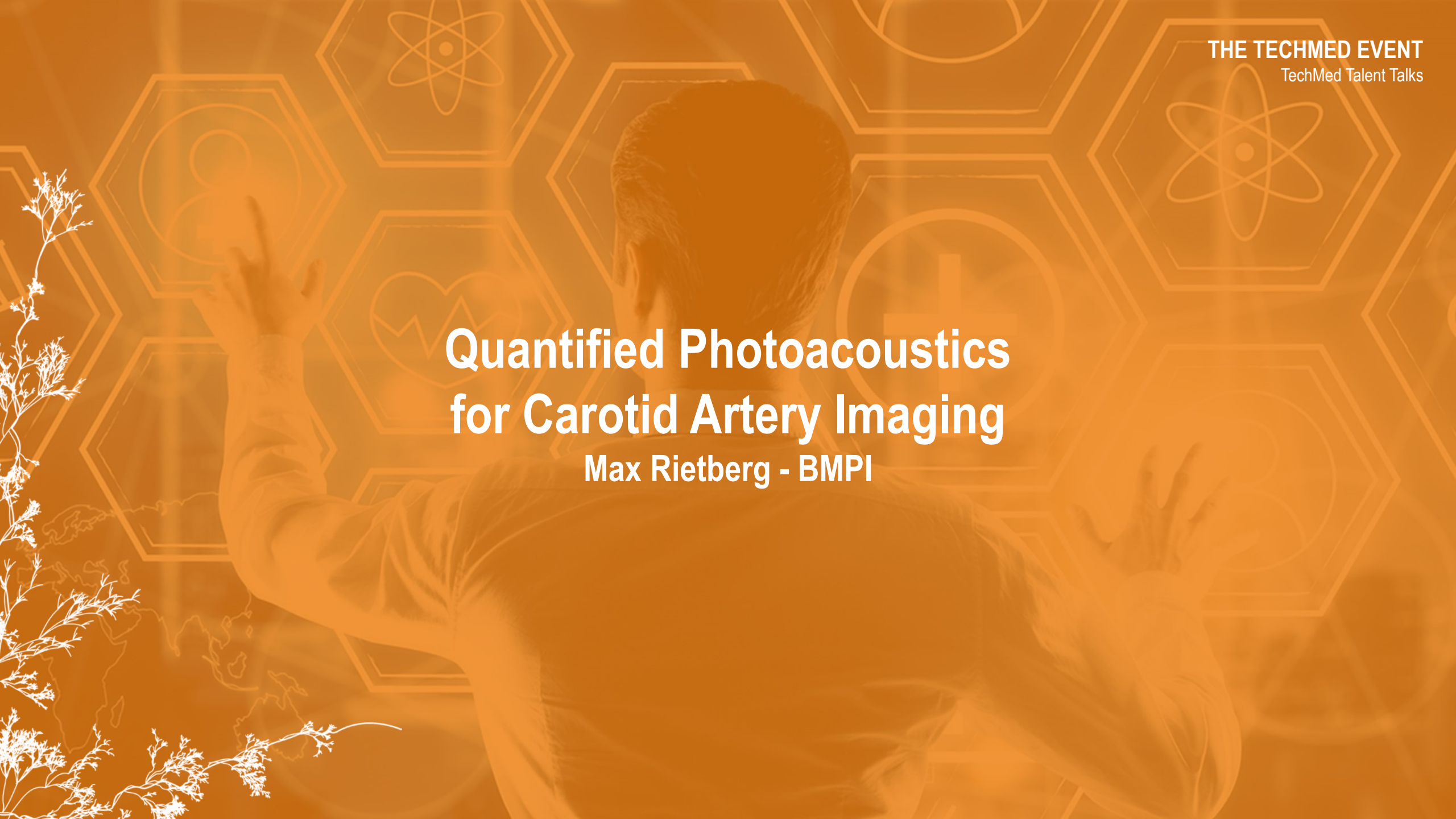


Quantified Photoacoustics for Carotid Artery Imaging

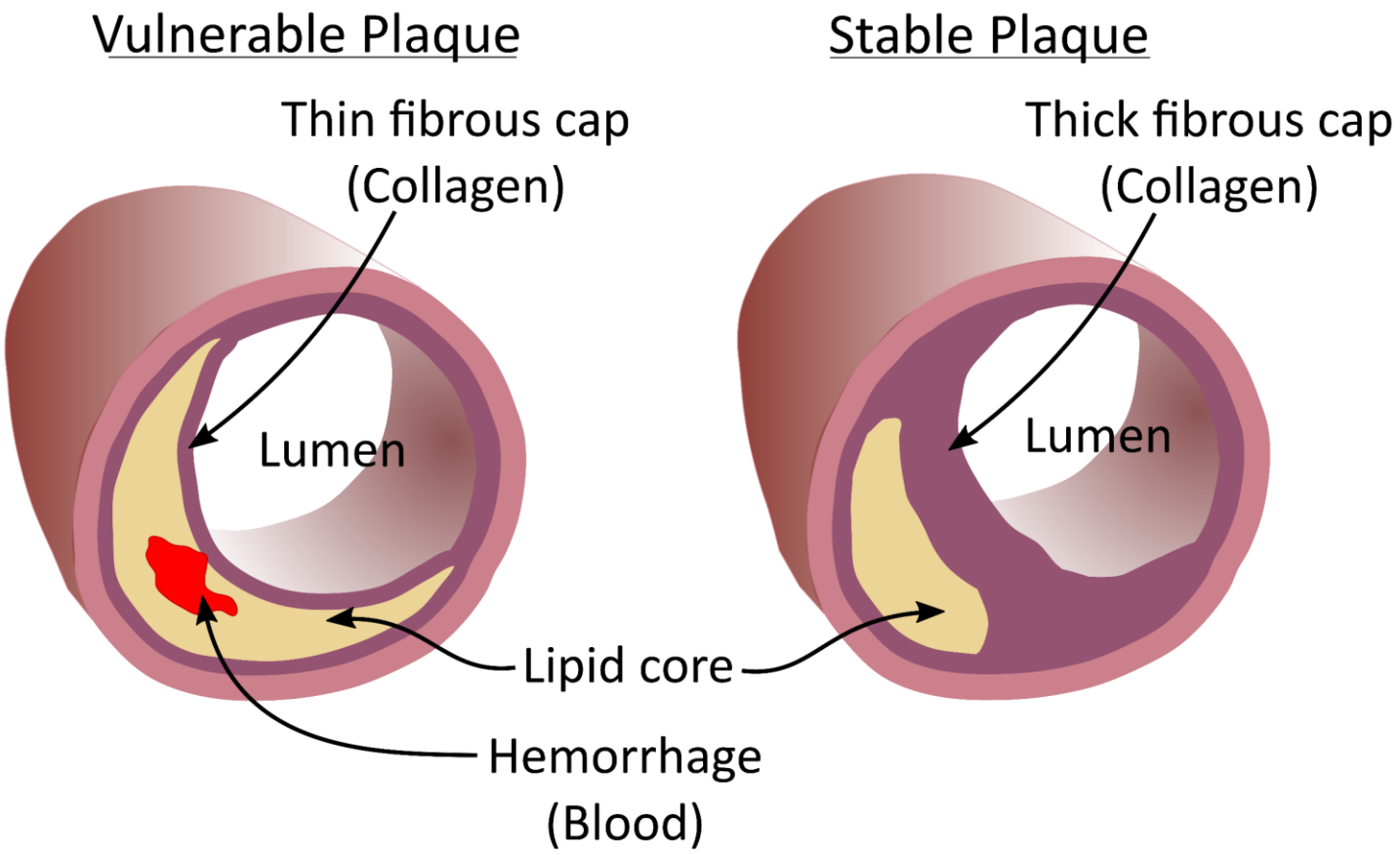
Max Rietberg - BMPI

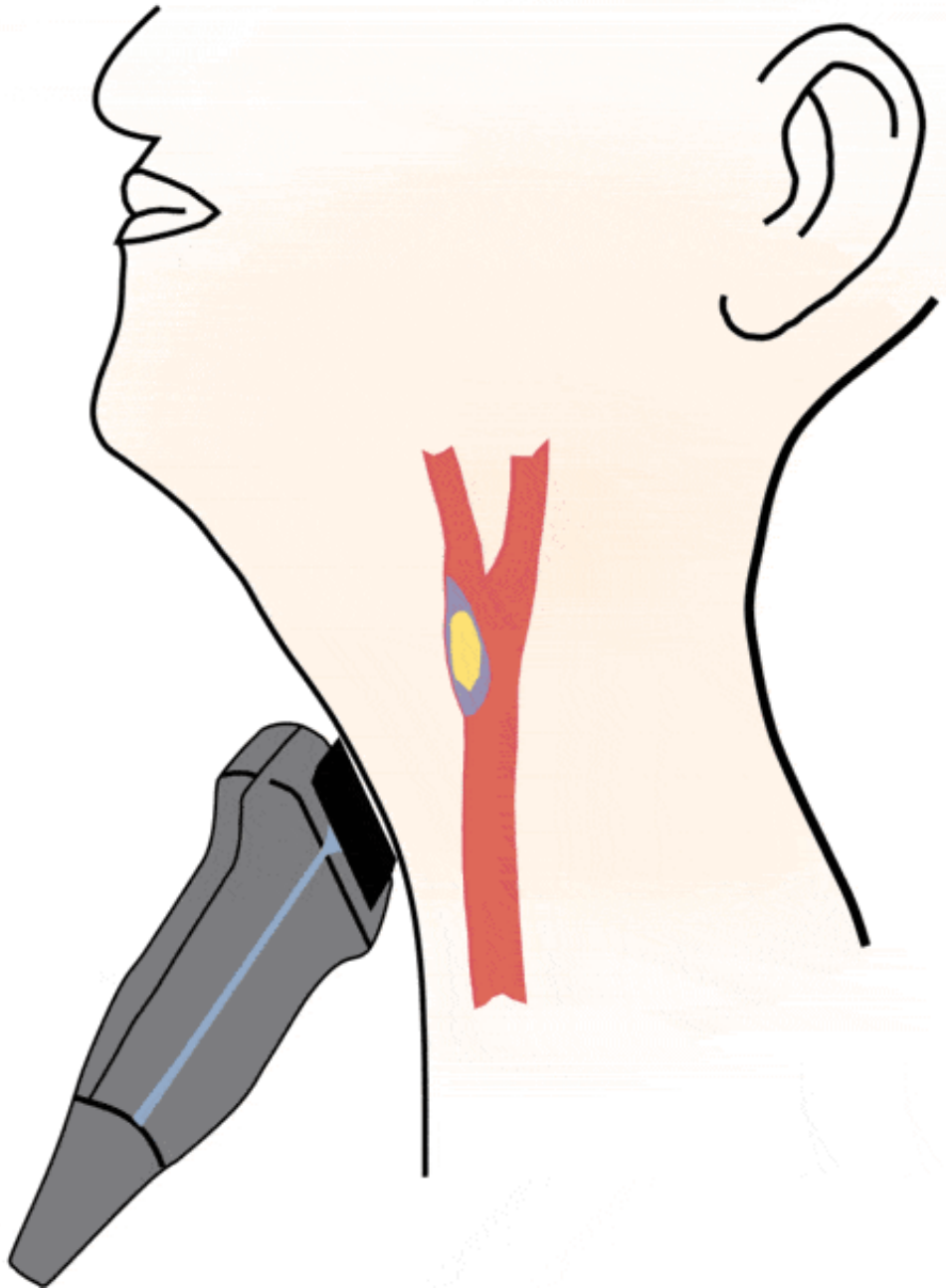
Clinical problem

- Stroke:
  - One of the leading causes of mortality
  - Europe: 1.1 million deaths per year [1]
- Carotid artery disease
  - Narrowing due to fatty deposits (plaques)
- Determination of plaque stability
  - Surgically remove or not?
  - 3 out 5 of patients are overtreated [1]

1: Fernandes e Fernandes et al. (2020)

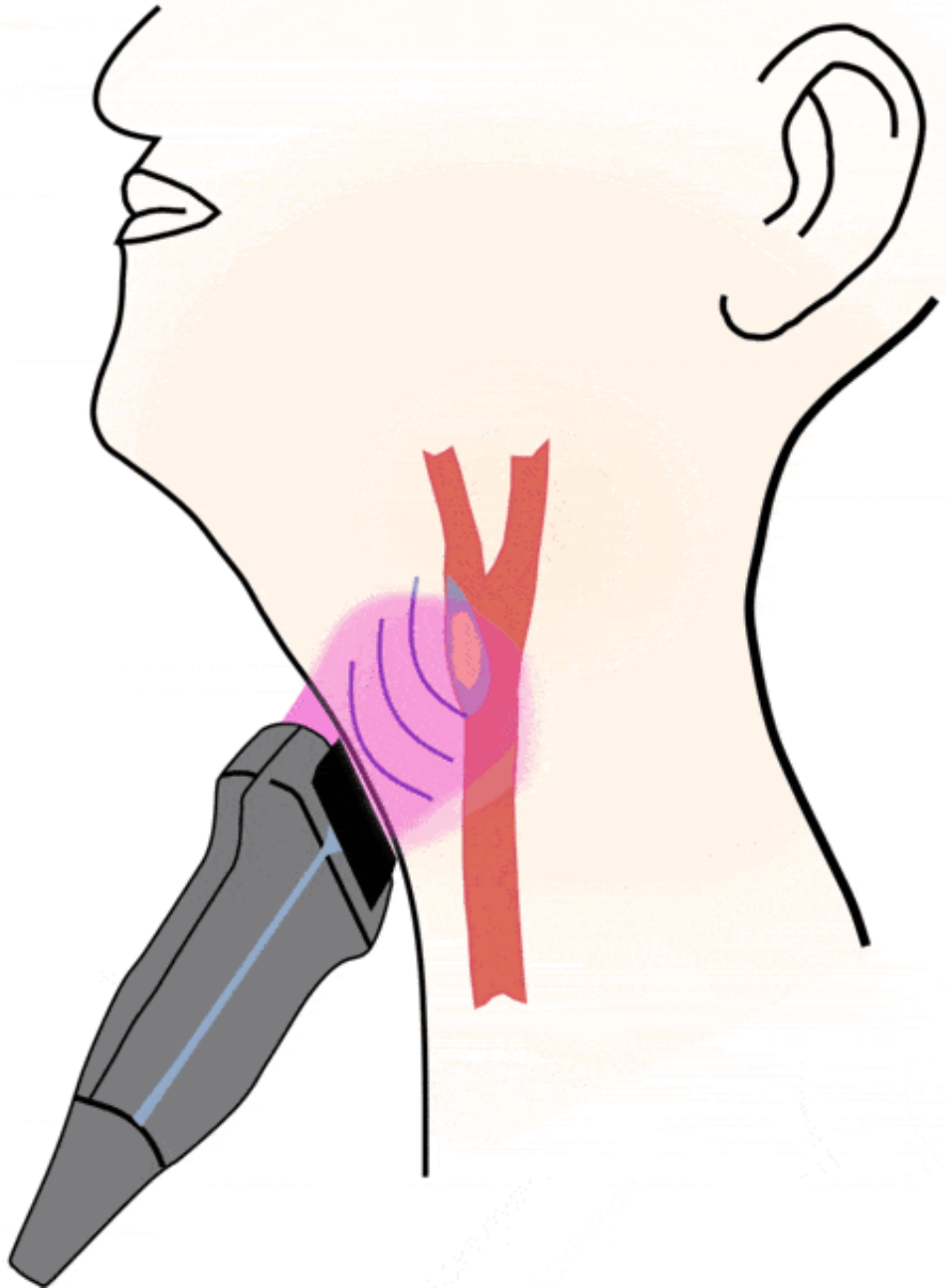
Stable plaques?





Ultrasound:
sound in, sound out

Photoacoustic imaging:
light in, sound out



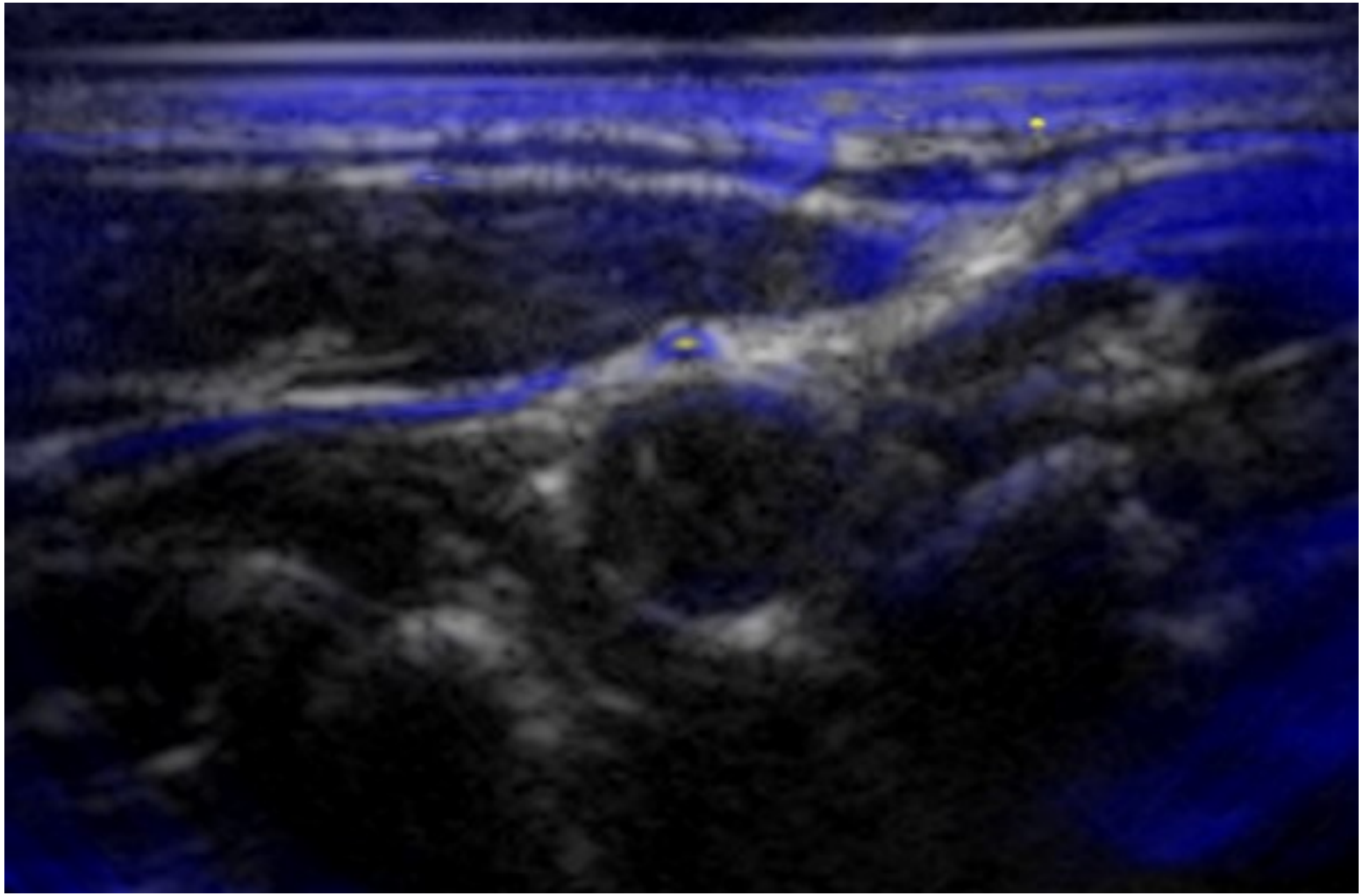
$$P_o(r) = \Gamma \mu_a(r) \Phi(r)$$

Photoacoustic Signal

Optical Absorption

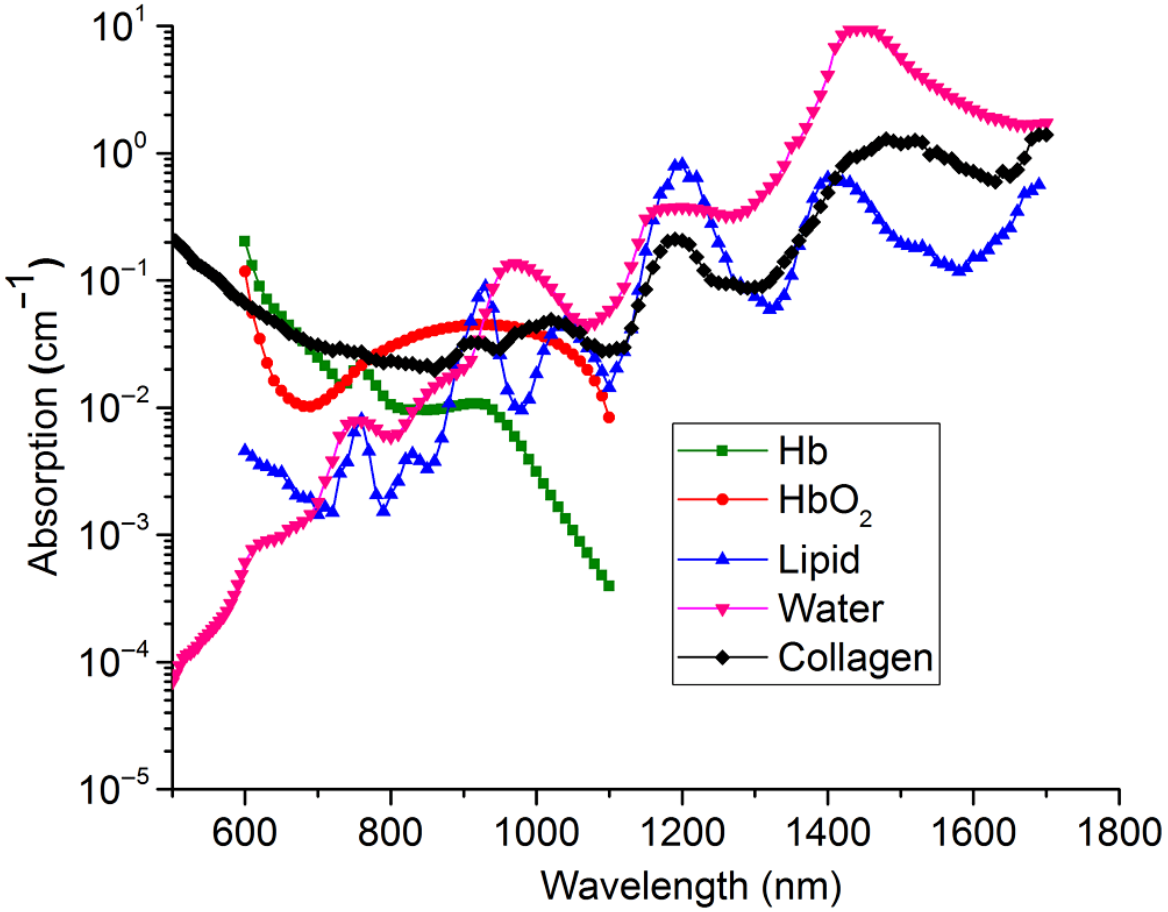
Fluence

Ultrasound+Photoacoustics



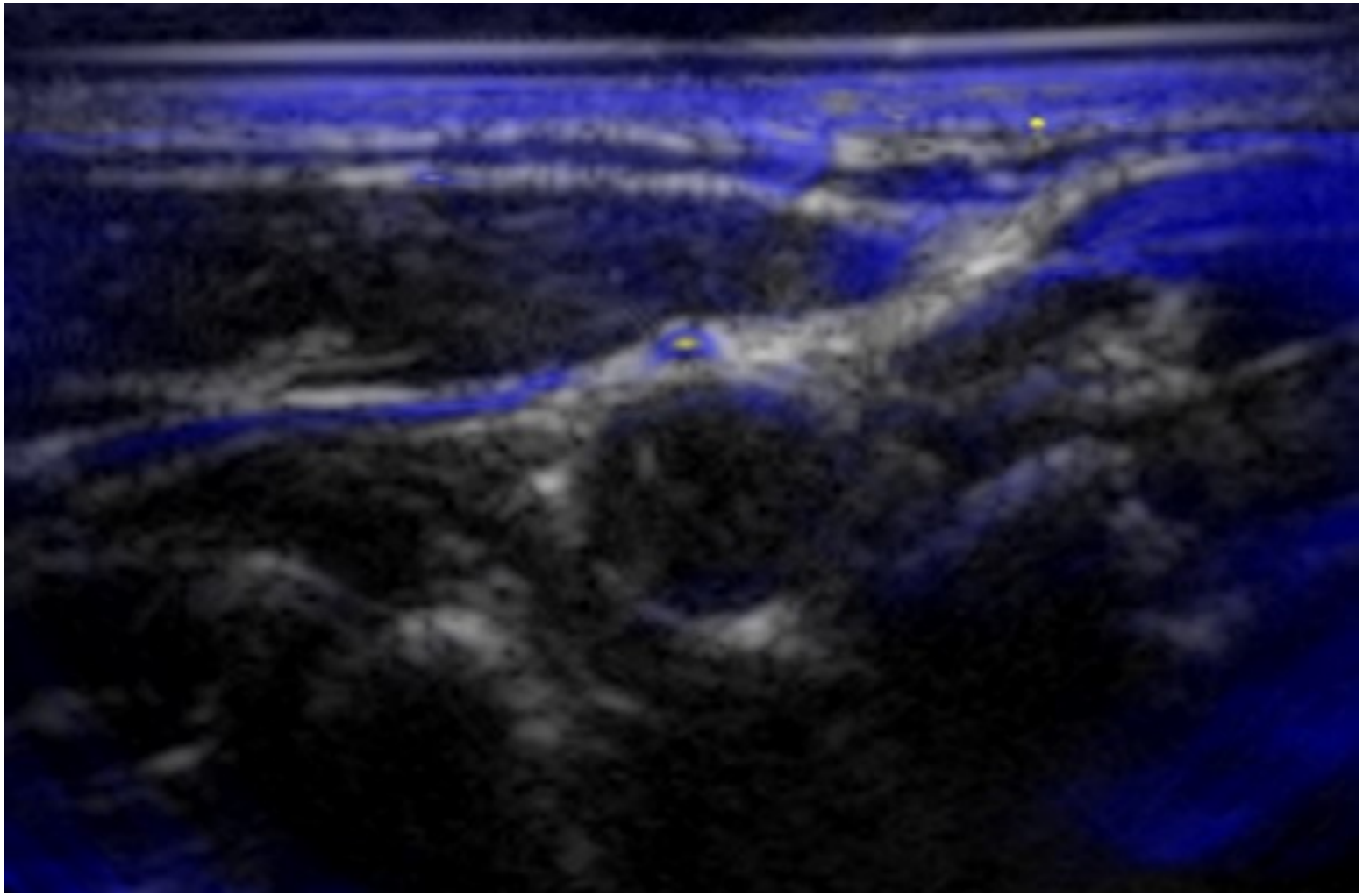
MSOT system, iThera

Plaque composition



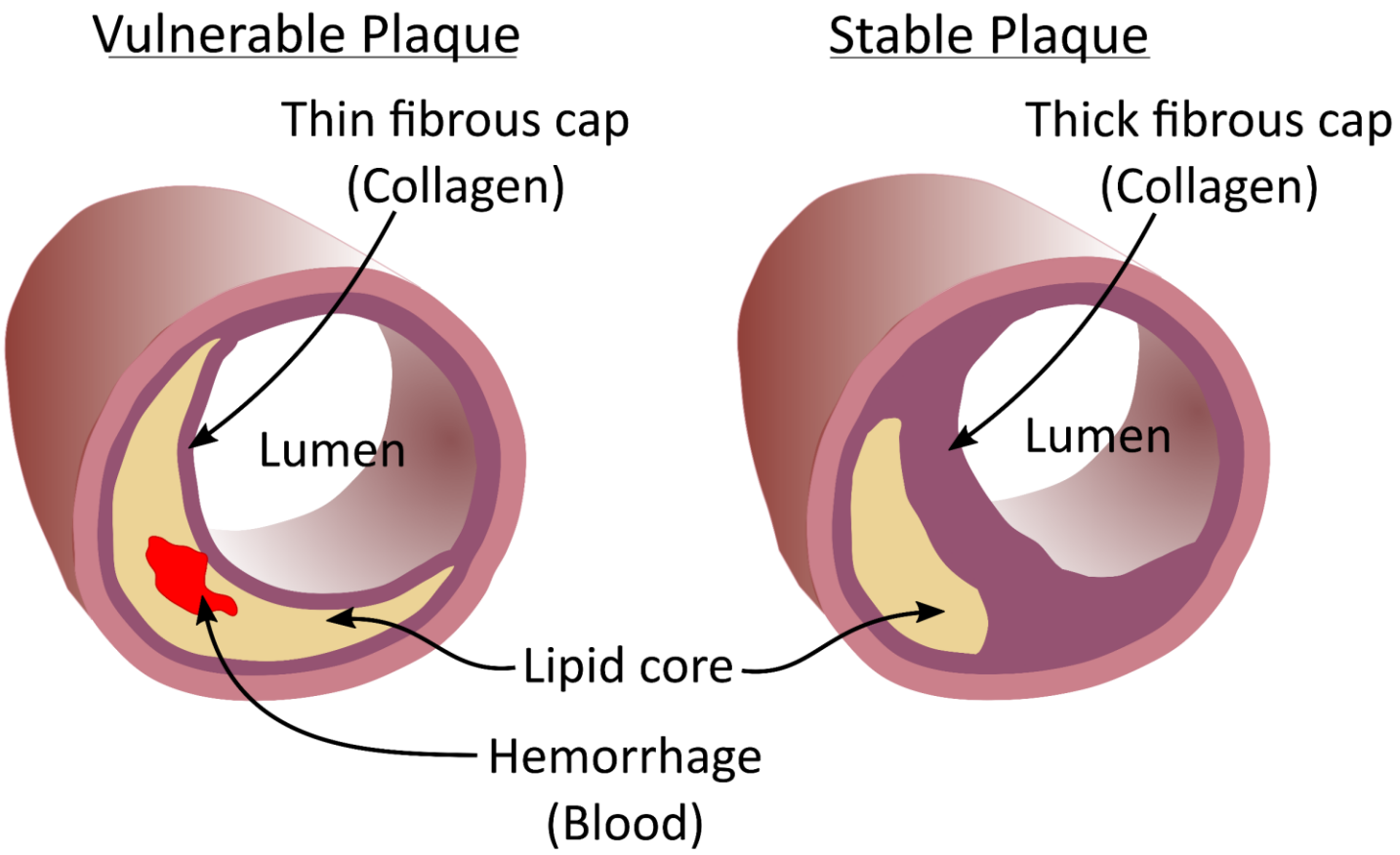
Sekar, Sanathana Konugolu Venkata, et al. (2017)

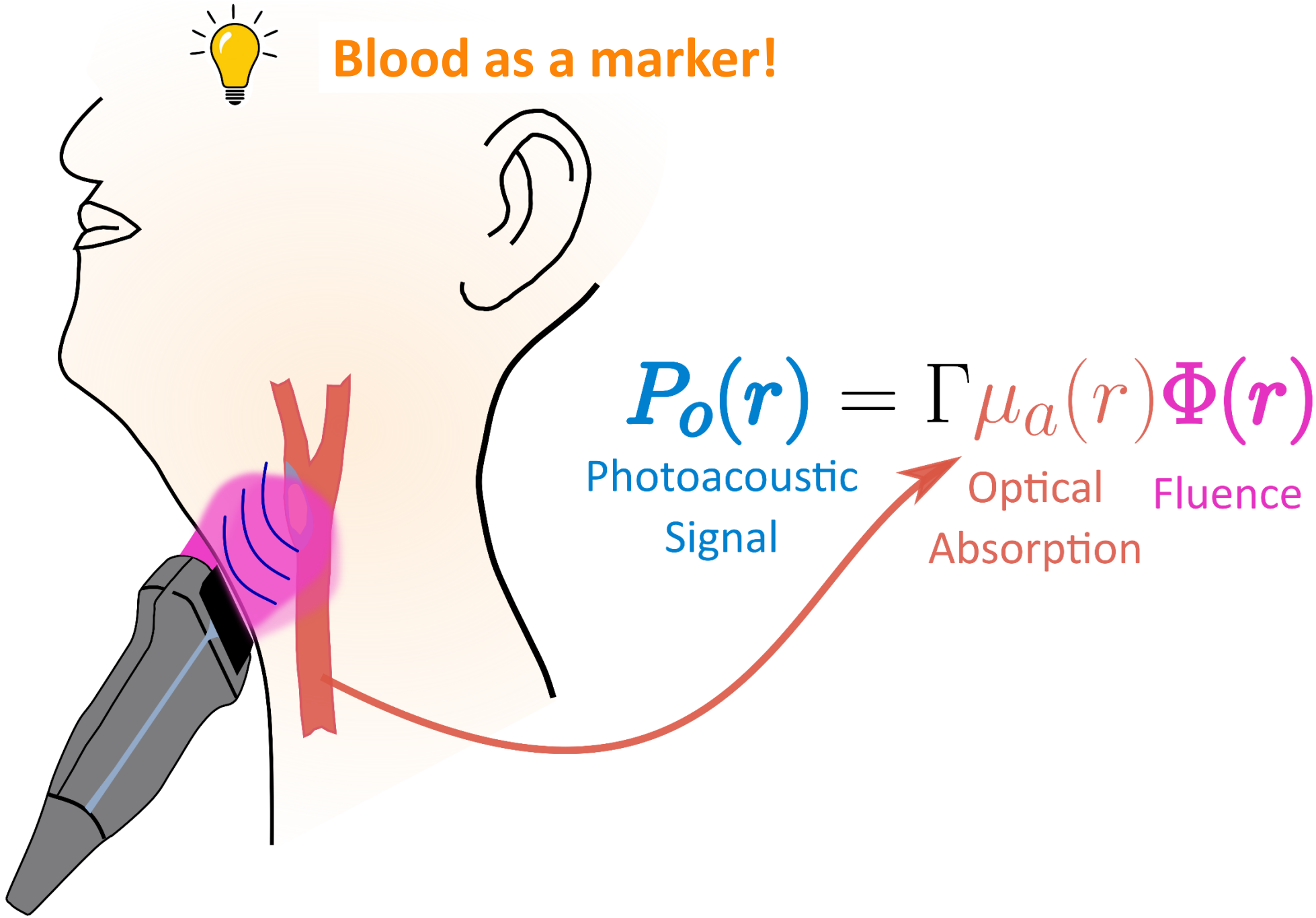
“Shadows”

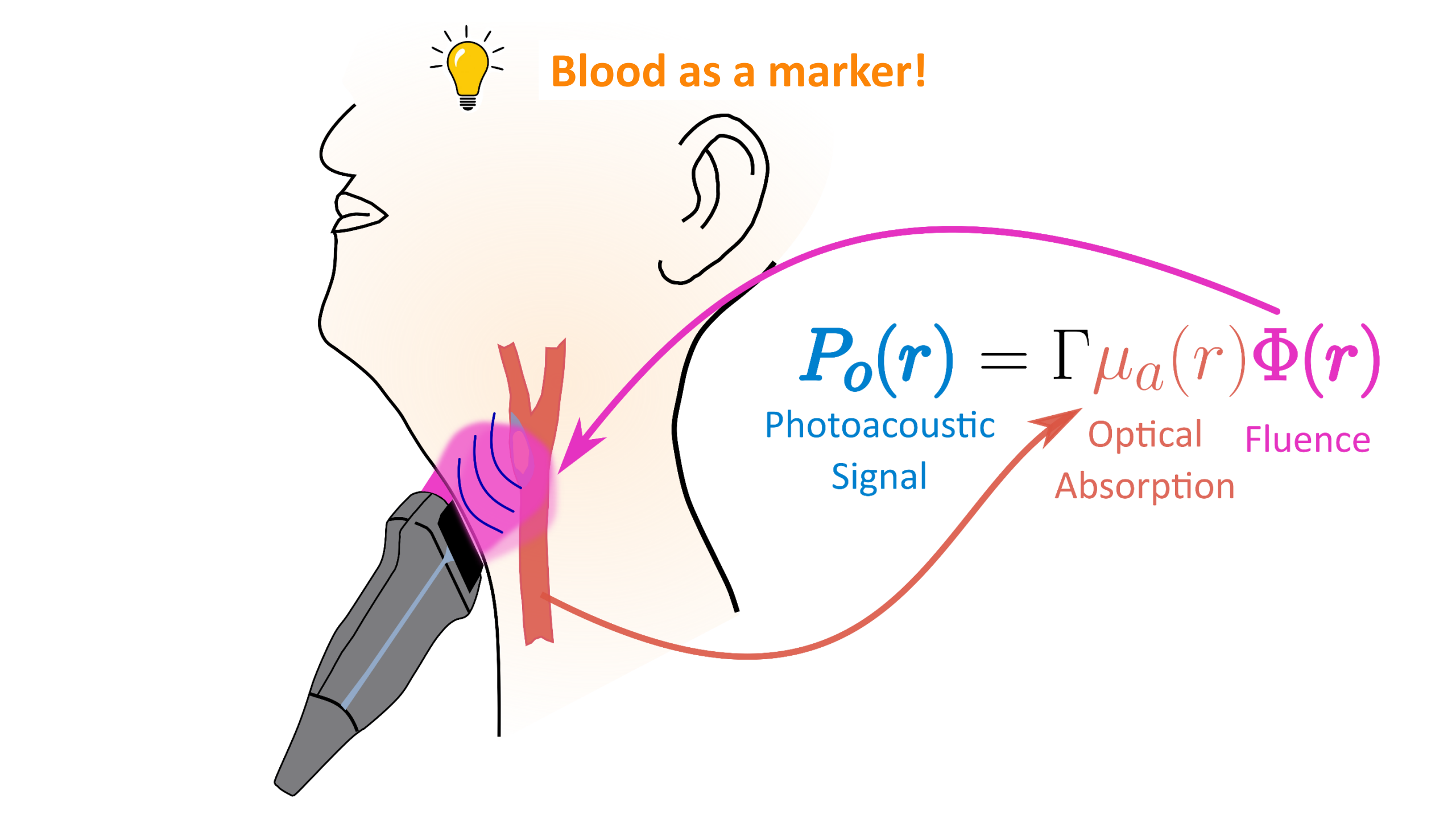


MSOT system, iThera

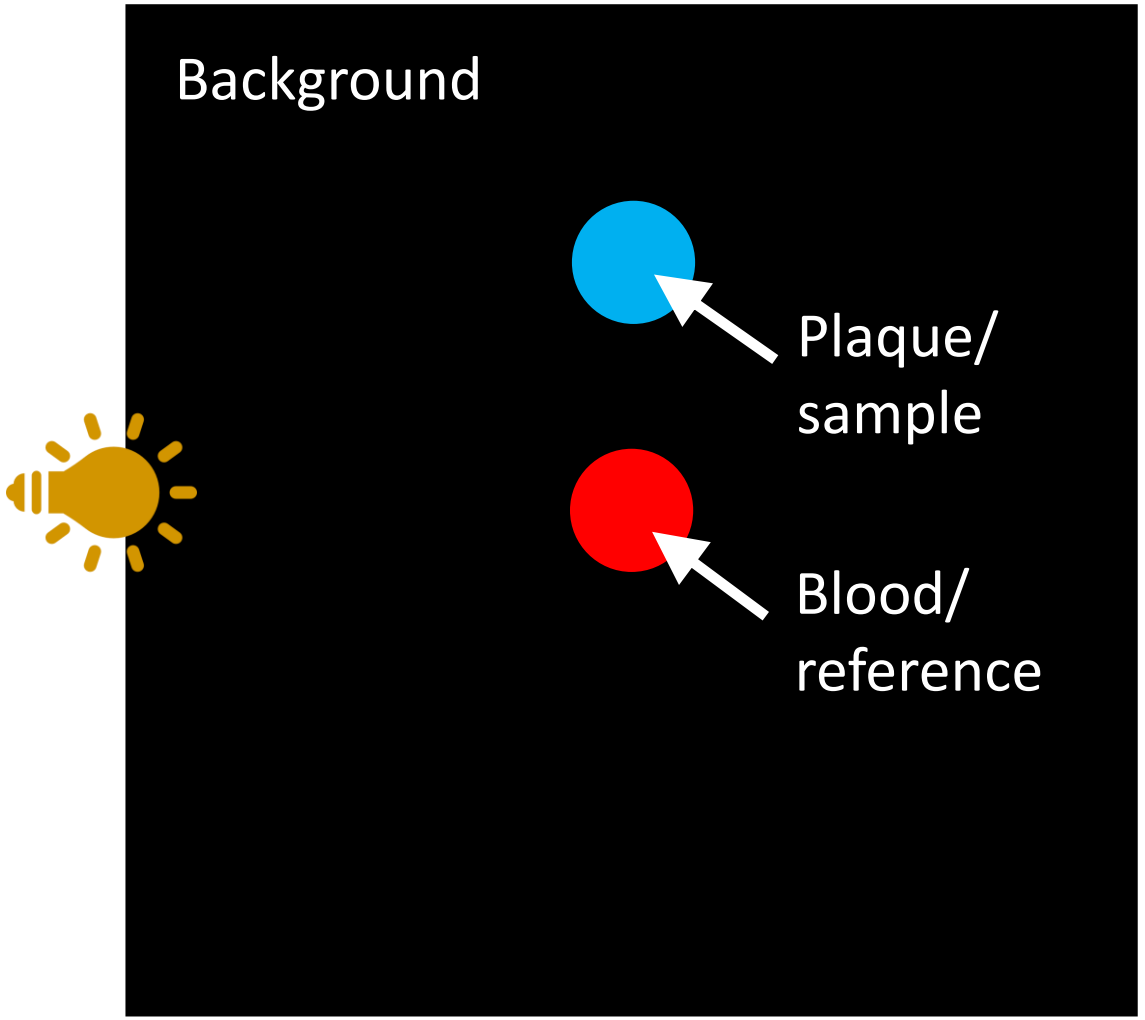
Stable plaques?




Blood as a marker!
$P_o(r) = \Gamma \mu_a(r) \Phi(r)$
Photoacoustic Signal
Optical Absorption
Fluence


Blood as a marker!
$P_o(r) = \Gamma \mu_a(r) \Phi(r)$
Photoacoustic Signal
Optical Absorption
Fluence

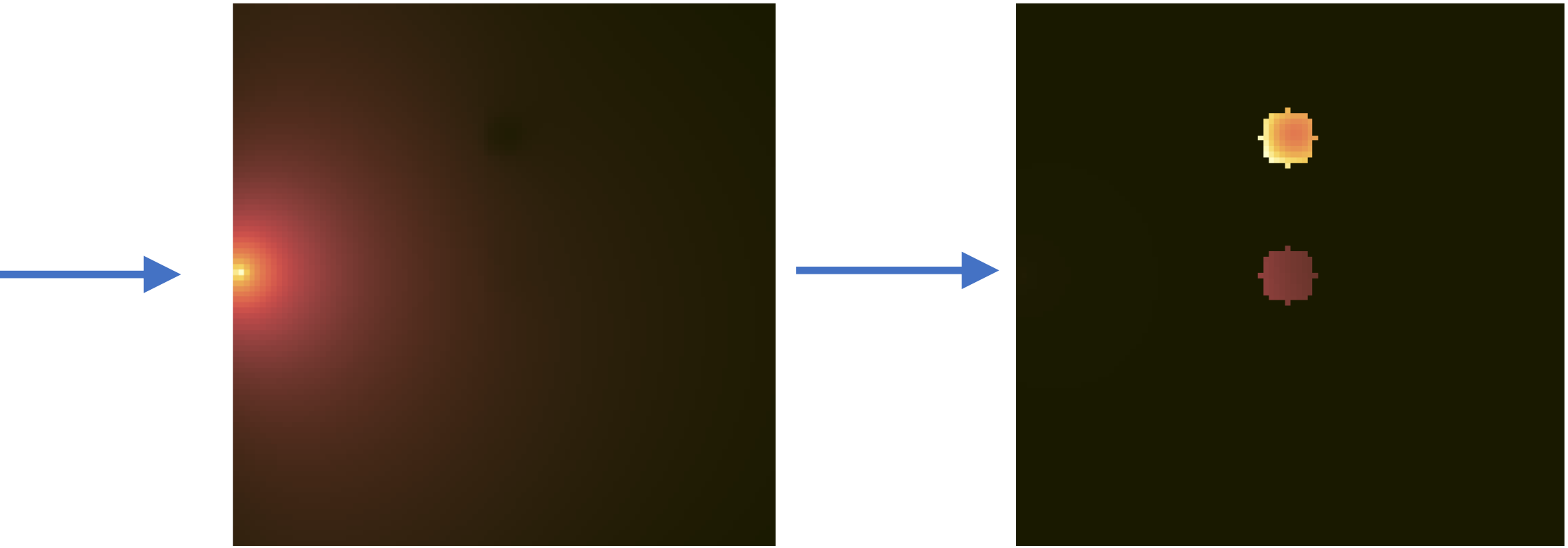
Setup



Simulation

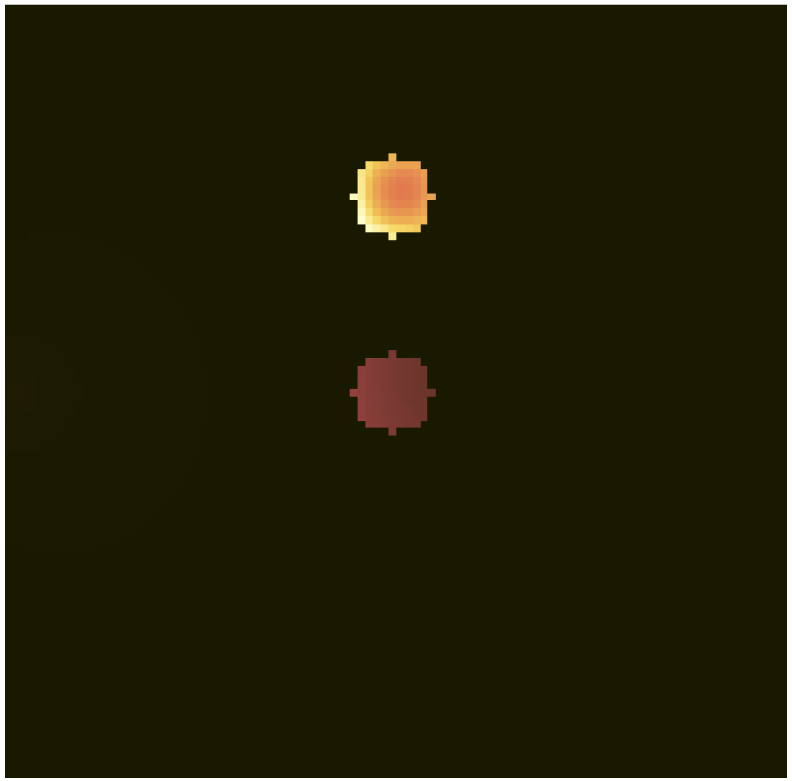
Light fluence

Photoacoustic signal

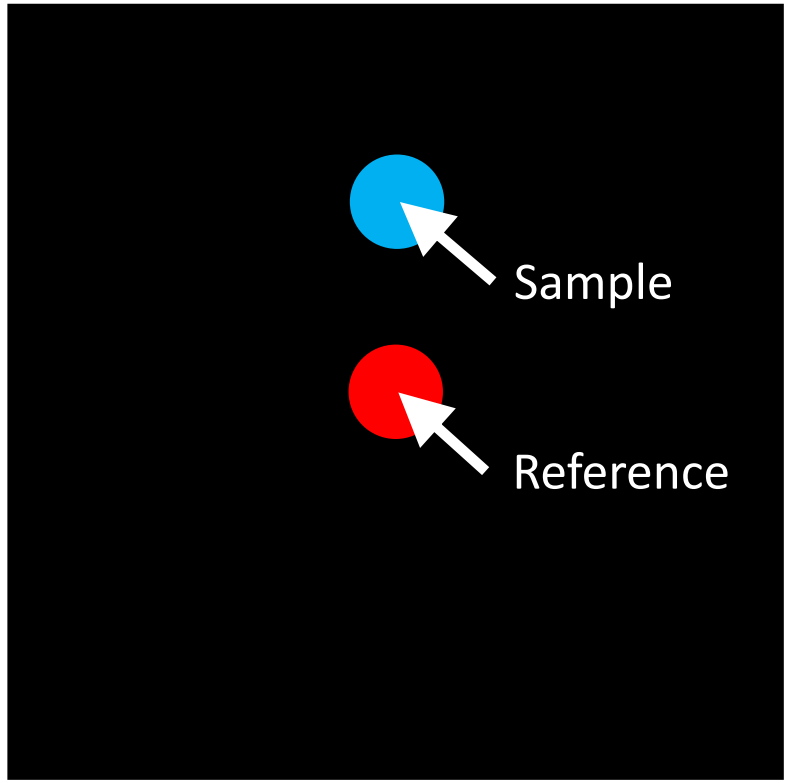


Reconstruction

Photoacoustic signal

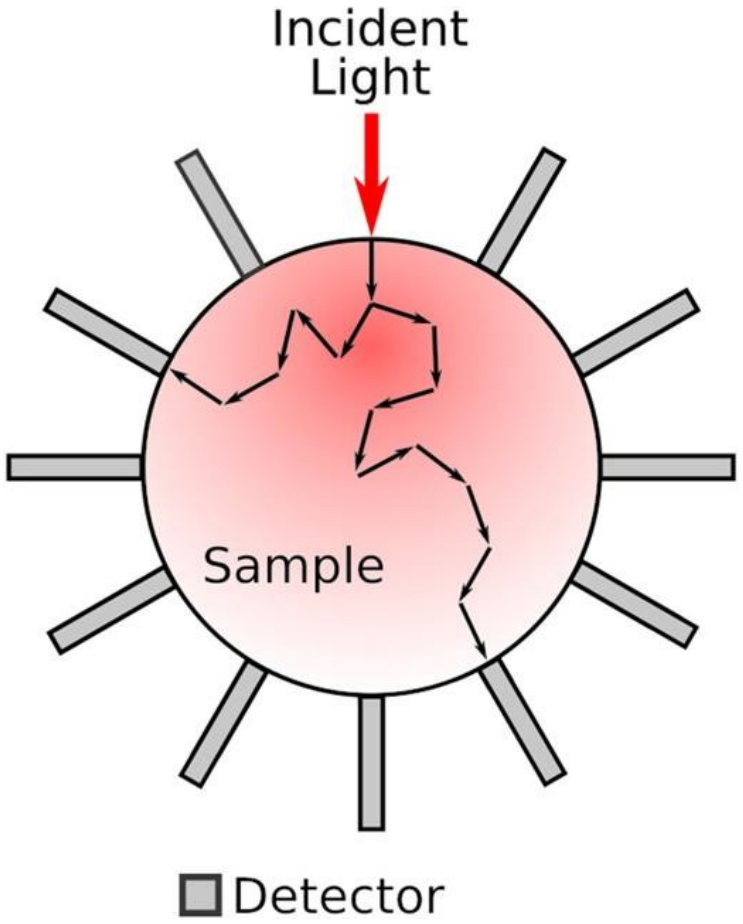


Optical properties



NIRFAST

- Originally developed for Diffuse Optical Tomography (DOT)
- Calculate fluence maps
- Reconstruct optical properties
- Number of publications about DOT has peaked in 2013



Dehghani, et al. (2008)

The NIRFAST method

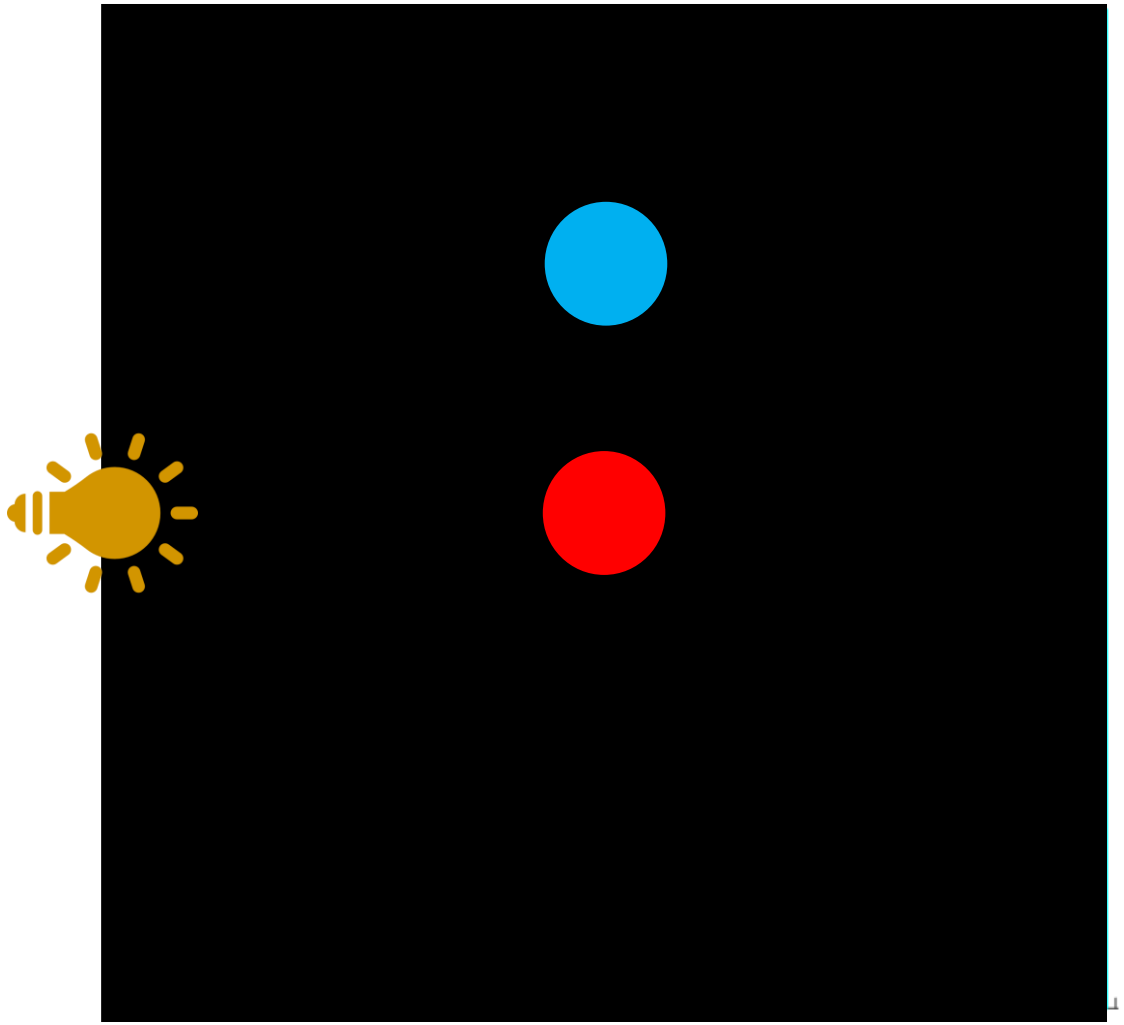
- Jacobian-based reconstruction

- NIRFAST requires:
  - 1 or more light sources
  - 1 or more light detectors
- Photoacoustics:
  - 1 or more light sources
  - **No light detectors**
- However:
  - Blood as a marker!

The NIRFAST method

- Jacobian-based reconstruction

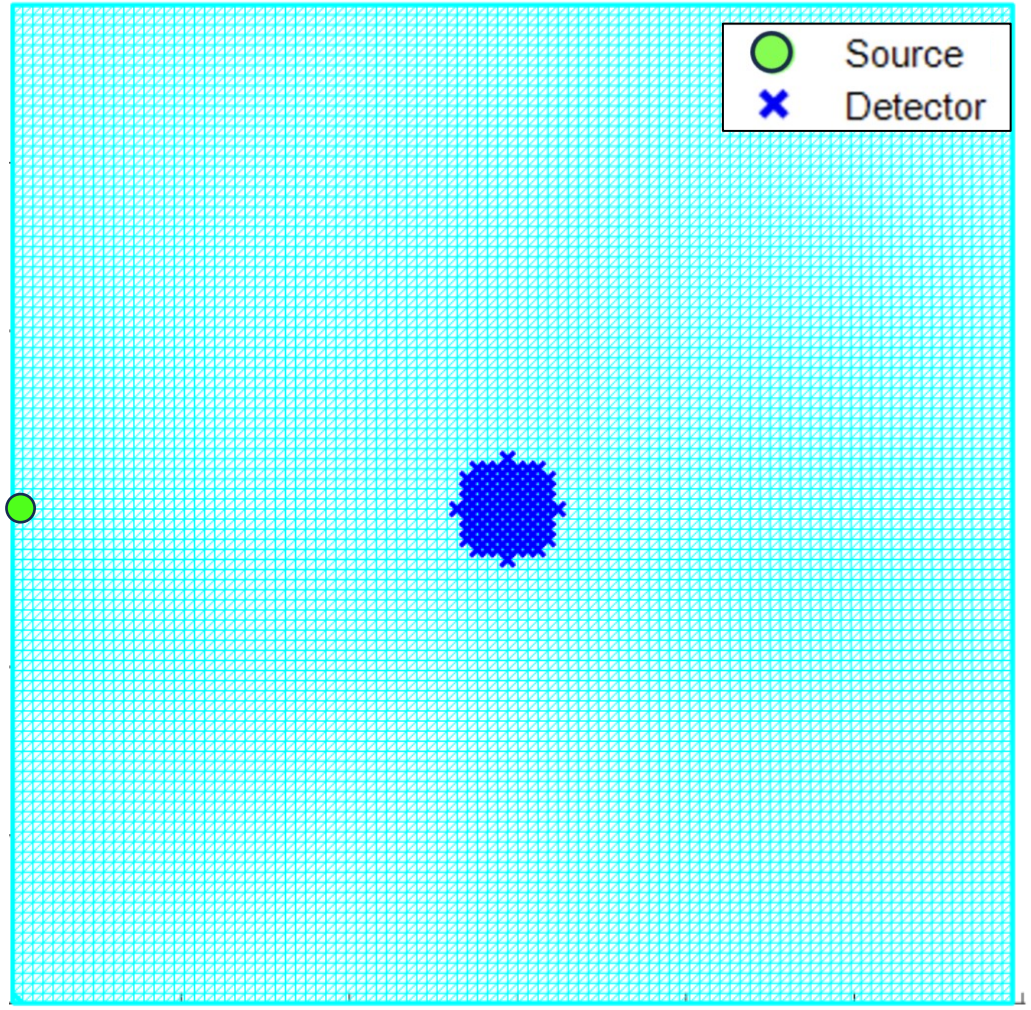
- NIRFAST requires:
  - 1 or more light sources
  - 1 or more light detectors
- Photoacoustics:
  - 1 or more light sources
  - **No light detectors**
- However:
  - Blood as a marker!



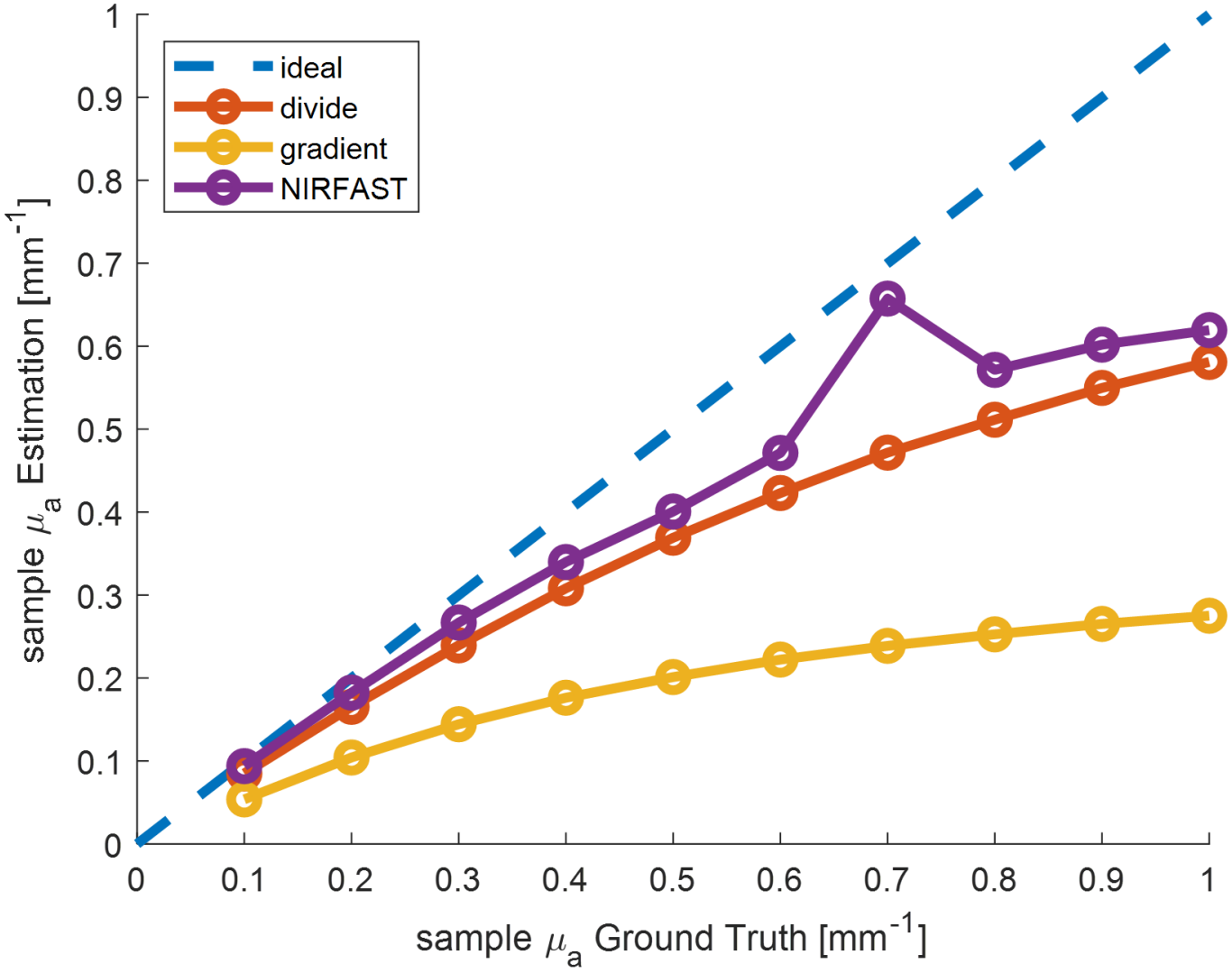
The NIRFAST method

- Jacobian-based reconstruction

- NIRFAST requires:
  - 1 or more light sources
  - 1 or more light detectors
- Photoacoustics:
  - 1 or more light sources
  - **No light detectors**
- However:
  - Blood as a marker!



Comparison of different methods

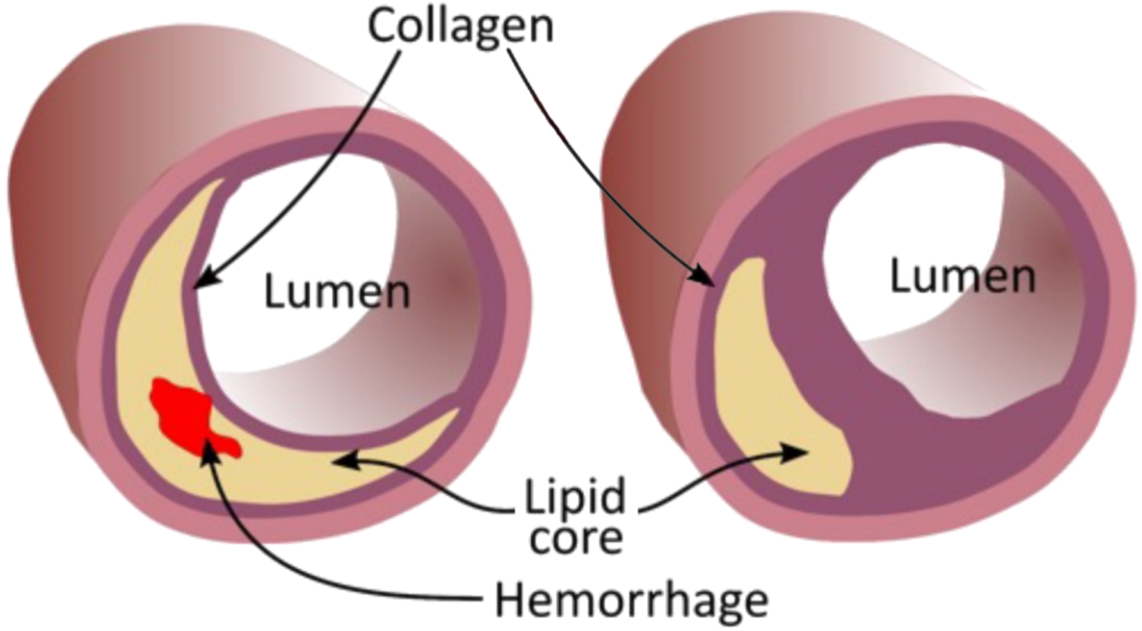


Summary

- Prevent over- and undertreatment by assessing plaque stability

- Quantifiy **stability**?
  - Quantify **composition**
  - Quantify **optical prop.** for multiple wavelengths

- Tested 3 different methods



BMPI
Biomedical Photonic Imaging