

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Measurements of the Channel Characteristics at 300 GHz

Date Submitted: 17 November 2009

Source: Thomas Kürner , Technische Universität Braunschweig

Address Schleinitzstr. 22, D-38092 Braunschweig, Germany

Voice: +495313912416 , FAX: +495313915192 , E-Mail: t.kuerner@tu-bs.de

Re: [doc.: IEEE 802.15- 15-09-0496-00-0thzr1-channel-measurements]

Abstract: In [doc.: IEEE 802.15- 15-09-0496-00-0thzr1-channel-measurements] preliminary results on channel measurements at 300 GHz have been presented. This contribution provides additional results by presenting measurements involving reflection, scattering and diffraction in a realistic indoor scenario. Furthermore the effect of antenna misalignment is investigated. The results can be used to derive a 300 GHz channel model.

Purpose: Input to THz Channel Modeling at IEEE 802.15 IG Thz

Notice: This document has been prepared to assist the IEEE P802.15. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

Release: The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.

Measurements of the Channel Characteristics at 300 GHz

Thomas Kürner¹, Sebastian Priebe¹, Martin Jacob¹
Christian Jastrow², Thomas Kleine-Ostmann², Thorsten Schrader²

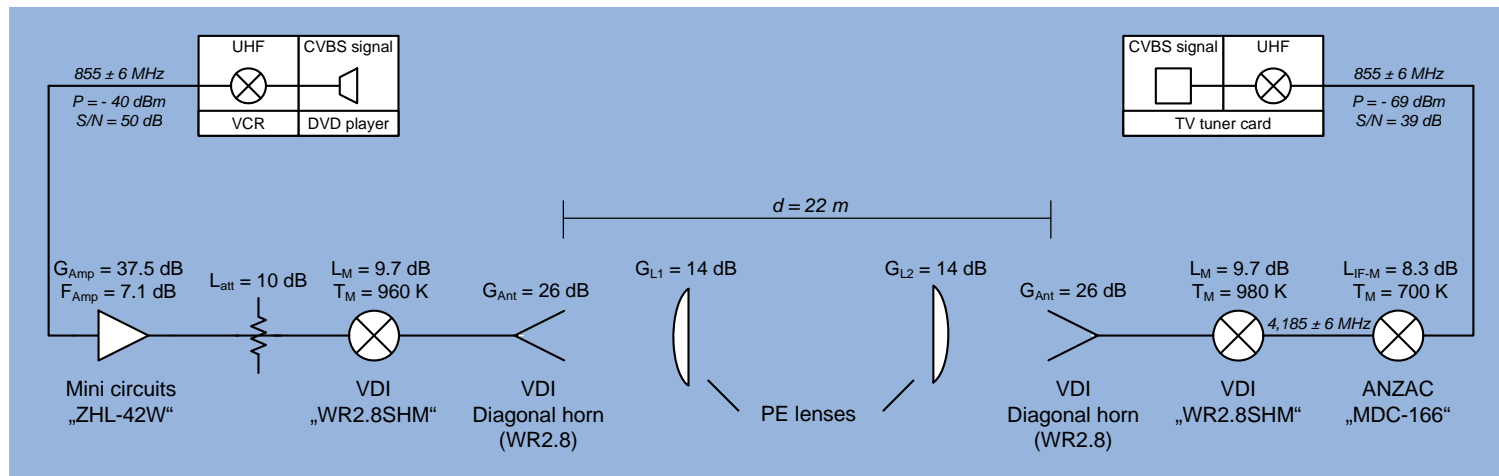
¹ Institut für Nachrichtentechnik, Technische Universität Braunschweig, Germany

² Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Content

- Measurement System
- Influence of Antenna Misalignment
- Characterising Propagation Phenomena
 - Reflection
 - Scattering
 - Diffraction
- Measurements in a complete Indoor Scenario
- Conclusions

300 GHz Transmission System



Jastrow, C., Münter, K., Piesiewicz, R., Kürner, T., Koch, M., Kleine-Ostmann, T., ‘300 GHz transmission system’, IET Electronics Letters, Vol. 44, No. 3, January 2008, pp. 213-214.

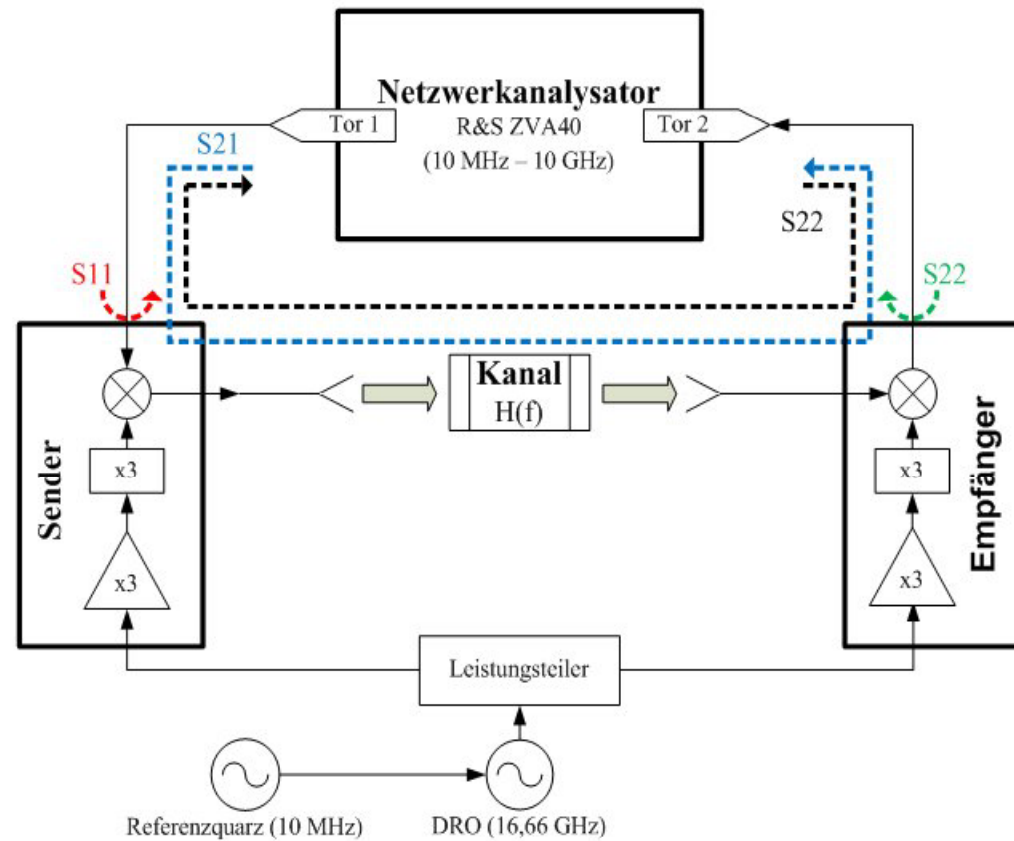
see also: doc.: IEEE 802.15-15-08-0336-01-0thz-thz-communications.pdf

300 GHz Radio Channel Measurement System - 1

- R & S ZVA40 Vector Network Analyzer
- External 300 GHz transmitter (Tx) and receiver(Rx) front ends
- Core component: subharmonic schottky diode mixer
- Same external local oscillator (DRO) (16.66 GHz x3 x3) for Tx and Rx for phase synchrony
- Three different types of antennas used
- Frequency range: 290 – 310 GHz
- Frequency Domain → Time Domain

see also: doc.: IEEE 802.15-15-09-0496-01-0thz-measuring-the-channel-characteristics-at-300GHz-preliminary-results.pdf

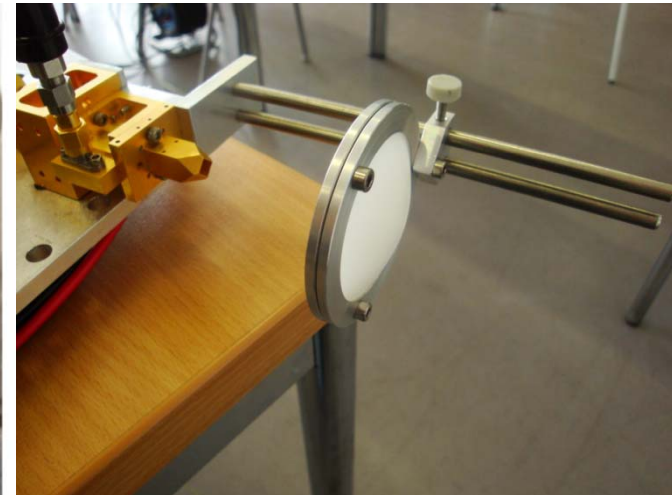
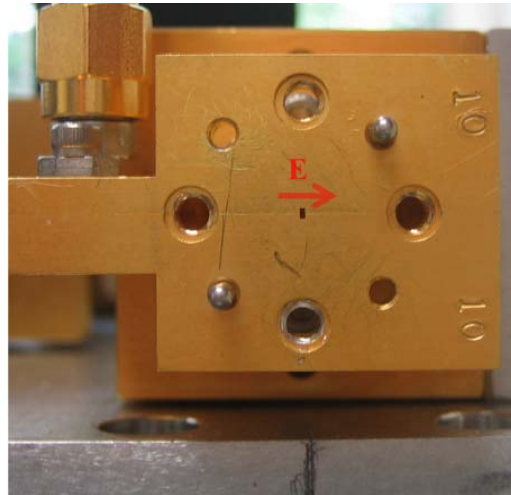
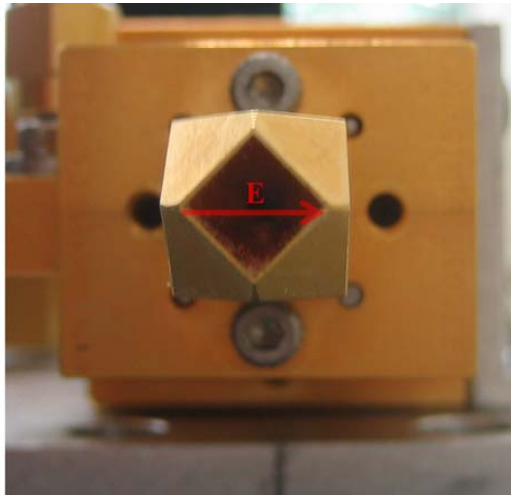
300 GHz Radio Channel Measurement System - 2



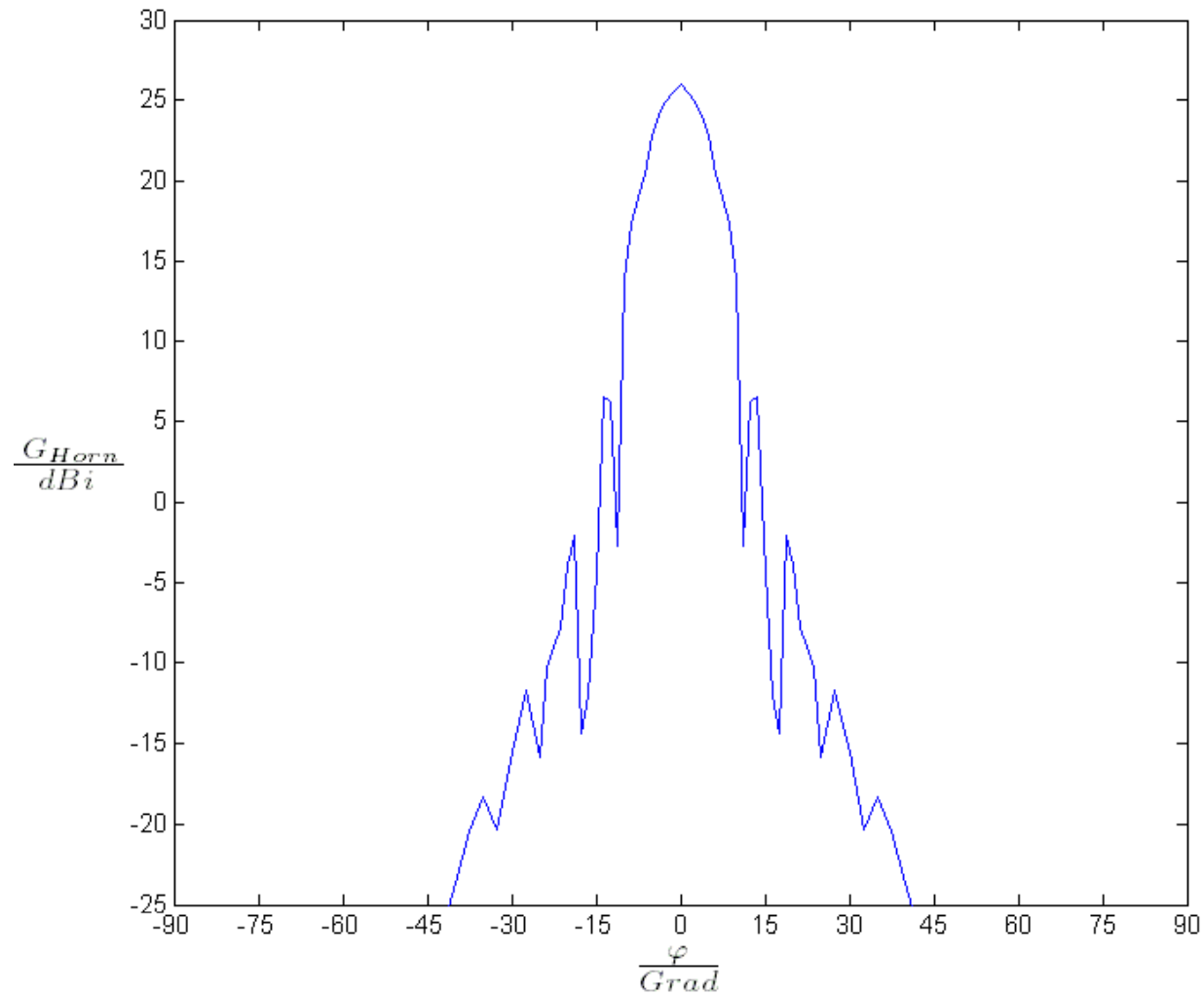
see also: doc.: IEEE 802.15-15-09-0496-01-0thz-measuring-the-channel-characteristics-at-300GHz-preliminary-results.pdf

Antennas

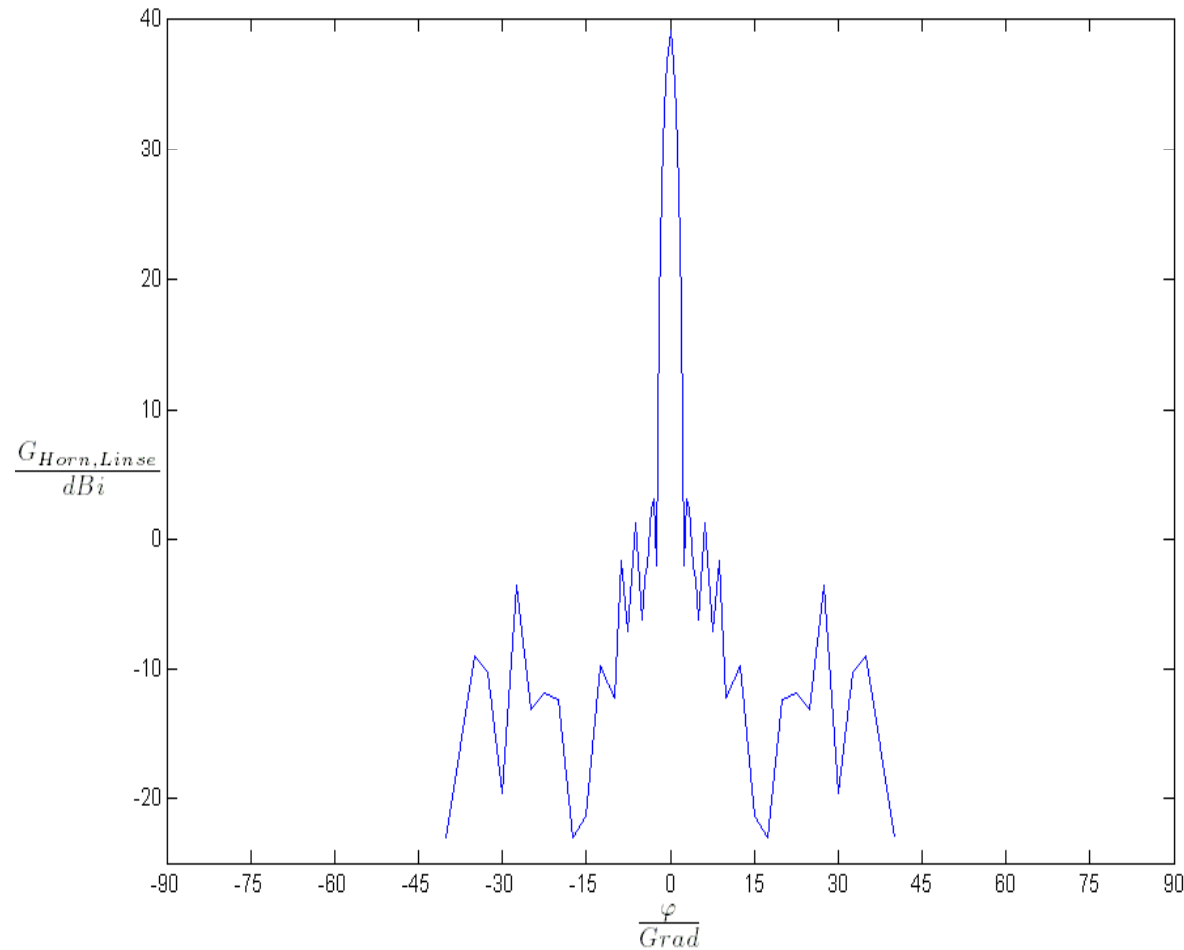
	Horn Antenna	Wave Guide	Horn Antenna with Polyethylen Lens
Gain	26 dBi	10 dBi	40 dBi
3 dB- width	11°	100°	1°



Antenna Diagram: Horn Antenna

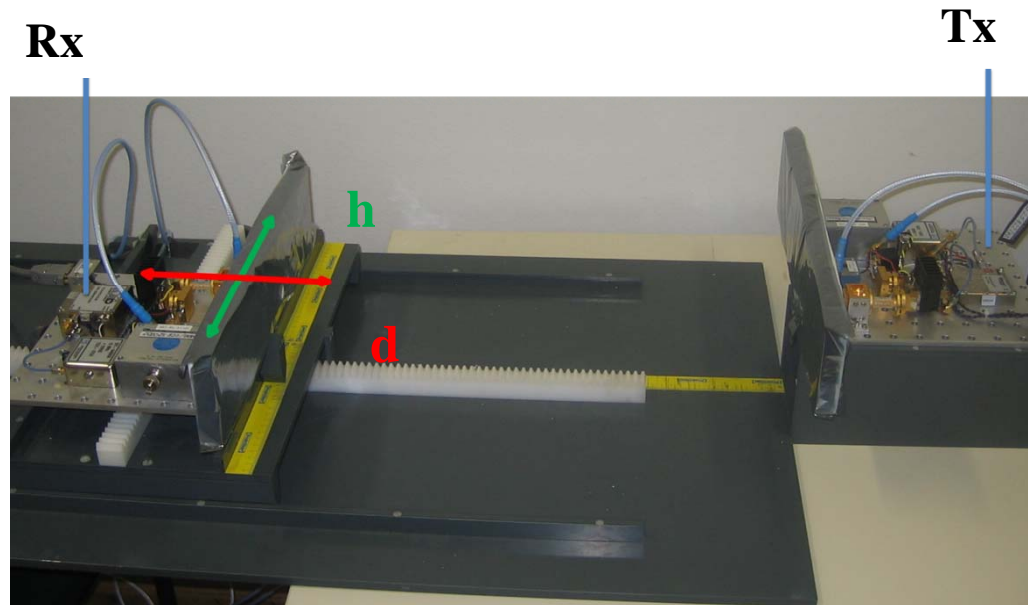


Antenna Diagram: Horn Antenna with Polyethylen Lens



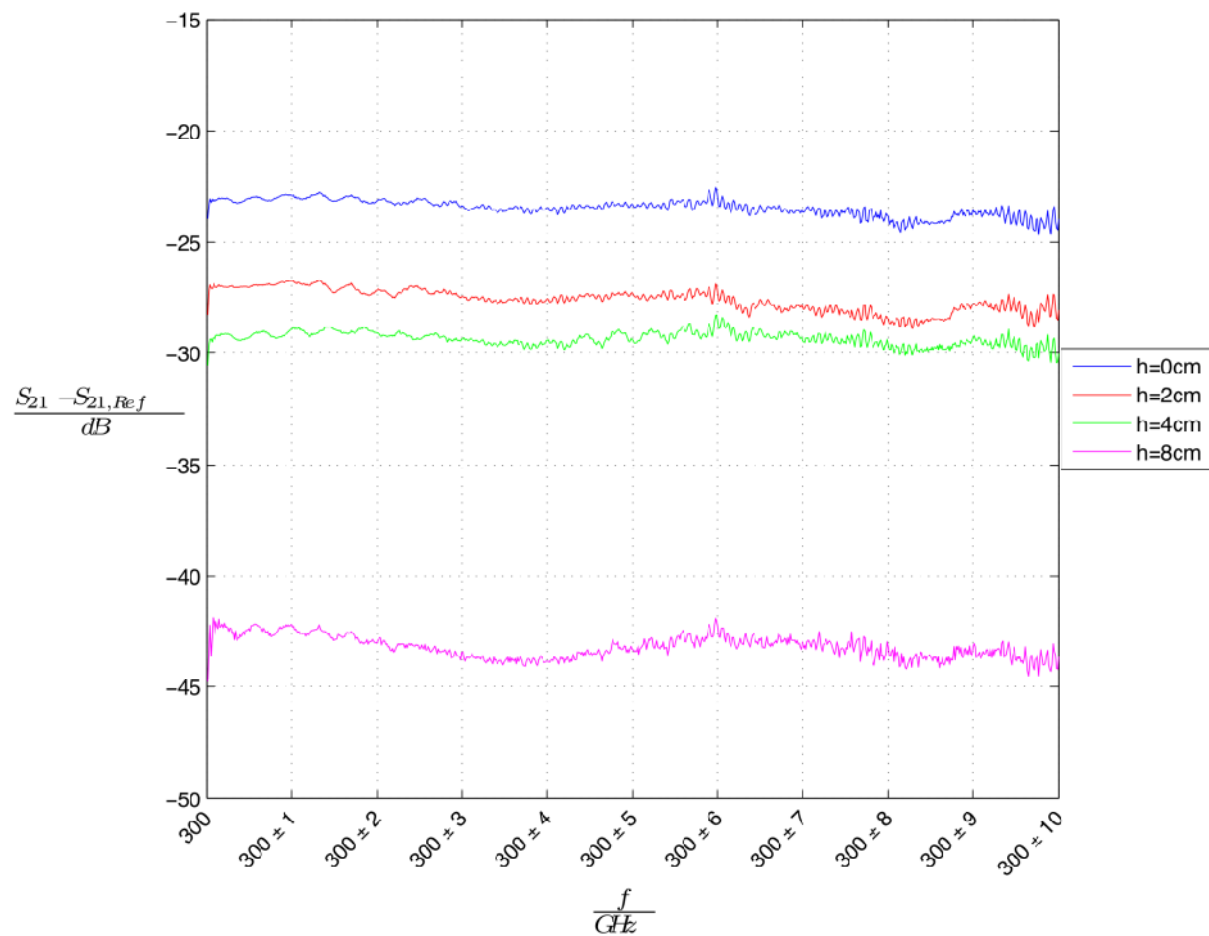
Influence of Antenna Misalignment

- Measurements for Horn Antenna at Tx and different Antennas at Rx



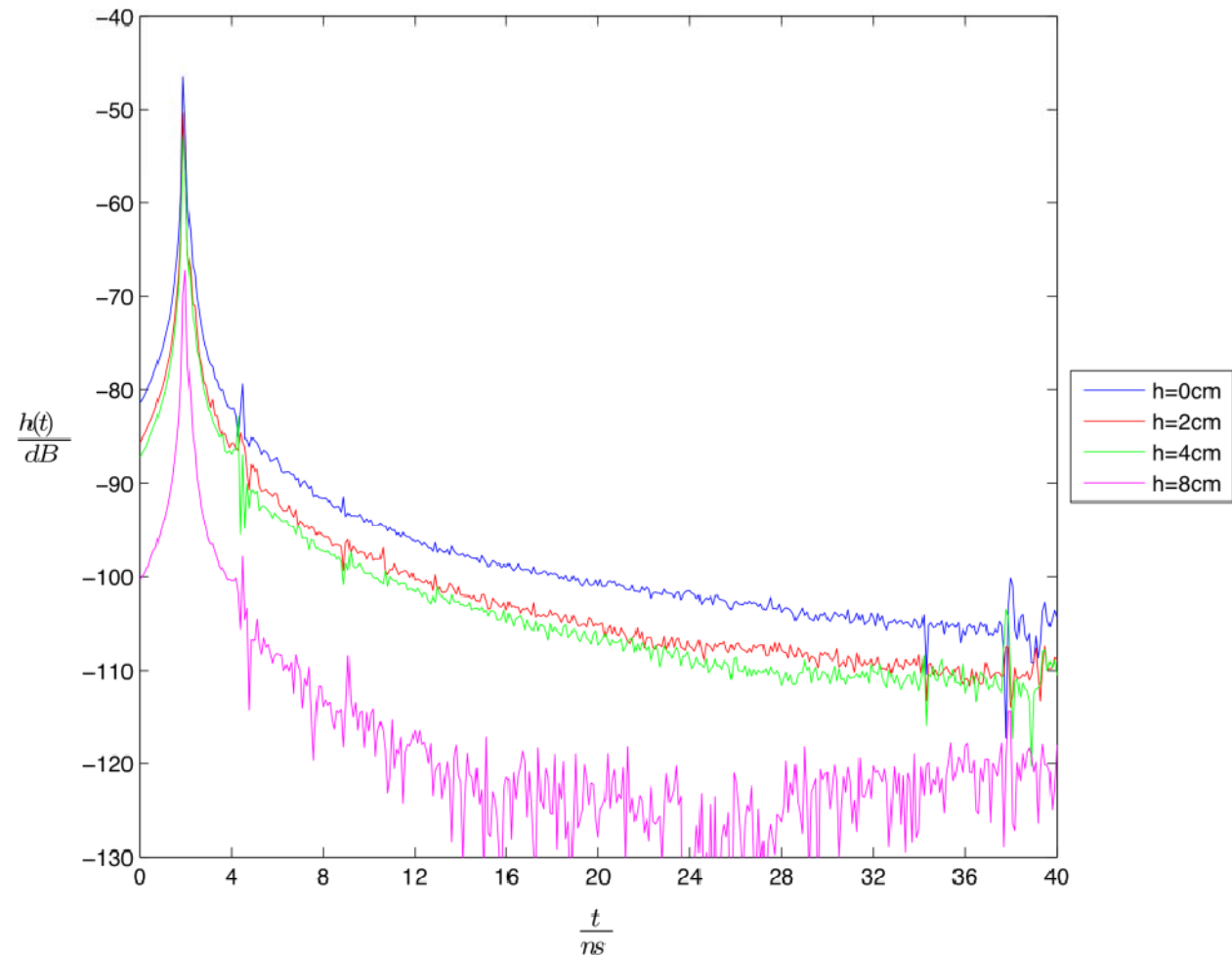
Example: Horn Antennas used at Tx and Rx

Analysis in Frequency Domain



Example: Horn Antennas used at Tx and Rx

Analysis in Time Domain



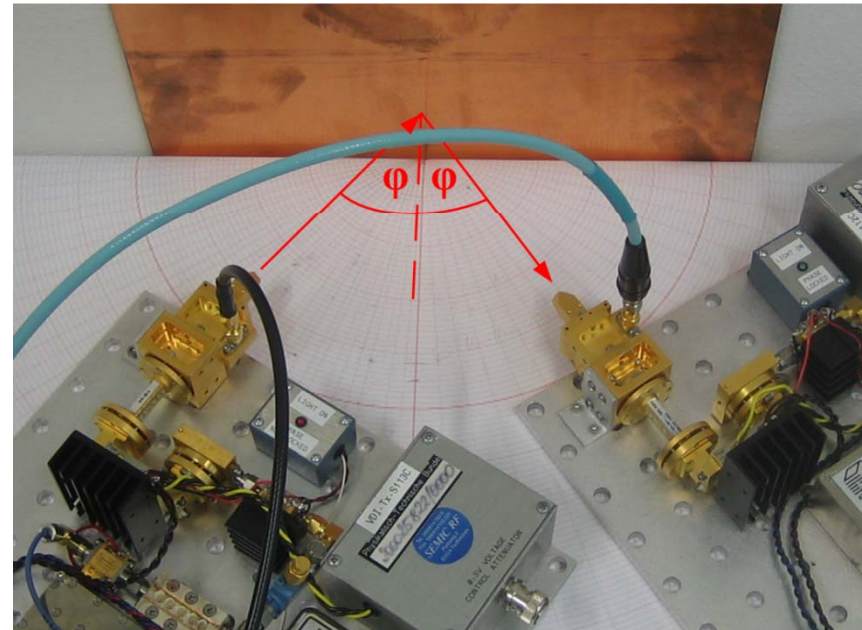
Summary on Antenna Misalignment

Displacement	Antenna at Rx		
	Horn Antenna	Wave Guide	Horn Antenna with Polyethylen Lens
d = 40 cm, h = 0 cm	-23,3 dB	-44,3 dB	-12,3 dB
d = 40 cm, h = 2 cm	-27,4 dB	-45,2 dB	-19,7 dB
d = 40 cm, h = 4 cm	-29,3 dB	-47 dB	-41,4 dB

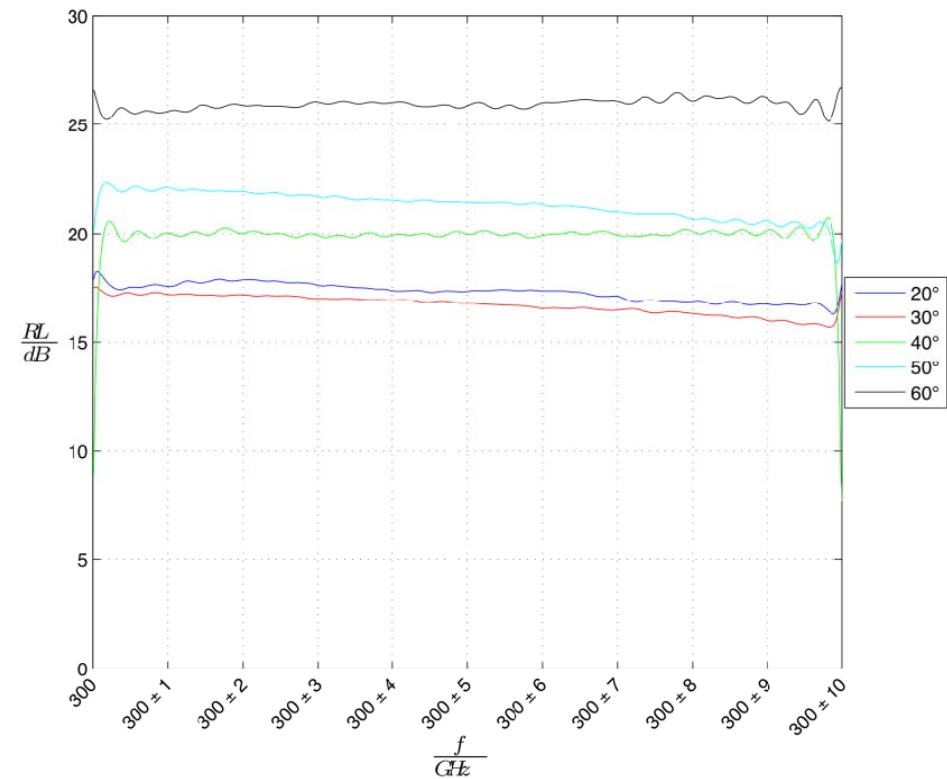
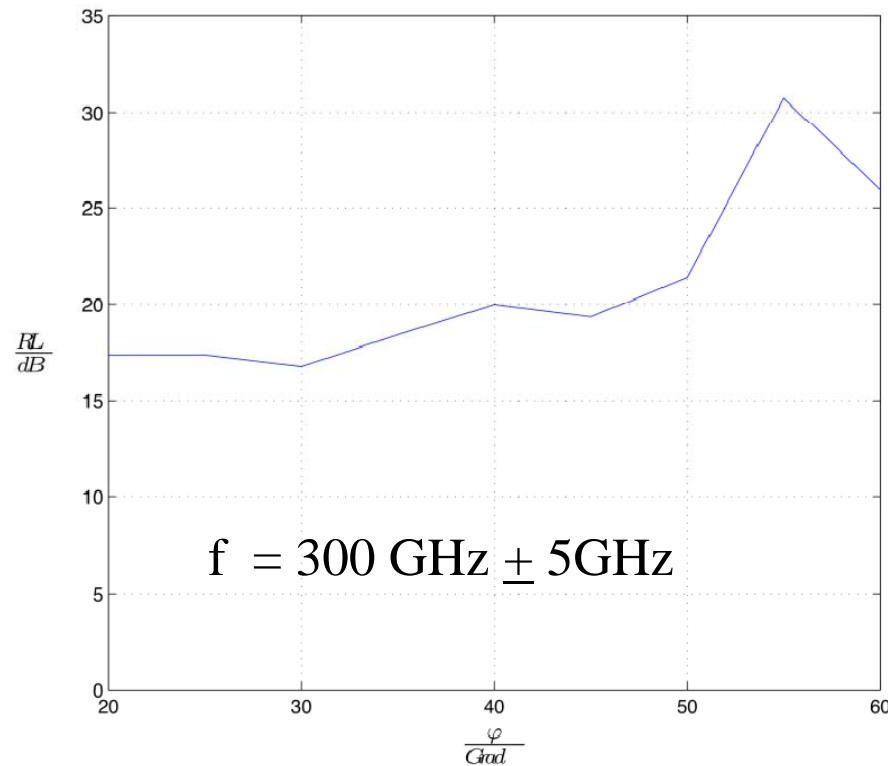
Reflection Measurements

- Measurement Set-up
 - Reference measurement using a copper plate
 - Reflection Loss

$$RL|_{dB} = S_{21,MUT}|_{dB} - S_{21,Copper}|_{dB}$$

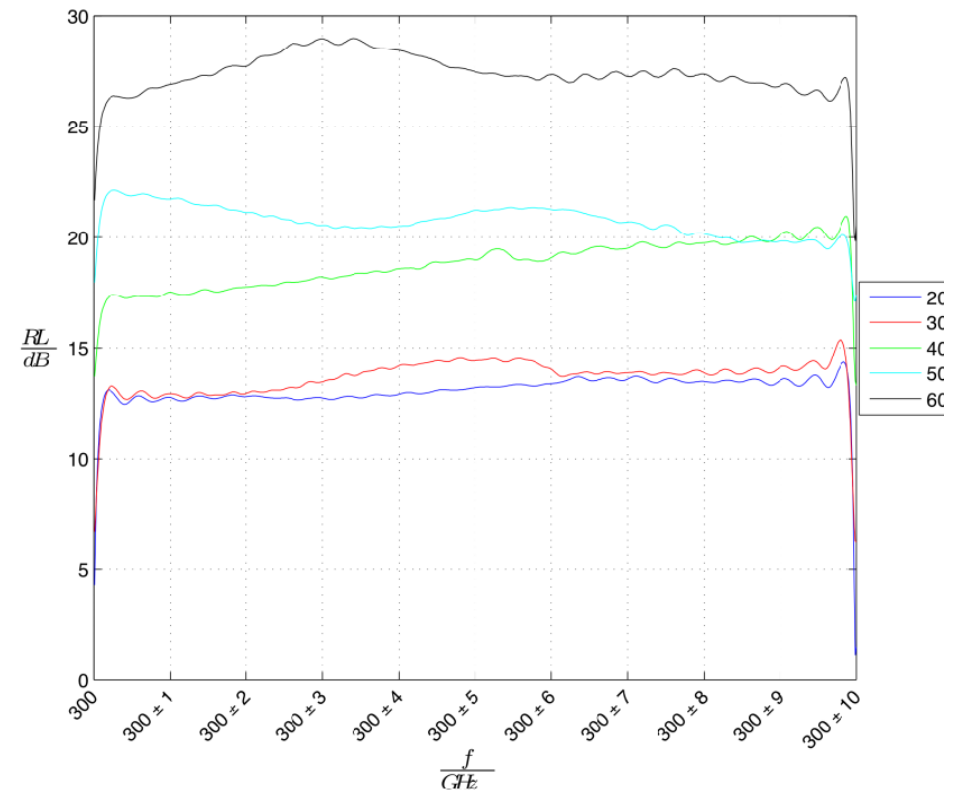
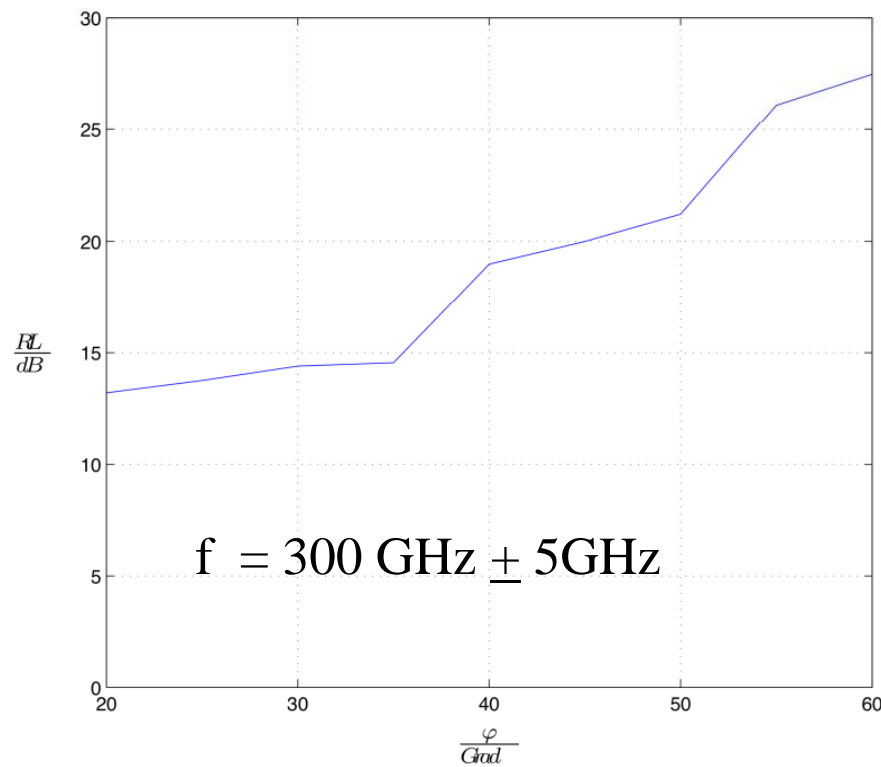


Reflection Loss: Wood



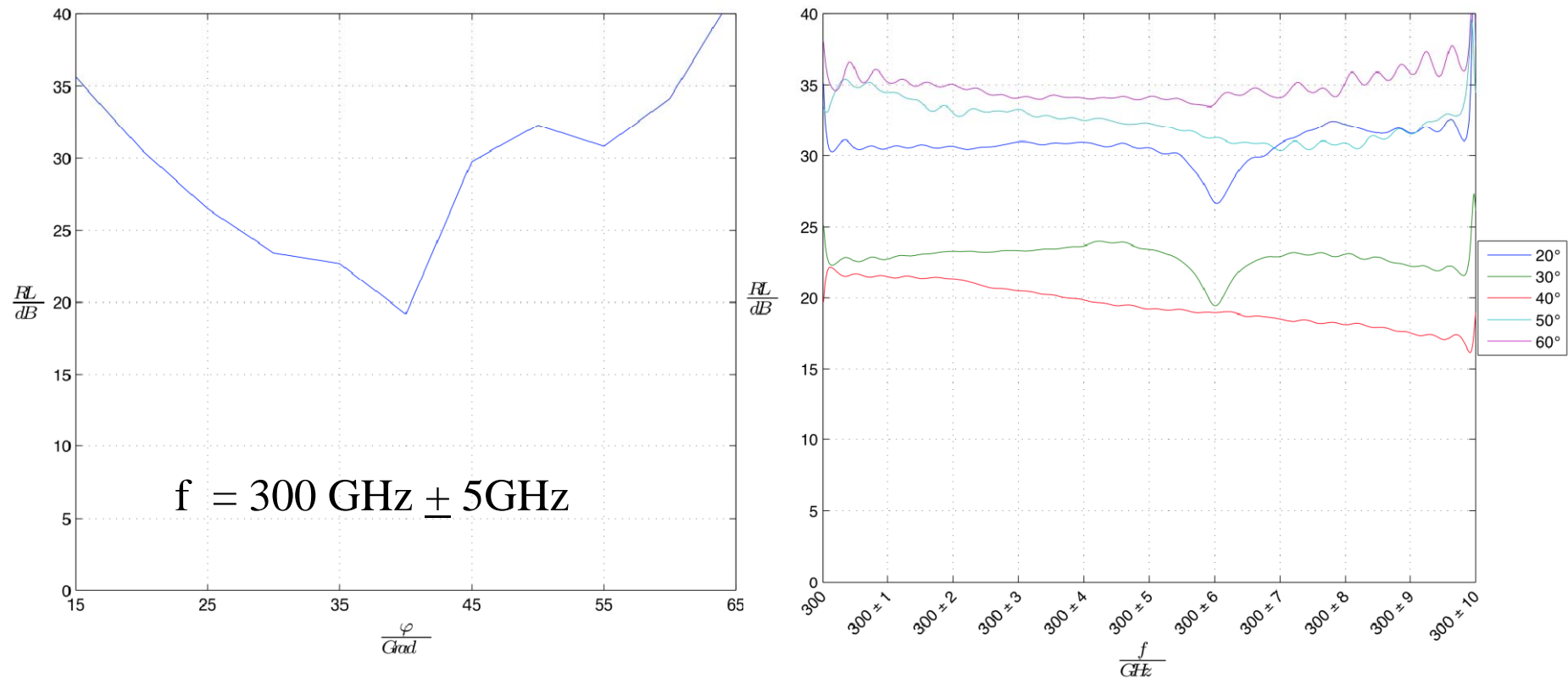
TM-Polarisation

Reflection Loss: Plaster



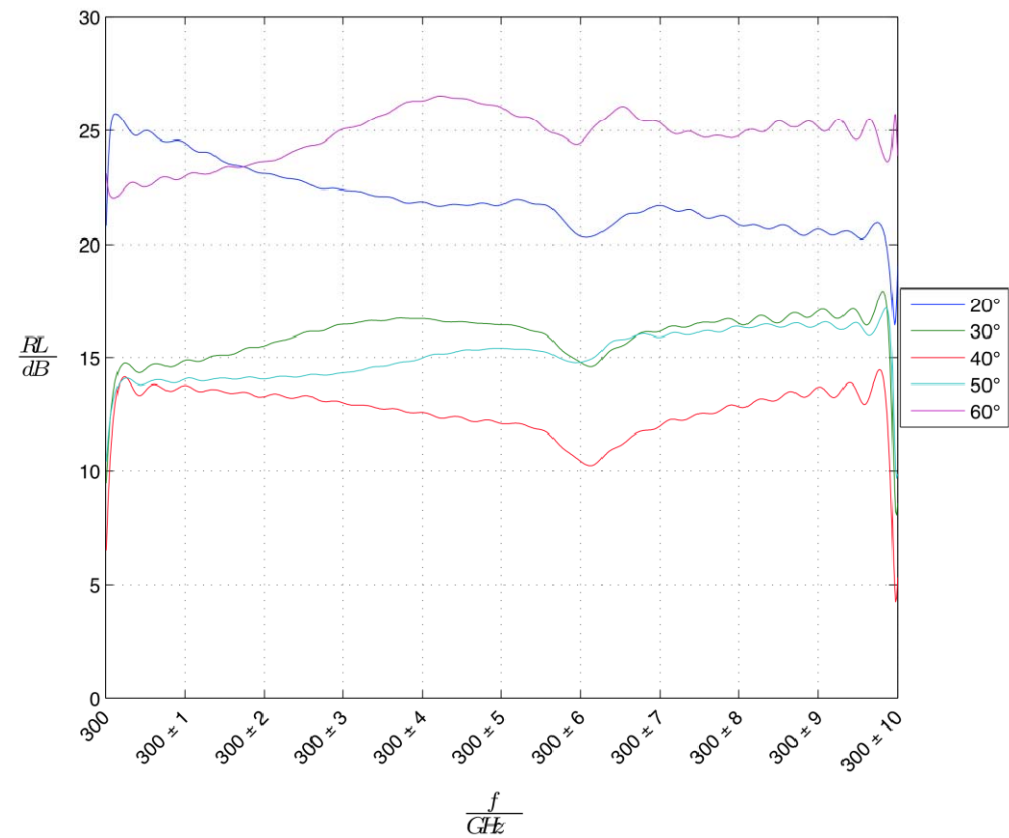
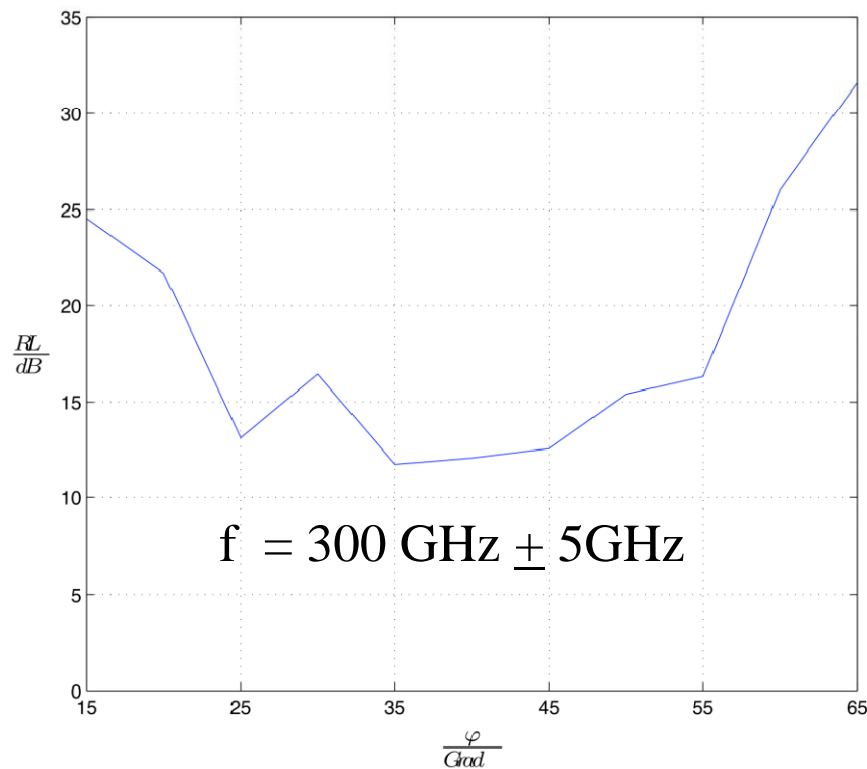
TM-Polarisation

Scattering Loss: Wood



TM-Polarisation; incidence angle $\varphi_i = 40^\circ$

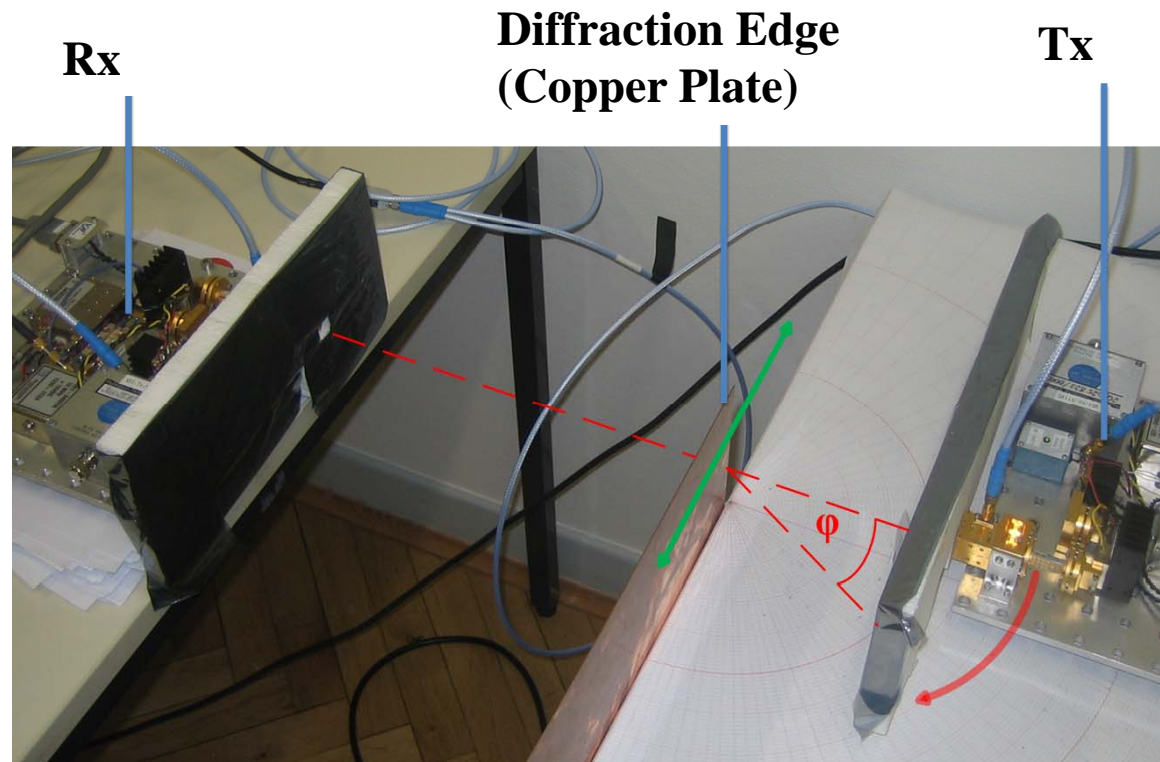
Scattering Loss: Plaster



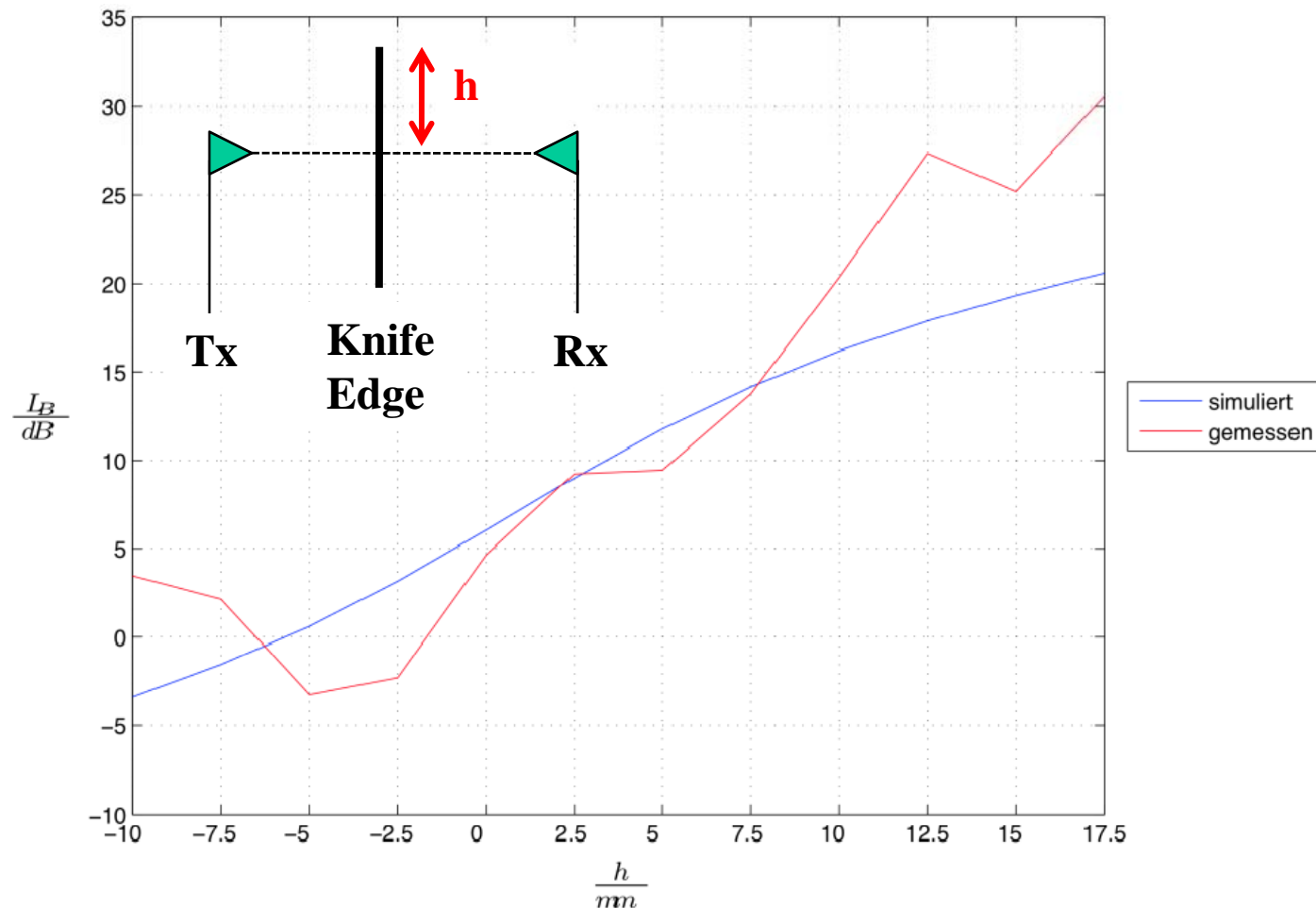
TM-Polarisation; incidence angle $\varphi_i = 40^\circ$

Measurement of Diffraction Loss

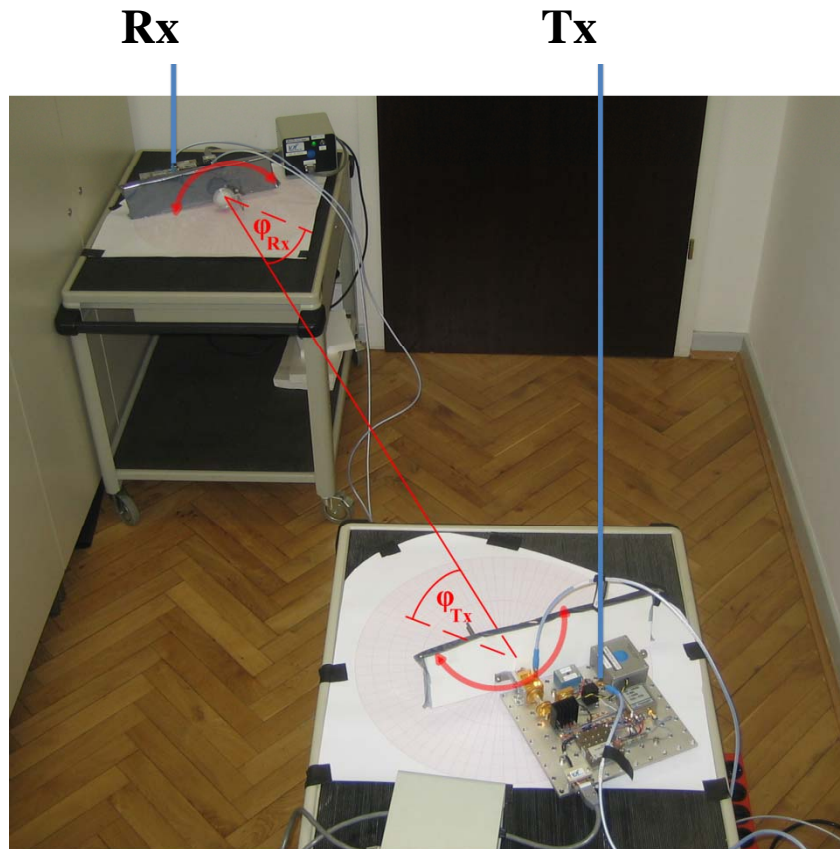
- Measurement Set-up



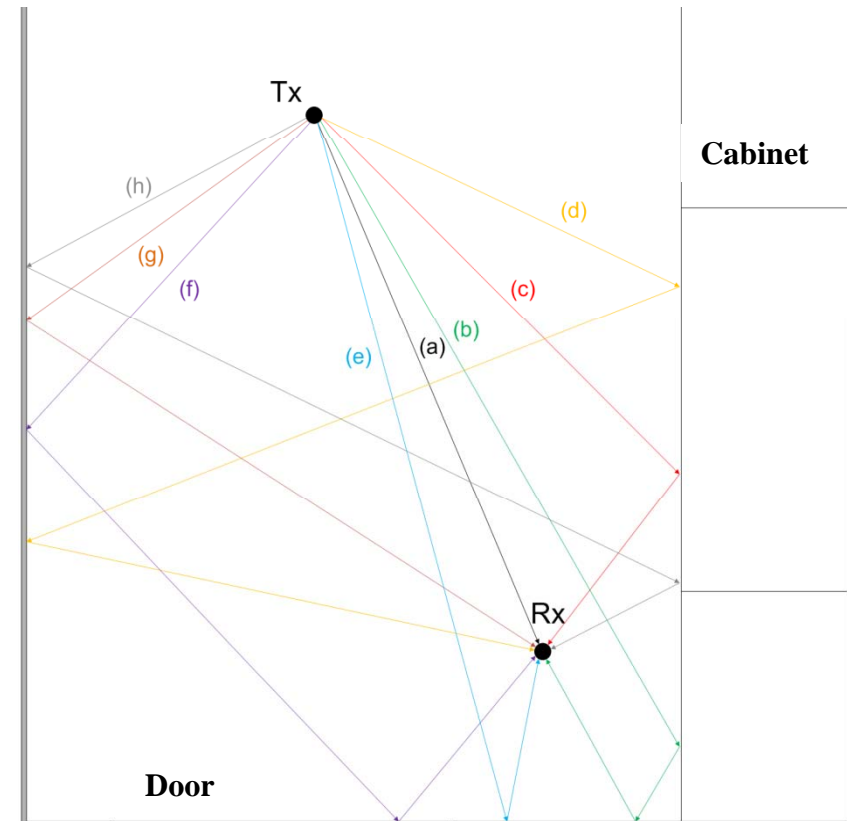
Comparison of Measured Diffraction Loss with Simulations based on a Knife Edge



Measuring a complete Indoor Scenario



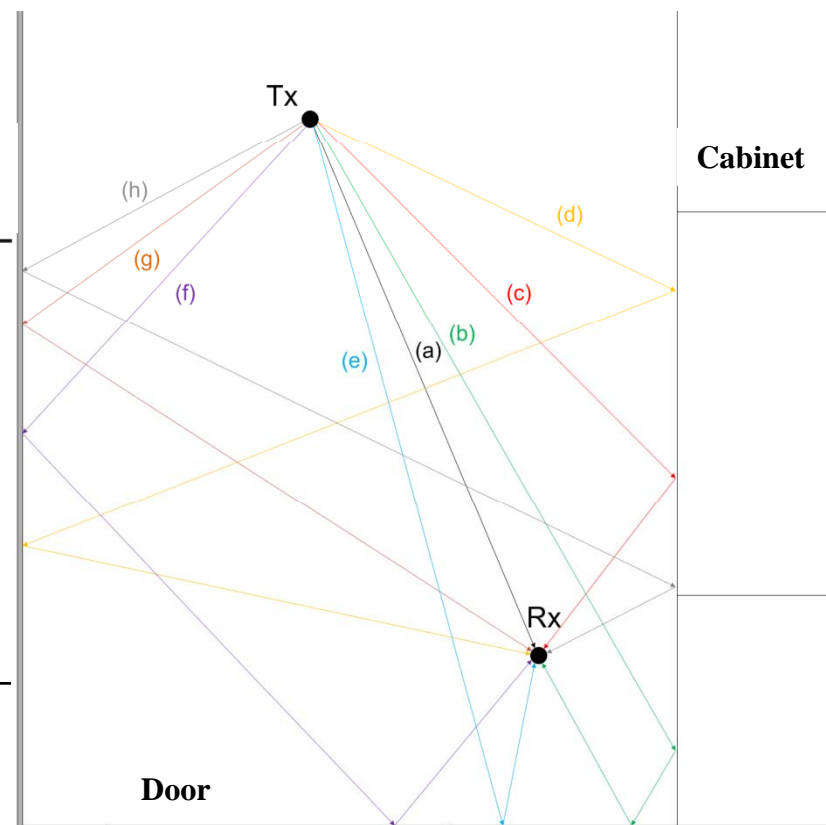
Measurement Set-up in a small room



Identified Rays within the room

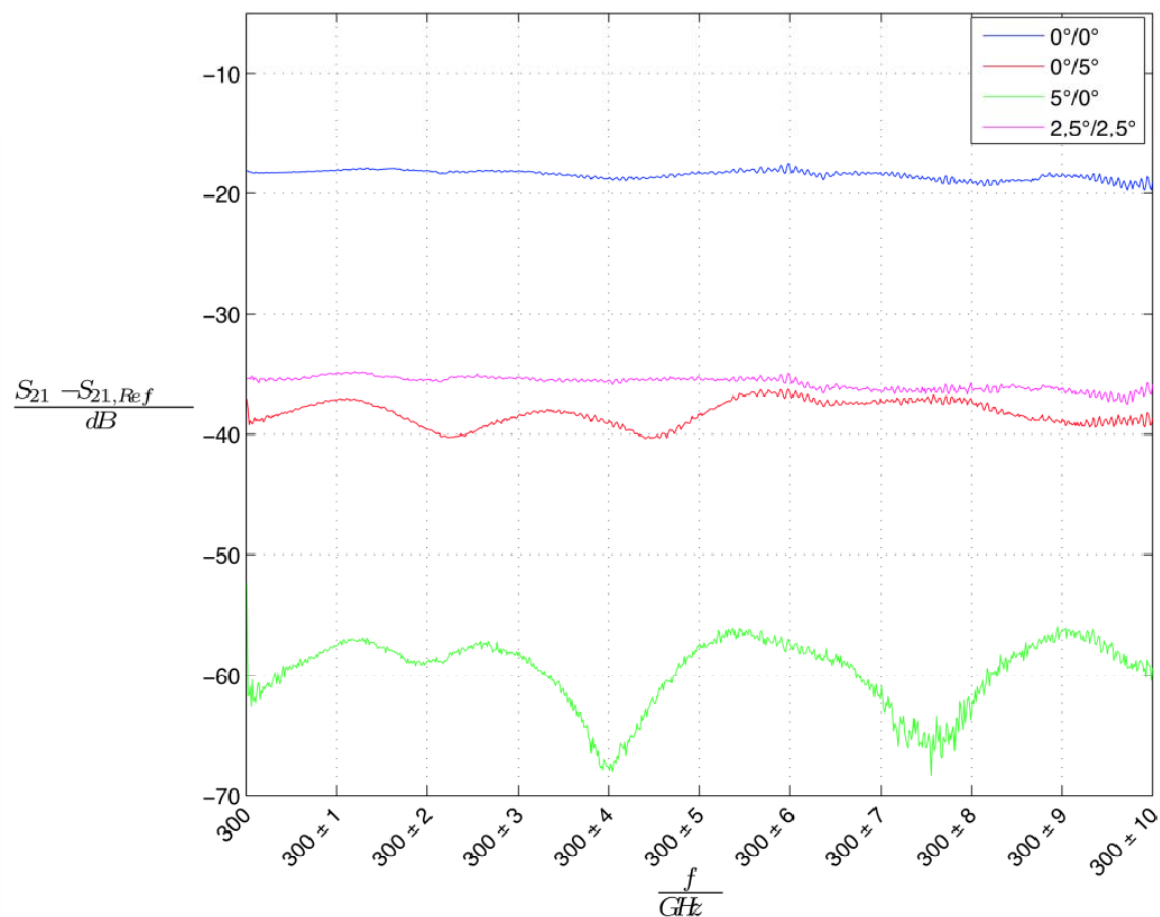
Measurement of Multipath Signals

Path	Path Length	Number of Reflections	Measured Path Loss	FSL	Other Losses
(a)	1,67 m	0	90,3 dB	86,4 dB	3,9 dB
(b)	2,93 m	2	129,3 dB	91,3 dB	38 dB
(c)	2,12 m	1	109,2 dB	88,5 dB	20,7 dB
(d)	4,77 m	2	125,3 dB	95,6 dB	29,7 dB
(e)	2,78 m	1	119,6 dB	90,7 dB	28,9 dB
(f)	3,45 m	2	145,1 dB	92,4 dB	52,7 dB
(g)	2,8 m	1	120,9 dB	90,9 dB	30 dB
(h)	3,51 m	2	128,4 dB	92,9 dB	35,5 dB

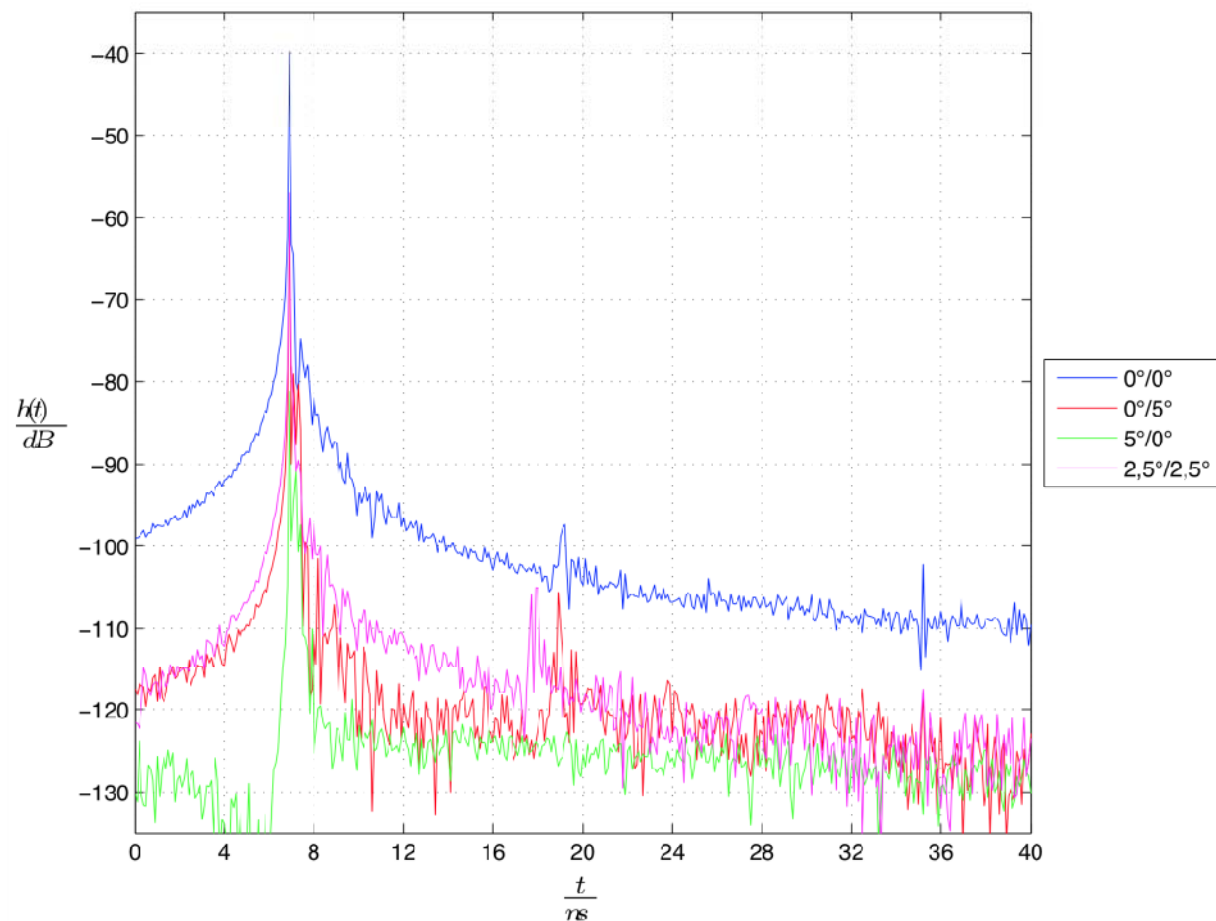


Identified Rays within the room

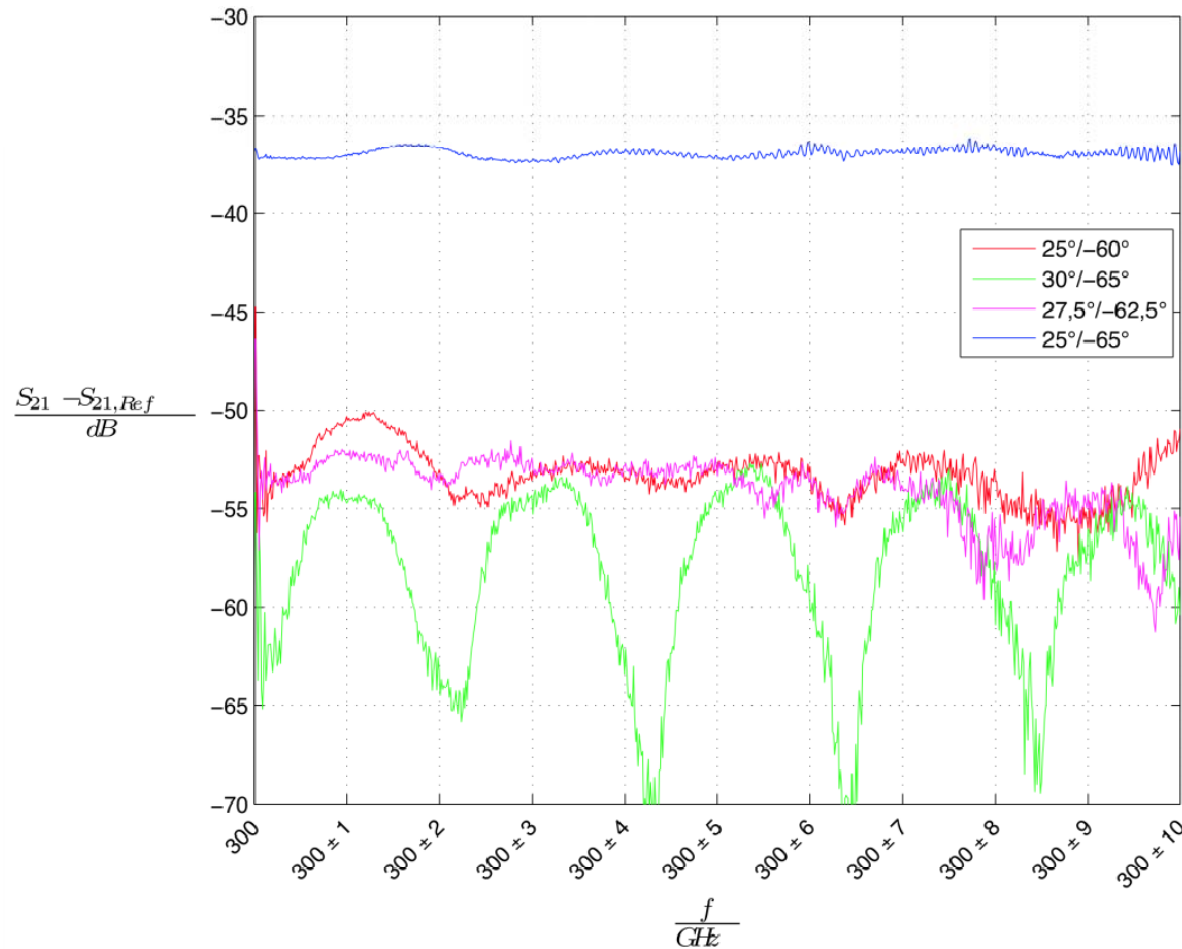
Effect of Antenna Misalignment: Direct Ray (Path a) – Frequency Domain



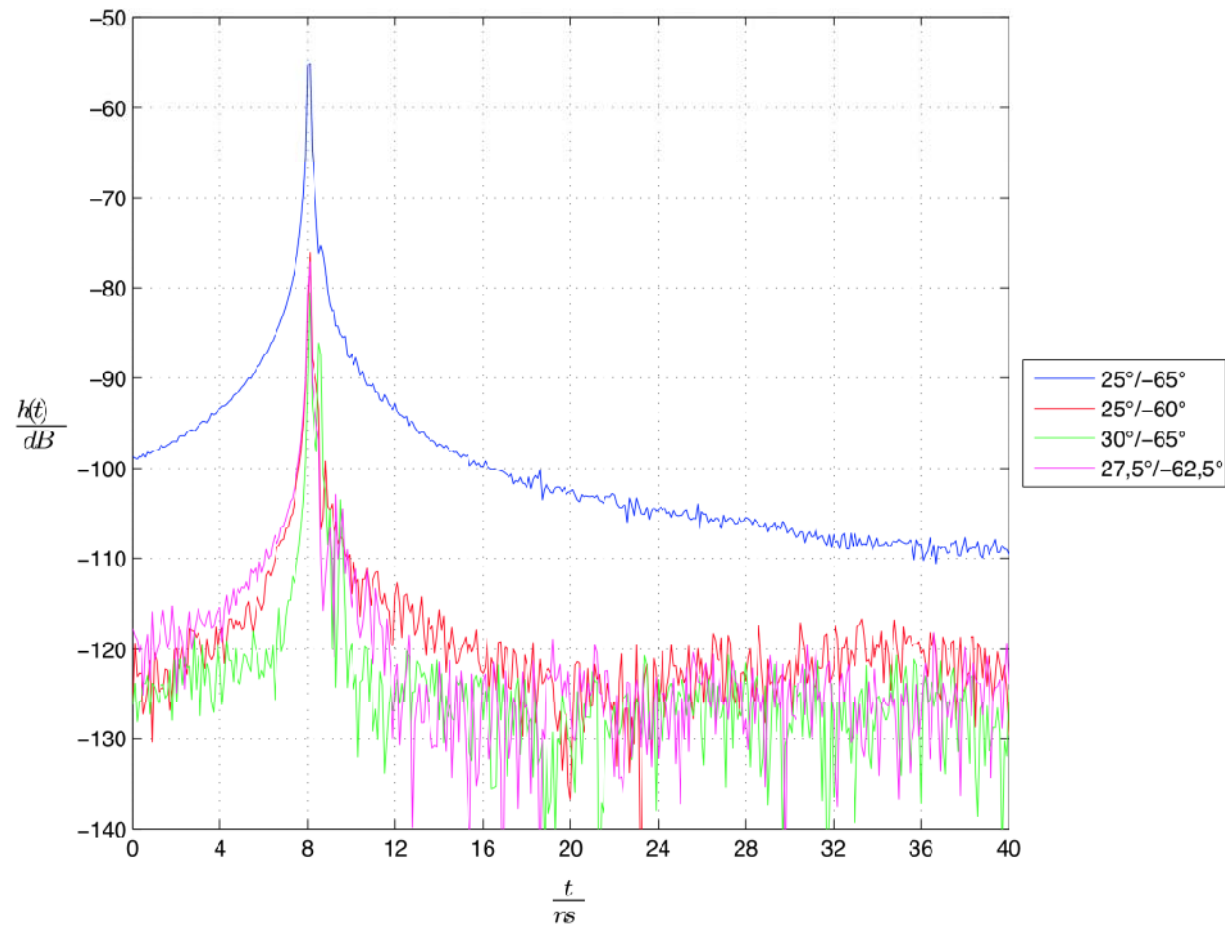
Effect of Antenna Misalignment: Direct Ray (Path a) – Time Domain



Effect of Antenna Misalignment: Reflected Ray (Path c) – Frequency Domain



Effect of Antenna Misalignment: Effect on Direct Ray (Path c) – Time Domain



Conclusions

- Comprehensive Measurement Campaign at 300 GHz
- Quantitative investigation of reflection and scattering processes from walls and diffraction effects
- Verification of ray-tracing approach in a small indoor room
- Effect of antenna misalignment has been investigated as well

Outlook

- Together with the results presented in [doc.: IEEE 802.15- 15-09-0496-00-0thzr1-channel-measurements] this document is a good starting point to derive indoor channel models for THz communications
- Potential to use ray-tracing to derive statistical channel models (comparable to channel modeling activities taking place in IEEE 802.11 TGad)