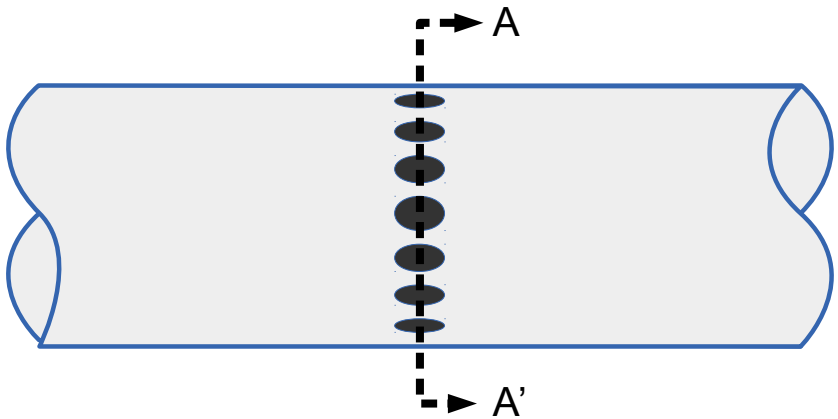
Process tomography: what's being done in medical applications?

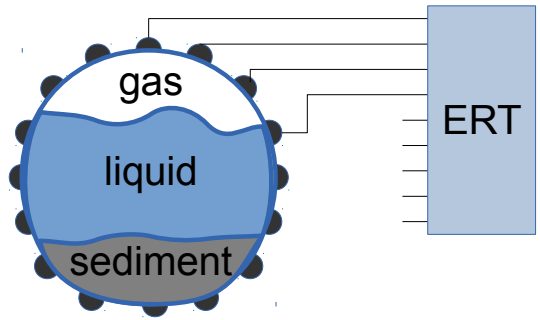
WCIPT 2018
Bath, UK
3 September 2018

Andy Adler

Systems and Computer Engineering, Carleton University, Ottawa

Electrical Resistance Tomography (ERT)





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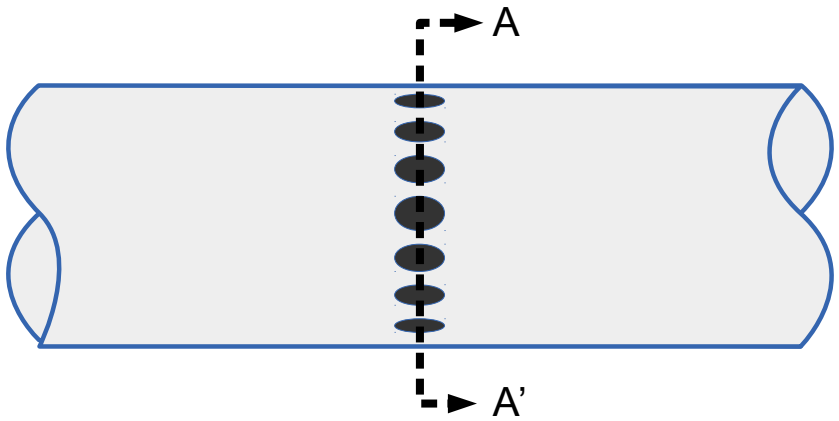
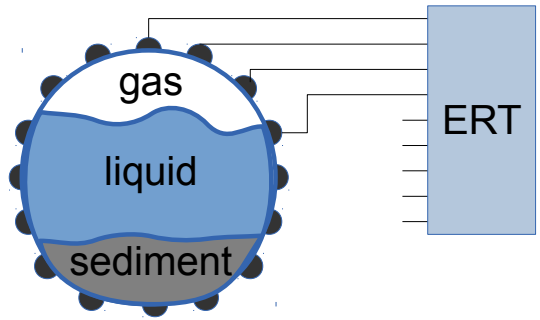
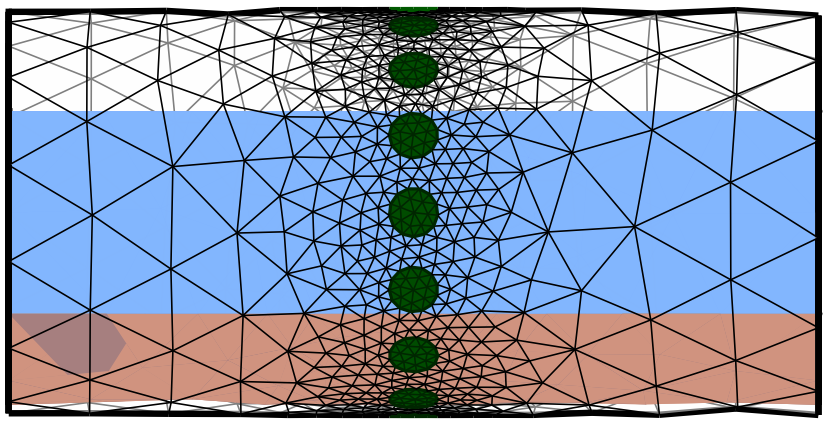
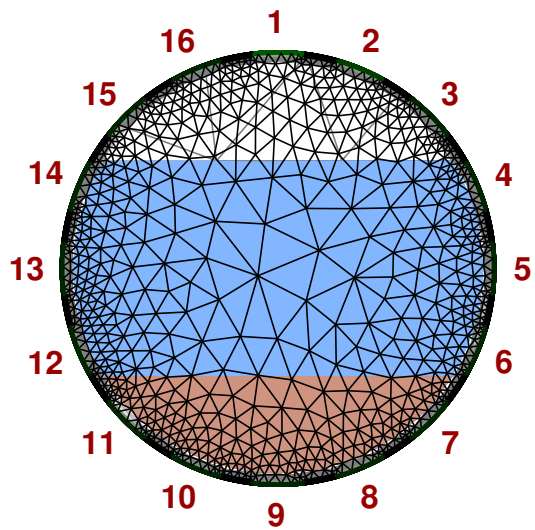


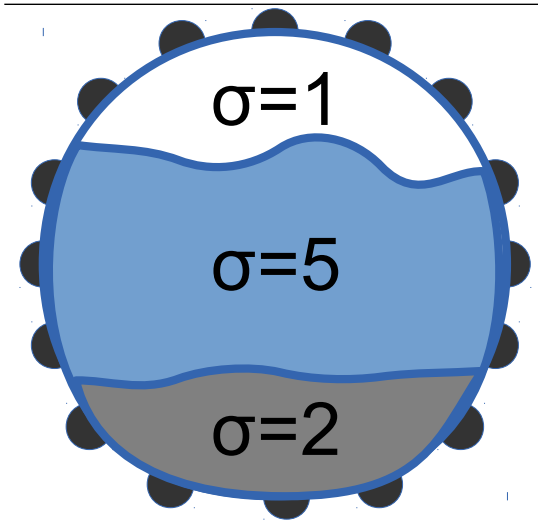


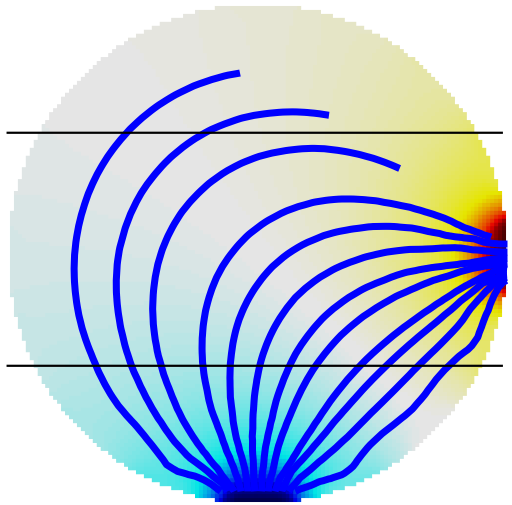




ERT: Measurements

	Homogenous (Water only)	Inhomogenous (Air, Water, & Sediment)





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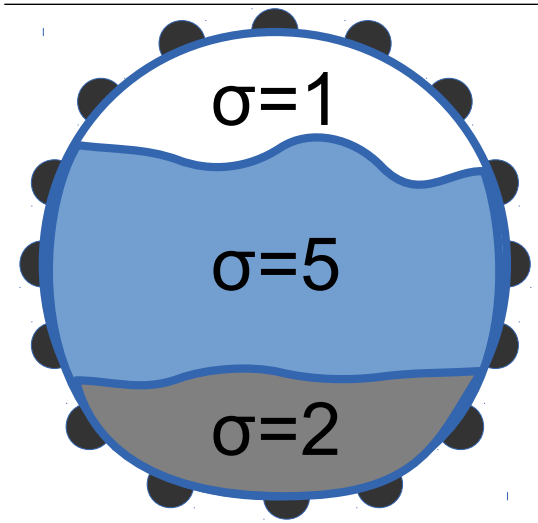

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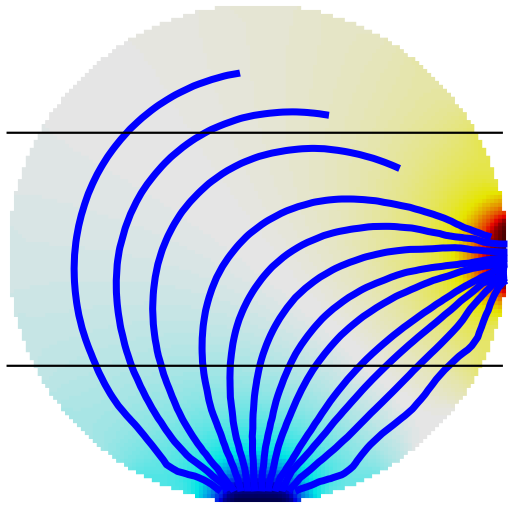

Inhomogenous
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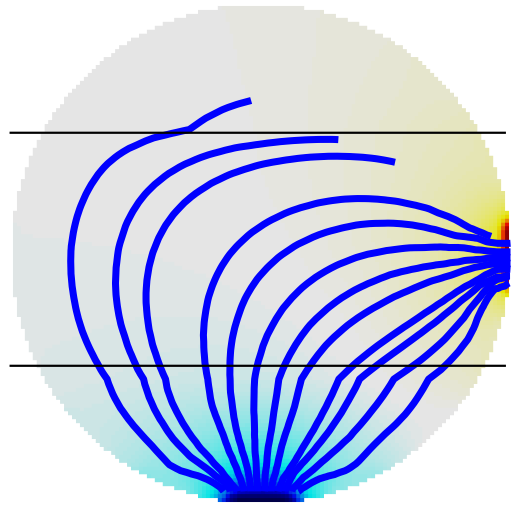

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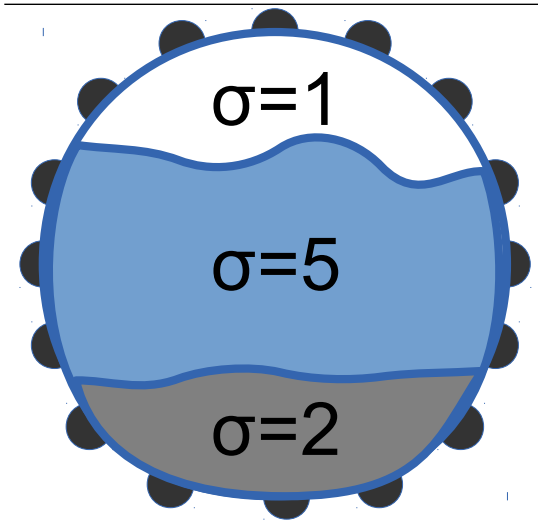

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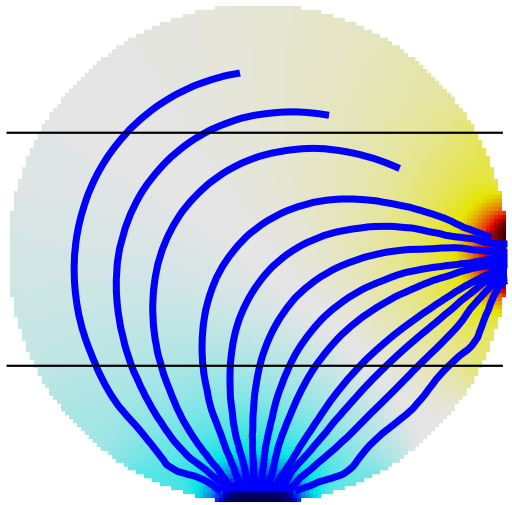

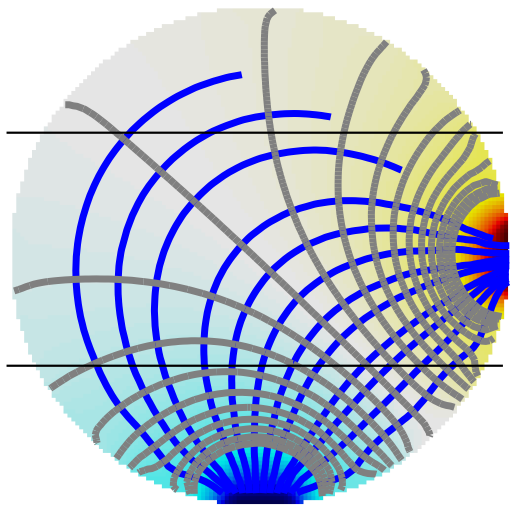

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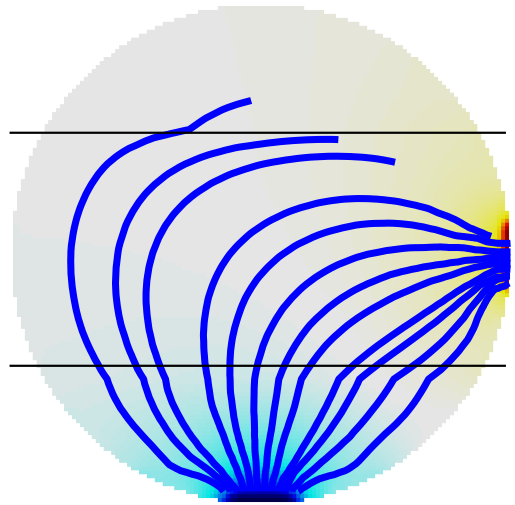

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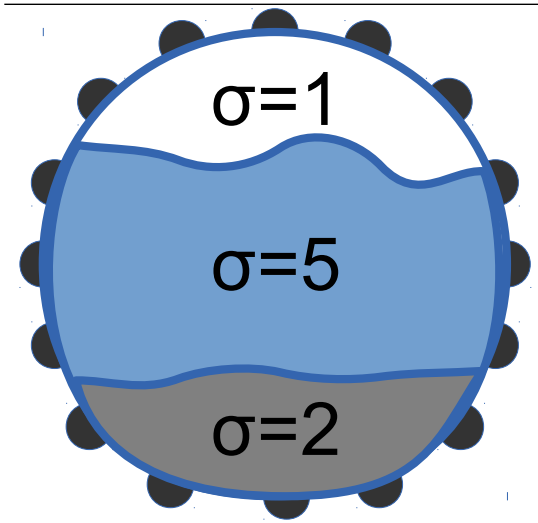

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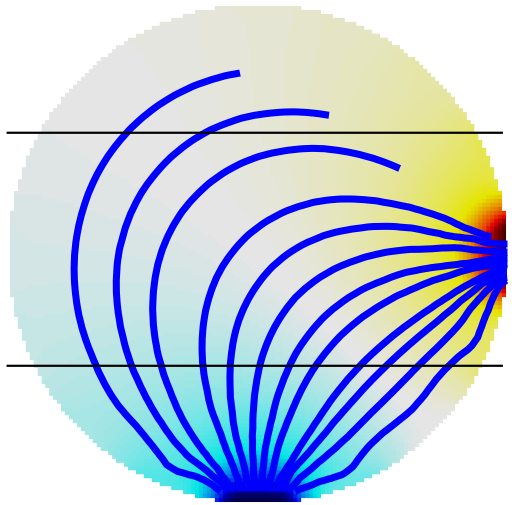
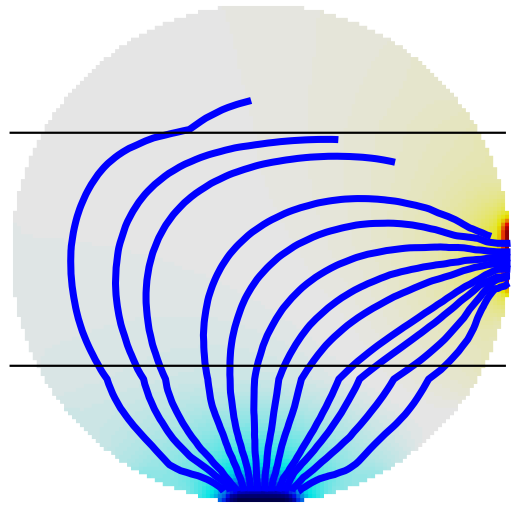
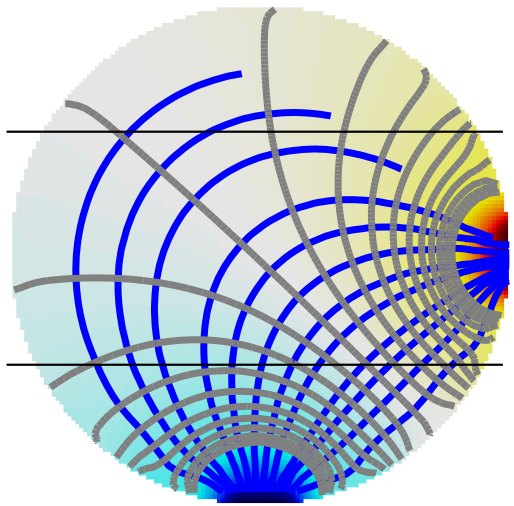






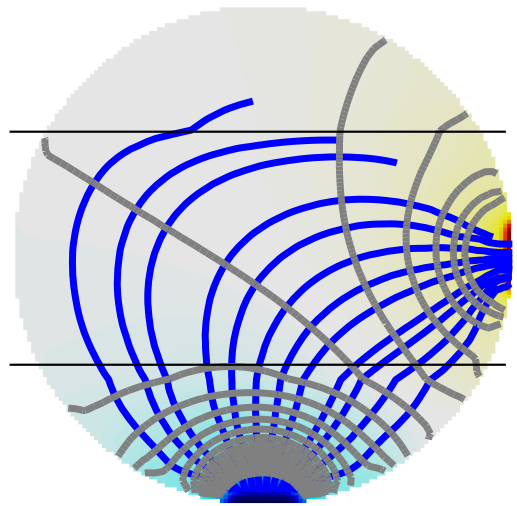
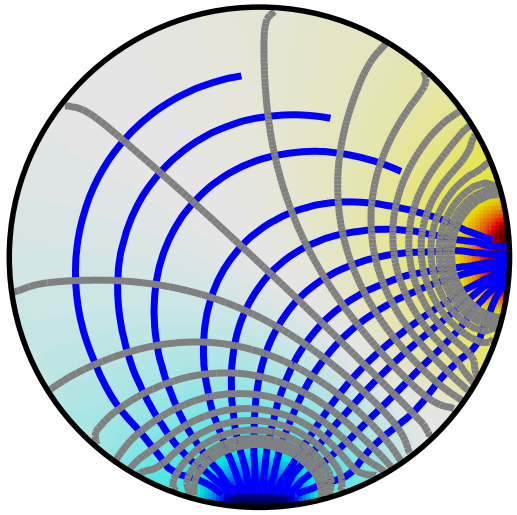
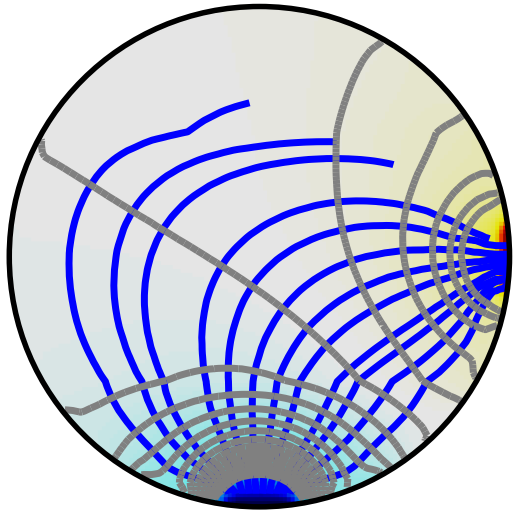


Image Reconstruction





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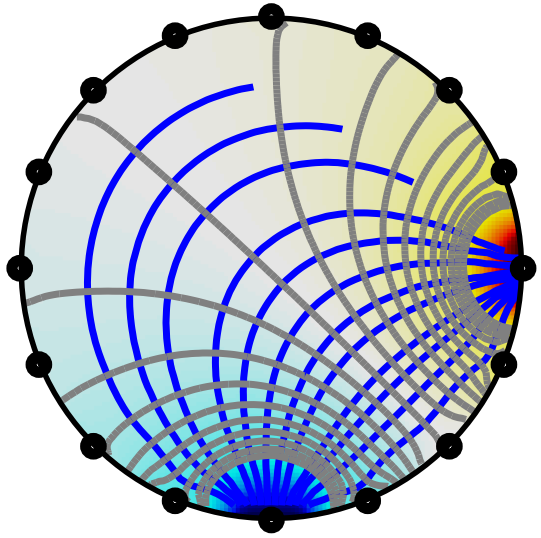

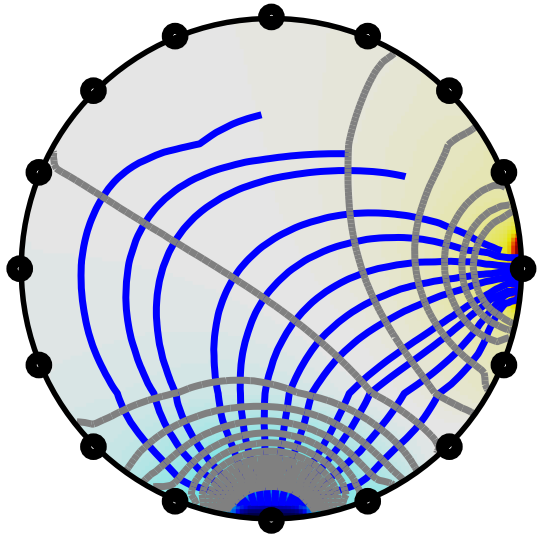

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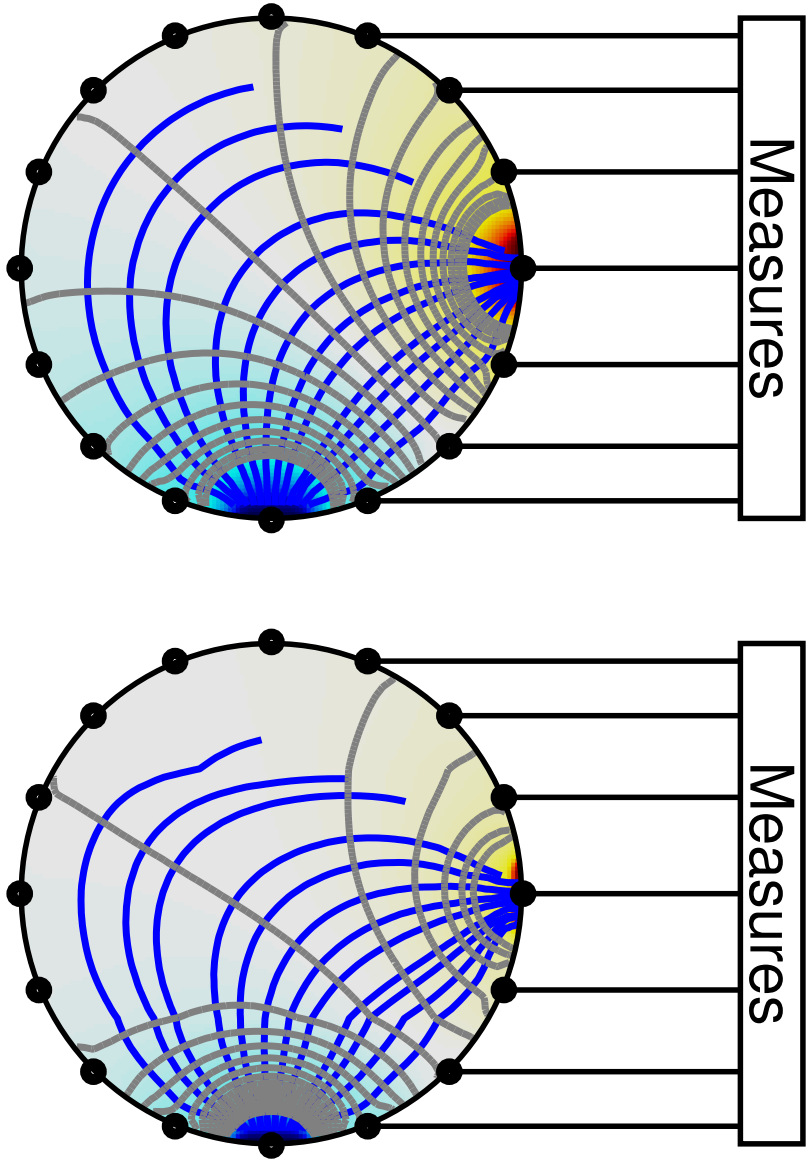

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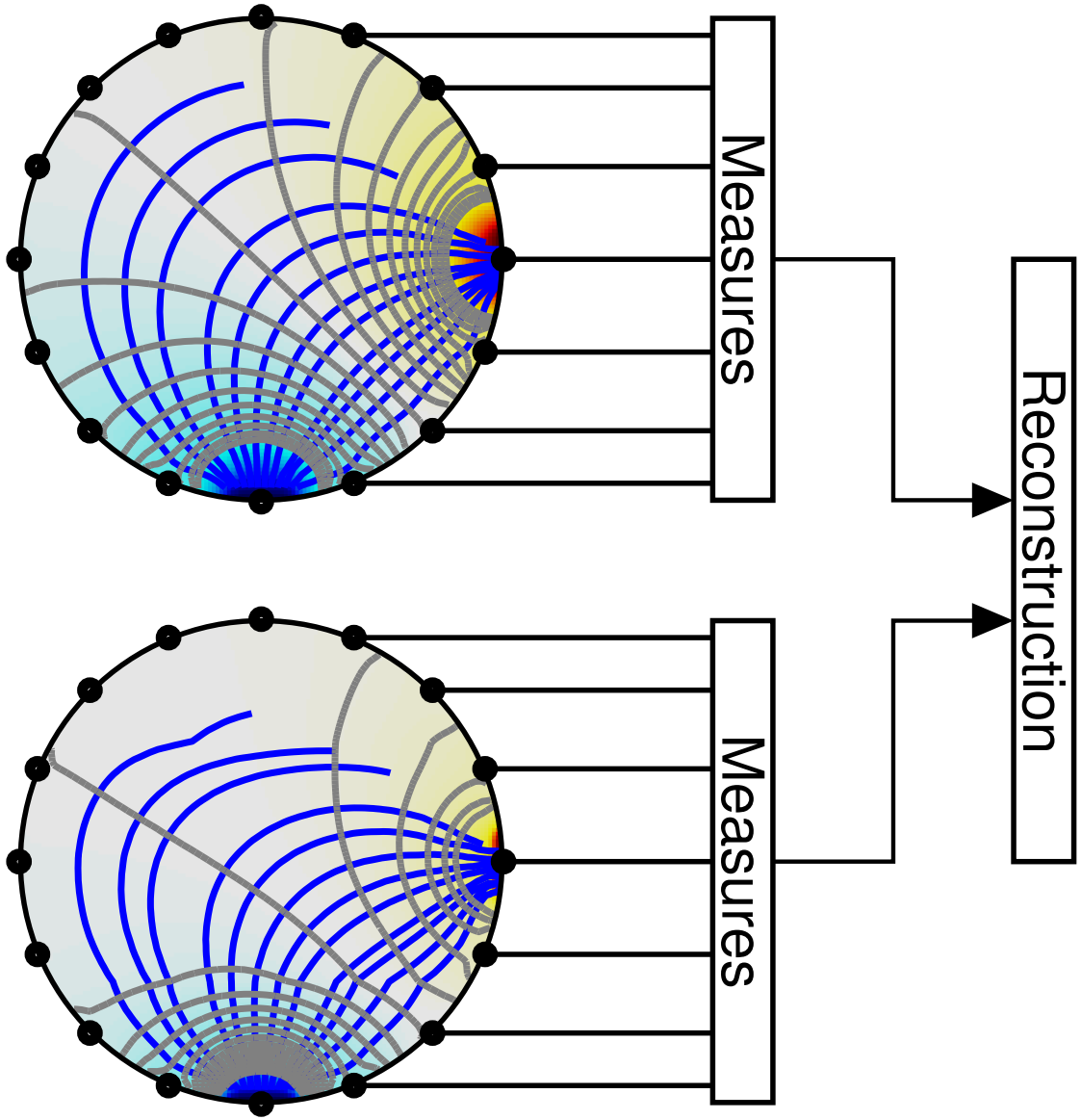
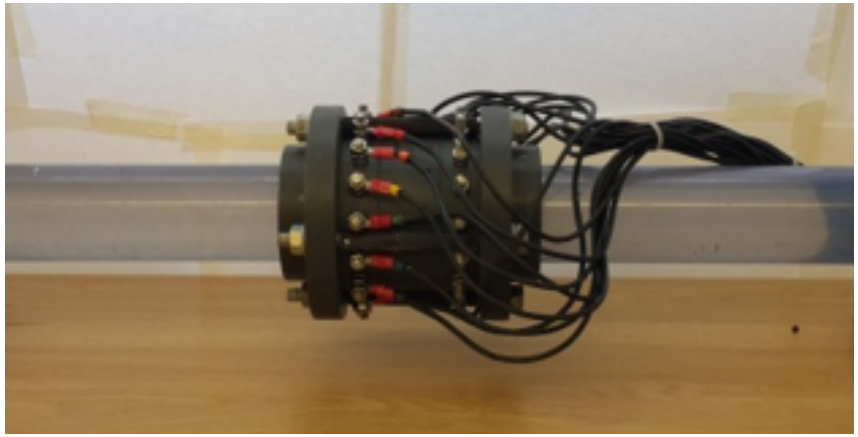
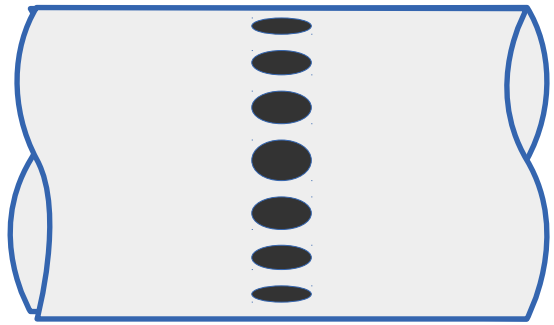
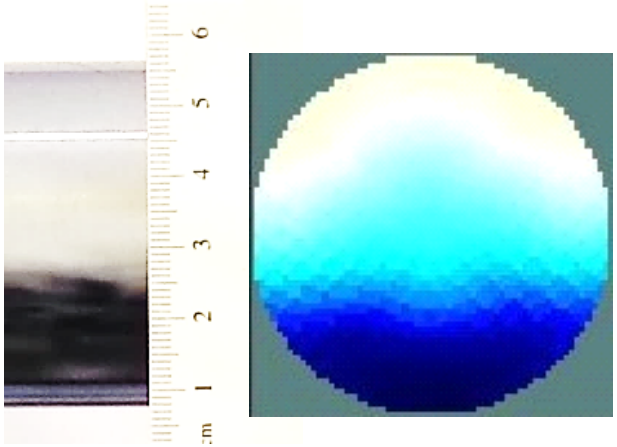


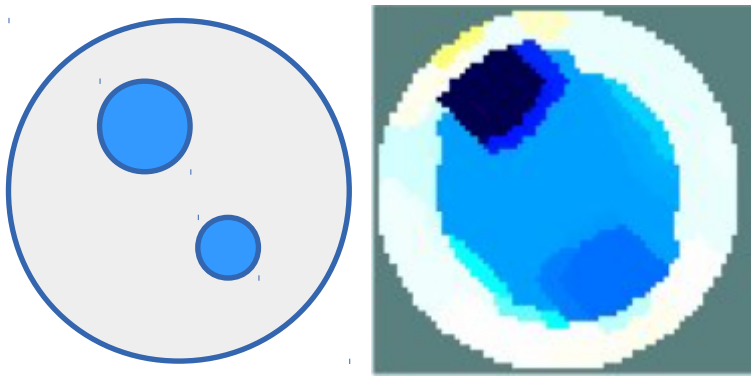
Example Images





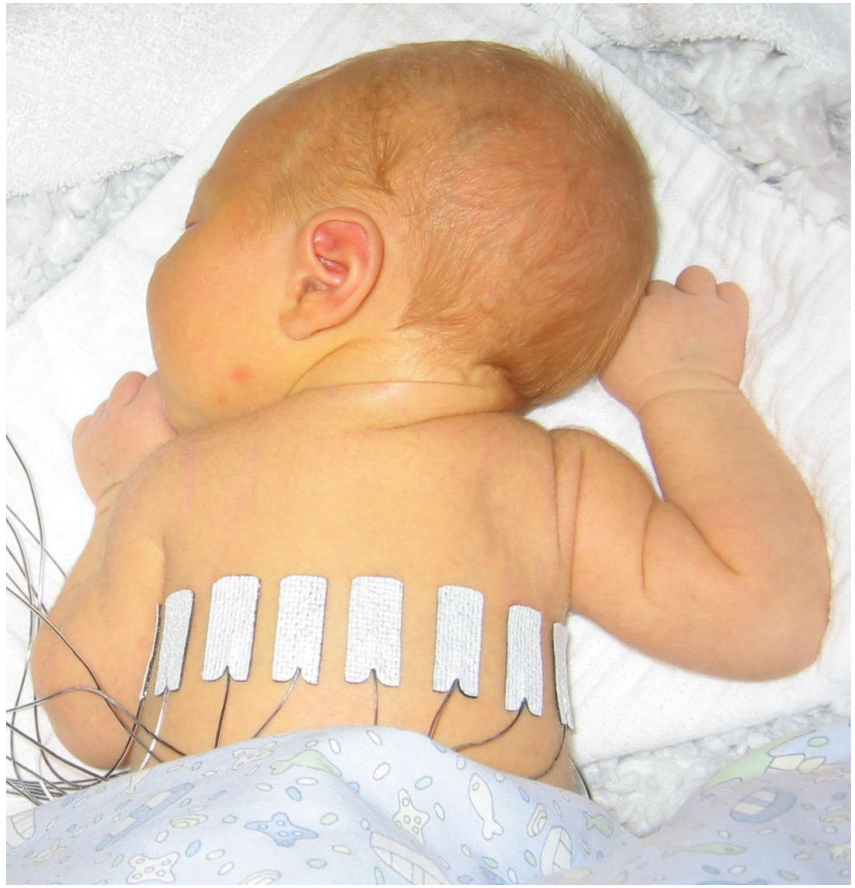


Flow Rate: 0.86 L/s
Bed level: 18 mm



Static Wood shapes

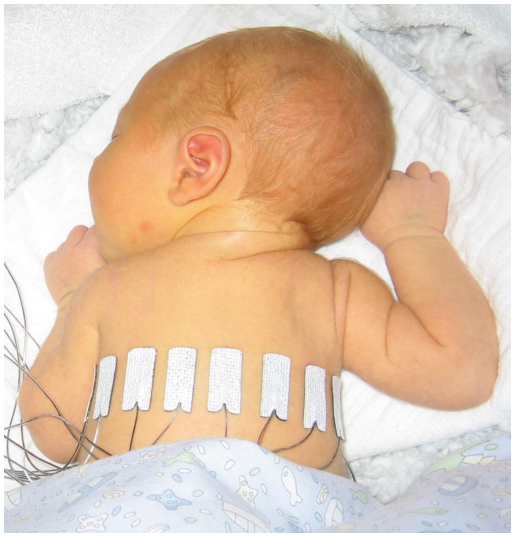
Electrical Impedance Tomography

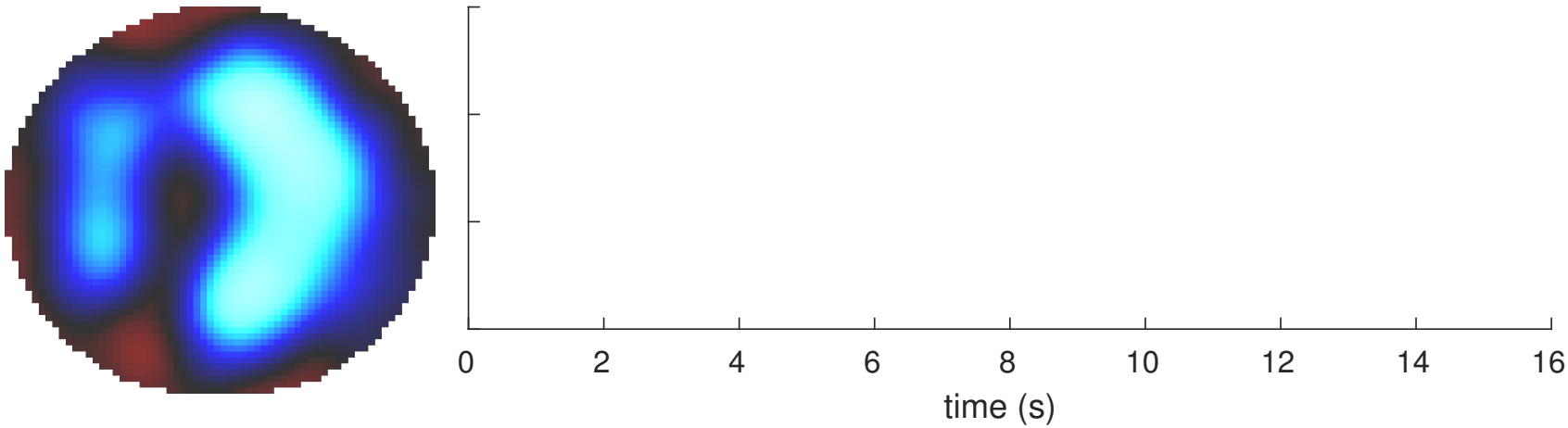


10-day old baby[1]

[1] Heinrich, *et al* (2006) "Body and head position effects on regional lung ventilation in infants: an electrical impedance tomography study" *Intensive Care Med*, 32:1392-1398

Electrical Impedance Tomography





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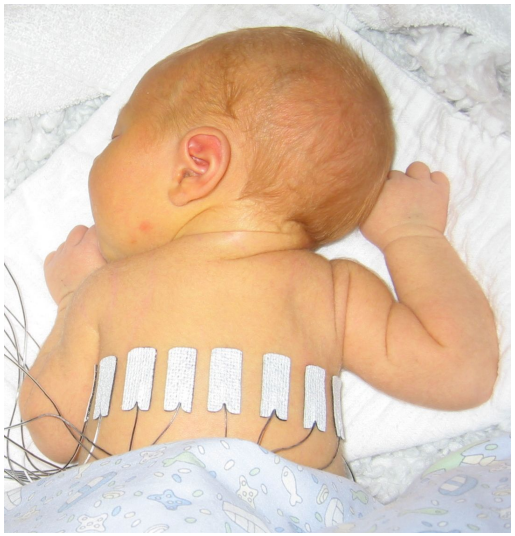

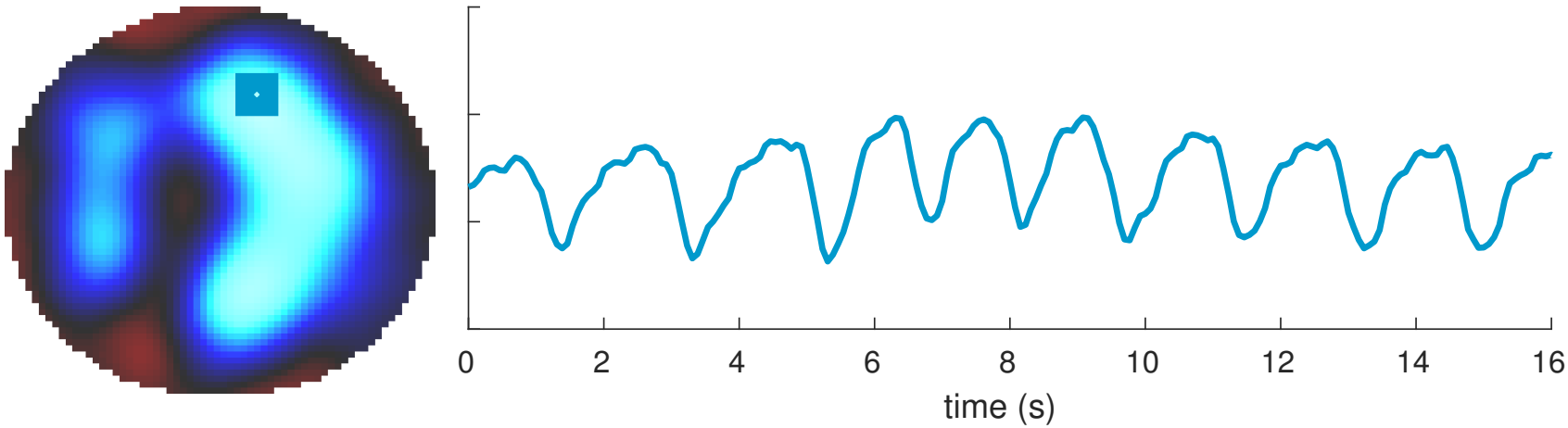

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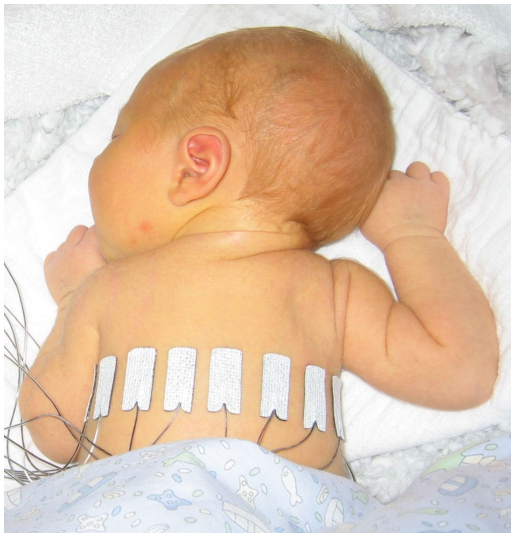

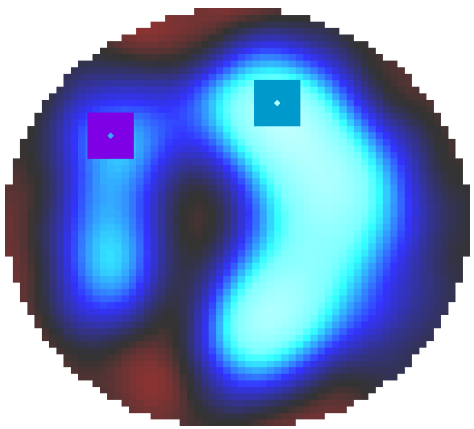

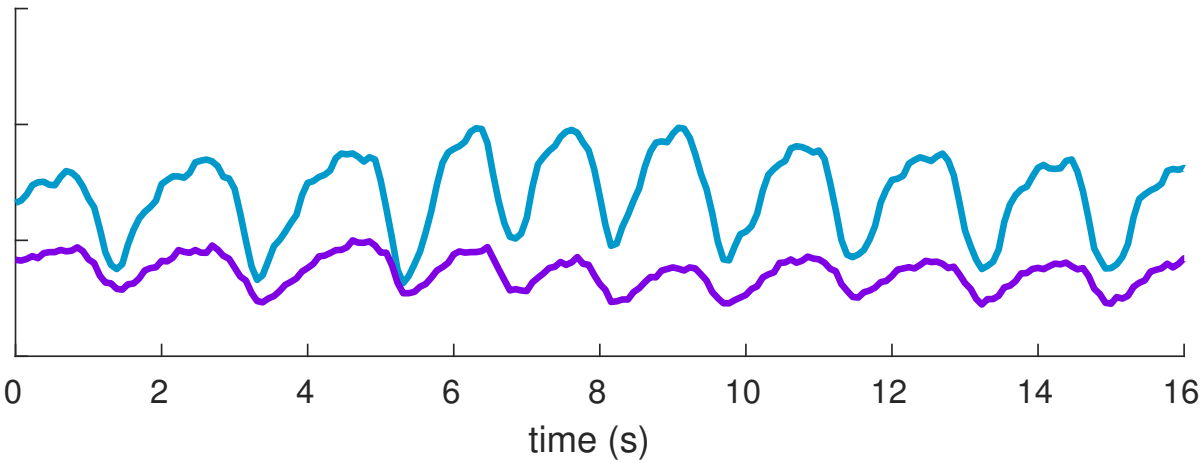

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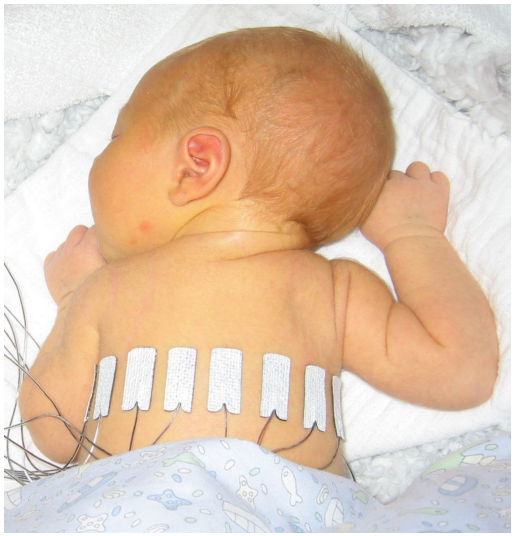
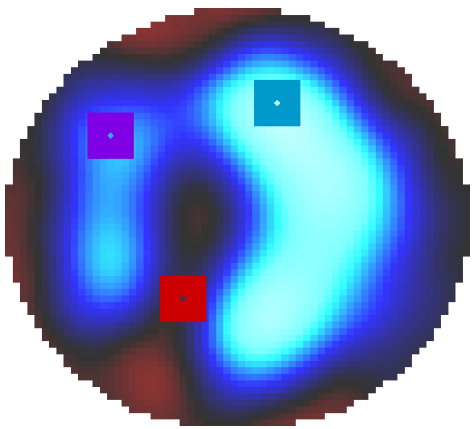
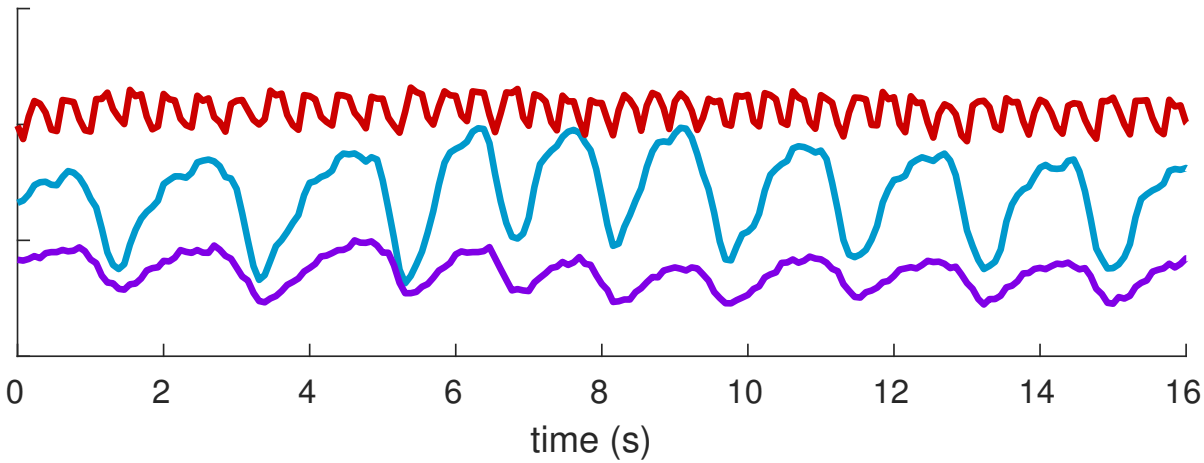
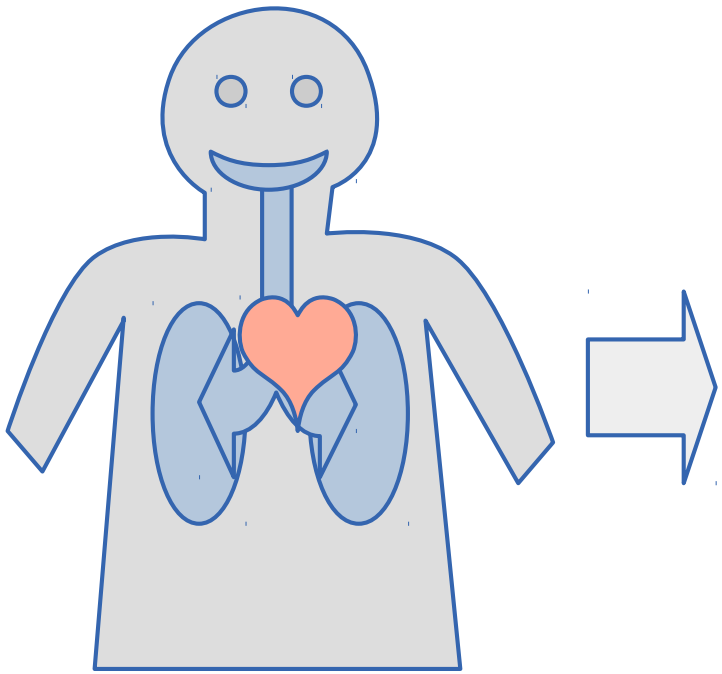






Human Physiology $\Leftrightarrow$ O_2 delivery system



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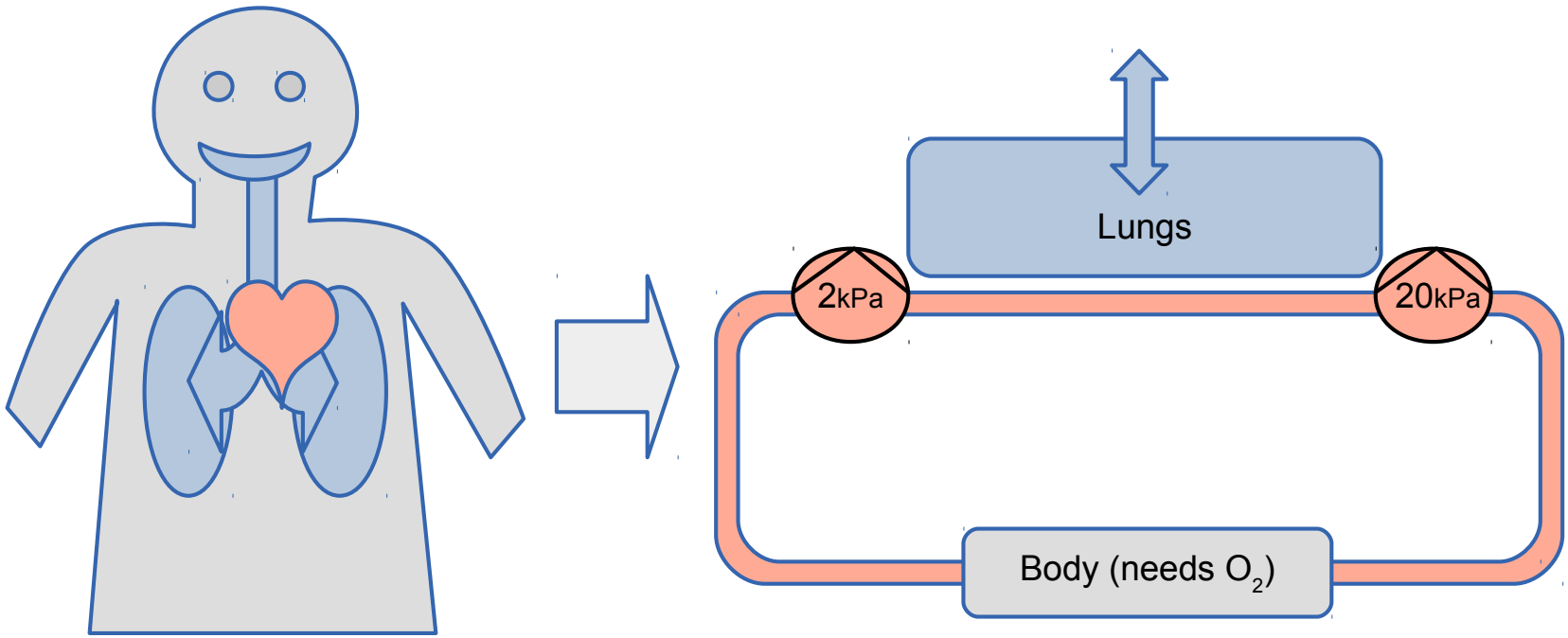
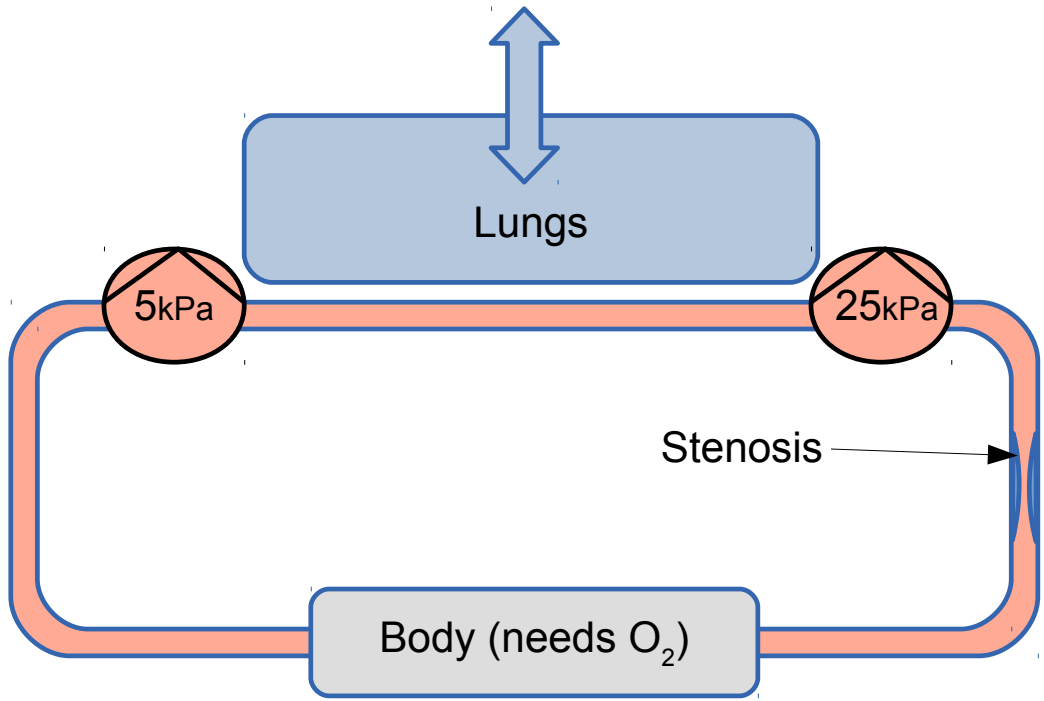


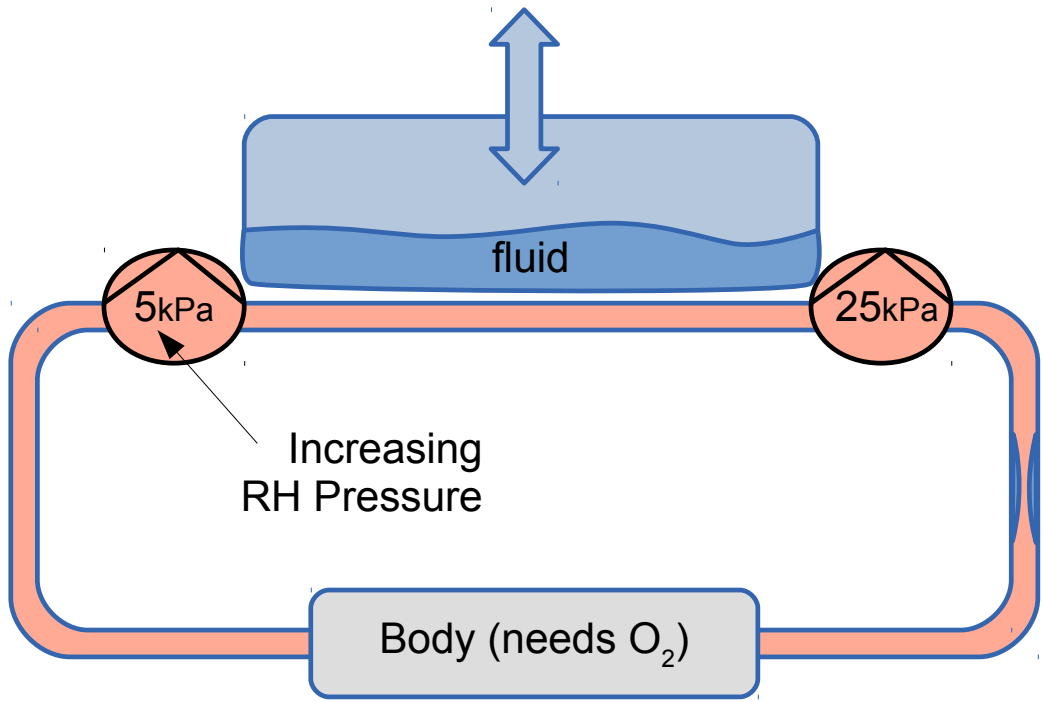
Example problem: Valve stenosis

- *Stenosis:* stiffened output valve can't open enough
- Δ*Pressure* $\uparrow$ across valve
- Body needs blood flow, so LH Pressure $\uparrow$
- If bad enough, RH pressure $\uparrow$



Valve stenosis $\Rightarrow$ Heart Failure

- Eventually, $\uparrow$LH Pressure is not enough
- RH pressure $\uparrow$ to help out
- But now lungs see high pressure
- Fluid “leaks” into lungs



Pulse Wave Velocity: Heart $\rightarrow$ Lungs

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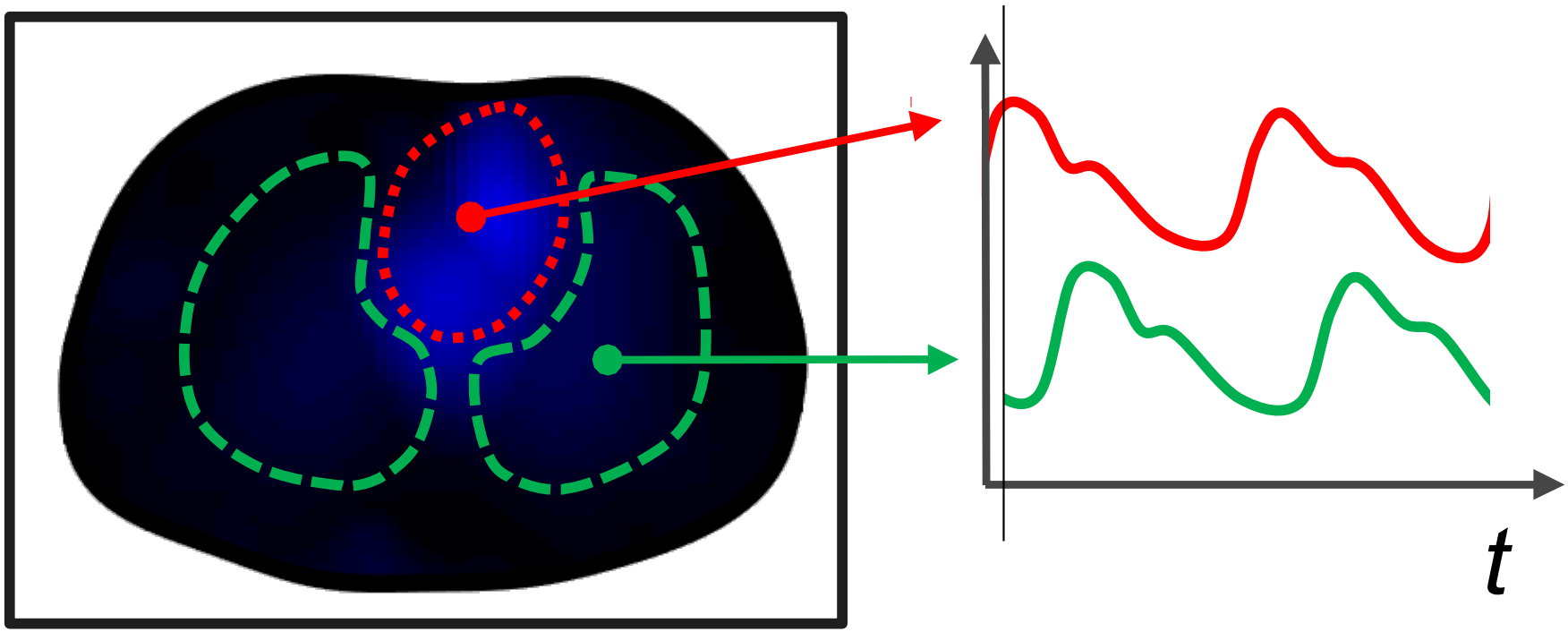
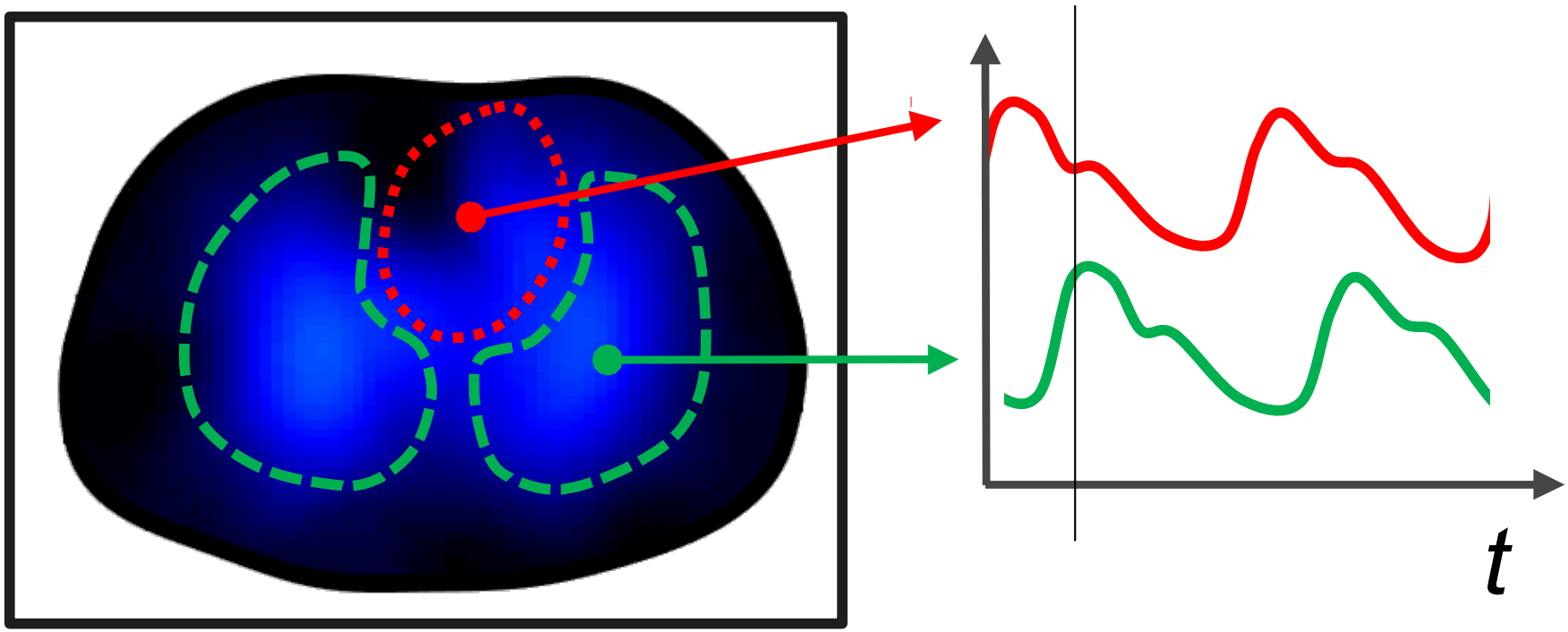


Pulse Wave Velocity: Heart → Lungs



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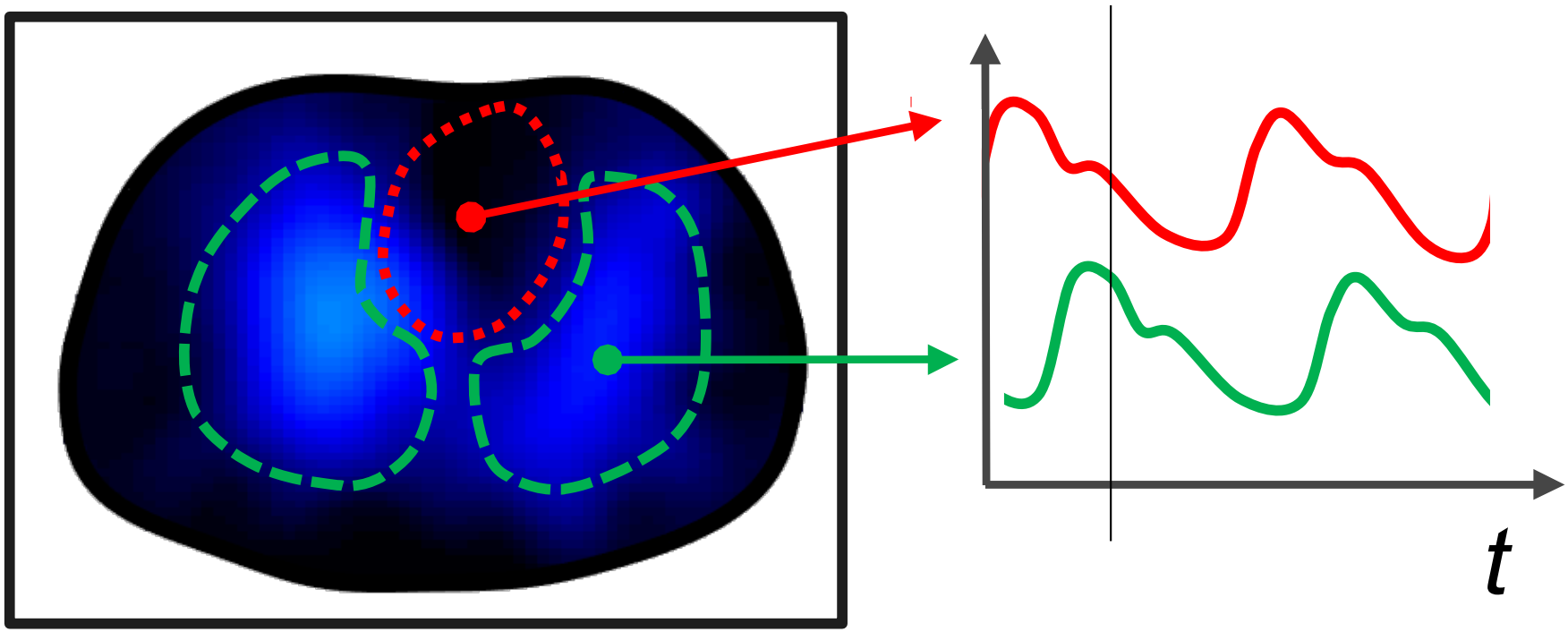
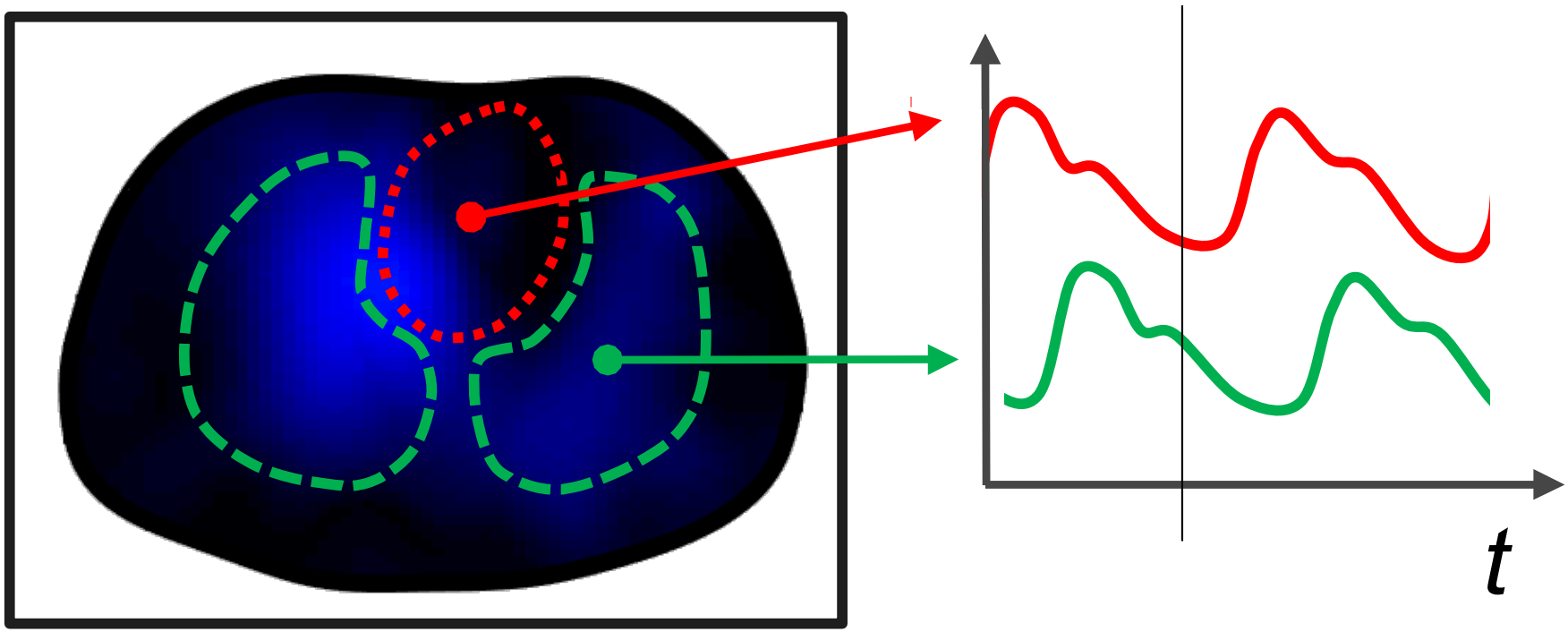
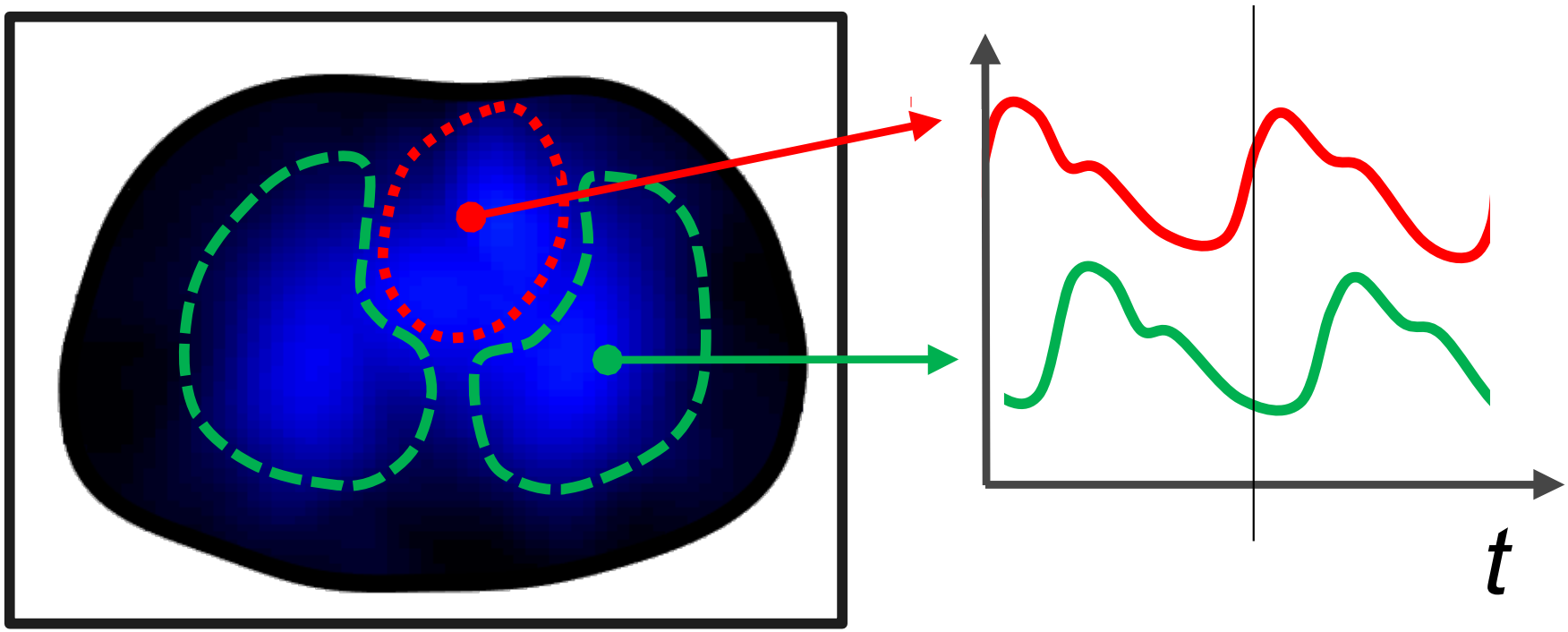


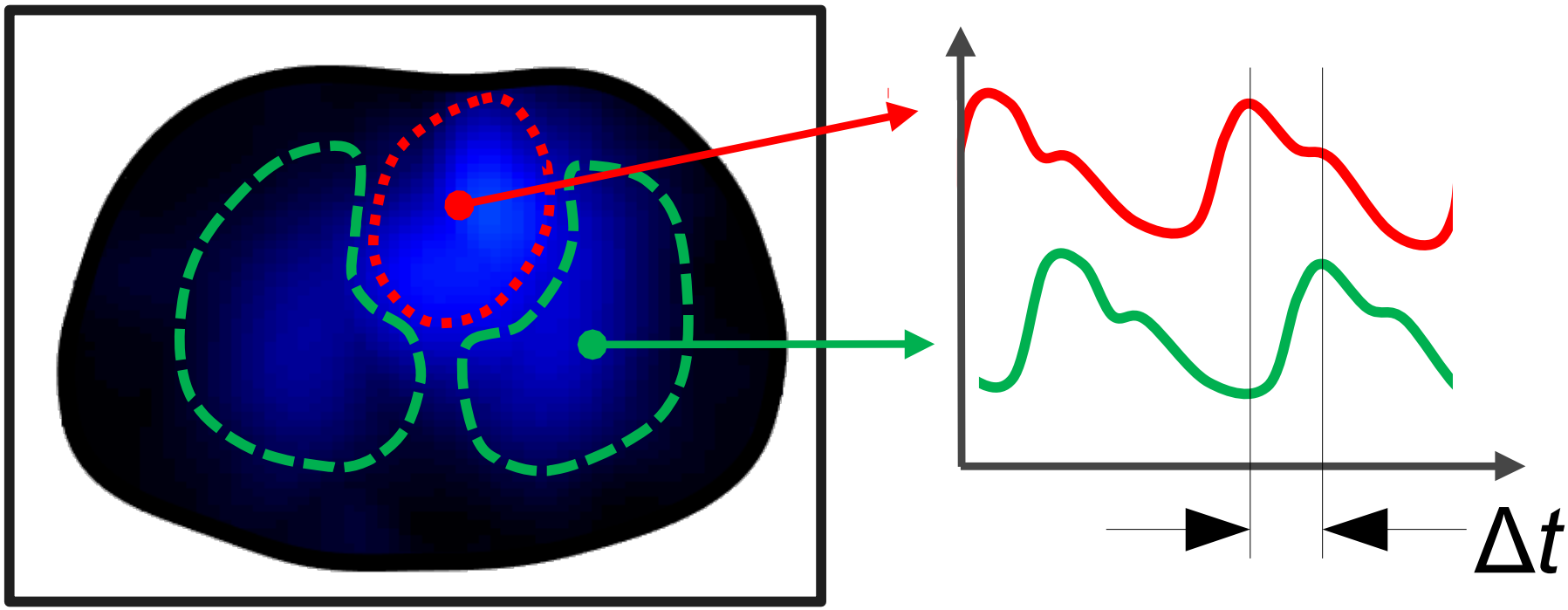
Pulse Wave Velocity: Heart $\rightarrow$ Lungs



Pulse Wave Velocity: Heart $\rightarrow$ Lungs

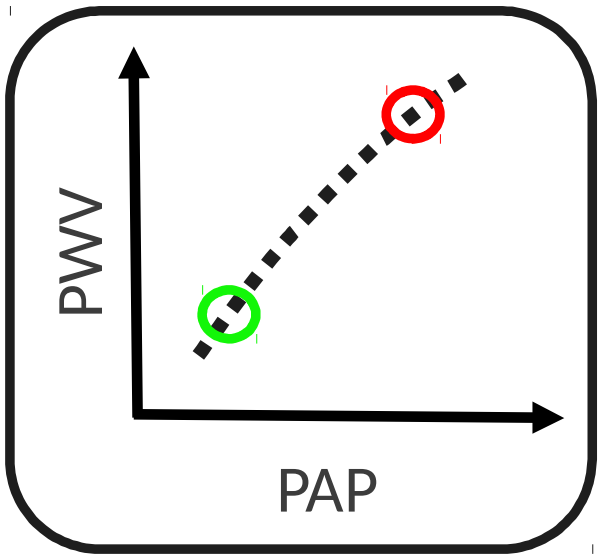


Pulse Wave Velocity: Heart → Lungs



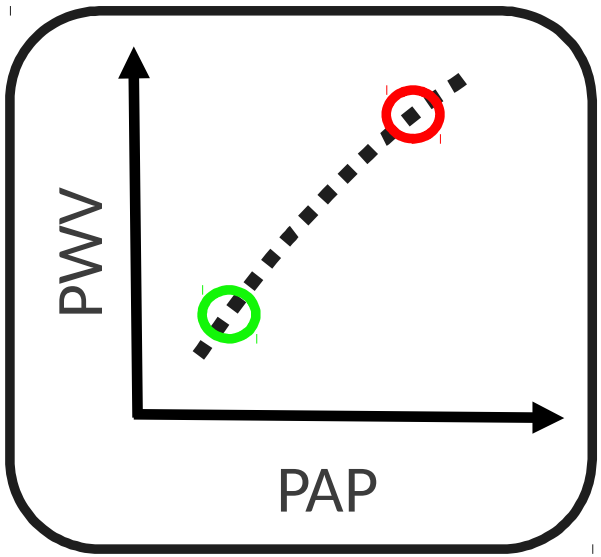
- $\Delta t \downarrow$ as Pressure $\uparrow$

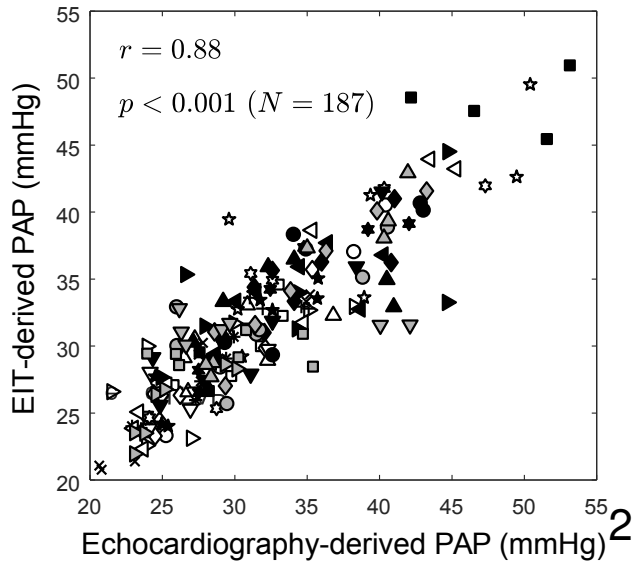
Pulse Wave Velocity: Measure RH Pressure



[2] Proença, (2016) *Physiol Meas* 37:713–726

Pulse Wave Velocity: Measure RH Pressure





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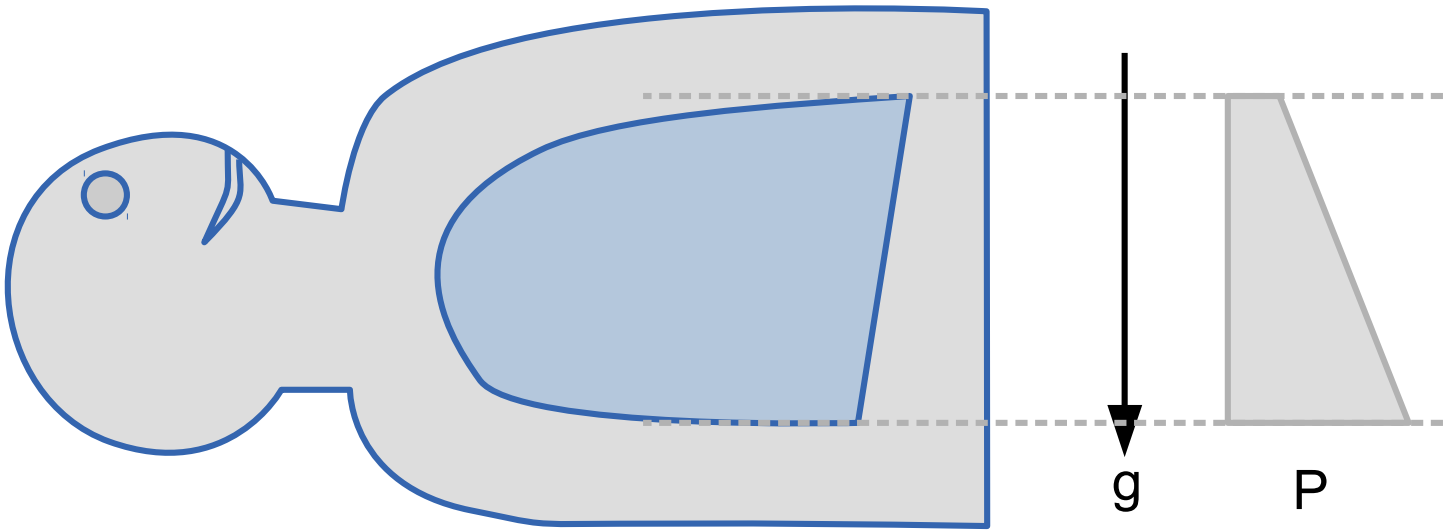
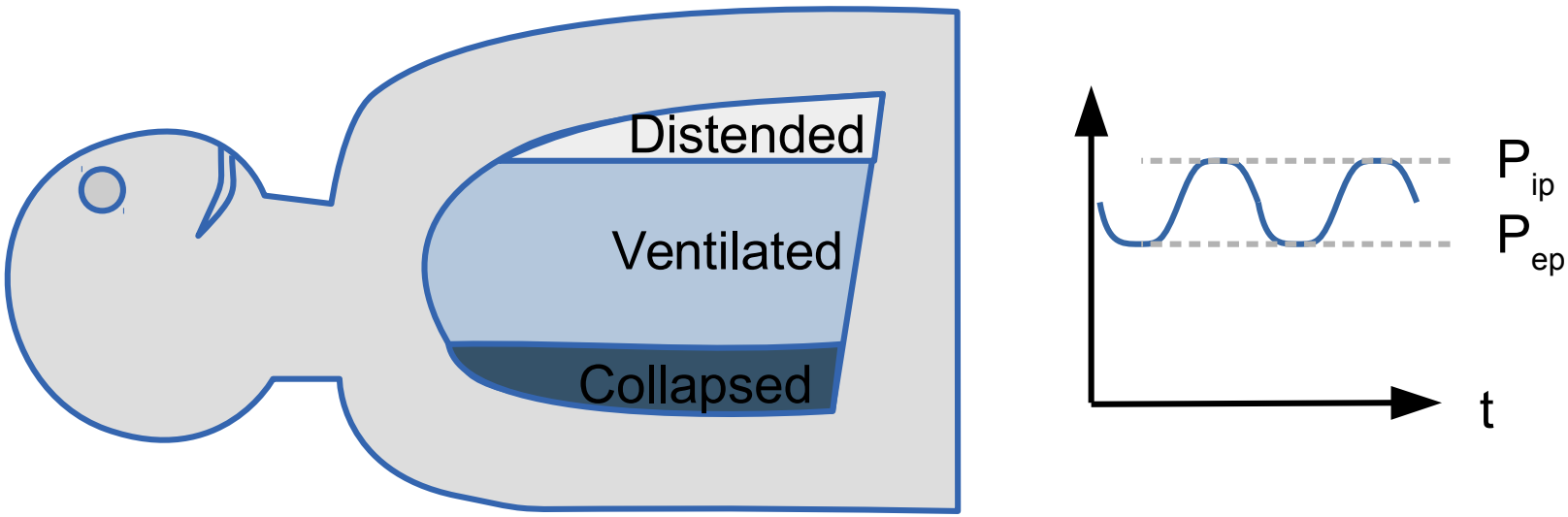
The ventilated patient



Heavy (wet) lungs have a ↑ pressure gradient

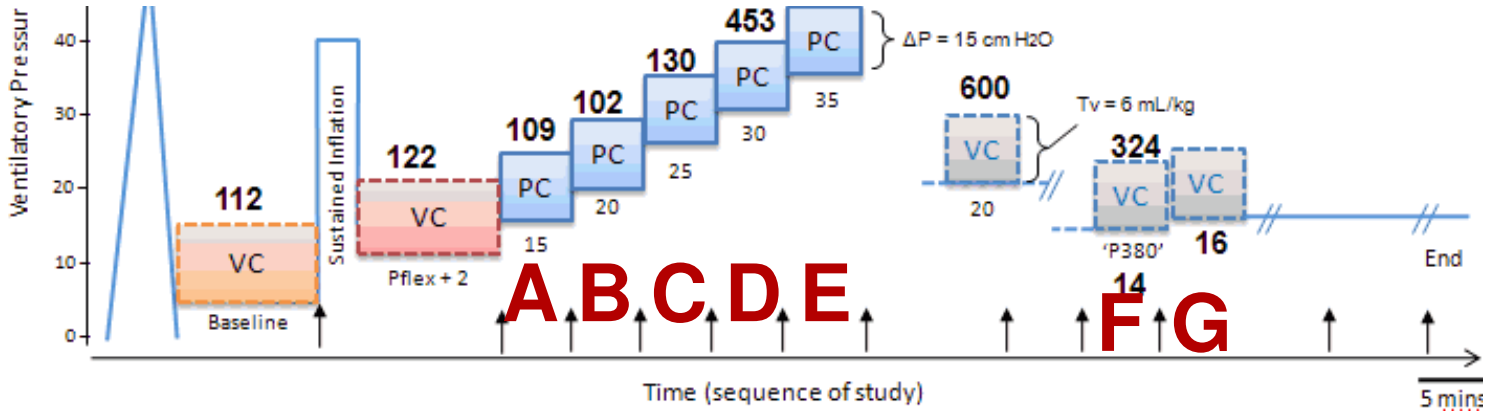
The ventilated patient



Ventilator pressures (P_{ip}, P_{ep}) open and close lungs

EIT + Lung Fluid

Patient: 5.9 years, ARDS triggered by pneumonia. (Gómez-Laberge, IEEE TMI, 2012)



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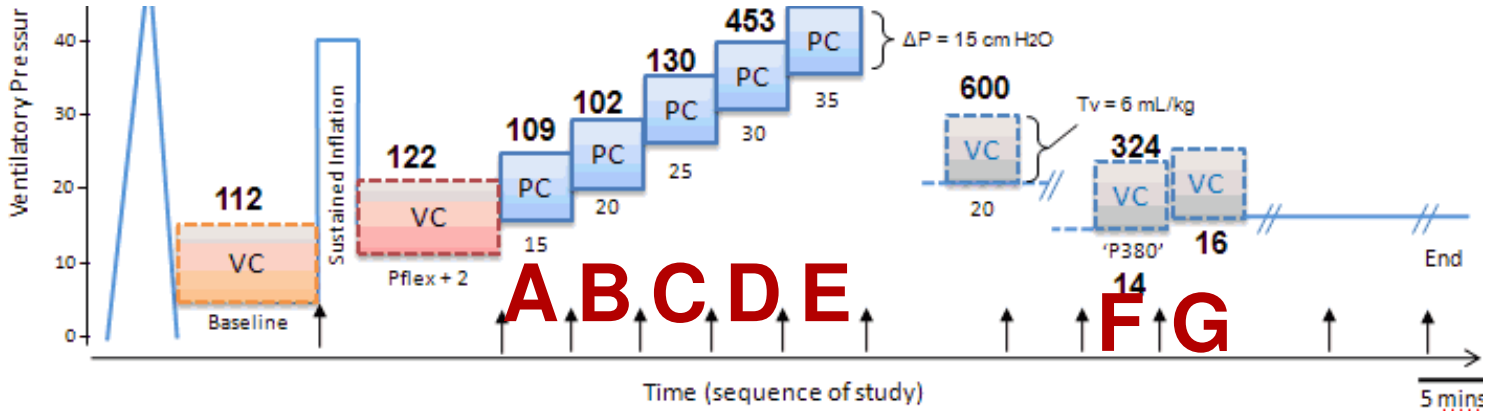
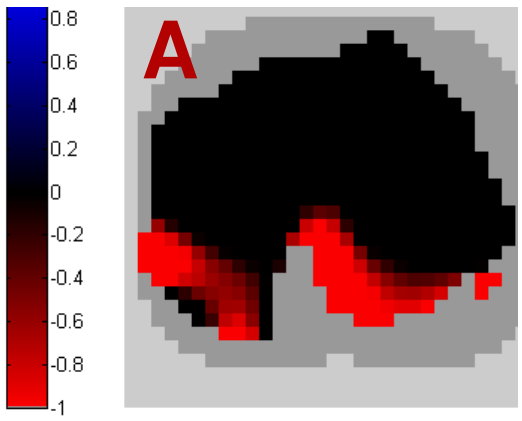


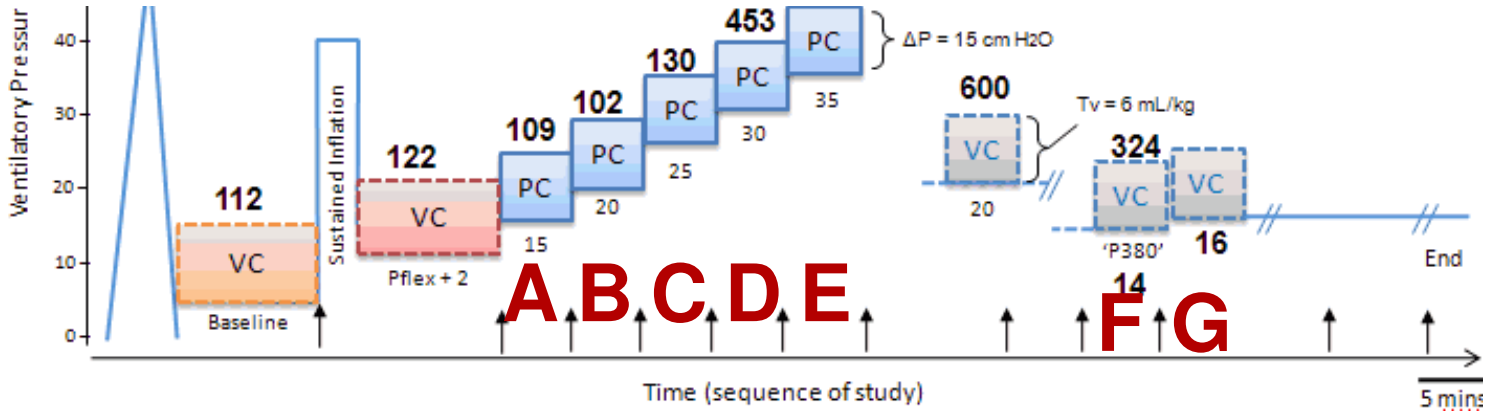
Overdistension



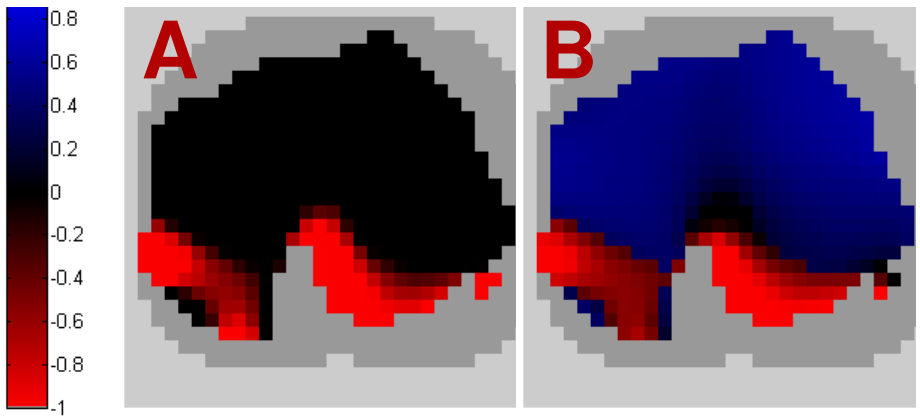
Collapse

EIT + Lung Fluid

Patient: 5.9 years, ARDS triggered by pneumonia. (Gómez-Laberge, IEEE TMI, 2012)



Overdistension



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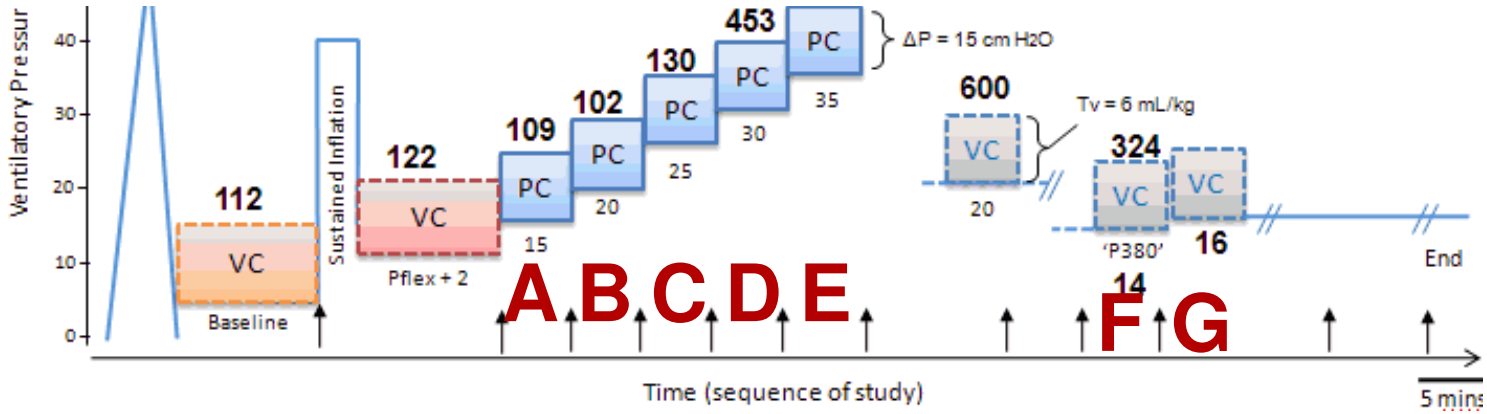

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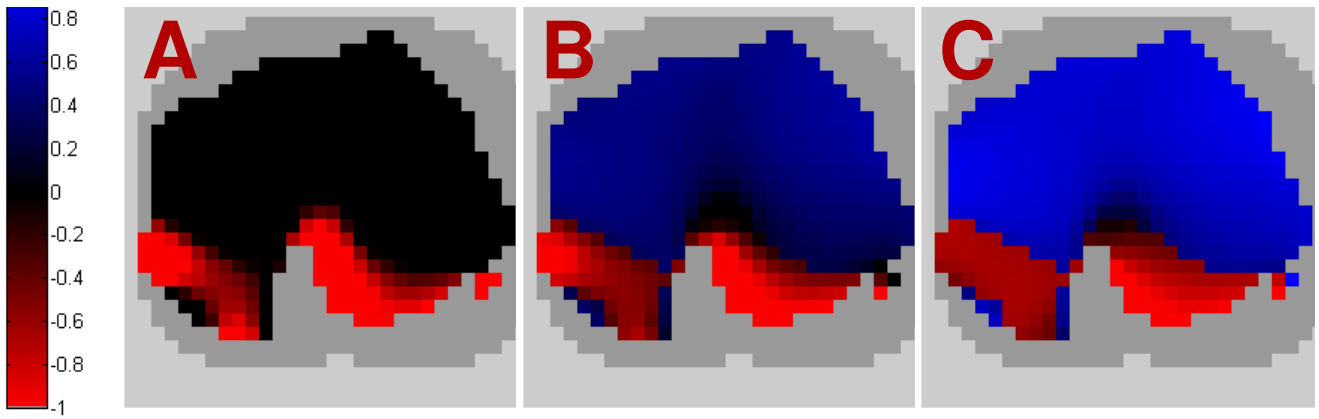

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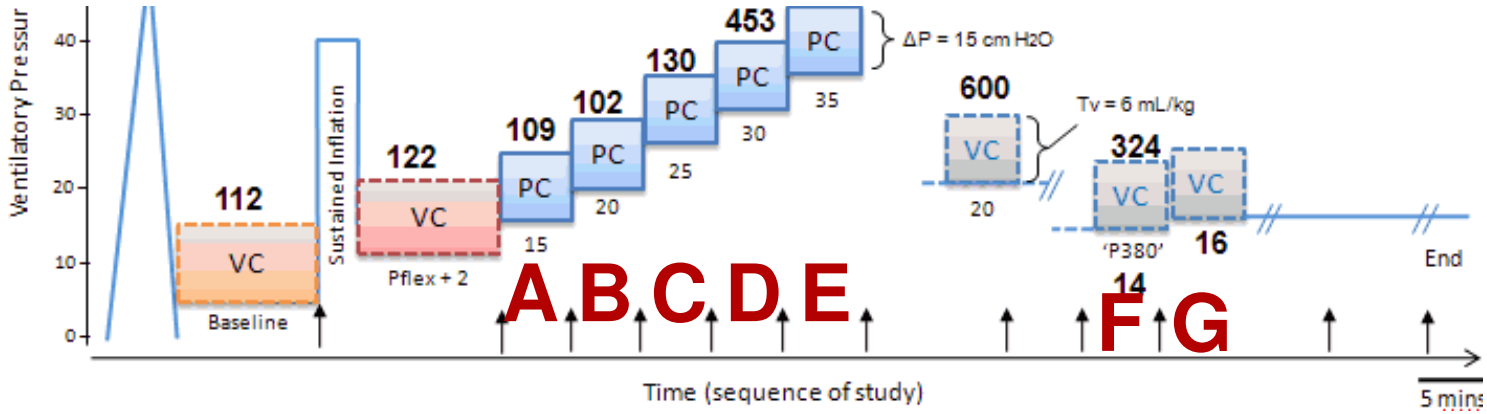

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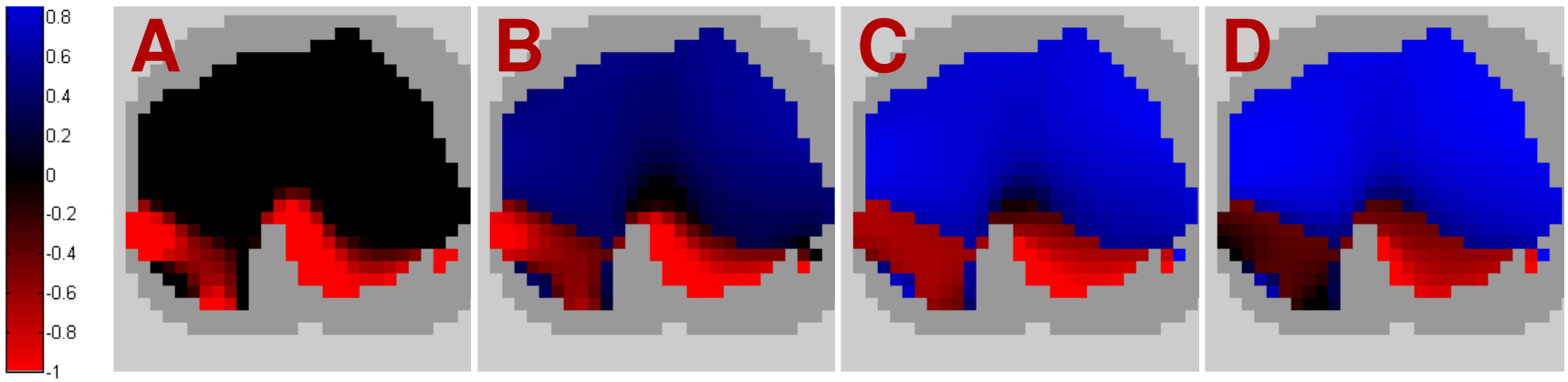

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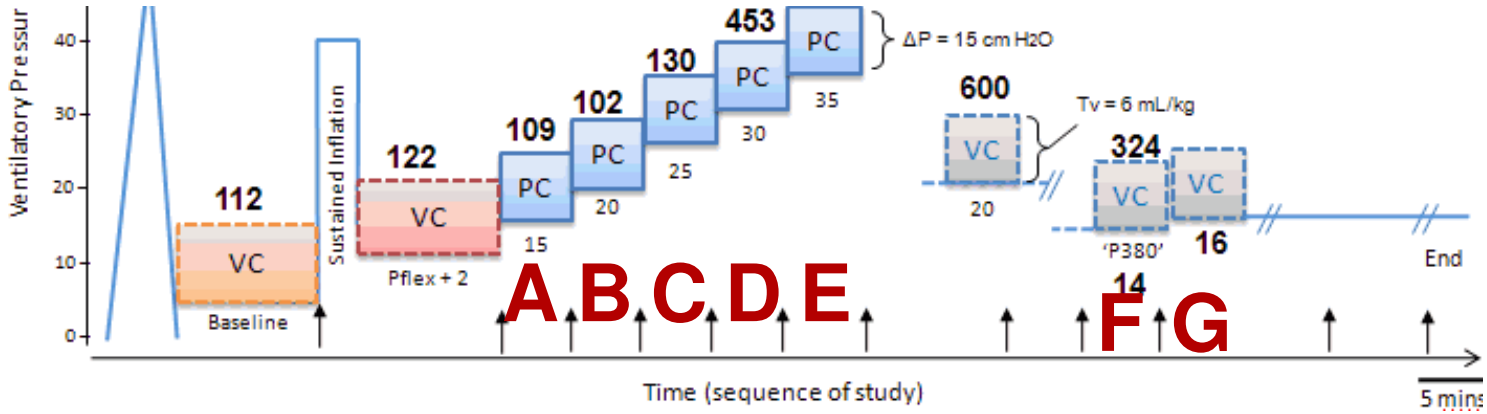

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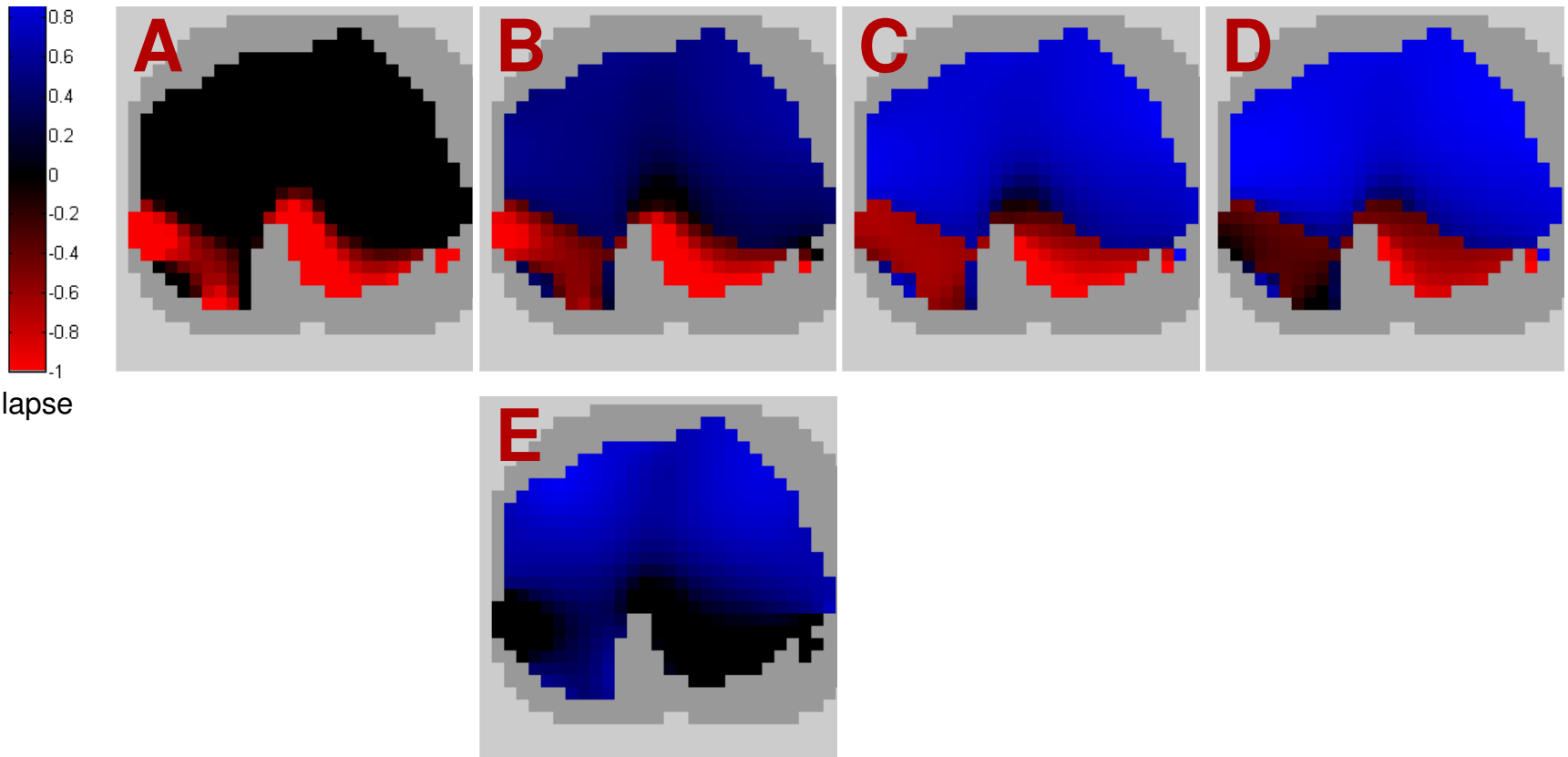

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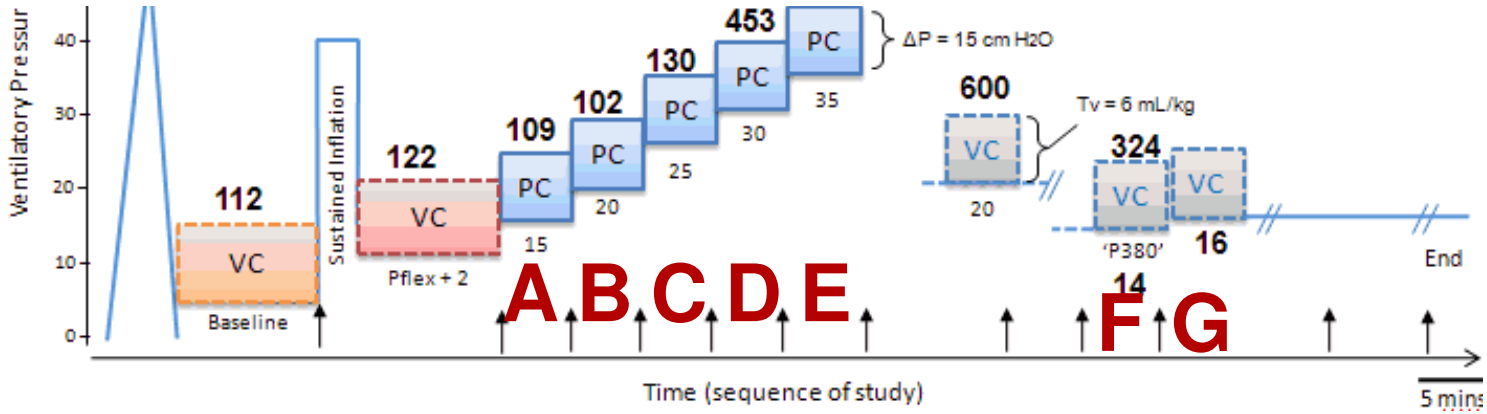

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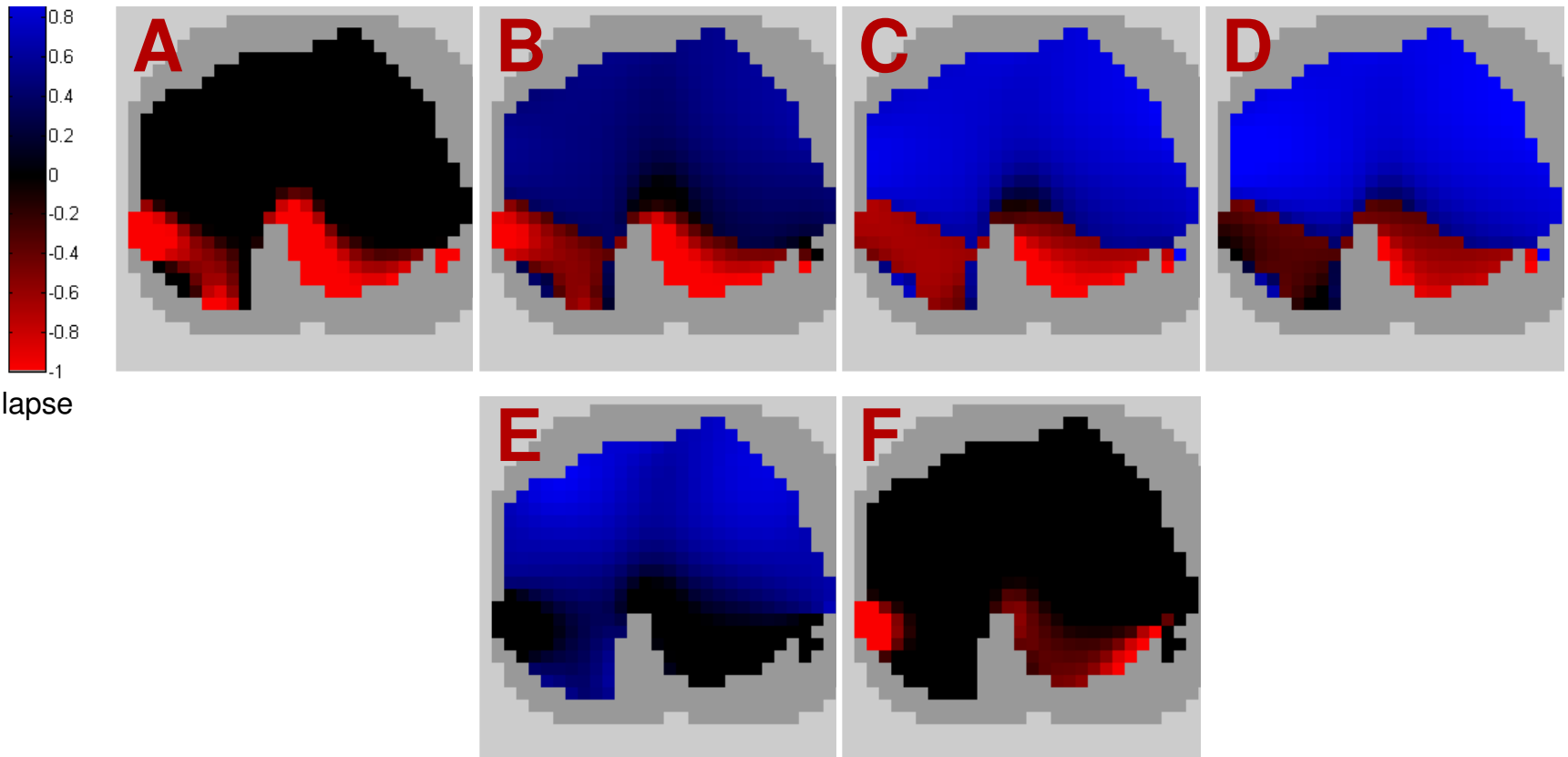

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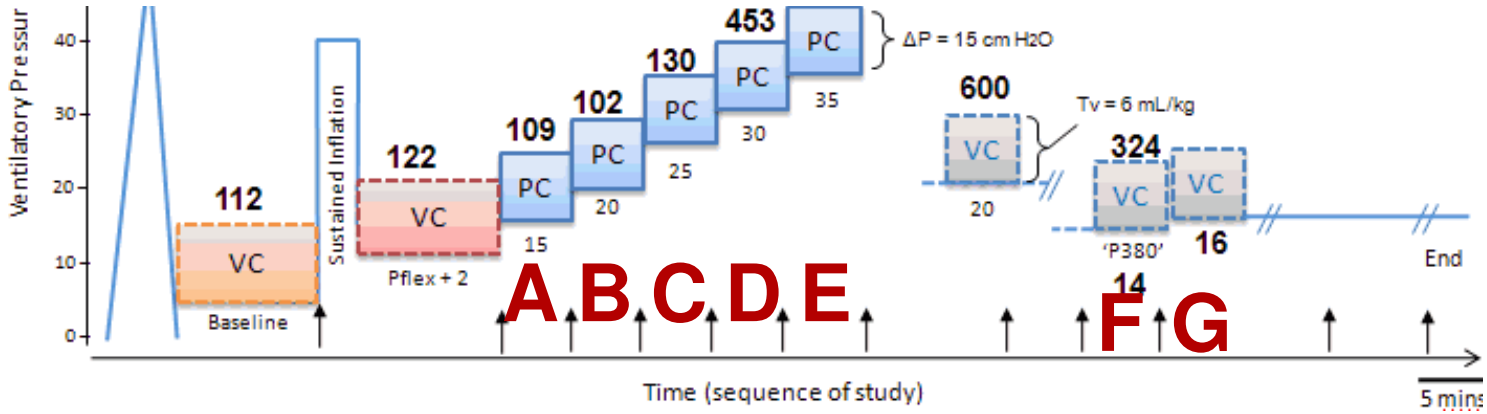

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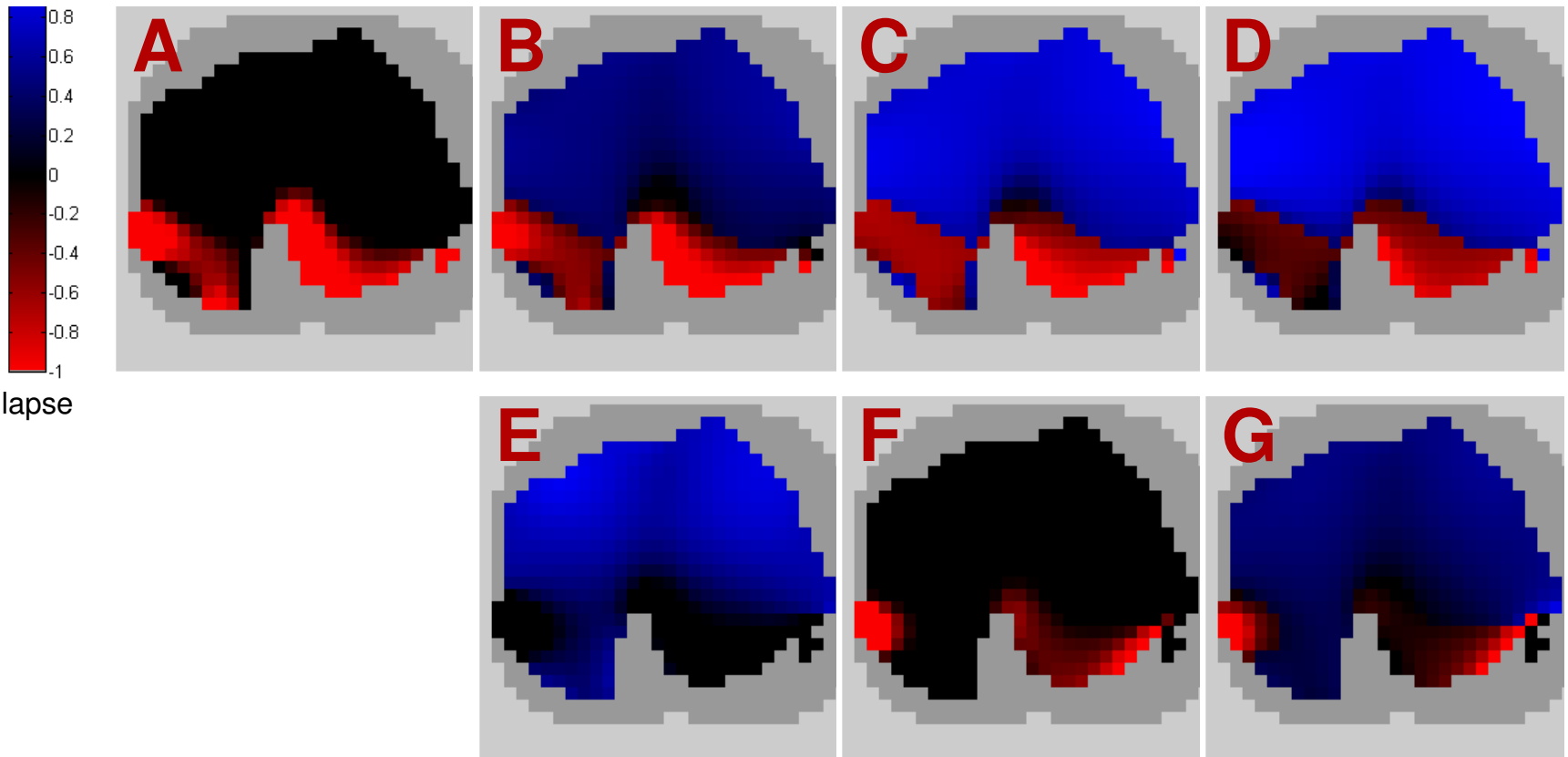

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Contrast Agents: hypertonic NaCl into the veins

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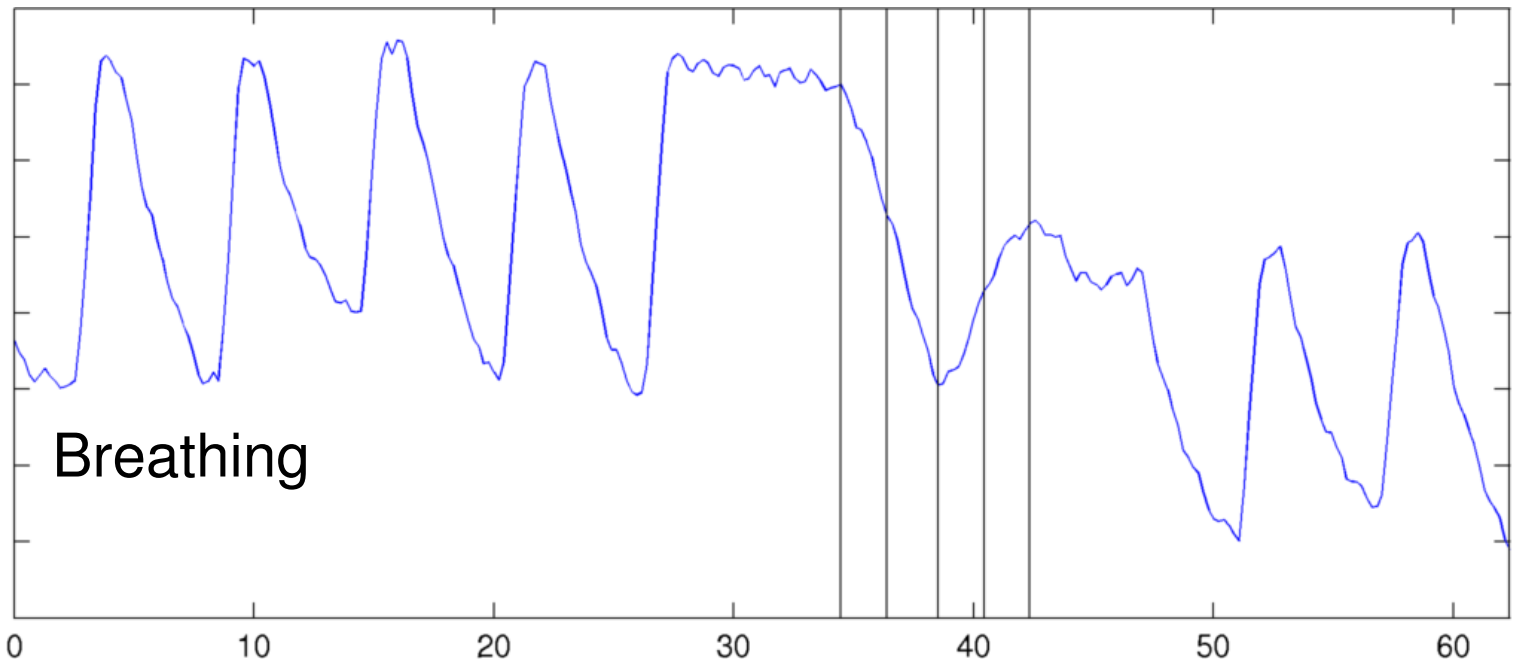
Adler *et al*, EIT Conf, 2016



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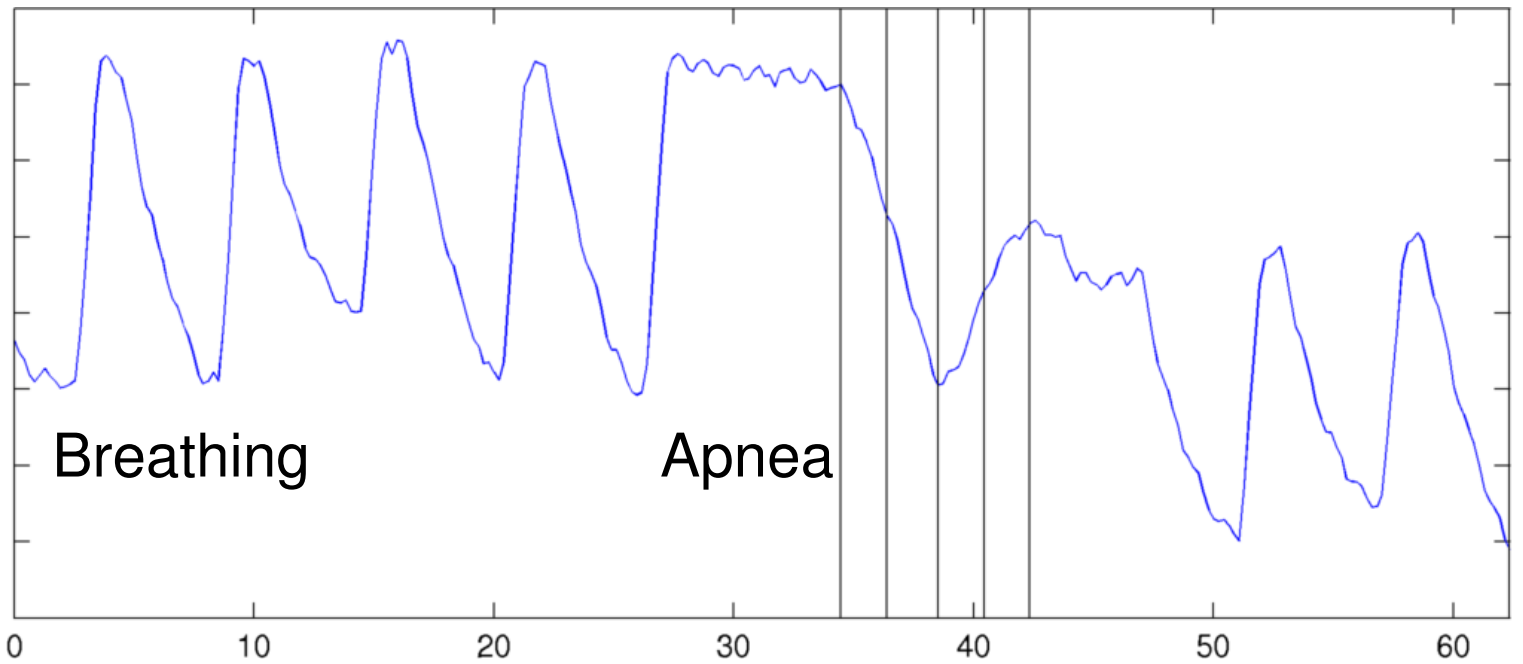

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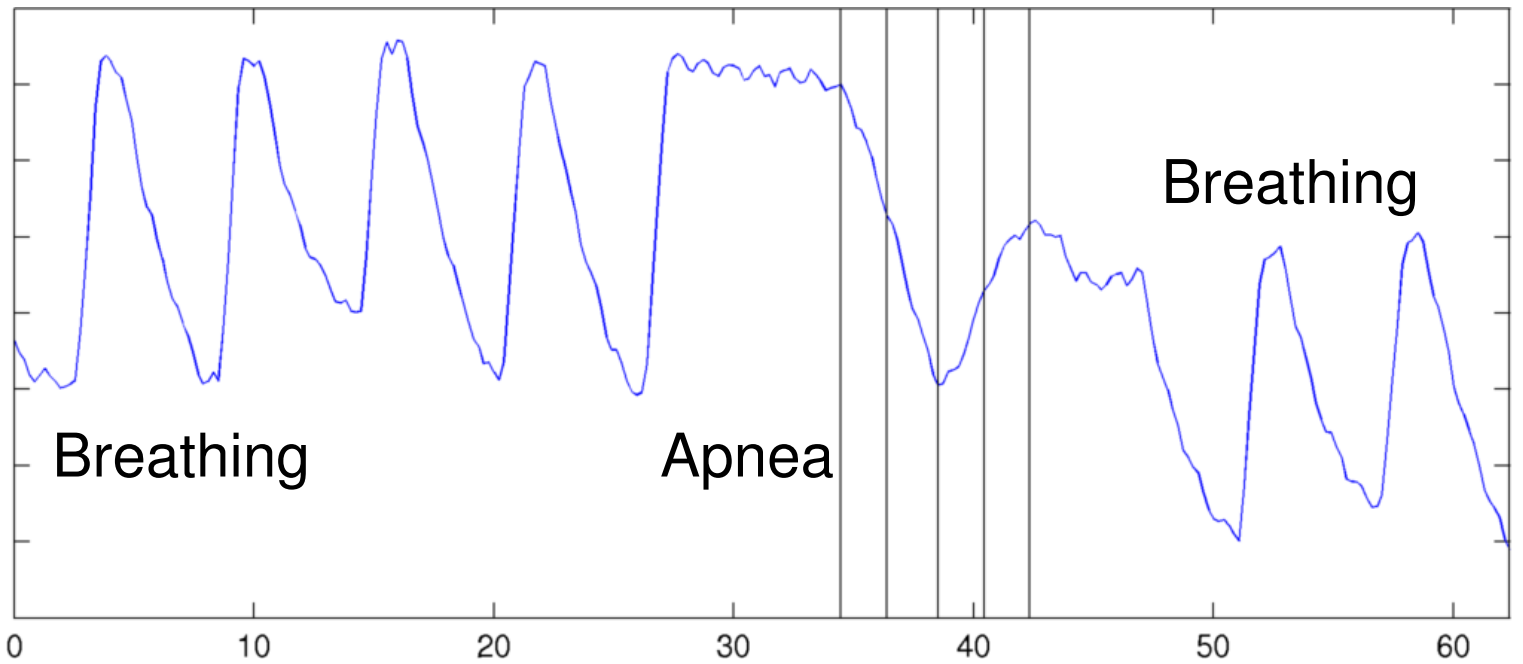

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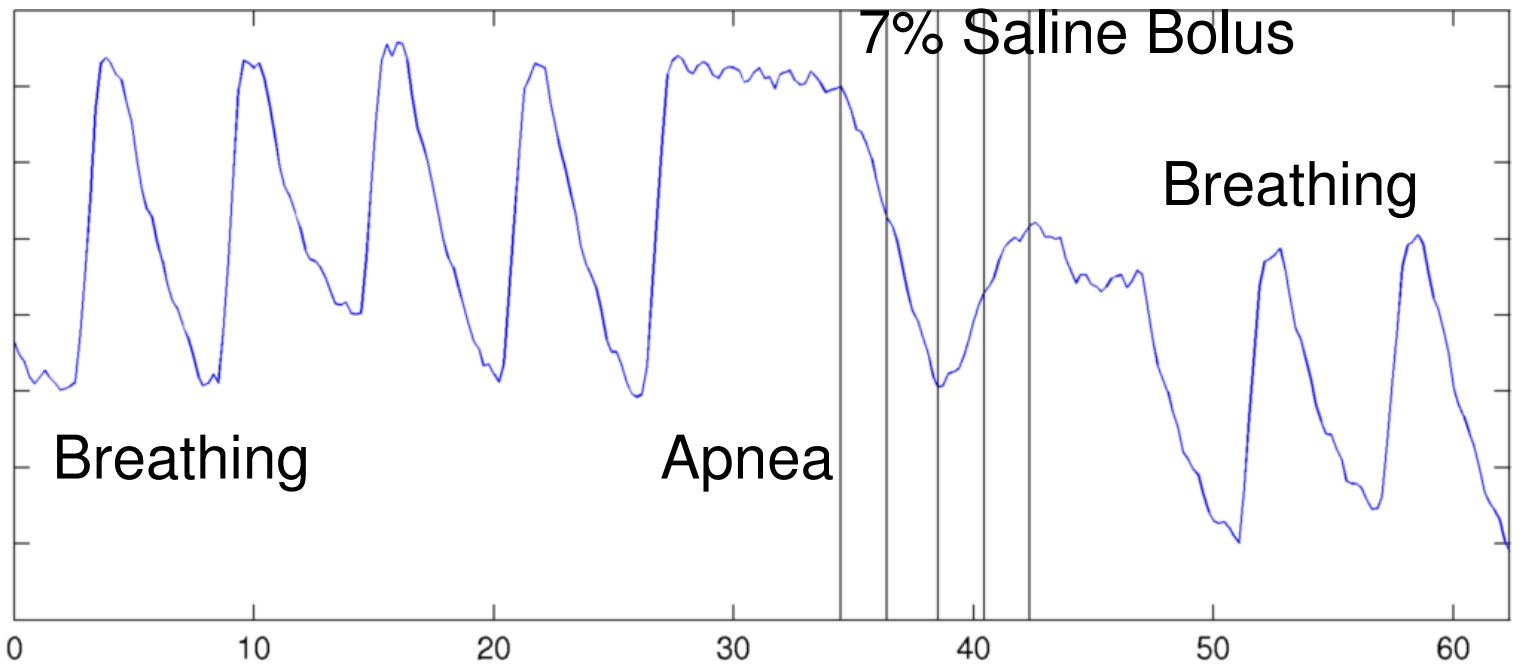

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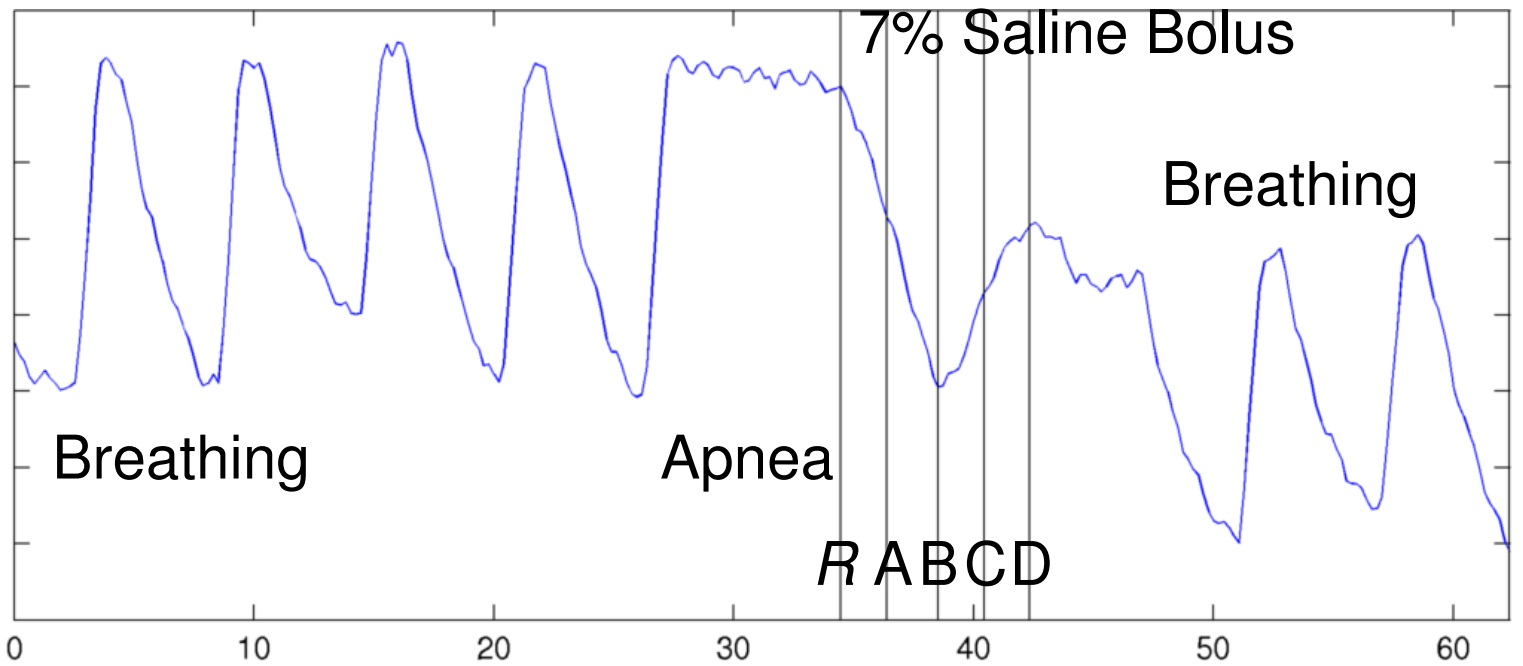

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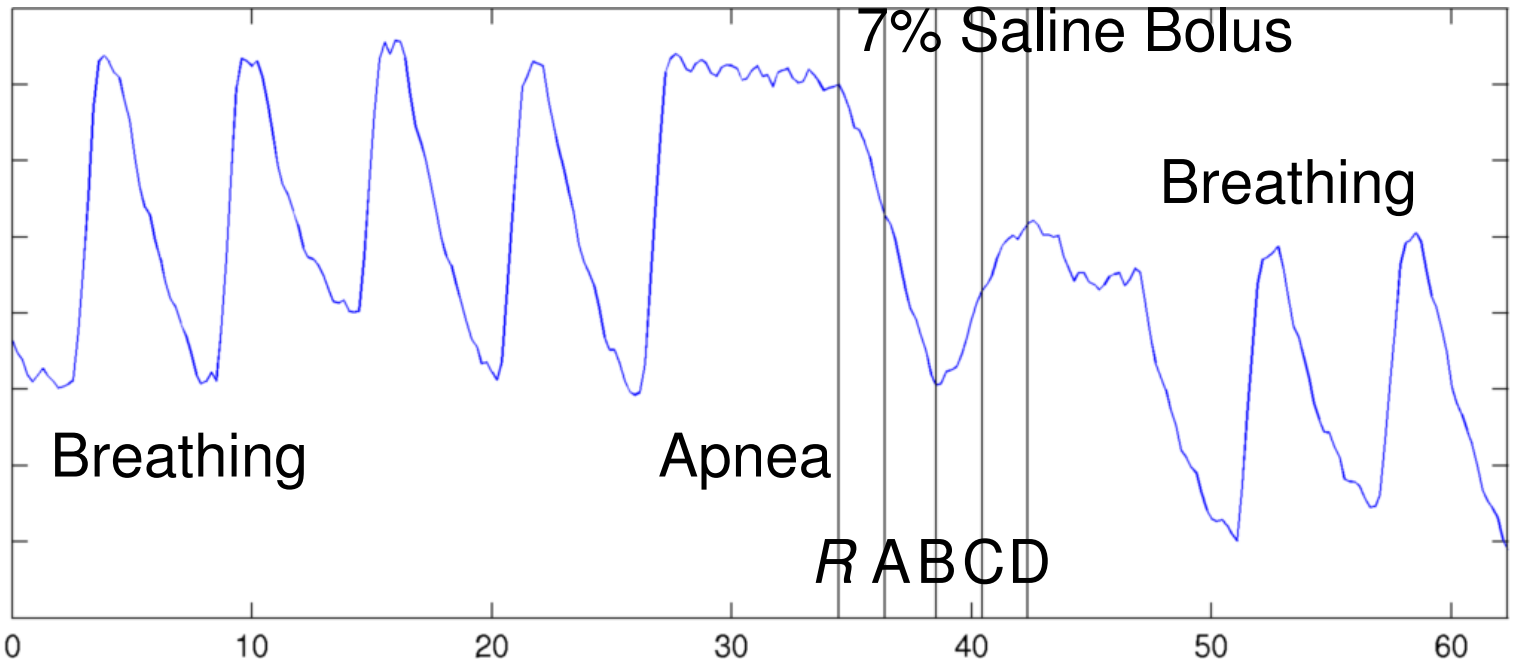
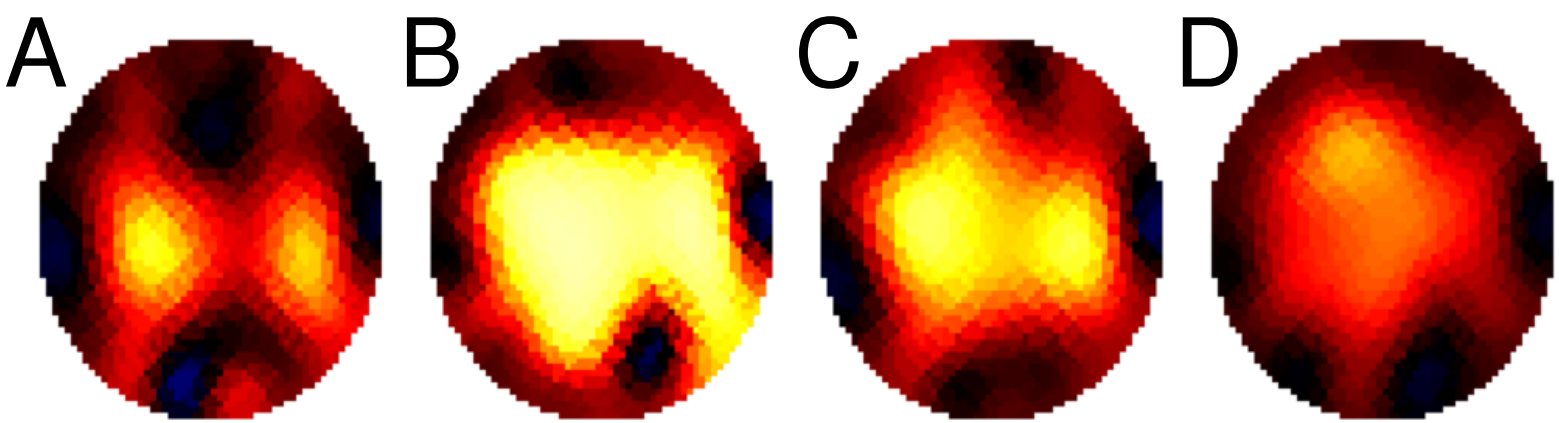
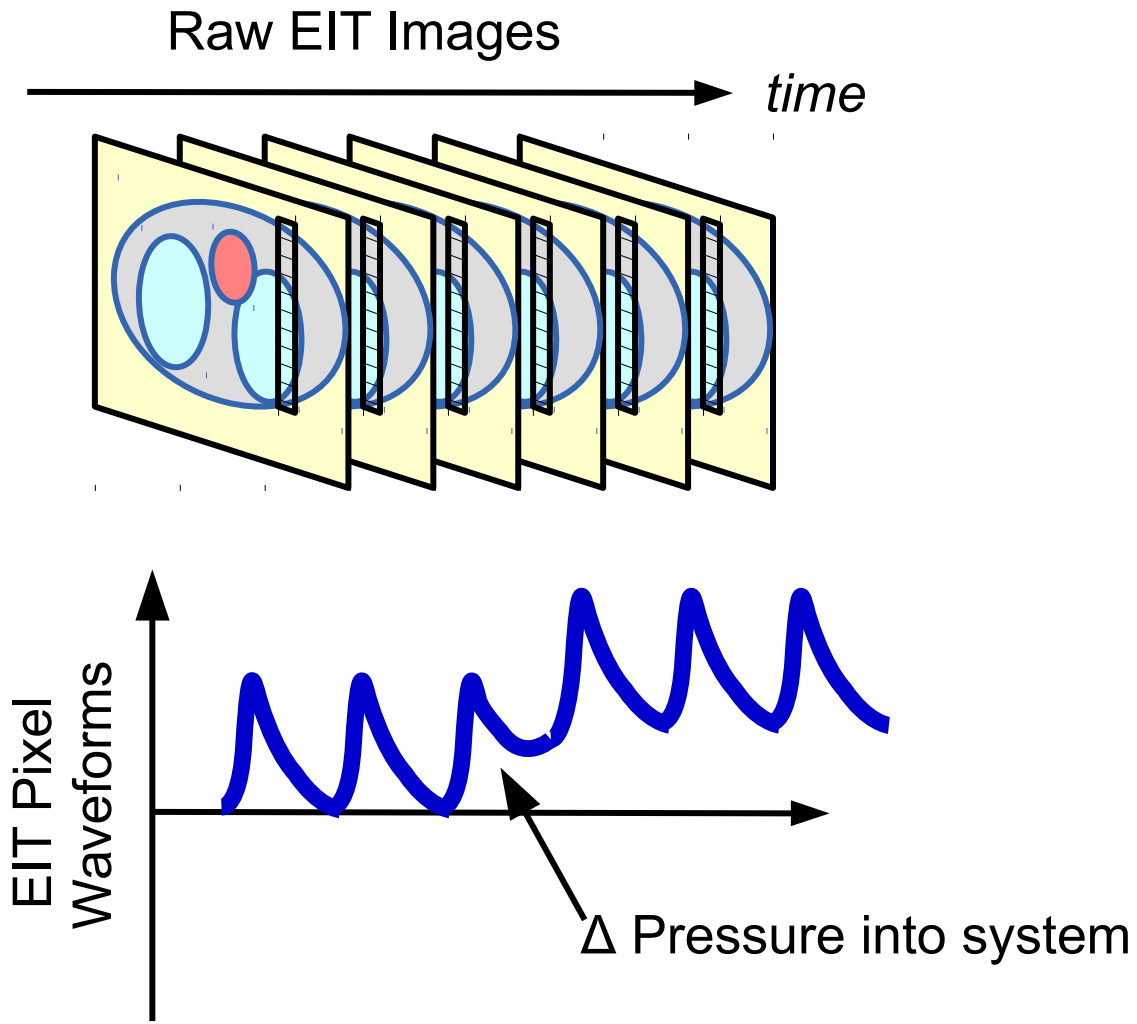




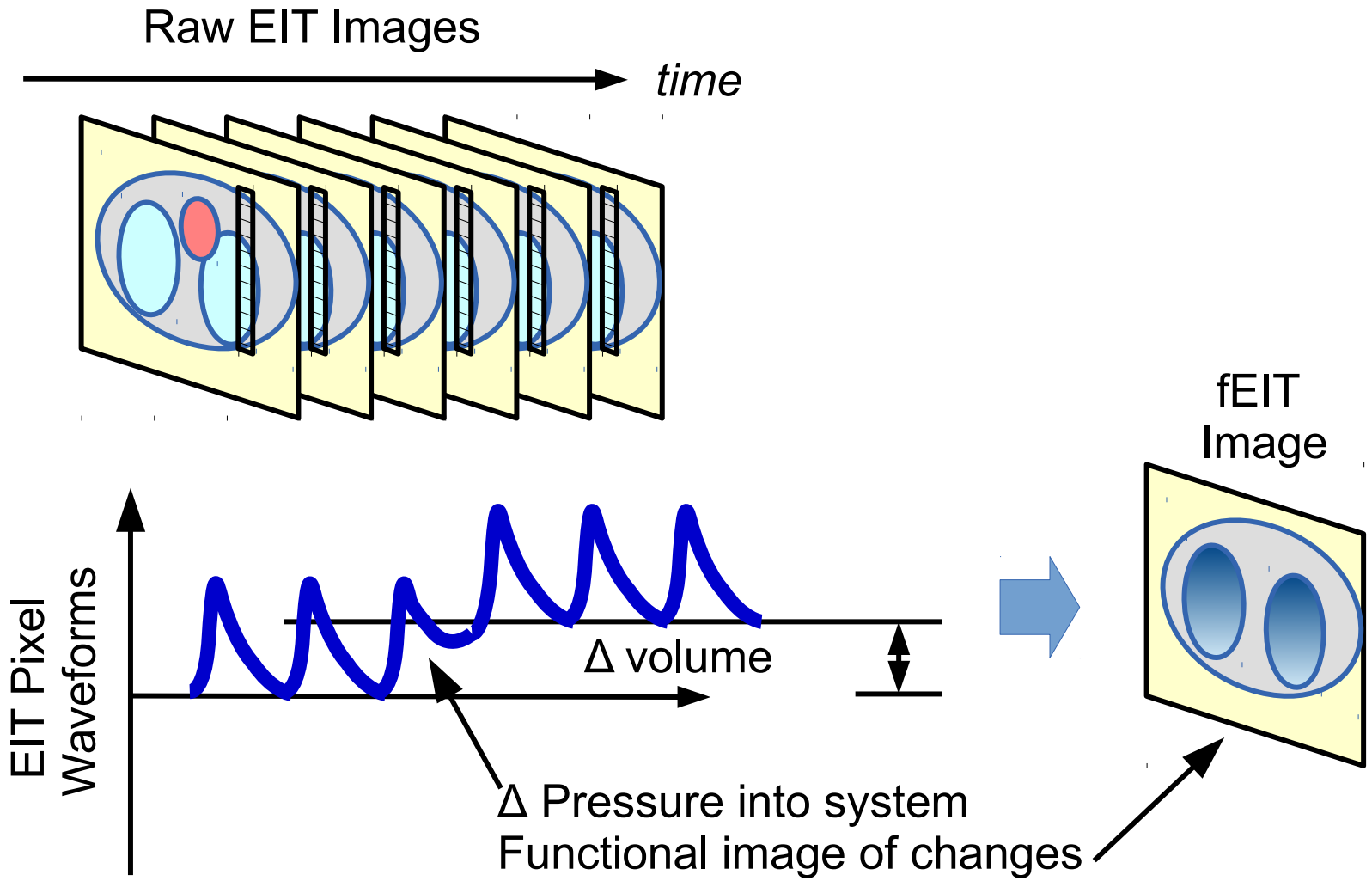
Any useful ideas from Medical tomography?

- Functional Imaging
- Temporal Dynamics

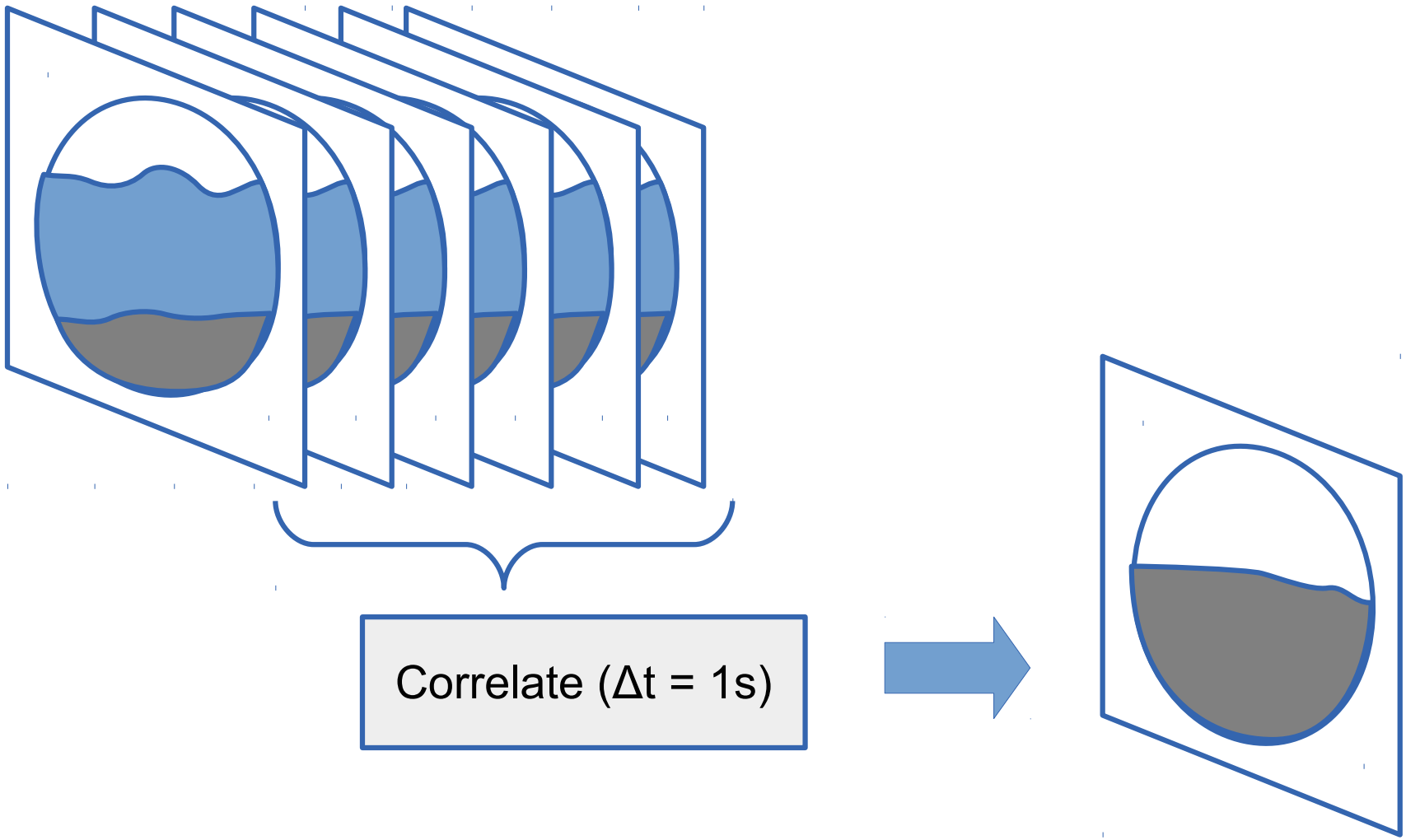
Functional Imaging



Functional Imaging



Temporal dynamics



Flow rate? Turbulence?

Process tomography: what's being done in medical applications?

Abstract: Electrical measurements on the surface are used to calculate internal images in many different fields. In process tomography images are used to monitor pipe flows and mixing. In geophysics, images are useful to understand hydrogeology and metallic ore locations. And for medical applications, images are useful to monitor movements of air and fluids in the body. Unfortunately, these communities do not share information well, and similar ideas are reinvented many times. The goal of this talk is to introduce some of the techniques and applications of electrical imaging in biomedical applications and to relate them to process tomography.