National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

High Directivity and Reconfigurable Sub-Wavelength Lens Coupled to a Rydberg Vapor Cell

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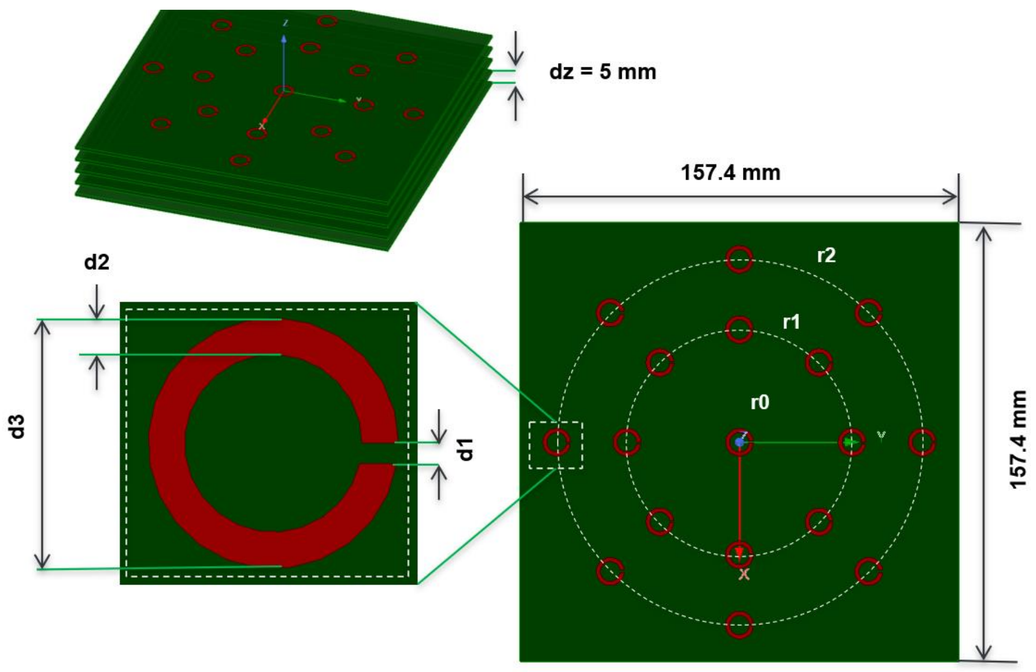
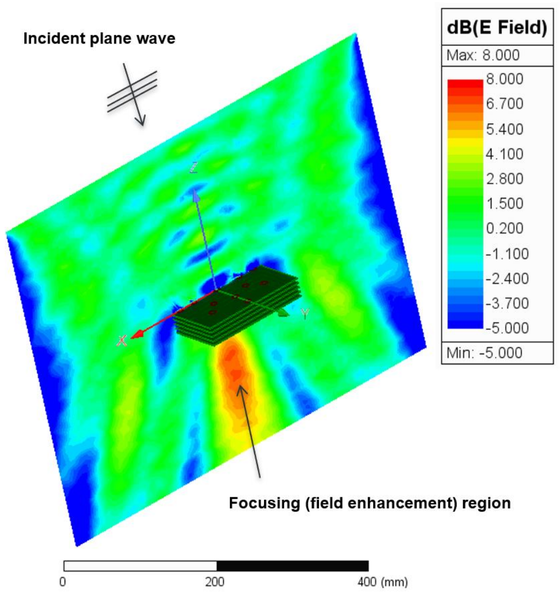
Objective: To develop a sub-wavelength Radio Frequency lens for the field enhancement and focusing of an incident electric field for the purposes of coupling energy into a Rydberg vapor cell

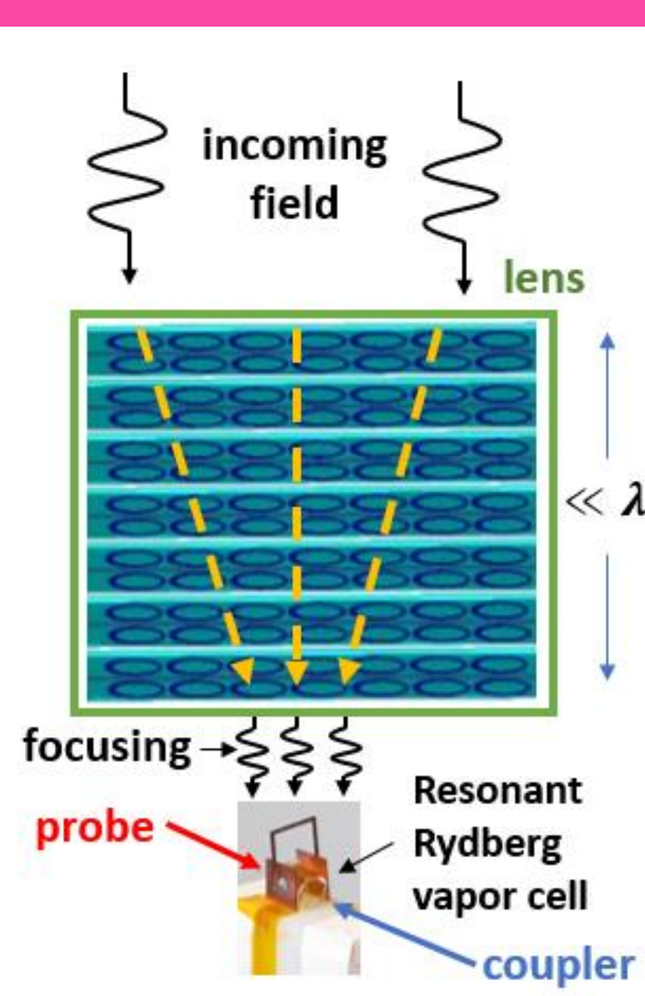
Background: As Quantum Rydberg Radars use a radically different approach to field sensing, traditional circuit-based RF systems cannot be used. GO/PO based beamforming techniques requires electrically large structures, which become cumbersome at low GHz frequencies. Sub-wavelength lenses show promise to shape radiation patterns and apply field enhancement to incident planewaves

Design

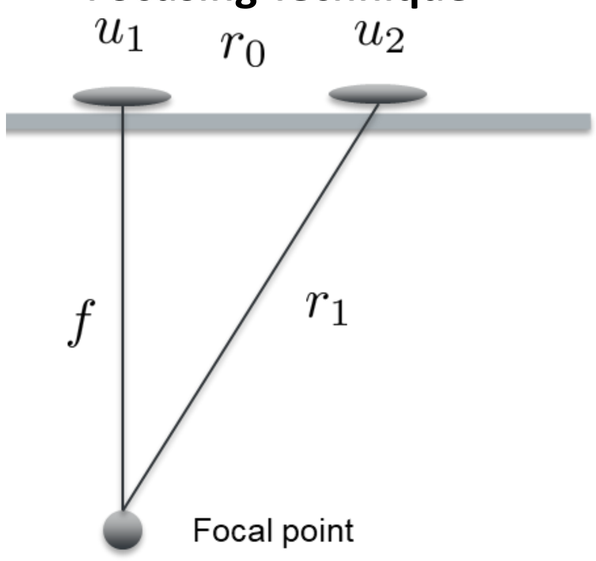


Simulation Results

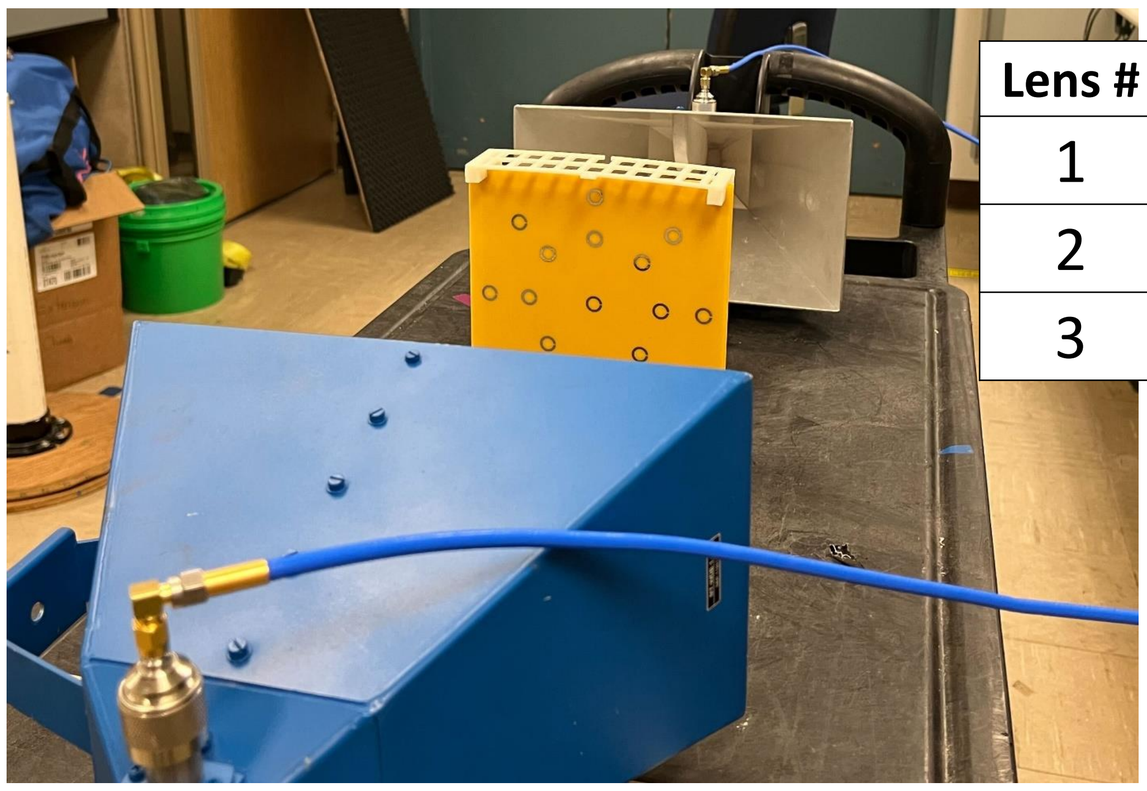




Focusing Technique

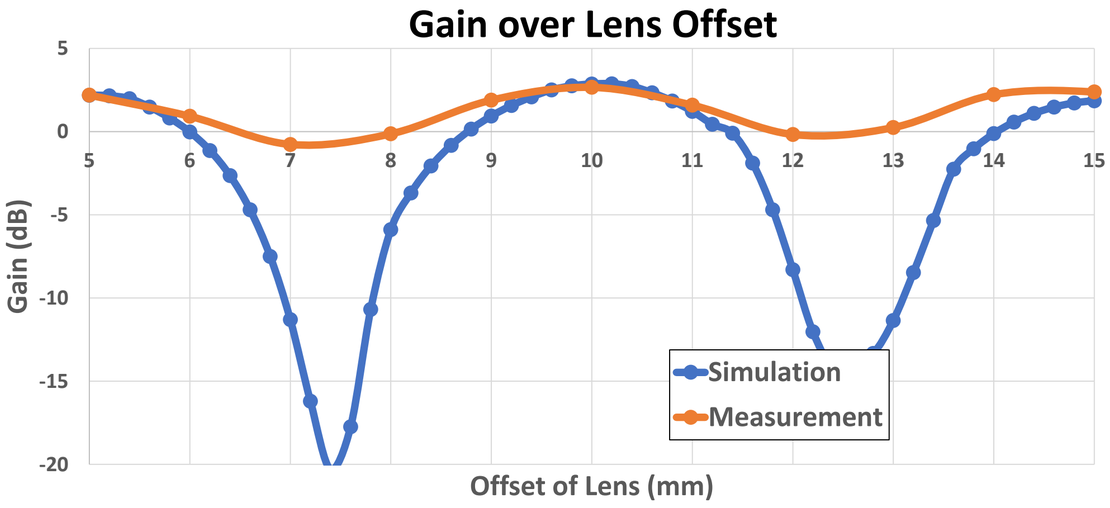


Experimental Setup

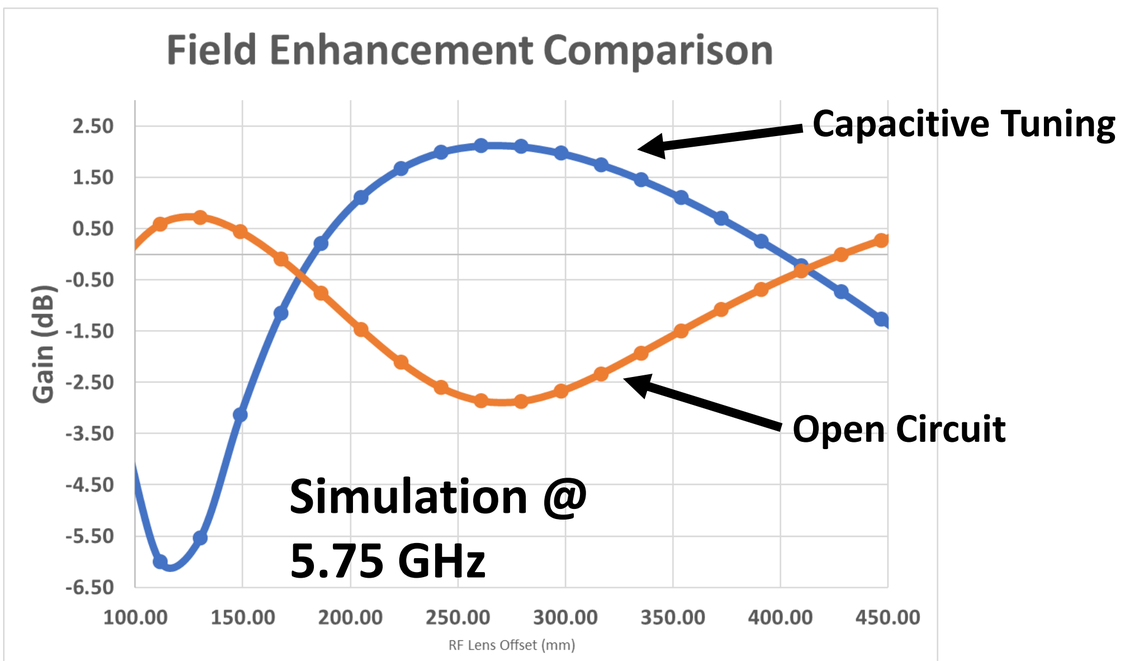


Lens #	Measured Gain
1	2.5 dB
2	3.54 dB
3	3.98 dB

Gain over Lens Offset



Field Enhancement Comparison



Approach and Results: Through simulation, a design was developed to operate at ~ 3 GHz. This design was fabricated and tested in the lab to characterize it's electrical parameters. Designs showed good agreement with simulation, with nearly **2.5 dB** gain with a single lens, and upwards of **4 dB** with 3 lenses. Future efforts are needed to continue this optimization process

Significance/Benefits to JPL and NASA: Allows for electrically small structures for field enhancements for non-metallic RF sensors.

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