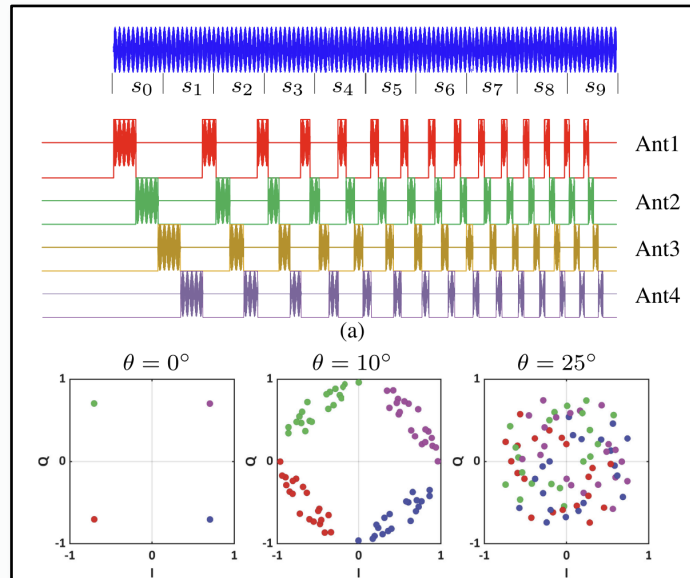
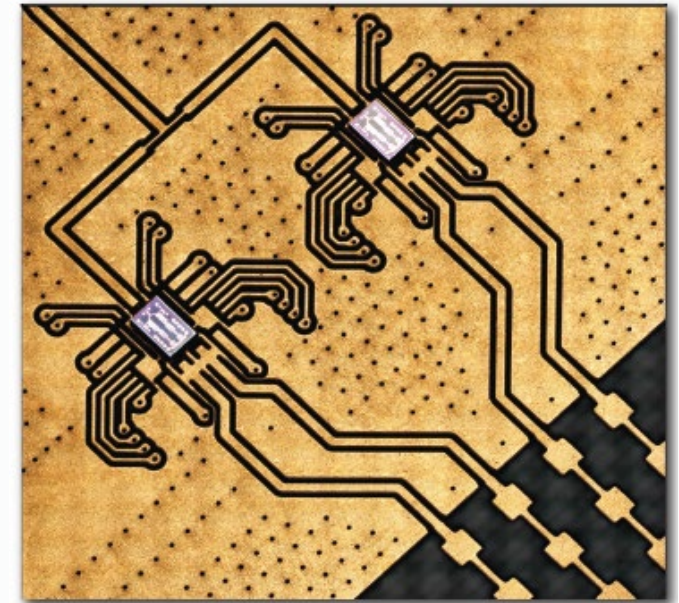


Space-Time Coded Waveforms for Secure and Resilient Wireless Links

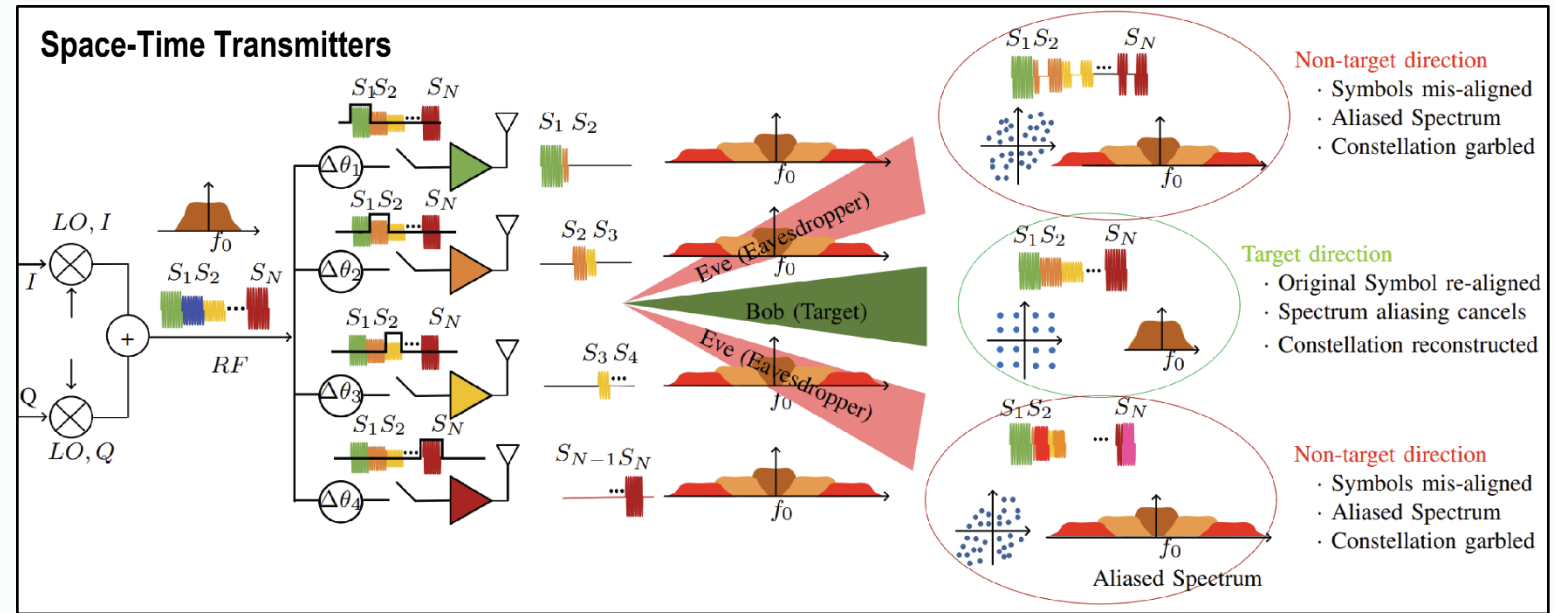
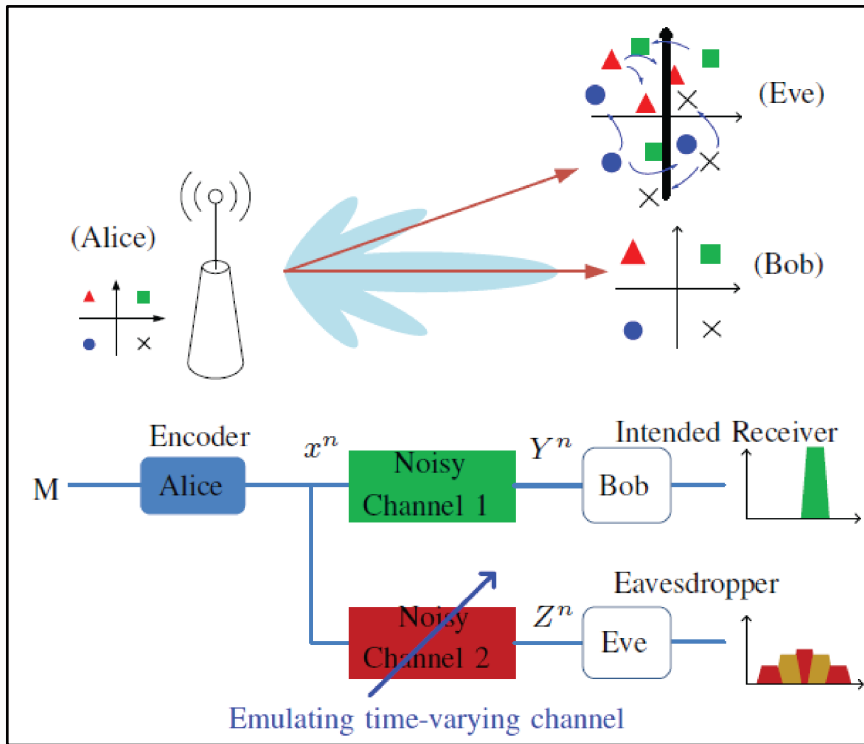
Suresh Venkatesh
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Security & Resiliency to wireless communications

- **Dynamic control of spectrum and channel**
 - Reconfigurable software-defined radios
 - AI-based channel estimation and equalization
- **Physical Layer Security for secure wireless links**
 - Space-time coded waveforms
 - ML based dynamic space-time coding for mitigating eavesdropper attacks
- **Resiliency in wireless links**
 - Dynamic waveform control through hardware control
 - Programming the wireless channel on-the-fly

Enabling Space-Time coded waveforms for secure dynamic channels

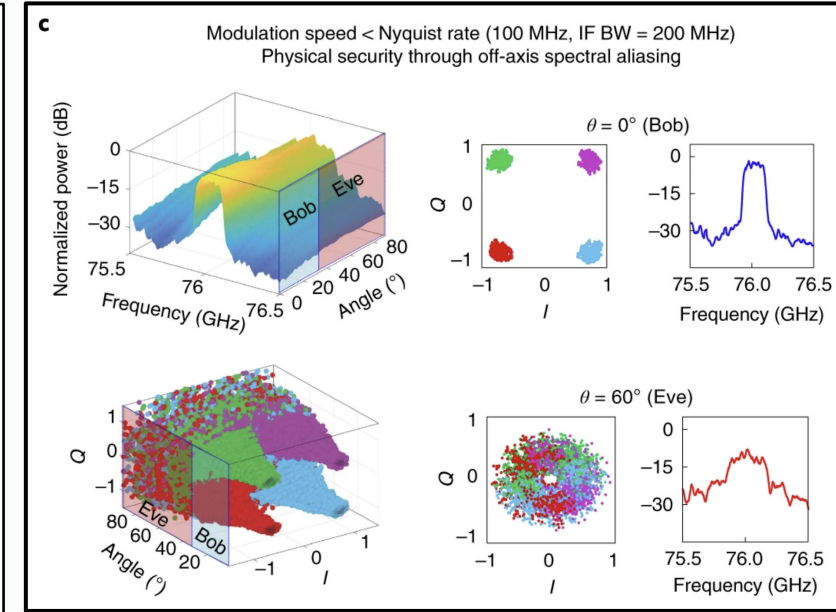
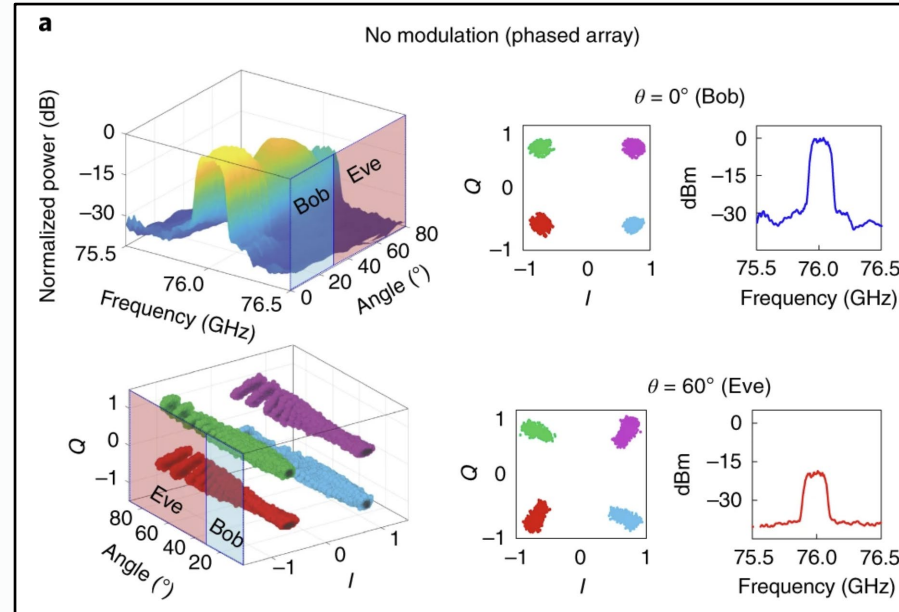
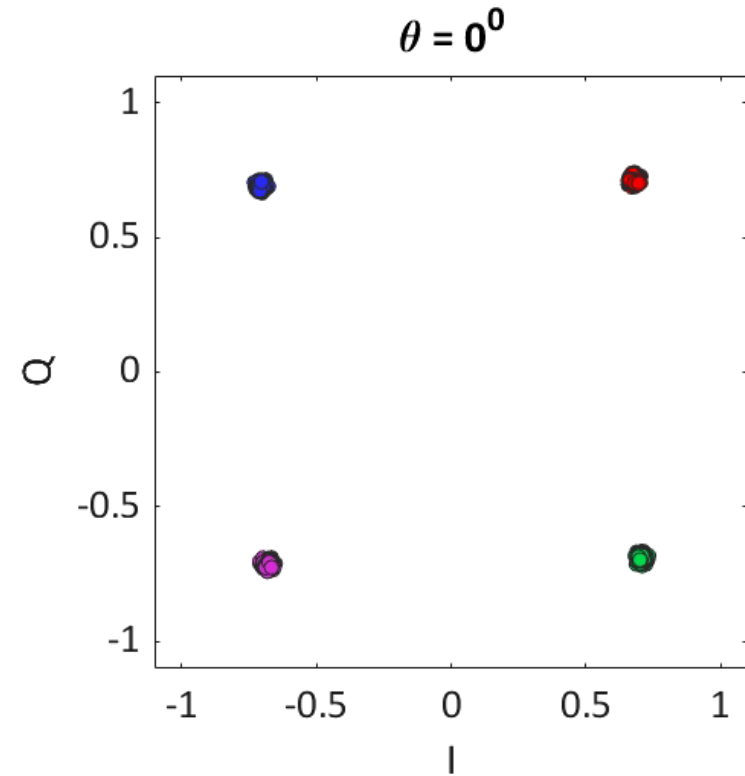


- Enable efficient space-time coded waveforms at the physical layer
- Creating dynamic secure zones and evaluate secrecy metric
- Simultaneous secure communication and RF jamming of eavesdropper

Goal: Machine Learning approaches to generate Space-Time coded waveforms to create secure communications links

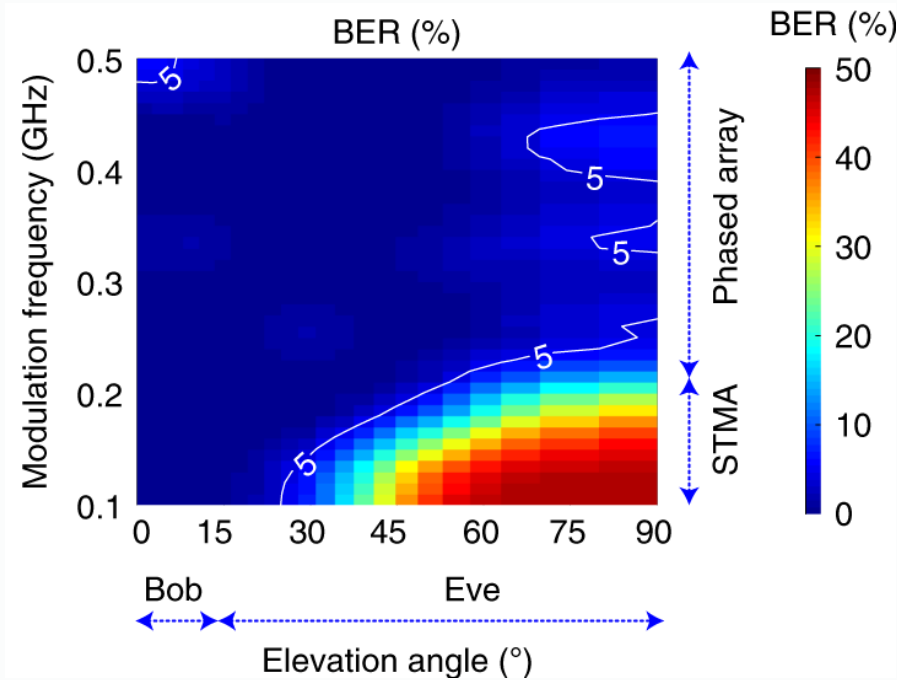
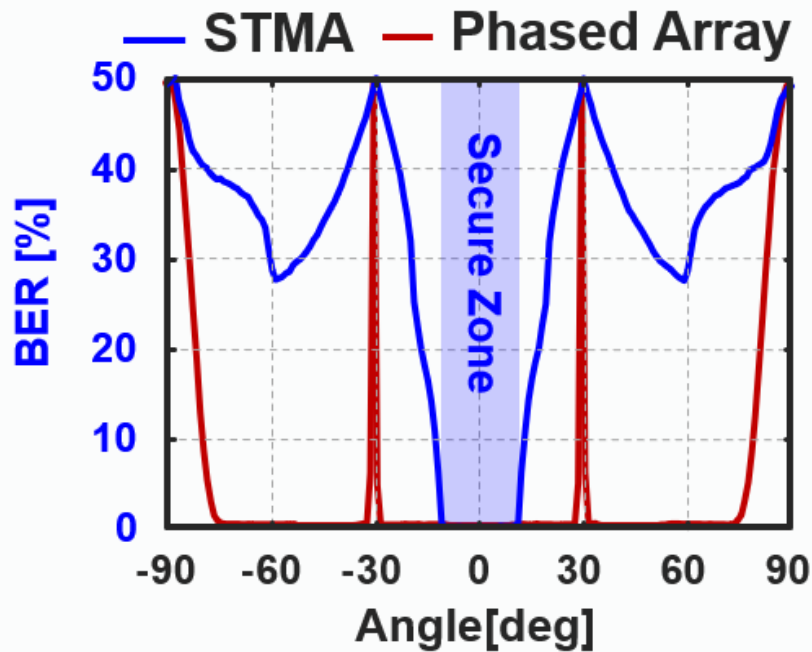
Nature Electronics, 2021; JSSC 2024; MWCAS 2024

Spatial Control of Data Constellation and Spectral Dynamics

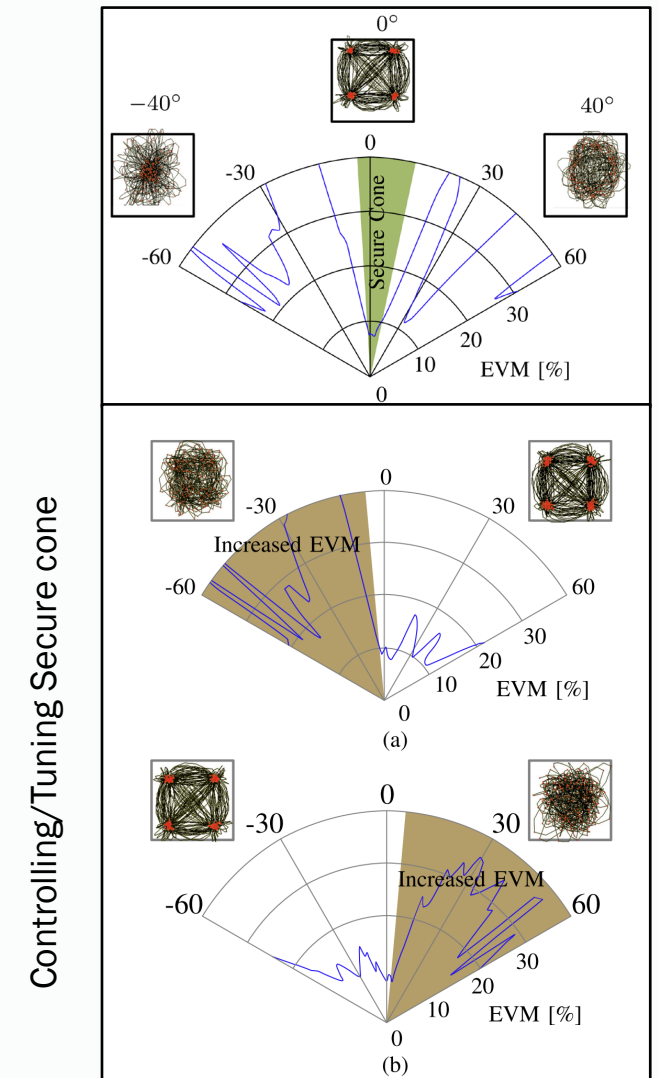


- Space-time coded waveforms to control data constellation dynamics
- Spatial harmonics to distort and RF jam eavesdroppers while maintaining secure wireless link to the intended user.

Enabling & Controlling Secure cones

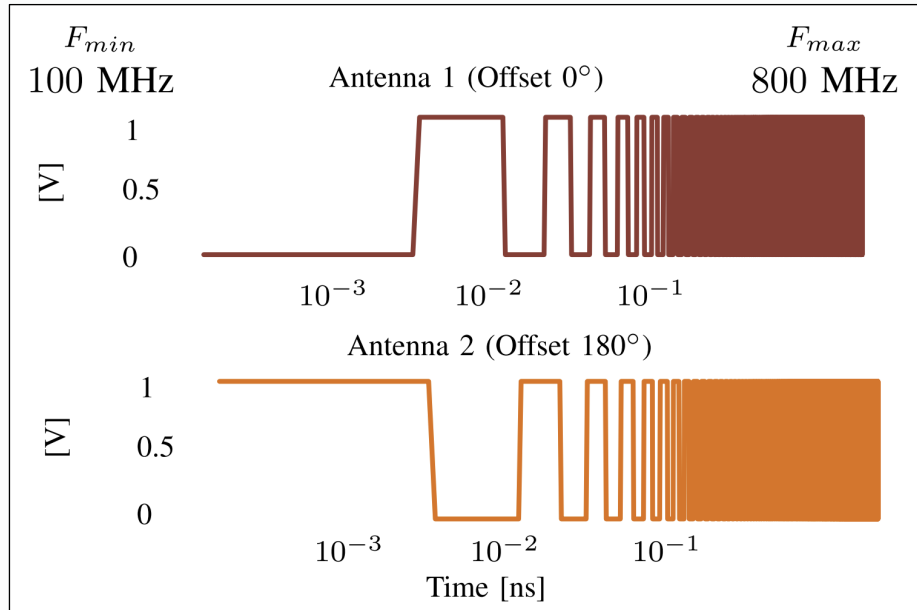


- Creating secure cones – information beamwidth < Antenna array beamwidth
- Secure cone spatial tuning with antenna array amplitude & phase coefficients.

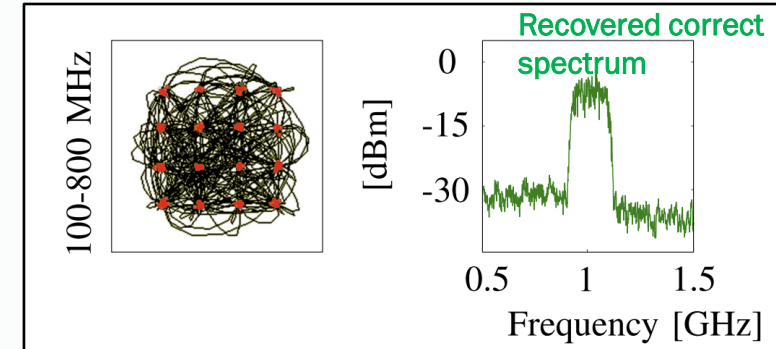


Nature Electronics, 2021; JSSC 2024; MWCAS 2024

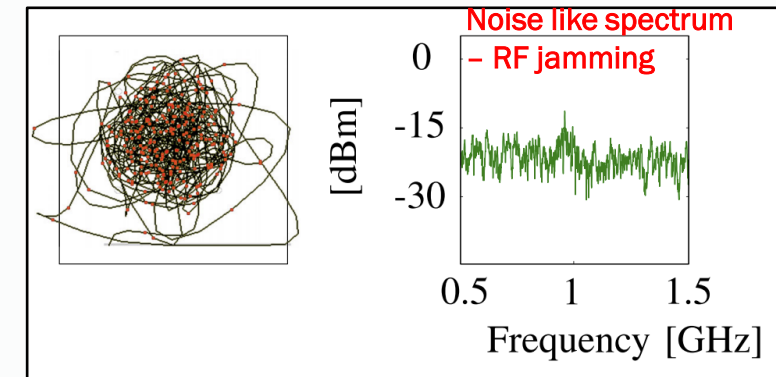
Chirped Space-Time coded Waveforms



Recovered Data Constellation at intended user

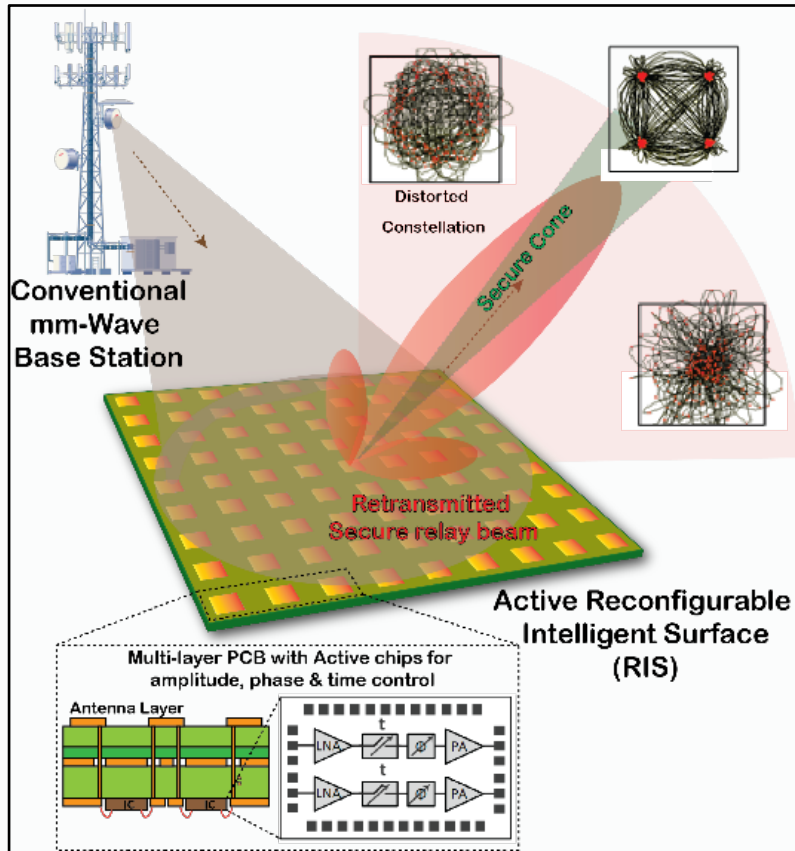


Distorted constellation at the eavesdropper

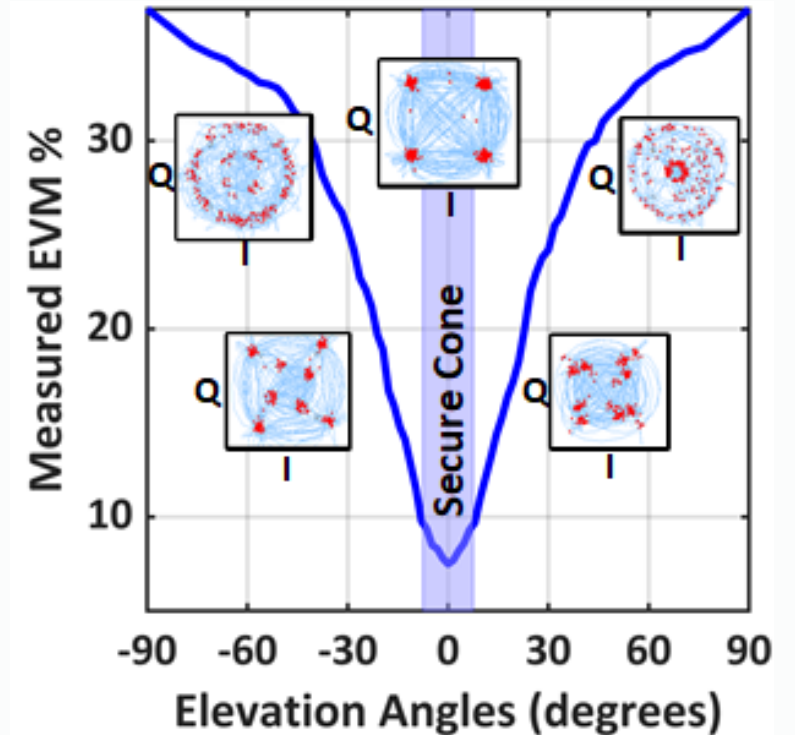
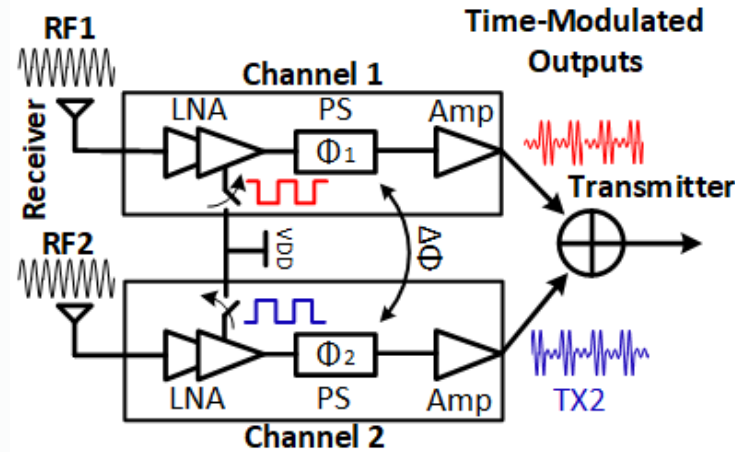
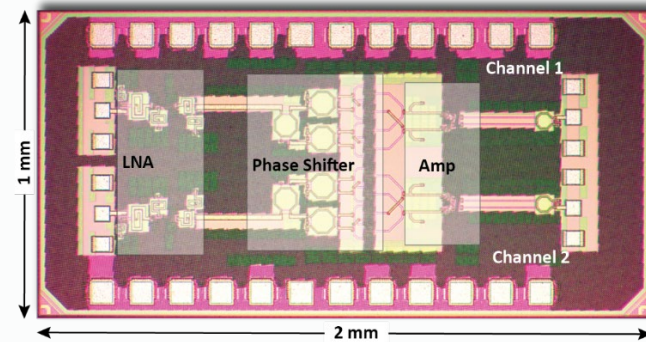


- Chirped Space-Time waveforms allow for time-varying harmonics
- Chirp frequency can be chosen strategically to RF jam the eavesdropper as well

Space-Time Waveforms in Reflector Array Mode



- RF secure relay approach (tunable reflector mode)
- Converting non-secure beams to secure beams



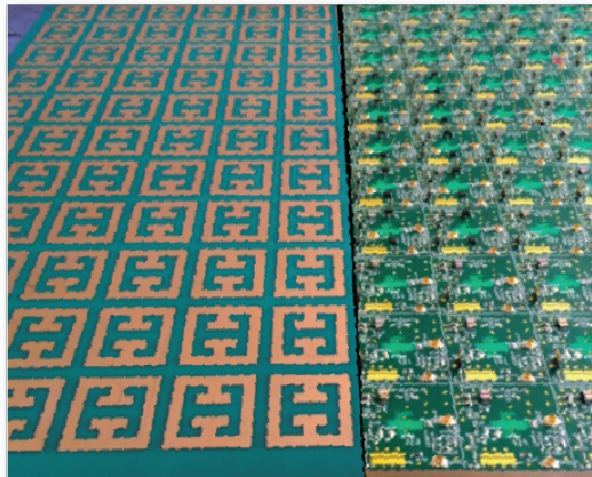
Programming the channel on-the-fly

RFIC 2022; ACM 2023; MWCAS 2024

Capability: Custom Programmable Software Defined Radios

Microwave to THz Electronically controlled Arrays/Surfaces

2 GHz



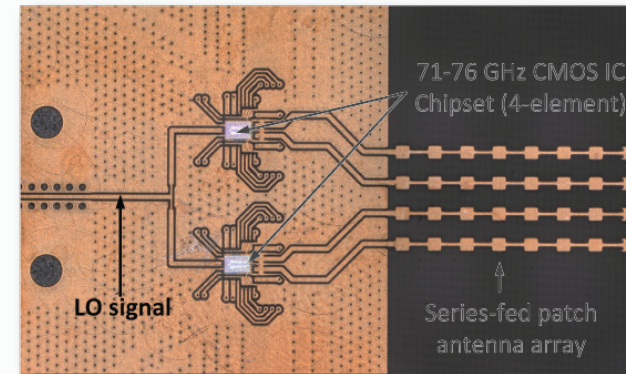
2 GHz Focal Plane Array with discrete components on back-end (Venkatesh.S, et.al.)

27 GHz



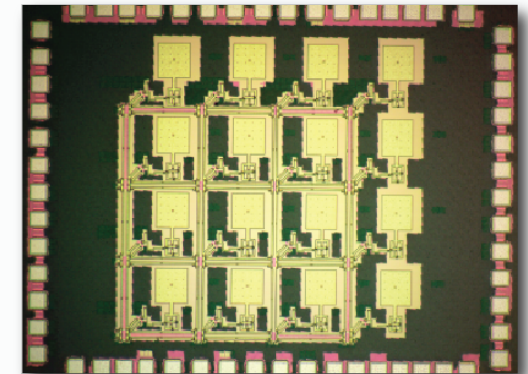
Shape-Morphing Conformal Origami Array (Venkatesh.S, et.al.)

75 GHz



71-76 GHz 4-element array (Venkatesh.S, X.Lu, et.al.)

0.4 THz



CMOS 0.4 THz on-chip Phased Array (H.Saeidi, Venkatesh.S, et.al.)

meters

centimeter

millimeter