Introducción a la imagen optoacústica mesoscópica y sus aplicaciones clínicas

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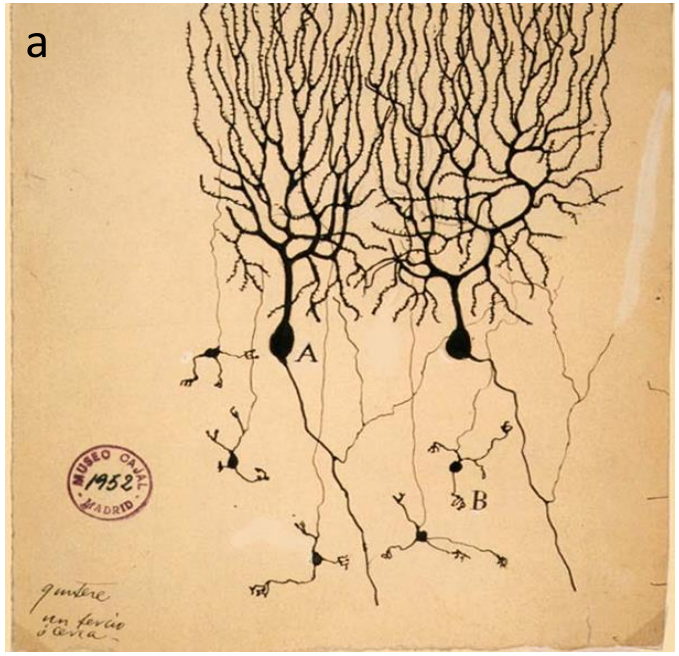
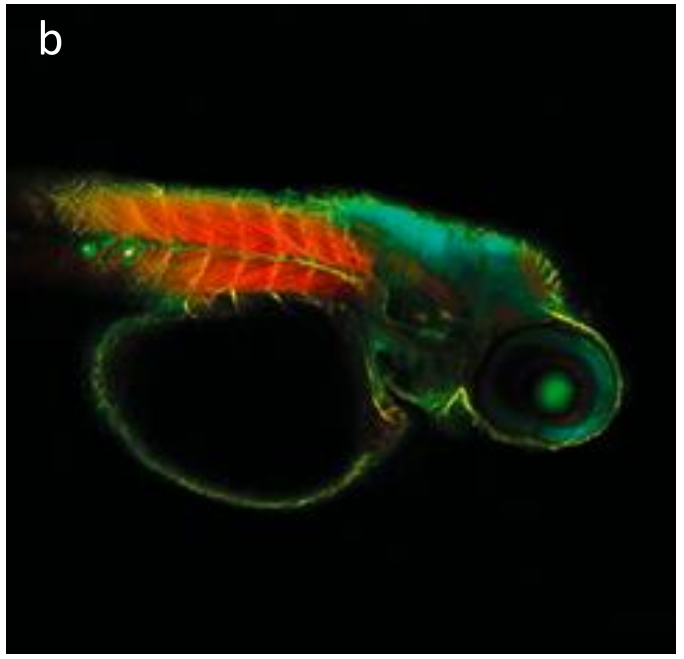
- Optoacoustic mesoscopy: motivation and basic concepts

Motivation: Optical imaging/contrast



Neurons under an optical miscrocope (Ramon y Cajal Nobel prize 1906)

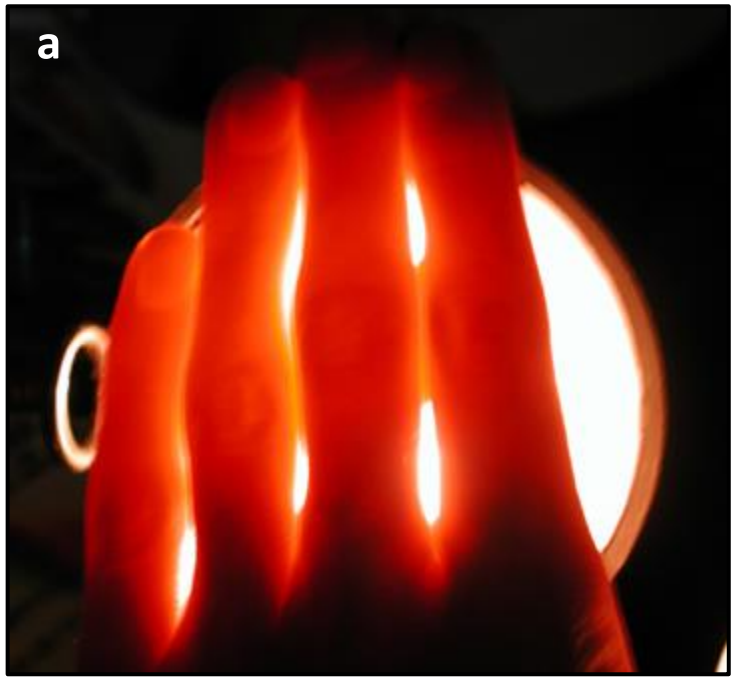


Zebra fish expressing green fluorescent protein under an optical microscope (2008 Nobel prize, Tsien, Shimomura and Chalfie)

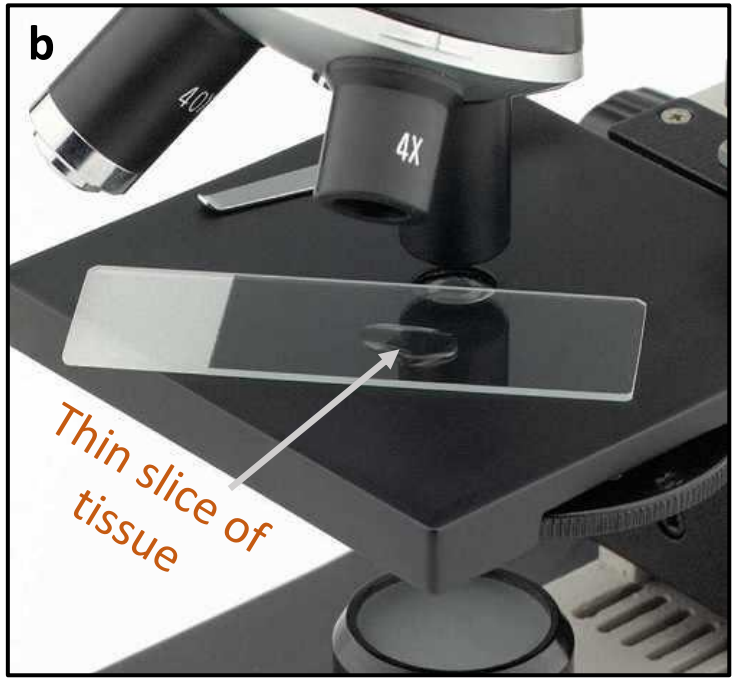
MD evaluating a patient using "optical imaging"

- Optical imaging technological advances largely drive biological discovery and clinical routine.
- However, optical imaging tech has severe fundamental limitations due to light scattering.

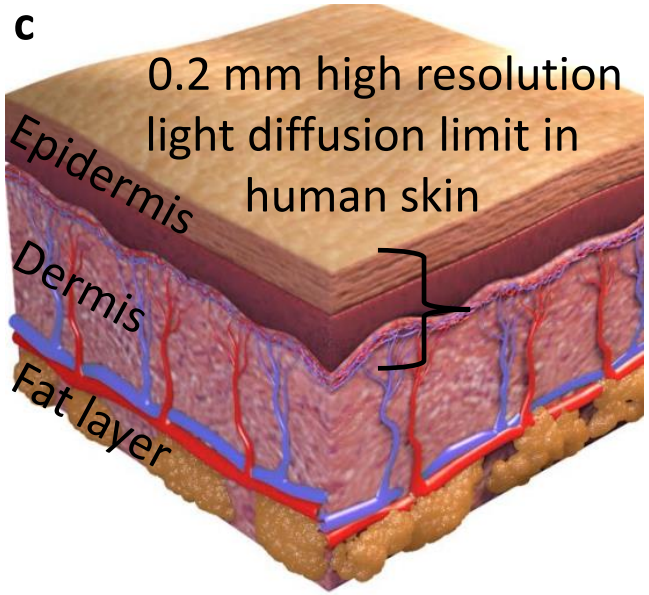
High resolution is only attained at shallow depths: the light diffusion limit



Light travels in tissue following a diffusion process due to light scattering.



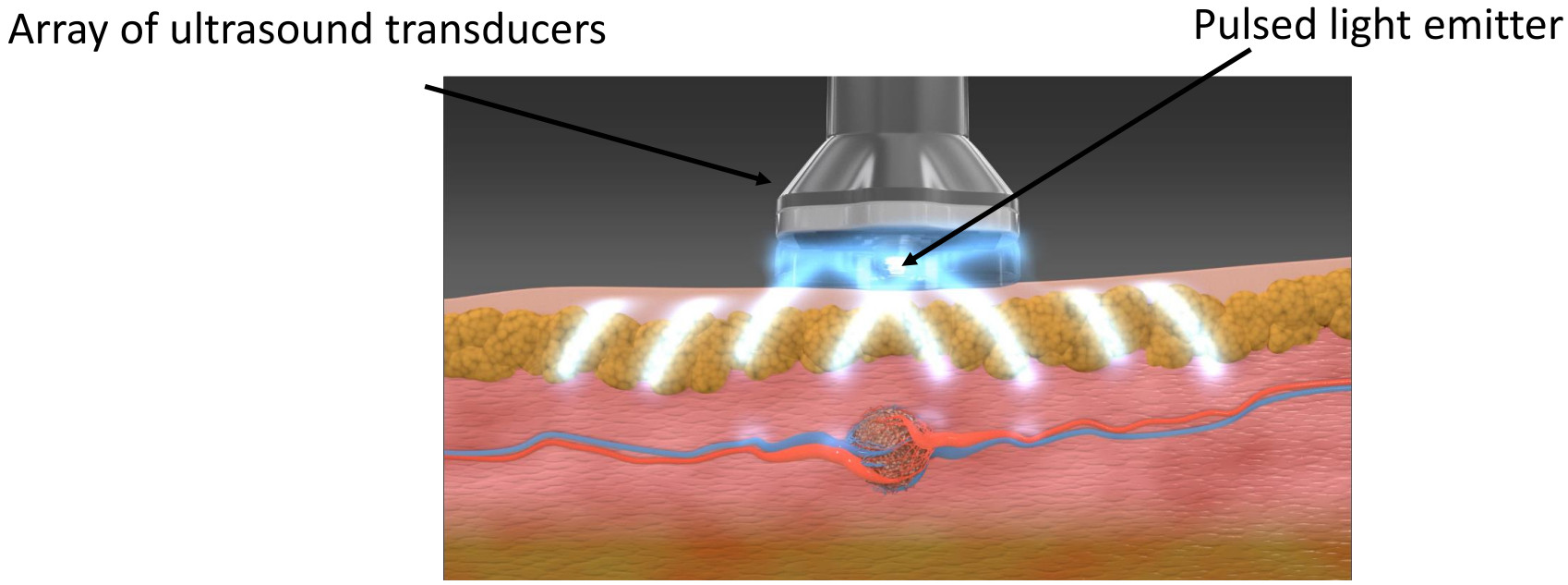
To avoid scattering, tissue must be thinly sliced (~0.01-0.2mm) to be observed with high resolution .



In case of the skin only epidermis and upper dermis is observable

- From surface to few hundred micrometers resolution is very high (~0.01-0.2mm)
- In deep tissue resolution degrades strongly due to light scattering.

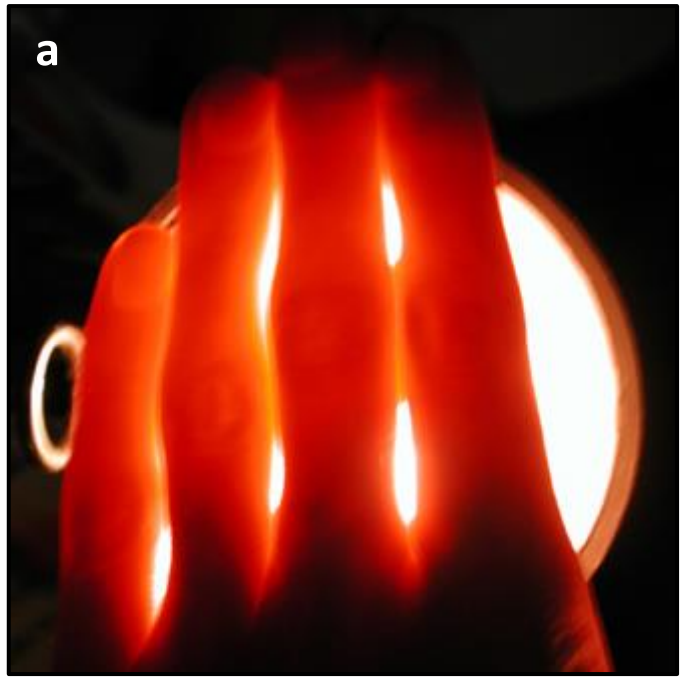
Optoacoustic imaging: beating the diffusion limit non-invasively



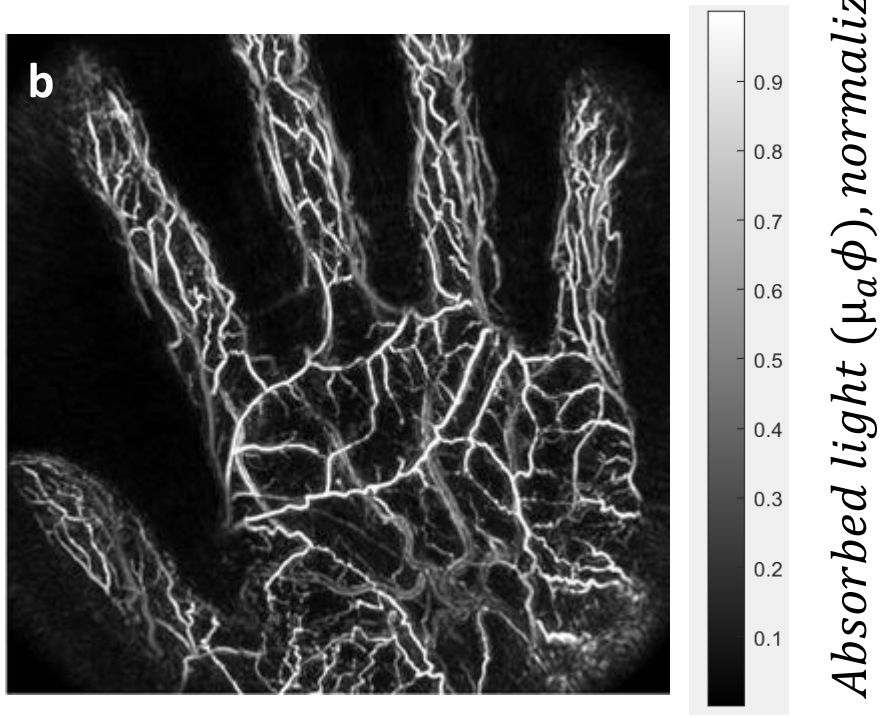
Optical contrast (3D distribution of light absorption) +
ultrasound high resolution to depth ratio

Optoacoustic imaging: beating the diffusion limit non-invasively

OPTICAL IMAGING



OPTOACOUSTIC IMAGING



Optical imaging at high resolution in deep tissue!

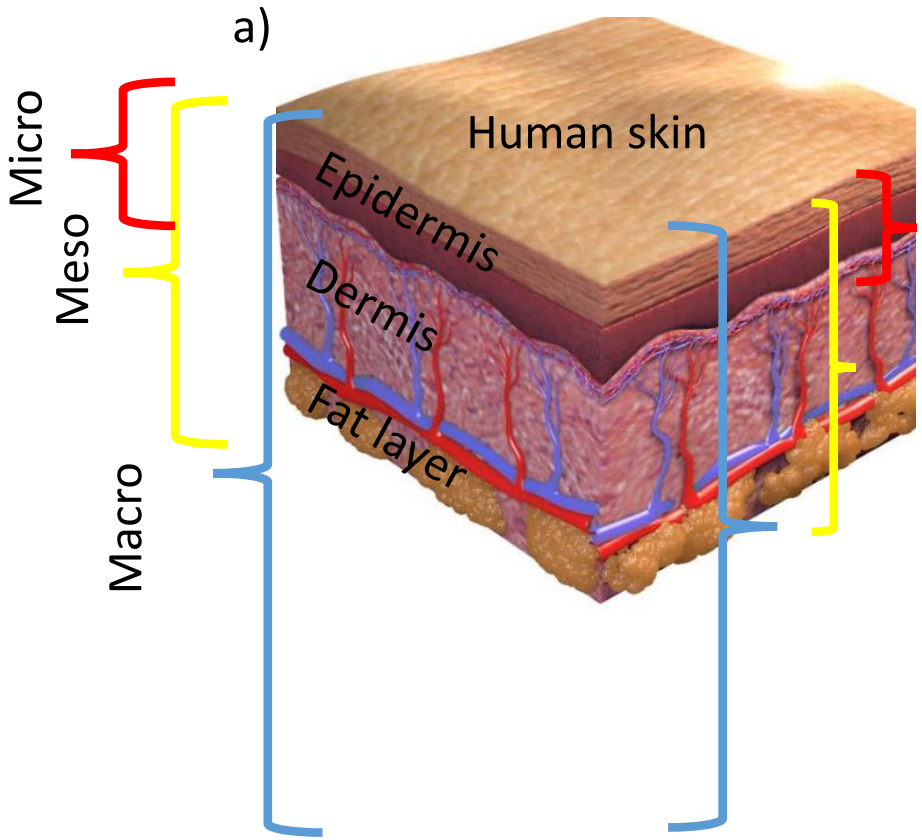
Pixel values: Absorbed light (deposited heat).

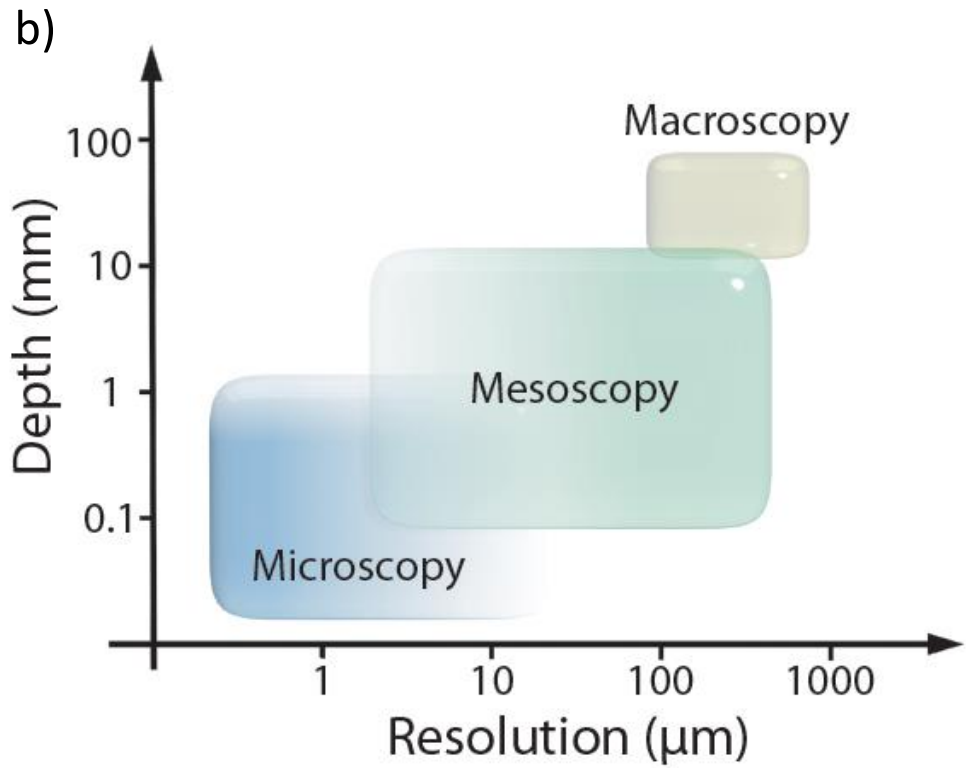
H α $\mu_a\phi$ (Jcm^{-3})

Hemoglobin: very high μ_a

Taken from Matsumoto et al. Scientific Reports 2018

The optoacoustic imaging regimes





Omar, Aguirre, Ntziachristos .Nature Biomed Eng 2019
Karlas,Pleitez, Aguirre, Ntziachristos .Nature Reviews Endocr 2021

Optoacoustic microscopy: cell level
Resolution: 1 µm
Depth: 0.1-1mm
(a.k.a OR-PAM)

Optoacoustic mesoscopy: tissue level
Resolution: 10-100 µm
Depth: 1-10mm
(a.k.a AR-PAM)

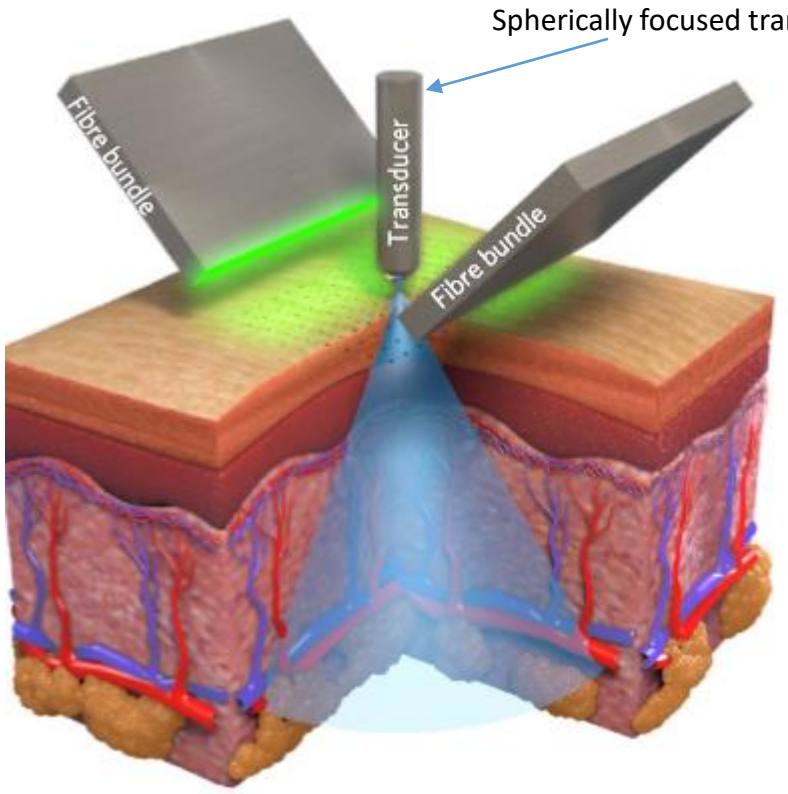
Optoacoustic macroscopy: organ level
Resolution: 150µm
Depth: 0.1cm-10cm
(a.k.a PACT)

- Optoacoustic mesoscopy: instrumentation and imaging capabilities

Clinical RSOM (Raster Scan Optoacoustic Mesoscopy)

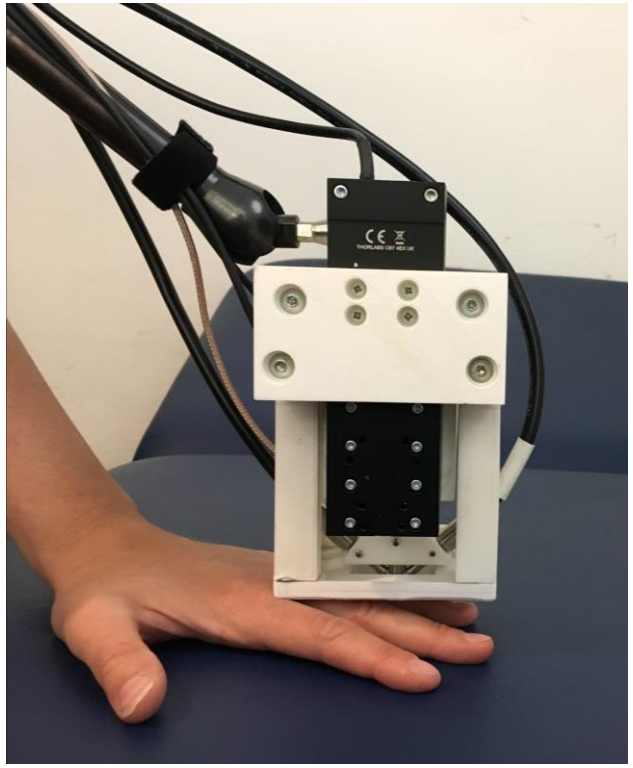
RSOM SYSTEM SCHEMATIC REPRESENTATION

a)



CLINICAL SYSTEM

b)



- Resolution: 30 µm and 7 µm (lateral and axial)
- 4 x 2 mm field of view. ~1min acquisition

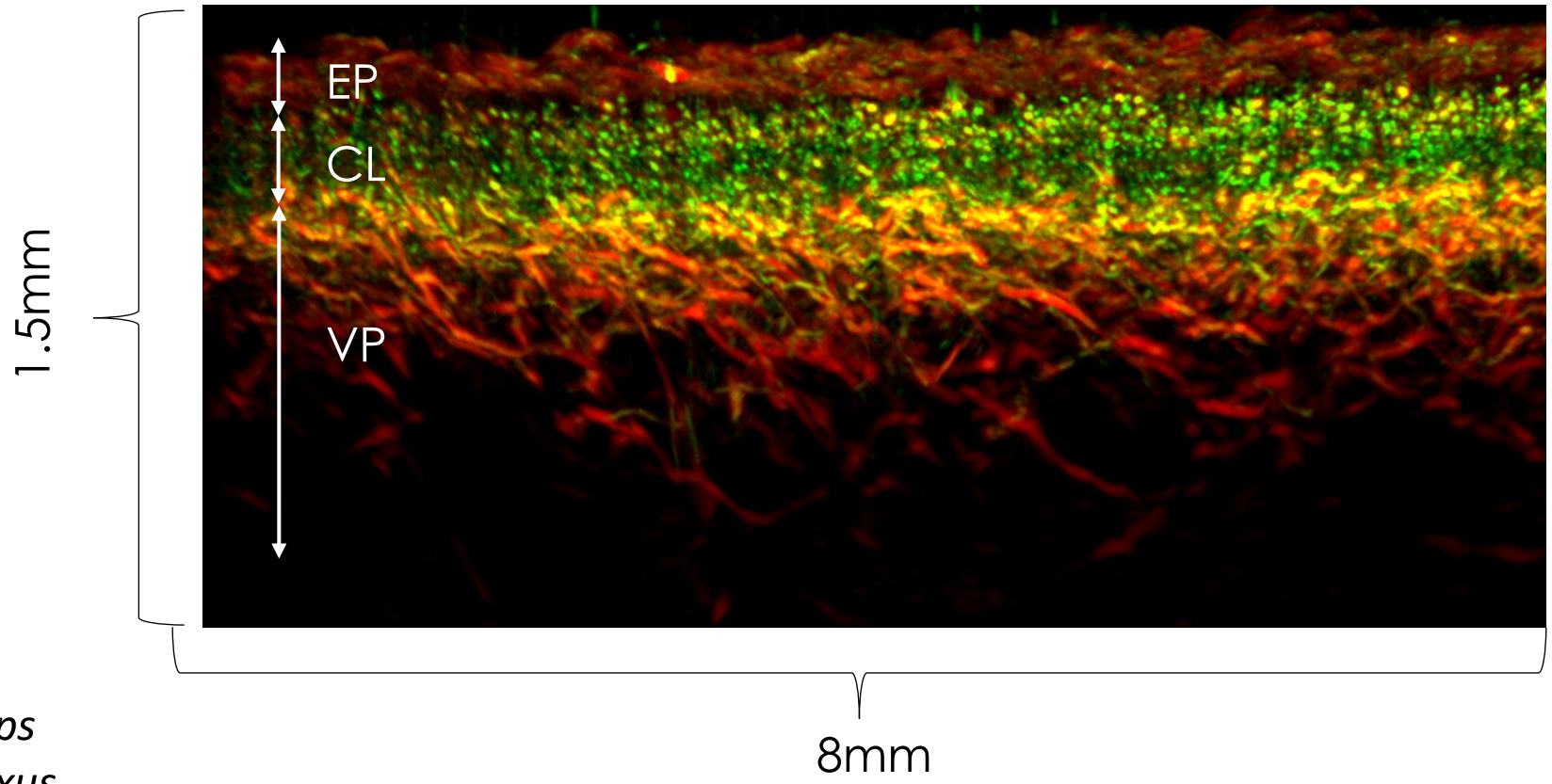
Aguirre et al. Nature Biomed Eng 2017

What can we observe/study with RSOM?: first comprehensive images of skin microvasculature

Low frequencies (10-40 MHz). “Big vessels“

High frequencies (40-180 MHz). “Small vessels“

RSOM cross sectional view of healthy skin



EP: Epidermis
CL: capillary loops
VP: vascular plexus

- *Implications for dermatology and several major diseases*

Aguirre et al. 2017
Nat Biomed Eng.

Agradecimientos

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