Laser OptoAcoustic Tomography: Towards New Technology for Biomedical Diagnostics

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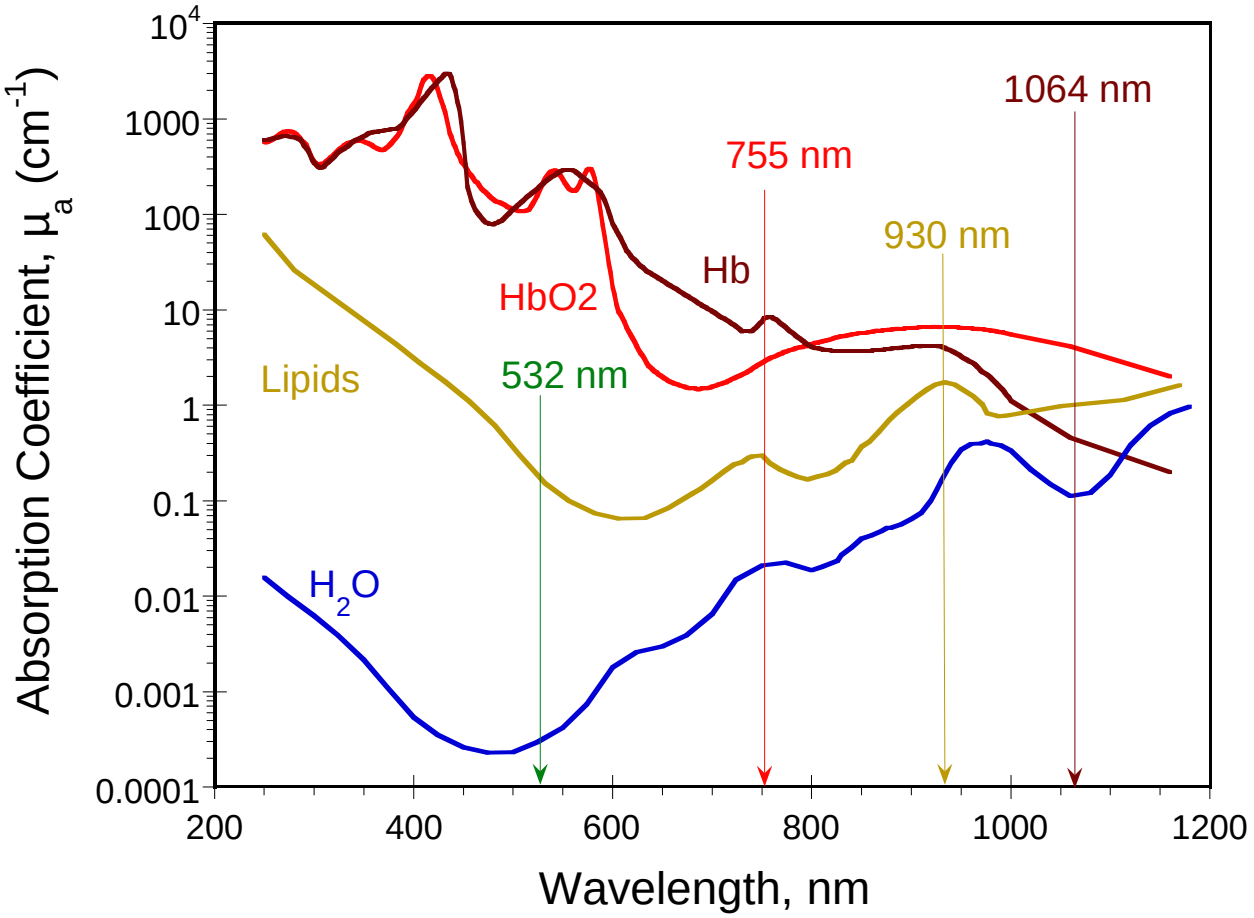
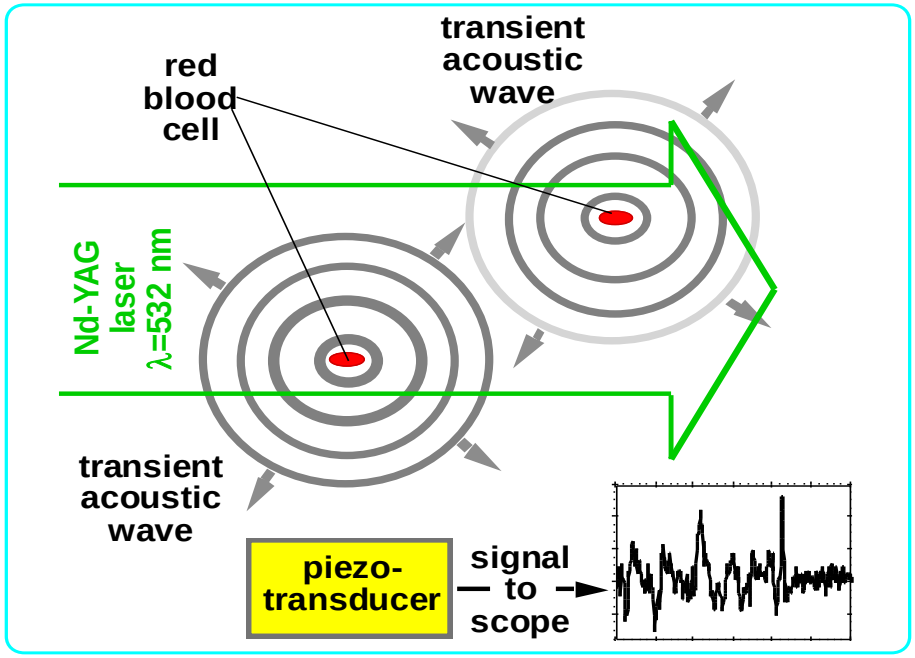
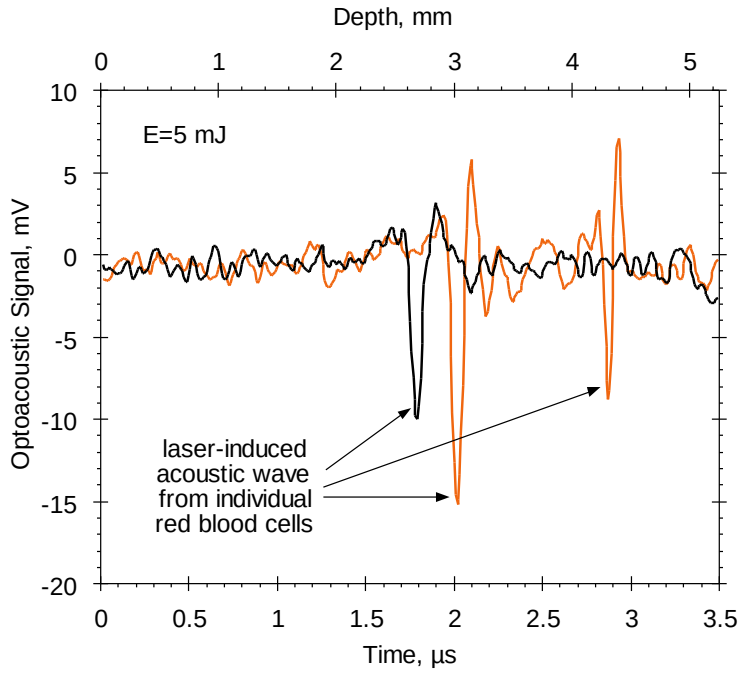
TomoWave Laboratories Inc.

Optimization of Laser Wavelength optical absorption contrast vs penetration depth in tissue



Optoacoustic Detection of Erythrocytes

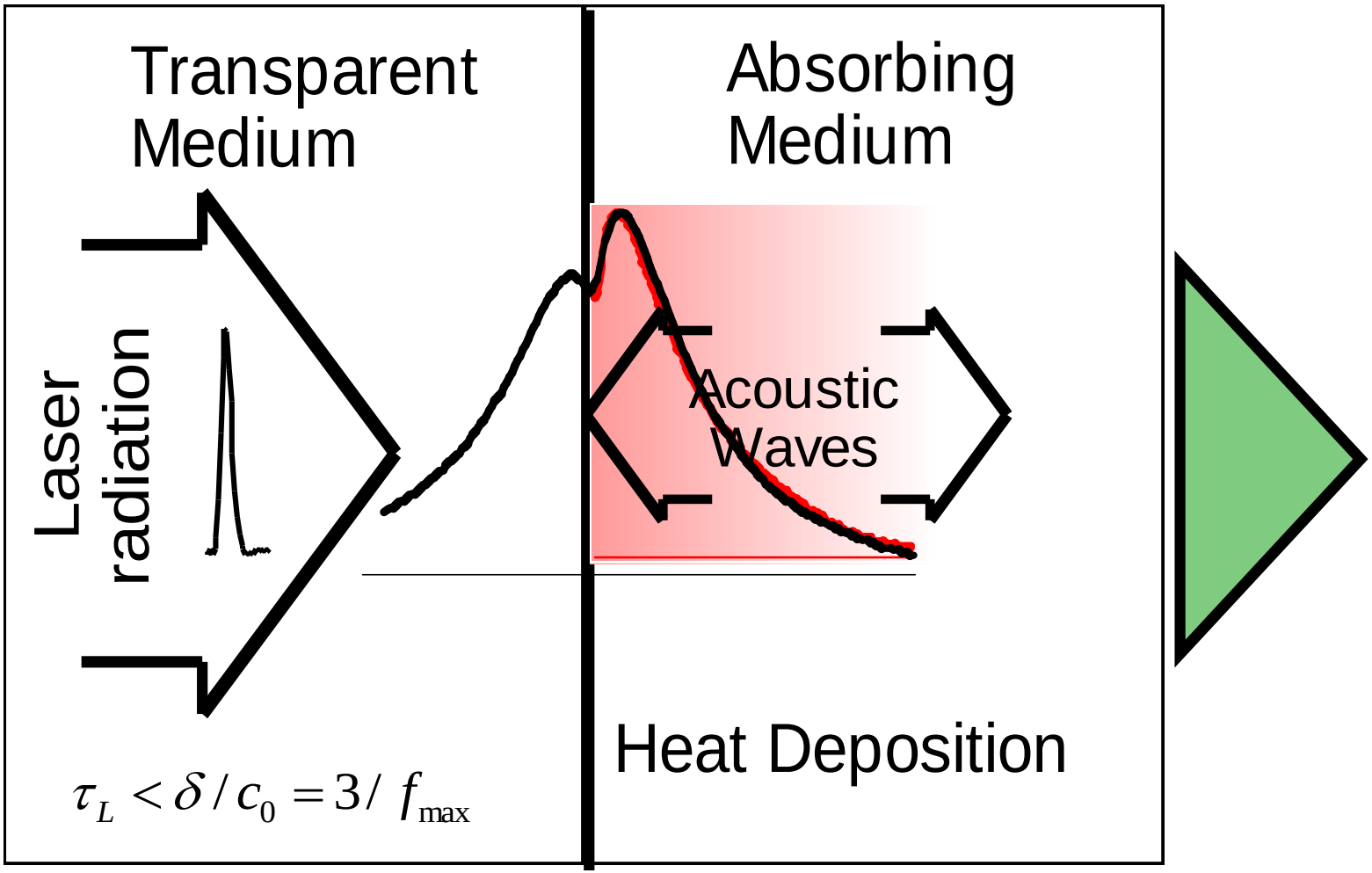




Demonstration of a single blood cell detection in tissue like phantom

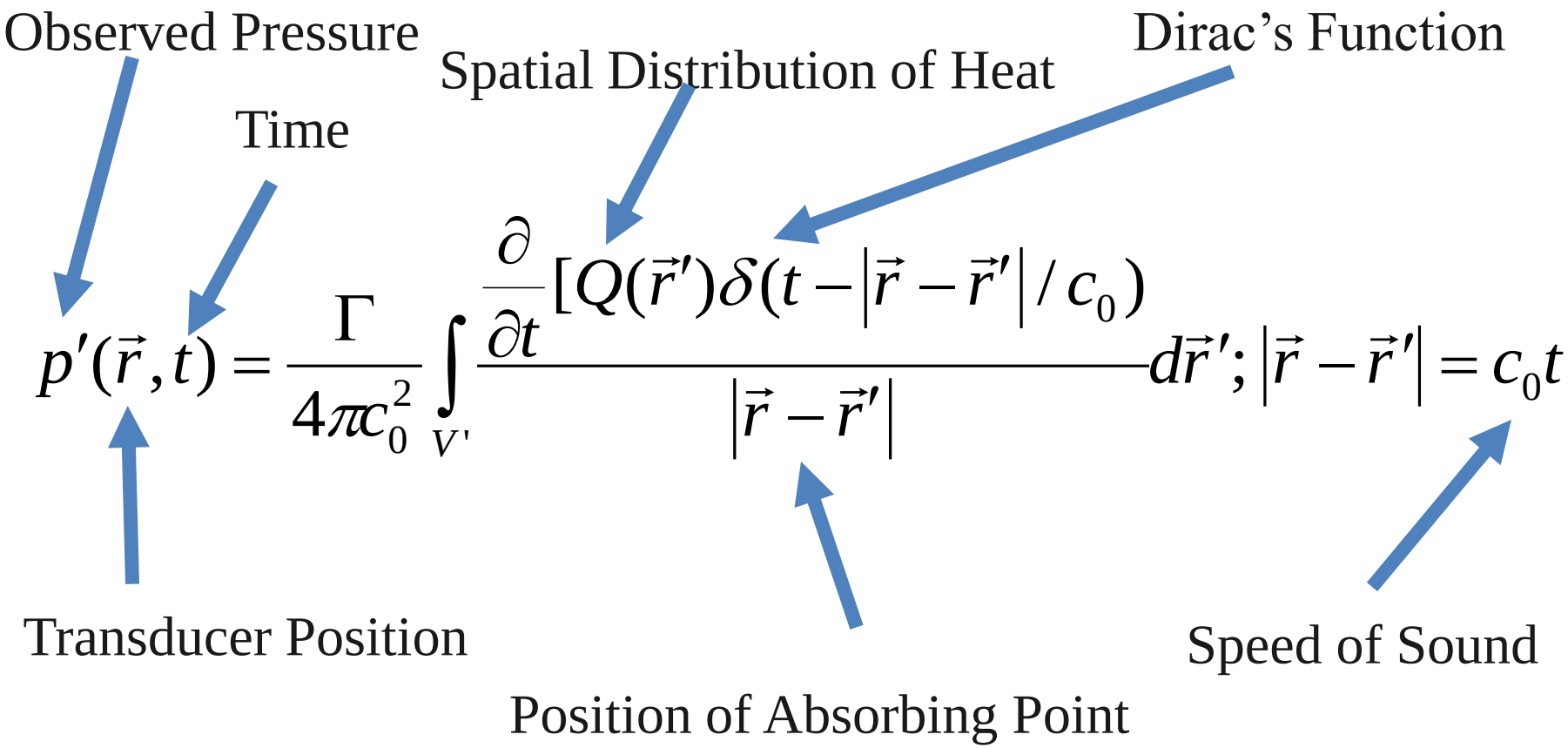
A.A. Oraevsky, E.V. Savateeva, Karabutov, V.G. Andreev et al: "Optoacoustic imaging of blood for visualization and diagnostics of breast cancer", *Proc. SPIE* 2002; **4619**: 81-94.

Basic Principle: OptoAcoustic Profile Replicates Distribution of Absorbed Optical Energy

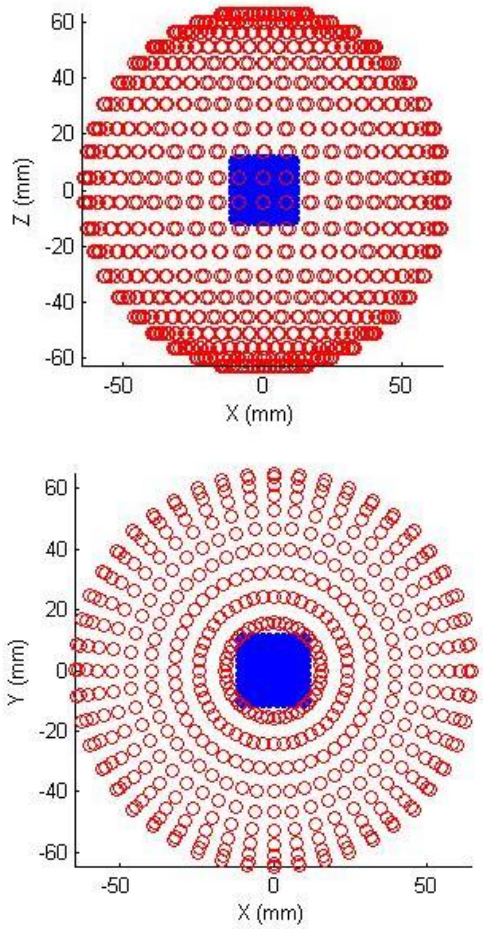


A.A. Oraevsky, F.K. Tittel, S.L. Jacques: Determination of tissue optical properties by time-resolved detection of laser-induced stress waves. *Proc.SPIE, Jan.*1993; **1882**: 86-101.

Fundamental Opto-Acoustic Equation



3D Spherical Reconstruction

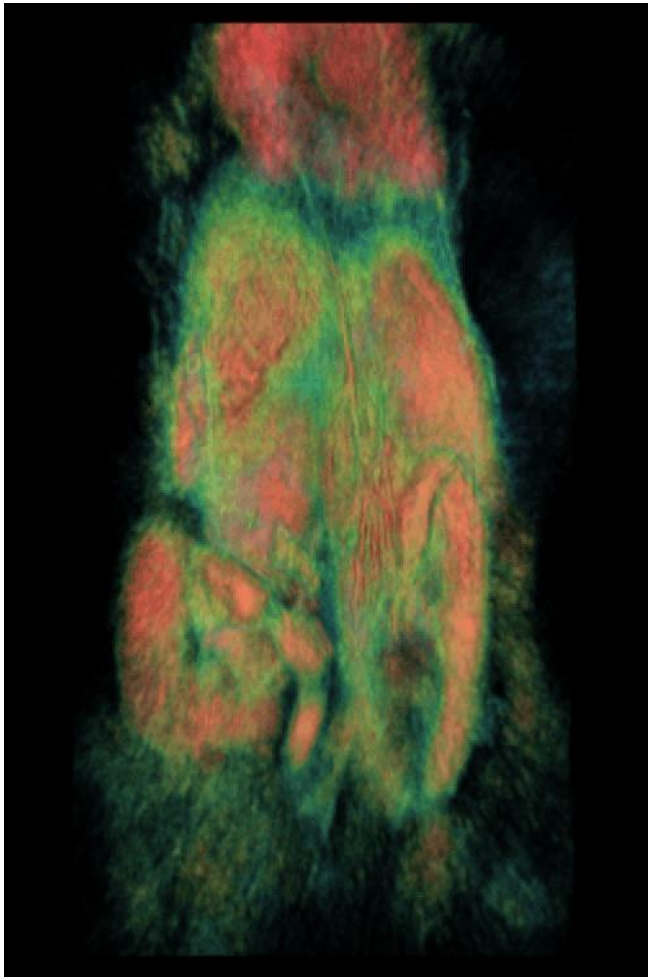


- Signal processing to include system transfer function
- 3D FRBP reconstruction
- Weighing for higher density of transducers at poles

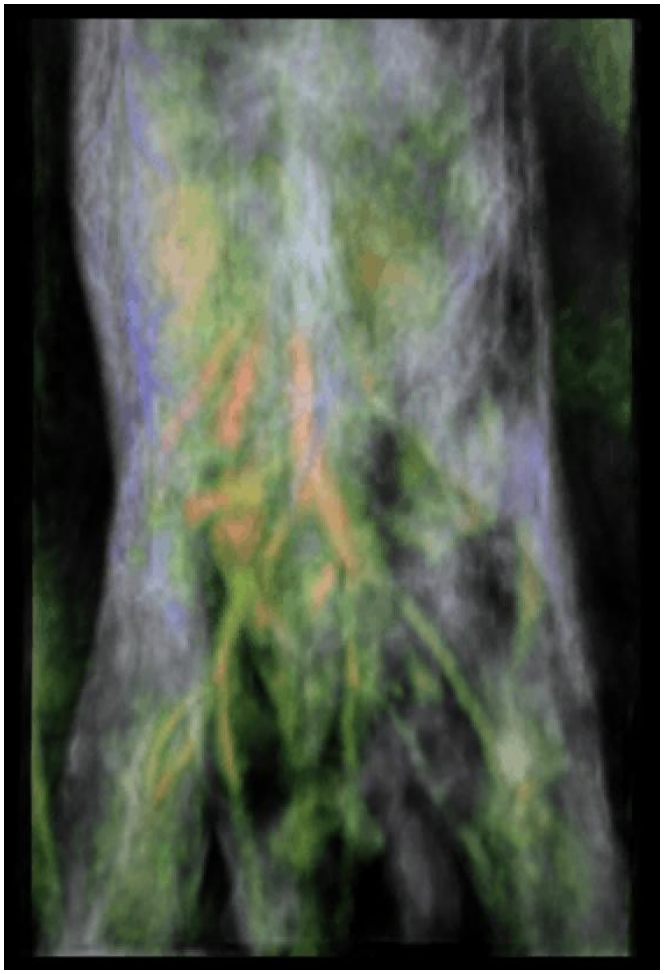
$$\overline{S}_i = \frac{2\ \pi\ r \cos\beta}{N_{Tr}} S_i$$

- 64 elements @ 150, 2.4° steps = 9600 elements
- Image processing that preserves quantitative information

PreClinical Molecular Imaging of Hb

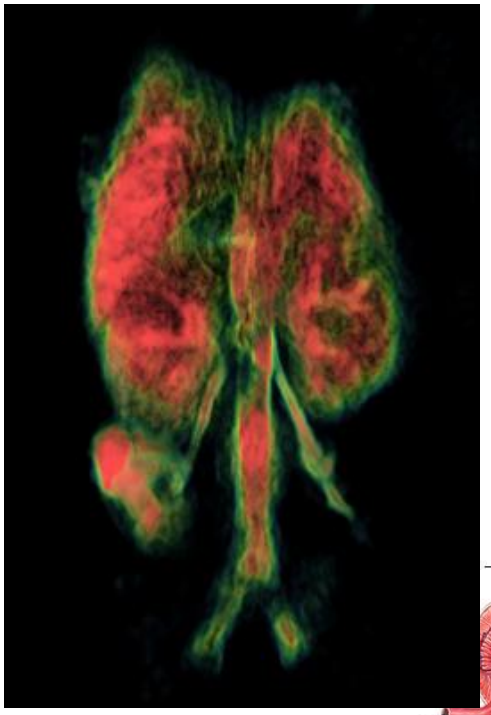


Organs and Vessels

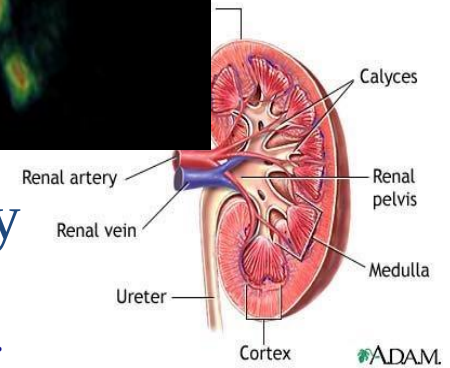


Mouse Skin and Internal Tissues

Details of Internal Organs and Vasculature

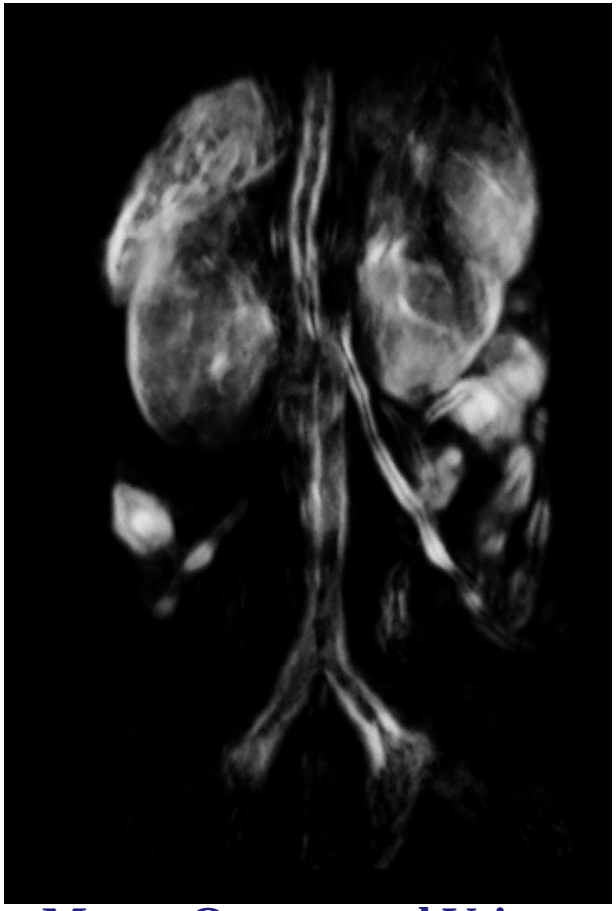


Kidney



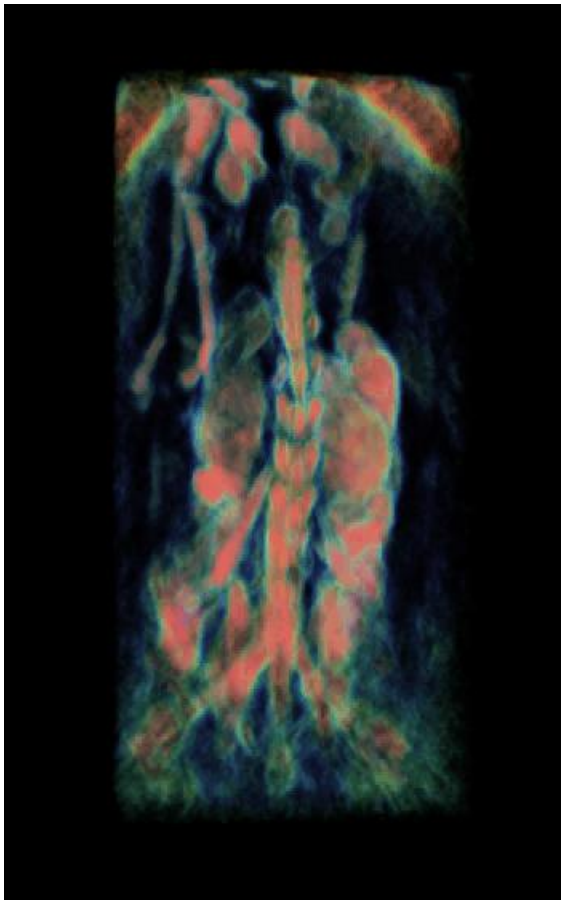
H.-P. Brecht, R. Su, M. Fronheiser, S. Ermilov, A. Conjusteau, A. Oraevsky et al: Optoacoustic 3D whole-body tomography: experiments in nude mice, *Proc.SPIE* 2009; 7177: 71770E.

Lower Frequencies – Larger Organs, Higher Frequencies - Microvasculature



Mouse Organs and Veins

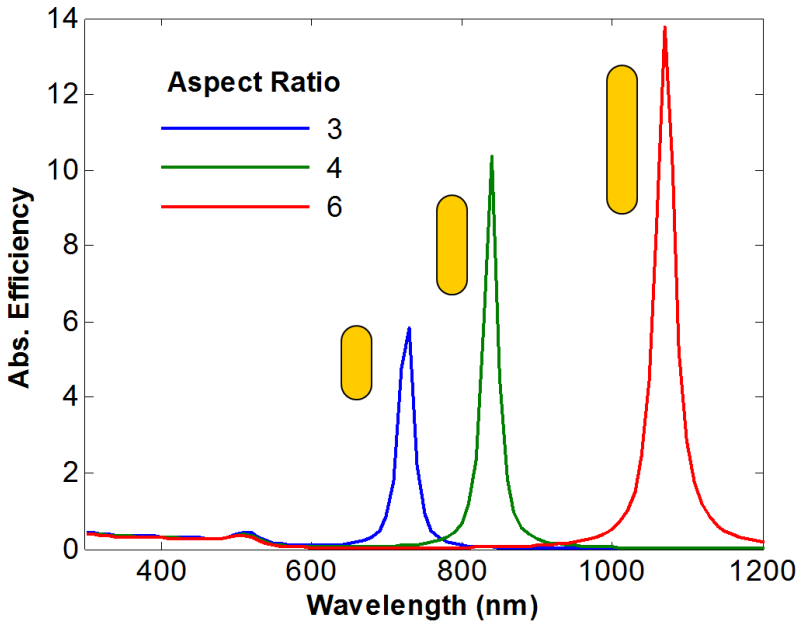
Mouse Circulation

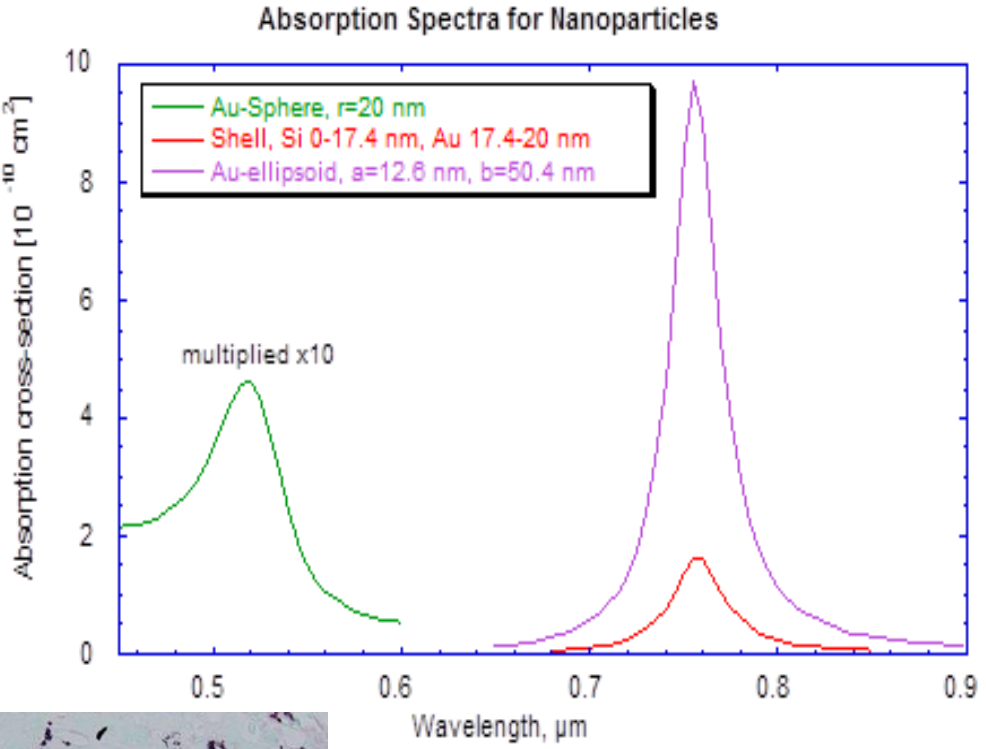


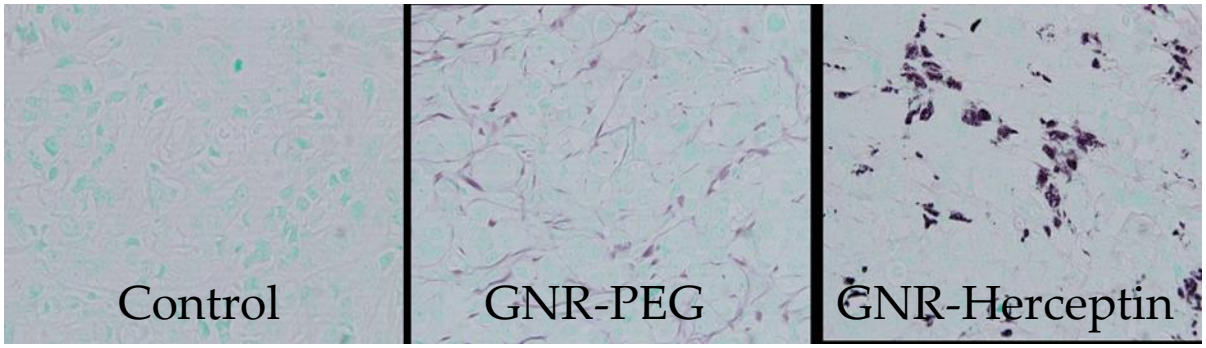
Mouse Spine

H.-P. Brecht, R. Su, M. Fronheiser, S. A. Ermilov, A. Conjusteau, and A. A. Oraevsky: Whole body three-dimensional optoacoustic tomography system for small animals, *Journal Biomedical Optics* 2009; **14**(6), 0129061.

Gold NanoRods (GNR) OptoAcoustic Contrast Agent



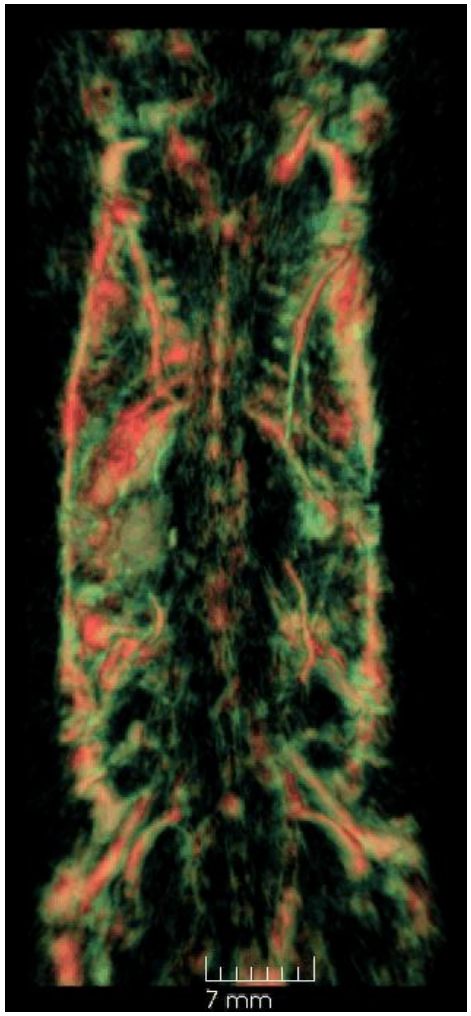


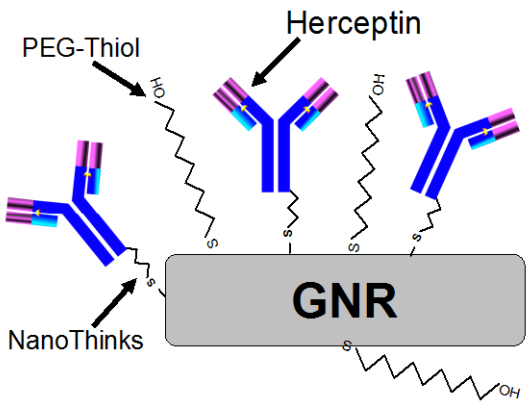


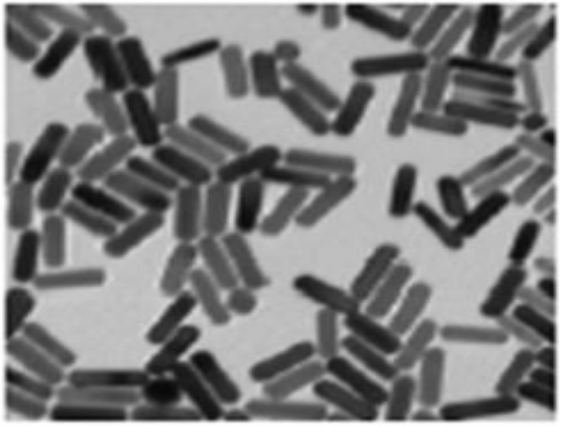
Targeting GNR to cancer cells

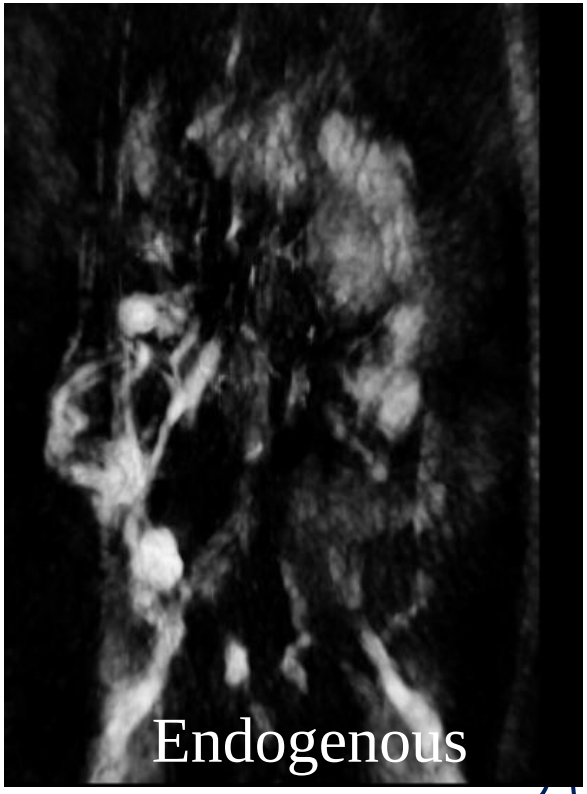
Whole body 3D OptoAcoustic Tomography of Mice

Mouse Rib Cage
Spine and Bones

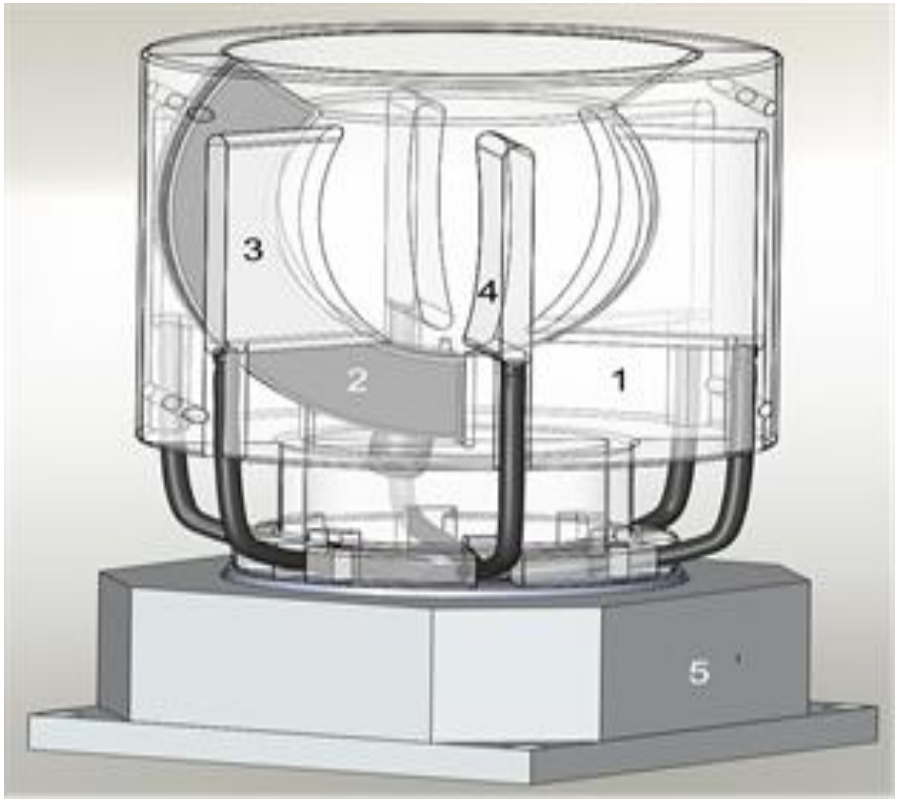


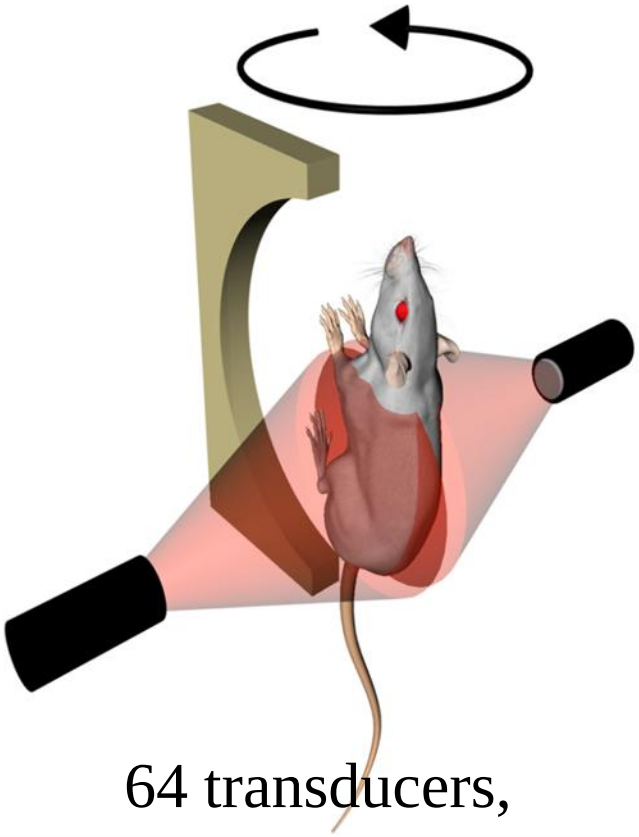






LOIS-3D





64 transducers,
9600 virtual transducers on sphere
Min Imaging Time: 90 sec + 20 sec

Horizons: Applications of 3D OAT

- **From preclinical research to clinical applications**

- **Quantitative Functional Imaging**
  - Measurement of [Hb] and [HbO] (hematocrit) in tissues and blood vessels, assessment of heart function and blood flow.
  - Assessment of tumor angiogenesis, Angiography, Detection and characterization of stroke and traumatic injury of the brain

- **Quantitative Molecular Imaging**
  - Measurement of distributions of protein-receptors in cells
  - Visualization of gene expression and enzymatic activity

- **Real-Time 3D Tomography (4D)**
  - Kinetics of biological/physiological processes
  - Kinetics of drug distribution in the body

Acknowledgement

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