July 3-5, 2023
Kameha Grand, Bonn, Germany
Please register on www.iwmts.org/registration

PROGRAM

Day 3 – Wednesday, July 5th

Session 5 - Terahertz Systems and Applications (2)
Room: Kameha Spirit
Session Chair: Mohammed El-Absi

09:00 – 09:30 Ultra Wide Band FMCW Transceiver Modules for Milimeter Wave Spectrum Analysis
K. Kother, J. Altholz, I. Rolfes, J. Barowski

09:30 – 10:00 Pulsed Free Space Photonic Vector Network Analyzers for Broadband Operation
F. Rushd Faridi, S. Preu

10:00 – 10:30 Multistatic 250 GHz Imaging Radar With 12x64 Elements
M. Kahl, R. Hussung, A. Keil, F. Friederich, P. Haring Bolívar

10:30 – 11:00 **Coffee Break**

11:00 – 11:30 Phase-Based Breathing Rate Monitoring in Patient Rooms Using 6G Terahertz Technology
S. Häger, A. Najjar, C. Bektas, D. Lessy, M. El-Absi, F. Sheikh, S. Böcker, T. Kaiser, C. Wietfeld

11:30 – 12:00 Acceleration of 2D SAR Imaging on FPGA by Reducing Off-Chip Memory Accesses
E. Aliagha, A. Kamaleldin, A. Batra, T. Nalapat, M. Wiemeler, T. Kaiser, D. Göhringer

12:00 – 12:30 A Look Through Artificial Human Tissues at Ka-Band and D-Band
A. Prokscha, F. Sheikh, M. Jalali, Y. Zantah, B. Sievert, M. Al-Hasan, D. Erni, T. Kaiser

12:30 – 13:00 Experimental Analysis of VNA-based Measurement Errors in Mobile THz Applications
Y. Zantah, A. Batra, A. Prokscha, F. Sheikh, M. Haidar, A. A. Abbas, N. Zarifeh and T. Kaiser

Session 6 - Insect and Plant Monitoring
Room: Kameha Green
Session Chairs: Daniel Erni, Fawad Sheikh

09:00 – 10:00 **Tutorial Talk: Numerical Modeling of Interactions of Radiofrequency Fields with Insects**
P. De Boose, E. De Borre, H. Herssens, F. O. Ribas, D. T. Carvajal, **A. Thielens**

10:00 – 10:30 Terahertz-Based Heavy Metal Detection in Plants - A First Approach
L. Kreuzer, F. Brix, P. Düchting, C. Brenner, M. Deumer, R. Kohlhaas, U. Krämer, M. Hofmann

10:30 – 11:00 **Coffee Break**

11:00 – 11:20 Experimental RCS Determination and Imaging of Honey Bees with THz Time-Domain Spectroscopy
T. Kubiczek, J. Balzer

11:20 – 11:30 Tracking of Honey Bees Inside the Hive Using THz Harmonic Radar
K. Kolpatzeck, J. Balzer

11:30 – 11:50 THz Interaction with Western Honey Bees
M. Jalali, J. T. Svejda, D. Erni

11:50 – 12:10 Miniaturized THz Chips For Water Content Monitoring
P. Alibeigloo, C. Preuss, E. Mutlu, R. Kress, S. Clochiatti, N. Weimann

12:10 – 12:30 Plant Stem Imaging by Combining RCS-Measurements and Semi-Analytical T-Matrix Based Field Calculation
B. Sievert, M. Degen, F. Brix, U. Krämer, D. Erni, A. Rennings

Save the Date: 7th Annual IWMTS, July 2nd – July 4th 2024

Plant Stem Imaging by Combining RCS Measurements and Semi Analytical T-Matrix Based Field Calculation

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Open-Minded

International Workshop on Mobile Terahertz Systems 2023 | Bonn | July 5th 2023

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Open-Minded

Motivation

Goal

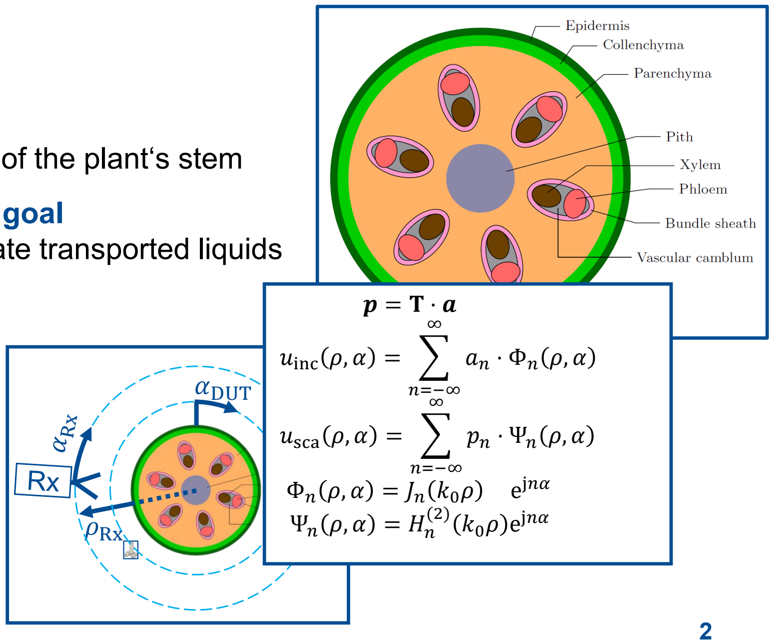
- Imaging of the plant's stem

Long-term goal

- Investigate transported liquids

Contents

- Semi-analytical **T**-Matrix-method for 2D-geometries w. arbitrary inclusions
- Dedicated measurement setup
- Measurement and **T**-Matrix-results are fitted to solve the inverse problem



$$\boldsymbol{p} = \mathbf{T} \cdot \boldsymbol{a}$$

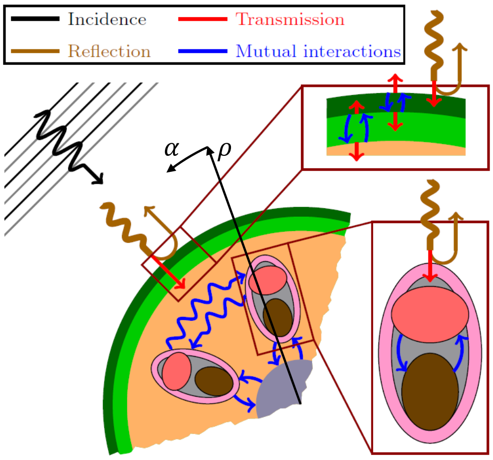
$$u_{\mathrm{inc}}(\rho,\alpha) = \sum_{n=-\infty}^{\infty} a_n \cdot \Phi_n(\rho,\alpha)$$

$$u_{\mathrm{sca}}(\rho,\alpha) = \sum_{n=-\infty}^{\infty} p_n \cdot \Psi_n(\rho,\alpha)$$

$$\Phi_n(\rho,\alpha) = J_n(k_0\rho) \quad \mathrm{e}^{\mathrm{j}n\alpha}$$

$$\Psi_n(\rho,\alpha) = H_n^{(2)}(k_0\rho)\mathrm{e}^{\mathrm{j}n\alpha}$$

Methodology



- Incident and scattered field is described using cylindrical coordinates

$$u_{\mathrm{inc}}(\rho,\alpha) = \sum_{n=-\infty}^{\infty} a_n \cdot J_n(k_0\rho) \cdot \mathrm{e}^{\mathrm{j}n\alpha}$$

$$u_{\mathrm{sca}}(\rho,\alpha) = \sum_{n=-\infty}^{\infty} p_n \cdot H_n^{(2)}(k_0\rho) \cdot \mathrm{e}^{\mathrm{j}n\alpha}$$

$$u(\rho,\alpha) \sim \begin{cases} E_z(\rho,\alpha) \text{ for TM} \\ H_z(\rho,\alpha) \text{ for TE} \end{cases}$$

- How to calculate p_n for given a_n?

RACTMA

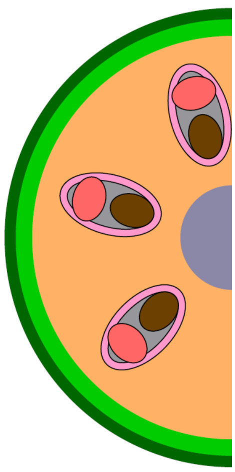
- T-matrix of scattering (efficiently & exactly)

$$\boldsymbol{p} = \mathbf{T} \cdot \boldsymbol{a}$$

- Arrangements of scatteres are evaluated by matrix calculations
- Recursive Centered T-Matrix Algorithm (RCTMA) has been improved by aggregating suitable clusters of scatterers

$N_{\mathrm{Inclusion}}$	RCTMA	RACTMA
100	10.3s	7.92s
500	350s	105s
2500	40000s	2900s

CPU Time = ΣCore Times



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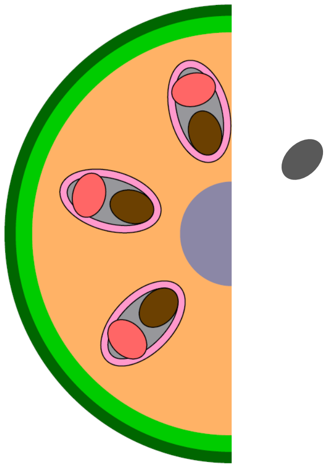

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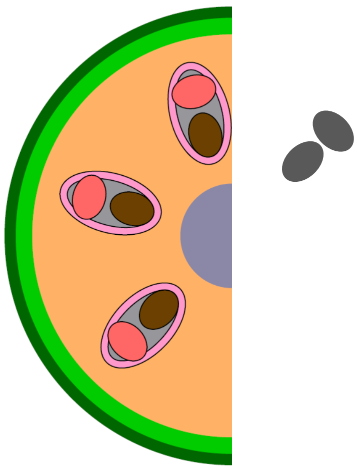

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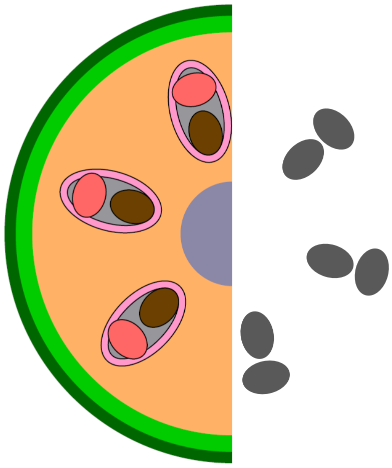

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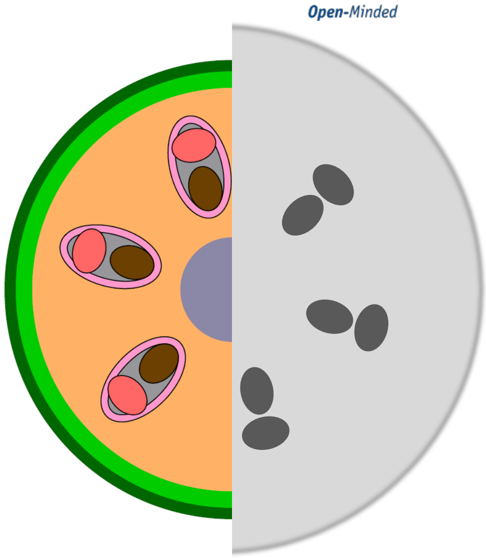

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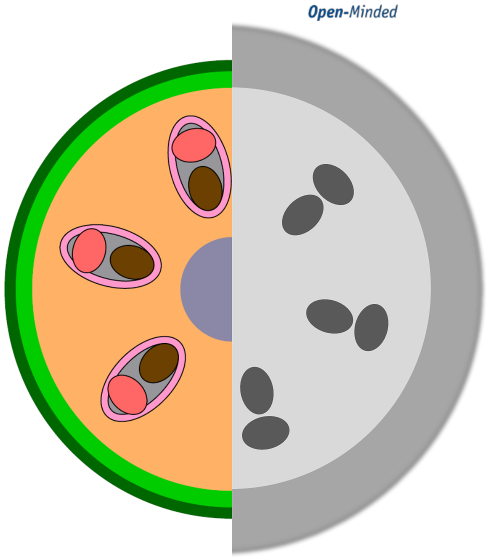

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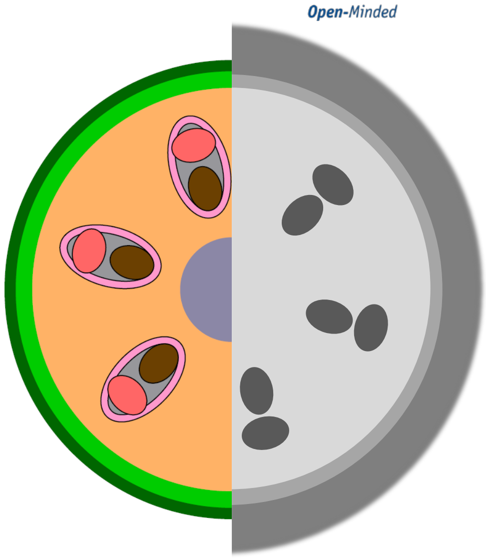

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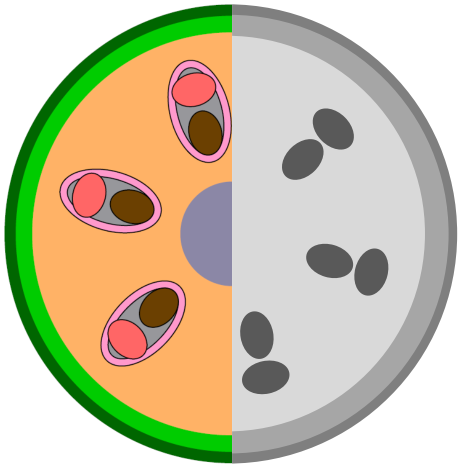


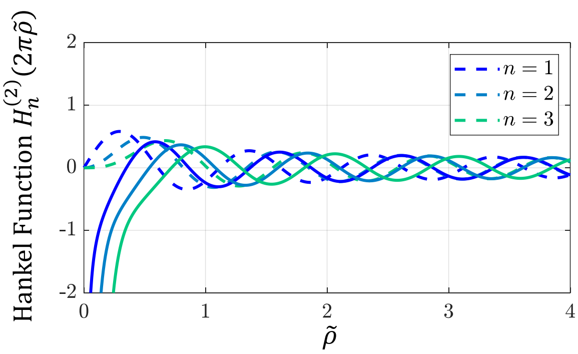
Measurement

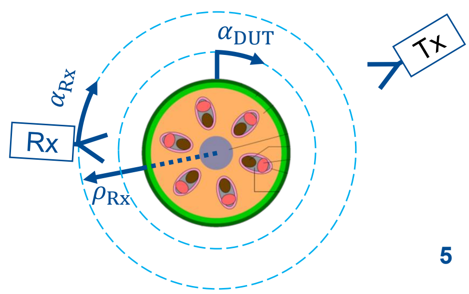
Near- and Farfield Measurement

- The measurement should be used to determine the T-matrix (the phytotomy) of the plant
  - ➢ Optimization problem
- How to gain maximum insight with limited number of measurmeents?
- $u_{\text{sca}}(\rho, \alpha) = \sum_{n=-\infty}^{\infty} p_n \cdot H_n^{(2)}(k_0\rho) \mathrm{e}^{\mathrm{j}n\alpha}$

$$u_{\text{sca}}(\rho, \alpha) \sim \begin{cases} E_z(\rho, \alpha) \text{ for TM} \\ H_z(\rho, \alpha) \text{ for TE} \end{cases}$$

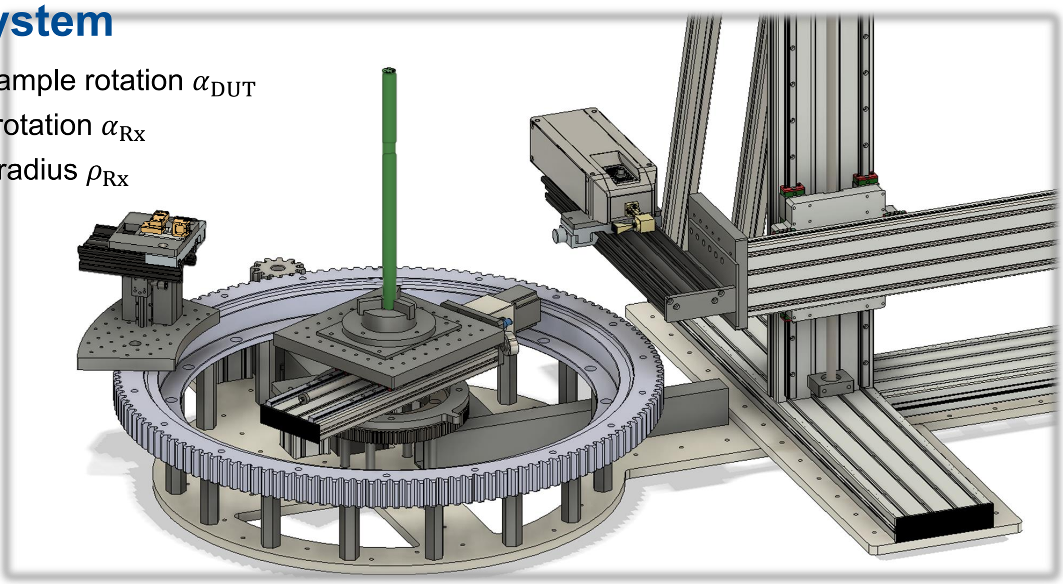
- Higher-order basis functions show steeper decay





Positioning System

- Rotation stage for sample rotation α_{DUT}
- Rotating arc for Rx rotation α_{Rx}
- Linear stage for Rx radius ρ_{Rx}



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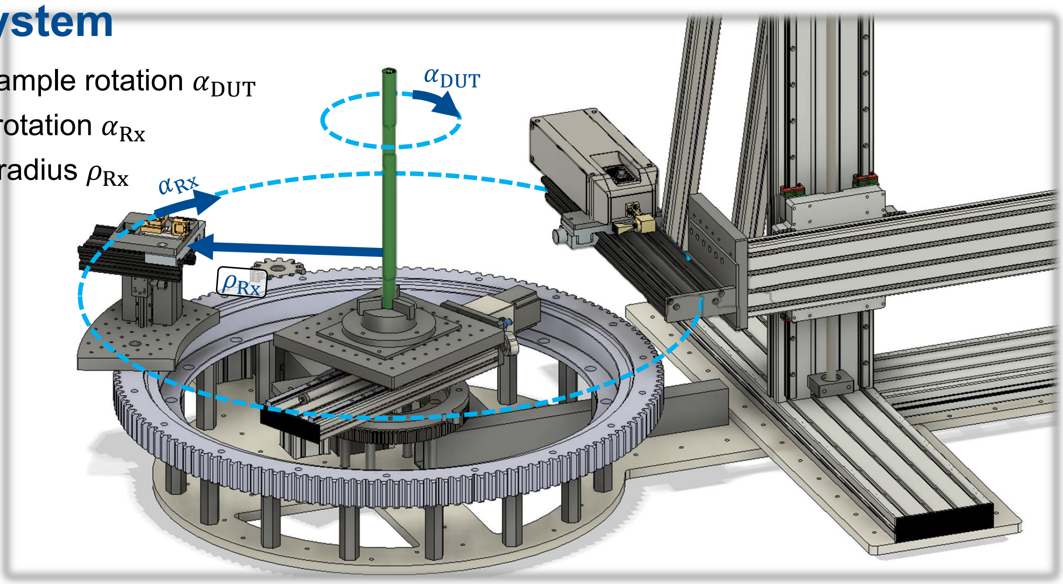
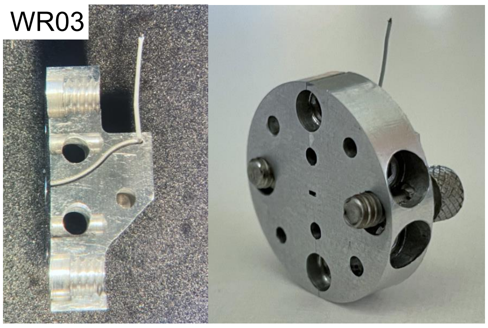
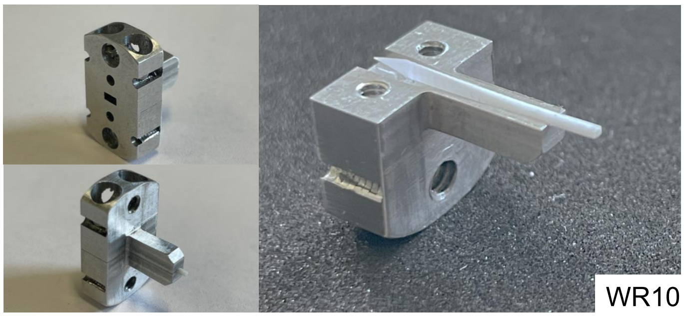


Tailored Near-Field Probes

Coaxial-cable based field-probe

- Dedicated H-Field Probe
- $\sim 0.5\ \mathrm{dB/mm}$ loss in cable
- Mechanically flexible





Dielectric Waveguide

- TE10-mode
- ‚*Low*‘ loss
- Mechanically rigid

Measurement

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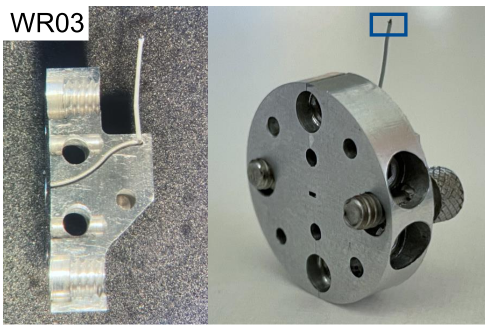

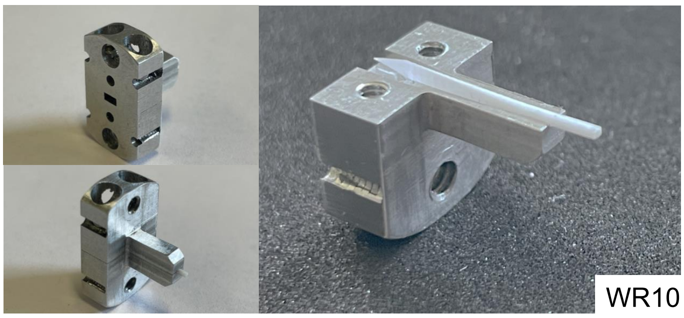

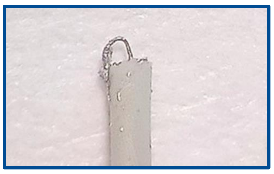

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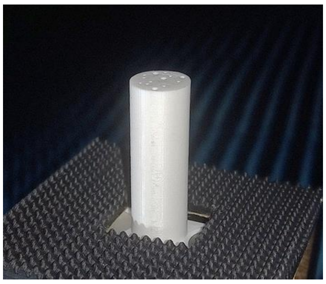
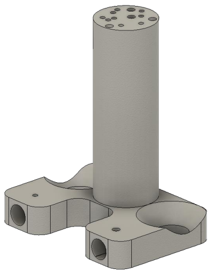
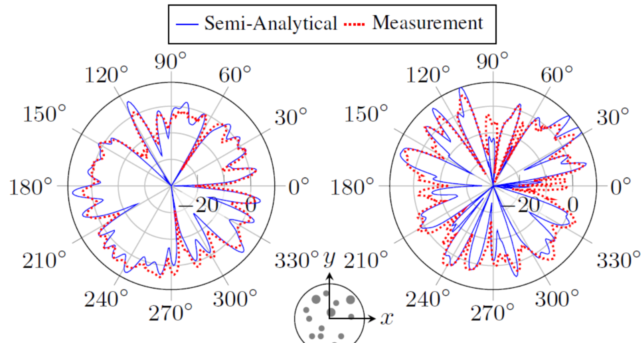
Results

Simplified Plant Mockup

- Here: well-known geometry
- Problem can be solved for single frequencies
- Feature size is not determined by bandwidth







(a) Norm. RCS (dB)$|_{120\,\mathrm{GHz}}$ (b) Norm. RCS (dB)$|_{160\,\mathrm{GHz}}$

- Measured monostatic radar cross-section (RCS) in the farfield
- More insight expected from bi-static and near-field measurements

IWMTS
INTERNATIONAL WORKSHOP ON MOBILE THZ SYSTEMS

Sixth International Workshop on Mobile Terahertz Systems (IWMTS), 3 - 5 July 2023, 5* Kameha Grand Hotel Bonn, Germany

The 2023 Sixth International Workshop on Mobile Terahertz Systems (IWMTS) will be held at 5* Kameha Grand Hotel, Bonn, Germany, on 3 - 5 July 2023.

IWMTS sets itself apart from well-known THz conferences by focusing on "Mobile THz Technology and corresponding THz Systems" since the organizing committee believes that "Mobility" will ultimately push THz solutions to mass markets. Of course, progress reports on traditional technological advances for THz components and theoretical studies on THz wave propagation as well as related topics are also highly welcome.

The topics of the workshop include, but are not limited to, the following areas focusing on THz frequencies (>100 GHz) and mobility:

- Devices and systems
- Antennas and propagation
- Measurements, simulations and modeling
- Electronic and photonic transceivers
- Prototypes and testbeds
- Material characterization
- Spectroscopy
- Signal processing
- Communications (in particular 6G)
- Localization
- Identification
- Imaging and remote sensing
- Beamforming and -management
- Data and sensor fusion
- Applications

Confirmed Keynote Speakers

- Emma MacPherson, "Advances in THz *in vivo* imaging of skin"
- Daniel Mittleman, "Conformal Antennas for THz wireless Links"
- Ullrich Pfeiffer, "THz Light-Field Imaging"

Apply for the IWMTS "TalentTravel" Program

Travel grants are available in the "TalentTravel" Program. For more information please visit www.iwmts.org.
Application deadline: March 31, 2023

Special Issue in IEEE Transactions on Microwave Theory and Techniques

Authors of all papers presented at IWMTS 2023 are invited to submit an extended version of their papers to a Mini-Special Issue of IEEE Transactions on Microwave Theory and Techniques. Every paper will be reviewed in the same manner as all other regular submissions. Further information can be found on www.iwmts.org

Join the Panel Session:
Is "Miniaturization" the Destiny of THz?

Important Dates

Full Paper Submission Deadline:
February 28, 2023

Proposals for Special Sessions:
February 28, 2023

Acceptance Notification:
April 24, 2023

Camera-ready Submission:
May 15, 2023

IWMTS Organizing Committee

- General Chair — **Thomas Kaiser**
- General Co-Chair — **Aydin Sezgin**
- TPC Chairs — **Andreas Czylwik, Ilona Rolfes**
- Tutorial Chair — **Daniel Erni**
- Publication Chair — **Feng Zheng**
- Finance Chair — **Munisch Wadwa**
- Publicity Chairs — **Mohammed El-Absi, Nidal Zarifeh**
- Local Arrangements — **Akram Najjar, Andreas Prokscha, Yamen Zantah**
- Internal Coordinators — **Ali Alhaj Abbas, Dien Lessy, Fawad Sheikh**
- Web Design — **Aman Batra**

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Papers are invited to be uploaded on the EDAS system: https://edas.info/newPaper.php?c=30226. The manuscript should follow the IEEE two column format with single spaced, 10 pt font in the text. MS or LaTex templates can be downloaded from https://www.ieee.org/conferences/publishing/templates.html. The manuscript length should be three to five pages, including all figures, tables, references, and so on. All papers which meet IEEE quality standards and presented by one of the authors will be submitted to IEEE Xplore for indexing. More details about the workshop can be found on www.iwmts.org.