Optical Interface for 100G SMF 10km PMD

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IEEE Interim Seoul, Korea
September 2007

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Agenda

- Next Steps to standardize SMF “short” reach PMD
- Wavelength Spacing; CWDM vs. Narrow Spacing (iWDM)
- Wavelength Grid Impact on Chromatic Dispersion Penalty
  - Modulation: EA type versus DM type
  - Reach Considerations

Path to Move Forward

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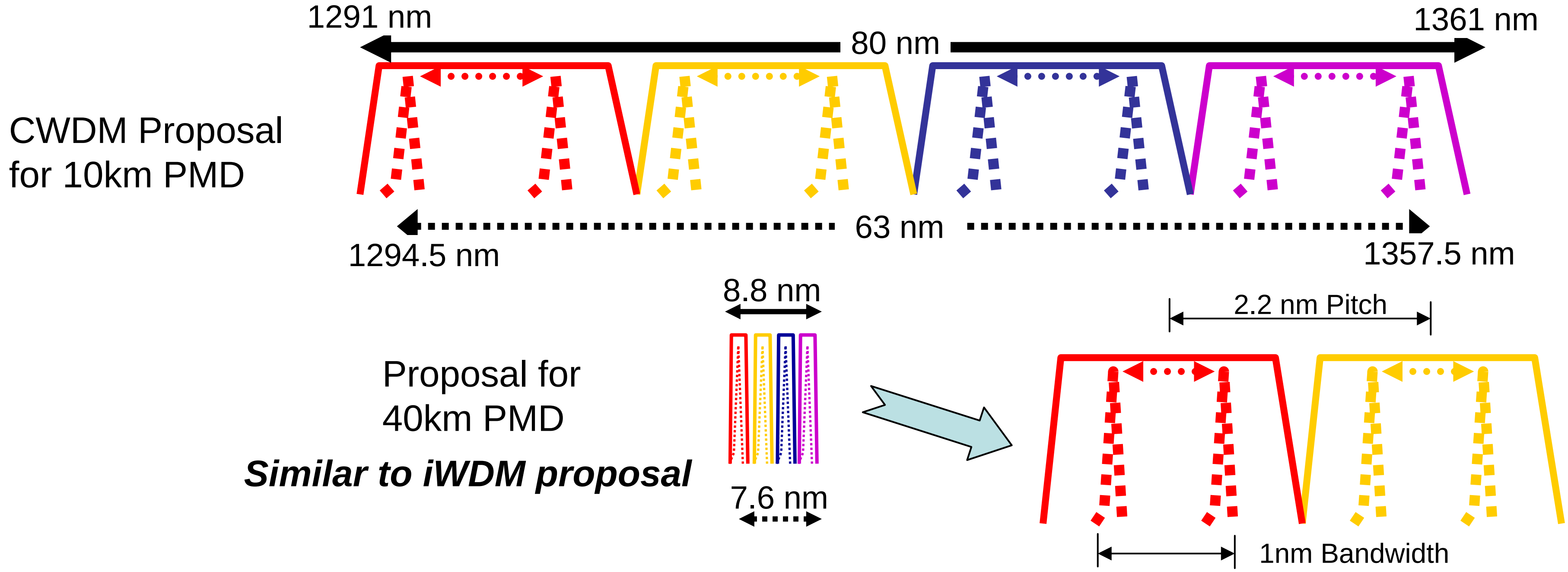
- Key Milestones for PMD Standardization
  - Approximate Distance and Media included in the PAR
    - "Provide Physical Layer specifications which support 100 Gb/s operation over: … at least 10km on SMF"
  - Outline in Brief
    - Select Lane width of optical interface
    - Select Wavelength(s) and Approximate Grid
    - Propose Optical Budget
    - Refine Distance Target & other parameters
    - Iterate Analysis and Refinements of PMD

Reiterate Case for 4x25Gbit/s

- Lane rate of ~25Gbit/s scales well for future generations of IC technology
- From optics point of view simpler interconnect and packaging than 40Gbit/s
  - Intention is to leverage 10Gbit/s packaging and interconnect technology
- Modulation of 25Gbit/s suitable for a direct modulation laser
  - Implementation of 25Gbit/s DML depends upon the final distance objective

CWDM vs. Narrow Spacing (iWDM)



- CWDM allows for use of uncooled lasers
- iWDM requires use of a thermoelectric cooler (TEC) to maintain the laser chip(s) at constant temperature
  - Likely that 4 individual TECs would be required for initial implementation
- CWDM spacing therefore will yield modules with lower power dissipation

Power & Cost comparison; CWDM vs. iWDM

	First Generation			Future		
	LD type	Power consumption (W)	Realtive Cost (Wavelength tolerance)	LD type	Power consumption (W)	Realtive Cost (Wavelength tolerance)
1310nm CWDM	Cooled EA-DFB	6	1.0 (+/-6nm)	Uncooled DFB	1.6	0.8 to 1 (+/-1.1 to 2.6nm)
1310nm iWDM	Cooled EA-DFB	6	2.8 (+/-0.35nm)	Cooled DFB	3.3	2.8 (+/-0.35nm)

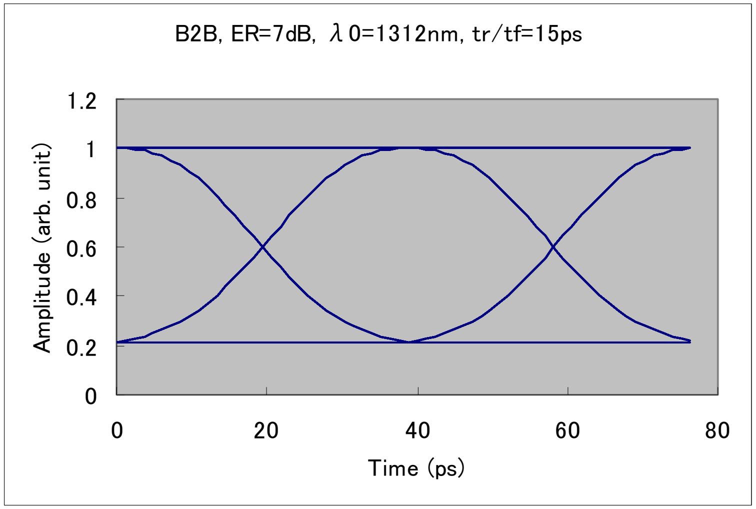
- CWDM module can achieve:
  - Lower cost than tighter wavelength spaced module
  - Considers the cost of the laser relative to the wavelength spread of the wafer
- Initially CWDM module will likely be similar in power consumption via wide-temperature semi-cooled EA-DFB
- In the future, as uncooled technology matures:
  - CWDM module can achieve ~ 2 W lower power consumption
  - Lower cost due to larger proportion of die in the acceptable wavelength region

CWDM(ITU-T) grid study for 10 km

- Objective
  - Which CWDM(ITU) grid set is better, 1271-1331nm or 1291-1351nm ?
  - How much is chromatic dispersion penalty ?

- Simulate the penalty of each CWDM grid set
- Hypothesis
  - Bit rate: 25.8Gbps
  - Distance: 10 km
  - Without non-linear effect
  - TX tr/tf: 15ps(20-80%)
  - Waveform: Super-Gaussian (*1)
- Parameter
  - α: -1~4 (EA:-1~1, DM:2~7) (*2)
  - Extinction ratio: 5~10dB

B2B optical waveform



Note(*1): Does not simulate actual waveforms of EML and DM DFB-LD.
Note(*2): alpha is set constant.

Chromatic dispersion

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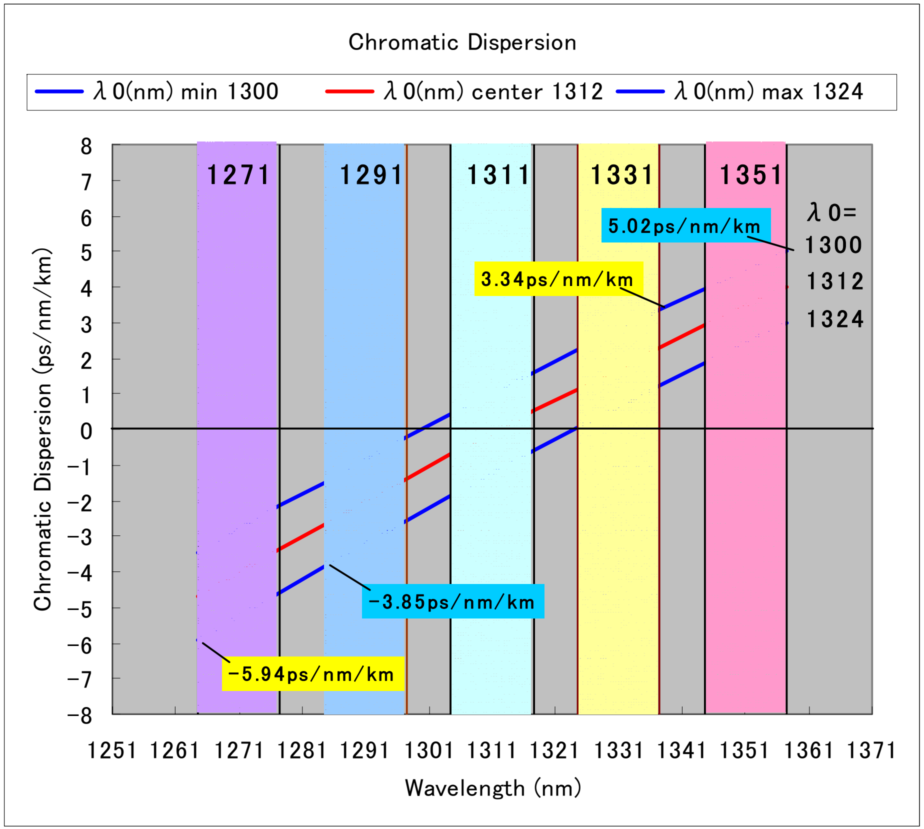
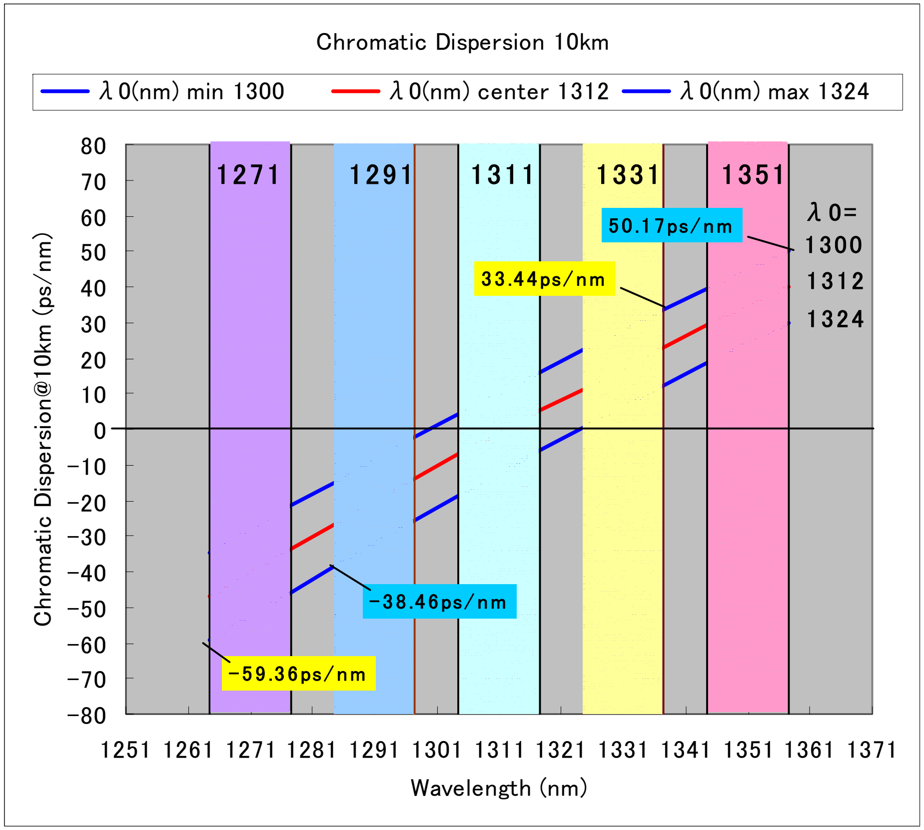
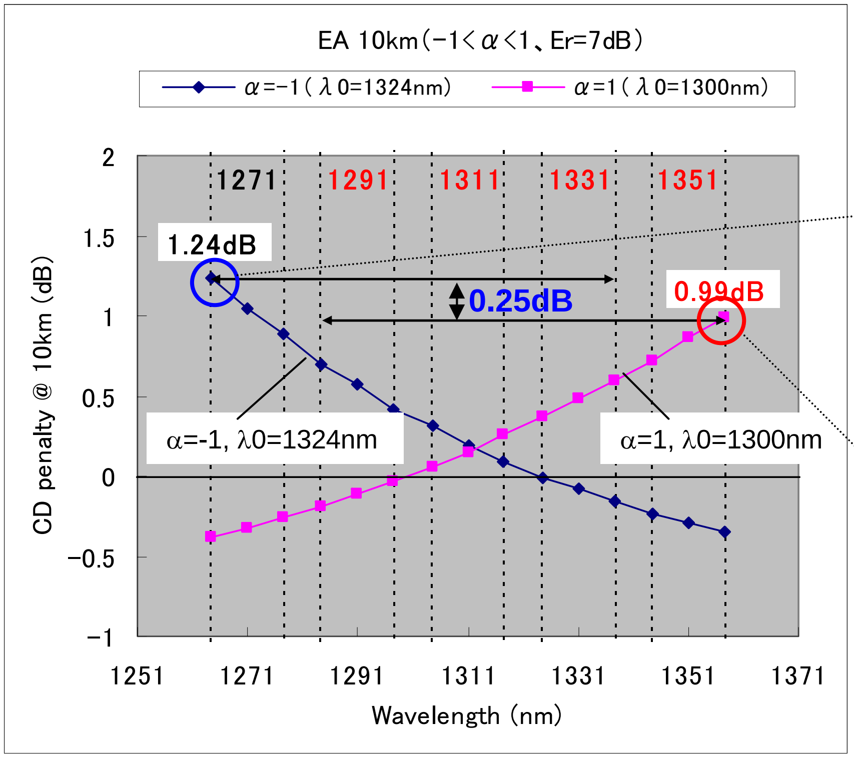
- Dispersion@10km,SSMF
  - 1271-1331nm: -59ps/nm(min), 33ps/nm(max), |DZ|=59ps/nm(max)
  - 1291-1351nm: -38ps/nm(min), 50ps/nm(max), |DZ|=50ps/nm(max)



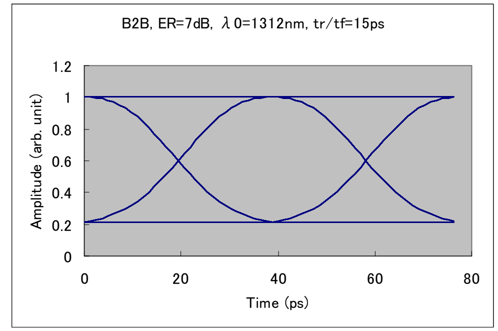


EA-Mod: 10km CD Penalty

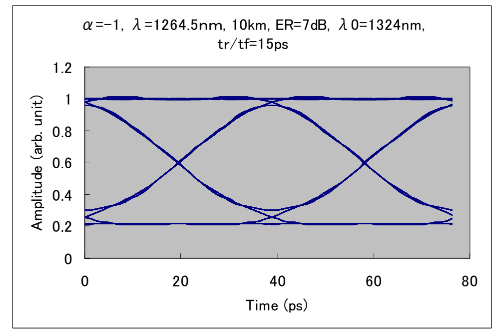
- CWDM grid set (EA: $-1<\alpha<1$)
  - 1291-1351nm grid set is better
  - CD penalty@10km: ~1dB



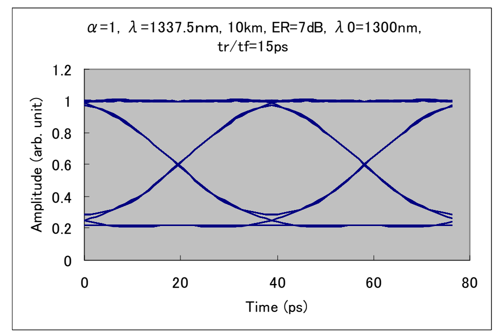
B2B



λ=1264.5nm
penalty=1.24dB
α=-1
λ0=1324nm



λ=1357.5nm
penalty=0.99dB
α=1
λ0=1300nm



Direct Mod: 10km CD Penalty

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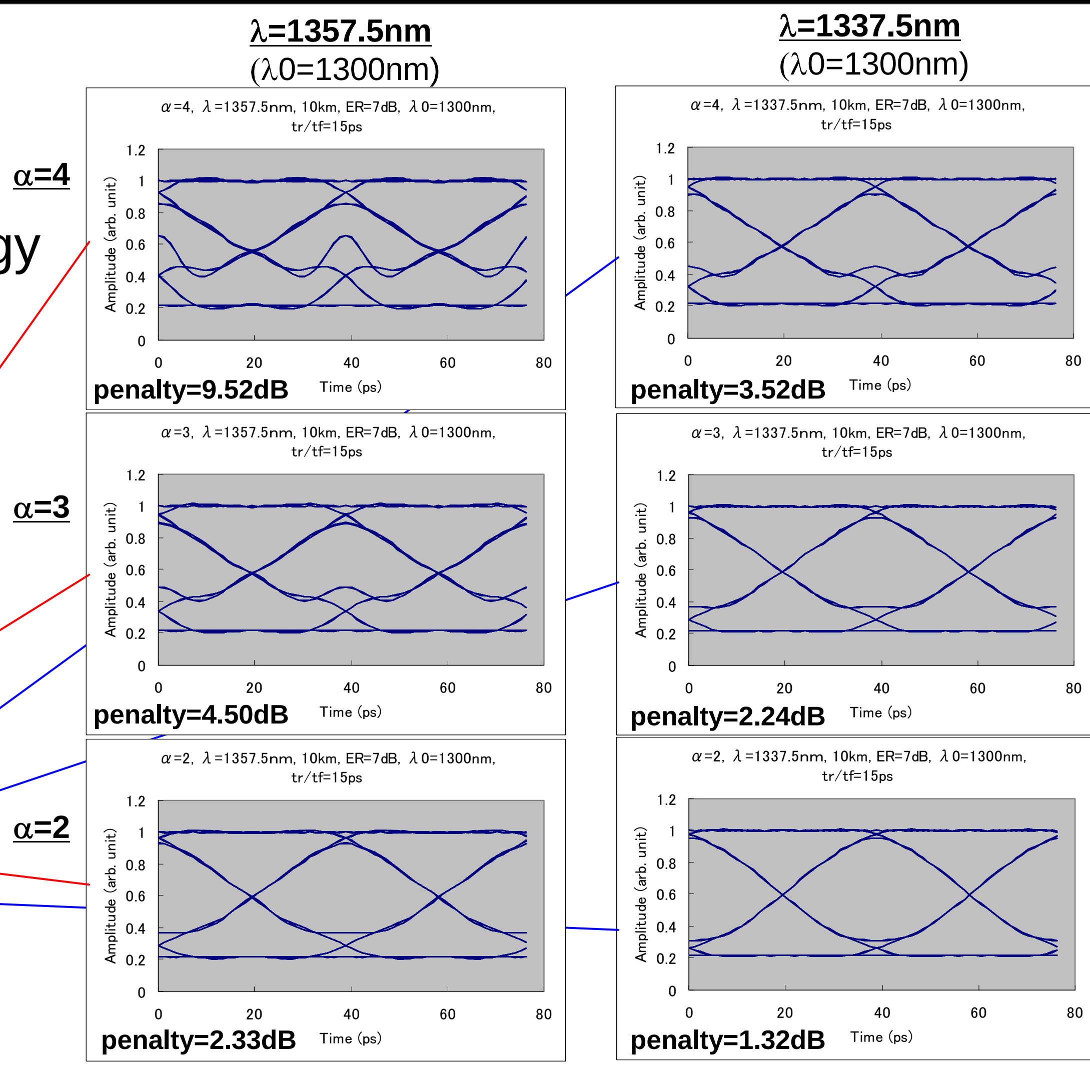
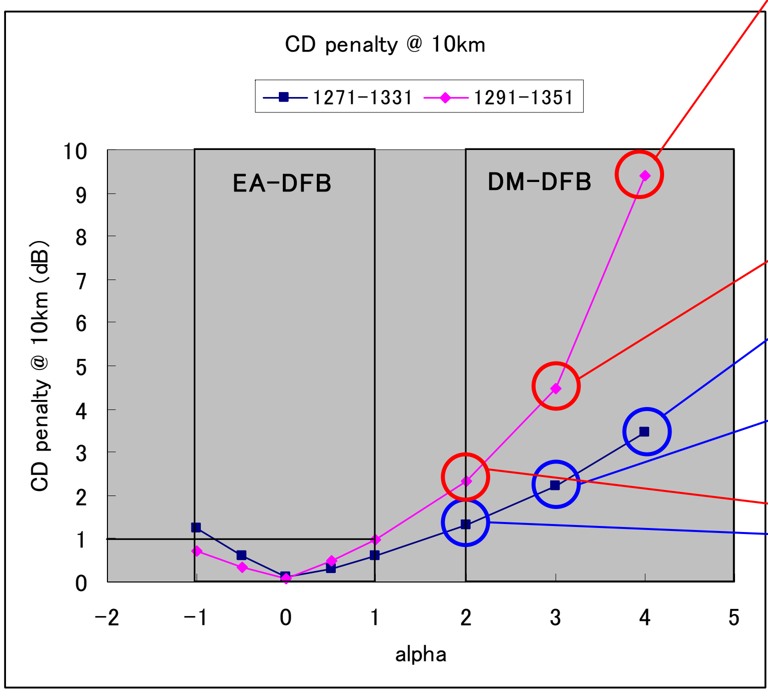
- CWDM grid set (DM: 2<α<4)
  - 1271-1331nm set is better
  - But penalty >>2dB
  - New lower chirping technology is needed (α<2)





Direct Mod: 2km CD Penalty

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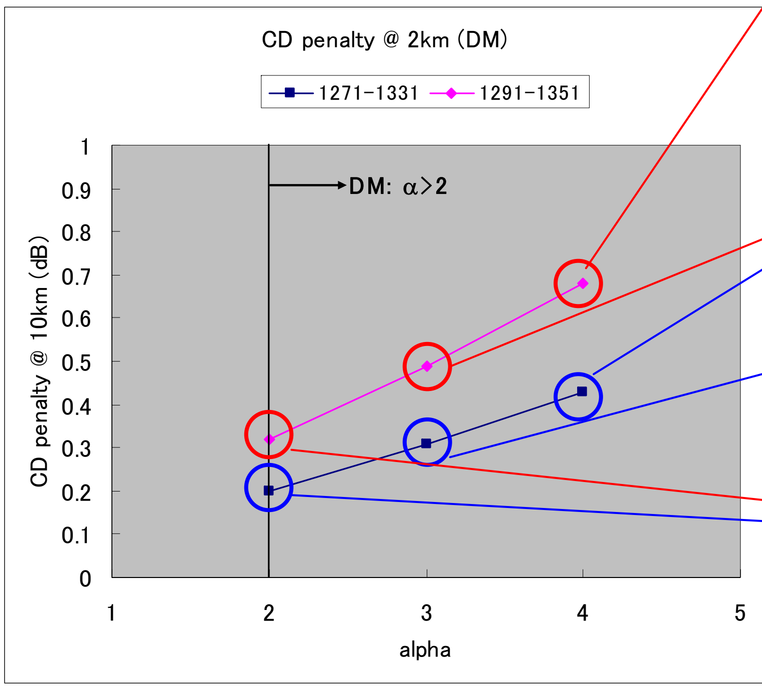
- CWDM grid set
  - CD penalty is less than 1dB each grid set (DM: 2<α<4)



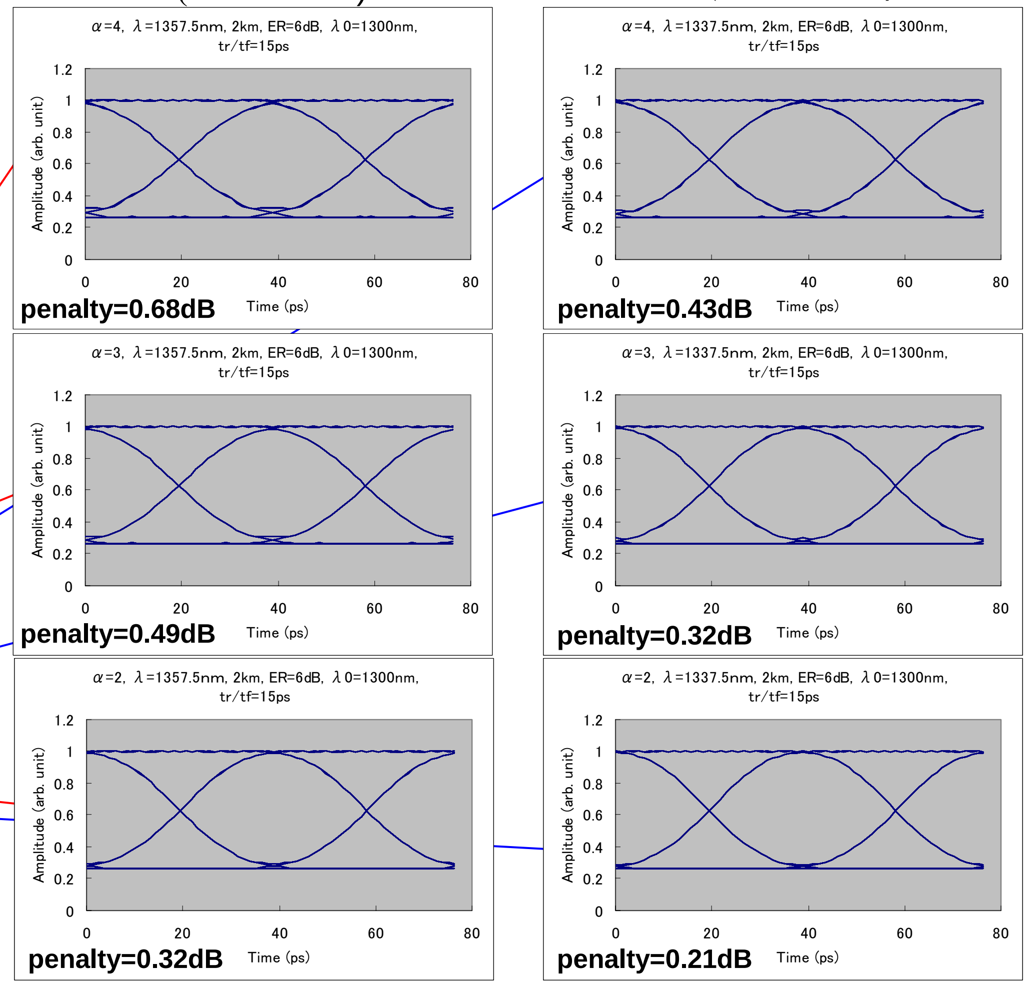
λ=1357.5nm (λ0=1300nm)

λ=1337.5nm (λ0=1300nm)

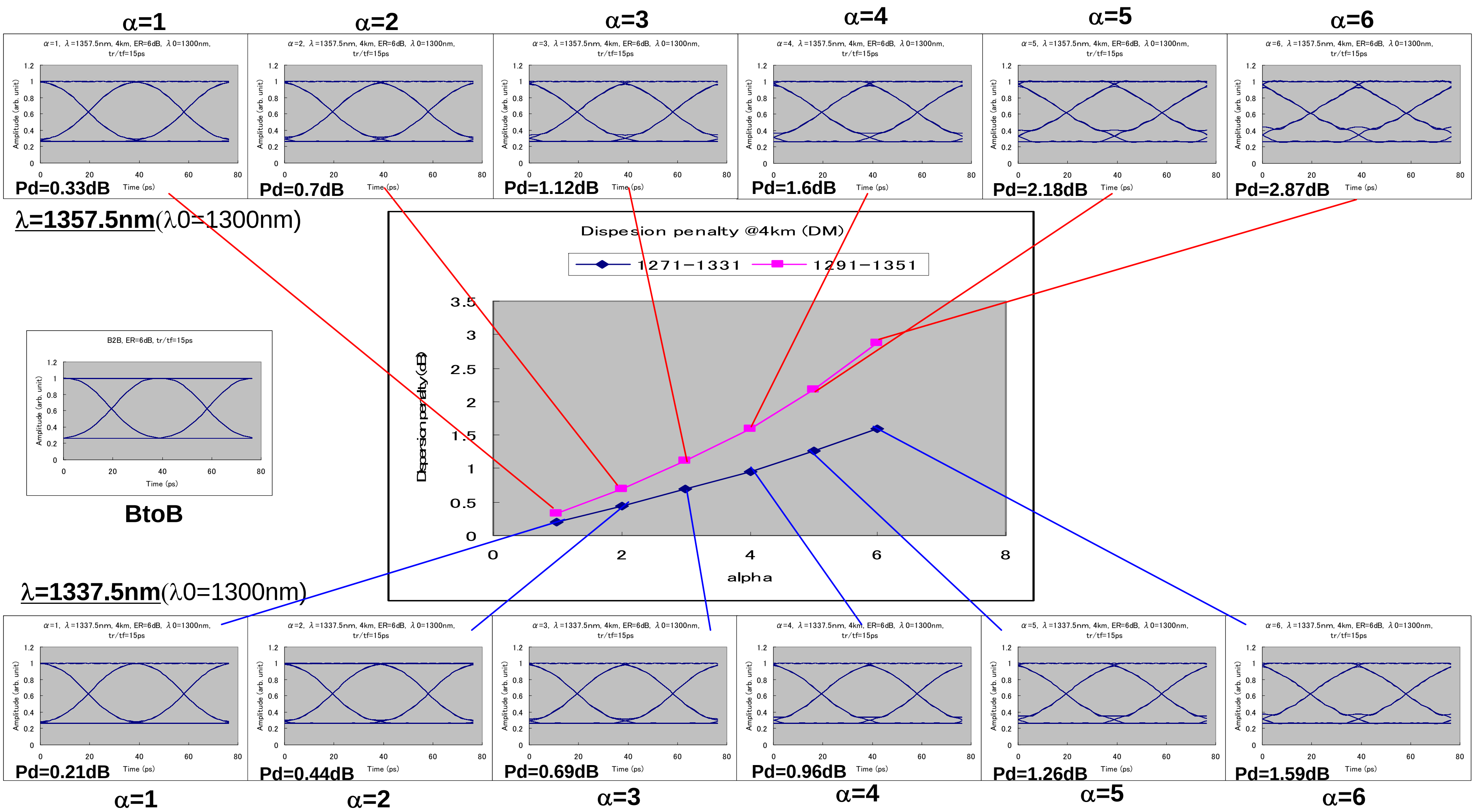
α=4

α=3

α=2



Direct Mod: 4km CD Penalty



Summary Wavelength Grid

- Optimum Wavelength Grid depends upon distance objective
  - 10km: 1291-1351nm
    - Dispersion penalty of ~1dB
      - Better by 0.25dB than 1271-1331nm set.
      - With α of EA from -1 to 1 ***(*NOTE 1)***
  - 4km: 1271-1331nm
    - Dispersion penalty of ~1dB ***(*NOTE 2)***
      - Better by 0.6dB than 1291-1351nm set.
      - With α of DM as 4
  - 2km: 1271-1331nm
    - Dispersion penalty of ~0.5dB
      - Better by 0.2dB than 1291-1351nm set.
      - With α of DM as 4

****NOTE 1: New DM technology required to achieve 10km application due to large α of current DM technology; (α<2 is needed)***

****NOTE 2: Fixed α was used, therefore the simulation may be optimistic relative to real DML & EA-DFB devices.***