Technische Universität Braunschweig

TPG
THz Photonics Group

Grundlagen der Informationstechnik (Wireless)

Drahtlose Kommunikation / THz-Kommunikation

Thomas Schneider

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- Motivation und Einführung
- Die elektromagnetische Welle
- Der drahtlose Kanal
- Antennen
- Ausbreitung e/m Wellen
- Berechnung von Funkstrecken
- **THz-Kommunikation**
- Funksysteme
- Optische Kommunikation
- Silizium Photonik
- Plasmonik

Inhalt

- **Physikalische Besonderheiten**
- **Maximale Kapazität eines THz Links**
- **Richtwirkung**
- **Beispiele**

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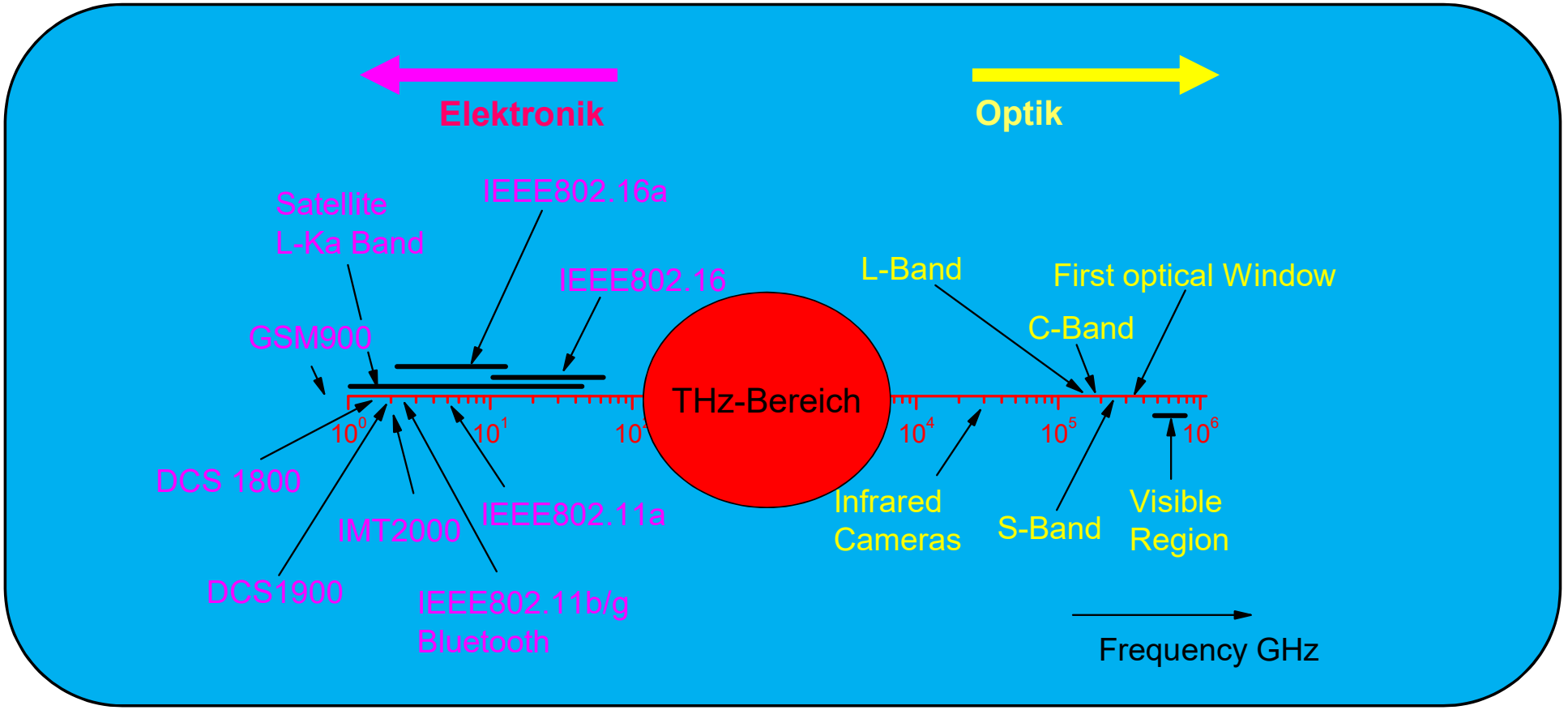
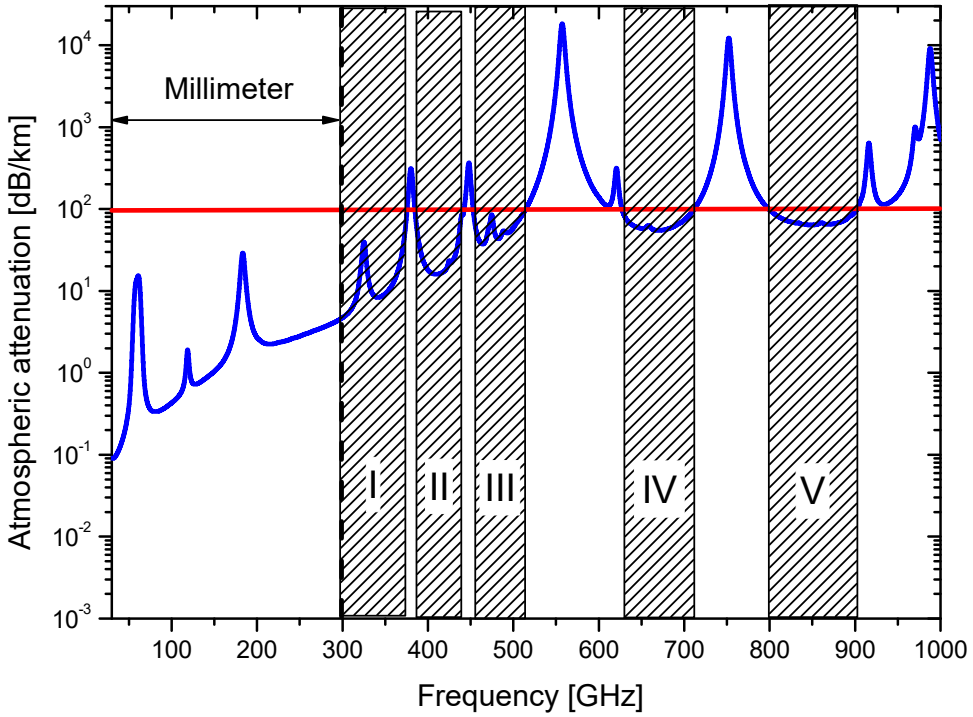
- Maximale Kapazität eines THz Links
- Richtwirkung
- Beispiele

Drahtlose Kommunikation



Drahtlose Kommunikation



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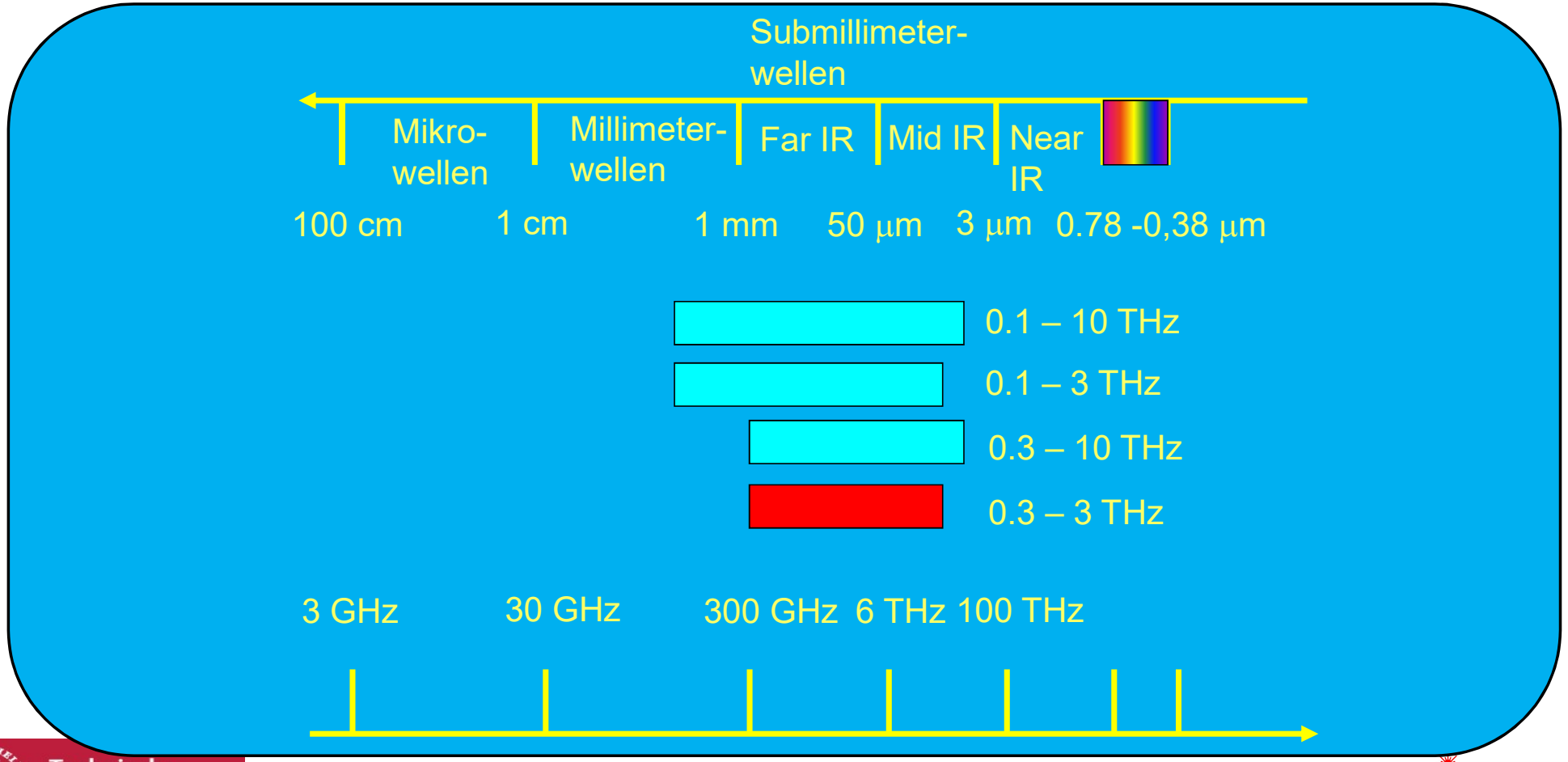
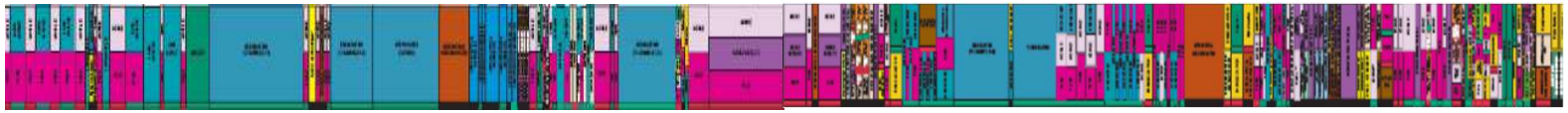


Drahtlose Kommunikation

Frequenz (THz)	Wellenzahl (cm^{-1})	W-Länge (μm)	Energie (meV)	Äqu. T.* (K)
0.1	3.33	3000	0.41	5
1	33.3	300	4.1	50
10	333	30	41	500
29.7	990	10.1 (CO_2)	123	1425
282	9398	1.064 (Nd:YAG)	1160	13530

Drahtlose Kommunikation

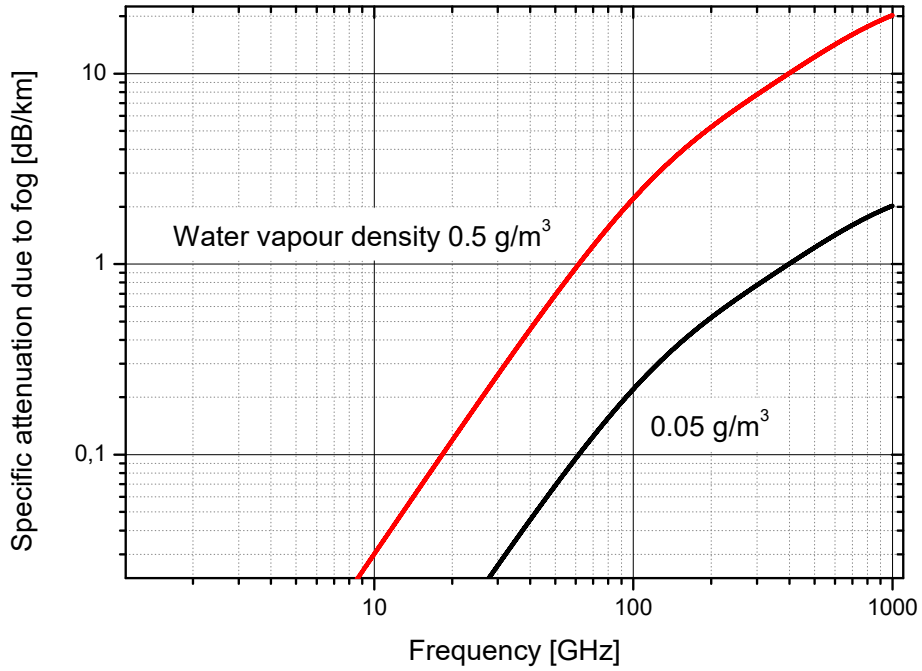


30 MHz 3 GHz

3 GHz 300 GHz

http://www.ntia.gov/osmhome/allochrt.pdf

Drahtlose Kommunikation



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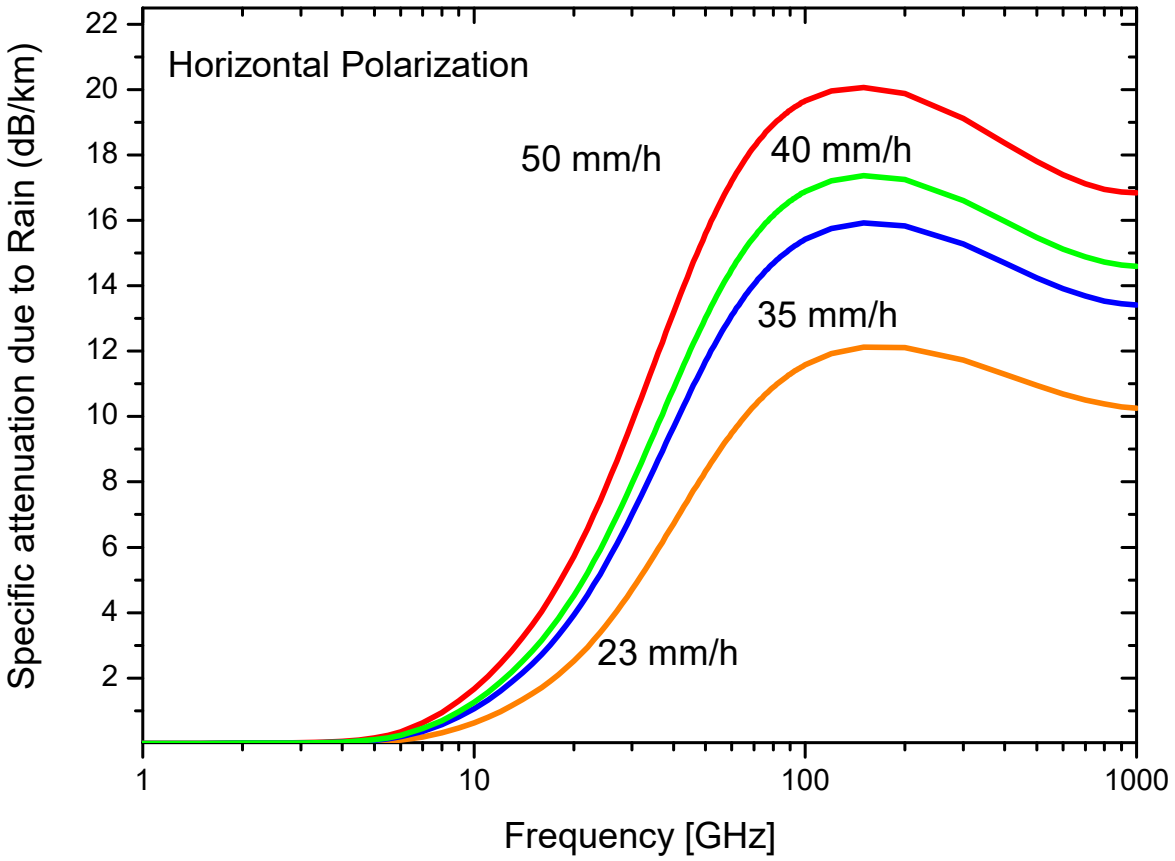

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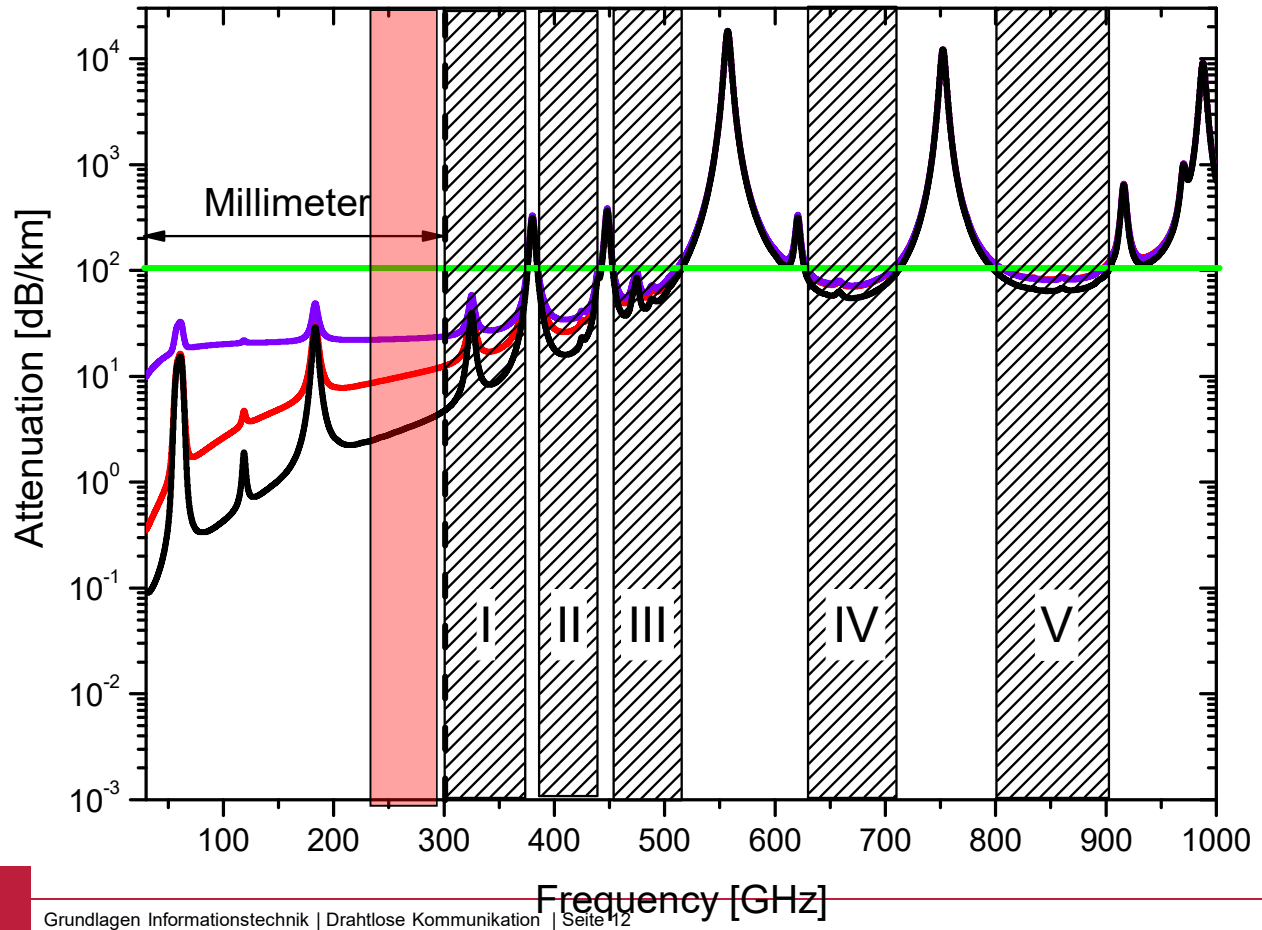
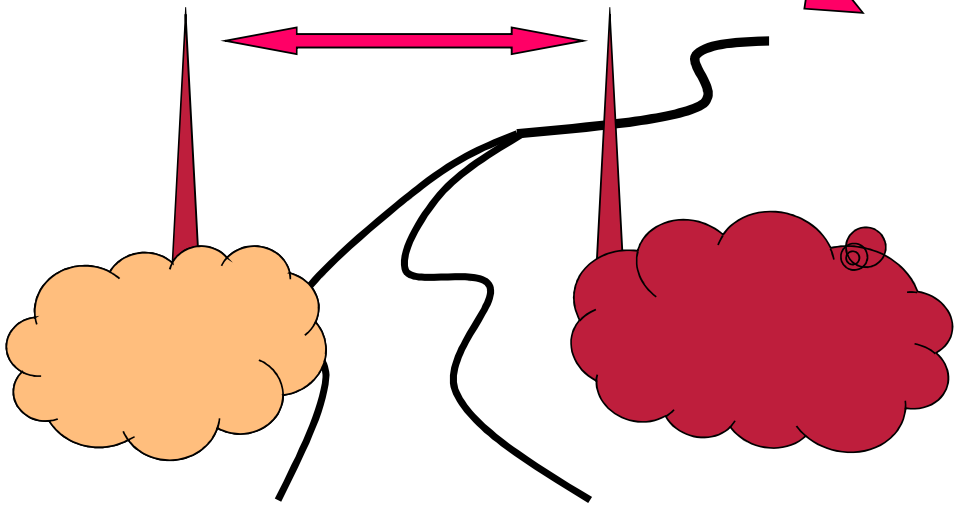


Drahtlose Kommunikation

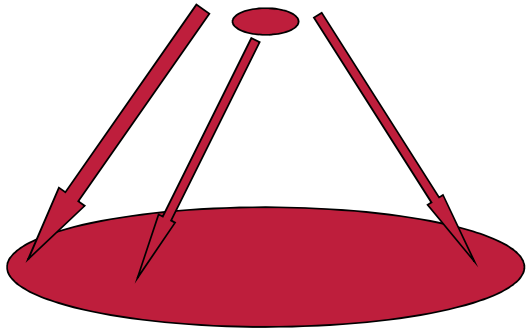
- Sehr große Bandbreite
- Physikalische Eigenschaften zwischen Radio- und optischen Wellen
- Beugung, Streuung und Reflexion besser als bei opt. Wellen

Große Datenraten drahtlos

Drahtloser Link,
z.B. für photonische Netze (Millilink)



Hochbitratige
Übertragung für kleine Zellen



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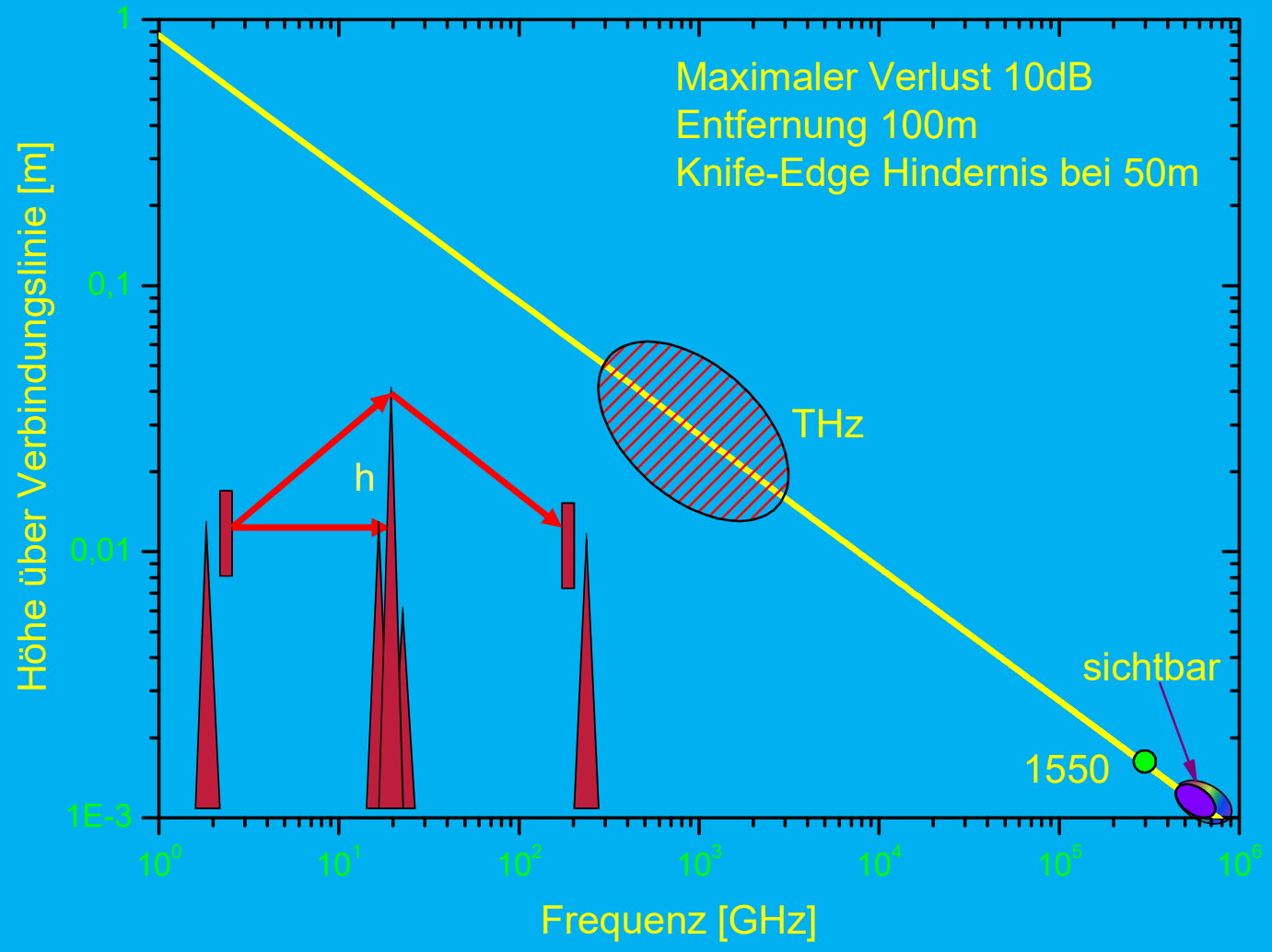
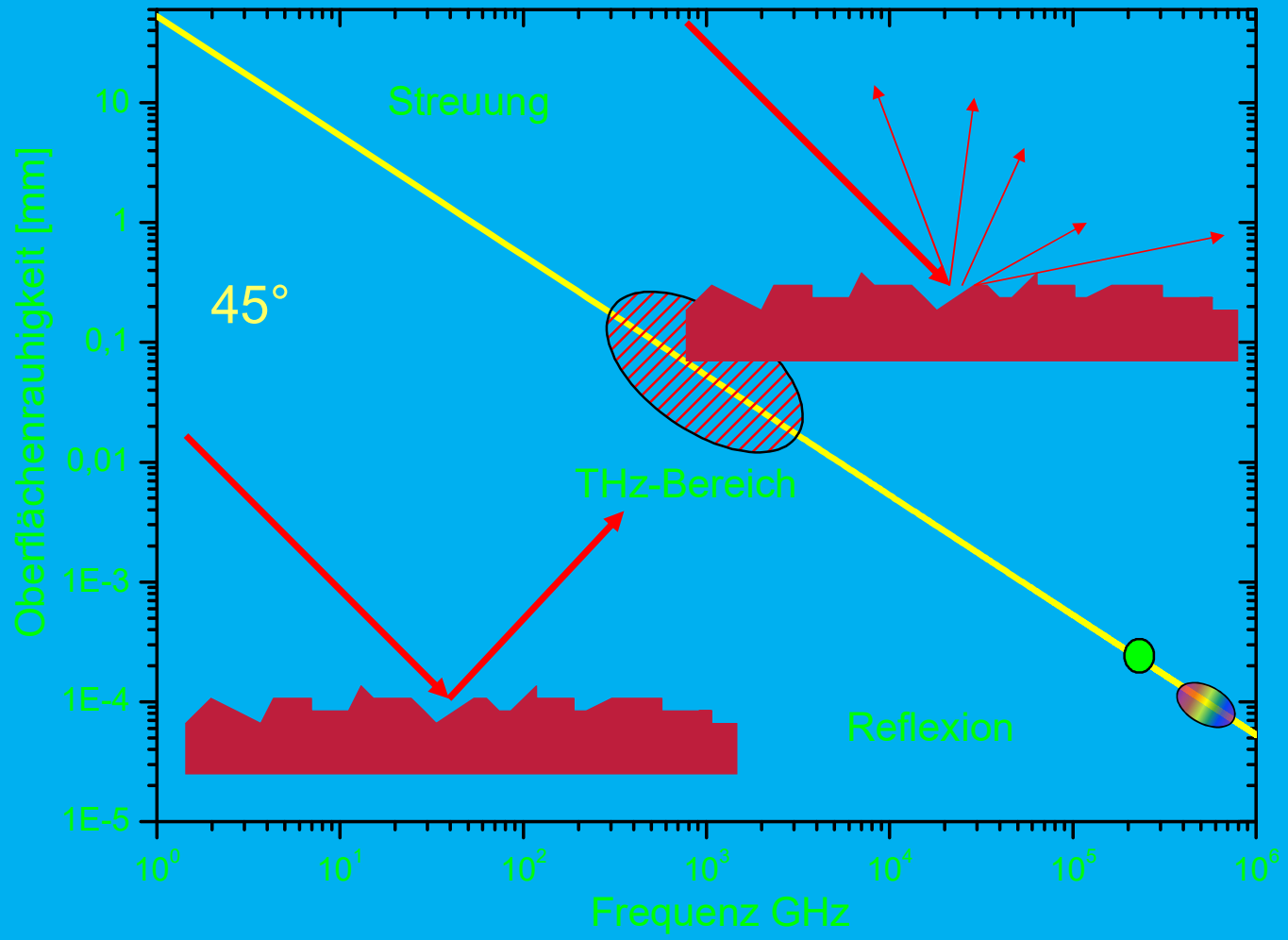


Beugung

Streuung/Reflexion



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Drahtlose Kommunikation

OSA http://www.osa.org/About_Osa/Newsroom/News_Releases/Releases/02.2012/Record-Speed-Wireless-Data-Bridge-Demonstrated.aspx

RECORD-SPEED WIRELESS DATA BRIDGE DEMONSTRATED: TAKES HIGH-SPEED COMMUNICATIONS THE 'LAST MILE'

German research team to present results at OFC/NFOEC 2012

WASHINGTON, Feb. 27—A team of researchers in Germany has created a new way to overcome many of the issues associated with bringing high-speed digital communications across challenging terrain and into remote areas, commonly referred to as the “last mile” problem. The researchers developed a record-speed wireless data bridge that transmits digital information much faster than today’s state-of-the-art systems.

Yahoo http://in.news.yahoo.com/wireless-bridge-takes-high-speed-communications-last-mile-113535811.html

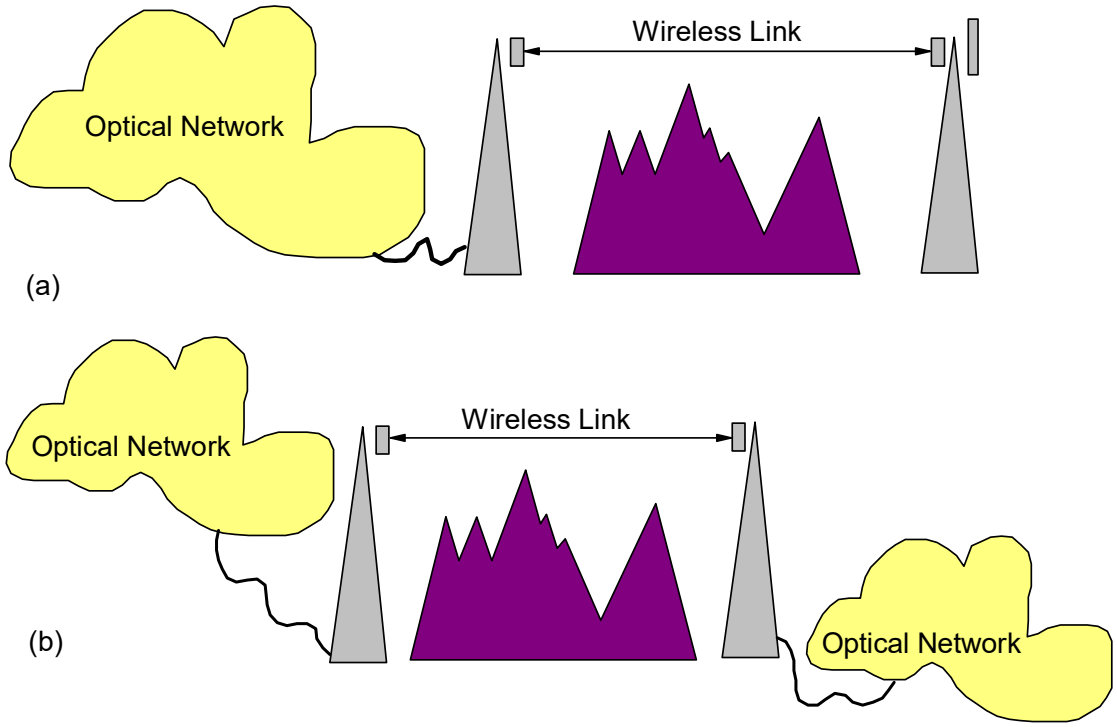
Business Wire http://www.finanznachrichten.de/nachrichten-2012-02/22827472-record-speed-wireless-data-bridge-demonstrated-takes-high-speed-communications-the-last-mile-004.htm

New Science Magazine http://www.newsciencemagazine.com/2012/02/28/record-speed-wireless-data-bridge-demonstrated-takes-high-speed-communications-the-last-mile/

Twitter

Science News *Daily*

Drahtlose Kommunikation



Wireless Link is AWGN-Channel

$$C = B \log_2 \left(1 + SNR\right)$$

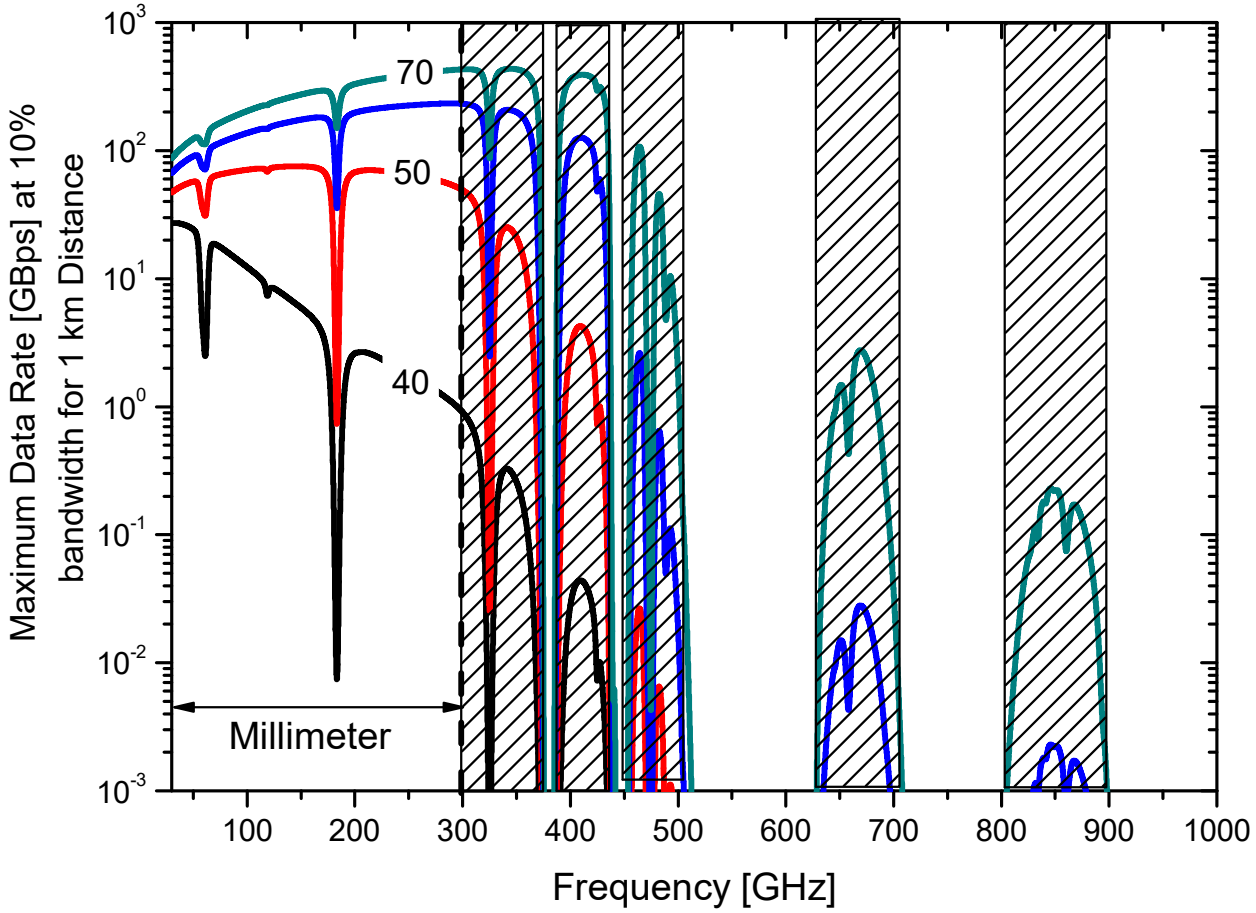
$$SNR = \frac{P_{Rx}}{FkTB}$$

$$P_{Rx} = P_{Tx} G_{Tx} G_{Rx} \left(\frac{c}{4\pi df} \right)^2 e^{-\alpha d}$$

Assumptions:

- The bandwidth is 10% of the transmitter frequency,
- The distance is 1 km,
- The transmit power is 10 dBm,
- The noise figure is 10 dB, and
- The ambient temperature is 300 K.

Drahtlose Kommunikation



Maximum Data Rates in different Bandwidths

Window	B [GHz]	Capacity for 50 dBi [Gbps]	Capacity for 60 dBi [Gbps]	Capacity for 70 dBi [Gbps]
220 - 260	40	90.1	342.4	608.0
188 - 318	130	126.4	858.4	1720.2
I	76	24.6	357.8	858.5
II	58	1.8	98.0	452.6
III	62	0.0	0.4	32.9
IV	85	0.0	0.0	0.9
V	94	0.0	0.0	0.1

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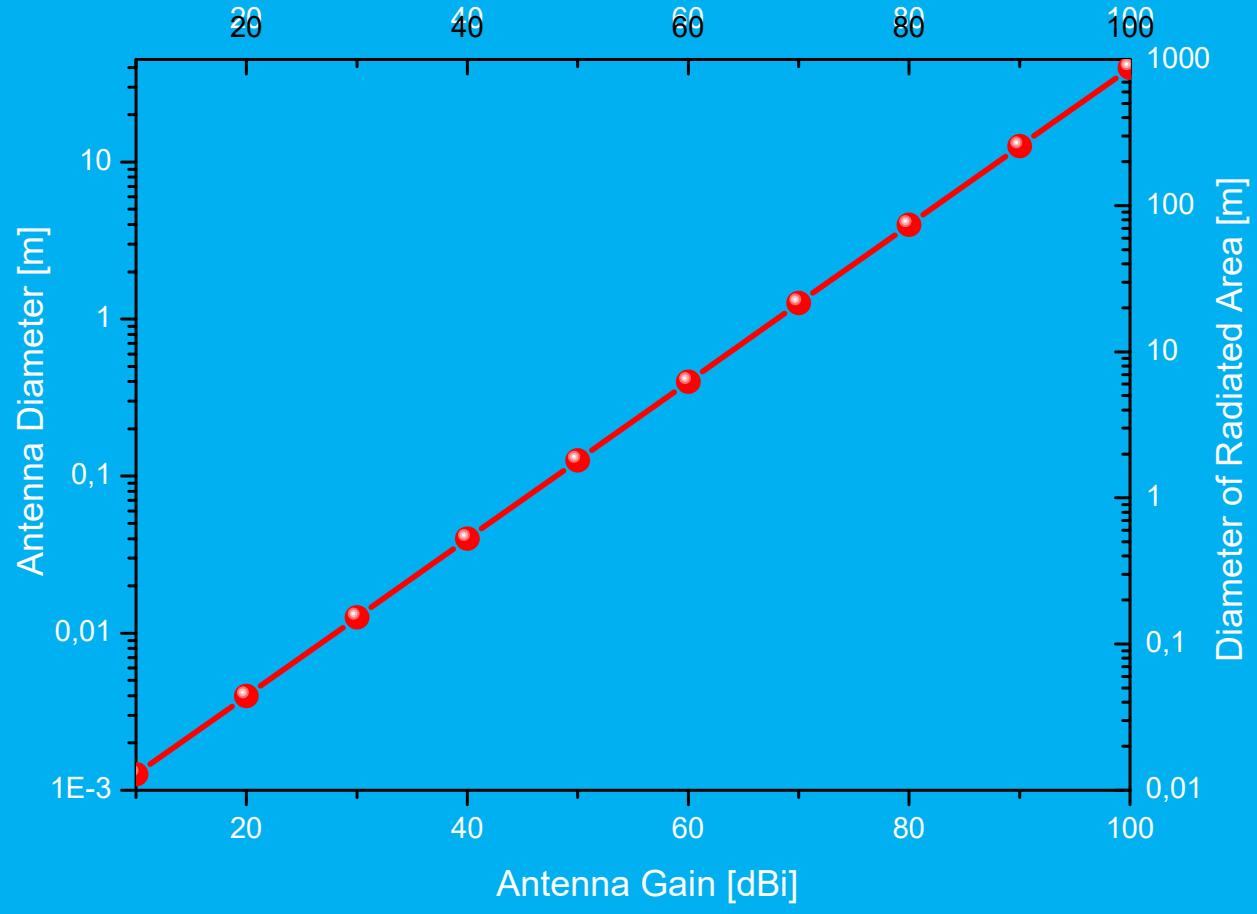
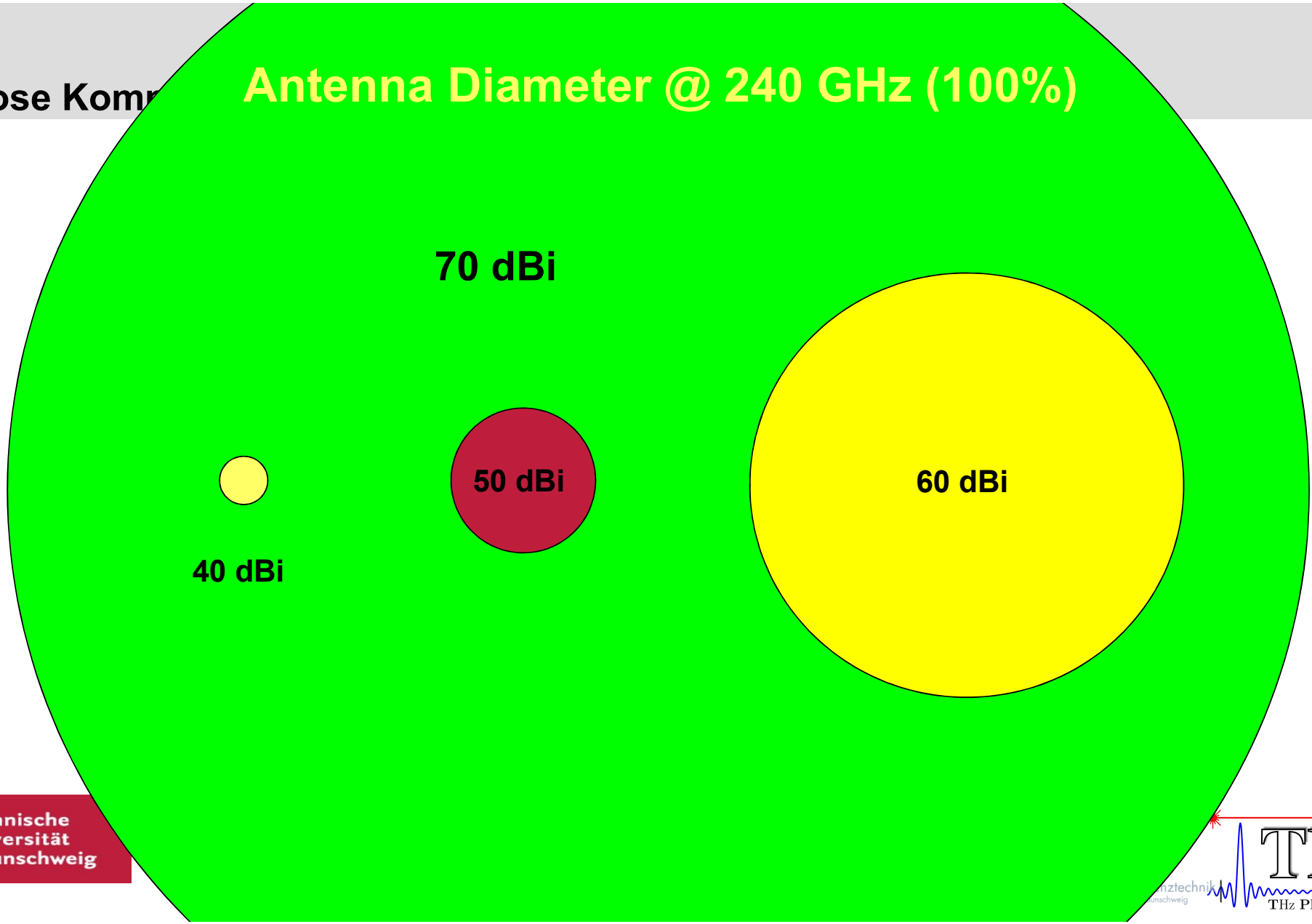
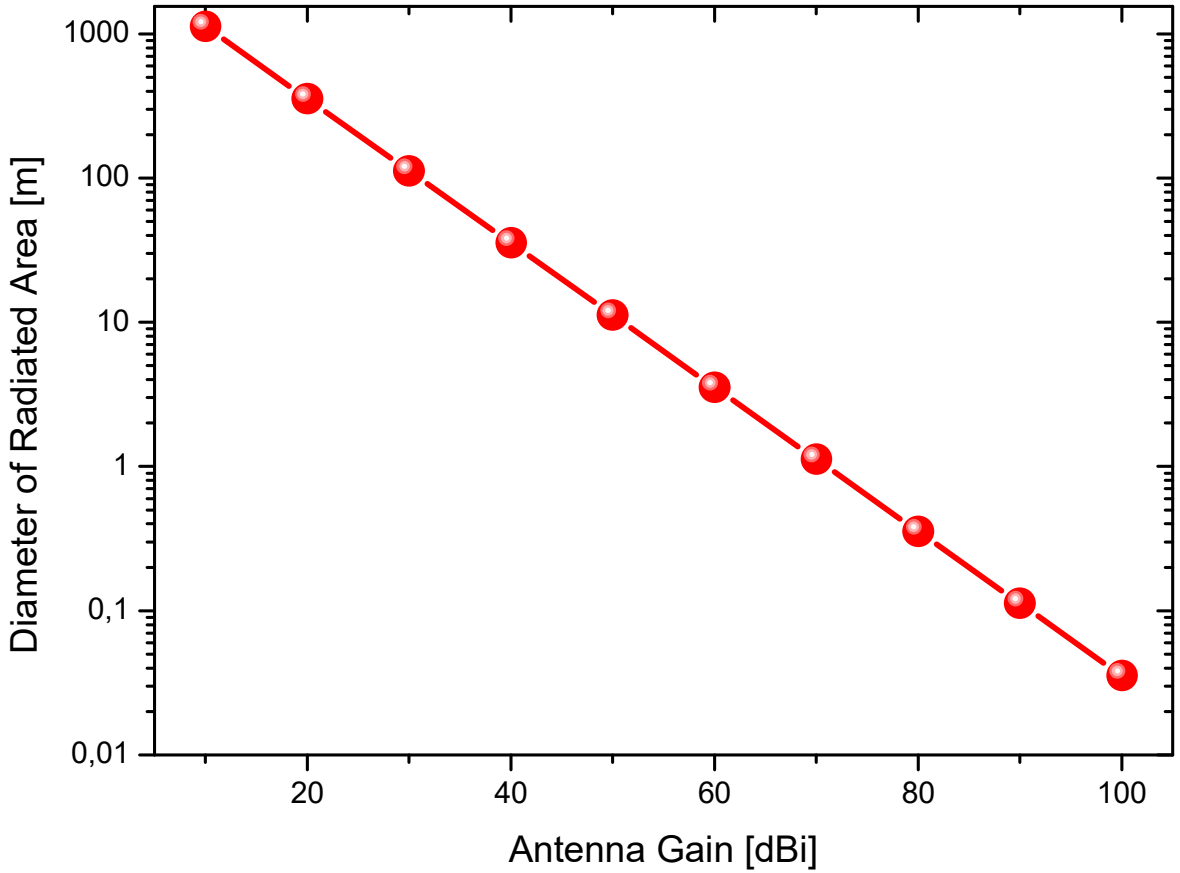



Antenna Diameter @ 240 GHz (100%)
70 dBi
50 dBi
60 dBi
40 dBi

Drahtlose Kommunikation



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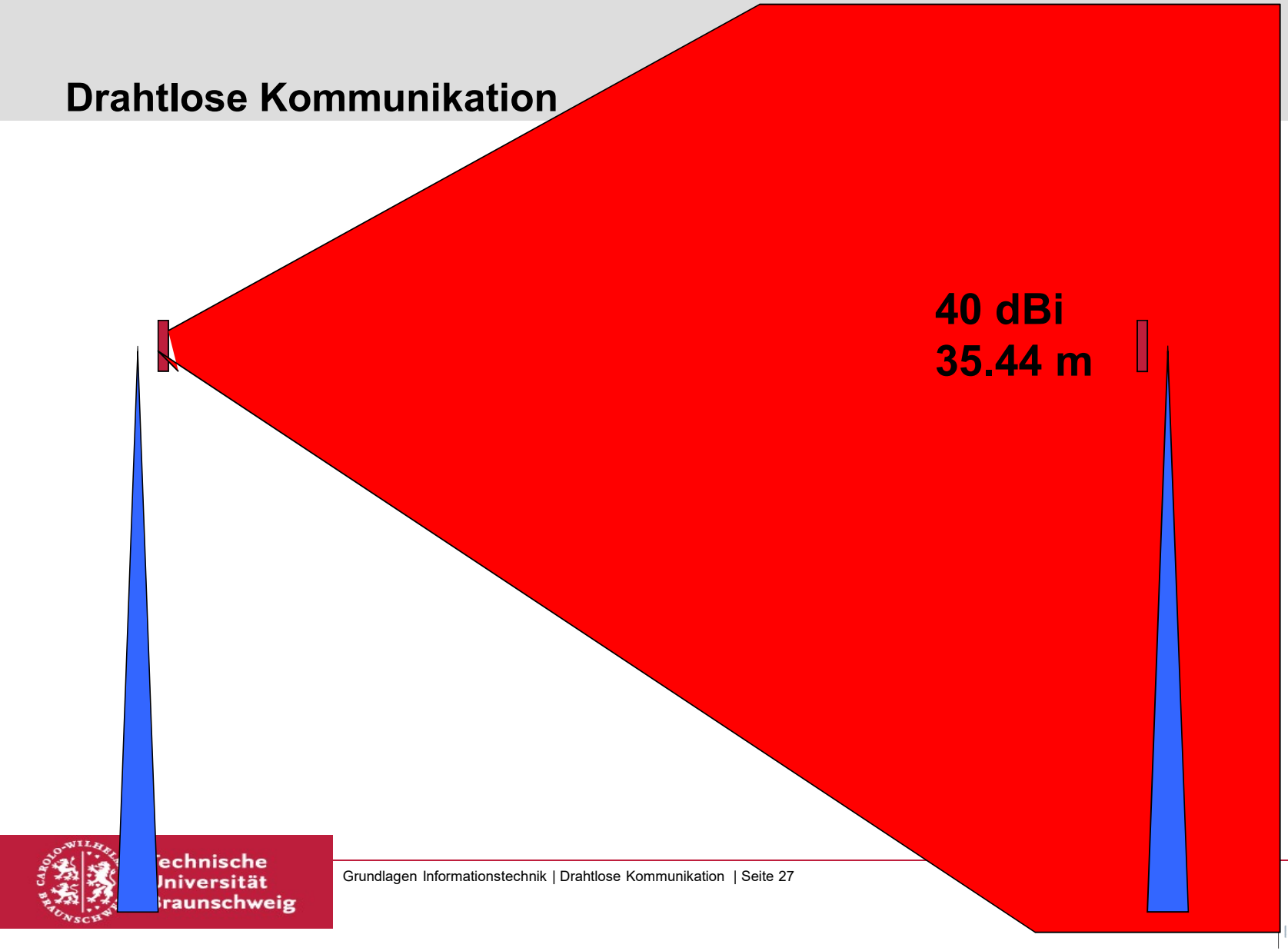

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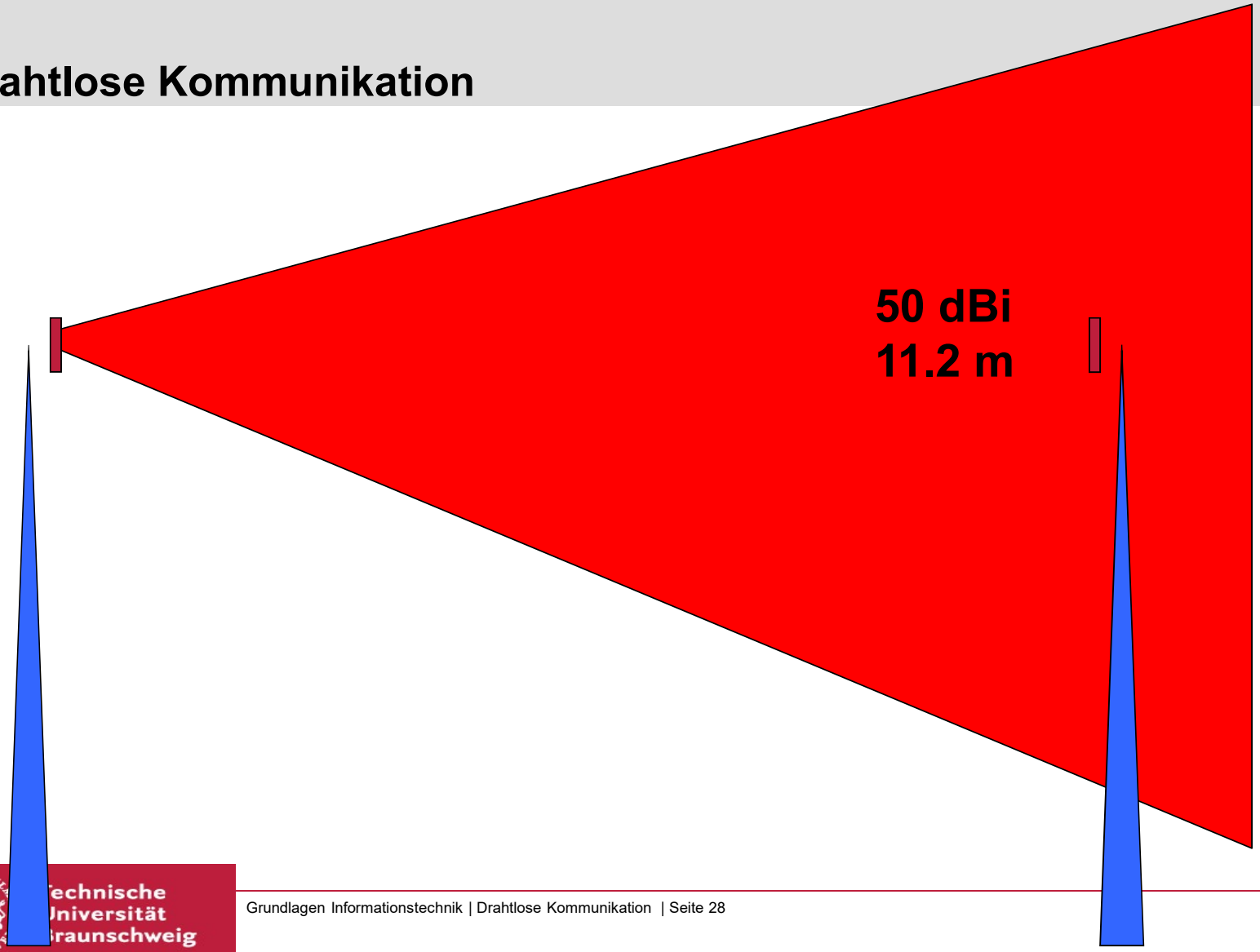

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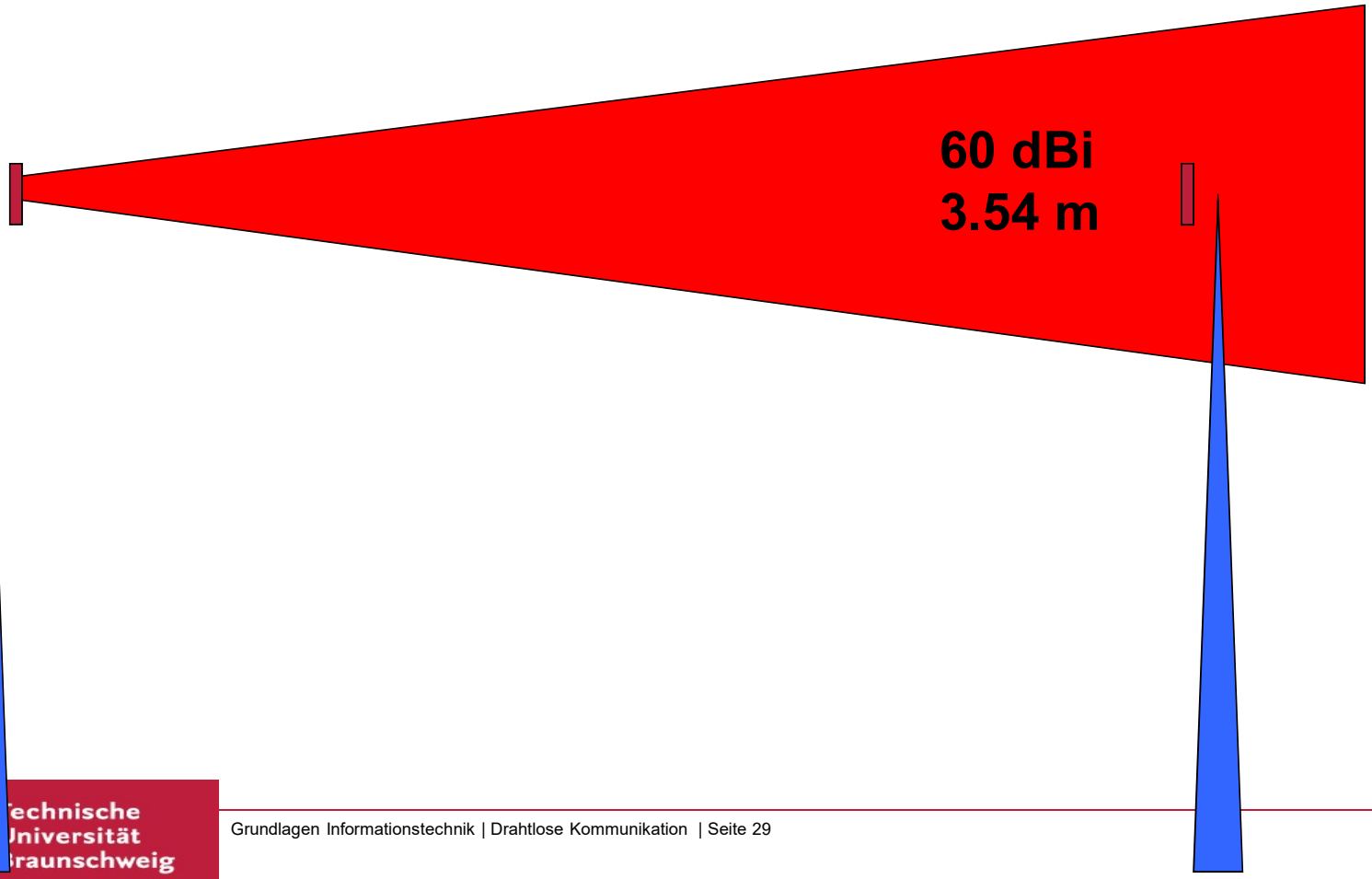

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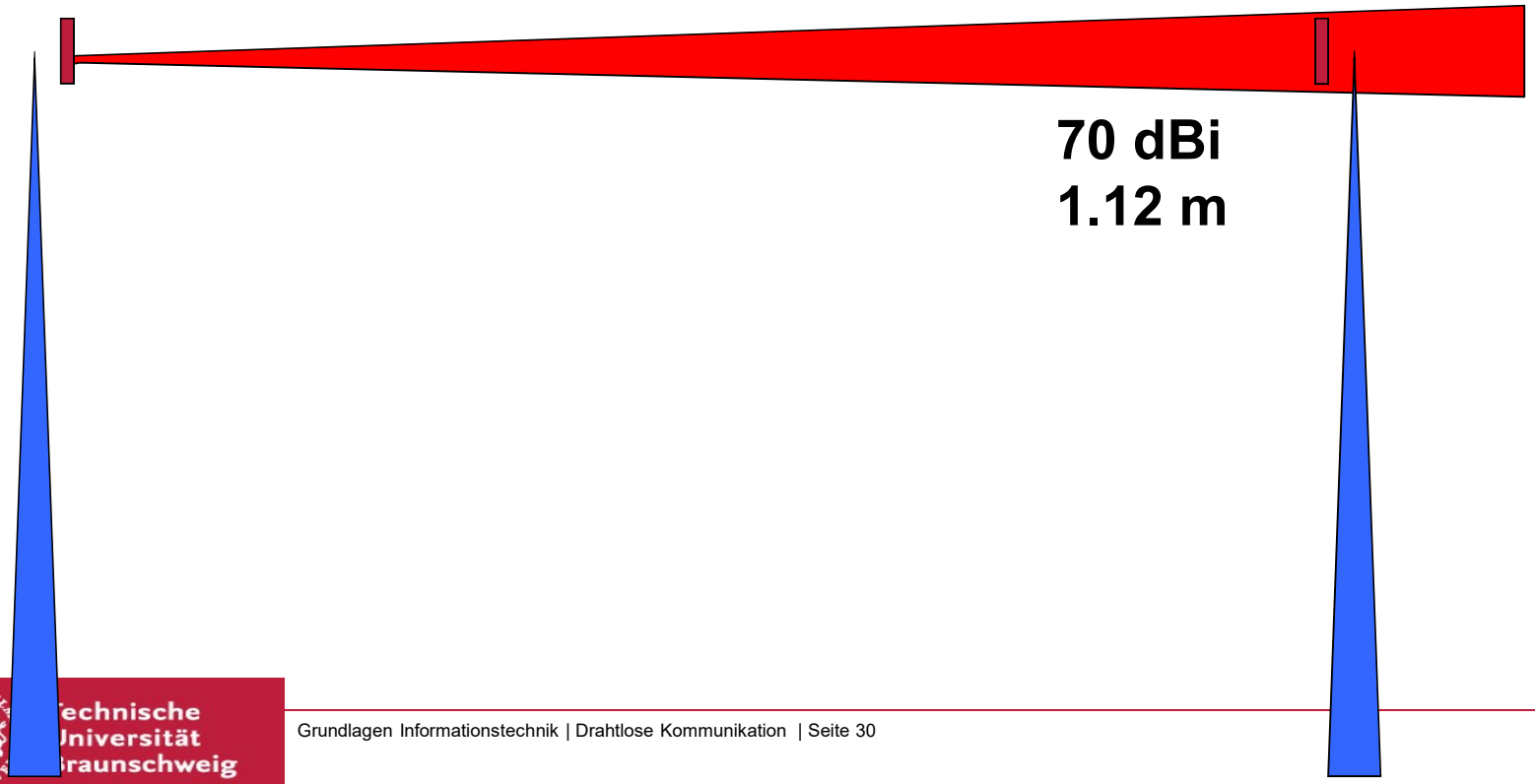

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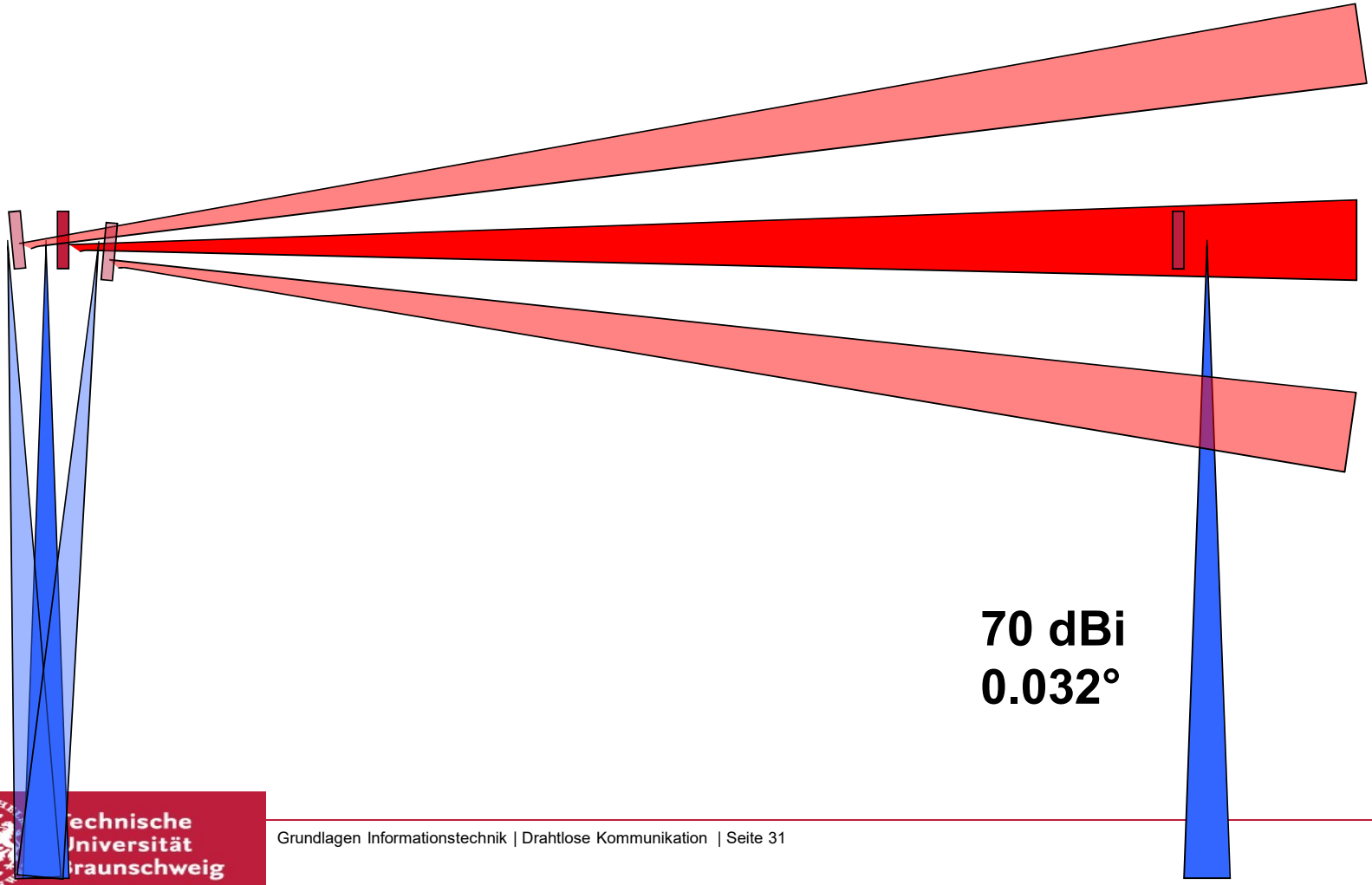

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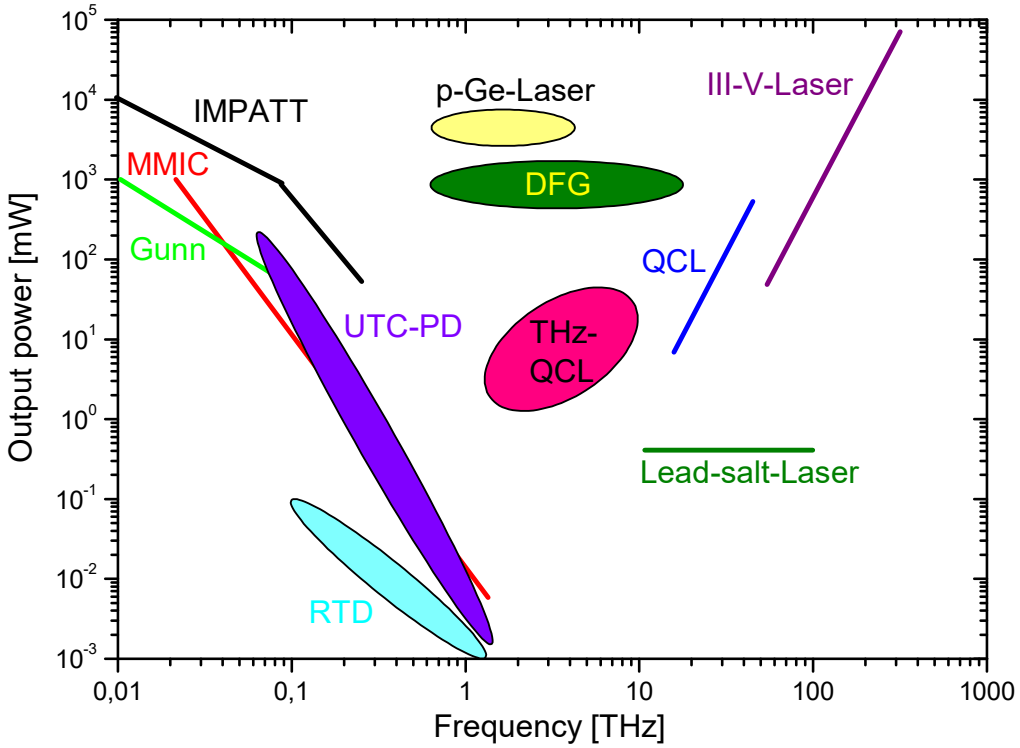


IMPATT diode: impact ionization avalanche transit-time diode

UTC-PD: uni-travelling carrier photodiode

DFG: difference frequency generation

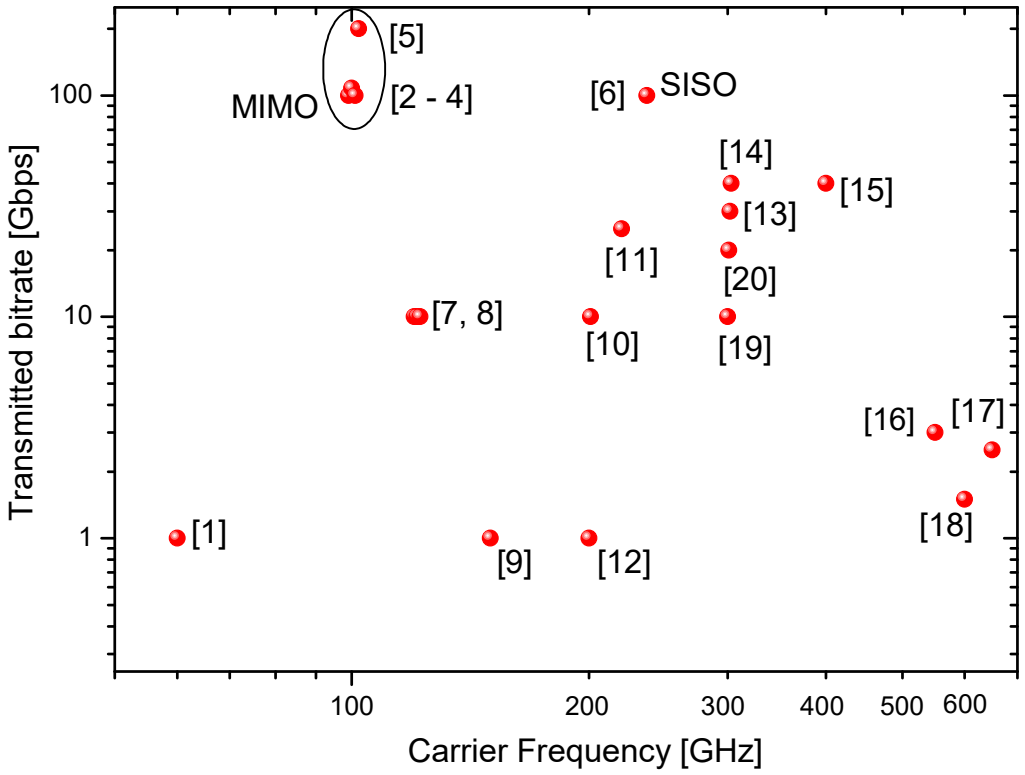
QCL: quantum cascade laser

MMIC: millimeterwave integrated circuit

RTD: resonant tunneling diodes

According to: M. Tonouchi, *Cutting-edge terahertz technology*, **Nat. Phot**. Vol.1 pp. 97 – 105 (2007).

Drahtlose Kommunikation



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[20] H.-J. Song et al., Electron. Lett., 48, 953 (2012)

Drahtlose Kommunikation

- Der THz-Bereich bietet die Möglichkeit extrem hohe Datenraten drahtlos zu übertragen.
- Der THz-Bereich verhält sich für physikalische Effekte wie ein Zwischenbereich zwischen Optik und Funksystemen.
- Auf Grund der sehr großen Pfaddämpfung sind Antennen mit sehr großer Richtwirkung nötig.
- Die große Richtwirkung führt zu einer annähernd optischen Ausbreitung.