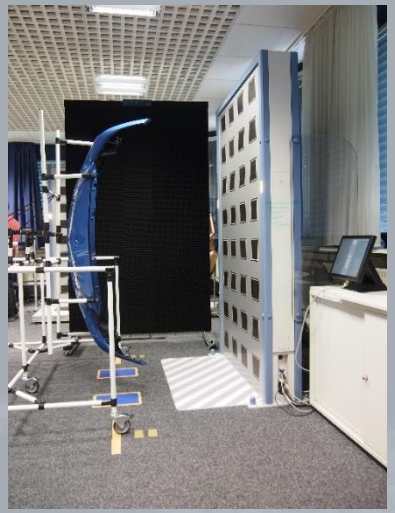
Unique Applications of microwave VNA technology



Ben Maarleveld - Sales Manager T&M - Rohde & Schwarz Benelux B.V.

Reaction to terrorist incidents – security measures increased strongly

Traditionally metal detectors and X-Ray luggage scanners

New threats since 9/11 created a demand for new technology: **Person security scanners**

Smiths detection

eqo™

Electronic scan

24 GHz (CW)

Pax rotates, arms up

L3 communications

ProVision®2

Rotating antennas

24 - 30 GHz

Single posture, arms up

Rohde & Schwarz

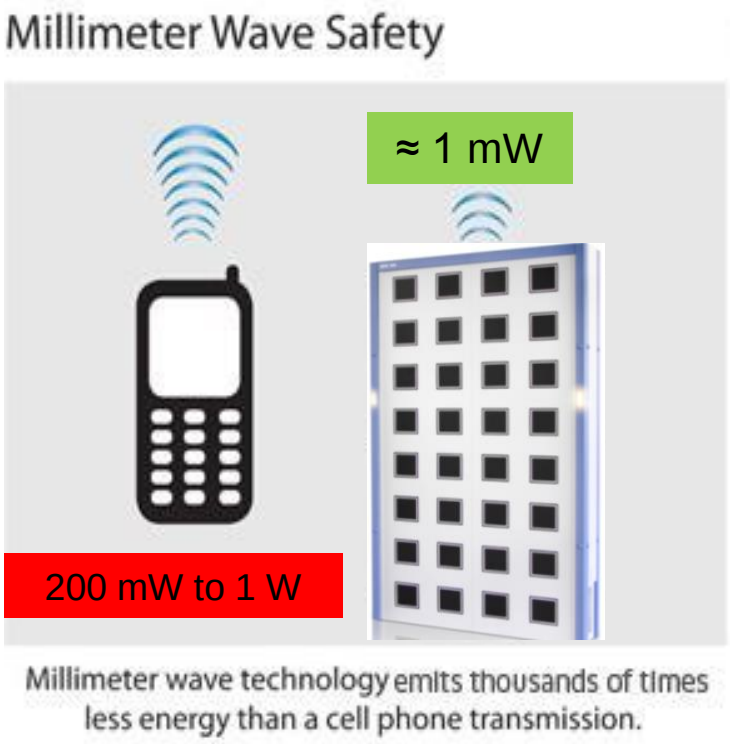
QPS Series

Electronic scan, multi-static

70 - 80 GHz

One or two postures, arms down

Safety of millimeter-wave security scanners



A typical cellular phone transmits

orders of magnitudes more output power

than Security scanners

Millimeter waves vs X-Ray

L3 Provision ATD

Smith Detection eqo

R&S QPS

Mm-waves

X-Ray

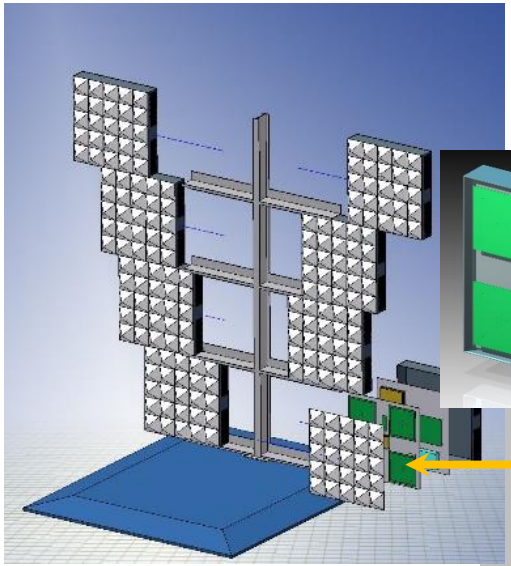
Braun iScan

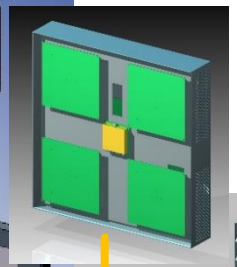
Forbidden in Europe

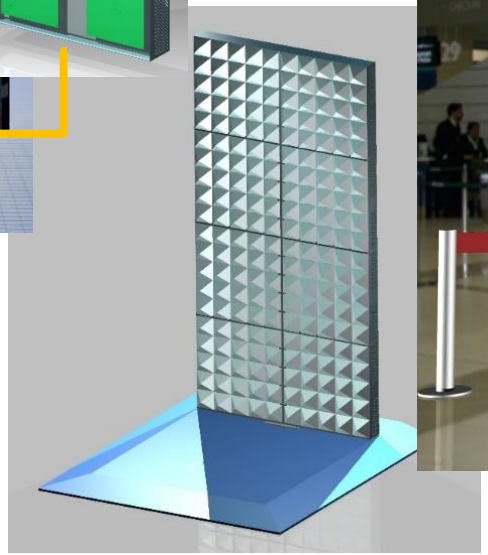
ASE SmartCheck

1 m	10 cm	1 cm	1 mm	100 µm	10 µm	1 µm	300 nm	30 nm	Wavelength
300 MHz	3 GHz	30 GHz	300 GHz	3 THz	30 THz	300 THz	1 PHz	10 PHz	Frequency
0,01	0,1	1	10	100	1.000	10.000	100.000	1.000.000	Wavecount (cm^{-1})

2008: R&S vision of a modular security scanner





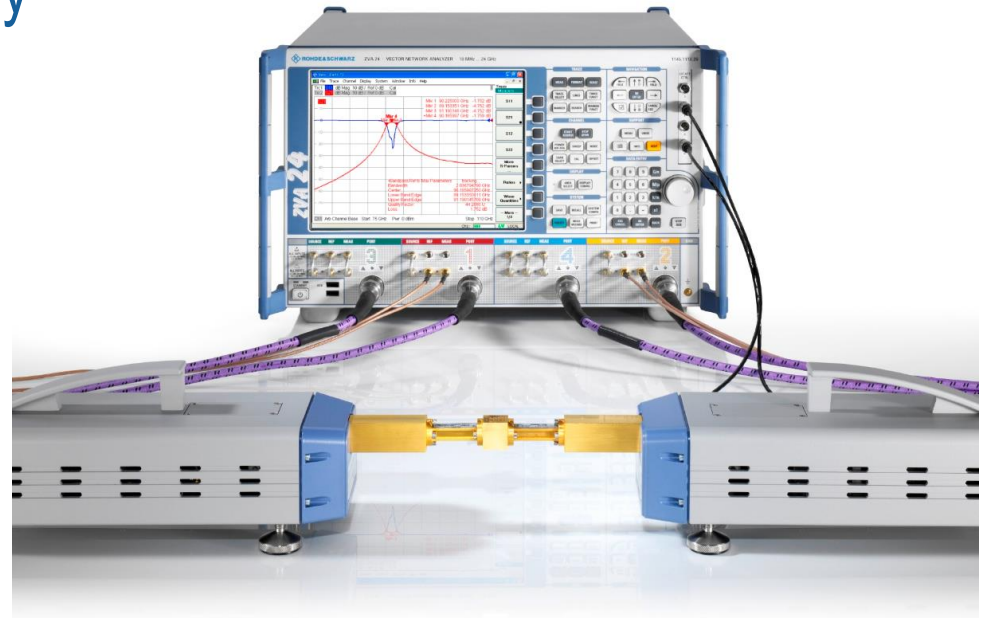


In modern

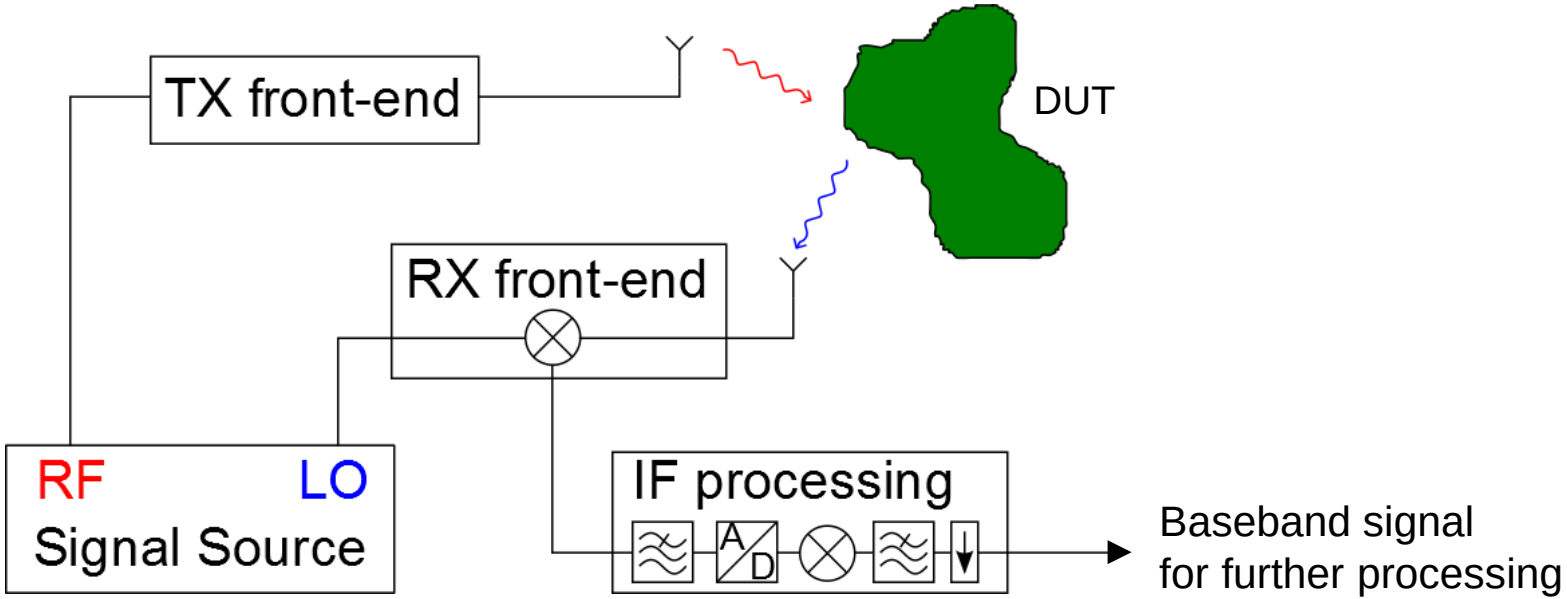
Vector Network Analyzers

microwave is a core technology

up to 100 GHz and higher

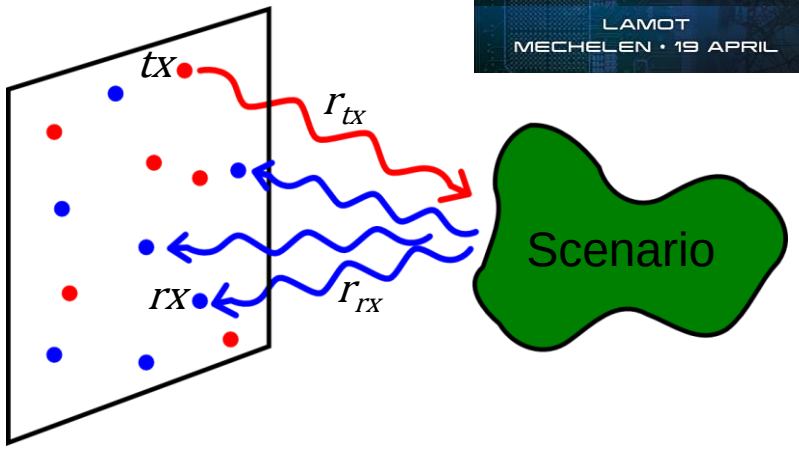


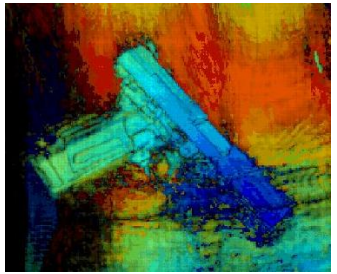
Basic principle of microwave scanner – Single channel block diagram



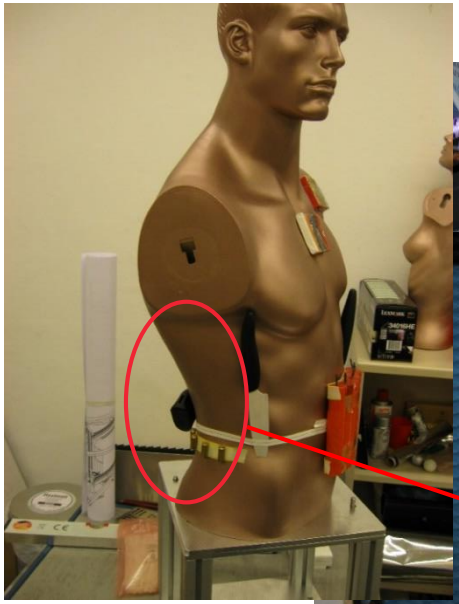
Principle of Multistatic Microwave Imaging

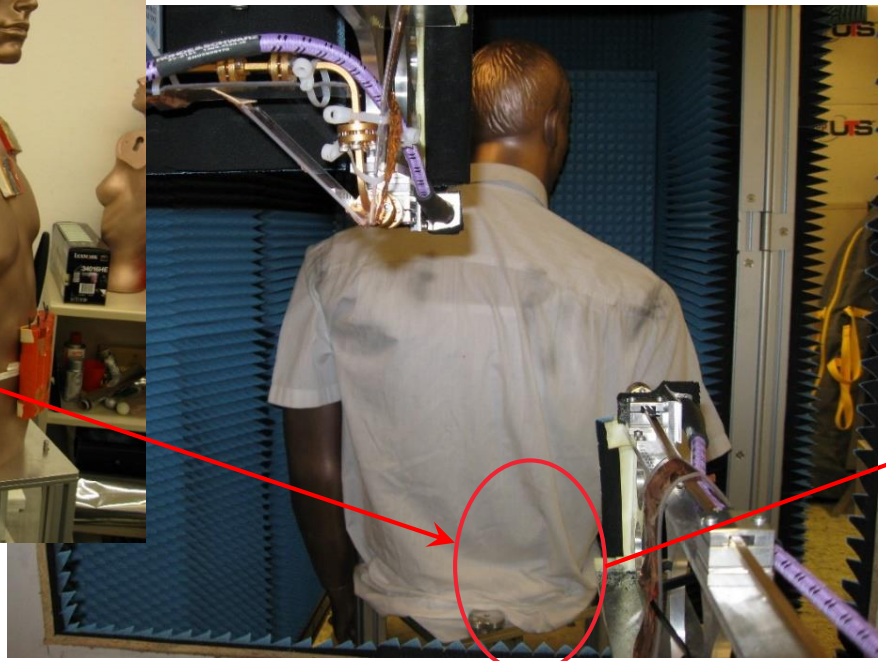
- A set of multiple transmitting and receiving antennas define the imaging array
- This array is used to measure the reflectivity of the „device under test“ with respect to each Tx-Rx-combination
- Image reconstruction:
  - $Voxel(x,y,z) = \sum_{N_f} \sum_{N_{rx}} \sum_{N_{tx}} s(tx,rx,f) e^{j\frac{2\pi f}{c_0}(r_{tx}+r_{rx})}$
  - „Correct the collected data of every transmitter-receiver-pair by their free space propagation for all frequency points and add everything up.“

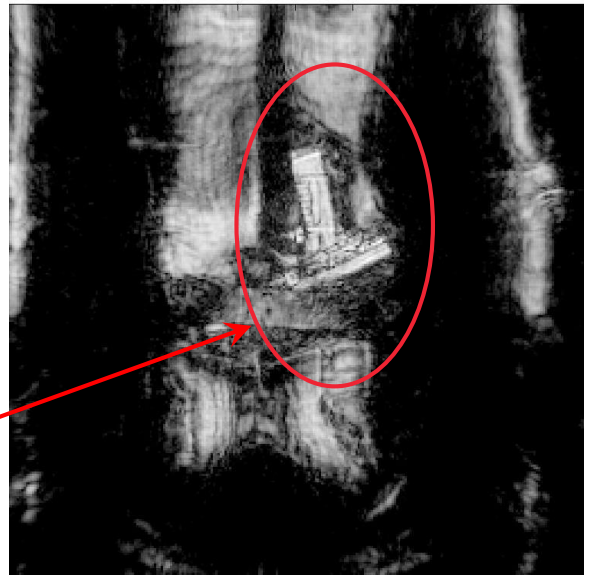




2008: first experimental test setup, two scanning antennas

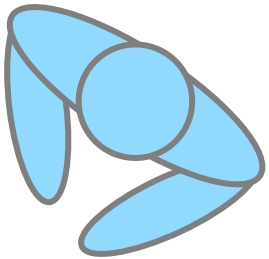




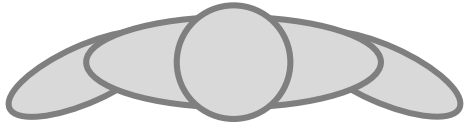


Scan Process

Operator
(Screener)



Passenger
(Pax)

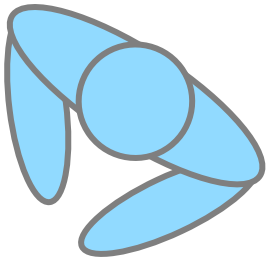


Scanner

Scan Process

Operator
(Screener)

Illuminating signal
coming from a single antenna



Passenger
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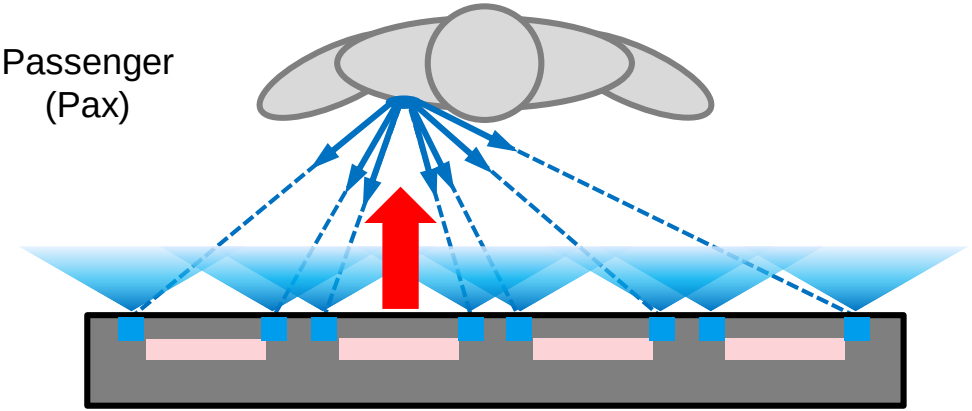
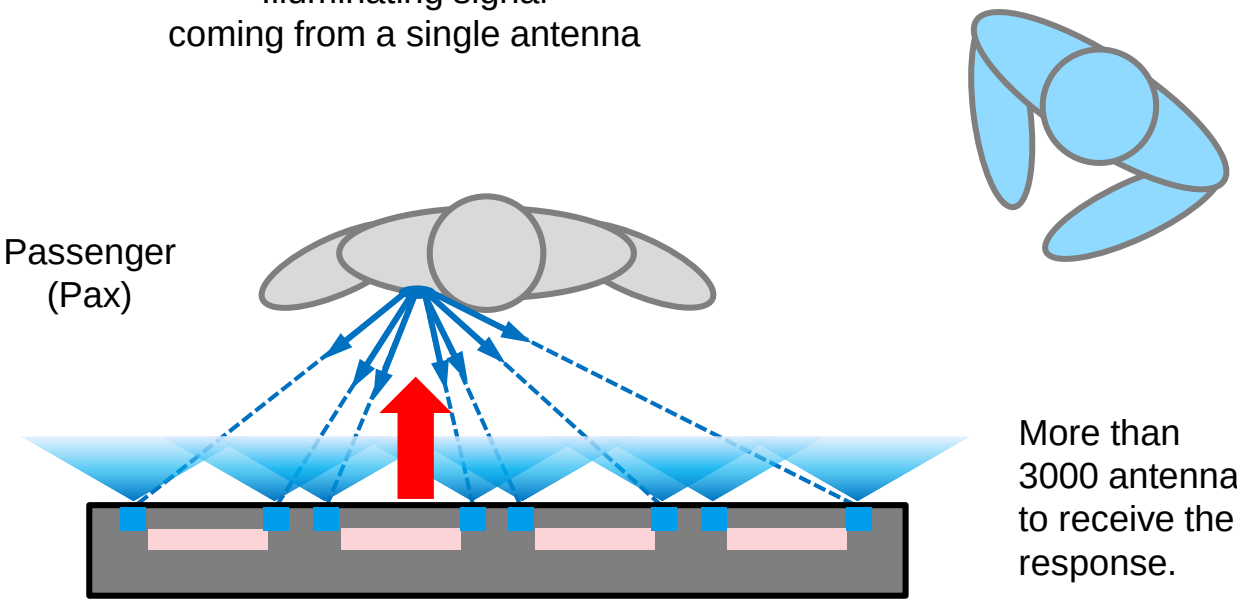


More than
3000 antennas
to receive the
response.

Scan Process

Operator
(Screener)

Illuminating signal
coming from a single antenna



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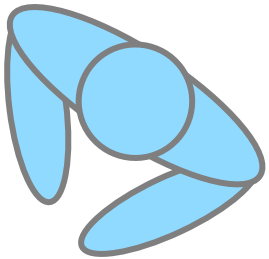
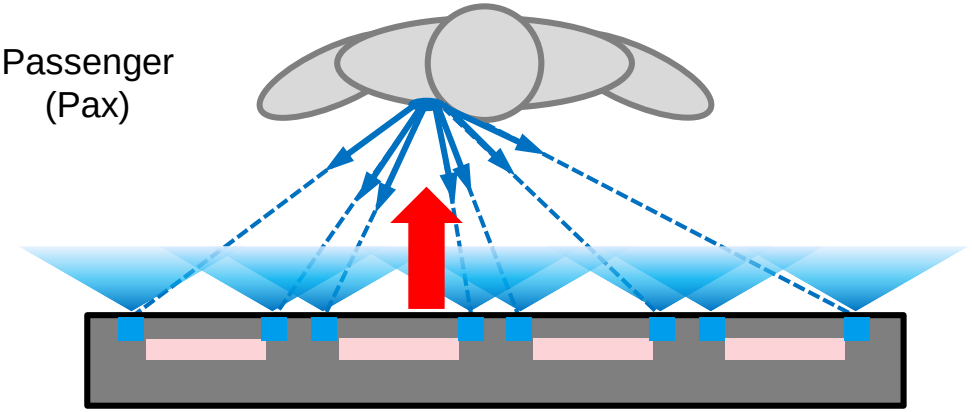


Passenger
(Pax)



More than
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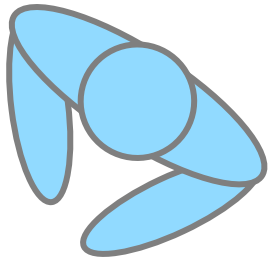
response.

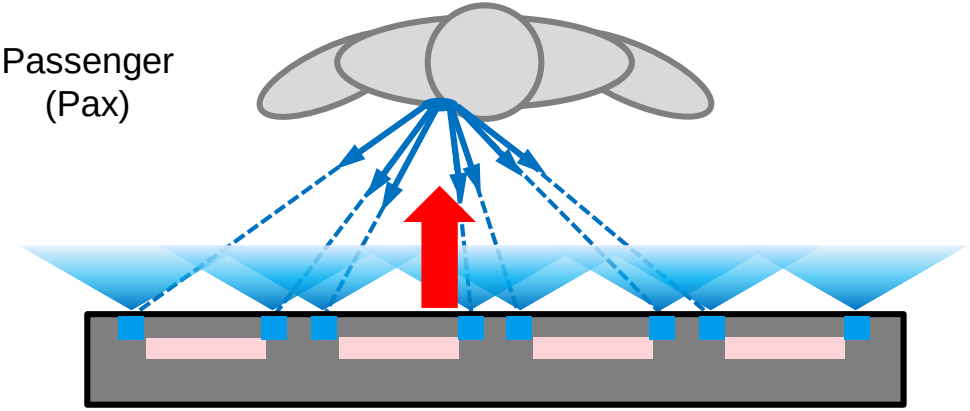
Scan Process

Illuminating signal
coming from a single antenna

Operator
(Screener)



Passenger
(Pax)



More than
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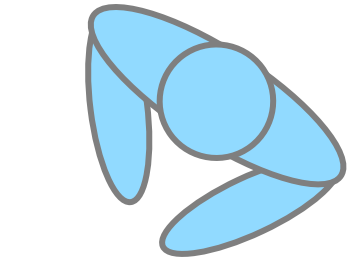
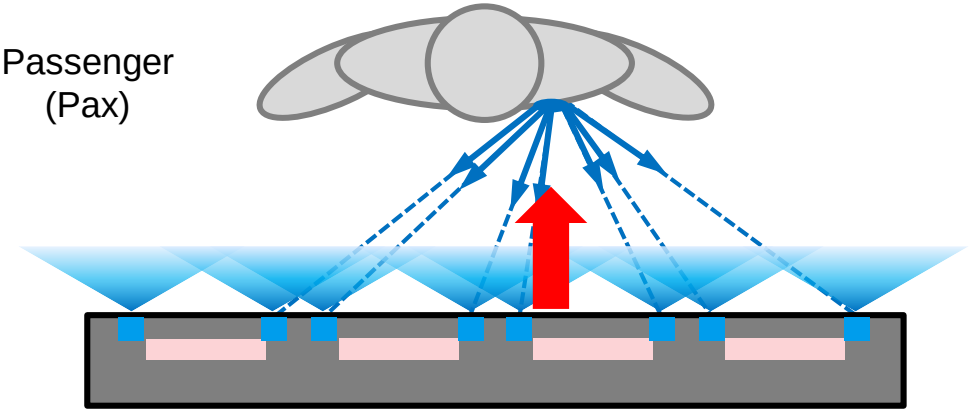
Scan Process

Operator
(Screener)

Illuminating signal
coming from a single antenna

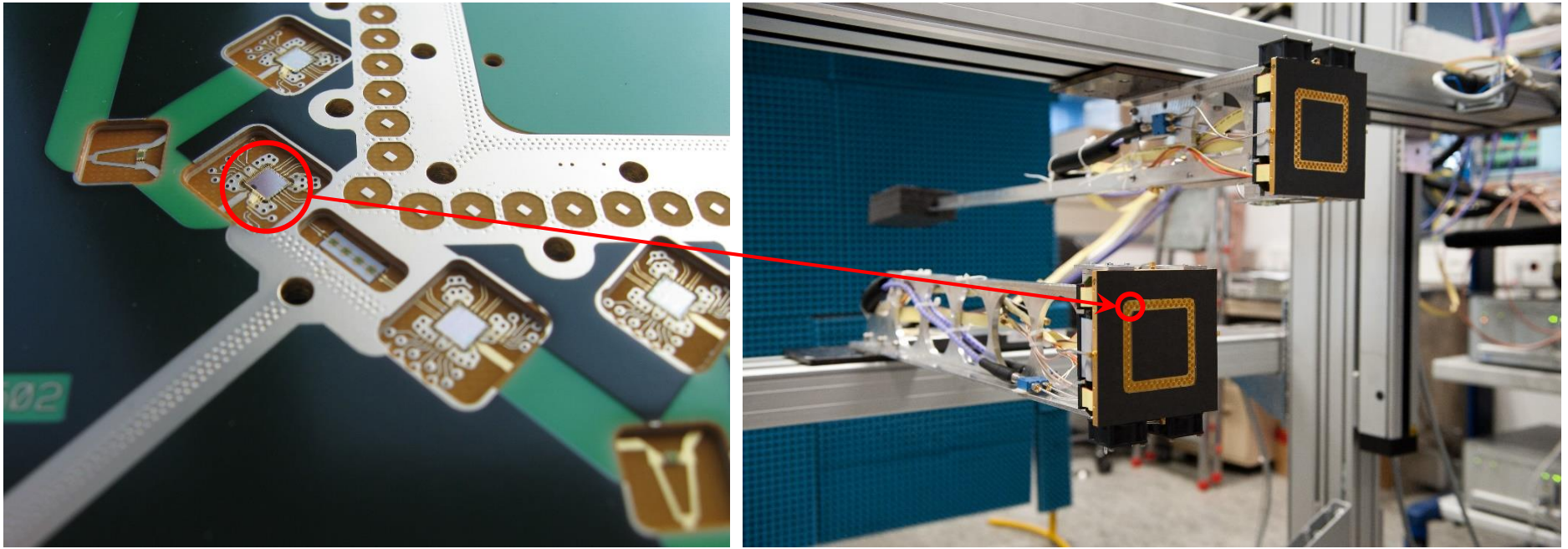


Passenger
(Pax)



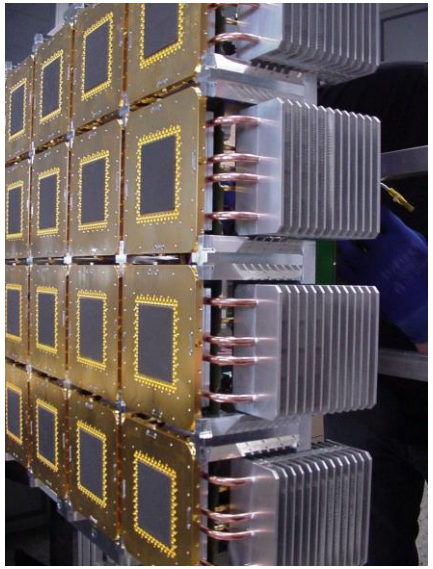
More than
3000 antennas
to receive the
response.

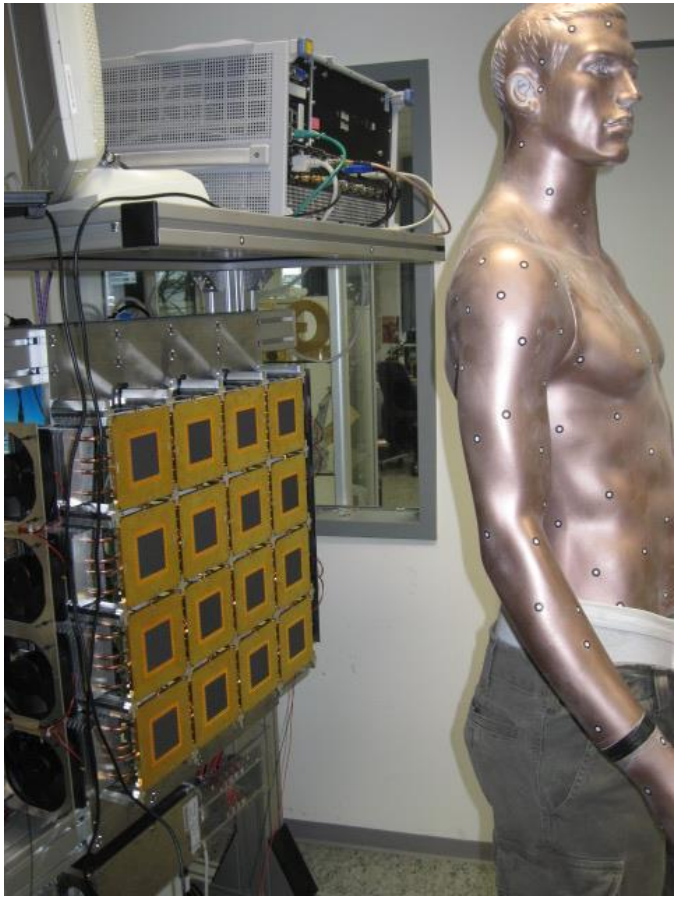
Module integration and testing – using a chip set designed by Infineon



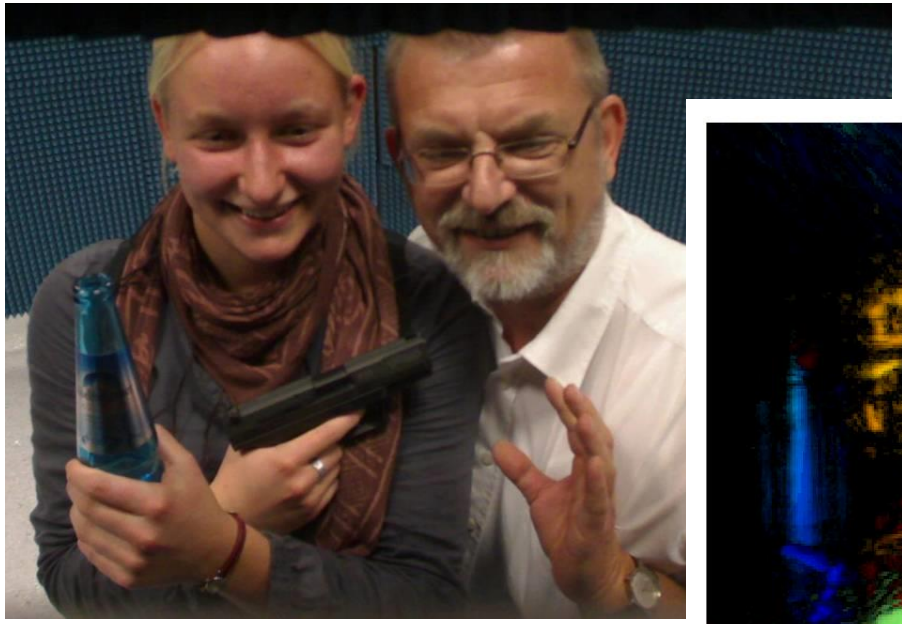
2010: first fully electronic demonstrator

- 4x4 Cluster
- Scan time 0,5 s
- Heat pipe cooling system
- First images of living humans

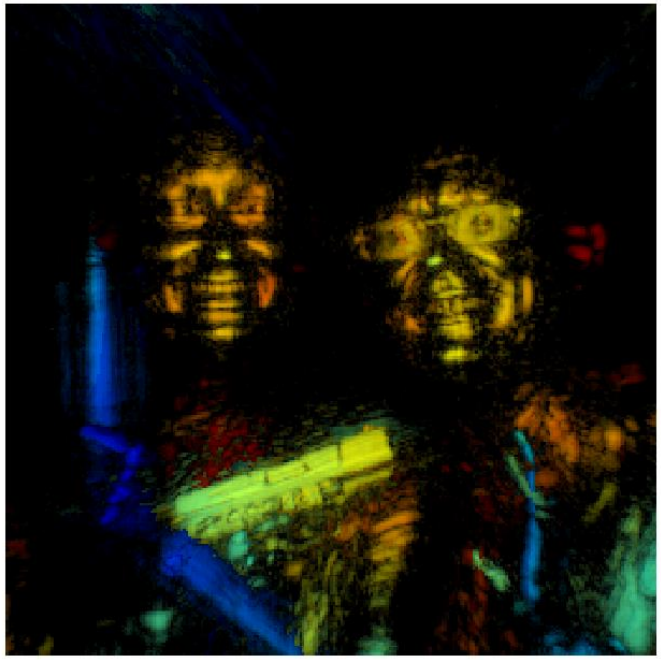




World‘s first images of Humans in E-Band (60 -90 GHz)

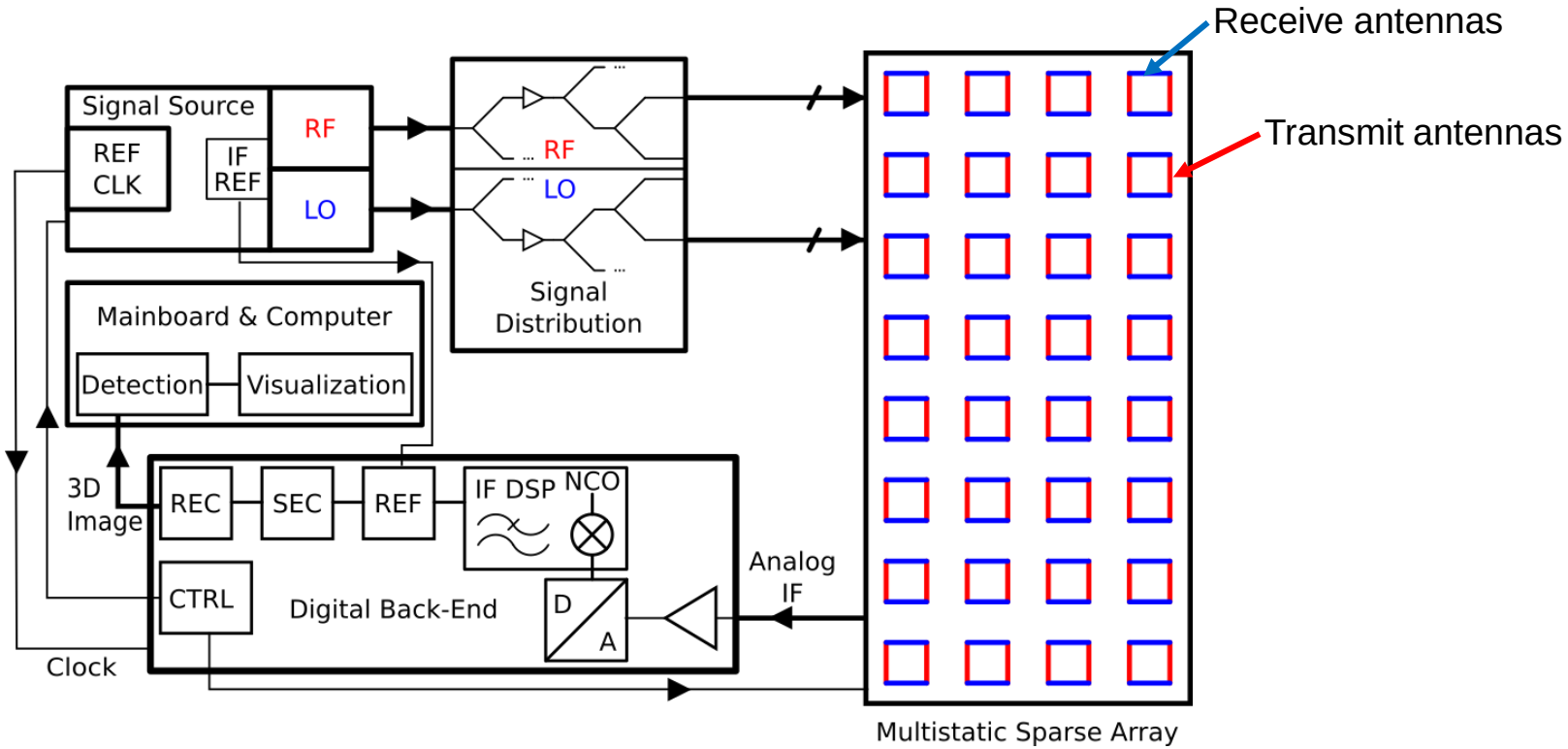


Inventor of the QPS and daughter



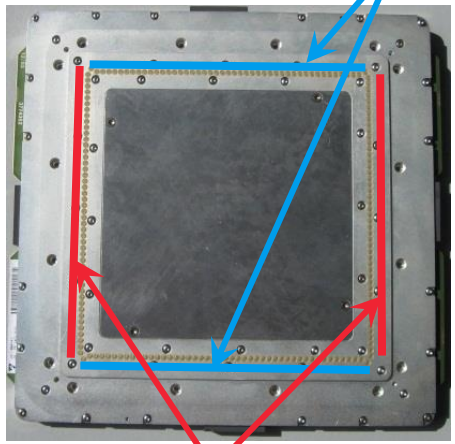
System Block Diagram

Thousands of fully synchronized Tx and Rx channels



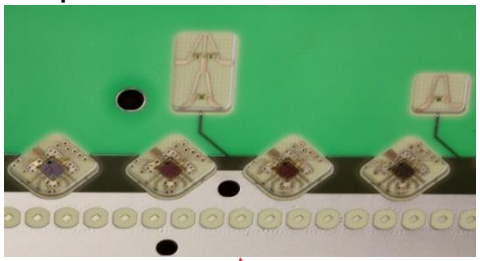
QPS technical data

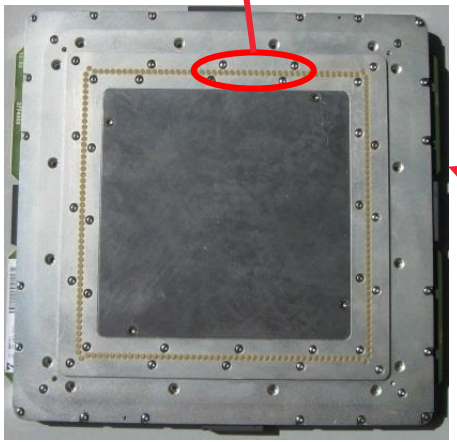
- **70 - 80 GHz** Operating frequency
- **94** Rx and Tx antenna's per module
- **32** Rx/Tx modules per scanner
- **3008 Tx** and **3008 Rx** antennas in total
- > **30 dB** Image dynamic range
- < **2 mm** High resolution
- **msec** range scan time



QPS System Integration

Chips & Antennas

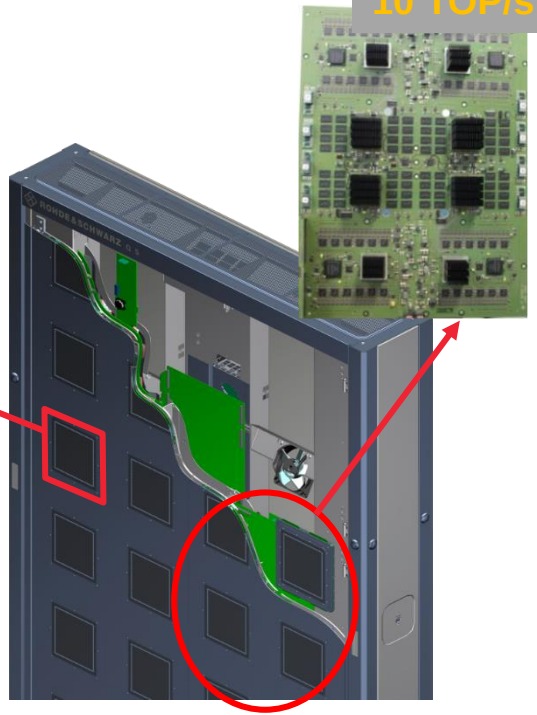




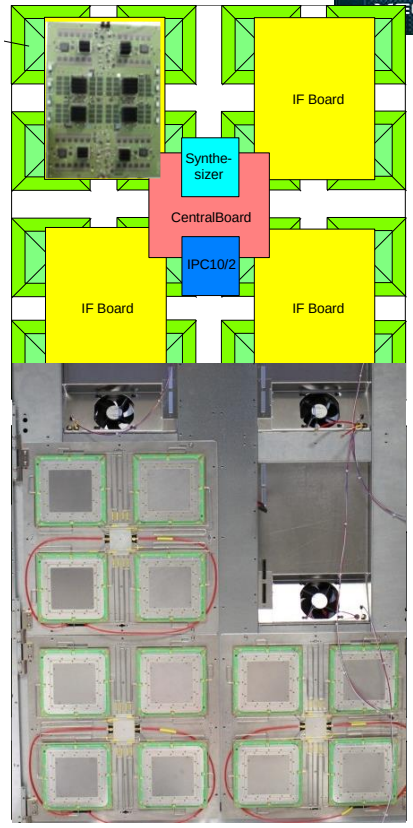
32x RX/TX array

8x Data transfer
and reconstruction

10 TOP/s



System
integration



Automated Threat Detection by powerful algorithms

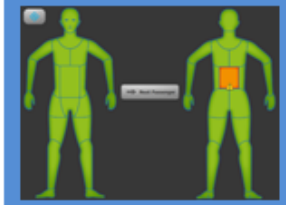
- Automatic detection of threats/objects in composite microwave images
- Detection software visualizes threats on abstract avatar
- Operator never sees raw images; fulfilling privacy and security requirements

Data

Raw MIP Image

Automated threat detection

Result



QPS Operator Screen

Same technology – another new application

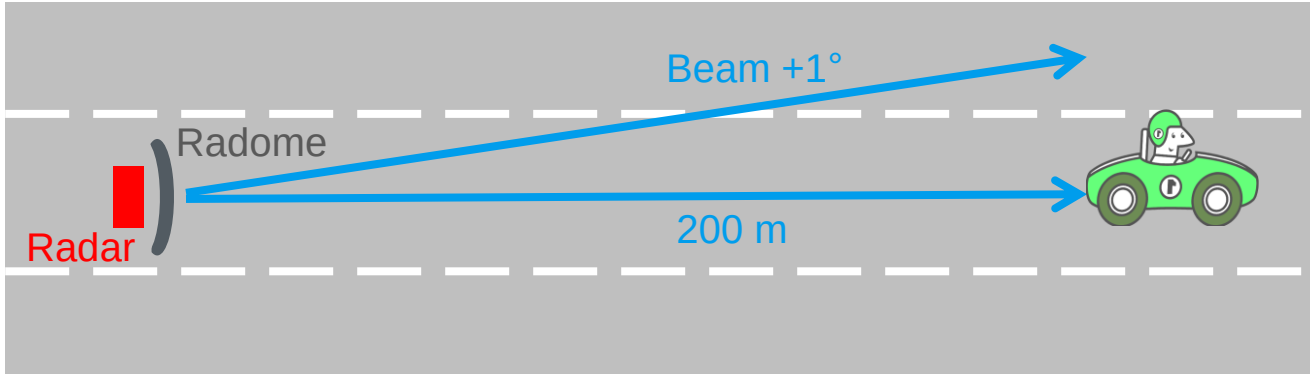
Automotive radar performance behind radomes and bumpers

Right now there are many different approaches for radar sensor integration.

Automotive radar operates in same 70-80 GHz frequency range

Same technology – another new application

Car radar performance

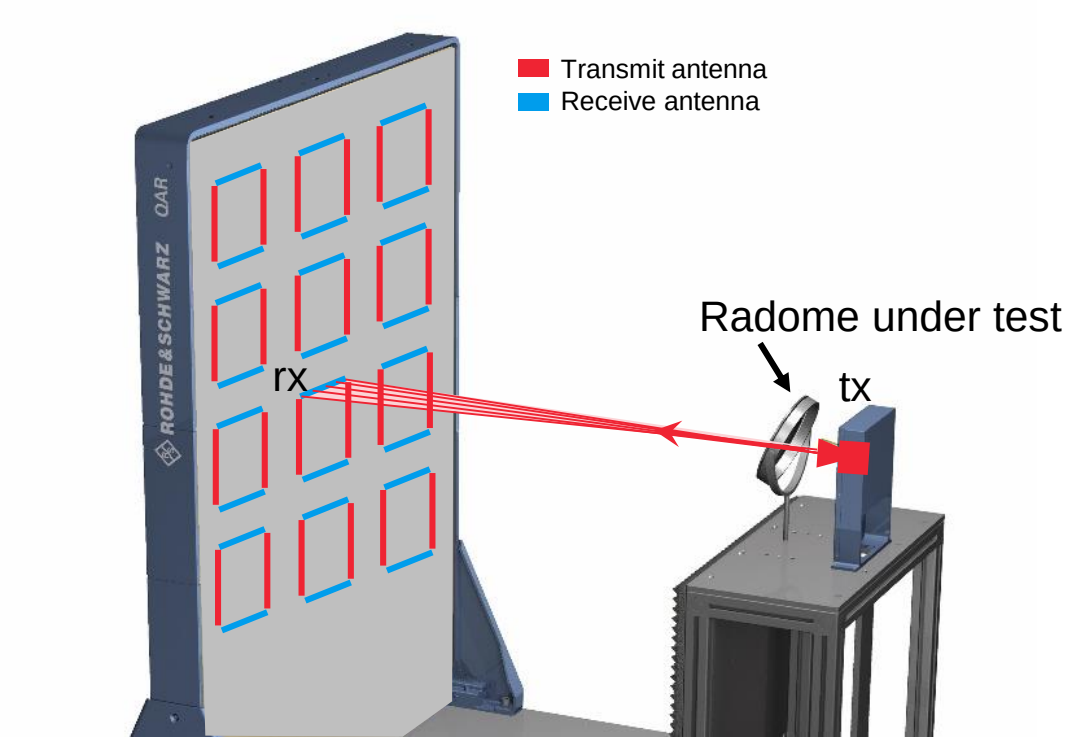


Radomes may cause angle errors!

- Rough estimate: Target is 200 m away -> angle error is 1° in broad sight -> Lateral detection error = 200 m x tan 1° = 3,5 m
  → The radome is a highly critical part!
  → Quality check required, especially at the end-of-line test?

Measurement principle

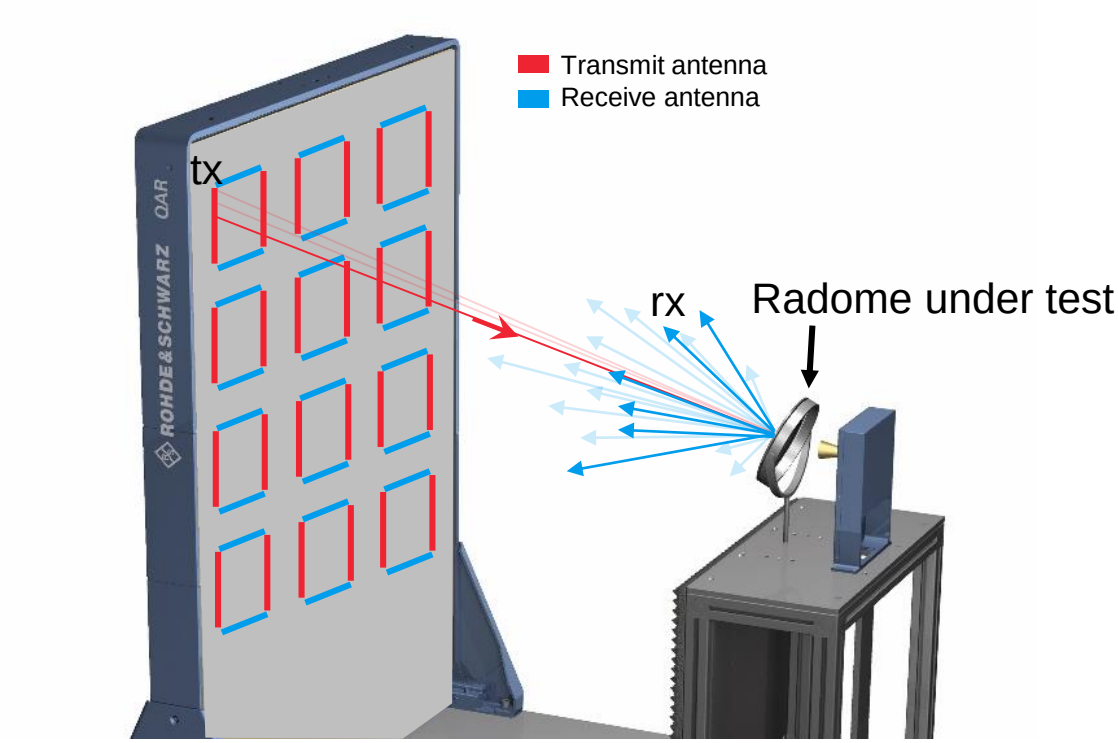
Transmission measurement



- Measures permeability of radome or bumper material
- The external transmit antenna is switched on and the received power level is measured at each of the antennas in the line.

Measurement principle

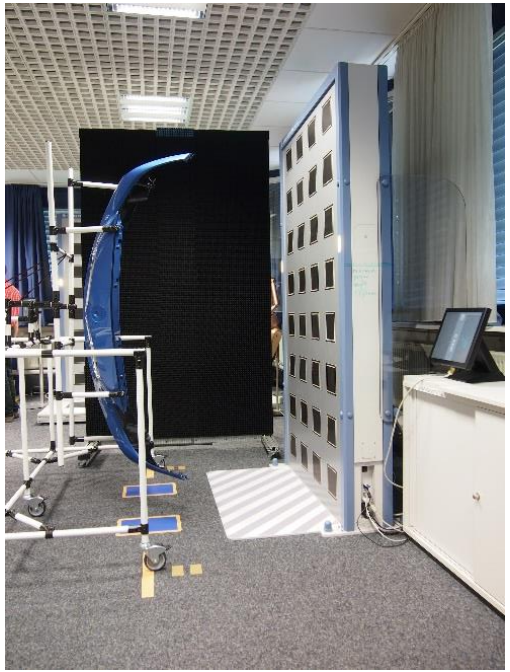
Reflectivity measurement



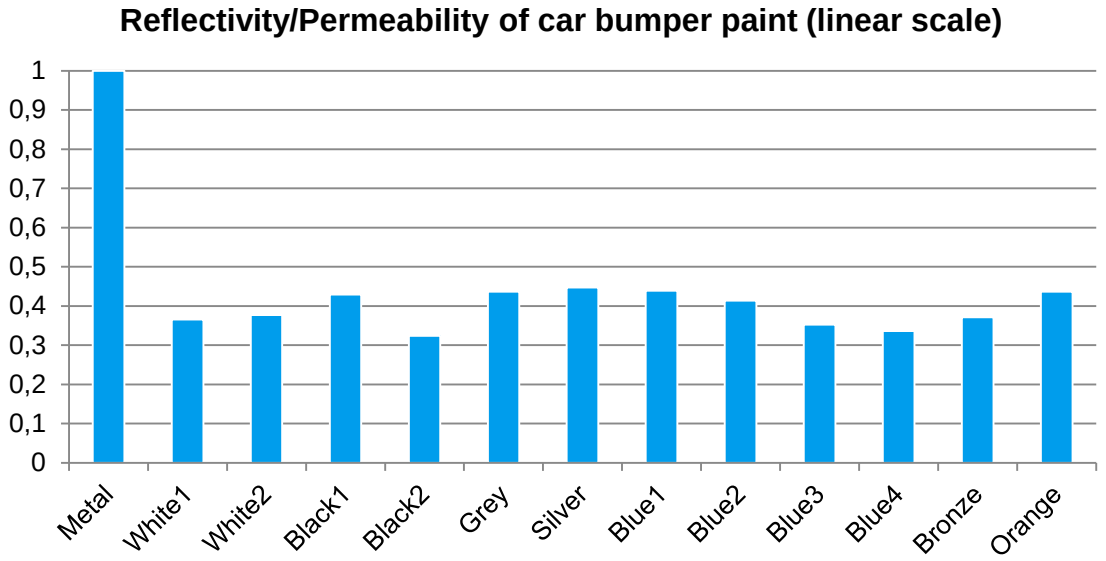
- Measures degree of reflection and reflection pattern of radome or bumper material
- For reflection measurement, each transmit antenna is switched on sequentially.
- The complex wave quantities are measured coherently at each single receive antenna.

Examples of measurement results

Differences in permeability of painted plastic bumpers



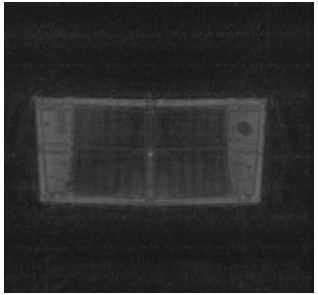
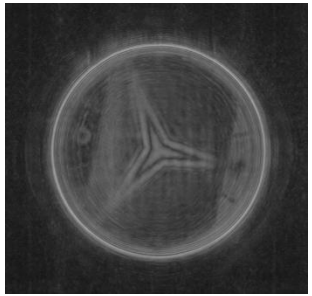
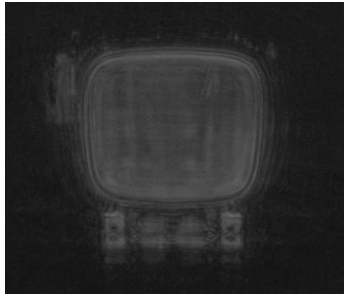
Bumpers usually have metallic paint
→ Is it possible to penetrate the paint with millimeter waves?
…….. Yes it is!



Examples of measurement results

Big differences in inhomogeneity of radomes



Rohde & Schwarz competence – R&D **and** Manufacturing

100% designed and produced in Germany, based on R&S IP's

Thanks for your attention!