Έλεγχος ποιότητας και ασφάλειας των συστημάτων laser: Ένα παράδειγμα από τον χώρο της φυσικοθεραπείας

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"For God's sake, Edwards. Put the laser pointer away."

1. According to nature of the material placed between two reflecting surfaces.

a) Crystal lasers (solid state lasers) include

- Ruby crystal (aluminum oxide and chromium)
- Neodymium crystal is embedded in yttrium-aluminium garnet (Nd:YAG) lasers.

b) Gas lasers include

- Helium neon (HeNe)
- Argon
- Carbon dioxide (CO_2)

c) Semiconductor or diode laser

- Gallium arsenide (GaAs)

d) Liquid laser

- Polyphenyle
- Oxazine

e) Chemical laser

- Laser with high intensity not used therapeutically but used in industrial production

2. According to intensity.

a) **High power:** known as "hot" lasers because of the thermal responses they generate. These are used in the medical realms in numerous areas, including surgical cutting and coagulation, ophthalmologic, dermatologic, oncologic, and vascular specialties.

b) **Low power:** known as "low power laser therapy" or "low level laser therapy". It used for wound healing and pain management. These lasers produce a maximal output of less than 1 milliwatt (1 mW = 1/1000 W) causing photochemical, rather than thermal effects. No tissue warming occurs.

3. According to hazards.

a) Class 1 (less than 0.5 mW)

- ✓ Visible and non-visible
- ✓ No eye or skin danger
- ✓ Laser printers, car entry, CD players
- ✓ No heating/no healing
- ✓ Safe in all uses unless focused through magnifier

a) Class 2 (less than 1 mW)

- ✓ Visible
- ✓ Safe for short periods on eyes and extended on skin
- ✓ Safe because blink reflex limits retina exposure
- ✓ No healing/no heating.

❑ Classification of laser continue...

a) Class 3 (1mW to 500 mW)

- ✓ Visible and invisible.
- ✓ Helium neon (HeNe).
- ✓ Galium Arsenide (GaAs)—infrared.
- ✓ GaAluminumAs (GaAlAs)—infrared.
- ✓ MPE can be exceeded with limited effects (skin).
- ✓ Protective eye ware if direct viewing of beam.

a)Class 4 (more than 500 mW)

- ✓ Increases tissue temperature--can burn
- ✓ Dehydrates tissue
- ✓ Coagulates protein
- ✓ Thermolysis
- ✓ CO2, Argon, YAG laser
- ✓ Eye danger can result from indirect or reflected beam

❑ Classification of laser continue…

- **Most Commonly Used Lasers**

  Helium neon (HeNe)

  Gallium arsenide (GaAs).

Lasers in Rehabilitation

2- Gallium arsenide (GaAs)

- The GaAs lasers utilize a diode to produce an infrared (invisible) laser at a wavelength of 904 nm. Diode lasers are composed of semiconductor silicone materials that are precisely cut and layered. An electrical source is applied to each side, and lasing action is produced at the junction of the two materials. The cleaved surfaces function as partially reflecting surfaces that will ultimately produce coherent light.

- The 904-nm laser is delivered in a pulsed mode because of the heat produced at the junction of the diode chips.

- **N.B: Diode laser can single beam or multisource cluster beam**

1- Reducing Pain

a) There is an increase in serotonin (5-HT) levels (inhibit pain transmission to brain and from nociceptors).

b) There are also increases in Beta Endorphins, which decrease pain sensation.

c) Decrease bradykinins (is an inflammatory mediator. It is a peptide that causes blood vessels to dilate (enlarge)) which can be prevalent in injured tissue, induce pain sensation by stimulating nociceptive afferents.

d) Increase release of Acetylcholine: Acetylcholine helps normalize nerve signal transmission in the autonomic and somatic pathways.

❑ Physiological effects continue…

2- Reducing Inflammation

a) Enhancement of ATP by stimulation of mitochondria.

b) Stabilization of the Cellular Membrane.

c) Acceleration of Leukocytic Activity

d) Increased Angiogenesis (is the physiological process through which new blood vessels form by vascular endothelial cells in proliferation (growth of new tissue)).

❑ Physiological effects continue...

3- Promoting Tissue Healing

a) Increased macrophage activity.

b) Increased fibroblast proliferation.

c) Keratinocyte proliferation. (Keratinocyte: the outermost layer of the skin

The primary function of keratinocytes is the formation of a barrier against environmental damage by pathogenic bacteria, fungi, parasites, and viruses, heat, UV radiation)

a) Early epithelialization.

b) Growth factors increase (Growth factors: act on stimulating cellular growth, proliferation and healing. Examples are fibroblast growth factors and vascular endothelial growth factors stimulate blood vessel differentiation (angiogenesis).

4- Recovery from nerve injury

a) Accelerate nerve regeneration (by stimulation of Nerve growth factor)

b) Increase frequency of action potential.

c) Increase rate of nerve conduction.

5- Increase bone and cartilage formation

(by stimulation of bone morphogenetic proteins that stimulate bone cell differentiation)

❑ Clinical application of laser

1. **Calculation of laser dose** dependent on:

   (1) The output power of the laser in mw.

   (2) The time of exposure in seconds.

   (3) The beam surface area of the laser in cm2 (area of irradiation).

- **Equations:**

  Energy or total energy (Joule) = Watts X Seconds\

  Time of exposure (seconds) = Joules/Watts.

$$\text{Energy density (Joules/cm2 \{J/cm2\})} = \frac{\text{Output power (mw) x time (seconds)}}{\text{Beam surface area (area of irradiation)}}$$

Indication	Dosage	Frequency	Application
Inflammation	2 – 5 J/cm^2	5000 Hz	Over inflamed tissue
Neuralgia	10 – 12 J/cm^2	Continuous	Along course of nerve
Pain, acute	6 J/cm^2	Continuous	Over pain area or TP
Pain, chronic	12 J/cm^2	Continuous	Over pain area or TP
Soft tissue injury, acute	4 – 8 J/cm^2	<100 Hz	Over lesion
Soft tissue injury, chronic	12 J/cm^2	Continuous	Over lesion
Tendinitis/Bursitis	2 – 10 J/cm^2	5000 Hz	Over inflamed tissue
Trigger points	5-12 J/cm^2	Continuous	Over TP
Wounds, acute	8 J/cm^2	700 Hz	In and around wound bed
Wounds, chronic	1 – 6 J/cm^2	Continuous	In and around wound bed
Joint Disorders, chronic	Finger: 0.5 J/cm^2	Continuous	Over joint surface
	Knee: 6 J/cm^2	Continuous	Over joint surface
	Spine: 12 J/cm^2	Continuous	Over joint surface

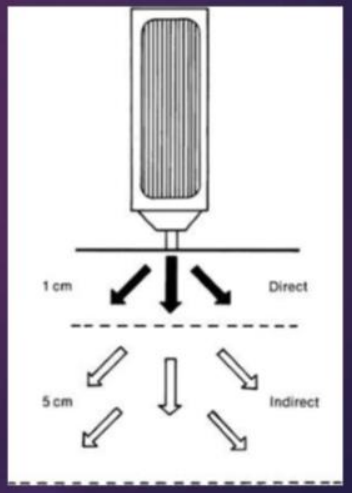
Note: As a general guideline, use wavelengths in the visible range (600-700 nm) for superficial lesions, in the infrared range (700-1000 nm) for deeper lesions.

❑ Clinical application of laser

2. Depth of Penetration

a)HeNe laser energy Absorbed rapidly in the superficial structures, especially within the first **2-5 mm** of soft tissue. The response that occurs from absorption is termed the "direct effect." HeNe laser has an indirect effect on tissues **up to 8-10 mm.**

a)The GaAs, which has a longer wavelength, is directly absorbed in tissues at depths of **1-2 cm** and has an indirect effect **up to 5 cm.**



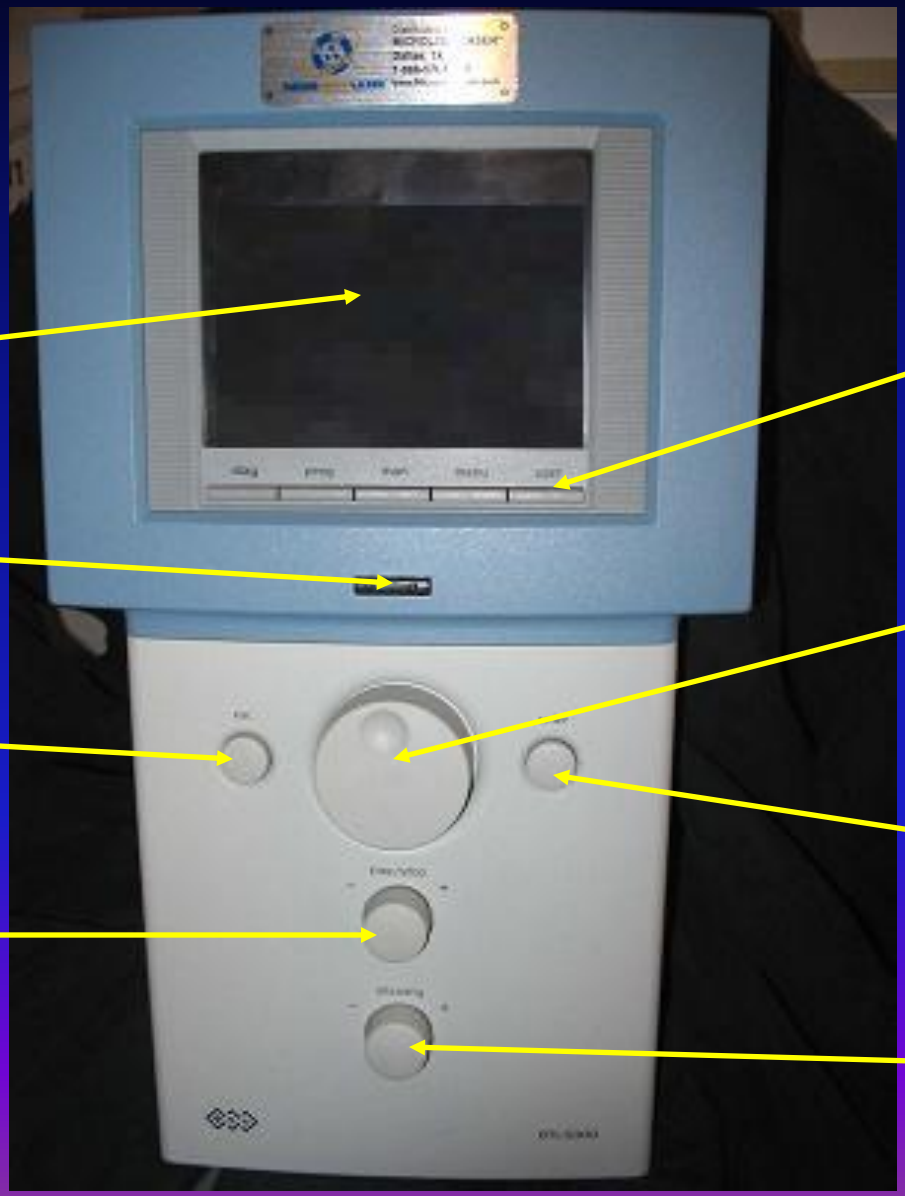
❑ Clinical application of laser

3) Laser treatment techniques

There are two main techniques

1. Contact technique: GaAs only for trigger points or around wound.
2. Non-contact technique: for HeNe and GaAs for superficial wounds or stimulation of wound bed

CONTROL CONSOLE – FRONT FACE



Touch activated display screen

Mode selection tabs

On / Off switch

Scroll / parameter adjustment key

Escape key

Enter key

Time / stop Adjustment key

Intensity adjustment key

CONTROL CONSOLE - BACK

Probe connection ports

Master power switch

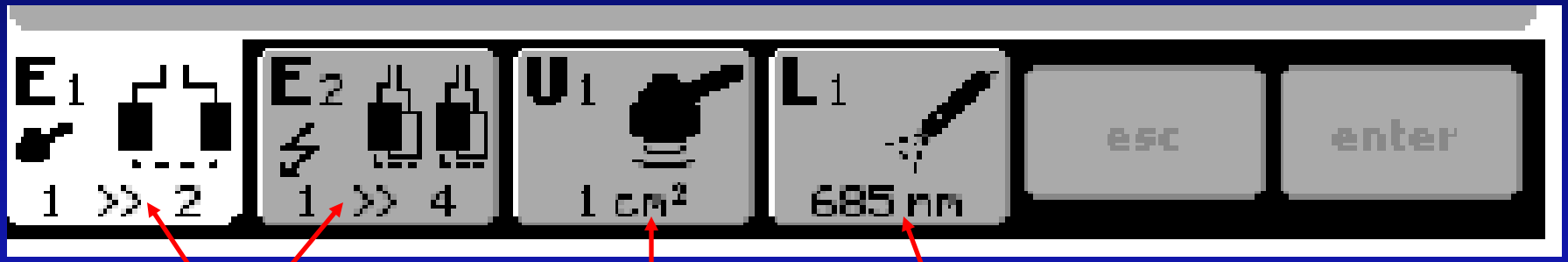
Power cord connection port

Main fuse

External communication ports – data / upgrades

Unit performs diagnosis and probe identification, then

Displays connected probes



Electrotherapy

Ultrasound

Probe type

Laser Therapy

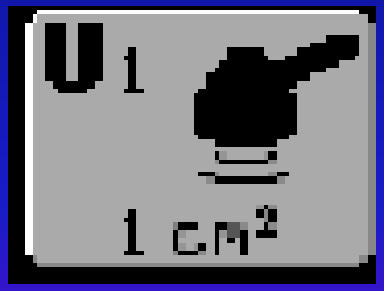
Probe type

Screen Icons

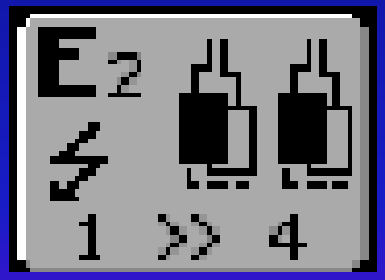
Single diode Laser

Cluster diode laser

Physiological Effects graph



Ultrasound probe

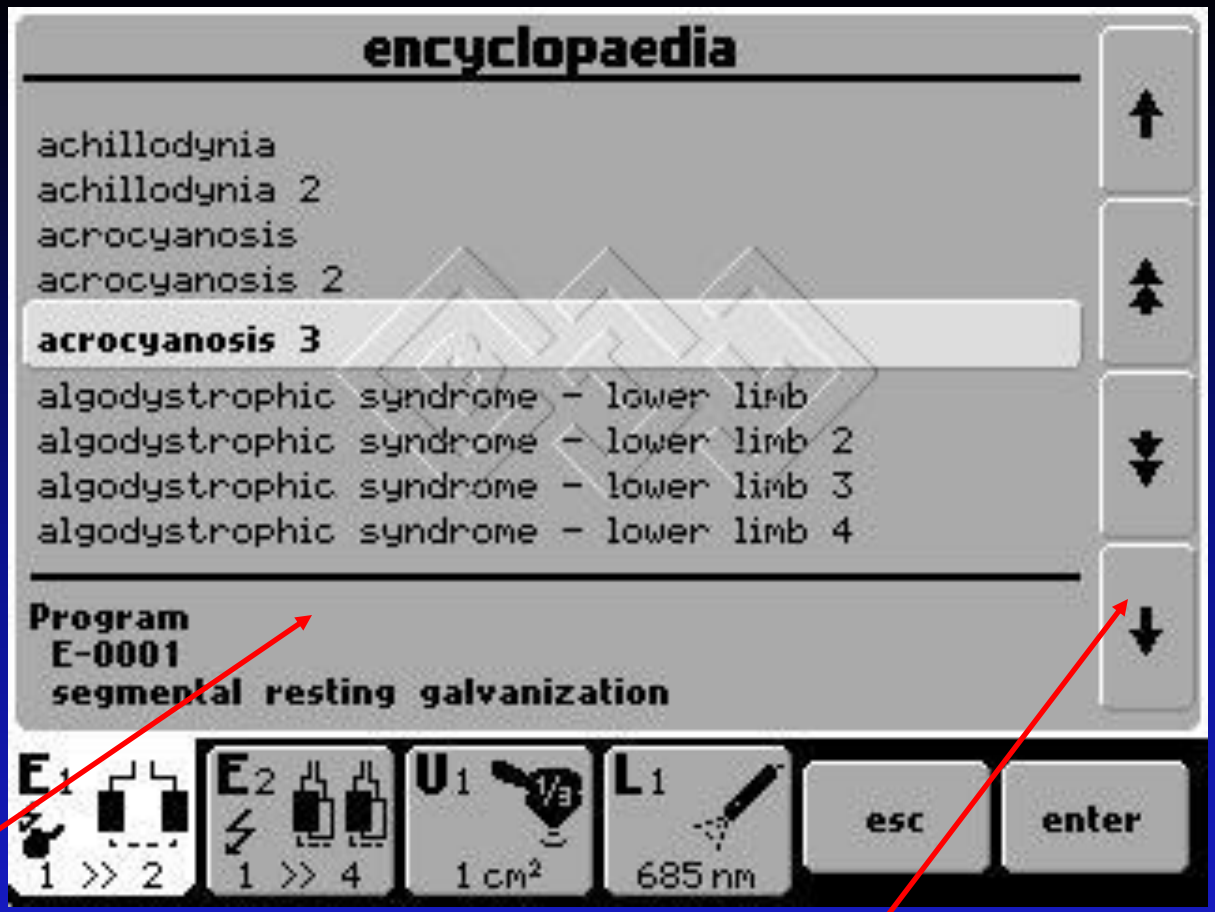


Electrotherapy leads

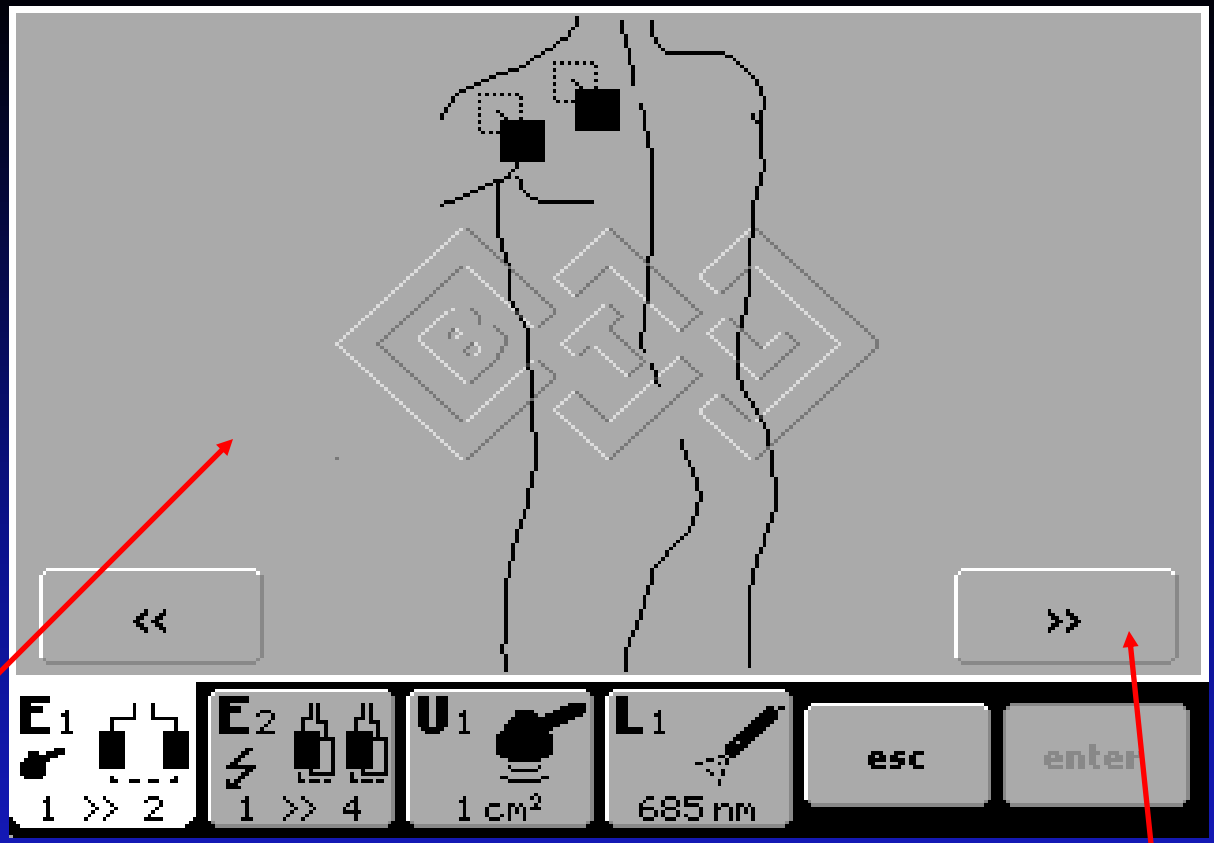
Encyclopedia

Anatomy illustrations

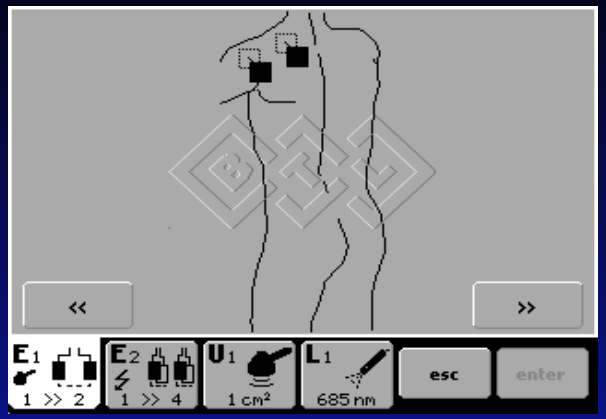
Activating Encyclopedia icon will take you to the encyclopedia library

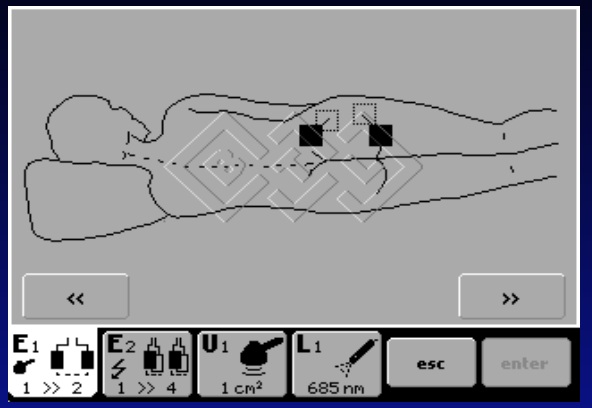


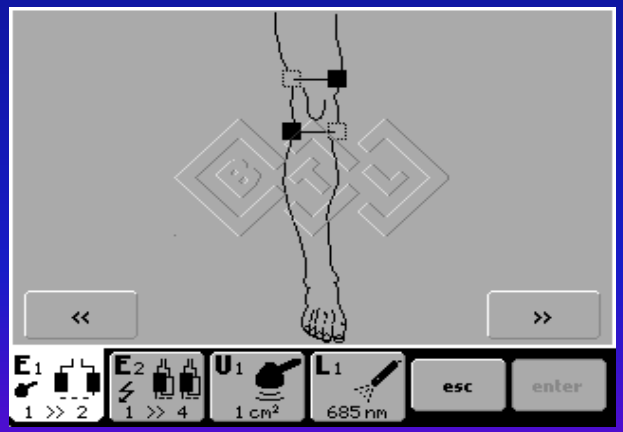
You can then scroll through options using the arrows or dial control

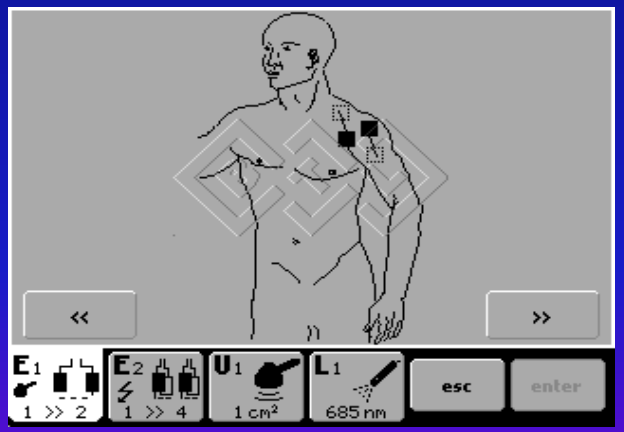


Activation of Anatomy Man icon will take you to the available anatomy chart for the selected protocol. Use of forward or back arrows will show any additional anatomy charts

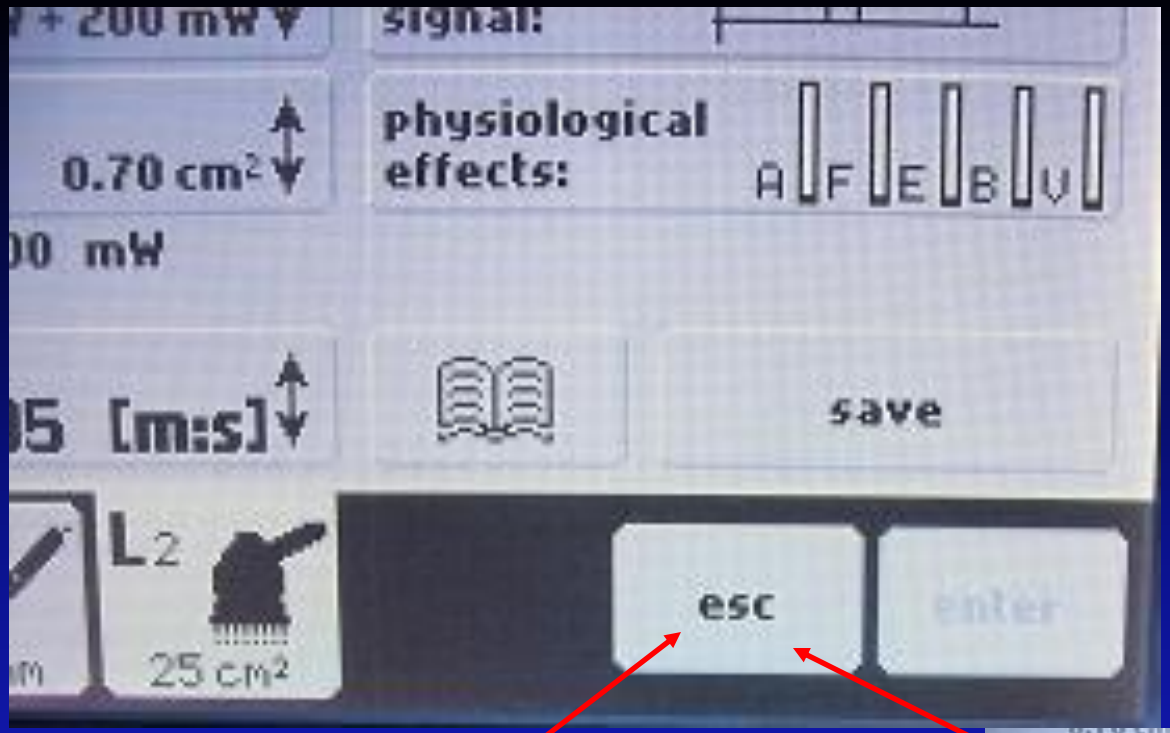

«
»
E1
1 >> 2
E2
1 >> 4
U1
1 cm²
L1
685 nm
esc
enter

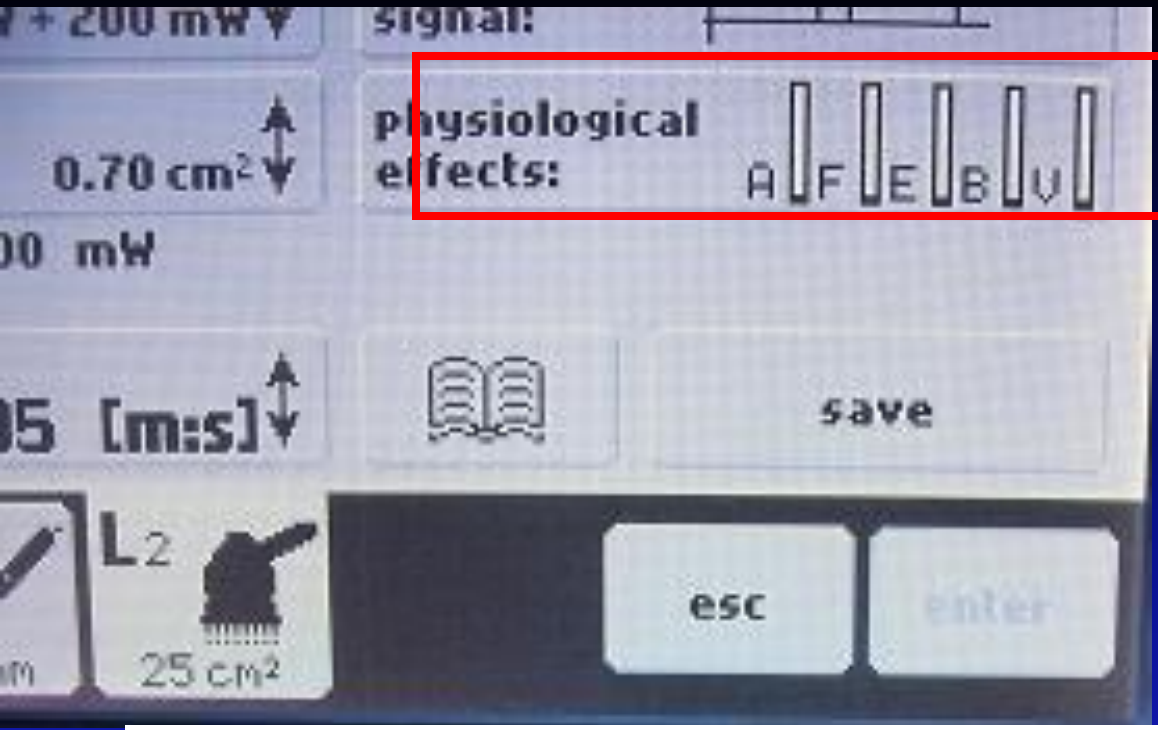

«
»
E1
1 >> 2
E2
1 >> 4
U1
1 cm²
L1
685 nm
esc
enter


«
»
E1
1 >> 2
E2
1 >> 4
U1
1 cm²
L1
685 nm
esc
enter


«
»
E1
1 >> 2
E2
1 >> 4
U1
1 cm²
L1
685 nm
esc
enter

To escape out of any screen displayed and go to previous screen, use either touch screen or escape button.





Physiological effects graph (laser)

A = Analgesic (pain control)

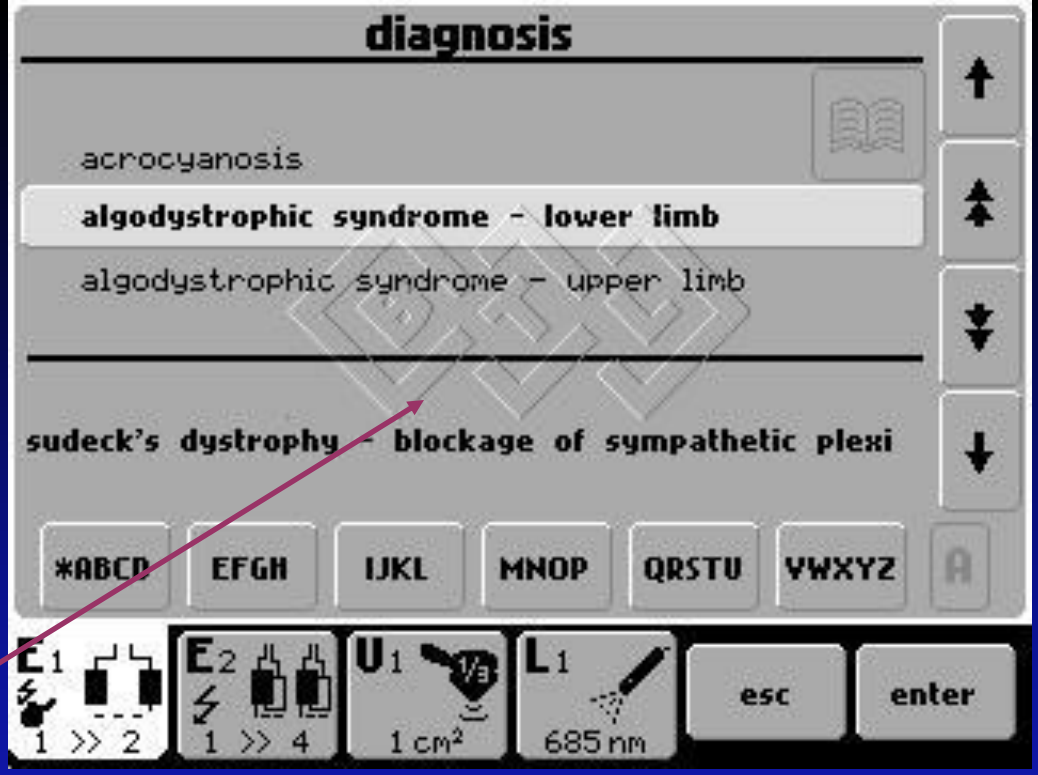
F = Antiflogistic (anti bacterial)

E = Antiedema (inflammation effect)

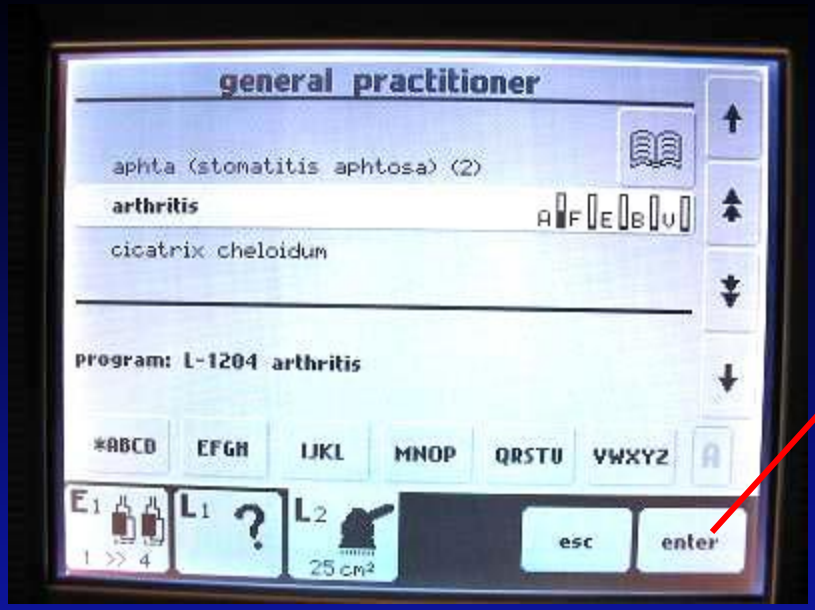
B = Biostimulation (increased cellular activity)

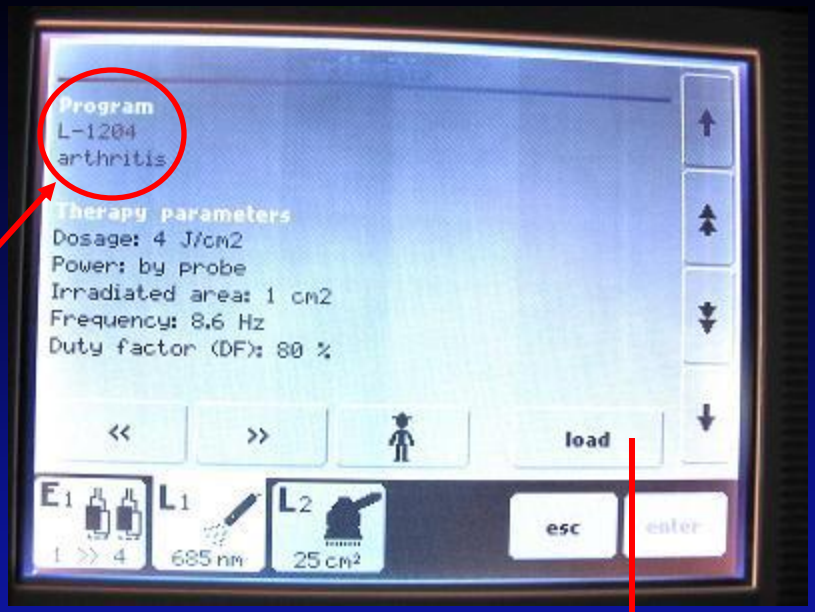
V – Vasodilation (circulatory effect)

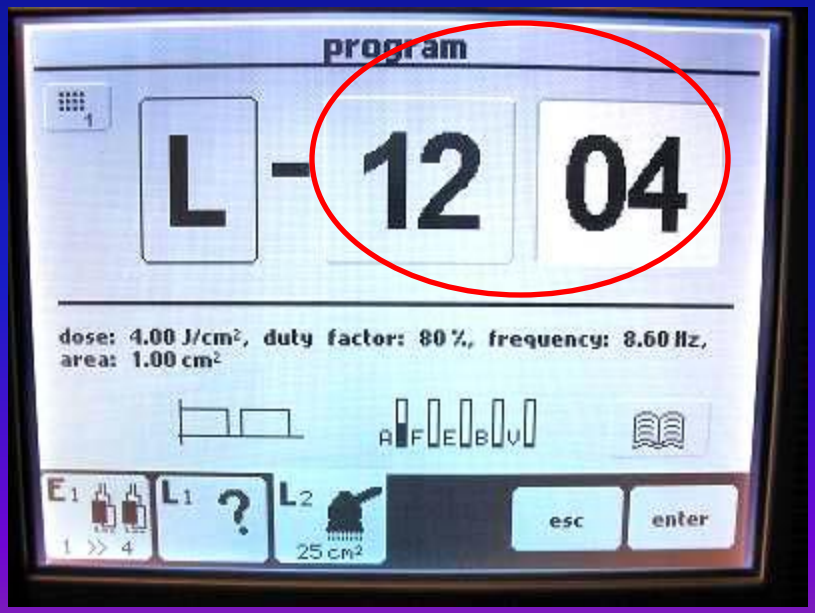
Depressing diagnosis button will take you to main diagnosis screen



In the diagnosis program, clinical specialties can be accessed if the laser probe has been selected.

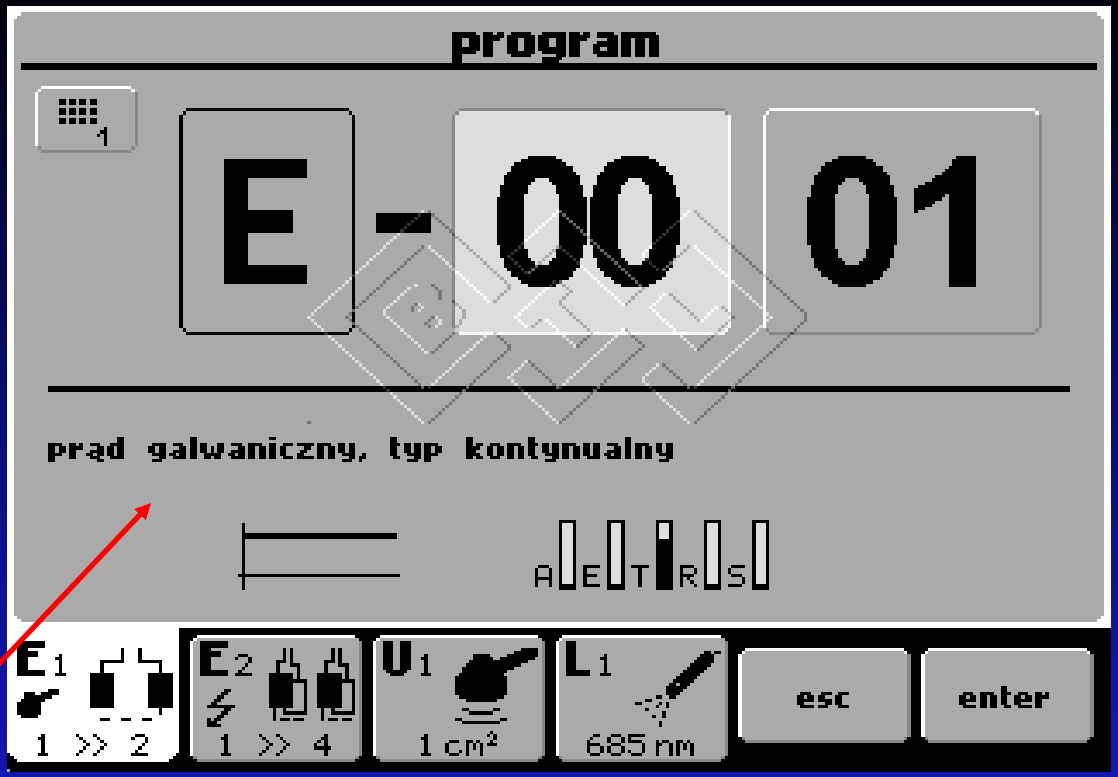

general practitioner
aphta (stomatitis aphtosa) (2)
arthritis
cicatrix cheloidum
program: L-1204 arthritis
*ABCD
EFGH
IJKL
MNOP
QRSTU
VWXYZ
esc
enter

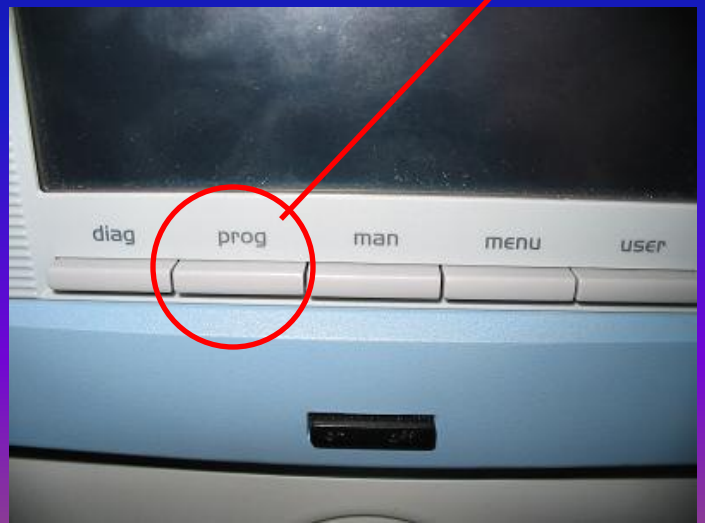

Program
L-1204
arthritis
Therapy parameters
Dosage: 4 J/cm2
Power: by probe
Irradiated area: 1 cm2
Frequency: 8.6 Hz
Duty factor (DF): 80 %
load
esc

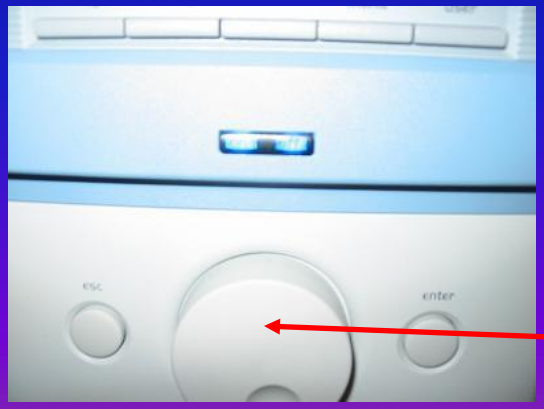

program
L - 12 04
dose: 4.00 J/cm², duty factor: 80 %, frequency: 8.60 Hz,
area: 1.00 cm²
esc
enter


program 1204
therapy:
laser
frequency:
8.60 Hz
dose:
4.00 J/cm²
power:
50 mW
course of signal:
area:
1.00 cm²
physiological effects:
max.power: 50 mW
laser ready
distance: 2.0 cm
time:
01:40 [m:s]
save
esc

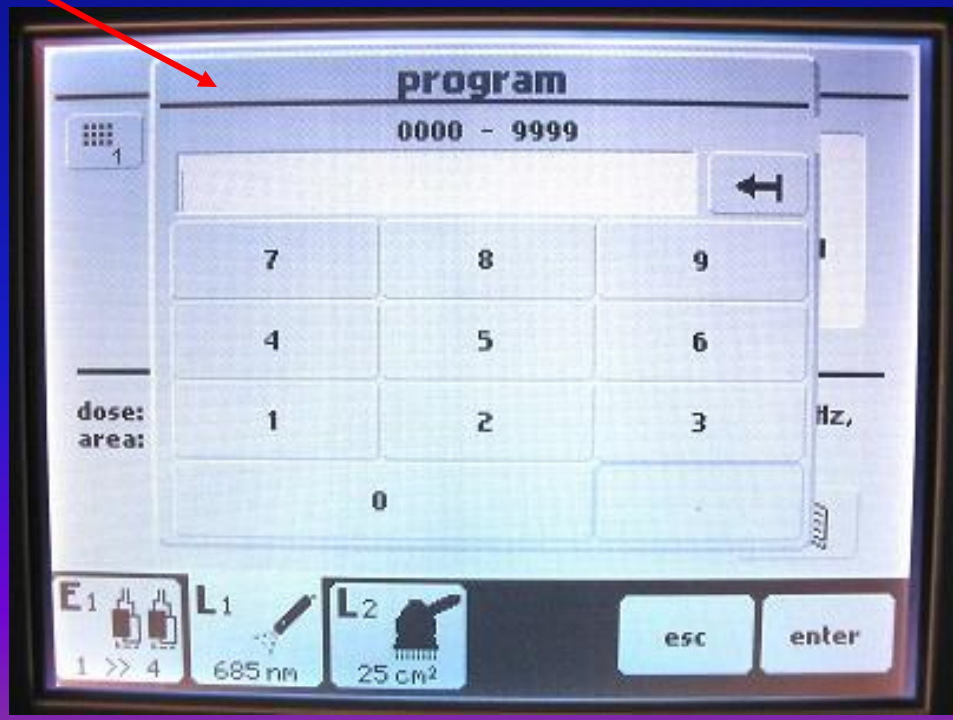
Depressing program button will activate the program main screen



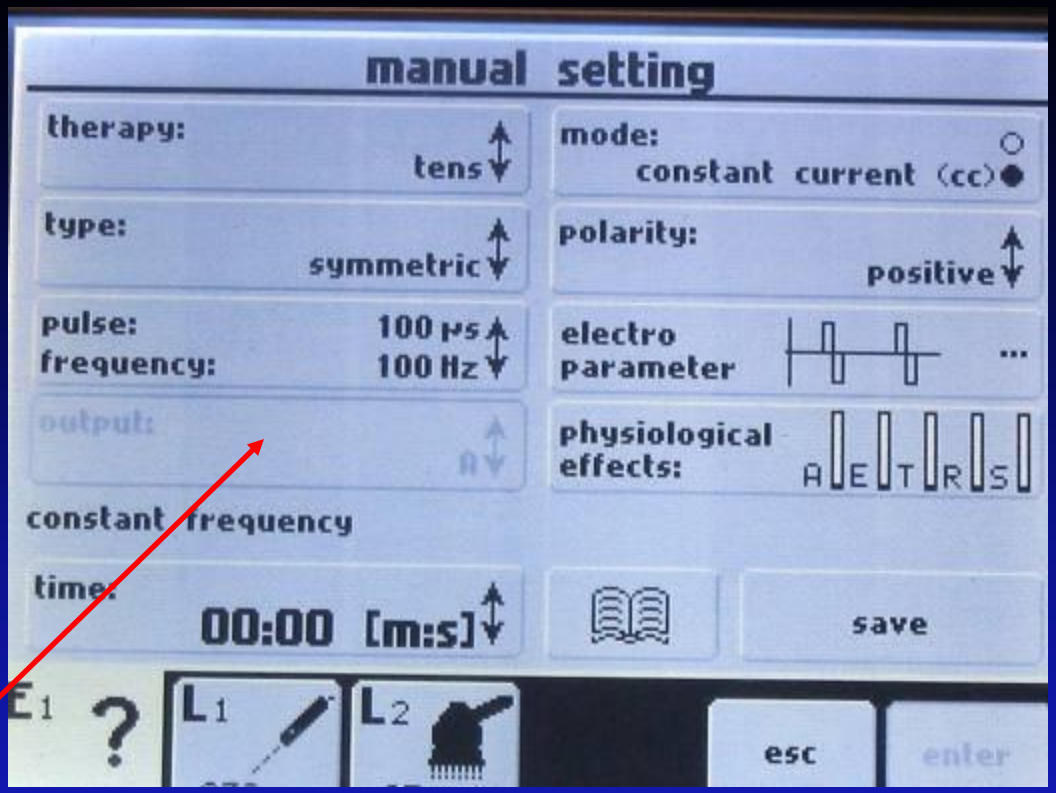




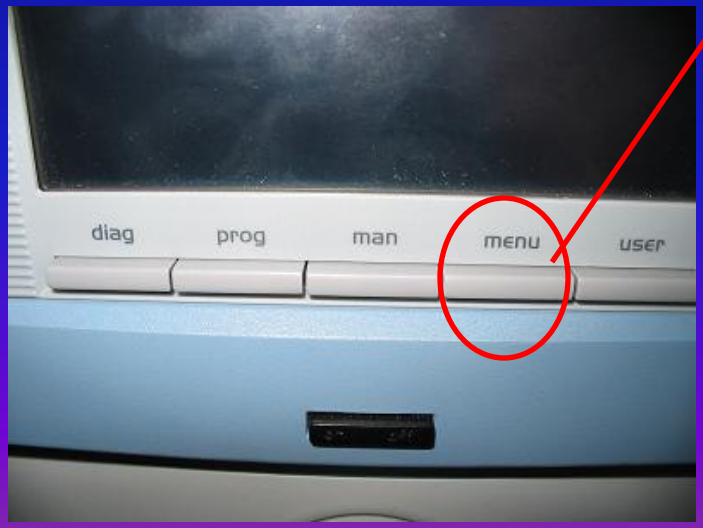
You can then scroll through options with dial

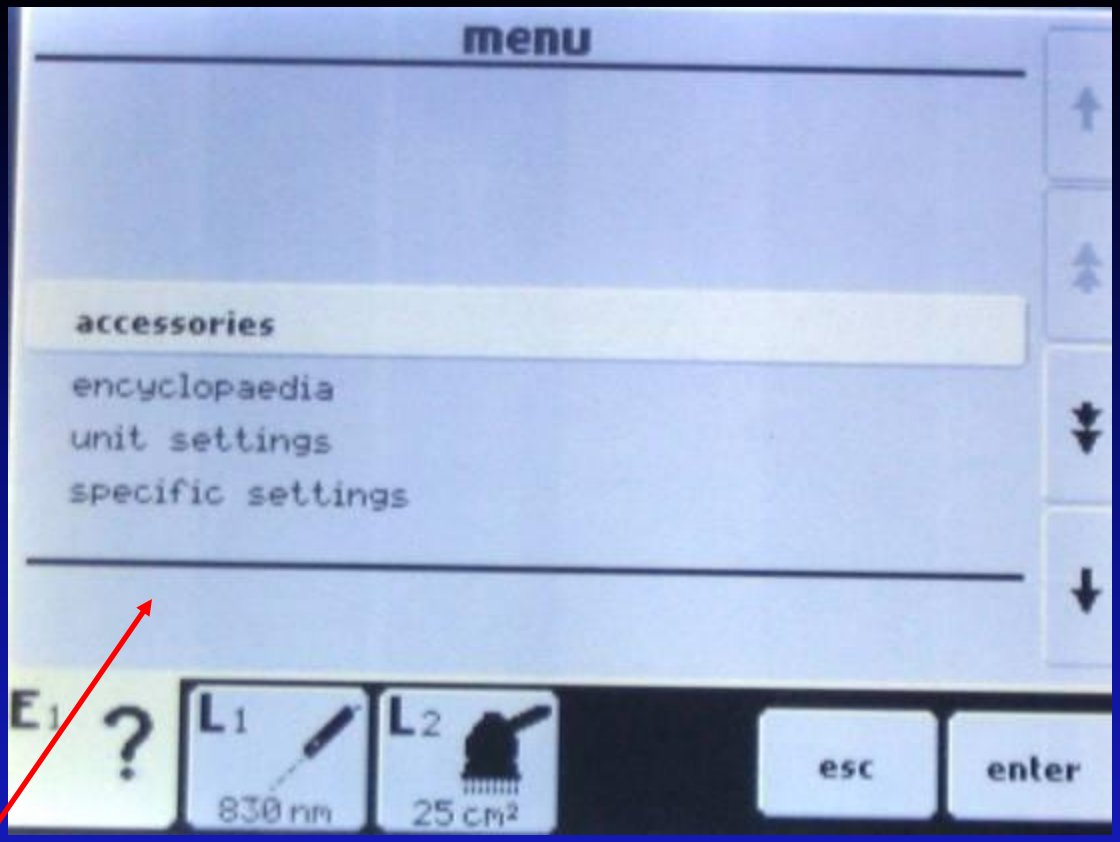


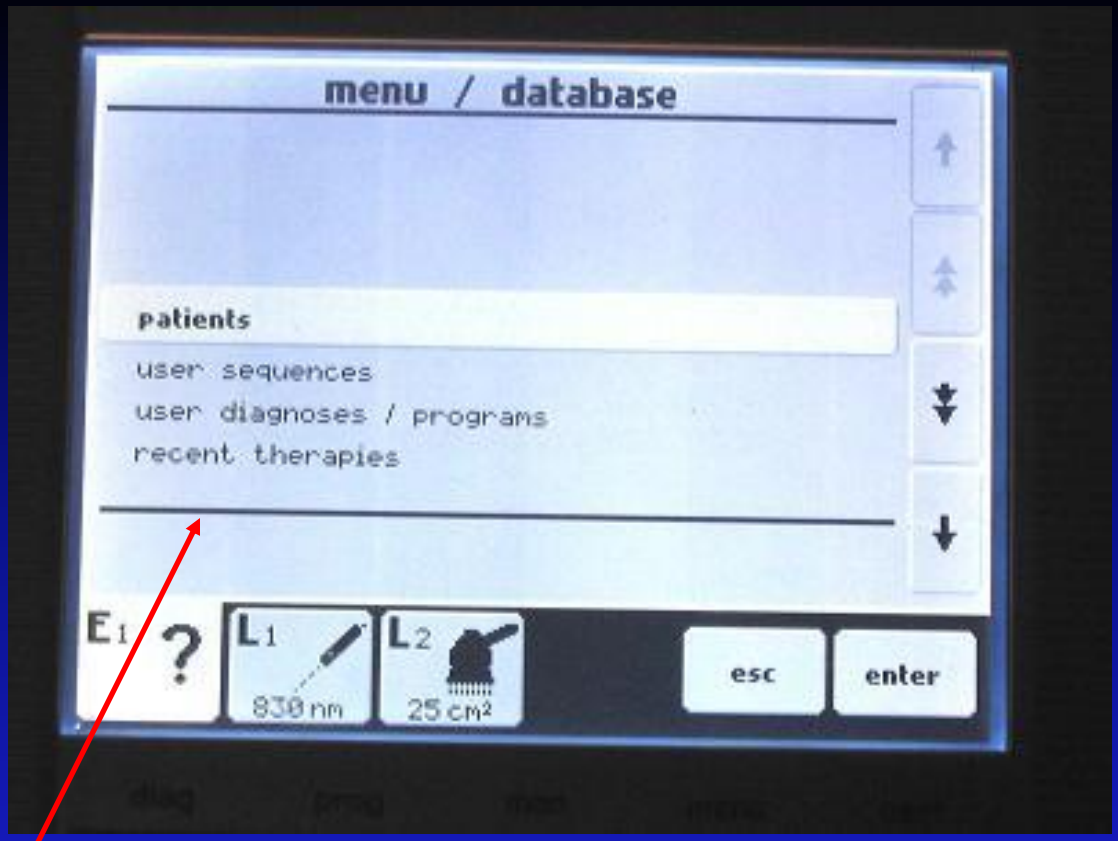
You can also go directly to your favorite program by pressing the small zip icon, then entering the program number you desire, then press enter, it will take you directly to that program

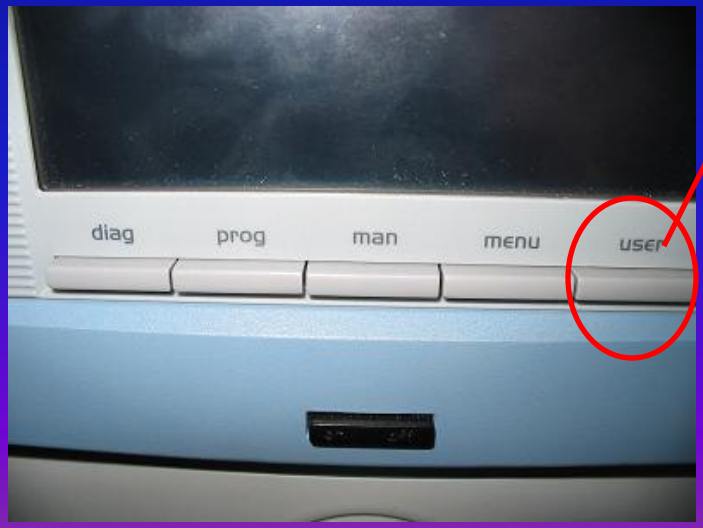


Depressing manual tab takes you to the manual setting main screen

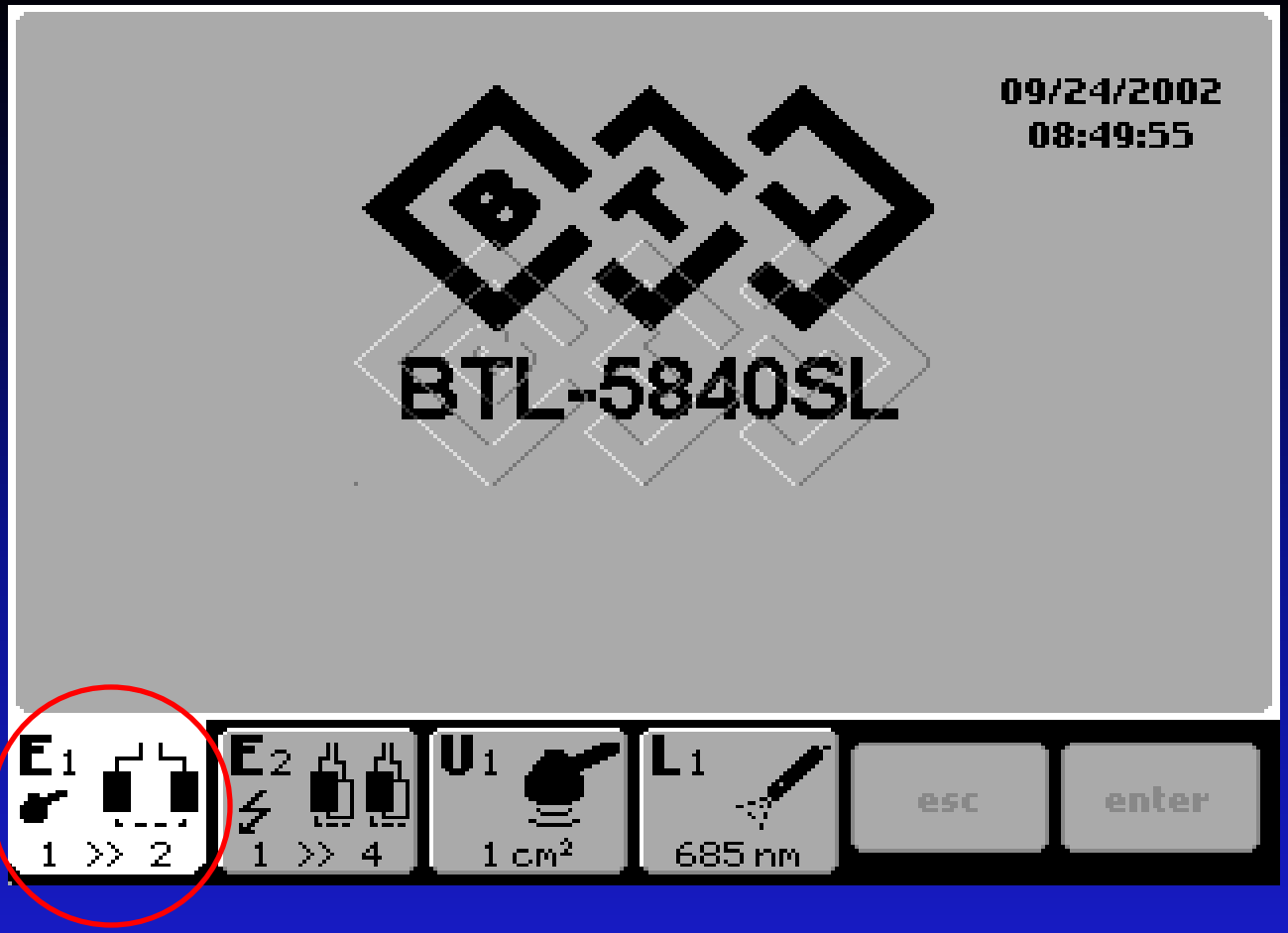

diag
prog
man
menu
user


menu
accessories
encyclopaedia
unit settings
specific settings
E1
?
L1
830 nm
L2
25 cm²
esc
enter

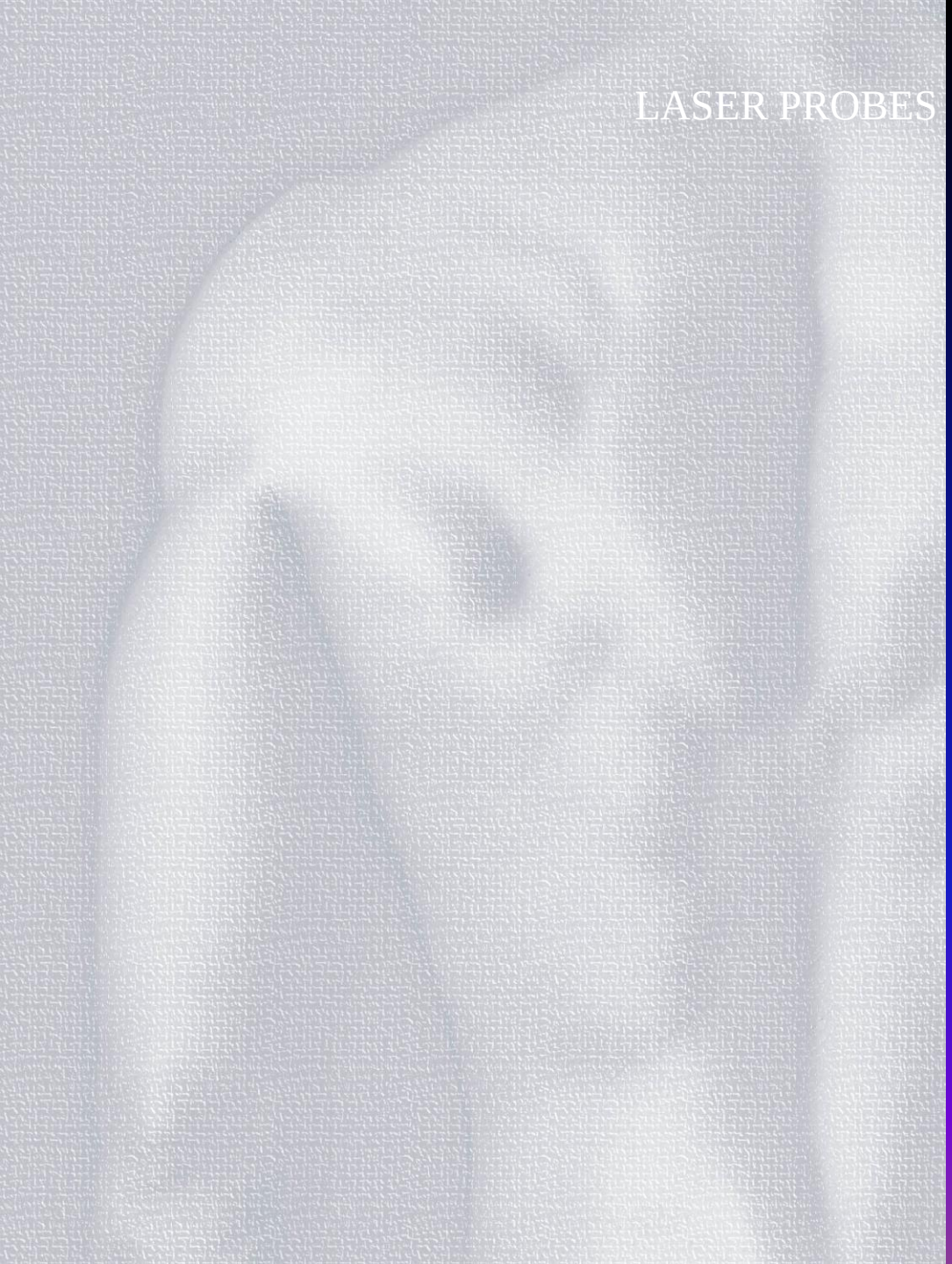




Depressing user tab will take you to user menu main screen



To select the desired probe / therapy, touch the desired probe icon at bottom of screen. The selected probe / therapy icon will then change color, indicating that probe is now the active probe.



LASER PROBES

Dose:

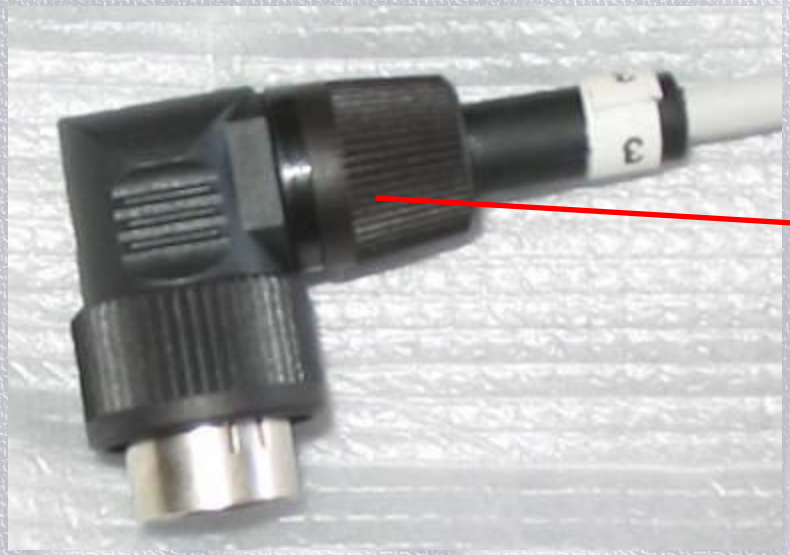
adjustable from 0.1 to 99 Joules

Laser Power: adjustable from 20 to 100 %

Therapy Area: adjustable from 0.1 to 99 cm2

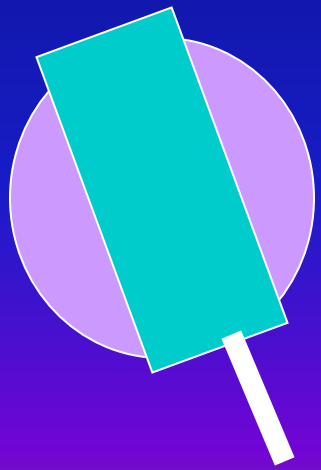
Duty Factor:

10 to 90 %

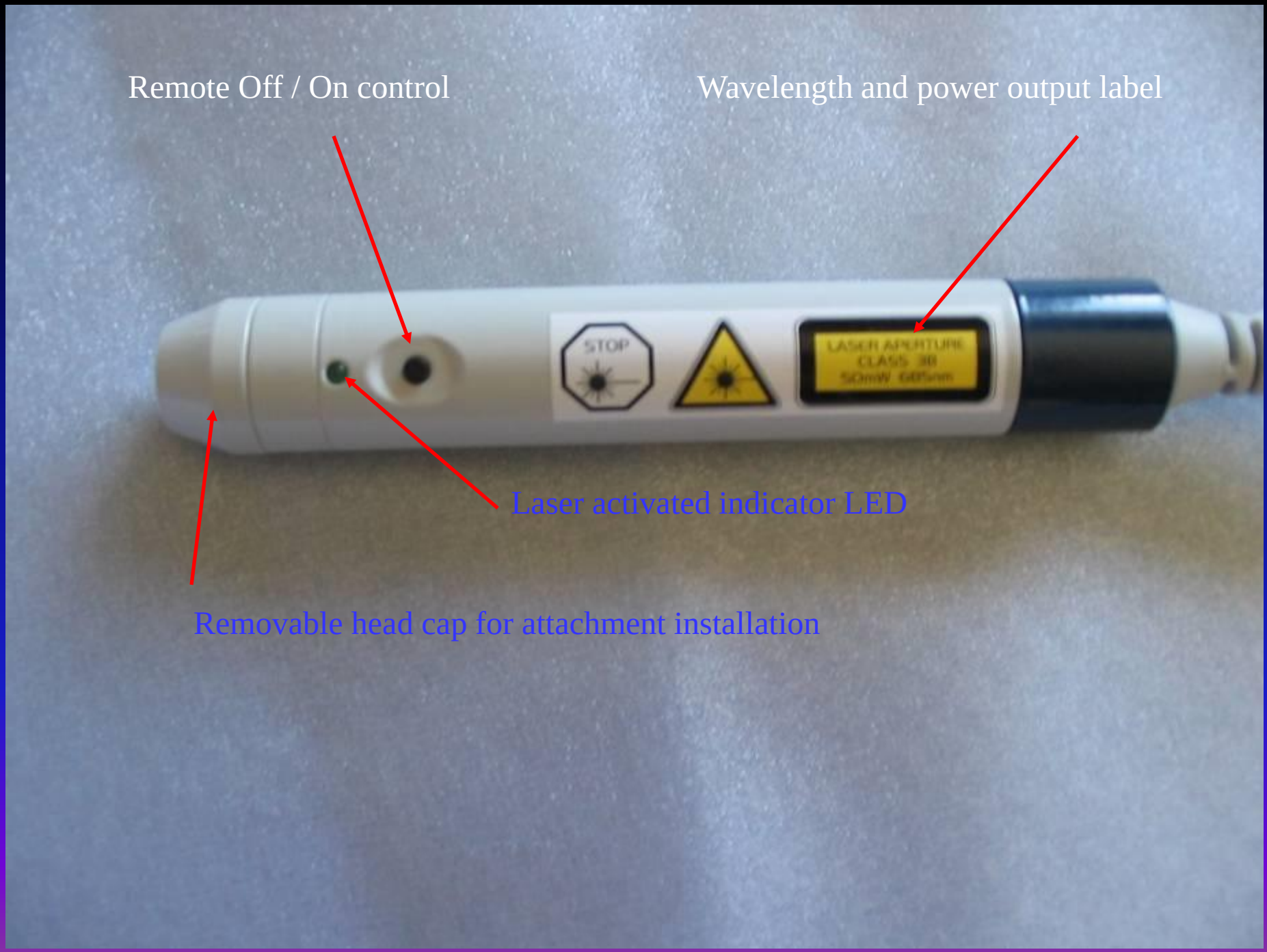


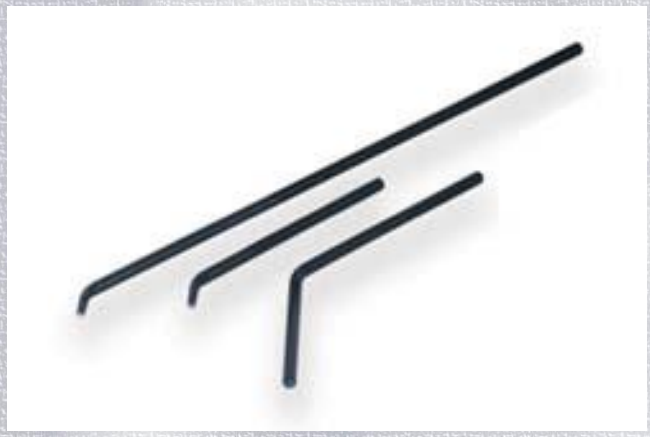
Probe connections

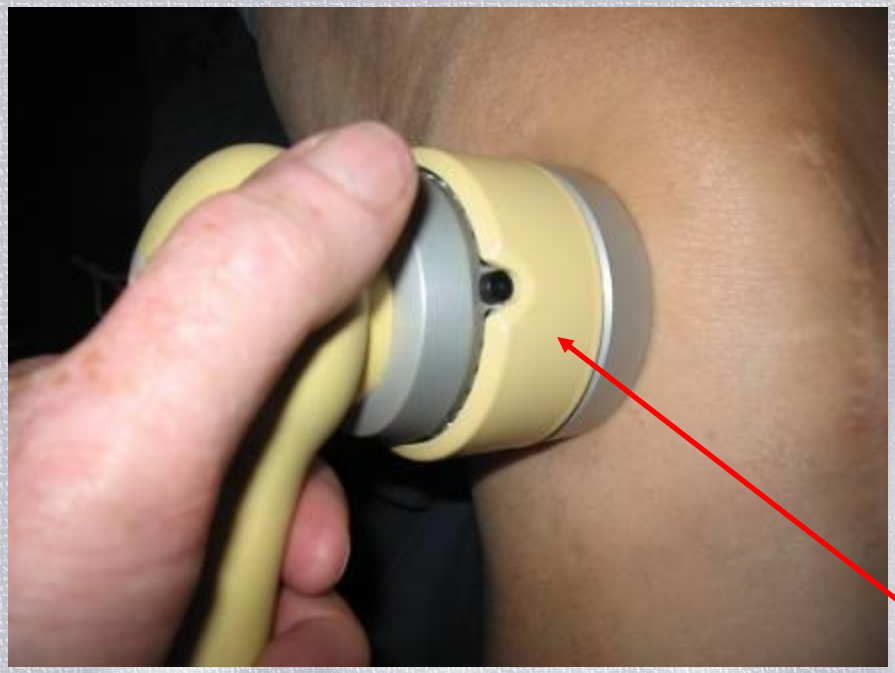
Note that with all connections of therapy cables, the cable connects at the 11:00 position for 2,4,6 and at the 1:00 position for 1,3,5



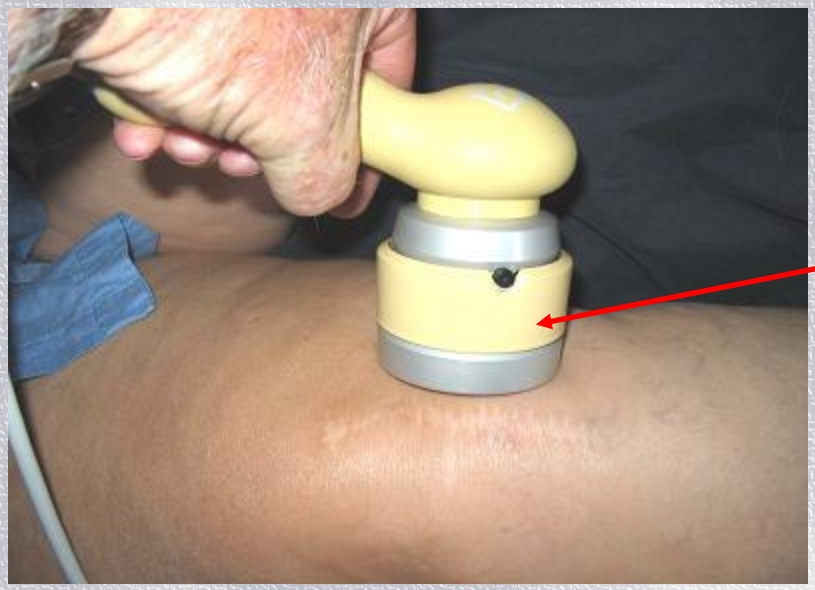
Single Diode Probes


Remote Off / On control
Wavelength and power output label
STOP
Laser activated indicator LED
Removable head cap for attachment installation

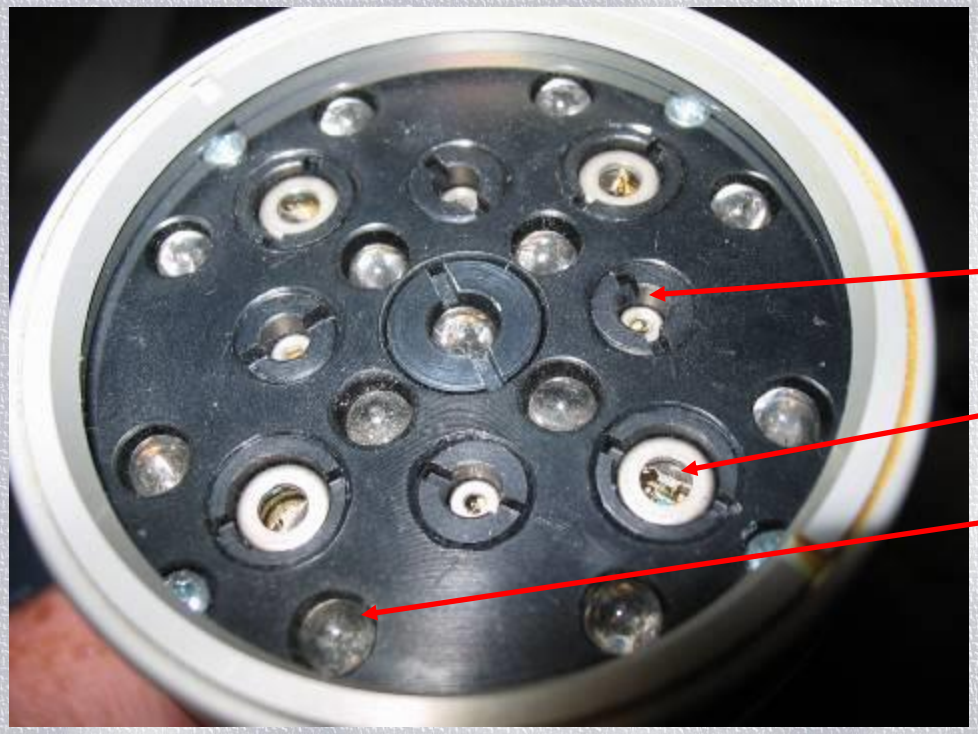




Remote Off/On control



Cluster probe is of metal construction with built in cooling fan for laser diodes



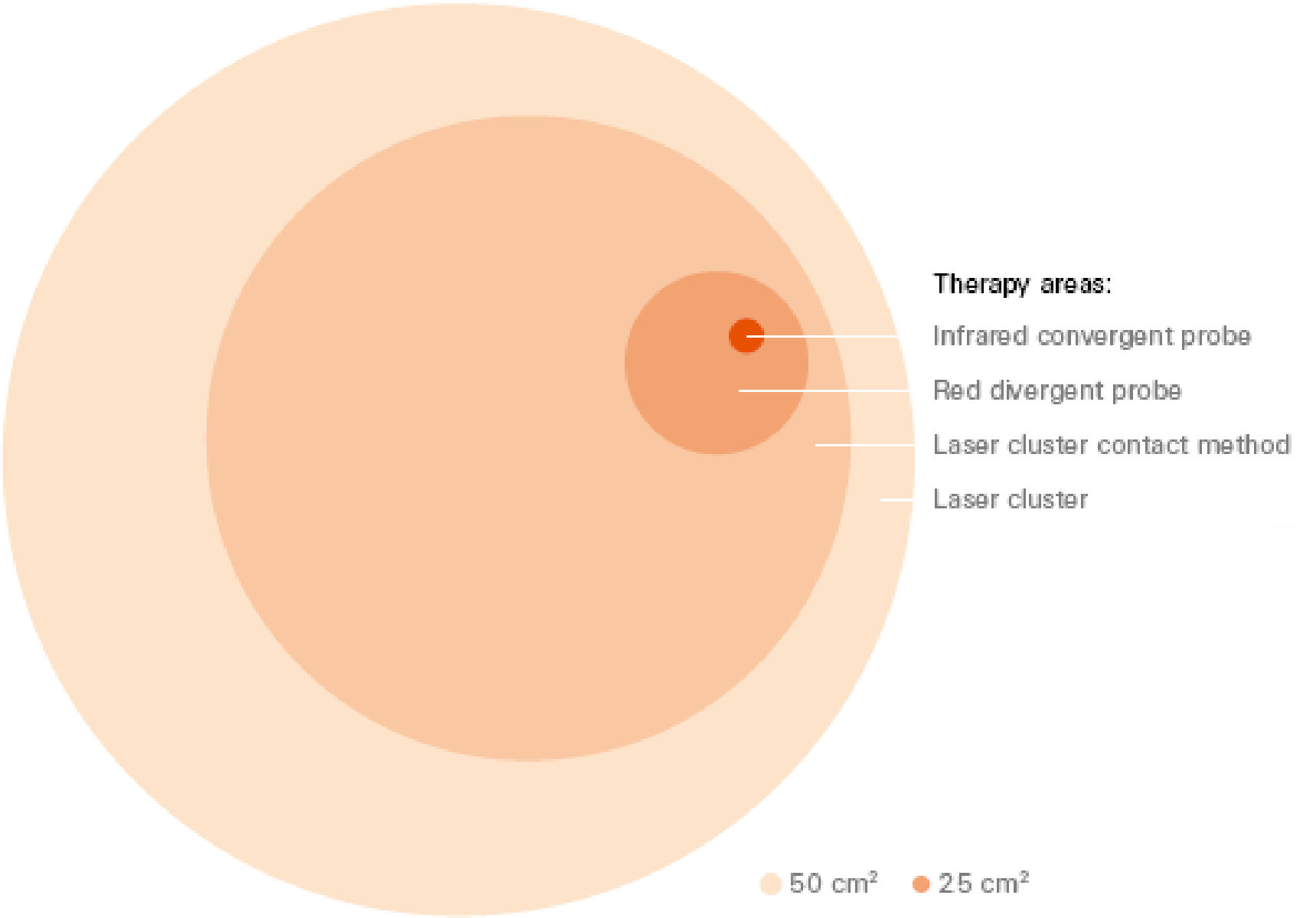
Cluster Probe Head

685 nm Laser diodes

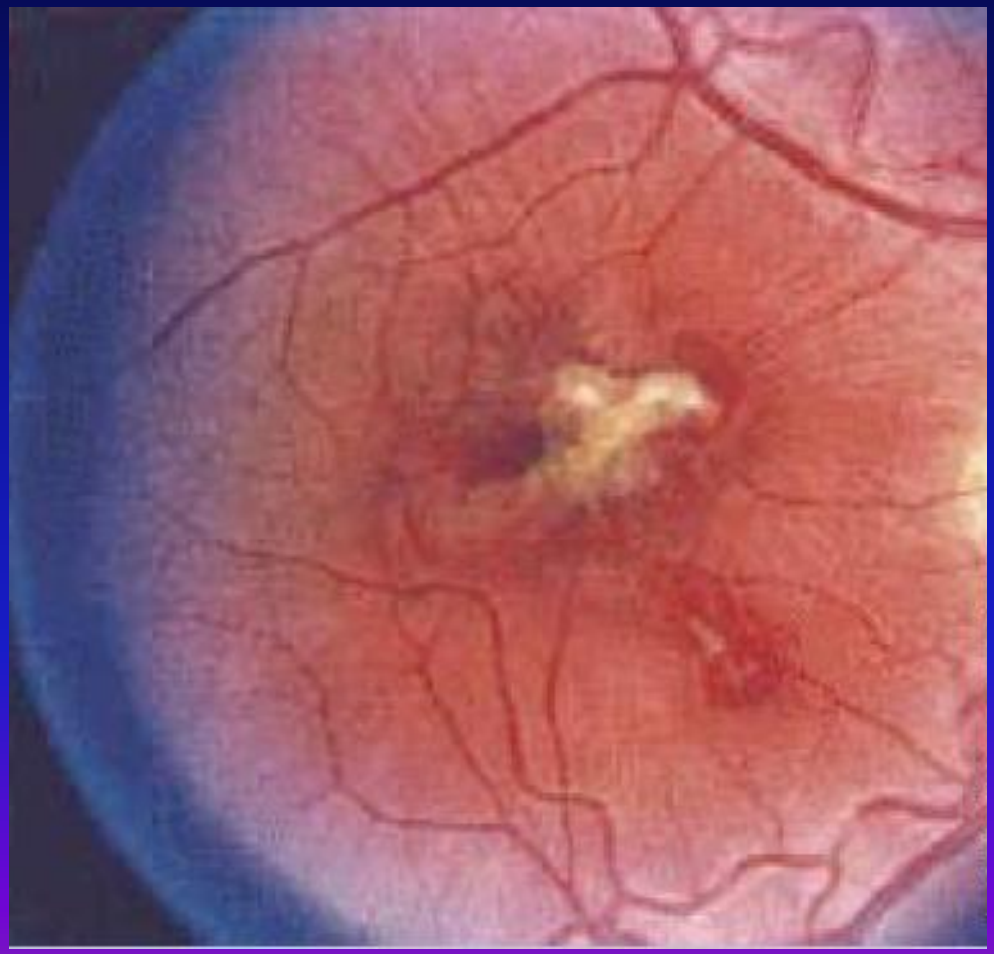
830 nm Laser diodes

470 nm SLED diodes

The blue SLED diodes are not figured into the total mW power output, as they do not provide any therapeutic value in our markets.


Therapy areas:
Infrared convergent probe
Red divergent probe
Laser cluster contact method
Laser cluster
50 cm²
25 cm²

Eye Injury



Protection of our Skin

- Ultraviolet (UV)
  - UV can cause skin injuries comparable to sun burn.
  - There is an increased risk for developing skin cancer from UV laser exposure.
- Thermal Injuries
  - High powered lasers, especially from the infrared (IR) and visible range of the spectrum, can burn the skin and even set clothes on fire.

Skin Burns

- CO2 laser reflected from a metal surface

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

Laser Scanners

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

CLASS 3R (Formerly 3a)

- Aversion response may not provide adequate eye protection
- CW maximum power (visible) 5 mW

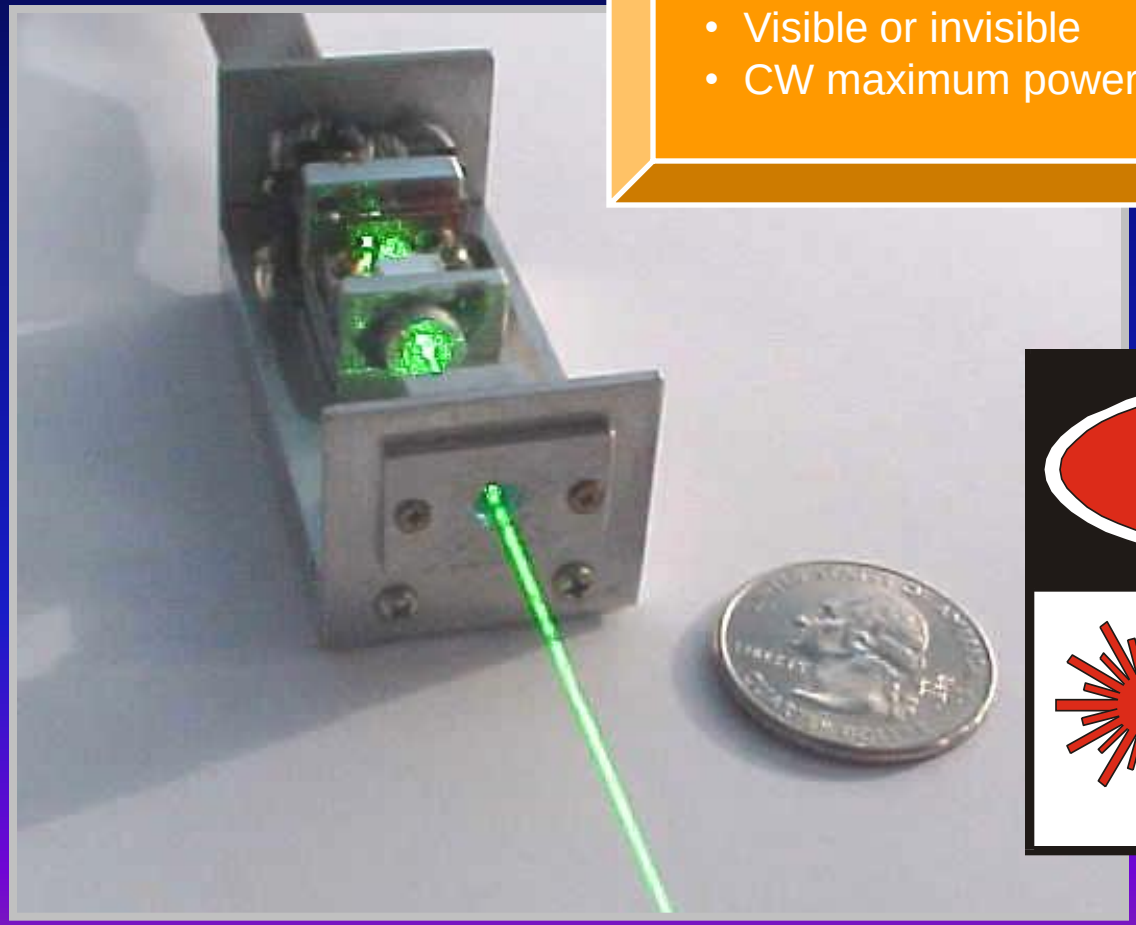
Expanded Beam

Small Beam

CLASS 3B

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

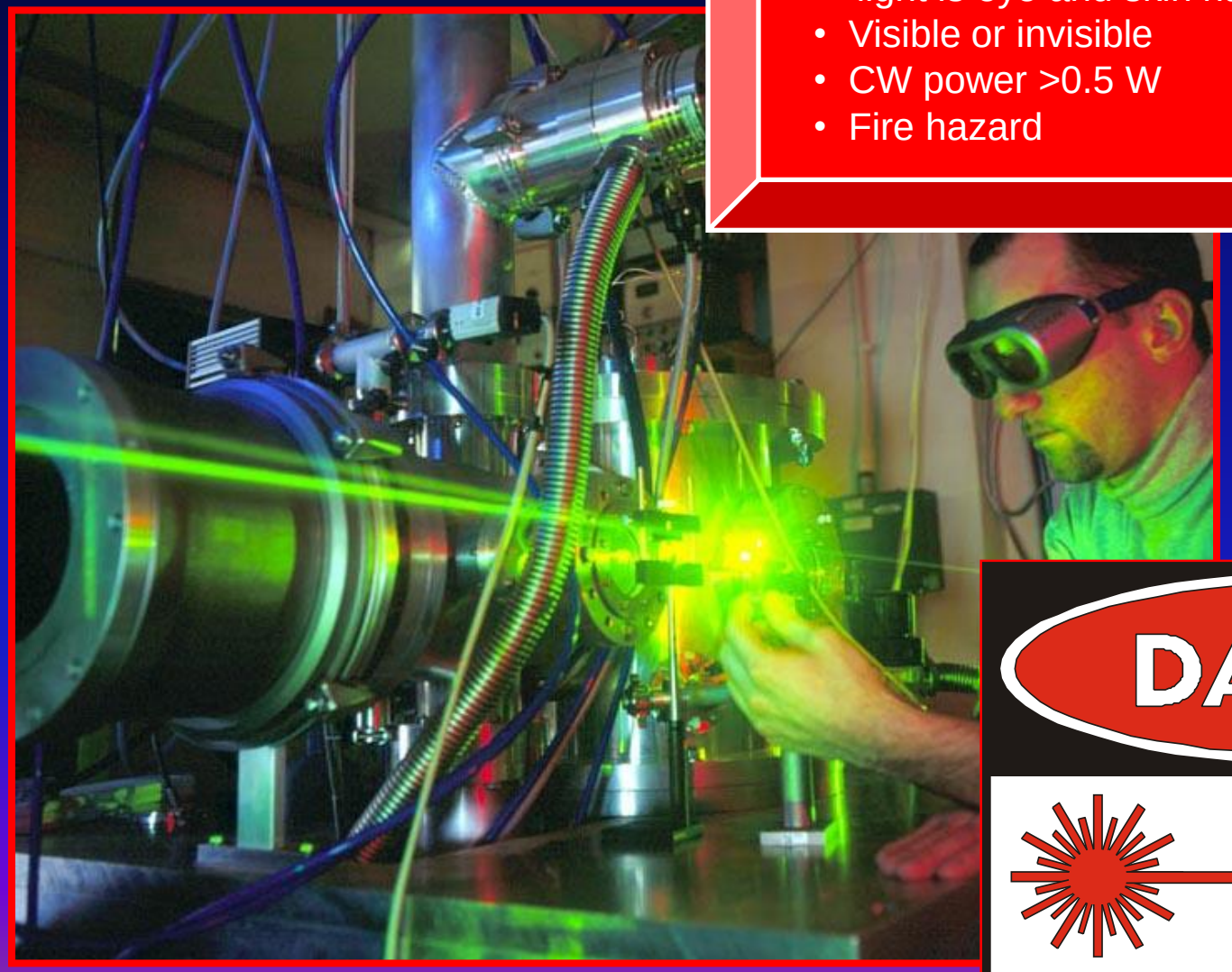
DPSS Laser with cover removed

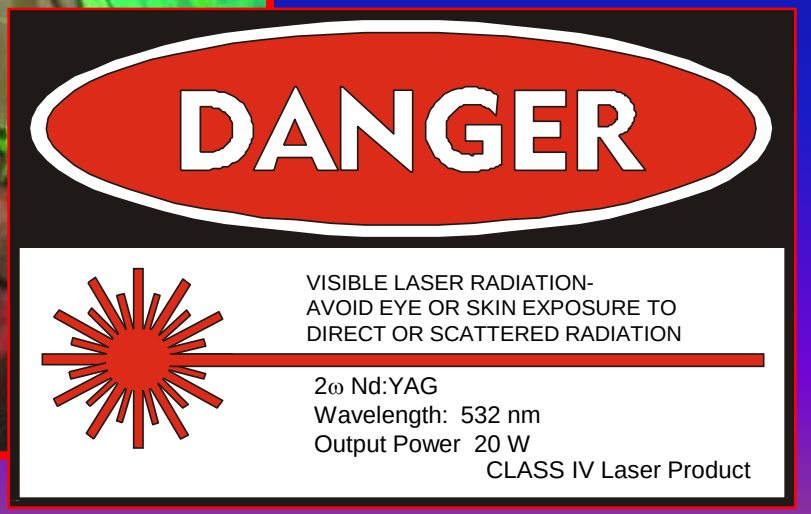


Courtesy of Sam's Laser FAQ, www.repairfaq.org/sam/lasersam.htm, © 1994-2004

CLASS 4

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





2. Non-Beam Hazards

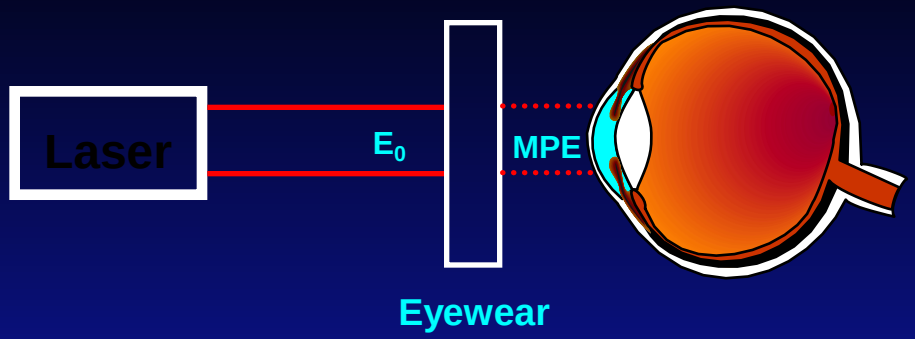
- Electrical Hazards
- Fire Hazards
- Laser Generated Air Contaminants (LGAC)
- Compressed Gases
- Chemical Hazards
- Collateral and Plasma Radiation
- Noise

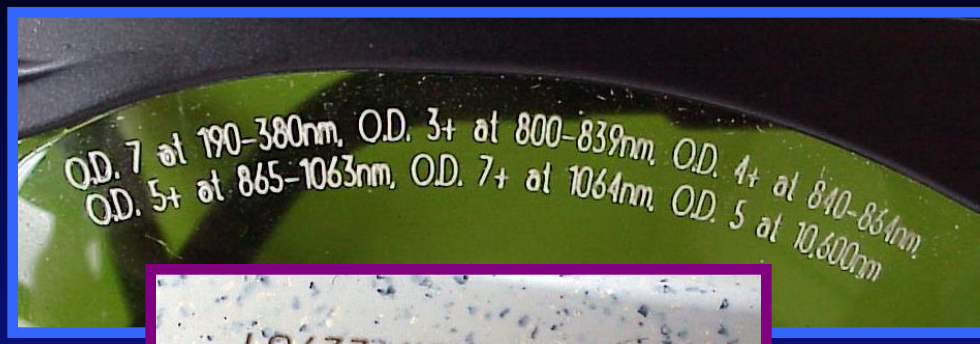
LASER PROTECTIVE BARRIERS

Photos courtesy o

KENTEK®
"Laser People Helping Laser People"®

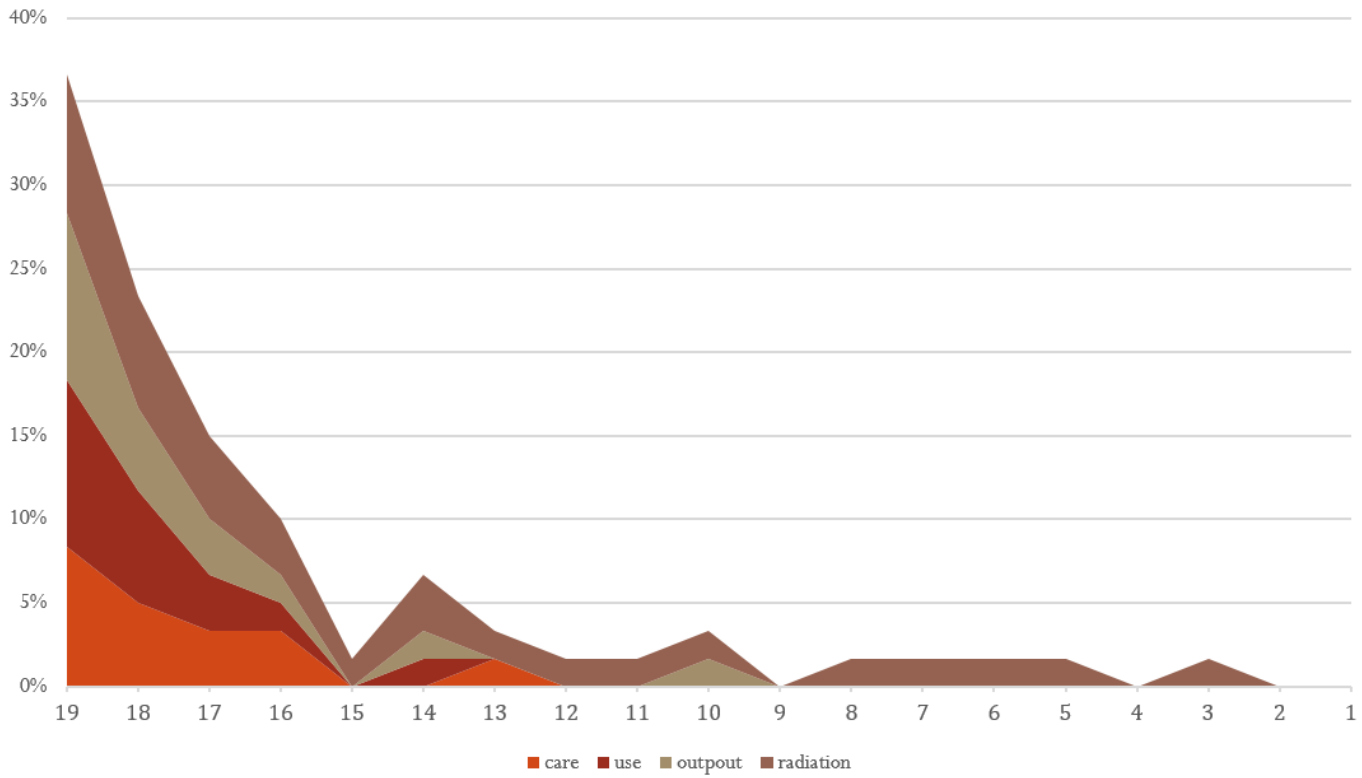
OPTICAL DENSITY OF LASER SAFETY EYEWEAR





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

Lack of maintenance



QC protocol	TEST SECTION	INCLUTED TESTS	CRITERIA				REFERENCE
	Safe use guidelines of operation exposure		Control of operation exposure				
			*frequency**	acceplable	desirable	*units*	
Care of equipment	*Mechanical Tests*	Secure casing	*b*	All panels in good condition, Access to internal components only with tools			NHMRC (1985)
		Functioning castors	*b*	Unit is portable			
		Operatinf castor breakes	*c*	Breakes immobilize uints			
		Movable treatment arms	*c*	Securely attached and freely movable			
		Treatment arms lock	*b*	Lock in place			
		Interchangable electrodes	*c*	Lock in place, Range available			
		Condition of electrodes	*c*	No signs of damage, Air-space adjastable, Rubber on pad electrodes not broken down			
		Functioning control	*c*	Lamps and controls operational, Dials are fixed and click at correct interval			
		Operation of patient circuit braker	*b*	Power output stops when operated			
		Timer accuracy	*b*	Unit only operate with timer Output switches off when timer is zeroed			IEC 60601-2-3 (1991)
				< 5 min : 30 sec	15 sec	*sec*	DHW (1993)
				5-10 min: 10 %	5%	*sec*	
				> 10 min: 60 sec	30 sec	*sec*	
Use of equipment	*Output tests*	Linearity	*a*	30% Max power output < 500 W	250	*w*	IEC 60601-2-3 (2007)
		Stability	*a*	20%	10%	*w*	
		Reproducibility	*a*	20%	10%	*w*	
		Waveform analysis	*a*	2445 - 2475 MHz	2455-2465 MHz	*Hz*	IEC 60601-2-6 (2012)
				Pulse Frequency: 30 %		*Hz*	
				Pulse width: 30 %		*w*	
	Electrical Safety	Visual inspection	*c*	Physical damage ruled out			IEC 60601-2-3 (2007)
		Earthing tests	*a*	200 mΩ	200 mΩ	*Ω*	
		Insulation Tests	*a*	> 50 MΩ	> 50 MΩ	*Ω*	
		Leakage current tests	*a*	Earth: < 1000 µA	500 µA	*A*	IEC 60601-2-3 (2007)
				Enclosure: < 500 µA	100 µA	*A*	
				Patient (AC): < 500 µA	100 µA	*A*	
				Patient (DC): <50 µA	10 µA	*A*	
		Auxillary current tests	*a*	AC: <0.1 mA	0.1 mA	*A*	IEC 60601-2-3 (2007)
				DC: < 0.05	0.01 mA	*A*	
Enviroment of equipment	*Environmental Survey*	Furniture	*c*	Beds and chairs non-metallic			NHMRC (1985), ENRAF NONIUS (1997), DHW (1993), APA (1992), CSP (1992), CSP (1994)
		Treatment area layout	*c*	Metal objects > 3m	> 5m	*m*	DHW (1983), APA (1992) NHMRC (1985), ENRAF NONIUS (1997)
				Mains filter present			
		Warning Signs	*c*	No use of mobile phones			IEC 60601-2-6 (2012)
				Danger for patients with pacemakers			
		Other modalities in area	*c*	Other electrotherapy units > 3 m	> 5 m	*m*	CSP (1992), CSP (1994)
	RF Radiation Measurements	Isotropic probe, frequency analysis Maximum averaging over 6 min	*a*	E-field : 61 V/m	61 V/m	*V/m*	ICNIRP (2004)
				H-field: 0.16 A/m	0.13 A/m	*A/m*	
		Distance 0.5 m, 1 m, 1.5 m , 2 m, 2.5 m. 3.0 m, 3.5 m, 4.0 m, 4.5 m, 5 m, 6 m Height 1.1 m, 1,5 m, 1.7 m Angle 0, +45, +90, +135, -45, -90, -135 degrees		SAR: 0.4 W/Kgr	0.08 W/Kgr	*W/Kgr*	IEC 61786 (1998), IEEE Std C95.3 (2002), CEPT Revised ECC/REC/(02) (2004), ETSI EG 202 373 V.1.1.1 (2005)

Integrated 2-Watt Broadband Power and Energy Meter System

The 13 PEM 001/J integrated 2-watt broadband power and energy meter is a high-sensitivity instrument for measuring optical radiation from the ultraviolet to the far infrared. The instrument features a sensitive, but low drift, thermopile sensor head. The sensor disc, made from high-density graphite, does not have a painted, plated, or anodized front surface that can be easily ablated. Consequently, the thermopile has a very high damage threshold. The 13 PEM 001/J is ideal for measuring the output power of cw lasers, the average power of pulsed (quasi-cw) laser sources, and the peak power of long-pulse lasers. It can also measure the energy of a laser pulse.

- Measures cw power from 10 μW to 2 W
- Calibrated from 200 nm to 20 μm
- Handles 200 W/cm² average power, 100 MW/cm² pulsed power
- Includes broadband (400 nm–2 μm) optical filter to eliminate thermal background radiation
- Displays output in analog and digital formats
- Adjustable tilt base for easy viewing

SPECIFICATIONS: INTEGRATED 2-WATT BROADBAND POWER AND ENERGY METER SYSTEM

Measurement Specifications:
- **Calibrated Spectral Range:** 200 nm to 20 μm (400 nm to 2 μm with filter)
- **Power (Energy):**
  - **Range:** 10 μW to 2 W (10 μJ to 2 J)
  - **Resolution:** 10 μW (10 μJ)
- **Range Selection:** 7-position switch, 3–3000 mW (mJ)
- **Offset:** ± 25 mW (mJ) with 10-turn potentiometer
- **Pulse Repetition Rate (energy mode):** Single pulse or 1 Hz maximum
- **Maximum Pulse Width:** 100 msec
- **Noise Equivalent Power (Energy):** 10 μW (10 μJ) rms
- **Drift:** Less than 15 μW over 60 min
- **Response Time:** <0.5 sec
- **Calibration:** ± 5% NIST traceable

Detector:
- **Type:** 10-mm-diameter large-area thermopile; high-density graphite disc
- **Uniformity:** ± 1% over central 8 mm
- **Maximum Power Dissipation:** 3 W
- **Maximum Energy Density:**
  - ~1 J/cm² for pulse width $\tau \geq 10^{-7}$ sec
  - ~$\tau/10^{-7}$ J/cm² for pulse width $\tau \leq 10^{-7}$ sec
  - (e.g., ~10^{-5} J/cm² for pulse width $\tau = 10^{-12}$ sec)

Displays:
- **Digital:** 3½-digit LED display
- **Analog:** Precision backlit mirror scale
- **External Analog Output:** Rear-panel BNC (1 Vdc full scale)

Power Requirements:
- **Voltage:** 115 Vac + 10%/ − 20%, 230 Vac ± 10% Rear-panel selector switch
- **Frequency:** 50–60 Hz
- **Power:** <10 W

Temperature:
- **Operating:** +15°C to +35°C
- **Storage:** −20°C to +55°C

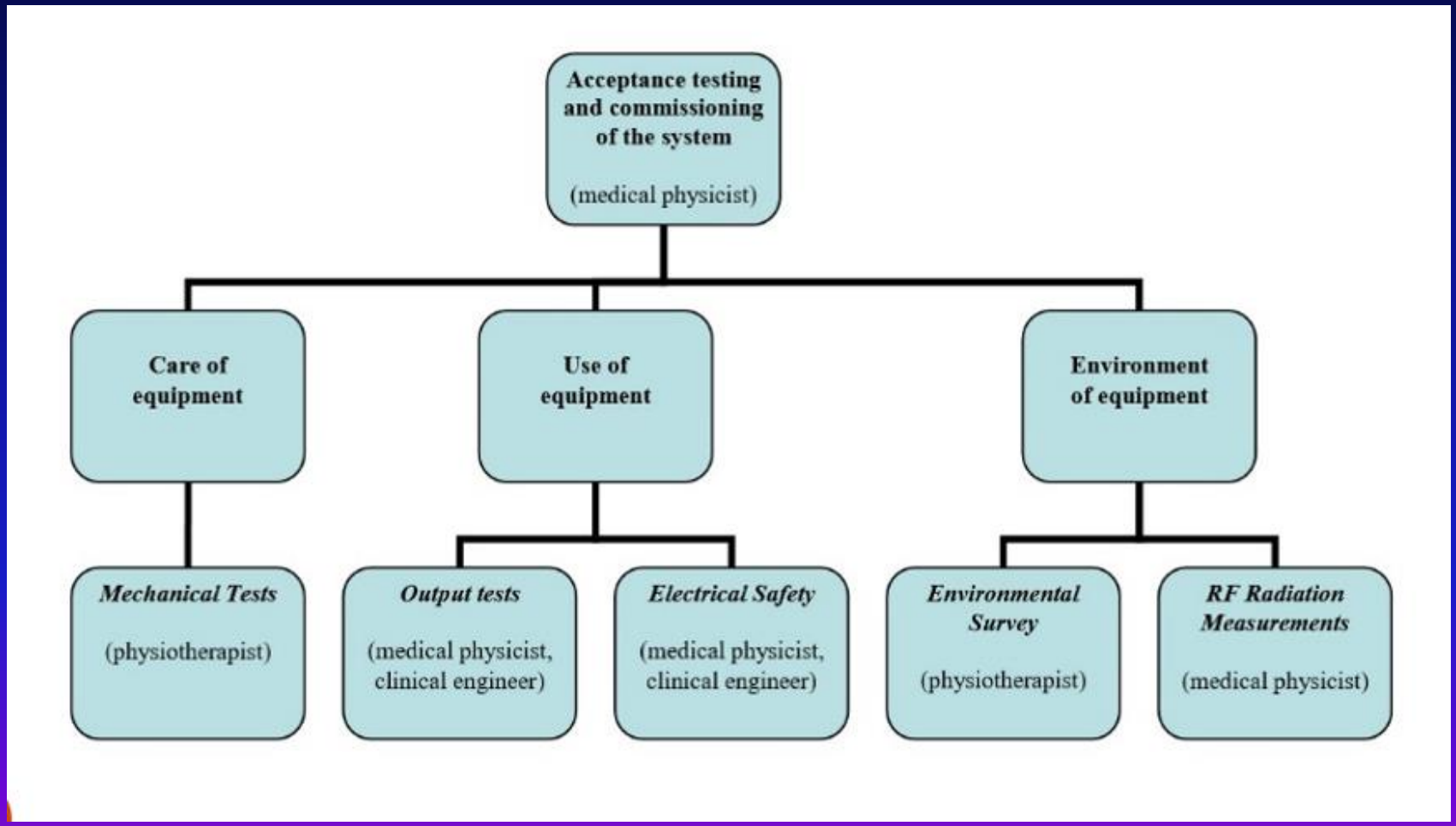
Dimensions:
- **Control/Display Unit:** 185 × 130 × 125 mm (7.3 × 5.1 × 4.9 in.)
- **Sensor Head:** 48 mm (1.9 in.) in diameter, 60 mm (2.4 in.) long
- **Cable:** 1.6 m (5.2 ft)

Safety: CE compliant

Integrated 2-Watt Broadband Power and Energy Meter System

	PRODUCT NUMBER
2-W Broadband Power and Energy Meter	13 PEM 001/J

Responsibilities



Ευχαριστώ πολύ για την προσοχή σας

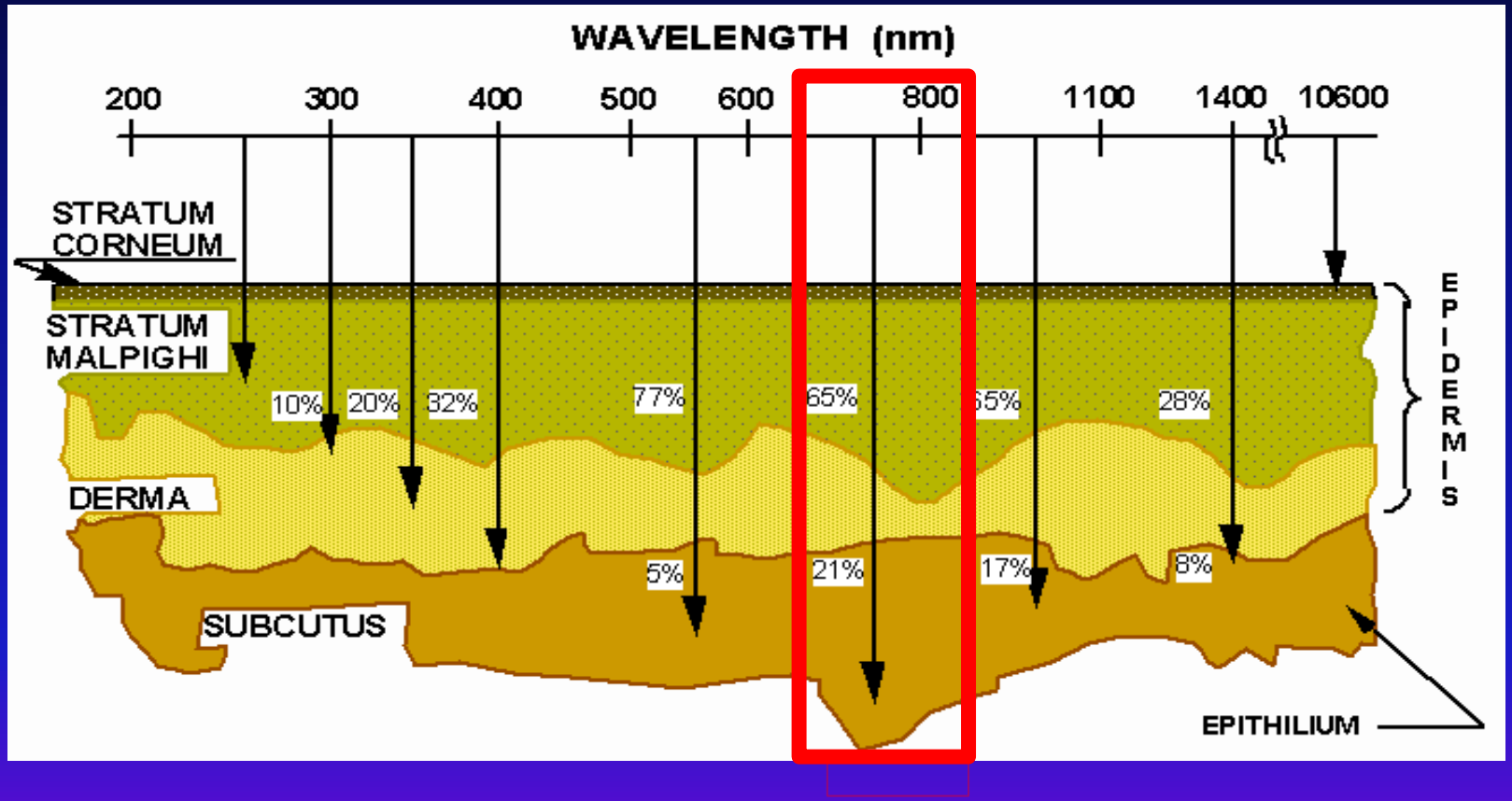


Figure 2. Different wavelengths of light penetrate the skin in different ways
(Photo source: http://ehs.oregonstate.edu/laser/training/laser-biological-hazards-skin)