Laser/Light Science & Safety

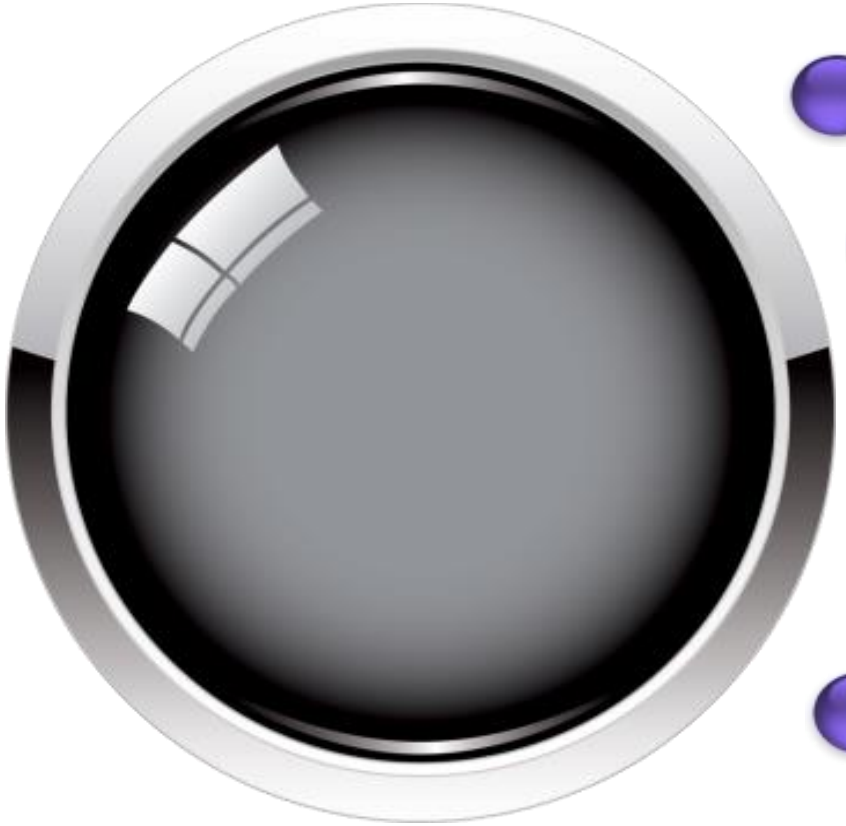
June 2021

Confidential

Laser Science & Safety

CYNOSURE® BEAUTIFUL ENERGY

Learning Objectives



- Laser Science Overview
- Understanding Selective Photothermolysis
- Lasers vs IPL
- Laser/Light Tissue Interactions
- Laser and IPL Safety Guidelines

What is a Laser?

Laser is an acronym – Light Amplification by Stimulated Emission of Radiation.

This describes exactly what laser light is doing in the apparatus prior to being released onto the tissue.

Light in the context of a laser beam is either Invisible or Visible.

Amplification is increasing energy to a certain intensity

Stimulated Emission is the molecular process by which light is amplified within the laser. (Einstein's theory)

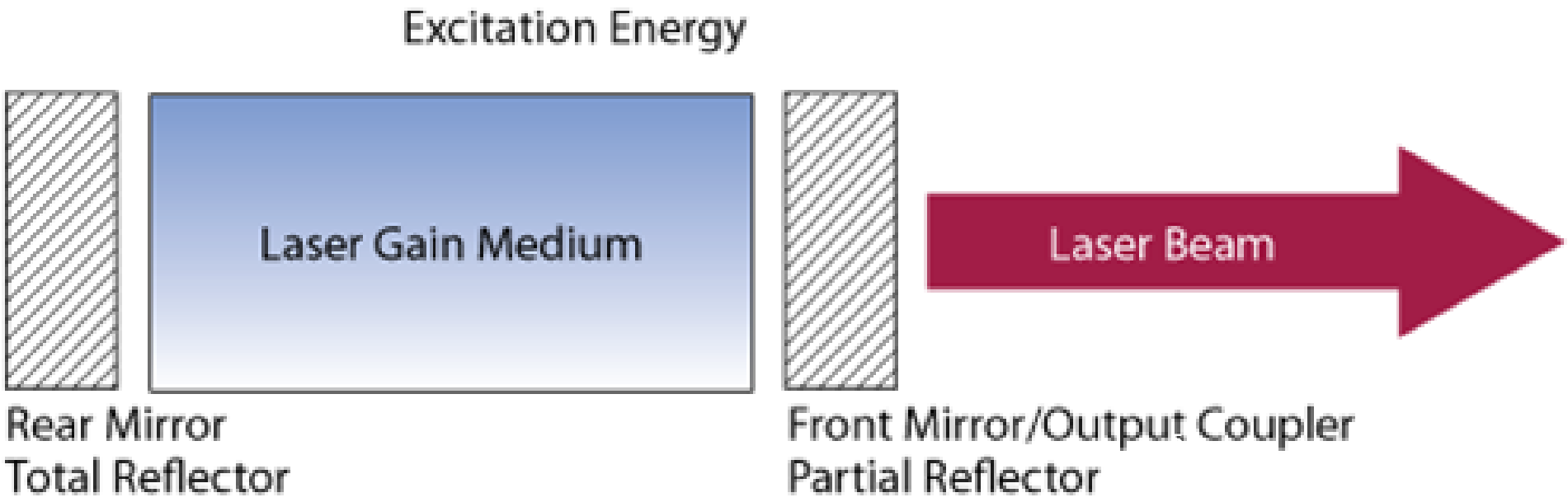
Radiation is a broad term used to describe the emission throughout the Electromagnetic Spectrum.

The Product of a Laser is LIGHT

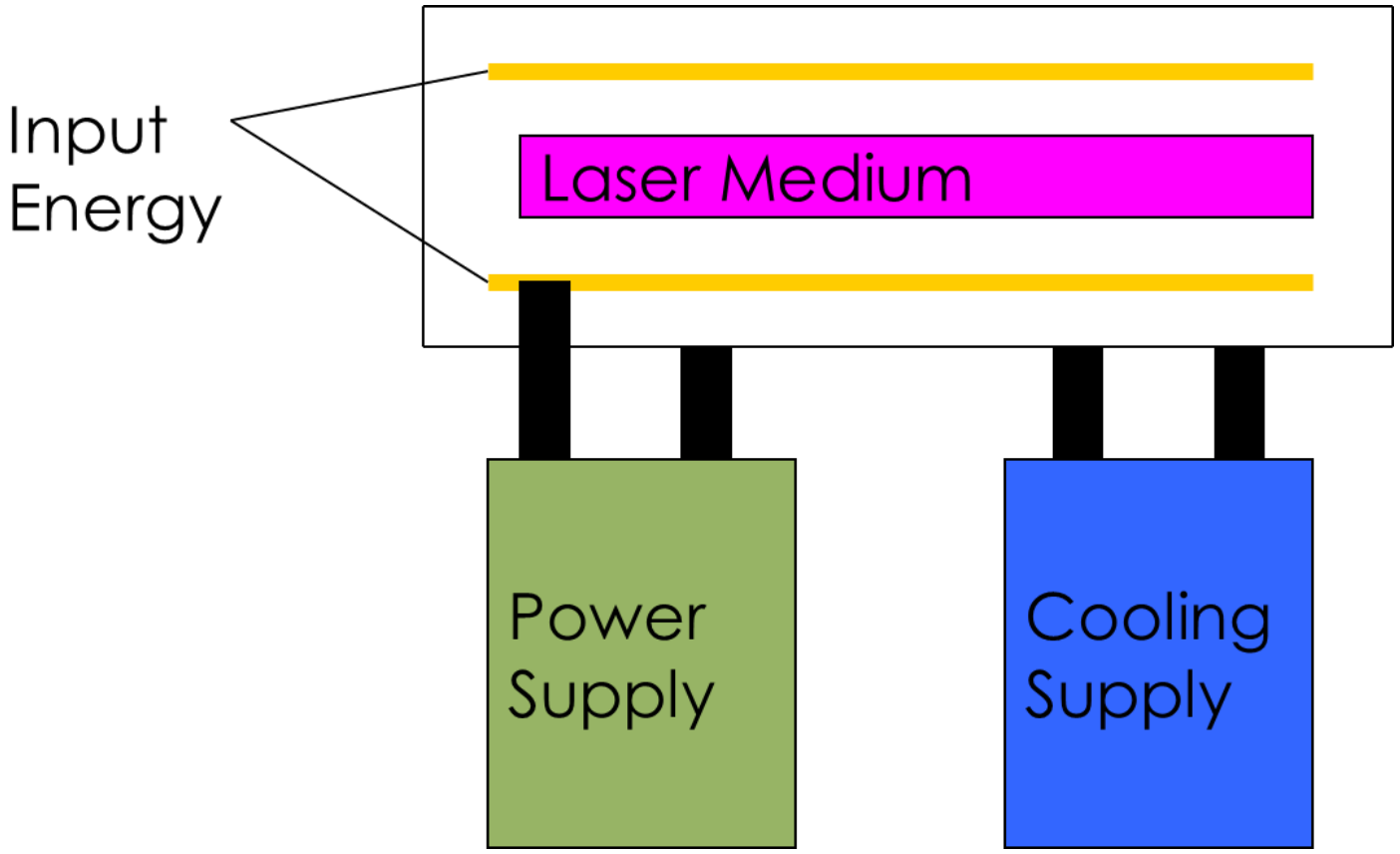
- Light is composed of packets of energy known as photons.
- All light on earth, other than laser light, is the result of ***spontaneous*** emission of photons.
- 1914 Albert Einstein postulated theory of ***Stimulated*** Emission of Radiation.
- Stimulated emission of radiation refers to the generation of extremely high intensity energy through an atomic process that results in release of identical and unidirectional photons.

Lasers

The Product of a Laser is Light…..



Lasers



Basics of a Laser:

- Power Supply
- Laser Medium
- Cooling Supply
- Delivery System

All Lasers have a Medium

The Medium of a laser is what it is named after as it is the energy source that creates the wavelength.

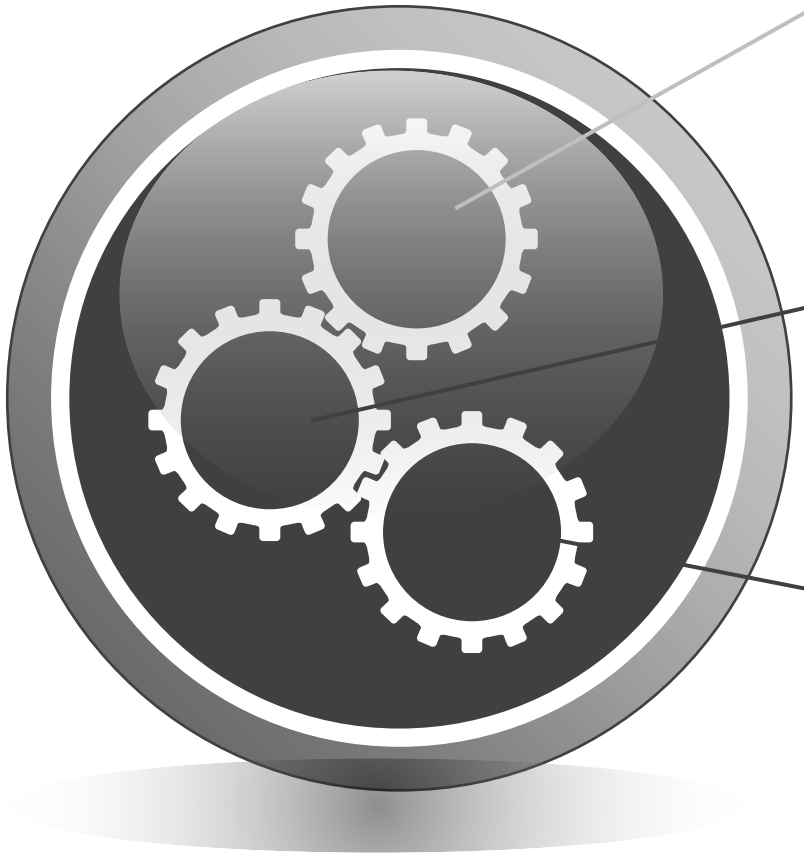
Solid lasers – Alexandrite 755NM, Diode 800-950 NM, 1064 NM Nd:YAG and 2940 NM Er;Yag These are solid substances.

Liquid lasers - PDL (Pulsed Dye Laser 585 NM to 595 nm)

Gas lasers – 532 NM KTP, 10,600 NM C02 to name a couple

Understanding Selective Photothermolysis

Theory of Selective Photothermolysis; Anderson & Parrish, 1983



Wavelengths

Light of a Specific wavelength is selectively absorbed by the target chromophore.

Pulsewidth

Exposure (**pulsewidth**) is limited to less than the thermal relaxation time of the chromophore.

Fluence

Sufficient *fluence* (**energy**) reaches the chromophore to cause the desired effect.

Selective Photothermolysis

Selective: The procedure “selects” an abnormal area to treat in contrast to the surrounding tissue.

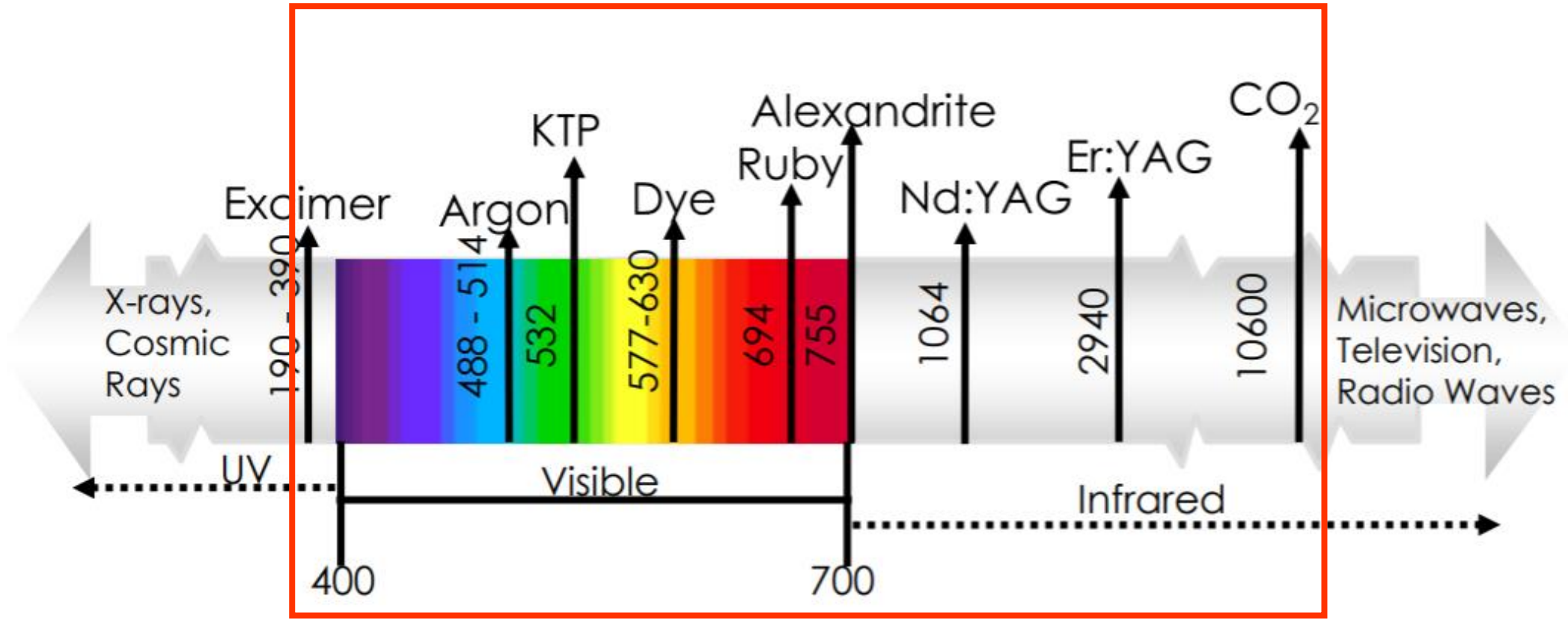
Photo: The laser sends out light

Thermo: HEAT – The light now creates heat

Lysis: Refers to destruction

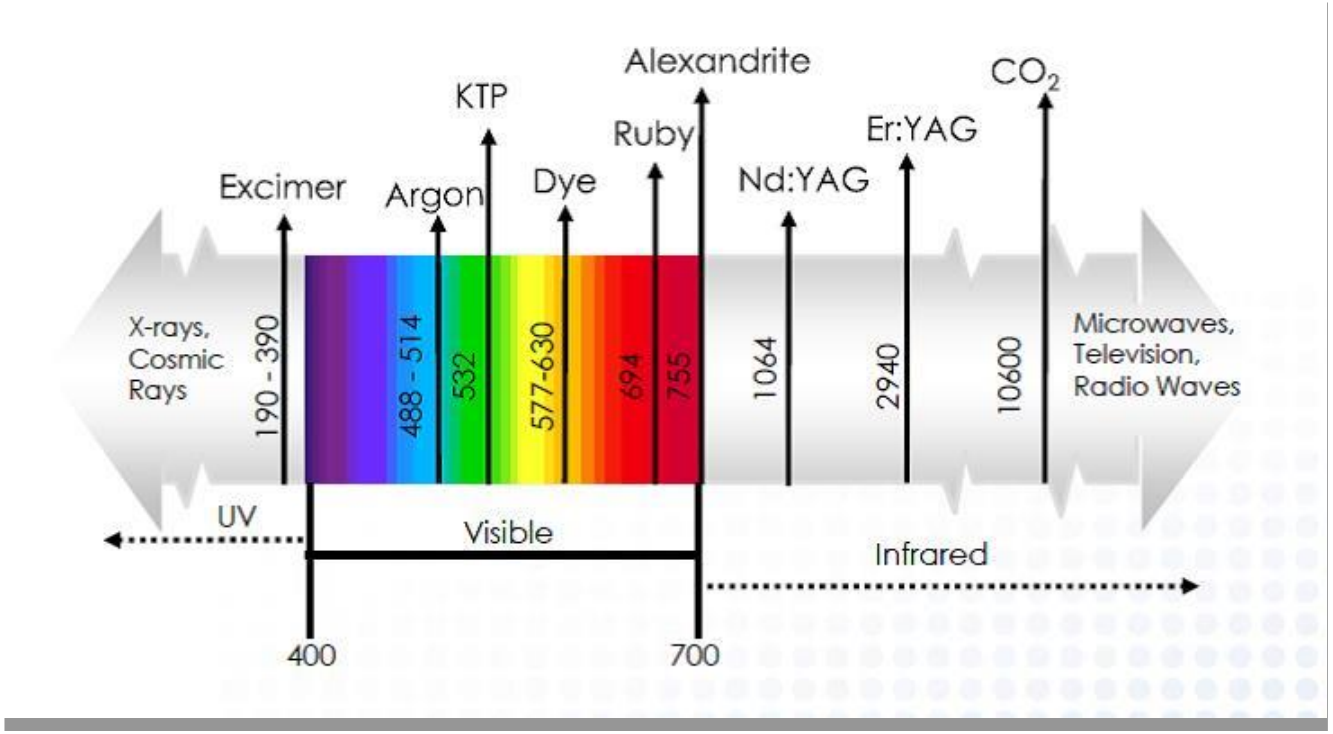
Selective Photothermolysis refers to using light to heat and destroy tissue in a selective area of the body.

Electromagnetic Spectrum- WAVELENGTHS

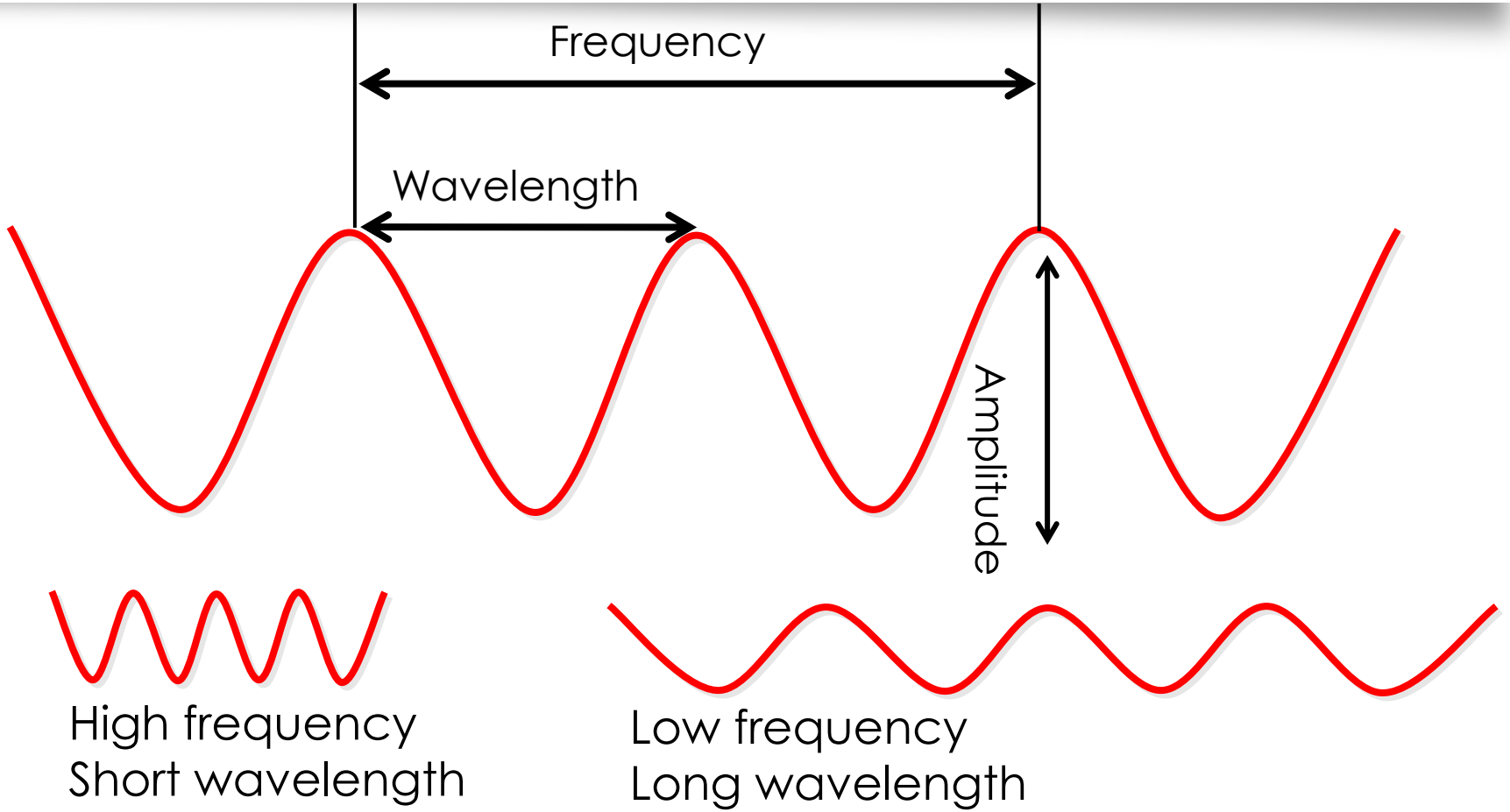


EMS: Electromagnetic Spectrum

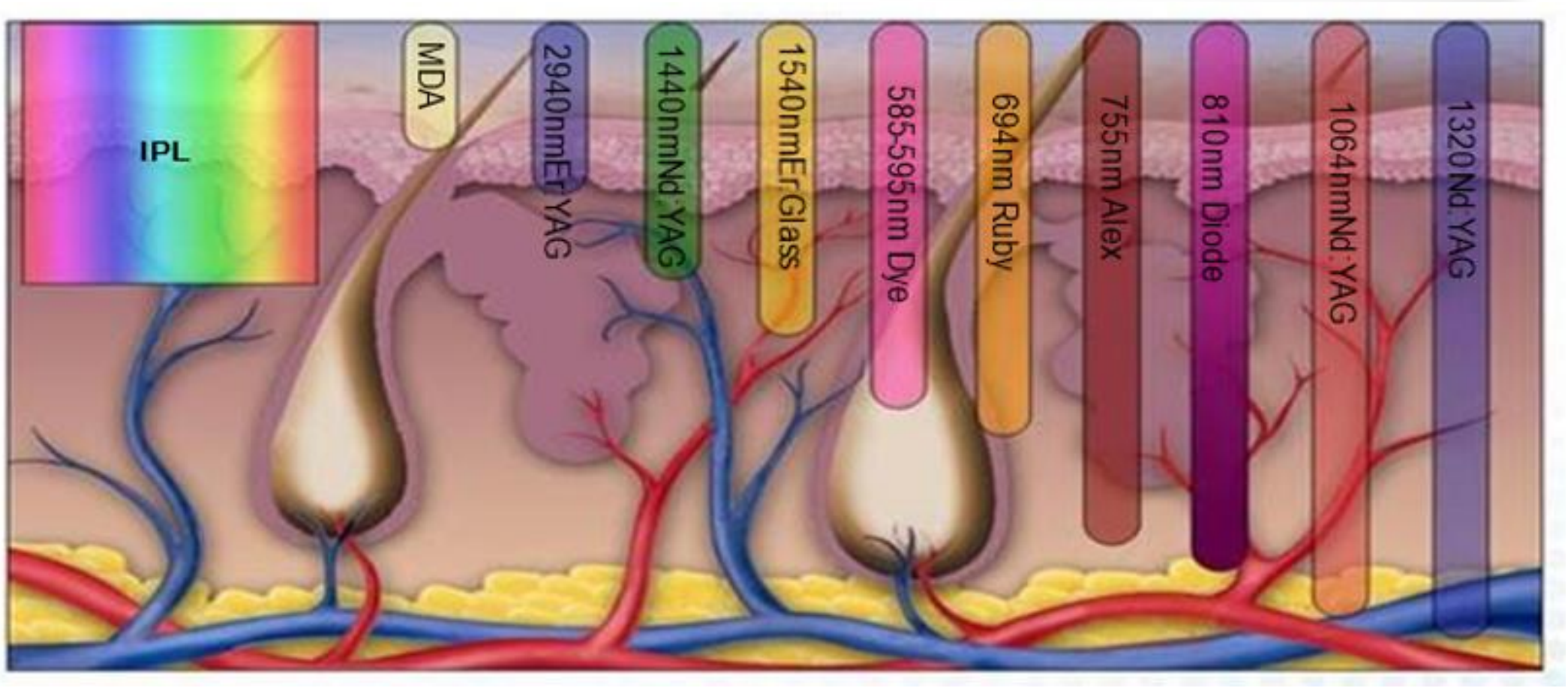
- This chart shows many different wavelengths for Aesthetic Lasers measured in Nanometers
- Nanometers is a measurement of light and measured as a billionth of a meter
- The EMS has 2 areas of Laser wavelengths – Visible and Invisible
- Visible wavelengths are what we can see with a naked eye
- When is comes to visible wavelengths – the shorter the wavelength the more hazardous it is to darker skin and the more heat on the surface of the skin



Frequency & Wavelength

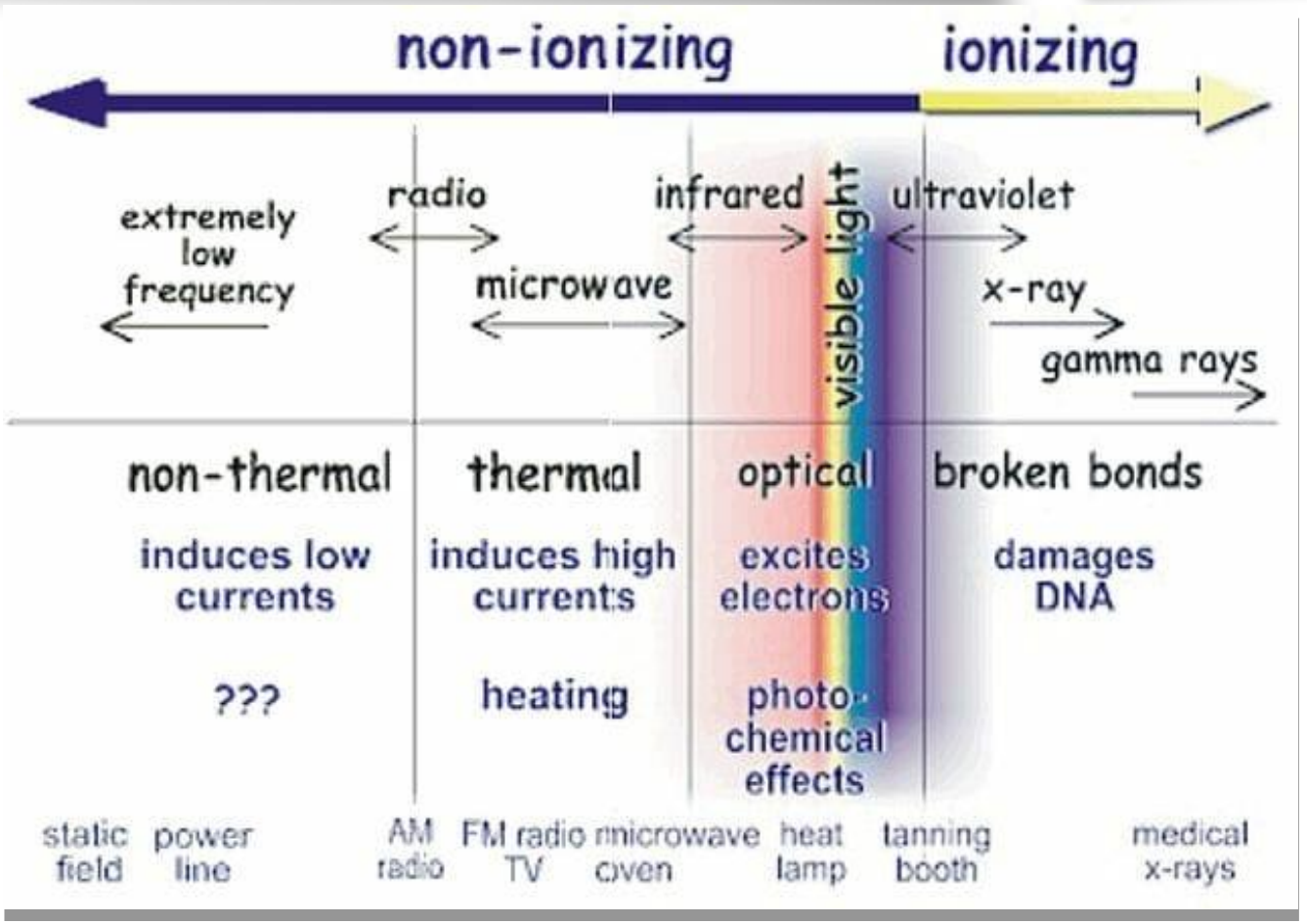


Wavelength Depth of Penetration with Comparable Spot Sizes Used



Non-Ionizing VS Ionizing

- There is Non-Ionizing Radiation and Ionizing Radiation in the EMS
- Aesthetic Lasers do not use Ionizing Radiation.
- Ionizing Radiation – Less than 400 NM is small and fast and can get into the DNA and RNA of your cells. This type of Radiation can cause cancer cumulatively and is why we do not use it.
- Non-Ionizing Radiation – 400 NM to 10,600 NM is what we use in the Medical Aesthetic Industry.

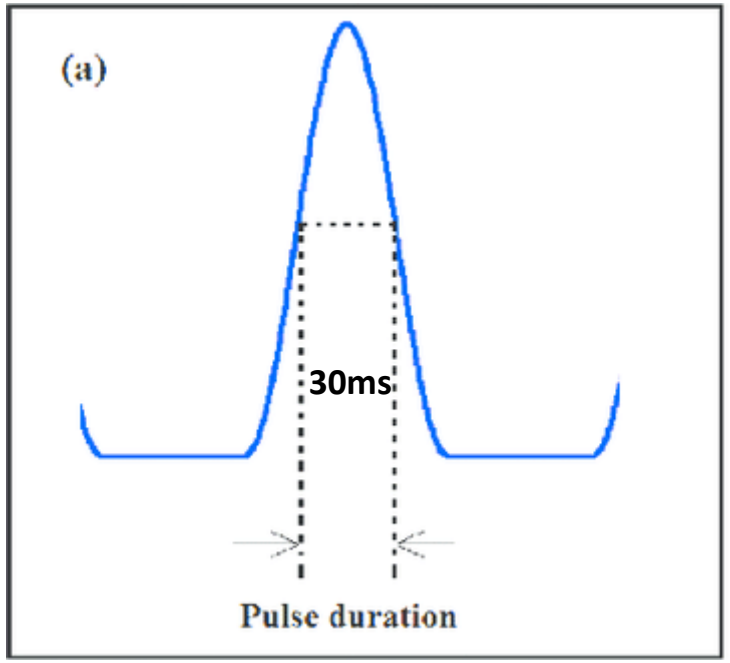


Understanding Pulsewidth

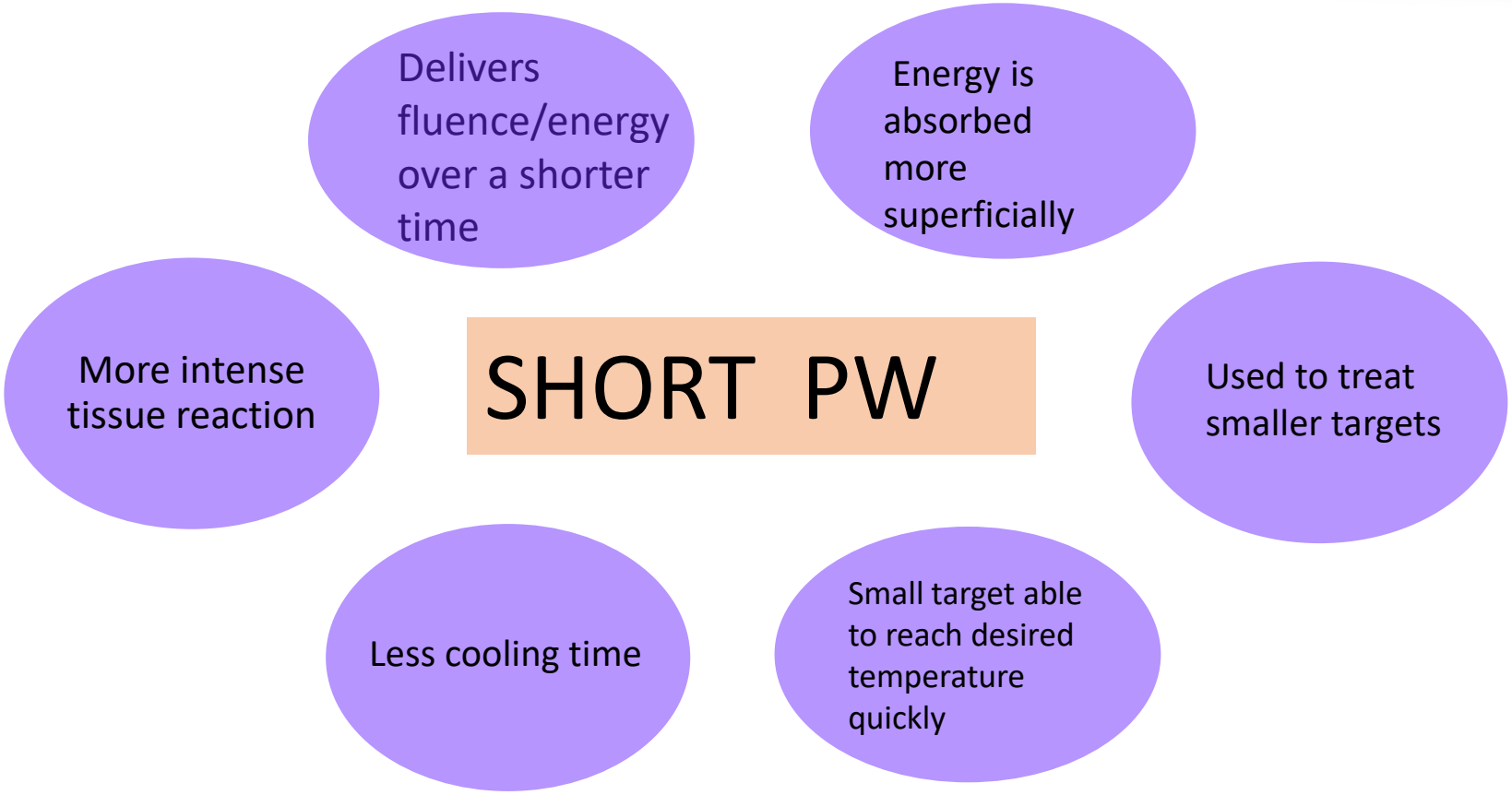
Different Words, Same Meaning

- Pulsewidth
- Pulse Duration
- Ms (millisecond)
- Time

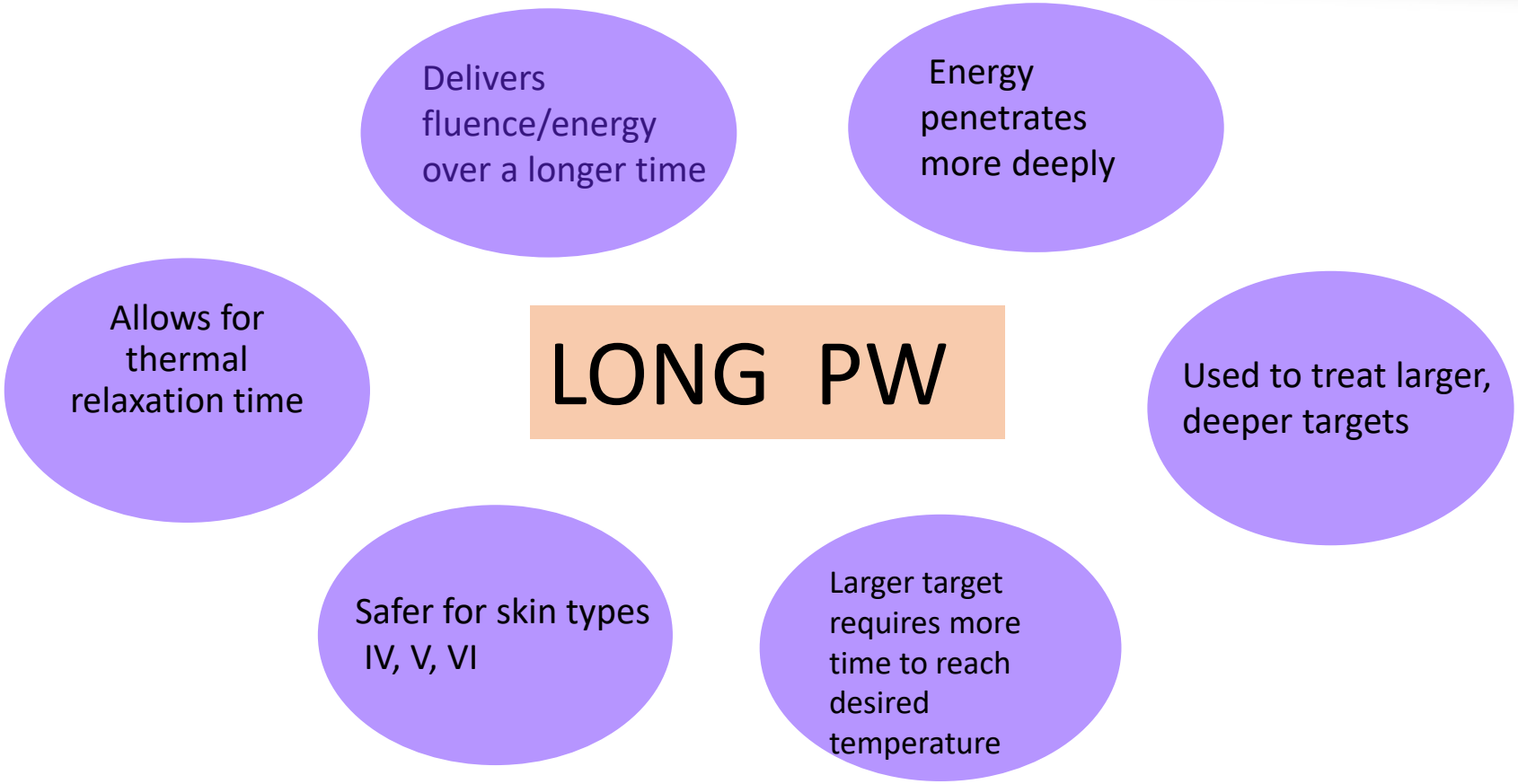
The length of time the laser or light is being emitted



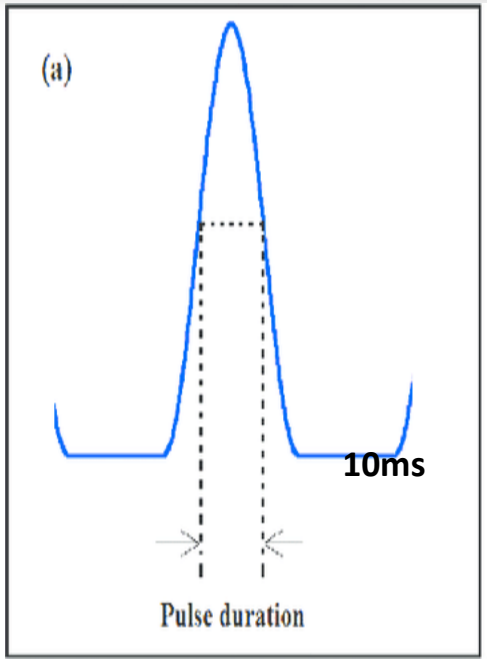
Characteristics of a Short Pulsewidth

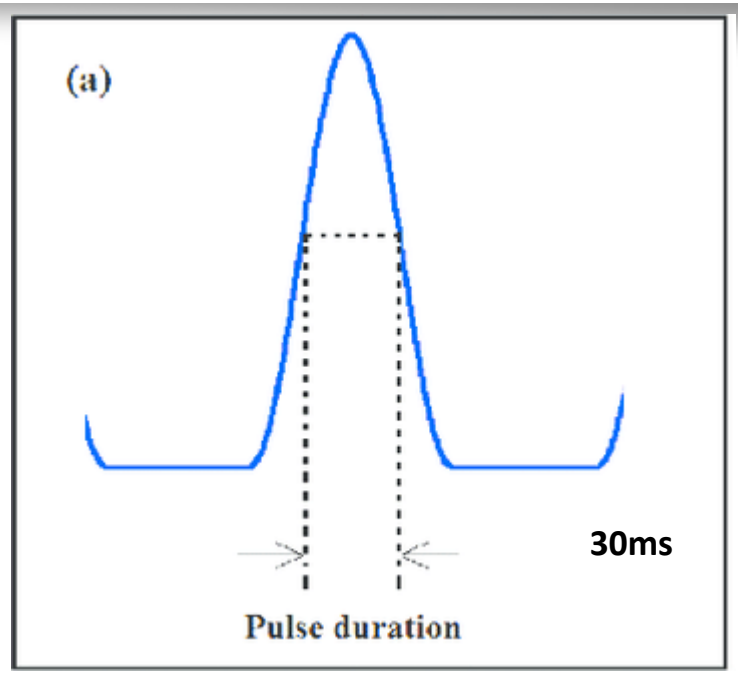


Characteristics of a Long Pulsewidth



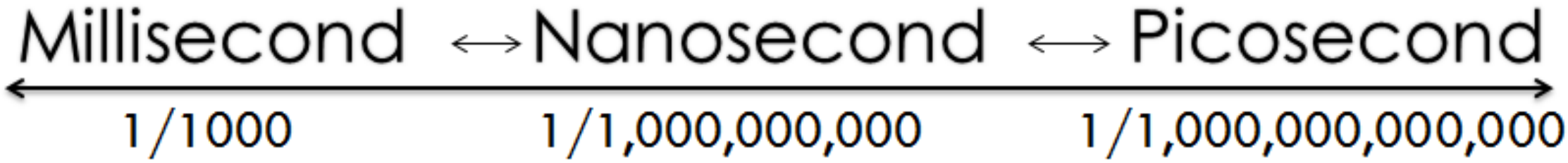
Short PW vs. Long PW - Simplified





Think… Short temper/Short PW = Aggressive

Pulse Duration (Pulsewidth)



Photothermal

Selective Photothermolysis

- Thermal confinement
  - Optimal heating
  - Minimum collateral damage
- Laser parameters
  - Strongly absorbed by target
- Wavelength
  - Pulse duration ≤ relaxation time

Photomechanical

- Mechanical forces
  - Target pressure
  - Minimum collateral damage
- Laser parameters
  - Strongly absorbed by target
    - Wavelength
  - Pulse duration consistent with acoustic propagation

Understanding Fluence

- **Energy fluence:** The energy contained within light is expressed in joules (J). The *energy fluence* determines the amount of laser energy delivered in a single pulse and is expressed in joules/cm^2
- The **fluence can** be **increased** by the reduction of the **laser** beam to a smaller spot size area. However, this results in a longer treatment time. More importantly, the effective treatment **fluence** is reduced at smaller spot sizes

Understanding Fluence

The Heat and Energy is measured and set on the device as Fluence or Joules. Although they are used as a same meaning most of the time the actual breakdown is shown below.

- Fluence – The parameter that is adjusted based on clinical response of the skin. It is increased or decreased to achieve desired results.

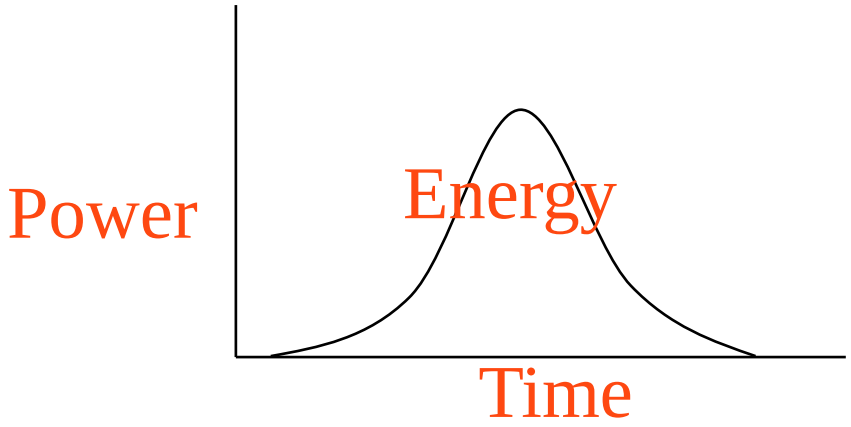
- Joule – The total amount of energy that a laser light delivers.

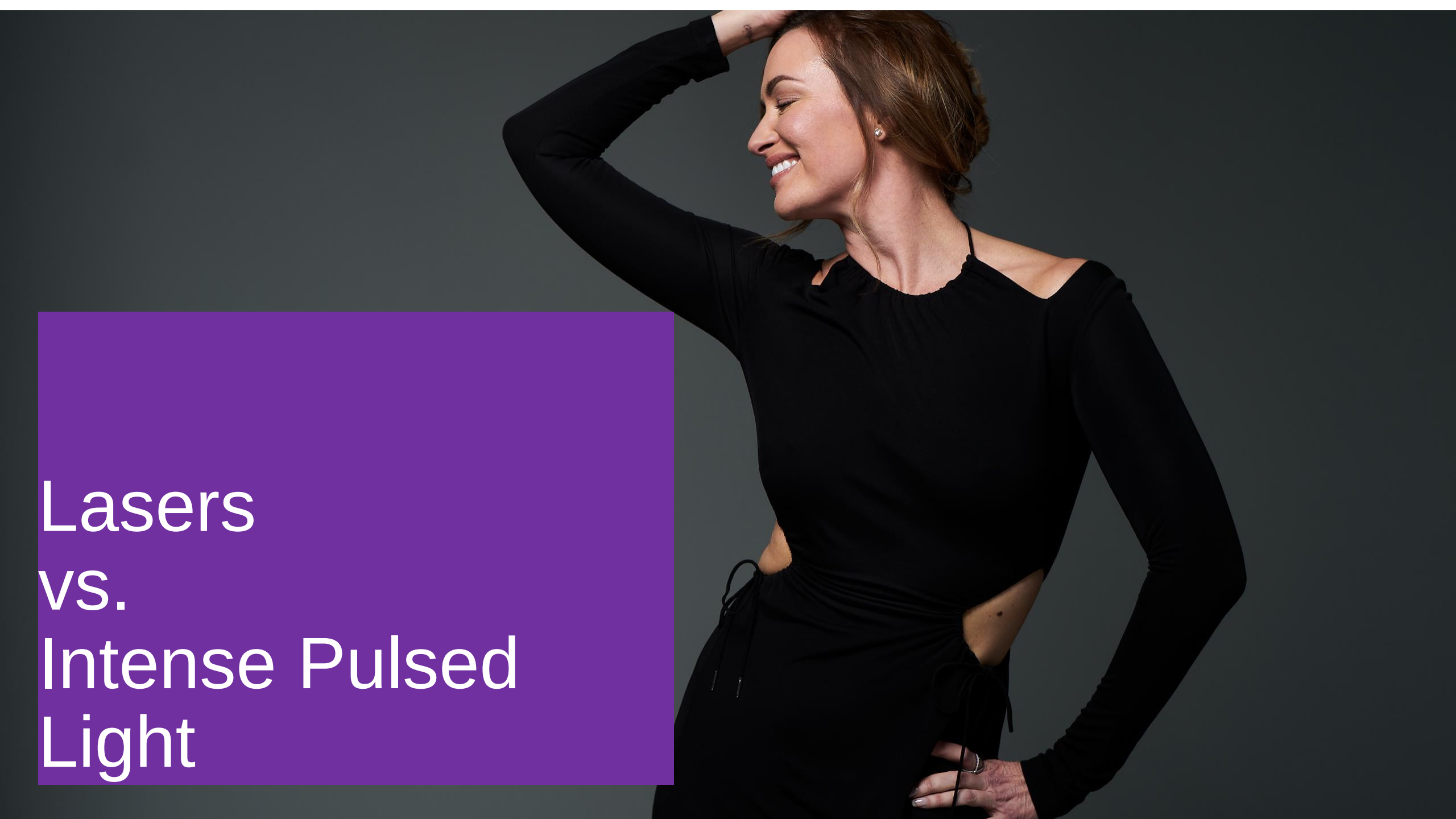
- Fluence = $\frac{\text{Joules}}{\text{CM2}}$

This formula is the energy over the spot size

Laser Output Terminology

- Power - measured in WATTS
- Pulse Duration - measured in SECONDS
- Energy - measured in JOULES
- Frequency - measured in HERTZ
- Fluence - the amount of energy(J) applied to the tissue per unit area (cm^2) or J/cm^2



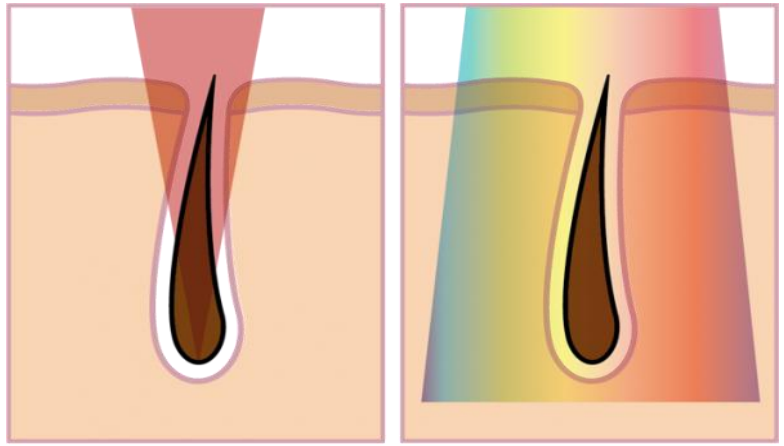


Lasers vs. Intense Pulsed Light

Lasers vs IPL

Lasers produce a very specific type of light consisting of one wavelength or color of light all going in one direction, which creates a single beam like a laser pointer.

IPL devices produce a wide range of wavelengths of light to produce a single white flash. This light is closer to natural light and can appear with an orange/red glow when the device is flashed against the skin, like a camera flash.



Properties of a Laser

Monochromatic

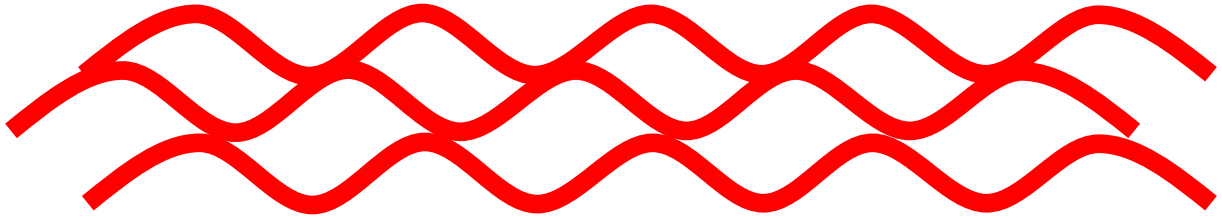
Coherent

Collimated

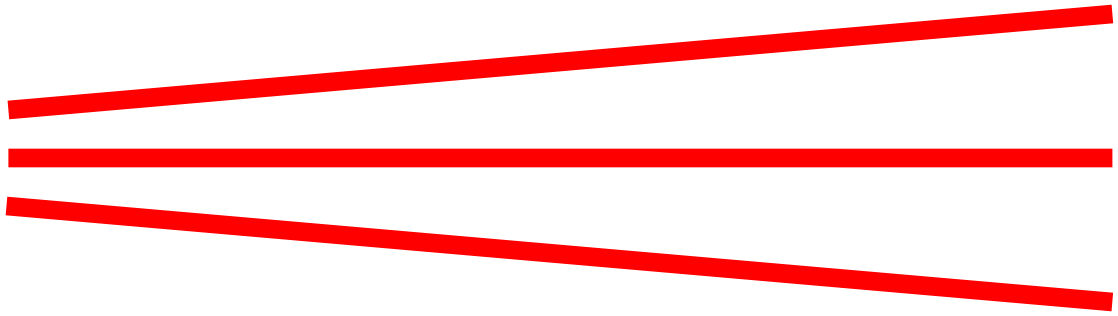
Properties of Pulsed Light

Polychromatic

Incoherent / Divergent

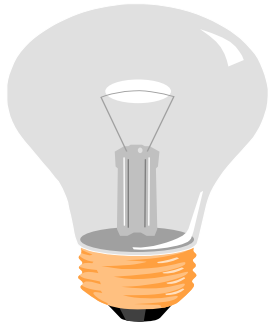


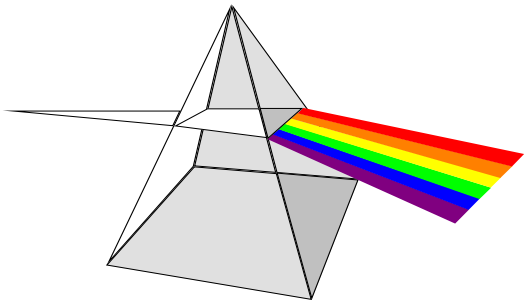
Non-Collimated / Diffused



Lasers vs. Pulsed Light

Lasers	Pulsed Light
Monochromatic	Polychromatic
Coherent	Divergent
Collimated	Diffused





Cynosure Correlation to IPL Wavelengths

Cynosure Device	Type of IPL System	Purpose	Wavelengths	Fitzpatrick Skin Type
Icon/ Max R, Rs,	Intense Pulse Light	IPL Hair Removal	650 NM to 1200 NM	1-6
Icon/ Max Ys	Intense Pulse Light	IPL Hair Removal and Photo Facial Body	525 NM to 1200 NM	1-4
Icon/ Max G	Intense Pulse Light	IPL Vascular, Pigment, and Photo Facial Face, Neck, Chest	500nm to 670nm & 870nm to 1200nm	1-4

Cynosure Correlation to Laser Wavelengths

Cynosure Device	Type of Laser System	Purpose	Wavelength	Fitzpatrick Skin Type
Elite, Elite Plus, Elite IQ	755 Alexandrite 1064 Nd:YAG Laser	LHR, Pigmented Lesions, Vein Reduction, Skin Rejuvenation	755 NM 1064 NM dual laser	1-3: 755 NM 1-6: 1064 NM
Vectus	800 Diode Laser	LHR	800 NM	1-6
Picosure	Picosecond Laser 532 optional 755 1064 optional	Tattoo Removal Skin Rejuvenation Pigmented Lesions, Fractional Focus	755 NM	1-6
Rev-Lite	532/1064 Q Switch, 585, 650 Dye Laser	Tattoo Removal Skin Rejuvenation, Pigmented Lesions		

Cynosure Correlation to Wavelengths

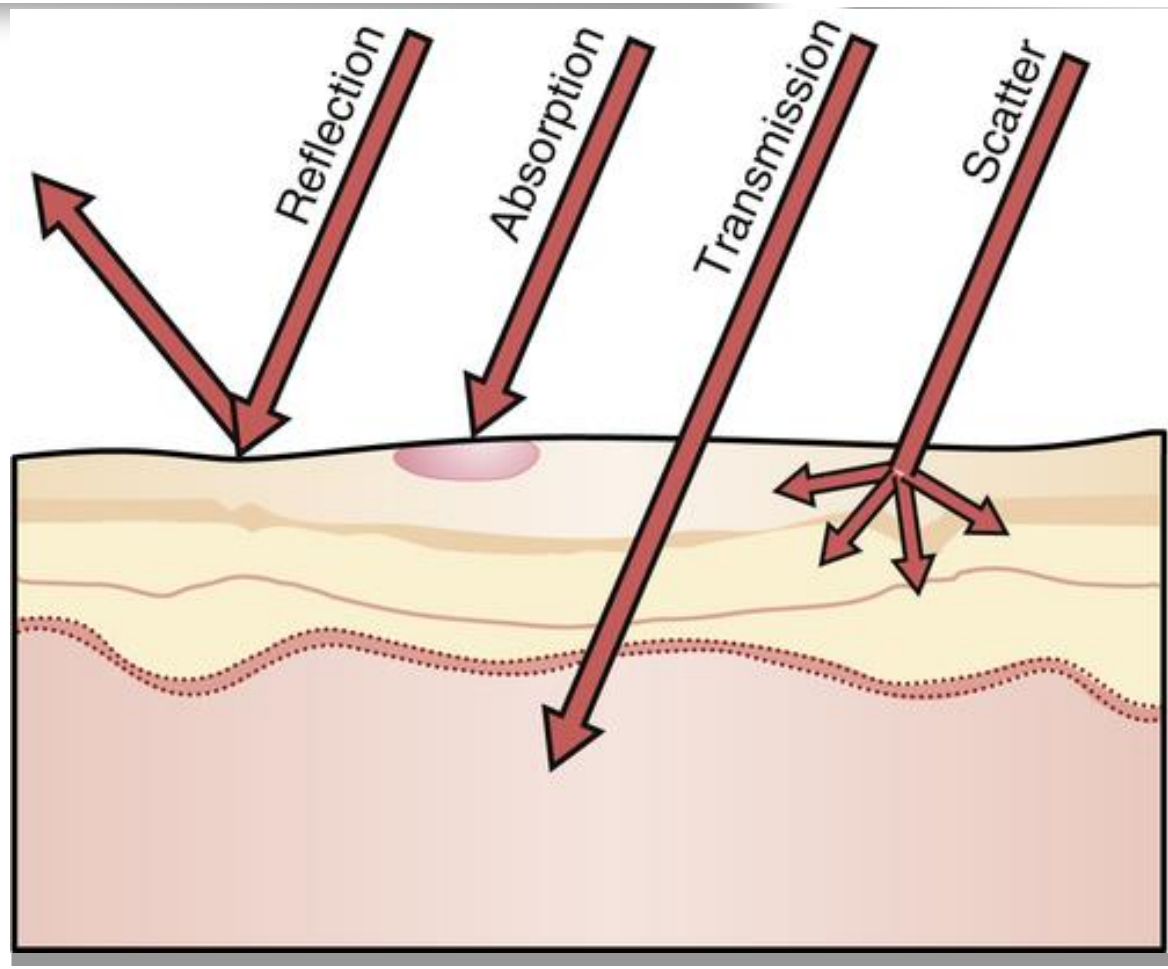
Cynosure Device	Type of Laser	Purpose	Wavelength	Fitzpatrick Skin Type
Sculpsure	1060 Diode	Body Contouring Lipolysis	1060 NM	1-6
Smart Lipo Triplex,Precision,Cellulaze	1064, 1320, 1440 Nd;YAG	Laser Assisted Lipolysis	1064 NM, 1320 NM, 1440 NM	1-6
Smart Xide Mona Lisa Touch, AXT, Surgical	10,600 C02	Gynecologic Use, Skin Revitalization/ Ablative, Surgical upgrade available	10,600 NM	1-6 Gynecological 1-3 Skin Revitalization
Smart Skin	10,600 C02	Skin Revitalization/ Ablative	10,600 NM	1-3

Lasers/Light Tissue Interactions

Light and Tissue Interaction

- When you use a laser or IPL on the skin, the following takes place.
- Refection/Absorption/

  Transmission/Scatter
- Absorption is the most important one and is directly relevant to the target chromophore present and the Spot size of the delivery.

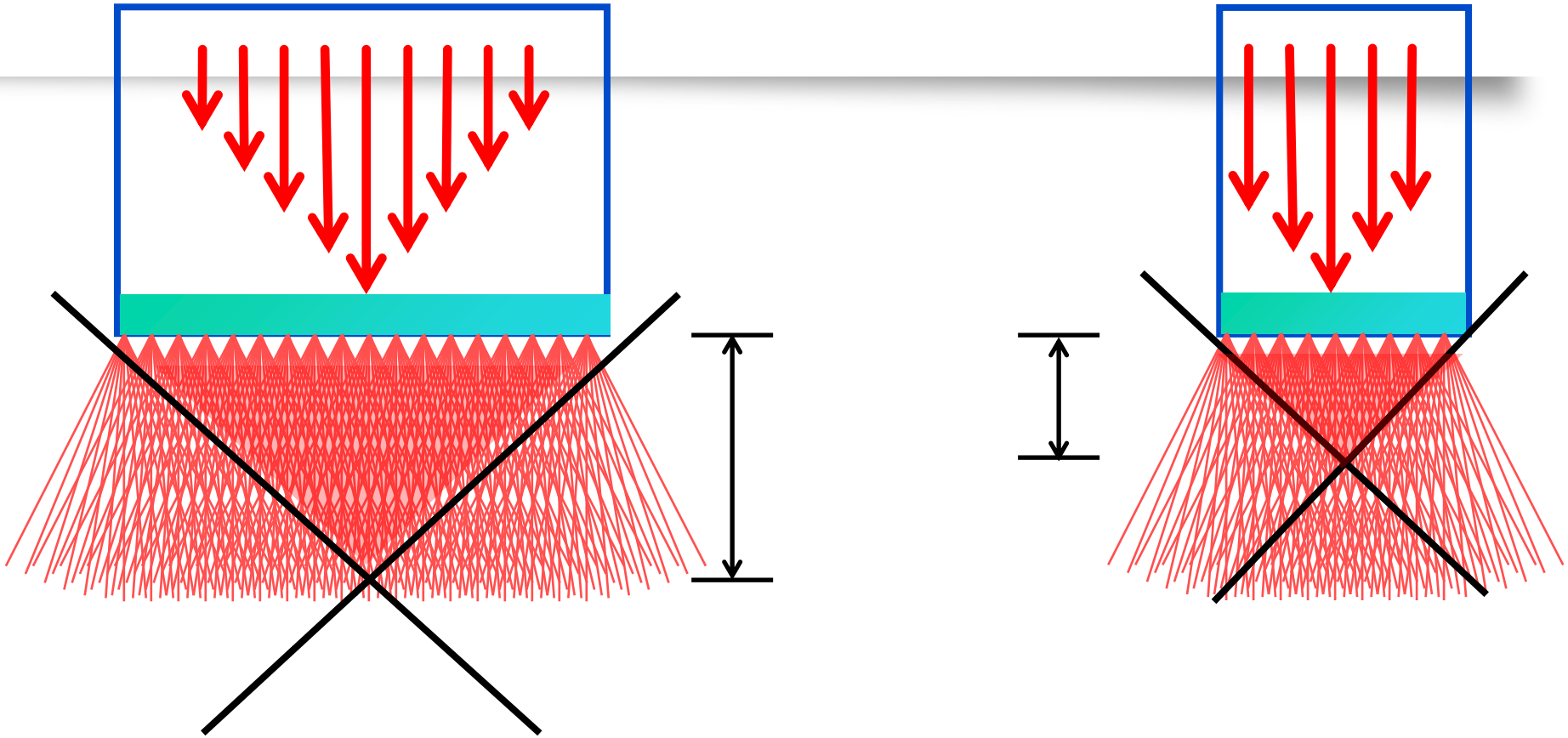


Understanding Spot Size

Spot Size

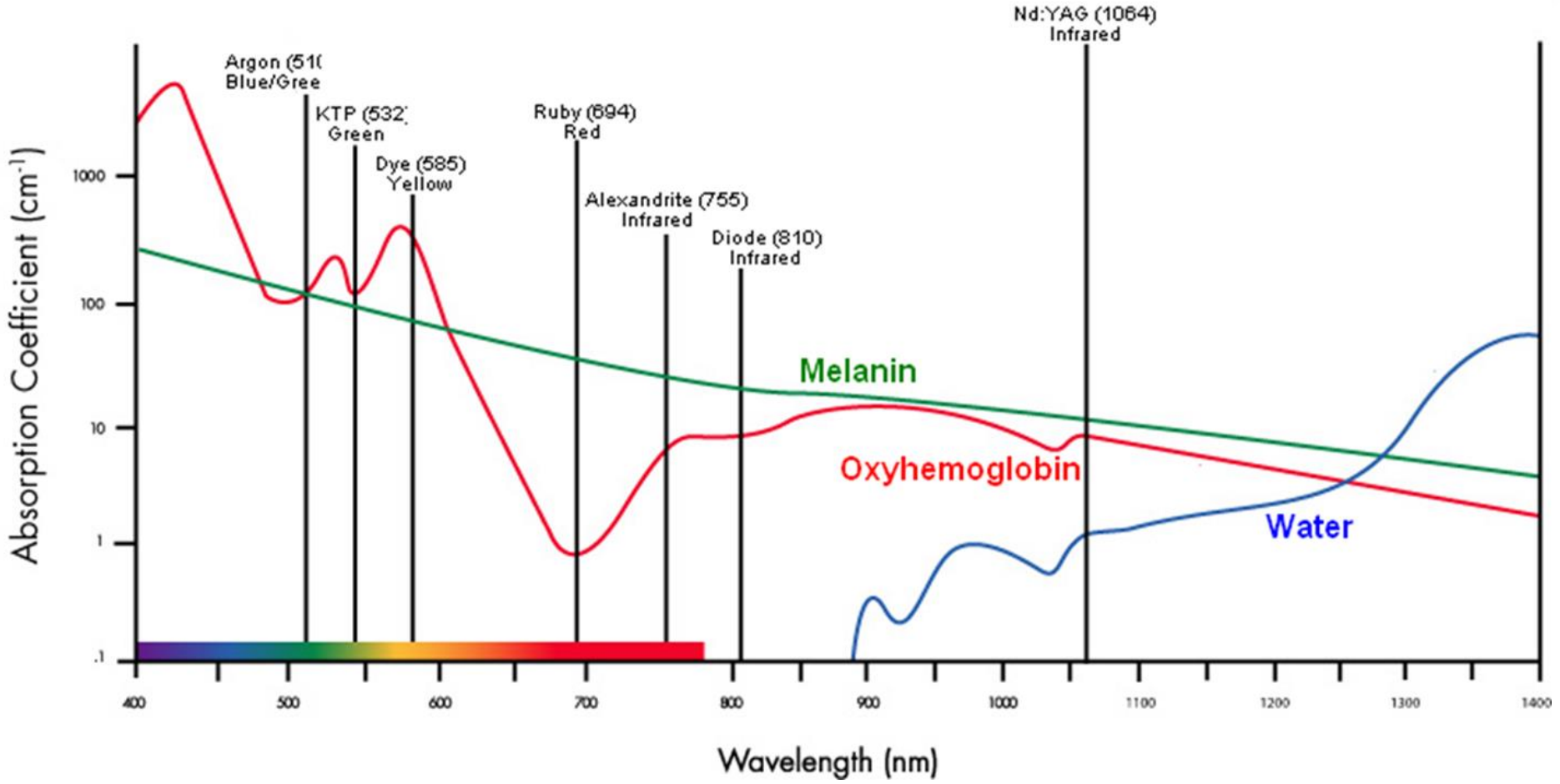
- Larger Spot sizes are used for deeper penetration and larger targets
- Smaller spot sizes are used to treat shallower conditions and smaller targets

Large Spot Size = Better Penetration



Note difference in depth of optimal penetration.

Target Chromophores



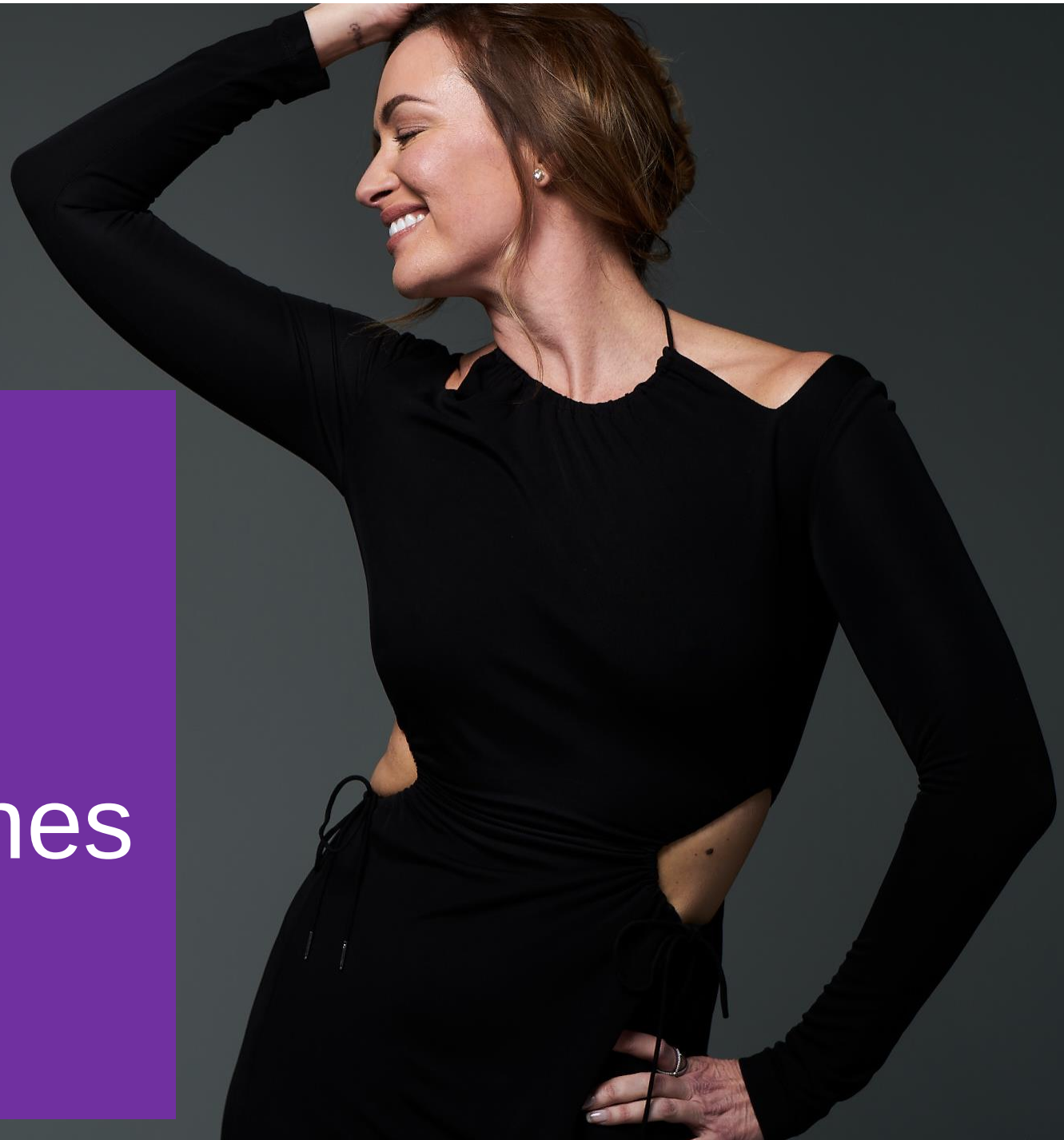
Target Chromophores

- Wavelengths that absorb Blood cauterize the vessel so it can be removed by the body
- Wavelengths that absorb Melanin trigger a response to rapidly proliferate cells off in the case of pigment on the face or body
- Melanin absorbing wavelengths also target artificial melanin in the case of a tattoo where it damages it to the point of body elimination with a wound healing response
- Melanin absorbing wavelengths also use the color of the hair to travel to the mother stem cell inside the follicle and perform hair reduction procedures
- Wavelengths that target Water, heat the tissue causing a wound and stimulating a growth of new Collagen and Elastin. This helps to reduce Acne pit scars, wrinkles, surgical scars and striae

Unique Clinical Targets (Chromophore)

Application	Target Chromophore	Effect
Hair Removal	**Melanin**	Cell Destruction
Pigmented Lesions	**Melanin**	Cell Destruction
Vascular Lesions	**Oxyhemoglobin**	Coagulation
Skin Rejuvenation	**Water**	Vaporization
Acne	**P. acnes Bacteria**	Inhibit Bacteria
Laser-Assisted Liposuction	**Lipid**	Lipid Liberation from Adipocytes

Laser/IPL Safety Guidelines



Regulatory Agencies

- ANSI
  - ANSI Z136.1-2014 – *Safe use of Lasers*
  - **ANSI Z136.3-2011**
    - ***Safe use of Lasers in Healthcare***
  - ANSI Z136.8-2012 – *Safe Use of Lasers in Research, Development, or Testing*
- FDA/Center for Device and Radiological Health (CDRH)
  - Federal Laser Product Performance Standard
- OSHA cites ANSI standards

LASER SYSTEMS AT CYNOSURE

- CO2 Laser - 10,600nm

- Er:YAG laser - 2940nm

- Nd:YAG laser - 1064nm and 532nm (dye: 585nm and650nm)

- Er:Glass Laser - 1540nm

- Diode Laser - 810nm

- Alexandrite Laser -755nm

IPL SYSTEMS

- Intense Pulsed Light (IPL) – Flashlamp
  - Not laser light
    - Multiple wavelengths
    - Not monodirectional
  - 500-1200 nm range
  - Can cause severe headaches from exposure
  - Safety glasses required during use

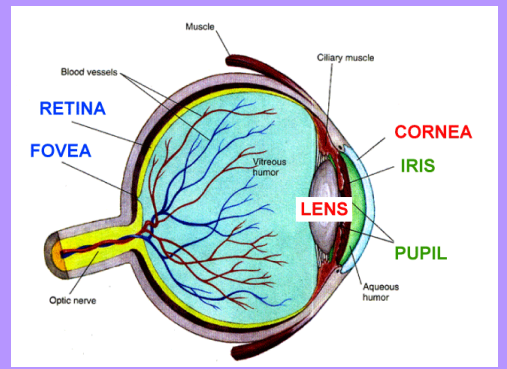
EYE HAZARDS

- Brightness and directionality are responsible for risk
- Beam is further concentrated on retina (up to 100X that of normal light)
- Wavelength of light determines portion of the eye at risk
- Beam may be invisible

- Aversion response is the normal body reflex of “blinking”
- Aversion response does NOT protect against invisible lasers
- Class 4 lasers can cause damage in less than the time it takes to blink

Susceptible Eye Structures

200nm-315nm	Cornea
315nm-400nm	Lens
400nm-1400nm	Retina
1400nm-3000nm	Cornea/Lens



Laser Eye Safety Precautions

Always knock on a labeled door before entering. Control access to the laser area, typically by closing the lab door.

The output from Nd lasers and other IR lasers is *invisible* to the human eye.

Laser beams should be treated like a gun – point towards floor, never at people, window

Avoiding Eye Injuries

NEVER look directly into handpiece in ready mode

Can cause permanent eye damage by direct/reflected exposure

Use caution when performing procedures around the eye

System should always be OFF or in STANDBY until ready to perform the treatment

Avoiding Eye Injuries

Never direct a beam upwards from horizontal

- Aim beam at floor - think of the laser as a gun

Always contain a beam in a room with appropriate curtains or shields, closed door, and proper warnings

Be aware of reflective surfaces in room and keep beam away from these

Root Causes of Eye/Skin Exposure Incidents

Unanticipated eye/skin exposure during alignment

Misaligned optics

Available eye protection not in use

Insufficient control of beam direction – beam not directed into safe area (directed upward, out open door, onto reflective surface, etc)

Everyone must have Eye Protection

CONTROL MEASURES

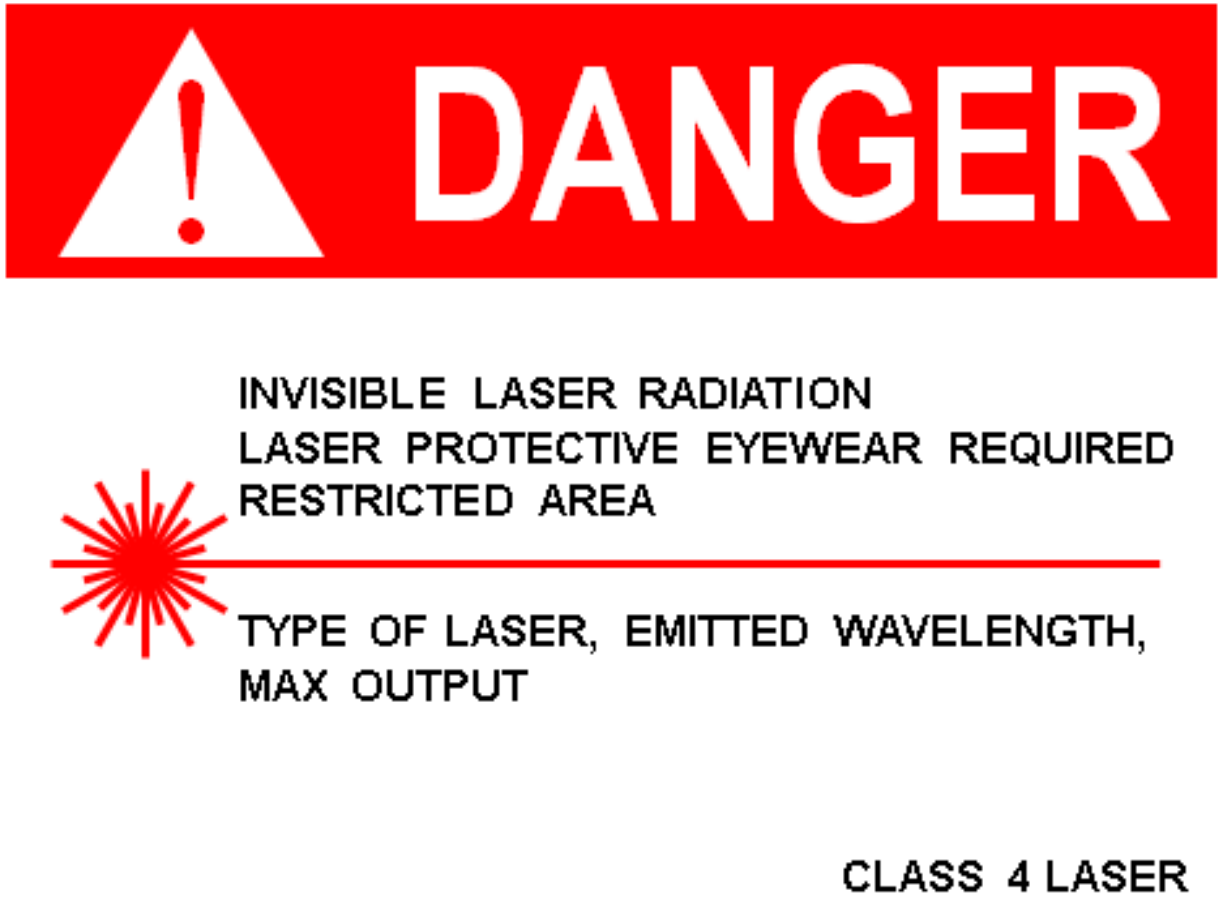
Engineering controls	Protective housing, Interlocks, Enclosed beam path, Signage, Remote interlock connector & Key control or password
Administrative controls	Standard Operating Procedures, Education and Training, Signs & Labels, Areas defined by Hazard
Personal protective equipment (PPE)	Laser safety eyewear & Protective clothing when appropriate

LASER WARNING SIGNS

- This sign means that you are entering an area where lasers may be in use

  If the door is closed, knock first

- Safety eyewear must be used when entering these areas



Safety Summary

During a treatment the practitioner must control the environment

Basic Rule: Treat the laser as if you would a gun

Everyone in the room wears CORRECT safety eyewear

Use appropriate signage

Questions?

Thank You!

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