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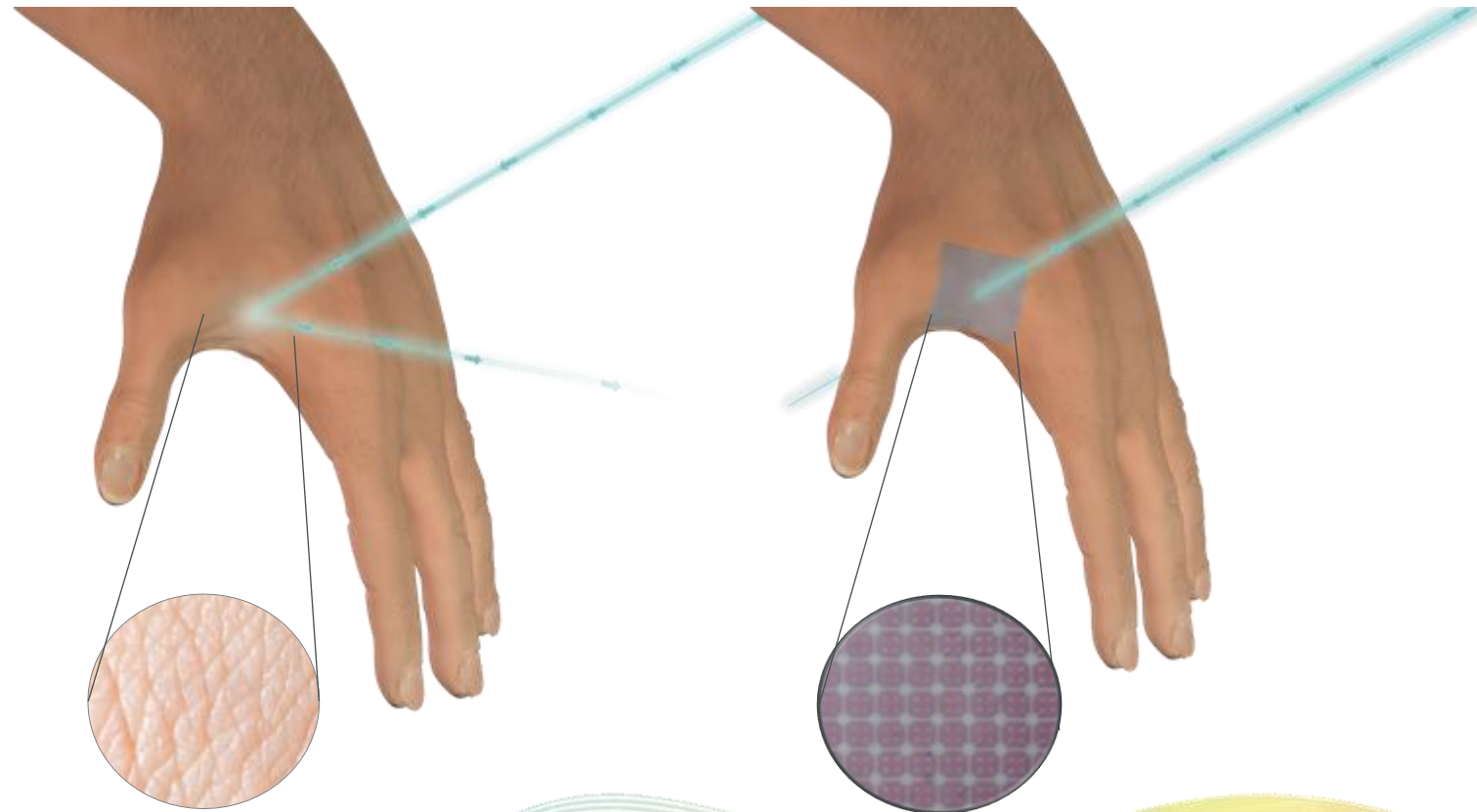
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# Metamaterials and Design: Biosensing

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# “See through the skin”



# Application

Non-Invasive Glucose Sensing

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# Monitoring Glucose as a Type 1



Recommended: 8-10 readings per day

Average: 5 readings per day

# GlucoWise Wearable Biosensor



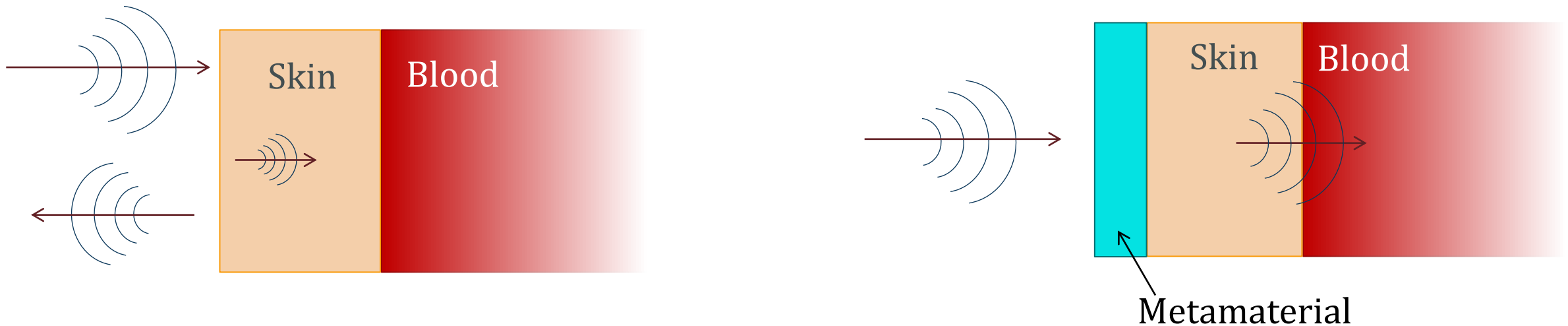
# Technology

Impedance Matching for Skin

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# Impedance Mismatch Problem

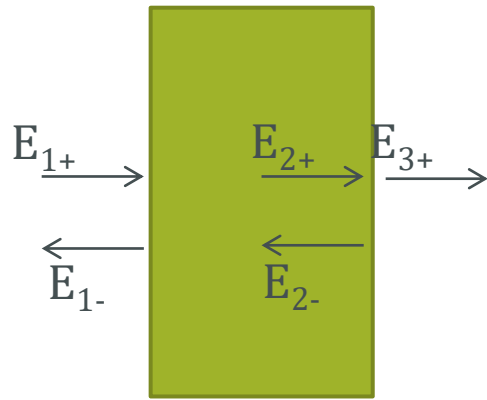
Can we improve transmission through biological tissue using a passive subwavelength film?



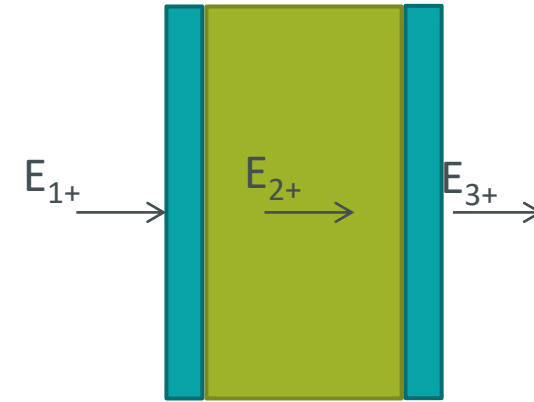


# Analytical Concept

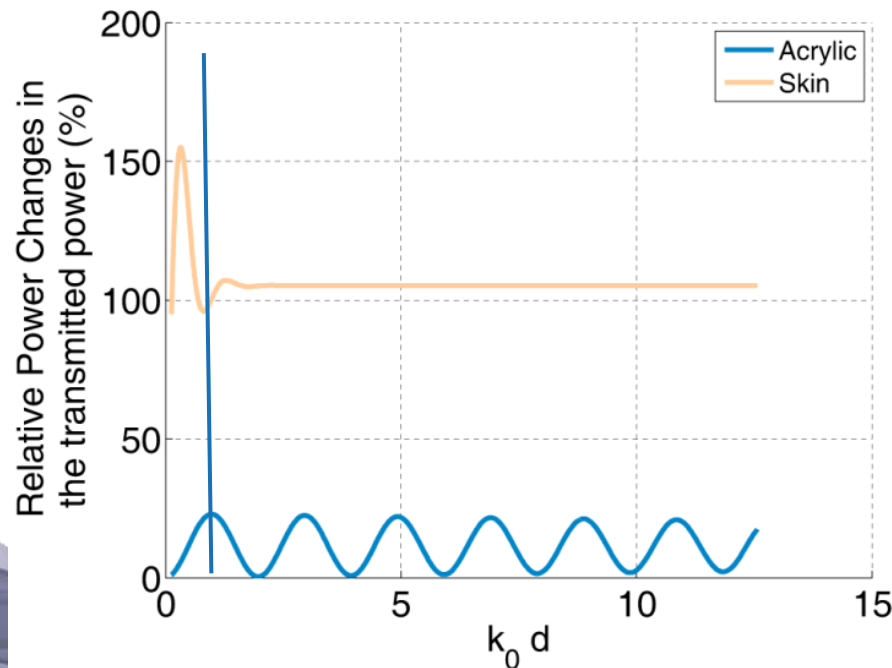
Material slab



Material slab and metamaterial



At 60 GHz



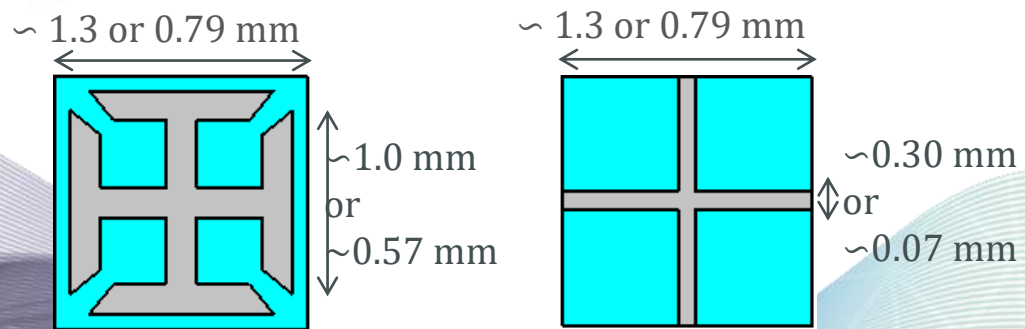
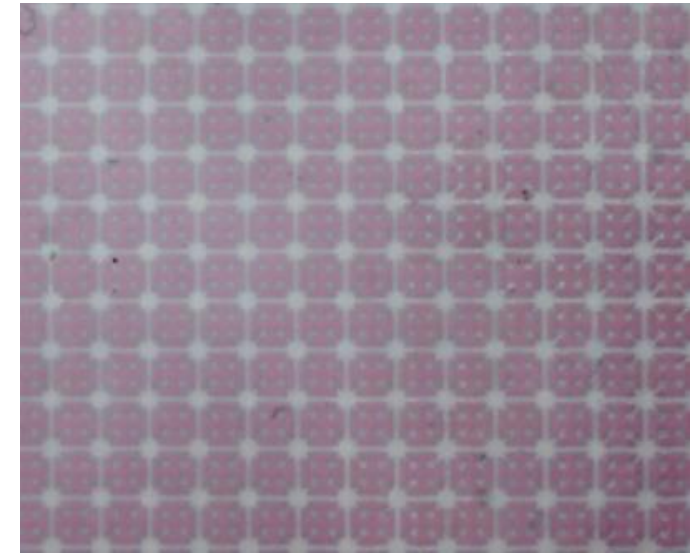
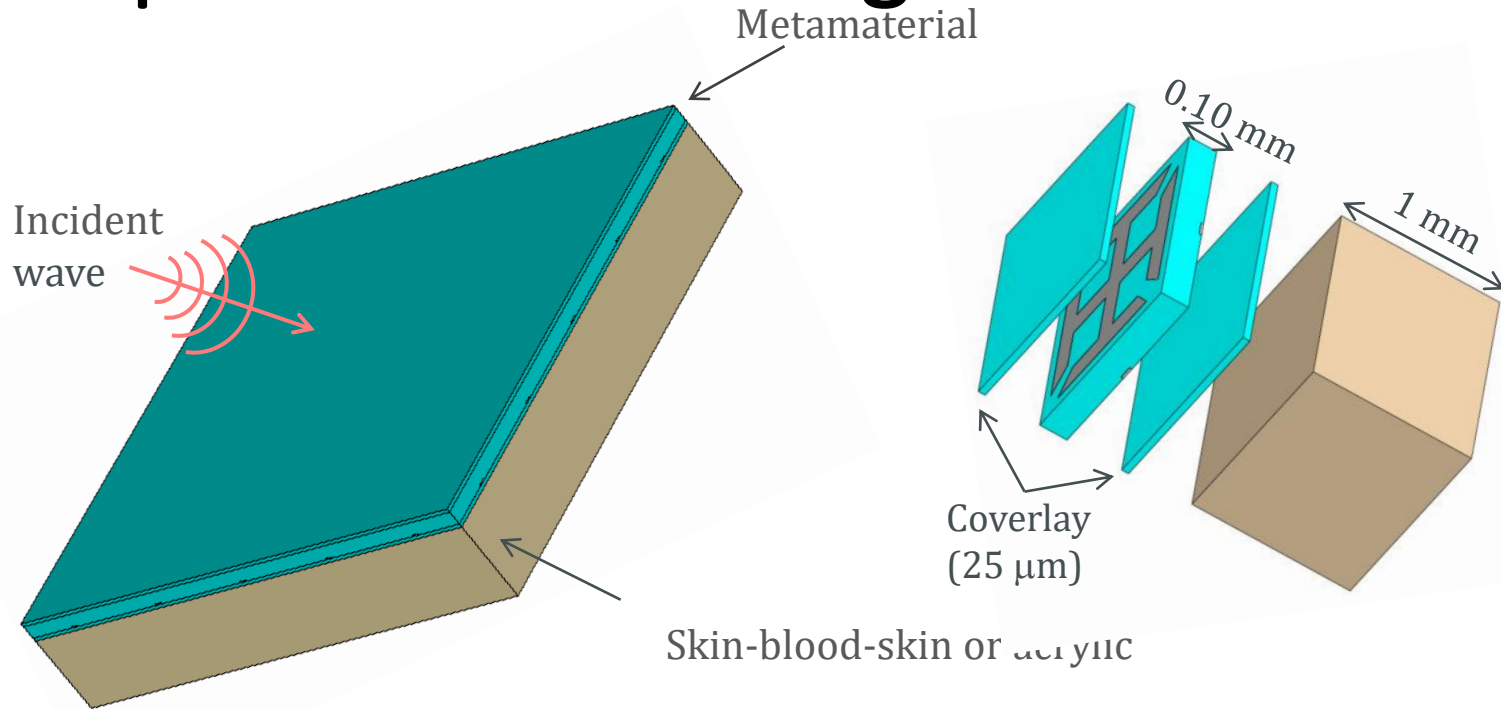
$$\text{Relative power changes} = \frac{P_{T\_MM} - P_{T\_no\_MM}}{P_{T\_no\_MM}}$$

Relative power changes for a 0.58mm material slab at 60 GHz

Acrylic: +19%  
Skin: +98%

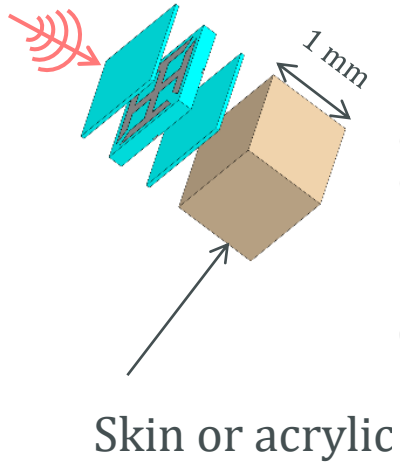


# Impedance Matching Metamaterial Design

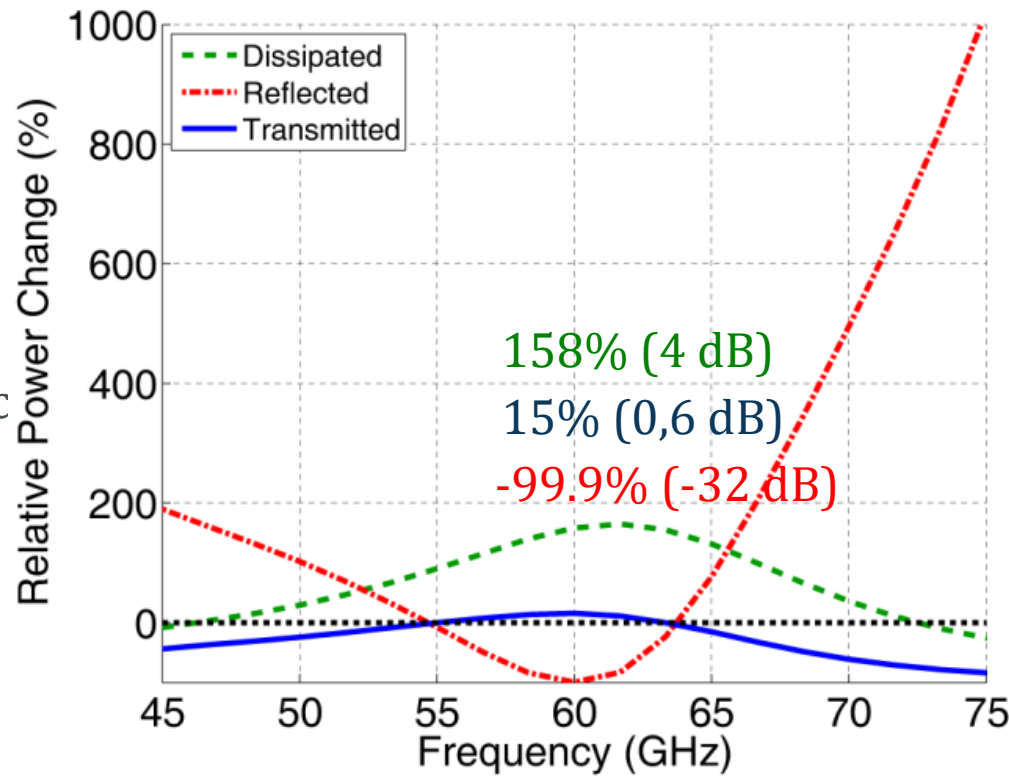


# Simulation Results

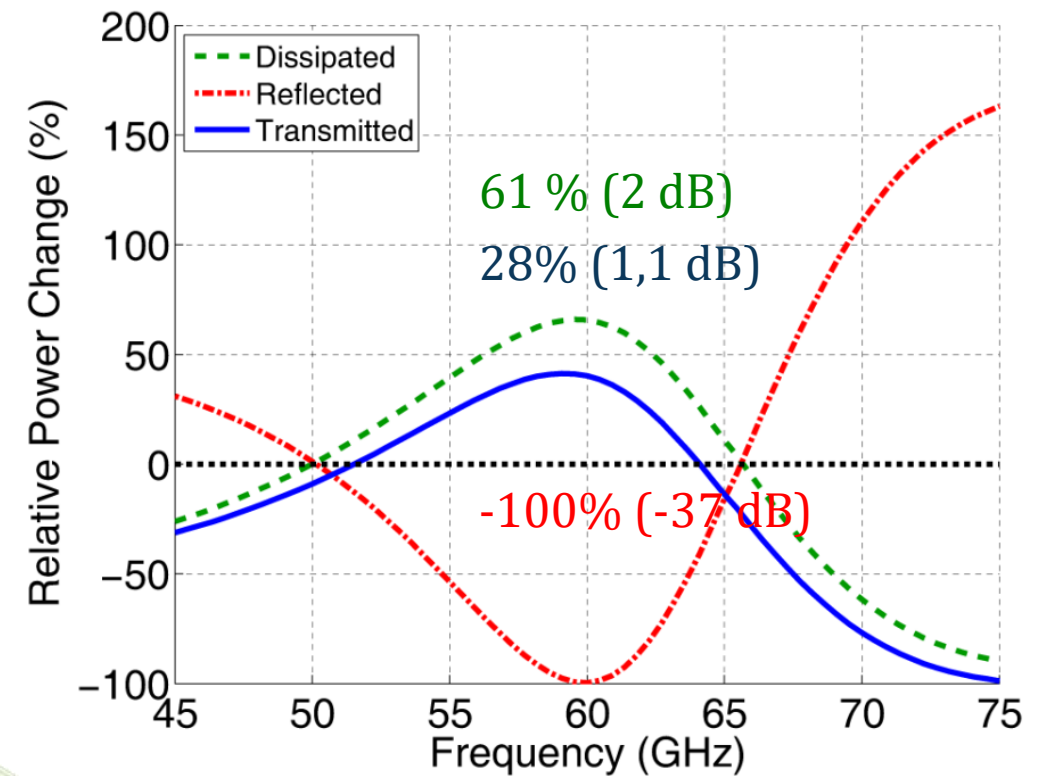
Relative power changes in the dissipated, reflected and transmitted power



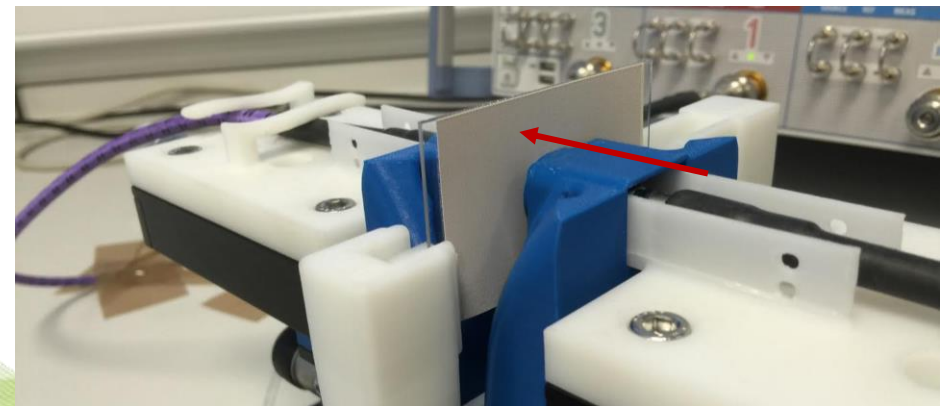
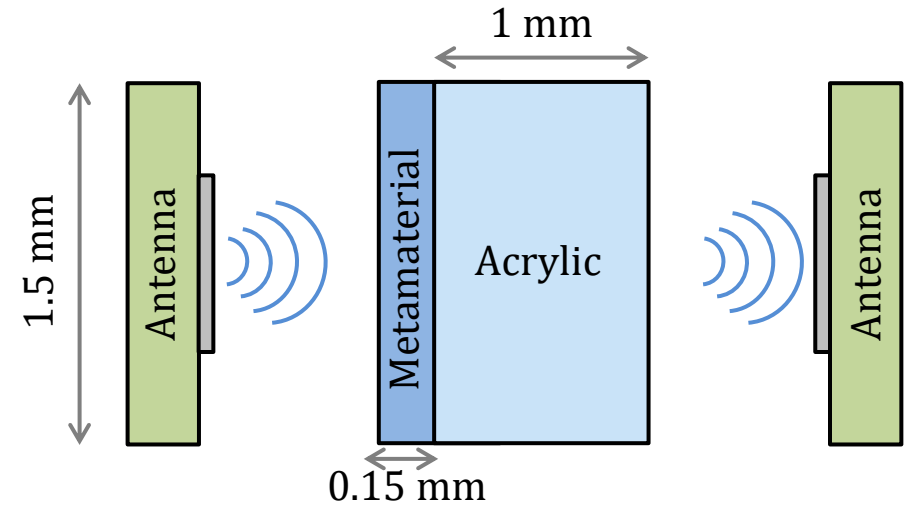
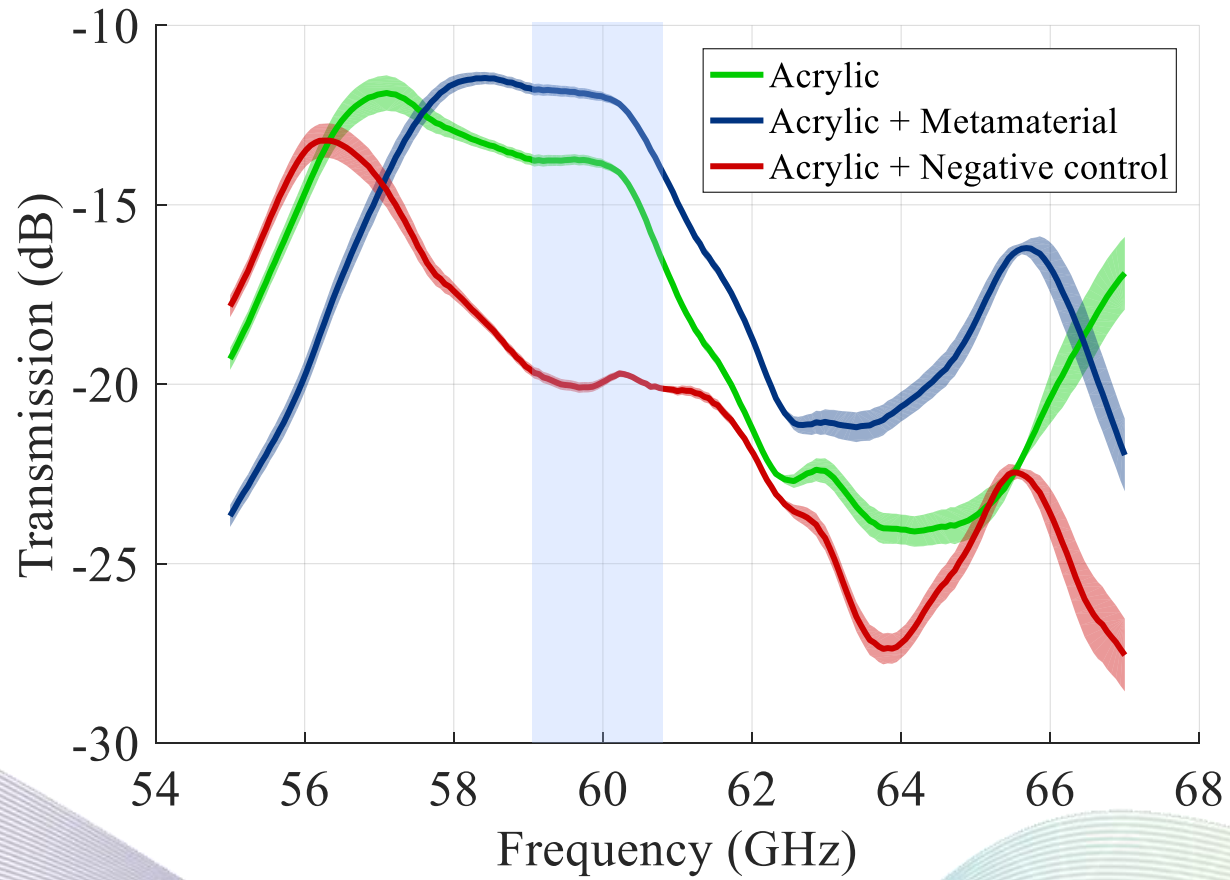
Acrylic Design



Skin Design

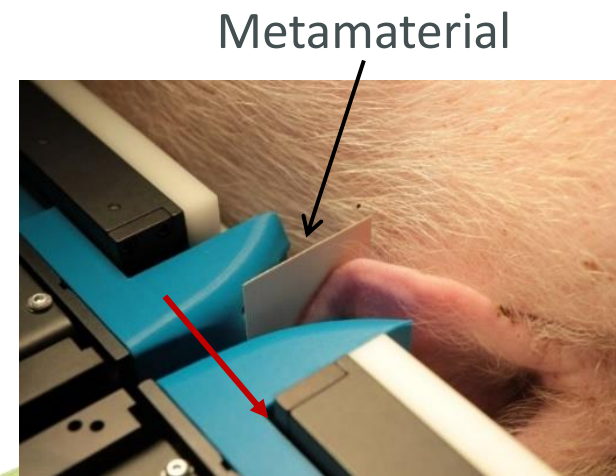
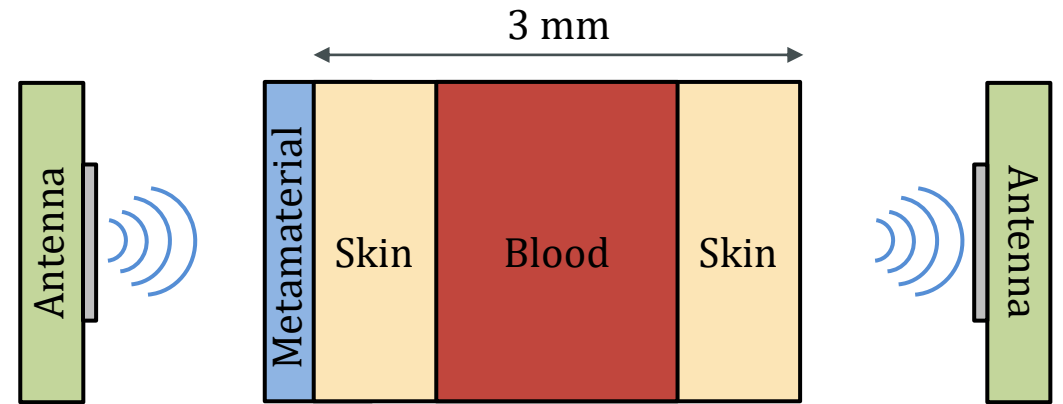
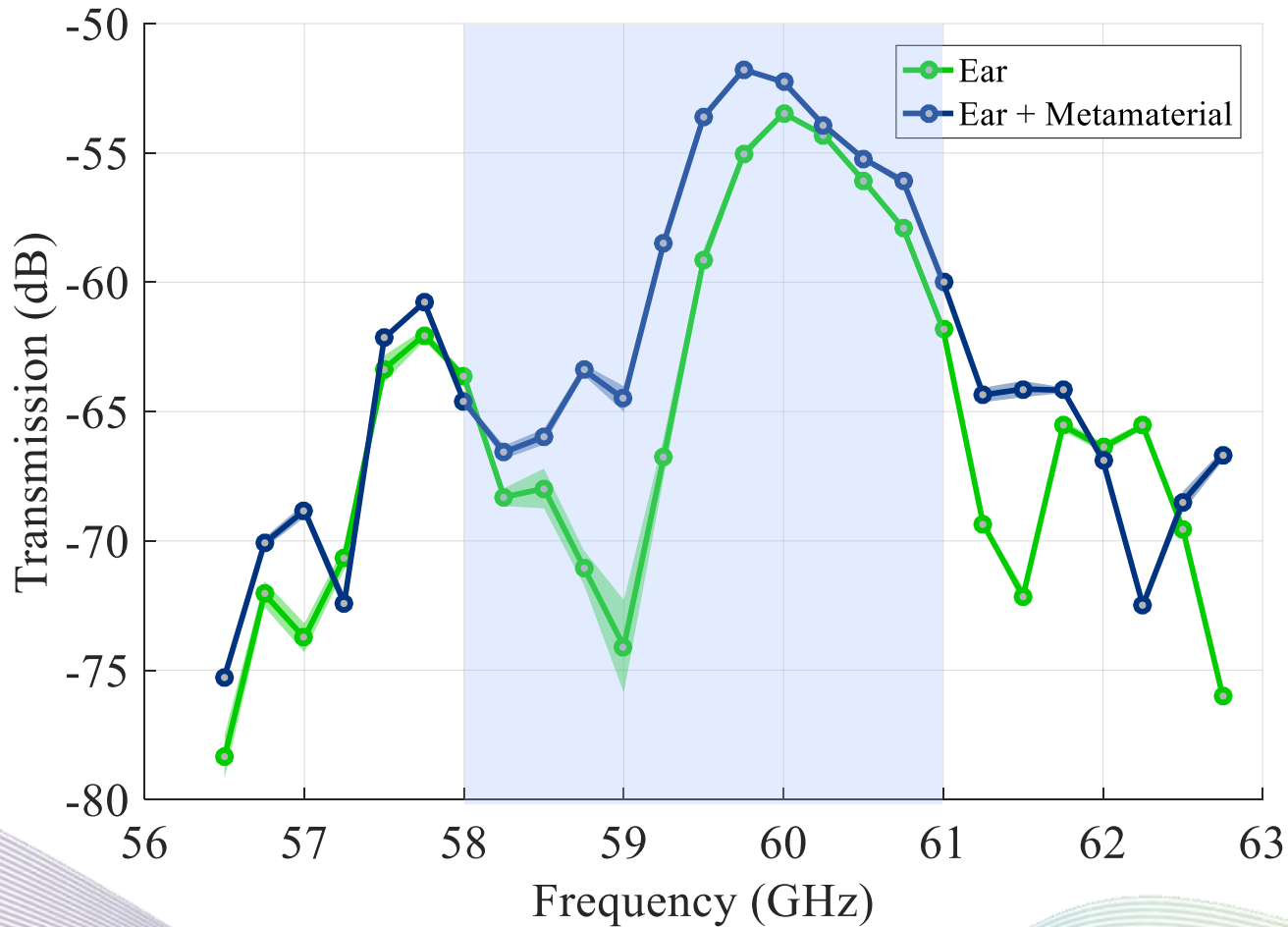


# Transmission Through an Acrylic Slab





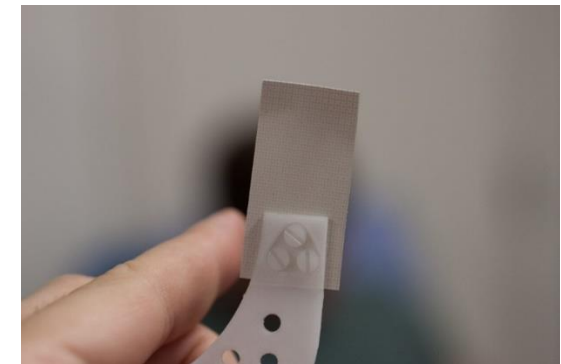
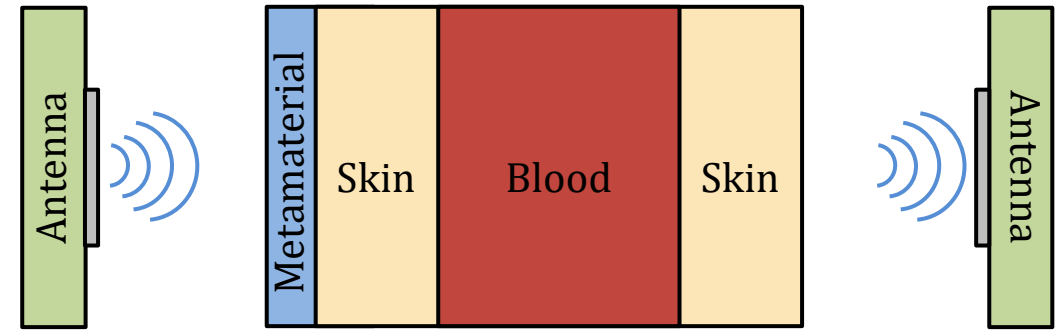
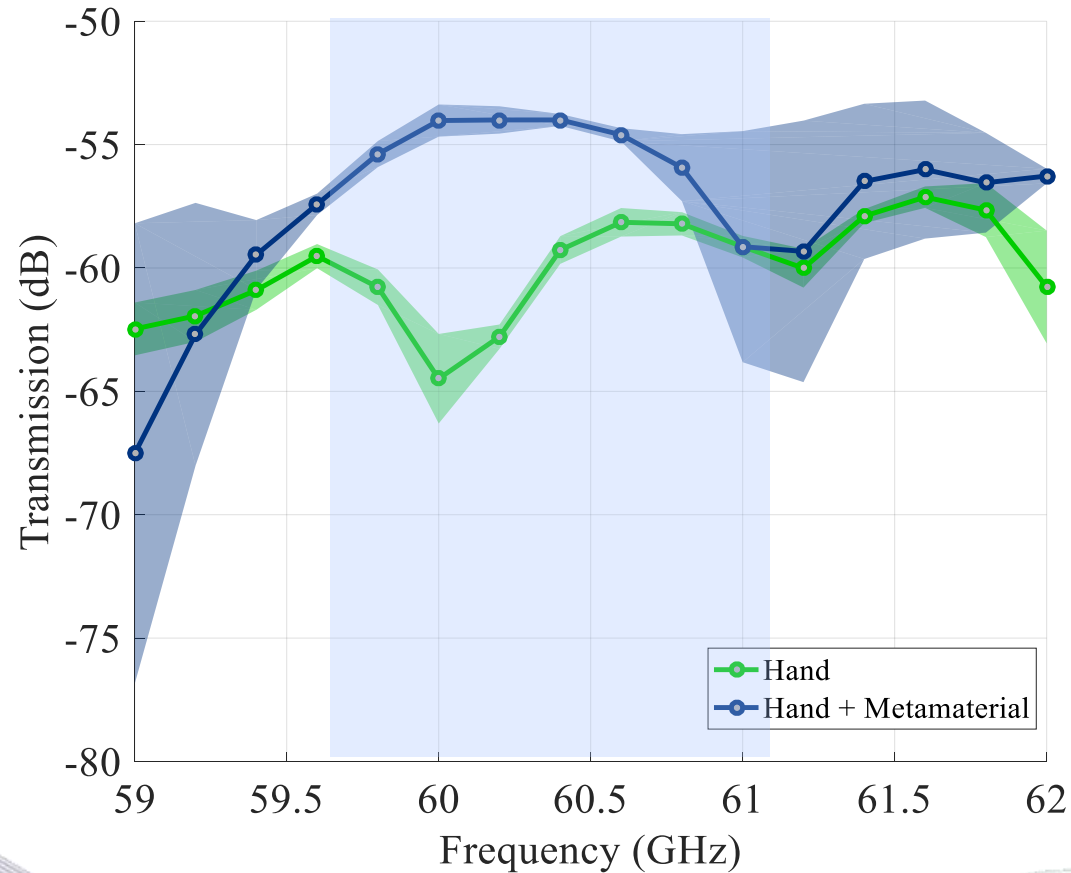
# Transmission Through a Pig Ear



H. Cano-Garcia, P. Kosmas, and E. Kallos, "Demonstration of enhancing the transmission of 60 GHz waves through biological tissue using thin metamaterial antireflection coatings," in *2016 10th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (METAMATERIALS)*, 2016.



# Transmission through Human Tissue

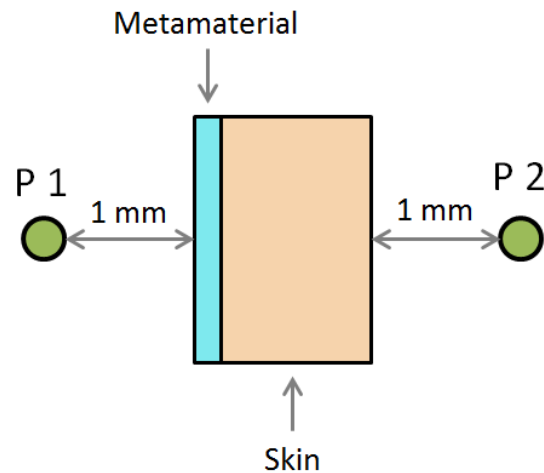
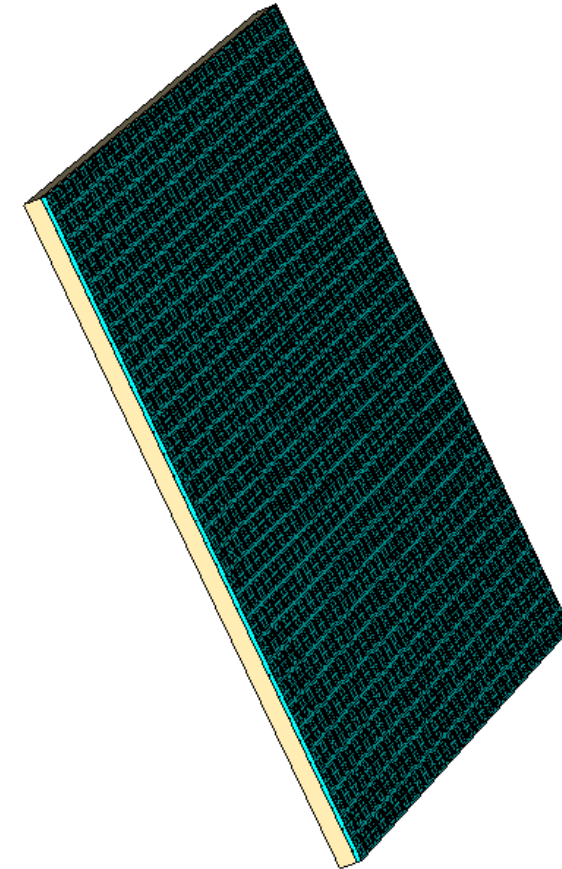


# Large Metamaterial Structures

Minimum size necessary to obtain same performance as the

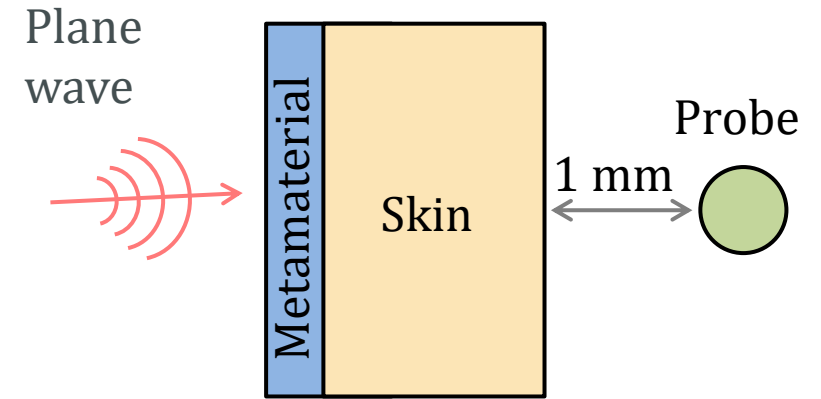
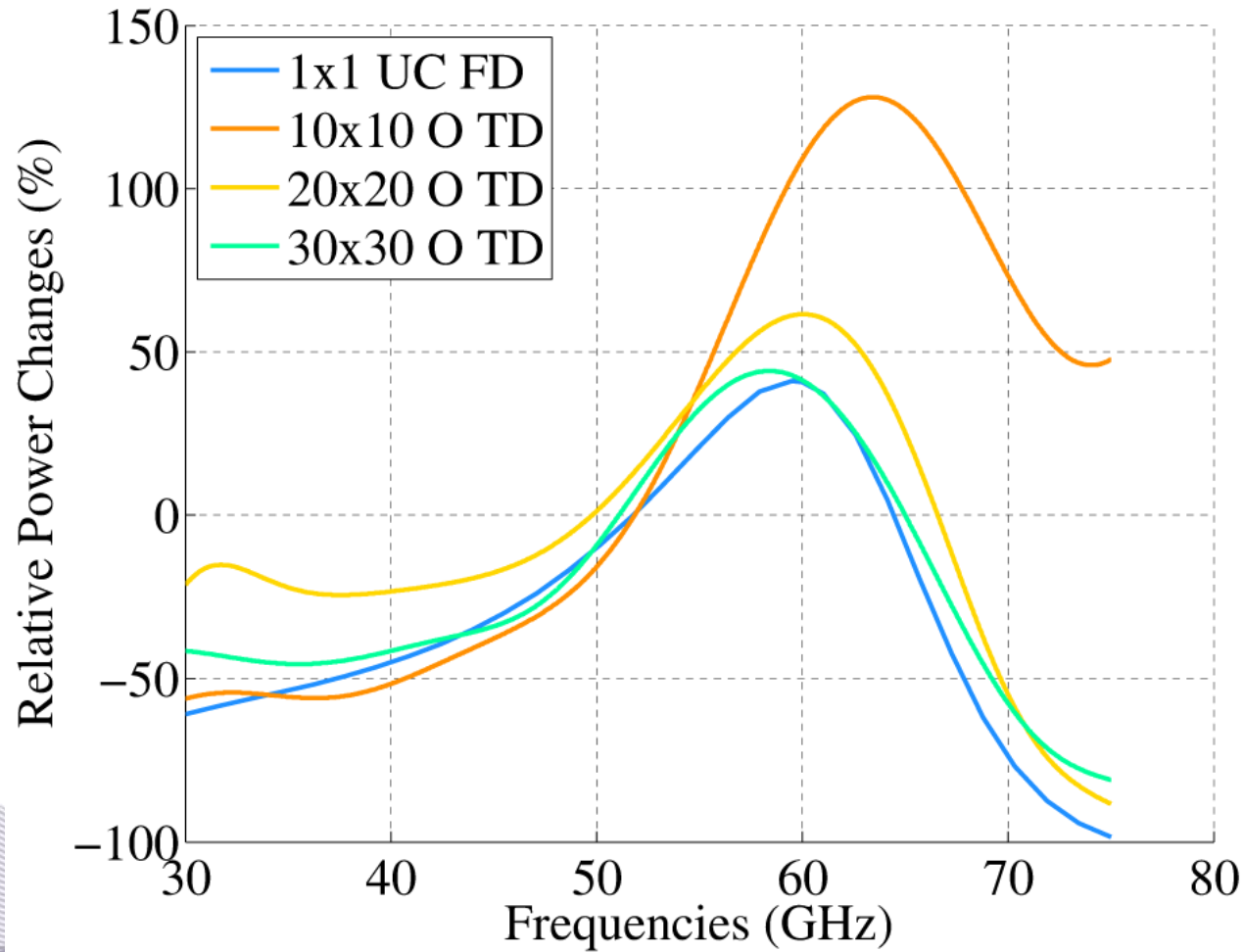
Time domain simulations with open boundaries

Electric field probes



30x30 Unit cells  
 ~ 22 x 22 mm

# Large Metamaterial Simulation Results

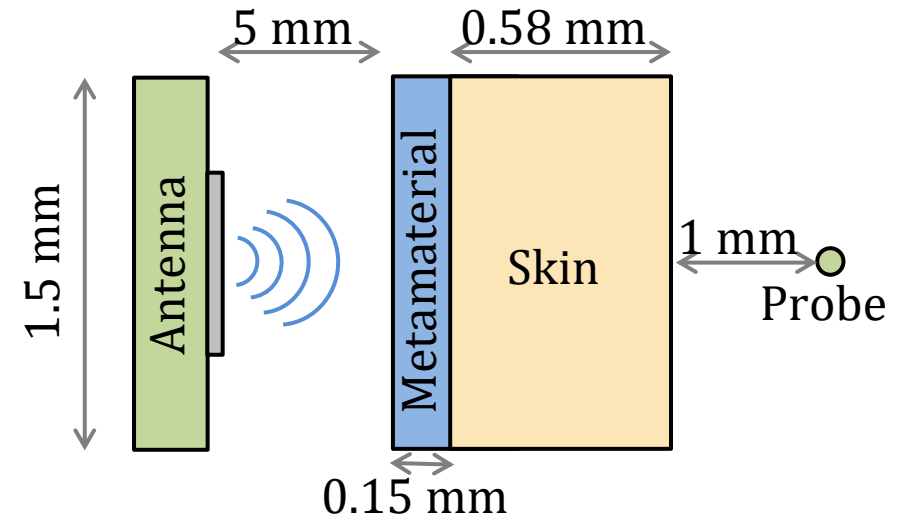
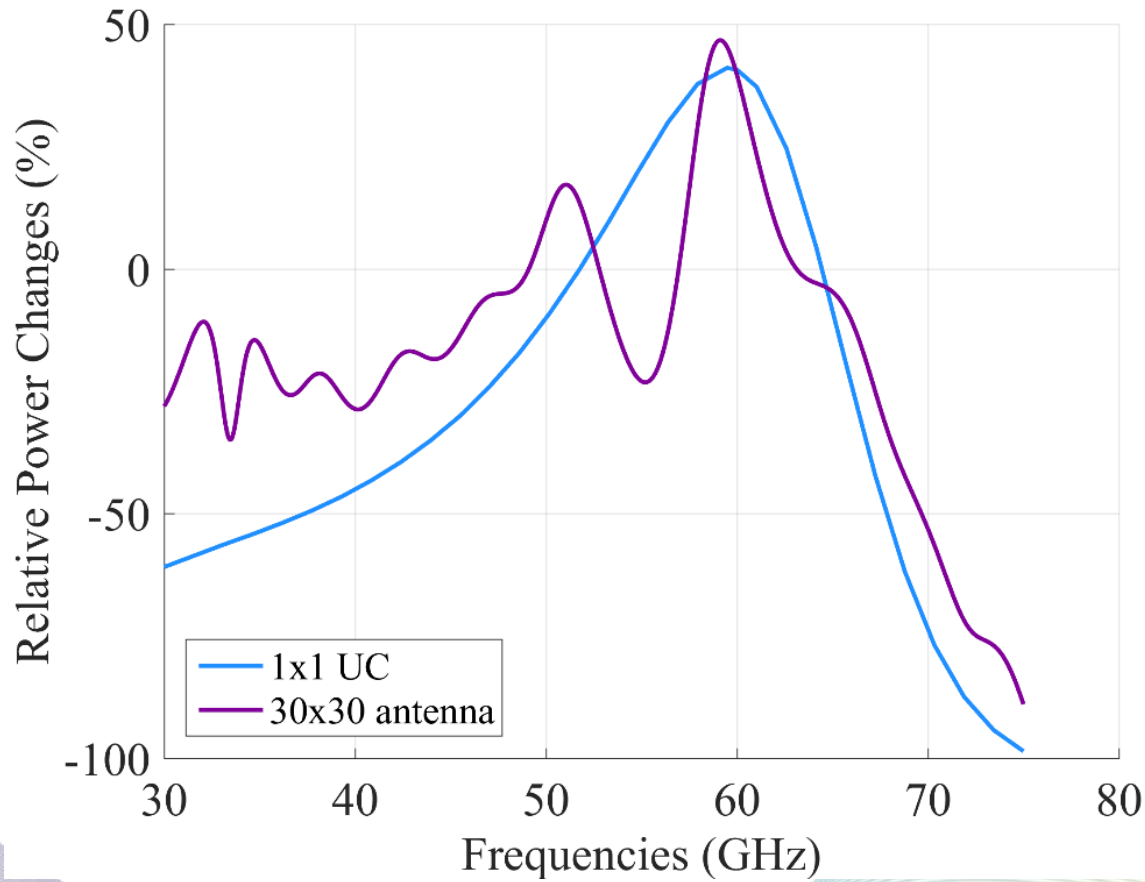


10x10 → 168.2% error

20x20 → 51.2% error

30x30 → 1.4% error

# Large Metamaterial Simulation Results





# Summary of Challenges

- Large scale, beyond unit cell
- Realistic excitation sources
- Interaction with biological tissues and other lossy materials

# Thank You

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