

COST2100 MIMO OTA Round Robin Measurement Campaign, Summer 2010

- First Results & Conclusions from Measurements performed at RheinMain University of Applied Sciences –

Yifei Feng¹ Jens Jonas¹ W. L. Schroeder¹ R. Acharkaoui²
M. Rumney³

¹ RheinMain University of Applied Sciences, Rüsselsheim, Germany

² Cetecom GmbH, Essen, Germany

³ Agilent Technologies, UK

October 5, 2010



Outline

1 Introduction

2 3D Sensitivity Measurements

- Measurement Setup
- Sensitivity Maps and Statistics
- Observations

3 2D Throughput Measurements

- Measurement Setup
- 2D Throughput Statistics
- Observations

Motivation, Limitations & Approach

- Motivation
 - ▶ Comparison of some **MIMO** Over-The-Air (**OTA**) measurement approaches with respect to their capability to uncover differences between **DL** performance of **UE**
- Limitations
 - ▶ Only Downlink (**DL**) receive diversity could be investigated in this first study (commercially available **HSDPA** User Equipment (**UE**)).
- Approach
 - ▶ “Low-effort methods” with at most two measurement antennas (probes) in anechoic environment.

Acknowledgements

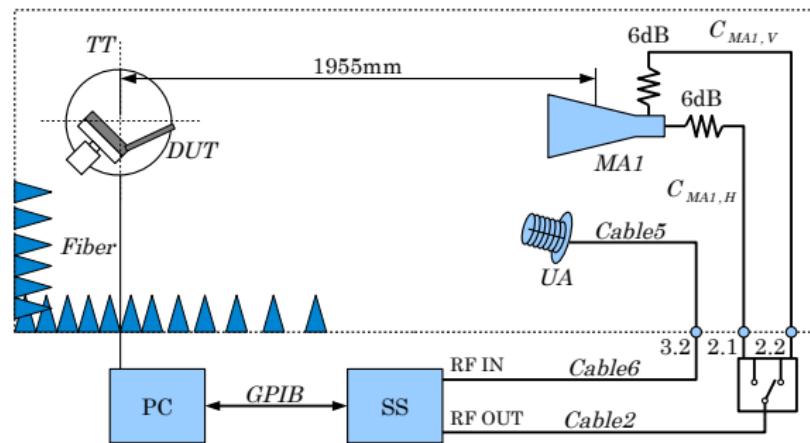
Special thanks go to Dr. Soon Leh Ling from Vodafone as initiator of this campaign and for his support. This work was partly funded by the German Federal Ministry of Education and Research under grant FKZ 17N1408.

Devices under Test & Device Coordinates



S1: Single Probe Sensitivity Measurement Setups

- S1-V: vertical polarization
- S1-H: horizontal polarization



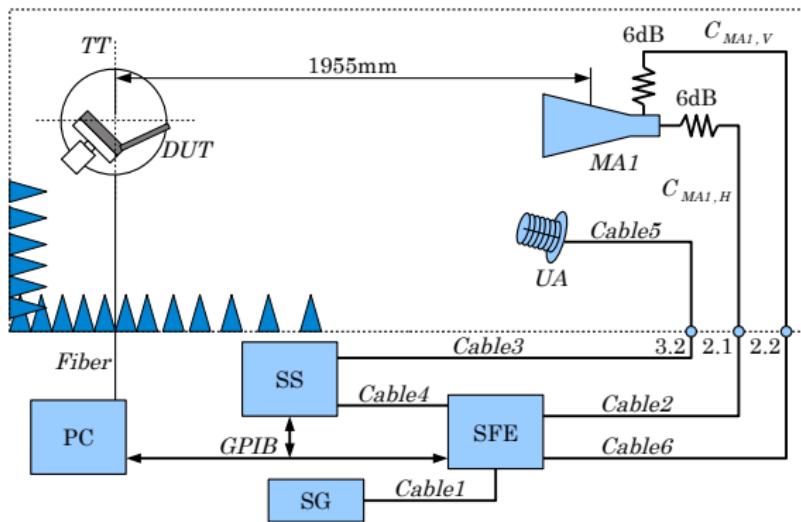
- Agilent 8960 used as base-station simulator (SS)
- H-set 6 (QPSK), level-set 1, channel 10562, HARQ off
- BLER values of multiple signal power levels recorded

S2: Dual Probe Sensitivity Measurement Setup

Two copies of DL signal from V-pol / H-Pol of dual-polarized horn.

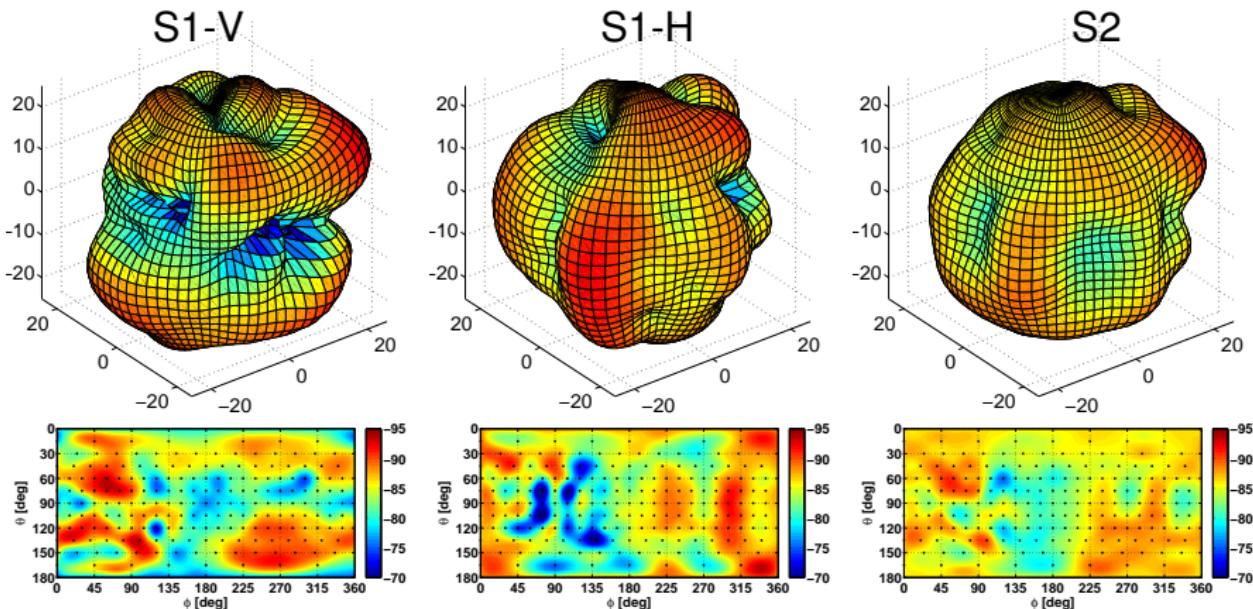
Half power each.

Decorrelation by application of a small Doppler shift.



- PropSim C2 Fading Emulator used to decorrelate signals (opposite Doppler shifts corresponding to $\pm 3 \text{ km/h}$)
- H-set 6 (QPSK), level-set 1, channel 10562, HARQ off
- BLER values of multiple signal power levels recorded

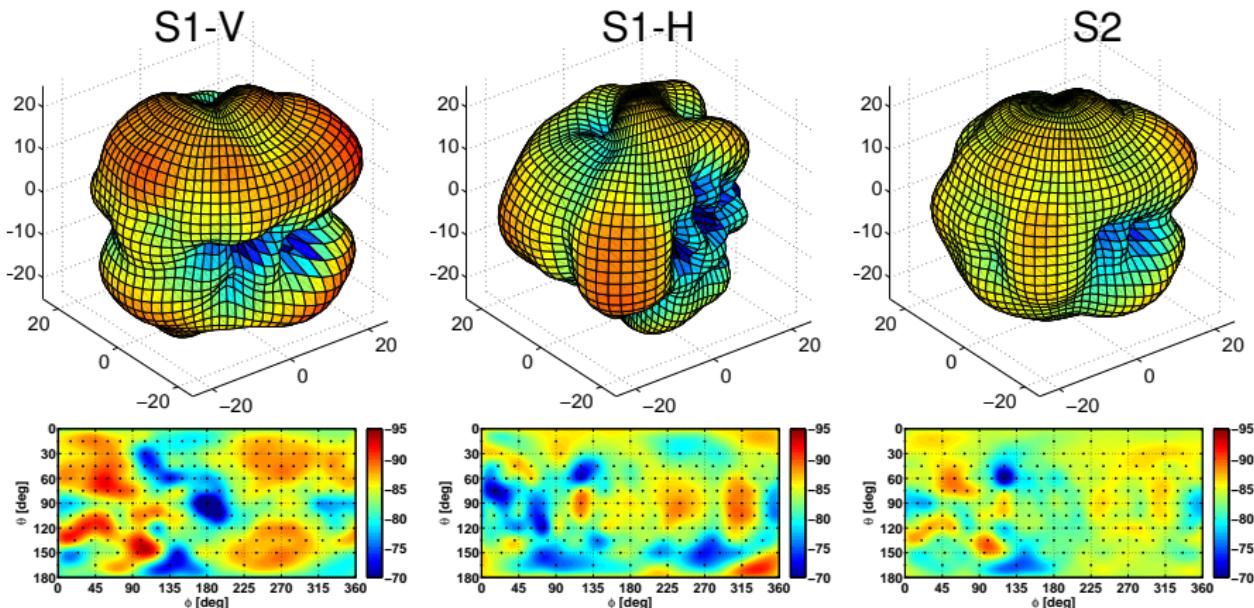
3D Sensitivity Maps for DUT1



50 % BLER sensitivity for H-set 6(QPSK), 1000 frames

S1-V, S1-H: single probe measurements, S2: dual probe measurement (half power per polarization, decorrelation by small Doppler shift)

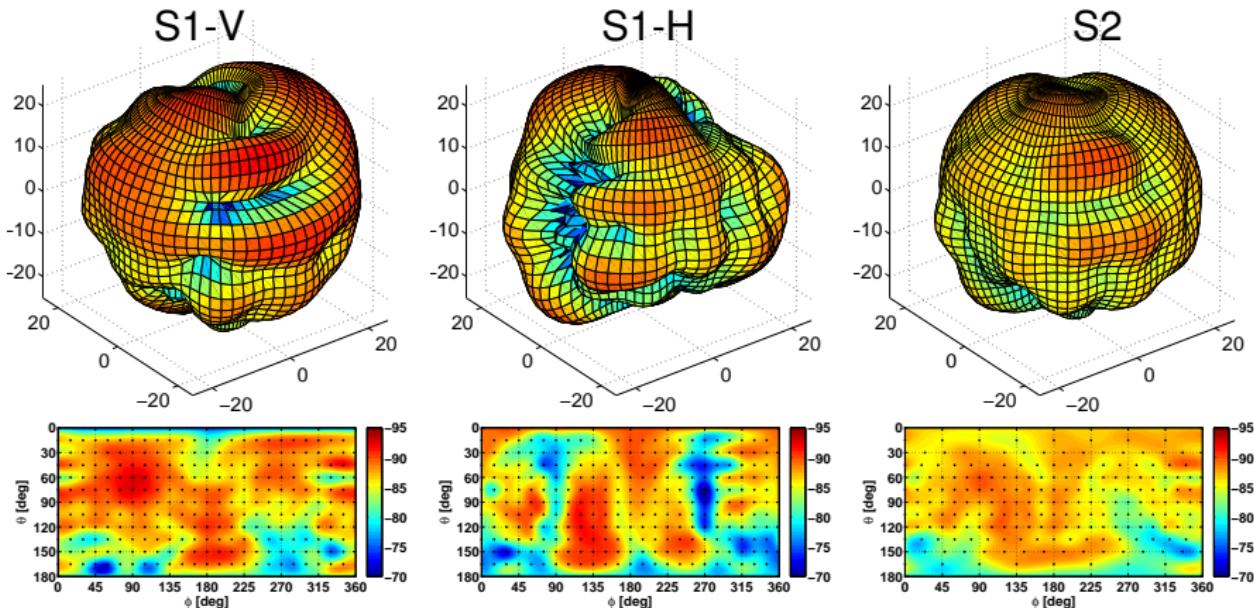
3D Sensitivity Maps for DUT2



50 % BLER sensitivity for H-set 6(QPSK), 1000 frames

S1-V, S1-H: single probe measurements, S2: dual probe measurement (half power per polarization, decorrelation by small Doppler shift)

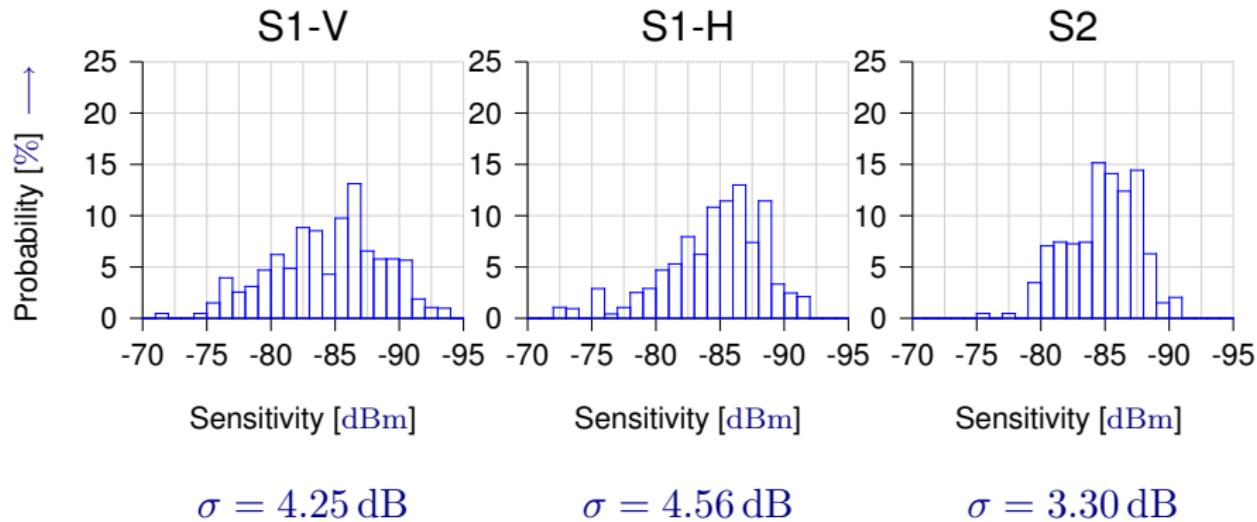
3D Sensitivity Maps for DUT3



50 % BLER sensitivity for H-set 6(QPSK), 1000 frames

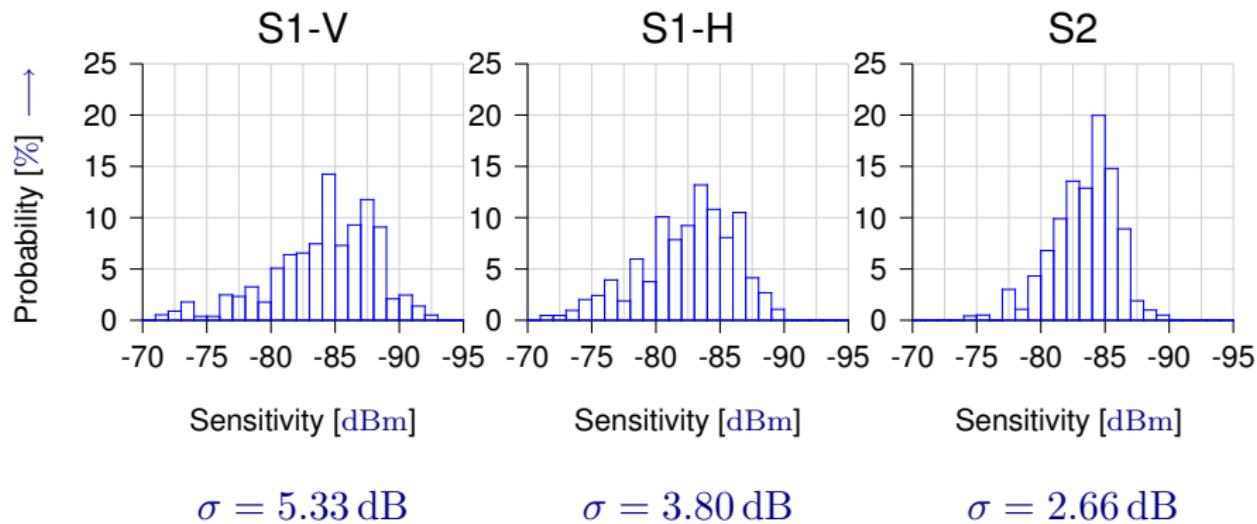
S1-V, S1-H: single probe measurements, S2: dual probe measurement (half power per polarization, decorrelation by small Doppler shift)

3D Sensitivity Distribution of DUT1



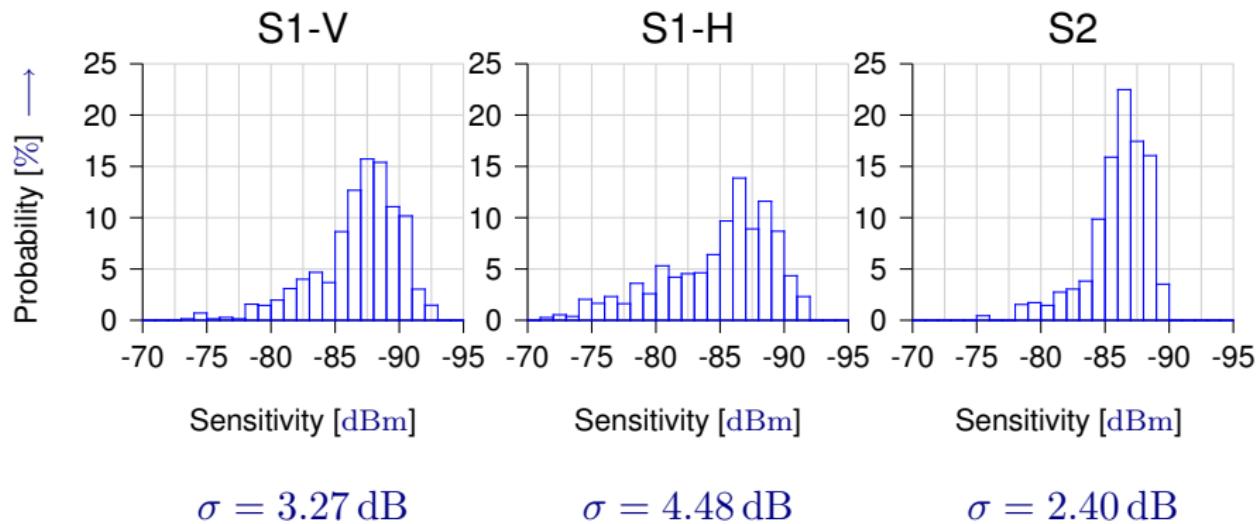
Remark: Graphs show histograms of sensitivity for all measured AOA, corrected for relative fraction of sphere they represent. Data thus reflects the probability distribution of sensitivity for arbitrary AOA.

3D Sensitivity Distribution of DUT2



Remark: Graphs show histograms of sensitivity for all measured AOA, corrected for relative fraction of sphere they represent. Data thus reflects the probability distribution of sensitivity for arbitrary AOA.

3D Sensitivity Distribution of DUT3



Remark: Graphs show histograms of sensitivity for all measured **AOA**, corrected for relative fraction of sphere they represent. Data thus reflects the probability distribution of sensitivity for arbitrary **AOA**.

Total Sensitivity

Total Sensitivity in dBm

	S1-V V-pol	S1-H H-pol p	S1-V&H TIS +3 dB	S2 dual-probe
DUT1	-86.2	-85.9	-86.1	-85.6
DUT2	-85.6	-83.8	-84.8	-84.0
DUT3	-87.8	-86.5	-87.2	-86.5

- Sensitivity corresponds to 50 % **BLER** level for H-Set 6 (**QPSK**), level 1, **HARQ** off
- Calculation otherwise in agreement with the CTIA **OTA** Test Plan

Remark: The conventional rule for calculation of **TIS** (from S1-V and S1-H) corresponds to a situation where twice the power is transmitted in DL. For easier comparison against the cases S1-V, S1-H and in particular S2 a correction of **3 dB** has been added to the conventional **TIS** result in column 4.

Observations from 3D Sensitivity Measurements

- ① USB-Dongles in laptop show strongly reduced sensitivity for vertical polarization near the horizon. This can be explained by the fact that little current is excited along the edges of the laptop's base part in this situation which otherwise improves reception by coupling to the dongle's antenna. (The effect becomes even stronger if the lid is closed.)

Conclusion

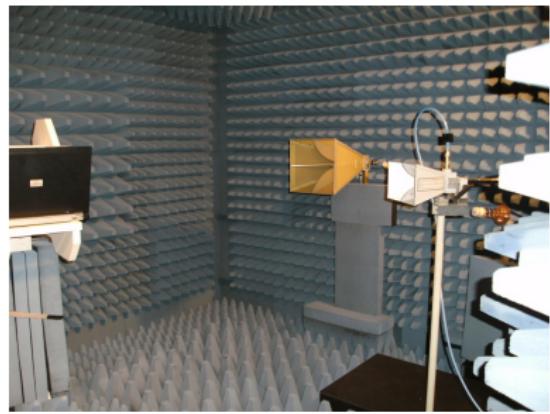
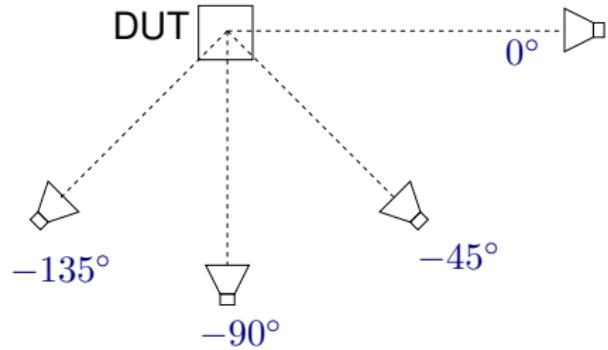
2D **MIMO OTA** measurements where all probes are exclusively in the azimuthal plane are unlikely to yield valid results for indoor scenarios.

- ② Inspection of the 3D sensitivity maps and in particular the probability distributions of sensitivity for arbitrary **AOA** seem to allow for a ranking of DUT performance (DUT3, DUT1, DUT2) (in agreement **TIS** results).
- ③ The variance of the sensitivity distribution in the dual stream result (S2) seems to be an indicator of Rx diversity performance.
- ④ The integral sensitivity values (**TIS** and alike) show much less difference.

Setup for 2D Throughput Measurements: Geometrie

Measurements with two probes in the azimuthal plane

- Fixed probe (dual polarized horn) at $\varphi = 0$.
- Moveable probe alternatively at $\varphi \in \{-45^\circ, -90^\circ, -135^\circ\}$, alternate polarizations
- Total of 13 geometrical scenarios:
VH/HV with $0^\circ, 45^\circ, 90^\circ, 135^\circ$ and VV/HH with $45^\circ, 90^\circ, 135^\circ$ offset



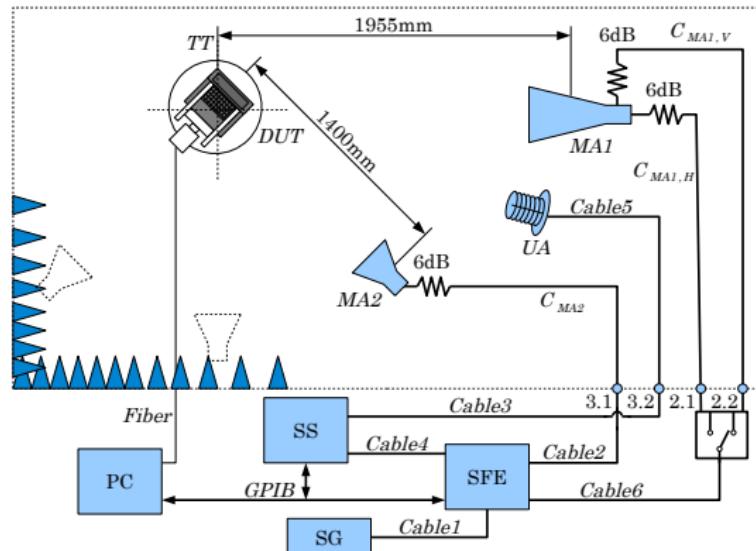
Setup for 2D Throughput Measurements: Channels

Scenario 1

- 2 cluster SCM, one cluster per probe
- 20 subpaths / cluster
- 3 km / h, 35° AS

Scenario 2

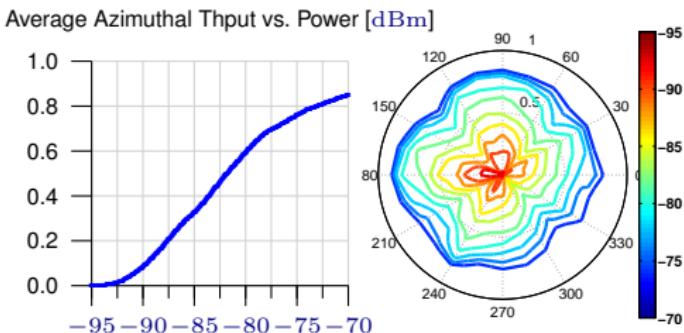
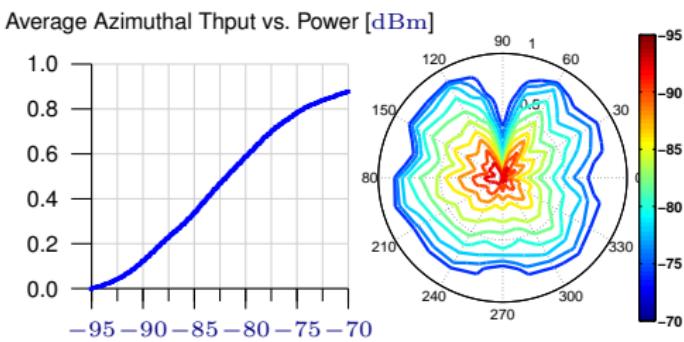
- 2 streams, decorrelated by application of opposite Doppler shifts ($\pm 3 \text{ km/h}$)



- Agilent 8960 (SS) and PropSim C2 Fading Emulator (SFE)
- H-set 6 (16QAM), level-set 1, channel 10562
- maximum HARQ transmission: 4

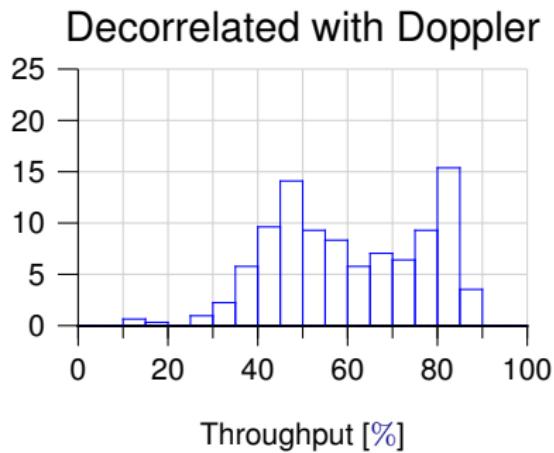
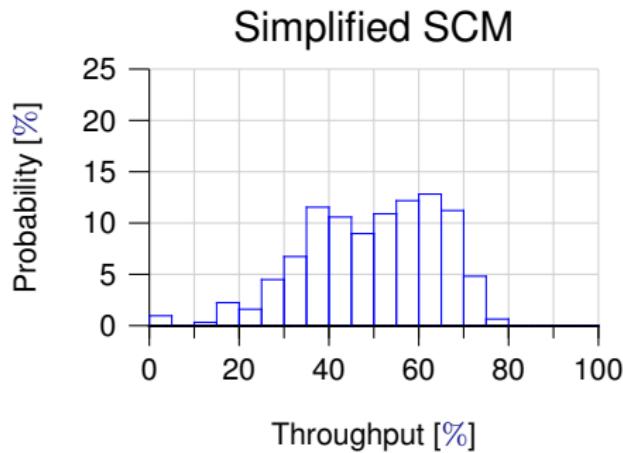
2D Throughput Measurements: Data

- For either scenario throughput is recorded as function of
 - power
 - probe angular offset
 - polarization (VV/VH/HV/HH)
 - DUT azimuthal rotation angle
- Example in Figures:
DUT3, SCM
 - top: H@ 0° , V@ -90°
 - bottom: H@ -45° , V@ 0°
- Many possible ways to extract information



Throughput @ -80 dBm for DUT1 in Azimuthal Plane

2D throughput statistics, taken over all 13 geometrical scenarios

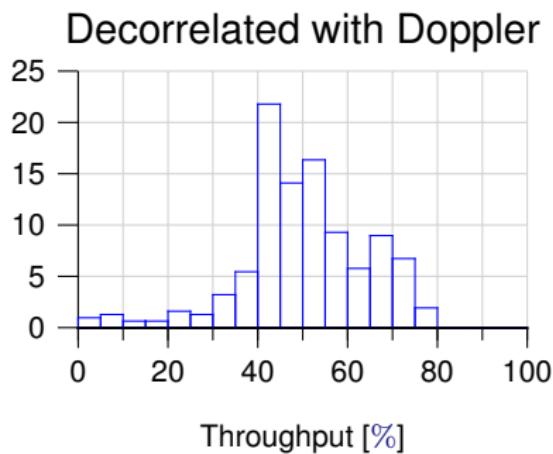
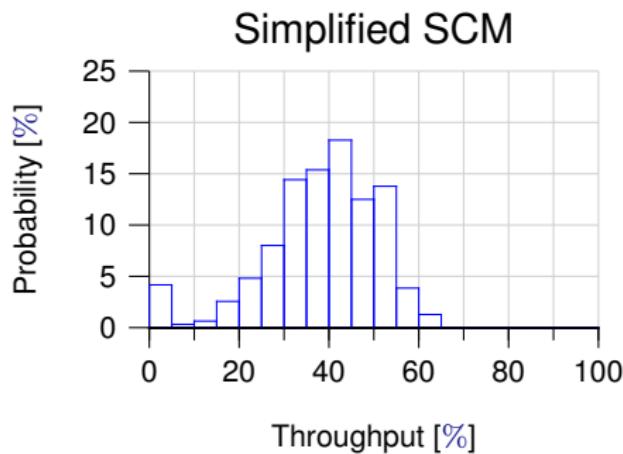


- mean: 49.5%
- σ : 15.9%

- mean: 61.0%
- σ : 17.3%

Throughput @ -80 dBm for DUT2 in Azimuthal Plane

2D throughput statistics, taken over all 13 geometrical scenarios

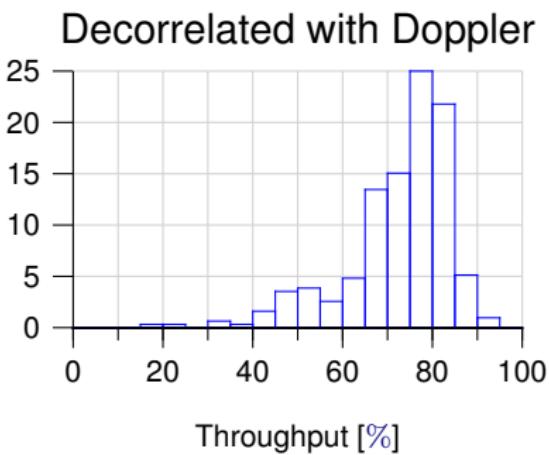
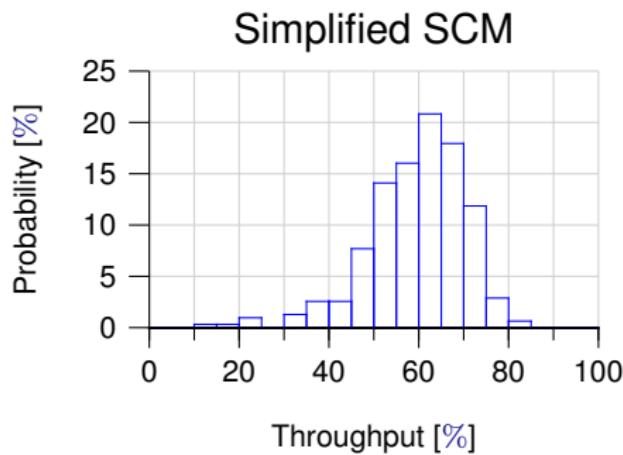


- mean: 38.3%
- σ : 12.7%

- mean: 49.9%
- σ : 14.1%

Throughput @ -80 dBm for DUT3 in Azimuthal Plane

2D throughput statistics, taken over all 13 geometrical scenarios



- mean: 59.5%
- σ : 10.9%

- mean: 72.7%
- σ : 12.1%

Observations from 2D Throughput Measurements

- ➊ Throughput results obtained for the 2 cluster SCM scenario and for 2 signals which are only decorrelated by Doppler shift are nearly proportional.
- ➋ Throughput results for the 2 cluster SCM scenario are systematically $\sim 10\%$ below those for the case of 2 signals which are only decorrelated by Doppler shift. The (unspecified) dynamics of the channel model as presented by the fading emulator may be considered a problem here (smaller or larger fraction of time where the UE has an invalid channel estimation).
- ➌ Average throughput comparison happens to yield the same DUT ranking as the 3D sensitivity measurements (DUT3, DUT1, DUT2).
- ➍ The variance of the throughput seems to be correlated with the diversity performance of a DUT's antenna system (better diversity performance \rightarrow smaller variance).

Abbreviations

AOA	Angle of Arrival
BLER	Block-Error-Rate
DL	Downlink
HARQ	Hybrid Automatic Repeat Request
HSDPA	High-Speed Downlink Packet Access
MIMO	Multiple Input – Multiple Output
OTA	Over-The-Air
QPSK	Quaternary Phase-Shift Keying
TIS	Total Isotropic Sensitivity
UE	User Equipment