ITSS

24th International Travelling Summer School on Microwaves and Lightwaves

5-11 July 2014, Copenhagen, Denmark

Terahertz sensor structures for biological applications

Fabian Dornuf

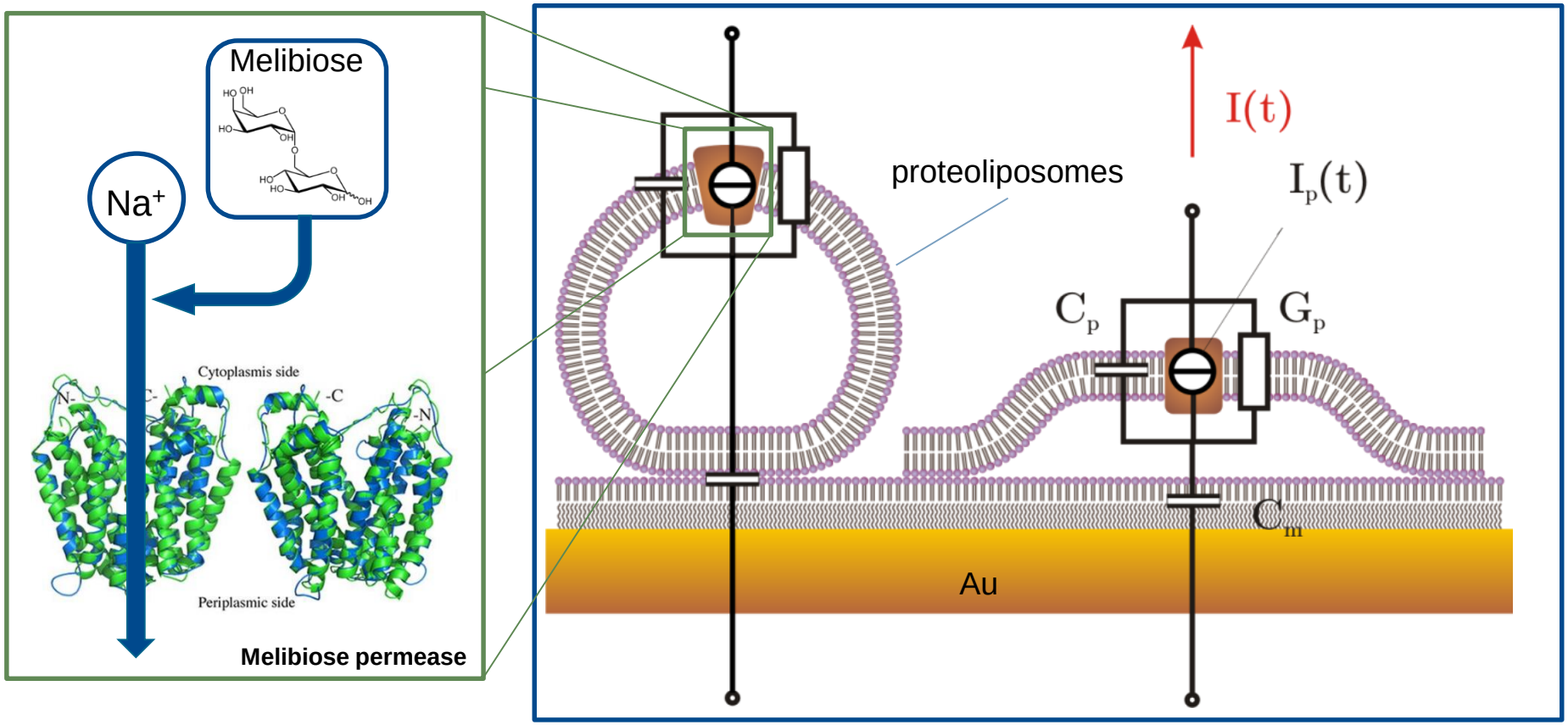
Ph.D.- Student in the LOEWE project:

„Sensors Towards Terahertz“

Terahertz Photonics - Institute of Physics

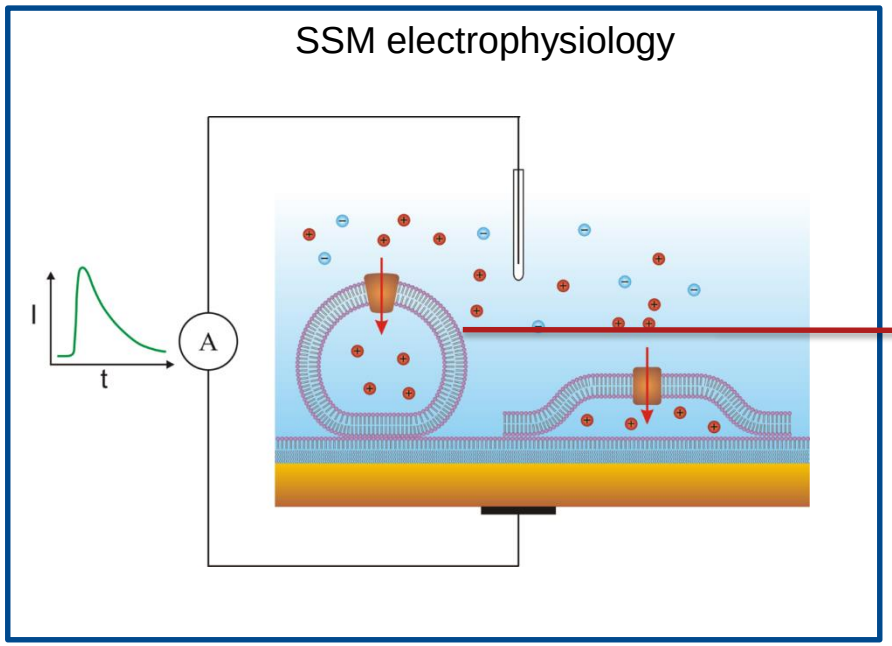
Goethe University Frankfurt am Main

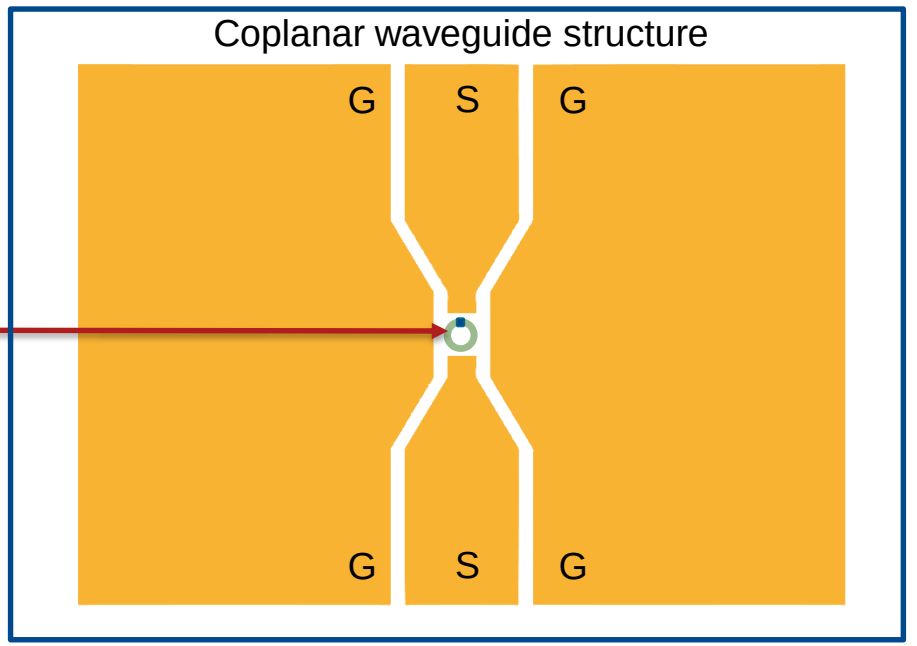
Solid supported membrane (SSM) based electrophysiology



- **Solid supported membrane (SSM) for immobilisation of the proteoliposomes**
- **Activity measurement of membrane proteins pumping ions through the membrane**
- **Ion transport leads to dielectric current**

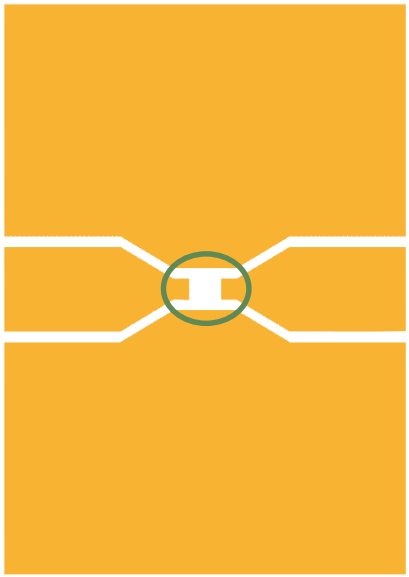
Aim of the project

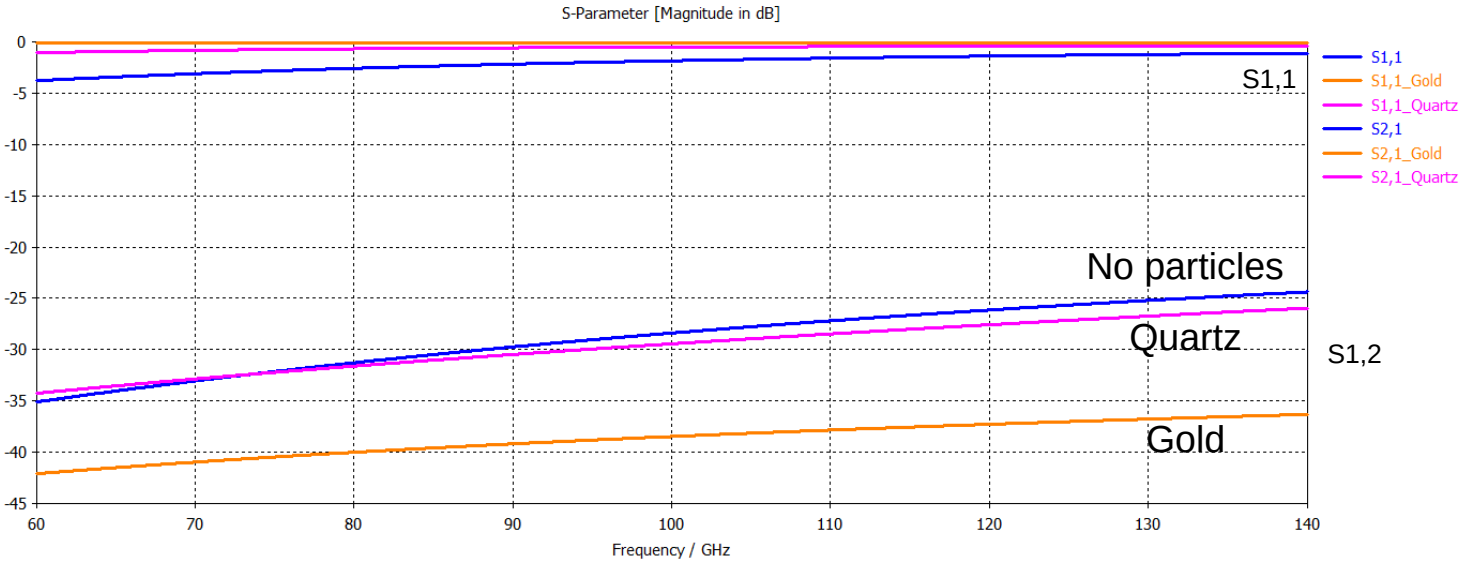


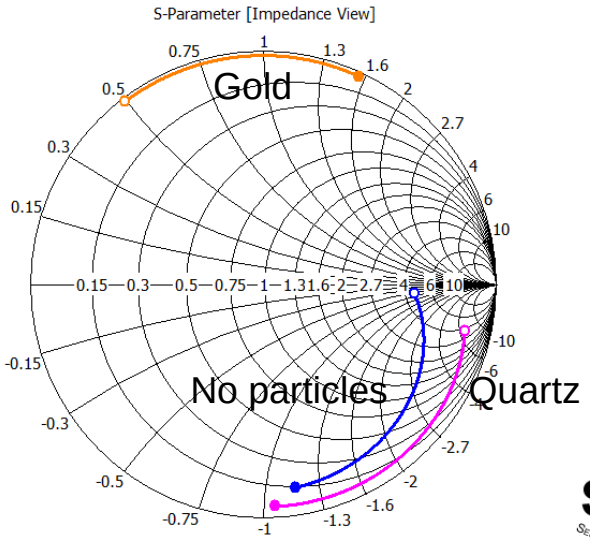


- **SSM based electrophysiology uses capacitive coupling measuring the dielectric current**
- **Aims of the project:**
  - Use of coplanar waveguide structures working in the terahertz regime
  - Measurement of the scattering parameters as a quick and precise alternative for small sample volumes

Coplanar waveguide with gap

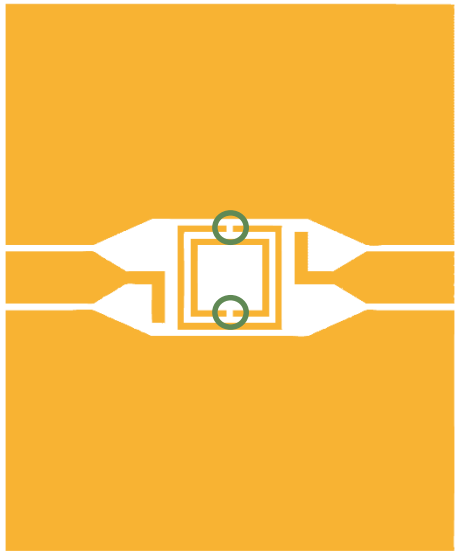


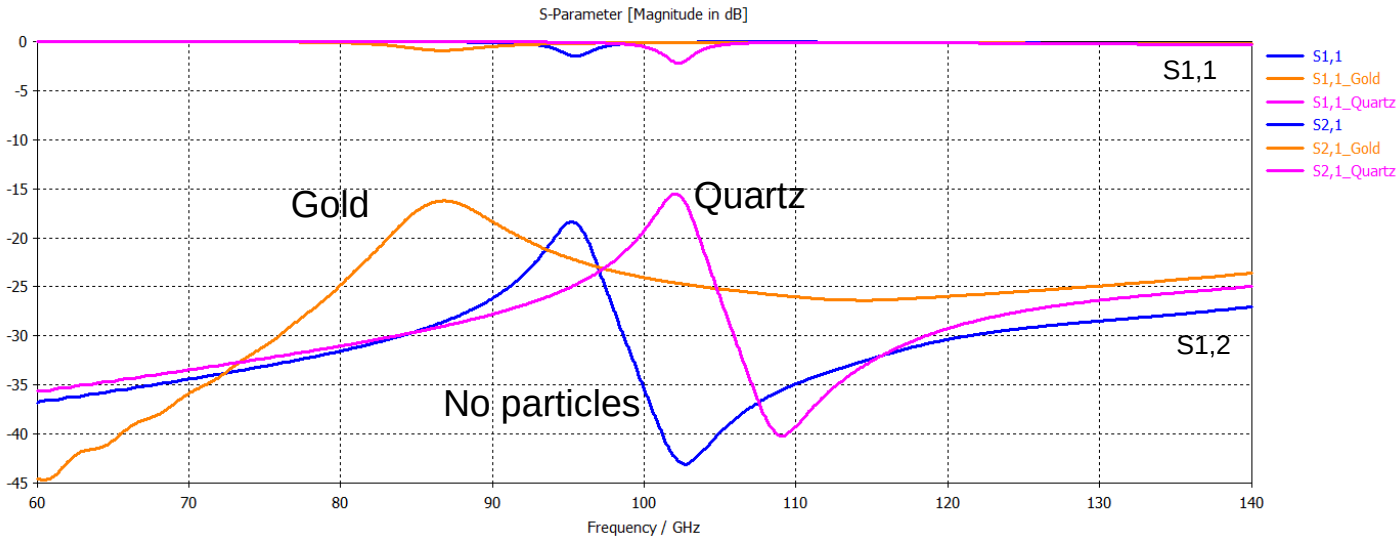


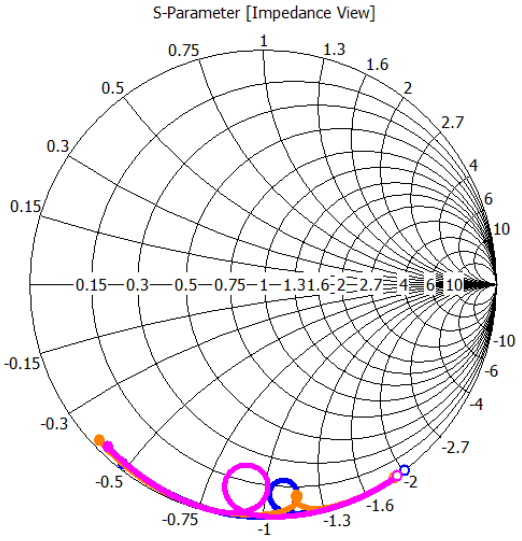


- **The structure behaves like a conductance without particles or with dielectric particles**
- **Conductive particles lead to an inductive behaviour**
- **Proteoliposomes with ion pumping proteins may also behave like conductive particles**

Double Split Ring Resonator

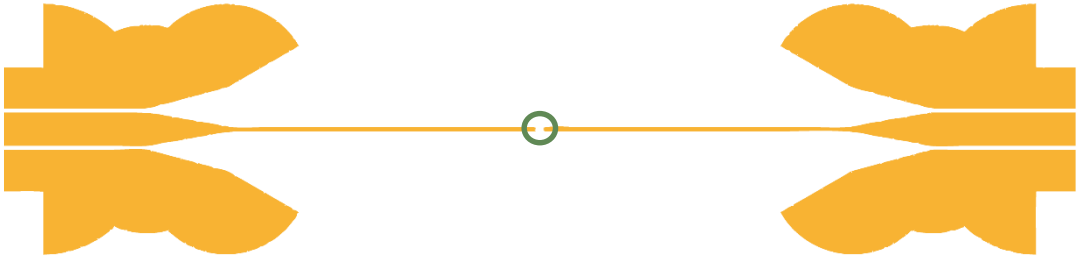




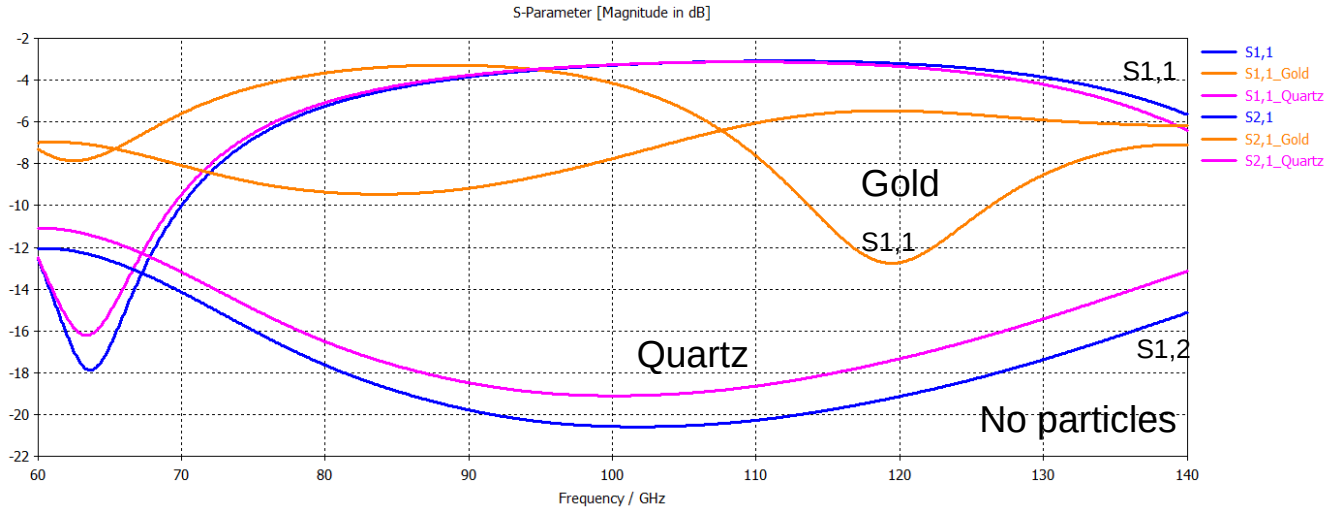


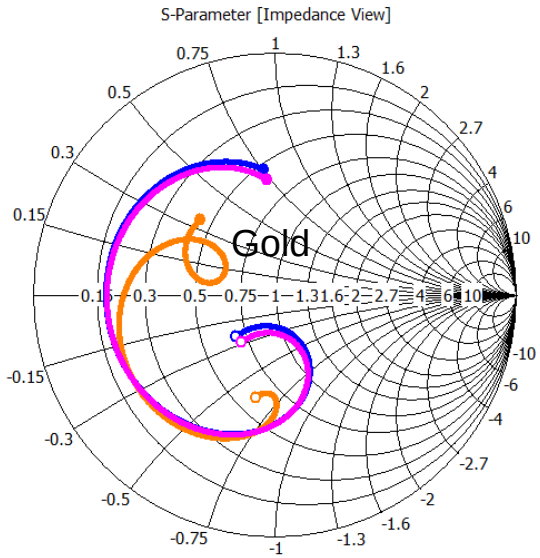
- **Resonance frequency of the double split ring resonator shifts according to the conductivity of the particles**
- **Differentiation using the inner or the outer gap of the double split ring resonator is possible**

Goubau Line with gap

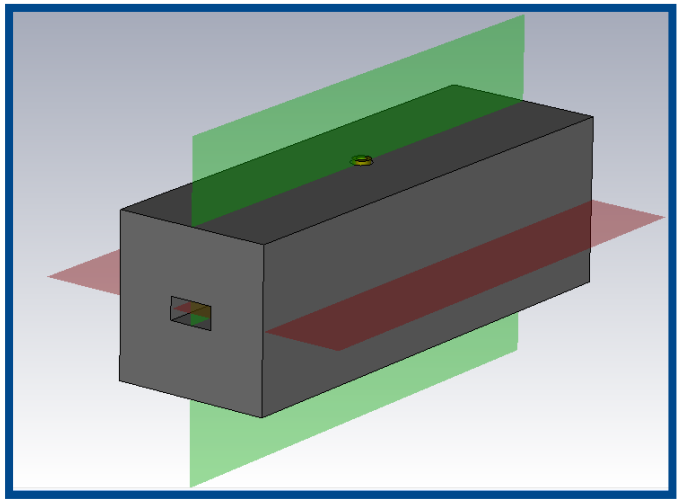


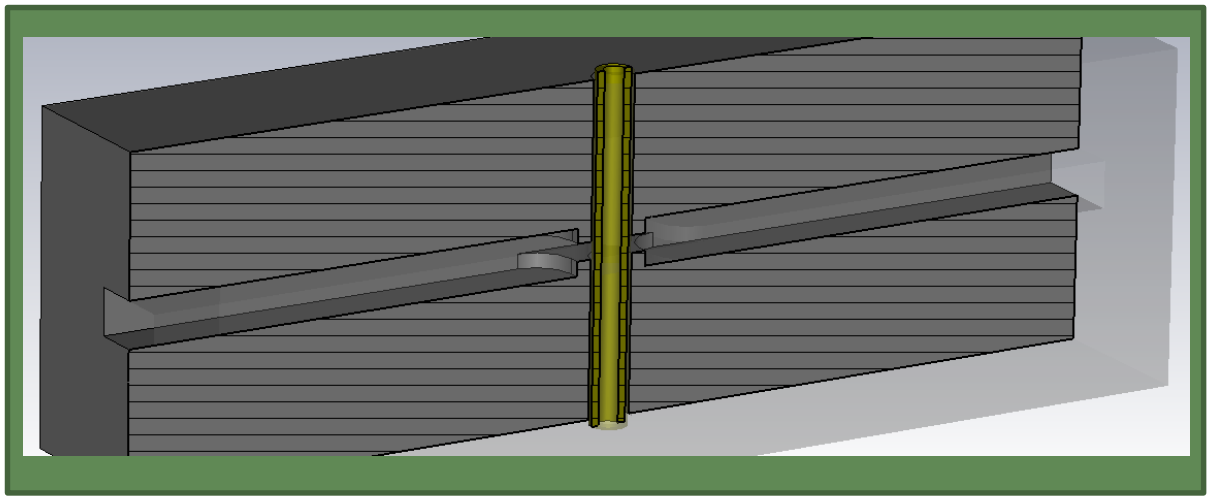
- **Goubau Line with gap shows resonant behaviour for simulations with conductive particles, otherwise no resonances in the frequency range are observed**



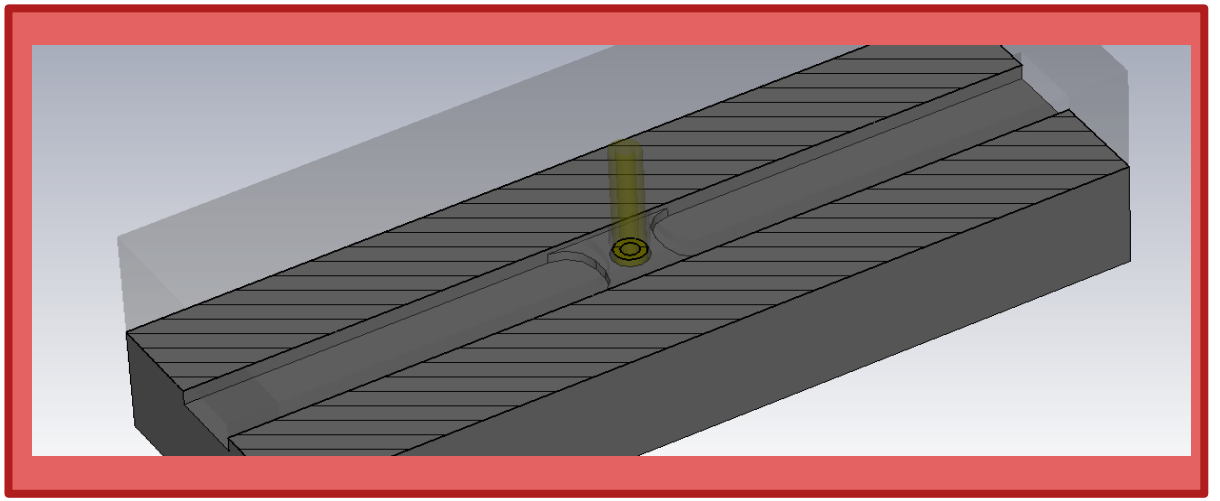


Rectangular waveguide with ridges

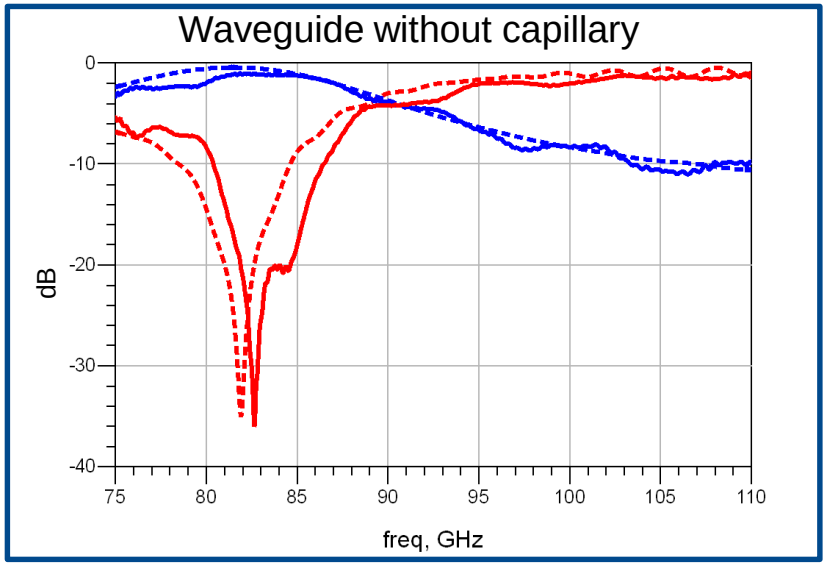


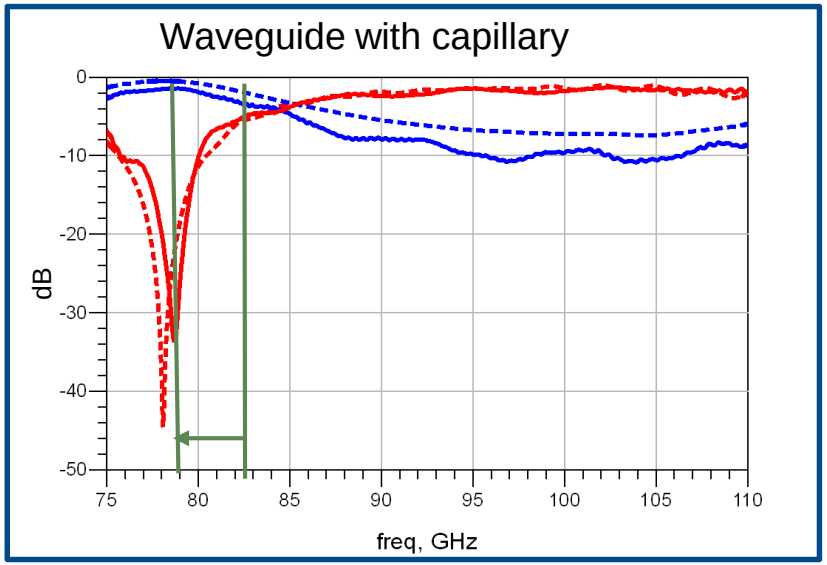


- **Waveguide with WR10 dimensions (2.54 x 1.27mm)**
  - 75-110 GHz
- **Extended with two ridges and a borehole for insertion of a glass capillary (OD=1mm)**



Influence of the waveguide modification and of the capillary



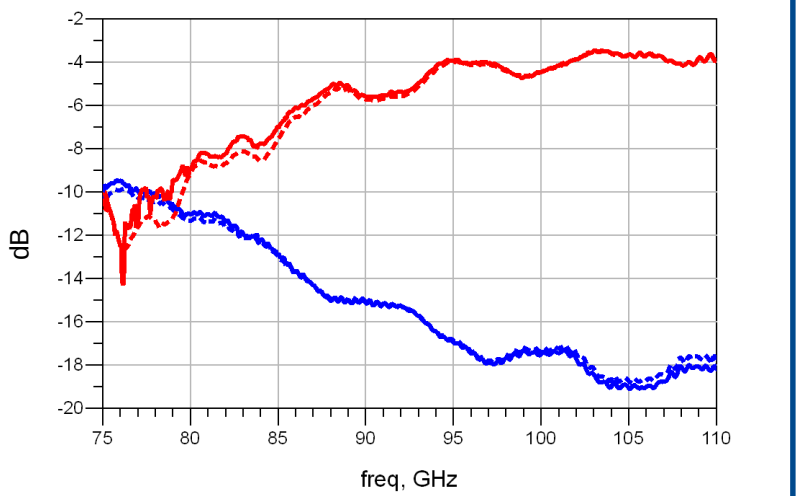


red: dB(S(1,1))
blue: dB(S(2,1))
solid line: measurement
dot: simulation

- **Waveguide with ridges shows resonant behaviour**
- **Measurements with the VNA in the frequency range 75-110 GHz are in good agreement with the electromagnetic simulations**
- **Insertion of capillary (OD=1mm, ID=0.58mm) leads to shift in the resonance frequency**

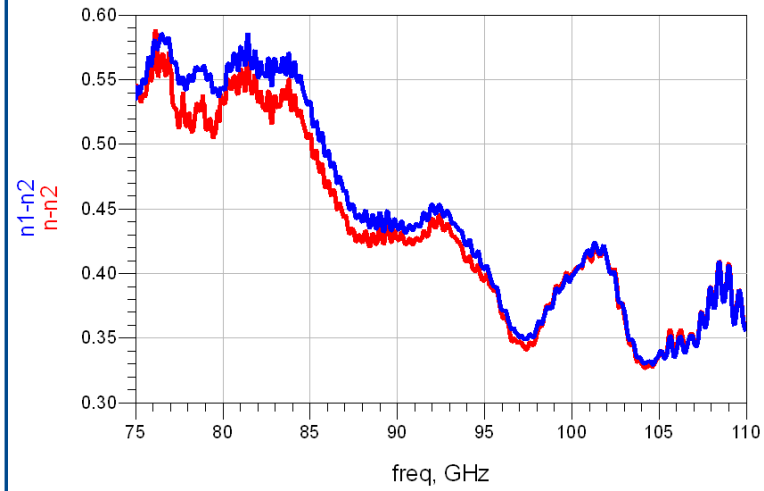
- **Measurements were done in cooperation with the Institute of Microwave Engineering and Photonics of the TU Darmstadt**

Difference between water and blood with microspheres



red: dB(S(1,1))
blue: dB(S(2,1))
solid line: capillary with whole blood and latex microspheres (d=1µm)
dot: capillary with water

$n=1-(S11)^2-(S21)^2$
n1-n2:capillary with **water** minus empty capillary
n-n2: capillary with **whole blood and microspheres** minus empty capillary



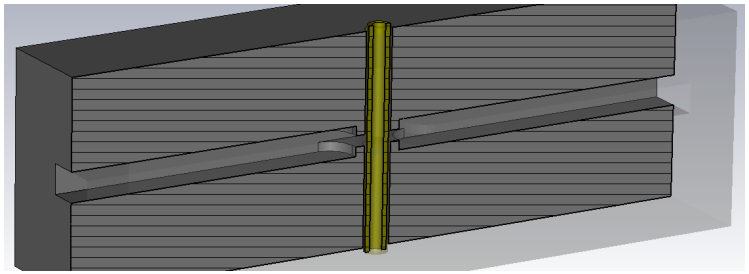
- **Whole blood with microspheres shows similiar behaviour as water at high frequencies**
- **At the resonance frequency the losses show differences between water and whole blood solution**

Future plans

Coplanar sensor structures

- **Measurements with dielectric and conductive particles for characterisation of the structures**
- **Studies according the immobilisation of the proteoliposomes in the gap region of the structure**
- **Liquid handling using microfluidic structures above the electronic sensor**

Rectangular waveguides



- **Usage of the simple setup characterising the response of model solutions in the terahertz regime**
  - protein, sugar
- **Characterisation of blood components for medical approaches**
- **Usage of conductive and dielectric particles for better responses in the structure**

Acknowledgement

- **Prof. Dr.-Ing. Viktor Krozer**
  Institute of Physics, Goethe University Frankfurt am Main

- **Technical University Darmstadt**

- LOEWE program „Sensors Towards Terahertz“

- Dr.-Ing. Andreas Penirschke
  Institute of Microwave Engineering and Photonics

- Dipl.-Phys. Roland Dörr
  Institute of Electromechanical Design

Thank you for your attention!