SWTEST

PROBE TODAY, FOR TOMORROW

5G Means Higher Frequency, Higher RF Port Count, and Higher Parallelism

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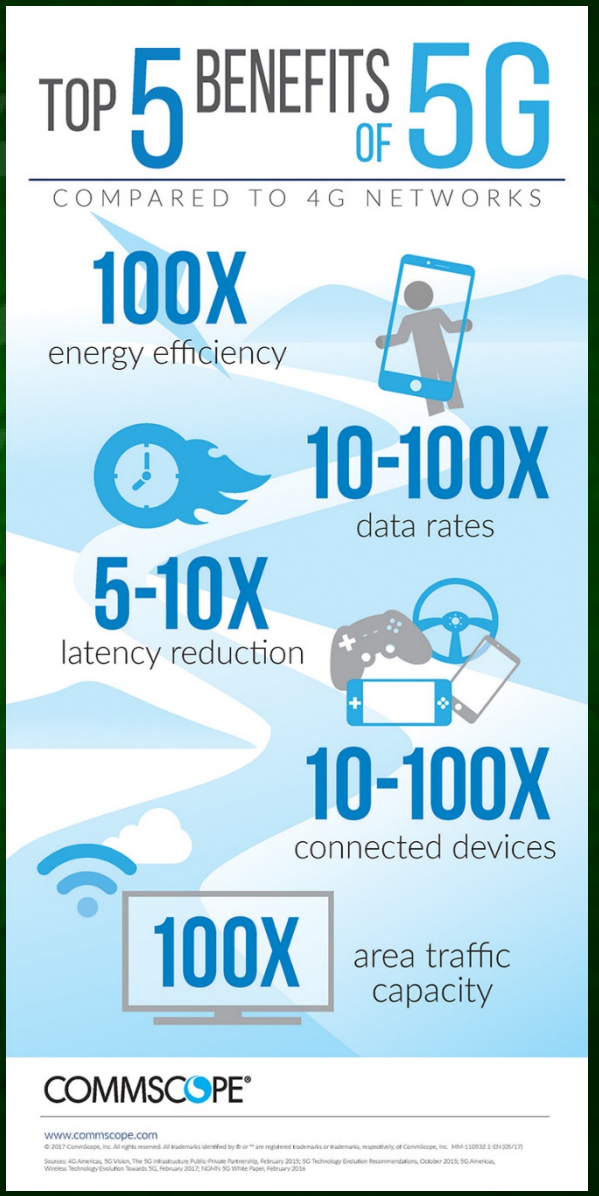
Agenda

- 5G Frequencies Bands
- Market Survey
- Frequency vs. Wavelength
- Probe Card Example
- Probe Card S-Parameters
- Measurement Method
- Need for Higher Parallelism
- Conclusion

5G, Everybody is talking about it

- **There is a lot of excitement about 5G, the 5th generation of mobile networks.**
- **Faster data rates, higher frequencies**
- **Quicker – less latency**
  - Source: https://www.commscope.com/NewsCenter/Infographics/Top-5-Benefits-of-5G/



5G, Frequency Bands

- **Frequency range 1 (FR1) of 5G covers the expected frequencies and protocols below 6 GHz.**
- **Frequency range (FR2) which starts at 24 GHz and goes up to 40 GHz or higher.**
  - For simplicity sake, the major frequency bands are referred to as 28 and 39 GHz.
  - These millimeter wave signals are processed through a separate RF path and dedicated chips.

New, Higher Frequencies

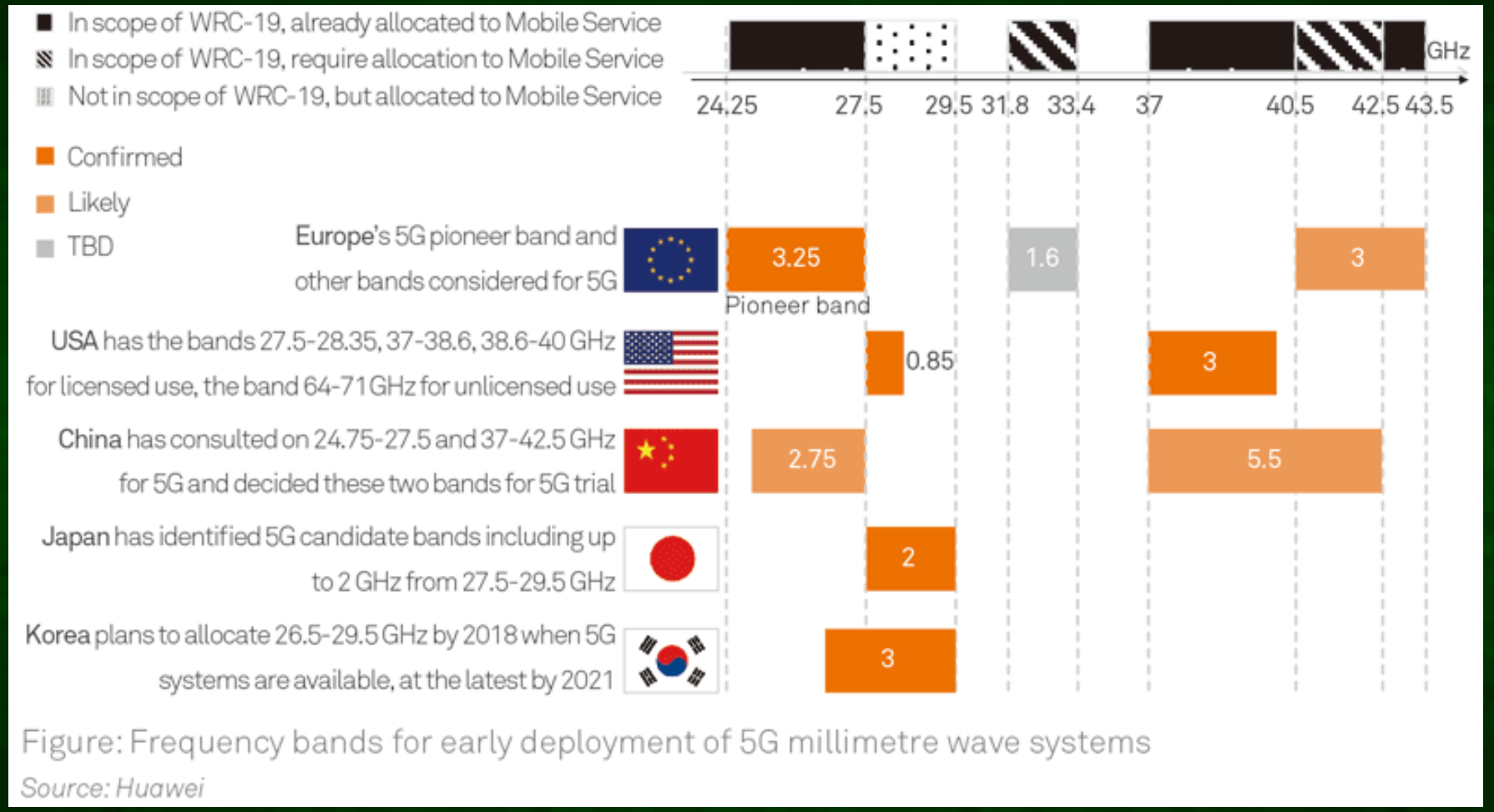


Figure: Frequency bands for early deployment of 5G millimetre wave systems

Source: Huawei

Source: https://www.huawei.com/nz/about-huawei/public-policy/5g-spectrum/need-for-globally-harmonised-5g-spectrum

5G Transceiver Market Survey

Per Die	Average	Standard Dev
RF Count	32	0
Solder Balls	393	187
Die Area (mm^2)	23.0	1.5
RF Signal Density	1.4/mm^2	0.1
Die Area/RF	0.7 mm^2/RF	0.05

28 and 39 GHz Wavelengths

- Higher frequency means shorter wavelengths and resonant structures
- Good for antennas in packages
- More difficult for PCB design

Frequency	Dielectric constant	Wavelength
28 GHz	1	10.714 mm
28 GHz	4	5.357 mm
39 GHz	1	7.692 mm
39 GHz	4	3.846 mm

- Dielectric constant of 4 results in propagation velocity ½ of the speed of light
- Ignore structures less than 1/10th of the wavelength

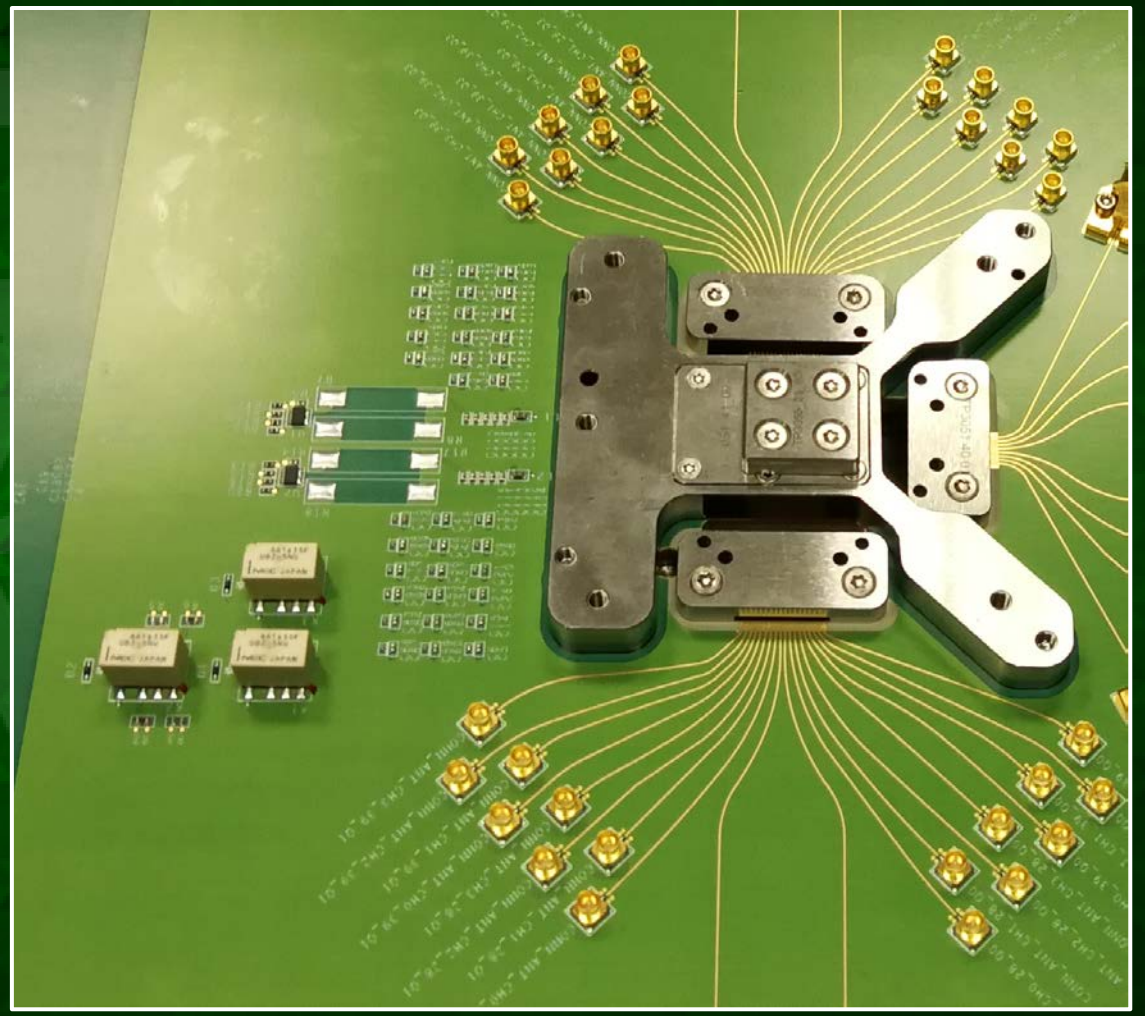
Higher Frequency Probe Cards

- **Simple. Just make everything smaller**

- **Challenges**
  - Reasonable path lengths for space transformation
  - Reasonable path length to reach components or connectors
  - The wavelength is nearly the same as common RF needle or spring pin lengths
  - Smaller structures that are mechanically compliant
  - Smaller structures that are repairable

Technoprobe Solution for 5G

- **Technoprobe Probe Card for 5G**
  - V93000 Wave Scale tester
  - Direct-Probe™ interface
- **32 RF signals for 5G**
  - SMPM connectors
  - 28 and 39 GHz



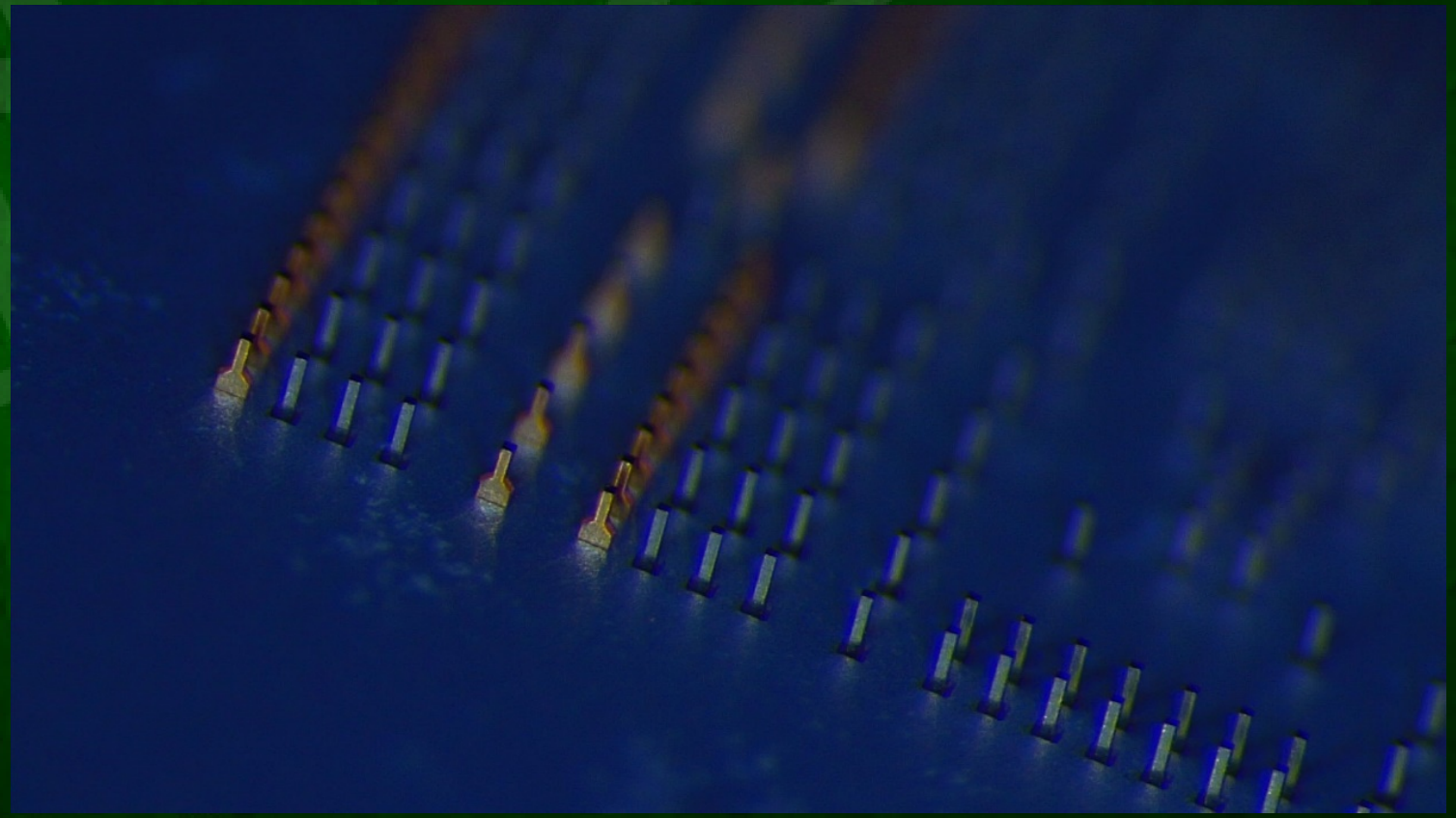
Technoprobe Solution for 5G

- **Optimized TPEG™ MEMS probe has been designed for RF applications**
- **TPEG™ MEMS RF probe allows designs with high parallelism**

PARAMETER	RF
Tip shape	Flat or pointed
X/Y Alignment	±10 µm
Z planarity	Δ 20 µm
Min pitch	100 µm (linear)
Max OT	70 optical
Force at 75 µm (3 mils) OT	2 or 4.5 g depending on application

Technoprobe Solution for 5G

- **TPEG™ MEMS RF needles can be coupled with standard TPEG™ MEMS technologies depending on application such as**
  - TPEG™ MEMS T3
  - TPEG™ MEMS S90
  - TPEG™ MEMS XS90
  - Etc…

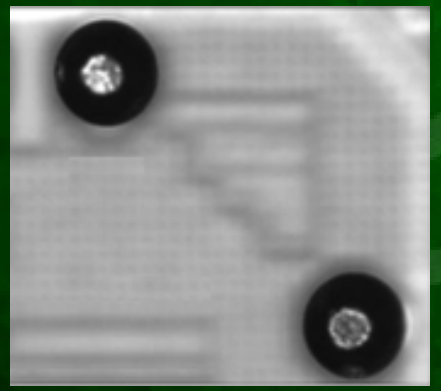


Technoprobe Solution for 5G

- **TPEG™ MEMS RF probe marks on bump compared with other TPEG™ MEMS:**

5TDs Overdrive 45 µm

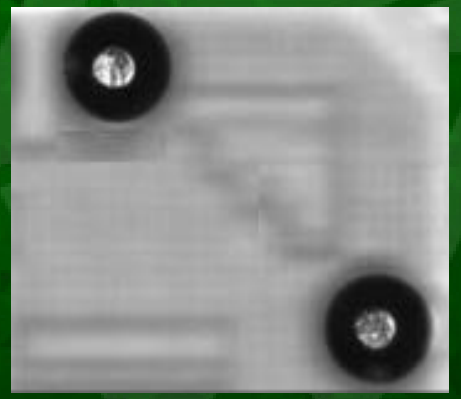
TPEG™ MEMS S90



RF

5TDs Overdrive 60 µm

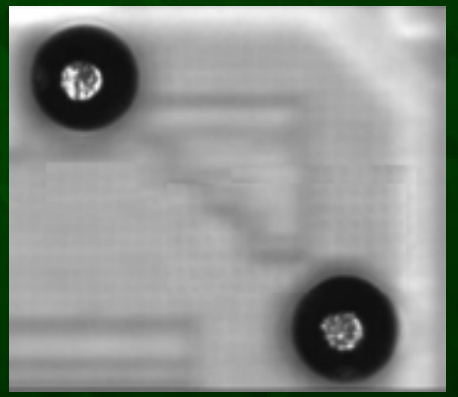
TPEG™ MEMS S90



RF

5TDs Overdrive 70 µm

TPEG™ MEMS S90

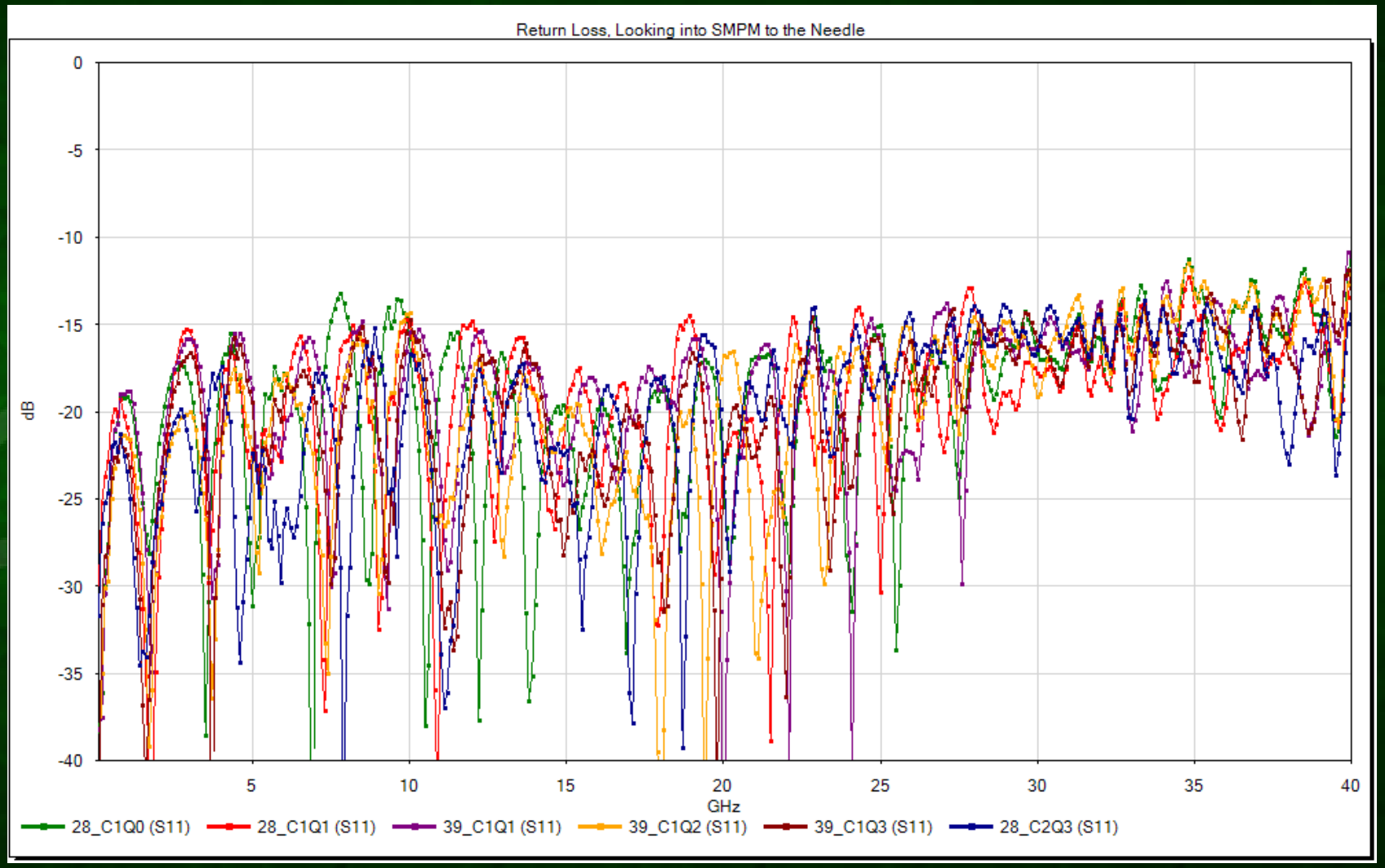


RF

- **Scrubs are same in shape, alignment and depth**

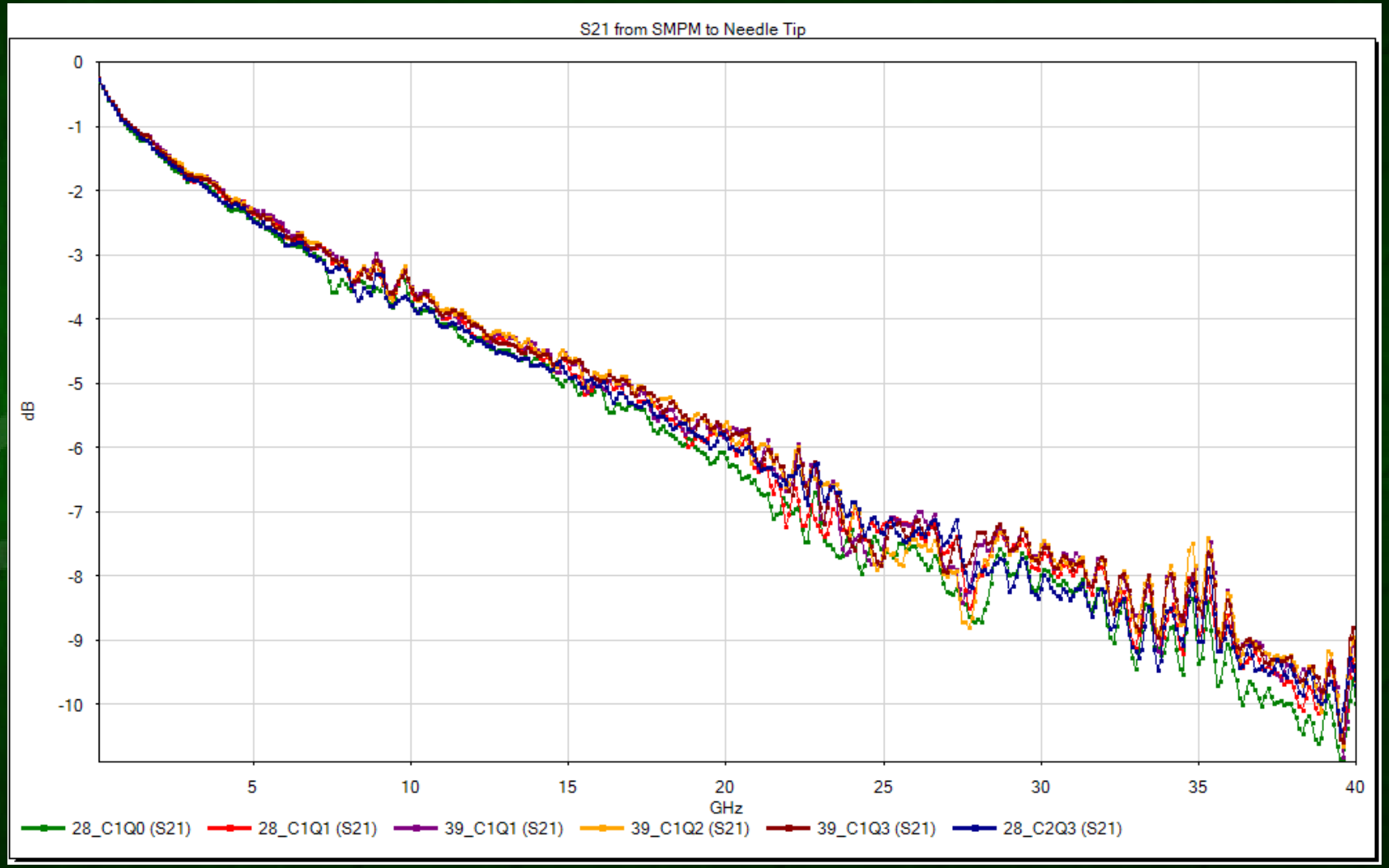
Technoprobe RF Probe Card Measurements

- **Return loss into SMPM connectors on the PCB**
  - Meets a return loss spec of -10 dB through 40 GHz



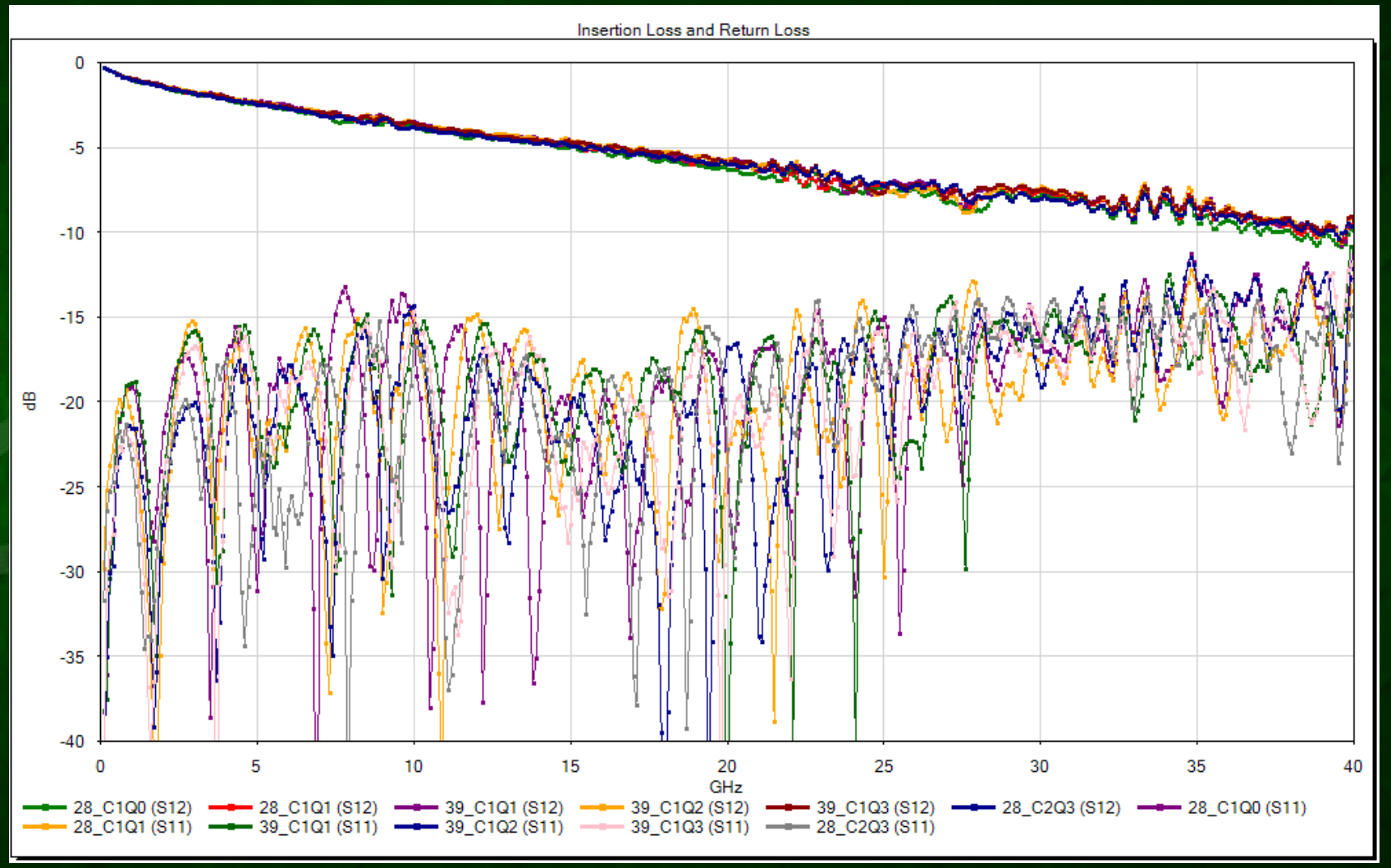
Technoprobe RF Probe Card Measurements

- **Insertion loss (S21) from SMPM to the probe tip**
  - Smooth, linear
  - Very small resonances



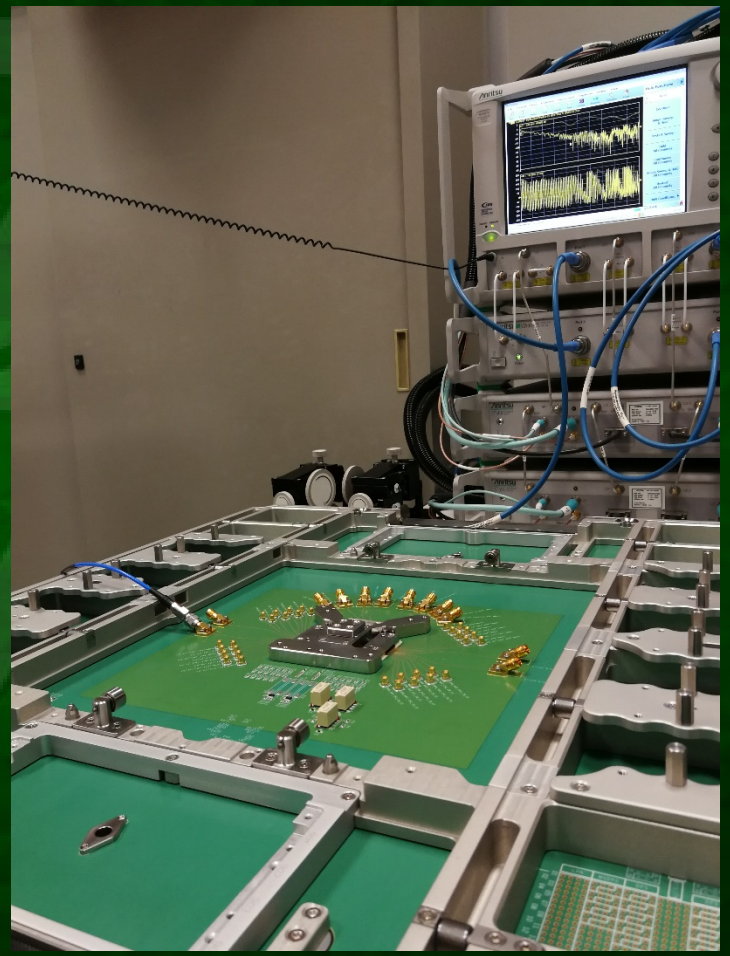
Technoprobe RF Probe Card Measurements

- **Return loss into SMPM connectors on the PCB**
  - Better than -10 dB through 40 GHz
- **Insertion loss**
  - Linear
- **Margin exists between insertion and return losses**



Measurement Method

- **Equipment**
  - Anritsu VectorStar 4 Port, 110 GHz VNA
  - Calibration substrate
    - Custom with short, open, and load (SOL) standards to match the device pattern



Measurement Method

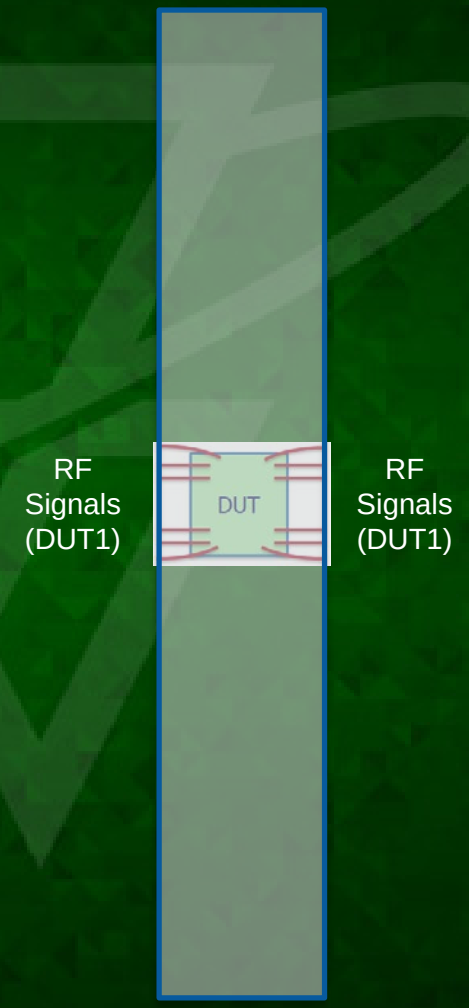
- **Calibrate to the cable ends using coaxial SOL standards**
  - Attach cables to the probe card
- **Calibrate to the needle tips with SOL standards on a ceramic substrate**
- **Use network extraction to find the difference between the two sets of calibration data**
  - The difference is the s-parameters of the path on the probe card

Growth

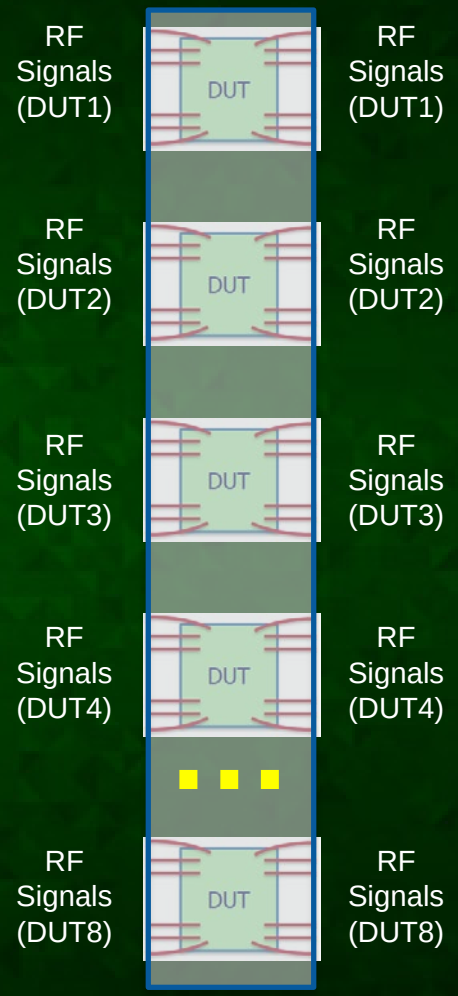
- **Indications are that there will be at least 2 RF transceivers for FR2 signals per cell phone. Also, the cells for these frequencies are small, meaning more cells and infrastructure per unit of area.**
- **Combining a steep ramp in production for a new protocol, dense infrastructure, and multiple devices per phone means there are significant advantages for multi-DUT testing.**
  - Any probe technology for this market needs to be able to scale as high as the tester resources will allow.
  - It could easily be x8 in production.

Technoprobe RF Multi-Site Capability

- **RF space transformer architecture is designed to easily extend single site to multi-site capabilities while maintaining the same RF performance across all sites**



x1



x8

Conclusion

- 5G means higher frequency, more RF ports, and requires high parallelism
- Vertical MEMS probe cards are proven for high parallelism, fine-pitch arrays, and high pin count
- This technology has been adapted in the Technoprobe RF architecture to allow testing of 5G millimeter wave transceivers using direct electrical connections to all of the many RF ports per die and the at millimeter wave frequencies

Thanks for your Support !

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Questions

- **Thank you for your attention**