Optoelectronică

Curs 5

2017/2018

Disciplina 2017/2018

- 2C/1L Optoelectronică OPTO
- **Minim 7 prezente curs + laborator**
- Curs – sl. Radu Damian
  - an IV μE
  - Vineri 8-11, P5
  - E – 70% din nota
    - **20% test la curs**, saptamana 4-5?
  - probleme + (? 1 subiect teorie) + (2p prez. curs)
  - toate materialele permise
- Laborator – sl. Daniel Matasaru
  - an IV μE, an IV Tc
    - Joi 14-16 par/impar
  - L – 15% din nota
  - C – 15% din nota

Orar 2017/2018

- Curs
  - Vineri 8-11, P5
  - 2C ⇨ 3C
    - 14*2/3≈9.33
    - 9÷10 C

Examen partial 2017/2018

- Vineri 16.03.2018, 10, P5
  - toate materialele permise
- 20% nota
  - Singura proba la care minim 5 nu e necesar
  - Absenta = 0p
- Primele 3 capitole
  - Introducere
  - Lumina ca undă electromagnetică
  - Fotometrie şi radiometrie

Recapitulare

Reprezentare logaritmică!!!

$dB = 10 \cdot \log_{10} (P_2 / P_1)$

$dBm = 10 \cdot \log_{10} (P / 1\ mW)$

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
–3 dB	= 0.5
–10 dB	= 0.1
–20 dB	= 0.01
–30 dB	= 0.001

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
–3 dBm	= 0.5 mW
–10 dBm	= 100 μW
–30 dBm	= 1 μW
–60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

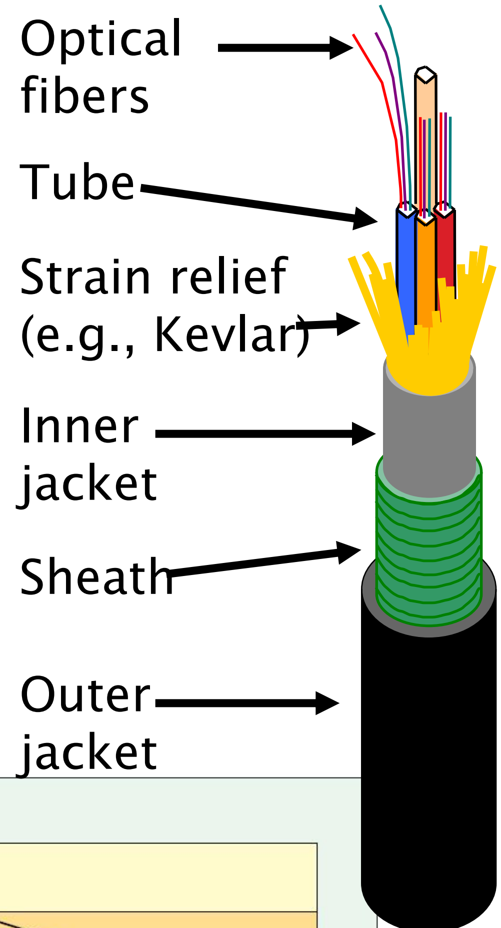
[x] + [dB] = [x]

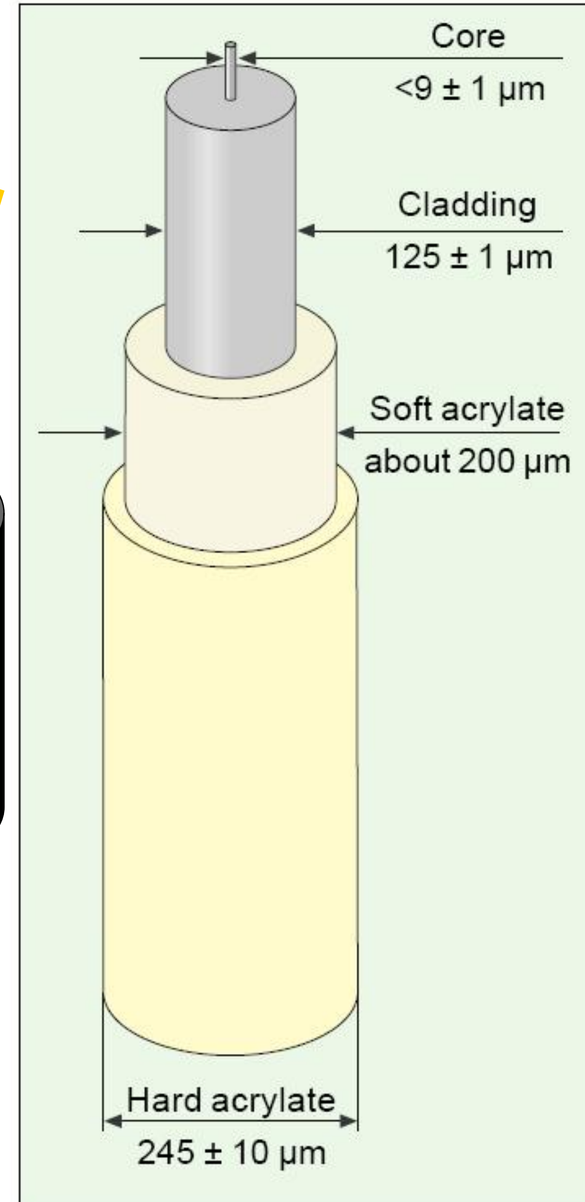
Fibra optică

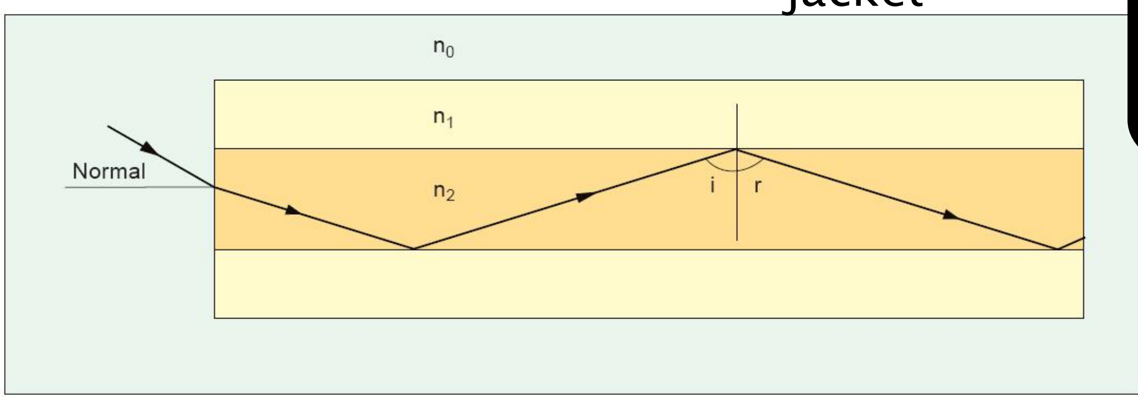
Capitolul 4

Fibra optica

- un ghid de unda dielectric
  - miez
  - teaca



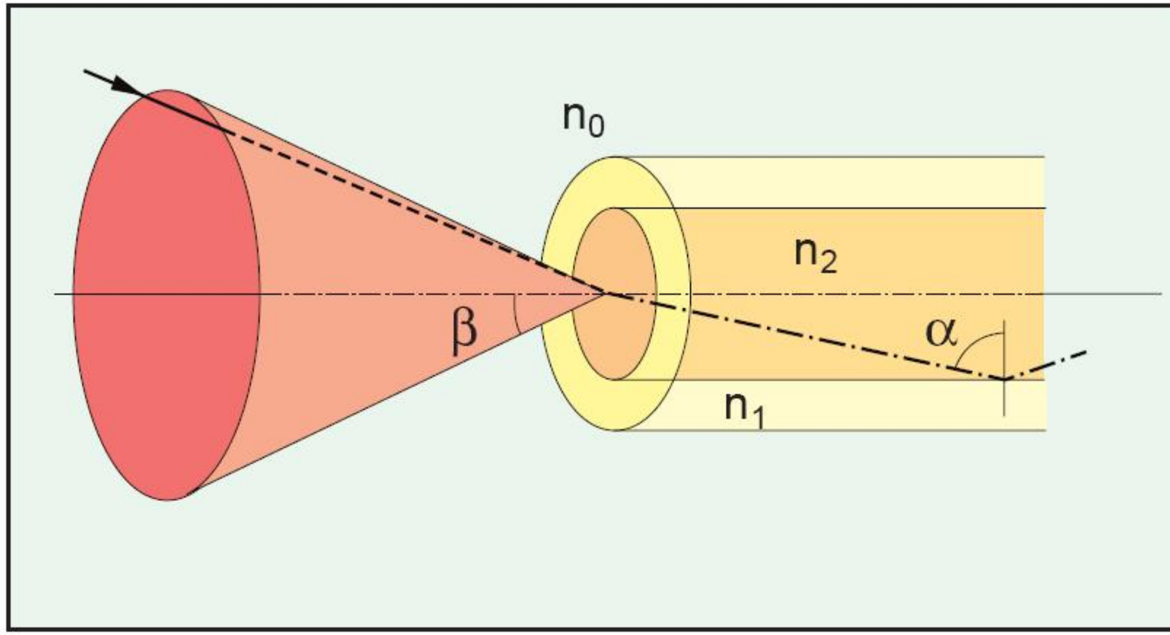




Unghi de acceptanta, apertura numerica

- Unghi de acceptanta

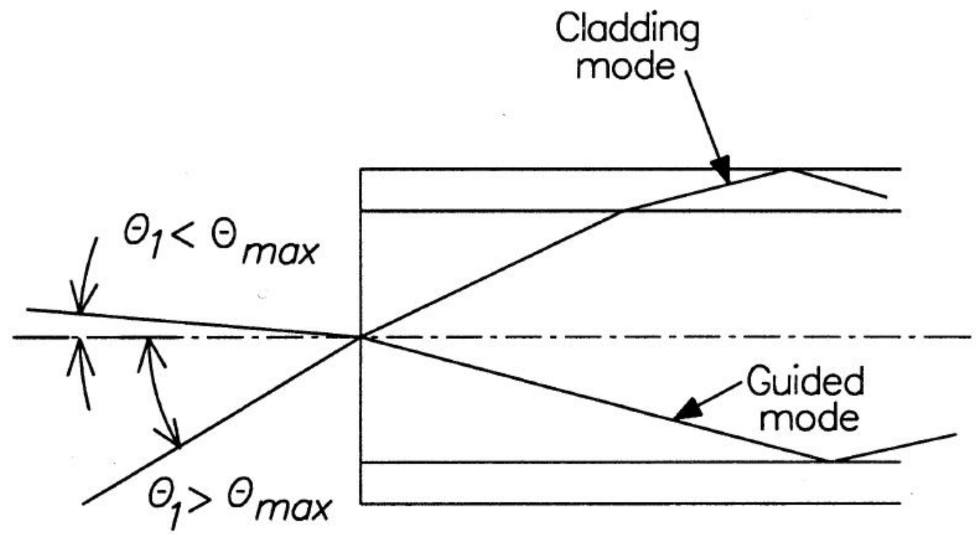
$$n_0 \cdot \sin\theta_{ACC} = n_2 \cdot \sin\phi_c$$



- **Apertura numerica**

$$NA = n_0 \cdot \sin\theta_{ACC}$$

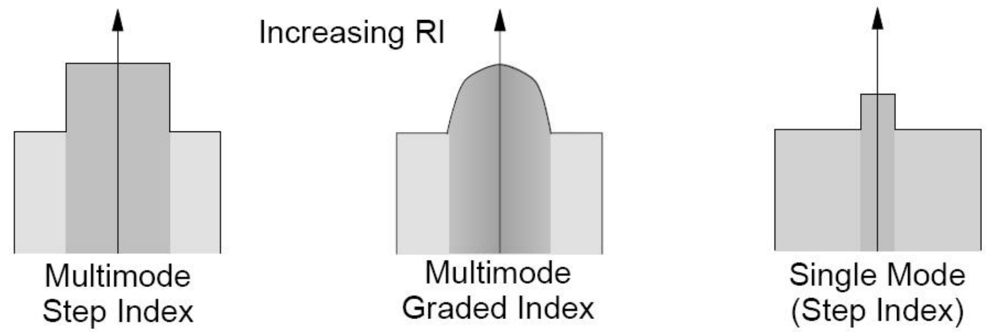
$$NA = n_2\sqrt{\frac{n_2^2 - n_1^2}{n_2^2}} = \sqrt{n_2^2 - n_1^2}$$

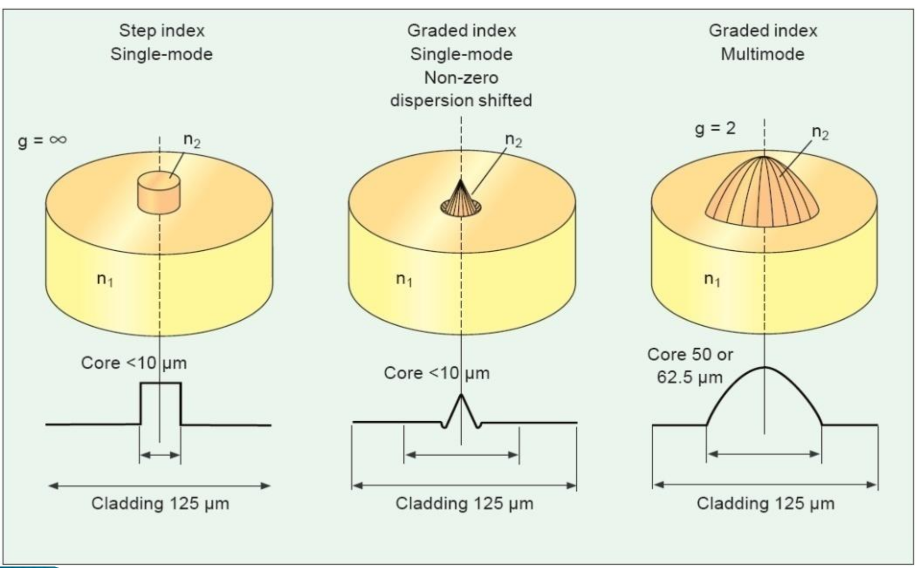


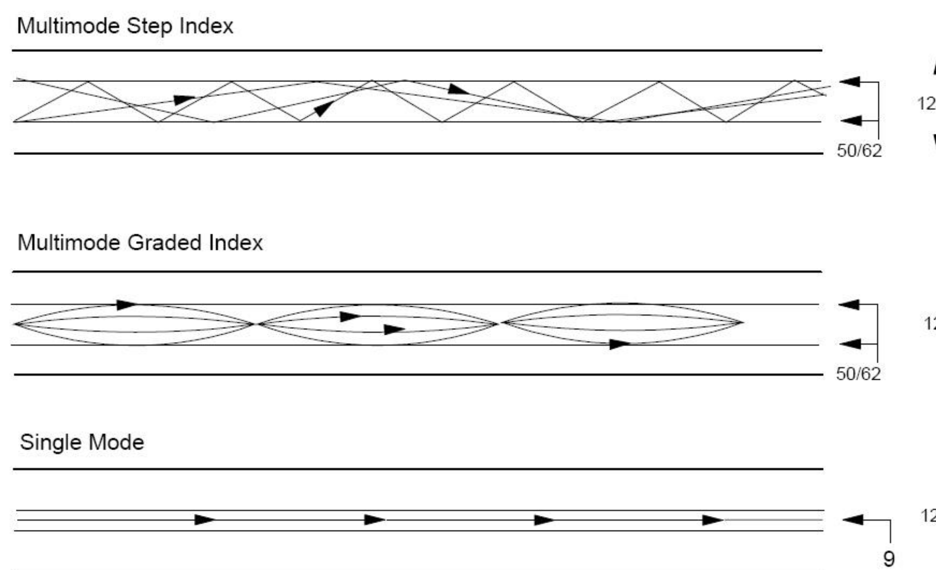
n_2 – miez
n_1 – teaca
$n_2 > n_1$!!

Tipuri de fibra

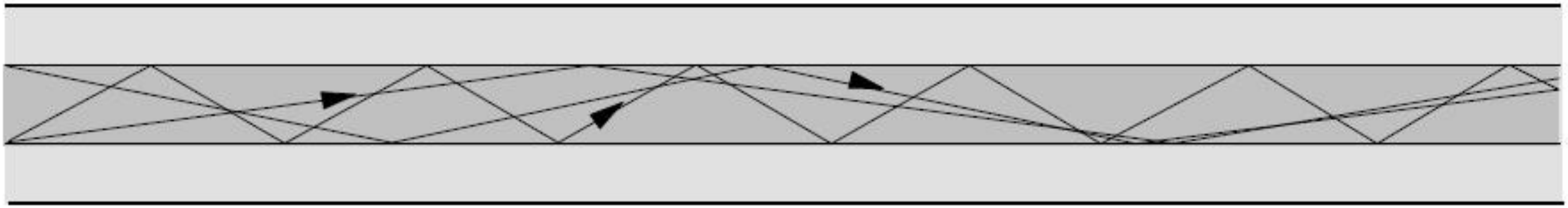
- Monomod
- Multimod
  - cu salt de indice
  - cu indice gradat



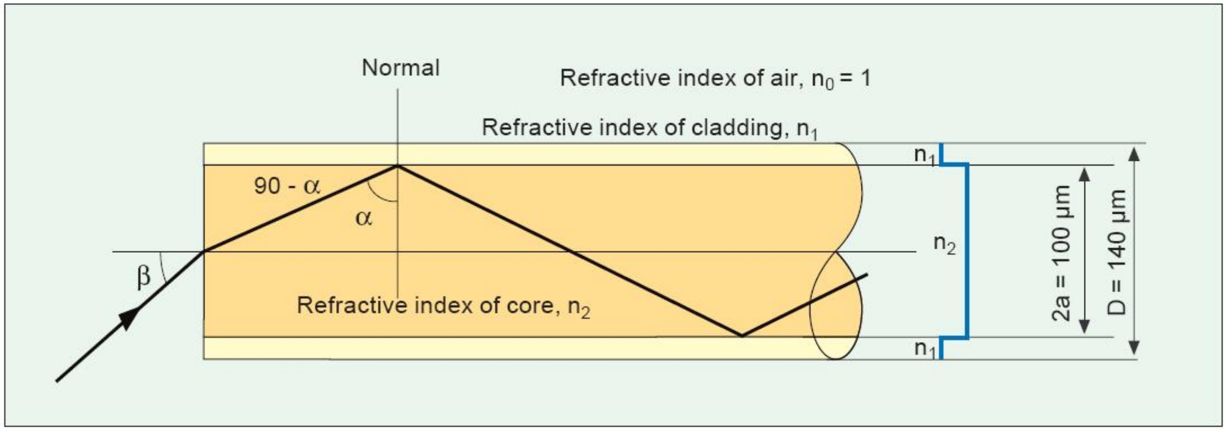


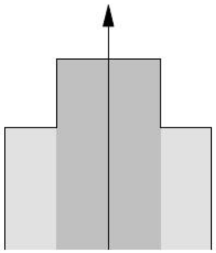


Fibre multimod cu salt de indice



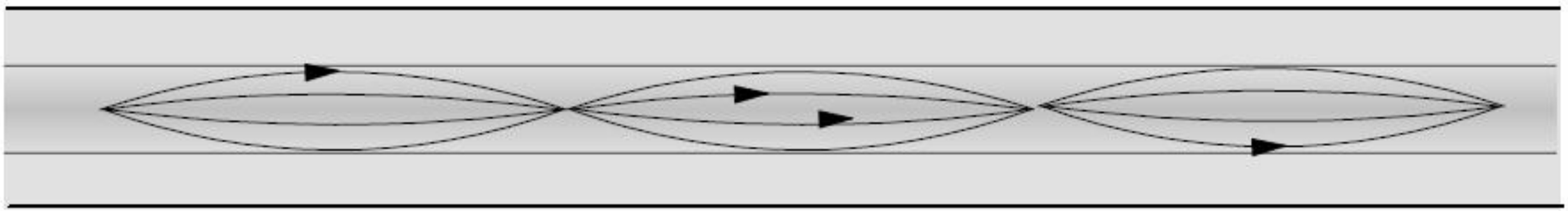
- 50/125 sau 62.5/125 (µm)
- 15-50 MHz · km



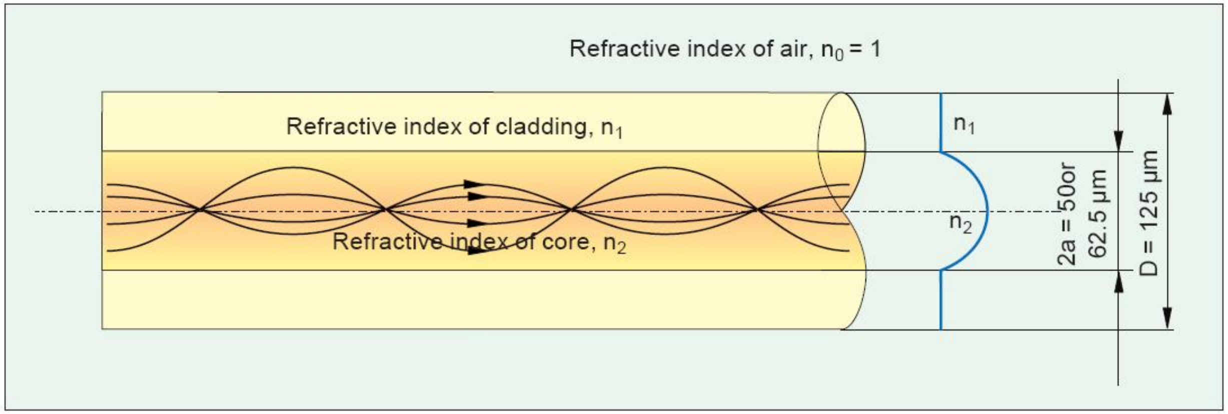


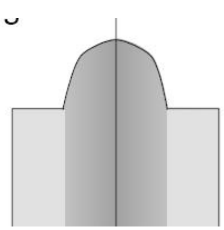
	glass	plastic
core diameter 2a	100 µm	980 µm
cladding diameter D	140 µm	1000 µm
core refractive index n_2	1.48	
cladding refractive index n_1	1.45	

Fibre multimod cu indice gradat



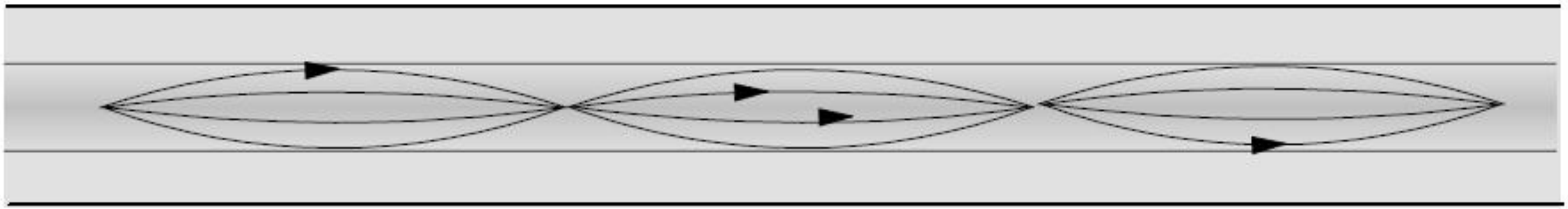
- 50/125 sau 62.5/125 (µm)
- 700-1200 MHz·km





Core diameter 2a	50 or 62.5 µm
Cladding diameter D	125 µm
Maximum refractive index, core	1.46
Relative differential refractive index	0.010

Fibre multimod cu indice gradat

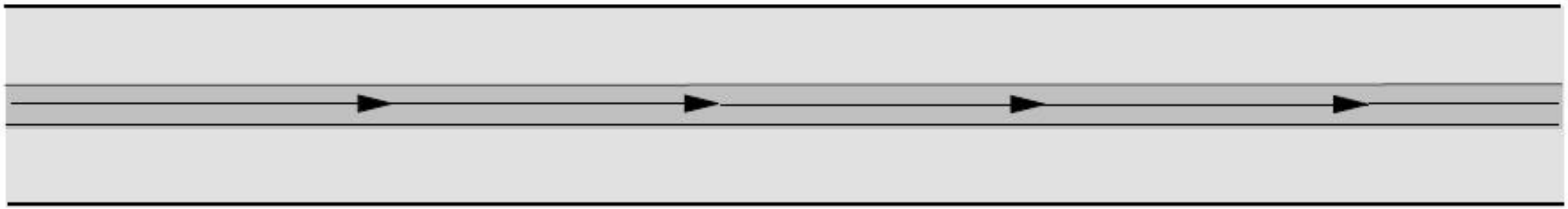


$$n(r) = n_2\left[1 - \Delta\left(\frac{r}{a}\right)^g\right]$$

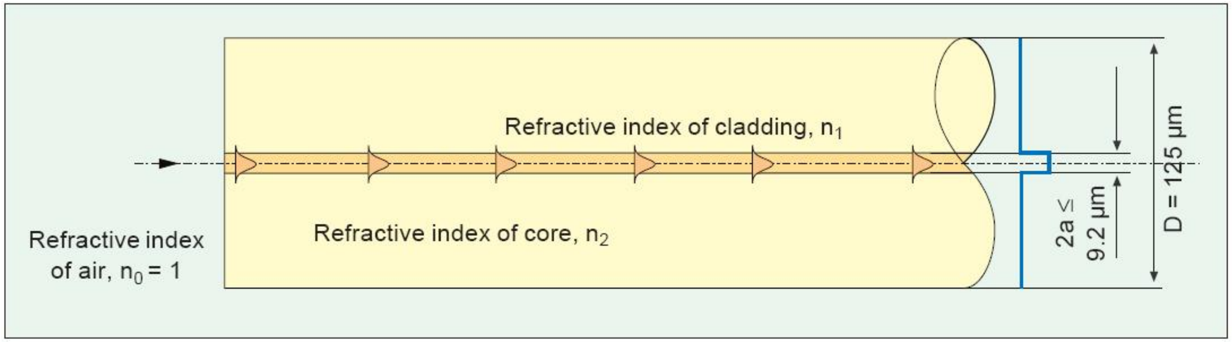
$$\Delta = \frac{NA^2}{2n_2^2} = \frac{n_2^2 - n_1^2}{2n_2^2} \approx \frac{n_2 - n_1}{n_2} \approx \frac{\Delta n}{n} \quad \text{for } \Delta << 1$$

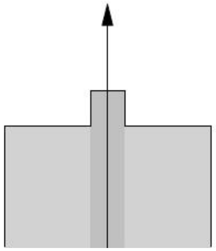
- g = 1 – indice gradat triunghiular
- g = 2 – indice gradat parabolic
- g = ∞ – salt de indice

Fibre monomod



- 6-8/125 (µm)
- MHz·km nerelevant
- MFD – Mode Field Diameter

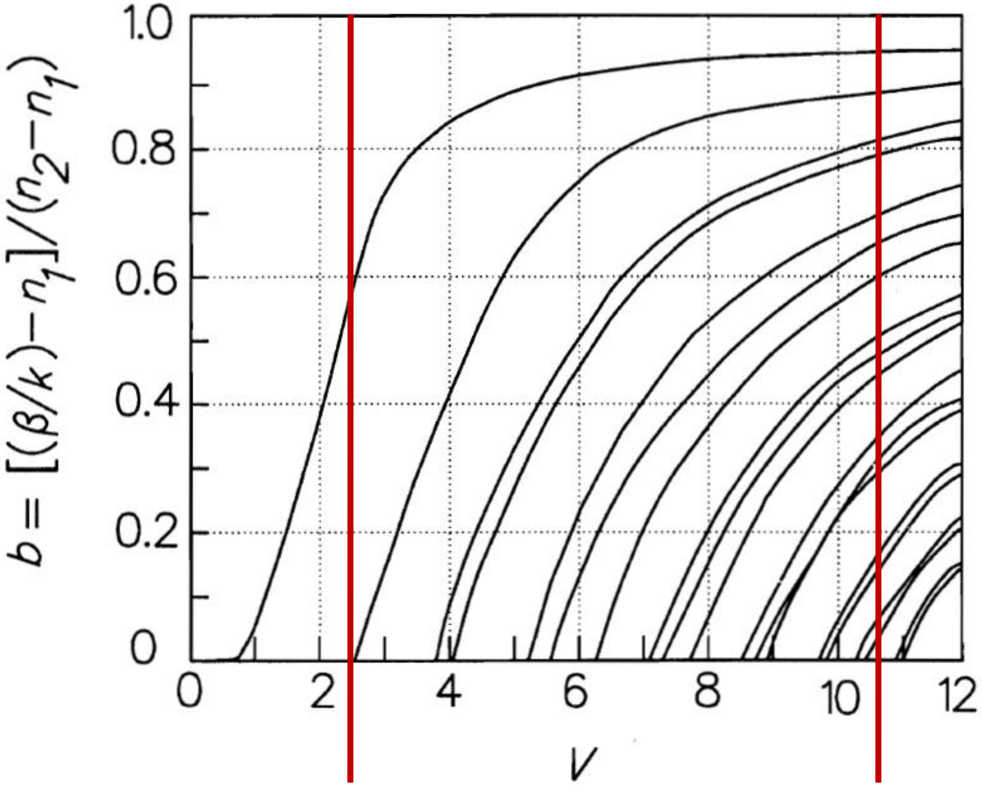




Cladding diameter D	125 µm
Core refractive index n_2	1.4485
Cladding refractive index n_1	1.4440
Refractive index differential	0.003 = 0.3%

Frecventa normalizata – monomod

- Fibre monomod



b – coeficient de propagare modal relativ

$$V \le V_C = 2.405$$

exista un **singur** mod (solutii fc. Bessel)

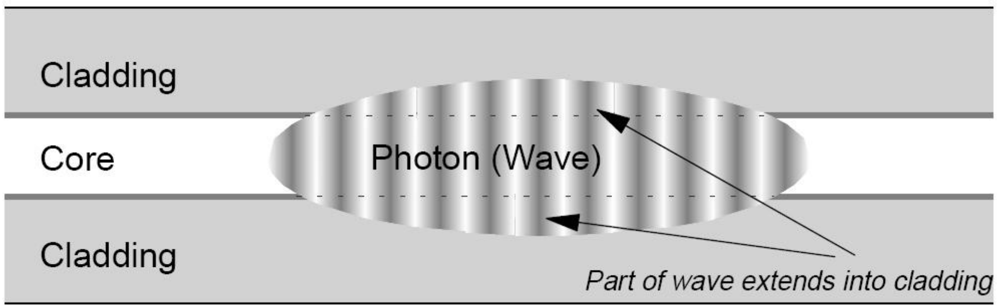
$$\lambda \ge \lambda_C = \pi \frac{2a}{V_C} NA = \pi \frac{2a}{2.405} NA$$

Exemplu:
2a = 8.5μm
NA = 0.11

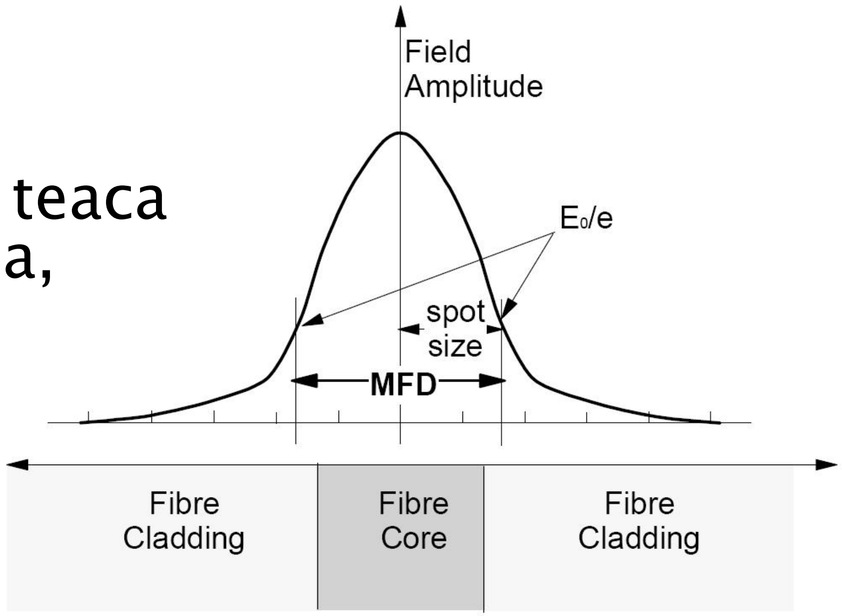
$$\lambda_C = \pi \frac{8.5}{2.405} 0.11 = 1210\text{nm}$$

Propagarea in fibra monomod

- Propagarea luminii poate fi explicata doar prin teoria electromagnetica



- Energia campului se extinde in teaca (diametrul efectiv al spotului luminos – MFD, Mode Field Diameter)
- MFD > 2a
- Adancimea de patrundere in teaca depinde de lungimea de unda, generand dispersia de ghid



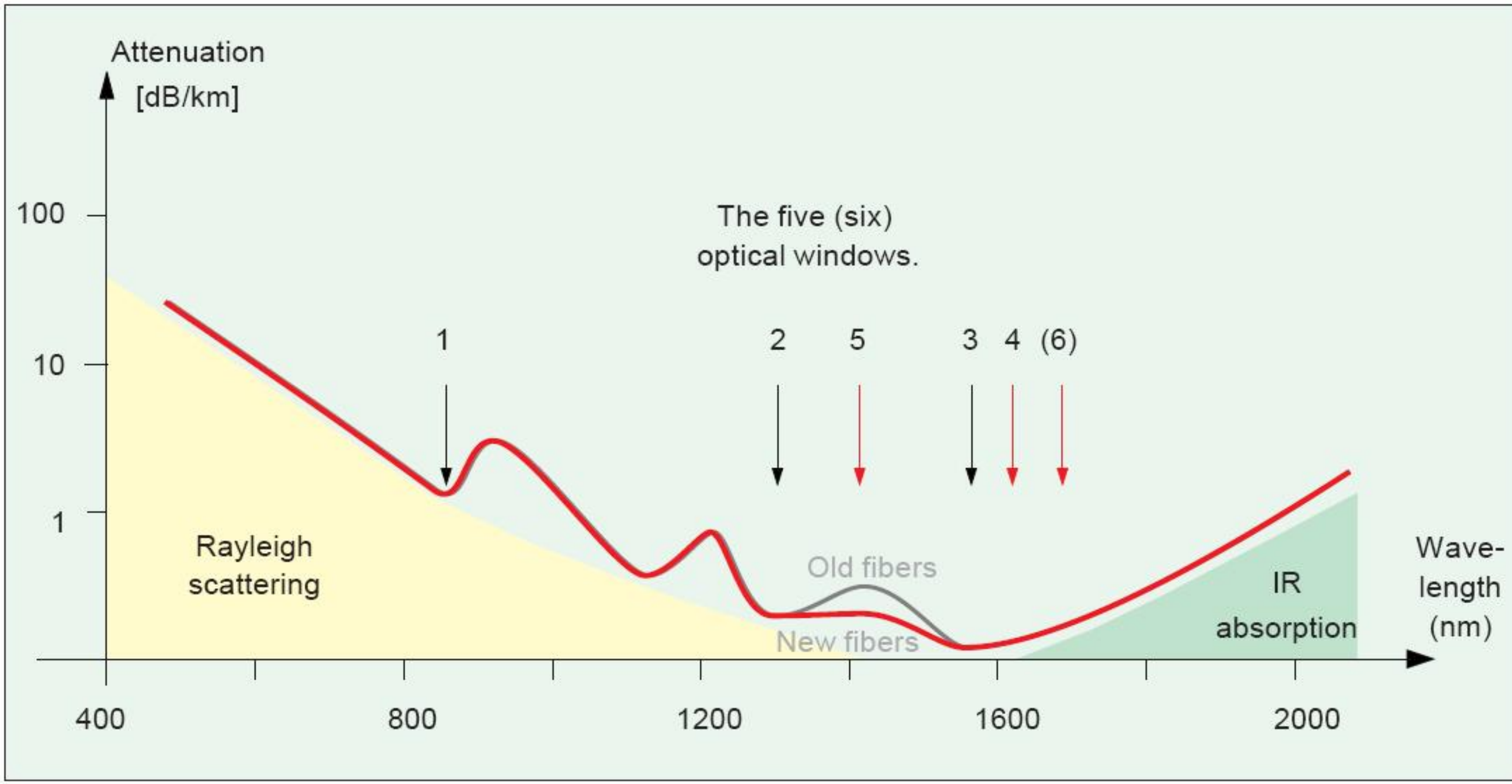
Fenomene de interes

- Cat de departe pot transmite semnalul luminos pe fibra
  - **atenuare**
- Cat de rapid pot transmite informația
  - dispersie

Atenuare

- Macrocurburi
  - utilizator, **localizat**, dB
- Discontinuitate in fibra
  - utilizator, **localizat**, dB
- Microcurburi
  - **distribuit**, tehnologie, dB/km
- Imprastiere
  - **distribuit**, tehnologie, dB/km
- Absorbtie
  - **distribuit**, material, dB/km

Absorbtie

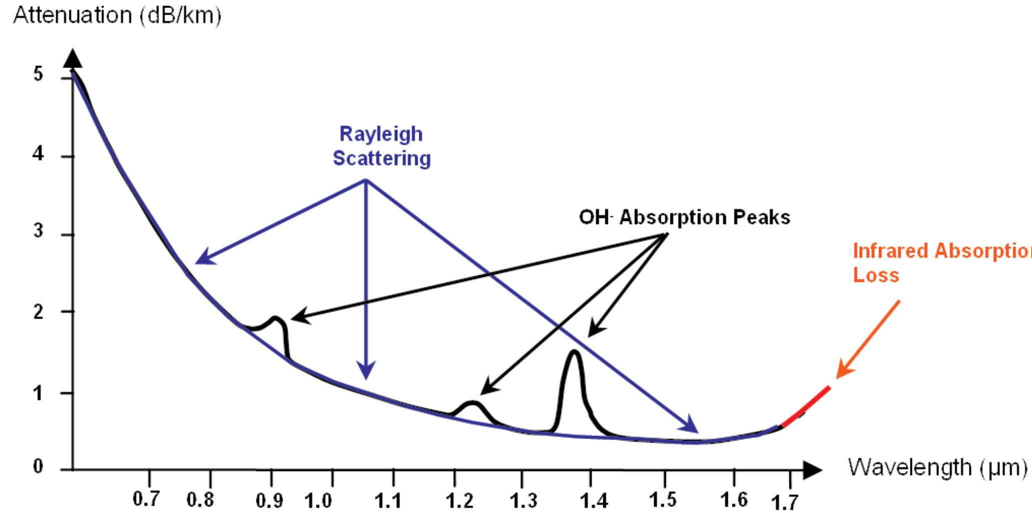


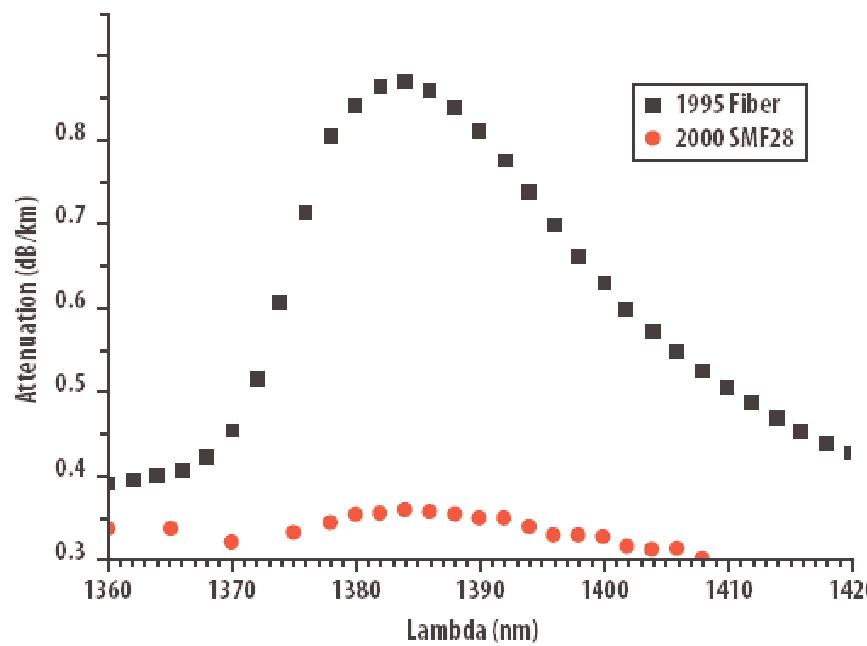
distribuit, material, **dB/km**

$$A[dB] = A_i[dB/km] \cdot L[km]$$

Absorbtie OH

- Absorbtie
  - 950nm
  - 1244nm
  - 1383nm
- Apa!





Fiber Attenuation Comparison

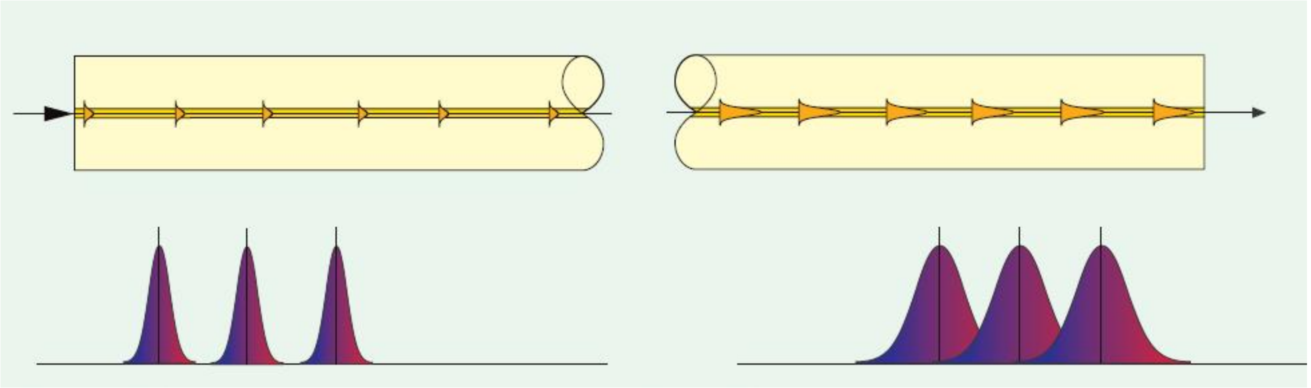
Continuare

Fenomene de interes

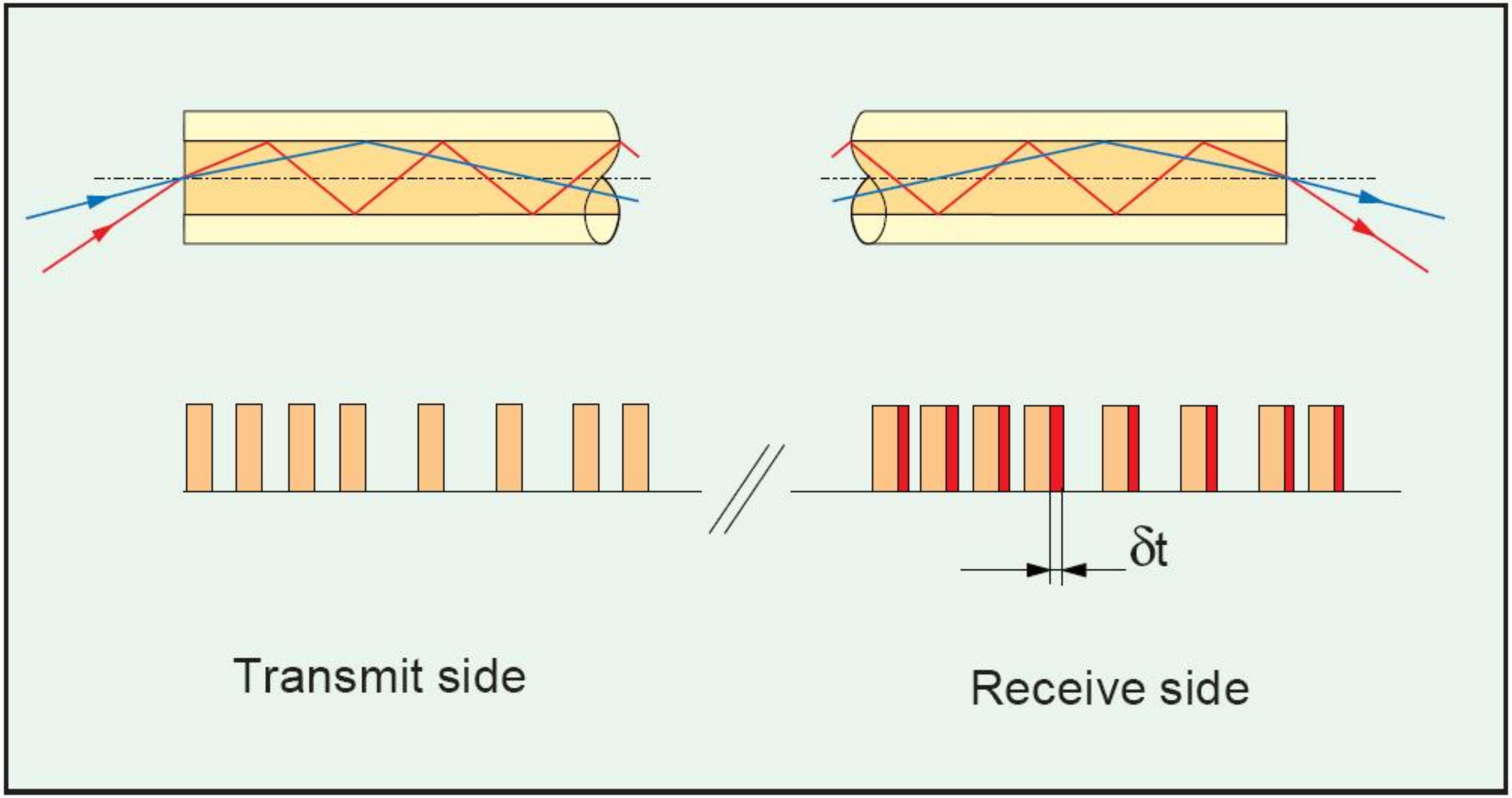
- Cat de departe pot transmite semnalul luminos pe fibra
  - atenuare
- Cat de rapid pot transmite informația
  - **dispersie**

Dispersia

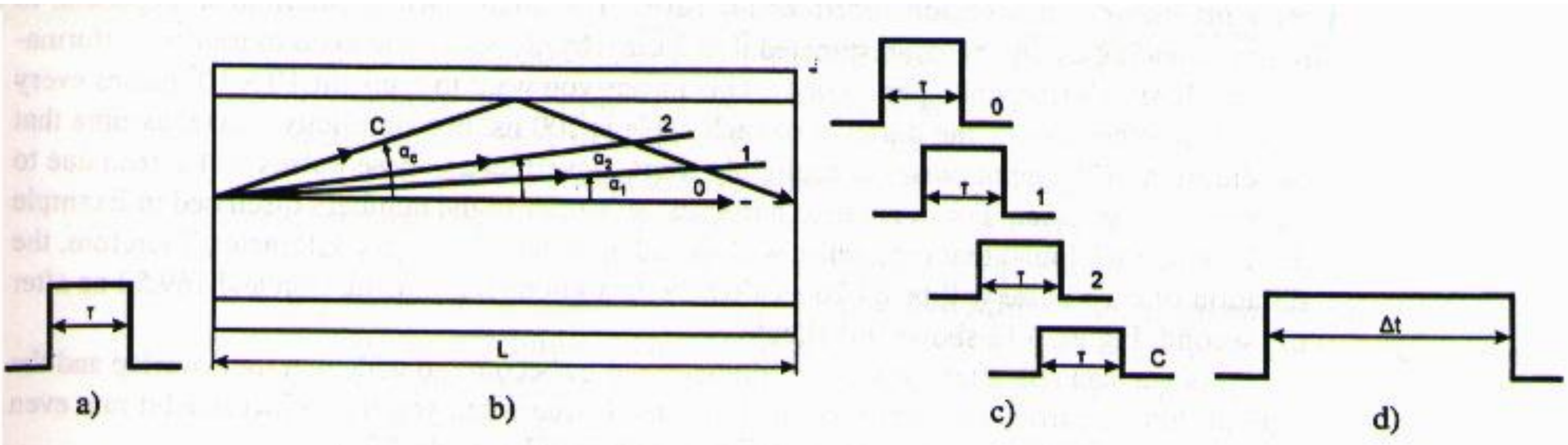
- Propagarea cu viteze diferite a radiatiilor cu lungimi de unda diferite
  - intermodala (modala – depinde de prezenta modurilor)
  - intramodala (cromatica – depinde de lungimea de unda)
    - de material
    - de ghid



Dispersia modala



Dispersia modala



$$t_0 = \frac{L}{v} \qquad t_C = \frac{L}{v \cdot \cos \alpha_C} \qquad v = \frac{c}{n_2} \qquad \cos \alpha_C = NA$$

$$\Delta t_{SI} = t_C - t_0 = \frac{L \cdot n_2}{c} \cdot \left(\frac{n_2 - n_1}{n_2} \right) \qquad \Delta t_{SI} = t_C - t_0 = \frac{L \cdot n_2}{c} \cdot \Delta$$

$$\Delta = \frac{n_2 - n_1}{n_1} << 1 \qquad \Delta t_{SI} = t_C - t_0 \approx \frac{L}{2 \cdot c \cdot n_2} \cdot (NA)^2$$

Dispersia modala

- salt de indice

$$dt = \frac{L \cdot n_2^2}{c \cdot n_1}\left(\frac{n_2 - n_1}{n_2}\right) \approx \frac{L \cdot NA^2}{2 \cdot c \cdot n_2}$$

intarzierea intre moduri cand $\Delta = \frac{n_2 - n_1}{n_1} << 1$

$$\Delta\tau_{\mathrm{mod}}^2 = \frac{1}{3}\left(\frac{dt}{2}\right)^2$$

$$\Delta\tau_{\mathrm{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

- indice gradat

$$dt = \frac{L \cdot n_2 \cdot \Delta^2}{2c} \approx \frac{L \cdot NA^4}{8 \cdot c \cdot n_2^3}$$

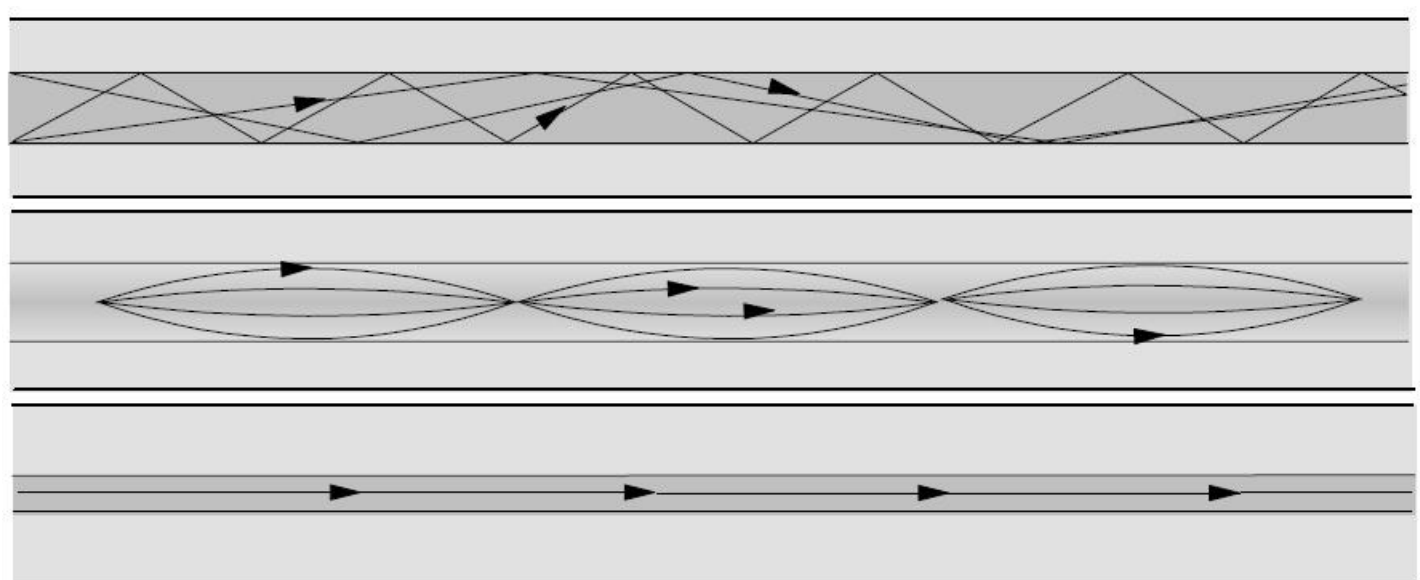
$$\Delta\tau_{\mathrm{mod}} \cong \frac{L \cdot n_2 \cdot \Delta^2}{4\sqrt{3} \cdot c}$$

$$NA = 0.1 \div 0.2 < 1$$

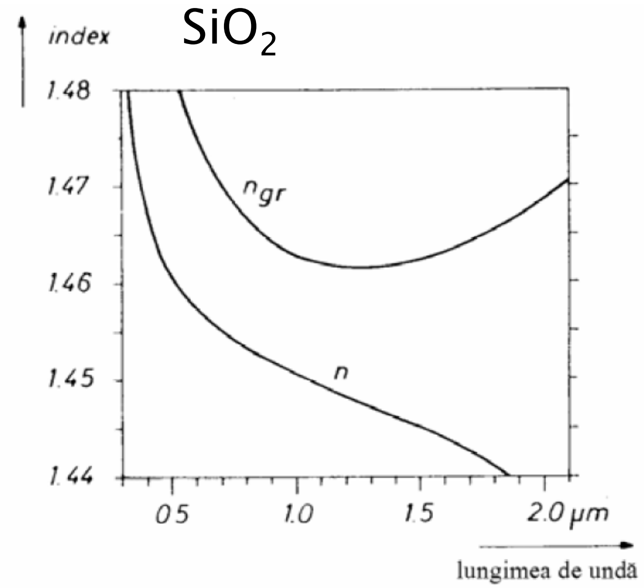
n_2 – miez
n_1 – teaca
$n_2 > n_1$!!

Dispersia modala

- Mai mare la fibre multimod cu salt de indice
- Mai mica la fibre multimod cu indice gradat
  - traseele mai lungi trec prin zone cu indice mai mic
- Inexistenta la fibrele monomod

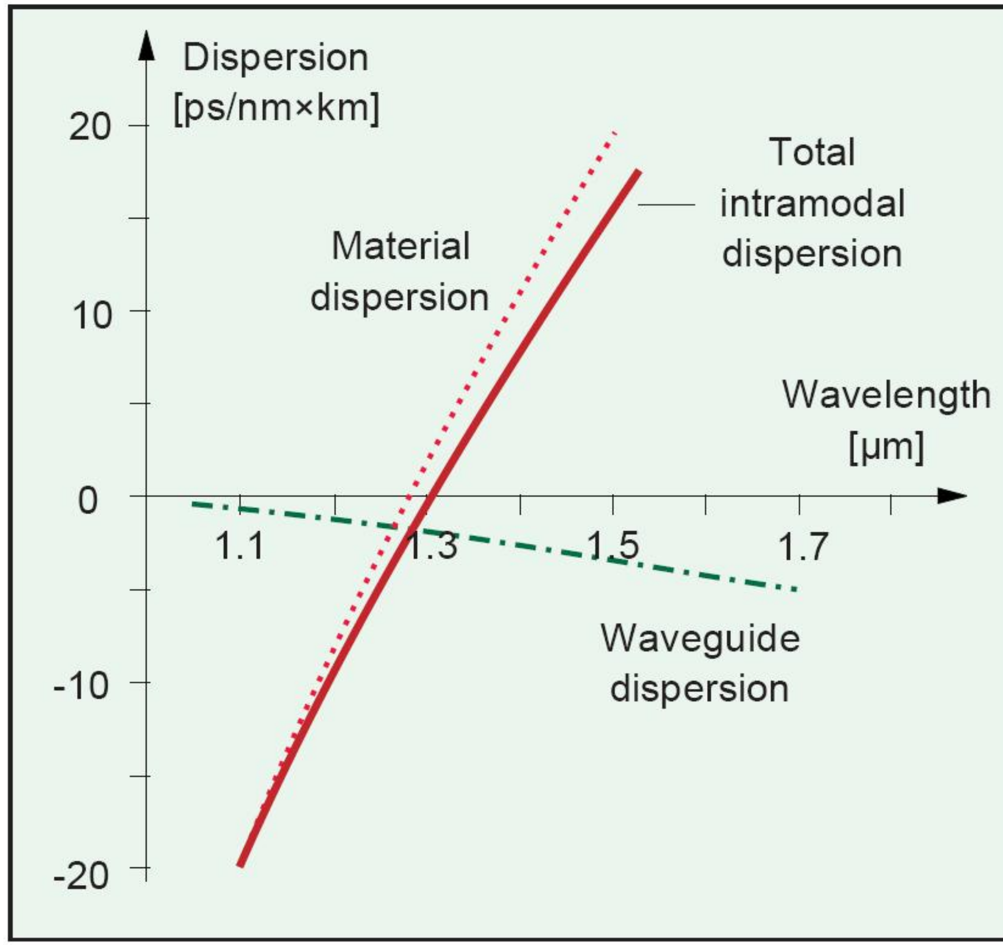


Dispersia de material



$$n_{gr} = n - \lambda \frac{dn}{d\lambda}$$

$$\Delta\tau_{mat} = \frac{L \cdot \lambda \cdot \Delta\lambda}{c} \cdot \frac{d^2 n}{d\lambda^2}$$

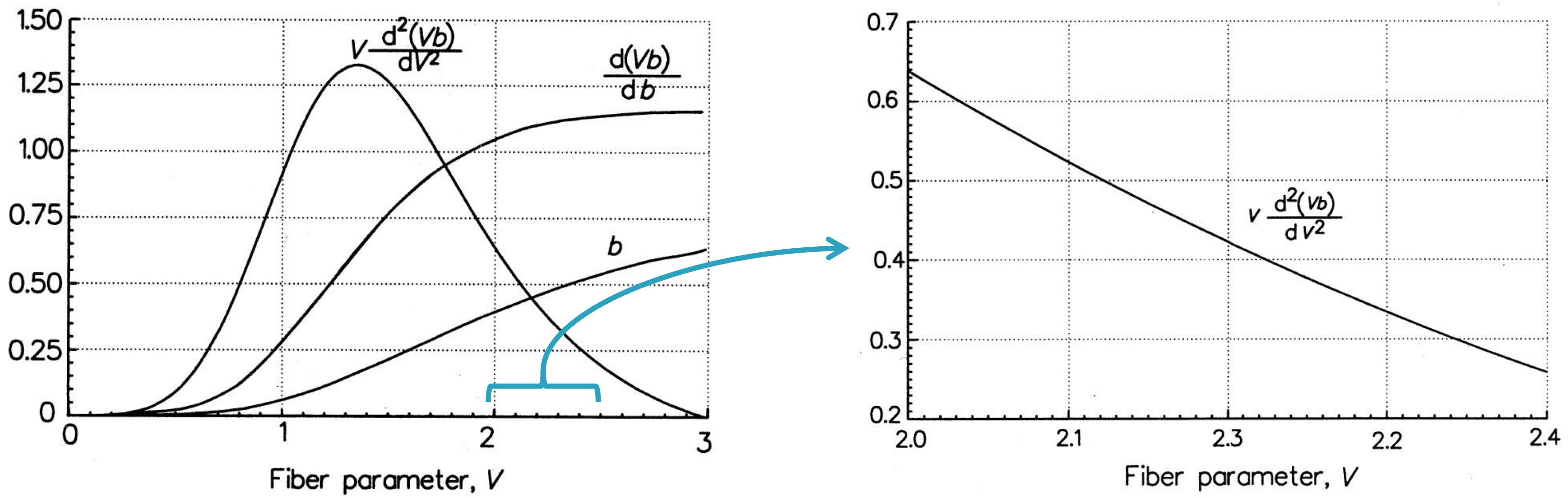


Dispersia de ghid

- Neglijabila in fibrele multimod fata de dispersia modala

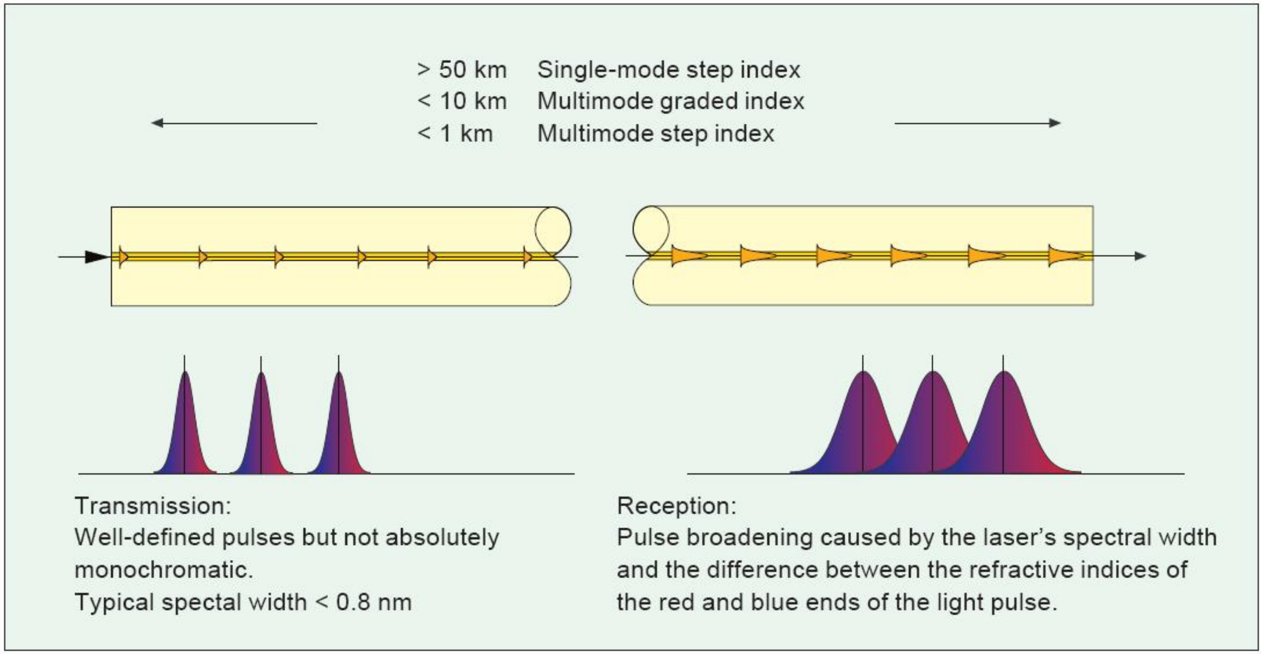
$$\Delta\tau_{gh} = \frac{n \cdot L \cdot \Delta}{c} \cdot \frac{\Delta\lambda}{\lambda} \cdot \left(V \frac{d^2(Vb)}{dV^2} \right)$$

b – constanta de propagare normalizata



$$V \leq V_C = 2.405$$

Dispersia cromatica (gh+mat)



$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$D(\lambda) = \frac{S_0}{4}\cdot\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$

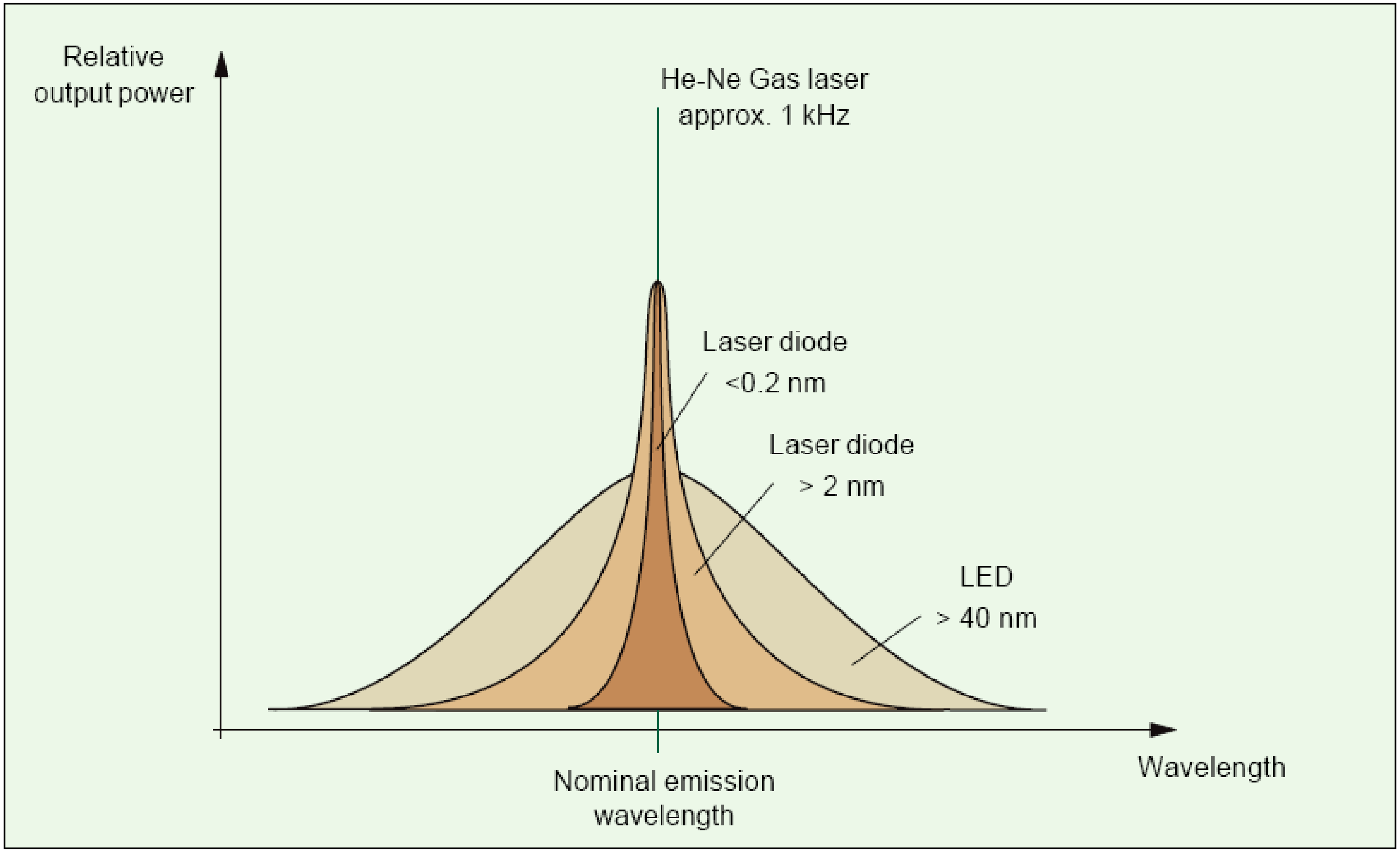
S_0 panta dispersiei – $ps/nm^2/km$

$$D(\lambda_0) = 0$$

- D(λ) ≈ 100 + 0.4 (850 – λ) [ps/nm/km] pentru 800 < λ < 900 nm
- D(λ) ≤ 3,5 ps/nm/km pentru 1285 < λ < 1330 nm
- D(λ) ≤ 17 ps/nm/km pentru 1525 < λ < 1575 nm

$$D(\lambda) = \frac{S_0}{4}\cdot\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$

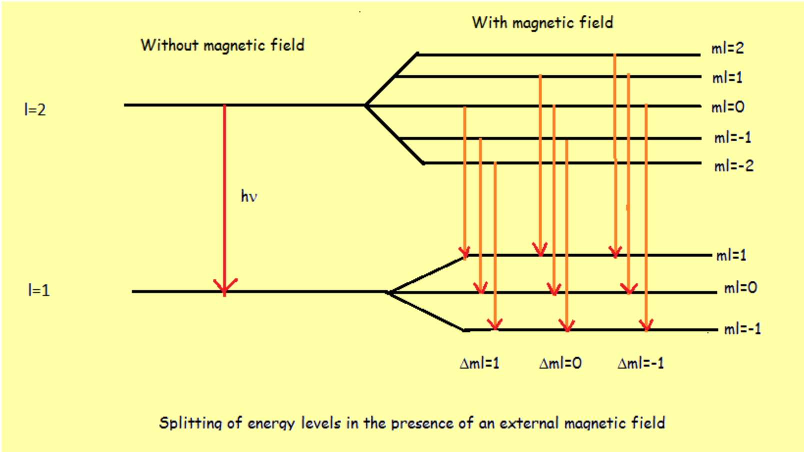
Calitatea spectrală a emiţătorilor optici



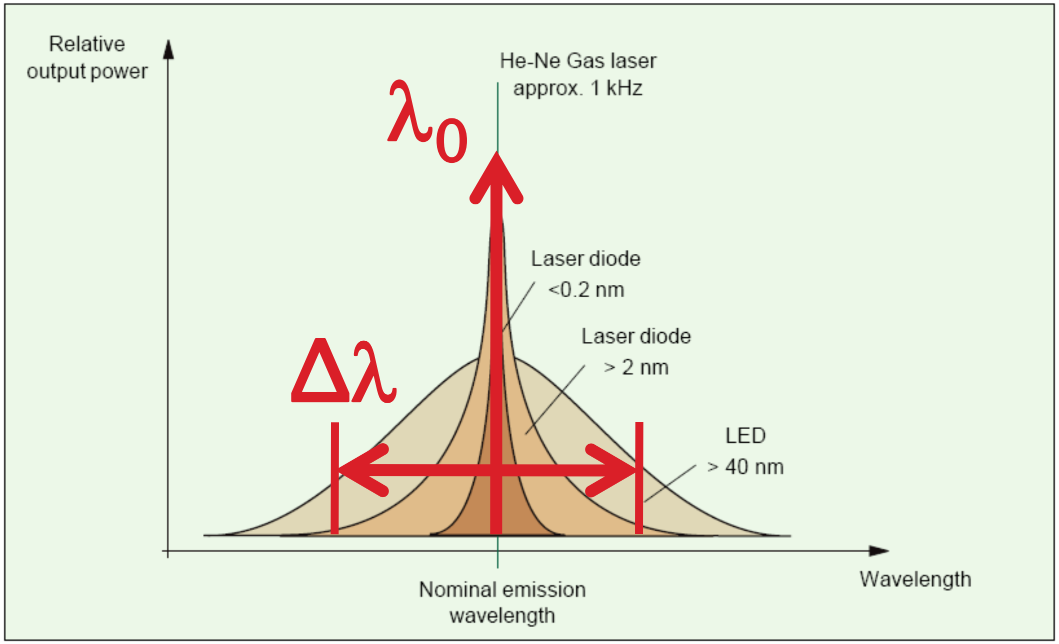
Calitatea spectrală a emiţătorilor optici

- degenerarea nivelelor energetice duce la aparitia benzilor energetice

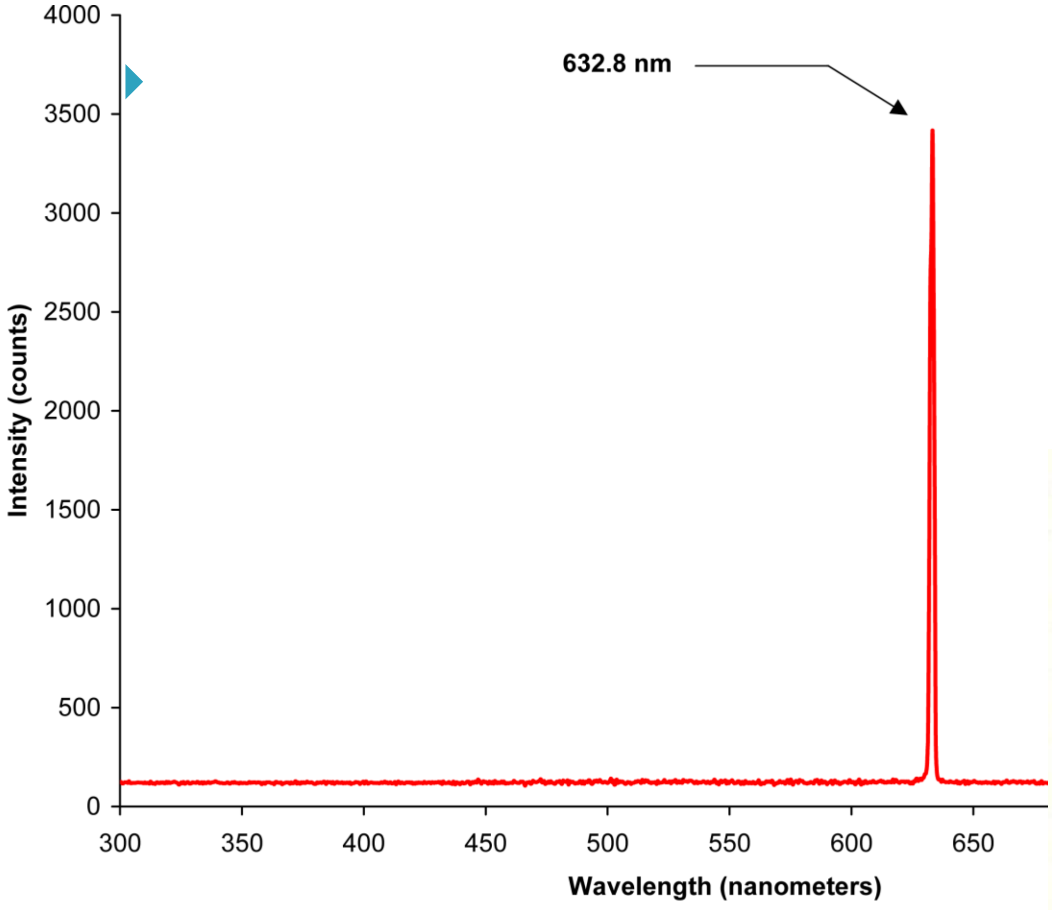
- Multitudinea de tranzitii posibile intre cate doua nivele situate in benzi energetice diferite duce la largirea caracteristicii spectrale a surselor

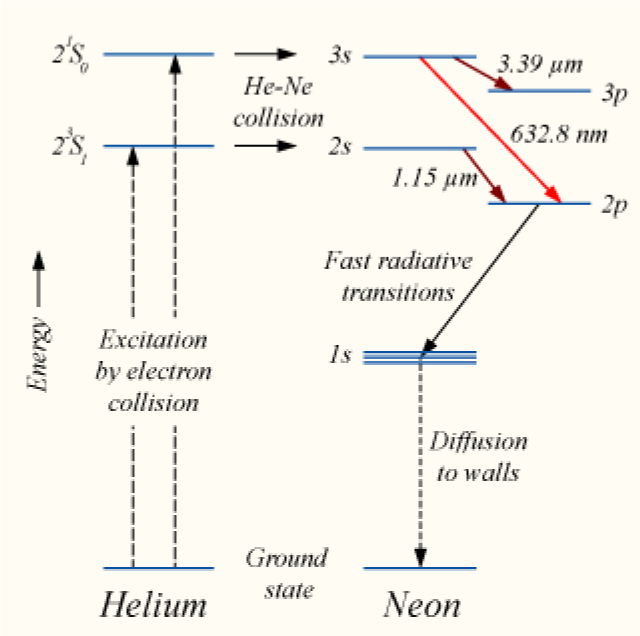


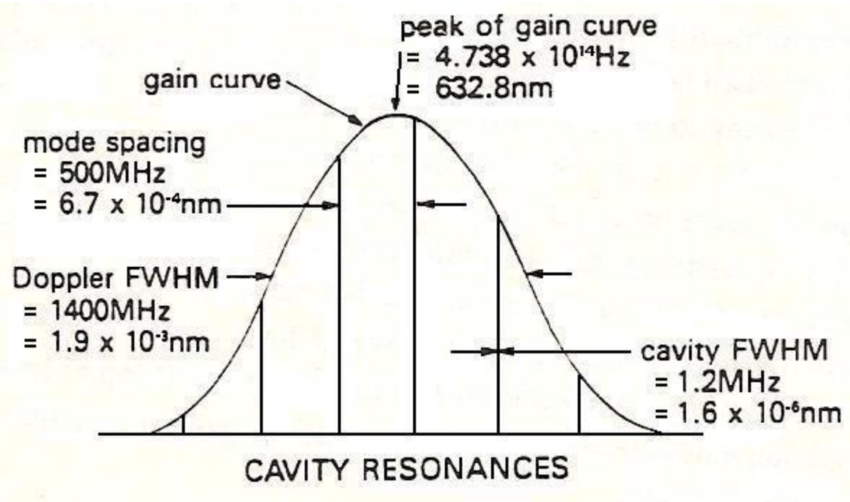
$$\lambda_0 \rightarrow \left[\lambda_0 - \frac{\Delta\lambda}{2}, \lambda_0 + \frac{\Delta\lambda}{2} \right]$$



He–Ne Laser

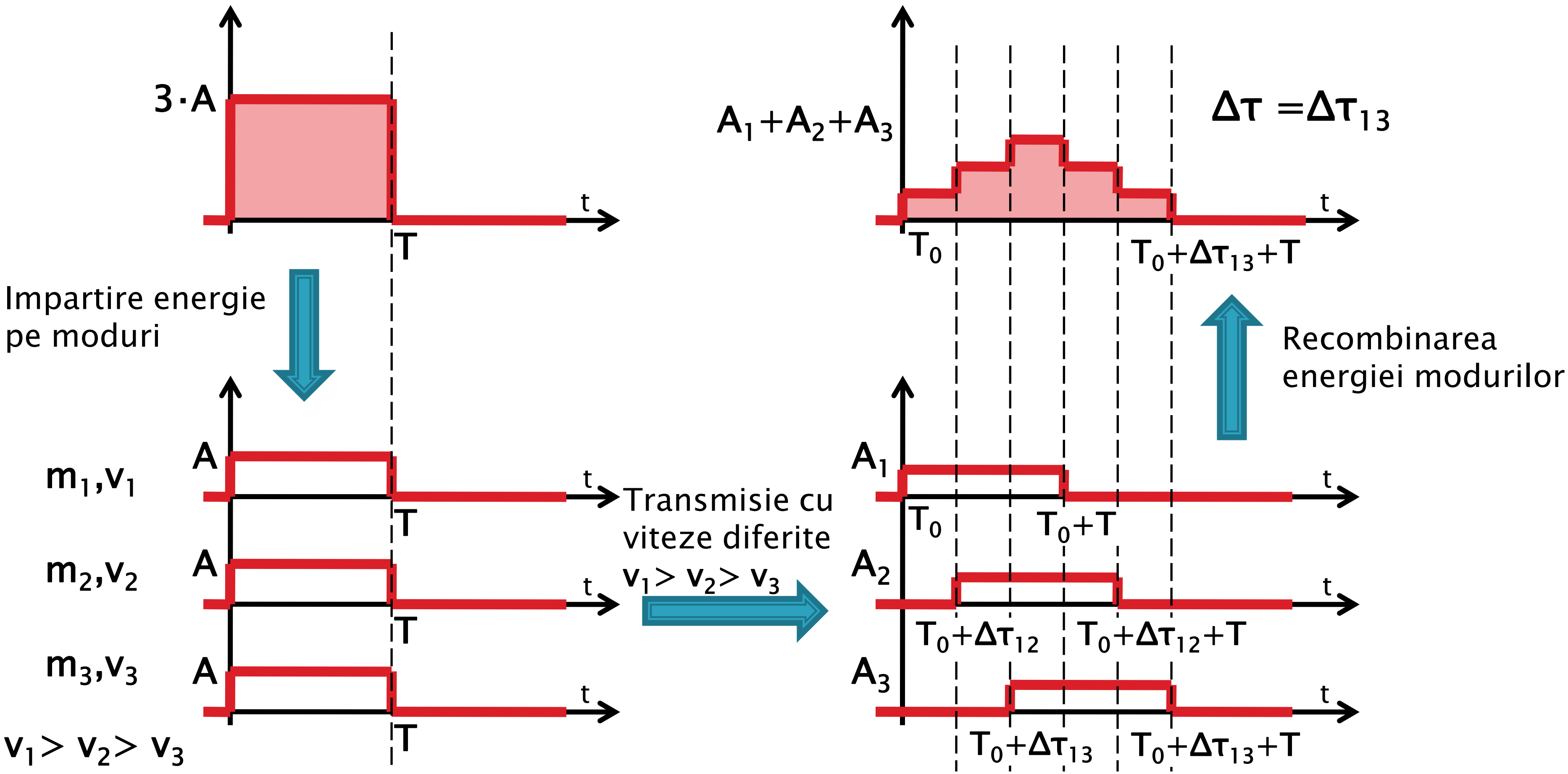






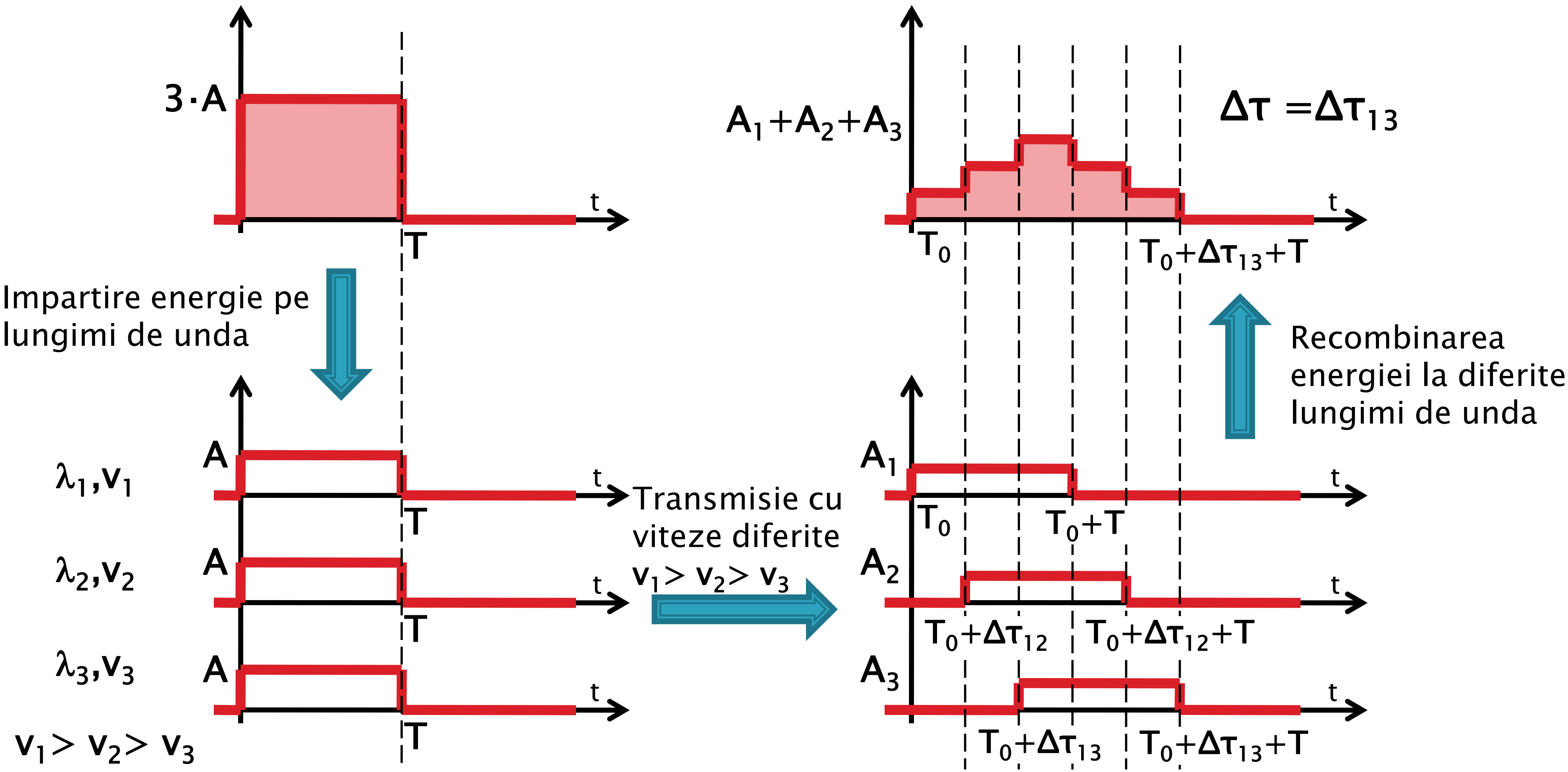
$$\Delta\lambda = 0.002\ nm$$

Dispersia modala



Conceptual→ $f(t)=\int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}d\omega$

Dispersia cromatica (gh+mat)

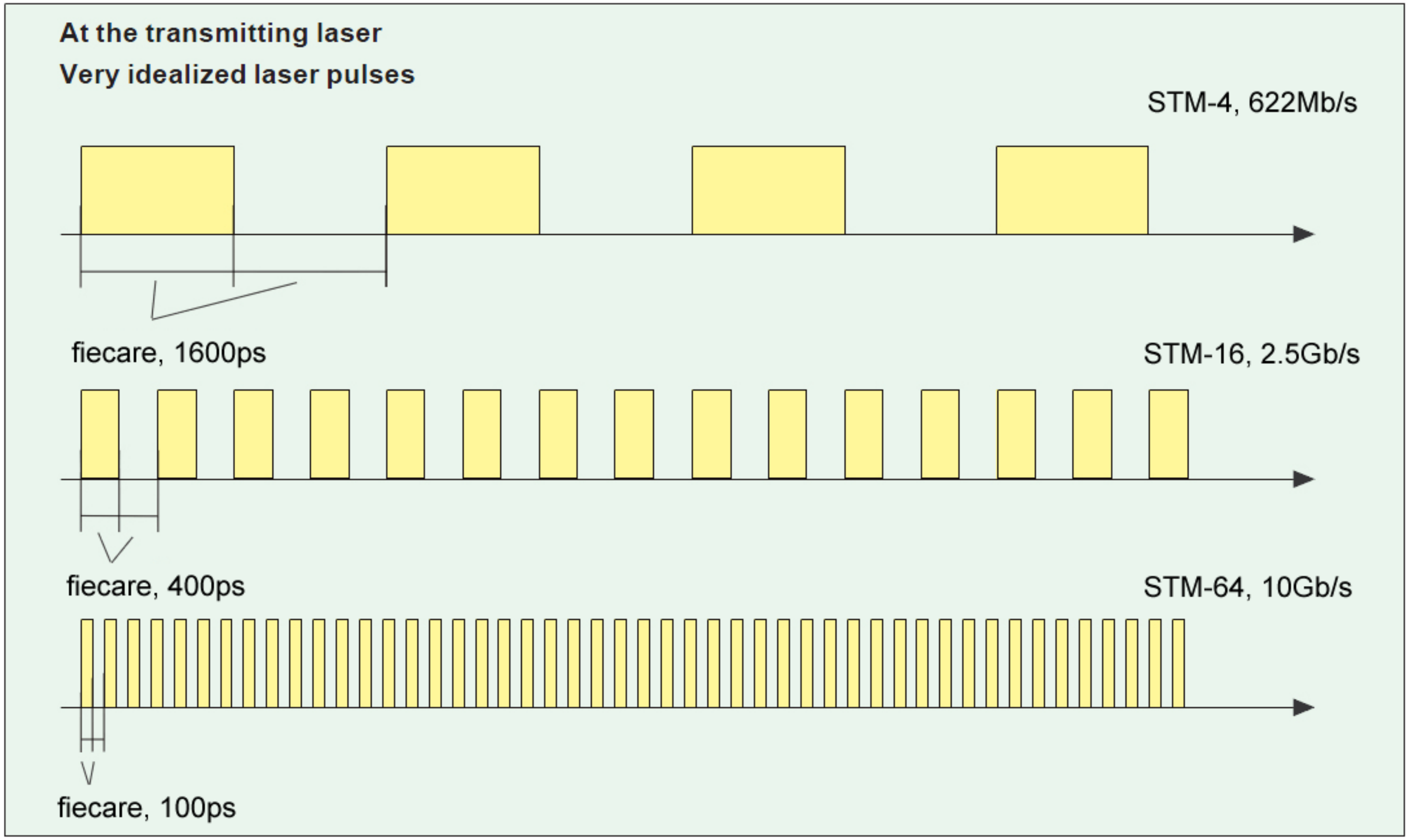


Efectiv→ $f(t)=\int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}d\omega$

Dispersie exemplu – 1

- transmisii cu viteze diferite

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$



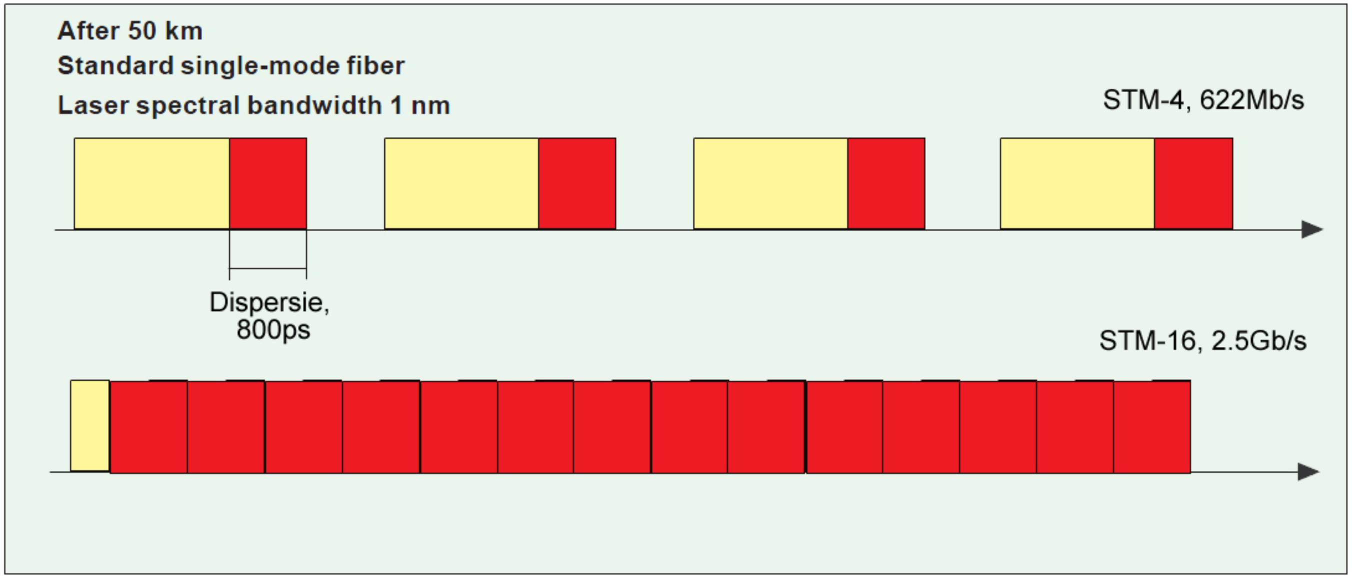
Dispersie exemplu – 2

- 1550nm
- Efectul **sursei**
  - fibra monomod cu dispersia 16ps/nm/km@1550
  - latimea spectrala a sursei Δλ=1nm
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 16\cdot1\cdot50\,ps = 800\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



100<400<800<1600

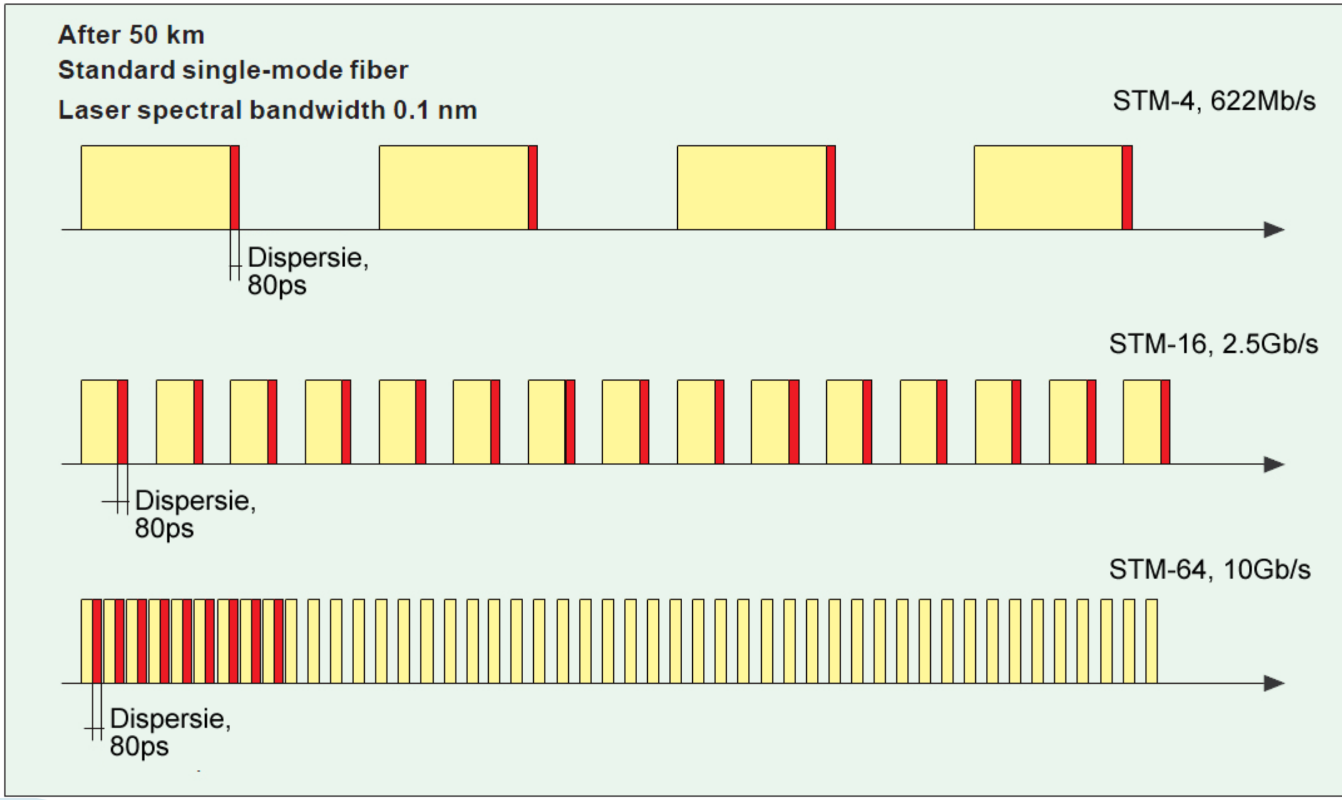
Dispersie exemplu – 3

- 1550nm
- Efectul **sursei**
  - fibra monomod cu dispersia 16ps/nm/km@1550
  - latimea spectrala a sursei **Δλ=0.1nm**
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 16\cdot 0.1\cdot 50\,ps = 80\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



100≈80<400<1600

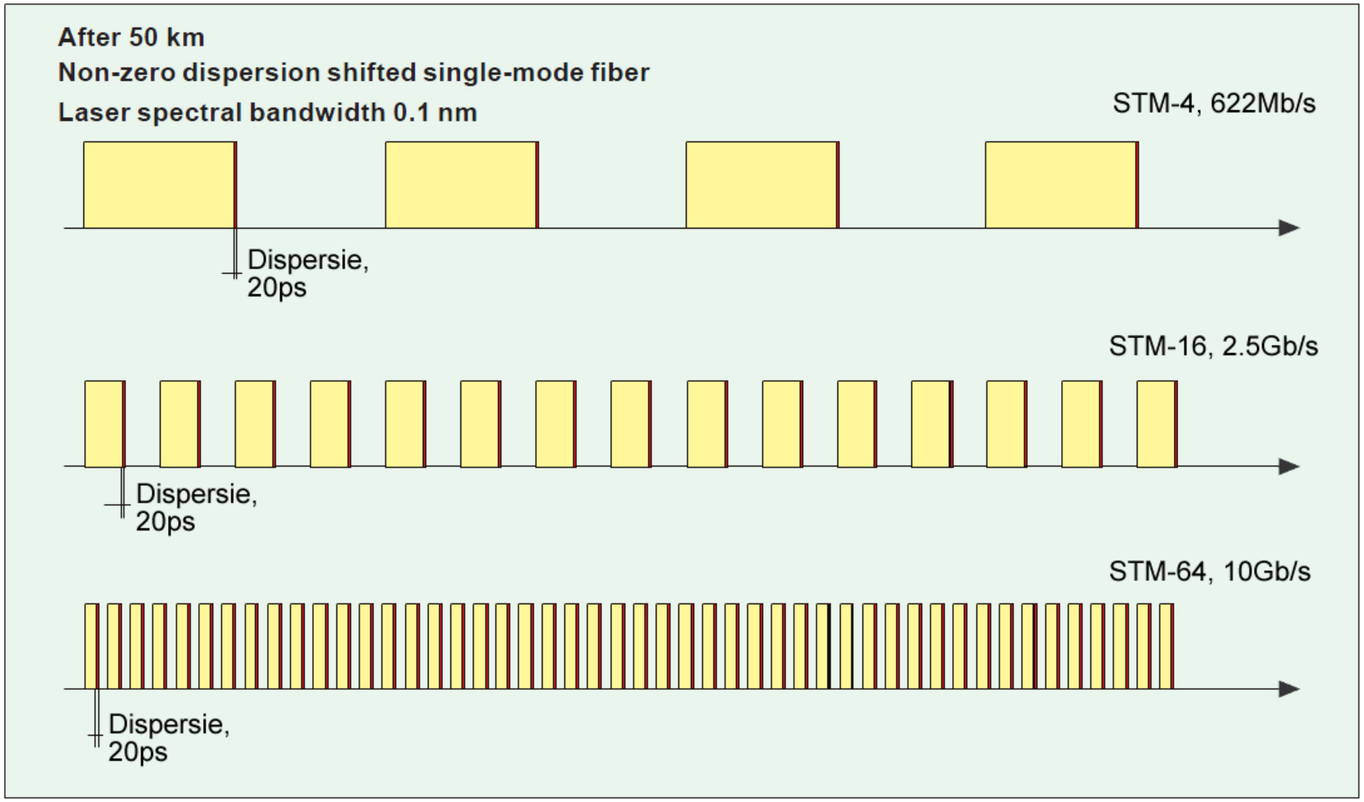
Dispersie exemplu – 4

- Efectul **fibrei**
  - fibra cu dipersie deplasata: **4ps**/nm/km@1550
  - latimea spectrala a sursei Δλ=0.1nm
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 4\cdot 0.1\cdot 50\,ps = 20\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



20<100<400<1600

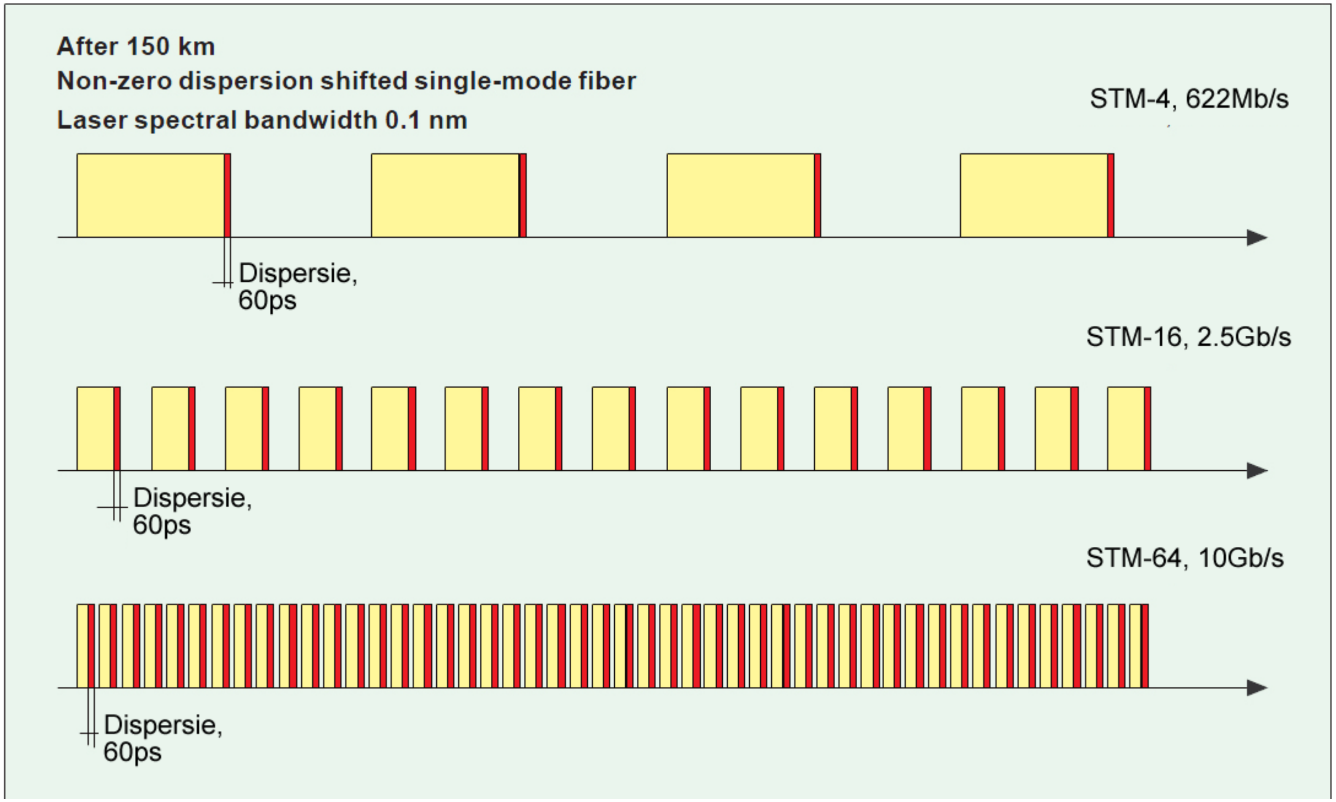
Dispersie exemplu – 5

- Efectul **fibrei**
  - fibra cu dipersie deplasata: 4ps/nm/km@1550
  - latimea spectrala a sursei Δλ=0.1nm
  - 150km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 4\cdot 0.1\cdot 150\,ps = 60\,ps$$

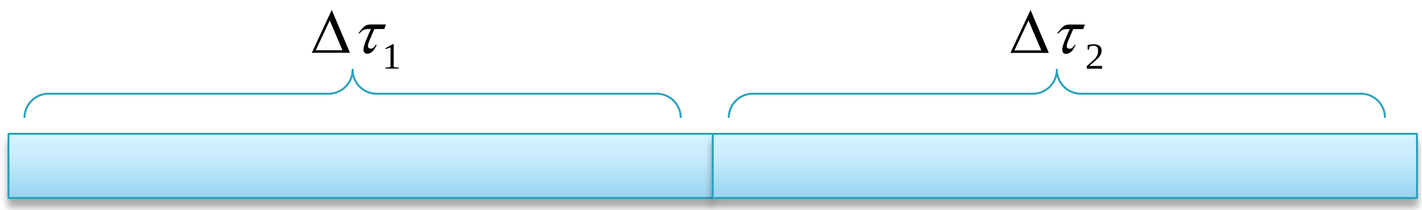
$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



60<100<400<1600

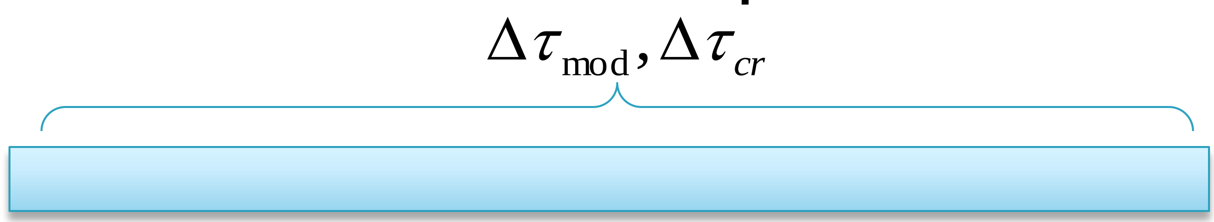
Sumarea efectelor

- efecte **succesive** se adună liniar



$$\Delta\tau_{tot} = \Delta\tau_1 + \Delta\tau_2$$

- efecte **simultane** se adună pătratic



$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\mathrm{mod}}^2}$$

Dispersia

- Dispersia modala
  - salt de indice

$$\Delta\tau_{\mathrm{mod}} \cong \frac{L\cdot n_2\cdot\Delta}{2\sqrt{3}\cdot c} \approx \frac{L\cdot NA^2}{4\sqrt{3}\cdot c\cdot n_2}$$

  - indice gradat

$$\Delta\tau_{\mathrm{mod}} \cong \frac{L\cdot n_2\cdot\Delta^2}{4\sqrt{3}\cdot c} \cong \frac{L\cdot NA^4}{16\sqrt{3}\cdot c\cdot n_2^3}$$

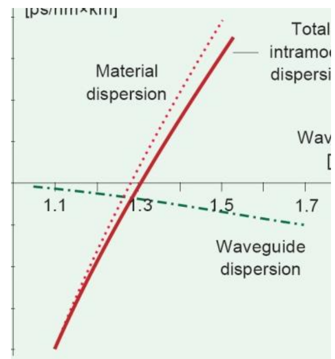
$$\Delta = 0.01 \div 0.02 << 1$$

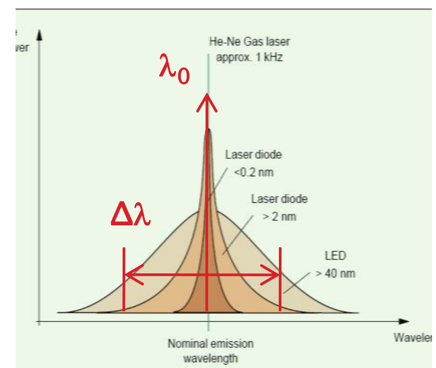
$$NA = 0.1 \div 0.2 < 1$$

- Dispersia cromatica

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\mathrm{D}(\lambda) = \frac{\mathrm{S}_0}{4}\cdot\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$





$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\mathrm{mod}}^2}$$

Banda

- Dispersia totala

$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\text{mod}}^2} \quad \text{sau} \quad \Delta\tau_{tot} = \Delta\tau_1 + \Delta\tau_2$$

- Banda

$$B_{opt} \cong \frac{0.44}{\Delta\tau_{tot}[ns]} \quad [GHz]$$

- Banda optica la 3 dB corespunde unei benzi electrice la 6 dB
  - $P_{opt} \sim I; \quad P_{el} \sim I^2$ $\qquad B_{opt} = \sqrt{2}B_{el}$
- Viteza legaturii

$$V[Gb/s] \cong 2 \cdot B_{el}[GHz]$$

Produs Banda · Distanta

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\text{mod}}^2}$$

$$\Delta\tau_{cr} = D(\lambda) \cdot \Delta\lambda \cdot L$$

$$\Delta\tau_{tot} = const \cdot L$$

$$B_{opt} = \frac{0.44}{\Delta\tau_{tot}[ns]} \quad [GHz]$$

$$B_{opt} = \sqrt{2} B_{el}$$

$$V[Gb/s] \cong 2 \cdot B_{el}$$

$$V[Gb/s] \cong \frac{const}{L}$$

$$V[Gb/s] \cdot L[km] \cong const$$

Produs Banda X Distanta

$$\Delta\tau_{\mathrm{mod}} \sim L \qquad \Delta\tau_{cr} \sim L \qquad \Delta\tau_{tot} \sim L$$

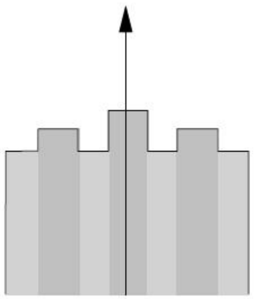
$$V\left[Gb/s\right] \sim B_{el}\left[GHz\right] \sim \frac{1}{\Delta\tau_{tot}} \sim \frac{1}{L[km]}$$

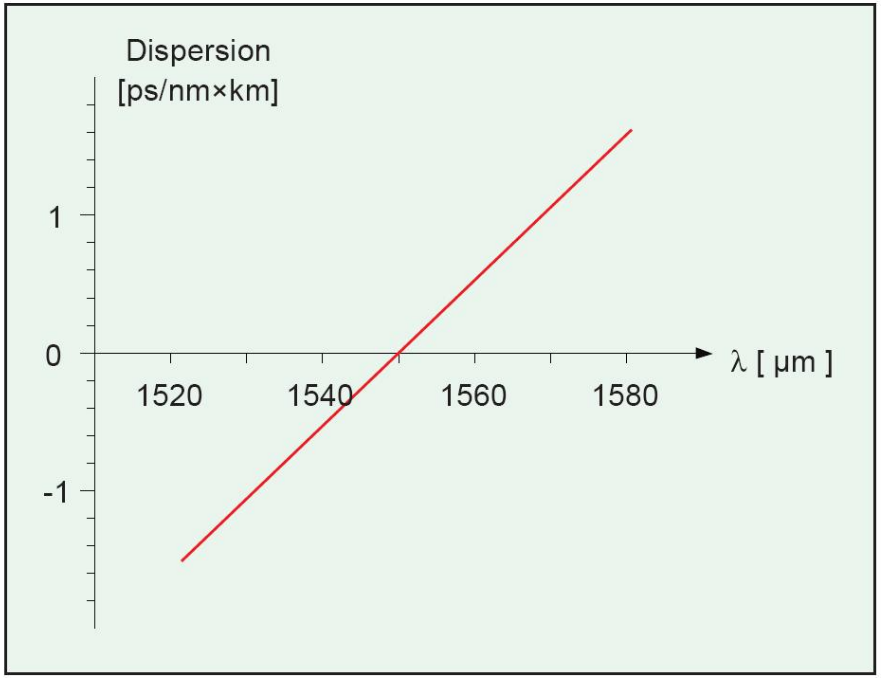
$$V\left[Gb/s\right] \times L[km] = \mathrm{ct.}$$

$$B_{el}\left[MHz\right] \times L[km] = \mathrm{ct.}$$

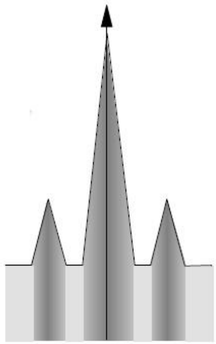
Dispersion shifted fibers

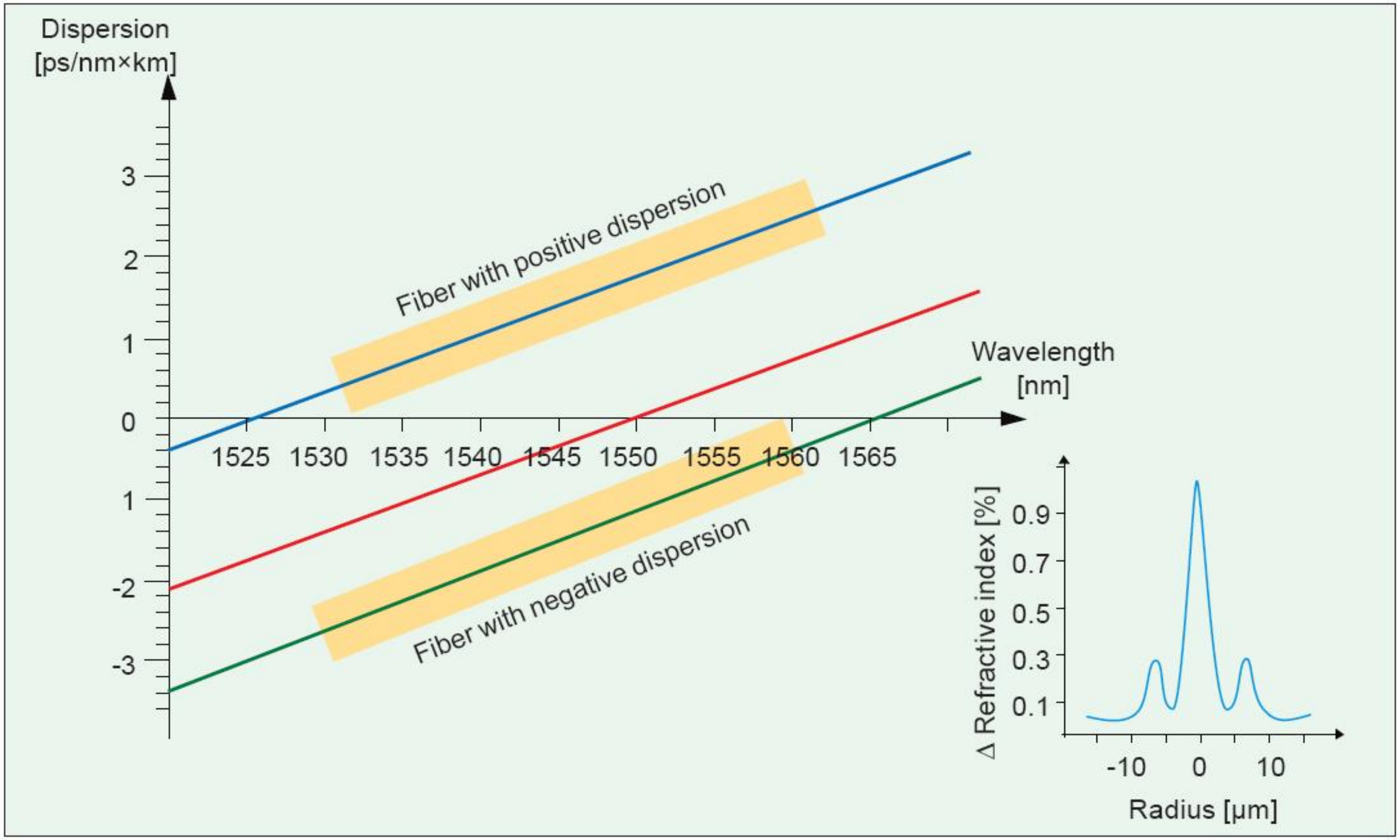
- Sticla are (nativ) dispersie cromatica 0 la 1310nm
- Atenuarea e mai mica la 1550 nm
- EDFA (Erbium doped fibre amplifiers) opereaza in banda 1550nm
- Sistemele WDM (Wavelength division Multiplexing) necestia banda larga amplificata



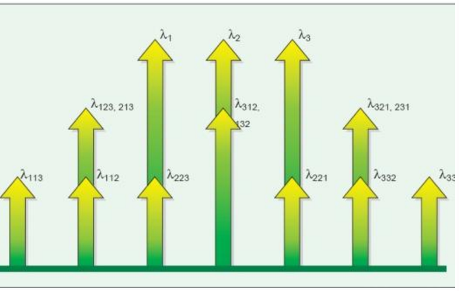


Non-zero Dispersion shifted fibers

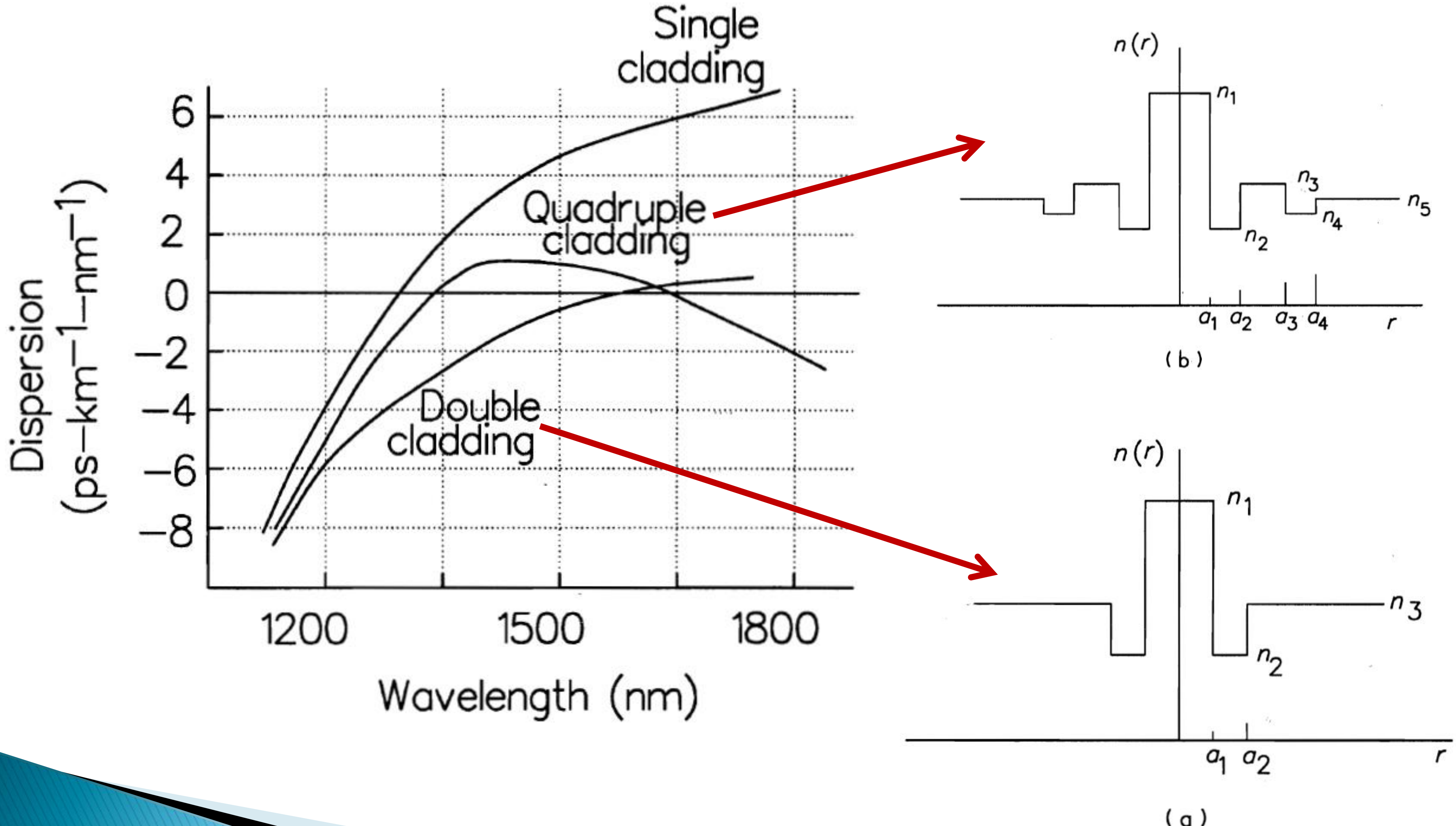




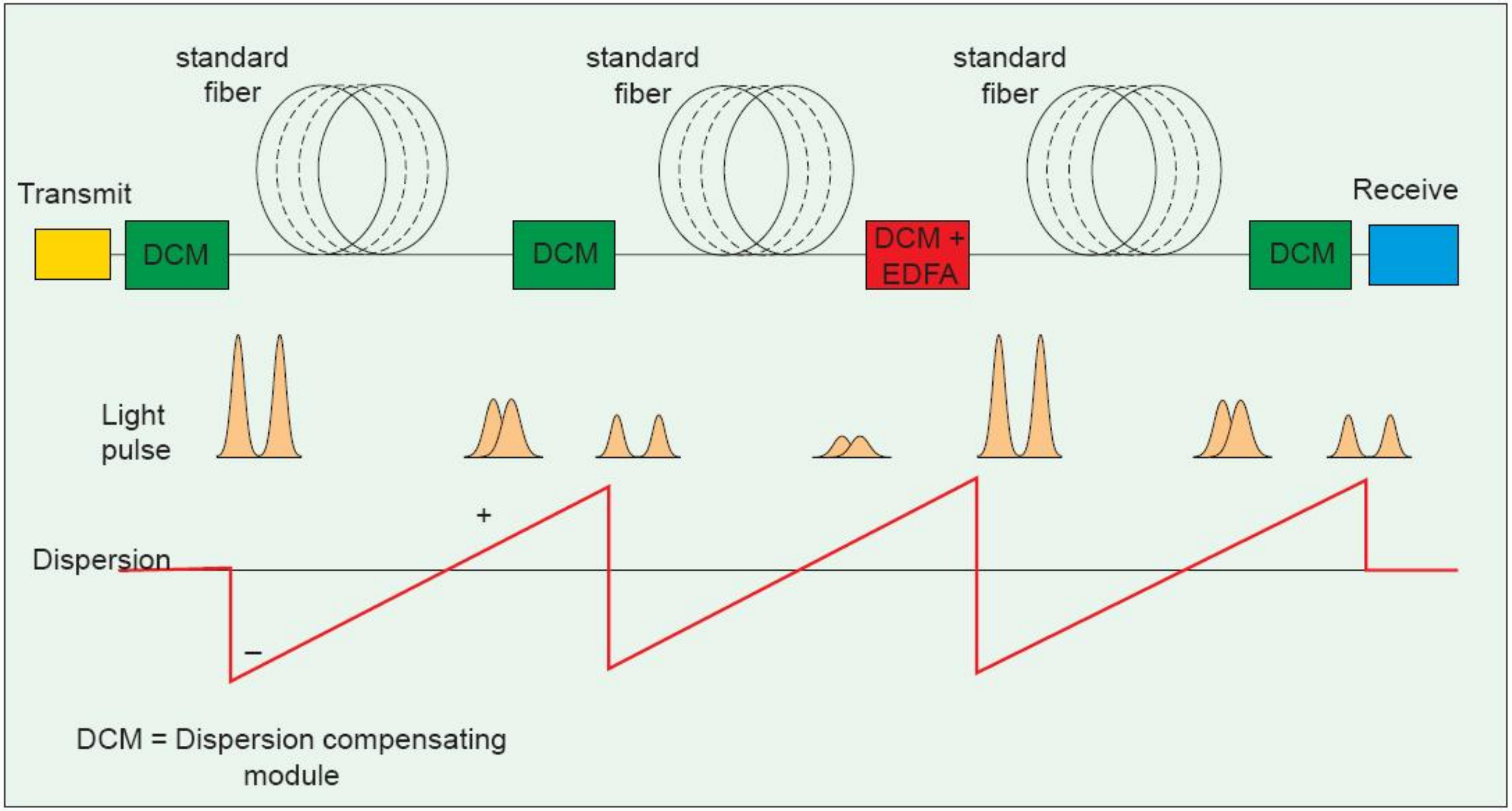
FWM



Dispersion shifted fibers



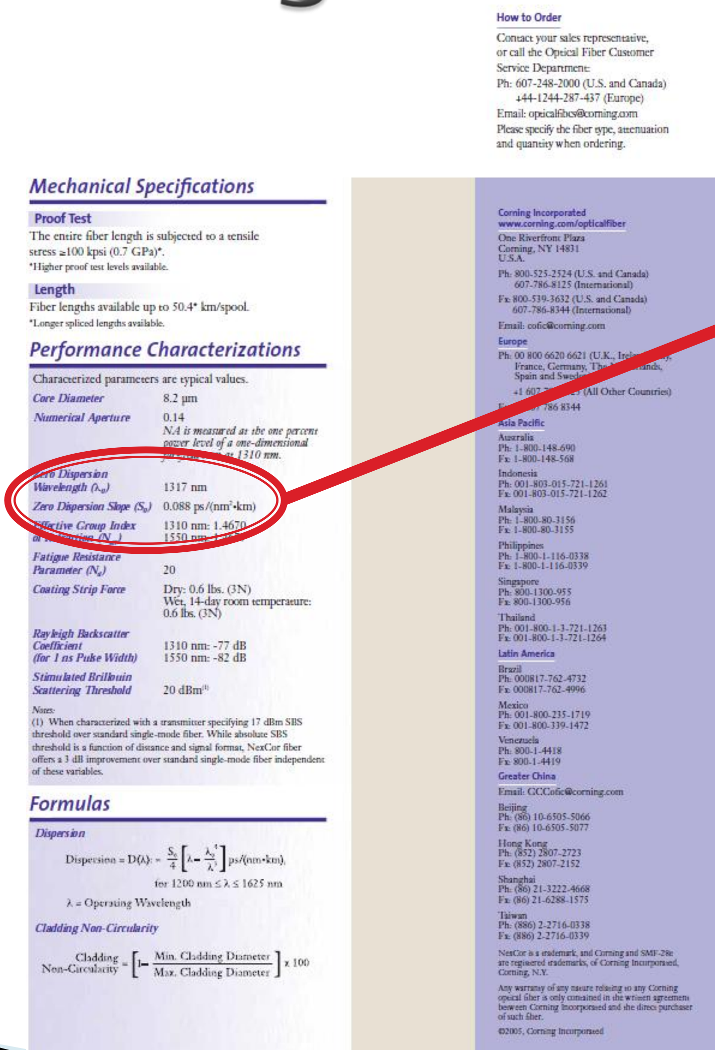
Fibra pentru compensarea dispersiei



- Dispersie: -100 ps/nm/km
- Atenuare 0.5 dB/km

Catalog – monomod

$$D(\lambda) = \frac{S_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$



How to Order

Contact your sales representative, or call the Optical Fiber Customer Service Department:
Ph: 607-248-2000 (U.S. and Canada)
+44-1244-287-437 (Europe)
Email: opticalfibers@corning.com
Please specify the fiber type, attenuation and quantity when ordering.

Mechanical Specifications

Proof Test

The entire fiber length is subjected to a tensile stress ≥100 kpsi (0.7 GPa)*.
*Higher proof test levels available.

Length

Fiber lengths available up to 50.4* km/spool.
*Longer spliced lengths available.

Performance Characterizations

Characterized parameters are typical values.

Core Diameter	8.2 µm
Numerical Aperture	0.14 *NA is measured at the one percent power level of a one-dimensional far-field scan at 1310 nm.*
Zero Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Slope (S_0)	0.088 ps/(nm²•km)
Effective Group Index of Refraction (N_{eff})	1310 nm: 1.4670 1550 nm: [illegible]
Fatigue Resistance Parameter (N_d)	20
Coating Strip Force	Dry: 0.6 lbs. (3N) Wet, 14-day room temperature: 0.6 lbs. (3N)
Rayleigh Backscatter Coefficient (for 1 ns Pulse Width)	1310 nm: -77 dB 1550 nm: -82 dB
Stimulated Brillouin Scattering Threshold	20 dBm[1]

Notes:
(1) When characterized with a transmitter specifying 17 dBm SBS threshold over standard single-mode fiber. While absolute SBS threshold is a function of distance and signal format, NexCor fiber offers a 3 dB improvement over standard single-mode fiber independent of these variables.

Formulas

Dispersion

$$\text{Dispersion} = D(\lambda) := \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)},$$

for $1200 \text{ nm} \le \lambda \le 1625 \text{ nm}$

λ = Operating Wavelength

Cladding Non-Circularity

$$\text{Cladding Non-Circularity} = \left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

Corning Incorporated
www.corning.com/opticalfiber
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Corning, NY 14831
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607-786-8125 (International)
Fx: 800-539-3632 (U.S. and Canada)
607-786-8344 (International)
Email: cofic@corning.com

Europe
Ph: 00 800 6620 6621 (U.K., Irel[illegible], France, Germany, The [illegible]ands, Spain and Swed[illegible]
+1 607 [illegible] (All Other Countries)
F[illegible] 786 8344

Asia Pacific
Australia
Ph: 1-800-148-690
Fx: 1-800-148-568
Indonesia
Ph: 001-803-015-721-1261
Fx: 001-803-015-721-1262
Malaysia
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Fx: 1-800-80-3155
Philippines
Ph: 1-800-1-116-0338
Fx: 1-800-1-116-0339
Singapore
Ph: 800-1300-955
Fx: 800-1300-956
Thailand
Ph: 001-800-1-3-721-1263
Fx: 001-800-1-3-721-1264

Latin America
Brazil
Ph: 000817-762-4732
Fx: 000817-762-4996
Mexico
Ph: 001-800-235-1719
Fx: 001-800-339-1472
Venezuela
Ph: 800-1-4418
Fx: 800-1-4419

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Fx: (86) 10-6505-5077
Hong Kong
Ph: (852) 2807-2723
Fx: (852) 2807-2152
Shanghai
Ph: (86) 21-3222-4668
Fx: (86) 21-6288-1575
Taiwan
Ph: (886) 2-2716-0338
Fx: (886) 2-2716-0339

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Any warranty of any nature relating to any Corning optical fiber is only contained in the written agreement between Corning Incorporated and the direct purchaser of such fiber.

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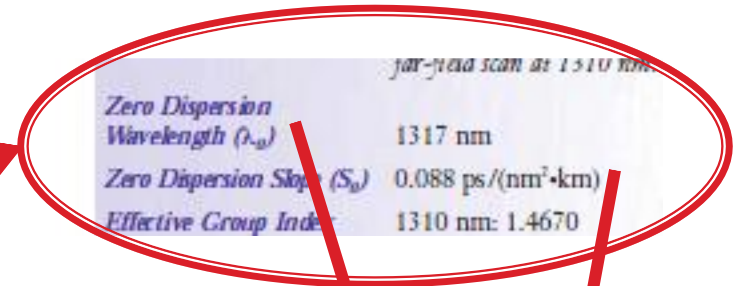
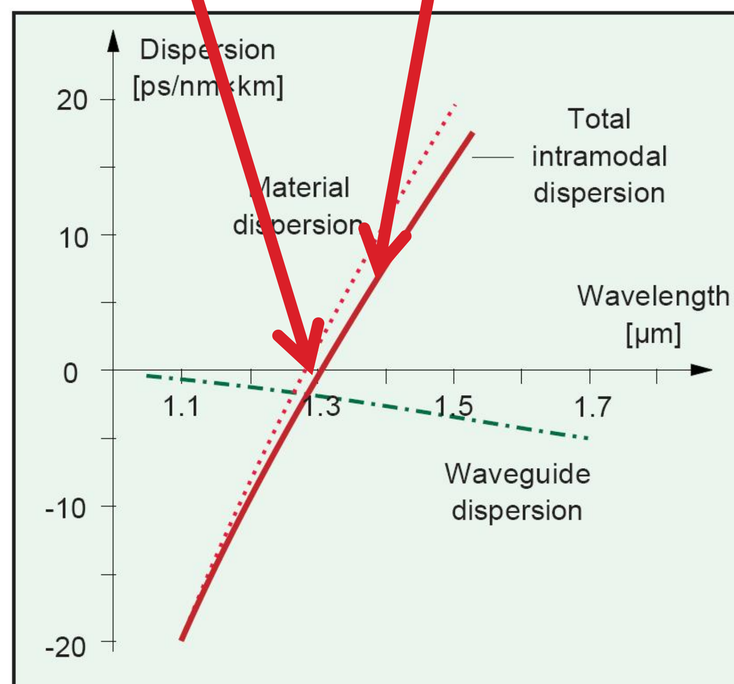




Catalog – multimod

$$D(\lambda) = \frac{S_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$

+

Bandwidth

Standard Bandwidth Cells
850/1300 nm (MHz•km)
400/400
400/600
400/1200
500/500
600/600
600/1000

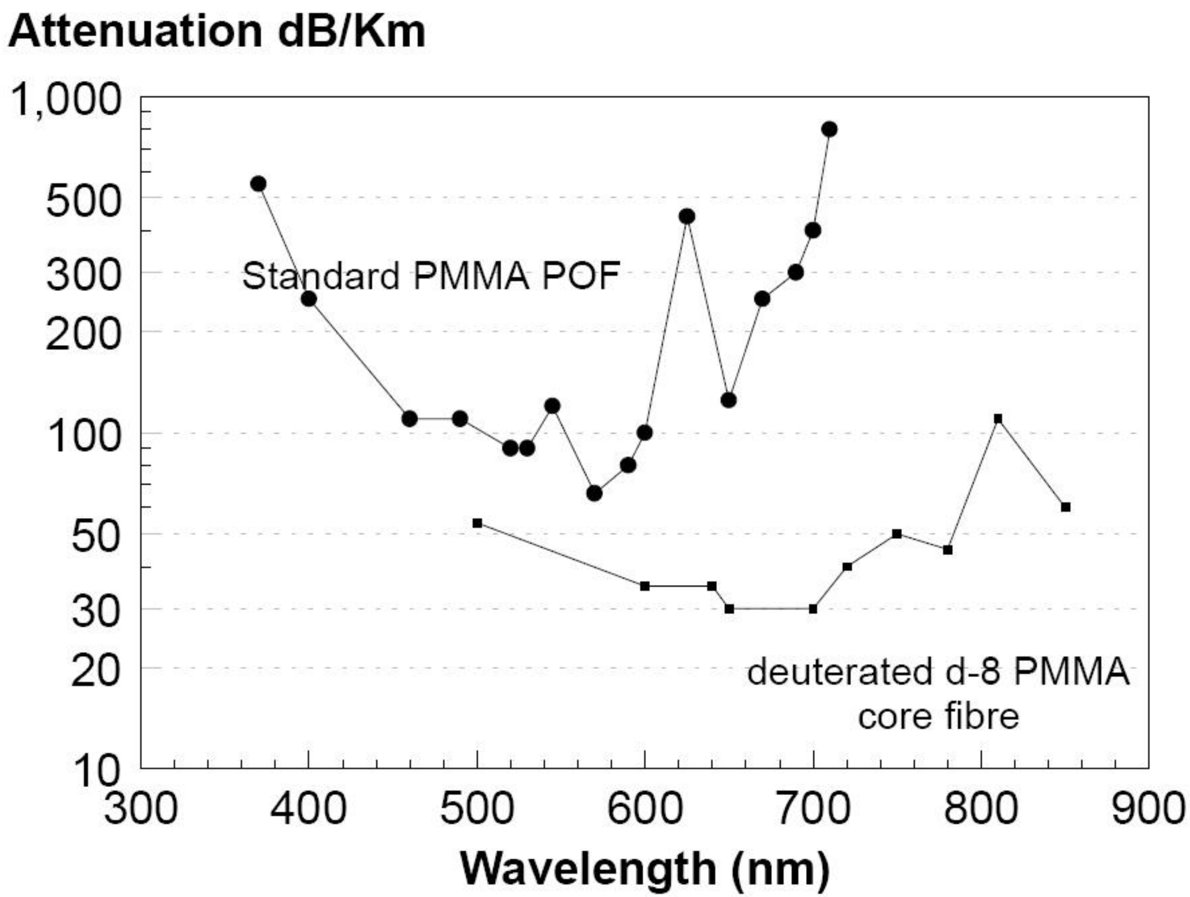
Other bandwidth cells available upon request.

Fibra standard ITU G.652

- Diametru teaca = 125 μm
- MFD = 9÷10 μm la 1300 nm
- λ_C = 1100÷1280 nm
- Pierderi de curbura (la 1550 nm) mai mici de 1 dB pentru 100 spire de fibra rulata pe un mosor cu 7.5 cm diametru
- Dispersia in banda 1300 nm (1285–1330 nm) mai mica de 3.5 ps/nm/km. La 1550 nm dispersia trebuie sa fie mai mica de 20 ps/nm/km
- Viteza de variatie a dispersiei (panta dispersiei S_0) mai mica de 0.095 ps/nm^2/km

ITU (International Telecommunication Union) is the United Nations specialized agency for information and communication technologies – ICTs

Fibra optica din plastic (POF)



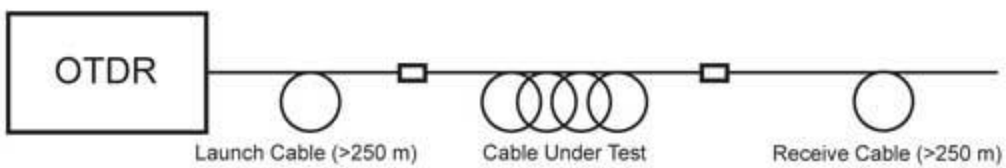
- Atenuare 180 dB/km
- NA = 0.3
- Diametru 1 mm
- Banda 125MHz (100m)

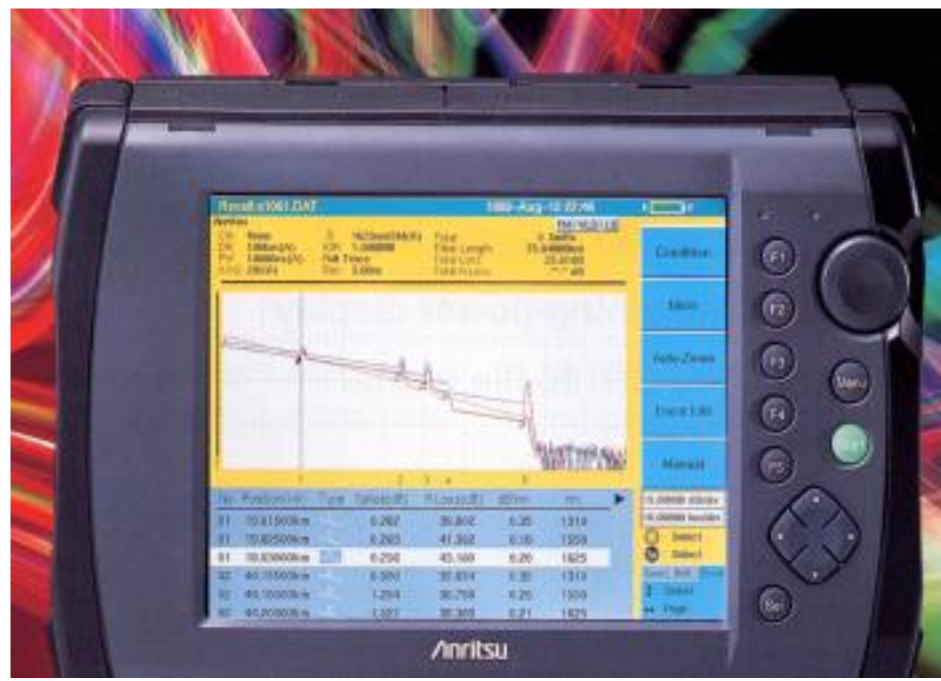
Fibra optică – Tehnologie

Capitolul 5

OTDR

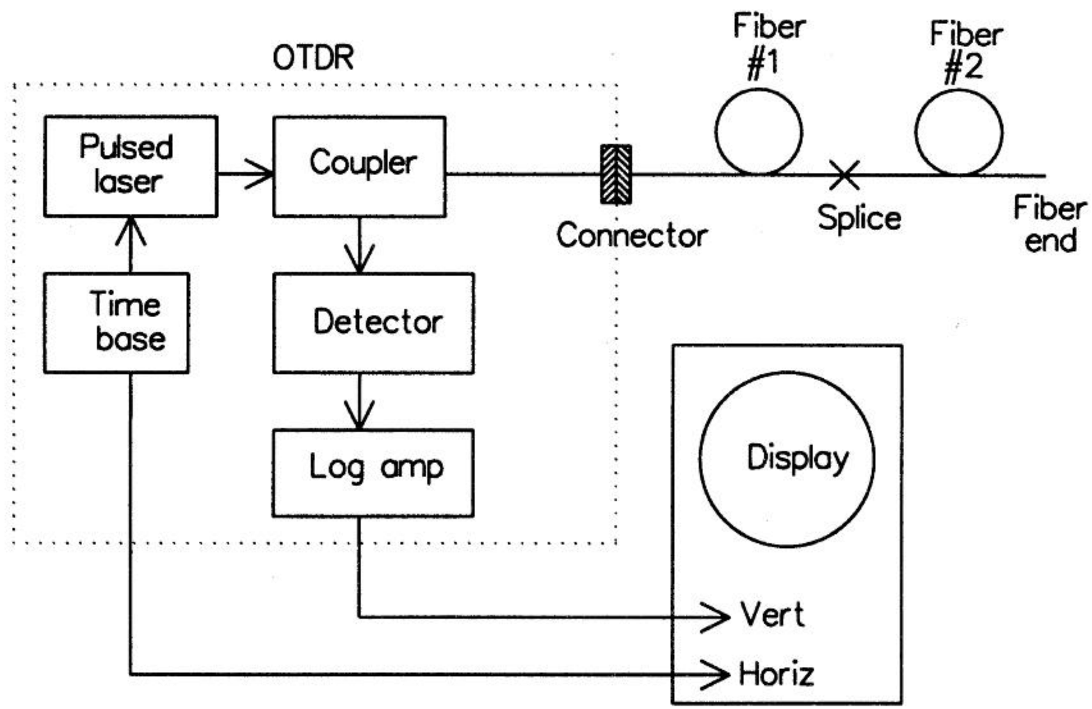
- Optical Time-Domain Reflectometer
- Localizarea defectelor



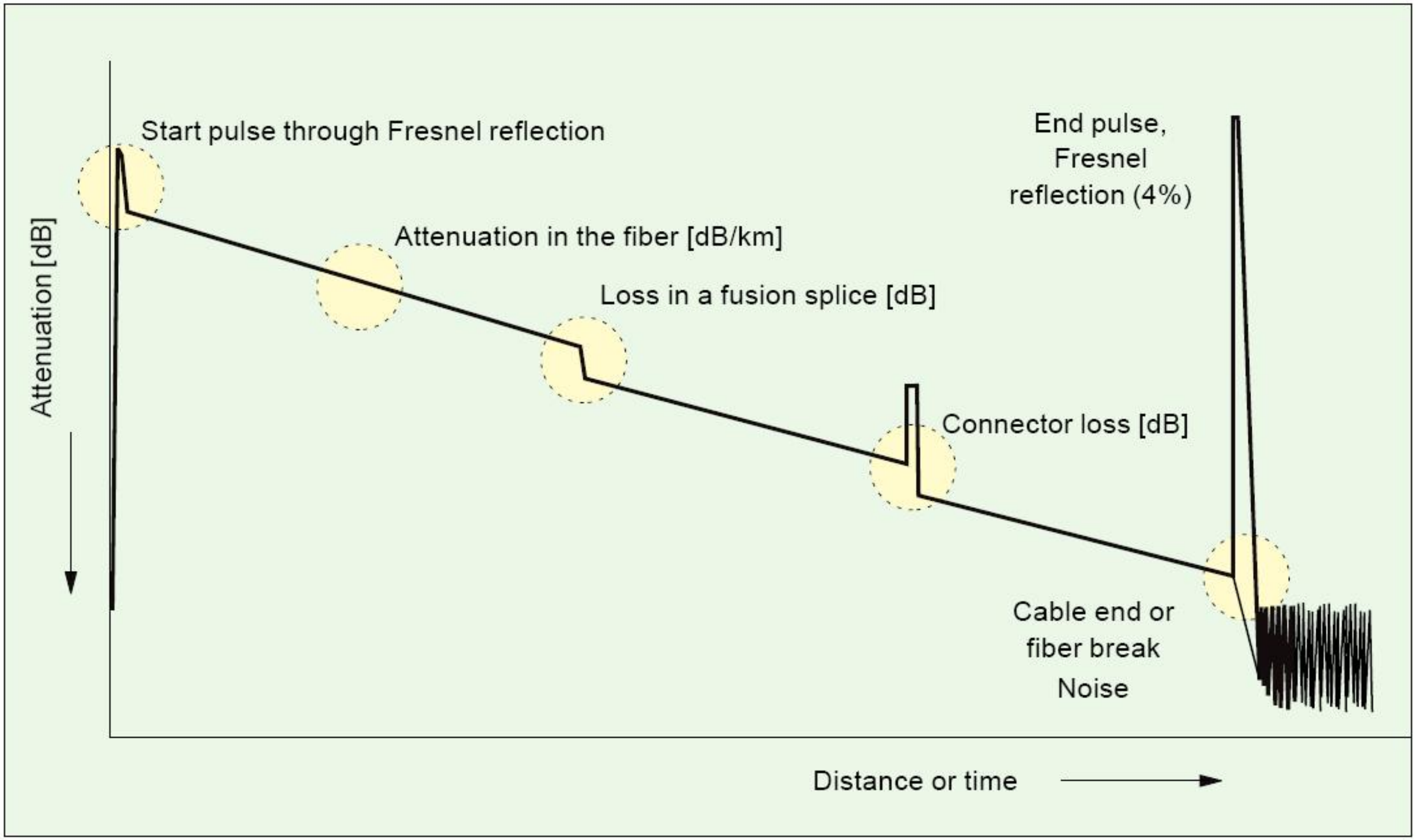


OTDR

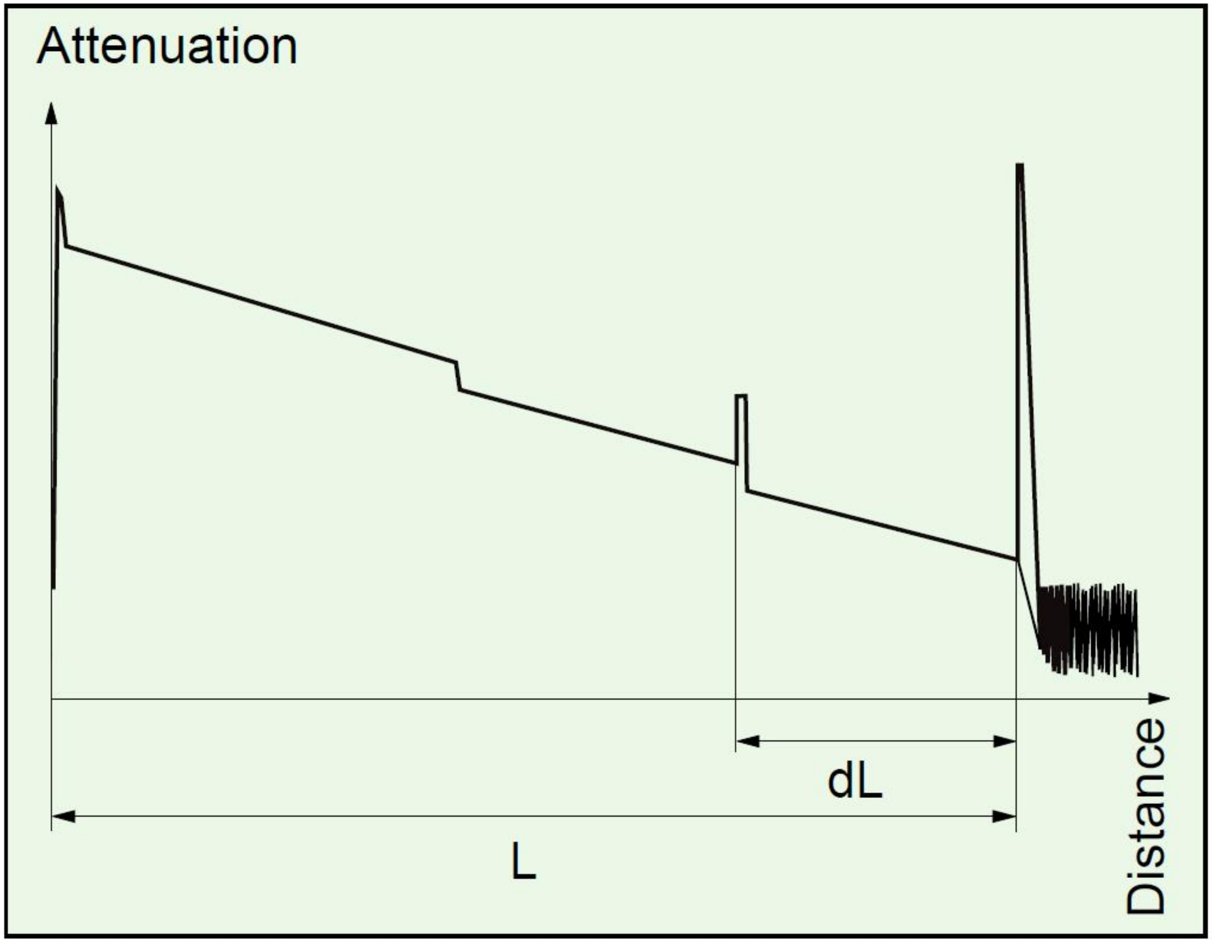
- Optical time-domain reflectometer
- Localizarea defectelor



Rezultat grafic al OTDR



Efecte vizibile OTDR



$$2 \cdot L = c \cdot t$$

$$L = \frac{c_0}{n} \cdot \frac{t}{2}$$

Efecte vizibile OTDR

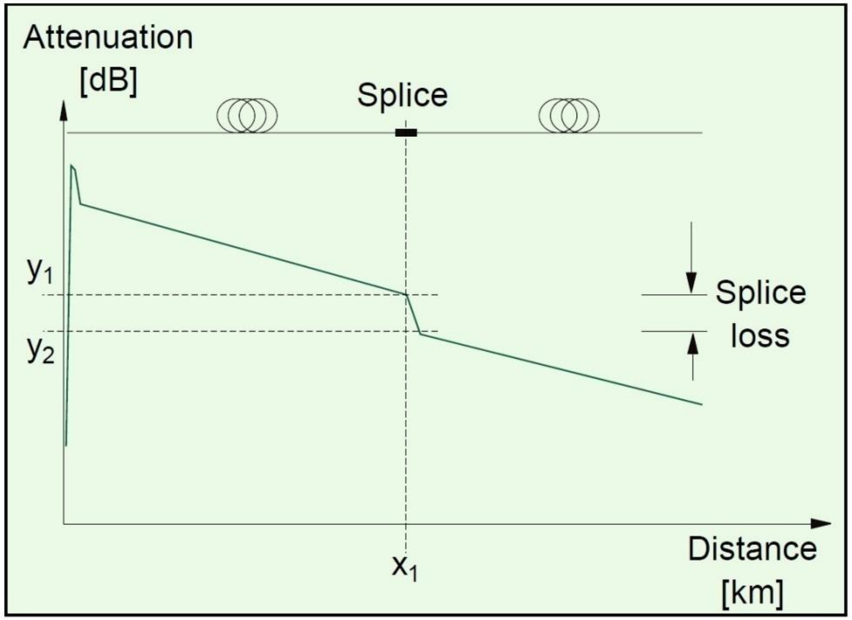
$$A[dB] = \frac{P_1 - P_2}{2}$$

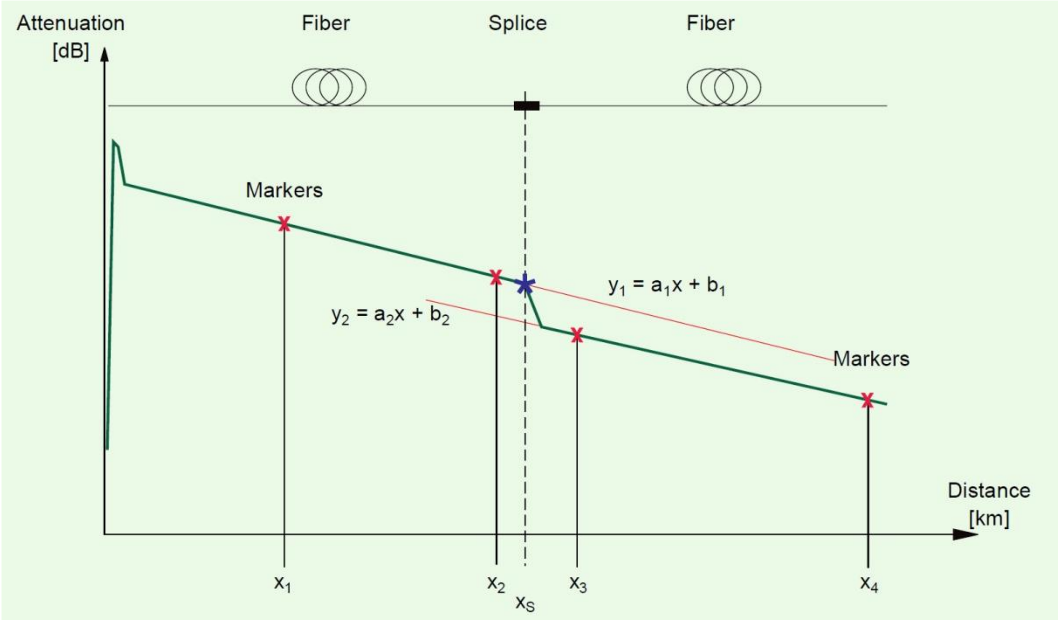
$$A[dB/km] = \frac{P_1 - P_2}{2 \cdot L}$$

panta curbei

Efecte vizibile OTDR – Splice

- splice loss – A(s)

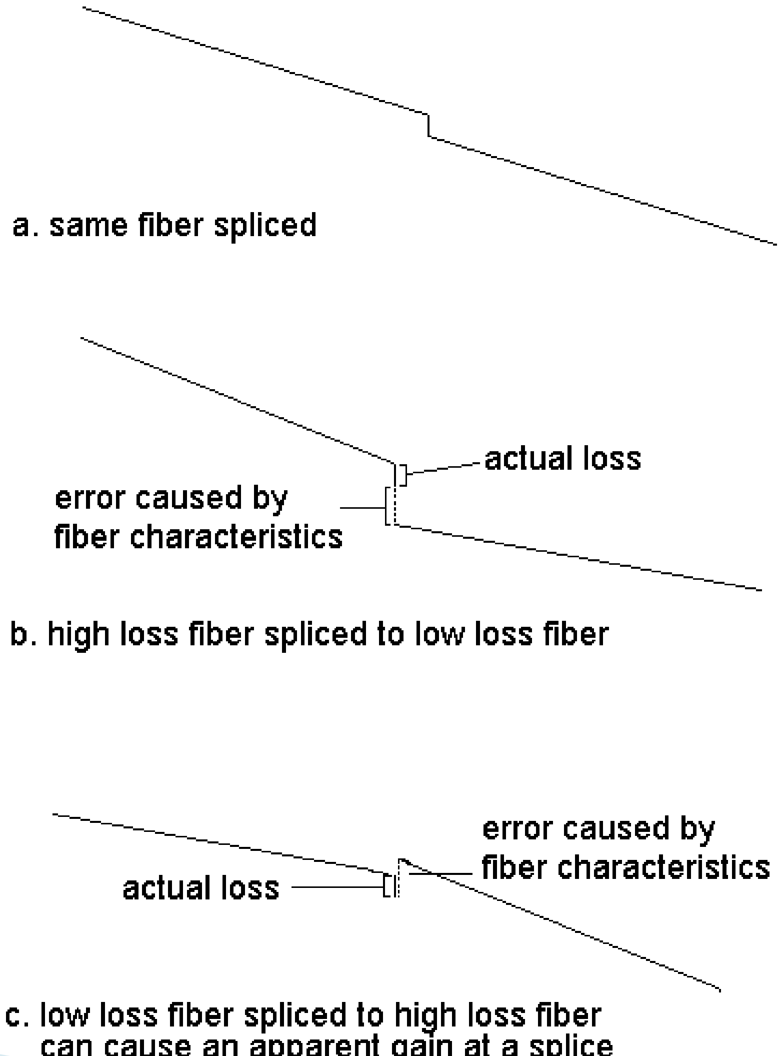




$$A(s) = y_1 - y_2$$

$$A(s) = y_1 - y_2 = x_s \cdot (a_1 - a_2) + (b_1 - b_2)$$

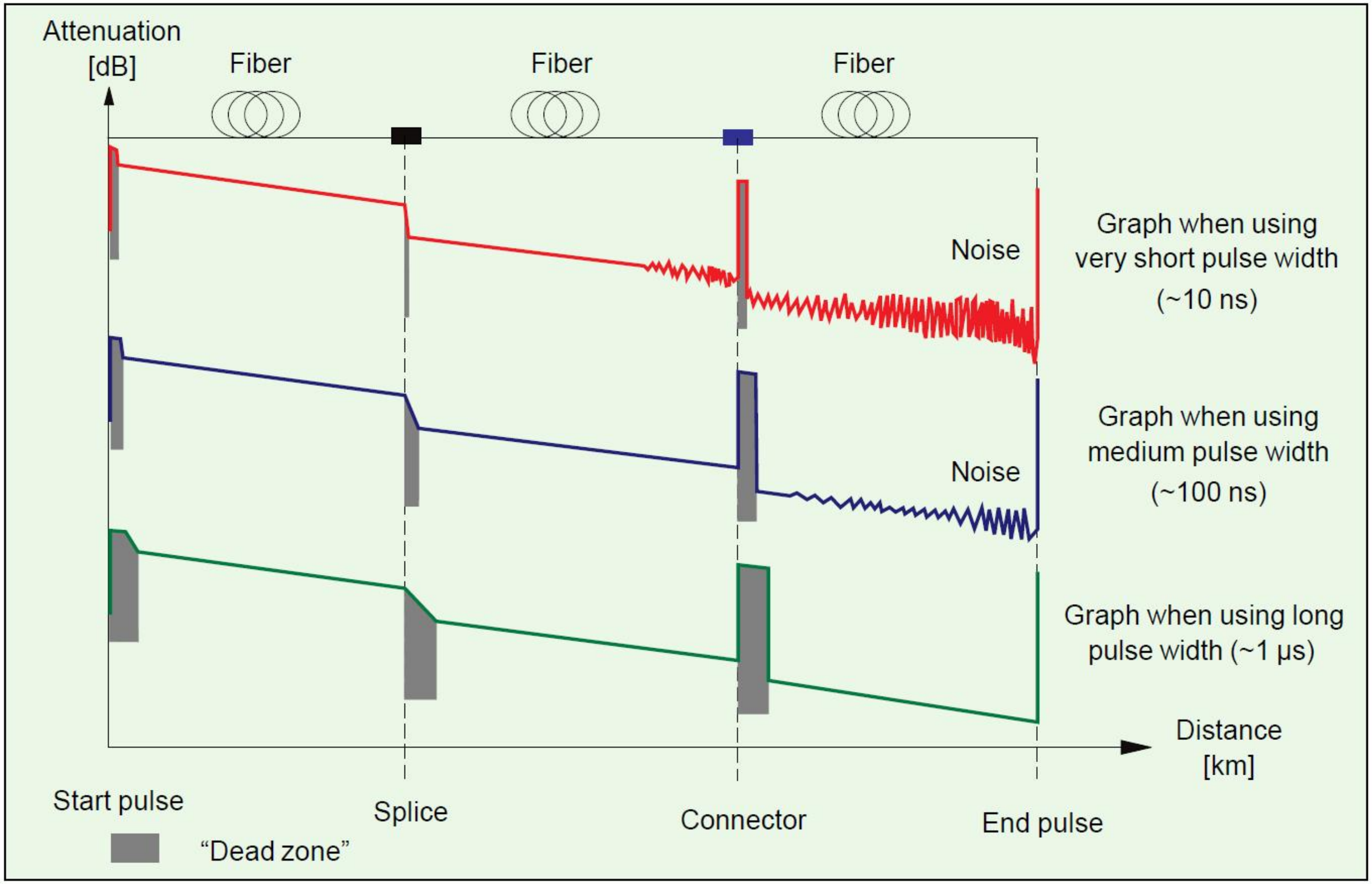
Efecte vizibile OTDR – Splice



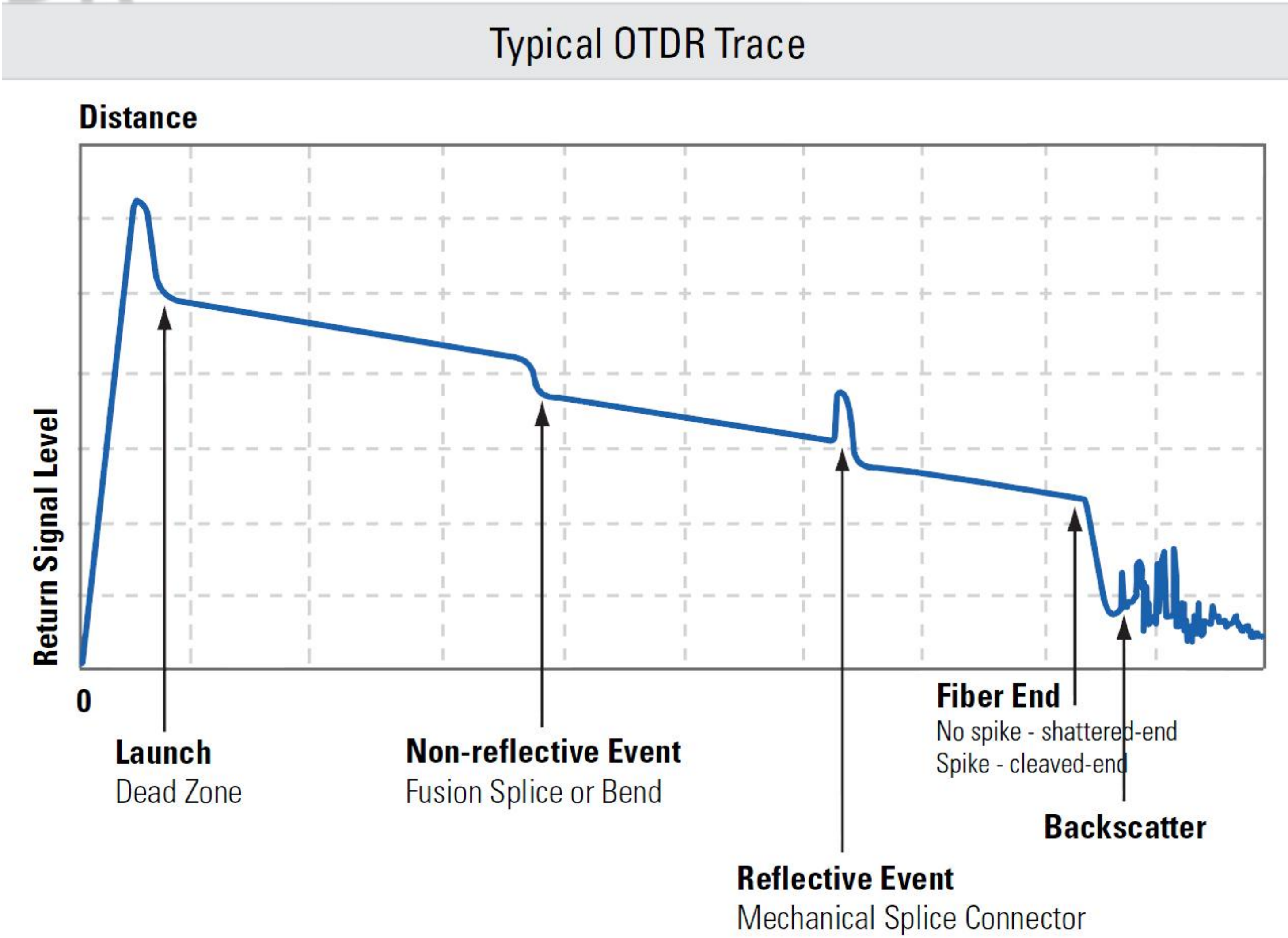
$$A(s)=\frac{A(s)_{A\to B}+A(s)_{B\to A}}{2}$$

Rezultat grafic al OTDR

- latimea pulsurilor luminoase



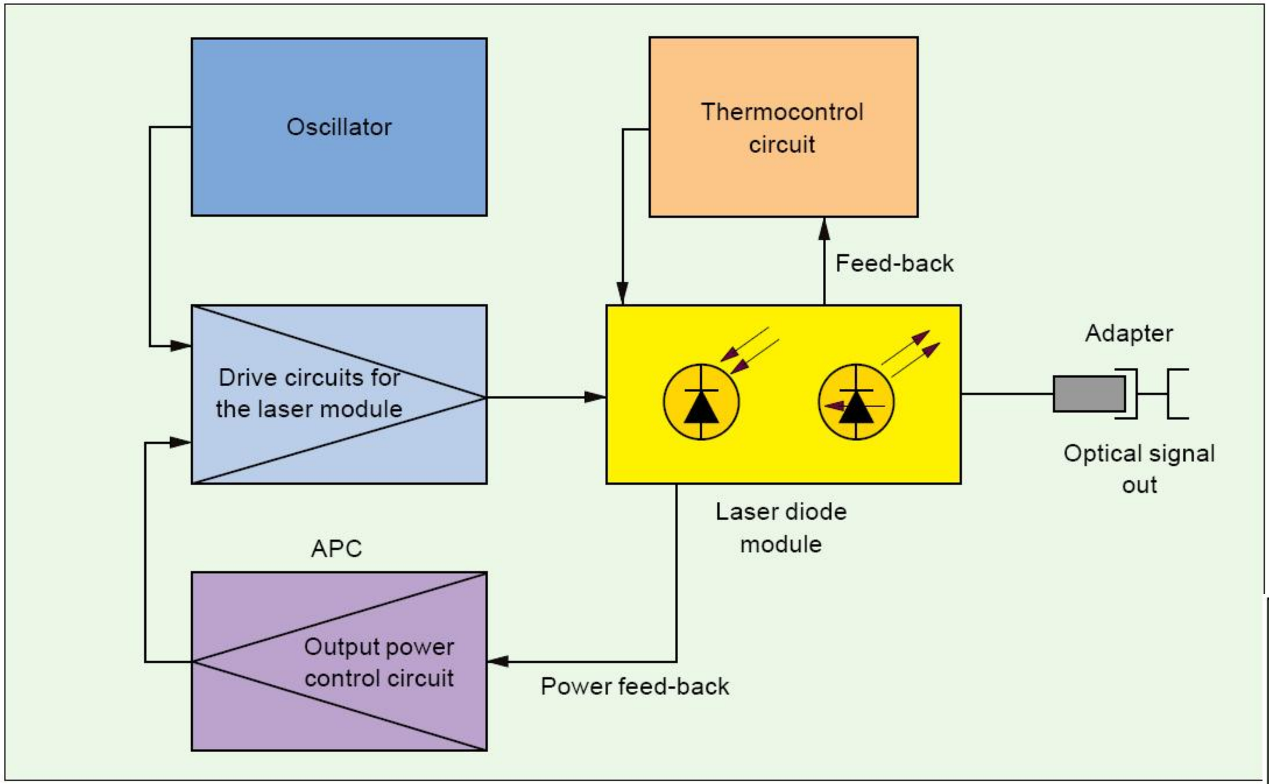
OTDR

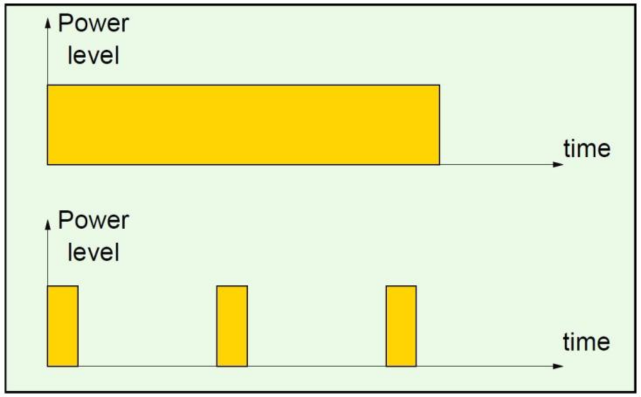


Typical OTDR Trace
Distance
Return Signal Level
0
Launch
Dead Zone
Non-reflective Event
Fusion Splice or Bend
Reflective Event
Mechanical Splice Connector
Fiber End
No spike - shattered-end
Spike - cleaved-end
Backscatter

Stabilized light source
Optical power meter

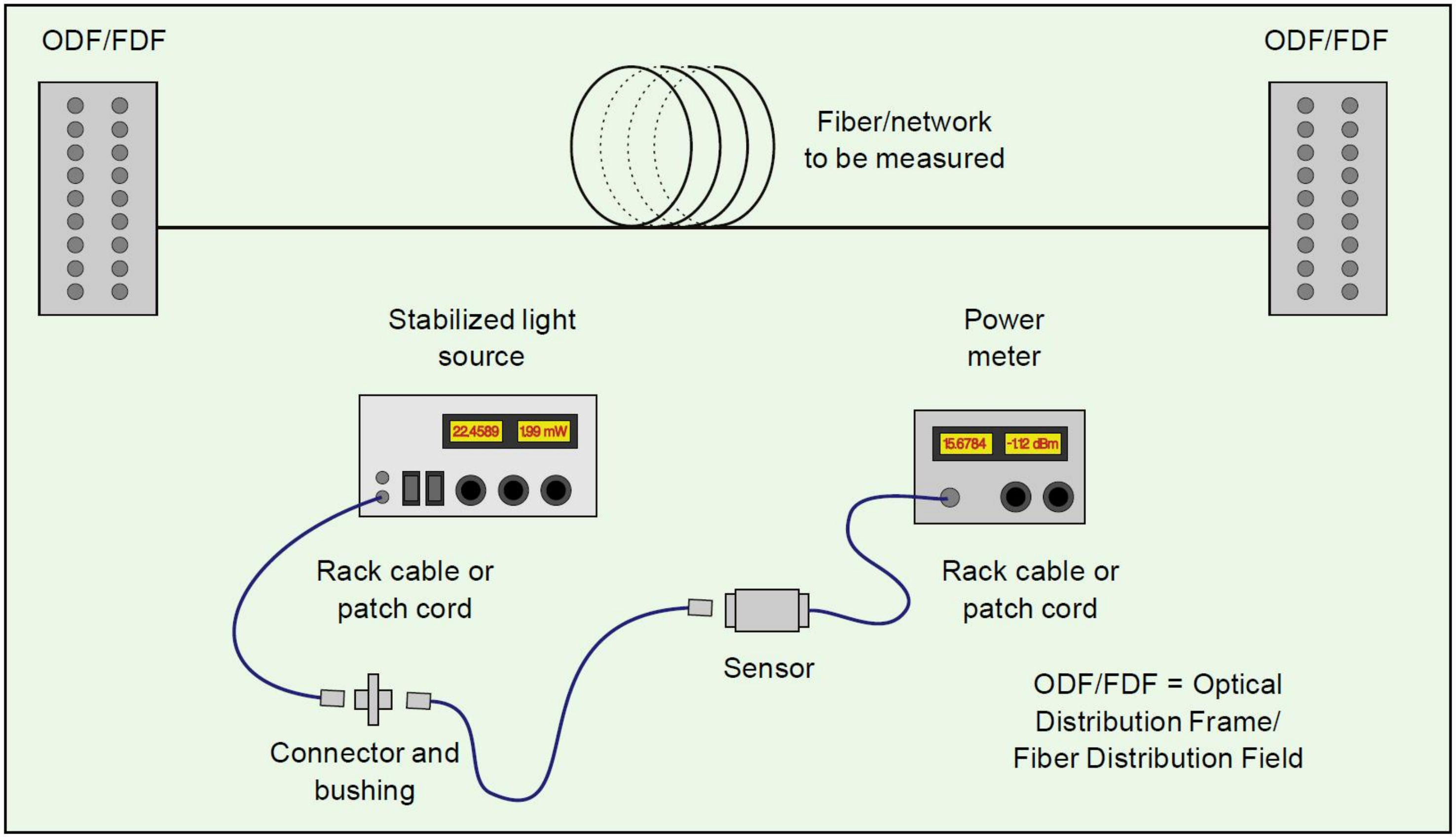
- Masurarea puterii si atenuarii





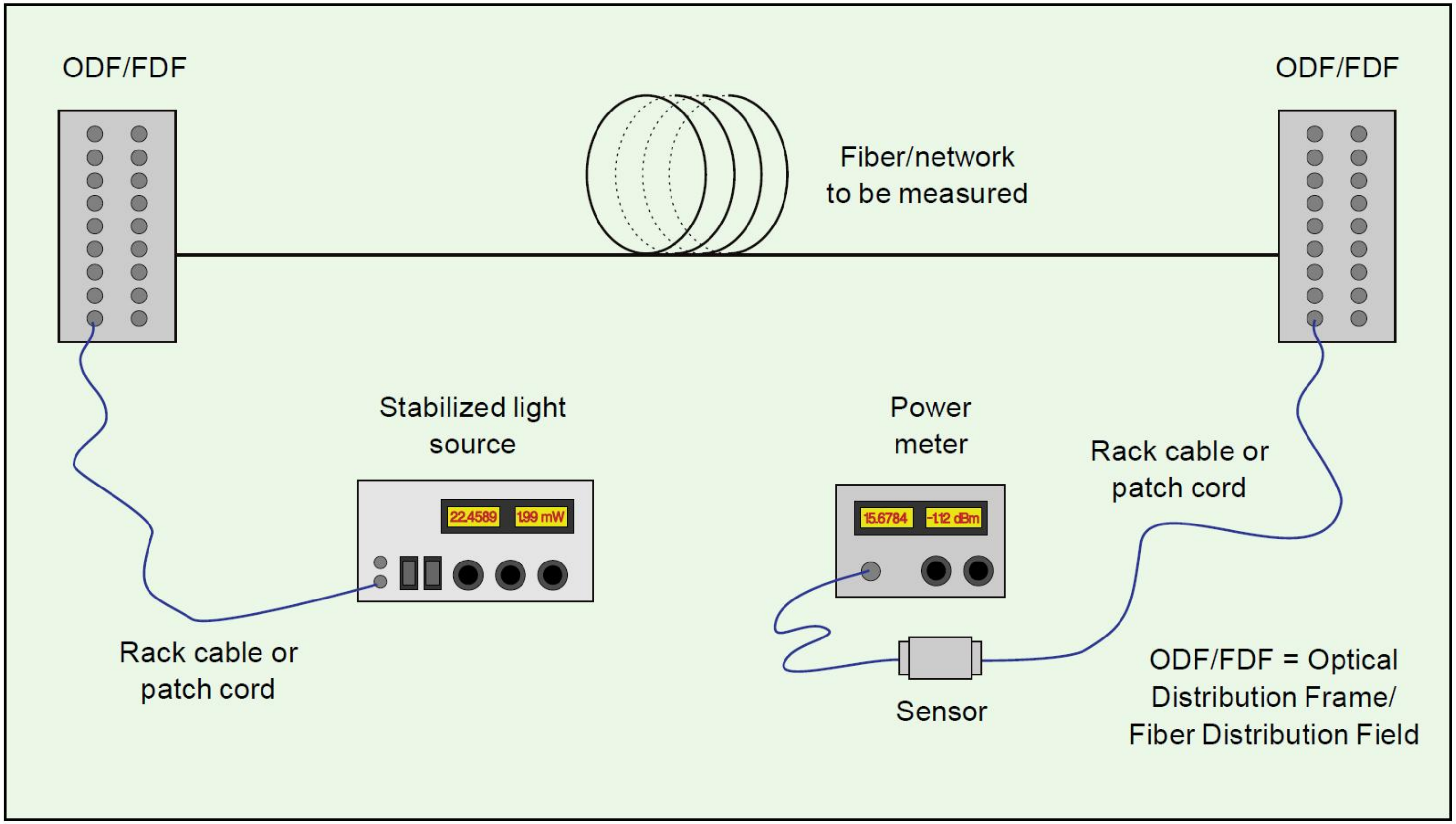
Masurarea puterii si atenuarii

- Masuratoare referinta



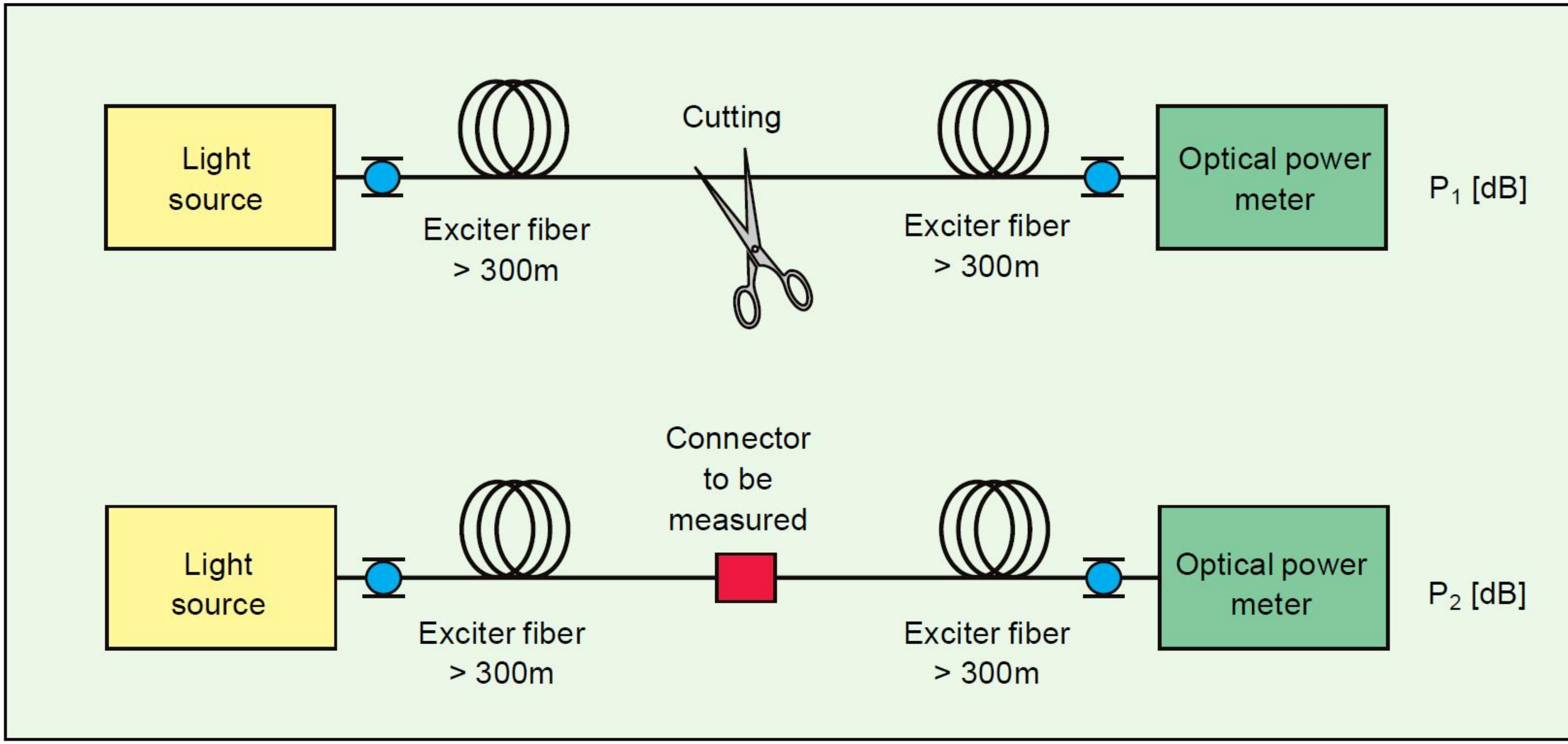
Masurarea puterii si atenuarii

- Masuratoare instalatie



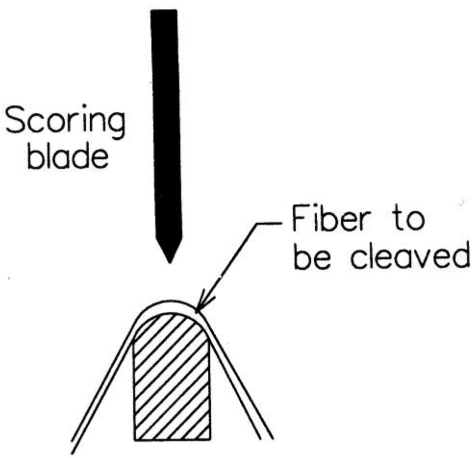
Masurare conectori si splice

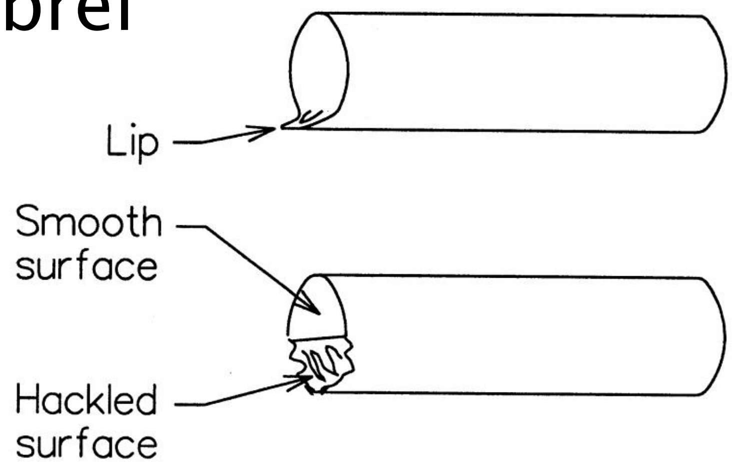
- Se elimina efectele fibrei



Taiere – Cleaving

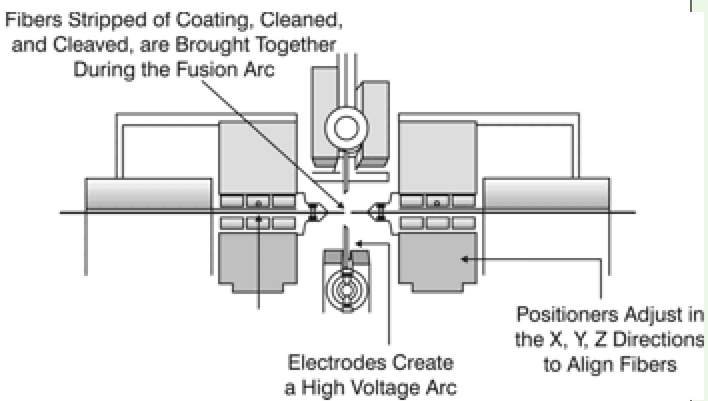
- Tehnici necesare pentru a asigura o taiere perpendiculara pe axa fibrei

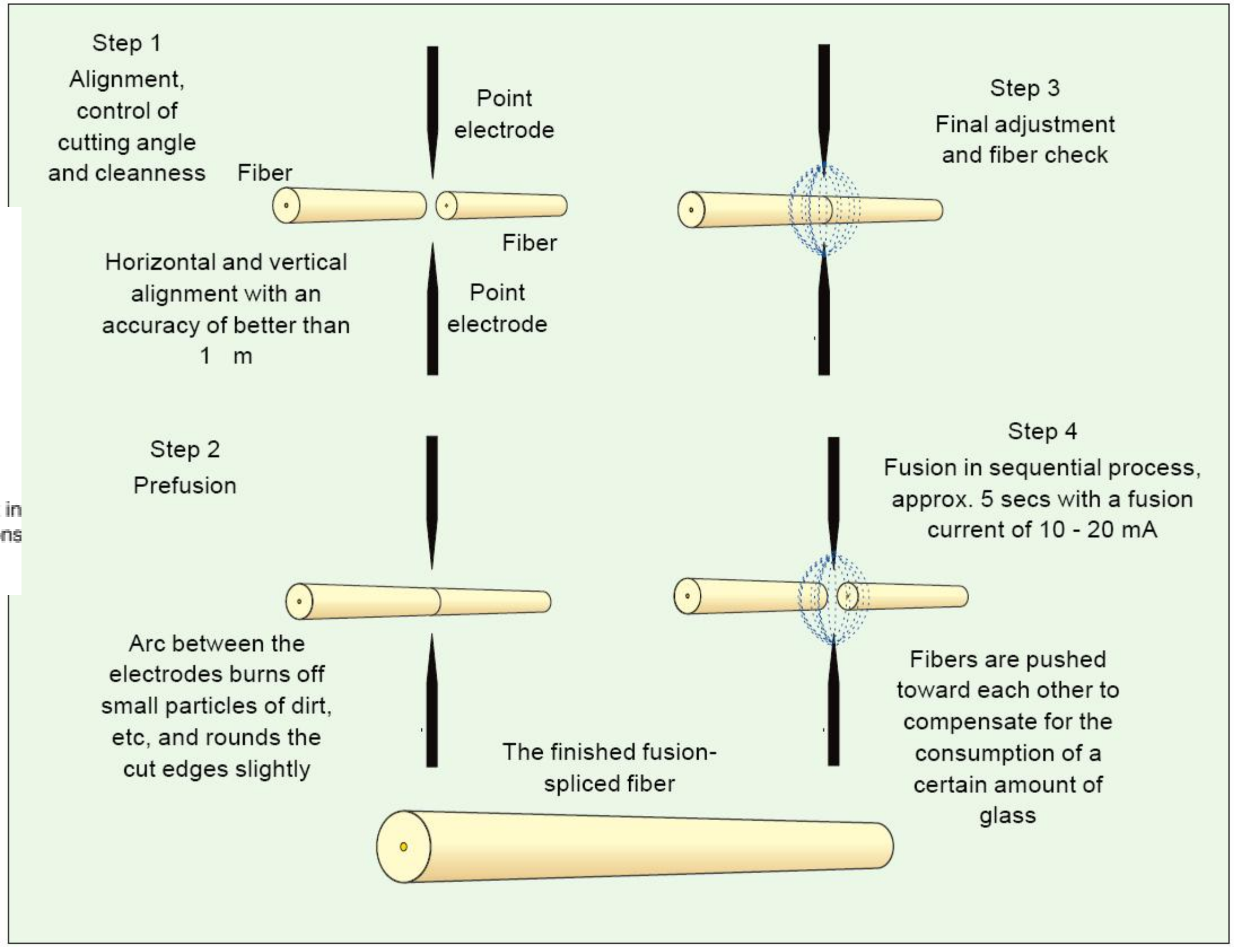




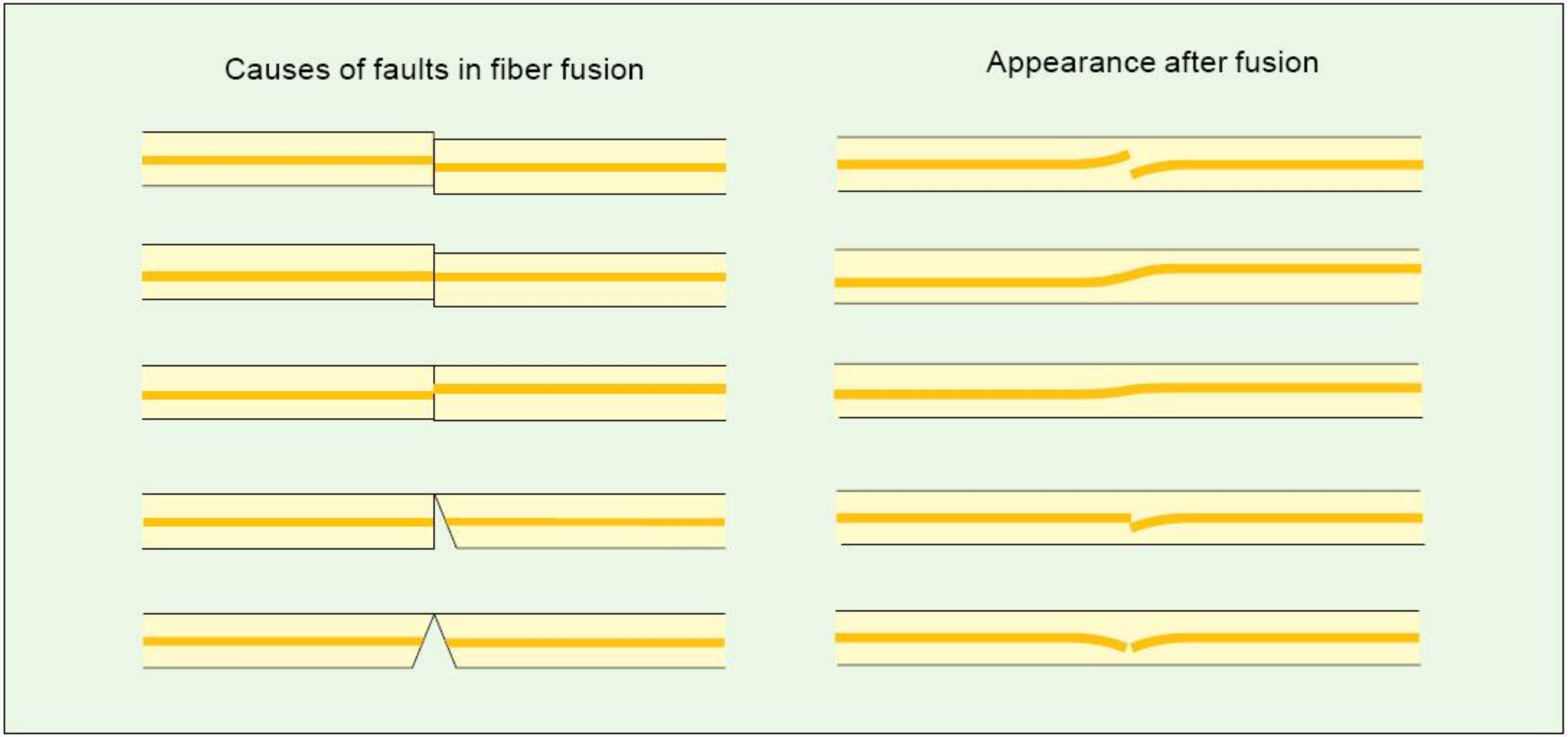
Lipire prin fuziune

Splice prin fuziune

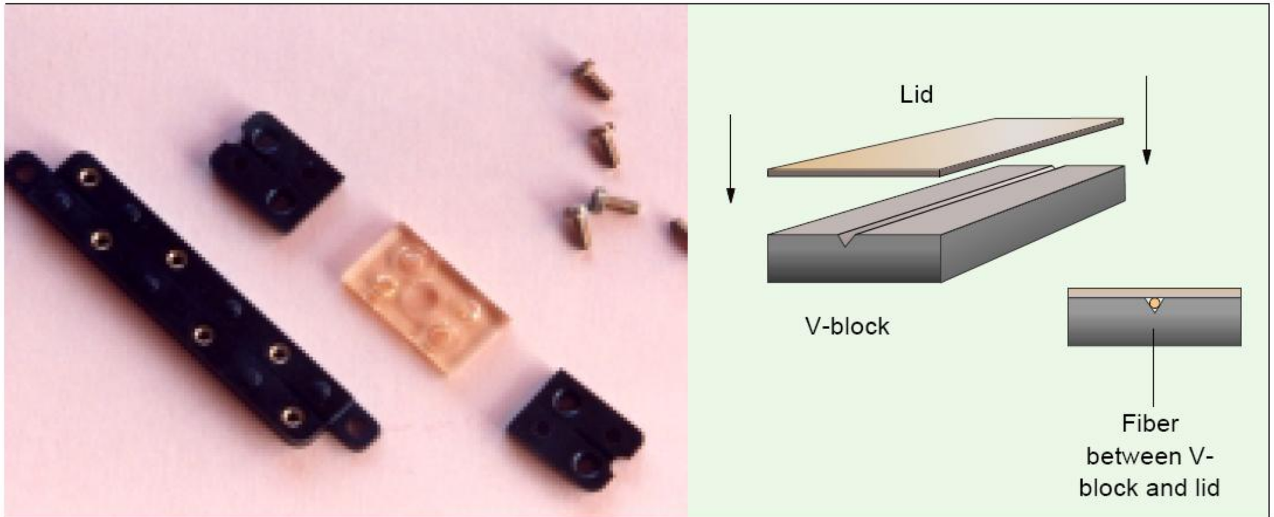


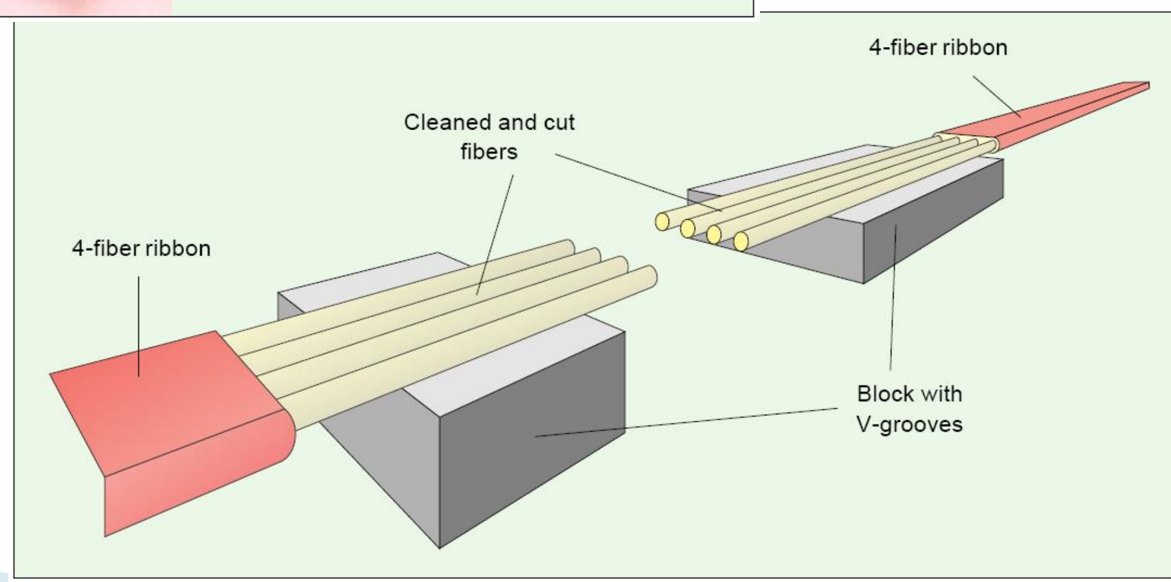


Splice prin fuziune

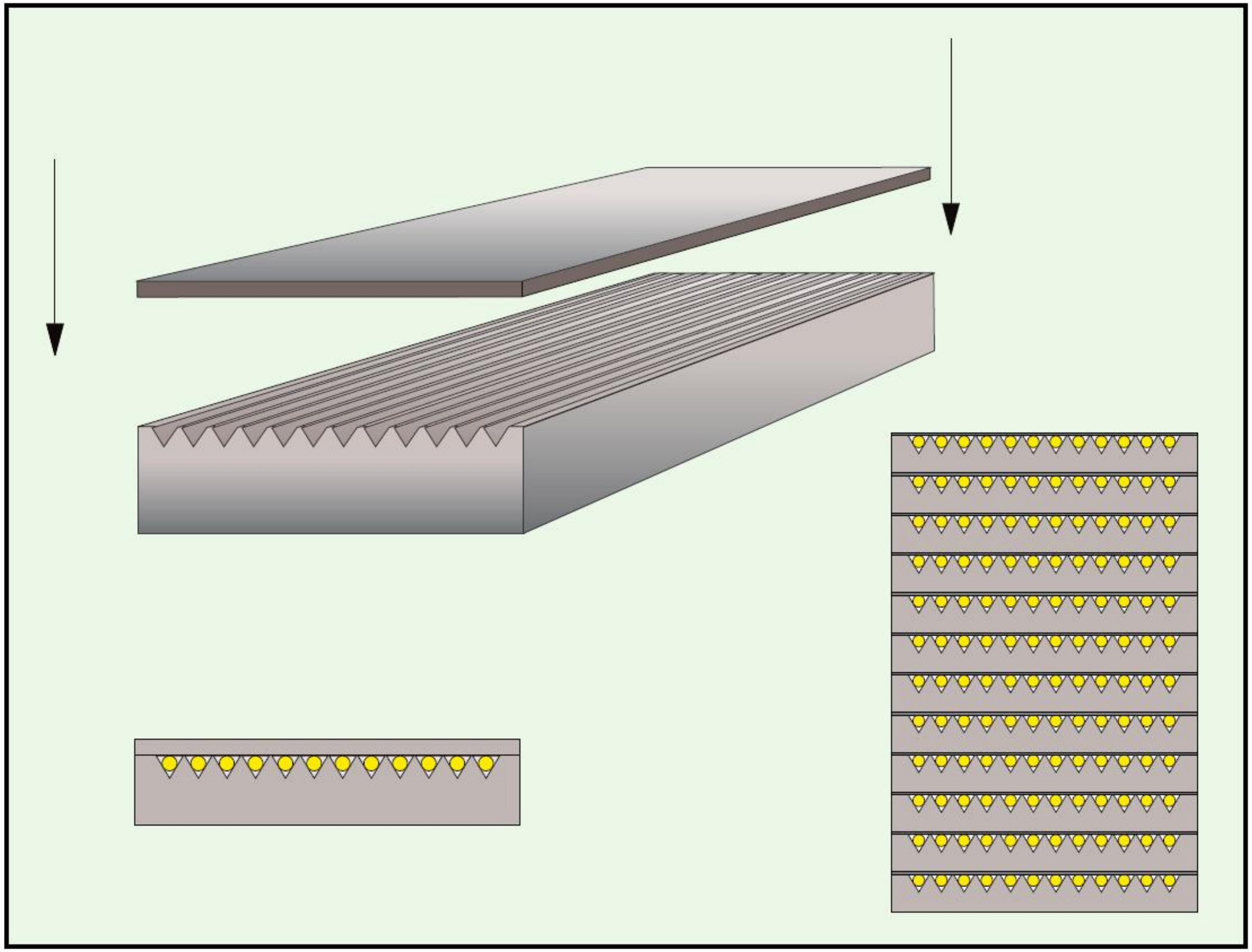


Splice mecanic – bloc V

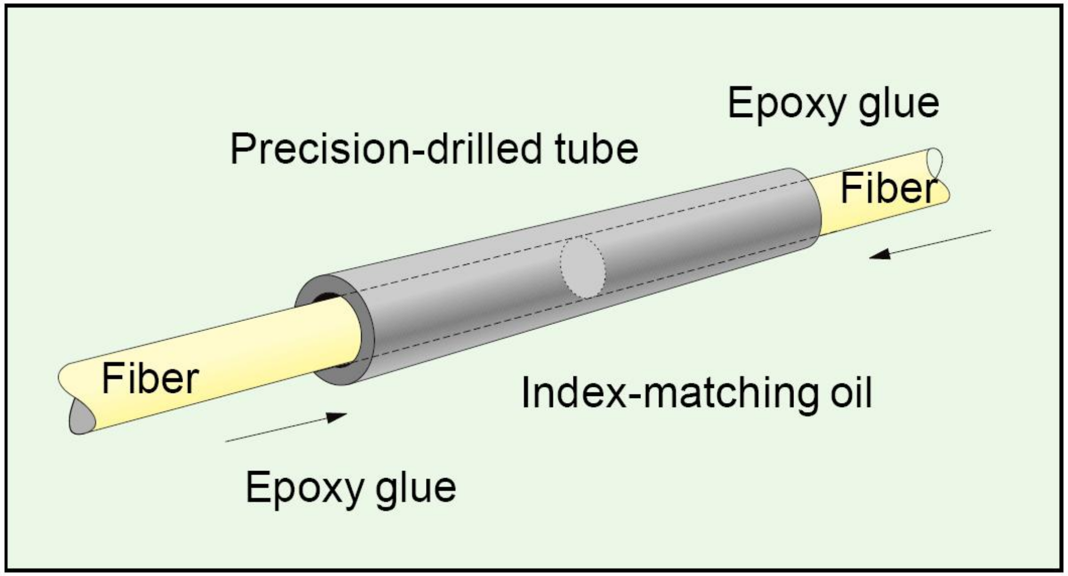


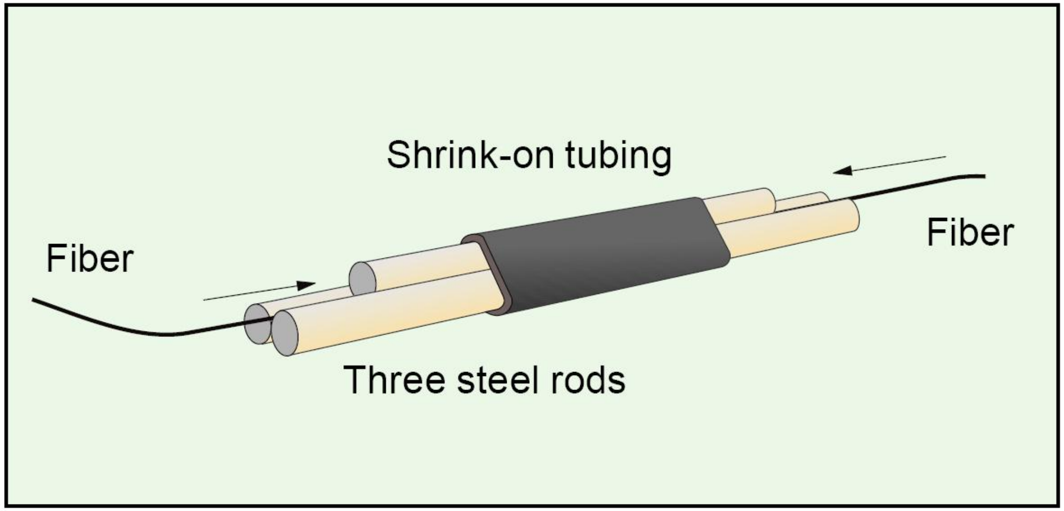


Splice mecanic – bloc V



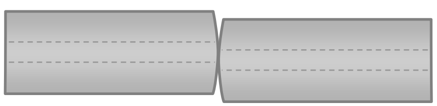
Splice mecanic



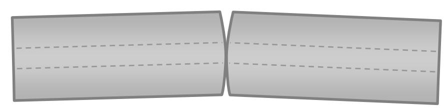


Probleme Fibre/Conectori

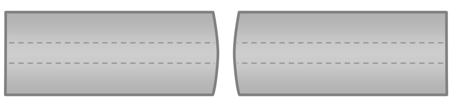
Offset



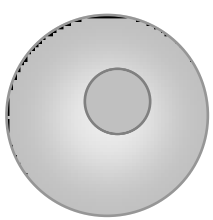
Angular Misalignment



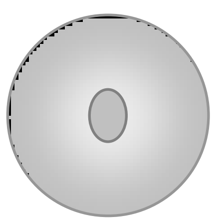
Separation



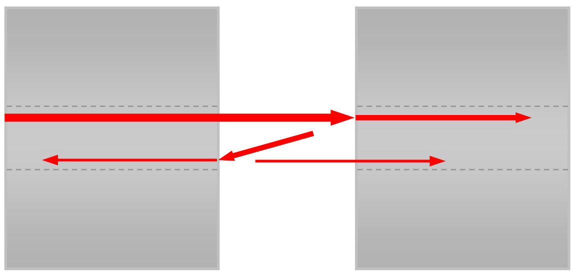
Core Eccentricity



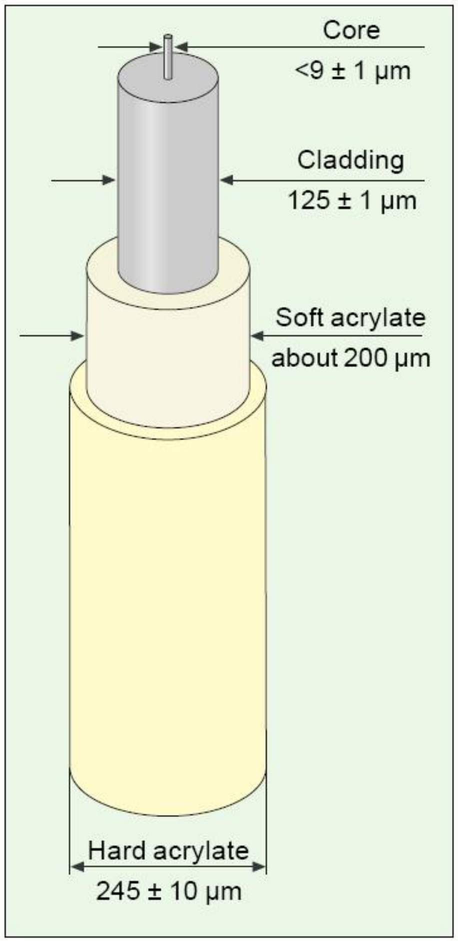
Core Ellipticity

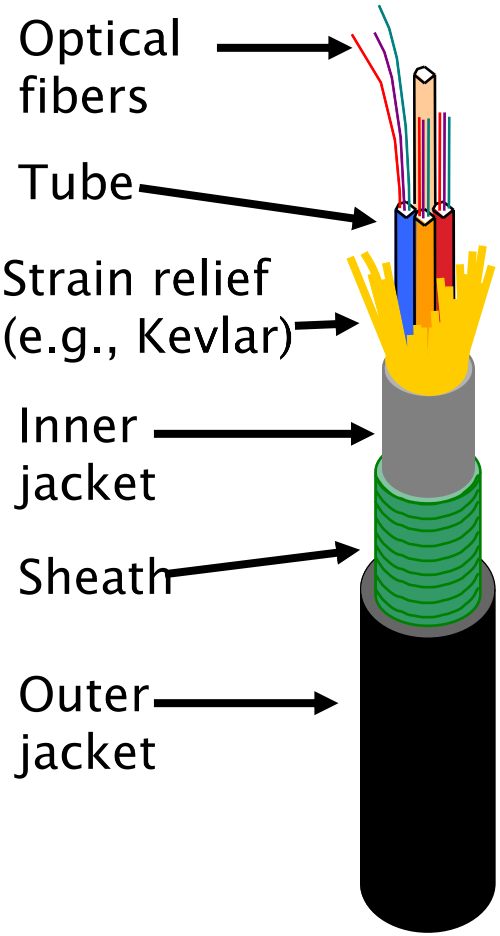


Reflections & Interference

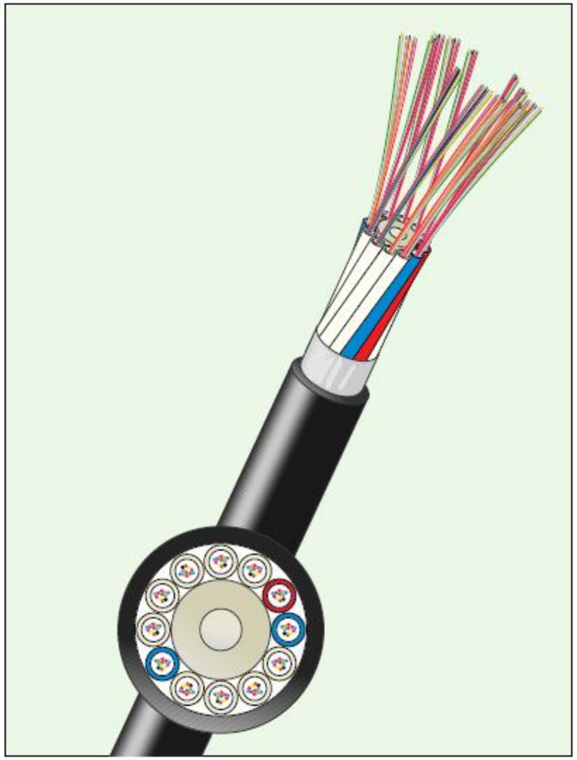


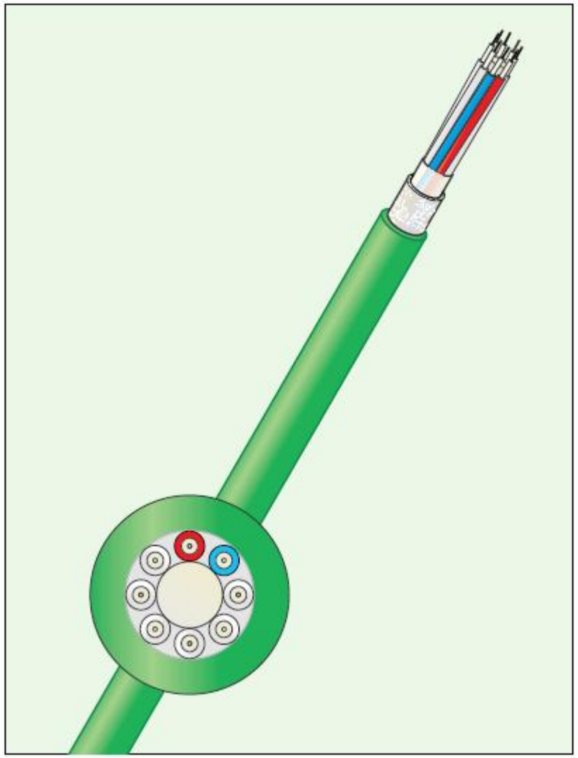
Cabluri

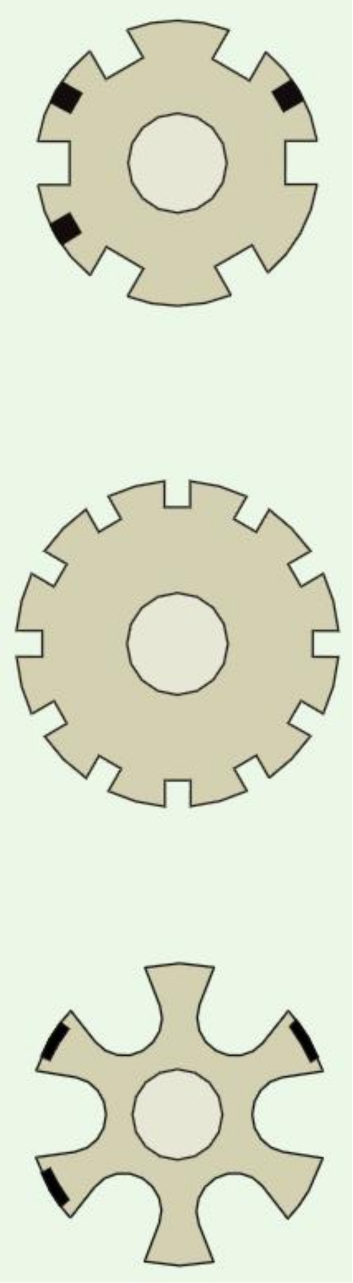

Core
<9 ± 1 µm
Cladding
125 ± 1 µm
Soft acrylate
about 200 µm
Hard acrylate
245 ± 10 µm


Optical fibers
Tube
Strain relief (e.g., Kevlar)
Inner jacket
Sheath
Outer jacket

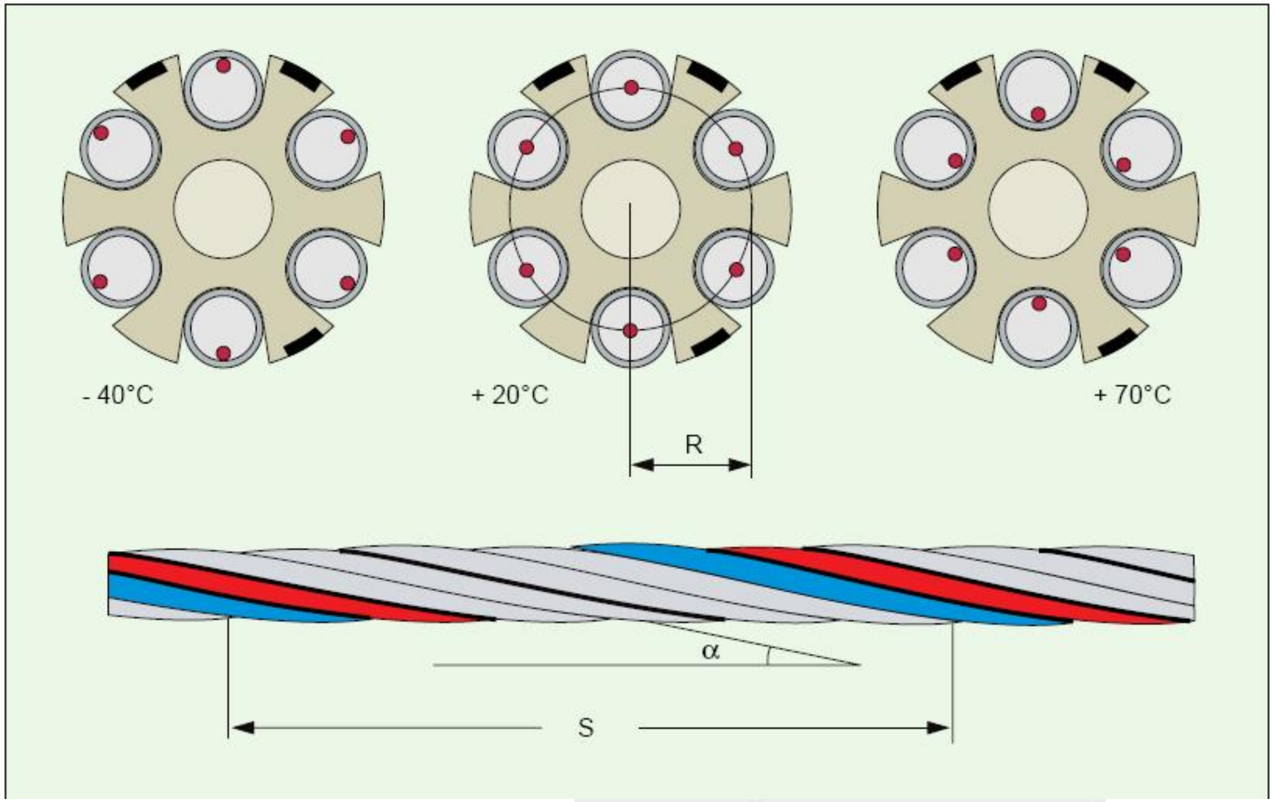
Cabluri



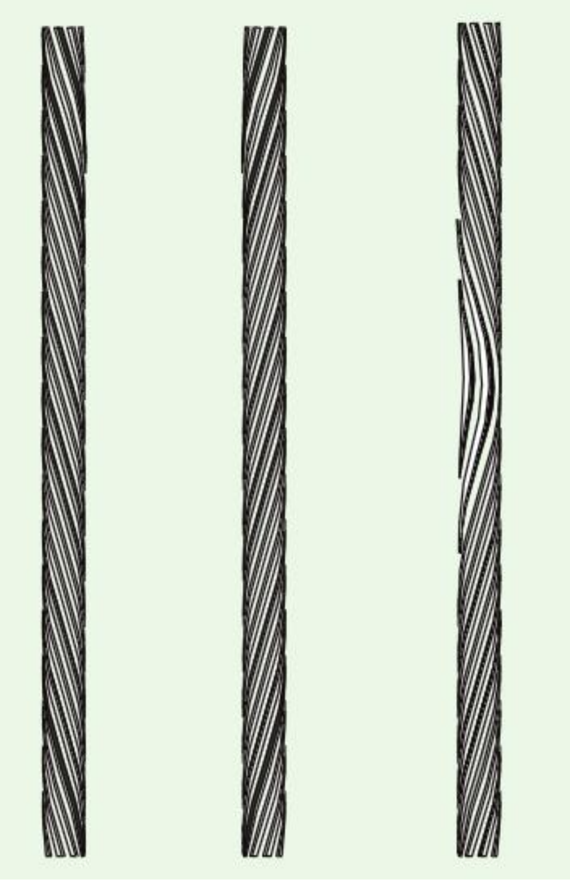




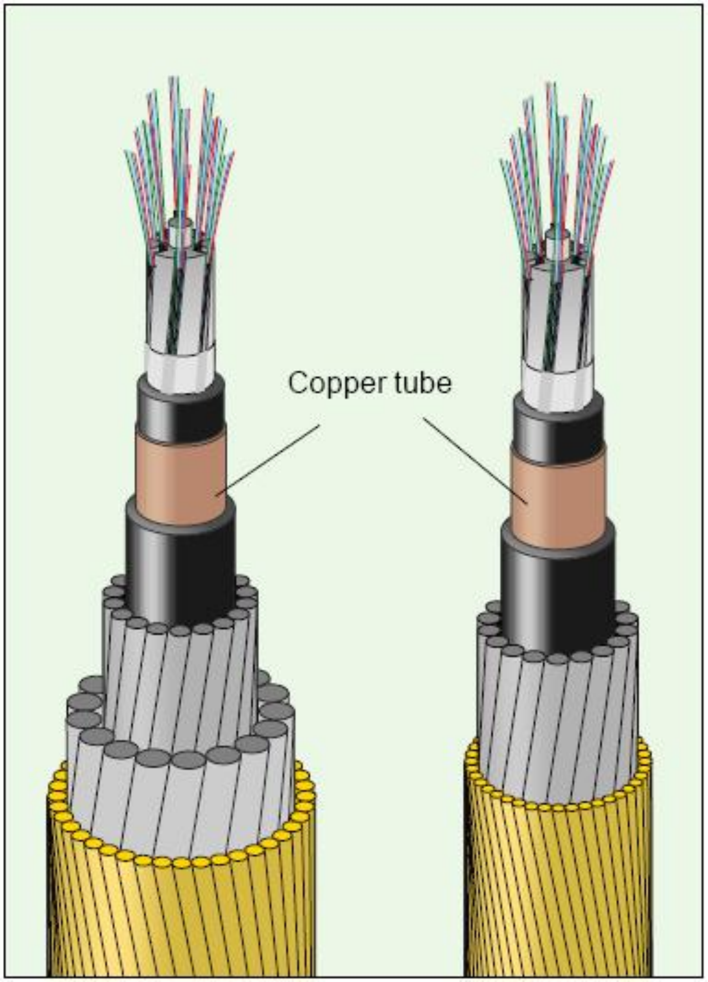
Cabluri

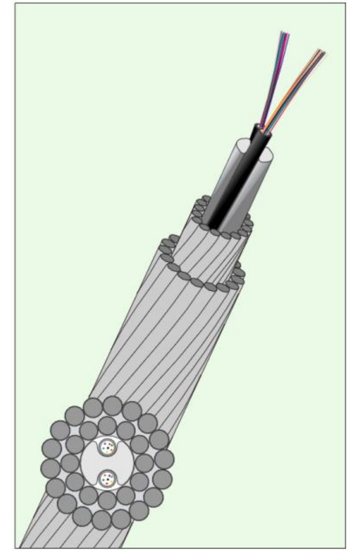


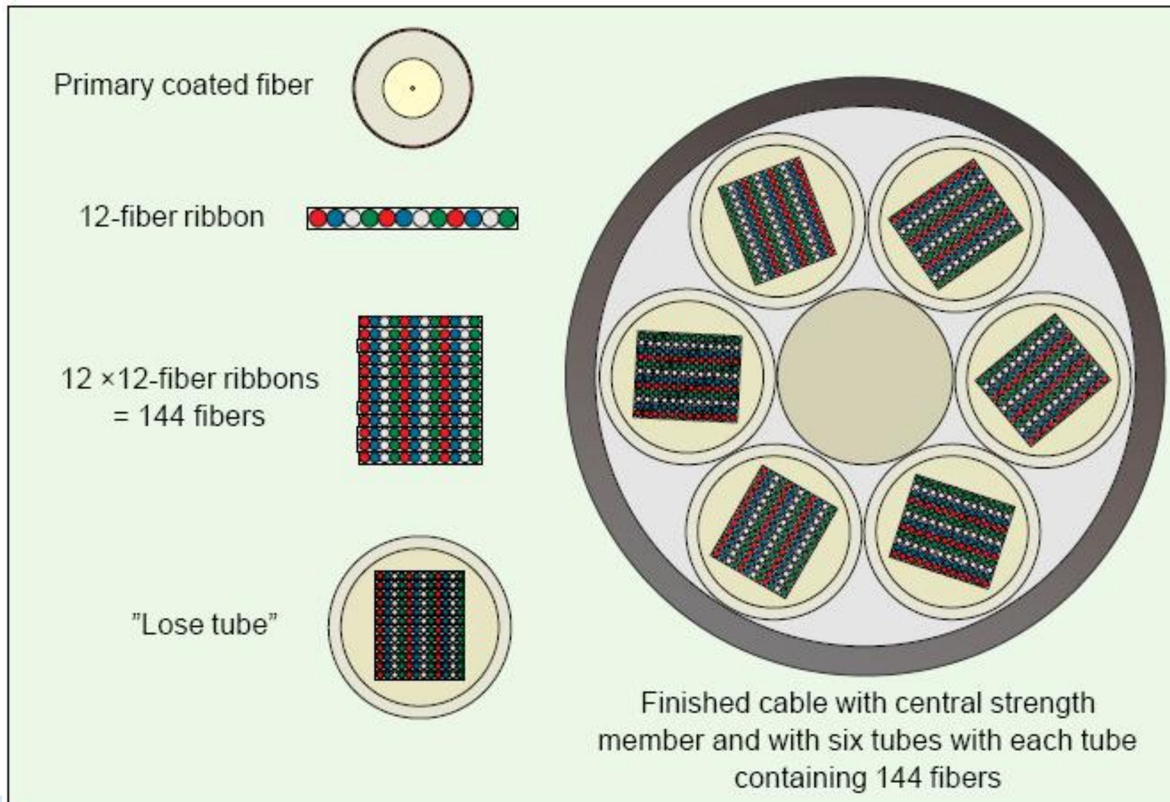
$$L = S\sqrt{1+\left(\frac{2\pi R}{S}\right)^2}$$



Cabluri


Copper tube

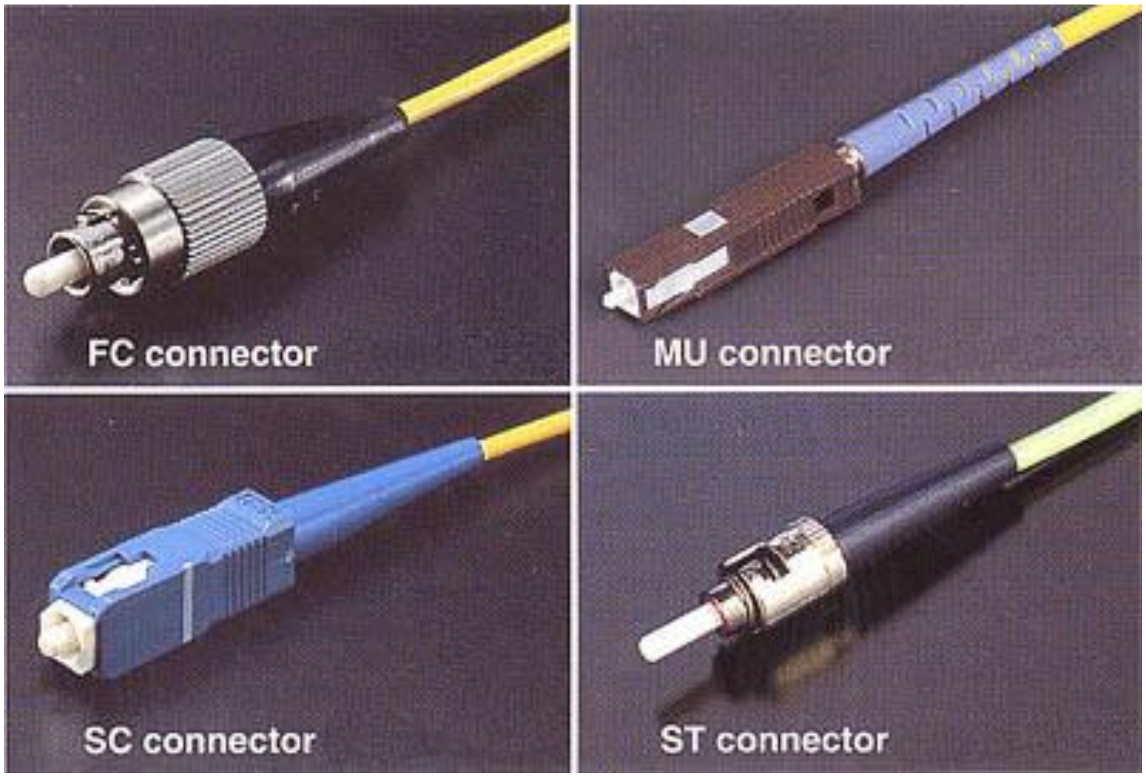



Primary coated fiber
12-fiber ribbon
12 ×12-fiber ribbons
= 144 fibers
"Lose tube"
Finished cable with central strength
member and with six tubes with each tube
containing 144 fibers

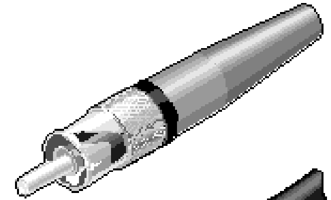
Conectori


FC - PC/PM
FC - APC/PM
DIN - PC
DIN-APC/HRL10
SC - PC
SC - APC
AVIO - PC
AVIO - APC
ST - PC
E2000 - PC
E2000 - APC

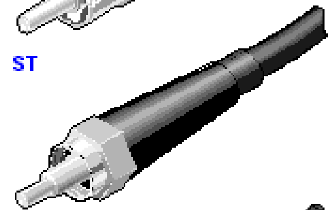
Conectori



All fiber-optic connectors use ferrules to hold the ends of the fiber and keep them properly aligned.

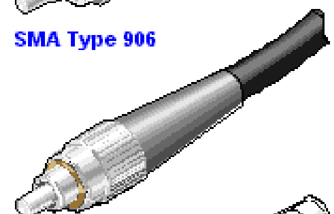


ST

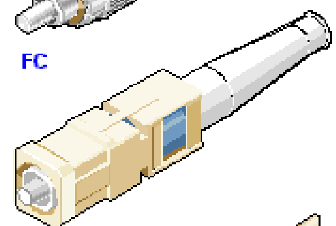


SMA Type 906

The ST connector uses a half-twist bayonet type of lock, while SMA and FC use threaded connections.



FC



SC

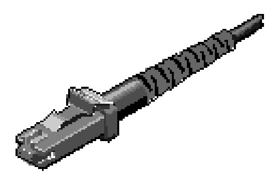
The SC uses a push-pull connector similar to common audio and video plugs and sockets.

MIC

The MIC is the standard FDDI connector.

Fiber Jack

The Fiber Jack connector attaches two fibers in a snap lock connector similar in size and ease of use as an RJ-45 connector.

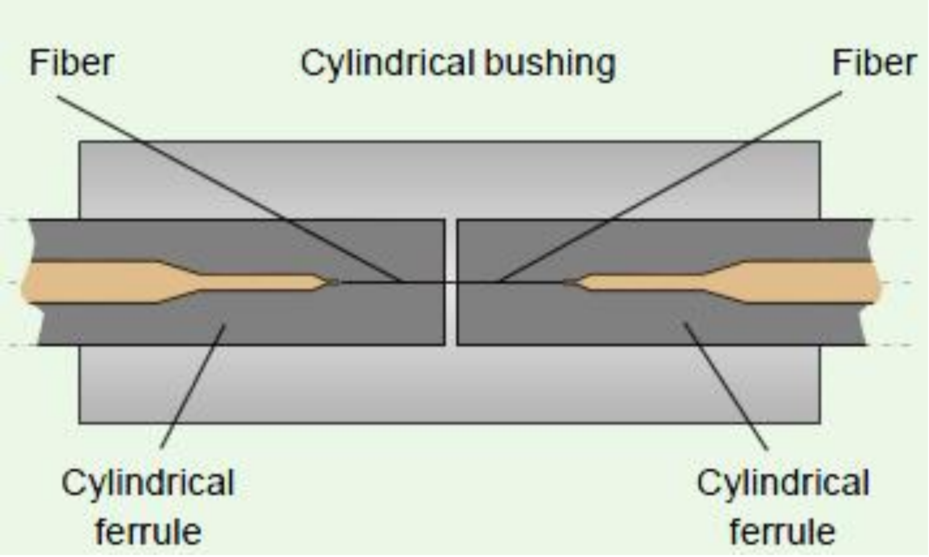


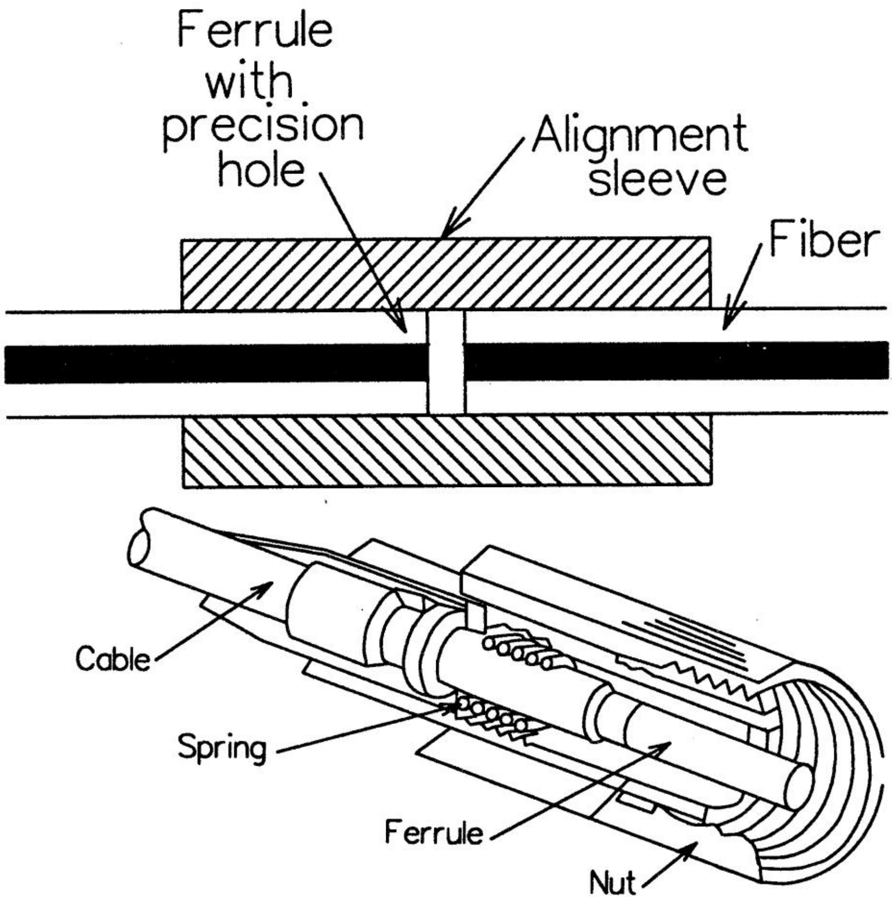
MT-RJ

MT-RJ is a popular connector for two fibers in a very small form factor.

Conectori

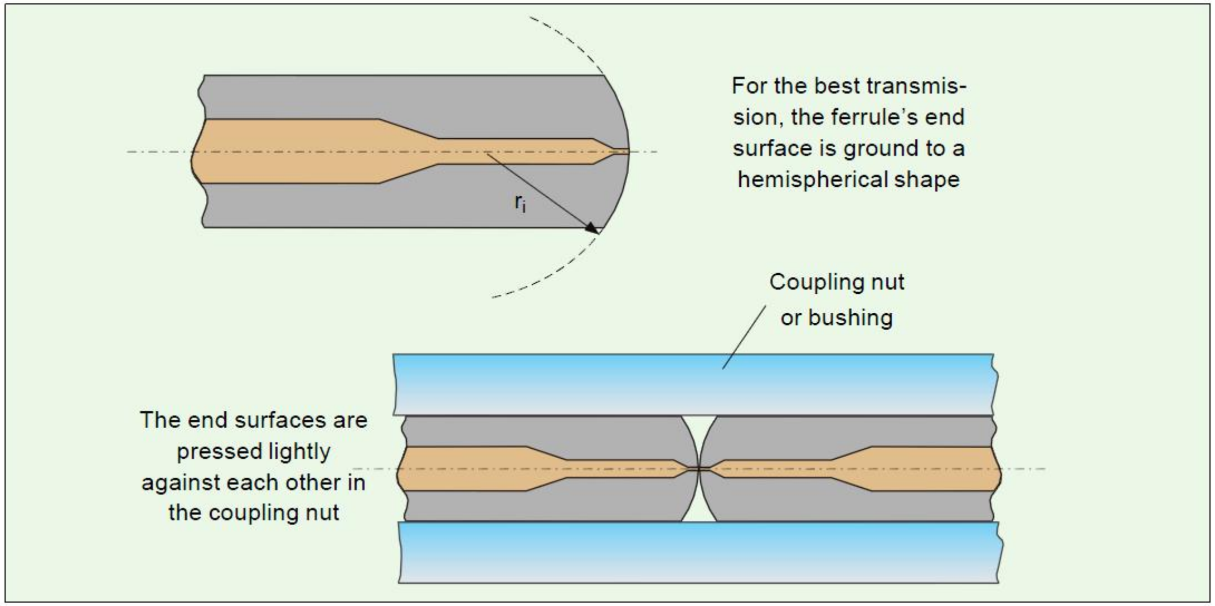
- Verificati http://rf-opto.etti.tuiasi.ro





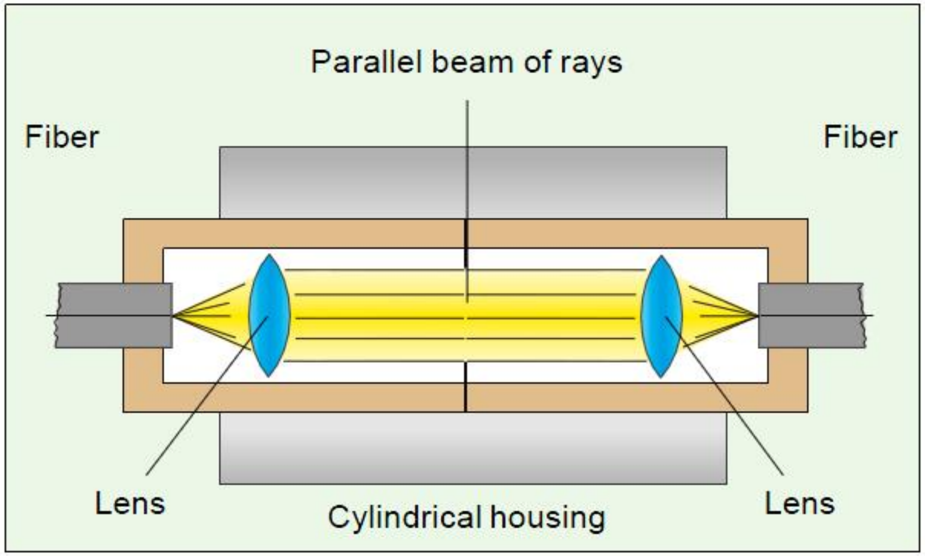
Conectori

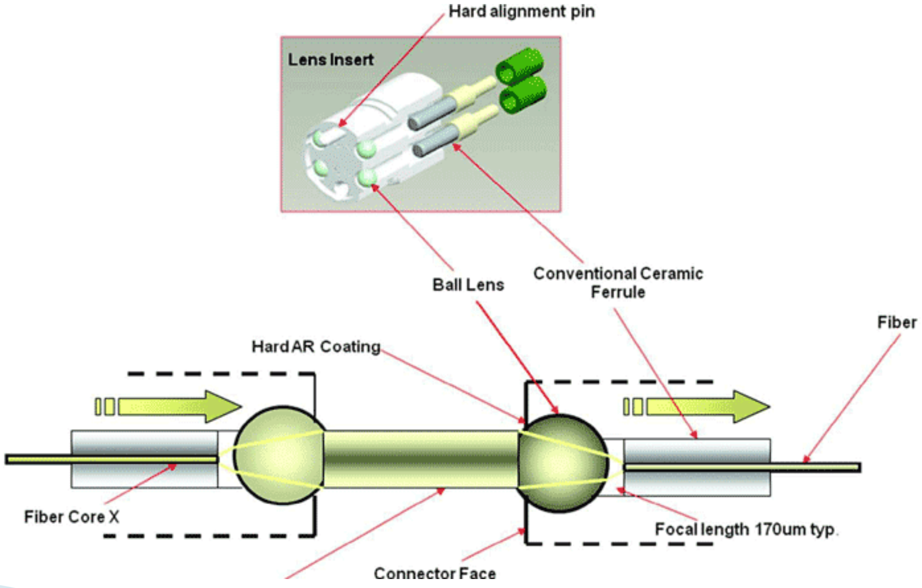
- Ferula semisferica
  - 20mm
  - 60mm



- Conectori multifibra

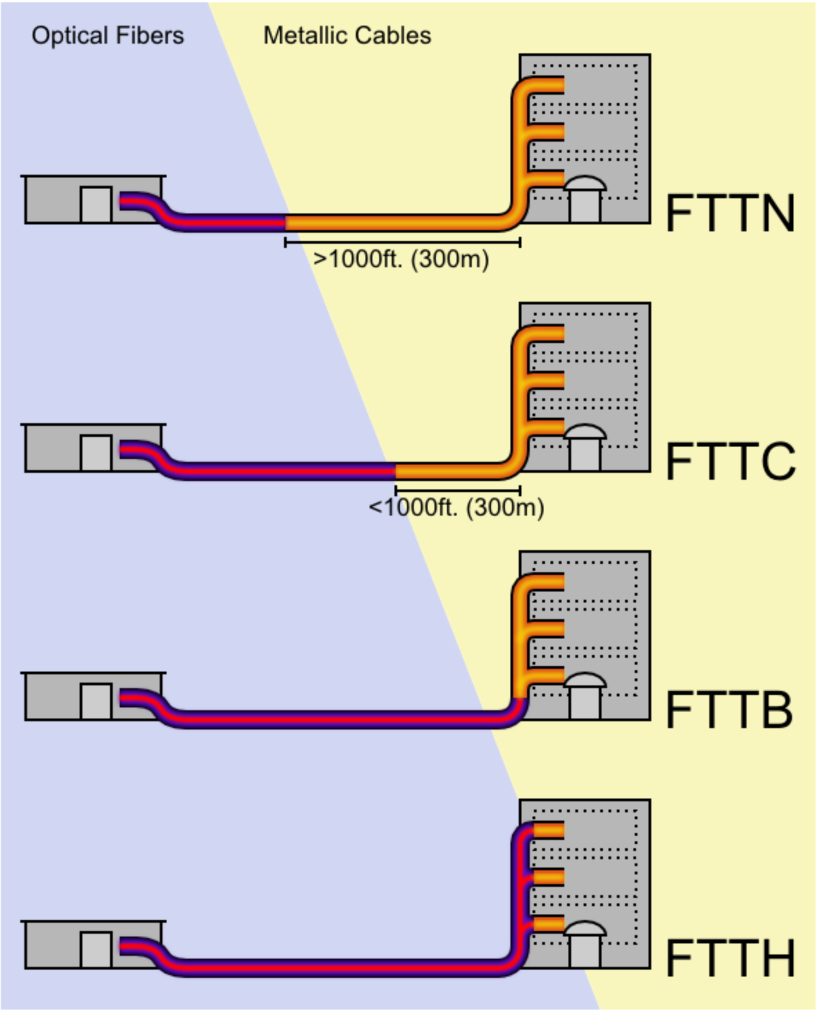
Expanded beam connector





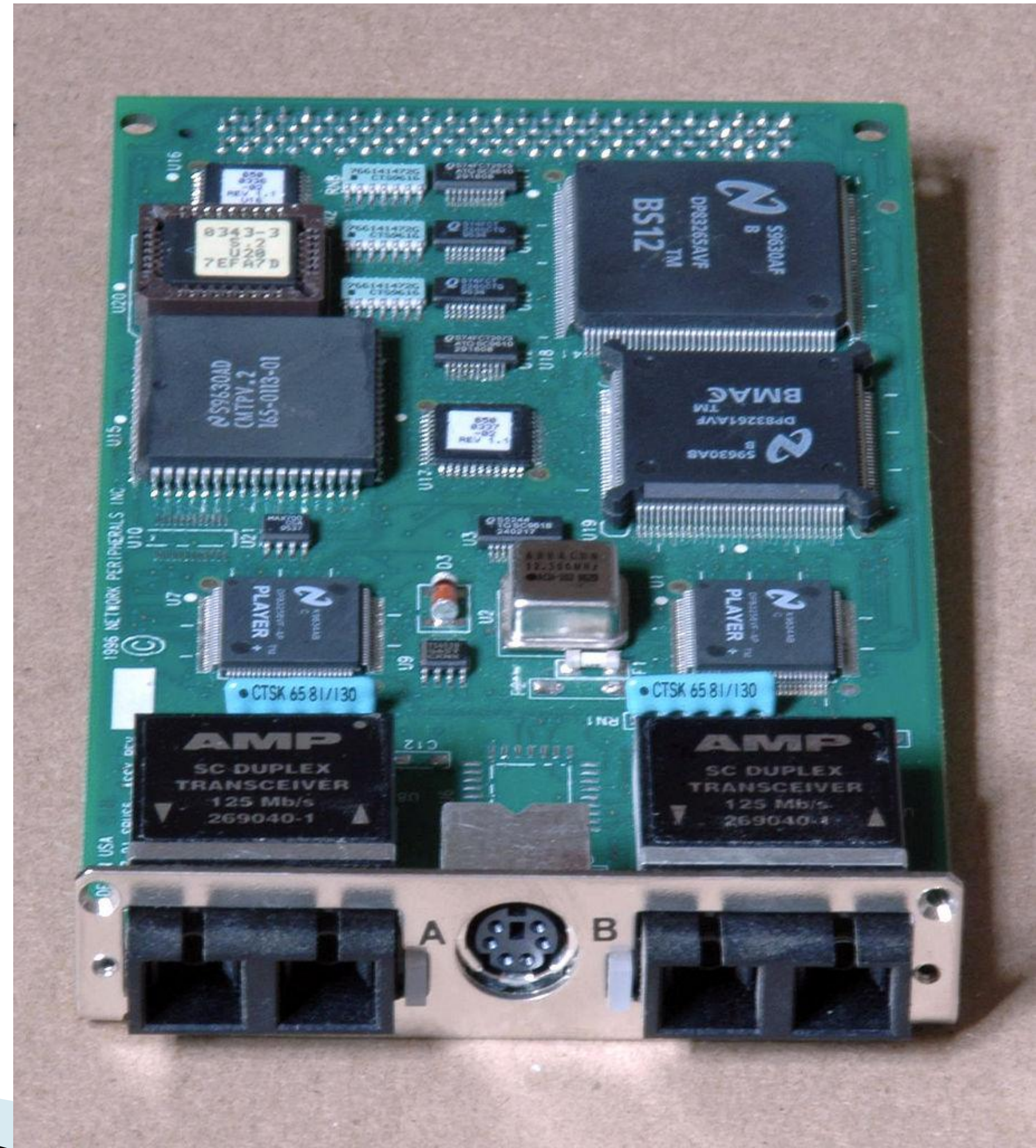
FTTH

- FTTN: Fiber to the node, neighborhood
- FTTC: Fiber to the curb
- FTTB: Fiber to the building
- FTTH: Fiber to the home



FDDI

- Fiber Distributed Data Interface



Contact

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