G & DWDM

H+S Cube Optics – Product Map

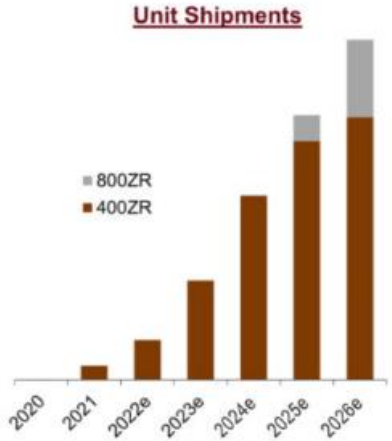
Form Factor	Technology: Passive Optical Multiplexing	Technology: Active Systems (Transport)
Outdoor Hardened environment		
Indoor 19” Chassis		
Components Sub-Systems		

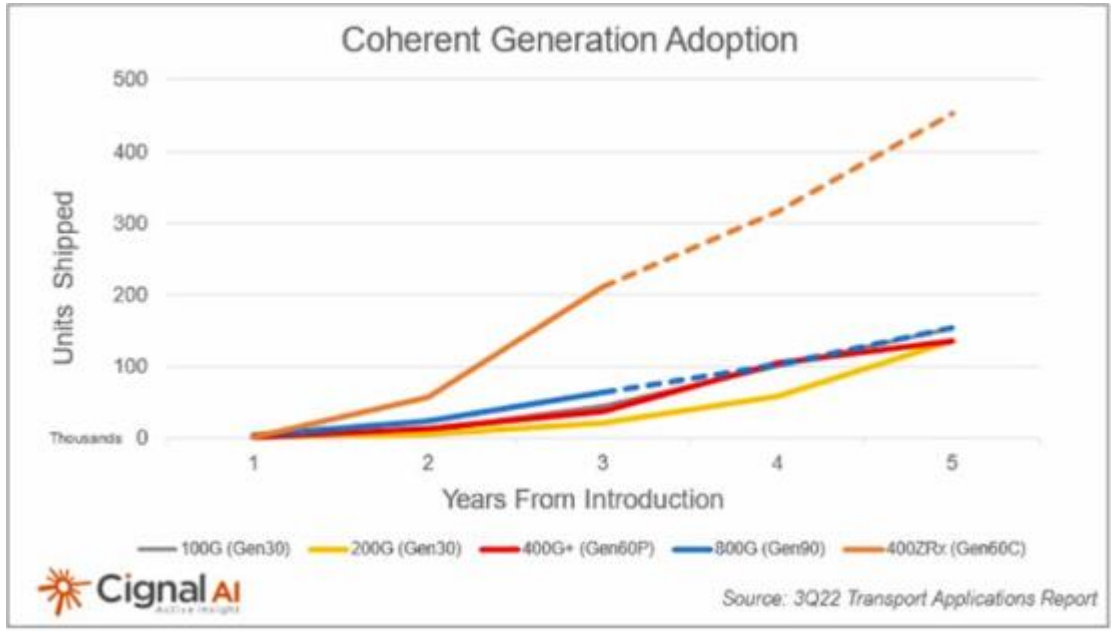
400G Coherent Market

ZR Optical Pluggable enables IPoDWDM
- ICPs expected to be largest purchaser
- CSPs and MSOs also to be large customers

400ZR volumes expected to reach over 250 K by 2026
- Revenue surpass $450 M

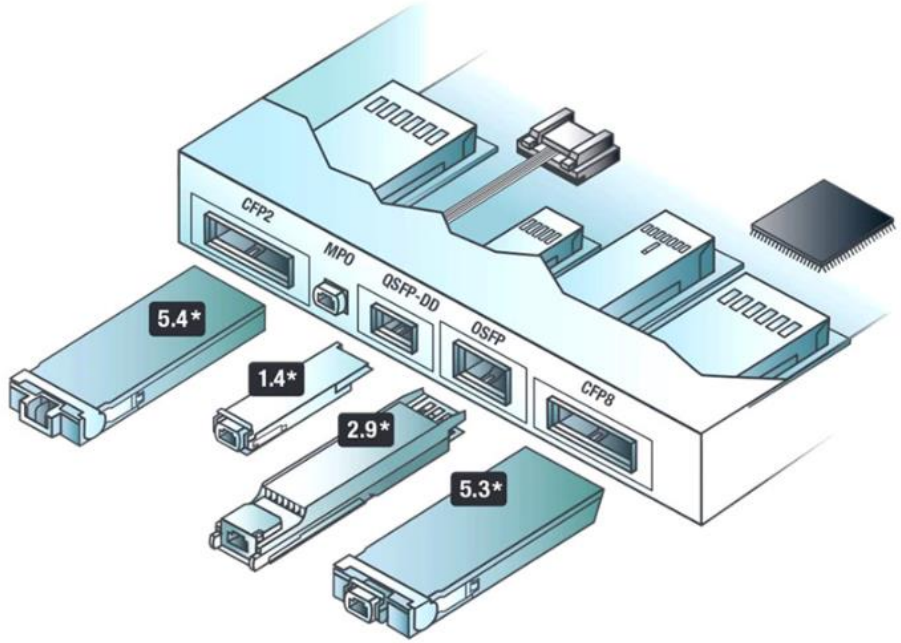
800ZR expected to be available in 2024
- Ramp faster than 400ZR





New pluggable Coherent optics challenges:

- More complexity
- Increased power (heat)
  - but reduced cost per bit
- Network integration



400G Transceivers

Type	Wavelength Channel Modulation	Optical Interface	Baud rate	Reach	Temp range / connector Type	power budget (dB)	Note:
SR8	8 / 850nm Band	8x50G PAM4 MPO	26.5625 GBd	70M on OM3 100M on OM4	0-70°C / MPO	1.9dB	
DR4	4 / 1310nm Band	4x100G PAM4 MPO	53.125GBd	500m	0-70°C / MPO	3dB	
FR4	4 / 1271nm, 1291nm, 1311nm, 1331nm	4x100G PAM4 LC	53.125GBd	2km	0-70°C / LC	4dB	
LR4	4 / 1271nm, 1291nm, 1311nm, 1331nm	4x100G PAM4 LC	53.125GBd	10km	0-70°C / LC	6.3dB	
LR8	8 / 1310nm Band	8x50G PAM4 LC	26.5625 GBd	10km	0-70°C / LC	6.3dB	
ER4	4 / 1310nm Band	4x100G PAM4 LC	53.125GBd	40km	0-70°C / LC	15.5dB	baud rate could be different due to FEC used
ER8	8 / 1310nm Band	8x50G PAM4 LC	26.5625 GBd ?	40km	0-70°C / LC	15.5dB	
ZR coherent (OIF Standard)	16QAM, DWDM, c-Band tunable, ~1528…1567nm	1x400G LC	400G ZR 59.843 GBaud 16QAM modulation	80km	0-70°C / LC		
ZR coherent (Open ZR+ Standard)	16QAM, DWDM, c-Band tunable, ~1528…1567nm	1x400G LC	400G ZR+ 60.138 GBaud 16QAM modulation (400G mode)	~80km...120km with EDFA	0-70°C / LC	<5dB	
ZR coherent (Open ZR+ Standard)	16QAM, DWDM, c-Band tunable, ~1528…1567nm	1x400G LC	400G ZR+ 60.138 GBaud 16QAM modulation (400G mode)	120+ km	0-70°C / LC		

IP over DWDM

IP over DWDM (**IPoDWDM**) is used to integrate Routers/Switches directly over DWDM - ITU-T G.709
(Without the need for Transponders)

In this way IP devices can monitor the optical path and implement the transport functionality as FEC (Forward Error Correction) specified by ITU-T G.709/Y.1331 or Super FEC functionality defined in ITU-T G.975.1.

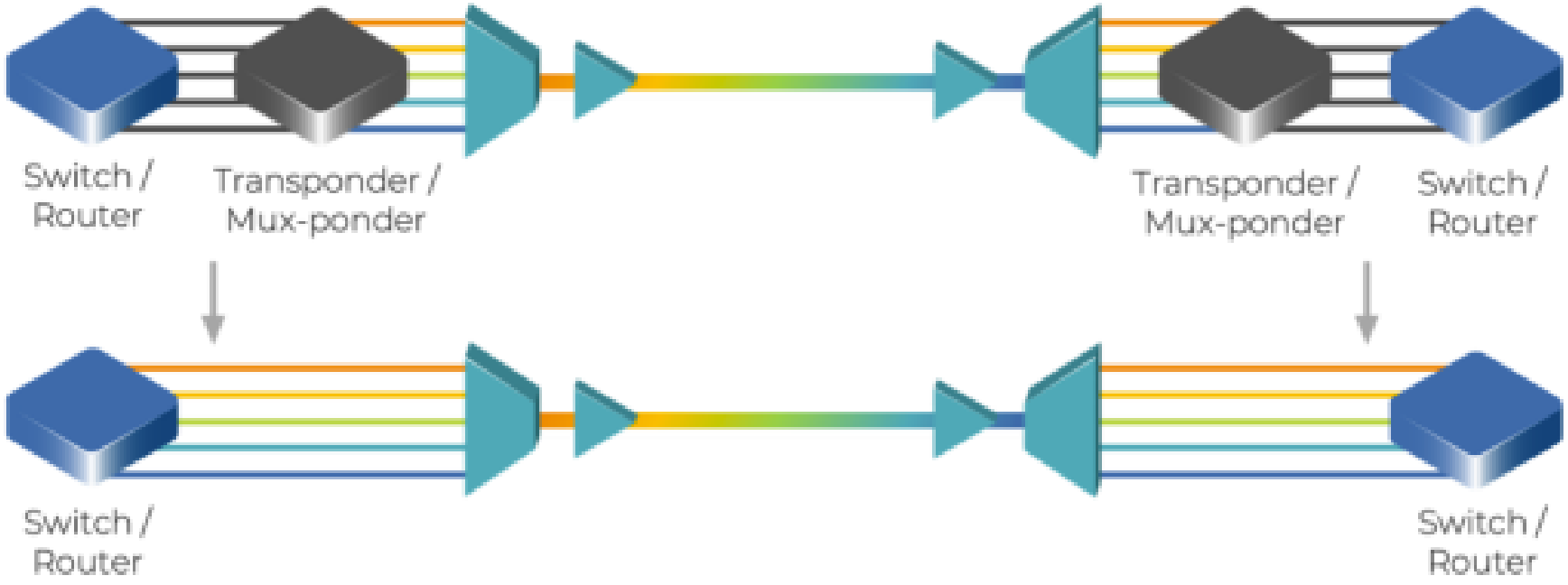
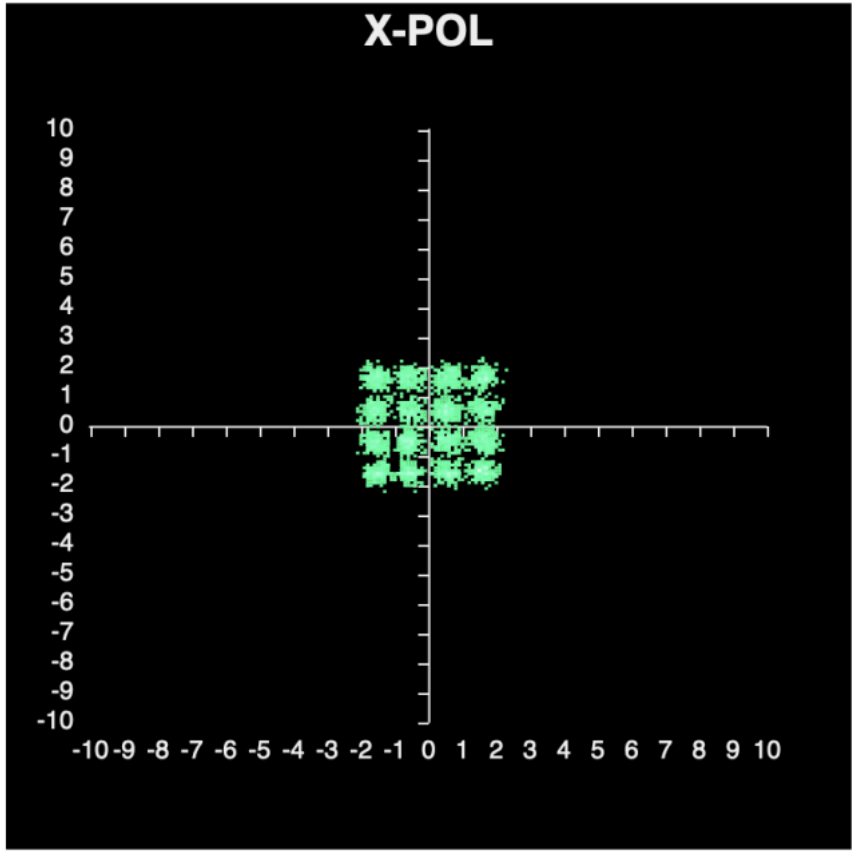
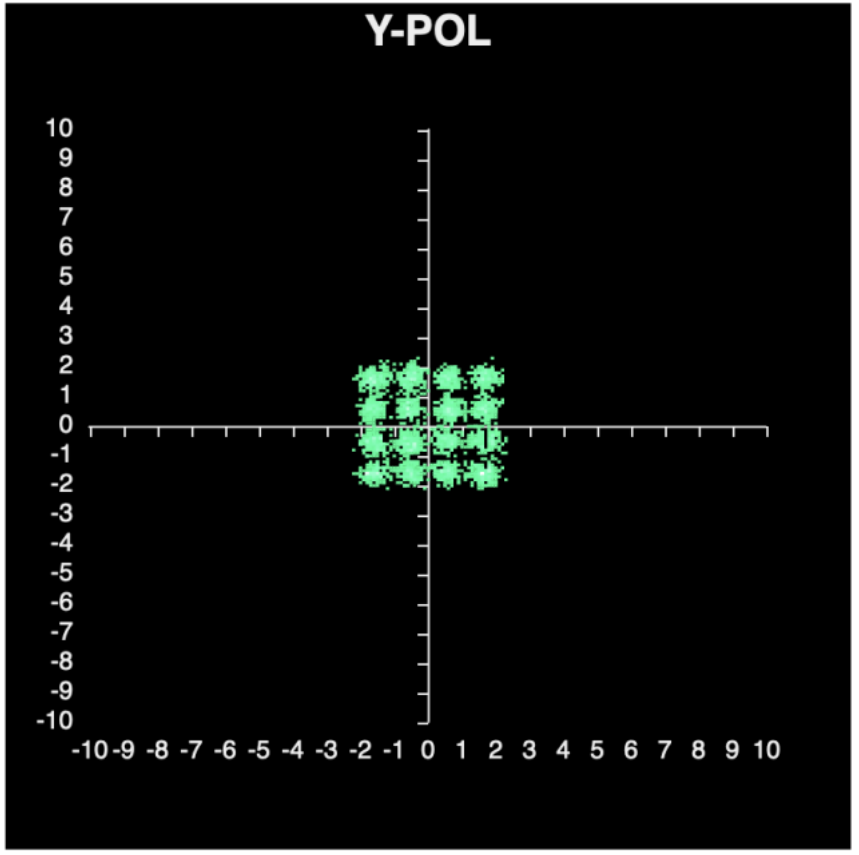


Figure 1. Traditional versus IPoWDM network architecture.

200G 16QAM Constellation

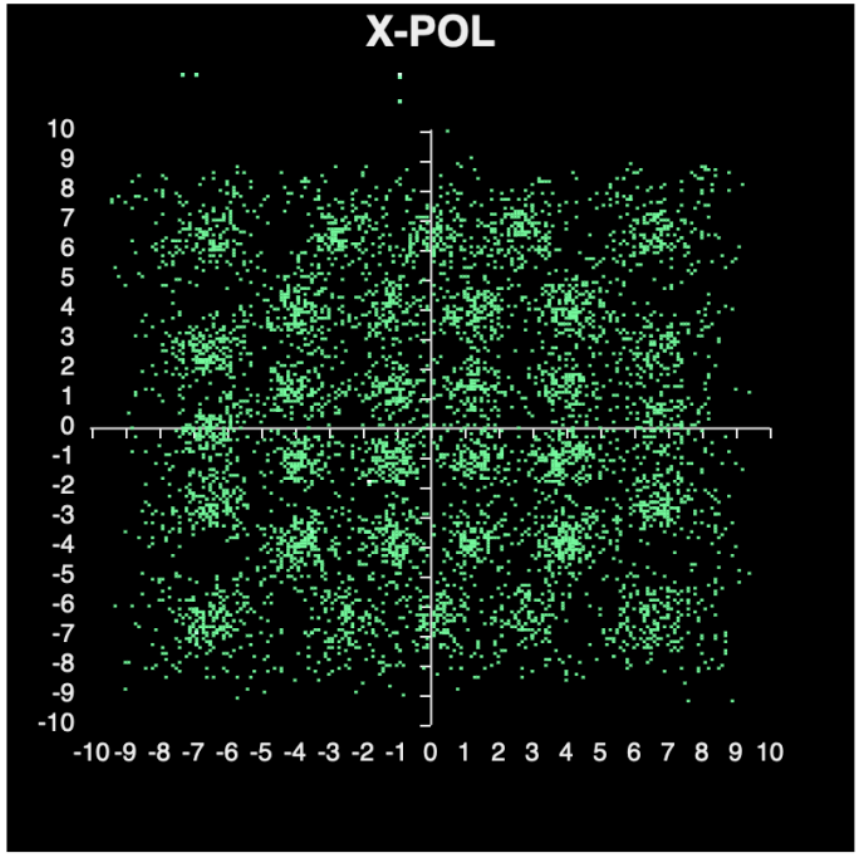
Constellation : port-1/1/1

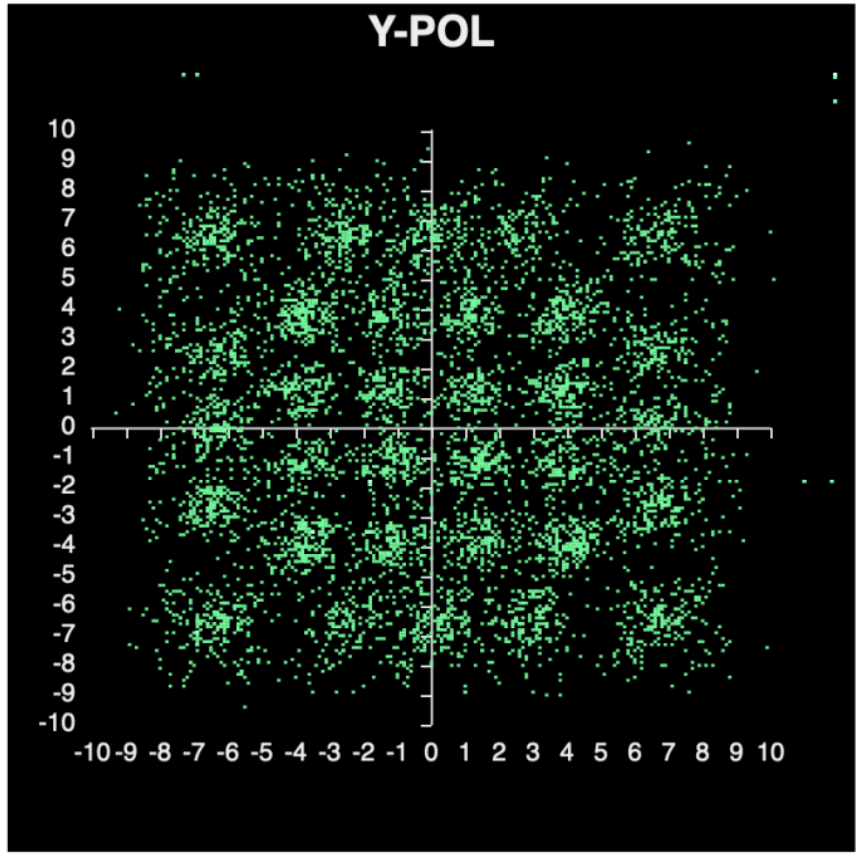




600G 32/64QAM Constellation

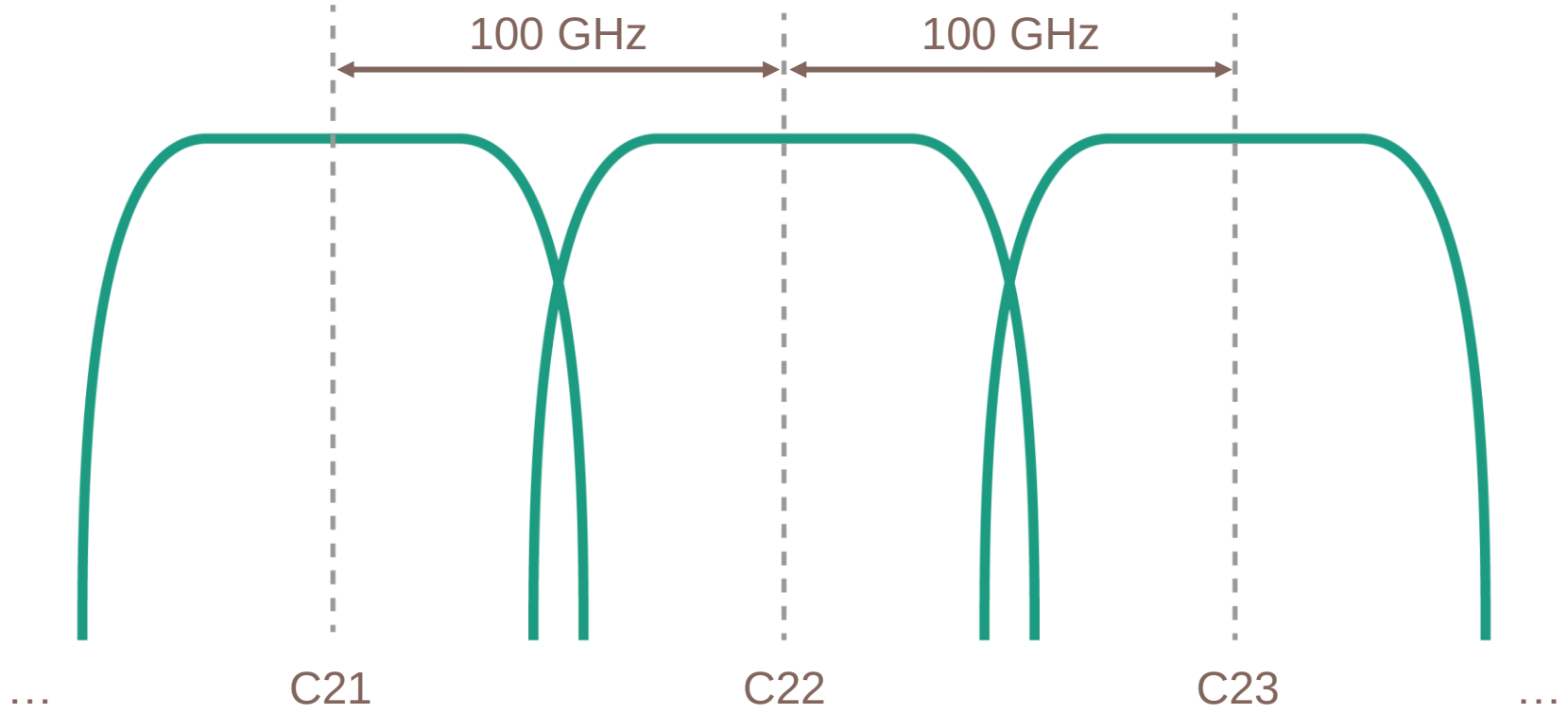
Constellation : port-1/1/1





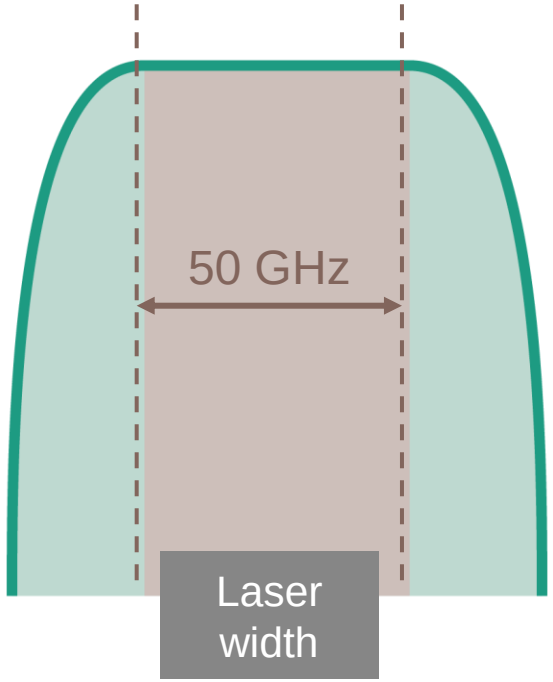
DWDM Grid Spacing

ITU G.694.1 standard DWDM region is from 1528.77 nm to 1563.86 nm that resides mostly within the C band.
A typical DWDM system would use 40 channels at 100 GHz (0.8nm) spacing.



WDM Passband

- Although the grid is100GHz, the passband of a DWDM generally is 50GHz
- This means that the laser has a 50GHz window to pass through

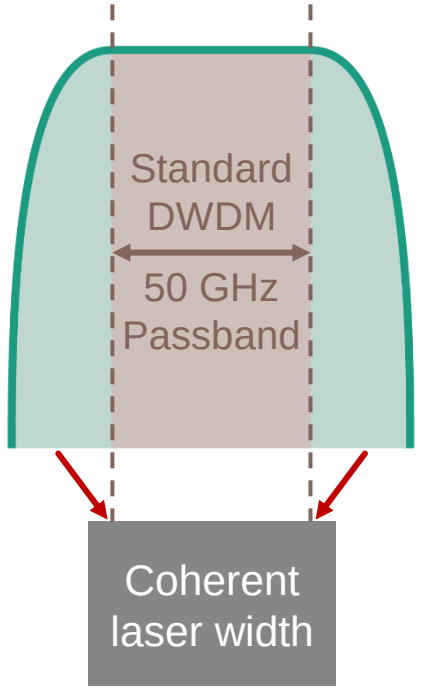


400G Coherent Lasers

- 400G is becoming more widely used
- Multiple 400G connections are increasingly being deployed
- The fastest/easiest to deploy and by far most cost-effective solution is passive optical multiplexing

However…

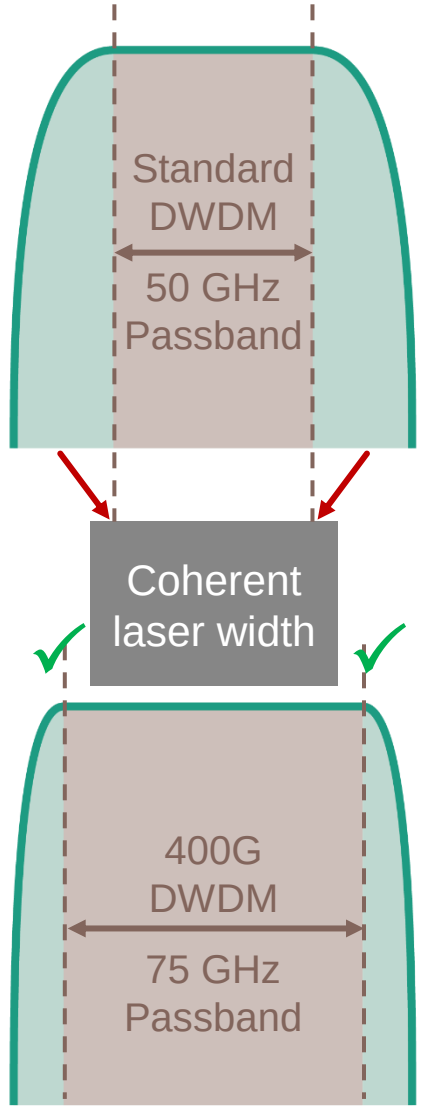
- 400G Coherent DWDM transceivers are available but their channel width is slightly broader than the usual DWDM transceiver
- Result is that the 50GHz DWDM **passband** of standard 100GHz grid multiplexers isn't always wide enough to work with some 400G Coherent optics



75GHz Passband

400G coherent passband

- You need a 75GHz passband for 100GHz DWDM grid
- 75GHz passband is wide enough for 400G coherent transceivers
- Will work with other (10G, 100G) DWDM transceivers



Vendor specific problems

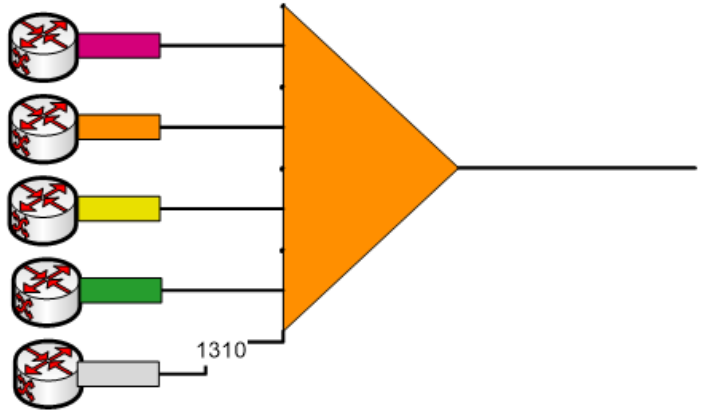
Could get the carrier wave running at 600G/64QAM, but it's out-of-spec:
the bit-error rate is unsuitable for production use.

- **The 600G modulation needs a 75GHz passband**

Still needed to support lower speed services, eg 1G / 10G

DWDM n*400G Coherent

N*400G Passive Optical Multiplexer

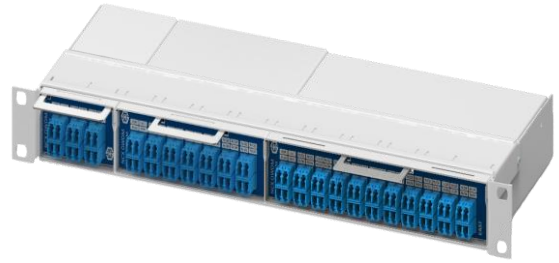


Option 1:

- Use 200GHz spaced DWDM muxs

Option 2:

- Use muxs capable of supporting 75Ghz passband



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Many thanks

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Connecting – today and beyond