From myth to reality - Leading the industry from conducted to radiated testing for 5G mmWave

5G

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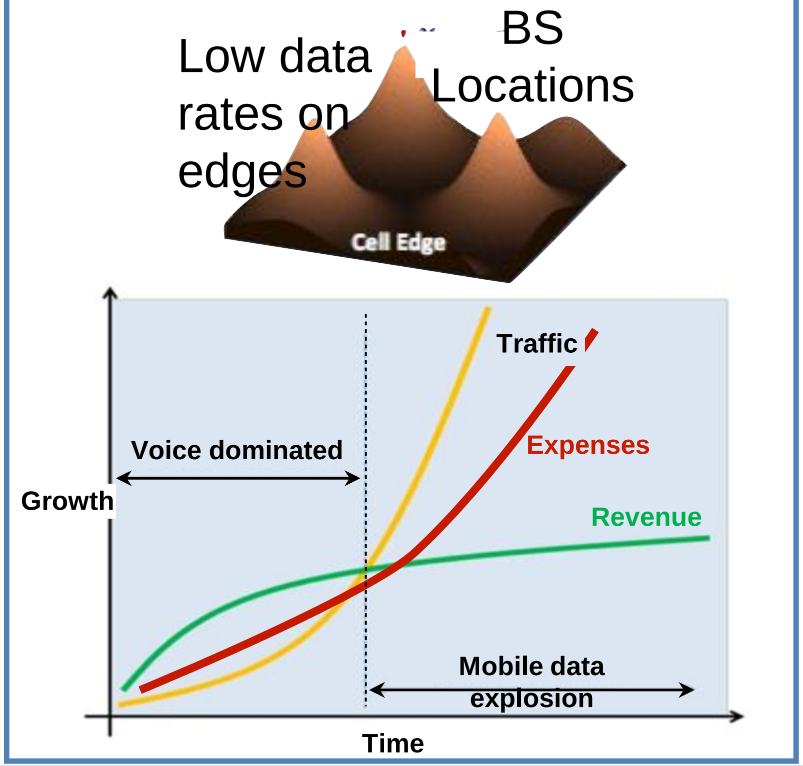
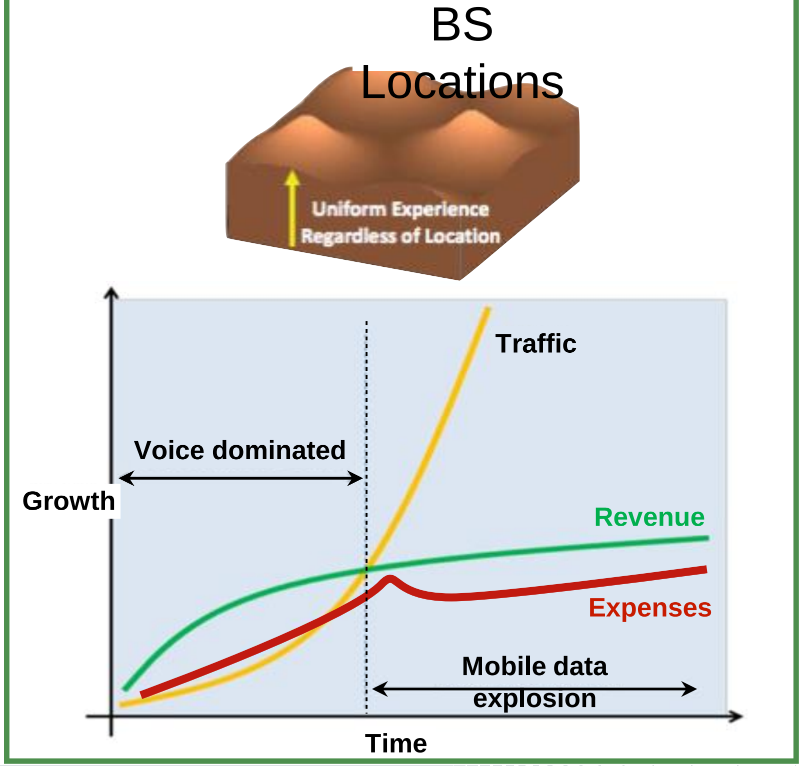
ROHDE&SCHWARZ

Why 5G?: Capacity vs. Revenue

Increased Capacity, Increased OPEX



Optimal Network



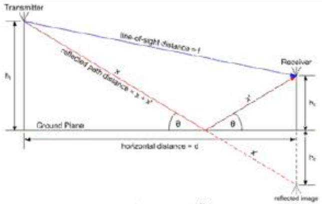
Massive MIMO can increase capacity & reduce OPEX

Why 5G?: Power Consumption

Path loss at mm waves (28 GHz)

mmWave: High Path Loss and EM Field Coupling

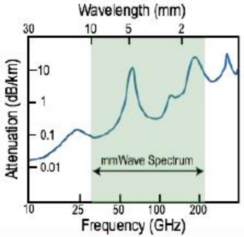
Path Loss



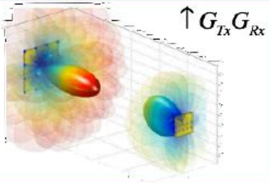
$$P_{Rx}(d) \approx P_{Tx}G_{Tx}G_{Rx}\left(\frac{c}{4\pi fd}\right)^{\gamma} \approx P_{Tx}G_{Tx}G_{Rx}\left(\frac{h_t h_r}{d^2}\right)^{\gamma}$$

Path Loss 28 GHz	Free Space $\gamma = 2$	Indoor LOS $\gamma = 1.5 - 1.8$	Urban Area $\gamma = 2.7 - 3.5$
1 m	-61 dB	-52 dB	-92 dB
10 m	-81 dB	-69 dB	-122 dB
100 m	-101 dB	-86 dB	-151 dB
1000 m	-121 dB	-103 dB	-181 dB

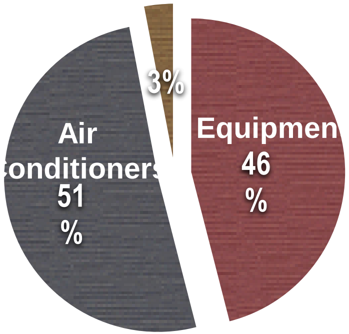
High Atmospheric Attenuation



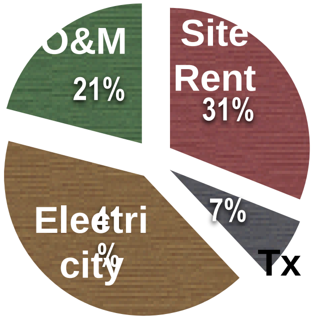
Beamforming in BS & UE



Radio Access Network Energy Consumption



CAPEX

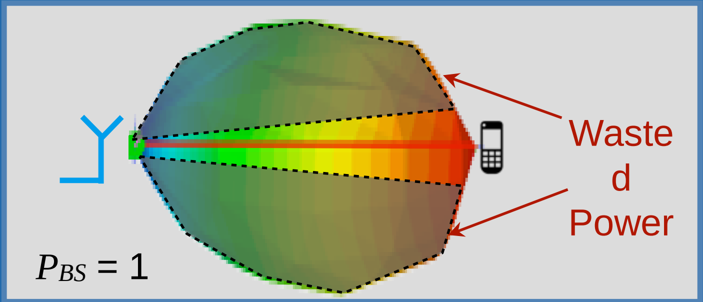


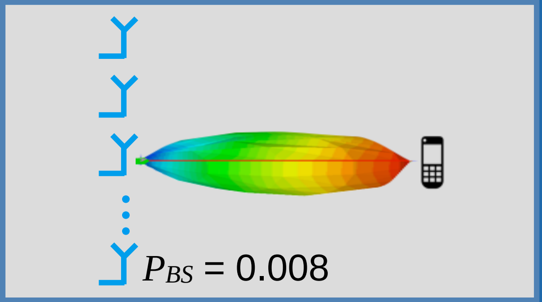
OPEX

Biggest CAPEX/OPEX Expense is Air Conditioning

Example: China Mobile Network in 2014 consumed over 15 Billion KWh

Energy Efficiency: Why Massive?





Number of Antennas = 1		Number of UEs: 1 120 antennas per UE
Number of BS Transmit Antennas	1	120
Normalized Output Power of Antennas	$P_{ant} = \frac{1}{M_t} = 1$	$P_{ant} = \frac{1}{M_t^2}$
Normalized Output Power of Base Station	$P_{total} = \sum_{i=1}^{M_t} P_{ant}^i = 1$	$P_{total} = \sum_{i=1}^{M_t} P_{ant}^i = 0.008$

Source: Signal Processing Magazine, IEEE, Jan 2013

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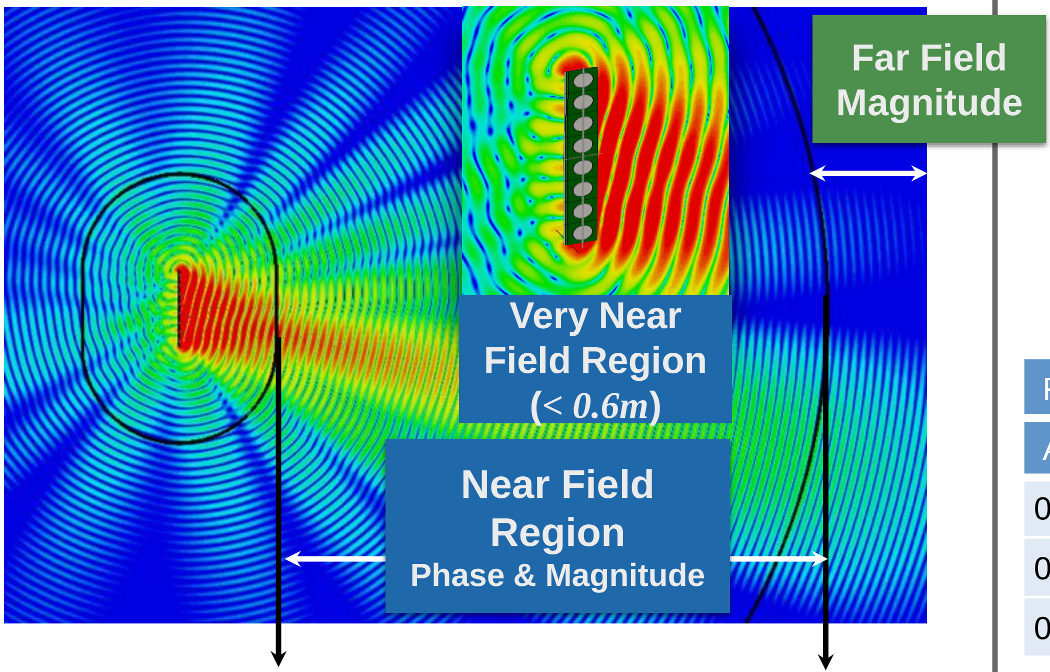
Easiest way to improve energy efficiency: more antennas

Measuring antenna patterns : Near Field vs. Far Field

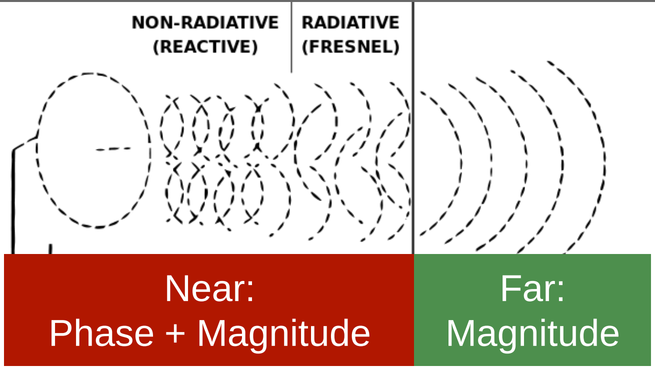
Basestation 8 Element Array at 2.69 GHz



$$0.62\sqrt{D^3/\lambda} = 0.6\ \text{m}$$

$$2D^2/\lambda = 4.1\ \text{m}$$

Far-field vs. Near-field



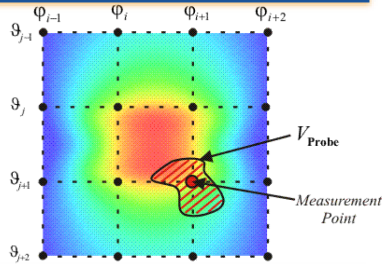
Required Chamber Size for Far-field

AUT Size (D)	Frequency	FF distance
0.5 meters	6 GHz	**10 meters**
0.5 meters	30 GHz	**50 meters**
0.15 meters	30 GHz	**4,5 meters**

Nearfield to Farfield Transformation – FIAFTA

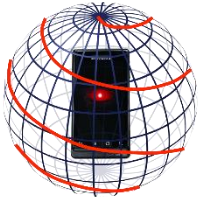
Features

Equivalent Sources



Probe Compensation

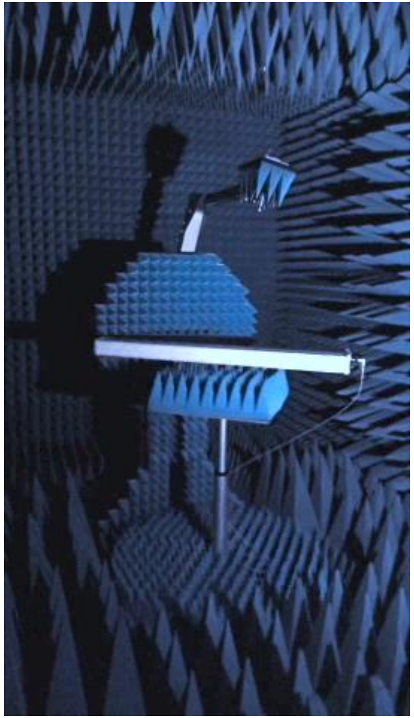
vs.



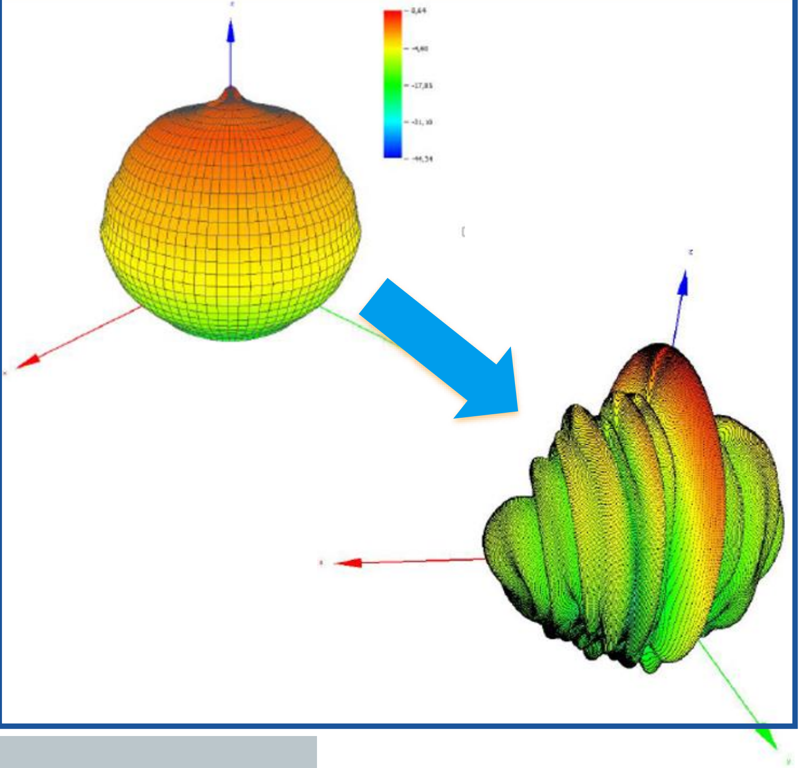
220 minutes

6 minutes

Arbitrary Grids

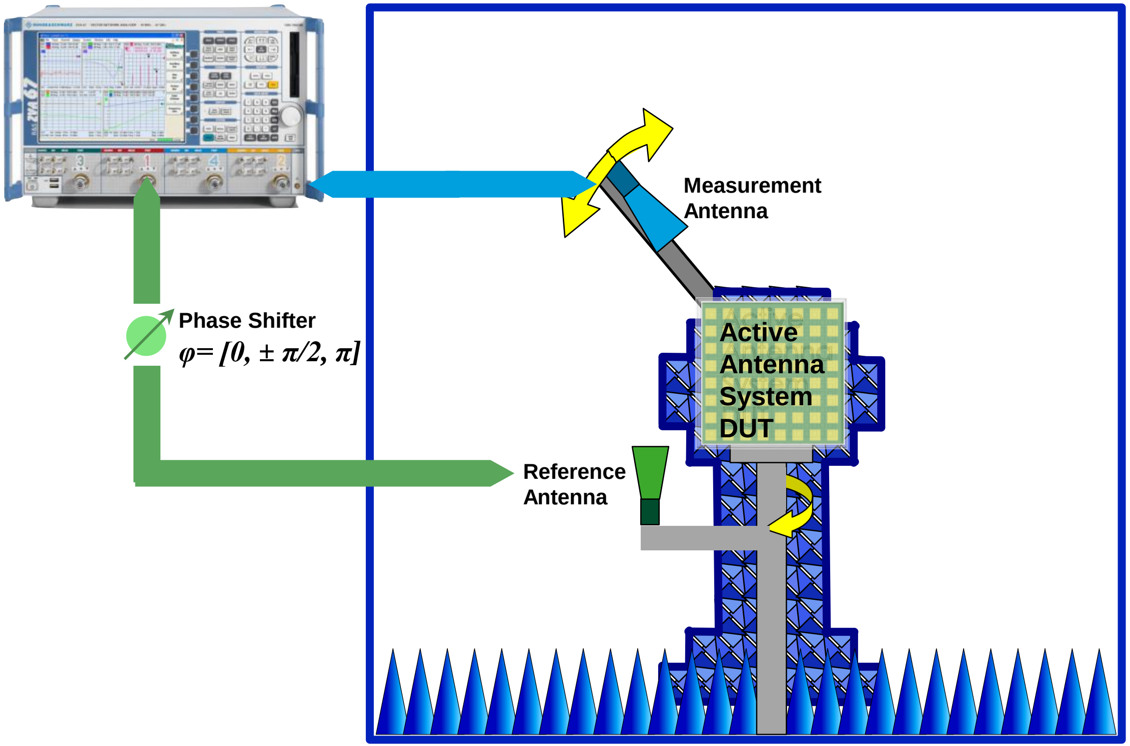


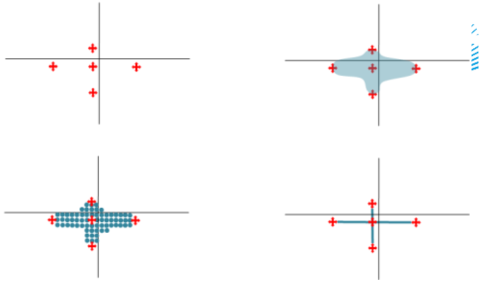
Transformation



NF-FF Reference Antenna Measurement

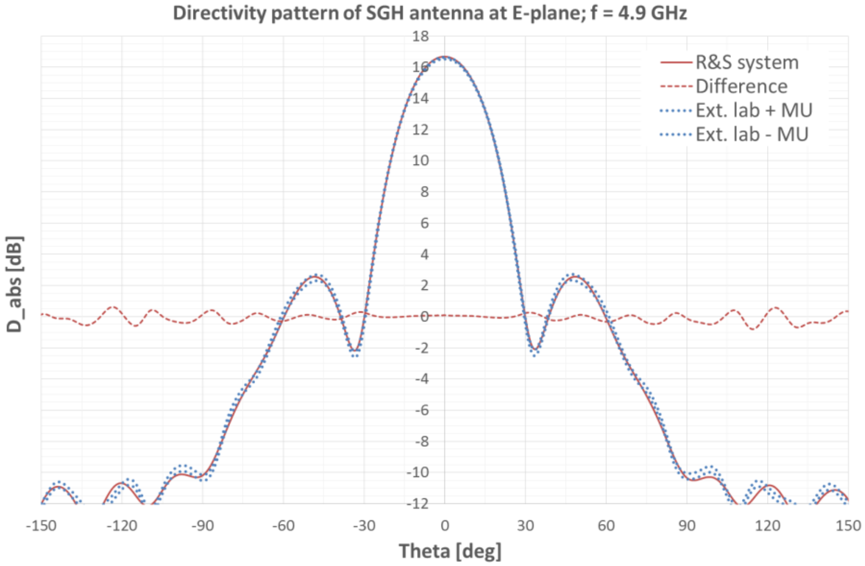
Application

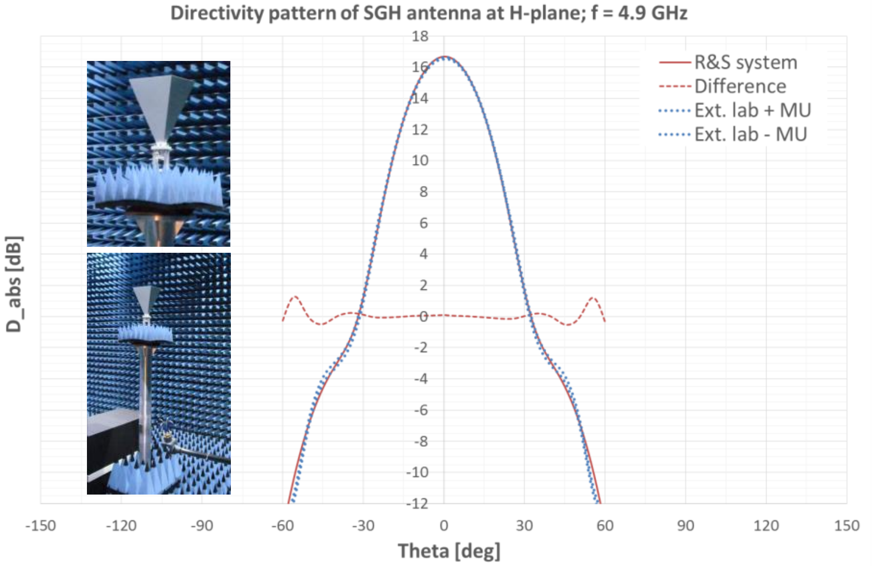




Magnitude only measurement
Pattern measurement (CW test mode)
1^{st} post-processing step: Phase retrieval by reference antenna measurement method
2^{nd} post-processing step: NF2FF transform
Digital I/F to DUT necessary for magnitude readout during Rx measurement
Signal quality measurements in relation to received signal power at spatial points identified during 1^{st} step

FIAFTA Algorithm Accuracy

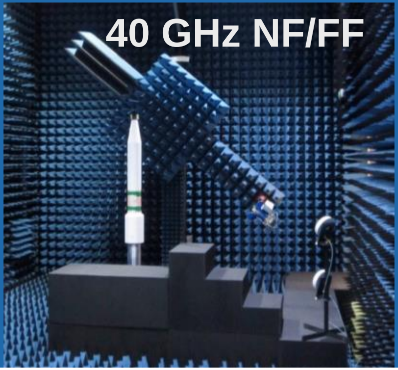




	R&S Test Chamber	External Accredited Lab	Difference
Gain IEEE [dBi]	16.16	16.36 ± 0.12	-0.2

Reference Projects

TU Wroclaw: EMI / OTA / 40 GHz NF/FF

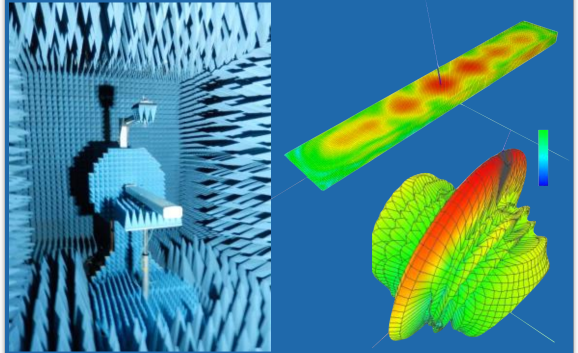


Setup & Results
Combined EMI + OTA Measurement
Chamber size: 12m x 6m x 6m
Active OTA: 6 GHz
MIMO OTA: R&S Decomposition
NF & FF measurement: 0.8 to 40 GHz
Moveable mast for far-field

Automotive Company: NF/FF

Setup & Results
Car Antennas: Passive Measurement
Frequency: 0.65 to 6 GHz
High precision positioner: 0.03°
ZVA8, Ext. Amplifier, and Vivaldi Antenna
NF to FF transformation

Beijing: BS antenna NF/FF

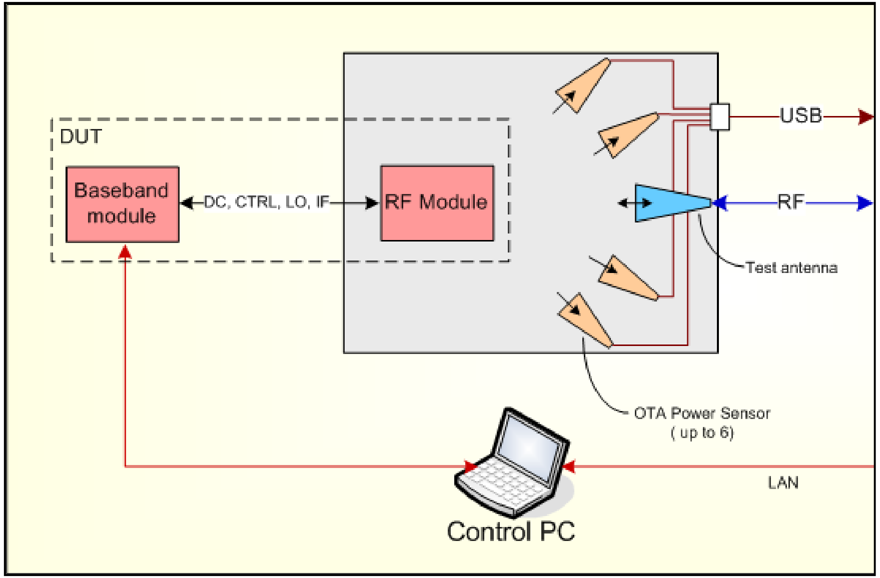


Setup & Results
5G Antenna: Passive Measurement
Frequency: 1.7 to 2.2 GHz
Dynamic Range: > 55 dB for 1 kHz BW
Beam tilt at 0 & 12 degrees
Measurement time: ~5 minutes
Accuracy: ± 0.04 dB & ± 0.06°

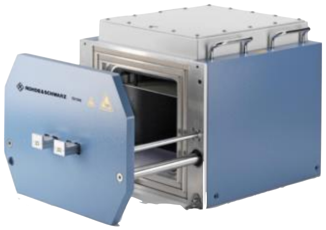
Benchtop OTA Power Measurements

mmWave devices will not have antenna connectors

OTA Measurements will be mandatory for production



Mechanical Equipment



Shielded chamber (TS7124)

Antenna Ring (1-6 probes)

Measurement Equipment

Power meter sensor

- DC to 110 GHz
- 3 channels
- No Cable Losses Digital Data

Vivaldi + Diode

- Linear from 28-77GHz
- Low RCS/reflectivity
- 8 dBi gain

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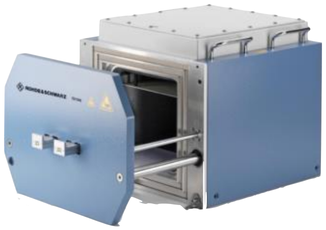

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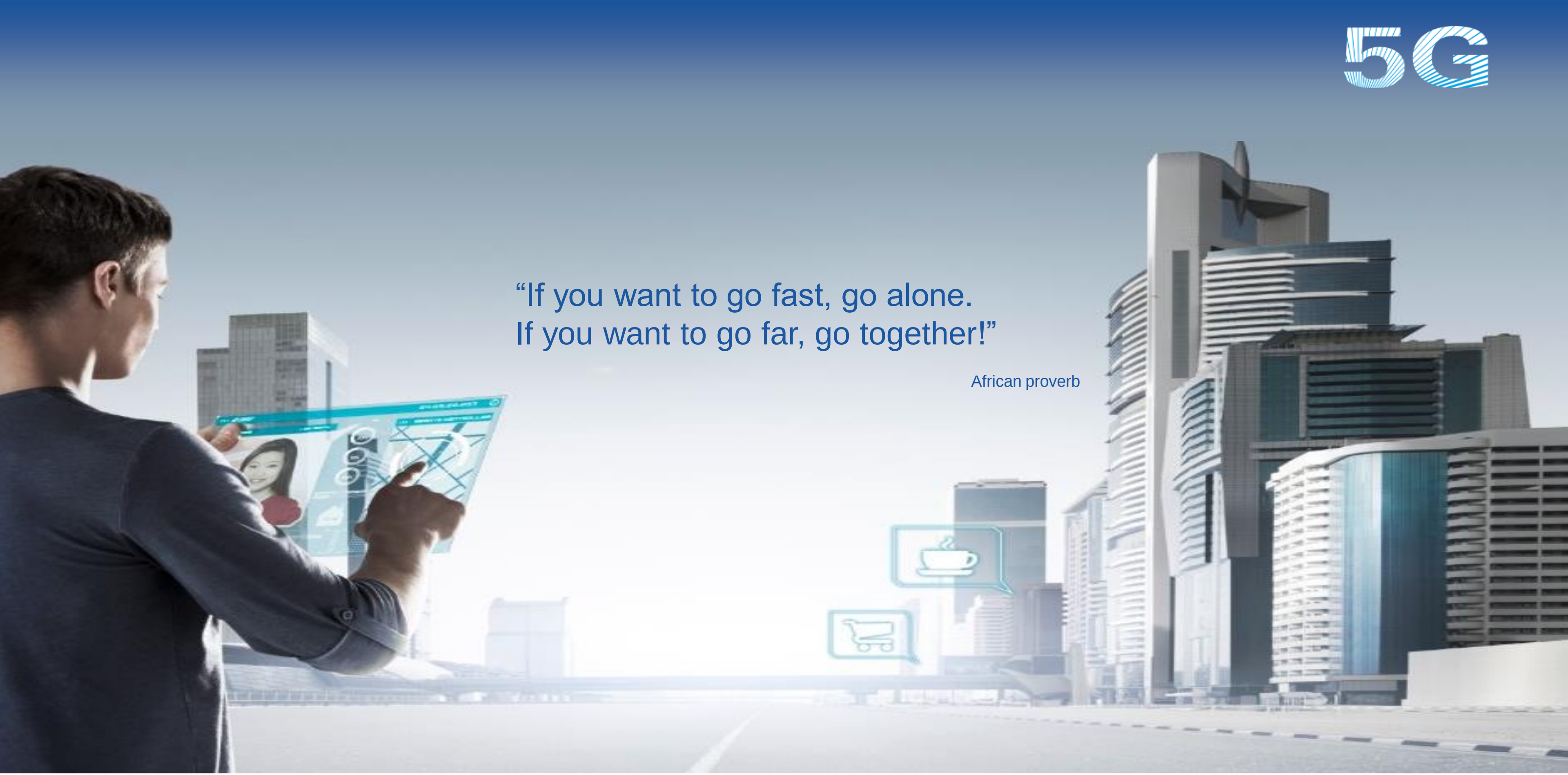

"If you want to go fast, go alone.
If you want to go far, go together!"

African proverb