# *Multimode fiber media types for 802.3cd*

*P802.3cd, Fort Worth, Texas*
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# Laser Optimized Multimode Fiber Types

| Fiber Type | EMB at 850 nm (MHz·km) | EMB at 953 nm (MHz·km) |
|---|---|---|
| OM3 | 2000 | NA |
| OM4 | 4700 | NA |
| WBMMF (OM4-W or OM5?) | 4700 | 2470 |

- OM3 and OM4 designed for high bandwidth at 850 nm
- WBMMF designed high bandwidth over wide range of wavelengths

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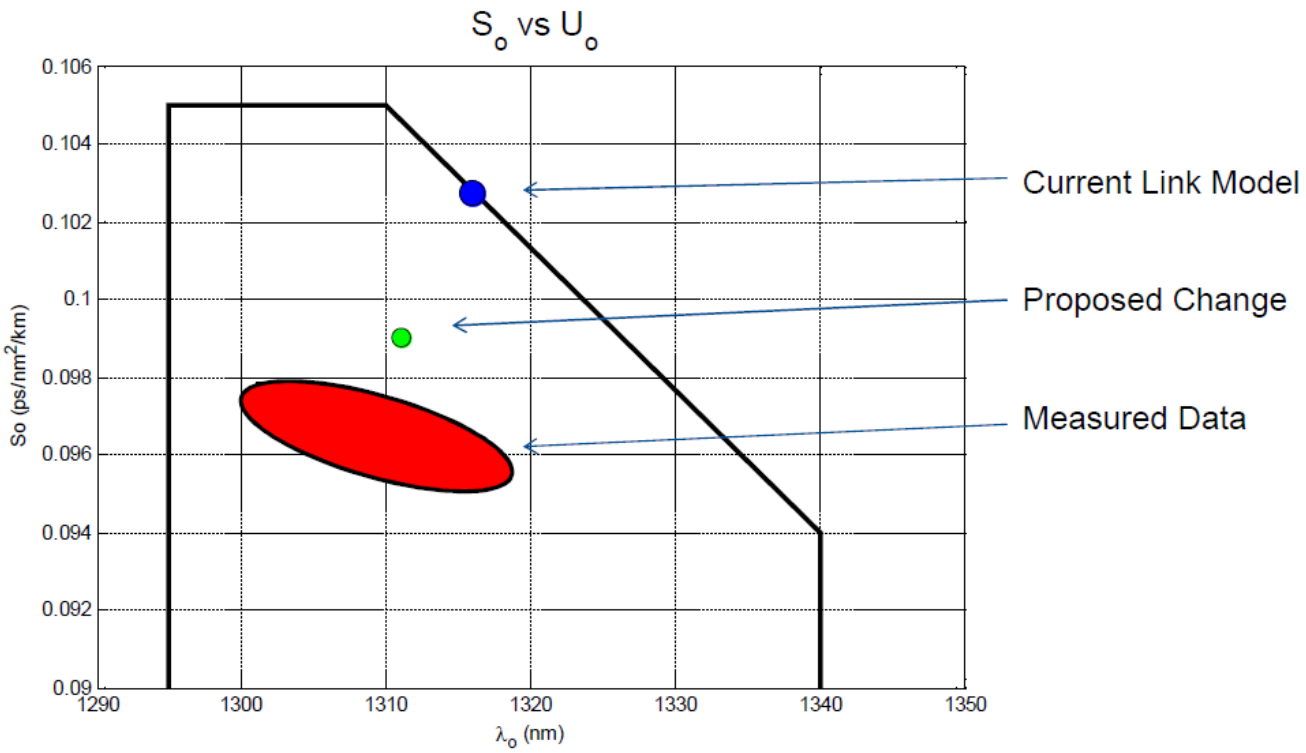
# TIA Round Robin Report – Used for Specifying WBMMF CD

## Utilize more realistic but conservative values for Uo and So



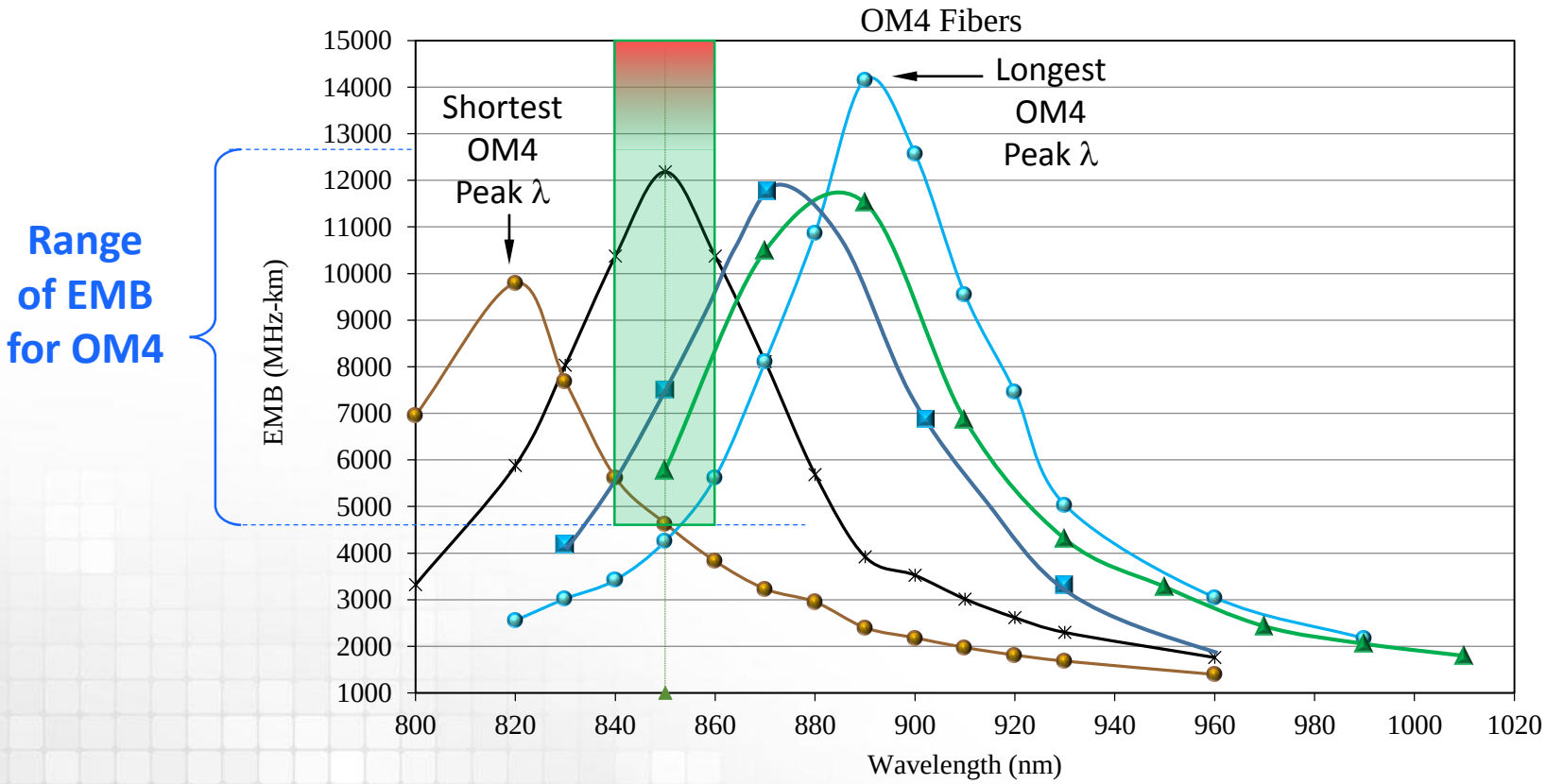

**Standard MMF**

Round Robin Participants

1. Corning
2. OFS
3. Panduit
4. Prysmian
5. J Fiber
6. YOFC

Source: TR42.12-2015-06-022

# Range of EMB peak wavelengths for 5 OM4 fibers - EMB wavelength dependence



# TIA 42.12 Presentation:

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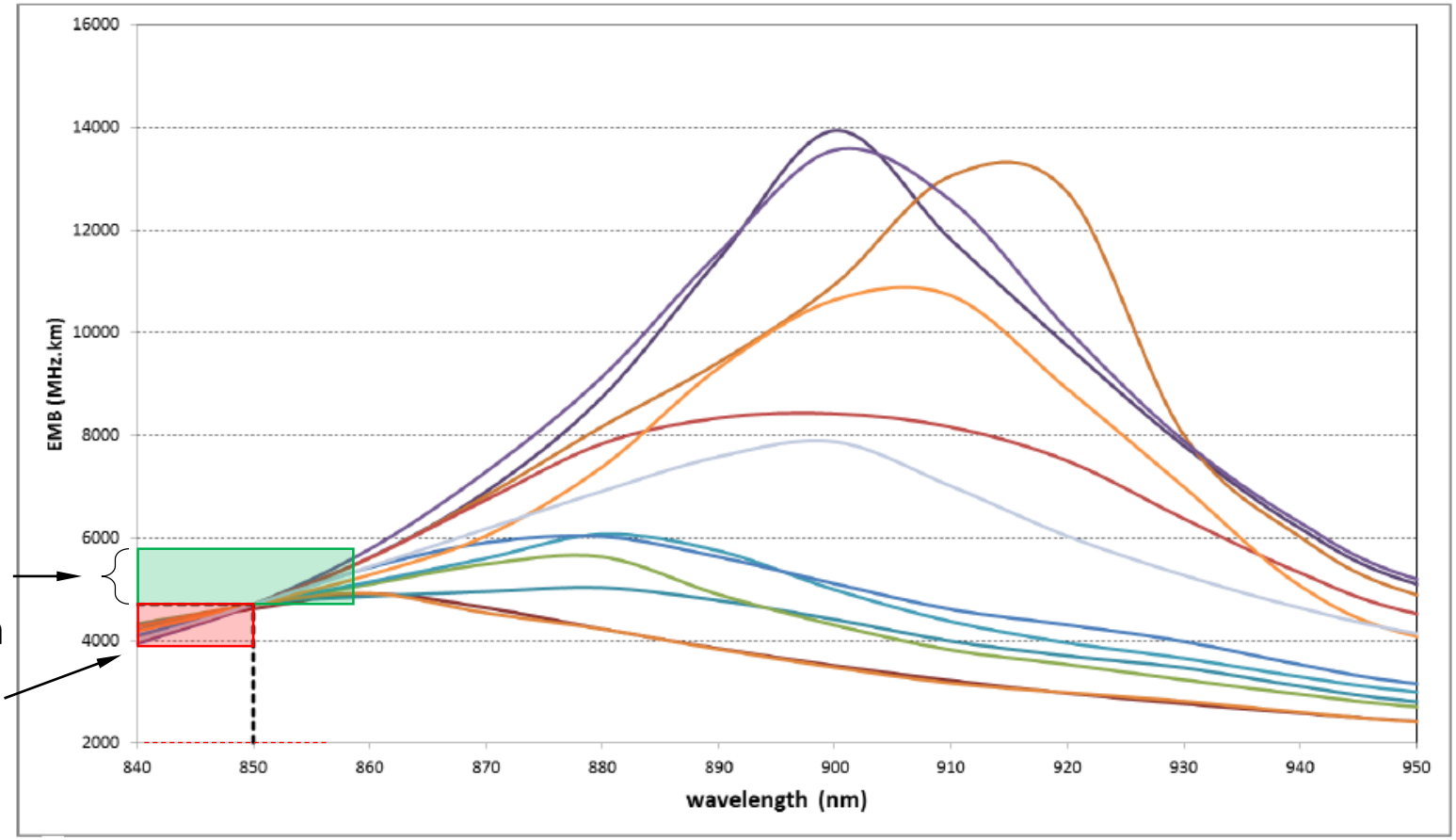
## Wideband fibers with EMBc = 4700MH.km @ 850nm



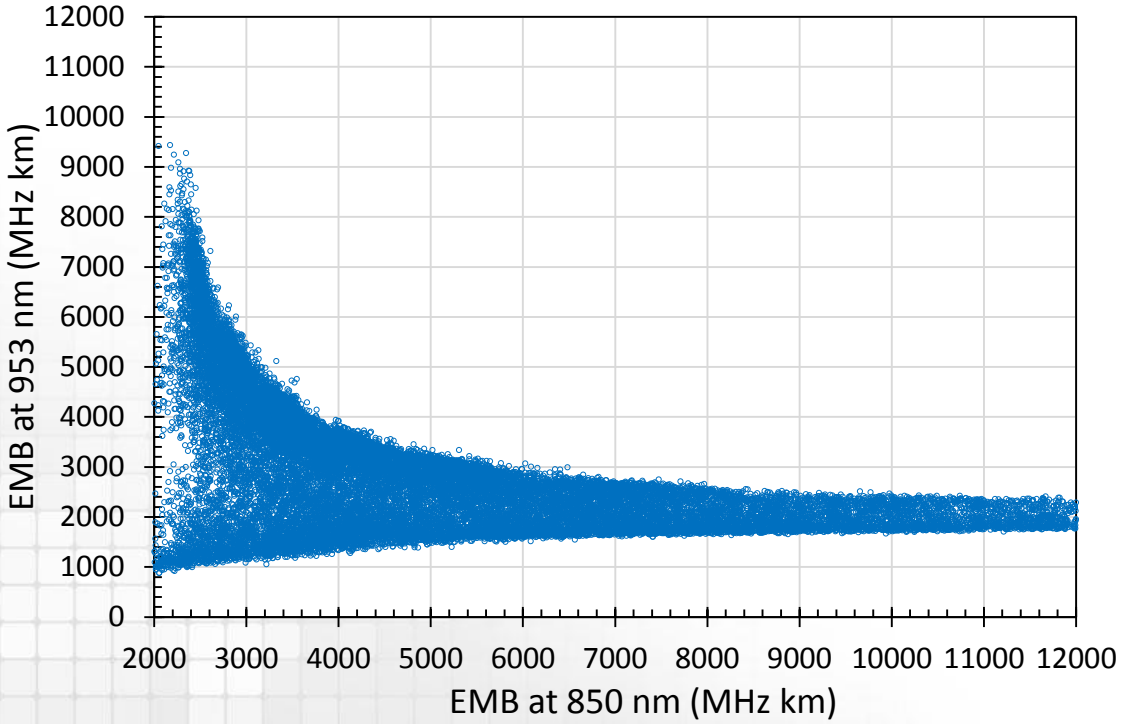

Range of EMB at 850 nm

Low EMB at 840 nm

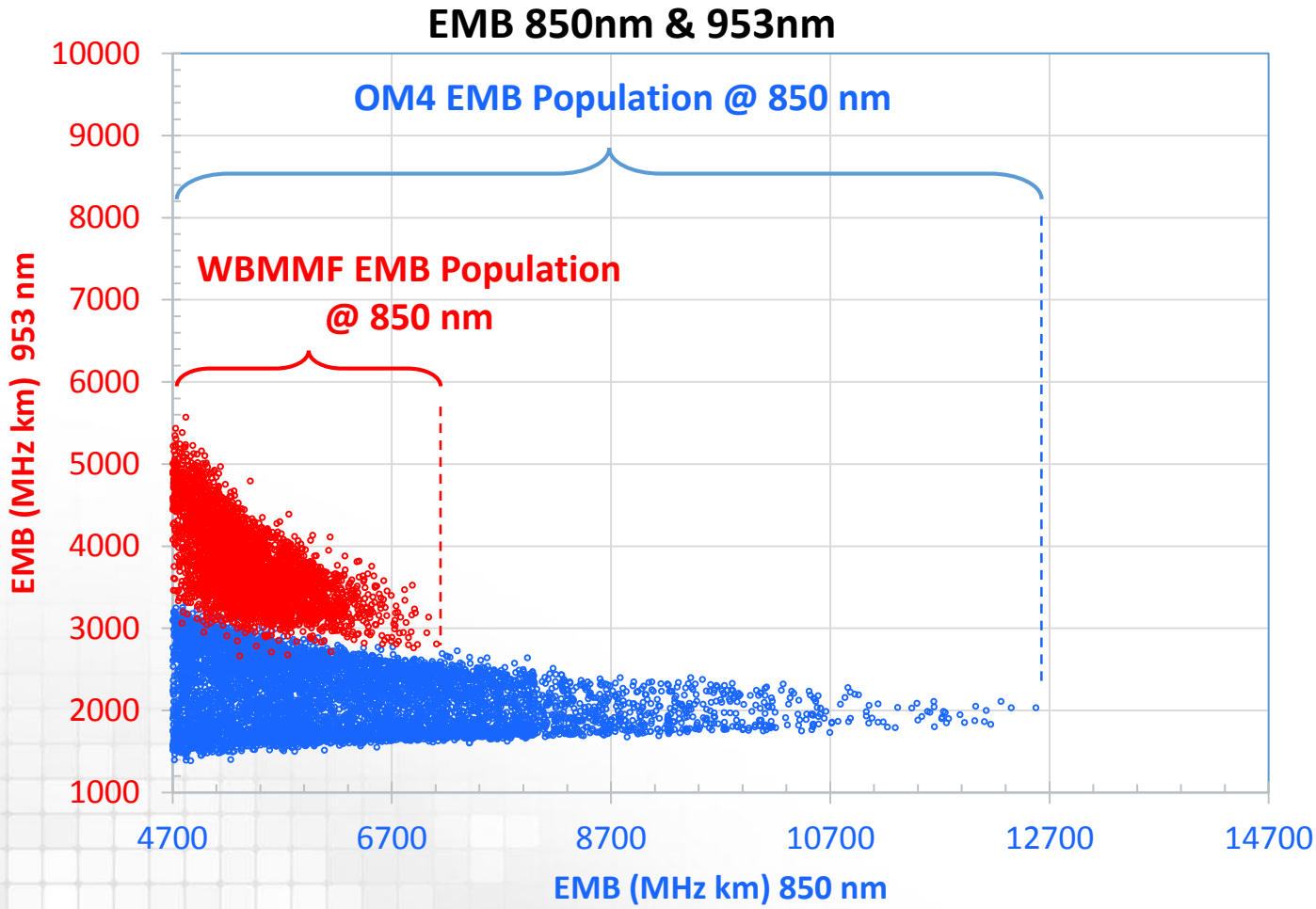
Source: TR42.12-2015-06-013

# Modeling of OM4 EMB wavelength dependence

- Simulation parameters
  - Fibers with both perfect alpha profiles and perturbed refractive index profiles
  - Magnitude of index perturbation normally distributed w/ standard deviation ~$10^{-4}$
  - Population of 40000 MMFs per wavelength generated over the range 830 nm to 980 nm
    - Wavelengths varied in 1 nm steps
    - Total fibers-wavelength combination = 6 million
    - Blue dots represent the universe of MMFs including OM3 and OM4



# Modeling of OM4 & WBMMF EMB wavelength dependence



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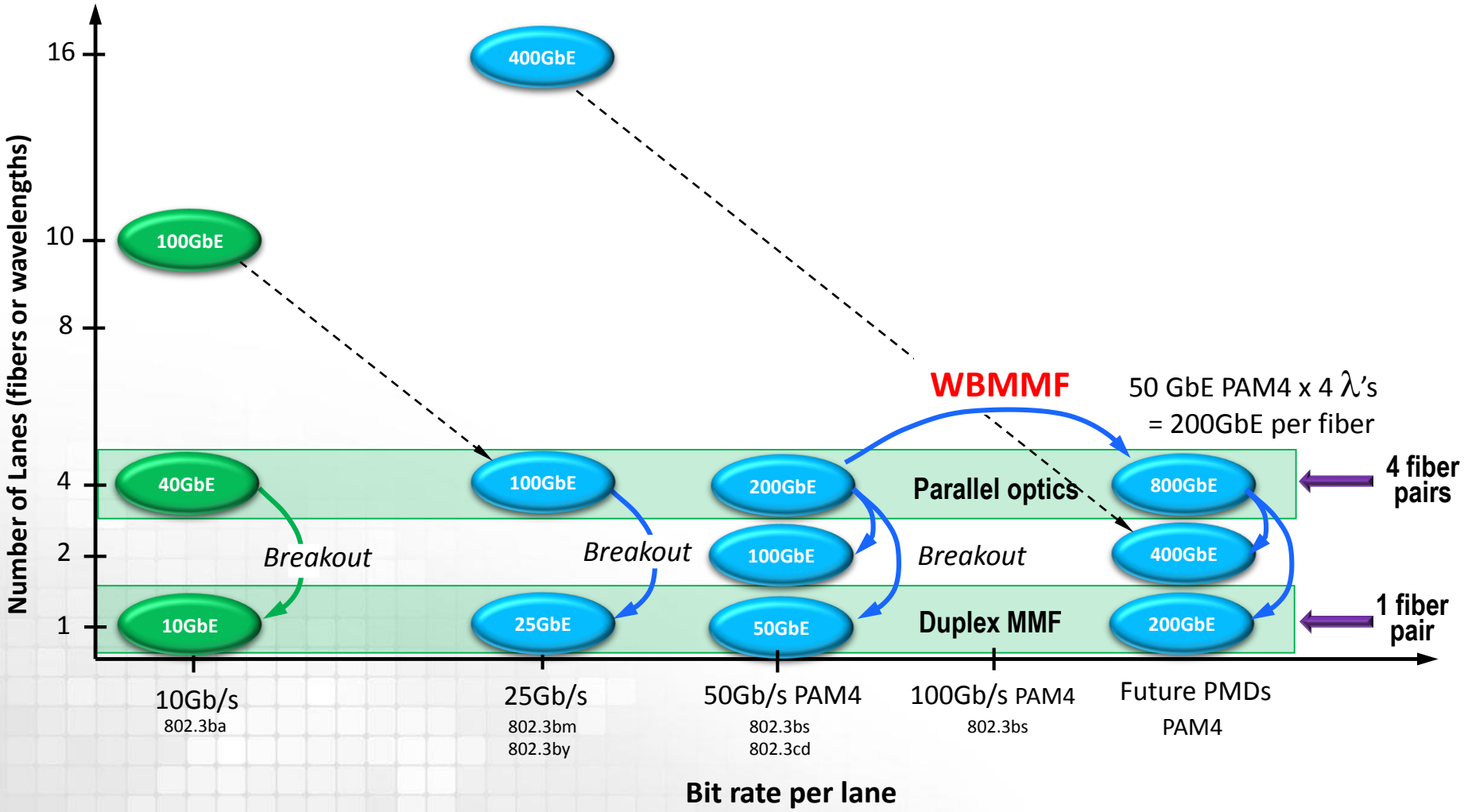
# WBMMF Required for Future higher speed Ethernet using SWDM



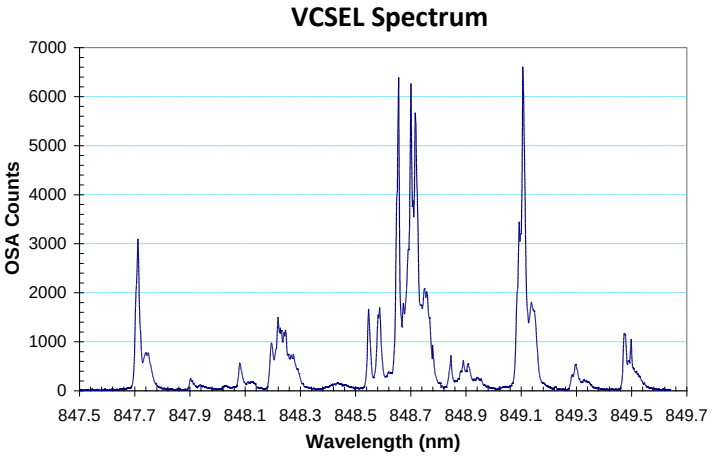
# Conclusions

- Inclusion of WBMMF as a media type option for P802.3cd depends on which 100G solution is adopted
  - *Required for SWDM*
  - *Not Required for parallel optics (SR2)*
- For SWDM, OM3 & OM4 EMB is not specified for λ's ≥ 860 nm
  - *Only WBMMF can be specified for 100G SWDM-2*
  - *PMDs will require different MMF types for different data rates*
- For parallel optics i.e., 100GBASE-SR2
  - *WBMMF provides no benefit*

    *(modal and chromatic dispersions are the same as OM4)*
- Concerns
  - *Including or excluding MMF media types for 50/200G vs 100G will confuse customers*
  - *The use of OM4 for SWDM can result in channel failures*
- Premature to specify SWDM or include Wideband MMF in 802.3cd

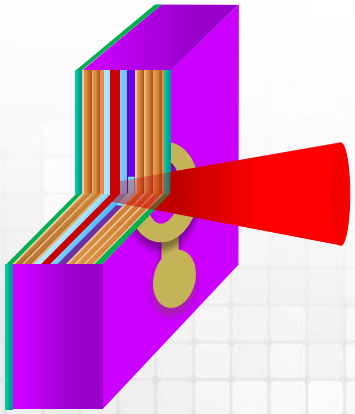
# BACKUP

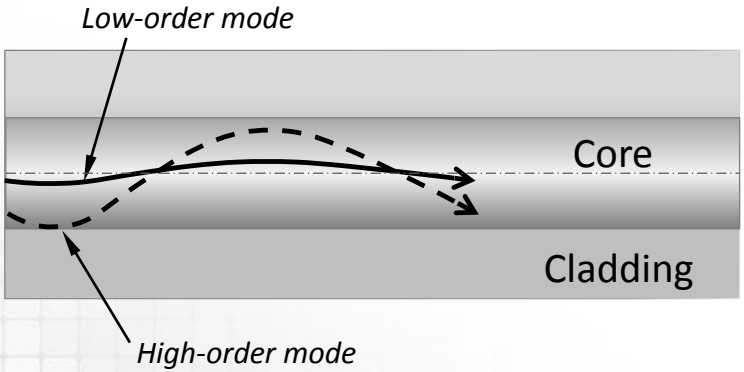
# Primary cause of BER performance disparity
## – *Spectral coupling of VCSEL–MMF modes*



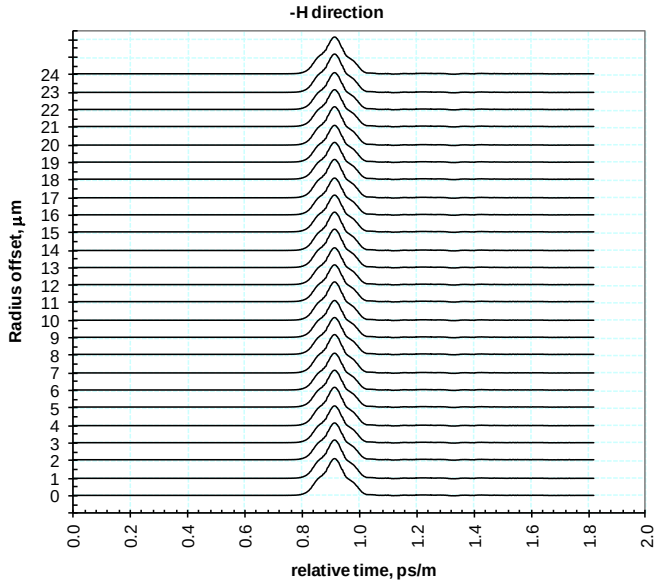

- ***Conventional system models assume homogenous fiber coupled spatial-spectral distribution versus fiber radius***
  - ***Modal and chromatic dispersion effects remain independent***

**VCSEL**



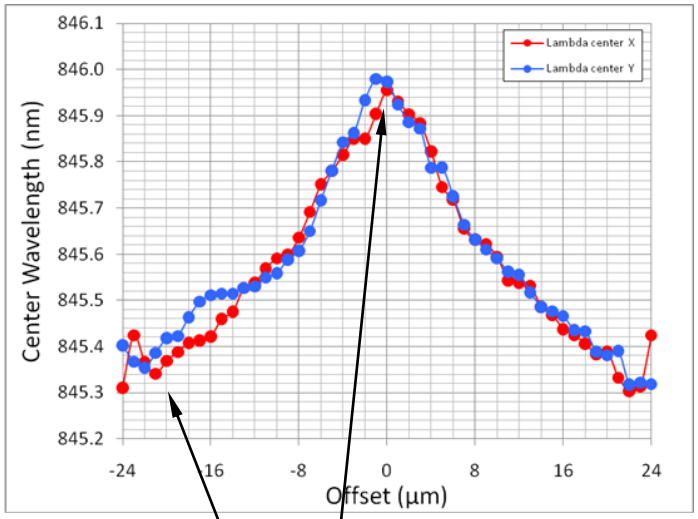



**Equal radial Mode Delays**
**Near Perfect DMD + Chrom. Disp'n**

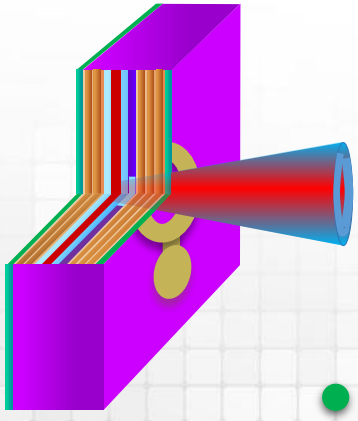



*VCSEL spectral width = 0.425nm*

# Actual VCSEL spatial-spectral coupling into MMF

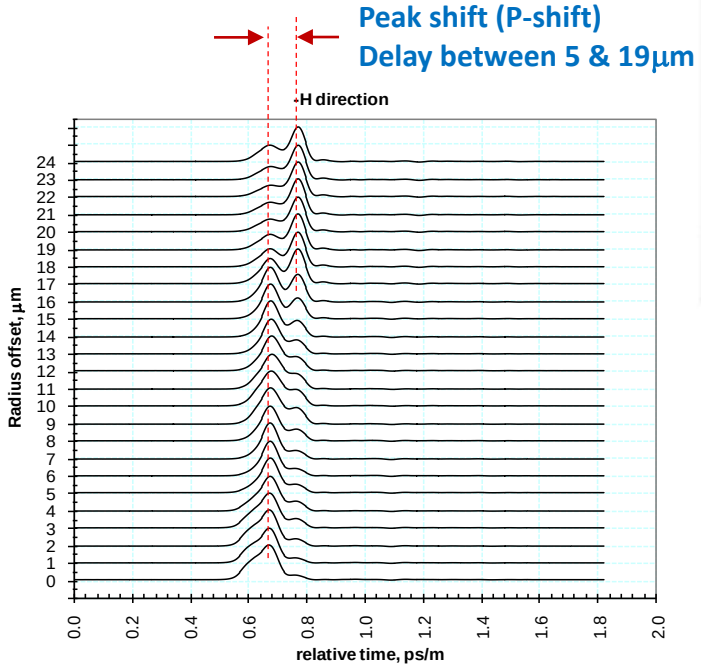



Radial Spectral Dependency



- Short wavelengths couple to high-order modes
- Long wavelengths couple to low-order modes

- *There is a significant fiber coupled spatial-spectral distribution*
  - *Shorter spectral components preferentially coupled to larger fiber radii*
- *Interaction of modal and chromatic dispersion*

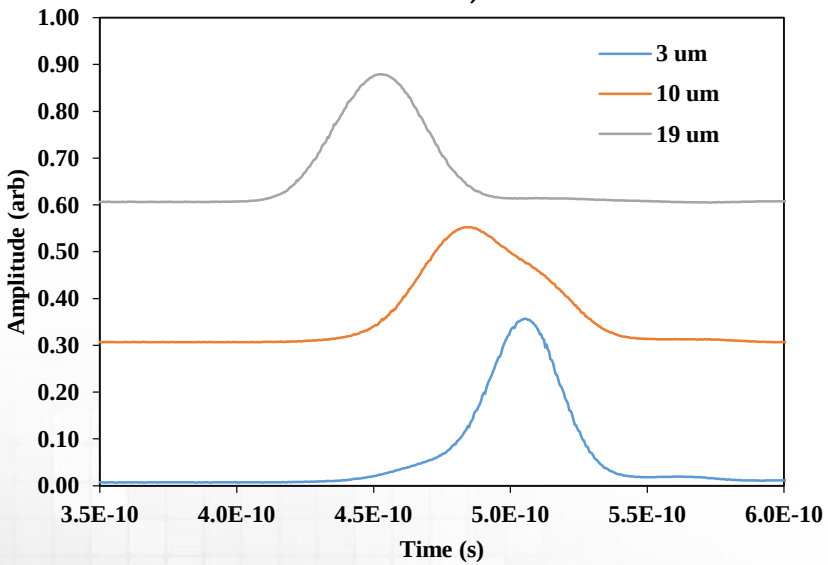



***Resultant DMD due to Modal Chromatic Dispersion***

# Modal-Chromatic Dispersion Interaction

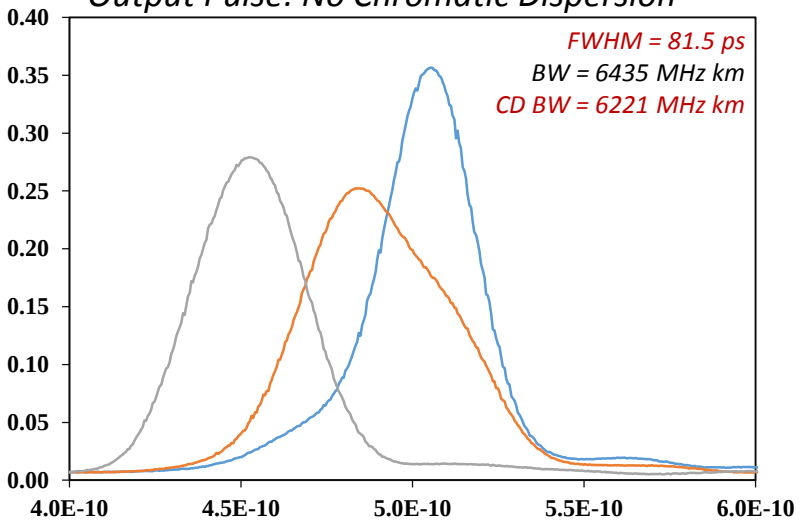
*Standard Algorithm*

*DMD Measurement, λ = 850 nm*

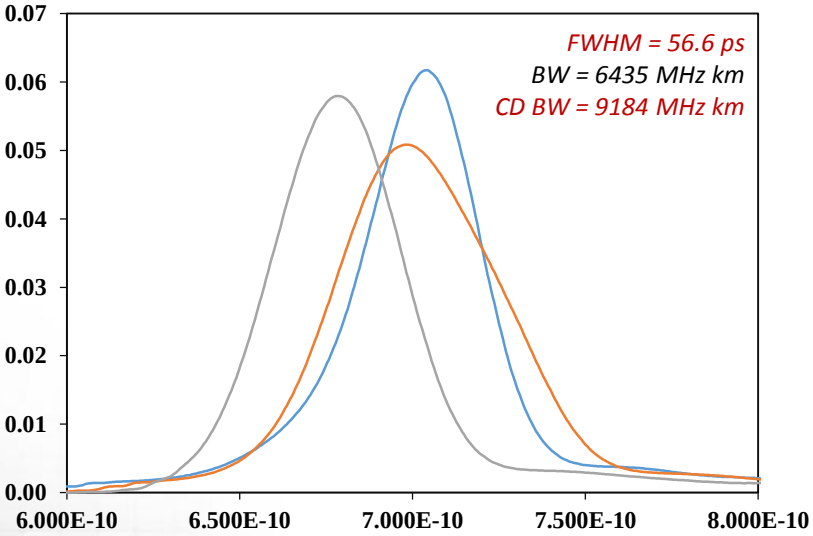



*Panduit Algorithm*

*Output Pulse: No Chromatic Dispersion*

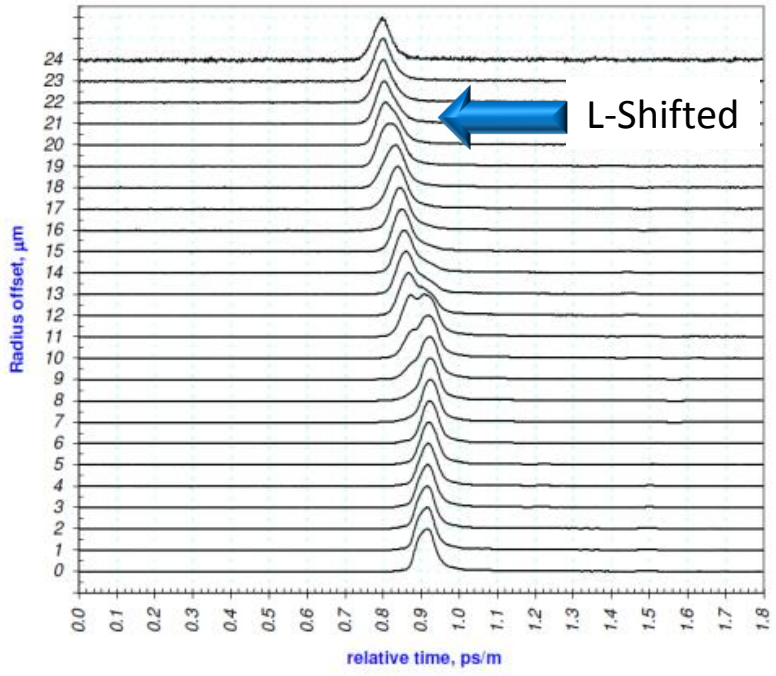



*Output Pulse: With Chromatic Dispersion*

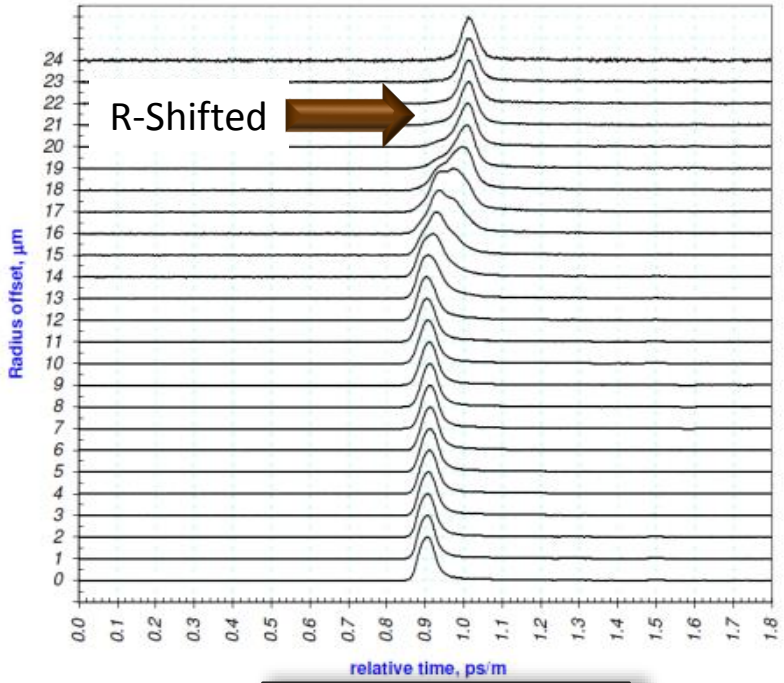


# System Performance versus Fiber Bandwidth

- *Two fibers from same cable with the same EMB (similar DMD)*
  - *L = 548 m*
  - *Ti:Sapphire Laser - DMD*



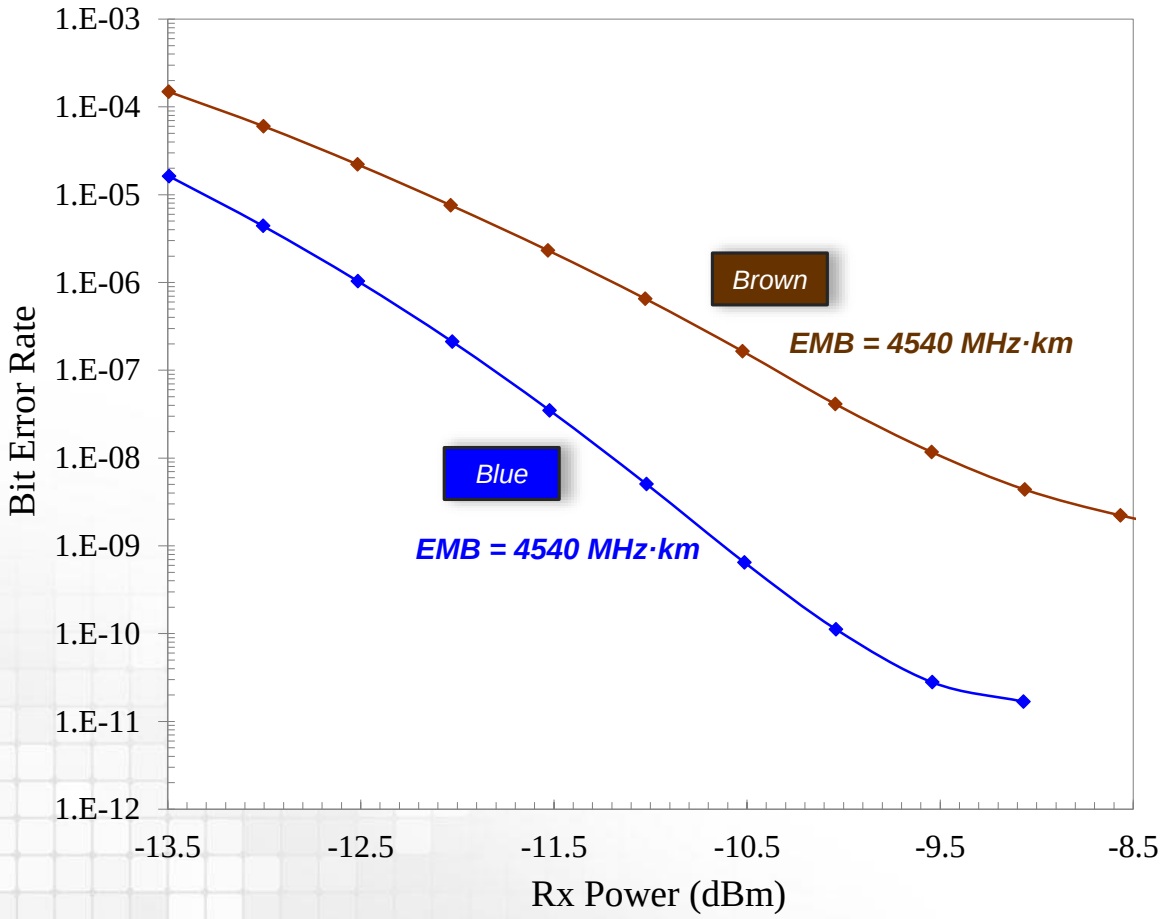

*Blue Fiber*
*EMB = 4540 MHz·km*
*$DMD_{inner}$ = 0.12 ps/m*
*$DMD_{outer}$ = 0.15 ps/m*
*$DMD_{sliding}$ = 0.11 ps/m*
*DMD P-Shift = -0.098 ps/m*




*Brown Fiber*
*EMB = 4540 MHz·km*
*$DMD_{inner}$ = 0.12 ps/m*
*$DMD_{outer}$ = 0.13 ps/m*
*$DMD_{sliding}$ = 0.13 ps/m*
*DMD P-Shift = +0.096 ps/m*

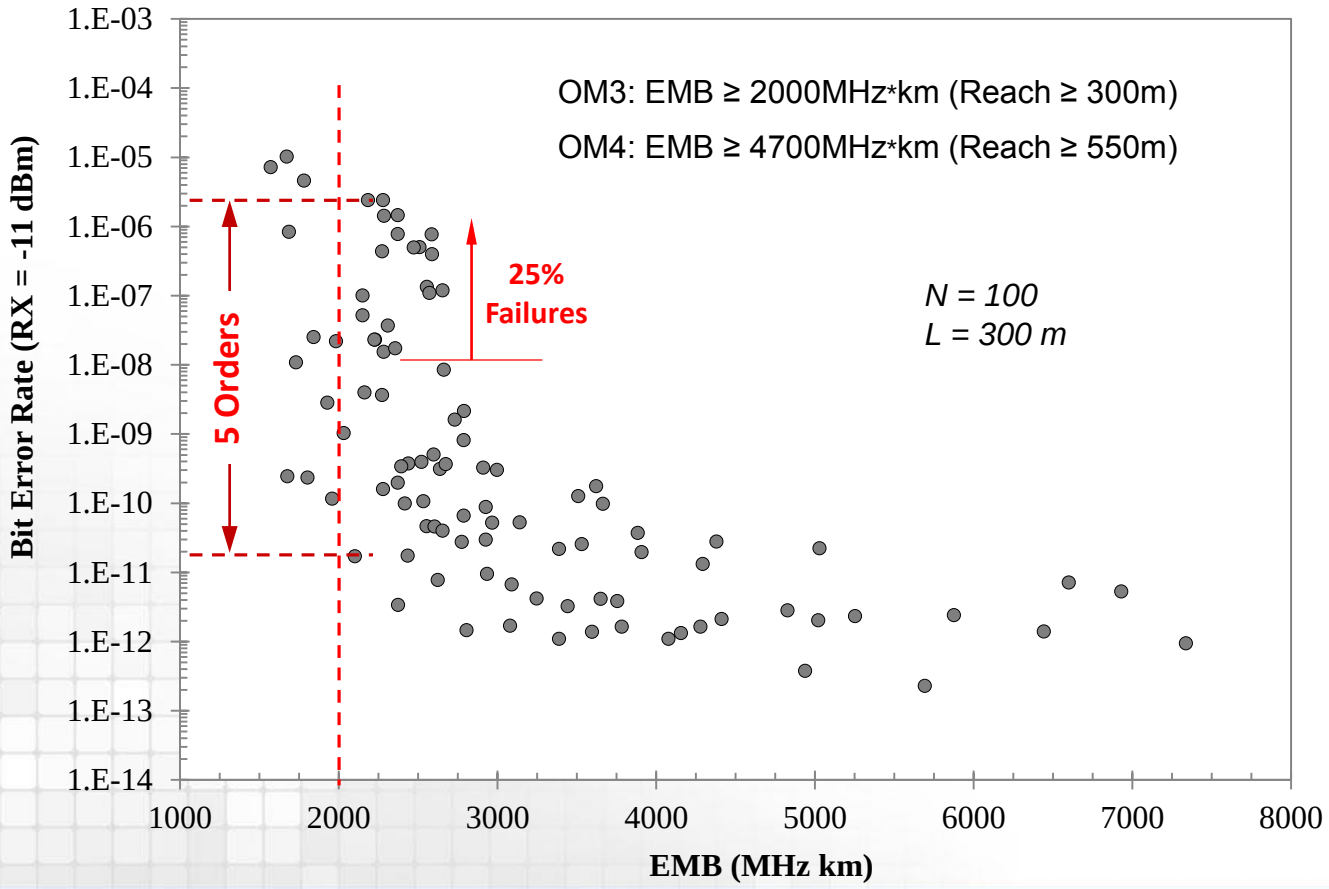
# Channel Performance Difference – Same EMB

- *Two fibers in same cable with the same EMB*
  - *L = 548 m*

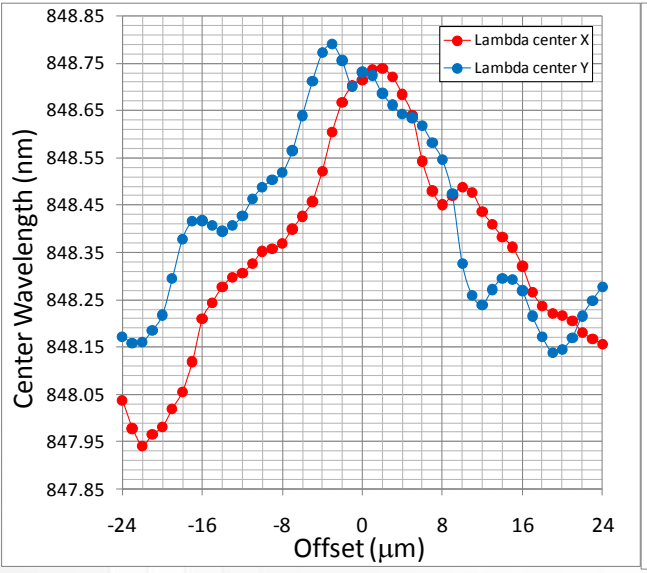


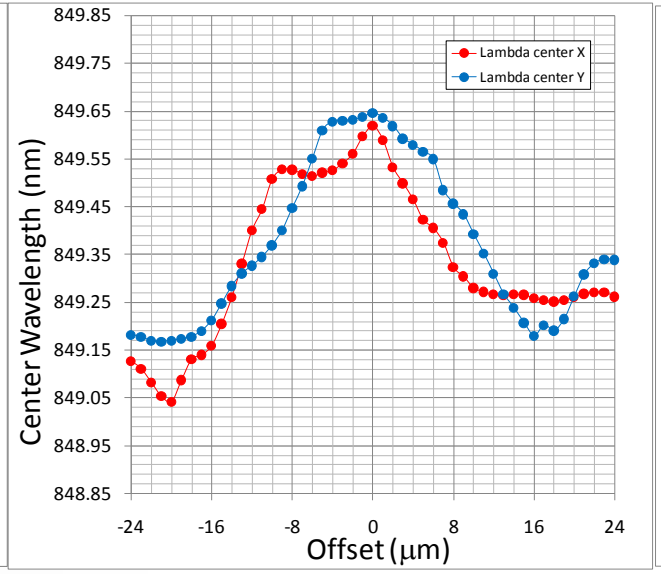
# System Performance vs. Fiber Bandwidth

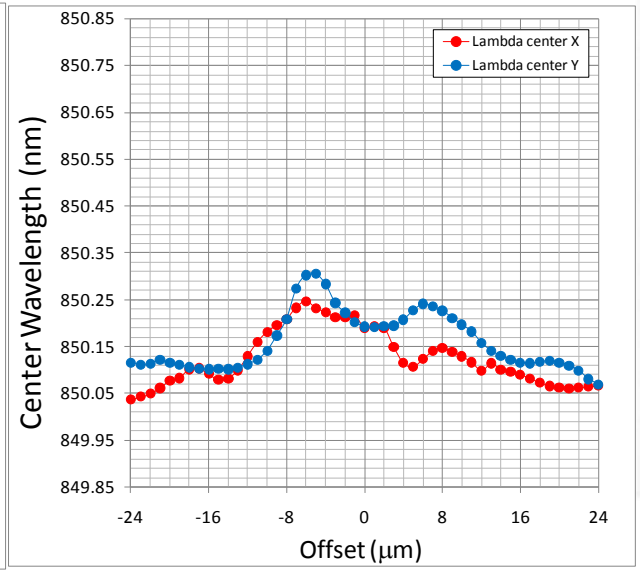
- *System Performance (BER) versus Fiber Bandwidth Correlation*
  - *Bit Error Rate Testing*
    - *10GBASE-SR compliant test mainframe*
      - *Identical TX & RX*
      - *Same fiber length, 300 m*
  - *Fiber Samples: OM3 included OM4*
    - *N = 100*
    - *Three fiber manufacturers*
    - *Various cable constructions & bare fiber*



# Three Transmitter spectral radial dependencies

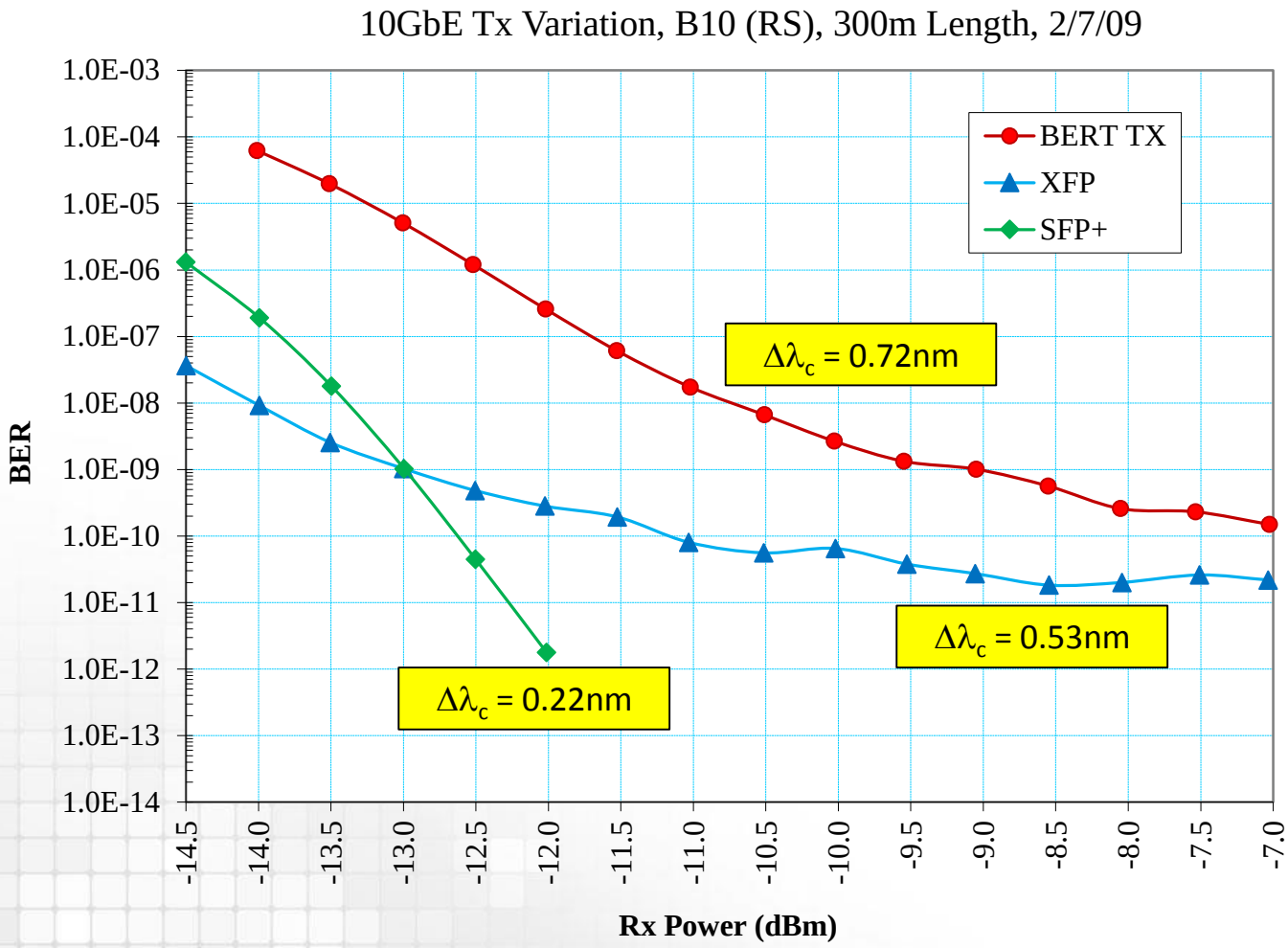



| | ***BERT*** | ***XFP JDSU032*** | ***SFP+ 2M*** |
|---|---|---|---|
| $\Delta\lambda_c$ (nm) | 0.72 | 0.53 | 0.22 |
| $\Delta\lambda$ (nm) | 0.45 | 0.34 | 0.23 |

# 300m Transceiver Performance – B10 (R-Shifted)



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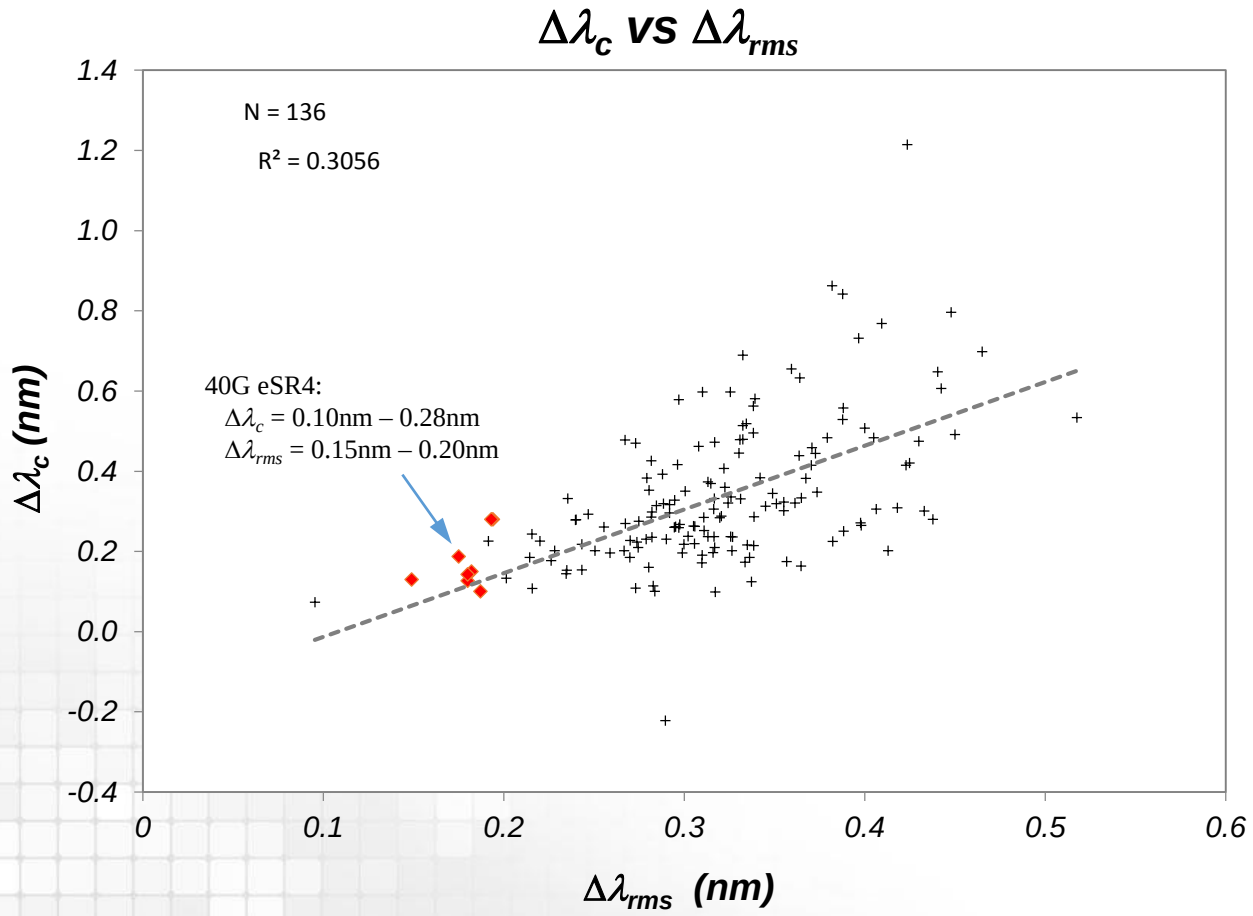
# Correlation Between $\Delta\lambda_c$ and $\Delta\lambda$ 136 Transceivers (+2 eSR4s)



https://www.networkscentre.com/Information/145/Cisco-Compatible.html

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- Tools & Testers
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Direct attach assemblies from Panduit and Siemon provide a cost-effective solution for interconnecting high speed switches and servers.

### Solutions for Cisco BiDi

Cisco have developed a 40G Ethernet optical module called BiDi (40GBASE-SR-BiDi), short for bidirectional. To use Cisco's 40G BiDi optical modules in place of existing 40G Ethernet modules, the same reach requirements as the existing modules must be achieved.

Standard OM4 multimode fibre cannot meet Cisco's 150m reach requirement. The Panduit® Signature Core™ Fibre Optic Cabling System allows Cisco's 40G BiDi module to be used out to 150m.

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