Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation

FOR 2863 Meteracom
Metrology for THz Communications

The 50th International Conference on Infrared, Millimeter, and Terahertz Waves
17-22 August, 2025

METERACOM

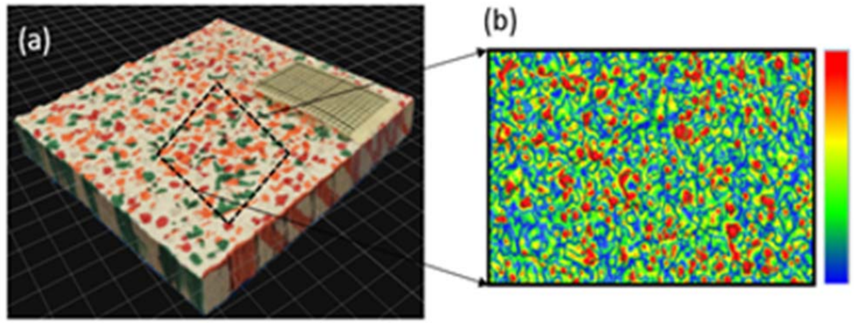
Introduction to DFG FOR 2863 Meteracom

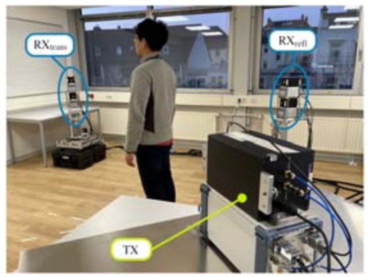
Prof. Dr.-Ing. Thomas Kürner, Spokesman DFG FOR 2863
Institut für Nachrichtentechnik, TU Braunschweig

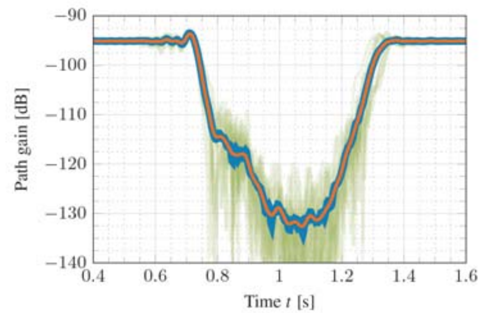
DFG FOR2863 Meteracom Final Workshop @ IRmmW-THz 2025, 20 August 2025

Outline

- Introduction of the DFG FOR 2863 Meteracom
  - *Why?* Motivation to work on Metrology for THz Communications
  - *What?* Project Structure
  - *Who?* Consortium
- Some exemplary Outcomes*
- Overview on the Workshop Program
  - Talks
  - Poster Presentations
- Overview on regular Contributions by Meteracom @IRmmW-THz 2025
- Introduction of the Meteracom Booth @IRmmW-THz 2025
- Introduction of the Meteracom OpenAccess Book Publication

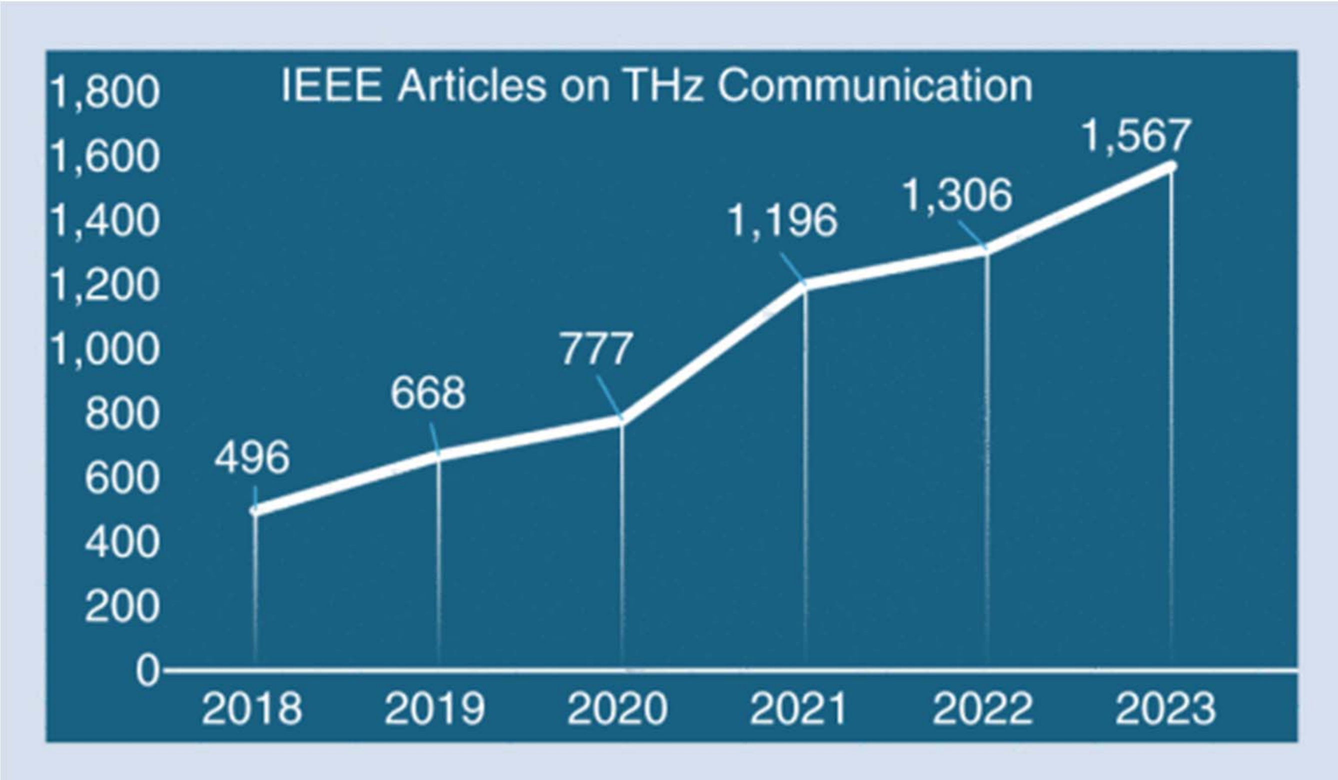






*and not presented elsewhere in the workshop

Research on THz Communications is booming….



Source: J. M. Jornet, H. Elayan, T. Nagatsuma, M. Juntti, E. T. Pinto, T. Kürner, H. Guerboukha, D. M. Mittleman, E. Knightly, "Mobile Terahertz Communication and Sensing Systems: A Future Look," in *IEEE Vehicular Technology Magazine*, vol. 19, no. 4, pp. 20-35, Dec. 2024,

…and THz Communication has even entered the Phase of (Pre-Standardisation) @ IEEE 802 and ETSI

IEEE STANDARDS ASSOCIATION IEEE

IEEE Standard for High Data Rate Wireless Multi-Media Networks

Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.15.3d™-2017
(Amendment to
IEEE Std 802.15.3™-2016
as amended by
IEEE Std 802.15.3e™-2017)

IEEE SA STANDARDS ASSOCIATION

IEEE Standard for Wireless Multimedia Networks

STANDARDS

IEEE Computer Society

Developed by the
LAN/MAN Standards Committee

IEEE Std 802.15.3™-2023
(Revision of IEEE Std 802.15.3-2016)

IEEE

ETSI GR THz 001 V1.1.1 (2024-01)

ETSI GROUP REPORT

TeraHertz modeling (THz);
Identification of use cases for THz communication systems

ETSI GR THz 002 V1.1.1 (2024-03)

ETSI GROUP REPORT

TeraHertz technology (THz);
Identification of frequency bands of interest for THz communication systems

ETSI GR THz 003 V1.1.1 (2024-12)

ETSI GROUP REPORT

TeraHertz modeling (THz);
Channel measurements and modeling in THz bands

ETSI GR THz 004 V1.1.1 (2025-01)

ETSI GROUP REPORT

TeraHertz technology (THz);
RF Hardware Modeling

ETSI WEBINAR: use-cases and spectrum – key starting points for Terahertz Standards

11 April 2024

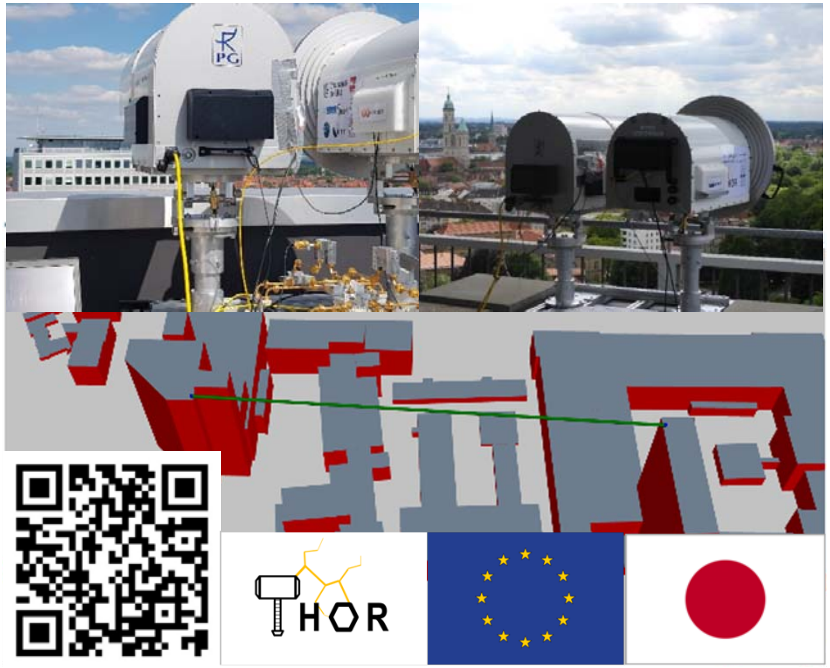
ETSI The Standards People

Channel Characterisation and RF Hardware Models for THz Communications

30 June 2025 – 15.00 cest

Numerous Hardware Demonstrators have shown the feasibility of THz Communications

THz Backhaul Demonstrator, Braunschweig, June 2022



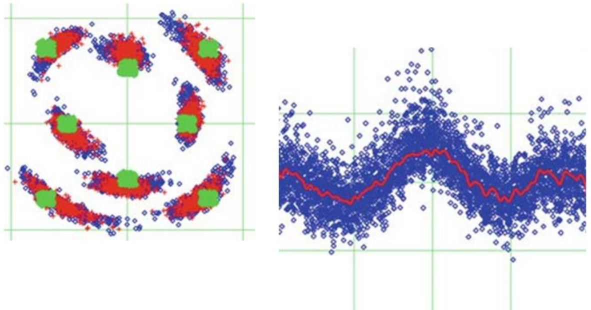
Source T. Kürner *et al.*, "THz Communications and the Demonstration in the ThoR–Backhaul Link," in *IEEE Transactions on Terahertz Science and Technology*, vol. 14, no. 5, pp. 554-567, Sept. 2024, doi: 10.1109/TTHZ.2024.3415480.

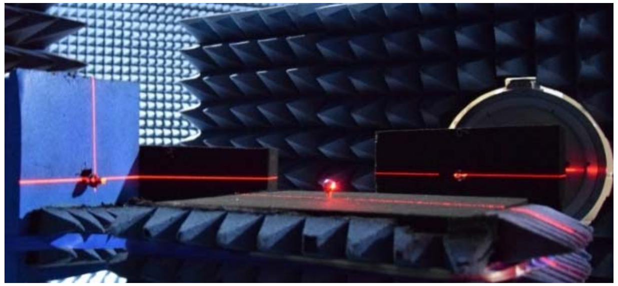
IEEE 802.15 WNG Tech Focus @Kobe/Japan, 15 January 2025

Challenges for Metrology of THz Communications

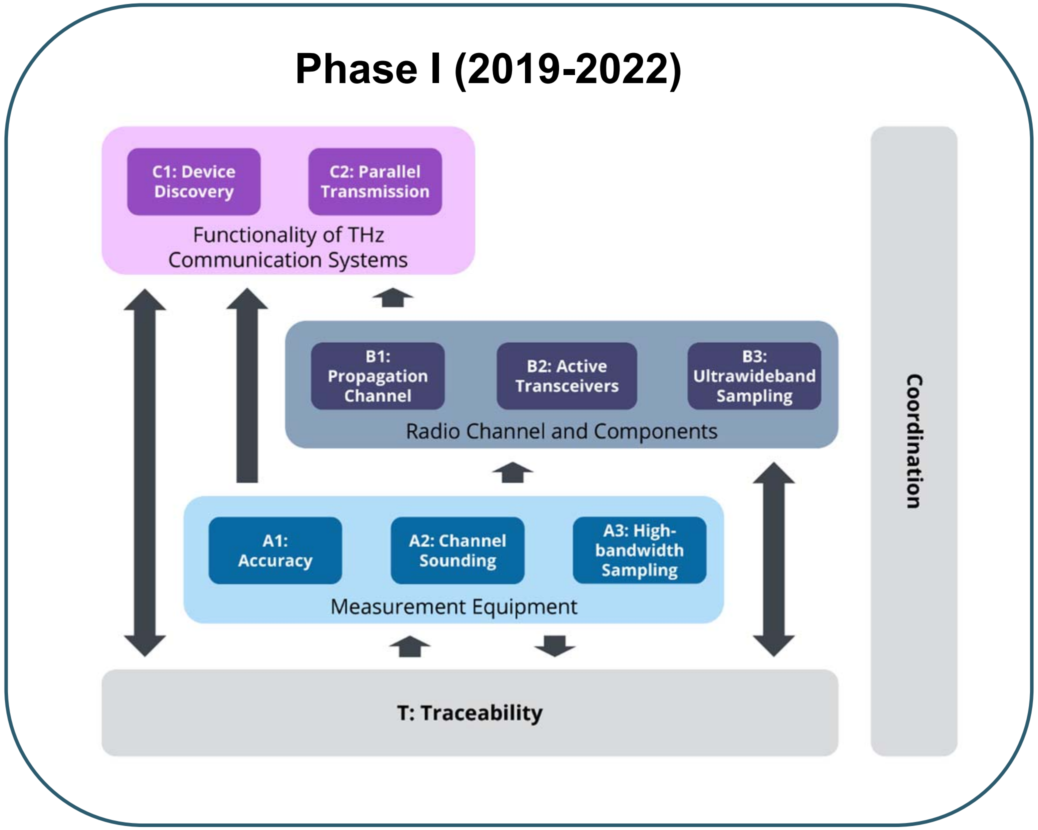
- The capability to performing measurements and evaluating measurements in a proper way are crucial for the advance of THz communication systems. Meteracom has addressed the grand challenge of metrology for THz communication measurements systematically, and in four distinct project areas:

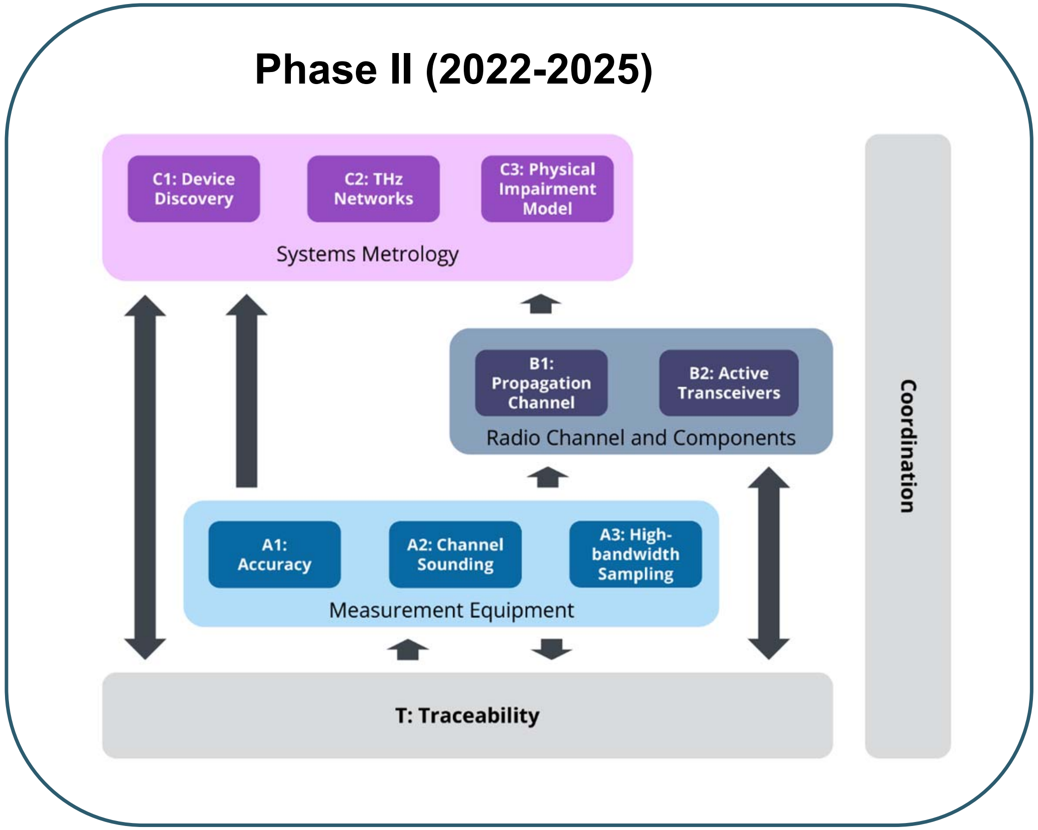
- T: Traceability to the International System of Units (SI)
- A: Characterisation of the measurement system itself
- B: Metrological characterisation of the RF components and the propagation channel
- C: Measurements required for enabling the functionality of THz communications / Systems Metrology.





Project Structure





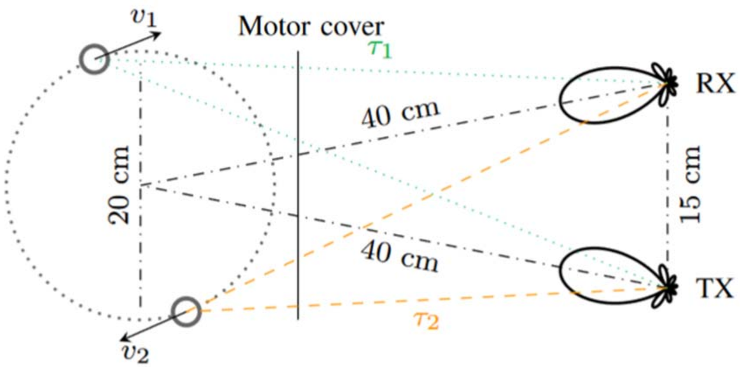
Source: based on T. Kürner, T. Doeker, D. Humphreys, T. Kleine-Ostmann, T. Schneider „Metrology for THz Communciations – Findings from DFG FOR2862“," in Springer 2025, to be published; https://link.springer.com/book/9783032019851; (Open Access Under a Creative Commons License)

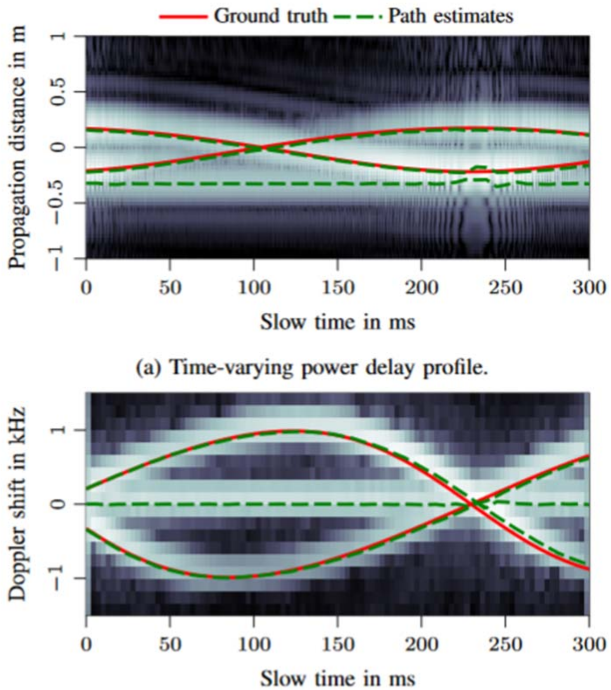
Meteracom Consortium

- Interdisciplinary and distributed research unit
- 10 Principal Investigators from 6 universities and PTB
- 2 Mercator Fellows from NPL (UK) and
  Brown University Rhode Island (USA), respectively
- Spokesman: Thomas Kürner (TU Braunschweig)

Technische Universität Braunschweig
Universität Stuttgart
TECHNISCHE UNIVERSITÄT ILMENAU
PTB
NPL
Philipps Universität Marburg
UNIVERSITÄT ZU LÜBECK
HEINZ NIXDORF INSTITUT UNIVERSITÄT PADERBORN

Exemplary Outcome Project Area A:
Joint Delay/Doppler Sounding and Resolution Verification via OTA artifact





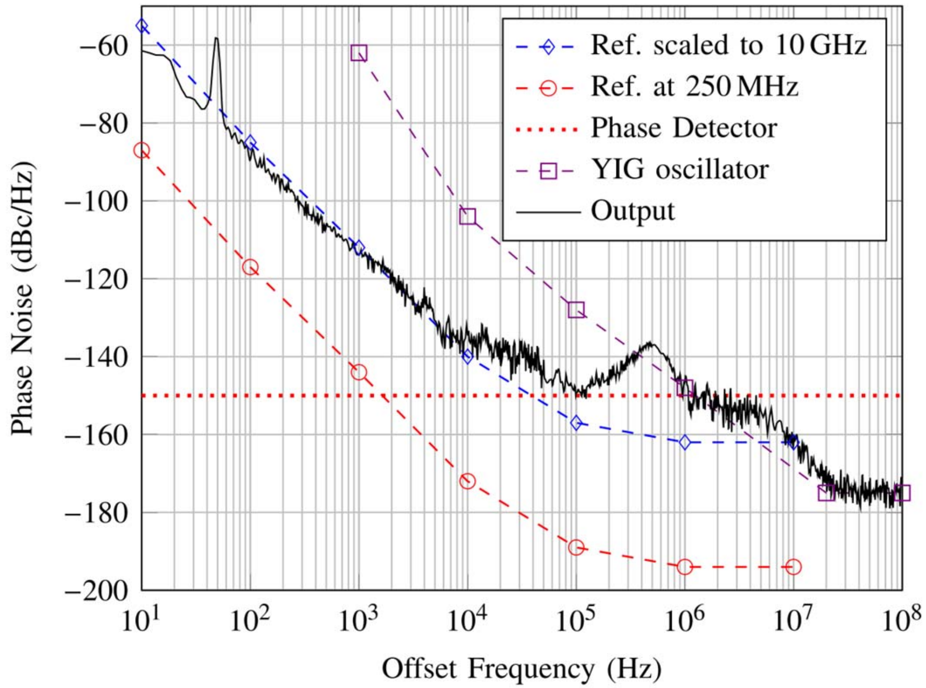
(a) Time-varying power delay profile.

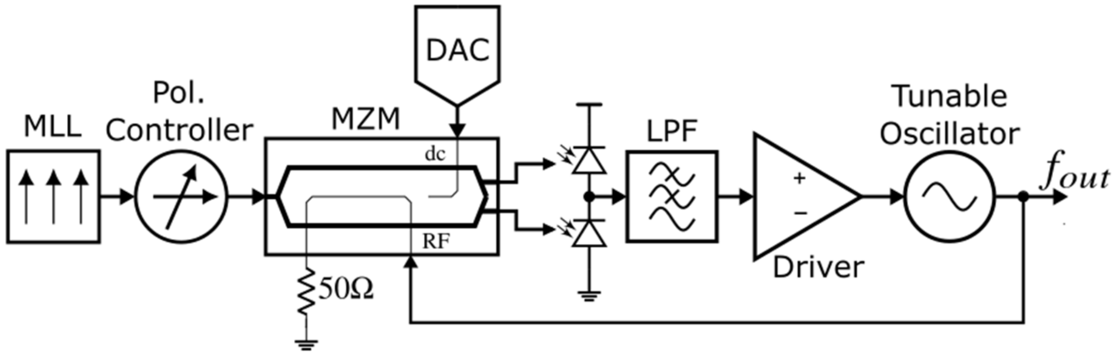
(b) Time-varying power Doppler profile.

FIGURE 9. Experimental measurement and estimation results of the proposed OTA artifact.

J. Gedschold *et al.*, "Metrology of Multicarrier-Based Delay-Doppler Channel Sounding for sub-THz Frequencies," in *IEEE Open Journal of Antennas and Propagation*, doi: 10.1109/OJAP.2025.3566473 (Open Access Under a Creative Commons License)

Exemplary Outcome Project Area B: Photonically Referenced Oscillator / Optoelectronic PLL (OE-PLL)

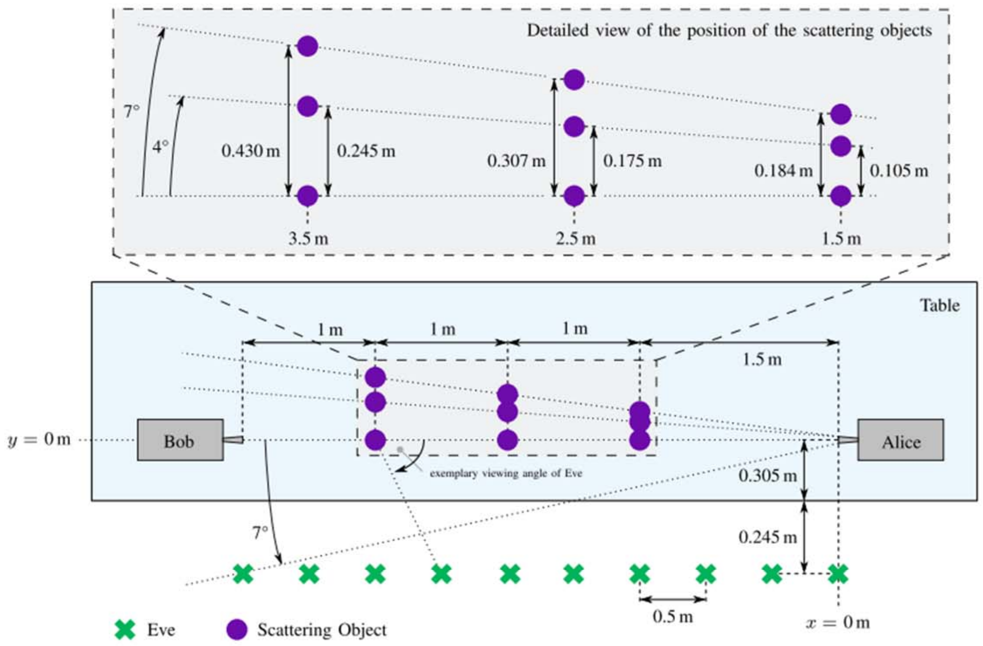


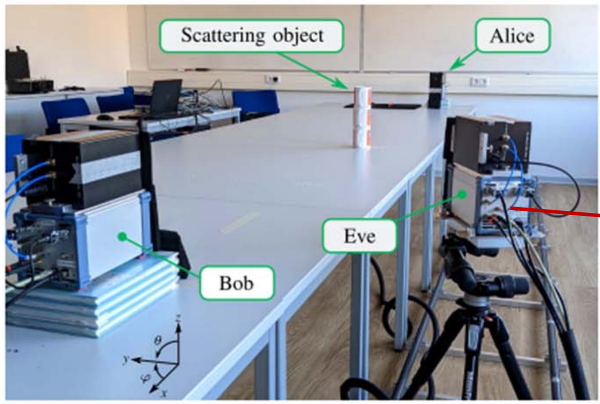


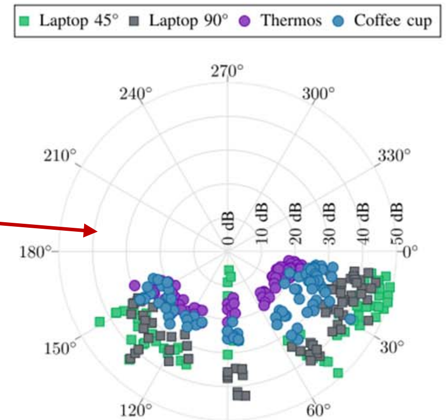
- 2.8 fs rms @ 10GHz [1 kHz-100MHz]

M. Bahmanian and J. C. Scheytt, "A 2–20-GHz Ultralow Phase Noise Signal Source Using a Microwave Oscillator Locked to a Mode-Locked Laser," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 69, no. 3, pp. 1635-1645, March 2021, doi: 10.1109/TMTT.2020.3047647. (Open Access (Open Access Under a Creative Commons License)

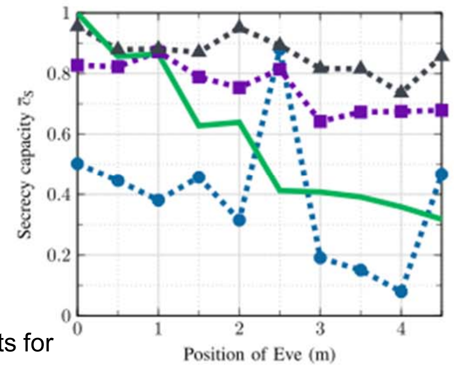
Exemplary Outcome Project Area C:
Measurements on Physical Layer Security at 300 GHz



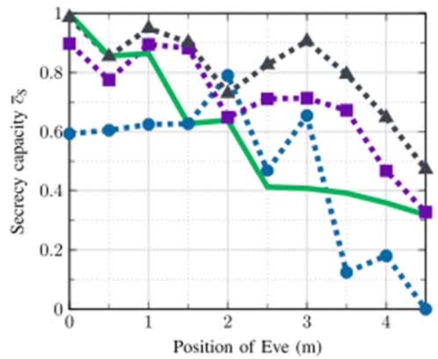




Source: T. Doeker, C. Herold, J. M. Eckhardt and T. Kürner, "Eavesdropping Measurements for Applications in Office Environments at Low THz Frequencies," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 71, no. 6, pp. 2748-2757, June 2023, doi: 10.1109/TMTT.2023.3236018. (Open Access Under a Creative Commons License)



(c) Coffee cup placed at $x_{\mathrm{scat}} = 3.5\,\mathrm{m}$.



(j) Laptop 90° placed at $x_{\mathrm{scat}} = 1.5\,\mathrm{m}$.

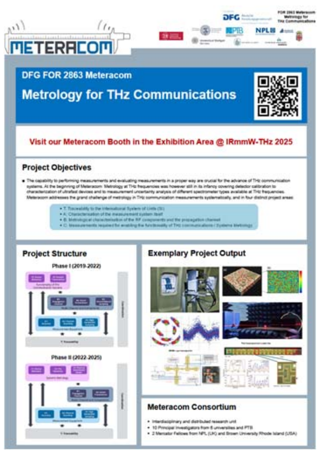
Overview on the Workshop Program

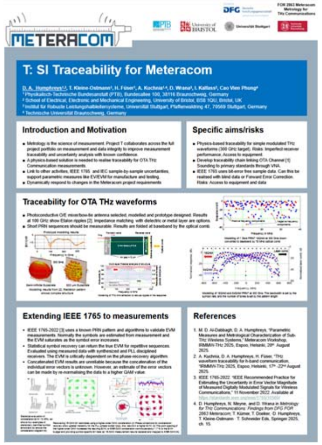
WORKSHOP PROGRAM – August 20, 2025 / Room M1

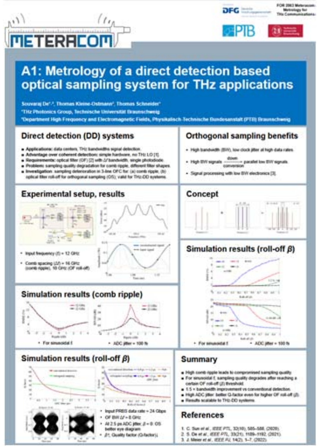
10:00 – 11:30	*Thomas Kürner, Technische Universität Braunschweig, Germany:* Introduction to DFG FOR 2863 Meteracom
	Invited Keynote *Tadao Nagatsuma, The University of Tokyo, Japan:* Effects of Phase Noise and Nonlinearity on Signal Integrity in Photonics-Enabled THz Links
	David Humphreys: Development Considerations for a THz Waveform Traceability for H-band Communication
	Younus Mandalawi, Technische Universität Braunschweig, Germany: Results of Metrology of High-bandwidth Sampling Systems
Lunch	
13:30 – 15:00	**Invited Keynote** *Iwao Hosako, National Institute of Information and Communications Technology (NICT), Japan:* New Use Cases and Strategies for Promoting Terahertz Wave Communications Based on IEEE 802.15.3-2023
	Thomas Kleine-Ostmann: Physikalisch-Technische Bundesanstalt, Germany: Measurement Techniques and Testbeds for Over-the-Air Sub-THz Channel Sounding Systems
	Benjamin Schoch, University of Stuttgart, Germany: Instrumentation for Traceable Distortion Characterization of Terahertz Transceivers
	Daniel M. Mittleman, Brown University, USA: Portable Reference Structure Enabling THz Channel Impulse Response Measurement System Comparisons
Coffee Break	
15:30 – 17:00	*Martin Koch, Philipps University of Marburg, Germany:* THz Characterisation of Building Materials
	Tobias Doeker, Technische Universität Braunschweig, Germany: Device Discovery and Beam Tracking
	Christoph Herold, Technische Universität Braunschweig, Germany: Link- and System Level Simulation for Metrology
	Panel Discussion Moderator: *Thomas Kürner* Panelists: *Tadao Nagatsuma, Iwao Hosako, Daniel M. Mittleman, David Humphreys, Thomas Kleine-Ostmann, and Martin Koch*

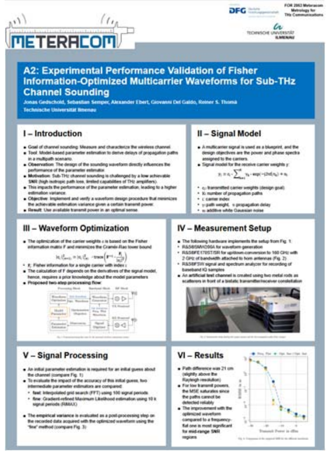
PDFs of all presentations available @ https://meteracom.de/workshop_irmmw-thz_2025/

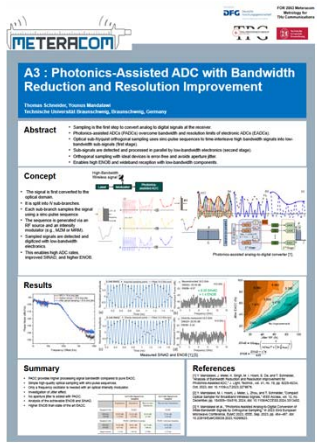
Poster Presentations @ this Workshop

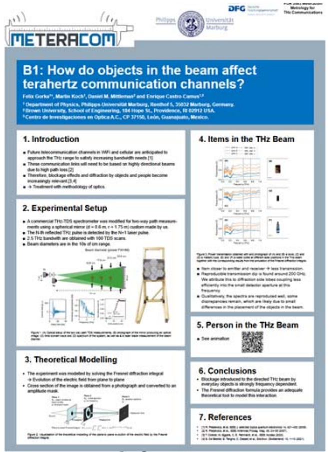


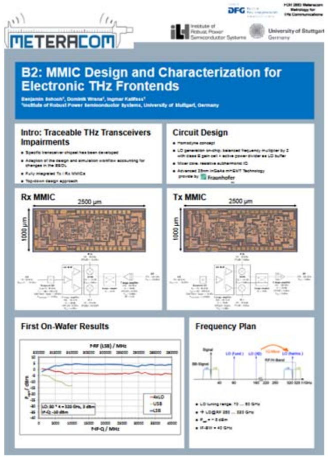


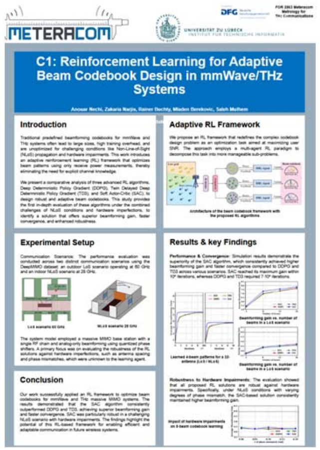


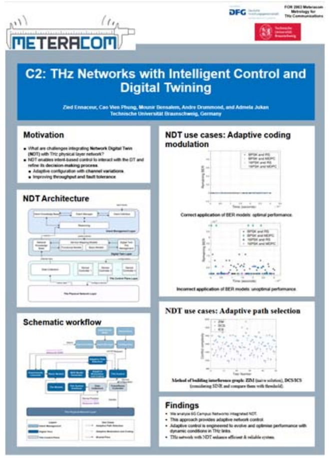


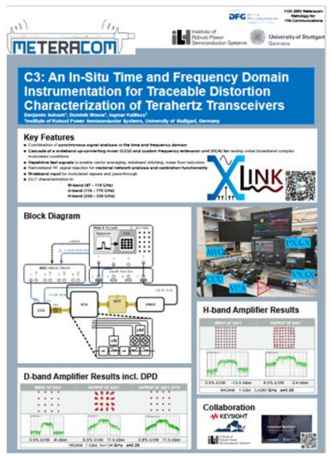












Overview on regular Contributions by Meteracom @IRmmW-THz 2025

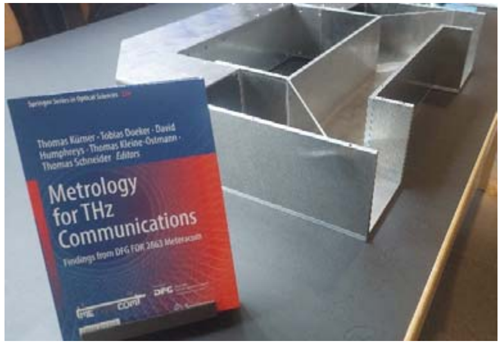
Wednesday, 20 August, Communication systems I, Hall D	
14.30-14.45	*Younus Mandalawi, Souvaraj De, Mohamed I. Hosni, Linjie Zhou, Thomas Schneider* Integrated Wideband Wireless Signal Receiver Based On Cascaded Ring Modulators

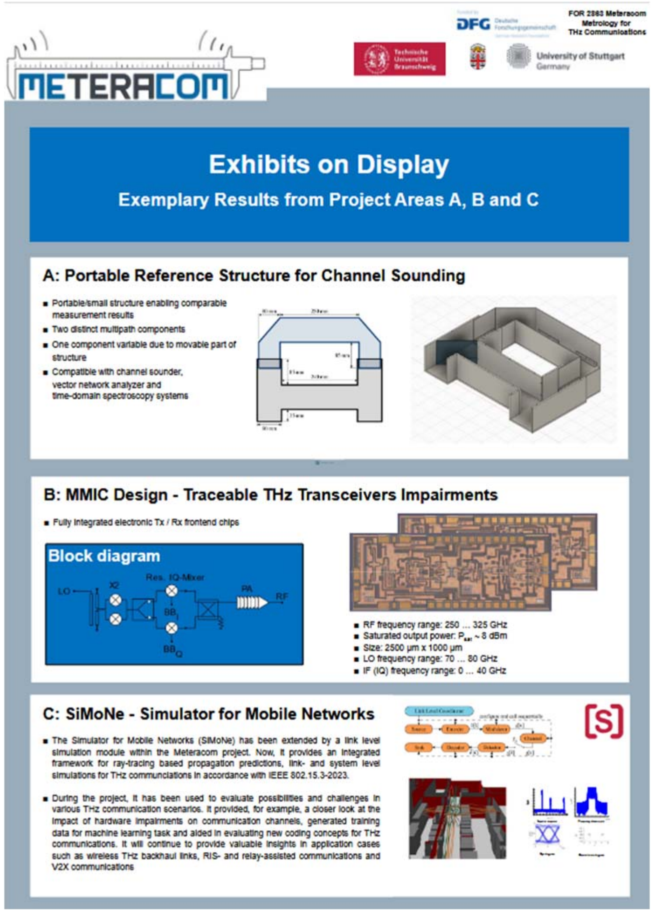
Thursday, 21 August, Session Metroloogy and Parameter Estimation, Hall D	
13.45-14.00	*Benjamin Schoch, Ingmar Kallfass* An In-Situ Time and Frequency Domain Instrumentation for Traceable Distortion Characterization of Terahertz Transceivers
14.00-14.15	*Benjamin Schoch, Simon Haussmann, Marc Guenter, Thomas Ufschlag, Philipp Neininger, Dirk Schwantuschke, Ingmar Kallfass* Intermodulation Distortion Analysis In Cascaded D-Band GaN Amplifiers

Thursday, 21 August, Communications signal processing and channel modelling, Hall E	
16.45-17.00	*Tobias Doeker, Carla E. Reinhardt, Yaseman Shiri, Daniel M. Mittleman, Thomas Kürner* Channel Impulse Response Measurements With Time-Domain Spectroscopy In The Low Terahertz Range

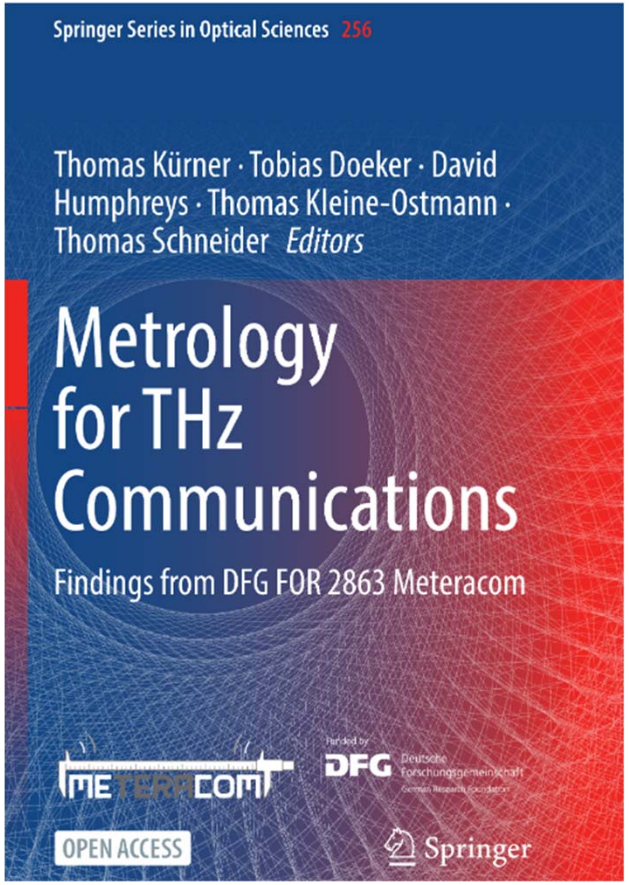
Thursday, 21 August, Poster, Hall	
17.00-18.30	*David Humphreys, Heiko Fueser, Adam Kuchnia* THz waveform traceability for h-band communication
	Martin Koch, Felix Gorka, Daniel Mittleman, Enrique Castro-Camus How Do Objects In The Beam Affect Terahertz Communication Channels?

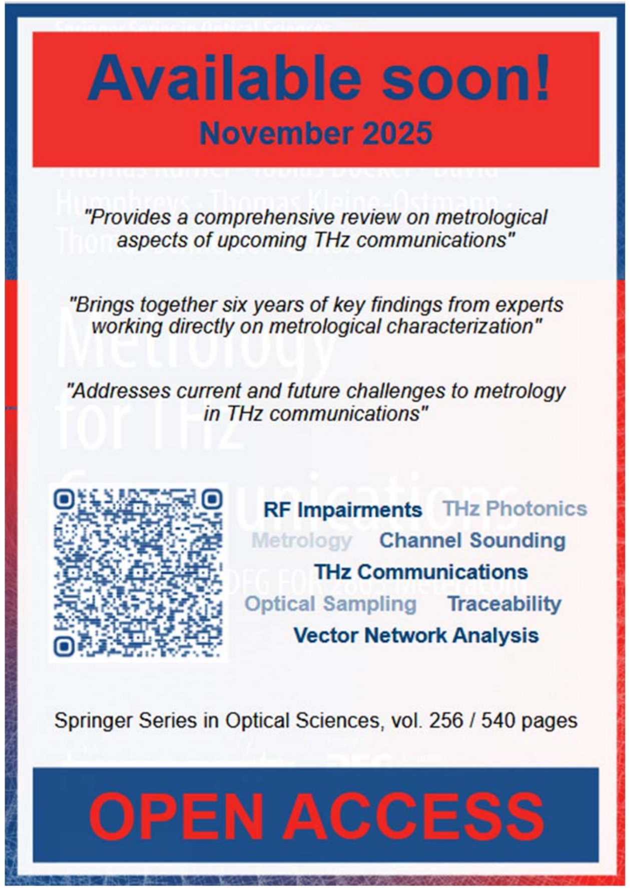
Introduction to the Meteracom Booth @ IRmmW-THz 2025





Introduction of the Meteracom OpenAccess Book Publication





Thank you very much for your Attention

E-Mail: t.kuerner@tu-braunschweig.de

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