

6G Devices, Applications and Related Measurements Challenges

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- Introduction and technology background
 - What is 6G and why is it considered so important?
- What frequencies are being considered for commercial 6G deployments and other applications
- Practical challenges and solutions for 5G/6G
- Anritsu solutions that are accelerating the fundamental research activities for 6G.
- Disadvantages of 6G

- Technology has surely taken a big leap forward
 - 2G : Voice services and data rates to 384Kbit/s
 - 3G : Data rates of 2 Mbit/s
 - 4G : Data rates to 1Gbit/s
 - 5G : Data rates up to 10Gbit/s
 - Enhanced mobile broadband (eMBB)
 - Ultra reliable and low latency communications (URLLC)
 - Massive machine type communication (mMTC)
 - AI (artificial intelligence and machine learning)
 - 6G coming up : Data rates of the order of 1 Tbit/s
 - Digital twin world,
 - Holographic calls , touch screen will go obsolete, and human would be talking to anything that is electronics !!
 - Non terrestrial network (5G/6G terminals in space)
 - Imaging, sensing, ultraprecision, gas detection etc.)
 - Meta verse – Human to Avatar , Avatar to Avatar (virtual world will exist !!)
 - Extended reality experience through lightweight glasses



- Making use of the spectrum that was available and various modulation techniques, with whatever hardware we could built at the time.
- Lower frequencies – Lesser modulation bandwidth available – lower data rates
- Moving higher in frequencies : mm-wave, wider modulation bandwidth available – higher data rates and other advantages
 - Smaller size of the devices and faster speed of data
 - More number of antennas can be deployed for beamforming – massive MIMO
- Advantages of moving higher in the frequency
 - More spectrum with wider modulation bandwidth available – so more data rates
 - Efficiency is enhanced , less power-hungry devices
 - Smaller size of the devices and components like antennas etc.
 - To overcome the limited gain at higher frequencies new antenna technologies like massive MIMO and beamforming etc. to be utilized to make system have enough gain (practically an advantage)

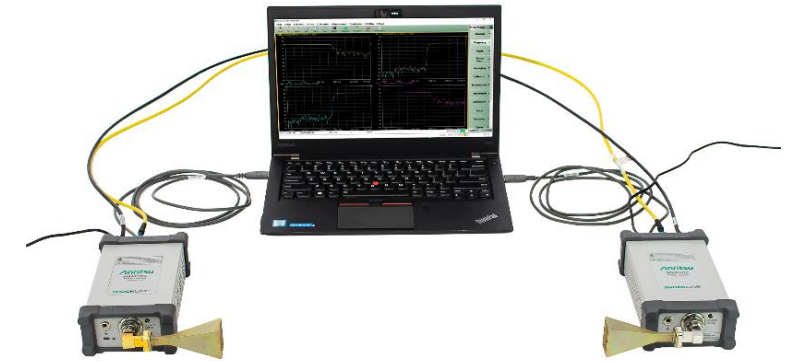
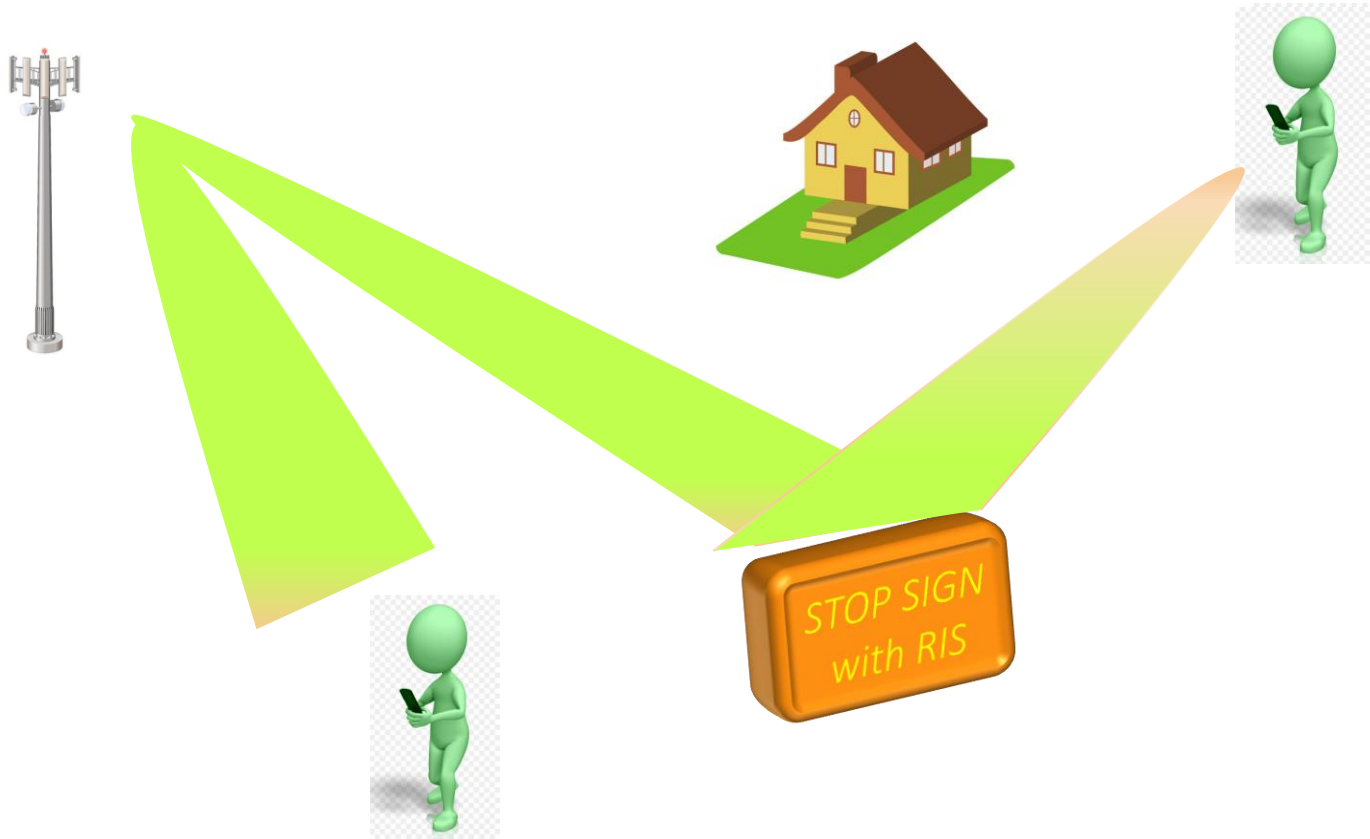
Frequencies being considered for 6G and why?

- Commercial 6G deployment (to support the “on to go” applications)
 - Lower frequencies to support mobile communications
 - Several candidates in the 7GHz to 24GHz range (in 5G we had FR1 and FR2 ranges)
 - **Challenges –**
 - Over the air losses for higher frequencies too high
 - Material characterization
 - **Solutions –**
 - Low-cost base stations with beamforming and higher modulations techniques
 - RIS (Reconfigurable intelligent surfaces)
 - Material measurement solutions (Dk/Df)
 - Research on higher frequencies (Fronthaul/Backhaul , Sensing, imaging etc.)
 - D band (110-170GHz)
 - G band (140-220GHz)
 - **Challenges**
 - Accurate and precise device characterization of fundamental devices – Amps/filters/mixers
 - **Solution**
 - New instrumentation to support measurements

Lower Frequencies

Reflective Intelligent Surface

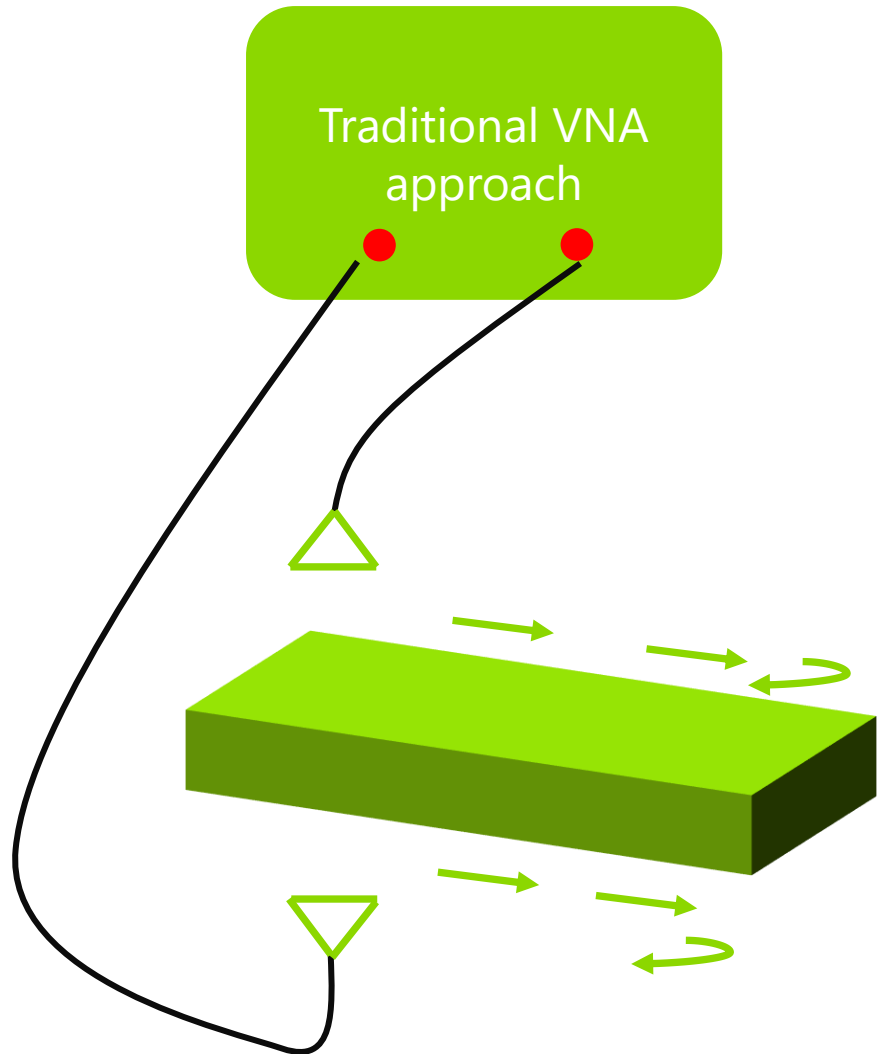
- Beyond 5G and 6G would need new devices to take care of the signal propagation at extreme high frequencies.
- The biggest research area right now is focused on two things
 - Channel sounding : How would 6G signals react to the propagation channel and
 - Reflective intelligent surfaces and on antenna on display.



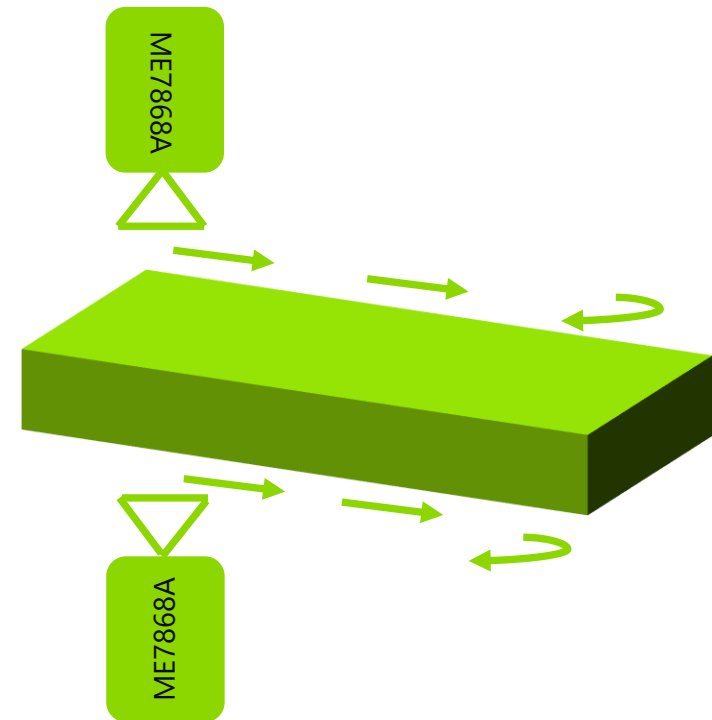
ME7868A - 2 port distributed VNA system

- Two ports of the VNA's separated by long distance
5m/25m/50m/75m/100m
- Full 2 port Vector corrected S parameter measurements
 - Magnitude and phase
- Ideal for testing
 - RIS
 - Channel sounding
 - Antenna measurements in Anechoic chambers
 - Outdoor antenna test ranges

Long, lossy and phase instability leading to erroneous results

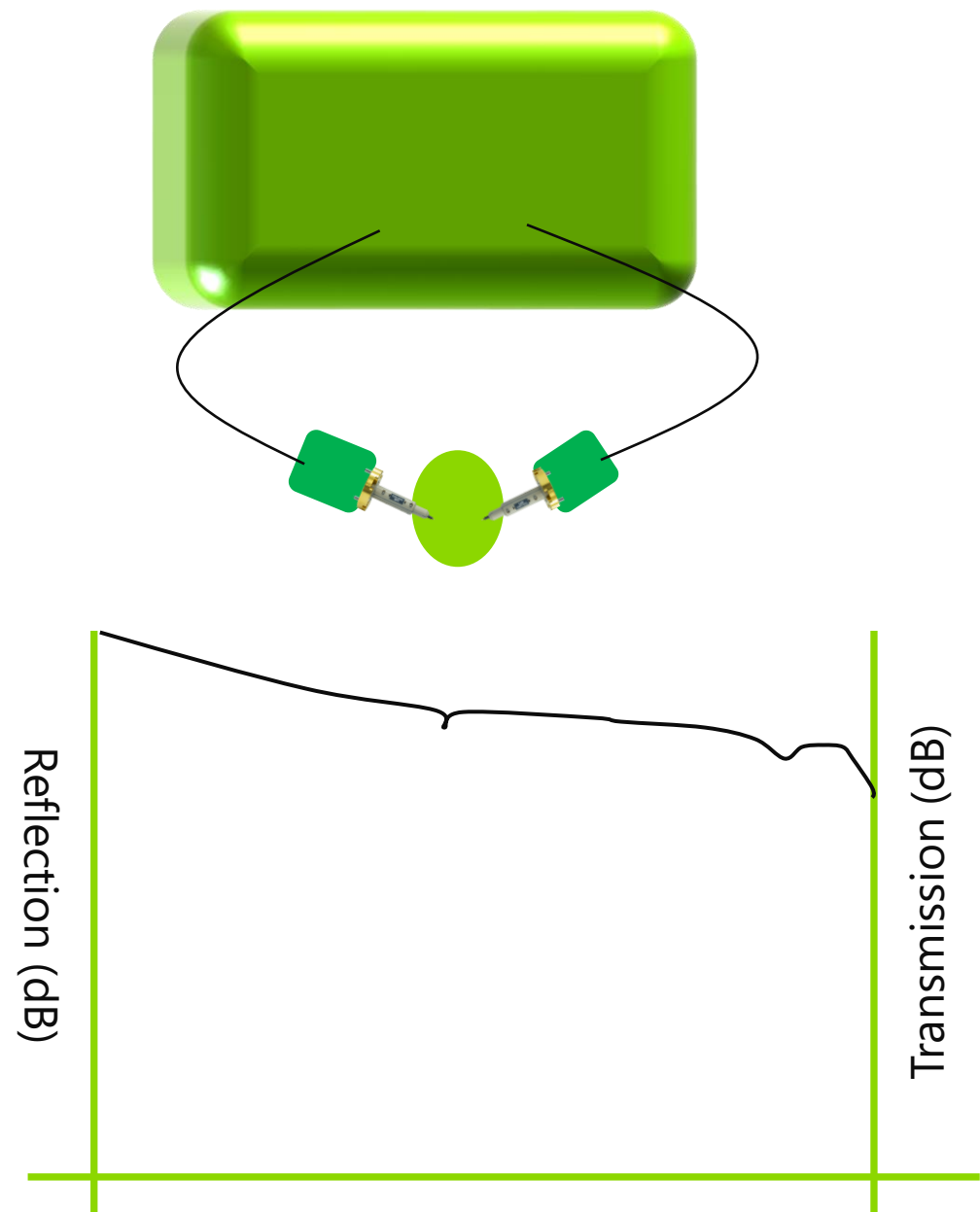
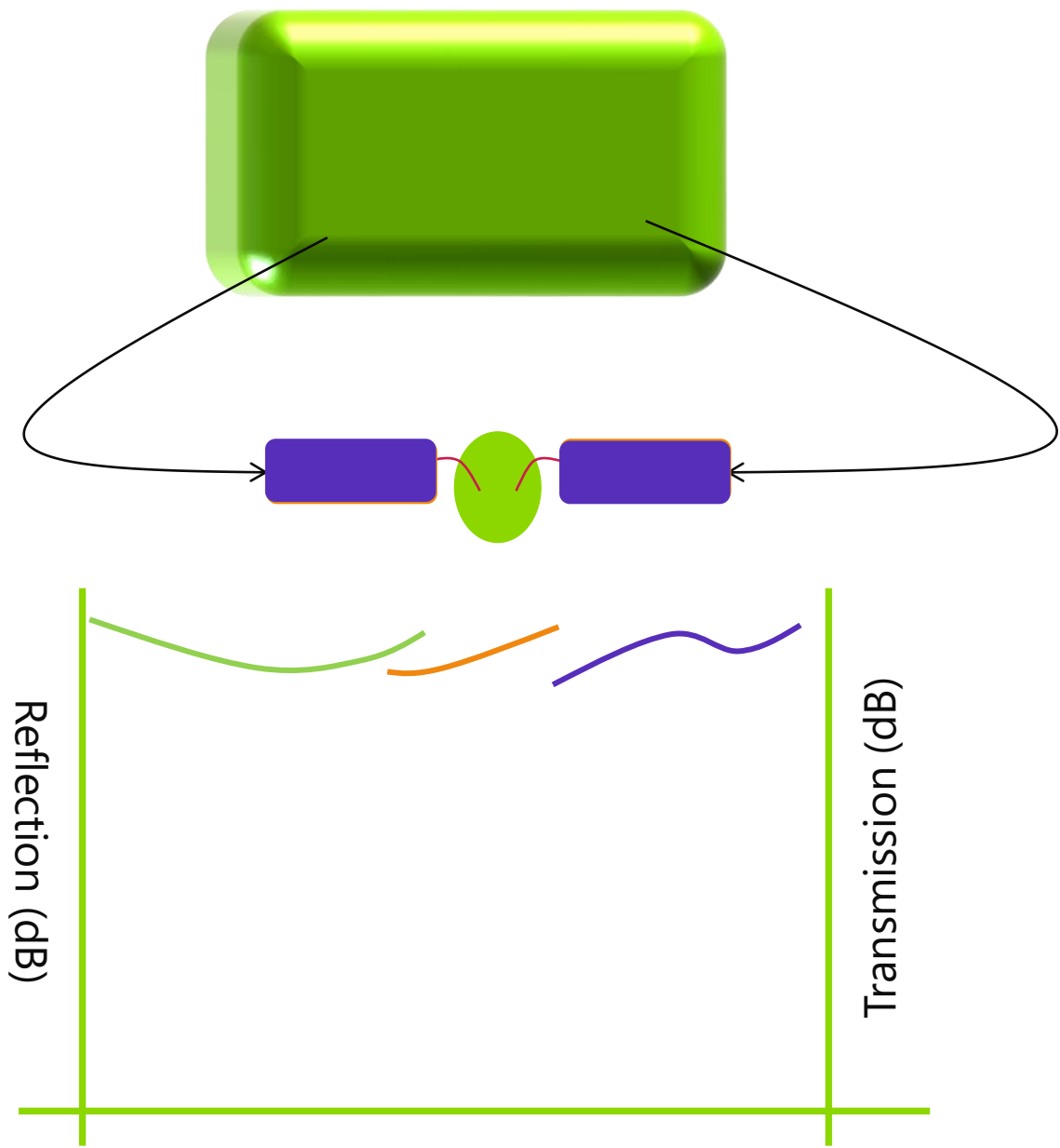


Anritsu Modular distributed VNA – no long cables, direct connection with material under test



Higher Frequencies – Challenges and solution

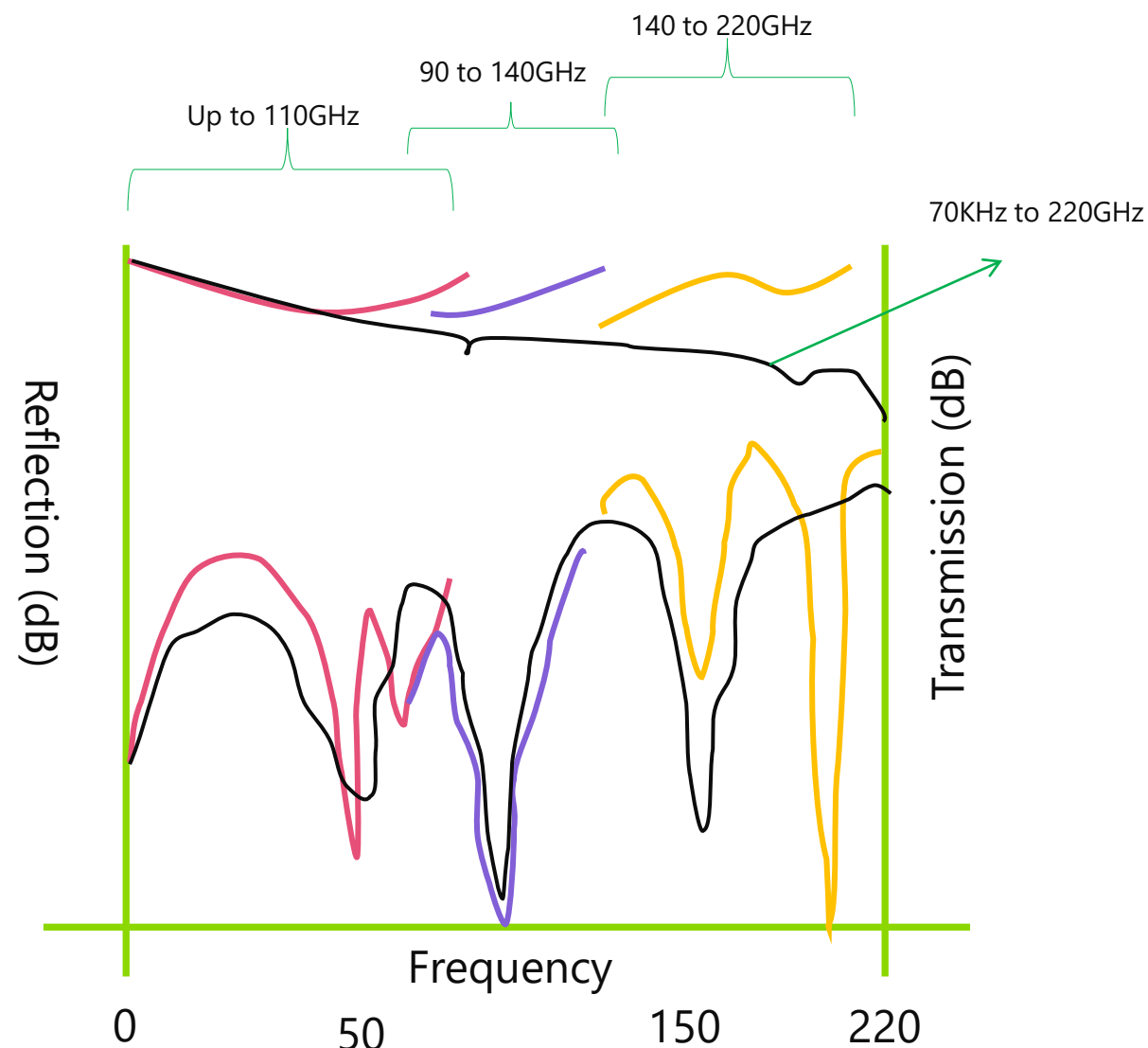
Challenges and solution of Device characterization



How does it work today? What are the solutions

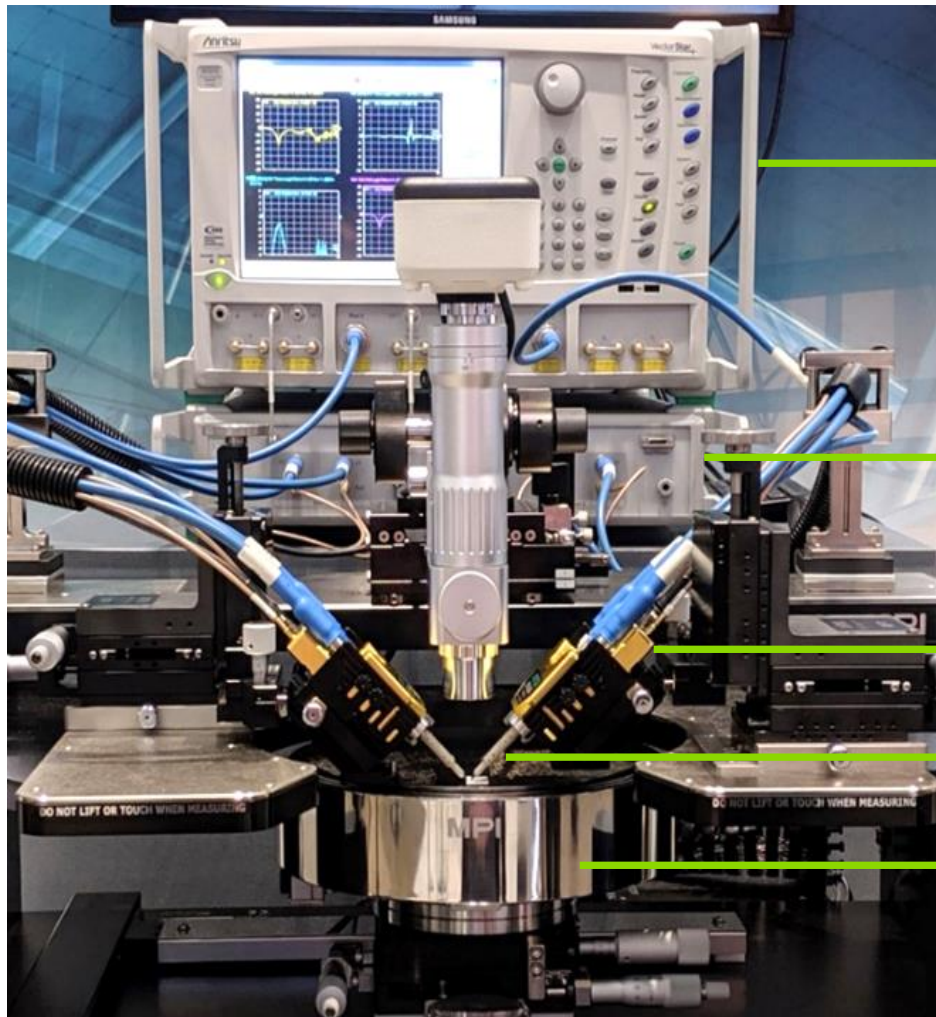
Existing solution

- Banded measurements being stitched together to see a wideband response, several challenges
 - Multiple mm-wave module setup and calibration
 - Time consuming, costly and error prone
 - Poor calibration and time stability in measurements
 - Repeated touchdowns on the device leads to repeatability issues and probability of damaging the device/ probes etc. is very high
 - Mm-wave modules are big/bulky to be setup on a probe station – physical challenges
 - Cables (co-axial) or waveguide bends are required at higher frequency to connect the probes and the mm-wave modules – leads to dynamic range reduction , magnitude and phase variations, causes stability issues and costly.



Anritsu Single sweep 70KHz to 220GHz – Single ended and differential

Anritsu ME738G – 70KHz to 220GHz



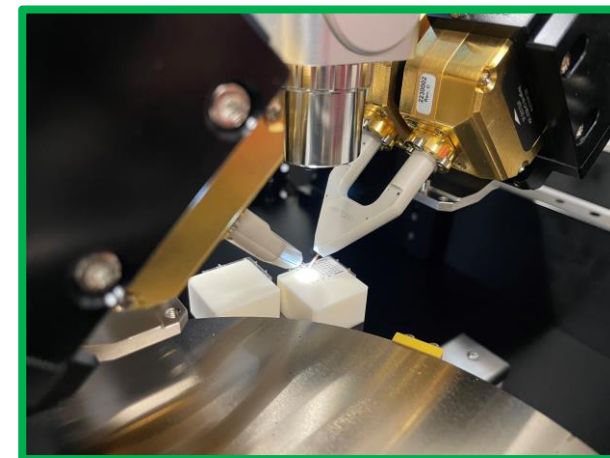
→ Vector Network Analyzer

→ Broadband Test set

→ Anritsu mm-wave modules

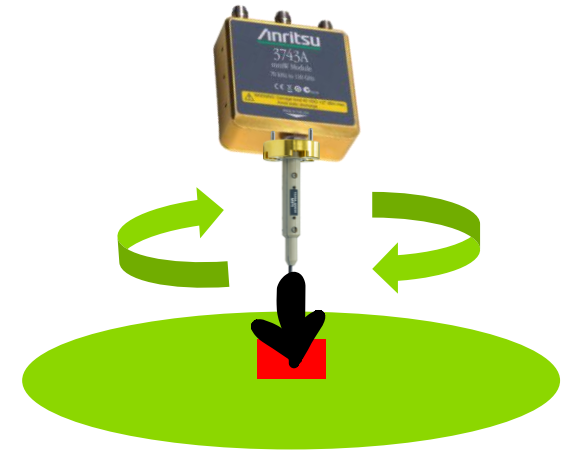
→ 220GHz probes

→ Probe station



Antenna measurements at extreme high frequency ranges

- AoC - Antenna on chip , AiP – Antenna in package needs to be characterized.
- There are several ways by which these antenna measurements are made. In chambers (Far field measurements) and on the chip itself (NF to FF analysis).
 - In case of FF : An anechoic chamber is required and the distance between the Tx and Rx several meters
 - In case of NF to FF : near field measurements are taken and then processed for FF measurements.





- To support the high data rates for 5G/6G, there would have to be enhancements done for chip-to-chip communication/ data centers etc.
- The computation rates today are reaching the rates with which the chips communicate with each other, hence a faster way of transferring data from one chip to the other is required.
- Opto-electronics is the key enabling technology for this
 - Electrical to optical Modulators
 - Optical to electrical converting photodetectors.
- The modulators needs to be wider bandwidth – a minimum of 70GHz and beyond (110GHz)
- These modulators and photodetectors are all on chip as TOSA, ROSA and BOSA.
- On wafer Opto-electronic device characterization is hence a must to perform. VNA's can perform this functionality
- Advanced De-embedding tools are required as one side is Optical probing and the other is RF probing

