5G OTA - The way forward to a new testing perspective

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Agenda

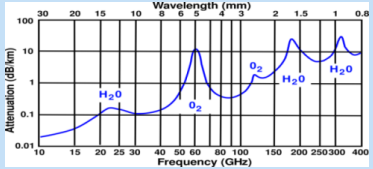
- 5G Key Technology Components
- Why OTA & Challenges
- Near Field and Far Field considerations
- NF to FF Transformations
- Summary

5G Key Technology Components

NR builds on four main pillars

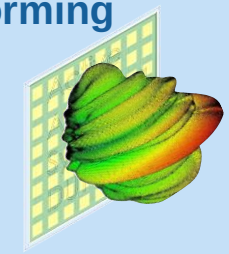
New Spectrum

- < 1GHz
- ~ 3.5 GHz
- ~ 26/28/39 GHz



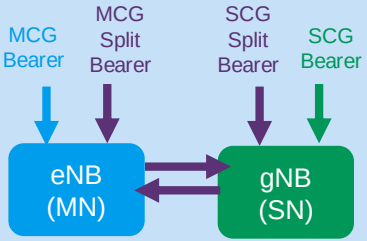
Massive MIMO / Beamforming

- Hybrid beamforming
- > 6GHz also UE is expected to apply beam steering



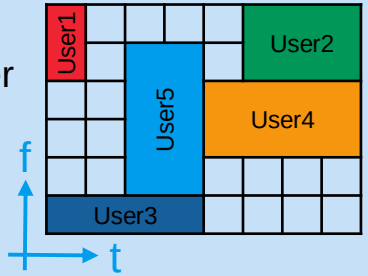
Multi-Connectivity

- Initially based on Dual Connectivity with E-UTRA as master



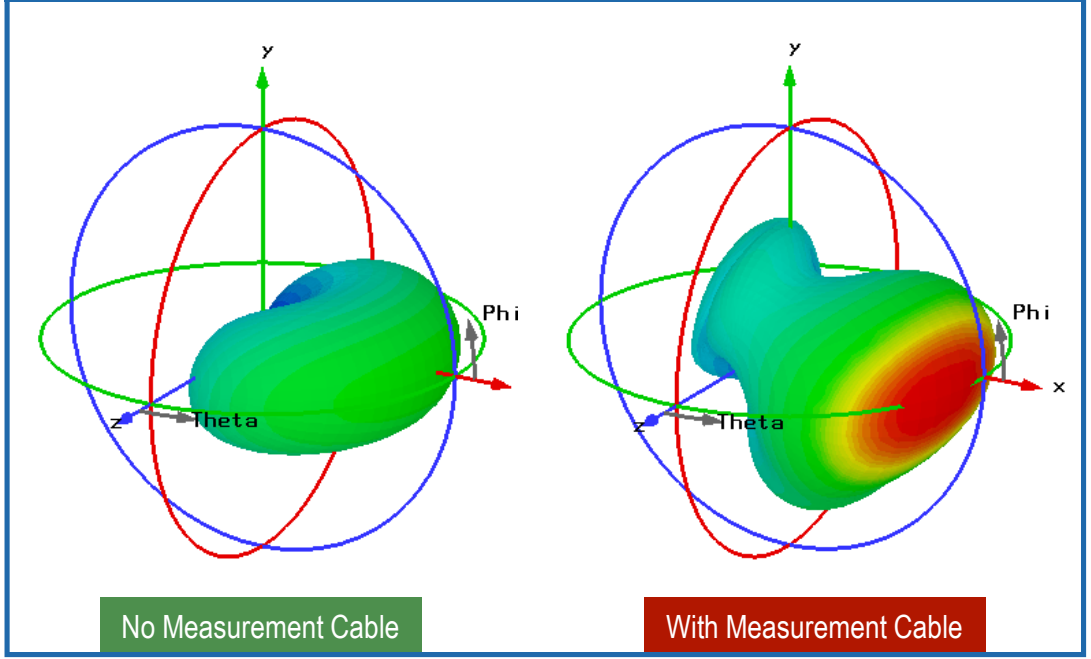
Network Flexibility

- Flexible physical layer numerology
- Network Slicing
- NFV/SDN



Can we use the cables….in 5G mmWave Systems

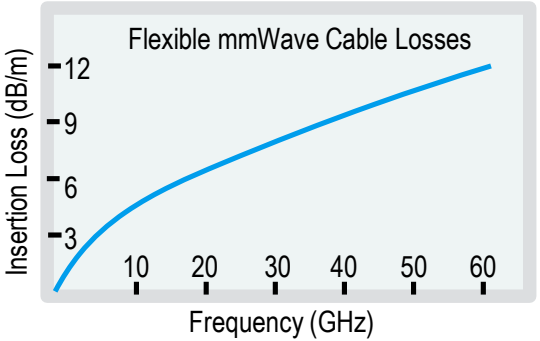
3D Gain Patterns of mmWave UE antenna



No Measurement Cable

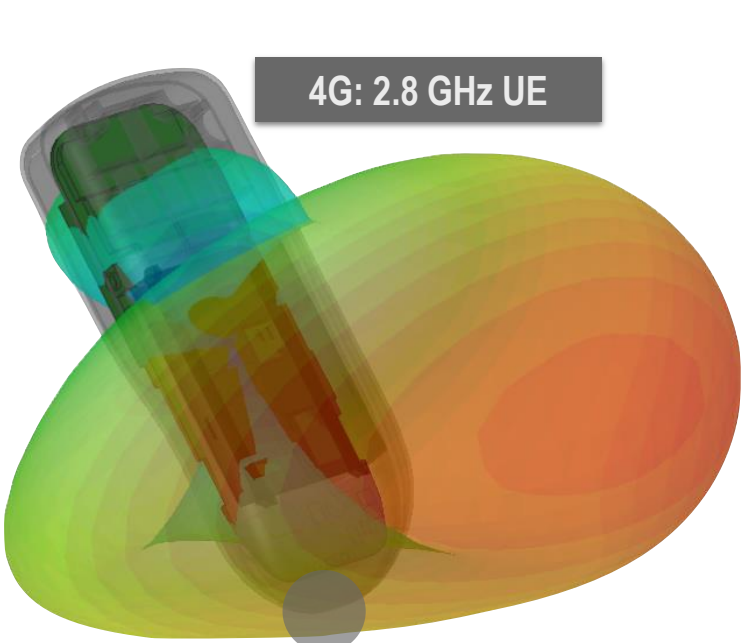
With Measurement Cable

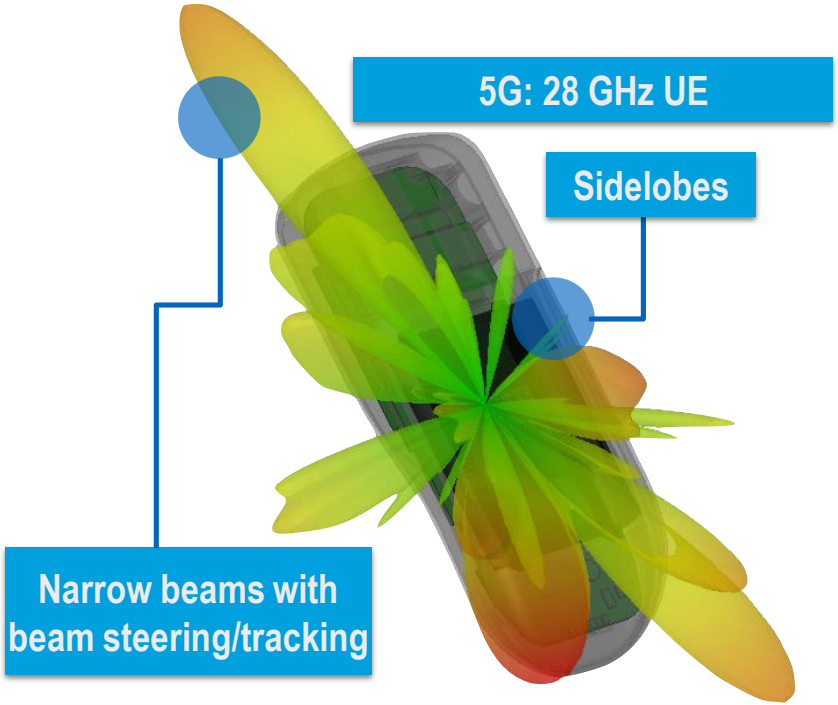
Antenna couples to all surrounding objects
Conductive measurements introduce large error



High Precision & Low-loss cable
70 GHz: > $1000/meter

How to measure EiRP/etc… for mmWave UEs?



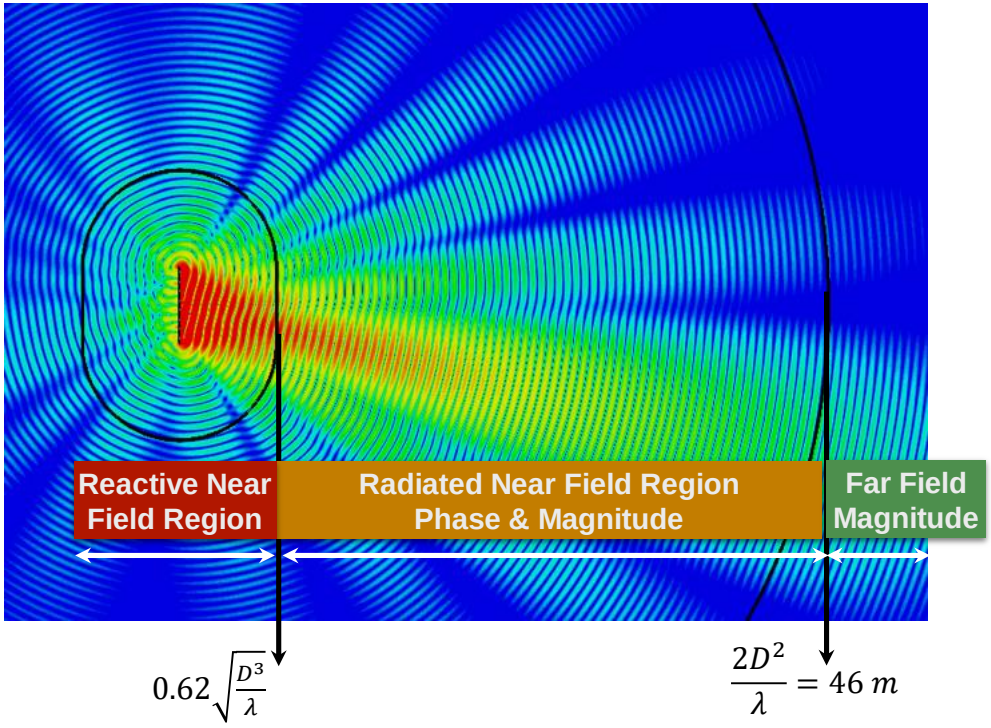


Omni/Uni-directional Single direction EiRP/EiS

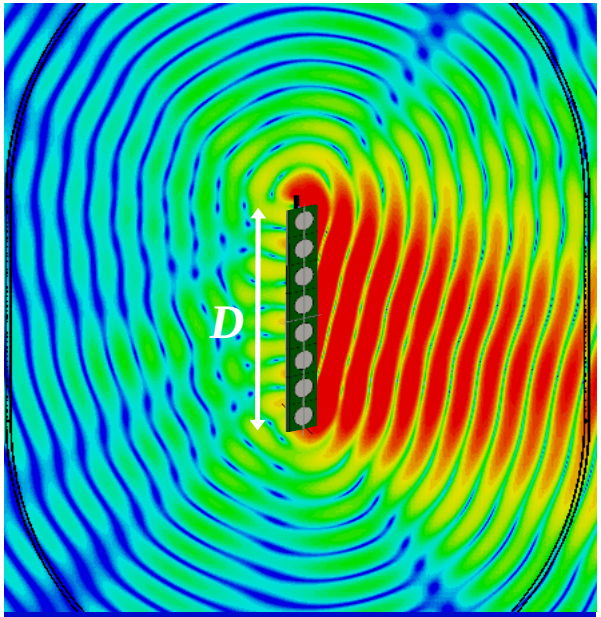
EVM, ACLR, Spurious Emissions, … will require 3D measurements

Electromagnetic Fields: What is the Far-field?

Basestation Antenna Array at 28 GHz

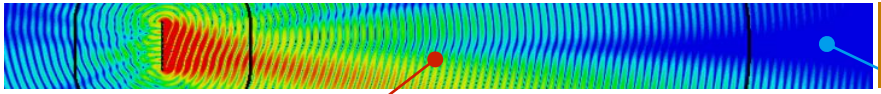


Reactive Near Field Region



Any object in this region becomes part of antenna system & interferes with the measurements

Near Field to Far Field Transformation



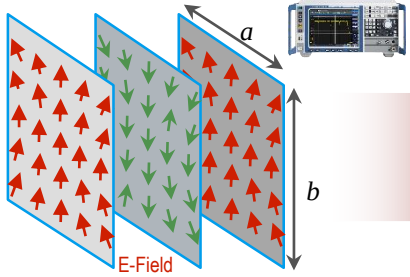
Radiated Near Field Region
Phase & Magnitude

1. Complex Wave: **Measurement**

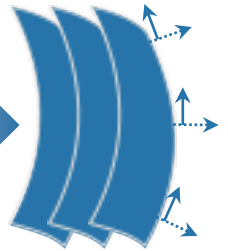
2. Fourier Transform: **Software**

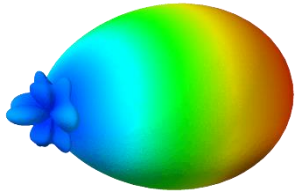
3. Far-field: **Generated**

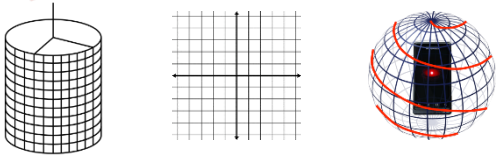
Near field E-field measurements over surface



$$f_{x,y} = A \iint E_{x,y} e^{+j\mathbf{k}\cdot\mathbf{r}}\, dxdy$$



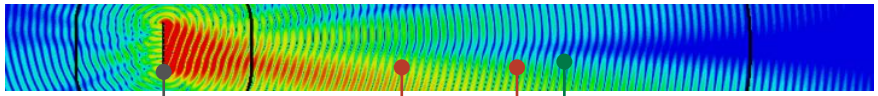




Cylindrical Planar Spherical

How to measure the phase for Massive MIMO DUT with no test ports?

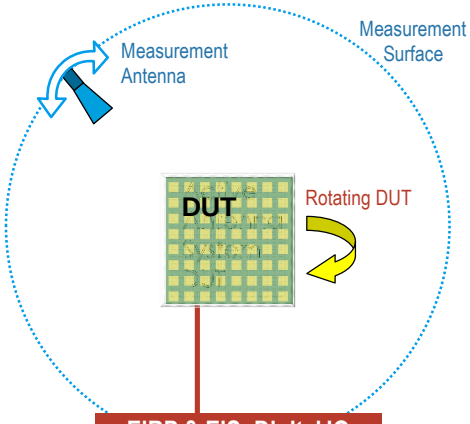
Near-field Systems: Phase Retrieval



Radiated Near Field Region
Phase & Magnitude

Direct Device Access

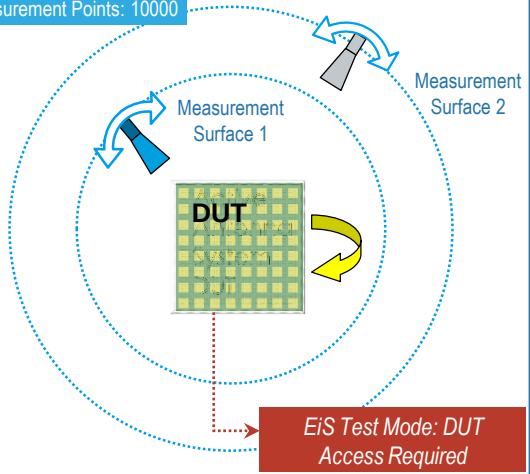
*Measurement Points: 5000



EiRP & EiS: Digital IQ and/or Test Interface

Two-Sphere Approach

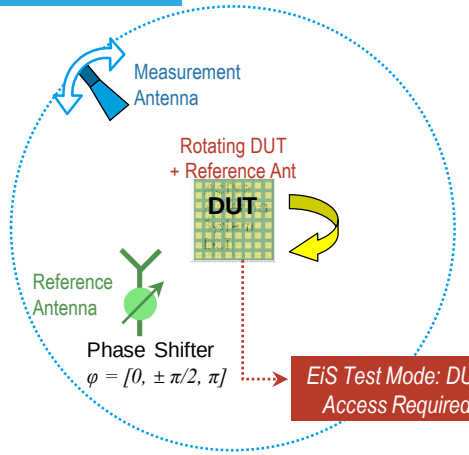
*Measurement Points: 10000



Use Surface 1 to as phase reference for Surface 2 measurement (unproven for high-gain antennas).

Interferometry (WPTC Spiral Scanner)

*Measurement Points: 40000

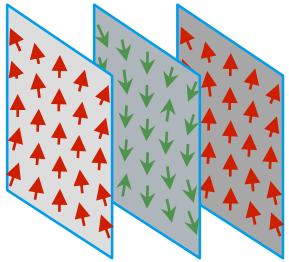


Combine signal of known phase with signal of unknown phase in order to extract unknown phase (optics)

*Measurement Points: Assume 5° spacing in φ and θ

Far-field in Near-field Systems: Hardware Fourier Transforms

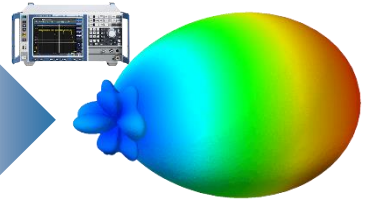
Complex near-field wave generated



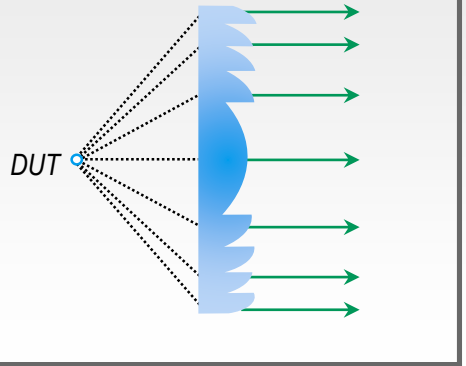
$$f_{x,y} = A \iint E_{x,y} e^{+j\mathbf{k}\cdot\mathbf{r}}\, dxdy$$

Amplitude Phase

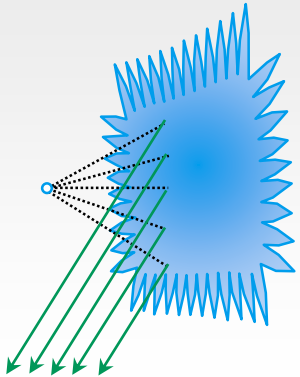
Measurement



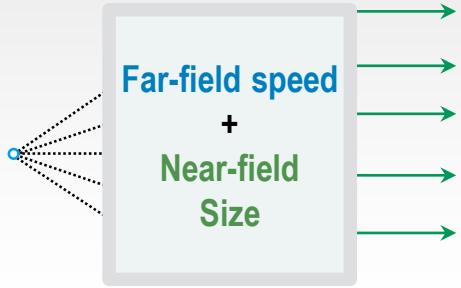
Plane wave far-field received



Fresnel Lens (Fourier Optics)

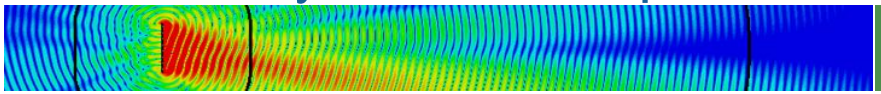


Reflector: Compact Antenna Test Range



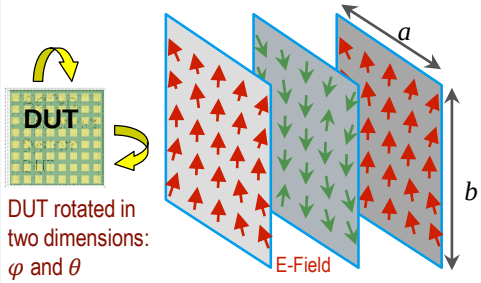
Array: Plane Wave Convertor

Far Field Systems: Compact Antenna Test Range (CATR/CA)

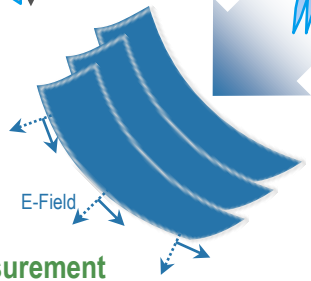


1. Complex Wave: **Generated**

2. Fourier Transform: **Reflector**

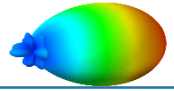


DUT rotated in two dimensions: φ and θ



3. Far-field: **Measurement**

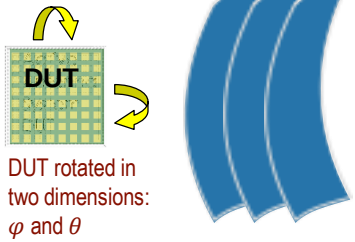
Far field E-field measurements over 2D surface



DUT Transmits

3. Plane Wave Quiet Zone

2. Fourier Transform: **Reflector**



DUT rotated in two dimensions: φ and θ

1. Signal Generation

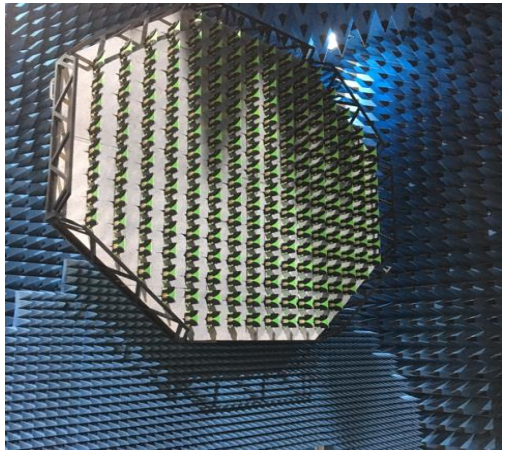
EiS Test Mode: DUT Reporting Required

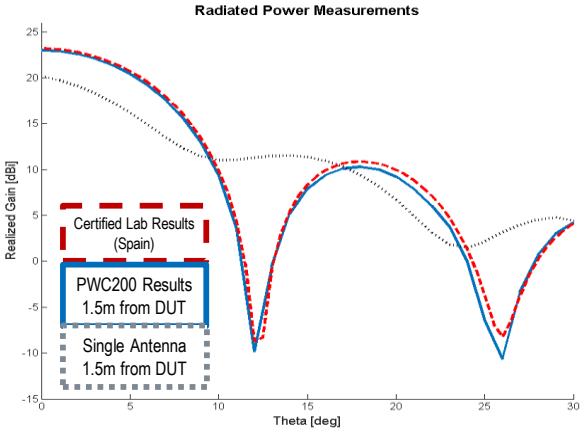
DUT Receives

Test solution for Massive MIMO

Plane Wave Converter

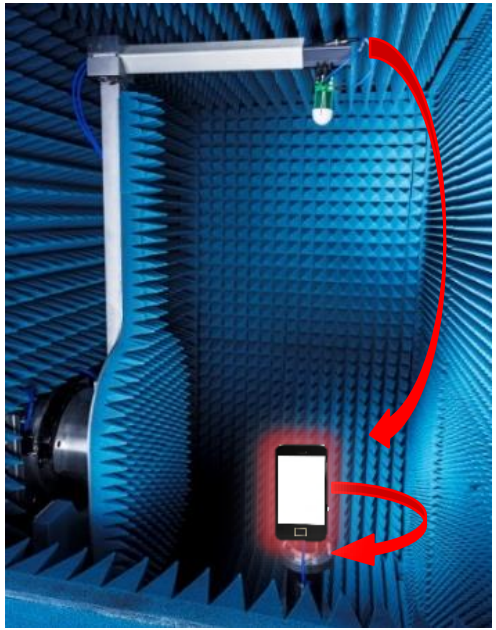
- One RF port
- Signal distributed to each antenna through phase shifters and attenuators
- The fields generated by the antennas combine in the target region to generate a plane-wave front
- The optimal region for this setup is at 1.5m distance from the array and gives a 1m spherical quiet zone with max variations of 0.2 dB in magnitude and 4 degrees in phase.





DFF solution for Whitebox

Direct far field: typically smaller QZ



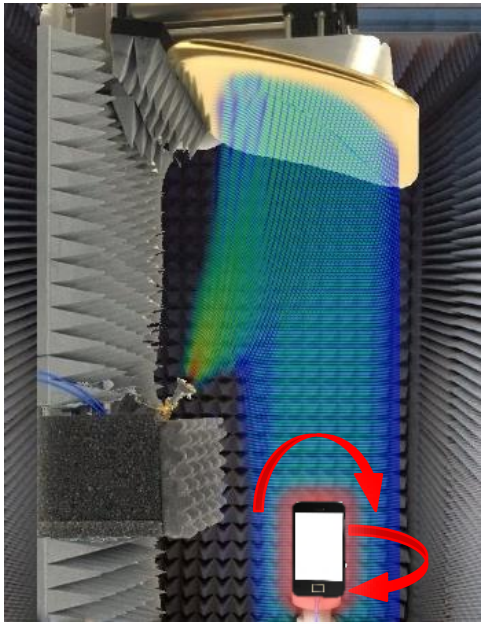
Elevation arm 0-168°

Azimuth +/- 180°

✓ **Both systems fit in ATS form factor**

IFF solution for Blackbox

Indirect far field: typically larger QZ



Azimuth & Theta +/- 180°

OTA test in extreme climatic conditions

Climate bubble

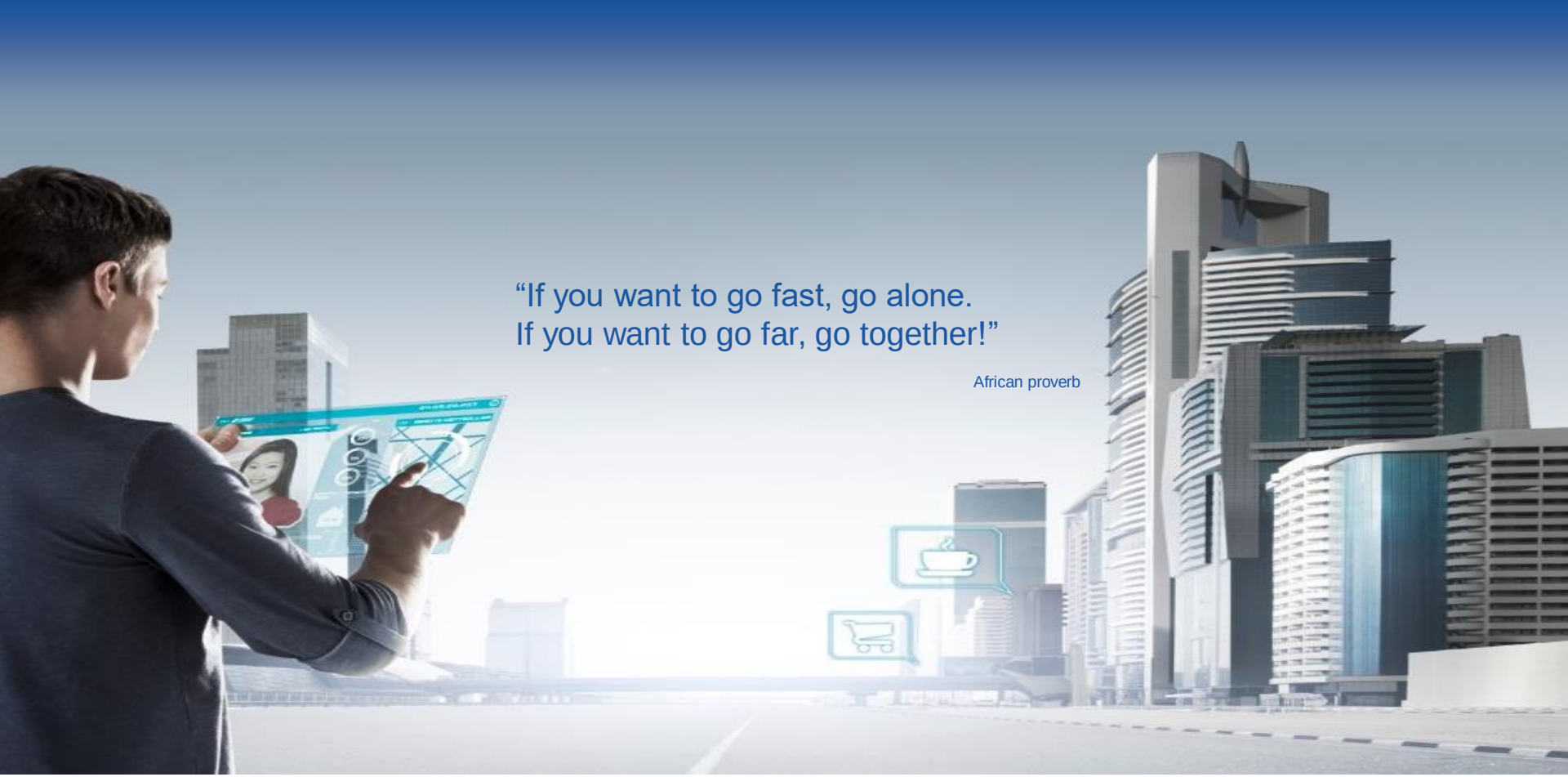
RF transparent material

- Minimized influence on DUT radiation
- Temperature tests from -55°C to +85°C

Thermal stream

Summary

- Measurements in 5G NR require OTA due to High Attenuation @mmWave and Massive MIMO
- The Far field Measurements require bigger Chamber size
- Both Software and hardware Near Field to Far Field Transformation Possible
- Near Field Measurements require both Phase and Magnitude information for Transformation
- Due to mmWave temperature variations have an influence on the measurement
- R&S has a complete Test Solution with Instrumentation and OTA solutions.


“If you want to go fast, go alone.
If you want to go far, go together!”
African proverb