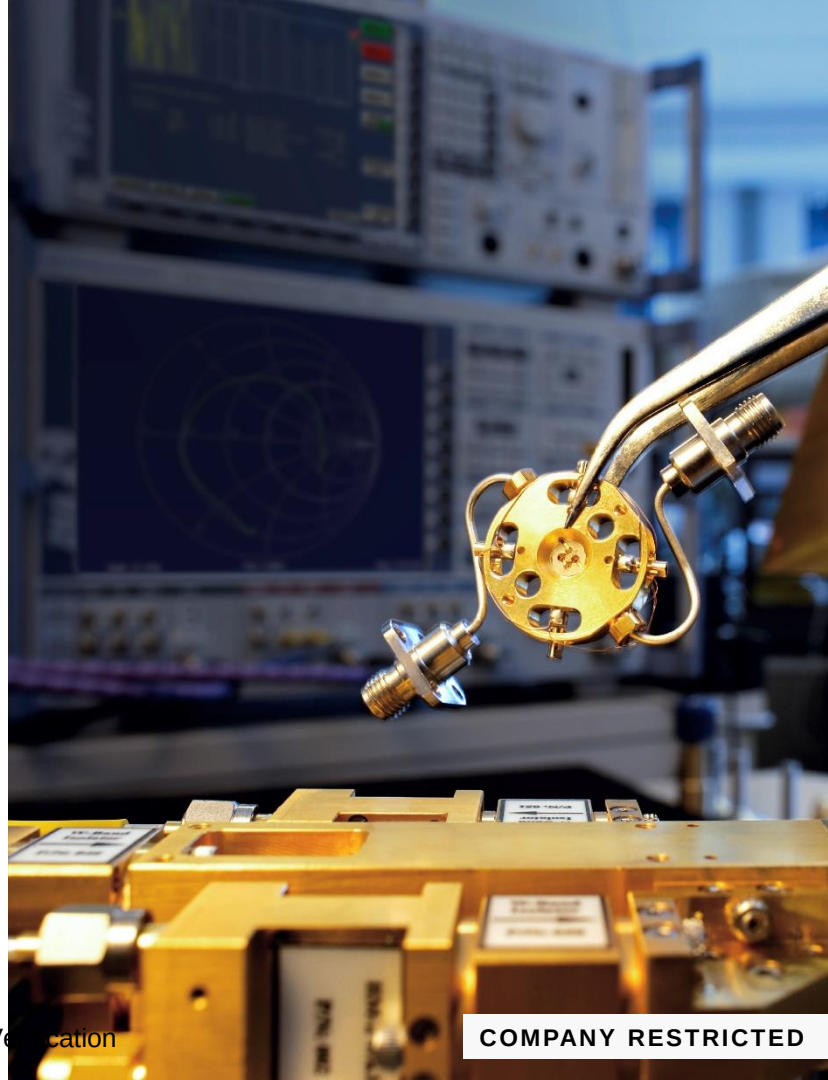
# SUB-THZ CHIP COMPONENT ANALYSIS AND VERIFICATION

Bryant Hsu
Product Manager
Business Development & Marketing Dept.

ROHDE&SCHWARZ
Make ideas real

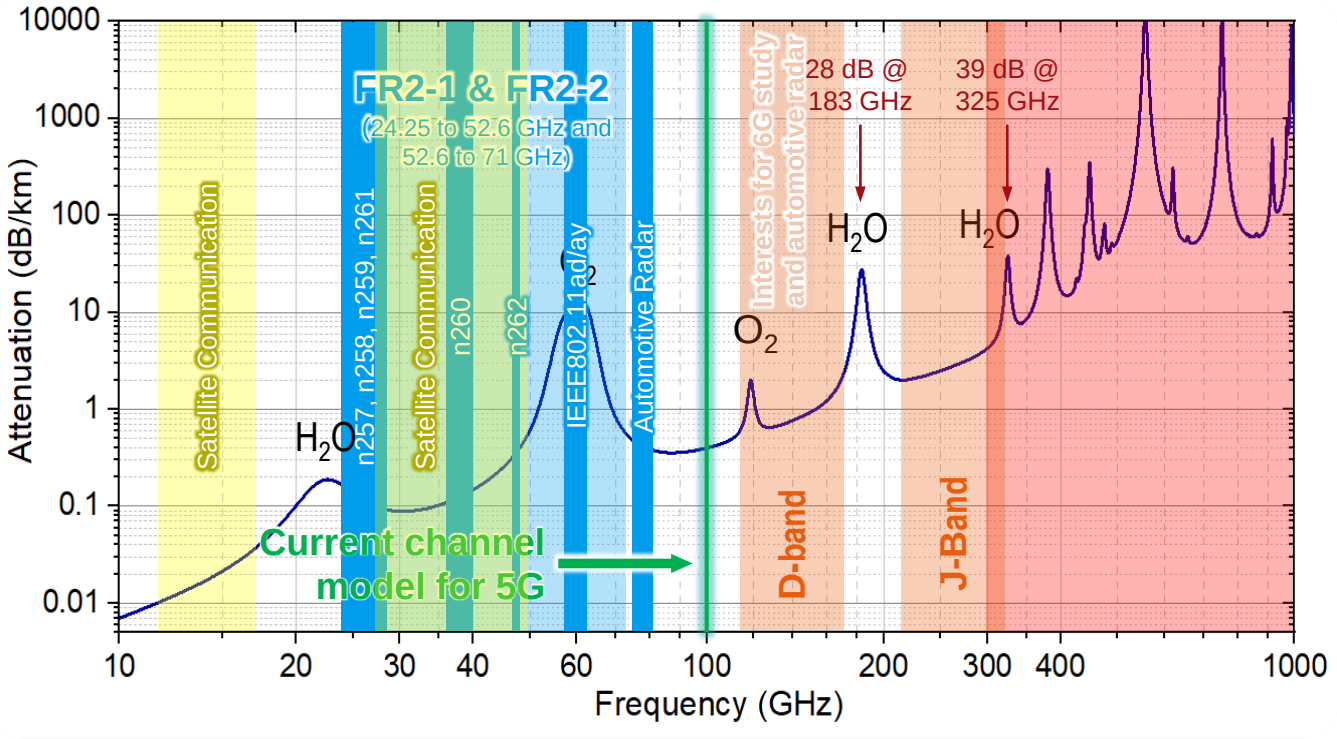
# OUTLINES

- Overview of Sub-THz Radio Communication
- Sub-THz Chip Component Analysis Challenges
- Measurement for Sub-THz Devices
- Conclusions



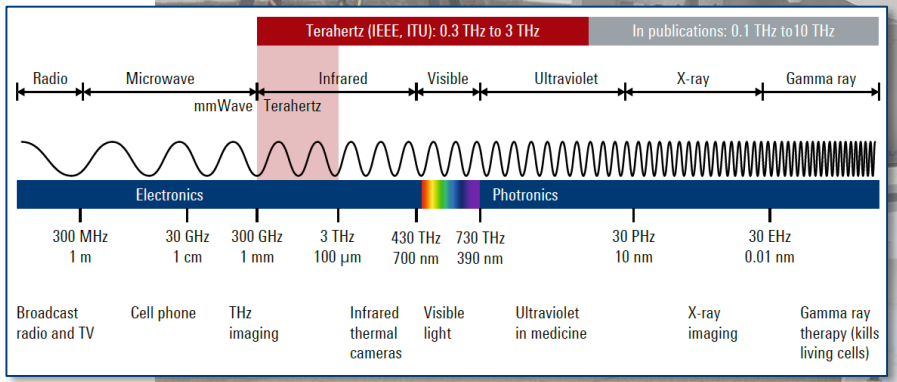
# SUB-THZ SPECTRUM OUTLOOK

- High attenuation in higher frequency region for gas molecular rotational and vibrational transitions of weak bonds.
- Low energy: does not initiate changes in chemical structure.
- The existing spectrum is getting crowded below 100 GHz



# POSSIBLE SUB-THZ WAVE CANDIDATES

- Mobile – 5G FR2 or beyond
- Wireless – 802.11ad/ay
- Satellite – Ka/Q/V-band
- Automotive radar – E-band
- Remote Sensing
  - Human Emotion or Gesture Detection
  - Forest Fire Warning
  - Water Level Sensor
- Radar Imaging
  - QPS Security Scanner
  - QAR Radome Tester
  - Cloud Radar



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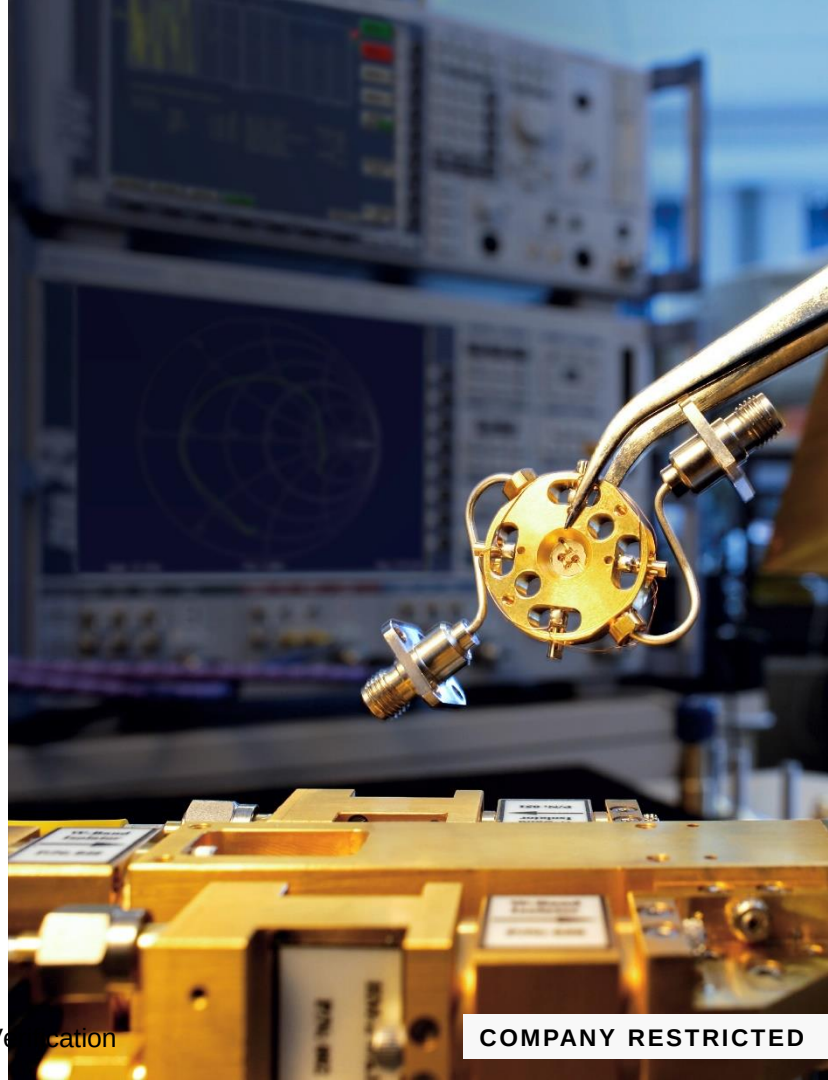
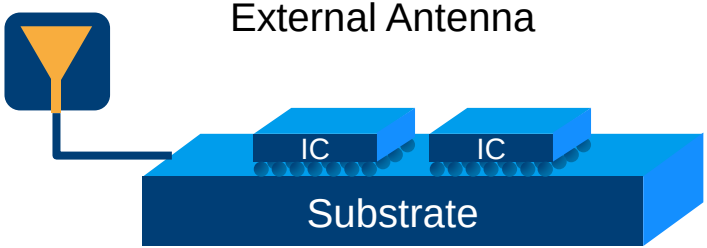
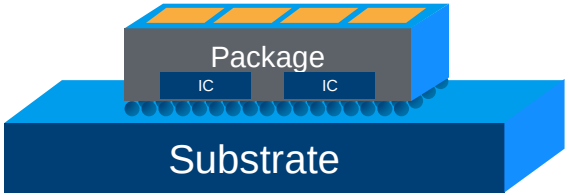


# TECHNOLOGY EVOLUTION

External Antenna

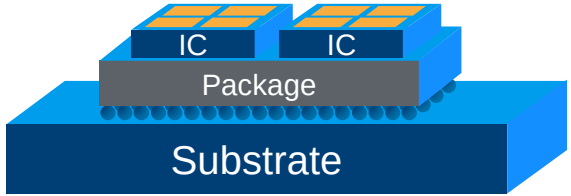



Antenna in Package




Embedded Antenna


Antenna on Chip



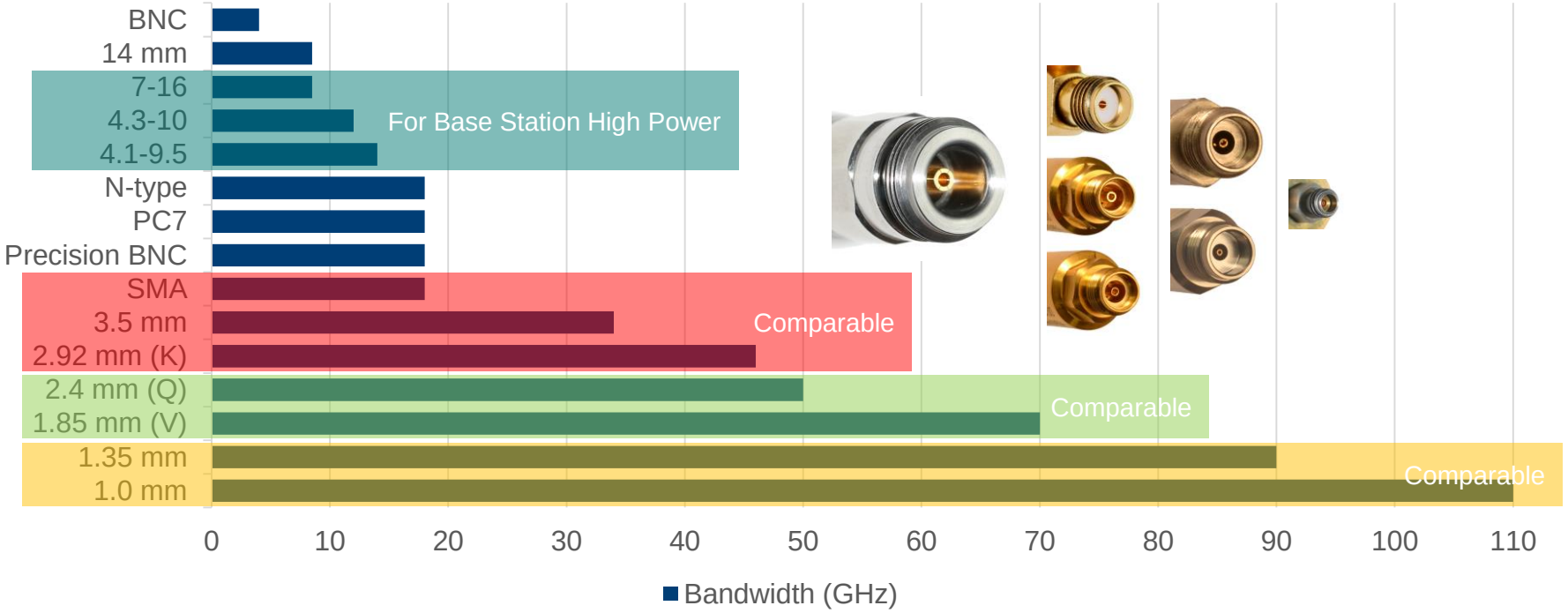

Conventional Design
Large devices: BTS, CPE

Embedded Design > 20 GHz
Portable devices: Phone, Tablet

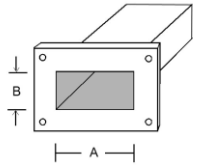
AiP < 100 GHz
5G Phone, User terminal

AoC > 100 GHz
Beyond 5G/6G

# STANDARD COAXIAL INTERFACE



# WAVEGUIDE INTERFACE

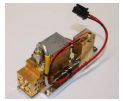

| Waveguide Name MIL | Waveguide Name IEEE | Waveguide Dimension (in) | Waveguide Dimension (um) | $TE_{10}$ Cut Off Frequency (GHz) | Frequency Range (GHz) | Operation Band |
|---|---|---|---|---|---|---|
| WR62 | | 0.622 x 0.311 | | 9.49 | 12.4 – 18 | Ku |
| WR28 | | 0.28 x 0.14 | | 21.1 | 26.5 – 40 | Ka |
| WR15 | | 0.148 x 0.740 | | 39.9 | 50 – 75 | V |
| WR12 | | 0.122 x 0.061 | | 48.4 | 60 – 90 | E |
| WR10 | WM-2540 | 0.100 x 0.050 | 2540 x 1270 | 59.014 | 75 – 110 | W |
| WR6.5 (WR6) | WM1651 | 0.065 x 0.0325 | 1651 x 825.5 | 90.791 | 110 – 170 | D |
| WR1.5 | WM-380 | 0.0150 x 0.0075 | 380 x 190 | 394.46 | 500 – 750 | |
| WR1 | WM-250 | 0.0100 x 0.0050 | 250 x 125 | 599.58 | 750 – 1100 | |

# SUB-THZ WAVE TESTING

Generator

Continuous wave?
Modulation signal?

Test items:
Output power
Linearity
Spurious
Stability
Signal quality
Sensitivity
Frequency offset
EVM
…



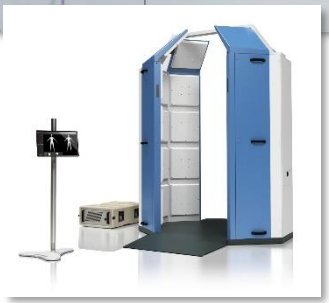
Analyzer

# MEASUREMENT IN SUB-THZ PRODUCT DEVELOPMENT

Component Design

Circuit Integration

Performance Verification



Product development flow

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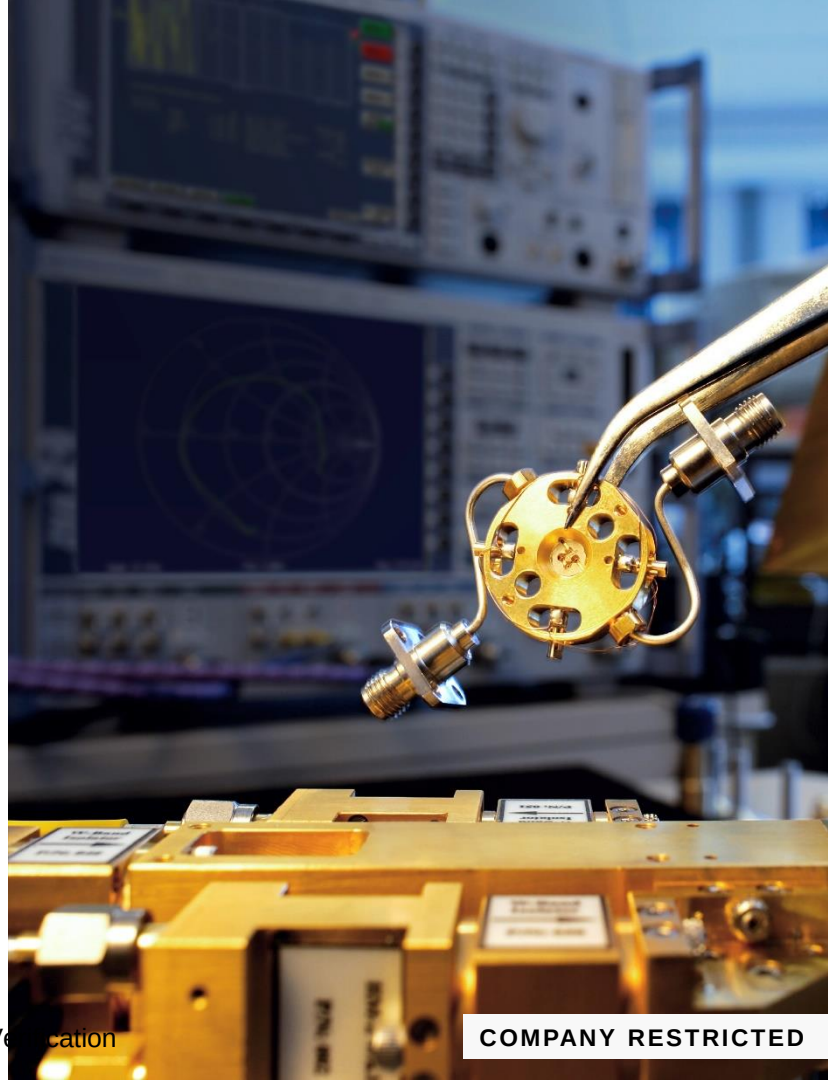
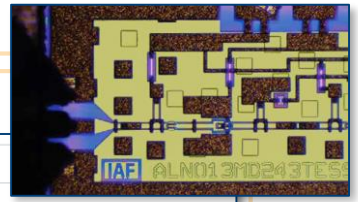
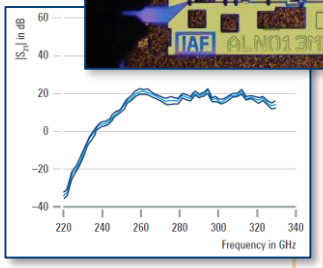


# TEST SETUP OF SUB-THZ TRANSCEIVER

325 GHz MMIC LNA Measurement






IF access

ZNA rear panel

Converter LO

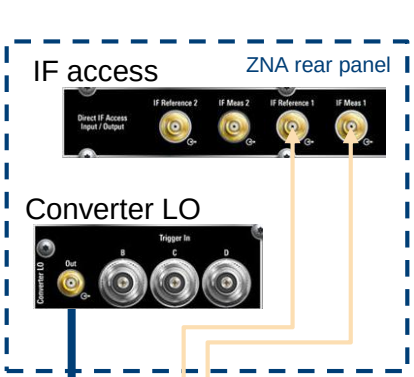
RF

RF

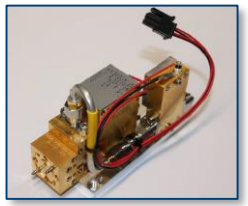
Sub-THz

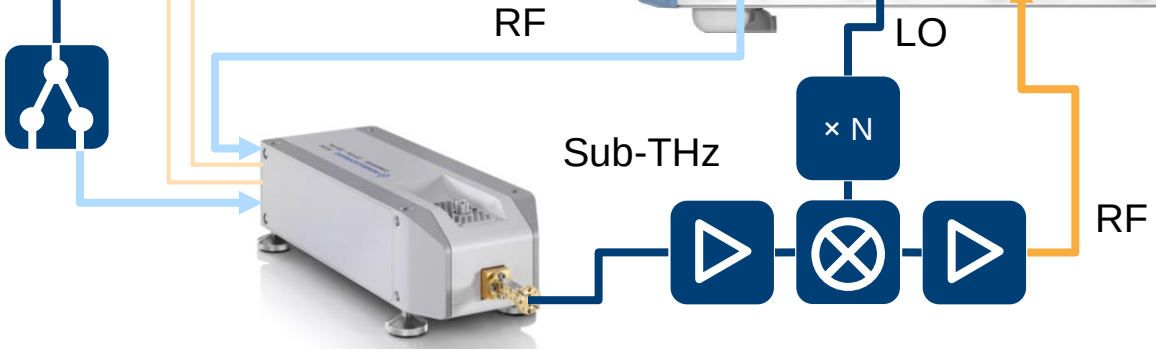
Sub-THz

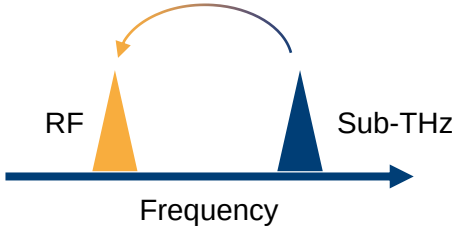
# TEST SETUP OF SUB-THZ DOWN-CONVERTER




500 GHz Dynamic Receiver





# TEST SETUP OF SUB-THZ UP-CONVERTER

JUICE/SWI 135-158 GHz

IF access

ZNA rear panel


Converter LO



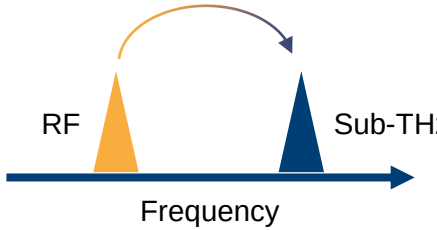
LO

RF

RF

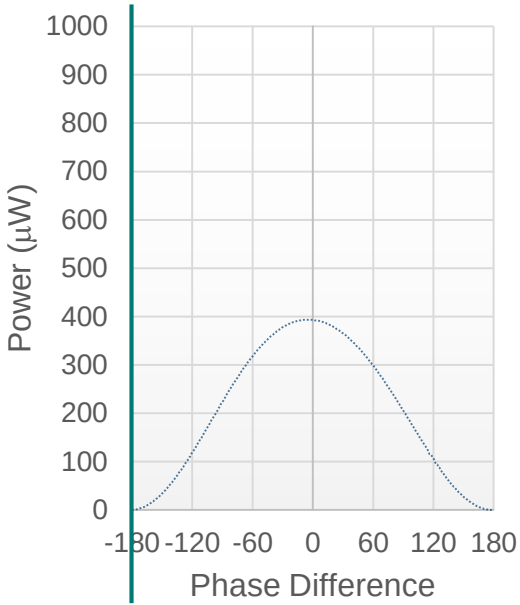
× N

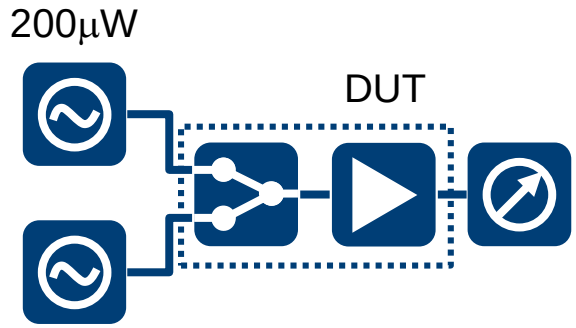
Sub-THz

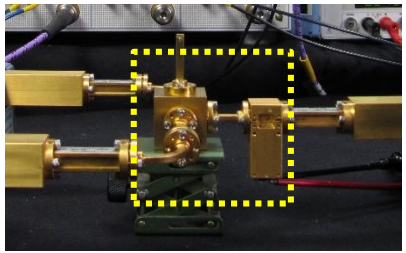


# COHERENCE SIGNAL GENERATION


Phase controlled signal generated by ZNA

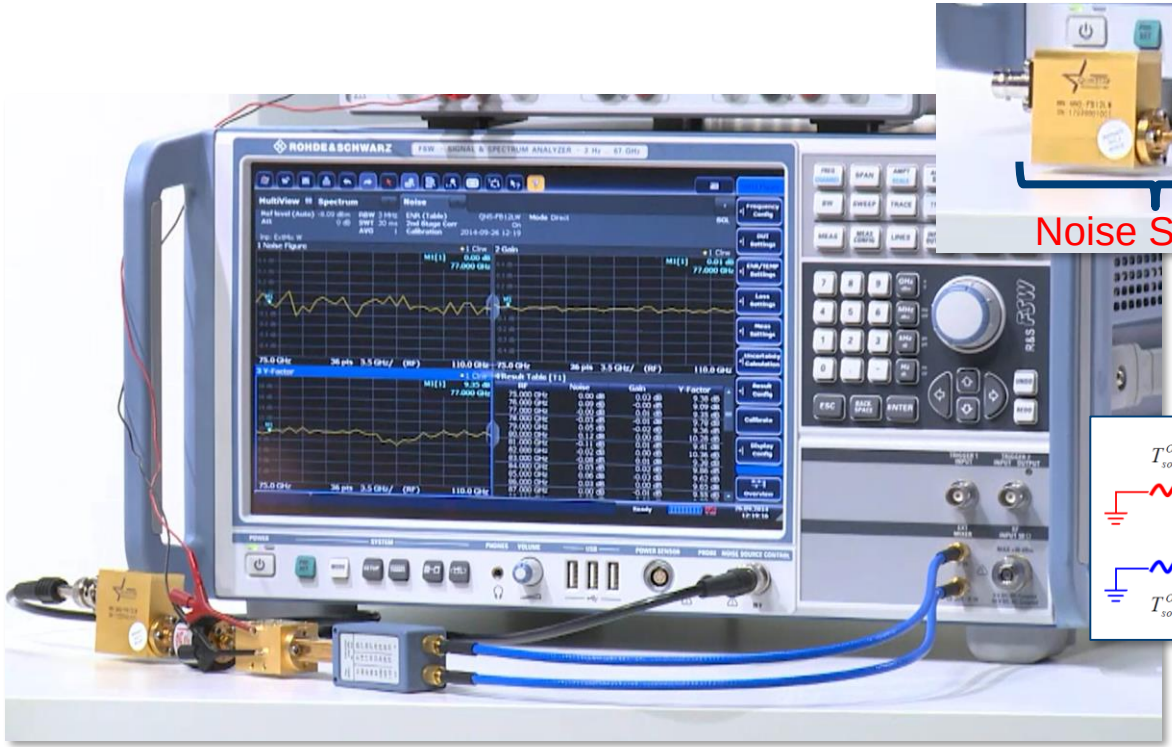


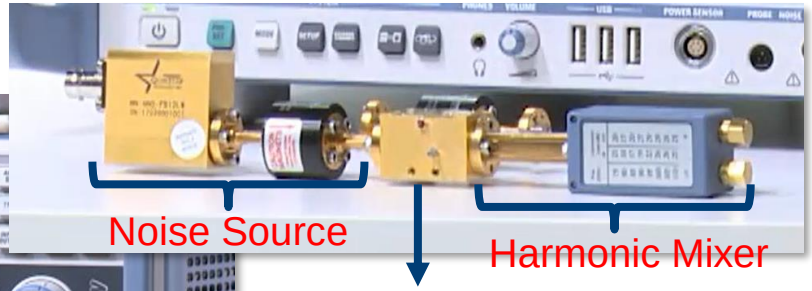



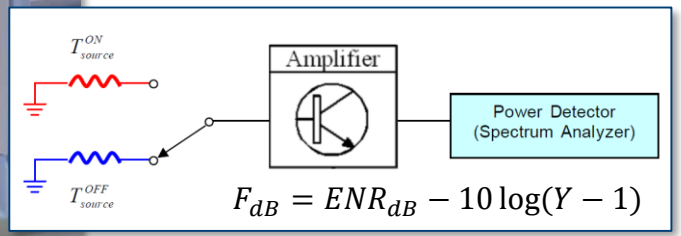
DUT

# SUB-THZ NOISE FIGURE MEASUREMENT

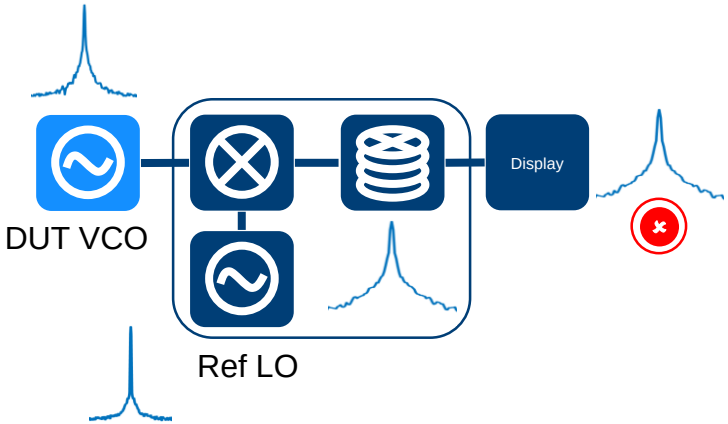


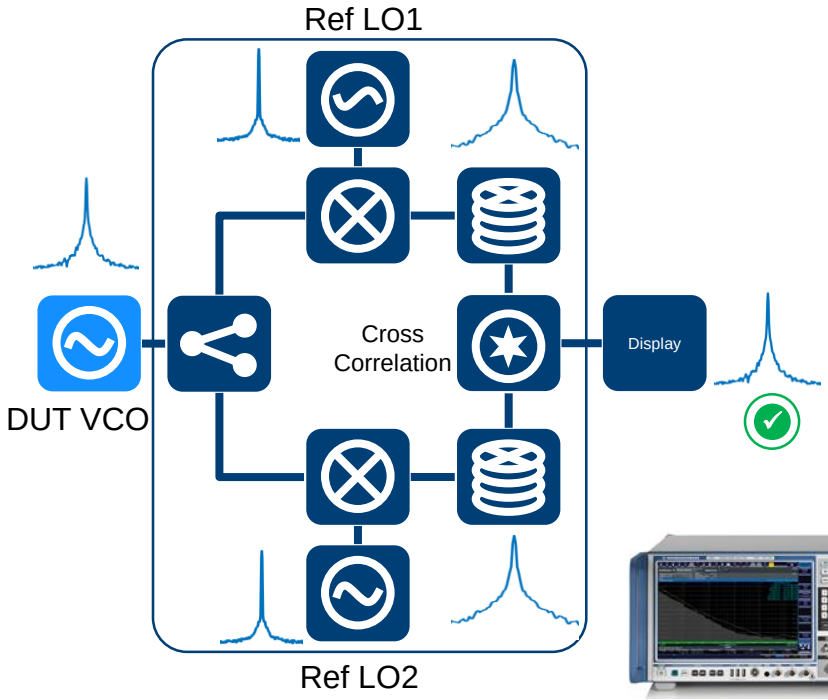




Sub-THz DUT



# VOLTAGE CONTROL OSCILLATOR MEASUREMENT
## CROSS CORRELATION METHOD



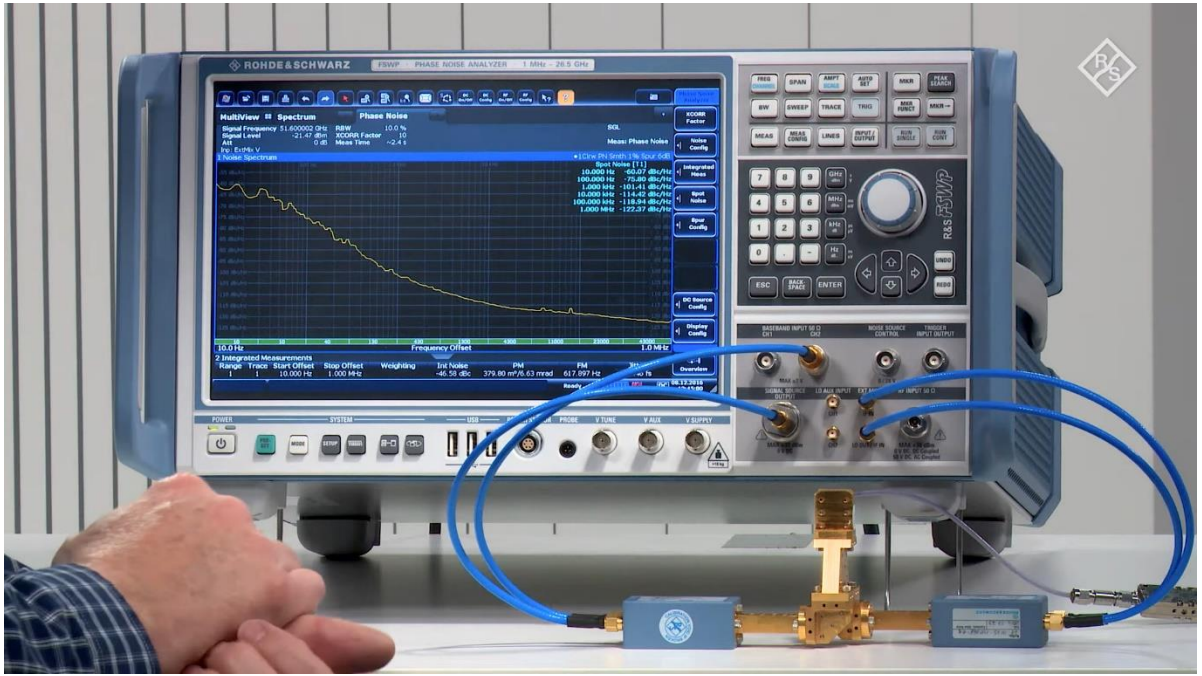




Conventional Spectrum Analyzer

Phase Noise Analyzer with Cross Correlation Method

# VOLTAGE CONTROL OSCILLATOR MEASUREMENT
## R&S FSWP WITH EXTERNAL MIXERS

Phase Noise Measurements with cross correlation above 50 GHz:



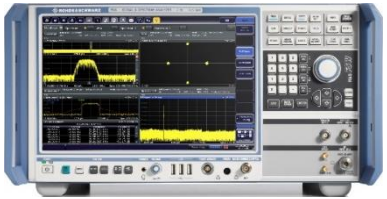

Example for 224 Gbps SerDes with for PAM 4:

- symbol rate: 112 Gbaud
- fundamental frequency: 56 GHz

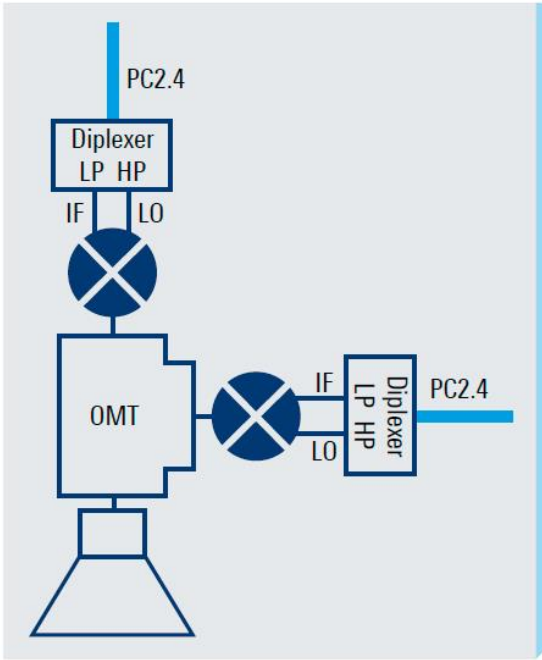
Video Link

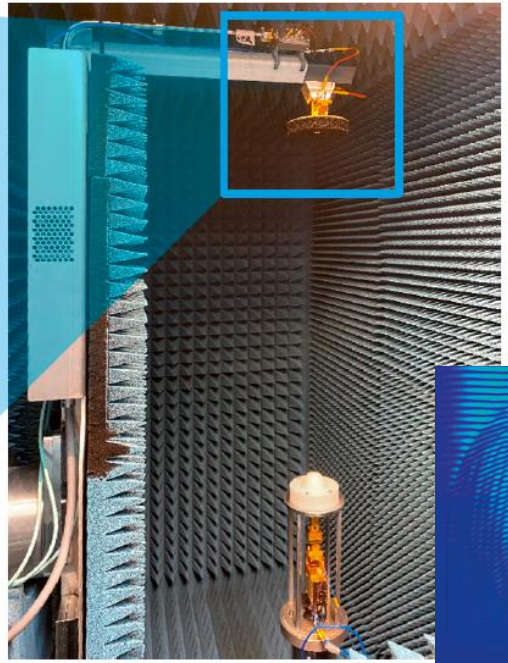
# CONVERTER TYPES

| Type | Converters | | |
|---|---|---|---|
| RX Module | Harmonic Mixer  | Dynamic Receiver   | |
| TX Module | Multiplier  | Transmitter  | I/Q Upconverter  |
| TRX Module | External Frontend  | Frequency Converter  | |

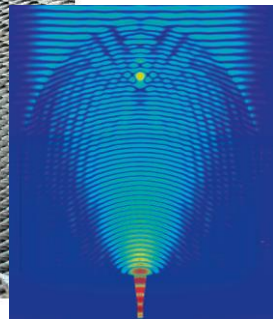


# D-BAND LEAKY-WAVE FED LENS ANTENNA MEASUREMENT



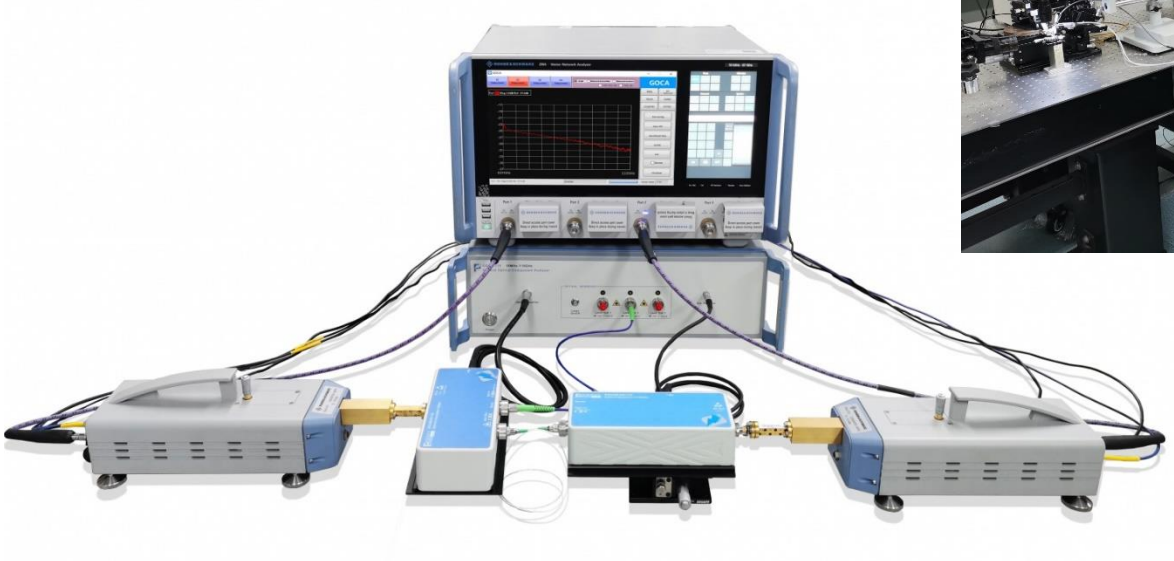



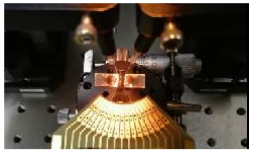
Demo Video



# NEWKEY GOCA OPTICAL SYSTEM

- Test devices: O/O, O/E, E/O
- Wavelength: O-/C-/L-band





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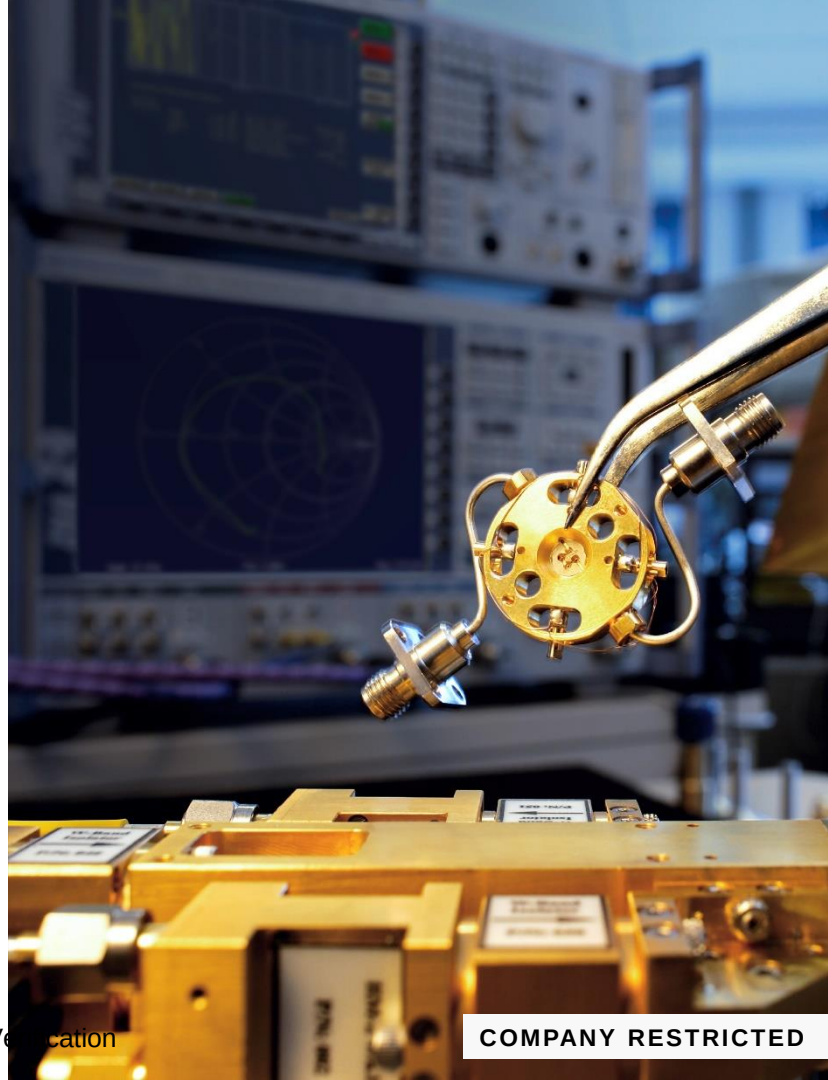
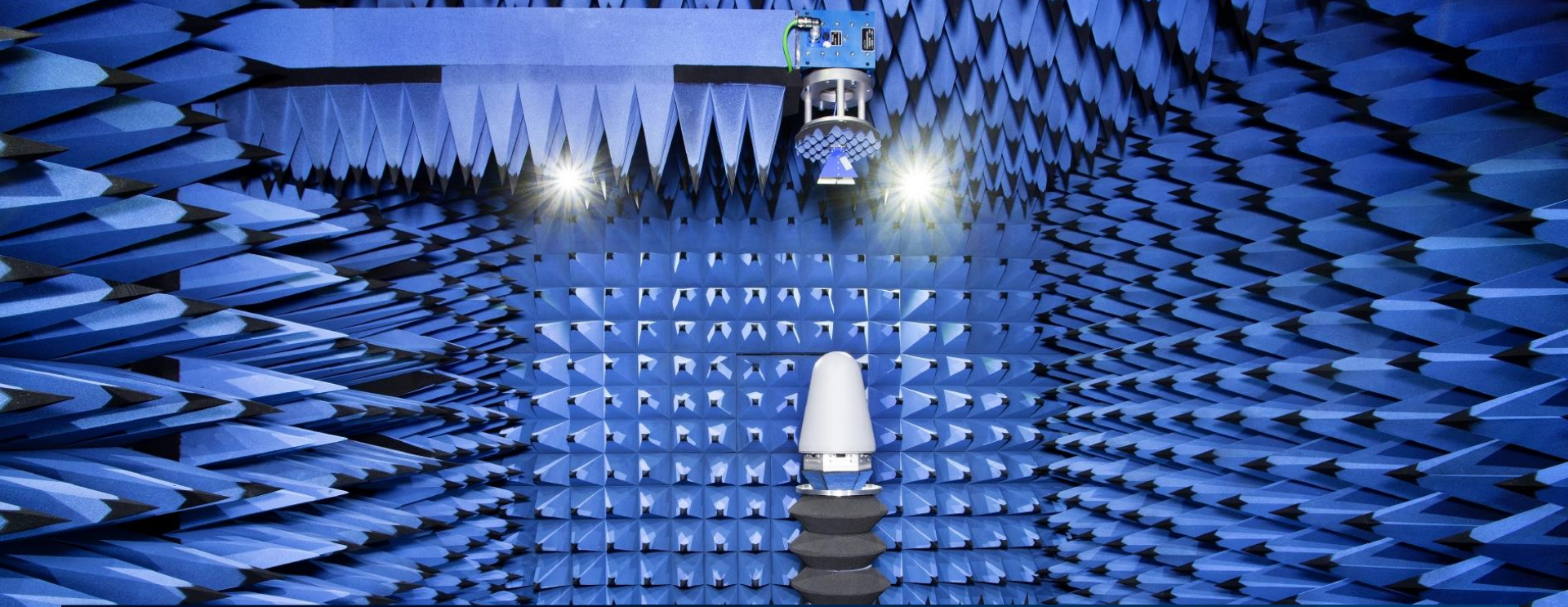


# CONCLUSIONS

- Terahertz wave falls between microwaves and optical waves are discussed for applications such as automotive radar, satellite communication, radar imaging, and remote sensing and are potential for B5G/6G applications.

- The connection interface for Sub-THz testing depends on the development phase, it is challenging for on-wafer probing and over-the-air testing.

- Different types of converters such as frequency converter, harmonic mixer, frequency multiplier, or frontend module can be addressed for various DUTs according to the test items.



# THANKS FOR YOUR ATTENTION