ANTERAL

Innovative Antenna and Terahertz Imaging Technologies

High Gain Antenna for Millimetre-Wave Communications

Aitor Martinez (Anteral, Spain)

EuMW 2016. 4th October, London.

Outline

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1. **Motivation**
2. Anteral's contribution to mmW and THz systems
3. mmW and THz communication systems
4. High gain antennas for communications
5. Success story
    1. 330 GHz parabolic offset reflector antenna.
6. Under development:
    1. D-band parabolic offset reflector antenna [M3tera project. H2020]
7. Conclusions

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Motivation

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The objective is to present some successful cases of high gain antennas developed by Anteral for Millimetre-Wave Communications.

The main requirements of the antennas are:

- High gain antenna (> 40 dBi)
- High frequency operation (> 100 GHz)
- Reduced manufacturing complexity.
- Manufacturing cost reduction.
- Single polarization.

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Anteral´s contribution (I)

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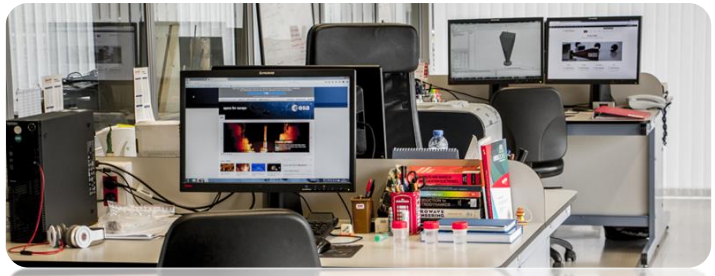
Anteral is an innovative SME born in 2010 as a spin-off of the Antenna Research Group of the Public University of Navarre (Spain).

The company works in the fields of space, telecommunications and science, providing Universities and various industrial enterprises with innovative solutions.



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Anteral´s contribution (II)

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High performance antennas

mmW & THz technology

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Anteral´s contribution (III)

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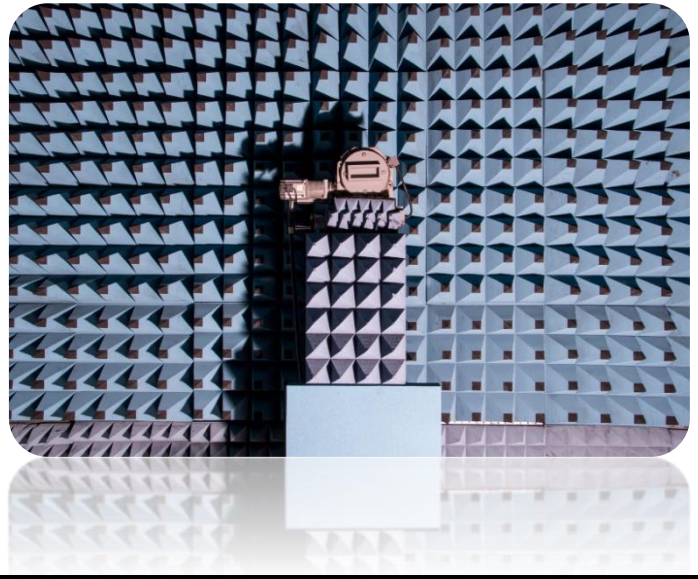
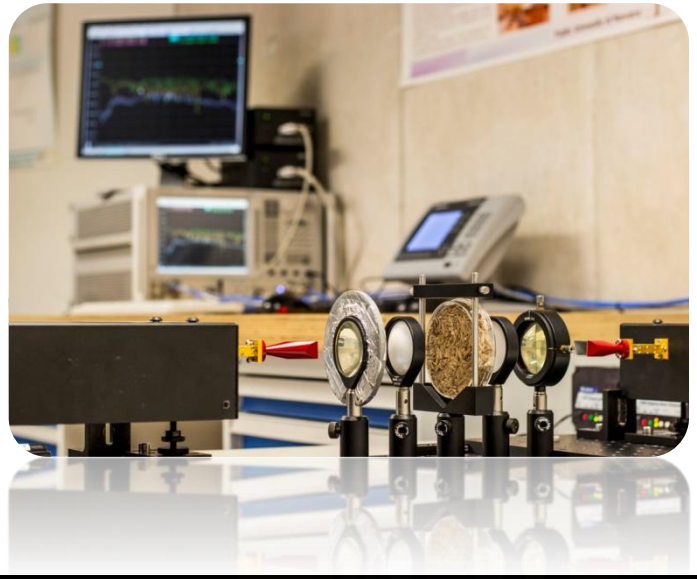
Anteral has access to:

- **THz laboratory** including VNA measurements capabilities 500 GHz.
- **Anechoic chamber** for far field and near field measurements.





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mmW & THz communication systems (I)

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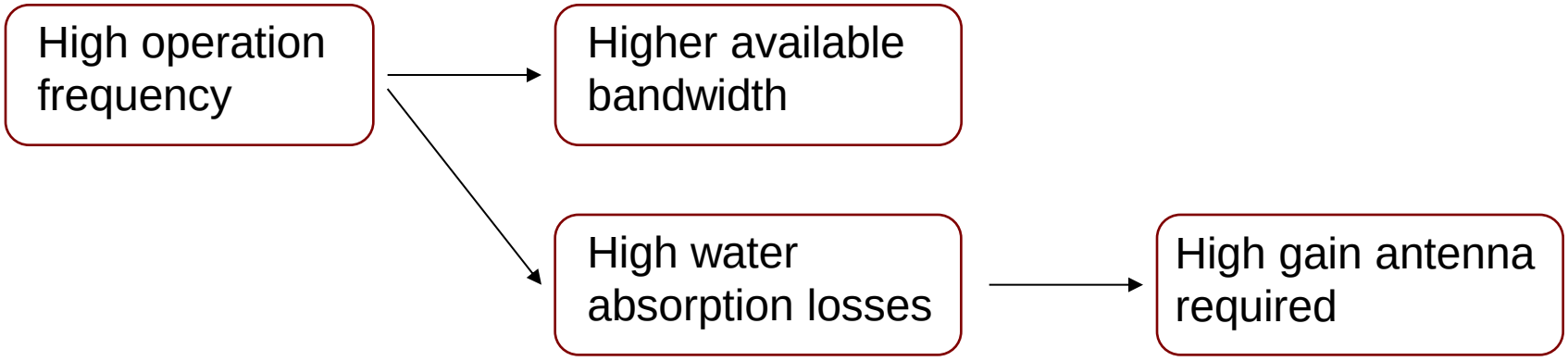
Nowadays, there are some commercial complete solutions in market operating at E-band, in 60 GHz and 80 GHz sub-bands.

The increase in applications with **high data rates requirements** is leading to the development of point-to-point outdoor communication solutions with higher bandwidths.



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mmW & THz communication systems

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Nowadays there are many projects developing communication systems operating over 100 GHz. Anteral last year has collaborated in:

- Many Asian proof of concept (POC) projects at 300 GHz band.
- M3Tera, H2020 project focused in analyse the feasibility of manufacturing techniques for volume production of communication systems at 145 GHz.

Advantages of communication over 300 GHz:

- High bandwidths available > 70GHz.
- Medium distances link can be achieved, from 100 m to 1km.
- Photonic and MMIC based component.

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High gain antenna solutions

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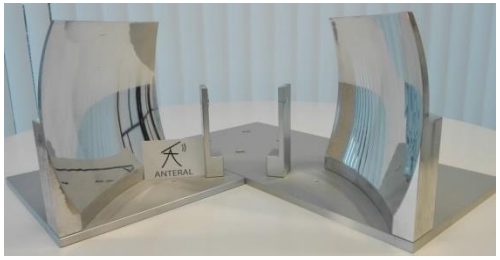
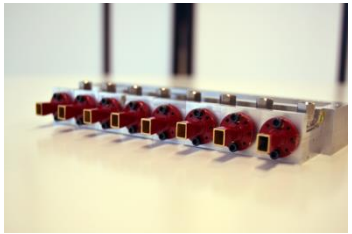
Parabolic reflector antennas

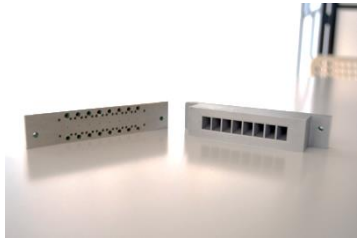
- Required feed horn.



Horn or planar antenna arrays

- Complex distribution networks.

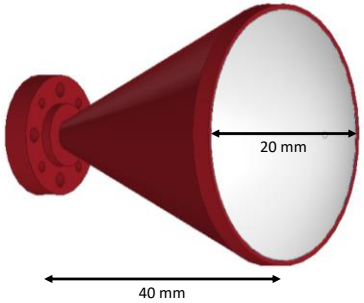




Lens horn antennas

- Dielectric losses increases at high frequencies.

W-Band Horn Lens Antenna



Slotted waveguide array antennas

- Very small slots > 100 GHz

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Success story

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Development of offset reflector antennas operating at 330 GHz.

Commercial reflector antenna solutions:

- Reflector solutions only up to 325 GHz.
- High manufacturing costs.
- Cassegrain / Greogorian dual reflector solutions.

Commercial dual reflector Cassegrain antenna, operating up to 325 GHz.

Our project main objectives and requirements:

- Design and manufacture high gain antennas > **50 dBi gain.**
- Manufacturing easiness – Costs reduction
- The frequency scalability.
- Single polarization, with no cross polar level restriction.

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Reflector antenna at 330 GHz (I)

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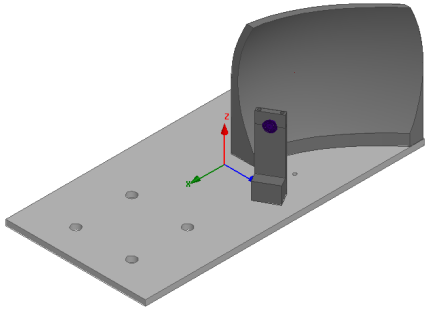
Reflector antenna composed by: Reflector surface, 12 dBi pyramidal feed and support structures.



Electrical specifications:

Parameter	Value
Central frequency	330 GHz
Bandwidth	70 GHz
Gain	> 50 dBi
Polarization	Single linear horizontal
Input waveguide	Standard WR-2.8

Mechanical specification:

Parameter	Value
Feed horn interface	UG387 U/M
Manufacturing material	Aluminum
Reflector maximum diameter	20 cm
Reflector weight	< 2.5 Kg
Input waveguide	Standard WR-2.8

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Reflector antenna at 330 GHz (II)

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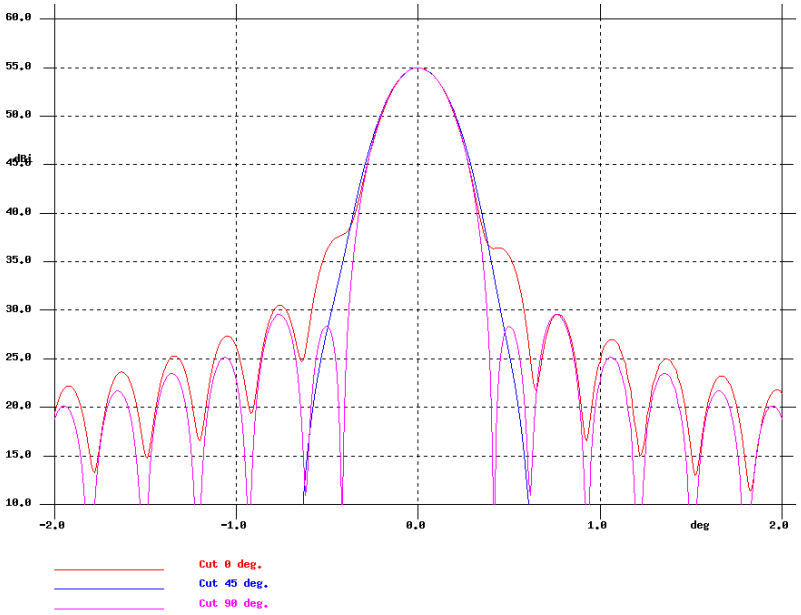
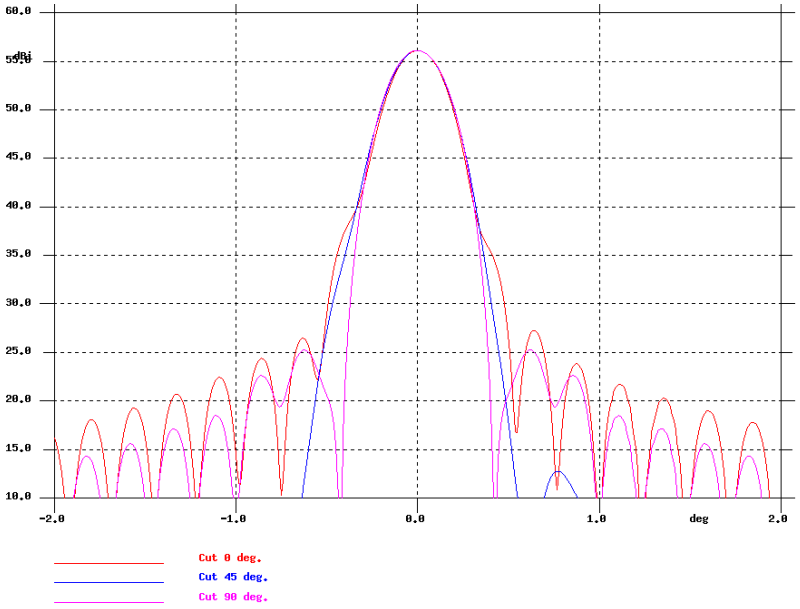
Complete antenna simulation results:



295 GHz far field radiation pattern.
55 dBi



365 GHz far field radiation pattern.
56.5 dBi

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Reflector antenna at 330 GHz (III)

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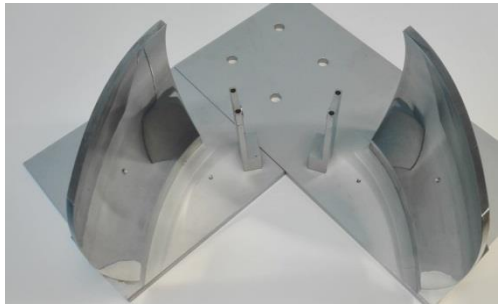
Two units of the designed antenna has been manufactured, transmission (TX) and reception (RX).

1. **Parabolic offset reflector**
   - Material: Aluminium (6061).
   - Using a high precision milling machining.
     - Surface roughness Ra= 2.4 µm.
   - Surface/geometry tolerances are ± 15 µm.
   - Polishing post-process.
     - Improves roughness (Ra=0.1 µm)
   - Optical reflecting surface -> Laser alignment .



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Reflector antenna at 330 GHz (IV)

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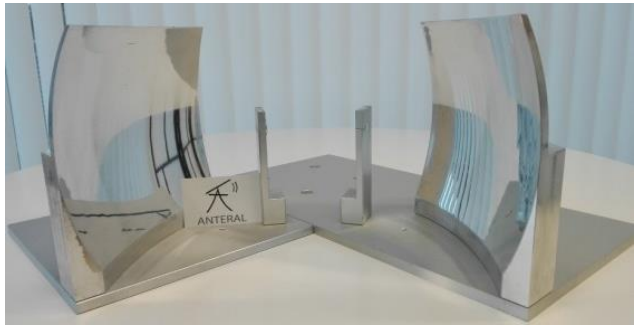
2. **Support and clamping structures**
   - Material: Aluminium (6061).
   - Using a precision milling machining.
   - Tight tolerances in support structures.
     - Focal point & phase centre positions.



3. **Pyramidal feed horn manufacturing**
   - Material: Aluminium (6061).
   - Wire electrode discharge machining (WEDM) process.
   - 2 different electrodes to enhance the surface finishing.

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Reflector antenna at 330 GHz (V)

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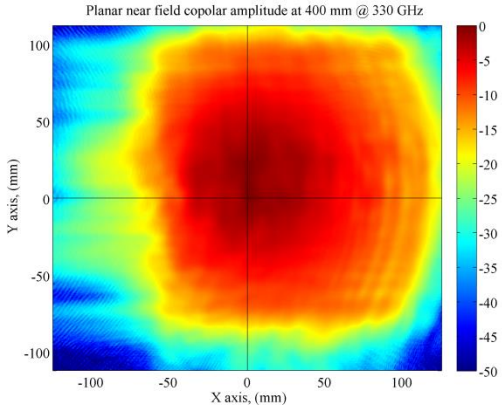
Test verification: Planar Near Field radiation patterns measurement.

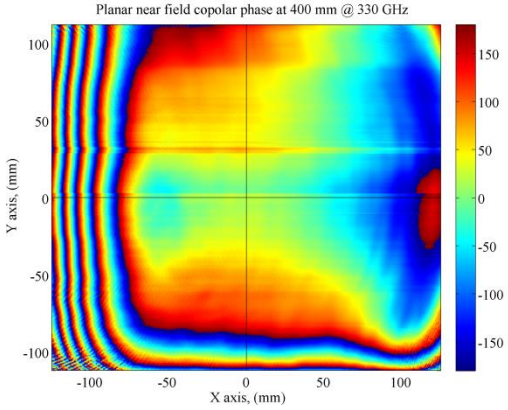
- Scanning area: 252 mm x 224 mm.
- Scanning resolution: 0.35 mm.
- Distance between probe and reflector 400 mm.
- More than 4 days measurements each reflector.

10 mm length Near field probe.

Planar near field measurement system with 330 GHz to 500 GHz frequency head extenders.



Planar near field MAGNITUDE at 330GHz.



Planar near field PHASE at 330GHz.

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Reflector antenna at 330 GHz (VI)

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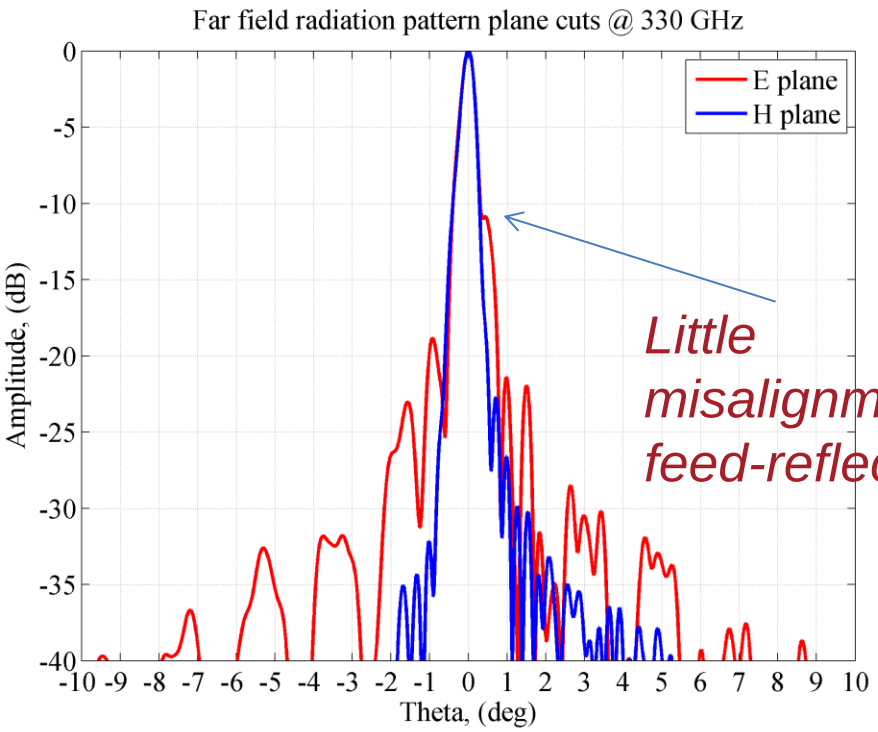
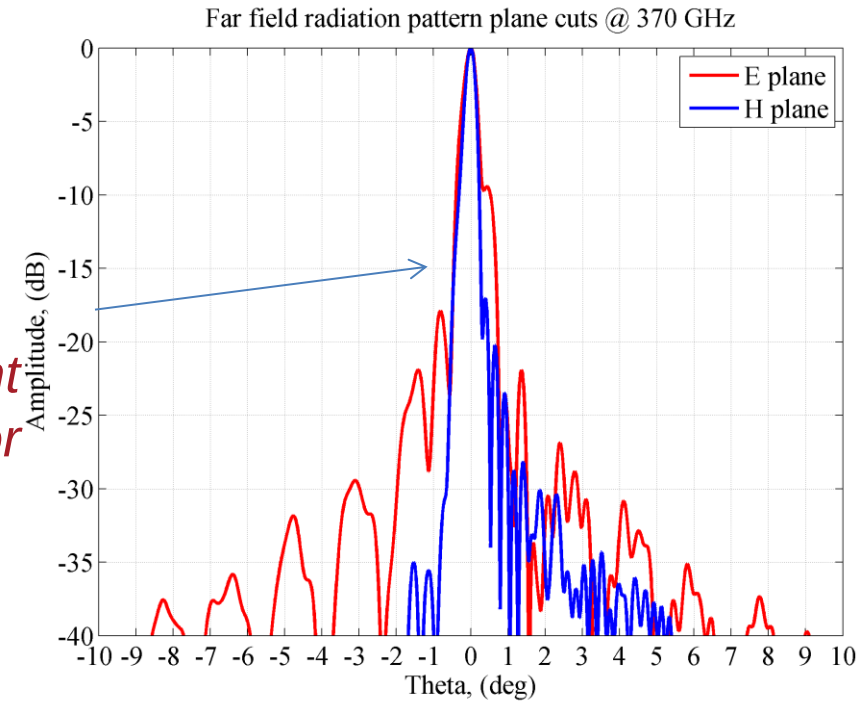


Little misalignment feed-reflector



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Reflector antenna at 330 GHz (VII)

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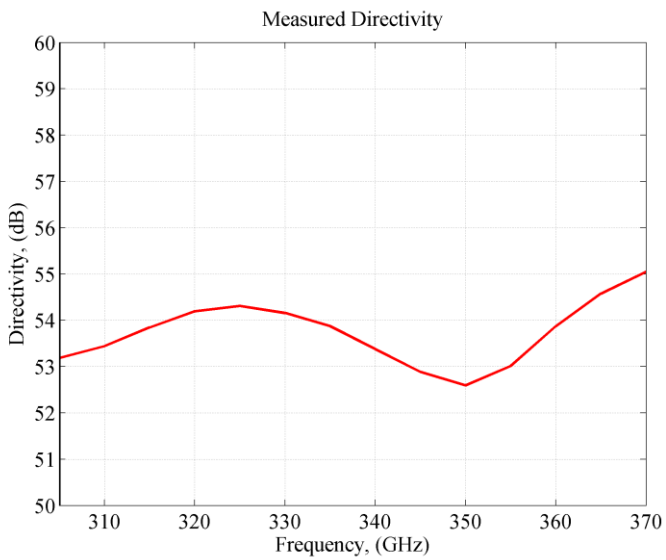
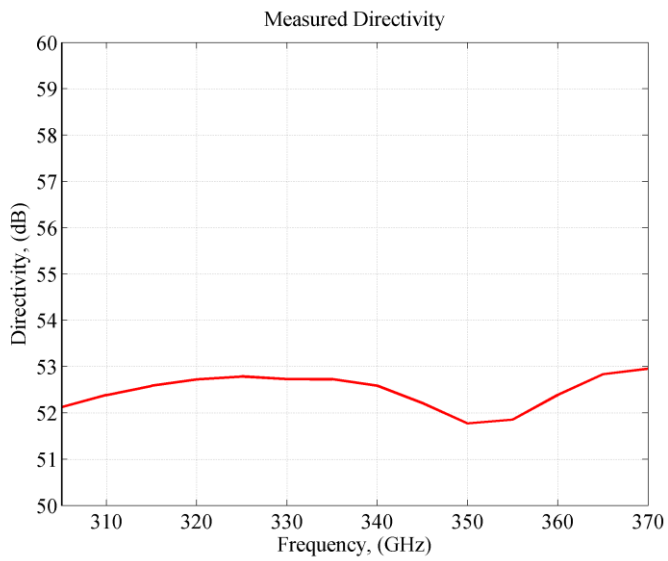
Near Field to Far Field transformation and phi cuts extraction.

Gain: Not measured.

- Far field distance is calculated to start at 100 m**.**
- Quite difficult to perform for the standard three antenna gain measurement methods.



TX module: Measured directivity > 52.5 dBi



RX module: Measured directivity > 51.8 dBi.

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Test under real conditions

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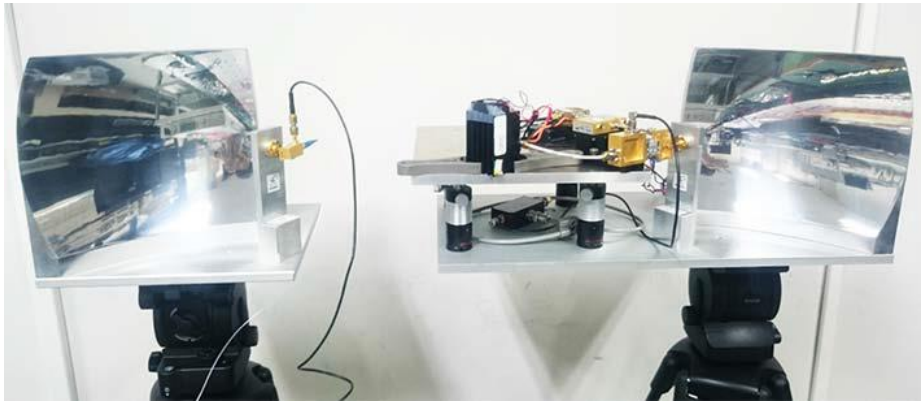
Two units of the presented high gain antenna have been part of the communication system, in a real time communication link test with **50 Gbit/s** data rate transmission over **100 m distance.**



Photograph of the transmitter and receiver, which are supported by tripods.

This sub-THz link test has been carried out by Dr. Tadao Nagatsuma (University of Osaka, Japan) and his researcher group involved in another successful test at 120 GHz . Such results are still unpublished

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M3Tera. D-Band reflector (I)

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EU project in the H2020 framework.

M3TERA

The goal of the project is to develop a low-cost THz technology, enabled by the proposed micromachined heterogeneous integration platform, which provides an unprecedent way to:

- highly-integrate
- volume-manufacturability
- reliable
- reconfigurable
- cost and energy efficient

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

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M3Tera. D-Band reflector (II)

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Anteral is the responsible of the high gain antenna design and manufacturing for the communication application demonstrator.

The project partners are:

CHALMERS UNIVERSITY OF TECHNOLOGY

infineon

csem

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M3Tera. D-Band reflector (III)

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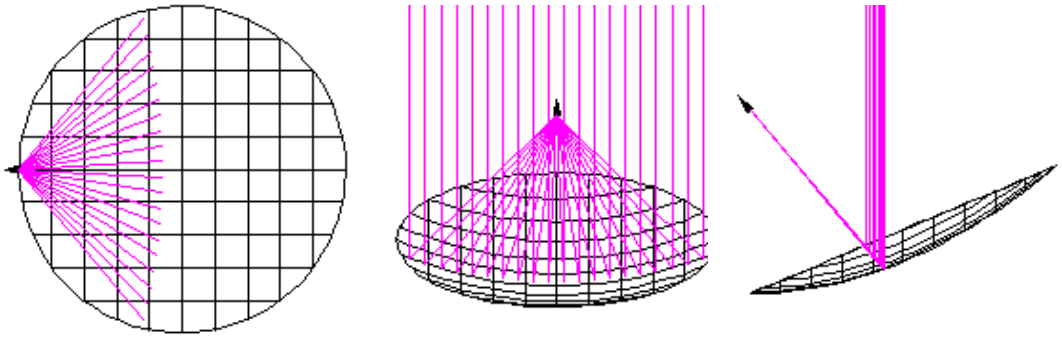
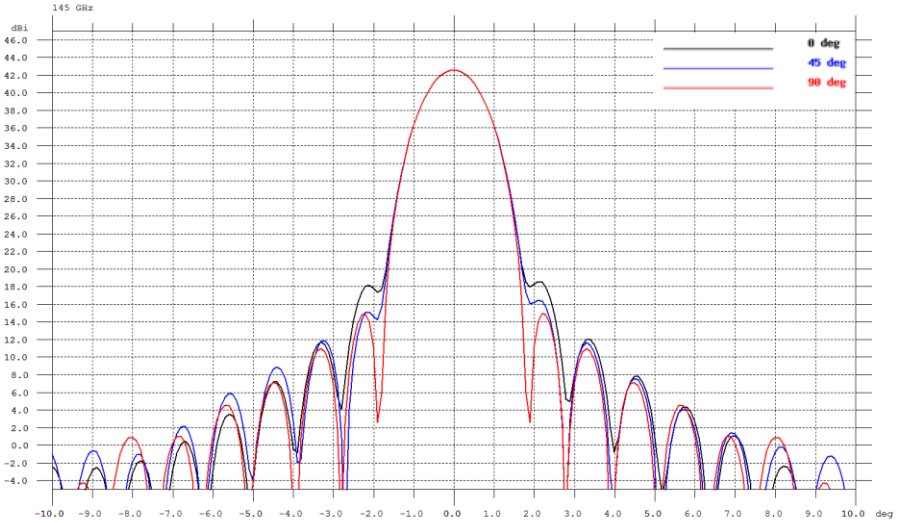
Proposed reflector antenna simulation results

- Reflector size: ø 10 cm
- Feed directivity: 13,5 dB
- Gain @ 145 GHz: 42,56 dB





Frequency	Directivity
110 GHz	39.57 dB
145 GHz	42.56 dB
170 GHz	43.54 dB

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M3Tera. D-Band reflector (IV)

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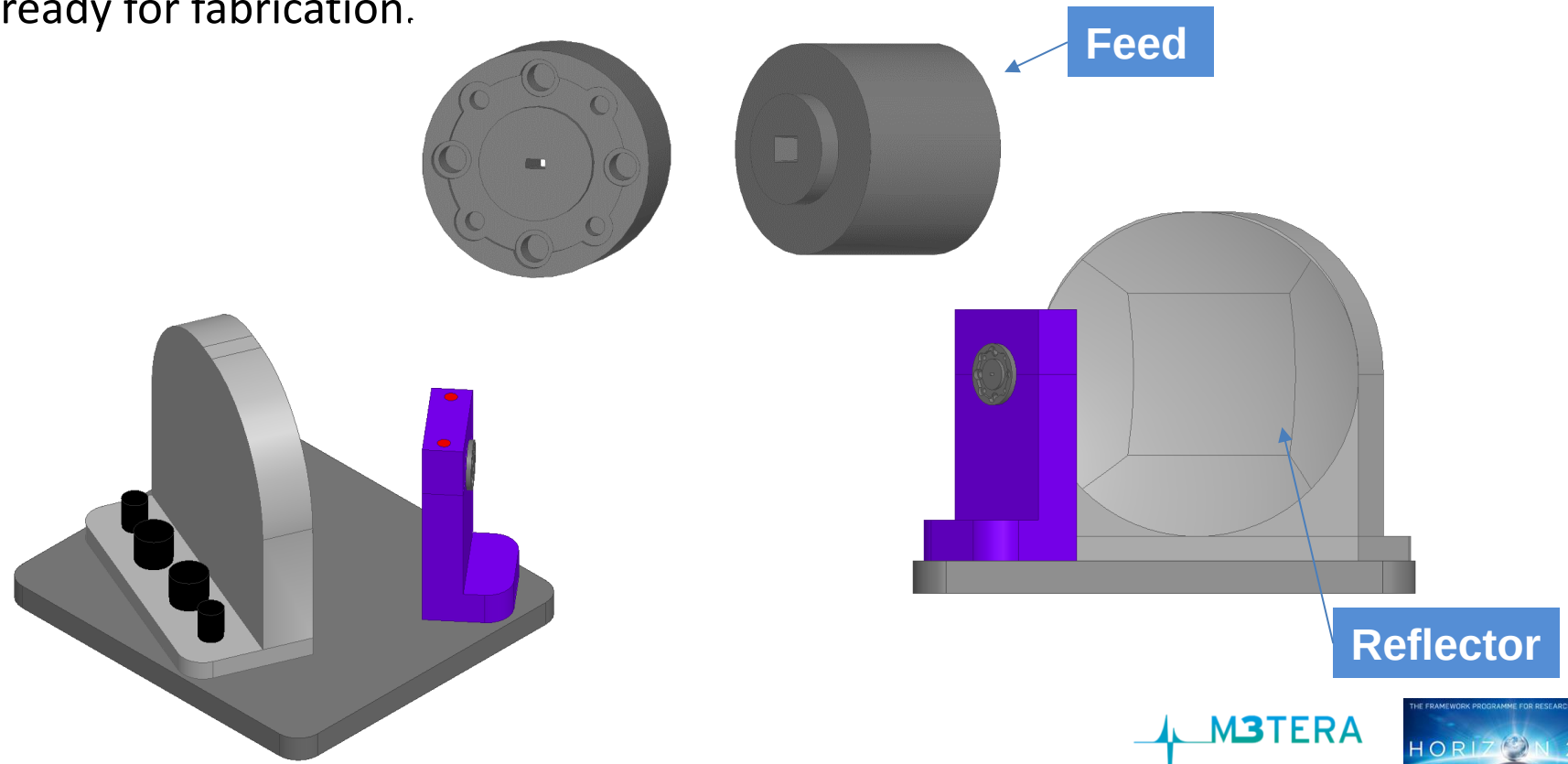
The reflector antenna for the M3tera communication application prototype is ready for fabrication.



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Conclusions

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1. A high gain antenna at 330 GHz has been developed with 70 GHz bandwidth.

2. The design, manufacturing and measured results are satisfactory.

3. The parabolic offset reflector antenna supposes a manufacturing complexity and cost reduction compared with other in the market.

4. A first test under real conditions have been carried out in Japan, achieving 50 Gbit/s at 100 m distance.

5. A new design of reflector antenna under the frame of M3Tera project has been presented for future high frequency telecommunications networks.

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Thanks for your kind attention

Any question?