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SAN DIEGO 2023

WE1B-5

# 3D Printed Metallized Polymer Slotted Waveguide Antenna Array for Automotive Radar Applications at 140 GHz


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HUBER+SUHNER

POLITÉCNICA

KIT
Karlsruher Institut für Technologie

# Outline



- Motivation
- Slot array design
- 3D printing challenges at higher frequencies
- Measurement setup
- Measurement results
- Conclusions

*here nice picture*

# HUBER+SUHNER
# 3D waveguide antennas

Mobile Backhaul

Pencil-beam
V- & E-band
antennas

Fixed Wireless Access

Facebook Terragraph
antenna
(steerable V-band)

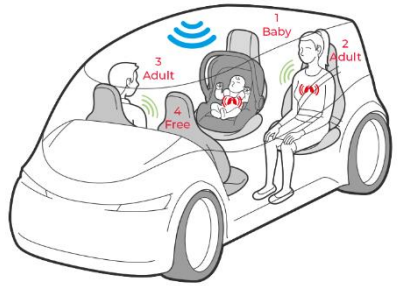
Autonomous driving

Automotive MIMO
radar antennas
at 77GHz

Gen6 for

Continental BOSCH

140GHz antenna




Antennas for
in-cabin radars
&
short range radars

# Motivation



## Why 140GHz radar?

10+ GHz bandwidth available
- range resolution improvement*

Large aperture size for the same antenna form factor - angular resolution improvement*

Better Doppler resolution*

Sensor size reduction

Drawback – limitation to short range radars

** with respect to 77GHz radars*

# Motivation



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Drawback – limitation to short range radars

** with respect to 77GHz radars*

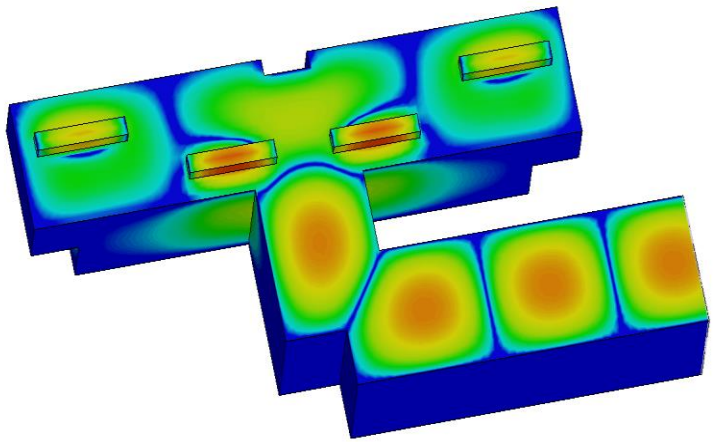
## Why metallized plastic waveguides?

- ✓ Low-cost mass production
- ✓ Low weight
- ✓ Low losses
- ✓ Large impedance bandwidth
- ✓ Larger aperture possibility

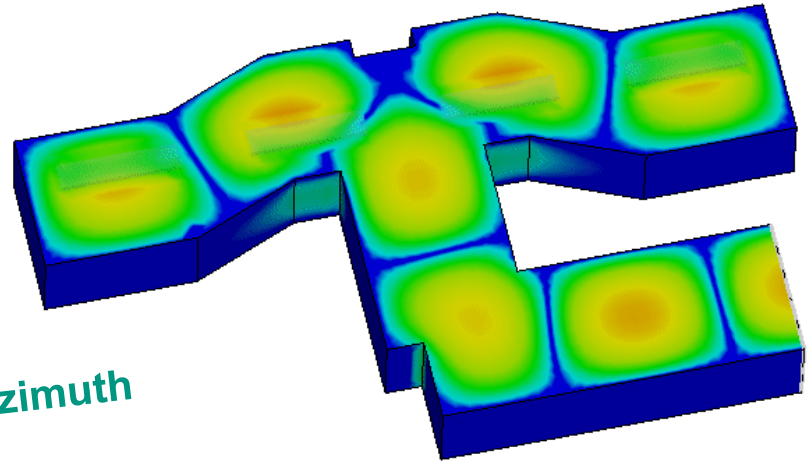
# Antenna concept

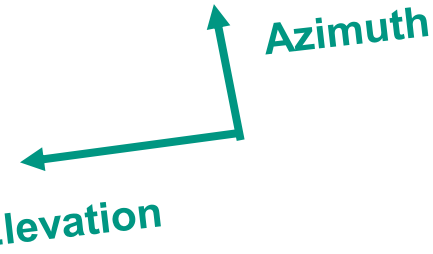


(a) Central fed slot array



(b) Central fed inline slot array [1]





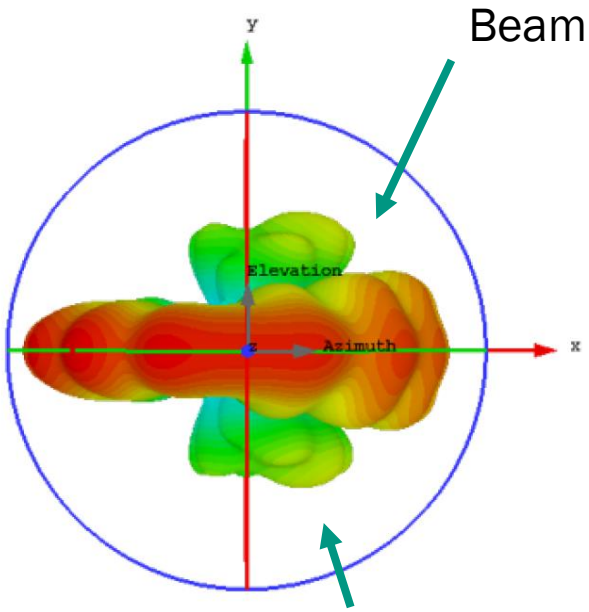

- Central feeding
- Four slots in elevation as a subarray
- Corporate to serial design
- Slots radiating almost in phase

[1] https://doi.org/10.1002/mmce.20936

# 3D pattern simulations

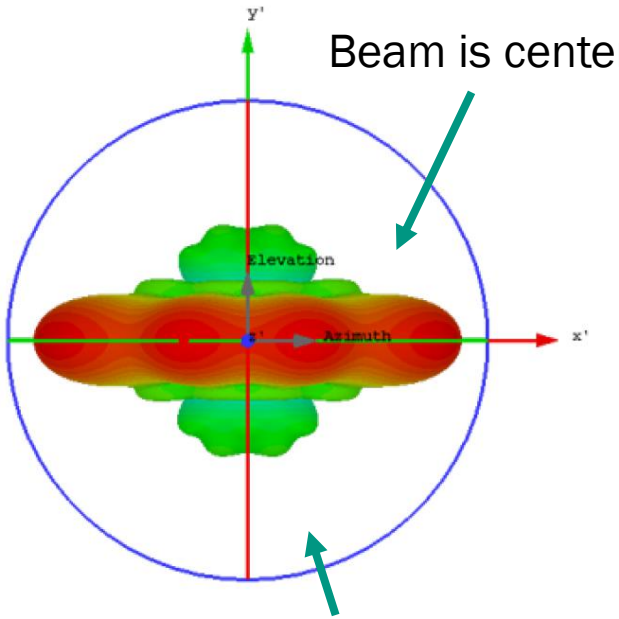


(a) Central fed slot array




Side lobes not symmetrical

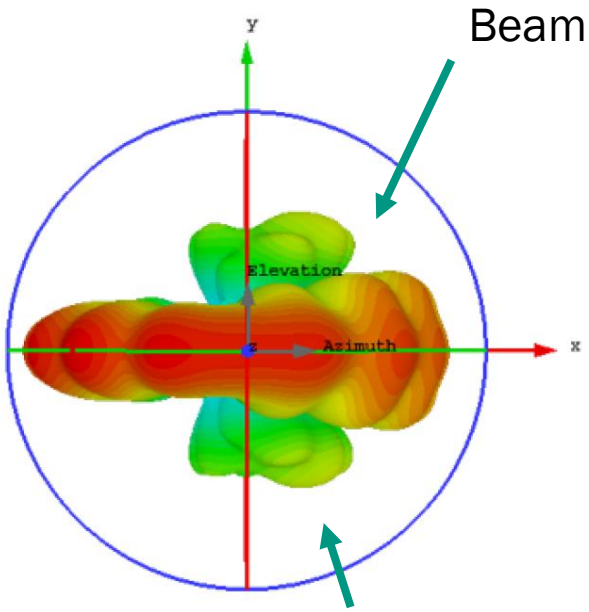
(b) Central fed inline slot array




Symmetrical pattern

# 3D pattern simulations

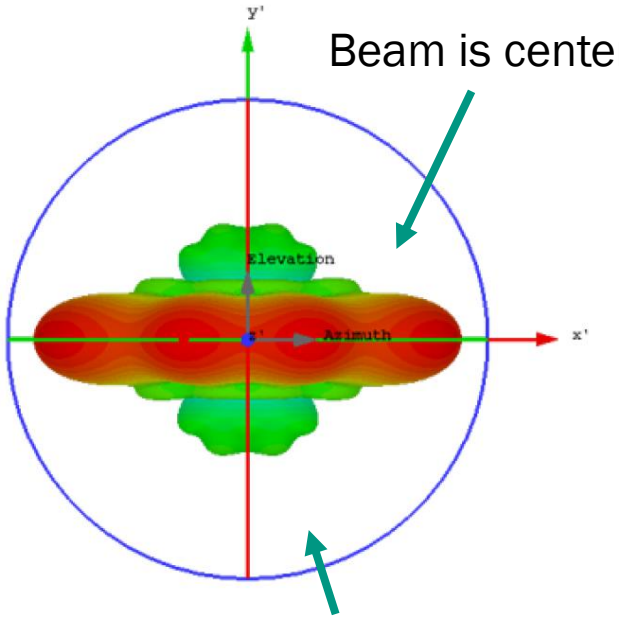
(a) Central fed slot array




Beam is tilted

Side lobes not symmetrical

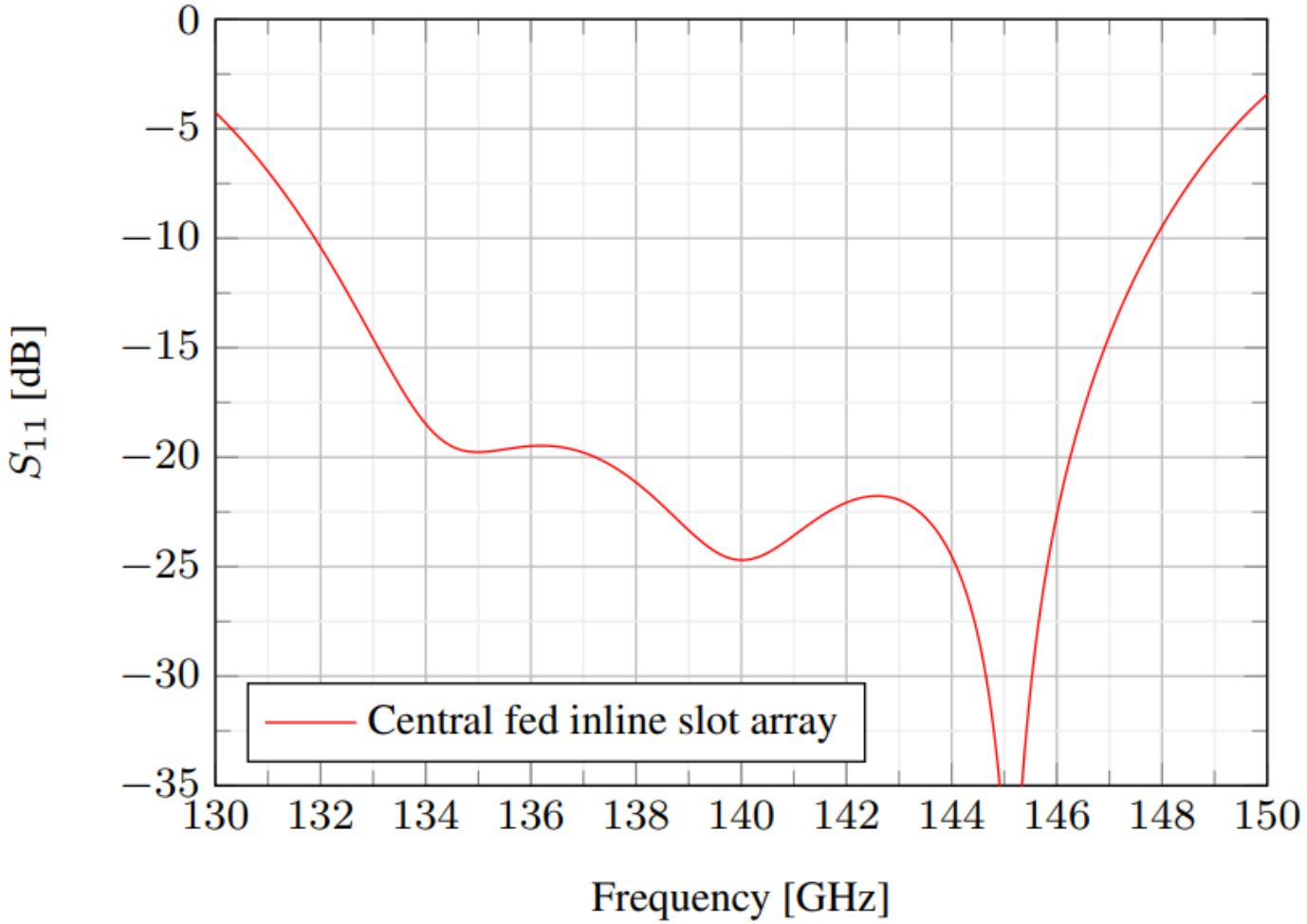
(b) Central fed inline slot array




Beam is centered at 0°

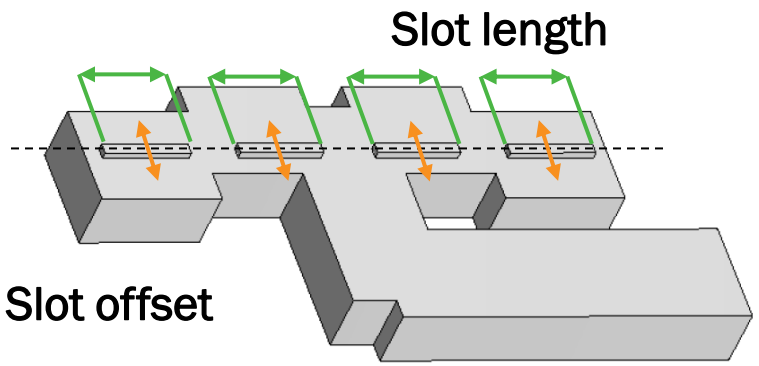
Symmetrical pattern

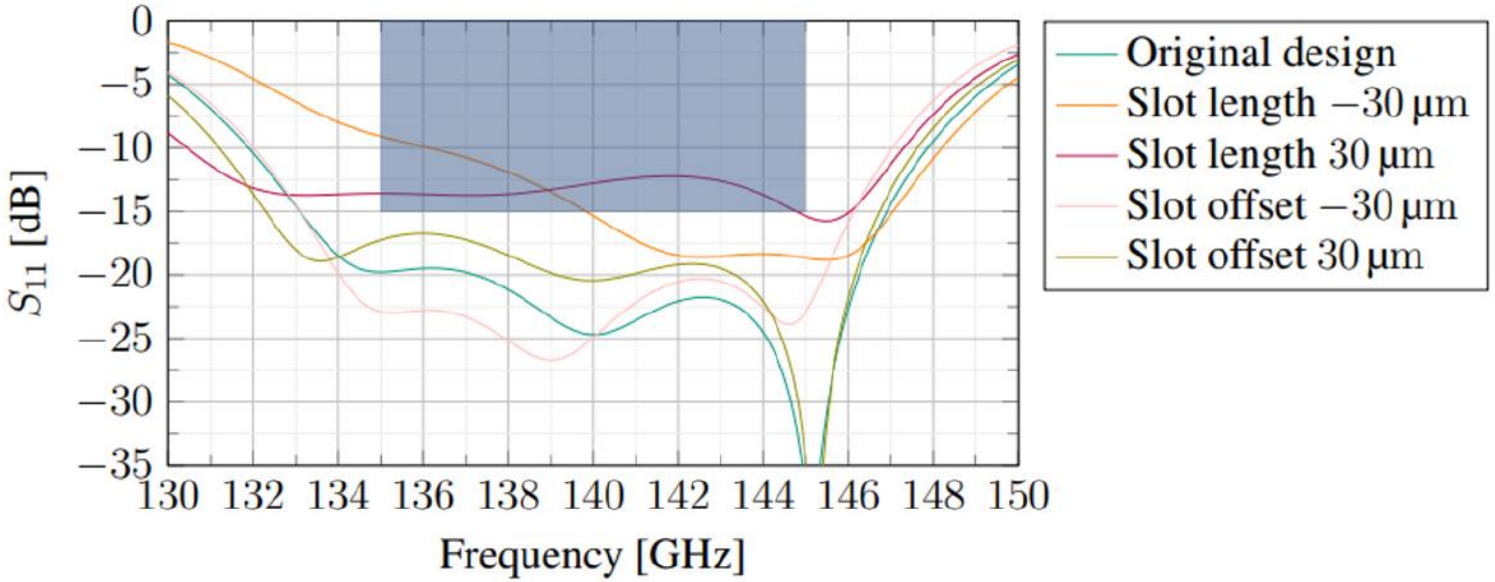
# Reflection coefficient simulations




- Antenna matched below -20dB for almost 10GHz
- Below -15dB wide bandwidth of 14GHz achieved in simulations

# 140GHz Tolerance analysis

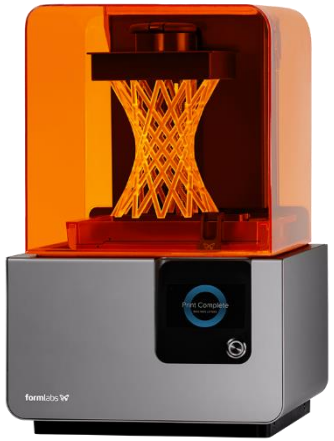



- The reflection coefficient of a slot array becomes worse when the length of a slot is varied.

# 3D printing – a challenge for higher frequencies

Stereolithography (SLA)



[2]

Challenges at 140GHz

- Tolerances in the range of micrometers
- Deviations from precise dimensions lead to significant changes in the performance parameters

Uses a liquid resin and a UV laser to cure the resin layer by layer, creating a solid object.
The process allows for high precision and fine details in the final print.

[2] https://scanse.io/blog/sla-stereolithography-technology-in-3d-printing/

# Manufacturing process

3D printing → PVD coating → Soldering → RF Testing

[2]

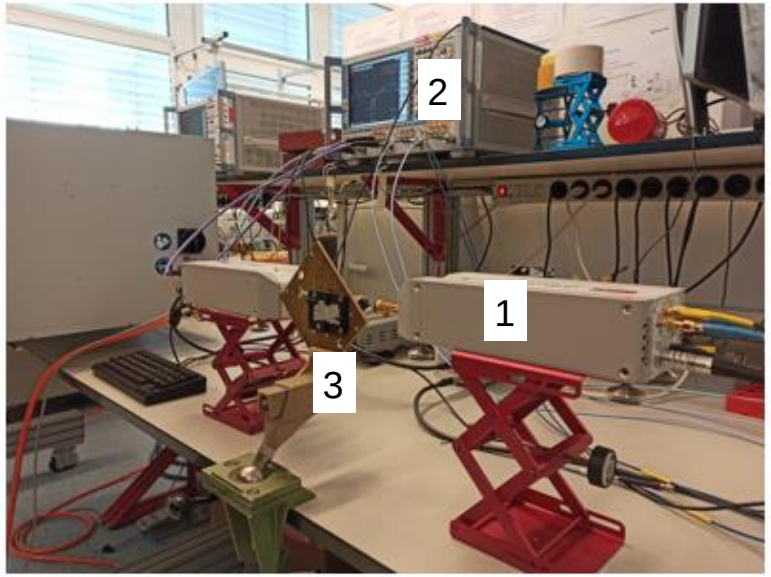

[3]


[3]

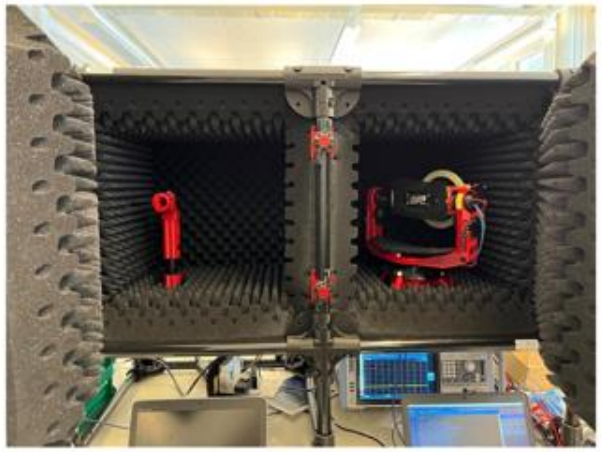
[4]

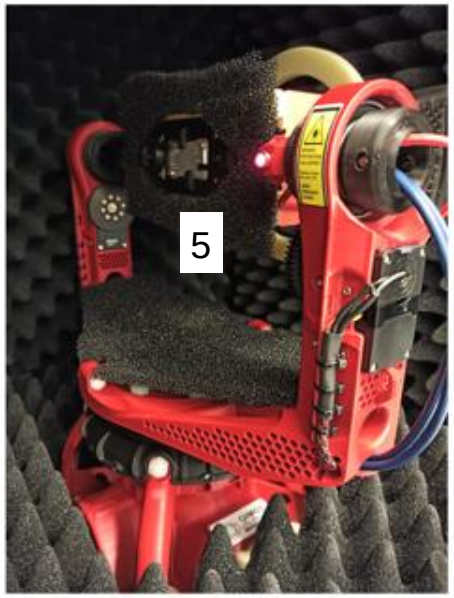
[3] https://www.hubersuhner.com/de/documents-repository/markets/pdf/automotive/mwr-8928-h-s-reprint
[4] https://millibox.org/

# Measurement setup










S-parameters setup

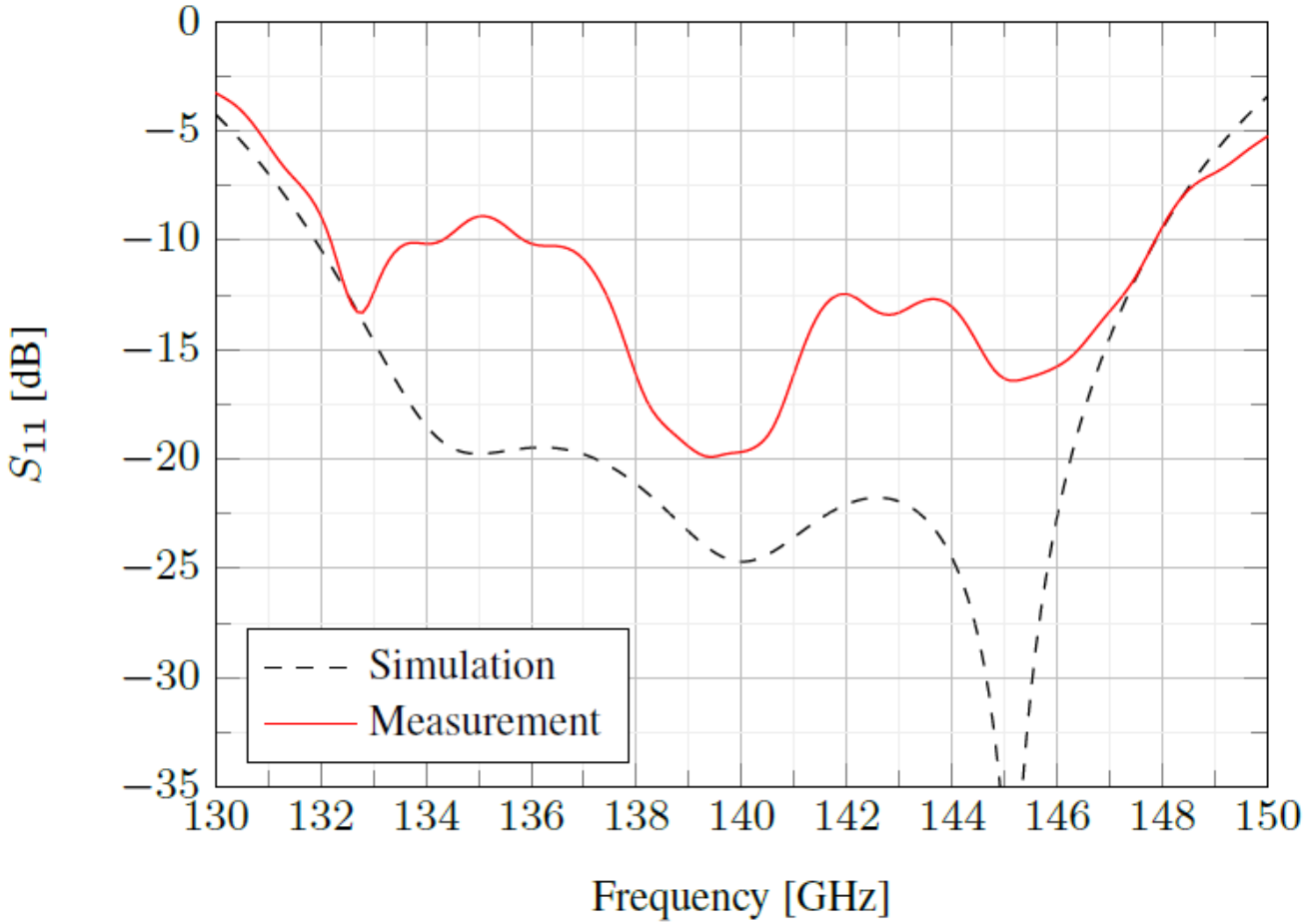
Far field pattern setup - Millibox - a compact antenna chamber

1- frequency multipliers 2 - VNA 3 - Mech. fixture

4 - TX positioner 5 - RX positioner

# Reflection coefficient





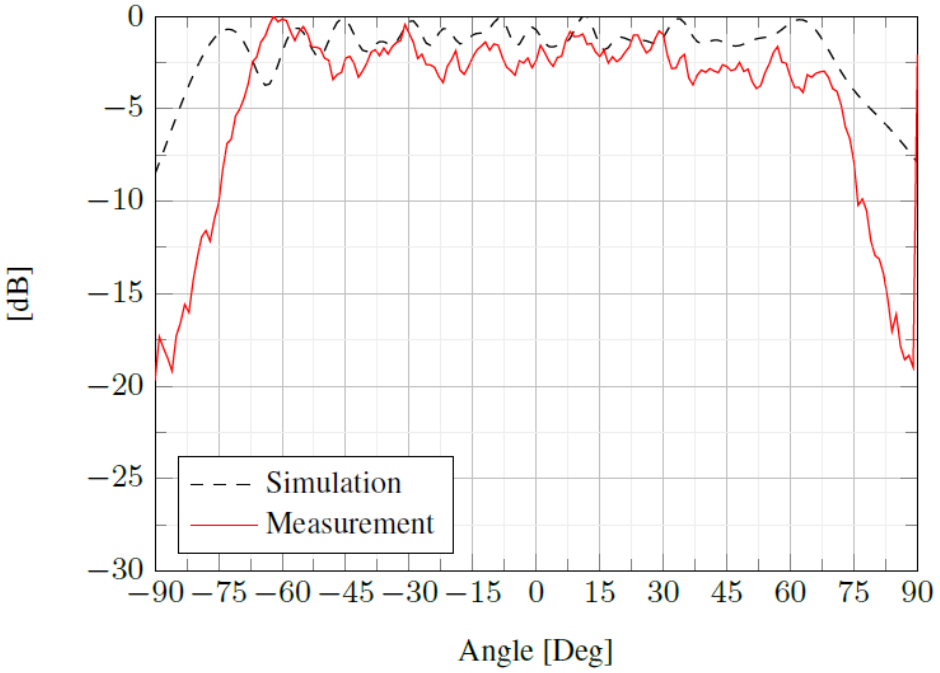

- 16GHz bandwidth below -10dB out of which 3.2GHz below -15dB

Reflection coefficient of the slot array antenna – simulation and measurement.

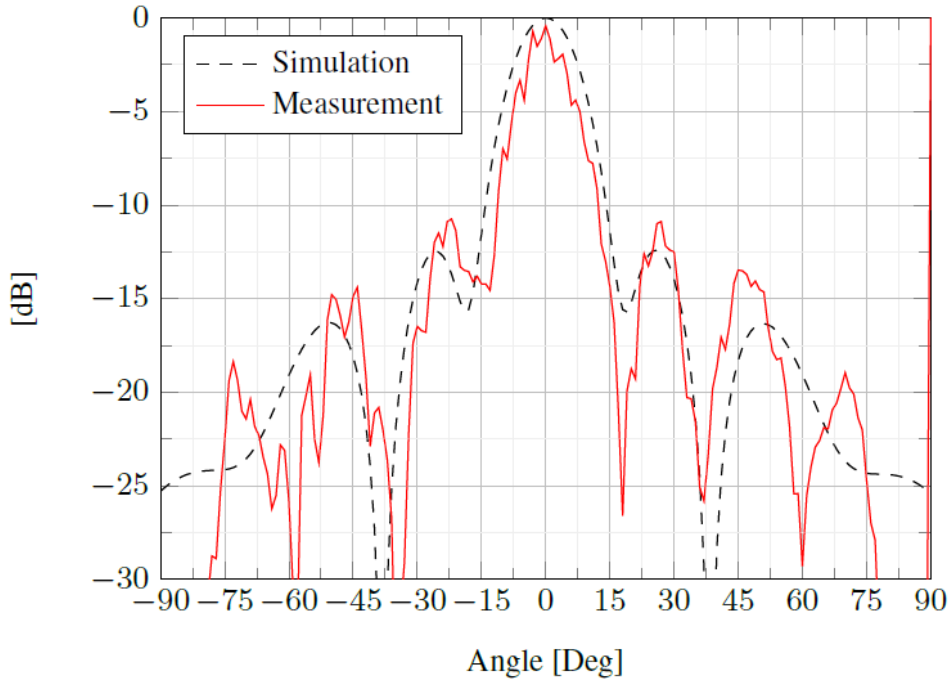
# Radiation characteristics



## Azimuth




## Elevation




Normalized radiation patterns of the fabricated inline slot array at 140GHz.

Measured realized gain: 10.9dBi

Antenna efficiency: ~80%

# Conclusions



- Successful implementation of a 3D printed metallized plastic waveguide antenna array at 140GHz
- The tolerances of commercially available 3D printing techniques are reaching their limit for antenna prototyping at D-band
- The metallized plastic antennas are an alternative to current state-of-the-art antennas at 140GHz

*here nice pictures*