



presents

Optical Fibers
Fiber Optic Cables
Indoor/Outdoor

Content

- Optical fiber
 - function, types
 - optical effects
 - applications
 - production of optical fibre

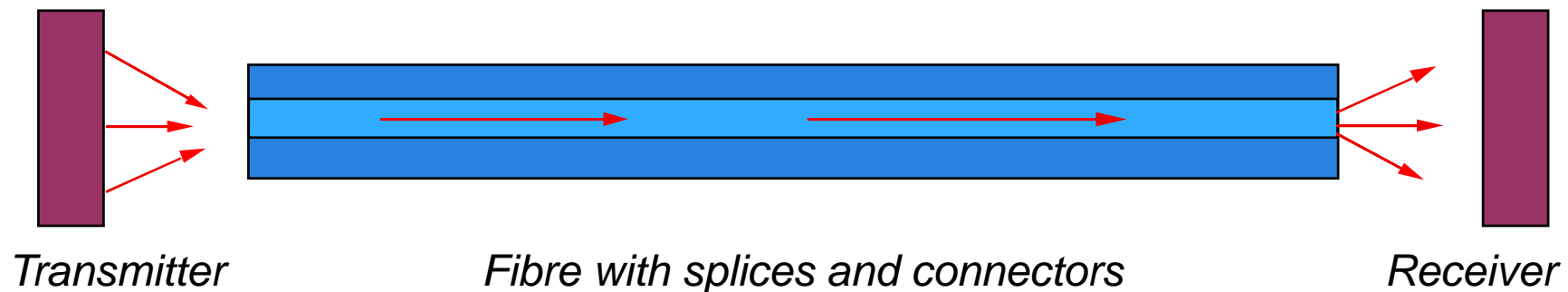
- Cable - general types
 - Indoor
 - Indoor / outdoor
 - Outdoor



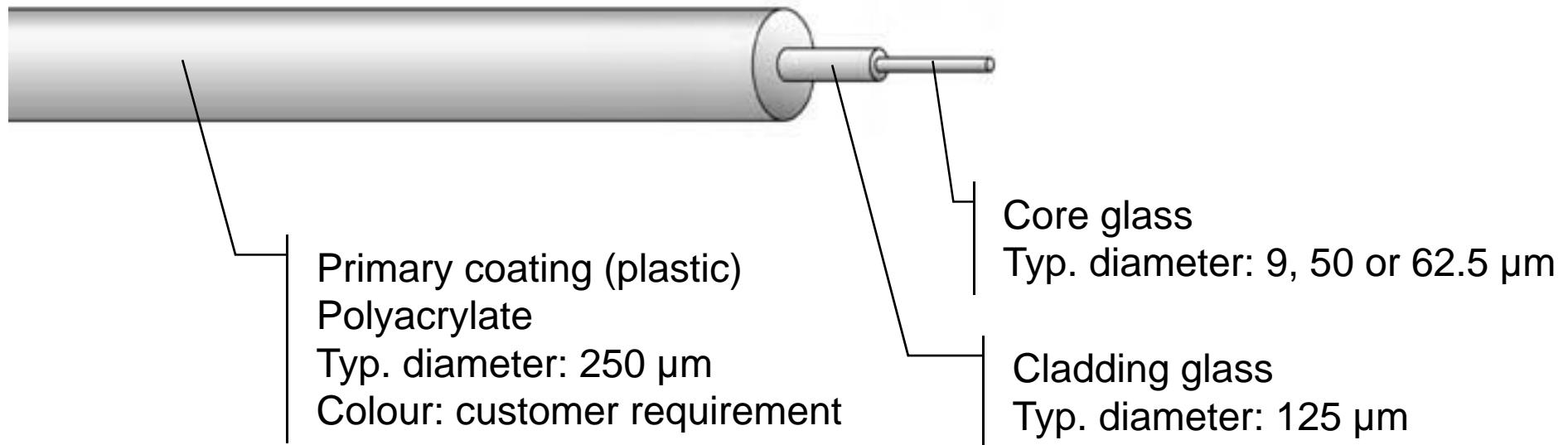
Optical Transmission System

Schematic of an optical fibre transmission system:

- Modulator / Transmitter (LED, laser diode, VCSEL (850 nm))
convert electrical signals into optical ones
- Fibre
transport medium (e.g. optical fibre cable, splices, connectors etc.)
- Receiver / Demodulator (PIN Photodiode, Avalanche Photodiode)
convert optical signals into electrical ones



General Construction Optical Fibres

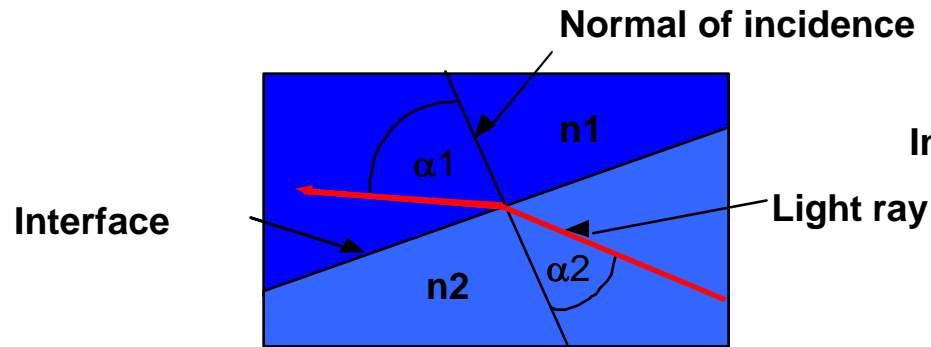


- **Fiber according to the requirements of:**

- ITU-T G.65x
- IEC 60793-x
- EN 60793-x
- ISO / IEC 11801
- EN 50173
- DIN VDE 0888

Light On Interfaces Of Two Medias

Refraction of light

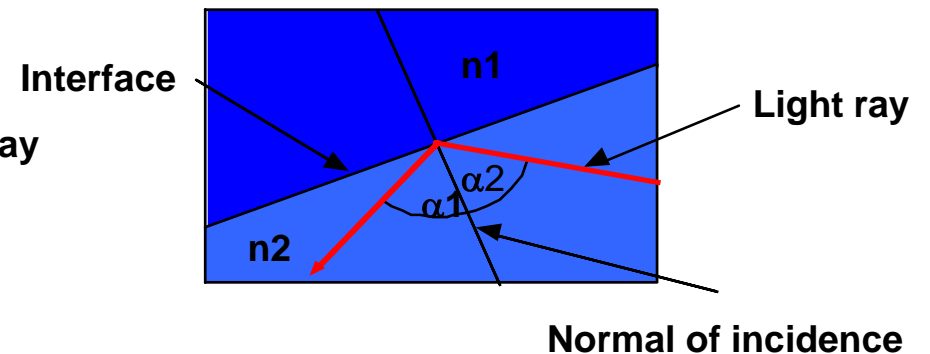


$$\alpha_1 > \alpha_2$$

$$n_1 < n_2$$

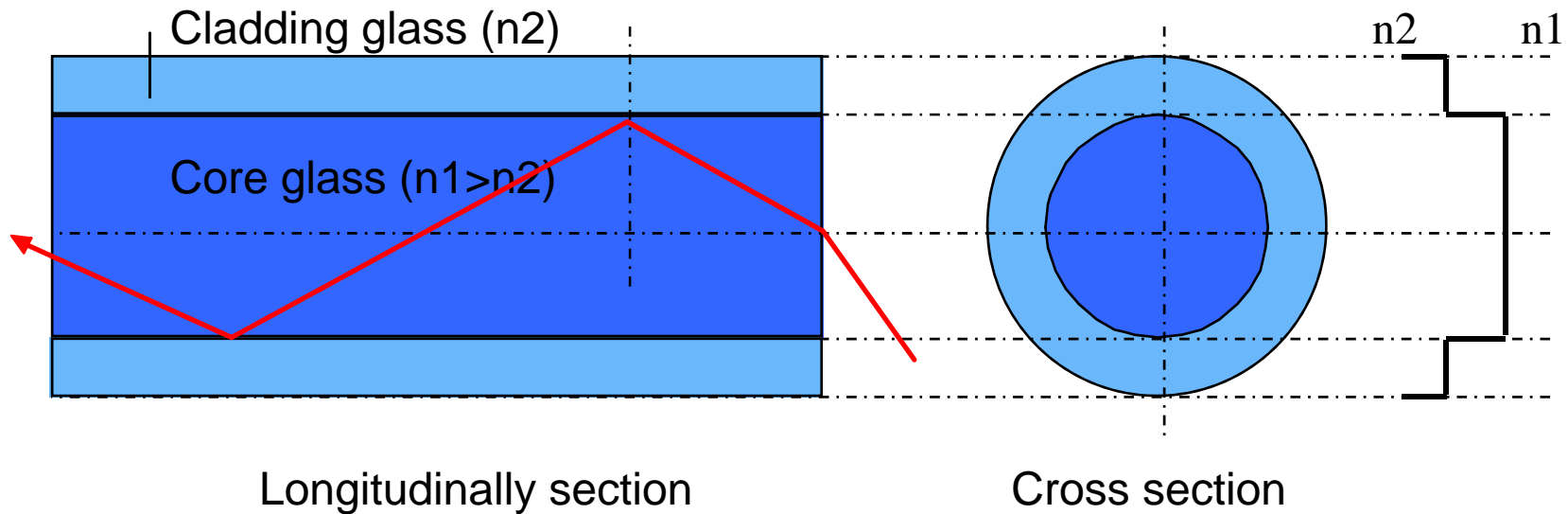
n_1 & n_2 : Refraction index of medium 1 & 2

Total internal reflection of light

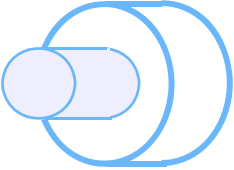
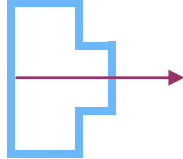
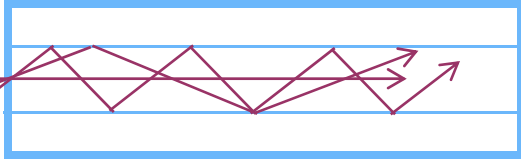
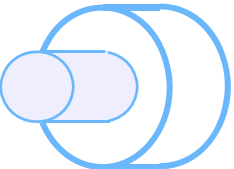
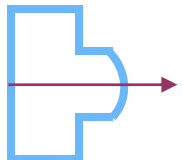
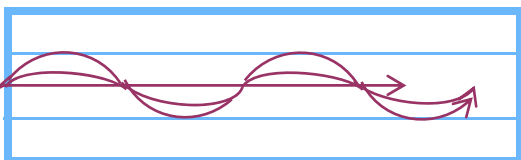
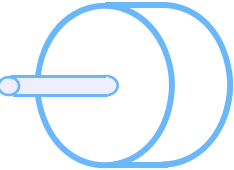
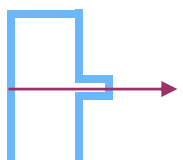



$$\alpha_1 = \alpha_2$$

Light Guidance In Optical Waveguide

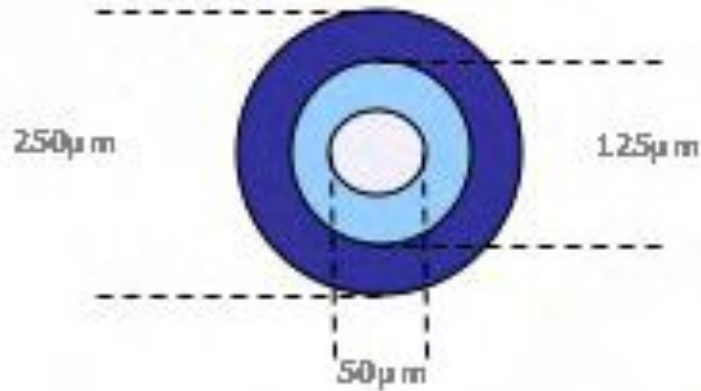


Types of fibers

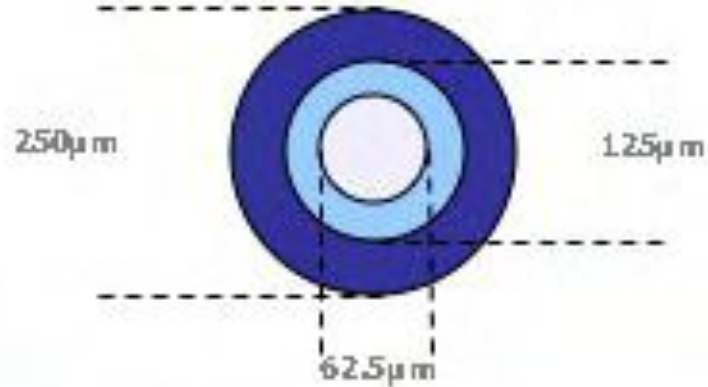
		<p>Multi mode Fiber, Step Index</p> 	<p>Properties:</p> <p>Multiple light paths (modes) of different length causing different modes to arrive at different time intervals which causes pulse broadening (Multimode Distortion or Modal Distortion)</p> <p>Bandwidth relatively small, low cost fiber</p>
		<p>Multi mode Fiber, Graded Index</p> 	<p>Properties:</p> <p>The parabolic profile of the index results in continual refocusing of the rays in the core, and compensates for multimode distortion. Therefore we encounter less pulse broadening</p> <p>Bandwidth bigger, more expensive</p>
		<p>Single mode Fiber, Step Index</p> 	<p>Properties:</p> <p>The core diameter is reduced so that only one mode can exist (single mode). Therefore Single mode fibers don't introduce any pulse broadening which enables higher bandwidth.</p> <p>Highest bandwidth</p>

Types of fibers

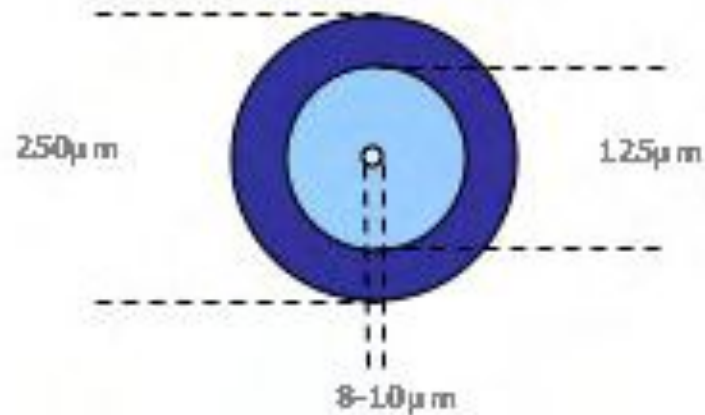
50/125 Multimode



62.5/125 Multimode



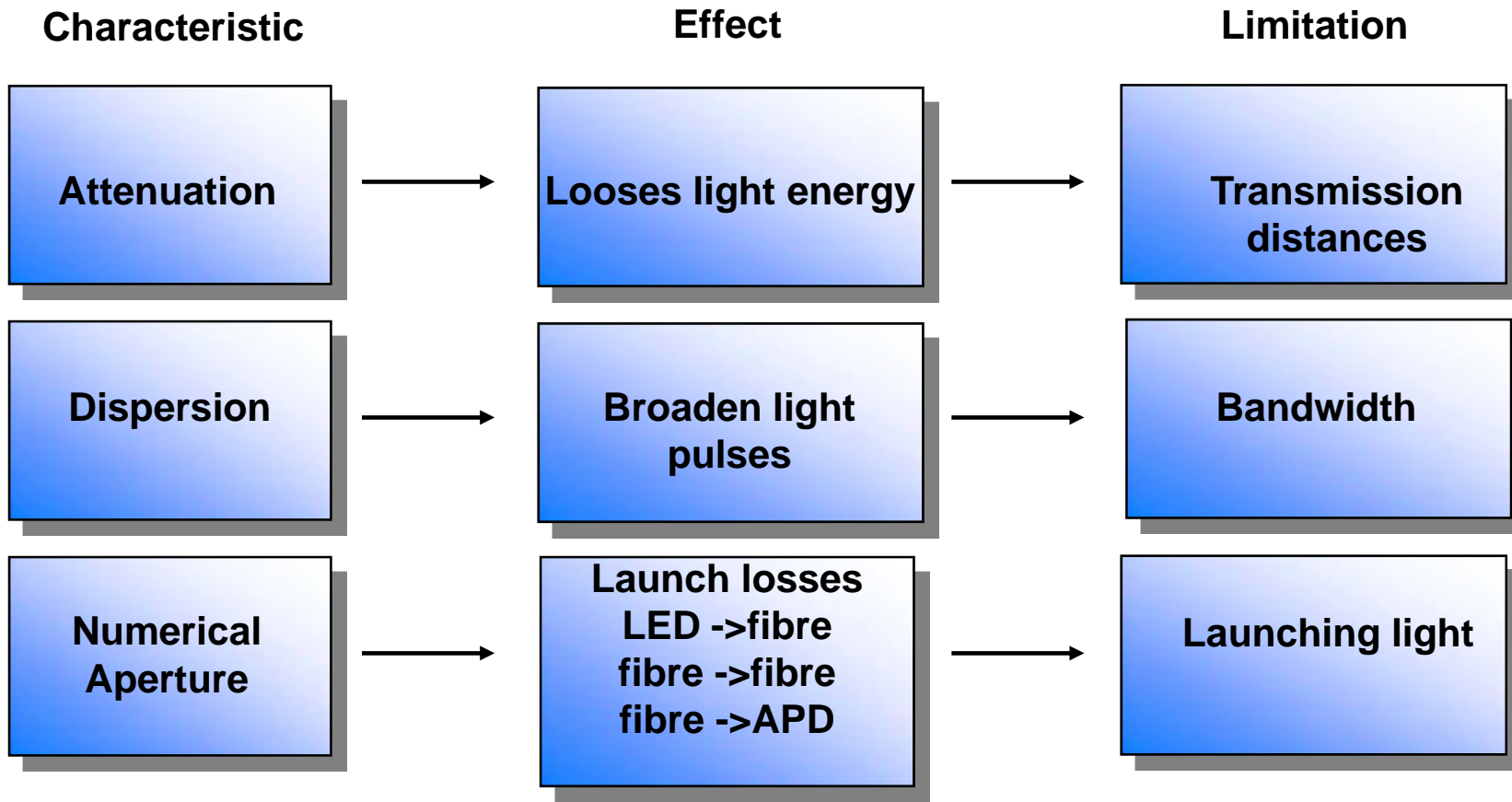
Single mode fiber



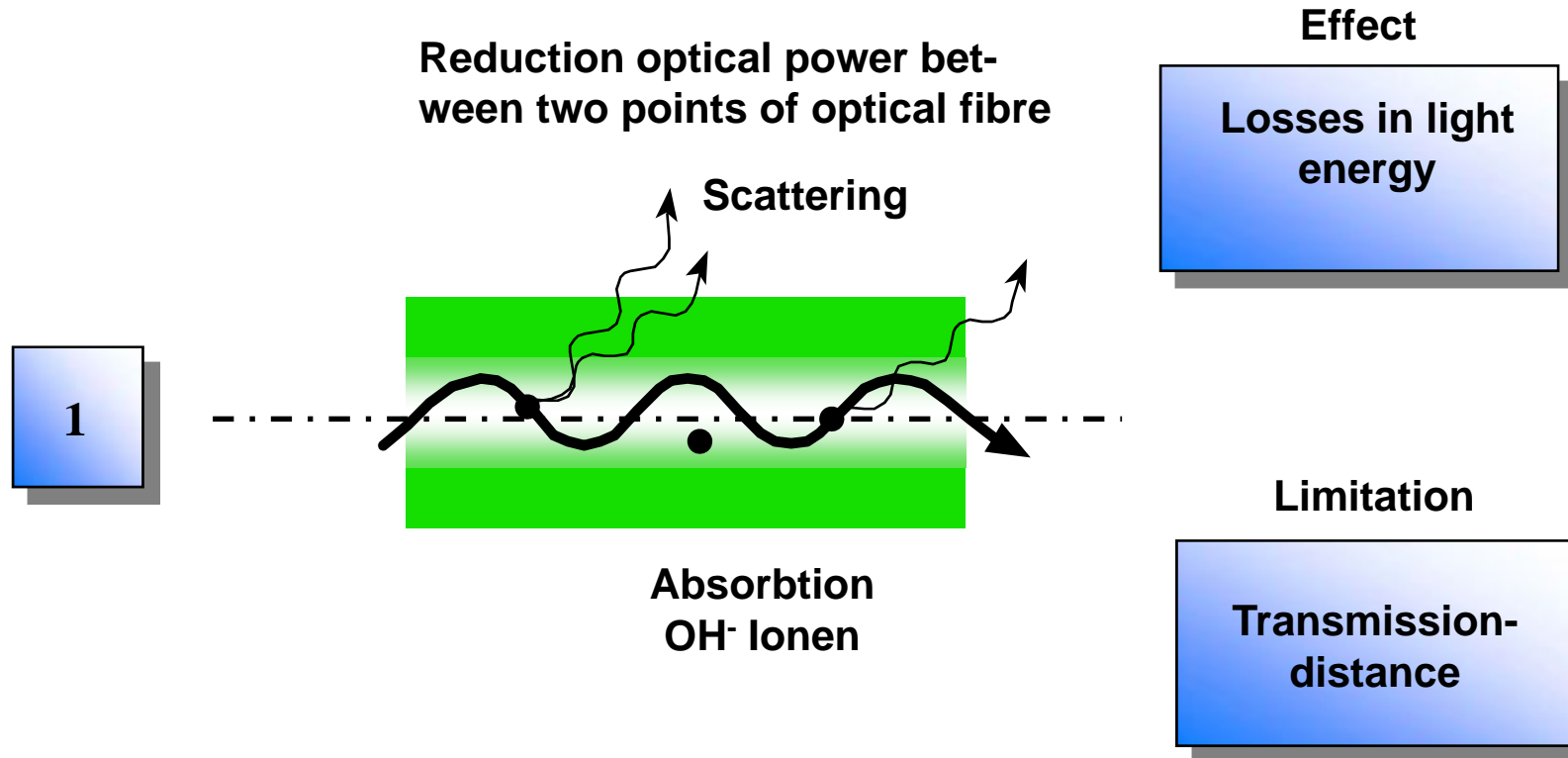
To give you an idea of
Thickness of a human hair



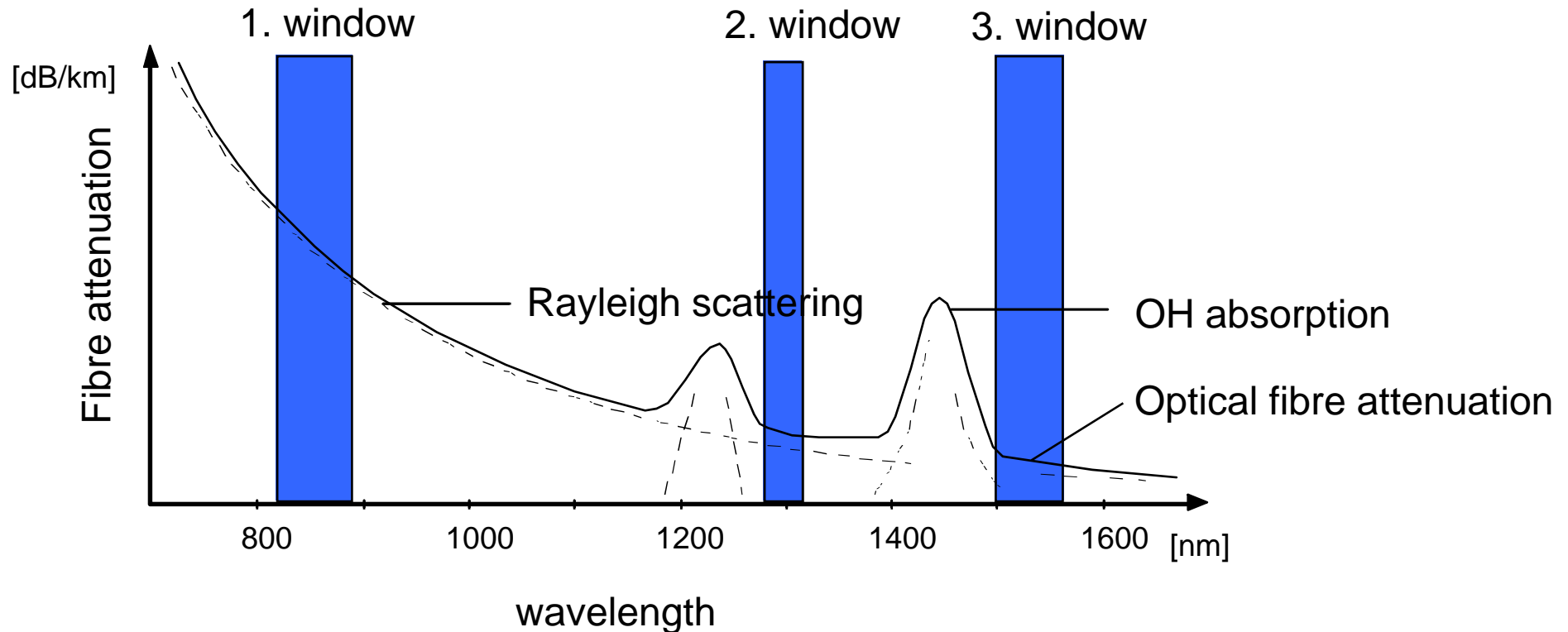
Optical Linear Effects



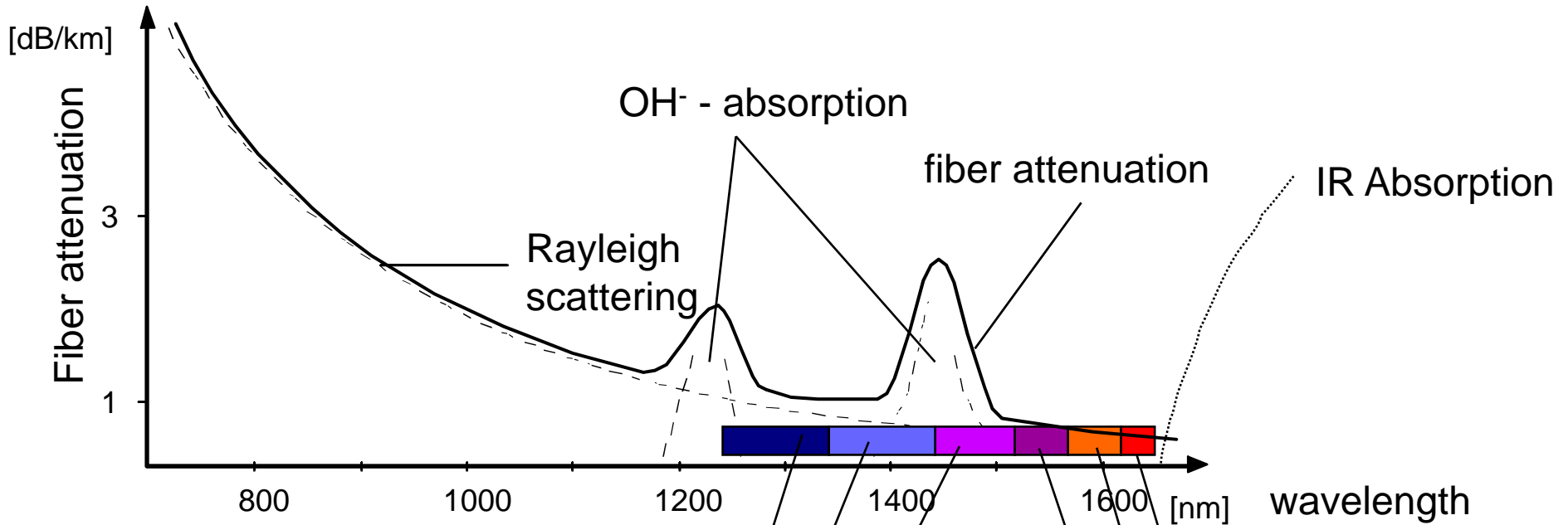
Attenuation



Rayleigh Attenuation Curve



Rayleigh Attenuation Curve



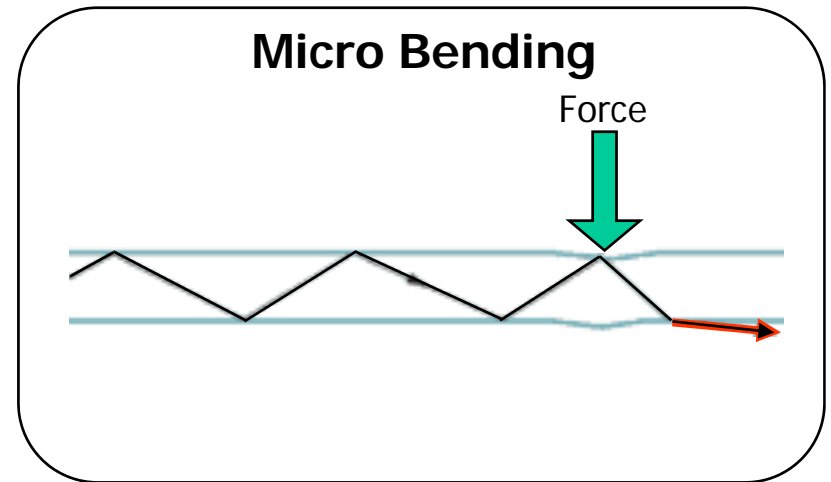
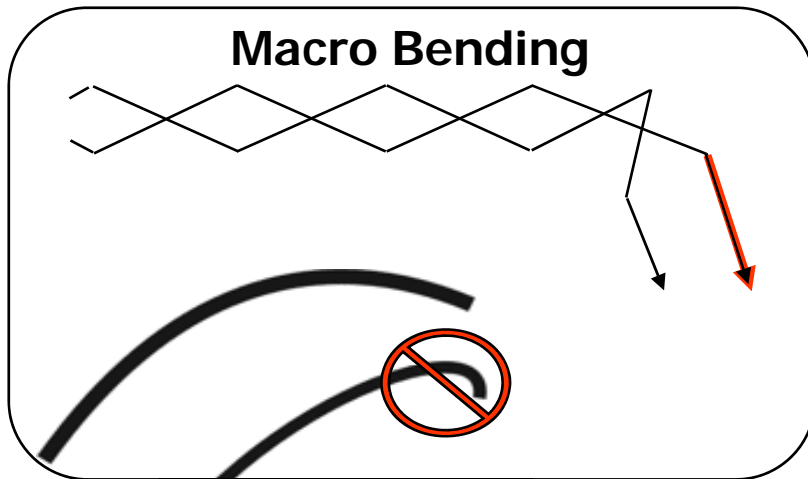
- O - Band = Original band $\lambda = 1260 - 1360 \text{ nm}$
- E - Band = Extended Band $\lambda = 1360 - 1460 \text{ nm}$
- S - Band = Short Band $\lambda = 1460 - 1530 \text{ nm}$
- C - Band = Conventional Band $\lambda = 1530 - 1565 \text{ nm}$
- L - Band = Long Band $\lambda = 1565 - 1625 \text{ nm}$
- U - Band = Ultra long Band $\lambda = 1625 - 1675 \text{ nm}$

O - Band U - Band
E - Band L - Band
S - Band C - Band

Attenuation

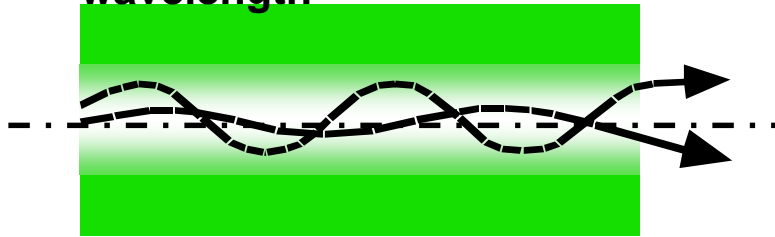
Bending Loss:

Last mentioned source of decrease of input- versus output-power are bending losses in the fiber caused by bending the fiber. When the angle of bend exceeds a certain degree the light waves will no longer be reflected in the core and enters the cladding of the fiber. We distinct two ways of bending, Macro bending and Micro bending.



Modal (Geometrical) Dispersion

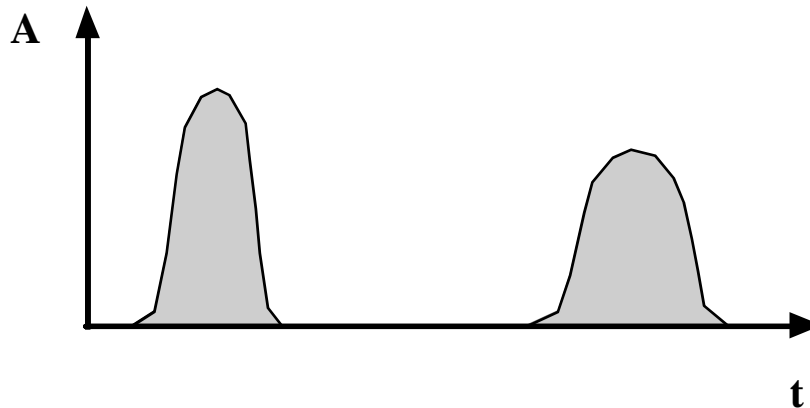
Superposition of modes with different delay times at the same wavelength



Effect

Broaden light pulses and loss in energy

2



Limitation

Bandwidth

Dispersion

Multimode fiber

**Mode
Dispersion**

Measured is the effect:
Bandwidth [MHz x km]

Singlemode Fiber

**Chromatic
Dispersion
[ps/km x nm]**

**Polarisation-
modedispersion
PMD
[ps/ \sqrt km]**

Applications

Single Mode or Multimode Fiber

Single Mode G.652.D (G.655/657)	Multi Mode G. 651
<ul style="list-style-type: none"> ● Single mode optical fiber is ideal for long distance transmission. ● Wavelengths used for Single mode fiber are 1310nm, 1550 nm and 1625nm. ● The costs for a Single mode transmission system are relatively high (Laser). ● High Bandwidth 	<ul style="list-style-type: none"> ● Multimode fiber is not suited for long communication distance but well suited for communication over short distances (below 2km). ● Wavelengths used for Multimode are 850nm and 1300nm ● The cost for a Multimode transmission system are less expensive than single mode equipment (LED). (2-4 times less expensive) ● Lower Bandwidth than Single mode

Selection Optical Fibres

Application	Specification type network	Fibre type
Tele-communication CATV	<ul style="list-style-type: none"> • Bandwidth 2 Mbit/s bis 10 Gbit/s • Distance 100 m bis 100 km • small part of connecting / jointing elements 	Singlemode
LAN/MAN	<ul style="list-style-type: none"> • Bandwidth 4 Mbit/s bis 1 Gbit/s • Distance 10 m bis 2 km • more connecting / jointing elements 	Multimode 62.5/125 µm 50/125 µm
WAN CCTV	<ul style="list-style-type: none"> • different requirements 	Singlemode /Multimode / special fibre

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Fiber Optic Cable



PATCHline, KONlan



BRUniversal



BRUclean



Metallic cable

Brugg Cable Types

Indoor cables
PATCHline, KONlan

Outdoor cables
BRUclean

Universal cable
BRUniversal

Metallic ropes
BRUsteel, OPGW

**Not longitudinally
water proof**

Flexible

Compact design

**Halogenfree,
flame retardant**

**Longitudinally
water proof**

**Blowing into
pipes
Rodent protected
Direct burial**

**Longitudinally
water proof**

**Laying into ducts
or trunks
Rodent protected**

**Halogenfree,
flame retardant**

**Longitudinally
water proof**

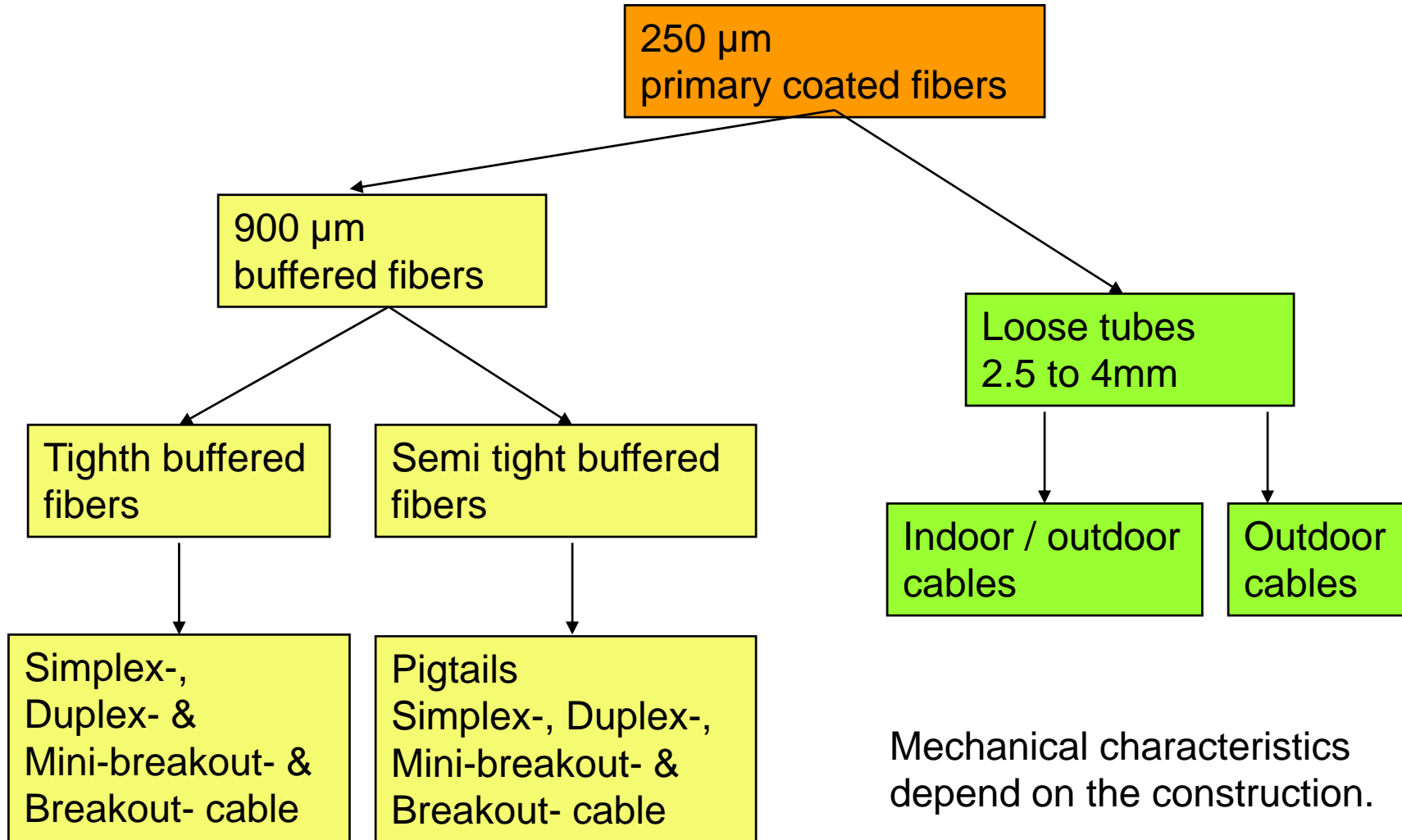
**High tensile strength
Excellent rodent
protection**

Flame retardant

Cable Types

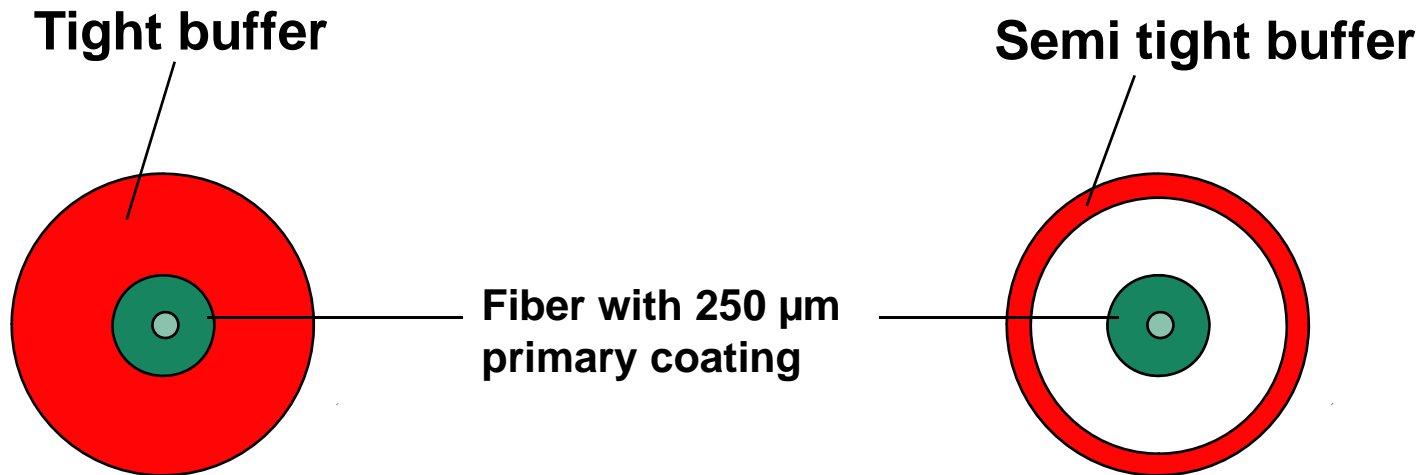
- Particular importance is placed on protecting the optical fibres against environmental influences such as mechanical stresses or temperature changes!
- The used cable type depends on:
 - Kind of laying up / installation
 - General application (indoor / outdoor etc.)
 - environmental conditions
 - Electro-magnetic influences

Overview cable families



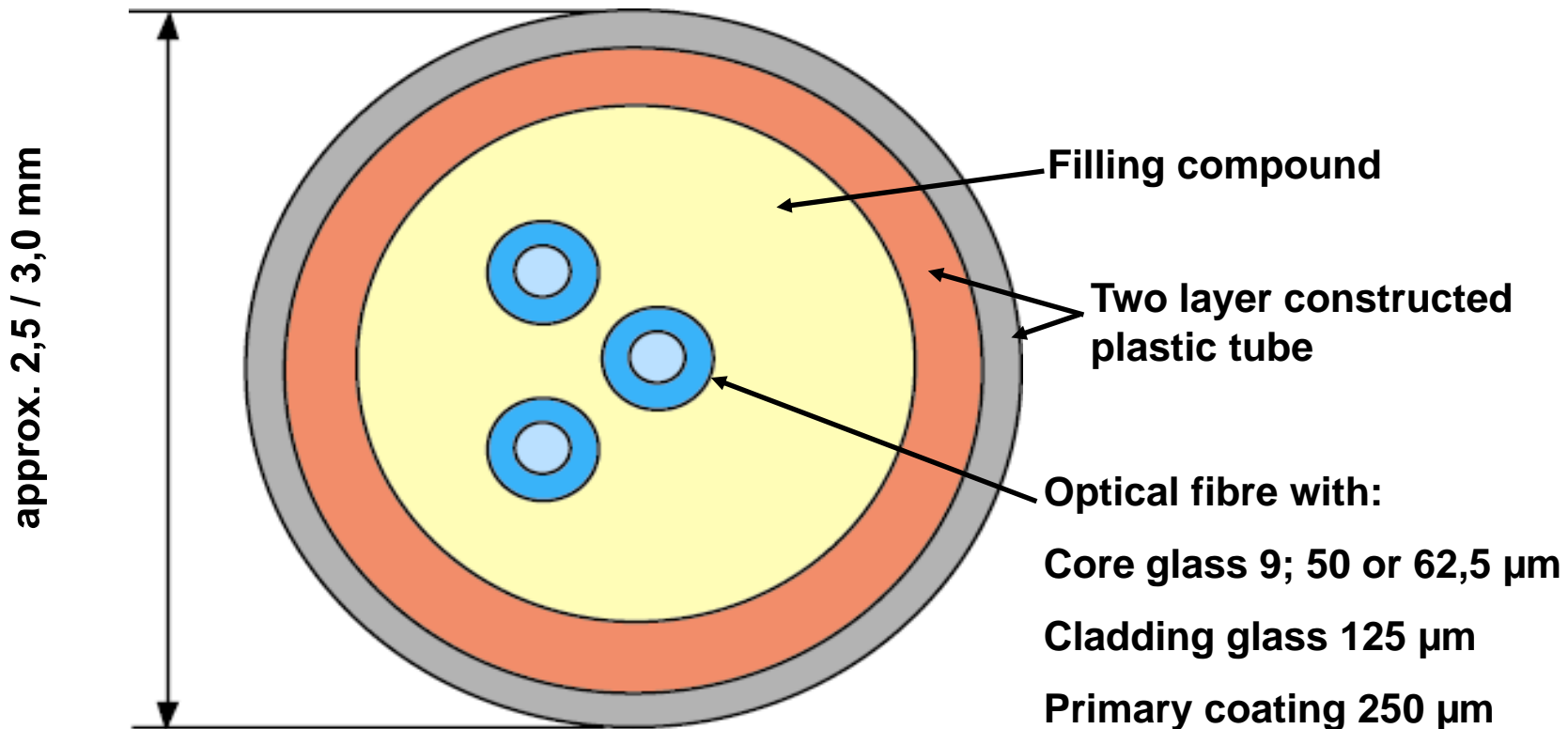
Secondary coating

900 μm buffer



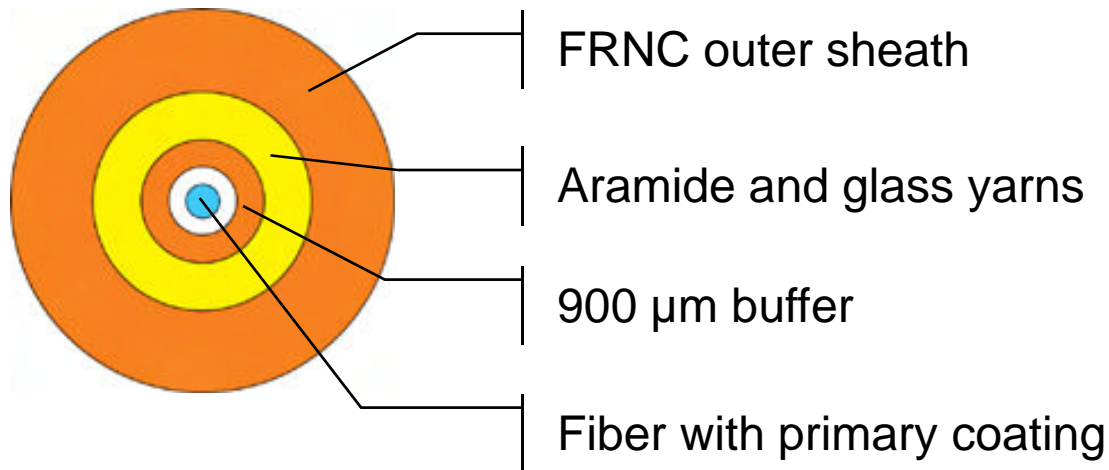
Loose tubes

Loose buffer, two layer constructed, with 2 to 24 optical fibers



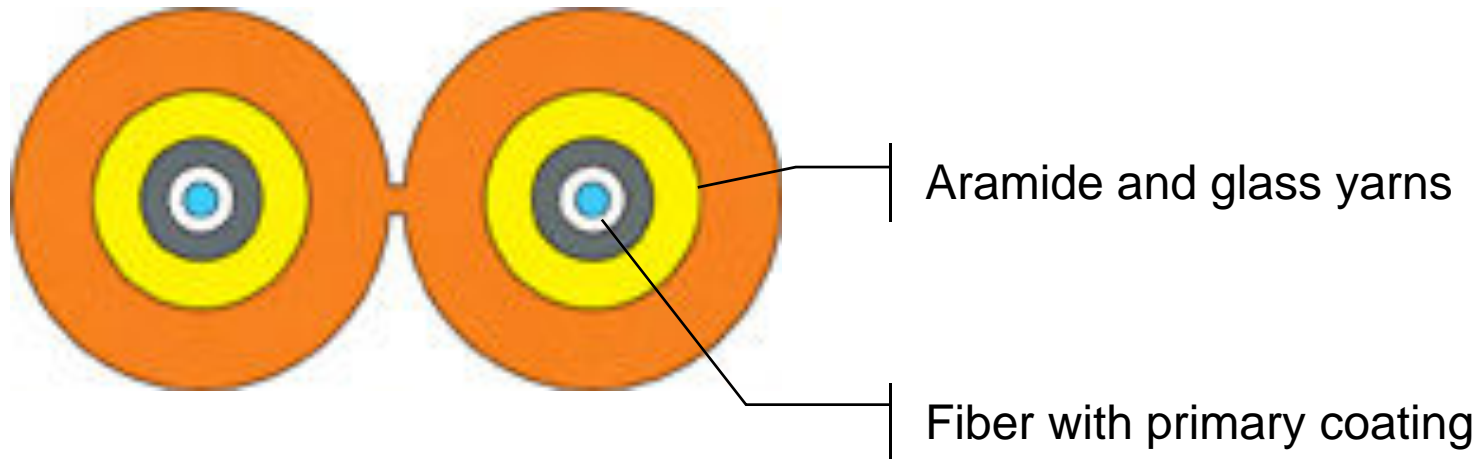
PATCHline Indoor cable

Simplex 2.1 / 2.4 / 2.8 mm



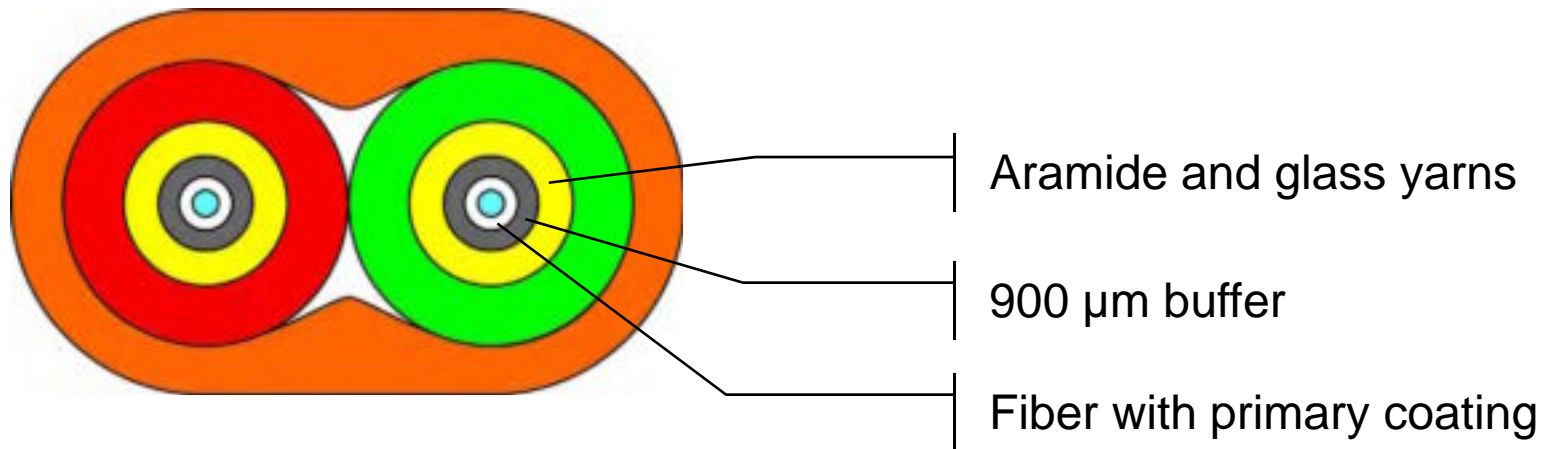
PATCHline Indoor cable

Duplex 4.2x2.1 / 5.6x2.8



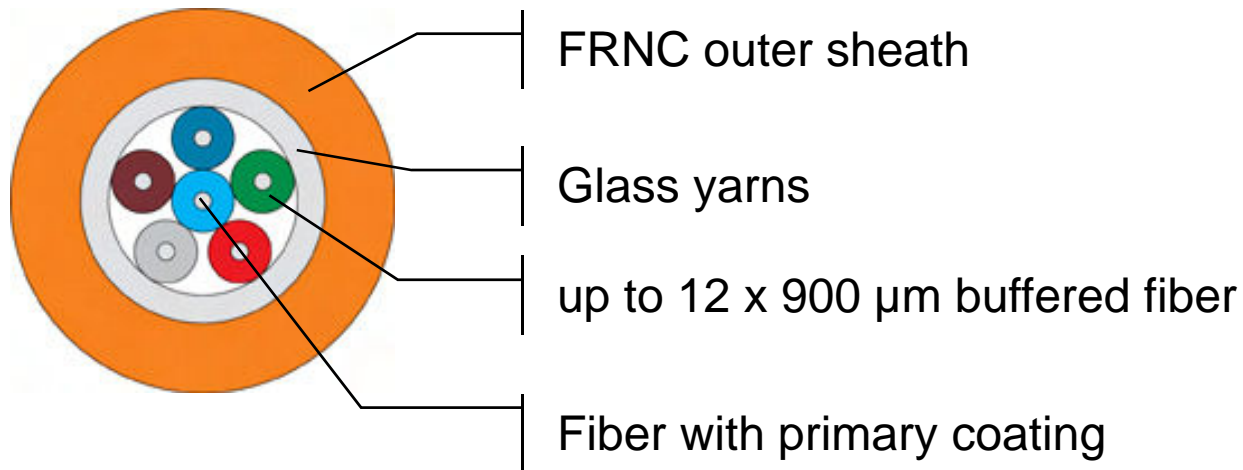
PATCHline Indoor cable

Duplex+ 5.3x3.1 / 6.6x3.8



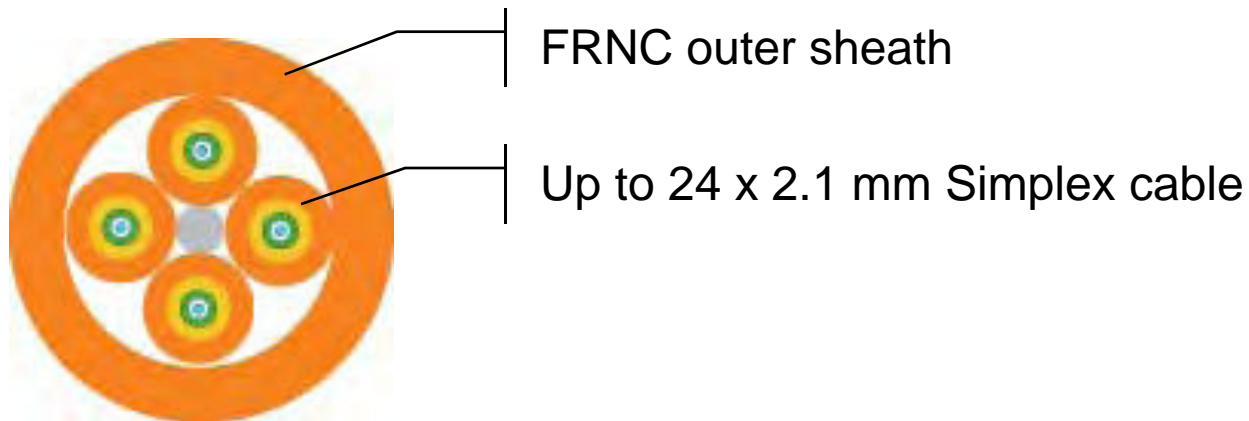
Indoor cable

Mini Breakout KONlan mini



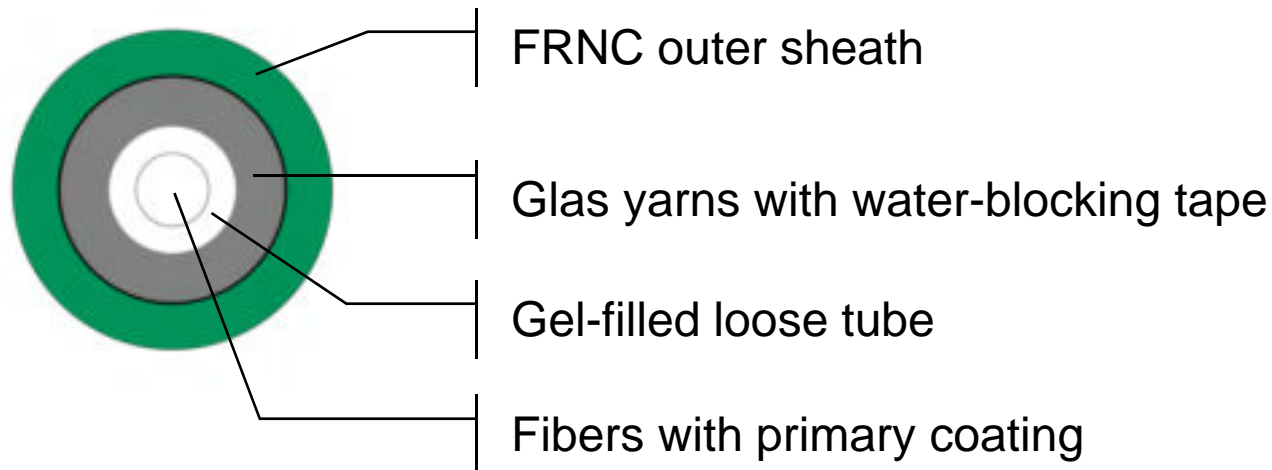
Indoor cable

Breakout Cable KONlan



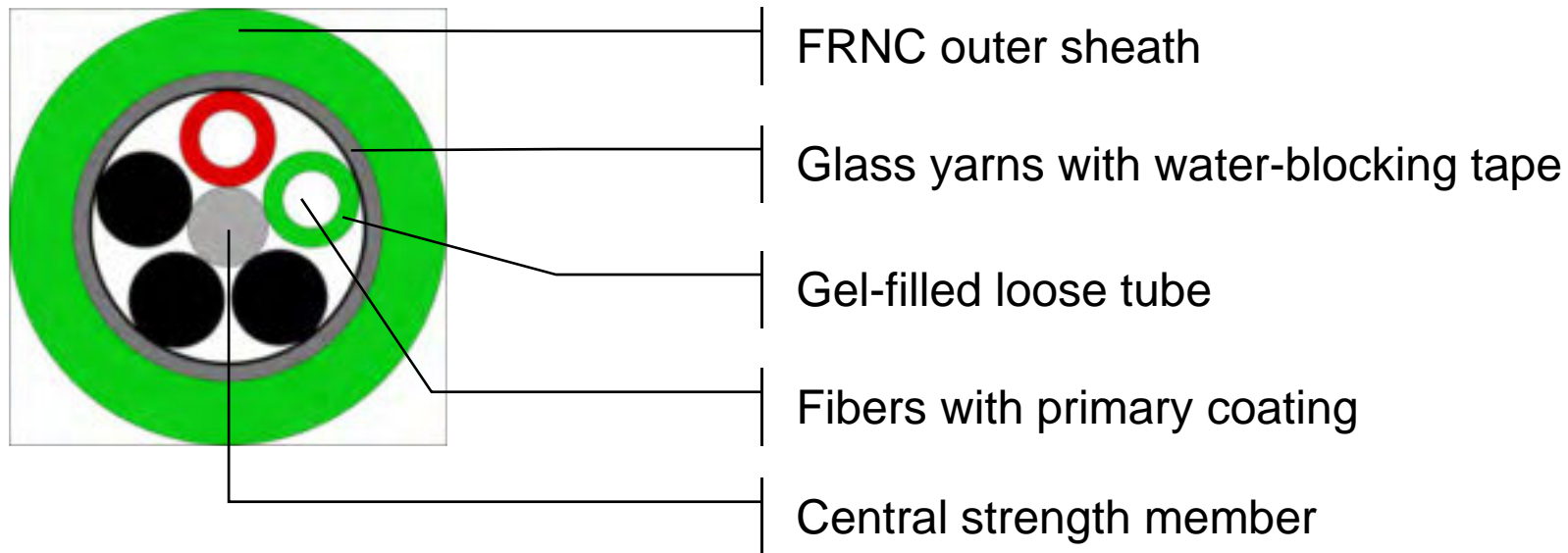
Indoor / outdoor cable BR*Universal*

Central loose tube cable 150 / 250

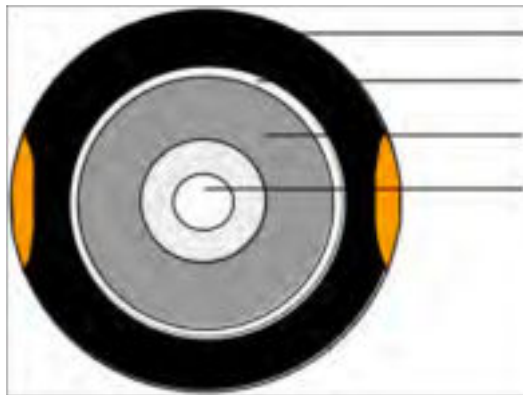


Indoor / outdoor cable BR*Universal*

Stranded loose tube cable 300 - 900



FO Outdoor Cable - Central Tube Type



PE - outer sheath
swellable tape
glass rovings
central loose buffer

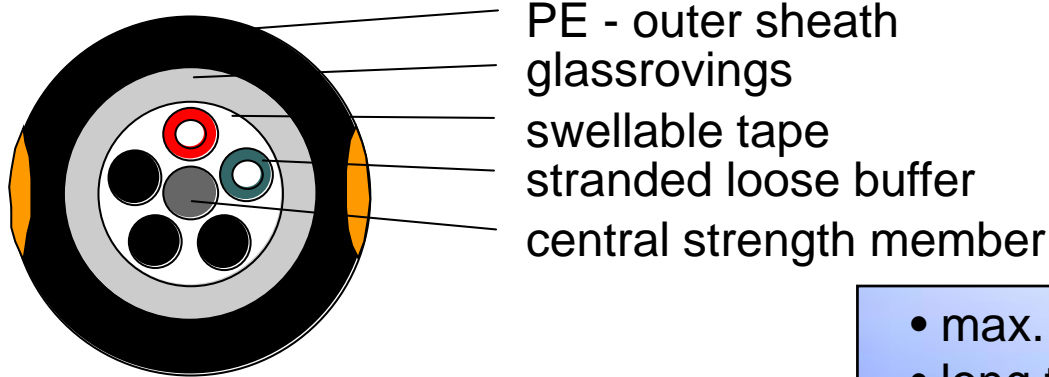
BRUclean 150 / 250

- max. number of fibers: 24
- high crush resistance
- longitudinally water proof
- blowing into pipes
- rodent protection

Application:

- outdoor use, WAN, LAN, campus backbone

FO Outdoor Cable - Stranded Tube Type



BRUclean 300-900

- max. number of fibers: 432
- long term tensile strength 3'000 - 9'000 N
- blowing into pipes
- rodent protection

Application:

- outdoor use, WAN, LAN, campus backbone
- for higher fiber count

Thank you for your Attention.

Further information: www.brugg.com