Modern 5G Millimeter Wave Antenna Array Evaluation in Near- and Far-Field Environments

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BEYOND MEASURE™

Introduction

- Wireless testing has always taken some liberties to make measurements in imperfect environments (like violating the far-field rule)

- With introduction of the FR2 frequency range for the wireless devices, there was a lot of discussions whether devices need to be tested in far-field environment.

- Industry (3GPP and CTIA) elected to adopt something between the sub-par and ideal to conduct their testing

- In this study we investigated how much the results of typical FR2 devices change when testing is conducted in different environments.

Background

- Utopia
  - Pure far-field environment with no amplitude / phase taper or ripple
  - Lossless from the AUT to the receiver
  - Plenty of dynamic range to deal with changing path loss when AUT is rotated in 3-dimensionally
 - Positioner would not cause any disturbance for the measurements

Background

- Utopia = Reality
  - ❌ Pure far-field environment with no amplitude / phase taper or ripple
  - ❌ Lossless from the AUT to the receiver
  - ❌ Plenty of dynamic range to deal with changing path loss when AUT is rotated in 3-dimensionally
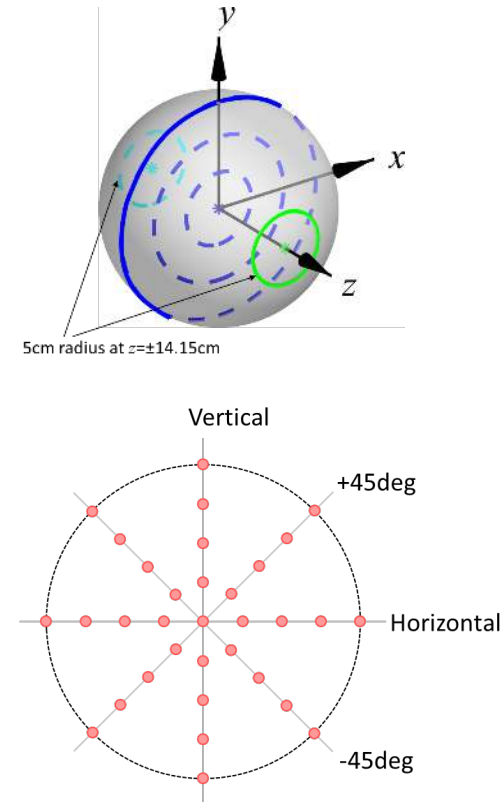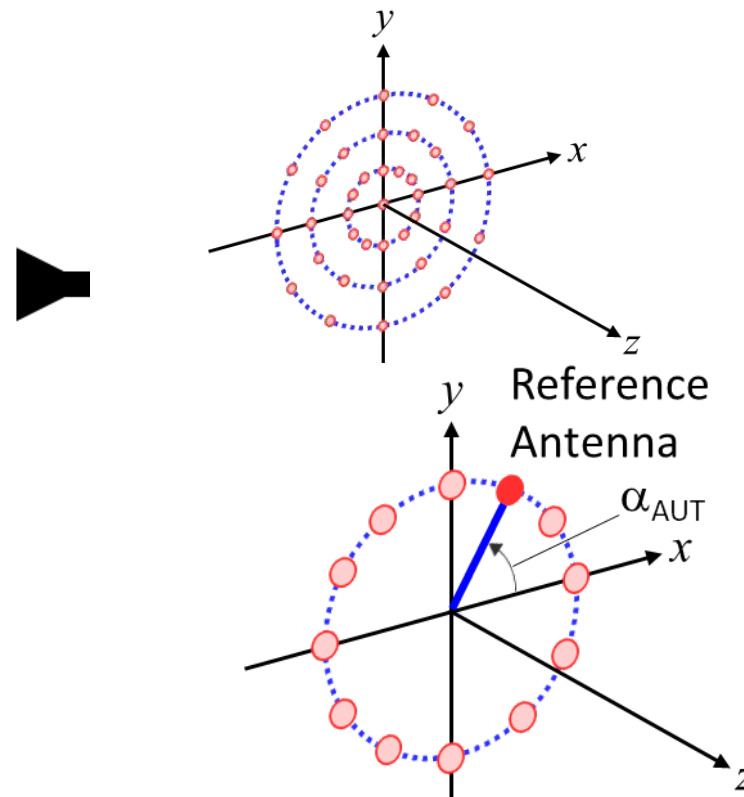 - ❌ Positioner would not cause any disturbance for the measurements

Validation

Amplitude, QoQZ
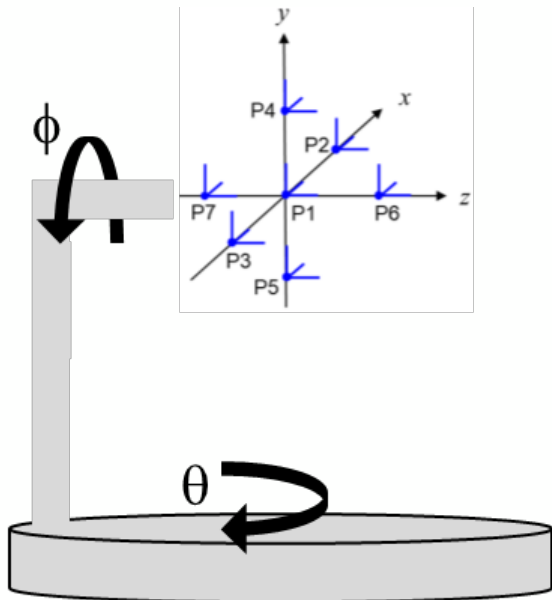
Phase Validation

So, what if we measure in near field ?

- Lot of talk about testing in near field for active devices.

- We took two distinctly different devices and measured them.
  - Active; UE measurements (range calibration in each distance)
    - CATR with 60cm QZ
    - 30cm and 50cm test distances
  - Passive; Phased Array Antenna
    - Planar near field range
    - ETS-Lindgren AMS-5703 CATR with 60cm QZ
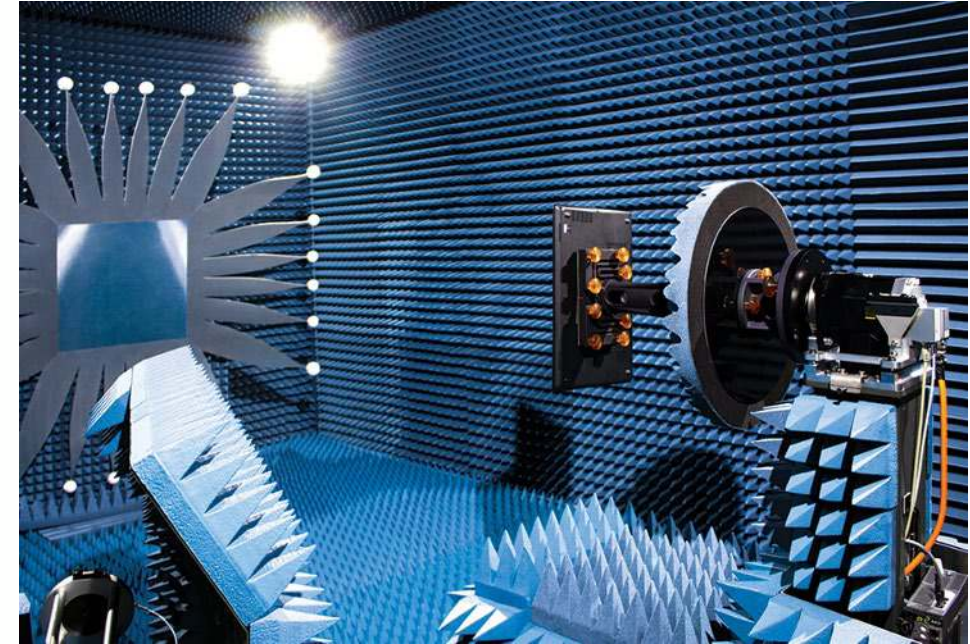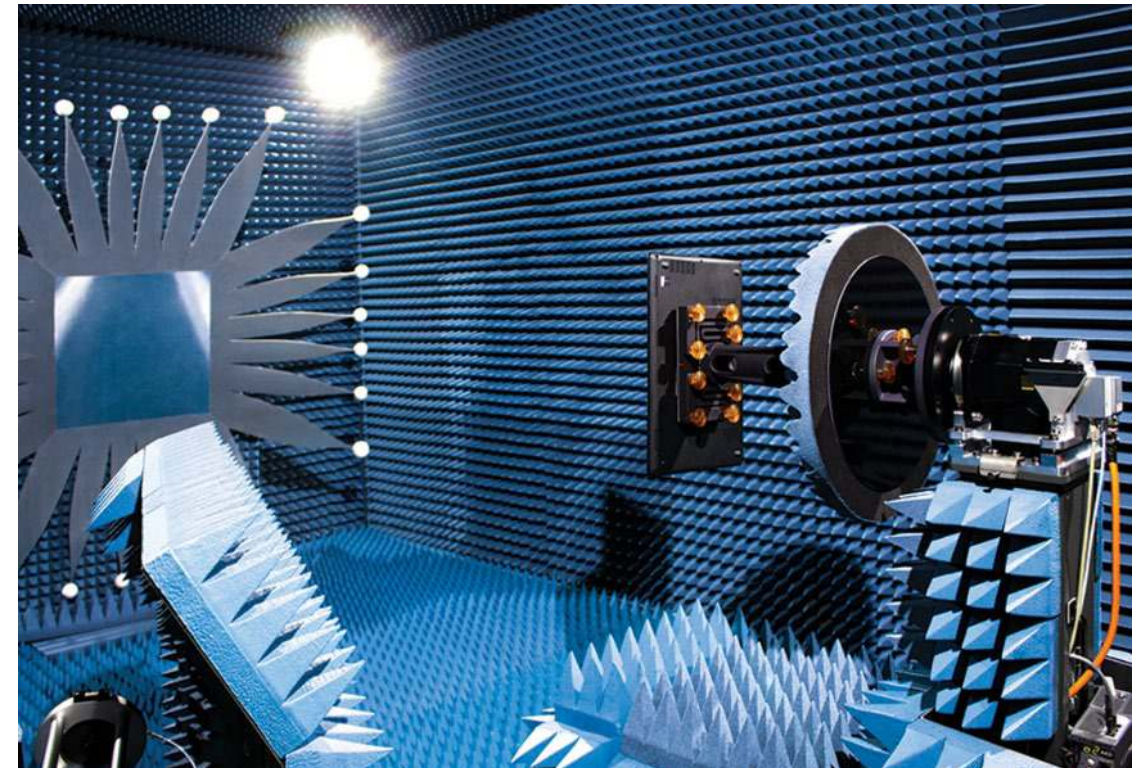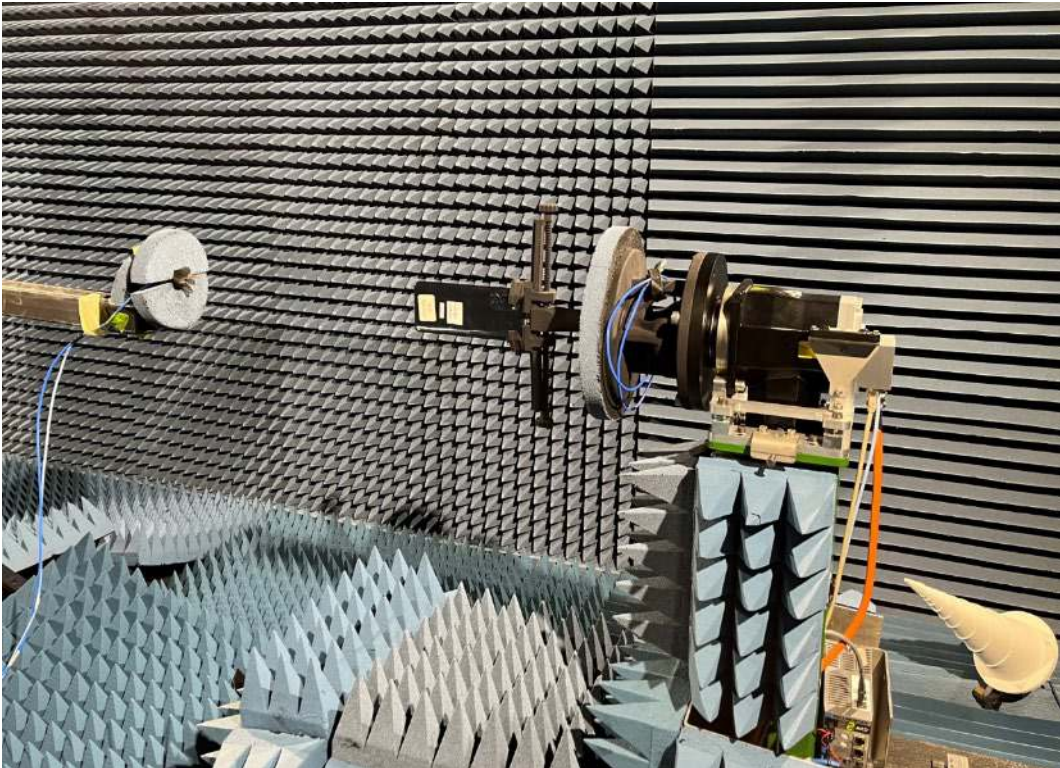   - 50cm test distance.

Planar NF and CATR
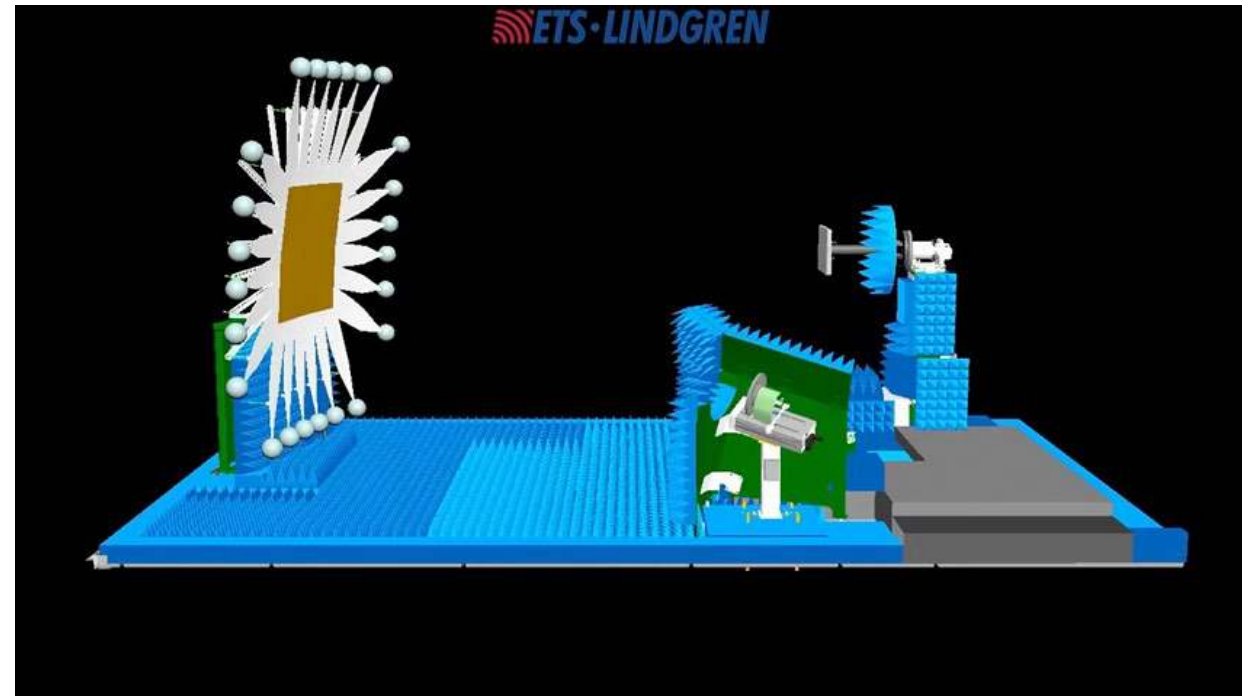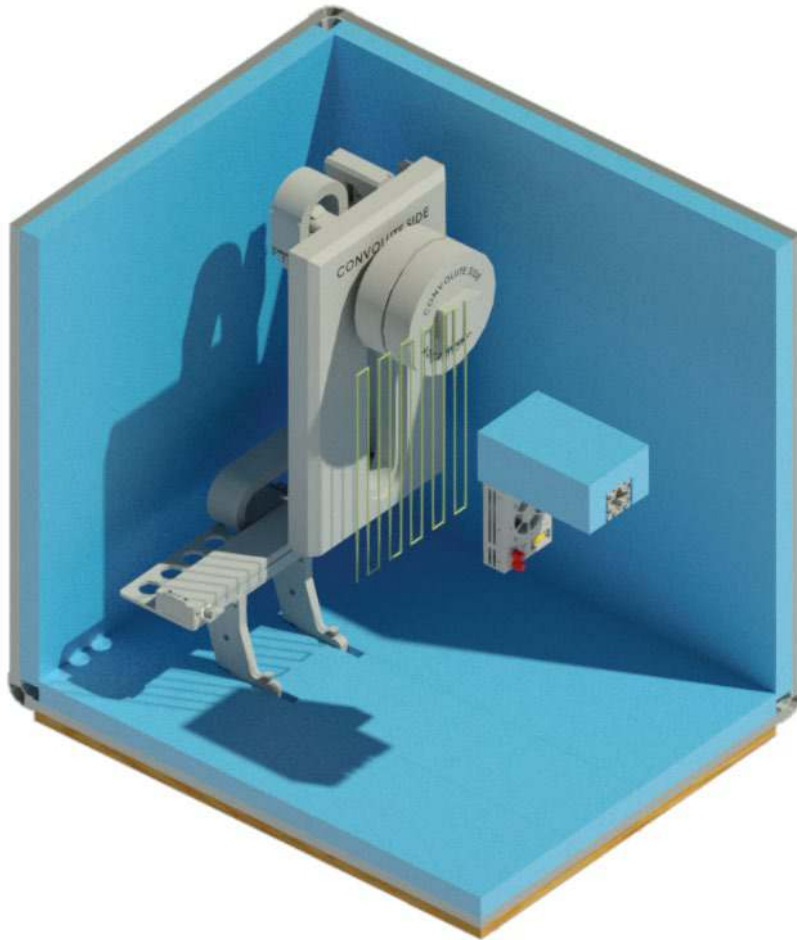
AMS-5703; 60cm CATR

- 60cm QZ per the 3GPP and CTIA

- Corner fed, Serrated edge reflector for excellent QZ performance

- Internal dimensions:
  - 15'-0" x 9'-0" x 8'-0" (≈ 4.6m x 2.7m x 2.4m)

- Nominal outside dimension:
  - 15'-2" x 9'-2" x 8'-6" (≈ 4.6m x 2.8m x 2.6m)

UE Testing; TX BPS

UE Testing; TX BPS

UE Testing; TX BPS
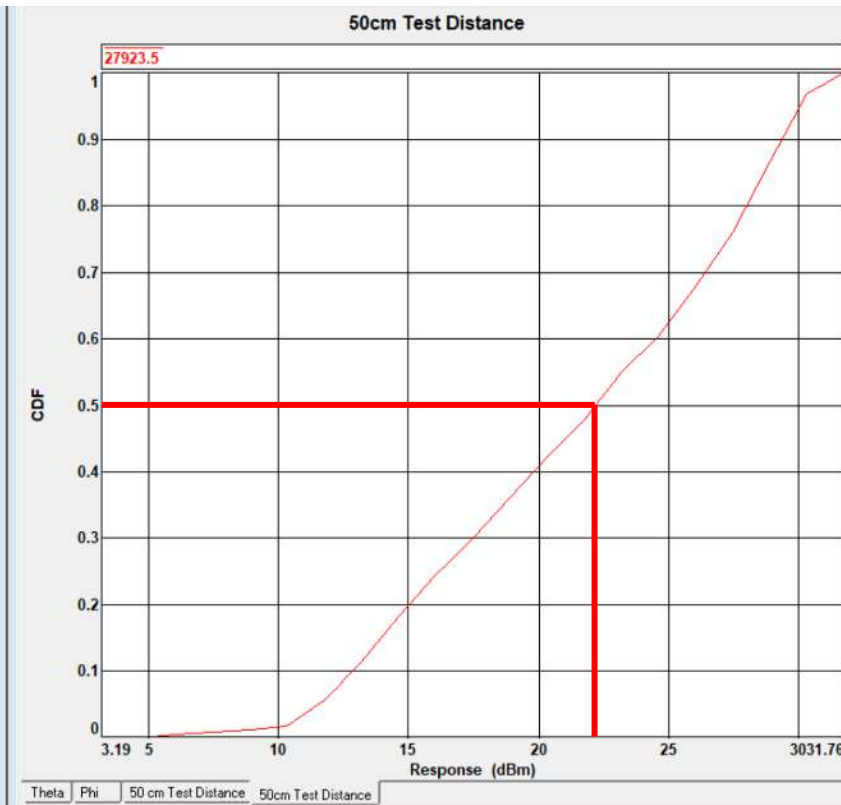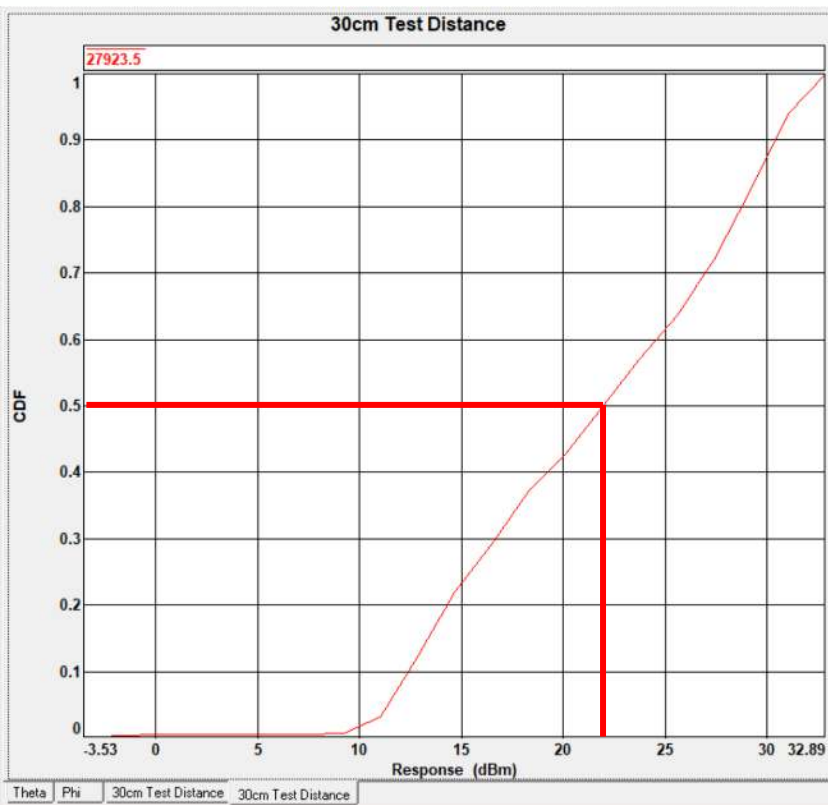
UE Testing; TX BPS

DS1 = 30cm, DS2 = 50cm, DS3 = CATR
27923.5 (Data Set 1) 27923.5 (Data Set 2) 27923.5 (Data Set 3)

Power vs CDF

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
30cm Test Distance	12.37	14.31	16.7	19.24	21.96	24.61	26.99	28.78	30.42	32.88
50cm Test Distance	12.86	15.02	17.45	19.81	22.18	24.54	26.41	28.01	29.36	31.75
CATR with 60cm QZ	11.73	14.96	17.4	19.68	21.92	23.8	25.39	26.8	28.29	31.06

■ 30cm Test Distance   ■ 50cm Test Distance   ■ CATR with 60cm QZ
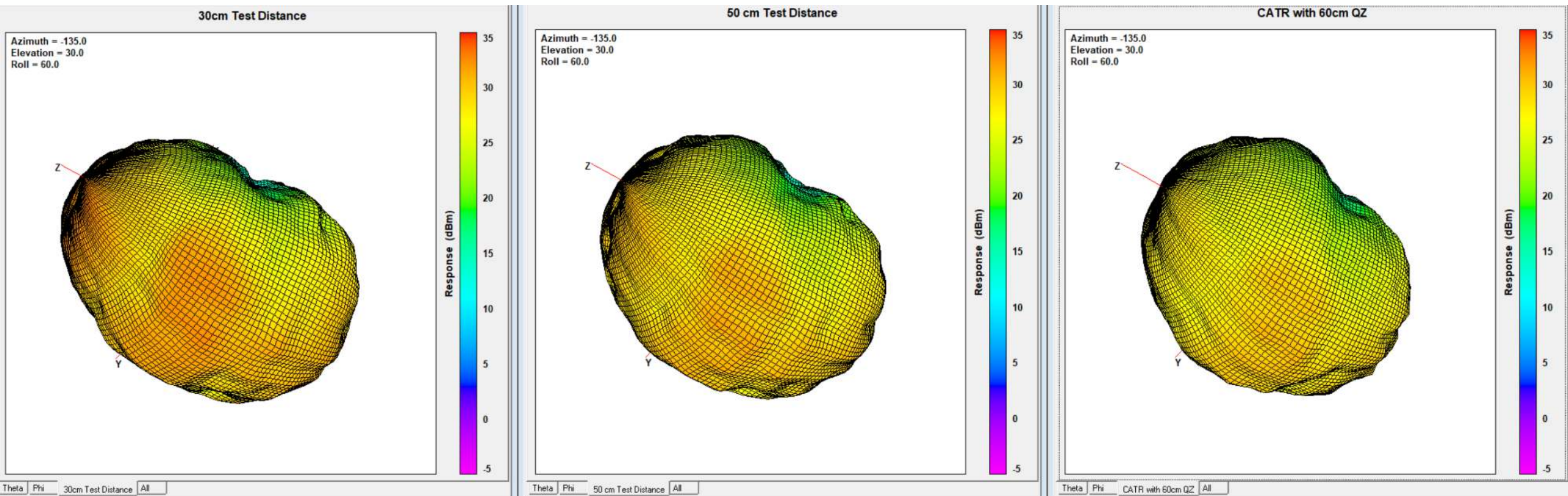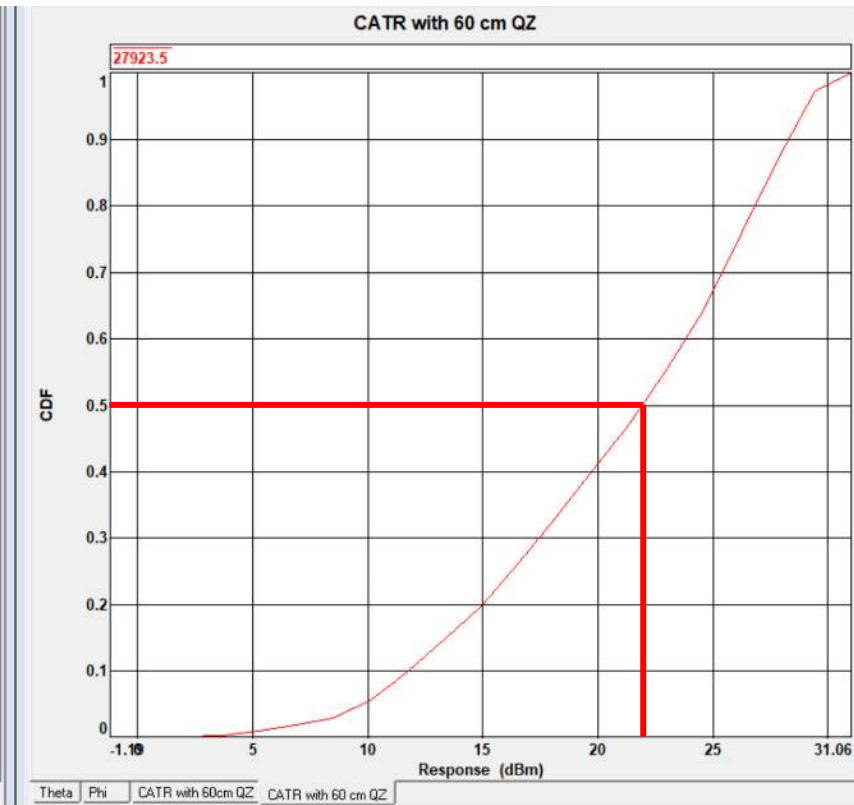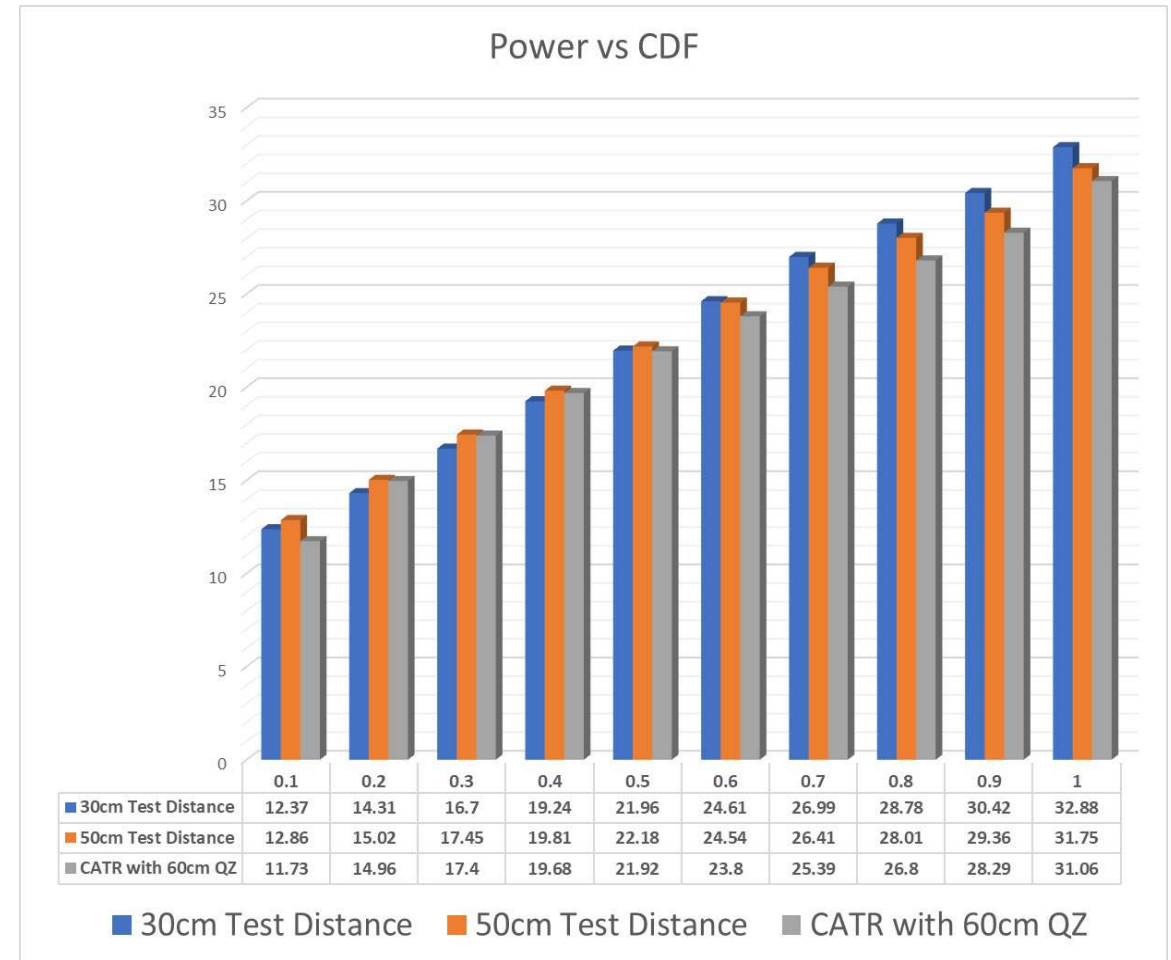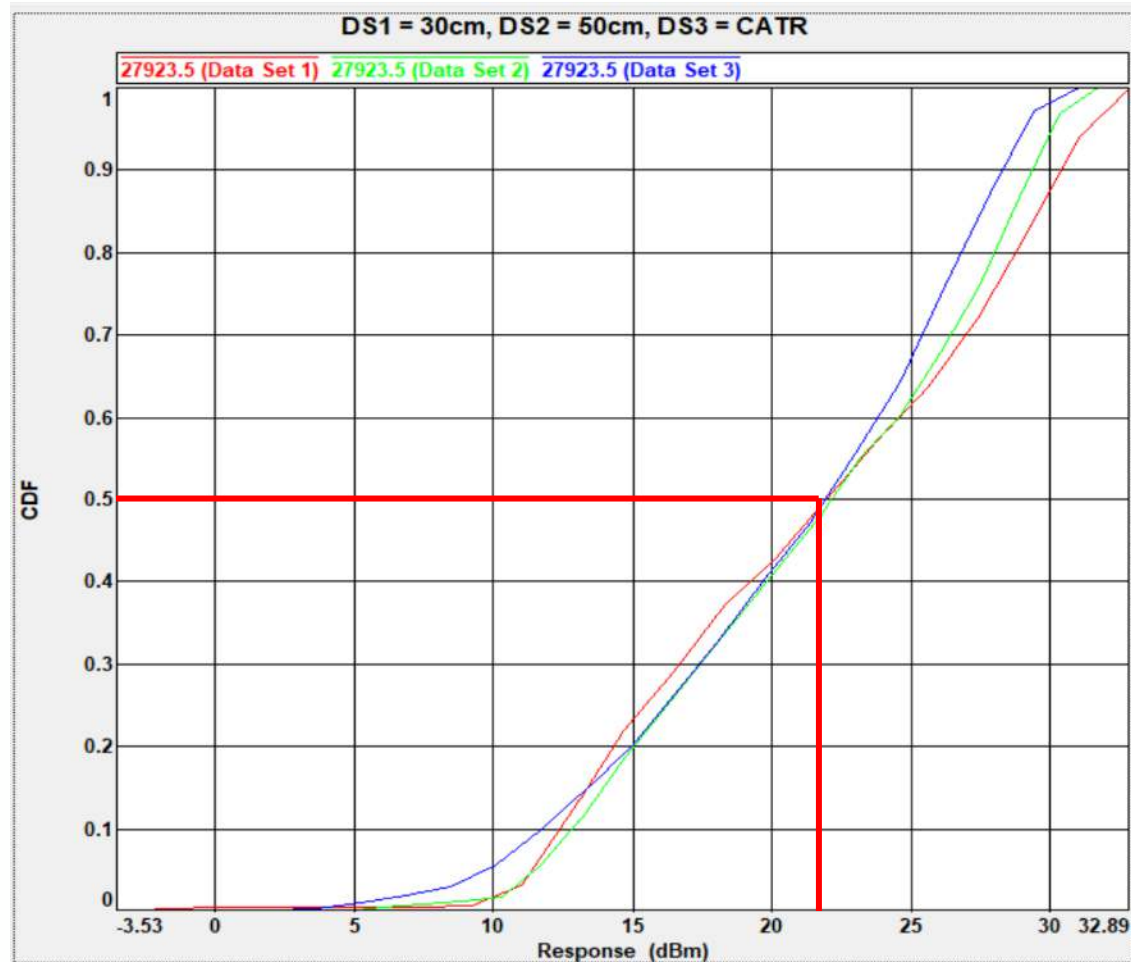
UE Testing; TRP
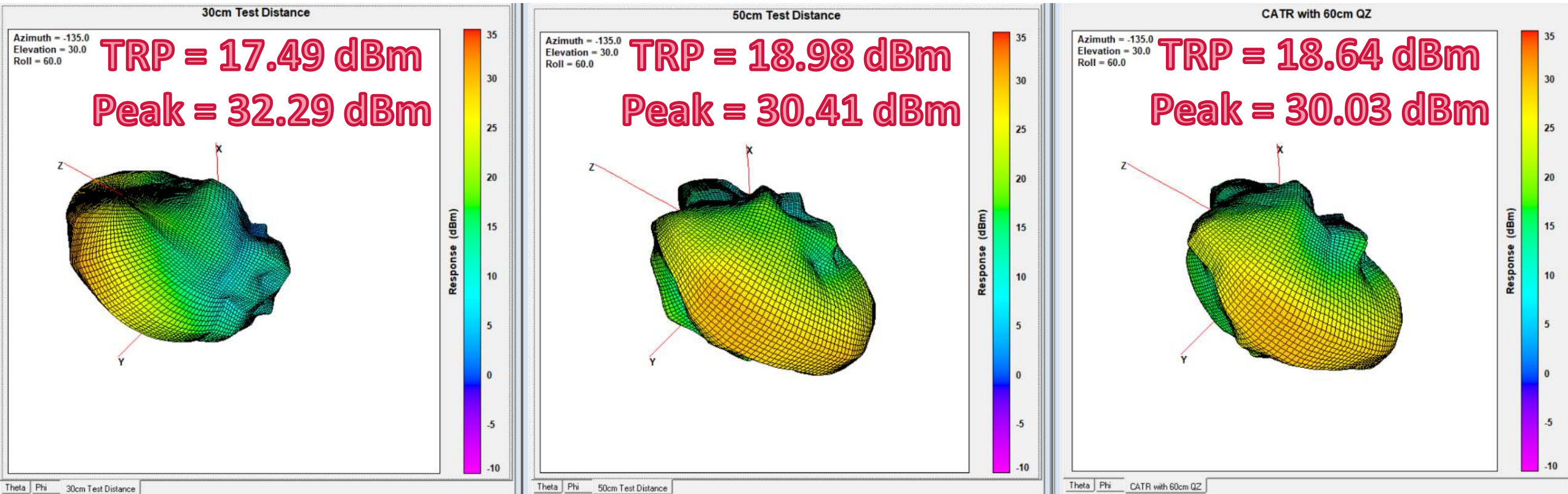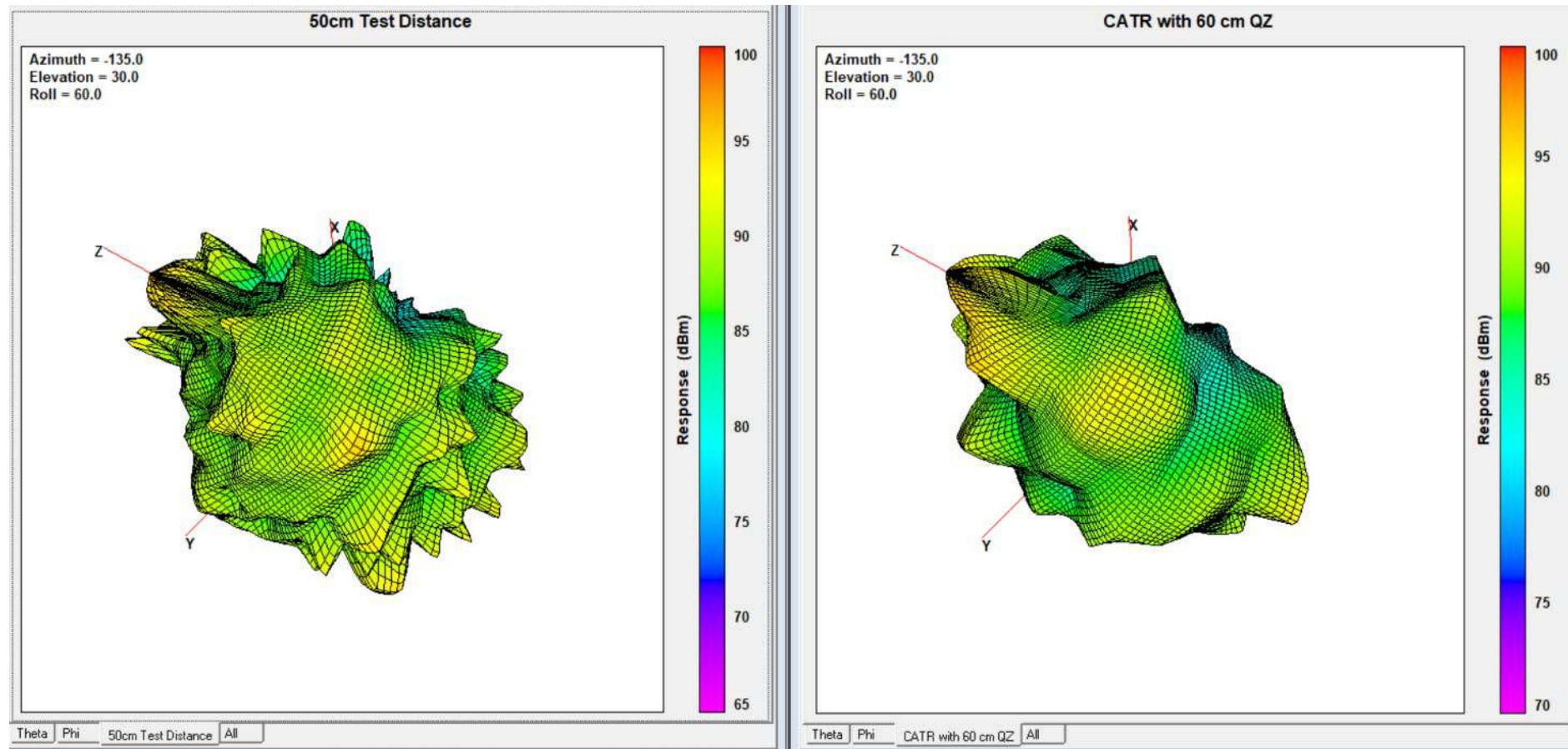
- <u>Note!</u> Different beam selected from the TX BPS for the 30cm test

30cm Test Distance
Azimuth = -135.0
Elevation = 30.0
Roll = 60.0

TRP = 17.49 dBm
Peak = 32.29 dBm

50cm Test Distance
Azimuth = -135.0
Elevation = 30.0
Roll = 60.0

TRP = 18.98 dBm
Peak = 30.41 dBm

CATR with 60cm QZ
Azimuth = -135.0
Elevation = 30.0
Roll = 60.0

TRP = 18.64 dBm
Peak = 30.03 dBm

UE Testing; RX BPS (no 30cm Data)

UE Testing; RX BPS (no 30cm Data)

UE Testing; RX BPS (no 30cm Data)

DS1 = 50 cm Test Distance; DS2 = CATR with 60cm QZ

27925 (Data Set 1)   27925 (Data Set 2)

Power vs CDF

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
30cm Test Distance										
50cm Test Distance	-66.97	-75.94	-77.59	-79.02	-80.8	-83.17	-85.16	-86.59	-87.96	-89.61
CATR with 60cm QZ	-72.99	-76.42	-77.49	-79.62	-81.58	-84.01	-85.45	-86.94	-88.47	-90.47

■ 30cm Test Distance   ■ 50cm Test Distance   ■ CATR with 60cm QZ

Phased Antenna Array

- Antenna loaned by Dr. Rebeiz @ Extreme Waves
- 8x8 (1/2 λ) dual polarized antennas
- Configuration for the test
  - TX mode
  - Vertical polarization
  - Single beam in principal direction
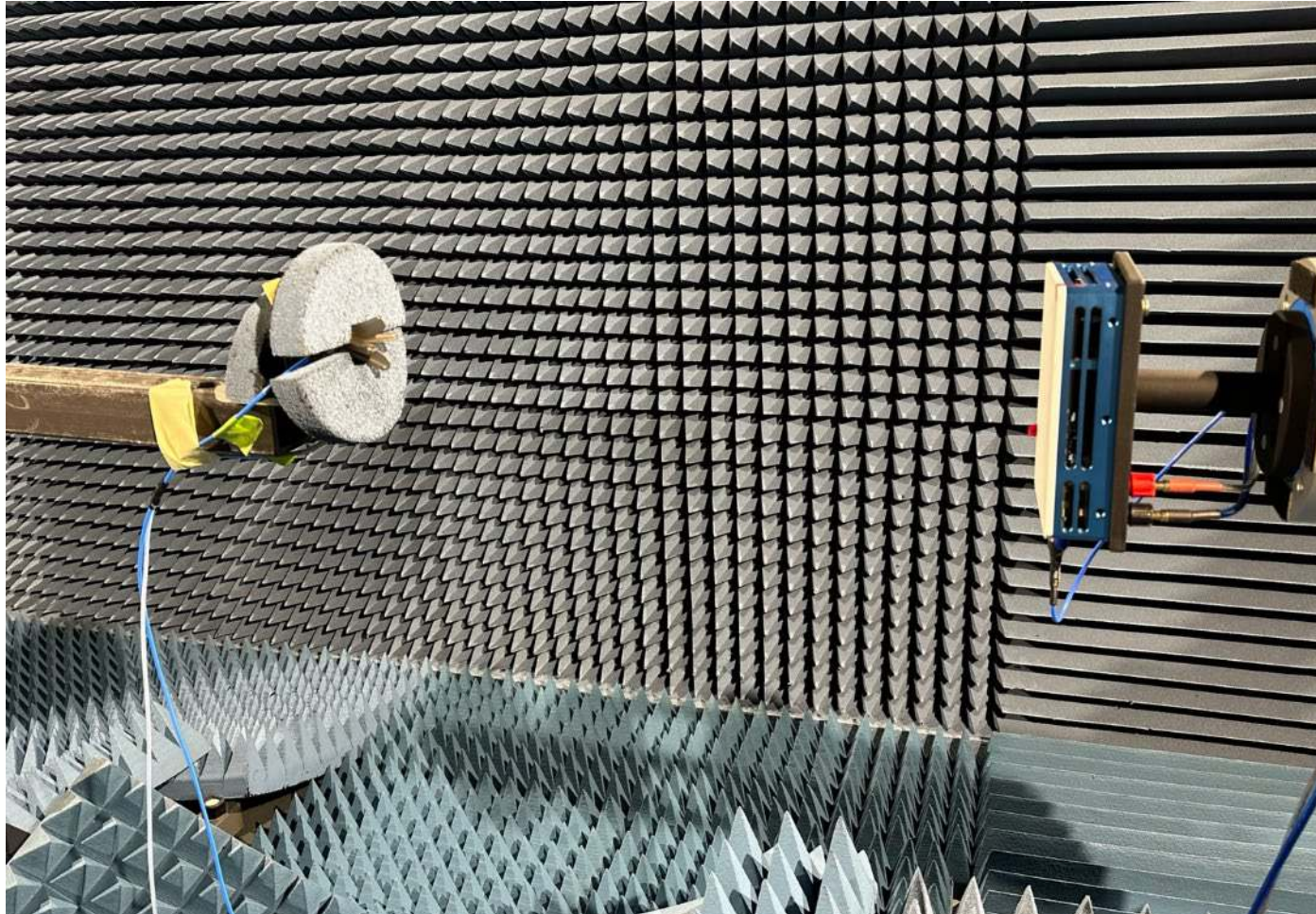- We wanted to see the difference from FF to NF without the use of the NF-FF transformation.

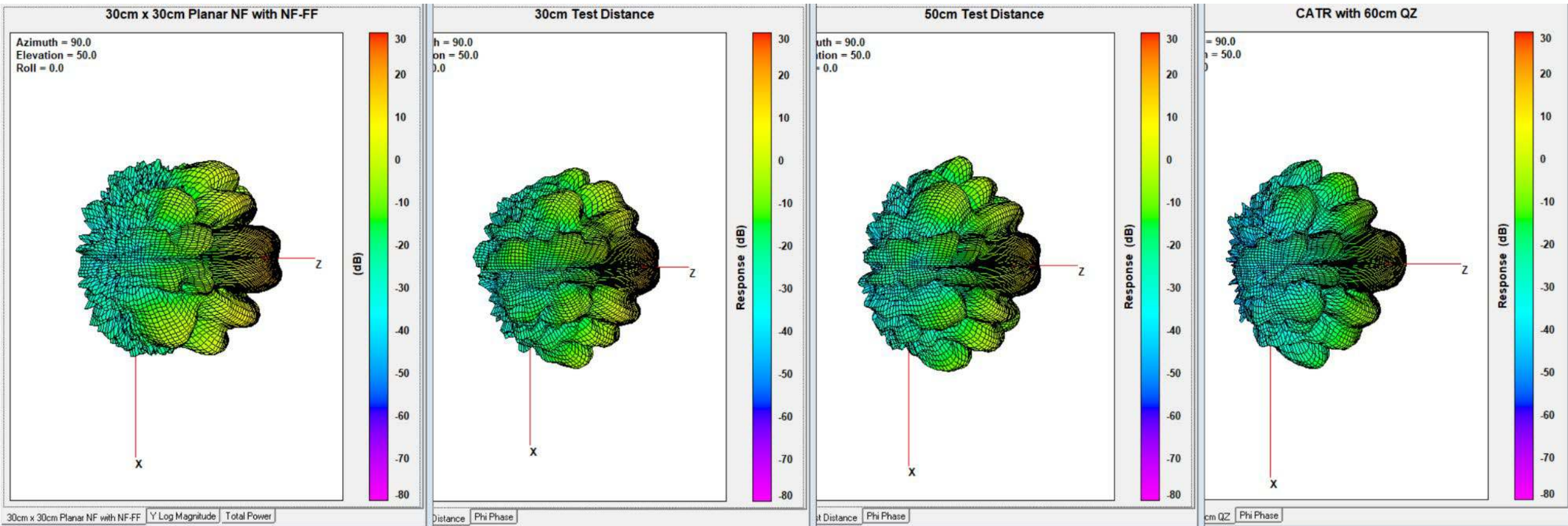Image Courtesy of https://www.extreme-waves.com
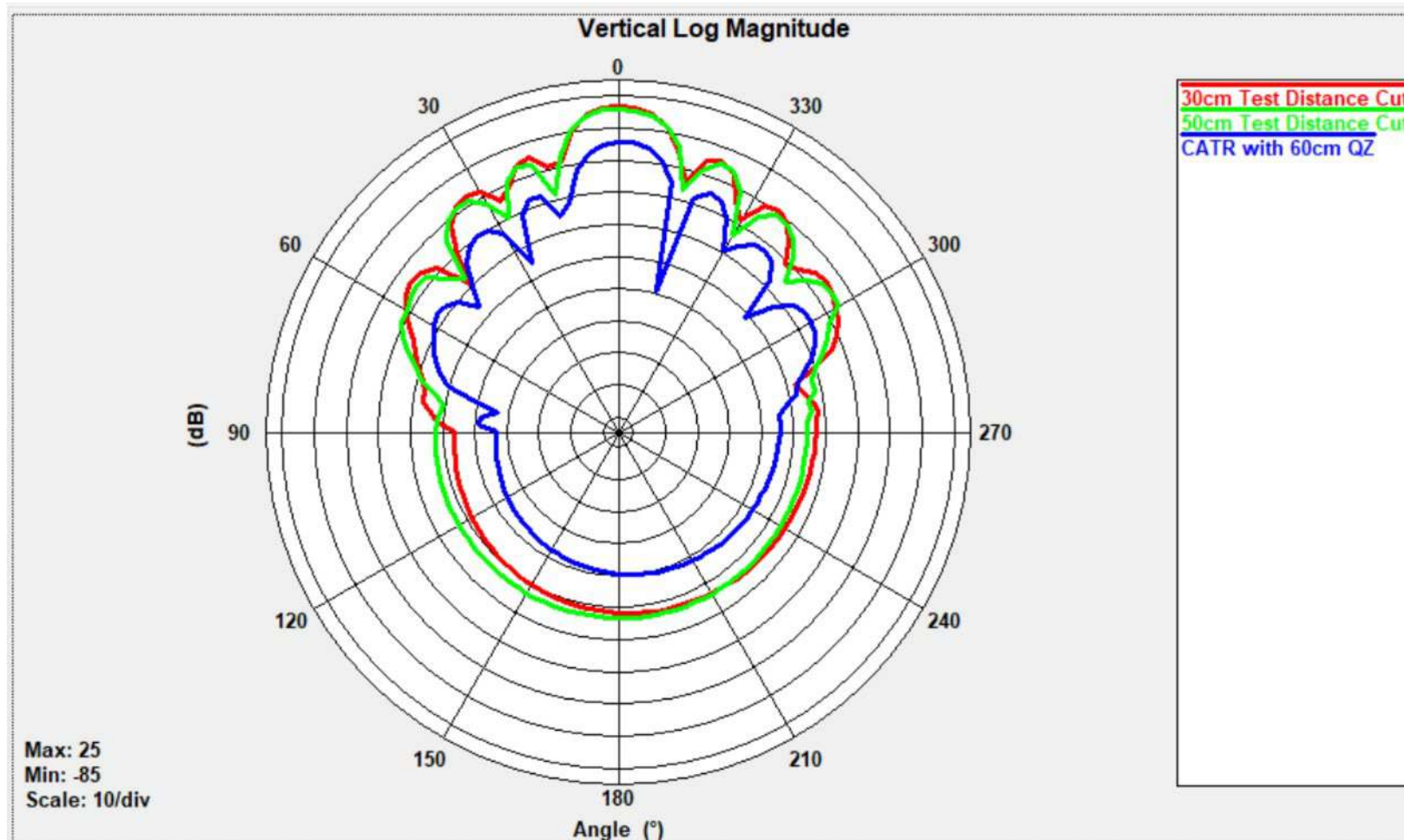
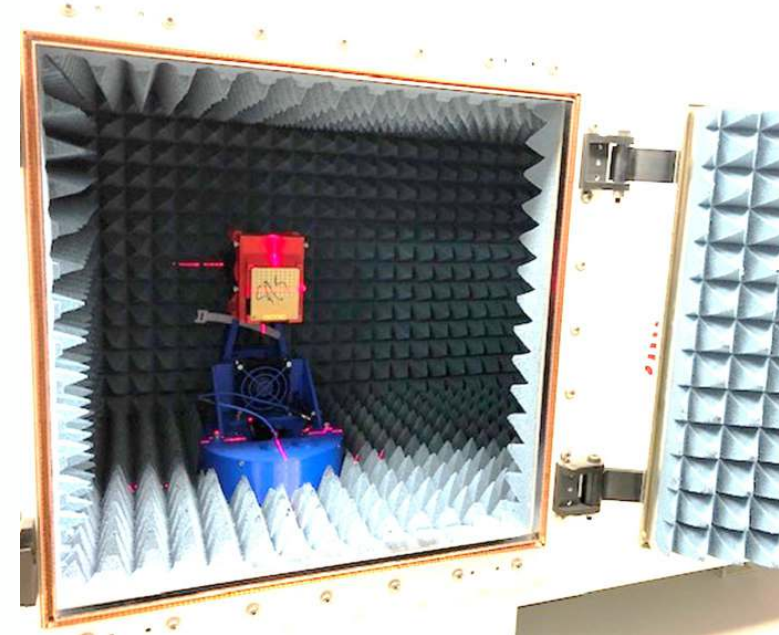# Phased Antenna Array
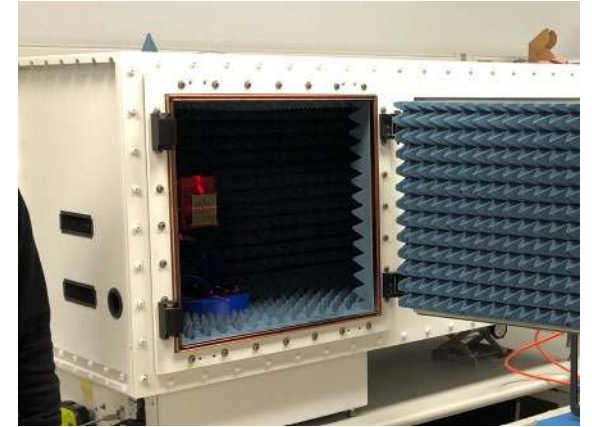
Phased Array Antenna

Phased Array Antenna

Other potential solutions

AMS-5700

- 2D test box
- Dual pol antenna 5-50GHz
- 1.06 m range length
- Laser alignment
- Precision Positioner
  - Power, RF, USB via slipring
- 3D upgradeable

AMS-5701

- Theta arm system on wheels
  - Theta 0-170 deg
  - Phi 0-360 deg
- Can go thru normal personnel door (comes in three pieces)
- Features
  - USB slipring on phi positioner
  - 67GHz rotary joint on phi axis
  - 6-67GHz dual polarized test antenna
  - Laser alignment system
  - DUT mount and calibration antenna w/mount

Conclusions

- Active testing in NF provide good correlation

- But are the results "good enough" for active testing ?
  - This really depends on what the use case is.
  - Certainly, this is good enough for pre-compliance work.

- The test ranges, with severely reduce test distance (in NF), would not meet any of the required measurement uncertainty (MU) limits but could be potential for R&D type of testing.

THANK YOU!

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