

Photo-thermal Excitation

$$\Delta T = (E\mu_a/\rho c)$$

ΔT : Temperature rise

E: Energy density

μ_a : Absorption

ρ : Density

c: Heat capacity

$$\rho_{\text{fat}} = 0.85 \text{ g cm}^{-3}$$

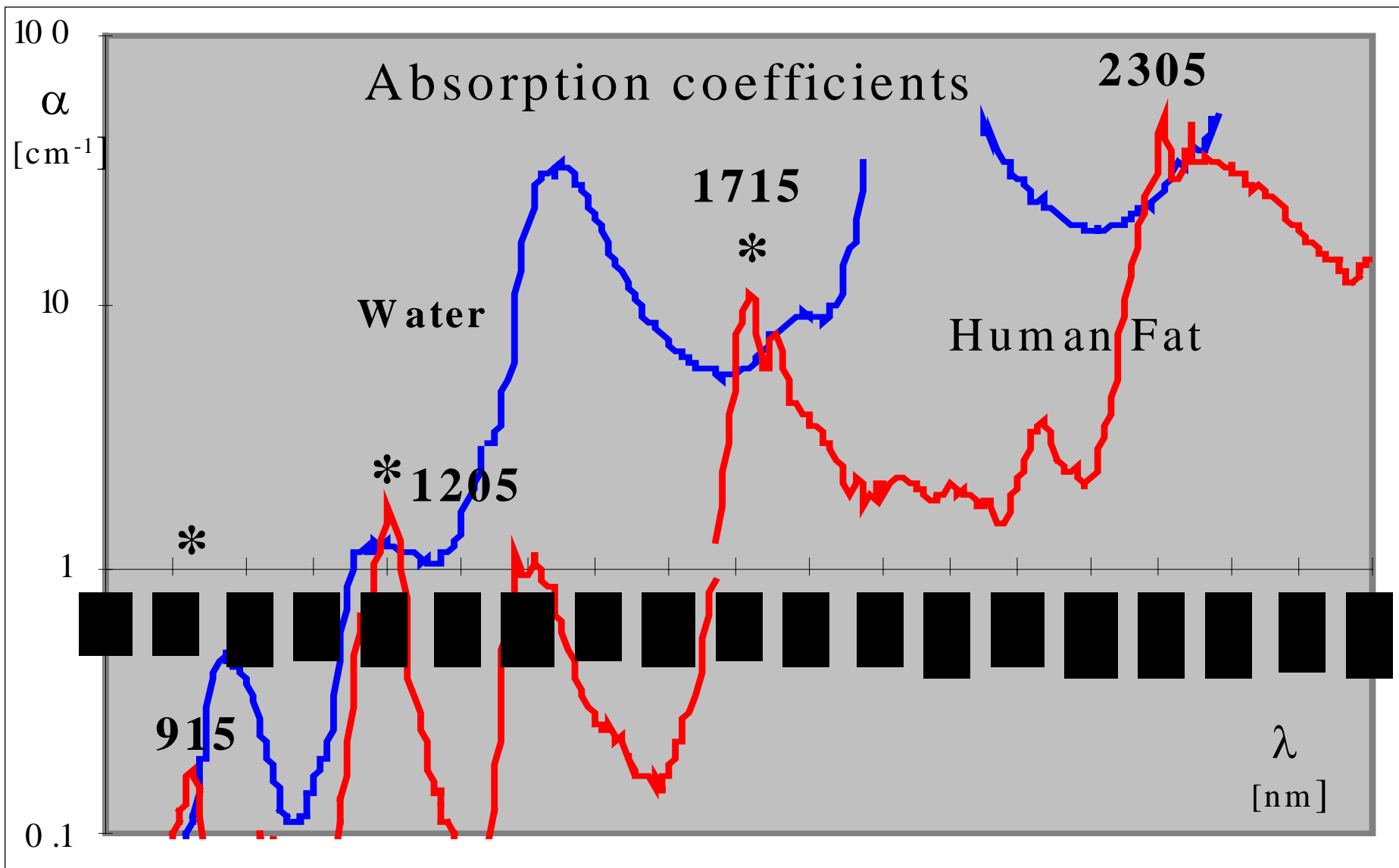
$$\rho_{\text{dermis}} = 1.08 \text{ g cm}^{-3}$$

$$c_{\text{fat}} = 2.3 \text{ J g}^{-1} \text{ K}^{-1}$$

$$c_{\text{dermis}} = 3.5 \text{ J g}^{-1} \text{ K}^{-1}$$

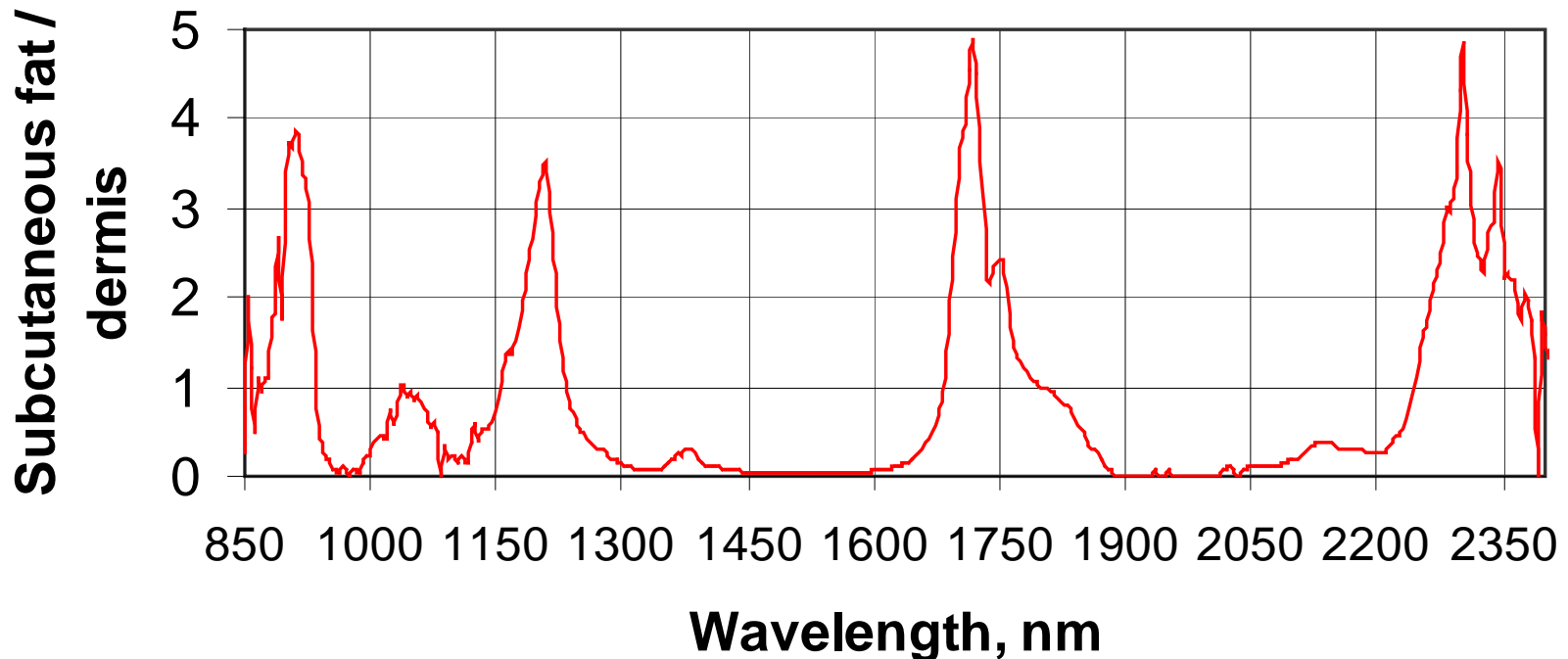
→ Because of low ρc , fat is a “sitting duck”

Fat and Water have nice “colors” in the NIR



Ratio of photothermal heating for fat vs. dermis

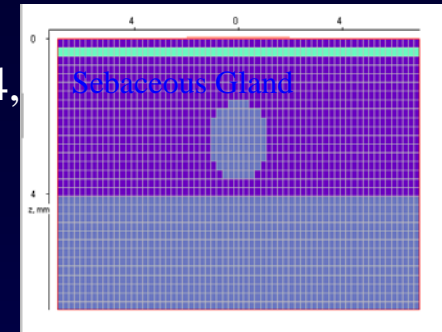
Ratio of the temperature rises



Selective Fatty Tissue Targeting

Monte Carlo Simulations :

Sebaceous gland (depth = 2.5 mm, radius = 1.0 mm
 $n=1.45$, $\mu_a=0.17$ /mm, $\mu_s'=0.58$ /mm) below epidermis ($n=1.4$,
 $\mu_a=0.039$ /mm, $\mu_s'=0.79$ /mm) and capillary layers ($n=1.37$,
 $\mu_a=0.04$ /mm, $\mu_s'=0.3$ /mm) within 3.8 mm thick dermis
($n=1.4$, $\mu_a=0.035$ /mm, $\mu_s'=0.2$ /mm) irradiated by focused
beam ($\lambda = 1200$ nm $r=2$ mm, focusing depth = 3.5 mm)



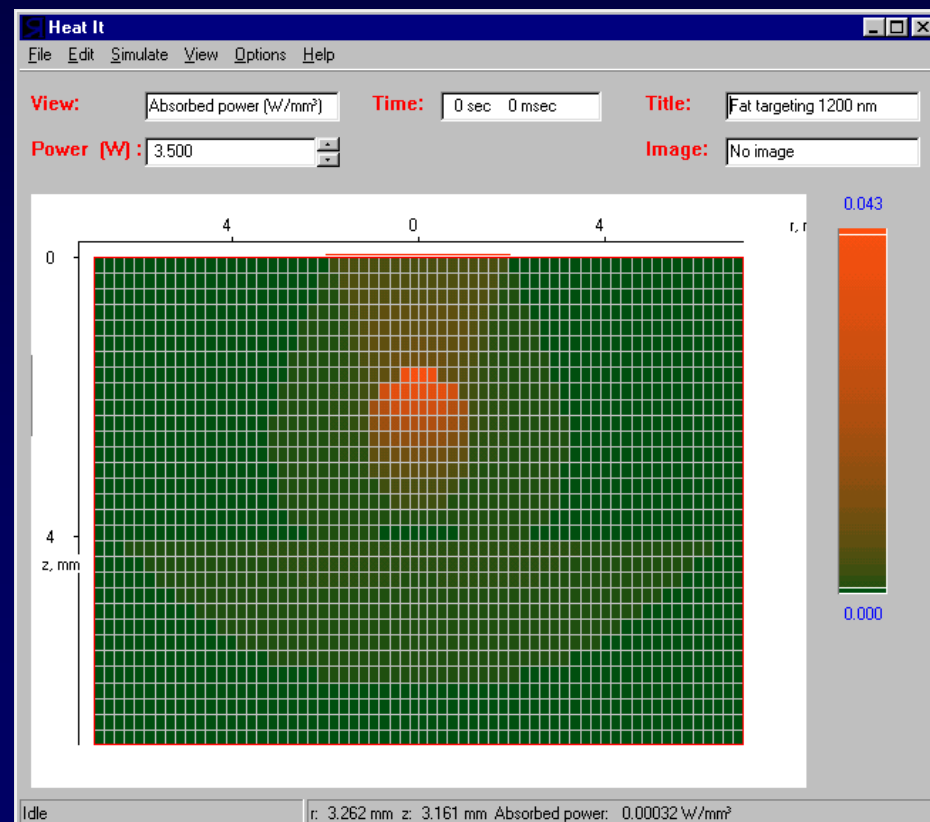
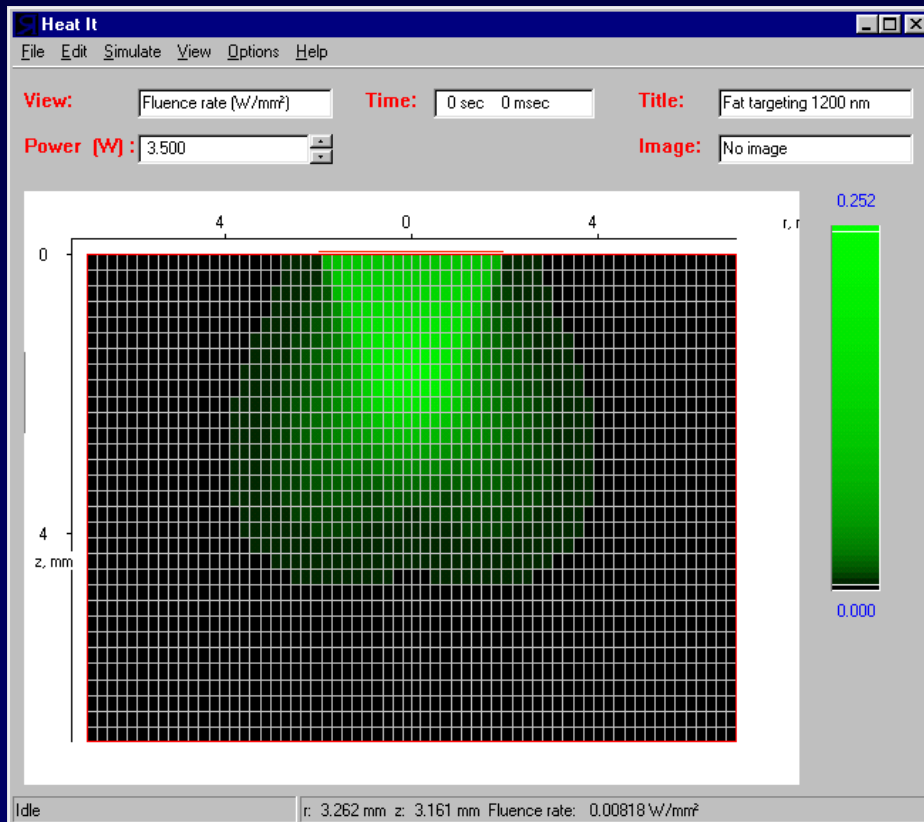
Epidermis

Blood

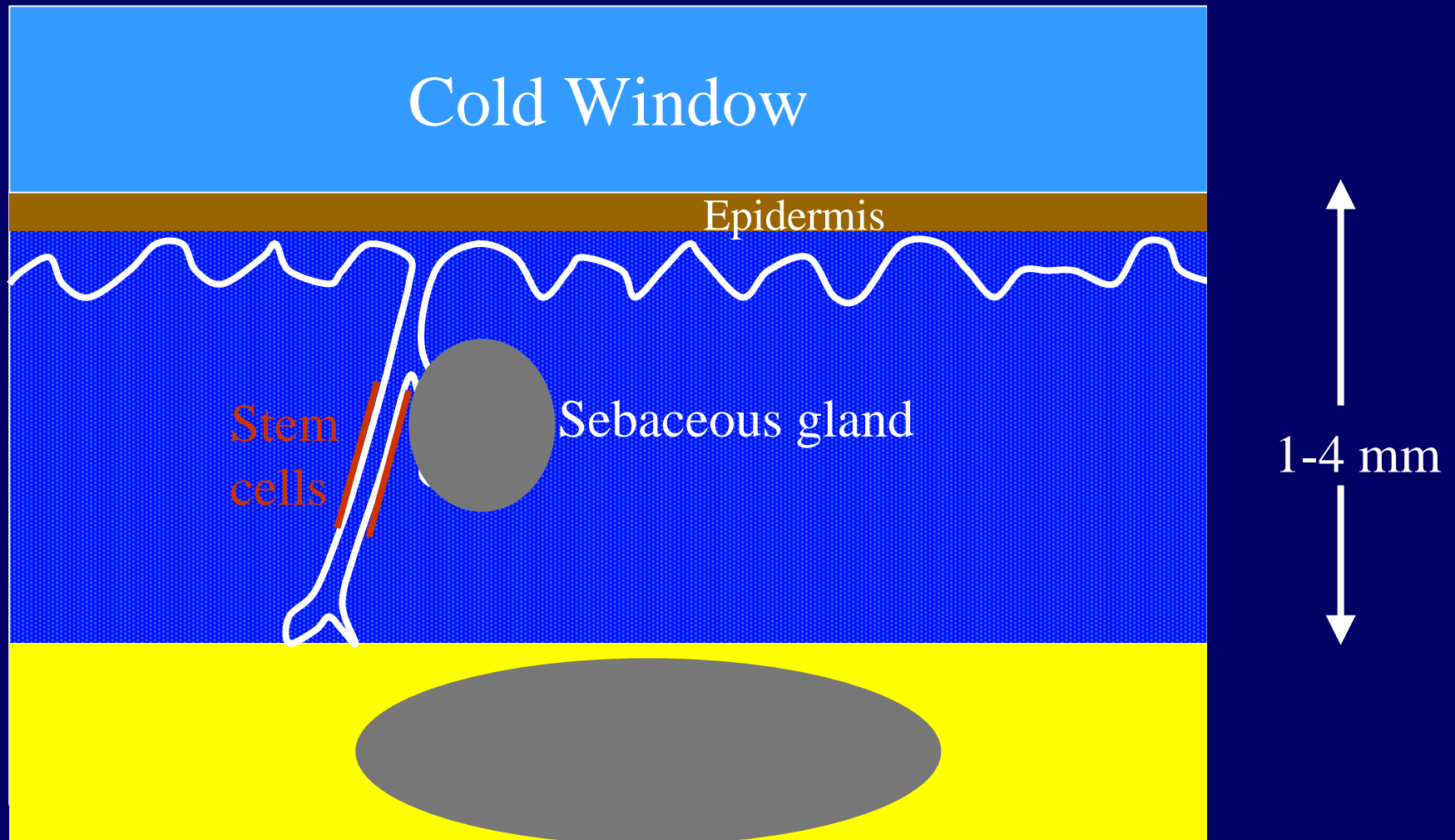
Dermis

Subcutaneous

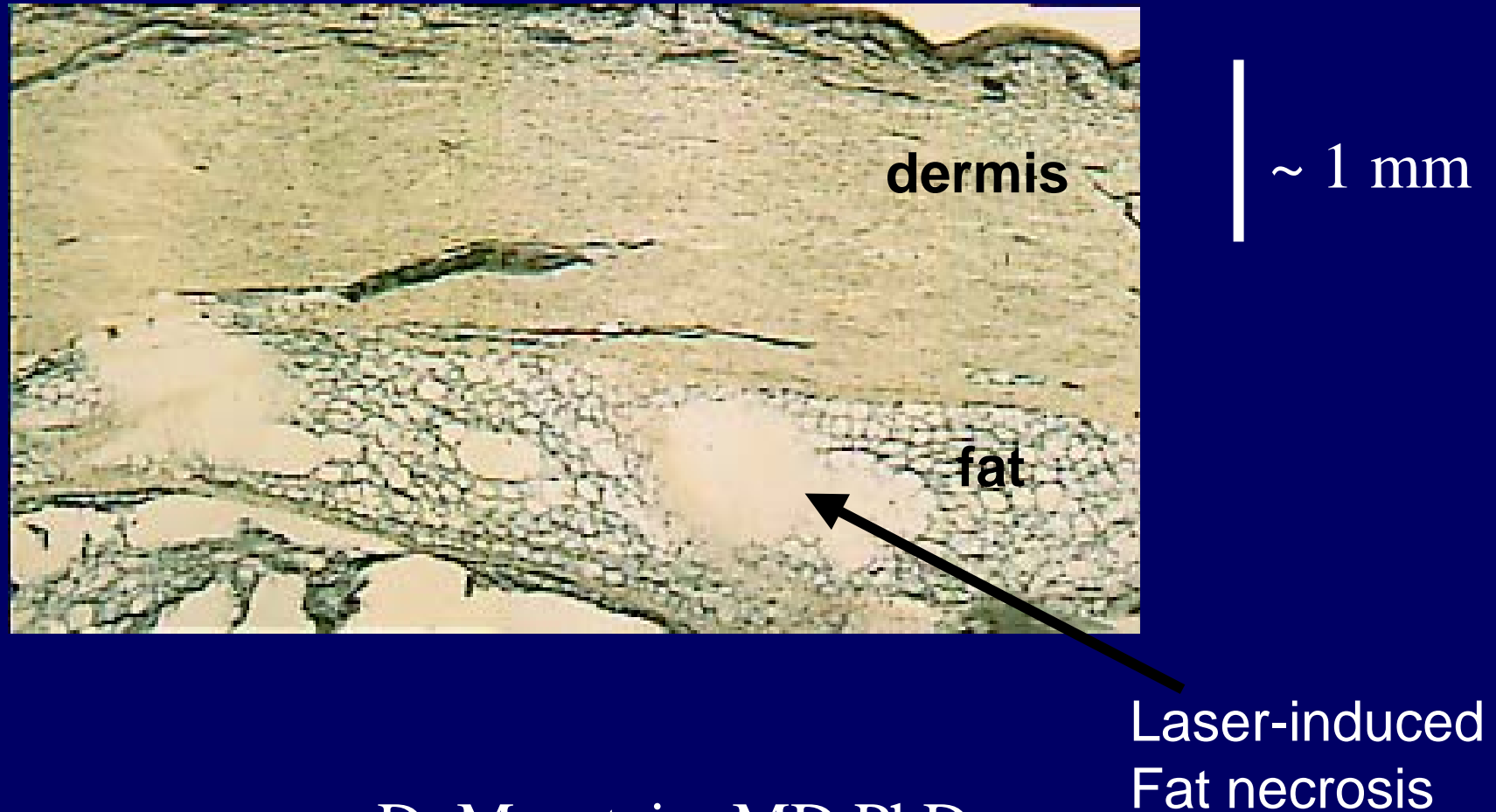
Fat



CH-selective Laser



Subcutaneous Fat Necrosis induced *in vitro* with a 1208 nm laser (LDH activity stain)



D. Manstein, MD PhD

Jlab FEL Experimental Aims

1. Selective photocoagulation of (1)subcutaneous fat, (2)sebaceous glands
 - Demonstrate feasibility (NTBC histology)
 - Determine wavelength dependence (PPTR spectroscopy with 7-12 μm fast detector)
 - Compare to tissue model predictions
2. Selective tissue ablation – fatty tissue
 - Determine threshold fluence & slope efficiency as a function of wavelength, by mass loss
 - Histology

FEL Needs

- 3-5 days of beam access in 3(?) sessions
- Approx λ , power, pulsewidth combos:
 - 1100-1300 nm; 0-50 W; 0.1-60 sec
 - 1600-1800 nm; 0-100 W; 1-1000 ms
 - 2800-3300 nm; 0-1000 W; 1-1000 μ s
- Beam control & beam diagnostics
- Some advice on safety, etc

Other Things We're Interested in Looking At

- Focused-beam tissue ablation
 - When does NIR ablation with a fs pulse train turn excimer-like?
 - Electron microscopic study in skin samples
- Amide II tissue ablation (6.45 μm)
 - Were Edward's observations with the Vanderbilt FEL due to mechanism, or limited power available?
- Multiphoton NIR photochemistry
 - Solution-phase action spectra for photosensitizer drugs, by 2 and 3-photon excitation
- UV action spectra