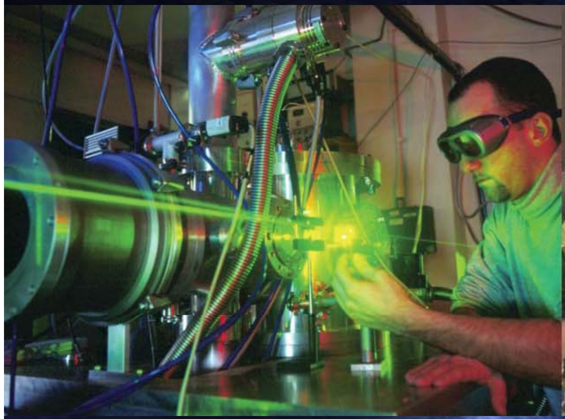
LASER SAFETY for STUDENTS



by

LASER-PROFESSIONALS Inc.

Where the laser user comes first

Johnny Jones and Pat Harris

COURSE CONTENTS

- Basics of Lasers and Laser Light
- Laser Beam Injuries
- Laser Hazard Classes
- Laser Safety Standards
- Laser Hazard Evaluation
- Laser Control Measures

BASICS OF LASERS AND LASER LIGHT

L ight

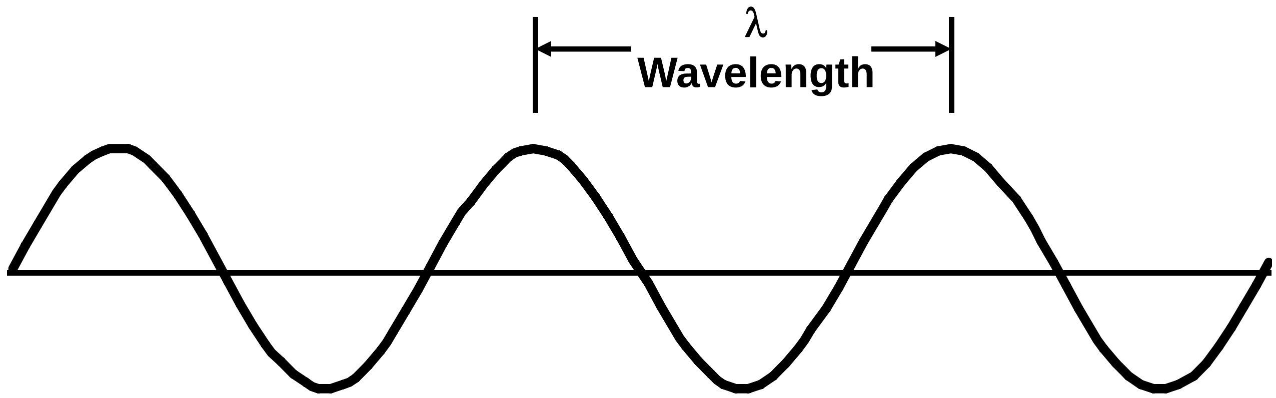
A mplification by

S timulated

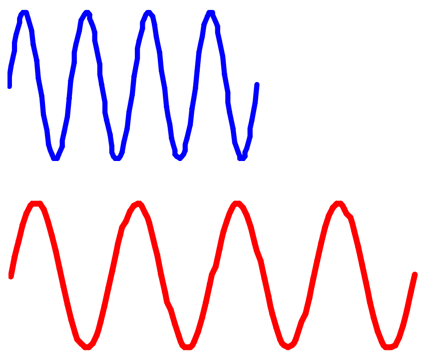
E mission of

R adiation

WAVE NATURE OF LIGHT



Blue: λ = 400 nm

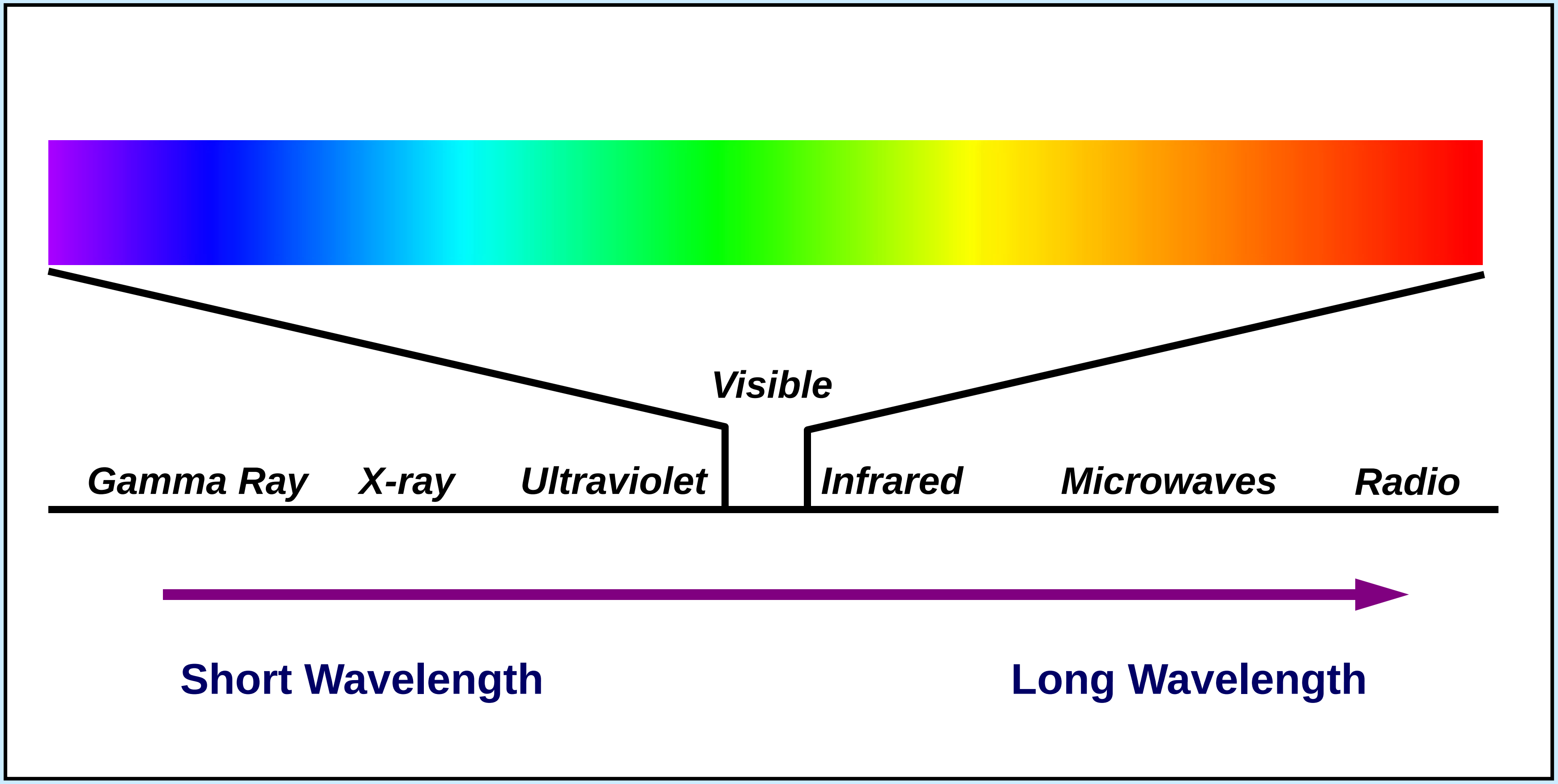


Red: λ = 700 nm

Light is an electromagnetic wave.

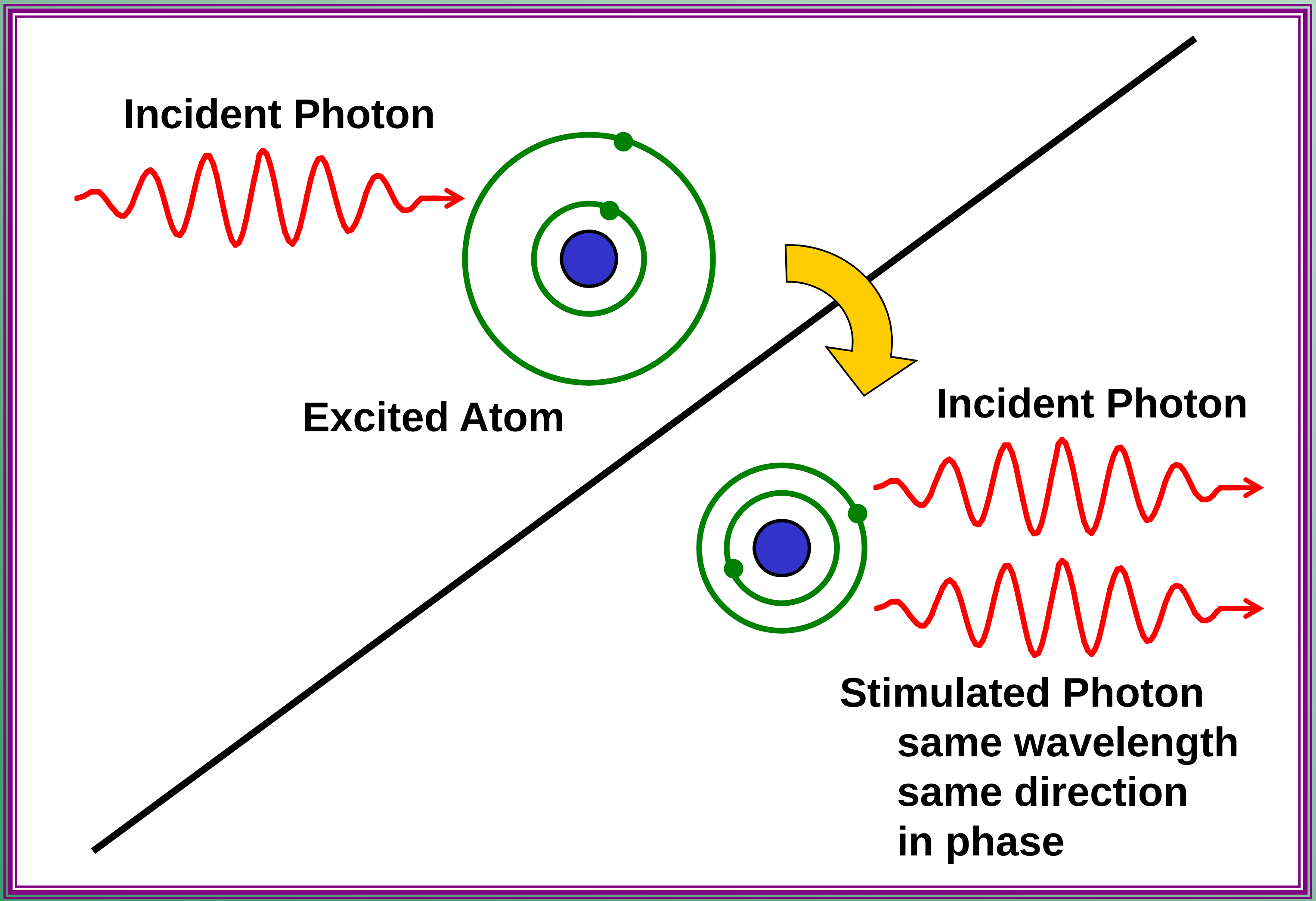
Different wavelengths in the visible spectrum are seen by the eye as different colors.

ELECTROMAGNETIC SPECTRUM



Lasers operate in the ultraviolet, visible, and infrared.

STIMULATED EMISSION

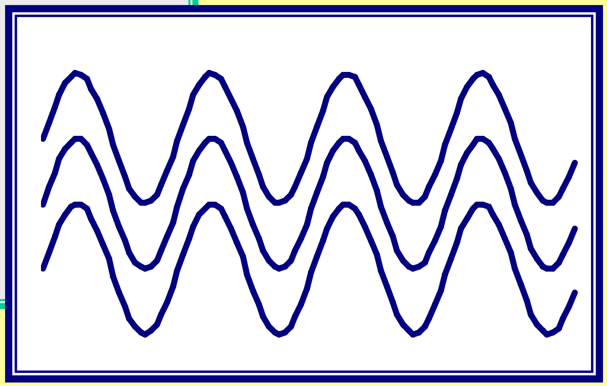


CHARACTERISTICS OF LASER LIGHT

MONOCHROMATIC

DIRECTIONAL

COHERENT



The combination of these three properties makes laser light focus 100 times better than ordinary light

LASER COMPONENTS

ACTIVE MEDIUM

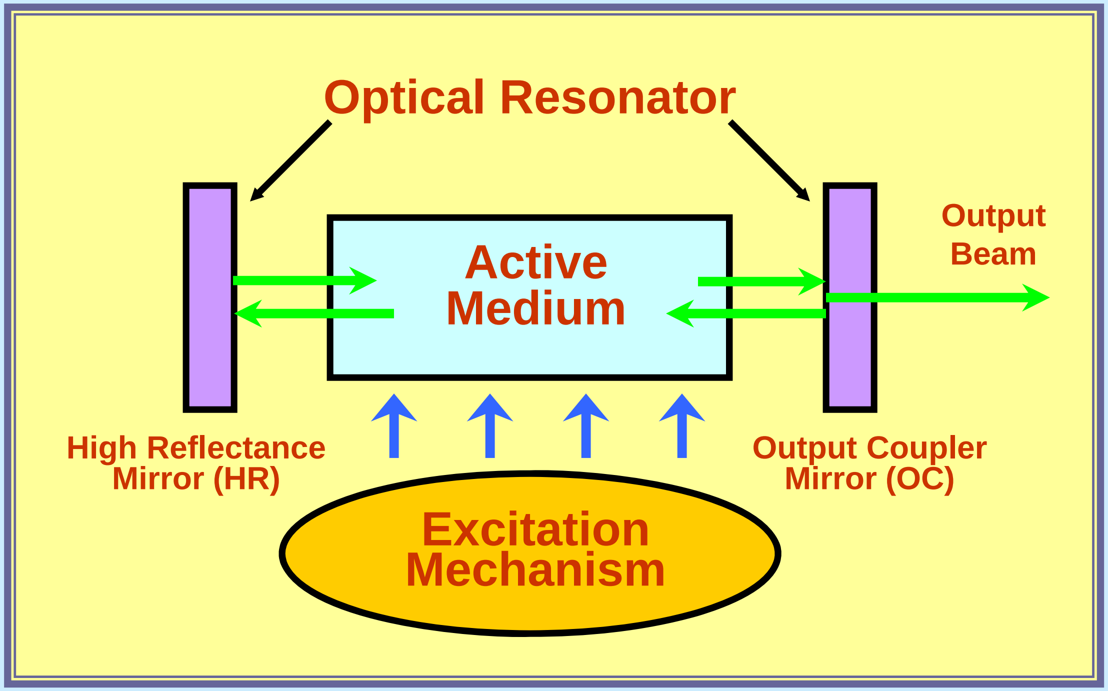
Solid (Crystal)
Gas
Semiconductor (Diode)
Liquid (Dye)

EXCITATION MECHANISM

Optical
Electrical
Chemical

OPTICAL RESONATOR

HR Mirror and
Output Coupler



The Active Medium contains atoms which can emit light by stimulated emission.

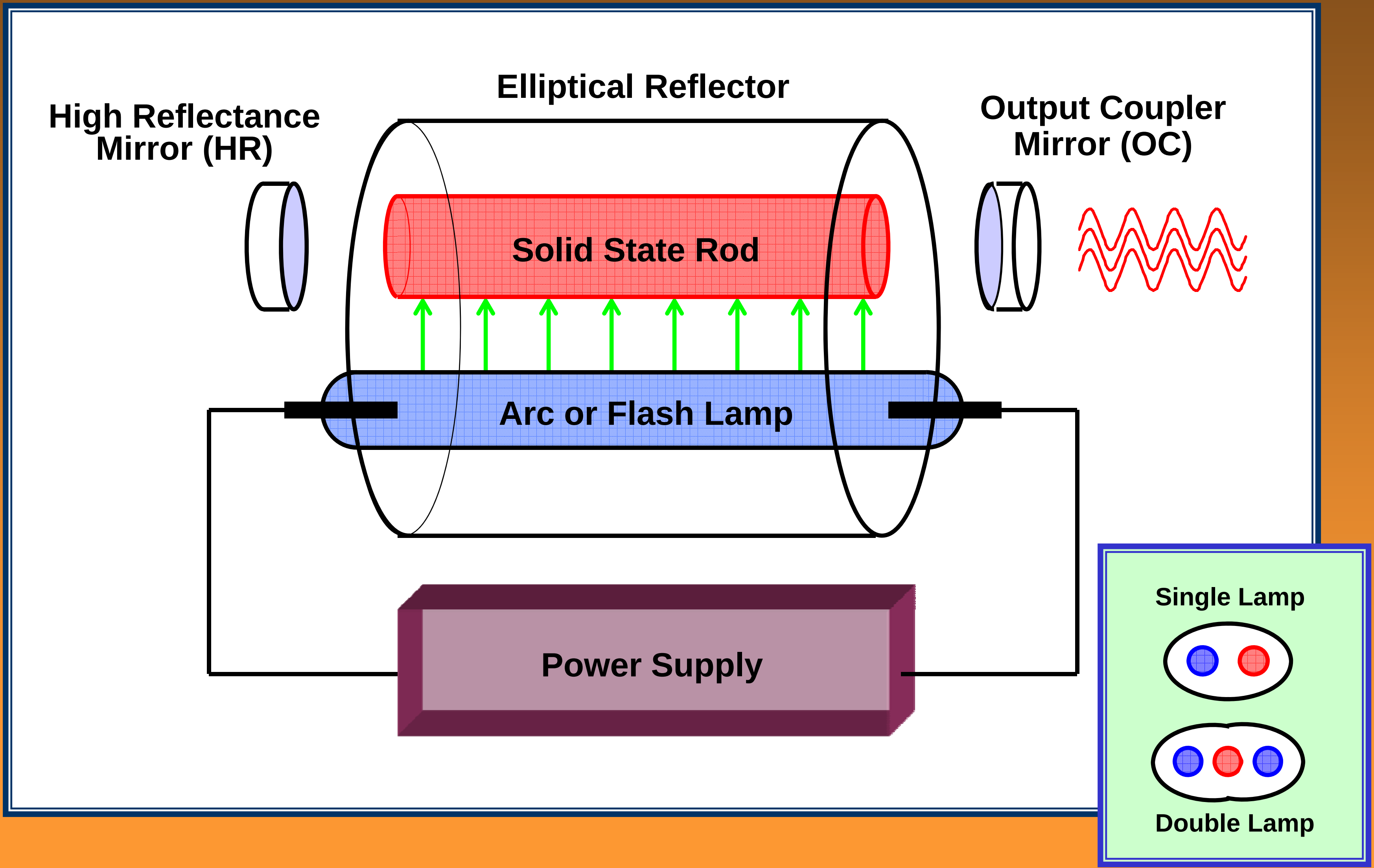
The Excitation Mechanism is a source of energy to excite the atoms to the proper energy state.

The Optical Resonator reflects the laser beam through the active medium for amplification.

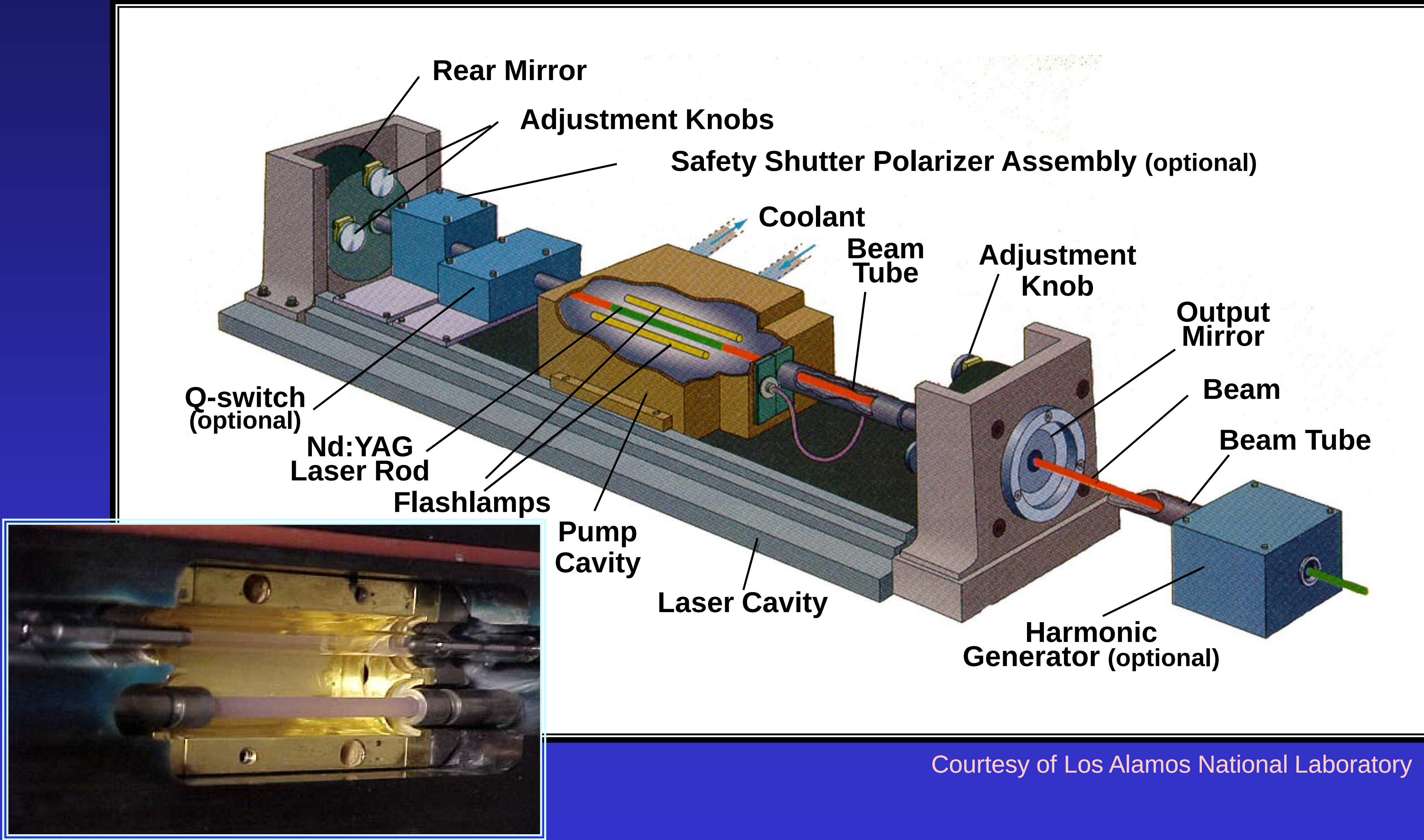
HELIUM-NEON GAS LASER

Courtesy of Metrologic, Inc.

SOLID STATE LASER

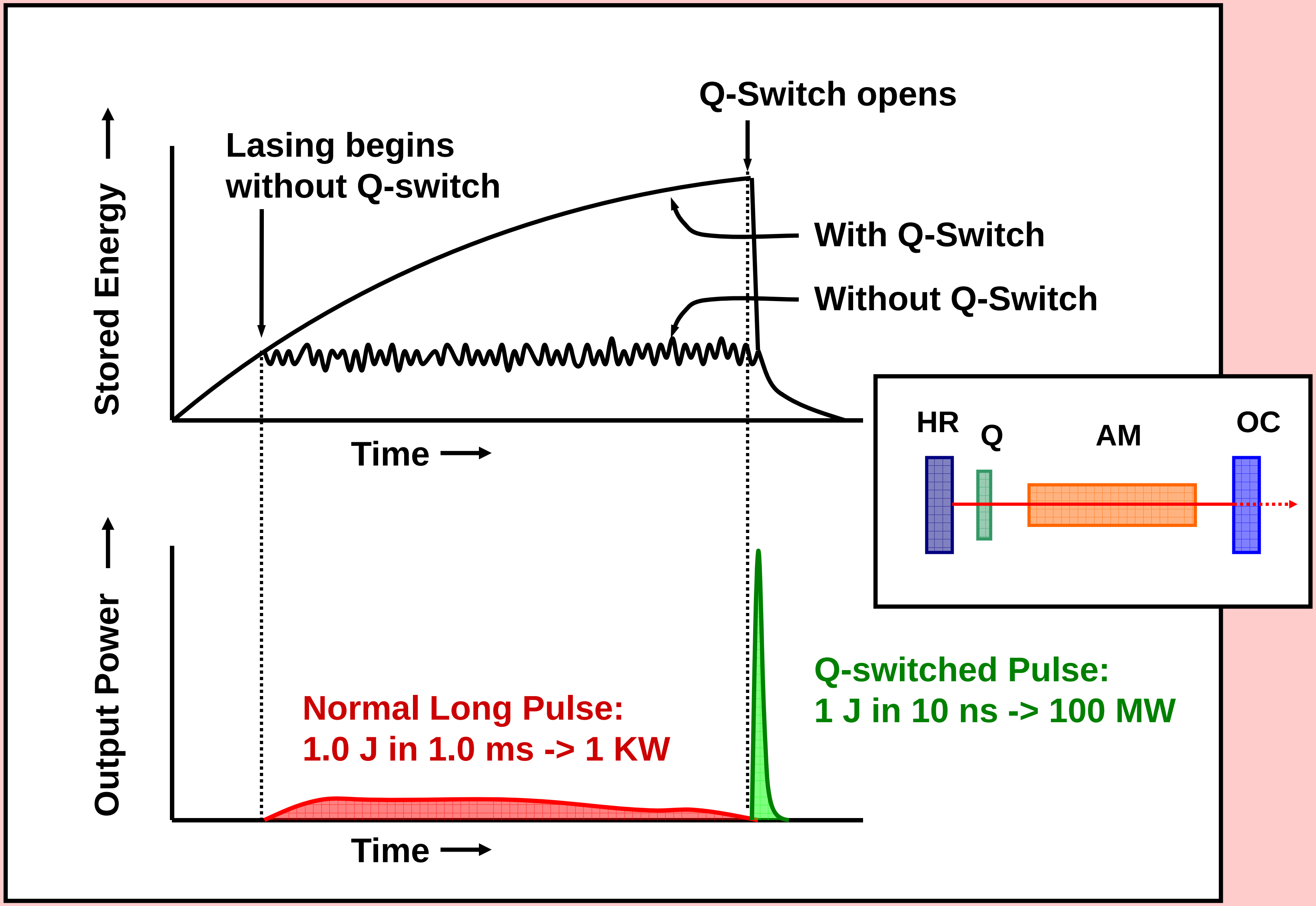


NEODYMIUM YAG LASER

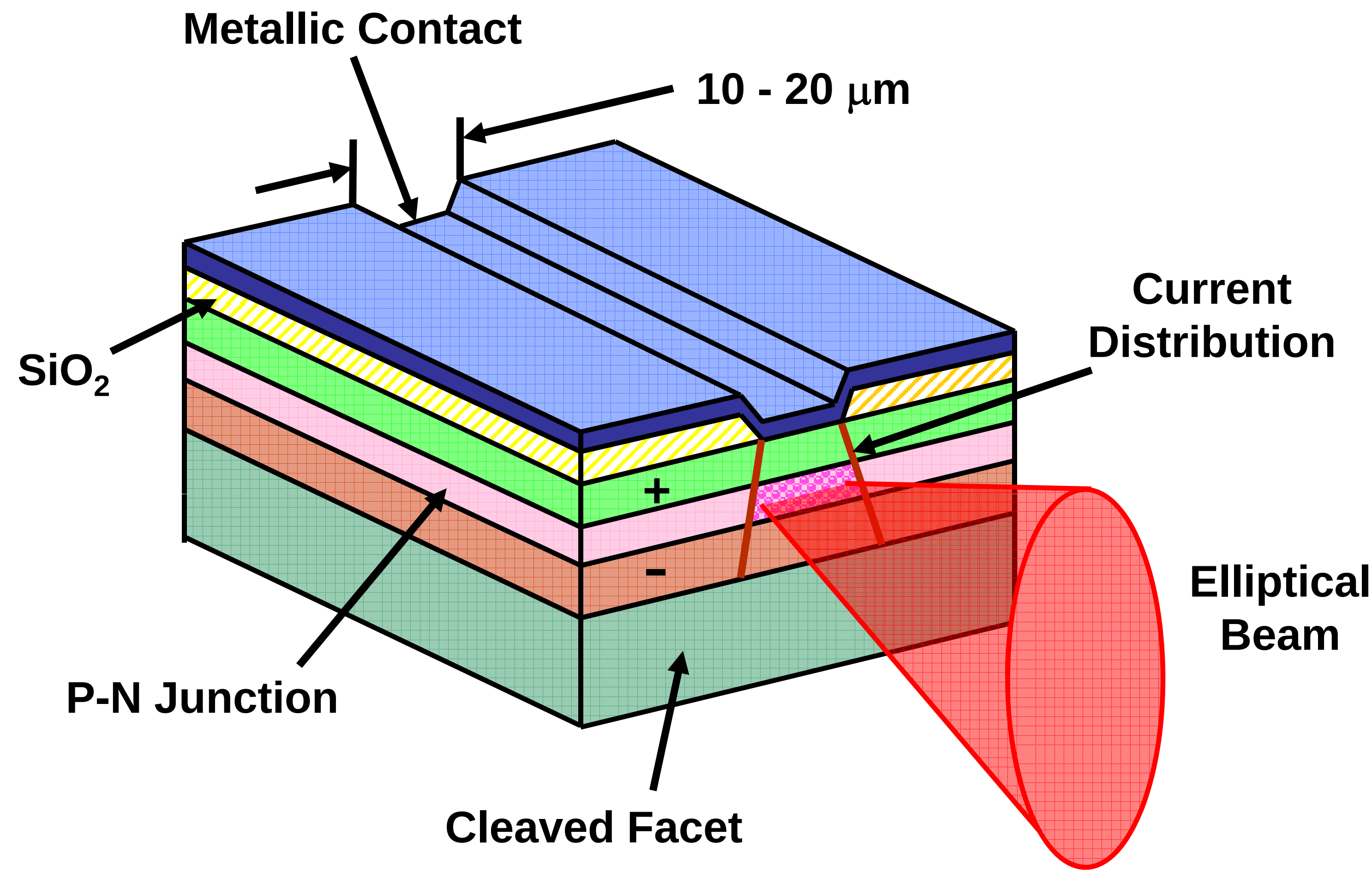


Courtesy of Los Alamos National Laboratory

FUNDAMENTALS OF Q-SWITCHING

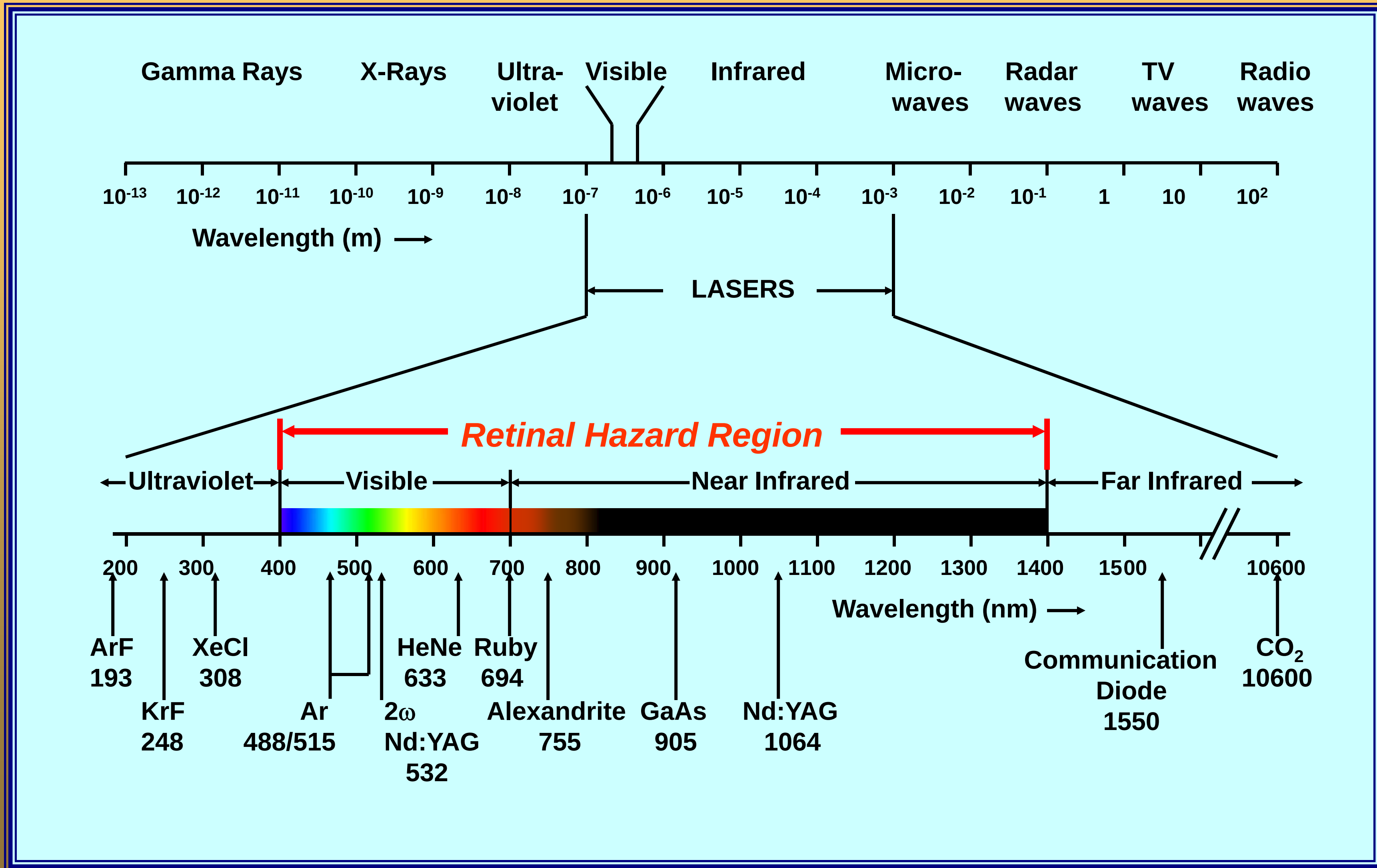


DIODE LASER

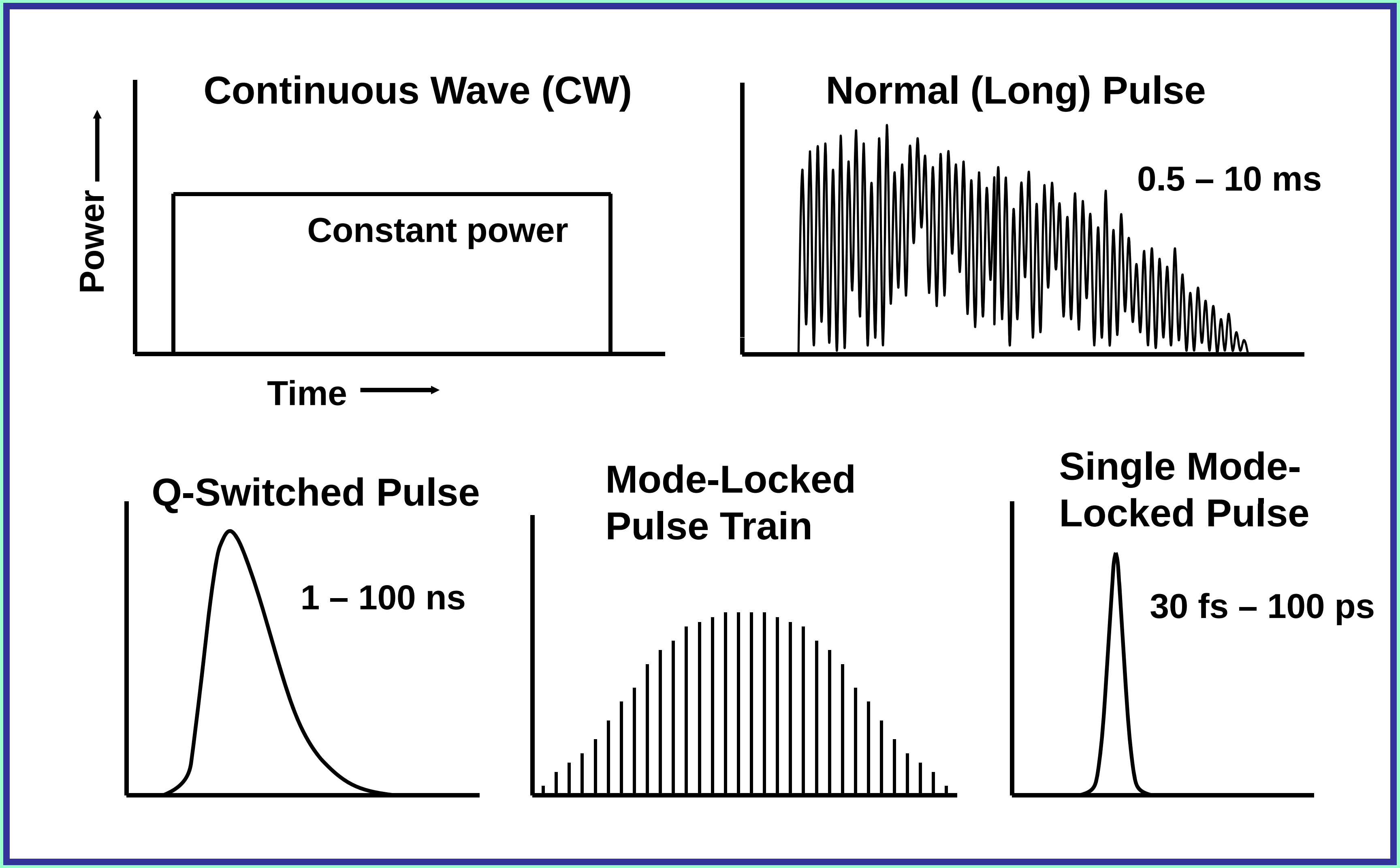


Metallic Contact
10 - 20 μm
Current
Distribution
SiO2
+
-
Elliptical
Beam
P-N Junction
Cleaved Facet

LASER SPECTRUM

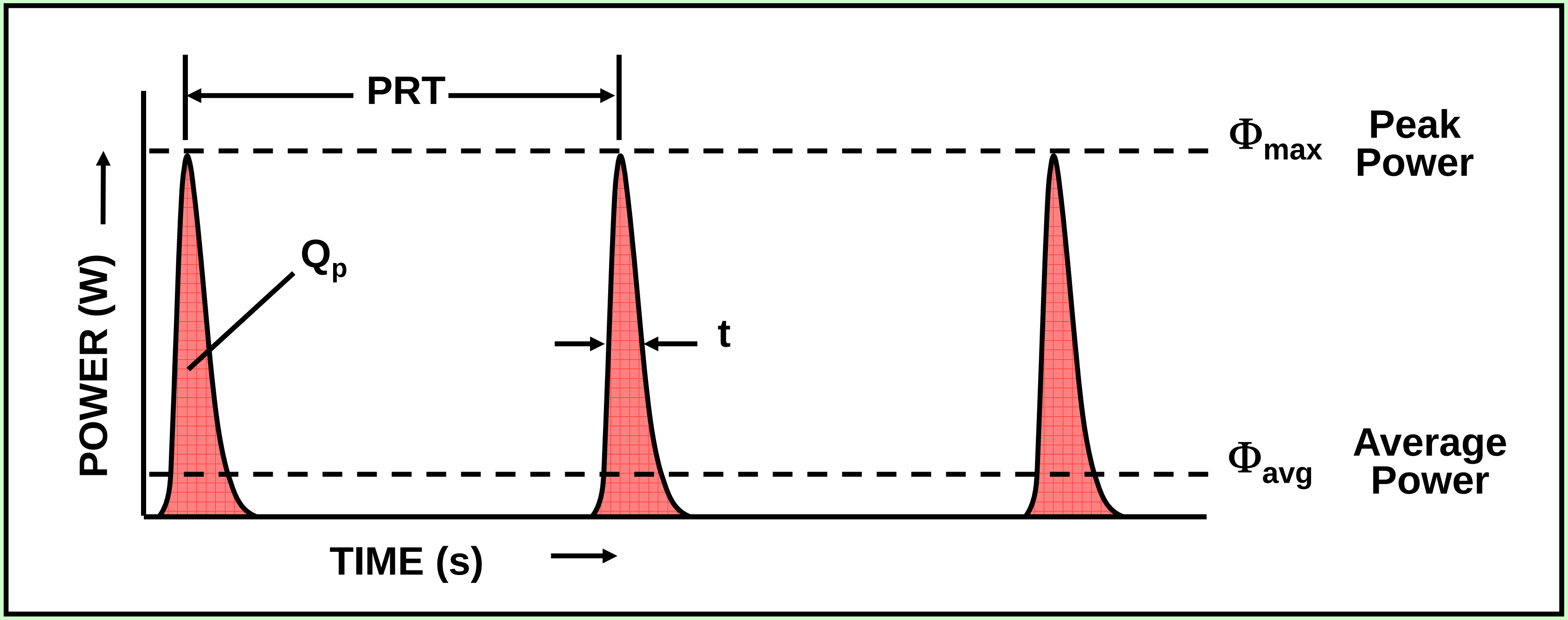


LASER TEMPORAL OUTPUTS



Shorter pulses produce greater hazards

REPETITIVE PULSED LASER POWER AND ENERGY



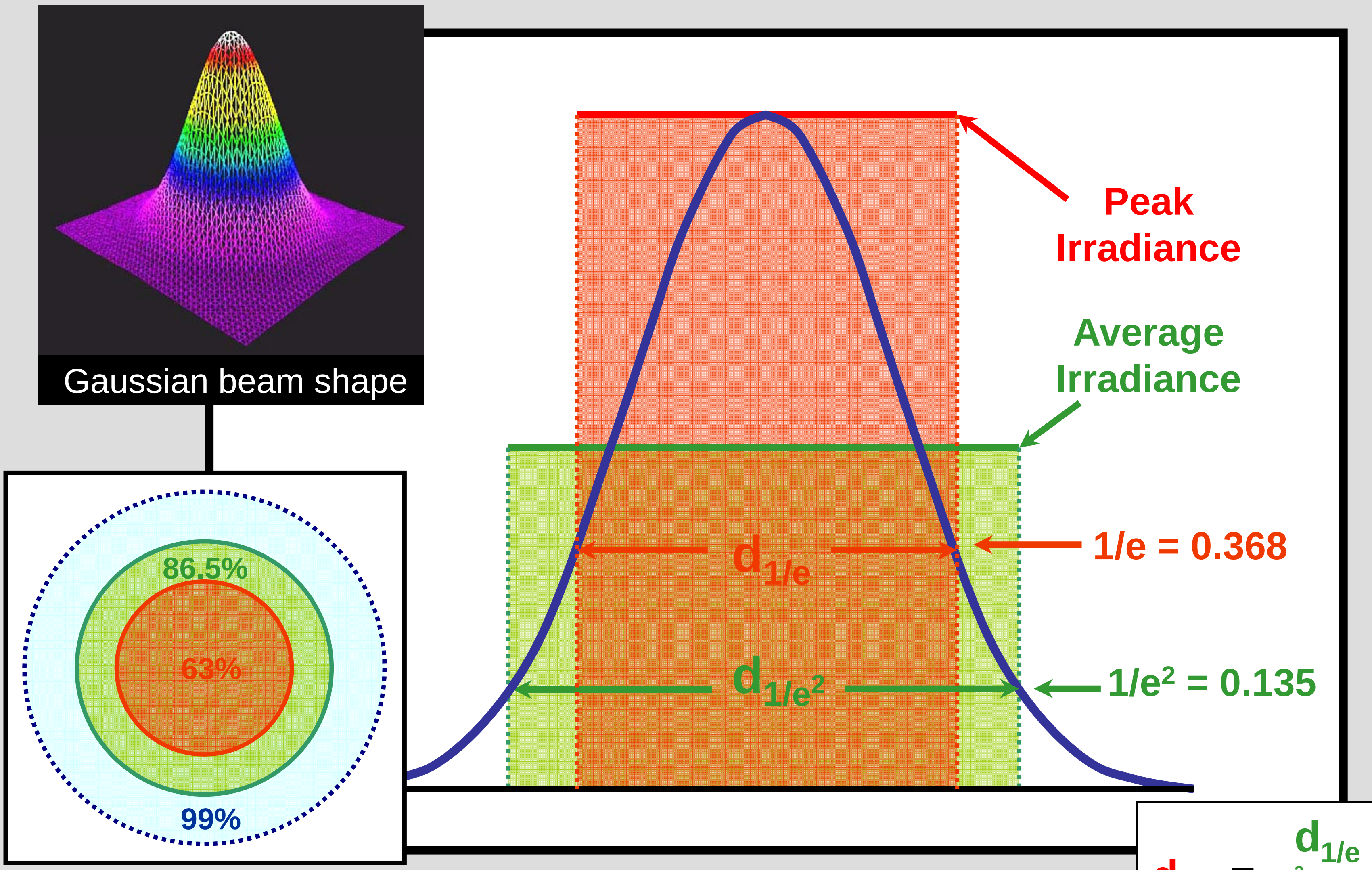
PRT: Pulse Repetition Time
PRF: Pulse Repetition Frequency

$$PRF = \frac{1}{PRT} \qquad \frac{t}{PRT} = \frac{\Phi_{avg}}{\Phi_{max}}$$

$$Q_p = \frac{\Phi_{avg}}{PRF}$$

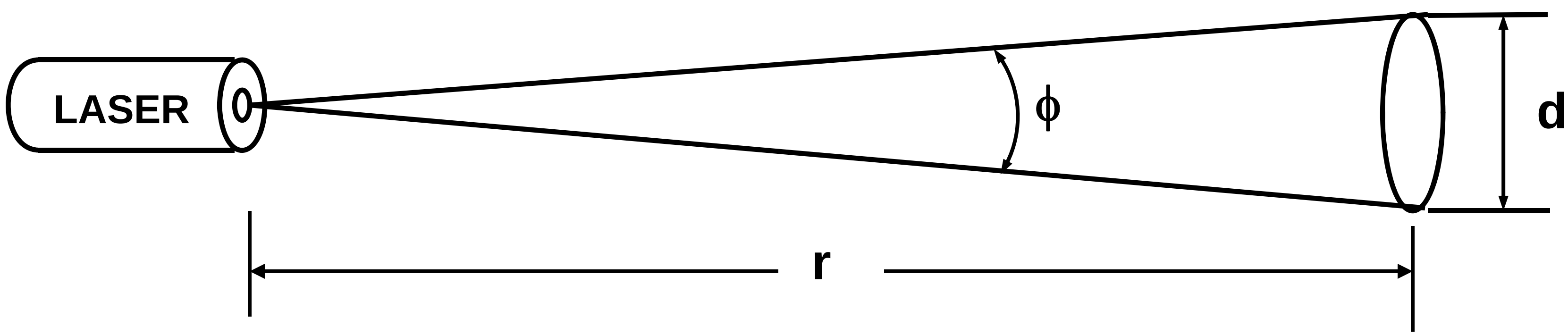
$$\Phi_{max} = \frac{Q_p}{t}$$

BEAM DIAMETER



$$d_{1/e} = \frac{d_{1/e^2}}{\sqrt{2}}$$

BEAM DIVERGENCE



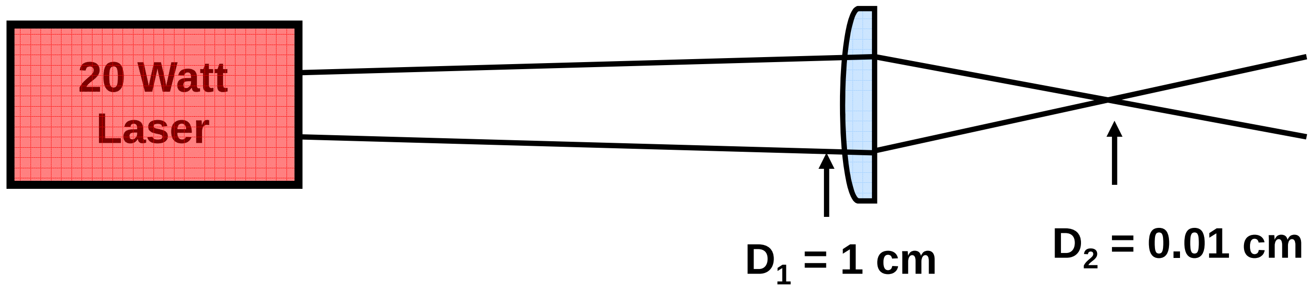
$$\phi = \frac{d}{r}$$

If the beam is 1 foot in diameter when it hits a wall 1000 feet away, the beam divergence angle is:

$$\phi = \frac{1\ \text{ft}}{1000\ \text{ft}} = 0.001\ \text{radian}$$

$$= 1\ \text{mrad}$$

IRRADIANCE CALCULATION



$$\text{Irradiance} = \frac{\text{Power}}{\text{Area}}$$

$$\text{Area} = \frac{\pi D^2}{4}$$

IRRADIANCE AT LENS:

$$E_1 = \frac{20 \text{ watts}}{(3.14)(1\text{cm})^2/4}$$

$E_1 = 25 \text{ watts/cm}^2$

IRRADIANCE OF FOCUSED SPOT:

$E_2 = 250{,}000 \text{ watts/cm}^2$

The diameter is reduced by a factor of *100*.

The irradiance is increased by a factor of *10,000*.

CHARACTERISTICS OF LASERS AND THEIR EFFECTS ON LASER HAZARDS

Spectral characteristic – Wavelength

In general, shorter wavelengths are more hazardous in any spectral region, but Near Infrared lasers are the most hazardous because they are invisible retinal hazards.

Temporal characteristic – Pulse Duration

In general, pulsed lasers are more hazardous than CW lasers.

The shorter the pulse duration, the higher the peak power and the greater the hazard.

Spatial characteristic – Beam Divergence

Low beam divergence results in a large intrabeam hazard distance.

Focusing characteristic

High retinal irradiance of focused beam creates extreme retinal hazard for visible and near infrared lasers.

LASER BEAM INJURIES

High power lasers can cause skin burns.

Lasers can cause severe eye injuries resulting in permanent vision loss.

LASER SKIN INJURIES

THERMAL SKIN INJURIES

- Surface burns from high power beams
- Deeper burn penetration at 1 μm wavelength
- Tissue vaporization by focused beams

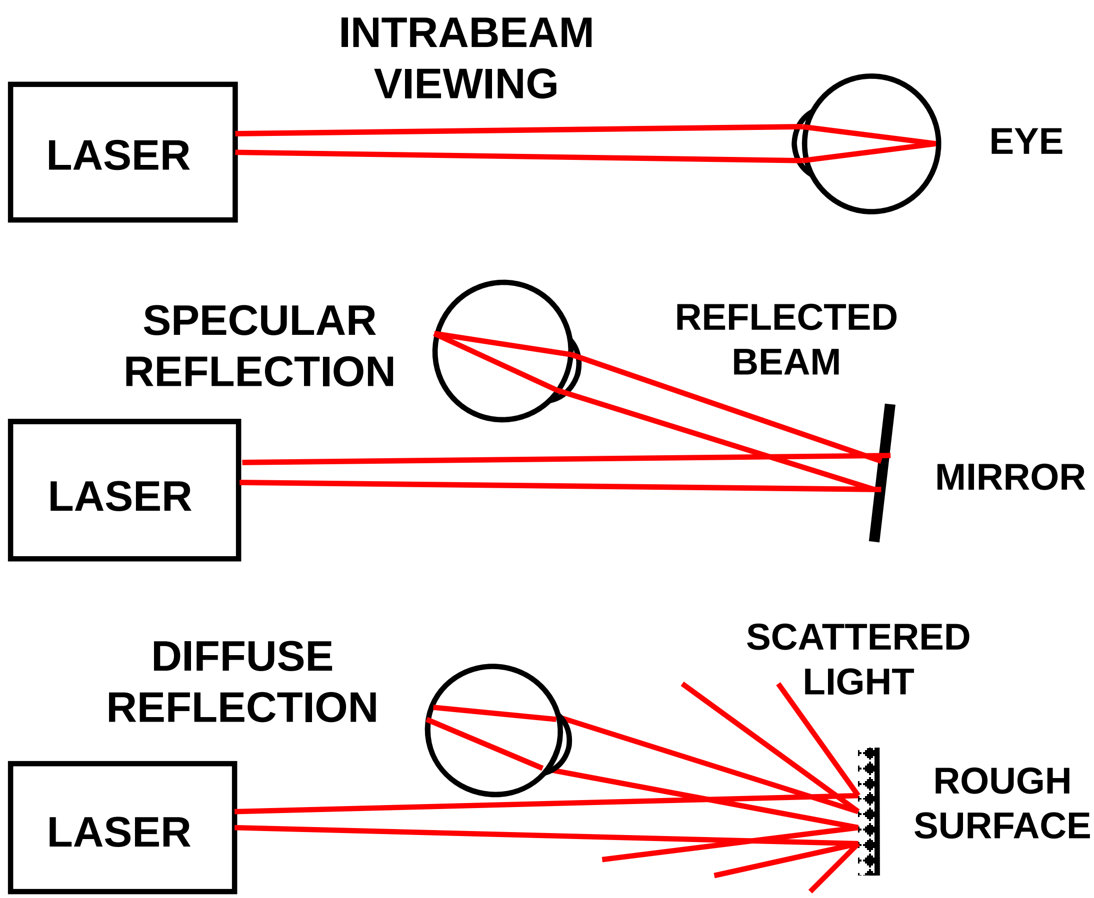
PHOTOCHEMICAL SKIN INJURIES

- Sunburn from scattered UV
- Possibility of skin cancer from long term UV exposure

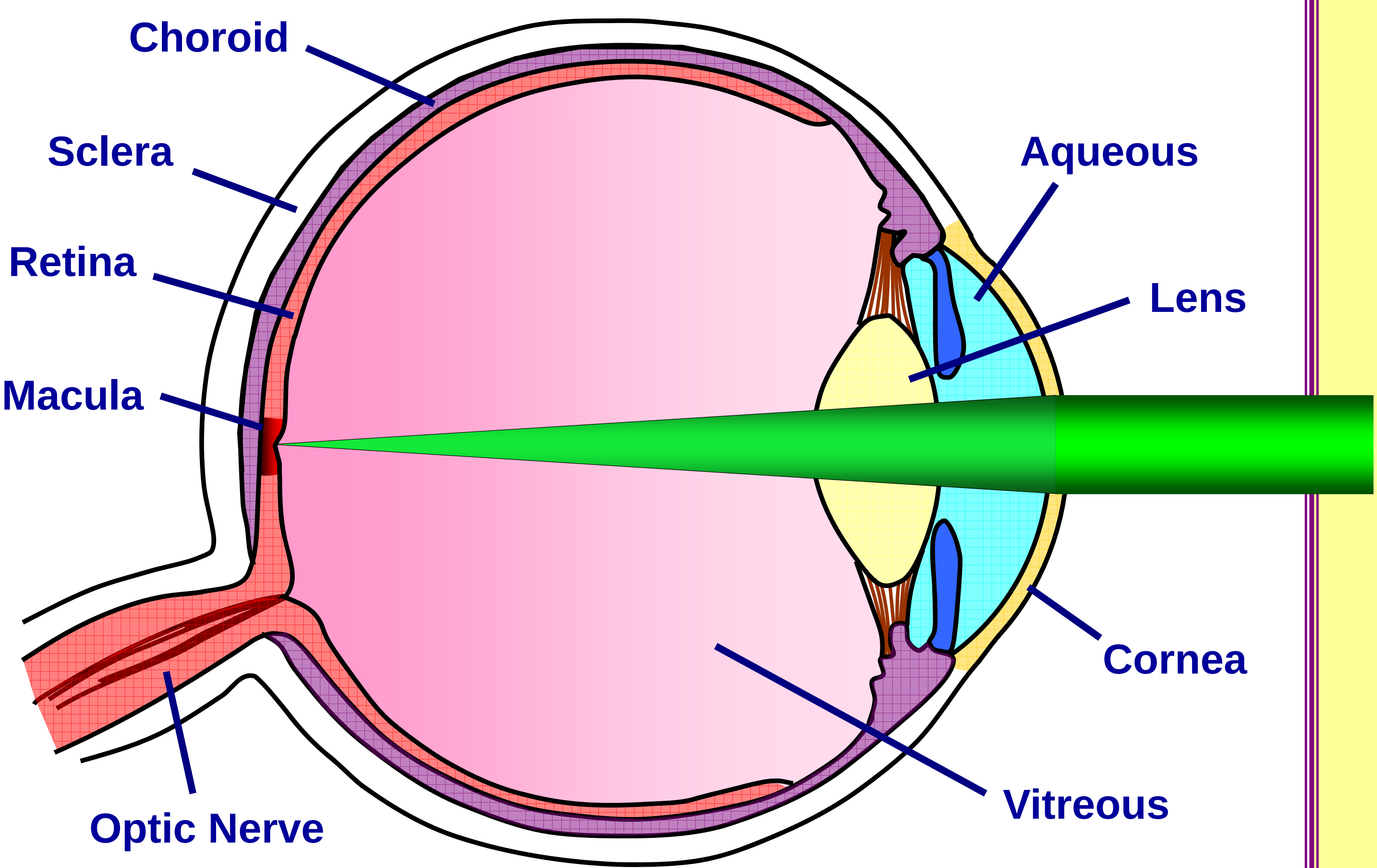
SKIN BURN FROM CO_2 LASER EXPOSURE

Accidental exposure to partial reflection of 2000 W CO_2 laser beam from metal surface during cutting

TYPES OF LASER EYE EXPOSURE



HUMAN EYE



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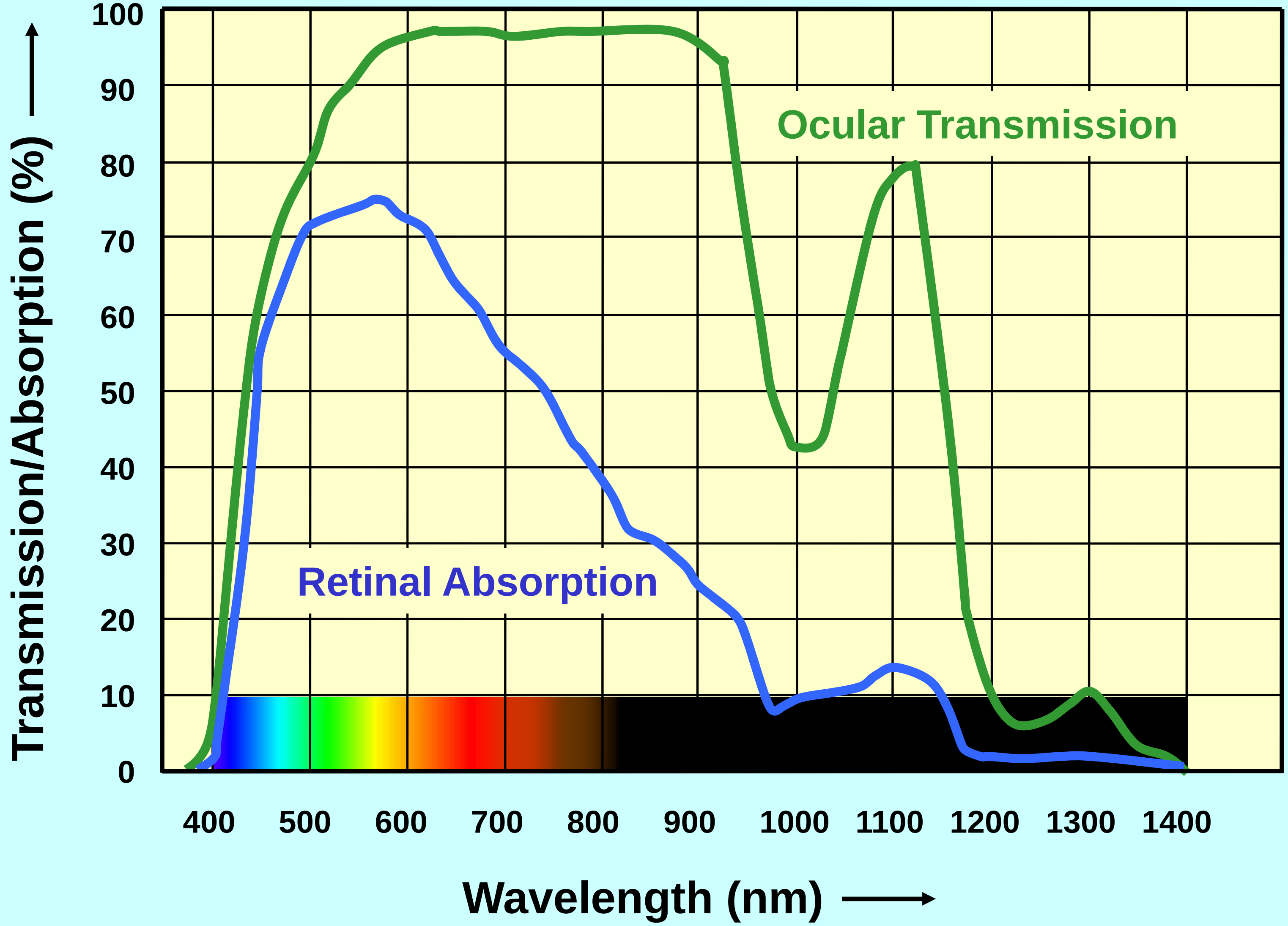
OCULAR TRANSMISSION AND RETINAL ABSORPTION



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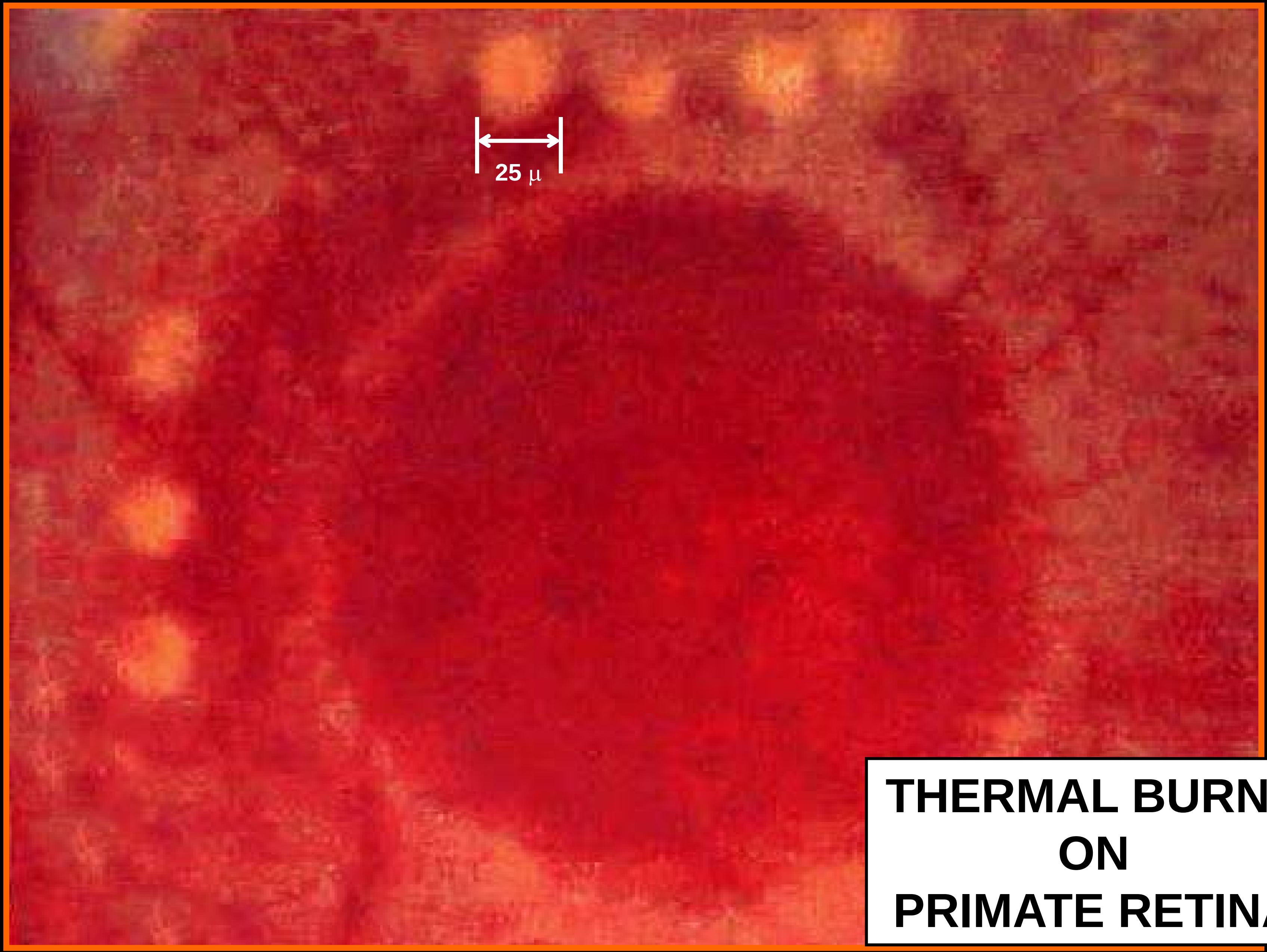


THERMAL BURNS
ON
PRIMATE RETINA

Photo courtesy of U S Air Force

MULTIPLE PULSE RETINAL INJURY

PRIMATE RETINAL HEMORRHAGE

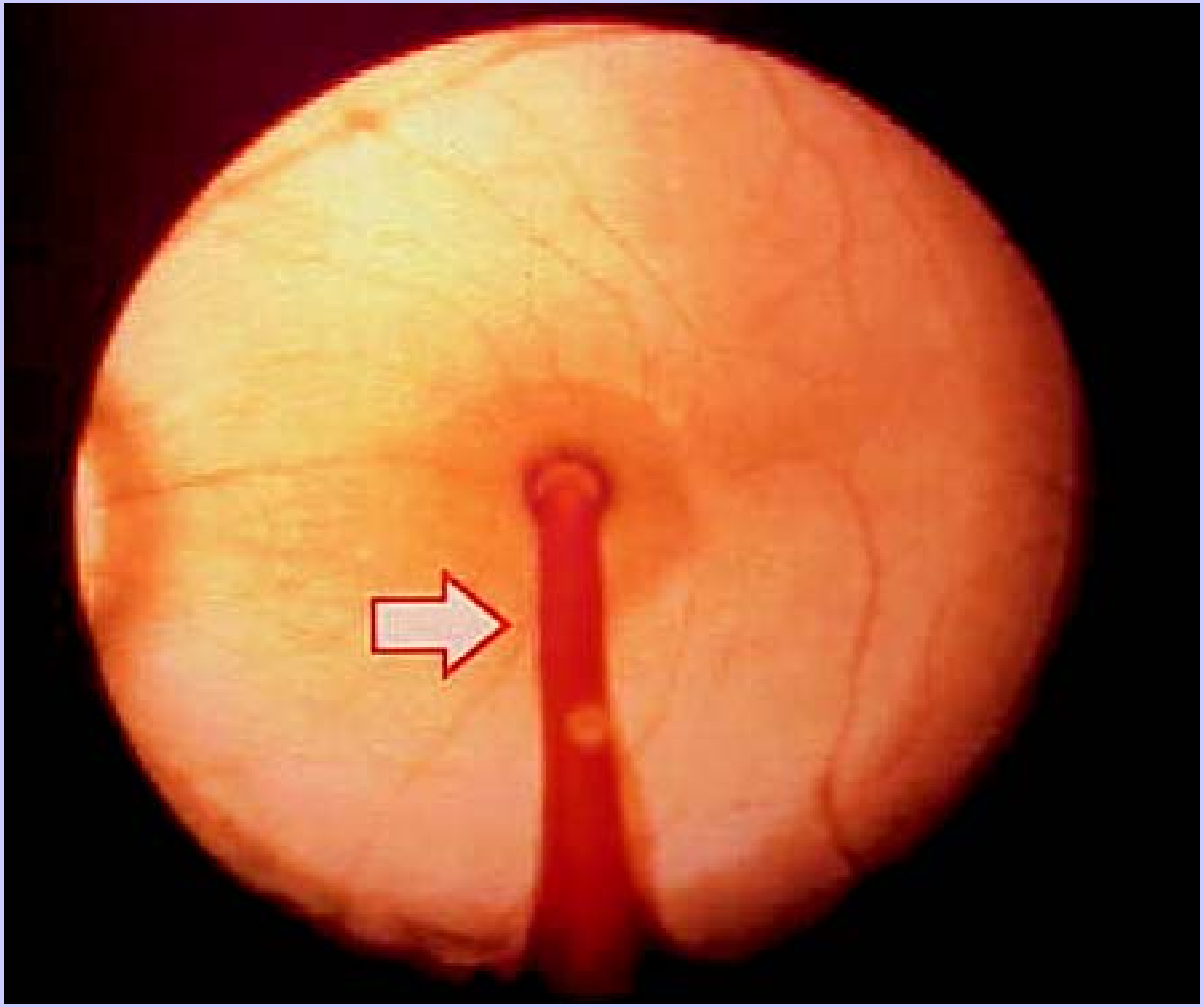


Photo courtesy of U S Air Force

EYE INJURY BY Q-SWITCHED LASER

Retinal Injury produced by four pulses from a Nd:YAG laser range finder.

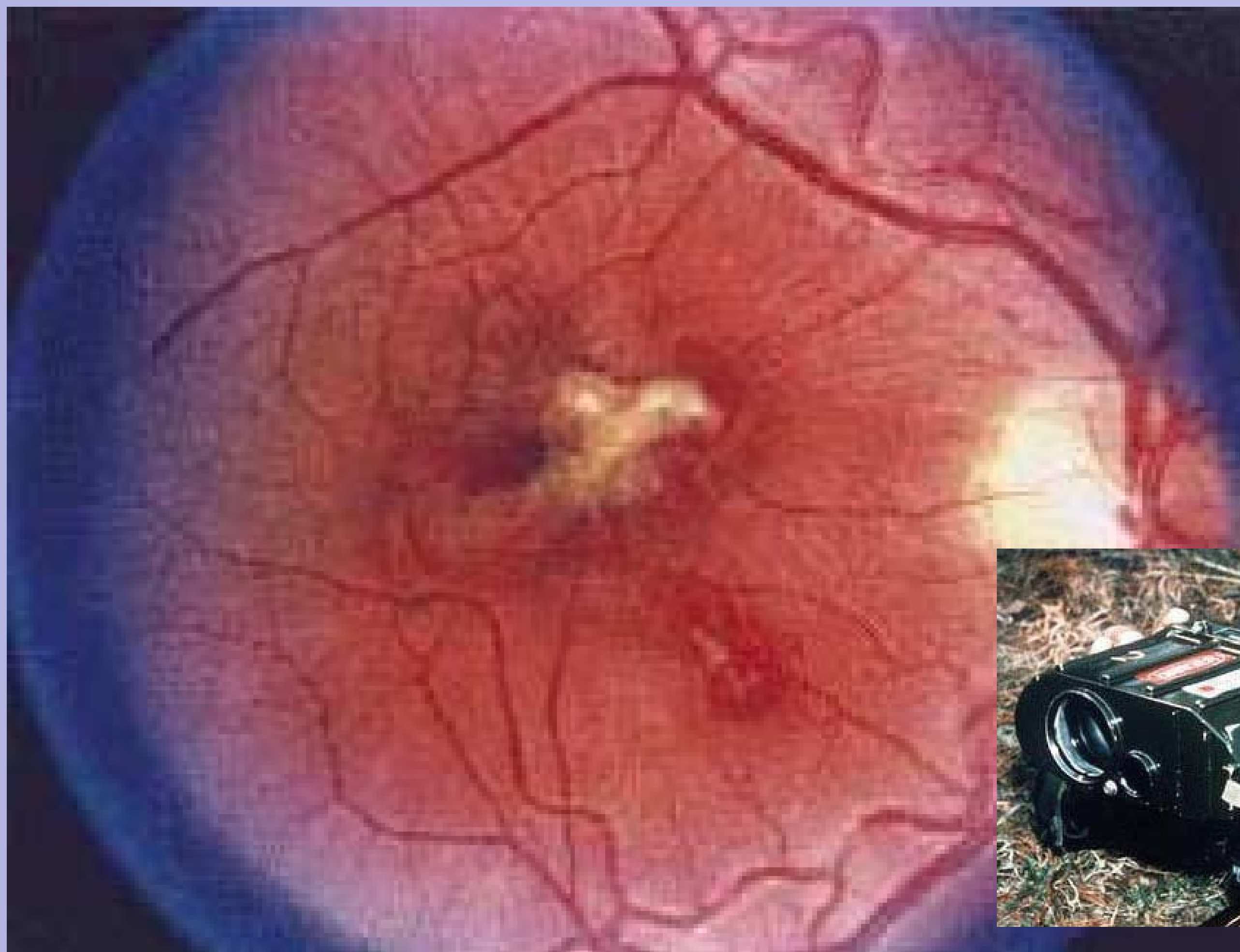


Photo courtesy of U S Army Center for Health Promotion and Preventive Medicine

CORNEAL BURN FROM CO_2 LASER EXPOSURE OF RABBIT EYE

CAUSES OF LASER ACCIDENTS

Studies of laser accidents have shown that there are usually several contributing factors. The following are common causes of laser injuries:

- Inadequate training of laser personnel
- Alignment performed without adequate procedures
- Failure to block beams or stray reflections
- Failure to wear eye protection in hazardous situations
- Failure to follow approved standard operating procedures or safe work practices

NON-BEAM HAZARDS

- **Electrical Hazards**
- **Smoke & Fumes**
- **Mechanical Hazards**
- **Process Radiation**
- **Flashlamp Light**
- **Chemical Hazards**

LASER HAZARD CLASSES

Lasers are classified according to the level of laser radiation that is accessible during normal operation.

CLASS 1

- Safe during normal use
- Incapable of causing injury
- Low power or enclosed beam

CLASS I Laser Product

Label not required

May be higher class during maintenance or service

Nd:YAG Laser Marker

CLASS 2

- Staring into beam is eye hazard
- Eye protected by aversion response
- Visible lasers only
- CW maximum power 1 mW

Laser Scanners

CLASS 3R (Formerly 3a)

- Aversion response may not provide adequate eye protection
- CDRH includes visible lasers only
- ANSI includes invisible lasers
- CW maximum power (visible) 5 mW

Laser Pointers

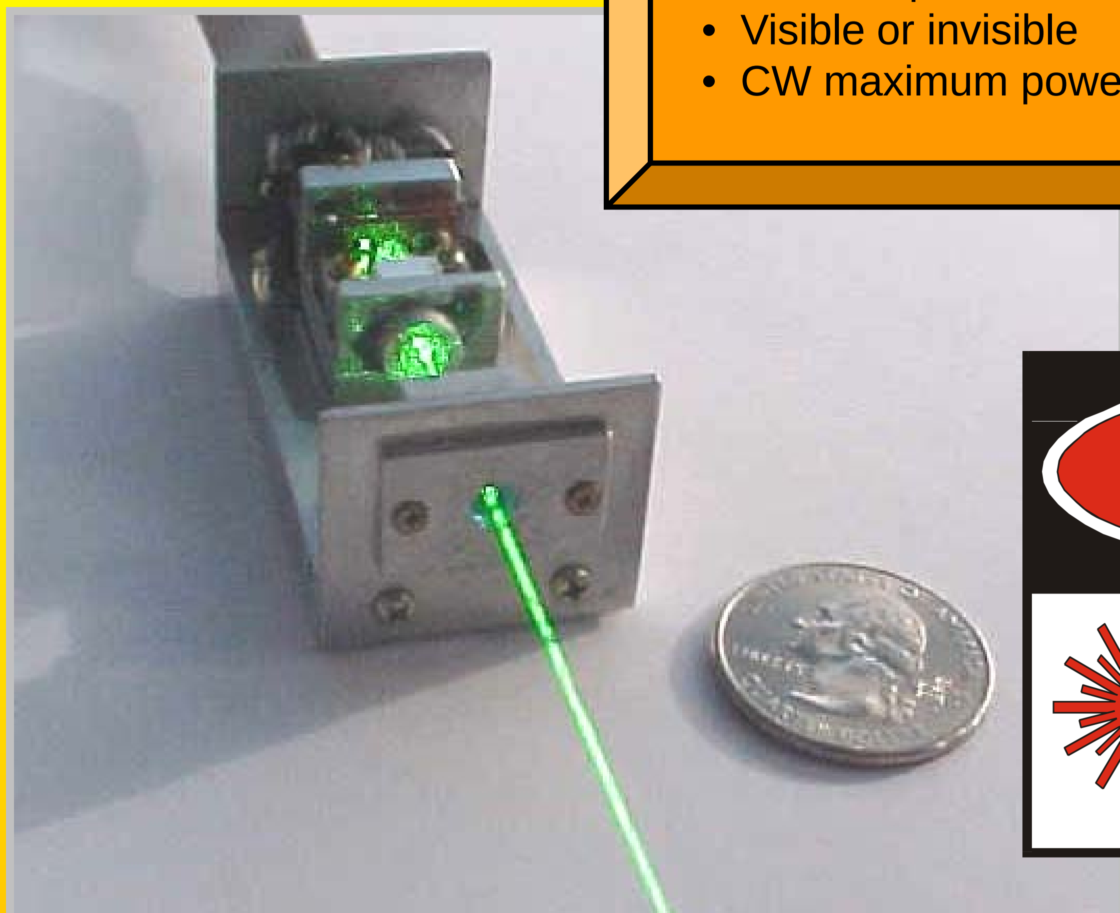
Expanded Beam

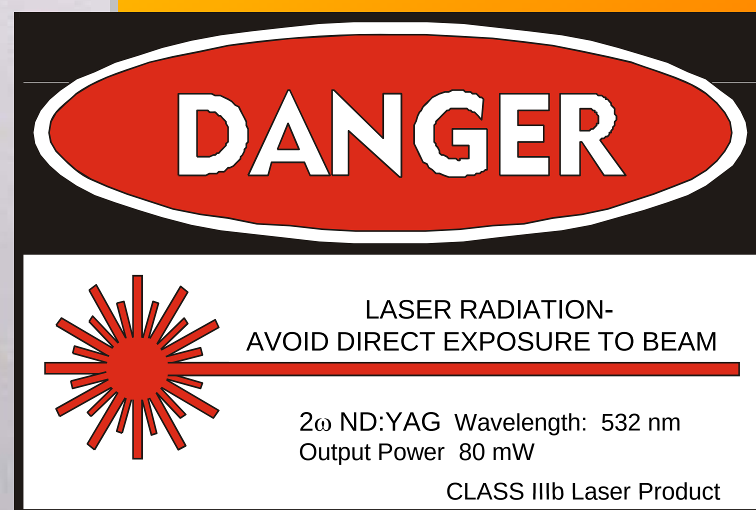
Small Beam

CLASS 3B

- Direct exposure to beam is eye hazard
- Visible or invisible
- CW maximum power 500 mW

DPSS Laser with cover removed





Courtesy of Sam's Laser FAQ, www.repairfaq.org/sam/lasersam.htm, © 1994-2004

CLASS 4

- Exposure to direct beam and scattered light is eye and skin hazard
- Visible or invisible
- CW power >0.5 W
- Fire hazard

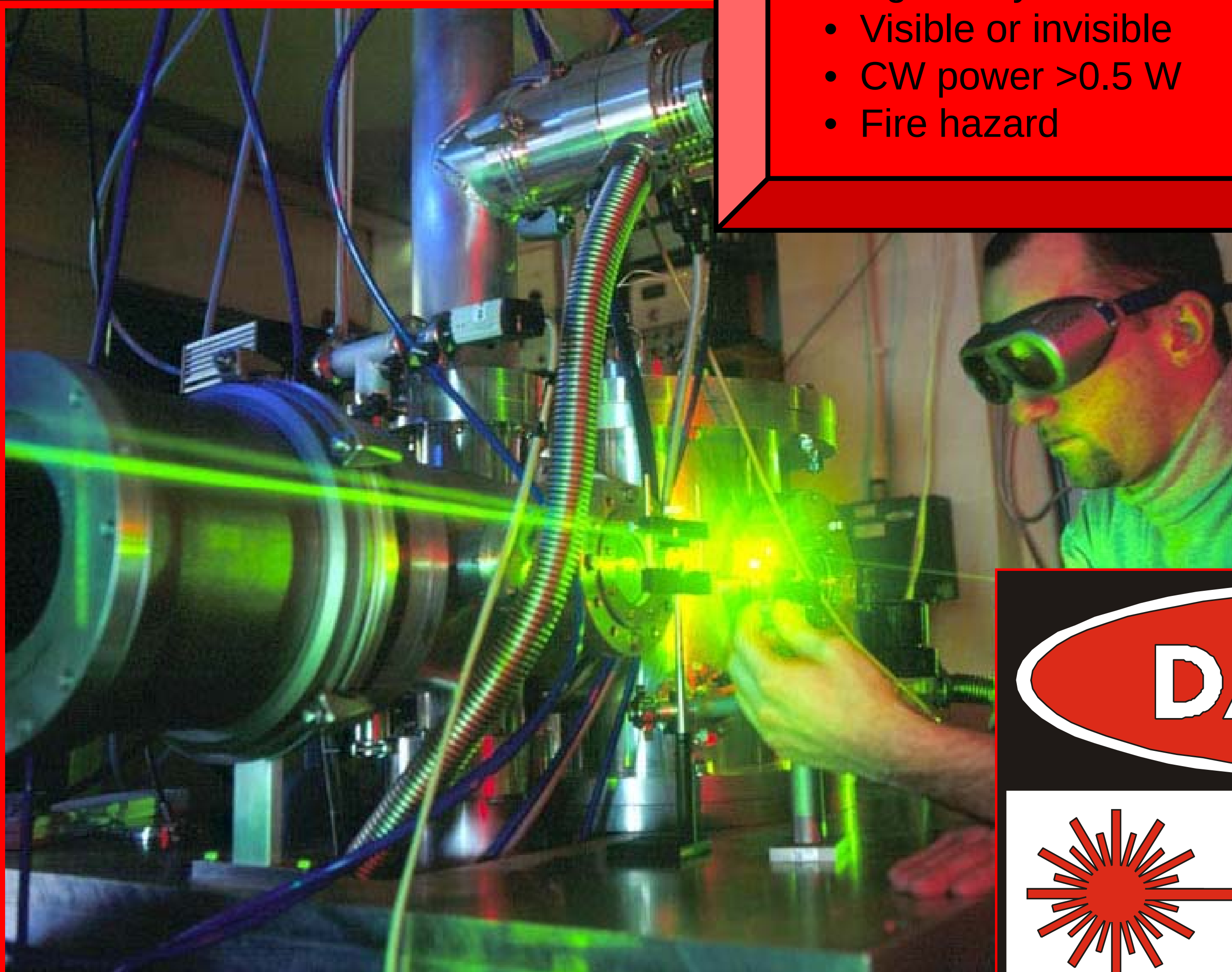


Photo: Keith Hunt - www.keithhunt.co.uk

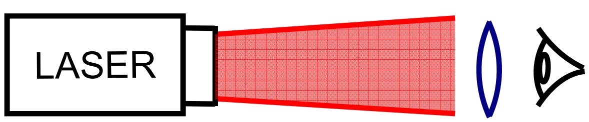
CLASS 1M & 2M

M is for magnification.

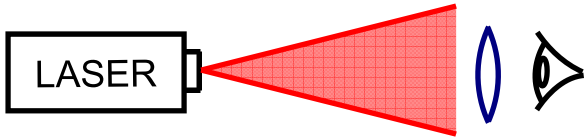
A class 1M laser is class 1 unless magnifying optics are used.

A class 2M laser is class 2 unless magnifying optics are used.

M classes usually apply to expanded or diverging beams.



Condition 1
Expanded Beam



Condition 2
Diverging Beam

LASER CLASSIFICATION SUMMARY

Class 1	Incapable of causing injury during normal operation
Class 1M	Incapable of causing injury during normal operation unless collecting optics are used
Class 2	Visible lasers incapable of causing injury in 0.25 s.
Class 2M	Visible lasers incapable of causing injury in 0.25 s unless collecting optics are used
Class 3R	Marginally unsafe for intrabeam viewing; up to 5 times the class 2 limit for visible lasers or 5 times the class 1 limit for invisible lasers
Class 3B	Eye hazard for intrabeam viewing, usually not an eye hazard for diffuse viewing
Class 4	Eye and skin hazard for both direct and scattered exposure

LASER SAFETY STANDARDS

- The Federal Laser Product Performance Standard (FLPPS)
  of the Center for Devices and Radiological Health (CDRH)
  This is federal law and applies to the manufacture of lasers.

- The American National Standard for Safe Use of Lasers (ANSI Z136.1)
  This is a VOLUNTARY Standard that applies to the use of lasers.
  It is “recognized by” :
  The Occupational Safety and Health Administration (OSHA)

- IEC 60825 International Standard

FEDERAL SAFETY REQUIREMENTS FOR CLASS 1 LASER SYSTEMS WITH ENCLOSED CLASS 3b AND 4 LASERS

Protective Housing
prevents access to laser radiation above safe level.

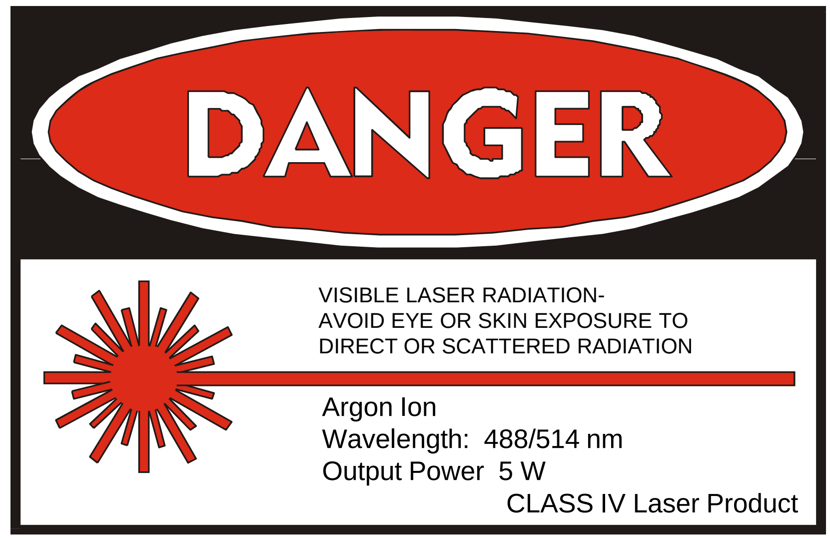
Safety Interlocks
terminate laser beam if protective housing in opened.

Only authorized personnel may operate laser with interlocks defeated.

Warning Labels
alert personnel if opening the housing might expose a laser hazard.

Viewing Windows and Optics
limit laser and collateral radiation to safe levels.

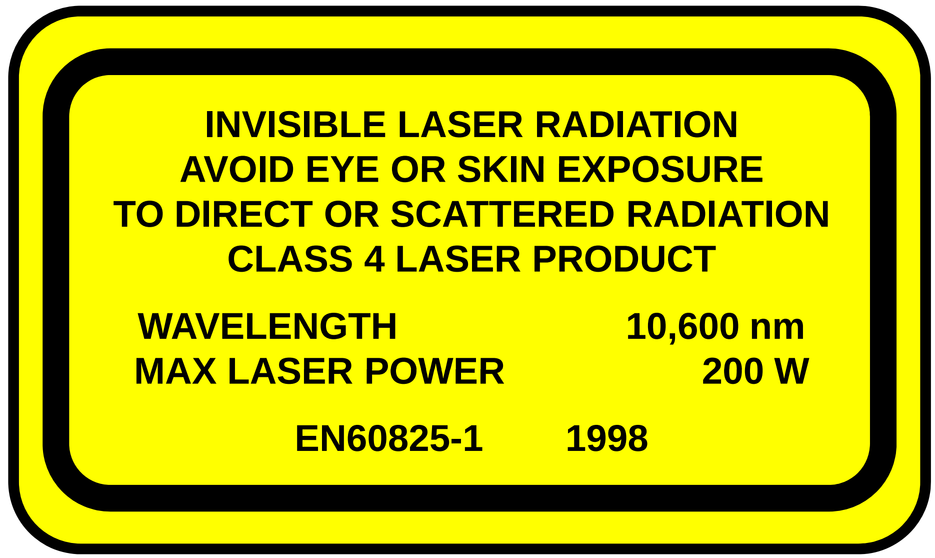
CDRH CLASS WARNING LABELS



Class II
Class IIIa with expanded beam

Class IIIa with small beam
Class IIIb
Class IV

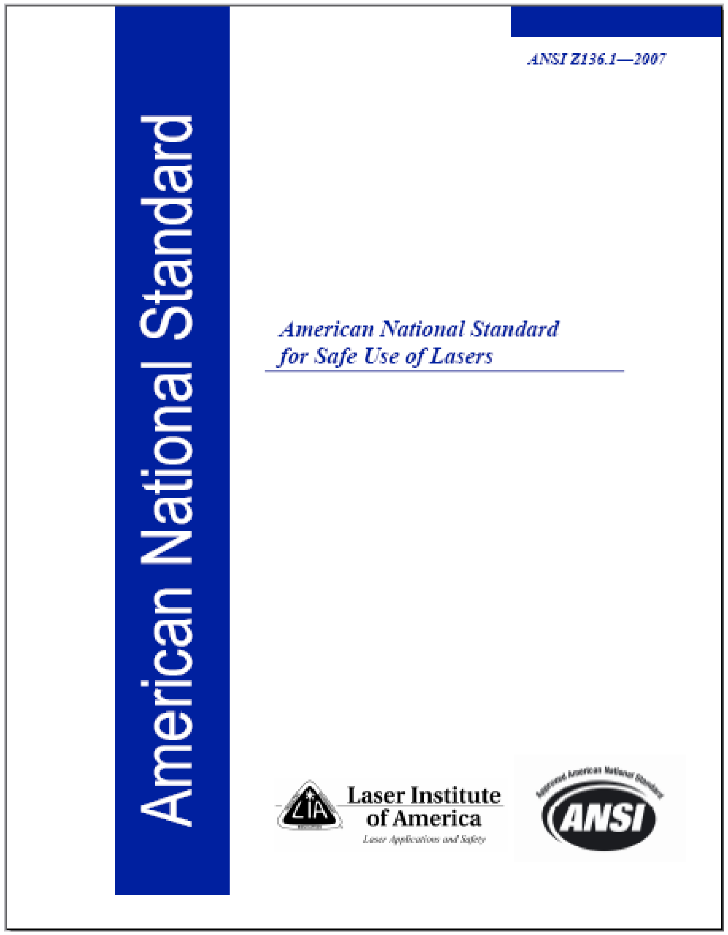
INTERNATIONAL LASER WARNING LABELS



Symbol and Border: Black
Background: Yellow

Legend and Border: Black
Background: Yellow

OVERVIEW OF ANSI Z136.1



1. MANAGEMENT APPOINTS LASER SAFETY OFFICER
2. LSO VERIFIES LASER CLASSIFICATION
3. LSO EVALUATES HAZARDS BY DETERMINING

   MPE -- OD -- NHZ

4. LSO SPECIFIES CONTROL MEASURES

   ENGINEERING CONTROLS
   - ENCLOSURES
   - INTERLOCKS
   - WARNING SYSTEMS

   ADMINISTRATIVE AND PROCEDURAL CONTROLS
   - AUTHORIZED PERSONNEL
   - SOP (INCLUDING ALIGNMENT)
   - TRAINING

   PROTECTIVE EQUIPMENT
   - EYEWEAR
   - BARRIERS

LASER HAZARD EVALUATION

FACTORS IN HAZARD EVALUATION

- The laser or laser system's capability of injuring personnel (Hazard Analysis Calculations)
- The environment in which the laser is used
- The personnel who may use or be exposed to laser radiation

DEFINITION OF MPE

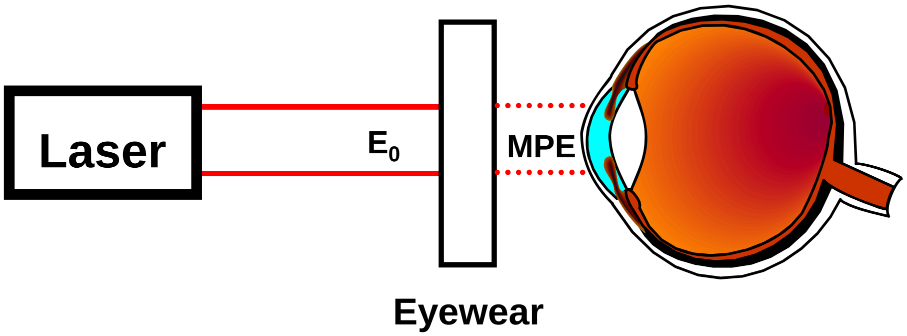
Maximum

Permissible

Exposure

The level of laser light to which a person may be exposed without risk of injury.

OPTICAL DENSITY OF LASER SAFETY EYEWEAR



OD	% Transmission
0	100%
1	10%
2	1%
3	0.1%
4	0.01%
5	0.001%
6	0.0001%

$$OD = \log \frac{E_0}{MPE}$$

Area of Limiting Aperture (Table 8)

Given:

λ = .488 μm

Φ = 5 W

d = 7 mm

A = 0.4 cm^2

E_0 = (5W)/(0.4 cm^2) = 12.5 W/cm^2

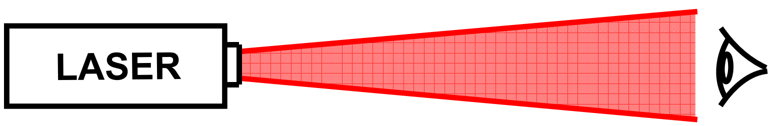
MPE = 2.5 x 10^{-3} W/cm^2 (for 0.25 sec.)

$$OD = \log_{10} \left[\frac{12.5 \text{ W/cm}^2}{2.5\times10^{-3} \text{ W/cm}^2} \right]$$

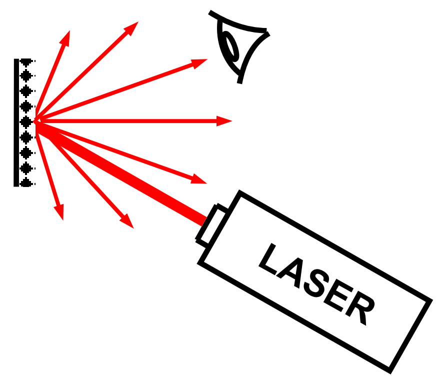
OD = 3.7

NOMINAL HAZARD ZONE

The space within which the potential exposure exceeds the MPE.



Intrabeam
Nominal Hazard Zone



Diffuse Reflection
Nominal Hazard Zone

TYPICAL NHZ VALUES

LASER TYPE & EXPOSURE	NHZ (m) INTRABEAM	NHZ (m) DIFFUSE REFLECTION
CW Nd:YAG 100 W, 10 s	1130	0.80
CW CO_2 1000 W, 10 s	1060	0.56

LASER HAZARD ANALYSIS #1

Class 3b Frequency Doubled CW Nd:YAG

- **Exposure parameters**
  - **Wavelength: 532 nm**
  - **Power: 200 mW**
  - **Beam diameter*: 1 mm**
  - **Beam divergence*: 1 mrad**
  - **Exposure time: 0.25 s**

- **Calculated values**
  - **MPE: 2.55 mW/cm^2**
  - **Eyewear OD: 2.31**
  - **Intrabeam NOHD: 141 m**
  - **Diffuse Reflection NHZ: 5 cm**

*** Note: All hazard analysis examples use 1/e^2 beam diameter and divergence**

LASER HAZARD ANALYSIS #2

Laser: CW Argon Ion Laser

- **Exposure parameters**
  - **Wavelength: 0.488 μm**
  - **Power: 10 W**
  - **Beam diameter: 1.1 mm**
  - **Beam divergence: 0.6 mrad**
  - **Exposure time: 0.25 s**
- **Calculated values**
  - **MPE: 2.55×10^{-3} W/cm^2**
  - **Eyewear OD: 4.01**
  - **Intrabeam NOHD: 1670 m**
  - **Diffuse Reflection NHZ: 0.354 m**

LASER HAZARD ANALYSIS #3

Q-Switched, Pulsed Nd:YAG Laser

- Exposure Parameters
  - Wavelength: 1.064 μm
  - PRF: 10 Hz
  - Pulse Duration: 10 ns
  - Energy per Pulse: 1 J
  - Beam Diameter: 6.4 mm
  - Beam Divergence: 0.23 mrad
  - Exposure Time: 10 s
- Calculated Values
  - MPE: 1.58 X 10^{-5} W/cm^2
  - Eyewear OD: 6.22
  - Intrabeam NOHD: 5520 m
  - Worst Case Diffuse Reflection NHZ: 4.49 m
  - (Peak Power: 10 MW)
  - (Average Power: 10 W)

FREE
LASER HAZARD ANALYSIS SOFTWARE

EASY HAZ®

www.laser-professionals.com

HAZARD EVALUATION
BY LASER USERS

All users of lasers with exposed beams should:

- **Understand the hazards associated with the laser they use**
- **Evaluate the control of hazards every time they operate the lasers**
- **Use their best judgment in controlling all laser hazards (be conservative; don't take chances)**
- **Consult their Laser Safety Officer whenever they have safety concerns or questions**

LASER CONTROL MEASURES

ANSI Section 4.1

"Control Measures shall be devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation."

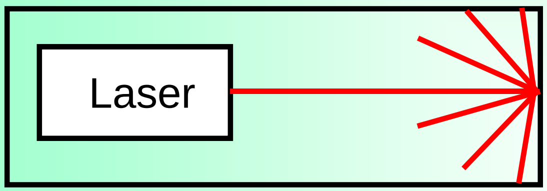
Types of Control Measures

- **Engineering**
- **Administrative**
- **Procedural**

BEAM PATH ENCLOSURES

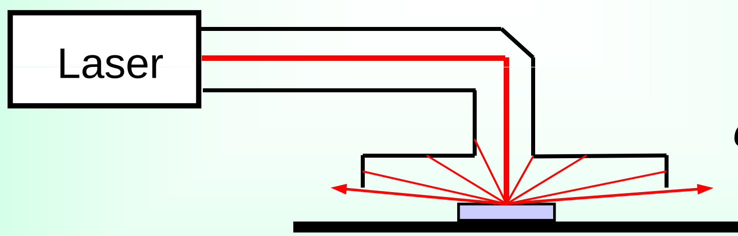
Section 4.3.6

FULLY ENCLOSED BEAM PATH



Class 1 System

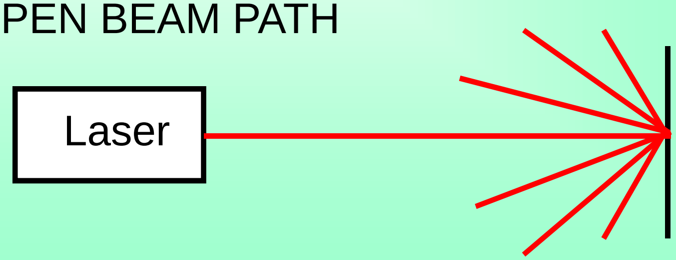
LIMITED OPEN BEAM PATH



Some scattered light escapes. NHZ is small.

FULLY OPEN BEAM PATH

Larger NHZ requires laser controlled area.



OPEN BEAM CONTROL MEASURES

Section 4.3.1.1

- Laser Controlled Area
- Eye Protection
- Beam Control
- Administrative and Procedural Controls
- Education and Training

Table 10. Control Measures for the Seven Laser Classes

Engineering Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.3.1)	X	X	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.3.2)	∇	∇	∇	∇	∇	X	X
Service Access Panel (4.3.3)	∇	∇	∇	∇	∇	X	X
Key Control (4.3.4)	—	—	—	—	—	•	X
Viewing Windows, Display Screens and Collecting Optics(4.3.5.1)	Assure viewing limited < MPE						
Collecting Optics (4.3.5.2)							
Fully Open Beam Path (4.3.6.1)	—	—	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	—	—	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled						
Remote Interlock Connector (4.3.7)	—	—	—	—	—	•	X
Beam Stop or Attenuator (4.3.8)	—	—	—	—	—	•	X
Activation Warning Systems (4.3.9.4)	—	—	—	—	—	•	X
Indoor Laser Controlled Area (4.3.10)	—	*	—	*	—	X NHZ	X NHZ
Class 3B Indoor Laser Controlled Area (4.3.10.1)	—	—	—	—	—	X	—
Class 4 Laser Controlled Area (4.3.10.2)	—	—	—	—	—	—	X
Outdoor Control Measures (4.3.11)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Temporary Laser Controlled Area (4.3.12)	∇ MPE	∇ MPE	∇ MPE	∇ MPE	∇ MPE	—	—
Controlled Operation (4.3.13)	—	—	—	—	—	—	•
Equipment Labels (4.3.14 and 4.7)	X	X	X	X	X	X	X
Laser Area Warning Signs and Activation Warnings (4.3.9)	—	—	—	—	•	X NHZ	X NHZ

“Should”
In 4.3.4

Table 10. Control Measures for the Seven Laser Classes (cont.)

Administrative and Procedural Control Measures	**Classification**						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures (4.4.1)	—	—	—	—	—	•	X
Output Emission Limitations (4.4.2)	—	—	—	—	LSO Determination		
Education and Training (4.4.3)	—	•	•	•	•	X	X
Authorized Personnel (4.4.4)		*		*		X	X
Alignment Procedures (4.4.5)	∇	∇	∇	∇	∇	X	X
Protective Equipment (4.6)	—	*	—	*	—	•	X
Spectators (4.4.6)	—	*	—	*	—	•	X
Service Personnel (4.4.7)	∇	∇	∇	∇	∇	X	X
Demonstration with General Public (4.5.1)	—	*	X	*	X	X	X
Laser Optical Fiber Transmission Systems (4.5.2)	MPE	MPE	MPE	MPE	MPE	X	X
Laser Robotic Installations (4.5.3)	—	—	—	—	—	X NHZ	X NHZ
Protective Eyewear (4.6.2)	—	—	—	—	—	•	X
Window Protection (4.6.3)	—	—	—	—	—	X	X NHZ
Protective Barriers and Curtains (4.6.4)	—	—	—	—	—	•	•
Skin Protection (4.6.6)	—	—	—	—	—	X	X NHZ
Other Protective Equipment (4.6.7)	Use may be required						
Warning Signs and Labels (4.7) (Design Requirements)	—	—	•	•	•	X NHZ	X NHZ
Service Personnel (4.4.7)	LSO Determination						
Laser System Modifications (4.1.2)	LSO Determination						

DANGER

VISIBLE and/ or INVISIBLE LASER RADIATION-AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.

ND:YAG 1064 nm
100 Watts Max. Average Power

CLASS 4 LASER

Laser-Professionals.com

Controlled Area Warning Sign

Old Style Sign

CLASS 4 ENTRYWAY CONTROLS

Section 4.3.10.2.2

1. ***Non-Defeatable Entryway Controls***
   - **Doorway interlock is non-defeatable**
   - **Training of authorized users only**

2. ***Defeatable Entryway Controls***
   - **Doorway interlock is defeatable**
   - **Training of all personnel with access**
   - **Barrier and eyewear at door**

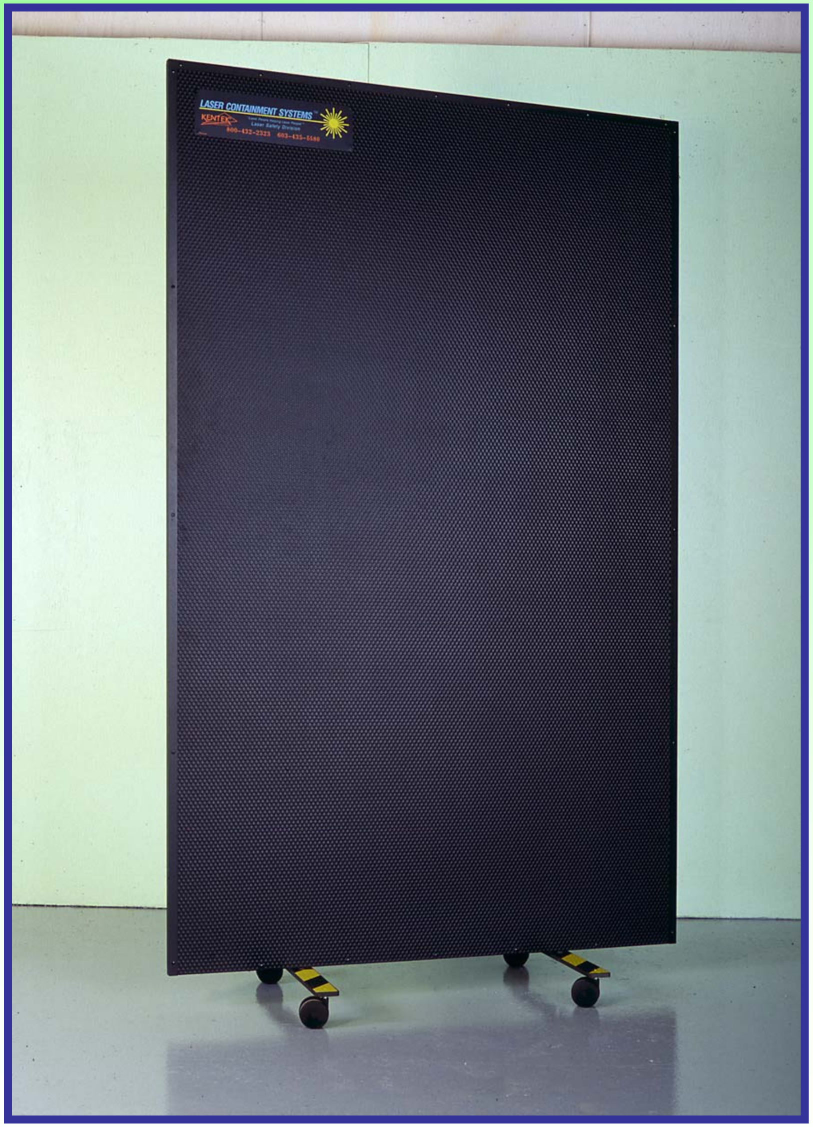
3. ***Procedural Entryway Controls***
   - **No doorway interlock**
   - **Training of all personnel with access**
   - **Barrier and eyewear at door**
   - **Visible or audible signal at doorway**

LABORATORY DOOR INTERLOCK

ENTRYWAY WARNING LIGHTS

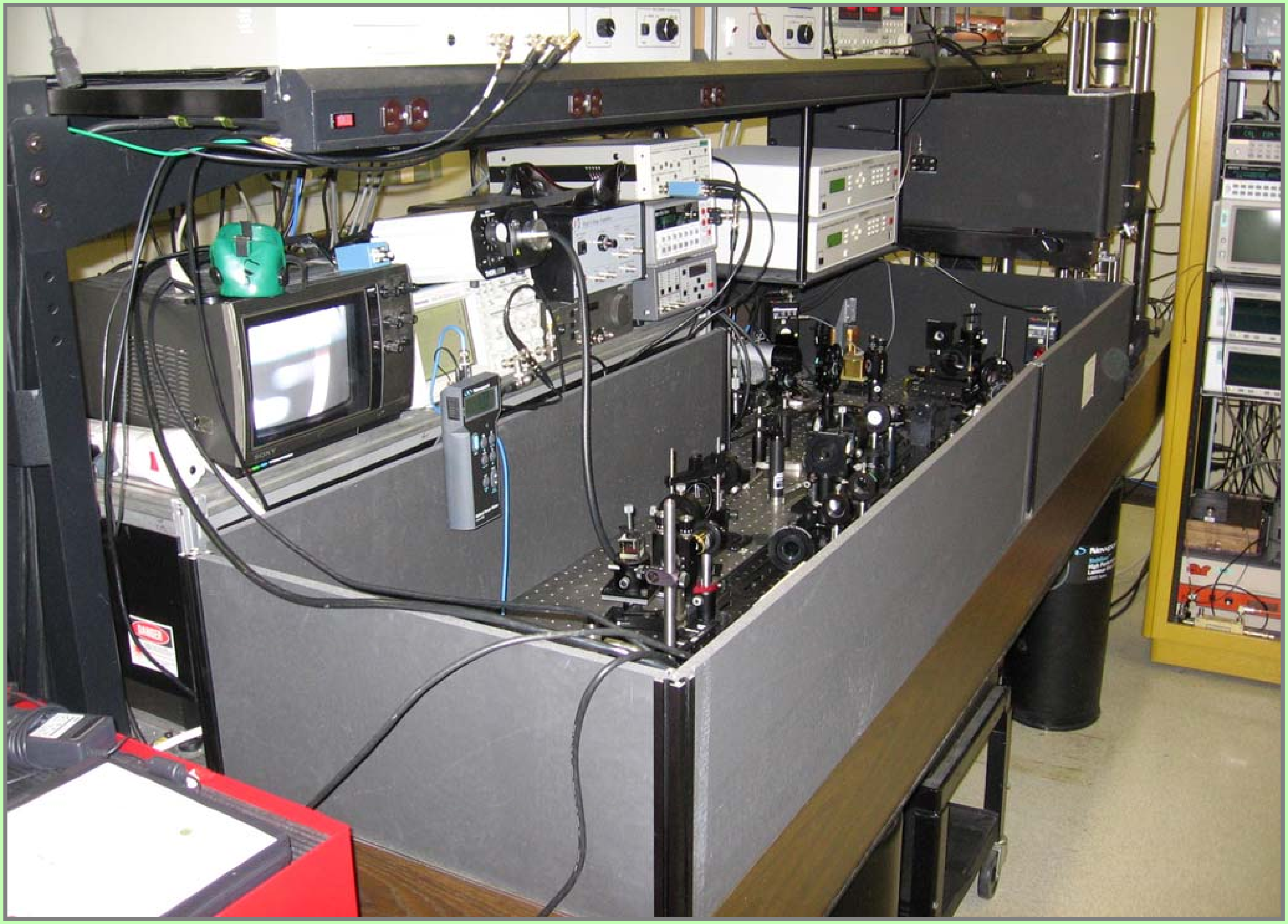
Laser-Professionals.com

LASER PROTECTIVE BARRIERS

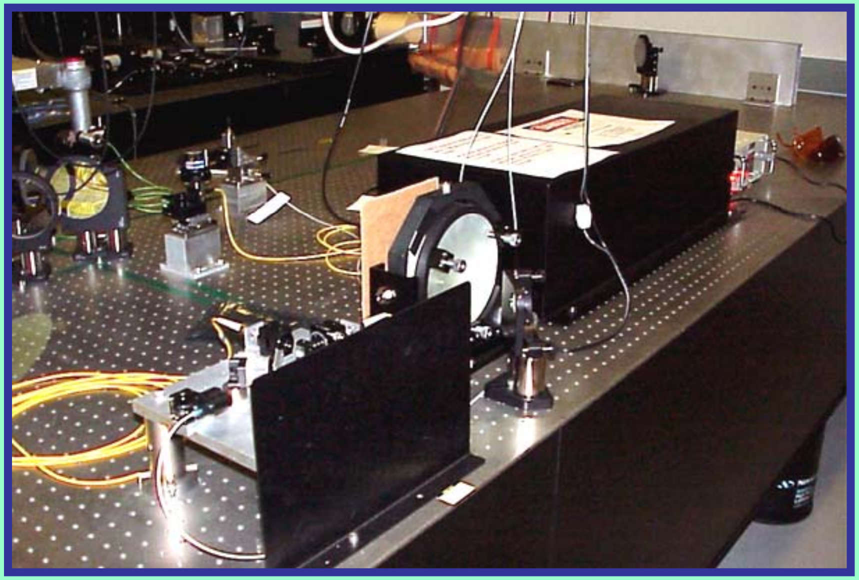


Photos courtesy of KENTEK "Laser People Helping Laser People"®

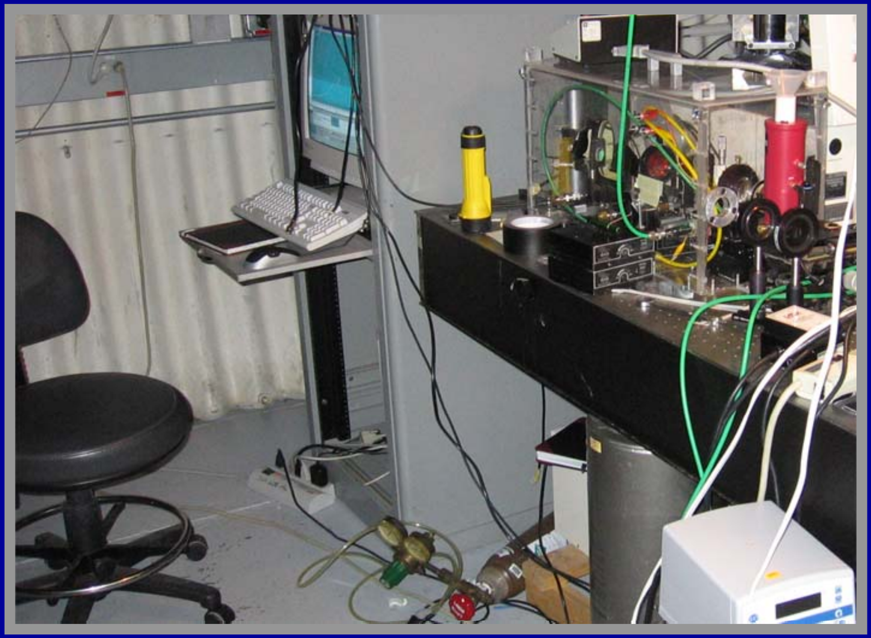
CURBS ON OPTICAL TABLE



BEAM CONTROL



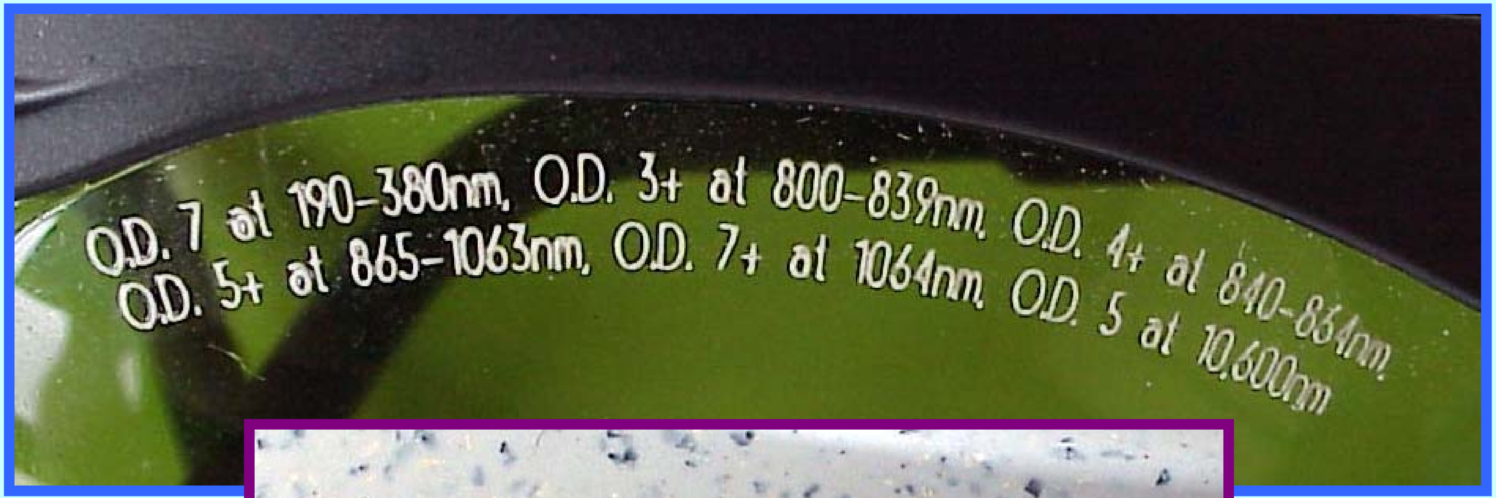
COMPUTERS IN RESEARCH LABS

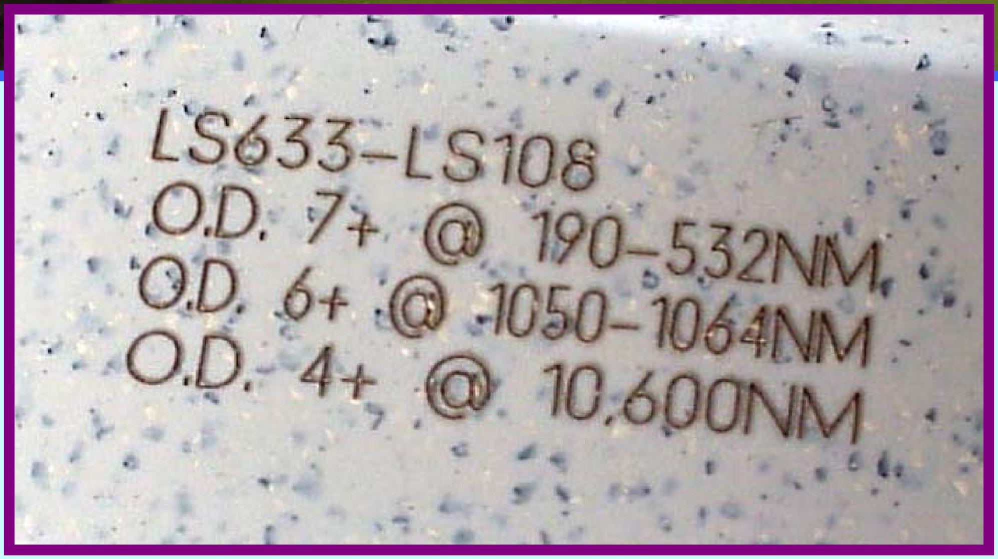


Allowing a direct view from a computer workstation into a laser experimental setup increases the risk of eye exposure to reflected beams.

LASER SAFETY EYEWEAR

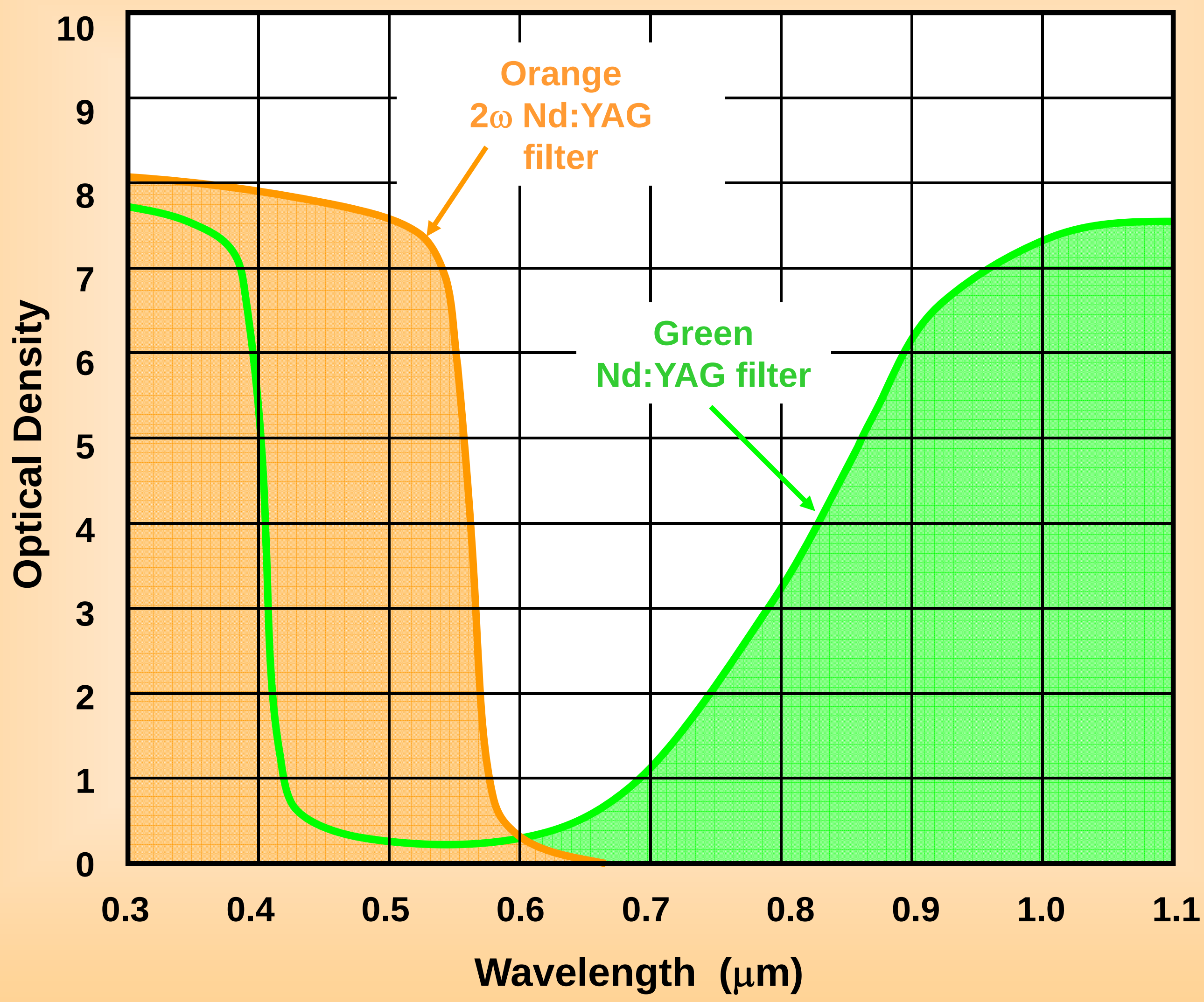
EYEWEAR LABELS



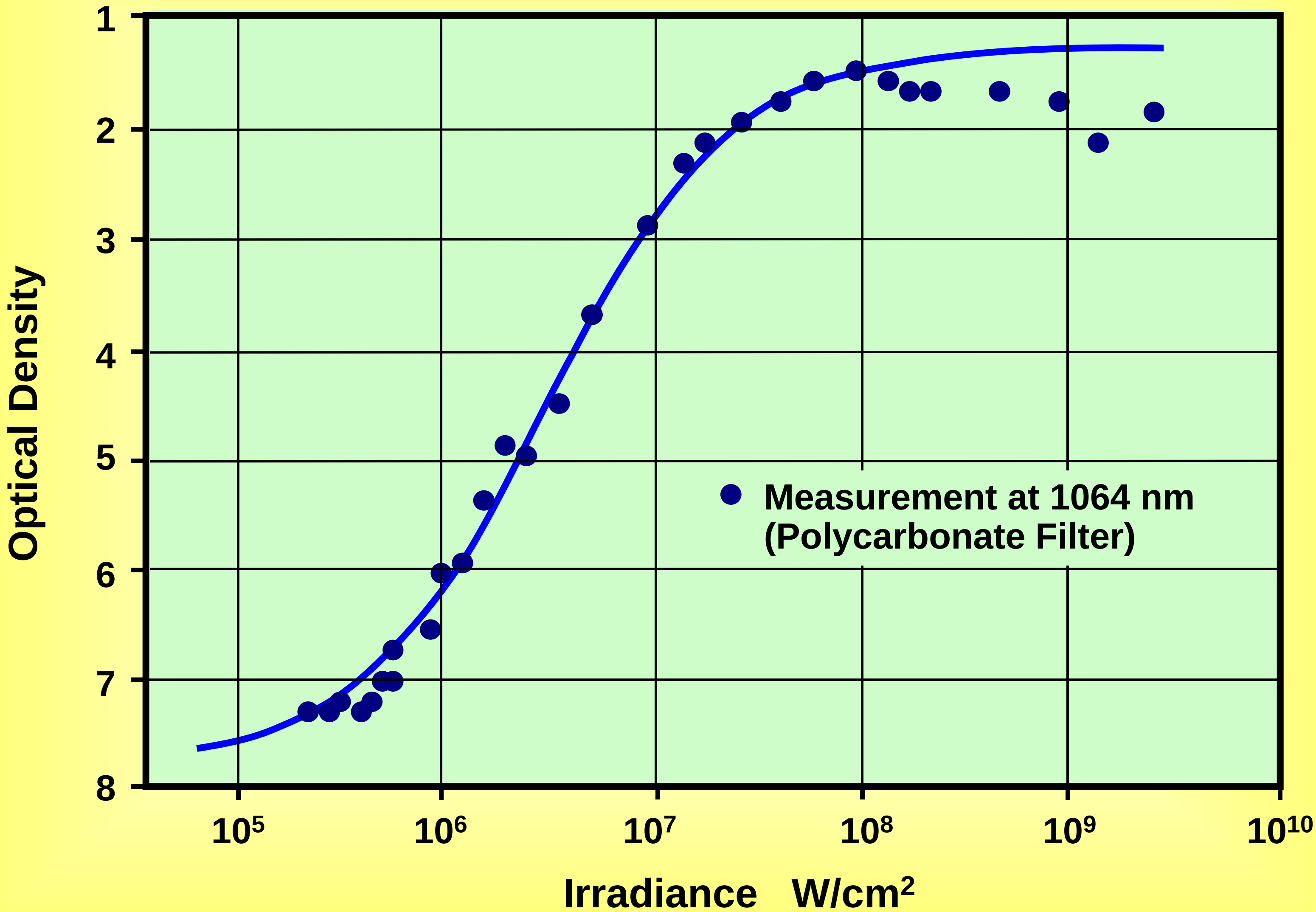


All eyewear must be labeled with wavelength and optical density.

PLASTIC EYEWEAR CHARACTERISTICS

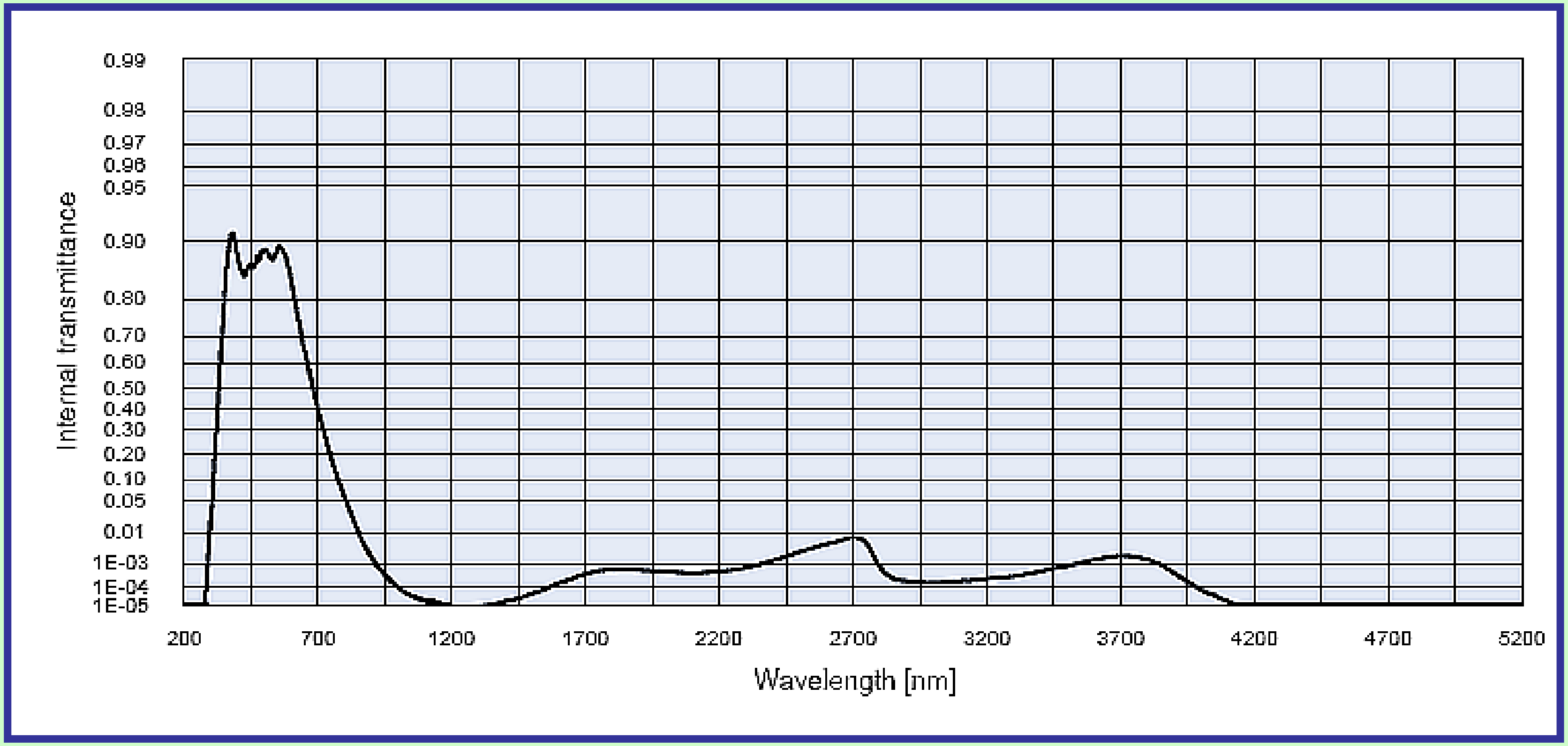


LASER INDUCED TRANSMITTANCE



“Induced Transmittance of Eye-Protective Laser Filters”
W. Koschinski, et.al.
Proceedings of ILSC, 1997 (pg 612)
Laser Institute of America

GLASS EYEWEAR CHARACTERISTICS



Transmission of Schott glass KG5 (thickness = 2 mm)

WHO HAS PRIMARY RESPONSIBLITY FOR LASER SAFETY ANY TIME A CLASS 3B OR CLASS 4 LASER IS OPERATED?

<u>The person operating the laser</u> always has the primary responsibility for all hazards associated with laser use.

SUGGESTED SOP FORMAT

1. **Introduction – Description of laser**
   - Type and wavelength; Intended application & Location
   - Average power or energy per pulse
   - Pulse duration and repetition rate for pulsed lasers

2. **Hazards – List all hazards associated with laser**
   - Eye and skin hazards from direct and diffuse exposures
   - Electrical hazards
   - Laser generated air contaminants
   - Other recognized hazards

3. **Control Measures – List control measures for each hazard**
   Include the following:
   - Eyewear requirement, include wavelength and OD
   - Description of controlled area and entry controls
   - Reference to equipment manual
   - Alignment procedures (or guidelines)

4. **Authorized Personnel**

5. **Emergency Procedures**

SAFE BEAM ALIGNMENT

- **Most beam injuries occur during alignment.**
- **Only trained personnel may align class 3B or class 4 lasers *(NO EXCEPTIONS!)***
- **Laser safety eyewear is required for class 3B and class 4 beam alignment.**
- **ANSI *REQUIRES* approved, written alignment procedures for *ALL* class 4 laser alignment activities and recommends them for class 3B.**

ALIGNMENT GUIDELINES FOR CLASS 3b AND 4 LASERS

1. Exclude unnecessary personnel from the laser area during alignment.
2. Where possible, use low-power visible lasers for path simulation of high power visible or invisible lasers.
3. Wear protective eyewear during alignment. Use special alignment eyewear when circumstances permit their use.
4. When aligning invisible beams, use beam display devices such as image converter viewers or phosphor cards to locate beams.
5. Perform alignment tasks using high-power lasers at the lowest possible power level.
6. Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process.
7. Use a laser rated beam block to terminate high-power beams downstream of the optics being aligned.
8. Use beam blocks and/or laser protective barriers in conditions where alignment beams could stray into areas with uninvolved personnel.
9. Place beam blocks behind optics to terminate beams that might miss mirrors during alignment.
10. Locate and block all stray reflections before proceeding to the next optical component or section.
11. Be sure all beams and reflections are properly terminated before high-power operation.
12. Post appropriate area warning signs during alignment procedures where lasers are normally class 1.
13. Alignments should be done only by those who have received laser safety training.

SAFE WORK PRACTICES

- Never intentionally look directly into a laser. Do not stare at the light from any laser. Allow yourself to blink if the light is too bright.
- Do not view a Class 3a (or any higher power) laser with optical instruments.
- Never direct the beam toward other people.
- Operate lasers only in the area designed for their use and be certain that the beam is terminated at the end of its use path. Never allow a laser beam to escape its designated area of use.
- Position the laser so that it is well above or below eye level.
- Always block the beam with a diffuse reflecting beam block.
- Remove all unnecessary reflective objects from the area near the beam's path. This may include items of jewelry and tools.
- Do not enter a designated Class 3b or Class 4 laser area (posted with a DANGER sign) without approval from a qualified laser operator. Eye protection is required in these areas.
- Always wear laser safety eyewear if a class 4 invisible beam is exposed.

KEYS TO A SUCCESSFUL LASER SAFETY PROGRAM

Active involvement and support of laser users

Effective oversight by Laser Safety Officer

Support from management at all levels

Thank you for promoting laser safety in your workplace.
We hope you will consider us for your
laser safety training needs.

Johnny Jones, President
Laser-Professionals Inc.
where the laser user comes first

EASY HAZ ©

Check out our *FREE* laser hazard analysis software at
www.Laser-Professionals.com