EDC performance vs. Relaxed transmitter specs

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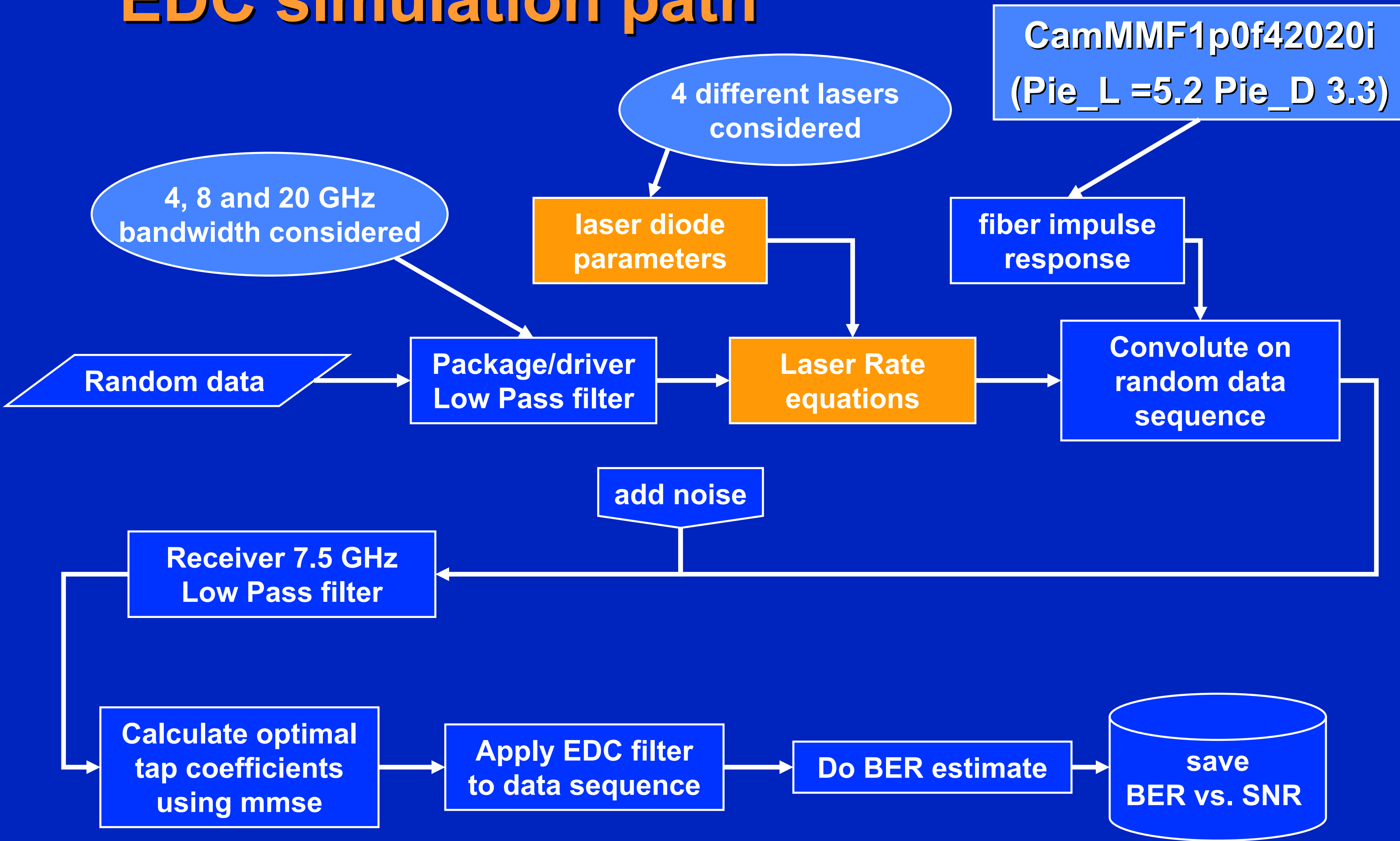
Objective of presentation

- Find penalty of using low cost (performance) optics
- Can EDC help on this?

Outline

- Simulation path
- Low performance options considered
- Simulation results/discussion

EDC simulation path

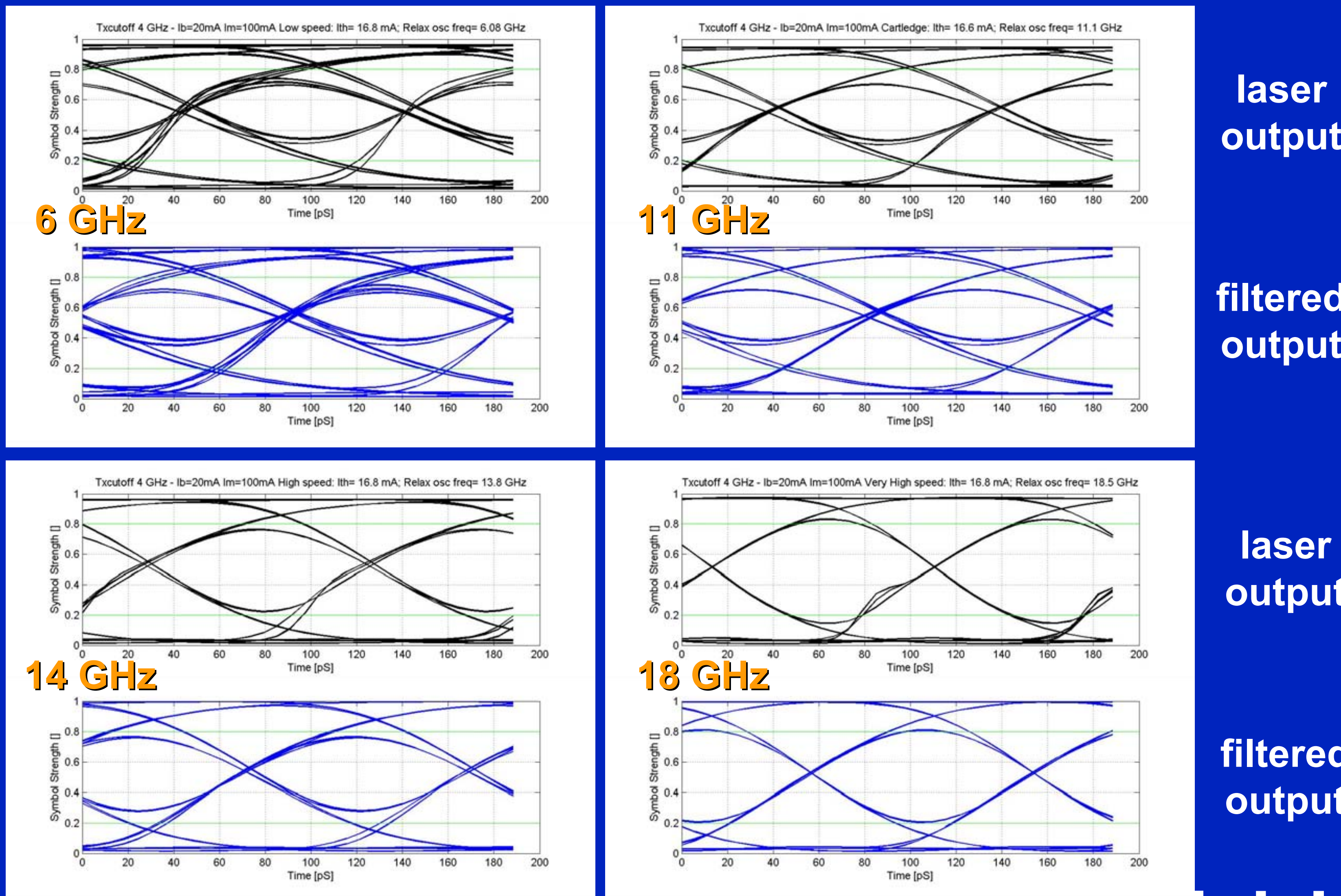


Laser Rate equations

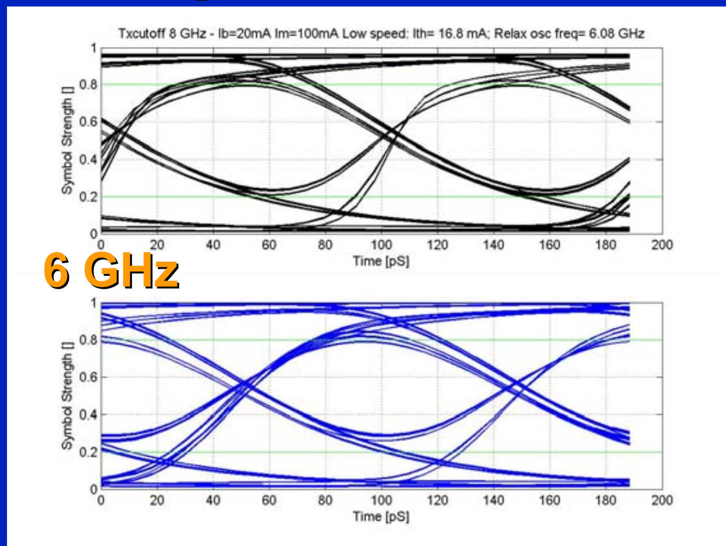
- Solve rate-equations using matlab
- Initial input data from Cartledge: J. Lightwave tech. vol 15, no. 5 1997 p 852 gives
- laser with threshold current of 16.6 mA and
- Relax. freq. of 11 GHz at a biascurrent of 70 mA
- Parameters modified to give 3 other lasers with approx. same I_{th} and 6, 14 and 18 GHz Relax. freq.
- I_{bias}= 70 mA; I_{mod} = 100 mApp

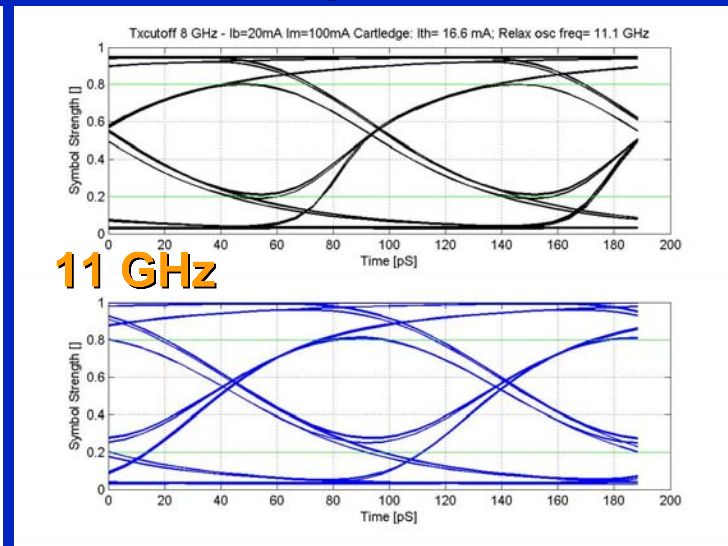
$$\begin{cases} \frac{dP}{dt} = G \cdot P + Rsp - \frac{P}{\tau_p} \\ -\frac{dN}{dt} = \frac{I}{q} - \frac{N}{\tau_c} - G \cdot P \\ G = G_N (N - N_0)(1 - \varepsilon_{NL}) \\ \frac{d\phi}{dt} = \frac{1}{2} \beta_c \left[G_N (N - N_0) - \tau_p \right] \end{cases}$$

Eyediagrams – 4 GHz package



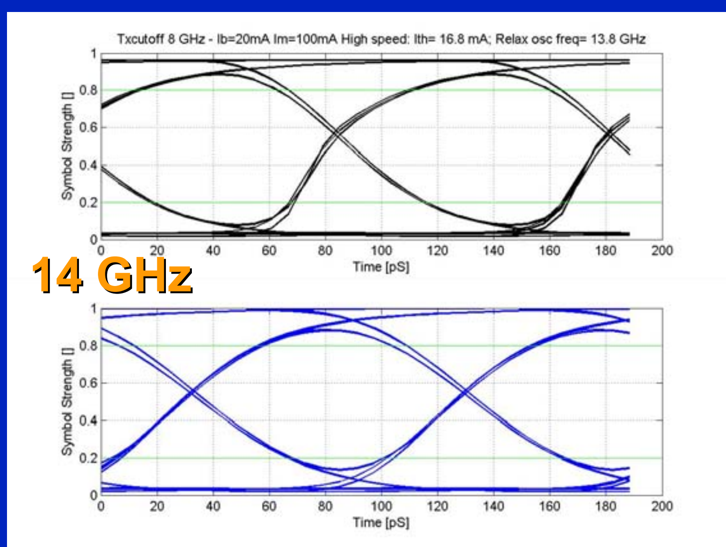
Eyediagrams – 8 GHz package

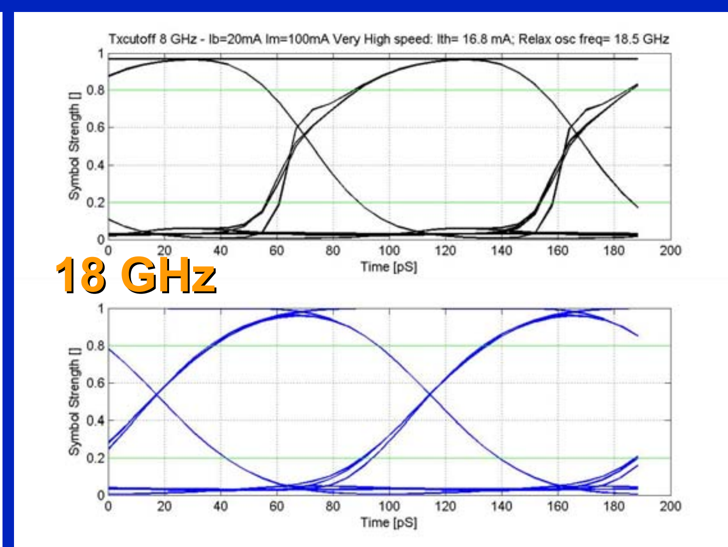




laser output

filtered output

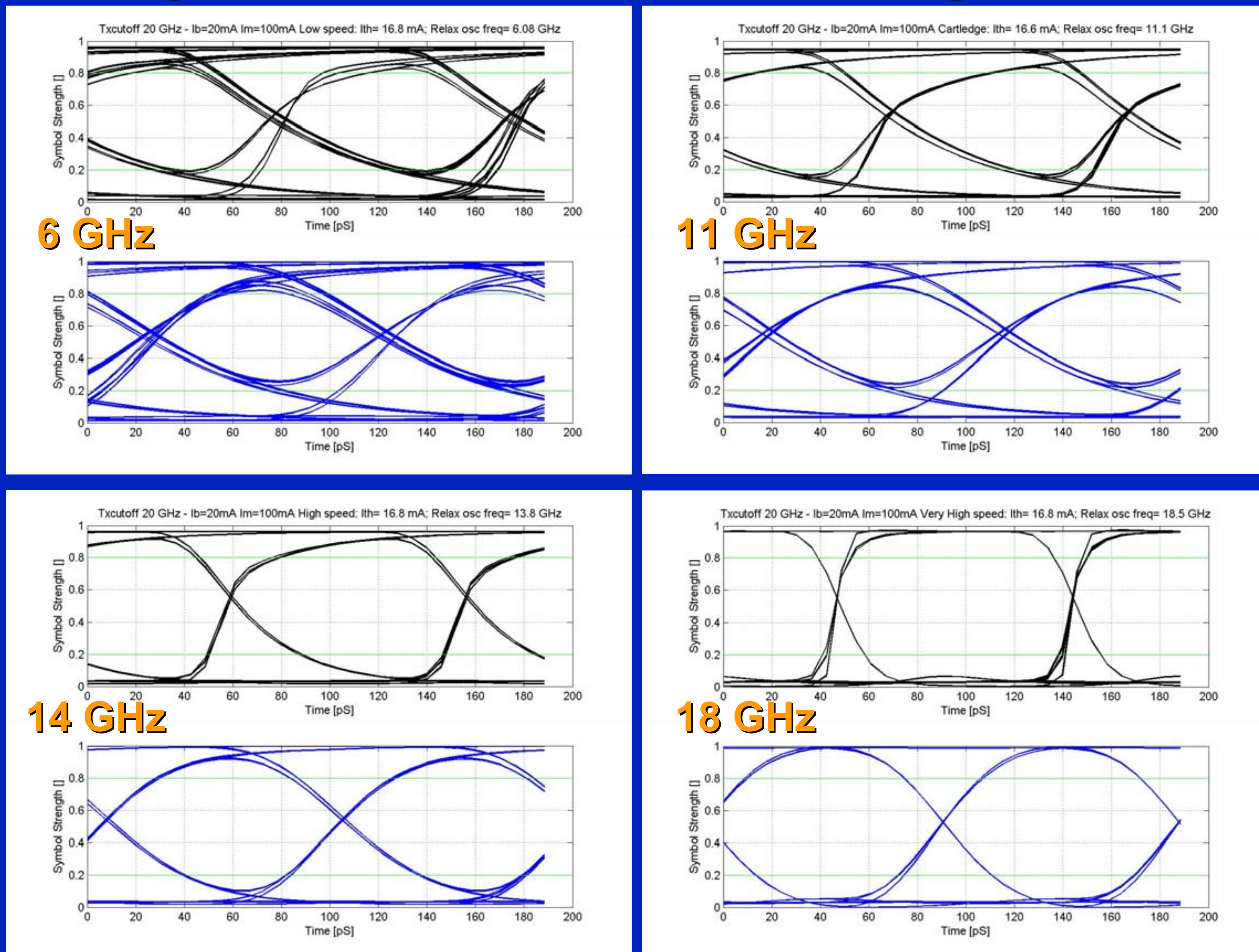




laser output

filtered output

Eyediagrams – 20 GHz package



laser output

filtered output

laser output

filtered output

Relative Penalty
Back to Back – no EDC

Penalty at BER=10^-9

Laser \ Package	Bad (4 GHz BW)	Good (8 GHz BW)	Perfect (20 GHz BW)
Bad (BW 6 GHz)	7.1	3.6	3.0
Good (BW 11 GHz)	5.8	3.1	2.4
Better (BW 14 GHz)	3.1	1.2	0.9
Perfect (BW 18 GHz)	2.2	0.5	0 (reference)

all numbers in dBo

Relative Penalty
Back to Back – with EDC
5 FF only

Penalty at BER=10^-9

Package / Laser	Bad (4 GHz BW)	Good (8 GHz BW)	Perfect (20 GHz BW)
Bad (BW 6 GHz)	7.3	3.7	2.6
Good (BW 11 GHz)	4.3	1.6	1.1
Better (BW 14 GHz)	2.6	0.4	~ 0
Perfect (BW 18 GHz)	1.1	~ 0	~ 0

all numbers in dBo

Observations

- 5 tap FFE can do some compensation
- FFE seems to handle a bad package better than a bad laser

- Note!
  large step-size (2 dBo) in input signal to noise ratio may give some inaccuracy in the numbers

Relative Penalty
Back to Back – with EDC
5 FF + 2 FB

Penalty at BER=10^-9

Package / Laser	Bad (4 GHz BW)	Good (8 GHz BW)	Perfect (20 GHz BW)
Bad (BW 6 GHz)	1.9	1.0	0.8
Good (BW 11 GHz)	1.7	0.8	0.6
Better (BW 14 GHz)	0.9	0.3	~ 0
Perfect (BW 18 GHz)	0.5	~ 0	~ 0

all numbers in dBo

Observations

- 5+2 tap DFE compensates very fine
- DFE is needed to handle a bad laser

Relative Penalty after 300m fiber – with EDC 5 FF + 2 FB

Penalty at BER=10^-9 CamMMF1p0f42020i (Pie_L =5.2 Pie_D 3.3)

Laser \ Package	Bad (4 GHz BW)	Good (8 GHz BW)	Perfect (20 GHz BW)
Bad (BW 6 GHz)	4.7	3.8	3.6
Good (BW 11 GHz)	4.5	3.6	3.4
Better (BW 14 GHz)	3.7	3.0	2.9
Perfect (BW 18 GHz)	3.2	2.6 9.7 (no EDC)	2.5 8.2 (no EDC)

all numbers in dBo

Observations

- 5+2 tap DFE is able to compensate ALL (within link budget) investigated combinations of packages and lasers even after 300 m of “bad” fiber.
- The penalty of the fiber and of the laser seems to add up. With DFE the penalty difference between BTB and fiber is around 2.8 dB for all combinations

Relative Penalty after 300m fiber – with EDC 5 FF only

Penalty at BER=10^-9 CamMMF1p0f42020i (Pie_L =5.2 Pie_D 3.3)

Package / Laser	Bad (4 GHz BW)	Good (8 GHz BW)	Perfect (20 GHz BW)
Bad (BW 6 GHz)	15.2	12.6	12.0
Good (BW 11 GHz)	13.8	11.5	11.1
Better (BW 14 GHz)	12.2	9.8	9.2
Perfect (BW 18 GHz)	11.0	8.4	7.6

all numbers in dBo

Observations

- 5 tap FFE only is NOT able to compensate ANY (within link budget) of the investigated combinations of packages and lasers
- The penalty of the fiber and of the laser seems to add up. With FFE the penalty difference between BTB and fiber is around 8 dB for all combinations

Conclusion

- Approximate penalty of relaxing transmitter specs is given by “Back to back – with EDC” values (slide 11)
  - 0 to 1.9 dB
- Question: any room in link budget?

Backup

Laser parameters

Cartledge laser

parameter	6 GHz	11 GHz	14 GHz	18 GHz	
nsp		1.7			Spontanous emission factor []
L		0.025			cavity length [cm]
w	0.0002	0.0001			active layer width [cm]
d	1e-5	8e-6			active layer thickness [cm]
Gamma		0.24			Confinement factor []
g0		1.6e-6	3e-6	1e-5	gain slope constant [cm^3/s)
neff		3.4			effective refractive index []
n		4			group refractive index []
vg		7.5e+9			Group Velocity [cm/s]
sig_g		2.13e-16	4e-16	1.33e-15	Diffential gain coeffienct [cm^2]
epsilon		1.48e-17			gain compression factor [cm^3]
eps_nl	2.96e-7	7.4e-7			Gain compression coefficient []
NT		1.07e+18			Carrier density of transparancy [1/cm^3]
Anr	4e+8	1e+8	1.27e+9	3e+9	Nonradiative recombination rate [1/s]
Brr		1e-10			Radiative recombination rate [cm^3/s]
C_Auger		3e-29			Auger recombination coefficient [cm^6/s]
a_int	25	20			internal loss [cm-1]
a_mir	48	155			Mirror loss [cm-1]

values not shown are common for all lasers