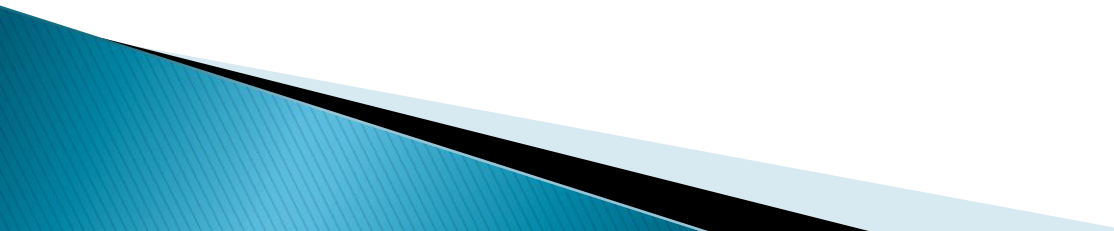


Optoelectronică, structuri și tehnologii

Curs 1
2016/2017

- ▶ La facultate, profesorul întreabă:
 - Întrebare de "nota 10": cum mă numesc?
Toti tac.
 - Întrebare de "nota 8": la ce obiect aveți examen?
Toti tac.
 - Întrebare de "nota 5": ce culoare are manualul (site-ul laboratorului)?
- Din ultimele rânduri se aude o voce:
- Vrea să ne pice măgaru'!
- 

Disciplina 2016/2017

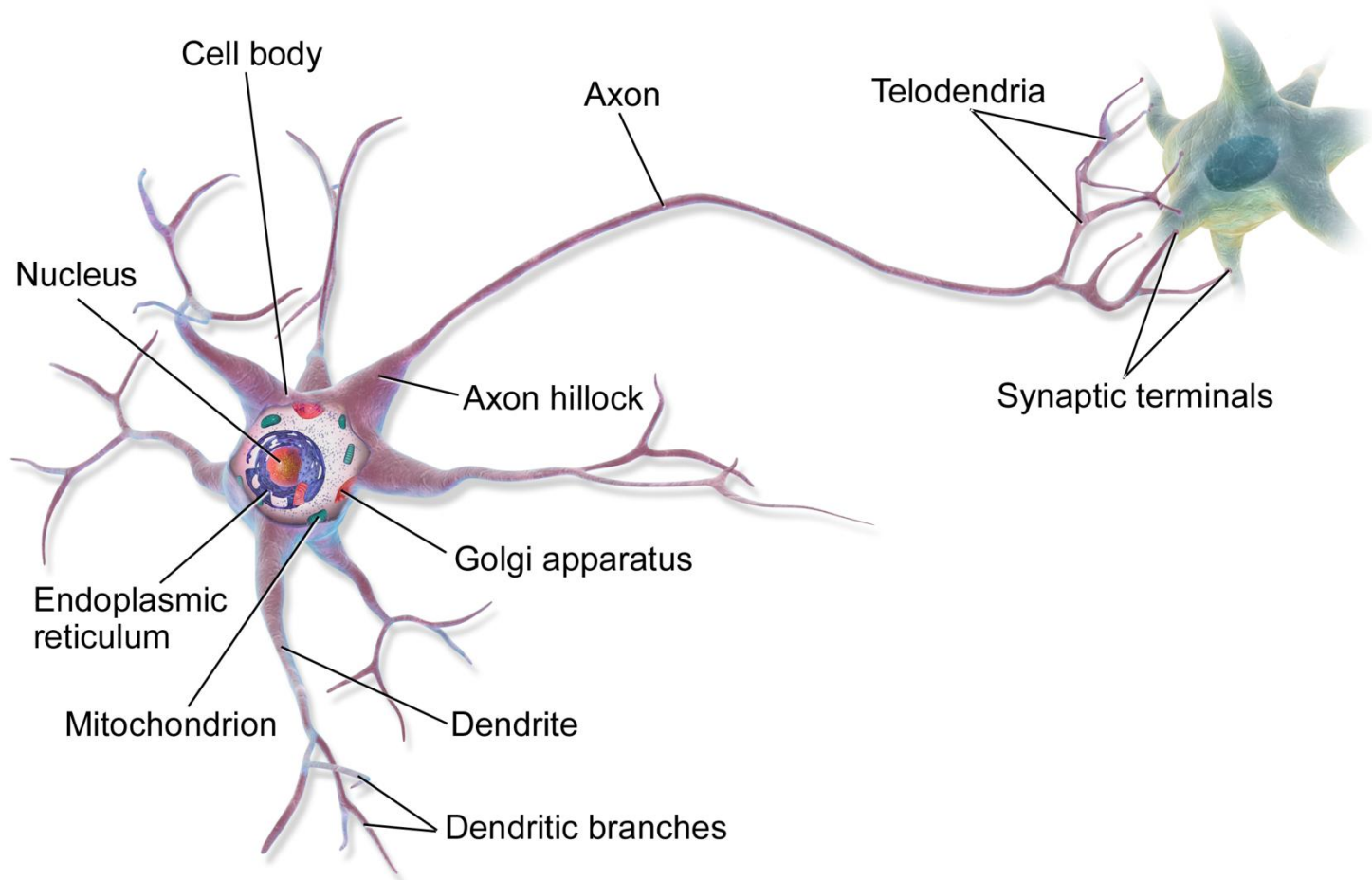
- ▶ 2C/1L Optoelectronică, structuri, tehnologii, circuite, OSTC
- ▶ **Minim 7** prezente curs + laborator
- ▶ Curs – **sl. Radu Damian**
 - an IV μ E
 - Joi 15–18, P5
 - E – 70% din nota
 - **20% test la curs**, saptamana 4–5?
 - probleme + (? 1 subiect teorie) + (2p prez. curs)
 - toate materialele permise
- ▶ Laborator – **sl. Daniel Matasaru**
 - an IV μ E, an IV Tc
 - Joi 12-14 par
 - L – 15% din nota
 - C – 15% din nota

Orar 2016/2017

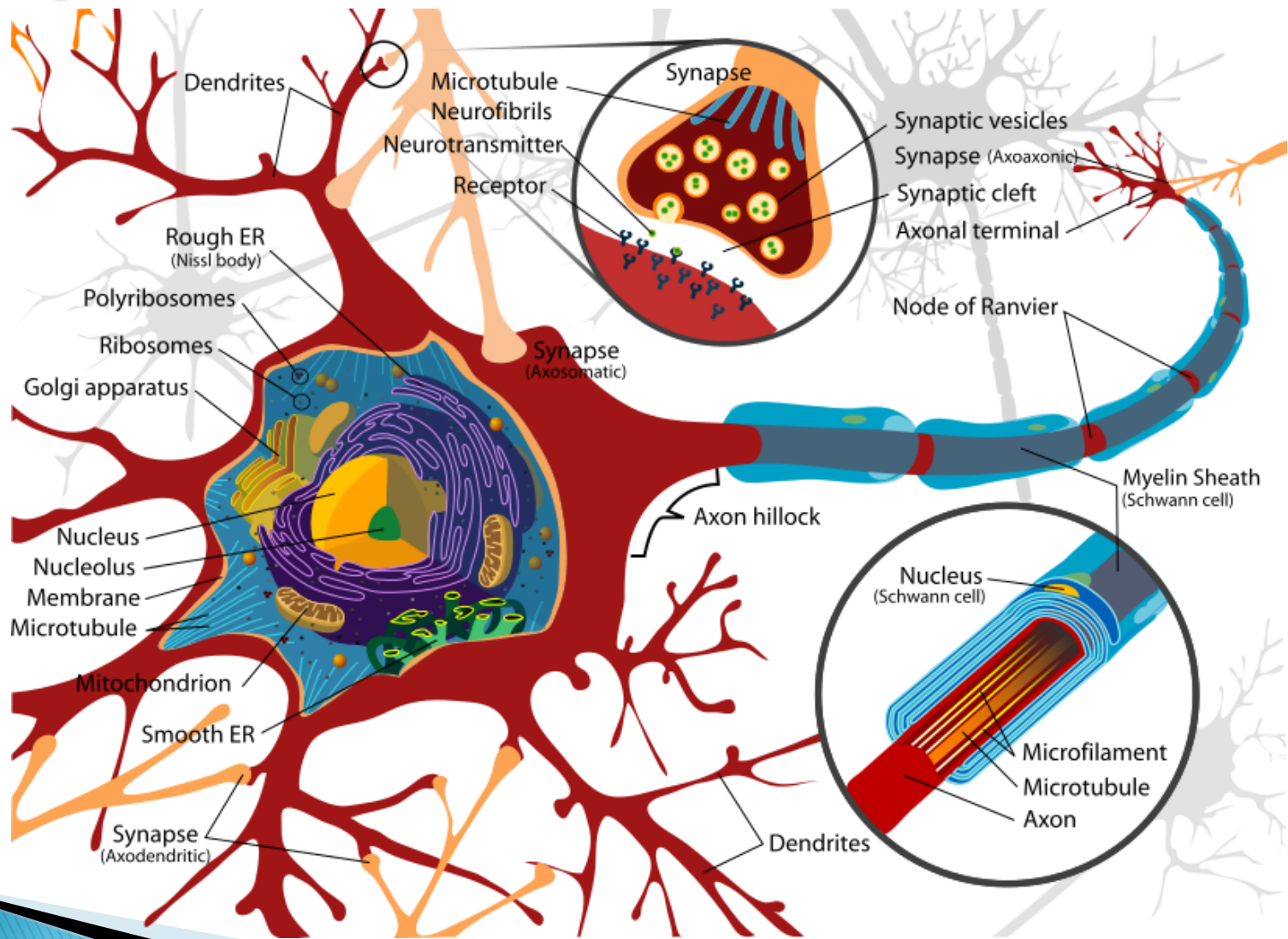
▶ Curs

- Joi 15–18, P5
- **2C ⇒ 3C**
 - $14 * 2/3 \approx 9.33$
 - $9 \div 10$ C

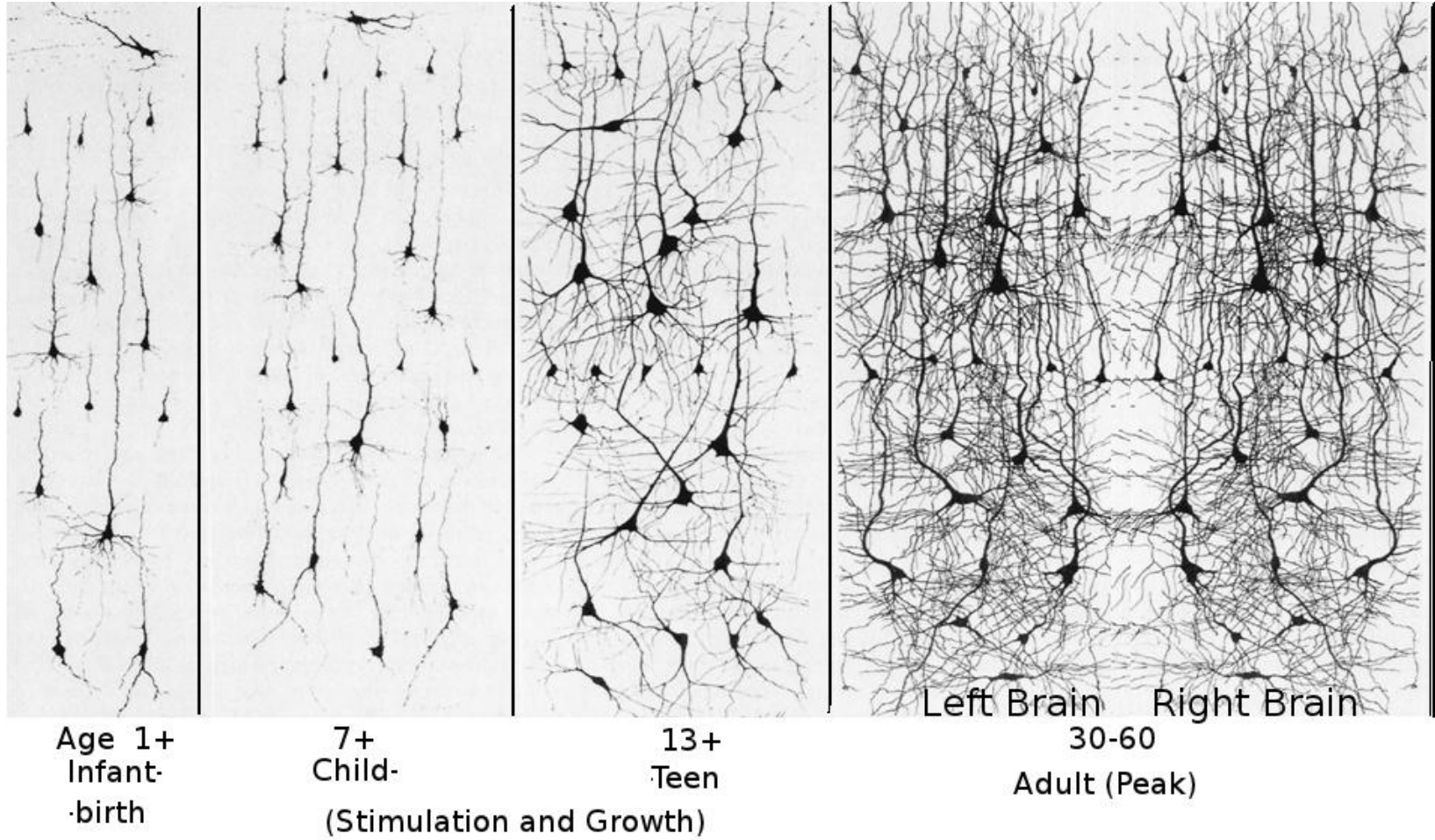
Scop 1



Scop 2



Scop 3



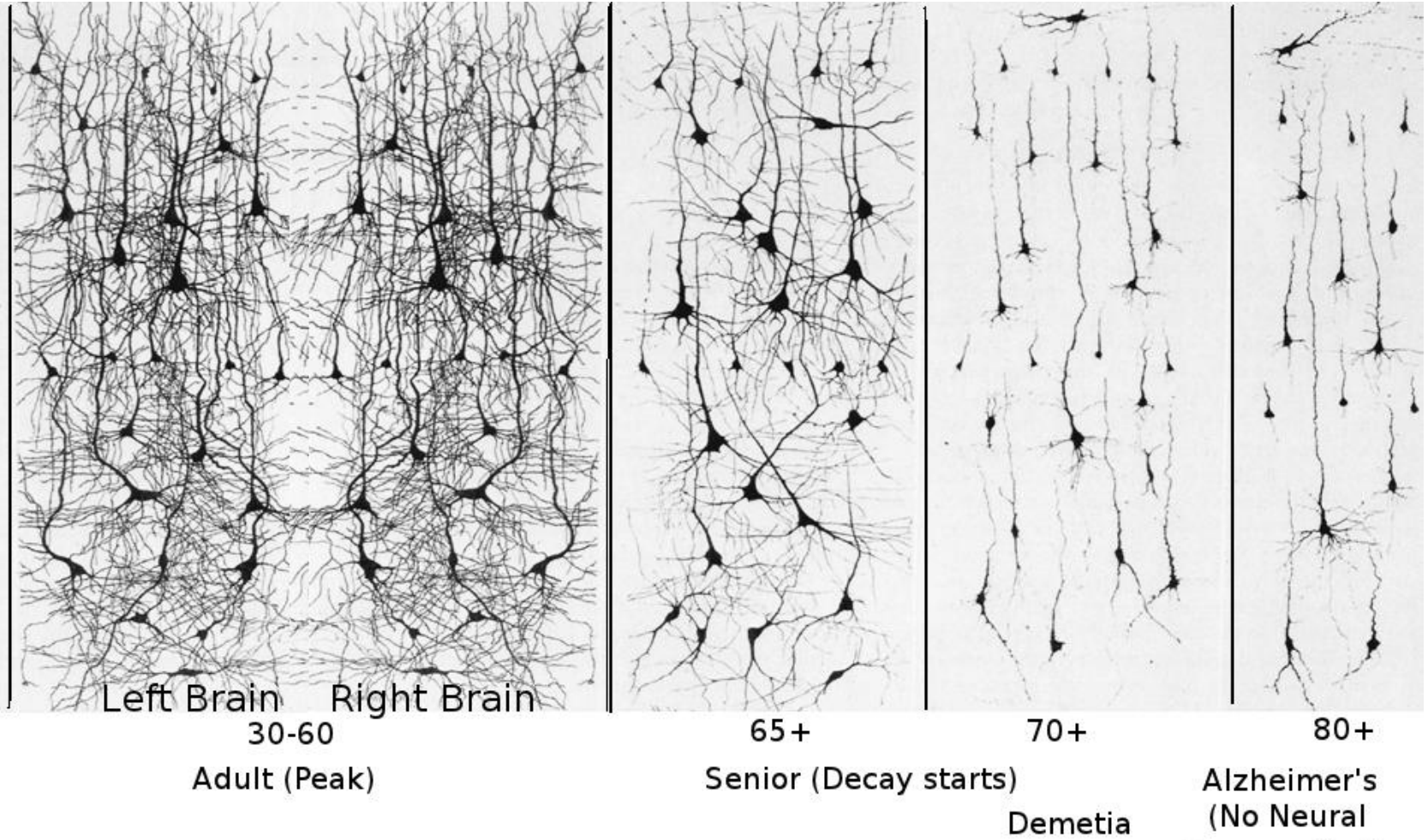
Scop 4



**Sinapse
“ingineresti”**



Termen



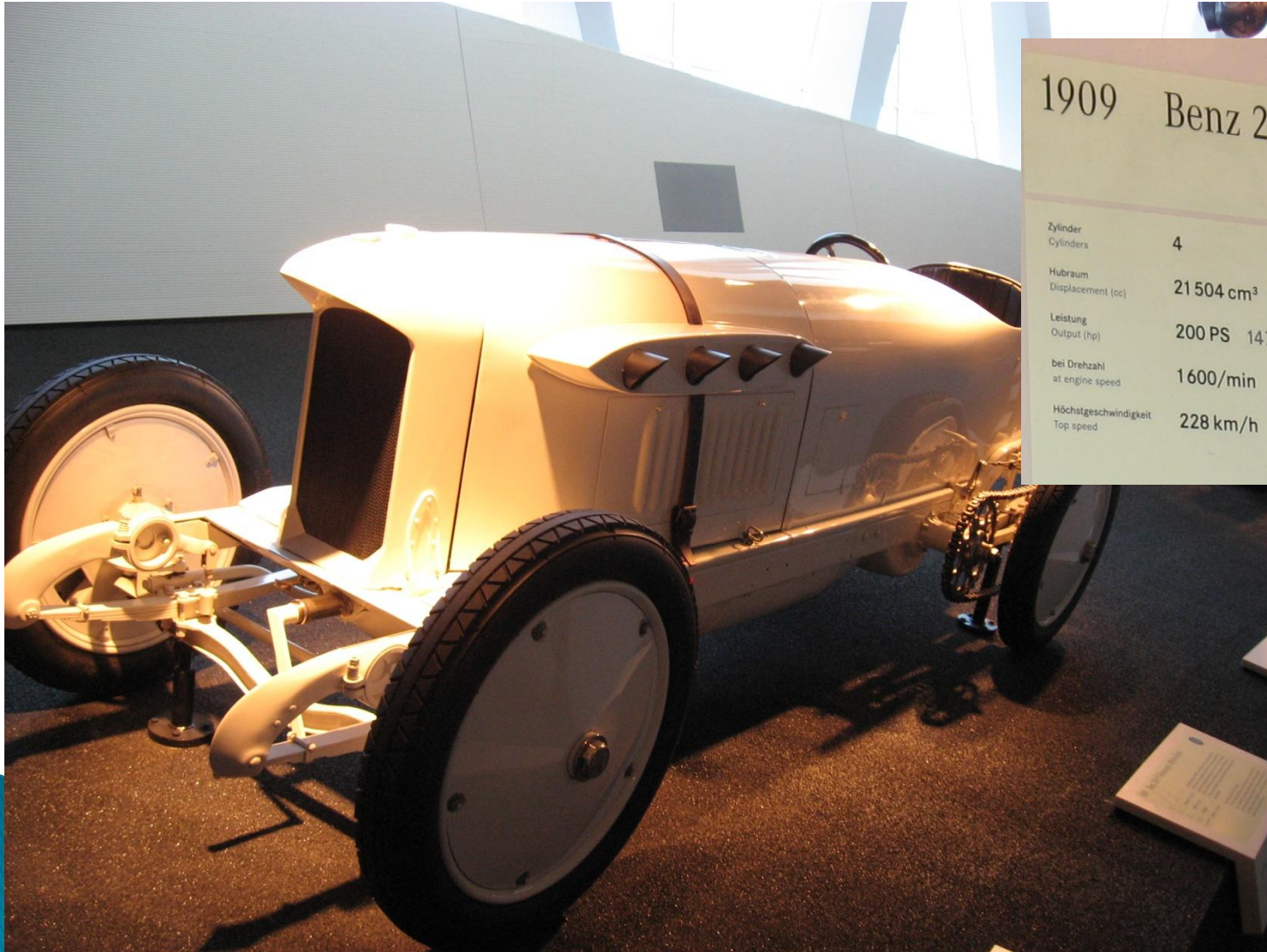
~1930



~1930



1909



1909 Benz 200 PS Rennwagen »Blitzen-Benz«

Zylinder Cylinders	4
Hubraum Displacement (cc)	21 504 cm ³ 1 312 cu in
Leistung Output (hp)	200 PS 147 kW
bei Drehzahl at engine speed	1 600/min
Höchstgeschwindigkeit Top speed	228 km/h 142 mph

Der »Blitzen-Benz« ist 1909 der erste 200 km/h fähige. Seine größten Erfolge erzielt er mit dem 4-Zylindermotor ausgestatteten Rekordwagen von Rudolf Carlsson mit 228 km/h über die Saale. Er ist damit das schnellste Fahrzeug, das jemals auf einer Eisenbahn gefahren ist.

Benz »Lightning Benz« 200 hp racing car
In 1909 the Lightning Benz was the fastest car in the world.

1930-1950



Tehnologie

> 2010

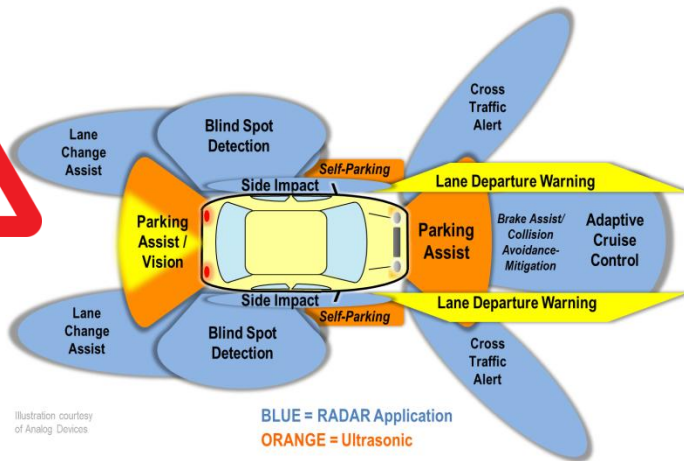


Illustration courtesy of Analog Devices

< 1950



Tehnologie

1x1 = 1	2x1 = 2	3x1 = 3	4x1 = 4	5x1 = 5
1x2 = 2	2x2 = 4	3x2 = 6	4x2 = 8	5x2 = 10
1x3 = 3	2x3 = 6	3x3 = 9	4x3 = 12	5x3 = 15
1x4 = 4	2x4 = 8	3x4 = 12	4x4 = 16	5x4 = 20
1x5 = 5	2x5 = 10	3x5 = 15	4x5 = 20	5x5 = 25
1x6 = 6	2x6 = 12	3x6 = 18	4x6 = 24	5x6 = 30
1x7 = 7	2x7 = 14	3x7 = 21	4x7 = 28	5x7 = 35
1x8 = 8	2x8 = 16	3x8 = 24	4x8 = 32	5x8 = 40
1x9 = 9	2x9 = 18	3x9 = 27	4x9 = 36	5x9 = 45
1x10 = 10	2x10 = 20	3x10 = 30	4x10 = 40	5x10 = 50
6x1 = 6	7x1 = 7	8x1 = 8	9x1 = 9	10x1 = 10
6x2 = 12	7x2 = 14	8x2 = 16	9x2 = 18	10x2 = 20
6x3 = 18	7x3 = 21	8x3 = 24	9x3 = 27	10x3 = 30
6x4 = 24	7x4 = 28	8x4 = 32	9x4 = 36	10x4 = 40
6x5 = 30	7x5 = 35	8x5 = 40	9x5 = 45	10x5 = 50
6x6 = 36	7x6 = 42	8x6 = 48	9x6 = 54	10x6 = 60
6x7 = 42	7x7 = 49	8x7 = 56	9x7 = 63	10x7 = 70
6x8 = 48	7x8 = 56	8x8 = 64	9x8 = 72	10x8 = 80
6x9 = 54	7x9 = 63	8x9 = 72	9x9 = 81	10x9 = 90
6x10 = 60	7x10 = 70	8x10 = 80	9x10 = 90	10x10 = 100

$$2 \times 1 = 2$$

$$2 \times 2 = 4$$

$$2 \times 3 = 6$$

$$2 \times 4 = 8$$

$$2 \times 5 = 10$$

$$2 \times 6 = 12$$

$$2 \times 7 = 14$$

$$2 \times 8 = 16$$

$$2 \times 9 = 18$$

$$2 \times 10 = 20$$

Cuprins

- ▶ **Lumina ca undă electromagnetică** (ecuațiile lui Maxwell, ecuația undelor, parametri de propagare)
- ▶ **Elemente de fotometrie și radiometrie** (mărimi energetice/luminoase)
- ▶ **Fibra optică** (realizare, principiu de funcționare, atenuare, dispersie, banda de frecvență)
- ▶ **Cabluri optice** (tehnologie, conectori, lipire – splice)
- ▶ **Proiectare sistemică a legăturii pe fibra optică** (bandă de frecvență, balanța puterilor)
- ▶ **Emitătoare optice** (LED și dioda laser – realizare fizică și funcționare)
- ▶ **Receptoare optice** (dioda PIN, dioda cu avalanșă – realizare fizică și funcționare)
- ▶ **Amplificatoare transimpedanță** (parametri, scheme tipice, TIA în buclă deschisă, cu reacție, diferențiale, control automat al câștigului)
- ▶ **Realizarea circuitelor pentru controlul emițătoarelor optice** (parametri, scheme tipice, controlul puterii, multiplexoare)
- ▶ **Dispozitive de captare a energiei solare** (principiu de funcționare, utilizare, proiectare)

Bibliografie

- ▶ <http://rf-opto.etti.tuiasi.ro>
- ▶ Irinel Casian-Botez, "Structuri Optoelectronice", Ed. "CANOVA", Iasi 2001, ISBN 973-96099-2-9
- ▶ Behzad Razavi - Design of Integrated Circuits for Optical Communications, Mc Graw Hill
~~<http://rf-opto.etti.tuiasi.ro/docs/opto/>~~
- ▶ IBM - Understanding Optical Communications: on-line <http://www.redbooks.ibm.com>
- ▶ Radu Damian, I Casian, D Matăsaru - „Comunicatii Optice” , Indrumar de laborator, 2005

Documentatie



STARECAT.COM

Documentatie

http://rf-opto.eti.tuiasi.ro/optical_comm.php

eti.tuiasi.ro

Laboratorul de Microunde s...

ro.wikipedia.org

English | Romana

Main **Courses** Master Staff Research Students

Microwave CD **Optical Communications** Optoelectronics Internet Practica Networks

Optical Communications

Course: CO (2014-2015)

Course Coordinator: Prof. Dr. Irinel Casian Botez
Code: DOS410T
Discipline Type: DOS; Alternative, Specialty
Credits: 4
Enrollment Year: 4, Sem. 7

Activities

Course: Instructor: Prof. Dr. Irinel Casian Botez, 3 Hours/Week, Specialization Section, Timetable:
Laboratory: Instructor: Assist.P. Dr. Petre-Daniel Matasaru, 1 Hours/Week, Half Group, Timetable:

Evaluation

Type: **Colocviu**

A: 70%, (Test/Colloquium)
B: 30%, (Seminary/Laboratory/Project Activity)

Grades

[Aggregate Results](#)

Attendance

Not yet

Materials

Course Slides

[Raze de lumina slides \(pdf, 232.99 KB, ro, IT\)](#)
[Fibre optic slides \(pdf, 902.07 KB, ro, IT\)](#)
[LED \(pdf, 664.51 KB, ro, IT\)](#)

Documentatie

- ▶ RF-OPTO

- <http://rf-opto.etti.tuiasi.ro>

- ▶ Fotografie

- de trimis prin email: rdamian@etti.tuiasi.ro

- necesara la laborator/curs

Fotografii

Studentii care au trimis fotografiile 🙌👏

Grupa: 5402

Nr.	Nume
1	APETRII MARIA

Grupa: 5403

Nr.	Nume
1	ALEXANDRESCU SEBASTIAN

Grupa: 5404

Nr.	Nume
1	APERGHIS MIHAI-ALIN

Grupa: 5405

Nr.	Nume
1	ANGHELUS MARIU

Studentii care **inca** nu au trimis fotografiile 🙄

Grupa: 5304

Nr.	Nume
-----	------

Grupa: 5402

Nr.	Nume
-----	------

Grupa: 5403

Nr.	Nume
-----	------

Grupa: 5404

Nr.	Nume
-----	------

Fotografii



Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

[Trimite email acestui student](#) | [Adauga acest student la lista \(0\)](#)

Detalii curente

Observatii

Finantare	Buget
Bursa	Fara Bursa



Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5244

[Trimite email acestui student](#) | [Adauga acest student la lista \(0\)](#)

Detalii curente

Observatii

Finantare	Buget
Bursa	Bursa de Studii



Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

[Acceseaza ca acest student](#)

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	Tehnologii Web					
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Colocviu Tehnologii Web 2013/2014	10	7.55	
	B	17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
	D	17/01/2014	Tema Tehnologii Web 2013/2014	9	-	

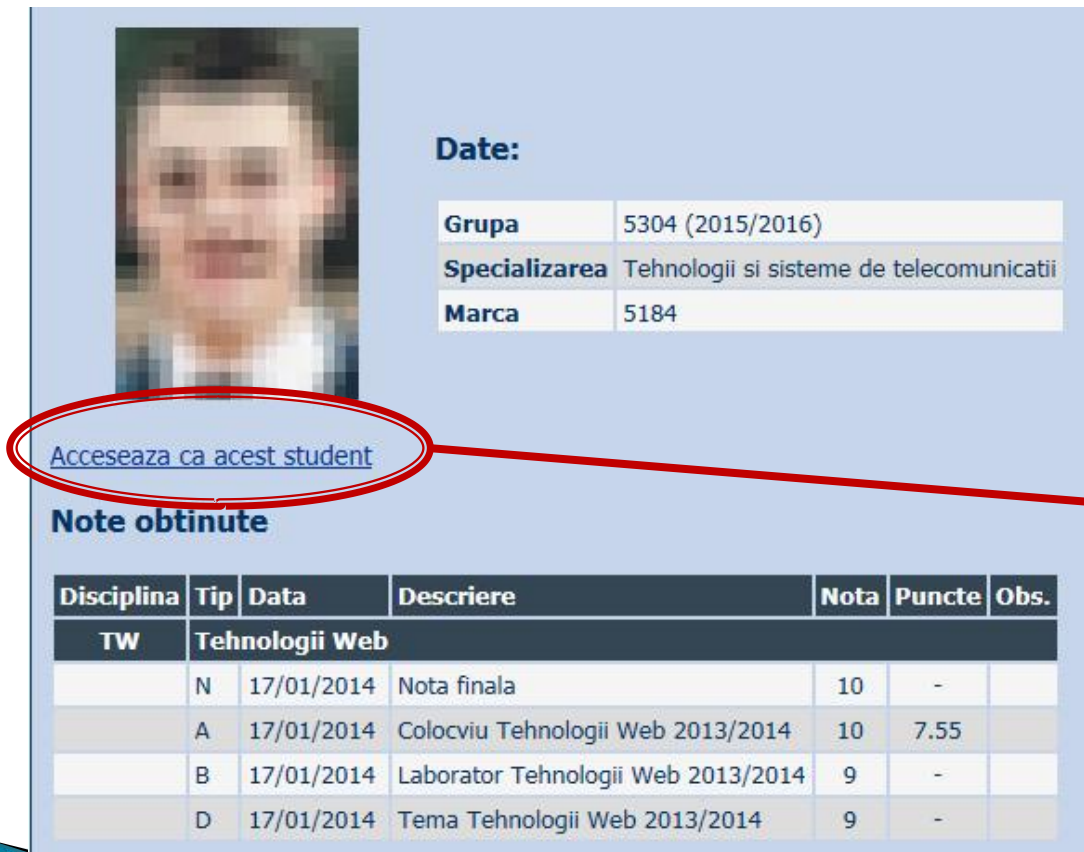
Fotografii

Nr. Student	Student	Prezent	Nr. Student	Student	Prezent	Nr. Student	Student	Prezent
1	ANGHELUS IONUT-MARIUS	<input type="checkbox"/>	2	ANTIGHIN FLORIN-RAZVAN	<input type="checkbox"/>	3	ANTONICA BIANCA	<input type="checkbox"/>
4	APOSTOL PAVEL-MANUEL	<input type="checkbox"/>	5	BALASCA DULIAN-PETRU	<input checked="" type="checkbox"/>	6	BOSTAN ANDREI-PETRICIA	<input type="checkbox"/>
7	BOTEZAT EMANUEL	<input type="checkbox"/>	8	BUTUNOI GEORGE-MADALIN	<input type="checkbox"/>	9	CHILEA SALUCA-MARIA	<input type="checkbox"/>
10	CHIRITOIU ECATERINA	<input type="checkbox"/>	11	COJOC MARIUS	<input checked="" type="checkbox"/>	12	COJOCARIU AURA-FLORINA	<input type="checkbox"/>

Nr. Student	Student	Prezent
2	ANTIGHIN FLORIN-RAZVAN	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:

Acces

▶ Personalizat



Student profile card showing a blurred photo, a 'Date:' section with a table of personal information, and a 'Note obtinute' table. A red oval highlights the link 'Acceseaza ca acest student'.

Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

[Acceseaza ca acest student](#)

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	Tehnologii Web					
N		17/01/2014	Nota finala	10	-	
A		17/01/2014	Colocviu Tehnologii Web 2013/2014	10	7.55	
B		17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
D		17/01/2014	Tema Tehnologii Web 2013/2014	9	-	



Login form with fields for Name, Email, and Verification Code. A red oval highlights the Email field, and another red oval highlights the Verification Code field. A red arrow points from the link in the student profile to the Email field. A verification code '344bd9f' is displayed below the code field, and a 'Trimite' button is at the bottom.

Nume

Email

Cod de verificare

344bd9f

Trimite

Examen

- ▶ subiecte individuale
- ▶ Note
 - 2007: $9.67 \pm 0.66 / 8.81 \pm 1.22$
 - 2008: $6.24 \pm 1.36 / 4.82 \pm 2.10$
 - 2009: 5.10 ± 1.46
 - 2010: 3.89 ± 1.32
- ▶ La prima aplicare (neanuntata)
 - 50% din studenti au parasit examenul in primele 10 minute
 - 50% din cei ramasi nu au promovat
 - promovabilitate totala **25%**, rata contestatiilor: **0%**
- ▶ Urmatoarele examinari (anuntate)
 - rata contestatiilor: 0%

Examen



Introducere

Capitolul 1

Aplicatii majore

- ▶ Comunicatii

- Infrarosu (InGaAsP)

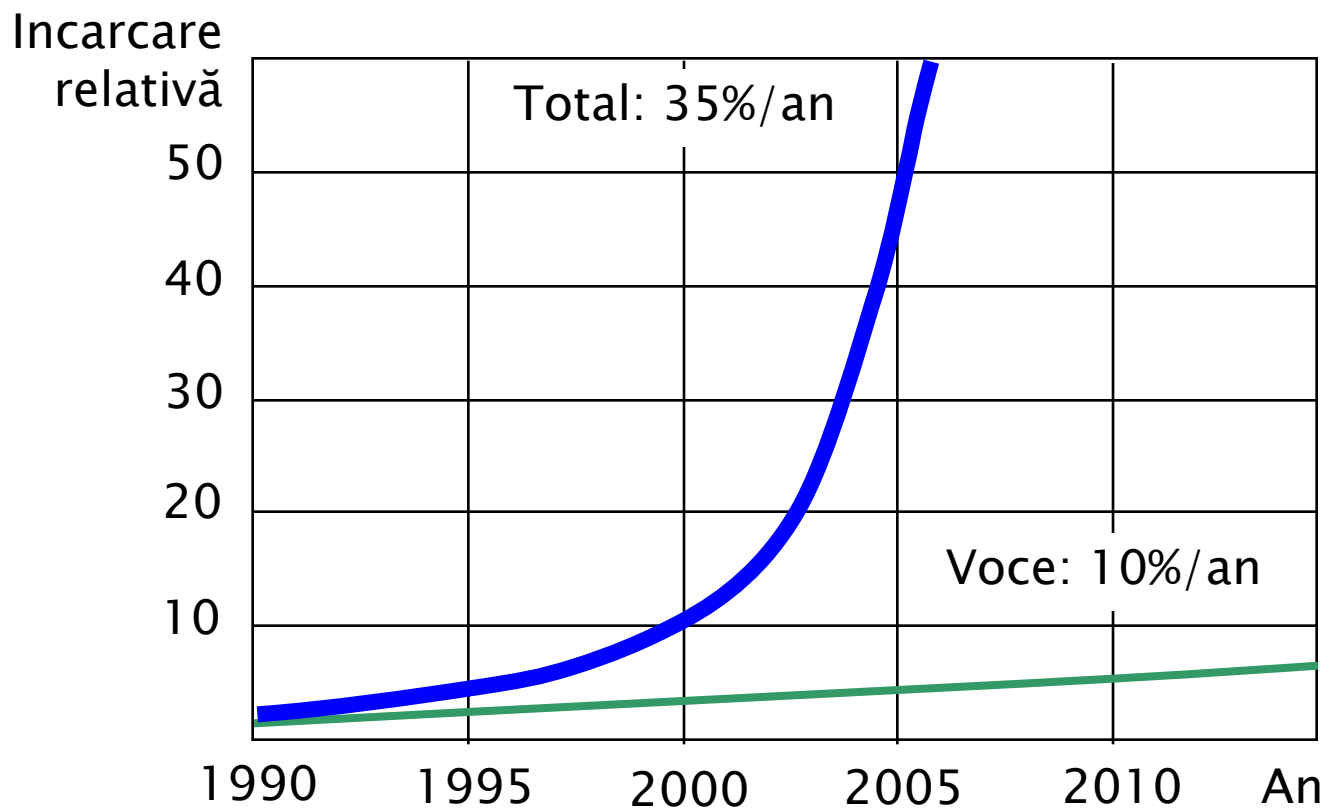
- ▶ Vizibil

- Spectru vizibil (GaAlAs)

- ▶ Iluminare

- Putere ridicata, lumina alba (GaInN)

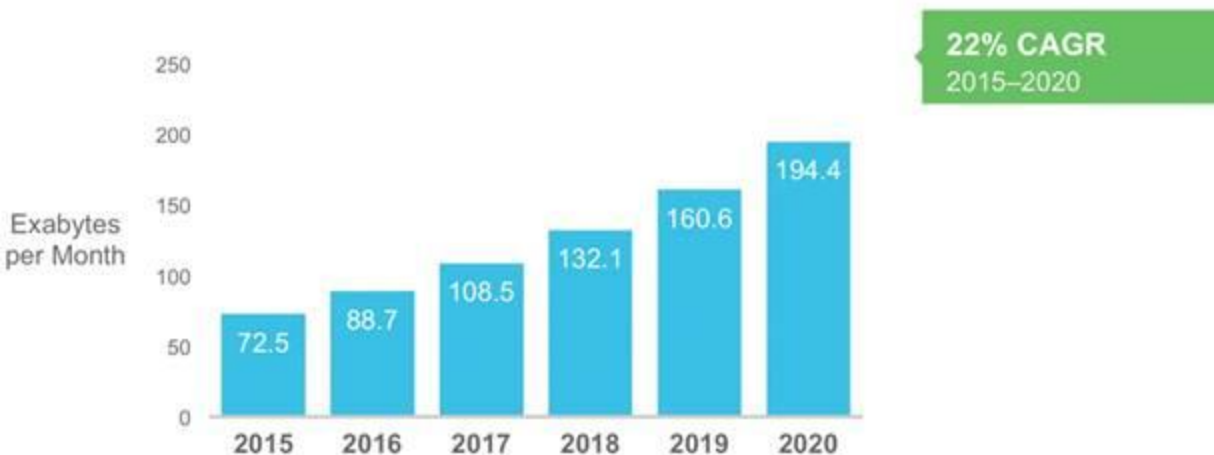
Evoluția lățimii de bandă utilizată în rețelele de telecomunicații



Sursa:

EC ELECTRONICAST
CORPORATION

Evoluția lățimii de bandă

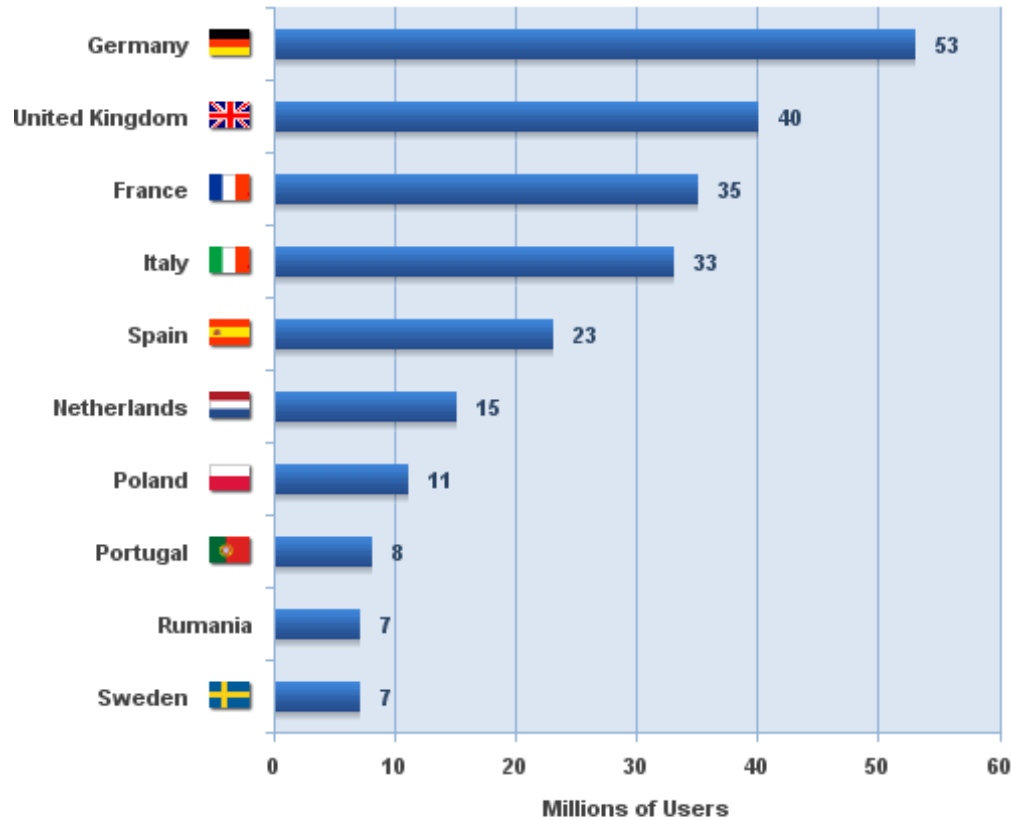


Source: Cisco VNI, 2016

Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GBps
2007	2,000 GBps
2015	20,235 GBps
2020	61,386 GBps

Utilizzatori Internet in EU

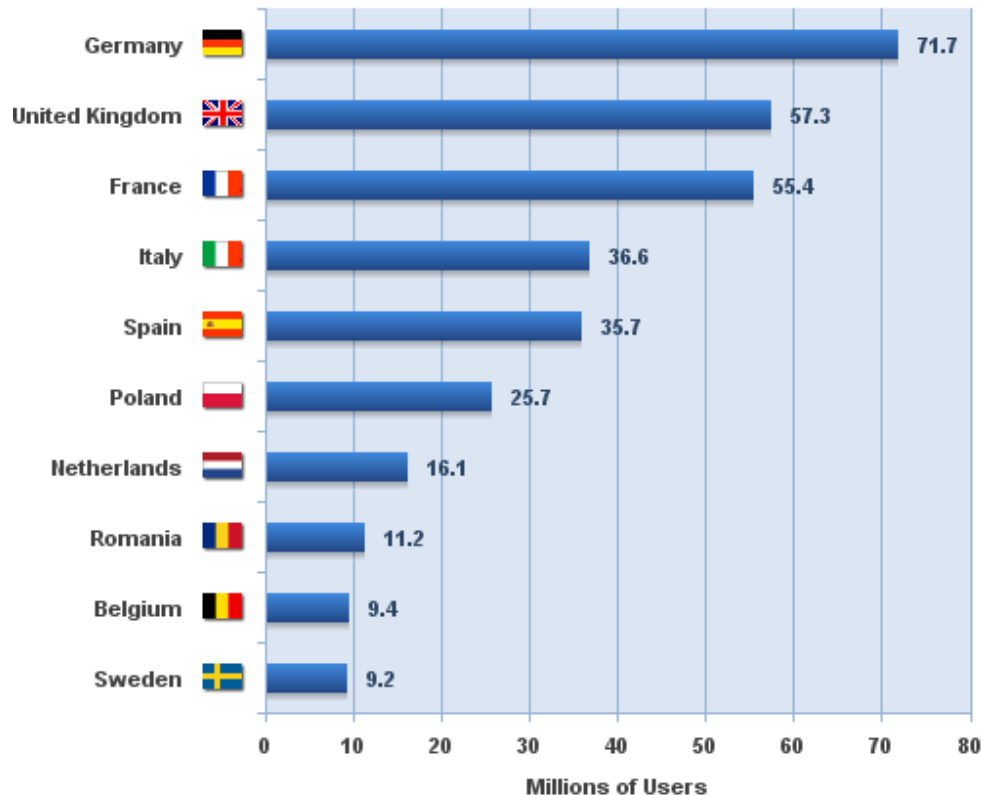
European Union Top 10 Internet Users November 2007



Source: www.internetworldstats.com
Copyright © 2008, Miniwatts Marketing Group

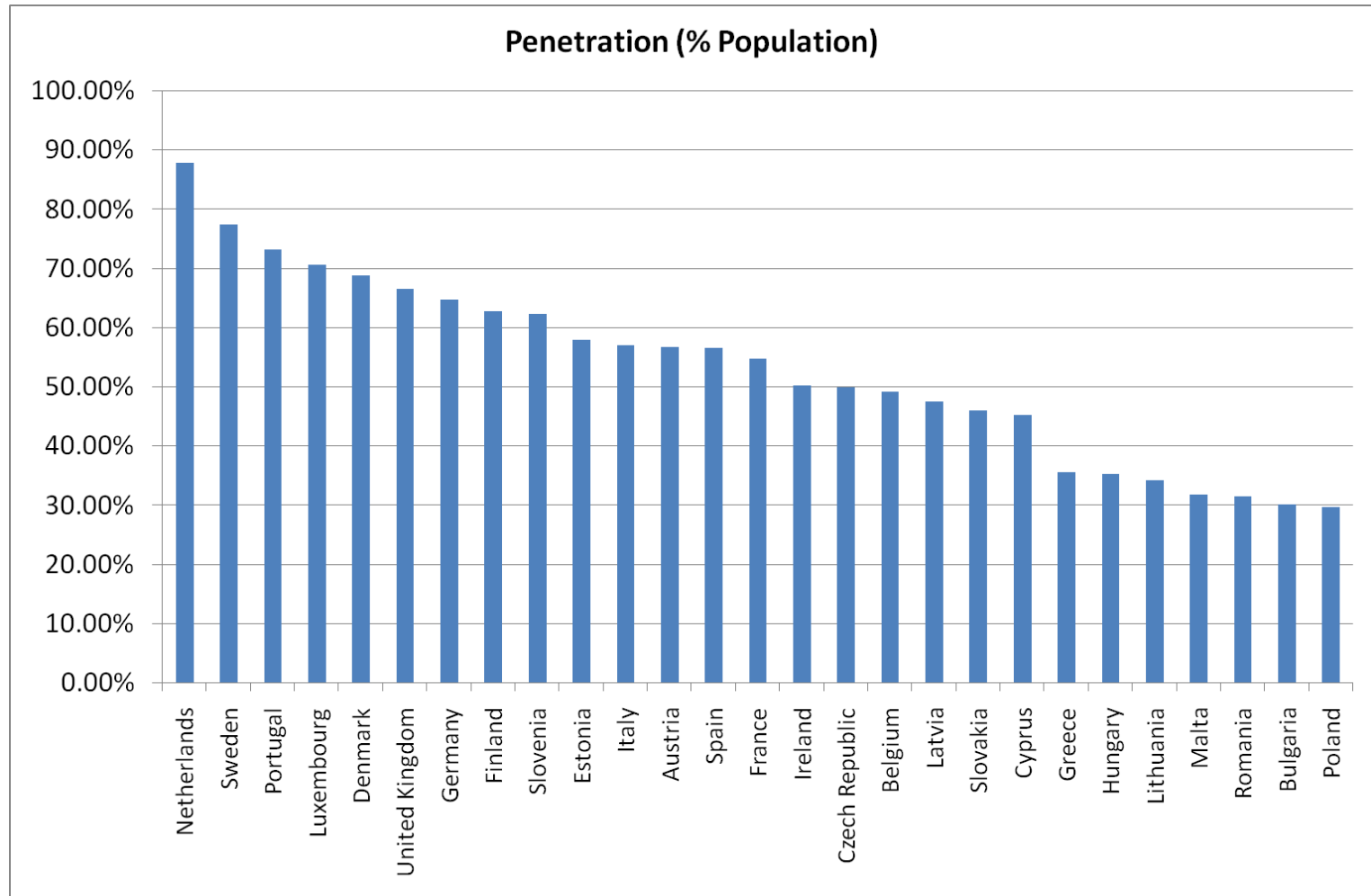
Utilizzatori Internet in EU

European Union - Top 10 Internet Countries December 31, 2014

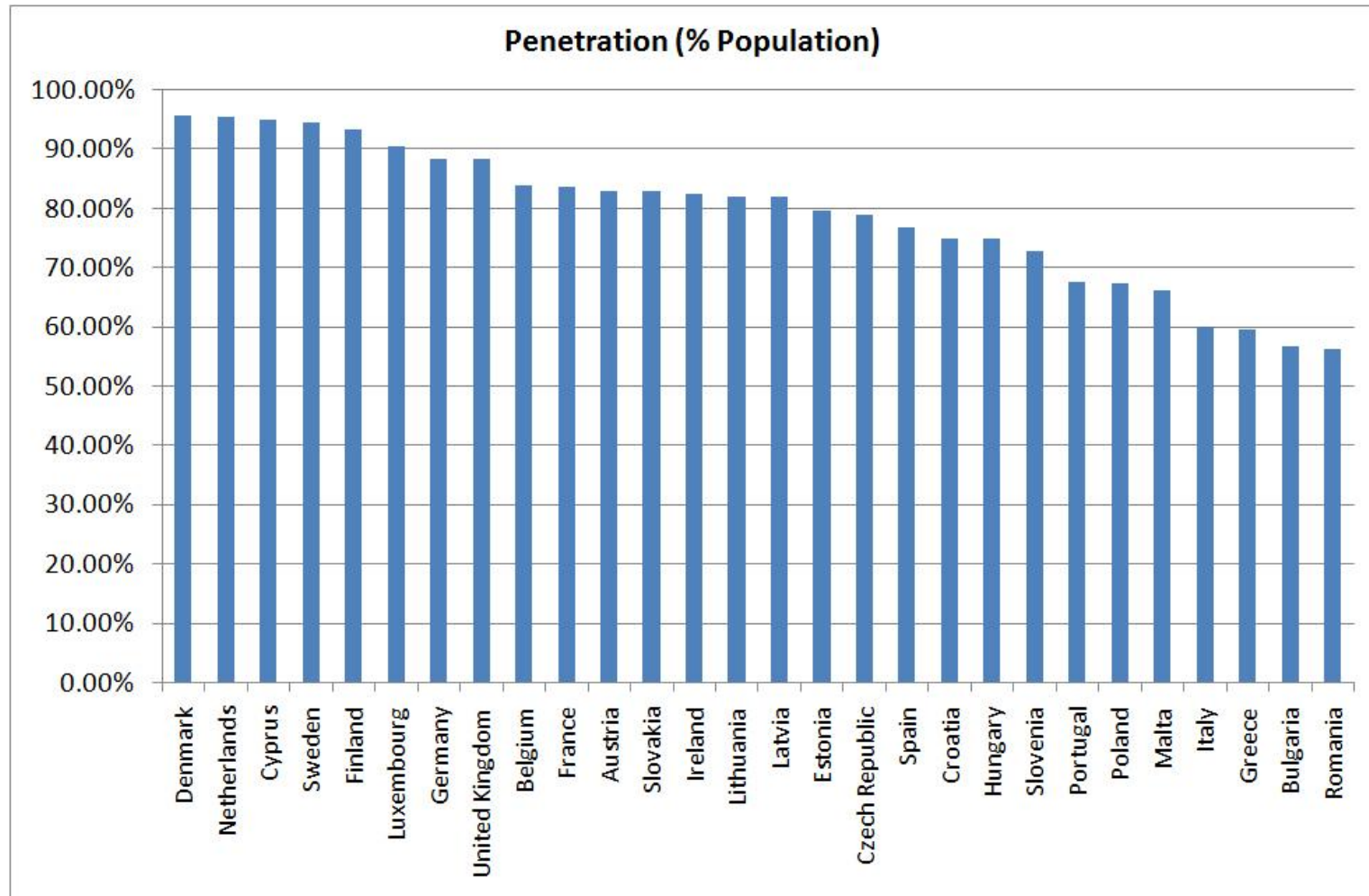


Source: Internet World Stats - www.internetworldstats.com/stats9.htm
398,972,533 estimated EU Internet users for 2014Q4
Copyright © 2015, Miniwatts Marketing Group

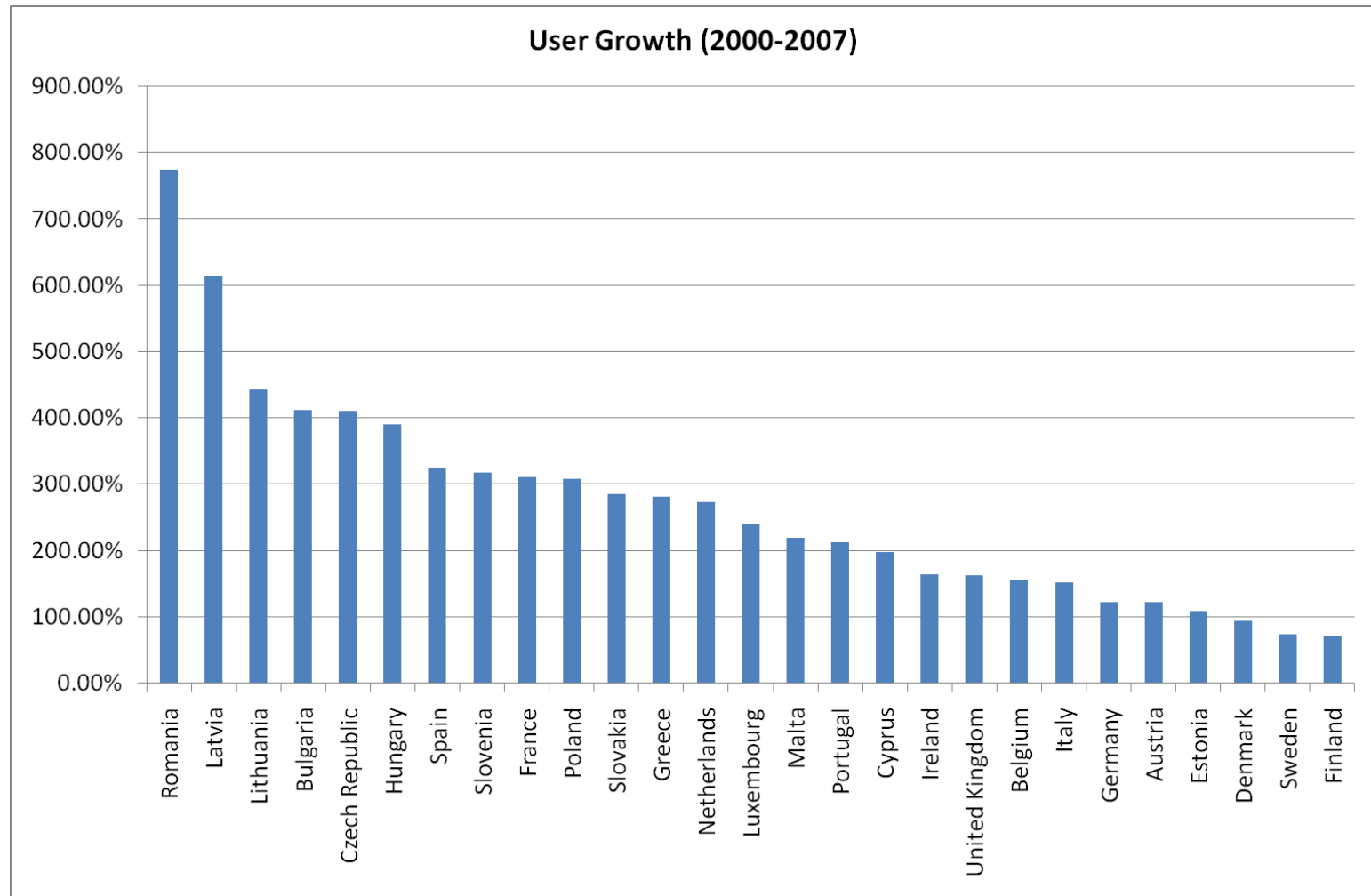
Rata de penetrare in EU 2007



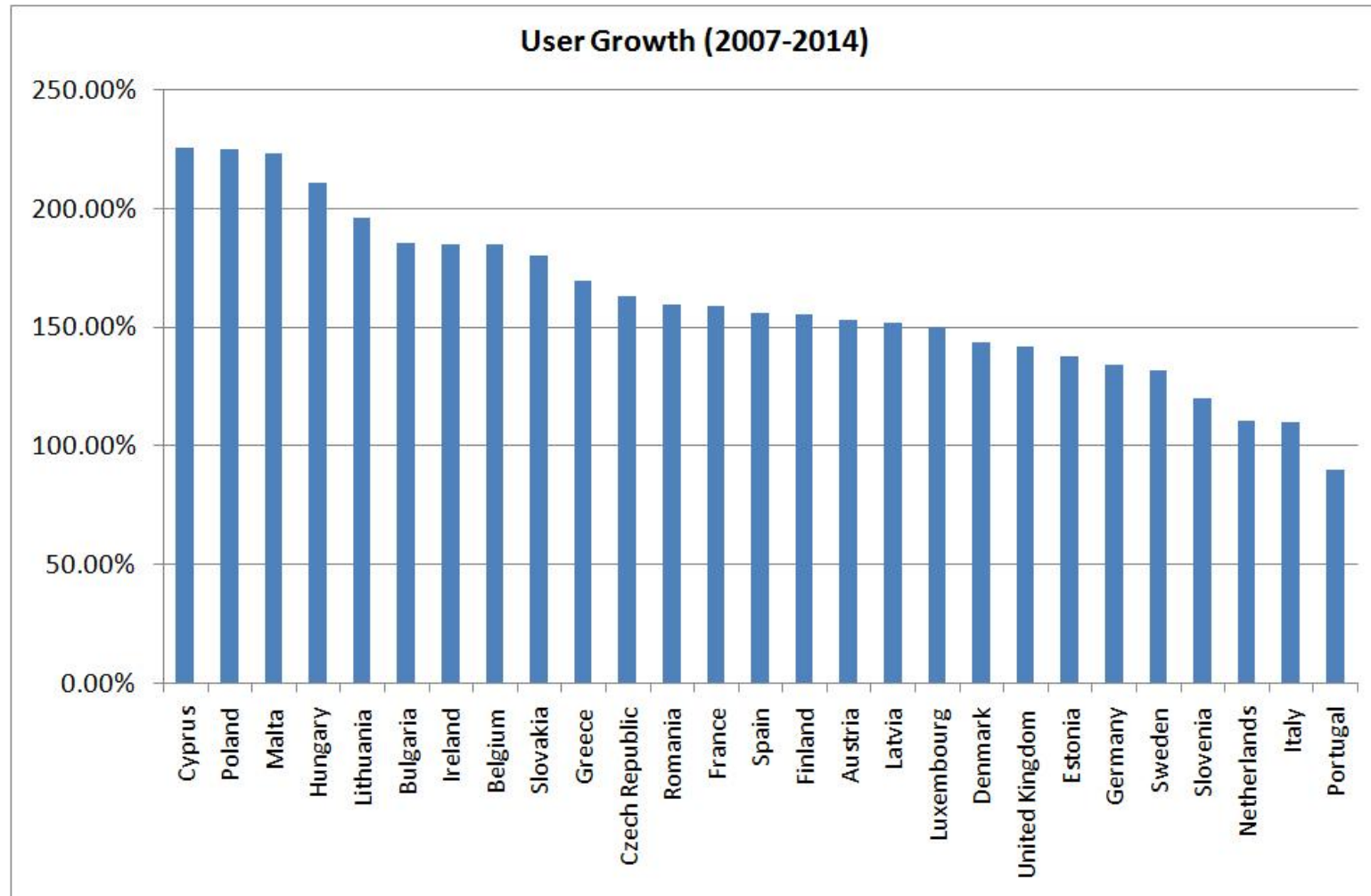
Rata de penetrare in EU 2014



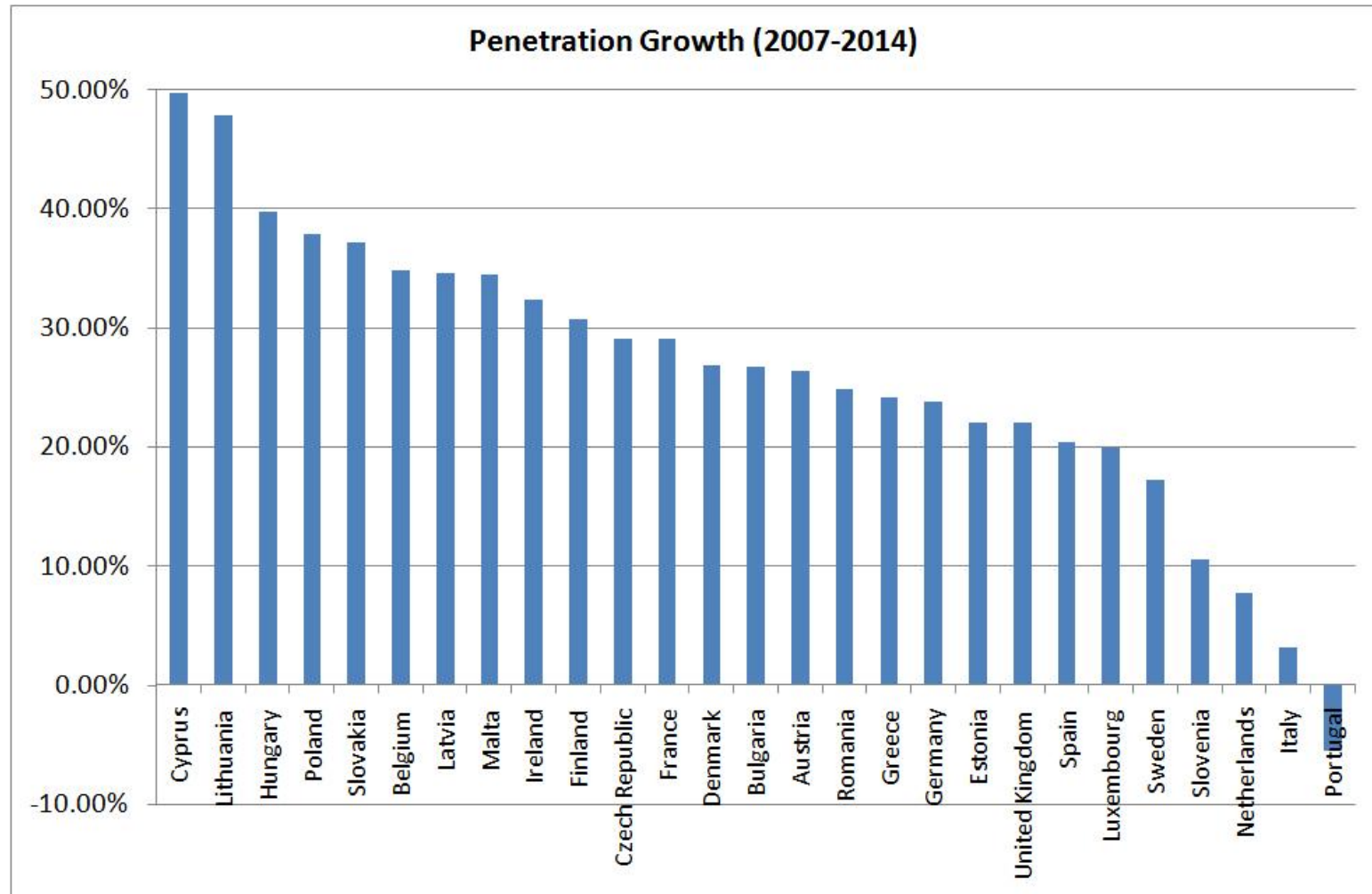
Crestere 2000-2007



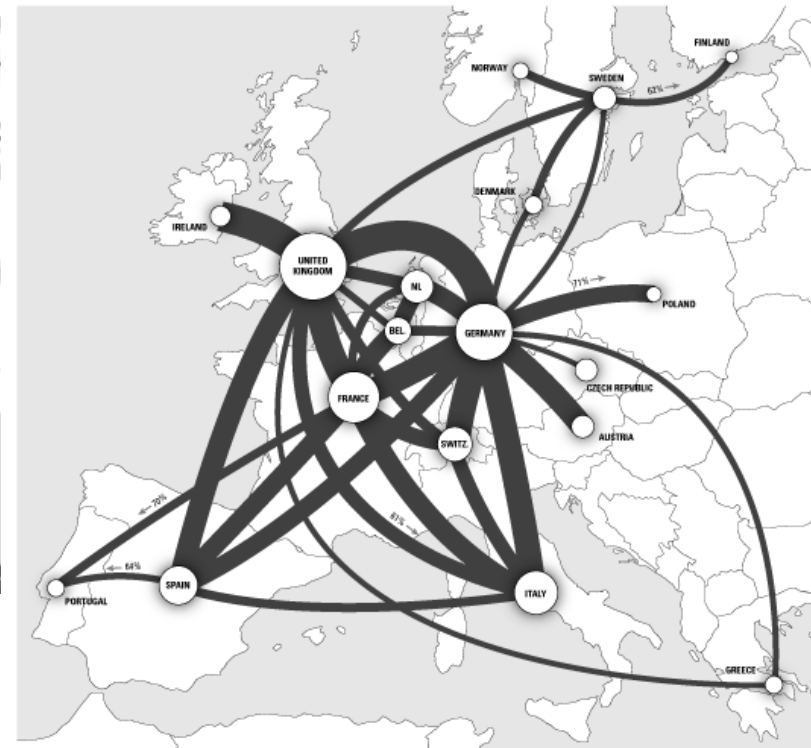
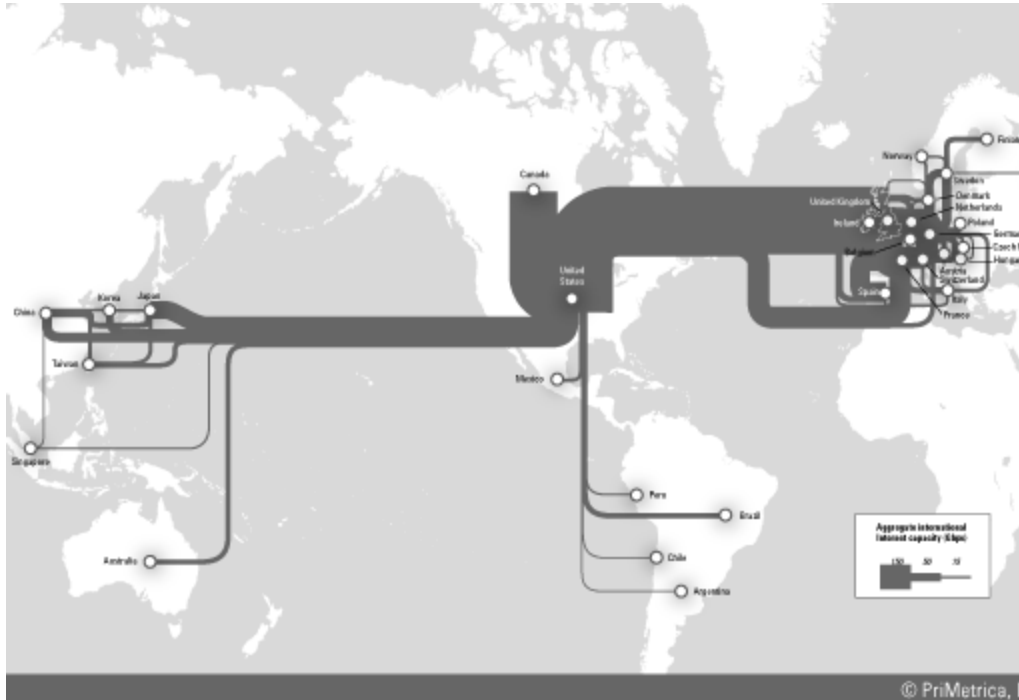
Crestere 2007-2014



Crestere 2007-2014



Internet Backbone

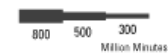


Key

All figures are given in millions of minutes of telecommunications traffic for the public telephone network.

The map shows all intra-European routes with a combined 2004 volume of more than 300 million minutes.

Traffic Flows



Each band is proportional to the total annual traffic on the public telephone network in both directions between each pair of countries.

Total Outgoing Traffic



The area of each circle is proportional to the volume of the total annual outgoing traffic from each country.

Balance of Traffic

On routes where traffic in one direction accounts for more than 50 percent of the total, an arrow shows the direction most of the traffic flows.

Internet Backbone



Avantajele comunicațiilor prin fibra optică – 1

- ▶ Greutate și volum
- ▶ Costul materialelor primare
 - SiO_2/Cu
- ▶ Capacitate de transmisie a informației **$f \sim 200\text{THz}$**
 - 15.5 Tbit/s @ 7000 km, 69.1 Tb/s @ 240km
 - Banda (Viteza) x Distanță [MHz · km] [? MHz/km]
- ▶ Lipsa conexiunilor electrice
 - Bucle de masă (1–2V/km)
 - Siguranță în exploatare
 - Imunitate la fulgere/lipsa scânteilor

Avantajele comunicațiilor prin fibra optică – 2

- ▶ Imunitate la interferență electromagnetică
- ▶ Distanța între repeatoare
 - 100km/2–5km
- ▶ Posibilitate de creștere a capacității de transmisie a informației
 - Teoretic extrem de mare (aproape infinită) **f~200THz**
 - Reutilizarea cablurilor existente
- ▶ Securitate
 - Interceptare dificilă și detectabilă
 - Inserare de semnal practic imposibilă

Dezavantajele comunicațiilor prin fibra optică

- ▶ Conexiuni complexe și esențiale
 - Costul circuitelor integrate crescut considerabil de cuplarea luminii în fibra
- ▶ Curbarea cablurilor optice
- ▶ Dezvoltarea greoaie a standardelor
- ▶ Optica folosită strict pentru transmisie (aproape)
 - EDFA – Erbium Doped Fiber Amplifier
- ▶ Sensibilitate la radiații gama și câmpuri electrice intense
- ▶ Rozătoare și termite

Esantionare

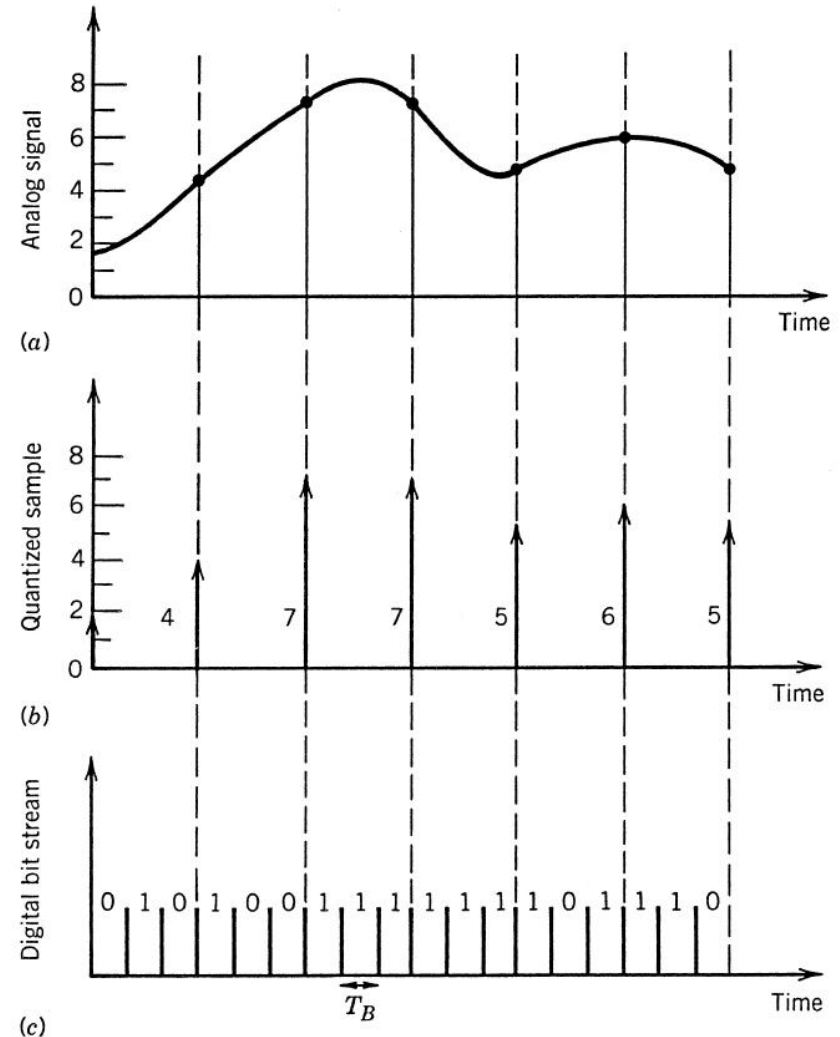
- ▶ pulse–position modulation
- ▶ pulse–duration modulation
- ▶ pulse–code modulation (PCM)

- ▶ esantionare (Nyquist)

$$f_s \geq 2 \cdot \Delta f$$

- ▶ cuantizare **M** intervale discrete
- ▶ zgomot de cuantizare
- ▶ minimizat

$$M \geq \frac{A_{\max}}{A_N}$$



Esantionare

- ▶ pulse-code modulation (PCM)
- ▶ cuantizare M intervale discrete, codificate cu m biți

$$M = 2^m$$

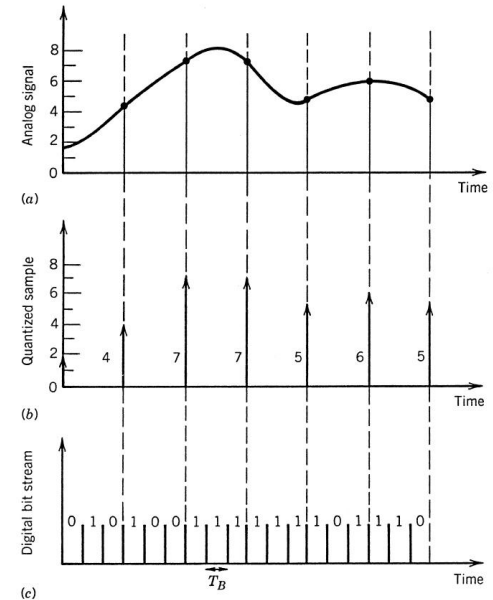
- ▶ viteza necesara (bit rate) [b/s]

$$B = m \cdot f_s \geq (2\Delta f) \cdot \log_2 M$$

$$M \geq \frac{A_{\max}}{A_N} \quad SNR [\text{dB}] = 10 \cdot \log_{10} \left(\frac{P_{\max}}{P_N} \right) = 20 \cdot \log_{10} \left(\frac{A_{\max}}{A_N} \right) \quad \log_2 10 \approx 3.33$$

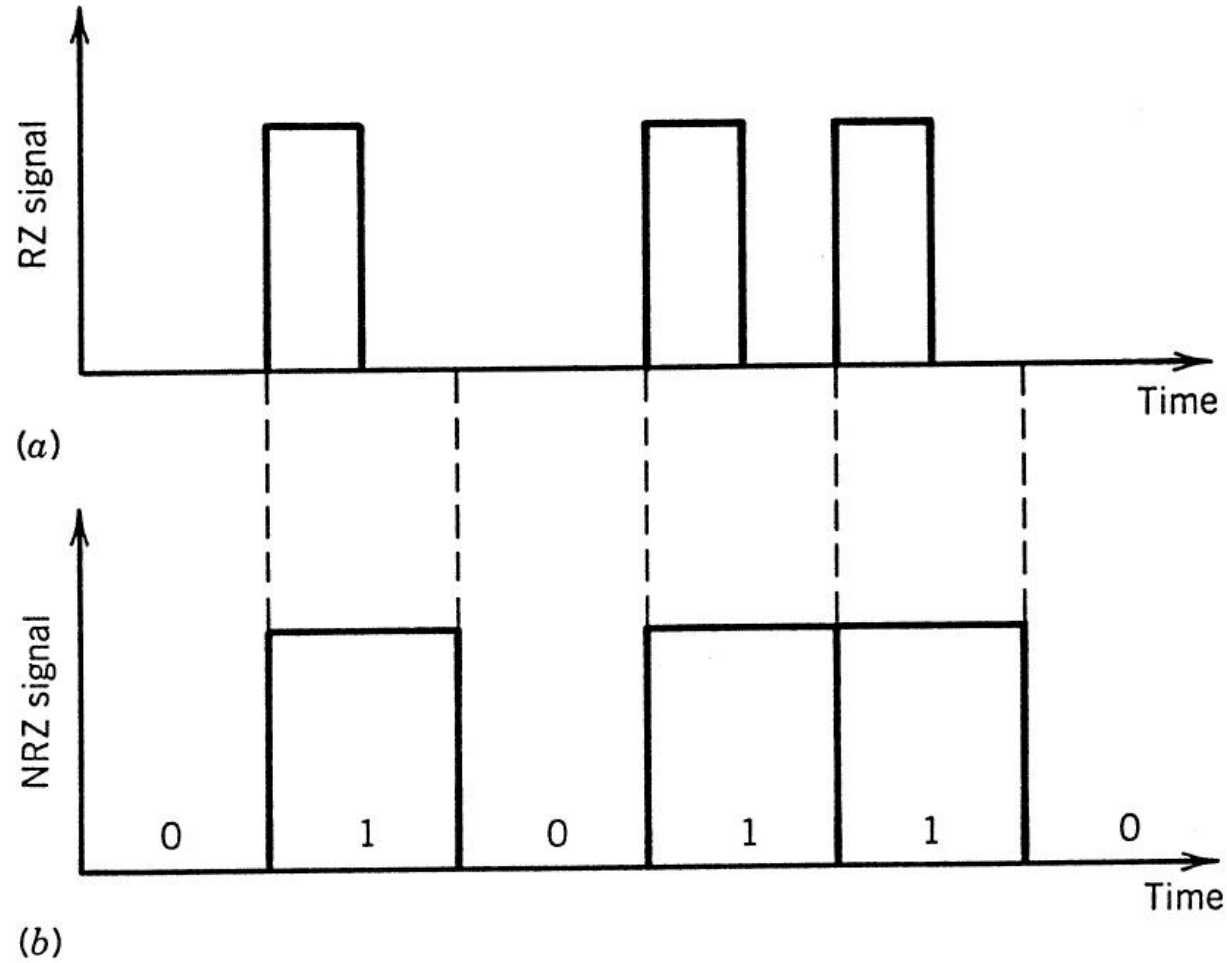
$$B > (\Delta f / 3) \cdot SNR$$

- ▶ telefonie: 3.1 kHz @ SNR=30dB
 - ▶ B=31 kb/s (64 kb/s)
- ▶ televiziune: 4 MHz @ SNR=50dB
 - ▶ B=66 Mb/s (100 Mb/s)

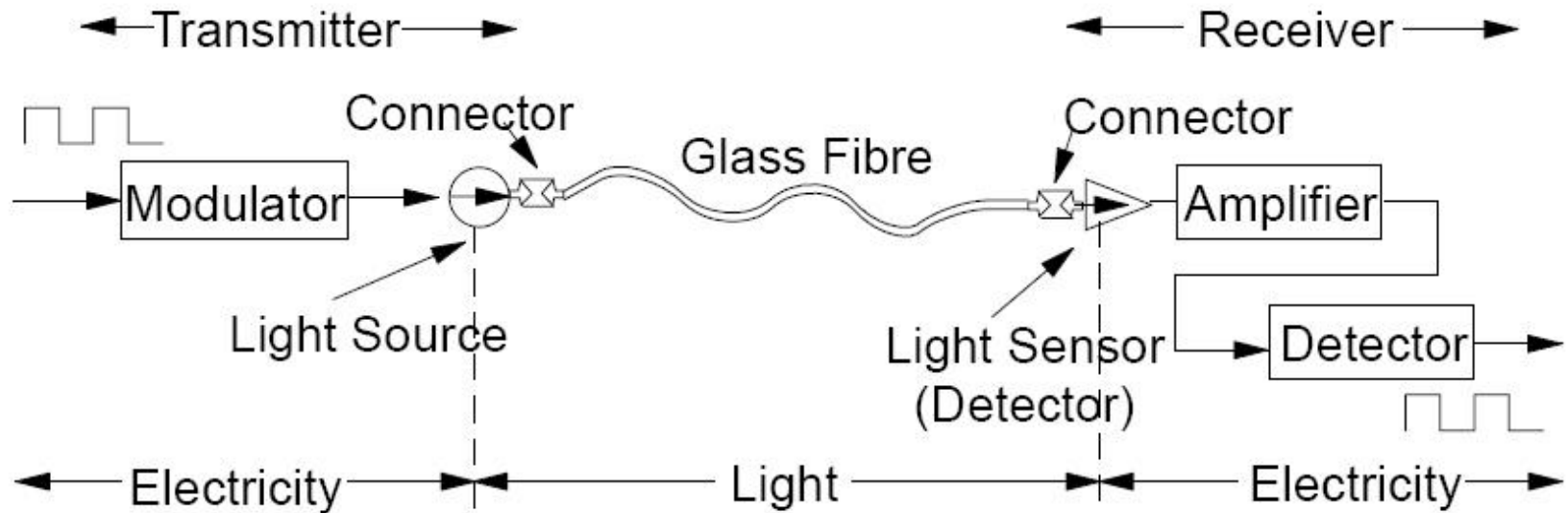


Modulare

- ▶ return-to-zero (RZ)
- ▶ nonreturn-to-zero (NRZ)

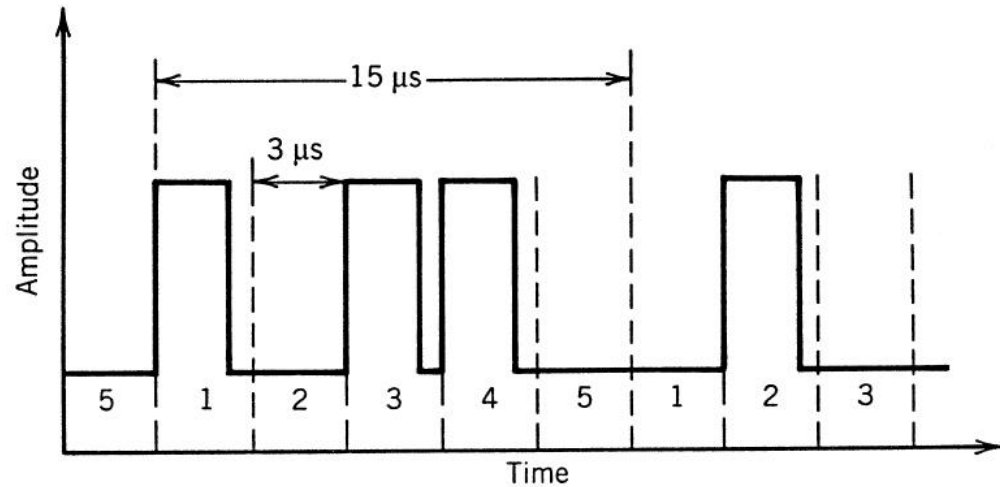


Transmisia optica

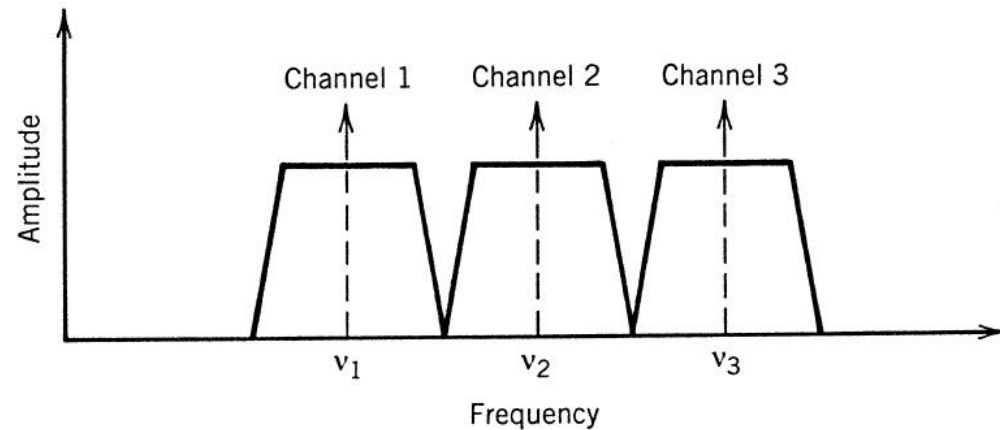


Multiplexare

- ▶ TDM
 - time-division multiplexing
- ▶ FDM
 - frequency-division multiplexing
- ▶ Realizabila in domeniul **electric/optic**
- ▶ WDM
 - wavelength division multiplexing

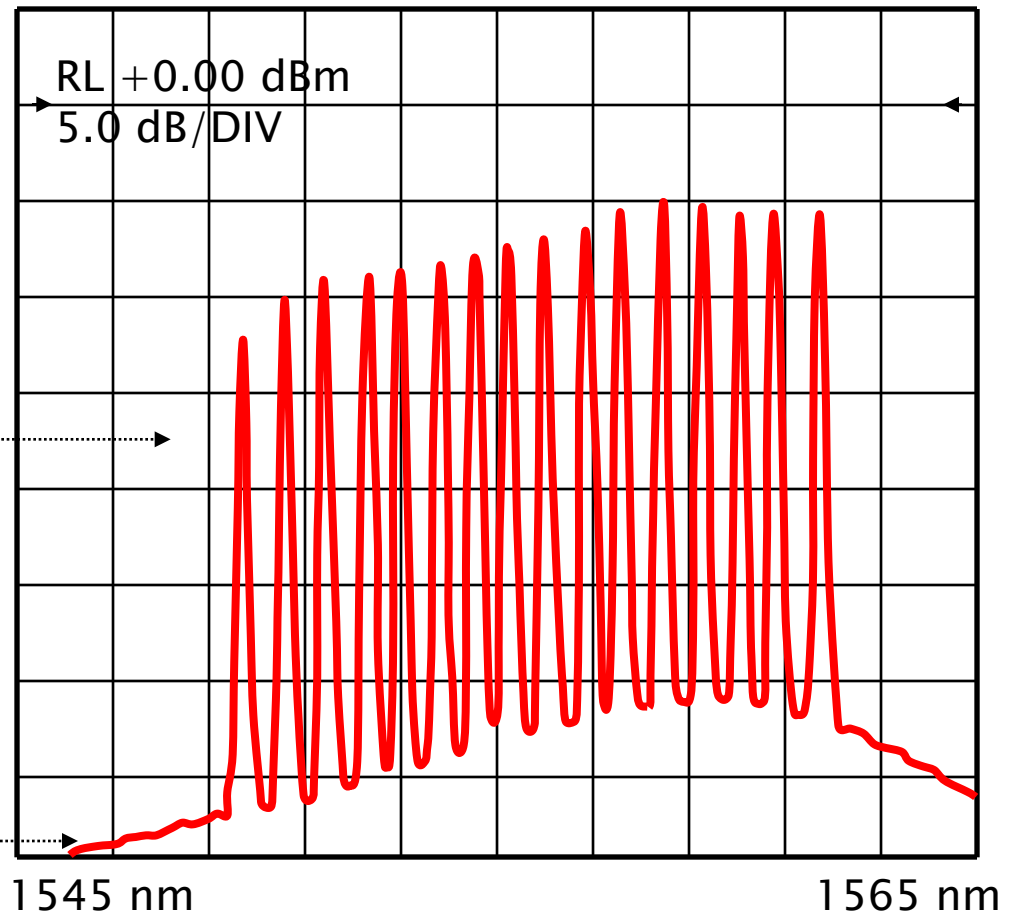


(a)



(b)

Spectrul WDM – Wavelength Division Multiplexing



Canale: 16
Spațiere: 0.8 nm

Emisie spontană
Amplificată (ASE)

Standardde

- ▶ SUA, Japonia

SONET	SDH	B (Mb/s)	Channels
OC-1		51.84	672
OC-3	STM-1	155.52	2,016
OC-12	STM-4	622.08	8,064
OC-48	STM-16	2,488.32	32,256
OC-192	STM-64	9,953.28	129,024
OC-768	STM-256	39,813.12	516,096

- ▶ SONET – synchronous optical network
 - ▶ inlocuit de
- ▶ SDH – synchronous digital hierarchy

Standard

▶ SUA

STS-1 and OC-1	51.840 Mb/s	
STS-3 and OC-3	155.52 Mb/s	same as STM-1
STS-9 and OC-9	466.56 Mb/s	
STS-12 and OC-12	622.08 Mb/s	same as STM-4
STS-18 and OC-18	933.12 Mb/s	
STS-24 and OC-24	1244.16 Mb/s	same as STM-8
STS-36 and OC-36	1866.24 Mb/s	
STS-48 and OC-48	2488.32 Mb/s	same as STM-16
STS-192 and OC-192	9953.28 Mb/s	same as STM-64
STS-256 and OC-256	13271.04 Mb/s	same as STM-86
STS-768 and OC-768	39813.12 Mb/s	same as STM-256
STS-3072 and OC-3072	159252.48 Mb/s	same as STM-1024
STS-12288 and OC-12288	639009.92 Mb/s	same as STM-4096

▶ Europa

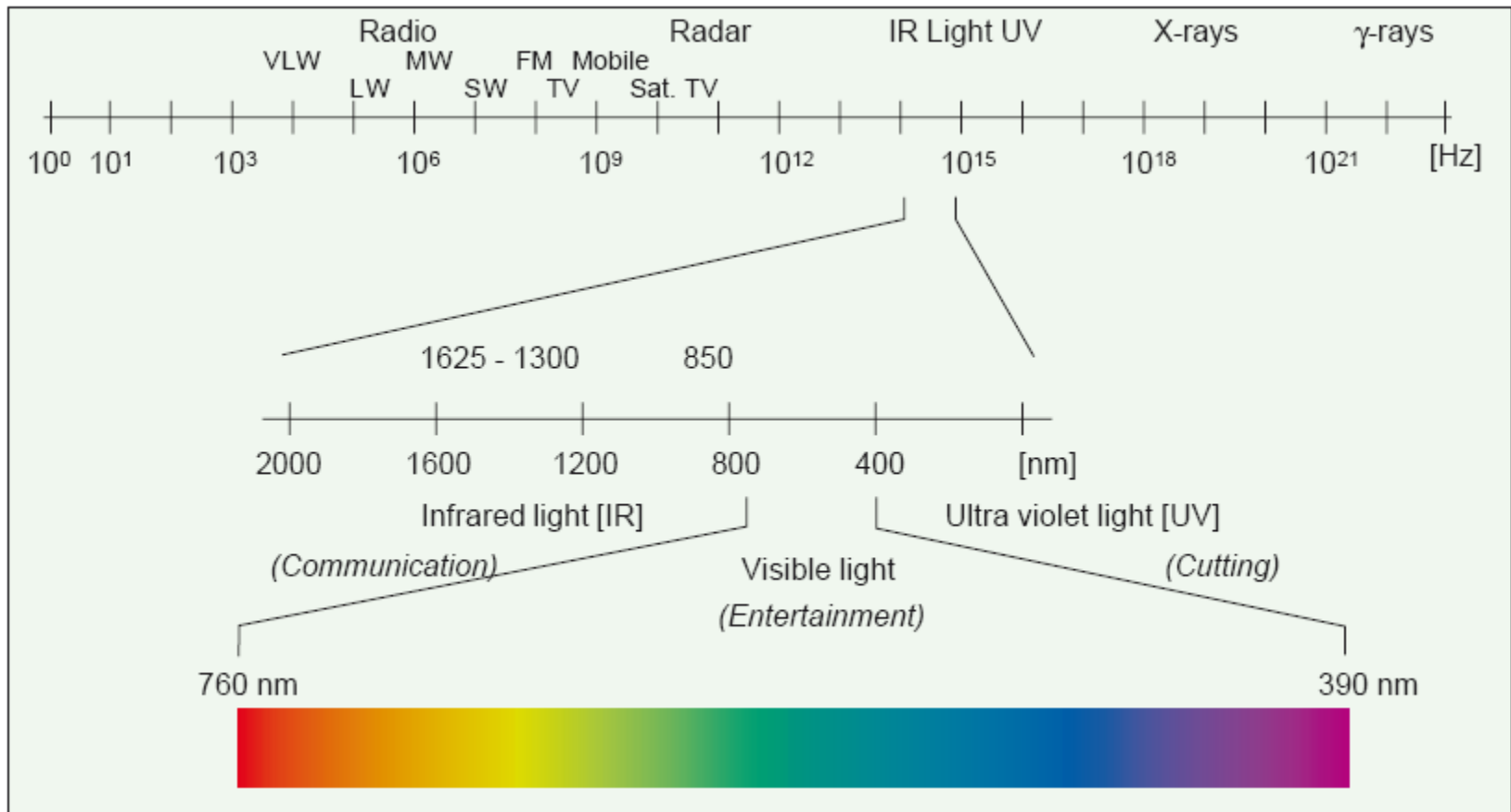
E0	64 Kb/s	
E1	2.048 Mb/s	
E2	8.448 Mb/s	4 E1s
E3	34.364 Mb/s	16 E1s
E4	139.264 Mb/s	64 E1s

1 mile = 1760 yards

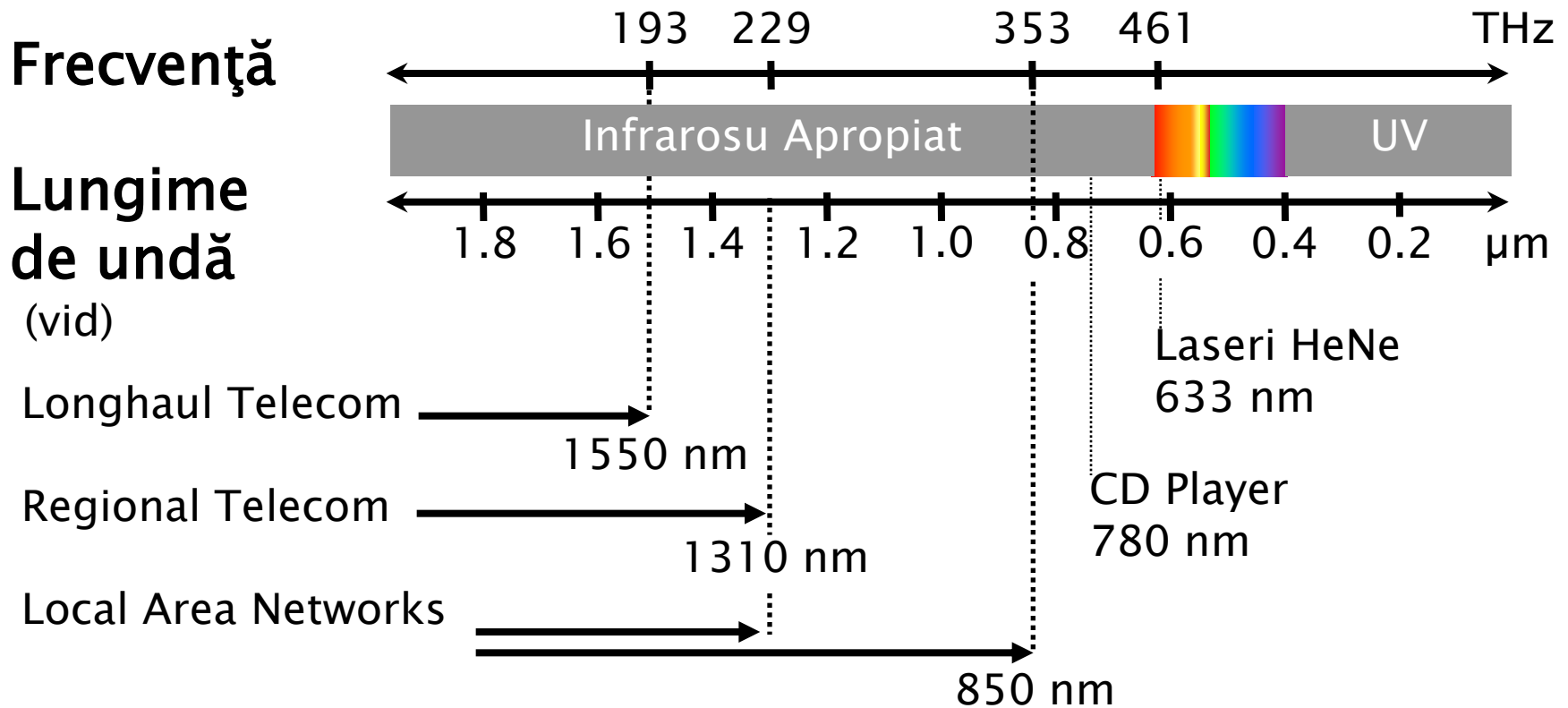
1 yards = 3 feet

1 mile \approx 1609.34 m

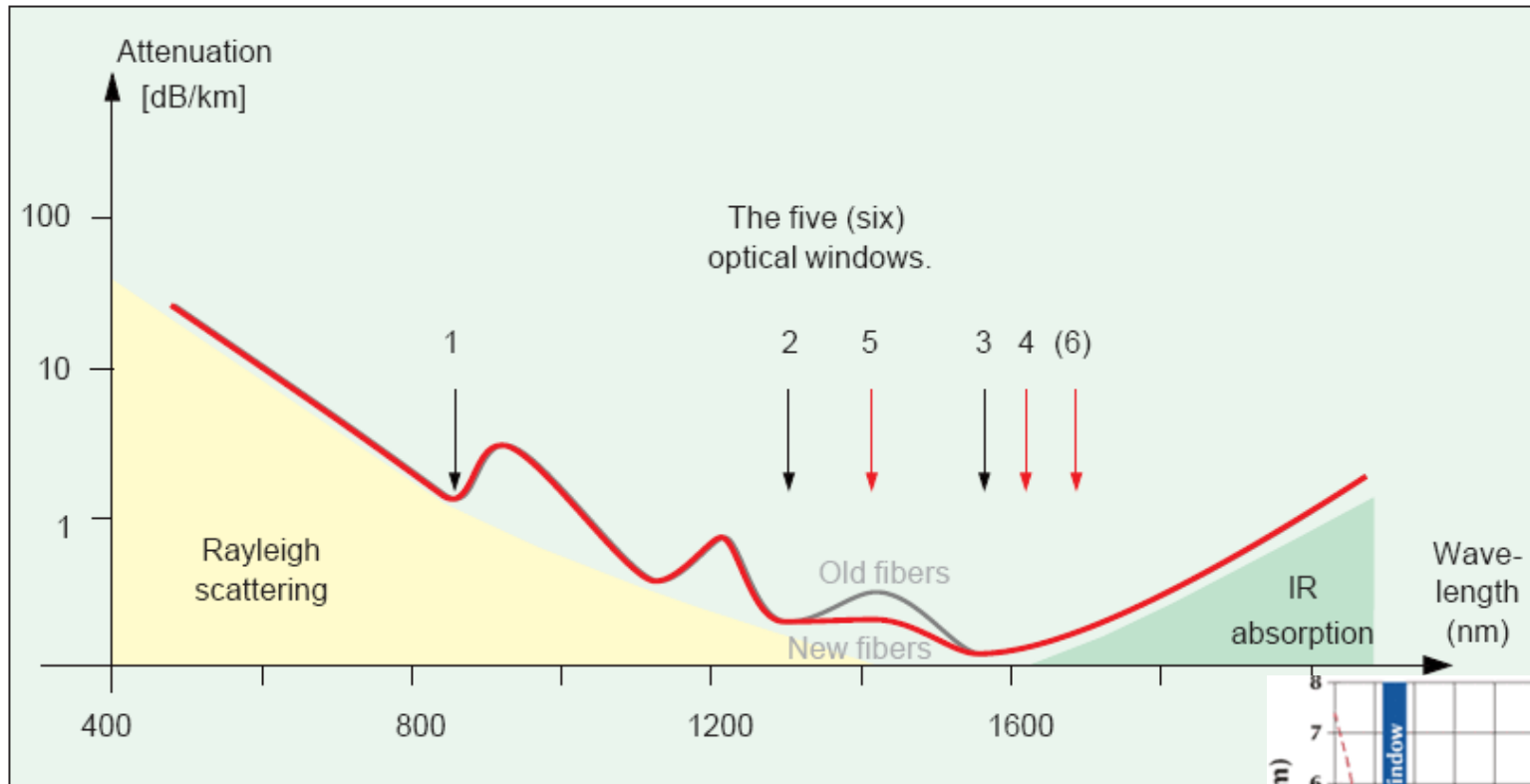
Spectrul electromagnetic



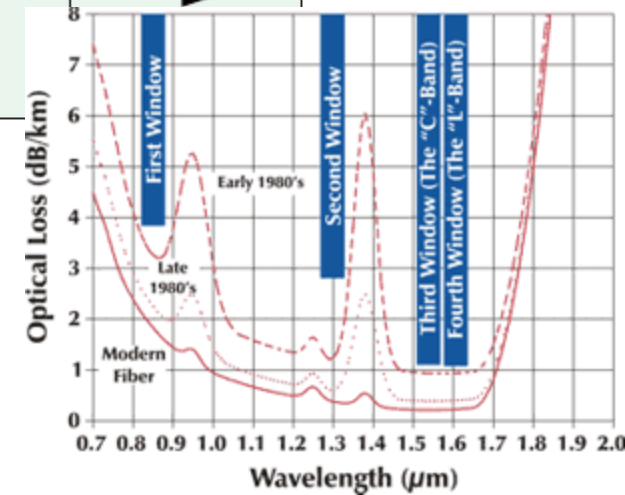
Benzi de lucru in comunicațiile optice



Atenuarea în fibra optică (SiO₂)



850nm, 1310nm, 1550nm



Aplicatii majore

- ▶ Comunicatii
 - Infrarosu (InGaAsP)
- ▶ Vizibil
 - Spectru vizibil (GaAlAs)
- ▶ Iluminare
 - Putere ridicata, lumina alba (GaInN)

Eficiența

- ▶ Bec cu incandescenta
 - 16 lm/W
- ▶ Tub fluorescent
 - 100 lm/W
- ▶ LED
 - curent: 250 lm/W
 - curand: 300 lm/W

Premiul Nobel, Fizica, 2014



The image is a graphic announcement for the Nobel Prize in Physics 2014. It features a blue background with a gold Nobel Prize medal icon in the top left. The text is in both Swedish and English. At the top, it says "Nobelpriset i fysik 2014" and "The Nobel Prize in Physics 2014". Below this, the Swedish text "Nobelpriset i fysik 2014" is prominently displayed. To the right is the logo of the Royal Swedish Academy of Sciences, "KUNGL. VETENSKAPSKAS AKADEMIEN". Three portraits of the laureates are shown in a row: Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura. Each portrait is accompanied by their name and affiliation. Below the portraits is the award citation in Swedish and English. At the bottom left is the date "2014-10-07" and at the bottom right is the copyright notice "© Kungl. Vetenskapsakademien".

Nobelpriset i fysik 2014

The Nobel Prize in Physics 2014

KUNGL. VETENSKAPSKAS AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

Isamu Akasaki
Meijo University, Nagoya, Japan
Nagoya University, Japan

Hiroshi Amano
Nagoya University, Japan

Shuji Nakamura
University of California,
Santa Barbara, CA, USA

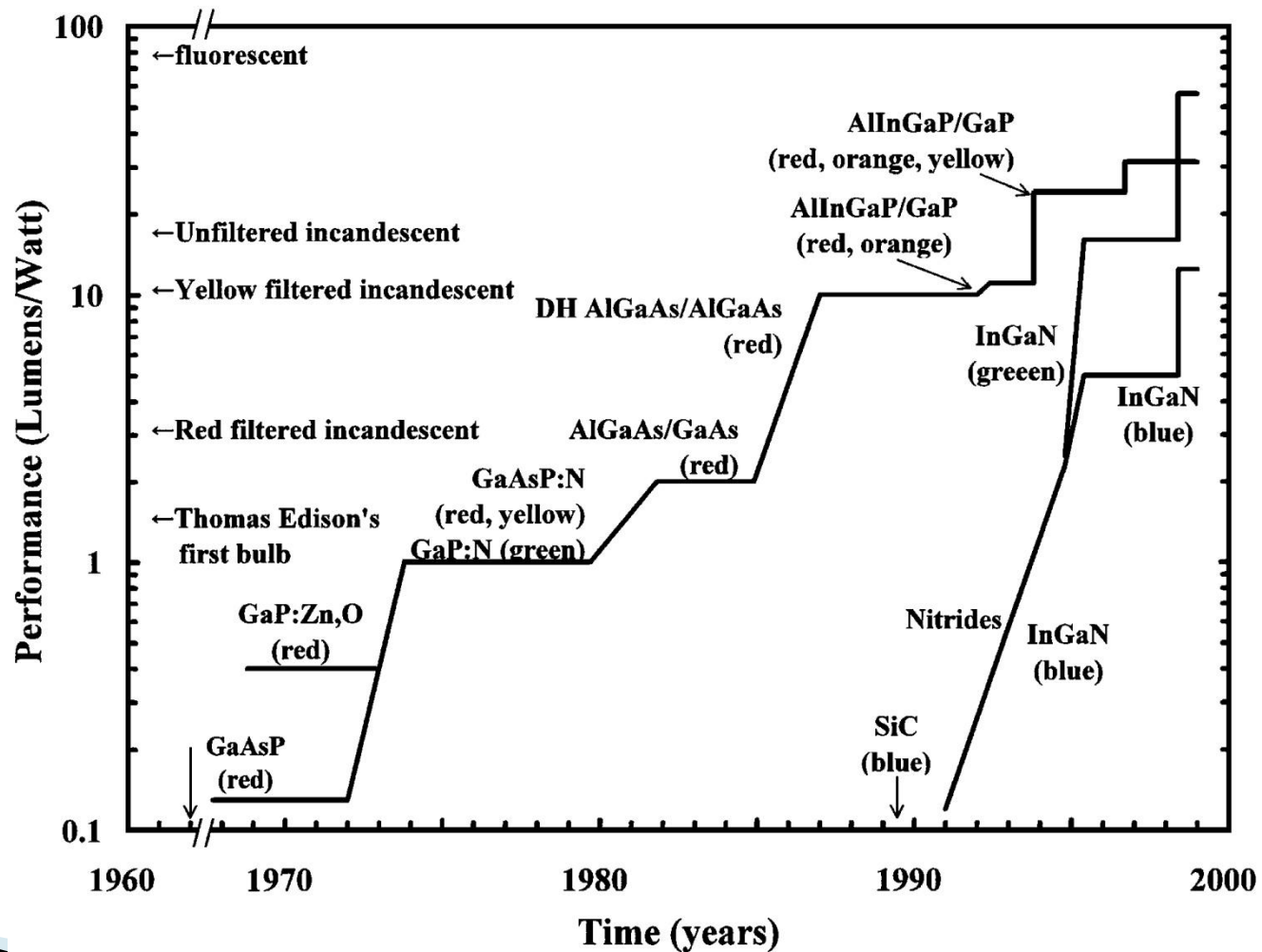
"För uppfindingen av effektiva blå lysdioder vilka möjliggjort ljusstarka och energisnåla vita ljuskällor"

"For the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"

2014-10-07

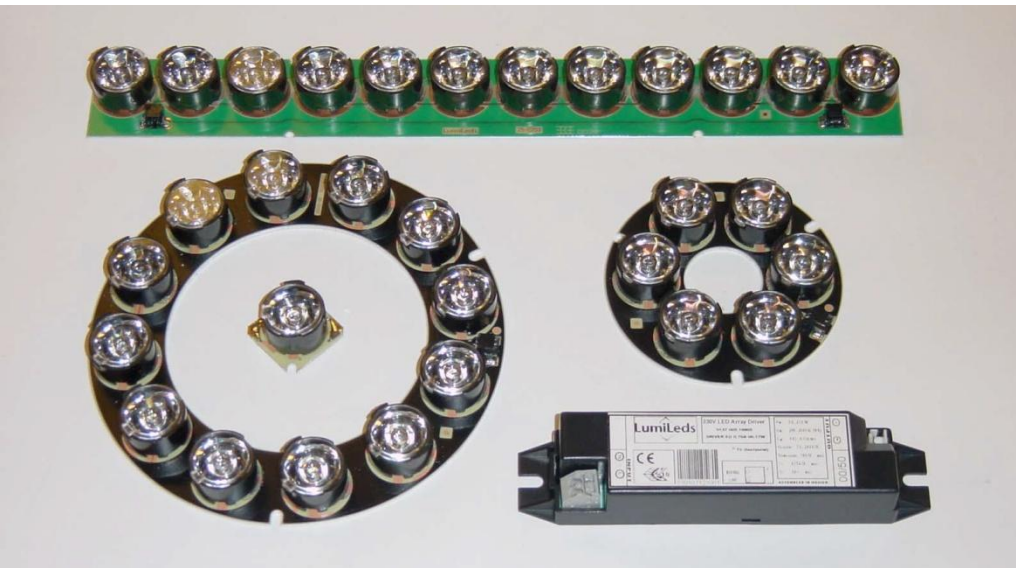
© Kungl. Vetenskapsakademien

Eficienta in timp

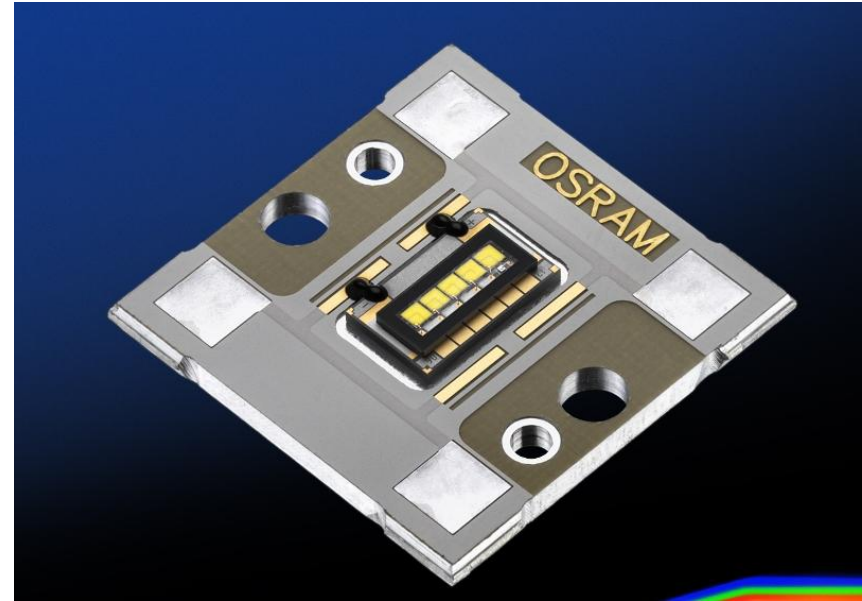


Aplicatii

▶ auto



Aplicatii



Aplicatii majore

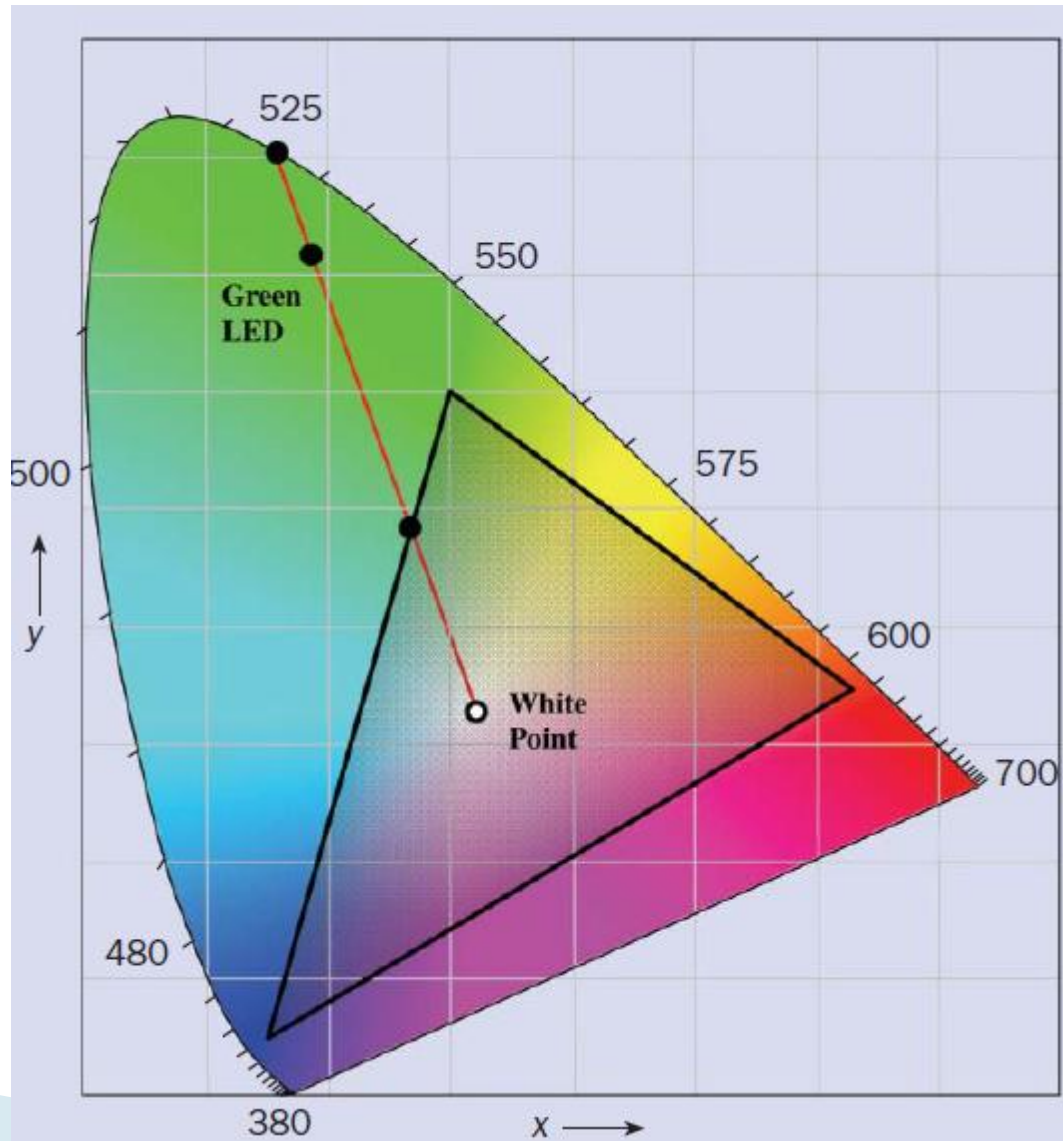
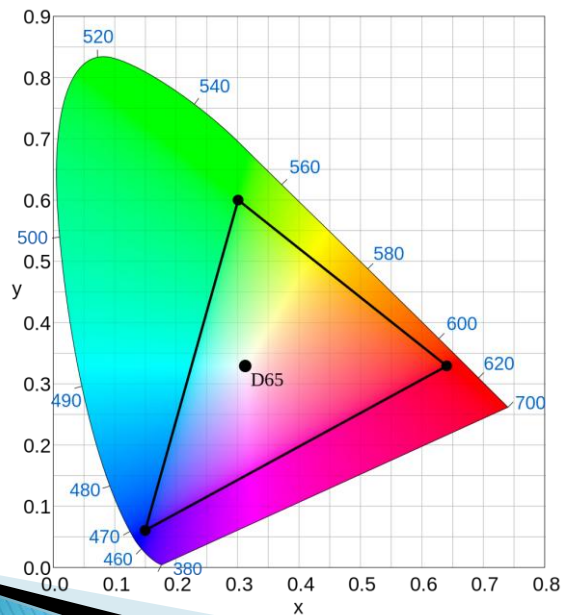
- ▶ Comunicatii
 - Infrarosu (InGaAsP)
- ▶ Vizibil
 - Spectru vizibil (GaAlAs)
- ▶ Iluminare
 - Putere ridicata, lumina alba (GaInN)

ITU-R BT.709

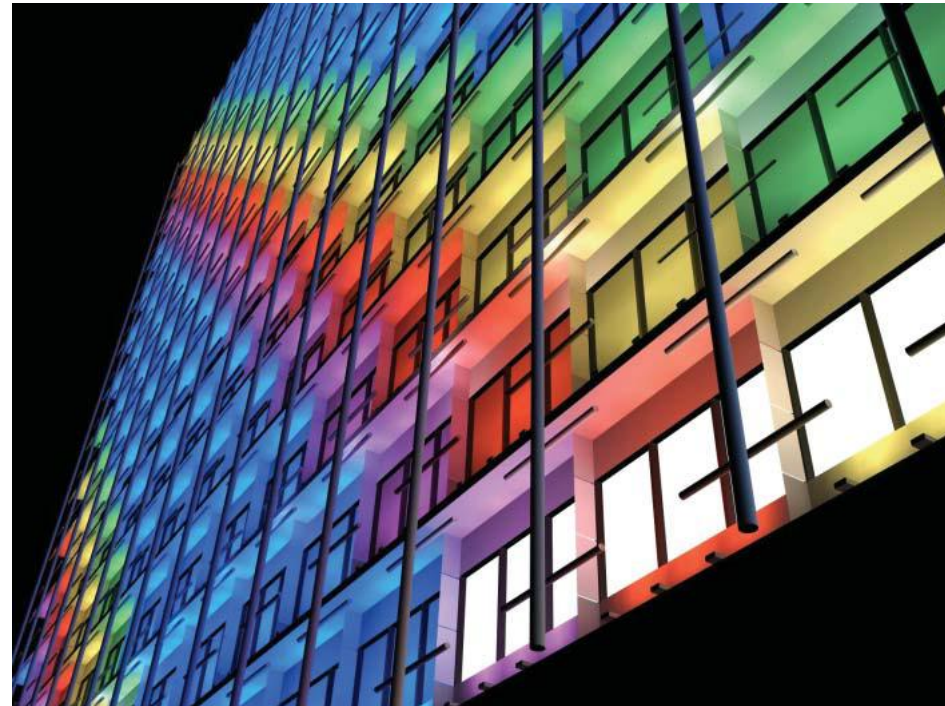


ITU-R BT.709 phosphor properties		
Phosphor	x	y
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060

Data refers to xy chromaticity co-ordinates of ITU-R BT.709 phosphors which are used in most CRT displays [1].



ITU-R BT.709



RGB values for Luxeon LEDs

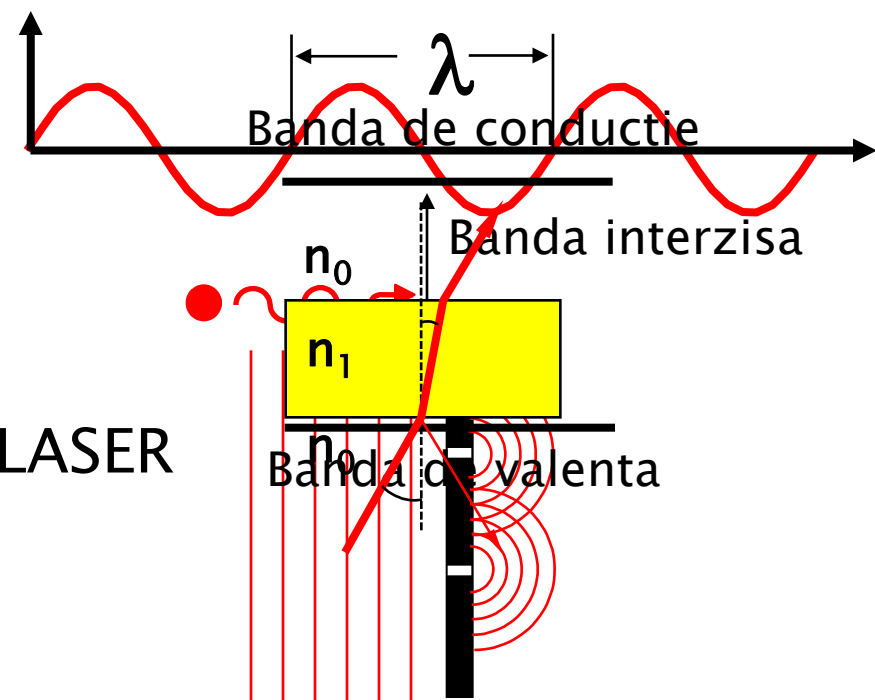
LED color	Dominant wavelength λ_D (nm)	RGB values
Royal blue	455	0.05, 0.00, 0.95
Blue	470	0.00, 0.11, 0.89
Cyan	505	0.00, 0.63, 0.37
Green	530	0.00, 0.77, 0.23
Amber	590	0.70, 0.30, 0.00
Red-orange	615	0.97, 0.00, 0.03
Red	625	0.92, 0.00, 0.08

Modelarea luminii

(tot) Capitolul 1

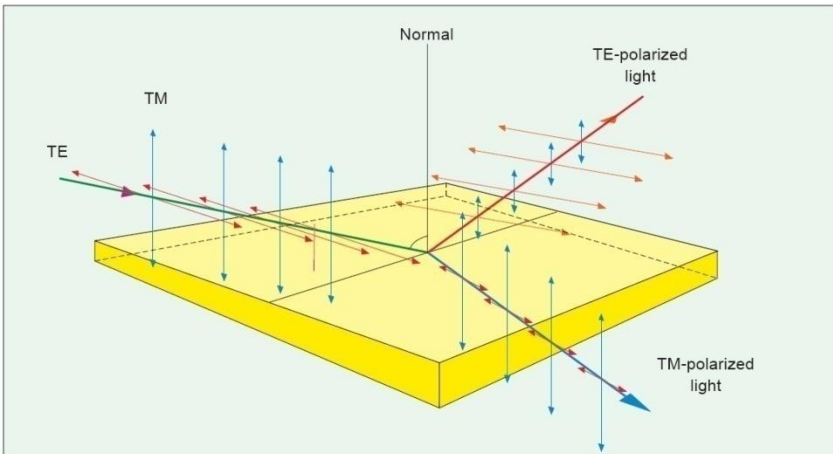
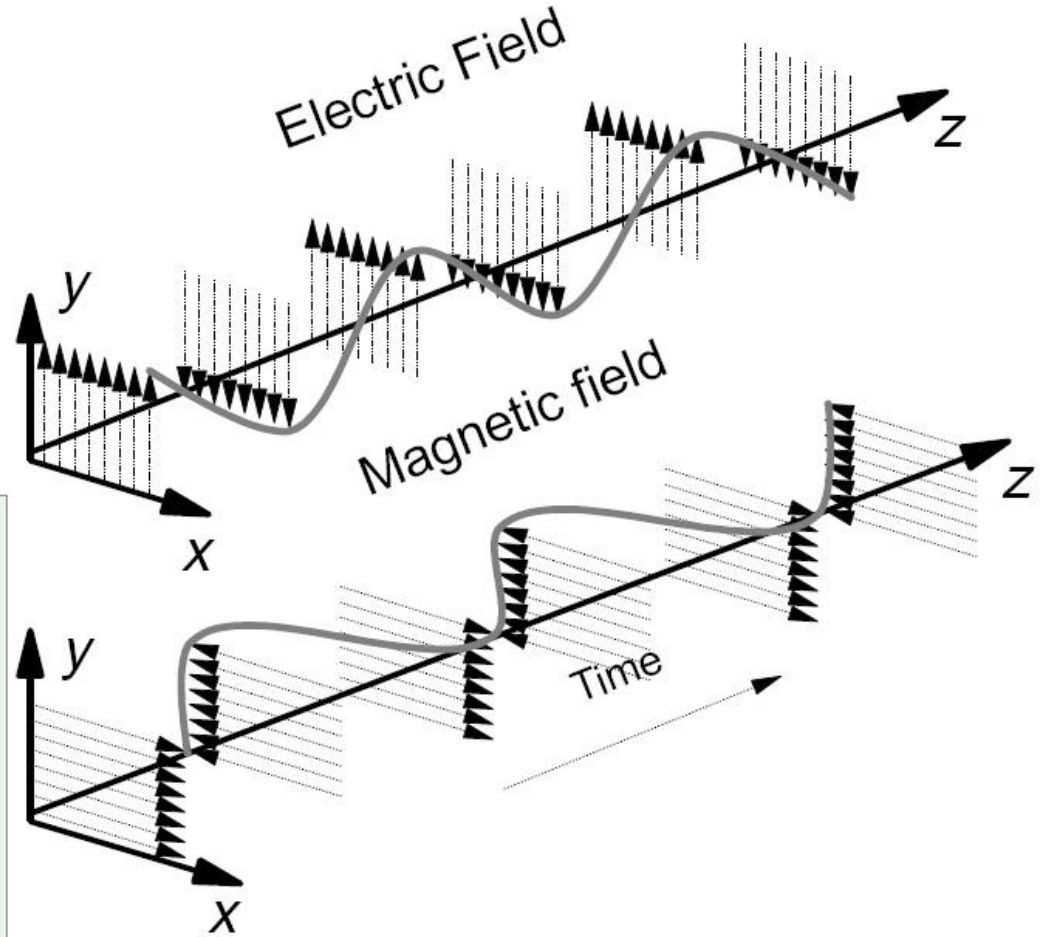
Modelarea luminii

- ▶ Undă electromagnetică
 - Ecuațiile lui Maxwell
 - λ , ϵ , ω , f
- ▶ Teoria cuantică
 - Benzi energetice $E = h \nu$
 - fotoni, emisie stimulată, LASER
- ▶ Optică geometrică
 - n , θ
 - raze de lumină
 - intuitivă

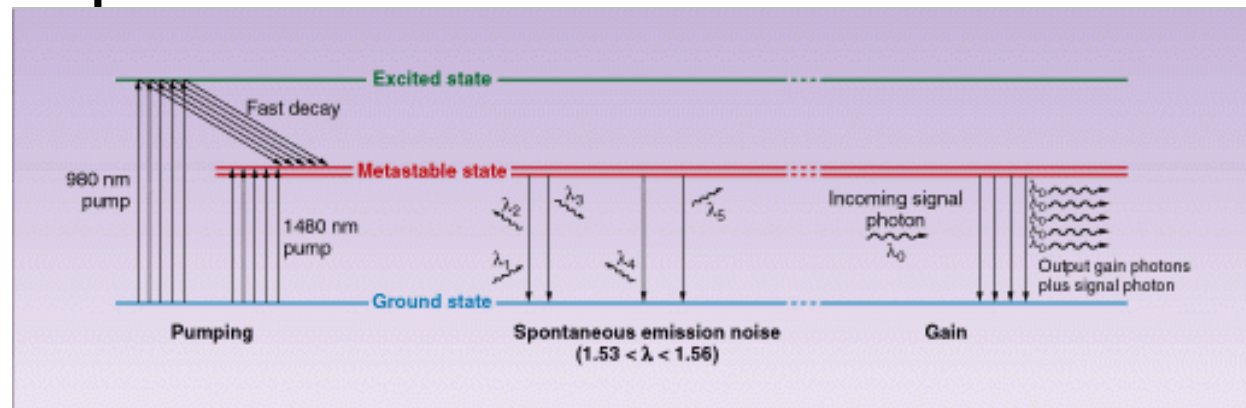
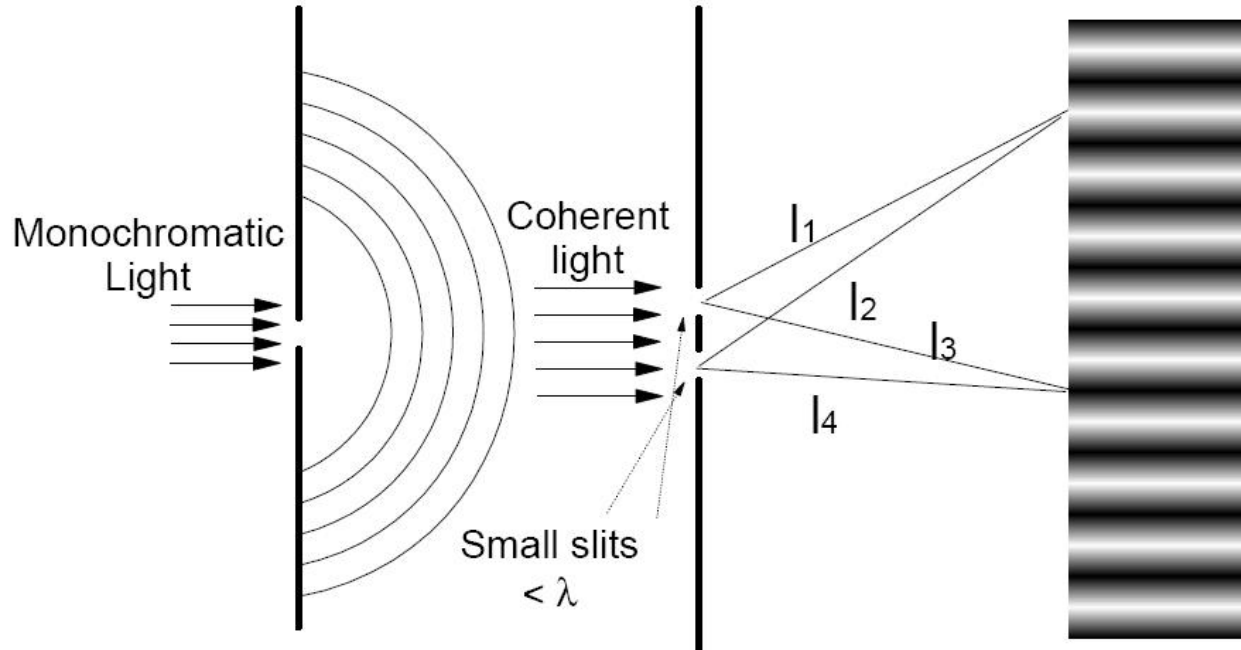


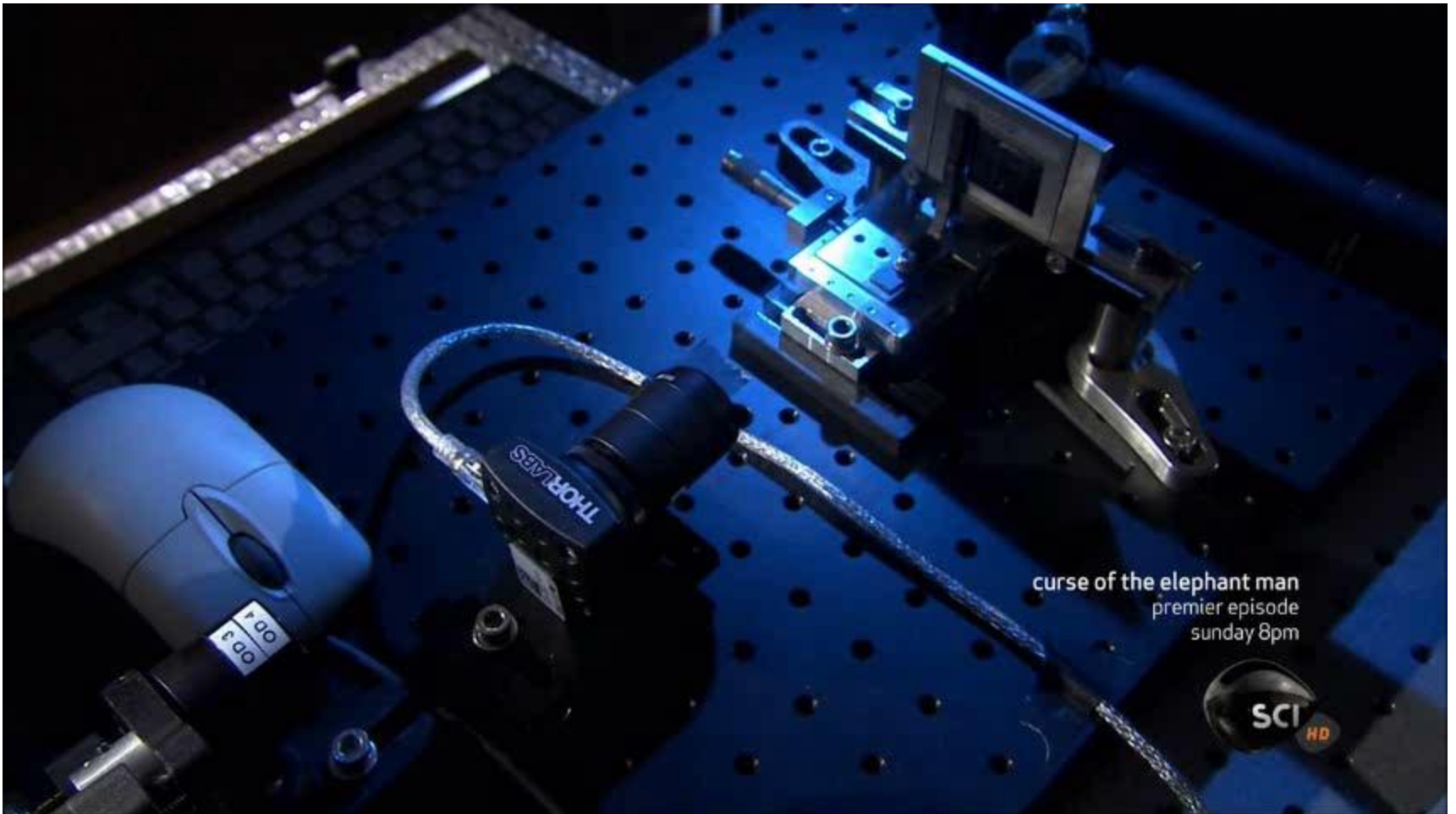
Unda electromagnetica

- ▶ Dispersie
- ▶ Fibre monomod
- ▶ Interferenta
- ▶ Polarizare



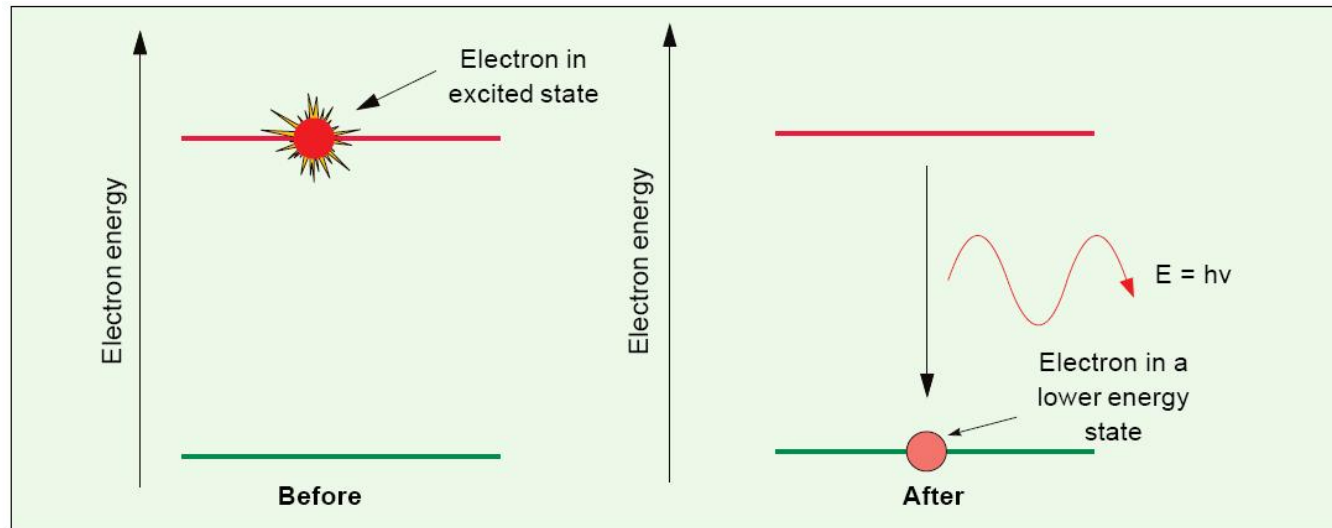
Fotoni/Unda





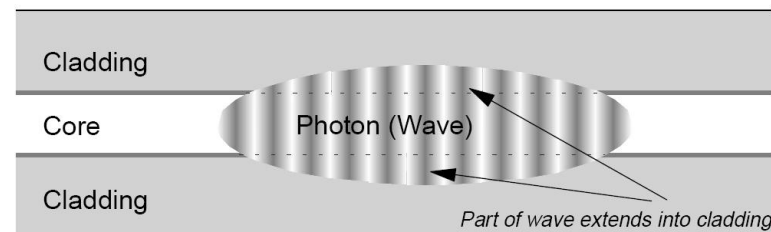
Through the Wormhole
S02E07 How Does the Universe Work

Model cuantic – foton



$$E_g = h\nu; \quad \lambda = \frac{hc}{E_g}; \quad \lambda[\mu\text{m}] = \frac{1.240}{E_g[\text{eV}]}$$

- ▶ h constanta lui Plank
 $6.62 \cdot 10^{-32} \text{ Ws}^2$
- ▶ c viteza luminii **in vid**
 $2.998 \cdot 10^8 \text{ m/s}$



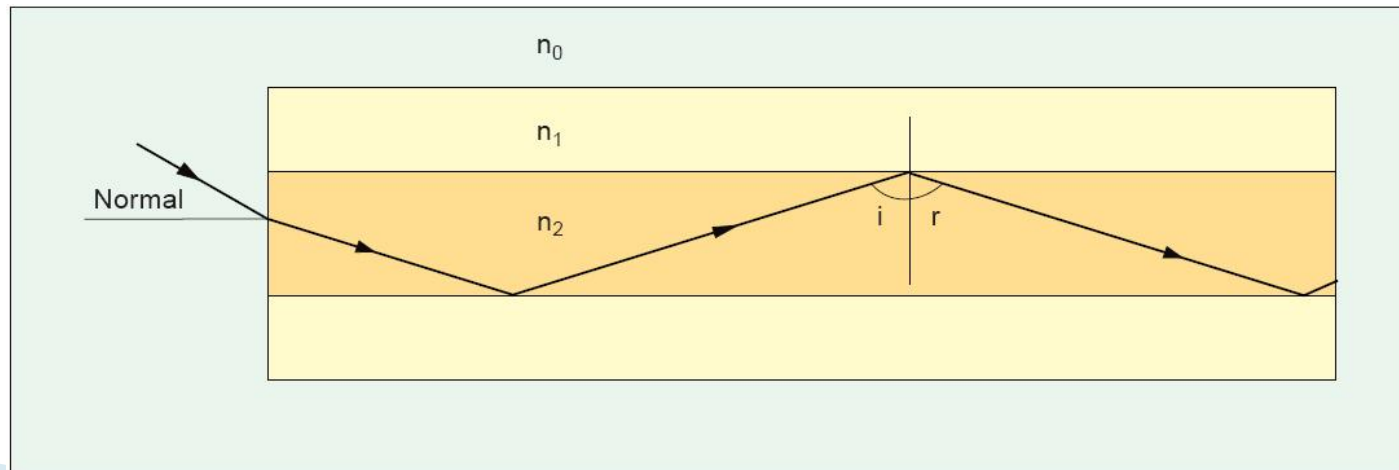
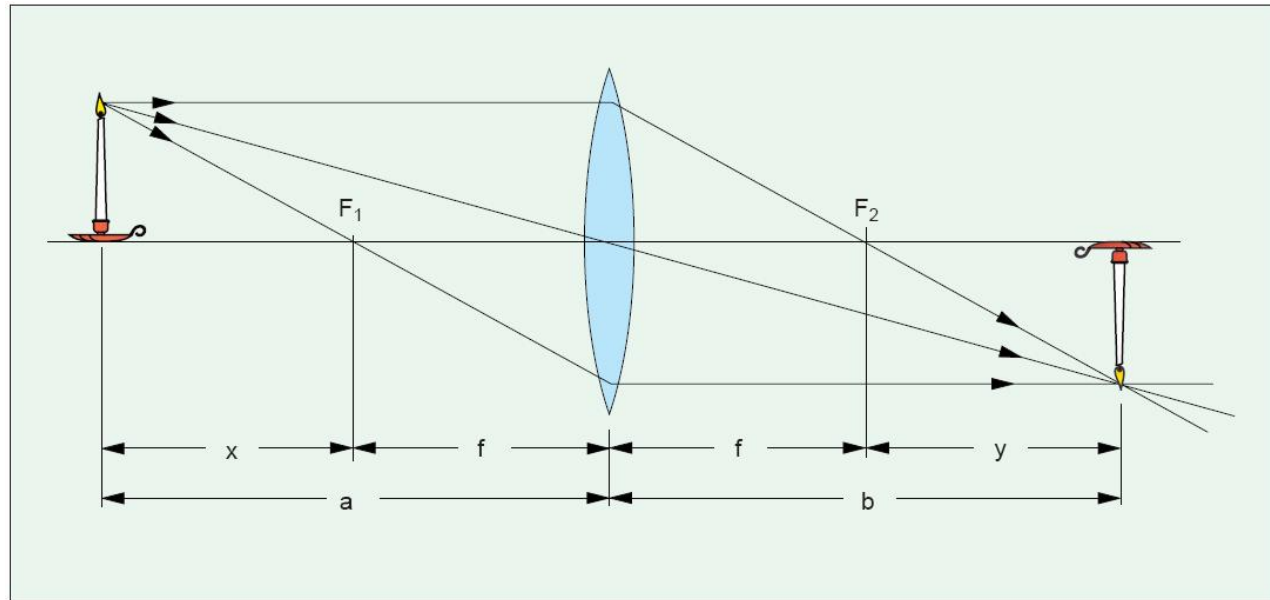
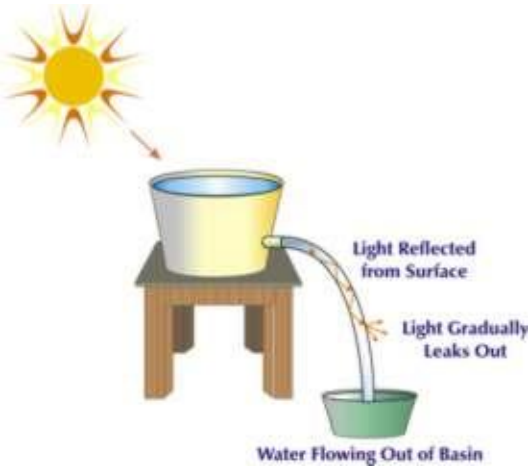


curse of the
premi
sunda



Through the Wormhole S02E07 How Does the Universe Work

Optica geometrica



Reprezentare logaritmică

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

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

$$0 \text{ dB} = 1$$

$$+ 0.1 \text{ dB} = 1.023 (+2.3\%)$$

$$+ 3 \text{ dB} = 2$$

$$+ 5 \text{ dB} = 3$$

$$+ 10 \text{ dB} = 10$$

$$-3 \text{ dB} = 0.5$$

$$-10 \text{ dB} = 0.1$$

$$-20 \text{ dB} = 0.01$$

$$-30 \text{ dB} = 0.001$$

$$0 \text{ dBm} = 1 \text{ mW}$$

$$3 \text{ dBm} = 2 \text{ mW}$$

$$5 \text{ dBm} = 3 \text{ mW}$$

$$10 \text{ dBm} = 10 \text{ mW}$$

$$20 \text{ dBm} = 100 \text{ mW}$$

$$-3 \text{ dBm} = 0.5 \text{ mW}$$

$$-10 \text{ dBm} = 100 \mu\text{W}$$

$$-30 \text{ dBm} = 1 \mu\text{W}$$

$$-60 \text{ dBm} = 1 \text{ nW}$$

$$[\text{dBm}] + [\text{dB}] = [\text{dBm}]$$

$$[\text{dBm/Hz}] + [\text{dB}] = [\text{dBm/Hz}]$$

$$[\text{x}] + [\text{dB}] = [\text{x}]$$

Calculul atenuarii

$$\text{Pierderi} = \frac{P_{out}}{P_{in}}$$

$$\text{Pierderi [dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

$$\text{Pierderi [dB]} = [-] (P_{out} [\text{dBm}] - P_{in} [\text{dBm}])$$



=

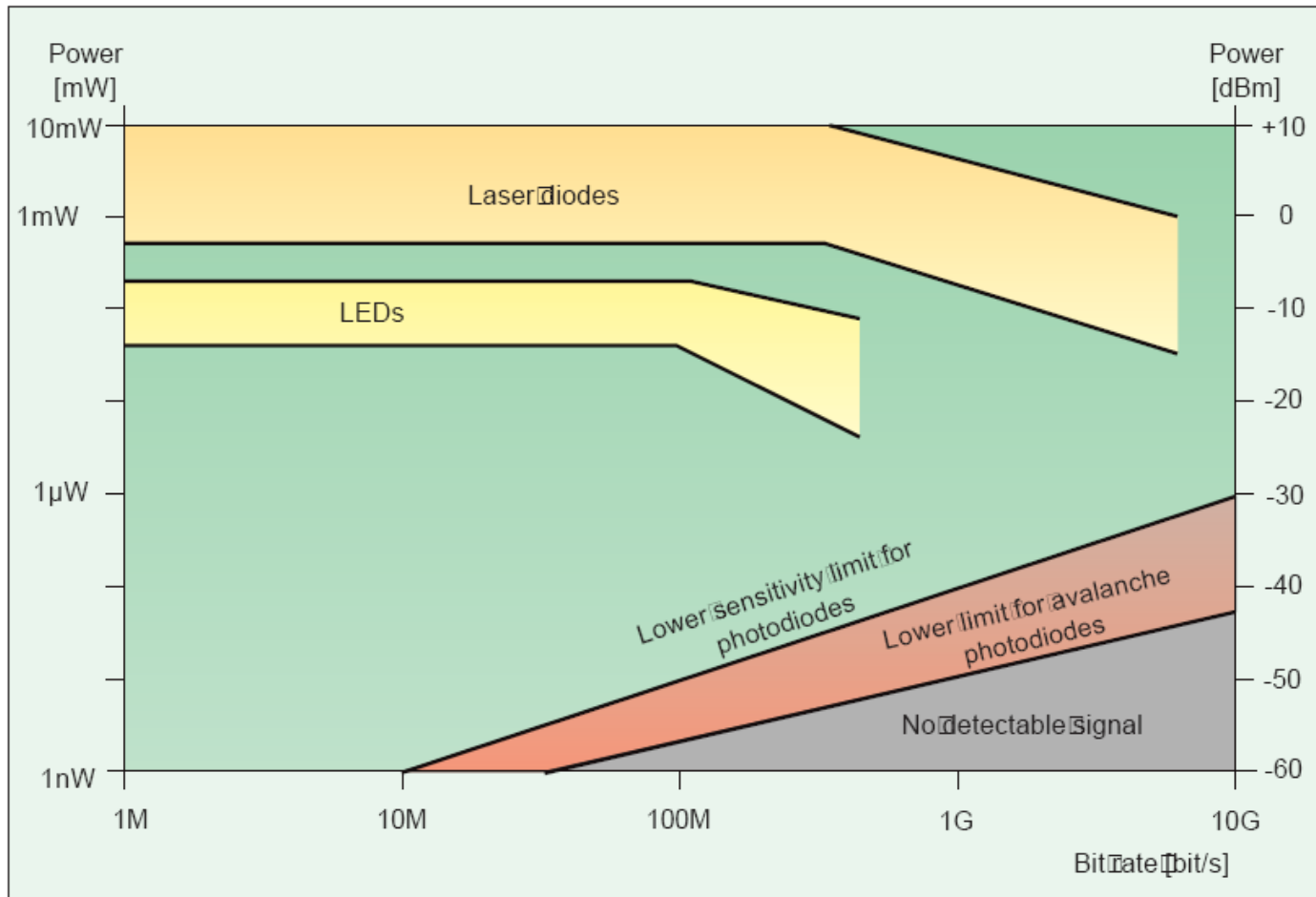


-



$$\text{Atenuare [dB/km]} = \frac{\text{Pierderi [dB]}}{\text{lungime [km]}}$$

Limite putere/bandă a dispozitivelor optoelectronice



Contact

- ▶ Laboratorul de microunde si optoelectronica
- ▶ <http://rf-opto.etti.tuiasi.ro>
- ▶ rdamian@etti.tuiasi.ro