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LEDs vs Lasers:
Tissue Penetration

Tom Kerber

President & Founder

Kerber Applied Research

Hamilton, CANADA | Buffalo, USA

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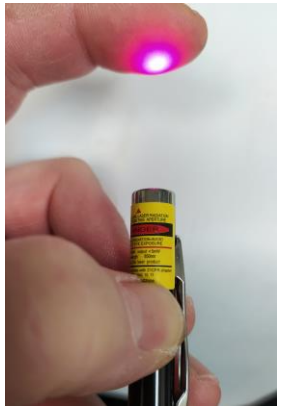
Introduction

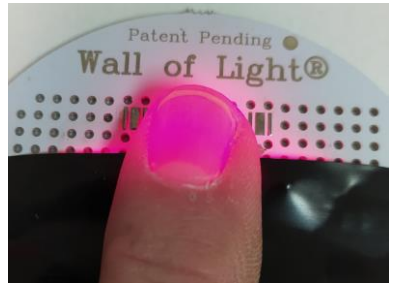
- **Laser** light is characterized by several key properties:
  - narrow monochromatic bandwidth
  - coherence
  - directionality
  - high intensity

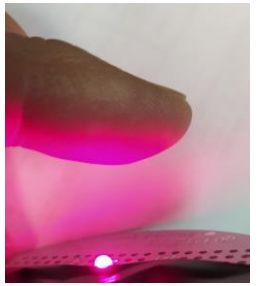
Above characteristics had rendered lasers suitable for medical applications requiring depth-of-tissue penetration, i.e. **photobiomodulation** and **photodynamic therapy**

- However, **LEDs** are assuming a greater role in biomedical treatment due to their simplicity, convenience, and low cost



[3.08mw Laser light source]





[3.08mw LED light source]

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How Do LEDs Compare to Lasers in Terms of Tissue Penetration – Light Transmittance?

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Purpose

- study was undertaken to compare effectiveness, measured in light transmittance (mW), of LEDs vs. Lasers using 3 different wavelengths, through 3 different tissues of various thicknesses

Procedure

- SunPowerLED devices were compared with Lasers at the visible (red light, 660 nm) and at 2 NIR wavelengths (810 and 1050 or 1064 nm [laser]) through 3 types of meat (chicken, pork and beef) of 3 different thicknesses (0.75, 1.5 and 2.25 inches) each

- a spherical culminator containing a suspended light sensor connected to a light meter was used to measure light transmittance

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Procedure (cont'd)

- **Laser** penetration data at 660 and 810 nm were corrected for differences in optical power between Lasers (K-Laser: 200 and 500 mW respectively) and LEDs (5 W)

Data at 1064 nm (Arc-Laser) were not corrected due to similarity in power (both were 5 W) and wavelengths (LEDs were 1050 nm)

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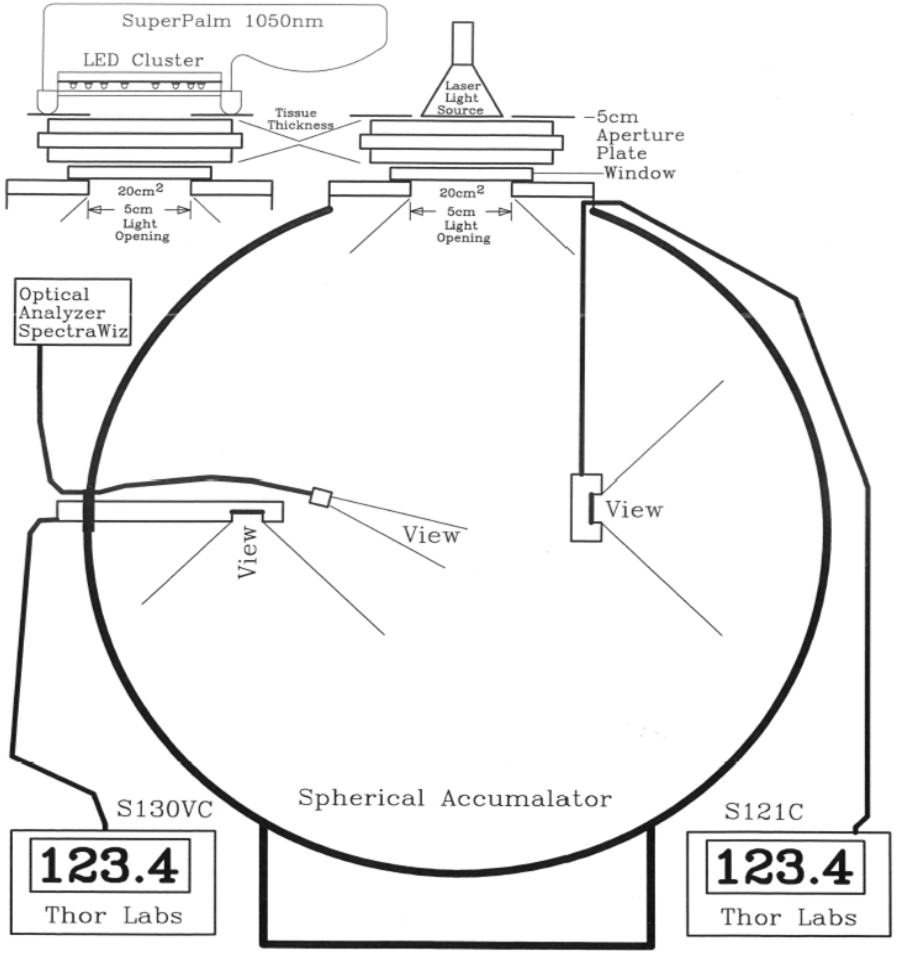
Test Set-Up



[Schematic of Spherical Culminator]

[Actual Instrument]

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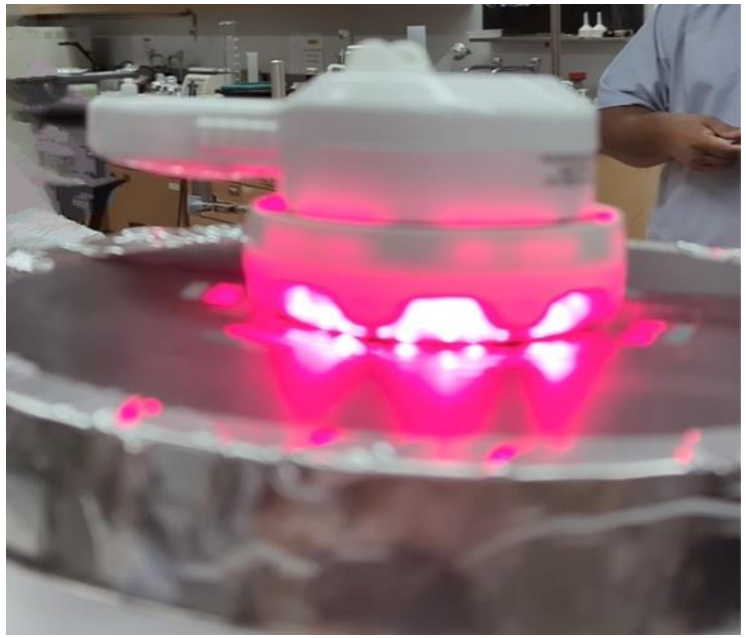

SunPowerLED device

K-Laser on Chicken

Arc-Laser on Pork

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SunPowerLED Palm
Classic, Professional & Ultimate

Palm Classic

Single Wavelength LED : 660nm (3500mw), 87 mW/cm^2, 4J in 46s

Palm Professional

Dual Wavelength LED : 660nm (5500mw), 137 mW/cm^2, 4J in 30s

810nm (3500mw), 87 mW/cm^2, 4J in 46s

Palm Ultimate

Dual Wavelength LED : 660nm (7500mw), 187 mW/cm^2, 4J in 22s

810nm (6000mw), 150 mW/cm^2, 4J in 27s

Palm 1050

Dual Wavelength LED : 660nm (7500mw), 187 mW/cm^2, 4J in 22s

1050nm (6500mw), 162 mW/cm^2, 4J in 25s

(all have 40cm^2 surface area of irradiation when against surface)

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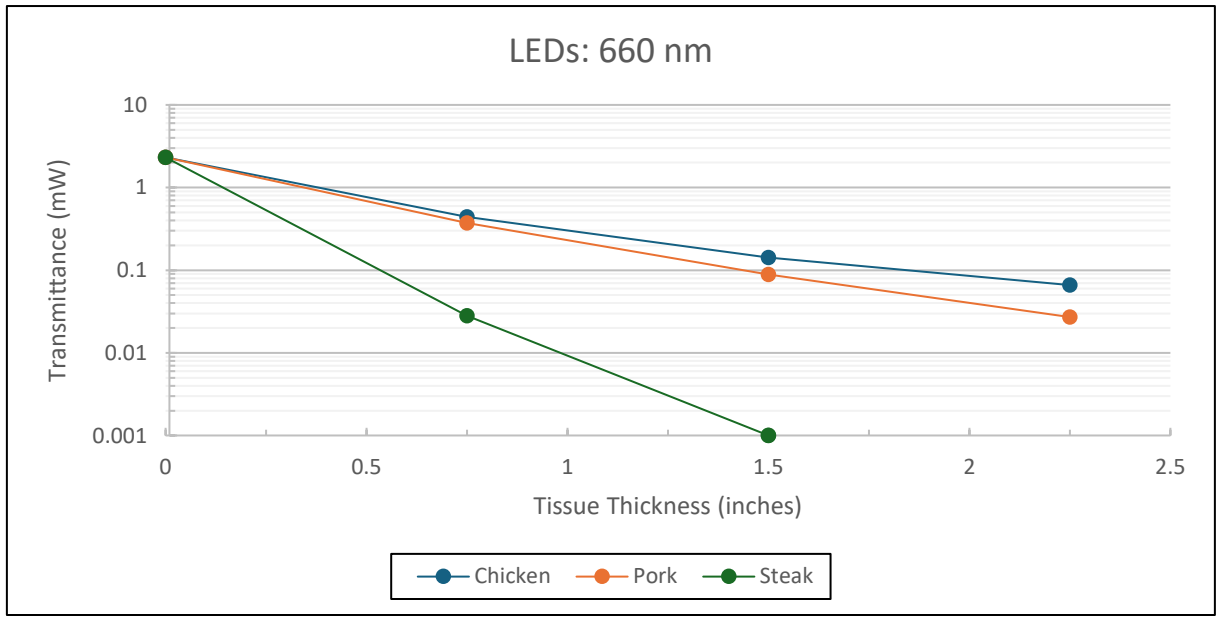
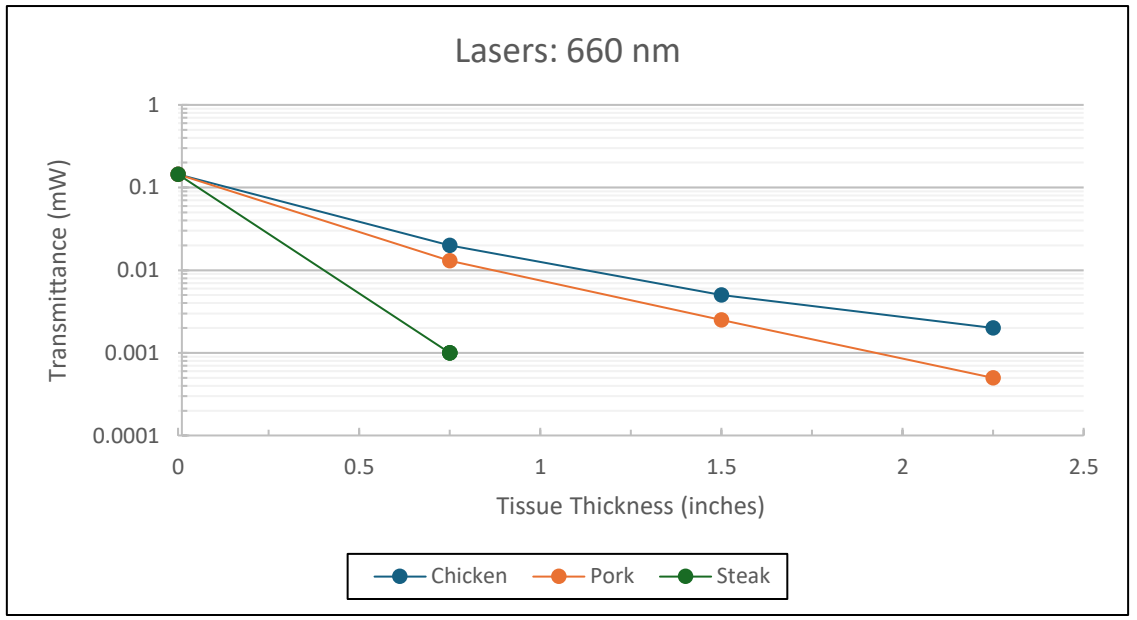
Results: LED vs Lasers at 660nm





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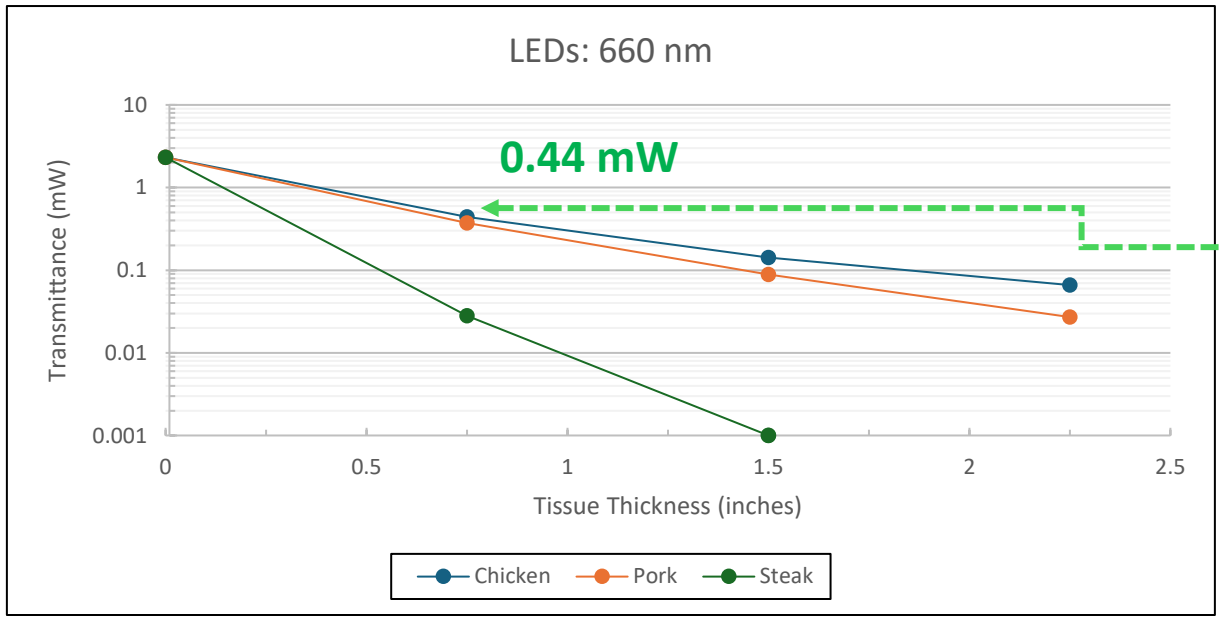
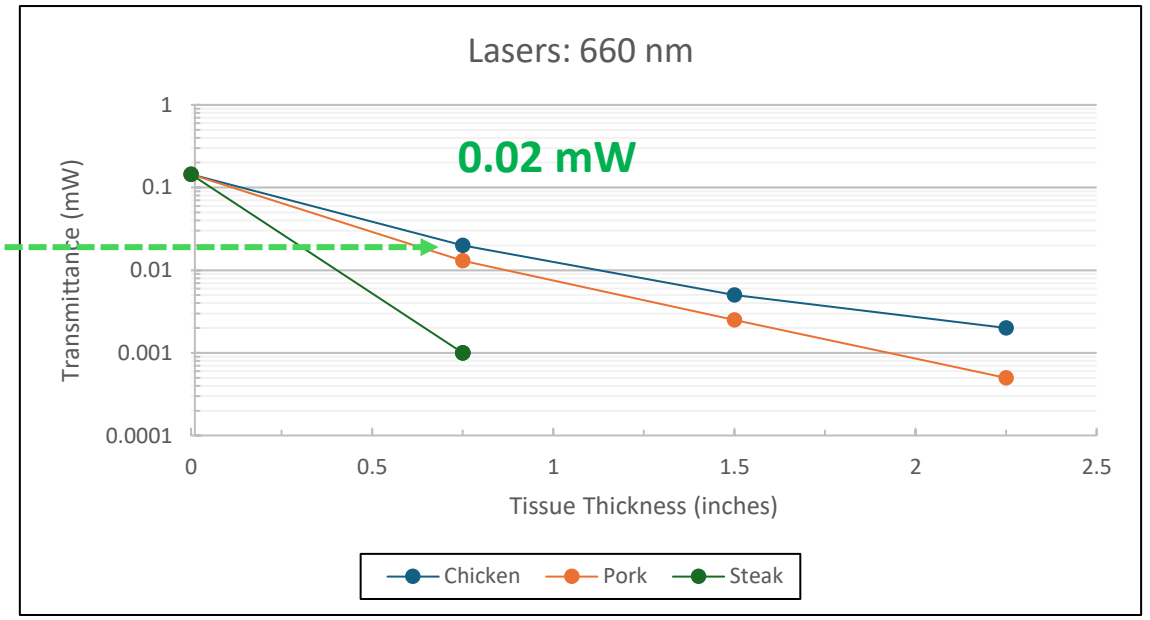
Results: LED vs Lasers at 660nm





… But this was before correction for the Actual Power Difference between the LED and Laser…

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Results:

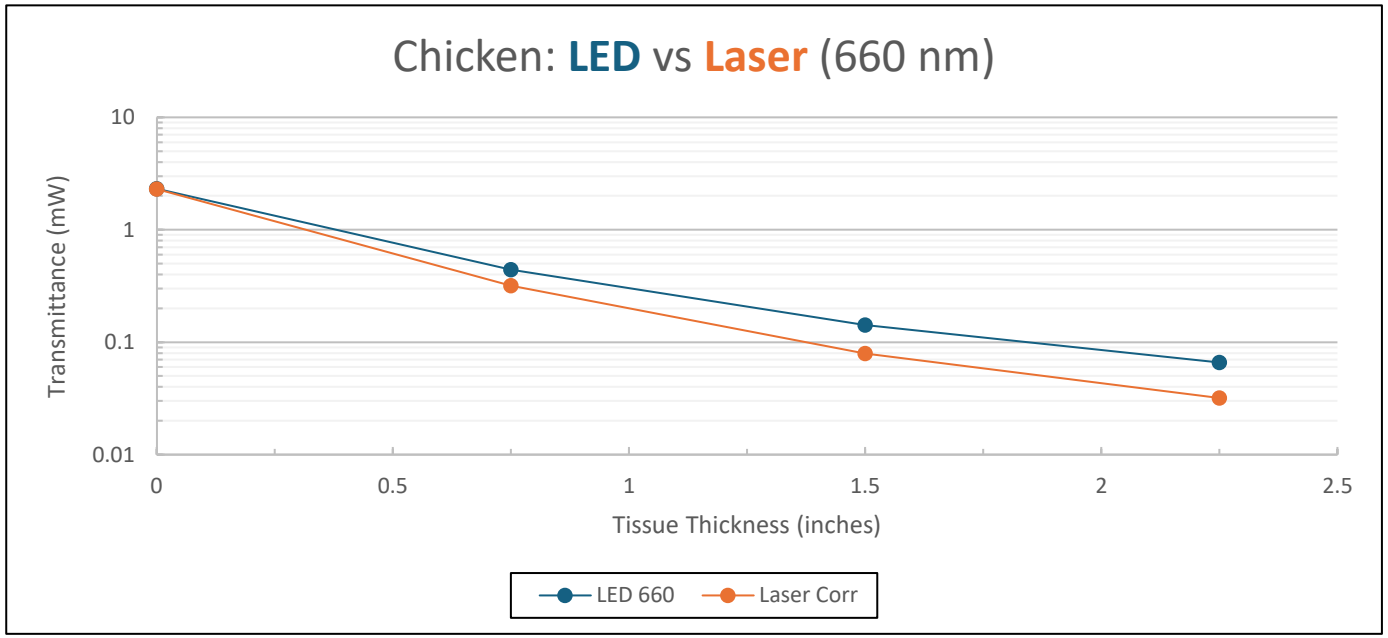
LED vs Lasers at 660nm

with correction for power difference

(for chicken at 0.75” thickness)

Chicken			Tissue Thickness (inches)			
	Power (W)	λ (nm)	0	0.75	1.5	2.25
				Transmittance (mW)		
LED	5	660	2.31	0.44	0.142	0.066
	5	810	2.24	0.65	0.276	0.13
	5	1050	2.98	0.45	0.1	0.025
Laser	0.2	660	0.145	0.02	0.005	0.002
	0.5	810	0.236	0.058	0.021	0.01
	5	1064	0.78	0.5	0.117	0.042

			Tissue Thickness (inches)			
	Power (W)	λ (nm)	0	0.75	1.5	2.25
				Transmittance (mW)		
Laser	0.2	660	0.145	0.02	0.005	0.002
	Corrected[1]		2.31	0.32	0.08	0.03
	0.5	810	0.236	0.058	0.021	0.01
	Corrected[2]		2.24	0.55	0.20	0.10
	5	1064	0.78	0.5	0.117	0.042
[1] X Factor = 2.31/0.145 = 15.9						
[2] X Factor = 2.24/0.236 = 9.5						



Results: LED vs Lasers at 660nm

in chicken (with correction for power difference)

Chicken			Tissue Thickness (inches)			
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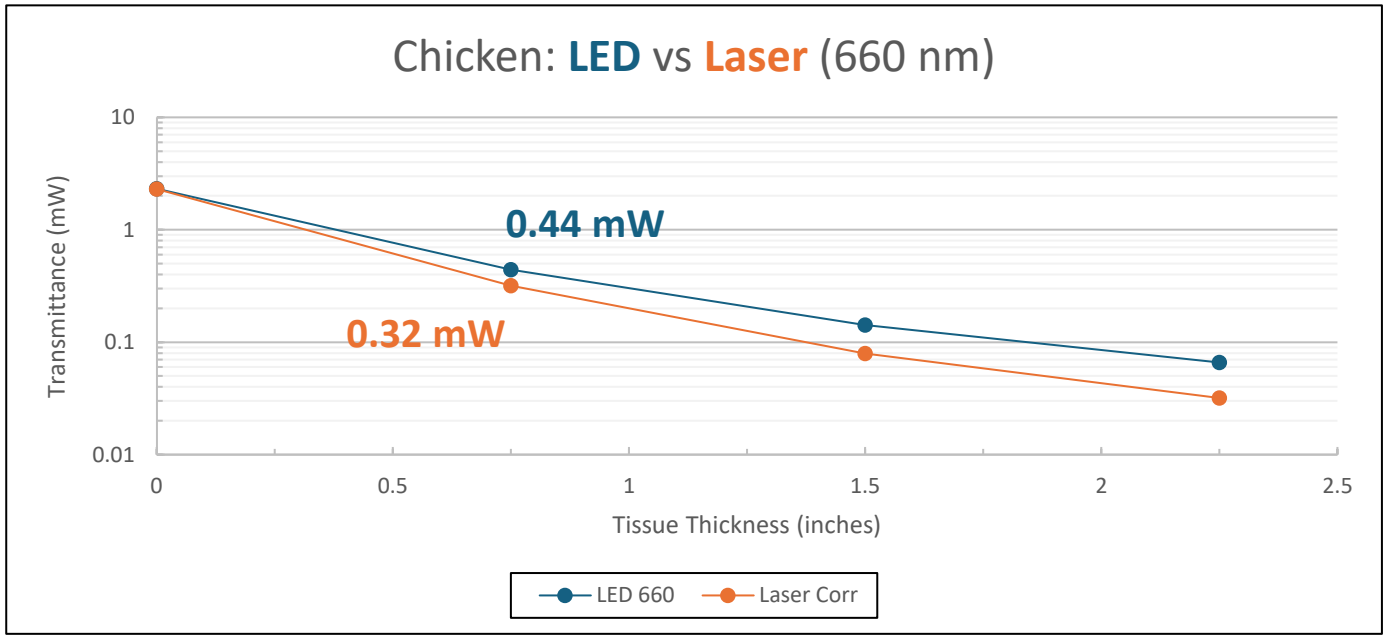

(for chicken at 0.75" thickness)

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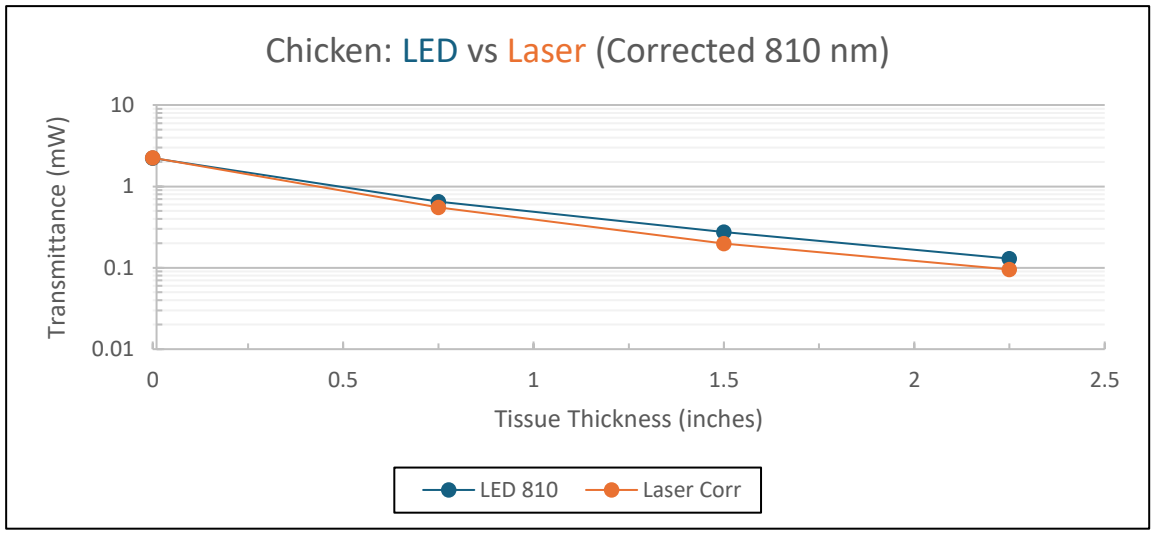
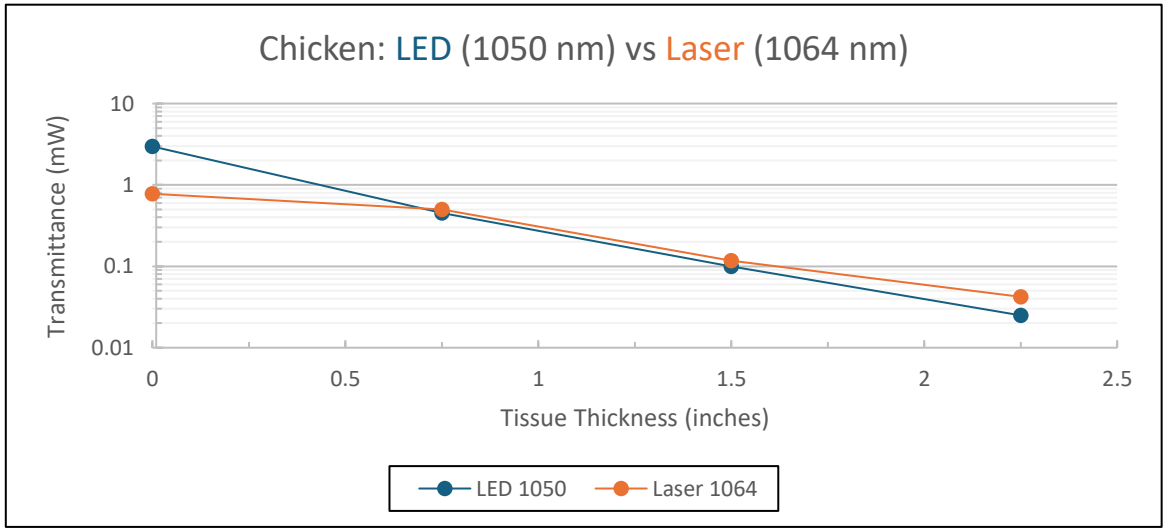
Results:

LED vs Lasers at 810nm and 1050 / 1064nm

in chicken (with correction for power difference)





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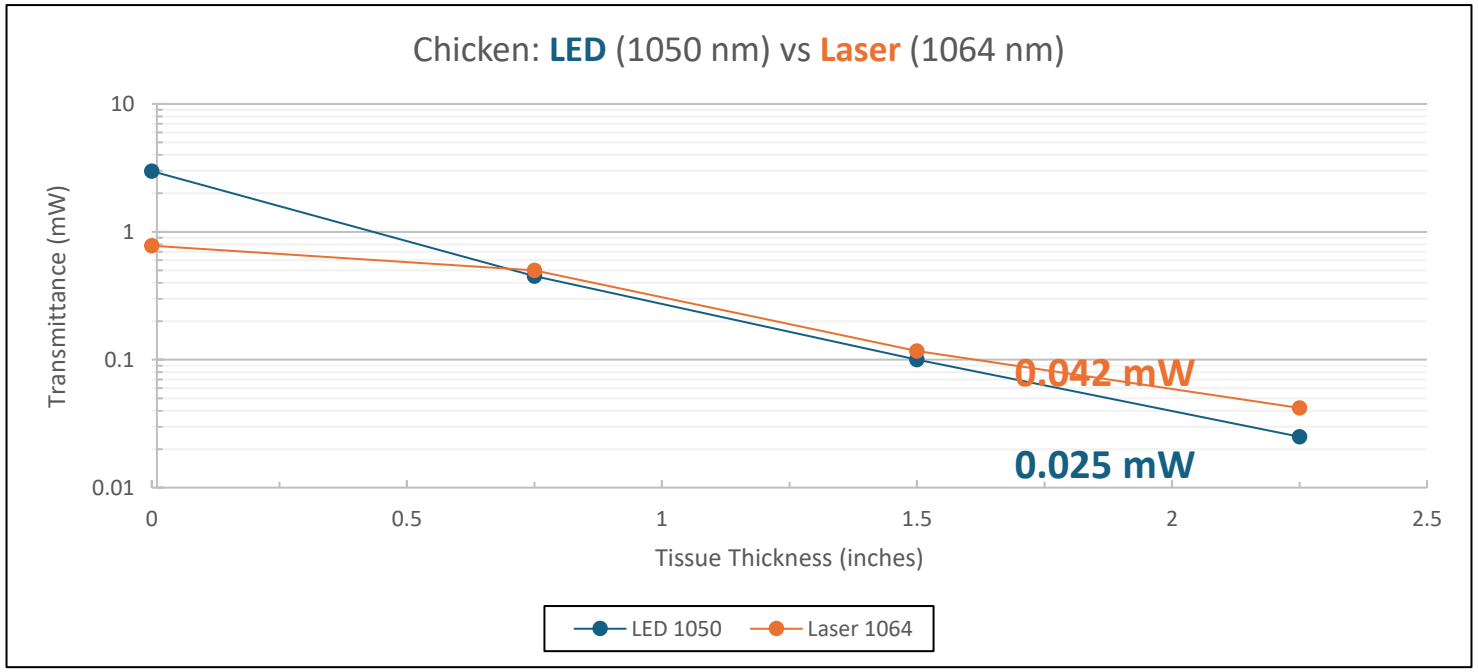
Results: LED vs Lasers at 1050 / 1064nm

in chicken (with correction for power difference)



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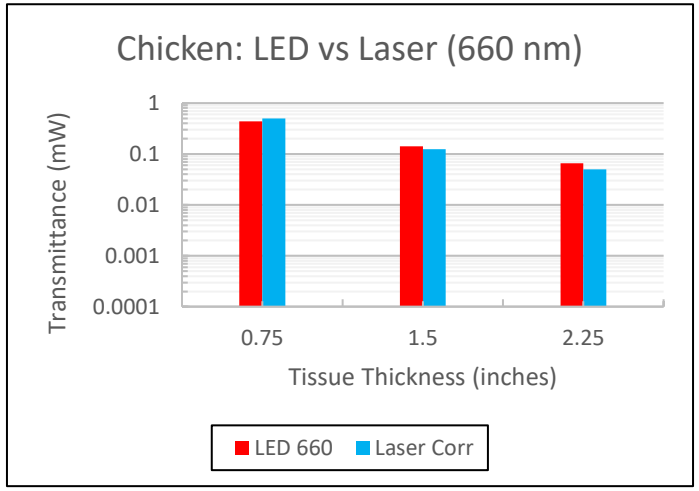
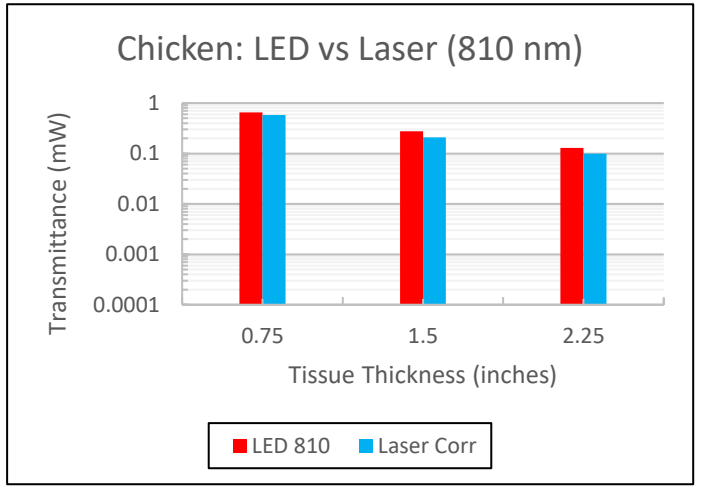
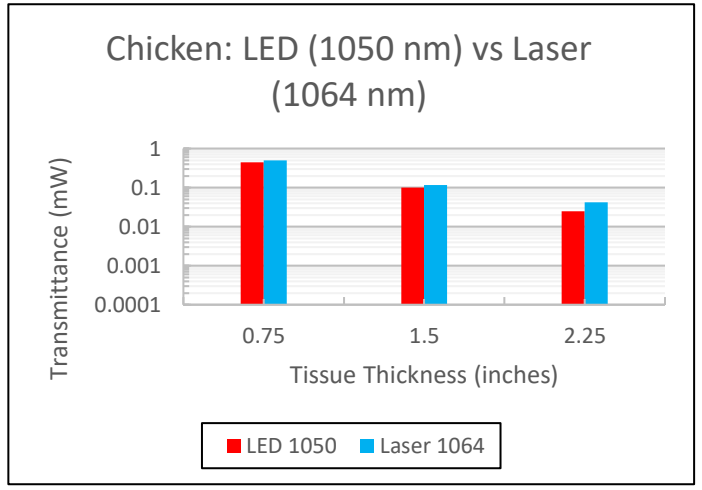
Light Energy (mW) Measured in Chicken as a Function of Tissue Thickness and Wavelength: LEDs vs Lasers







- ***LEDs*** and ***Lasers*** showed similar transmission profiles at each wavelength
- Rank order of tissue penetration: 660 < 810 > 1050, 1064 nm

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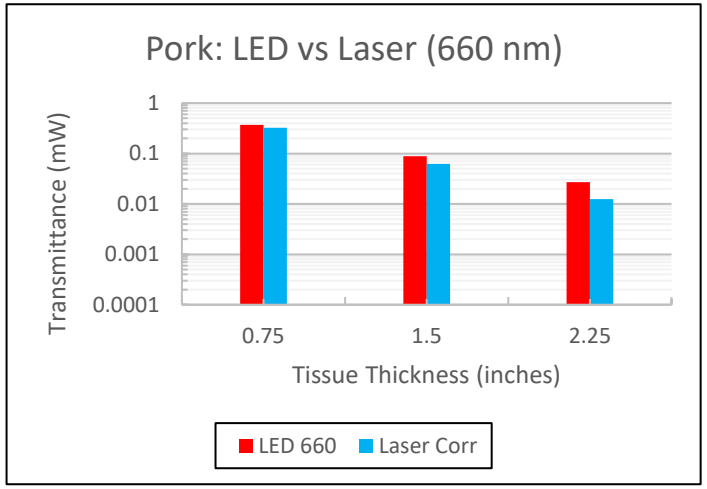
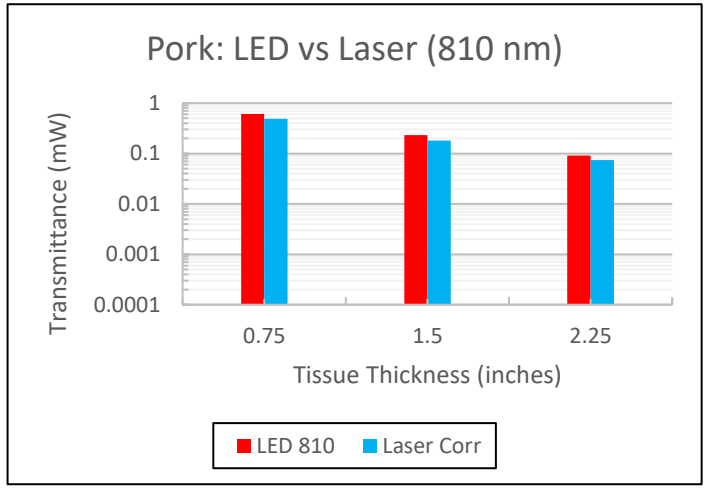
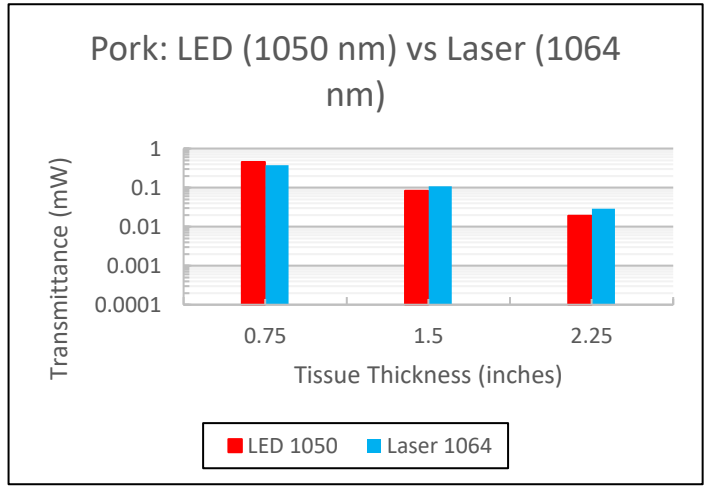
Light Energy (mW) Measured in Pork as a Function of Tissue Thickness and Wavelength: LEDs vs Lasers







- ***LEDs*** and ***Lasers*** showed similar transmission profiles at each wavelength; Pork and chicken showed similar levels of light transmission
- Rank order of tissue penetration same as in chicken: 660 < 810 > 1050, 1064 nm

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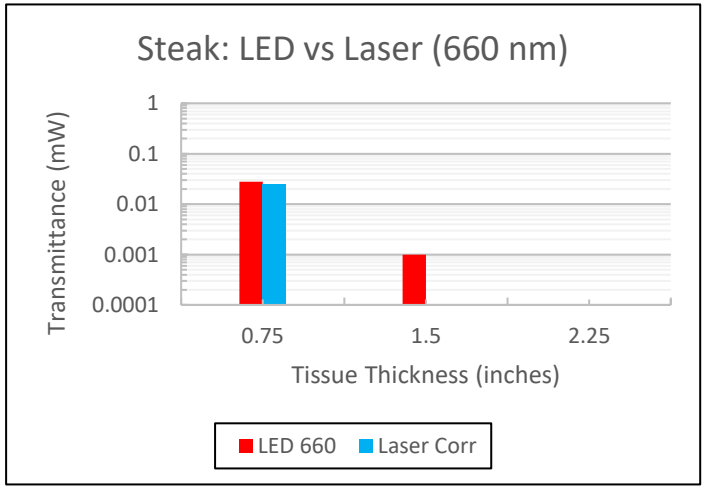
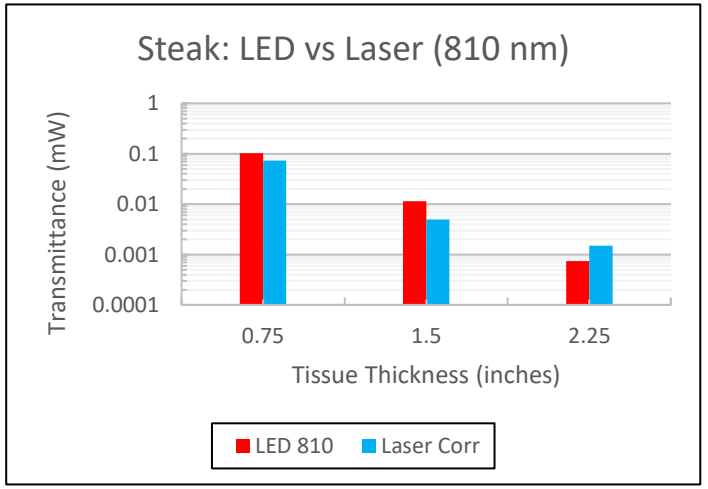
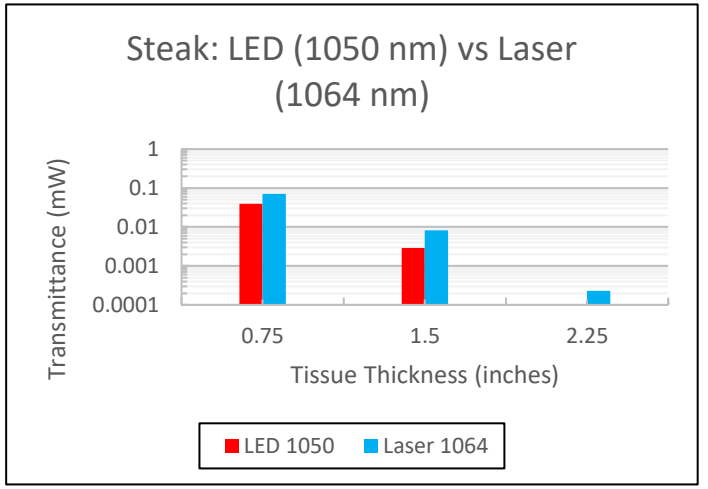
Light Energy (mW) Measured in Steak as a Function of Tissue Thickness and Wavelength: LEDs vs Lasers







- ***Laser*** was less effective than ***LEDs*** at 660 nm, ***LEDs*** and ***Lasers*** showed similar profiles at 810 nm and ***Laser*** at 1064 nm was slightly better than ***LEDs*** at 1050 nm
- ***Laser*** light transmission through steak was lower than in chicken and pork at all wavelengths

Results Summary

- ***LEDs*** and ***Lasers*** exhibited similar levels of optical density and attenuation at tissue thicknesses of 0.75, 1.5 and 2.25 inches in the visible (660 nm) and NIR spectral ranges (810 and 1050 or 1064 nm) in **chicken** and **pork** tissue ***ex-vivo***

- Rank order of tissue penetration by light was: 660 < 810 > 1050, 1064 nm

- Both light sources showed substantially reduced activity in **steak** compared to the other tissues
- ***Laser*** at 660 and 810 nm showed lower energy density at 0.75 and 1.5 inch tissue thickness than ***LEDs***
- ***Laser*** at 1064 was more effective than ***LEDs*** at 1050 nm in penetration at all depths, reaching measurable levels at 2.25 inches, when ***LEDs*** showed none
- Calculated ***Laser*** light transmitted (%) is inflated due to anomalous “0” value

Conclusions

This comparative ***ex vivo*** study revealed unexpected similarities between ***LEDs*** and ***Lasers*** in effectiveness of tissue penetration up to 2.25 inches deep, at 660 and 810 nm, in 2 of 3 tissues examined. It can be speculated that the broader bandwidth of the ***LED*** source contributed to greater tissue exposure and light scattering, facilitating deeper penetration. Alternatively, it is conceivable that these similarities are more apparent than real. It can be argued that the mathematical correction applied to ***Laser*** power differences with ***LEDs*** is not an appropriate substitution for equal ***Laser*** power densities .

Also unexpected was the lower tissue penetrability in all 3 tissues of ***LED*** and ***Laser*** lights at 1050 and 1064 nm compared to 810 nm. It is possible that the presence of tissue moisture resulted in light absorption at these wavelengths.

Take Away

SunPowerLED started as Kerber Applied Research working with halogen light sources several years ago. Tom Kerber then worked with lasers.

SunPowerLED switched to LED light sources to increase performance, convenience and accessibility, while decreasing cost!

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Acknowledgements

- Dr. Robert Zawydiwski
- Dr. Hayman
- SunPowerLED Team

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LEDs vs Lasers:
Tissue Penetration

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Safety advantages of SunPowerLED

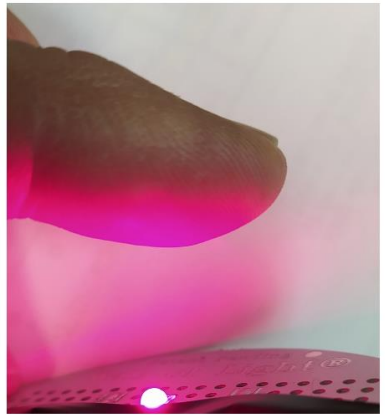
Safety Advantages:

- Non-coherent light source
- No hot spots created
- Special Safety glasses are still recommended.
- LED illumination covers a larger area

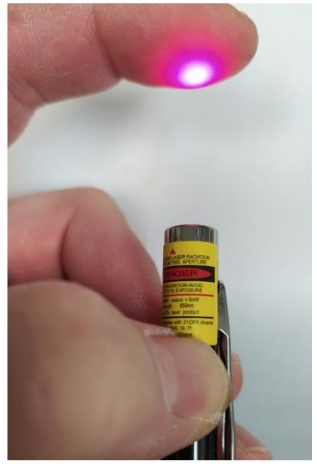
Note: Other small spot illumination technologies (e.g. Laser) are coherent light sources that create a **high energy spot capable** of burning the retina. Consequently, safety glasses are required.

High Safety Level even without Glasses
Safety Glasses are still recommended

Safety Glasses Required
Damage could occur
to the retina without glasses



LED wide area illumination
Wall of Light Technology ™



Laser small spot illumination

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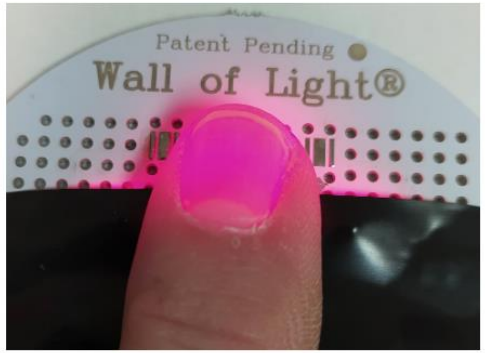
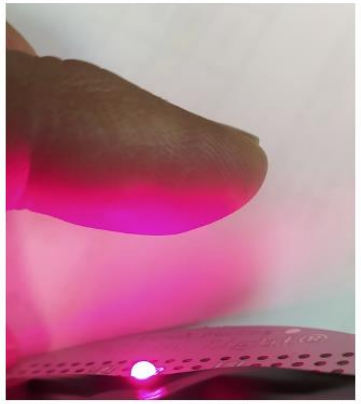


Very safe, diffused beam eliminates hotspots



LED light source at 1/80 power level
3.08mw Optical Power

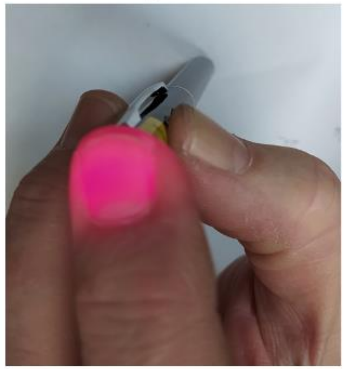
Safety and Depth

Diffused Wide Area Illumination vs. Spot Illumination with the same optical power

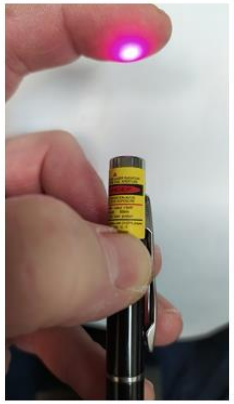
Note: Same Power, same diffused depth!

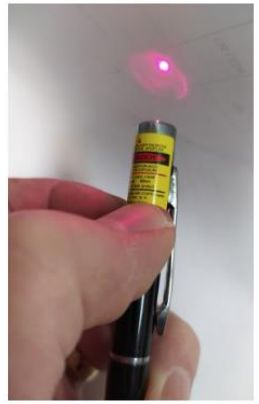
Optical Power
Measured at 3.08mw

Laser pointer



Hot spot potential with high power





3.08mw Laser light source

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Cases

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Boiling Water Burn
– my 3-year-old granddaughter: 2x Daily LED PBM Therapy



Day 0

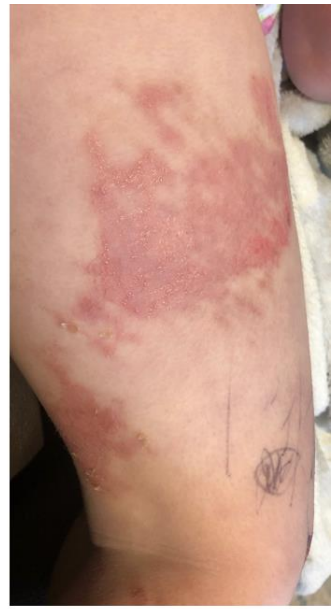


Day 1


Day 2


Day 4


Day 6


Day 8


No Visible Scars 2yr

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SunPowerLED Palm™ healing examples:

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SunPowerLED Palm™ healing examples:

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SunPowerLED Palm™ healing examples:

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SunPowerLED Palm™ healing examples:

High Power LEDs
Provides Deep Penetration

Two Weeks
Post Treatment

Three Weeks
Post Treatment

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SunPowerLED Palm™ healing examples:

High Power LEDs
Provides Deep Penetration

Two Months
Post Treatment

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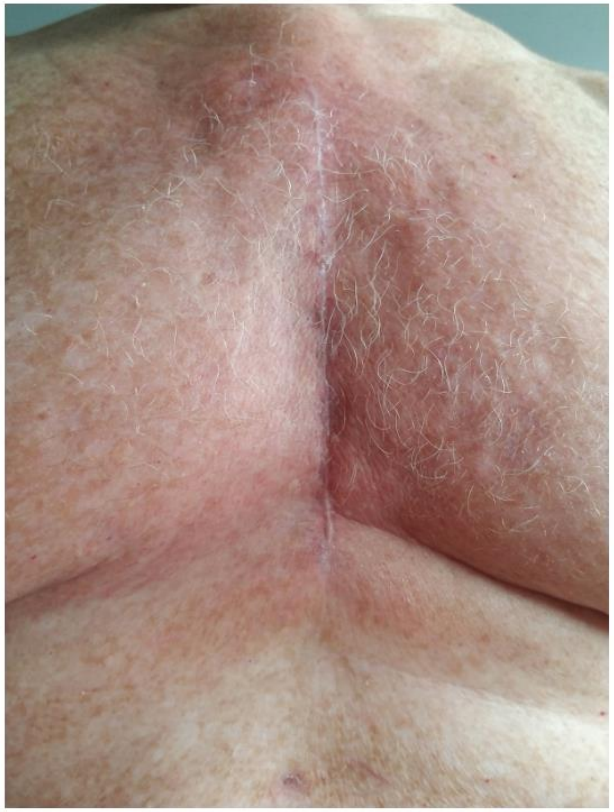
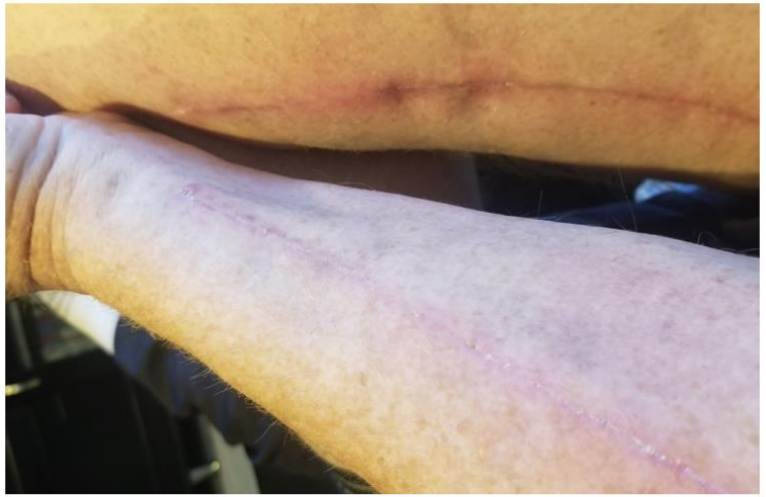
SunPowerLED Palm™ healing examples:

April 19 Chest Surgery
Leg, Arm and Chest



May 22
Post PBM Treatment



May 25
Post PBM Treatment Leg and Arm

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I fell face first onto a concrete sidewalk

PBM
3x / day

4 Days Later

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SunPowerLED healing example: **Post-Stroke Pain and Inflammation**

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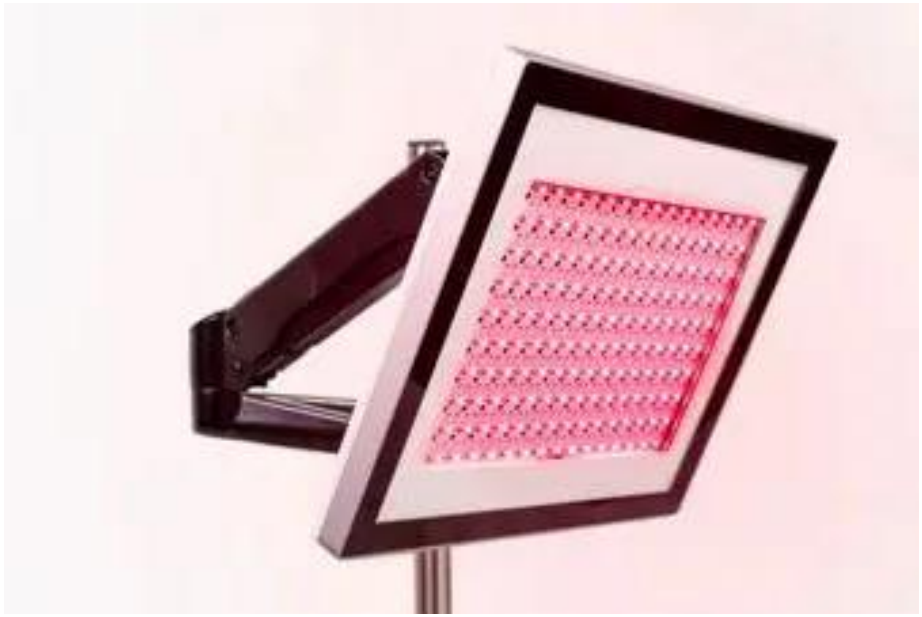

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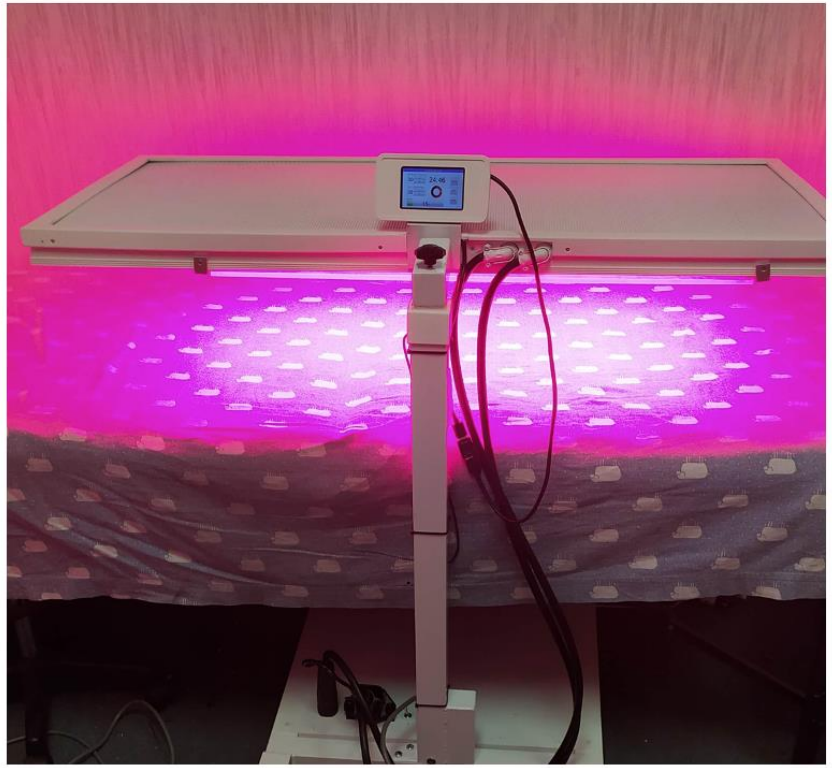
Stroke Recovery

Concussion



Premium Products at a reasonable cost

SunPowerLED

TECHNOLOGY TO IMPROVE YOUR HEALTH

1050 SuperPalm

Dual Wavelength LED: 660nm, 1050nm (Switchable) Faster treatment time

Average Radiant Power:
7500 mW (7.5 Watts) 660nm
6500 mW (6.5 Watts) 1050nm

Irradiance Intensity:
187 mW/cm2 660nm,
162 mW/cm2 1050nm

Joules/cm² delivered:
4J/cm² in 22s (660nm),
4J/cm² in 25s (1050nm)

Electrical: 120Vac / 24 Vdc, 24 W, Wall plug Adaptor (UL Approval), with a 6 foot cord extension to the LED unit

Misc: Air Fan, Temperature monitoring and fuse protection circuitry, On/Off/On switch, or attach/detach power cord operation

2 year warranty

FDA Registered, Patent Pending

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Features

- FDA Registered
- Part of a comprehensive family of LED based Medical and home use devices
- Handheld form factor for ease of use in many applications
- Switchable dual light frequencies
- Diffused wide area illumination, treat large muscles quickly
- Powerful light for deep penetration, easily reaches deep into the oral cavity from externally
- Patent pending cooling technology allows for high power in a lightweight design
- 10 high power LEDs at 660nm (Palm Ultimate™)
- 12 high power LEDs at 810nm (Palm Ultimate™)
- Proven technology with real world success stories
- Plug in low voltage adapter, no batteries to replace
- Very safe and effective with no adverse side affects
- Durable high-quality design with 1 year warranty
- Built in safety features

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- **Large Area Illumination: 40cm^2 treatment area**

Big enough to cover the whole of each facial muscle with one application; which will be very quick for the clinicians and saves time

- **High Power Output: 5500mW 660nm Red, 3500mW 810nm NIR**

Powerful enough to allow for a 4 J/cm^2 treatment in 30s (660nm), 46s (810nm)

- **High Safety: LED as a light source diffuses with distance in the air**

Even though the power level is very high, the optical power is spread out over the entire treatment area not allowing any hot spots to occur

- **Easy to Use: Easy enough to use for at home treatments**

Patients can take home for pain relief and faster healing; providing opportunities for rental revenue

- **Light Weight: Less then 0.5 pounds in weight**

Light enough to hold over multiple treatment areas without fatigue

- **Light source maintains high output: Durable High Power LEDs**

Provides ultralong LED life of 50,000 hours

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Palm Classic

Single Wavelength LED : 660nm (3500mw), 87 mW/cm^2, 4J in 46s

Palm Professional

Dual Wavelength LED : 660nm (5500mw), 137 mW/cm^2, 4J in 30s

810nm (3500mw), 87 mW/cm^2, 4J in 46s

Palm Ultimate

Dual Wavelength LED : 660nm (7500mw), 187 mW/cm^2, 4J in 22s

810nm (6000mw), 150 mW/cm^2, 4J in 27s

Palm 1050

Dual Wavelength LED : 660nm (7500mw), 187 mW/cm^2, 4J in 22s

1050nm (6500mw), 162 mW/cm^2, 4J in 25s

(all have 40cm^2 surface area of irradiation when against surface)

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New Light Probe Adapter directs the light for intraoral treatments

- Improves salivary output
- Possible regenerative effect
- Treat and improve healing time of dental sores and glossitis
- Help restore harmony to the oral mucosa
- Improved quality of life

SunPowerLED Palm used in Intraoral Treatments

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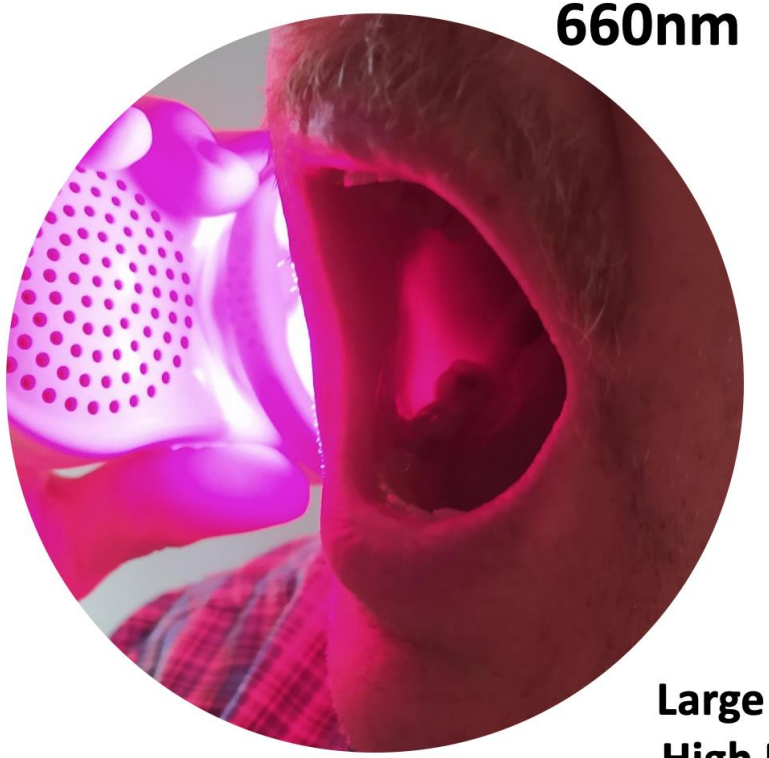
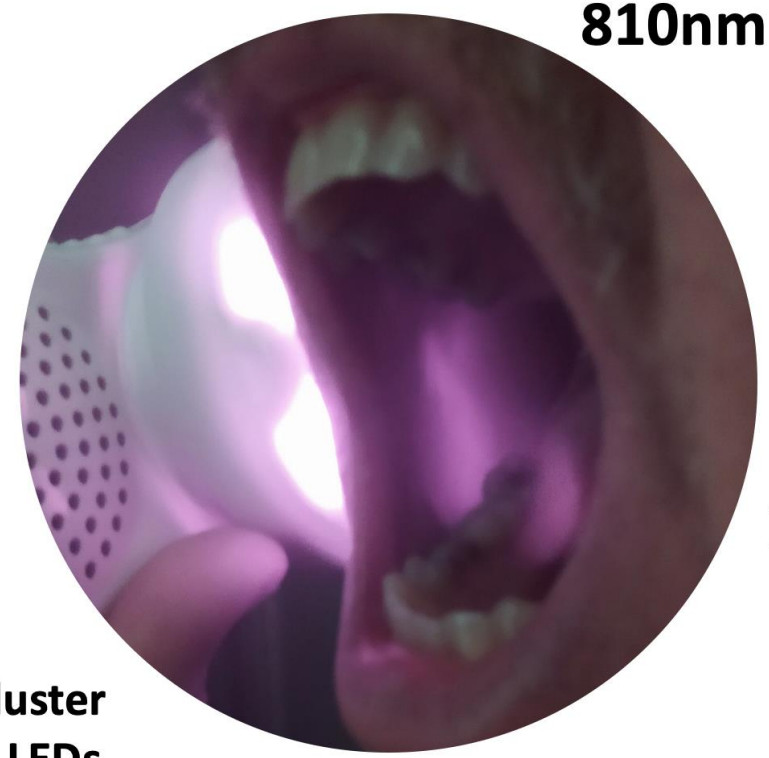
660nm



810nm



(Light can be seen passing through the gums)

Large LED Cluster
High Power LEDs
Provides Deeper Penetration

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Concussions

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SunPowerLED Helmet - Healing Example: **Concussion**

- memory loss, inability to read, headaches, stayed in dark room

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Opioid Addiction & Depression

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Opioid Addiction & Depression

Dr. Flora & Dr. Watson Huffer's

Research with Our

SunPowerLED Helmet

See:

https://sunpowerled.com/research/pbm2024

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Tom Kerber

President & Founder

Kerber Applied Research

Hamilton, CANADA | Buffalo, USA

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Thank you!