KEYSIGHT WORLD 2019

# Overcoming the Challenges of 5G Data Throughput

*Keysight Technologies*

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# Agenda

- Introduction
- How to increase 5G data throughput
- A look at some real measurements
- Questions

# Cellular Radio

## A QUICK TOUR THROUGH HISTORY…


**0.5G** **1G** **2G** **3G** **4G** **5G**

C W

Analog Cellular
1980's

Digital Cellular
1990's

Internet Connected
Early 2000's

Internet Perfected
~2010

?

# The 5G New Radio Vision

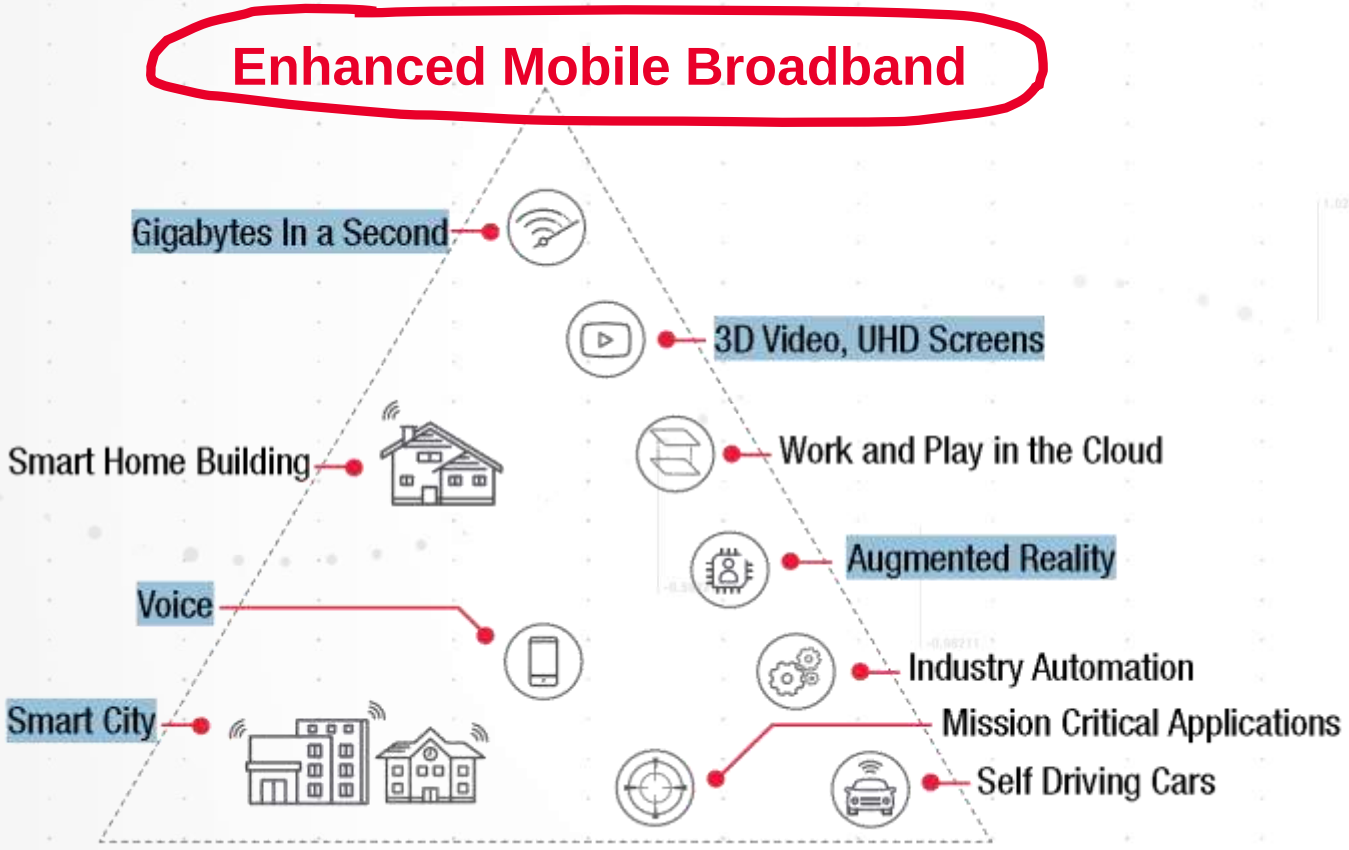



Figure 1: Source ITU 5G Recommendations 9/2015

## Better Spectral Efficiency

- Clever modulation & coding schemes

## Cell Densification

- Add more base stations

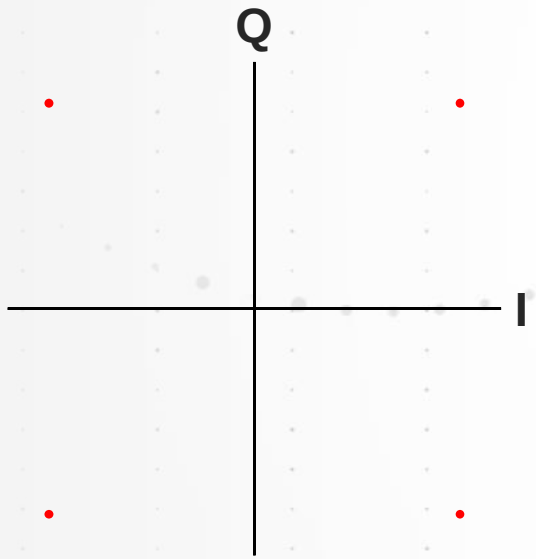
## Use more spectrum

$$C = B\ LOG_2\left(1 + \frac{S}{N}\right)$$

# Clever Modulation & Coding Schemes

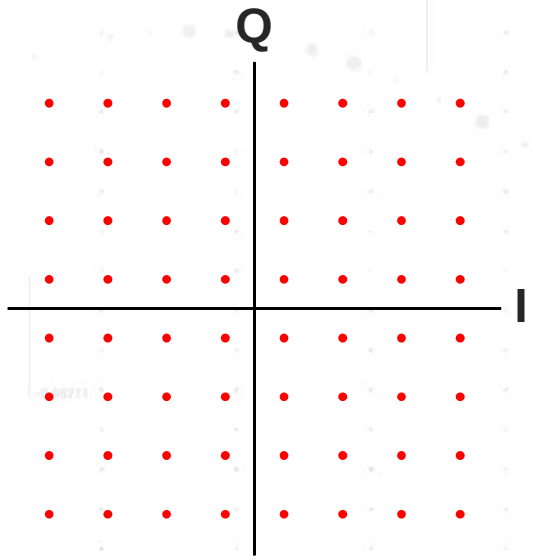
## HIGHER ORDER MODULATION – THE CURE

### QPSK




2 bits / symbol

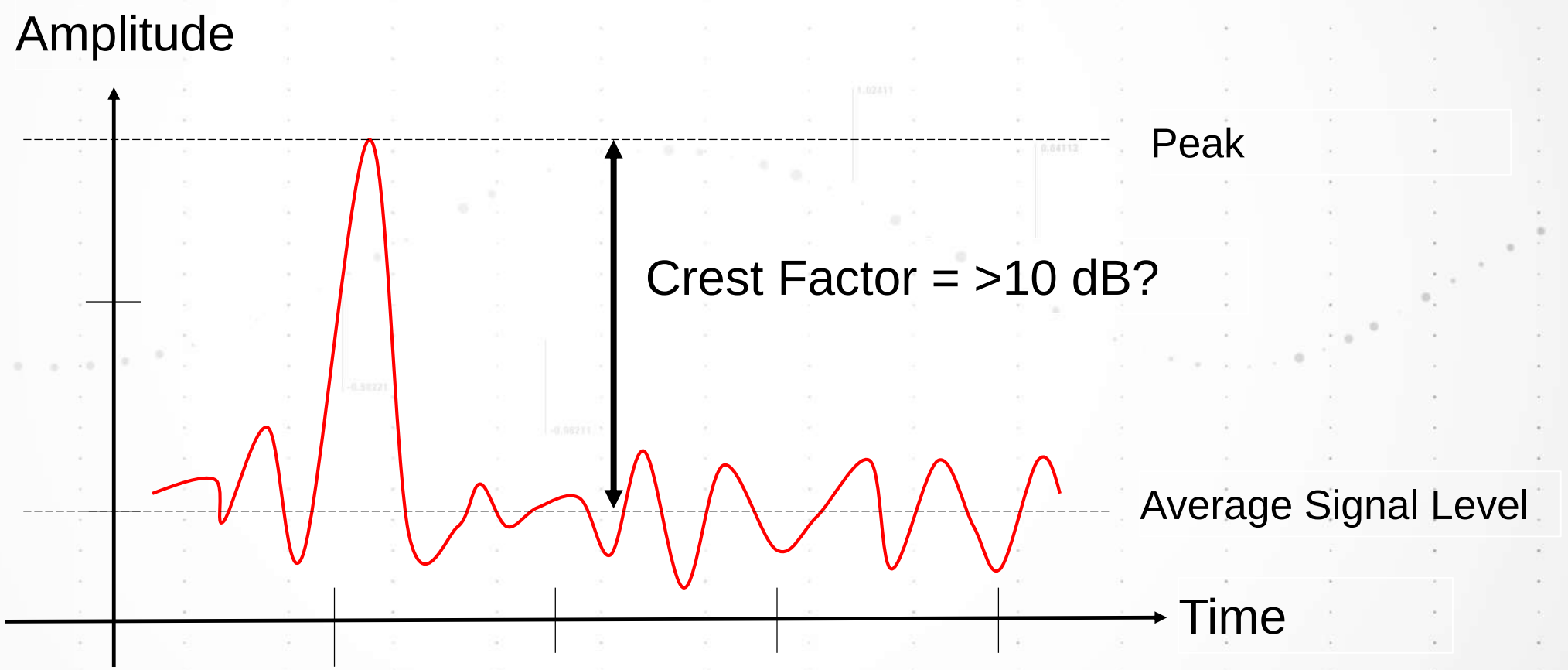
### 64QAM




6 bits / symbol

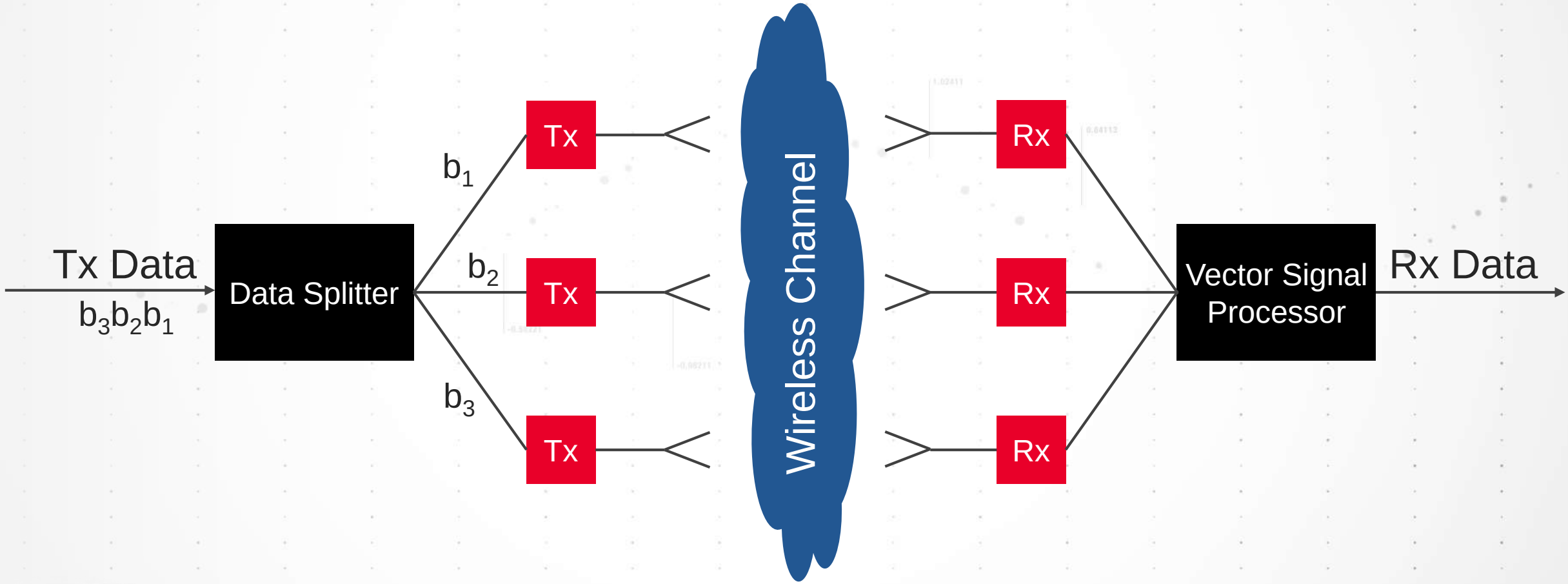
# Clever Modulation & Coding Schemes

## HIGHER ORDER MODULATION – THE PROBLEM



# Clever Modulation & Coding Schemes

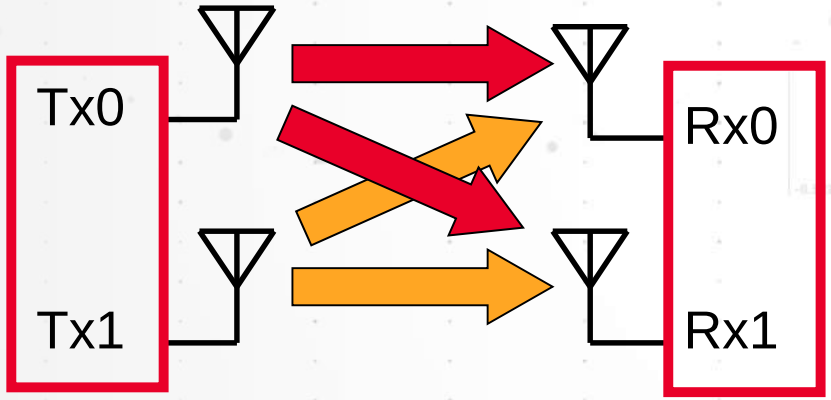
## SPATIAL MULTIPLEXING – THE CURE



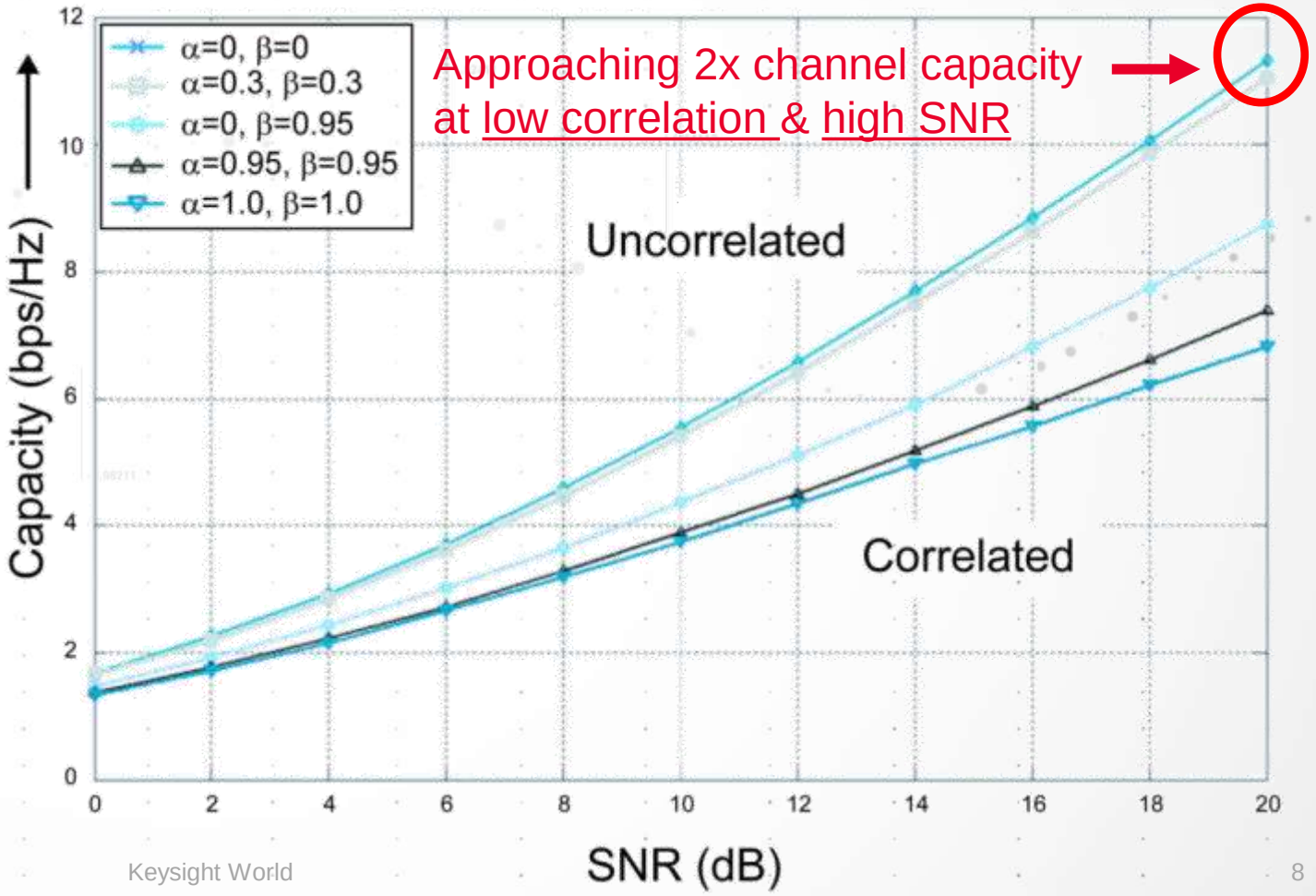
# Clever Modulation & Coding Schemes

## SPATIAL MULTIPLEXING – THE PROBLEM

### Spatial Multiplexing

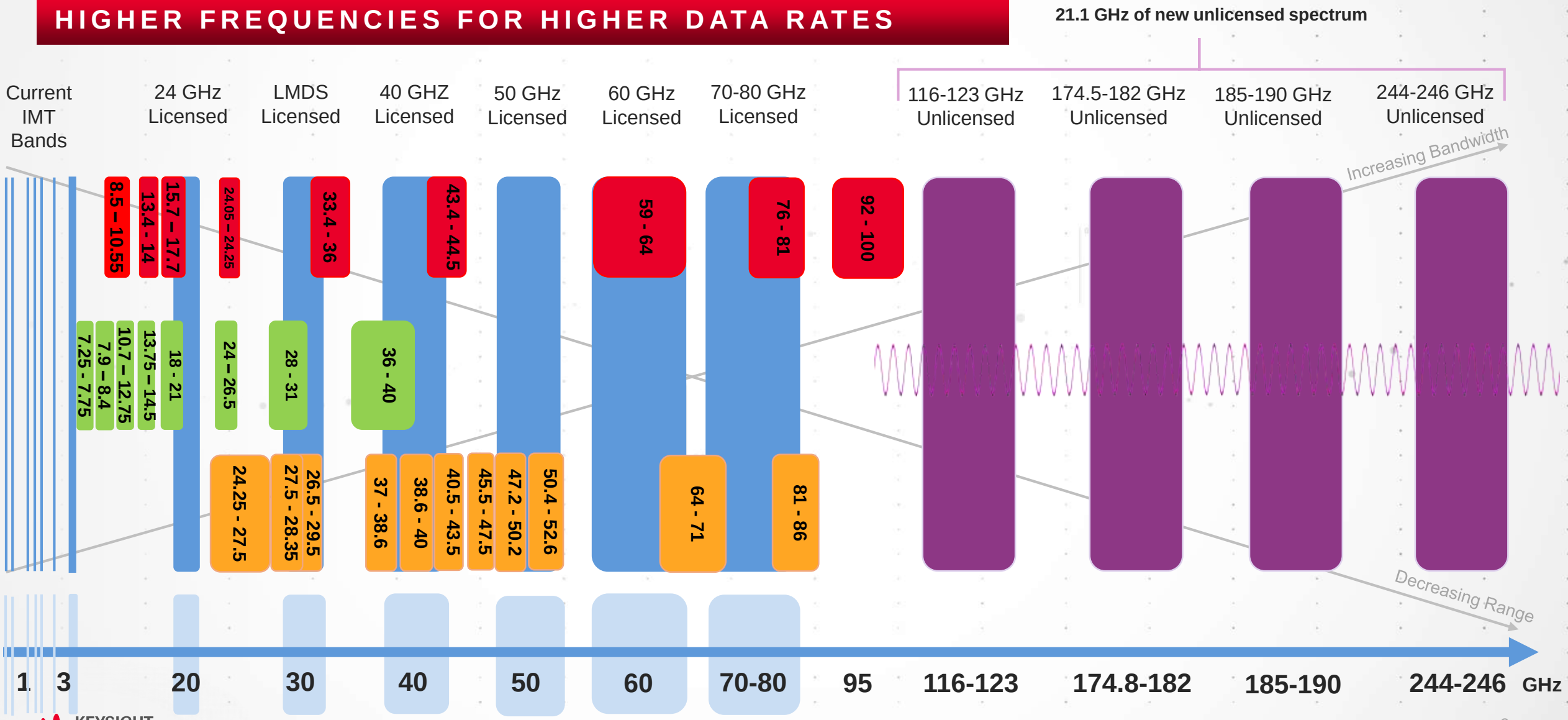



### Spatial Multiplexing Performance



# Spectrum

## HIGHER FREQUENCIES FOR HIGHER DATA RATES

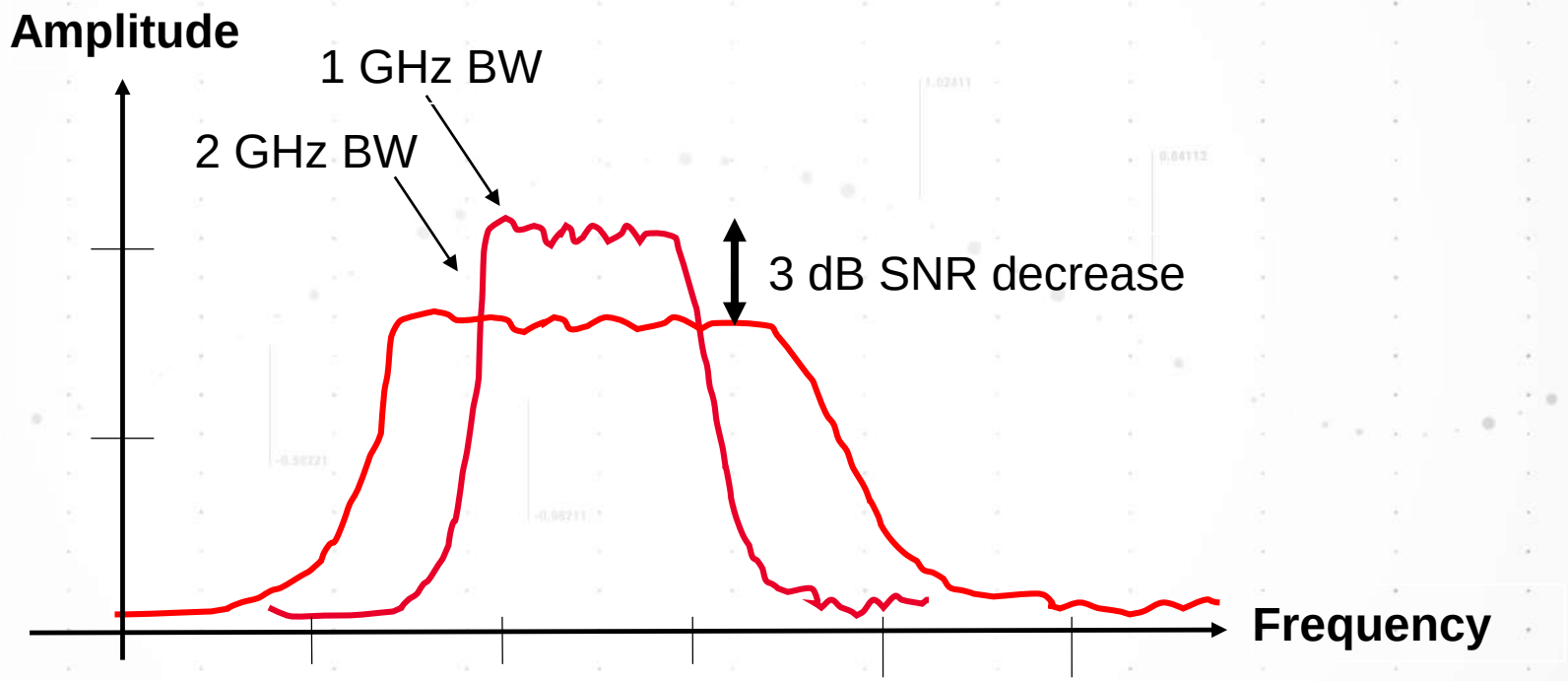



10 yr Experimental license use on any frequencies between (95 GHz – 3 THz)

*Gigabit LTE and beyond: Mobilizing millimeter wave

# Spectrum

## WIDER BANDWIDTHS – THE PROBLEM

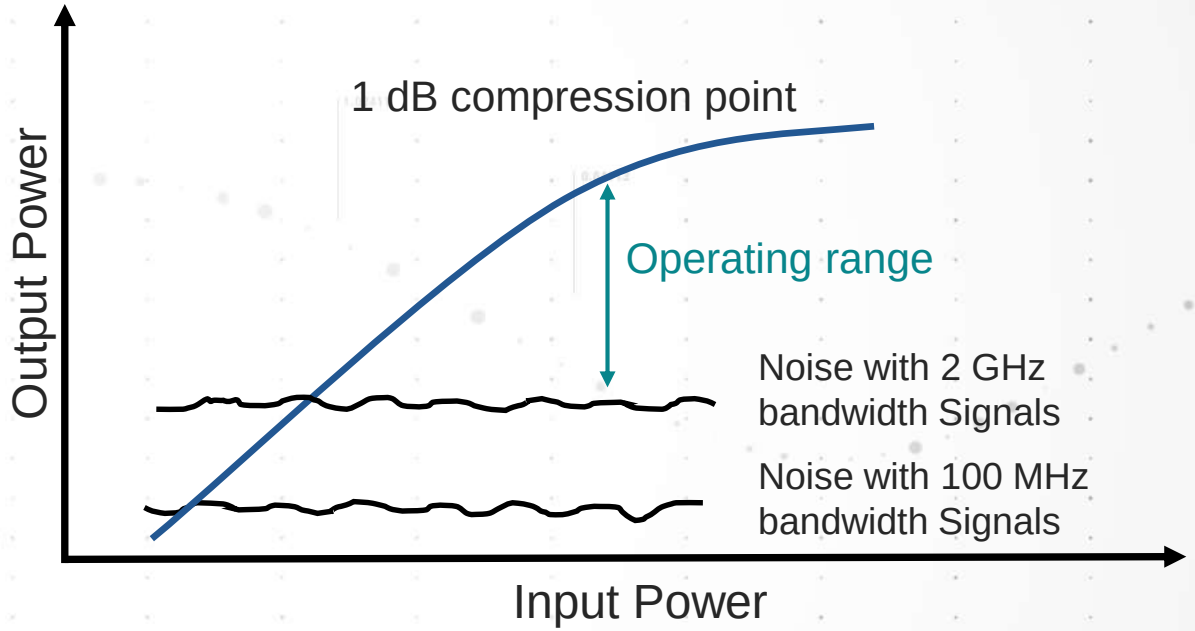



LTE (20 MHz BW) compared to 5G (2 GHz BW):  SNR delta = 20 dB!

# Wider Bandwidths and Higher Order Modulation

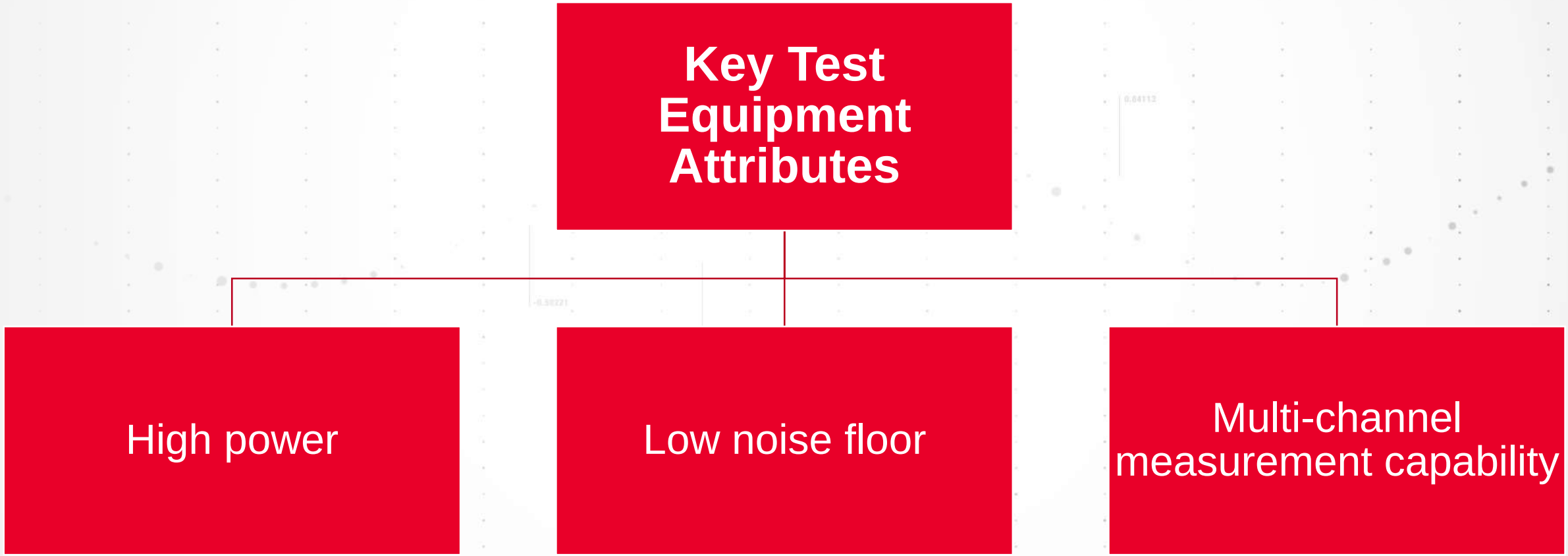
## INCREASED SYSTEM NOISE

- Wideband noise will often limit device & measurement performance
- Any back-off needed to prevent signal compression makes the problem worse



# 5G Data Throughput

## CHALLENGES



# A Quick Look at Some Real Measurements…

# Multi-Channel 5G Testbed for NR FR1 and FR2

## 3GPP CONFORMANCE READY – HIGH PERFORMANCE

**Test Signal**
2x2 MIMO at 28 GHz

## Key Features

- 44 GHz Signal Creation / 110 GHz Analysis
- Multi-channel
- High Output Power
- 2 GHz signal Creation BW
- 110 GHz BW Demodulation Analysis
- Swept-tuned measurements to 110 GHz
- Import S-Parameters to de-embed test fixture

**Device Under Test**
Cross-polarized 28 GHz phased array

**DC Power Analyzer**

**VXG**
44 GHz Dual Ch. Source

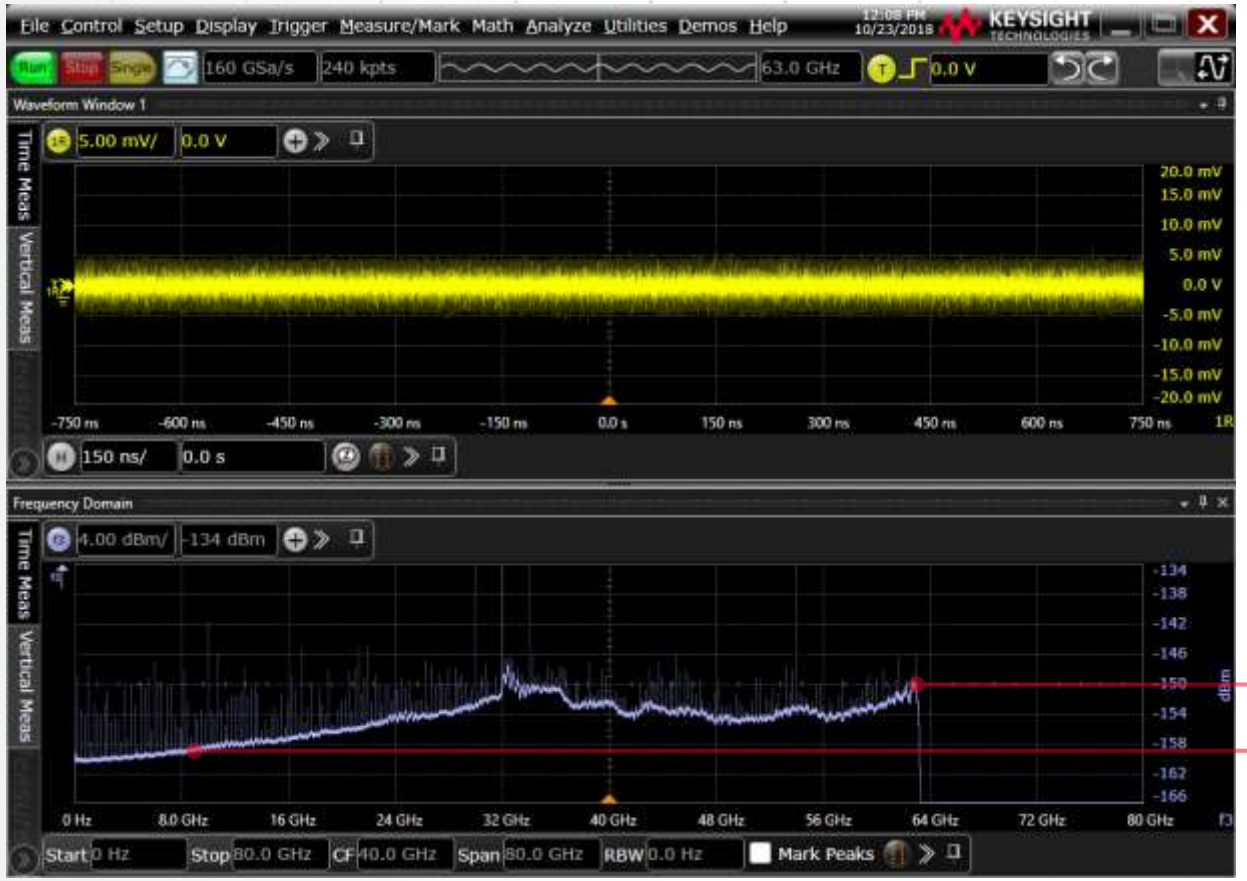
**UXR**
110 GHz Oscilloscope

**UXA**
110 GHz Signal Analyzer

# Noise Density Comparison (Current Z-series vs UXR)

**NOW YOU CAN: ACHIEVE SUB 10 GHZ NOISE LEVELS AT 70 GHZ SPEEDS**

## Z-Series




50 Ω Terminated

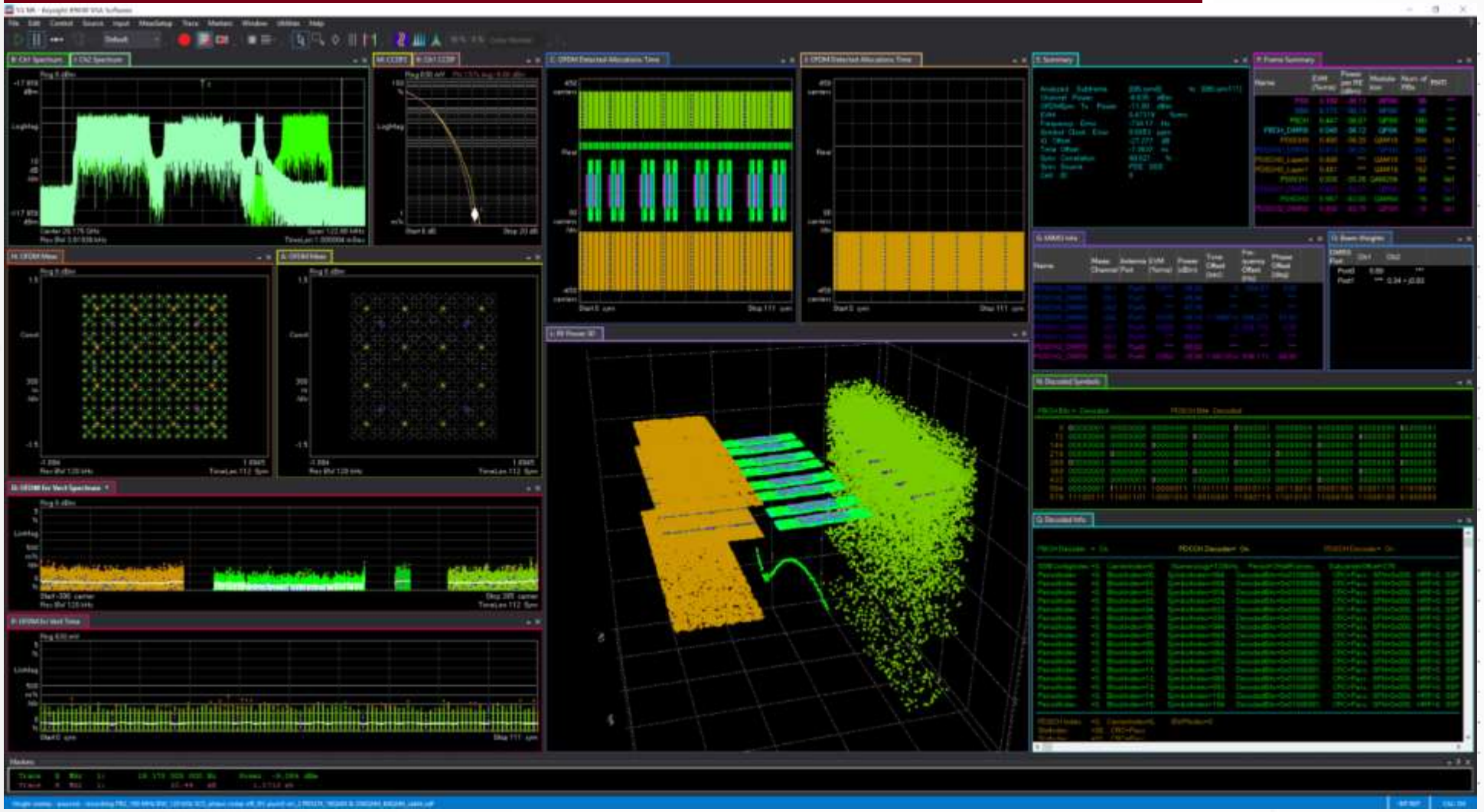
## UXR


50 Ω Terminated

UXR has >8 dB/Hz better noise density

# Multi-Channel 5G Testbed for NR FR1 and FR2

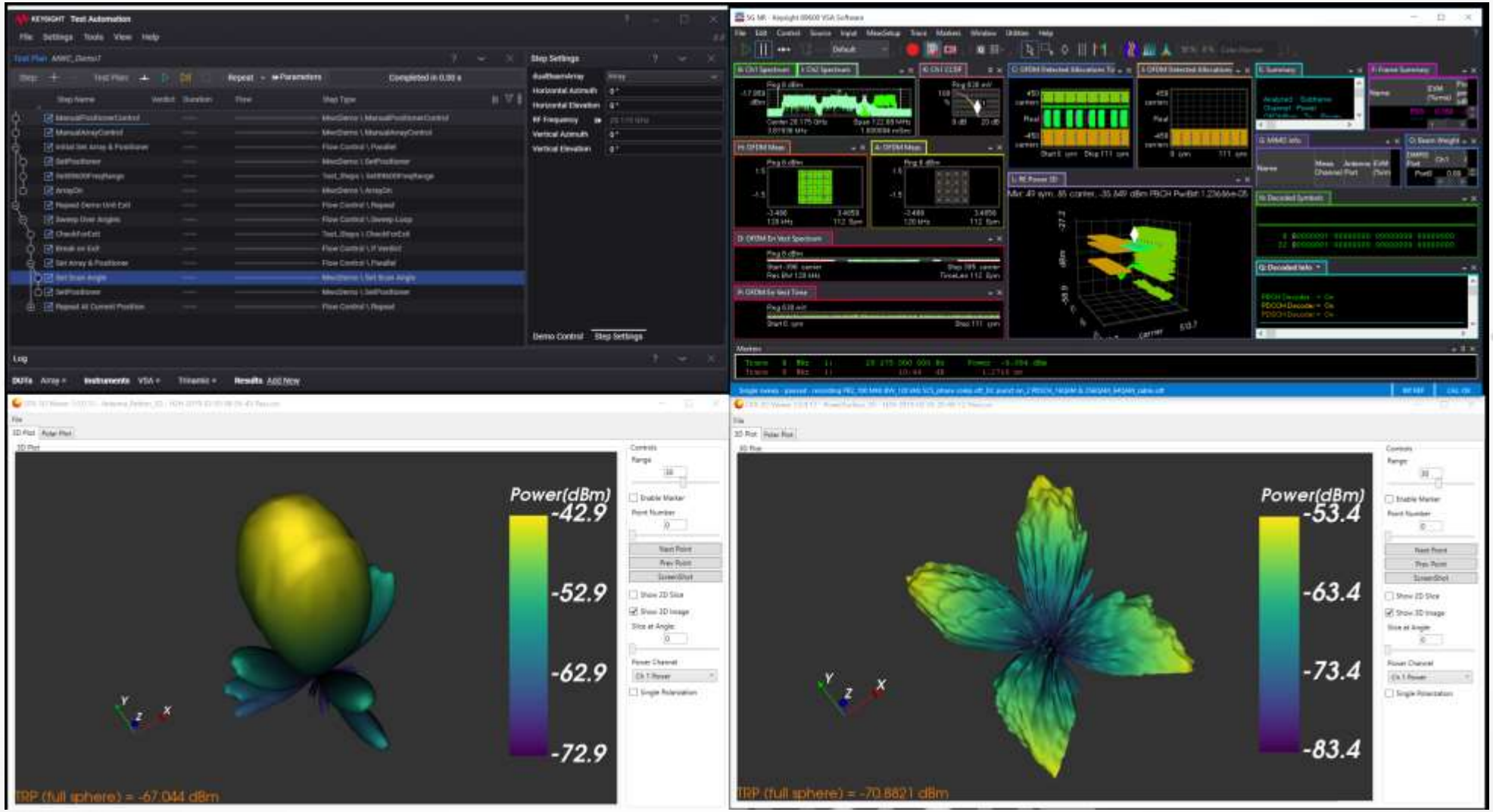
## VSA MEASUREMENT DETAIL



# VSA Demo

# Multi-Channel 5G Testbed for NR FR1 and FR2

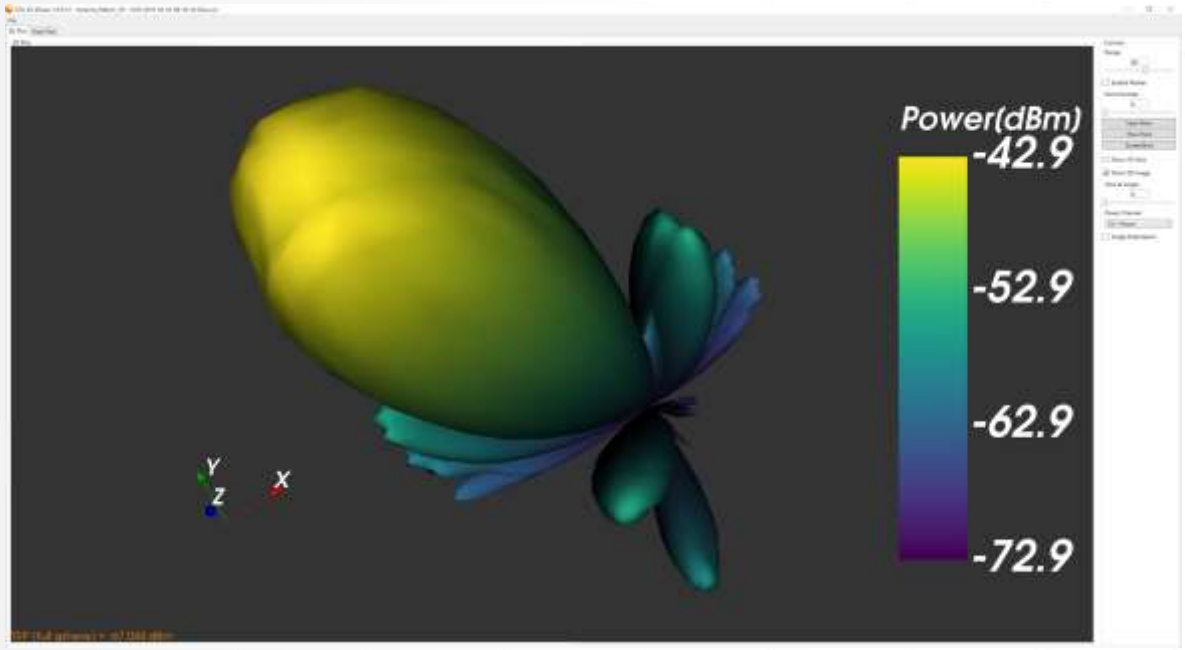
## ADDITIONAL MEASUREMENTS



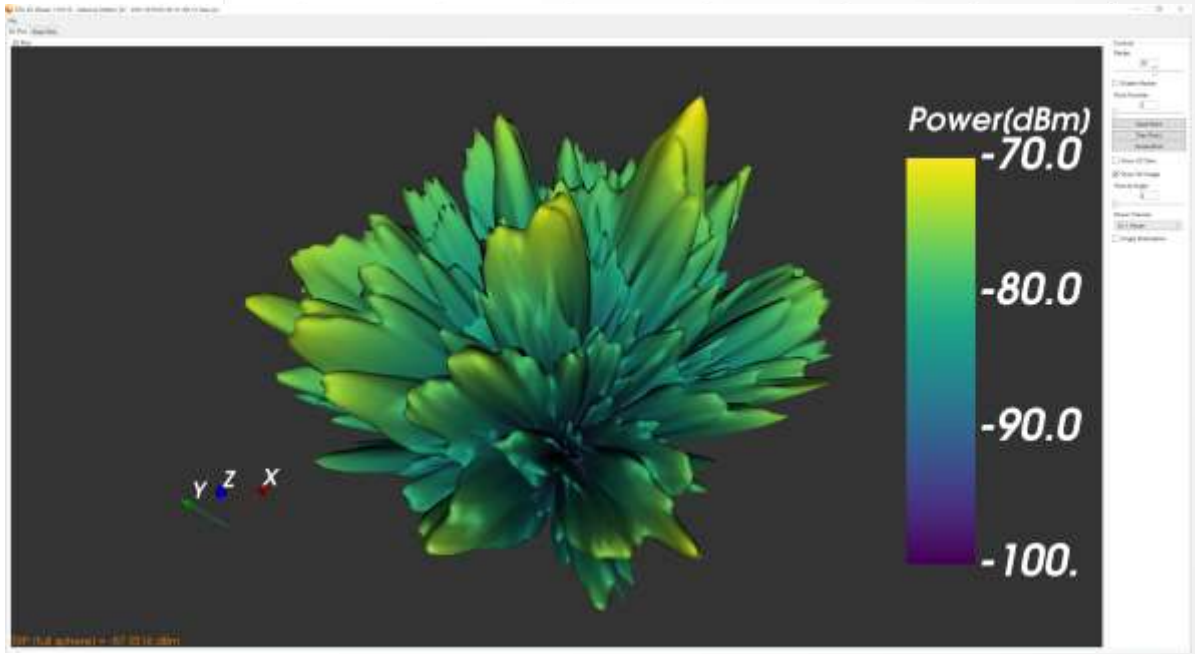
# Multi-Channel 5G Testbed for NR FR1 and FR2

## ANTENNA PATTERN

### Antenna Pattern
Transmit H, Receive H



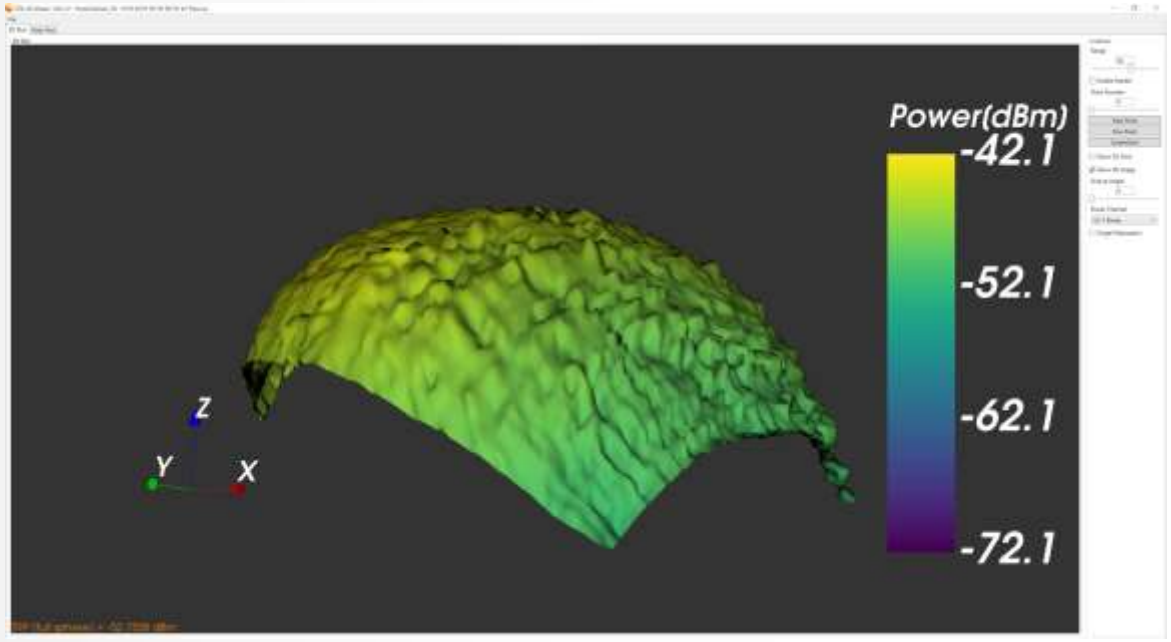

### Antenna Pattern
Transmit H, Receive V



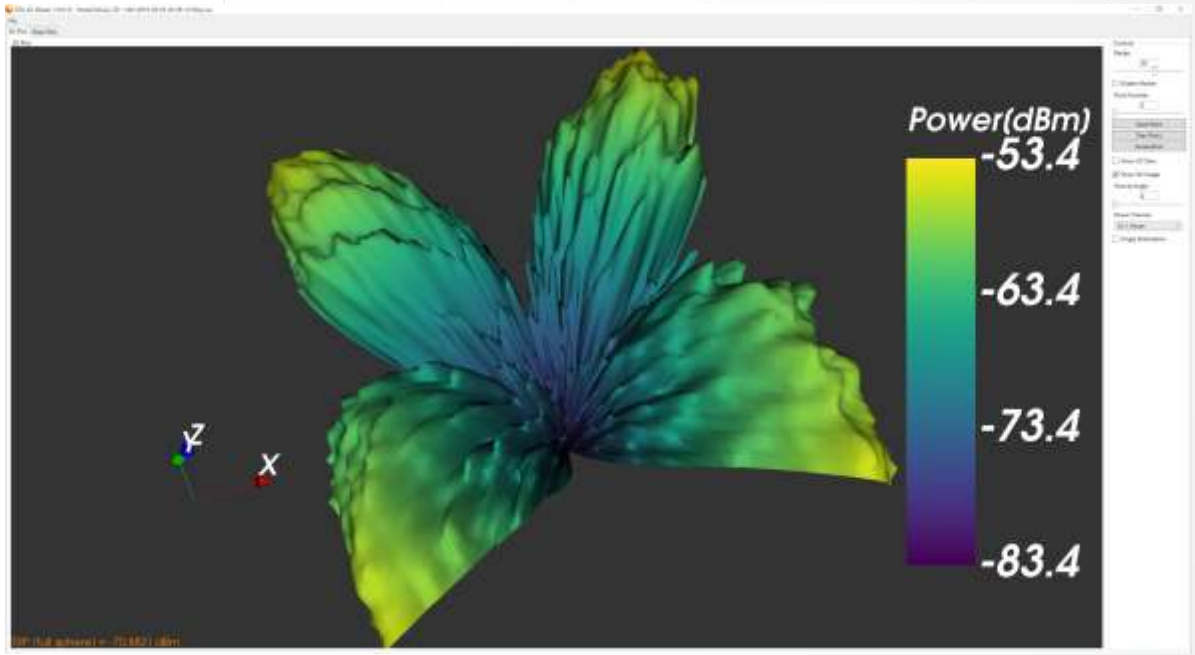
# Multi-Channel 5G Testbed for NR FR1 and FR2

## ADDITIONAL PATTERNS

### Power Surface
Transmit H, Receive H




### Power Surface
Transmit H, Receive V



# UXR Teardown

## THE SIGNAL PATH TAKES A CLOSER LOOK

### Search Signal Path UXR on YouTube

- Independent Blogger looks inside the UXR
  - Performs live measurements
  - Circuit analysis
  - ~1 hr. video
- Recent comments on YouTube
  - ‘All that RF voodoo’
  - ‘That is too far from the electronics.  That is pure witchcraft :D’
  - ‘...had to explain office-mate why I was drooling...’
- https://www.youtube.com/watch?v=DXYje2B04xE&t=1338s

# The End…

## QUESTIONS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