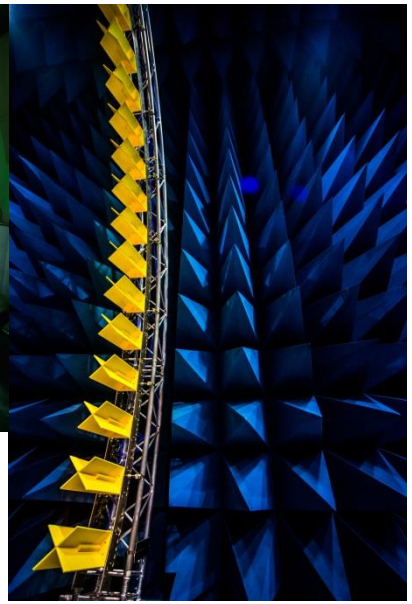
Cost Efficient Testing of Large MIMO DUT in Virtual Electromagnetic Environments



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Department Wireless Distribution Systems / Digital Broadcasting DVT

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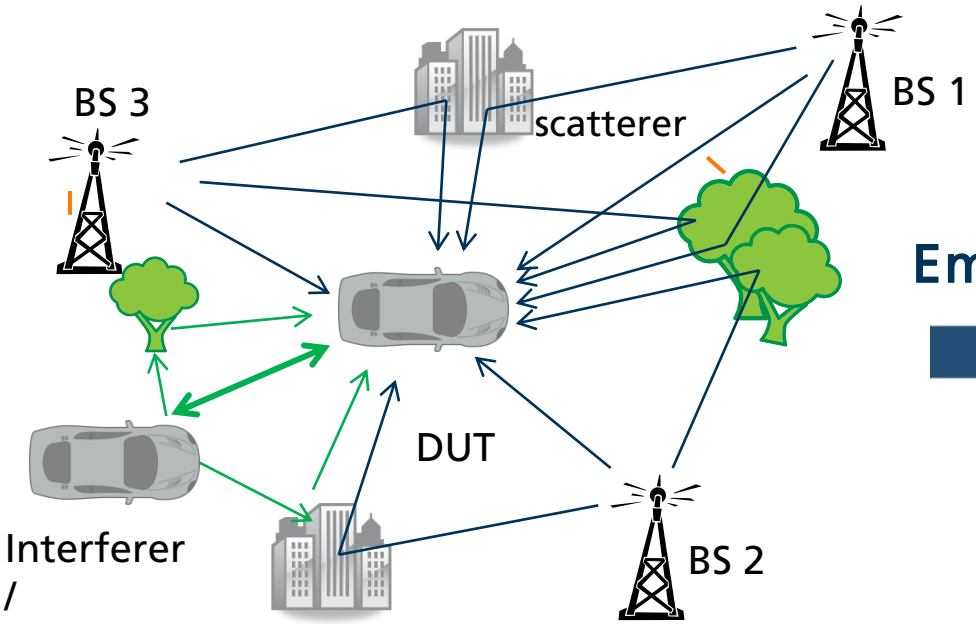
Cost Efficient Testing of Large MIMO DUT in Virtual Electromagnetic Environments

Overview

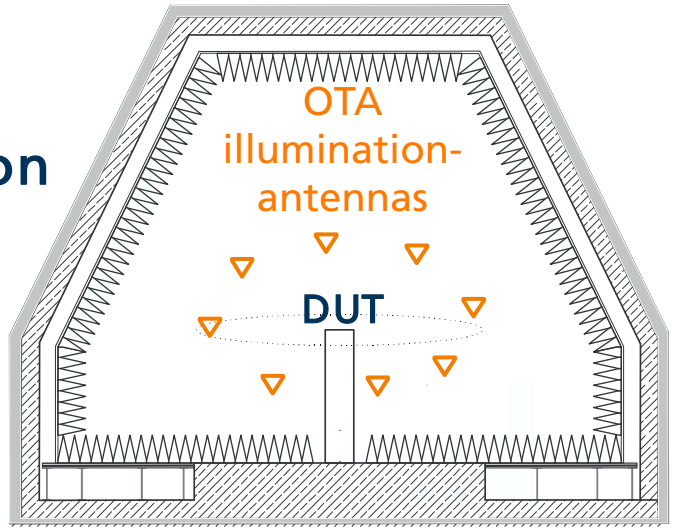
- MIMO Over the Air Testing
- Two Stage test method
- Radiated two-stage (“Wireless Cable”)
- Measurement results at FORTE (**F**acility for **O**ver the Air **R**esearch and **Te**sting)
  - Emulation Quality
  - Car2X channel emulation applying the Radiated two stage method

MIMO Over-The-Air Testing

Motivation



Emulation



Interference/communication scenario

Anechoic chamber/ Reverberation Chamber

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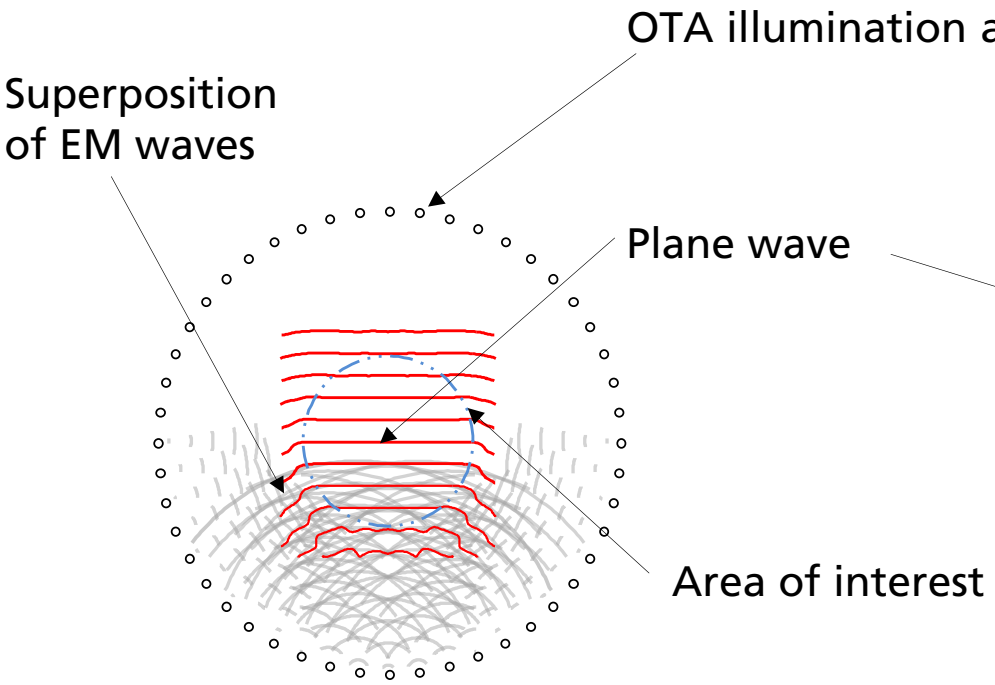
MIMO Over-The-Air Testing
Motivation - General

- Need for:
  - Emulation of real world radio wave propagation under laboratory cond.
  - Controllable and repeatable DUT test conditions
  - testing arbitrary radio and application scenarios
  - testing over wide frequency range for arbitrary standards (LTE-A, Cognitive Radio Technologies, C2X, etc.)
  - Coexistence and interference has to be emulated realistically
  - Tests in licensed frequency bands without disturbance of existing systems (shielded chamber)

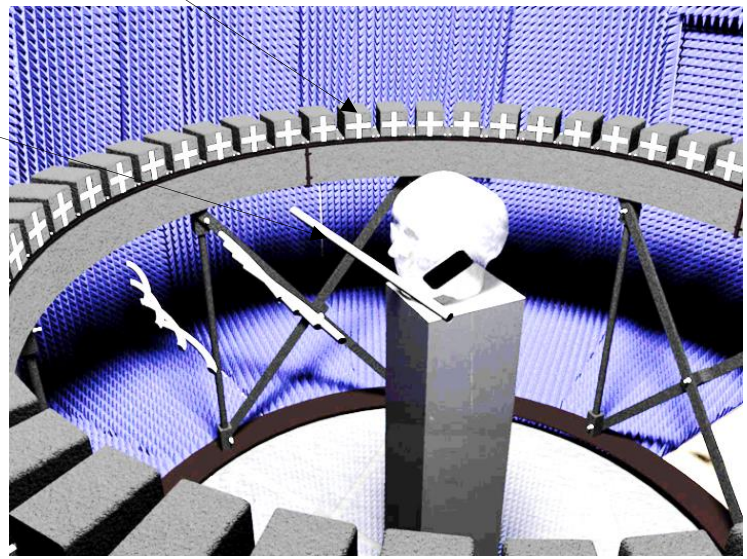
- No need for:
  - Extensive/expensive often weather dependent field tests
  - Acquiring frequency license (especially when testing for different regions of the world)

MIMO Over-The-Air Testing

Wave Field Syntheses (WFS) for small devices



Priciple Single plane wave



Inside view anechoic chamber

Note : Multiple Plane Waves from arbitrary direction can be generated!

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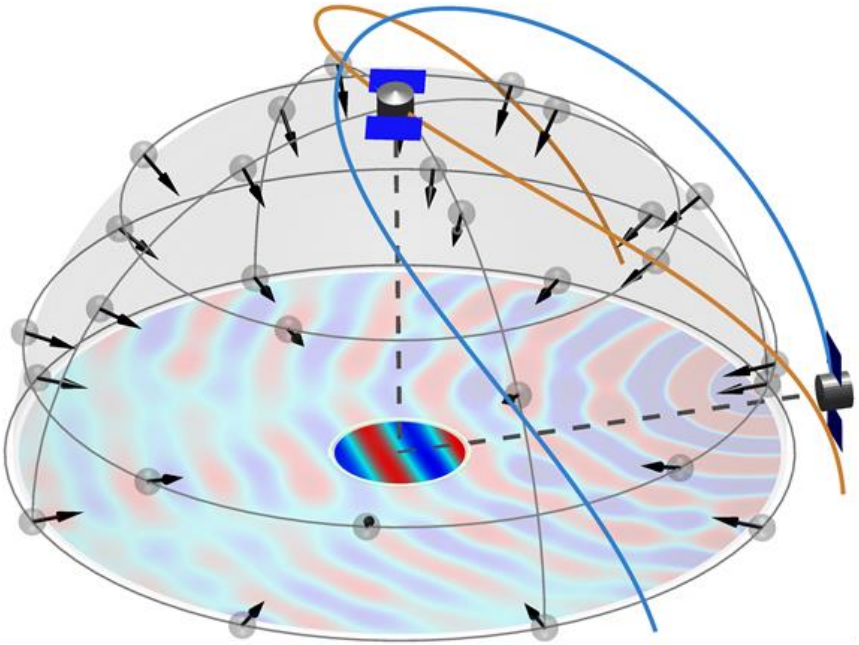
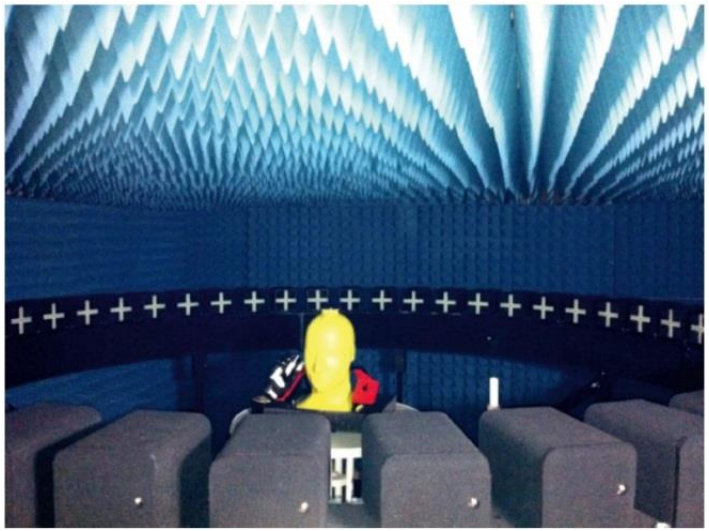
MIMO Over-The-Air Testing

2D/3D Wave Field Syntheses (WFS) for small DUTs

Testing of GNSS beamforming receivers / antennas



Testing of MIMO receivers/antenna systems (LTE,...)



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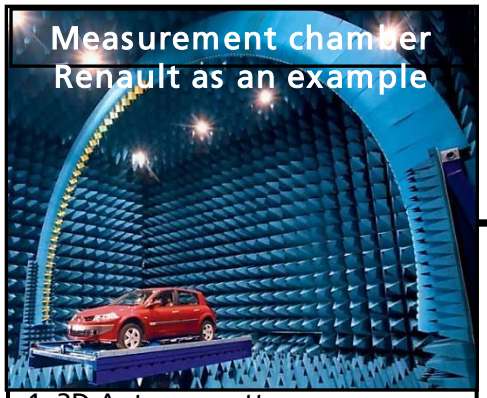
Two-Stage Method
Motivation & Idea

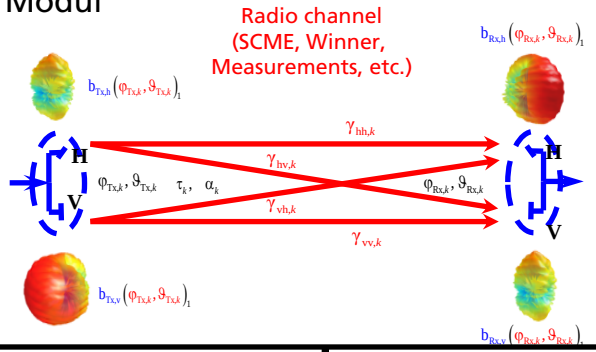
- Motivation:
  - Wave field synthesis for large objects prohibitive expensive
  - MIMO/array/beam forming antenna systems → large number of OTA emulation antennas/channels required
- Idea, Emulation of realistic multipath conditions with conducted test in 2 stages:
  1. Over the air radiation pattern measurement
  2. Realtime convolution with channel characteristic and measured antenna characteristics during channel emulation for MxN channles in Up and Downlink
- Drawback: Self interference as well as coexistent systems are neglected

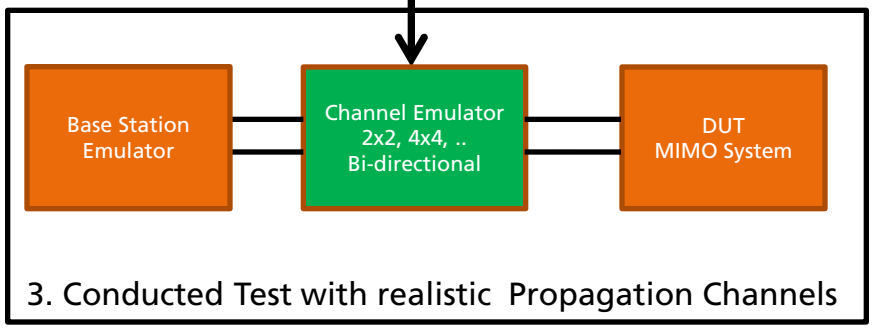
Two-Stage Method
Motivation & Idea



1. 3D Antenna pattern measurement

2. MIMO Channel & Antenna Pattern Modul





3. Conducted Test with realistic Propagation Channels

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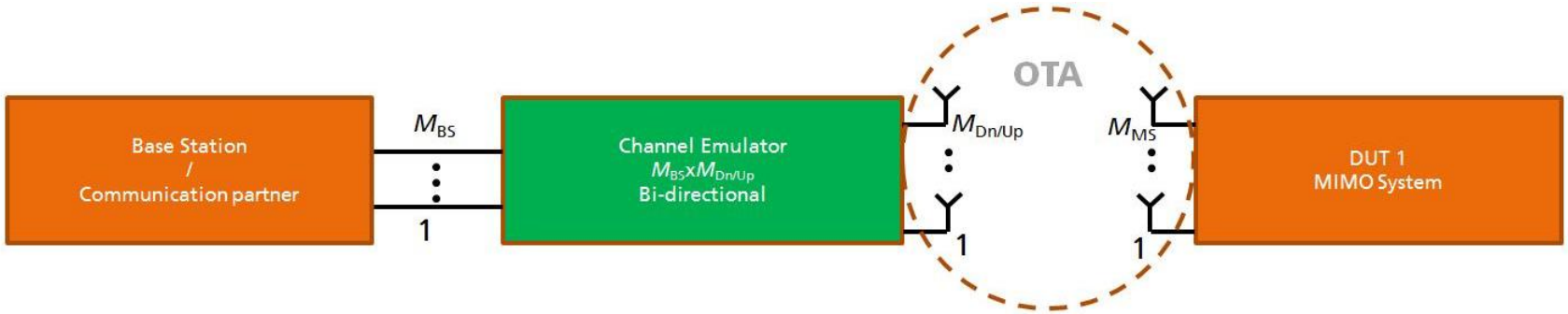
Radiated Two Stage
Idea

- Over the Air with orthogonal channels – “Wireless Cable”
- Several OTA antennas are used to generate orthogonal channels to each physical DUT antenna in space and time
- transfer matrix between all OTA antennas and DUT antennas has to be measured



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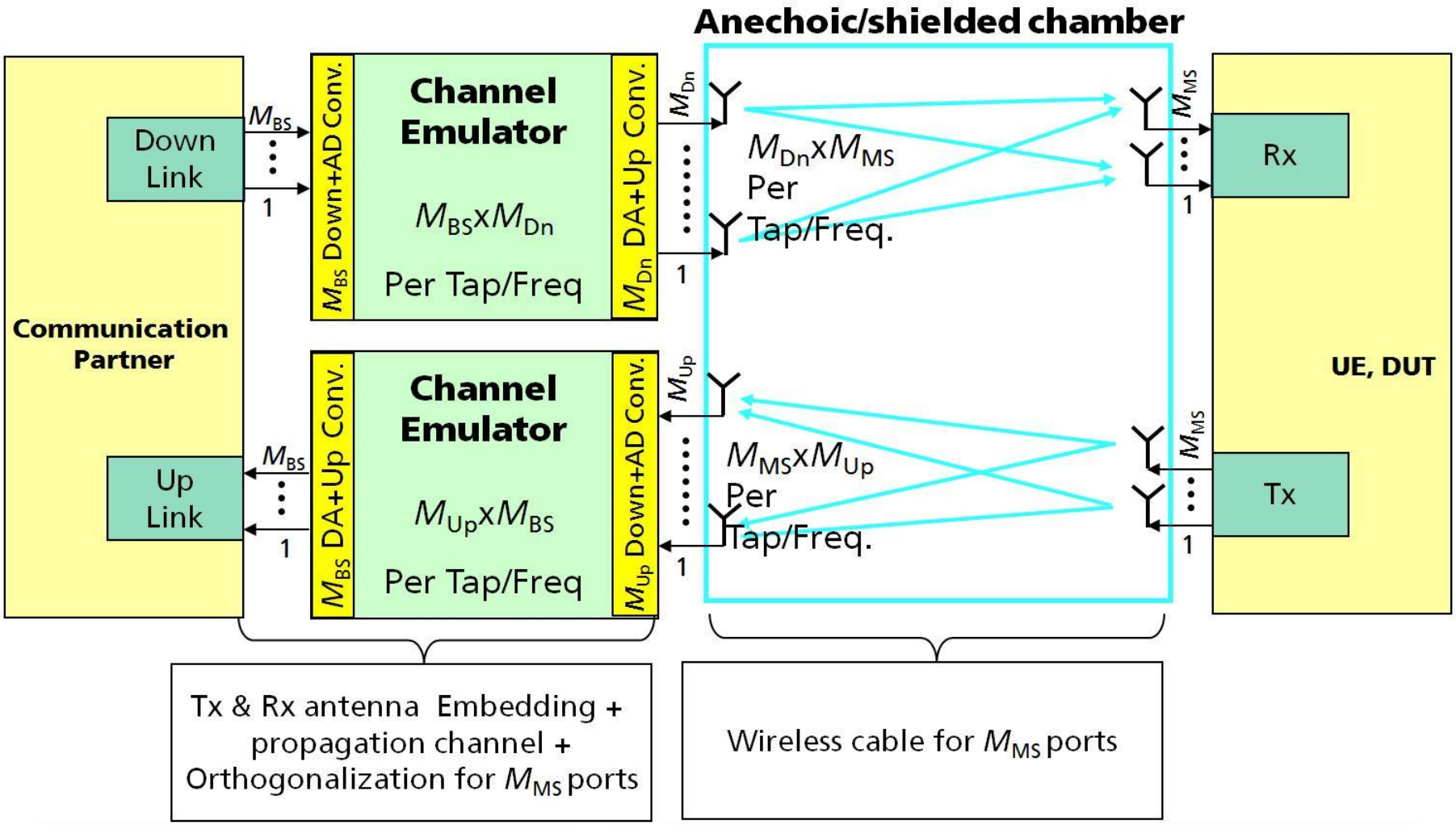
Radiated Two Stage
Down & Uplink



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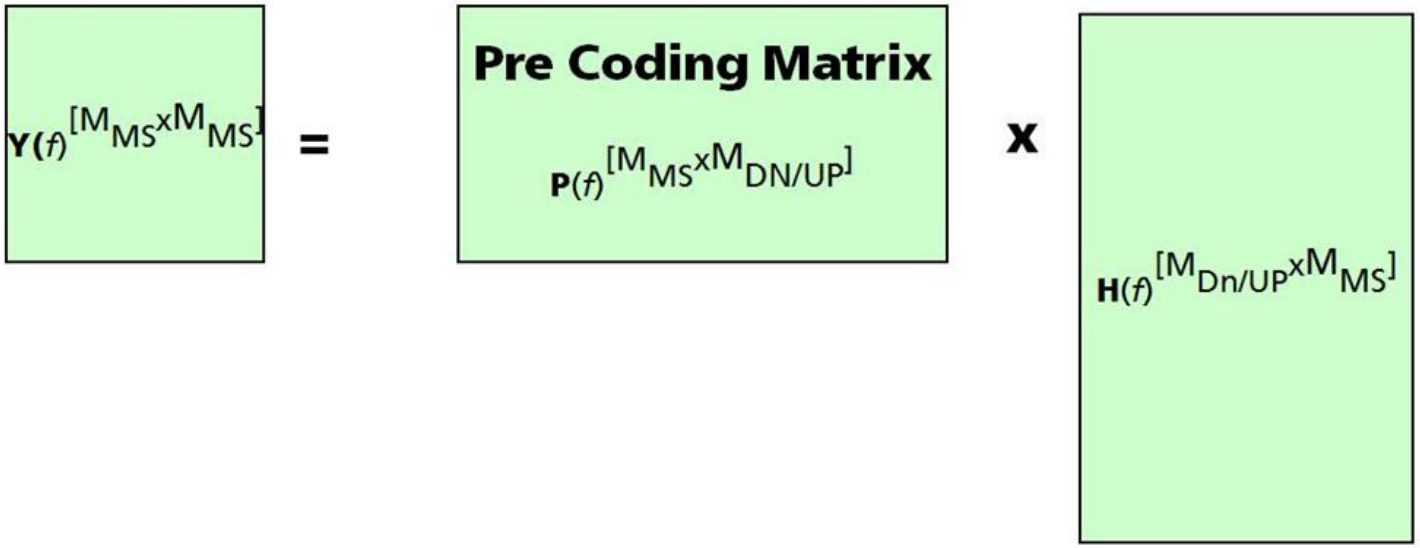
Radiated Two Stage
Problem formulation

„Wireless cable“ for M_{MS} ports if Y=I can be achieved

Channel emulator weights / Precoding Matrix

Measured Transfer Matrix



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Measurement Results

Test Facilities in Ilmenau

VISTA *(Virtual Street)*	*FORTE* *(Facility for Over the Air Research and Testing)*

Thuringian Centre of Innovation in Mobility *(ThIMo)*

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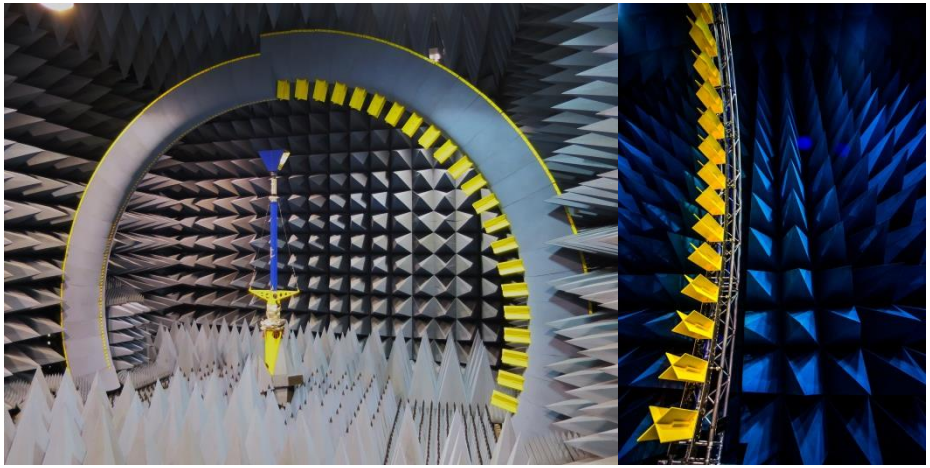

Measurement Results
Test Facilities in Ilmenau

Specification	*VISTA*	*FORTE*
Frequency range (MHz)	70…6000 MHz	70…3000 MHz (6 ch 6 GHz)
Chamber dimensions L (m) × W (m) × H (m)	16 × 12 × 9	4,8 × 4,3 × 3
Channel emulator Connectivity	tbd	12 × 32 (80 MHz Bandwidth) IZT Channel Emulators
Dynamometer	Yes	No
Antenna radiation pattern measurement	D<6m	D < 0.7 m
Type of channel emulation	Sparse Cluster emulation (tbd)	Dense or sparse EM WFS / 2 Stage, Radiated 2 Stage, meshed network @radiolevel
Additional Emulators & Base stations	tbd	LTE Macro and Femto cell BS, GSM, UMTS, ITS G5, WLAN, Core Network Components EPC, Multi channel GNSS emulator

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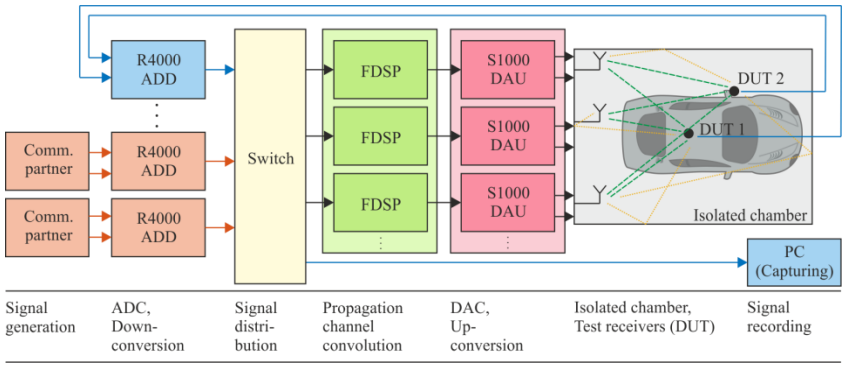
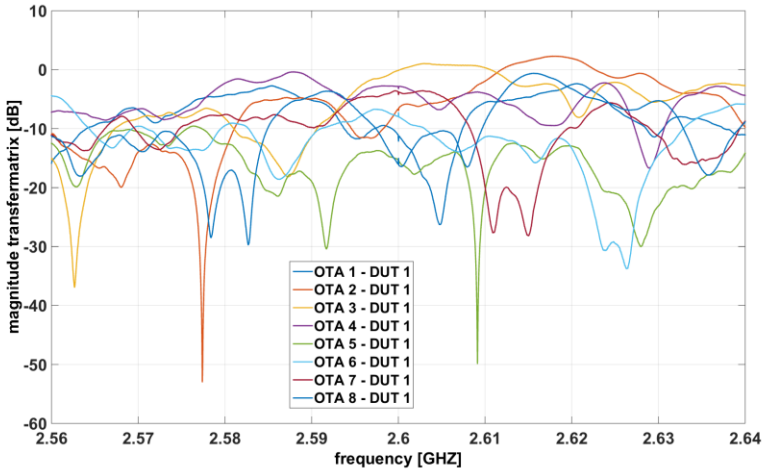
Measurement Results

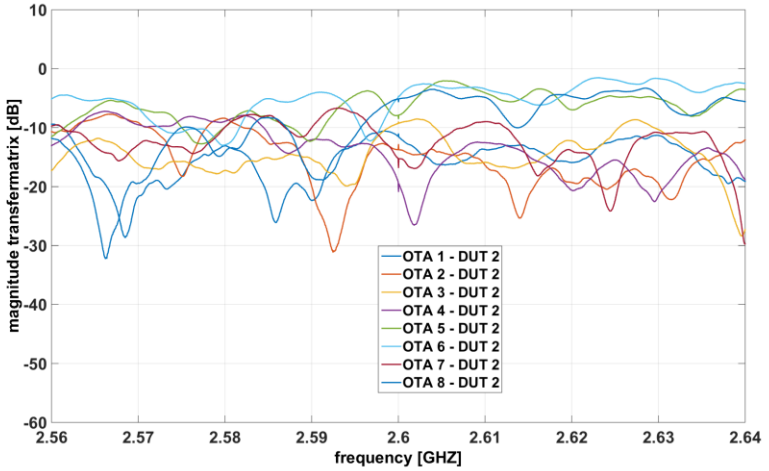
Transfer Matrices in non anechoic chamber



DUT 1



DUT 2



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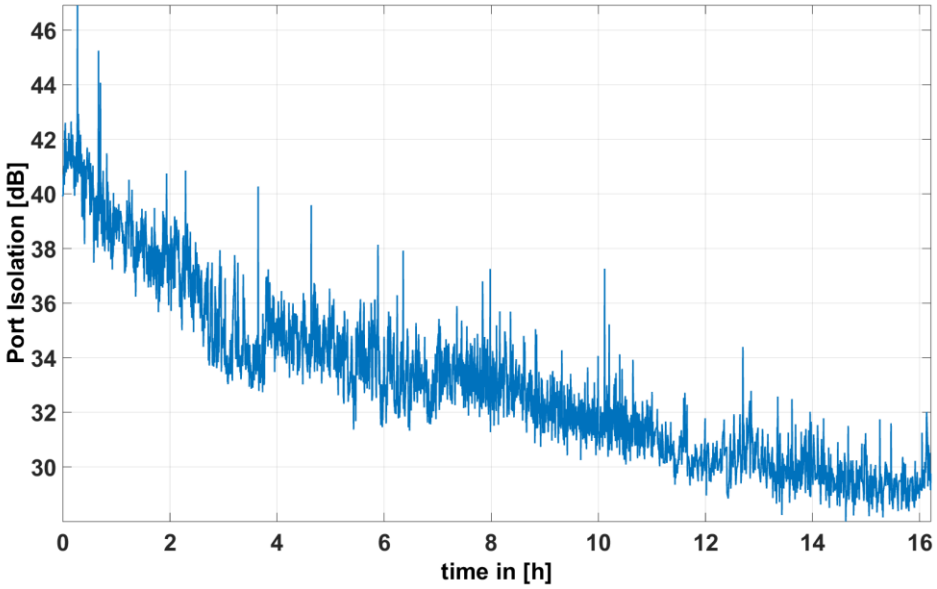
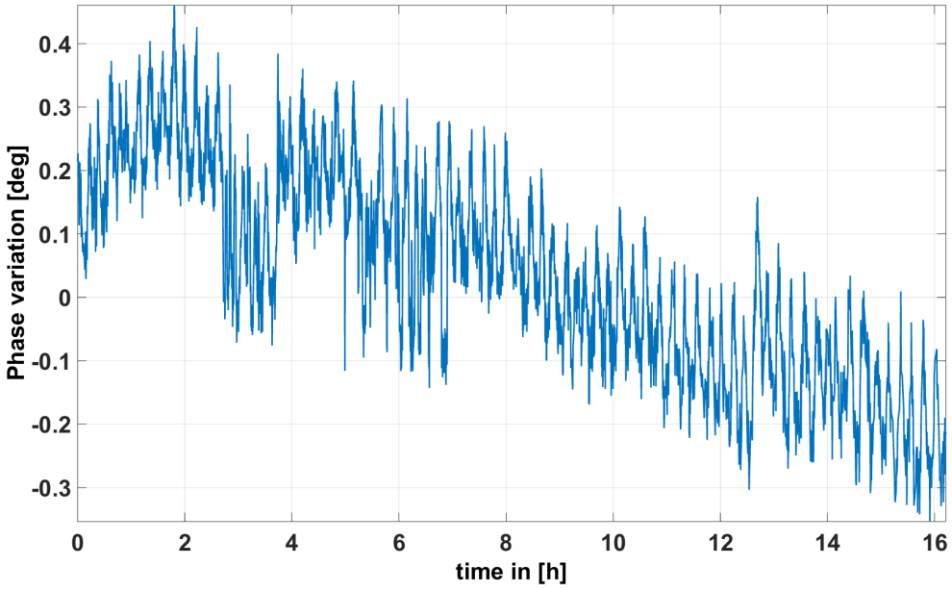
Measurement Results
"Wireless Cable" Long term stability

Port Isolation



Phase stability



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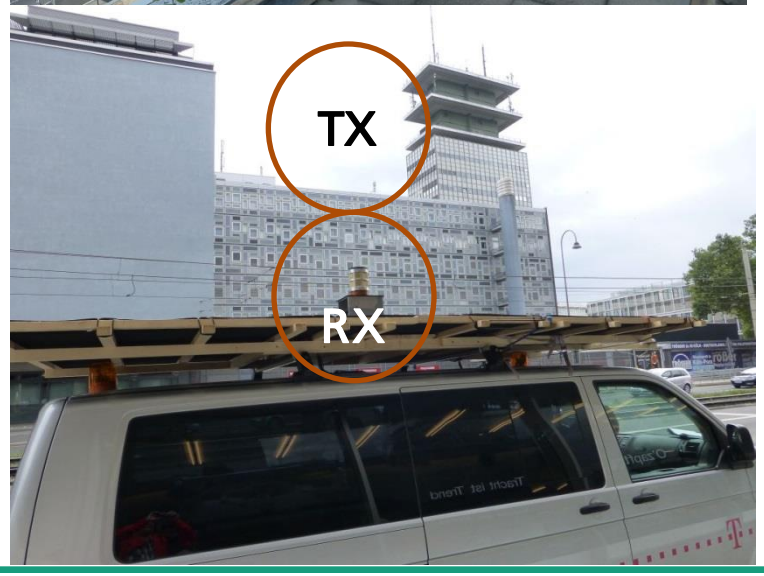
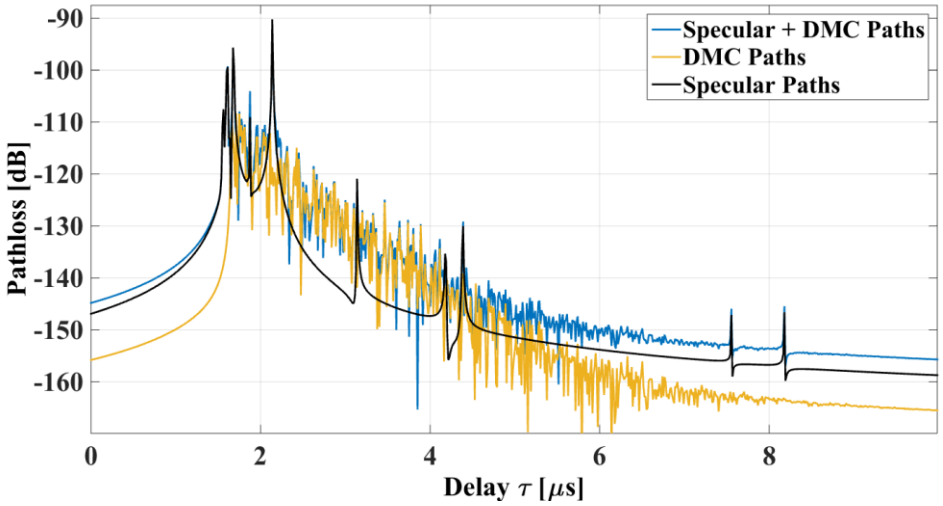
Measurement Results

Car2x Channel sounding campaign



- Double directional channel measurements of Ilmenau University of technology (EMT) and Deutsche Telekom in Cologne
- High Resolution Parameter estimation
- Reconstruction for emulation including the vehicular MIMO antennas



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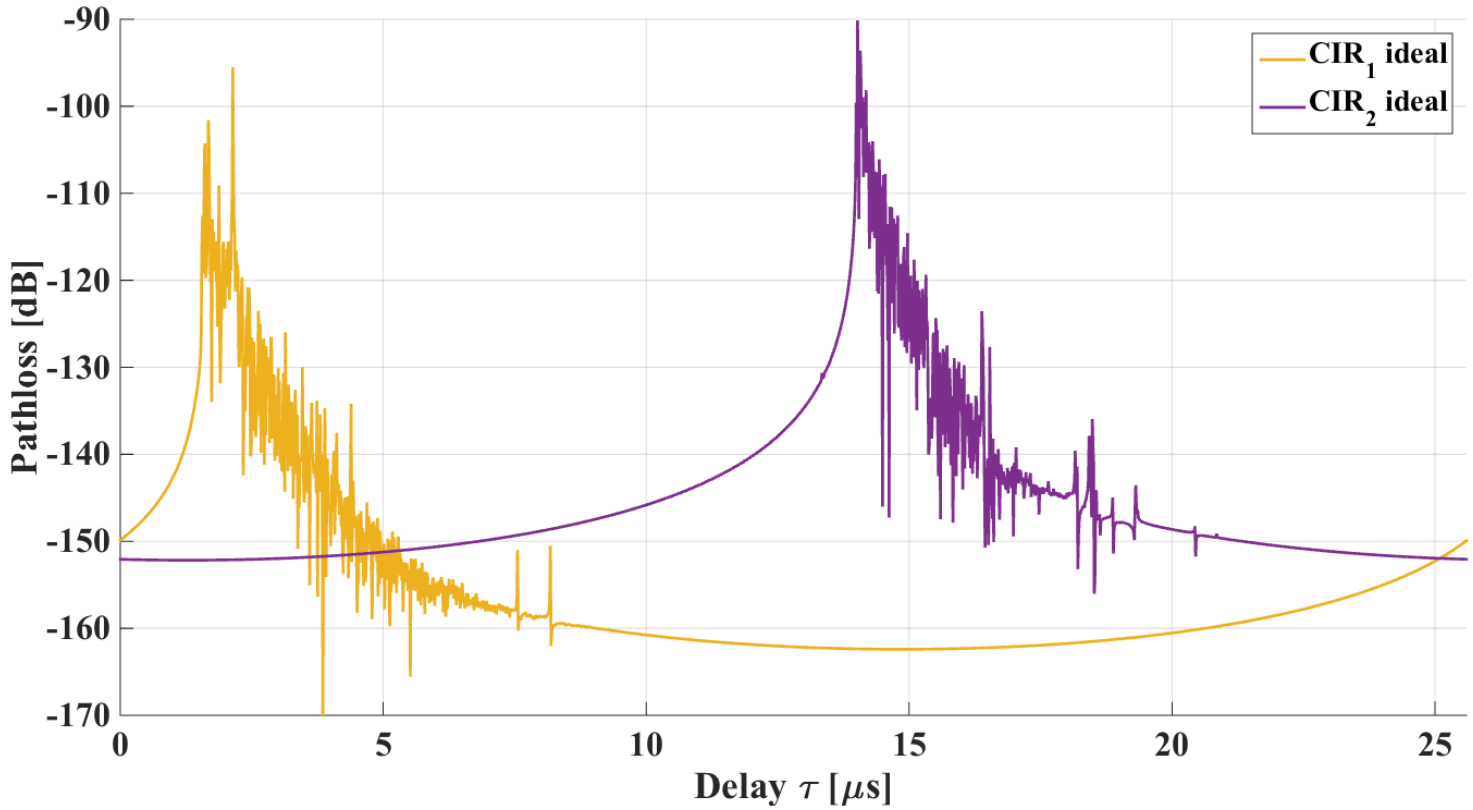
Measurement Results

Car2x channels to be emulated



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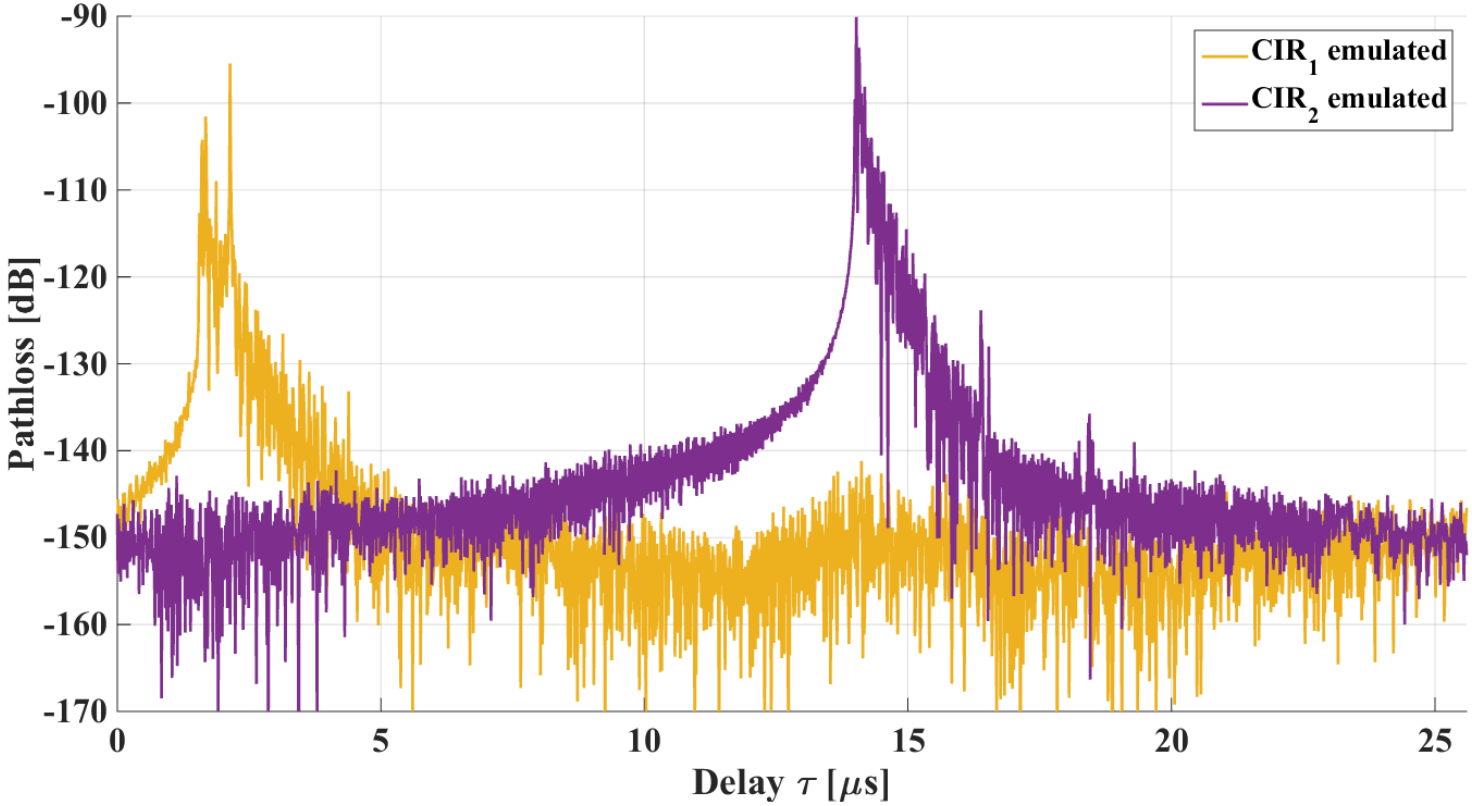
Measurement Results

Emulated Car2x channel the “Wireless Cables”



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Radiated Two-Stage („Wireless Cable“)
Conclusion

- Suitable for large objects such where the antenna patterns of the multiple antennas can be measured without distortion
- Self interference as well as coexistent system can be on air as in reality
- Simplified scenarios as well as very complex/realistic propagation scenarios can be emulated
- Still convincing in terms of contact free but realistic measurements
- Fewer channels needed in comparison to wave field synthesis
- Wideband equalization available -> method suitable for non anechoic chamber

Thank you for your attention!

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