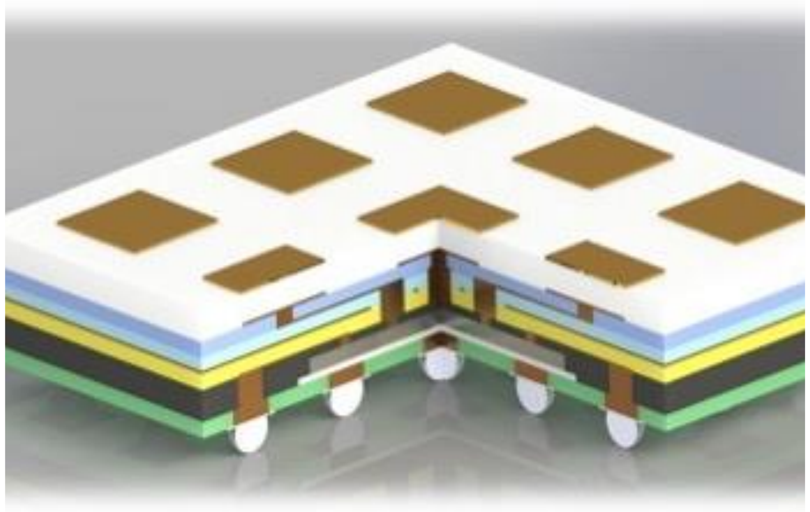
ANTENNEX

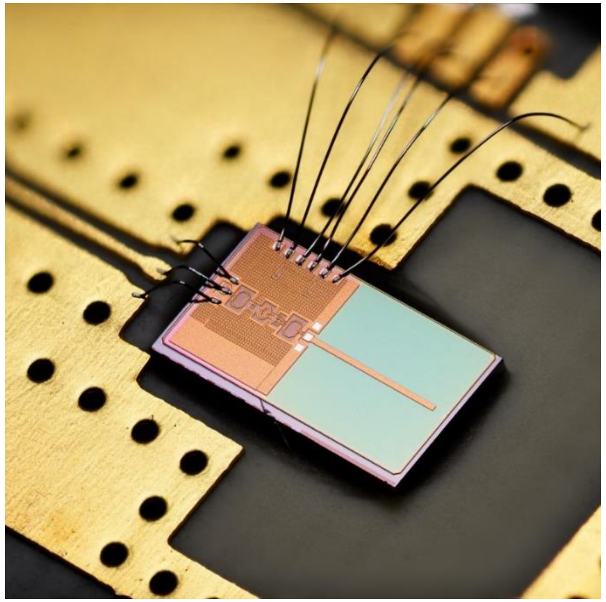
Methods for Wireless Testing of Phased-Array Antennas

Anouk Hubrechsen, ANTENNEX B.V.

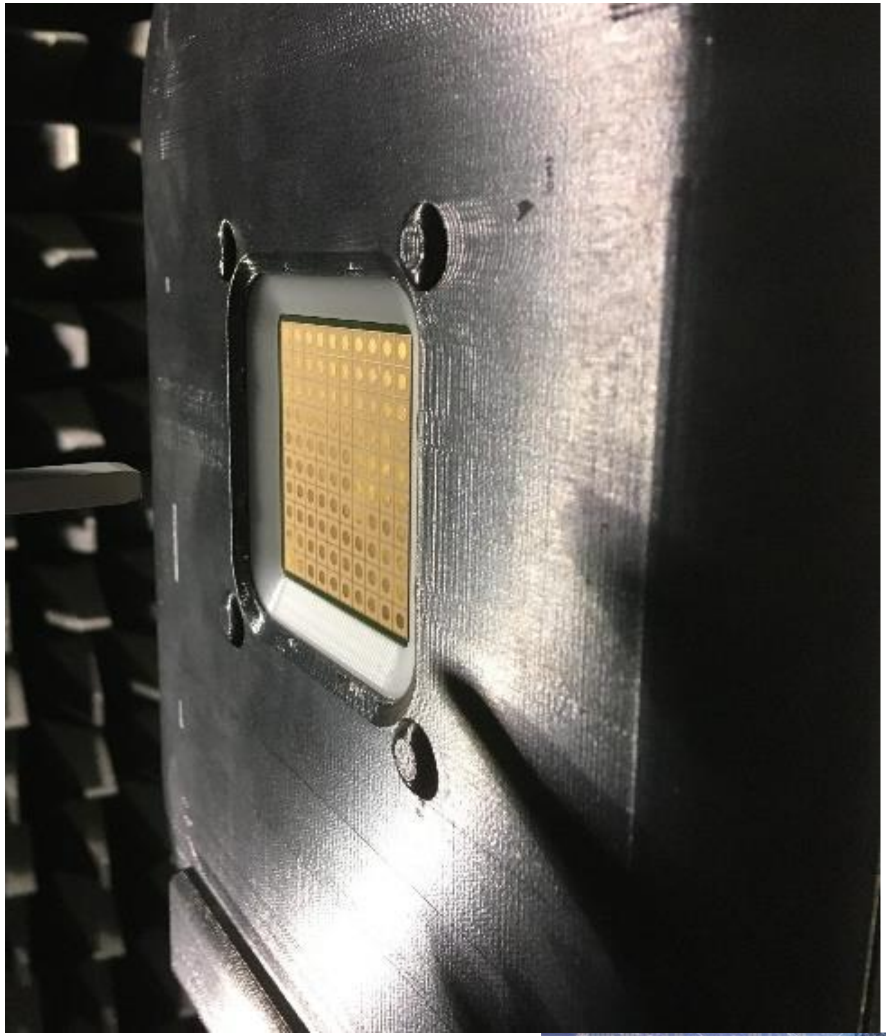
Integration antennas and RFICs

CITC



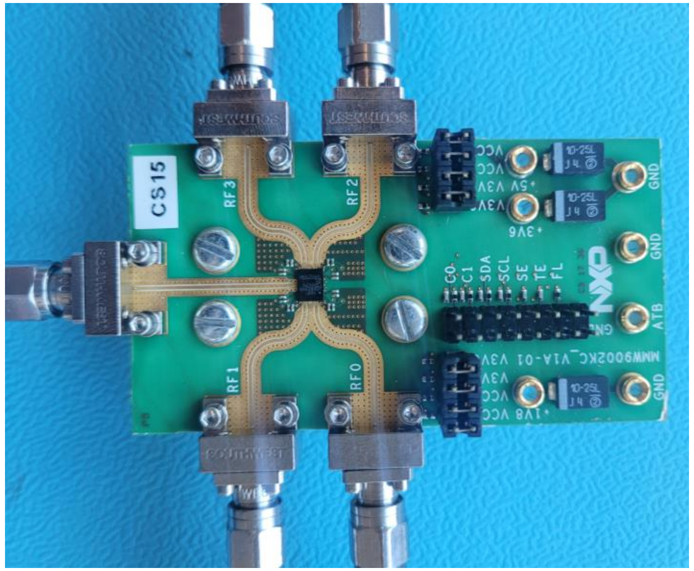


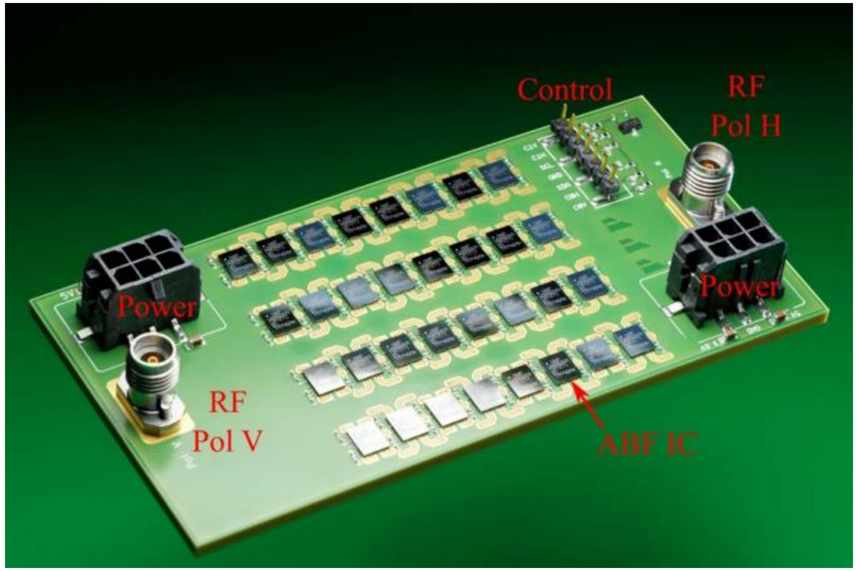
Eindhoven University of Technology

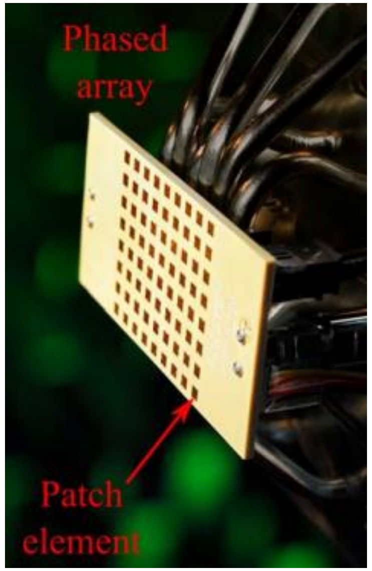


NXP

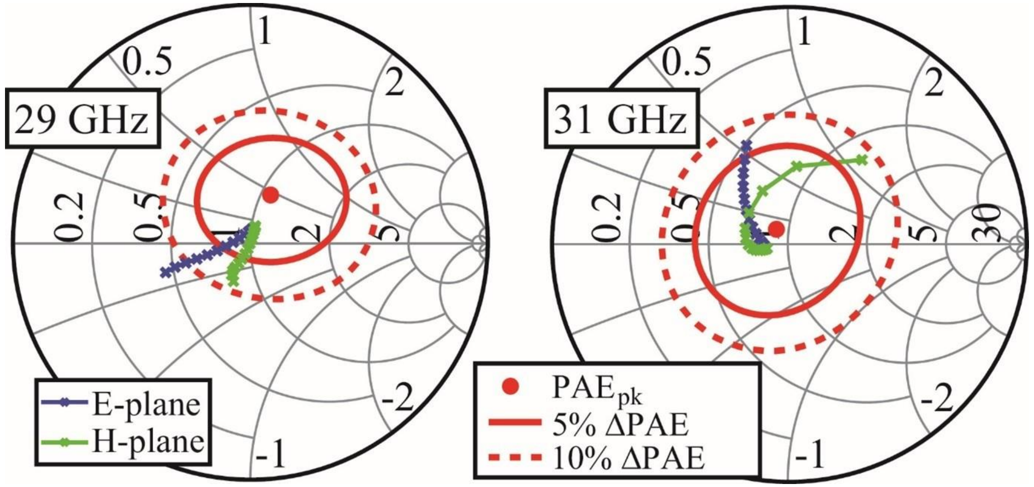
RF 2024 TECHNOLOGY EVENT 18 APRIL 2024 FHI Leusden





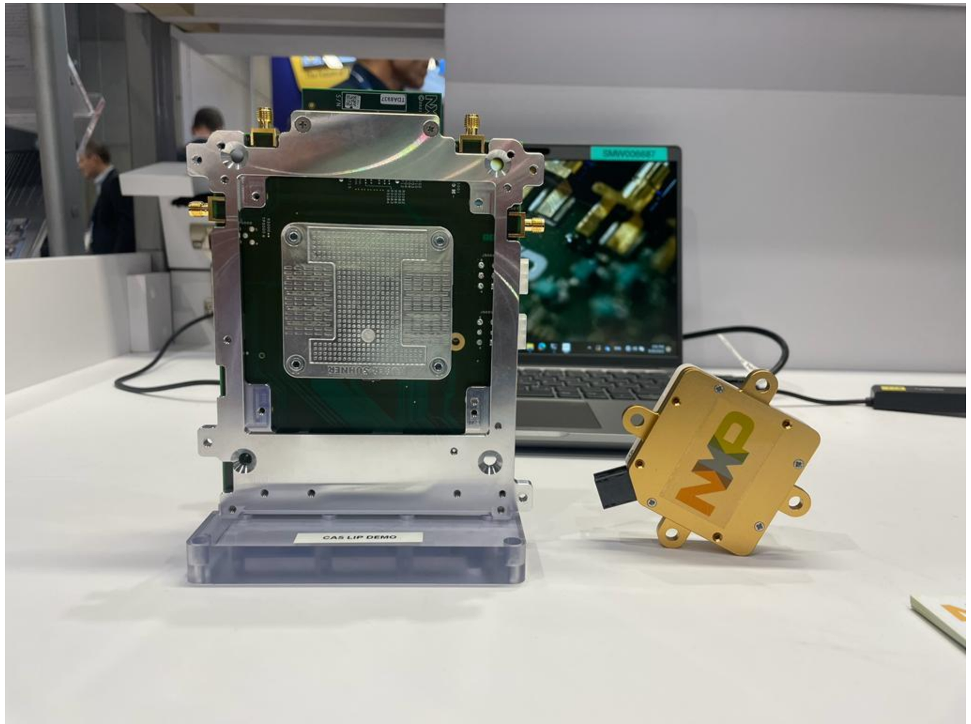


"Integrating antennas can change the behavior of the RFICs"



M. de Kok, et al., "A Review of PA-Antenna Co-design: Direct Matching, Harmonic Tuning and Power Combining," EuCAP 2022

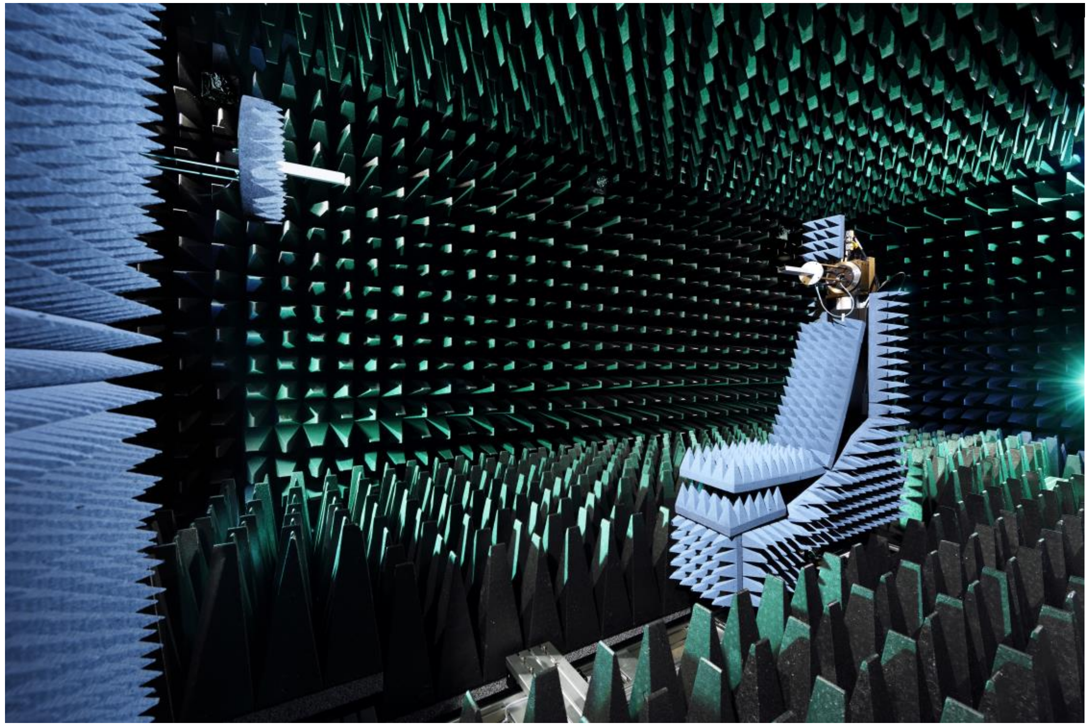
What if there is no RF input?

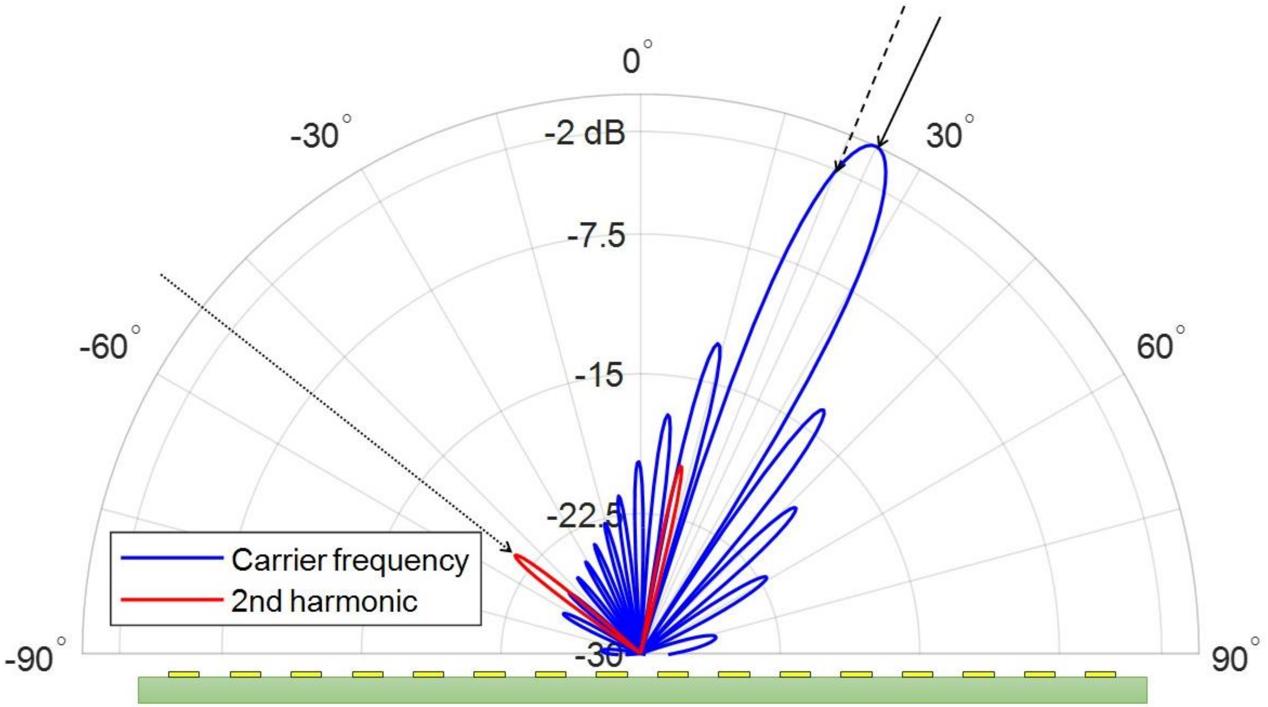


NXP radar

Pharrowtech EVK (V-band)

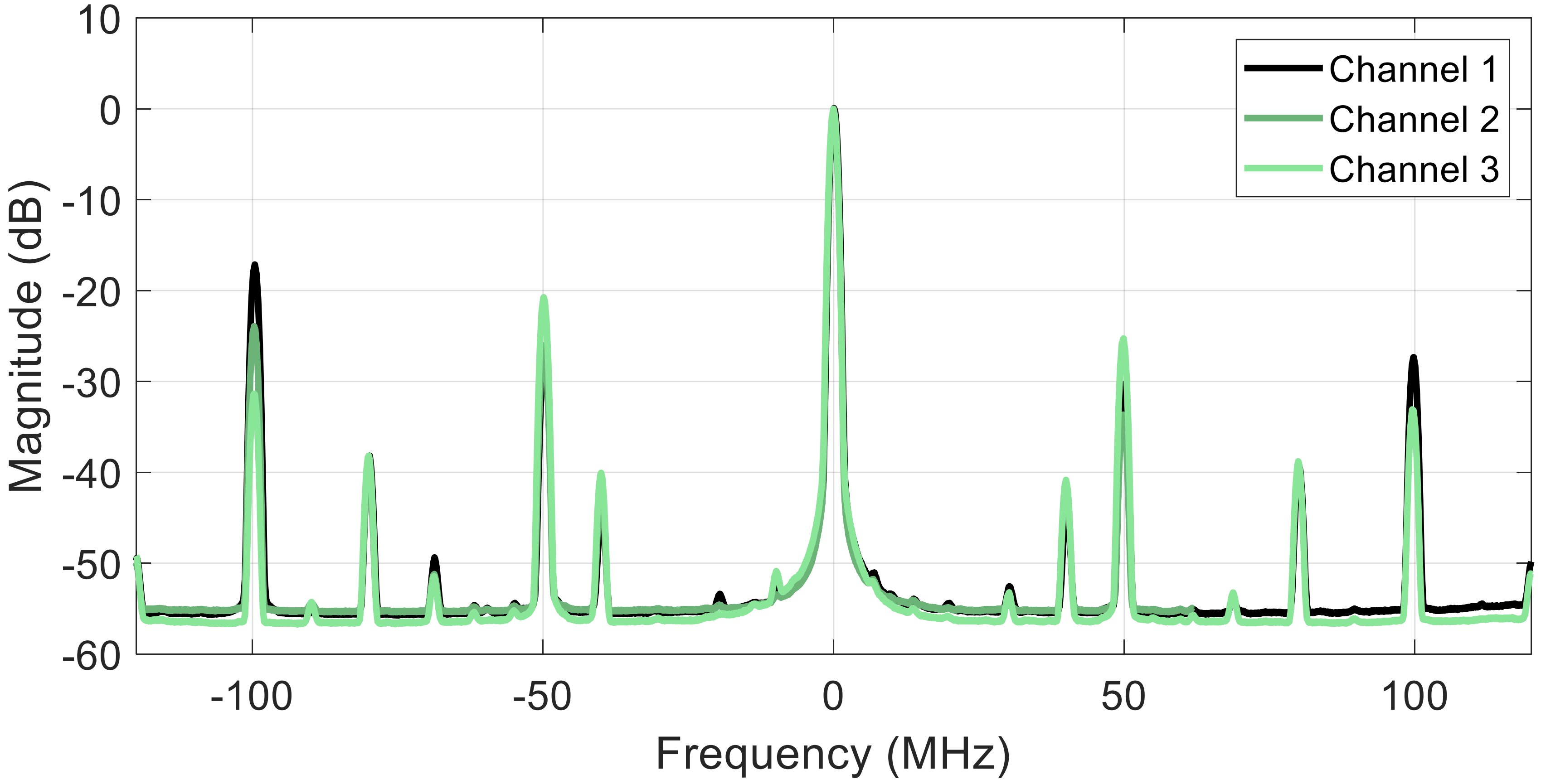
Anechoic chamber





"Measurement errors easily occur when the antenna gain and radiation patt
are not exactly known."

Radiated PSD of integrated antenna system



“Measuring multiple channels for a wide frequency range and high spatial resolution can take weeks”

“Measuring a pattern is important, but we also want…”

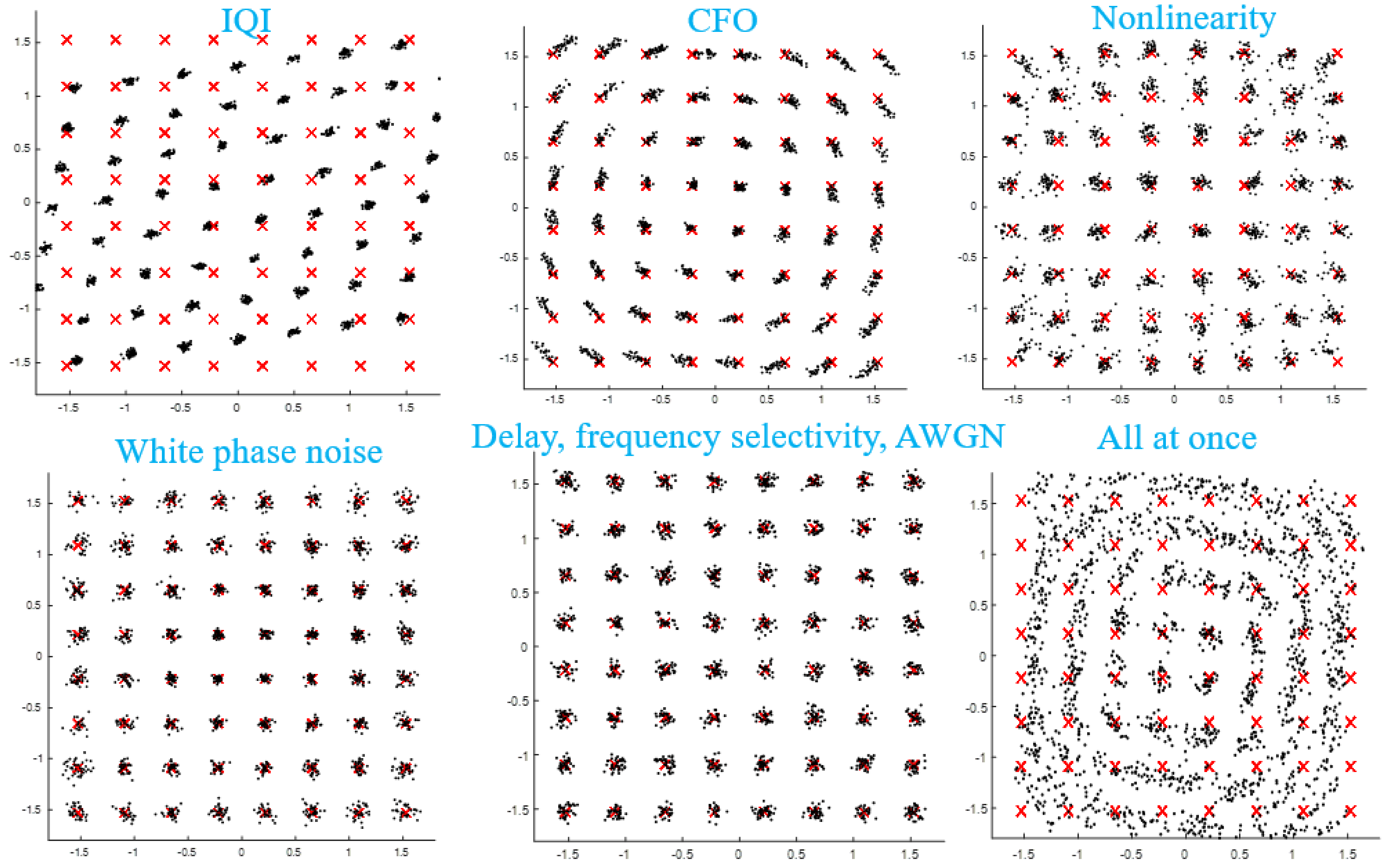
Transmitting

Total radiated output power, Power Spectral Density, IIP3, OIP3, ACPR, Power-added efficiency, Drain efficiency, Power gain, PAPR, P1dB, Spectral regrowth, intermodulation products, Radiated and in- and out-of-band emissions, harmonic distortion, EVM, etc..

Receiving

Receiver gain, Linearity, IIP3, IIP2, P1dB, Efficiency, harmonic distortion, in- and out-of-band emissions, noise figure, etc..

The effect of imperfect hardware



Slide credit to Thomas Eriksson

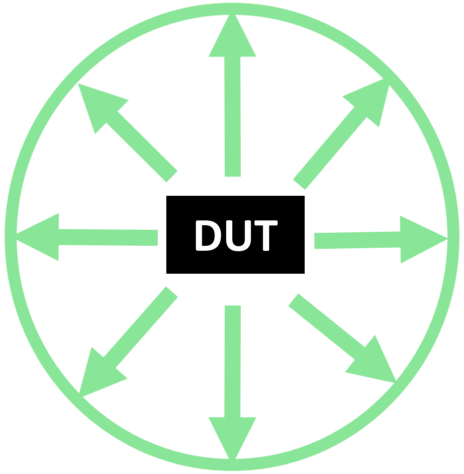
Outline

- Background
- **Reverberation Chamber**
- Measurement methods and examples
- New measurement methods
- Other applications
- ANTENNEX

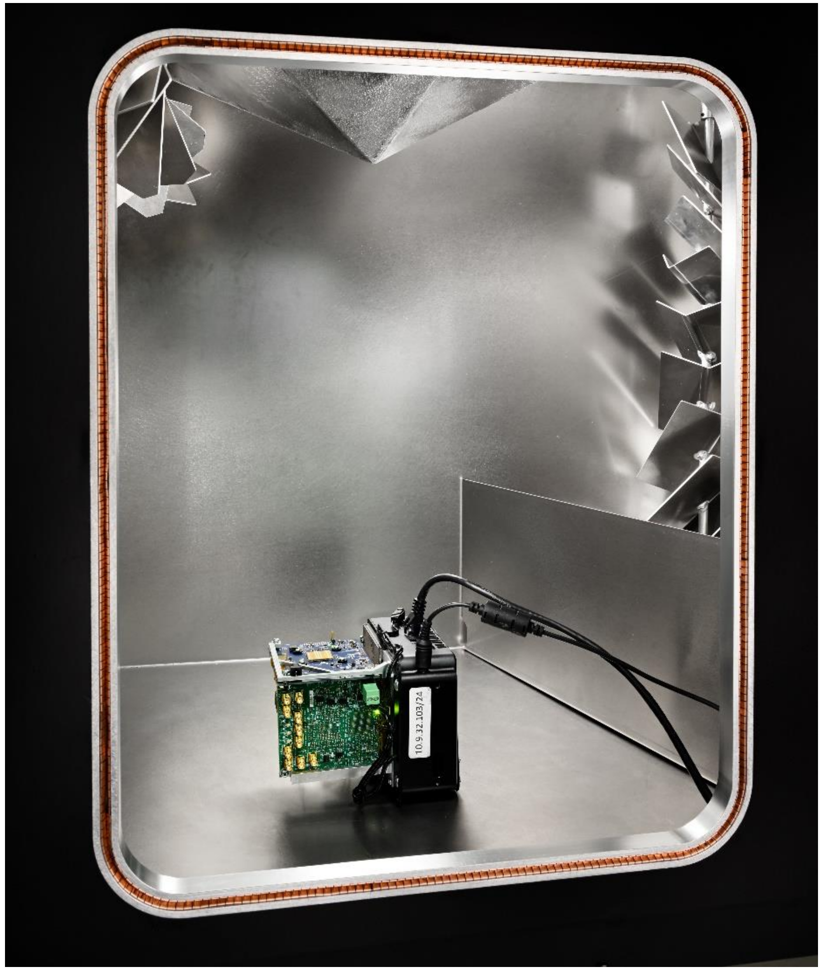
Reverberation chamber

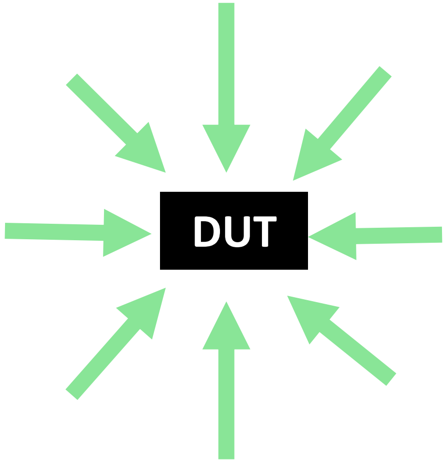
“Over-the-air equivalent of a coaxial connector”

Reverberation chamber

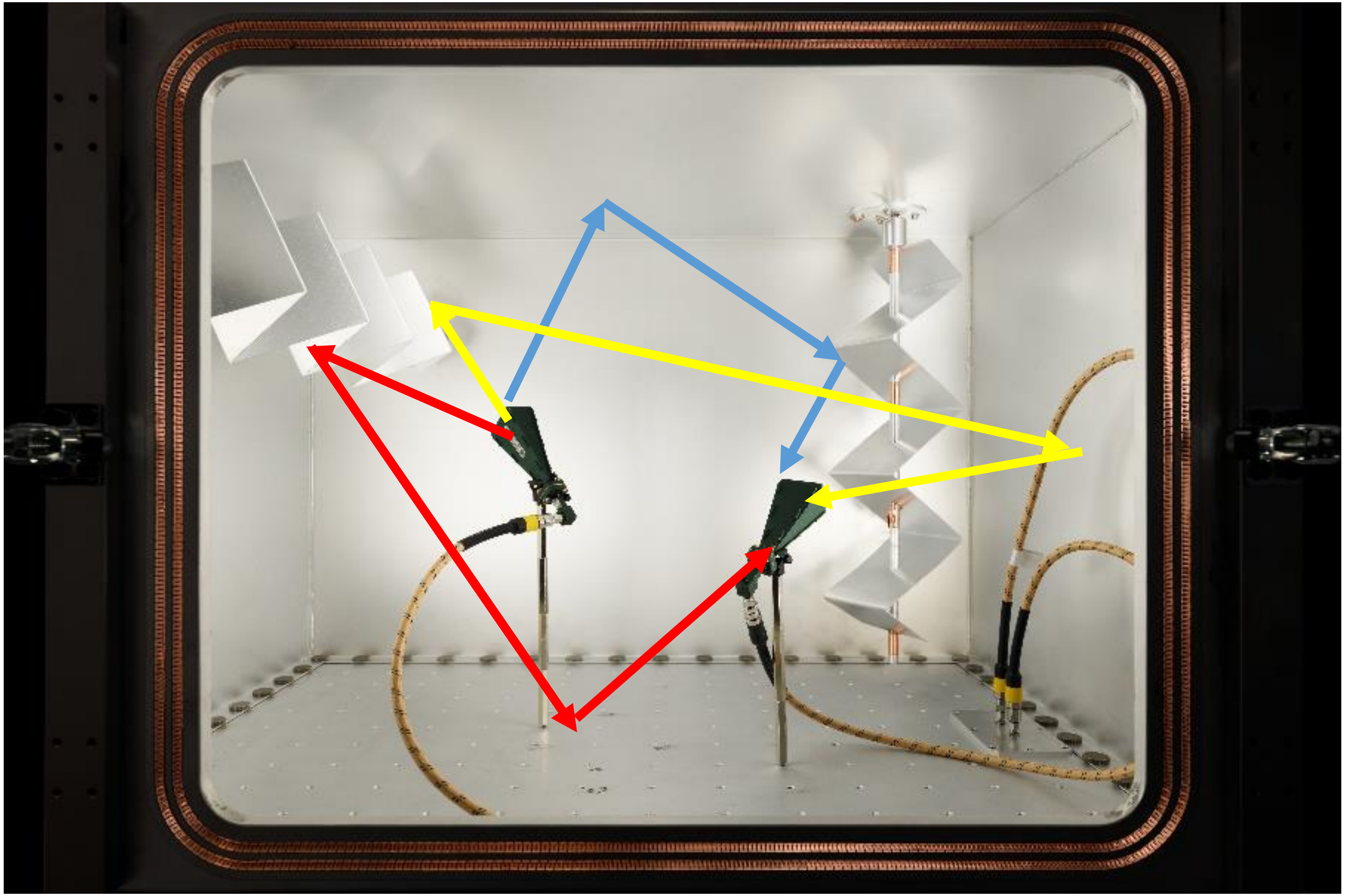


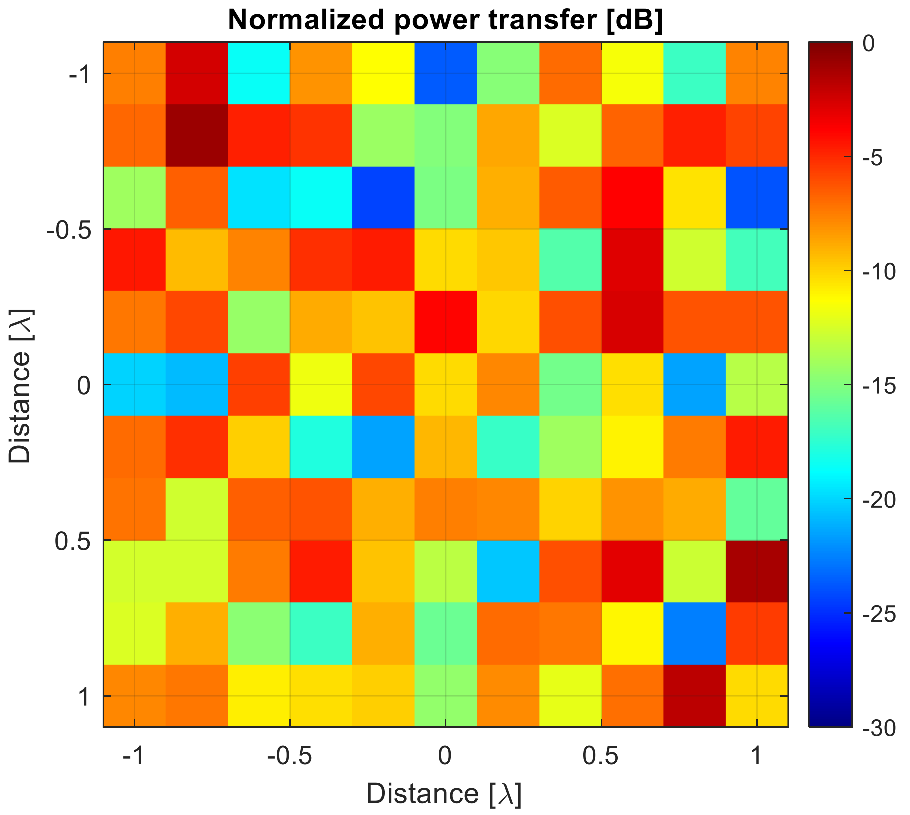
Integrating sphere



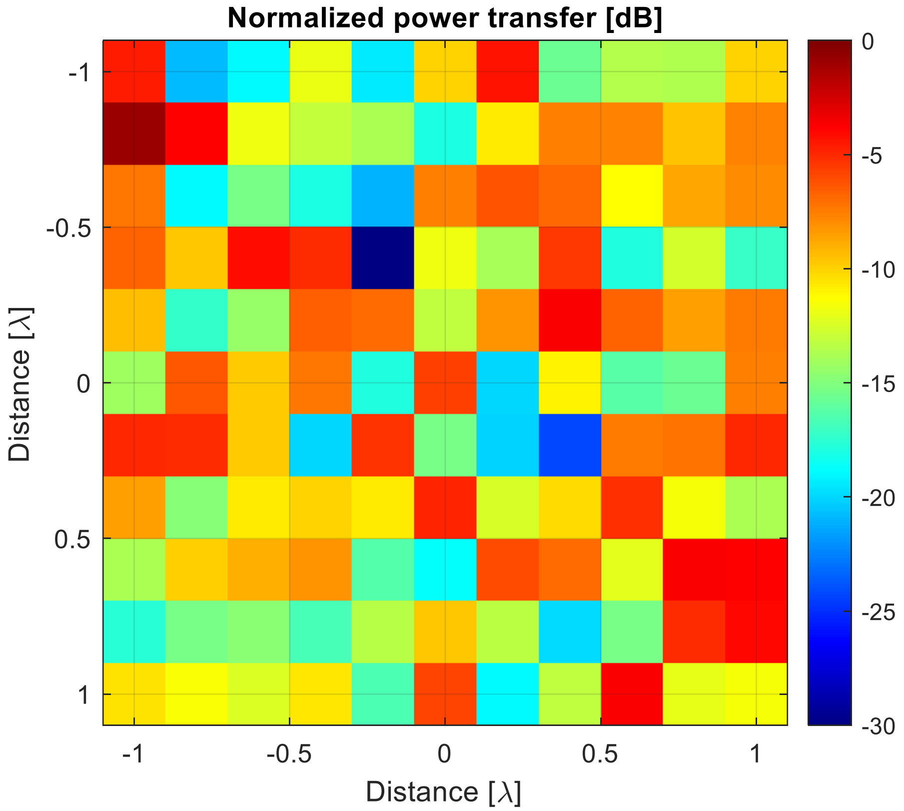


Illumination from all sides



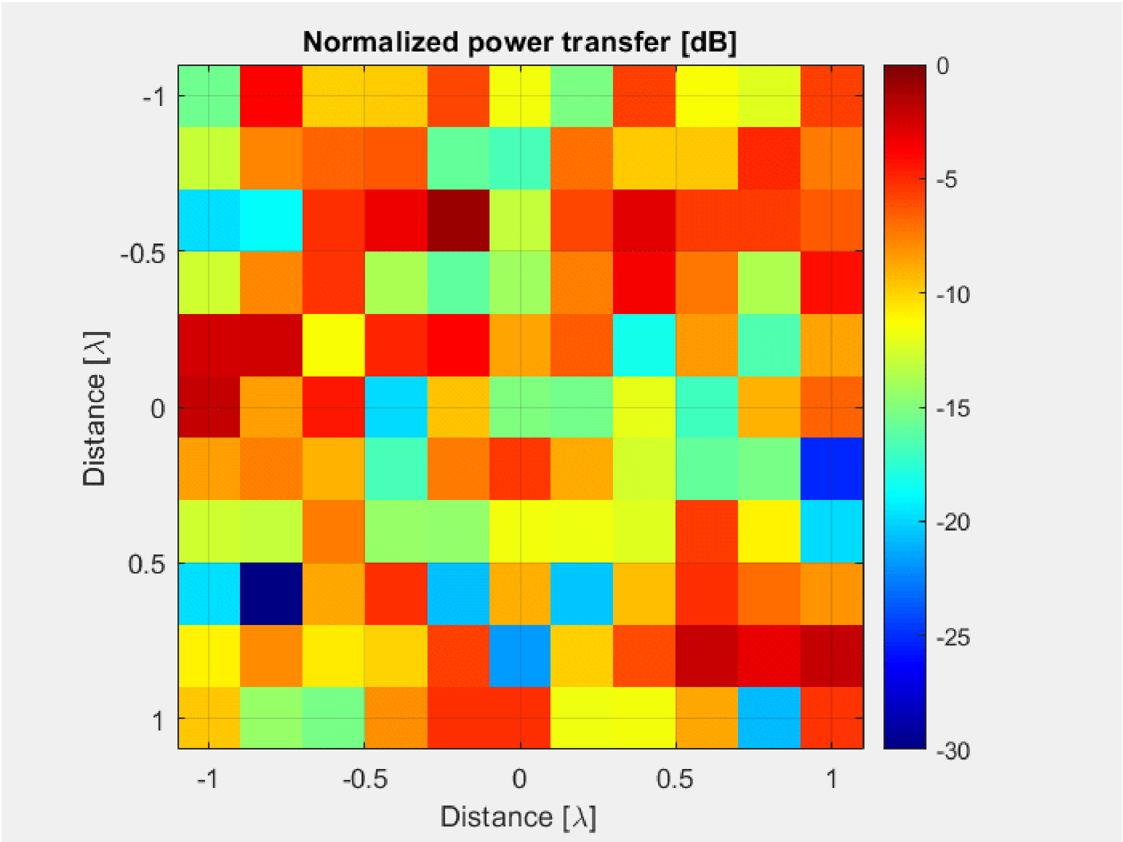

Normalized power transfer [dB]
Distance [λ]
Distance [λ]
-1
-0.5
0
0.5
1
0
-5
-10
-15
-20
-25
-30


3°

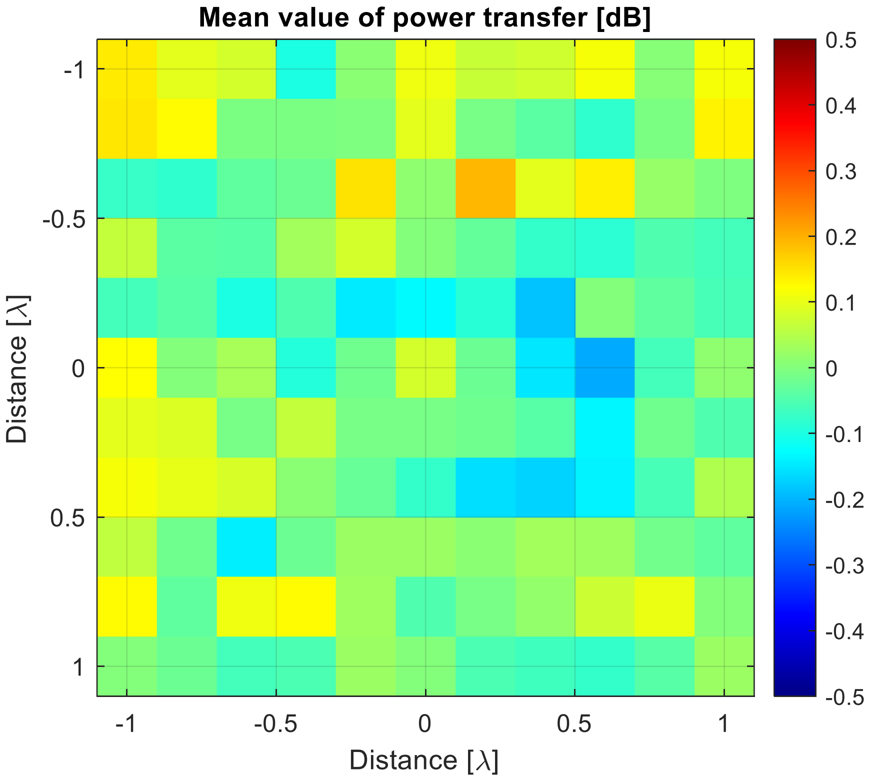

Normalized power transfer [dB]
Distance [λ]
Distance [λ]
-1
-0.5
0
0.5
1
0
-5
-10
-15
-20
-25
-30

Steps of 3°


3°

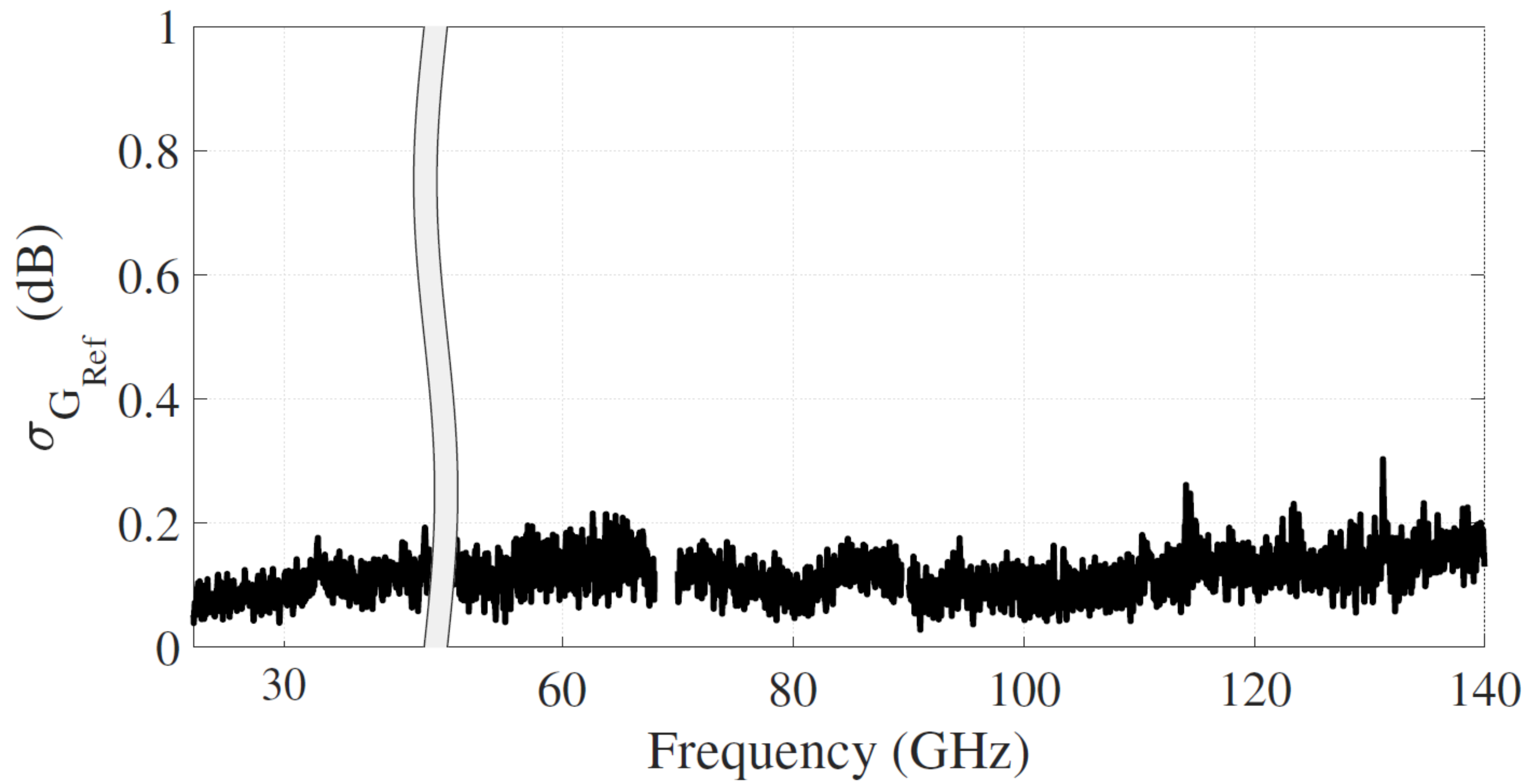

Normalized power transfer [dB]
Distance [λ]
Distance [λ]
-1
-0.5
0
0.5
1
0
-5
-10
-15
-20
-25
-30

Statistically uniform field



"Sensitivity to positioning removed"

Uncertainty



Standard deviation taken over measurements from different:

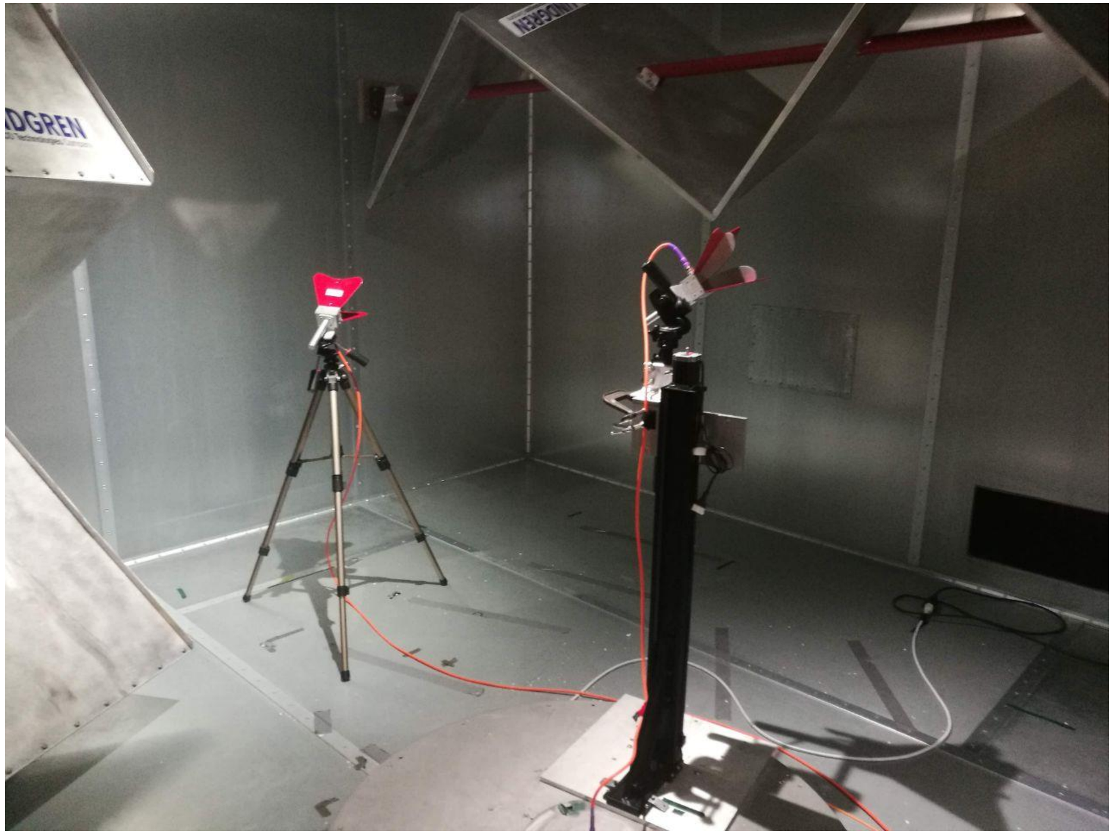
- Days
- Antenna positions
- Calibrations

45.2 m^3

400 MHz – 30 GHz (rough estimate)

<1 m^3

<20 GHz to >140 GHz



ANTENNEX

RF 2024

TECHNOLOGY EVENT

18 APRIL 2024

FHI Leusden

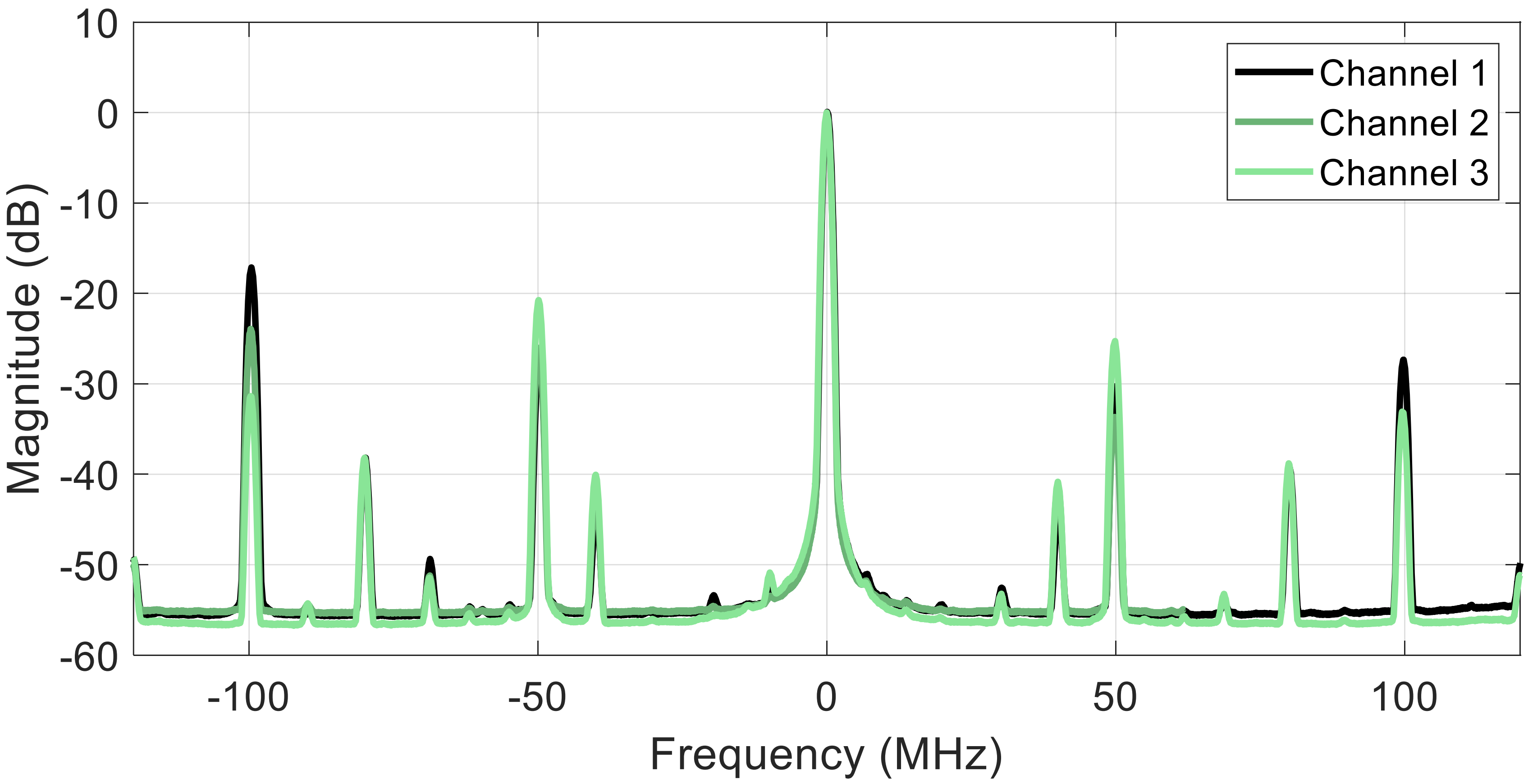
Reverberation chamber benefits

- Flexibility in positioning
  - On average uniform and isotropic field
- Fast
- (Almost) independent of form factor
- Independent of external influences
- Scalable for high frequencies

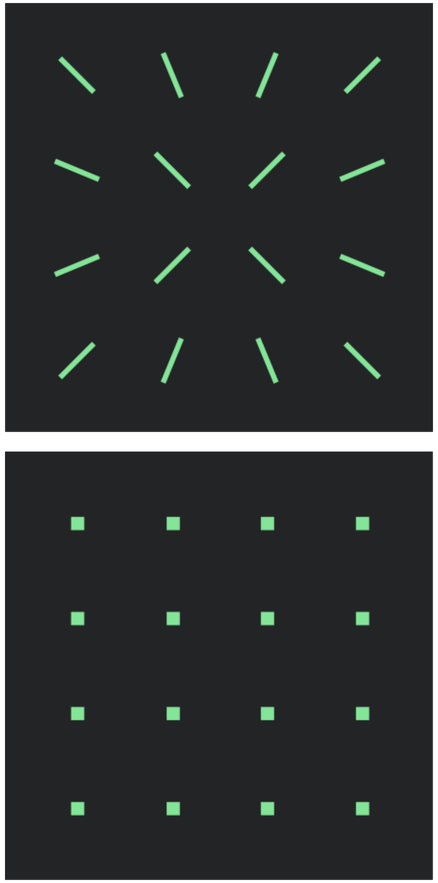
Outline

- Background
- Reverberation Chamber
- **Measurement methods and examples**
- New measurement methods
- Other applications
- ANTENNEX

Radiated PSD of integrated system



PSD-based measurements

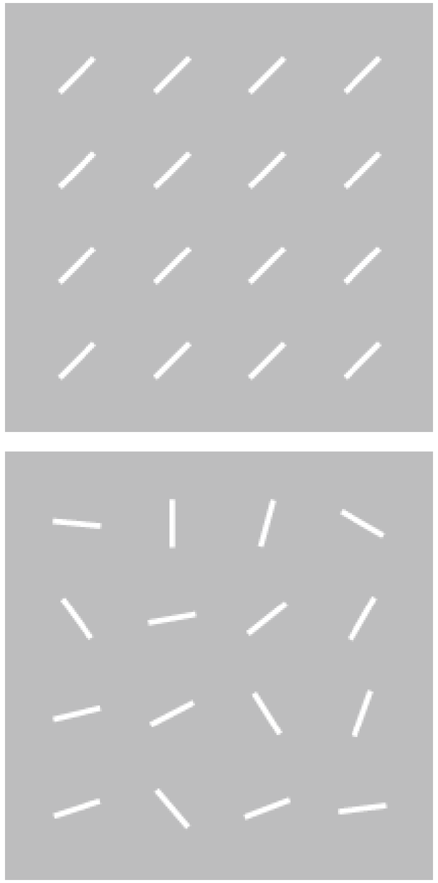


Transmitting

- Total radiated power
- ACLR/ACPR
- Efficiency (PAE)
- Compression
- IM
- Harmonics
- etc…

Receiving (limited by DUT)

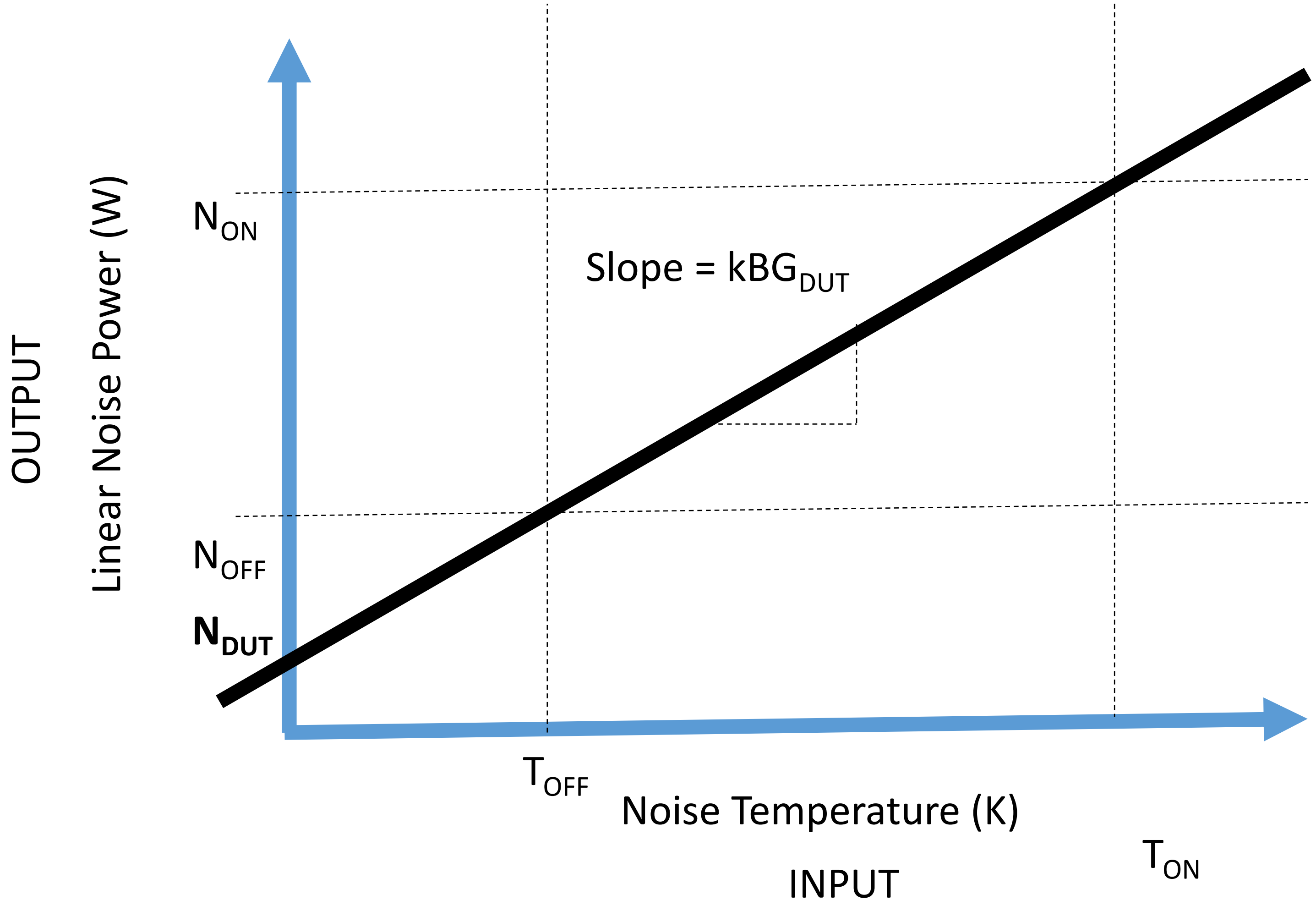
- Efficiency
- Receiver gain
- OOB
- IIP3
- etc…

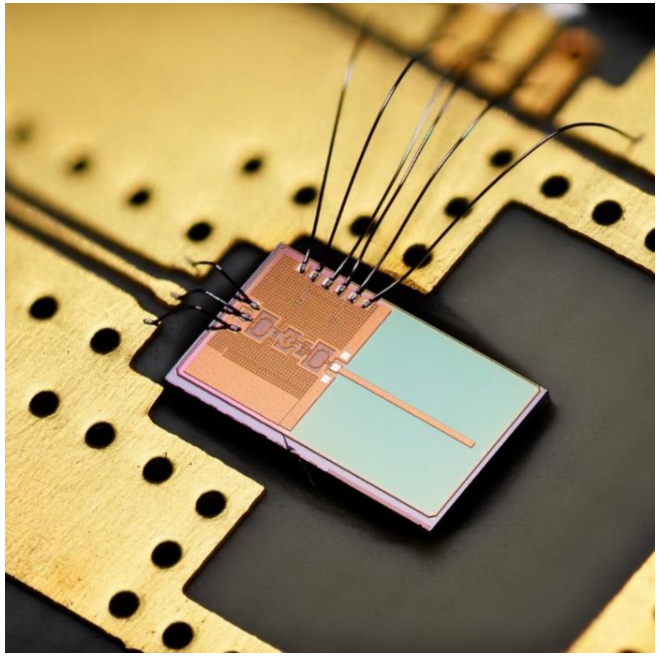


Outline

- Background
- Reverberation Chamber
- Measurement methods and examples
- **New measurement methods**
- Other applications
- ANTENNEX

Noise Figure





Antenna noise temperature

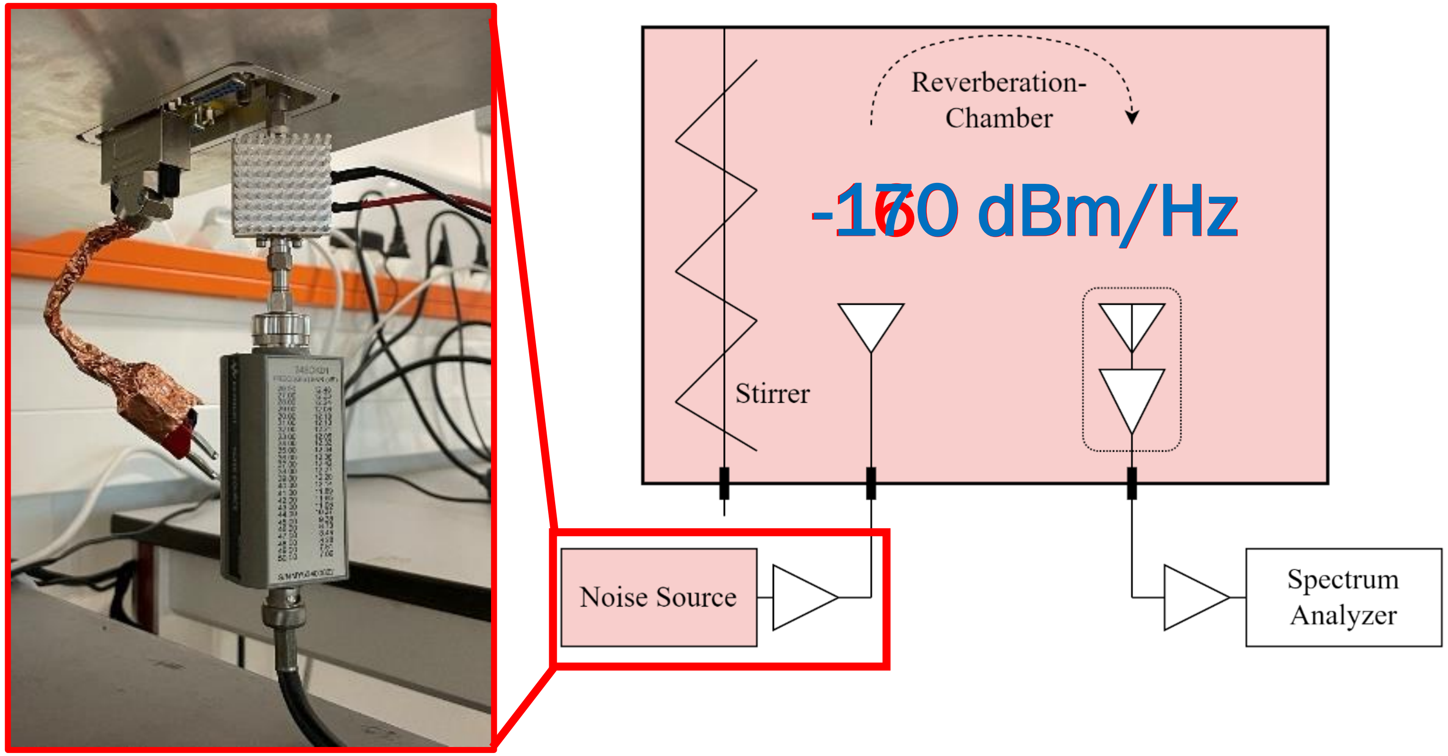
$$T_A = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} R(\theta,\varphi)T(\theta,\varphi)sin\theta d\theta d\varphi$$

Antenna noise temperature

$$T_A = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} R(\theta,\varphi)T(\theta,\varphi)sin\theta d\theta d\varphi$$

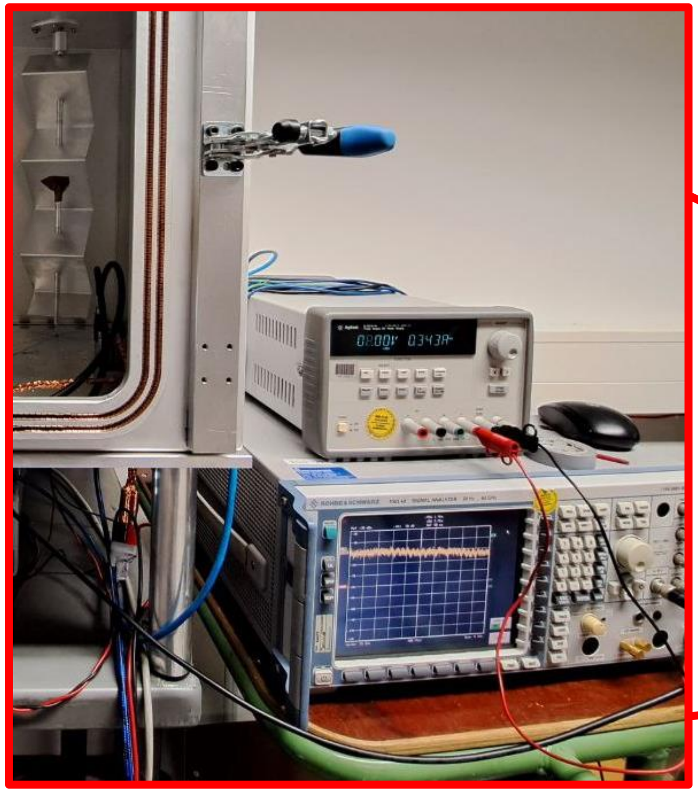
Integrate over a sphere the radiation pattern and the noise temperature of the environment

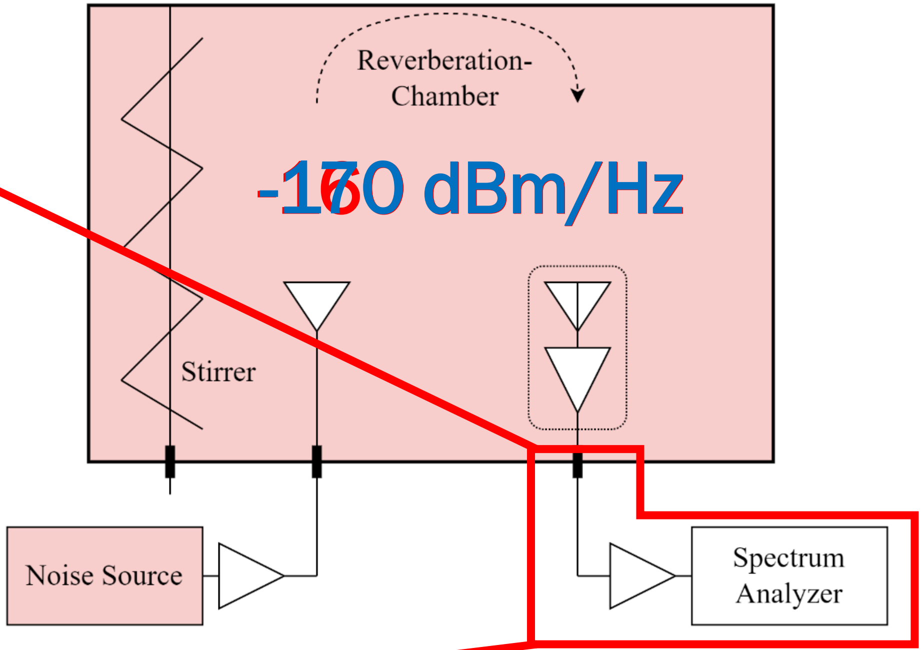
Wireless noise source



1. Create two noise-power levels

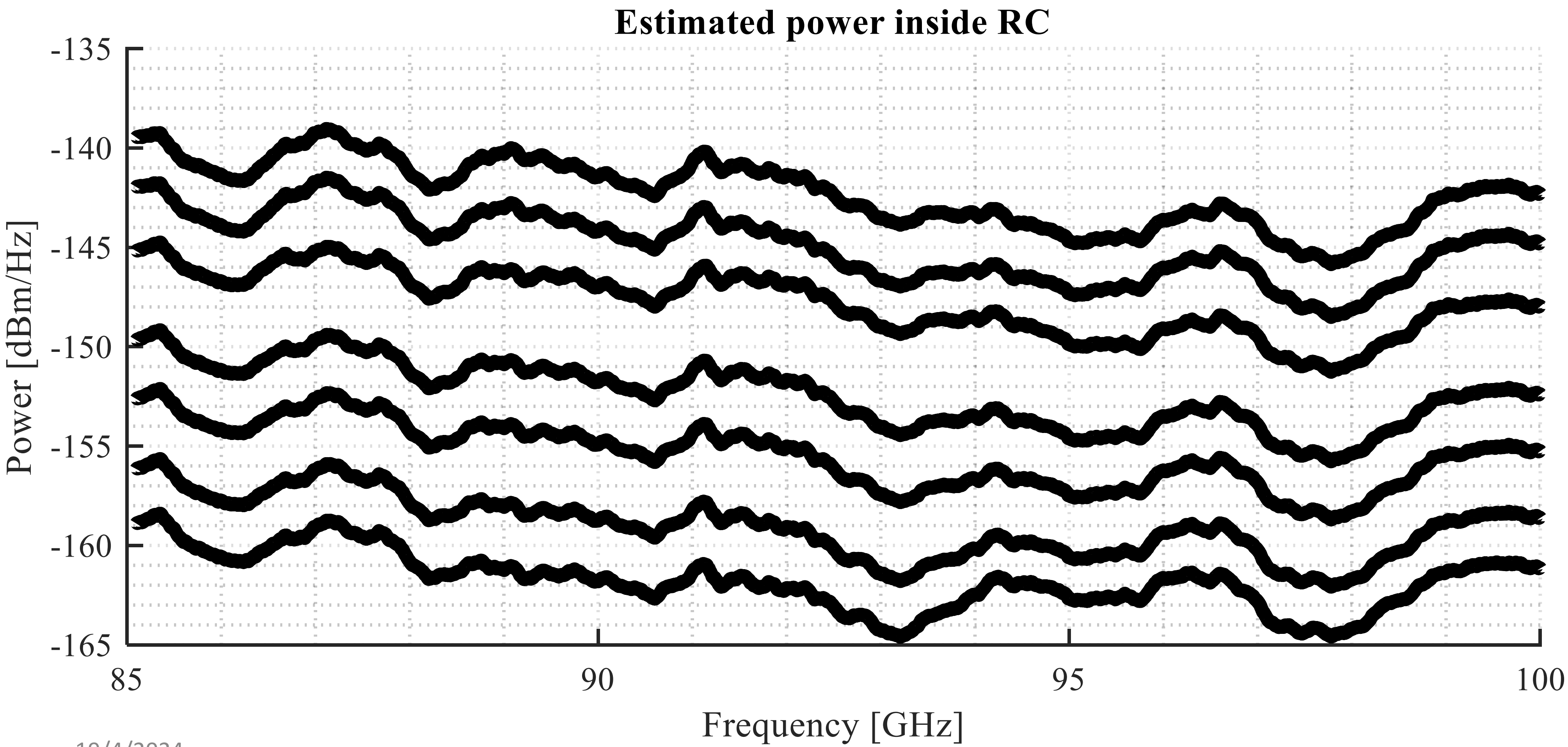
Wireless noise source



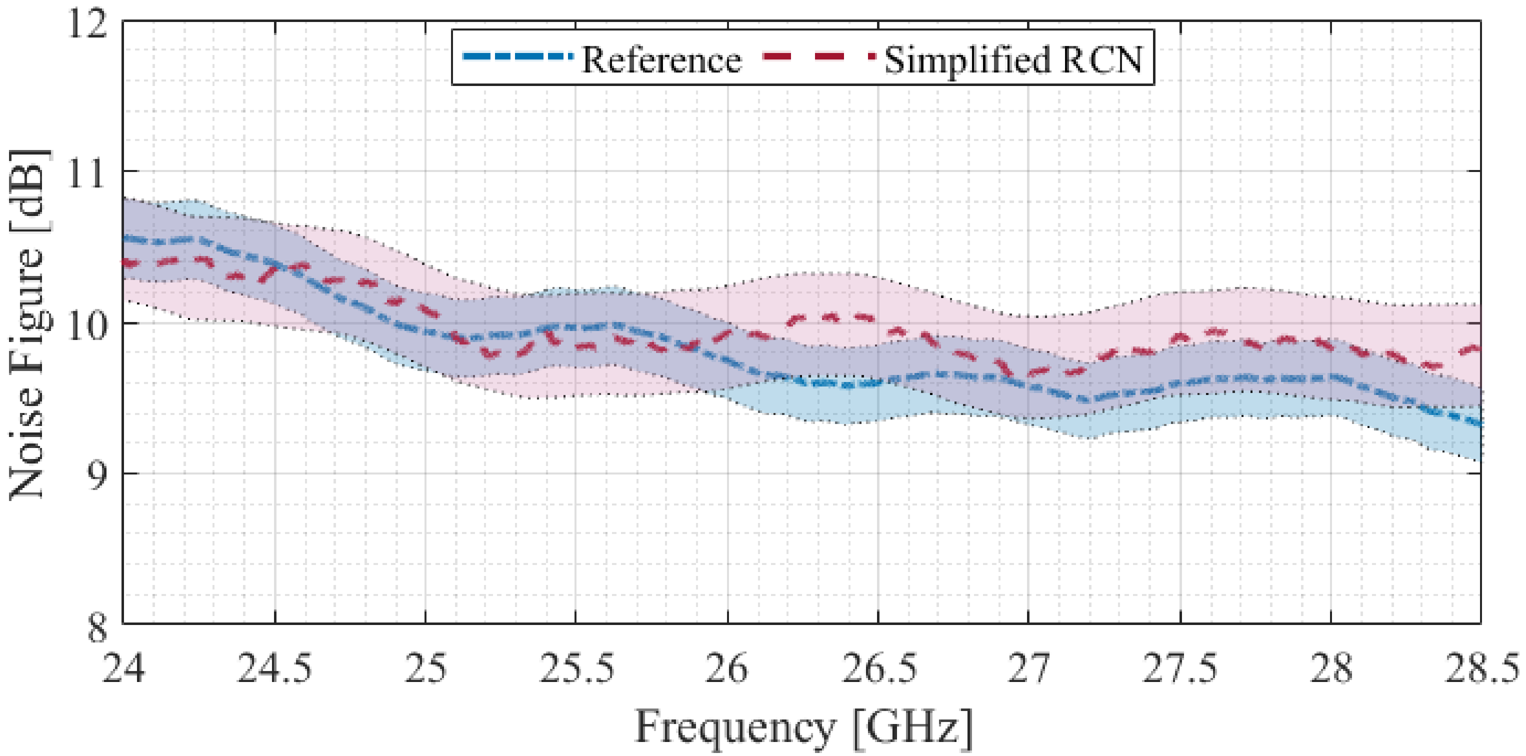


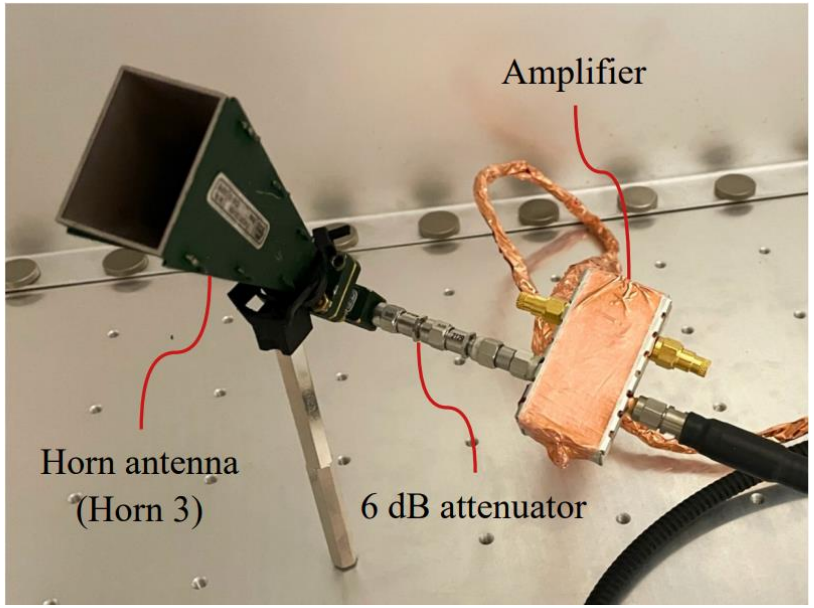
1. Create two noise-power levels
2. Measure received power
3. Estimate NF and gain

Wireless noise source



Result @ Ka-band



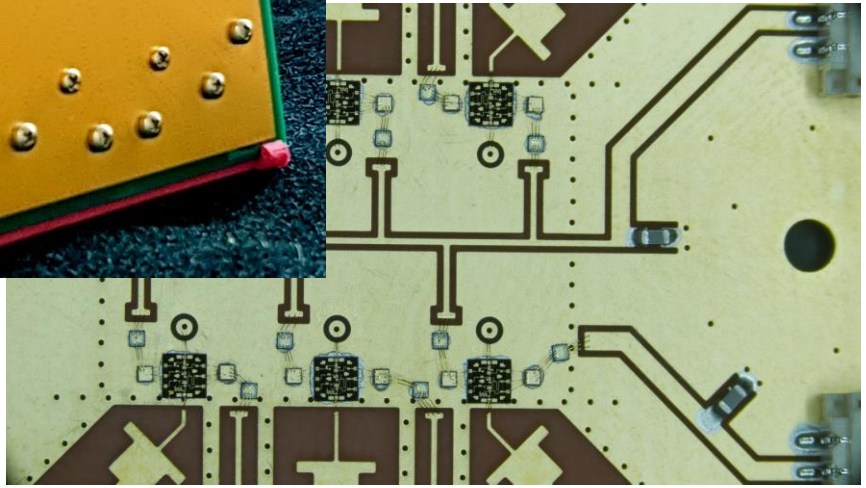


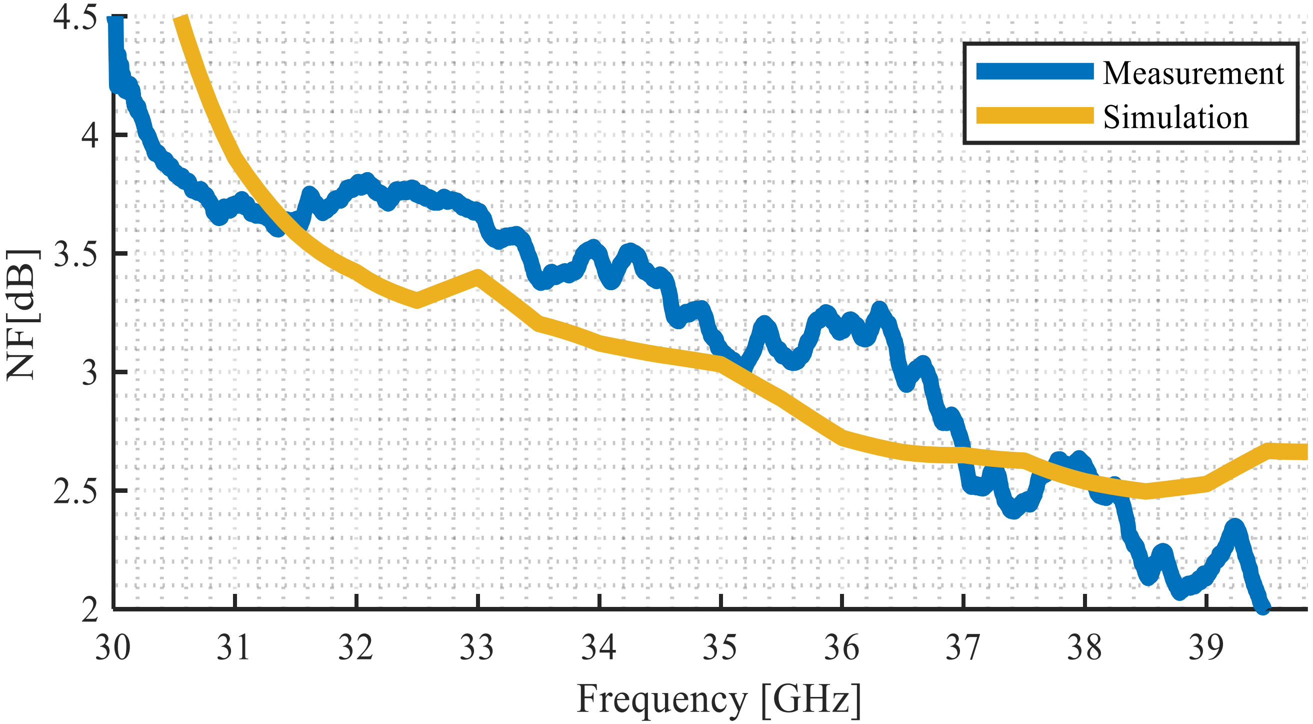
Expanded uncertainty (95% confidence): OTA 0.37 dB; Reference 0.25 dB

A. Hubrechsen, T. Stek and A. B. Smolders, "Simplified Over-the-Air Noise Figure Measurement Method for Reduced Uncertainty," *IMS 2023*

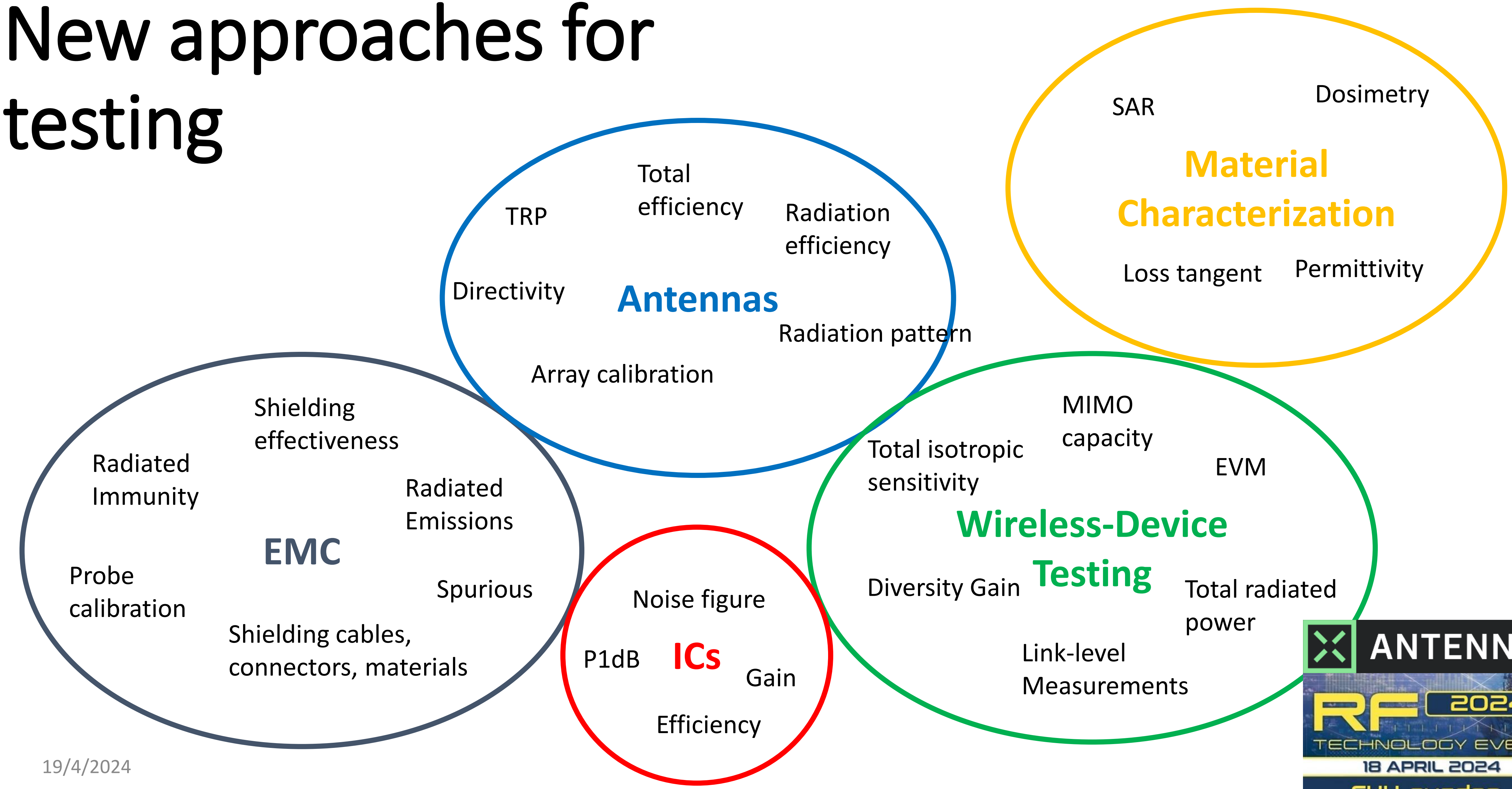
NF of an integrated antenna

Courtesy of Kirill
Alekseev, TU/e





New approaches for testing



ANTENNEX

www.antennex.tech | info@antennex.tech

Visit us at Booth #13