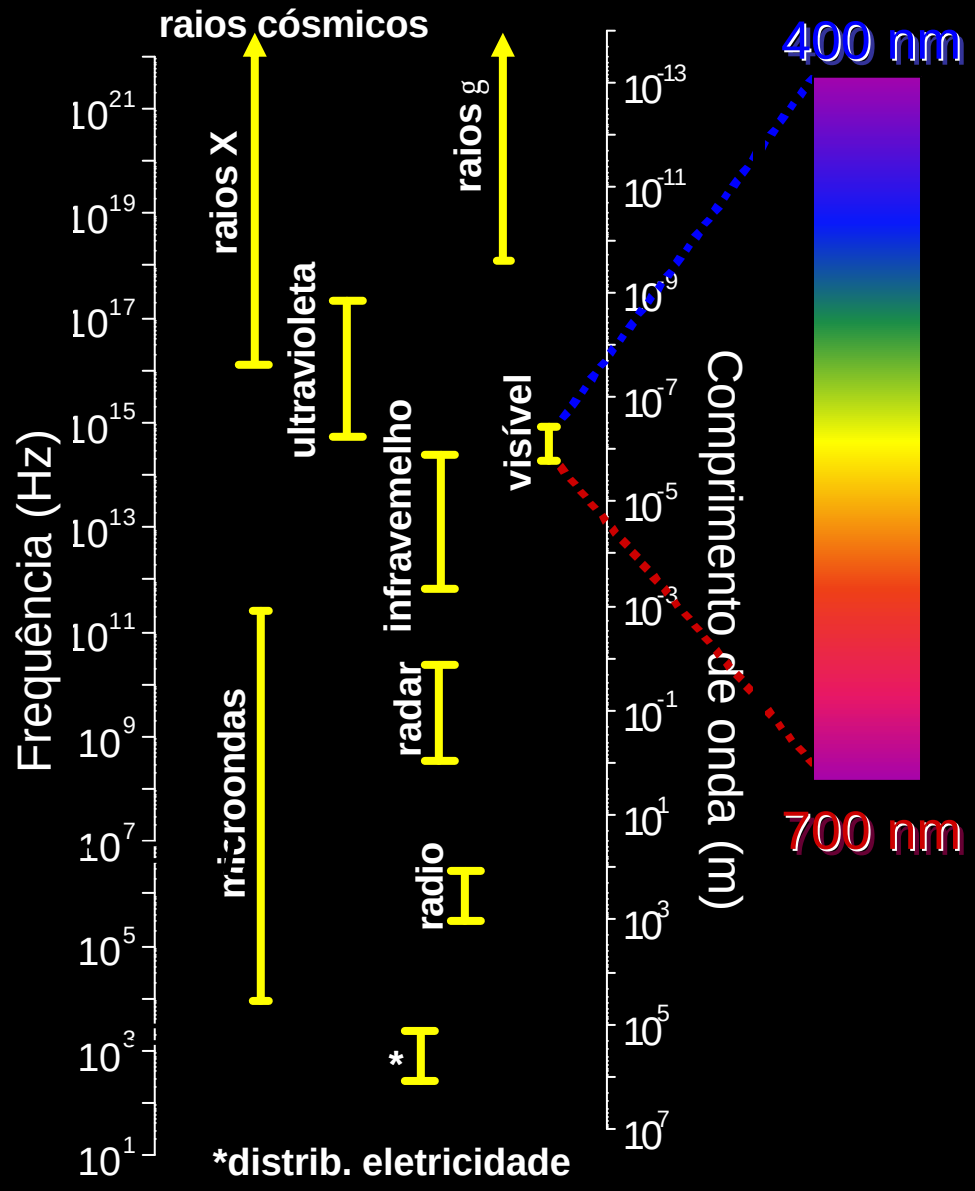
Light
Amplification
Stimulation
Emission
Radiation

LLA
IFSC-USP
Laboratório de Laser e Aplicações



$$E = h.f$$

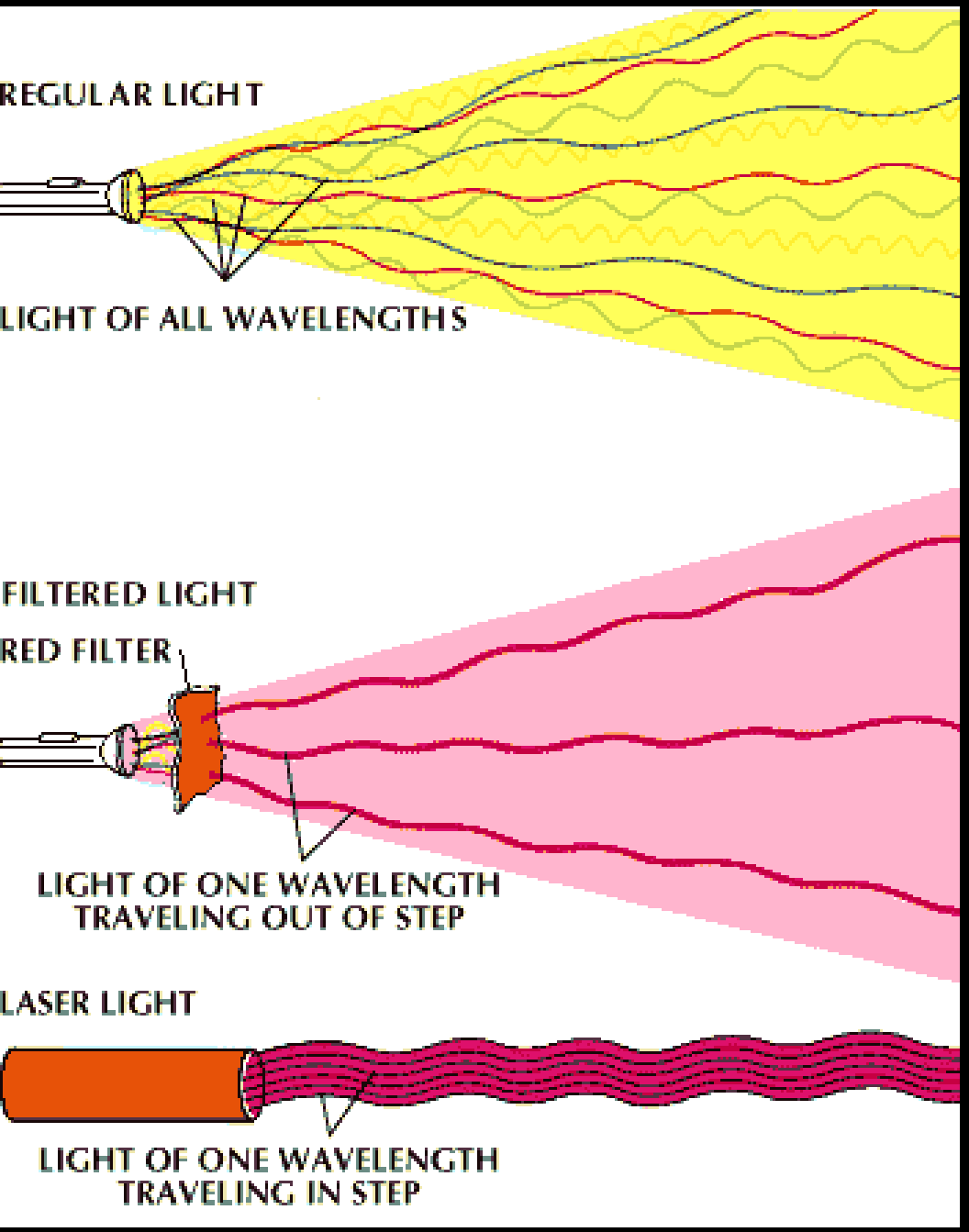
$$f = \frac{c}{l}$$

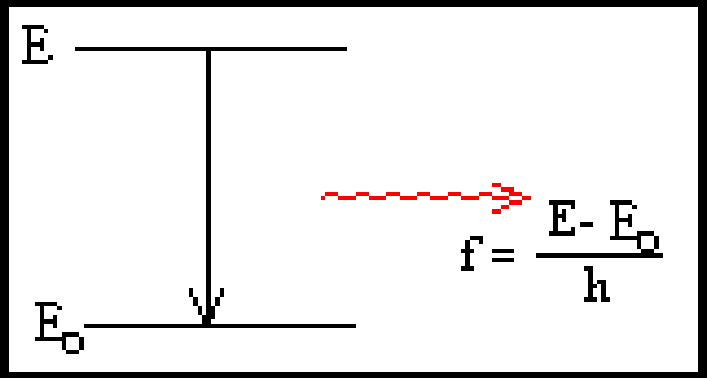
$$P = n.h.f$$

l =400nm Azul

l =550nm Verde

l =400nm Vermelho

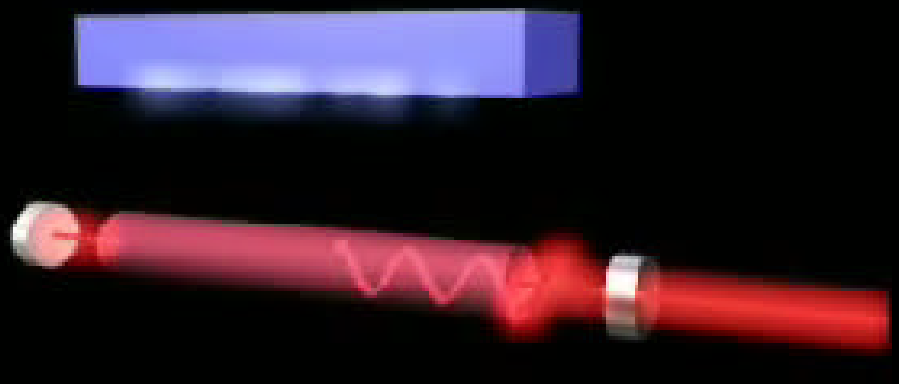




- *Tipos de Luz*
  - *Lâmpada Incandescente*
  - *Lâmpada Fluorescente*
  - *Laser*

Luz Laser

- *Direcional*
- *Monocromática*
- *Coerente*



Meio Ativo:

Sólido, Liquido, Gá

Cavidade:

Energia:

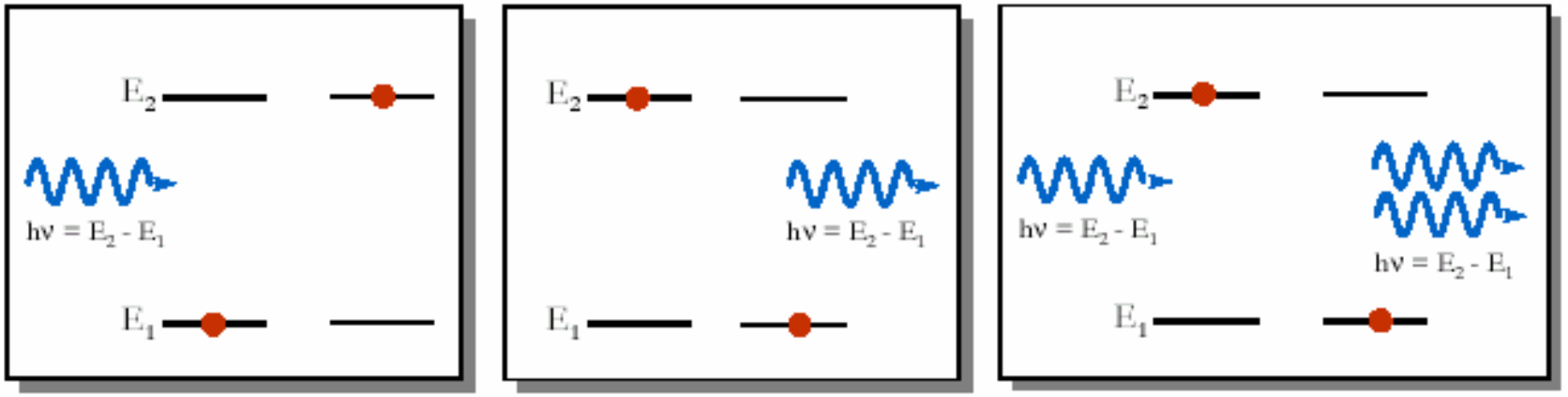
Luz

Corrente elétrica

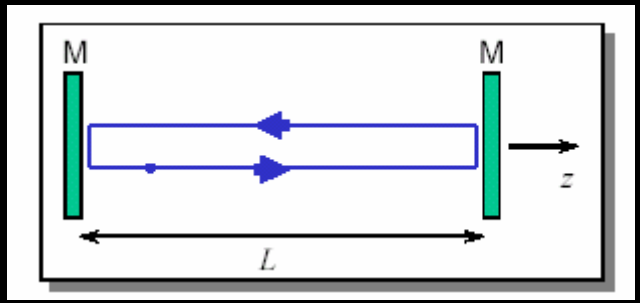
Reação Química

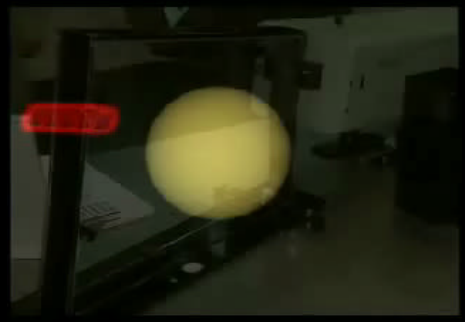
Nuclear

Basic processes (A. Einstein, 1916)



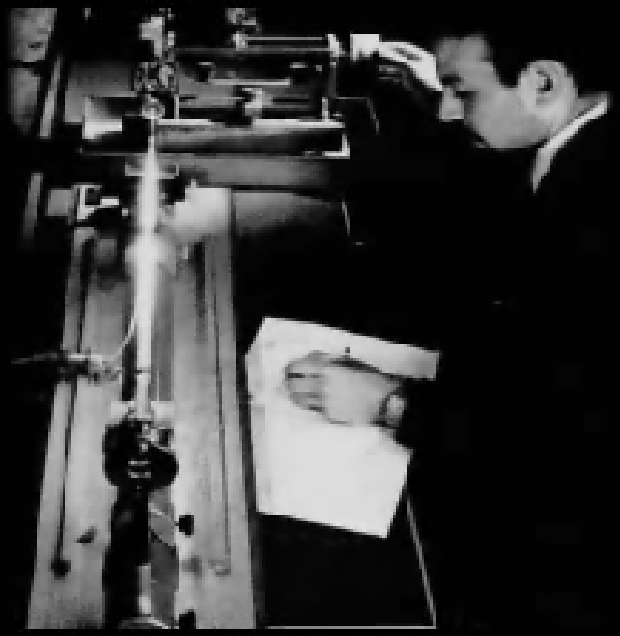
Absorption | Spontaneous emission | **Stimulated emission**



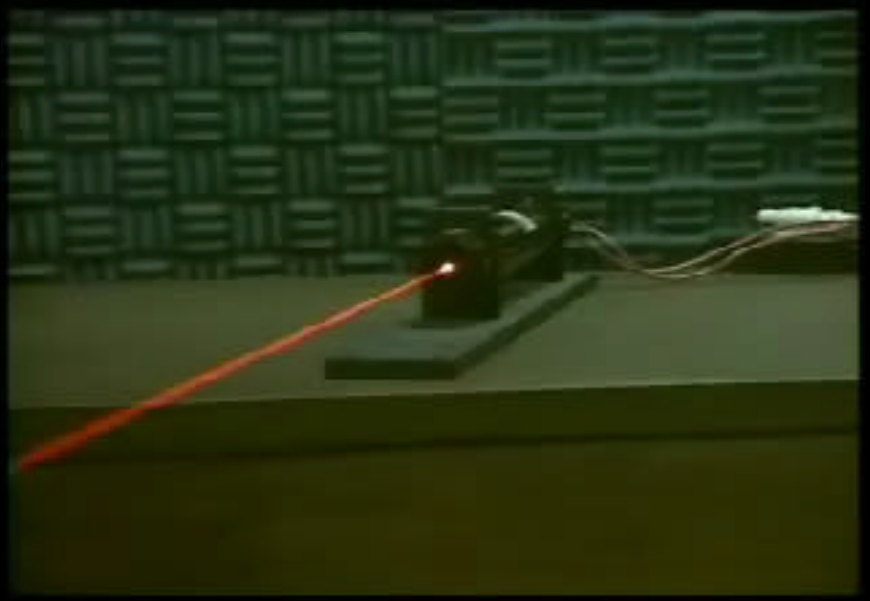


aser (**L**ight **A**mplificatiom by **S**timulated **E**mission of **R**adiatio

1917 Albert Einstein - Emissão Estimulada
1950 Maser (Micro-Wave/Amônia)
1050 Arthur Schawlow e Charles Townes (T. L)
1960 Theodore Maiman (Laser de Ruby)



Características do Laser

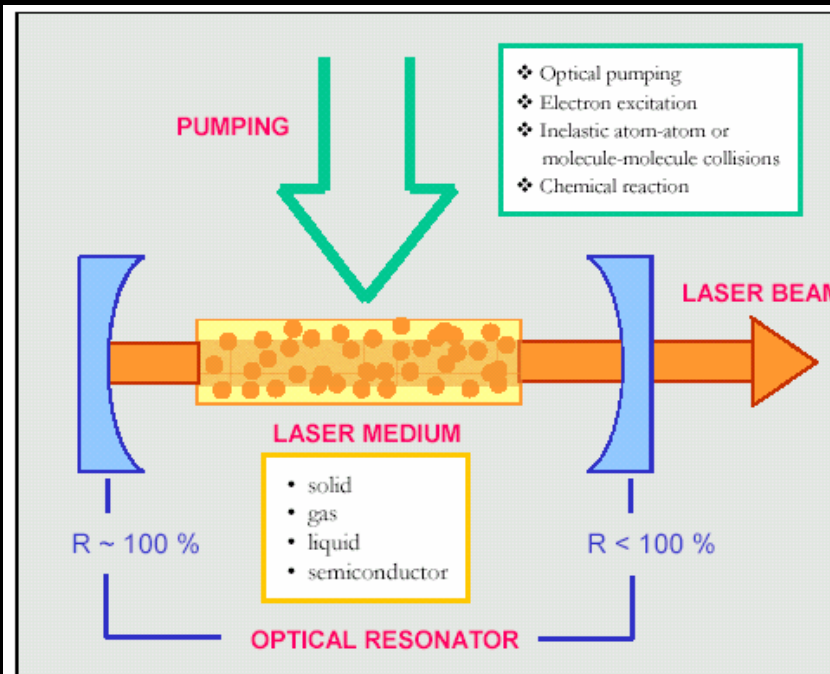


- Direcional
- Monocromática
- Coerente

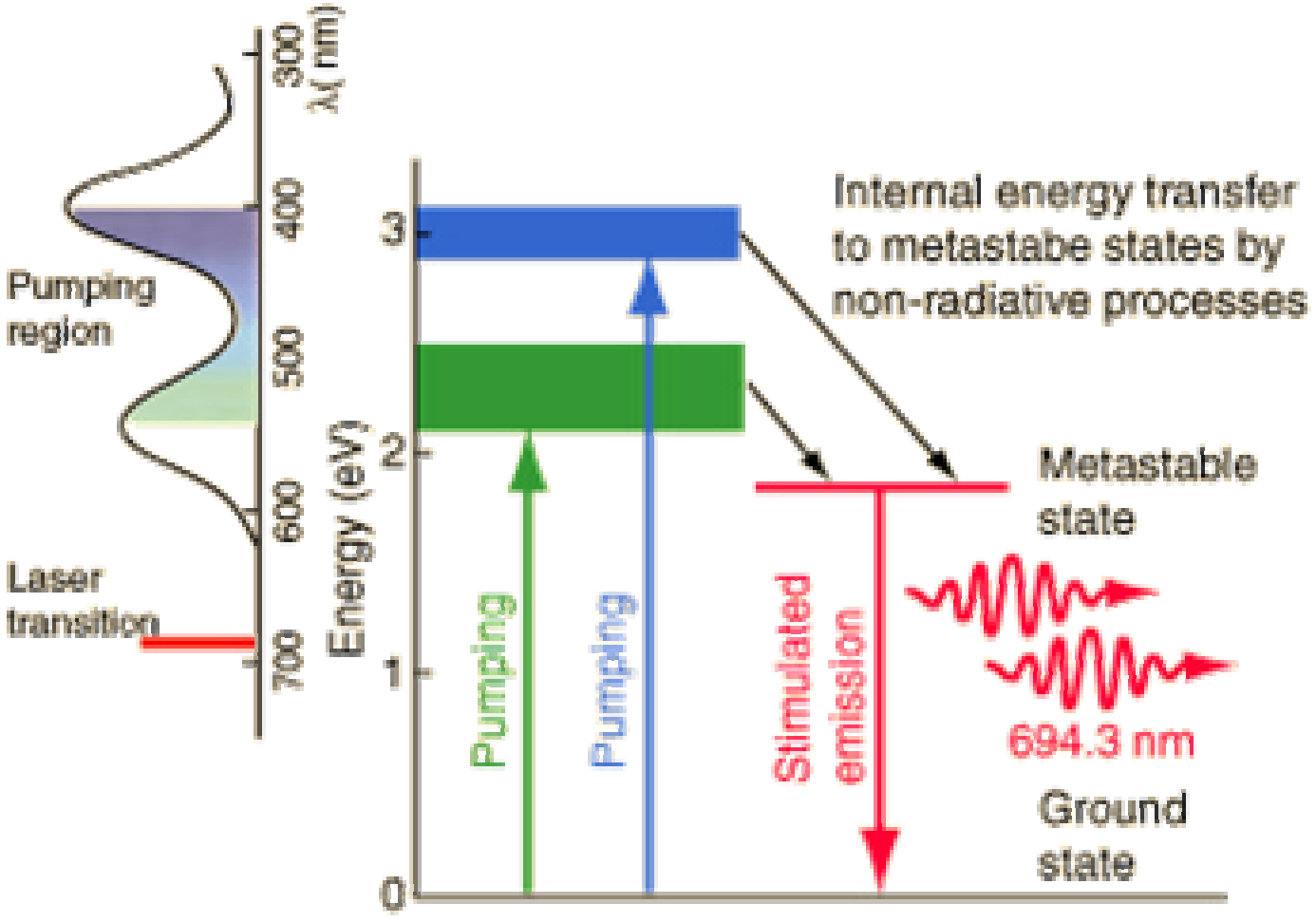
Como Fazer um LASER

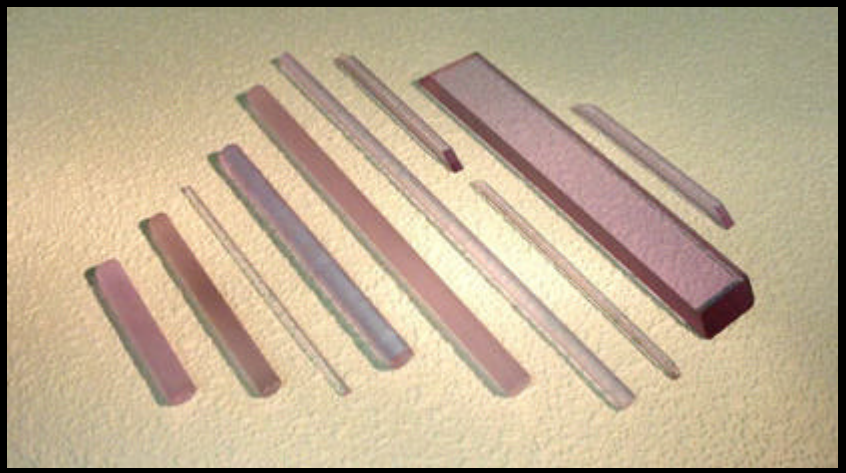
- Meio Ativo
  - *Gás*
  - *Sólido*
  - *Liquido*
- Mecanismo de Bombeio
  - Luz
  - Corrente Elétrica
  - Reação Química

- Estimular
- Amplificar
  - Cavidade

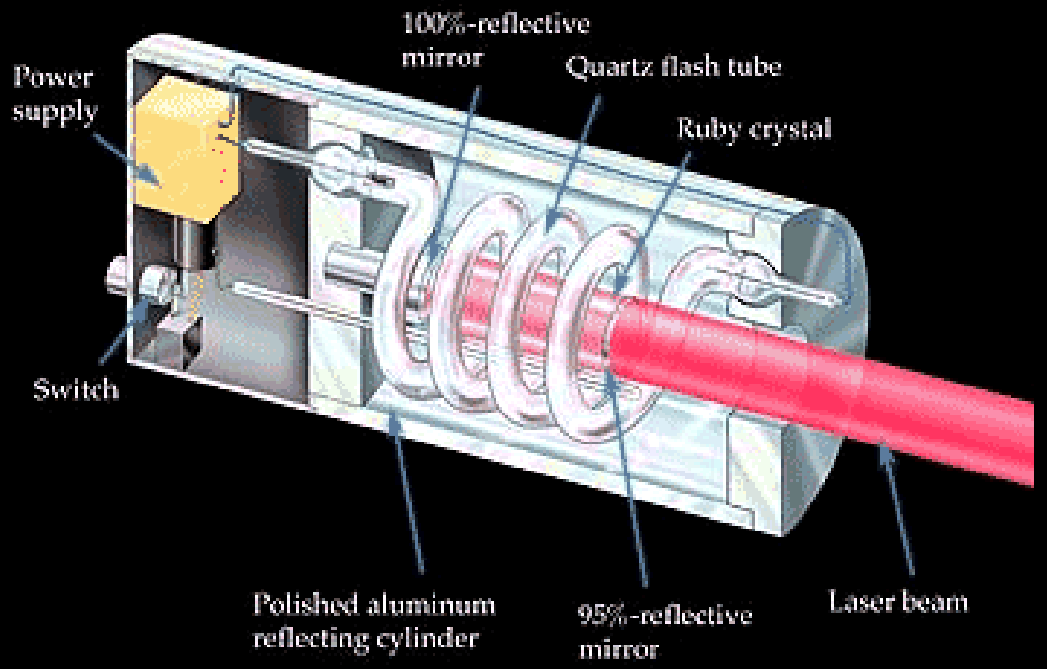


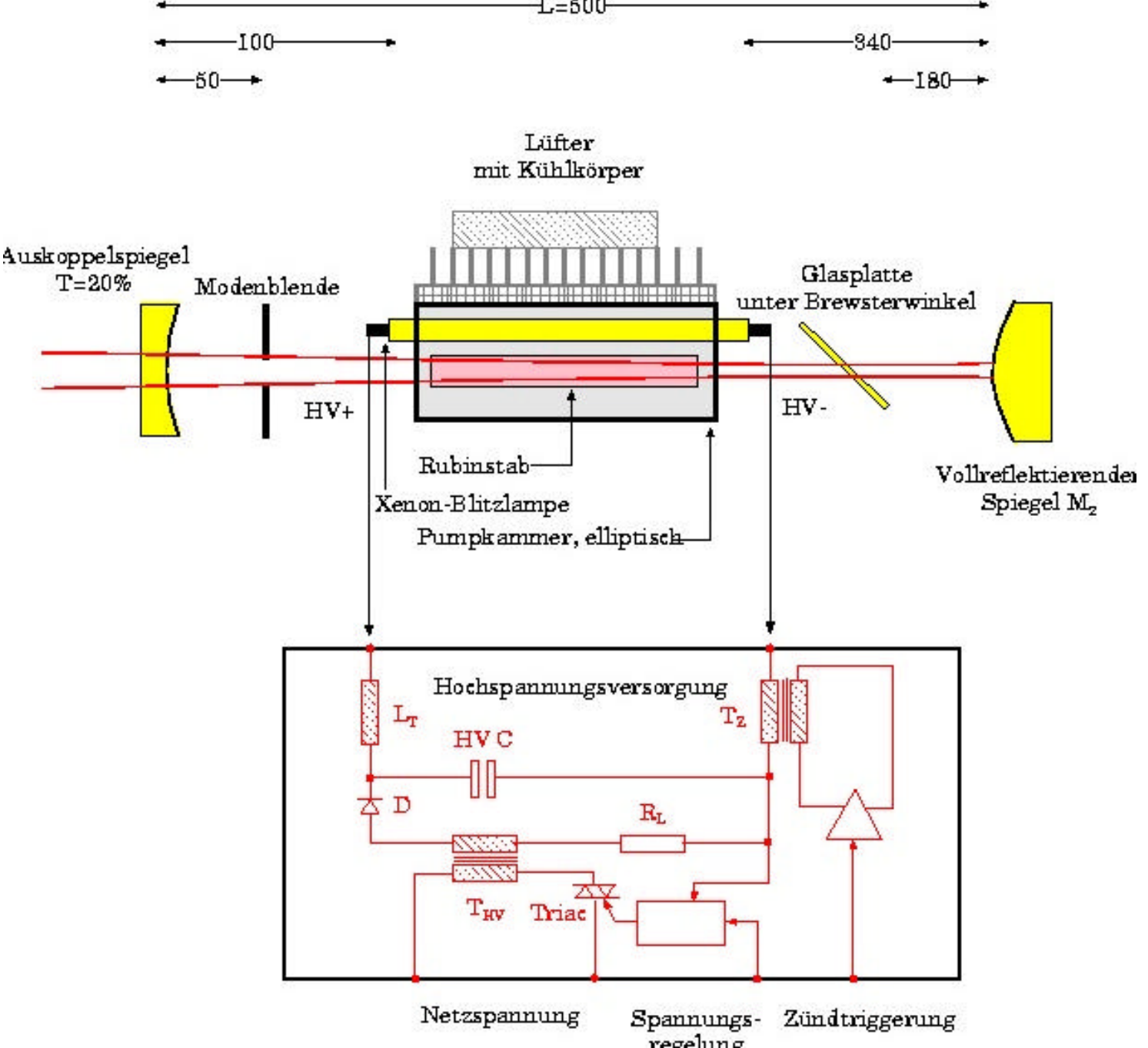
Ruby $Al_2O_3:Cr^{+3}$

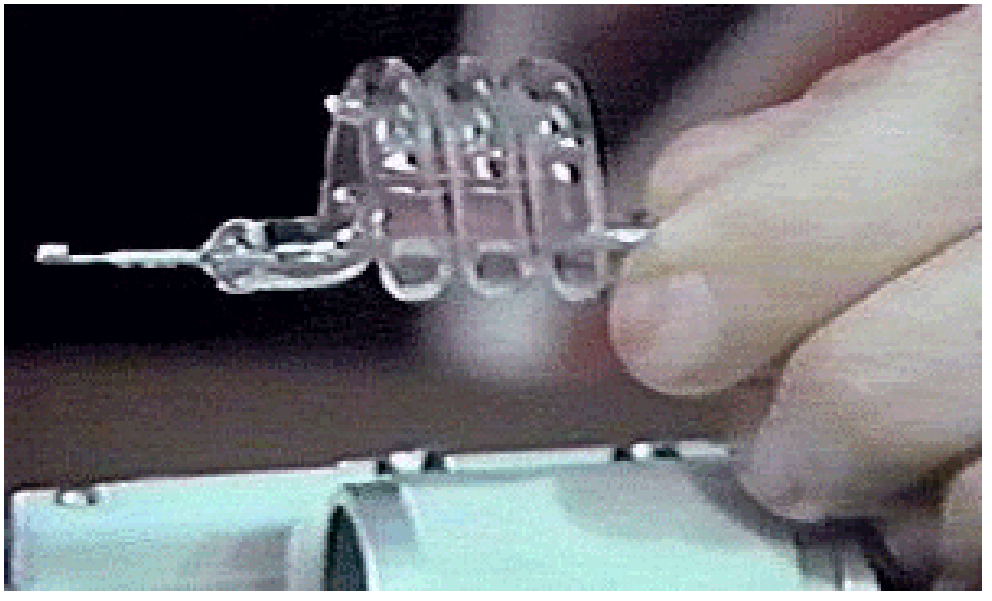


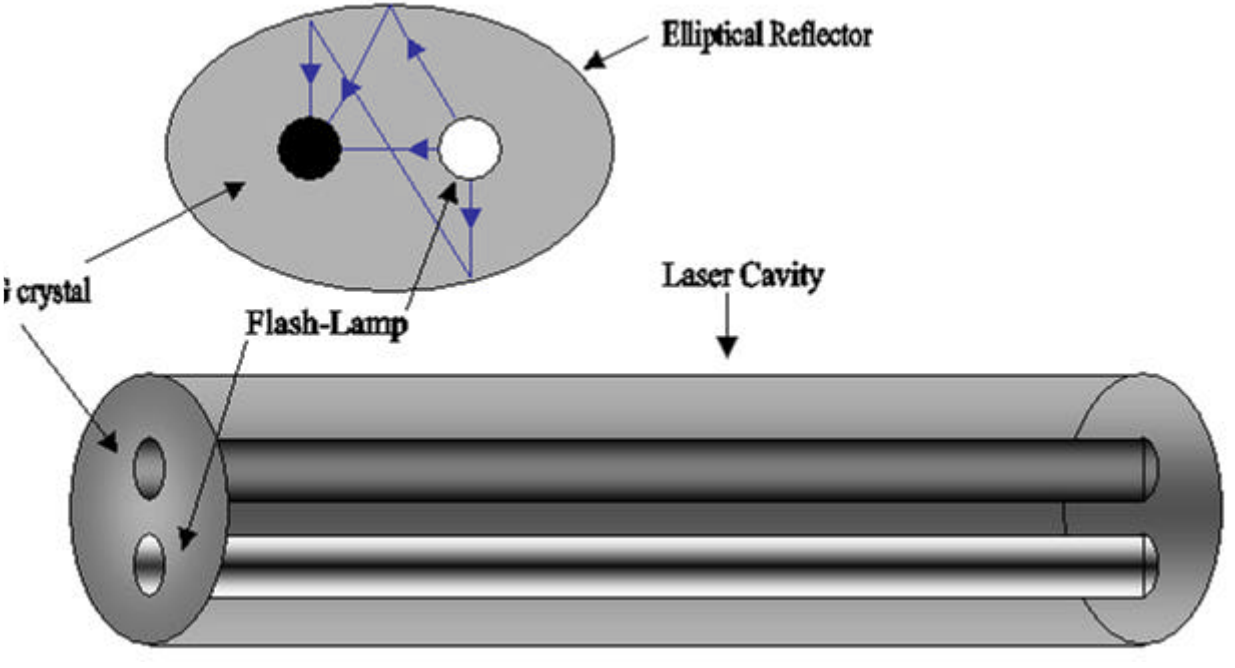


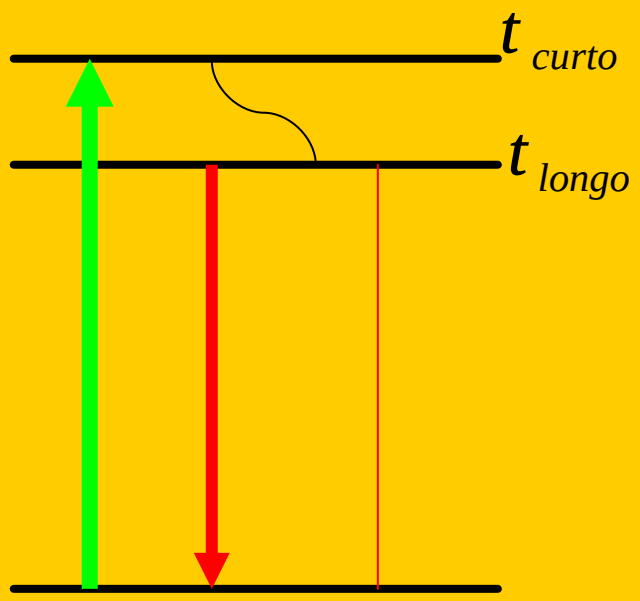
Components of the first ruby laser

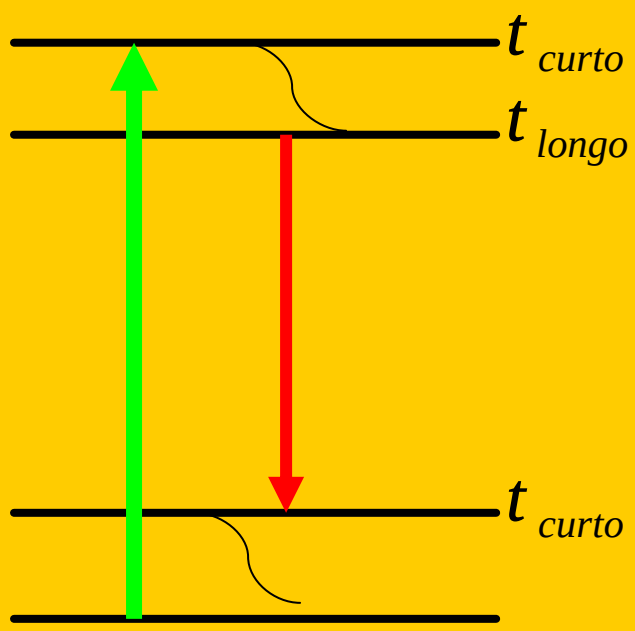



L=500
100
340
50
180
Lüfter
mit Kühlkörper
Auskoppelspiegel
T=20%
Modenblende
Glasplatte
unter Brewsterwinkel
HV+
HV-
Rubinstab
Xenon-Blitzlampe
Pumpkammer, elliptisch
Vollreflektierender
Spiegel M2
Hochspannungsversorgung
LT
HV C
TZ
D
RL
THV
Triac
Netzspannung
Spannungs-
Zündtriggerung




Elliptical Reflector
crystal
Flash-Lamp
Laser Cavity





Sistema de Três Níveis

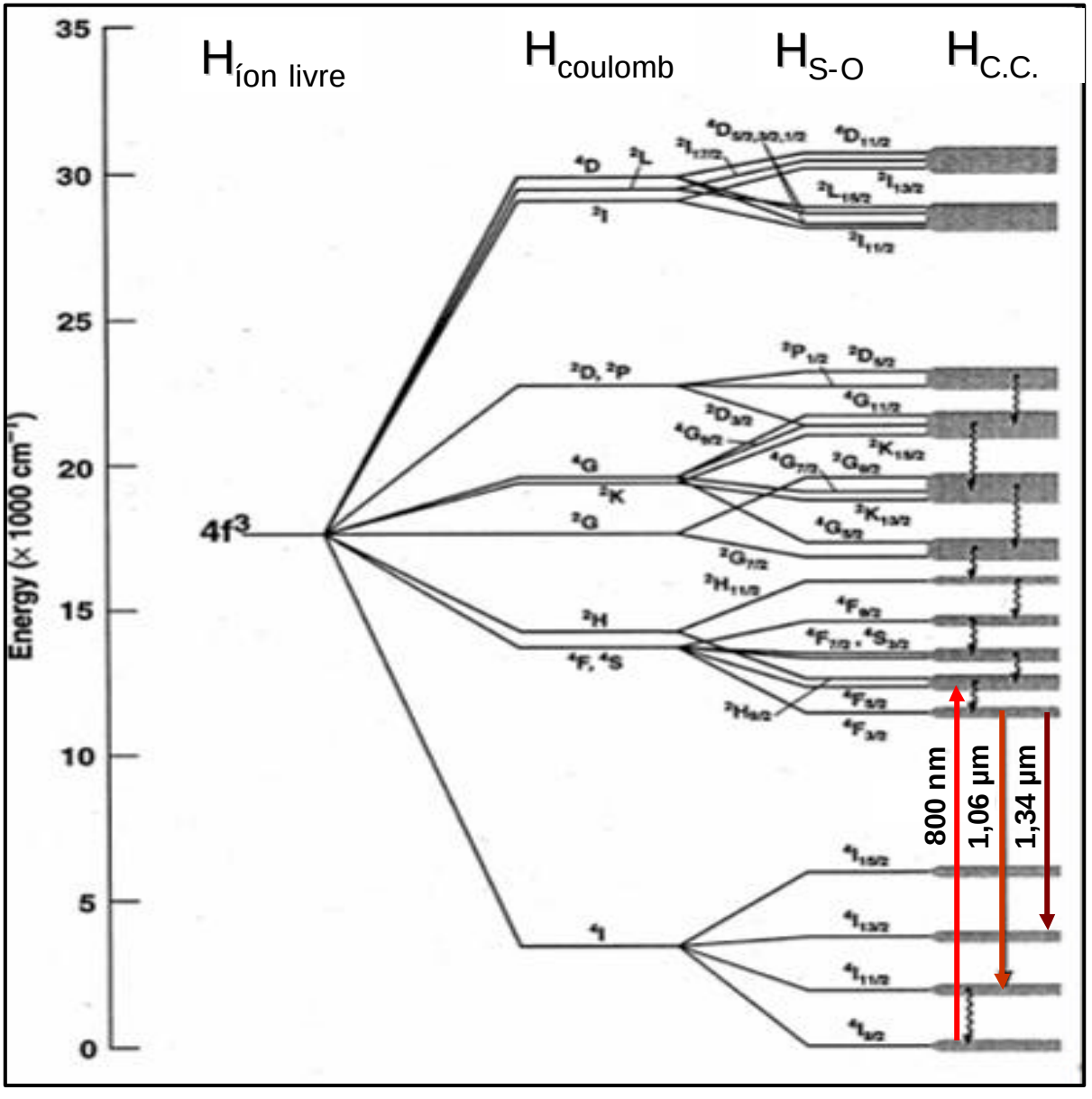
Laser de Alto Limiar

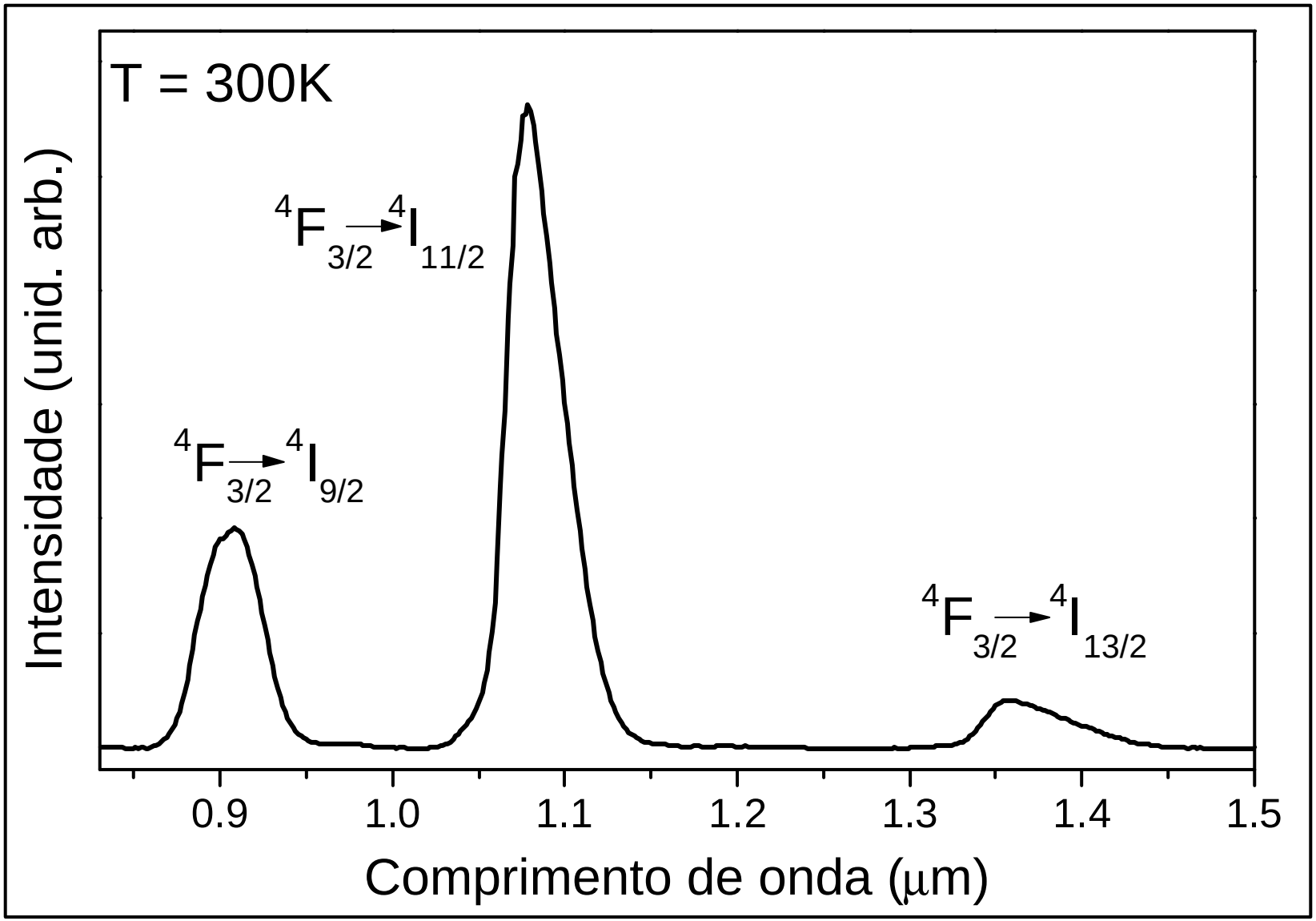
- Cr^{+3} , Er^{+3}...

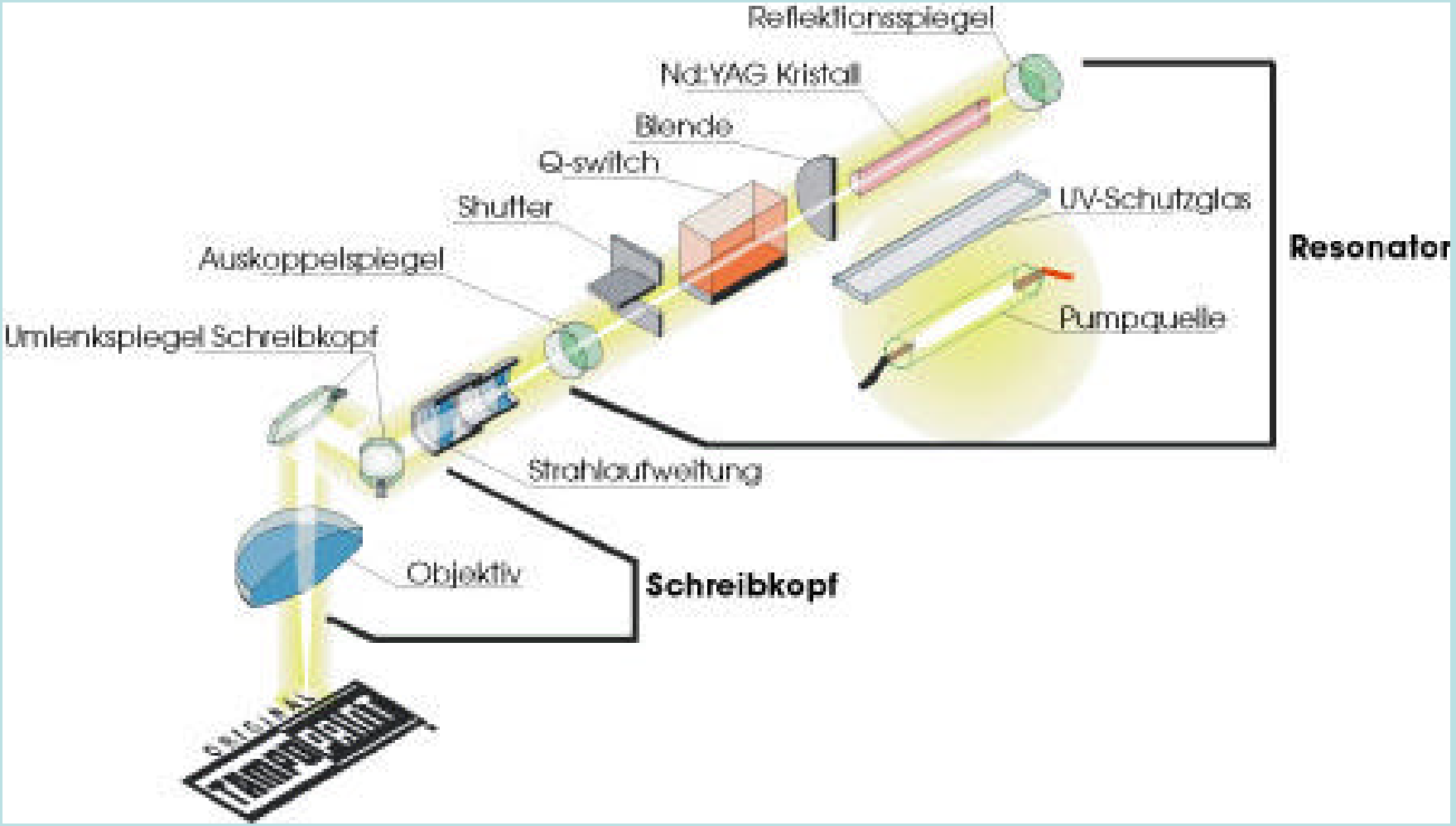
Sistema de Quatro Níveis

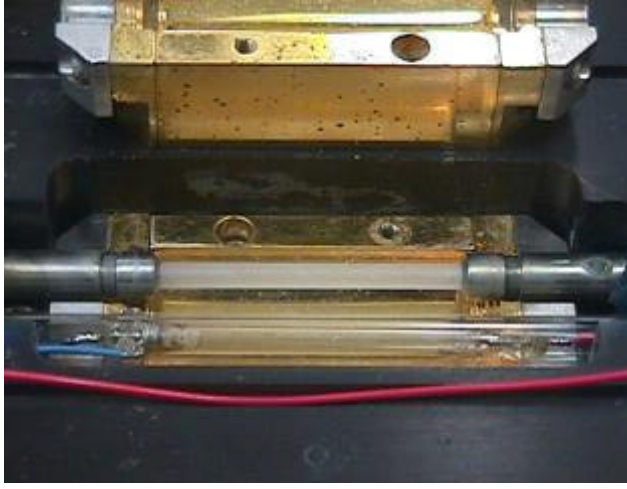
Laser de Alta Eficiência

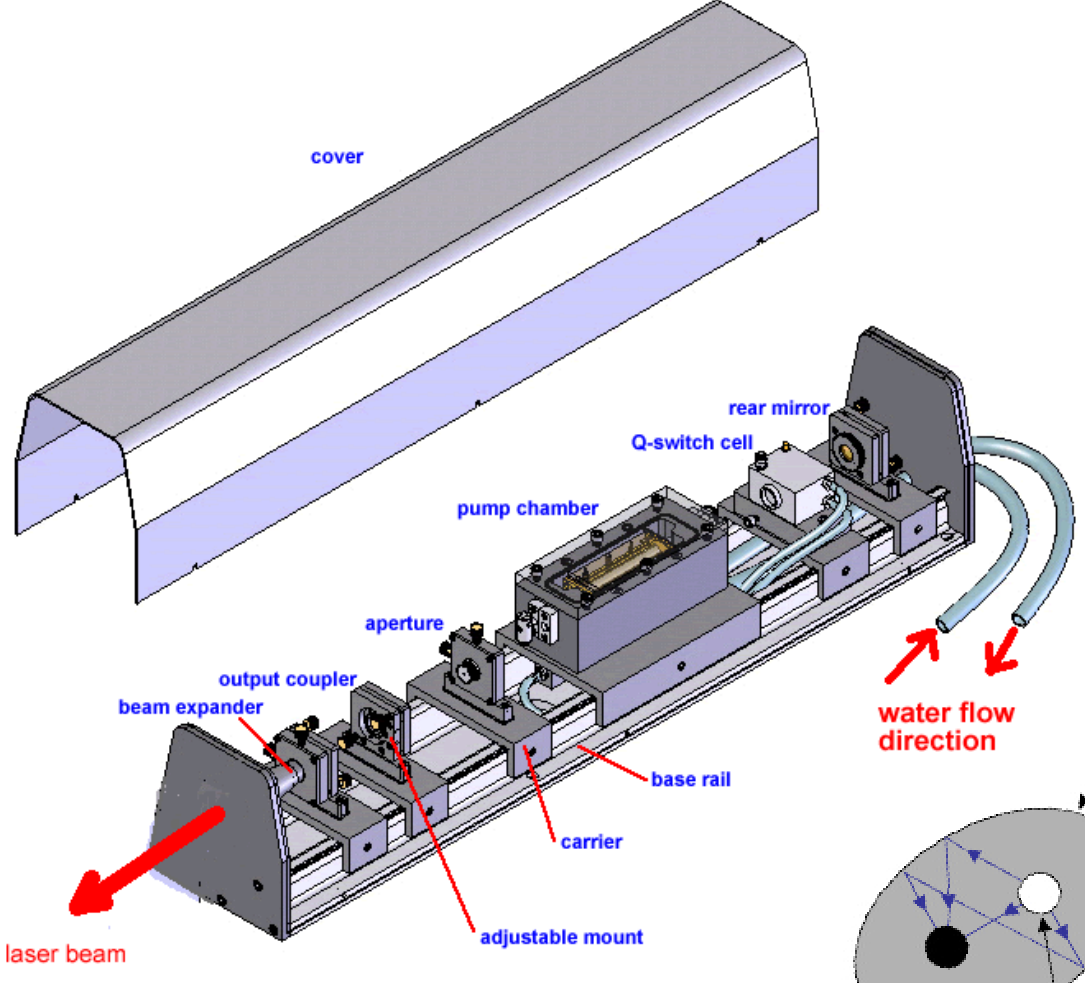
Nd^{+3}

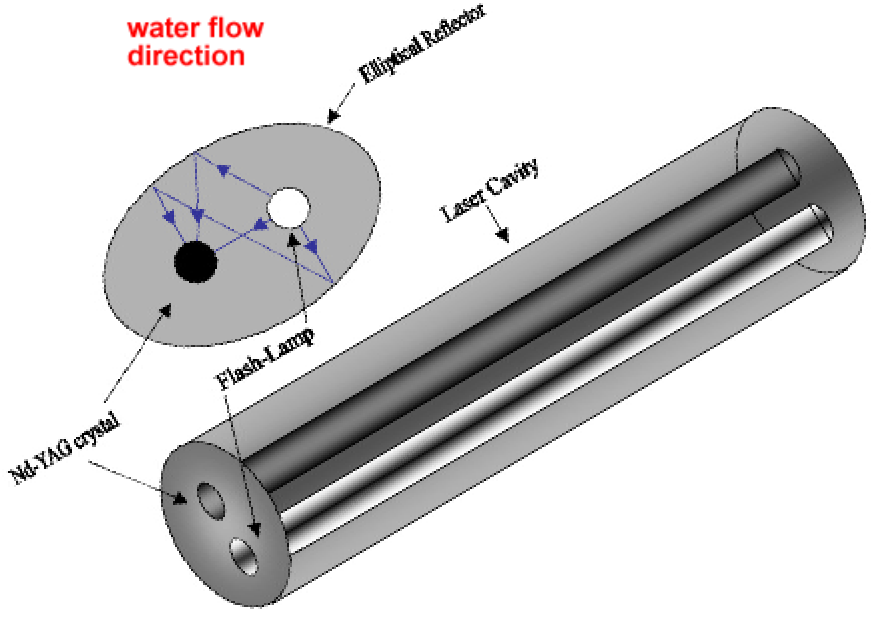

H ion libre
H coulomb
H S-O
H C.C.
Energy (× 1000 cm⁻¹)
35
30
25
20
15
10
5
0
4f3
800 nm
1,06 µm
1,34 µm


T = 300K
$^4F_{3/2} \rightarrow {}^4I_{11/2}$
$^4F_{3/2} \rightarrow {}^4I_{9/2}$
$^4F_{3/2} \rightarrow {}^4I_{13/2}$
Intensidade (unid. arb.)
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Comprimento de onda (μm)


Reflektionsspiegel
Nd:YAG Kristall
Blende
Q-switch
Shutter
Auskoppelspiegel
UV-Schutzglas
Resonator
Pumpquelle
Umlenkspiegel Schreibkopf
Strahlaufweitung
Objektiv
Schreibkopf

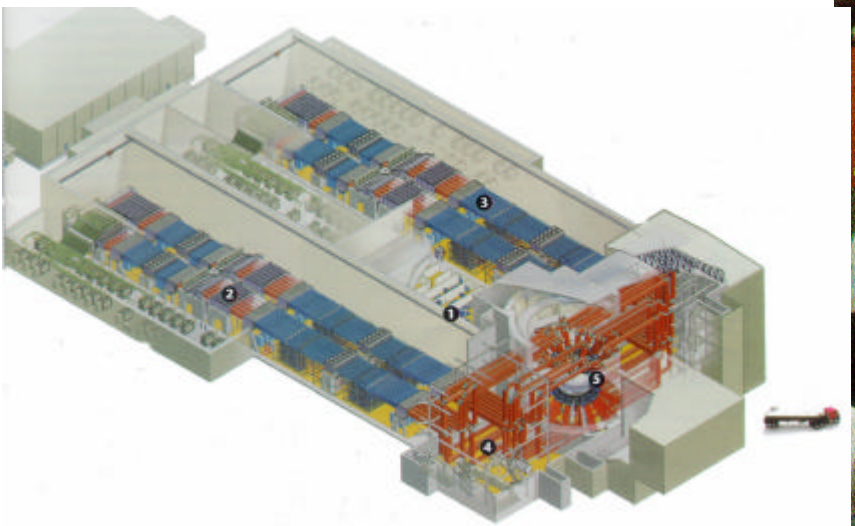



cover
rear mirror
Q-switch cell
pump chamber
aperture
output coupler
beam expander
base rail
carrier
adjustable mount
laser beam
water flow direction


Elliptical Reflector
Laser Cavity
Flash-Lamp
Nd-YAG crystal

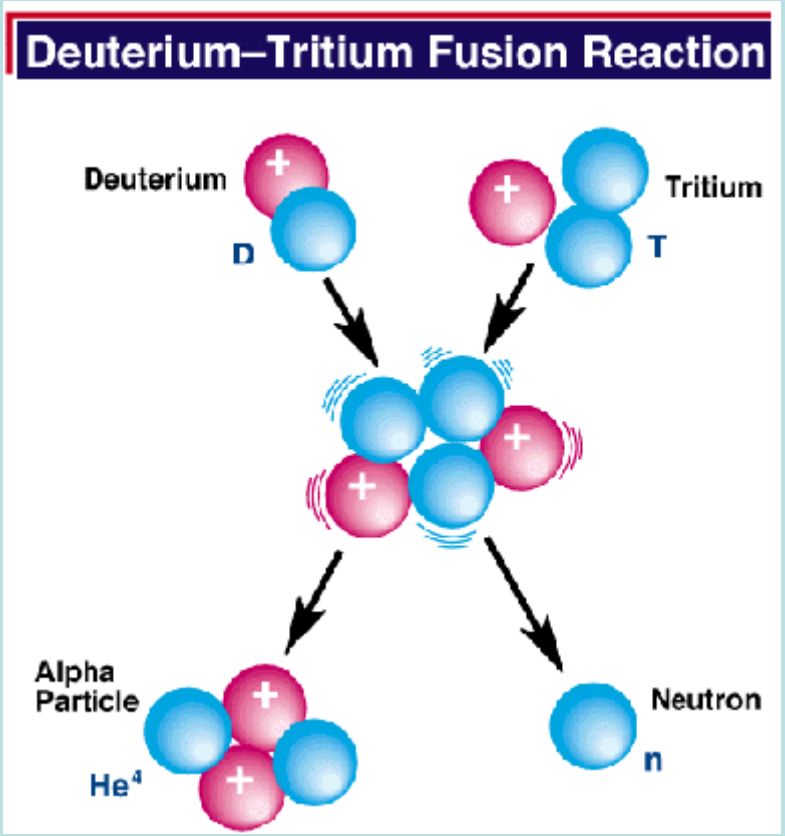
Laser NOVA

- Uma das 3072 placas de vidro fosfato dopado com Nd^{3+}, utilizada no laser NOVA



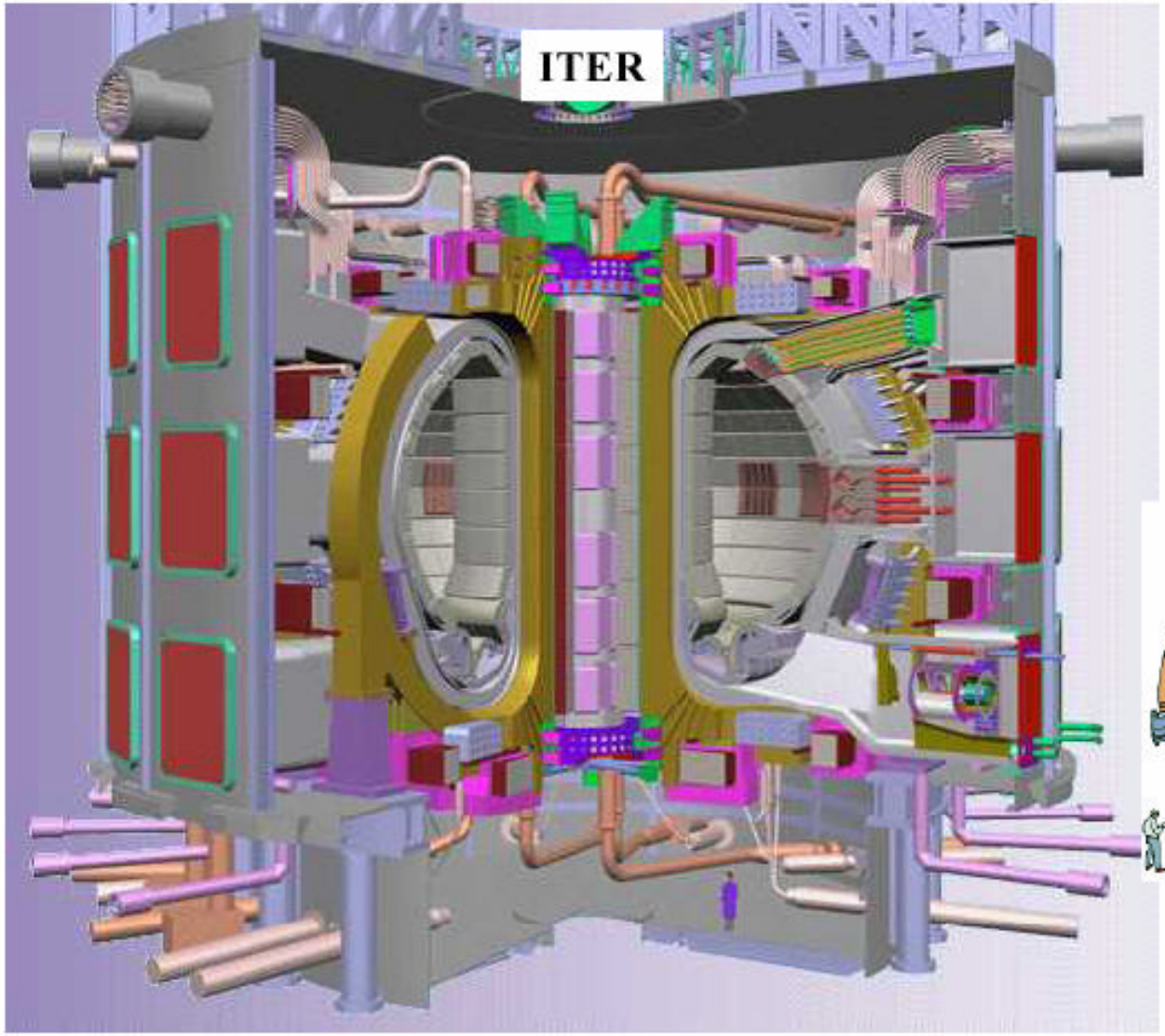

Optics
Assembly
Building
Capacitor Bay 4
Laser Bay 2
Capacitor Bay 3
Capacitor Bay 2
Laser Bay 1
Capacitor Bay 1
Switchyard 2
Target Bay
& Chamber
Diagnostics
Building
Switchyard 1

Fusão Nuclear

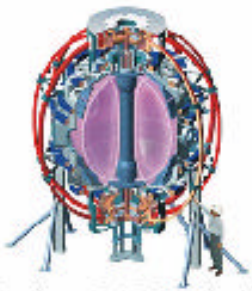


$$^{2}H + ^{3}H \quad \Rightarrow \quad ^{4}He + n + 17{,}6MeV$$

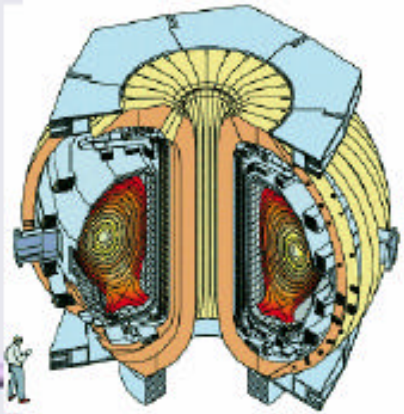
Some Fusion Experiments



MTF (Los Alamos)



National Spherical
Torus Experiment
NSTX (Princeton)

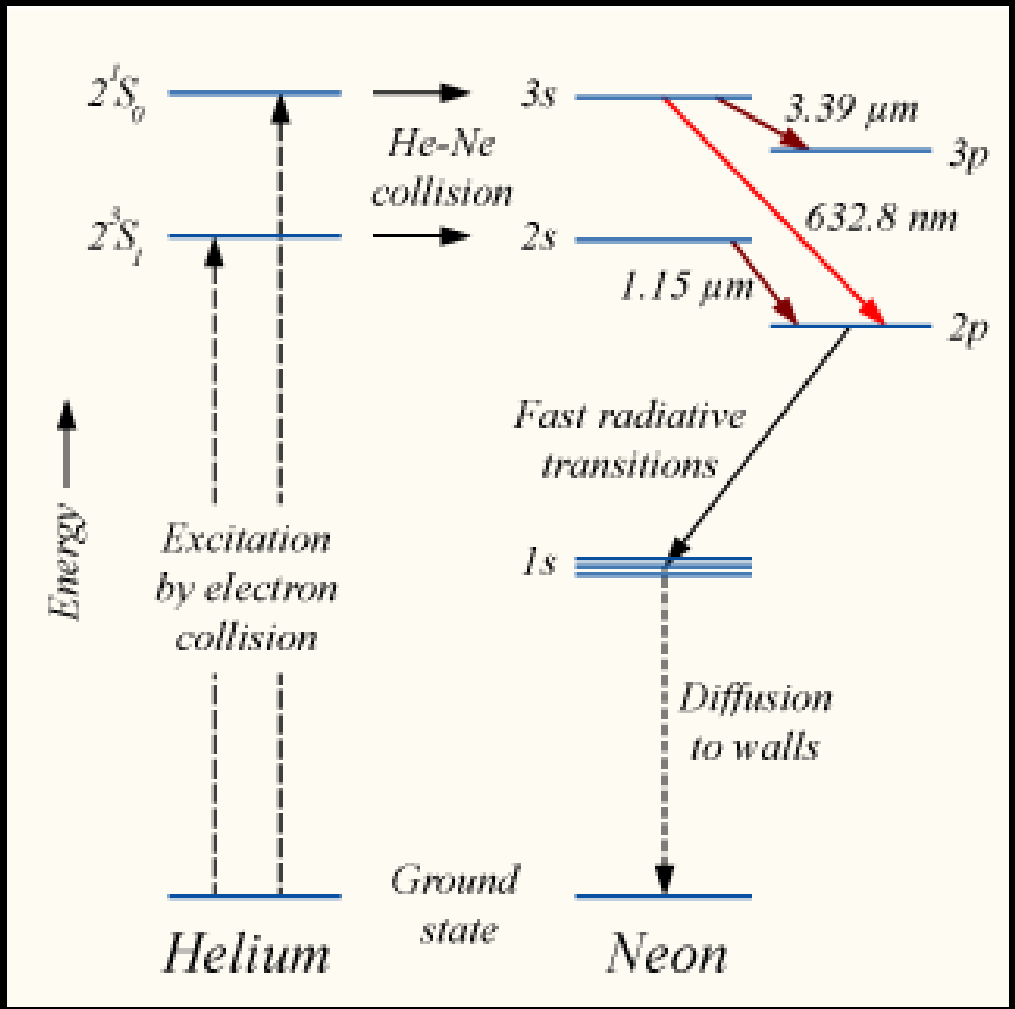


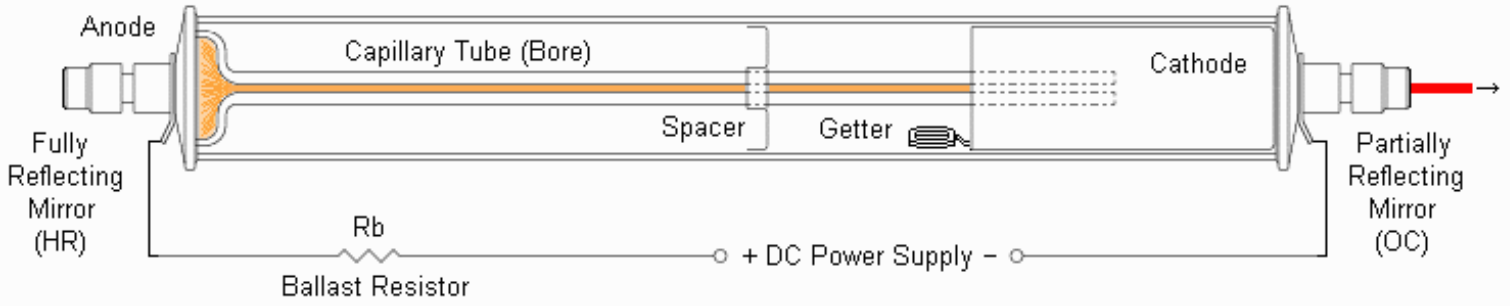
DIII-D Tokamak
General Atomics
(San Diego)

Tipos de Laser:

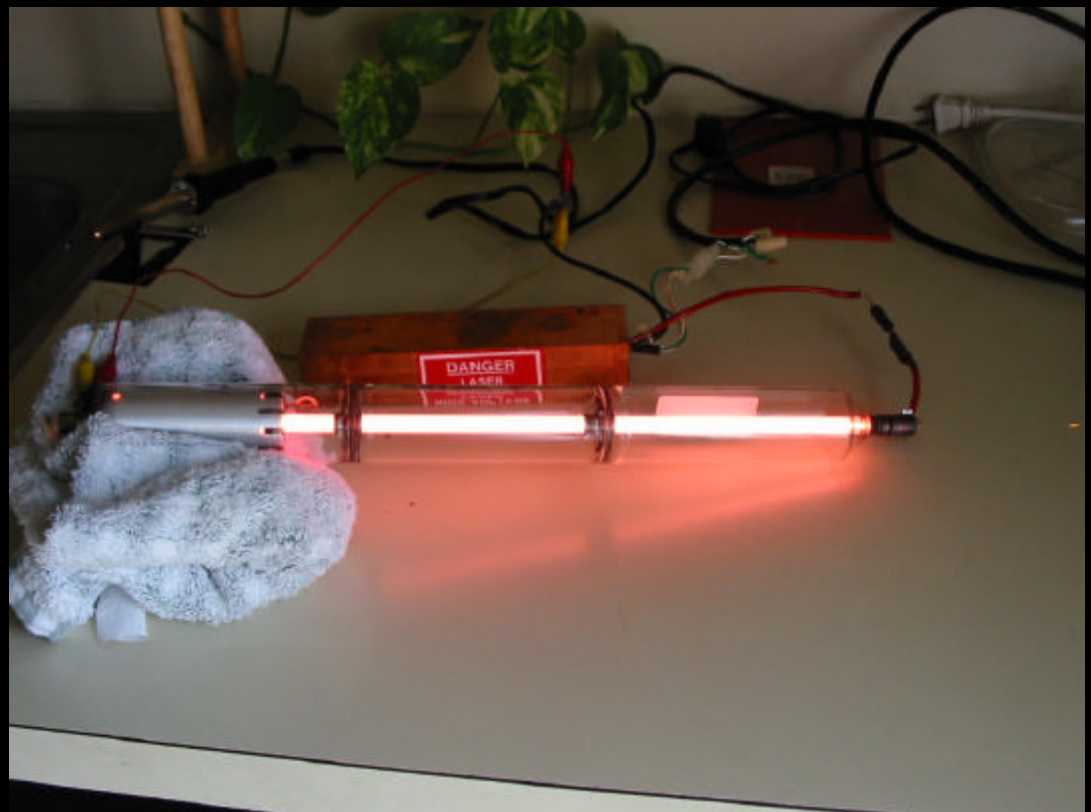
Laser de Gás

HeNe

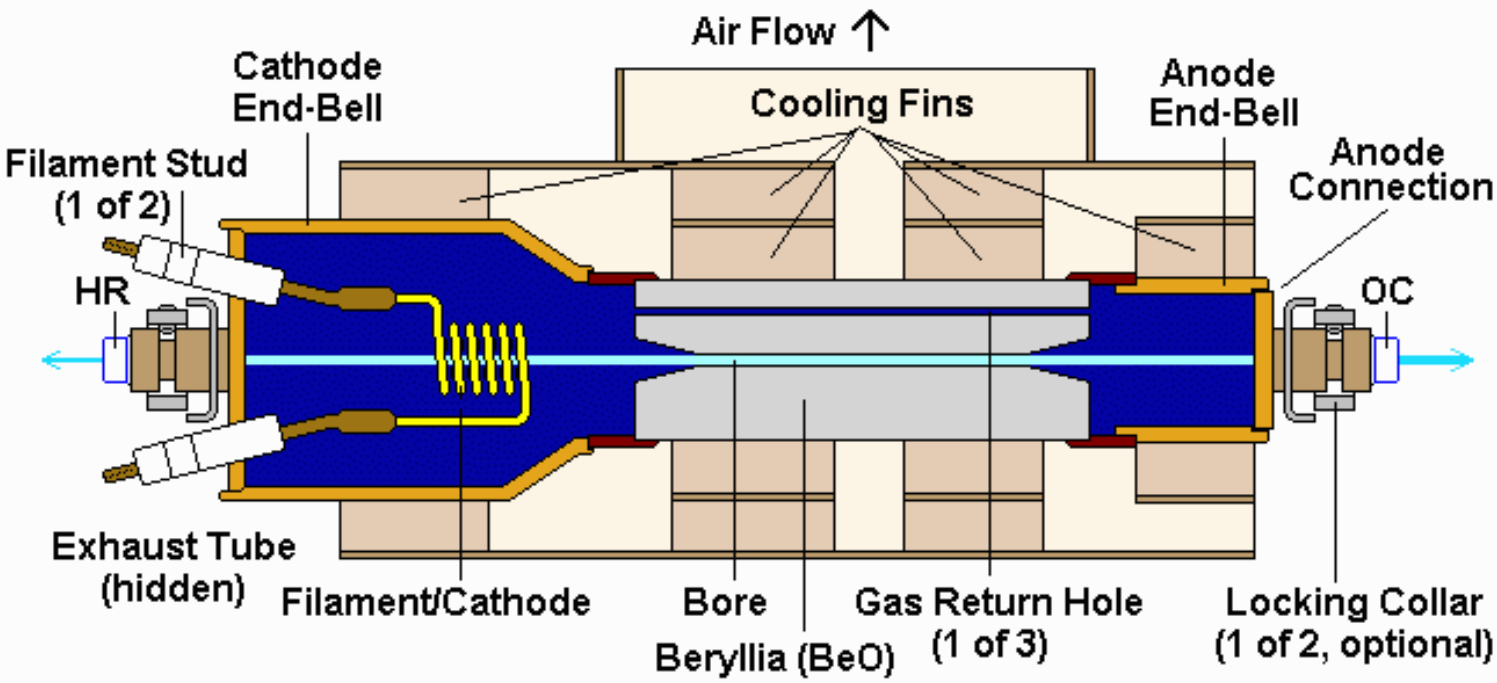




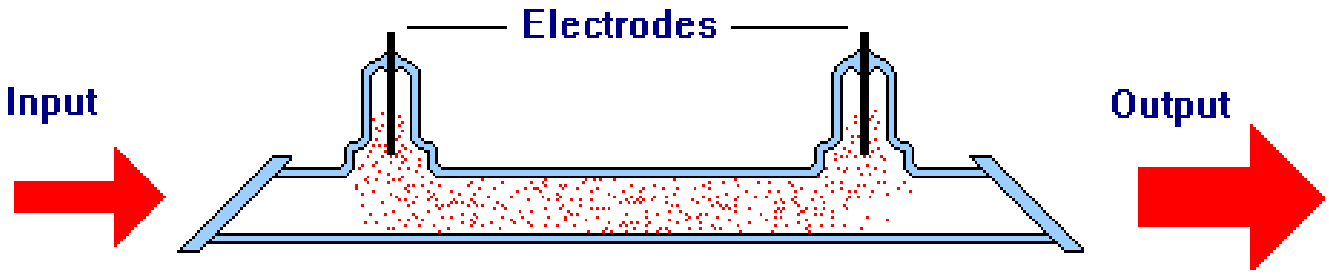
Typical HeNe Laser Tube Structure and Connections

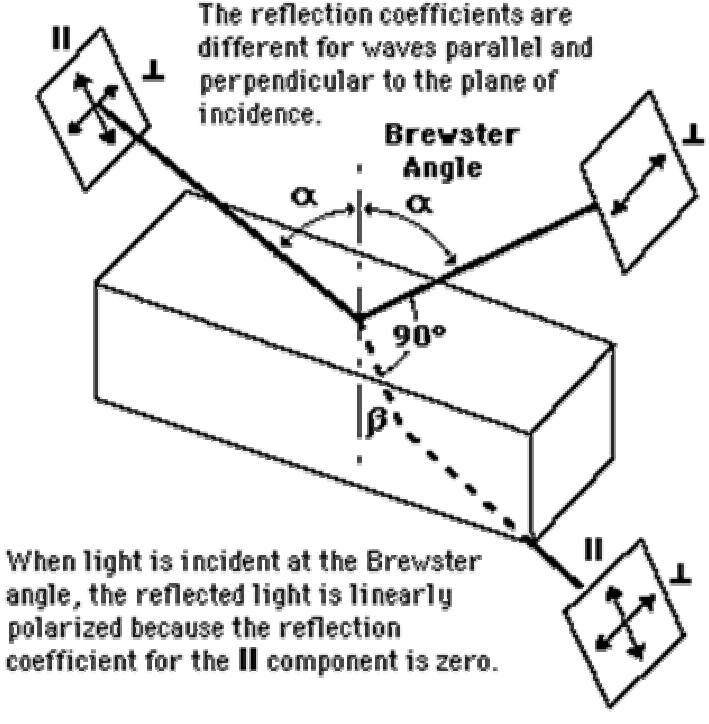


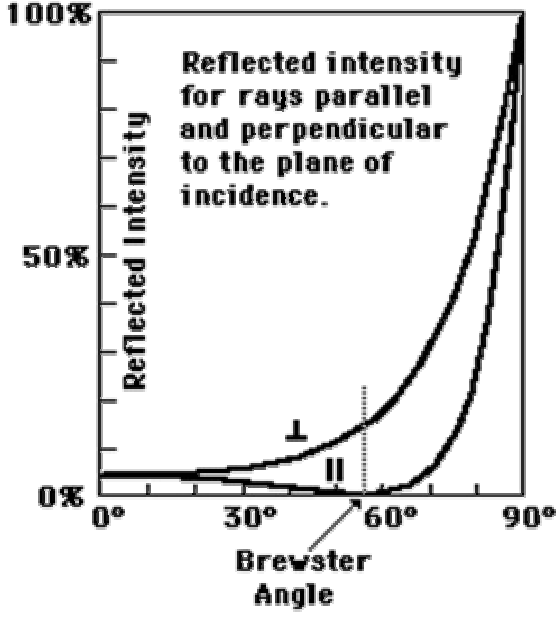
Laser de Argônio

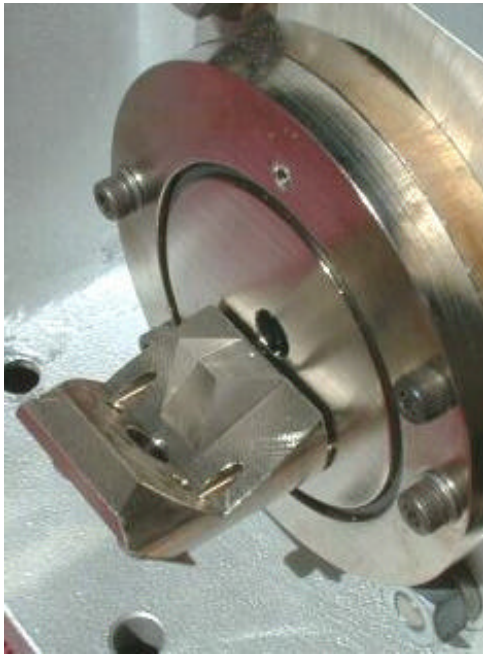


Structure of Typical Cynonics/Uniphase Argon Ion Laser Tube

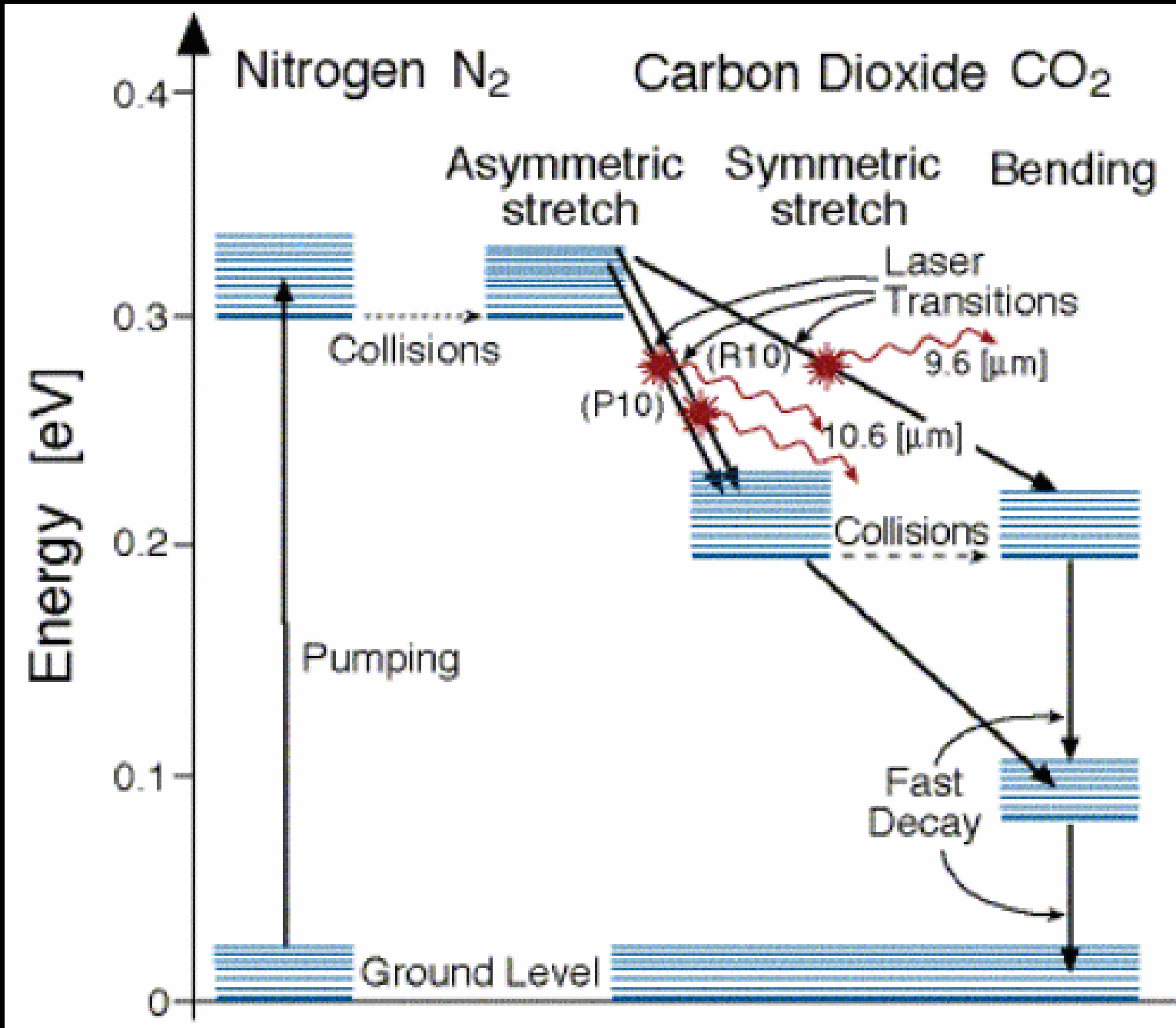

Electrodes
Input
Output
Gaseous amplifying medium

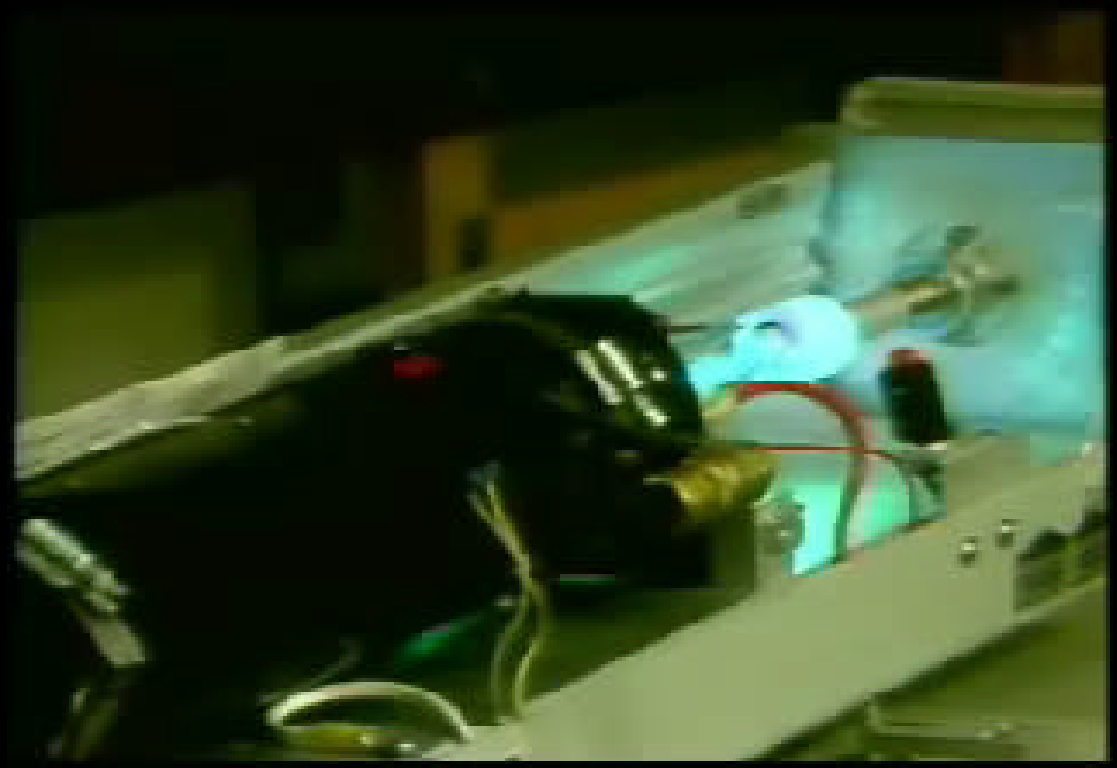

The reflection coefficients are different for waves parallel and perpendicular to the plane of incidence.
Brewster Angle
α
α
90°
β
When light is incident at the Brewster angle, the reflected light is linearly polarized because the reflection coefficient for the II component is zero.


100%
50%
0%
Reflected Intensity
Reflected intensity for rays parallel and perpendicular to the plane of incidence.
0°
30°
60°
90°
Brewster Angle



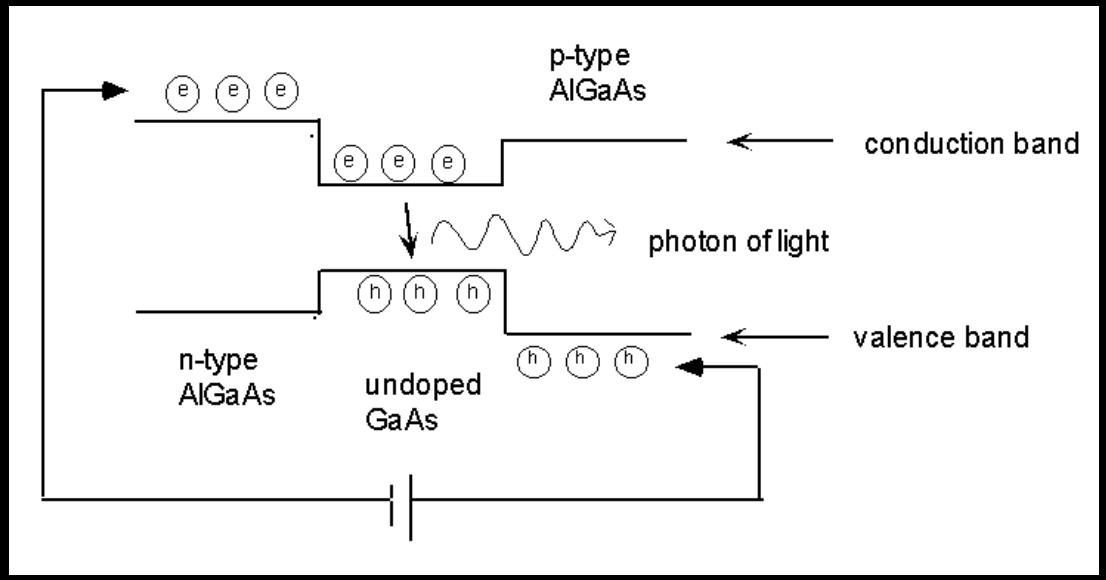
Laser CO_2

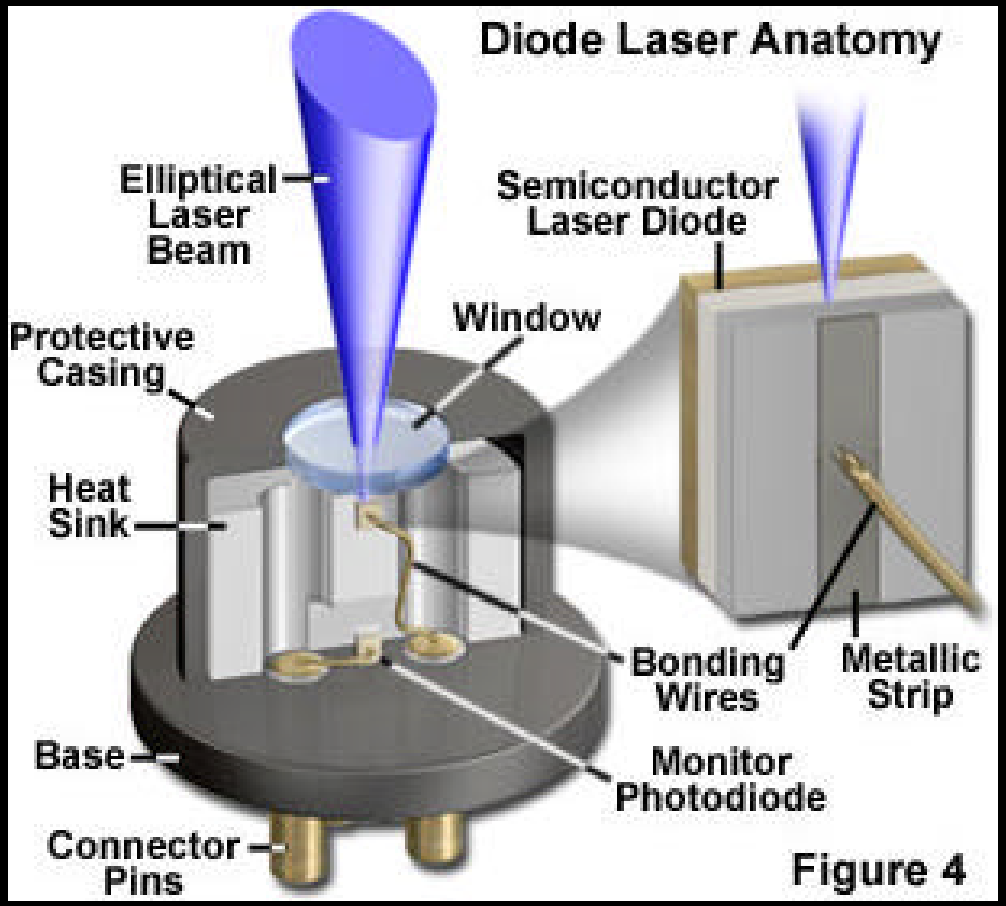

Nitrogen N_2
Carbon Dioxide CO_2
Asymmetric stretch
Symmetric stretch
Bending
Laser Transitions
Collisions
(R10)
(P10)
9.6 [μm]
10.6 [μm]
Collisions
Pumping
Fast Decay
Ground Level
Energy [eV]
0.4
0.3
0.2
0.1
0

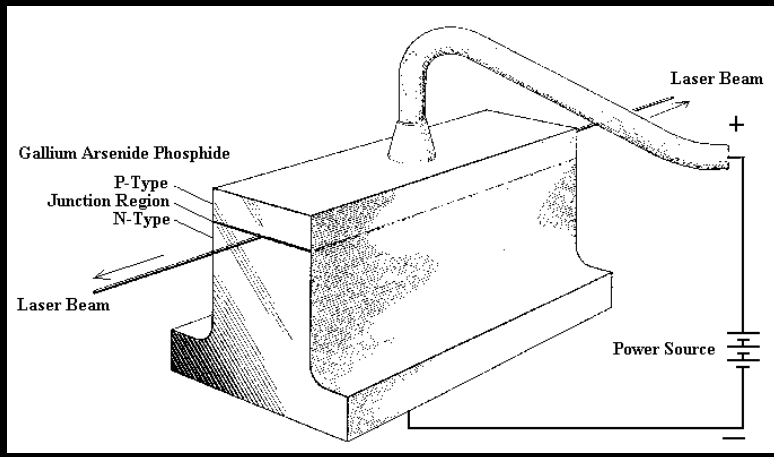


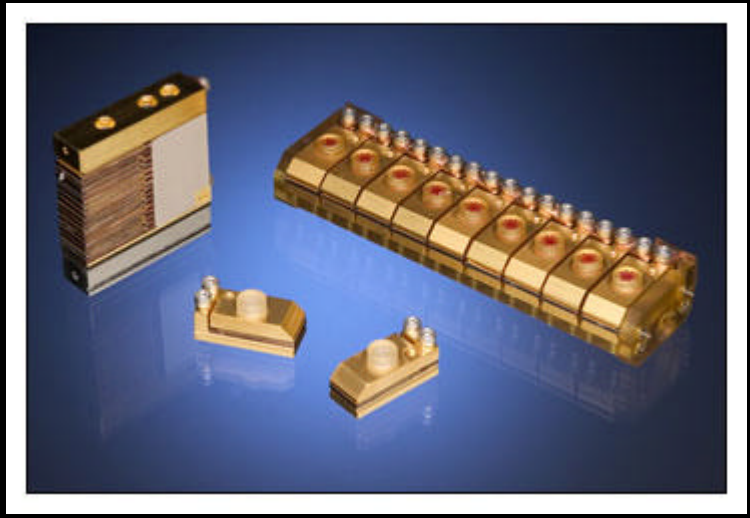
Discutir sobre a eficiência dos lasers

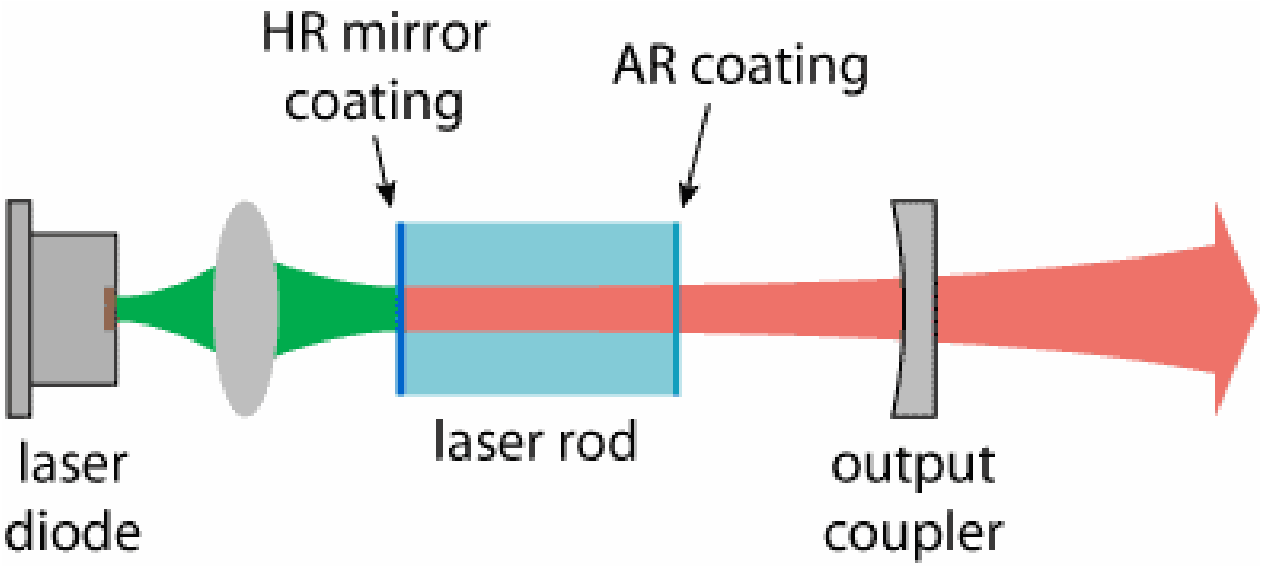
Laser de Semicondutor

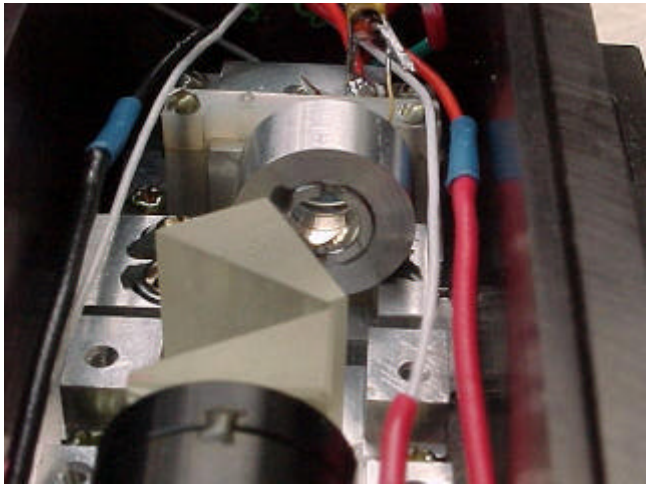


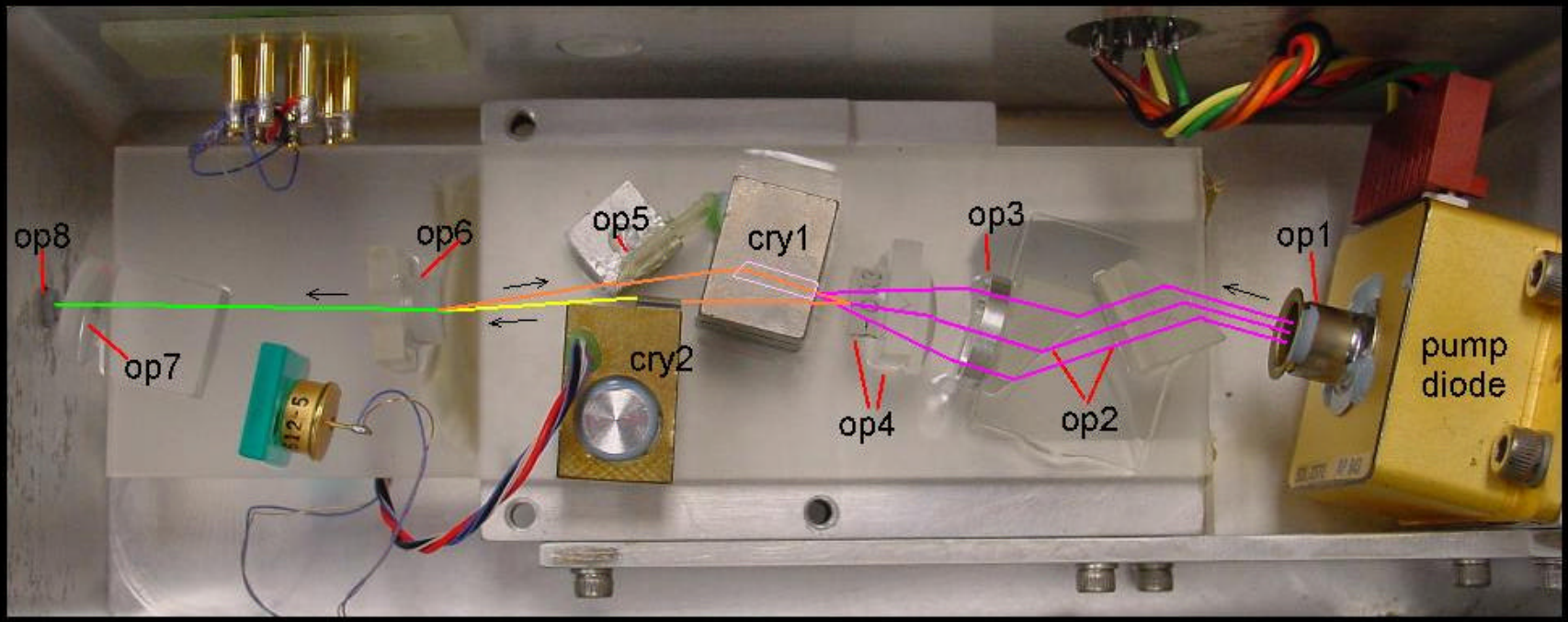

Diode Laser Anatomy
Elliptical Laser Beam
Semiconductor Laser Diode
Window
Protective Casing
Heat Sink
Bonding Wires
Metallic Strip
Base
Monitor Photodiode
Connector Pins
Figure 4


Laser Beam
+
Gallium Arsenide Phosphide
P-Type
Junction Region
N-Type
Laser Beam
Power Source
–




HR mirror
coating
AR coating
laser
diode
laser rod
output
coupler



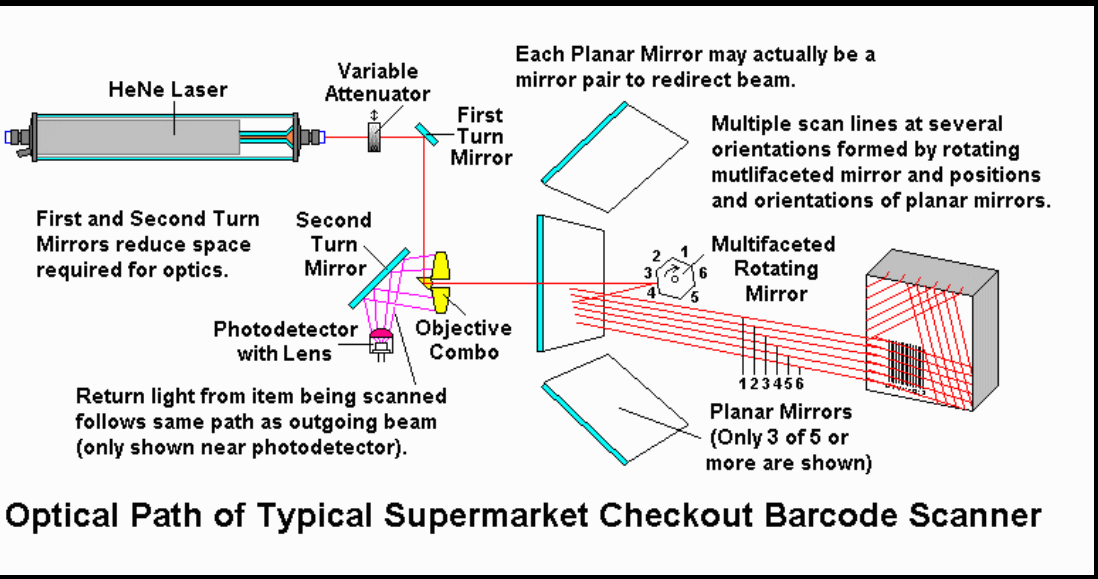


Beam Paths:	808 nm	1064 nm	1064+532 nm	532 nm

Legend: op1-op3: Pump beam shaping, op4: HR@1064nm, cry1: YAG crystal assembly, cry2: KTP SHG crystal, op5: Angled plate, op6: HR@1064nm;HT@532nm/beam expander, op7: collimator, op8: IR filter/polarization rotator.

Coherent 532-200 Cavity Components and Output Optics

Aplicações:
Leitor de Código de Barra



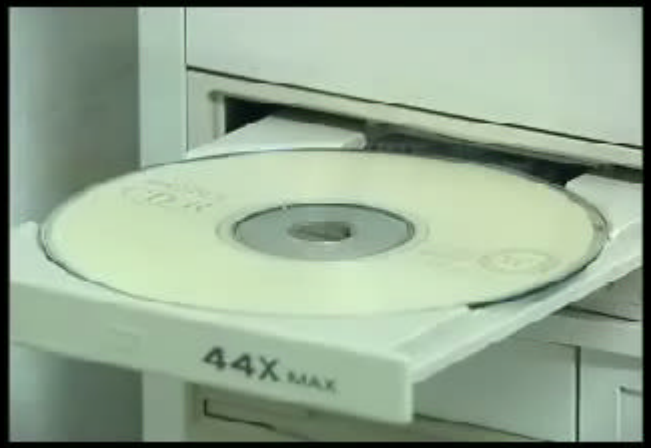
Comunicação:

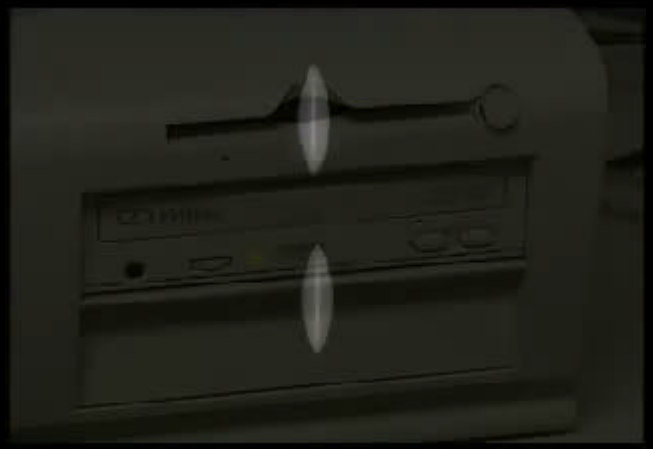
- Velocidade Máxima de Transmissão em fios de Metal 100.000.000 eventos por segundo

- Velocidade Máxima de Transmissão em fibra 200.000.000.000.000 eventos por segundo

Gravar Informação

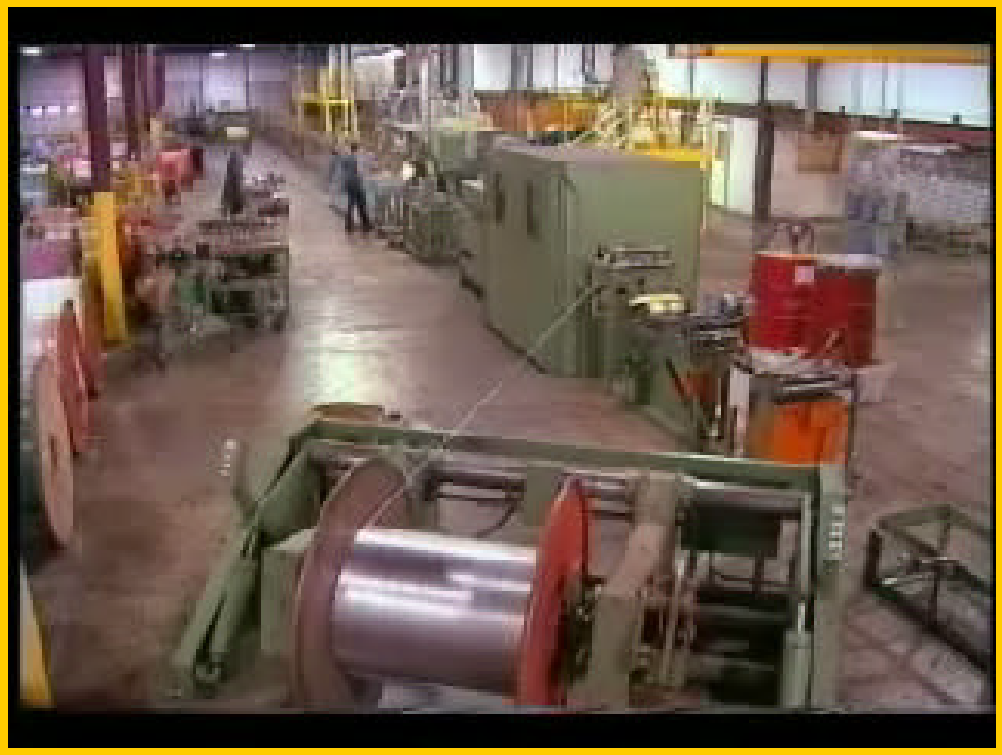
- CD
- DVD





Construção Civil

Perfilhamento de Fio de Cobre



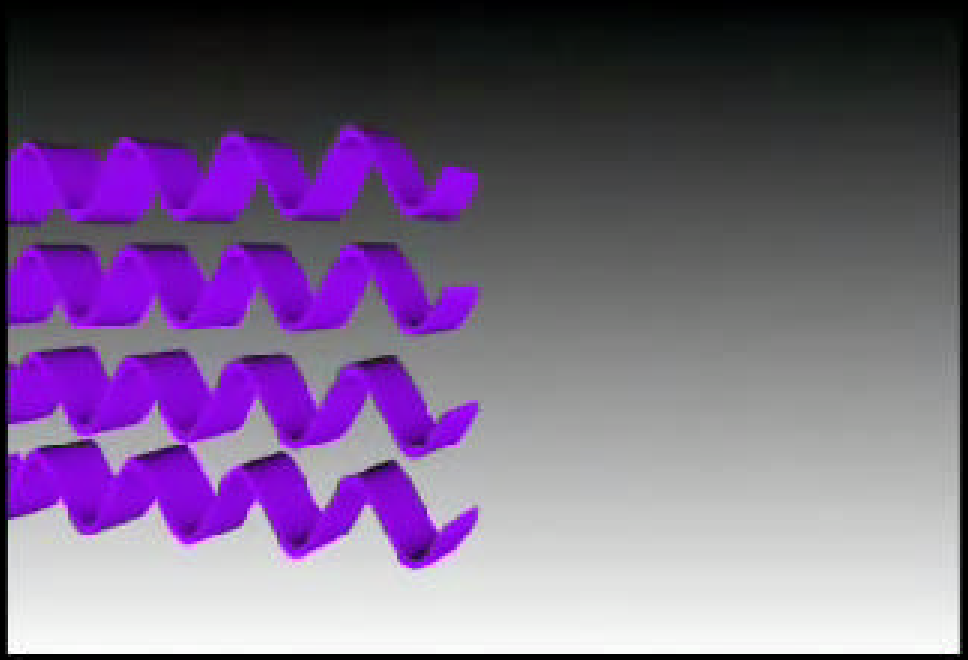
$$n\,l = d.sen(q)$$

Aplicações Industriais

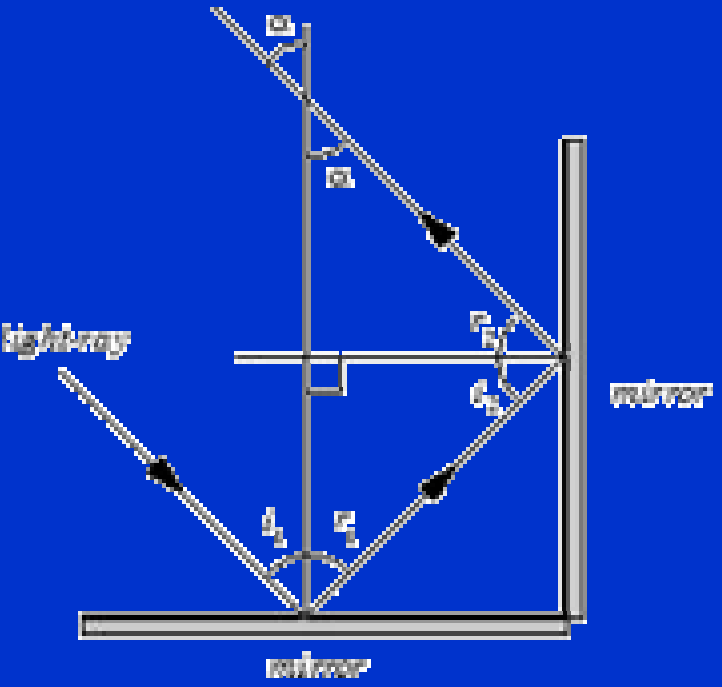

SUZUKI

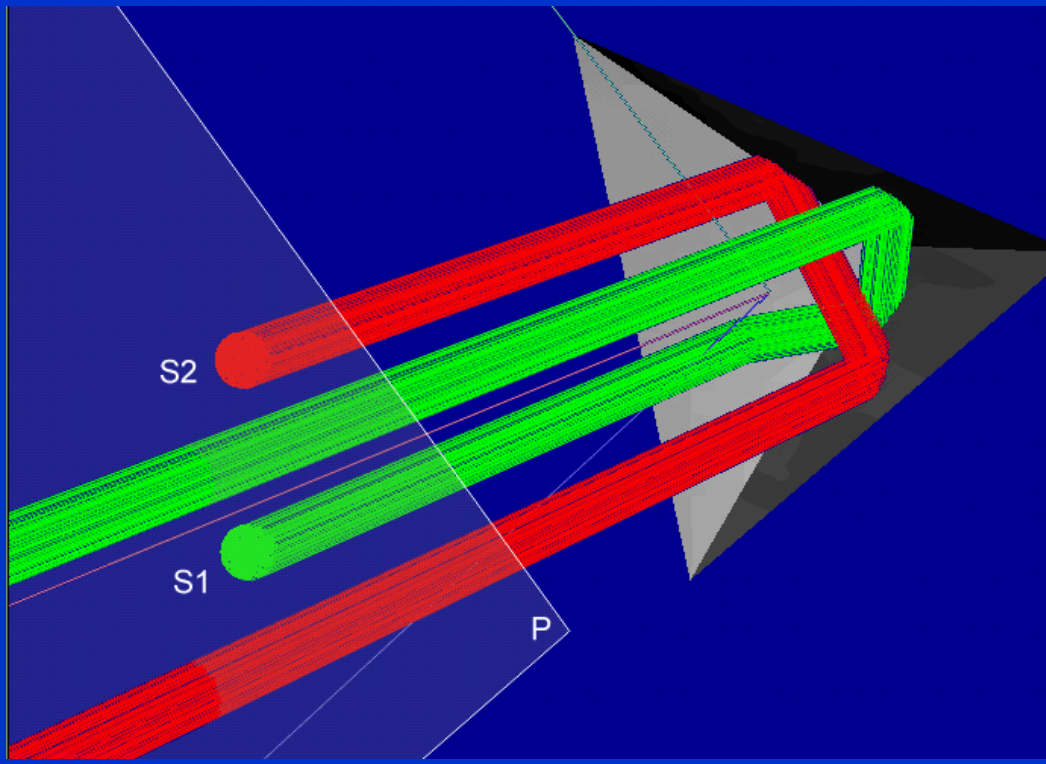

祝
寿

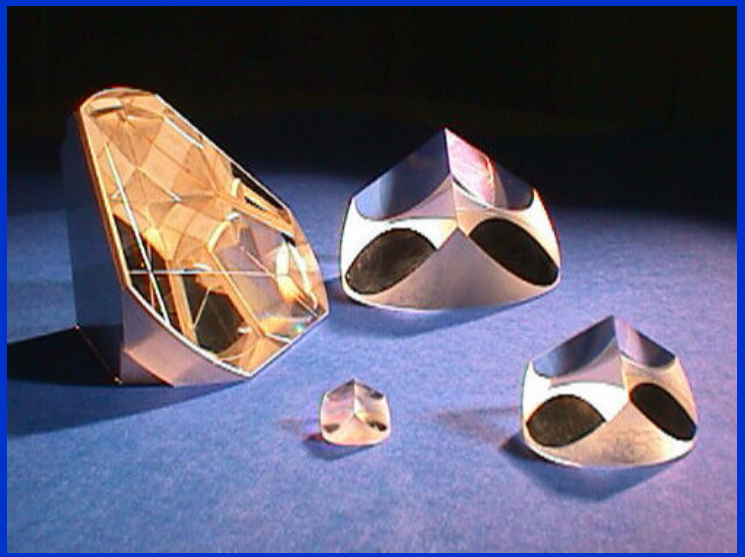
Sensor de Vibração



Medidas de Distancia


mirror
mirror

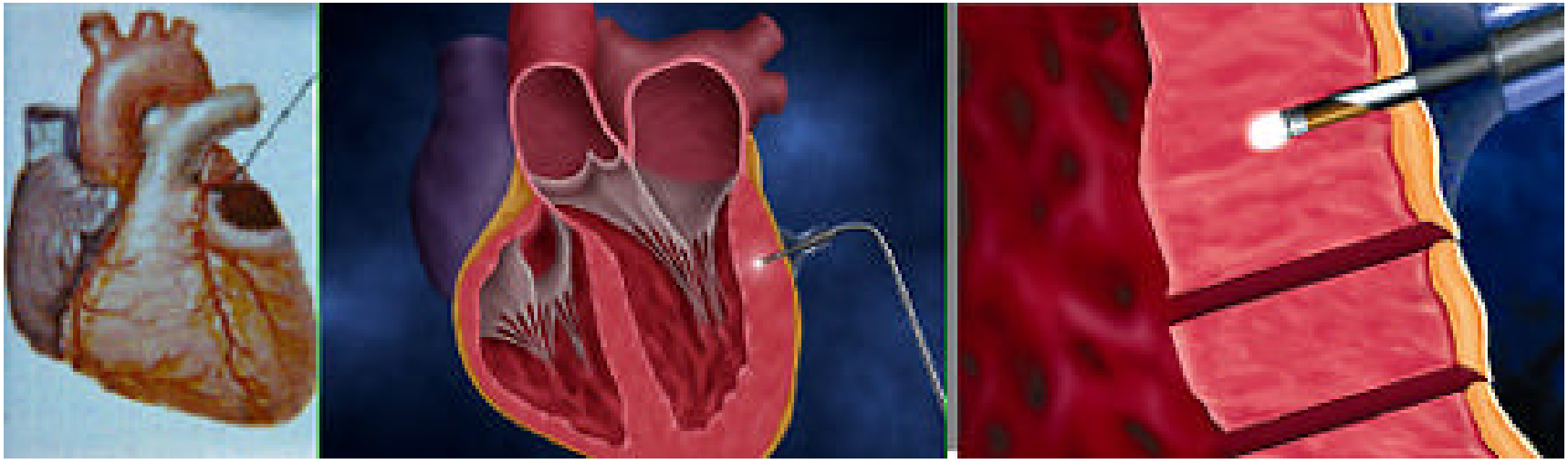

S2
S1
P



Estética

Oftalmologia

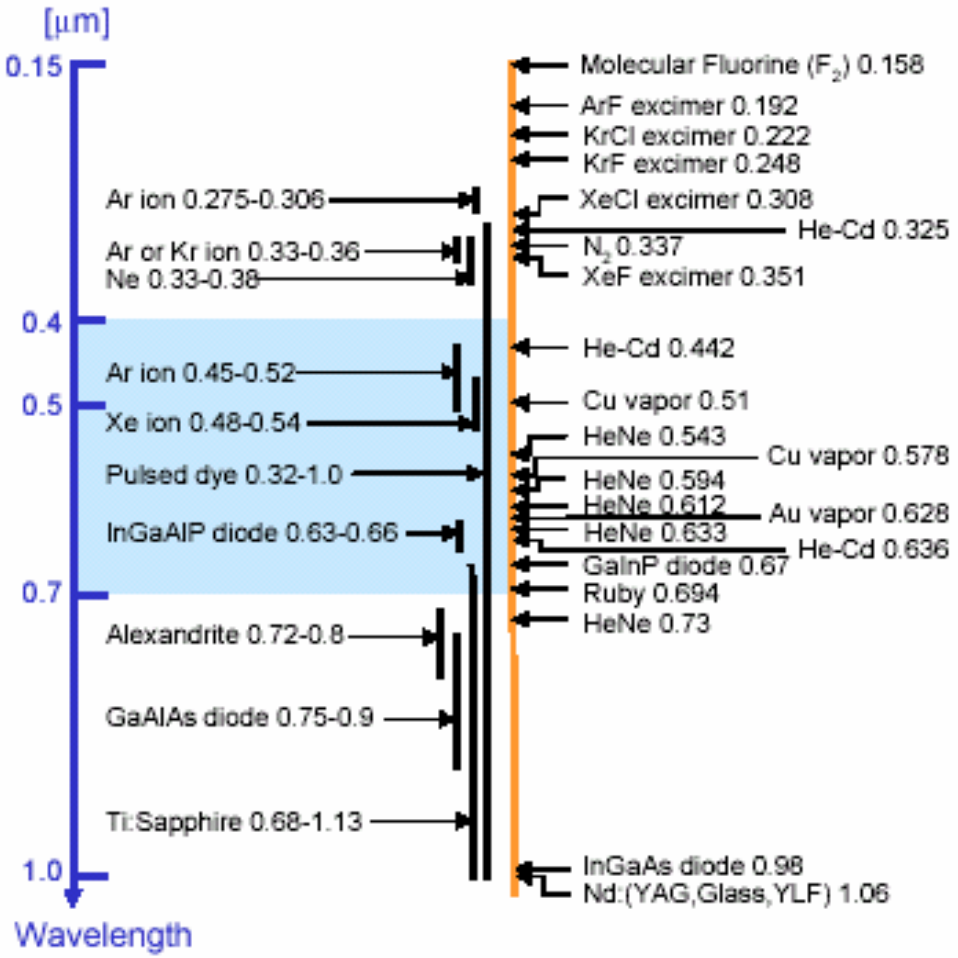
Cirurgia de Revascularização

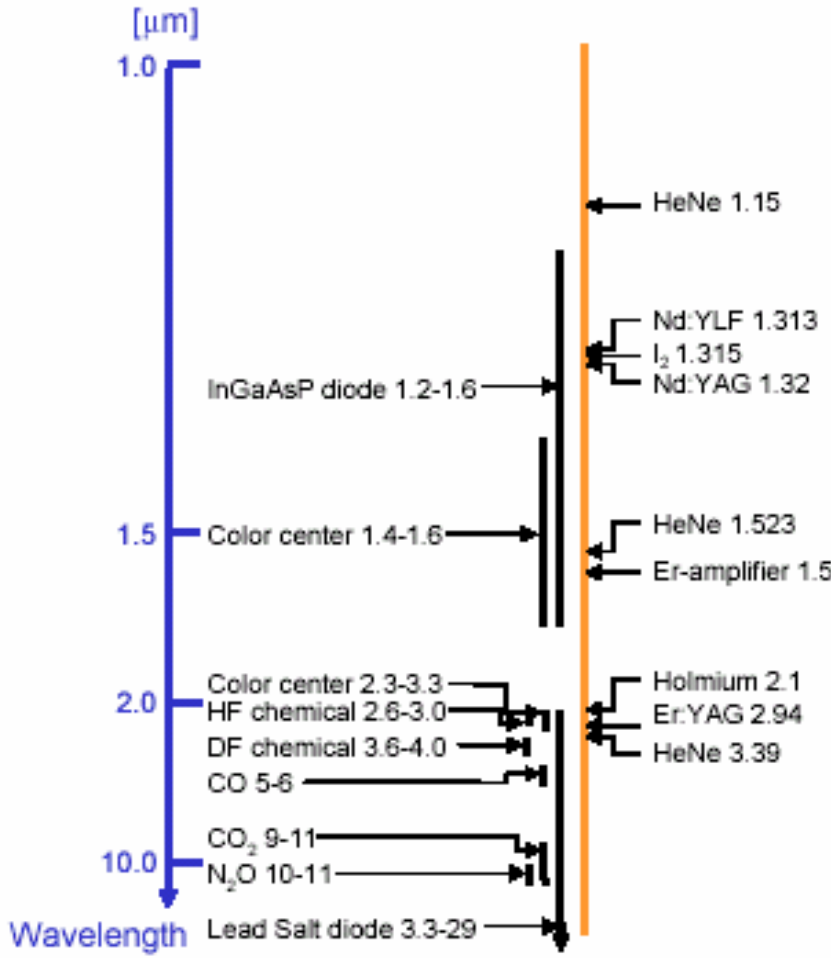


Aplicações Militares

Aplicações Militares

Lasers Mais Comuns





FIM

Written, Produced and Directed by

Glenn Rosin