Conditions for 100m and >100m reaches on OM3 and OM4 MMF at 10Gb/s/ch

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Goals

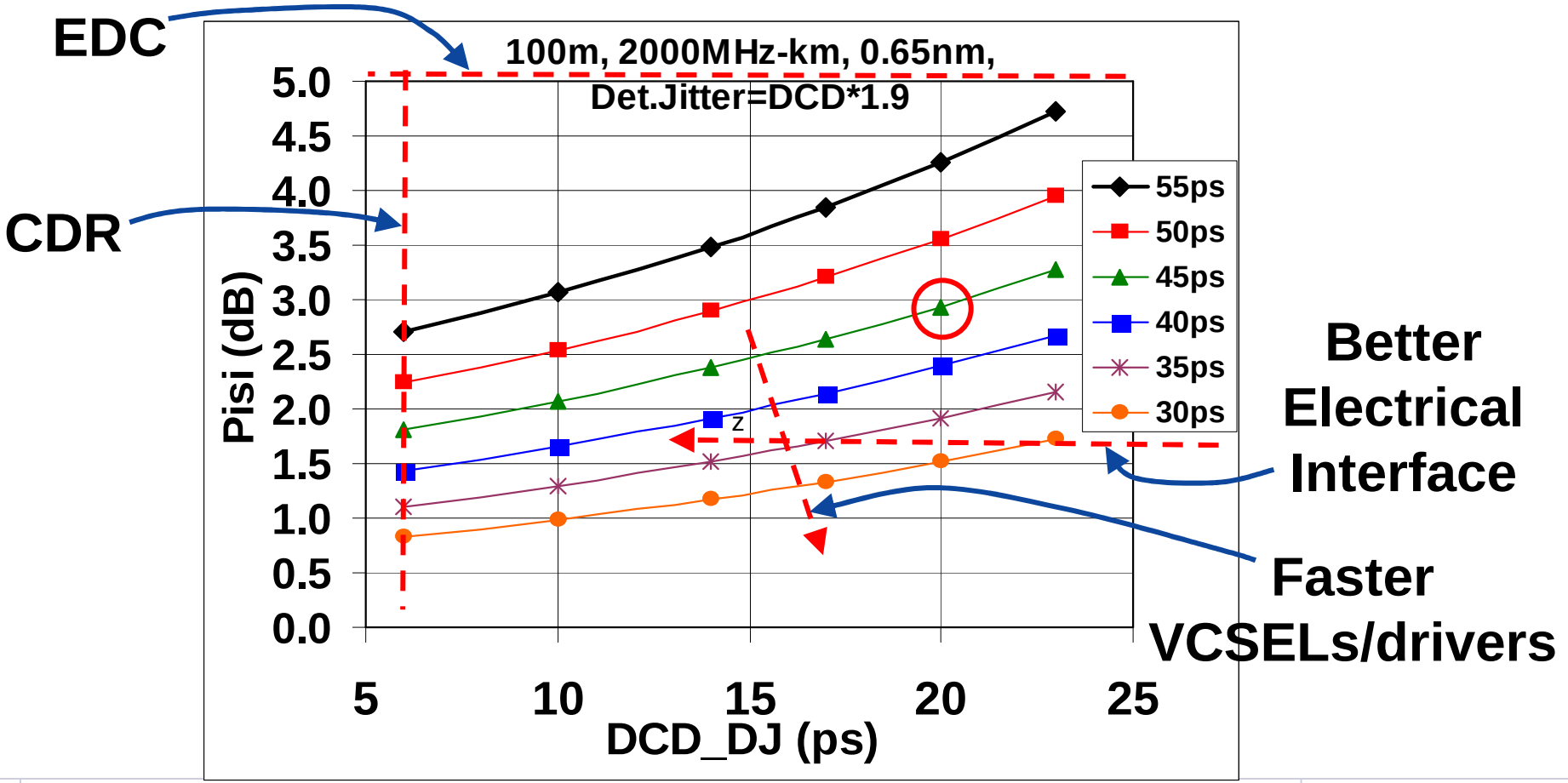
- Understand requirements/tradeoffs for a low-cost, robust 100m link on OM3 fiber at 10Gb/s/ch
- Explore feasibility for practical, >100m links on OM3 and OM4 fibers at 10Gb/s/ch
- Addition of the >100m links must not affect the costs for 100m products
- Compared to SMF links, the >100m links should provide significant savings in cost and power dissipation, while enabling higher density and faster time to market

Use 3_1_16a spreadsheet

- Parameters described use 3_1_16a nomemclature
- Always have (straight from 3_1_16a):
  - Wavelength Uc = 840nm
  - RIN (OMA) = -128dB/Hz (3_1_16a uses -130dB/Hz)
  - MPN k (OMA) = 0.3; ModalNoisePen = 0.3dB
  - Baseline wander SD = 0.025 fraction of ½ eye
  - Rec_BW = 8,250MHz; Test Rx BW = 7500MHz
  - Nominal Rx Sensitivity (OMA) = 11.1dBm
  - Power Budget P = 8.3dB
  - Connections C = 2.0dB
- Nominal: (RMS Spectral Width) Uw = 0.65nm (varies)
- Nominal: DCD_DJ = 20ps; Det. Jitter = 38ps (varies)
  - Maintain 1.9X ratio when they vary
- Variable: (Effective Modal Bandwidth) Eff. BWm
  - Nominal values 2000MHz-km for OM3, 4400MHz-km for OM4
- Variable: (Rise/fall) Ts(20-80)
- Arbitrary: Upper limit on Pisi = 3.0dB (SR uses 3.6dB)

100m OM3 link motivates 35-45ps rise/fall

- RMS=0.65nm
- Nominal: DCD_DJ=20ps, Det. Jitter=38ps
- Want Pisi < 3.0



Sample details for 100m, OM3

- **Rise/fall = 45ps**
- **RMS = 0.65nm**

Link Power Budget and Penalties

Description	1	2	3	4	5	6
Operating Distance (m)	100	100	100	100	100	100
Fiber Modal BW (MHz-km)	2000	2000	2000	2000	2000	2000
Wavelength Range (nm)	840-860	840-860	840-860	840-860	840-860	840-860
Link Power Budget (dB)	8.3	8.3	8.3	8.3	8.3	8.3
Channel Insertion Loss (dB)	2.36	2.36	2.36	2.36	2.36	2.36
Link Power Penalties (dB)	2.63	3.03	3.56	4.07	4.74	5.68
Unallocated Margin (dB)	3.28	2.87	2.35	1.83	1.16	0.22
Pisi (dB)	1.80	2.07	2.38	2.64	2.94	3.27
DCD_DJ (ps)	6	10	14	17	20	23

Varying DCD_DJ and Det. Jitter

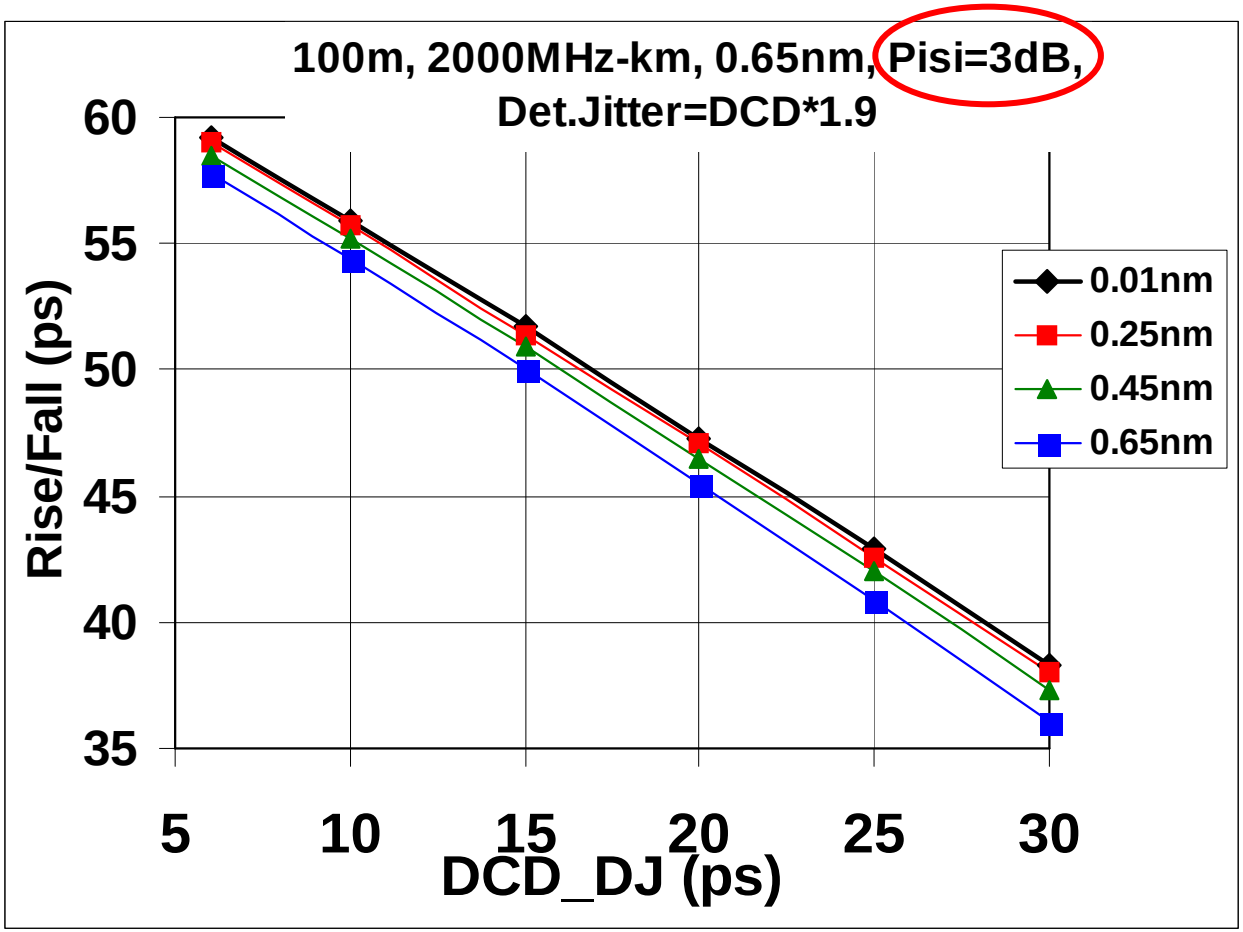
Transmit Characteristics

Description						
Signal Speed (Gbaud)	10.3125	10.3125	10.3125	10.3125	10.3125	10.3125
Wavelength (nm)	840	840	840	840	840	840
Trise / Tfall (20%-80%) (ps)	45	45	45	45	45	45
RMS Spectral Width (nm)	0.65	0.65	0.65	0.65	0.65	0.65
Max Avg Launch Power (dBm)	1.0	1.0	1.0	1.0	1.0	1.0
Avg Launch Power (dBm)	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
Optical Mod. Amp. (mW)	0.521	0.521	0.521	0.521	0.521	0.521
OMA (dBm)	-2.83	-2.83	-2.83	-2.83	-2.83	-2.83
Extinction Ratio (dB)	5.0	5.0	5.0	5.0	5.0	5.0

Example values, not min or max

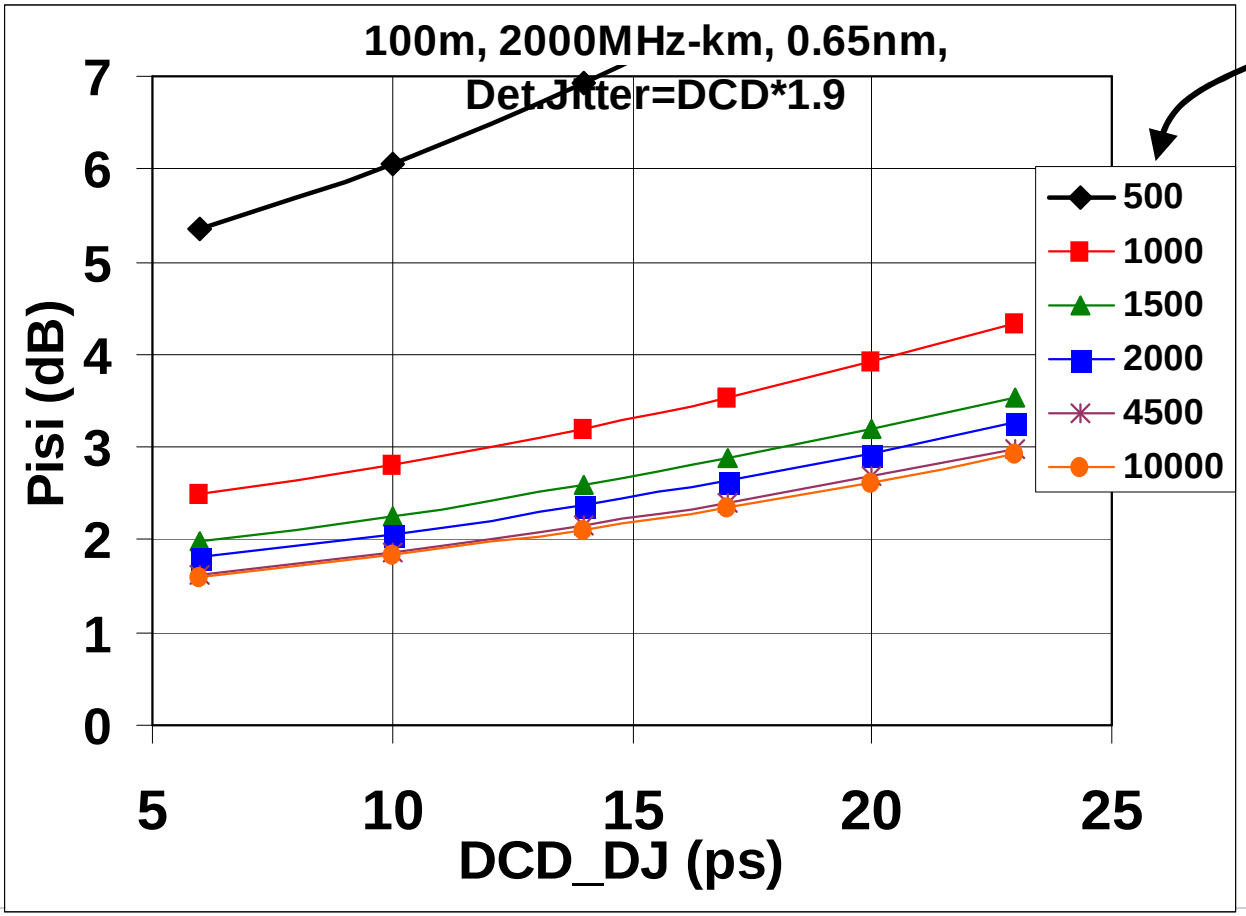
Jitter and rise/fall tradeoff for 100m, OM3

- Spectral width has negligible effect due to short distance
- Motivates a TWDP to combine the effects of rise/fall, jitter



100m on OM2, OM3, OM4, OMX

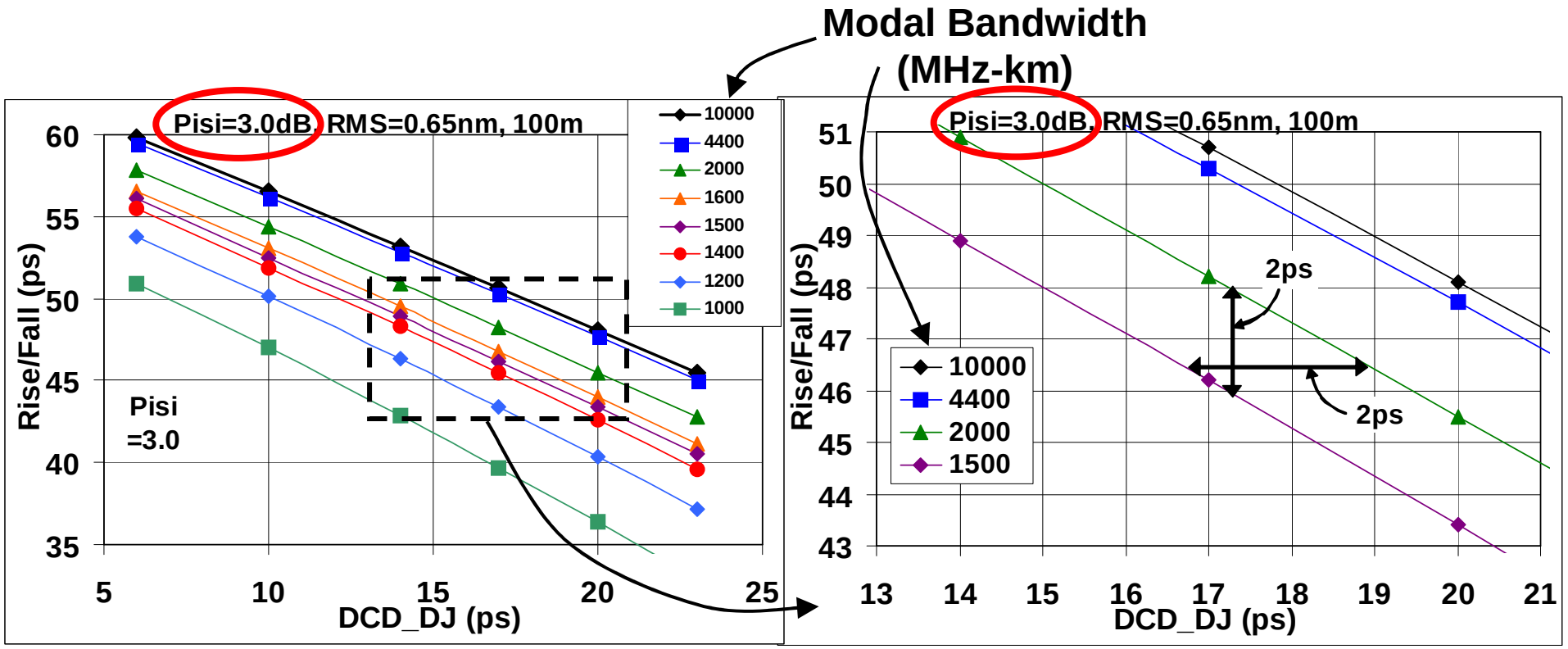
- Rise/fall = 45ps
- Not very sensitive to modal bandwidth >1500 MHz=km
- Underscores dominance of r/f, jitter to penalties



Modal Bandwidth MHz-km

100m sensitivity to modal bandwidth

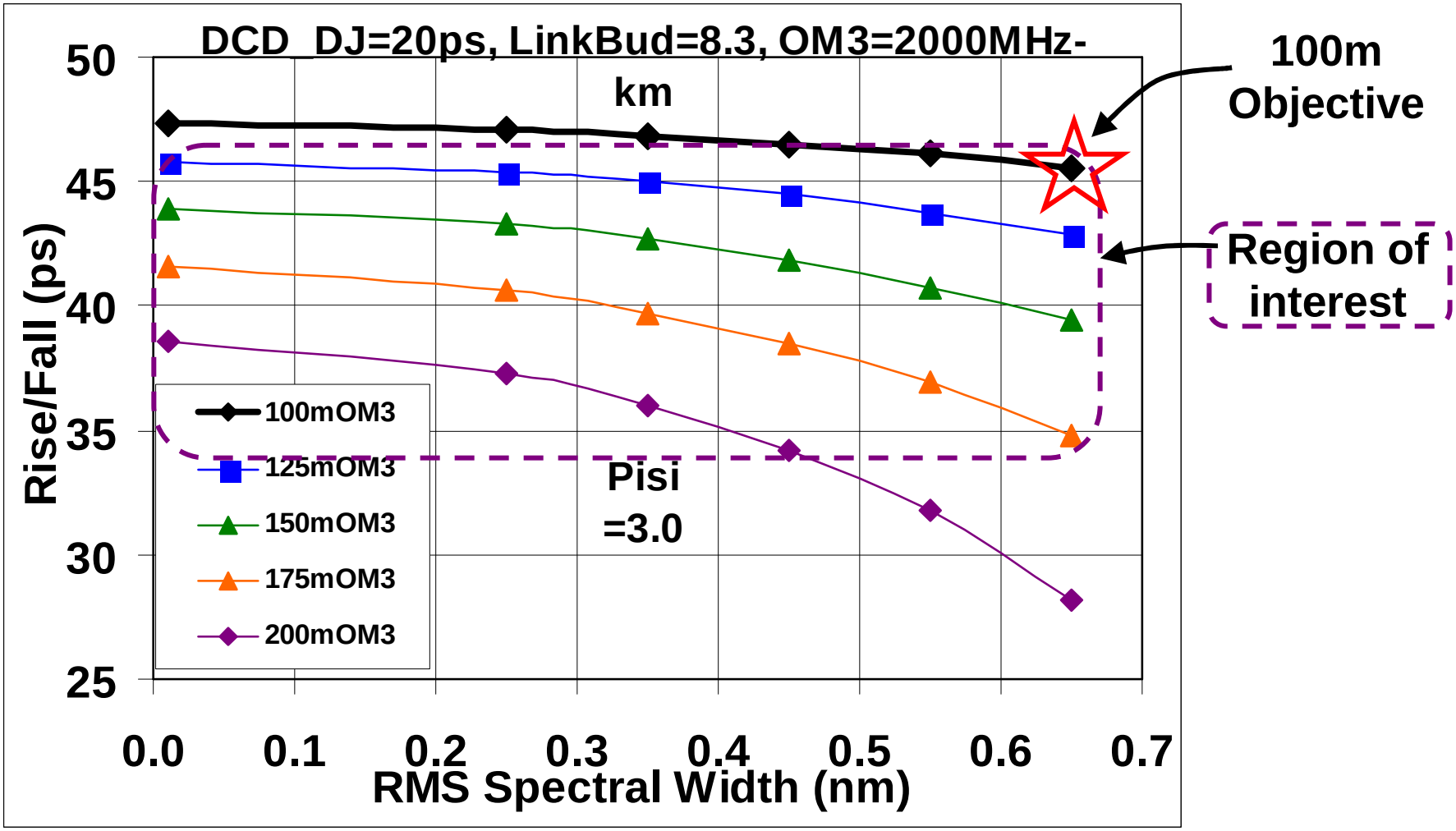
- **OM3: Res. Launch → 2000MHz-km; OFL → 1500MHz-km**
- **1500MHz-km vs 2000MHz-km requires**
  ~2ps faster rise/fall OR ~2ps less DCD_DJ



JDSU

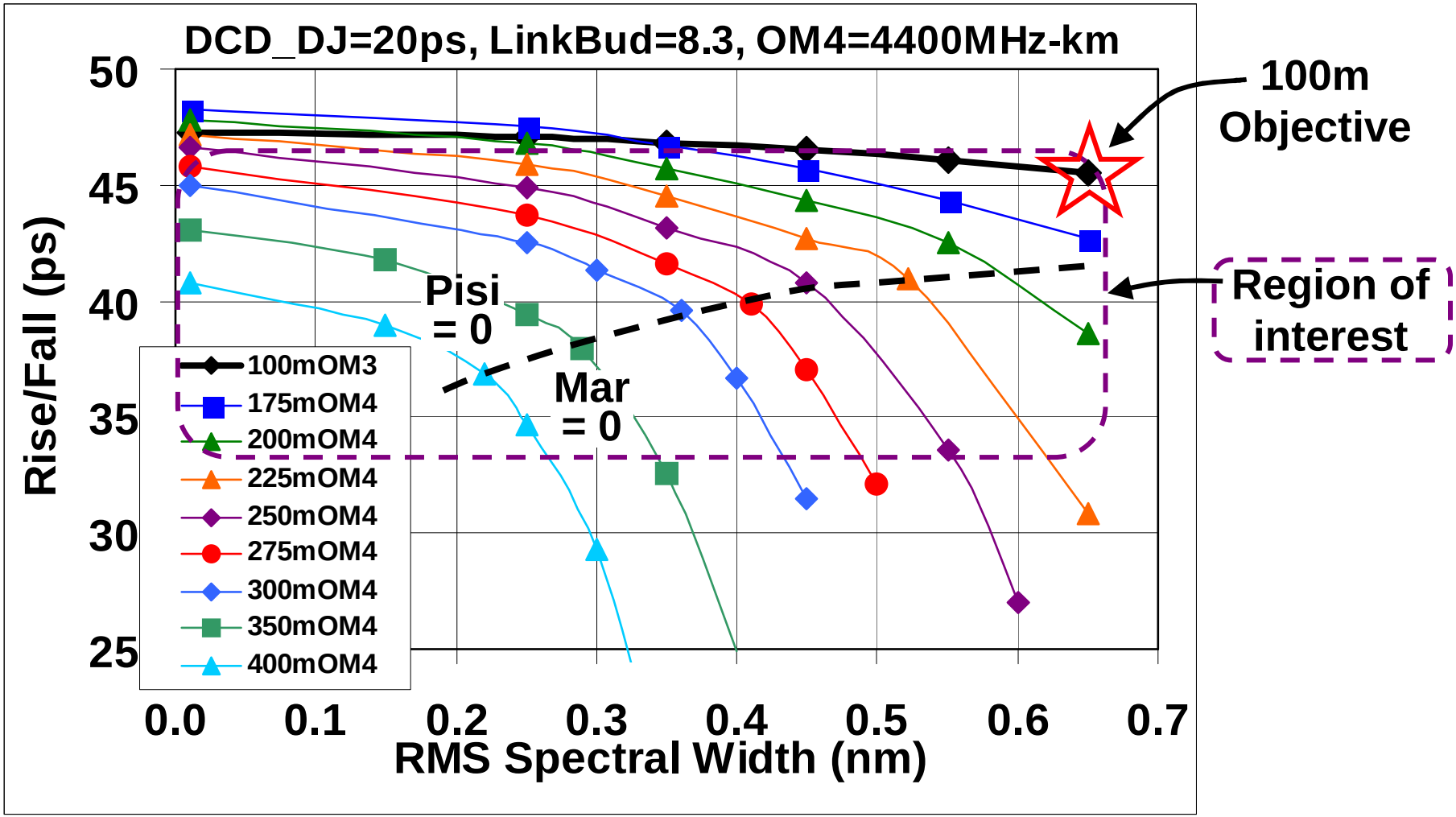
≥100m reach on OM3 MMF

- Pisi=3.0 for all points except one (where rise/fall <30ps)
- DCD_DJ = 20ps, Det. Jitter = 38ps



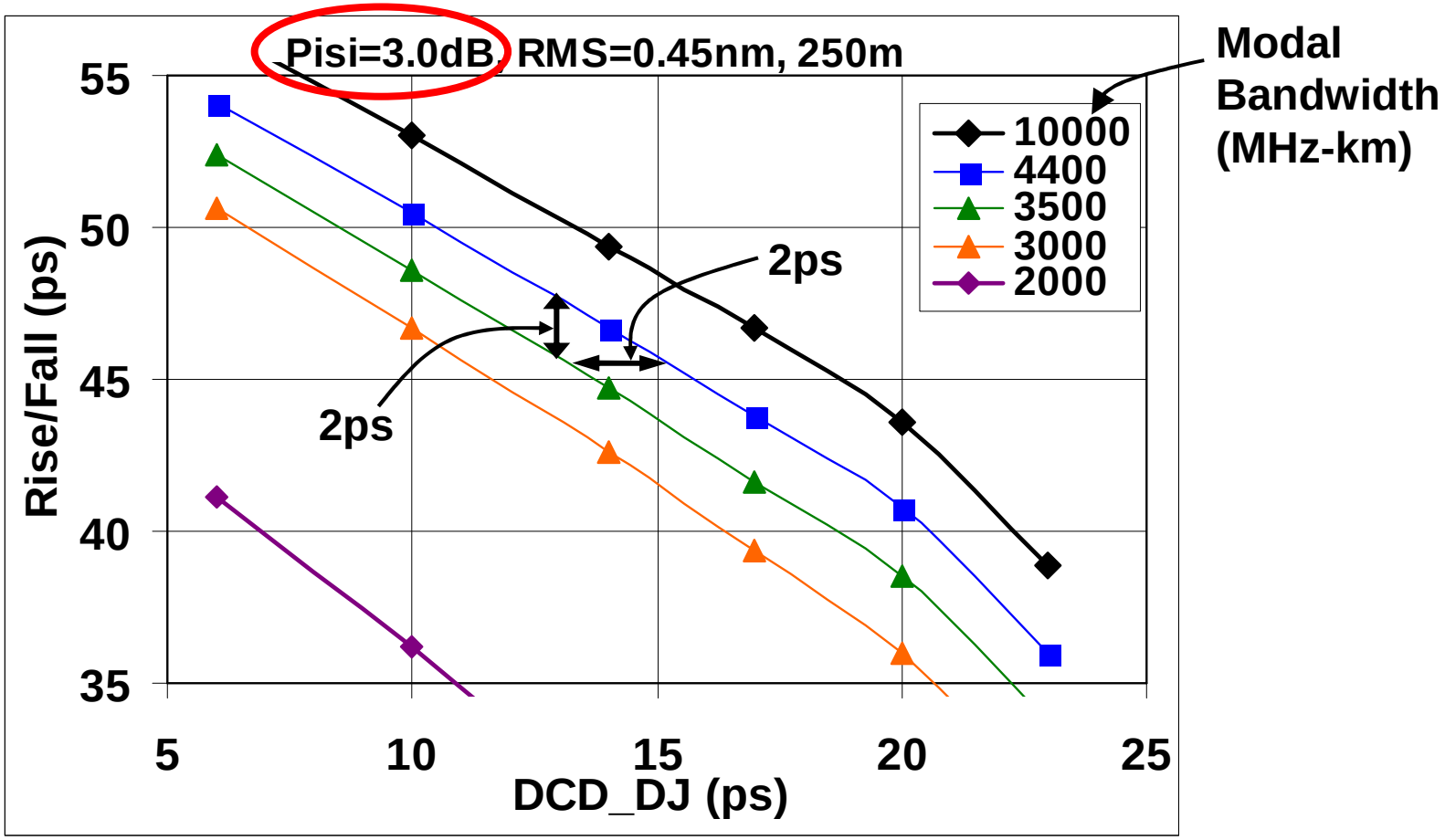
≥100m reach on OM4 MMF

- Points above black dashed line at Pisi = 3.0
- Points below black dashed line at Margin = 0.0



250m OM4 sensitivity to modal bandwidth

- **3500MHz-km vs 4400MHz-km requires ~2ps faster rise/fall time OR ~2ps less DCD_DJ**



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Details for 250m, OM4

- **ISI and margin limits are balanced when RMS spectral width = 0.45nm and rise/fall = 40.8ps**

Link Power Budget and Penalties

Description	1	2	3	4	5	6
Operating Distance (m)	250	250	250	250	250	250
Fiber Modal BW (MHz-km)	4400	4400	4400	4400	4400	4400
Wavelength Range (nm)	840-860	840-860	840-860	840-860	840-860	840-860
Link Power Budget (dB)	8.3	8.3	8.3	8.3	8.3	8.3
Channel Insertion Loss (dB)	2.91	2.91	2.91	2.91	2.91	2.91
Link Power Penalties (dB)	4.82	4.82	4.95	5.31	5.36	5.36
Unallocated Margin (dB)	**0.54**	**0.54**	**0.41**	**0.05**	**0.00**	**0.00**
Pisi (dB)	3.00	3.00	3.00	3.00	2.63	1.86
DCD_DJ (ps)	20	20	20	20	20	20

Pisi limited

Margin limited

Transmit Characteristics

Description						
Signal Speed (Gbaud)	10.3125	10.3125	10.3125	10.3125	10.3125	10.3125
Wavelength (nm)	840	840	840	840	840	840
Trise / Tfall (20%-80%) (ps)	46.6	44.9	43.2	40.8	33.6	15.0
RMS Spectral Width (nm)	0.01	0.25	0.35	0.45	0.55	0.65
Avg Launch Power (dBm)	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Avg Launch Power (dBm)	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
Optical Mod. Amp. (mW)	0.521	0.521	0.521	0.521	0.521	0.521
OMA ((dBm)	-2.83	-2.83	-2.83	-2.83	-2.83	-2.83
Extinction Ratio (dB)	5.0	5.0	5.0	5.0	5.0	5.0

Example values, not min or max

Observations

- 35-45ps rise/fall is “sweet spot” for 100m over OM3, and >100m links over OM3 and OM4
- Key parameters for 100m on OM3: rise/fall and jitter
  - Connector loss, max optical power also important
- ≥150m on OM3 links appear feasible for RMS≤0.65nm
- Tradeoffs among rise/fall, jitter, spectral width, and modal bandwidth expand the product space for parallel MMF without compromising the low-cost benefits of the 100m, OM3 objective
- ≥250m on OM4 links appear feasible for RMS≤0.45nm

- Compared to SMF links, the >100m links would provide significant savings in cost and power dissipation, while enabling higher density and faster time to market