

Electrical Impedance Tomography

EIT and animals: from subject to patient

Conf. EIT 2024, Hangzhou, China

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Biomedical Applications of Electrical Impedance

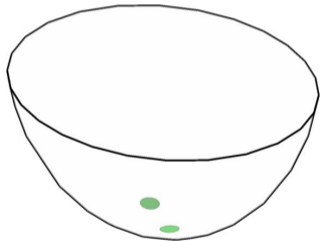
Biomedical Applications of Electrical Impedance

[1]



¹Fisher-Price Cheer for Me! Potty, toddler toilet training seat with music and sounds

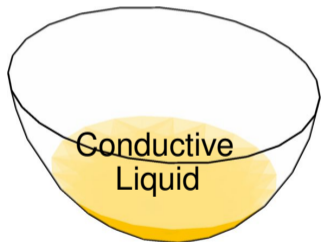
Biomedical Applications of Electrical Impedance



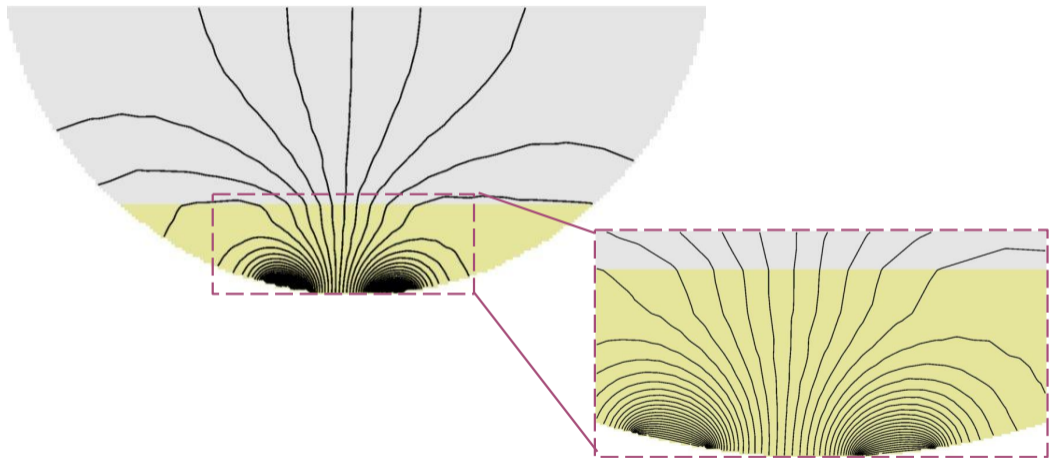
Biomedical Applications of Electrical Impedance



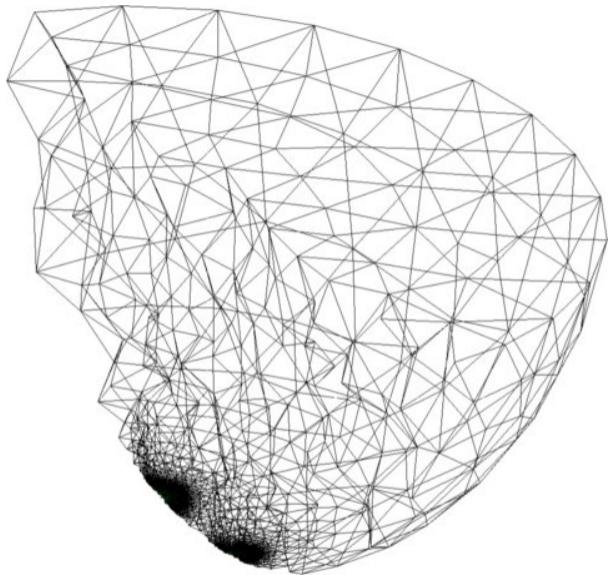
Biomedical Applications of Electrical Impedance



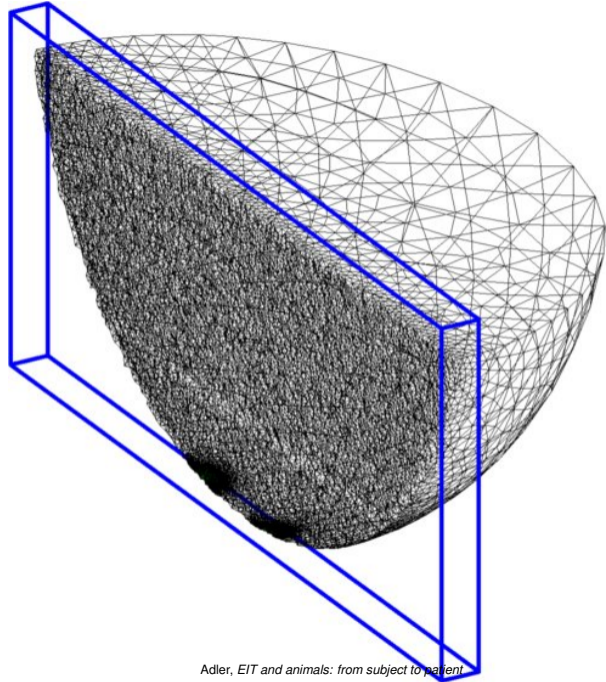
Electrical current flows between electrodes



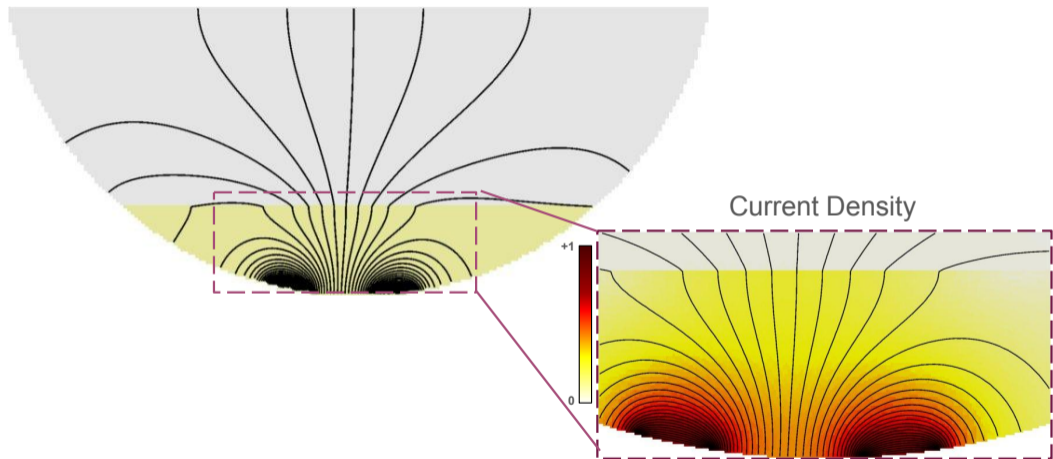
Why so ugly?



Better FEM model:
use 500k elements
(up from 5k)



Electrical current density and equipotentials between electrodes (v2)



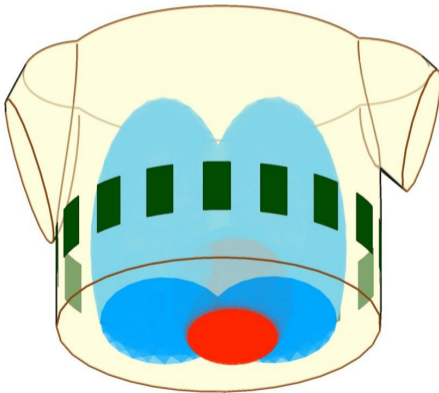
EIT: “Wikipedia” baby



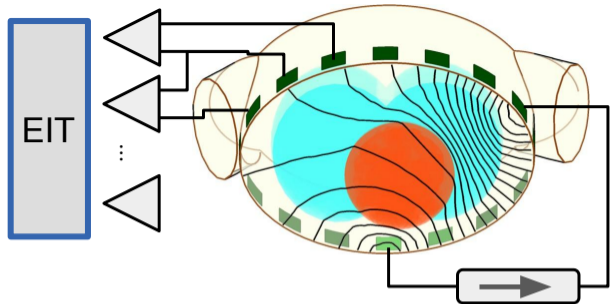
[1]

²Heinrich *et al* (2006) **Body and head position effects on regional lung ventilation in infants ...** Int Care Med 32:1392–1398

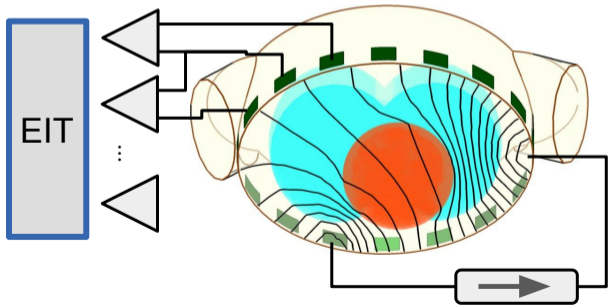
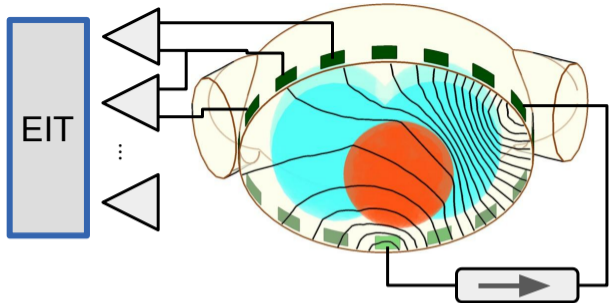
EIT and Body Model



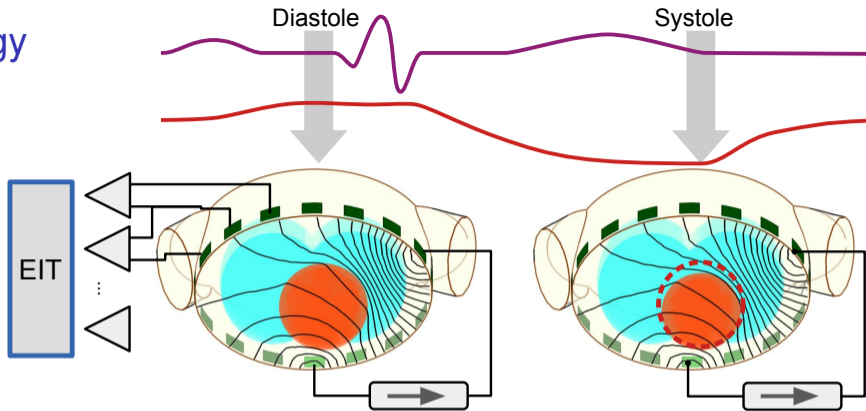
EIT: apply current
and measure voltages



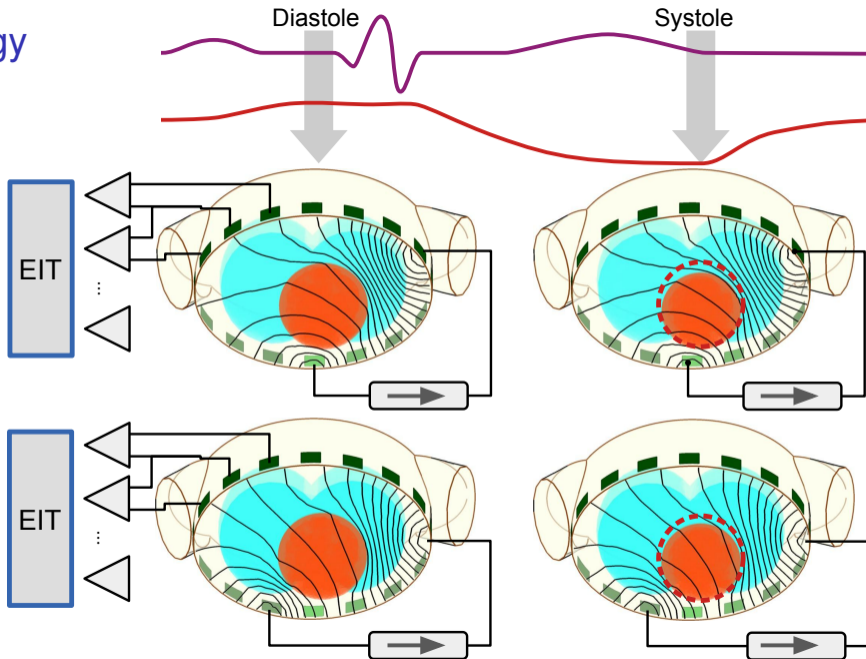
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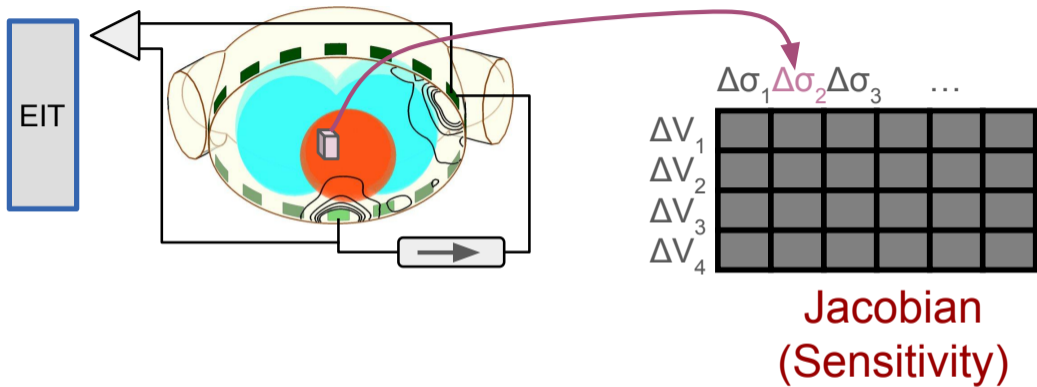
EIT: Physiology



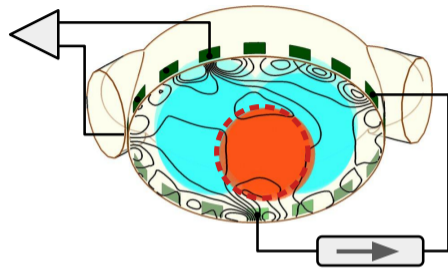
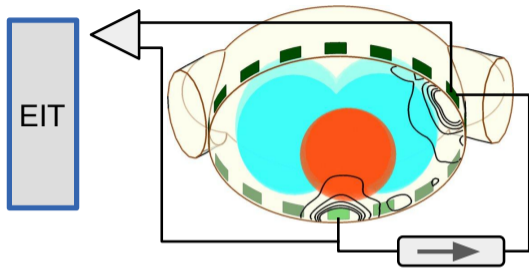
EIT: Physiology



EIT Sensitivity



EIT Sensitivity



EIT Sensitivity

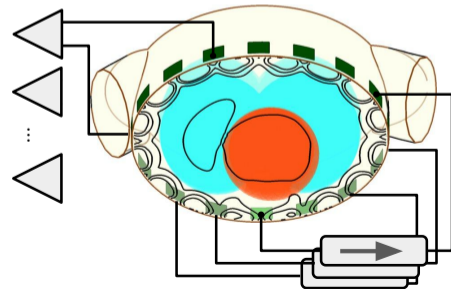
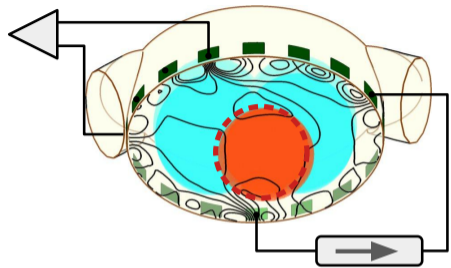
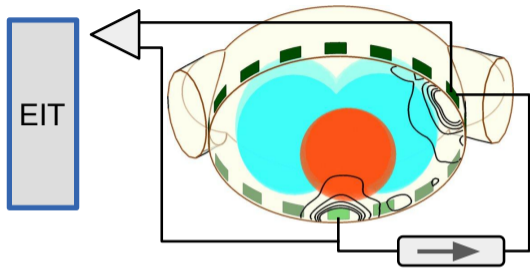
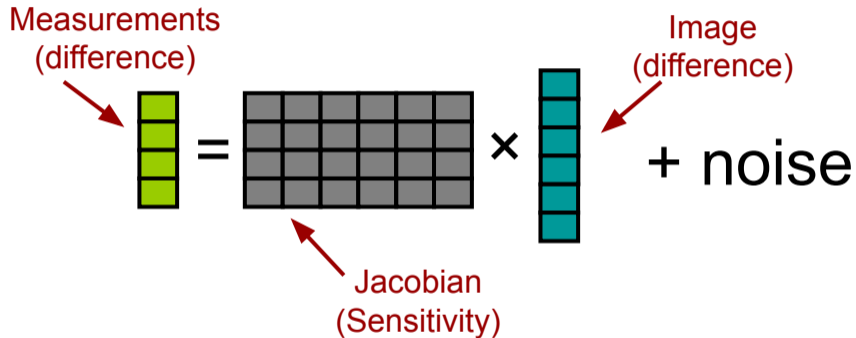
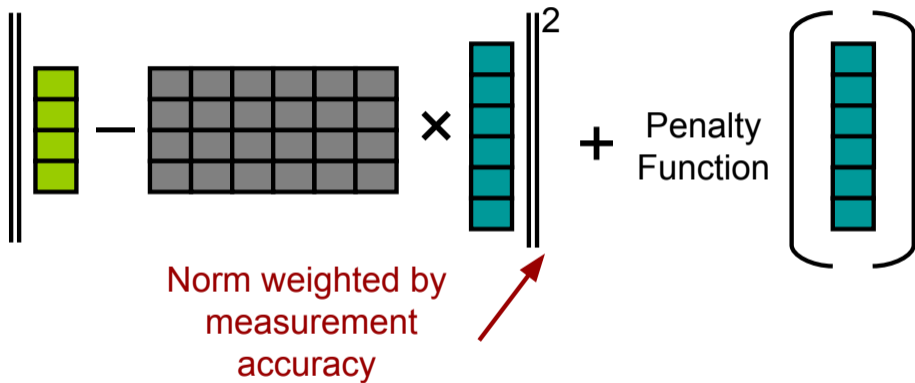


Image Reconstruction: Concept = Optimization



Reconstructed image : $\min(\text{data } \img alt="green square" data-bbox="528 35 558 65"/> \text{ mismatch} + \text{image penalty})$



Data errors: Modify data SNR for that channel

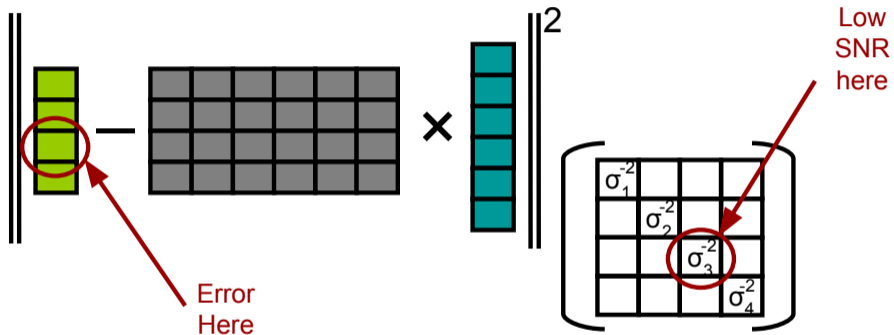


Image Reconstruction

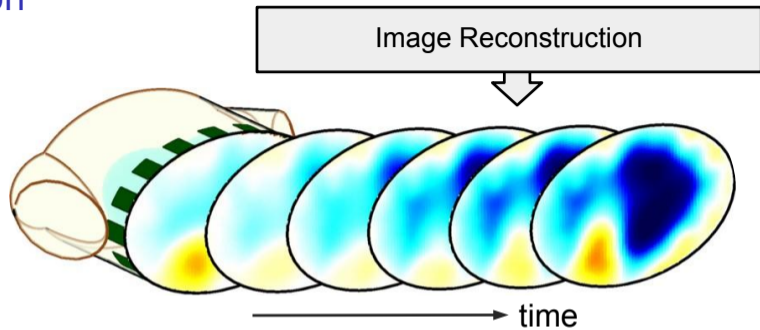
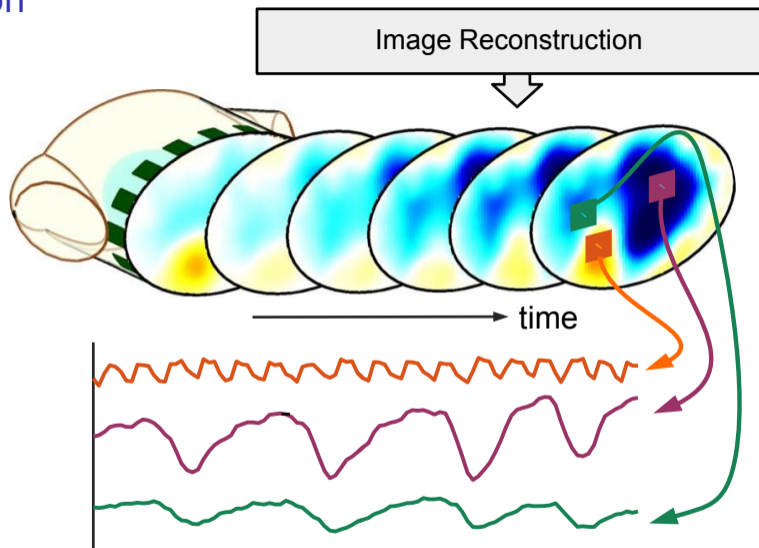
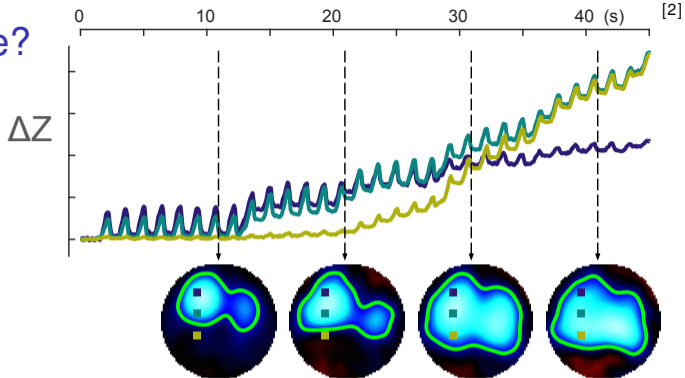


Image Reconstruction

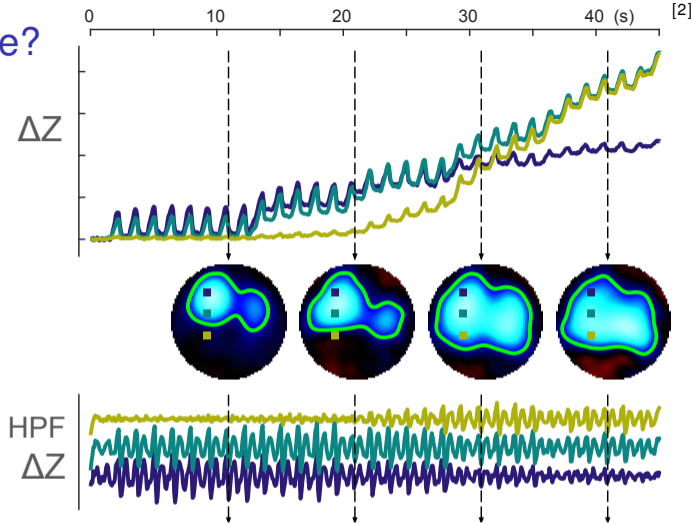


What does EIT measure?



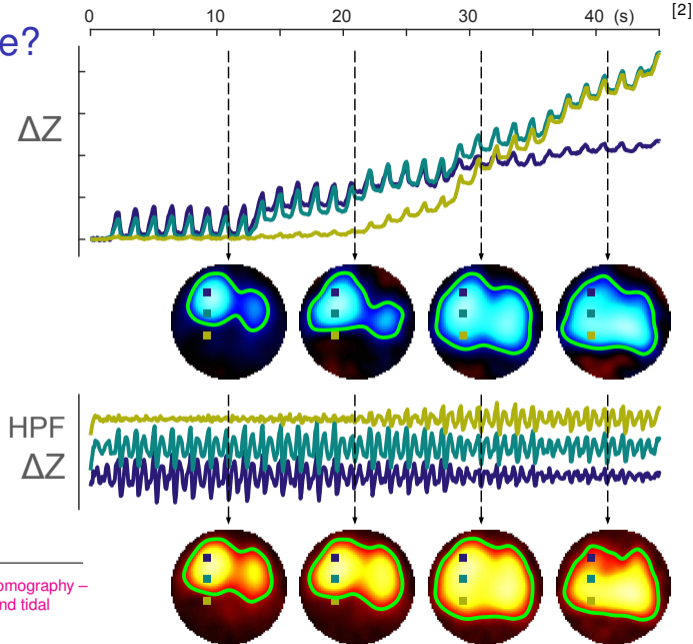
²Frerichs *et al* (2003) **Electrical Impedance Tomography – a method for monitoring regional lung aeration and tidal volume distribution** *Int Care Med* 29:2312–2316

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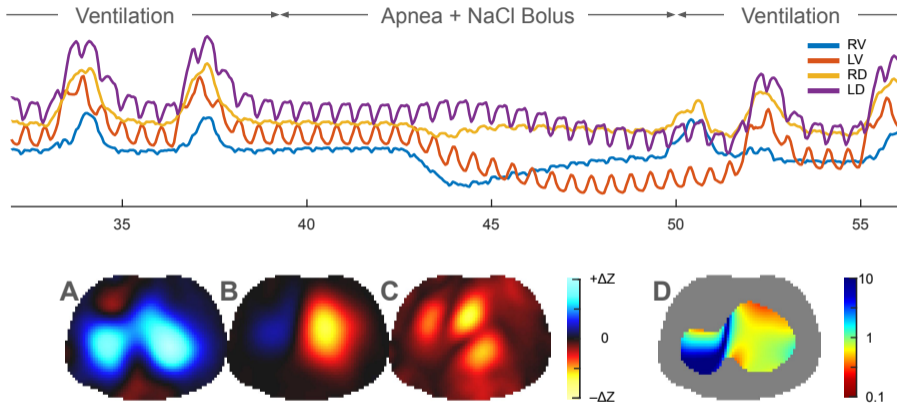
²Frerichs *et al* (2003) **Electrical Impedance Tomography – a method for monitoring regional lung aeration and tidal volume distribution** *Int Care Med* 29:2312–2316

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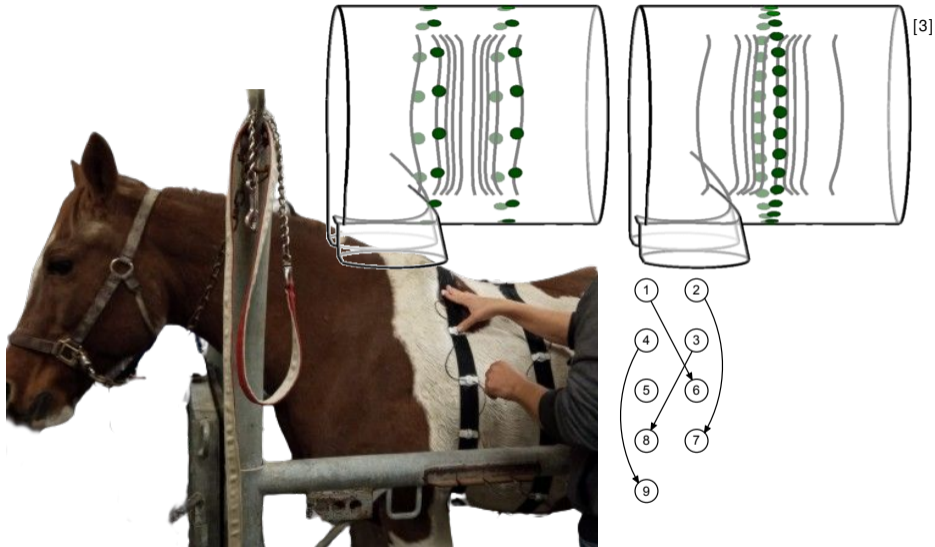
²Frerichs *et al* (2003) *Electrical Impedance Tomography – a method for monitoring regional lung aeration and tidal volume distribution* *Int Care Med* 29:2312–2316

EIT and blood flow: Bolus- and Filtering-based



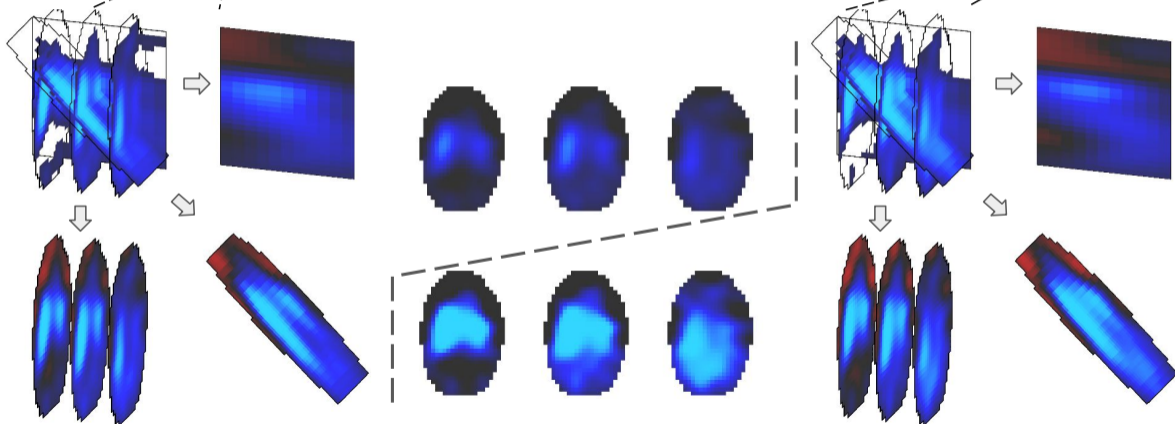
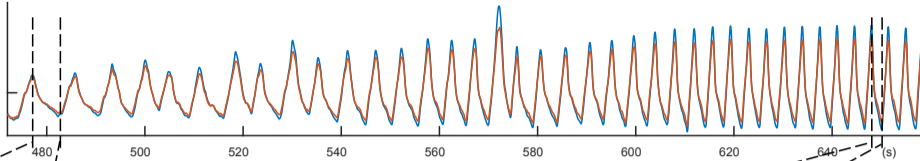
EIT waveforms and images from [Wang et al 2024] during a NaCl bolus and apnea (38–50 s) in 4 quadrants. A) Tidal Ventilation, B) Bolus-based perfusion image, C) HR-filtered EIT image, D) relative EIT-V/Q in lungs.

EIT in 3D

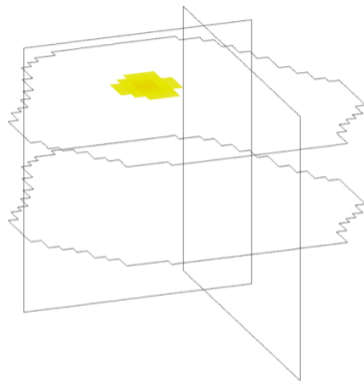
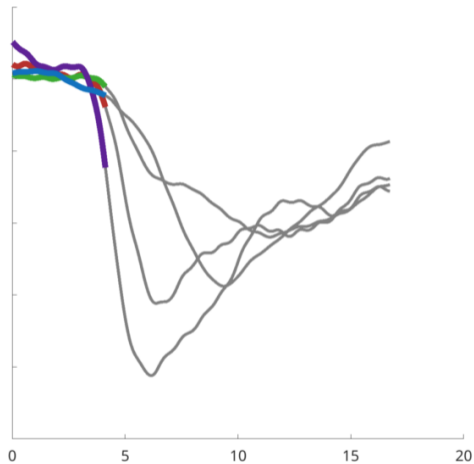


³Byrne *et al* (2023) [Validation of three-dimensional thoracic ...](#) *Physiol Meas* 45:035010

EIT in 3D



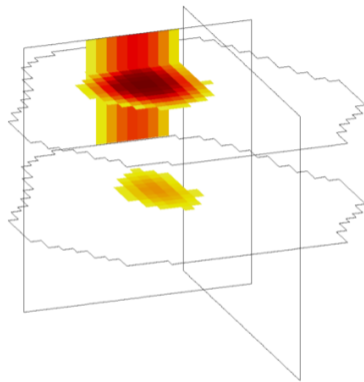
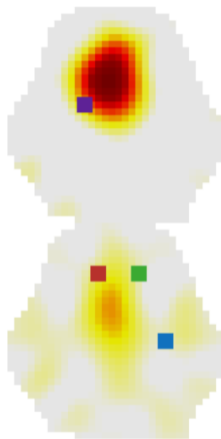
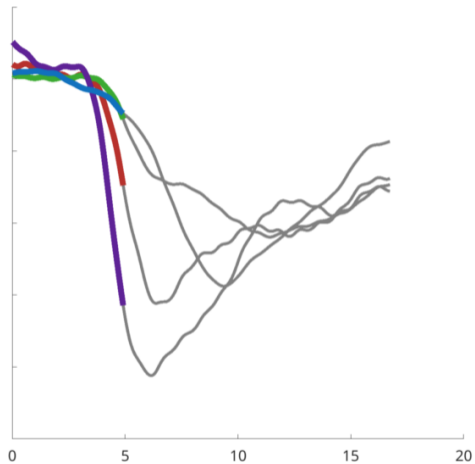
Perfusion with 3D EIT



4

⁴Larrabee *et al* (2023) *Am J Physiol: Lung*

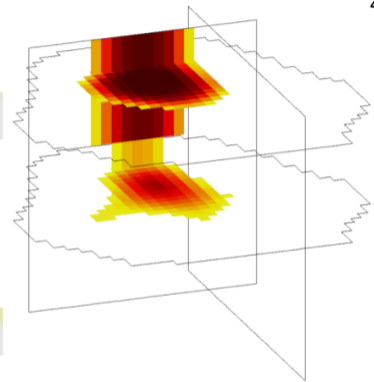
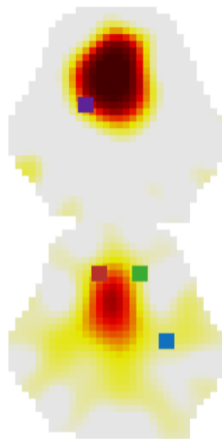
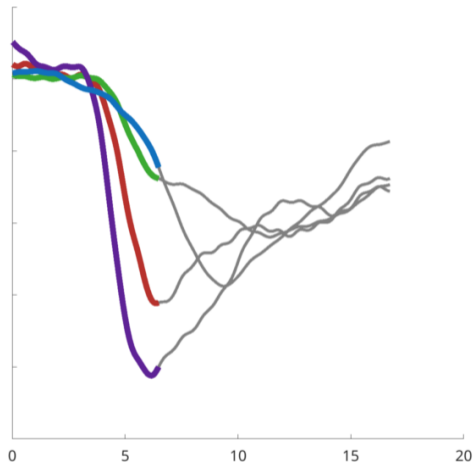
Perfusion with 3D EIT



4

⁴Larrabee *et al* (2023) *Am J Physiol: Lung*

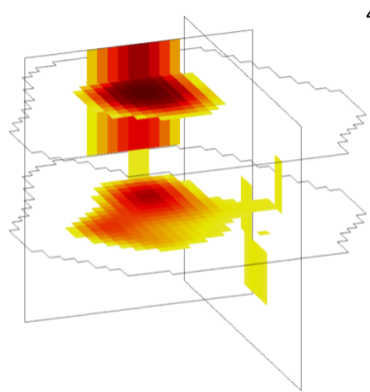
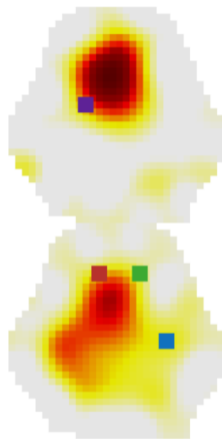
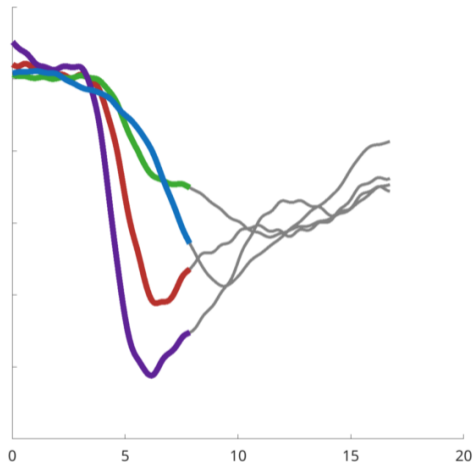
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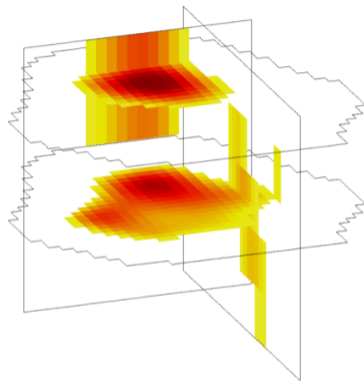
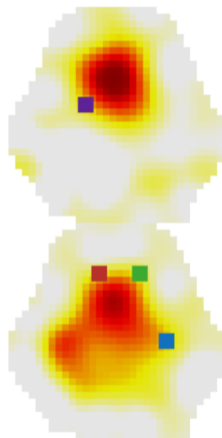
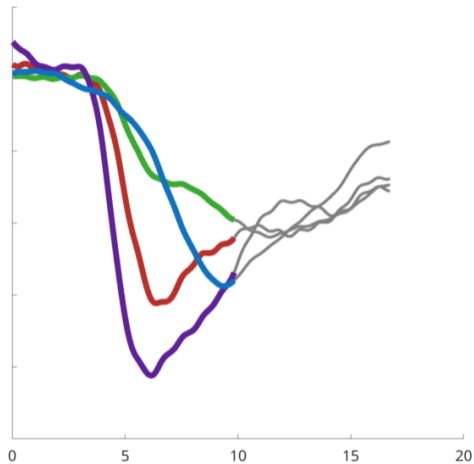
Perfusion with 3D EIT



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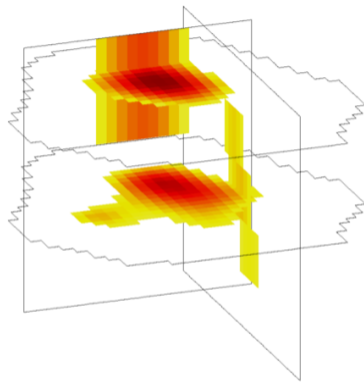
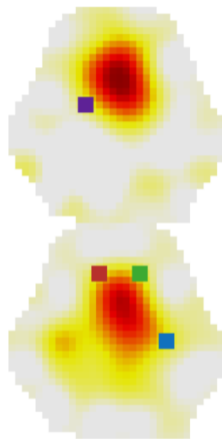
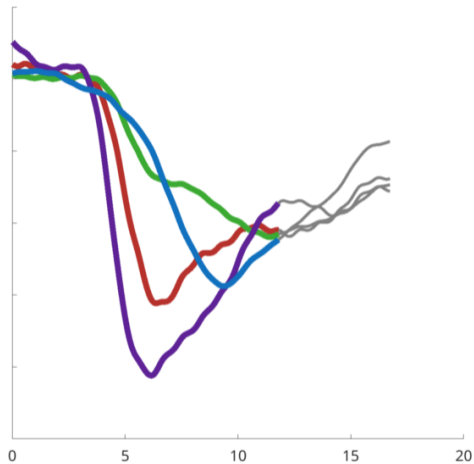
Perfusion with 3D EIT



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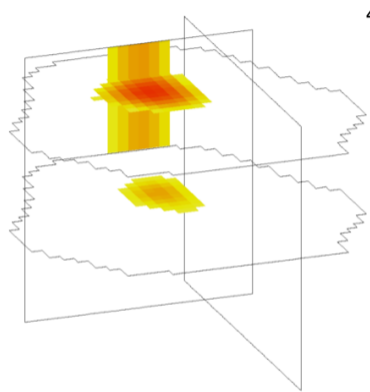
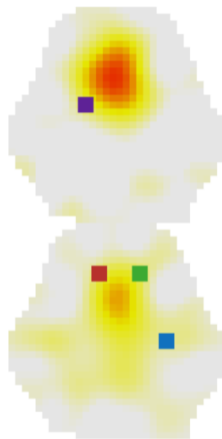
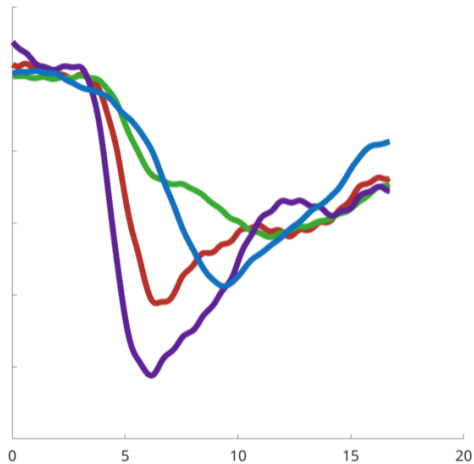
Perfusion with 3D EIT



4

⁴Larrabee *et al* (2023) *Am J Physiol: Lung*

Perfusion with 3D EIT

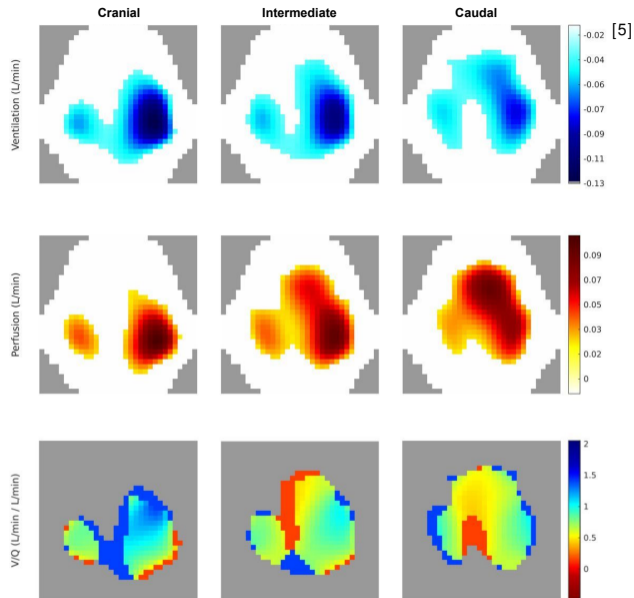


4

⁴Larrabee *et al* (2023) *Am J Physiol: Lung*

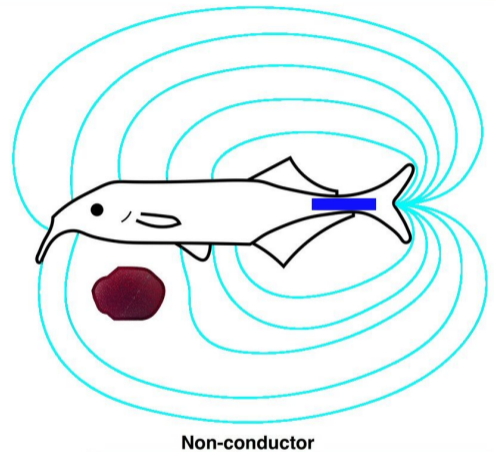
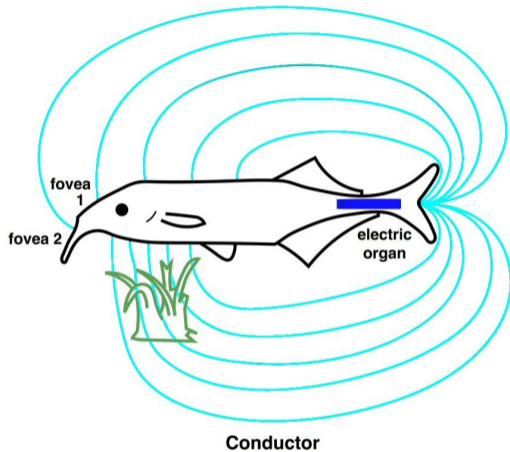
3D Ventilation / Perfusion

$$\dot{V} / Q$$



Can animals benefit from EIT?

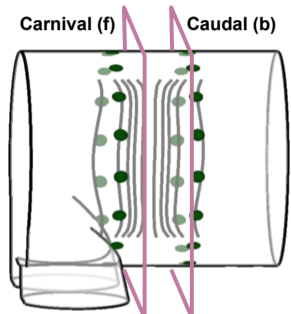
Electrically Sensitive Fish



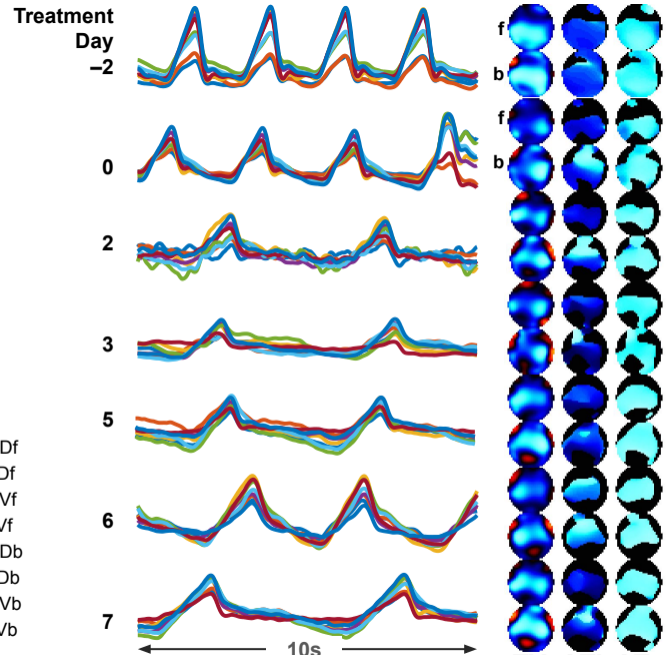
[6]

⁶en.wikipedia.org/wiki/Electroreception_and_electrogenesis

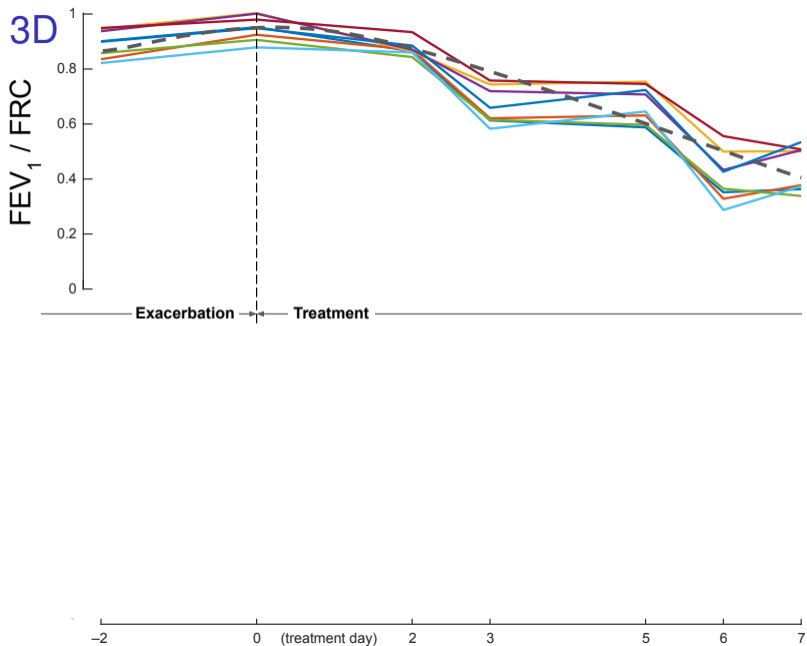
Horse asthma in 3D



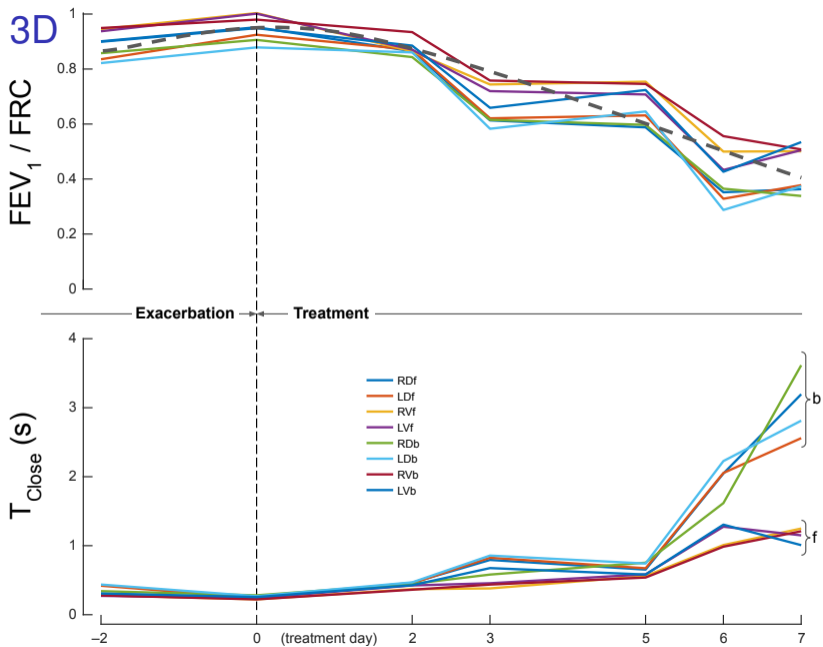
- Rdf
- LDf
- RVf
- LVf
- RDb
- LDb
- RVb
- LVb



Horse asthma in 3D



Horse asthma in 3D

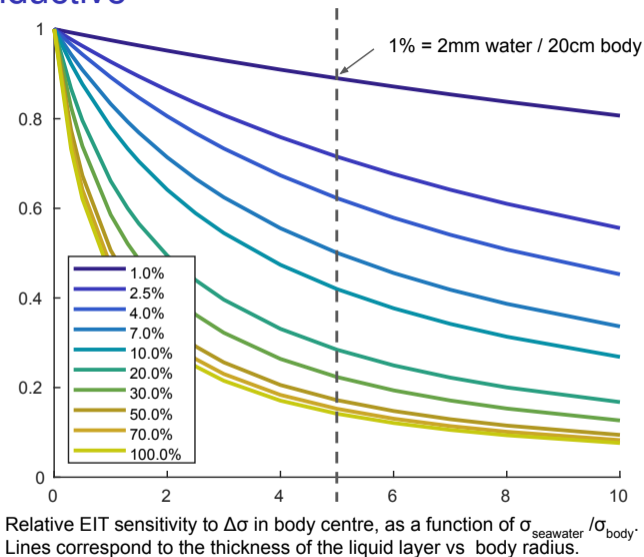
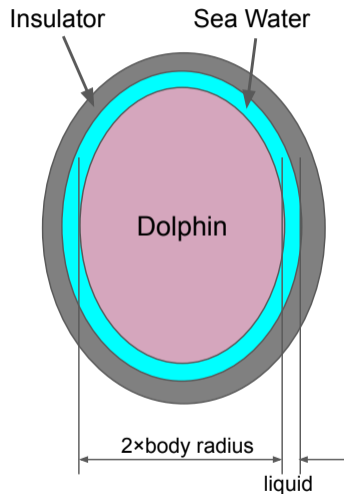


Sea Mammals

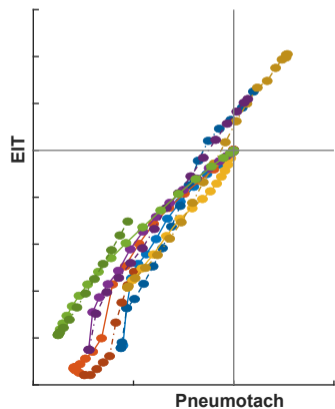
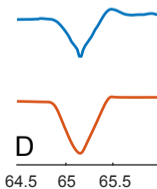
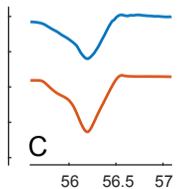
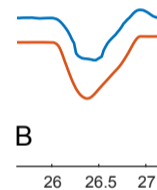
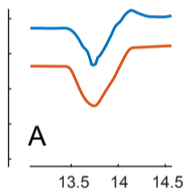
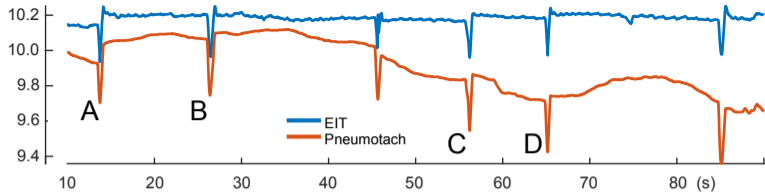


Problem: Seawater is conductive

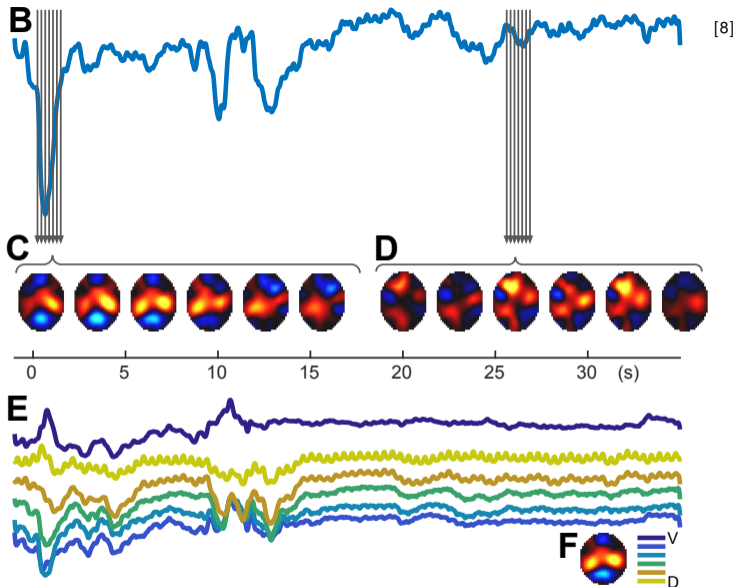
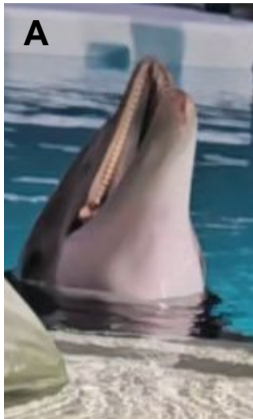
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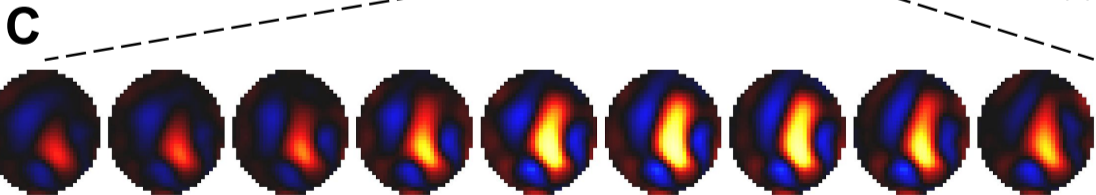
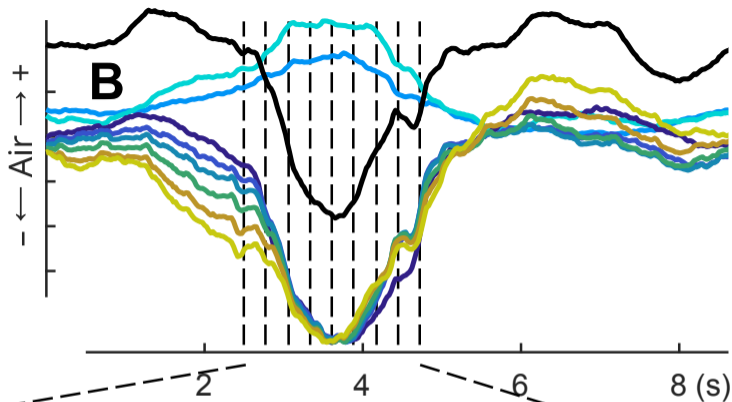
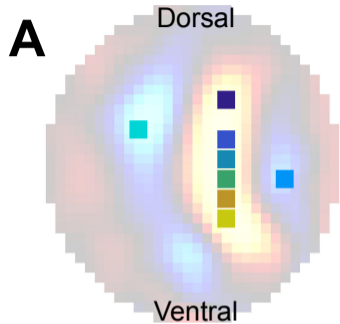
Dolphins: EIT vs Spirometry



Dolphins



Dolphins: One Breath



Next Steps

EIT is exciting tool for

- Physiological monitoring of experimental animals
- Surgical and post-operative monitoring of pet animals
- Cattle health monitoring
- Monitoring wild animals non-invasively

Challenges

- Need 3D EIT systems
- Contact-quality is difficult: need compensation
- Is there a market for veterinary devices?
- Software tools are needed