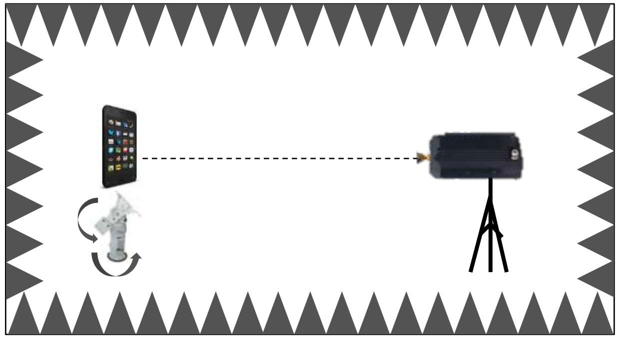
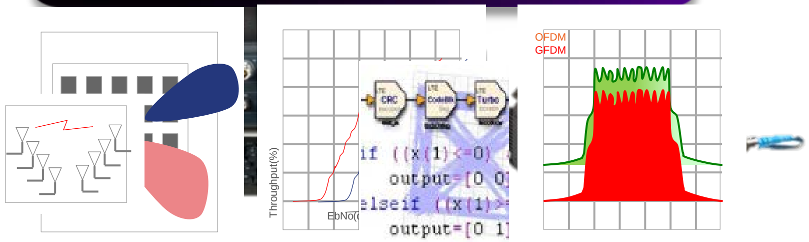
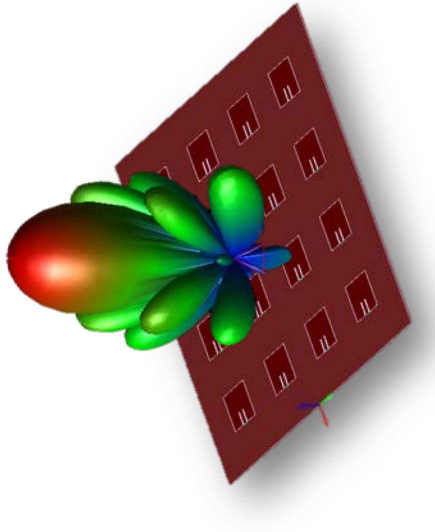
Implications of mmW to Communications Systems Design & Test

Oct 2016



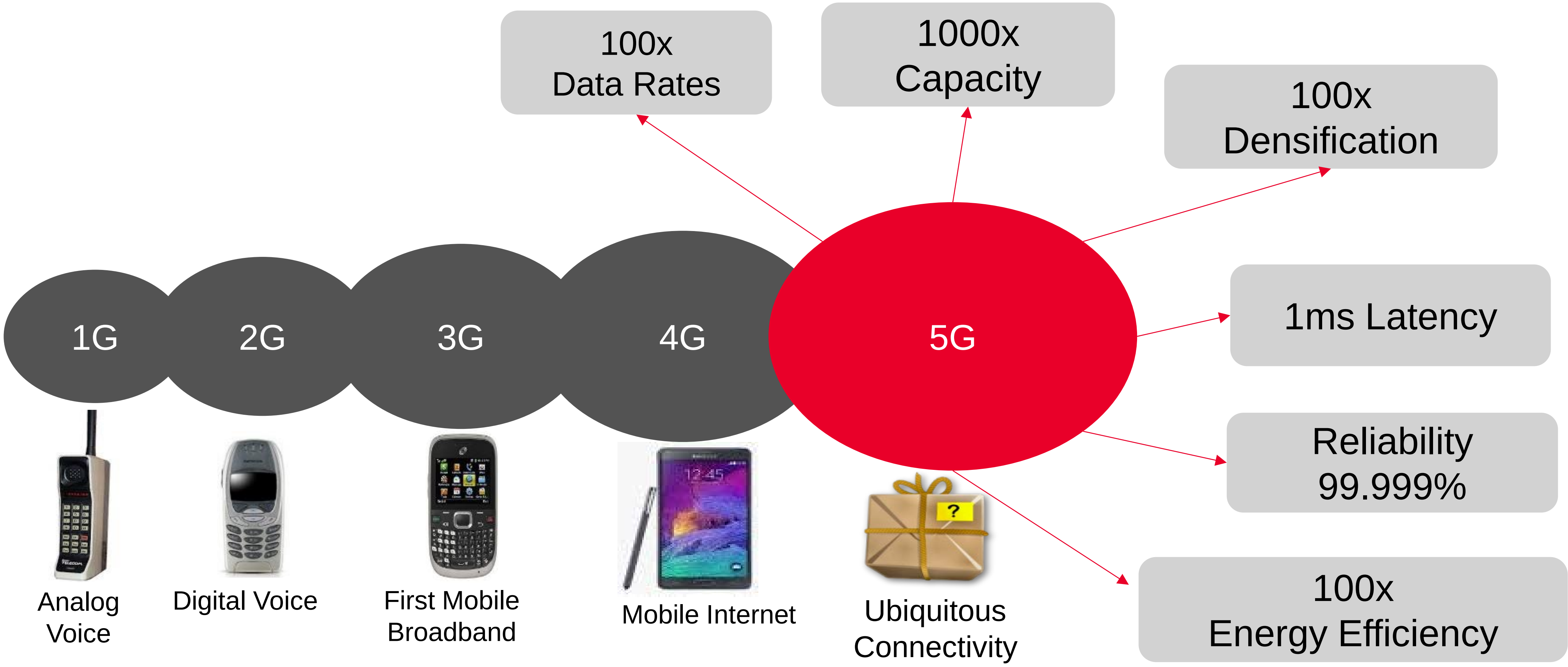




Satish Dhanasekaran
Vice President and General Manager
Wireless Device and Operators

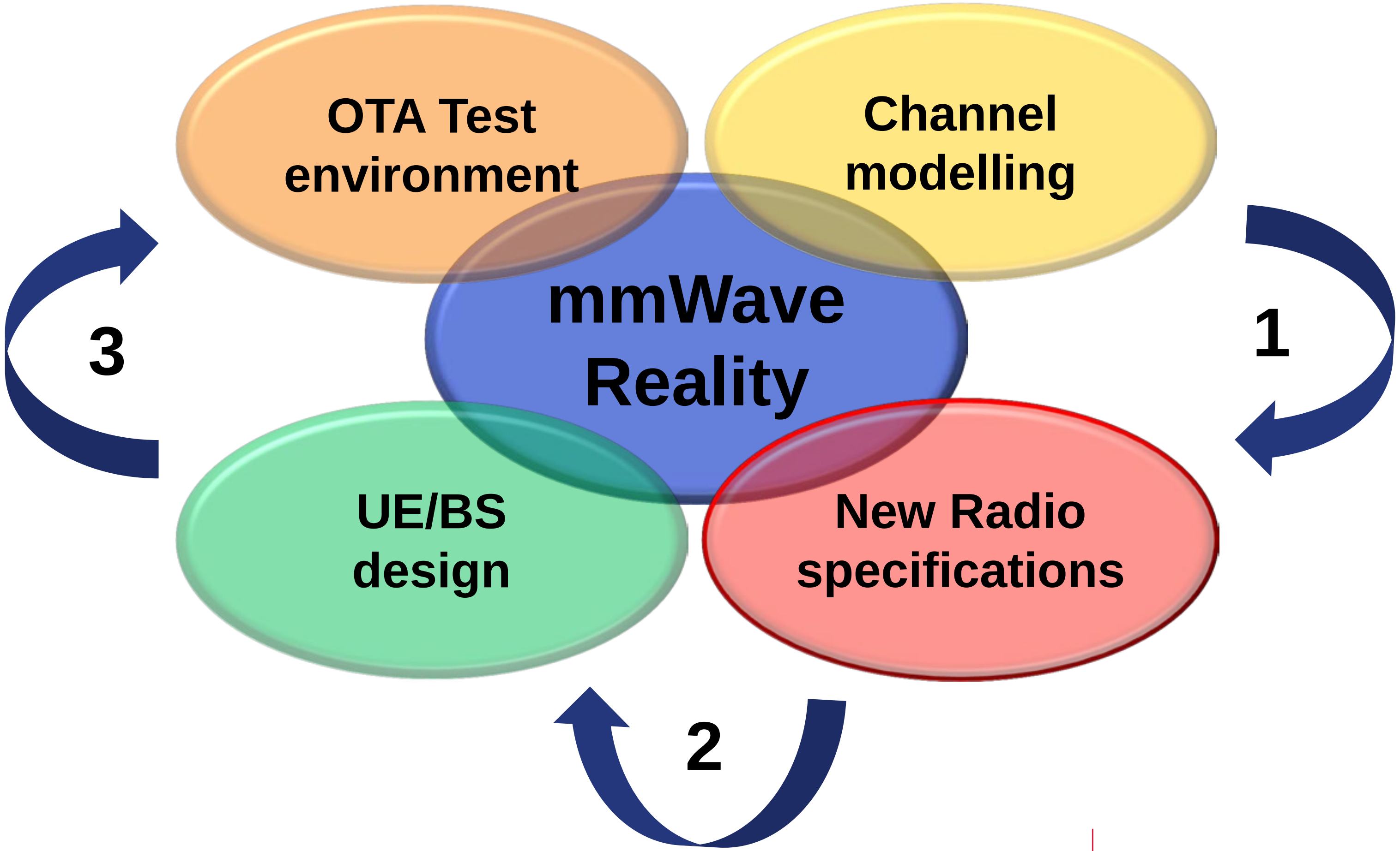
KEYSIGHT TECHNOLOGIES

5G : Cellular Revolution



The new activity for 5G Systems Engineers

How many beams? How wide at each end of the link?
How dynamic – spatial, power, temporal, frequency?

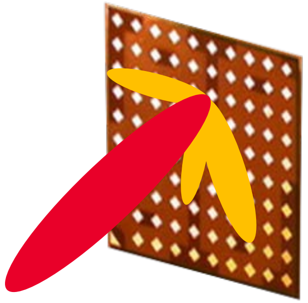


mmWave ≠ 10x RF

Large available bandwidth at mmWave

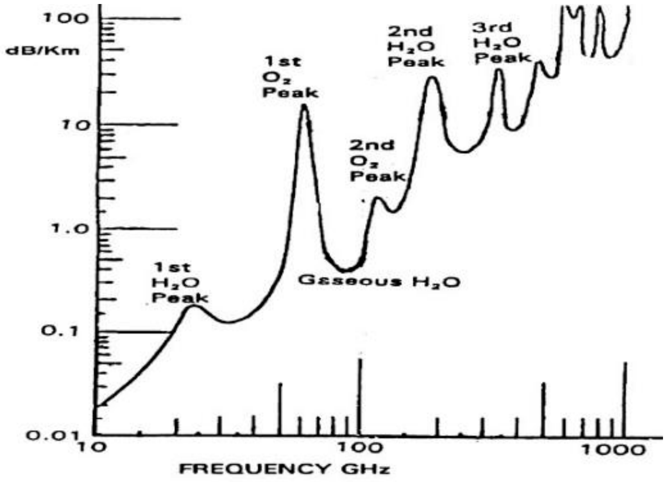
Frequency range	6-20 GHz	20-40 GHz	40-60 GHz	60-100 GHz
Specific bands identified	*10 GHz band* *10.125-10.225 GHz* *10.475–10.575 GHz*	32 GHz band *31.8-33.4 GHz*	40 GHz band *40.5-43.5 GHz* '45 GHz' band *45.5-48.9 GHz*	66 GHz band *66-71 GHz*
Potential bandwidth	*2 x 100 MHz*	*1.6 GHz*	*5.8 GHz total*	*5 GHz*

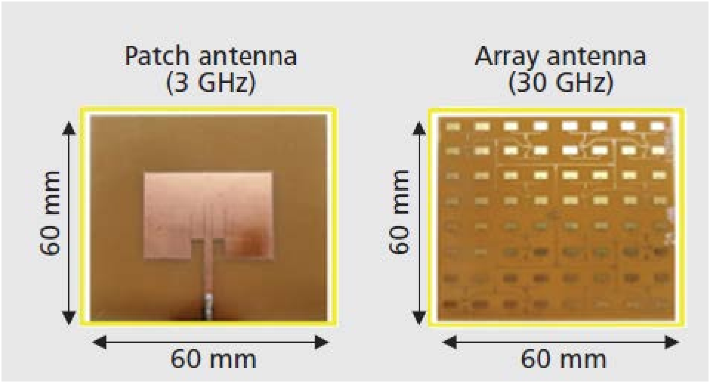
Source: Ofcom, Apr 2015



Path loss can be mitigated by high gain directional antennas

High path loss due to atmospheric absorption





mmWave geometry allows for very small, high gain antennas

Averaging the channel in space – good or bad?

Spaghetti junction:
Averaged in 2D there are many interconnected routes, in the reality of 3D there are very few

So how should we model the mmWave channel?

Ground bounce

Diffraction

Delay spread

Path loss

Channel hardening

3D

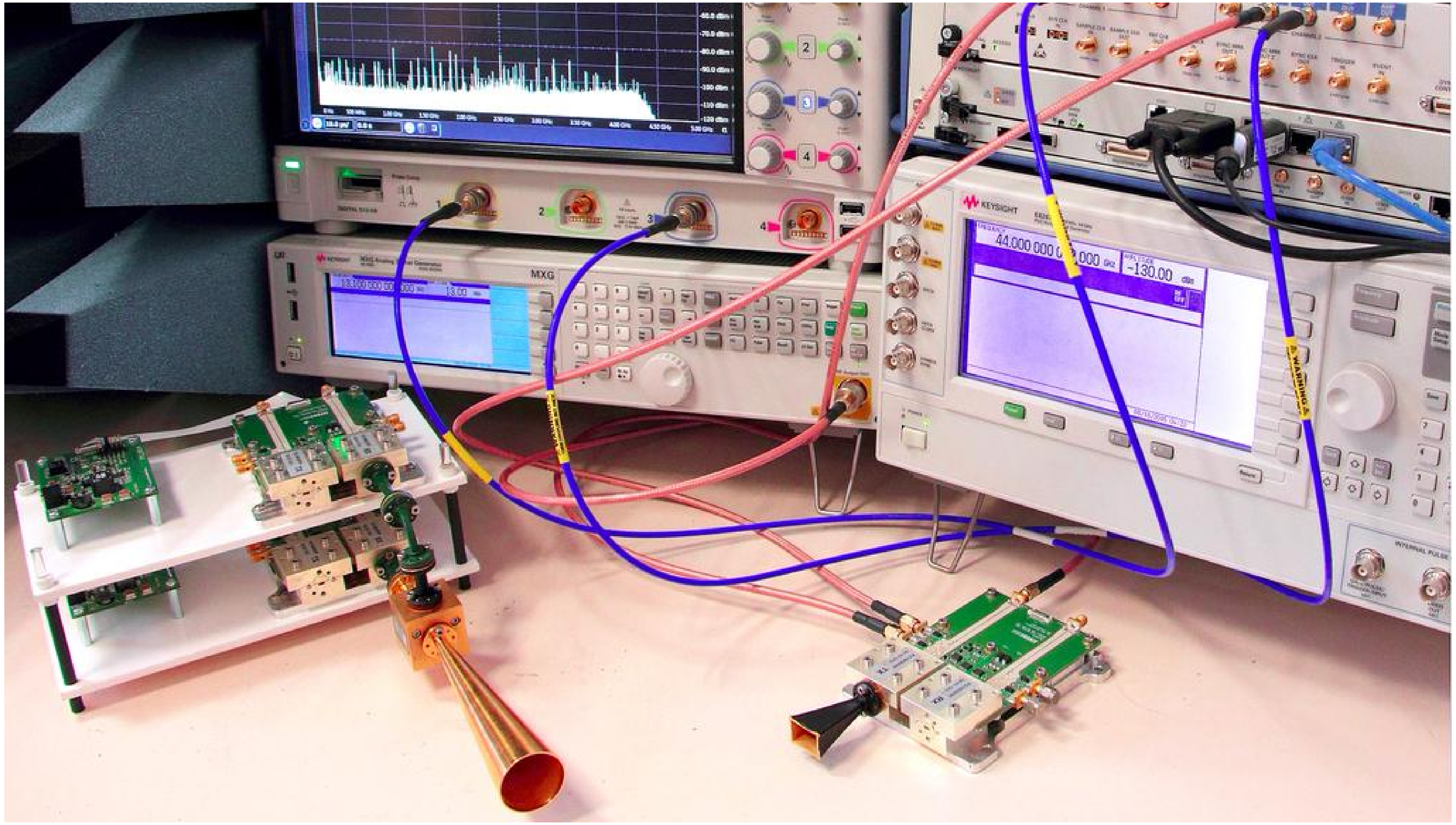
Narrow beams

Polarization

Doppler

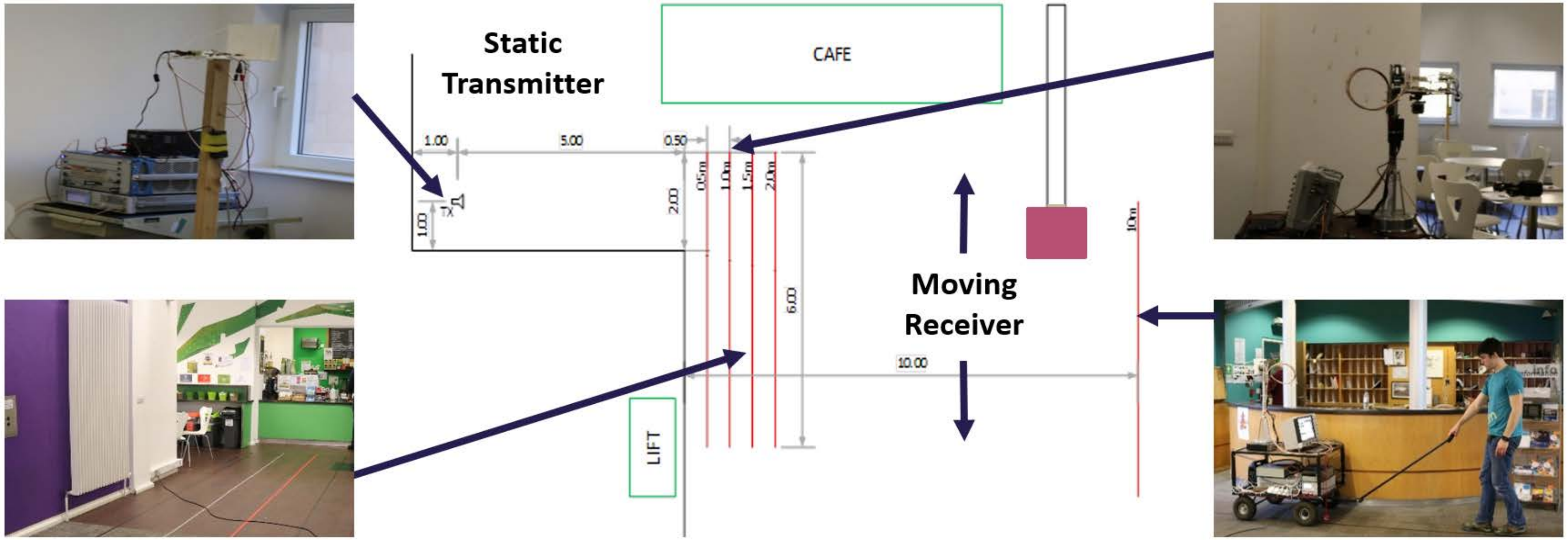
Keysight 60 GHz channel sounder with 2 GHz real-time bandwidth

University of Bristol in mmMAGIC project



Corner diffraction study

ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_84b/Docs/R1-162872.zip



How well do 60 GHz signals bend round corners?

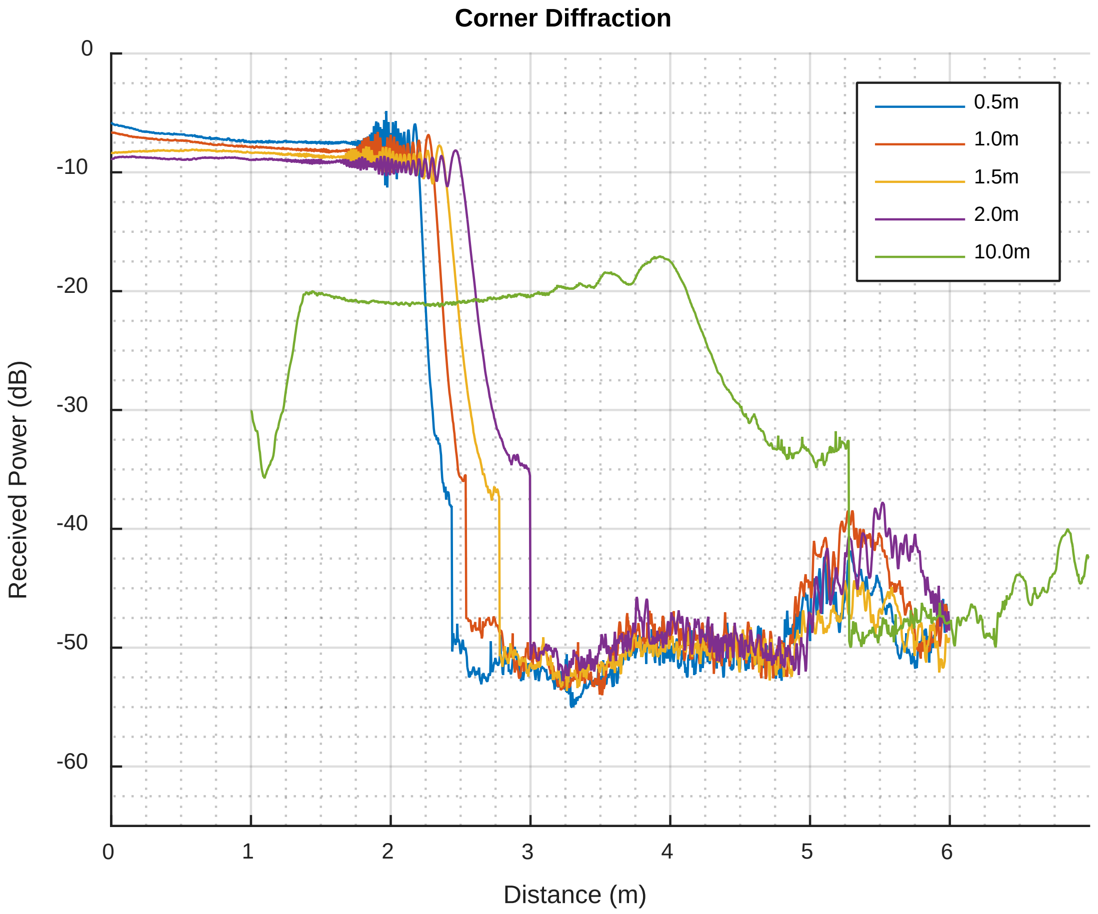
Corner diffraction measurements

They don't!

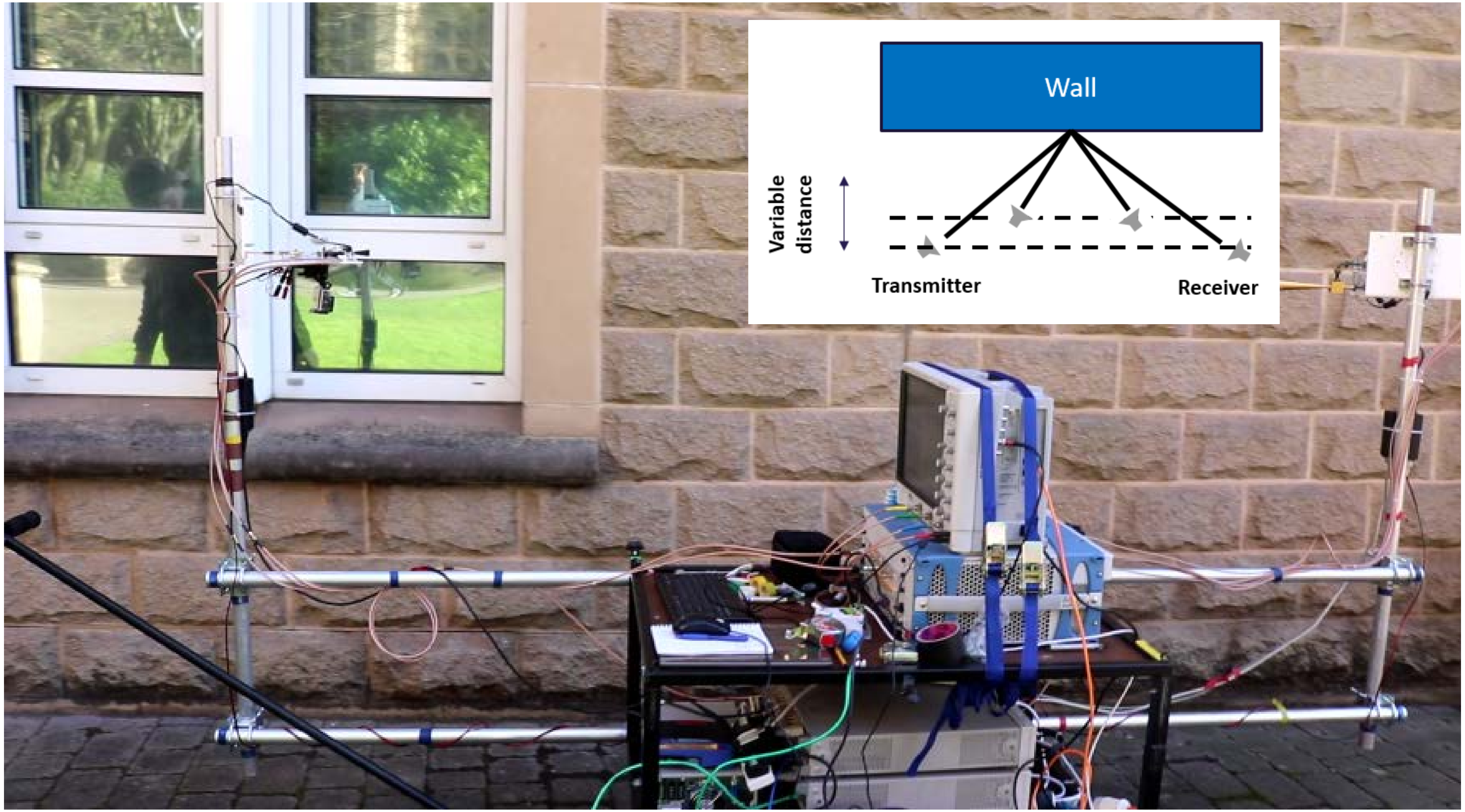
25 dB signal loss
in just 10 cm of travel

At these frequencies propagation is quasi-optical

Now you see me, now you don't

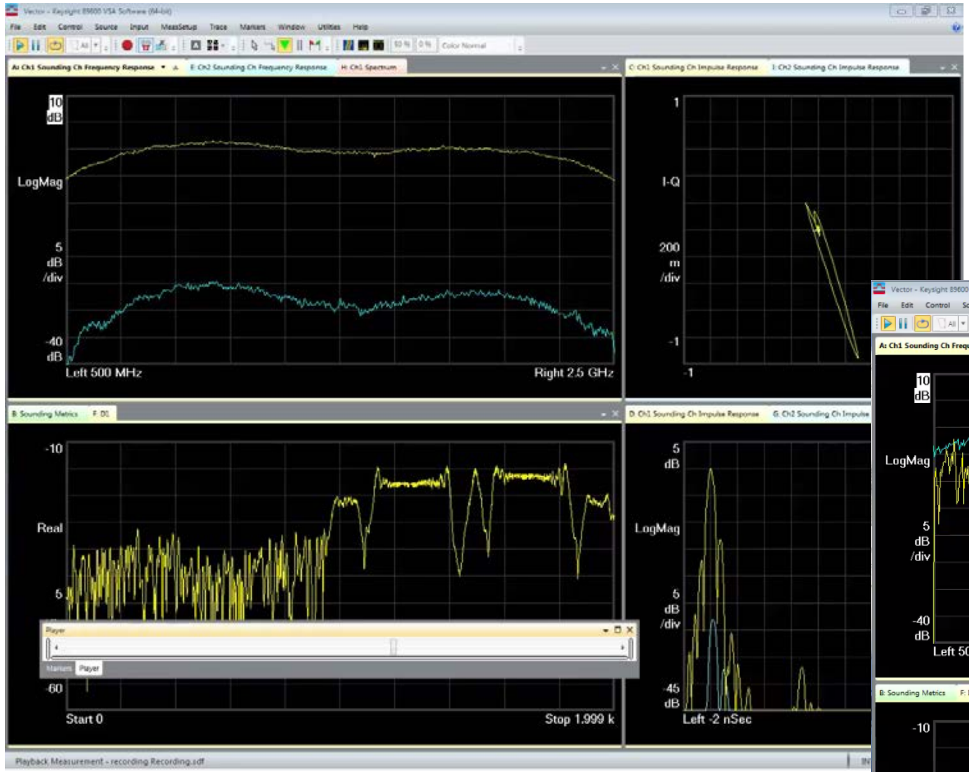


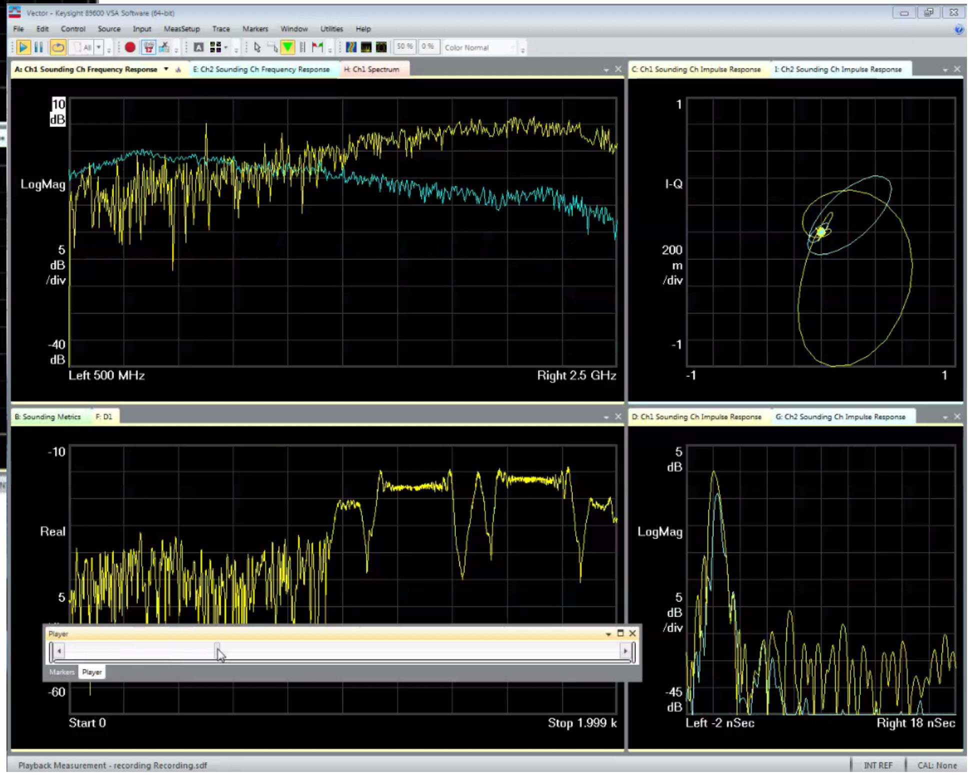
Surface scattering measurement setup



Mixed wall scattering: In-channel analysis

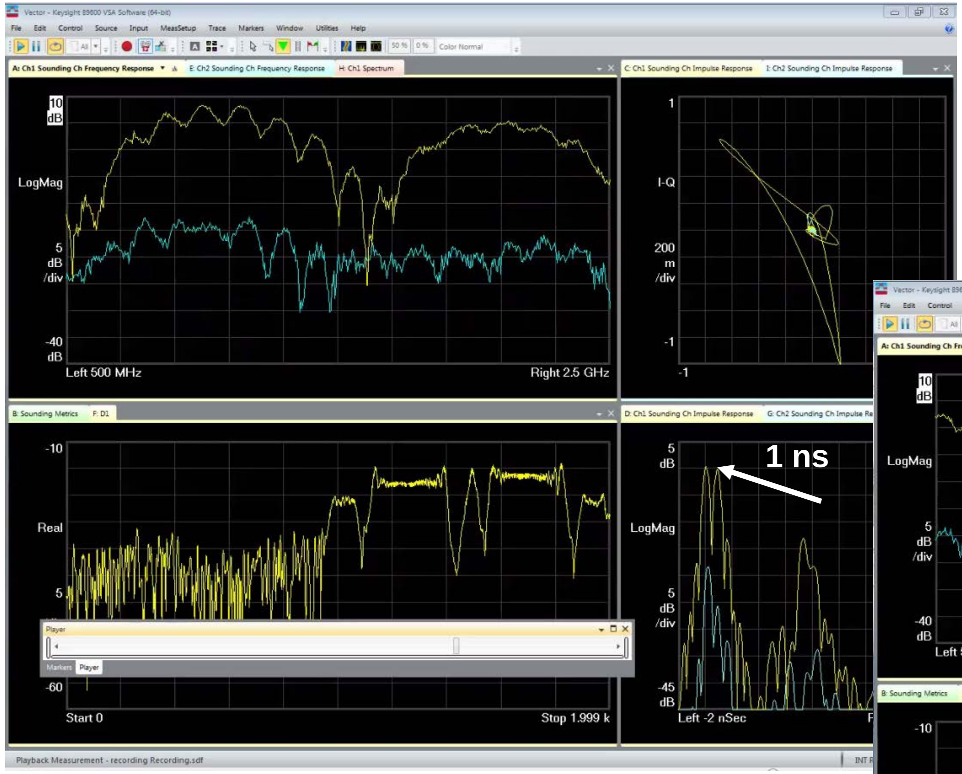
For rough stone:
The signal has lost its polarization diversity and has a 10 dB slope



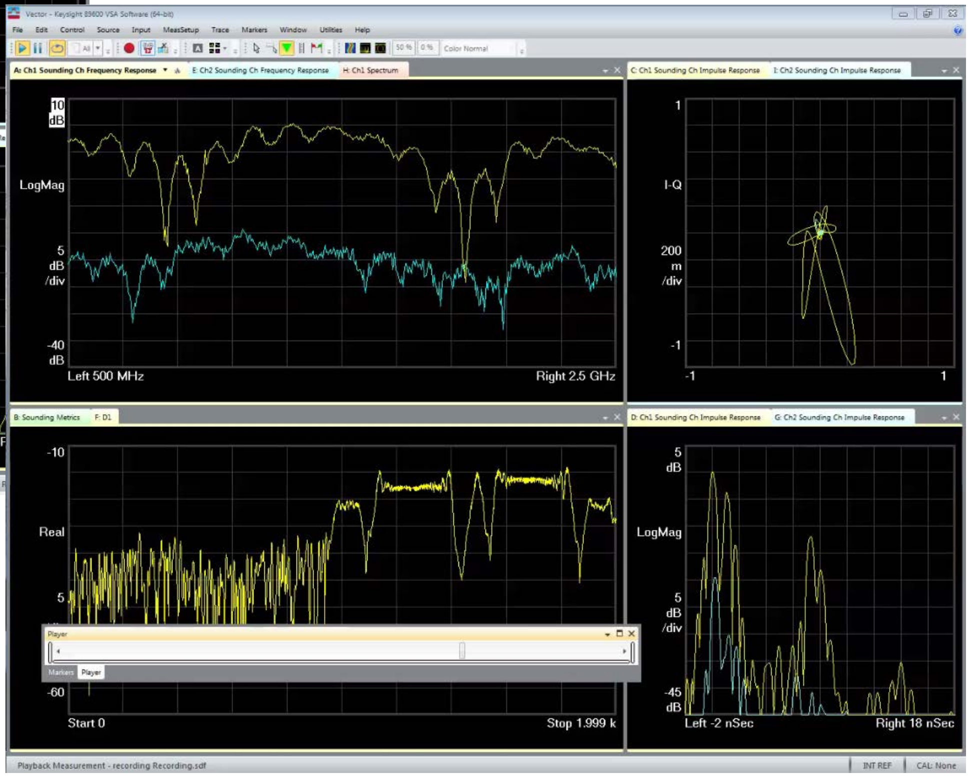


For glass:
The received signal shows
25 dB polarization diversity and
flat frequency response

Mixed wall scattering: In-channel analysis at transition

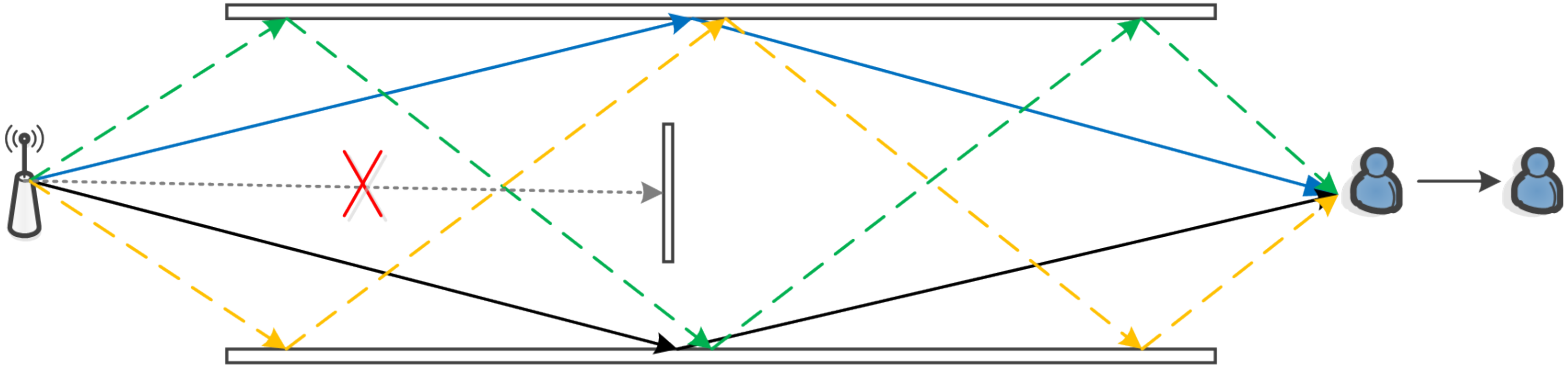


At transition from wood to glass:
A few ms later and the null has moved across the channel making this a hard demanding signal to equalize



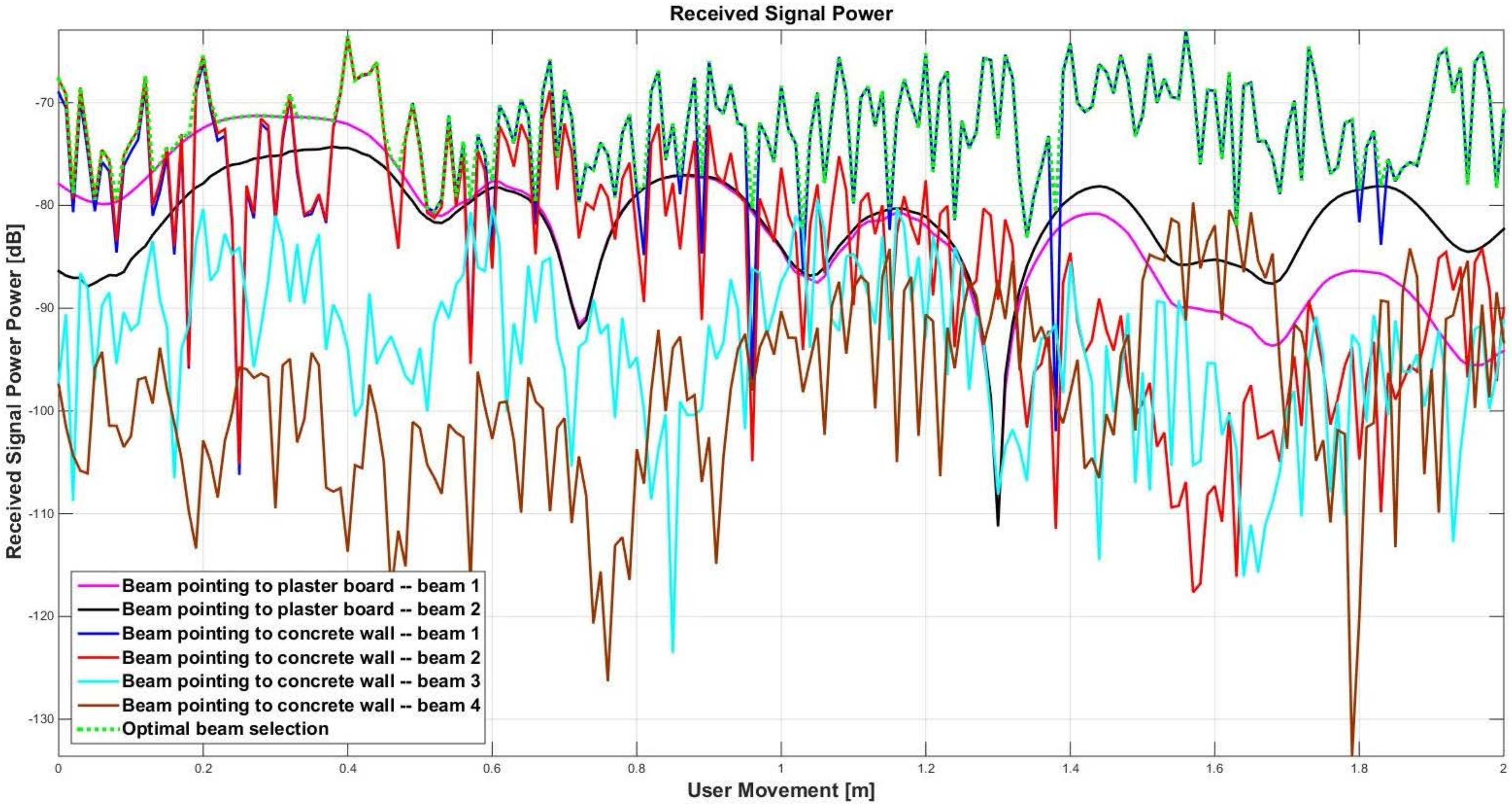
At transition from wood to glass:
A strong reflection at 1 ns causes serious 20 dB fade mid-channel

Specular Reflection and Diffuse Scattering in mmWave



- The LoS is blocked and the user moves 2 meters away from the AP;
- **Analogue beamforming**: exhaustive search is exploited
- **AP**: 32 antenna elements and forms 64 beams;
- **User**: 8 antenna elements and forms 16 beams;
- **Specular reflection**: the signal power of the reflection path from a given surface is calculated using the Fresnel reflection formula;
- **Diffuse scattering**: the small-scale fluctuations on top of the mean signal power is modelled along a route as a function of a K-factor and a coherence distance;
  - Rough wall: K-factor = -3dB and coherence distance < 1cm;
  - Smooth wall: K-factor = 5dB and coherence distance = 5cm;

Specular Reflection and Diffuse Scattering in mmWave



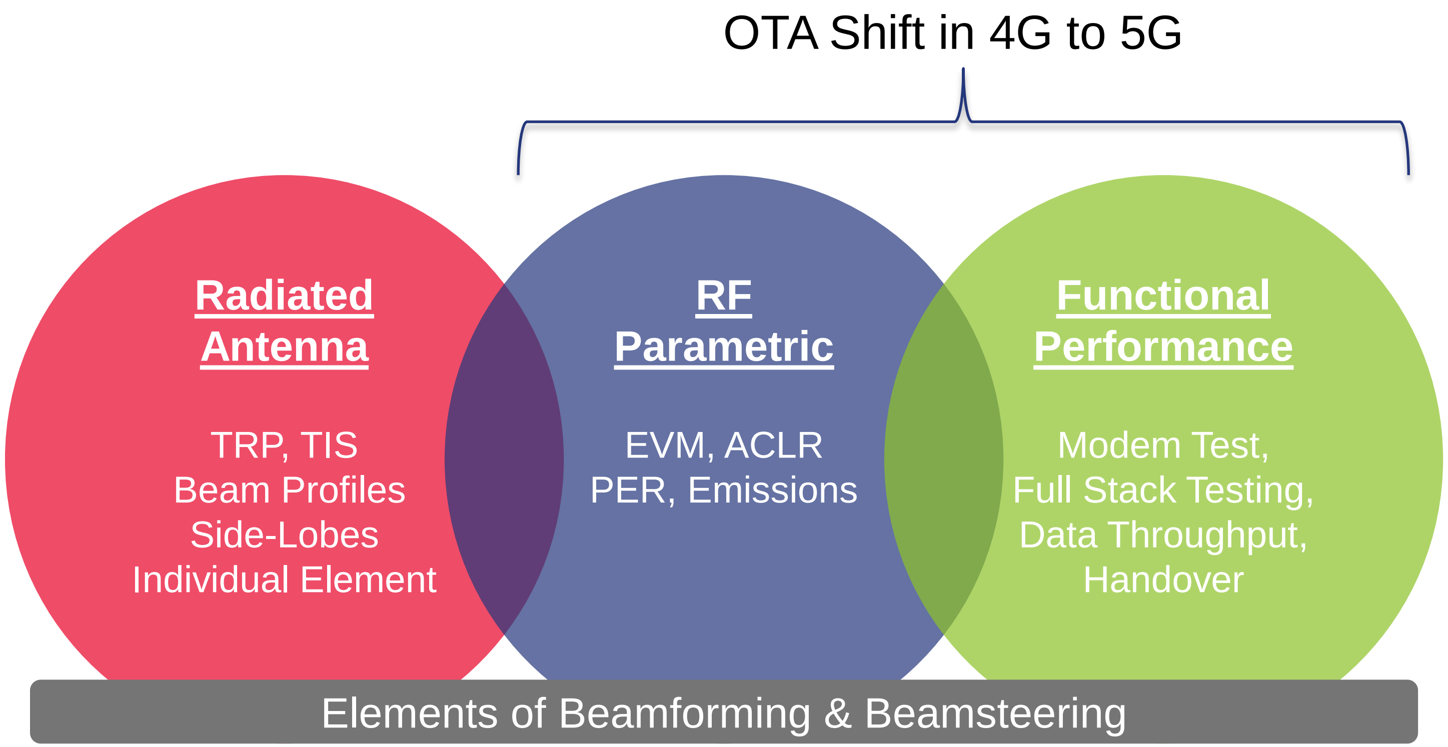
It's complicated!

The mmWave paradigm shift

What we know well	Here be dragons!
RF Cellular (< 6 GHz)	mmWave Cellular (> 28 GHz)
How **GOOD** is my signal?	**WHERE** is my signal?
↓	↓
Non-spatial requirements and cabled testing	3D spatial requirements and OTA testing

Testing OTA: The Cable is Gone

Commercial mmWave bring Changing Paradigm in Test



- ***Today***: mmW Radiated Antenna measurements solutions already exist for pure antenna characterization.
- ***Tomorrow:*** @ mmW RF Parametric and Functional Performance need definition.

OTA/Connectorless Testing Through the Development Cycle

Test Measurements	R&D	Design Verification	Conformance	Manufacturing
Near Field vs Far Field	Both	Far Field	Far Field	Both
Spatial (angular) vs Non-Spatial	Both	Both	Both	Limited spatial
Functional vs Parametric	Both	Both	Both	Parametric

Commercialization of an OTA/Connectorless Test Solution

- Cost effective
- Fast, accurate
- Support Beamforming and Beamsteering
- Easy to calibrate
- Compact
- Innovative, New Measurement Methodologies & Form Factors

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Wake up and smell the…

CHANNEL Nº 5G

Thank you

HARDWARE + SOFTWARE + PEOPLE = INSIGHTS

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