Technische Universität Braunschweig

TIMES

Institut für Nachrichtentechnik

TIMES: Channel Characterisation in Industrial Environments at 300 GHz

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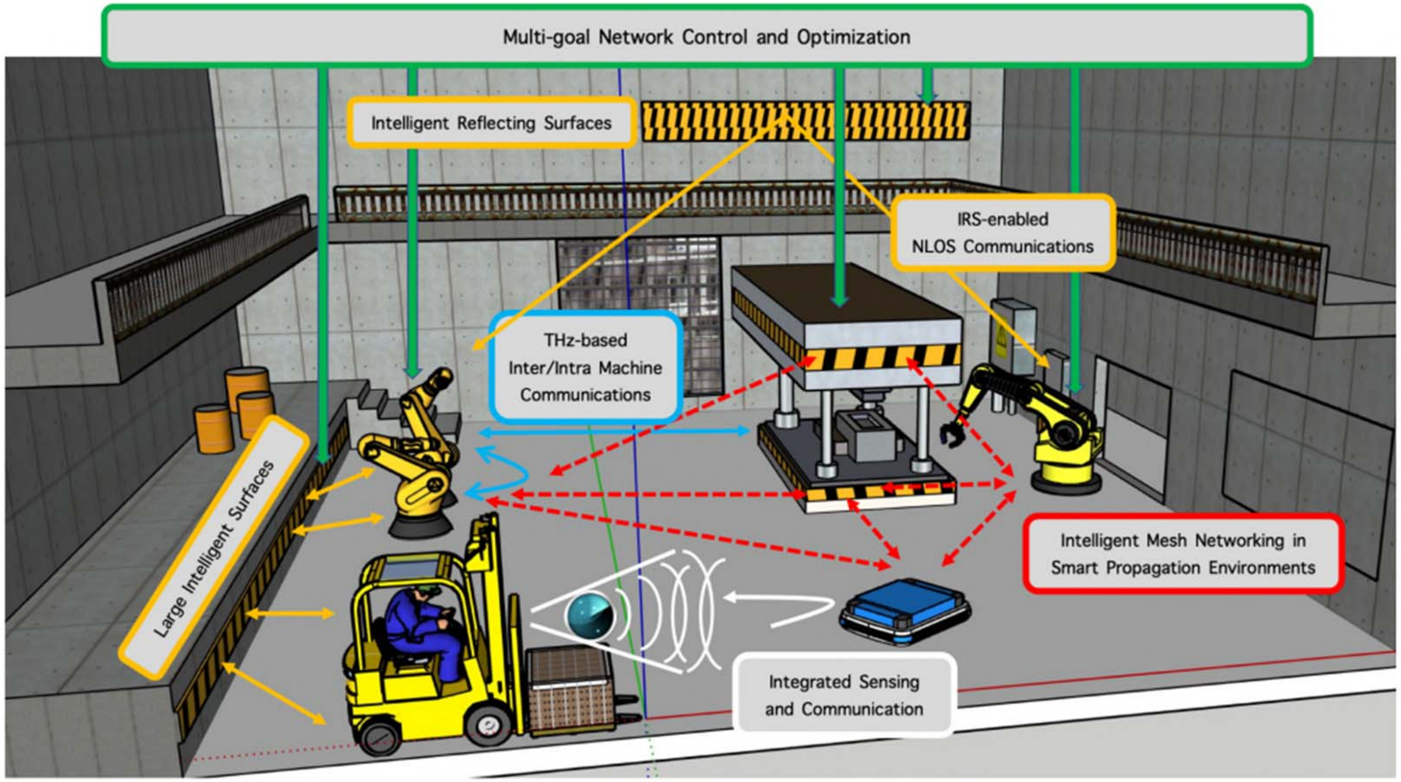
TIMES is working on THz Systems in industrial Environments



TIMES concept illustration for industrial scenarios and key technological enablers

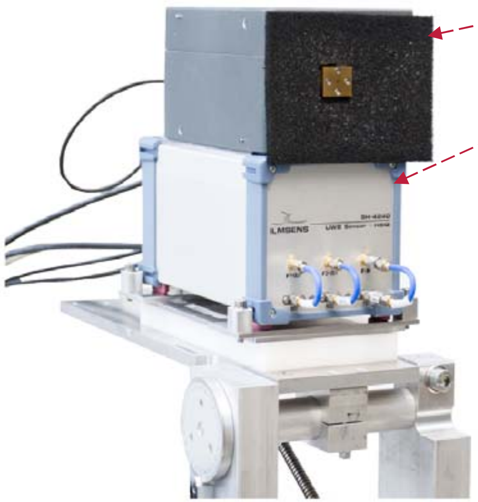
https://smart-networks.europa.eu/wp-content/uploads/2023/05/sns-journal-2023-web-1.pdf

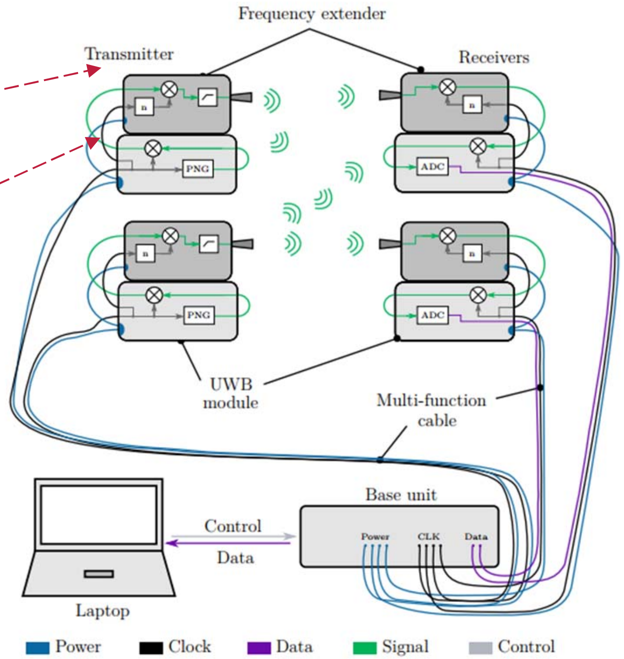
www.times6G.eu

Wihin TIMES first 300 GHz Channel Measurements have been carried out in industrial envronments

Measurement Equipment

- The measurements were conducted using an ultra wide band (UWB) sub-mmWave correlative channel sounder (CS)





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°

[1] 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
[2] 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

In the following we will show selected Results from two Mesurement Campaigns

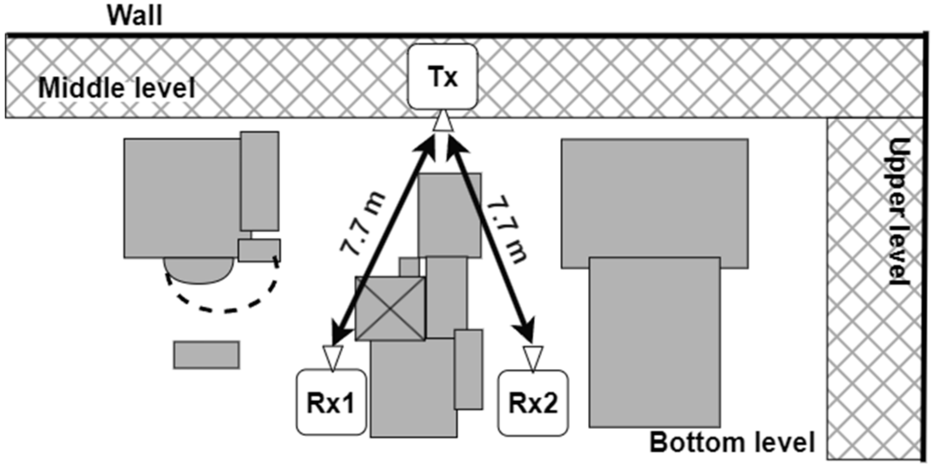
Campaign I: Industrial Production Hall

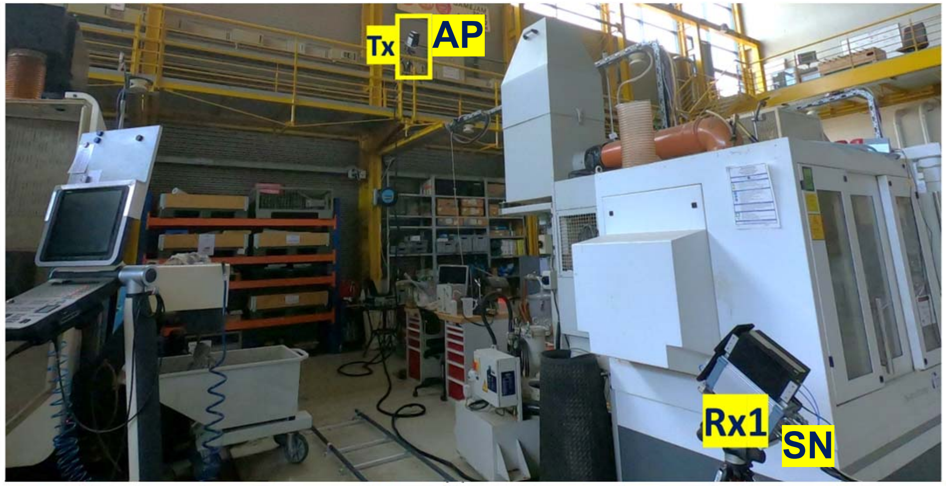
C. E. Reinhardt, V.V. Elesina, J. M. Eckhardt, T. Doeker, L. C. Ribeiro, T. Kürner, "Channel Measurements in an Industrial Environment for Access Point-to-Sensor Communication at 300 GHz," Proc. of *German Microwave Conference*, Duisburg, Germany, 2024

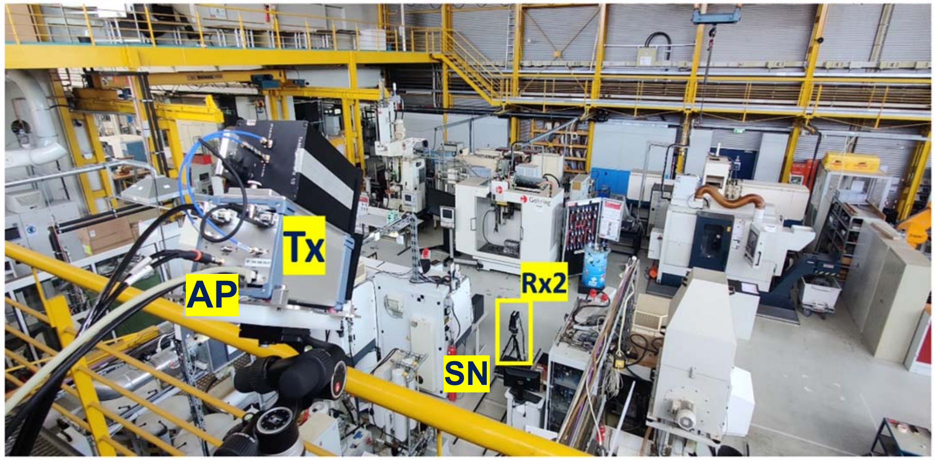
Campaign II: Robotic Lab

V. V. Elesina, C. E. Reinhardt and T. Kürner, "Channel Measurements in Workspace with Robotic Manipulators at 300 GHz and Recent Results," *2024 18th European Conference on Antennas and Propagation (EuCAP)*, Glasgow, United Kingdom, 2024, pp. 01-05, doi: 10.23919/EuCAP60739.2024.10501210

Campaign I: Static Scenario







Setup name	α_{Tx}°	α_{Rx}°	β_{Tx}°	β_{Rx}°
Misaligned Rx1	0	0	0	180
Aligned in elevation Rx1	-35	35	0	180
Rx1 with aligned Tx	-35	0	15	180
Aligned Rx1	-35	35	15	195
Misaligned Rx2	0	0	0	180
Aligned Rx2	-35	35	15	195

Results: Static Scenario

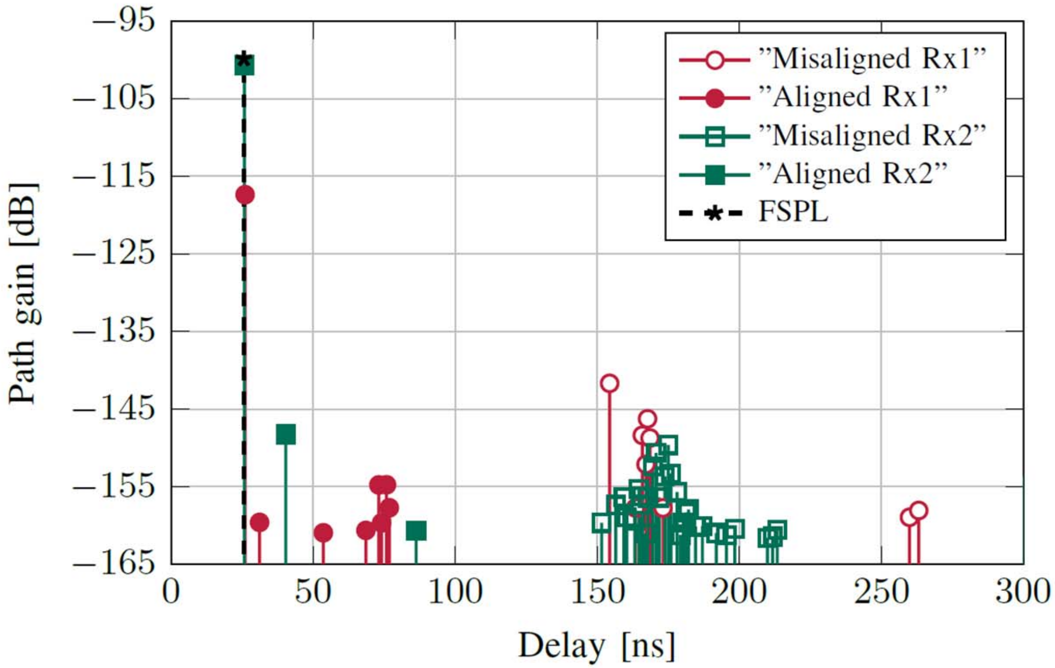


Fig. 1: Rx1 and Rx2 PDPs comparison in extreme cases

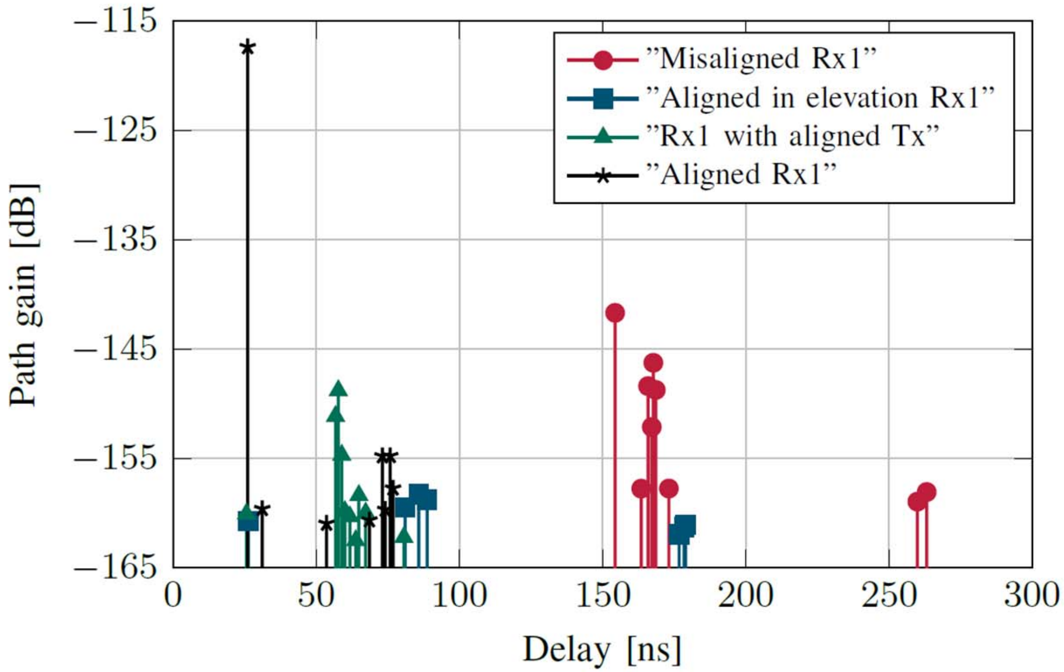
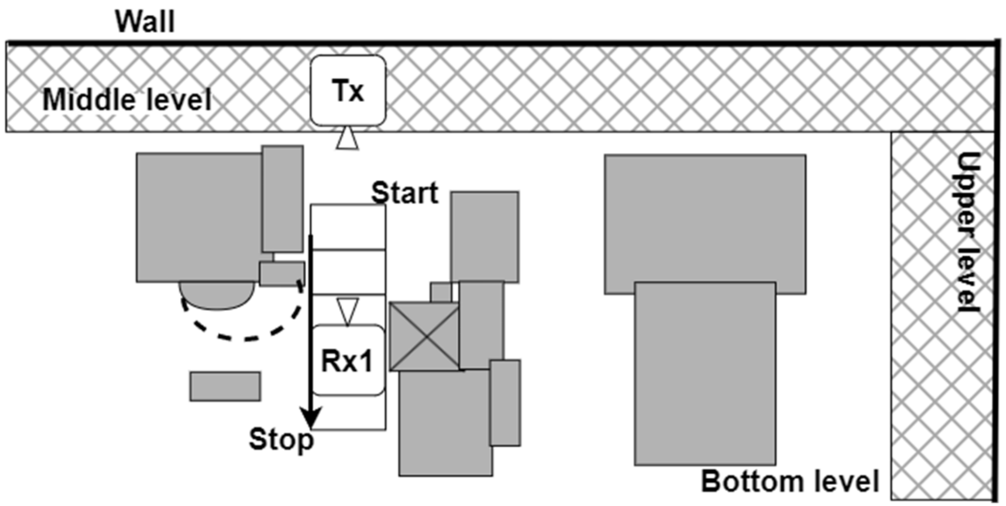


Fig. 2: PDPs in cases of different levels of aligns for Rx1

Campaign I: Dynamic Scenario



Setup name	α_{Tx}°	α_{Rx}°
Misaligned	-35	0
Aligned	-35	35

Results: Dynamic Scenario

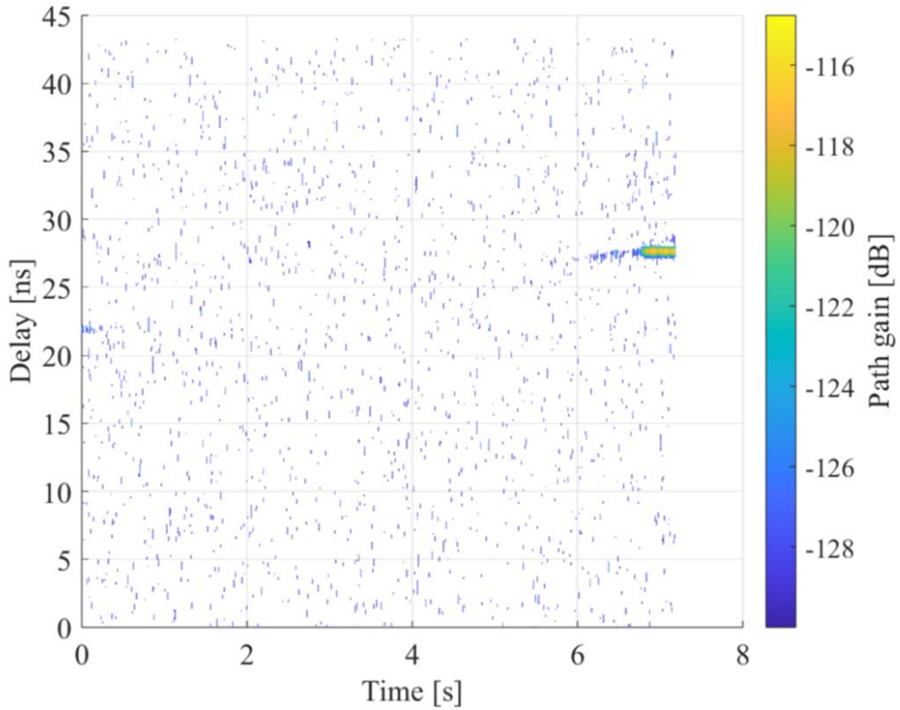


Fig. 1: Time-variant PDP “Misaligned Rx”

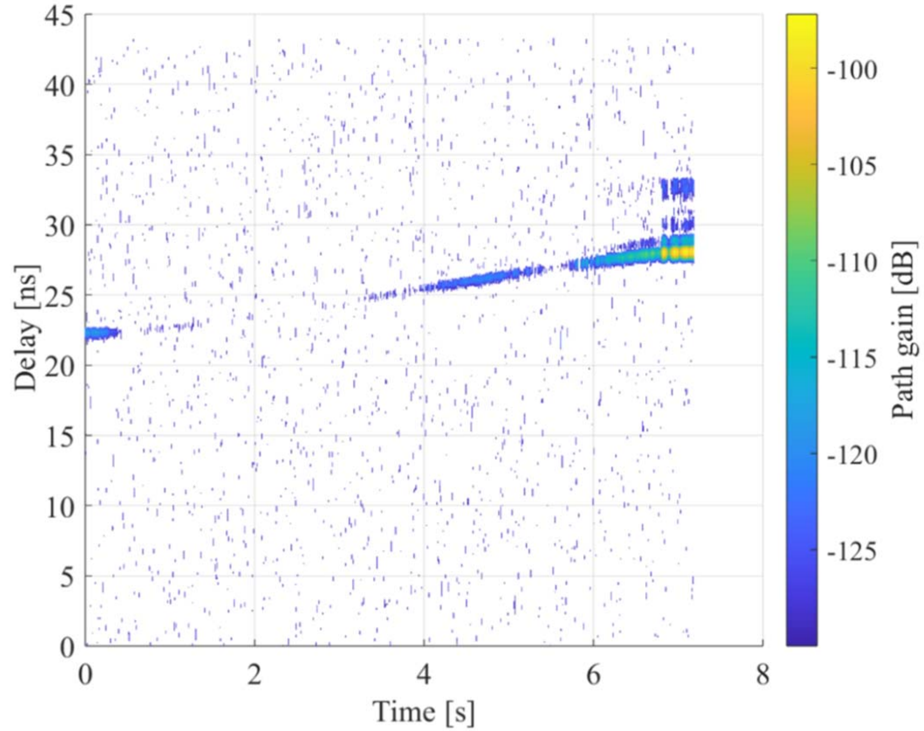


Fig. 2: Time-variant PDP “Aligned”

Campaign II: Measurement Environment

- Measurements were conducted in the Robotics Lab at TUBS
- Up to 3 robotic arms were used in different configurations
- Frank Emika robotic arms
- Setup included the movement of one arm

Dynamic Scenario: Two Arm Communication

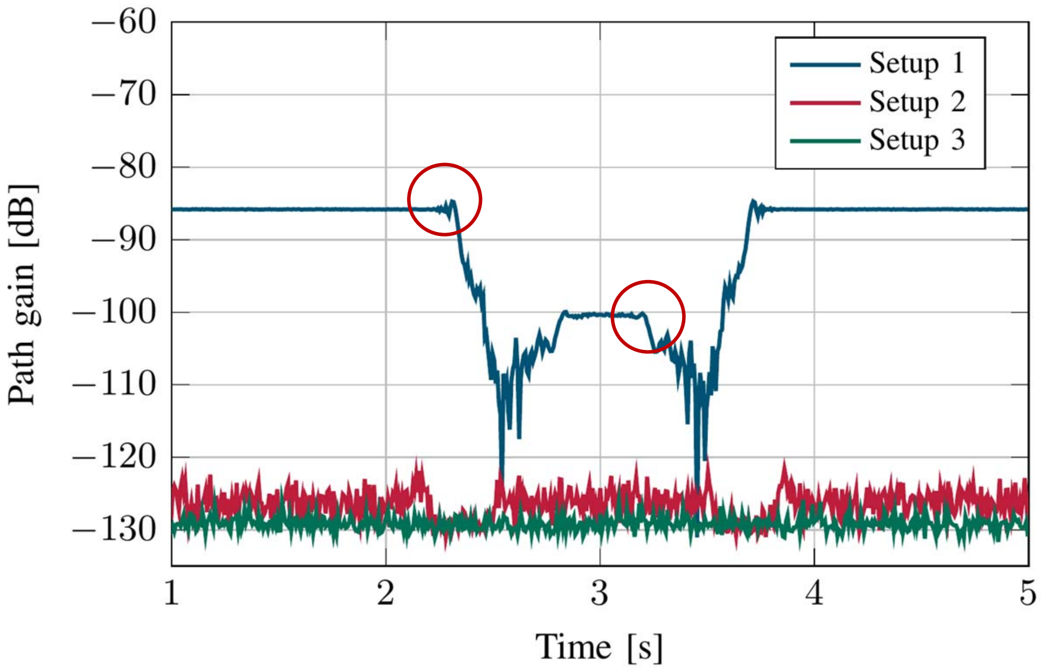
- Two different movements
  - Vertical movement
  - Rotational movement
  - Three different heigths

Setup	h_{TX}, m	h_{RX}, m	d_{TX-RX}, m	Movement direction
1	0.98	0.98	1.4	vertical
2	1.39	0.98	1.4	vertical
3	1.65	0.98	1.4	vertical
4	0.98	0.98	1.4	rotational
5	1.39	0.98	1.4	rotational
6	1.65	0.98	1.4	rotational

Setup 1

Results: Dynamic Scenario – Two Arm Communication

- Three different configurations
- Diffraction effect at the intersection between LOS/OLOS/NLOS
- OLOS attenuation of ~15dB
- Alignment has a strong influence on the communication



Power Delay Profile

Conclusion

First analysis of the two measurement campaigns

- Prove the feasibility of communication between the AP and SN in NLOS industry scenarios, due to MPCs, but underscore the importance of further research of interference effect and parameters like delay and angular spread;
- Shows a notable 16 dB difference between LOS and OLOS cases.
- Demonstrates that communication between the AP and the SN on the moving machine is feasible;
- Highlights strong dependence of communication success with alignment of the Tx and Rx antennas.
- Shows that the movement of the robotic arms significantly influence the propagation channel.

Further detailed evaluations will be performed
and the results will be used to develop Channel Models for THz in industrial environments

Thank you for your attention!

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