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Submission Title: Multi-Frequency Measurements at 9, 64 and 304 GHz using an Ultra-Wideband Channel Sounder

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Abstract: The alignment of high gain antennas used for 300 GHz links is challenging in the device discovery phase. Brute-force scanning of the angle-of-arrival at the receiver and of the angle-of-departure at the transmitter is too time-consuming. Therefore, a two-step process can be applied which appies a rough estimation of the angles at lower frequencies using lower-gain antennas. A pre-requisite to apply such a method are similarities of the channel at both carrier frequencies. This presentation provides a comparison of measured power angular spectra at carrier frequencies of 9, 64 and 304 GHz.

Purpose: Information of the IG THz

Multi-Frequency Measurements at 9, 64 and 304 GHz using an Ultra-Wideband Channel Sounder

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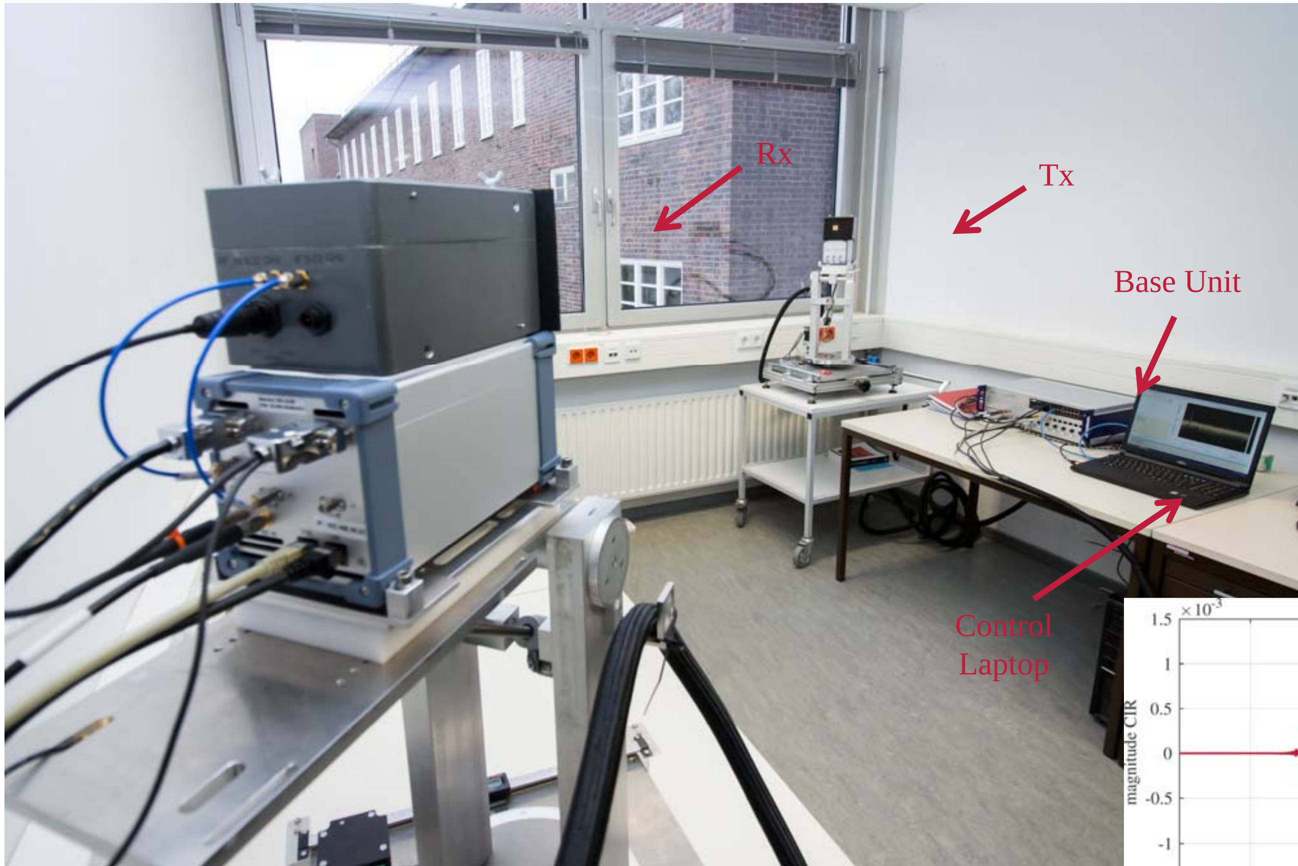
Outline

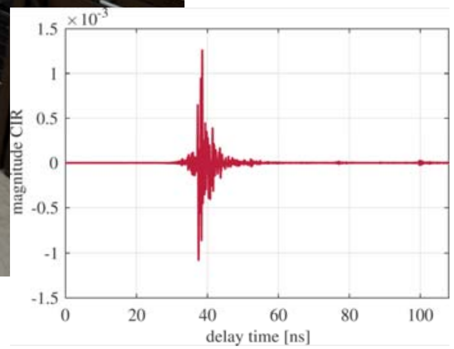
- Motivation
- Description the Channel Sounder and the Measurement Scenario
- Measurement Results
- Comparison with Simulations derived from Ray Launching
- Conclusions

Motivation

- The alignment of high gain antennas used for 300 GHz links is challenging especially in the device discovery phase during the set-up of the connection.
- Brute-force scanning of the angle-of-arrival at the receiver and of the angle-of-departure at the transmitter is too time-consuming.
- Therefore, a two-step process can be applied, where rough estimations of the angles are derived at lower frequencies with antennas having lower gains in the first step [1].
- A pre-requisite to apply such a method are similarities of the channel at the higher and lower frequencies.
- This presentation provides a comparison of measured spatial channel characteristics at carrier frequencies of 9 GHz, 64 GHz and 304 GHz using an ultra-wideband channel sounder [2].
- Aditionally the results are compared with simulated characteristics using ray launching [3].

TUBS‘ Time-Domain Channel Sounder





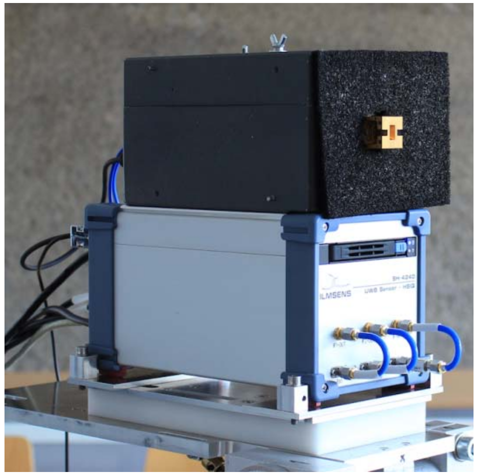
Technical Parameters of the Channel Sounder

Parameter	Value
Clock Frequency	9.22 GHz
Bandwidth	~ 8 GHz
Chip duration	108.5 ps
M-sequence order	12
Sequence length	4095
Sequence duration	444.14 ns
Subsampling factor	128
Acquisition time for one CIR	56.9 µs
Measurement Rate	17,590 CIR/s
Center Frequencies	9.2 / 64.3 / 304.2 GHz
SISO/MIMO	up to 4x4

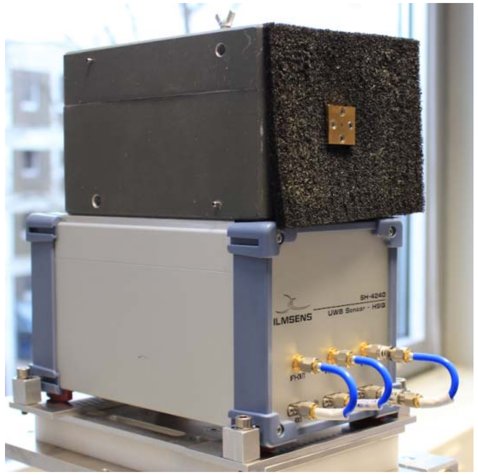
Set-Up for the three Bands

Sensor node with frequency extension and antenna

Double ridged horn antenna for 9 GHz



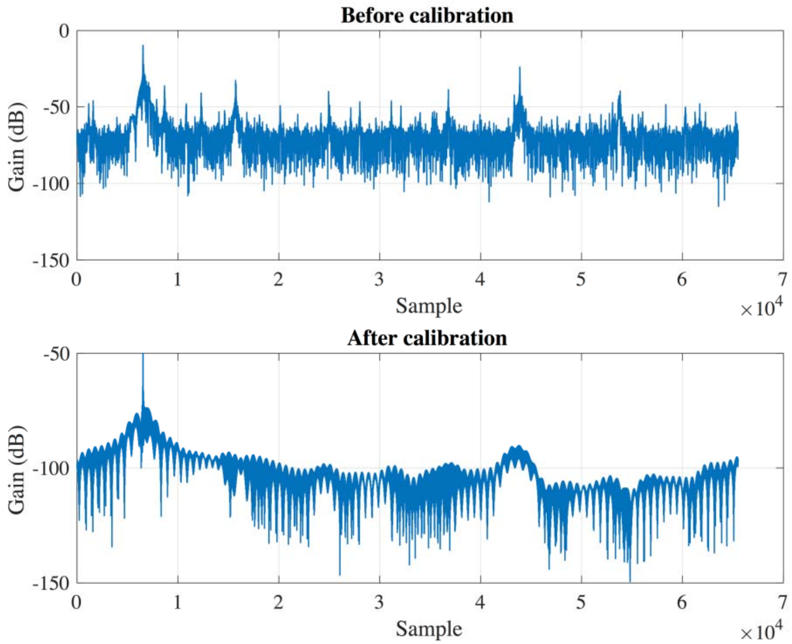
Horn antenna for 60 GHz



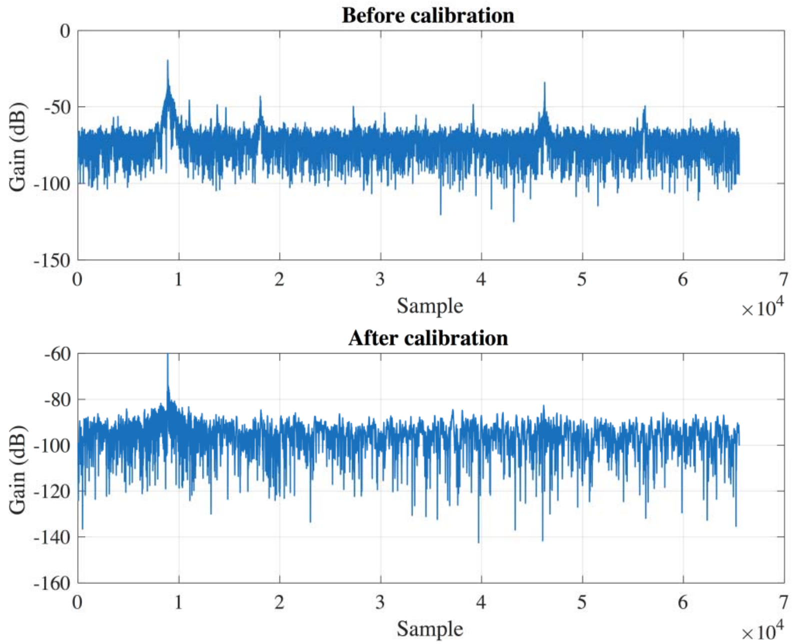
Horn antenna for 300 GHz

Calibration with Back-to-Back Measurement

- A reference measurement (B2B measurement) is carried out for a calibration to compensate for the imperfection of RF frontend.
- In the B2B measurement, Tx and Rx are connected with a 50 dB attenuator.
- The calibration has significantly supressed the ”fake” signals and improved the SINR.

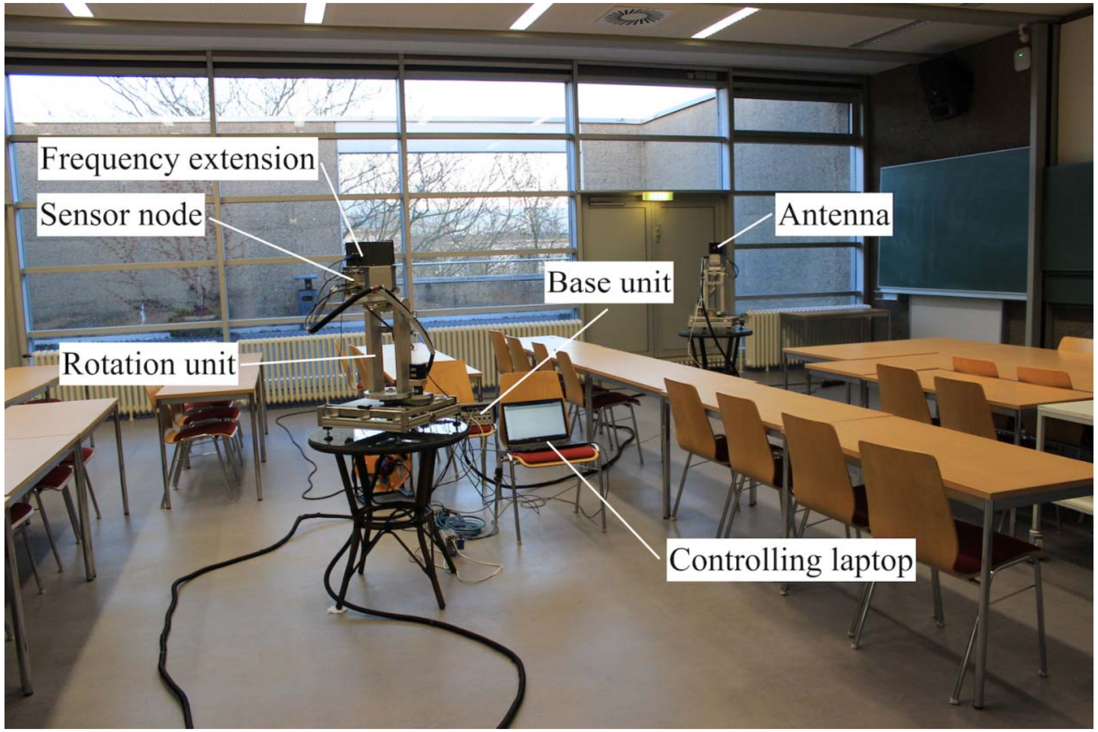


B2B Measurement (50 dB attenuator in between)



LoS Measurement (Tx and Rx looking at each other)

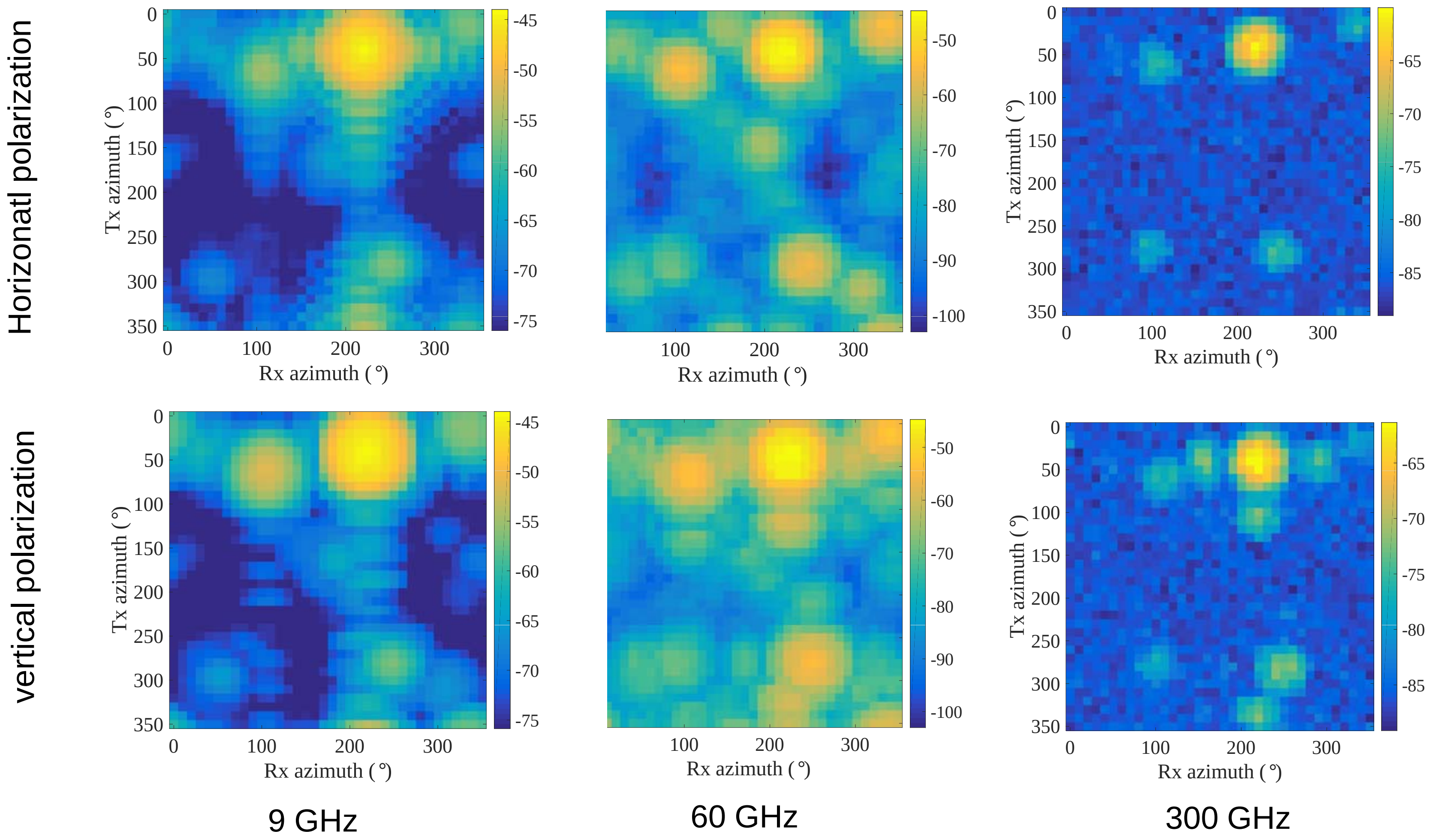
Measurement Scenario (Lecture Room)



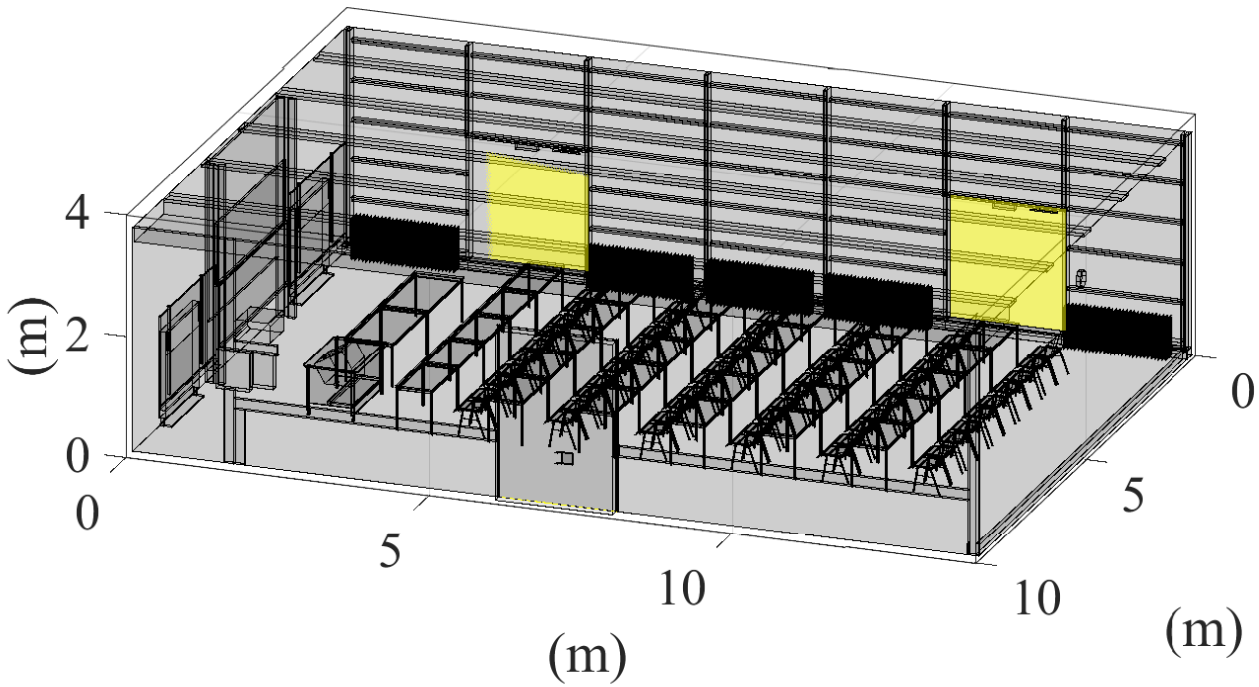
Techncial Parameters of the Measurement Campaign

Parameter	9 GHz	60 GHz	300 GHz
Azimuth HPBW	14°	10°	10°
Antenna Gain	10 dBi	15 dBi	15 dBi
Scanning resolution	10°	10°	10°
Center Frequency	9.2 GHz	64.2 GHz	304.2 GHz
Bandwidth	8 GHz	8 GHz	8 GHz

Measured Power Angular Spectra

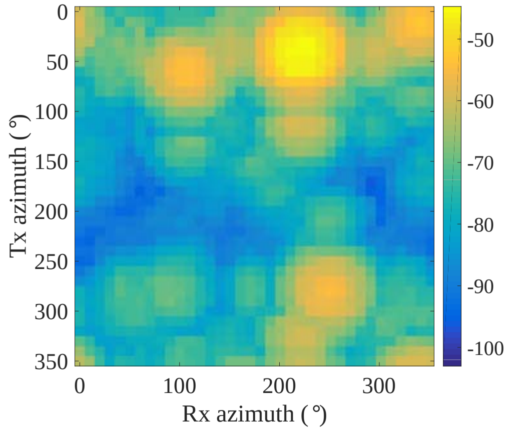


Simulation Scenario

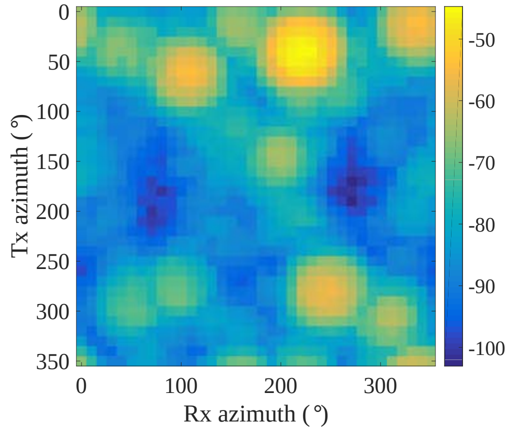


- Simulations have been performed using Ray Launching in a 3D model of the lecture room

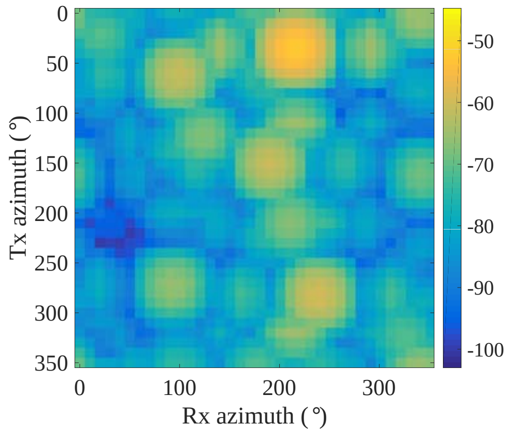
Measured vs. Simulated Power Angular Spectra at 60 GHz



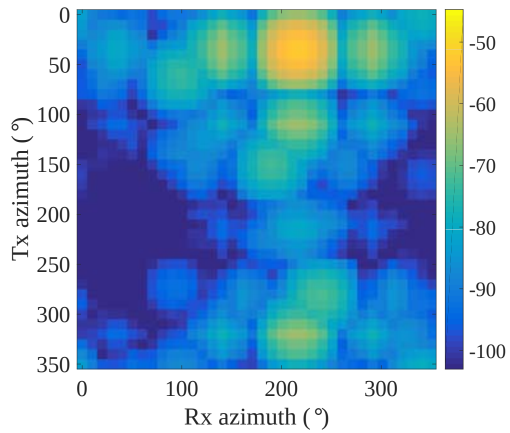
Measured, vertical polarization



Measured, horizontal polarization

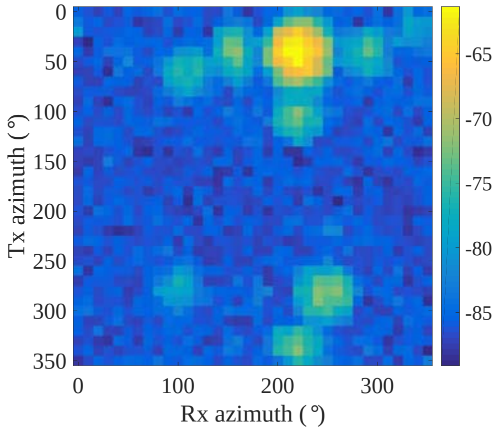


Simulated, vertical polarization

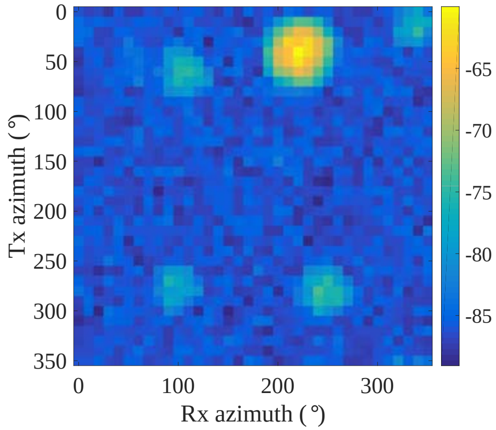


Simulated, horizontal polarization

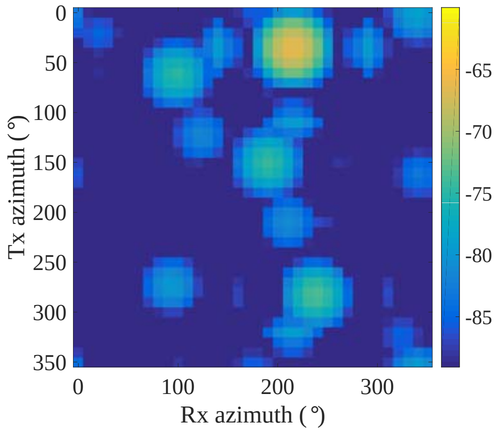
Measured vs. Simulated Power Angular Spectra at 300 GHz



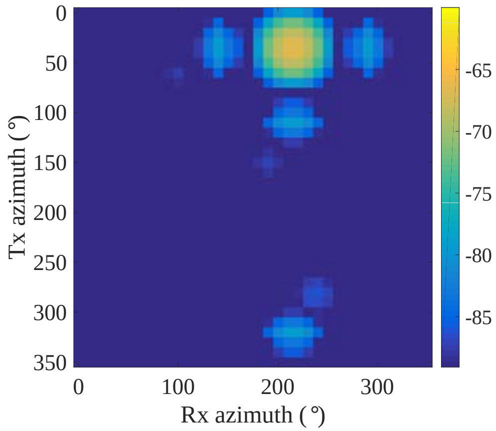
Measured, vertical polarization



Measured, horizontal polarization



Simulated, vertical polarization



Simulated, horizontal polarization

Conclusion

- Visual inspection of measurements of angular power spectra at carrier frequencies of 9, 64 and 304 GHz in a lecture room has revealed reasonable agreement across the freqeuncies.
- This supports first findings from an earlier simulation-based study on the applicability of a two-step approach for the determination of the angles-of-arrival/angles-of-departure during device discovery
- Reasonable agrement is also achieved, when comparing the maeasurements with simulated angular power spectra in the same lecture room.

References

[1] B. Peng, S. Priebe, and T. Kürner, “Fast Beam Searching Concept for Indoor Terahertz Communications,” in Proc. 8th European Conference on Antennas and Propagation (EUCAP), pp. 483–487, IEEE, 2014.

[2] S. Rey, J. Eckhardt,. Peng, K. Guan, T. Kürner, Channel Sounding Techniques for Applications in THz Communications, 2nd Workshop on THz Communications (THZCOM) at the 9th International Congress on Ultra Modern Telecommunications and Control Systems, 8 November 17, 5 pages.

[3] D. M. Rose, S. Rey and T. Kürner, "Differential 3D ray-launching using arbitrary polygonal shapes in time-variant indoor scenarios," *2016 Global Symposium on Millimeter Waves (GSMM) & ESA Workshop on Millimetre-Wave Technology and Applications*, Espoo, 2016, 4 pages