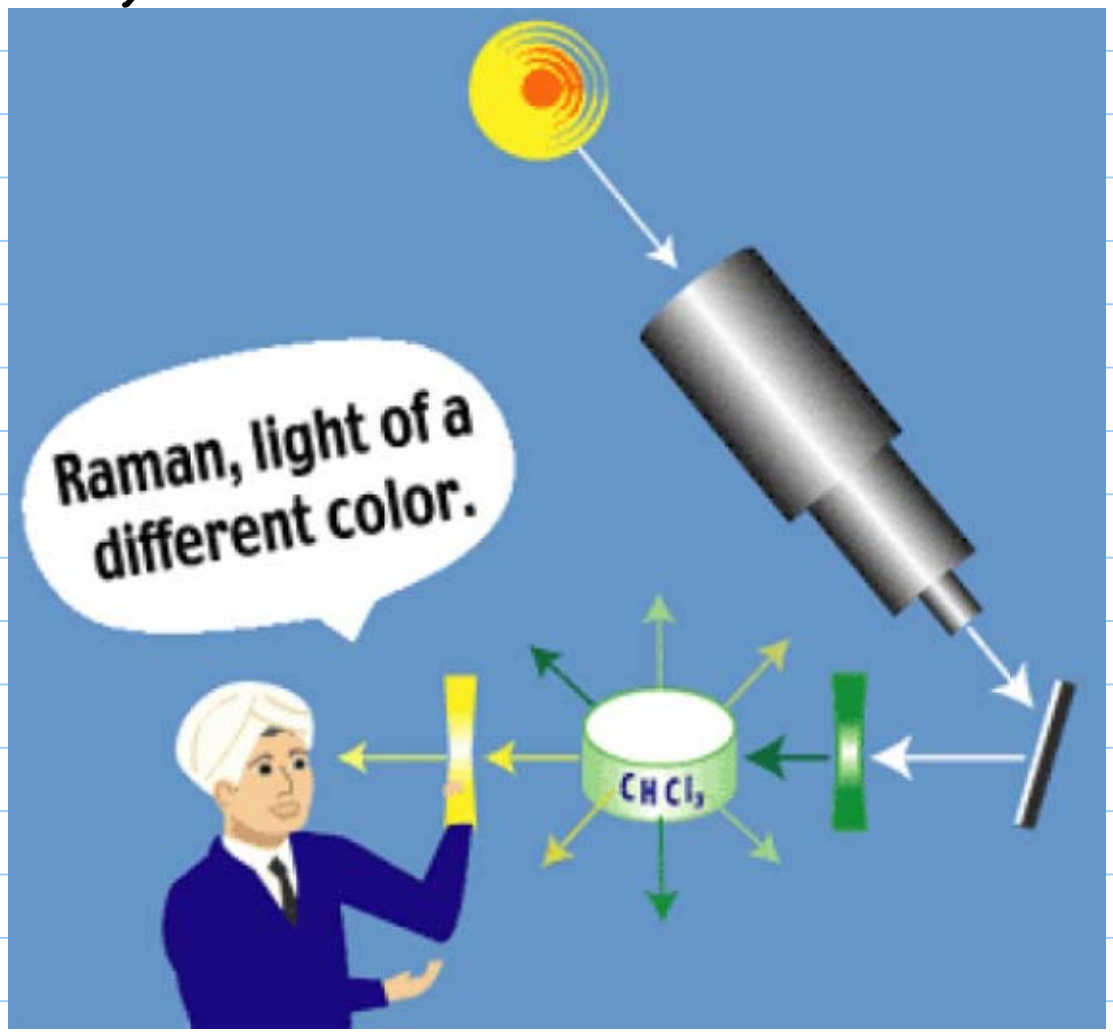
Light Sources

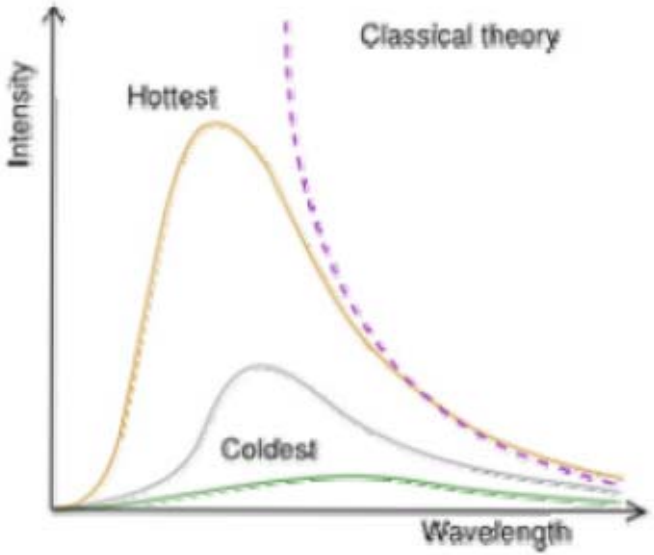
Note Title 2/25/2007

Sun

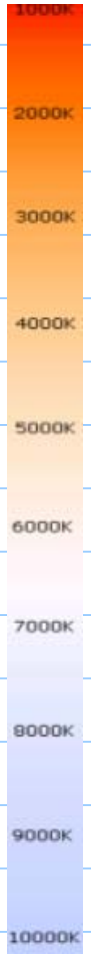
Discovery of the Raman Effect



Black Body



Lava



Planck's law of black-body radiation

$$I(\nu) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$

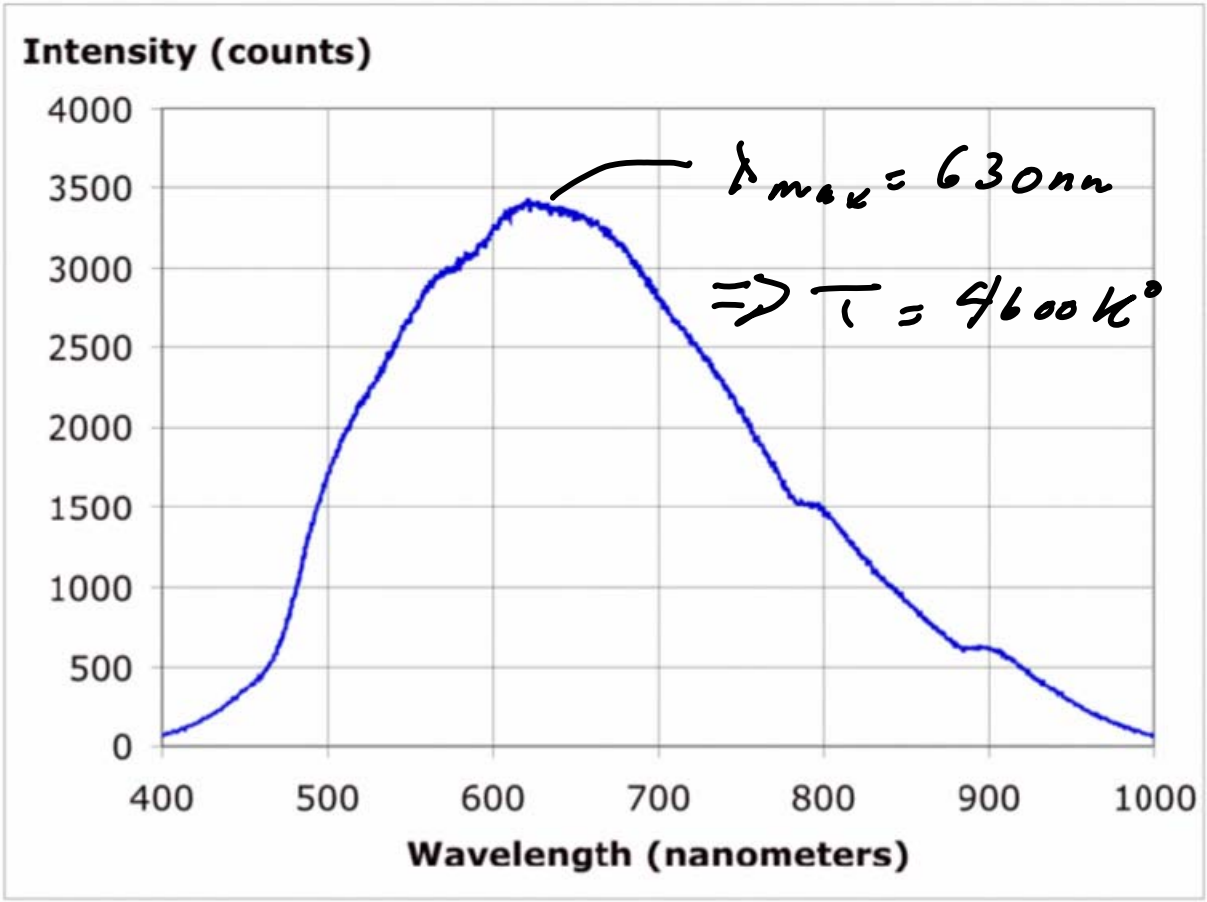
where

- $I(\nu)d\nu$ is the amount of energy per unit surface per unit time per unit solid angle emitted in the frequency range between ν and ν+dν;
- T is the temperature of the black body;
- h is Planck's constant;
- c is the speed of light; and
- k is Boltzmann's constant.

Flashlight Spectrum

Weins Law

$T \lambda_{max} = 2.898 \times 10^{6} \text{ nm K}$



Stefan - Boltzman Law

net power radiated

$$P_{net} = P_{emit} - P_{absorb}$$

$$P_{net} = A \sigma \varepsilon \left(T^4 - T_0^4 \right)$$

People

2 meters^2

1 emissivity

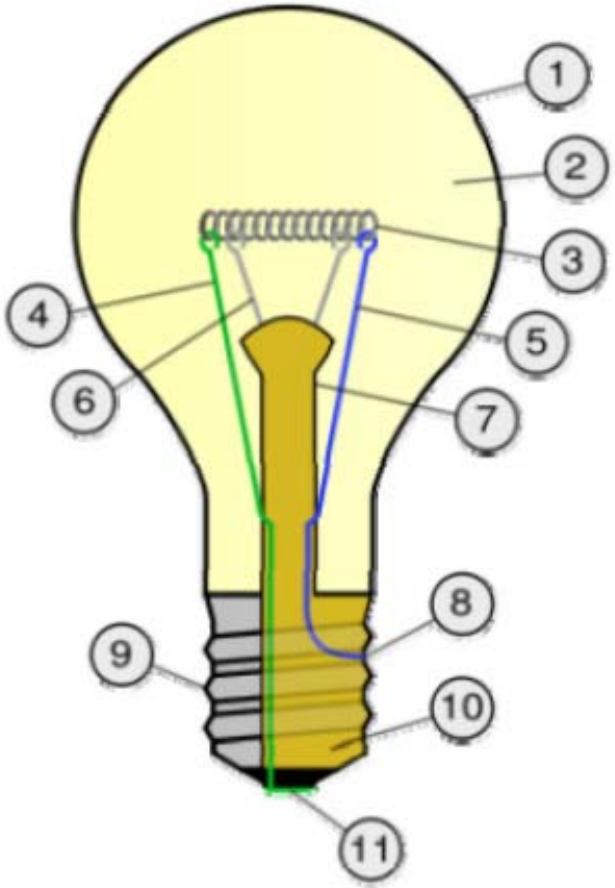
32°C Skin temp

20°C environment

$P_{net} = 95$ watts

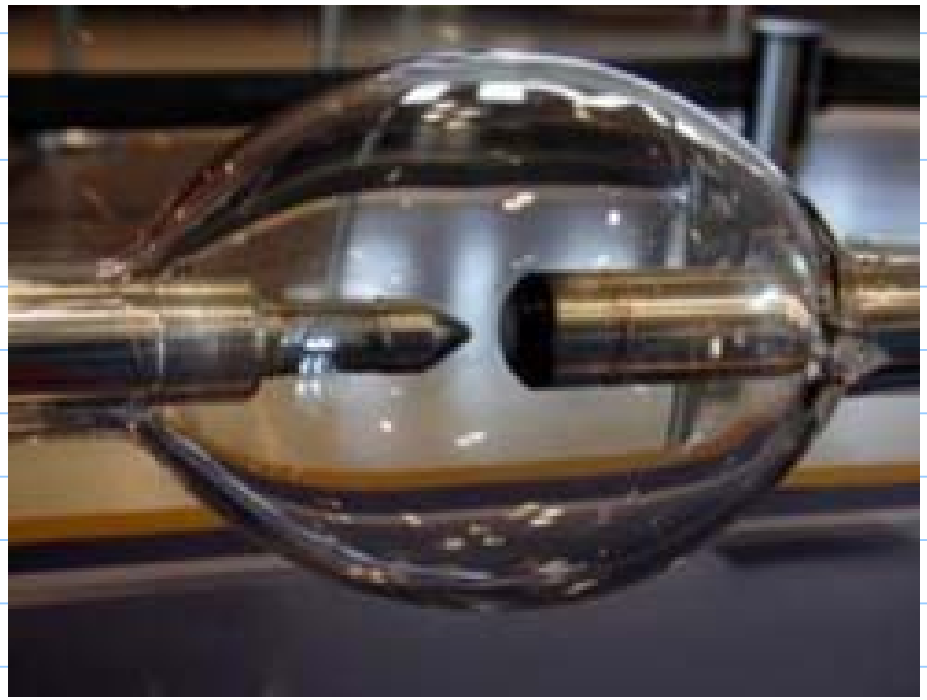
$$\lambda_{peak} = \frac{2.898 \times 10^6 \text{ k nm}}{305 \text{ K}} = 9500 \text{ nm}$$

Tungsten Light Bulb



1. Glass bulb
2. Low pressure inert gas
3. Tungsten filament
4. Contact wire (goes out of stem)
5. Contact wire (goes into stem)
6. Support wires
7. Stem (Glass mount)
8. Contact wire (goes out of stem)
9. Cap (Sleeve)
10. Insulation (Vitrit)
11. Electrical contact

High Intensity Discharge Lamp



IMAX Projector Lamp

Infrared Spectroscopy Source

Globar

Globar (neu) Globar (Skizze)

Gas Discharge Lamps

Gas	Color	Notes	Image
Helium	Whitish orange; under some conditions may be grayish, bluish, or green-bluish	Used by artists for special purpose lighting.	
Neon	Red-orange	Intensive light. Used frequently in neon signs and neon bulbs.	
Argon	Violetish pale lavender blue	Often used together with mercury vapor.	
Krypton	Grayish dim off-white. May be greenish. At high peak currents bright blue-white.	Used by artists for special purpose lighting.	
Xenon	Grayish or bluish-gray dim white, at high peak currents very bright green-bluish	Used in xenon flash lamps, xenon HID headlamps, and xenon arc lamps, and by artists for special purpose lighting.	

Gas Discharge Lamp

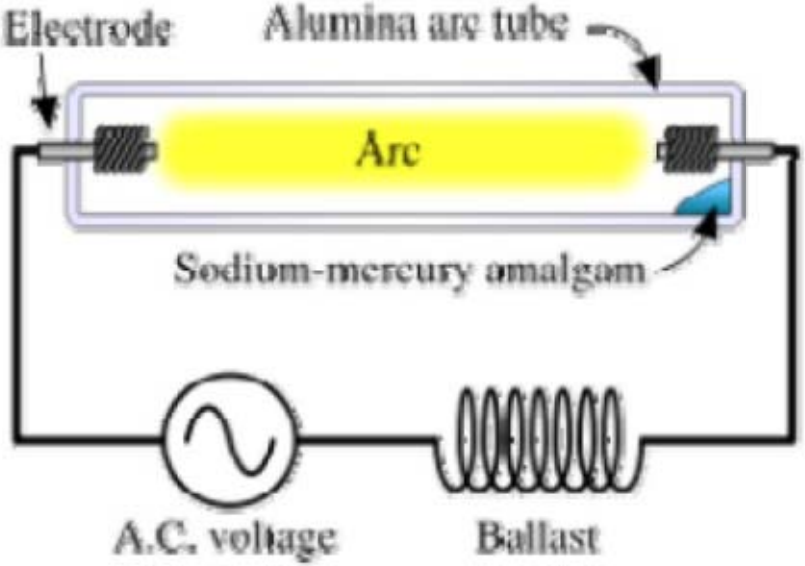
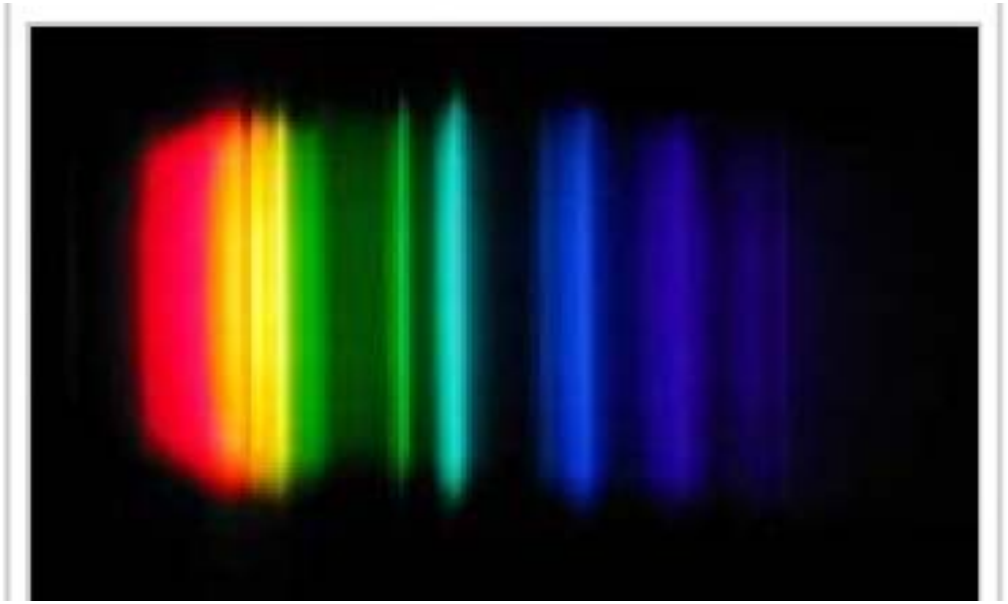


Diagram of a high pressure sodium lamp.

Sodium High Pressure Discharge Lamp



Chemoluminescence

$$[\mathbf{A}] + [\mathbf{B}] \rightarrow [\Diamond] \rightarrow [\textit{Products}] + \text{light}$$

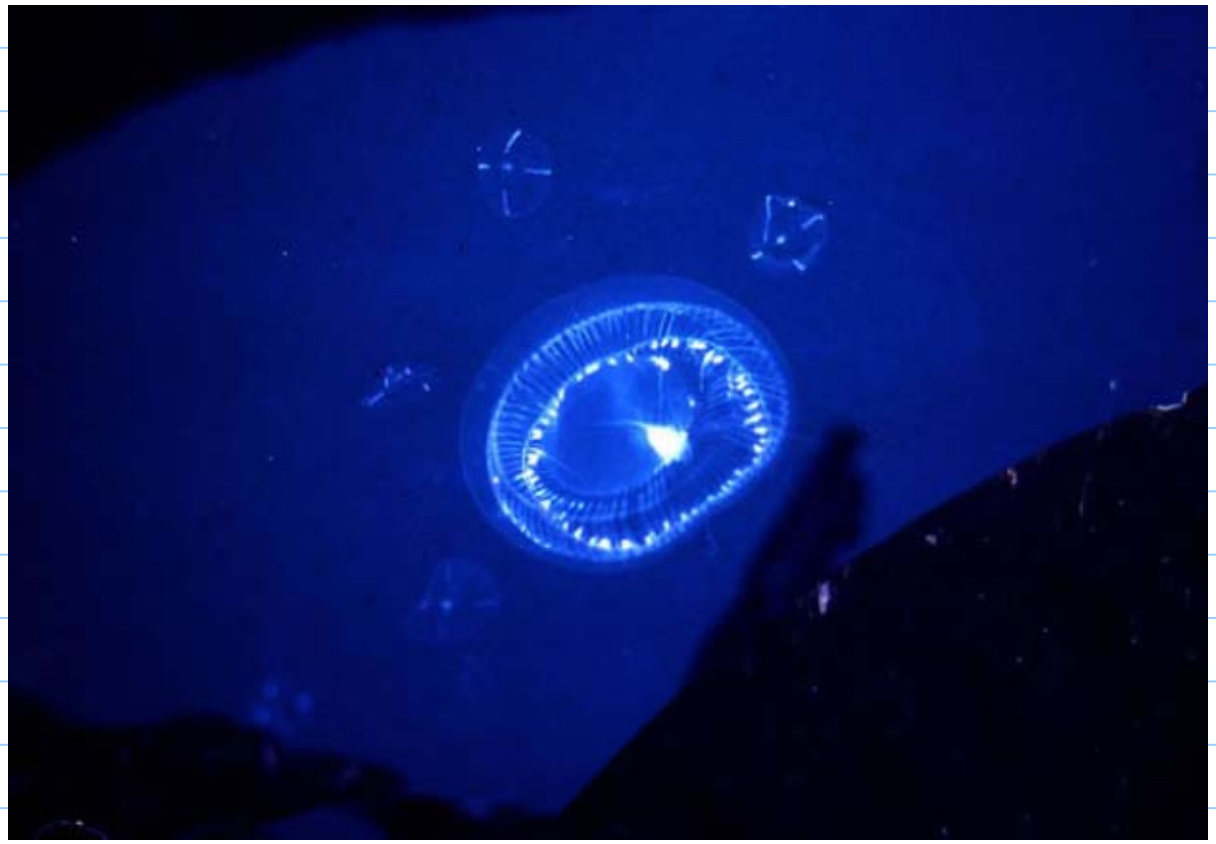
Example

$$\text{luminol} + H_2O_2 \rightarrow \text{3-APA}[\Diamond] \rightarrow \text{3-APA} + \text{light}$$

Where 3-APA is 3-aminophthalate.

A chemoluminescent reaction carried out in an erlenmeyer flask producing a large amount of light.

Aequorea Victoria



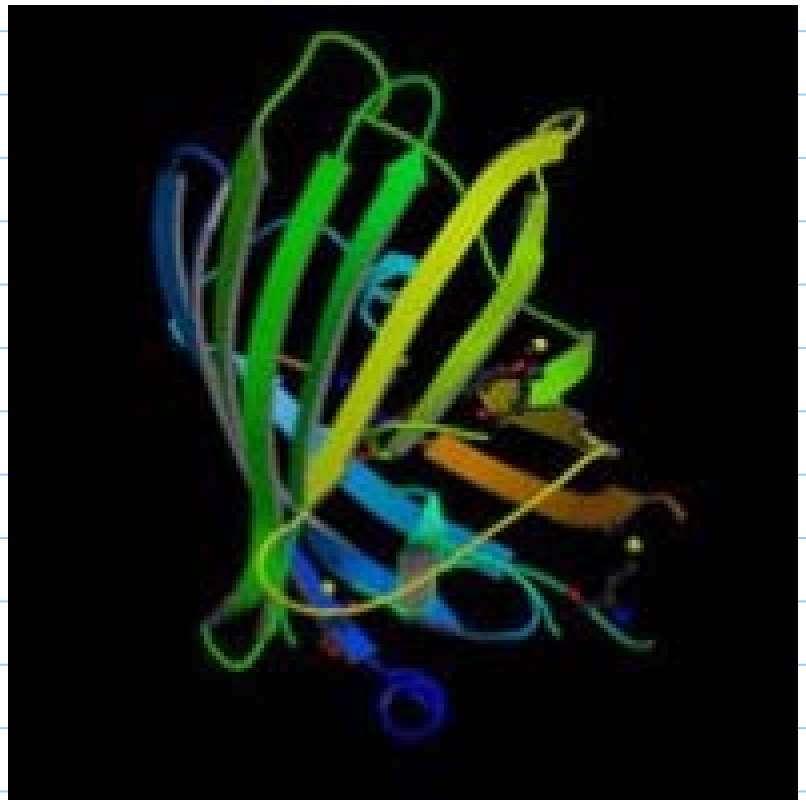
Blue light by a quick release of Ca^{2+}

Green Fluorescent Protein (GFP)

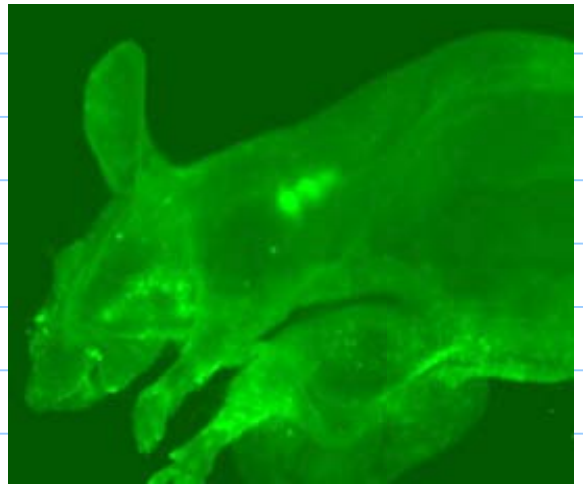
238 amino acids from jellyfish Aequorea Victoria

Used as reporter of gene expression

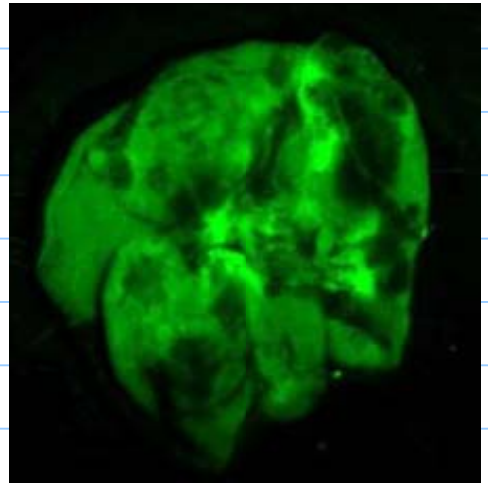
GFP can be introduced through breeding or local injection



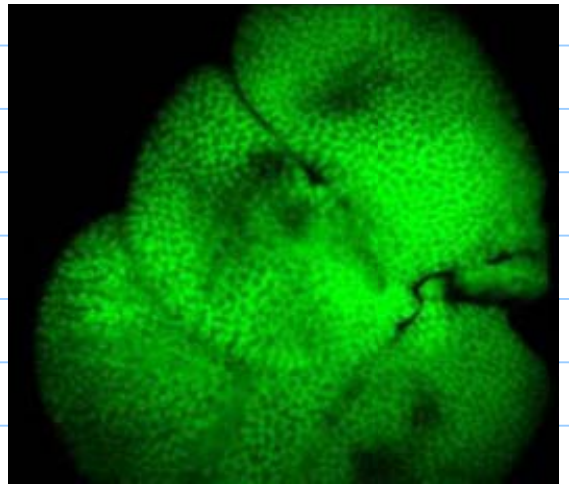
GFP Bioimaging



live mouse



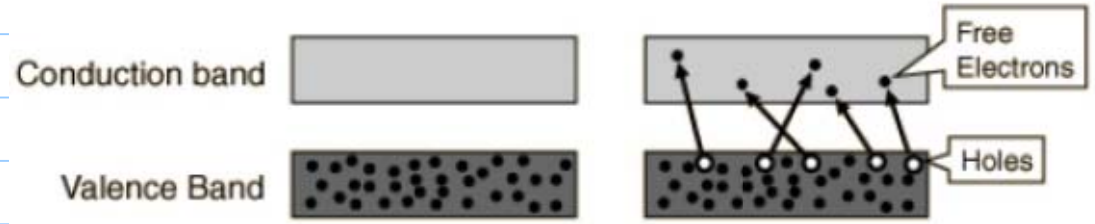
mouse lung



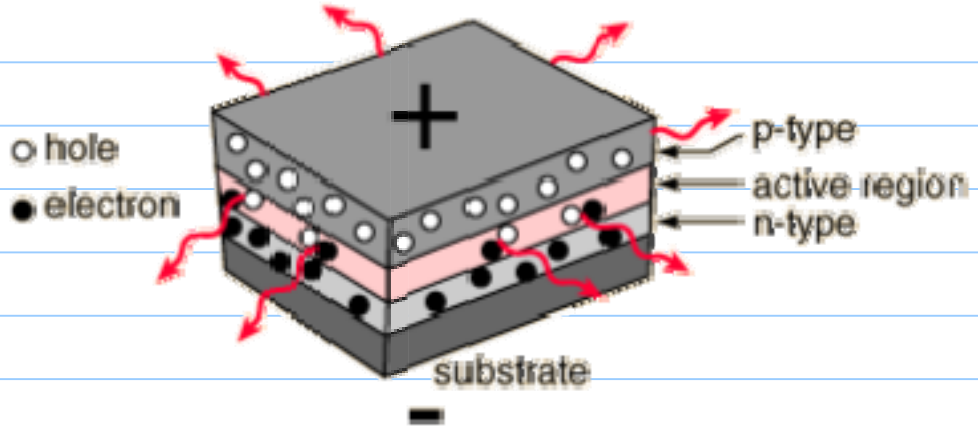
mouse liver

Fluorescence in various sized CdSe quantum dots

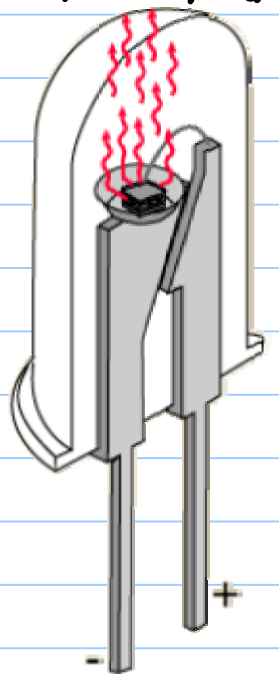
Light Emitting Diodes



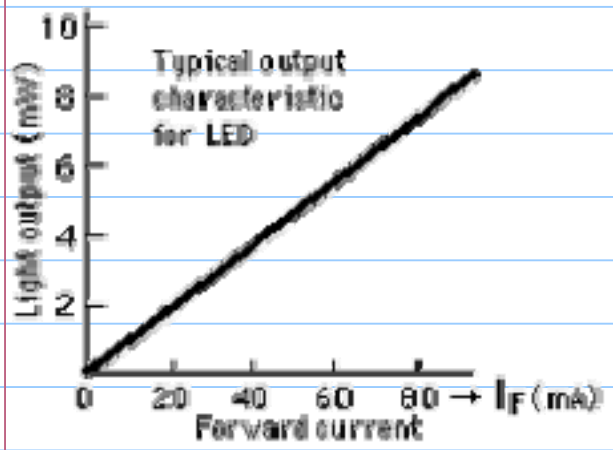
device structure

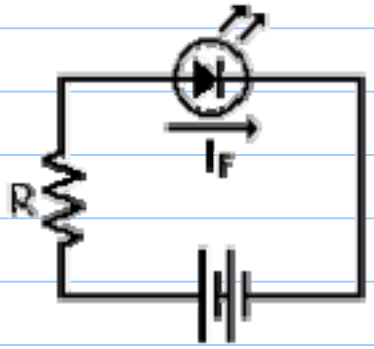


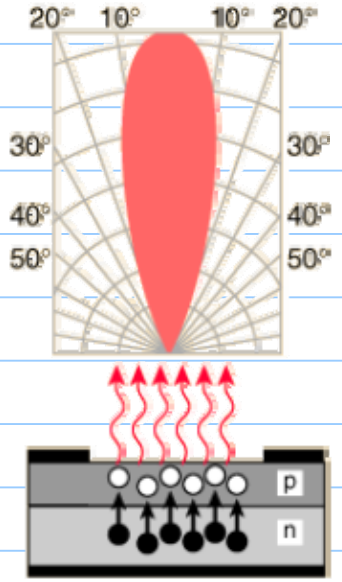
Actual Device



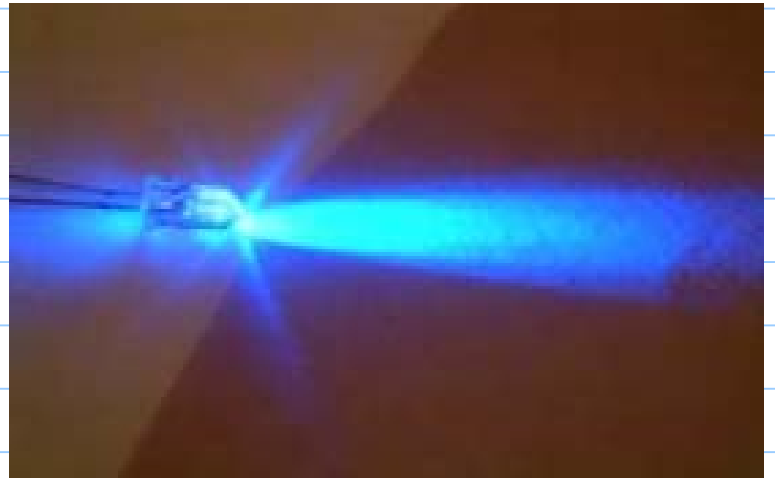
LED Characteristics



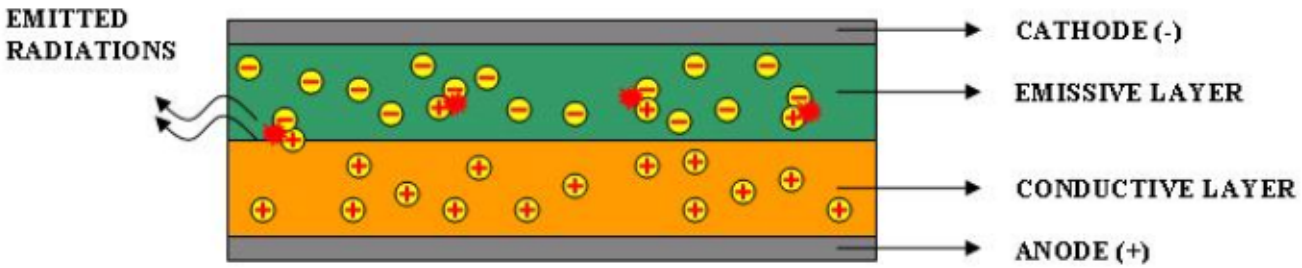




LED's cover spectral range from infrared to ultraviolet



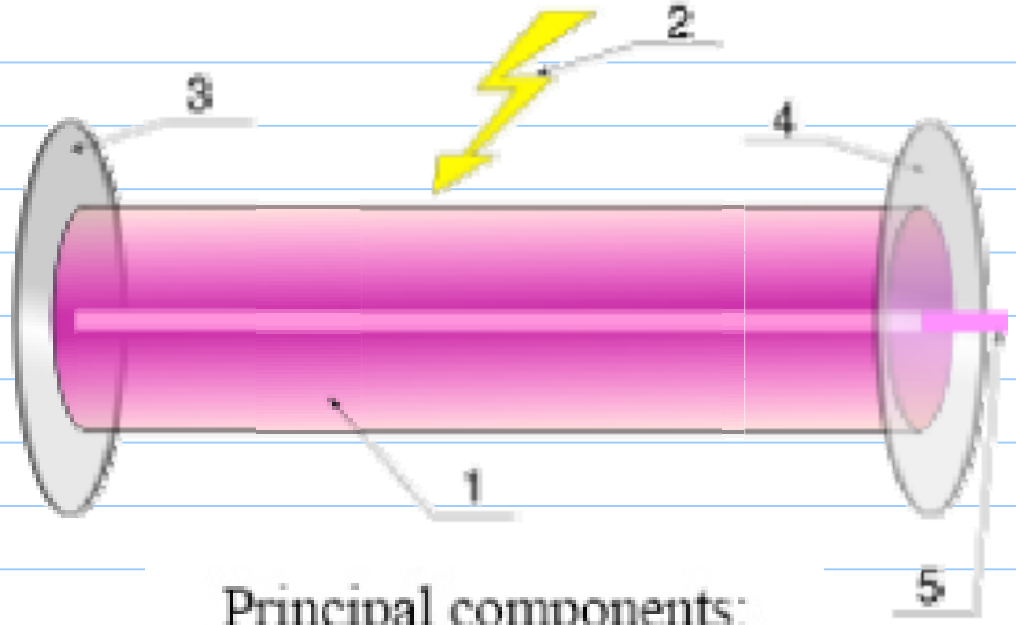
Organic LED's



OLED STRUCTURE

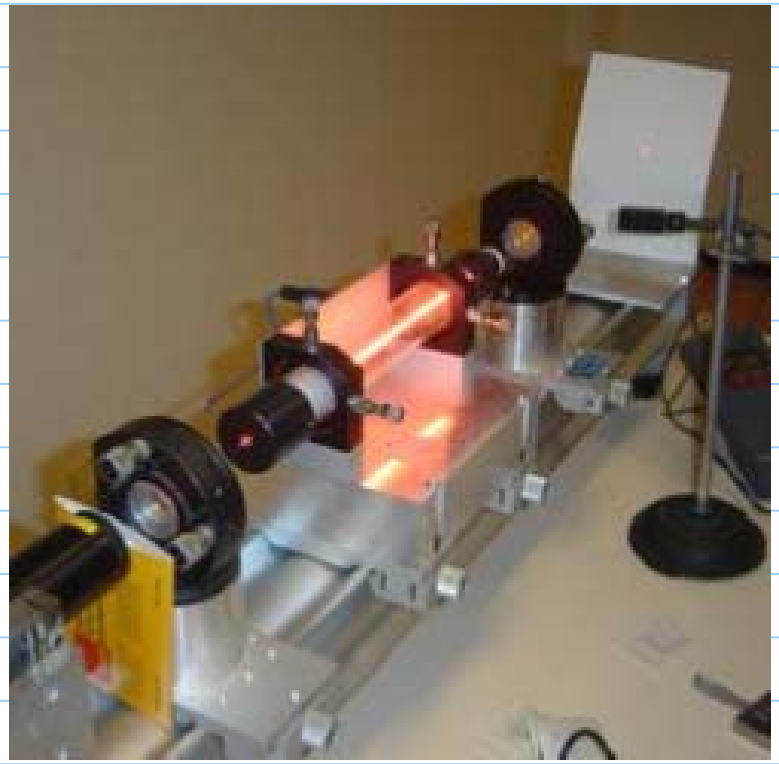
Organometalic chelates

Laser Principle

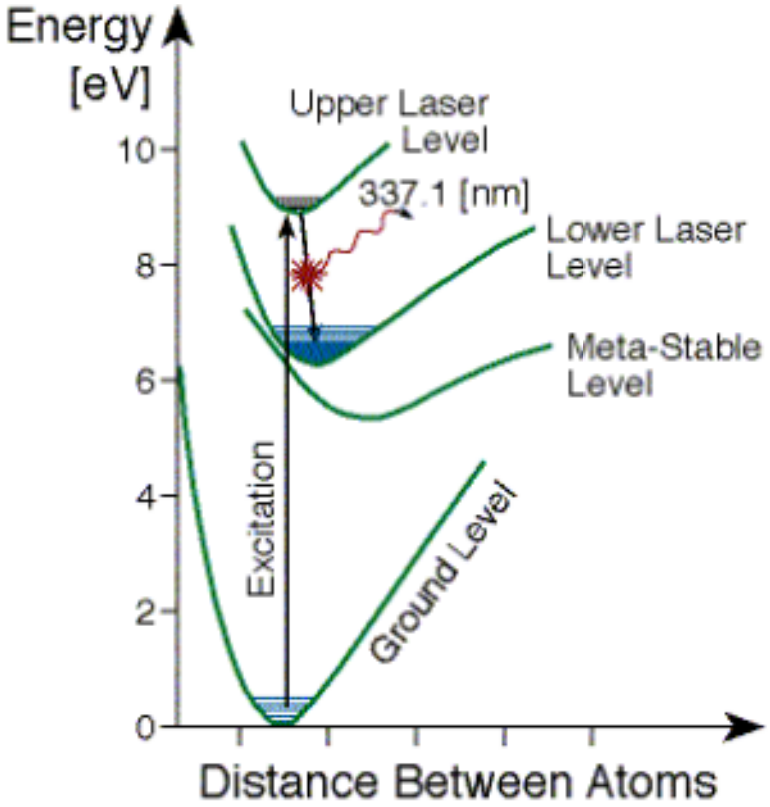


Principal components:
1. Active laser medium
2. Laser pumping energy
3. High reflector
4. Output coupler
5. Laser beam

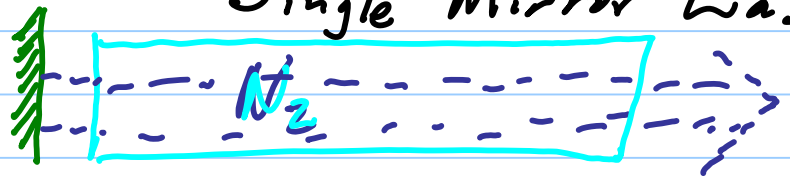
Demonstration Laser



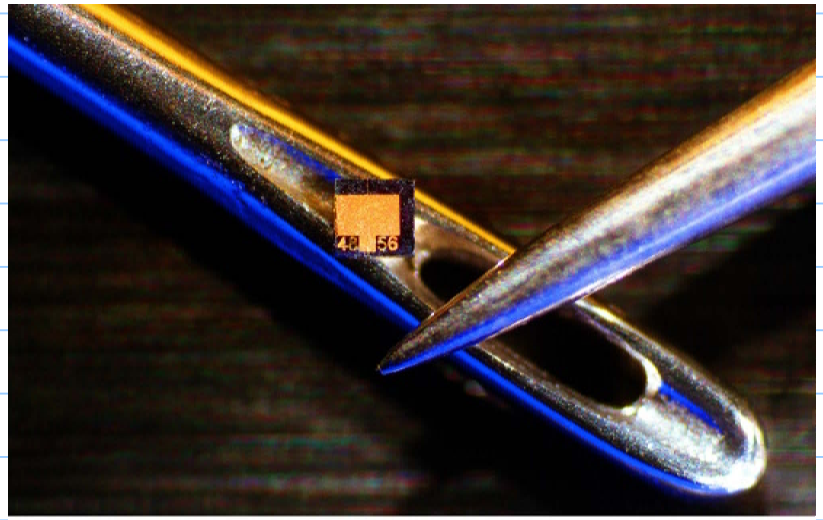
Nitrogen N_2 Laser



Single Mirror Laser

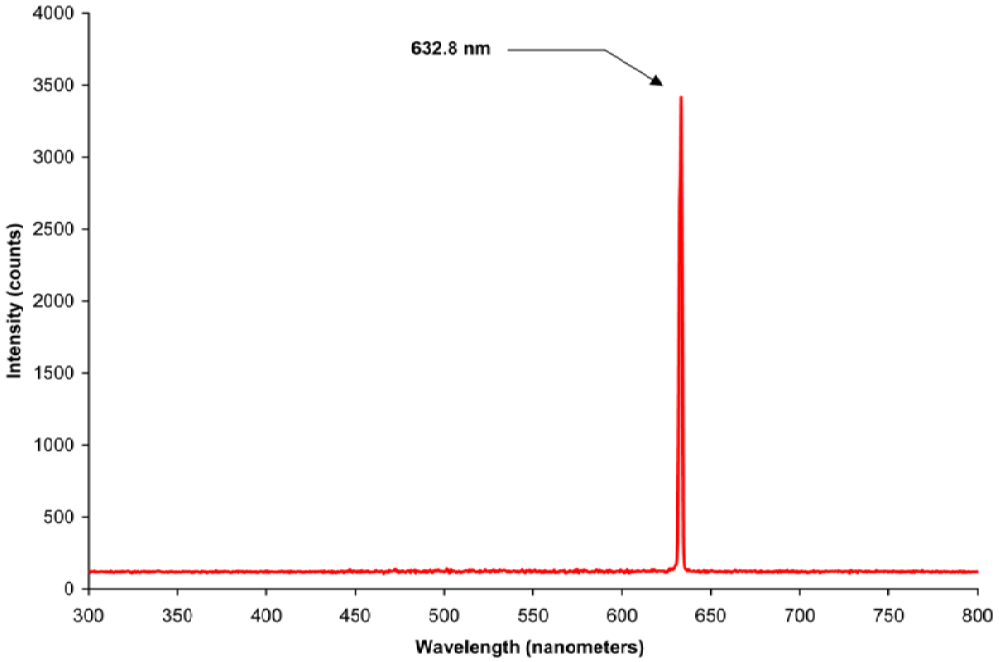


Laser Sizes

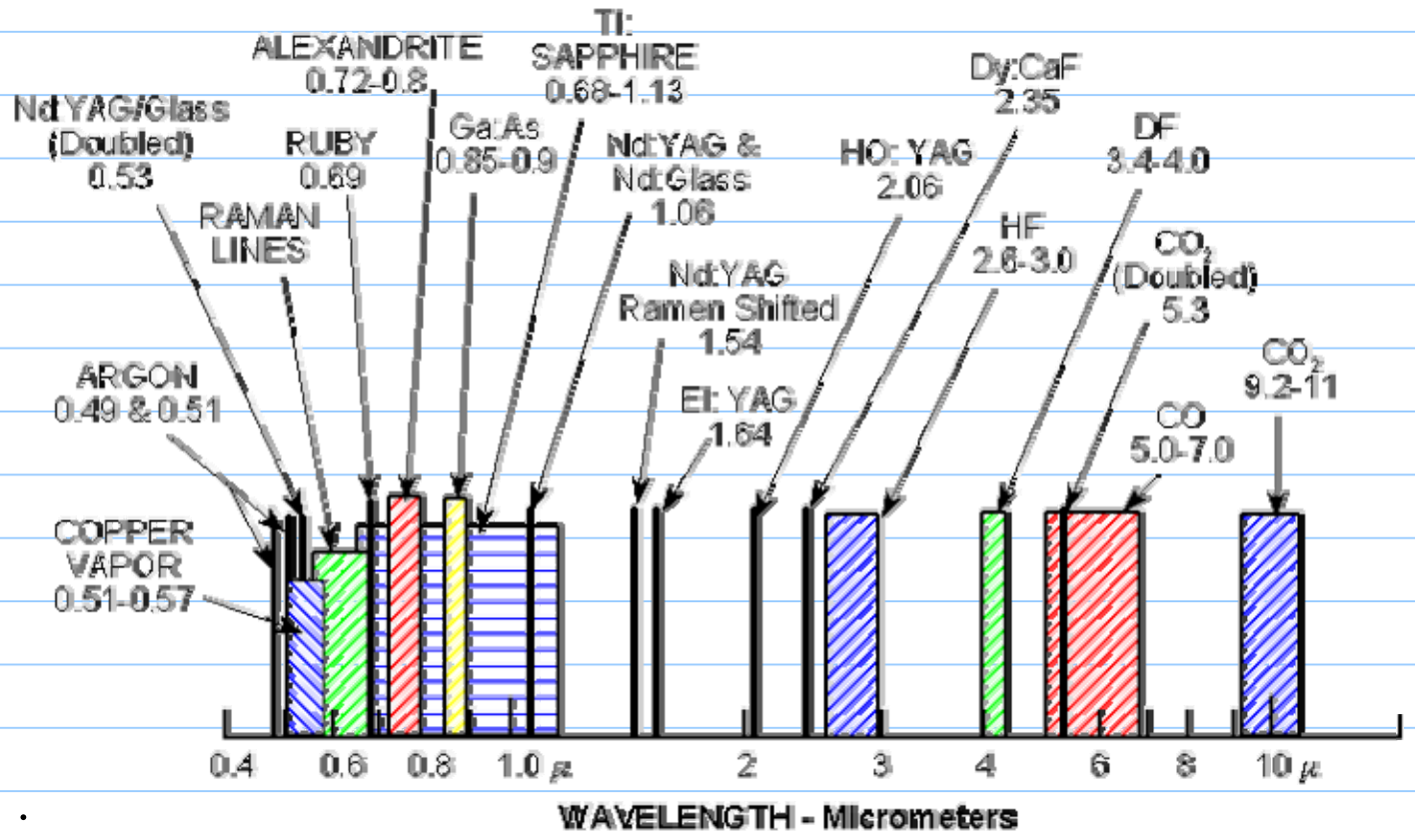


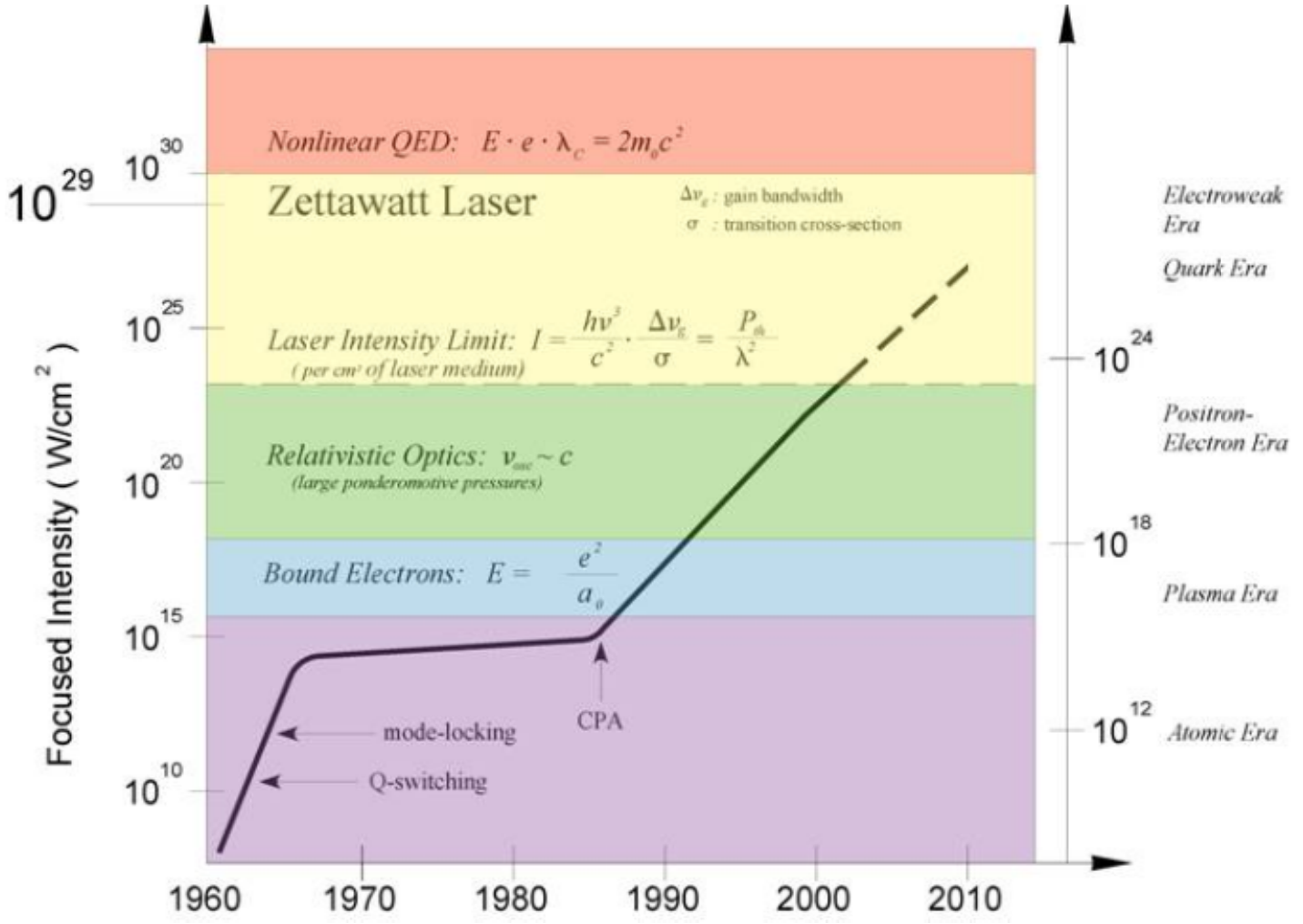
Guidestar

HeNe Laser



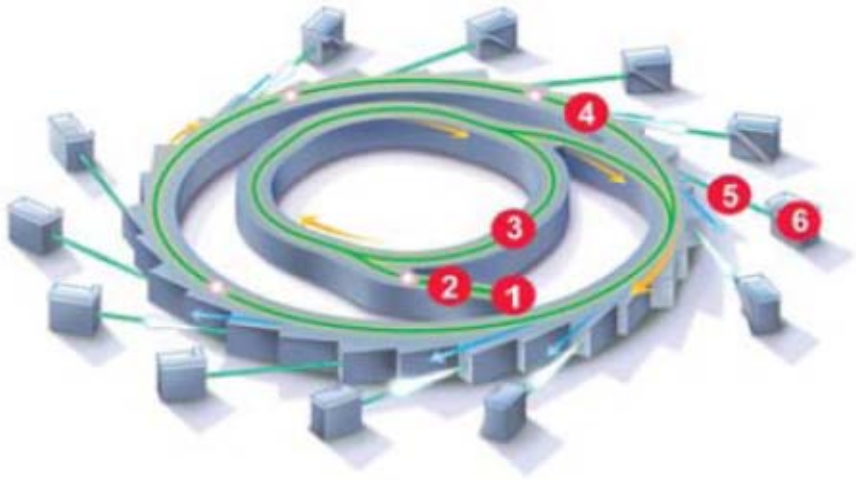
Laser Spectral Coverage




Nonlinear QED: $E \cdot e \cdot \lambda_C = 2m_e c^2$
Zettawatt Laser
$\Delta\nu_g$: gain bandwidth
σ : transition cross-section
Laser Intensity Limit: $I = \frac{h\nu^3}{c^2} \cdot \frac{\Delta\nu_g}{\sigma} = \frac{P_{th}}{\lambda^2}$
(per cm² of laser medium)
Relativistic Optics: $v_{osc} \sim c$
(large ponderomotive pressures)
Bound Electrons: $E = \frac{e^2}{a_0}$
mode-locking
Q-switching
CPA
Focused Intensity (W/cm²)
10^{29}
10^{30}
10^{25}
10^{20}
10^{15}
10^{10}
1960
1970
1980
1990
2000
2010
10^{24}
10^{18}
10^{12}
Electroweak Era
Quark Era
Positron-Electron Era
Plasma Era
Atomic Era

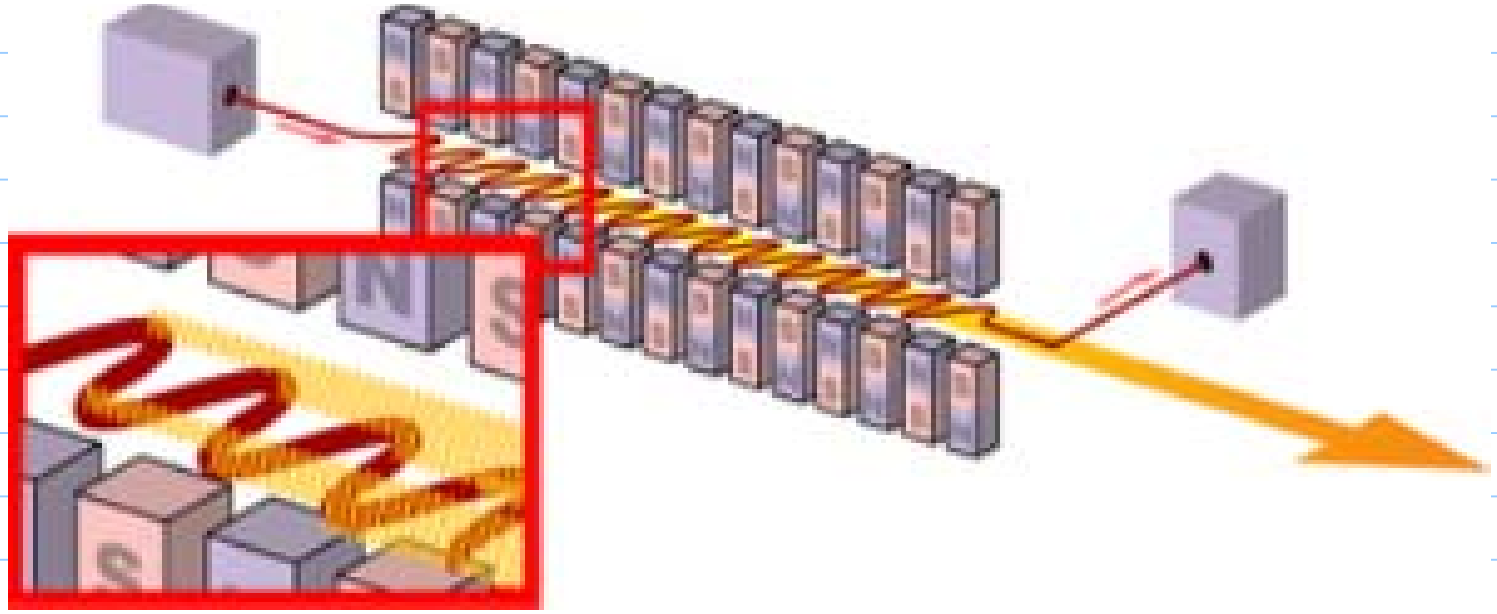
Synchrotron Picture

How is Synchrotron Light Created?

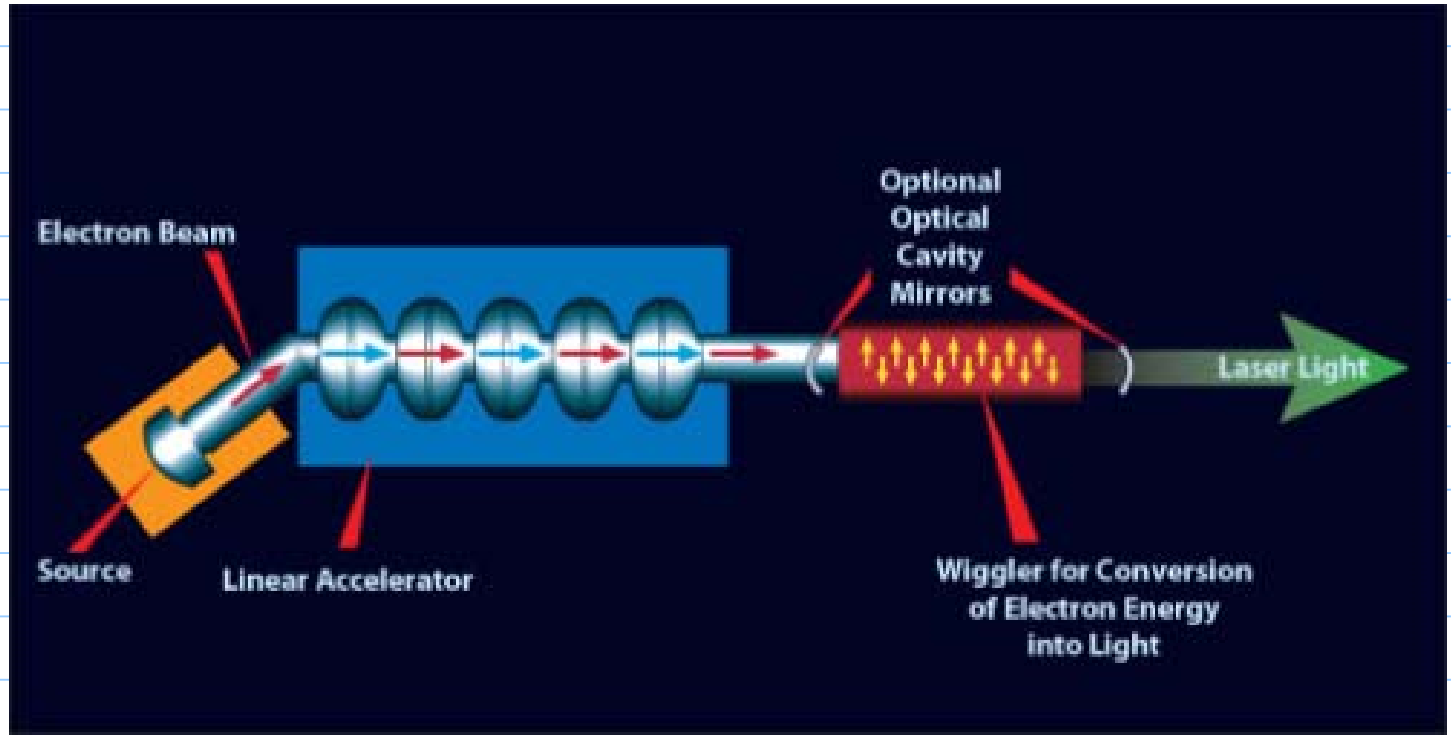


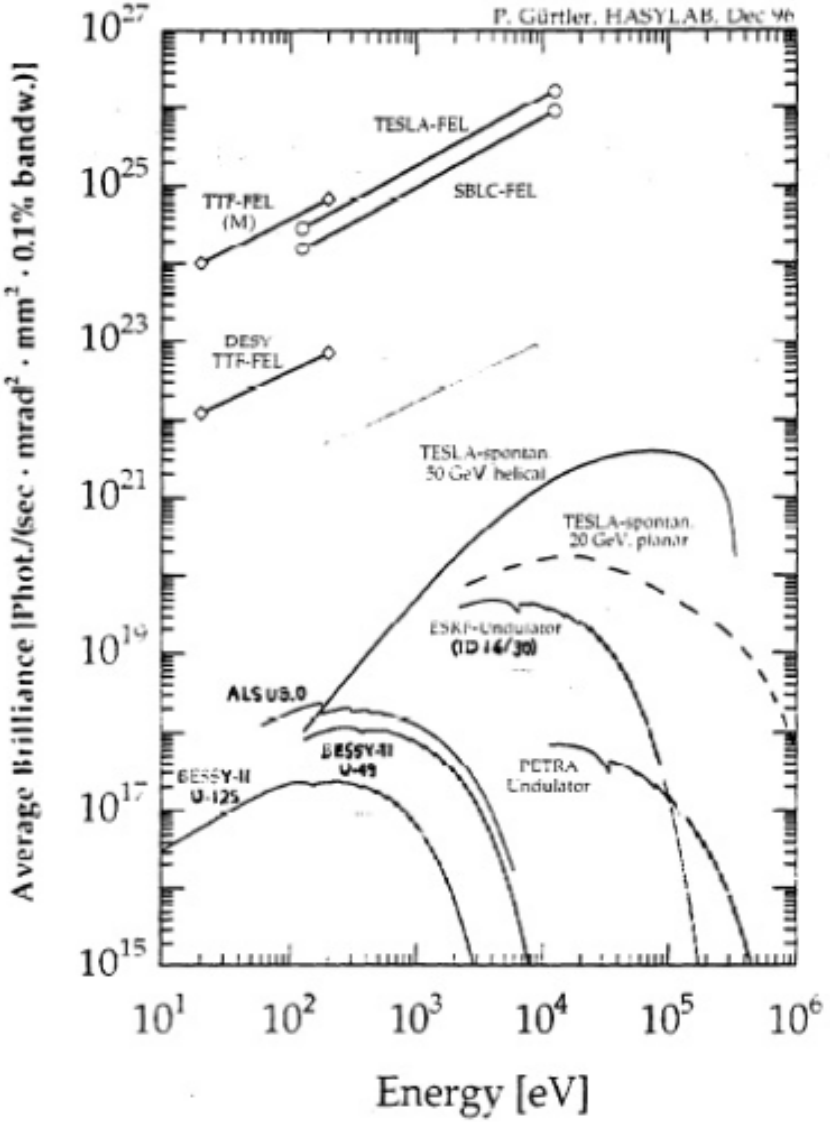
1. electron gun
2. linac
3. booster ring
4. storage ring
5. beamline
6. end station

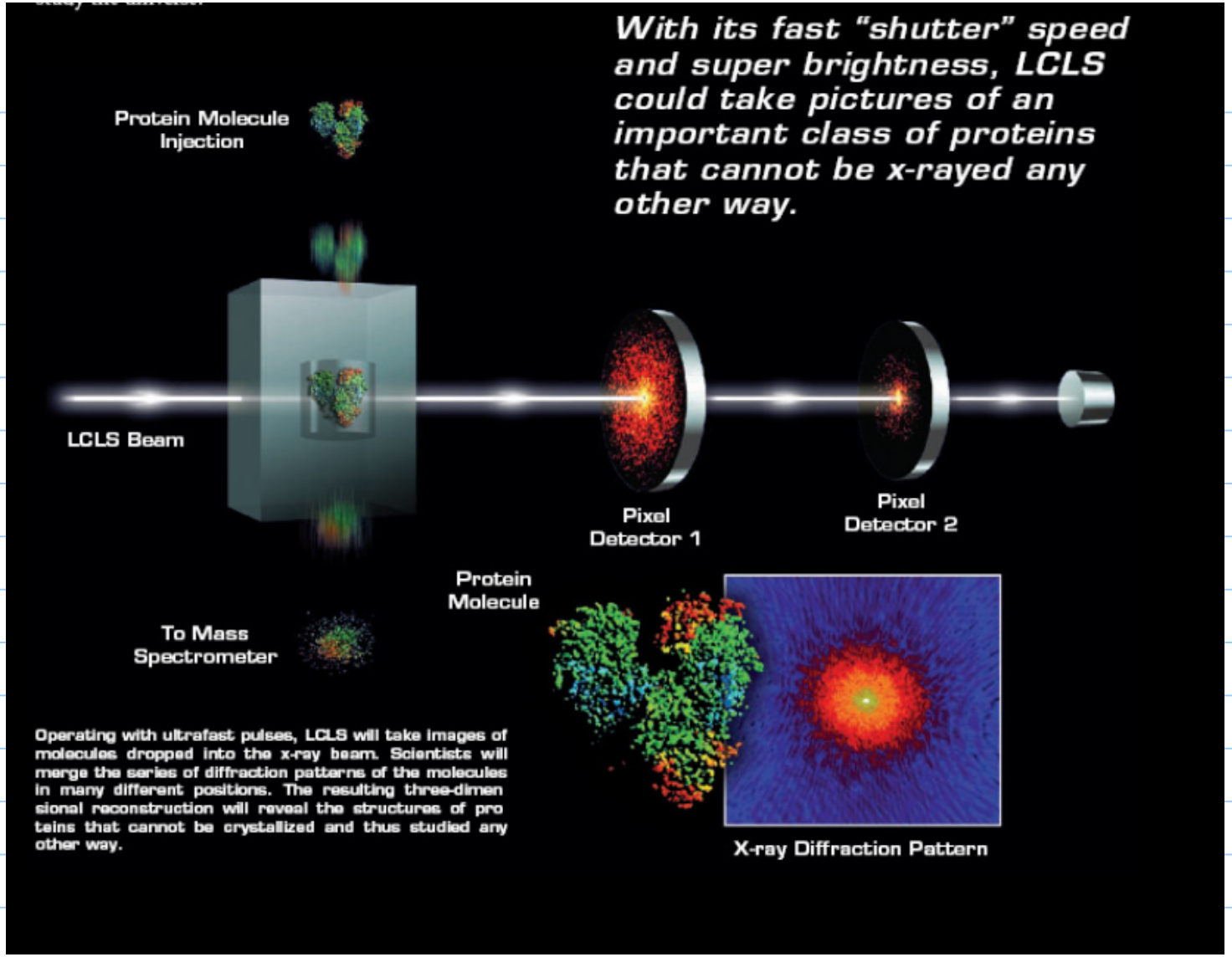
Free Electron Laser



Free Electron Laser




P. Gürtler, HASYLAB, Dec 96
Average Brilliance [Phot./(sec · mrad² · mm² · 0.1% bandw.)]
Energy [eV]
TESLA-FEL
SBLC-FEL
TTF-FEL (M)
DESY TTF-FEL
TESLA-spontan. 50 GeV helical
TESLA-spontan. 20 GeV, planar
ESRF-Undulator (ID 16/30)
ALS U5.0
BESSY-II U-49
BESSY-II U-125
PETRA Undulator


With its fast "shutter" speed and super brightness, LCLS could take pictures of an important class of proteins that cannot be x-rayed any other way.
Protein Molecule Injection
LCLS Beam
Pixel Detector 1
Pixel Detector 2
Protein Molecule
To Mass Spectrometer
X-ray Diffraction Pattern
Operating with ultrafast pulses, LCLS will take images of molecules dropped into the x-ray beam. Scientists will merge the series of diffraction patterns of the molecules in many different positions. The resulting three-dimen sional reconstruction will reveal the structures of pro teins that cannot be crystallized and thus studied any other way.