

CHIST-ERA Projects Seminar
*Topic Terahertz Band for Next-
Generation Mobile
Communication Systems*

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Brussels, March 22-23, 2017

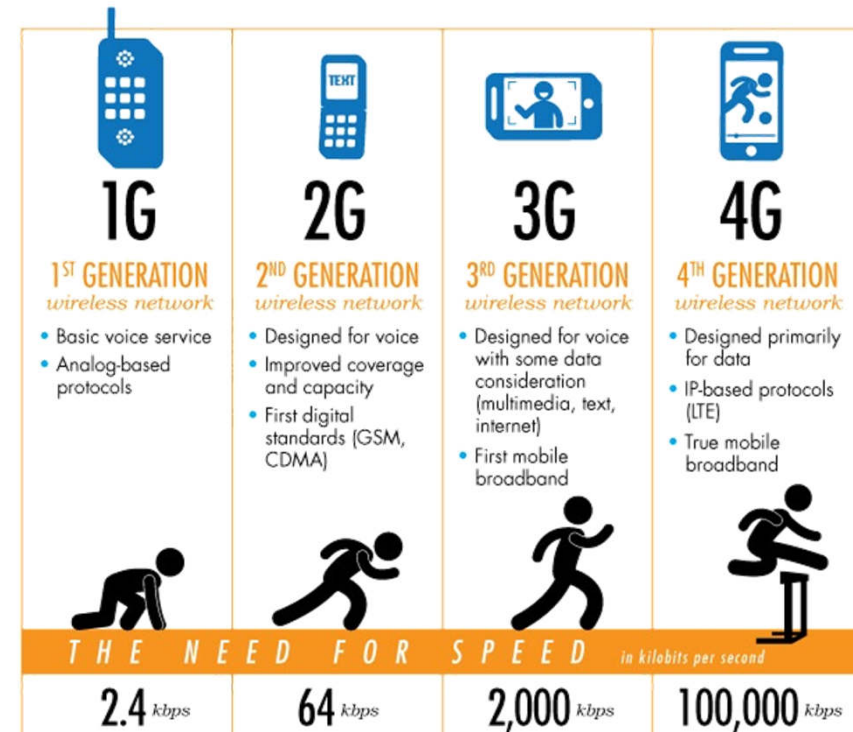


Terahertz Band for Next-Generation Mobile Communication Systems

❖ Motivation

- ✓ With the latest and advanced 4G mobile telephony, LTE, a 100 up to 300 Mbps could be reached.
- ✓ As the number of users per cell increase, the system saturates and limits the maximum available rates.

EVOLUTION OF THE G



Terahertz Band for Next-Generation Mobile Communication Systems

❖ Initial solutions: 5G

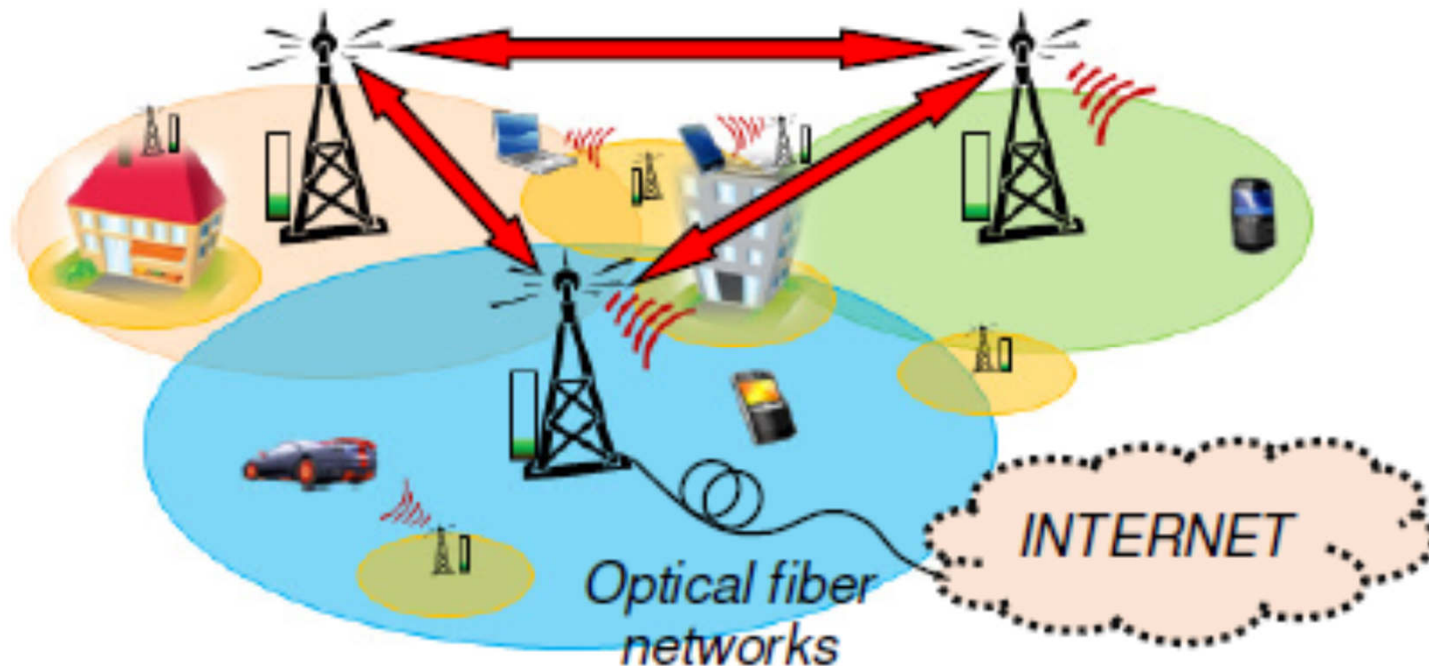
- ✓ With the promise of the 5G, even higher data rates are provided to the user.
- ✓ Several strategies to improve the user link:
 - Increasing gain (at user and network sides),
 - Scanning capabilities in both sides
 - MIMO systems,
 - To increase the number of cells reducing their coverages,
 - To use higher capability modulations,
 - New frequency bands...



Terahertz Band for Next-Generation Mobile Communication Systems

❖ Technological problem: Backhaul system

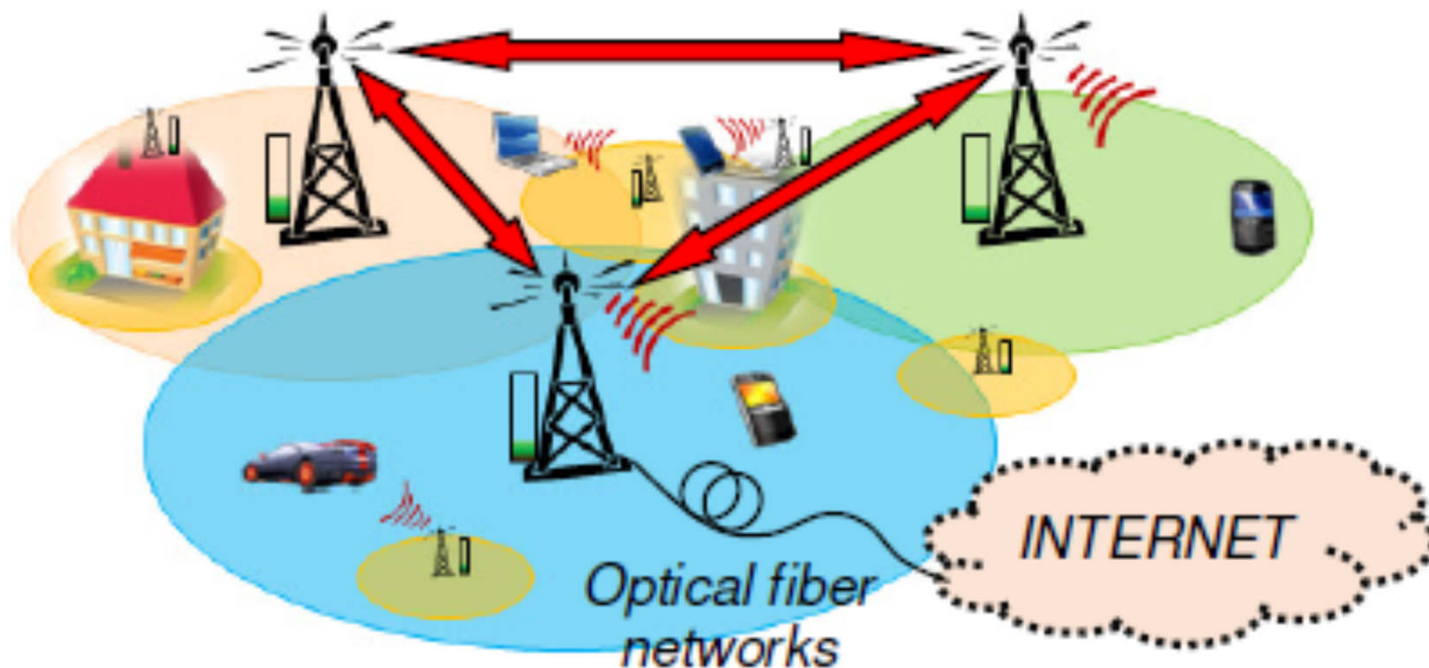
- ✓ The bottle neck of the system would be the base stations, since they need to be fed with enough capacity to share it between the users.



Terahertz Band for Next-Generation Mobile Communication Systems

❖ Technological problem: Backhaul system

- ✓ Many wireless links should be planned in the system to provide the final base stations with enough capability to share with the final users.





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Terahertz Band for Next-Generation Mobile Communication Systems

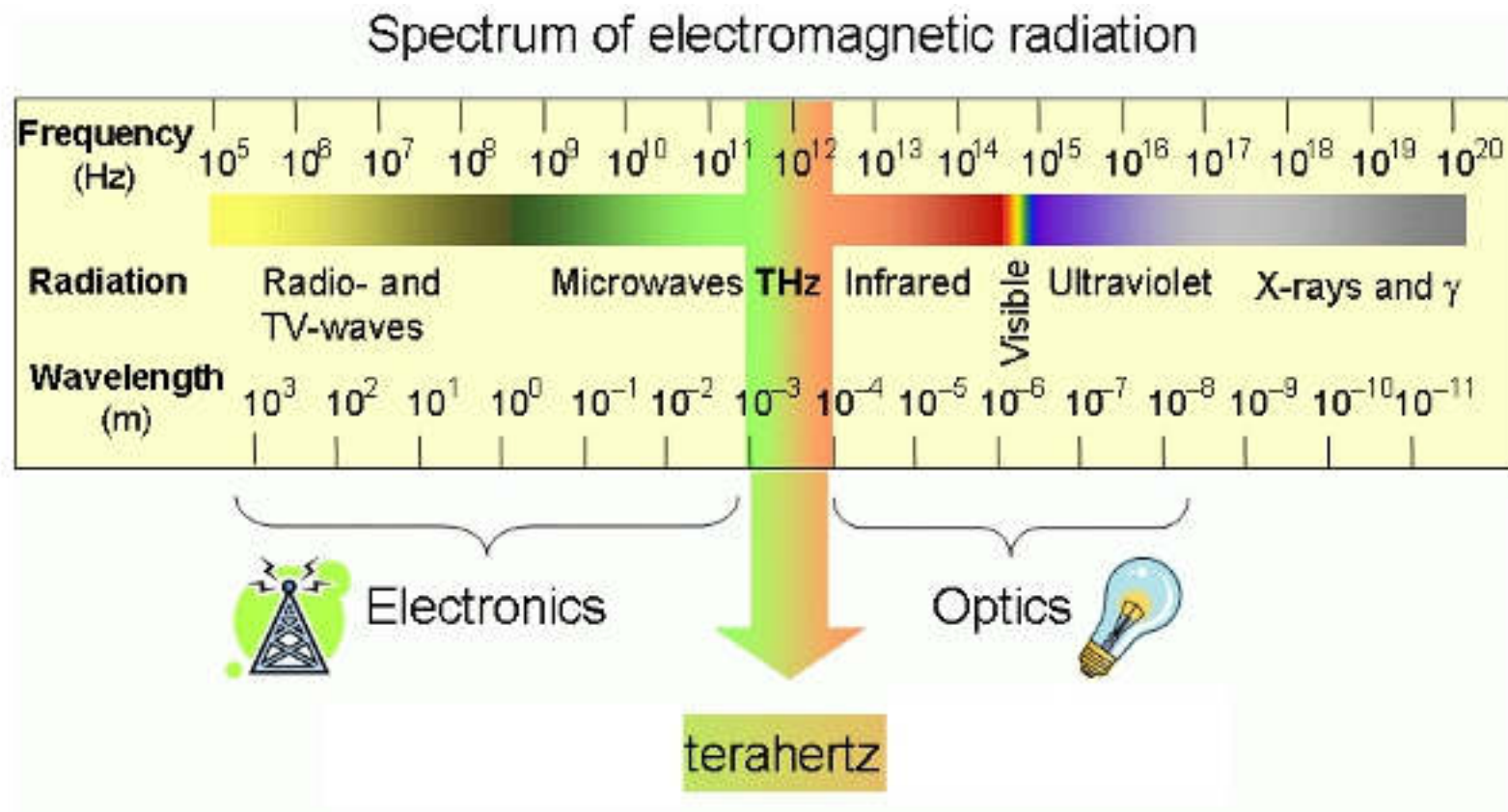
❖ **Technological problem: Backhaul system**

- ✓ Many wireless links should be planned in the system to provide the final base stations with enough capability to share with the final users.
- ✓ Normally, for the components of Communications systems, 10-20% bandwidth could be easily achievable, and if more bandwidth is required, higher frequencies are needed.
- ✓ Terahertz band could be a solution to be able to transport 10-100 Gbps up to the base stations, since it will use the required fractional bandwidth

Terahertz Band for Next-Generation Mobile Communication Systems

❖ Terahertz Gap

- ✓ There remains a lack of sources at the THz frequency range.
- ✓ Two possibilities:





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Terahertz Band for Next-Generation Mobile Communication Systems

❖ Terahertz Gap

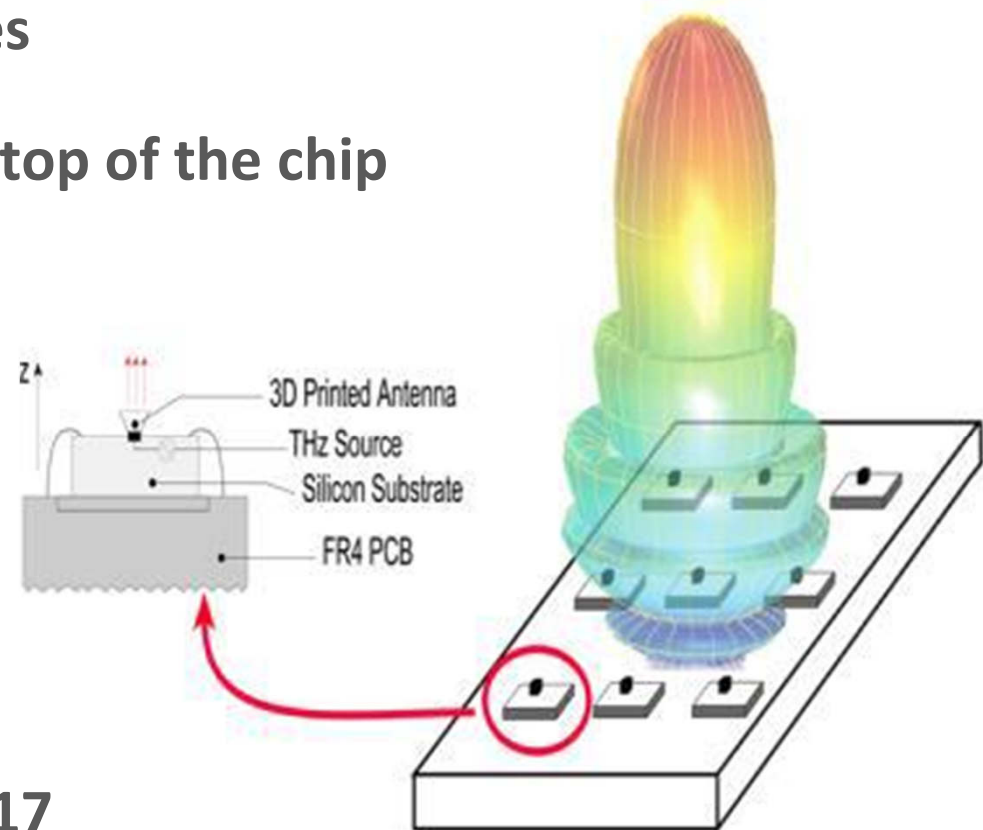
- ✓ There remains a lack of sources at the THz frequency range.
- ✓ Two possibilities:
 - **Growing from Microwaves (multipliers)**
 - Conversion losses are huge, and the final power at Terahertz is really low.
 - Very complicated system.
 - Amplitude and phase
 - **Going down from optics (beating two mode lines of a laser)**
 - The conversion losses are also important
 - A Little bit simpler system.
 - Only amplitude.

Introduction: Projects of the topic

- ❖ **Within the topic TMCS there two different project:**
 - ✓ **WISDOM, Wideband Low-Cost Smart Passive and Active Integrated Antennas for THz Wireless Communications**
 - ✓ **TERALINKS, TERAhertz high power LINKS using photonic devices, tube amplifiers and Smart antennas**

WISDOM Project Goal

- ❖ Cheap CMOS THz sources
- ❖ 3D printed antennas on top of the chip
- ❖ Antenna array
- ❖ Beam steering



- ❖ Kick-off: 16 February 2017

WISDOM Consortium

WISDOM

KU LEUVEN

Patrick Reynaert

**CMOS THz
sources**

University of
Kent

Steven Gao

Antennas and beam steering



Wolfgang Bösch

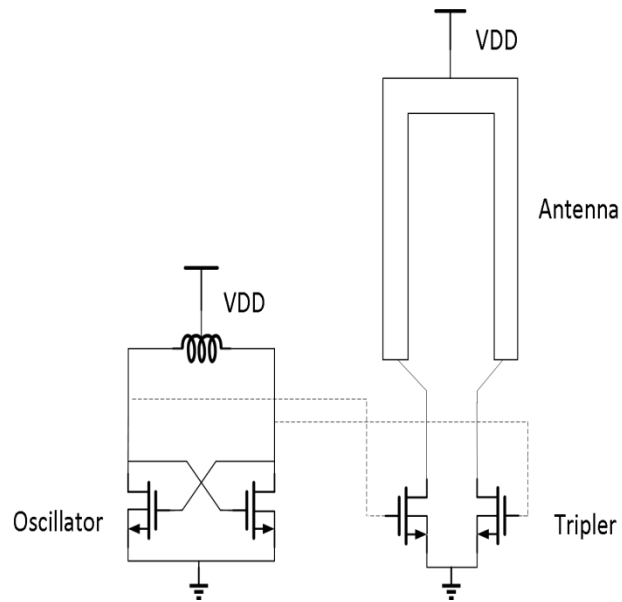


WARWICK
THE UNIVERSITY OF WARWICK

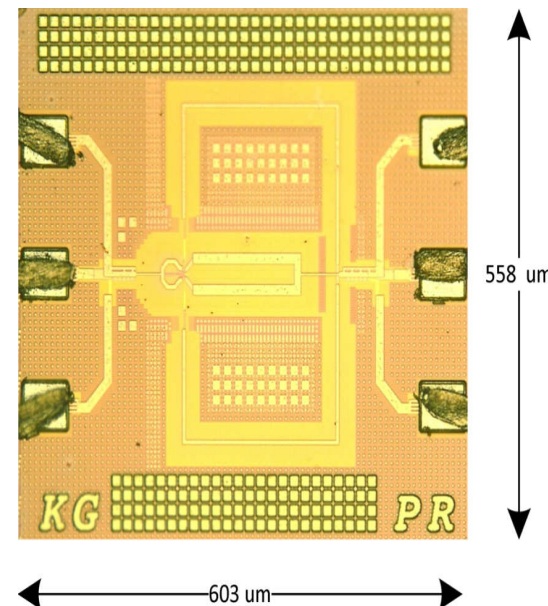
Gregory J. Gibbons

**3D printing
manufacturing**

A 0.53 THz radiating source in 28 nm CMOS



Schematic of 530 GHz radiating source



Photograph of 530 GHz radiating source

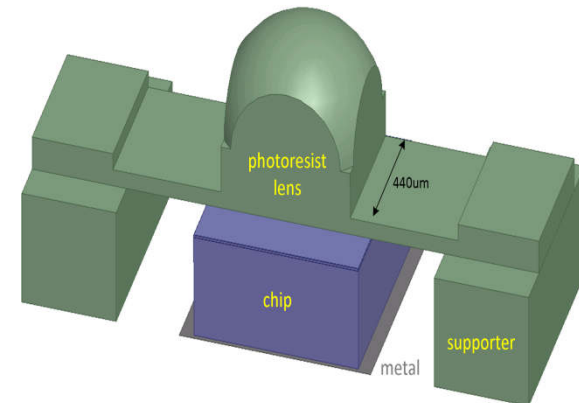
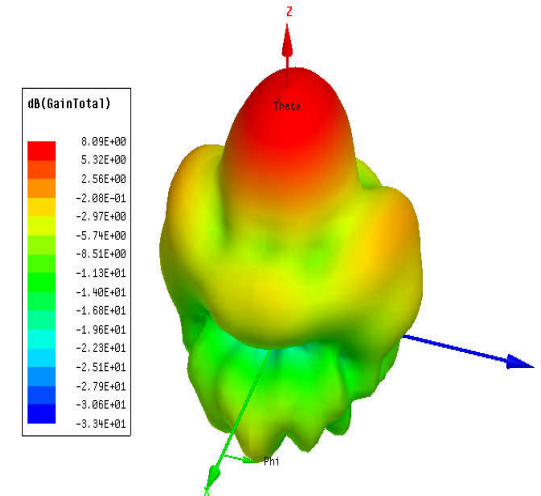
- Antenna act as a big inductance at fundamental frequency and provide conjugate match at 3rd harmonic frequency.

Antenna with photoresist lens on top of chip



3D printer “Photonic Professional GT”

- Accurately fabricate tiny structure using photoresist material.
- Simulated 8 dB antenna gain at 530 GHz.



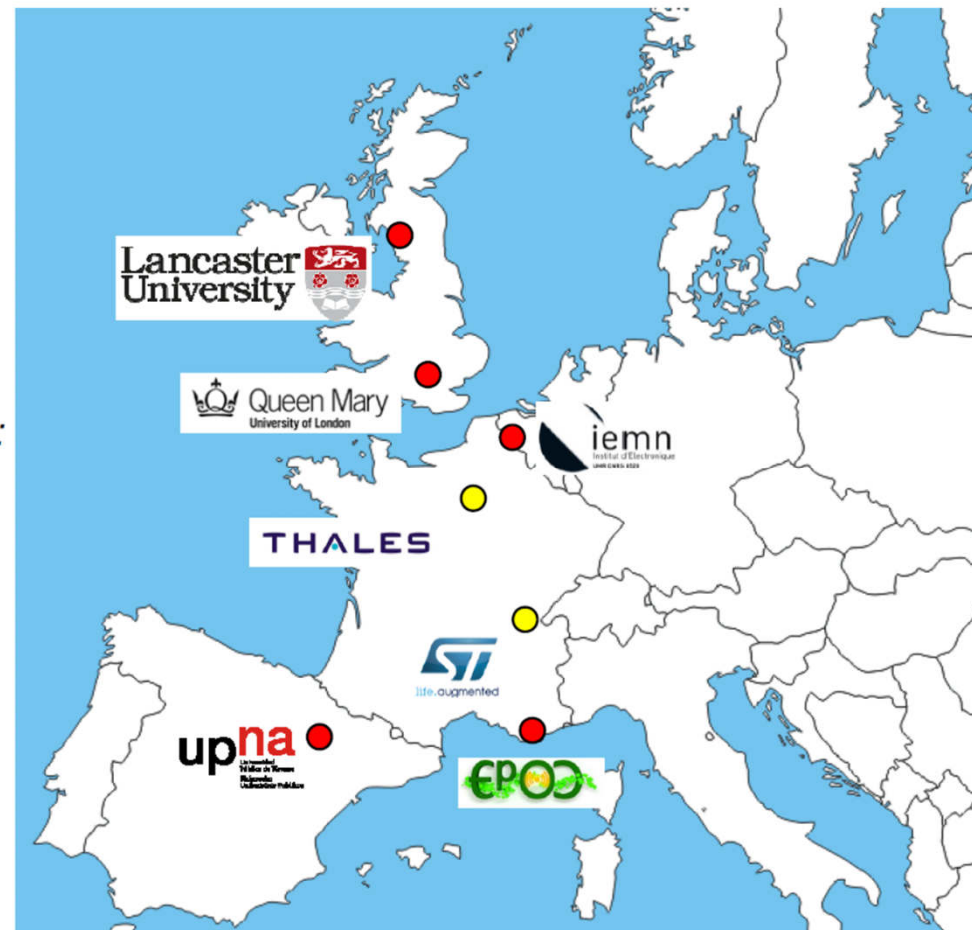
3D model of the photoresist lens

TERALINKS Consortium

Partner ●

Industrial
support ●

UC Davis/DMRC:
(USA)



❖ Consortium

<i>Country</i>	<i>Institution/ Department</i>	<i>Name of the Principal Investigator (PI)</i>
France	University Lille 1 (IEMN)	Guillaume Ducournau
France	University of Nice, EpOC	Cyril Luxey
U.K.	Queen Mary – Univ London (QMUL)	Yang Hao
U.K.	Lancaster University (LU)	C. Paoloni
Spain	University public of Navarra (UPNA)	Carlo del Rio Bocio

❖ Industrial partners:

France	ST- Microelectronics	Frederic Gianesello
France	THALES	Daniel Dolfi

USA	UC Davis	Professor Neville C. Luhmann, Jr.
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TERALINKS Project Goal

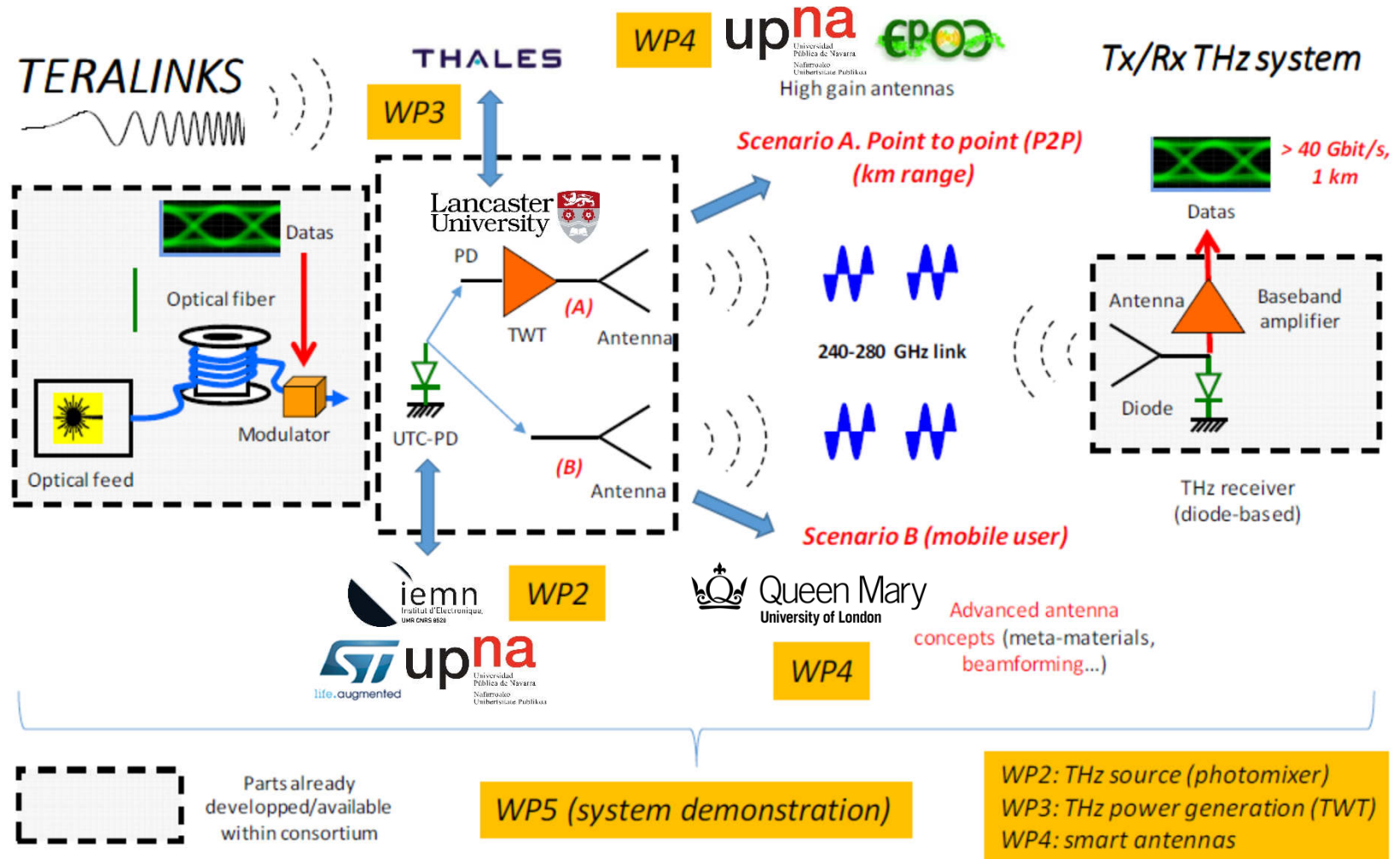
❖ Kick-off planned for April 7th...

Frequency	220-260 GHz
THz source	up to 1 mW / packaged
TWT power amplifier	Gain > 30 dB Power: 3-4 W
Antenna	50 dBi (high gain) > 20 dBi, beam-steering capable (indoor)
Receiver (direct)	Zero bias detector Schottky ~ 1 kV/W
Rx bandwidth (GHz)	40 GHz, including baseband amplifier
Modulation	ASK (real-time) 40 Gbit/s
Link budget (outdoor)	140 dB (1 km) 40 dB with 50 dBi antennas

❖ TERALINKS target is to establish a THz communication demonstrator:

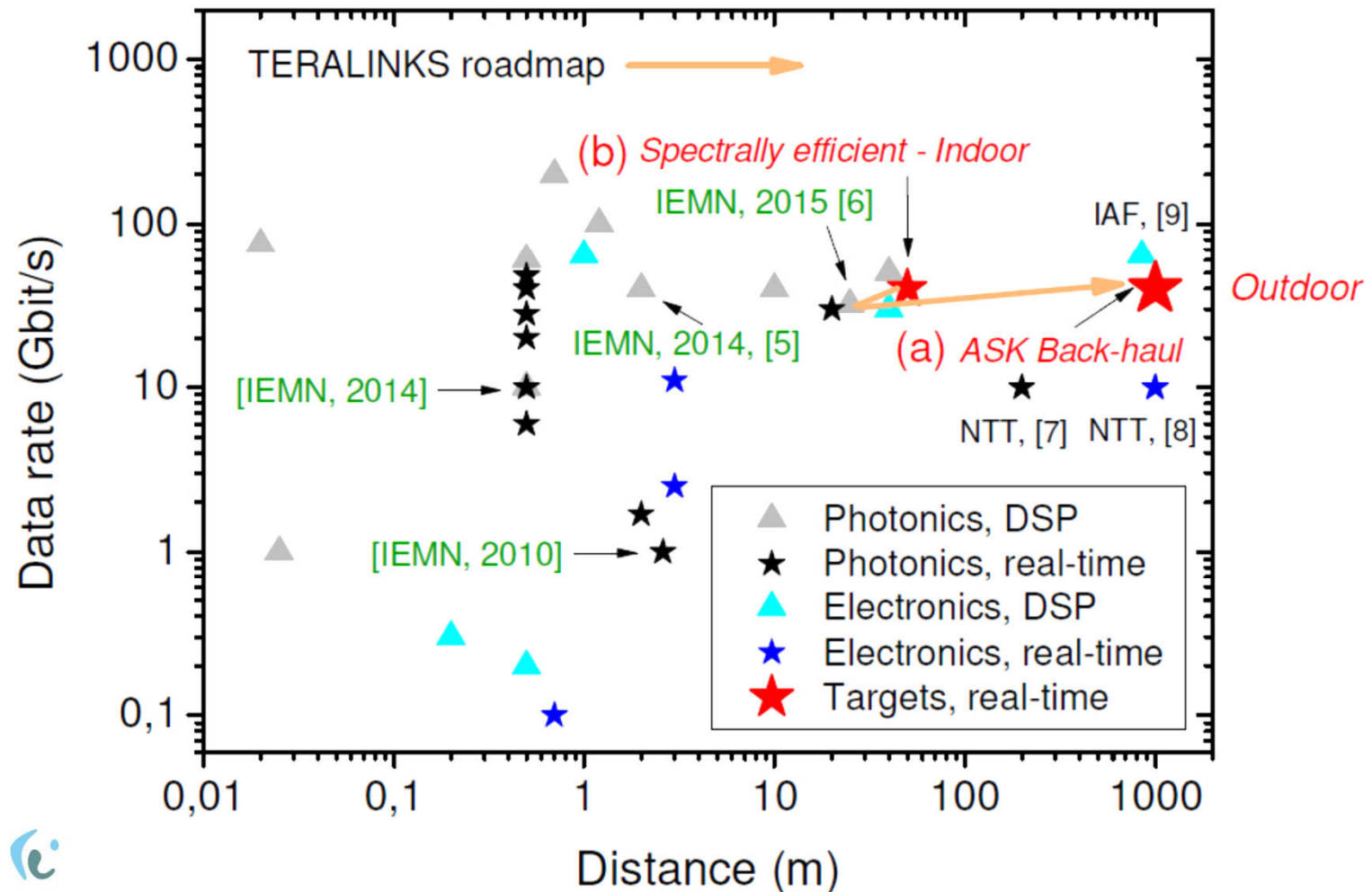
- ✓ i) with targeted 40 Gbit/s performance, real-time, for up to 1 km range (outdoor)
- ✓ ii) Indoor link demonstrating beam-steerable antennae.

TERALINKS System



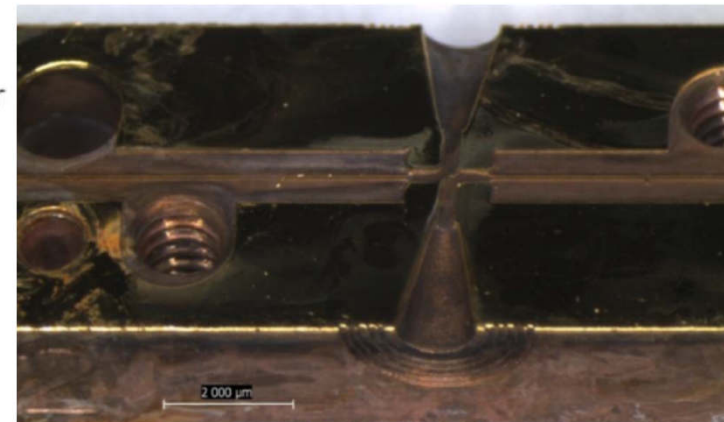
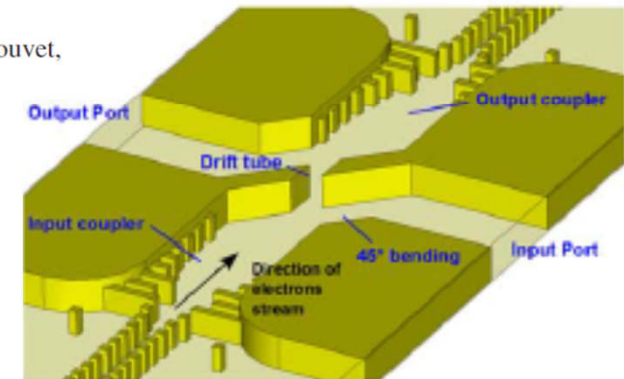
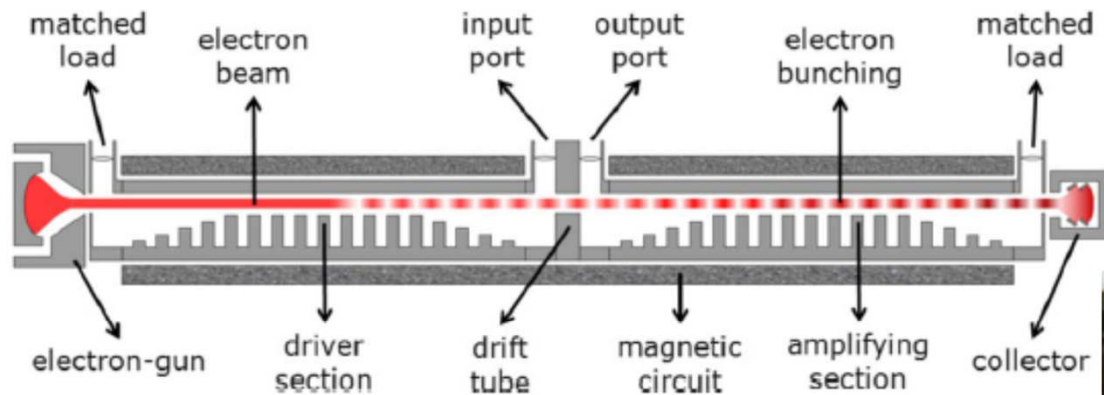
TERALINKS System

THz com. systems demonstrated



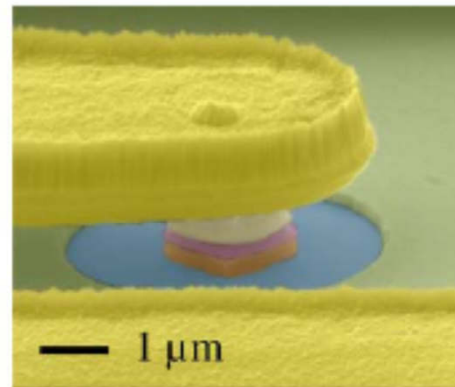
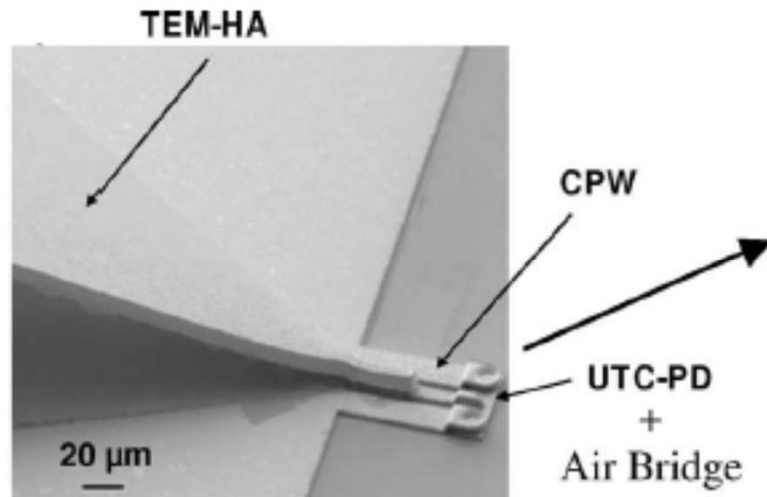
Design and Realization Aspects of 1-THz Cascade Backward Wave Amplifier Based on Double Corrugated Waveguide

Claudio Paoloni, *Senior Member, IEEE*, Aldo Di Carlo, *Member, IEEE*, Fayçal Bouamrane, Thomas Bouvet, Alain J. Durand, Mikko Kotiranta, *Student Member, IEEE*, Viktor Krozer, *Senior Member, IEEE*, Stephan Megtert, Mauro Mineo, and Vitaliy Zhurbenko, *Member, IEEE*

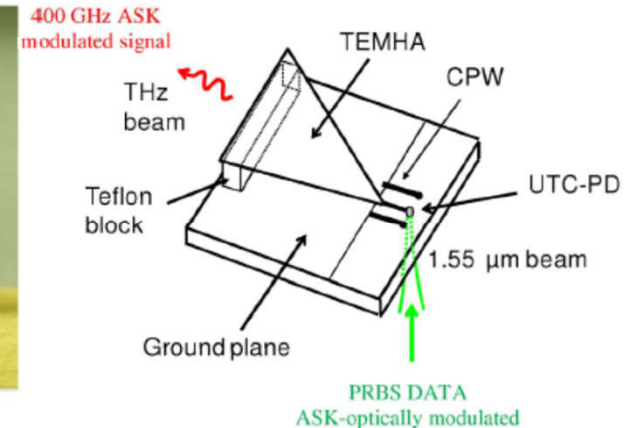


Ultrawide-Bandwidth Single-Channel 0.4-THz Wireless Link Combining Broadband Quasi-Optic Photomixer and Coherent Detection

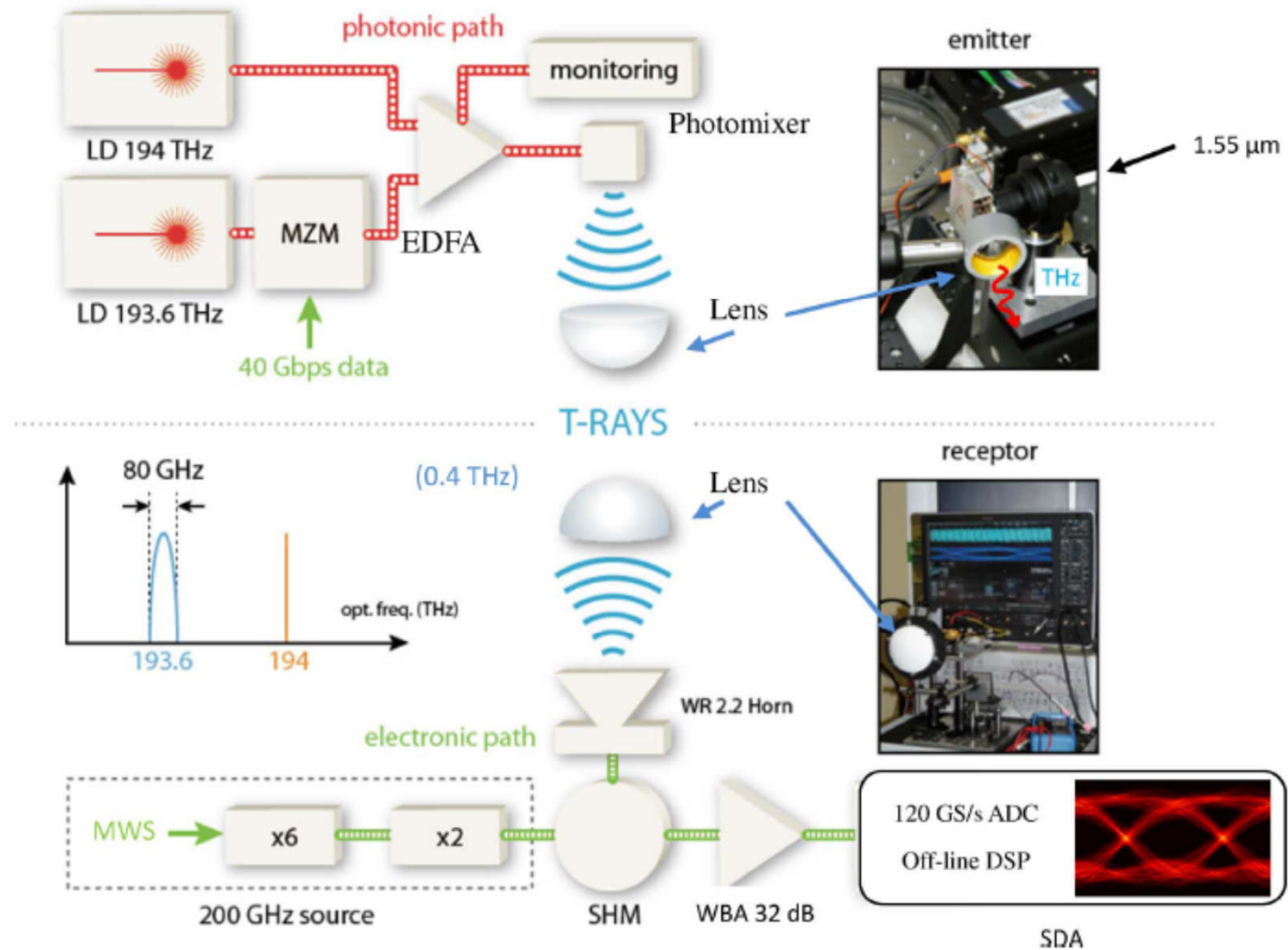
Guillaume Ducournau, Pascal Szriftgiser, Alexandre Beck, Denis Bacquet, Fabio Pavanello, Emilien Peytavit, Mohammed Zaknoune, Tahsin Akalin, *Member, IEEE*, and Jean-François Lampin



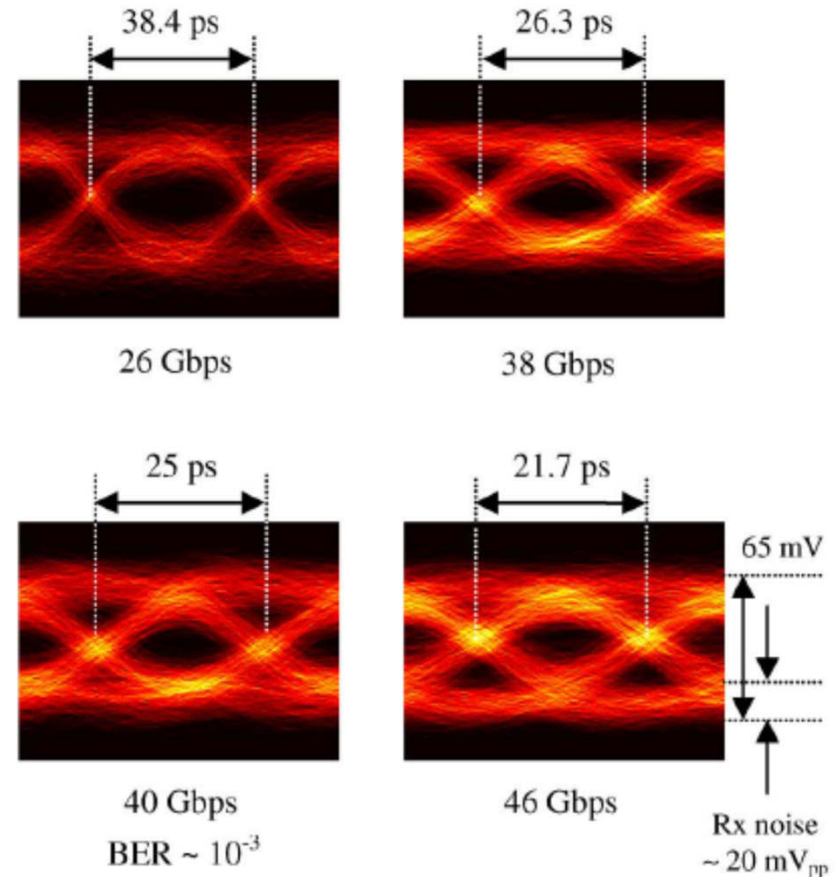
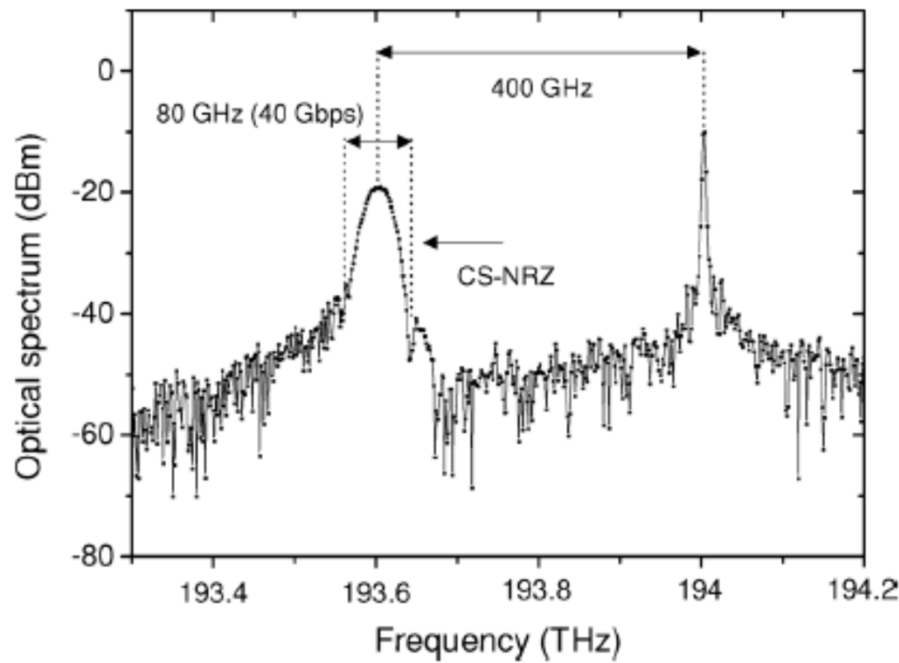
Zoom on mesa



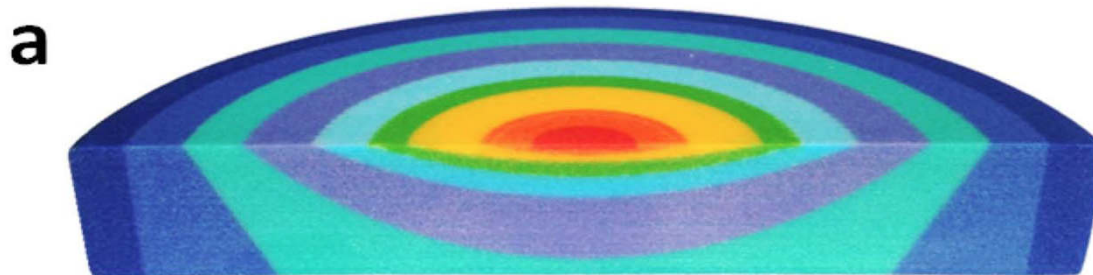
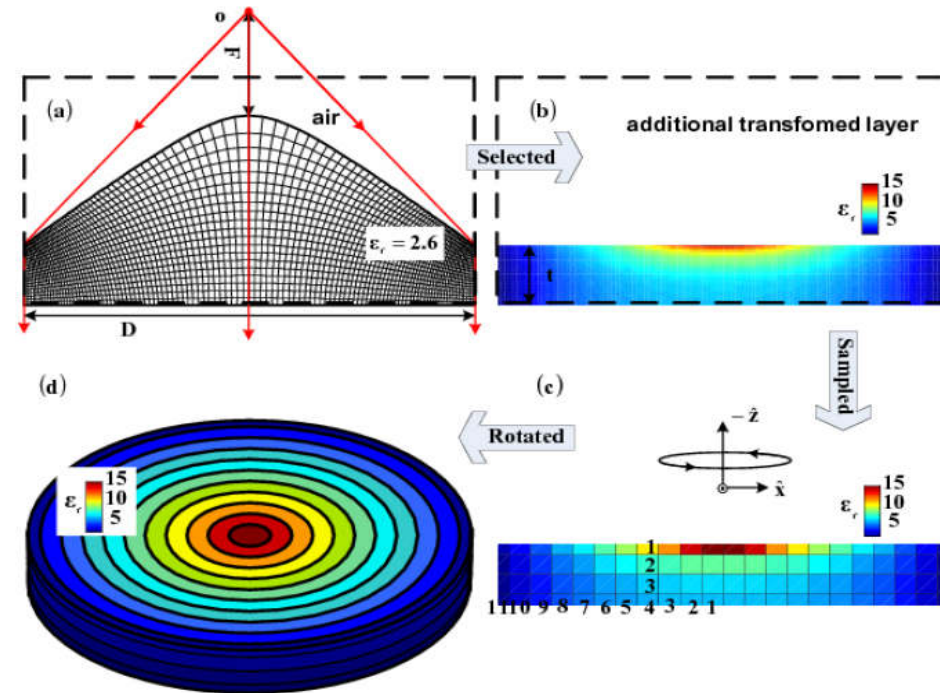
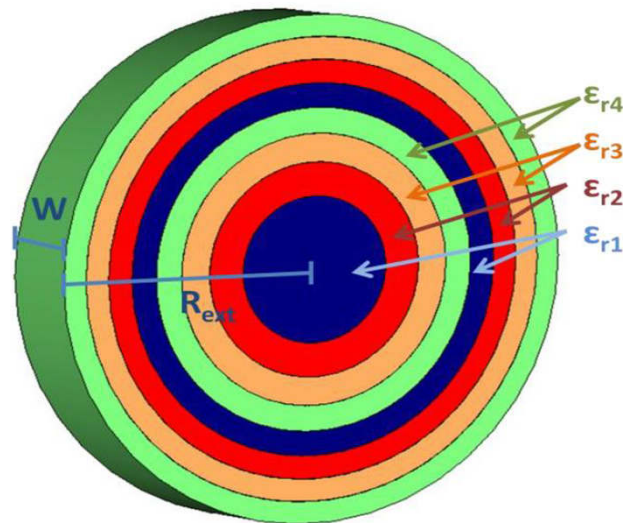
TERALINKS Broadband Wireless Link



TERALINKS Broadband Wireless Link



TERALINKS Transformational Optics For THz Lens Antennas



Conclusions

- ❖ **The two projects are in a very initial state**
- ❖ **Two strategies quite complementary**
 - ✓ Growing up from Microwave sources, WISDOM
 - ✓ Down converting from optical range, TERAHERTZ
- ❖ **Really exciting technology that it should be a reality as soon as possible, many people waiting for interesting results.**
- ❖ **So you should wait for the first results...**