4 x 25 G WDM of 200 GHz Grid for Both 10 km & 40 km Distance Objectives

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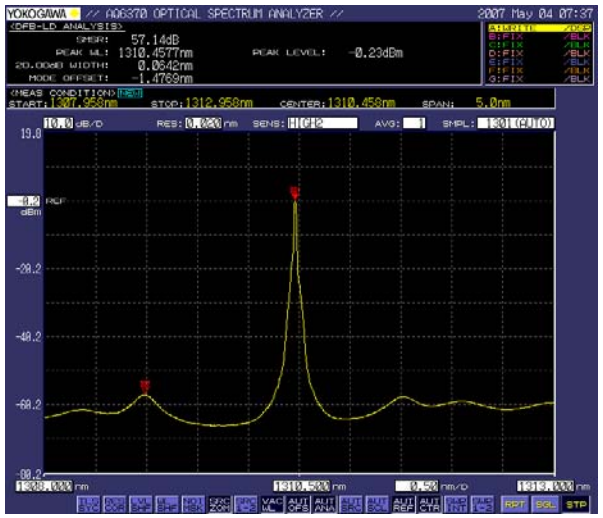
Background

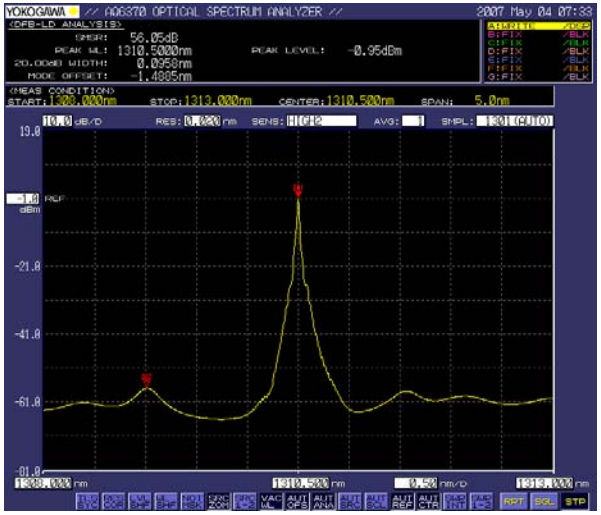
- Laser transmitter spectral width broadens when modulated due to
  - Intrinsic Modulation bandwidth
  - Chirping
- Dispersion penalty increases due to increased spectral width
- 4x25G CWDM PMD is subject to large dispersion penalty over 10km single mode fibers

Spectral Width Broadening due to Modulation @ 10G

EML

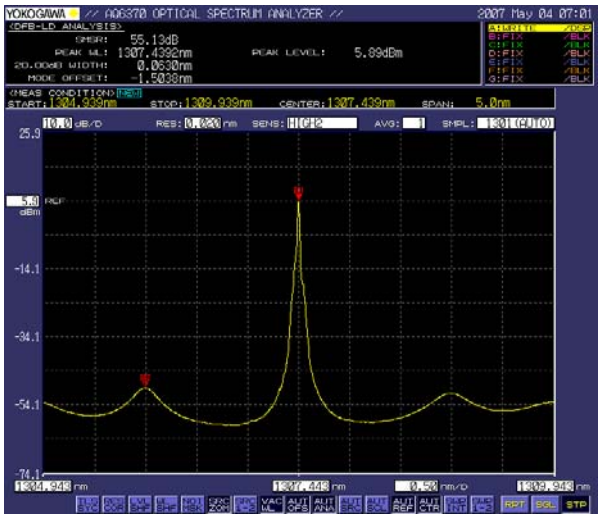


20dB Δλ RMS 0.06nm @ CW

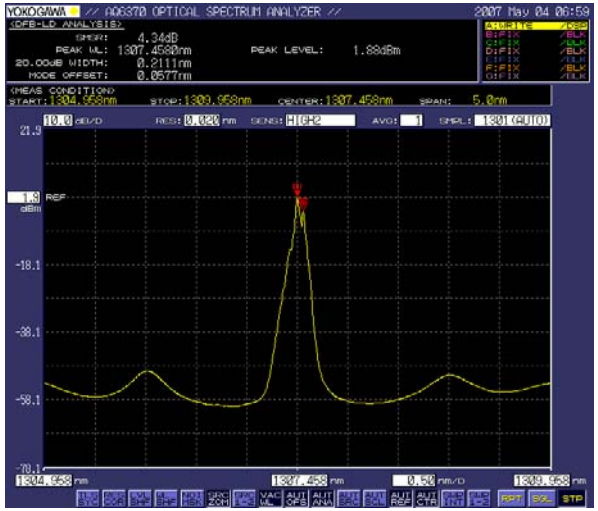


20dB Δλ RMS 0.10nm @ 10G

DML

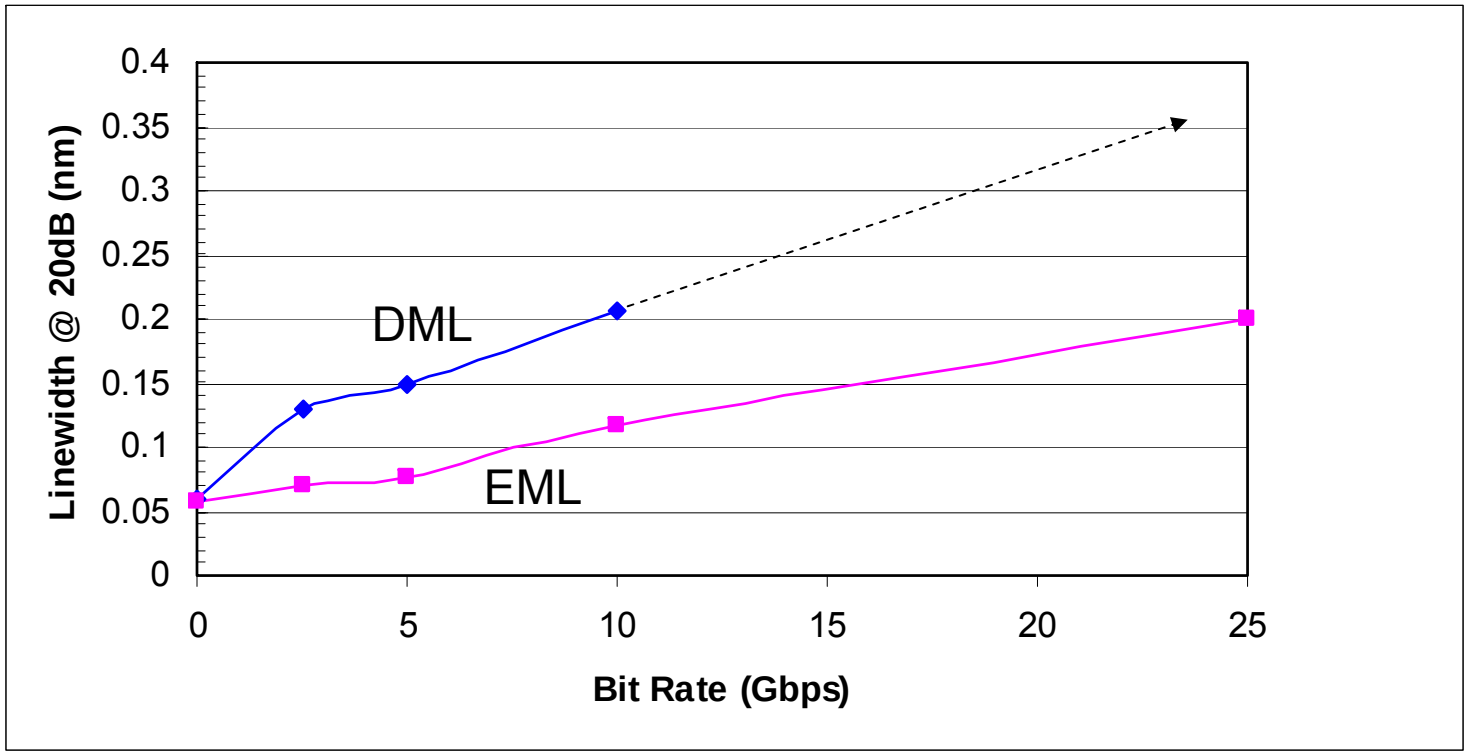


20dB Δλ RMS 0.06nm @ CW



20dB Δλ RMS 0.21nm @ 10G

Spectral Width Broadening Trend to 25G



EML spectral width broaden to around 0.2 nm @ 25G
DML spectral width is projected to be around 0.4 nm @ 25G

SMF-28 Dispersion

$$D_\lambda = S_0/4(\lambda - \lambda_0^4/\lambda^3)$$

Where

$S_0 = 0.092$ ps/(nm^2 km)

$\lambda_0 = 1302 – 1322$ nm (spec by Corning)

Dispersion Induced Bit Rate & Distance Limitation

Reference

G. P. Agrawal, *Fiber-Optic Communication Systems*, John Wiley & Sons, Inc., 1997

Optical source with a large spectral width:

$BL|D|\sigma_\lambda \leq ¼$ (5.2.2)

Optical source with a small spectral width:

$B(|\beta_2|L)^{½} \leq ¼$ (5.2.3)

Where

B is bit rate

L is distance

D is dispersion coefficient

σ_λ is RMS spectral width

β_2 is GVD parameter and relates to *D* by

$D = - (2\pi c/\lambda^2)\beta_2$

Assumptions

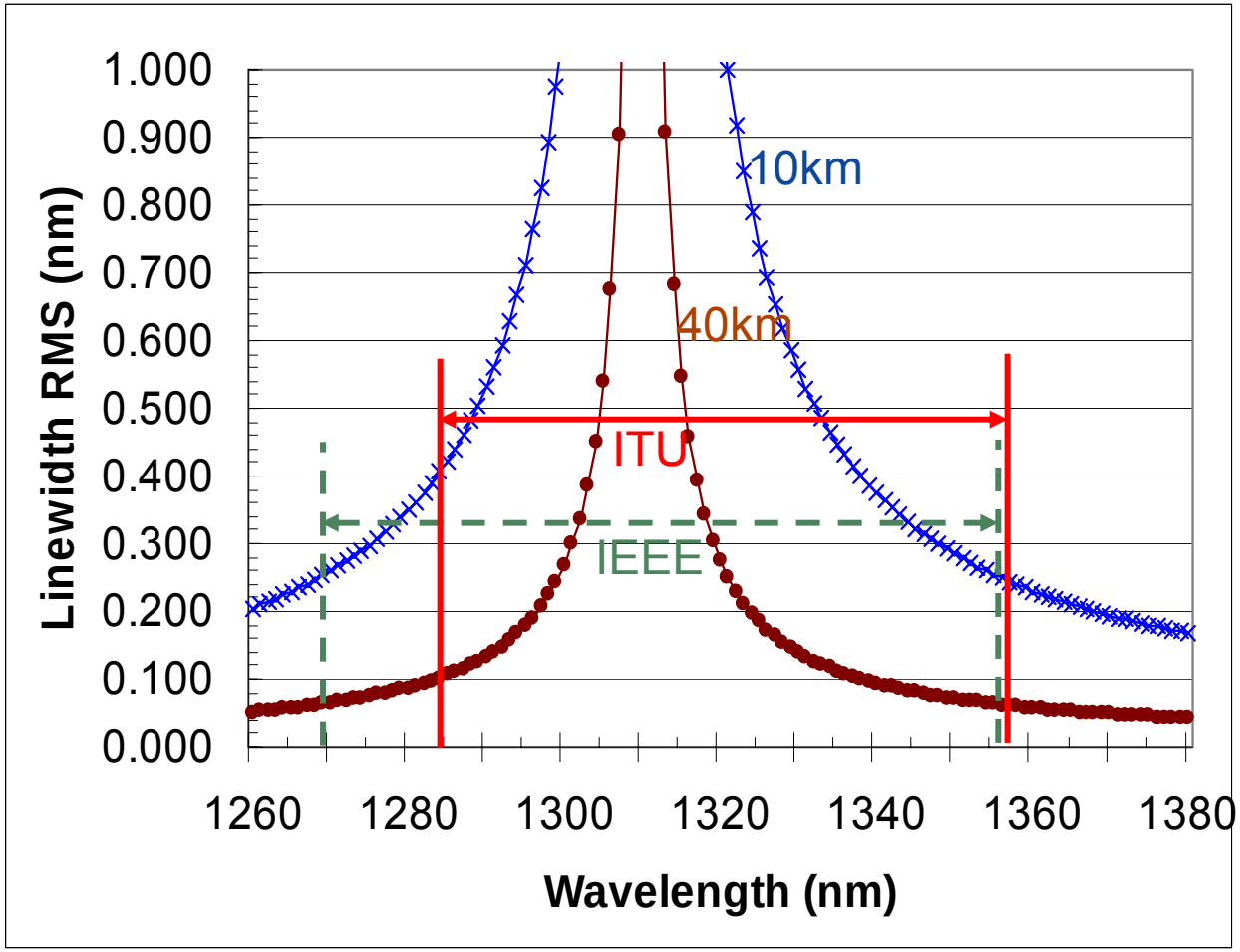
1. Gaussian pulse (a narrower shaped pulse, such as super-Gaussian, broadens faster.)
2. Chirp negligible (DML is typically negatively or down chirped, and broadens faster.)
2. Wavelength away from zero-dispersion wavelength

CWDM Wavelengths around Zero Dispersion Wavelength

- IEEE:
  - 1275.7 nm, 1300.2 nm, 1324.7 nm, 1349.2 nm
    - Channel bandwidth 13.4 nm
  - Wavelength range: 1269.0 nm – 1355.9 nm
    - Span of 86.9 nm
- ITU:
  - 1291 nm, 1311 nm, 1331 nm, 1351 nm
    - Channel bandwidth 13 nm
  - Wavelength range: 1284.5 nm – 1357.5 nm
    - Span of 73.0 nm

RMS Spectral Width Requirement *vs*. Wavelength for 10km and 40km with Large Spectral Width Source @ 25 Gbps

Assuming Nominal Fiber Minimum Dispersion Wavelength @ 1310 nm

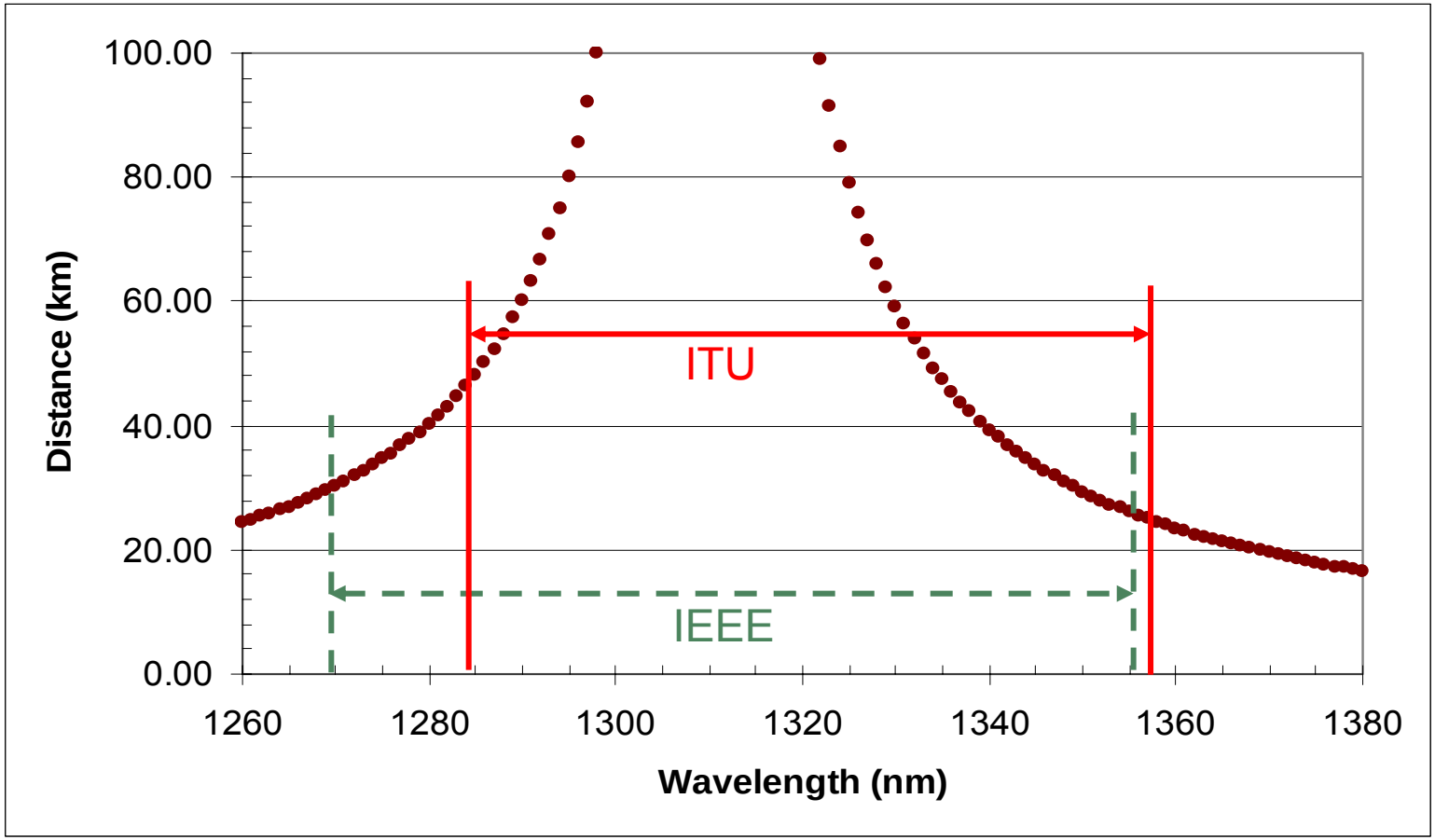


Spectral width for CWDM

	10 km	40 km
IEEE	0.25 nm	0.06 nm
ITU	0.24 nm	0.06 nm

- CWDM does not support 40km
- Only EML supports 10km

Distance with a Small Spectral Width Source @ 25G

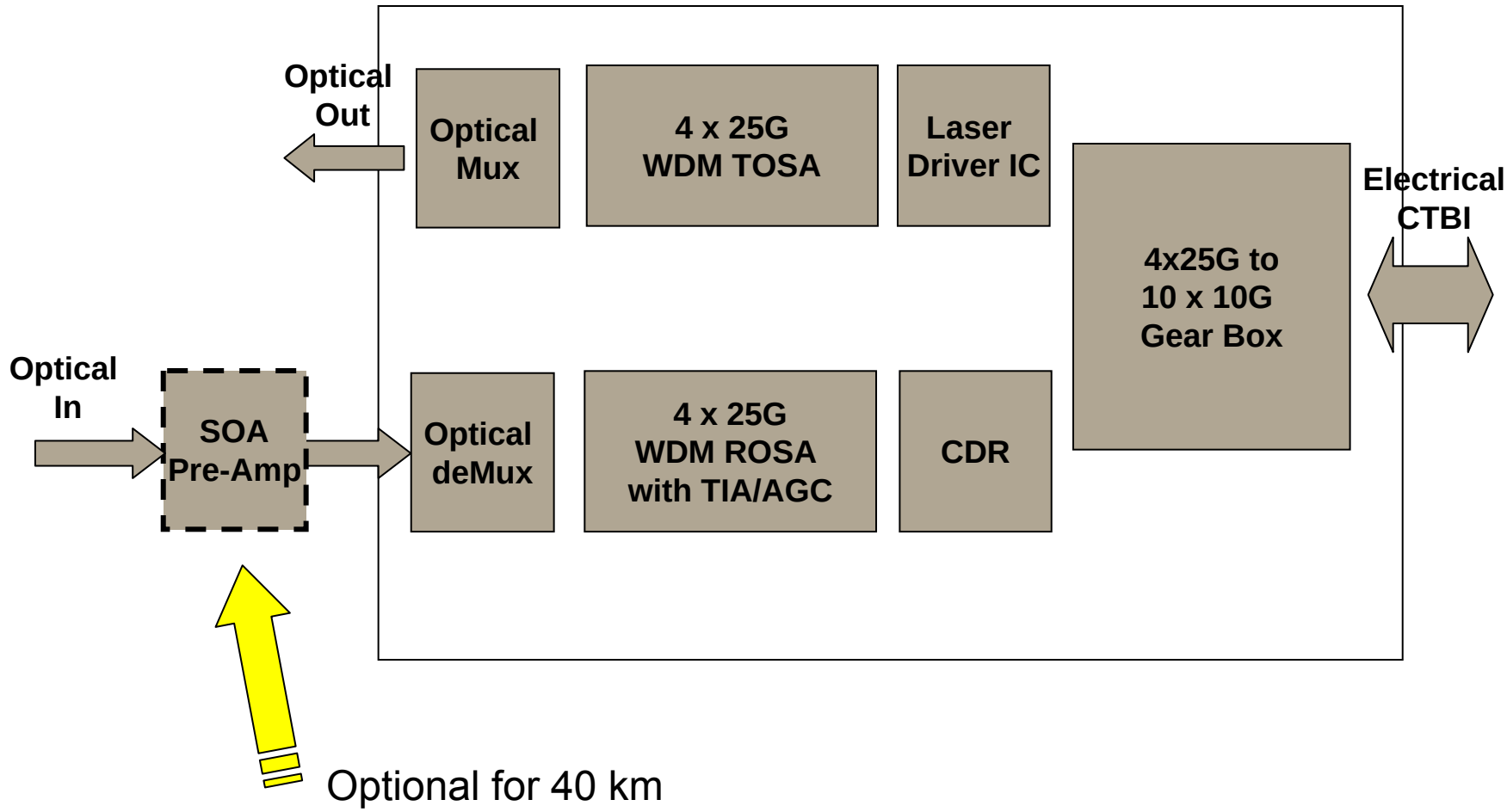


4 x 25G CWDM PMD supported distance is limited to around 25 km

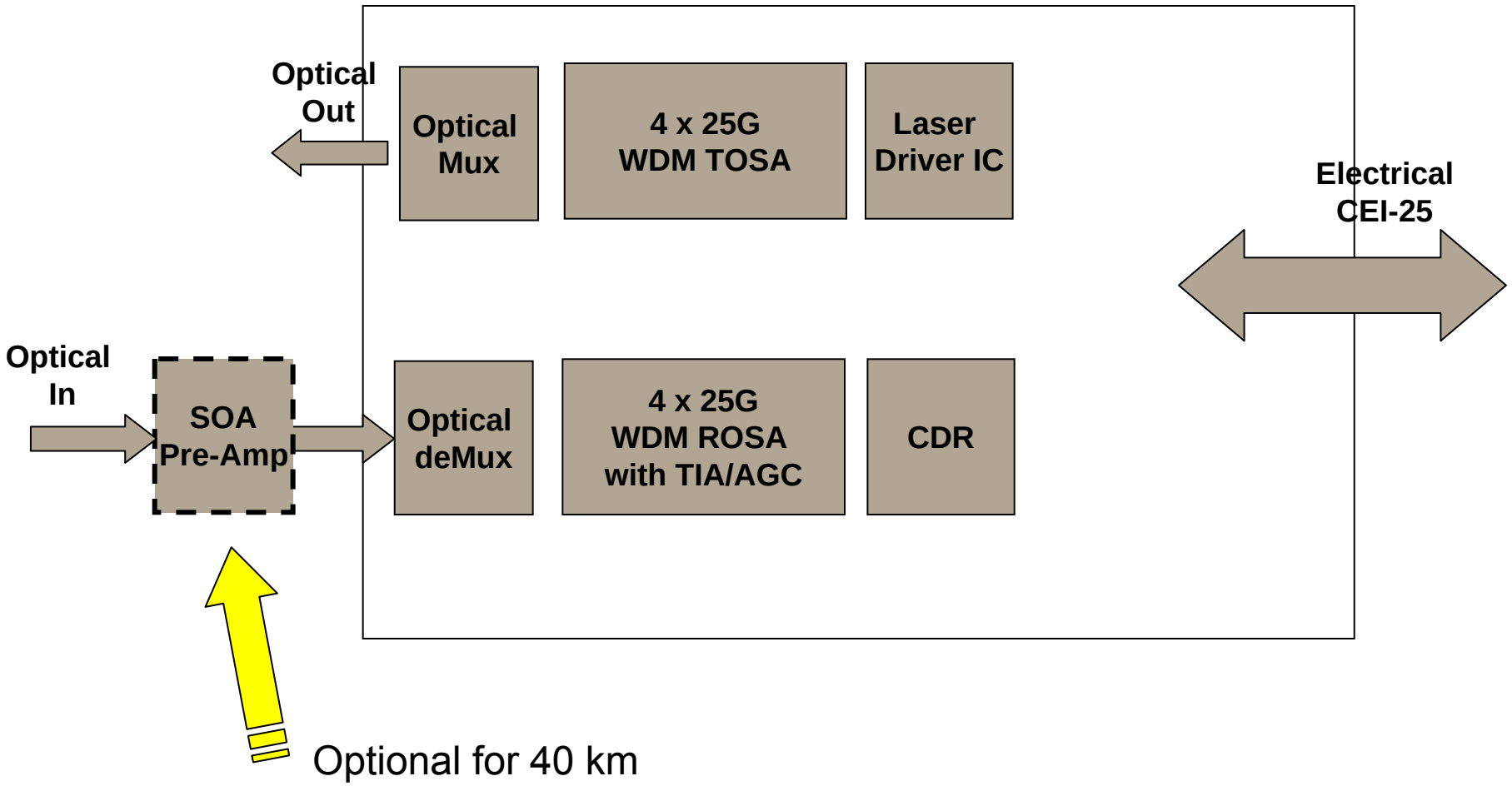
Proposal

- Narrow grid 4 x 25G WDM around the minimum dispersion wavelength is required to support the HSSG 40km distance objective to overcome dispersion limit
  - Propose 200 GHz WDM grid for the transmitters
    - Allow to use one EML design with temperature tuning to cover all four wavelengths, thus achieving higher laser volume for lower cost
    - 400 GHz grid as an alternative is possible, but requires either larger temperature tuning range for two laser chip design
  - SOA pre-Amp + PIN for the receiver
- EML is required to marginally support the HSSG 10km distance objective with the 4 x 25G CWDM PMD option
  - Propose to adopt the same WDM grid as the 40km PMD
    - Increase the total volume base with the combined 10km & 40km market demand
    - Enable DML for the 10km distance objective for future lower cost potential
    - Allow to use one EML/DML design with temperature tuning to cover all four wavelengths, thus achieving higher laser volume for lower cost
  - PIN for the receiver

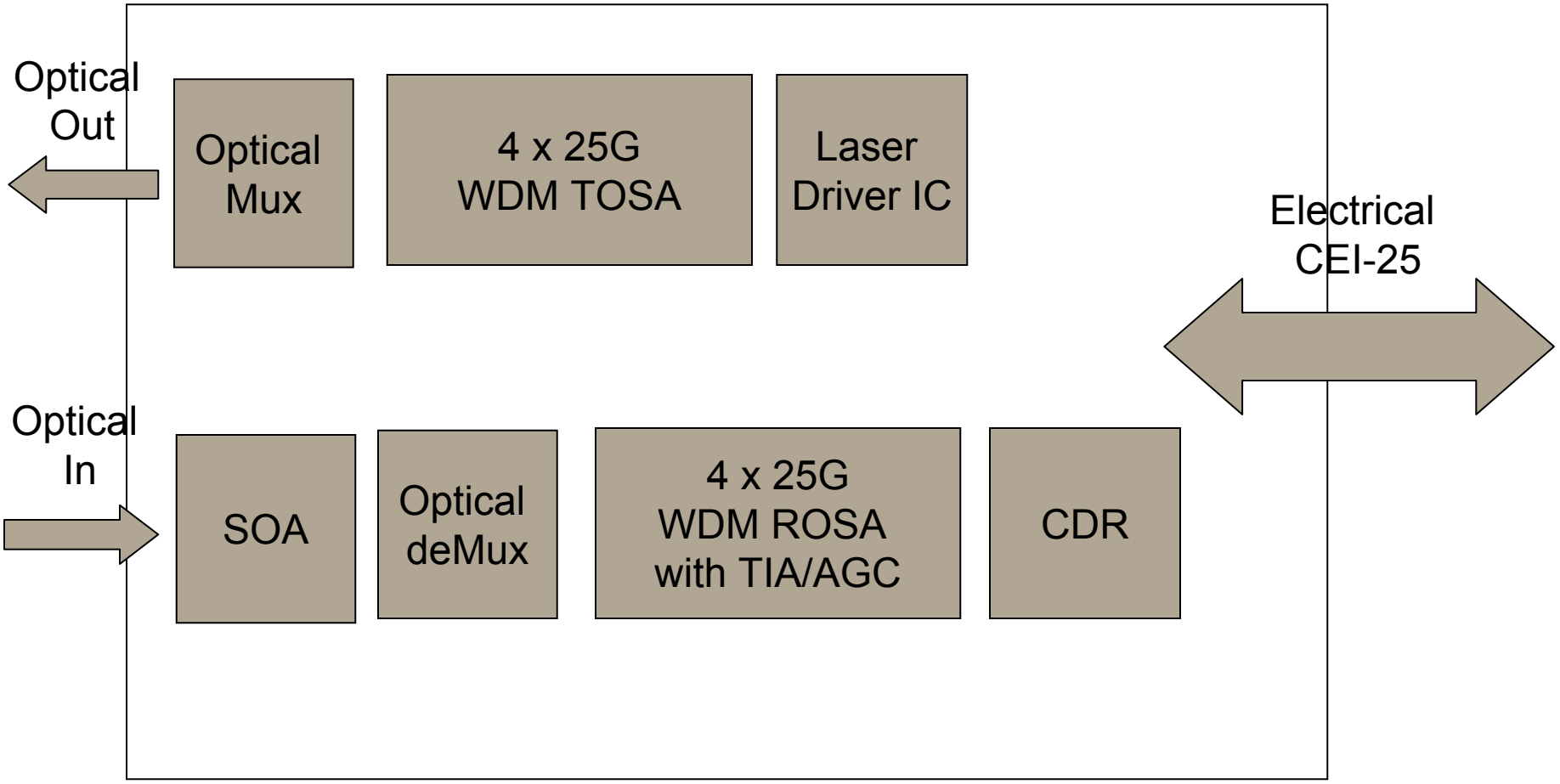
4x25G Optical Module Block Diagram --- 1st Gen



4x25G Optical Module Block Diagram --- 2nd Gen

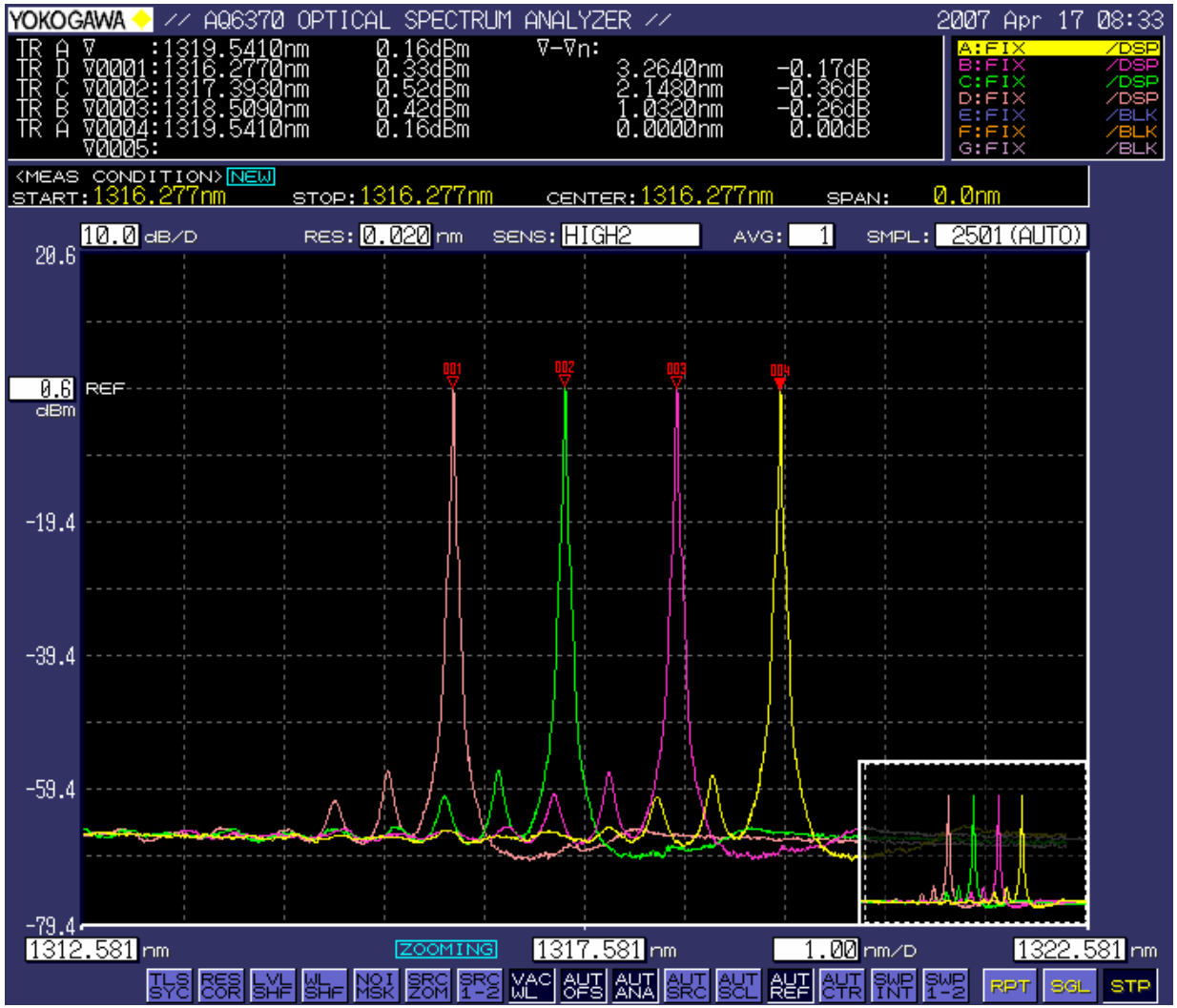


Alternative Conceptual 4x25G Optical Module for 40 km



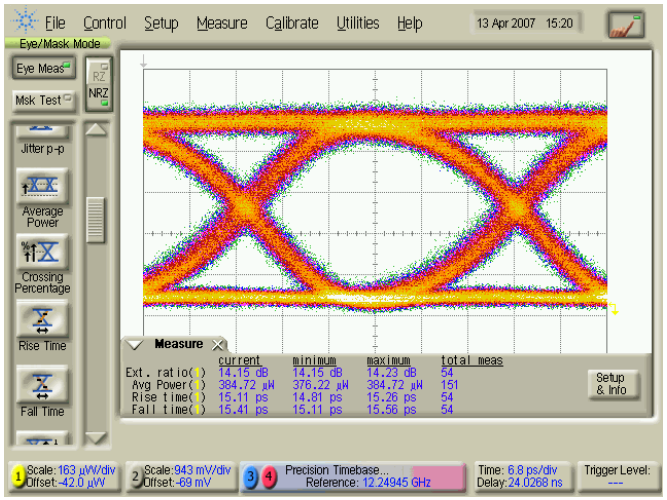
25 G Transmitter Optical Assembly

200 GHz Grid for WDM with Temperature Tuning

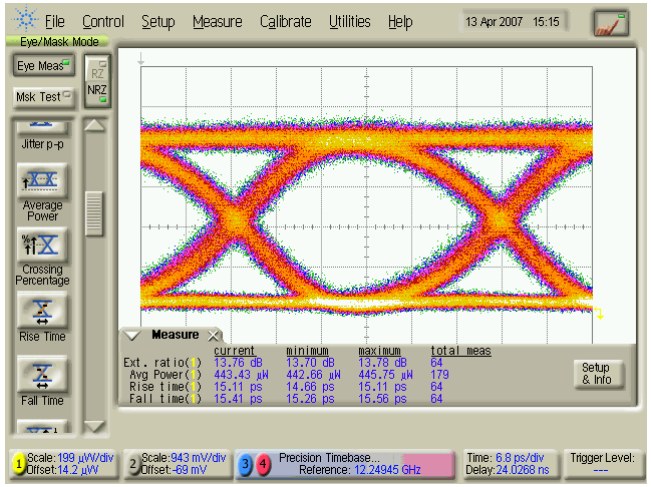


25G Eye Diagrams over Temperatures

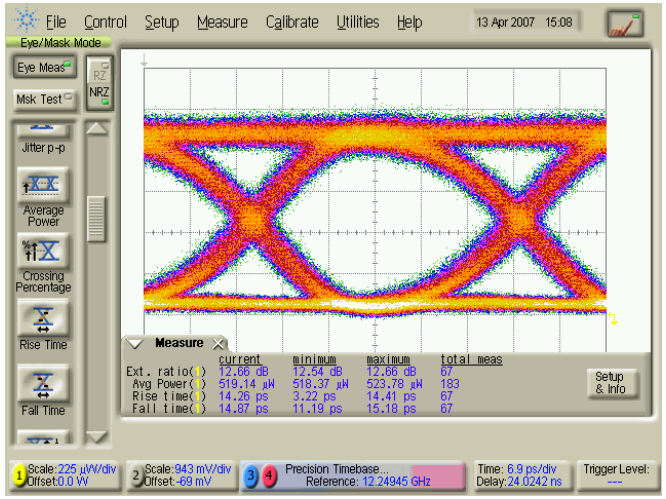
70°C



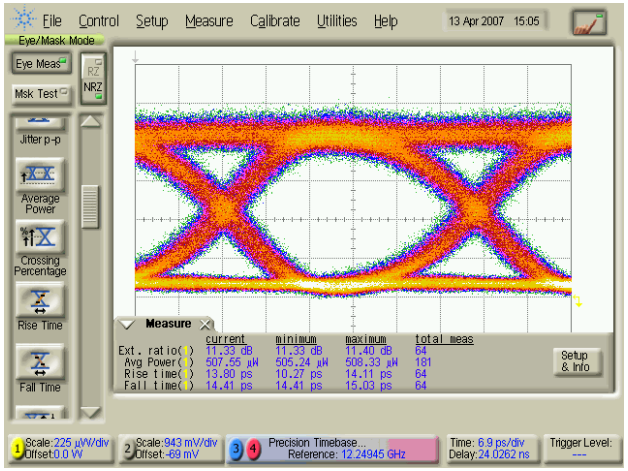
65°C



50°C

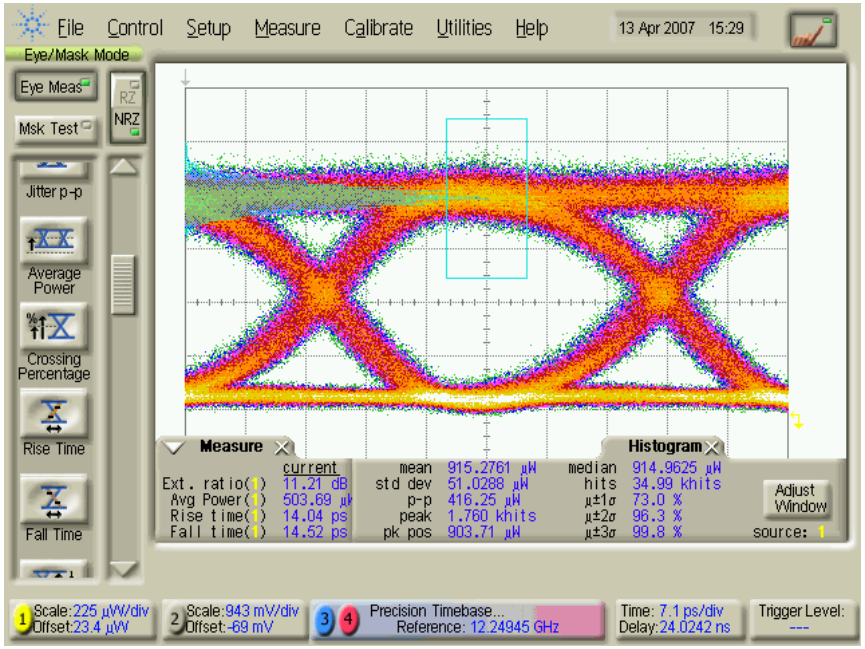


30°C

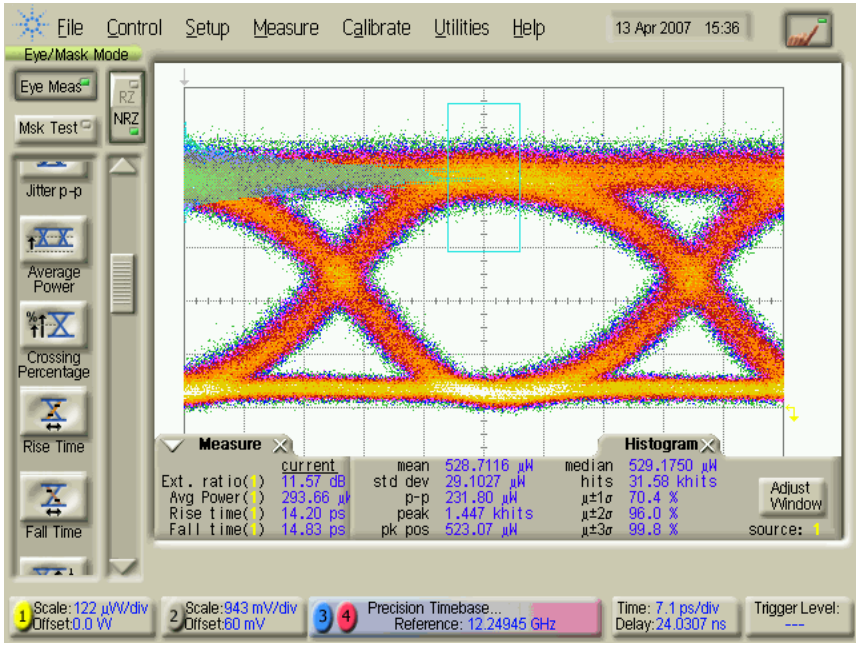


25G Transmissions over 10 km SMF

1m



10km



Commercially Available SOA Spec from a Vendor

Parameter	Symbol	B-type			L-type			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Drive Current	I_F		250			250		mA
Peak Wavelength	λ_p	1280		1340	1280		1340	nm
3 dB Optical Bandwidth	$\Delta\lambda_{3dB}$	55			45			nm
Small Signal Gain @ λ_p	G_{max}	13	16		18	22		dB
Gain Ripple with Respect to λ	ΔG		0.5	1.0		0.5	1.0	dB
Saturation Output Power	P_{sat}	10				10		dBm
Polarization Dependent Gain	PDG		0.5	1.0		0.5	1.0	dB
Noise Figure	NF		7	7.5		7	7.5	dB

One SOA may cover all four wavelengths with 200 GHz WDM grid