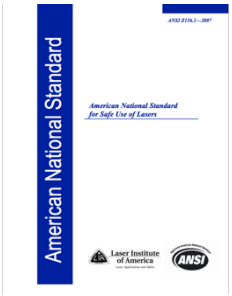
Choosing The Right Laser - Class 3b vs. Class 4

The following document outlines the main differences between Class IIIb and Class IV laser technology.

1. Laser Safety Standards

As set forth by *The American National Standards Institute (ANSI)* Z136 Series.

ANSI Z136.1 – SAFE USE OF LASERS



The foundation of laser safety programs.

1) Classifies laser systems according to their relative hazards.
2) Specifies appropriate controls for each classification.

Lasers are classified based on:

a) The potential risk of causing injury/damage
b) Power output
c) The accessible emission limit (AEL)
d) Purposes/use

OVERVIEW OF LASER CLASSES

Class	Power Output	Meaning	Relationship to MPE*	Hazard Area	Typical AEL*	Purpose/Use
Class IIIb	5-500 mW	Hazardous when eye is exposed (wear eye protection); usually no hazard to skin; diffuse reflections safe	Ocular MPE may be exceeded more than 5 times; skin MPE usually not exceeded	Eye hazard with direct exposure; no hazard for skin	500 mW	Photobiomodulation (Therapeutic)
Class IV	> 500 mW	Hazardous to eye and skin; also diffuse reflection may be hazardous; fire hazard	Ocular and skin MPE exceeded; diffuse reflections exceed ocular MPE	Eye hazard with direct or diffuse exposure; skin hazard	No upper limit	Photothermal (Surgical)

***Accessible Emission Limit (AEL)** – the maximum power (in mW) or energy (in J) that can be emitted by a laser.

***Maximum Permissible Exposure (MPE)** – the highest power or energy density of a light source that is considered safe (i.e., safe exposure limit).

2. Safety Control Measures

As set forth by *The American National Standards Institute (ANSI)* Z136 Series.

Control measures are devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and other hazards associated with laser devices. These measures include engineering, administrative & procedural, and personal protective controls.

OVERVIEW OF SAFETY CONTROL MEASURES		
Engineering Control Measures	**Classification**	
	3b	**4**
Key Control	•	X
Remote Interlock Connector	•	X
Beam Stop or Attenuator	•	X
Activation Warning Systems	•	X
Controlled Operation	-	•
Administrative & Procedural Control Measures		
Standard Operating Procedures	•	X
Protective Equipment	•	X
Spectators	•	X
Protective Eyewear	•	X
Window Protection	X	X NHZ
Skin Protection	X	X NHZ

*This list is not an exhaustive list. It is meant to outline the key differences.

Legend:

•	Recommended
X	Required
-	No requirement
NHZ	Nominal Hazard Zone analysis required

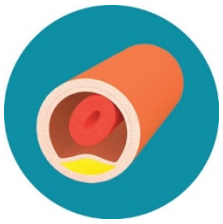
3. Physiological / Therapeutic Effect

Each wavelength of light corresponds to the absorption and action spectra of key mitochondria chromophores, such as cytochrome c oxidase and cellular membrane lipids, to activate specific cellular pathways.

Mechanisms of Action of Class 3b Lasers

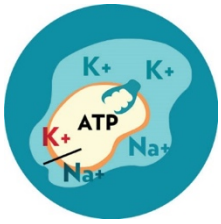
Accelerate Healing

660 nm - Adenosine Triphosphate (ATP) Pathway:
Stimulates the mitochondria to produce more ATP to accelerate tissue repair.



Reduce Inflammation

905 nm - Nitric Oxide (NO) Pathway:
Increases the production of Nitric Oxide (NO) by over 700%, increasing vasodilation and decreasing inflammation.



Eliminate Pain

905 nm - Lipid Absorption Pathway
Effectively removes the pain signal at the source by rebalancing the sodium potassium pump.

Mechanisms of Action of Class 4 Lasers

Due to the high absorption of laser light by water at wavelengths > 950 nm, > 90% of the energy produced is absorbed before penetrating the dermis of the skin.

The only mechanism of action remaining is a **photothermal effect.**

4. Laser Dosage

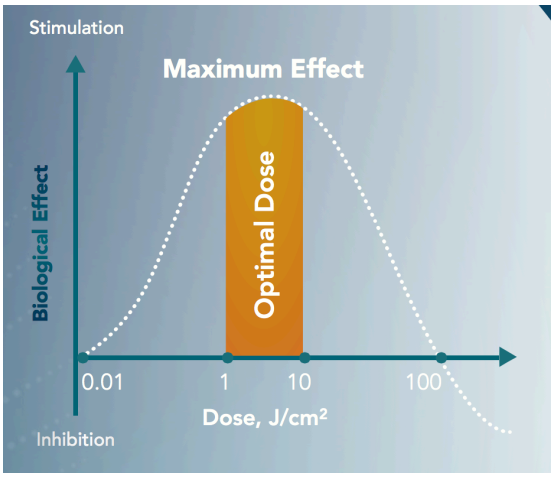
According to the Arndt-Shultz Law, in order to maximize treatment efficacy, the laser therapy device must deliver the required dose of laser light to the tissue of interest.

Dose (J) = Power (mW) x Time (sec)

What power do you think is optimal for tissue regeneration, pain relief and inflammatory effects?

A common misconception is that more power means better results. This is not the case. There exists an optimal dose of light for any particular application between which laser therapy is effective.

BIPHASIC DOSE RESPONSE

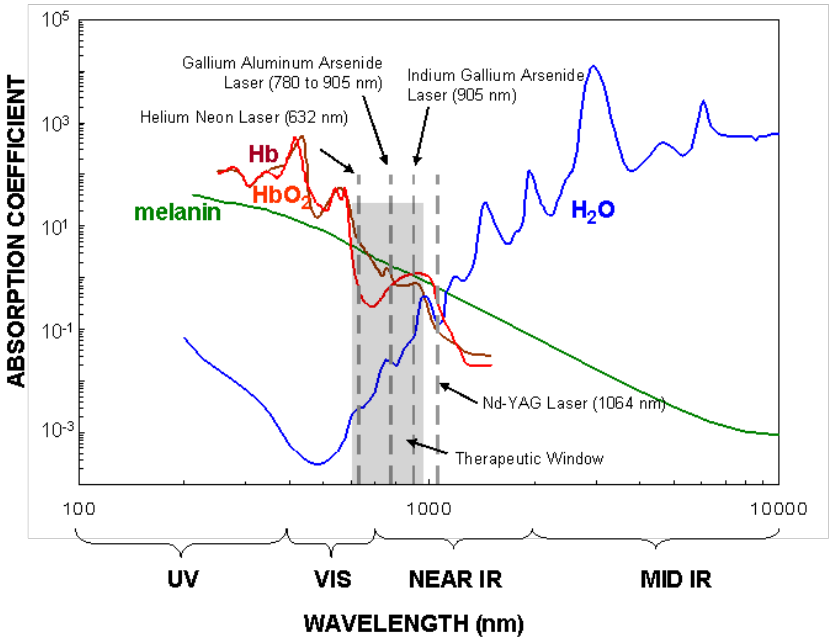


Too little laser energy = No or minimal efficacy

Excess laser energy = Bio-inhibition or lack of efficacy

5. Wavelength

The Grotthuss-Draper Law (1st Law of Photochemistry) states that light must be absorbed by tissues in order to have an effect. This depends greatly on the wavelength. Light of the correct wavelength must be used to activate the correct chromophore(s).

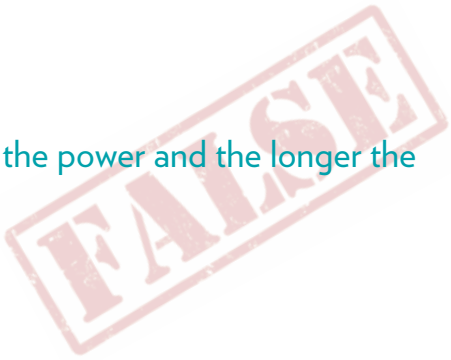


Below 600 nm – primarily absorbed by blood; severely limits penetration depth.

600 nm to 950 nm – ideal therapeutic range.

Above 950 nm – primarily absorbed by water; leads to excessive tissue heating.

6. Depth of Penetration

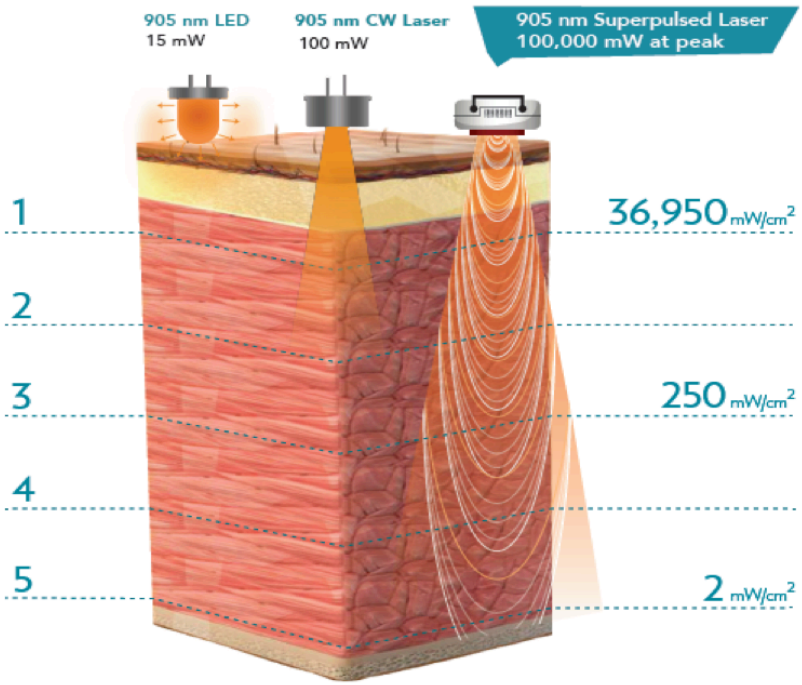


Another common misconception is that the higher the power and the longer the wavelength, the deeper the tissue penetration.

The truth is...

The longer the wavelength, the greater the risk of thermal damage and low depth of penetration. The depth of penetration is superficial and is restricted, at best, to the top layer of the dermis. There is no biostimulatory effect due to a lack of cellular mechanism activation. The only mechanism of action is a thermal effect.

7. Delivery Mode



The Theralase TLC-2000 laser system can penetrate up to 5 inches in depth.

Continuous Wave (CW) – set output power *(peak power = average power)*

Pulsed Wave (PW) – continuous wave laser diodes or LEDs that are pulsed at low frequencies (100 Hz to 1kHz), and usually, delivered at 50/50 duty cycles, *cutting the average power in half*

The key is...

Superpulsed Laser Technology

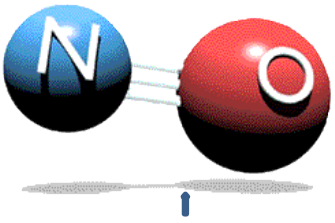
High peak power (50 to 100 W) delivered in bursts of very short duration (200 nanoseconds) at high frequencies (10kHz) *(peak power dramatically higher than average power)*

Improved dose delivery and increased depth of penetration without creating heat or tissue damage. "Quench periods" (pulse OFF times) following pulse ON times allow the use of much higher peak power densities than those that could be safely used in CW.

Study Results

Moriyama, Y., Nguyen, J., Akens, M., Moriyama, E. H., & Lilge, L. (2009). In vivo effects of low level laser therapy on inducible nitric oxide synthase. *Lasers Surg. Med., 41*(3), 227-

905 nm superpulsed laser diodes lead to a significant (700%) increase in the levels of a key signaling molecule, Nitric Oxide ("NO").



905 nm continuous wave had no impact on the production of Nitric Oxide. Neither did the **690**, **785**, and **808 nm** wavelengths.

8. Clinical Application

OVERVIEW OF CLINICAL APPLICATION		
	Classification	
	3b	4
Contraindication – Metal Implants	X	√
Contraindication – Pacemakers	X	√
Sensation	Usually none; some warmth or tingling may be reported	Heat generated
Probe application technique	Stationary, with contact	Constant motion
Physiologic effect	Photobiomodulation	Photothermal
Therapeutic effect	Enhance cell function	Cell destruction
Clinical support (i.e., research)	√	X