Project: IEEE P802.15 Working Group for Wireless Speciality Networks (WSN)

Submission Title: Double Directional Channel Measurements at 300 GHz in Indoor Environments Enhanced by Reconfigurable Intelligent Surfaces

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Abstract: To comprehensively understand its influence of introducing Reflecting Intelligent Surfaces (RIS) at THz frequencies on the propagation channel, channel measurements were conducted in an indoor environment comprising a RIS using a channel sounder operating at a frequency range of 300 Gigahertz (GHz). The contribution presents the results and findings of the double directional channel measurement using a non-configurable passive RIS. The measurement results exhibit improved spatial diversity through the use of RIS.

Purpose: Information of IEEE 802.15 SC THz

Acknowledgement

- The material presented here is based on the following publication:
  - B. K.Jung, J. M. Eckhardt, V. V. Elesina and T. Kürner, „Double Directional Channel Measurements at 300 GHz in Indoor Environments Enhanced by Reconfigurable Intelligent Surfaces," Proc. EuCAP 2025, Stockholm, April 2025; ; also presented at ETSI ISG THz as THz(25)00028r2 on 10 June 2025

- This work has been carried out as part of a collaborative measurement campaign between the TERRAMETA and the TIMES project, which have received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101097101 and No 101096307, respectively, including top-up funding by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee for TERRAMETA.

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Double Directional Channel Measurements at 300 GHz in Indoor Environments Enhanced by Reconfigurable Intelligent Surfaces

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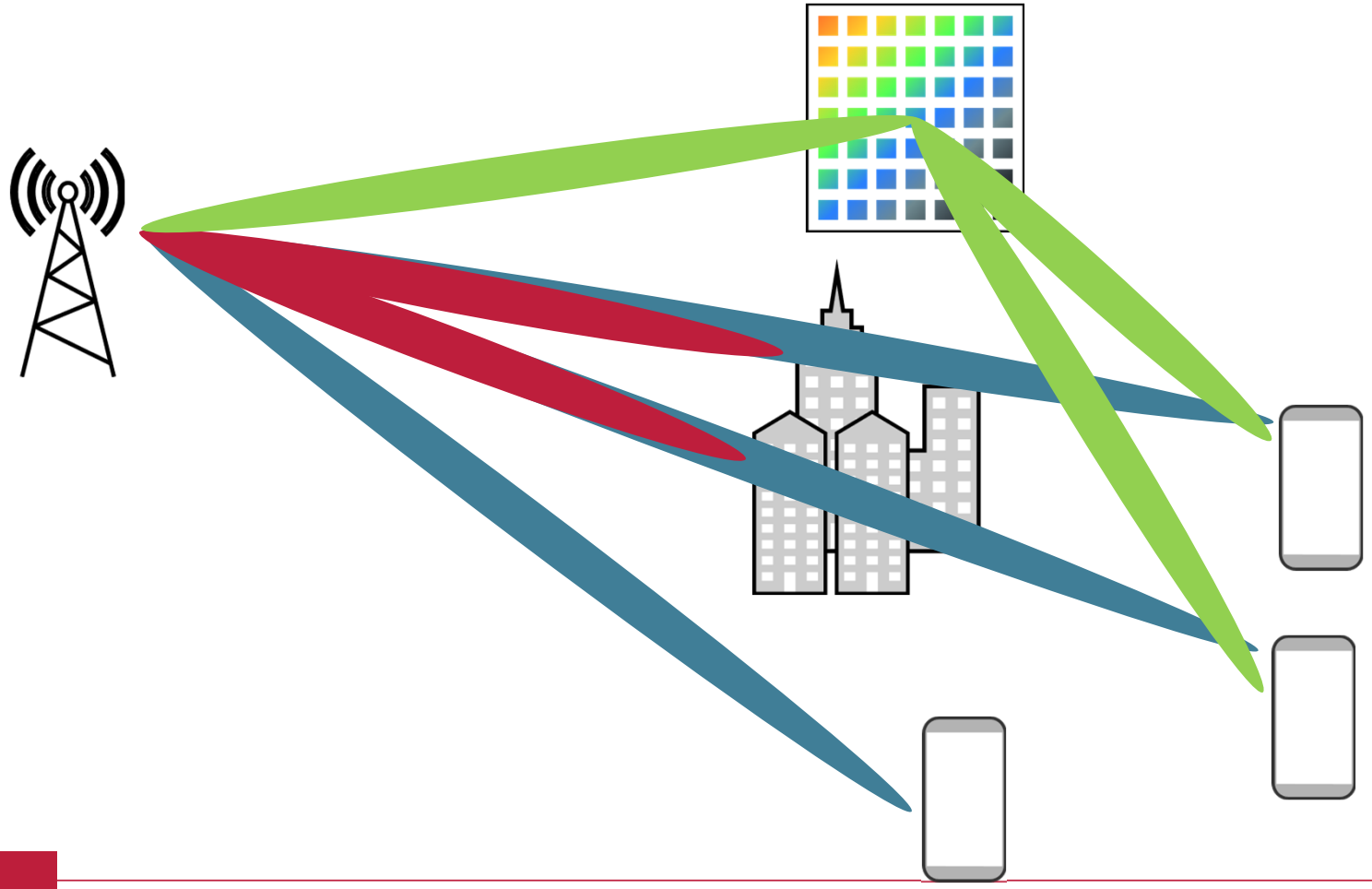
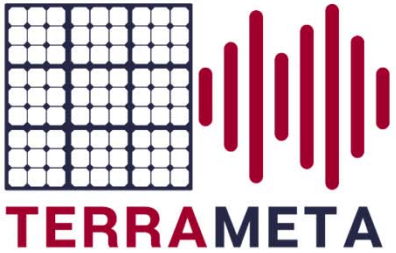
Motivation

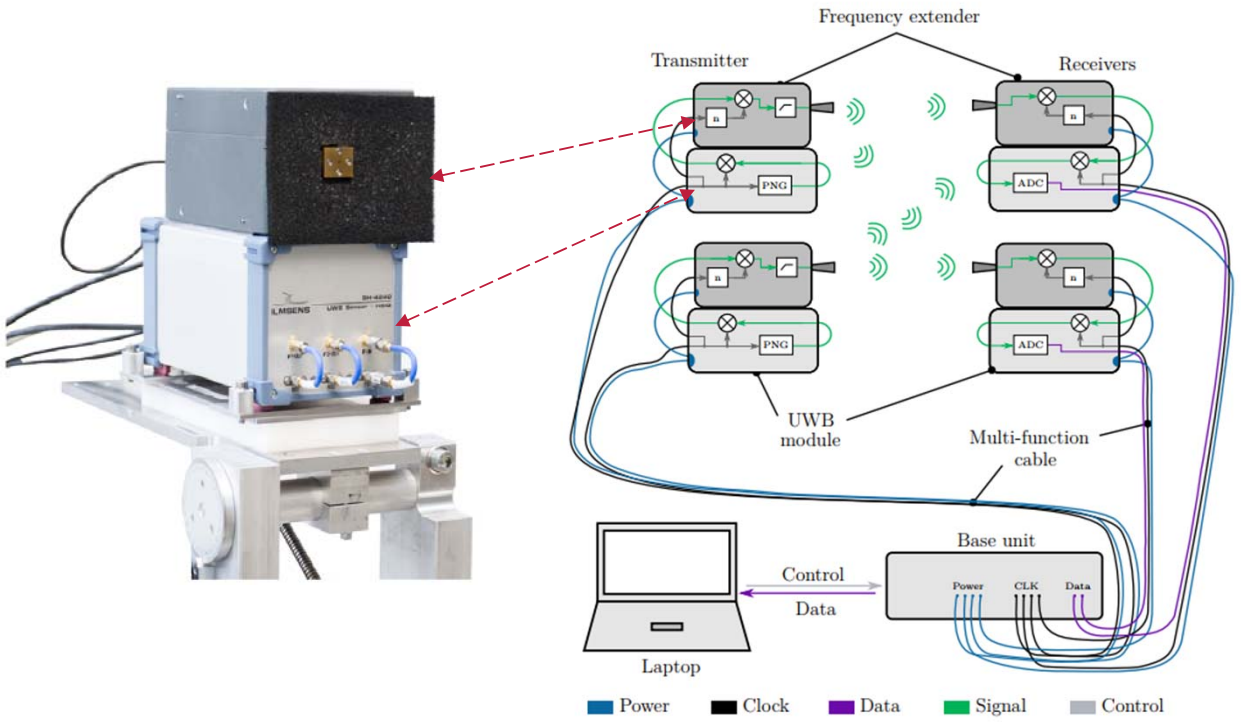


Motivation of Channel Measurement at 300 GHz

- Sub-THz communication for future mobile communication system.
- Reconfigurable Intelligent Surfaces (RIS) to overcome limitations of THz communication.
- Channel sounding for insights of the propagation channel including RIS.



Measurement Equipment: Channel Sounder

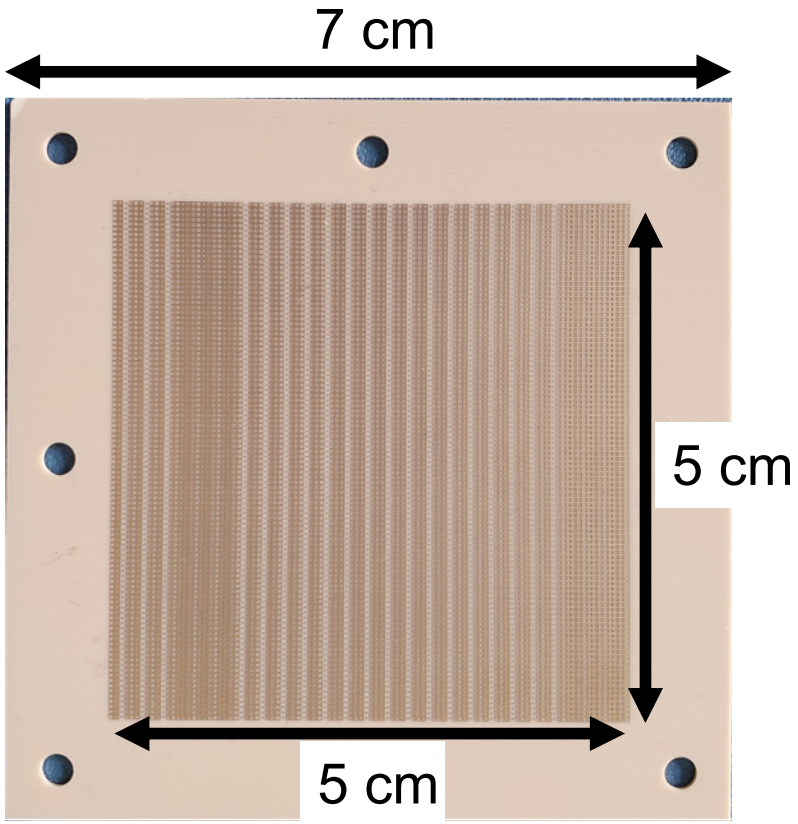


Parameter	Value
Center Frequency	304.2 GHz
Clock Frequency	9.22 GHz
Bandwidth	approx. 8 GHz
Chip duration	108.5 ps
Order of M-Sequence	12
Sequence length	4095
Sequence duration	444.14 ns
Subsampling factor	128
Measurement Rate	17,590 CIR/s
TX/RX antenna gain	26.4 dBi
TX/RX antenna HPBW	8.5°

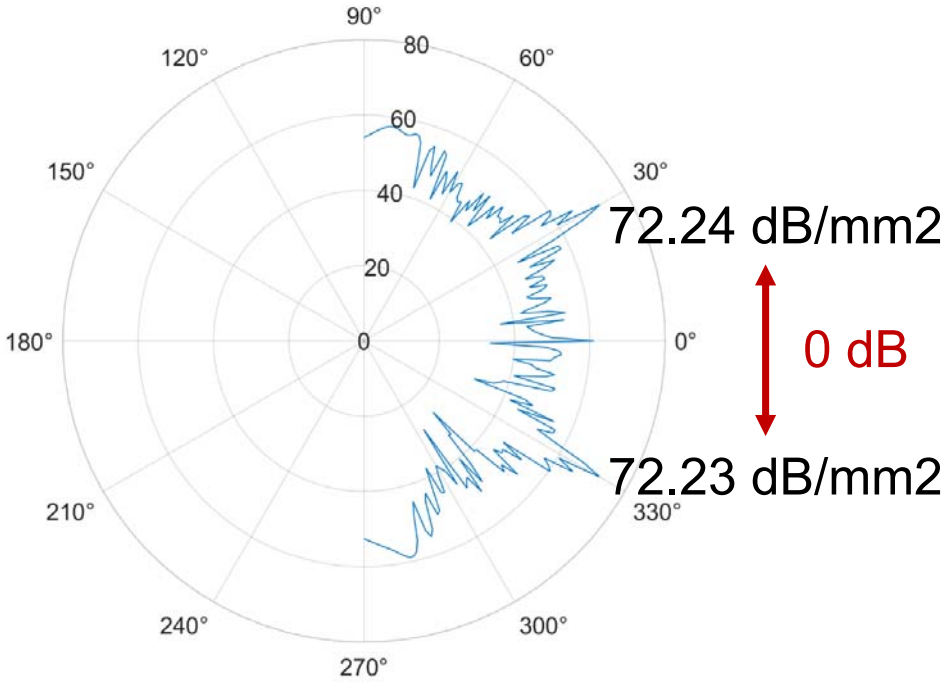
S. Rey, J. M. Eckhardt, B. Peng, K. Guan and T. Kürner, "Channel sounding techniques for applications in THz communications: A first correlation based channel sounder for ultra-wideband dynamic channel measurements at 300 GHz," 2017 9th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), Munich, Germany, 2017, pp. 449-453
J. M. Eckhardt, A. Schultze, R. Askar, T. Doeker, M. Peter, W. Keusgen, T. Kürner, “Uniform Analysis of Multipath Components From Various Scenarios With Time-Domain Channel Sounding at 300GHz,” IEEE Open Journal of Antennas and Propagation, vol. 7, pp. 446-460, March 2023

Measurement Equipment: Reflective RIS

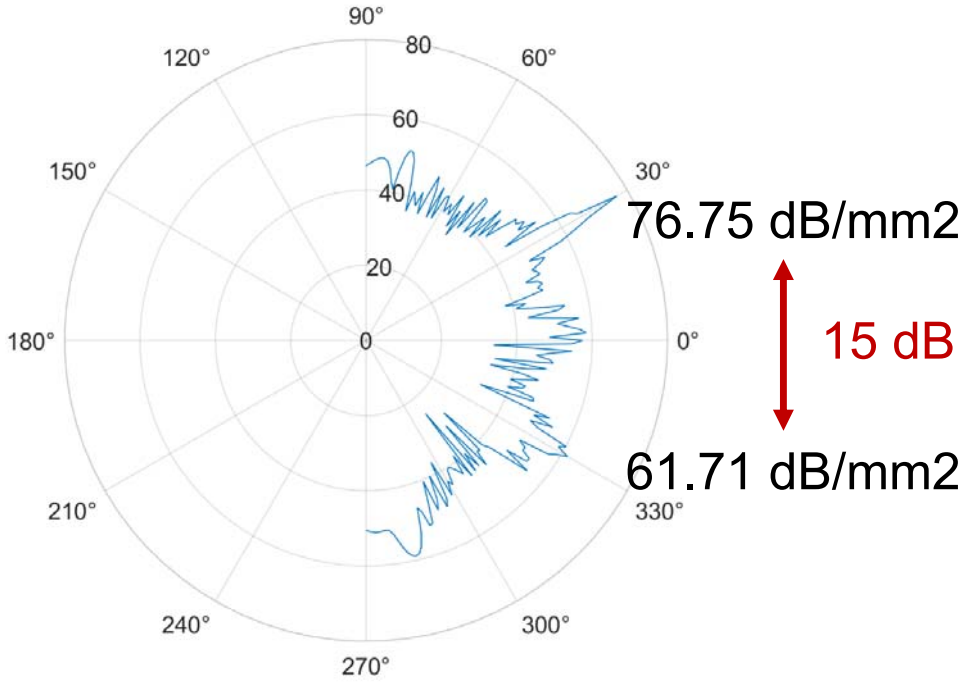
- RIS (passive surface) designed for 300 GHz.
- Emulation of a single pattern of unit cells.
  - 0° incidence angle and 30° reflection angle.
- A dimension of 5 cm by 5 cm RIS.
  - (100 by 100 unit cells).
- Three different types of RISs.
  - 1, 2, and 3-bit.



Measurement Equipment: Reflective RIS

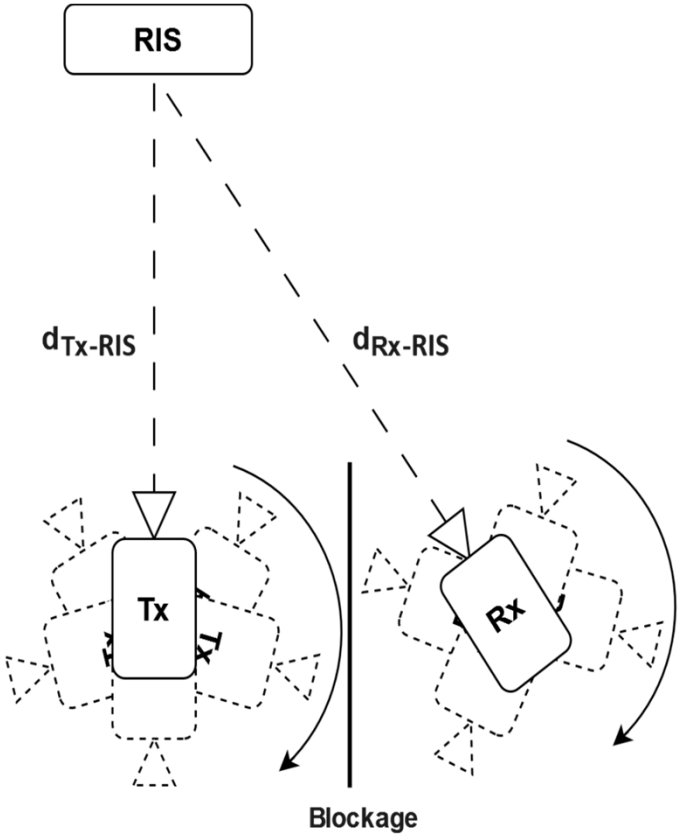


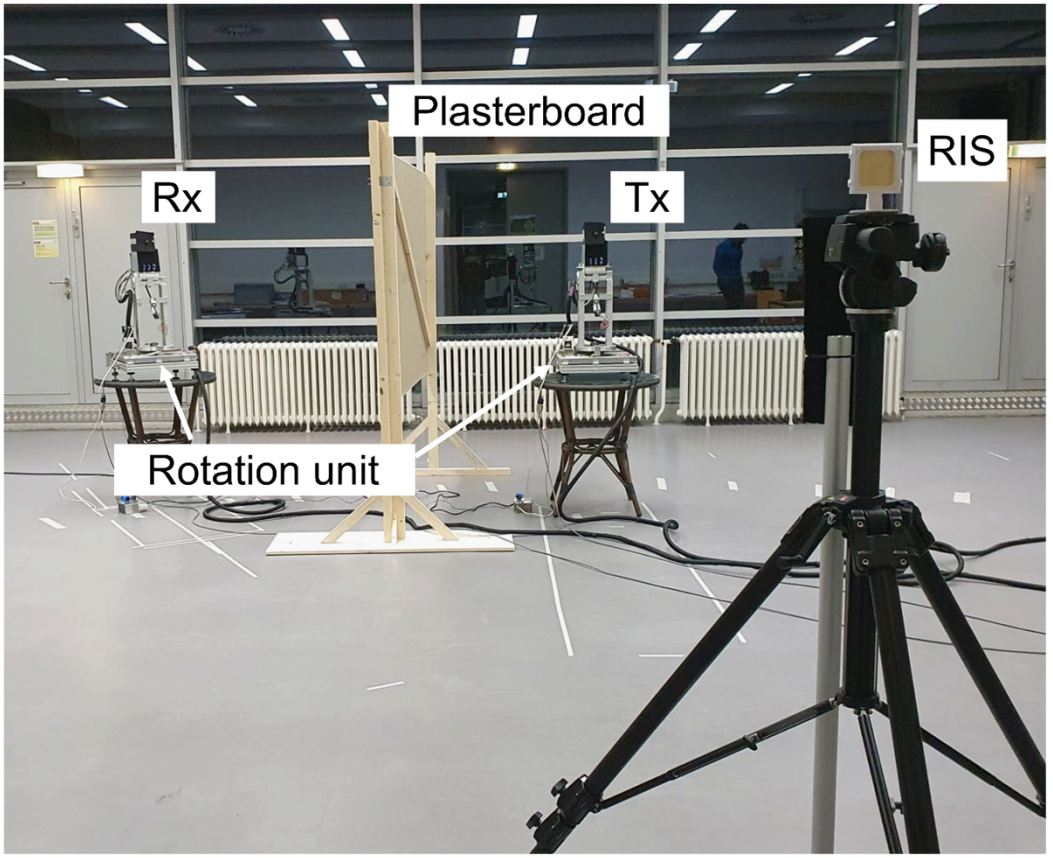
1-bit



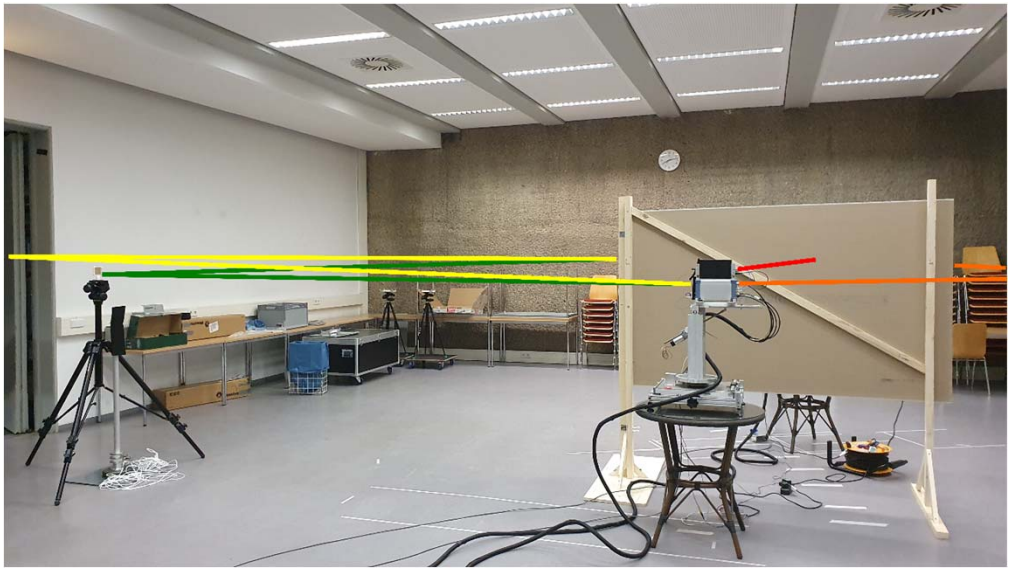
3-bit

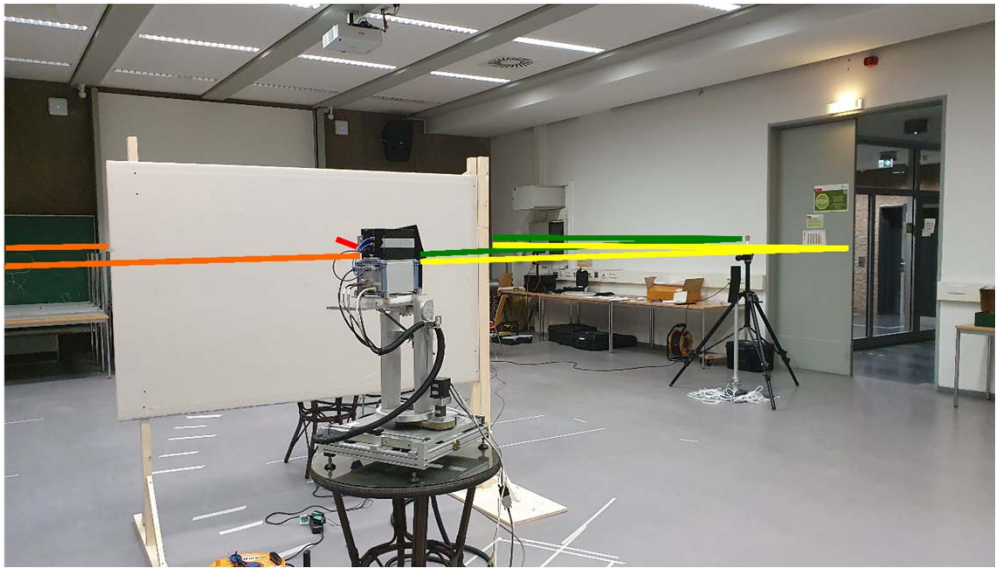
Measurement Setup





Measurement Result: Multipath Component

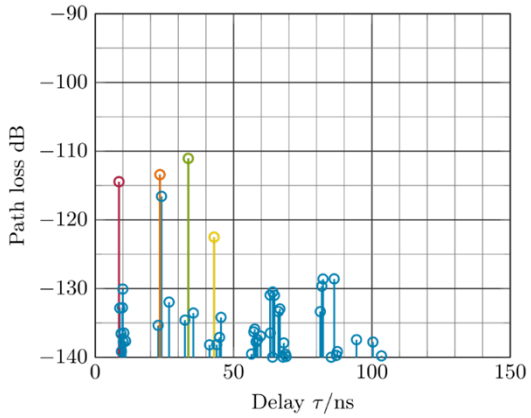




- Green line (direct path via RIS).
- Red line (path through the blockage).
- Yellow line (reflection path at the wall behind the RIS).
- Orange line (reflection path at the opposite wall).

Measurement Result: Power Delay Profile

- 3bit case: the strongest MPC is the path over RIS.
- 1bit case: MPC over RIS < MPC over reflection on wall.
- LoS: RIS is third strongest.
- RIS Increases the spatial diversity.



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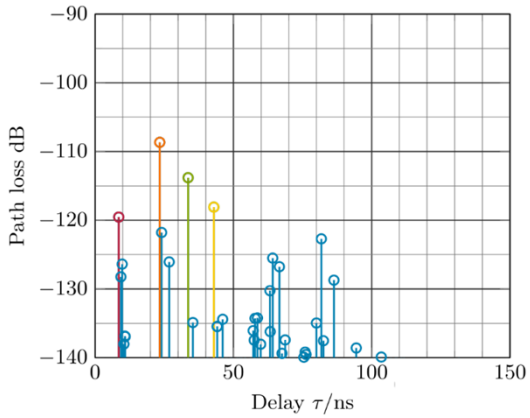
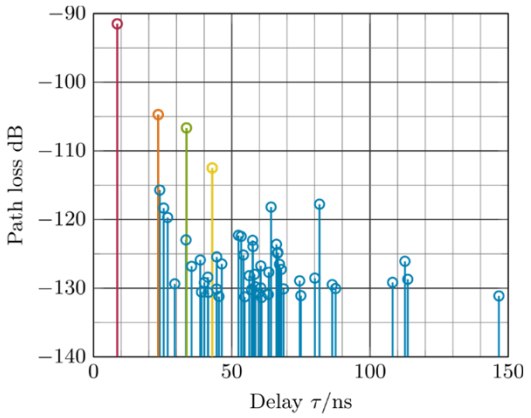


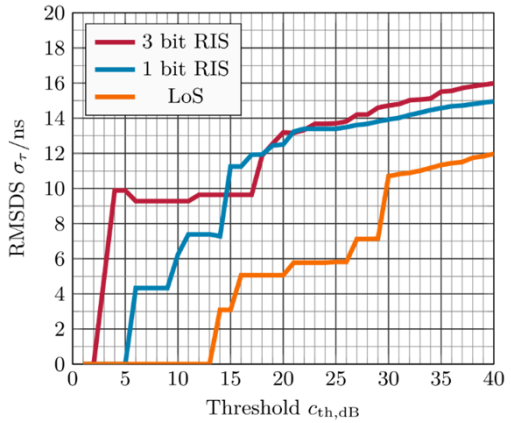
1 bit



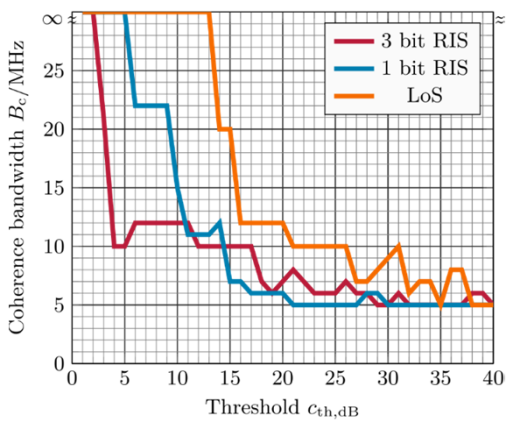
LoS

Measurement Result: Channel Parameters

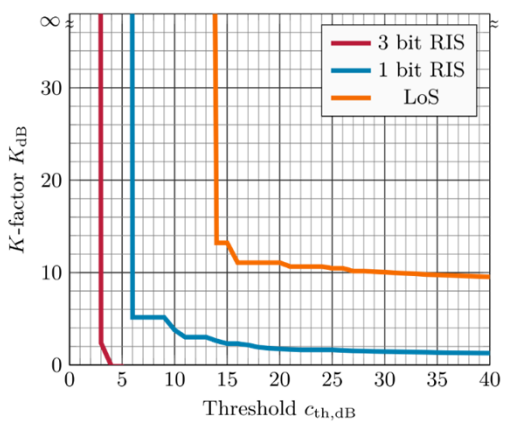
- Threshold refers to the maximum acceptable gain difference between the strongest and weakest MPC.
- RMSDS for both RIS cases exhibits a notable increase compared to LoS.
- The use of RIS results in a frequency selective channel.
- Considering K-factor, the use of RIS imposes a highly scattered environment.



RMSDS



Coherence bandwidth

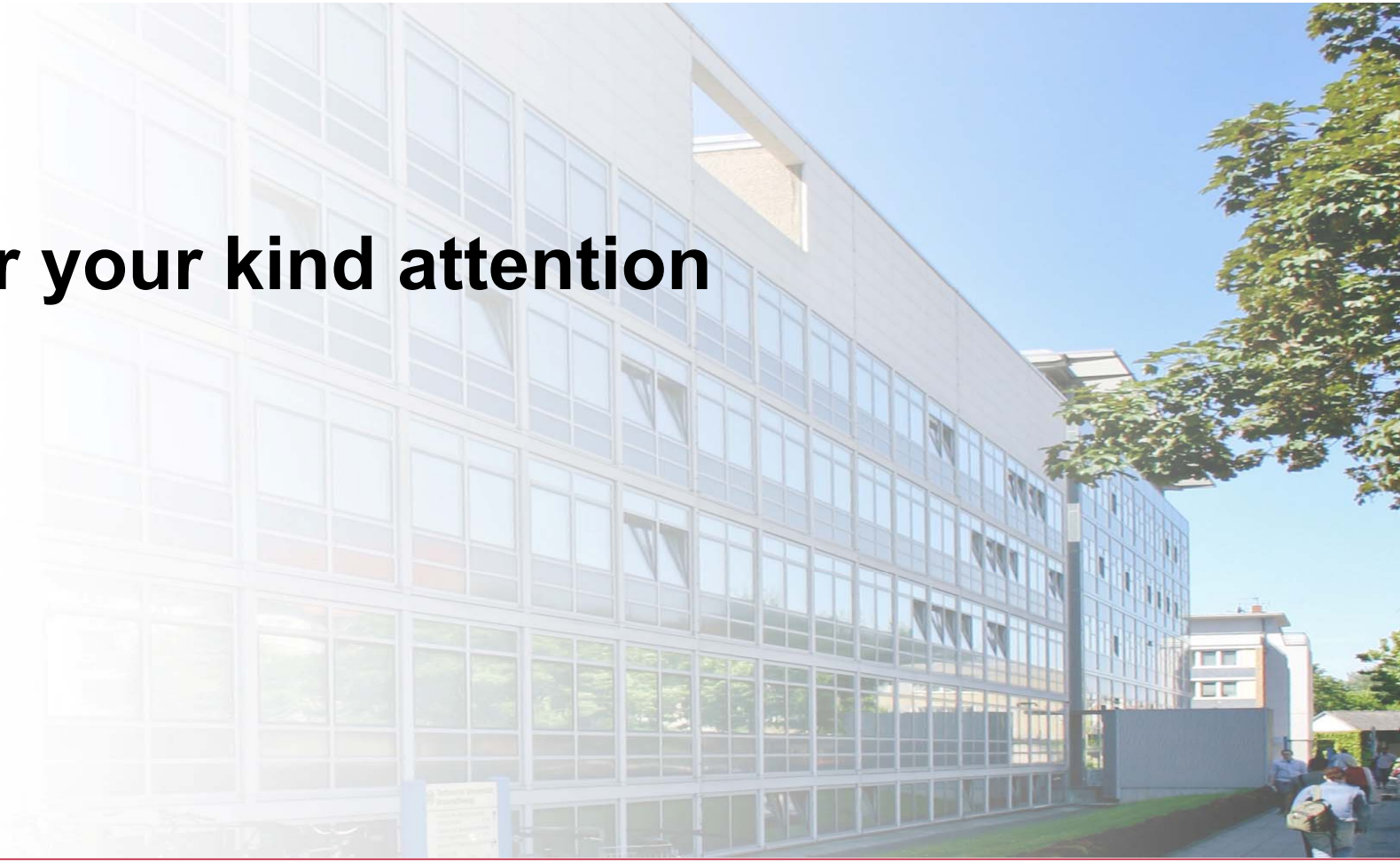


K-factor

Conclusion

- Channel measurements including RIS were performed in an indoor environment.
- Alignment will be a challenging task for future wireless communications using RIS.
- Measurement results showed expected results and an increased spatial diversity for a setup with RIS.
- Especially, for 1bit phase quantization, MPC over RIS was not the strongest but over reflection.

Thank you for your kind attention



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