Instalaciones de fibra óptica en entornos de centros de datos y campus para suportar 40, 100g y más

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Fluke Networks

BICSI

Agenda

- Where is the technology today
  - 10 G per Wavelength λ
  - SM vs MM (OM5)
- How to increase the Data Throughput of Fiber
  - More efficient encoding – PAM 4
  - More fiber – MPO
- What parameters do we measure
  - Tier I – Loss, Length, Polarity
  - Tier II – Tier I + OTDR (troubleshooting)

Where are we Today with Fiber

10 Gig Per Wavelength

2 fibers 10 Gig full Duplex

4 fibers (10 X 4) 40 Gig

10 fibers (10 X 10) 100 Gig

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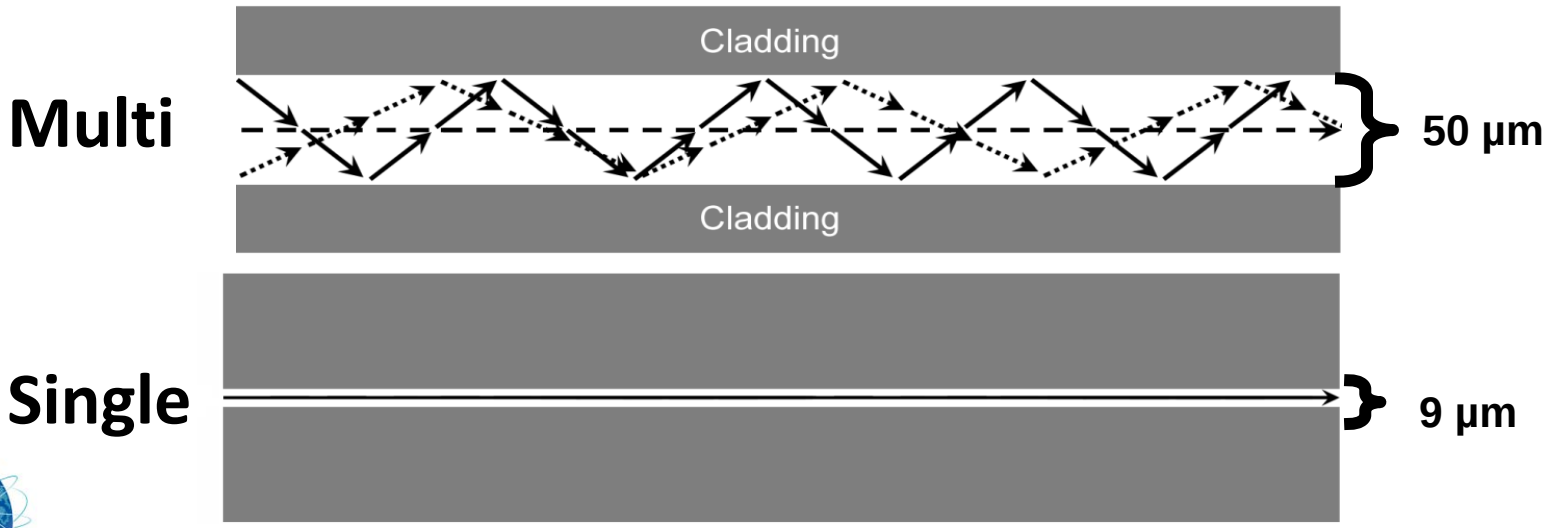
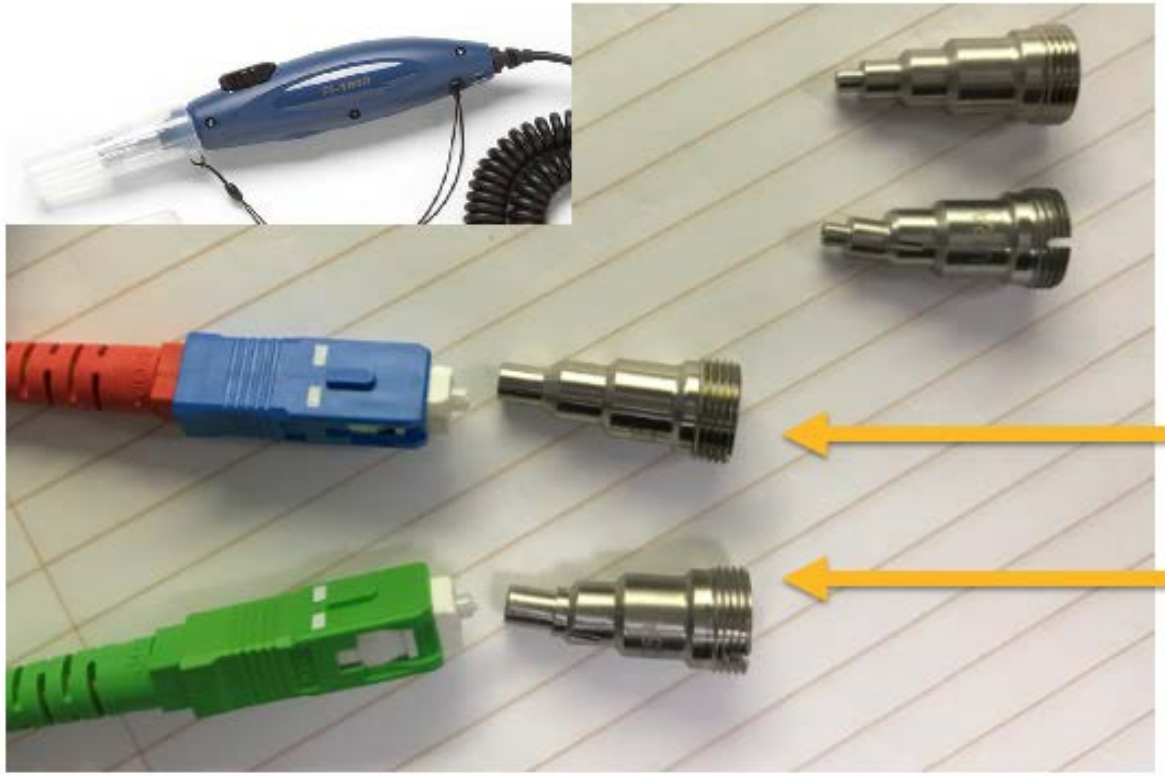
Single Mode vs Multimode

- Number of Wavelengths λ
- Cost of electronics
- Distance Requirements
- Ease of Use
  - UPC vs APC



Single Mode vs Multimode

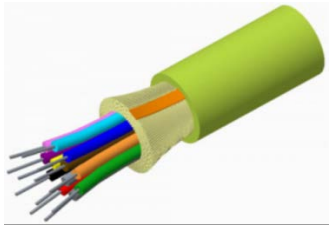


- LC/UPC
- LC/APC
- SC/UPC
- SC/APC

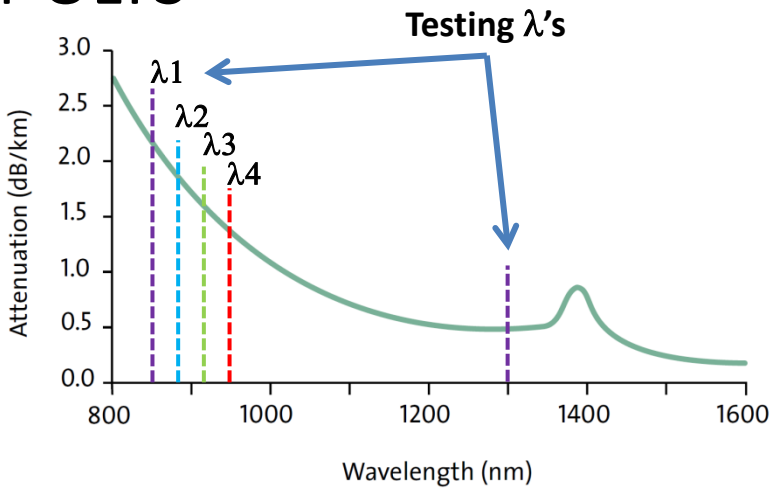
New Capabilities for Multimode Fiber
Wideband Multimode Fiber OM5 (WBMMF)

- Optical characteristics other than bandwidth remain essentially the same.
- At 10 G per Wavelength, we can do 40 Gig (4 x 10 G) on a single fiber
- New Wavelengths Available – Short Wave Division Multiplexing
  - 850, 880, 910, and 953 nm

Wideband Multimode Fiber OM5 (WBMMF)



- Field Testing is the same as OM4
  - Tier I at 850 and 1300
  - Tier II at 850 and 1300
  - Loss at 850 = 3 dB/Km; 953 = 2.3 dB/Km;1300 = 1.5 dB/Km
- Test with traditional duplex fiber OLTS
  - Encircled Flux compliant
  - Wavelengths at 850/1300nm
    - Bounds all wavelengths between
- And the jacket will be green



Increased Throughput with the Same Fiber

- PAM
  - 4
- Fro
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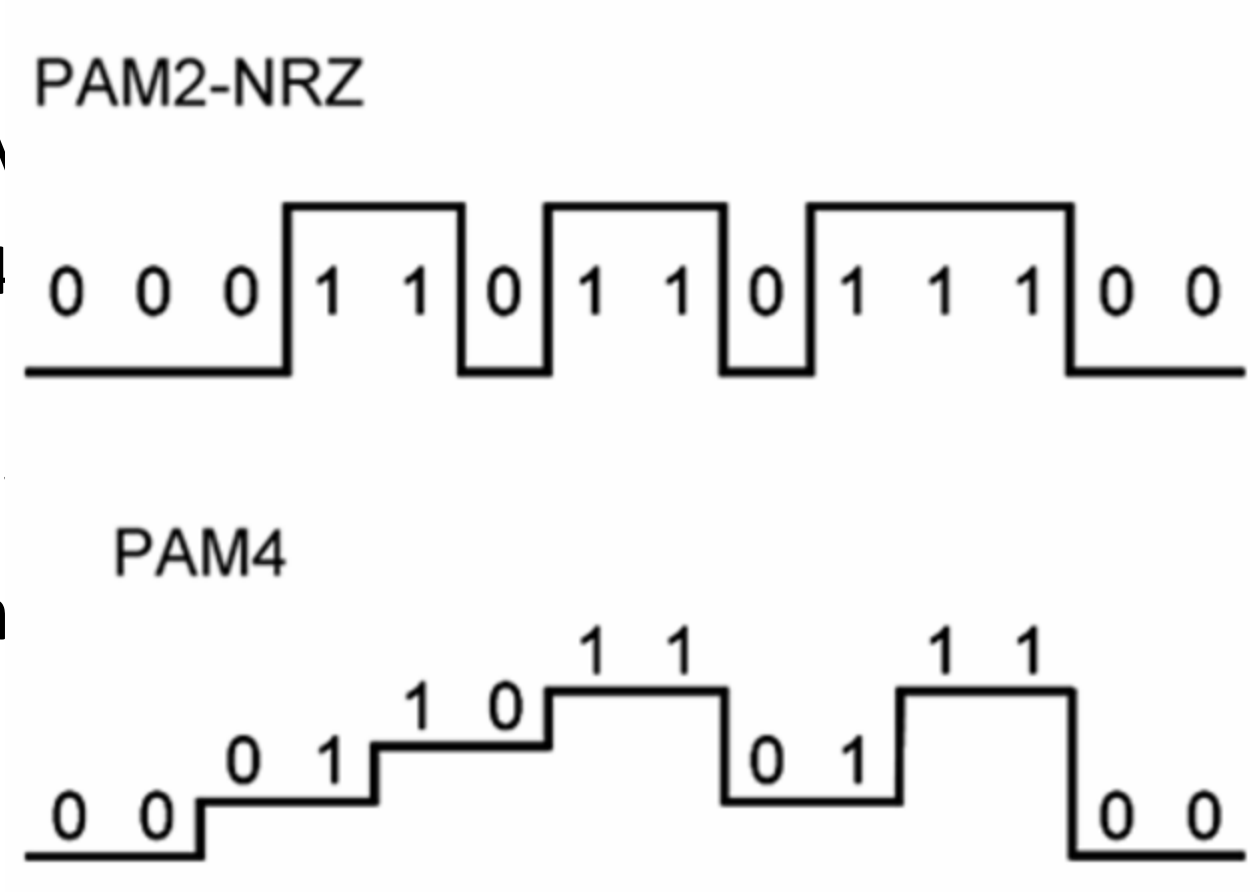
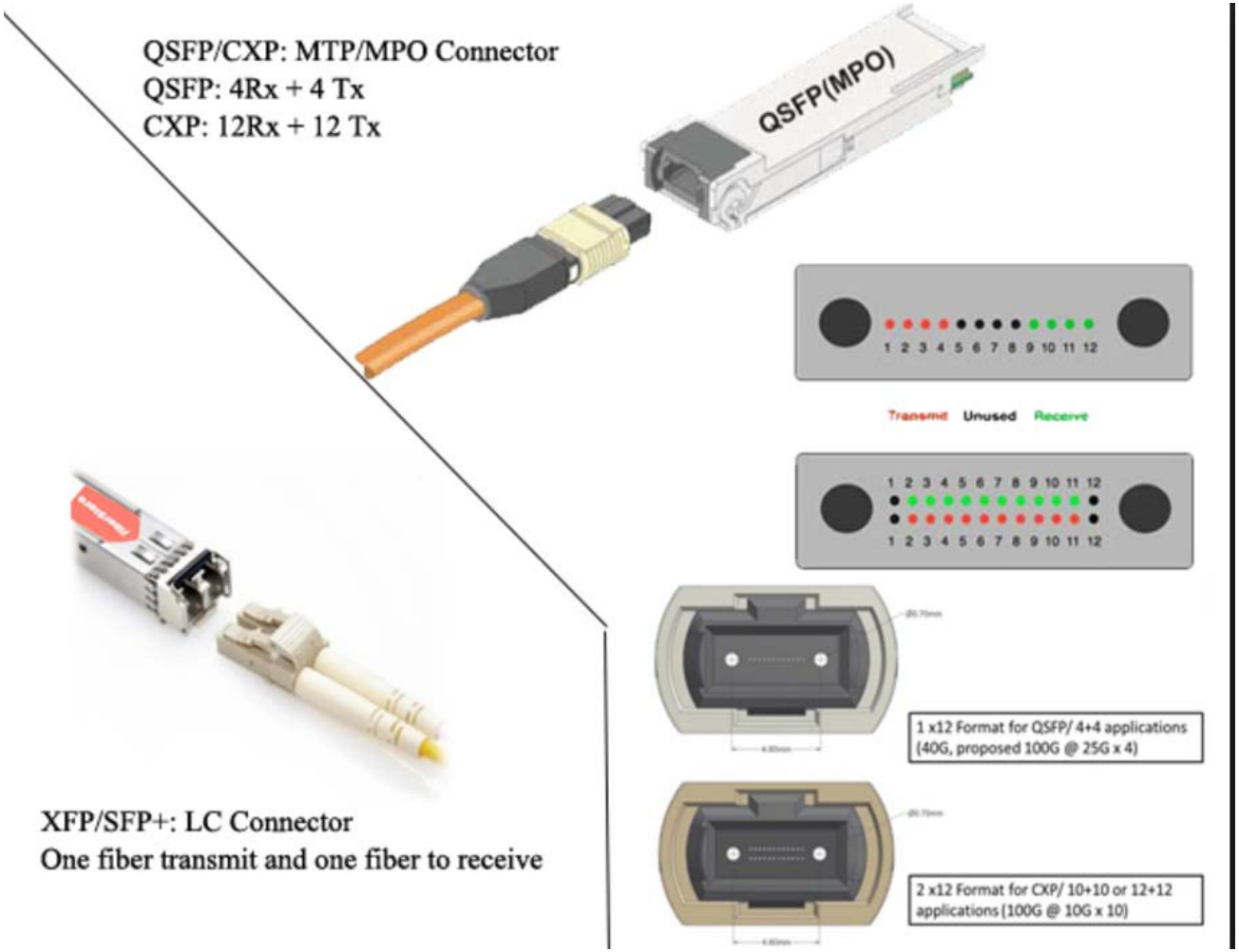


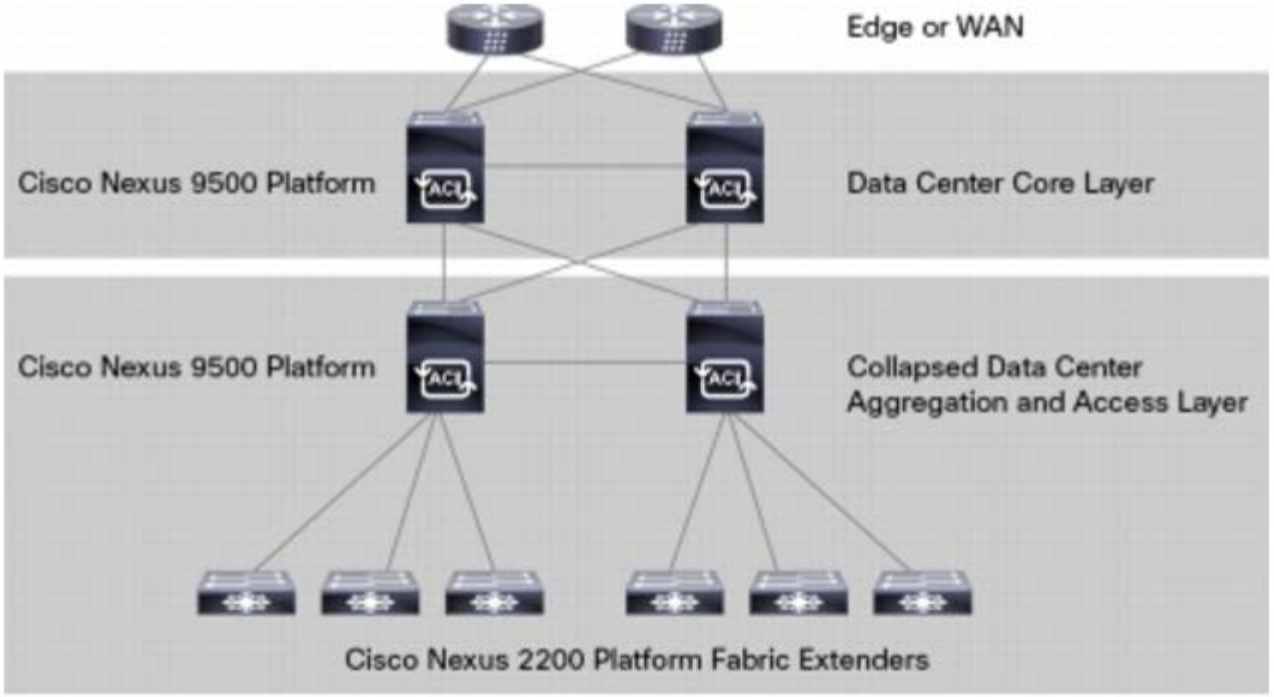
Serial LC/SC or Parallel MPO/MTP

QSFP/CXP: MTP/MPO Connector
QSFP: 4Rx + 4 Tx
CXP: 12Rx + 12 Tx



XFP/SFP+: LC Connector
One fiber transmit and one fiber to receive

From – Less Efficient Core/Aggregation/Access – More Latency



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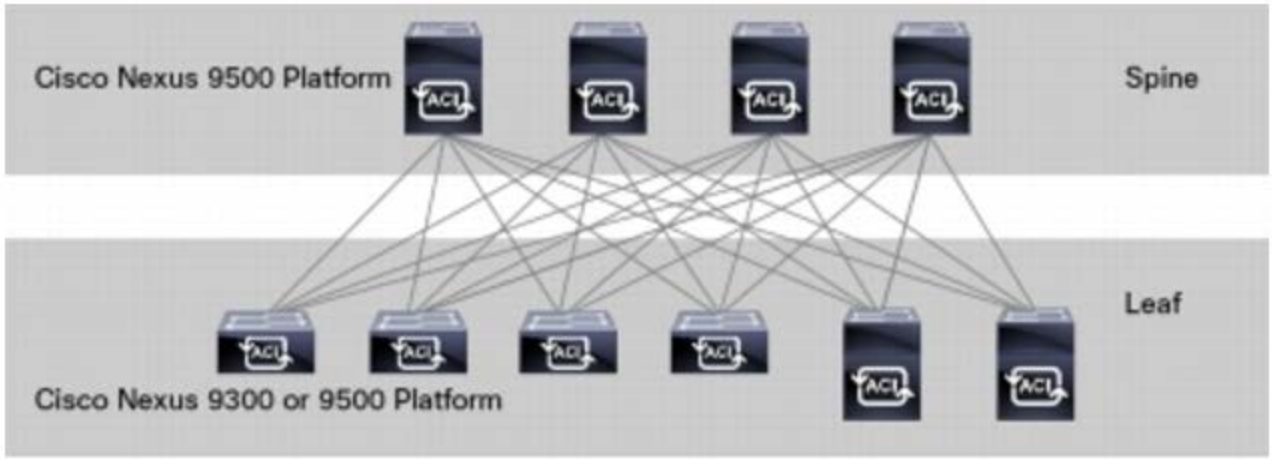
To More Efficient – Spine and Leaf - Faster



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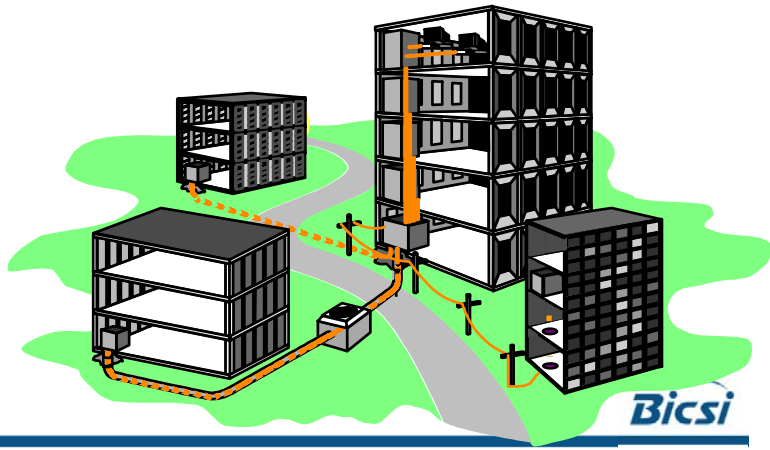
For Port Density, put a 12 or 24 fiber QSFP in the spine and, potentially, 2 fiber LC in the Leafs (leaves?)

Fiber Testing and Certification

How can you determine if your premise fiber is good?

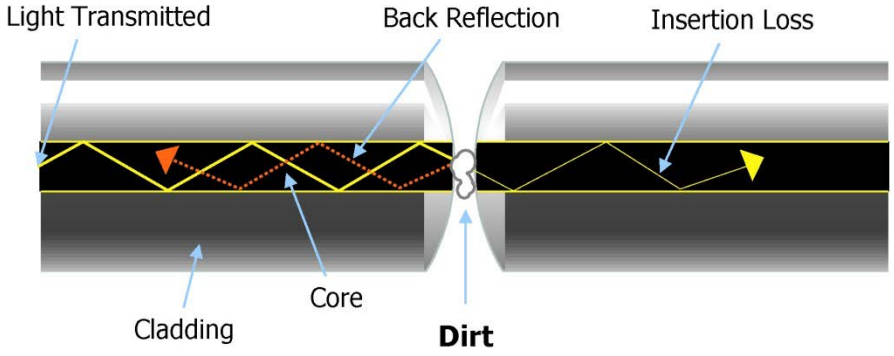


Fiber Cleaning

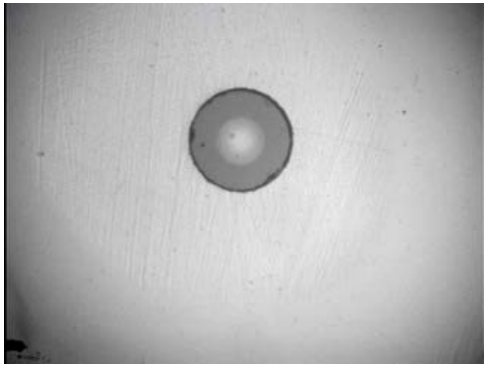
FLUKE networks

#1 Problem: Dirt!

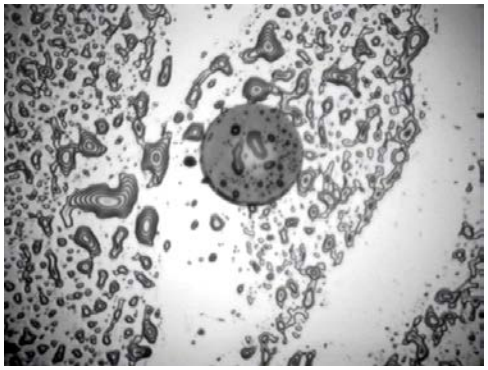
- **Contaminated connector end-faces: Leading cause of fiber link failures**
- **Particles of dust and debris trapped between fiber end faces cause signal loss, back reflection, and damaged equipment**
- **Many Sources of contamination:**
  - ***Equipment rooms & Telecommunication rooms in filthy environments***
  - ***Improper or insufficient cleaning tools, materials, procedures***
  - ***Debris and corrosion from poor quality adapter sleeves***
  - ***Hands of technicians***
  - ***Airborne***



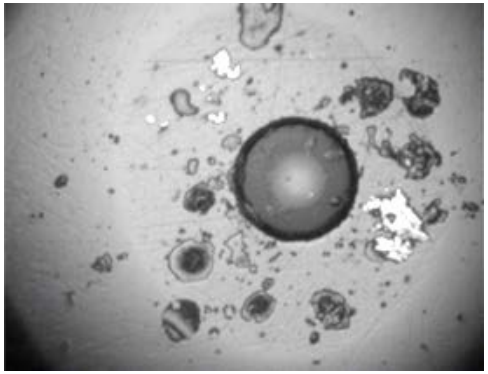
Inspection images



Good Connector



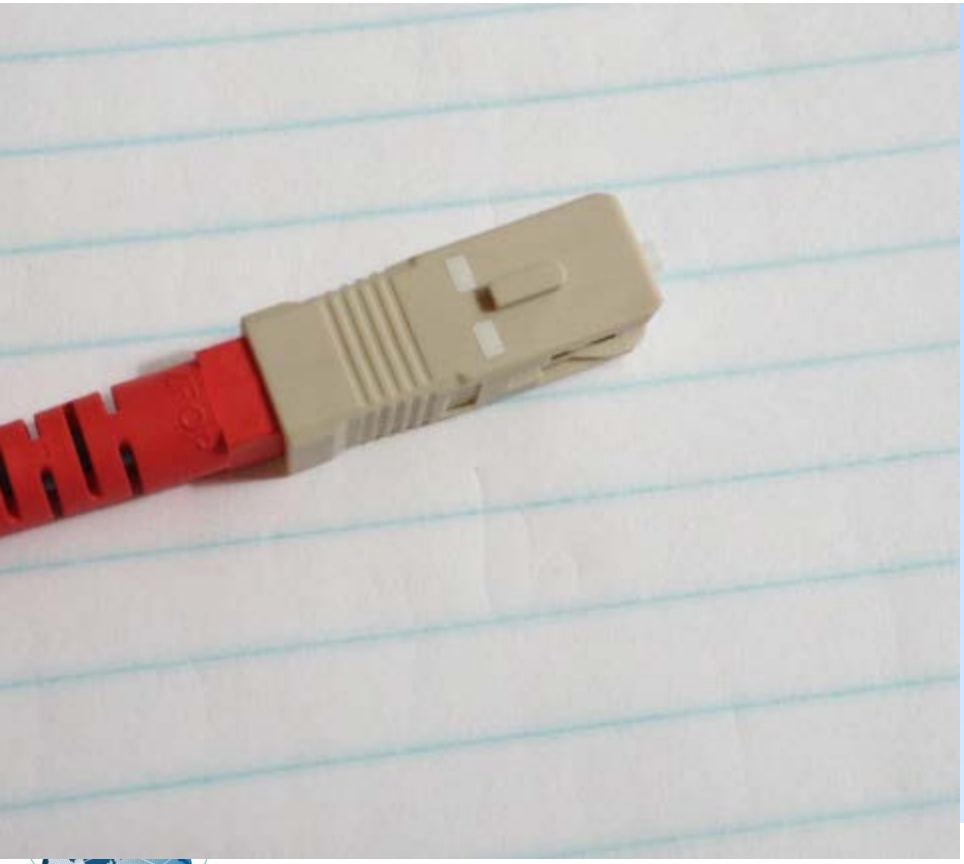
Fingerprint on Connector



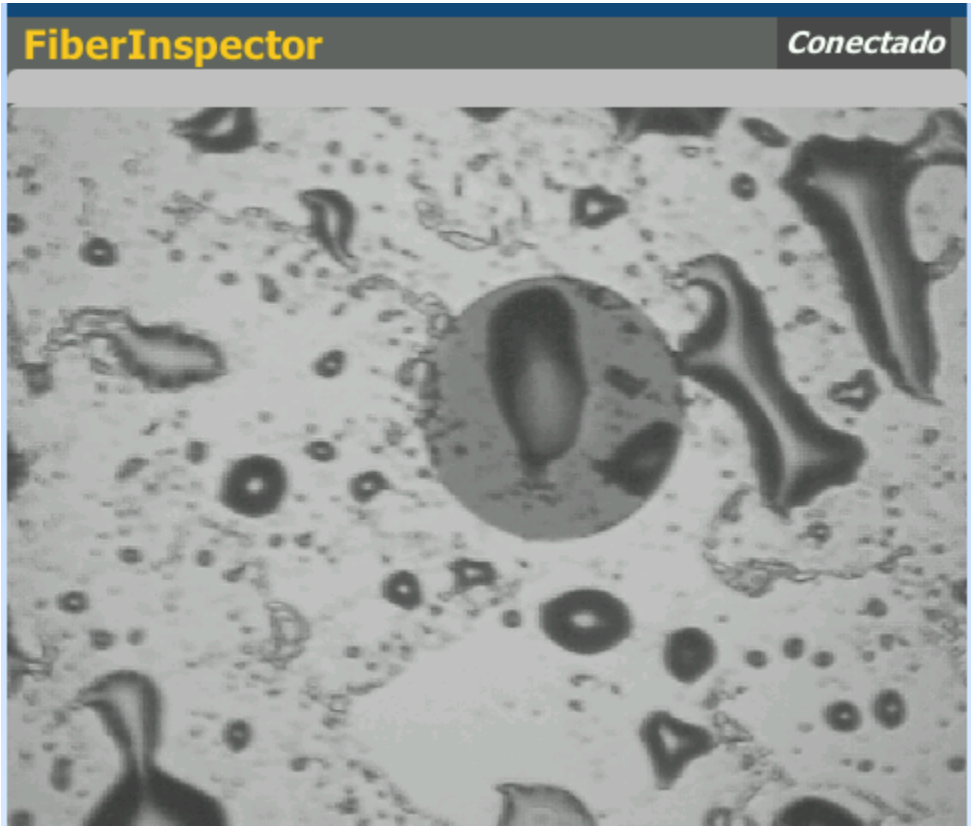
Dirty Connector

Real images

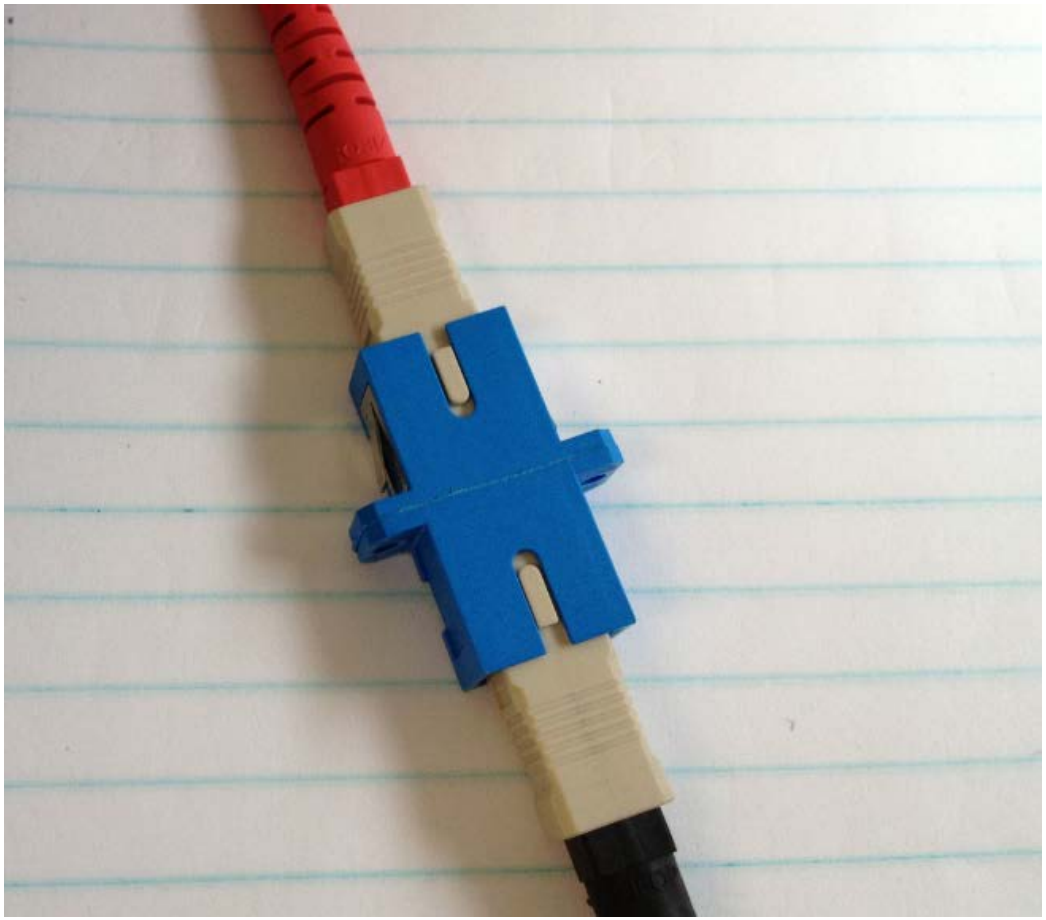
A Clean Connector



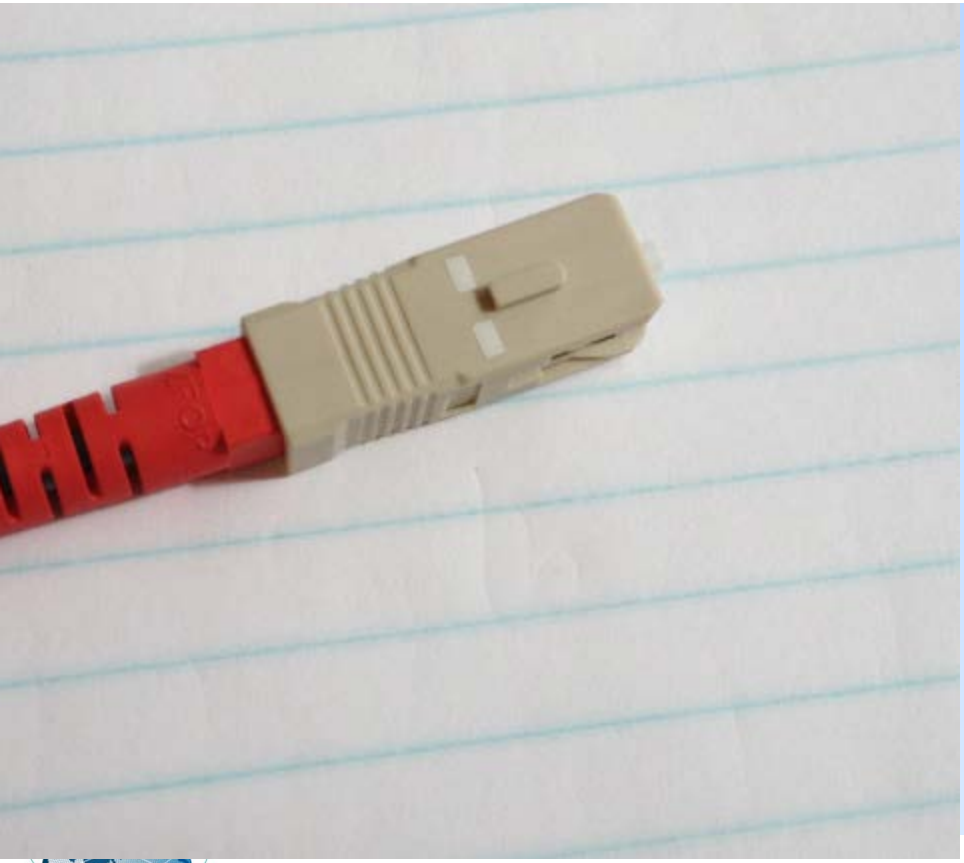
Connector with a Finger Print

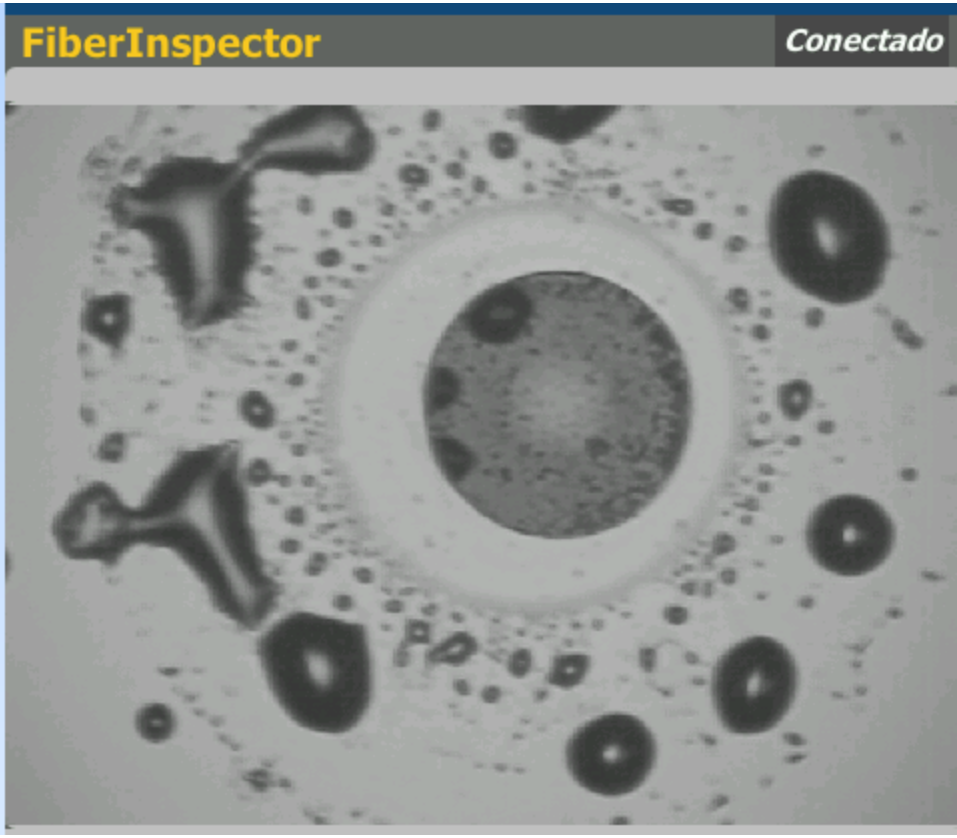


This part of the presentation is only for those >17 years old



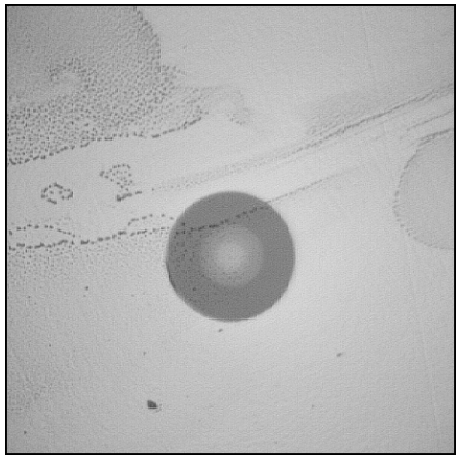
Notice the ring where the contact occurred in the center





Fiber Inspection

- We all know how important it is
- It is rare that calls to our Technical Assistance Center from techs have ANY inspection equipment – but they tell us they have cleaned it
- Cleaning without inspection can result in this:



- Solvent pens are better than IPA

Cleaning with a Solvent Pen

- **Start with a clean, lint-free wiping surface every time**
  - Material left exposed accumulates ambient dust
  - Material used once should not be used again
- **Use a minimal amount of specialized solvent**
  - Important that solvent be removed after cleaning
  - Move the end-face from the wet spot into a dry zone
    - Cleaning with a saturated wipe will not fully remove solvent
    - Cleaning with a dry wipe will not dissolve contaminants and can generate static, attracting dust
- **Proper handling and motion**
  - Apply gentle pressure with soft backing behind cleaning surface
  - Hold end-face perpendicular to cleaning surface
  - No figure-8 motion as that's for polishing only
- **Inspect both end-faces of any connection before insertion**
  - If the first cleaning was not sufficient, then clean again until all contamination is removed

Primero – Inspecion! Video Microscope

- 2-second automated PASS/FAIL certification of fiber end-faces
- Graphical indication of problem areas due to contamination, pits, chips, and scratches
- Certify to industry standards
  - IEC 61300-3-35
- Eliminate human subjectivity from end-face measurements
- Save end-face views during certification process

On a not completely unrelated note…

How Automated Analysis Works

IEC 61300-3-35 UPC Multimode Specification

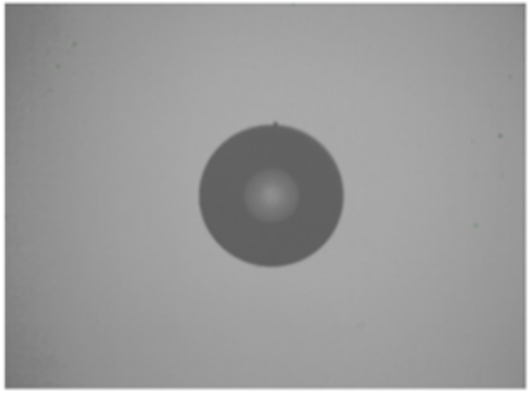
	PC polished connectors, multimode fibers	
Zone Name	**Scratches**	**Defects**
Core	No limit <= 3 um 0 > 3 um	2 <= 3 um None > 3 um
Cladding	No limit <= 5 um 0 > 5 um	No limit < 2 um 5 from 2 um to 5 um None > 5 um
Adhesive	No limit	No limit
Contact	No limit	No >= 10 um

Cleaned ***and*** Inspected

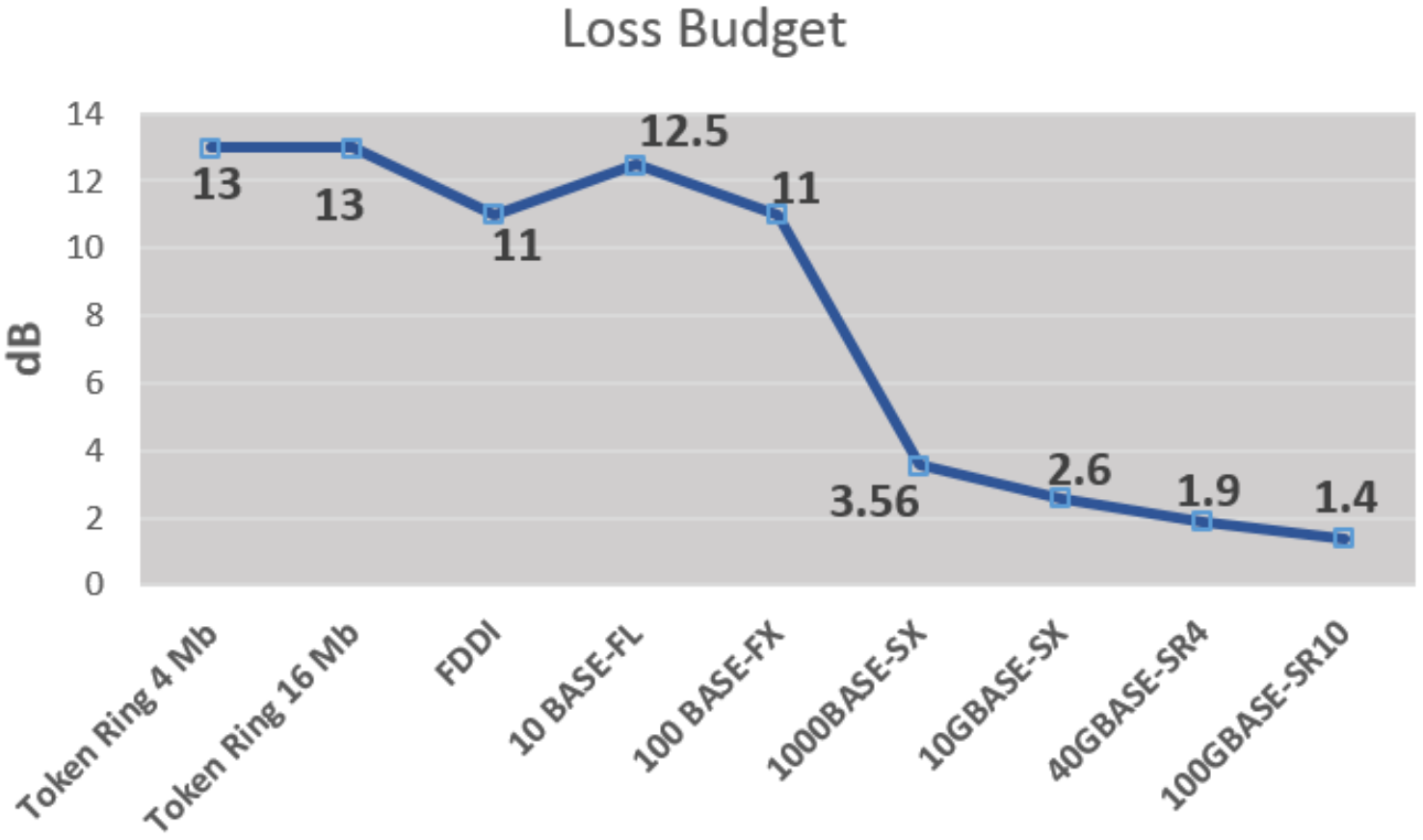
ID. Cable: FI-02A
Fecha / Hora: 05/28/2014 08:31:40 AM
Tipo de Cable: OM3 Multimode 50
n = 1.4820 (850 nm)
n = 1.4770 (1300 nm)

Sumario de Pruebas: PASA
Ancho de banda modal: 2000MHz-km (850 nm)
Ancho de banda modal: 500MHz-km (1300 nm)
Coeficiente de retrodispersión: -68.0dB (850 nm)
Coeficiente de retrodispersión: -75.8dB (1300 nm)

Imagen Final1
PASA
Fecha / Hora: 05/28/2014 08:10:15 AM
Limite de Prueba: IEC 61300-3-35 ED.1 MM
Version de Limites: 3.0
Operador: JIM
OptiFiber Pro (1989006 V3.0 Build 6)



Loss Limits for Multimode are getting tighter as speeds increase



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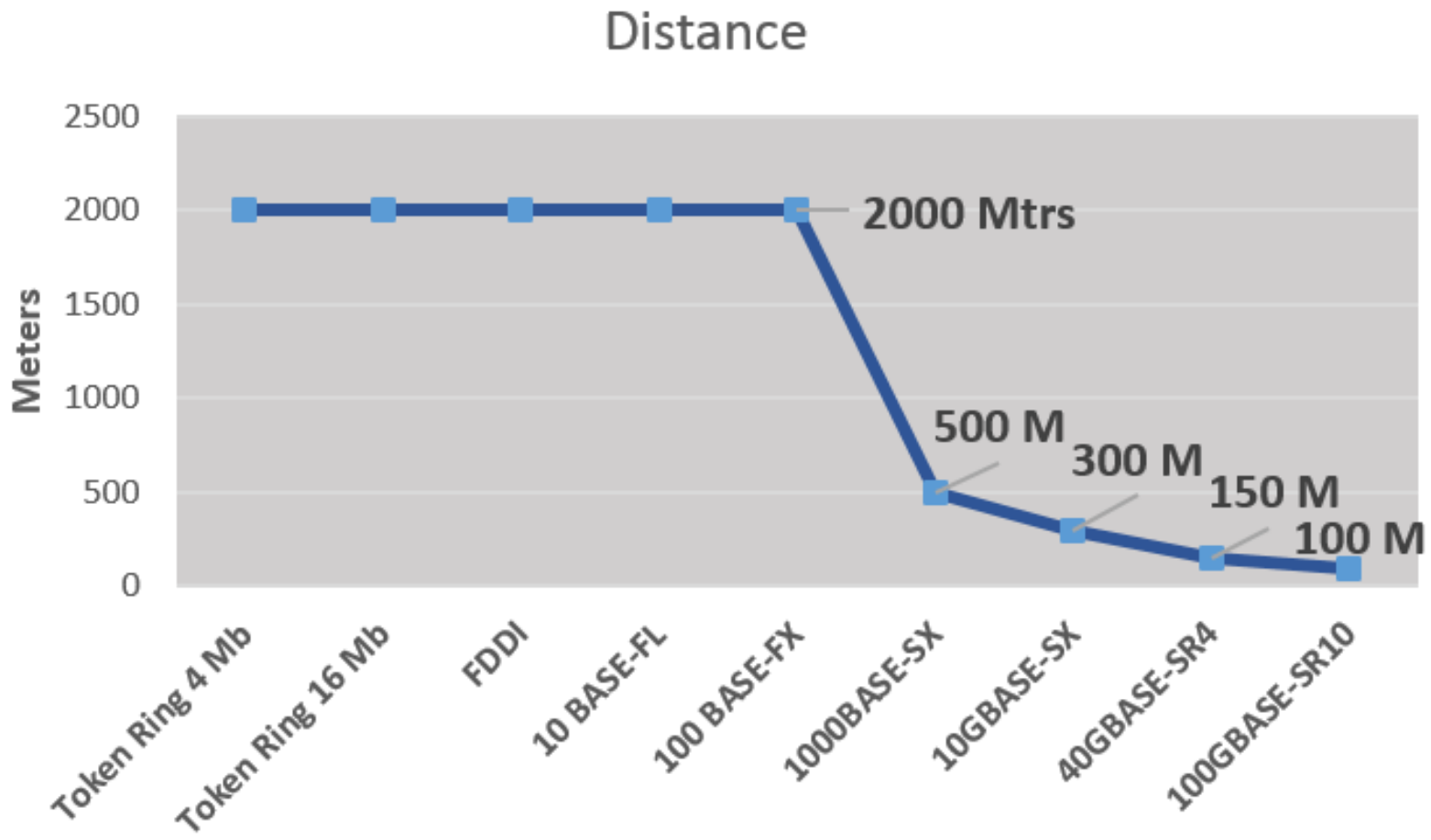
Distances for MM are getting shorter

Limited by Modal Dispersion



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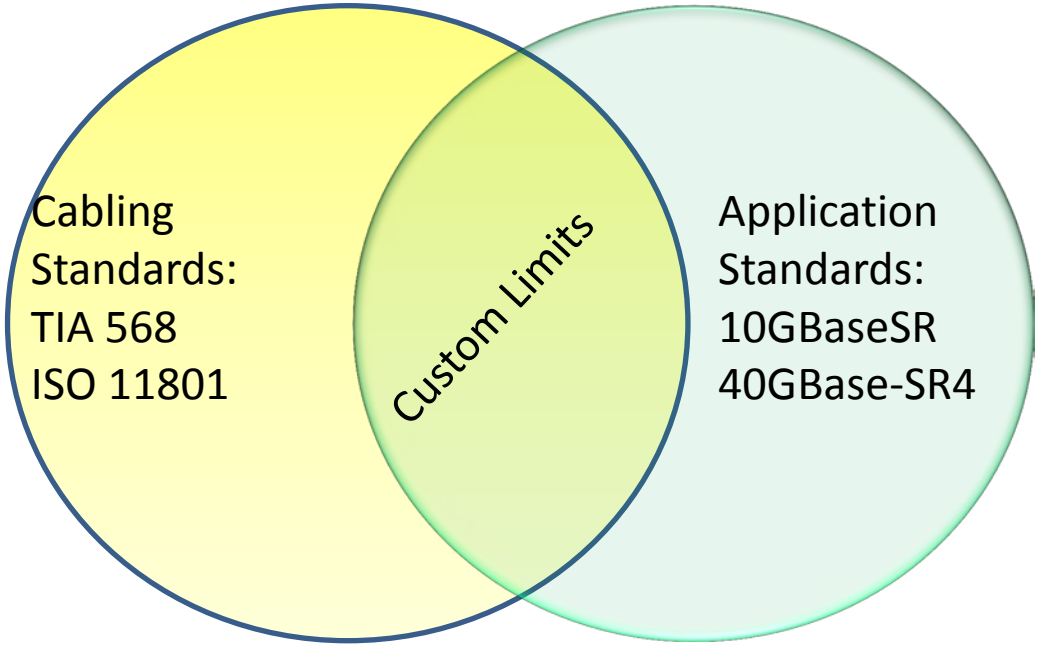
Types of Standards and Specifications define the loss budget

- Application Standards
  - Fixed test limits are defined by *'system'* specs
  - Examples: 100BASE-FX, 1000BASE-SX, 1000BASE-LX, 10GBASE-S, ATM, Fibre Channel
- Cable Installation Standards
  - Test limits for installed fiber link are independent of any network application
  - Limit is calculated, based on cable length, number of adapters, and number of splices
  - Examples: ANSI/TIA-568.D-3, ISO11801, EN50173

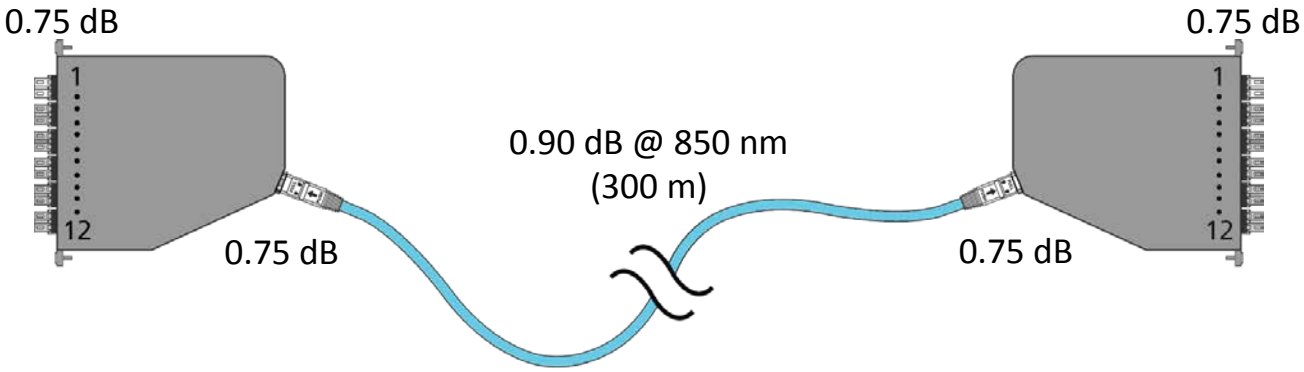
Which Limits to use?

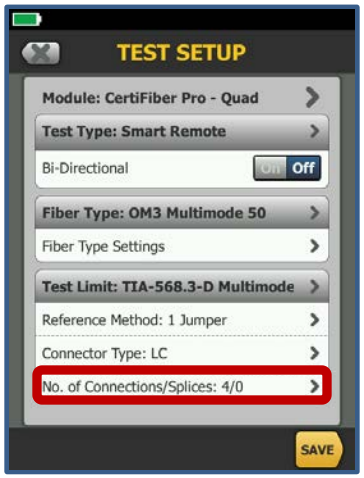
- There is no “Cat 5e” for fiber
- There is conflict between what the standard will support and what the application requires



Using a TIA limit without understanding the application

- Customer wants to run 10GBASE-SR on this multimode link





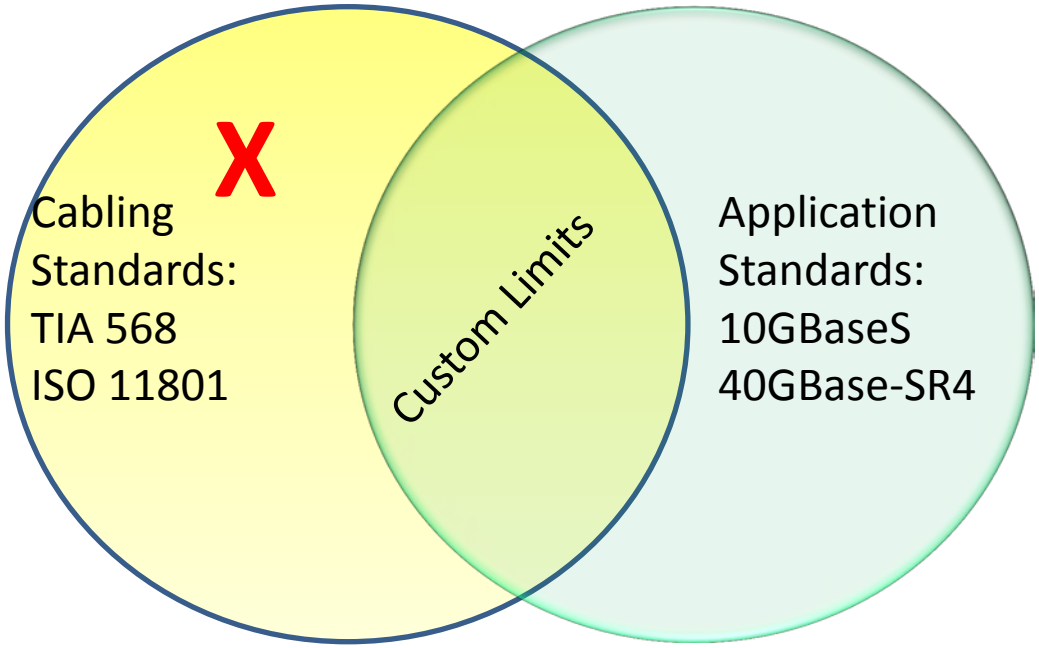
TIA (tester) Limit = 0.75 dB + 0.75 dB + 0.90 dB + 0.75 dB + 0.75 dB
= **3.90 dB @ 850 nm**

10GBASE-SR Limit = **2.55 dB @ 850 nm**

This design will not support 10GBASE-SR

Loss Budget 3.9 dB = Pass for TIA

- But not 10GBase-SR



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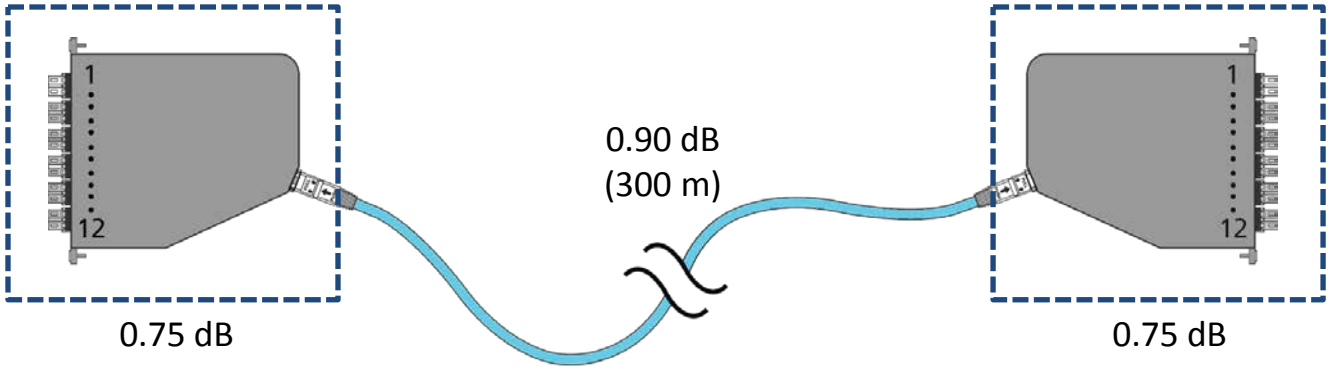
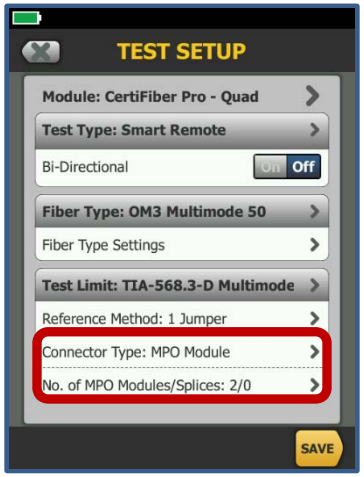


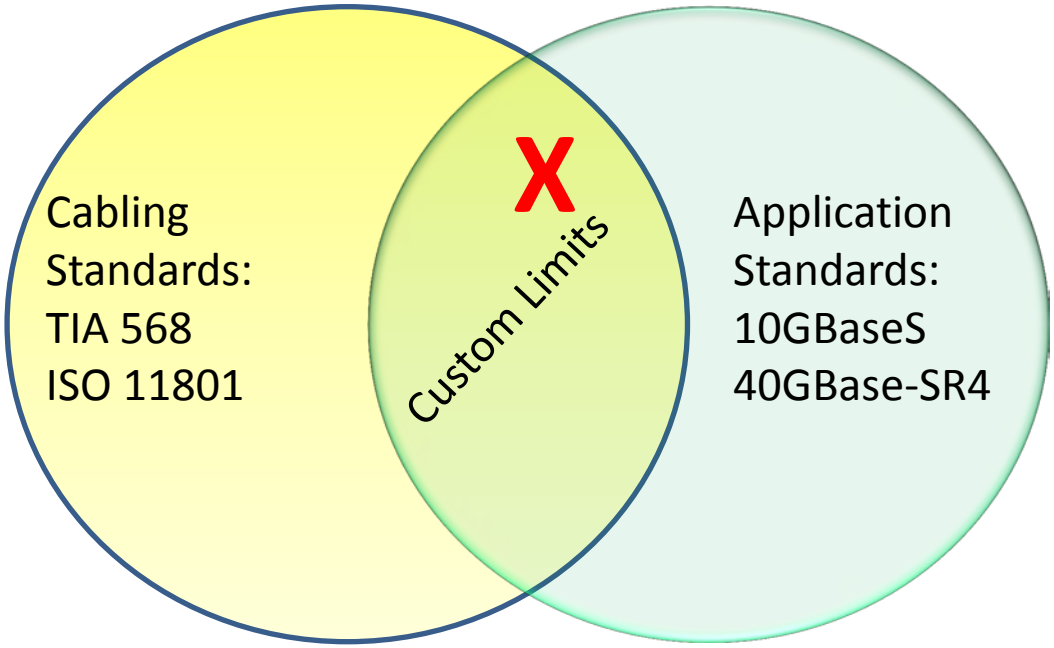


TIA (tester) Limit = 0.75 dB + 0.90 dB + + 0.75 dB
= **2.40 dB @ 850 nm**

10GBASE-SR Limit = **2.55 dB @ 850 nm**

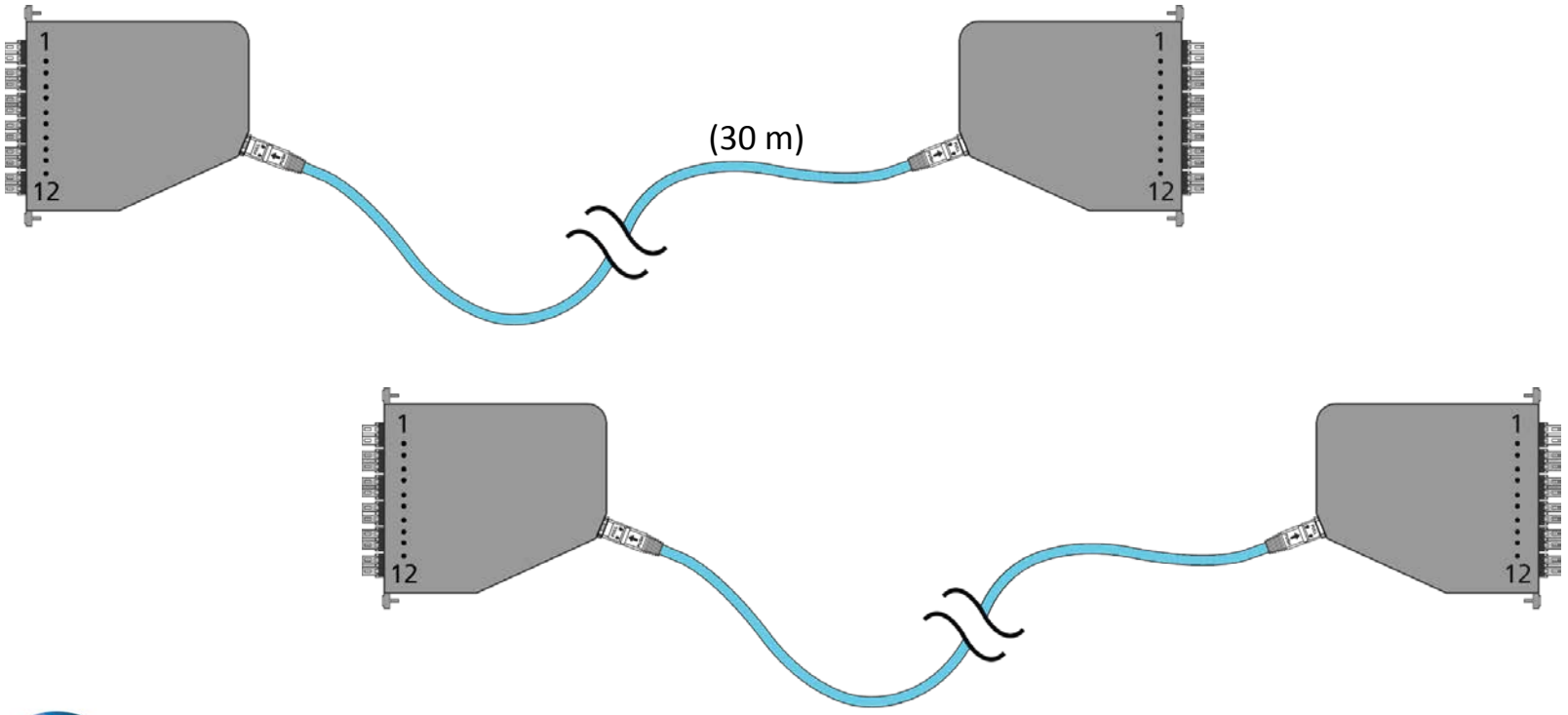
This design will support 10GBASE-SR

Loss Budget 2.4 dB = Pass for Both



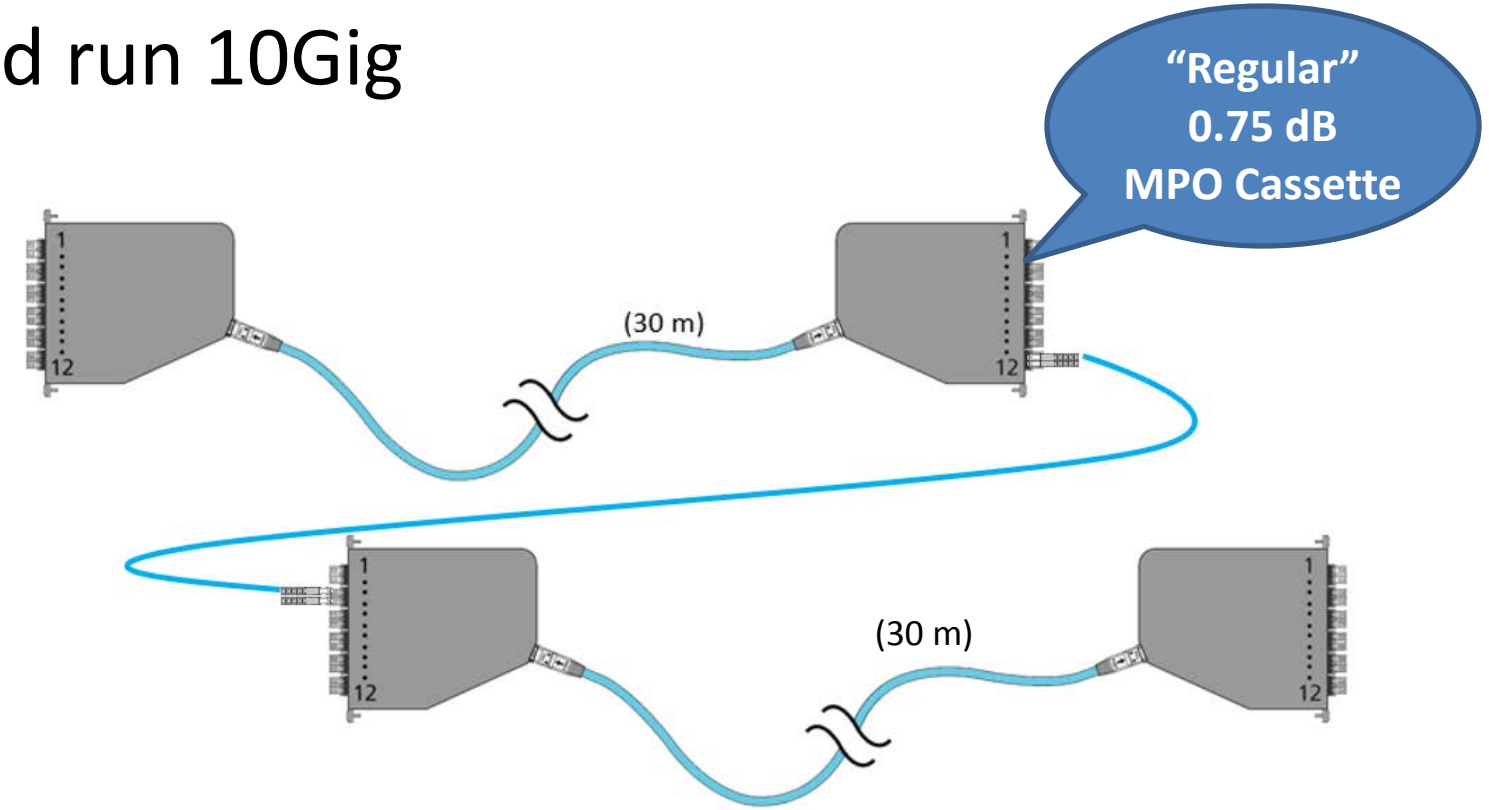
What if your customer wants to do this?

- Concatenate two MPO jumpers/trunks



What if your customer wants to do this?

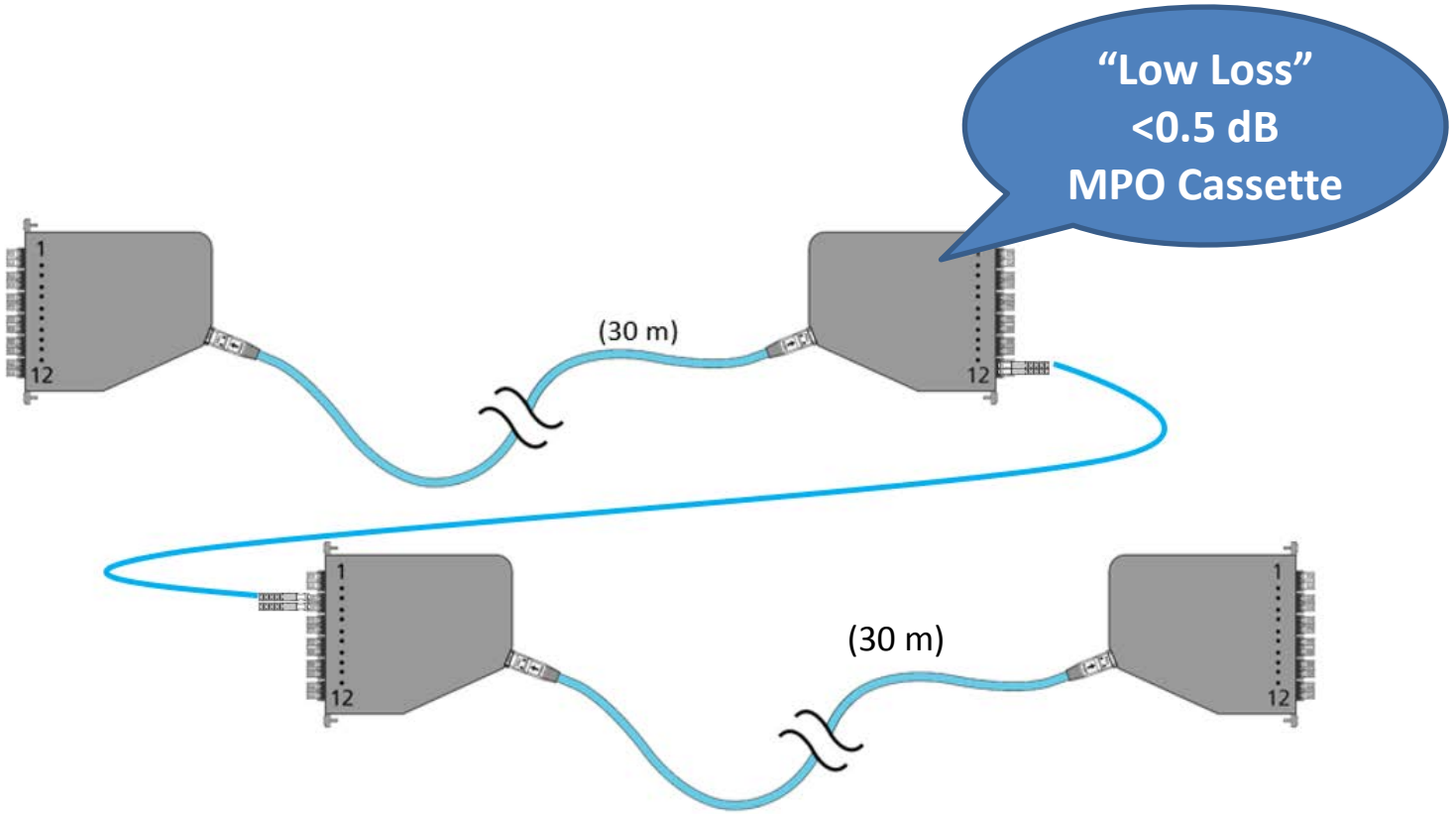
- Concatenate two MPO jumpers/trunks
- And run 10Gig



4 X 0.75 + 62 m * 3 dB/Km > 2.6 dB

Welcome to Low Loss Cassettes

- Manufacturers offer cassettes with > 0.5 dB of loss



4 X 0.50 + 62 * 3 dB/Km < 2.6 dB

Tier I Testing – How much Light is Coming Out of the Fiber

How to measure reliably and repeat-ably

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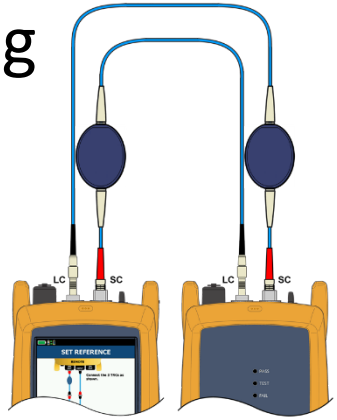
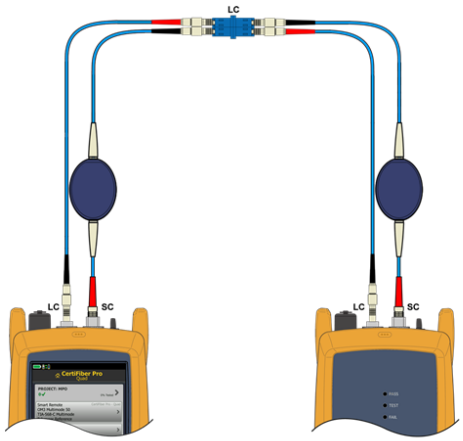
Keys to Running an Accurate Test
Reducing Uncertainty

- One Jumper Reference
  - Better if you can verify the ‘known good’ leg
    - < 0.15 dB of loss in Multimode
    - < 0.25 dB of loss in Single-mode
    - May not be possible with pinned plugs
  - EF with Multimode
  - LED Source with Multimode
  - Reference Grade Connectors



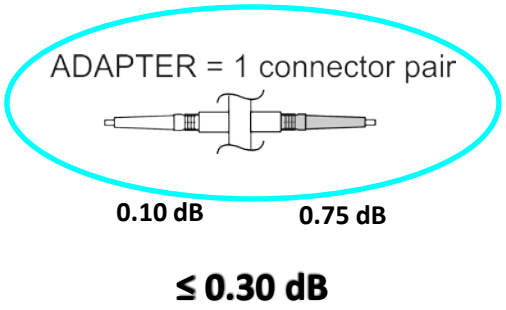
Keys to Running an Accurate Test
Reducing Uncertainty

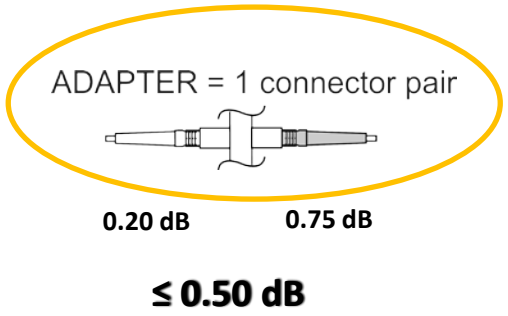
- One Jumper Reference
  - Better if you can verify the ‘known good’ leg
    - < 0.15 dB of loss in Multimode
    - < 0.25 dB of loss in Single-mode
    - Save Results!!
    - May not be possible with pinned plugs
  - EF with Multimode
  - LED Source with Multimode
  - Reference Grade Connectors



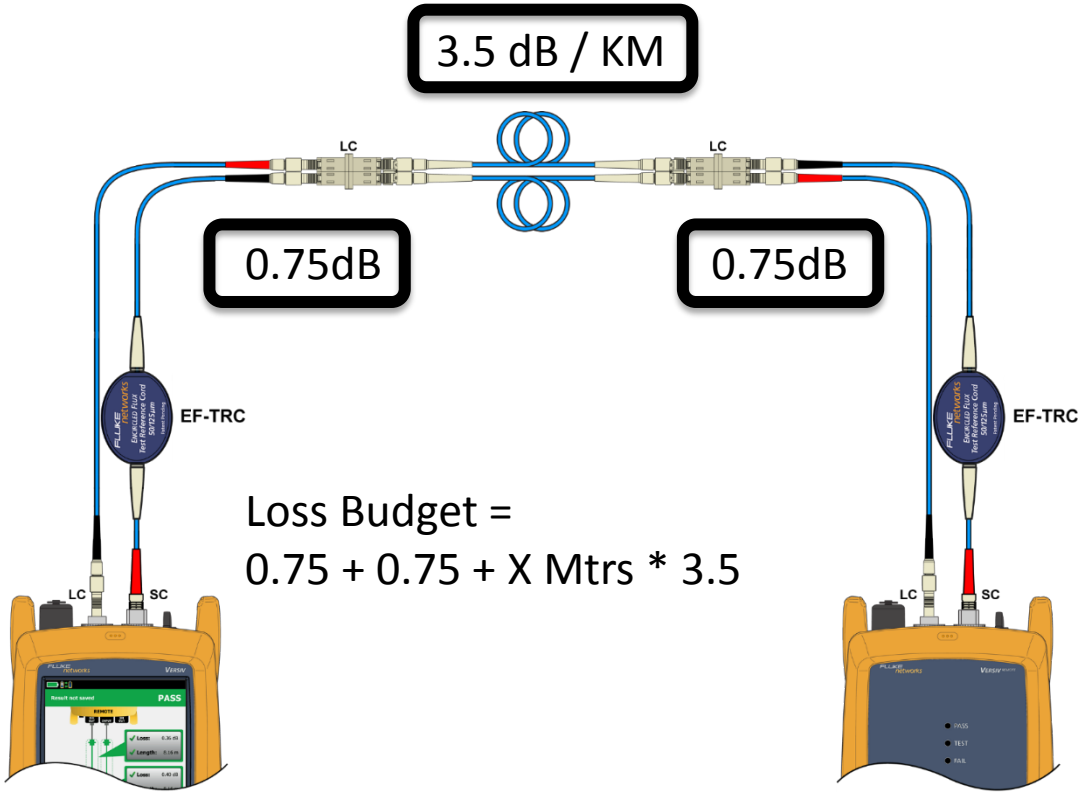
Loss Budgets must be more accurate to support these new links

- In ISO/IEC 14763-3 (2006), cords were recognized as a source of great uncertainty
- This standard reduced uncertainty by defining the performance of the test cord connector
- Reference grade connectors were required
  - Multimode ≤ 0.10 dB
  - Singlemode ≤ 0.20 dB

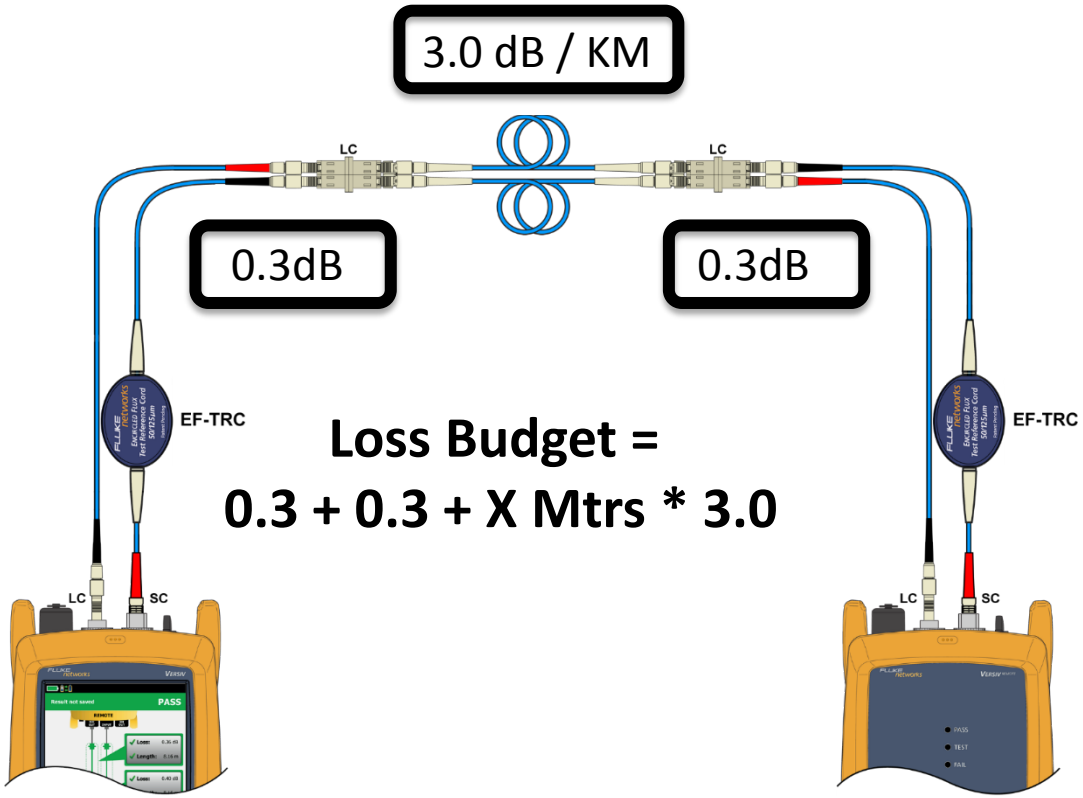




Multimode Old Values with Reference Grade TRCs



Multimode New Values with Reference Grade TRCs



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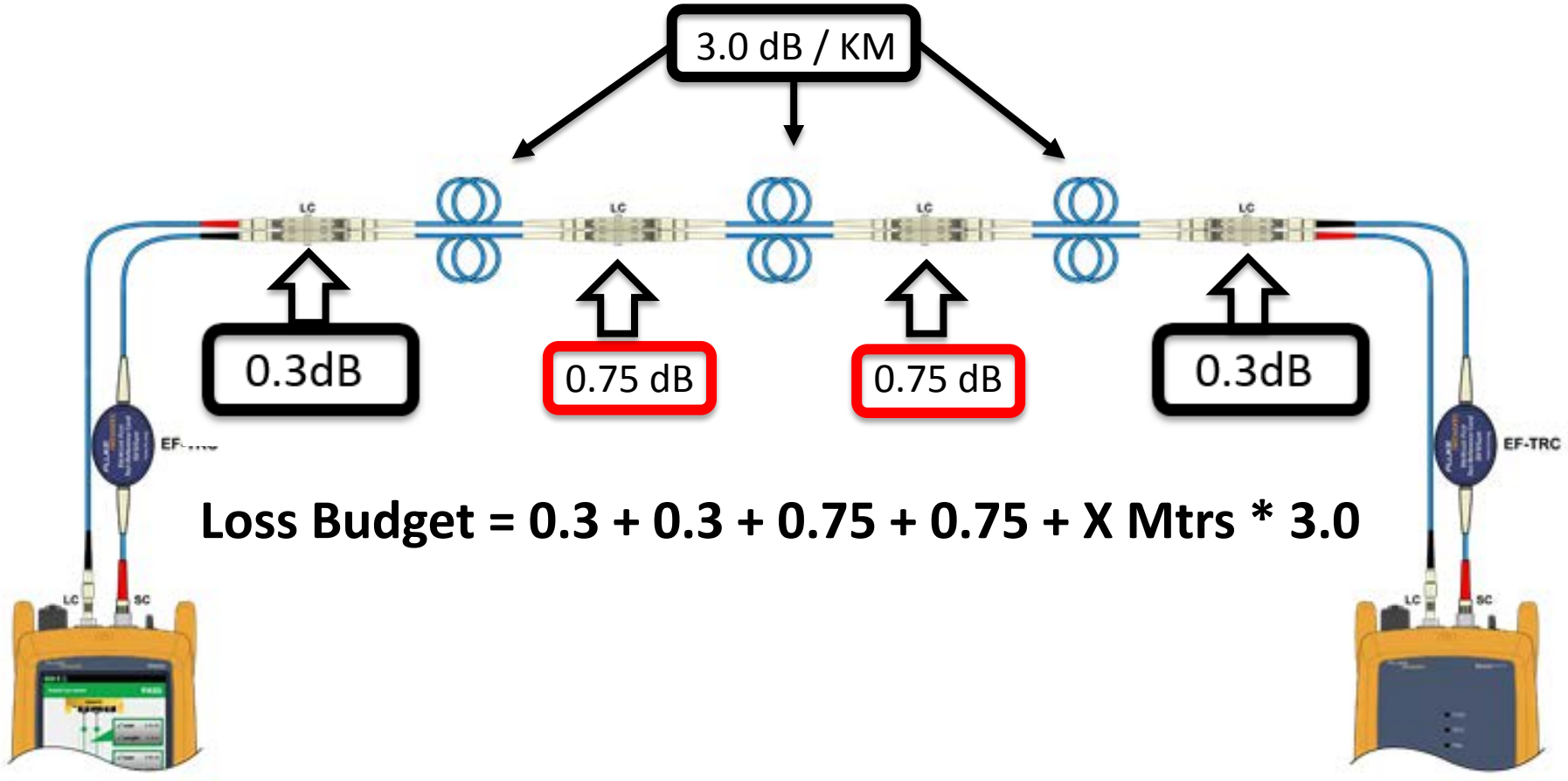

Loss Budget = 0.3 + 0.3 + 0.75 + 0.75 + X Mtrs * 3.0

Vamos Ver si esta bien!

LINKWARE™ PC

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
Limit (dB)	2.08	1.34
Margin (dB)	0.20	0.32
Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

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Valor de Referencia esta bien +/- -22 dB

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
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Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

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Limit de perdida esta Bien Para TIA y tambien para 10GBASE-SR

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
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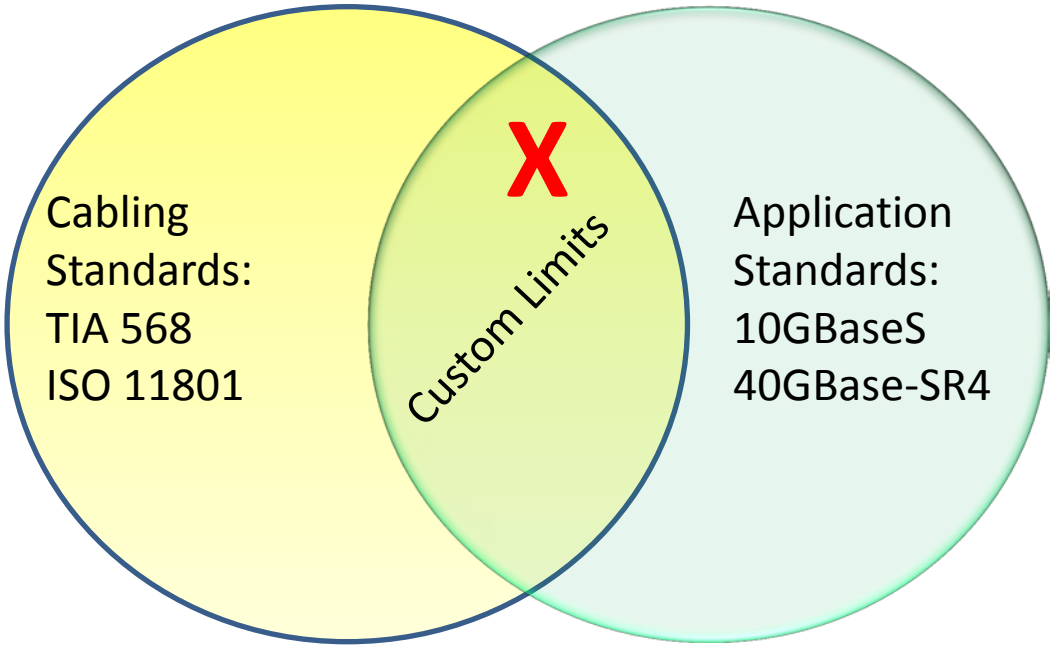
Margin (dB)	0.20	0.32
Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

Bicsi

2.08 dB = Solo Pasa TIA
Limit de IEEE 10GBASE-SR= 2.55



Como llegamos al limit?
#Km * 3dB/Km

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
Limit (dB)	2.08	1.34
Margin (dB)	0.20	0.32
Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

492 * 3 dB/Km = 1.47 dB

Bicsi

Como llegamos al limit?

#Km * 3dB/Km

+ # adaptadores * 0.75 dB

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
Limit (dB)	2.08	1.34
Margin (dB)	0.20	0.32
Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

492 * 3 dB/Km = 1.47 dB

2 * 0.3 dB = 0.6.

Como llegamos al limit?

1.47 + 0.60 = 2.08 dB

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
Limit (dB)	2.08	1.34
Margin (dB)	0.20	0.32
Reference (dBm)	-23.26	-23.76

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

492 * 3 dB/Km = 1.47 dB

2 * 0.3 dB = 0.6

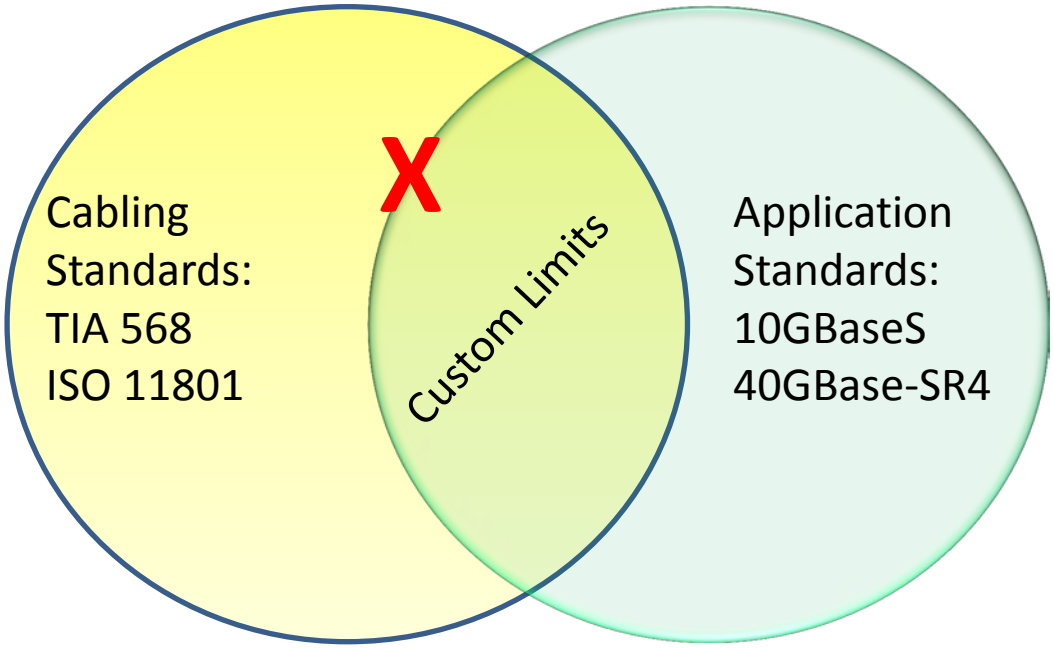
Valor Medido < Limit
1.88 vs 2.08

Propagation Delay (ns)	2426		
Length m	492.2	PASS	
Limit 2000			
	850 nm	1300 nm	
Result	PASS	PASS	
Loss (dB)	1.88	1.02	
Limit (dB)	2.08	1.34	
Margin (dB)	0.20	0.32	
Reference (dBm)	-23.26	-23.76	

Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/
1 Jumper

Bicsi

1.88 dB = Pasa TIA y Limit de IEEE 10GBASE-SR= 2.55

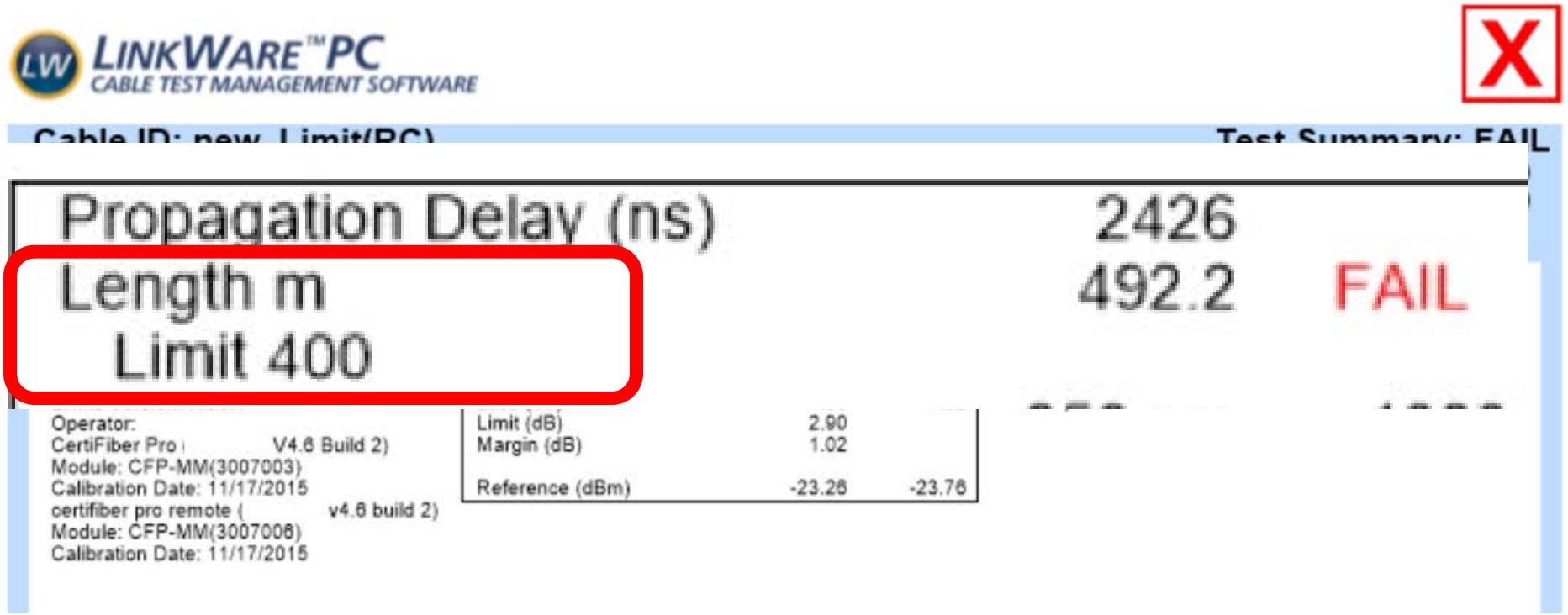


Este Link Supporta 10GBASE-SR??

Propagation Delay (ns)	2426	
Length m	492.2	PASS
Limit 2000		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.88	1.02
Limit (dB)	2.98	2.24
Margin (dB)	1.10	1.22
Reference (dBm)	-23.26	-23.76

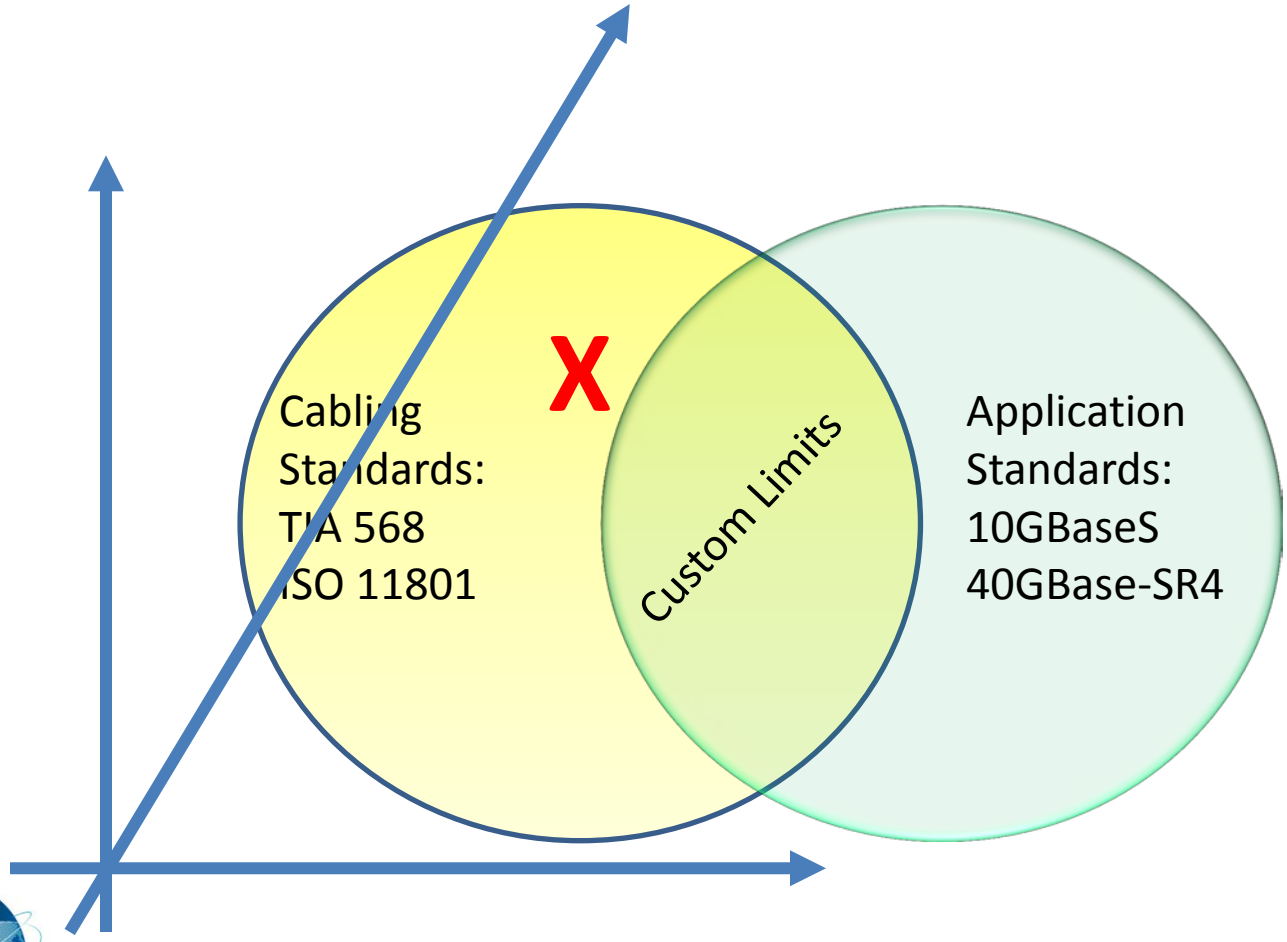
Number of Adapters: 2
Number of Splices: 0
Connector Type: LC
Patch Length1 (m): 2.0
Reference Date: 05/31/2
1 Jumper

Como?!?


LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE
X
Propagation Delay (ns) 2426
Length m 492.2 FAIL
Limit 400
Operator:
CertiFiber Pro (V4.6 Build 2)
Module: CFP-MM(3007003)
Calibration Date: 11/17/2015
certifiber pro remote (v4.6 build 2)
Module: CFP-MM(3007006)
Calibration Date: 11/17/2015
Limit (dB) 2.90
Margin (dB) 1.02
Reference (dBm) -23.26 -23.76

Bicsi

2Km = Pasa TIA y Limit de IEEE 10GBASE-SR= 400



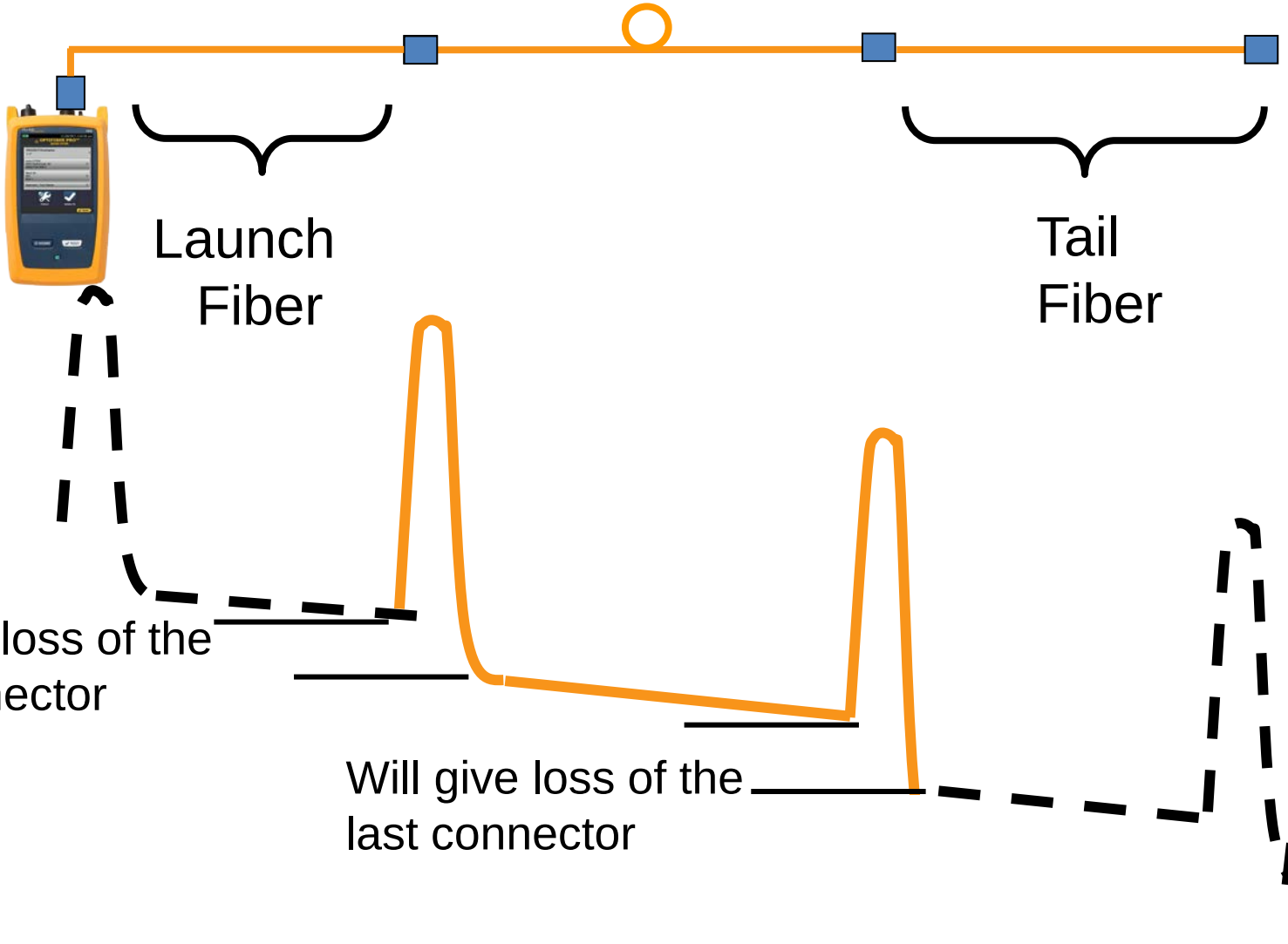
TIER 2 TESTING

Tier II testing is Tier I *plus* the use of an OTDR

Ideal for Troubleshooting

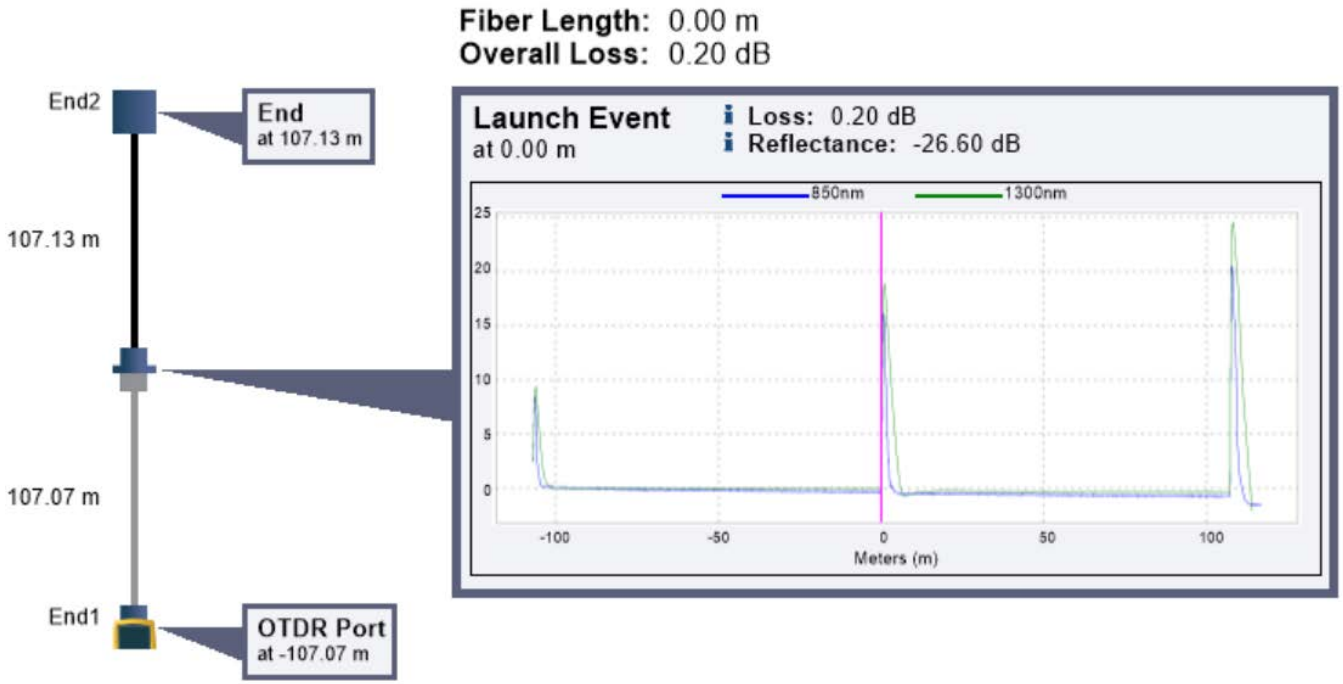
Bicsi

Accurate OTDR Testing for HighSpeed Links

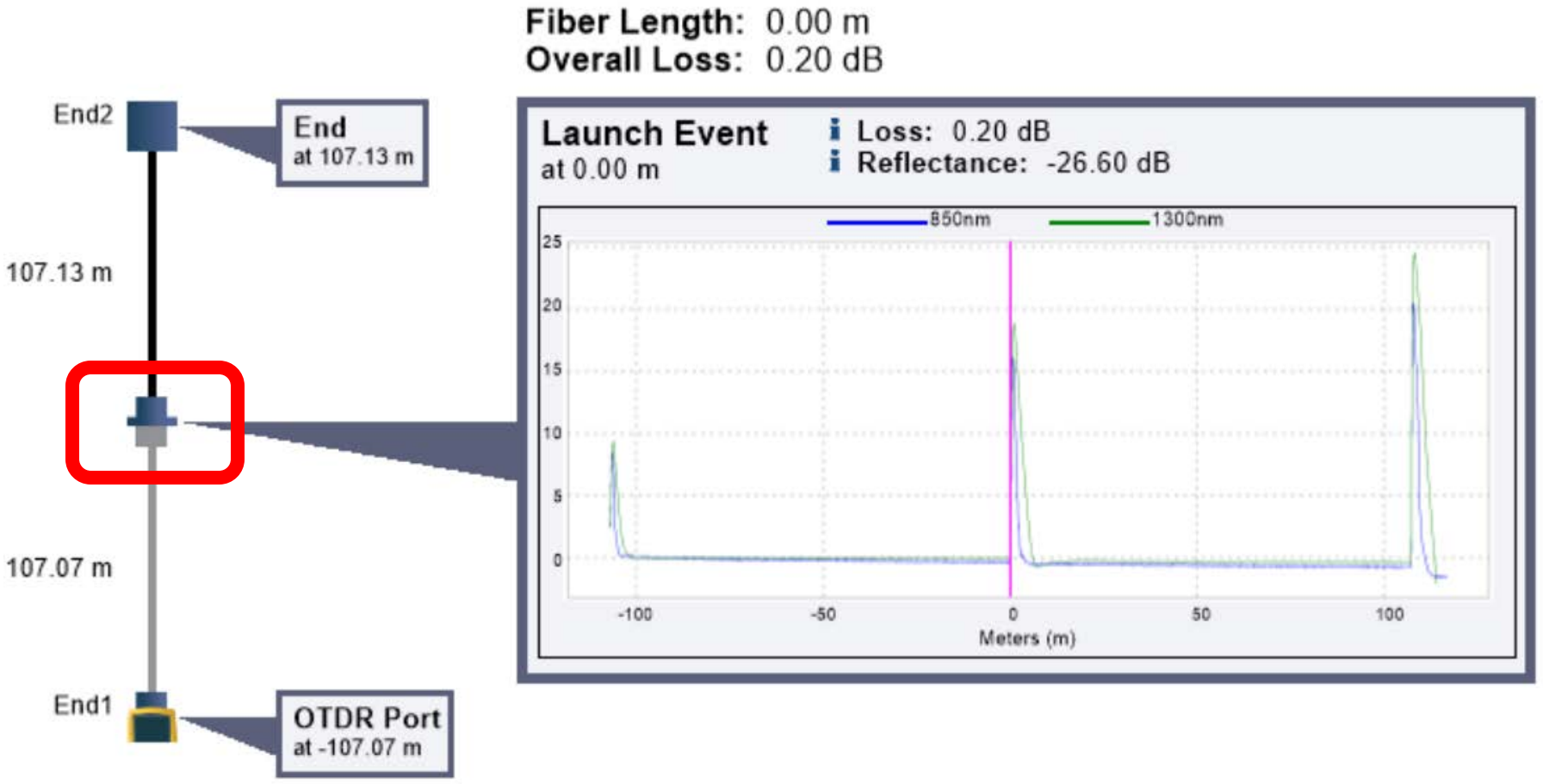


OTDR testing for High Speed Links

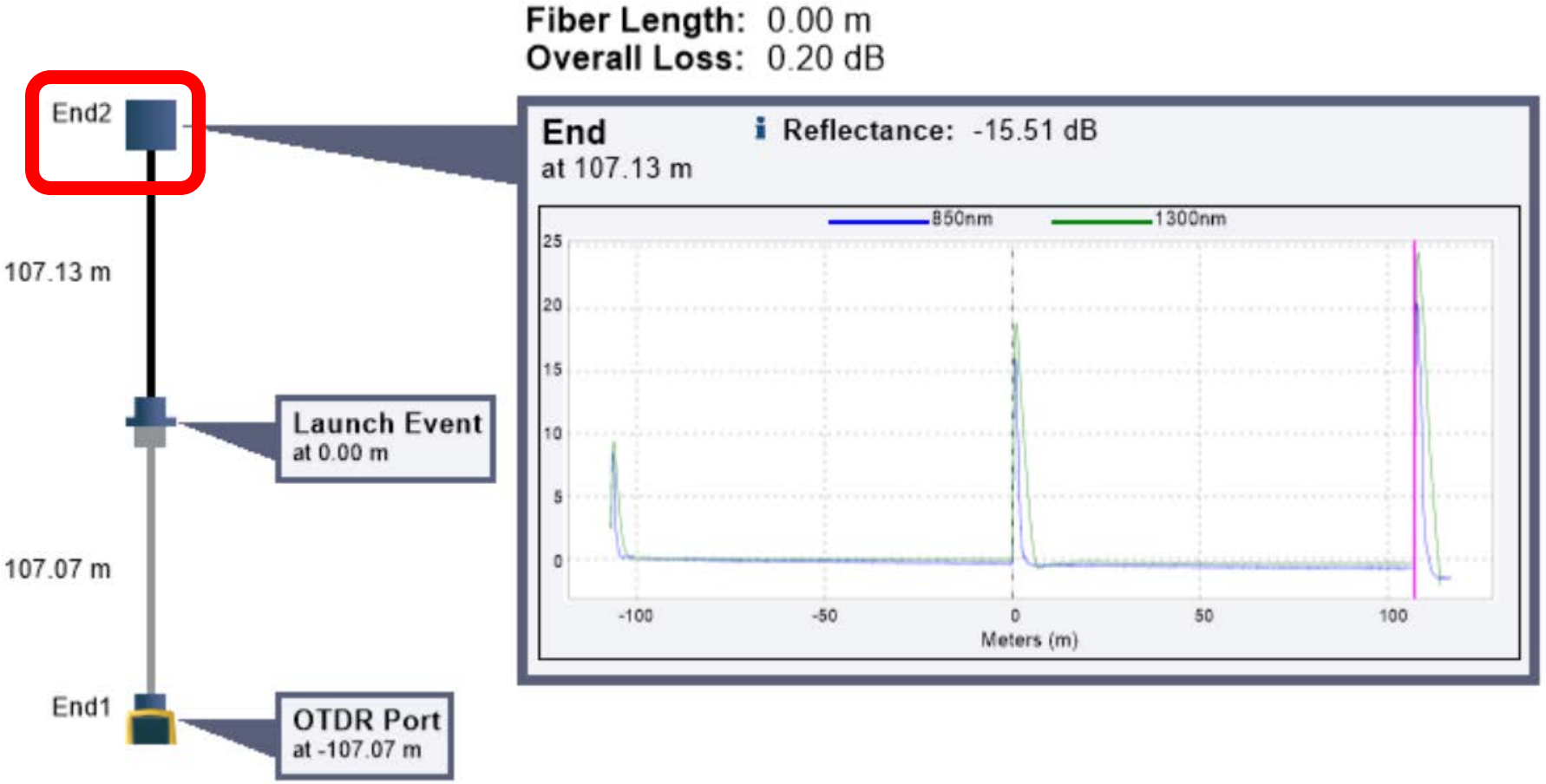
- Must use launch and receive fibers
- Need to run the test Bi-Directionally
- Need to measure reflectance



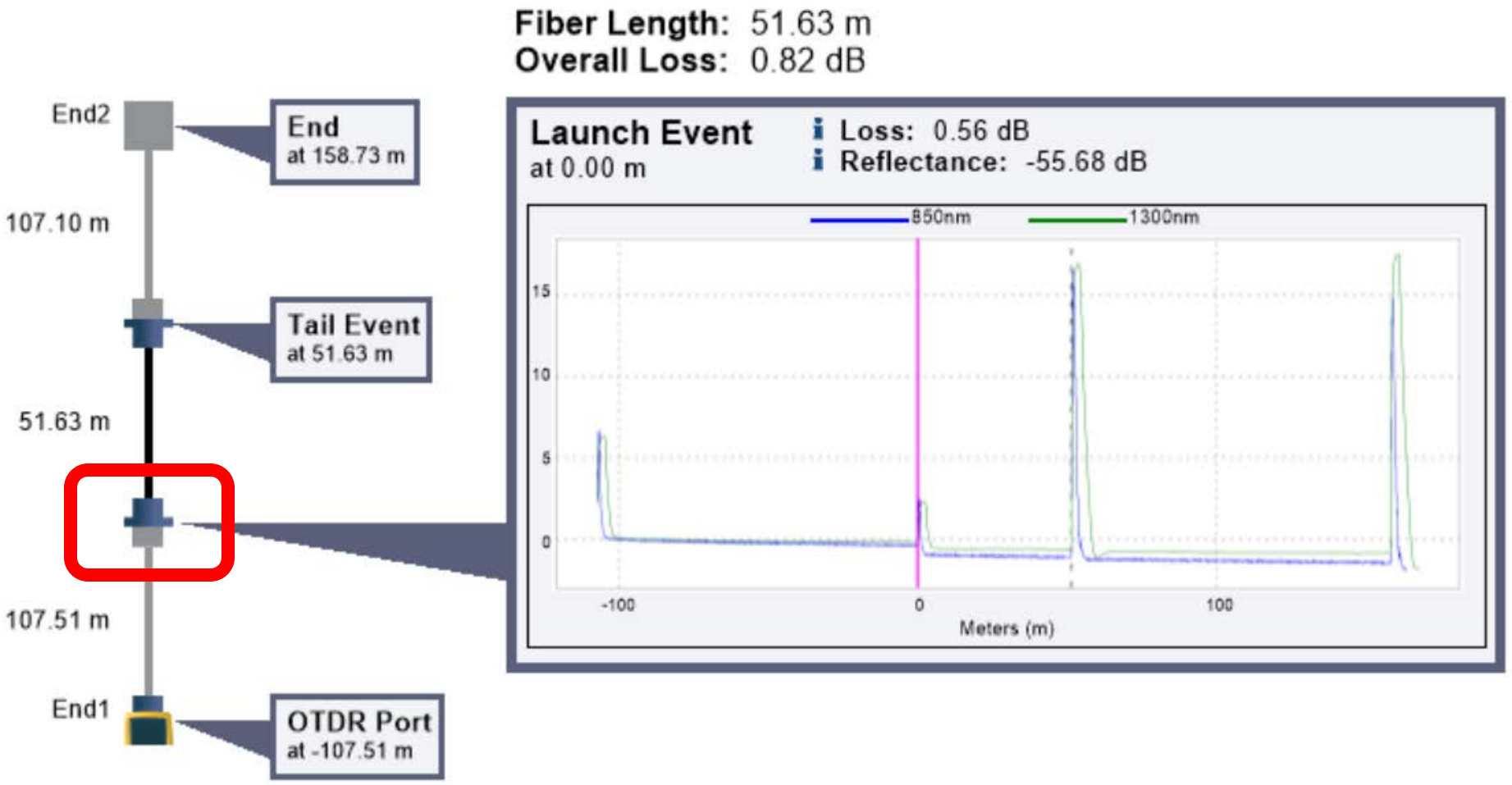
Bad – No Tail/Receive fiber – what is loss at far connector?



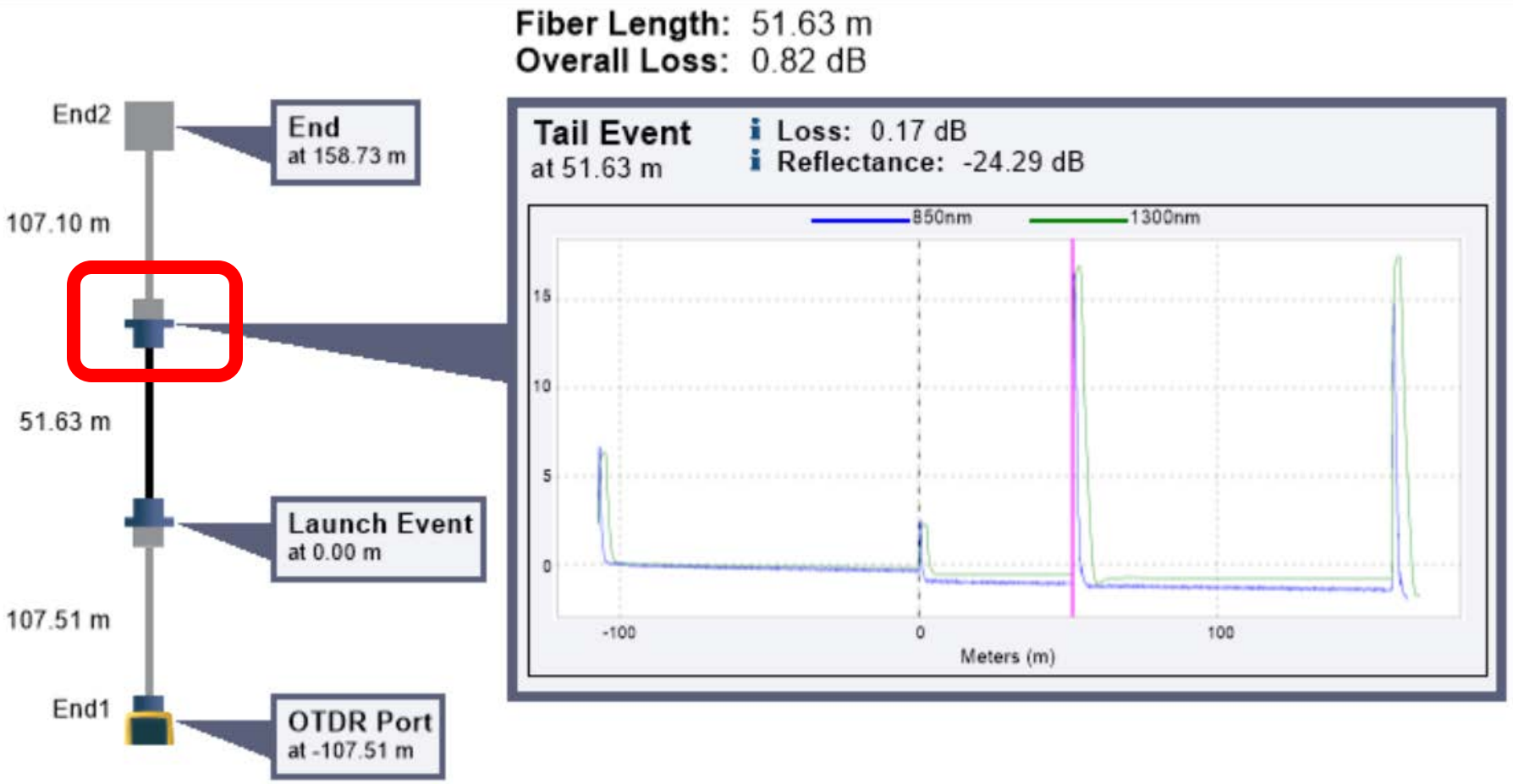
Bad – No Tail/Receive fiber – what is loss at far connector?



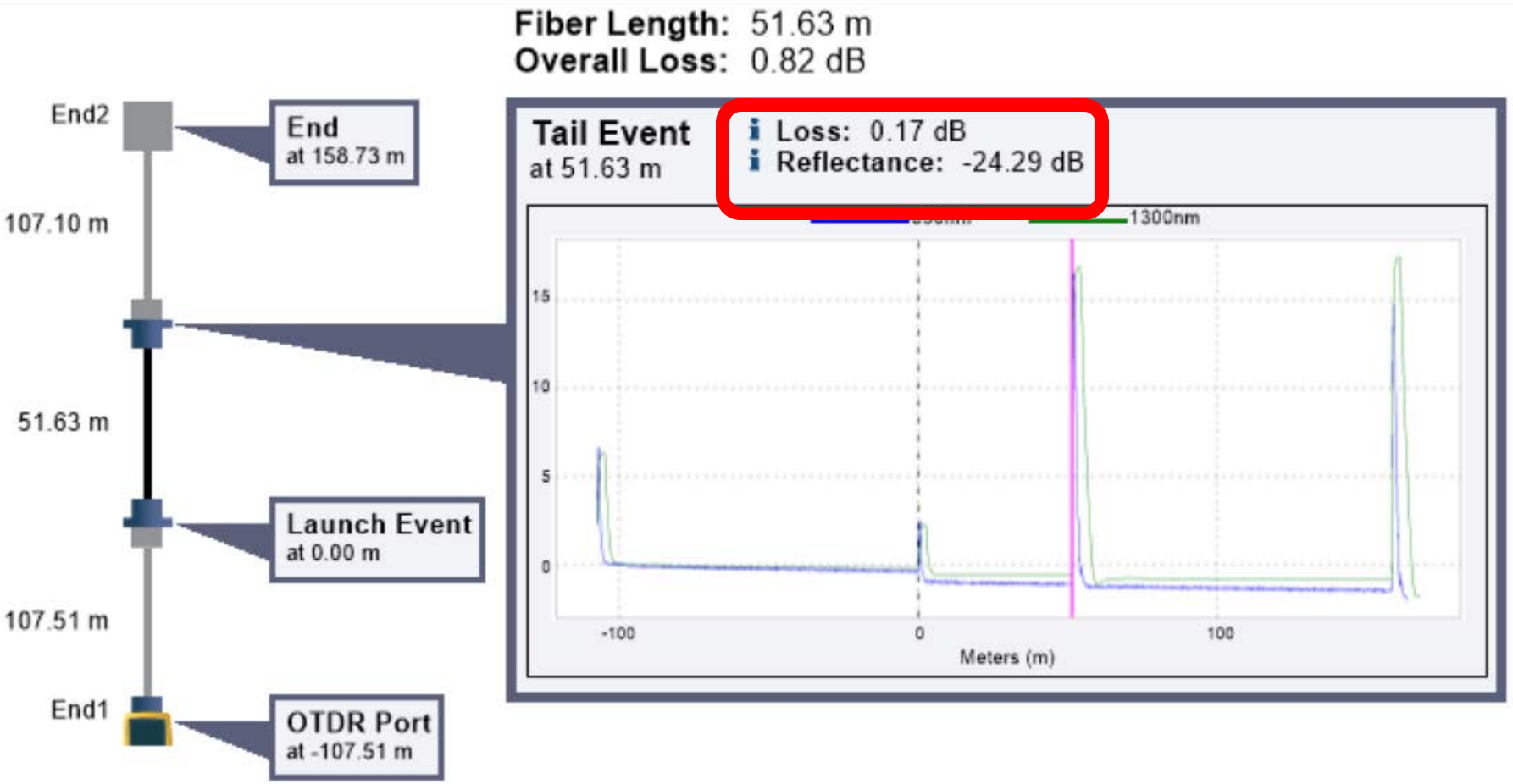
Good Measurement – Launch and Tail/Receive Fiber used so both connectors can be measured



Good Measurement – Launch and Tail/Receive Fiber used so both connectors can be measured



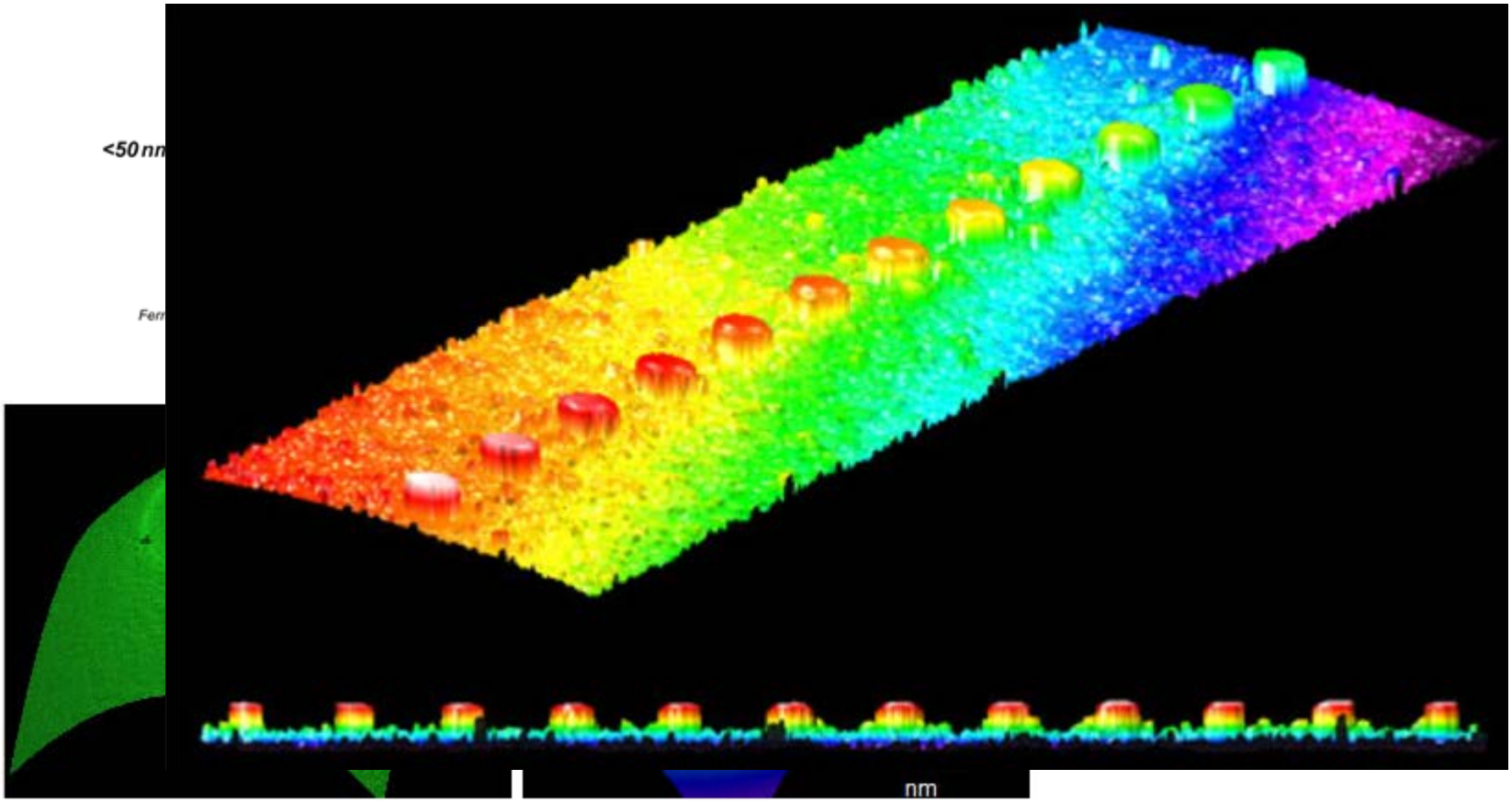
By the Way, the 2nd Connector is Bad
Notice the Poor Reflectance Value



What is reflectance?

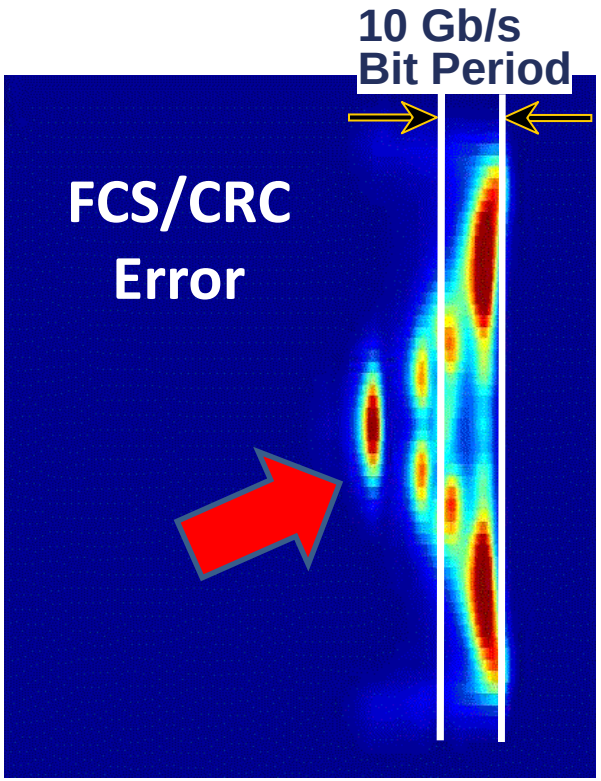
An air gap between the end faces of a fiber also cause Fresnel reflections to occur.

Reflectance is Caused by Poor Termination and Dirty Connectors

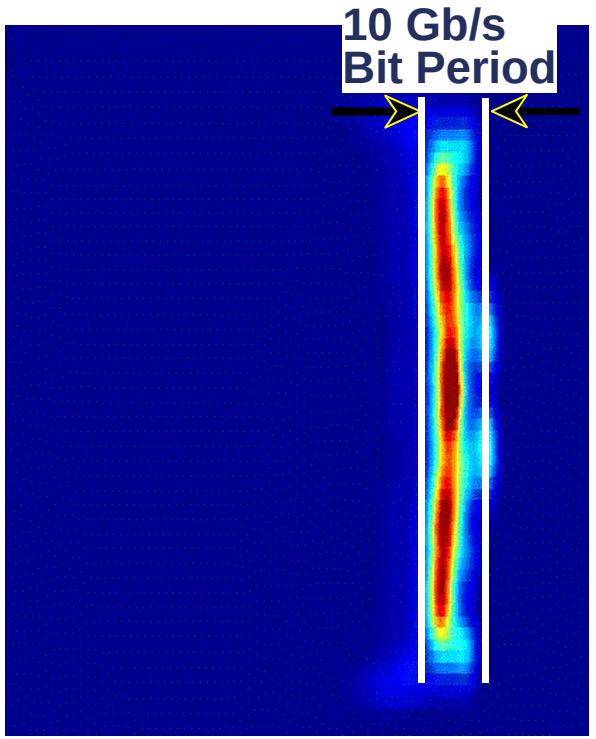


Reflected Signal Arriving Outside of Bit Period

Fiber with poor reflectance



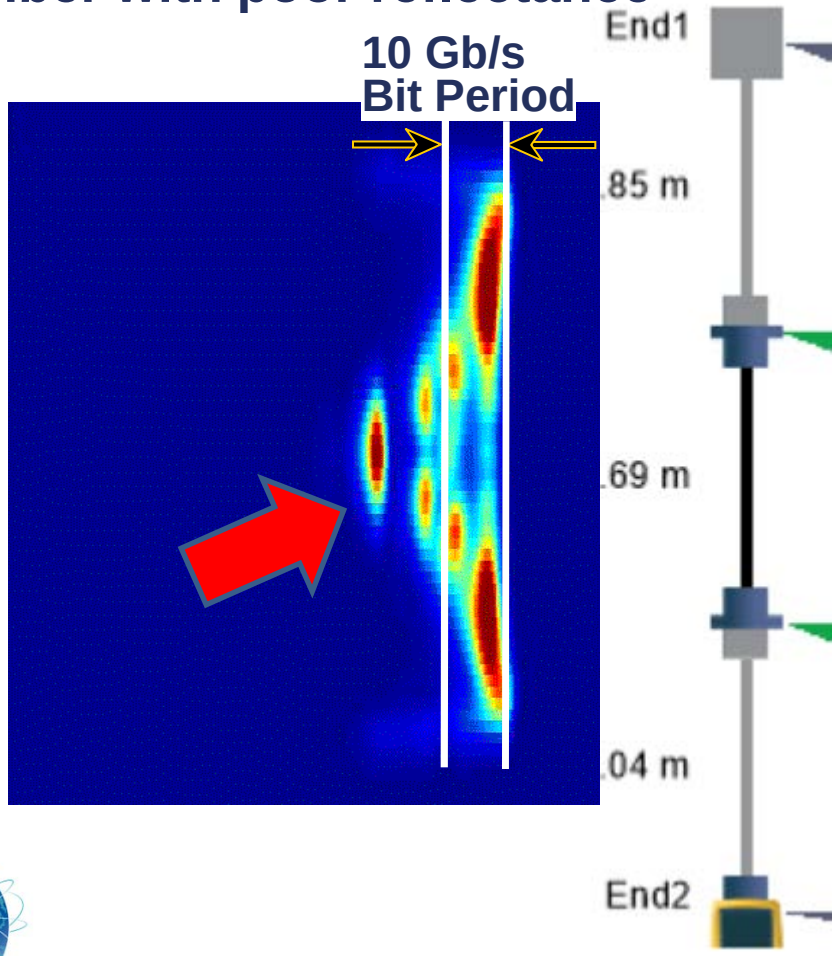
Fiber with Good Reflectance



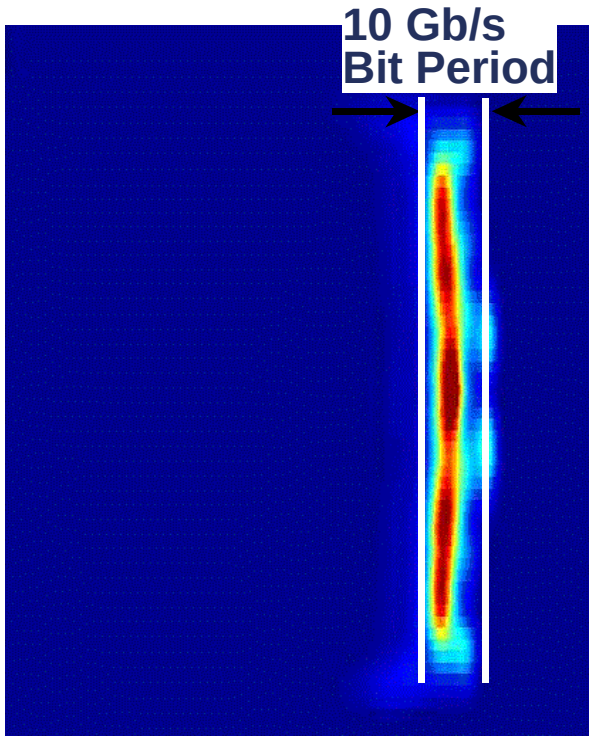
Slide courtesy of OFS

Reflected Signal Arriving Outside of Bit Period

Fiber with poor reflectance

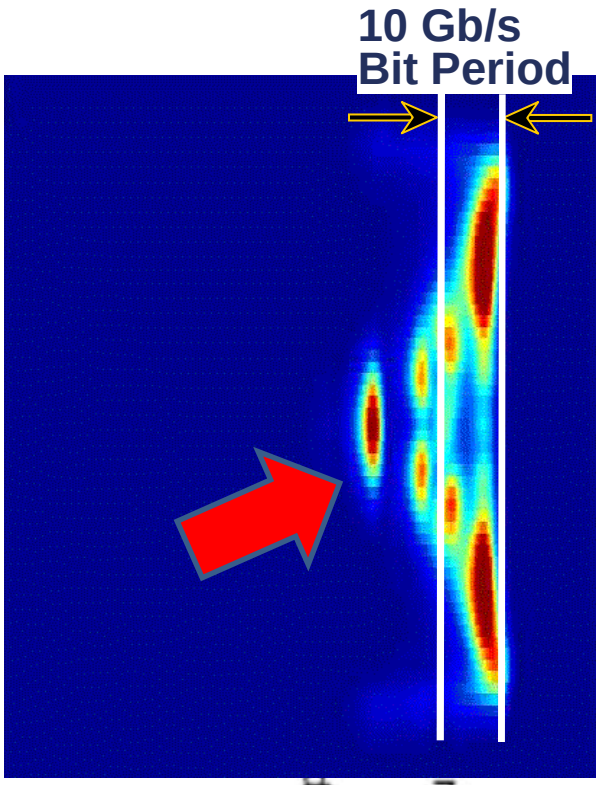


Fiber with Good Reflectance

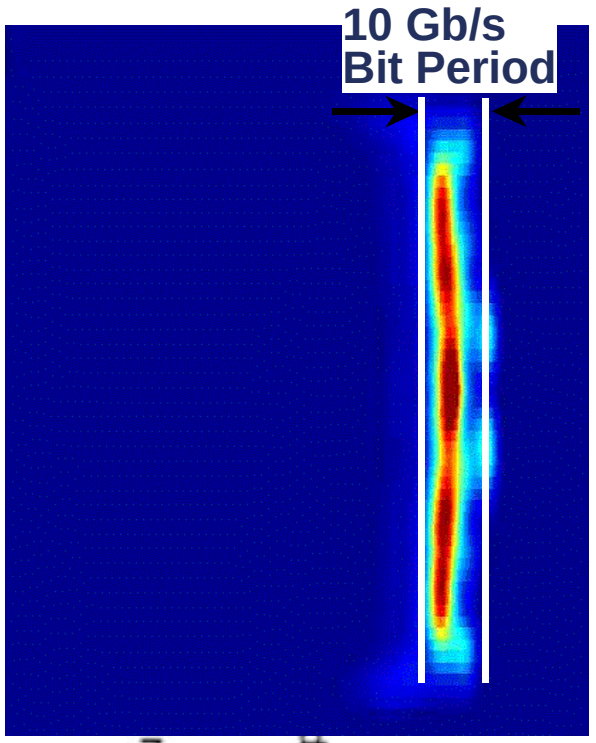


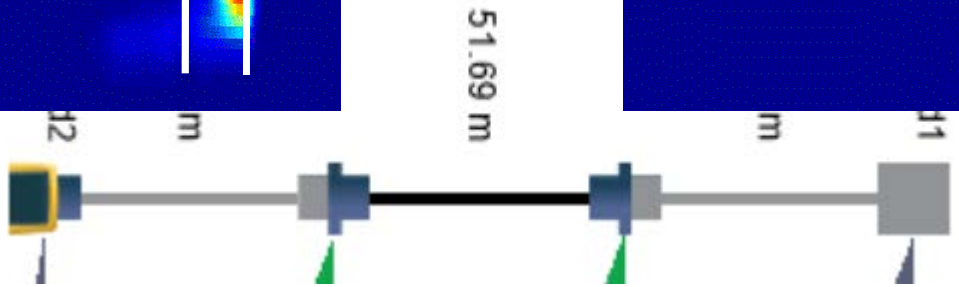
Reflected Signal Arriving Outside of Bit Period

Fiber with poor reflectance

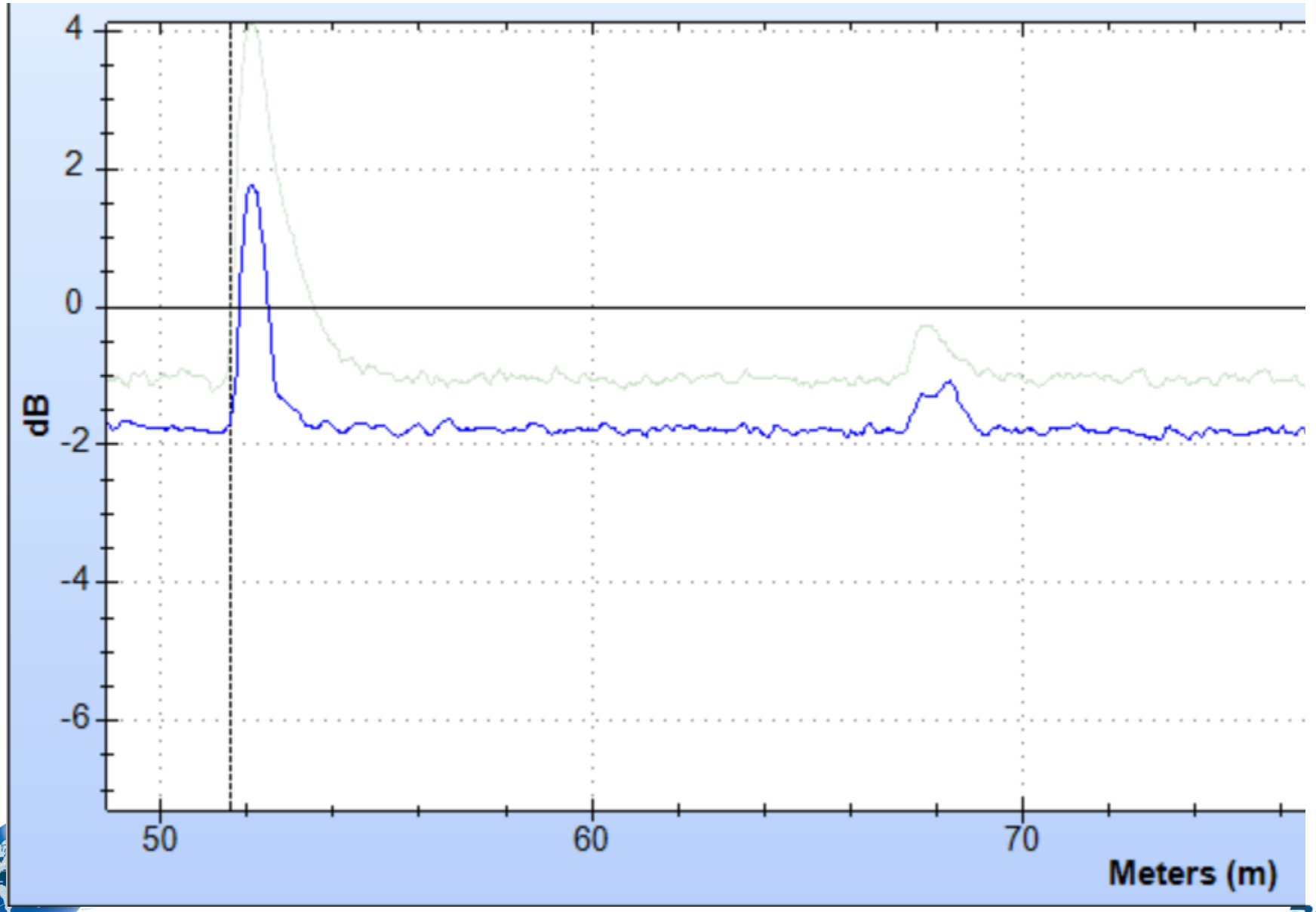


Fiber with Good Reflectance



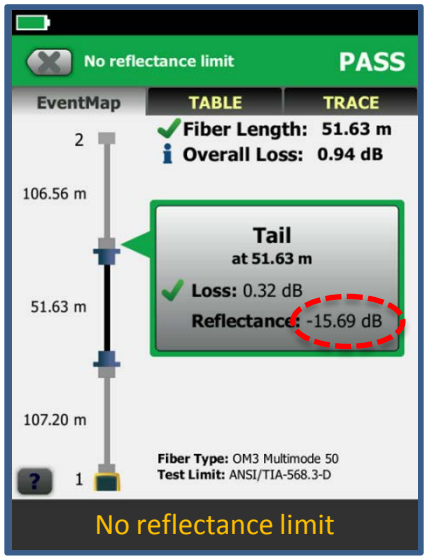


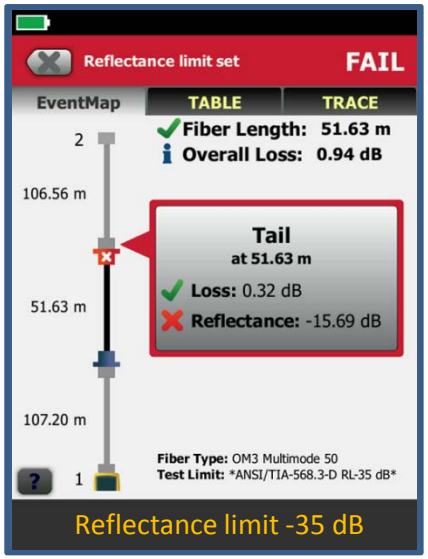
Exemplo de una Fantasma



Specify a Reflectance Limit for OTDR testing

- OTDR loss event measurements heavily rely on good reflectance
- Poor reflectance can result in
  - Optimistic / negative loss readings
  - Errors when the application runs
- Agree on a reflectance limit
- As a guide (talk to your vendor)
  - -35 dB for multimode
  - -40 dB for singlemode
  - -55 dB for APC singlemode





Same link tested

Vamos ver otro ejemplo?

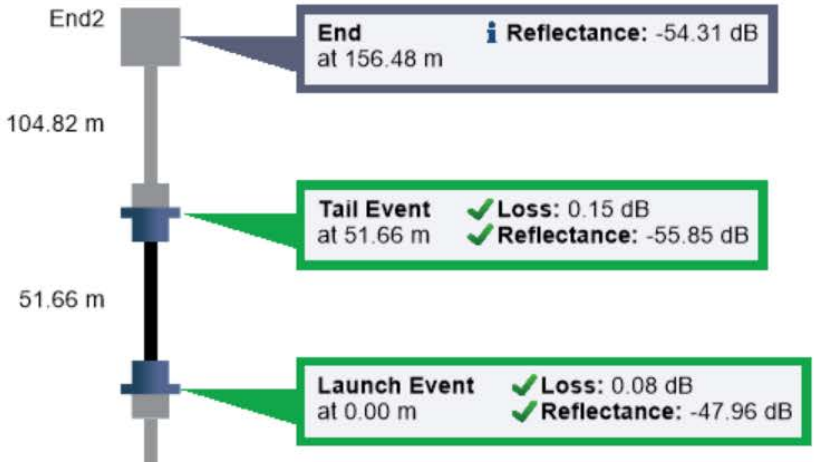
LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: 007B6
Date / Time: 02/09/2017 07:29:37 AM
Cable Type: OM3 Multimode 50
Backscatter Coefficient: -68.0dB (850 nm)
n = 1.4820 (850 nm)
n = 1.4770 (1300 nm)
Backscatter Coefficient: -75.8dB (1300 nm)

Test Summary: PASS
Modal Bandwidth: 2000MHz-km (850 nm)
Modal Bandwidth: 500MHz-km (1300 nm)

OTDR Bidir. Avg. EventMap

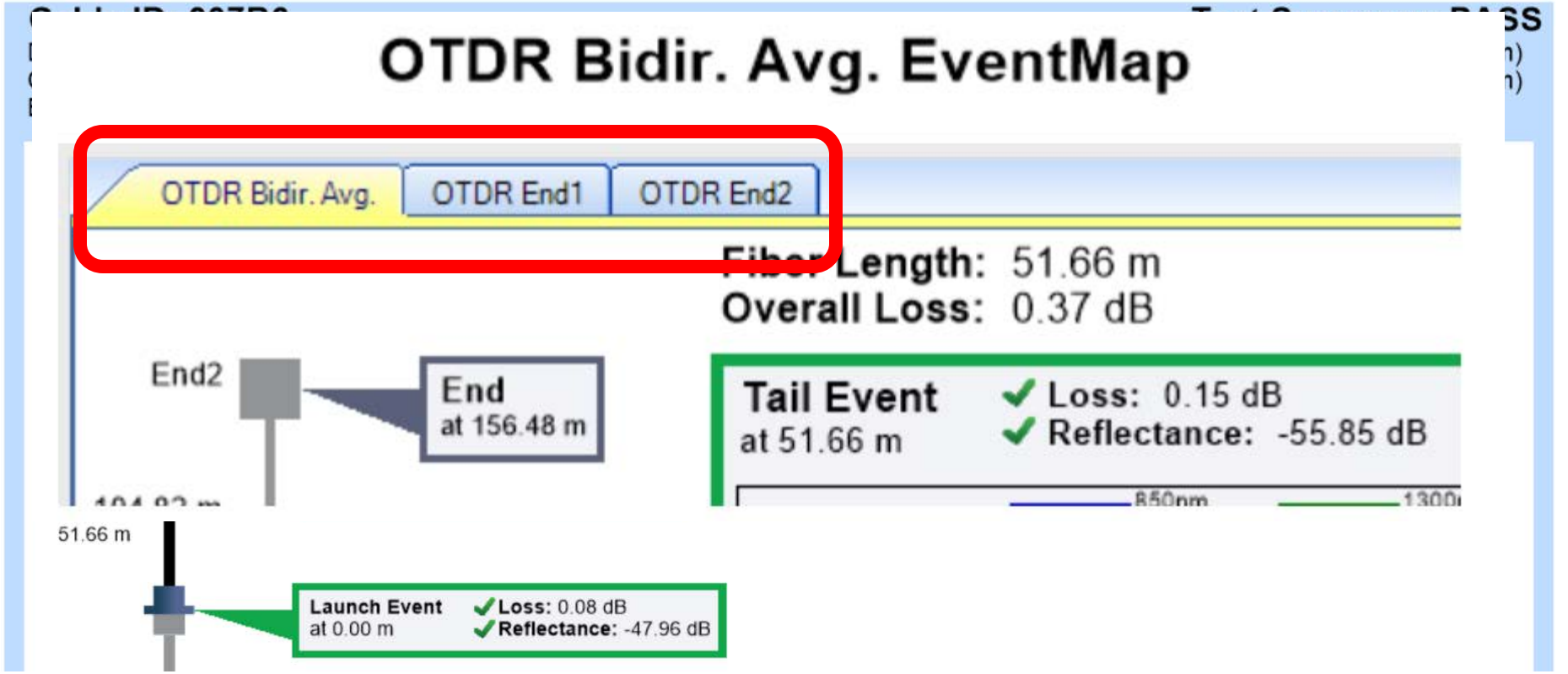
Fiber Length: 51.66 m
Overall Loss: 0.37 dB



Bicsi

Tenemos Resultados Bi-Direcionales
Esto esta bien!

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE



Pocos eventos, nada inesperado

Events		Loss (dB)			Reflectance (dB)		
		850 nm	1300 nm	Limit	850 nm	1300 nm	Limit
156.48 m	End	N/A	N/A		-54.31	-55.15	
51.66 m	Tail Event	0.15	0.10	0.75	-55.85	-56.42	-35.00
0.00 m	Launch Event	0.08	0.05	0.75	-47.96	-52.10	-35.00
-107.32 m	OTDR Port	N/A	N/A		-48.89	-48.65	

Bicsi

Perdidas Menores a 0.75 dB

Events		Loss (dB)			Reflectance (dB)		
		850 nm	1300 nm	Limit	850 nm	1300 nm	Limit
156.48 m	End	N/A	N/A		-54.31	-55.15	
51.66 m	Tail Event	0.15	0.10	0.75	-55.85	-56.42	-35.00
0.00 m	Launch Event	0.08	0.05	0.75	-47.96	-52.10	-35.00
-107.32 m	OTDR Port	N/A	N/A		-48.89	-48.65	

Bicsi

Y la Reflectancia? Esta Bien ☺

Events		Loss (dB) 850 nm	Loss (dB) 1300 nm	Loss (dB) Limit	Reflectance (dB) 850 nm	Reflectance (dB) 1300 nm	Reflectance (dB) Limit
156.48 m	End	N/A	N/A		-54.31	-55.15	
51.66 m	Tail Event	0.15	0.10	0.75	-55.85	-56.42	-35.00
0.00 m	Launch Event	0.08	0.05	0.75	-47.96	-52.10	-35.00
-107.32 m	OTDR Port	N/A	N/A		-48.89	-48.65	

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: 007B6
Date / Time: 02/09/2017 07:29:37 AM
Cable Type: OM3 Multimode 50
Backscatter Coefficient: -68.0dB (850 nm)
n = 1.4820 (850 nm)
n = 1.4770 (1300 nm)
Backscatter Coefficient: -75.8dB (1300 nm)

Test Summary: PASS
Modal Bandwidth: 2000MHz-km (850 nm)
Modal Bandwidth: 500MHz-km (1300 nm)

OTDR Bidir. Avg. EventMap

Fiber Length: 51.66 m
Overall Loss: 0.37 dB

In Conclusion

- Looking forward to 25G per λ
- Know your current requirements
  - At least 10G?
- Future applications will have tighter loss and length budgets
- Measure accurately
  - Tier I – use correct budget values REF vs STD
  - Tier 2 – Measure reflectance in addition to loss

Thank you, Gracias, Obrigado

Jim Davis

Fluke Networks

Jim.Davis2@flukenetworks.com

6920 Seaway Blvd

Everett, WA 98271