

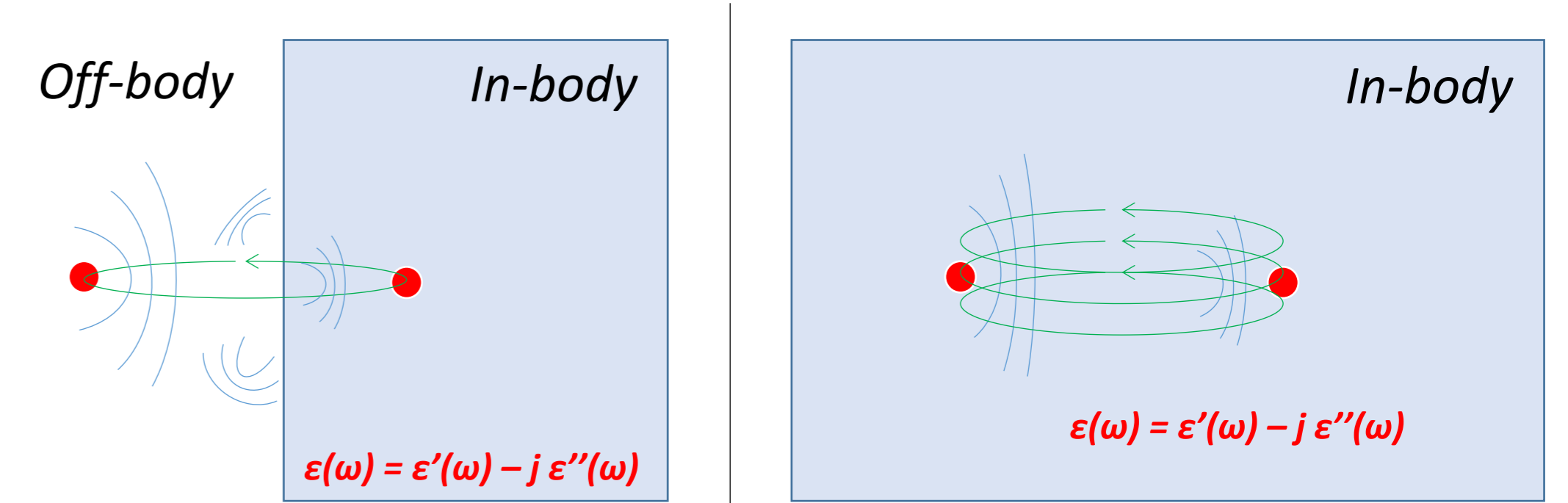
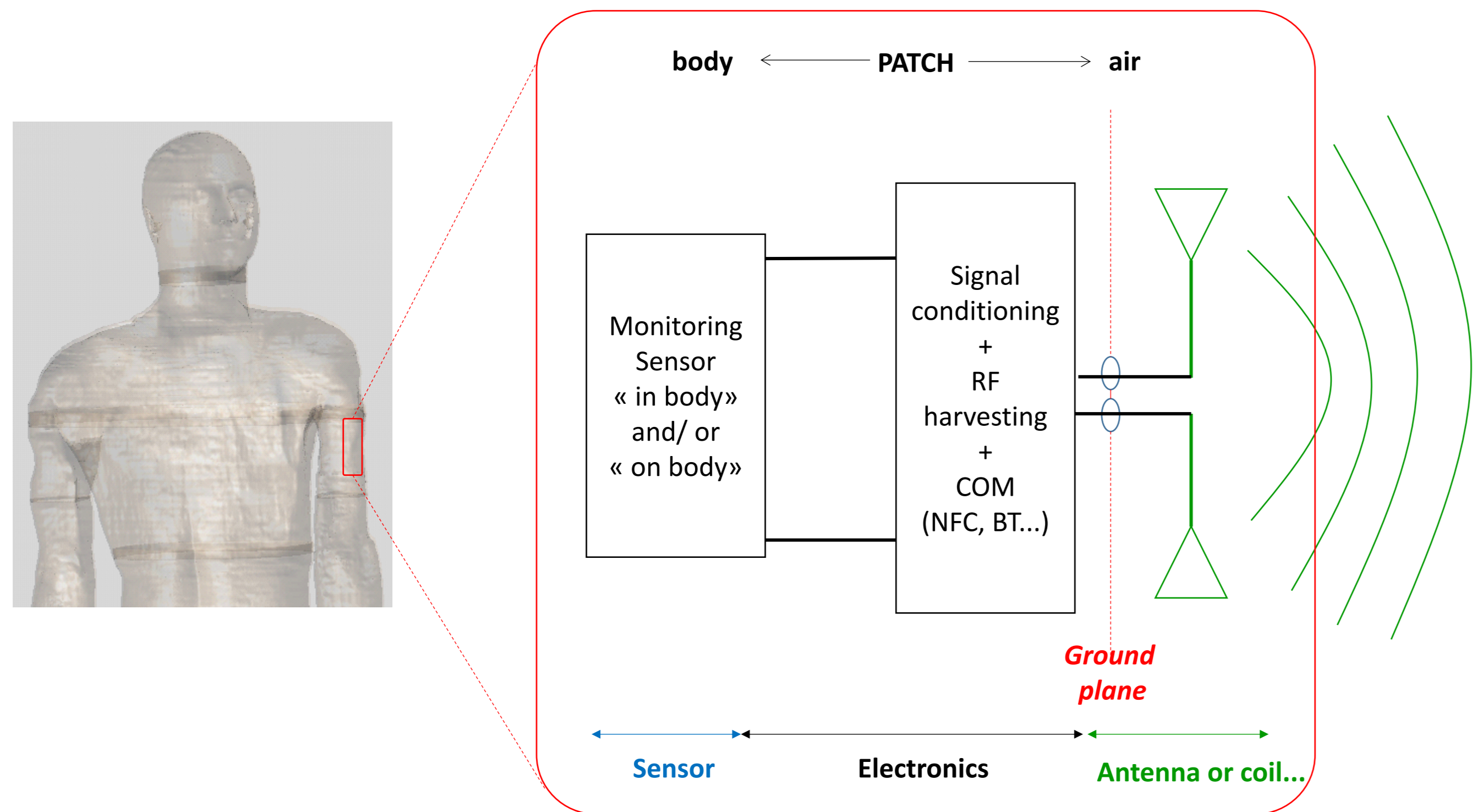
RF link for Implanted Medical Devices (IMDs) and Sub-GHz Inductive Power Transmission



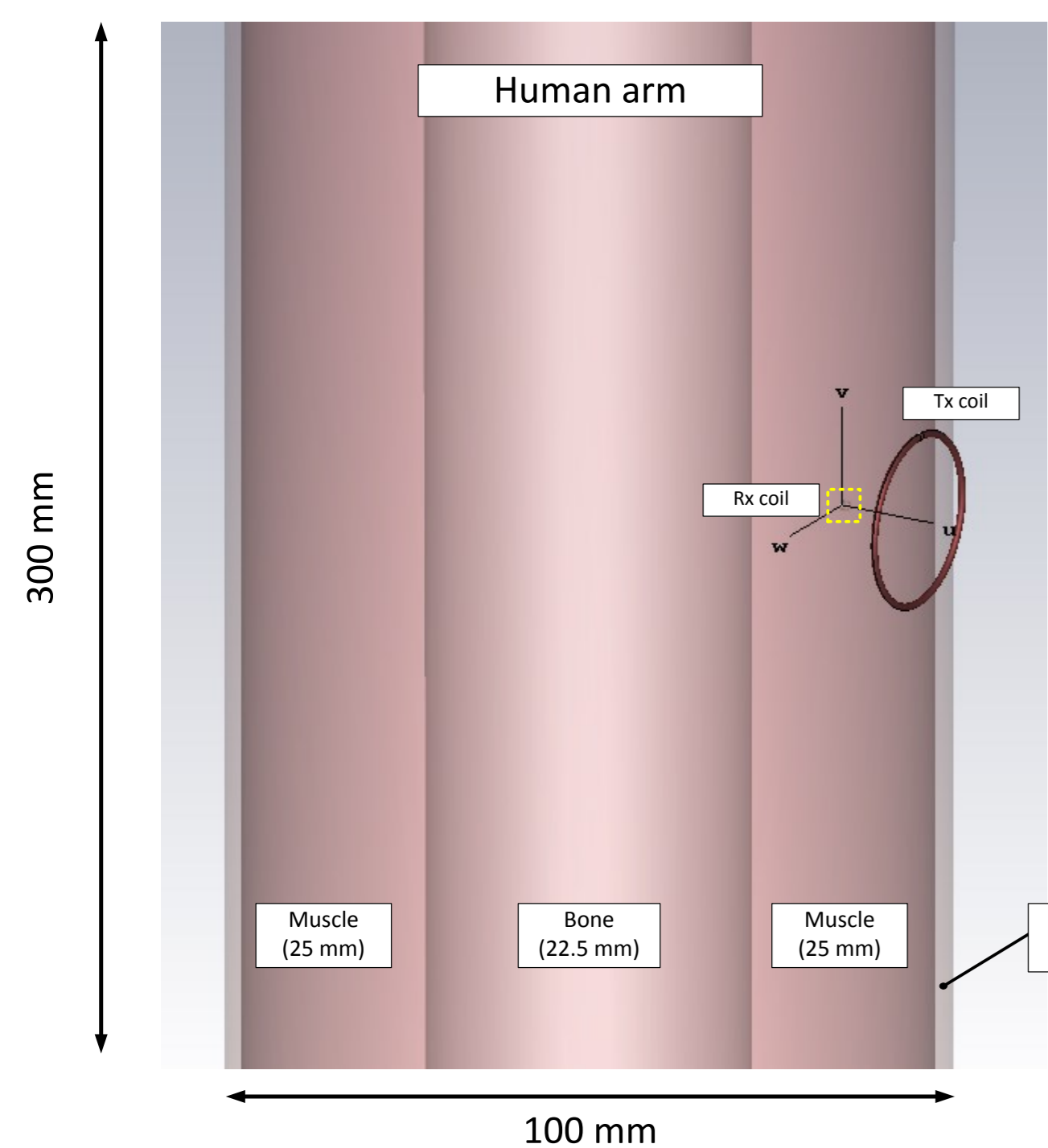
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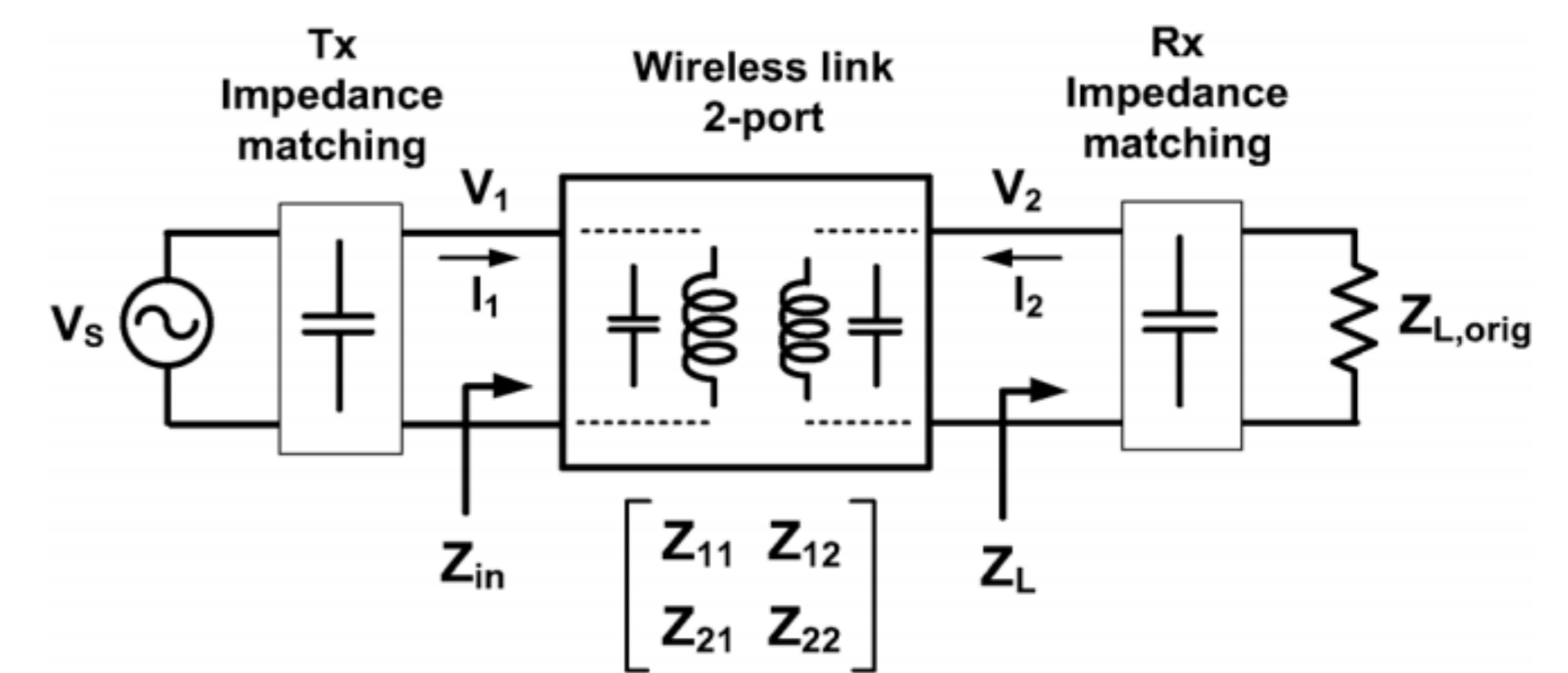
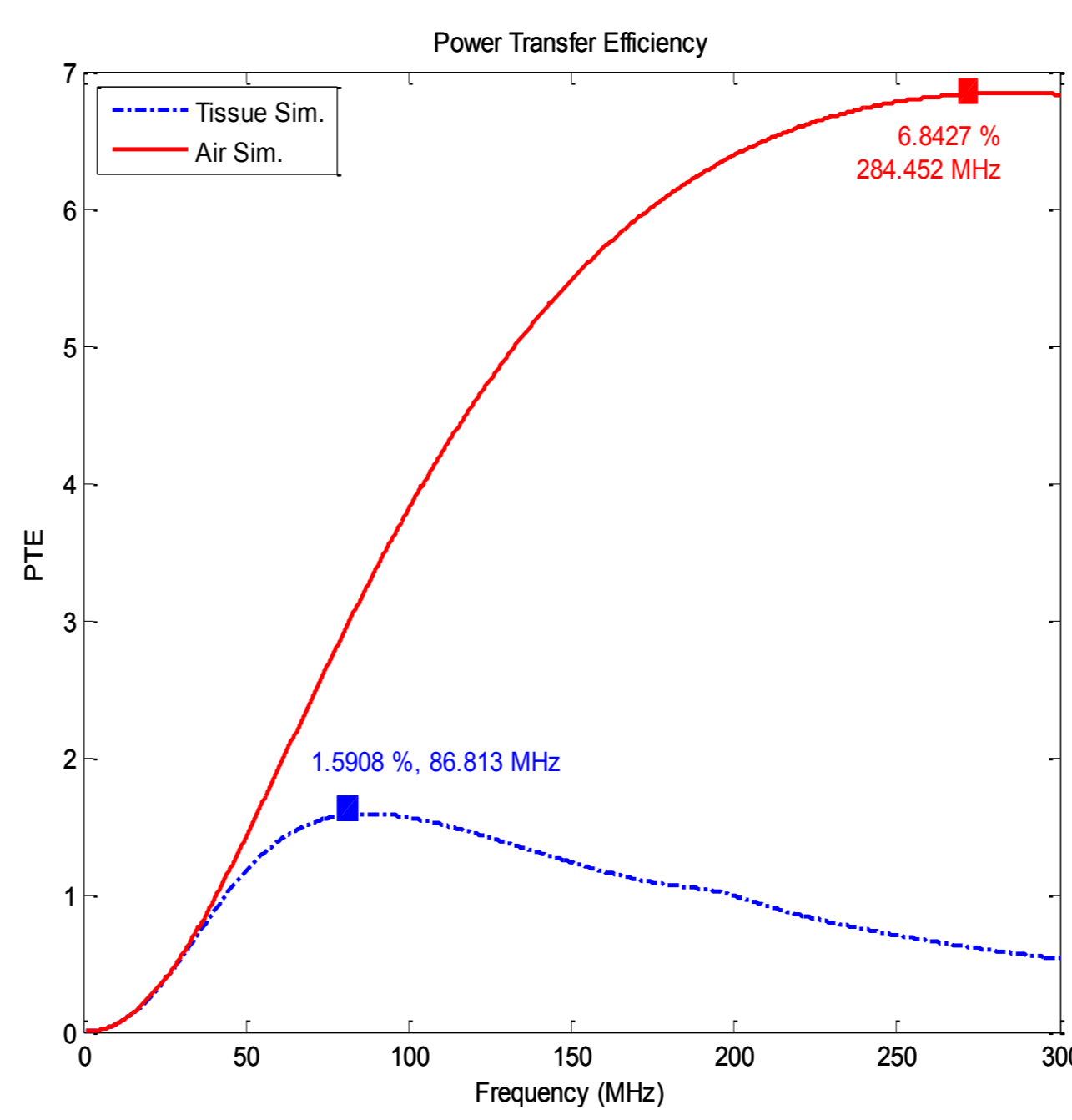
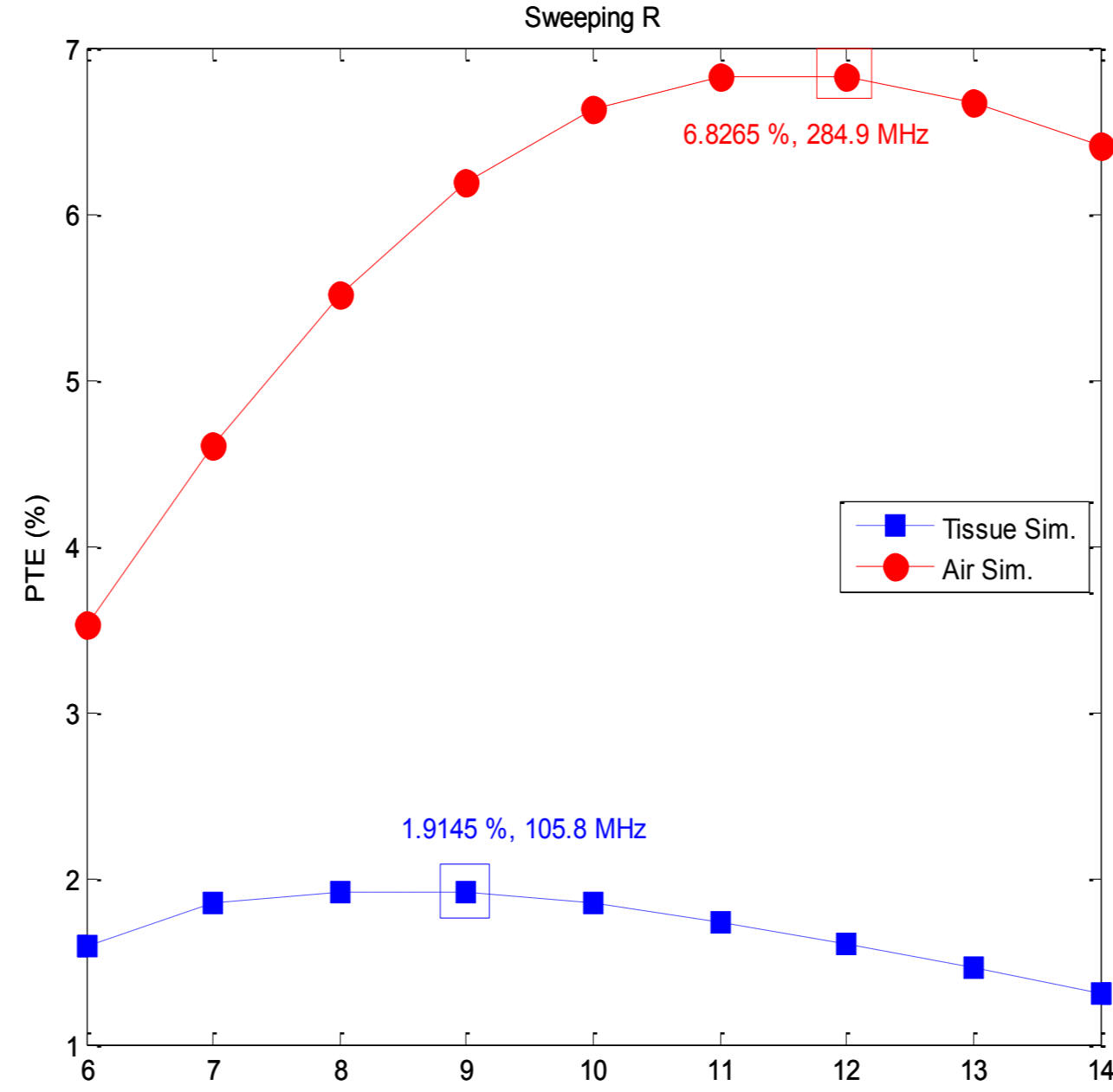


- IMDs → high impact of the body on EM fields (modelling needed with ϵ' and ϵ'') + radiating and non-radiating modes
- Design of helical RX coils → impacted by the body, lowering performances (need a figure of merit, see PTE)



Configuration of the Tx and Rx coil			
Parameter	Tx coil	Rx coil	
Radius	12 mm	0.5 mm	
Height	1 mm	1 mm	
Number of turns	1	7	
Distance between two coils	12 mm		
Configuration of the tissue model			
Parameter	Skin	Muscle	Bone
Thickness (mm)	2.5	25	22.5
μ_r	1	1	1
ρ (kg/m ³)	1100	1041	1850
Therm. Cond. (W/K/m)	0.293	0.53	0.41
Blood flow (W/K/m ³)	9100	2700	3400

Using only two coils, Implanted depth: 10 mm

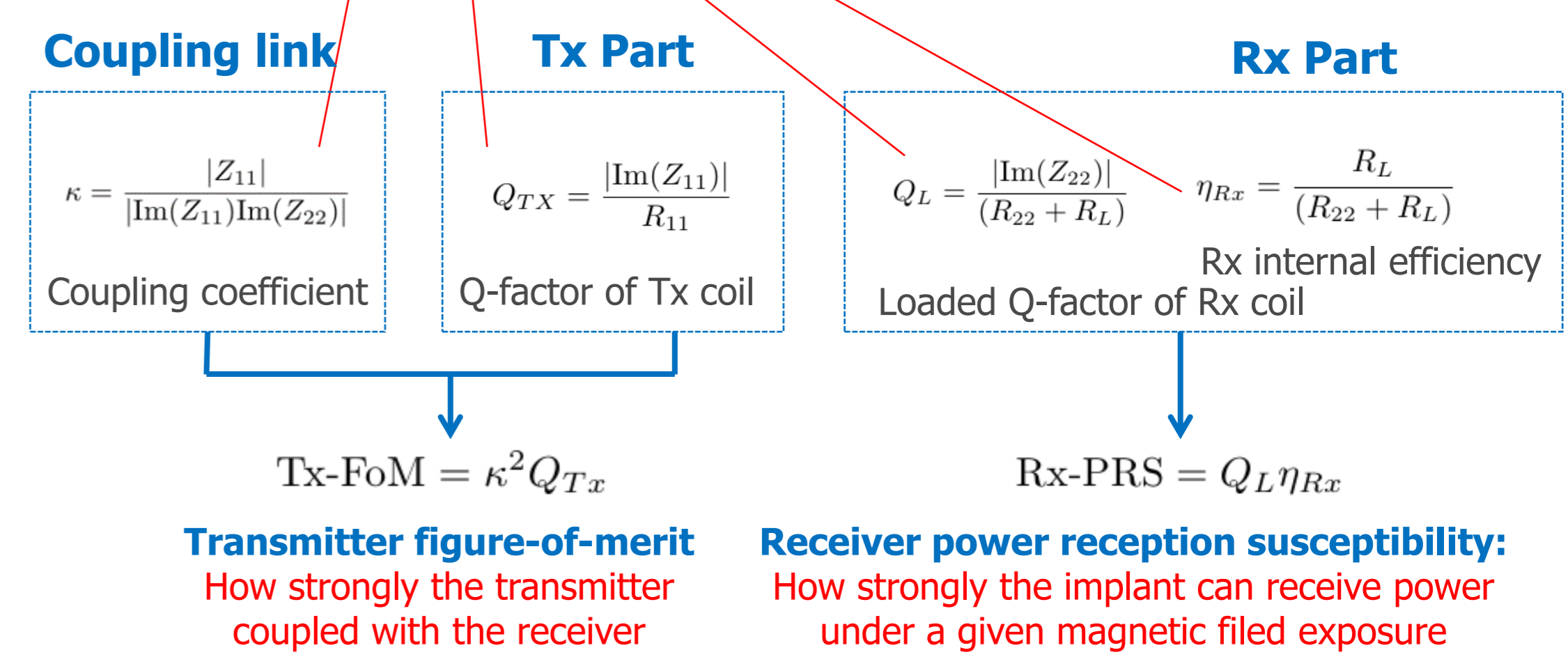


Equivalent circuit using Z-matrix as the wireless link between Tx and Rx coil
[D. Ahn et al., Optimal Design of Wireless Power Transmission Links for Millimeter-Sized Biomedical Implants, IEEE Trans. Biomed. Circuits Syst., pp. 1-13, 2014.]

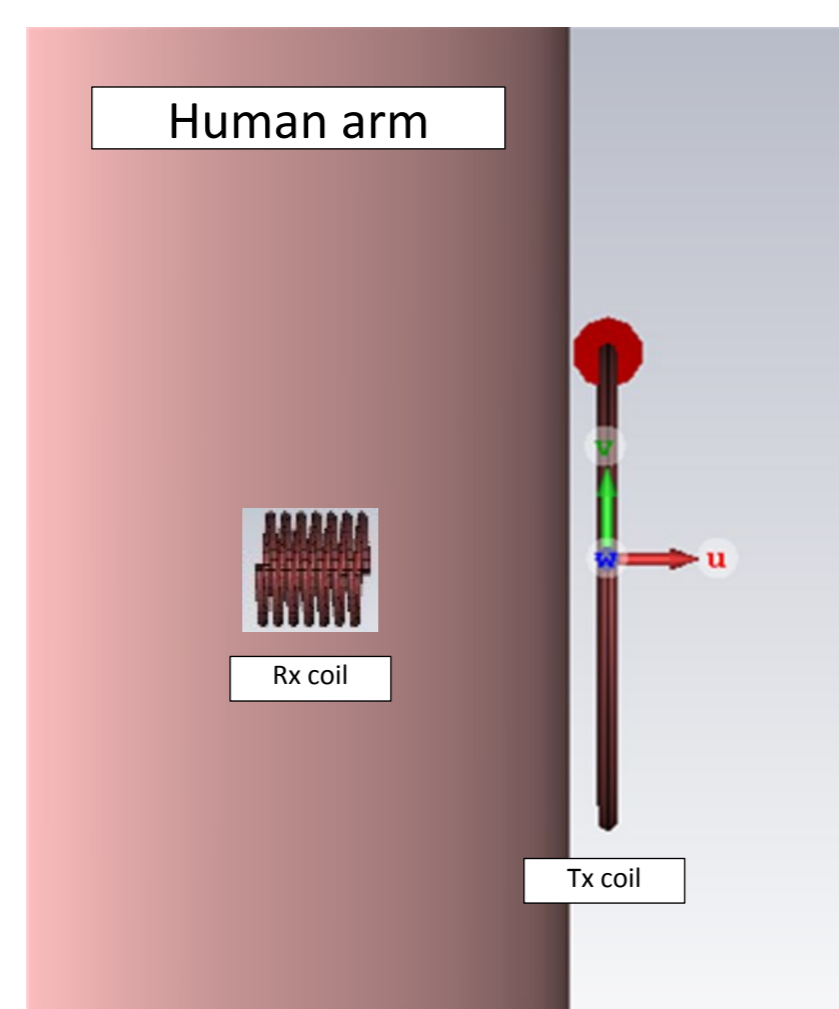
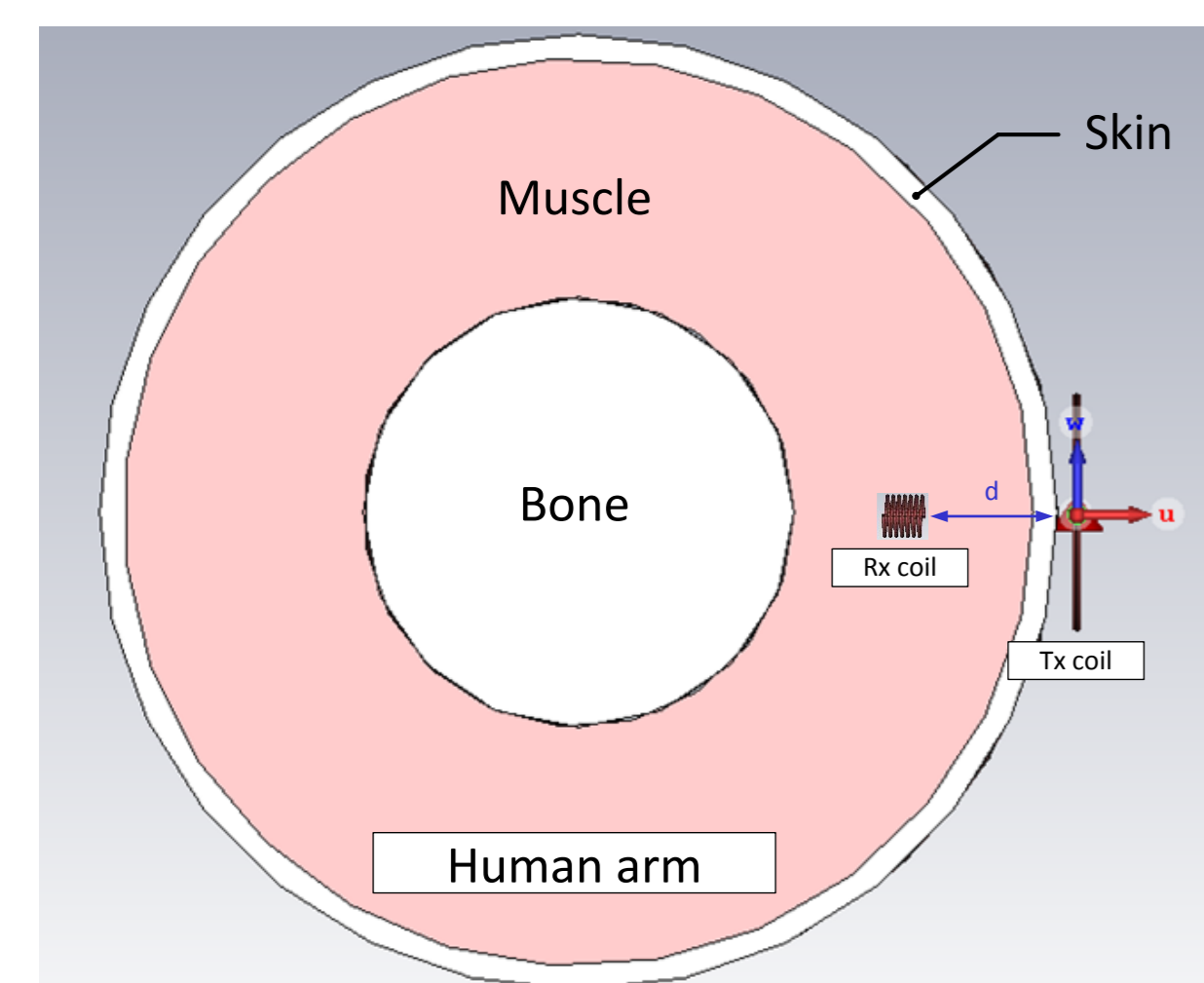
Power Transfer Efficiency (PTE)

$$PTE \approx \frac{|Z_{21}|^2}{|\text{Im}(Z_{11})\text{Im}(Z_{22})|} \frac{|\text{Im}(Z_{11})|}{R_{11}} \frac{|\text{Im}(Z_{22})|}{(R_{22} + R_L)} \frac{R_L}{(R_{22} + R_L)}$$

$$= \kappa^2 Q_{TX} Q_L \eta_{Rx}$$

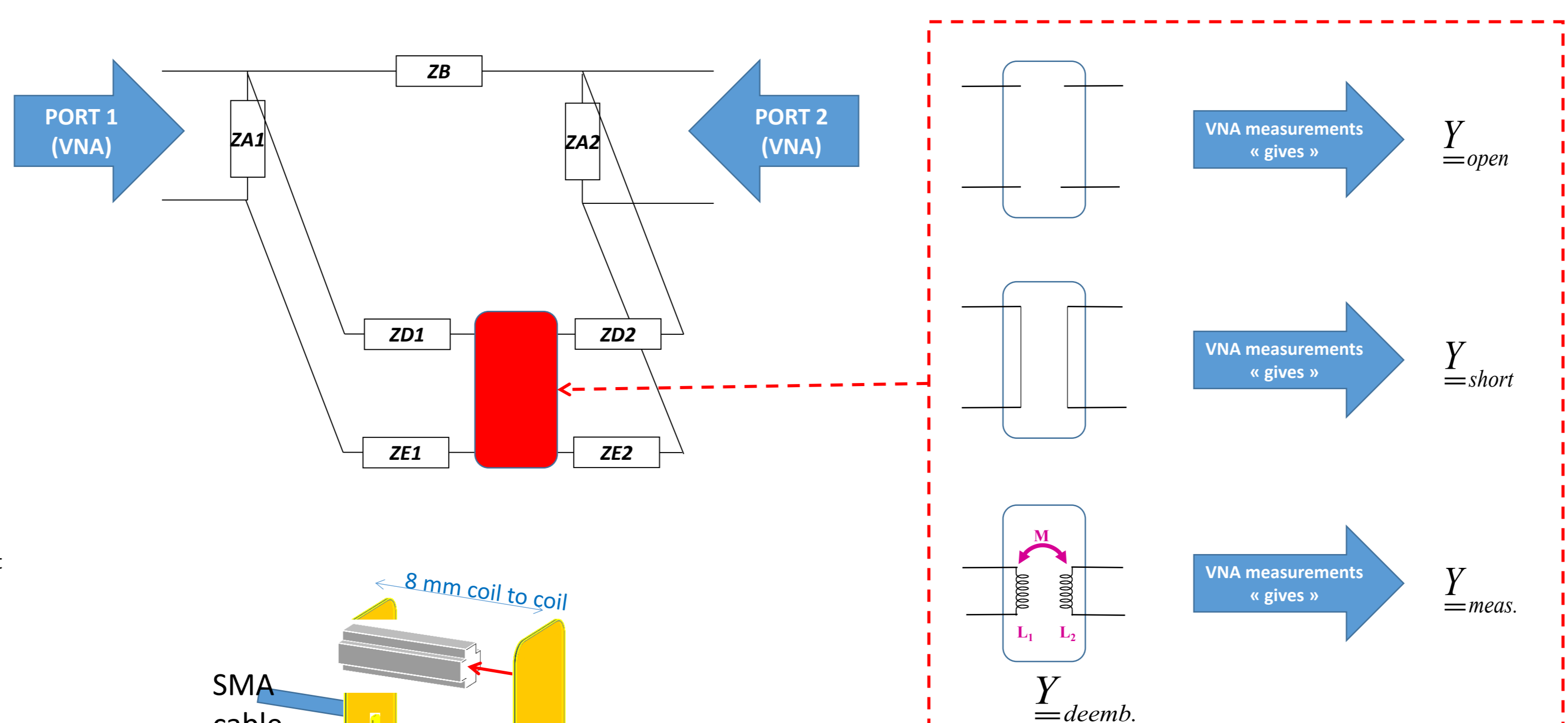
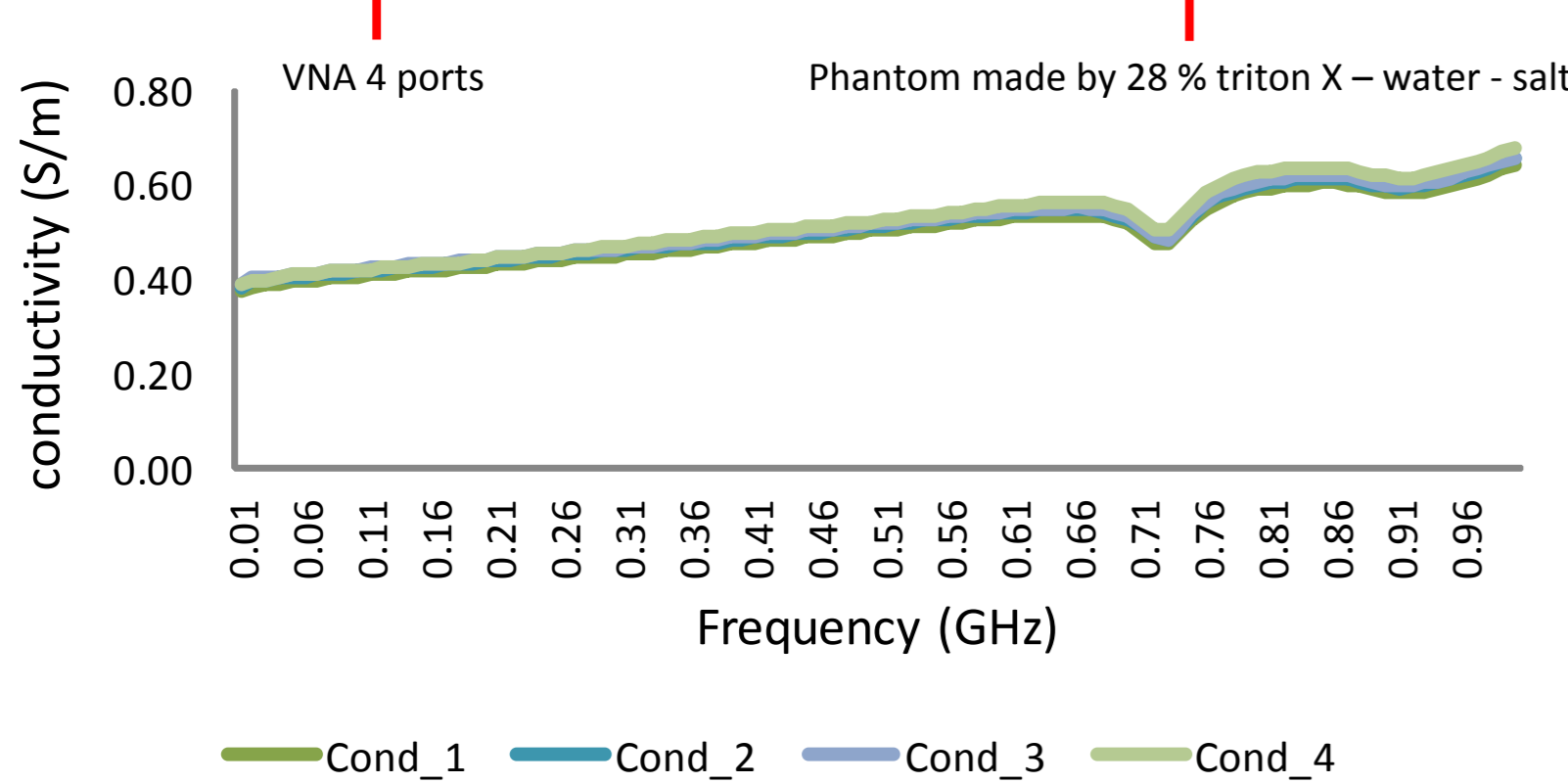
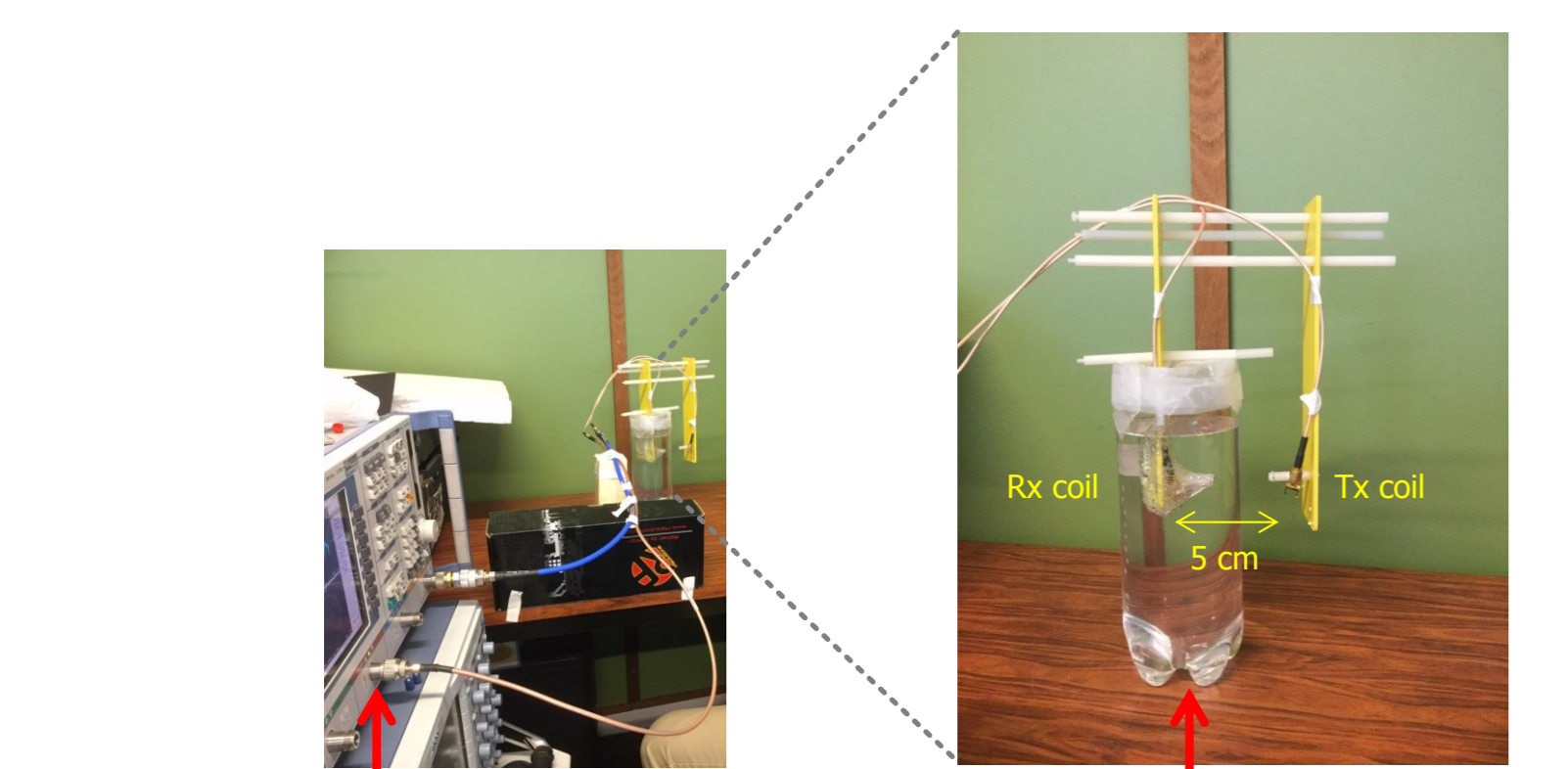
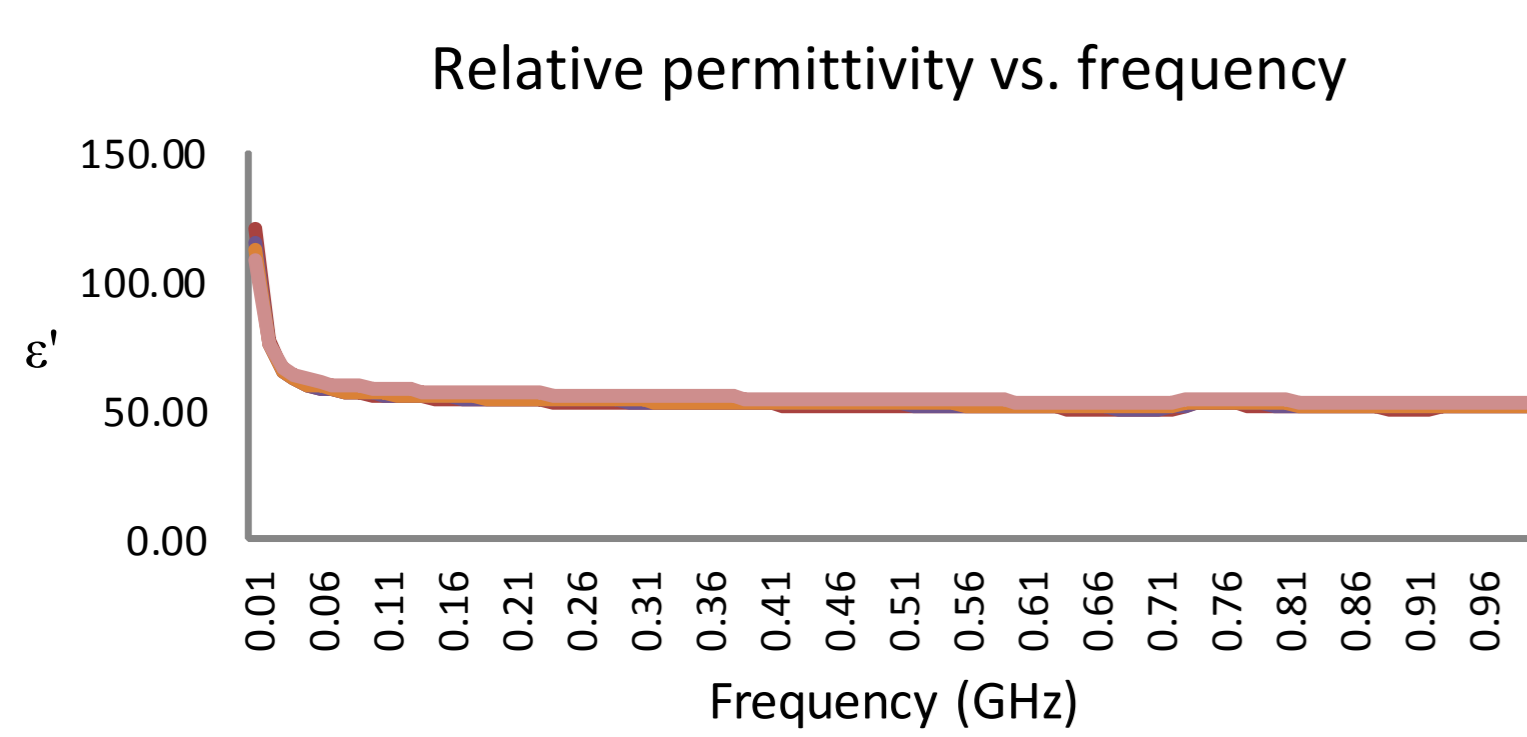


- OPTIMAL frequency, mainly due to body losses and dispersion effects
- OPTIMAL size and orientation, due to the distribution of H and E



top view

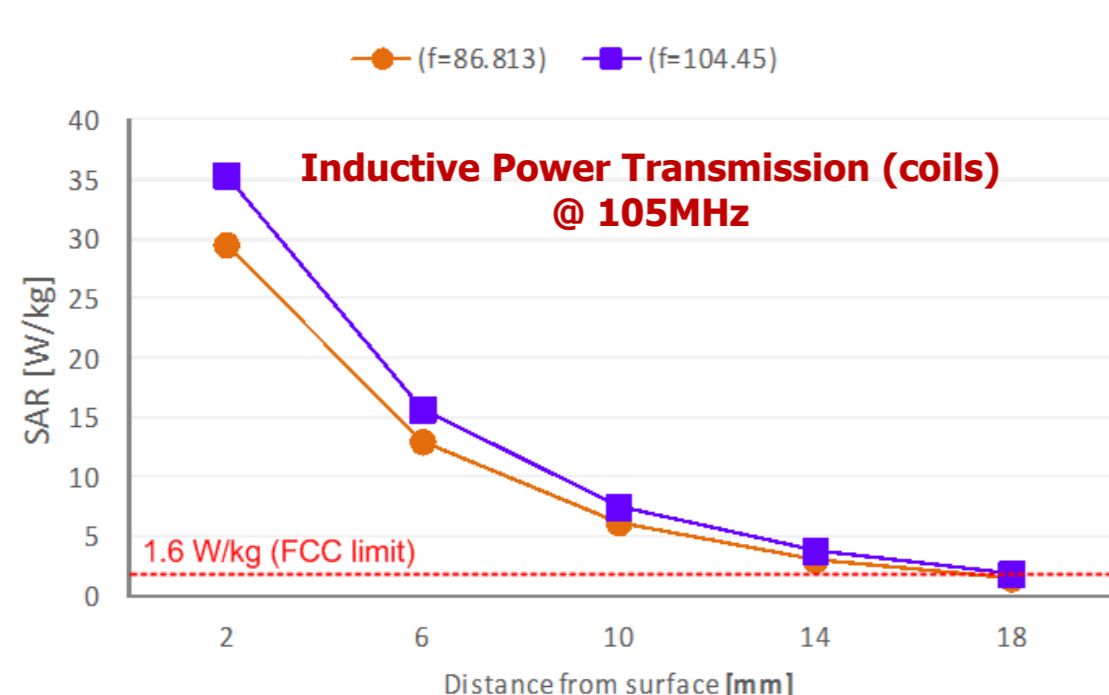
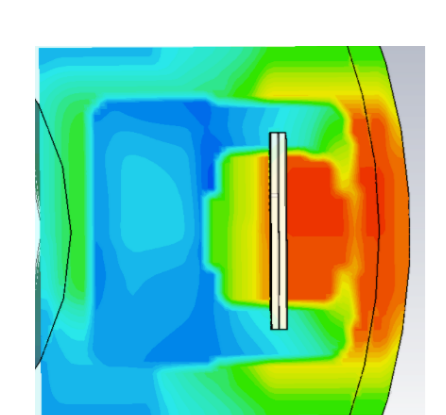
front view



$$Y_{deemb}^{-1} = (Y_{meas} - Y_{open})^{-1} - (Y_{short} - Y_{open})^{-1}$$

SAR evaluation...

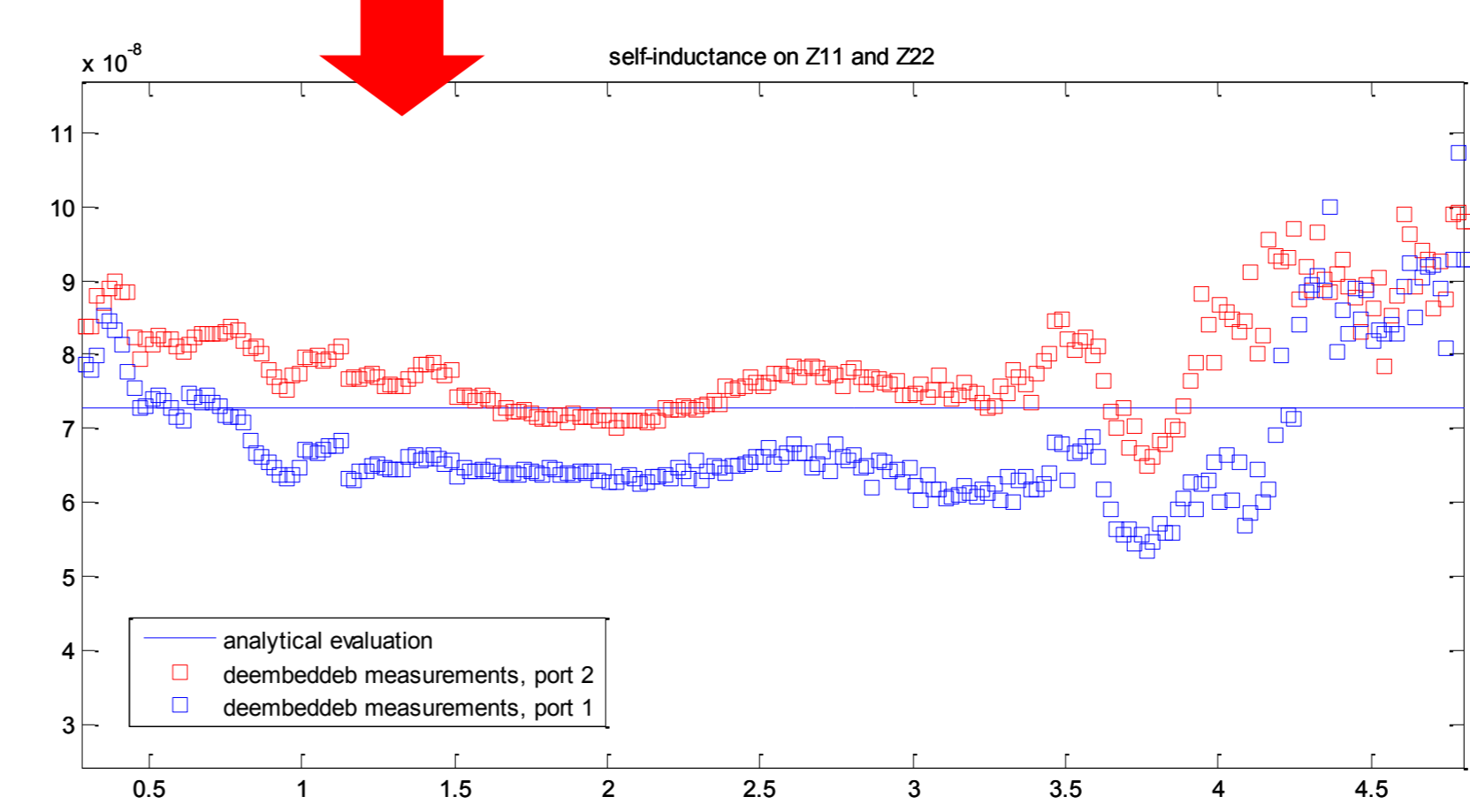
$$SAR = \frac{\sigma |E|^2}{\rho} [W/kg]$$



TEST FIXTURE NEEDED:

- ...for deembedding connector effects (size and frequency)
- ...for deembedded measurements in presence of the phantom (in progress)
- ...for an accurate control of the position

5-turns coil... or « SHORT », or OPEN
1 mm height
1,25 mm radius



CURRENT WORK AND CONCLUSION

The measurements show an interesting agreement for self-inductance evaluation under 300 MHz with a simple calibration test fixture. Some parasitic elements are still present after deembedding and we need to improve the design of the test fixture to be able to evaluate the whole impedance matrix of the 2 coils system.

The design of the coils in the presence of a biological tissue can be fruitfully helped with measurements of the coil inside a phantom made with Triton X, water and salt.

This phantom relative permittivity and conductivity are also given in function of the frequency. Next step of the design process is to accurately deembed and re-simulate to match the characteristics of the medium for optimization of the small coils.