COLORADO SCHOOL OF MINES

Optimization of Surface Wave Excitation

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April 17th, 2025

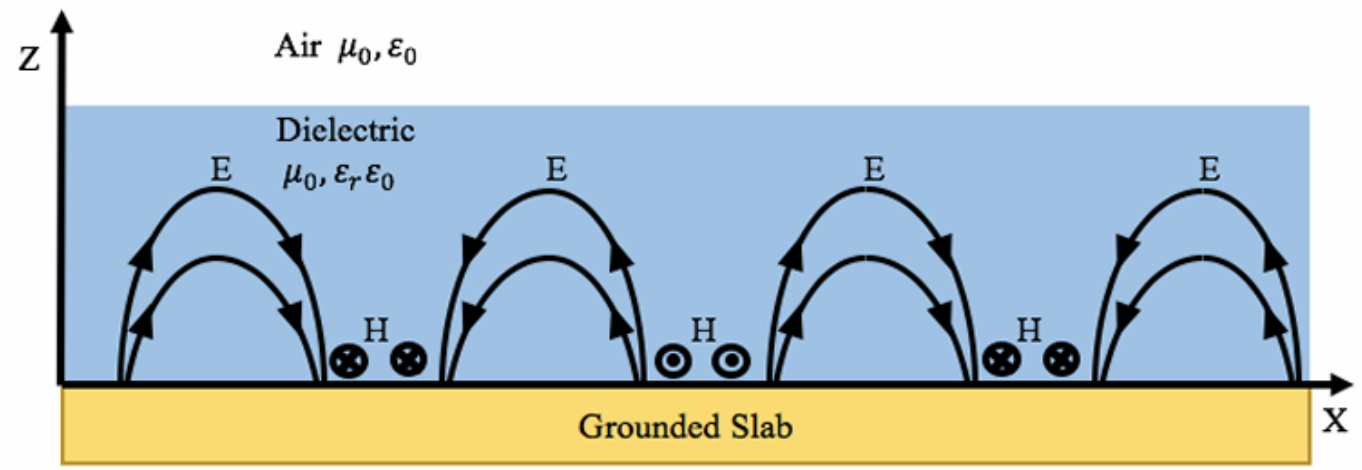
MURF 2025 Symposium

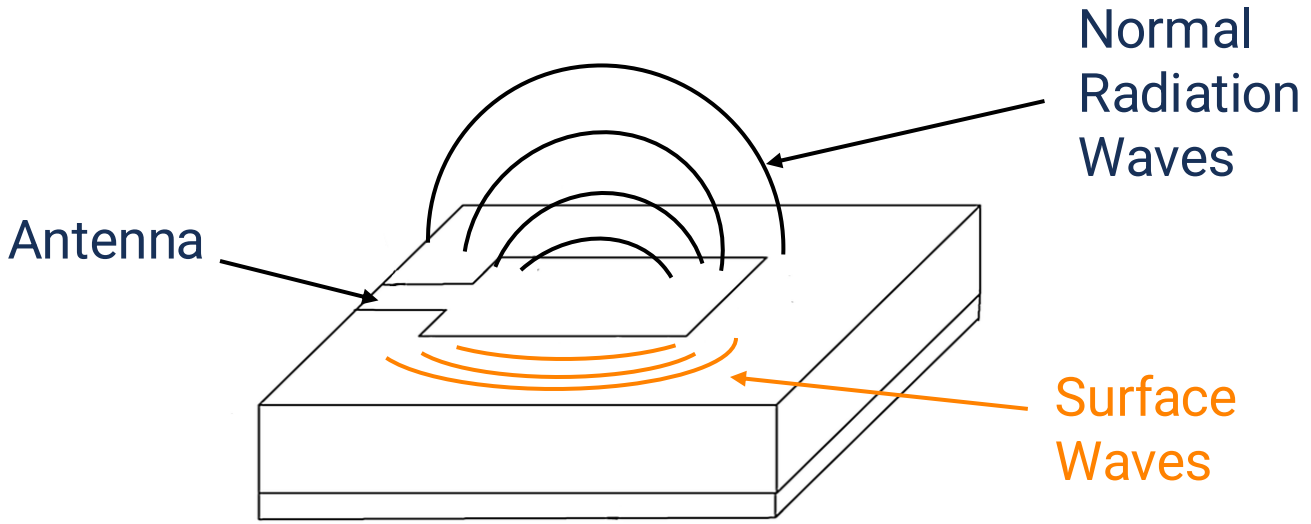
What are Surface Waves?

Electric and Magnetic Energy Traveling Along a Surface

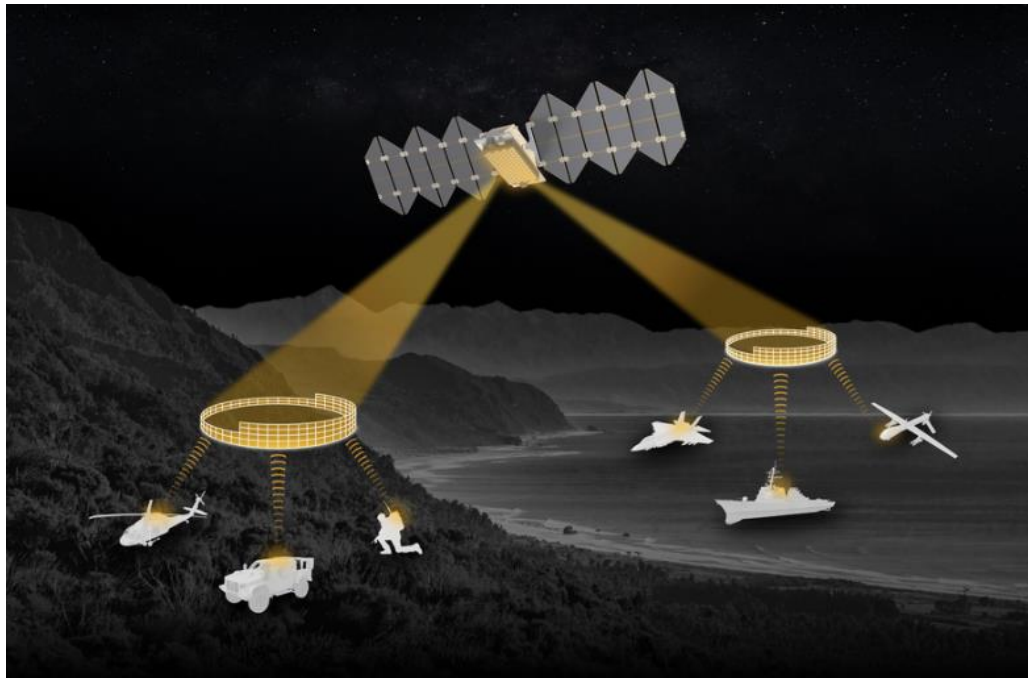
- Stick to the surface — they don't fly off into the air
- Cause coupling between antenna elements – leading to distortion of signals
- Energy trapped in surface waves don't contribute to radiated power

[1,2]





Surface Waves Affect You



Real World Impact:

Imagine a future where

- All Wi-Fi is received through Satellite
- Your phone stays connected in remote locations

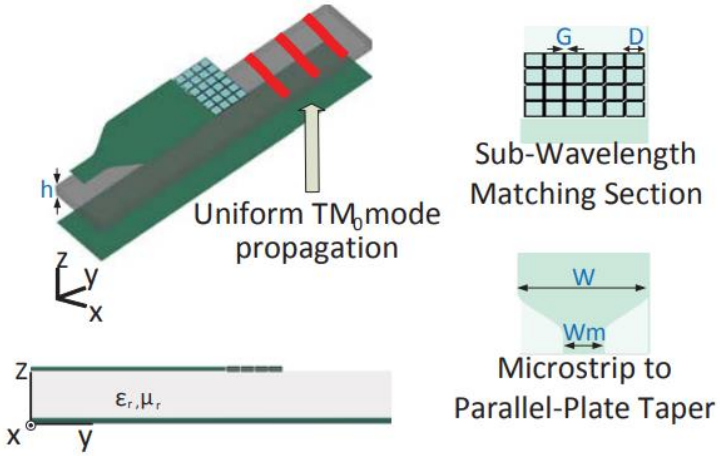
[3,4]

Why They're Undesirable:

- Wasted energy during antenna radiation
- Surface waves interfere with other antennas on an array

Synthesis of Surface-Wave Launcher

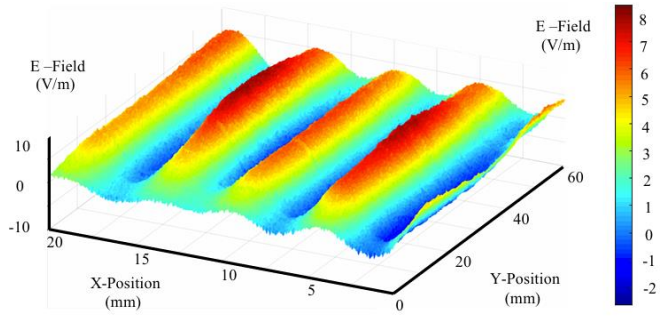
1. Objective



Create a PCB that:

- Propagates a surface wave on a substrate

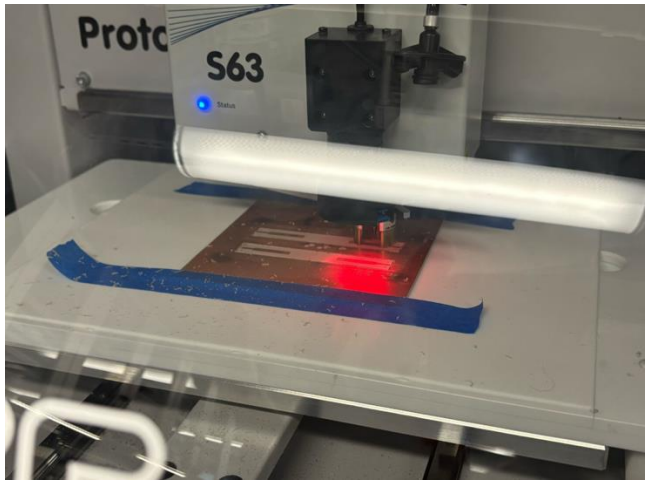
2. Simulation



Use electromagnetic simulation to:

- Optimize the propagation of surface waves

3. Fabrication



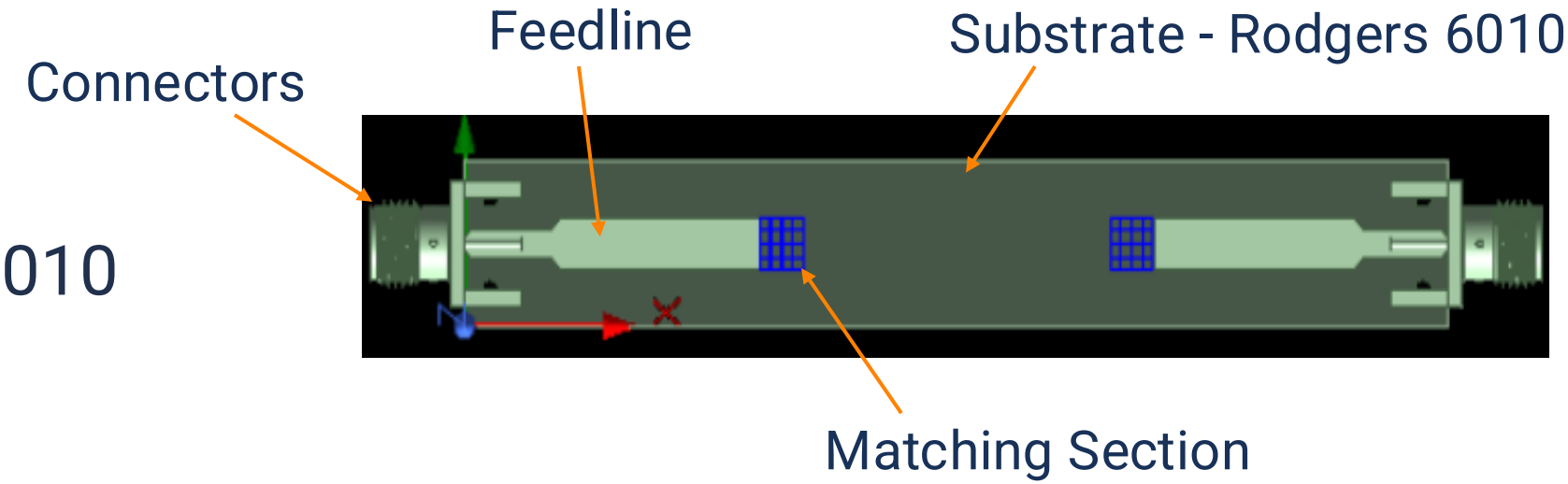
Milling equipment:

- In house manufacturing of the PCB using lab equipment

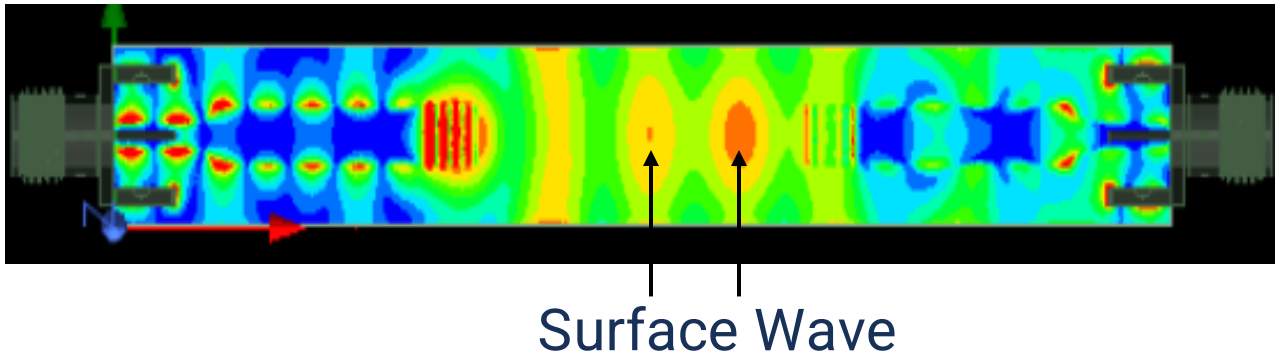
[1,5]

Electromagnetic Simulation

- Substrate - Rogers 6010
- SMA connectors
- Microstrip Feedline
- Matching Section



Visualization of Electric Fields

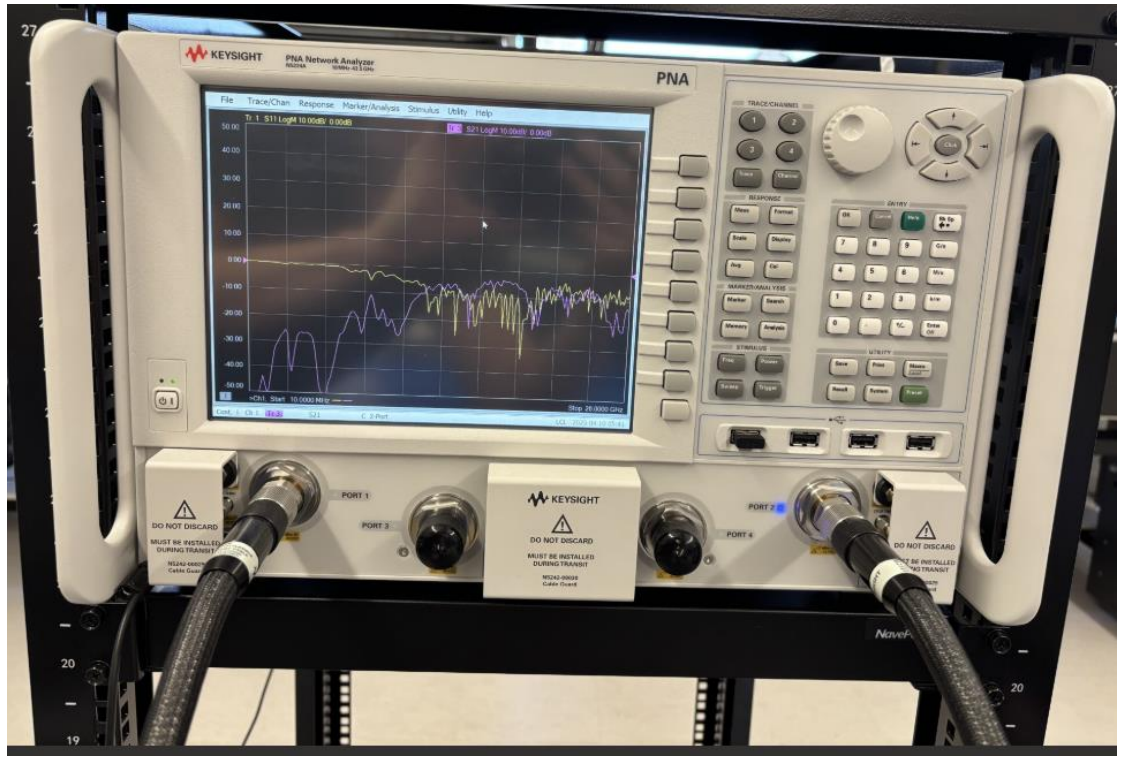


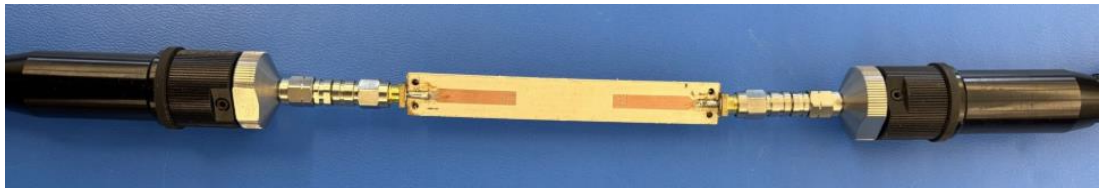
[5,6]

Transmission and Reflection Measurements

Vector Network Analyzer (VNA)

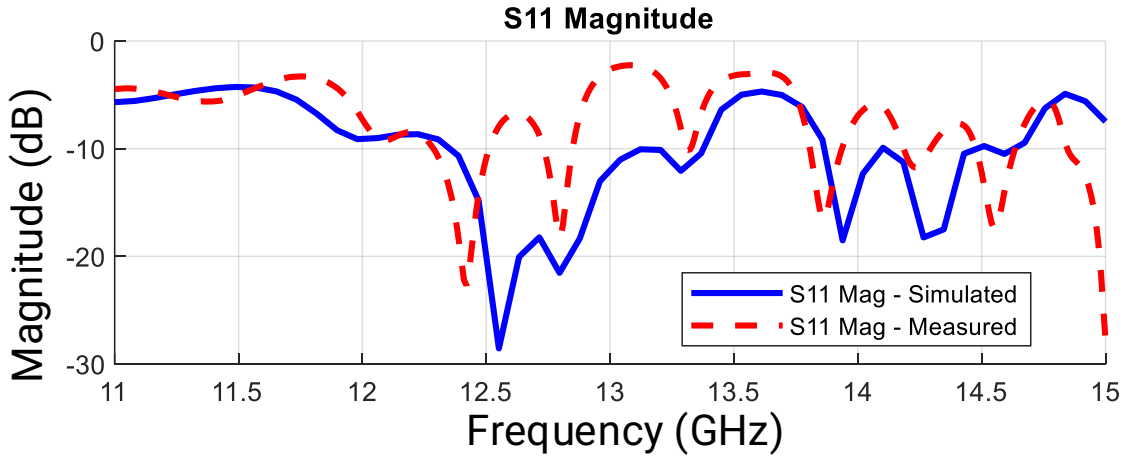
- Measure reflection and transmission power: scattering parameters
- Used to evaluate how electrical signals propagate through a device
- Evaluates signals by sweeping frequency



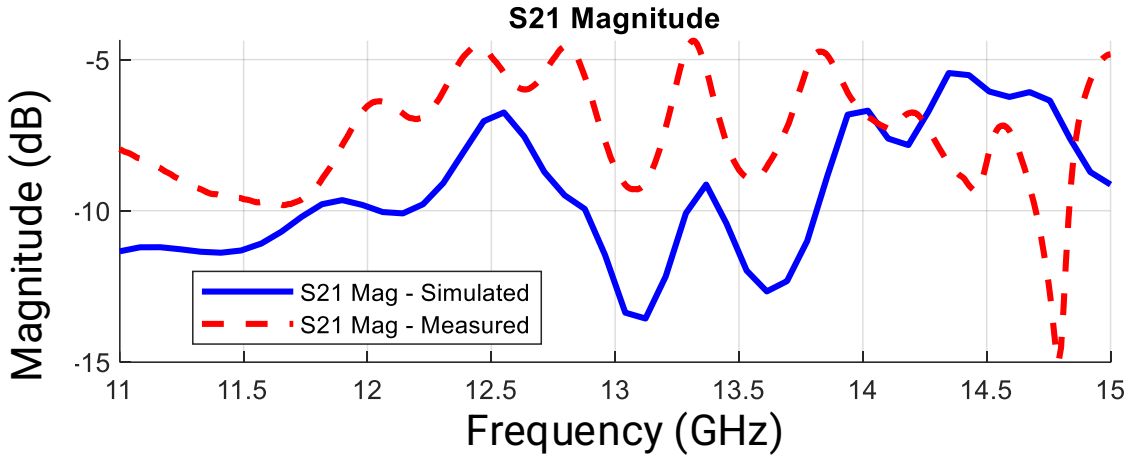


S-parameters

- Similar trends and magnitude
- Lower S_{11}; less power is being reflected, therefore more efficient
- Higher S_{21}; more power is making it to the output port



Measure of power reflected back towards the input port

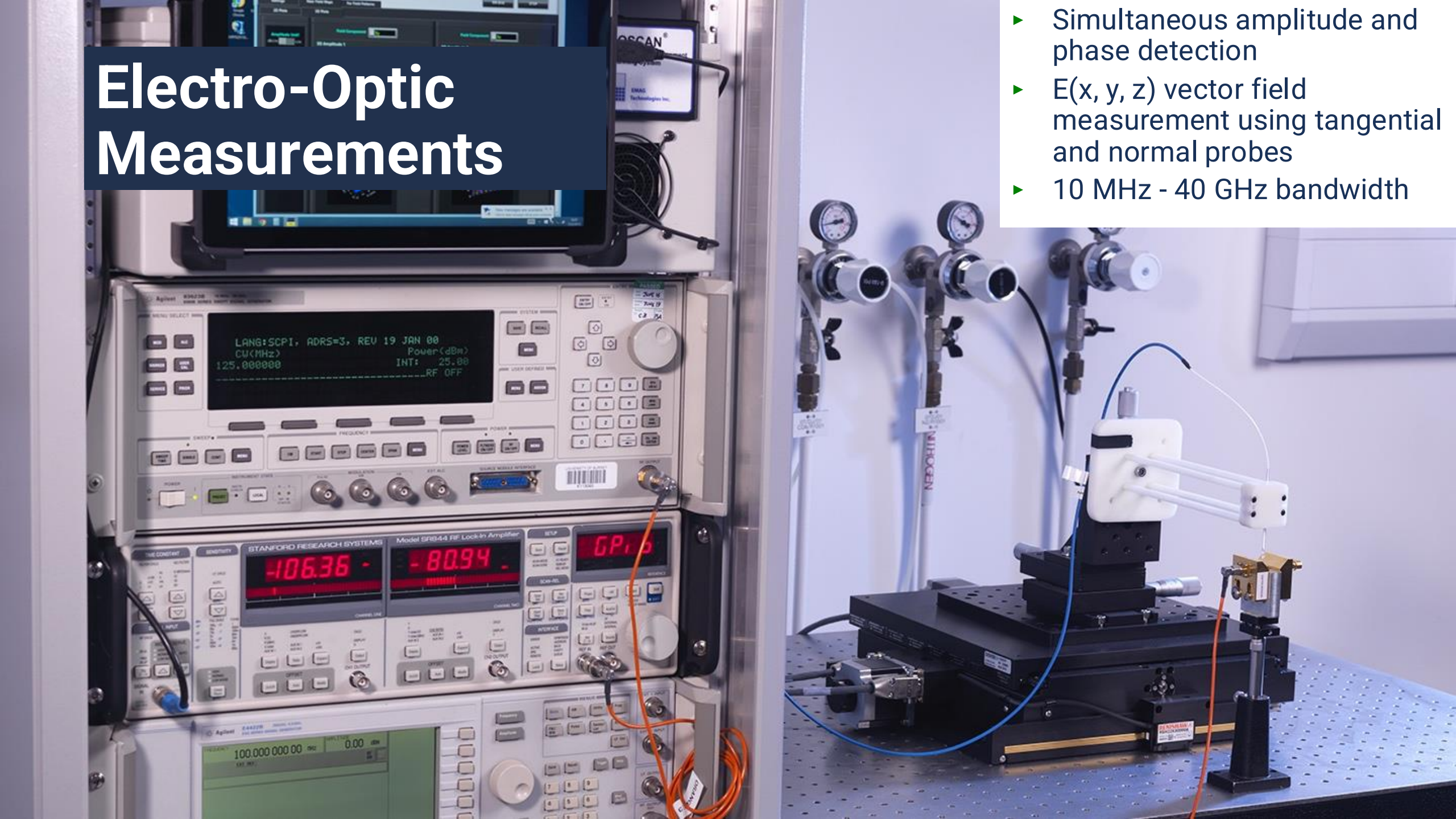


Measure of power transmitted through the device, to the output port

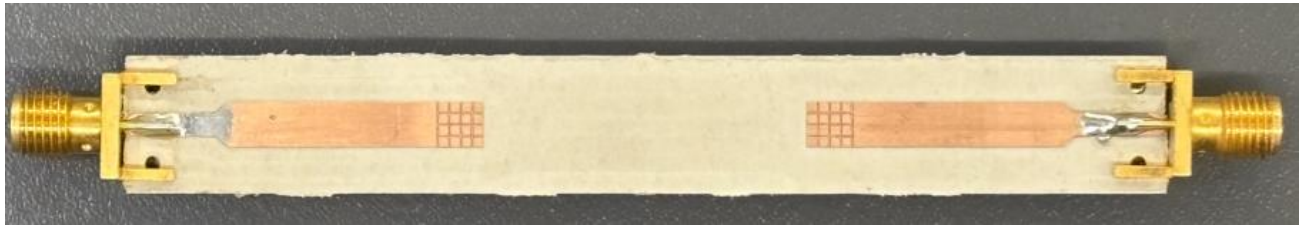
[7]

Electro-Optic Measurements

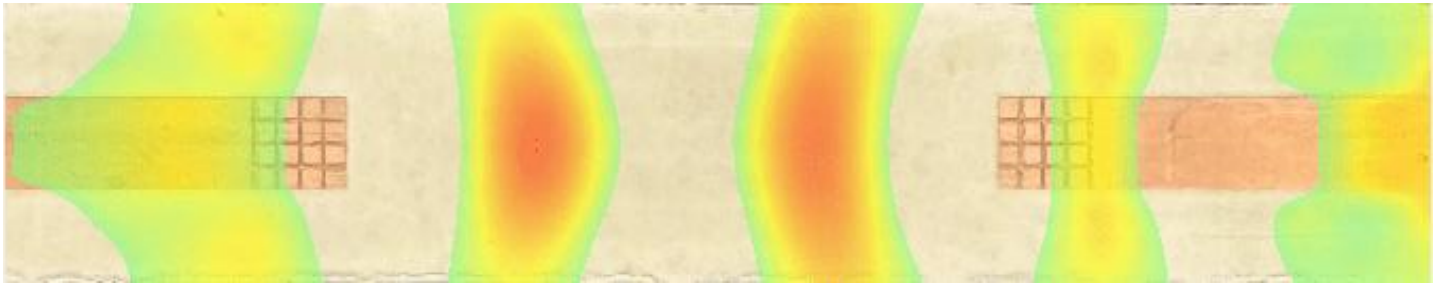
- Simultaneous amplitude and phase detection
- E(x, y, z) vector field measurement using tangential and normal probes
- 10 MHz - 40 GHz bandwidth



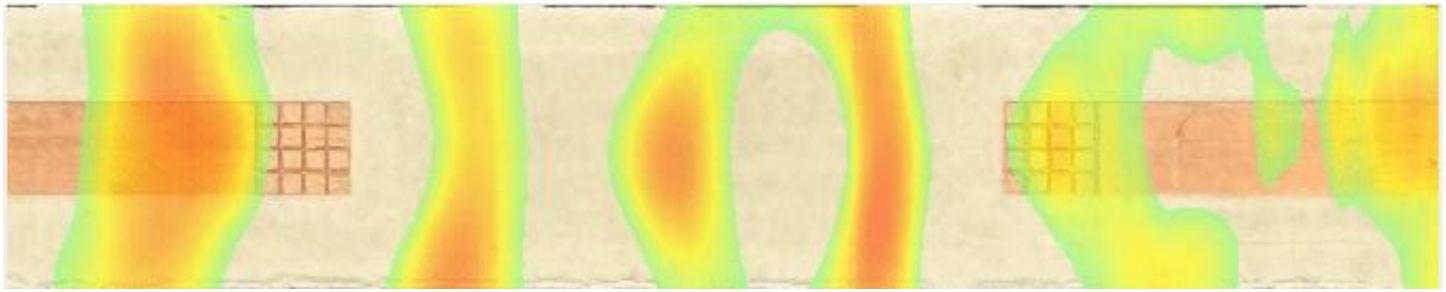
Animation of E_Z



- MATLAB animations
- Animates the phase change of the electric field
- Simulation and measurements E_z are normalized to the same scale
- Plotted on the actual design
- Almost identical results!



Simulation of E_Z

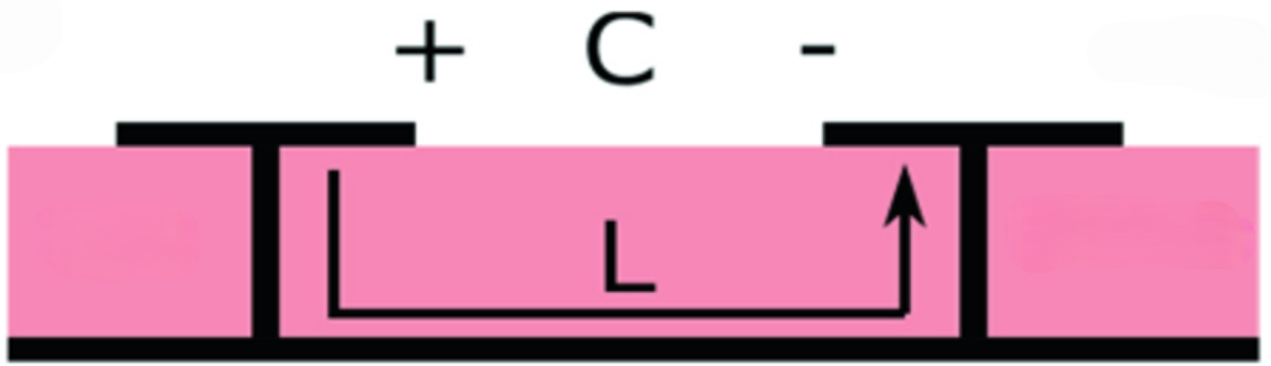


Measurement of E_Z

Investigation of Electromagnetic Bandgap Materials (EBGs)

Optimal EBG structure for surface wave termination and propagation

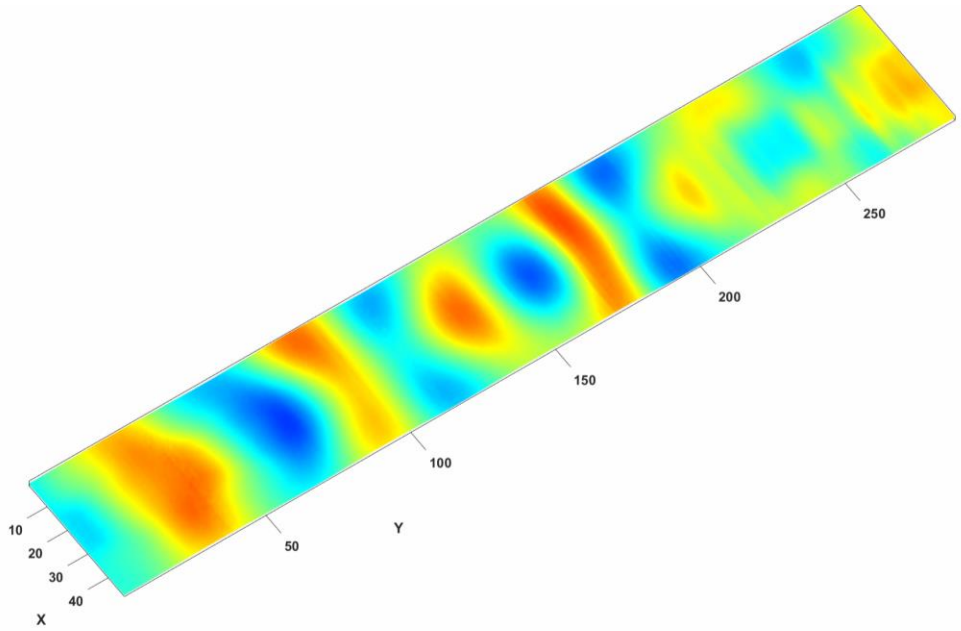
- EBGs can stop surface waves
- Provide frequency selective behavior
- Reduce coupling of antenna array elements



[8]

Conclusion

- Researched surface waves
- Designed and simulated a surface wave launcher
- In house manufactured the launcher
- Compared simulated and measured results to confirm existence of surface waves



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Acknowledgements

Dr. Peter Aaen

Dr. Gaberiel Santamaria-Botello

Dr. Atef Elsherbeni

Dr. Art Morris

Jackson Willner

Connor Denney

Steffen Kross

Ethan Hansen

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Questions?

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MANIPULATING SURFACE WAVES TO IMPROVE ANTENNA ARRAY PERFORMANCE