

UNIVERSITY OF TWENTE.

Photoacoustic Imaging



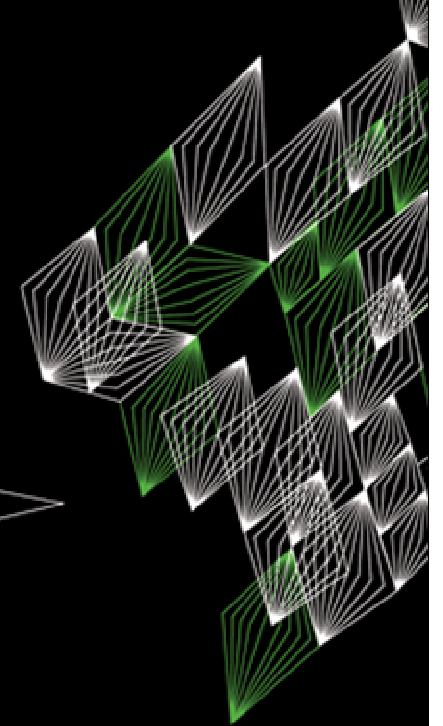
Srirang Manohar, PhD.

Biomedical Photonic Imaging

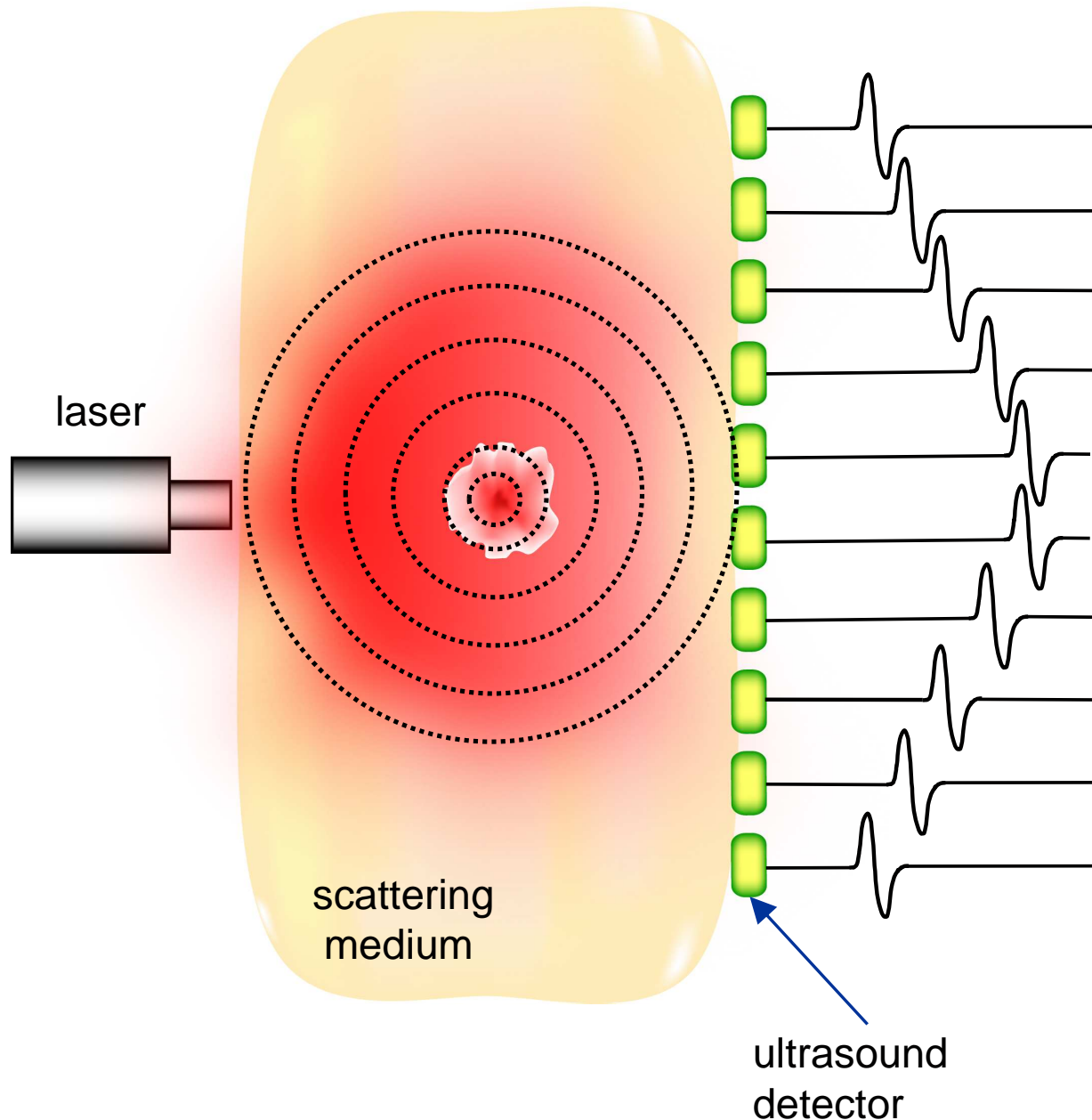
Mira Institute, Faculty of Science and Technology

University of Twente, Enschede

The Netherlands



Photoacoustic Imaging



- Absorption of light
- Temperature rise
- Thermal expansion
- Pressure buildup
- Stress wave

- Initial pressure:

$$P = \Gamma \Phi \mu_a(\lambda)$$

μ_a – Absorption coefficient

Φ – Fluence rate

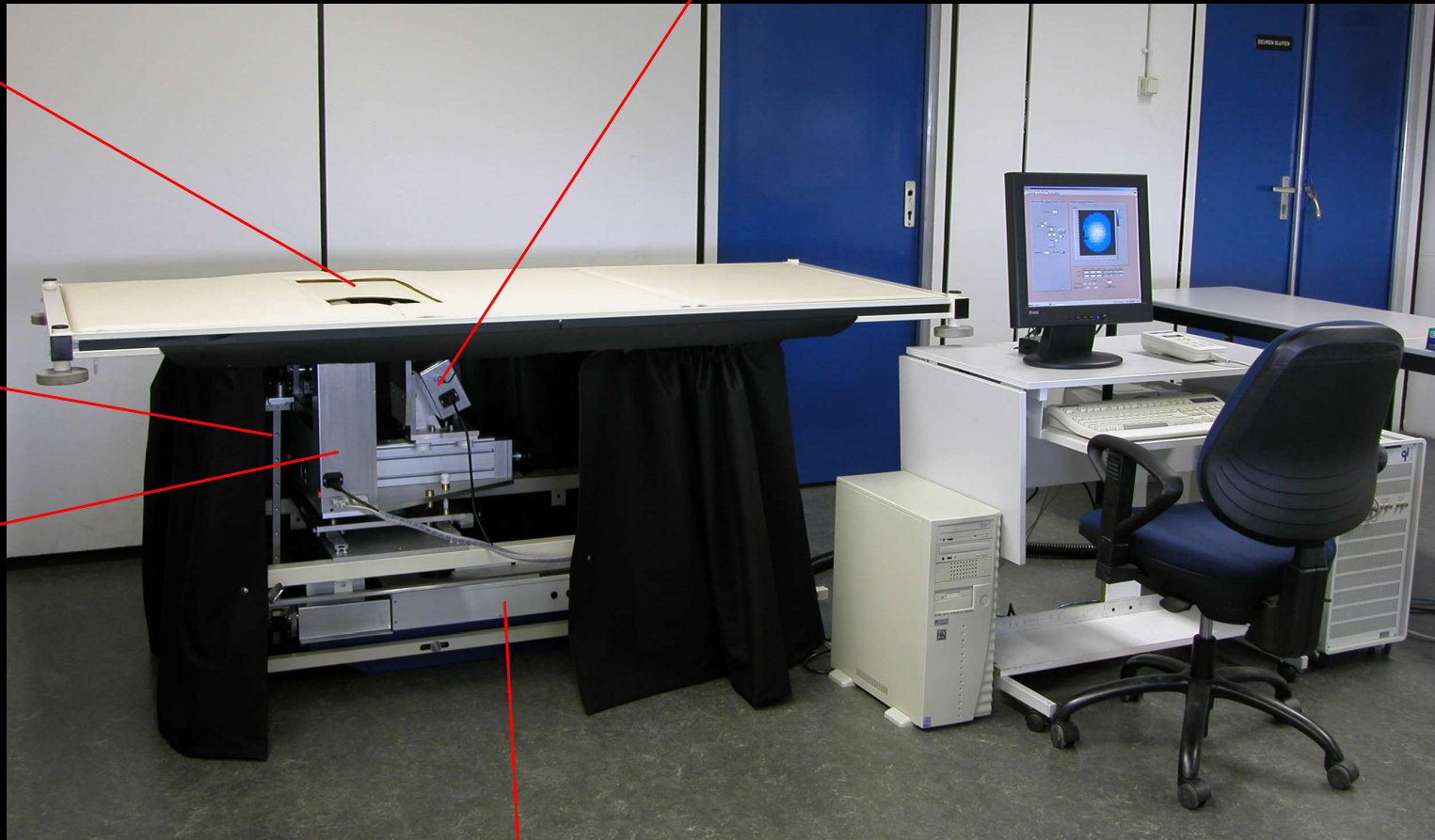
Γ – Grüneisen coefficient

The Twente Photoacoustic Mammoscope (PAM)

aperture to
accommodate
breast

ultrasound detector + electronics

light
delivery
system
+
scanning
system

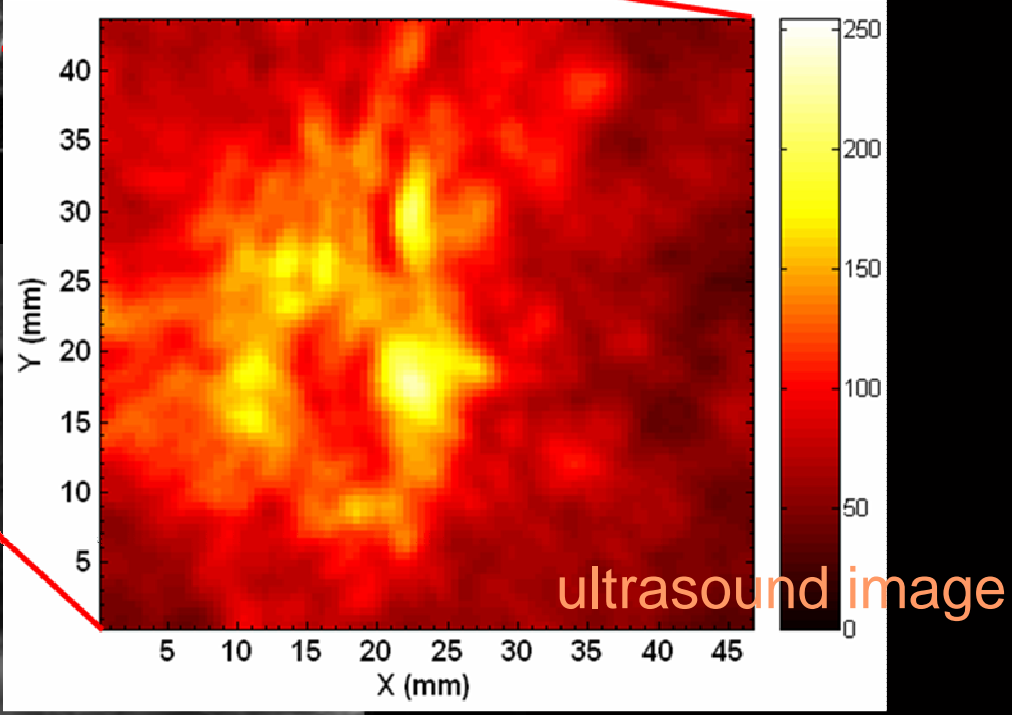
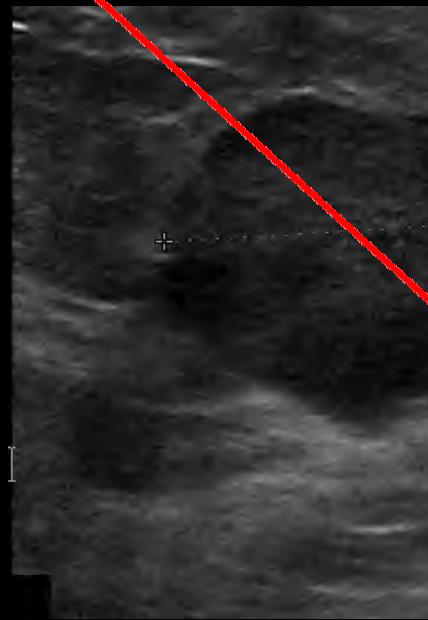
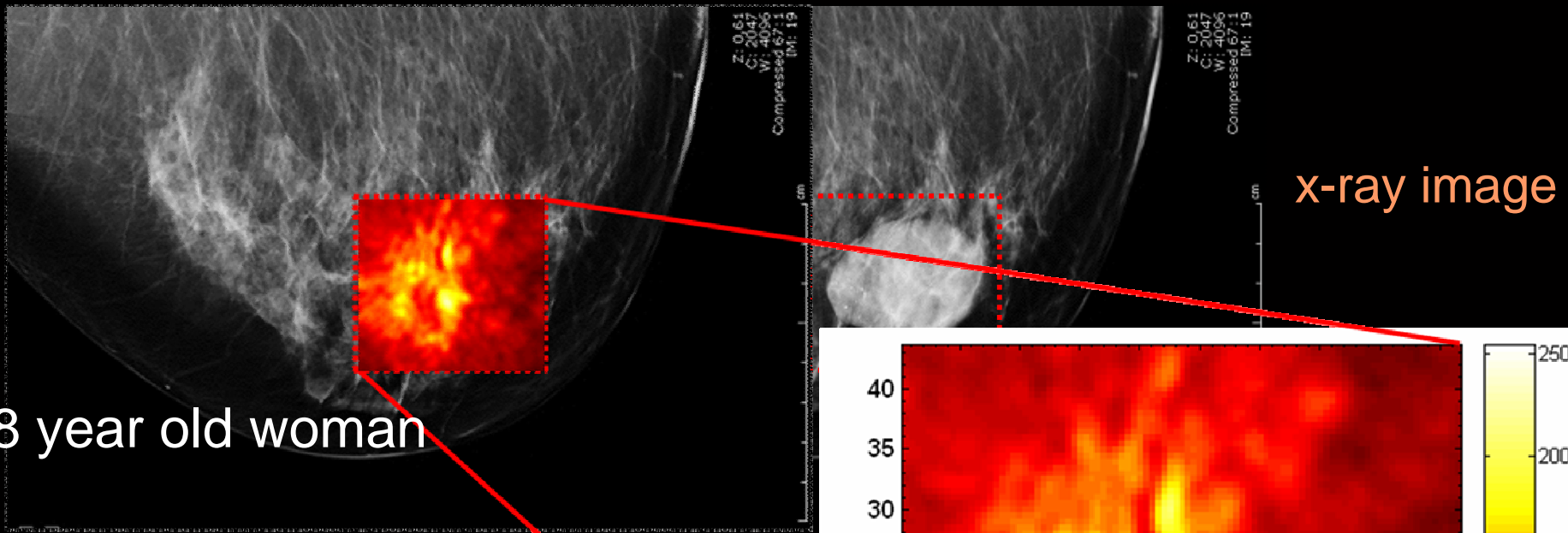


laser

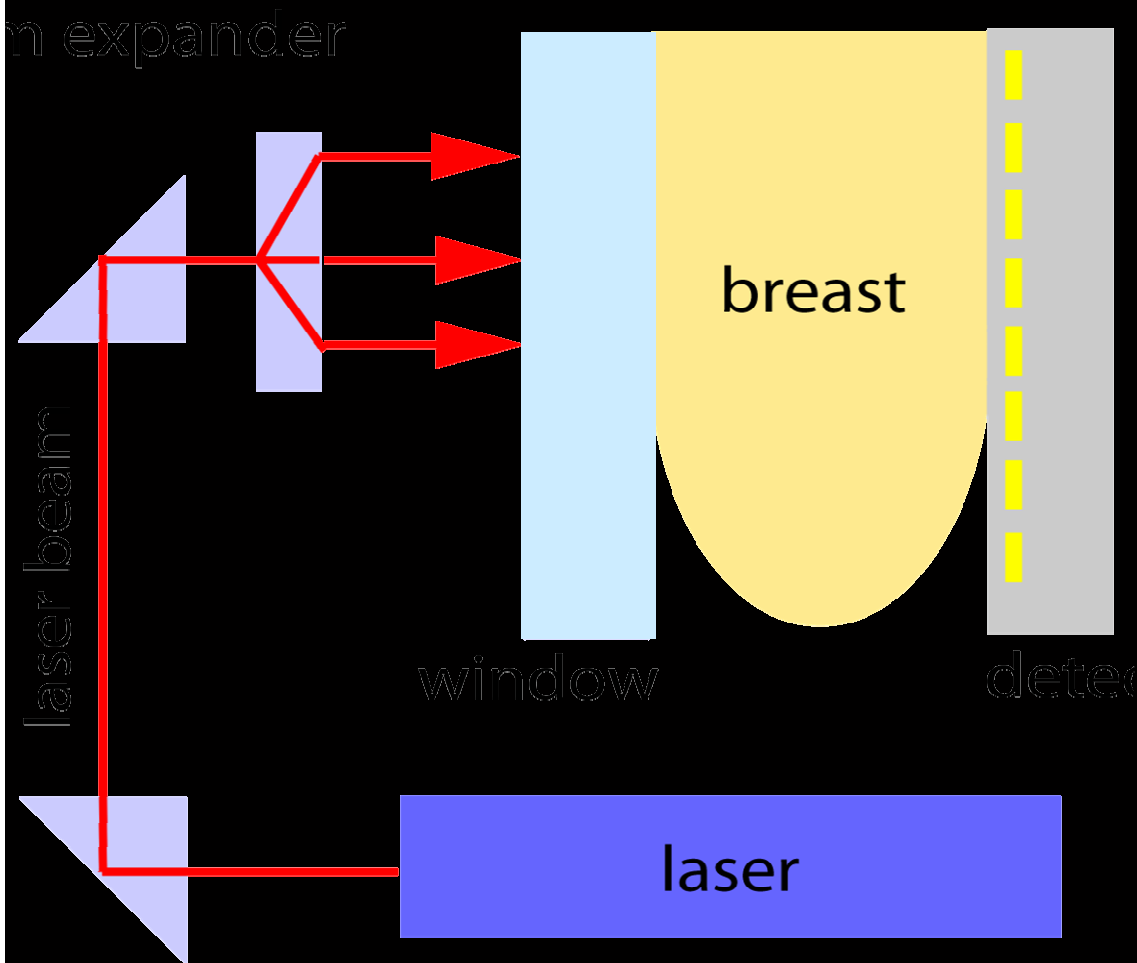
Case 2: Infiltrating ductal carcinoma

58 year old woman

Palpable lump at 11 'o' clock RB

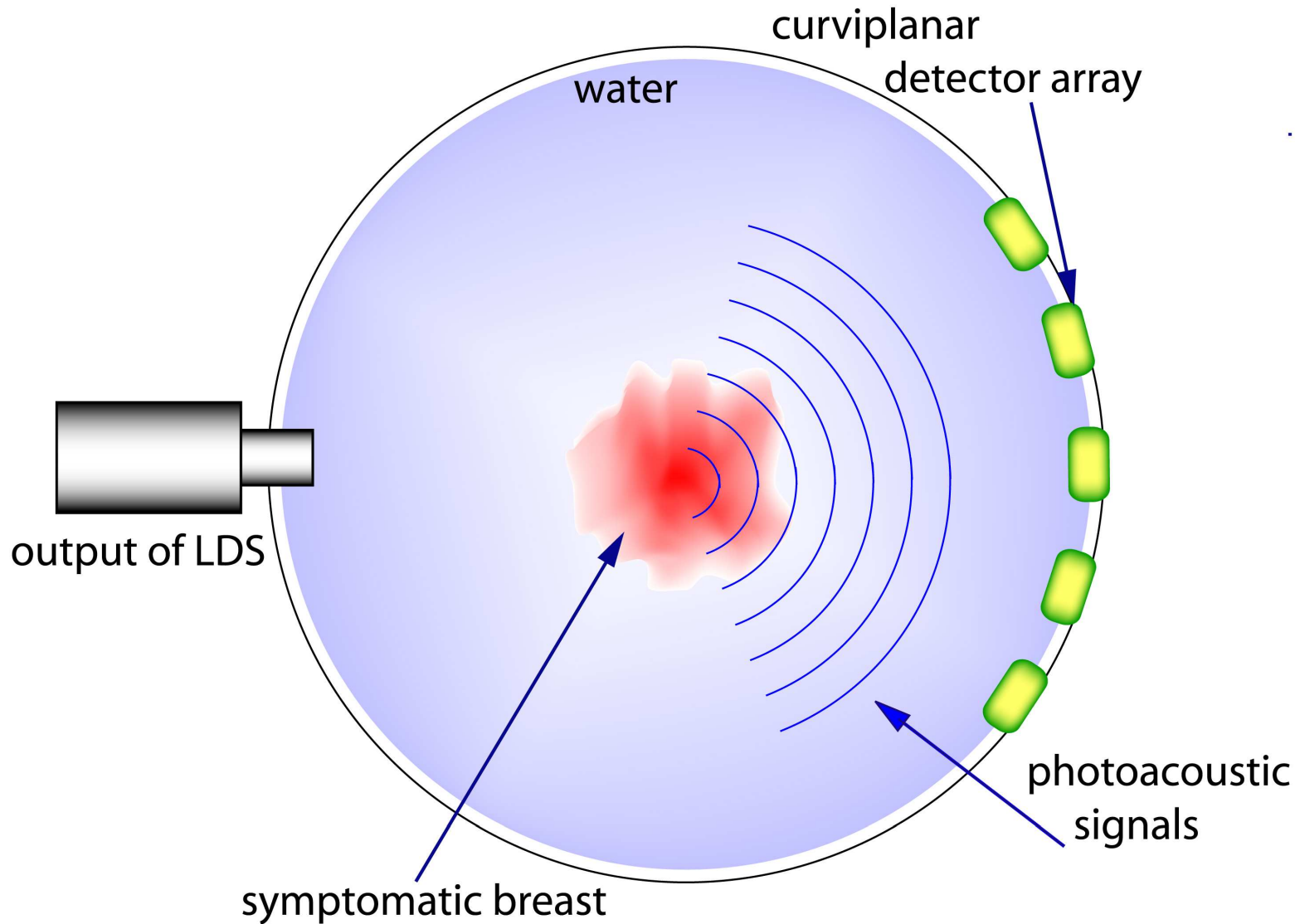


Parallel-plate geometry

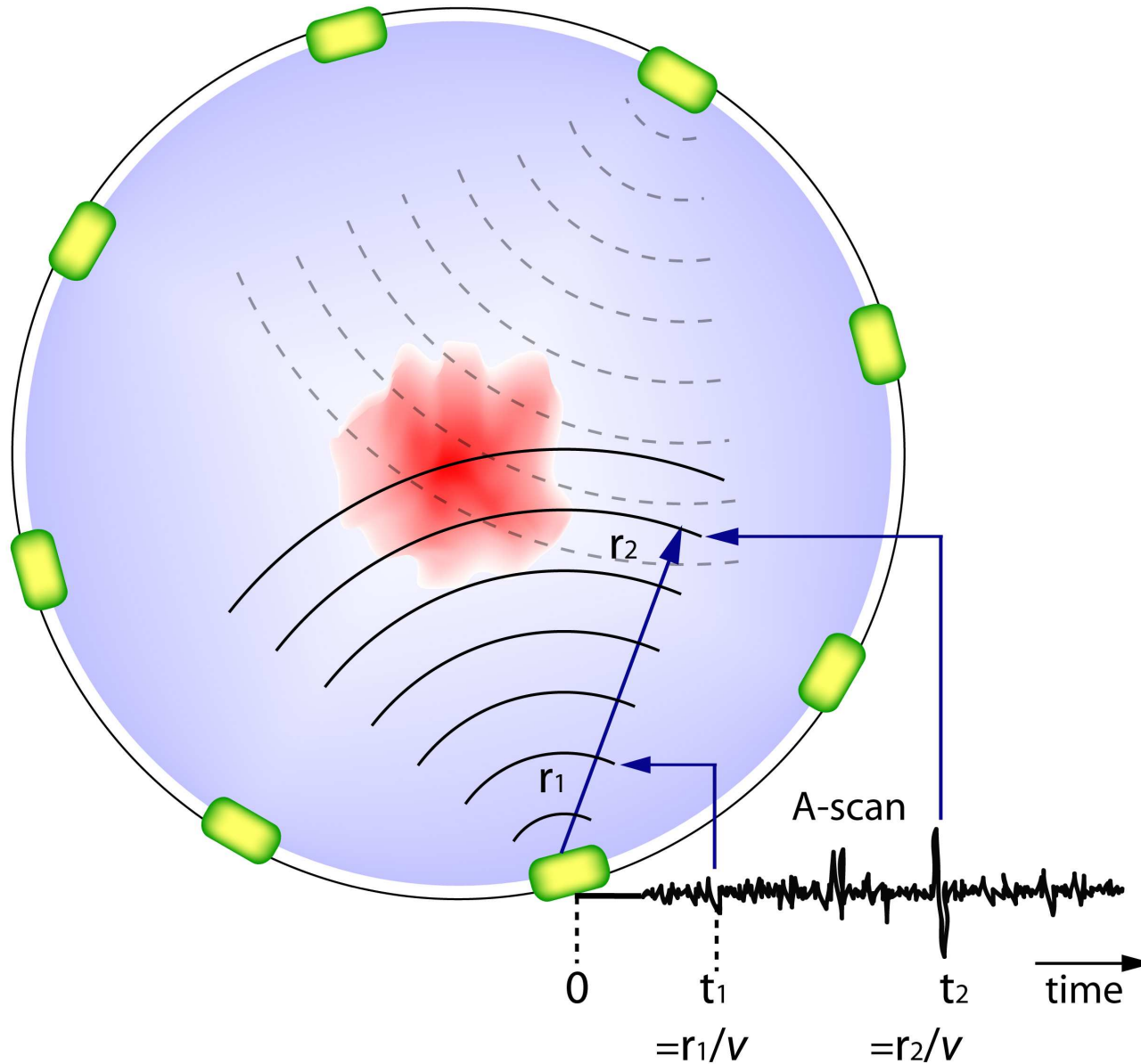


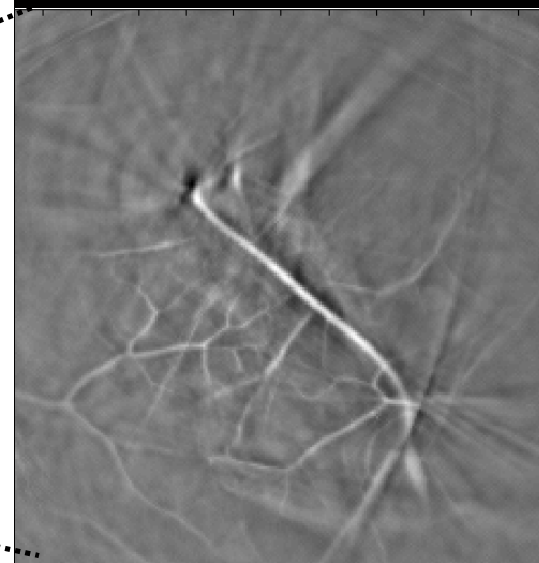
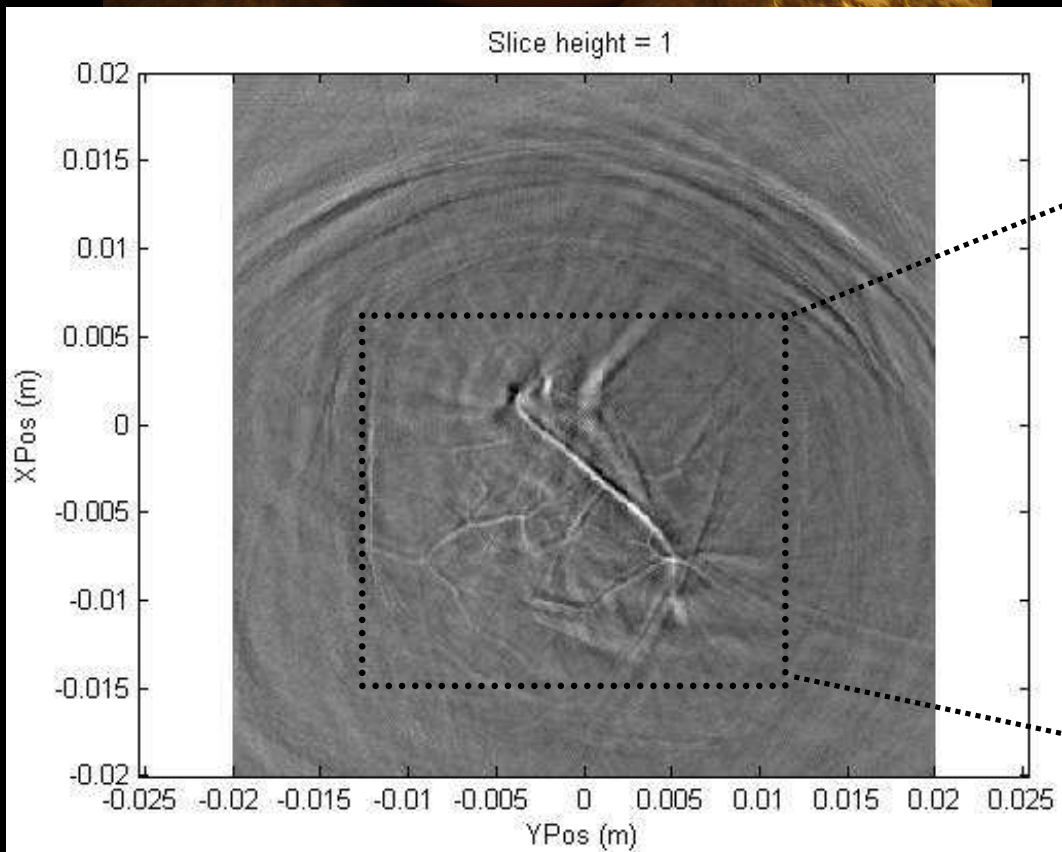
- Single projection
Cranio-caudal
- Light compression but
breast deformed
- Breast not completely flat
in imaging field
- Depth coverage could be
limited
- Finite planar aperture
compromises resolution

Photoacoustic Computed Tomography

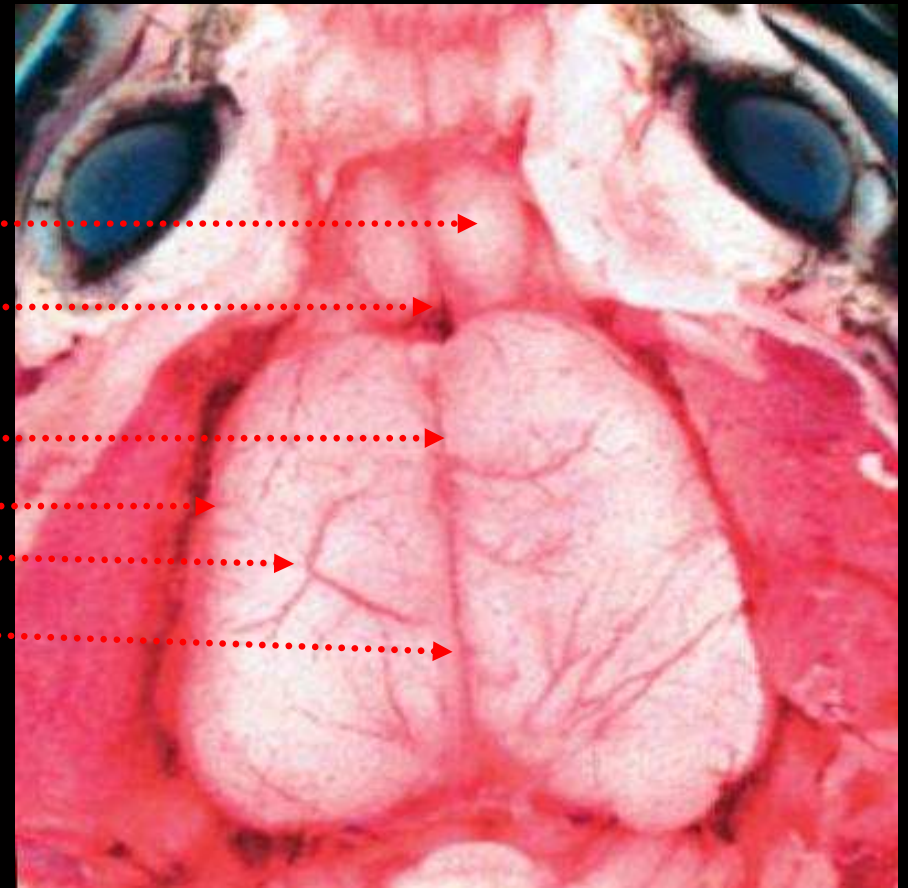
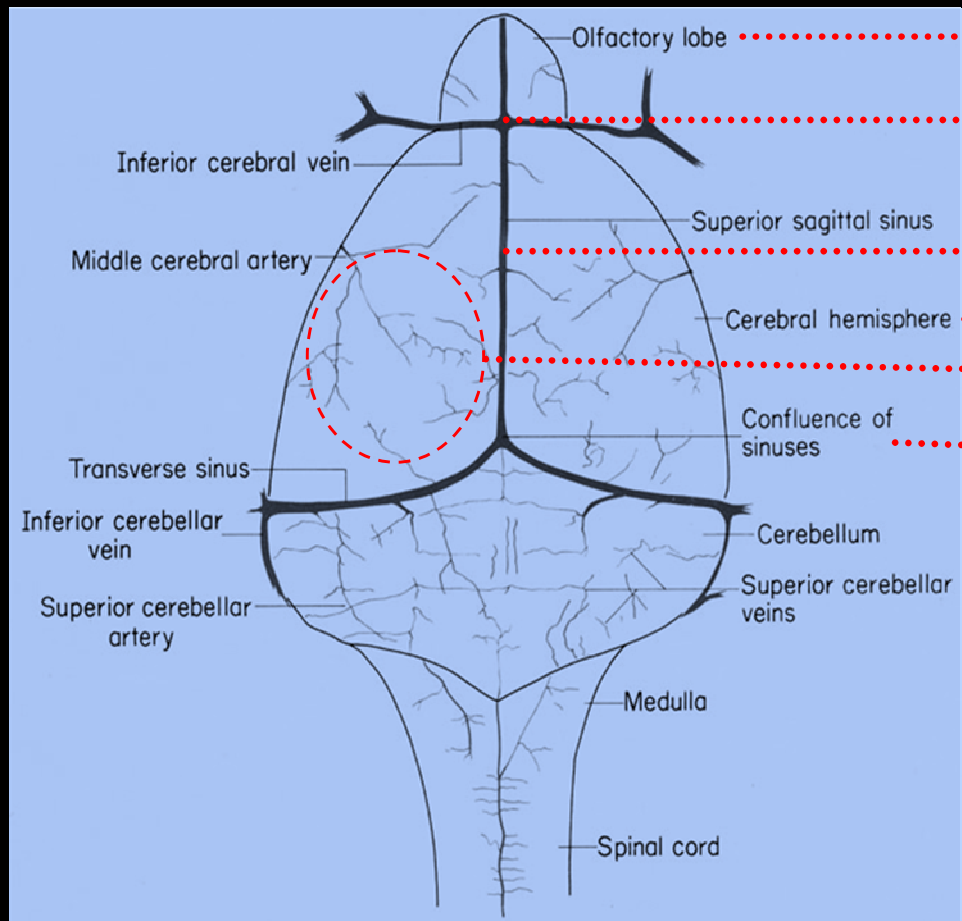


Reconstruction: acoustic backprojection

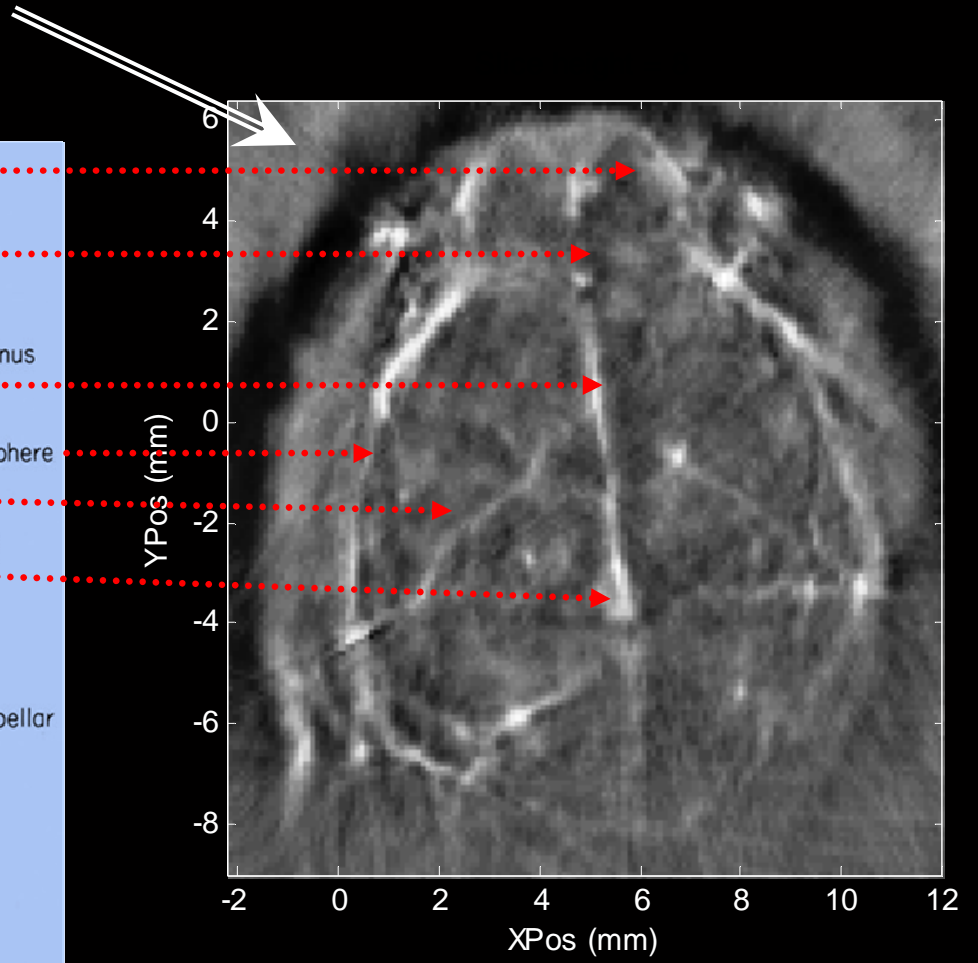
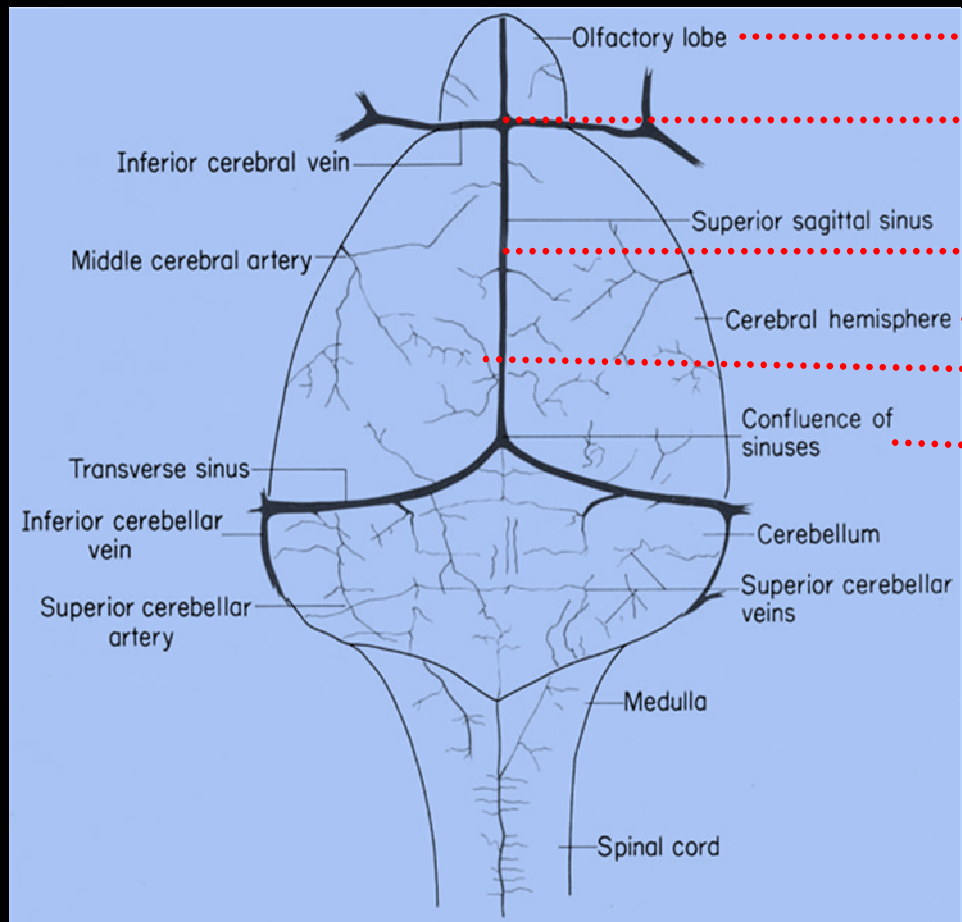
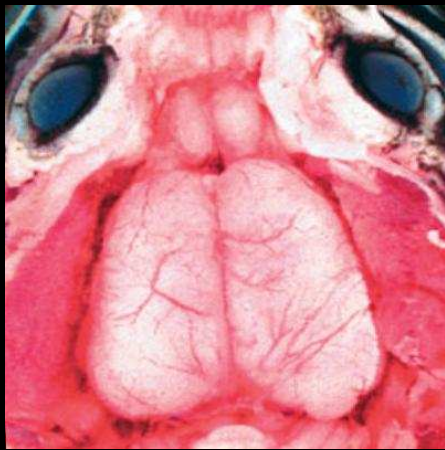




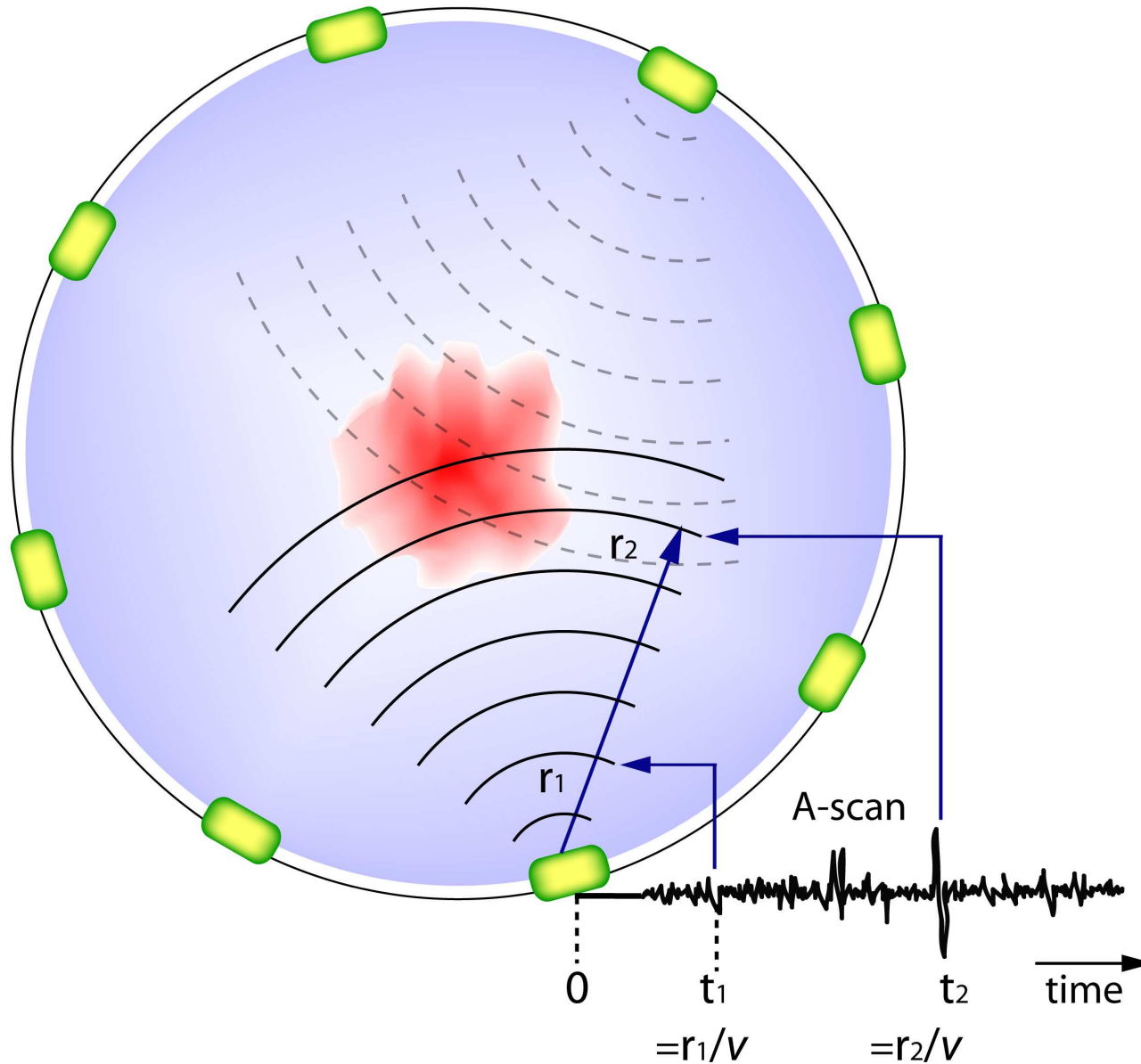
Dead rat-puppy brain vasculature imaging



Photoacoustic measurement



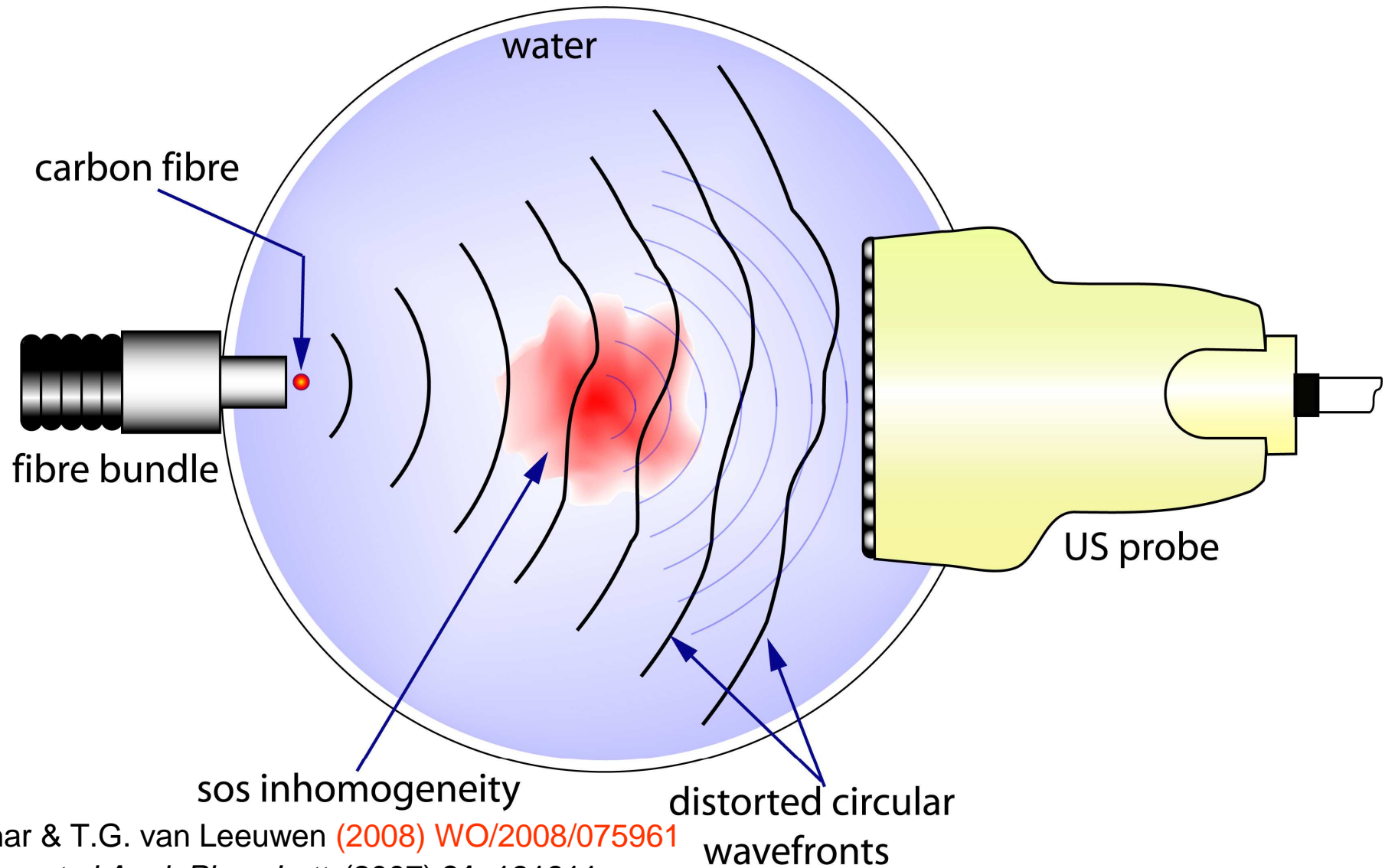
Reconstruction: acoustic backprojection



Limitations of acoustic backprojection

- **Two assumptions** in image reconstruction
 - ◆ Acoustic velocity is known
 - ◆ Tissue is **acoustically homogeneous**
- Choice of incorrect acoustic velocity => **compromised resolution and contrast**

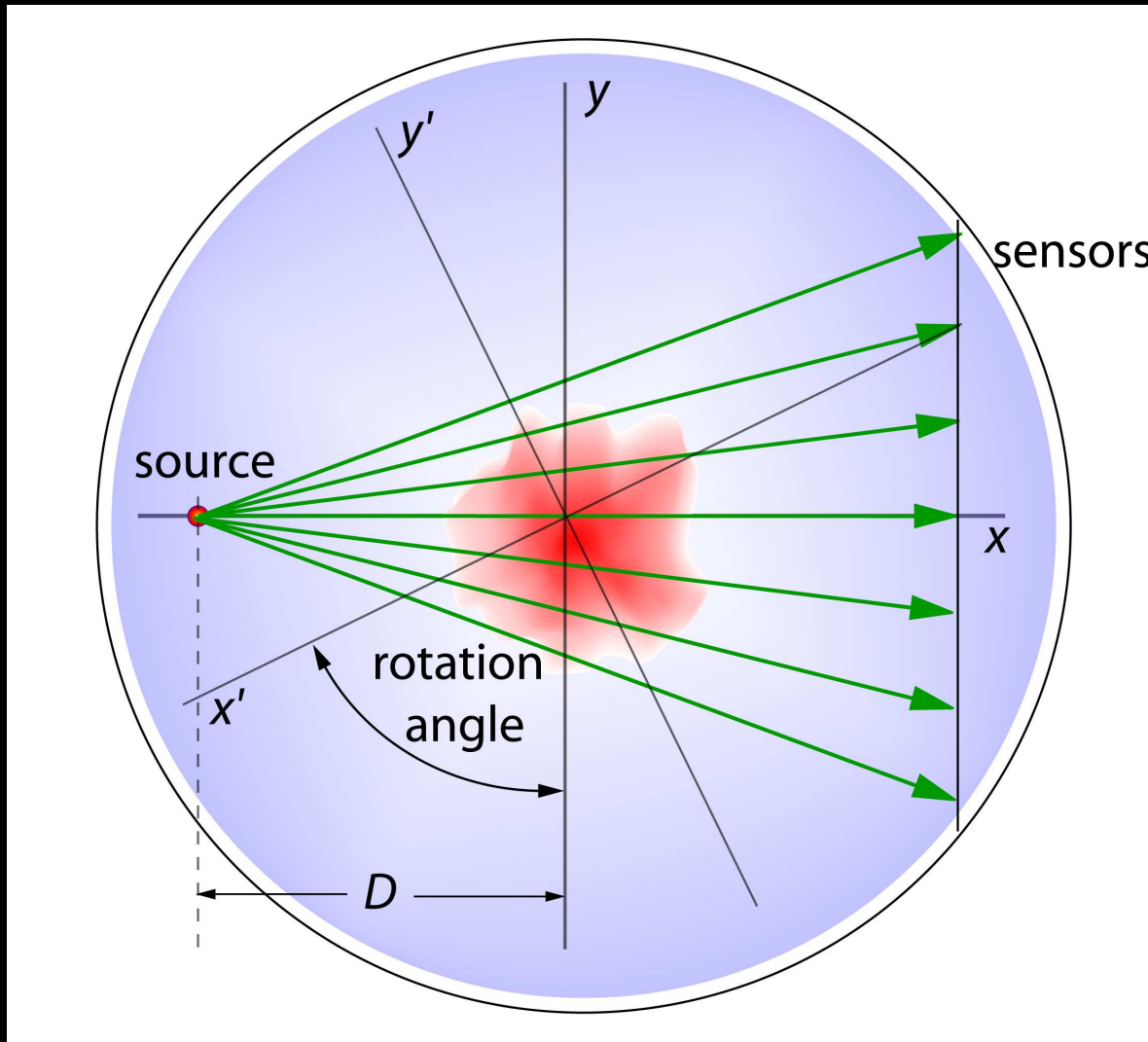
Method for obtaining UST parameter tomograms



S. Manohar & T.G. van Leeuwen (2008) [WO/2008/075961](#)

S. Manohar *et al Appl. Phys. Lett.* (2007) **91**, 131911

Fan beam projection geometry



Normalized TOA
at element n

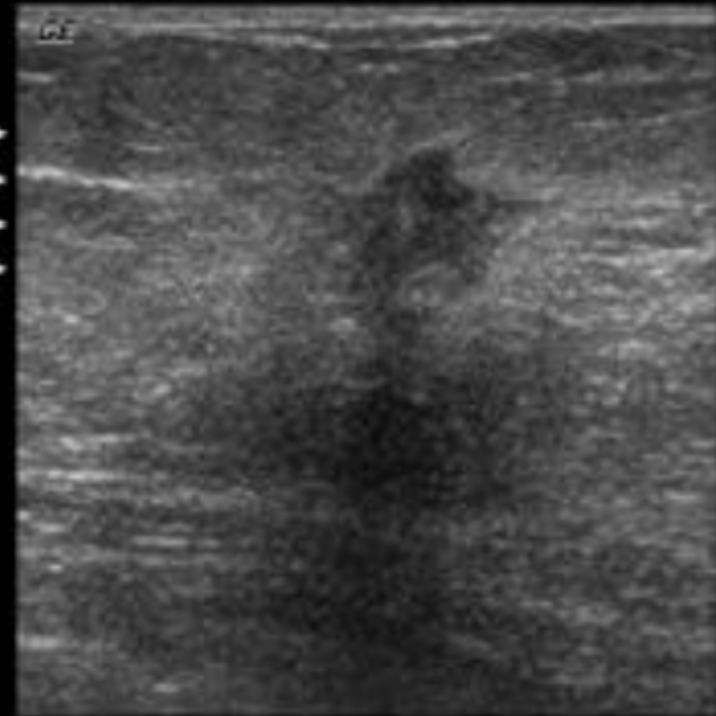
$$t_{\phi}(n) = \int \frac{ds}{v} - \int \frac{ds}{v_w}$$

Clinical significance of SOS and acoustic attenuation

- Speed-of-sound depends on **bulk modulus and density**

$$c = \sqrt{\frac{K}{\rho}}$$

- Acoustic attenuation also **related to tissue density**

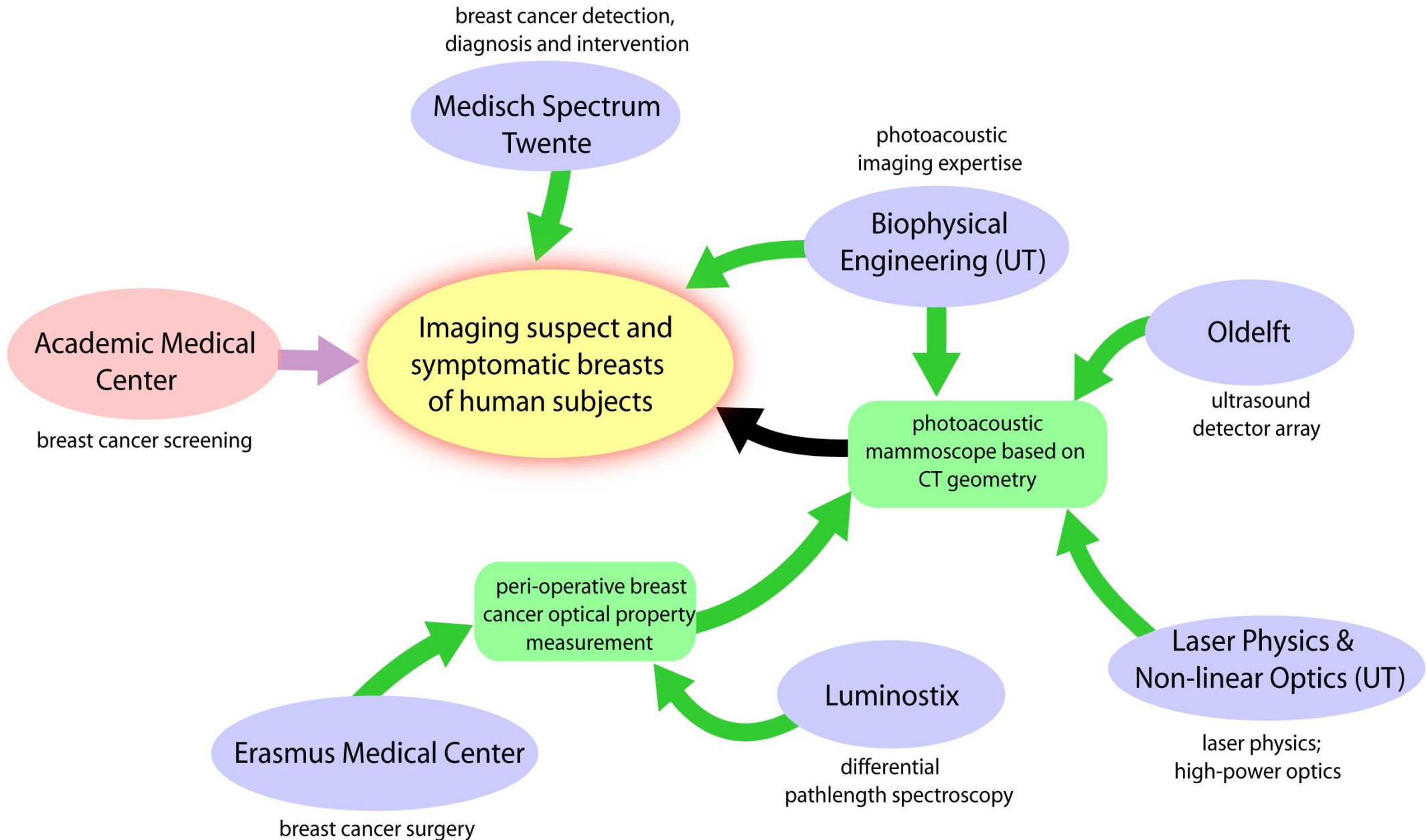


TIS<0.4 MI=0.3 RO=100%



Hypoechoic mass with an irregular border and posterior acoustic shadowing

HYMPACT: Hybrid Mammography using Photoacoustic Computed Tomography



Areas for collaboration

- Ultrasound detector characteristics
- Choice of illumination wavelength
- Imaging geometry
- Quantification of optical absorption
 - ◆ Correction for **acoustic inhomogeneities**
- Insufficient patient data

Contributions



Universiteit Twente
de ondernemende universiteit

Biomedical Photonic Imaging Group

- Wiendelt Steenbergen (Head)
- Prof. Ton van Leeuwen (AMC)
- Sanne Vaartjes
- Jithin Jose
- Steffen Resink
- **Wengfeng Xia**
- **Daniele Piras**
- **Michelle Heijblom**
- **Rajagopal Rayavarapu**
- **Constantin Ungureanu**
- Johan van Hespén



Medisch Spectrum Δ Twente

Medisch Spectrum Twente

- Joost Klaase
- Frank van den Engh

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- ◆ IOP-Photonic device project PRESMITT- Senternovem

