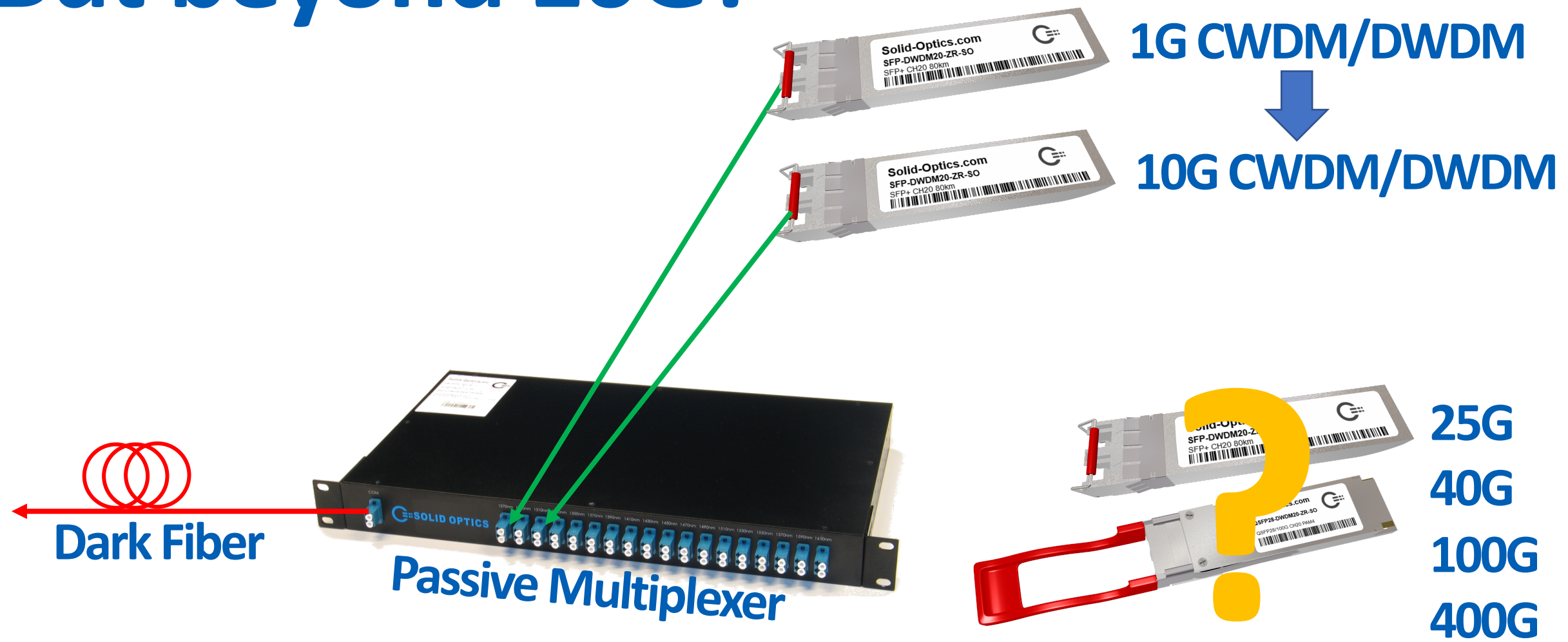




**Future of passive multiplexing
&
Multiplexing beyond 10G**

From 1G to 10G was easy But beyond 10G?

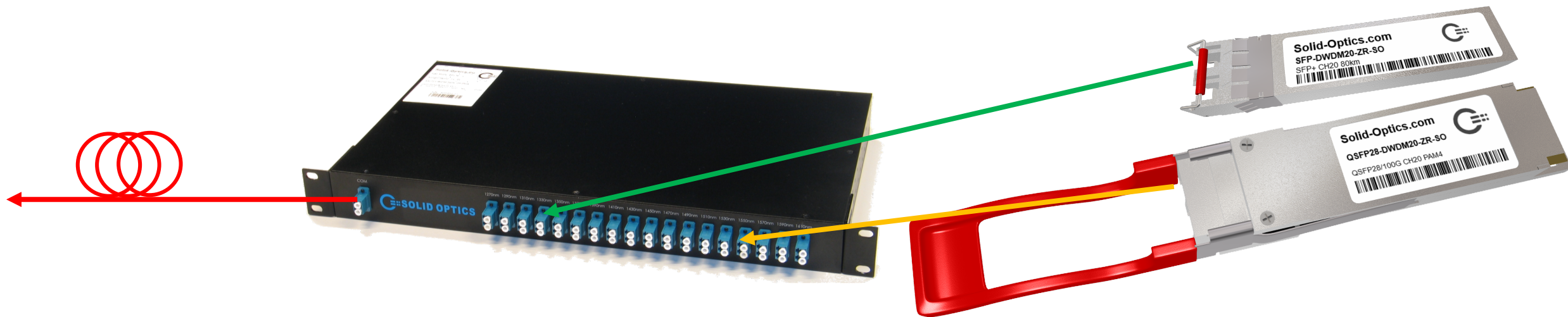


Ingredients for Multiplexing

1 Dark Fiber

2 Multiplexer

3 Light + Transceiver

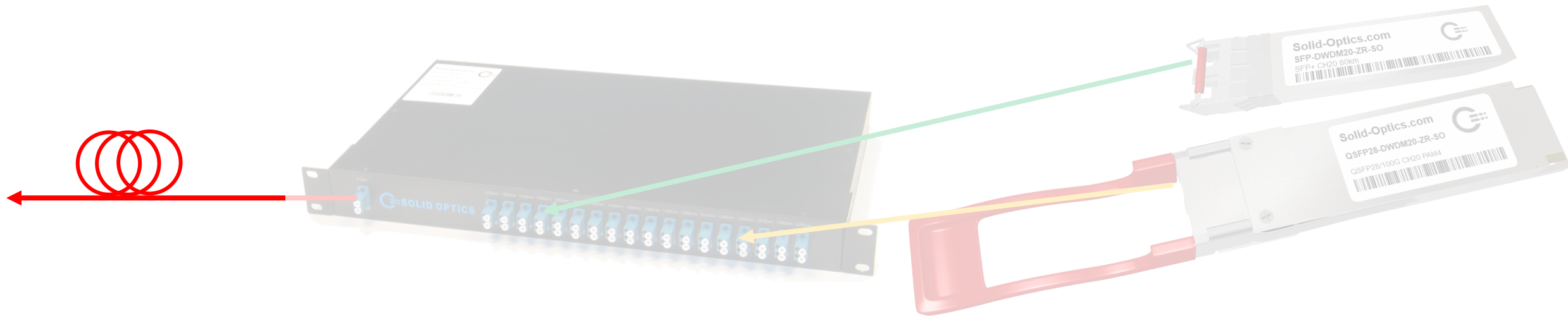


Ingredients for Multiplexing

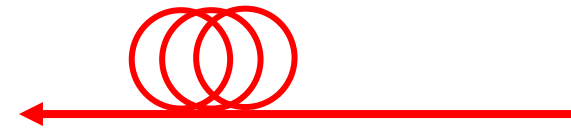
1 Dark Fiber

2 Multiplexer

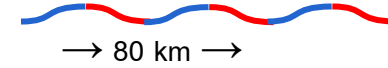
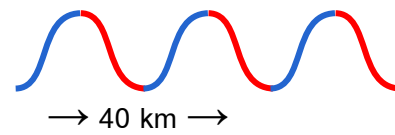
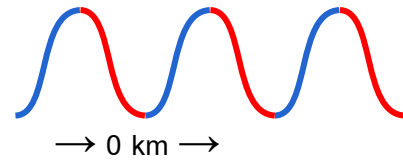
3 Light + Transceiver



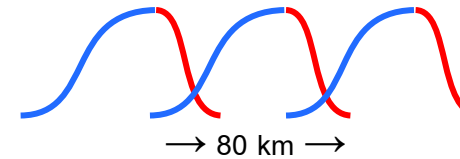
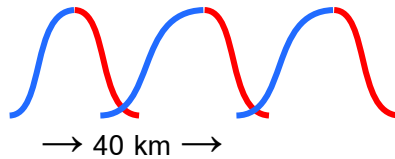
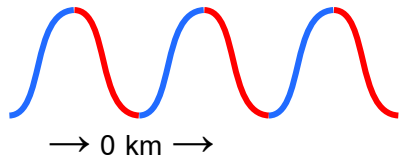
Dark Fiber



Attenuation

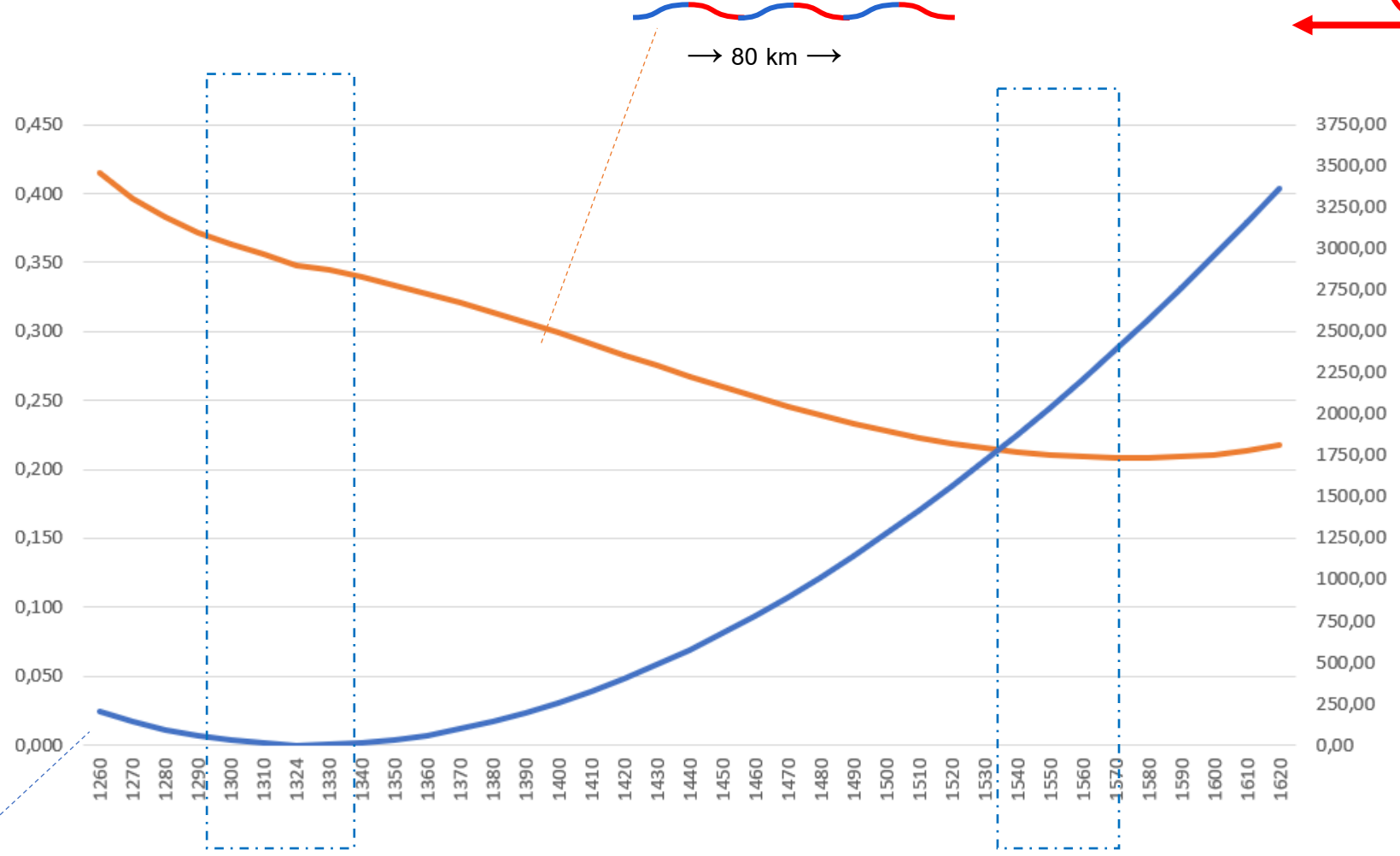
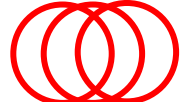


Dispersion



Dark Fiber

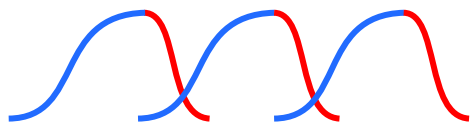
Attenuation



1310nm window

1550nm/DWDM

Dispersion



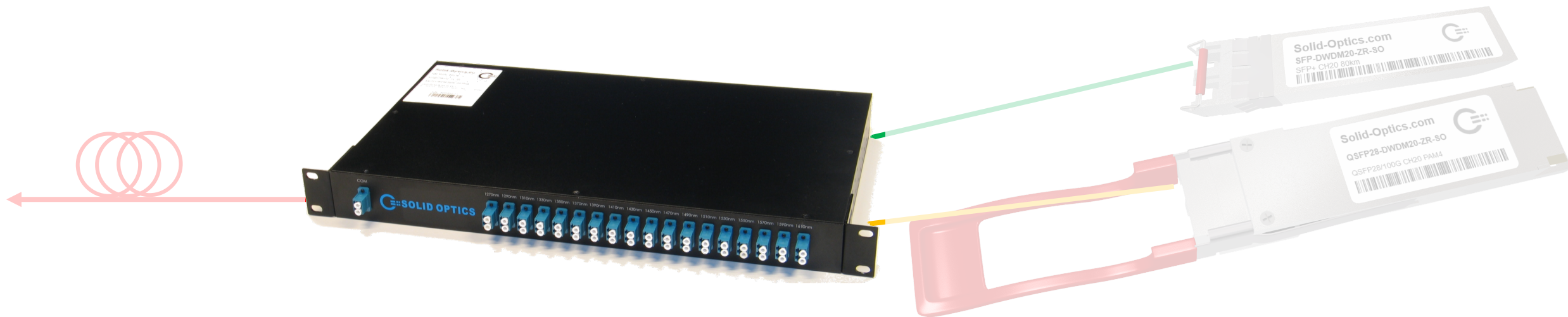
→ 80 km →

Ingredients for Multiplexing

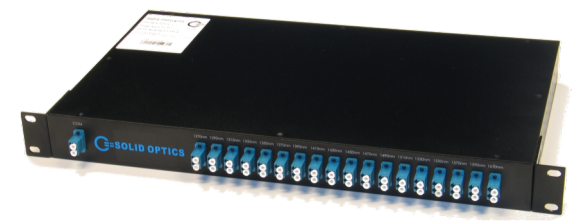
1 Dark Fiber

2 Multiplexer

3 Light + Transceiver



Multiplexers



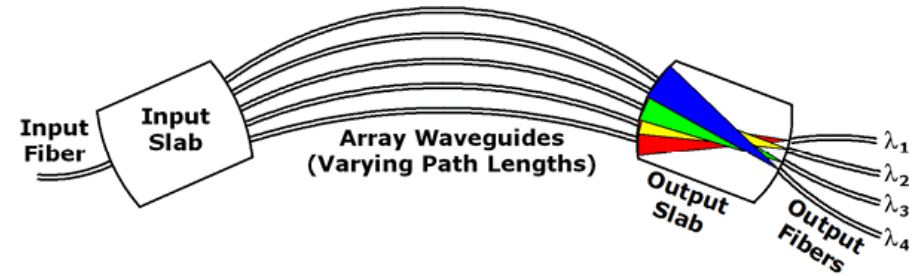
2 types

- Cascaded TFF



95% of all communication

- AWG

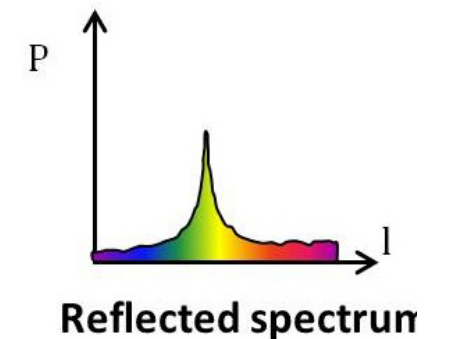
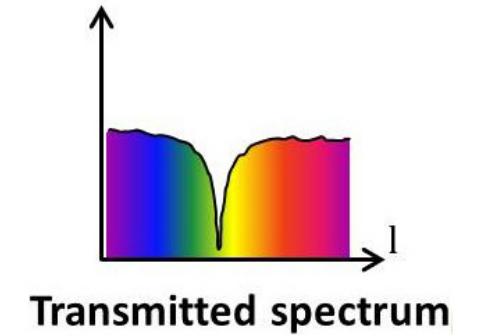
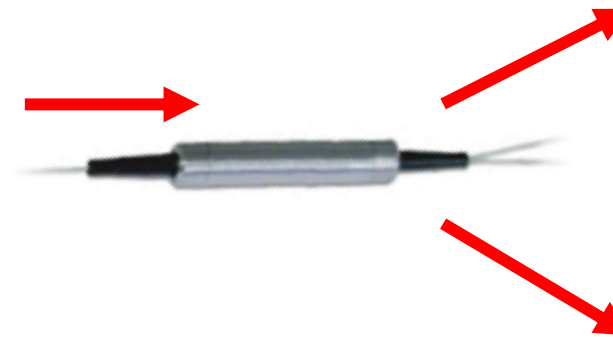
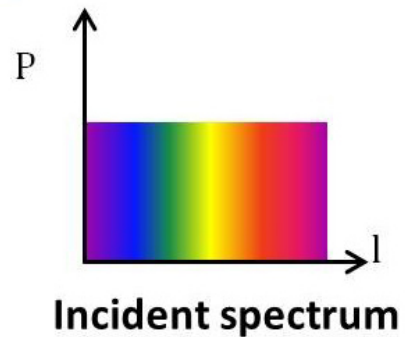
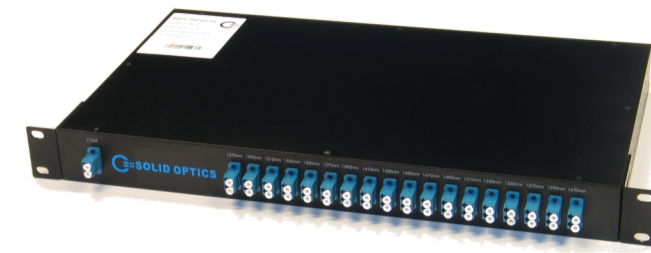


-Larger muxes such as
40Ch/96Ch

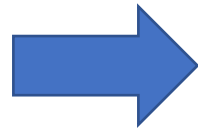
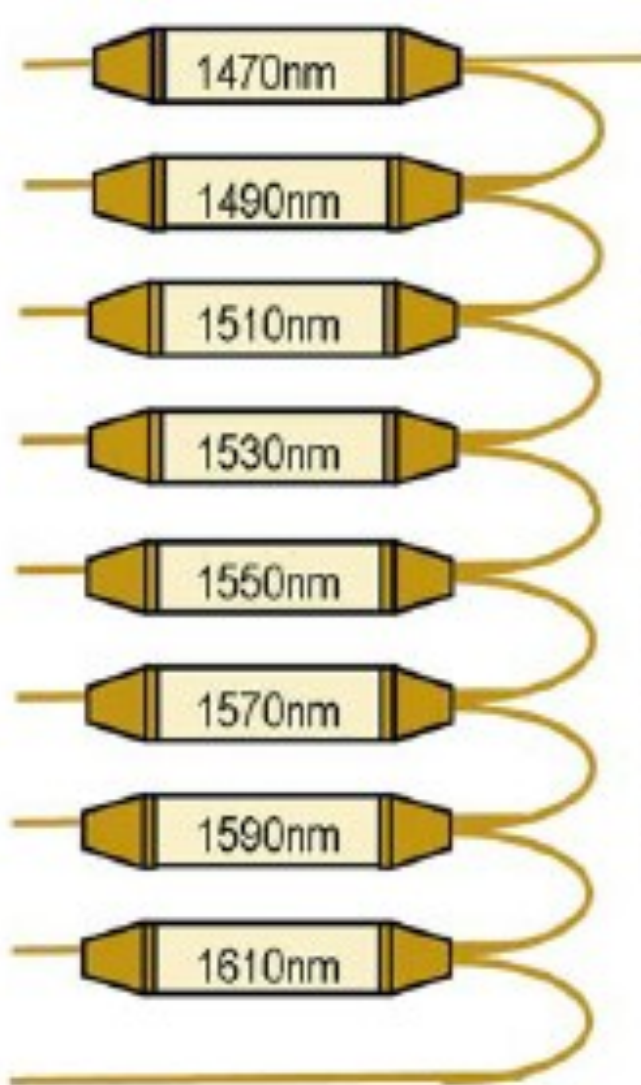
Multiplexers

TFF: Thin film filter

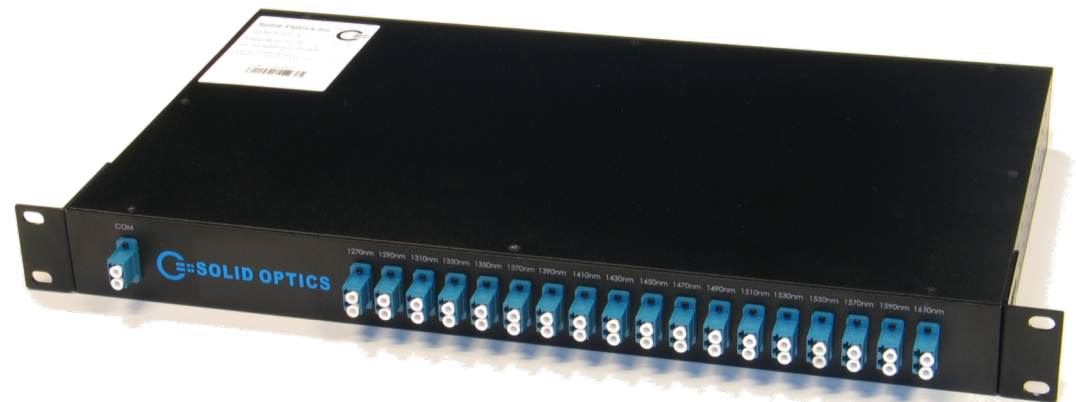
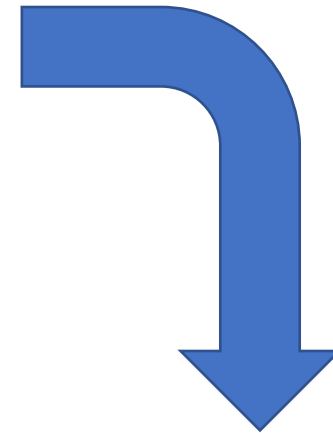
- Metal or glass tubes 2cm*4mm
- 3 fibers: com / color / reflect
- Each tube as 0,3dB loss
- 95% of muxes & OADM



Multiplexers



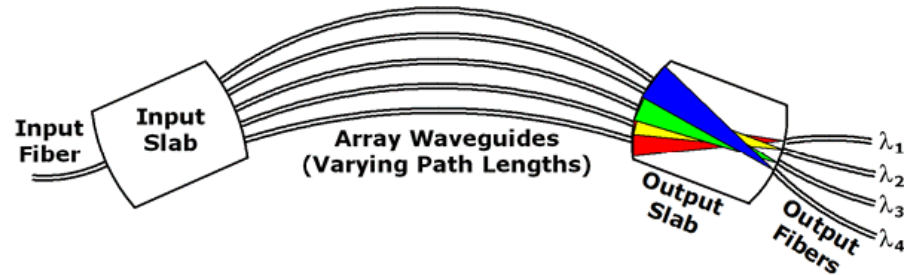
ABS casing



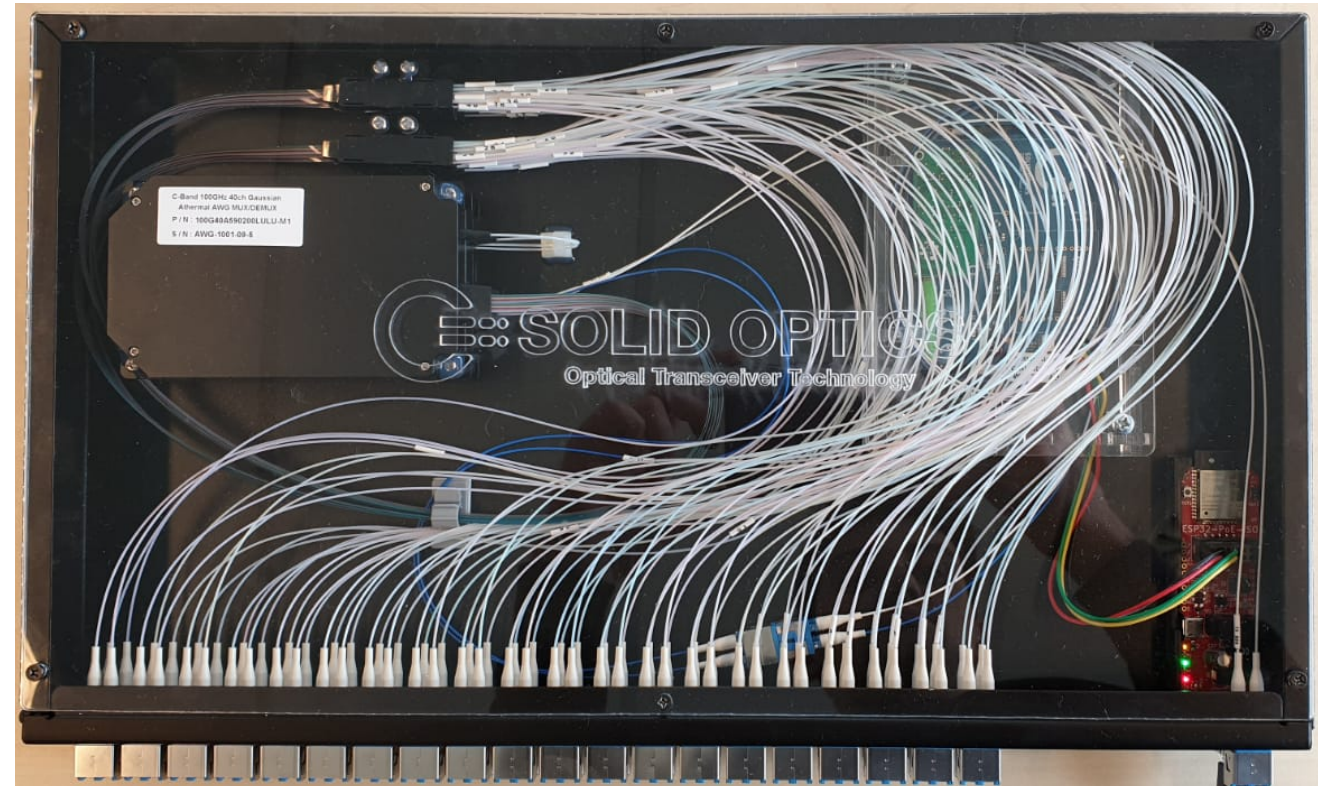
Multiplexers



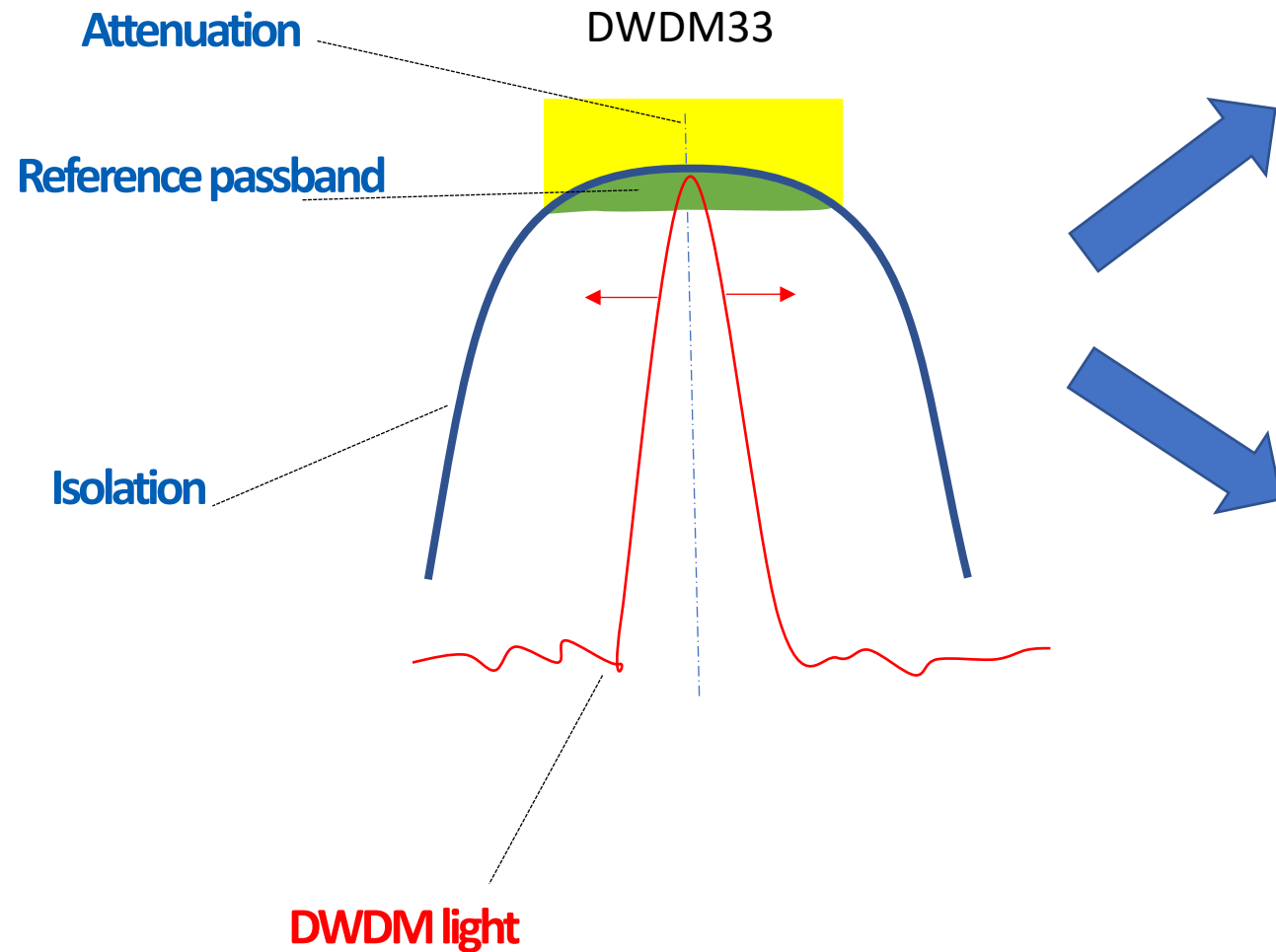
AWG: arrayed wave grading



- Larger muxes such as 40Ch/96Ch
- Lower loss
- insertion loss 40ch = 3,0dB

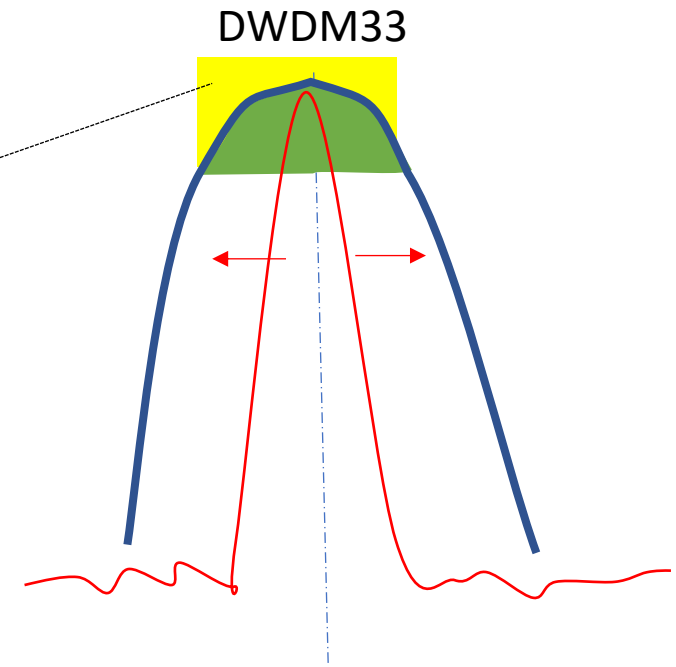


Transmission Window AWG



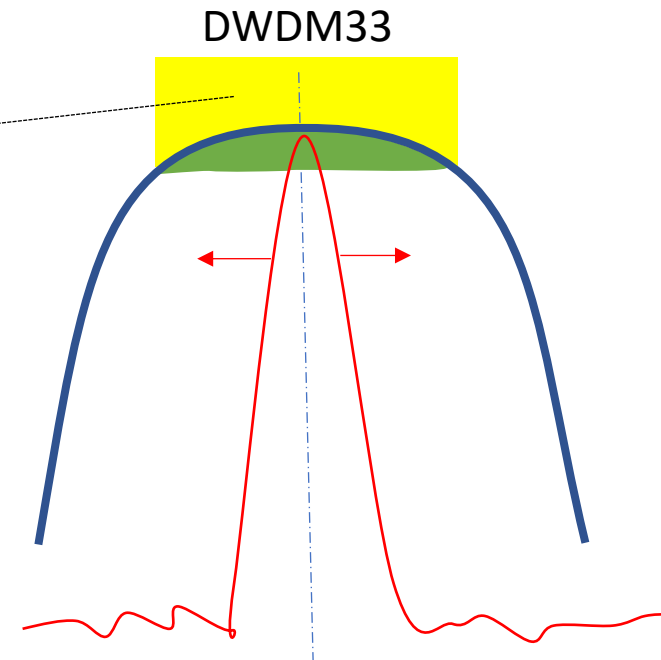
Gaussian Fit

Low attenuation
Small passband



Flat top

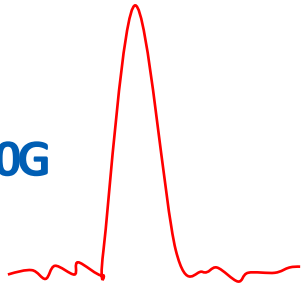
Higher attenuation
wide passband



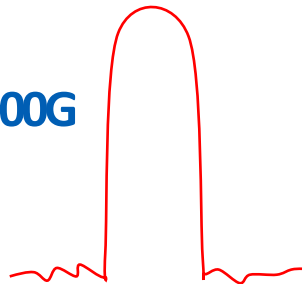
ALL TFF is Flat top

Transmission Wave types

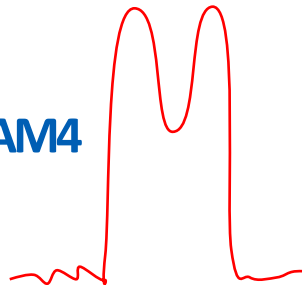
DWDM 10G



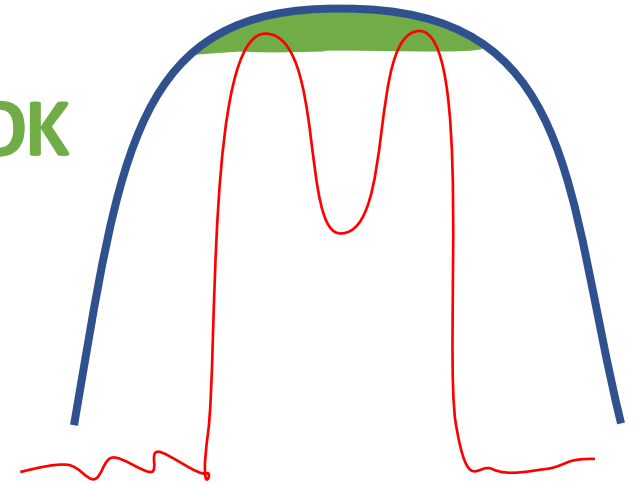
Coherent 100G



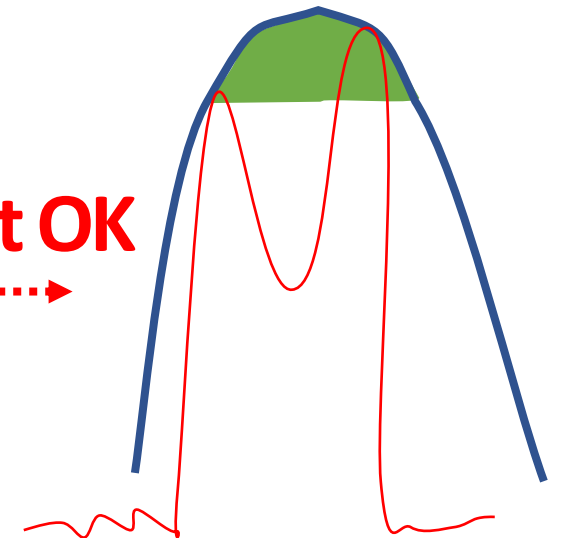
DWDM PAM4



Flat top: OK



Gaussian Fit not OK

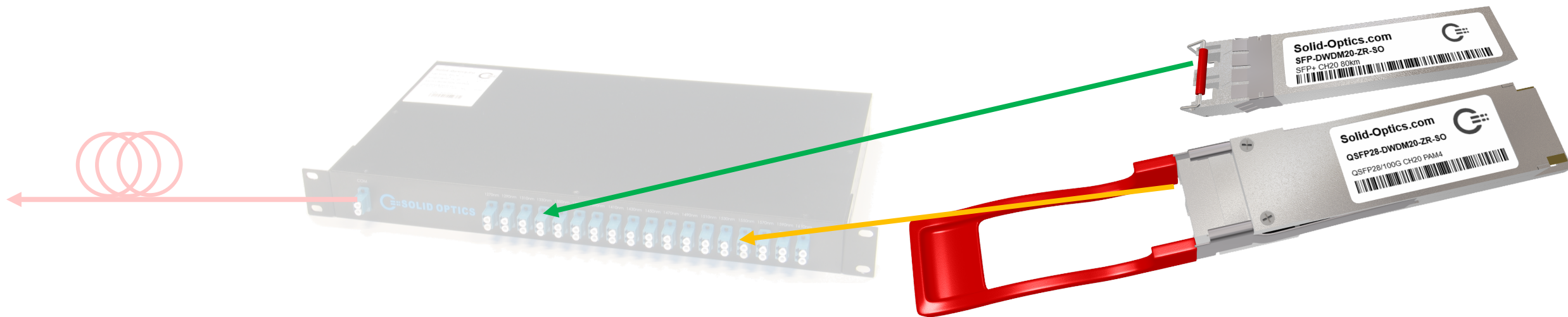


Ingredients for Multiplexing

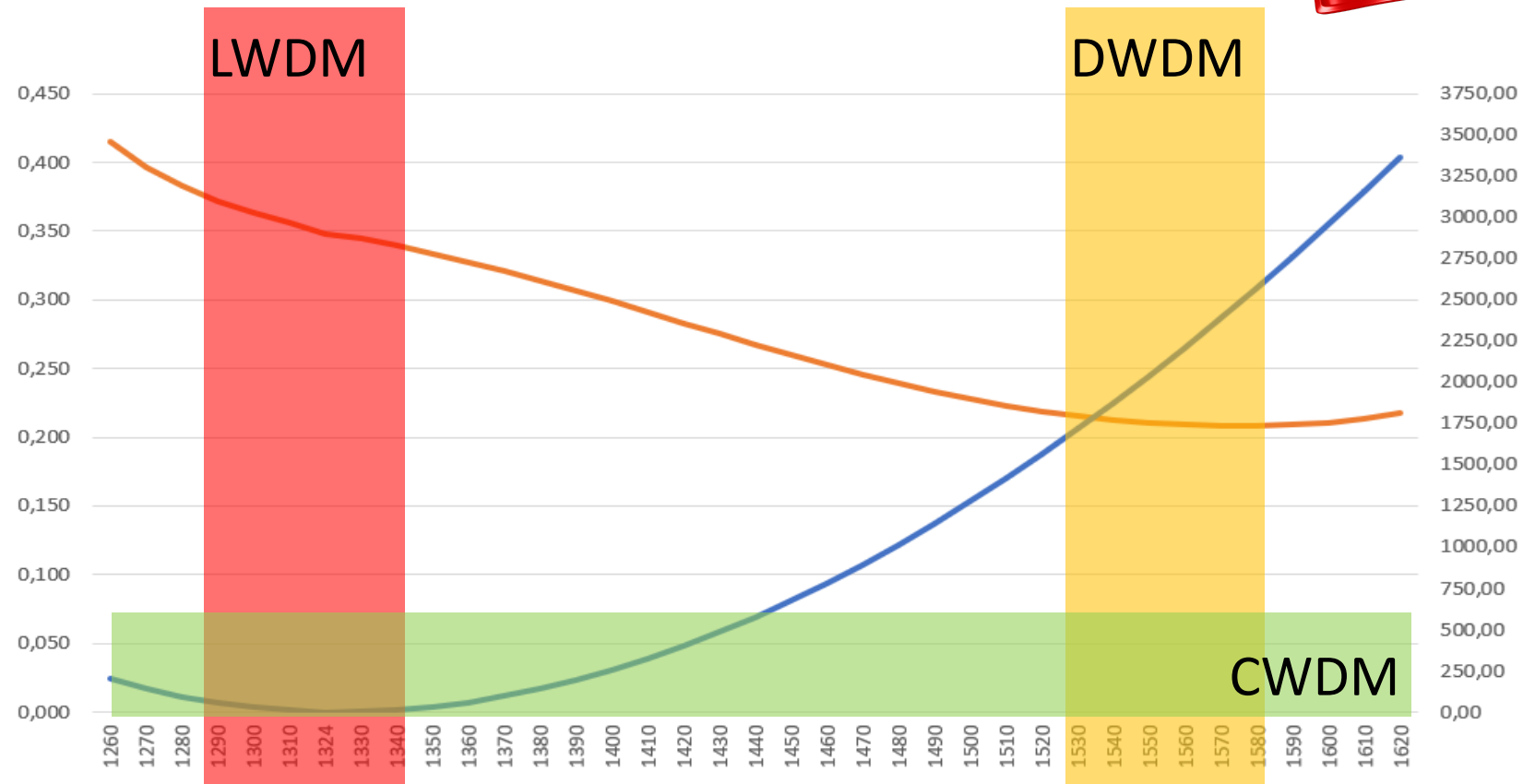
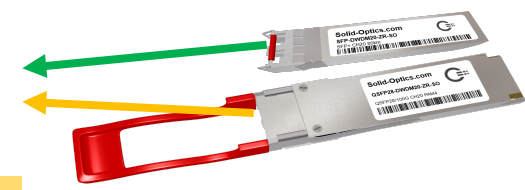
1 Dark Fiber

2 Multiplexer

3 Light + Transceiver

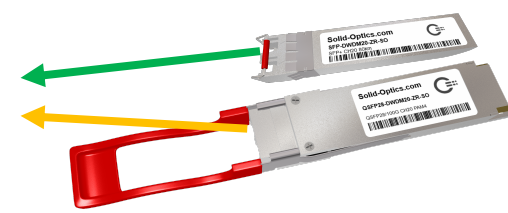


ITU grids



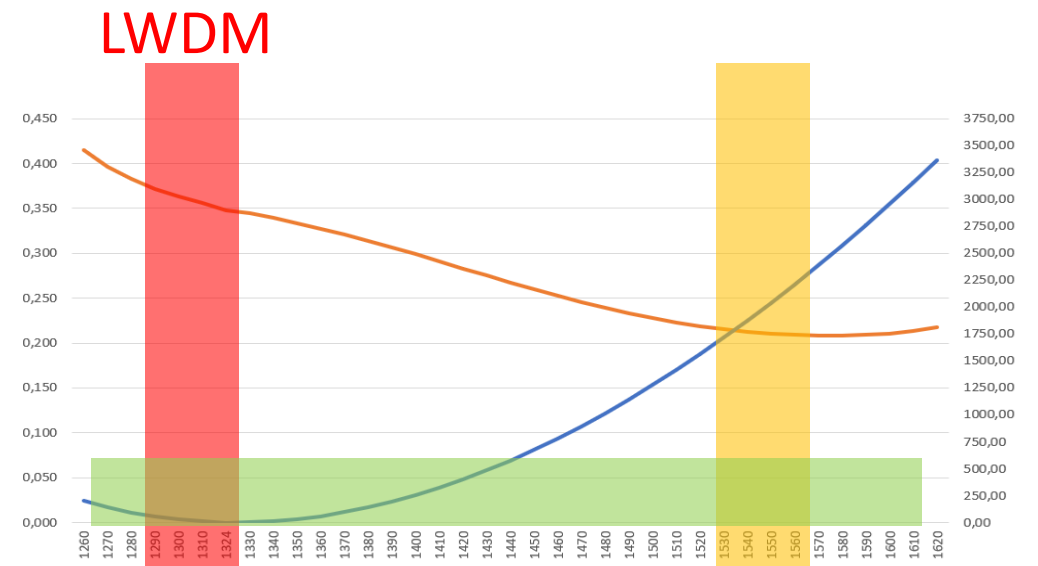
	Attenuation	Dispersion	10G	25G/100G
DWDM	Low	High	80km	15km
LWDM	High	Low	40km	40km

LWDM multiplexing

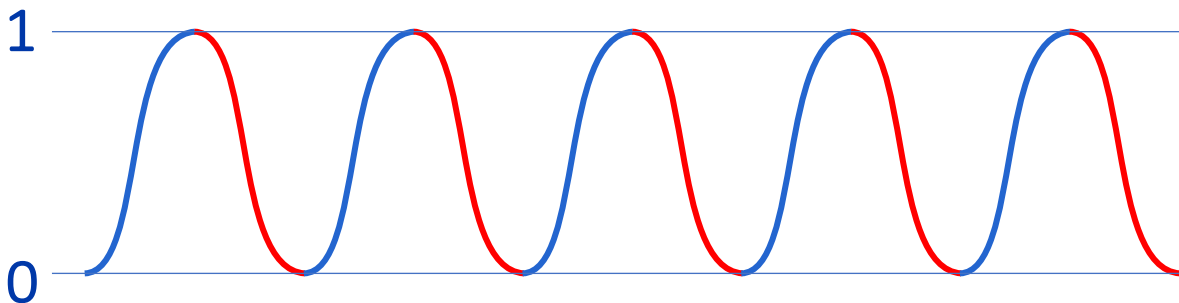
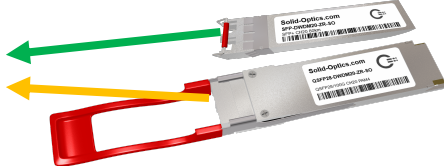


New ITU band

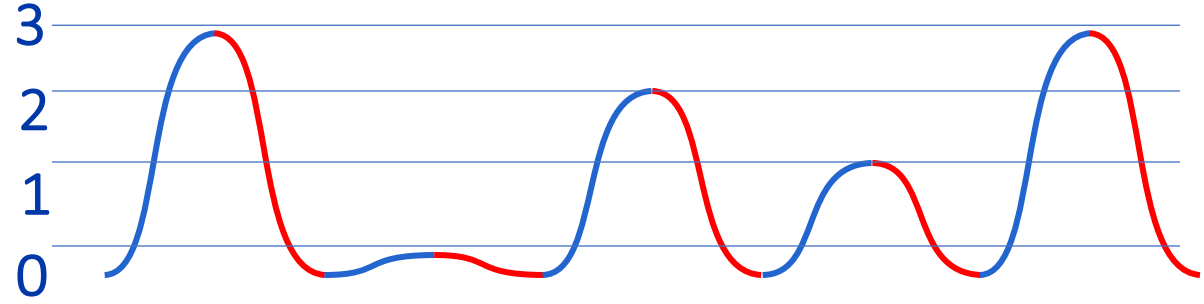
- 8 channels in the 1310nm band
- 8 x 25G multiplexing up to 40km
- regular optics and regular passive muxes
- possible 8x 100G up to 15km(future)
- used in Korea a lot for 5G deployment



Modulation & Coherent 100G

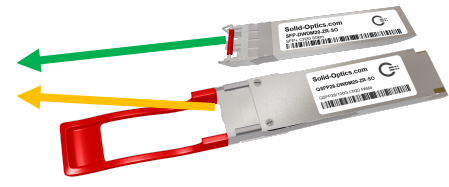


DSP chip



More info per "pulse"
Needs a lot of processing power = Watts
Example CFP2-DCO = 20 Watts
QSFP28 is 4,5W so cannot work
Extra "active box" for the CFP2-DCO

QSFP28 DWDM



100G DWDM in QSFP28

PAM4 modulation

Due to modulation no optical power budget

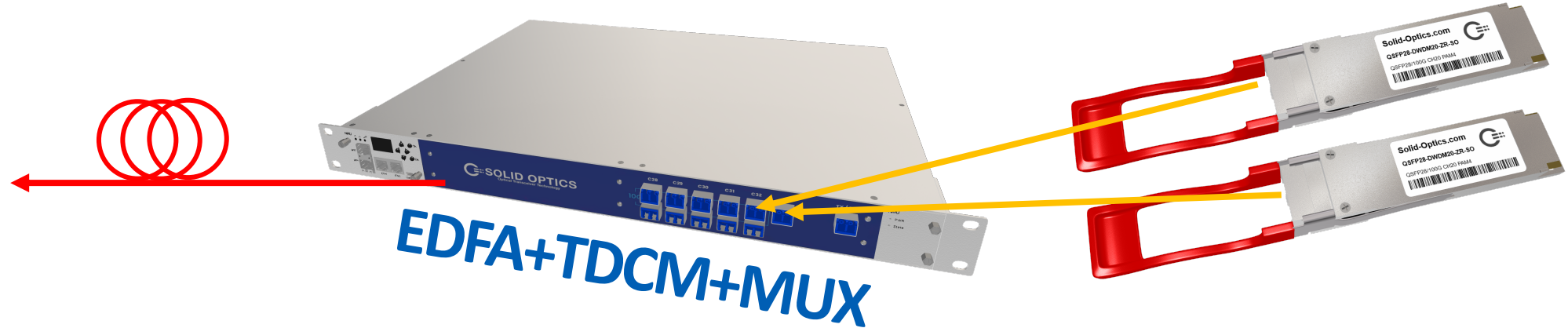
Need Amplification = EDFA to work

PAM4 needs Dispersion Compensation

Cheapest and easiest 100G Multiplexing method

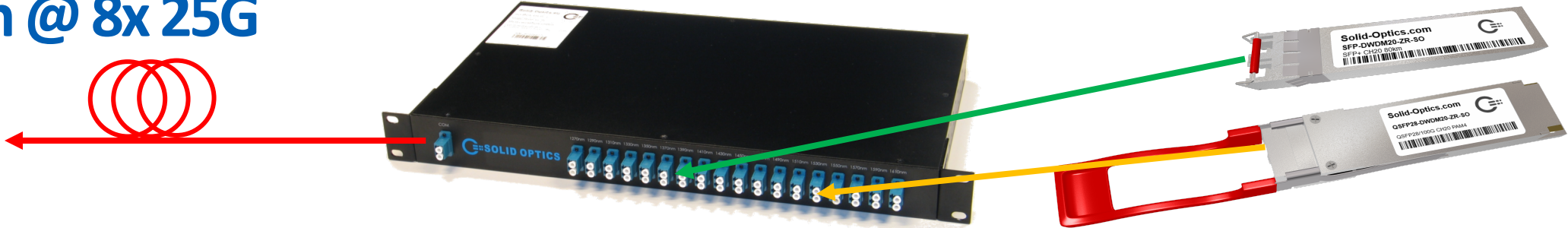
Microsoft pushed this product

Solid Optics offer “All in one box” for 16 x 100G



Summery

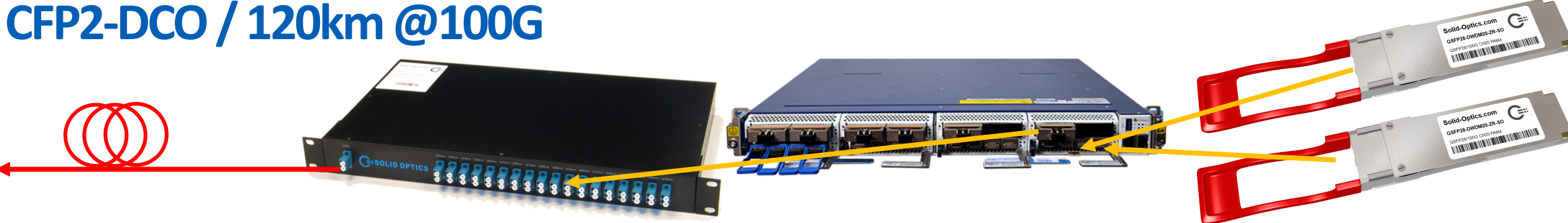
LWDM / 40km @ 8x 25G



QSFP28 / 80km @ 100G



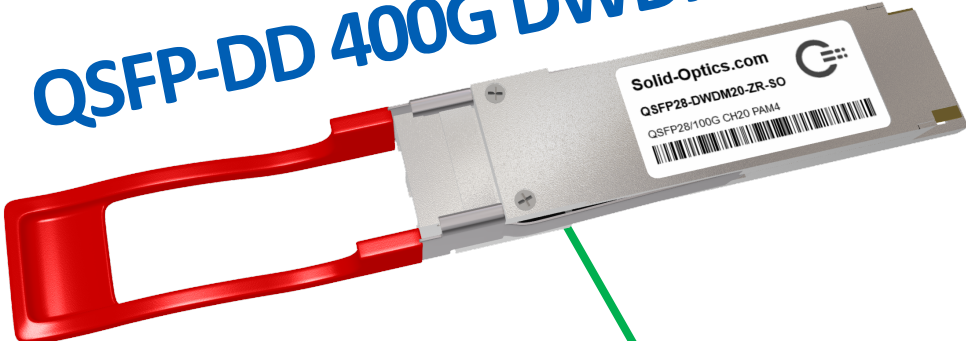
CFP2-DCO / 120km @ 100G



400G ZR is coming !!



QSFP-DD 400G DWDM



1G DWDM ZR



10G DWDM ZR



400G DWDM ZR

Dark Fiber



Passive Multiplexer

Q & A

Wouter van Diepen
wouter@solid-optics.com

