High power light sources used in medicine

Stephen G Bown MD, FRCP
Prof. of Laser Medicine & Surgery
Director, National Medical Laser Centre
University College London

Clinical and Lab Lasers

CE marked medical lasers

- Designed to be safe
- Interlocks etc.
- Aiming beam
- Almost always diverging beam

Lab lasers

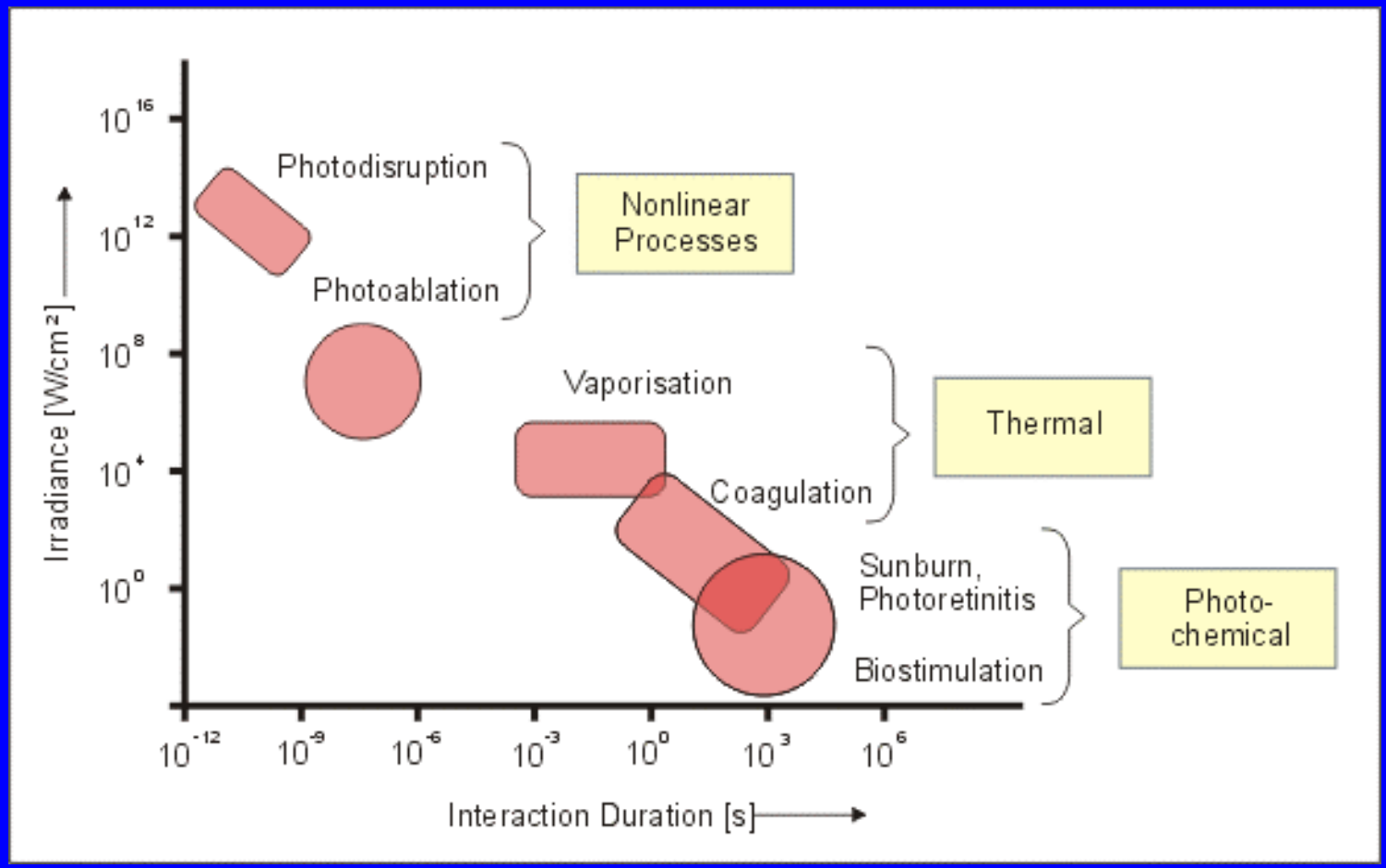
- Not designed for safety
- Designed for “expert” users
- Parallel, pencil beam
- Much more dangerous

Photo hazards

- **Skin**
- **Fire -** In particular down endoscope
- **Eye -** Retinal or corneal burns
- Internal organs

- Medical lasers – just need wavelength, power, power density, total energy, easy delivery

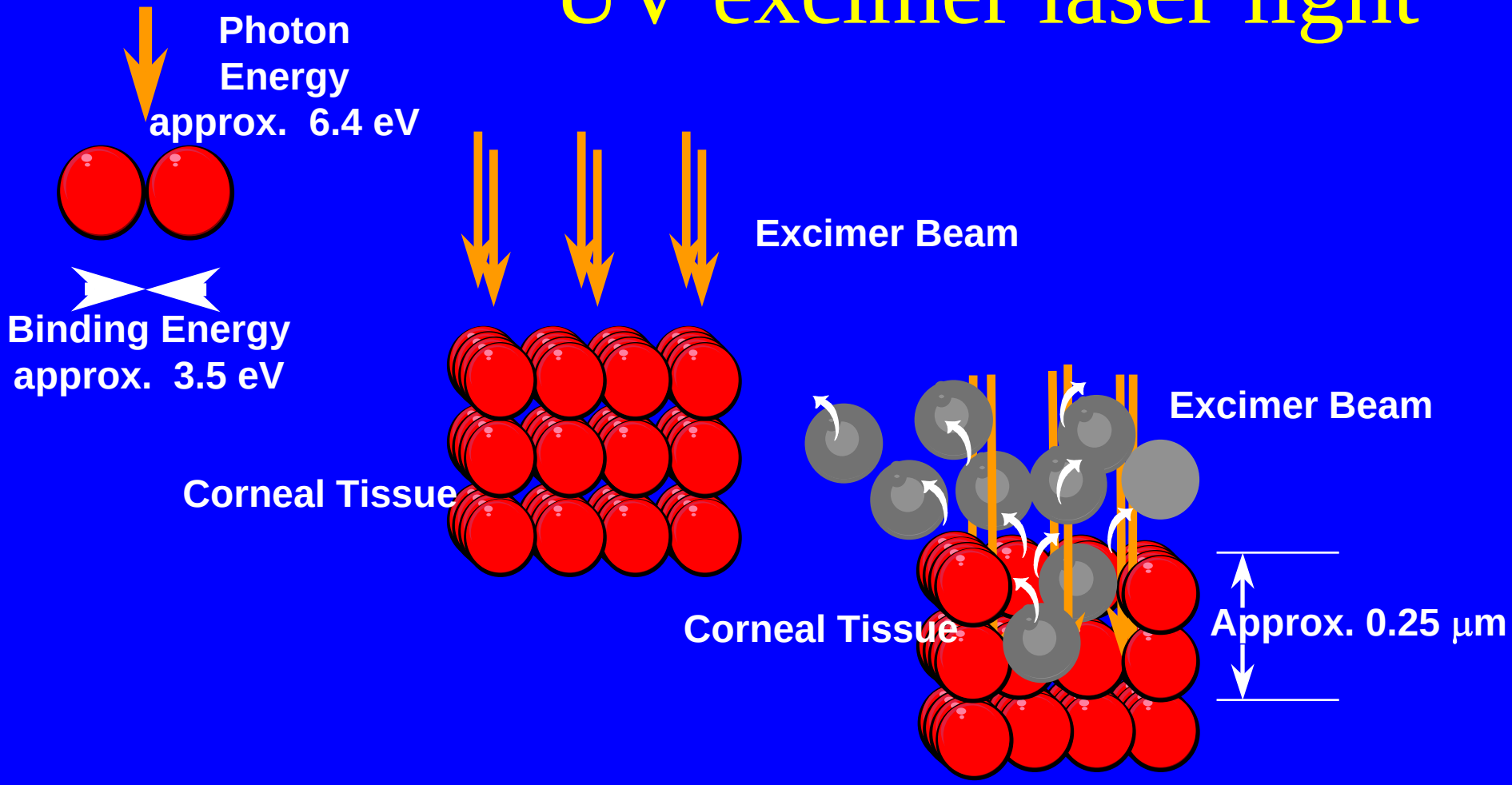
Time and Power



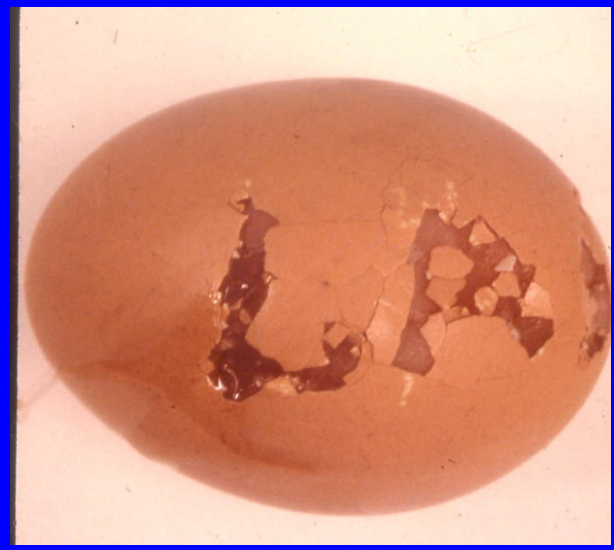
Some lasers in medical use

CO_2	10.6 micron
Er:YAG	2.94 miron
Ho:YAG	2.1 micron
Nd:YAG	1064 nm
Cu vapour	511/578 nm
Dye	eg 630/675 nm
Diode	eg 532 / 905 nm
Excimer	< 350 nm

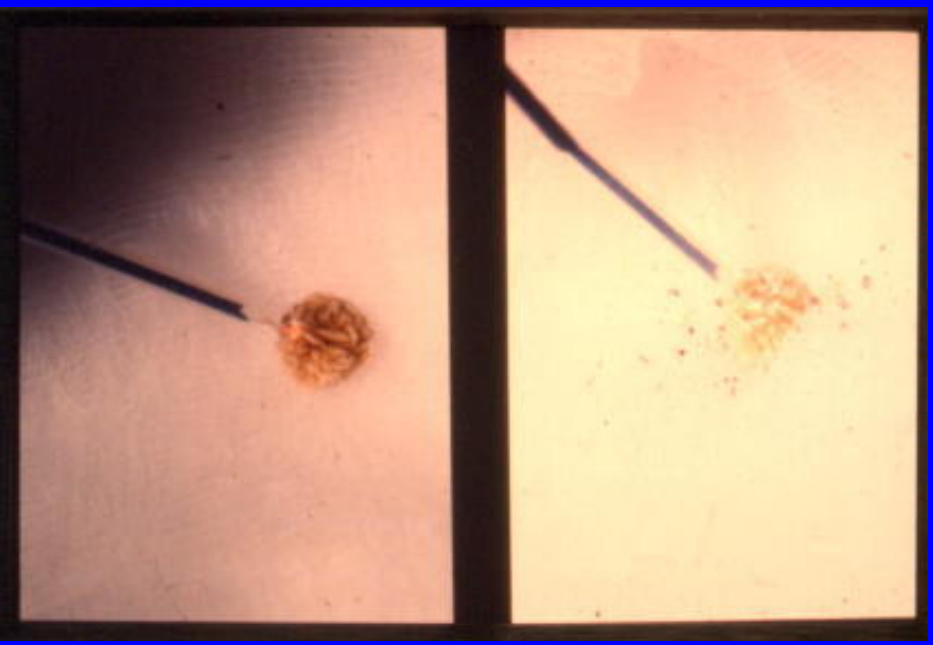
Photoablative effect of UV excimer laser light



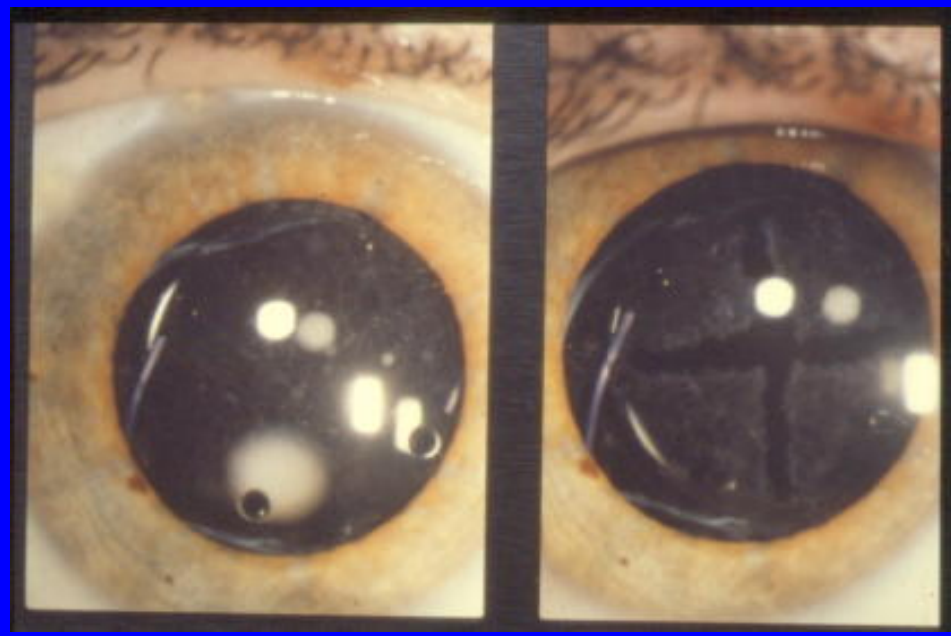
Impact of pulsed lasers on biological tissue



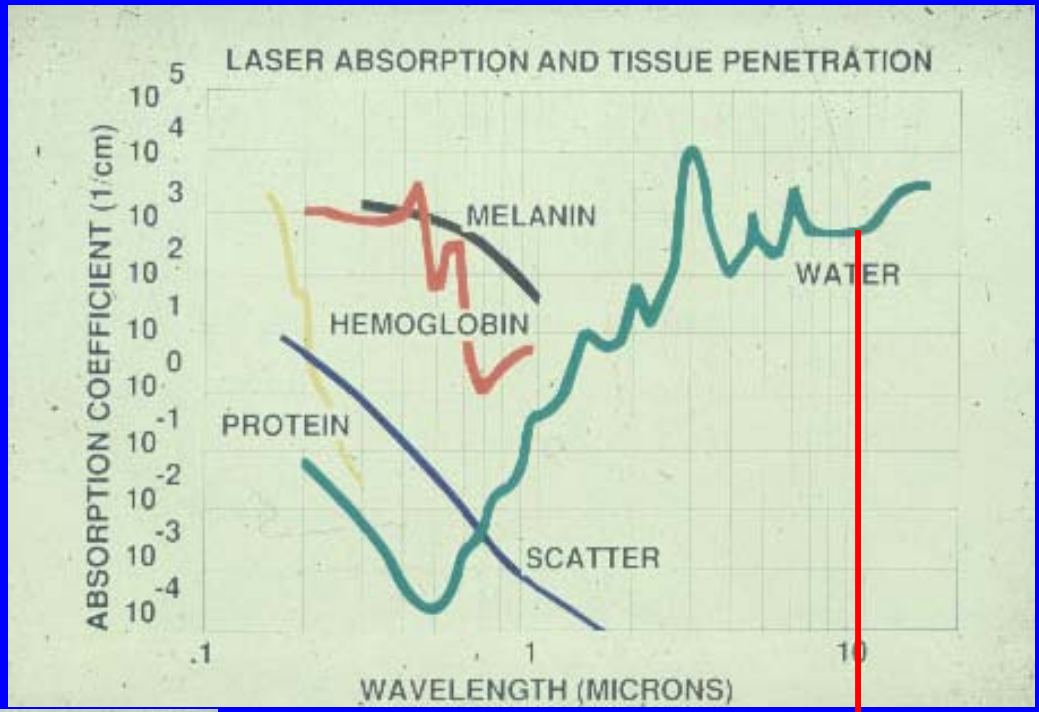
Shattering a kidney stone



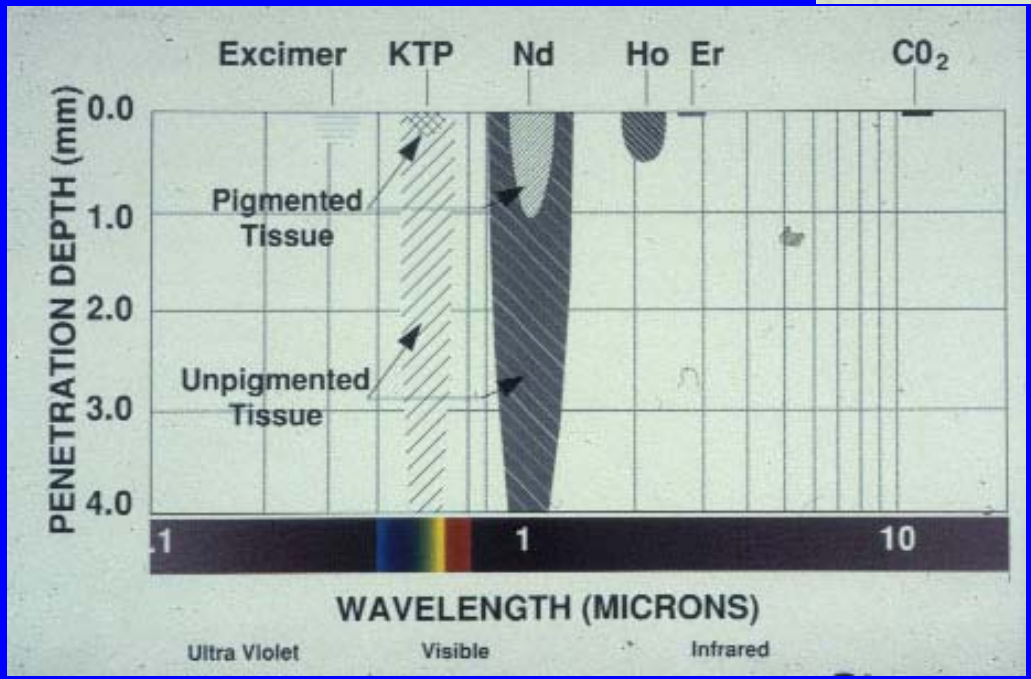
Splitting a membrane in the eye



Tissue absorption



Tissue penetration



CO_2 Laser

Carbon Dioxide Laser Surgery

Wavelength 10,600nm

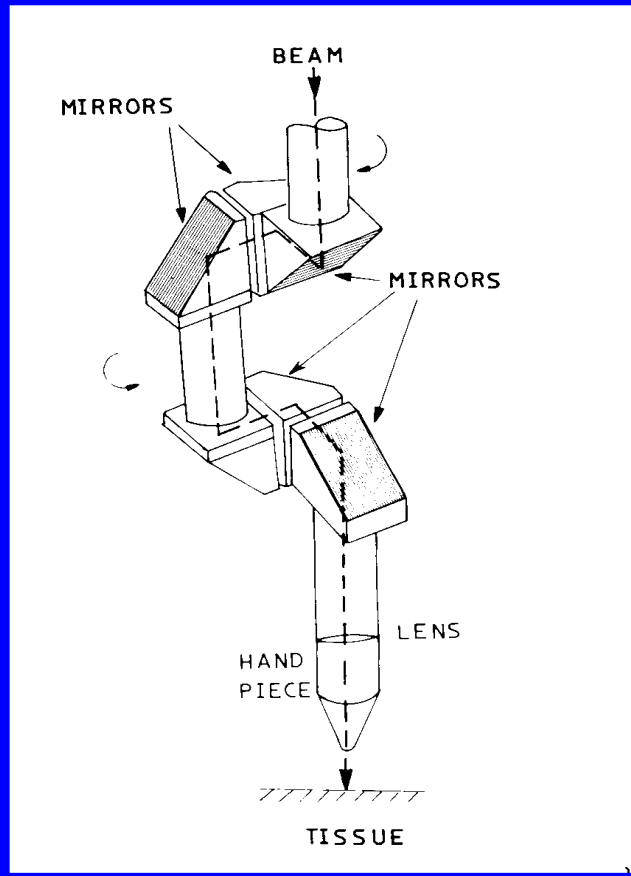
Strong absorption by water

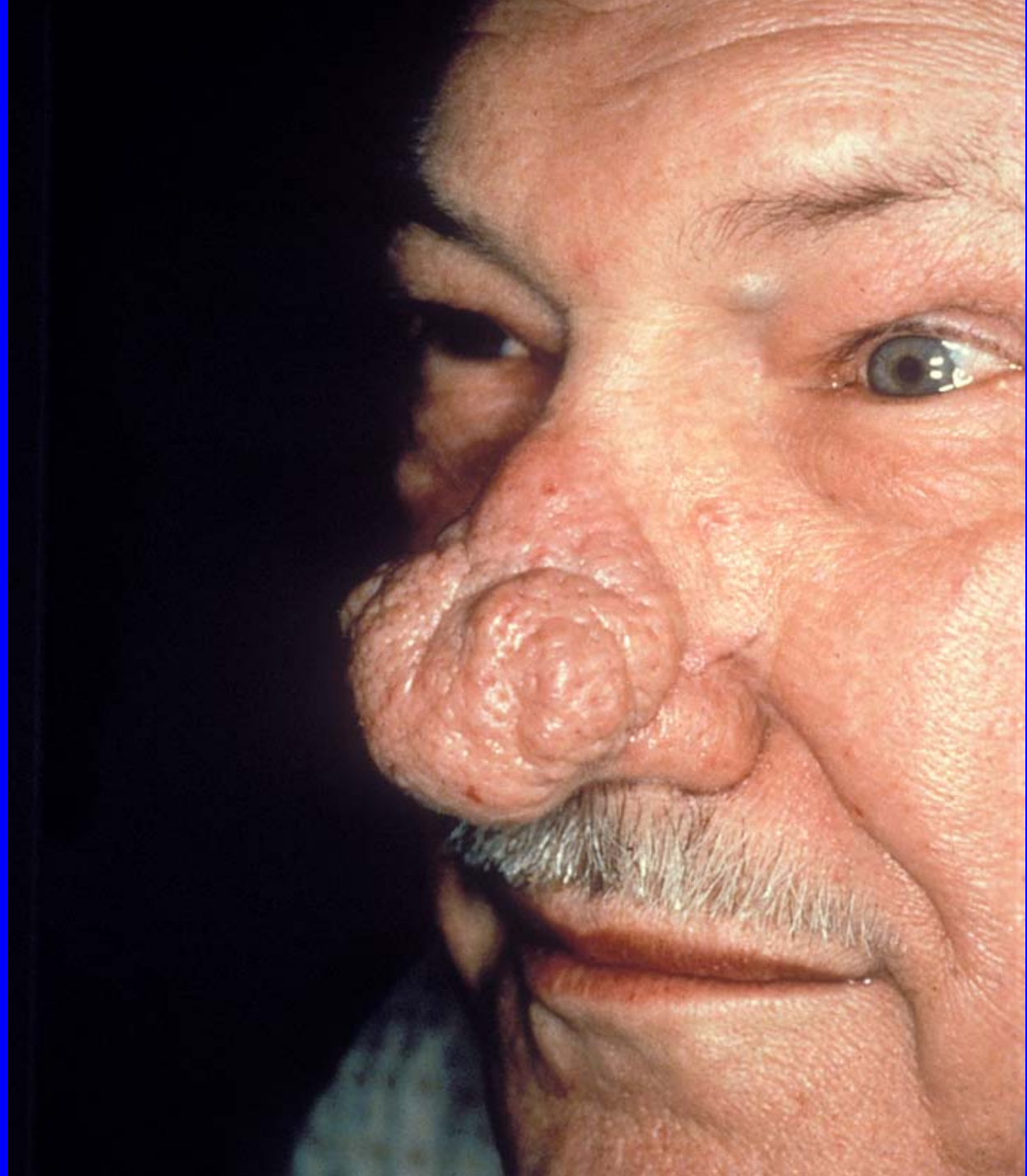
Non-contact laser knife

No suitable fibre for clinical use

Collimated beam

Typical power 15-60W

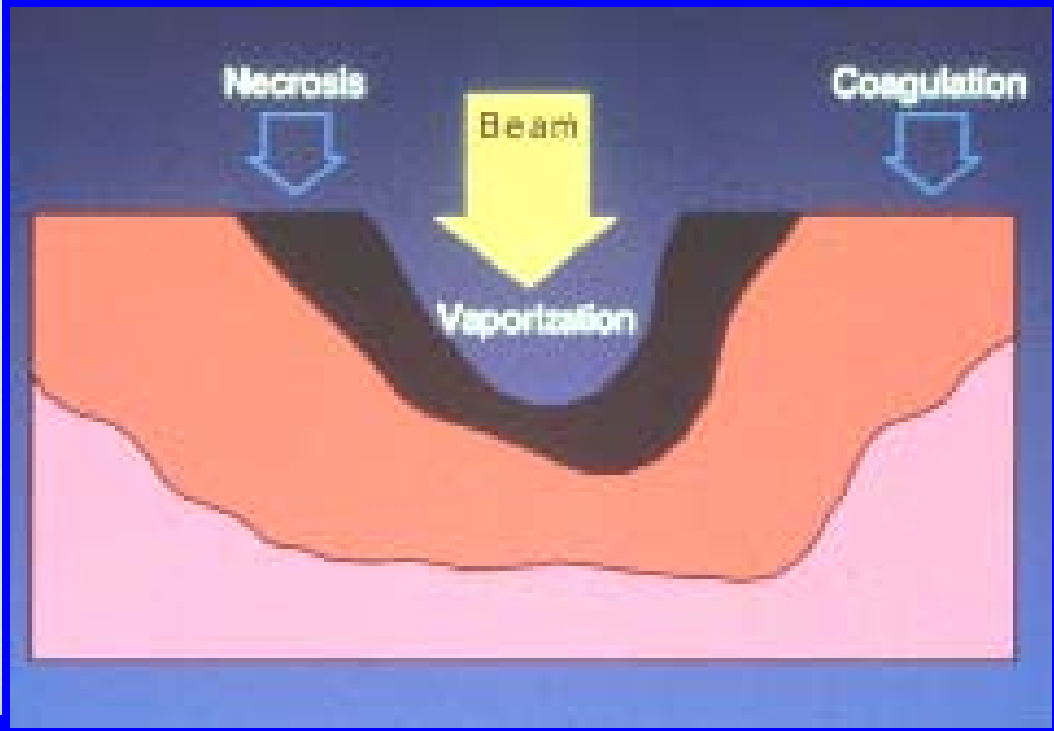




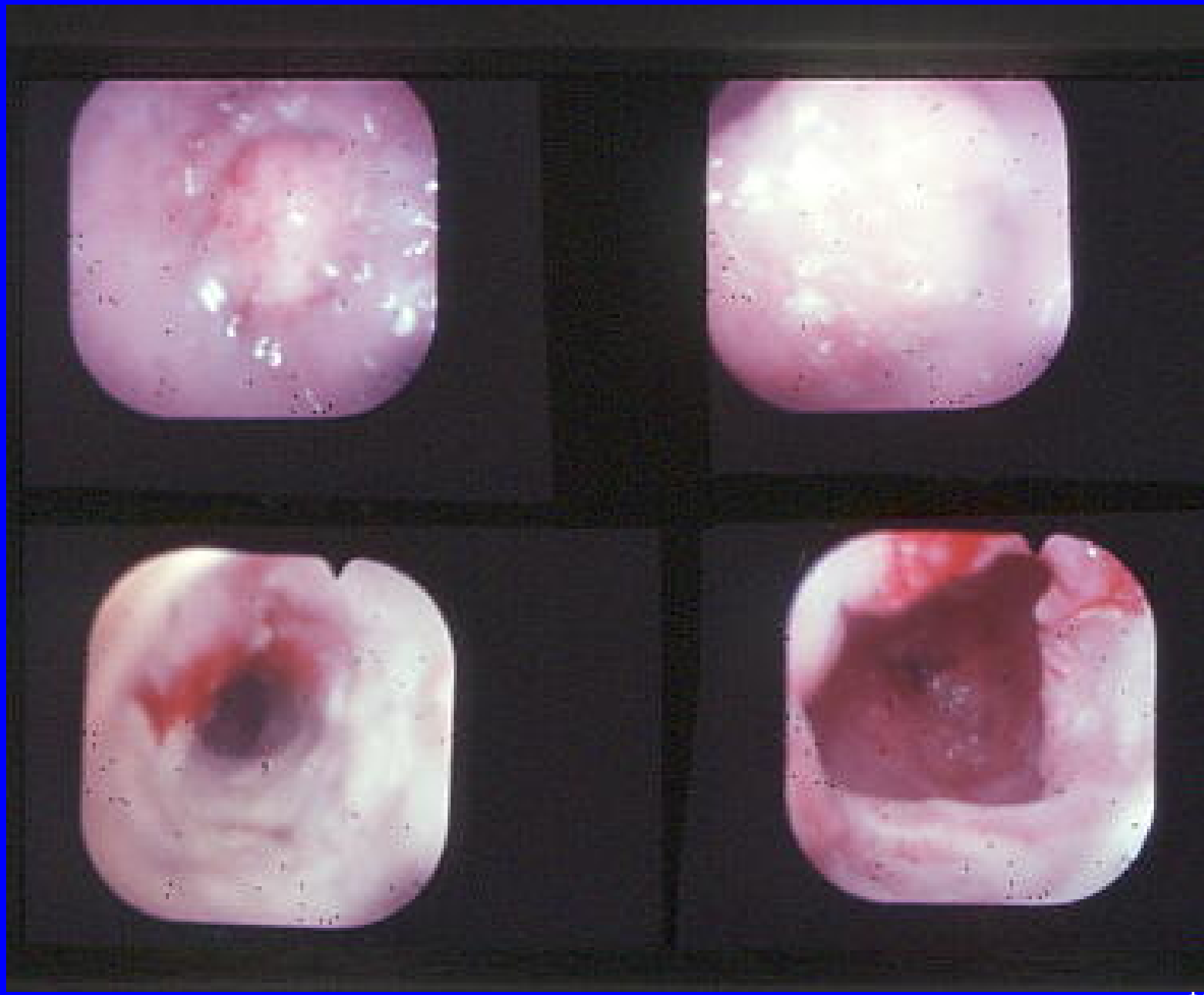

I said "pass the laser, nurse". Had I wanted you to switch on the laser, I would have said "switch on the laser, nurse."

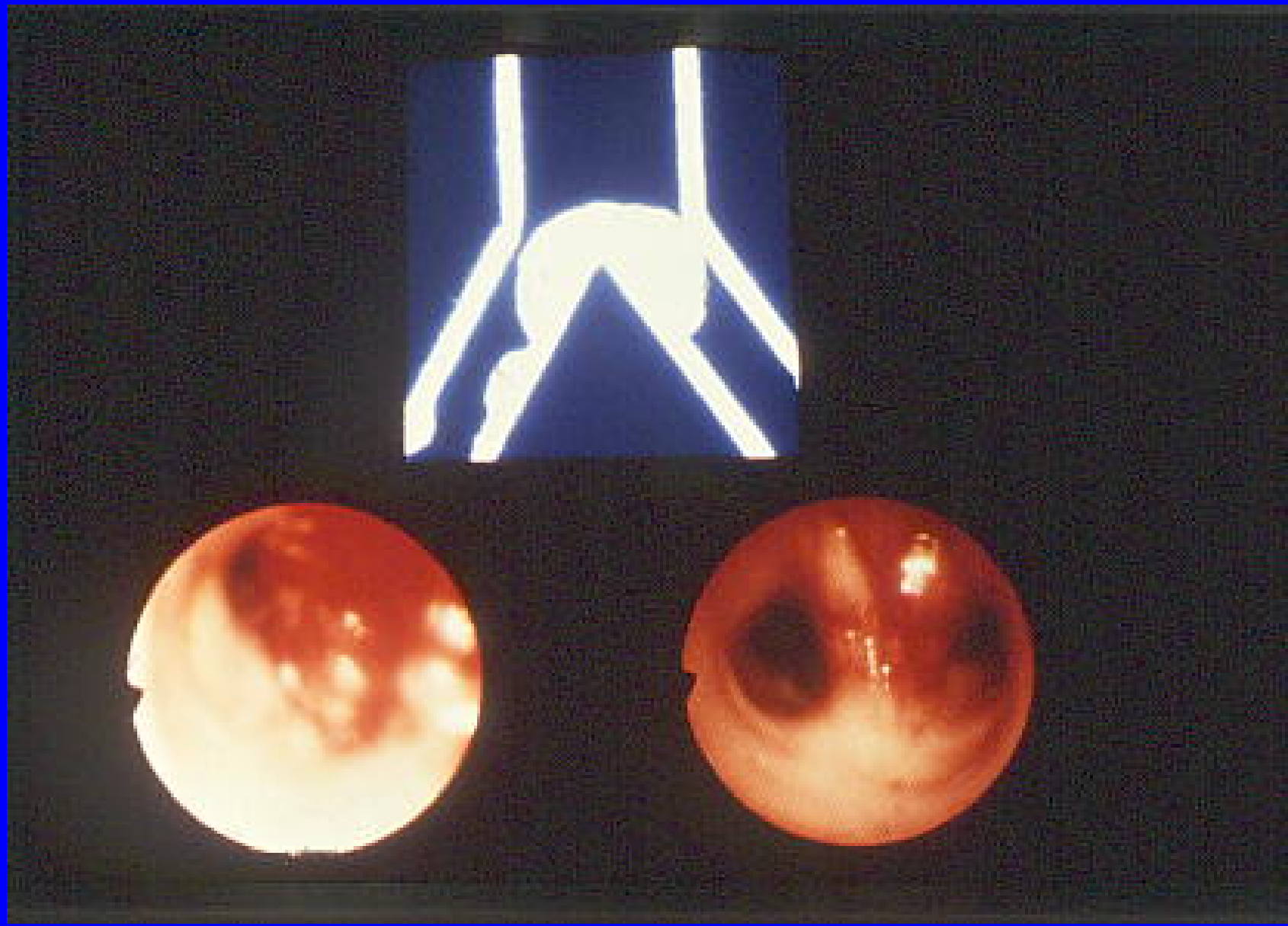
Effects of heat on tissue

Photothermal - high power density. Ablation



Endoscopic use of lasers



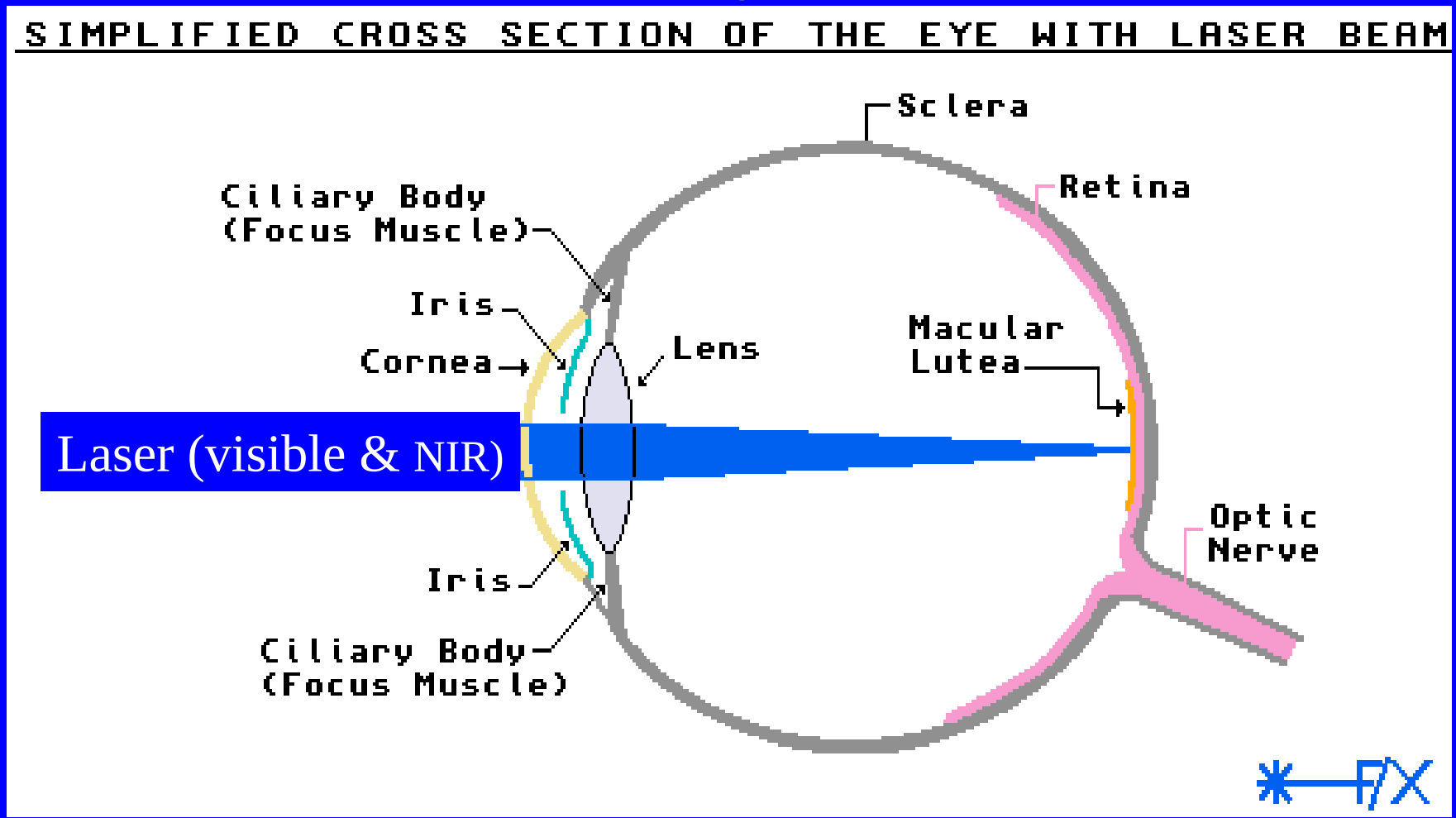


Lasers and Cancer Therapy

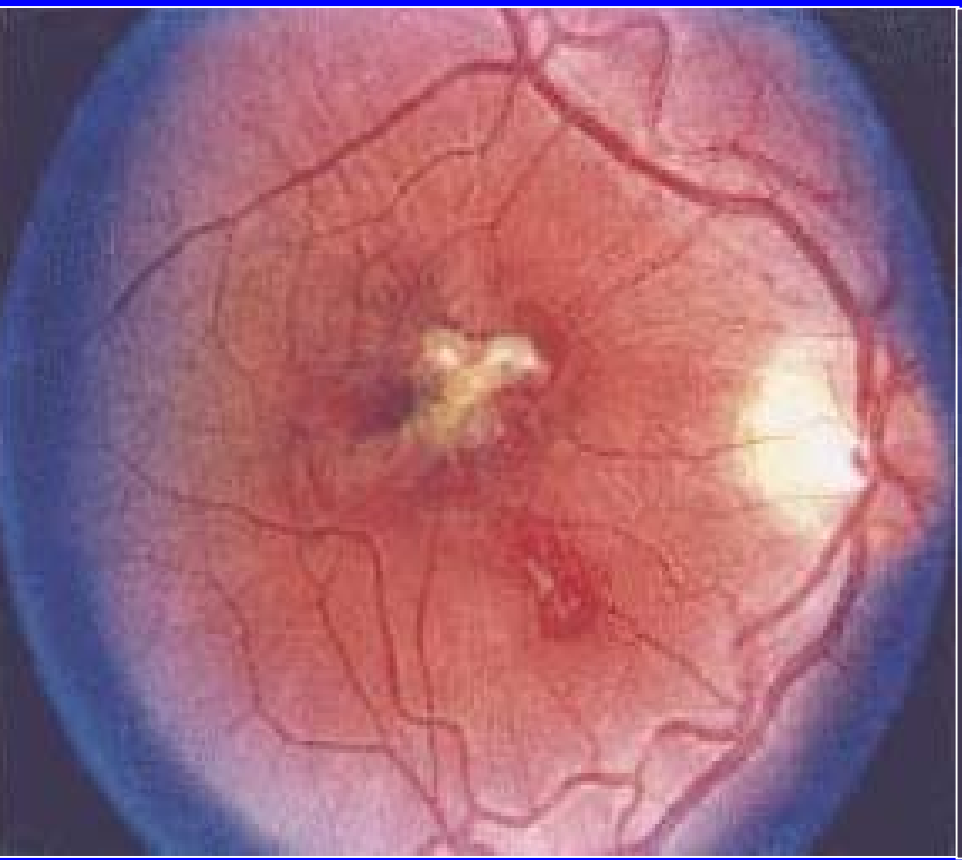
- High power thermal – blasting a passage through advanced cancers. ***Typically 30-70W***
- Low power thermal – gentle cooking of tumours in solid organs. ***Typically 1-5W***
- Photodynamic therapy – photosensitising drugs activated by laser light. ***Typically 0.2-3W***


CM
CM
CM
CM
CM
CM

Eye

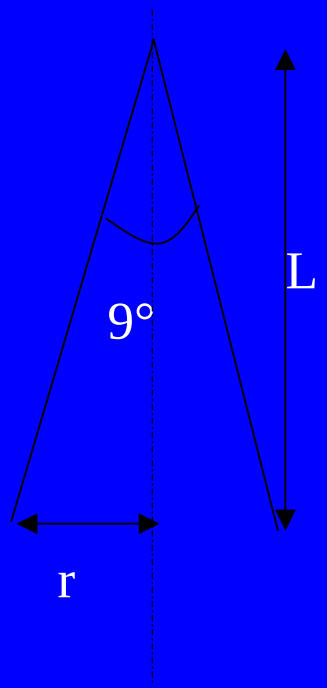

SIMPLIFIED CROSS SECTION OF THE EYE WITH LASER BEAM
Sclera
Retina
Ciliary Body
(Focus Muscle)
Iris
Cornea
Lens
Macular
Lutea
Laser (visible & NIR)
Optic
Nerve
Iris
Ciliary Body
(Focus Muscle)

True stories - Eye Injury



Nd:YAG (1064 nm) - permanent damage.
Victim saw white flash, heard a click, then immediately a dark spot in visual field

Sample calculation



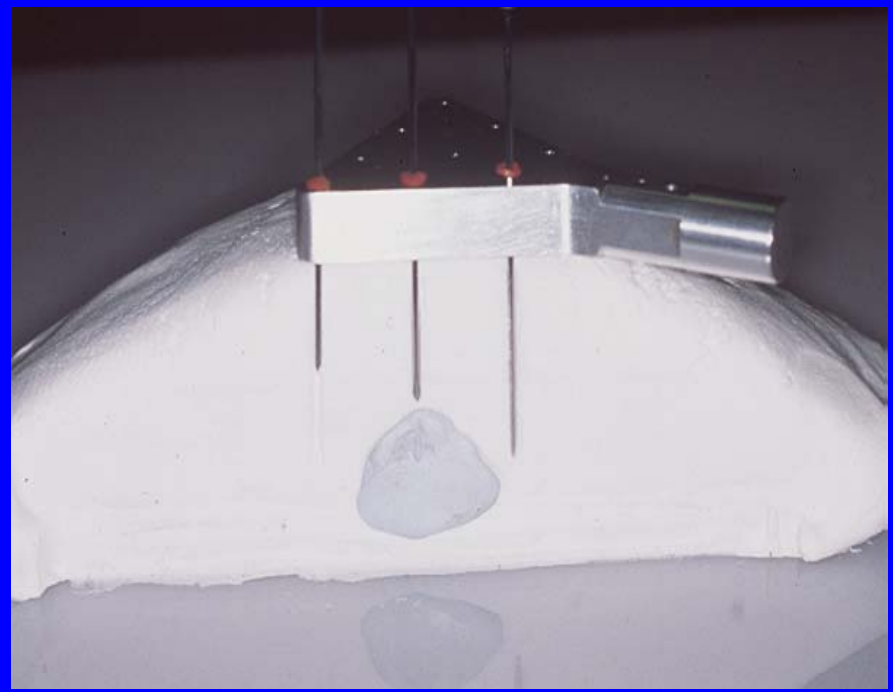
Safe distance for intrabeam viewing
60W, 1064 nm, CW Nd:YAG laser.

Using the aiming beam, we find the angle of light from a fibre = 18°

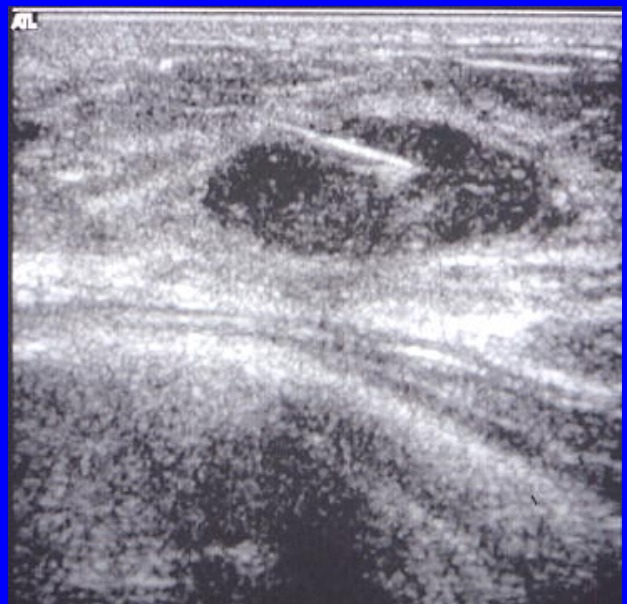
No blink response
Taking t = 1 s, MPE = 90 J m^{-2}
Max energy per unit area = (60 x t)/A
Therefore A = 60/90 m^2
L = 5.7 m
For t = 10s, **L = 7.7 m**
Room windows will need screening.

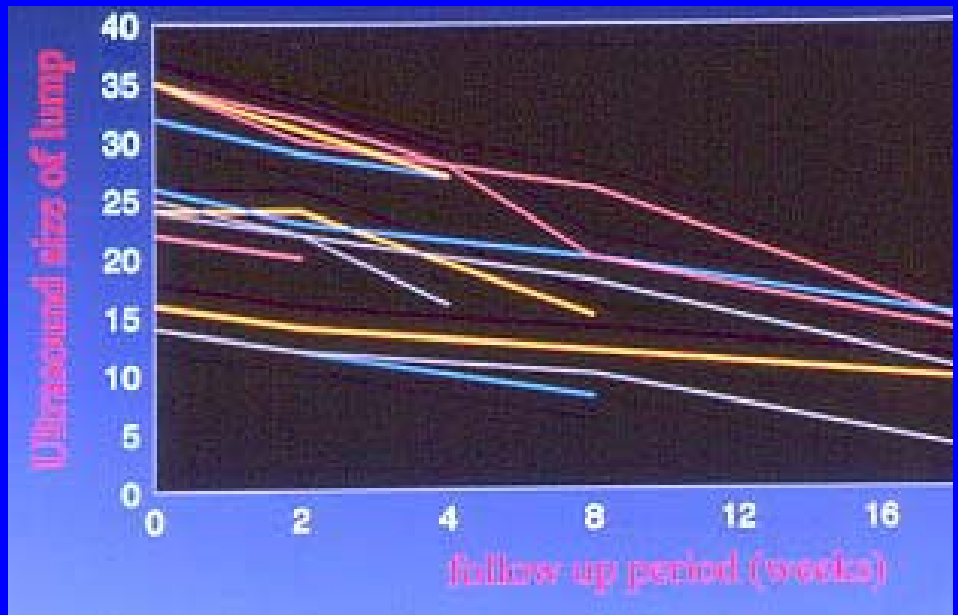
Interstitial laser therapy

- Needles inserted through the skin under image guidance
- Laser fibres passed through the needles to deliver light into the diseased tissue
- No effect on overlying tissues



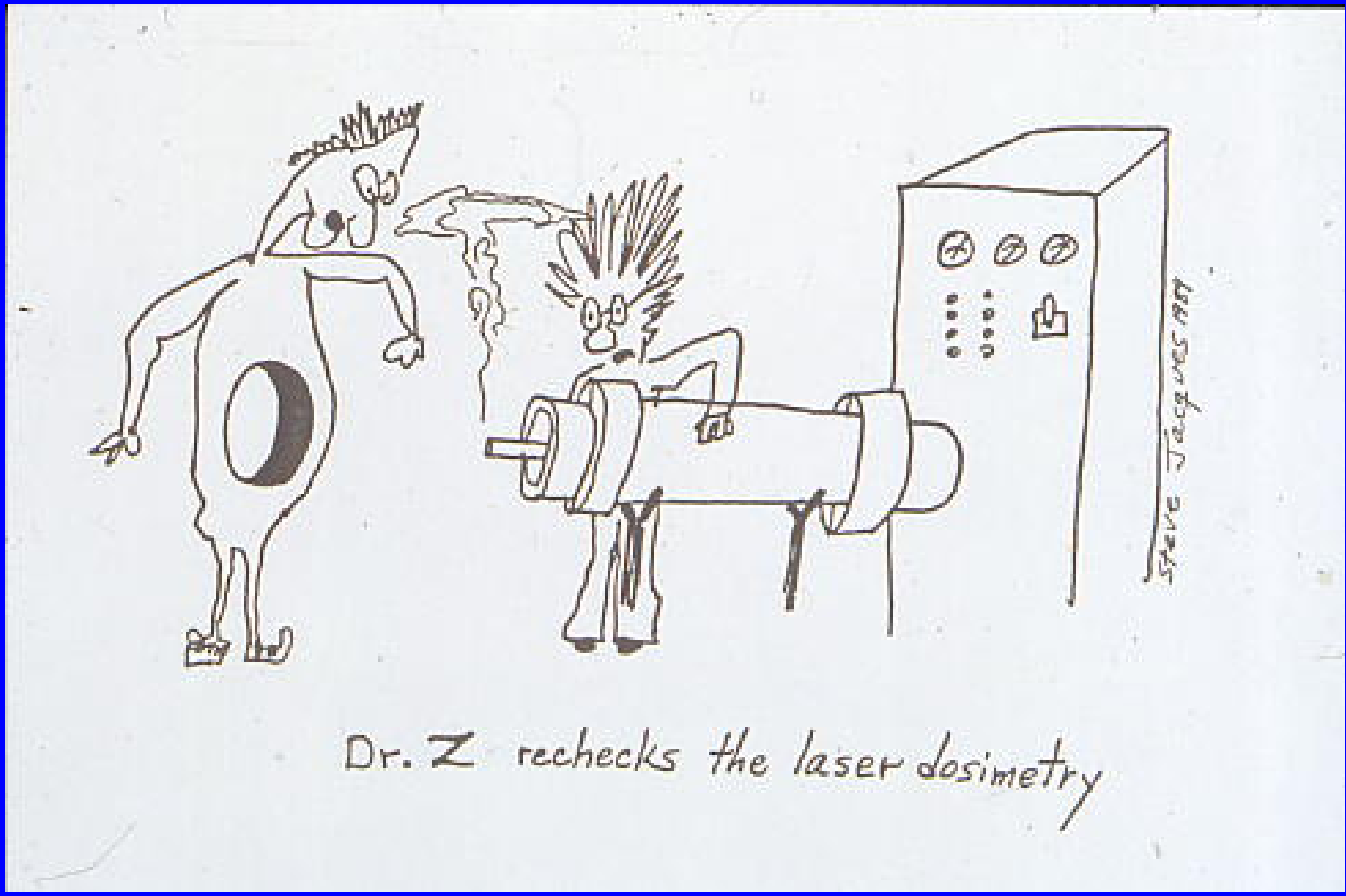
ILP for a breast fibroadenoma





True stories - Fire Blouse Set Alight

- A radiologist was using a NIR diode laser applied through 4 light fibres for ILP (heating a tumour to kill it).
- She was holding one fibre and inadvertently pointed it at her blouse.
- Others present enjoyed extinguishing her!
- Fortunately no burn to the Doctor.


Dr. Z rechecks the laser dosimetry

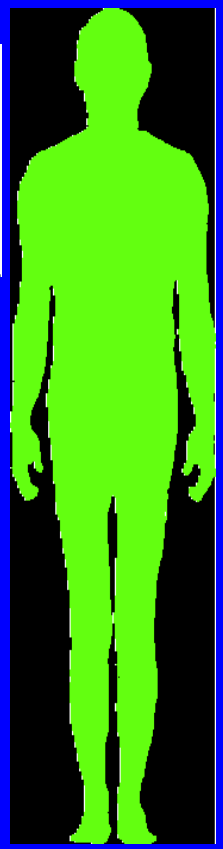
Photodynamic therapy (PDT)

application

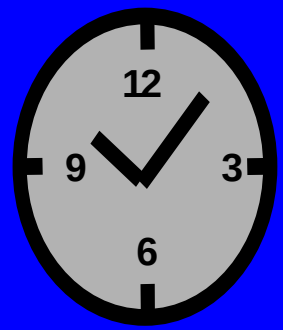
accumulation

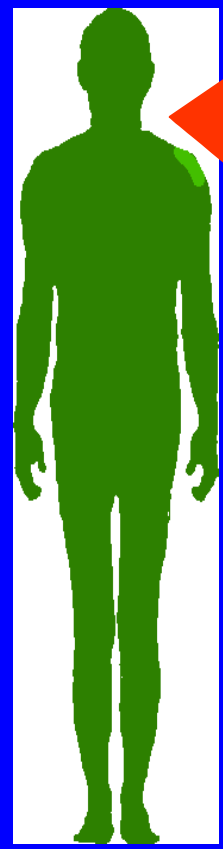
therapy

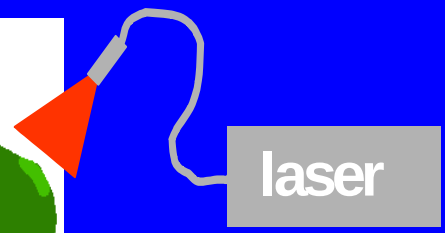
photosensitiser



96 h







Bowen’s disease on a finger

(photos courtesy of Dr Sally Ibbotson)

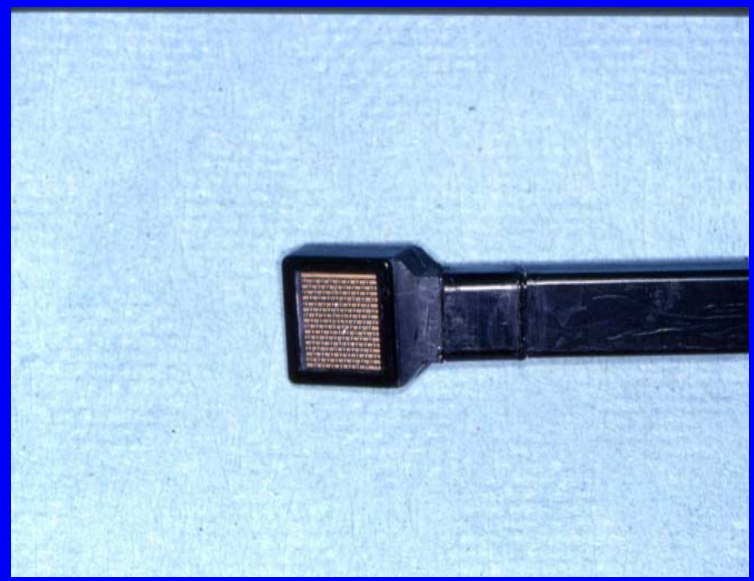
before PDT

3 m. after ALA-PDT (x2)

Non-laser light sources for PDT

Paterson lamp

LED



Semiconductor Laser

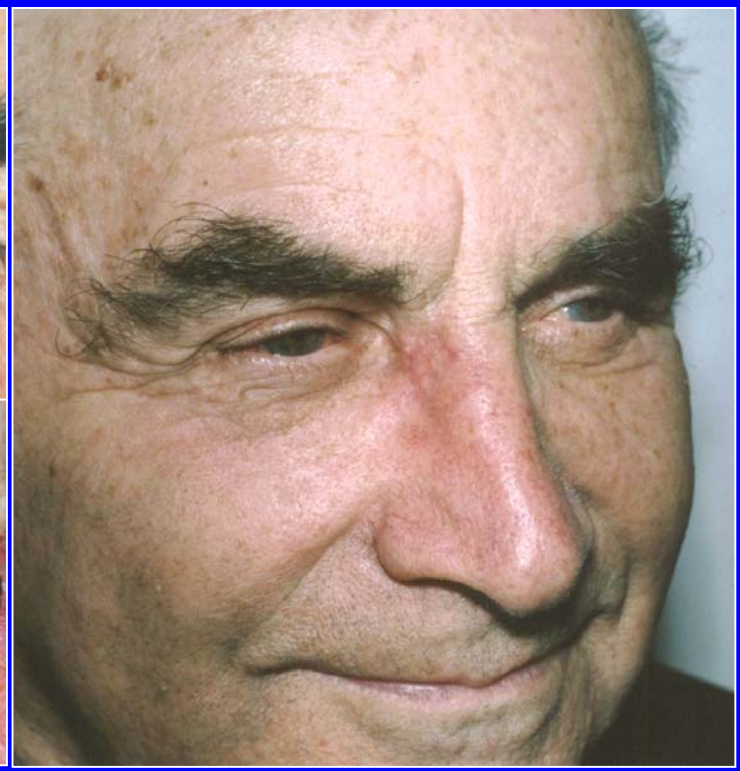
(power up to 5W)

Recurrent basal cell carcinoma

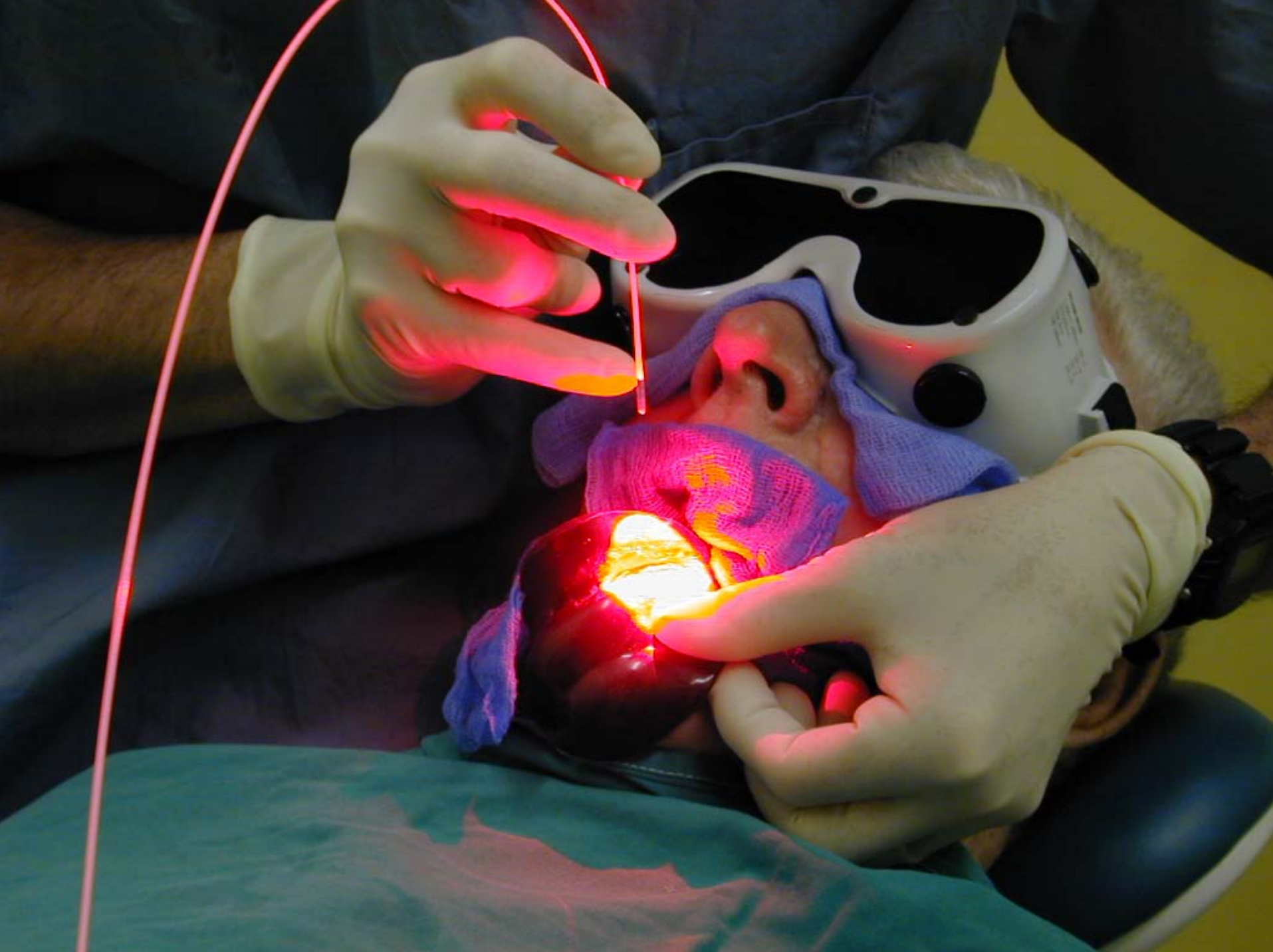
(photo courtesy of Prof Stradnako, Moscow)

Before PDT

Day 5



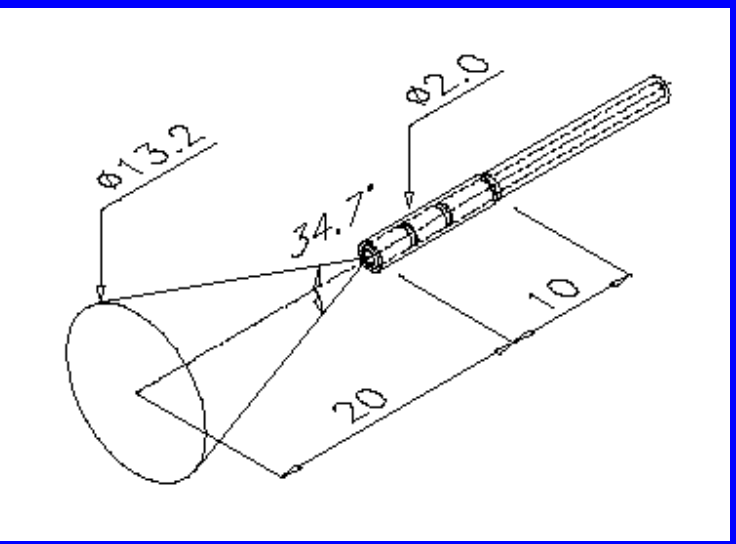
After healing

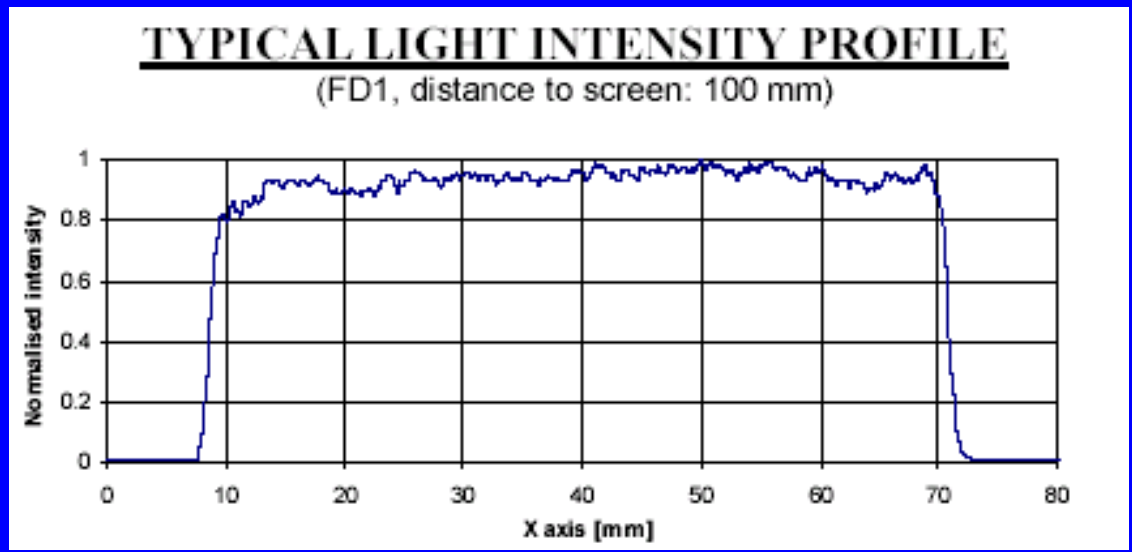


Light delivery devices

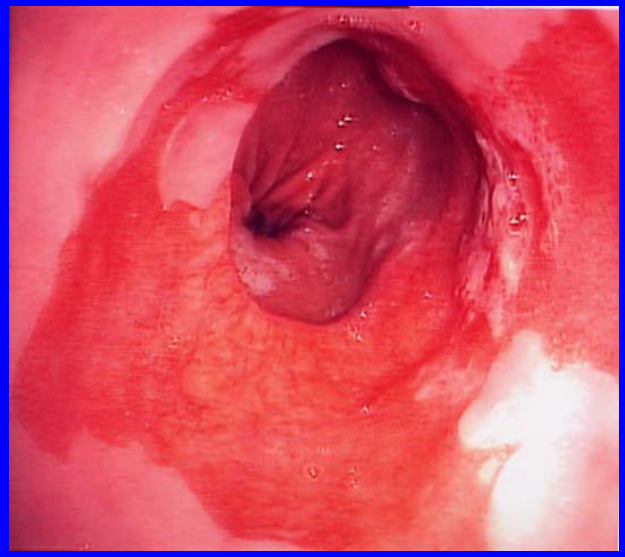
Diffuser fibre

Microlens



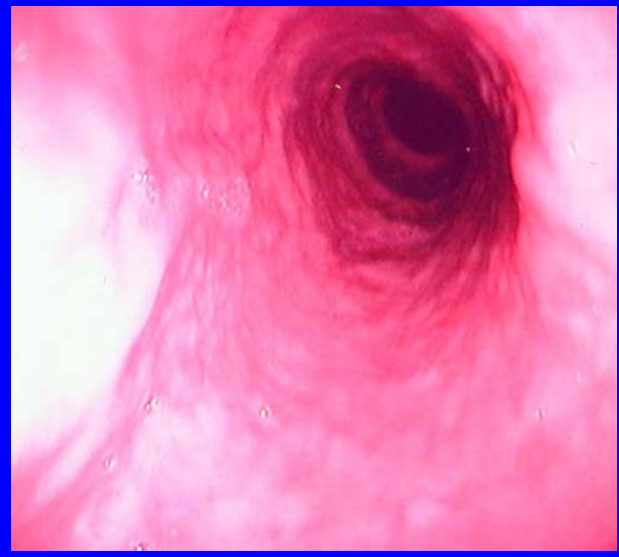


Photodynamic Therapy
Barrett's Oesophagus



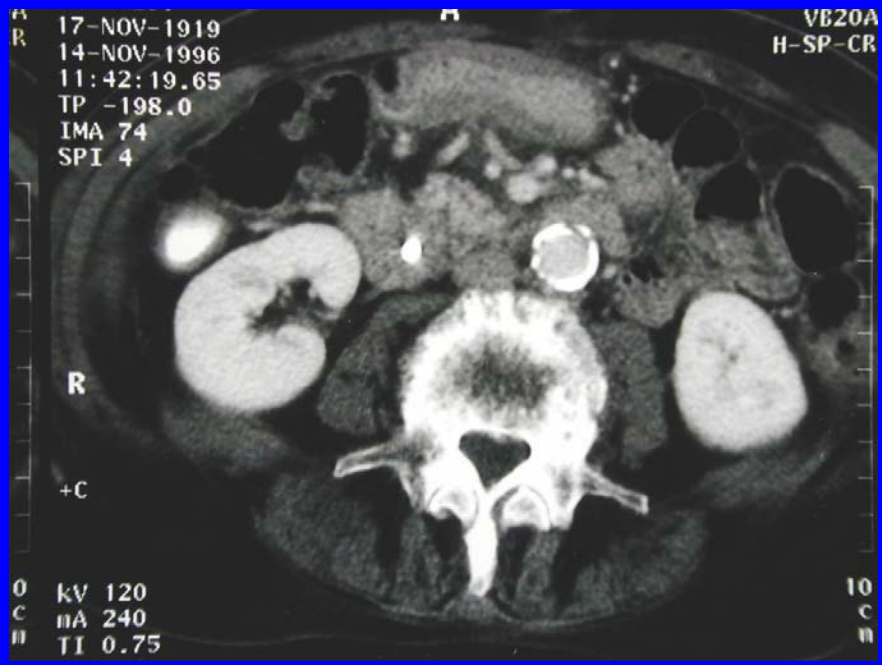
Prior to Therapy

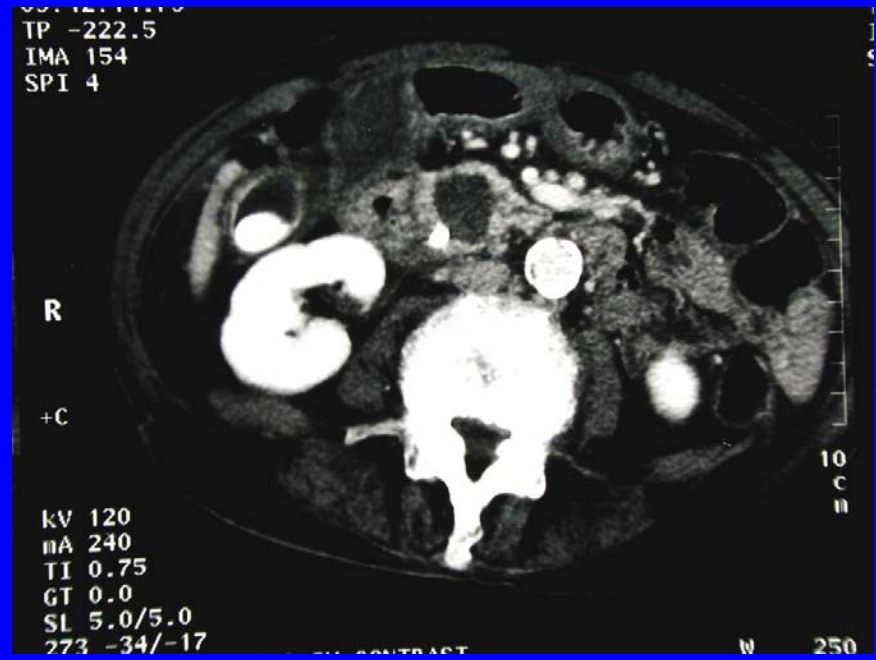
One day after treatment: Necrosis of Oesophageal Mucosa



A month after treatment: Squamous Regeneration and Dysplasia Eradicated

Interstitial PDT for cancer of the pancreas





Laser Therapies - summary

- Photothermal
  - High power density, thermal ablation
  - Low power density, photocoagulation
- Photochemical, PDT
- Photomechanical - eg stone breaking
- Photoablation
- Biostimulation

Five Steps to risk assessment

1. Look for hazards
2. Decide who might be harmed and how
3. Evaluate risk factor
4. Record your findings
5. Review and revise

http://www.hse-databases.co.uk/pubns/indg163.pdf