

SOLVE FOR



It's fiber to anywhere.



“Fiber 101”

Tom Warren

Applications Engineering

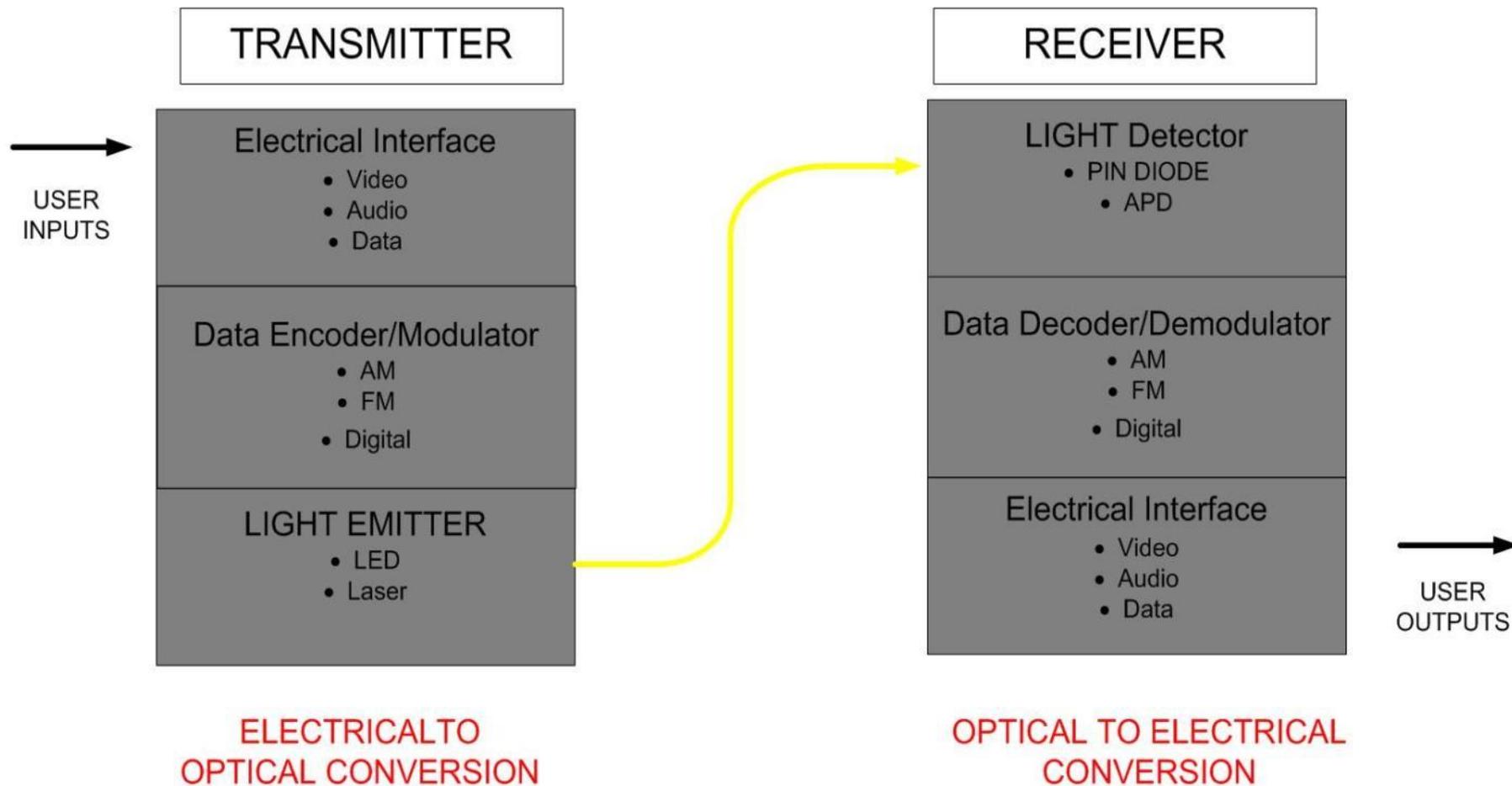
Tom Warren

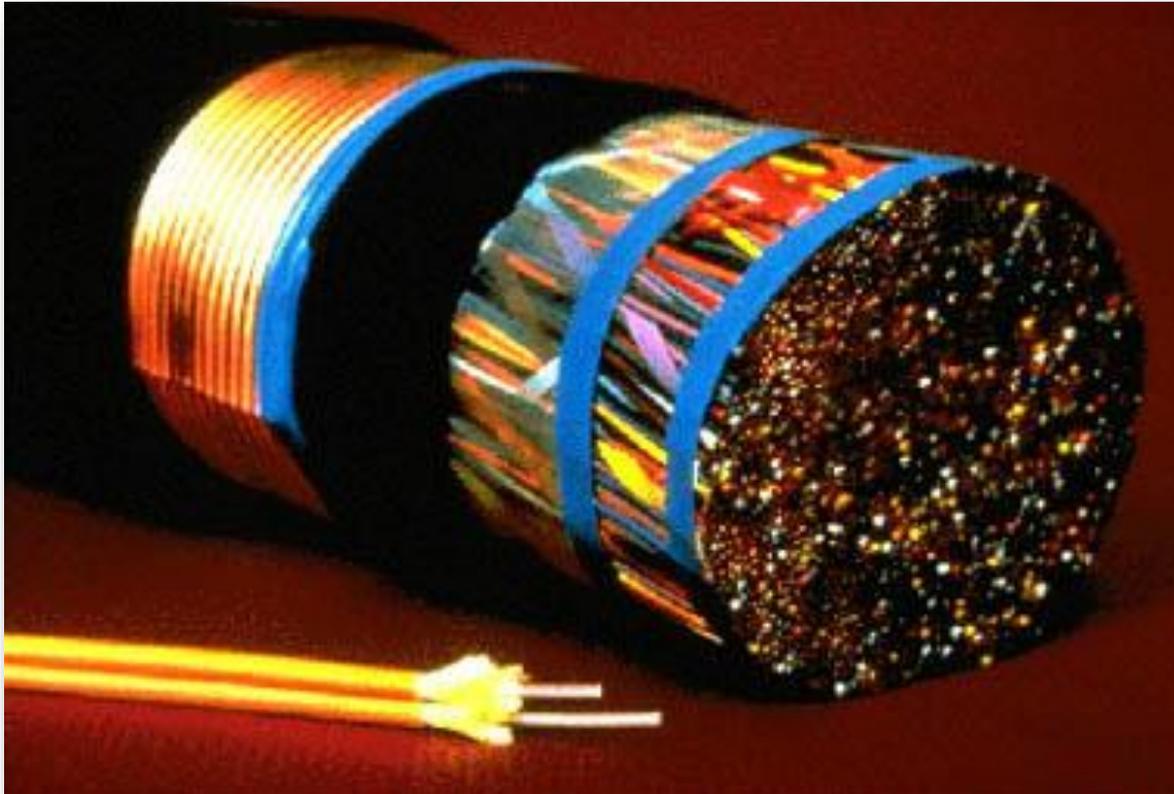
Applications Engineering
Clearfield®

- Worked in Communication Industry for 15 years
- Specializes in passive connectivity products for CWDM, DWDM, FTTx and HFC applications
- SCTE Member North Country Region

1. Fiber Basics, Transmitters/Receivers, LASERs and LEDs
2. Transmission Characteristics
3. Optical Loss Budgets, Testing/Inspection
4. Fiber Management and Maintenance
5. HFC Applications
6. Advanced Optical Systems
 - FTTx, PON, RFOG, WDM's

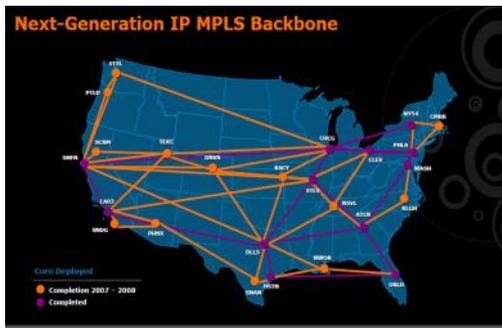
Section 1 - Fiber Optic Systems



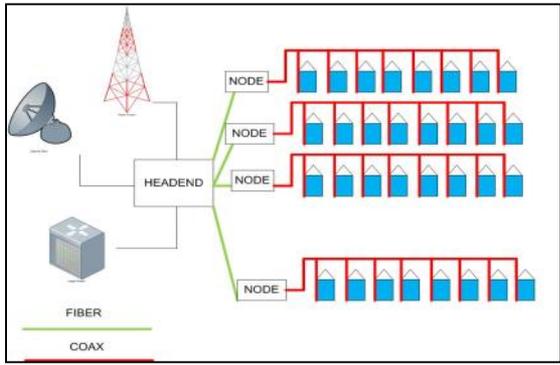


Why do we use it?

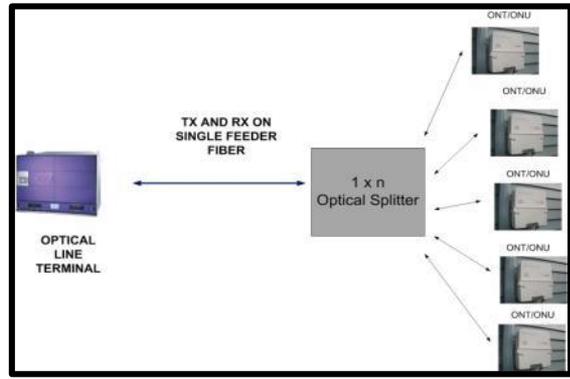
Applications for Fiber Optics



LONG HAUL TELECOM



HFC



FTTx



WIND FARM/POWER

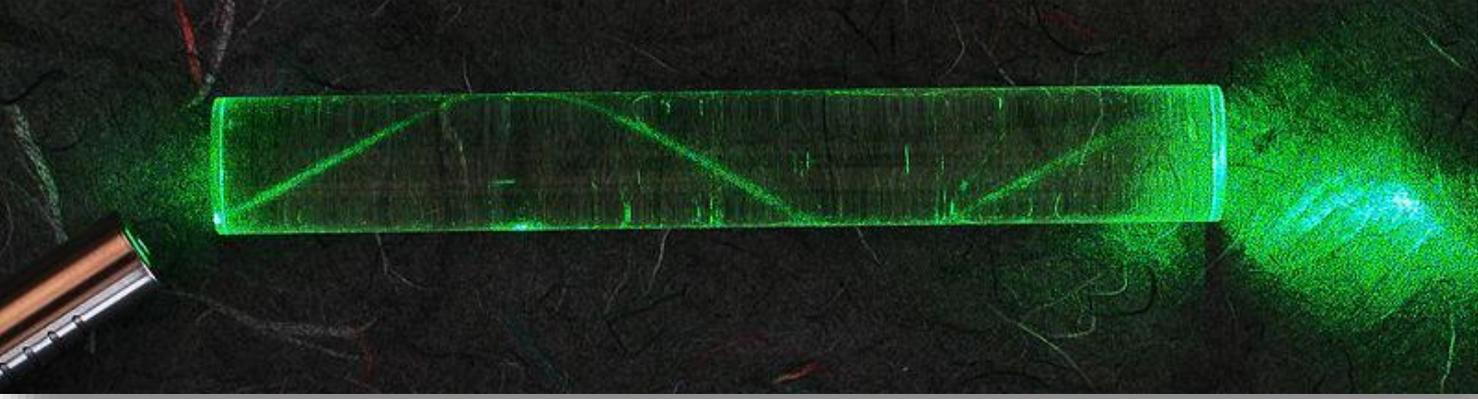
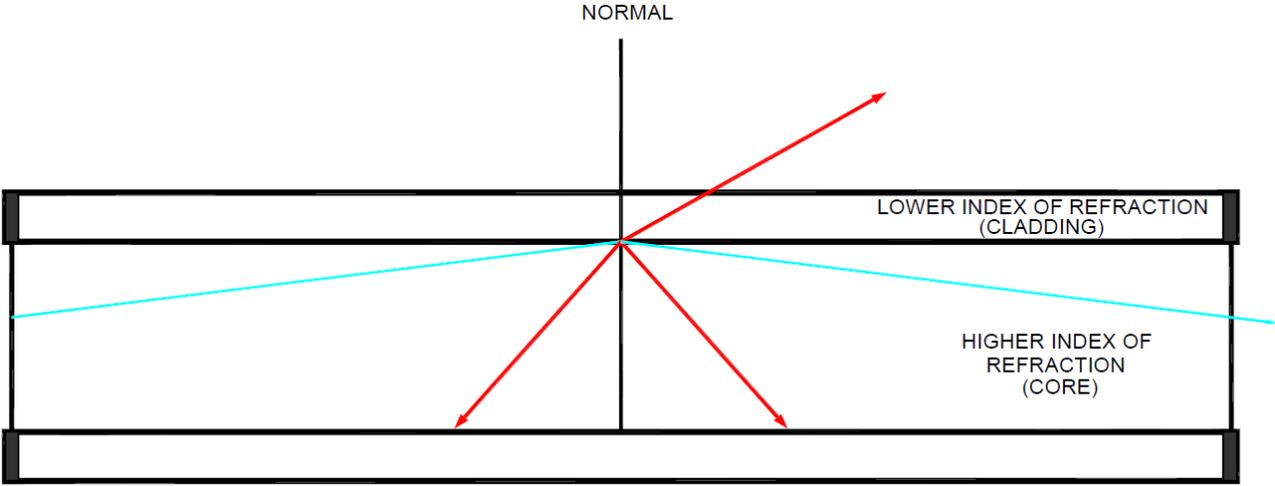


D.O.T.



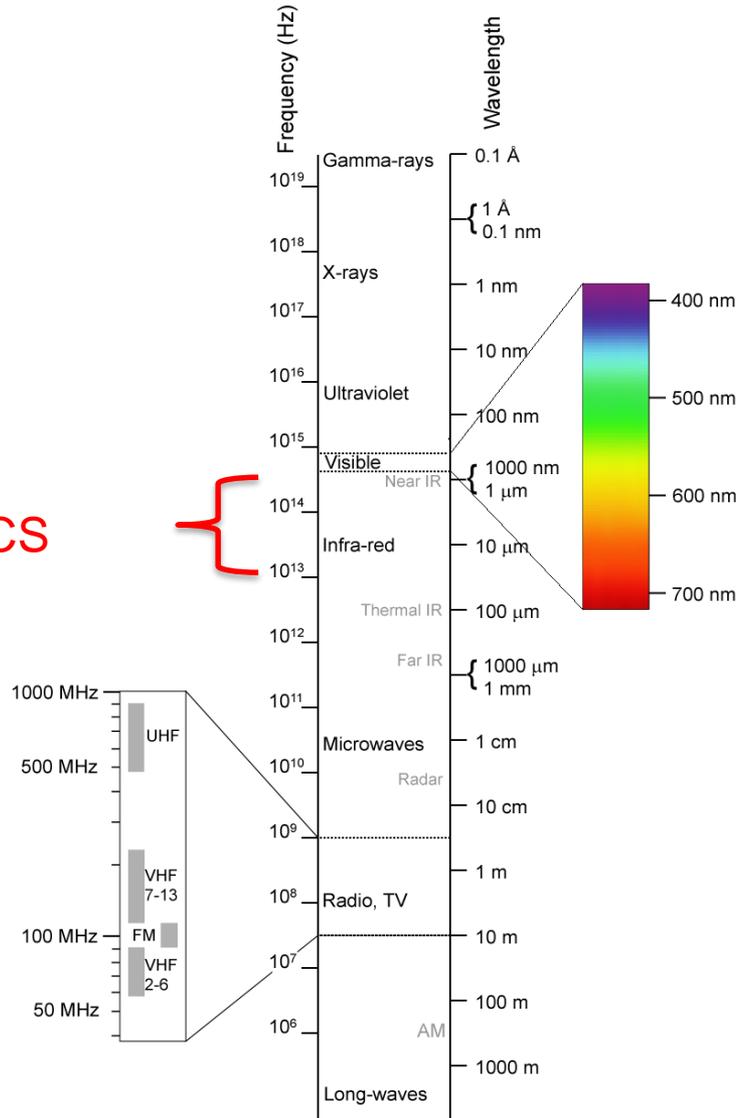
CELL BACKHAUL

How Fiber Works (Total Internal Reflection)

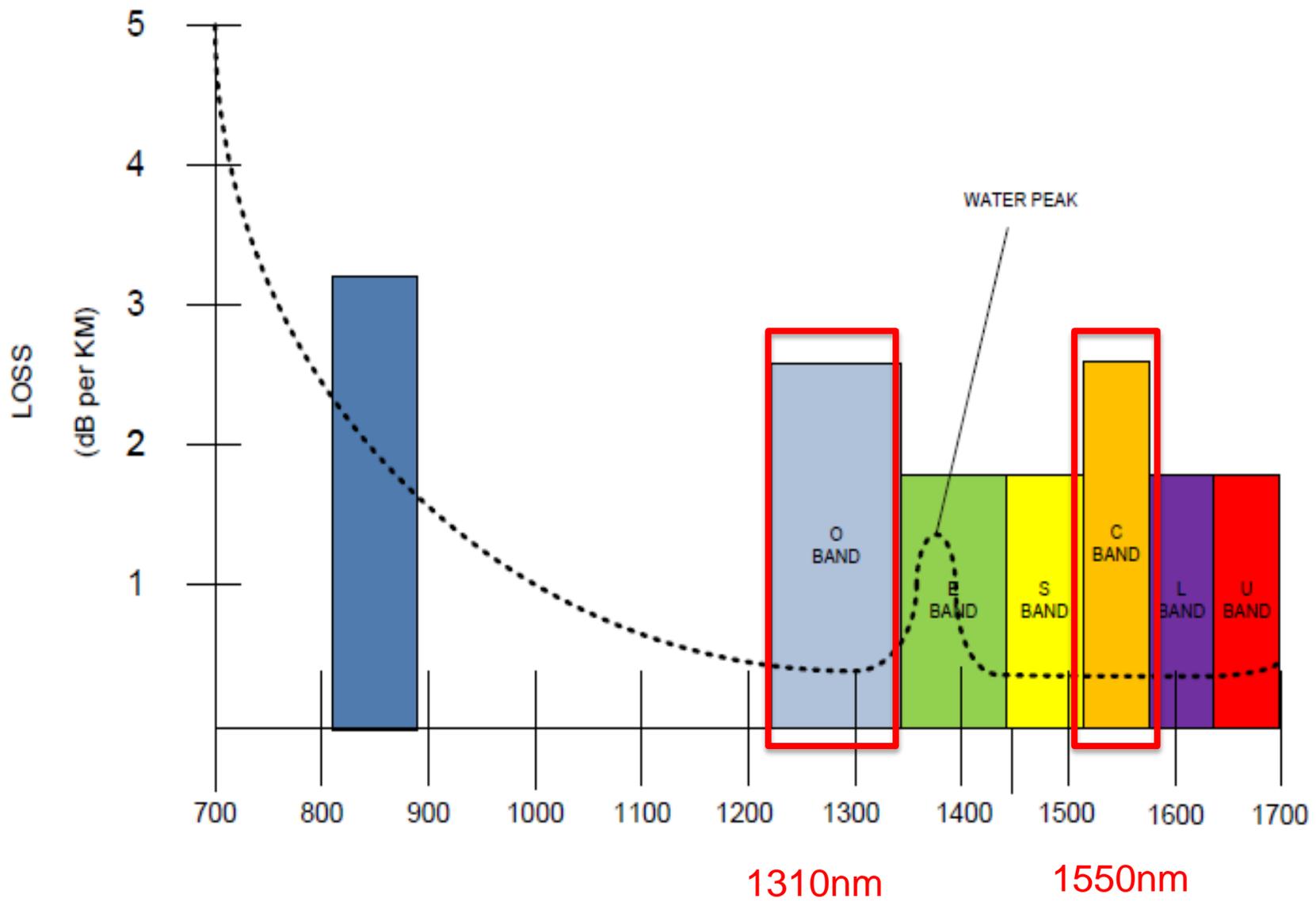


Fiber Optic Spectrum

FIBER OPTICS



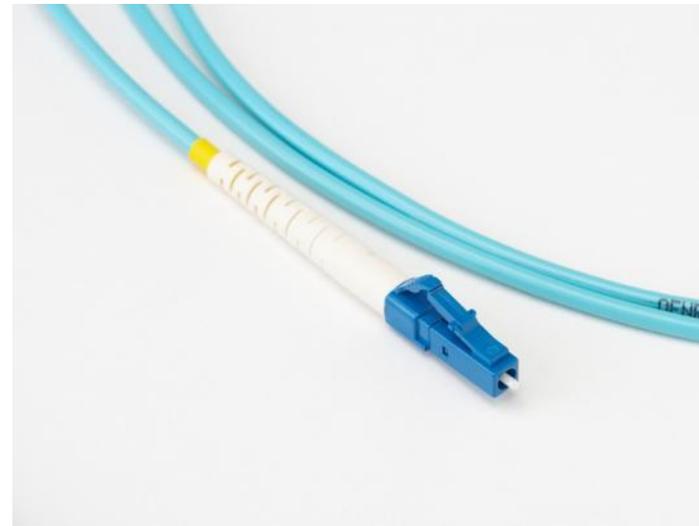
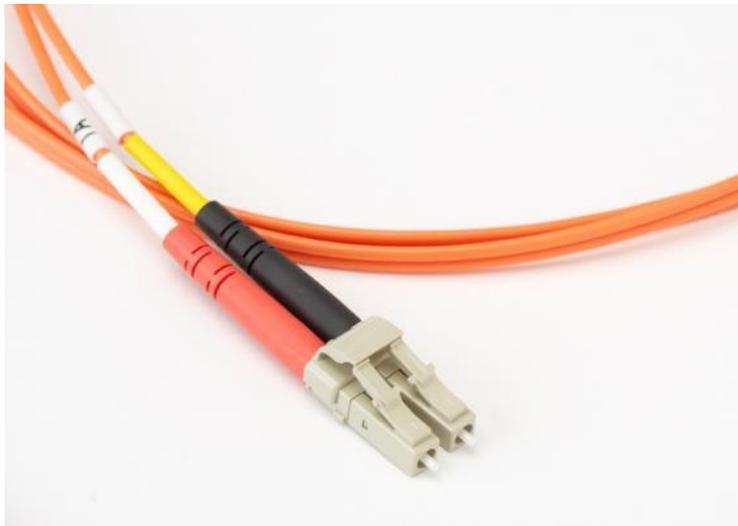
Commonly Used Wavelengths



Types of Fiber (Multi-Mode)

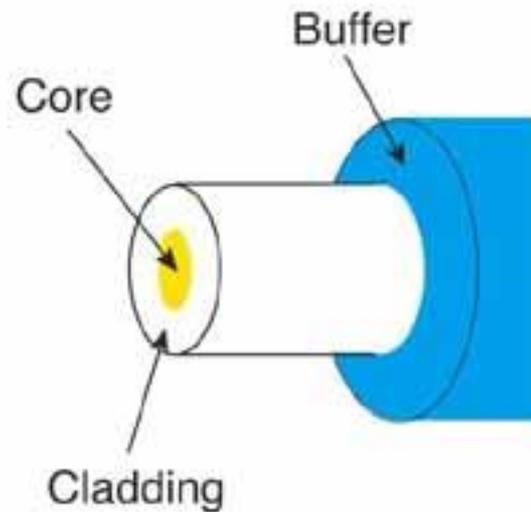


Multimode fiber: has a bigger core (almost always 62.5 microns - a micron is one millionth of a meter - but sometimes 50 microns) and is used with LED sources at wavelengths of 850 and 1300 nm for **short distance**, **lower speed** networks like LANs.



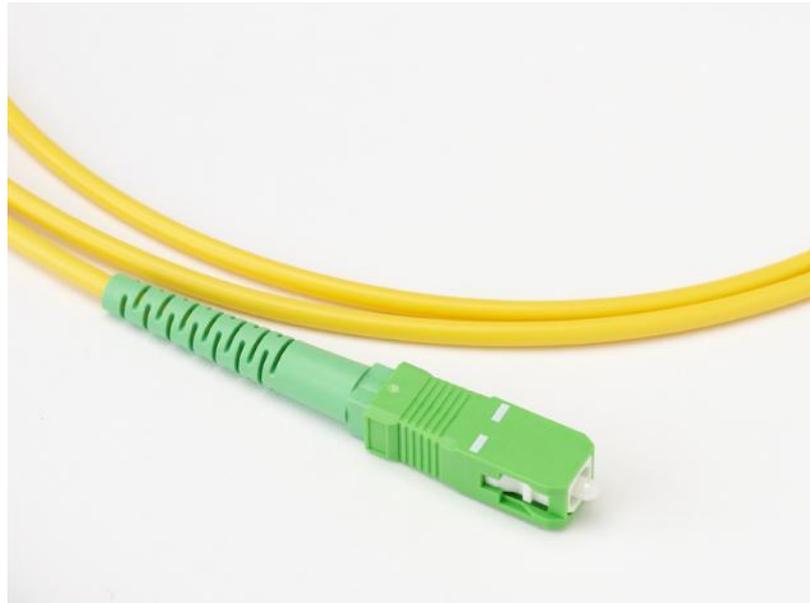
The Structure of an Optical Fiber

Typical optical fibers are composed of core, cladding and buffer coating.



Types of Fiber (Singlemode)

Singlemode fiber: has a much smaller core, only about 9 microns, and is used for telephony and CATV with laser sources at 1310, 1490, 1550 and 1625nm. **It can go very long distances at very high speeds.**



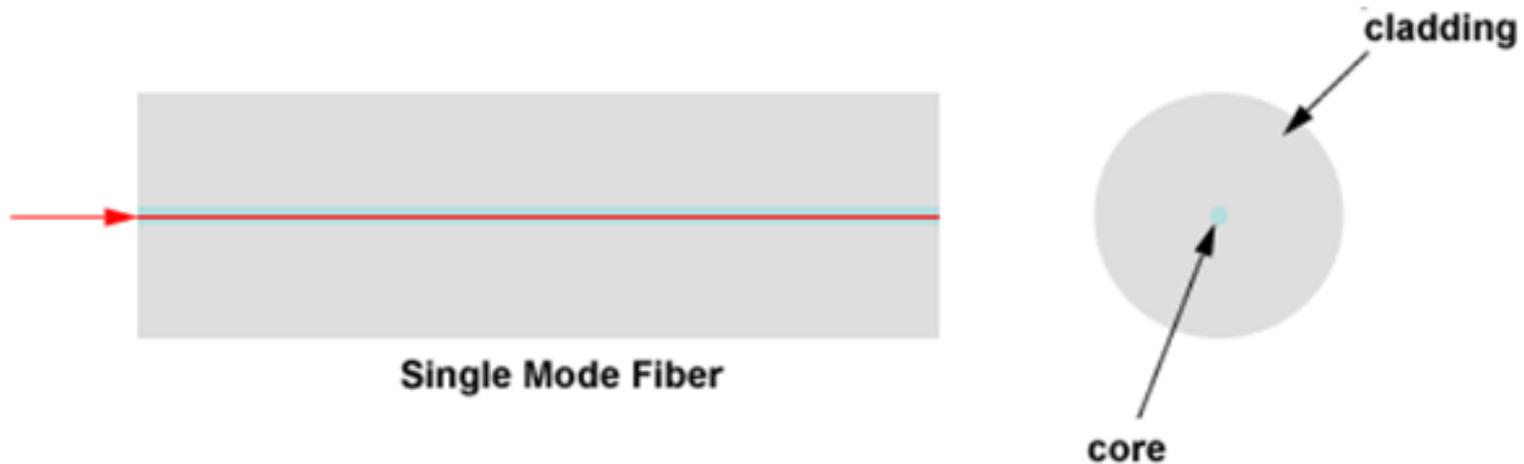
The Structure of an Optical Fiber



SINGLEMODE

Core 8 – 10 micron

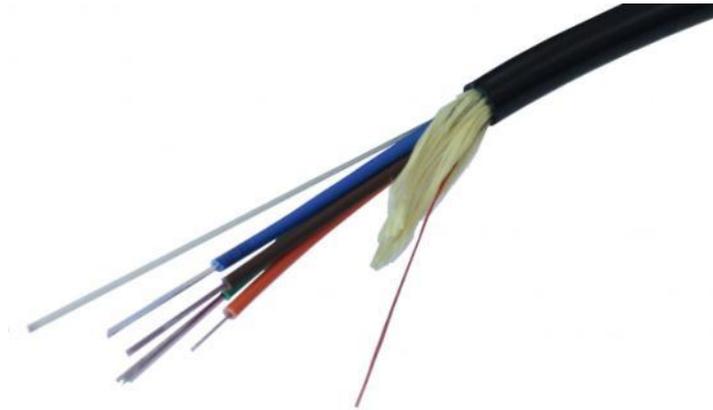
Cladding 125 micron



Fiber Optic Color Code

Number		Color
1		Blue
2		Orange
3		Green
4		Brown
5		Slate
6		White
7		Red
8		Black
9		Yellow
10		Violet
11		Rose
12		Aqua

Stranded vs. Ribbon Fiber



Stranded Fiber



Ribbon Fiber

VARIOUS WAVELENGTHS

VARIOUS DISTANCES



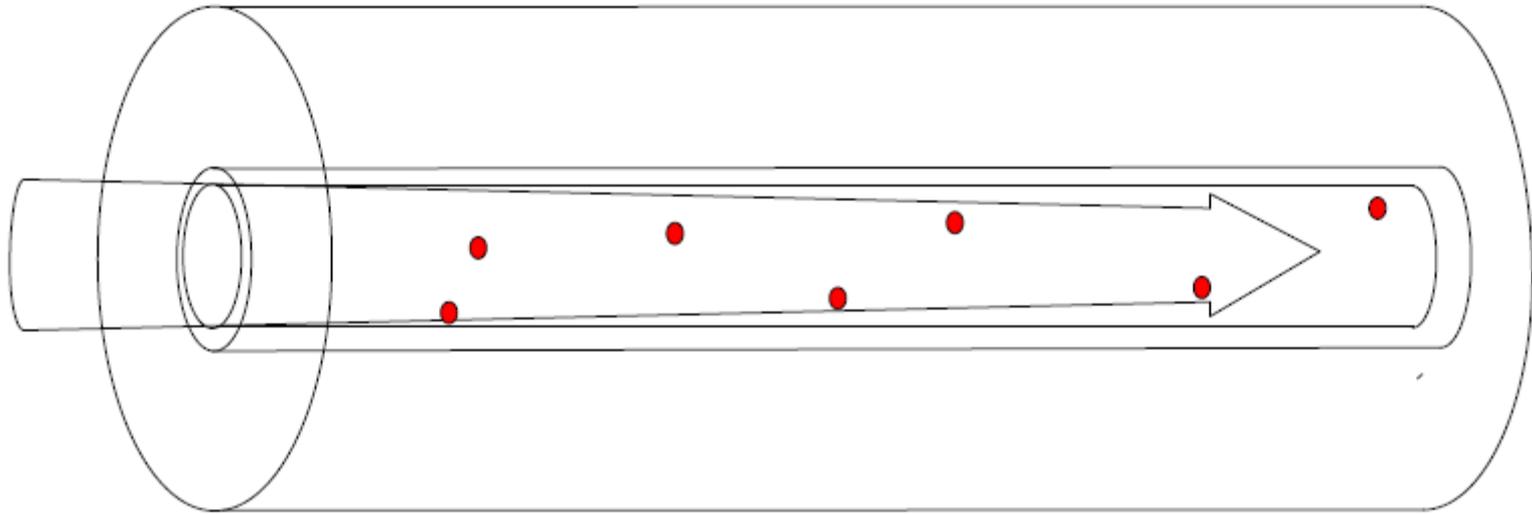
SFP



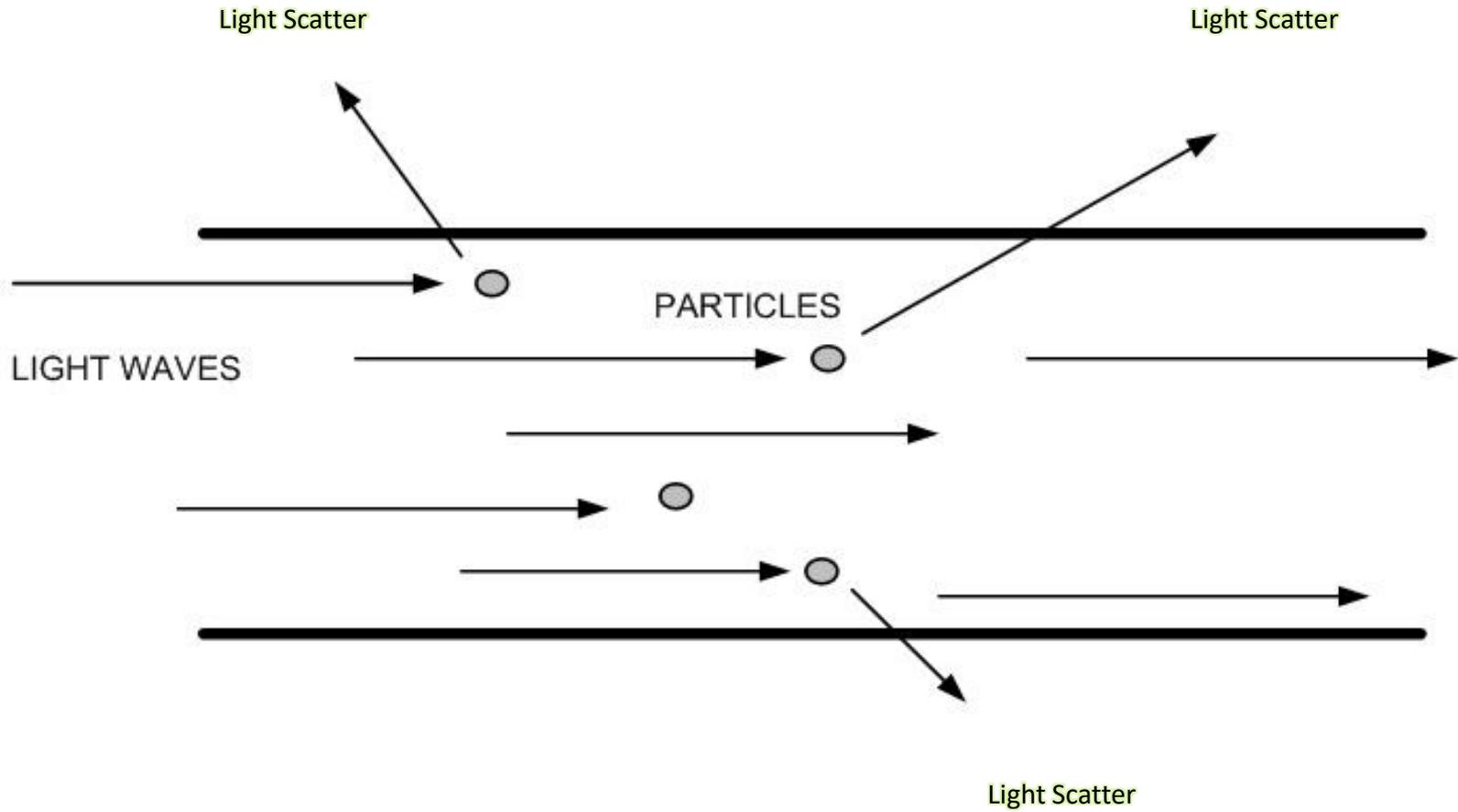
GBIC

- Absorption
- Scattering
- Micro/Macro Bending

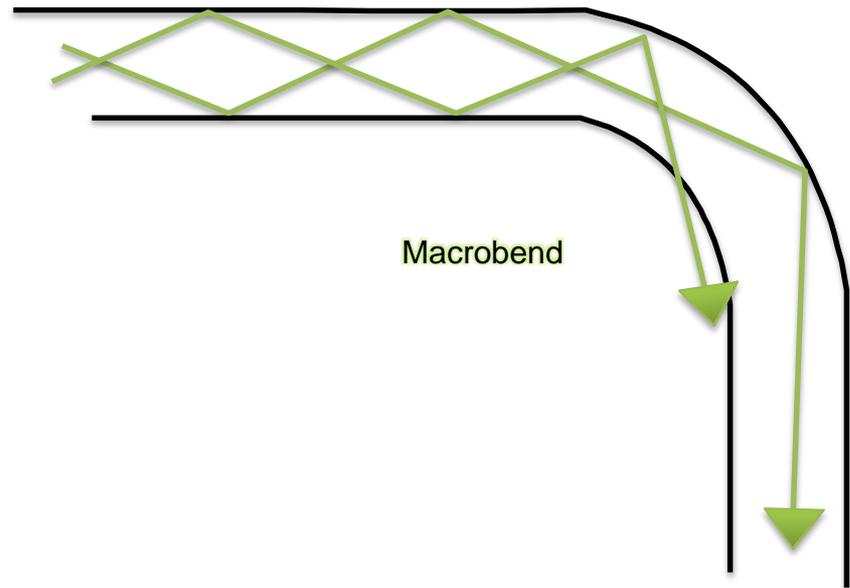
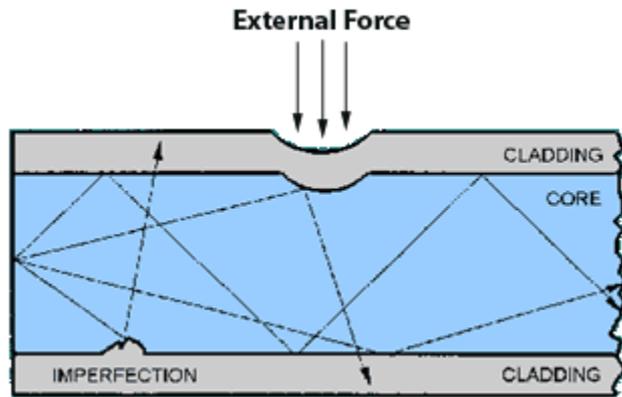
Absorption



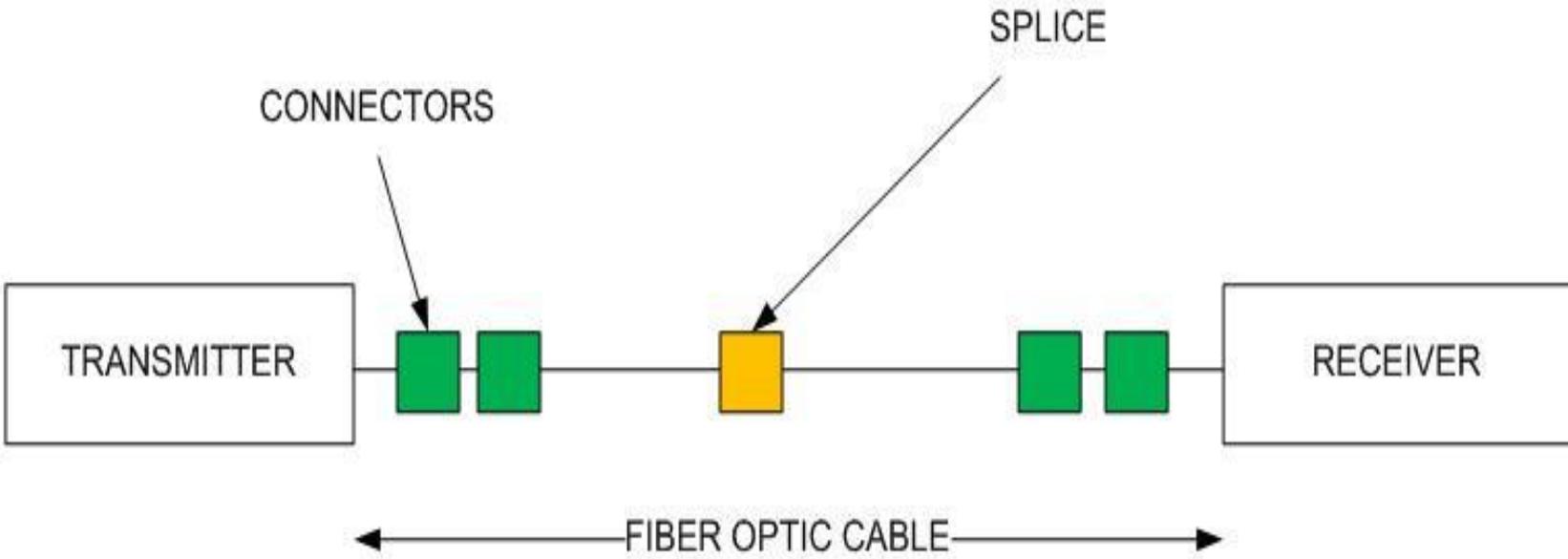
Scattering



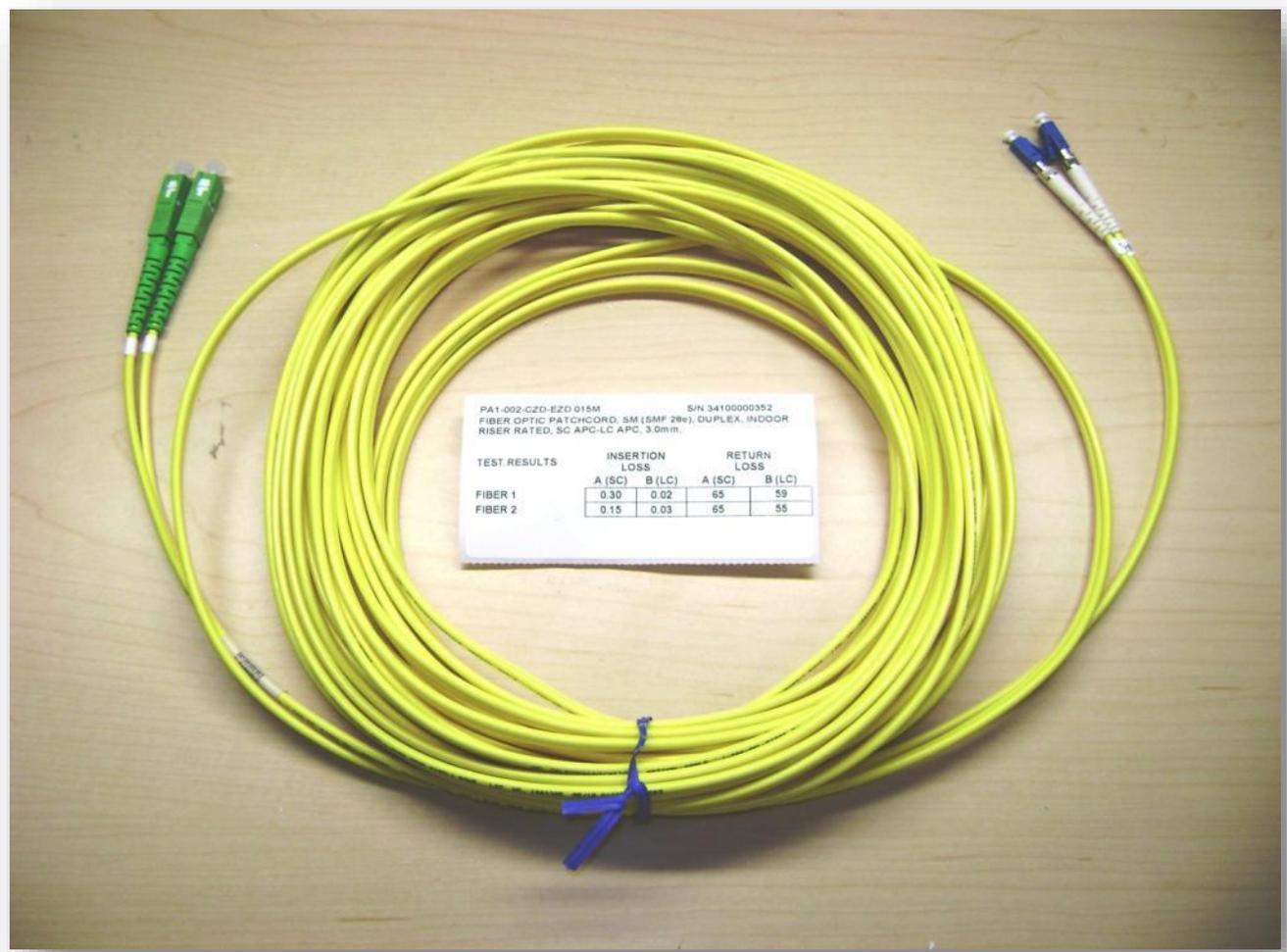
Micro Bends/Macro Bends



Section 3: Optical Link/Power Budget



Connector Loss Attenuation



Singlemode Fiber Connectors



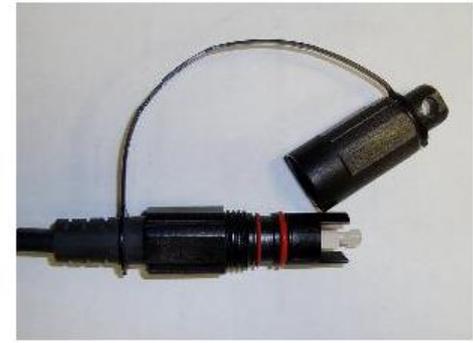
FC UPC



FC APC



HFOC



LC UPC



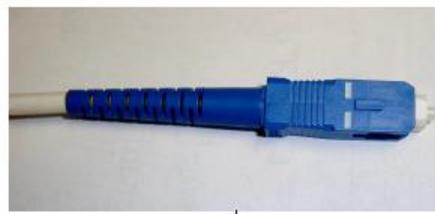
LC APC



MPO/MTP



SC UPC



SC APC

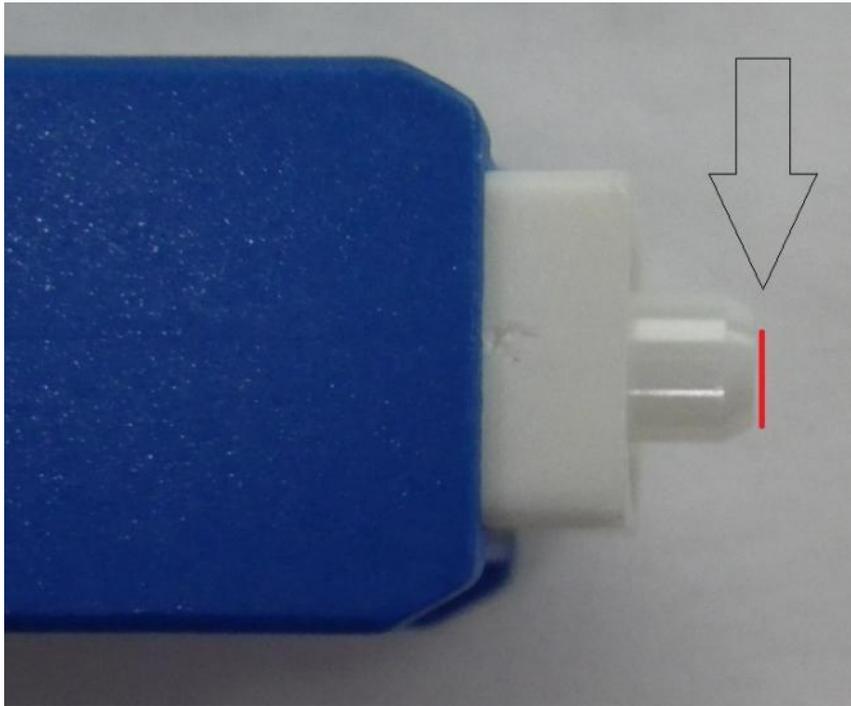


ST UPC

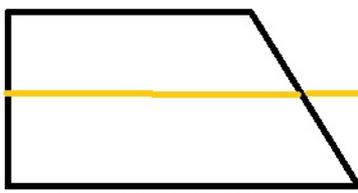


SINGLEMODE FIBER CONNECTORS

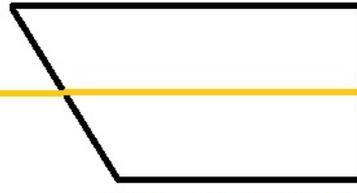
UPC vs. APC Close Up



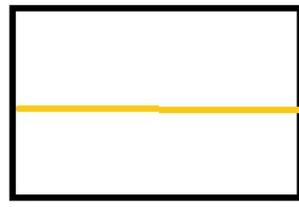
Connector Types (UPC and APC)



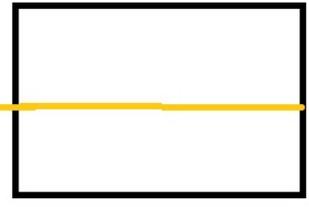
ANGLE POLISH (APC)



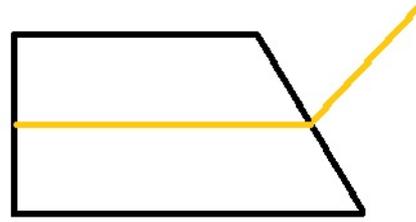
ANGLE POLISH (APC)



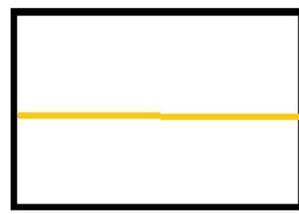
ULTRA POLISH (UPC)



ULTRA POLISH (UPC)



ANGLE POLISH (APC)



ULTRA POLISH (UPC)

Splice Loss Attenuation



Fiber Cable Distance Attenuation



Maximum Attenuation	
Wavelength (nm)	Maximum Value (dB/km)
1310	0.33-0.35
1383	0.31-0.35
1550	0.19-0.20
1625	0.20 -0.23

Splitter Loss



Dual Window - Wavelength Flattened (Terminated Specifications)						
		1 x 2	1 x 4	1 x 8	1 x 16	1 x 32
Max. Insertion Loss	dB	3.6	7.2	10.7	14.0	17.6
Max. Uniformity	dB	0.8	1.0	1.3	1.6	1.9
Max. PDL	dB	0.2	0.3	0.4	0.5	0.6
Center Wavelengths nm	1310 and 1550					

CWDM Loss



Parameter	Unit	Value		
		Add/Drop	4 CH	8 CH
Wavelength Range	nm	1471 - 1611		
Bandwidth	nm	c +/-6.5		
Insertion Loss	dB	<0.8	<2.0	<3.0
Insertion Loss (Reflection)	dB	<0.3	na	na
Isolation	dB	>30		
Isolation (Reflection)	dB	>12	na	na
Uniformity of I.L.	dB	na	<1	<1
PDL	dB	<0.2		
Return Loss	dB	>45		
Operation Temperature	°C	-5 -85		
Maximum Input Power	mW	500		
Mechanical Dimension	mm	3.6 (D) x 40 (L)	100 x 80 x 8	100 x 80 x 8

Loss Budget Equation



Number of Connectors x Loss per Connector

+

Number of Splices x Loss per splice

+

Length of Fiber in Km x Loss per Km

+

Number of Optical Components x Loss per Component

+

Margin

=

Total Loss

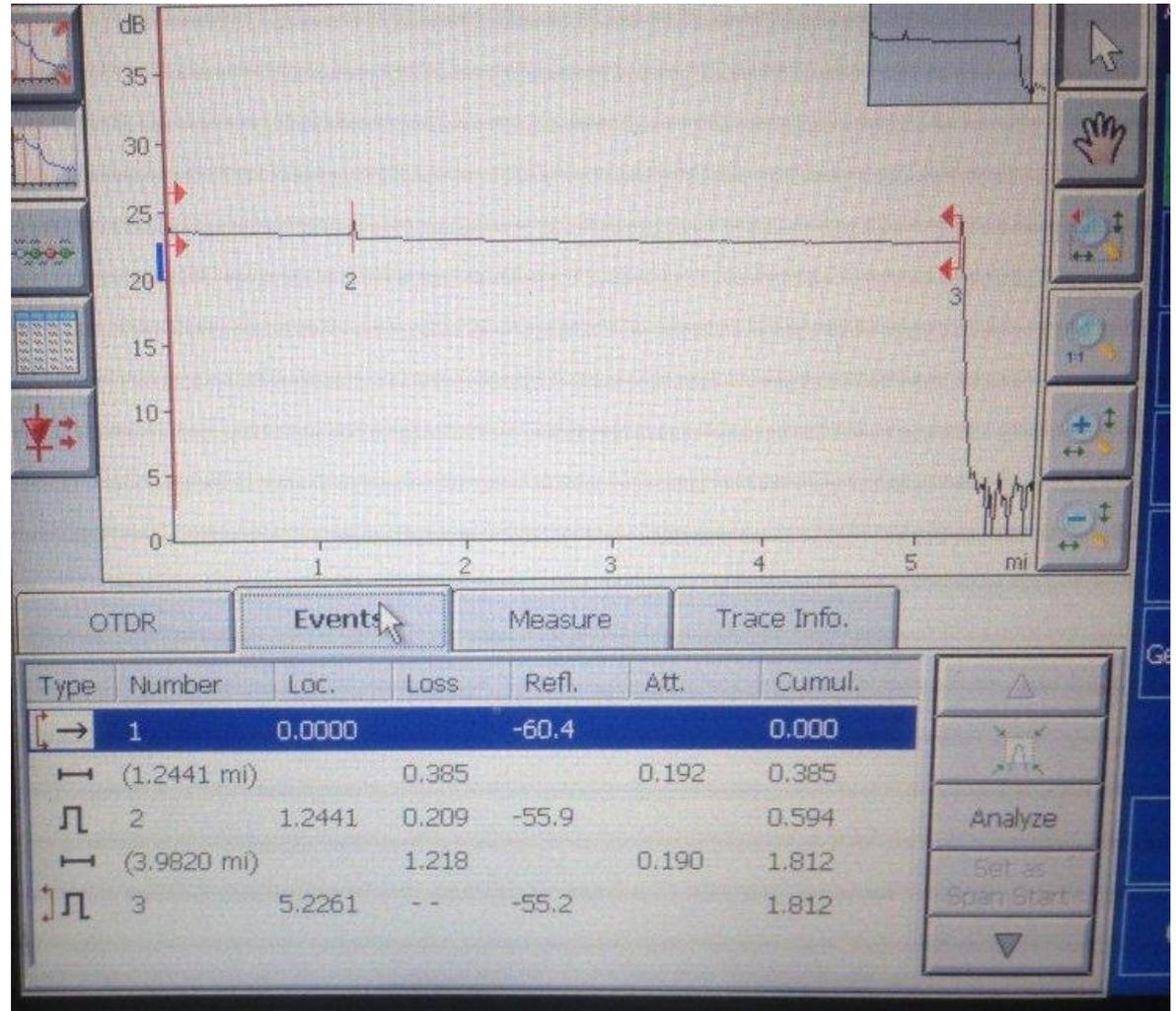
**1550nm 23KM link with four SCAPC mated pairs,
four splices and two 8 channel CWDM's:**

Connector Loss : 0.3dB x 4	1.2 dB
Splice Loss: .02 x 4	.08 dB
Length Loss 0.22dB/Km x 23Km	5.06 dB
CWDM Loss: 3.0dB x 2	6 dB
System Margin: 3dB	3 dB
<hr/>	
Total Loss:	16.06 dB

Light Source/Meter



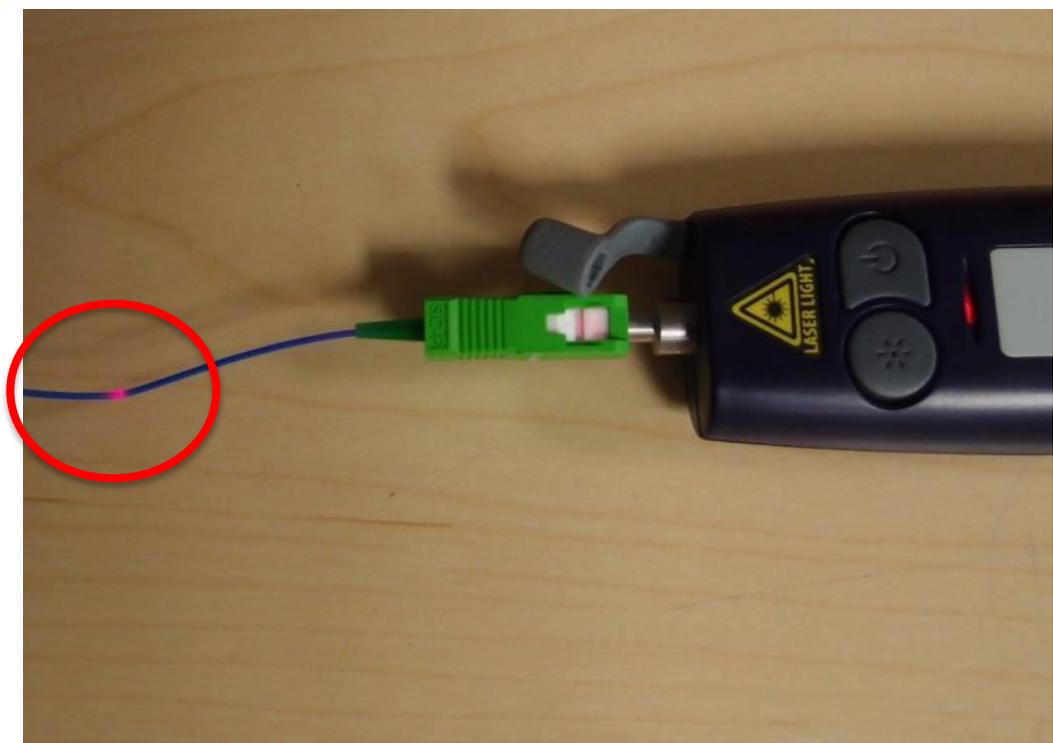
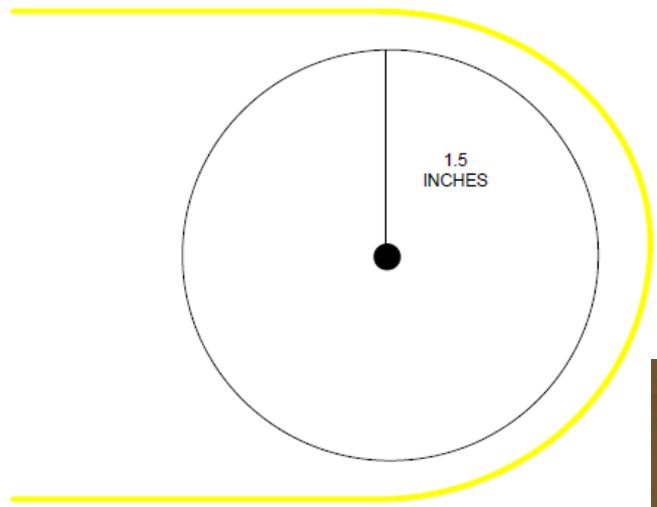
OTDR



Fiber Management Maintenance



Bend Radius



- Telcordia standard (GR-449) states that fiber cable build-up should never exceed two inches in depth at any point within the fiber network.
- 44 x 3mm Jumpers per square inch
- 102 x 2mm Jumpers per square inch
- 142 x 1.7mm Jumpers per square inch

- 3" H x 5" D Trough can handle
 - 1420 x 1.7mm Jumpers
 - 1020 x 2mm Jumpers
 - 440 x 3mm Jumpers

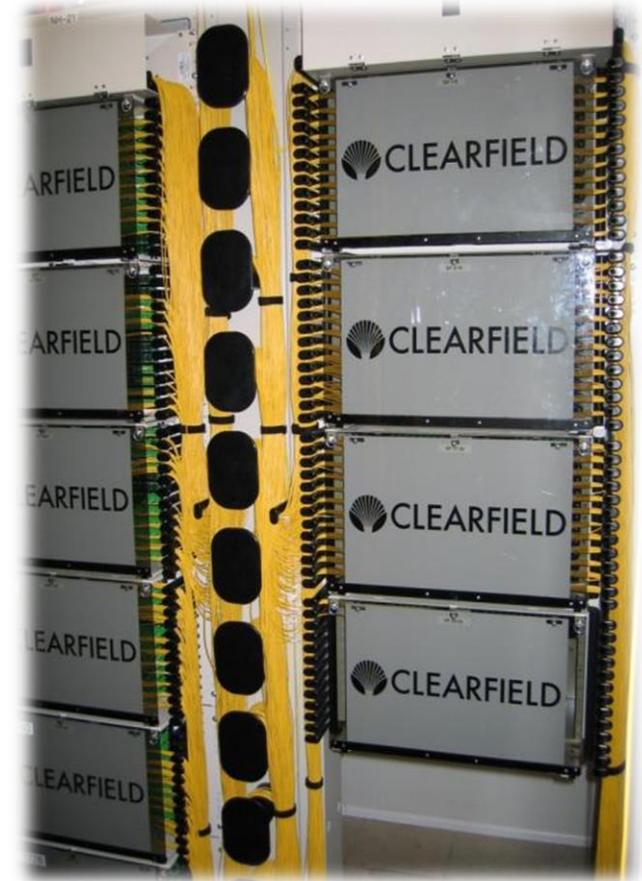


- Access
- Bend Radius Protection
- Physical Fiber Protection
- Route Diversity
- Density
- Labeling/Port Identification

- Access
 - Clear circuit access to jumpers and both sides of adapter
 - Easy access improves bend radius protection
 - Minimal live circuit disturbance
 - Improves configuration time



- Bend Radius Protection
 - GR-449
 - Prevent micro and macro bends
 - Long term reliability
 - Improper radius is a critical point of failure over time



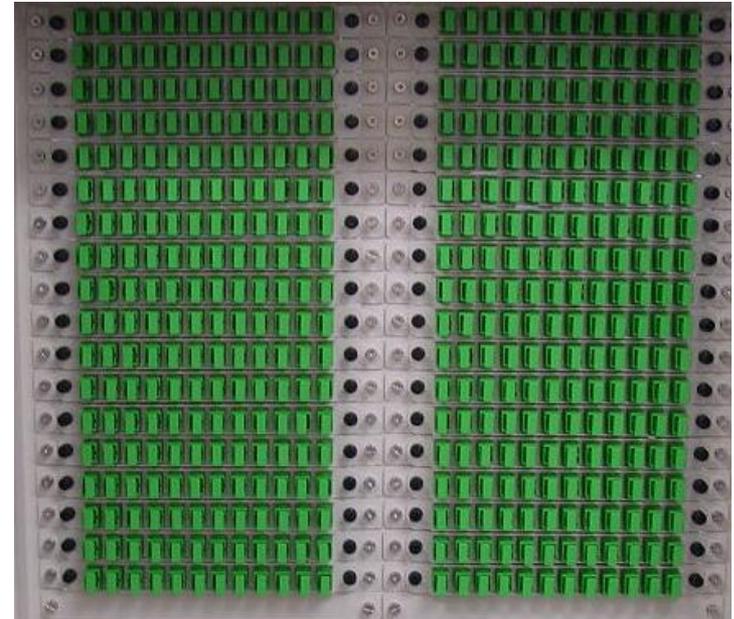
- Physical Fiber Protection
 - Physical protection of fibers when not being accessed
 - Accidental damage



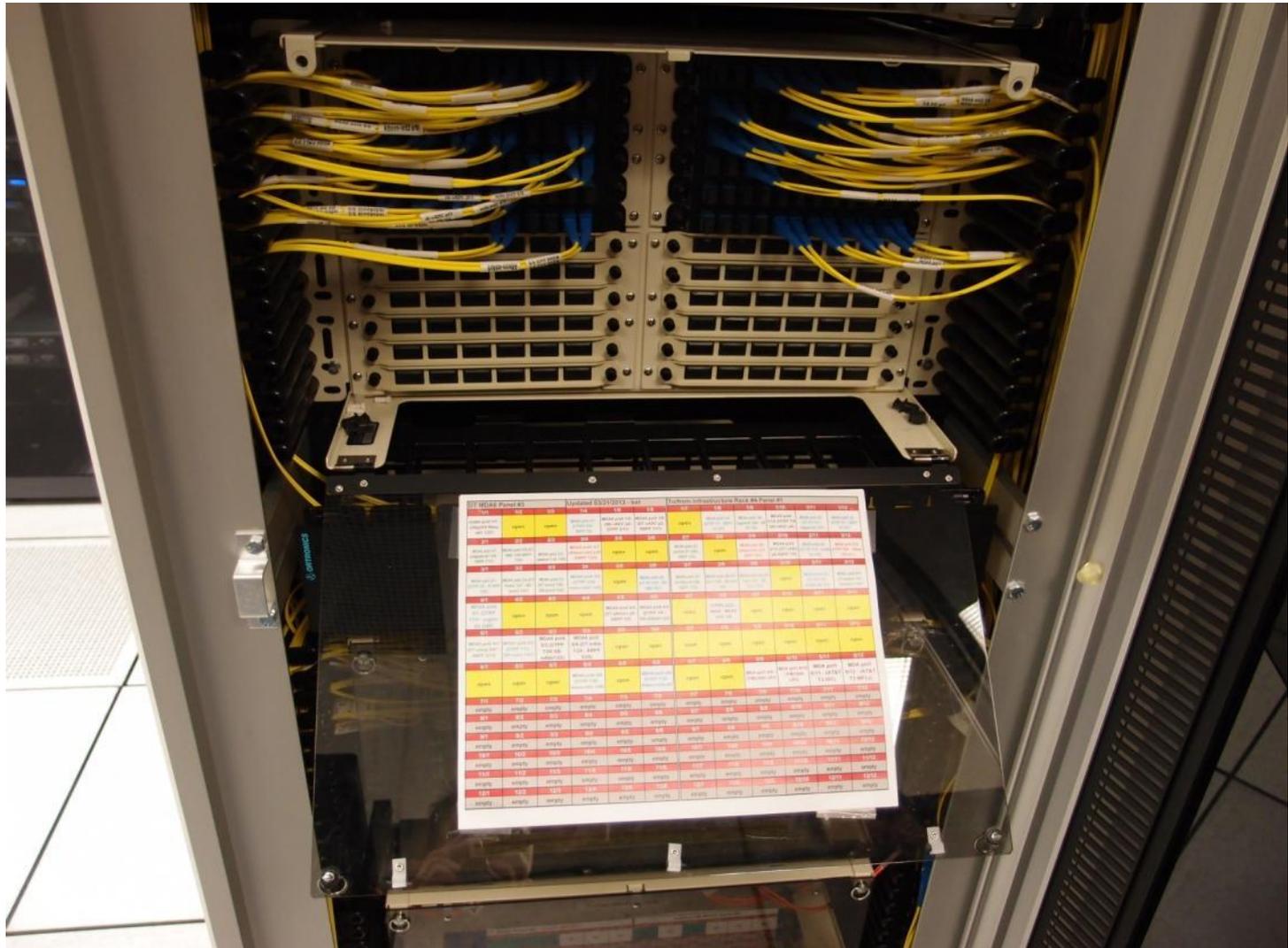
- Route Diversity
 - Multiple routes reduce pile-up
 - Congestion causes confusion
 - Improves access



- Density
 - Whose definition?
 - Sacrifices
 - Maintain protection



Labeling/Fiber Identification

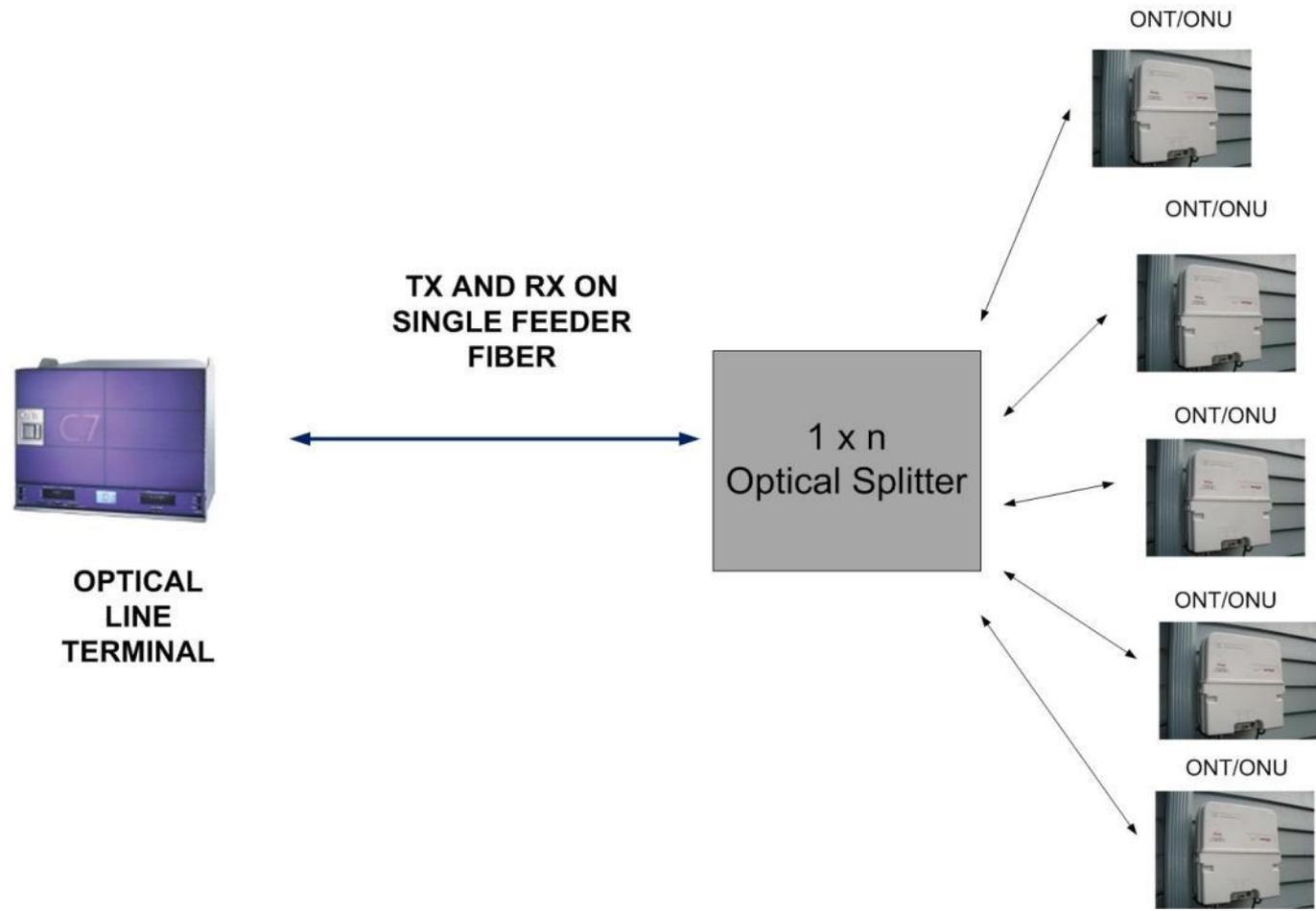


- Bend radius protection
- Keep it clean
- Inspect it
- Identify it

Current and Future Fiber Applications

- PON (Passive Optical Network)
- RFOG (Radio Frequency Over Glass)
- Active Ethernet
- WDM Networks

What is a PON?



ONT (Optical Network Terminal)



SINGLE FAMILY ONT

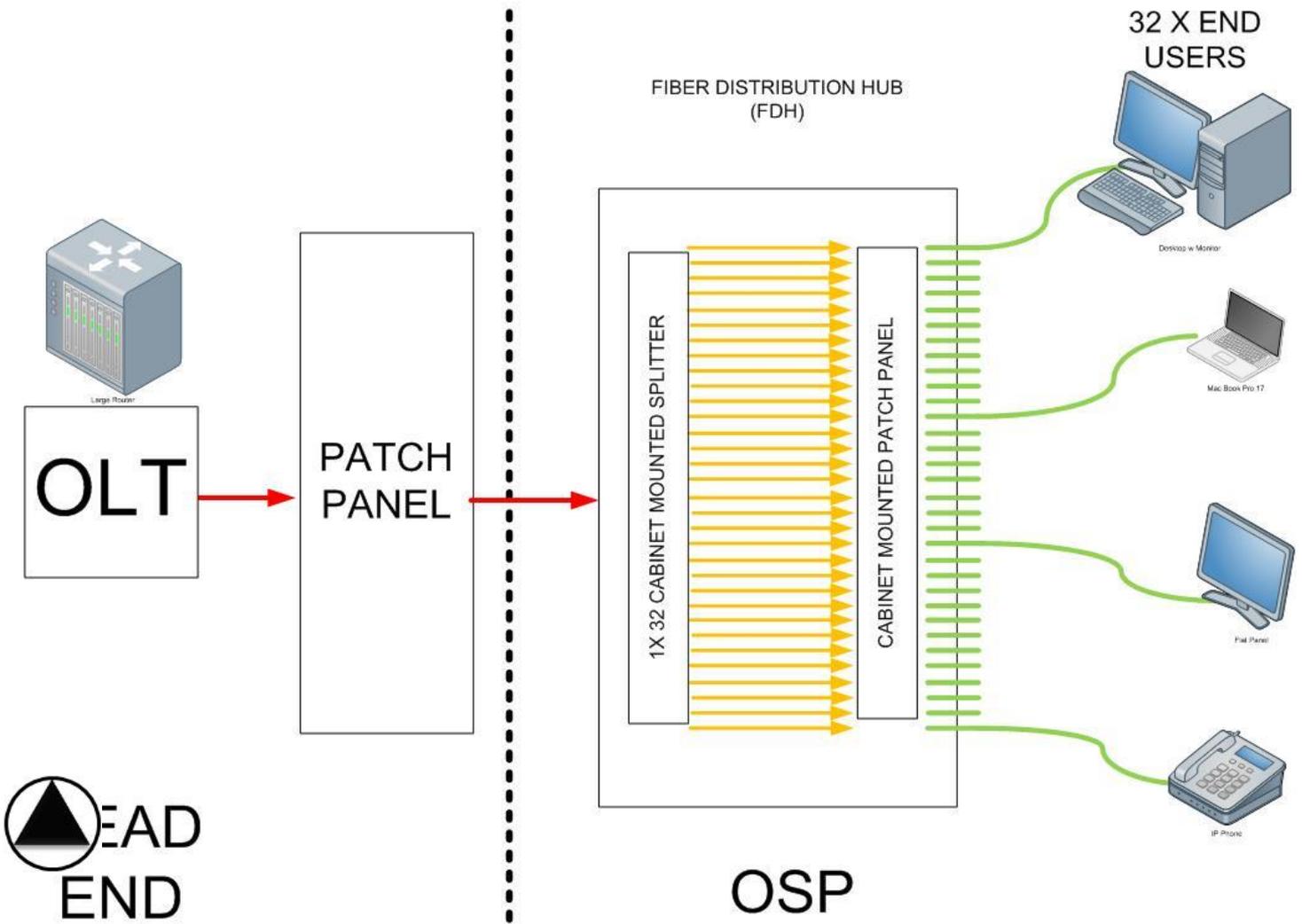


MDU FAMILY ONT

- No Actives in the field
- No Network Powering or Batteries in OSP
- High Bandwidth
- Lower Maintenance Costs

- Centralized split
- Home run
- Distributed split
- Tapped splitters

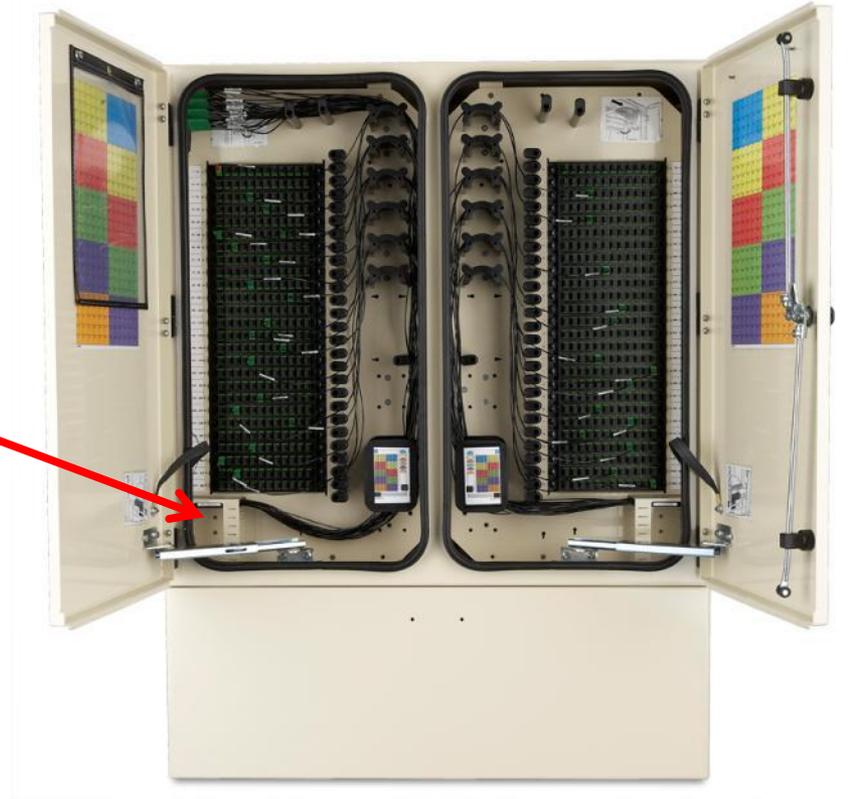
Centralized Field Splitting



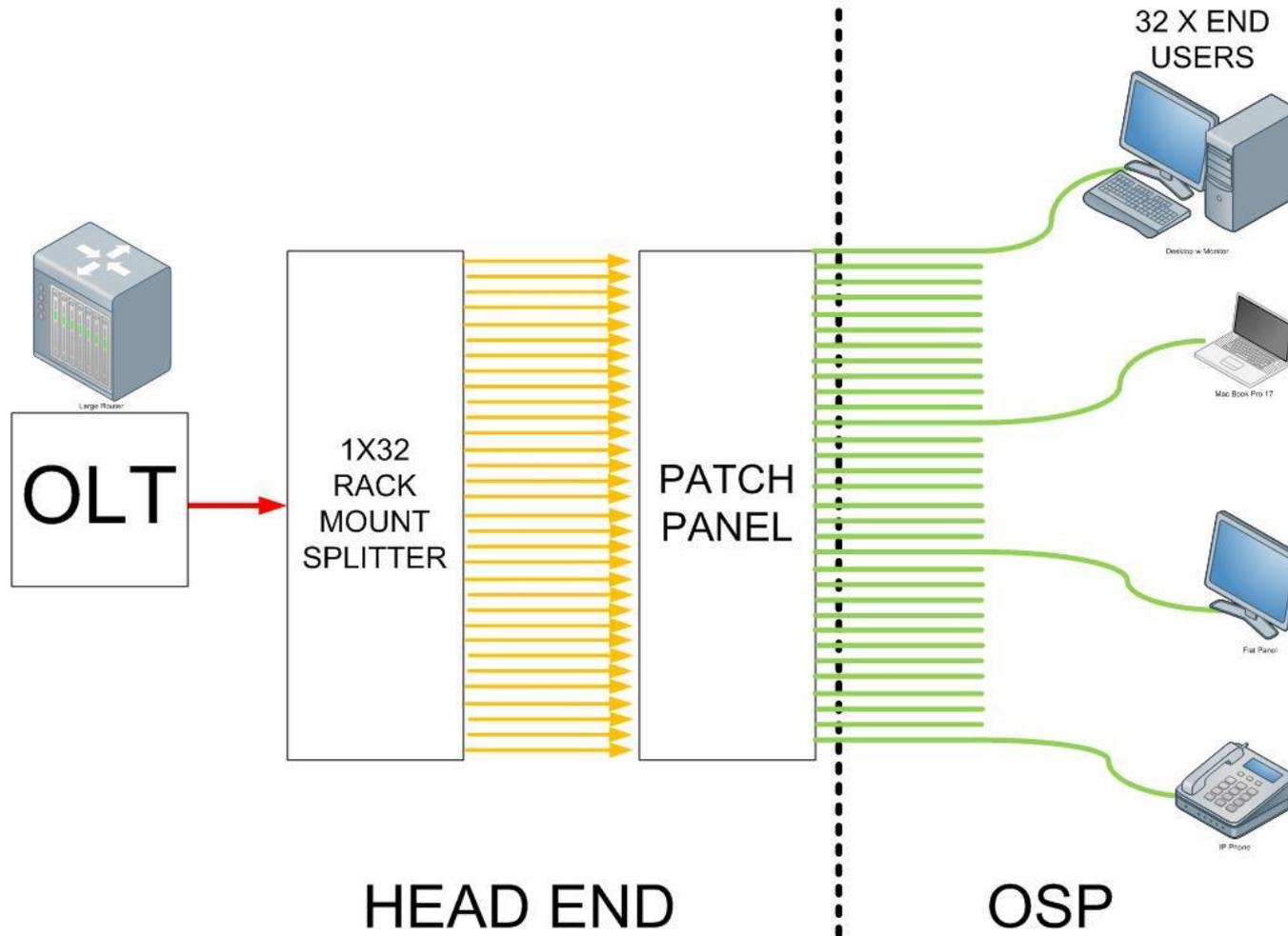
Centralize Field Split Picture



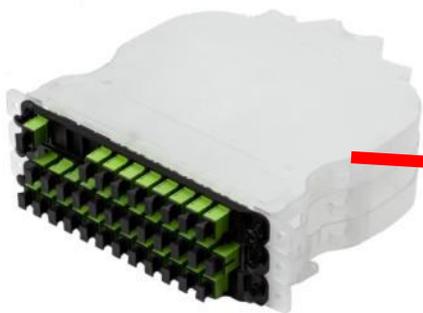
1x32 Splitter with pre-terminated legs



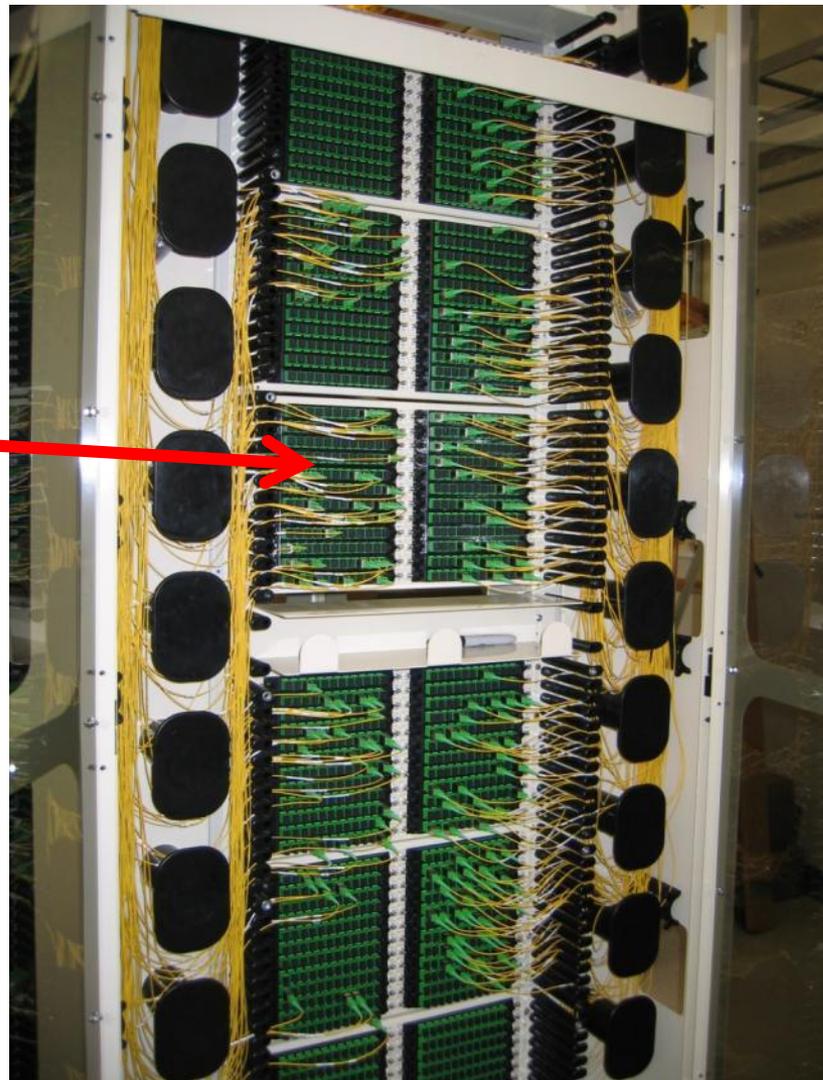
“Home Run” PON Architecture



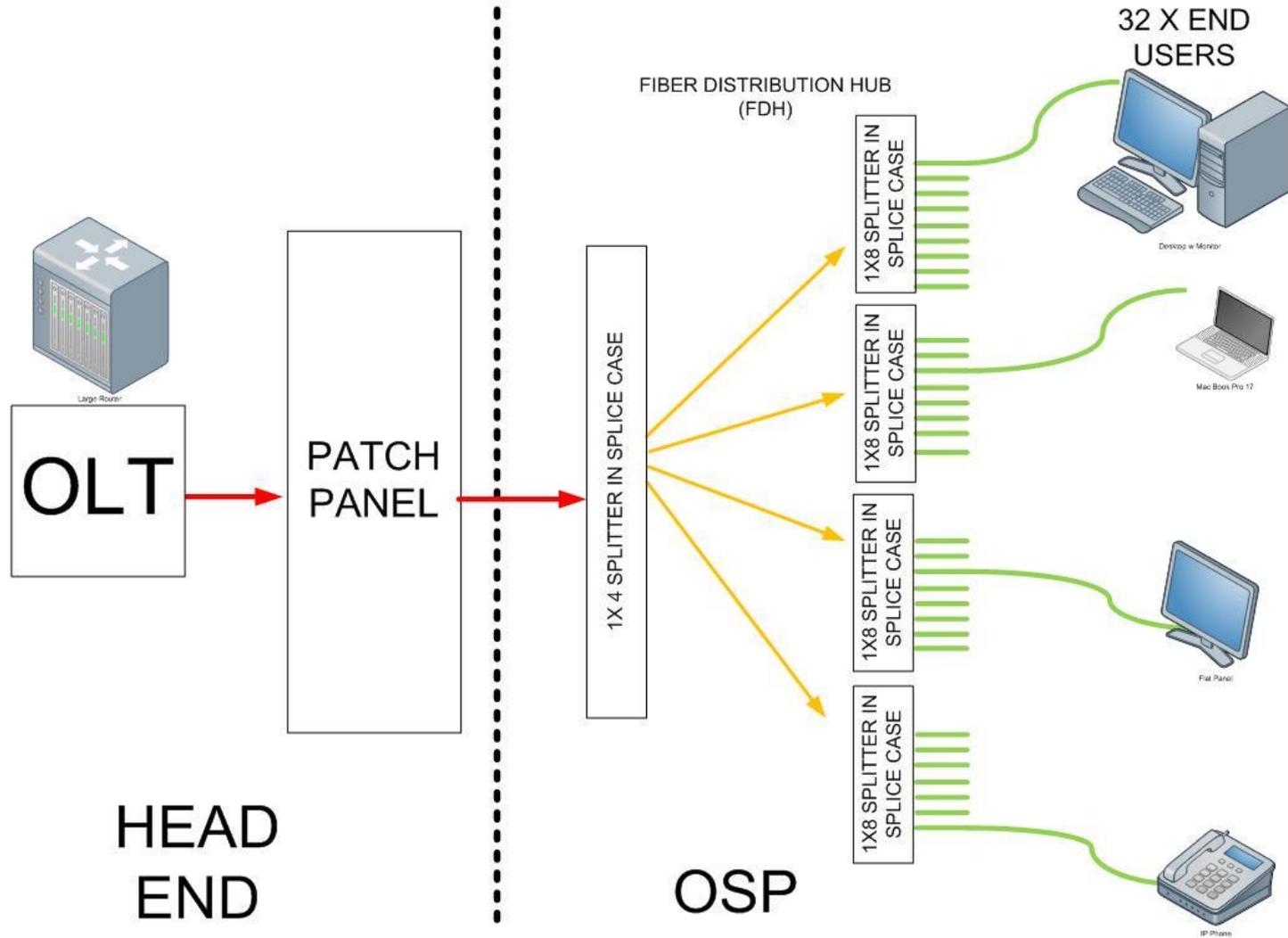
FTTH Home Run Frame



1x32 adapter splitter
mounted in frame in
Head End



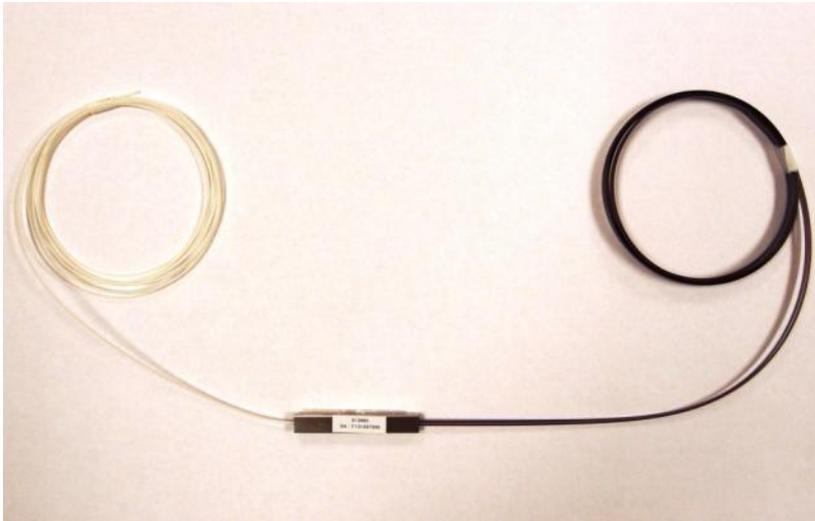
Distributed Split Architecture



Distributed Split Picture

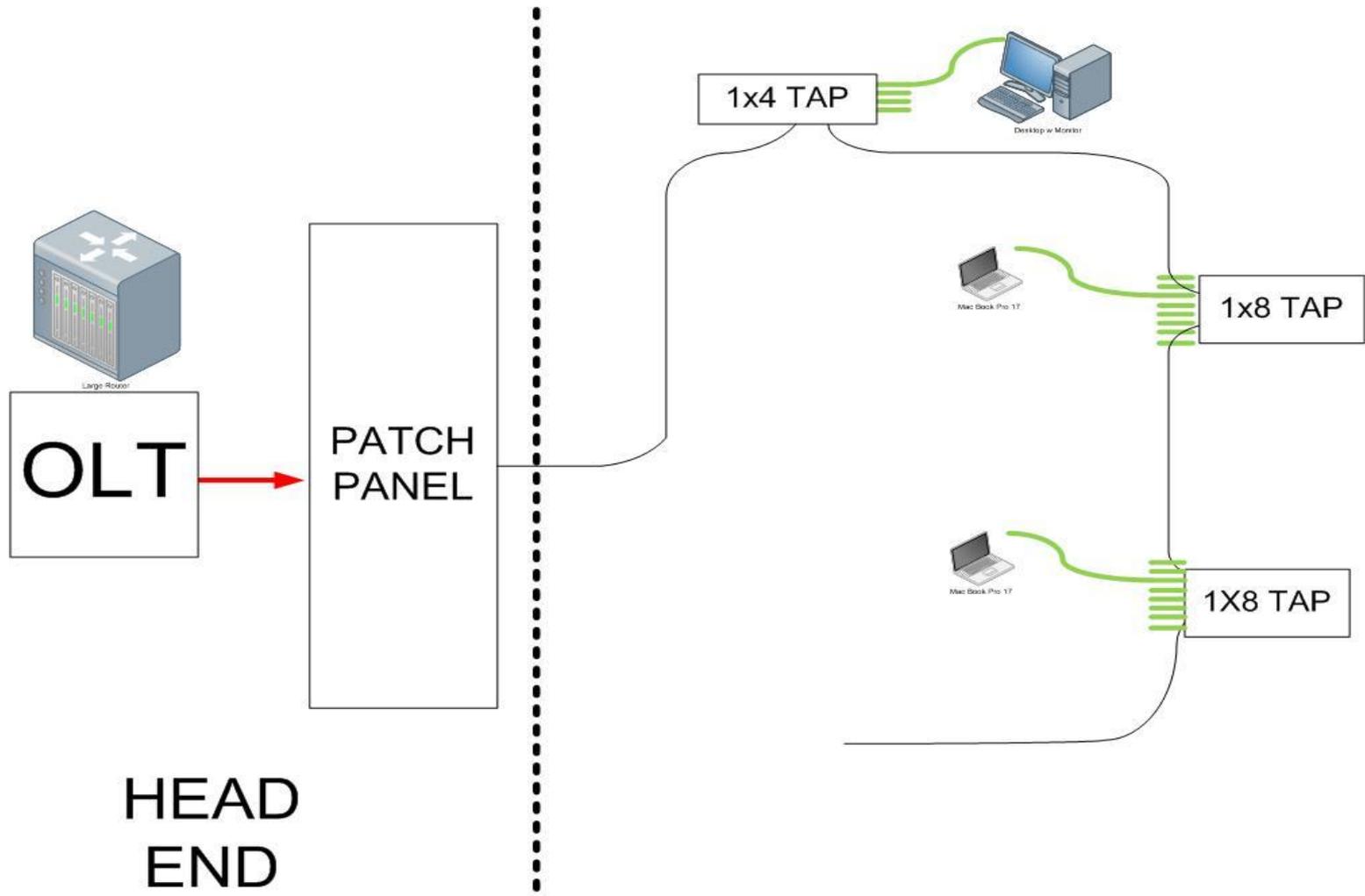


RUGGEDIZED SPLITTER



BARE/RAW SPLITTER

Tapped Optical Splitter Architecture



Active Ethernet FTTH



- 1:1 Fiber to Subscriber ratio
- Expensive
- Scalable – each sub has port on router in Head End/CO

WDM Technology

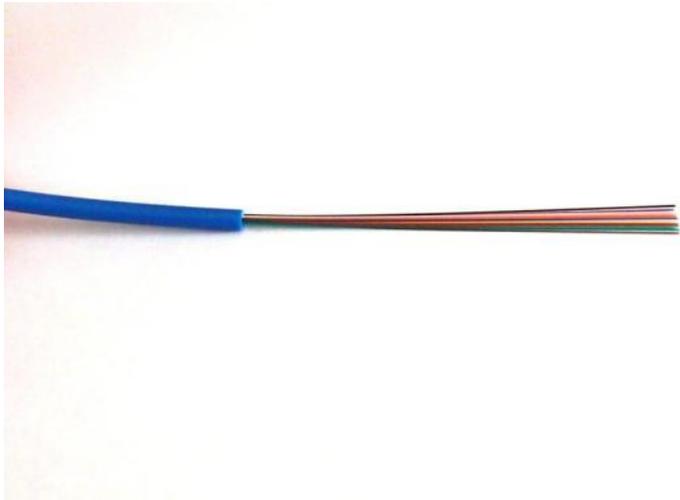


Legacy
Technology

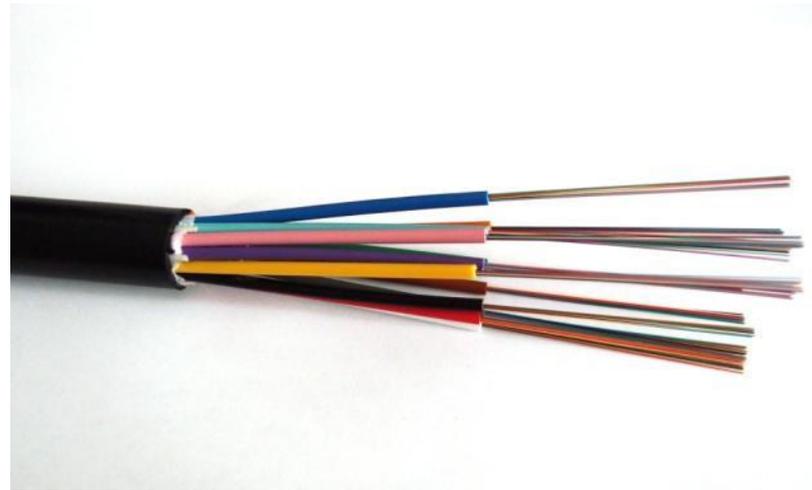


WDM Technology

Fiber Exhaust



(What we DID put in)



(What we need now)

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