Laser Safety Training

Presented

Kasai Consulting

Scope

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

Requirements of the Employer

- The employer must ensure not to allow anyone to work with this laser system unless they:
  - Are familiar with the basic regulations concerning safety at work and accident prevention and have been instructed in the use of this product
  - Have been instructed as to the dangerous effects of laser radiation
  - Receive instruction at regular intervals

Environmental Health & Safety Responsibilities

- Assists the LSO in maintaining a comprehensive laser safety program
- Laser safety training
- Coordination of baseline eye examinations (if needed)
- Preparation of required laser warning signs and inspections

Laser Safety Officer Responsibilities

- Ensure the rest of the staff knows who you are
- Establish and maintain procedures to control laser hazards and insure compliance with ANZI Z136.1, Federal and State requirements
- Classify all lasers on site and document inventory
- Insure control measures are implemented and maintained
- Approve Class 3B and 4 standard operating procedures and laser installations and equipment prior to initial use and insures laser hazard control measures are adequate
- Recommend and approve protective equipment
- Review area signs and equipment labels
- Insure adequate safety training for laser users
- Insure medical surveillance is performed if needed
- Keep records in accordance with Sound Retention requirements
- Respond to incidents
- Conduct unannounced inspections to insure adequate functionality of the laser safety control features and document

Area Supervisors/Managers Responsibilities

- Responsible for assuring all laser users under their supervision are properly trained and tested and conduct laser activities in a safe manner.

Laser Users Responsibilities

- Laser users are responsible for:
  - Obtaining a laser eye exam if determined to be necessary
  - Wearing appropriate personal protective equipment
  - Attending training
  - Following work instructions
  - Conducting laser activities in a safe manner

Basics of Lasers and Lasers Lights

LASER

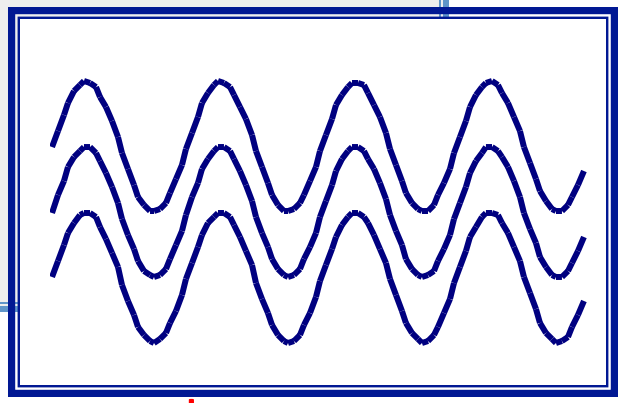
Light Amplification by the Stimulated Emission of Radiation

Laser Fundamentals

MONOCHROMATIC

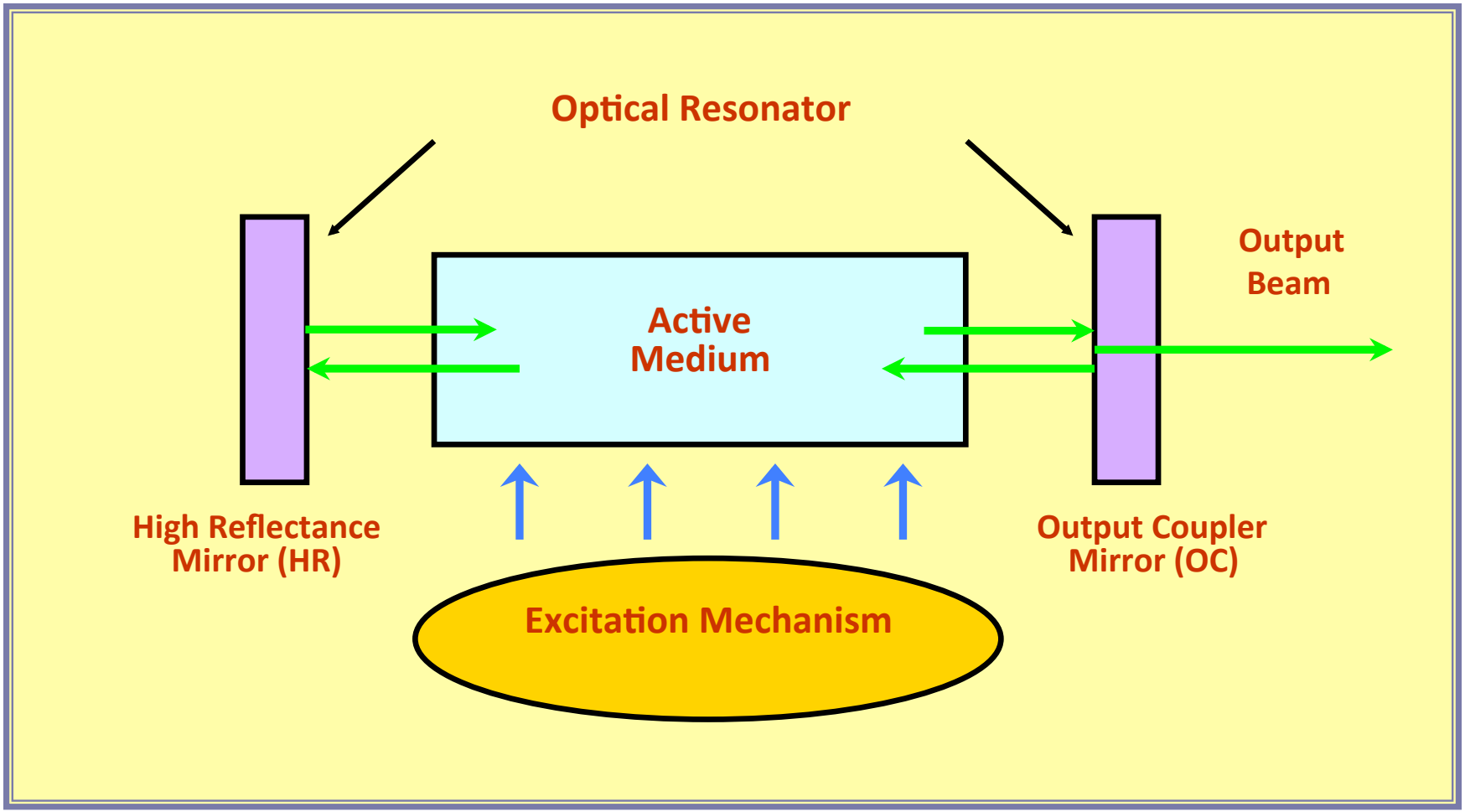
DIRECTIONAL

COHERENT

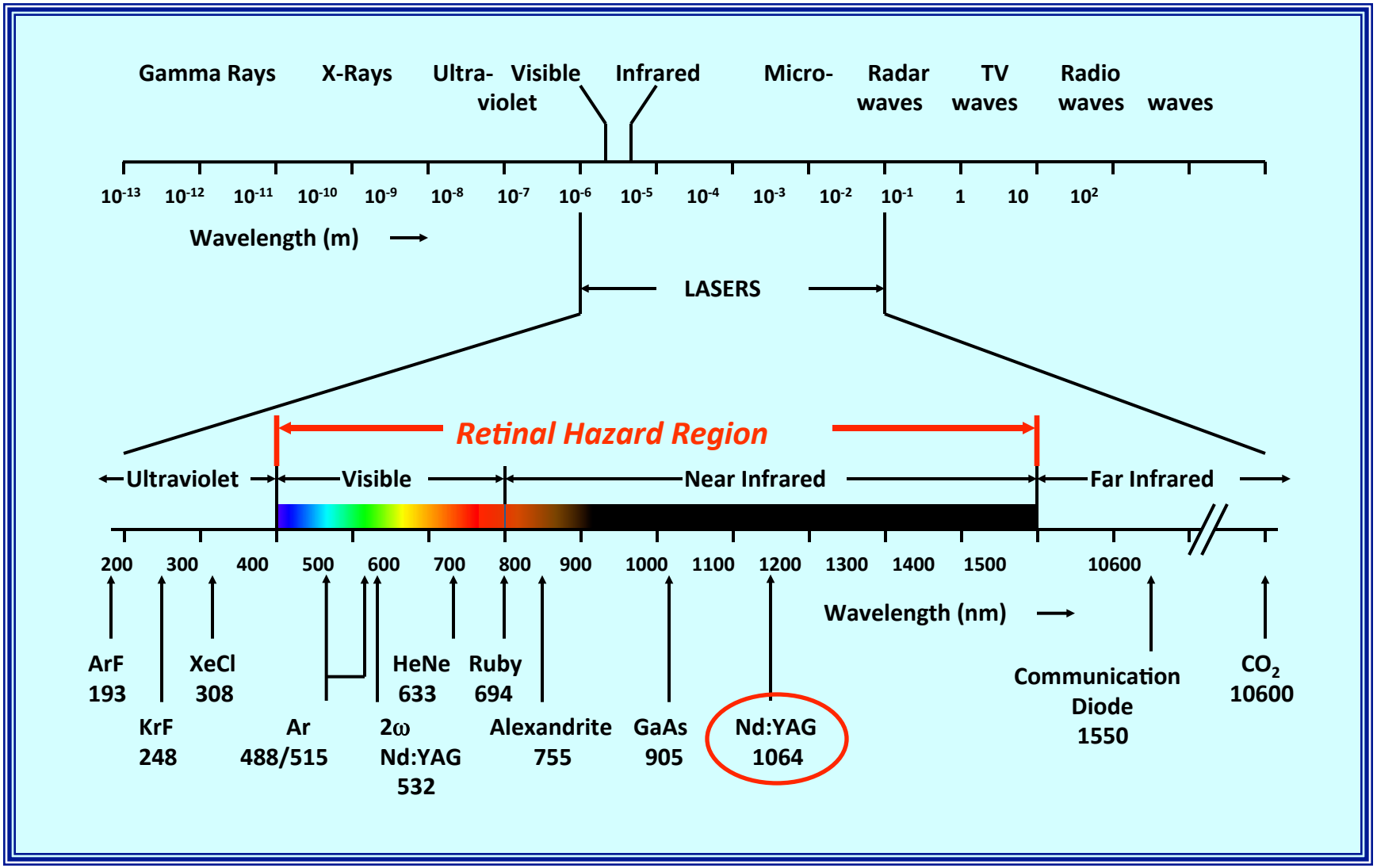


These three properties of laser light are what can make it more hazardous than ordinary light. Laser light can deposit a lot of energy within a small area.

Laser Components



LASER SPECTRUM



Laser Beam Injuries

- Laser injuries result from two types of effects:
  - **Thermal** injuries are caused by heating of the tissue as a result of the absorption of laser energy.
    - Micro-cavitation is a type of thermal effect that occurs when a short laser pulse is focused onto the retina. Most of the pulse energy is absorbed in a small volume heating the water in that volume to steam. This results in a microscopic steam explosion that separates retinal layers and ruptures blood vessels in the retina. This occurs with pulse durations of less than 18 ms for 400 to 1050 nm. This kind of injury results in significant vision loss and is the greatest risk for short pulse visible and near IR lasers.
  - **Photochemical** injuries occur because powered energy beams break molecular bonds inside living cells.

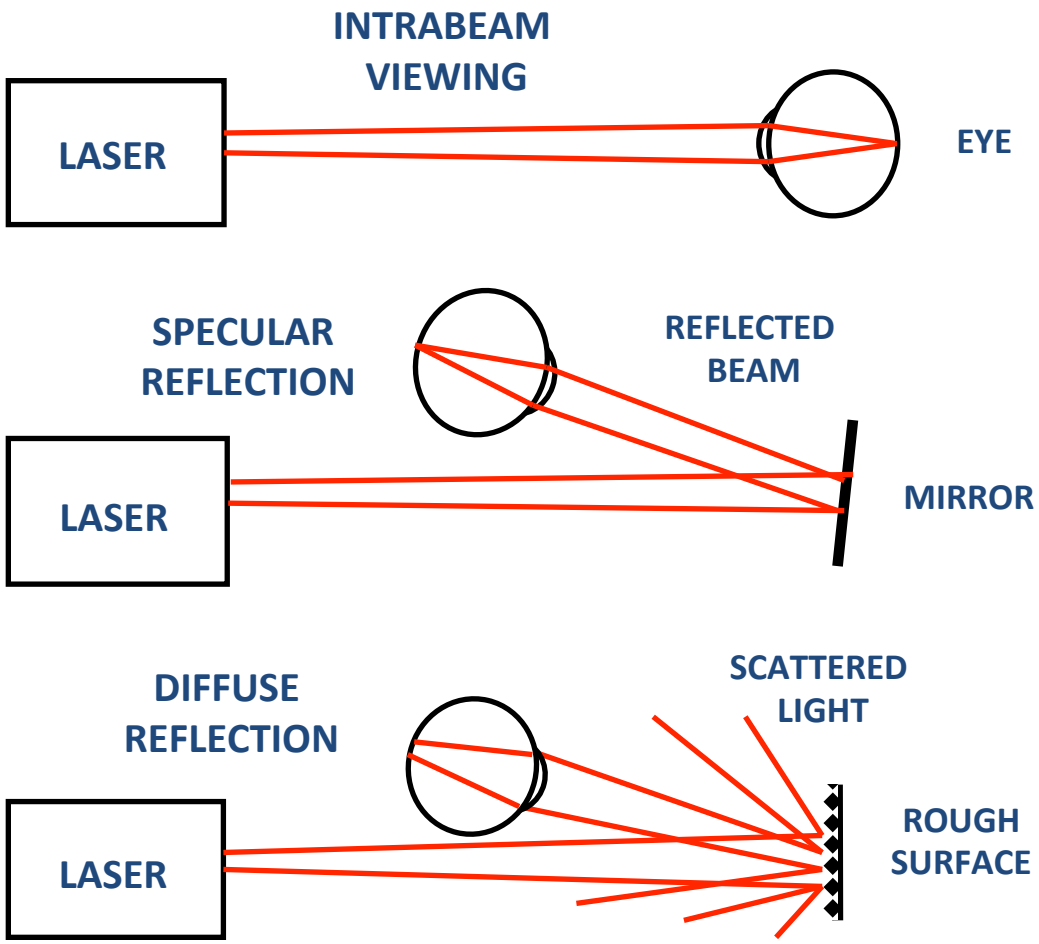
Lasers and Eyes

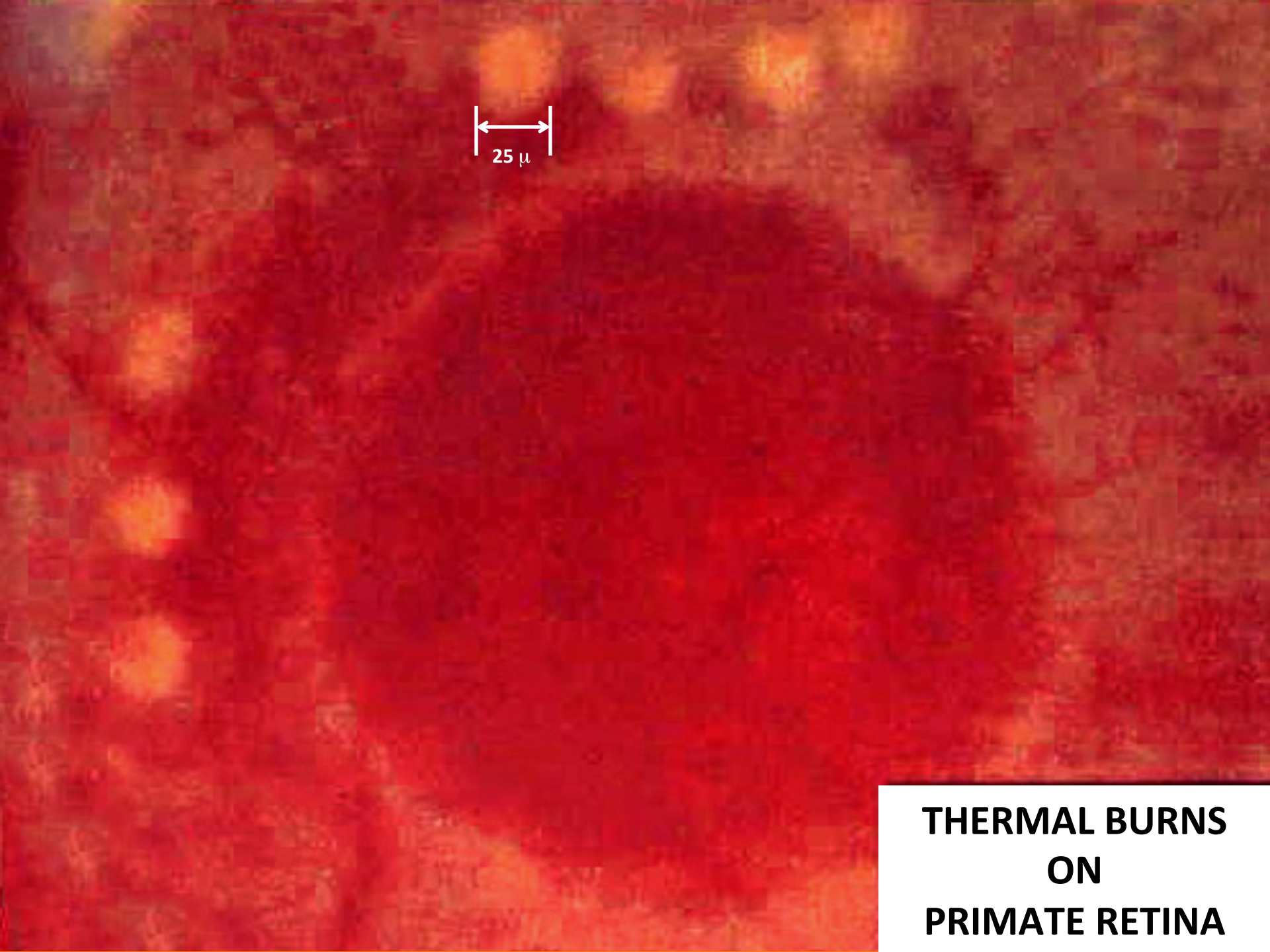
- What are the effects of laser energy on the eye?
  - Laser light in the visible to near infrared spectrum (i.e., 400 - 1400 nm) can cause damage to the retina resulting in scotoma (blind spot in the fovea). This wave band is also know as the "retinal hazard region".
  - Laser light in the ultraviolet (290 - 400 nm) or far infrared (1400 - 10,600 nm) spectrum can cause damage to the cornea and/or to the lens.
- Visual disorientation due to retinal damage may not be apparent to the operator until considerable thermal damage has occurred.

Symptoms of Laser Eye Injuries

- Exposure to a visible laser beam can be detected by a bright color flash of the emitted wavelength and an after-image of its complementary color (e.g., a green 532 nm laser light would produce a green flash followed by a red after-image).
- When the retina is affected, there may be difficulty in detecting blue or green colors and pigmentation of the retina may be detected.
- Exposure to the **Nd:YAG** laser beam (1064 nm) is especially hazardous and may initially go undetected because the beam is invisible and the retina lacks pain sensory nerves.

Types of Laser Eye Exposure





THERMAL BURNS ON PRIMATE RETINA

Multiple Pulse Retinal Injury

Skin Hazards

- Exposure of the skin to high power laser beams (1 or more watts) can cause burns.
  - At the under five watt level, the heat from the laser beam will cause a flinch reaction before any serious damage occurs.
  - With higher power lasers, a burn can occur even though the flinch reaction may rapidly pull the affected skin out of the beam.
    - Skin forms a hard lesion that takes considerable time to heal.
- Ultraviolet laser wavelengths may also lead to skin carcinogenesis.

Causes of Laser Accidents

- 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

Classification of Lasers

- Lasers are classified according to the level of laser radiation that is accessible during normal operation.
- In the U.S., laser classifications are based on American National Standards Institute's (ANSI) Z136.1 Safe Use of Lasers.

Laser Class

- The following criteria are used to classify lasers:
  - **Wavelength**. If the laser is designed to emit multiple wavelengths the classification is based on the most hazardous wavelength.
  - For continuous wave (CW) or repetitively pulsed lasers the **average power output** (Watts) and **limiting exposure time** inherent in the design are considered.
  - For pulsed lasers the **total energy per pulse** (Joule), **pulse duration, pulse repetition frequency** and **emergent beam radiant exposure** are considered.

ANSI Classifications

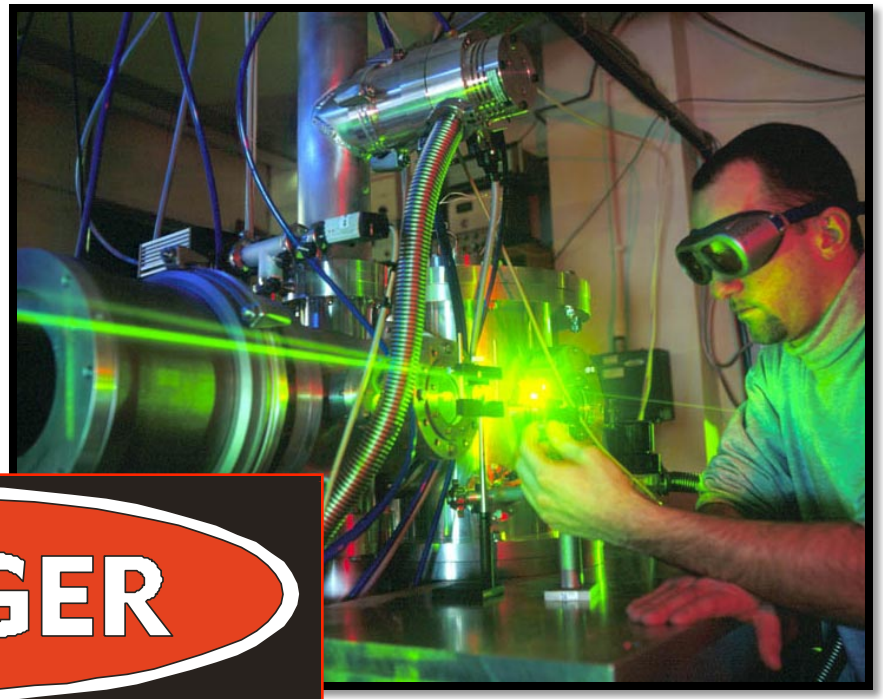
- **Class 1** denotes laser or laser systems that do not, under normal operating conditions, pose a hazard.
- **Class 2** denotes low-power visible lasers or laser system which, because of the normal human aversion response (i.e., blinking, eye movement, etc.), do not normally present a hazard, but may present some potential for hazard if viewed directly for extended periods of time (like many conventional light sources).

ANSI Classifications

- **Class 3R** denotes some lasers or laser systems having a CAUTION label that normally would not injure the eye if viewed for only momentary periods (within the aversion response period) with the unaided eye, but may present a greater hazard if viewed using collecting optics.
  - Class 3R lasers have DANGER labels and are capable of exceeding permissible exposure levels. If operated with care Class 3R lasers pose a low risk of injury.
- **Class 3B** denotes lasers or laser systems that can produce a hazard it viewed directly. This includes intrabeam viewing of specular reflections.
  - Normally, Class 3B lasers will not produce a hazardous diffuse reflection.

ANSI Classifications

- **Class 4** denotes lasers and laser systems that produce a hazard not only from direct or specular reflections, but may also produce significant skin hazards as well as fire hazards.



ANSI Classifications

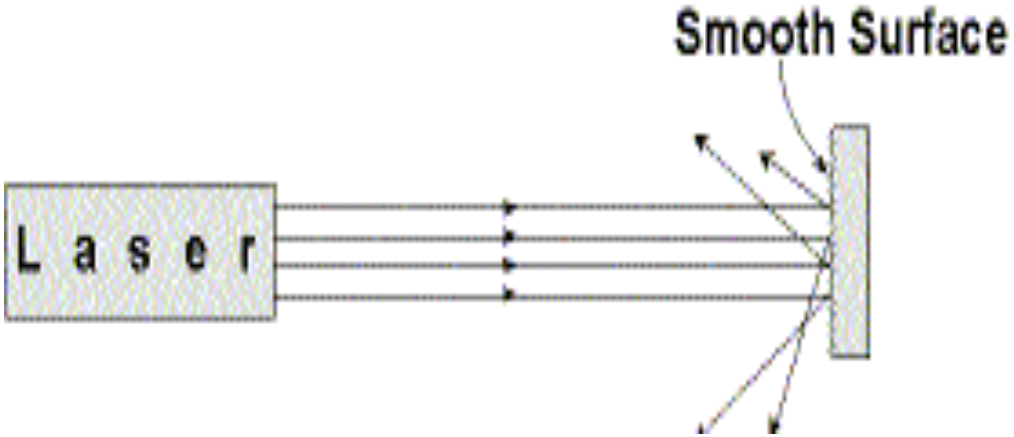
Class 1		Class 2		Class 3		Class 4
Class 1	**Class 1M**	**Class 2**	**Class 2M**	**Class 3R**	**Class 3B**	**Class 4**
Class I	No special FDA class	Class II	No special FDA class	Class IIIa (definition is different but results are similar)	Class IIIb	Class IV
For visible light, emits beam less than 0.39 milliwatts, or beam of any power is inside device and is not accessible during operation.		Emits visible beam of less than 1 milliwatt.		For visible light, emits beam between 1 and 4.99 milliwatts.	For visible light, emits beam between Class 3R limit (e.g. 5 milliwatts) and 499.9 milliwatts	For visible light, emits beam of 500 milliwatts (1/2 Watt) or more
No special caution/ warning indication		No special caution/ warning indication		**CAUTION**	**WARNING**	**DANGER**
	DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS	DO NOT STARE INTO BEAM	DO NOT STARE INTO BEAM OR EXPOSE USERS OF TELESCOPIC OPTICS	AVOID DIRECT EYE EXPOSURE	AVOID EXPOSURE TO BEAM	AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION
Safe, even for long-term intentional viewing. For visible light, usually applies when the laser is enclosed inside a device (ex: CD or DVD player) with no human access to laser light.	Safe for unaided eye exposure.	Safe for unintentional exposure less than 1/4 second. Do not stare into beam.	Safe for unintentional (< 1/4 sec) unaided eye exposure.	Unintentional or accidental exposure to direct or reflected beam has a low risk. Avoid intentional exposure to direct or reflected beam.	Eye hazard; avoid exposure to direct or reflected beam.	Severe eye hazard; avoid exposure to direct or reflected beam.
	May be hazardous if viewed with optical instruments such as binoculars or eye loupe.		May be hazardous if viewed with optical instruments such as binoculars or eye loupe.			
Not an eye hazard --	Consult an LSO as	**NOHD of 0.99 mW**	Consult an LSO as	**NOHD of 4.99 mW**	**NOHD of 499.9 mW**	**NOHD of 1000 mW**

Reflection Hazards

- **Specular reflections** are mirror-like reflections and can reflect close to 100% of the incident light.
- **Diffuse reflections** result when surface irregularities scatter light in all directions.

Reflection Hazards

Specular Reflection

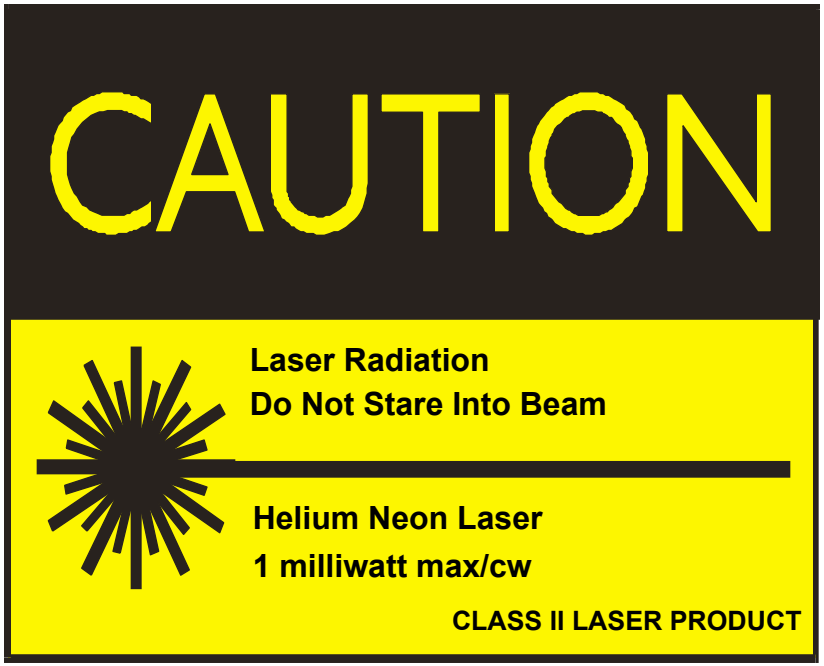


Diffuse Reflection

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)

CDRH Class Warning Labels

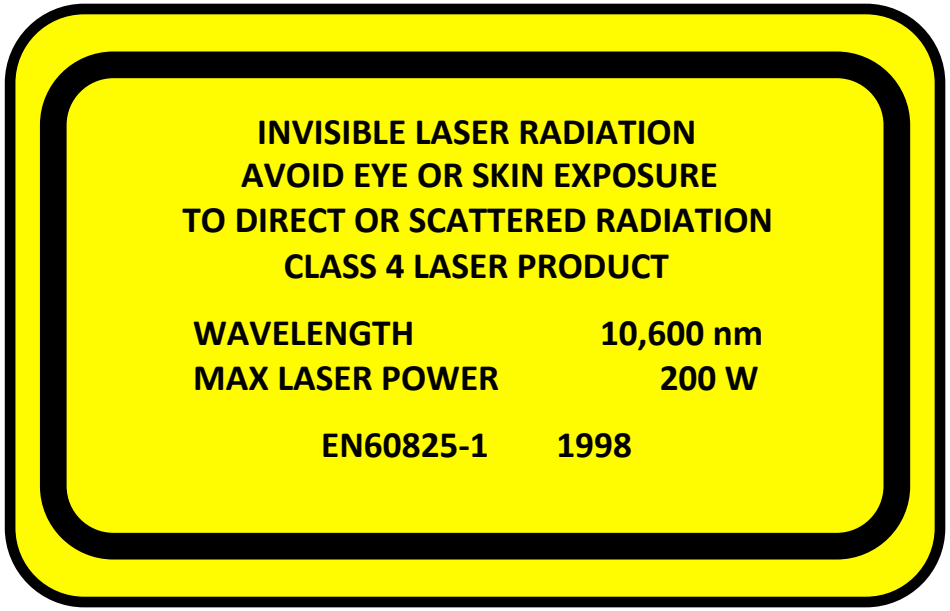


Class II
Class IIIR with expanded beam

Class IIIR with small beam
Class IIIB
Class IV

International Laser Warning Labels

Symbol and Border: **Black**
Background: **Yellow**



Legend and Border: **Black**
Background: **Yellow**

Laser Control Measures

- Engineering Controls
  - Interlocks
  - Enclosed beam
- Administrative Controls
  - Standard Operating Procedures (SOPs)
  - Training
- Personnel Protective Equipment (PPE)
  - Eye protection

Laser Protective Eyewear Requirements

- **Eyewear should always be worn when a near IR class 3B or class 4 beam is accessible.**
- The attenuation factor (optical density) of the laser protective eyewear at each laser wavelength should be specified by the Laser Safety Officer (LSO).
- All laser protective eyewear shall be clearly labeled with the optical density and the wavelength for which protection is afforded. This is especially important in areas where multiple lasers are housed.
- Laser protective eyewear shall be inspected for damage prior to use.

Common Laser Signs and Labels

Laser Protective Barrier

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

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

Eye Safety

- Always wear laser protective goggles when working with direct access to the laser beam.
  - Goggles provide protection against direct, reflected and scattered radiation.
  - Never look directly at the beam as intense laser radiation is capable of destroying the protective filter.
- If adjustment or maintenance work on the Class 4 laser equipment is necessary, all persons in the laser area must wear appropriate protective goggles.

Laser Injury

- If laser injury or suspected laser injury has occurred, immediately:
  - Switch off the laser
  - Notify your laser safety officer
  - Consult a doctor or go to the hospital

Fire Hazard

- Because of the high output power of certain laser systems, a wide range of material can be set on fire by direct or reflected laser radiation.
  - Paper
  - Curtains
  - Thin wooden panels
  - Flammable or explosive cleaning agents

Safety Manual

- Refer to the manual for important information on the safe operation of the system.

Any Questions?