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Current distribution and impedance in monopolar needle electrode systems

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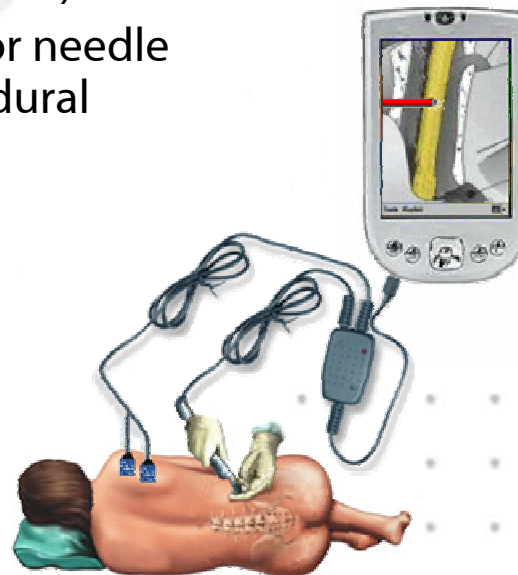
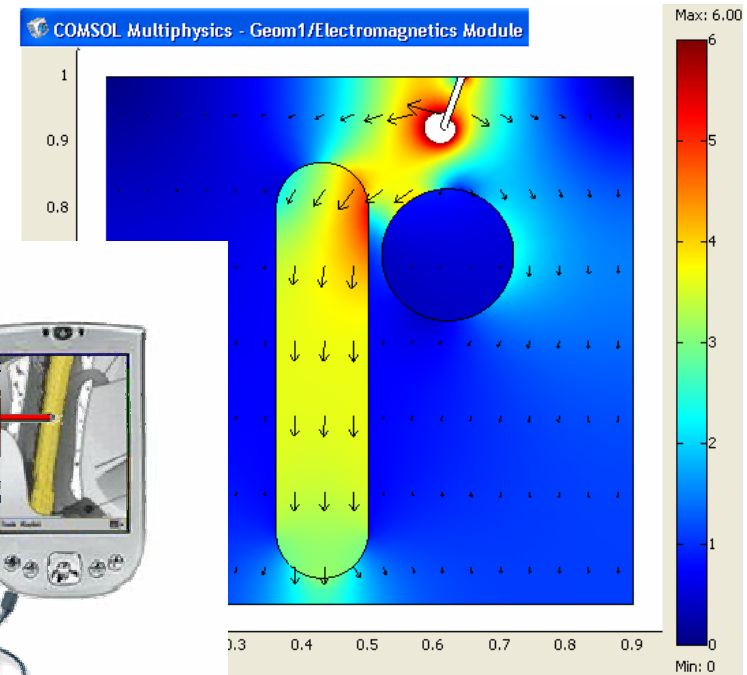




Current distribution and impedance in monopolar needle electrode systems

Motivation:

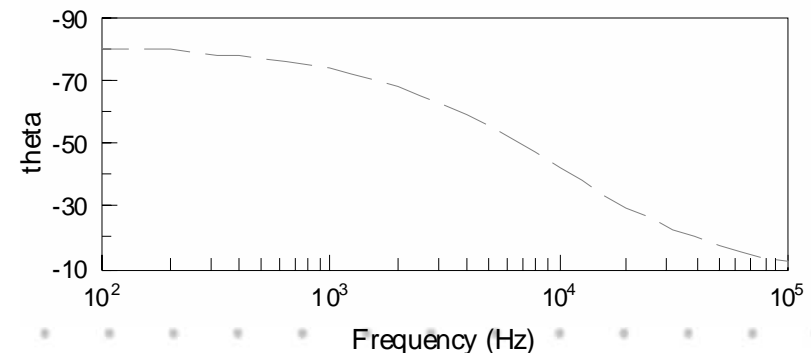
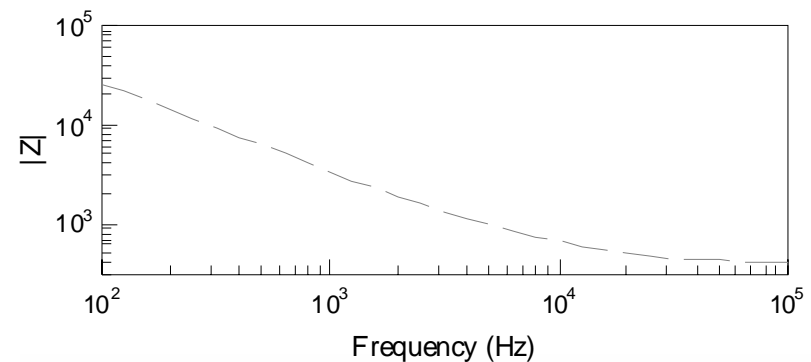
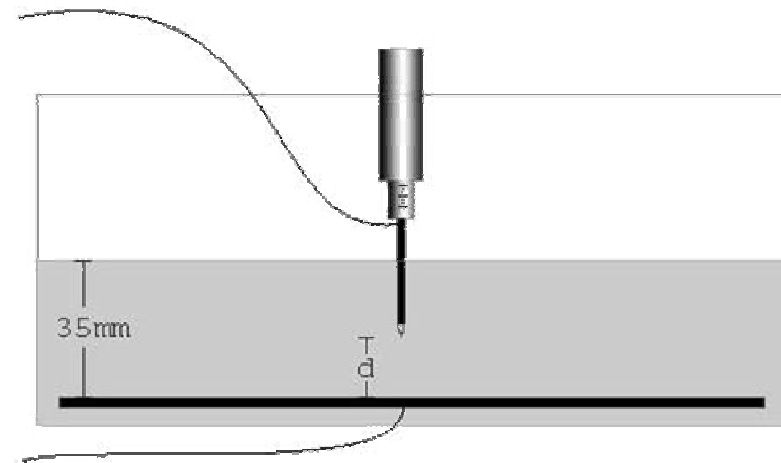
- Obtain fundamental knowledge and better descriptions of electrode systems used in clinics today (e.g. Ablation and PNB)
- Develop a new method for needle position guiding (e.g. Epidural anesthesia)





Theoretical modeling

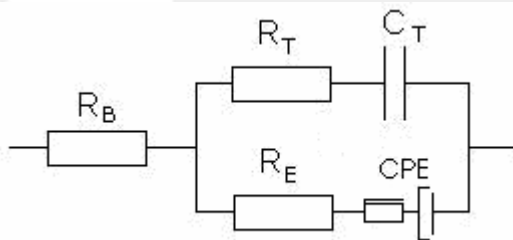
- Lab experiments were done with a small needle electrode 0,3 mm² ("Medtronic, Monopolar Needle electrode") in a insulating vessel (15 x 20 cm).
- A large neutral electrode (15000 mm²) was placed at the bottom, and saline (NaCl 0,9%) was filled to 35,0 mm above the electrode.
- Small needle electrode and large neutral electrode gave monopolar measurement.
- Complex Impedance spectrum was measured with a Solartron 1260/1294 system





Theoretical modeling

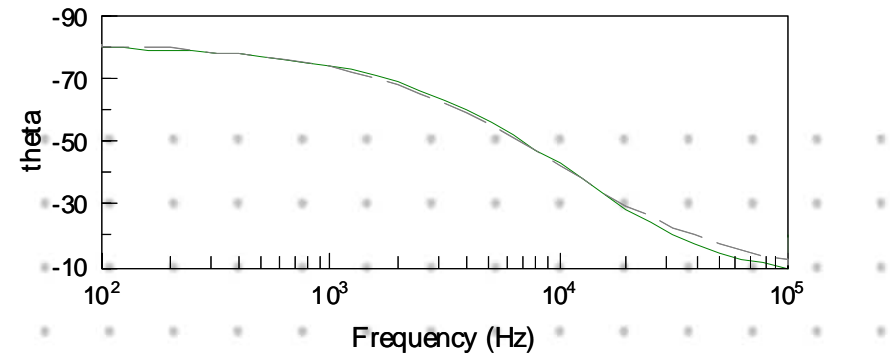
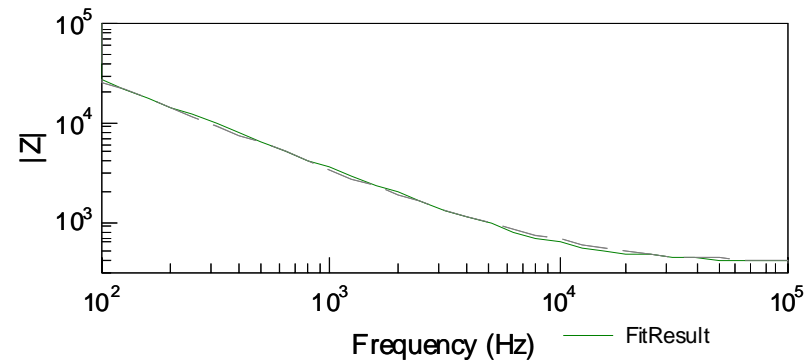
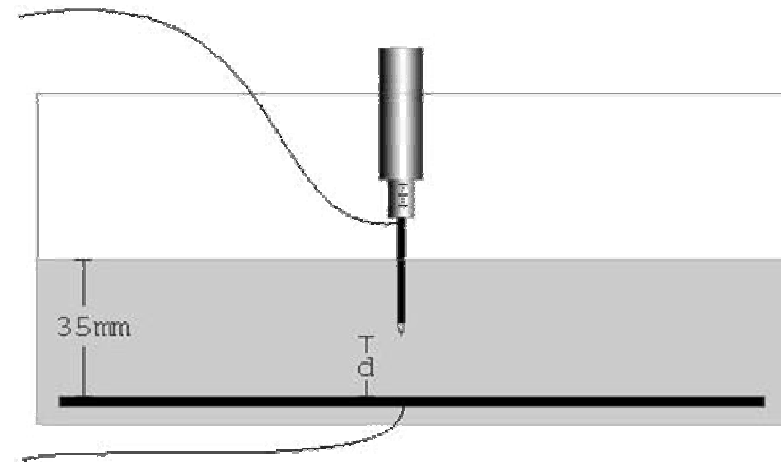
- To describe the electrical properties of the needle, a model of discrete electrical components was developed



R_T and C_T - Teflon insulation

R_E and CPE (Constant Phase Element)
- electrode surface

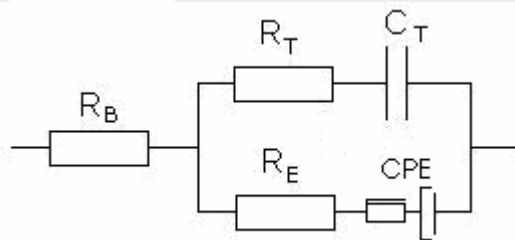
R_B - bulk impedance





Theoretical modelling

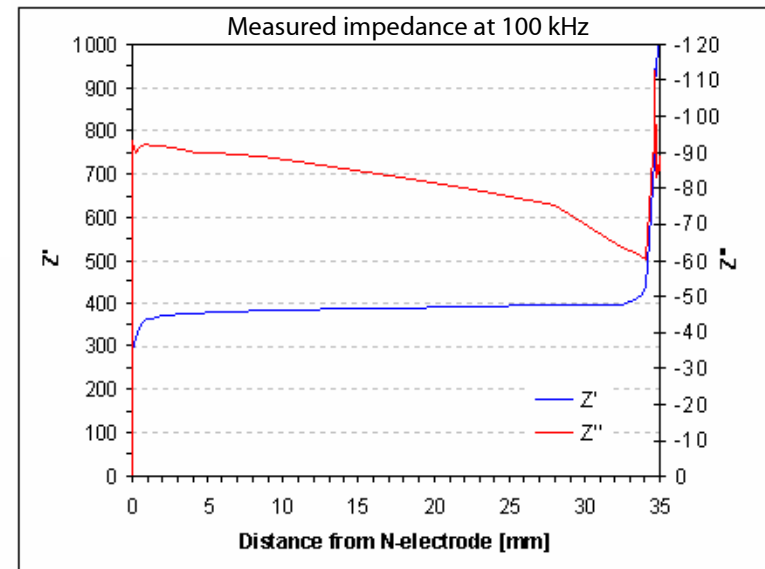
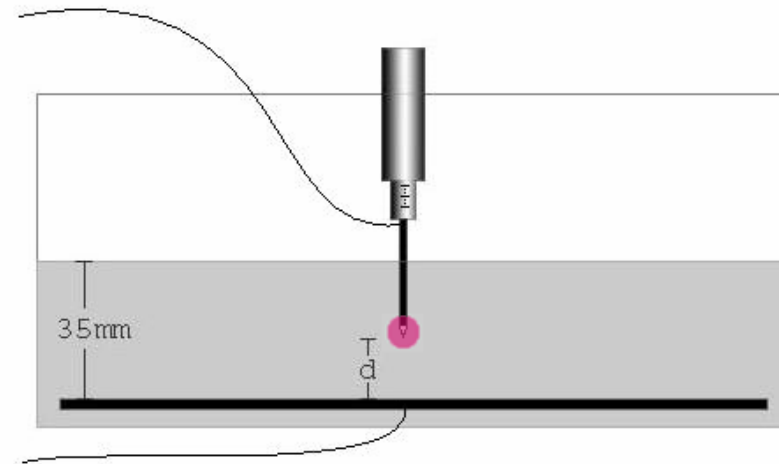
- To describe the electrical properties of the needle, a model of discrete electrical components was developed
- We also measured the Impedance at 100 kHz while the needle was moved in small steps (micrometer screw)



R_T and C_T - Teflon insulation

R_E and CPE (Constant Phase Element)
- electrode surface

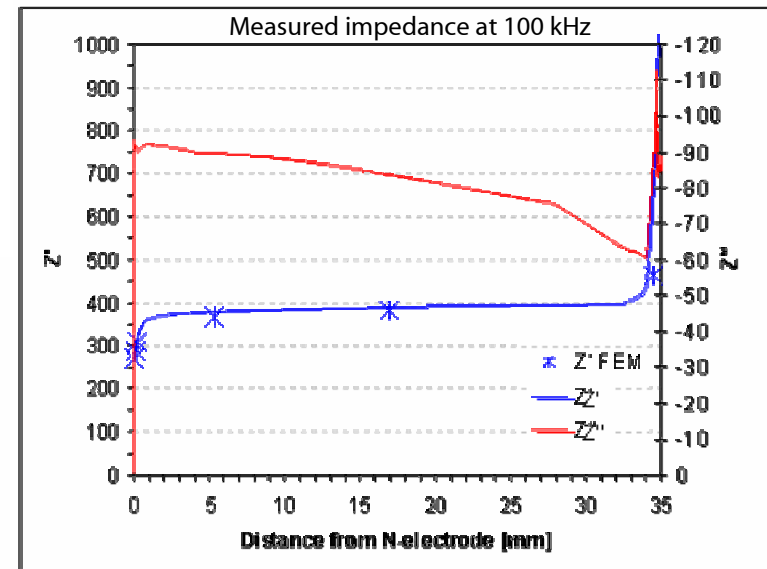
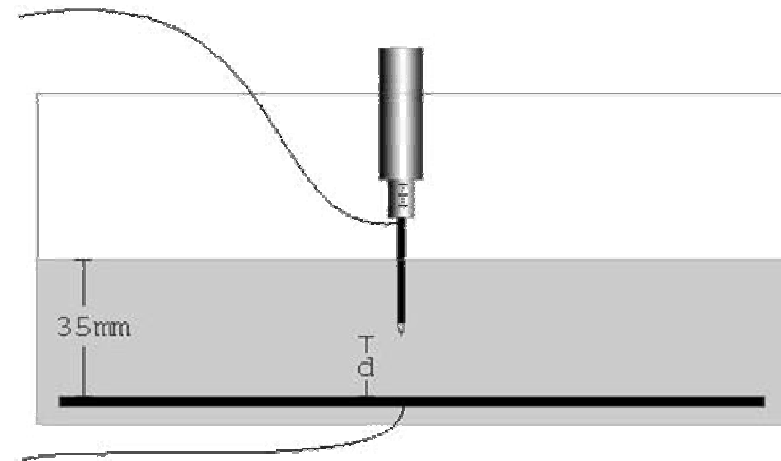
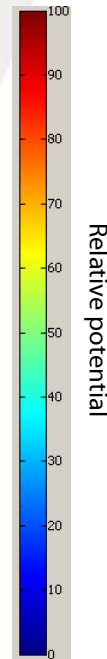
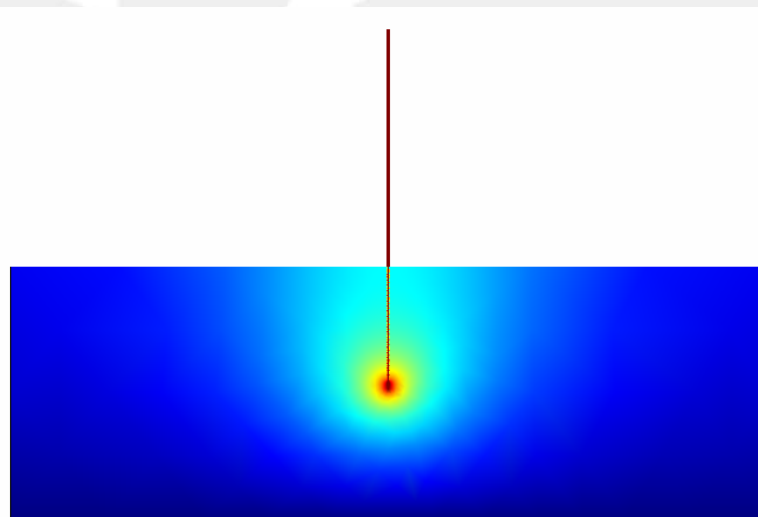
R_B - bulk impedance





Sensitivity zone

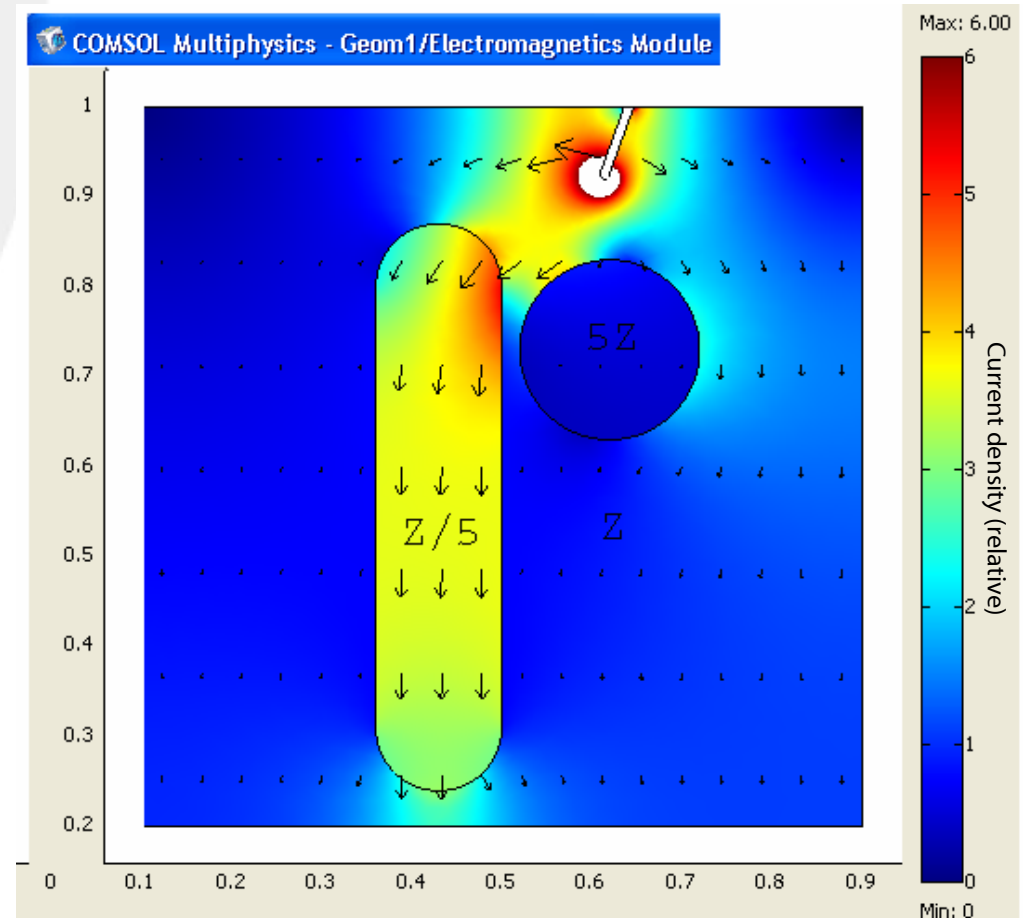
- Modeling was followed by simulations with Finite Element Analysis (Comsol Multiphysics)





Current distribution

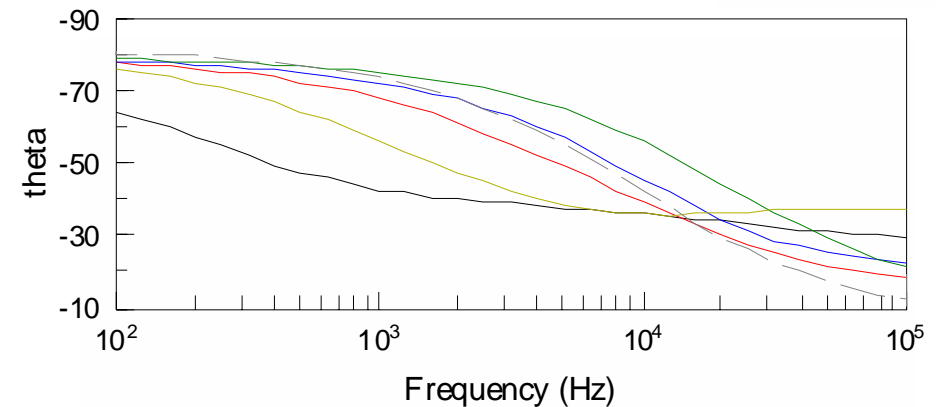
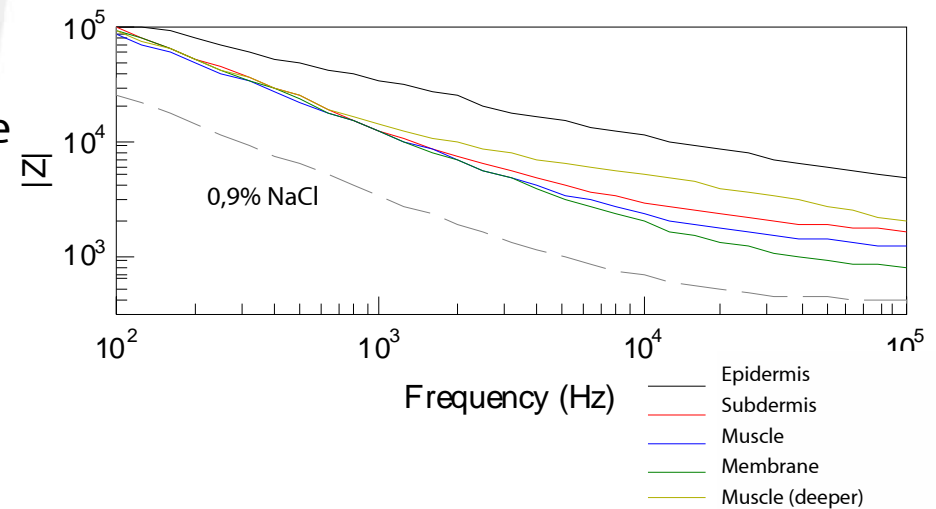
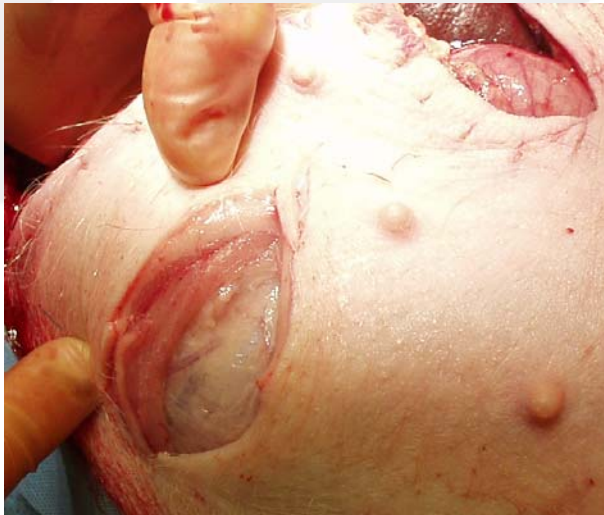
- Simulations was done to explain examples from the clinic
- With reliable impedance data this method can be a important tool (tissue and Tissue-electrode-system)





In-vivo tissue measurements

- Impedance spectra was measured for different types of pig tissue in-vivo
- The spreading of the data confirms the feasibility of our methods





Needle position guiding

Laboratory experiment

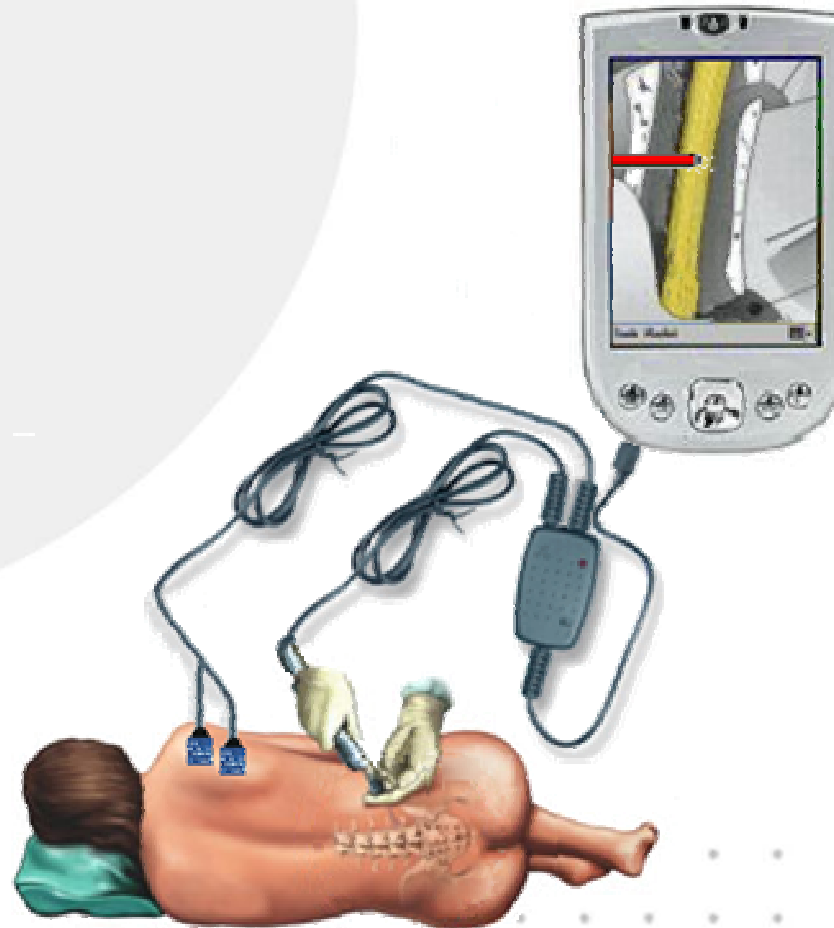
- A piece of bacon was used as a model
- The impedance at 10 kHz was measured as function of time
- By using constant insertion speed we could reconstruct the position of the needle
- A visual representation of the result was made by plotting the measured impedance modulus on a picture of the bacon
- We found distinct differences in modulus between fat and muscle tissue





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Needle position guiding





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Thank you for listening !

