

# A New Antenna Beam Calibration Method:

Applicable to the Astronomical Assets?

---

Mohammad Azadifar,

Mohammad Khalvati

[Mohammad.Azadifar@heig-vd.ch](mailto:Mohammad.Azadifar@heig-vd.ch)






**EM** *Path*

**HE<sup>VD</sup>**  
**IG**

# Beam Characterization in Radio Astronomy

Ref: Prof. H. Cynthia Chiang, SKA days 2023, Zurich

## Instrument characterization and verification The ultimate smackdown

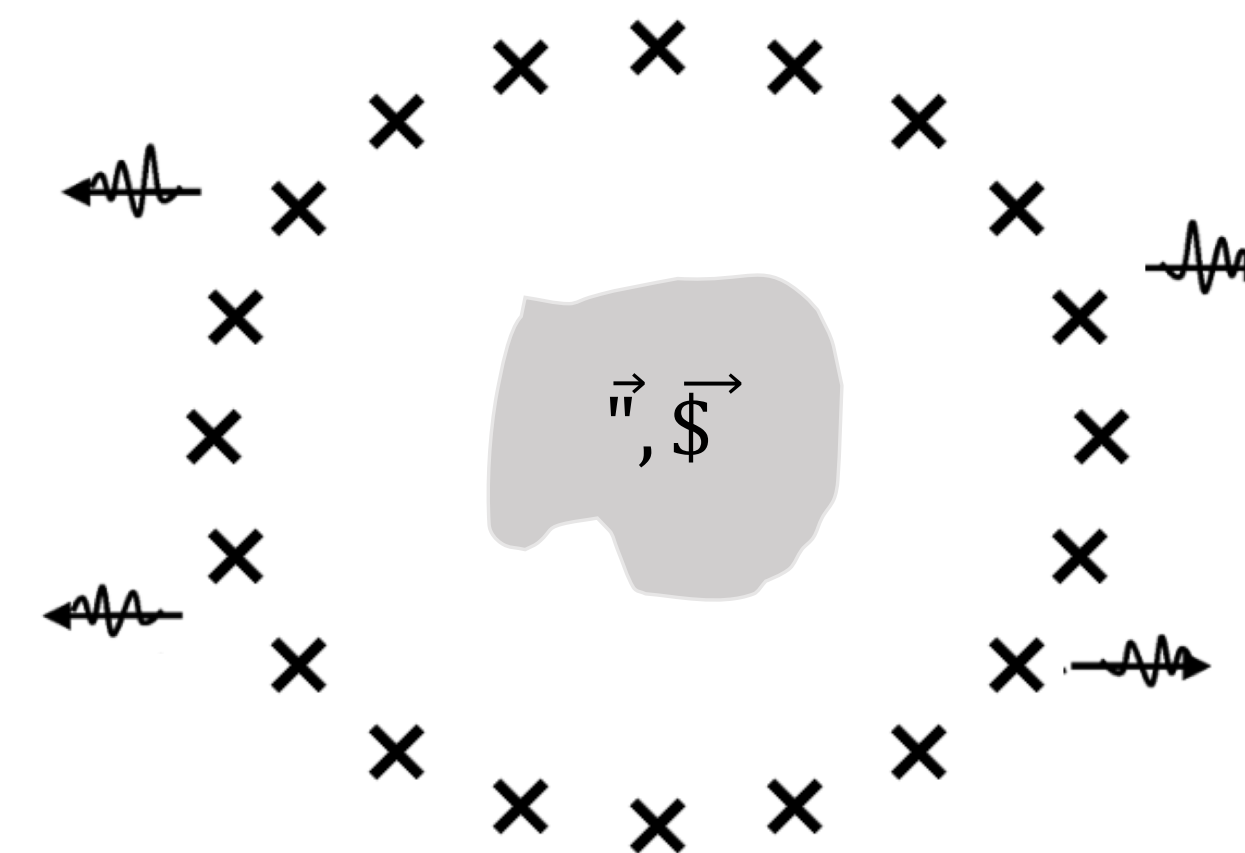
	Laser tracker	Photogrammetry	Reflectometer	Holography	Drone
Distance from dish	0m*	0m*	0m*	Far field	~100m
Meas. time	~Hrs/dish	<Hr/dish	~Hrs/dish	~Hrs/array	~Hrs/array
Cost	\$\$\$\$	\$\$\$	\$	\$\$ / \$\$\$\$\$\$	\$\$
1D or 2D	2D	2D	2D	1D (-ish)	2D
Density of points	High	Medium	Low	High (1D)	High
Measurement systematics					

\* Need to combine with EM sims



# Antenna Characterization

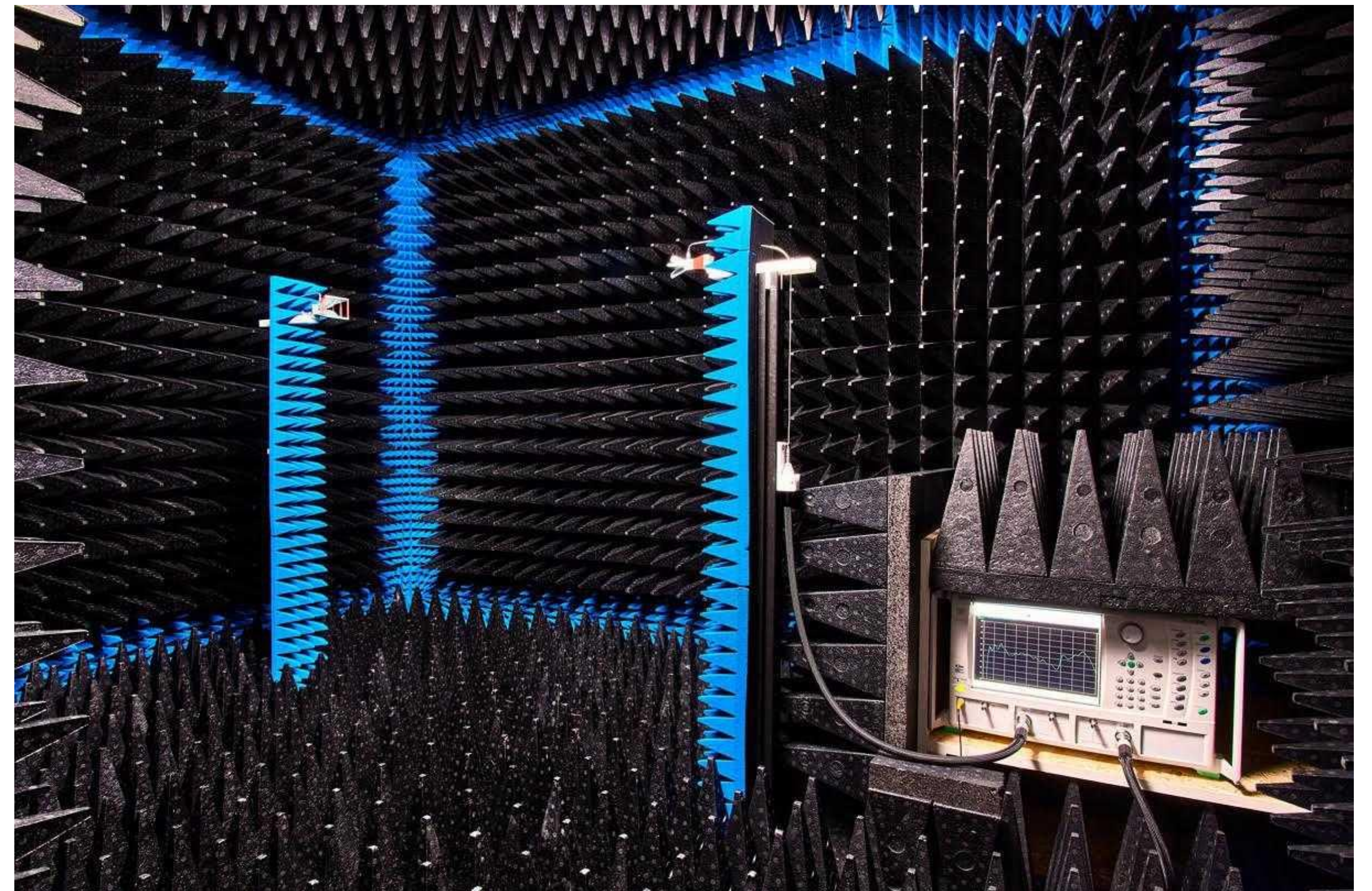
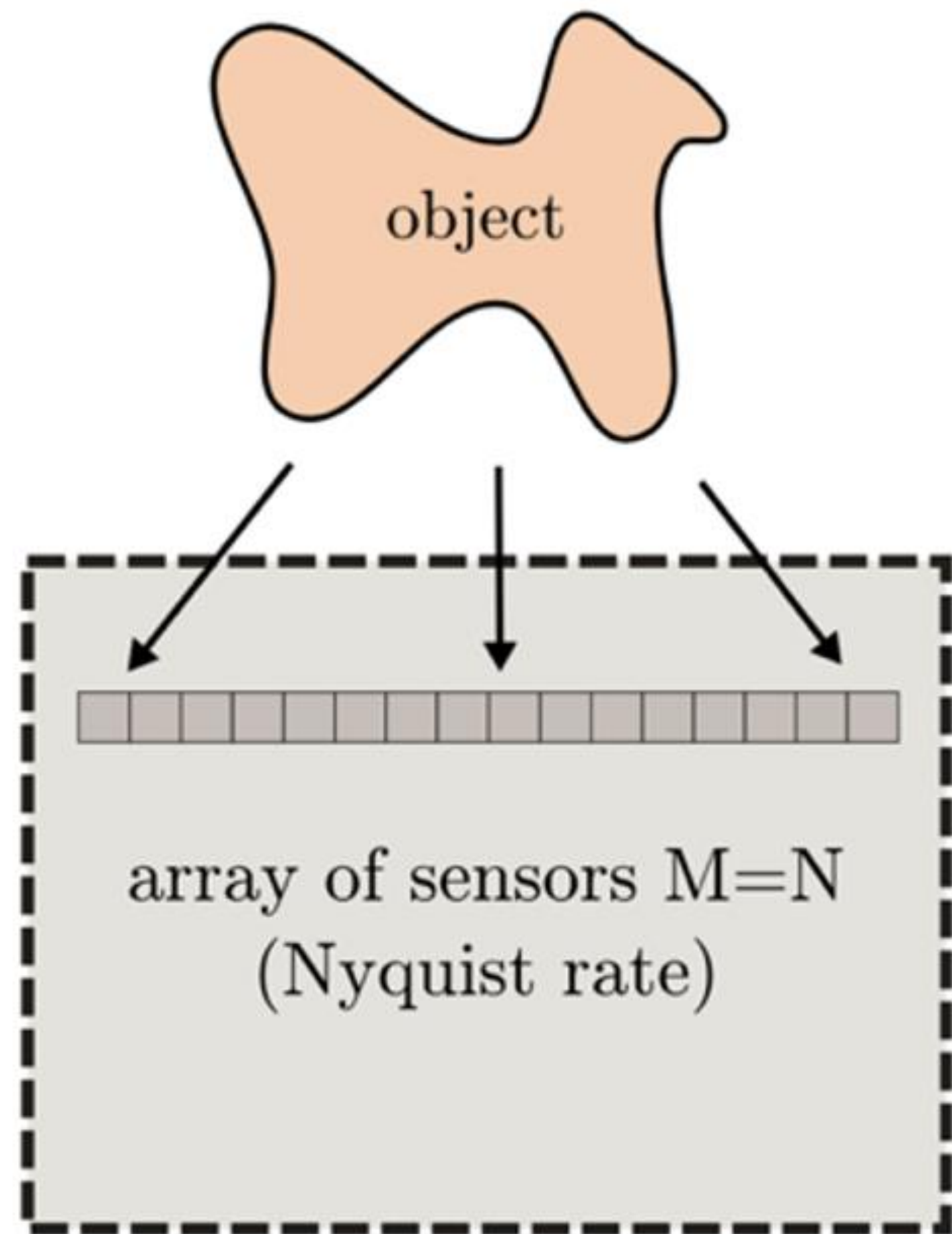
A: Point-to-point scanning and avoiding reflections.





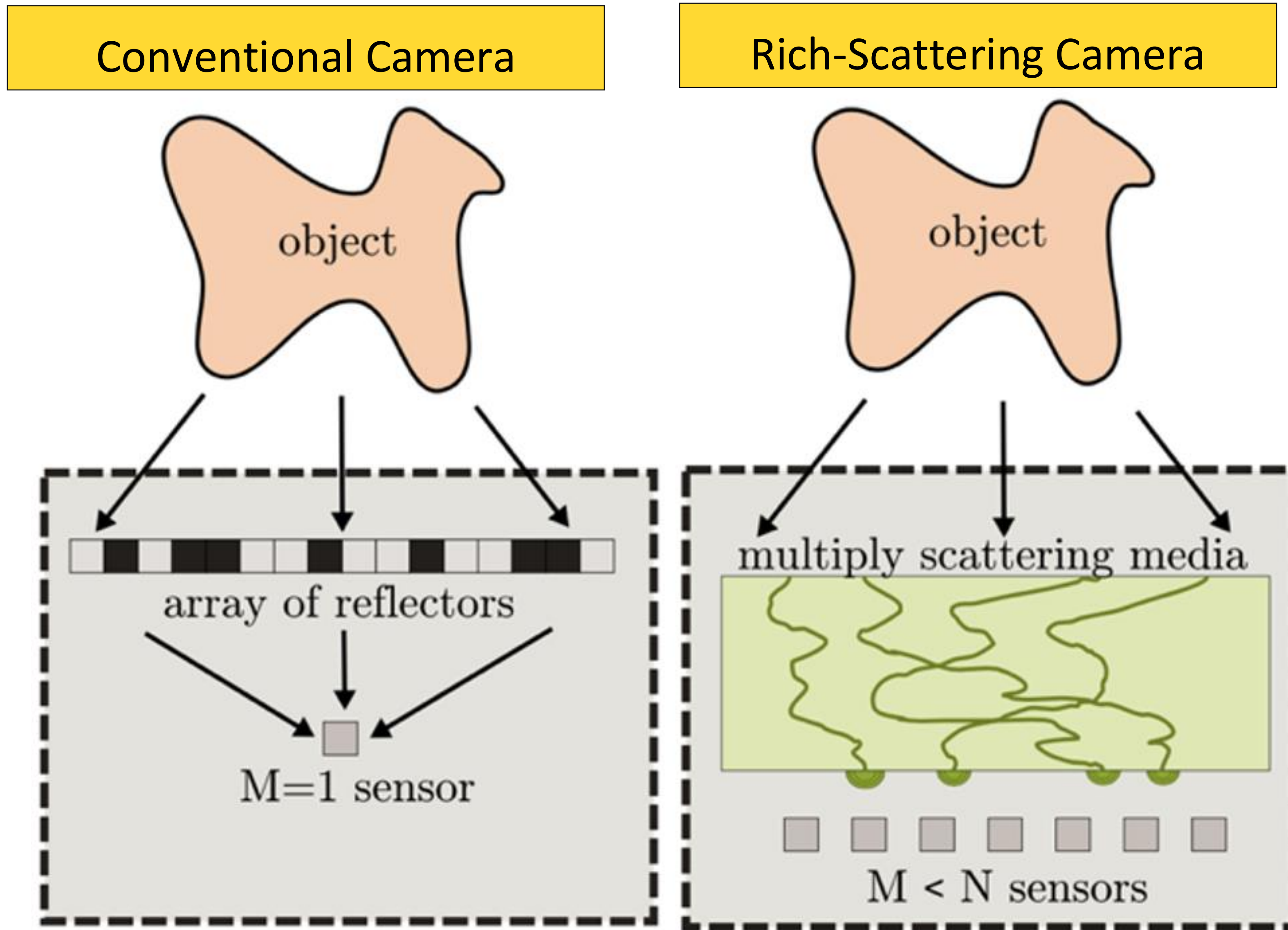
# Localisation and Imaging

Conventional camera





# Localisation and Imaging



Ref: A. Liutkus et al, "Imaging With Nature: Compressive Imaging Using a Multiply Scattering Medium,"  
*Sci. Reports* 2014 41, vol. 4, no. 1, pp. 1–7, Jul. 2014, doi: 10.1038/srep05552.



# Intuitive Analogy



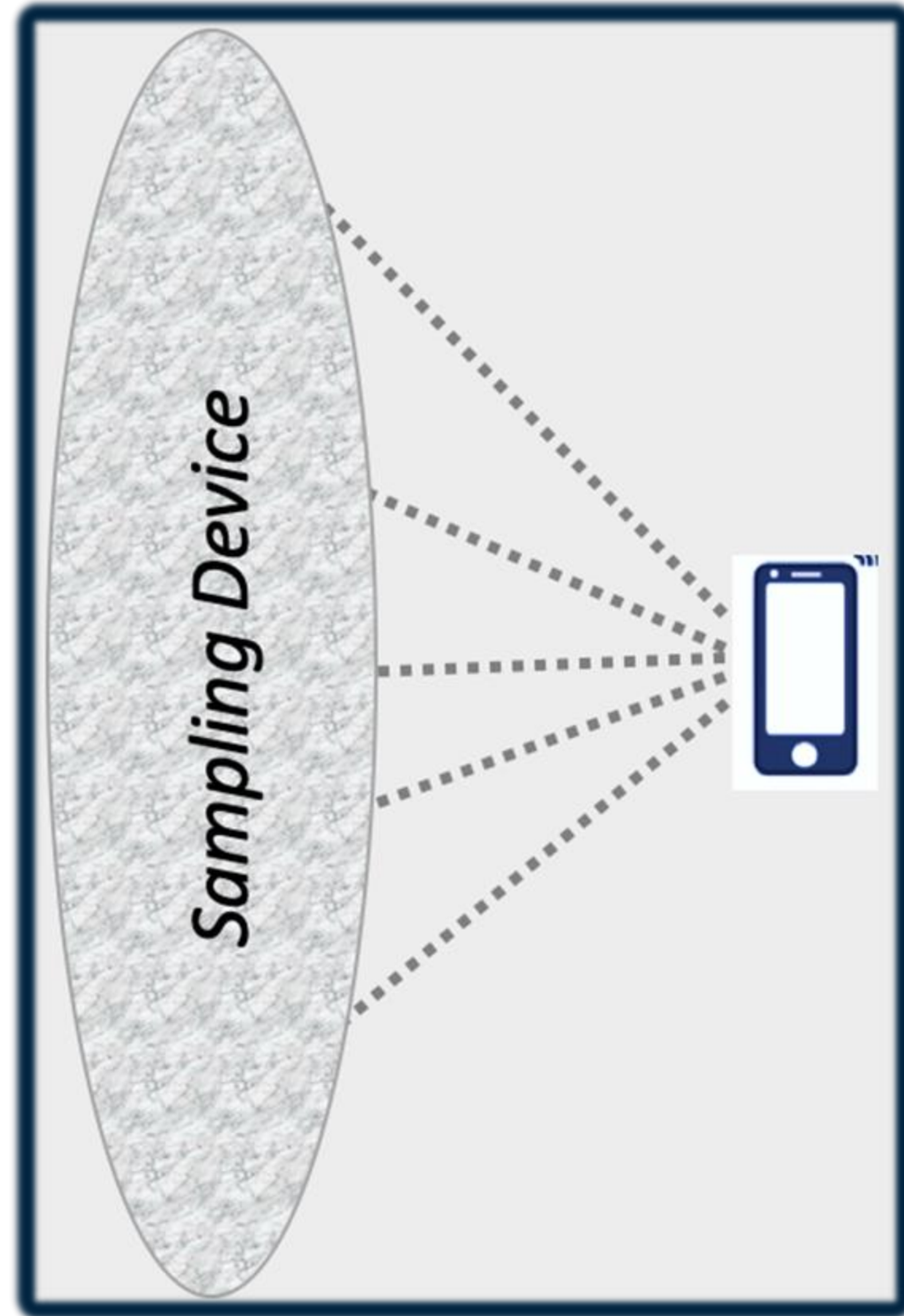
- ✓ Implementation at microwave frequencies?
- ✓ Embracing all reflections.





# Tech and Innovation

Hardware

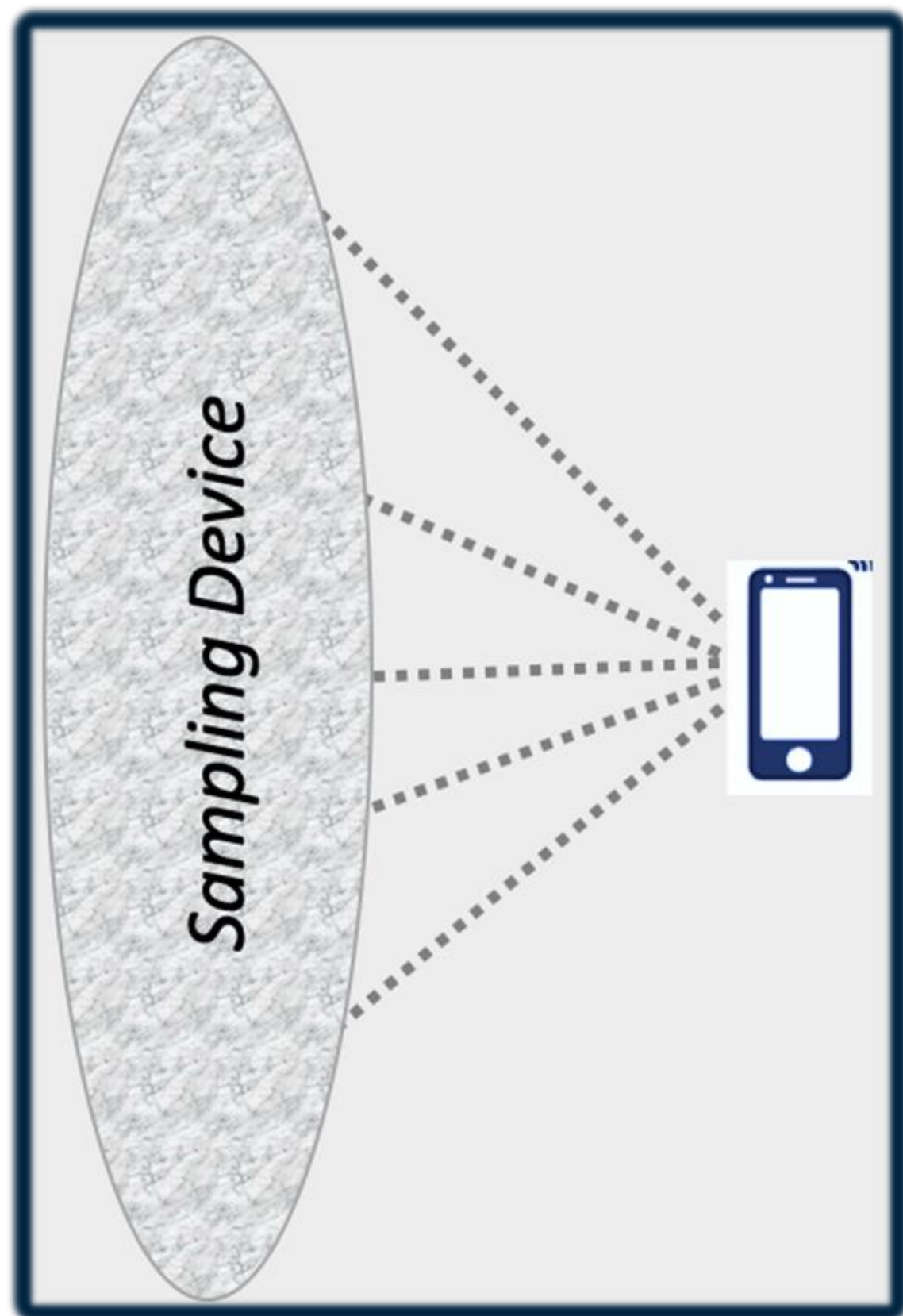


Passive Spatial Sampling  
and Wave Encoding



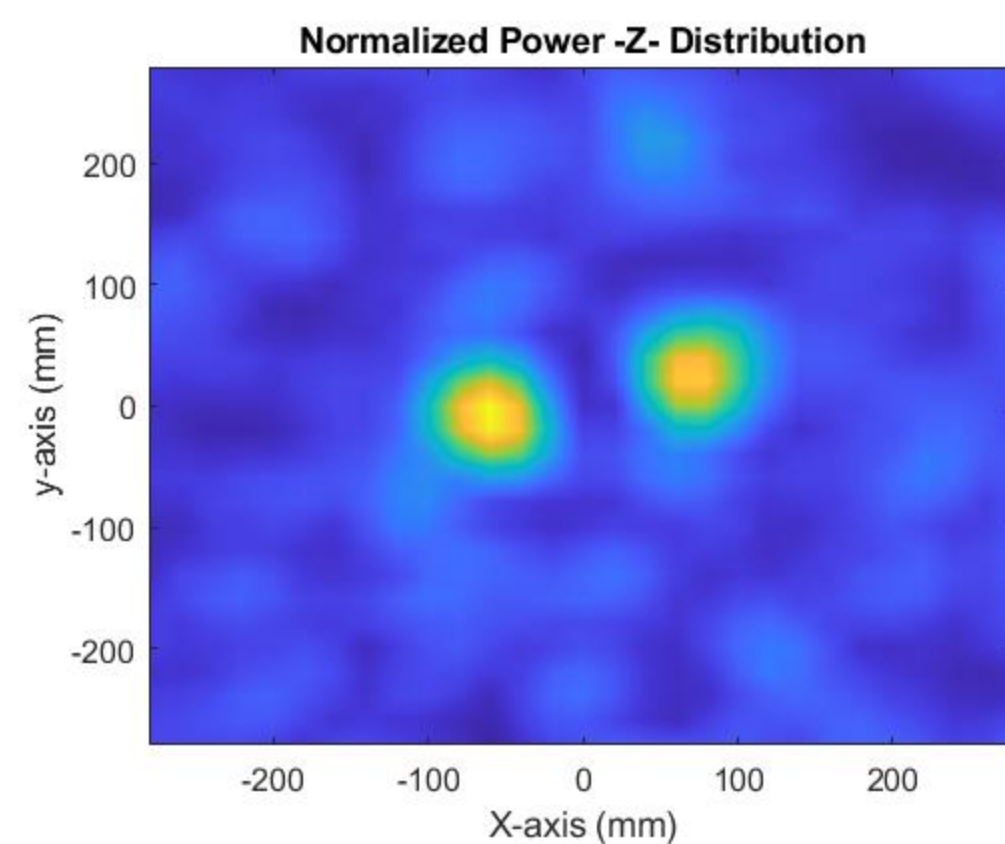
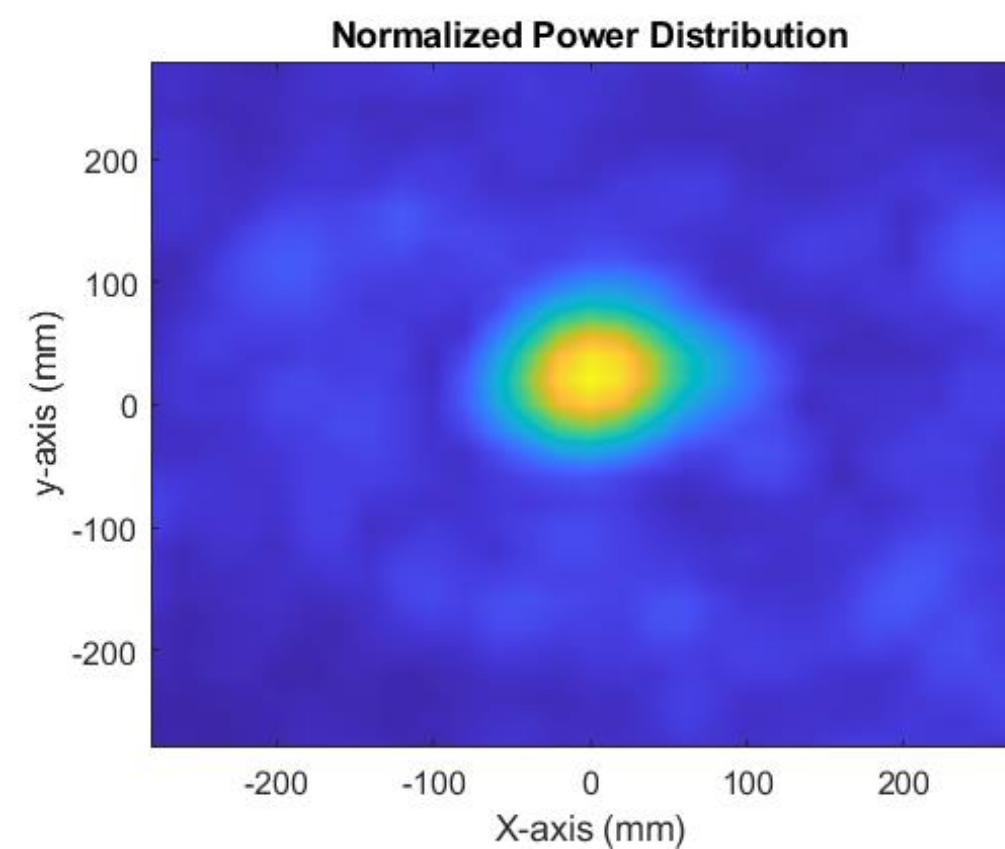
# Tech and Innovation

## Hardware

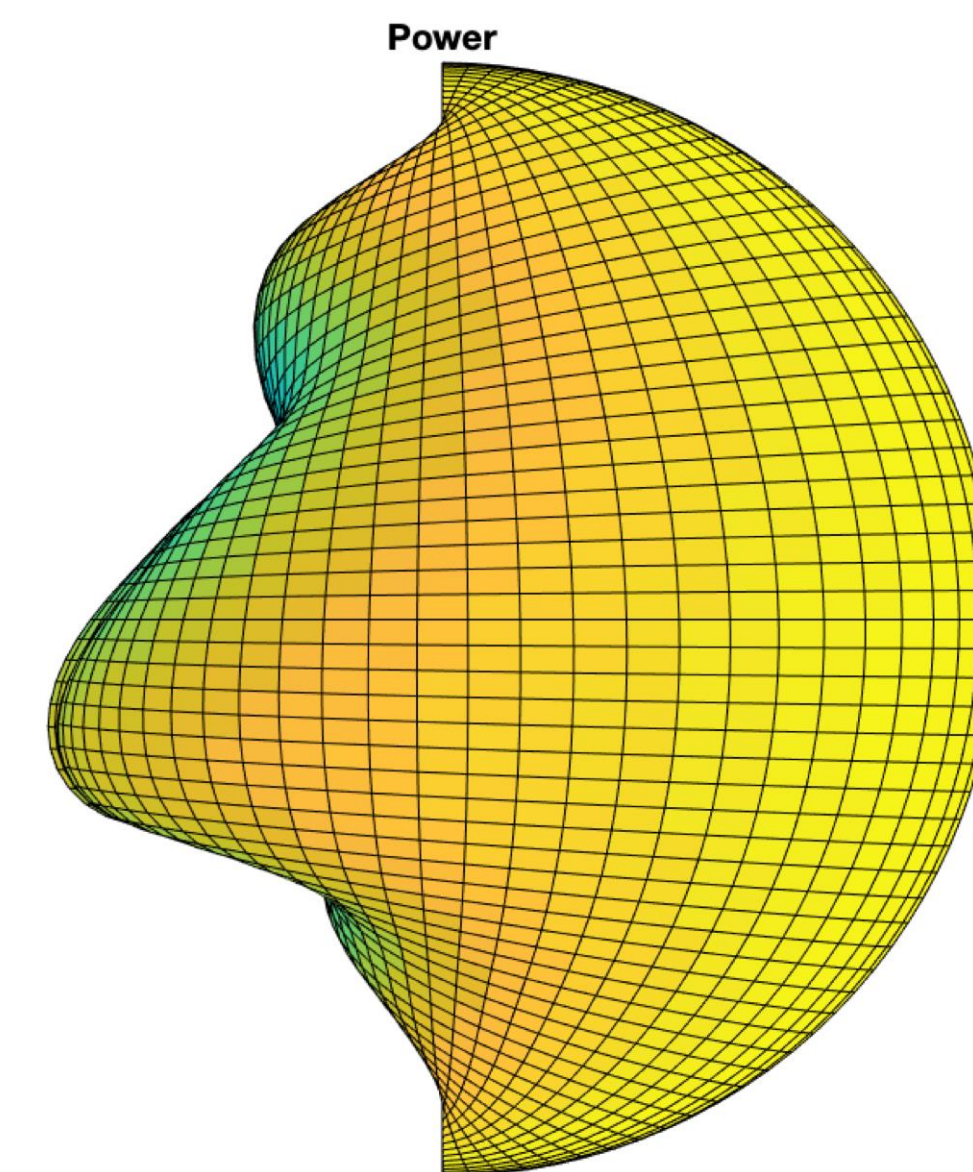


Passive Spatial Sampling  
and Wave Encoding

## Software



Recovering Near Field

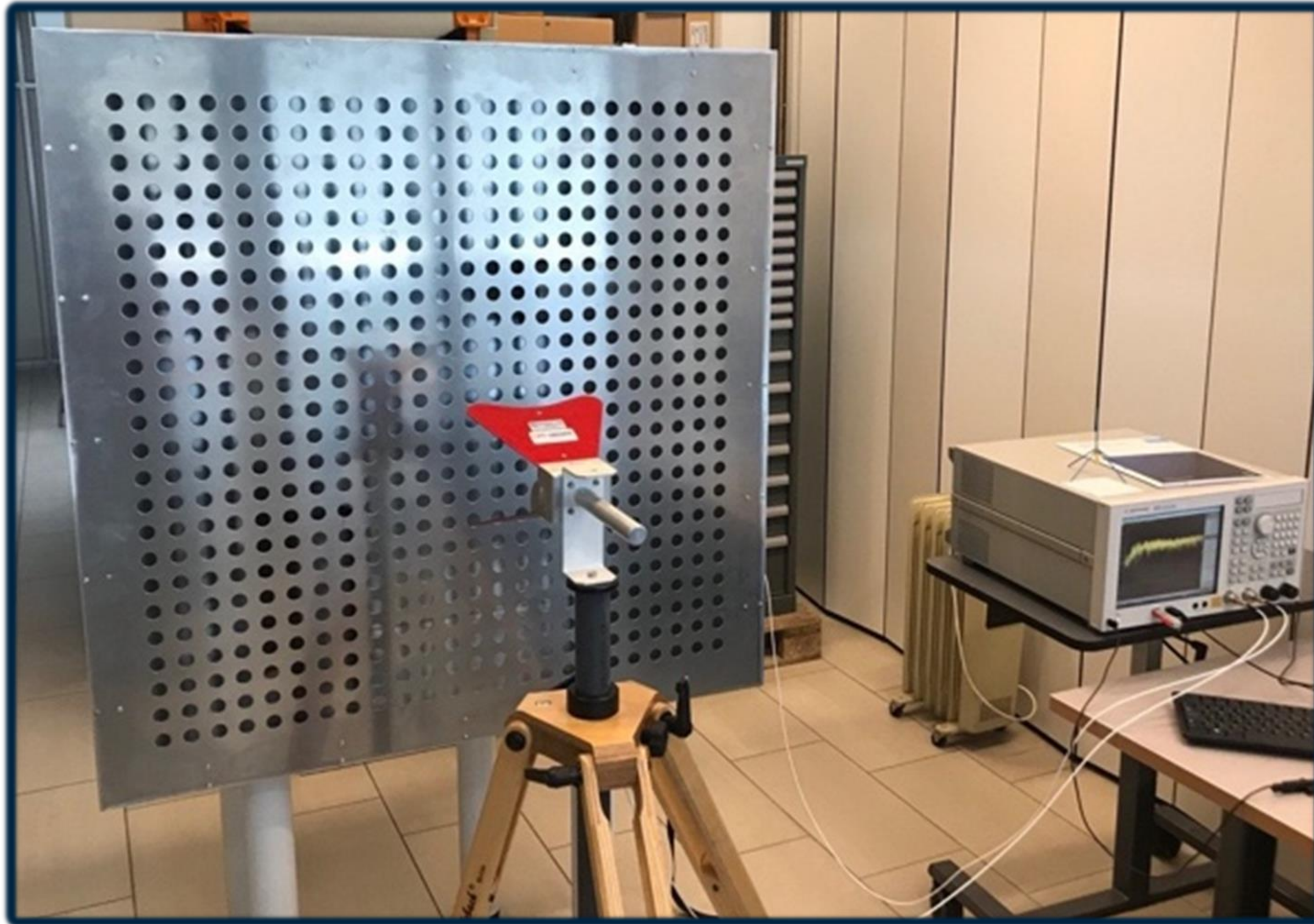


3D Reconstruction





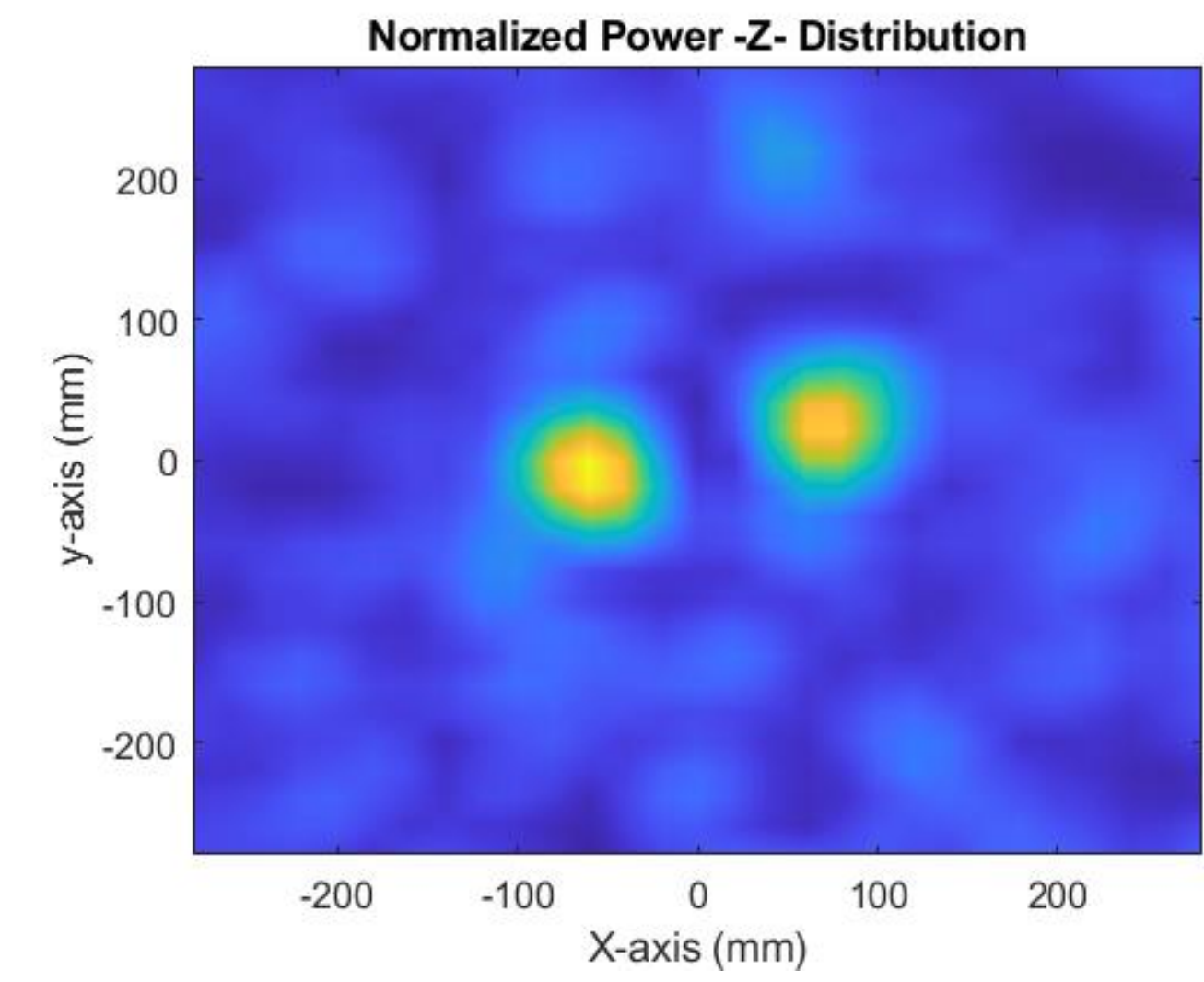
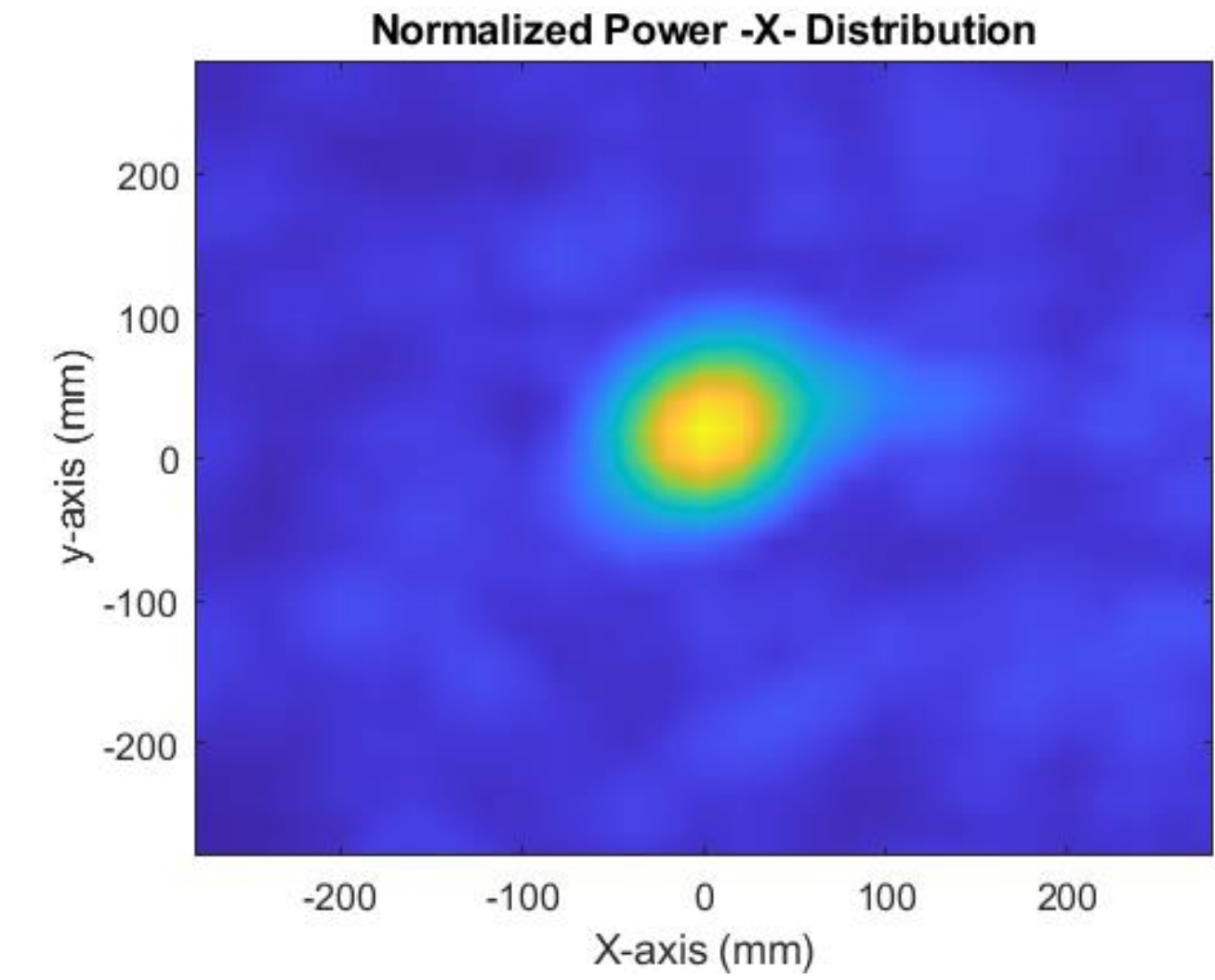
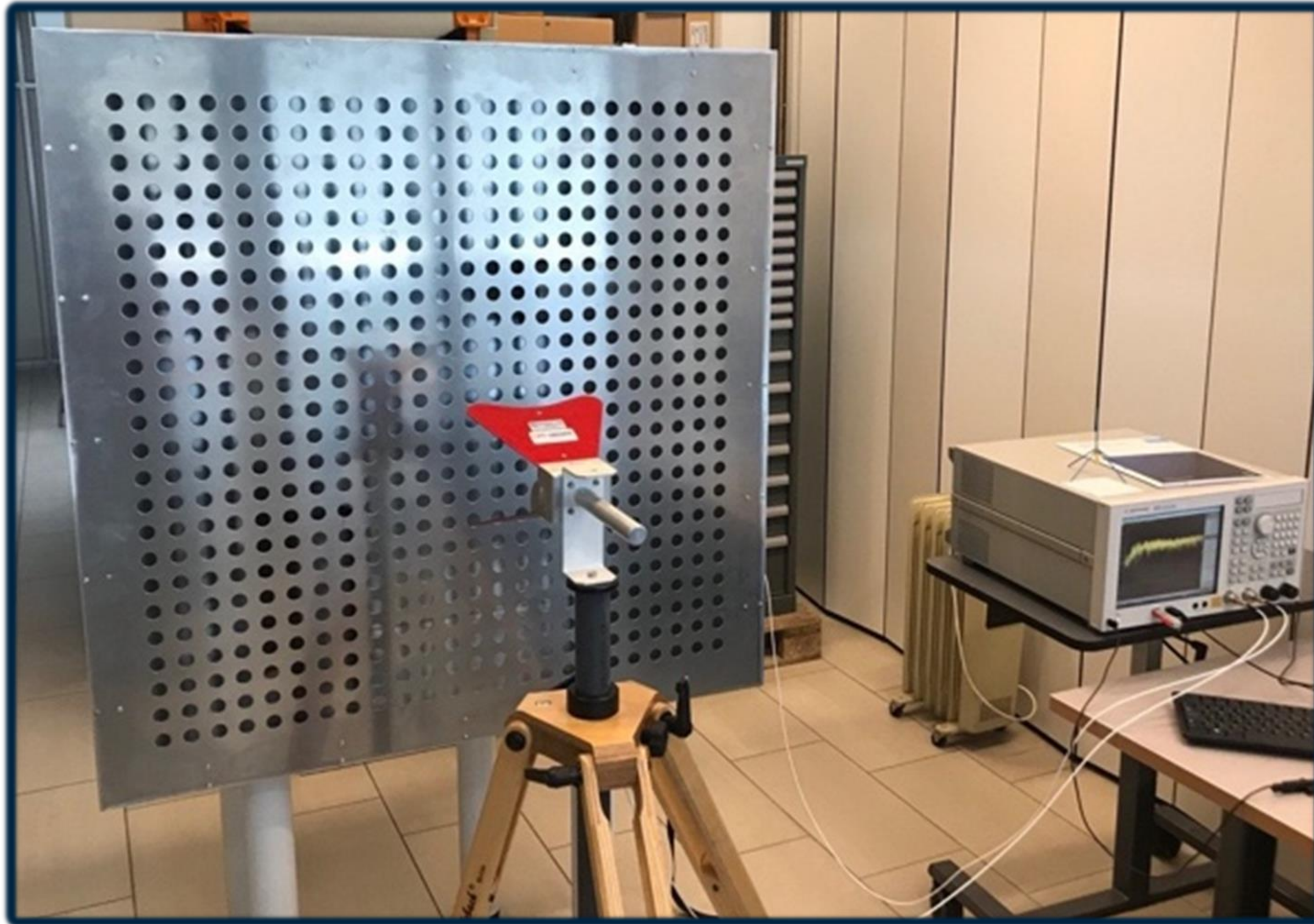
# Proof of Concept (1-6 GHz)



- ✓ No Absorber
- ✓ Single Sweep of VNA for all frequencies
- ✓ Single Probe
- ✓ No mechanical movement
- ✓ Acquisition in seconds

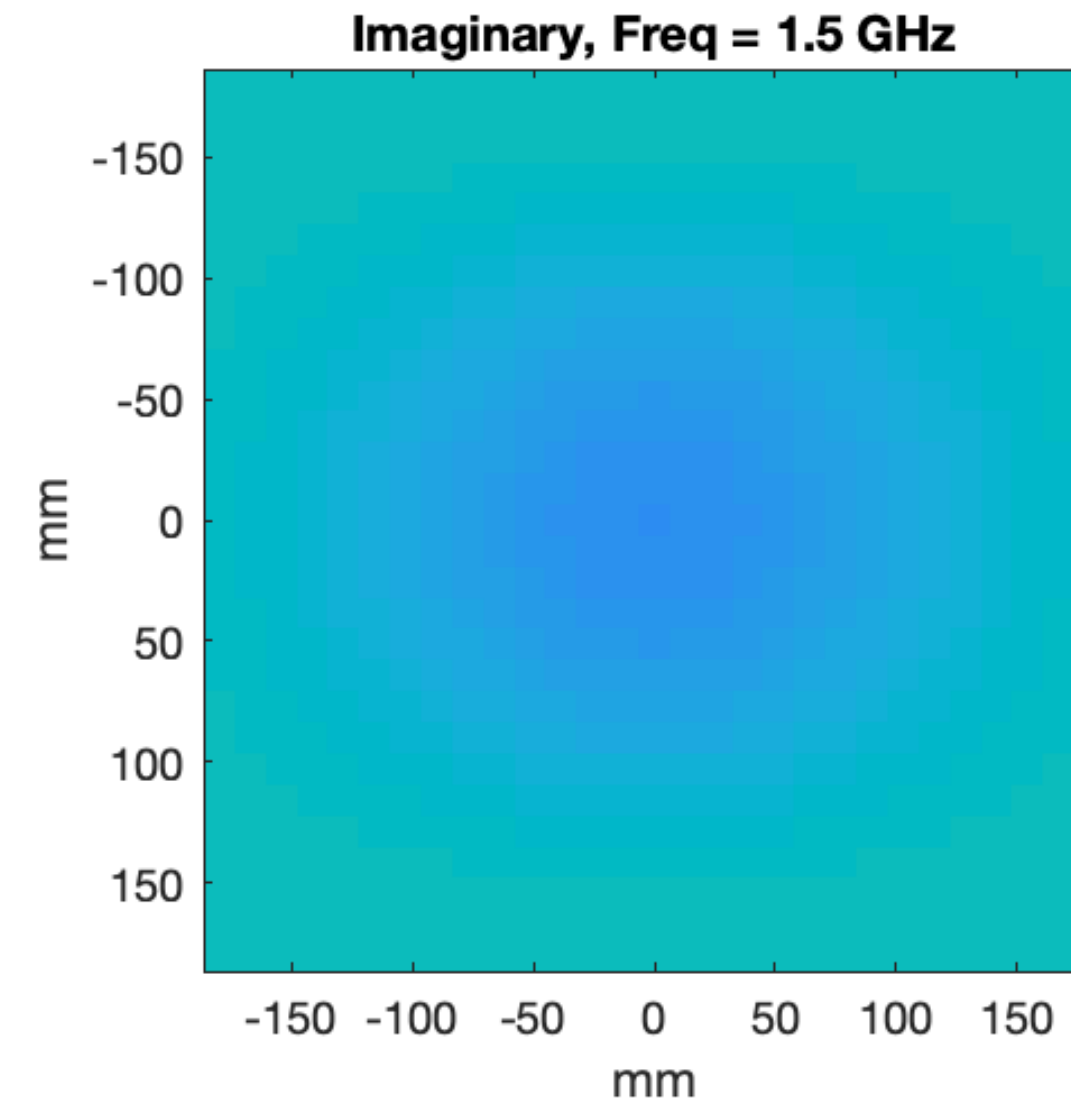
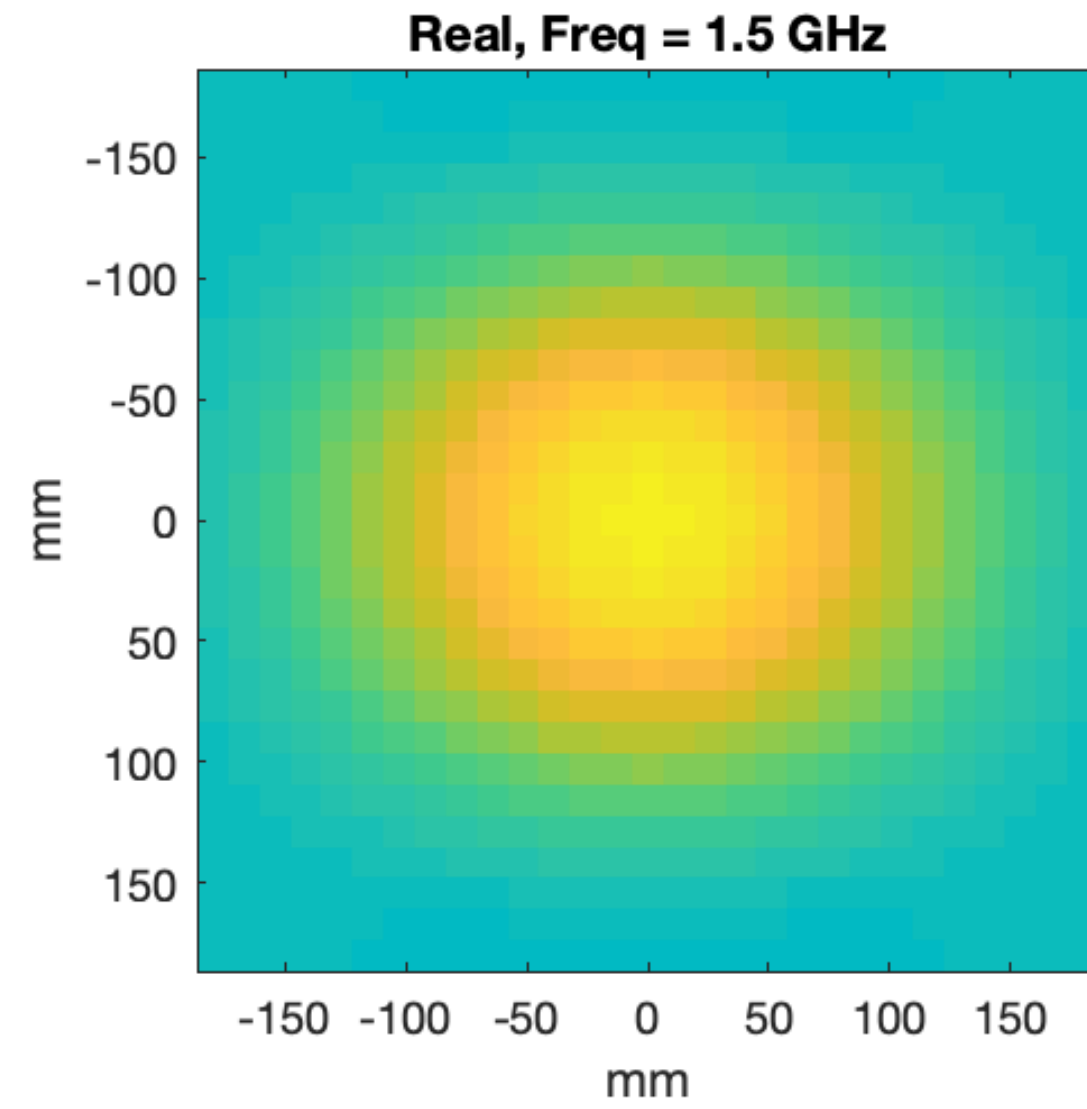


# Proof of Concept (1-6 GHz)

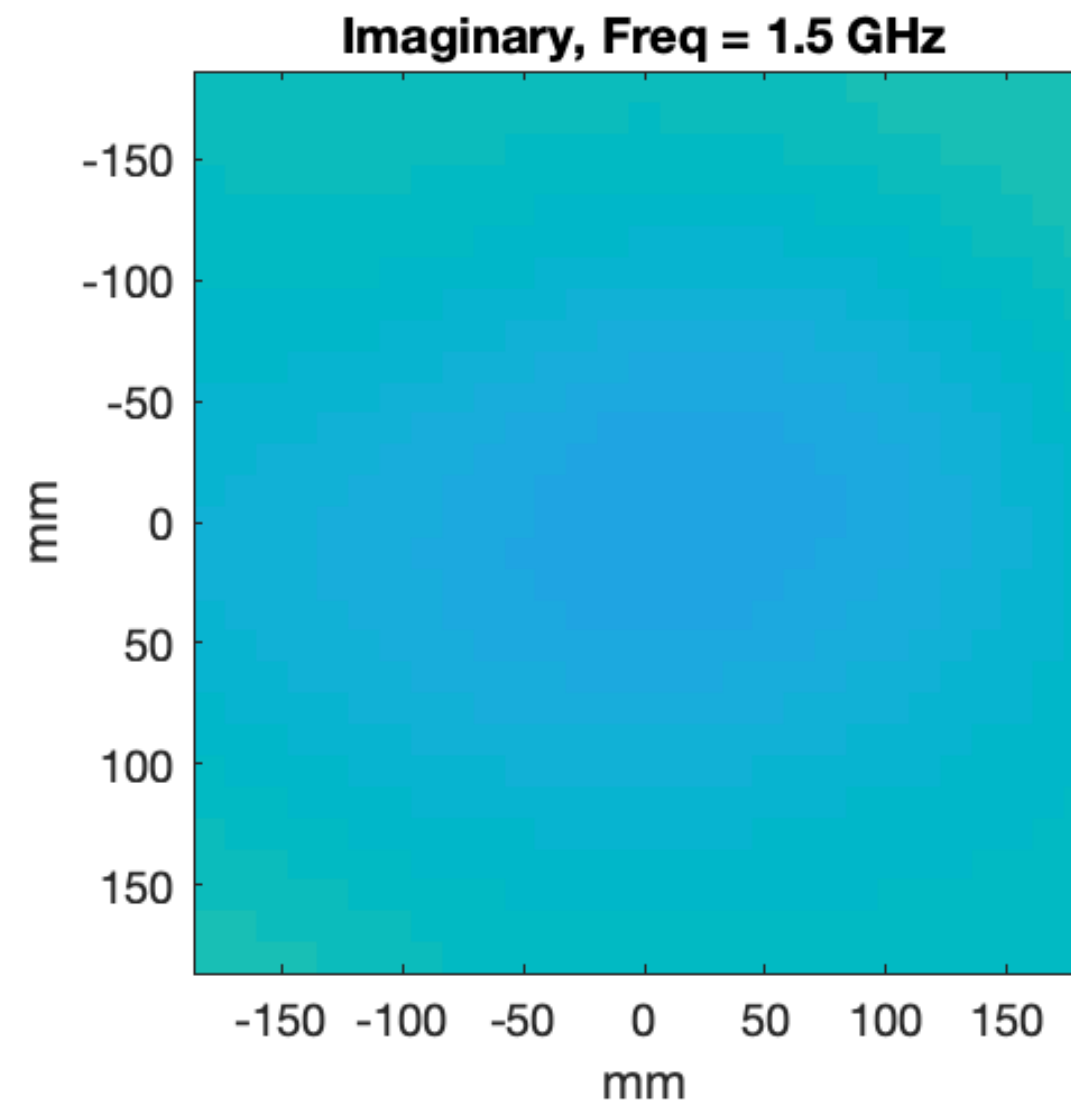
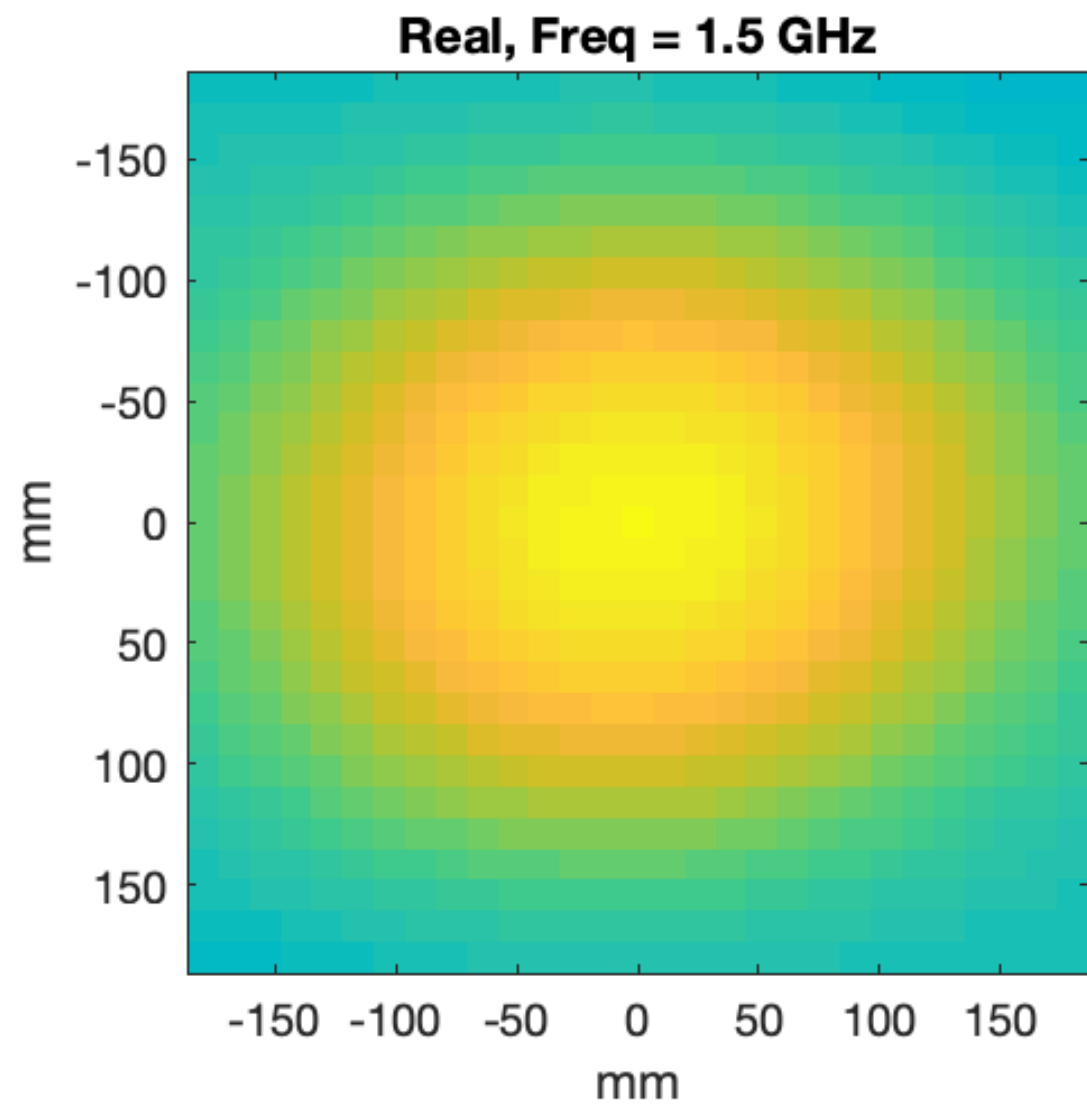




# Numerical Simulations



Reference



Reconstructed

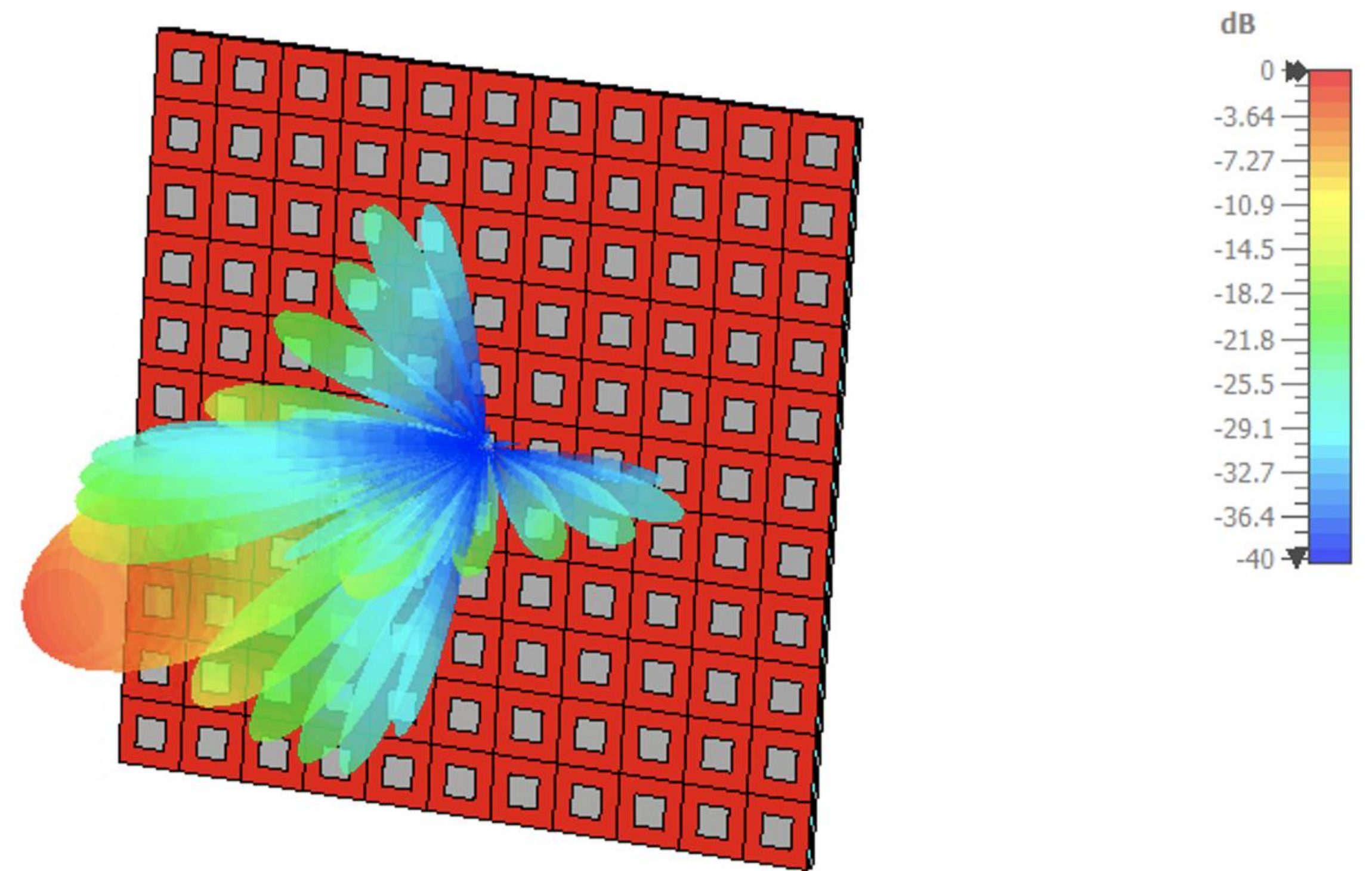


# ○ Numerical Simulations

Can this work for a more complex antenna? For example, Feed of a reflector?

121 element Array @30GHz.

With Gain of 24 dBi:

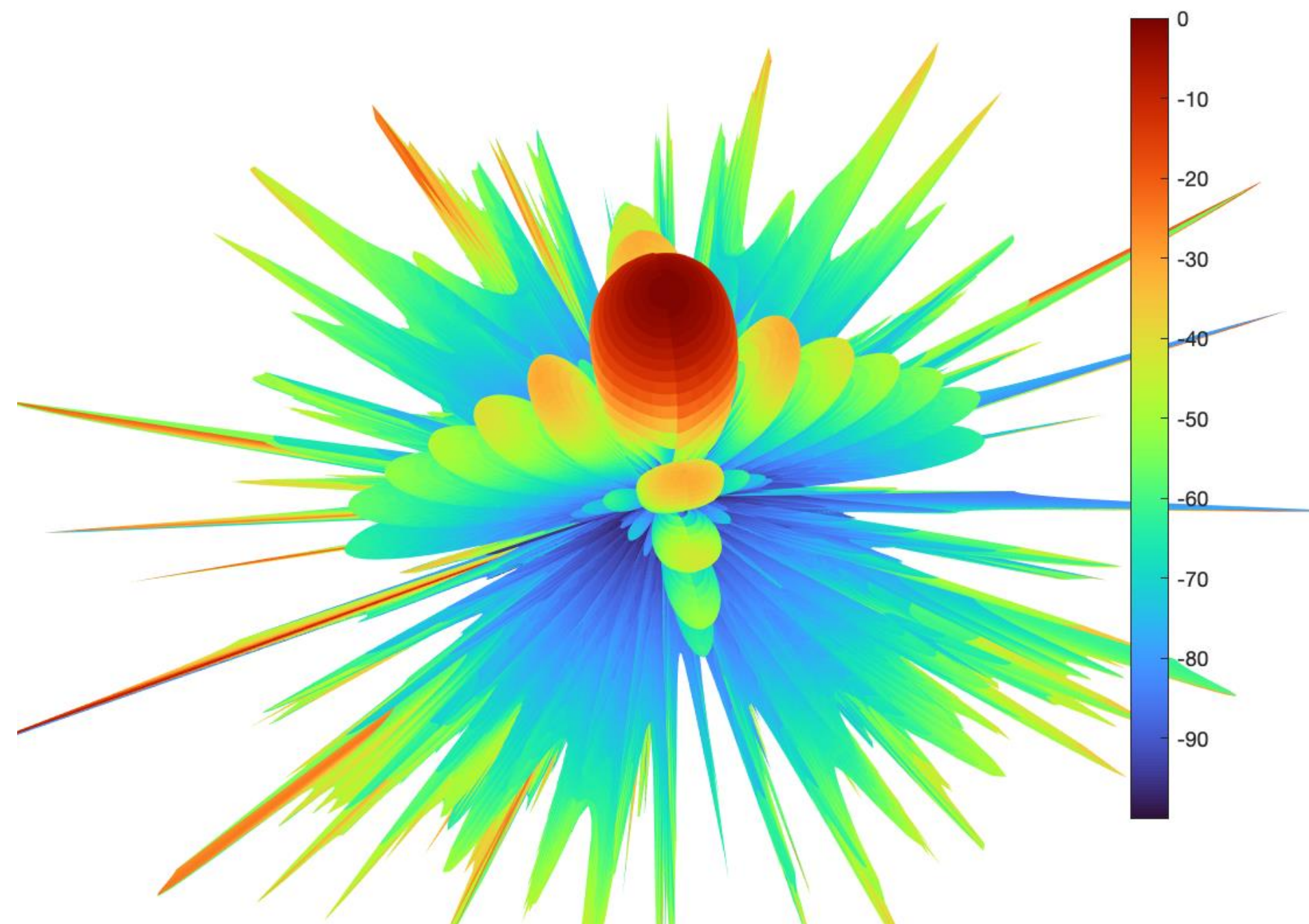




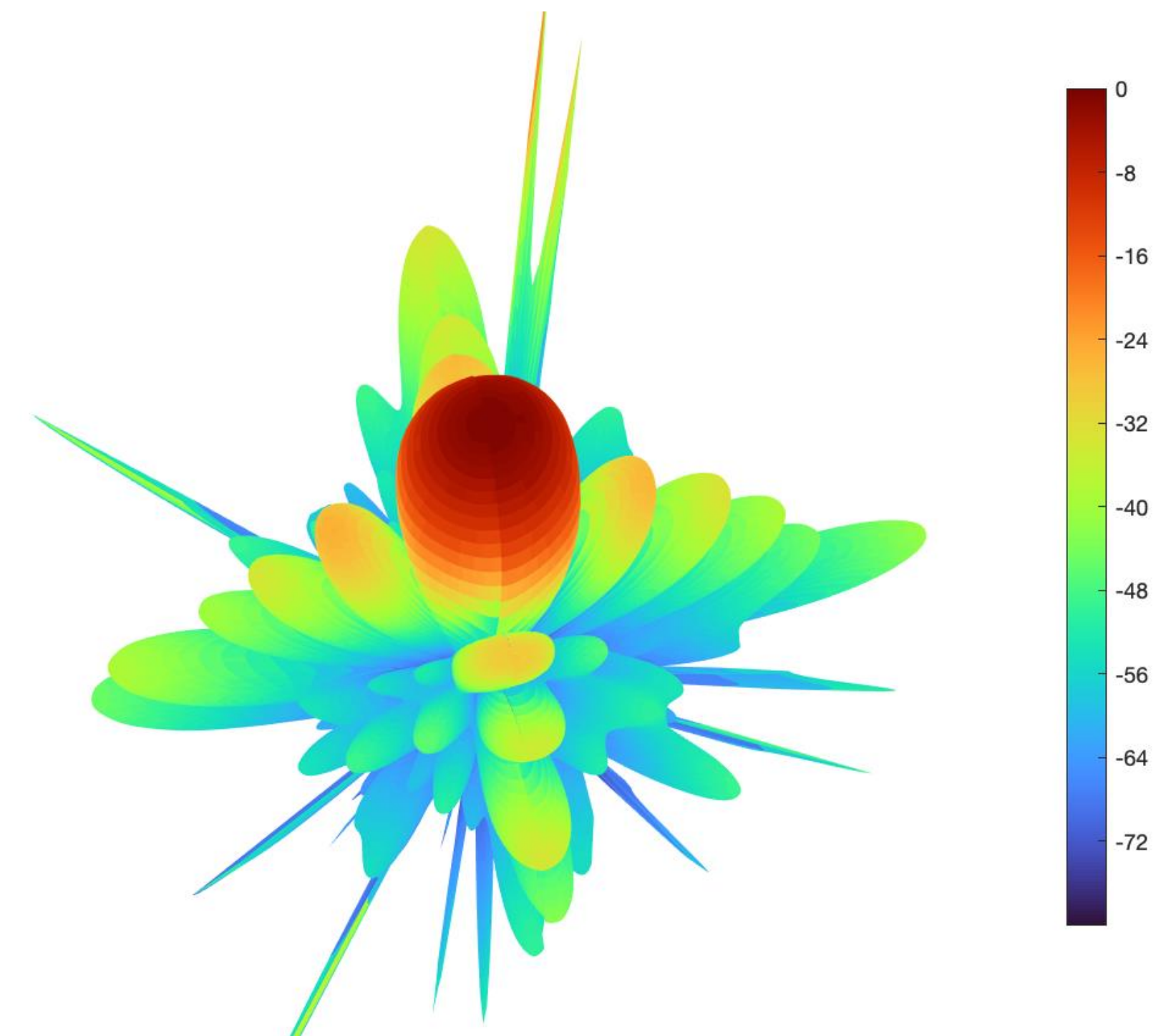
# ○ Numerical Simulations

Single Observation. Less than a second! Limited FOV (60 degrees)!

Reference  
(Planar Scanner)



Reconstructed





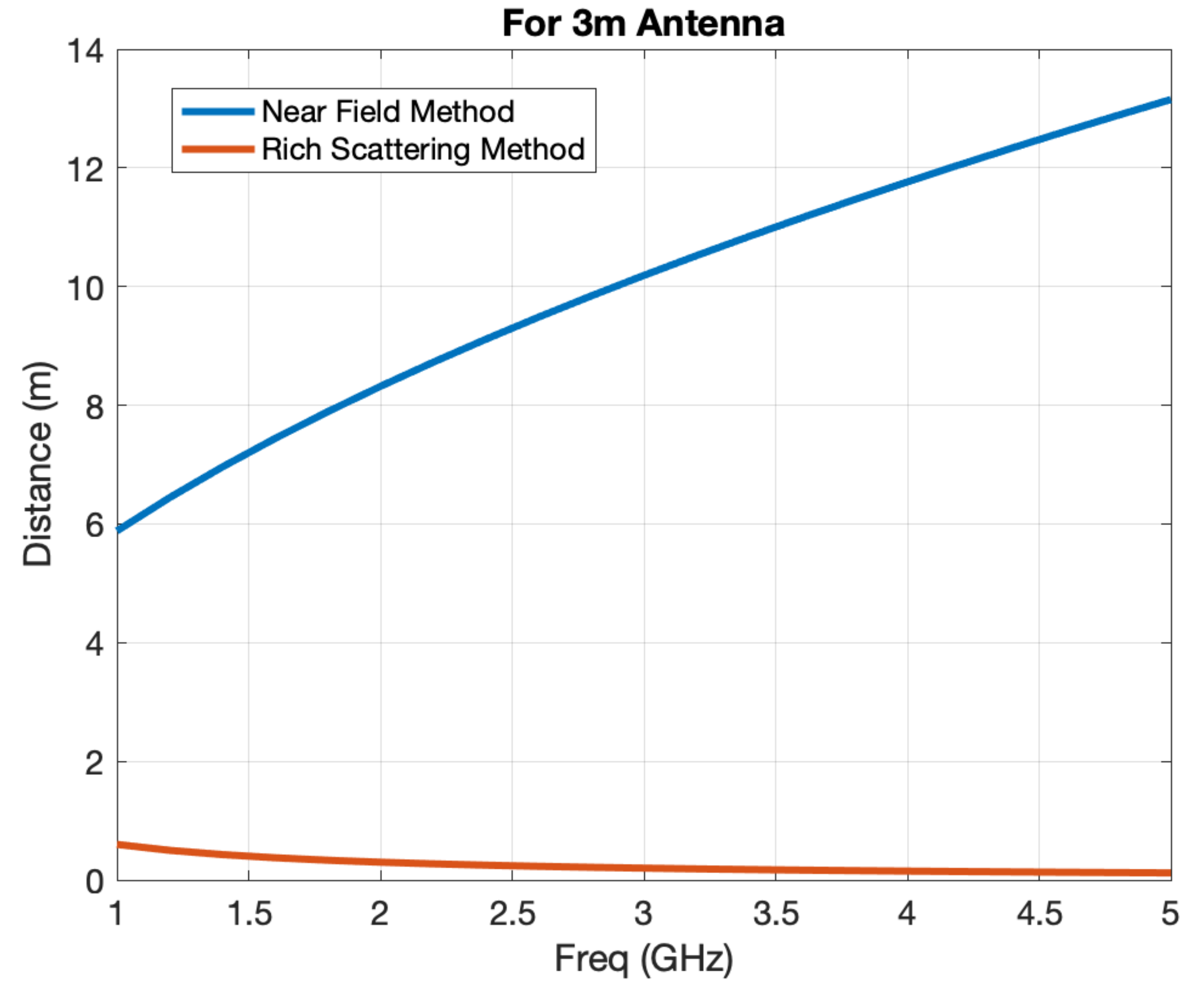
# ○ Feasibility for Radio Astronomy

- ✓ **Application on Calibrating Feed Antennas**
- ✓ Calibrating Large Dishes → To be Validated!
- Size of the Sampling Device?
- Distance from the Dish?



# Feasibility for Radio Astronomy

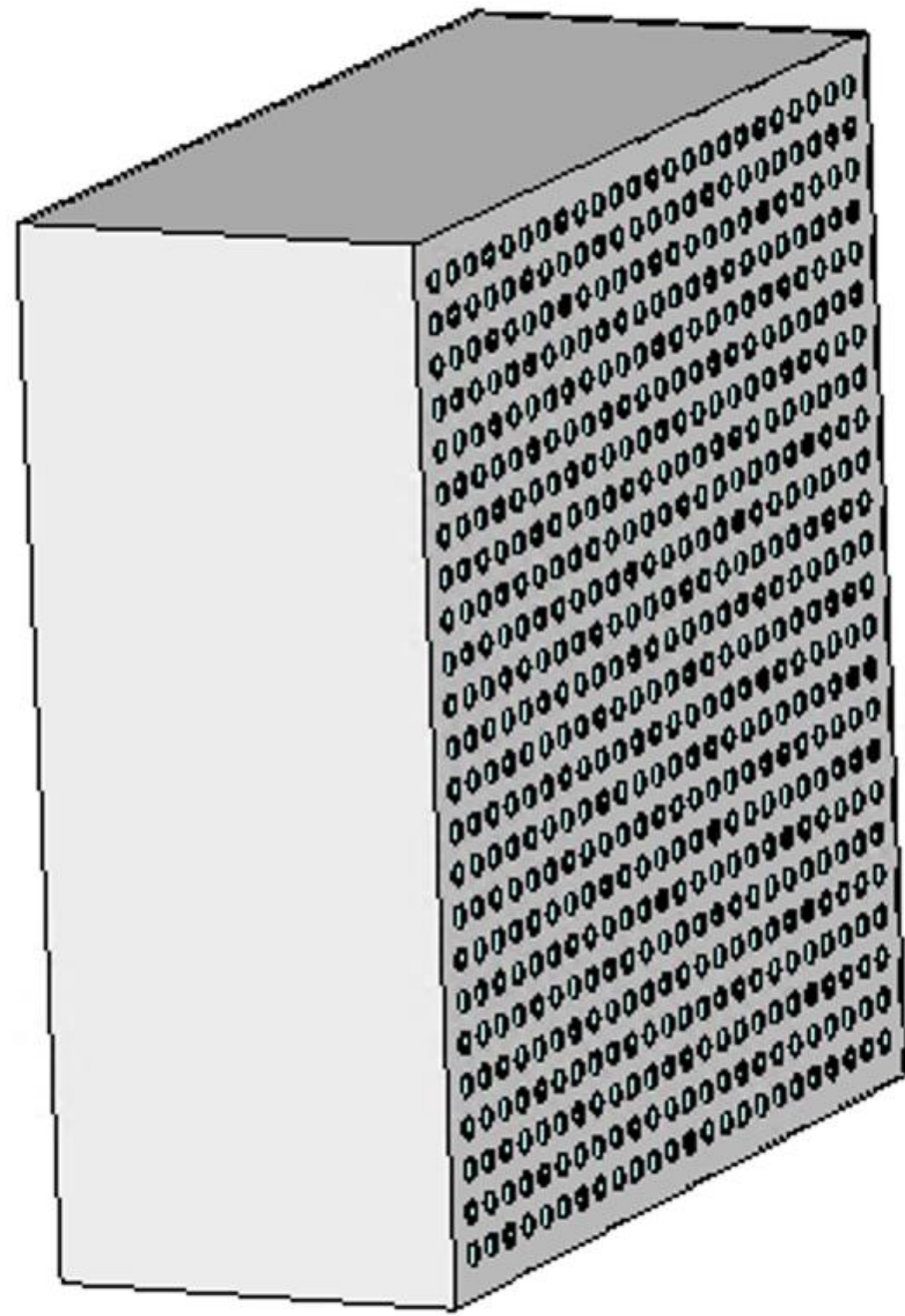
- Distance from the antenna:
- Far field distance:  $(2D^2)/\lambda$
- Near field distance:  $0.6 [(D^3)/\lambda]^{0.5}$
- Rich Scattering Method:  $2 * \lambda$





# Feasibility for Radio Astronomy

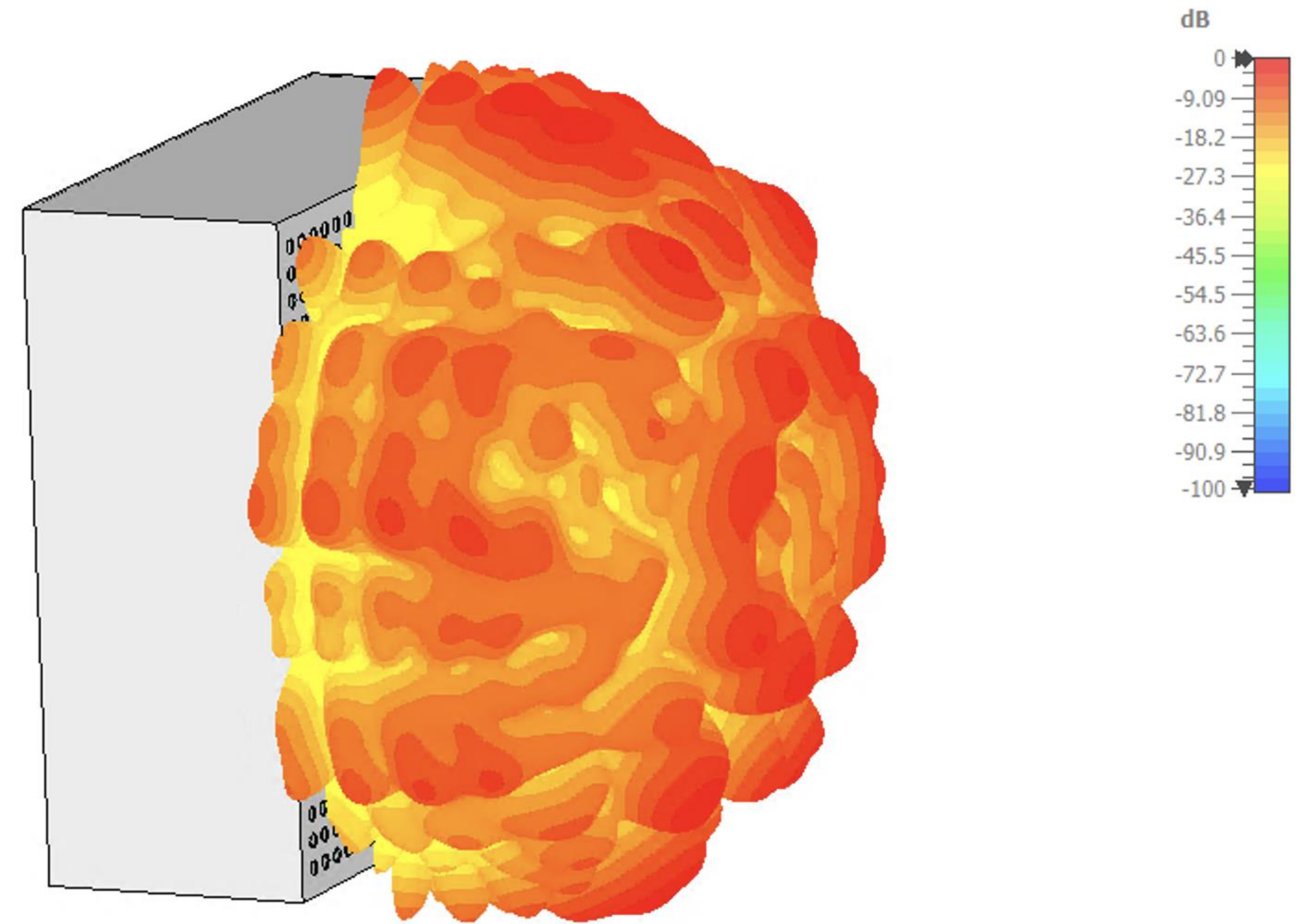
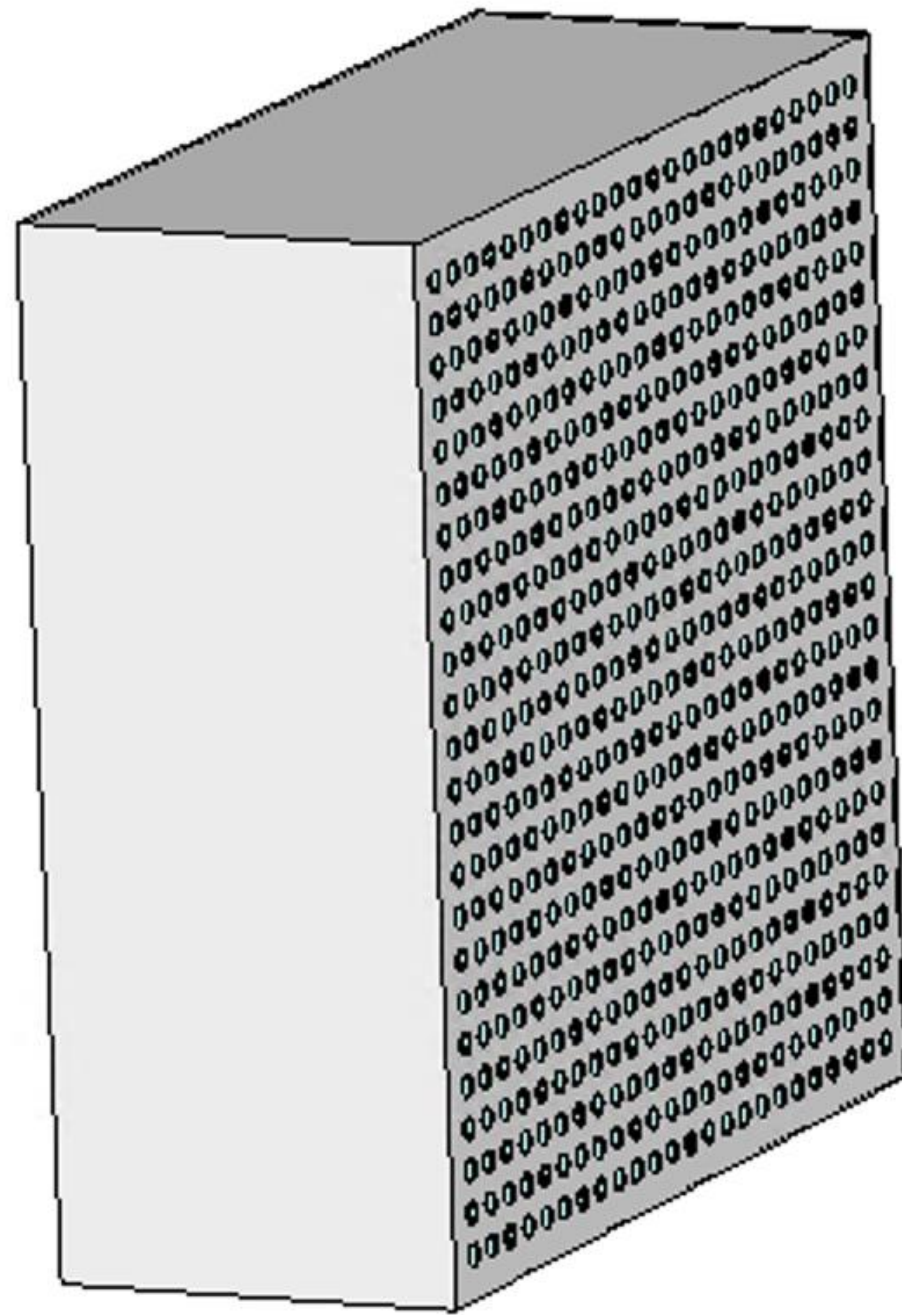
Size of the Sampling Surface





# Feasibility for Radio Astronomy

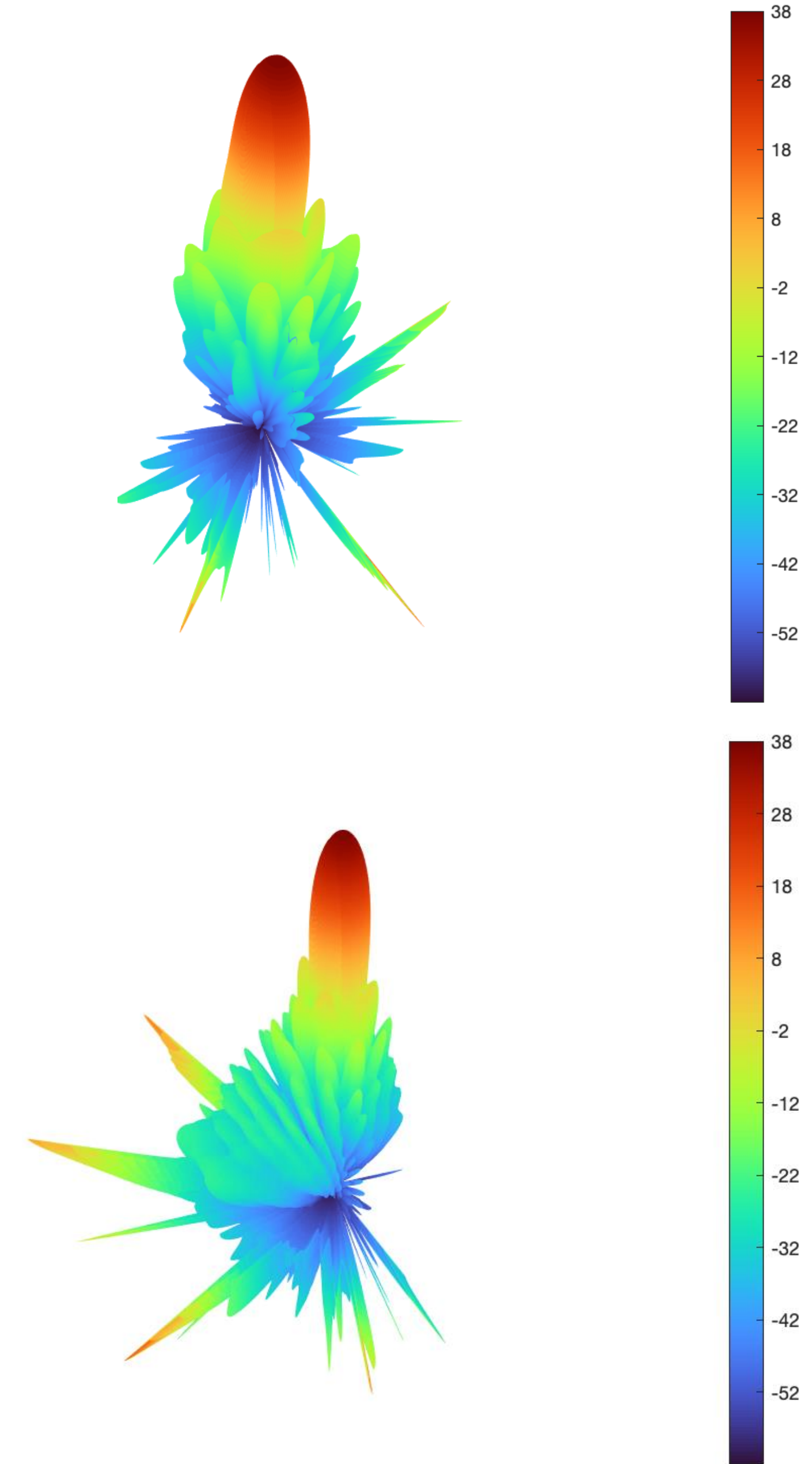
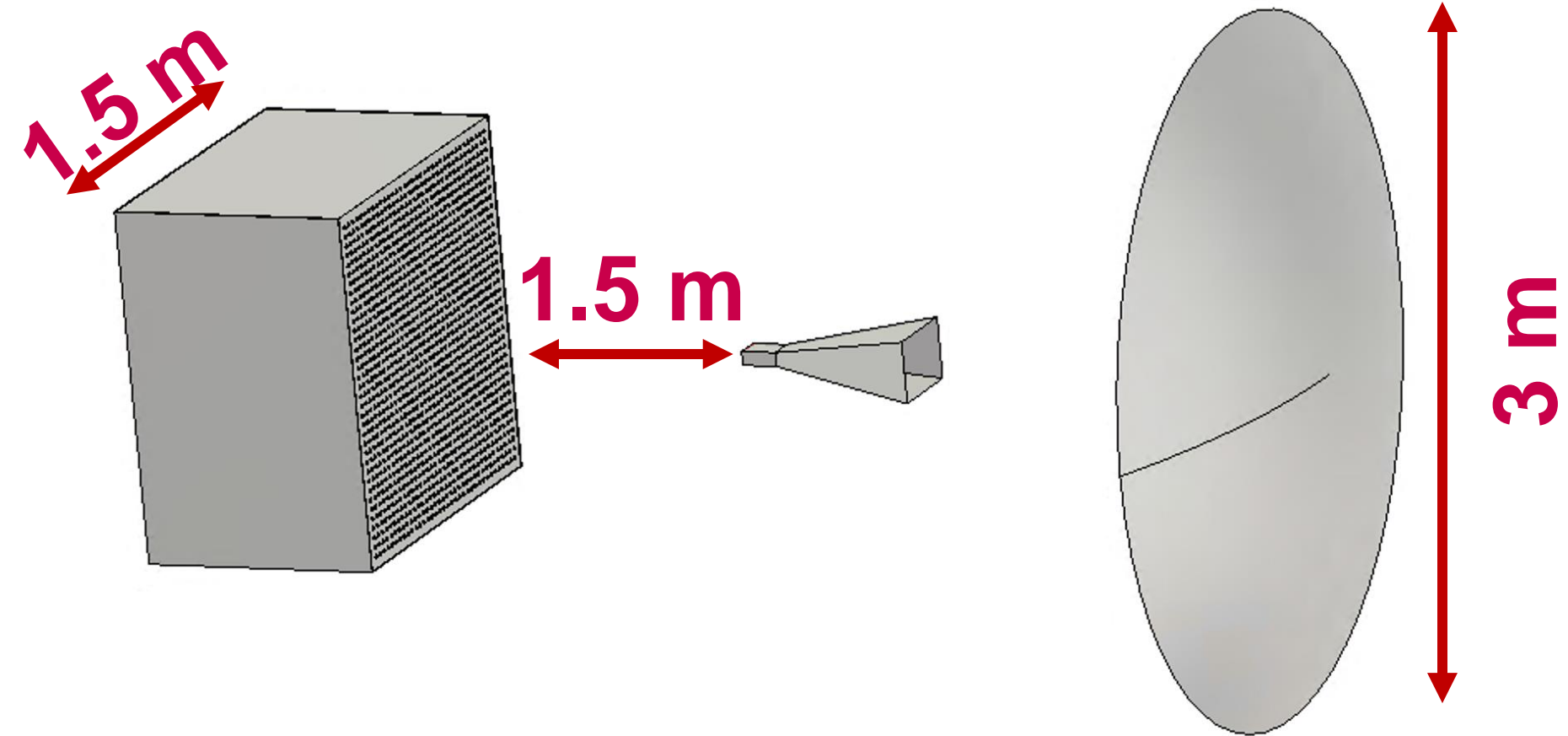
## Size of the Sampling Surface





# ○ Preliminary Results

3m Dish system @ 2GHz

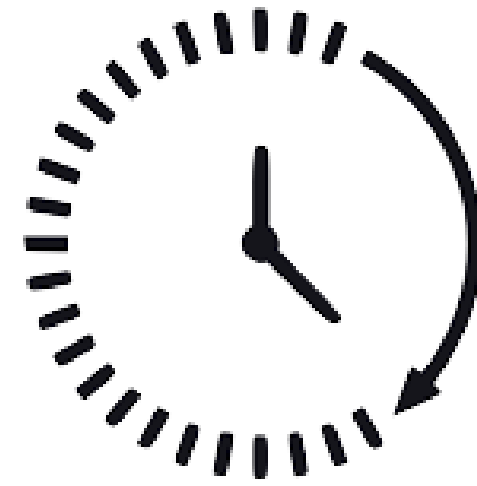




# Value Proposition



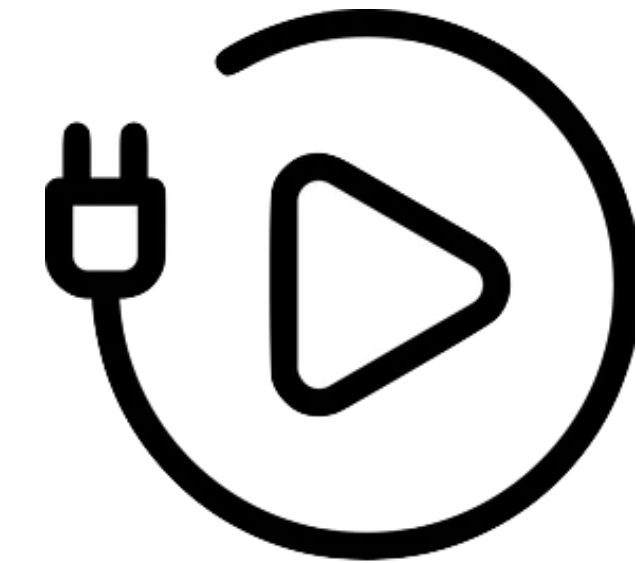
Compact



50-10000 x  
Faster



3D Pattern  
On-site  
Testing



Plug & Play



# ○ Feasibility for Radio Astronomy

Next Steps:

- Experimental validation @ X-band
- Numerical Validation of Required Sampling Size for 15m Dishes



# EMPath

Thank you very much

Innovation project  
supported by



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Confederation

Innosuisse – Swiss Innovation Agency

>>venture>>  
WINNER

VENTURE  
KICK



FIT  
fondation  
pour l'innovation  
technologique

HE<sup>VD</sup>  
IG

Follow Us:

