Can you spot the dangerous ones?

Towards Multiscale Models for Bioimpedance of Human Skin with COMSOL Multiphysics

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The outline is as follows

- Impedance measurements of skin
- Mathematical model and implementation in COMSOL Multiphysics
- Calibration and validation with measurements
- Model reduction
- Additional length scales and resolution
- Conclusions and outlook

Impedance measurements of skin

(a)

(b)

Stratum Corneum

Epidermis

Dermis

Subcutis
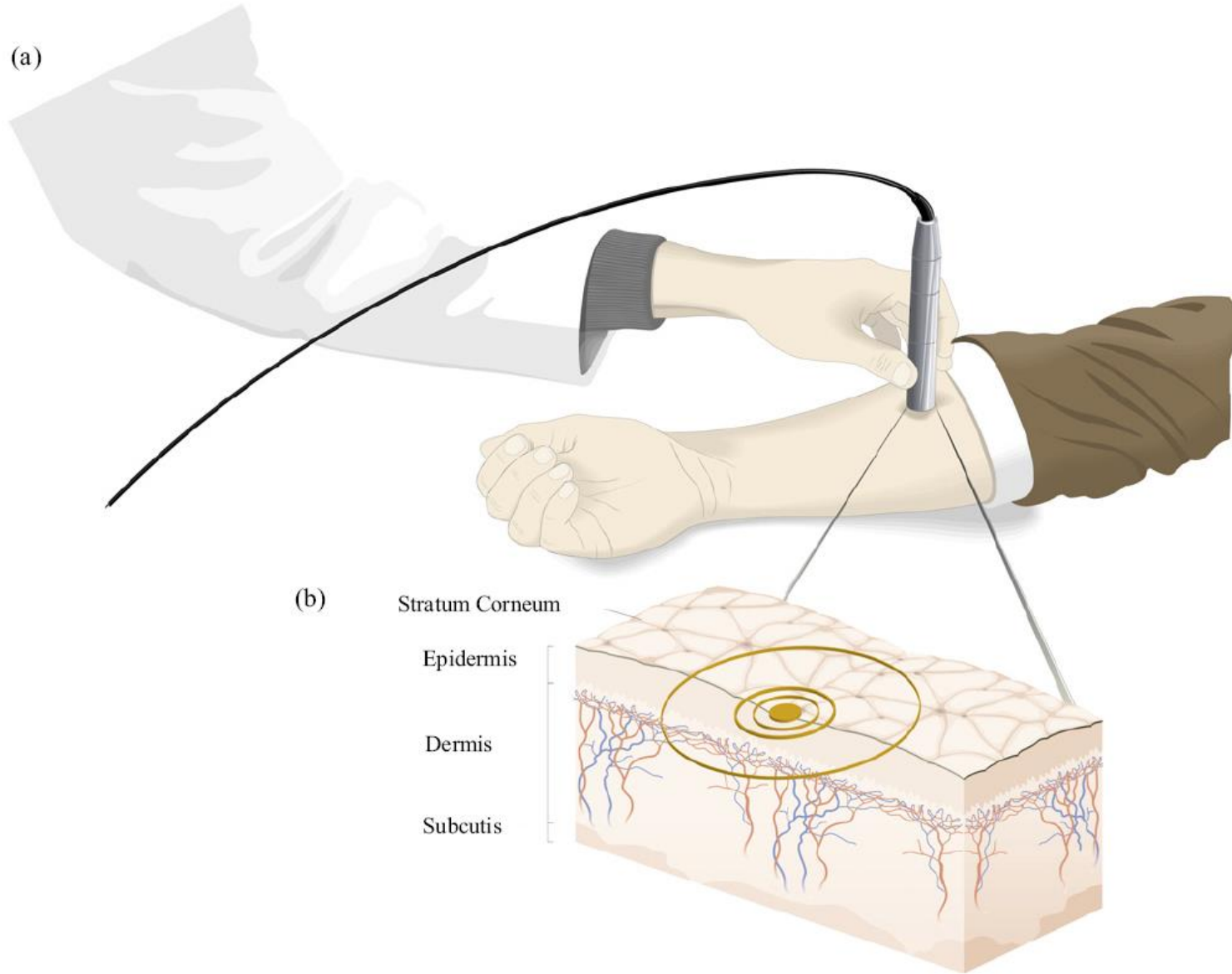
A mathematical model was solved with COMSOL Multiphysics

- Complex-valued Laplace equation for charge transport
- 1 kHz – 1 MHz
- Neuman and Dirichlet boundary conditions
- Reduction to three skin layers
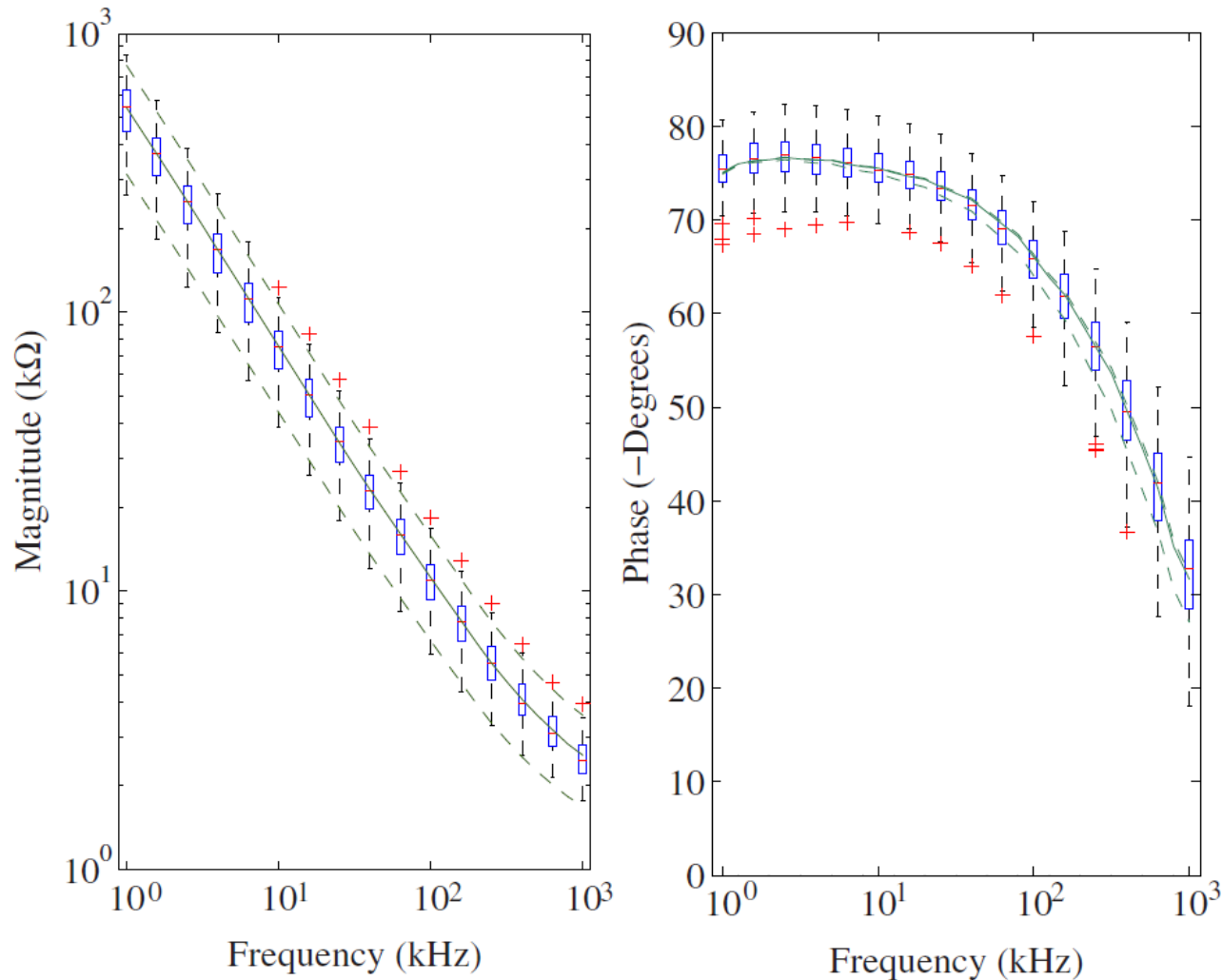- Electrostatic application in COMSOL or PDE mode
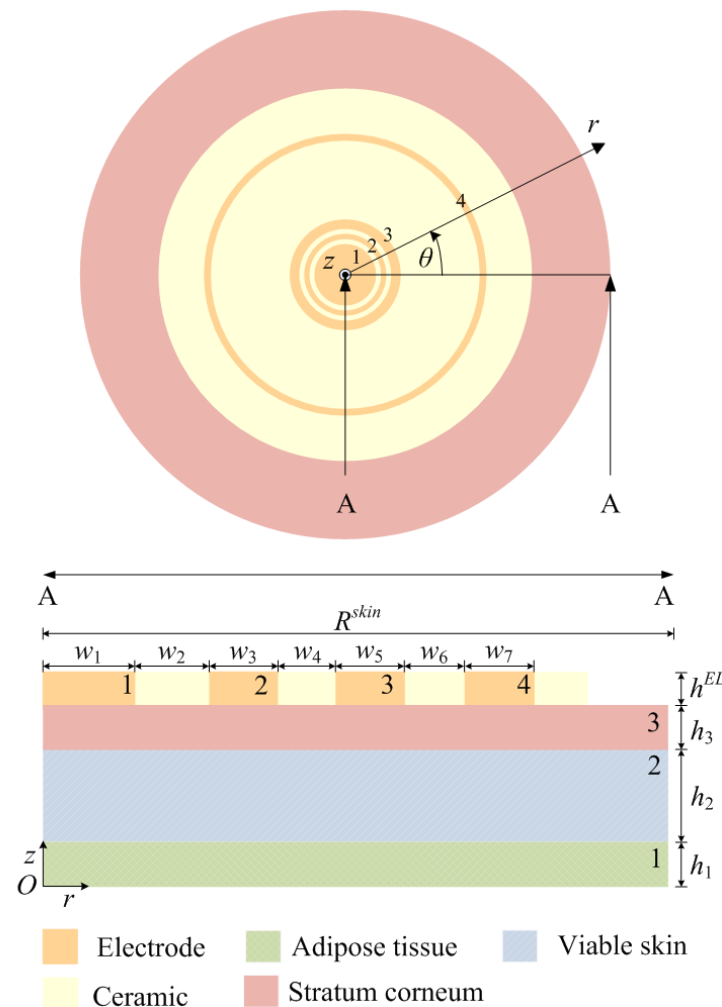
Calibration and validation of the mathematical model was carried out with LiveLink for Matlab
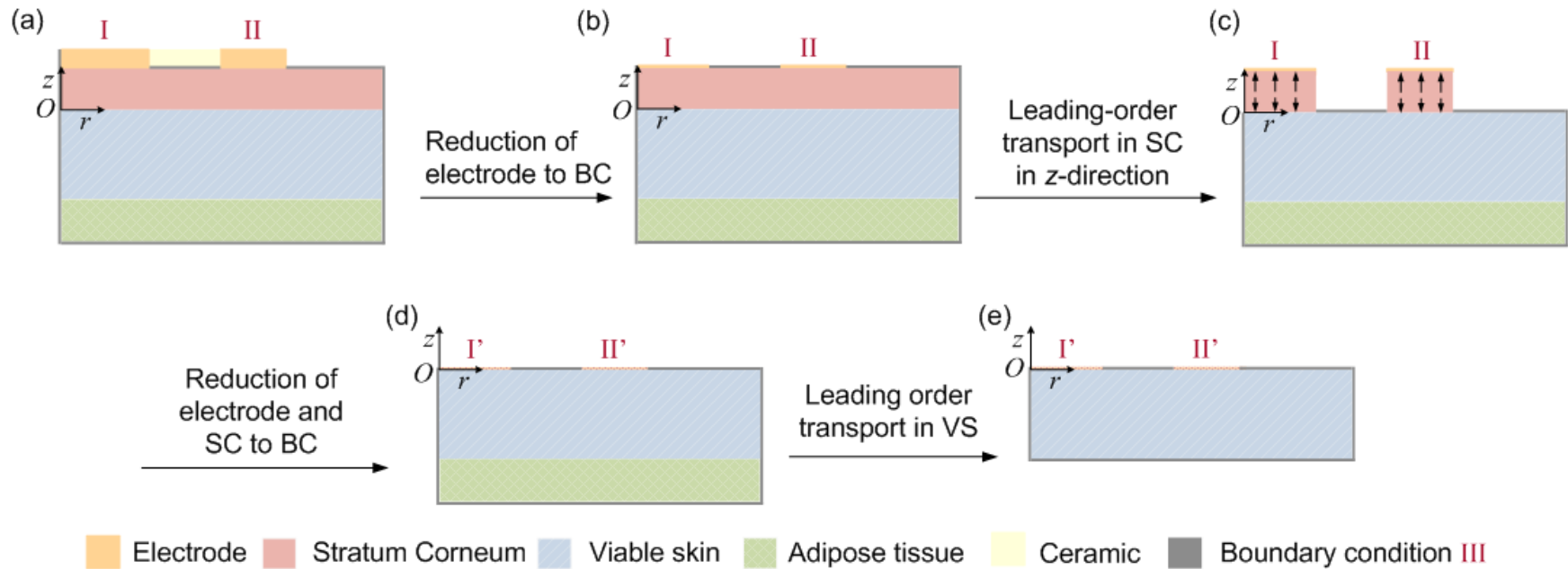
- **Stripped skin measurements**
  - 26 healthy volunteers
  - 12 men, 14 women at 27±6 years
- **Intact skin measurements**
  - 120 healthy volunteers
  - equal distribution of men and women at 24 ±3 years
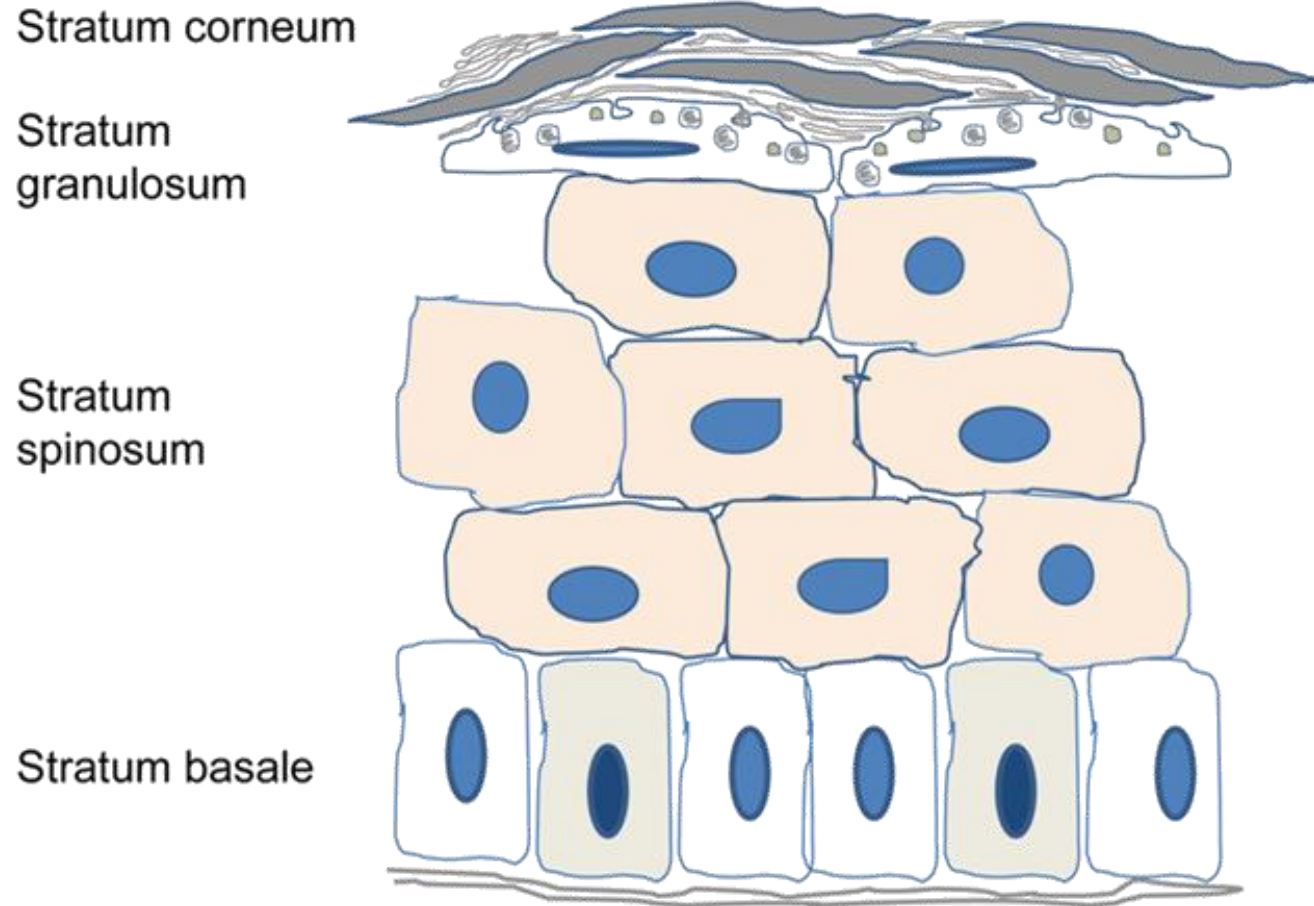

Birgersson et al. *Physiological measurement* 34.6 (2013): 723.
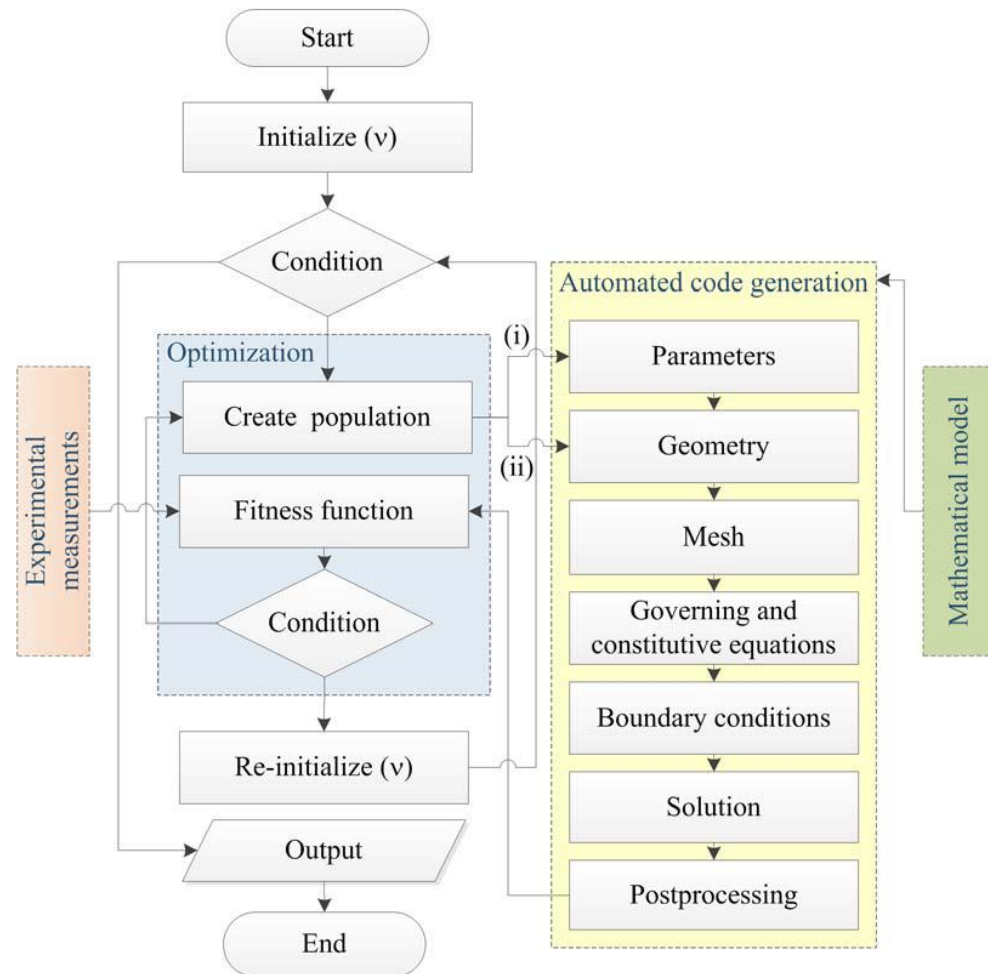
Good agreement between model predictions (lines) and experiments (box plot) for intact skin

Birgersson et al. *Physiological measurement* 34.6 (2013): 723.

Reducing the model through a scaling analysis and easily implementing it in COMSOL Multiphysics

Electrode | Stratum Corneum | Viable skin | Adipose tissue | Ceramic | Boundary condition III

Adding length scales and resolution to the mathematical model

Stratum corneum

Stratum granulosum

Stratum spinosum

Stratum basale

Saladin. Anatomy & physiology *McGraw-Hill.* (1998)

Conclusions and outlook

- Implemented a model for impedance of skin in COMSOL Multiphysics

- Calibration and validation with the help of the LiveLink for Matlab

- Demonstrated a model reduction

- Working on adding length scales towards a multiscale representation