Fiber Certification: The Impact of New Standard for Multimode Fiber Measurements

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EXPERTISE REACHING OUT

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OUTLINE

- Introduction
- Experiments performed on various Links
- Experimental results
- Conclusion

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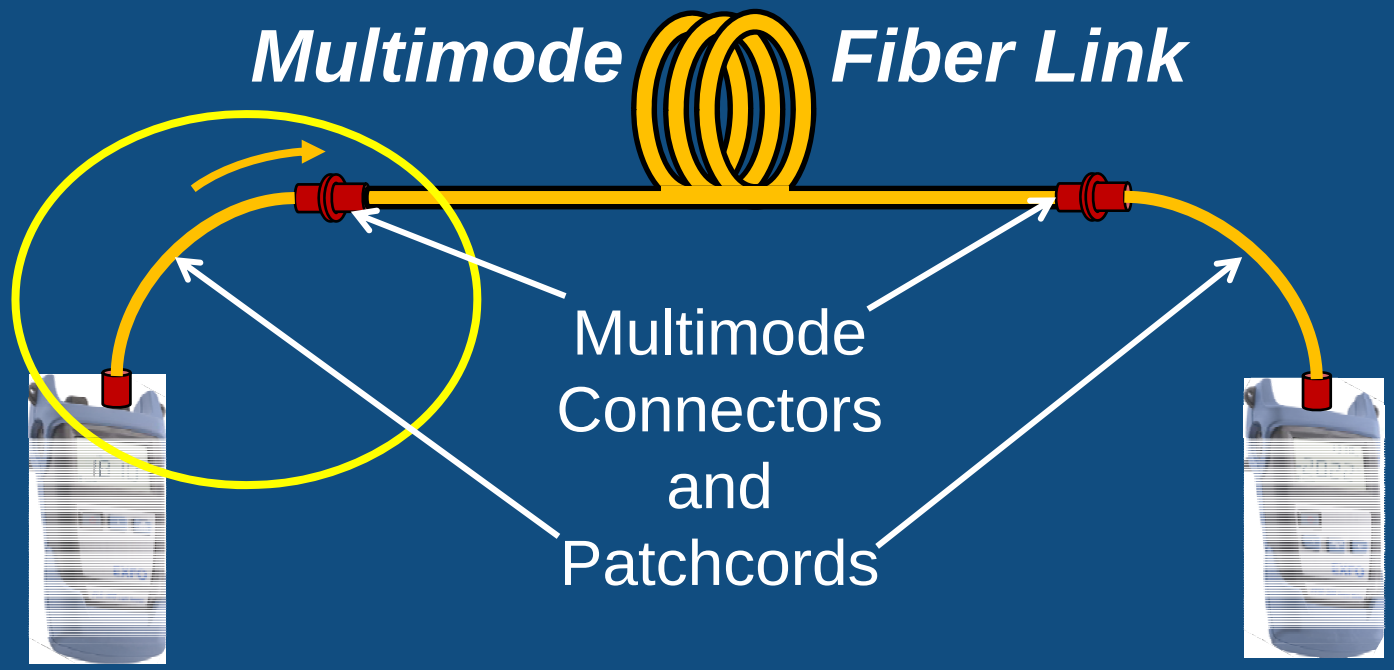
Measurements on MMF Links



How Many Acronyms Do We Need to Remember?

- CPR: Coupled Power Ratio
- EF: Encircled Flux
- FF: Far Field
- HOMP: High Order Mode Power
- MMF: Multi-Mode Fiber
- MPD: Mode Power Distribution
- NF: Near Field
- OFL: Over-Filled Launch
- RP: Relative Power (%)
- SMF: Single-Mode Fiber

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9 Types of MLCs (!?#$%)

1. OFL + 1 km of MMF
2. 70 / 70 launch
3. OFL + Mandrel
4. CPR
5. HOMP
6. NF / FF with diameter requirements for RP at
   - 5 % or
   - 75 %, 15 % and 5 %
7. MPD Template
8. ***EF Template = target with upper and lower limits***

Review of Current MLCs:

(1) 1-km MMF after OFL

(2) 70/70 launch

(3) Mandrel after OFL

- Define ¨How to do it¨; but…
  - ***Better define what you get than how to do it!***
- Practically under-fill launch
- Methods *(1)* and *(2)* = not practical in the field
- OFL definition = “fuzzy” → MLC = “fuzzy”

Review of Current MLCs:
(4) Coupled Power Ratio (CPR)

- From MMF to SMF
- Defined at source output
- Simple/easy-to-do NF power distribution measurement
  - ***Works only if well controlled NF PD***
- But with little information on high-order modes (HOM)
  - ***Loss = dependent on HOM power distribution***

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Review of Current MLCs:
(5) High-Order Mode Power (HOMP)

- Power difference (in dB) with and without HOM filter acting as a mandrel
- Works with OFL = but causes bad measurement reproducibility, because:
  - Size of fiber core
  - ***Macro-bending dependence***
  - ***Too many transient losses***
- ***Not widely used in the industry***

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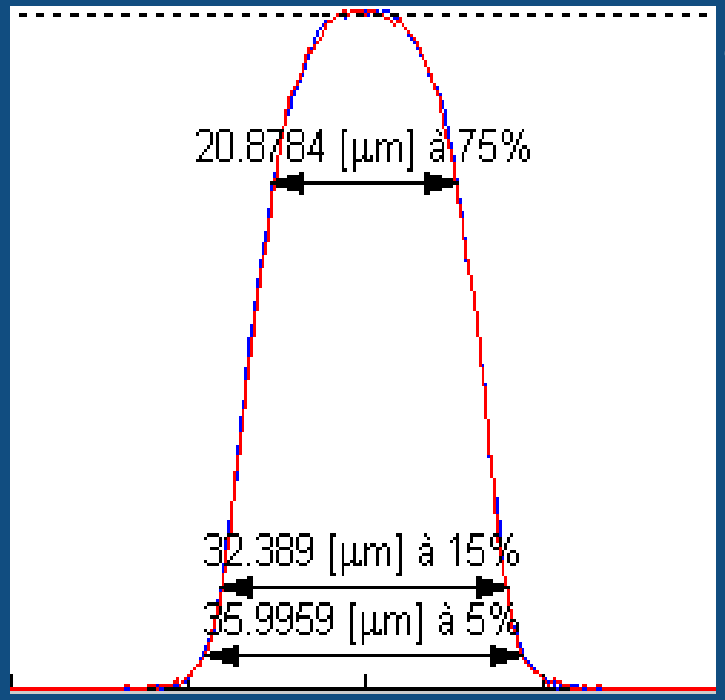
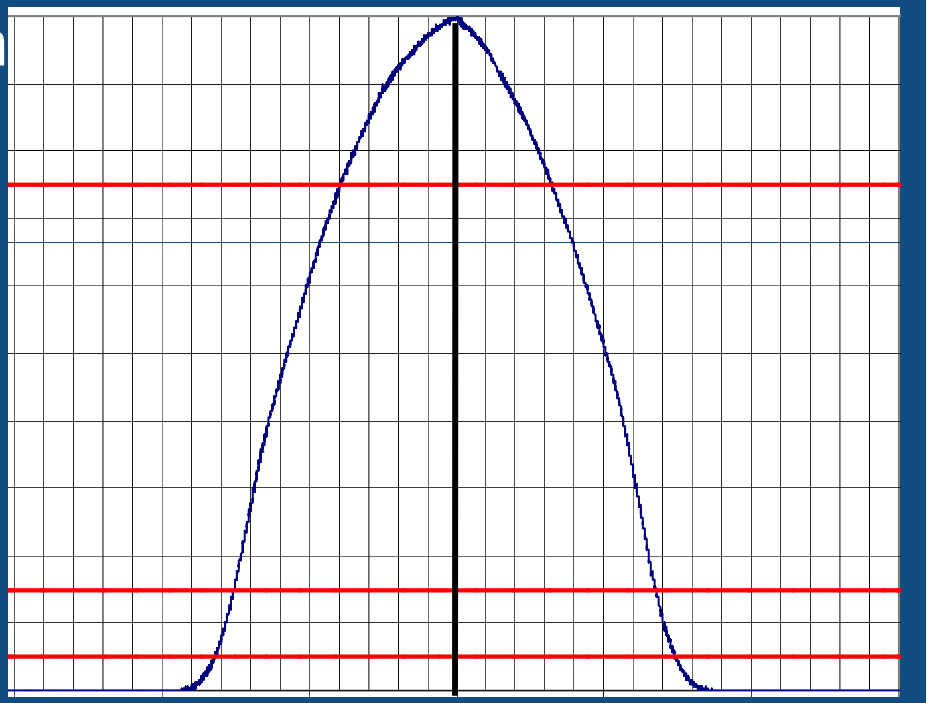
Review of Current MLCs:
(6) Near and Far Fields (NF / FF)

NF Power Distribution



850nm
50µm

FF Power Distribution



- Good control
- ***Need both NF and FF test equipments***
- Used internally as reference metrics

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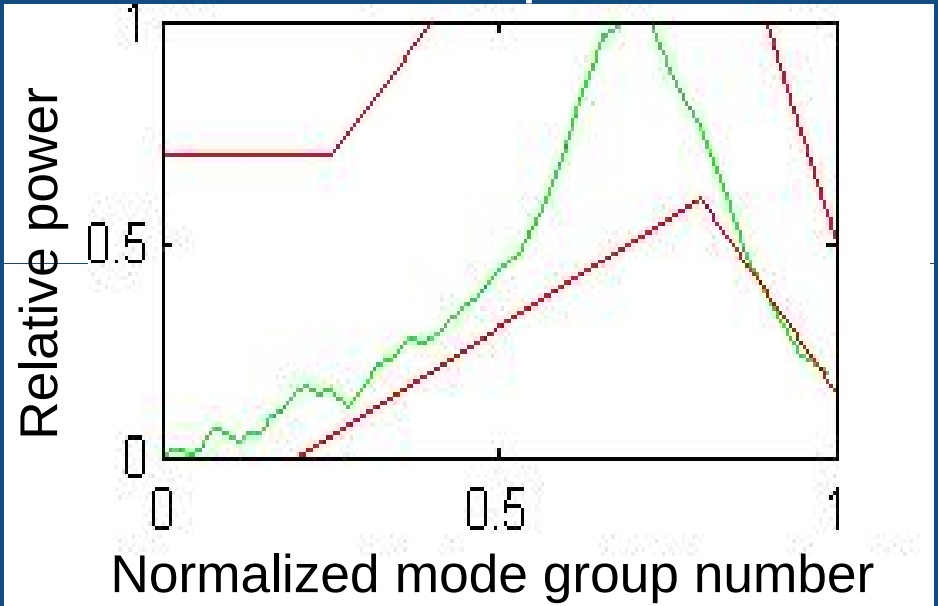
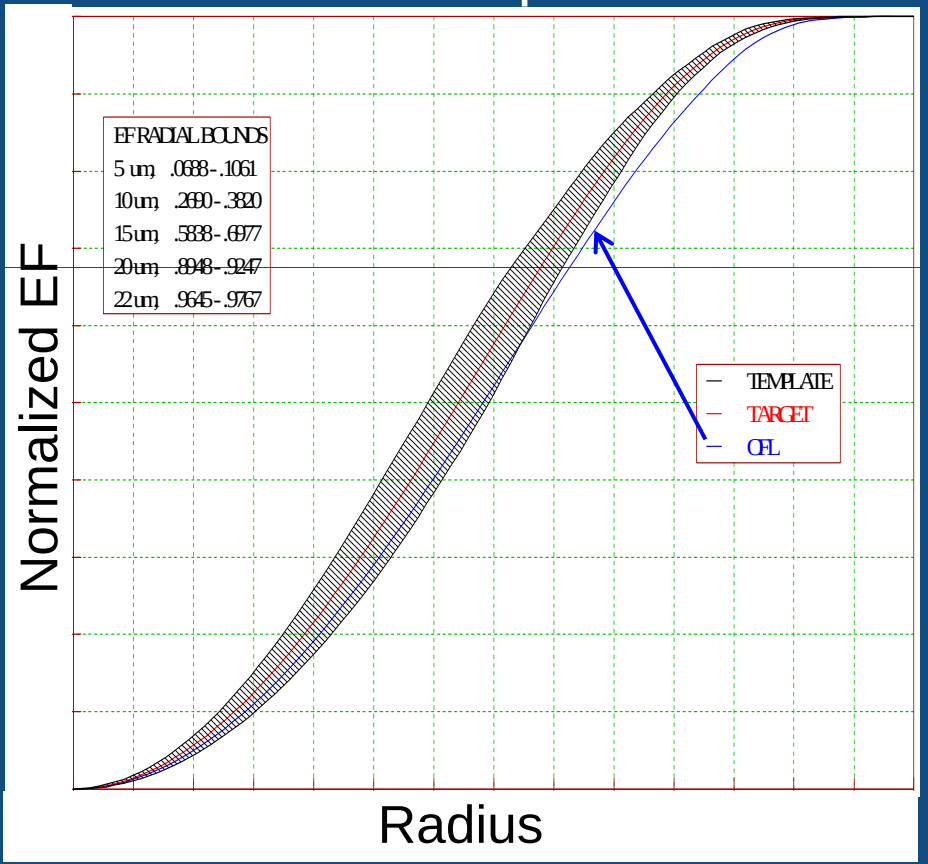
Review of Current MLCs:
(7) MPD Template and (8) EF Template

MPD Template



EF Template



Both obtained from NF power distribution:

- MPD obtained from power derivation
- EF obtained from power integration

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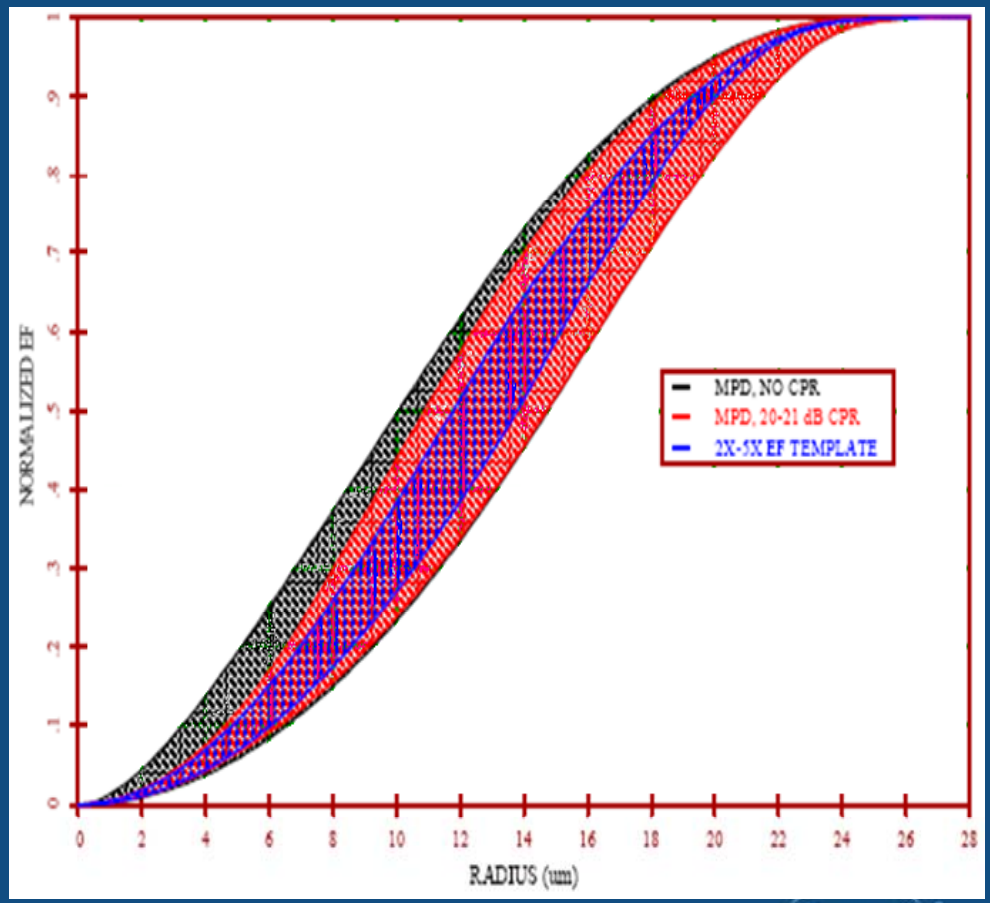
Advantages of EF Template

- Not sensitive to noise fluctuations
- Reproducible and repeatable measurements
- With EF template, slight under-filled MLCs: *good correlation between loss and connector lateral off-set*
- In a multi-connector link using EF target MLCs: *the loss of a connector does not depend on its location*



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OTDR versus LSPM

- Many studies done with LSPM
- *Not much done with OTDR*
- For instance: compared to LSPM, does the OTDR:
  - ***Measure the same loss?***
  - ***Have the same limits for obtaining 10% loss accuracy?***
  - ***Give the same ORL?***

We will now answer these questions

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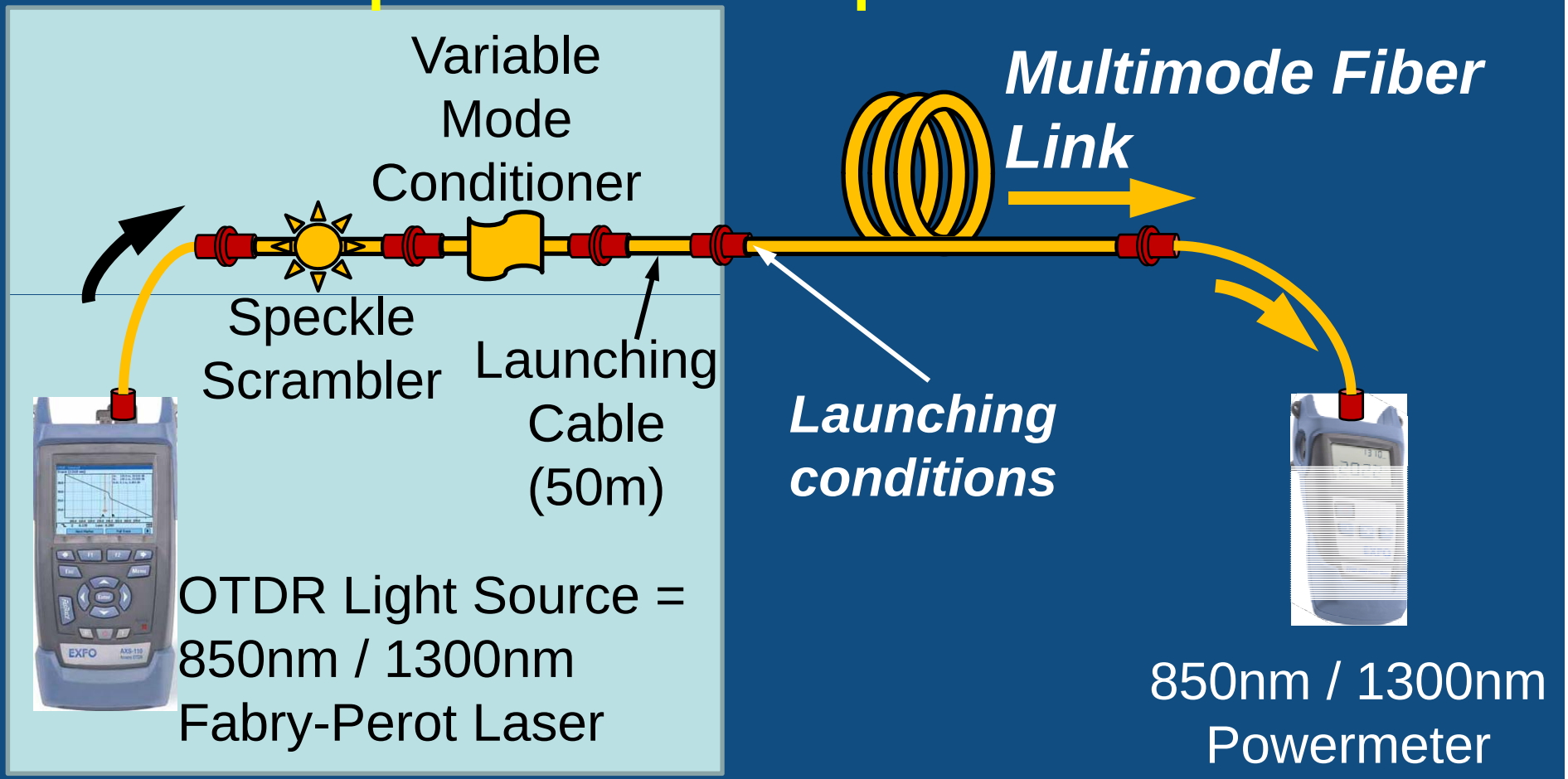
Loss Issues with MMF

3 main loss contributors + an effect in a MMF link probed by an OTDR:

1. *Connector loss due to lateral offset*
2. *Long MMF*
3. *Macro-bending*
4. *The OTDR pulses traverse the Link twice* with additional mode scrambling effects from backscattering

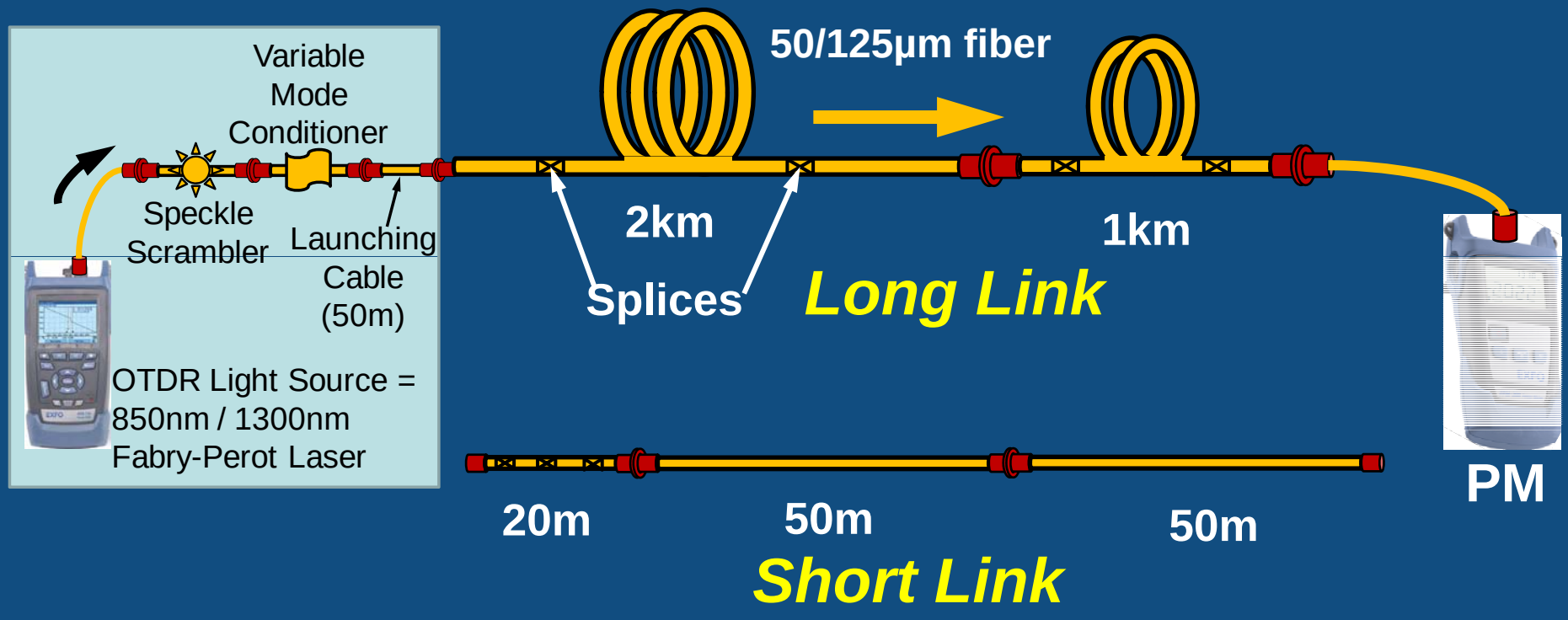
Experiments Performed With MMF Links

Experimental Set-up - This is it!

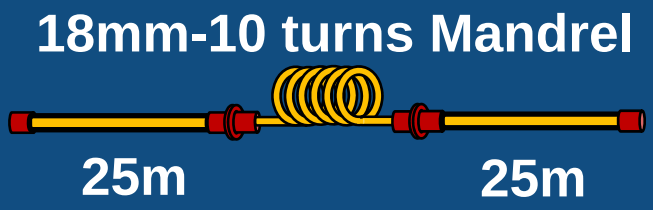


Experiments Performed With MMF Links

Link Types Tested



Macro-bending Link



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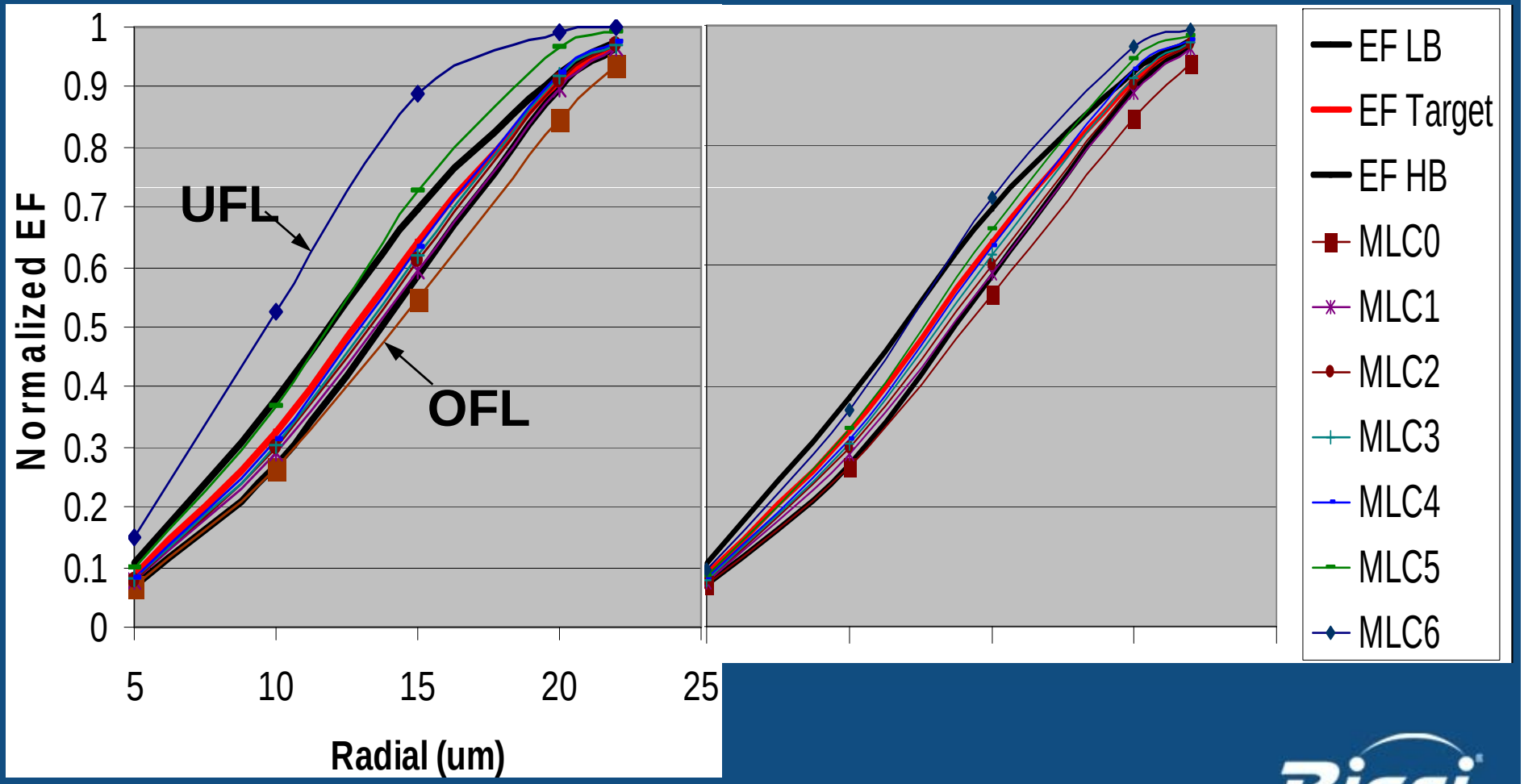
Experiments using EF Launch Conditions

Loss Measurements at

850 nm

1300 nm



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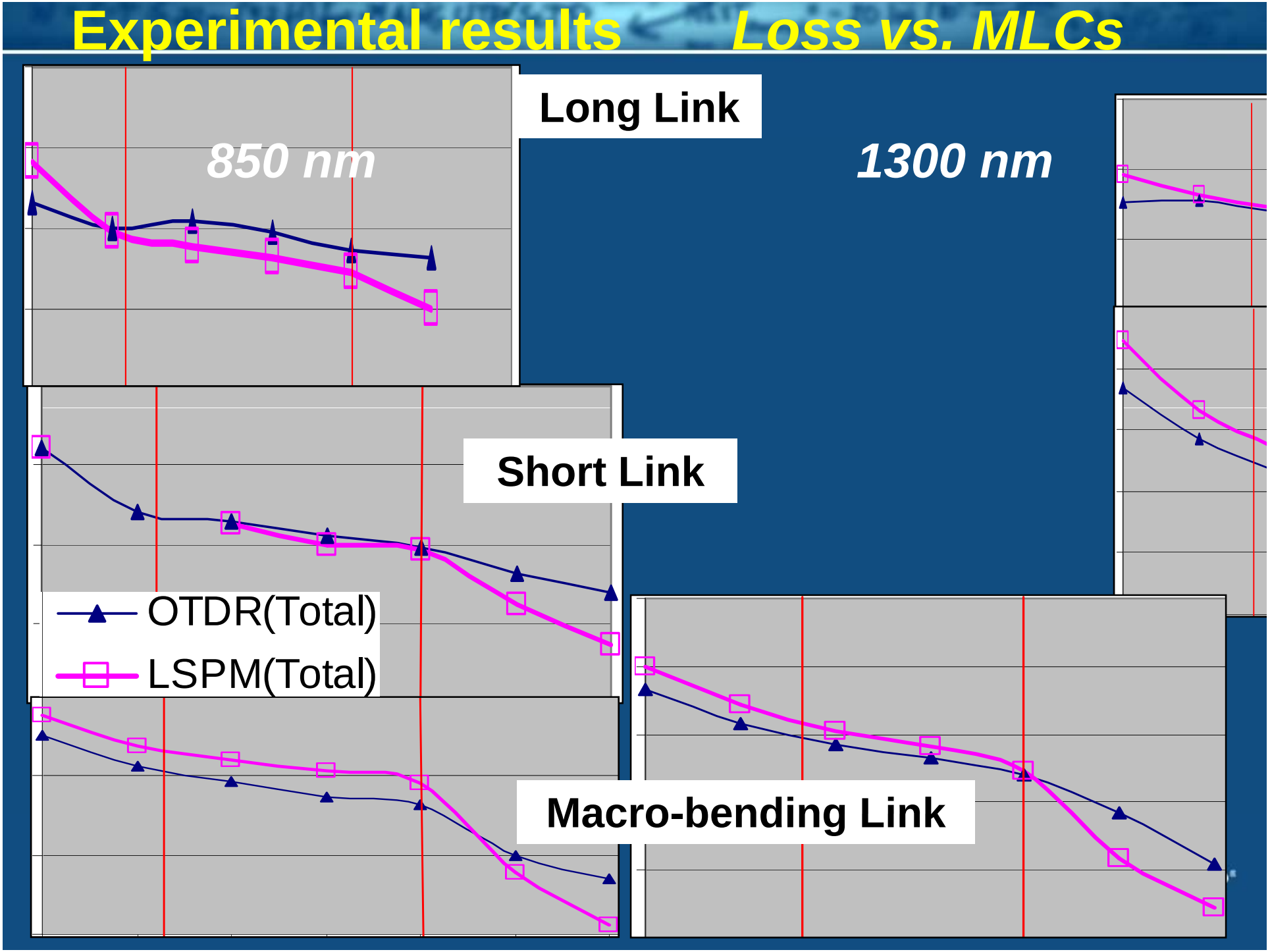
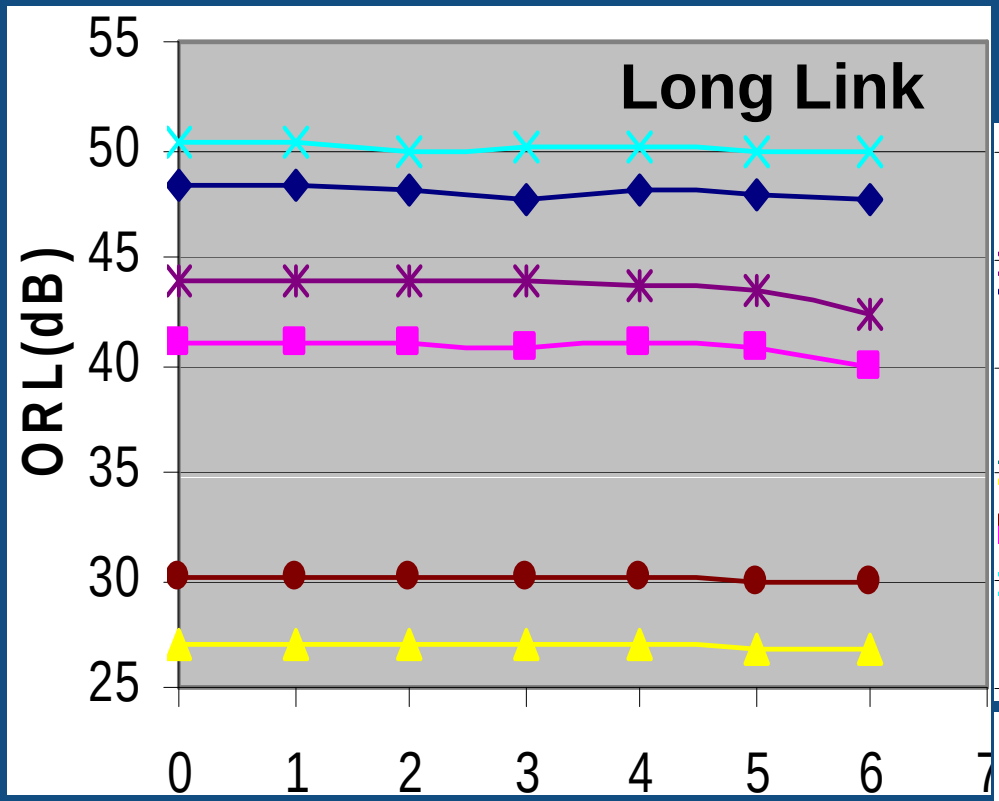
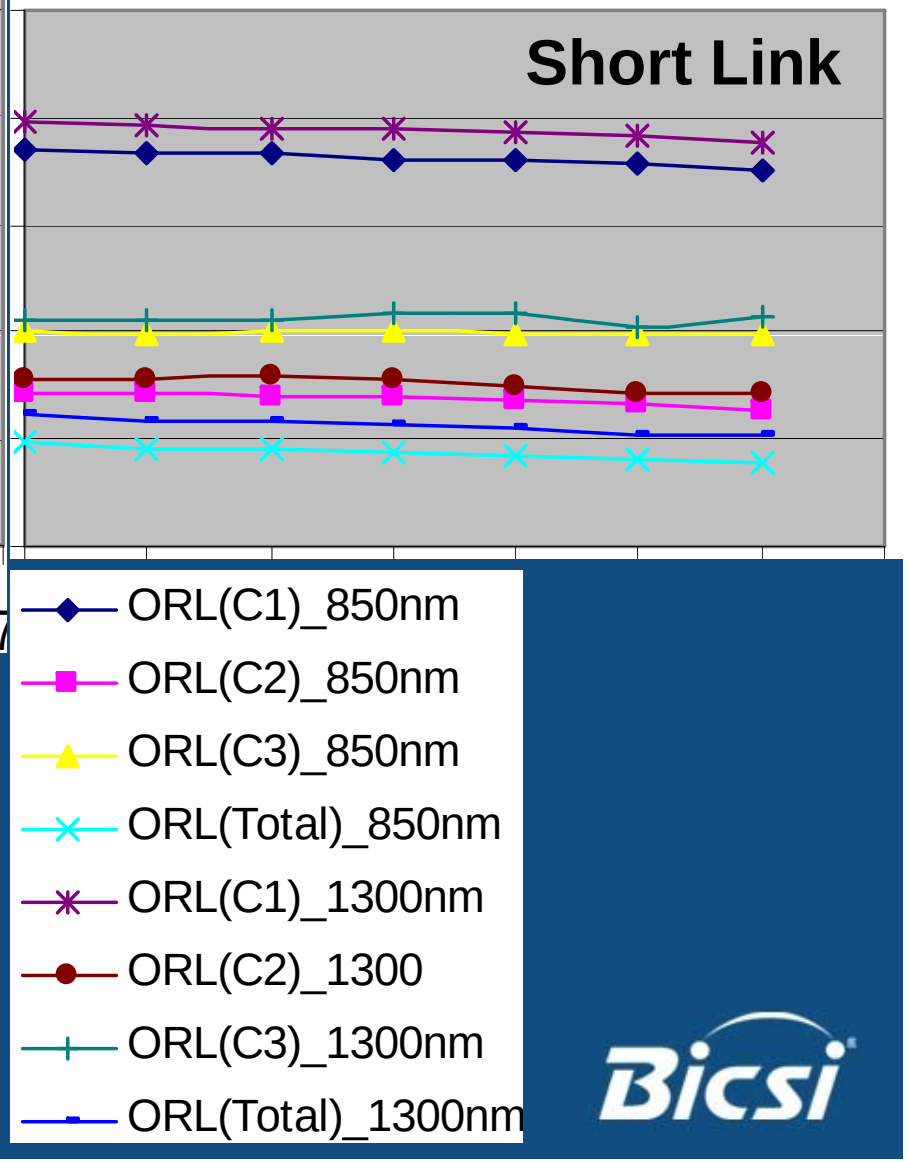
Experimental results *Loss vs. MLCs*



Experimental results
ORL vs. MLCs

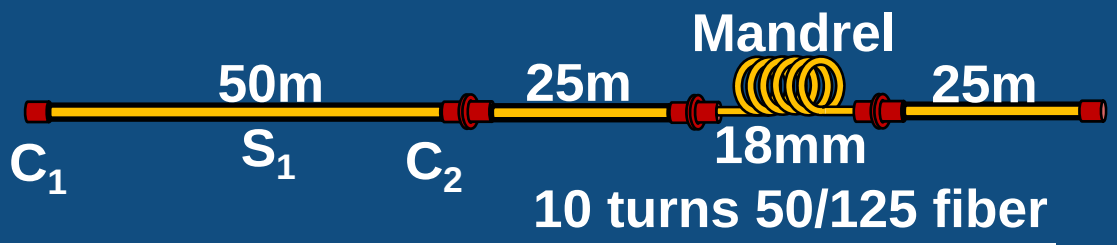


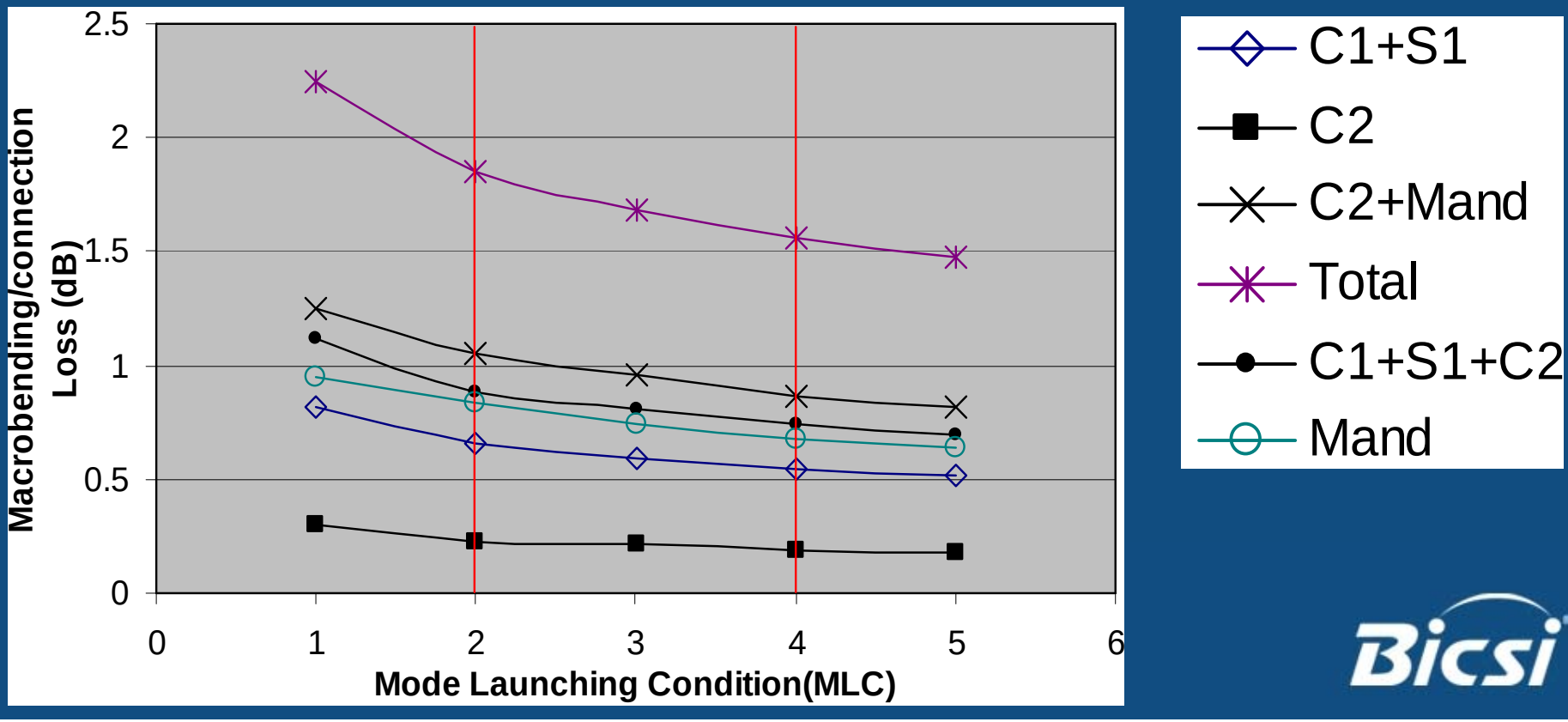


OTDR Experiment results vs. MLCs

Connectors and Macro-bending Losses

New Proposed MC Artifact





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Conclusions

Experiments were performed =

Compare losses of 50/125 MMF at 850nm and 1300nm by OTDR and LSPM for 3 types of links

1. A Link with a few km length (Long link)
2. A link with a short length (100 m) and many connectors (6) and splices (3)
3. A short link with macro-bending
4. All with various launching conditions

Conclusions

With Encircled Flux Template, it was shown that:

- Loss varies less in Long Links than in Short Links
- In Long Links, loss does not vary much at 850nm
- In general, loss varies less at 850 nm than at 1300nm
- ***The loss measured by OTDR or LSPM exhibits good agreement***

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Conclusions

With Encircled Flux Template, it was shown that:

- OTDR and LSPM loss = same behavior for any 3 Link types
- *70/70 MLCs do not work with OTDR and LSPM, especially in Short Links" with multiple connectors and macro-bending*
- ORL is insensitive to MLCs

Conclusions
And Finally…

- *At last, the Encircled Flux Template provides MPD maintaining launch*
- *<u>Reconciles MMF link loss measurements using either LSPM and OTDR</u>*
- *A new physical MLCs artifact is proposed and recommended for OTDR*
  - *Verification*
  - *Qualification, and*
  - *Calibration*

Thank you very much for your attention; and…