TERA▲6G

TERAhertz integrated systems enabling 6G Terabit-per-second ultra-massive MIMO wireless networks

Guillermo Carpintero

Universidad Carlos III de Madrid, Spain

Co-funded by
the European Union

6G SNS

TERA6G Consortium

	Beneficiary		Beneficiary Short name
1.	Universidad Carlos III de Madrid	ES	UC3M
2.	Institute of Communications & Computer Systems	EL	ICCS
3.	Fraunhofer Heinrich-Hertz Institute	DE	FhG-HHI
4.	LioniX International BV	NL	LXI
5.	PHIX BV	NL	PHIX
6.	University of Piraeus Research Center	EL	UPRC
7.	Oulun Yliopisto	FI	UOULU
8.	Cumucore OY	FI	CMC
9.	Intracom Telecom Solutions	EL	ICOM
10.	Telefónica Investigación y Desarrollo	ES	TID
11.	Leapwave Technologies	ES	LWT
12.	Universidad Politécnica de Madrid	ES	UPM

**Hardware** | **Network** | **Socio-Economics**

TERA6G in a nutshell

TERA6G aims to unlock the Fiber-over-the-air concept

The goal is to enable wireless links with the information capacity of a fiber.

We use photonic integration technology to develop hardware components based on chiplets, which can be reconfigured through network orchestration commands to reach Terabit-per-second data throughput.
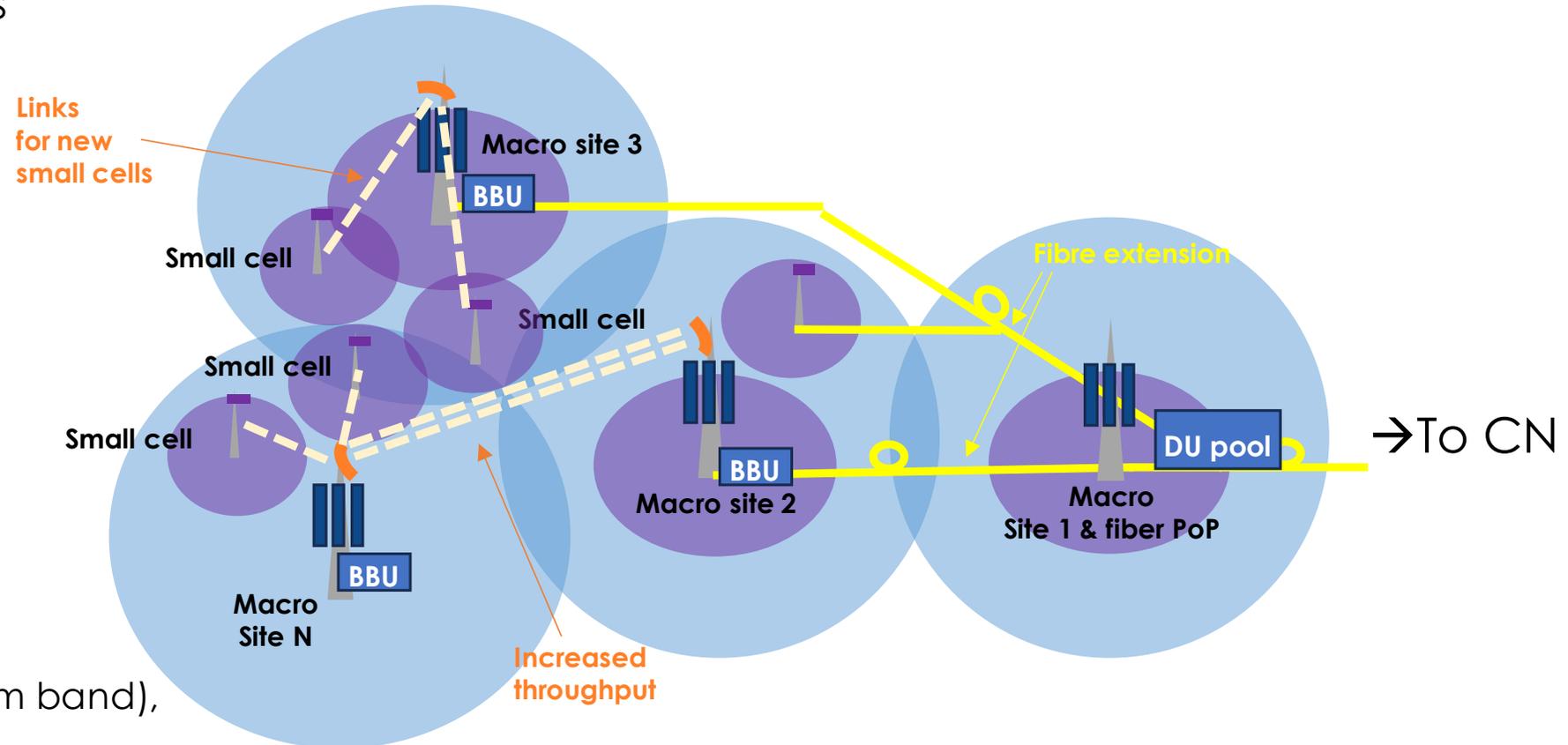
Agile (operating spectrum band),

Scalable (adapt network capacity) and

Reconfigurable (Comms and sensing)

Links for new small cells

Macro site 3

BBU

Small cell

Small cell

Small cell

Small cell

Fibre extension

→To CN

DU pool

BBU

Macro site 2

Macro Site 1 & fiber PoP

Macro Site N

BBU

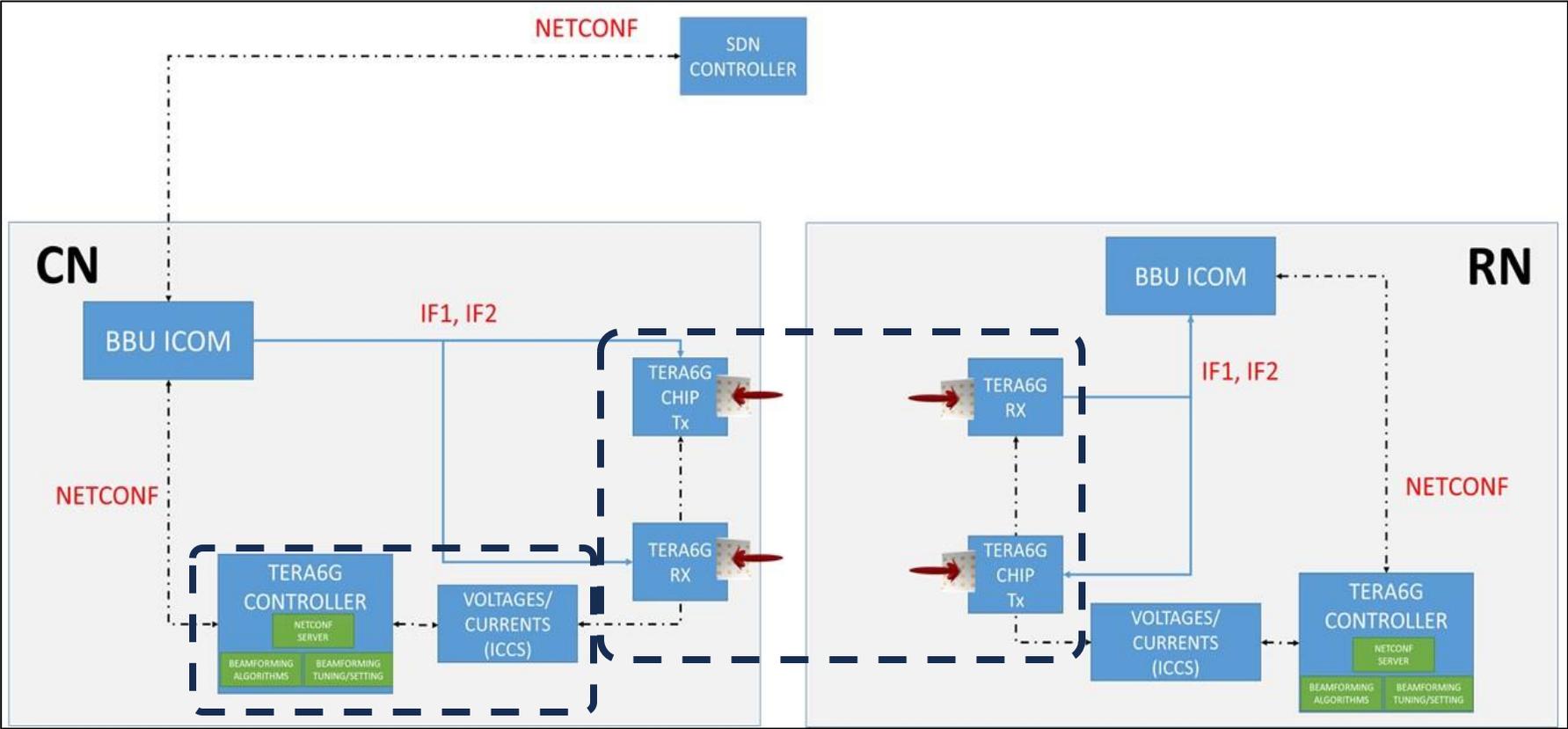Increased throughput

TERA6G Goals

TERA6G GOALS

- Develops a 6G millimetre/terahertz wave transmitter module based on Blass matrix optical beamforming network and 3D optical distribution network.

- Creates a scalable multi-beam receiver module for 6G millimetre/terahertz wave transmissions using hybrid photonic integration technology.

- Assembles and demonstrate the developed transmitter and receiver modules with functionalities such as terabit-per-second wireless data links, channel sounding, and radar ranging.

- Designs network functions and interfaces to manage multi-beam THz wireless systems resources and integrate them into existing end-to-end orchestrated communication networks, following 3GPP standards.

- Develops methods and algorithms to maximise the energy efficiency of THz wireless multi-beam nodes in dynamic networks using a Data Analytics Function (DAF).
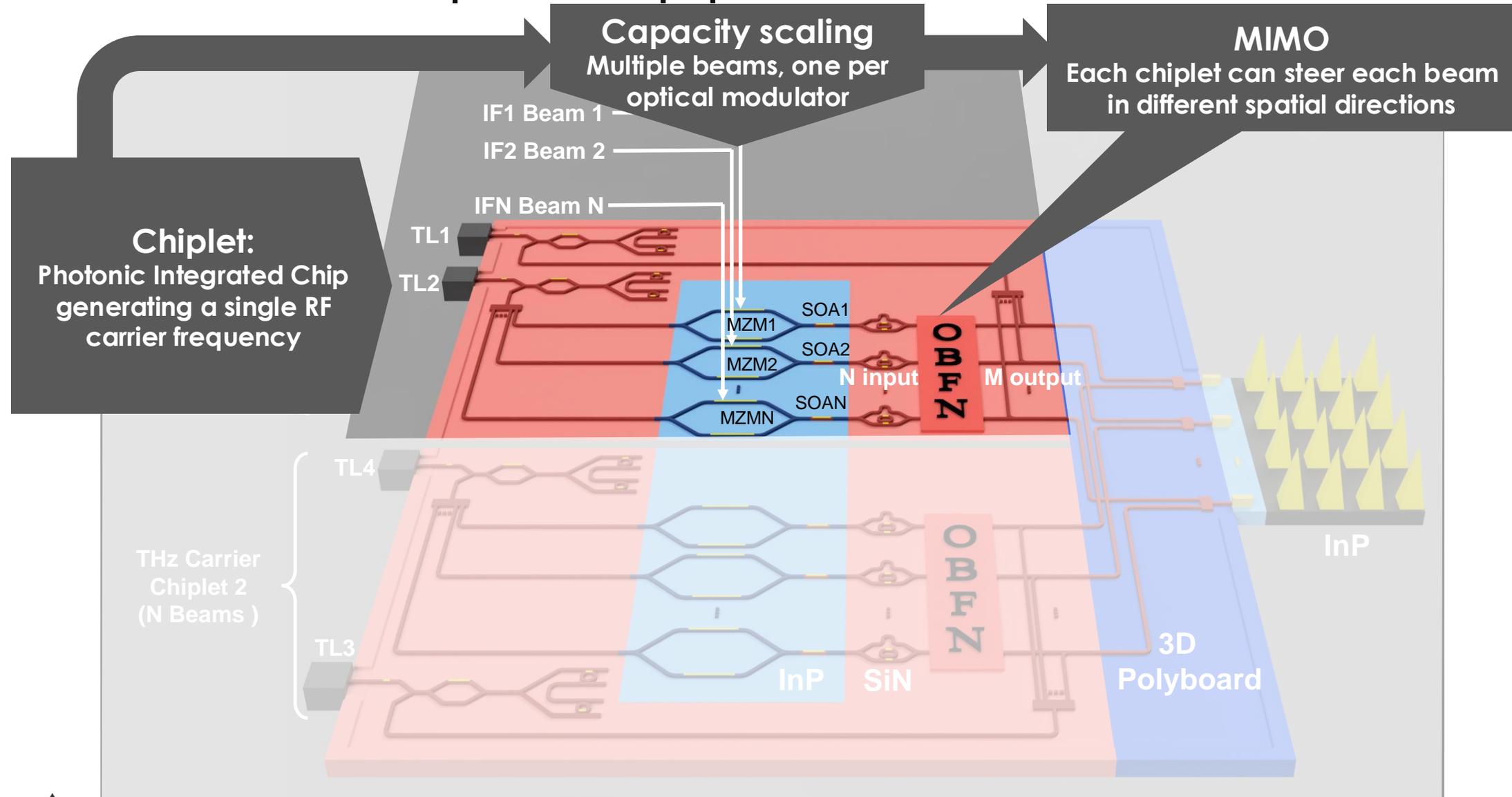
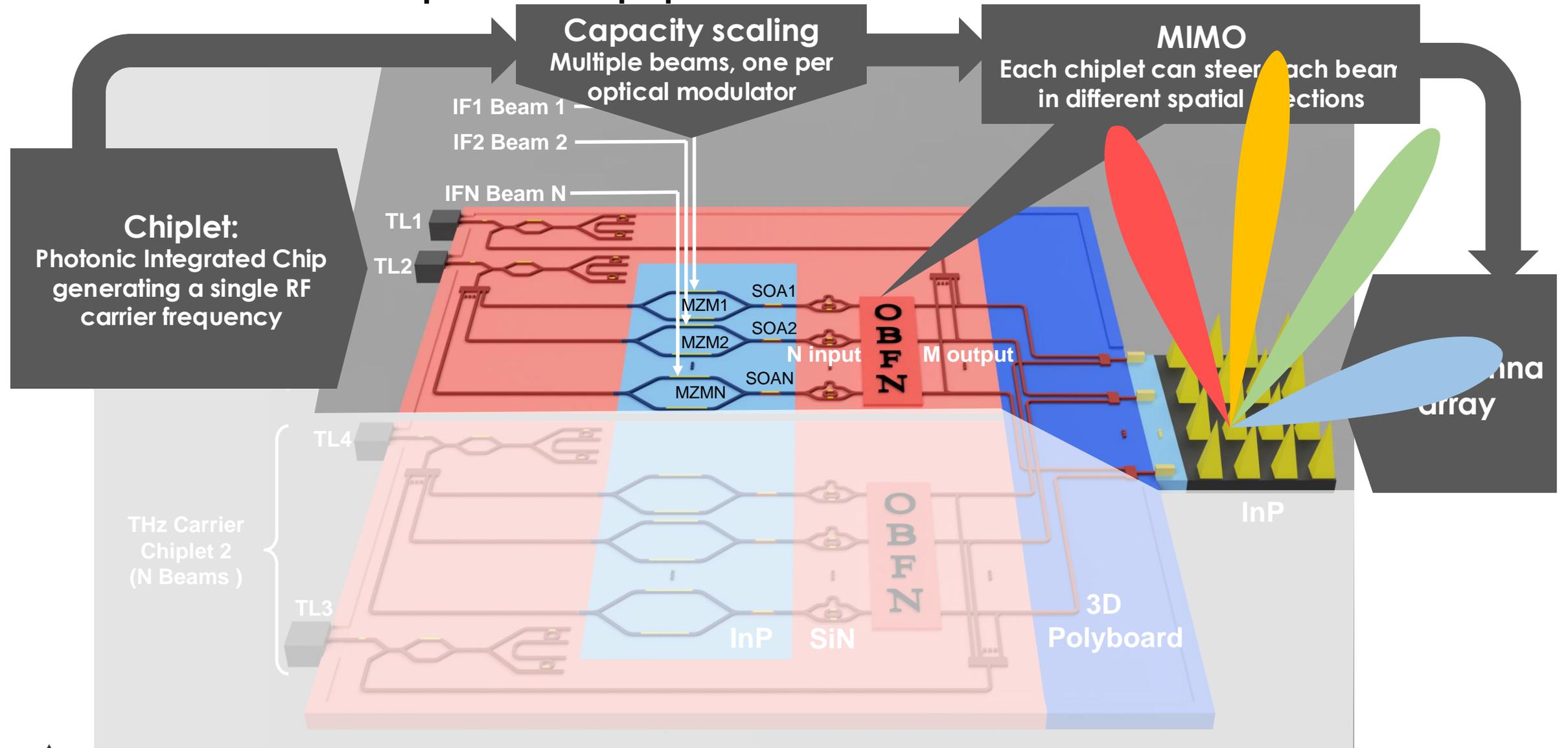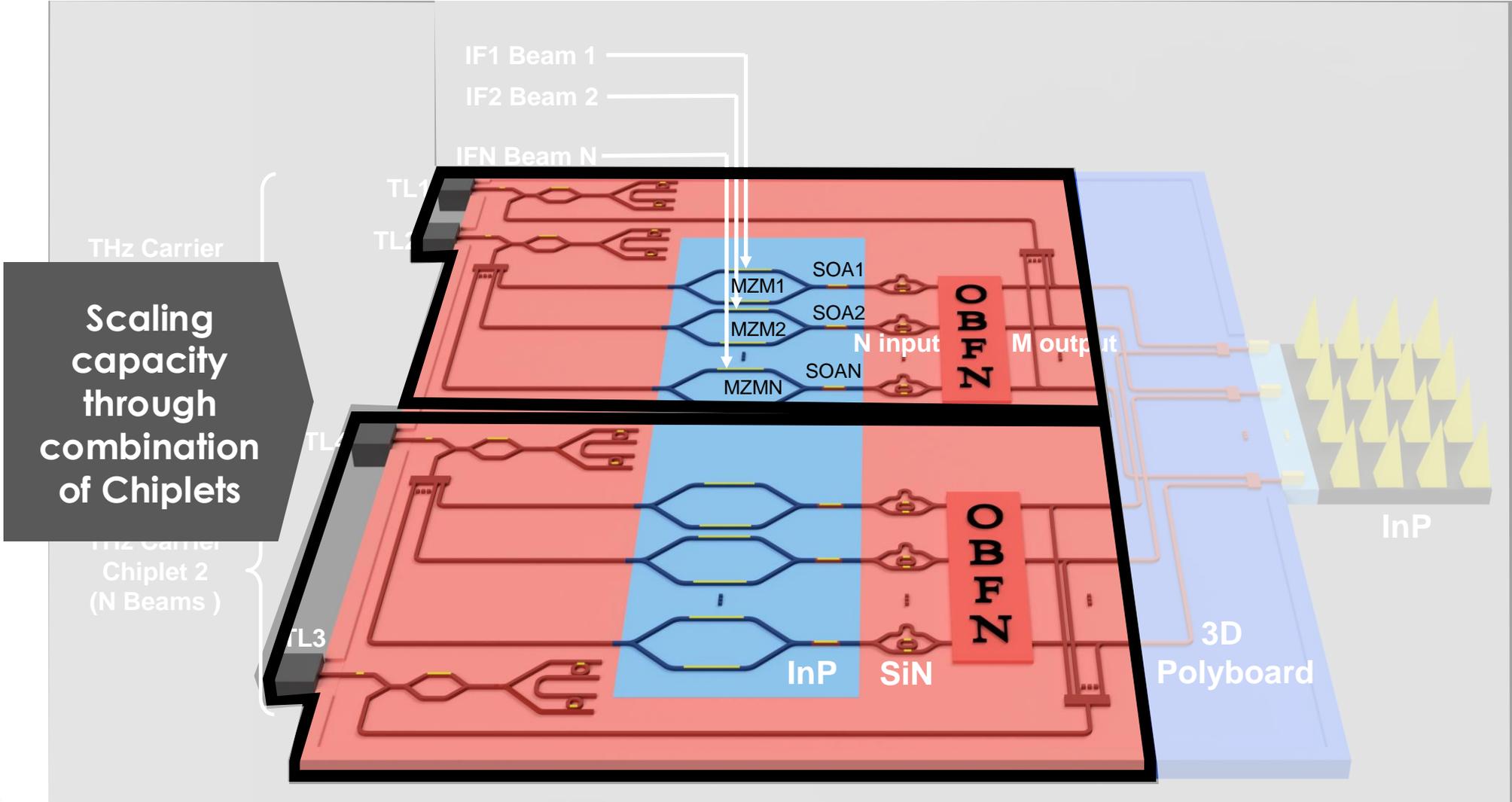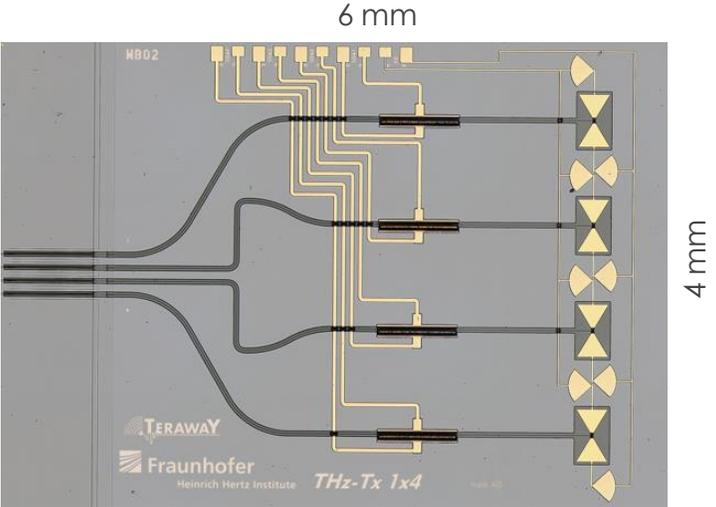| Attribute	Requirement - xHaul small cell	Requirement - smart factory
Remote nodes (RNs) per central node (CN)	Max: 6 Min: 2	Max: 10 (2 CNs/factory) Min: 2 (4 CNs/factory)
Channels (ch) per RN	Max: 4 (2 spatial ch/freq; 2 freq) Min: 2 (1 spatial ch/freq; 2 freq)	Max: 4 (2 spatial ch/freq; 2 freq) Min: 2 (1 spatial ch/freq; 2 freq)
Number of Tx and Rx ch	Max: 24 (4ch ´ 6RN) Min: 4 (2ch ´ 2RN)	Max: 40 (4ch ´ 10RN) Min: 4 (2ch ´ 2RN)
Distance (m)	Max: 100 Min: 30	Max: 30 Min: 10
Rate (Gbit/s) per ch	Min: 100 Gbit/s	Min: 100 Gbit/s
Frequency	Min: 1st THz window (252 GHz – 322 GHz) & D-band (110 GHz – 170 GHz) & W-band (75 GHz – 100 GHz)	Min: 1st THz window (252 GHz – 322 GHz) & & D-band (110 GHz – 170 GHz) & W-band (75 GHz – 100 GHz)
Scan Angle (°) horizontal plane	Max: ±60 Min: ±45	Max: ±60 (2 CNs/factory) Min: ±30 (4 CNs/factory)
Scan Angle (°) vertical plane	Min: ±45	Max: ±60 (2 CNs/factory) Min: ±45 (4 CNs/factory)

TERA6G architecture

TERA6G chiplet approach

Capacity scaling
Multiple beams, one per optical modulator

MIMO
Each chiplet can steer each beam in different spatial directions

Chiplet:
Photonic Integrated Chip generating a single RF carrier frequency

IF1 Beam 1
IF2 Beam 2
IFN Beam N

TL1
TL2

SOA1
MZM1
SOA2
MZM2
SOAN
MZMN

OBFN

N input   M output

THz Carrier Chiplet 2 (N Beams)

TL4
TL3

OBFN

InP   SiN

InP

3D Polyboard

TERA6G chiplet approach

Capacity scaling
Multiple beams, one per optical modulator

MIMO
Each chiplet can steer each beam in different spatial directions

Chiplet:
Photonic Integrated Chip generating a single RF carrier frequency

IF1 Beam 1
IF2 Beam 2
IFN Beam N

TL1
TL2

SOA1
MZM1
SOA2
MZM2
SOAN
MZMN

N input   M output

O B F N

THz Carrier Chiplet 2 (N Beams)

TL4
TL3

InP   SiN

3D Polyboard

InP

Antenna Array

TERA6G chiplet approach

Scaling capacity through combination of Chiplets

IF1 Beam 1
IF2 Beam 2
IFN Beam N

TL1
TL2

THz Carrier

TL4

THz Carrier Chiplet 2 (N Beams)

TL3

MZM1 SOA1
MZM2 SOA2
MZMN SOAN

N input OBFN M output

InP SiN

OBFN

3D Polyboard

InP

TERA6G advances in the 2D antenna array

6 mm

4 mm

Packaged by

Effective index technique used to
have 4 independent DRA
in a single silicon piece
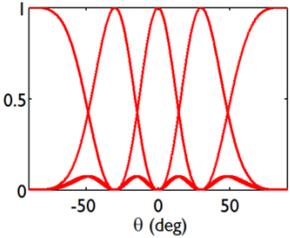

210 GHz
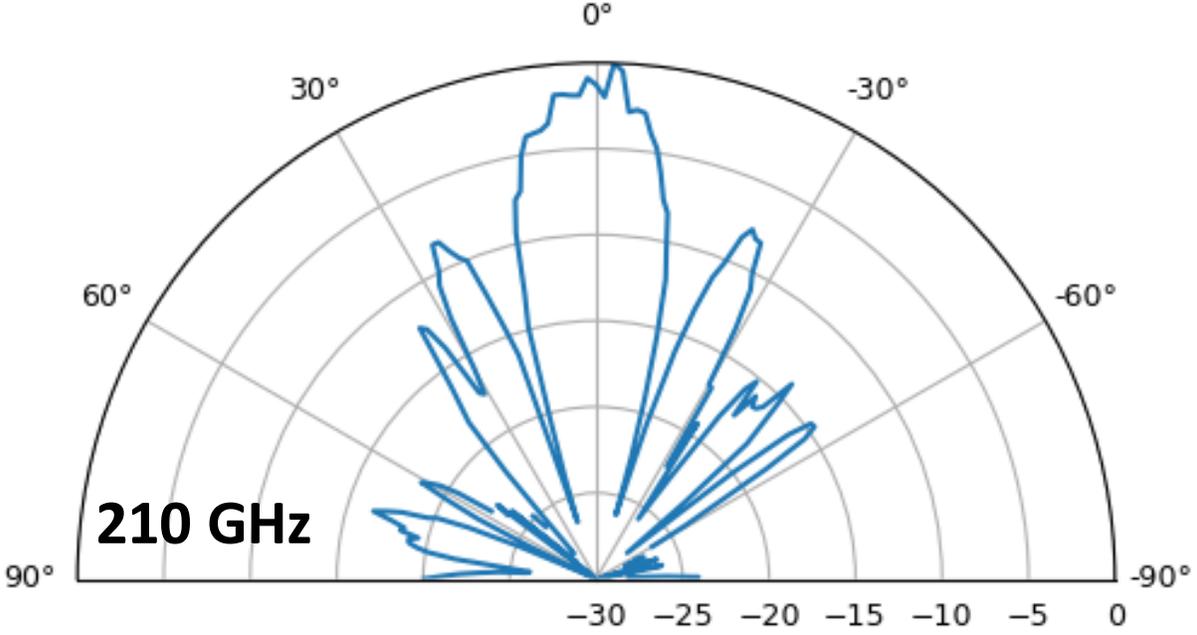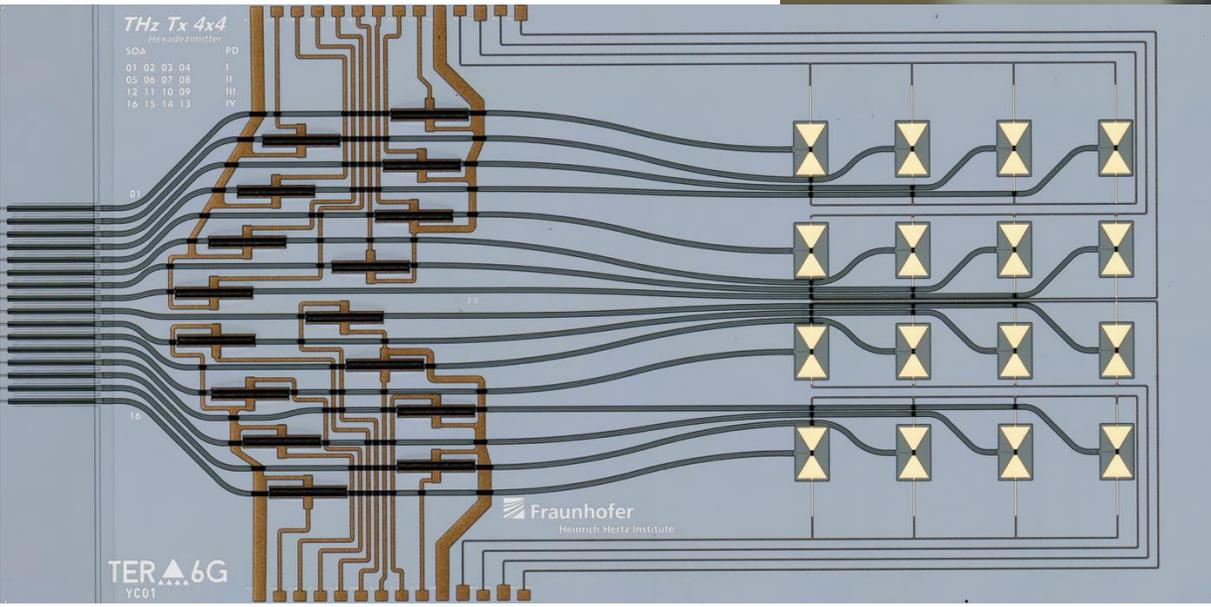
Total power (1x4): -11.3 dBm (I_{SOA}@150 mA)

TERA6G beamsteering control

TERA6G beamsteering control

level 1: 2^1 codewords

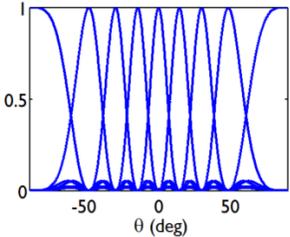**level 2: 2^2 codewords**

level K: 2^k codewords
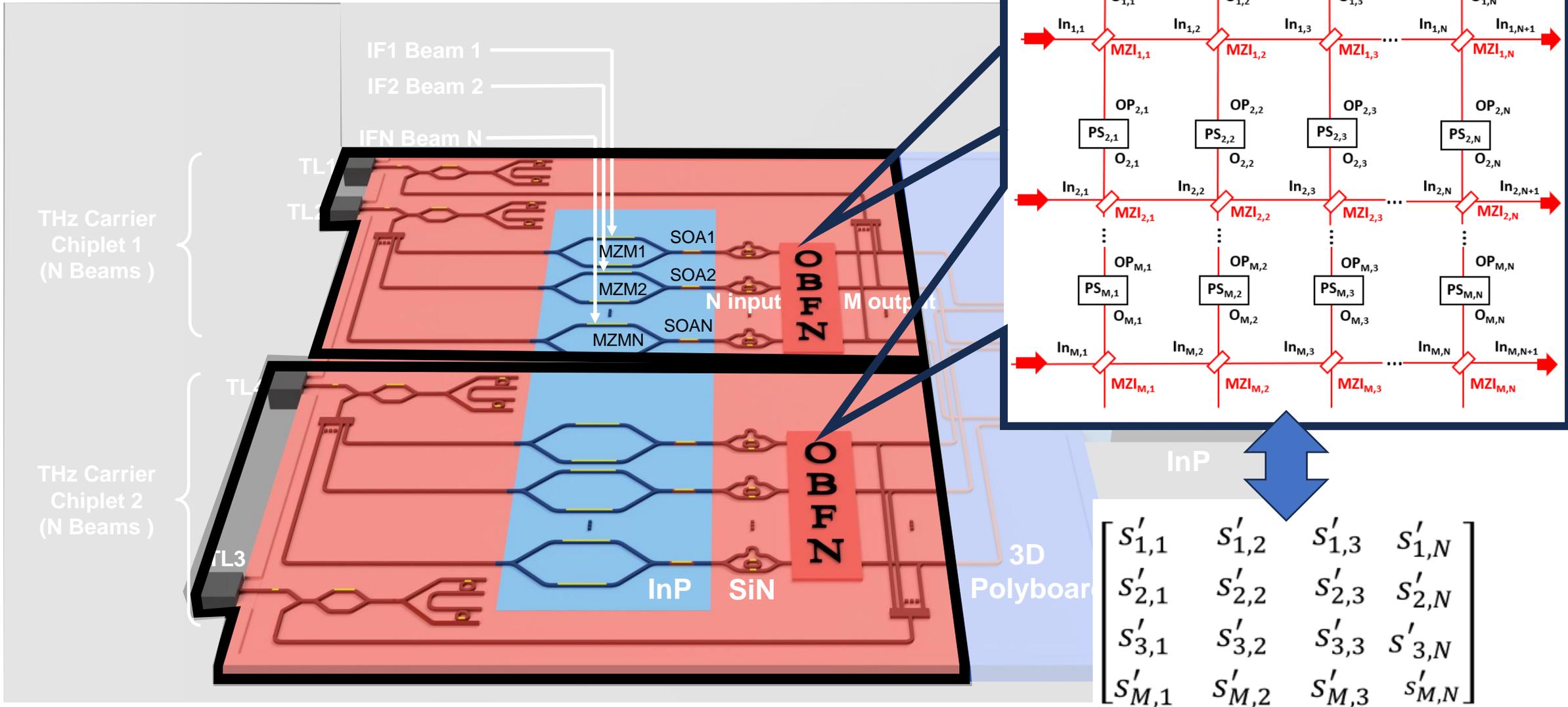
N = 16 antenna elements (K = 4 levels)
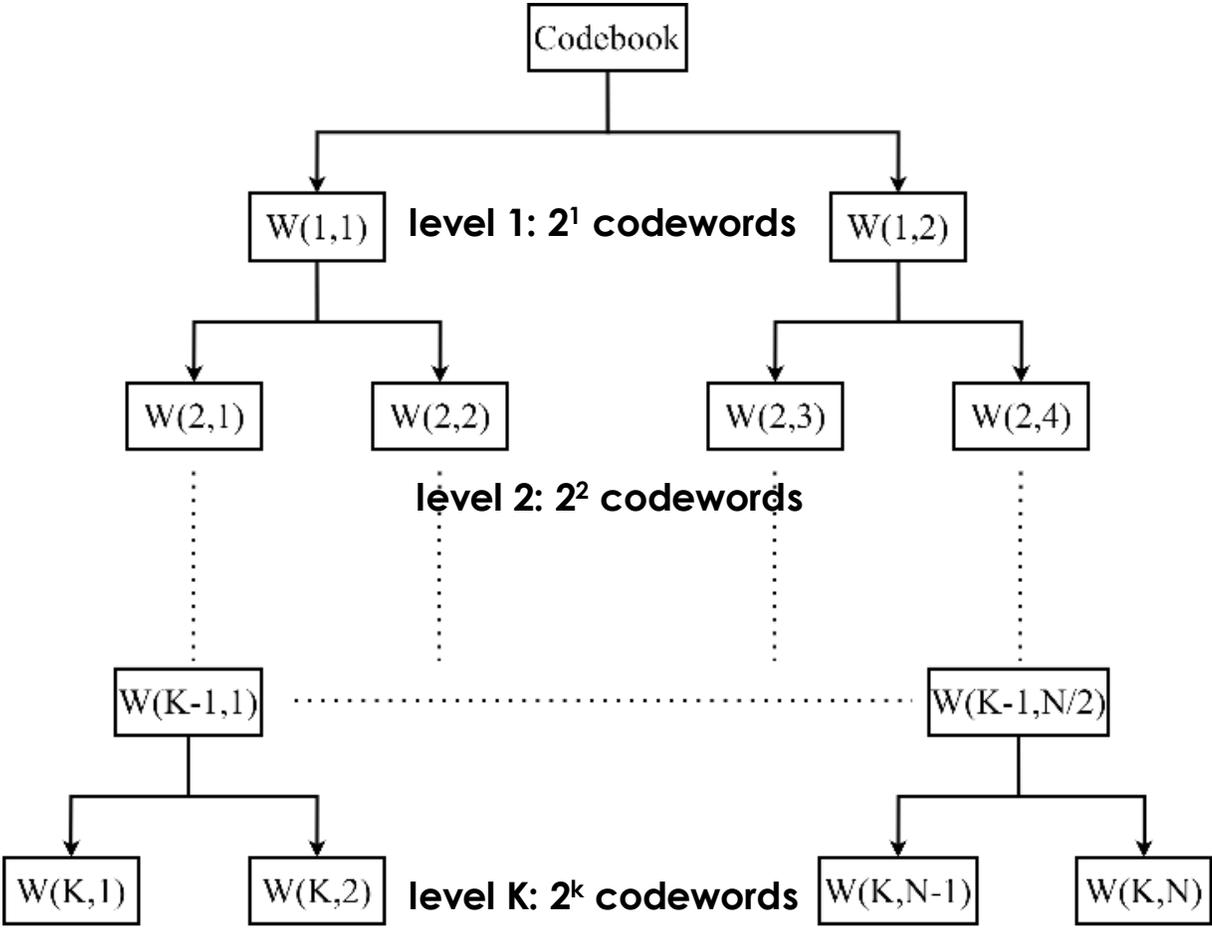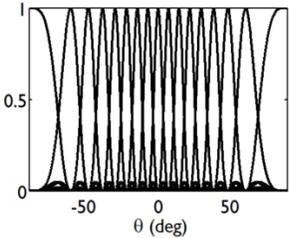
Level 1

Level 2

Level 3

Level 4
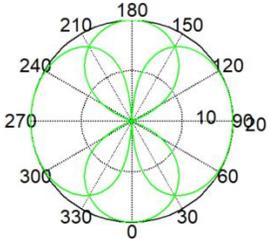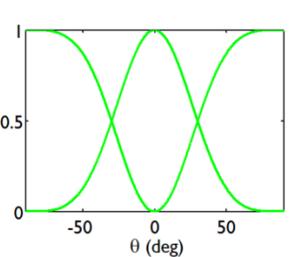
Thank you!
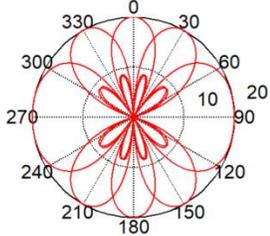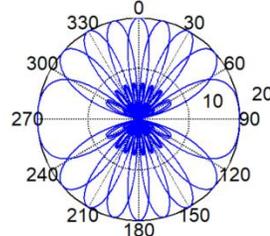
guiller@ing.uc3m.es
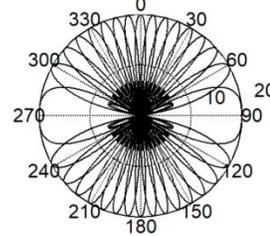
TERA△6G

Project contact email   tera6g@uc3m.es
Project website: uc3m.es/research/tera6g
Instagram: tera6g_eu_6gsns
LinkedIn   TERA6G Project