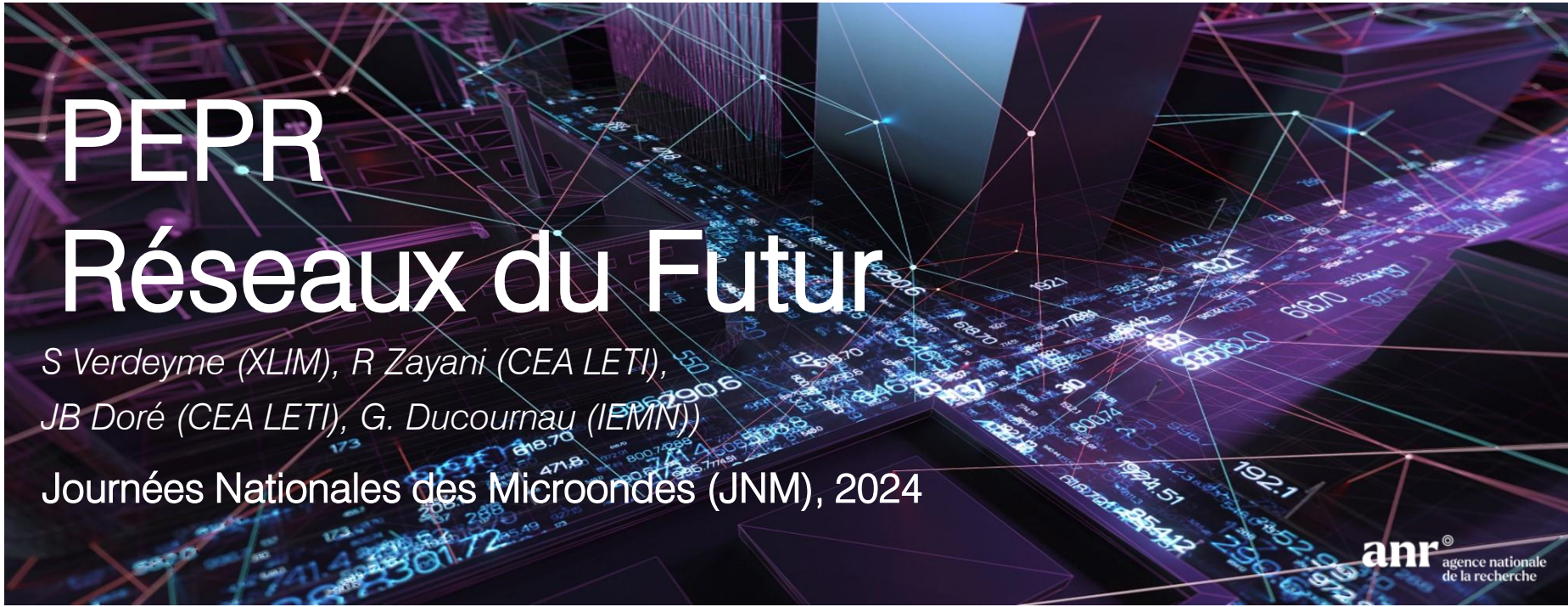


PEPR Réseaux du Futur

S Verdeyme (XLIM), R Zayani (CEA LETI),
JB Doré (CEA LETI), G. Ducournau (IEMN))

Journées Nationales des Microondes (JNM), 2024

PROGRAMME DE RECHERCHE FUTURE NETWORKS

PEPR Réseaux du futur

Positionnement du PEPR

Dimitri Kténas, CEA

Daniel Kofman, IMT

Serge Verdeyme, CNRS

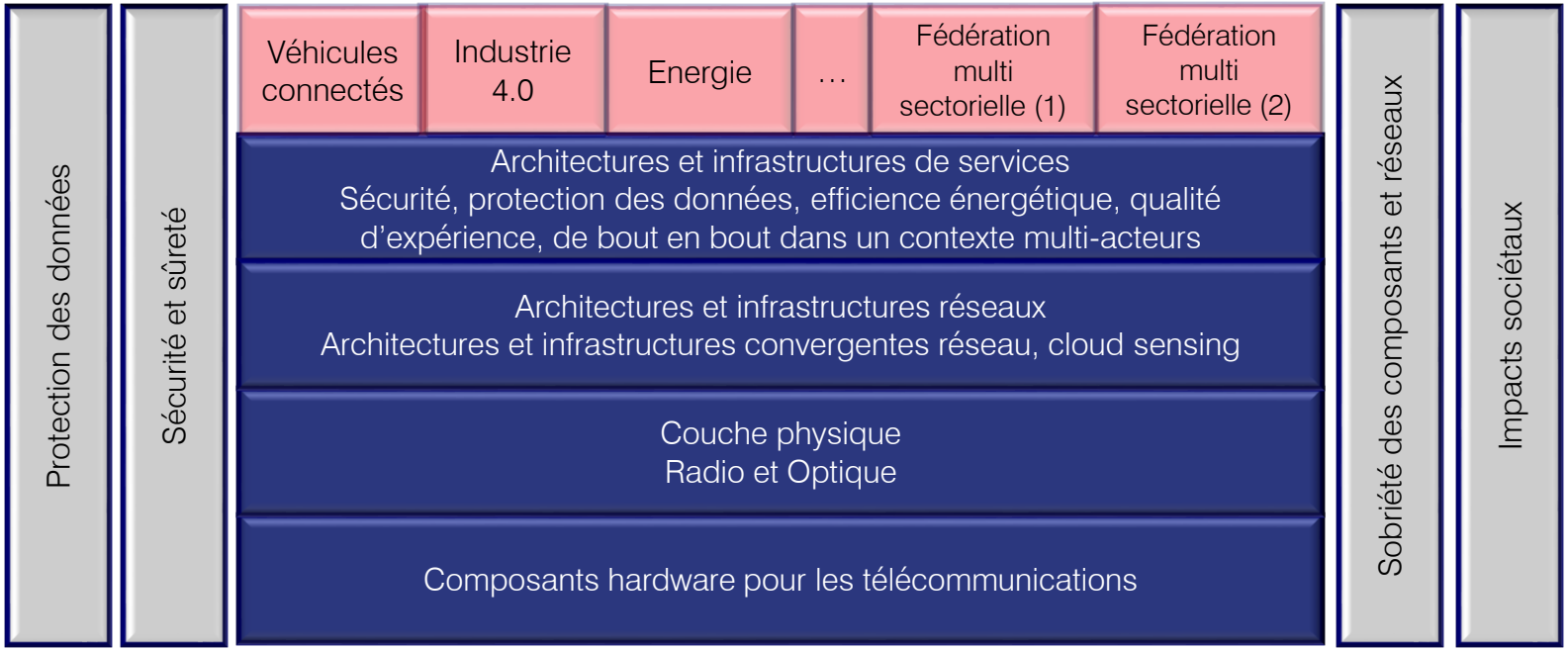
Contexte Général

PIA4 et Stratégie nationale sur les réseaux du futur

- Contribuer à la compétitivité de l'économie française en développant les usages 5G au profit des territoires et de l'industrie - **Axe 1** (volet demande);
- Constituer une offre française souveraine sur les réseaux télécoms à horizon 2022-2023 - **Axe 2** (volet offre);
- Soutenir une R&D française de très haut niveau sur les futures technologies de réseaux - **Axe 3** (volet R&D);
- Renforcer l'offre de formation sur les futurs réseaux télécoms et attirer les talents étrangers en France - **Axe 4** (volet formation).

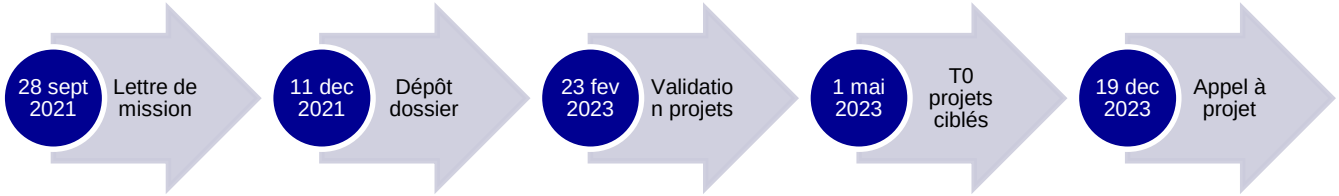
→ Instrument: PEPR

Couverture thématique du programme



Positionnement complémentaire entre PEPR (Cloud, Cyber, Electronique)

La structuration en projets



10 projets ciblés : 40.5 M€ (Recrutement de 104 doctorants, 67 post doc)
AAP Photonique, SES/SHS, Réseaux : 7.5 M€ 6 M€ restent à engager

Total 54 M€

Architecture des reseaux et des services

Project 1 – Archi and infra. Services
Project 2 + AAP – Archi and infra. Networks

Briques technologiques

Projet 3 – « Cell free » sub 6GHz
Projet 4 – Bande millimétrique
Projet 5 – Vers le THz
AAP - Photonique

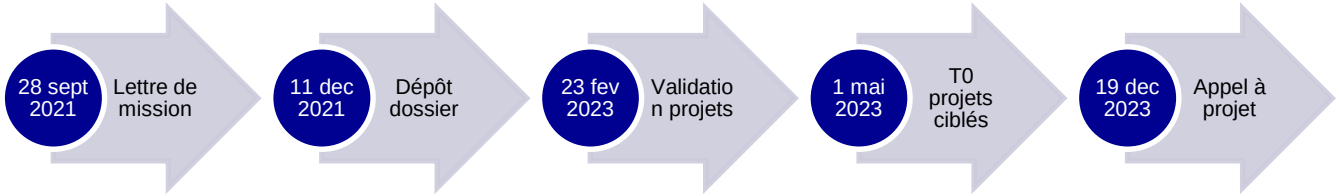
Systèmes de bout en bout

Project 6 – IoT et services enrichisProject 7 – Réseaux sobres et ajustés
Project 8 – Sécurité et protection des données
Project 9 – Fondamentaux des futurs réseaux
AAP – SES/SHS

Validation expérimentale démonstrateurs

Plateformes ouvertes et mutalisées

La structuration en projets



10 projets ciblés : 40.5 M€ (Recrutement de 104 doctorants, 67 post doc)
AAP Photonique, SES/SHS, Réseaux : 7.5 M€ 6 M€ restent à engager

Total 54 M€

Technology Building blocks

PERSEUS : Power-EfficientRadio interface for Sub-7GHz distributEd massive MIMO infrastructUreS

Rafik Zayani (CEA)

YACARI: 5G+ systems: High Data Rate in Millimetre Band (FR2 and < 90 GHz)

Jean-Baptiste Doré (CEA)

SYSTERA: Devices and SYStems enabling Ultra High Data-rates links in sub-TERAhertz

Jean-Baptiste Doré (CEA), pour Guillaume Ducournau (CNRS)

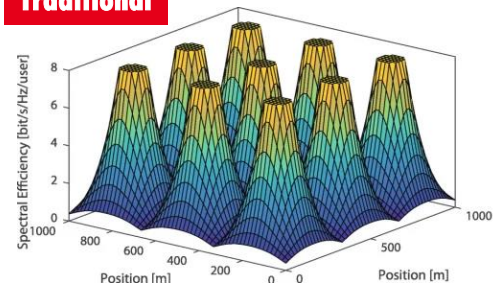
PERSEUS

Rafik Zayani (CEA-Leti)

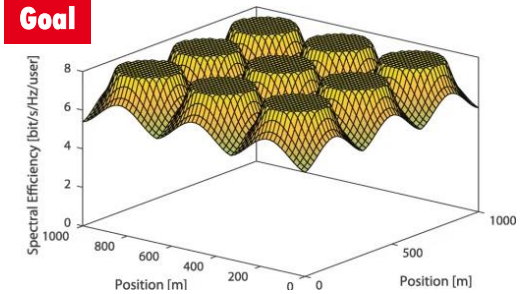
NF-PERSEUS

Power-Efficient Radio interface for Sub-7GHz distributEd massive MIMO infrastructUreS

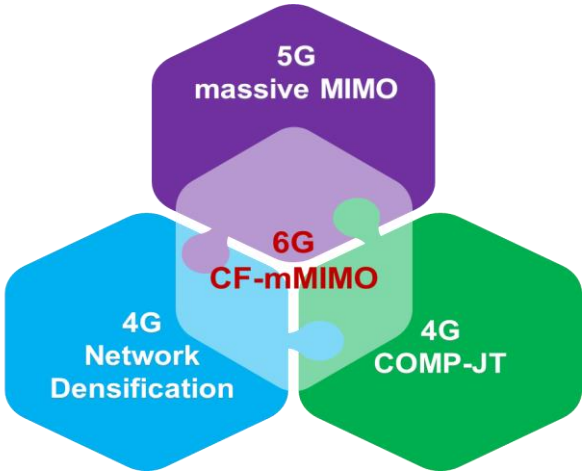
Traditional

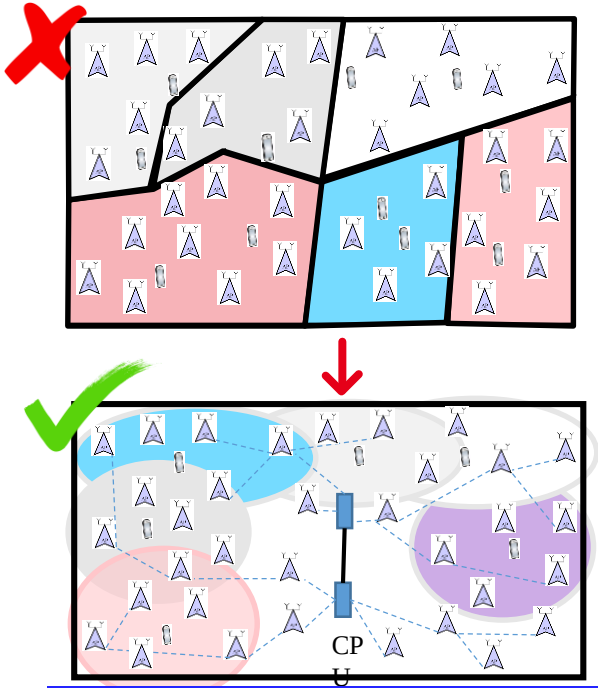


Goal



More consistent good Service Quality!





Going beyond the cellular paradigm

Enjeux et Objectifs scientifiques

- ❑ Accroître la **maturité** de la technologie **« sub-7GHz Cell-free massive MIMO »**
  - ✓ Evaluation des technologies CF-mMIMO sur des scénarios réalistes (propagations et imperfections matérielles)
- ❑ **Passage à l'échelle** des solutions CF-mMIMO sous contrainte d'efficacité énergétique
  - ❑ Solutions *PHY*, *MAC* pour CF-mMIMO **scalable**
  - ❑ *Antennes* et *circuits*: faible consommation énergétique
- ❑ **RIS** and **AI**
- ❑ **Ecosystème:** Démontrer les meilleurs compromis cout/complexité/performance

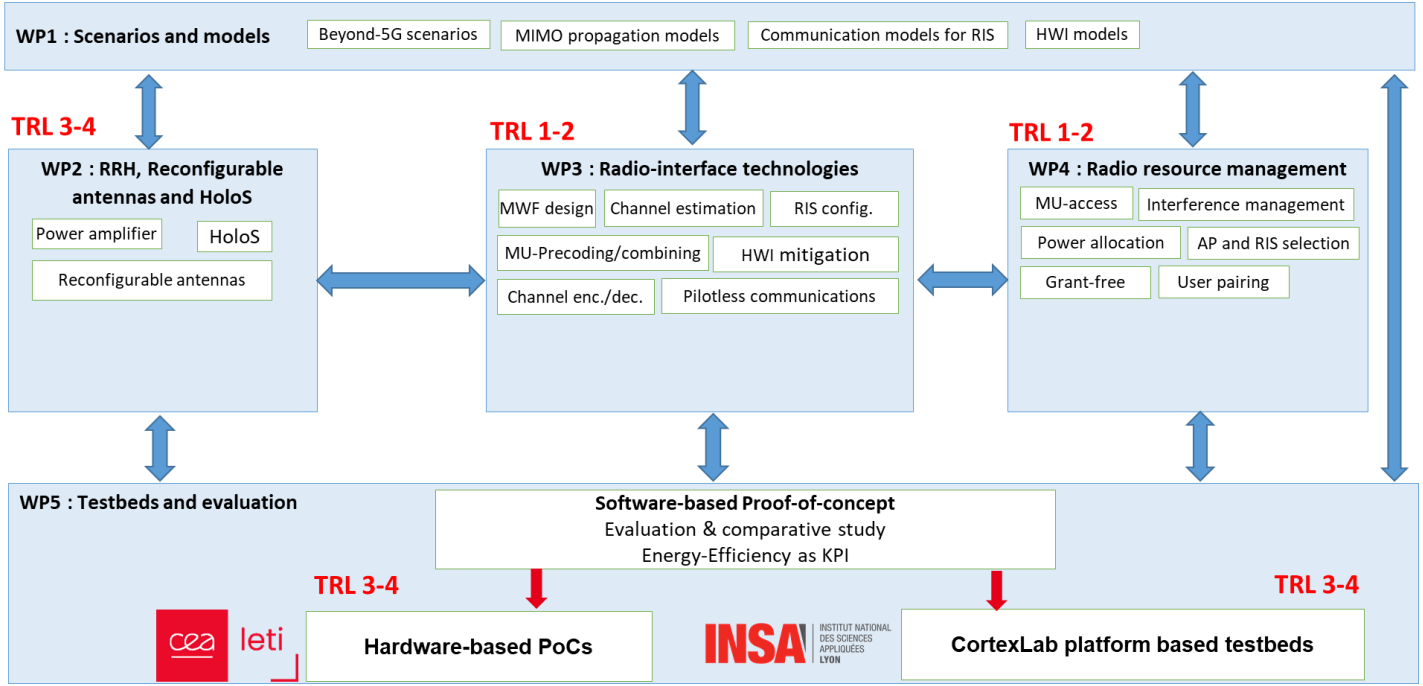
❑ Réseaux privés

❑ Communications d'urgence et de secours

❑ Applications à faible consommation énergétique

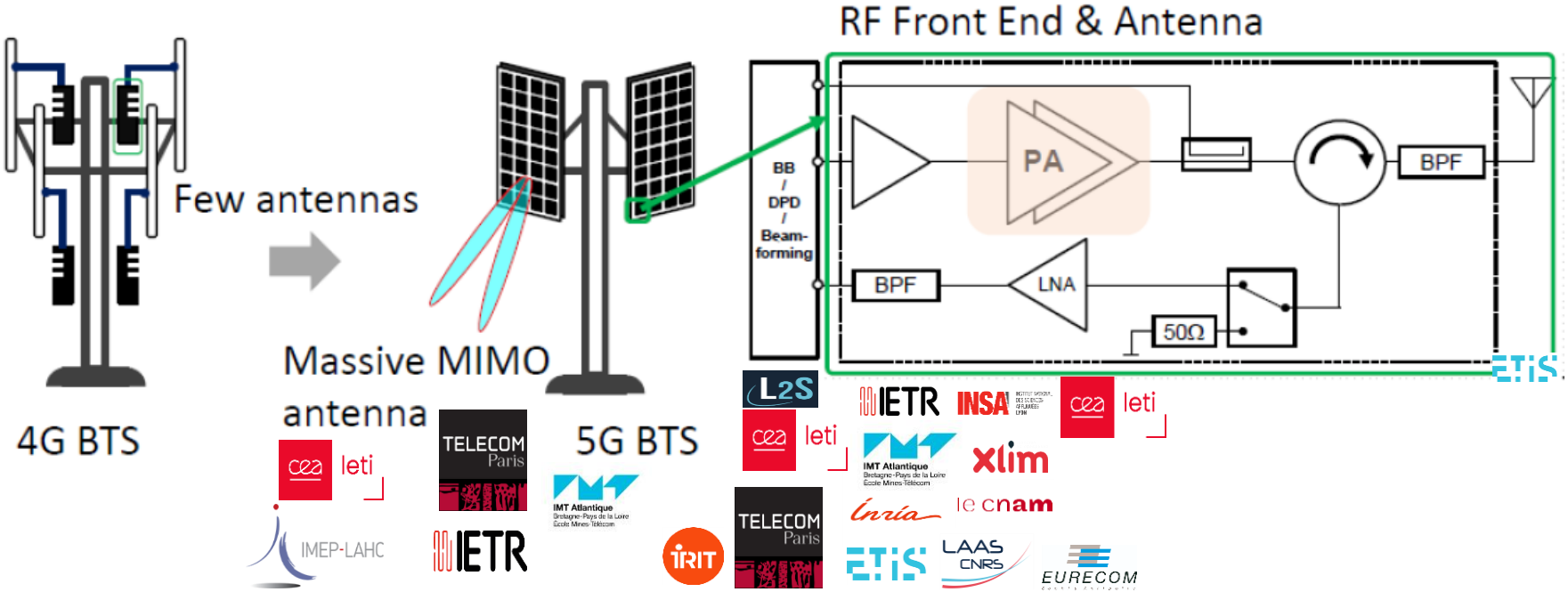
Structure du projet

Coordinator : Rafik Zayani (CEA)

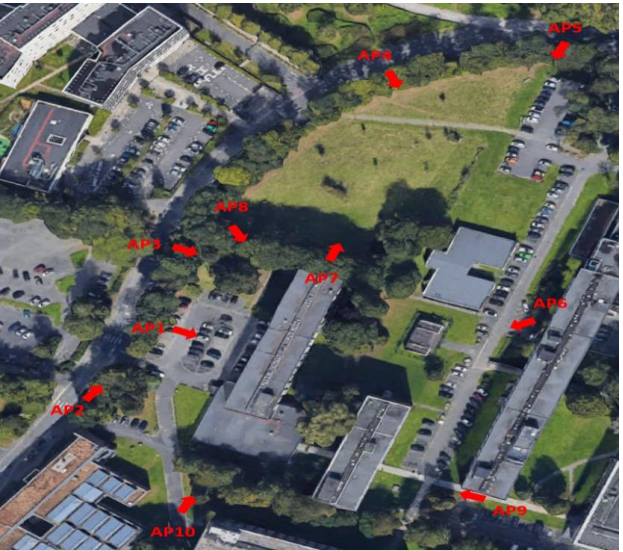


Prochaines étapes

- ❑ Design of scalable PHY and MAC solutions
- ❑ Design of innovative power amplifier architectures
- ❑ Design of advanced antenna structures
- ❑ Design of RIS

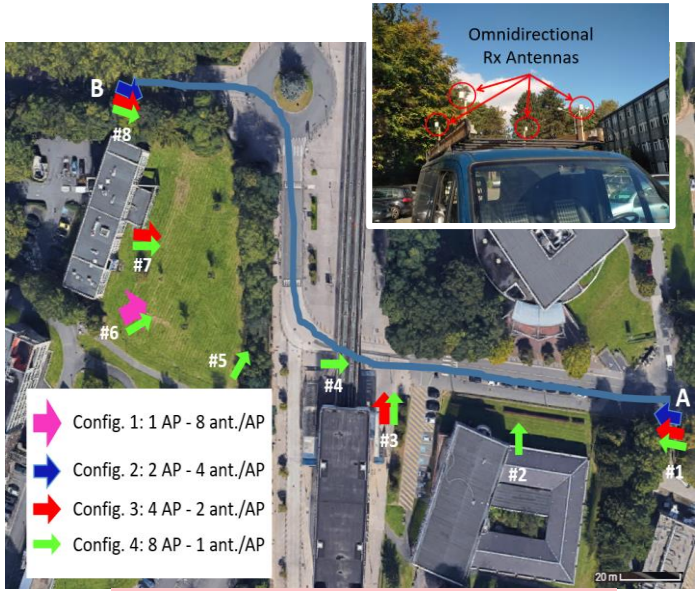


FOCUS# Definitions of NF-PERSEUS uses-cases/scenarios

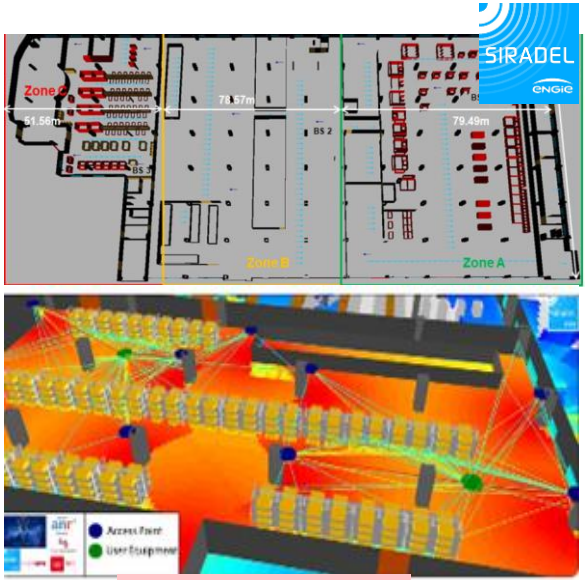


[S1] Tbps experienced data rates for ultra-dense areas

Cité Scientifique campus à Villeneuve d'Ascq



[S3] V2I in sub-urban environment



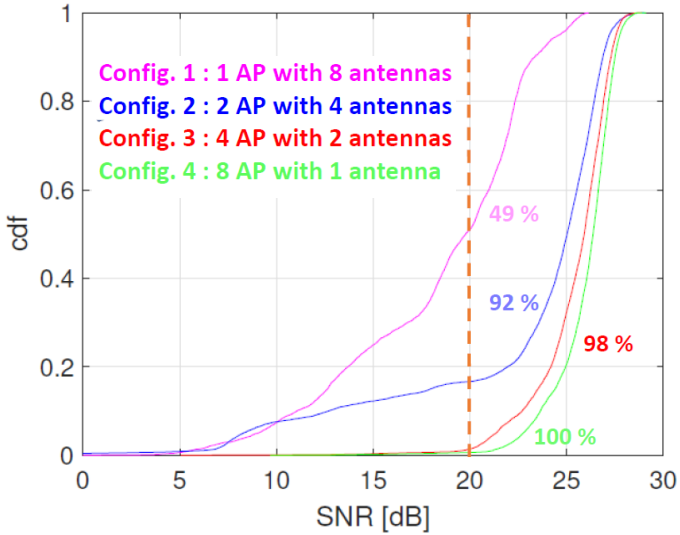
[S2] Smart factory

[D1] Deliverable D1 - Technical Report NF-PERSEUS 2023 : https://cea.hal.science/cea-04564147/

FOCUS# Measurement of Radio Channel in Cell-free Networks

V2I Channel with the Distributed MaMIMOSA Channel Sounder

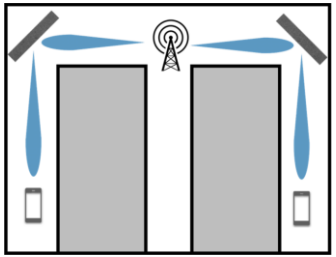
[S3] V2I in sub-urban environment



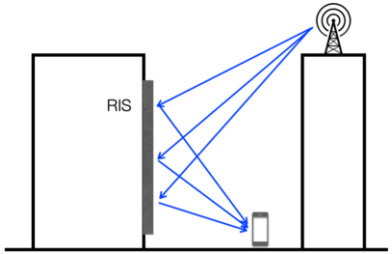
More consistent good Service Quality offered by distributed MIMO!

FOCUS# ETSI-ISG Use cases & Communication models for RIS

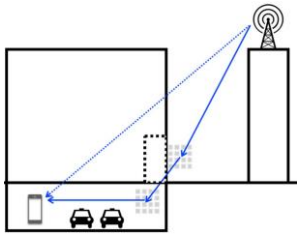
Coverage enhancement



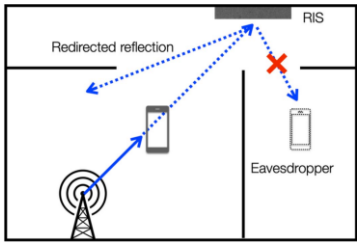
Spectral efficiency



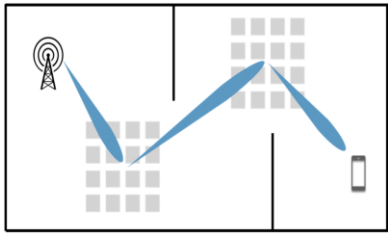
Beam management



Physical layer security

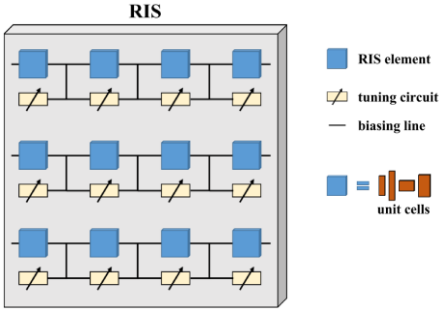


Localization and sensing

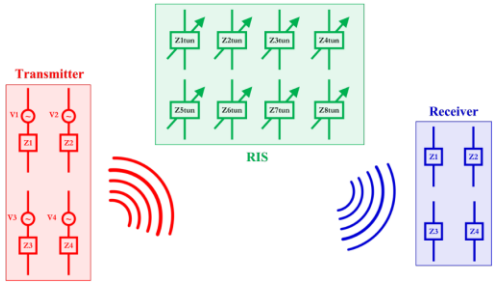


Energy efficiency

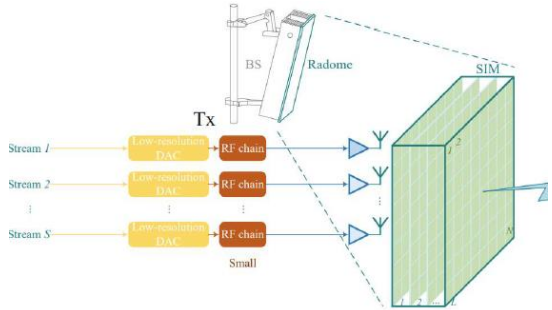
Locally Periodic Discrete Model



Multiport Network Model



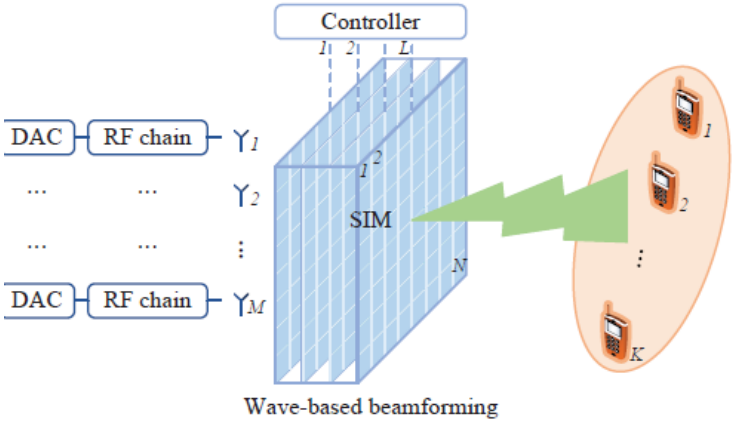
Stacked Intelligent Metasurface (SIM)

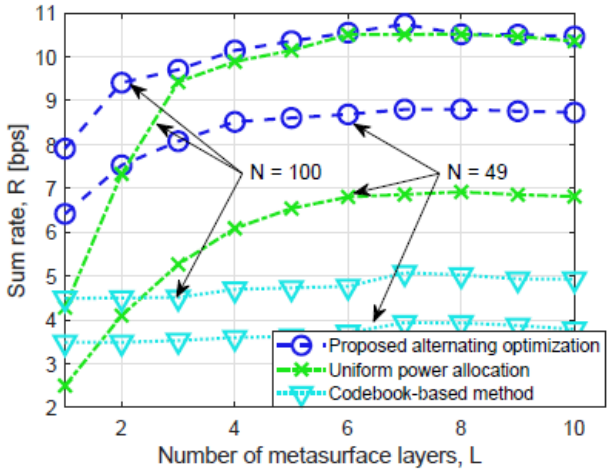


[D1] Deliverable D1 - Technical Report NF-PERSEUS 2023 : https://cea.hal.science/cea-04564147/

FOCUS# Holographic Communications

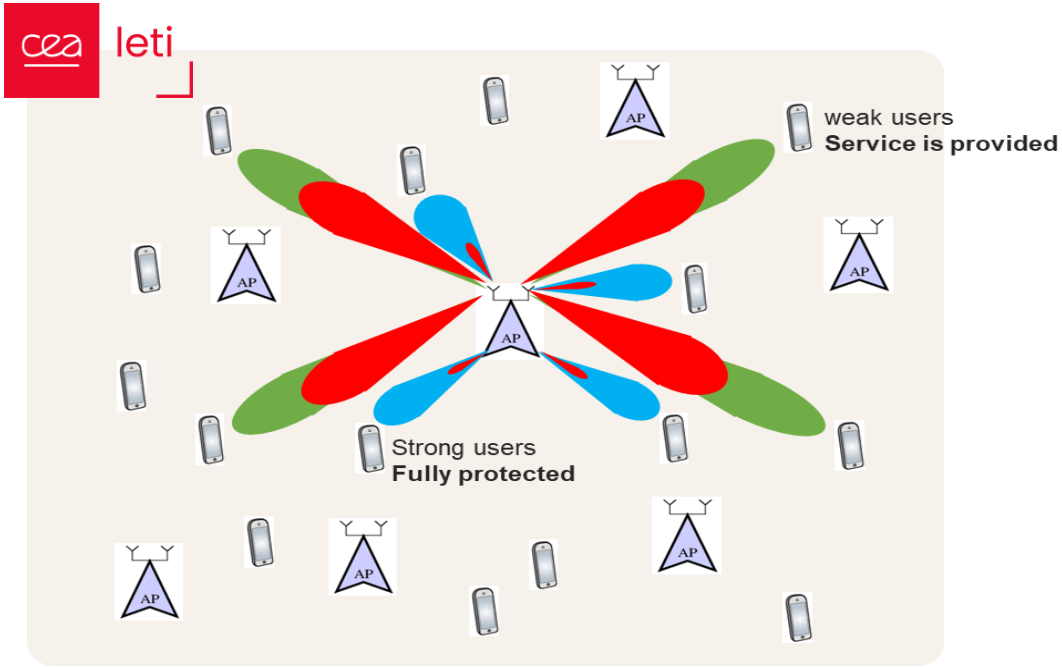
SIM-based MU beamforming in the wave-domain



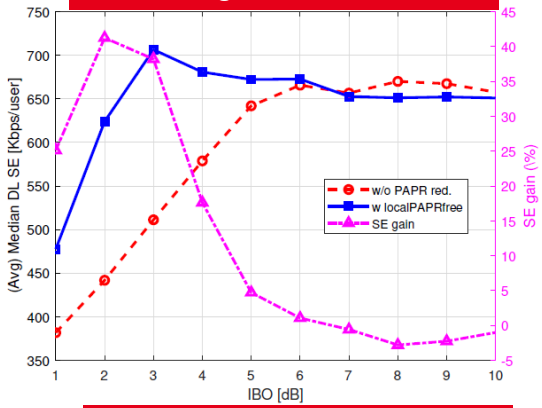


L2S Laboratoire Signaux & Systèmes

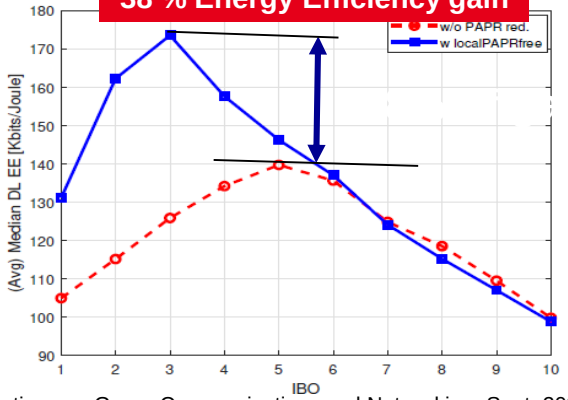
FOCUS# Hardware-aware Pecoding for Cell-free massive MIMO



60 % SE gain @ IBO = 3 dB



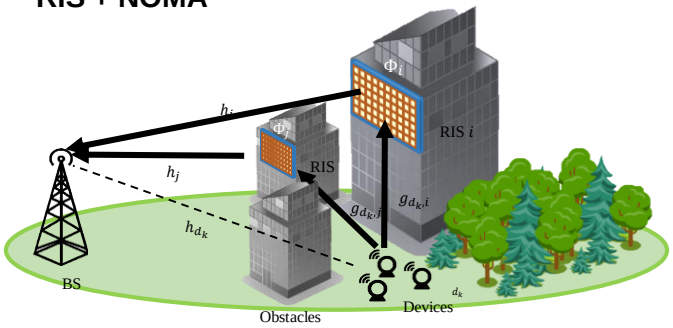
38 % Energy Efficiency gain

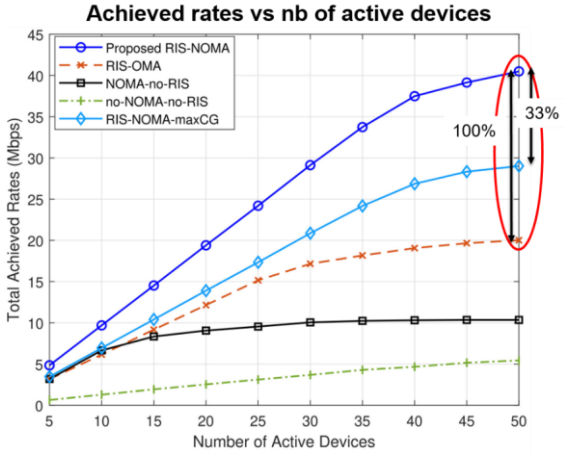


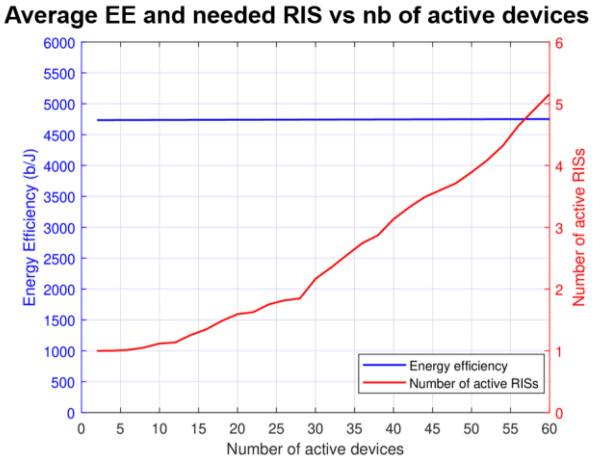
[ZAY23] R. Zayani, et al. "Local PAPR-Aware Precoding for Energy-Efficient Cell-Free Massive MIMO-OFDM Systems," in IEEE Transactions on Green Communications and Networking, Sept. 2023.

FOCUS Distributed grant-free resource allocation for multiple access

RIS + NOMA







IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

- ~33% gain for 50 devices when compared to prior art works
- ~100% gain for 50 devices when compared to OMA method

- EE maintained at a constant level for a same requested rate for the devices
- In average for 40 devices, 3 RISs are essential for a constant EE.

YACARI

Jean-Baptiste Doré (CEA-Leti)

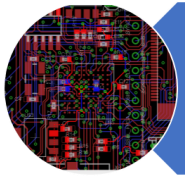
Au-delà de la 5G : Circuits, antennes et RIS mmWave

Enjeux et Objectifs scientifiques (techniques et écosystème)

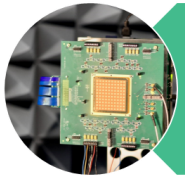
1. Maturation des technologies RF & PA (SOI/GaN)
2. Proposer des systèmes antennaires mmWave performants et intégrés
3. RIS: Conception, caractérisations, intégration dans le réseau
4. Explorer de concepts système/traitement du signal autour du traitement d'antennes, JCAS et RIS

Champs d'application

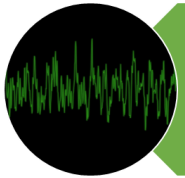
1. Mobile et gNodeB: 5G mmWave => FR3
2. Communications satellitaire
3. V2X



Advanced mmWave circuits and sub-systems



New active antenna & RIS concepts



Dedicated signal processing

HPA design & integration

mmWave Integrated circuits

Technological demonstrators

Phase array design

Holographic beamforming-based

RIS design & propagation model

Technological demonstrators

RIS & Radio functionalization

Beamforming

System architecture

TELECOM Paris

L2S Laboratoire Signaux & Systèmes

xlim iemn

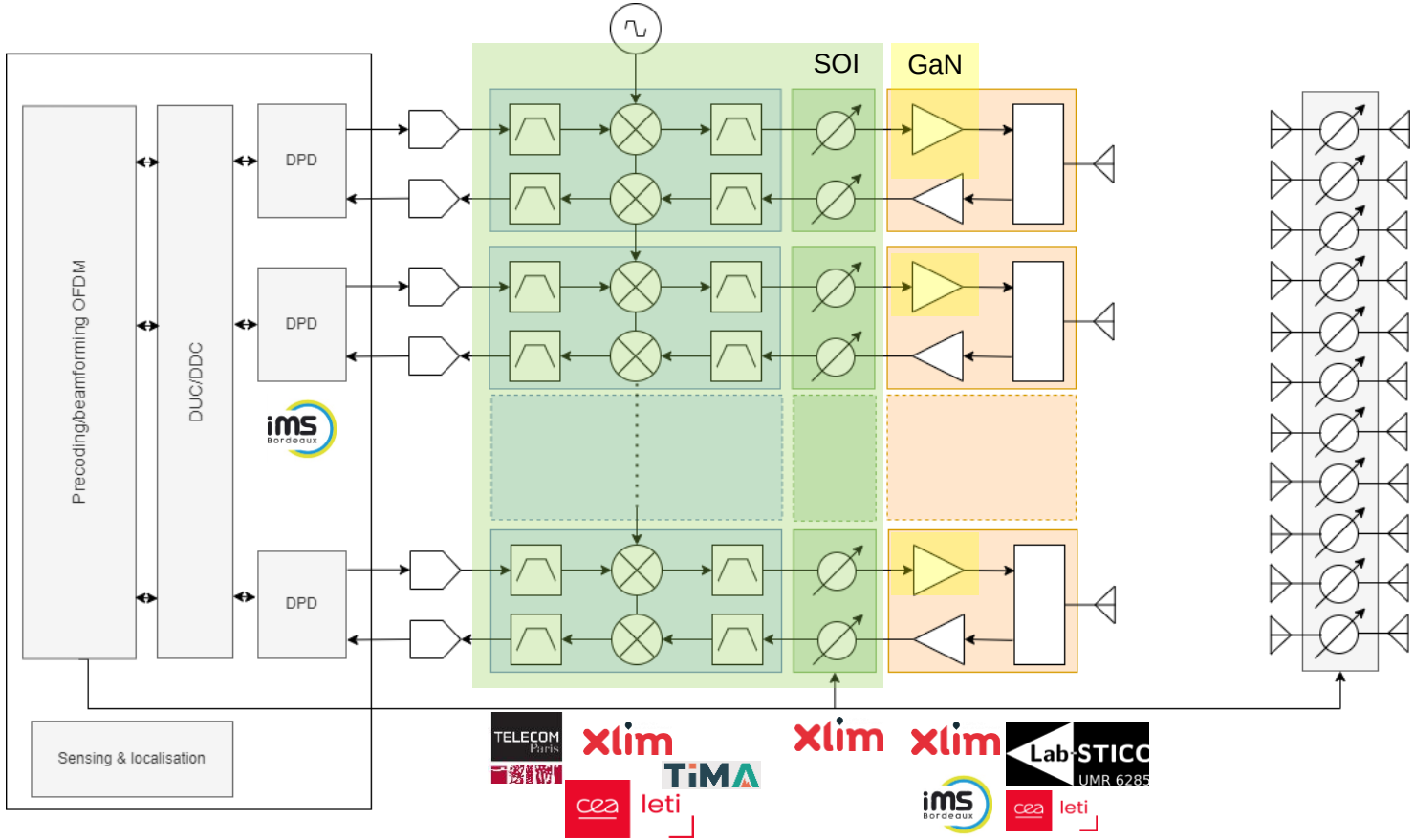
IETR EURECOM Sophia Antipolis

citilab ims Bordeaux

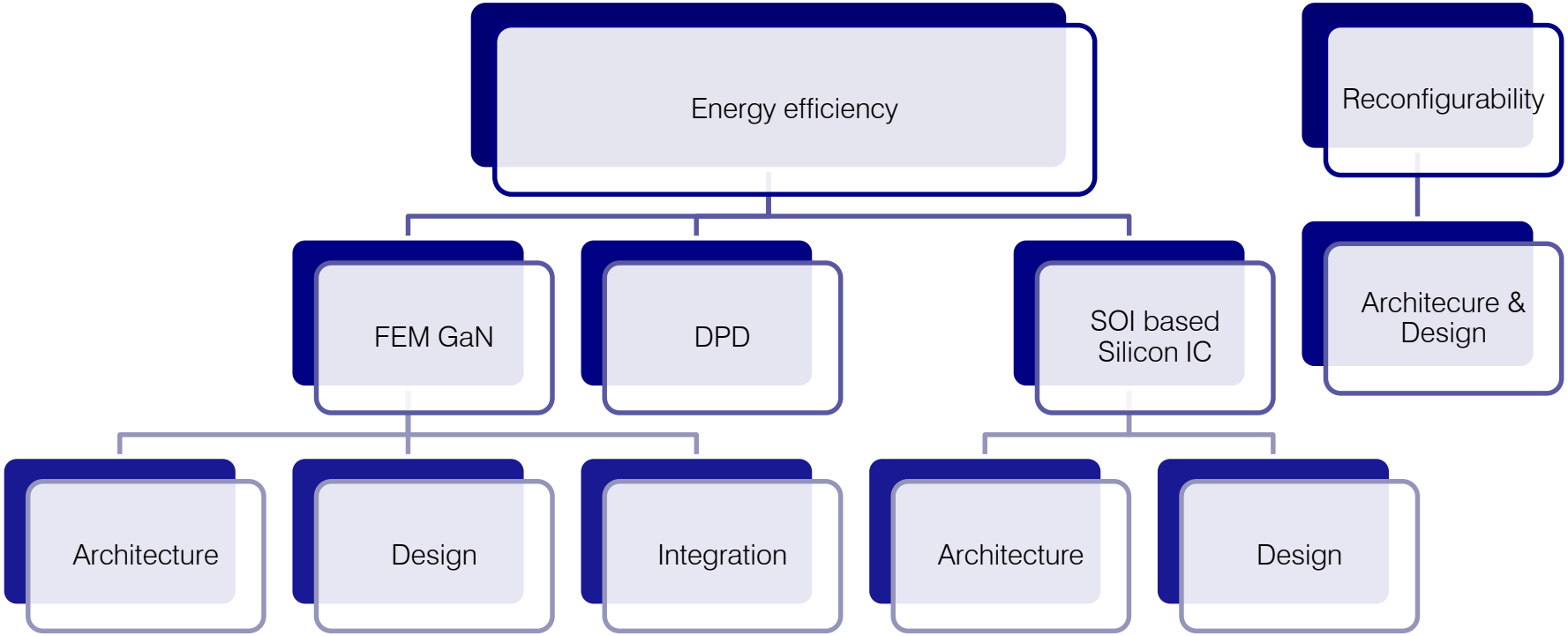
ETIS Lab-STICC

cea

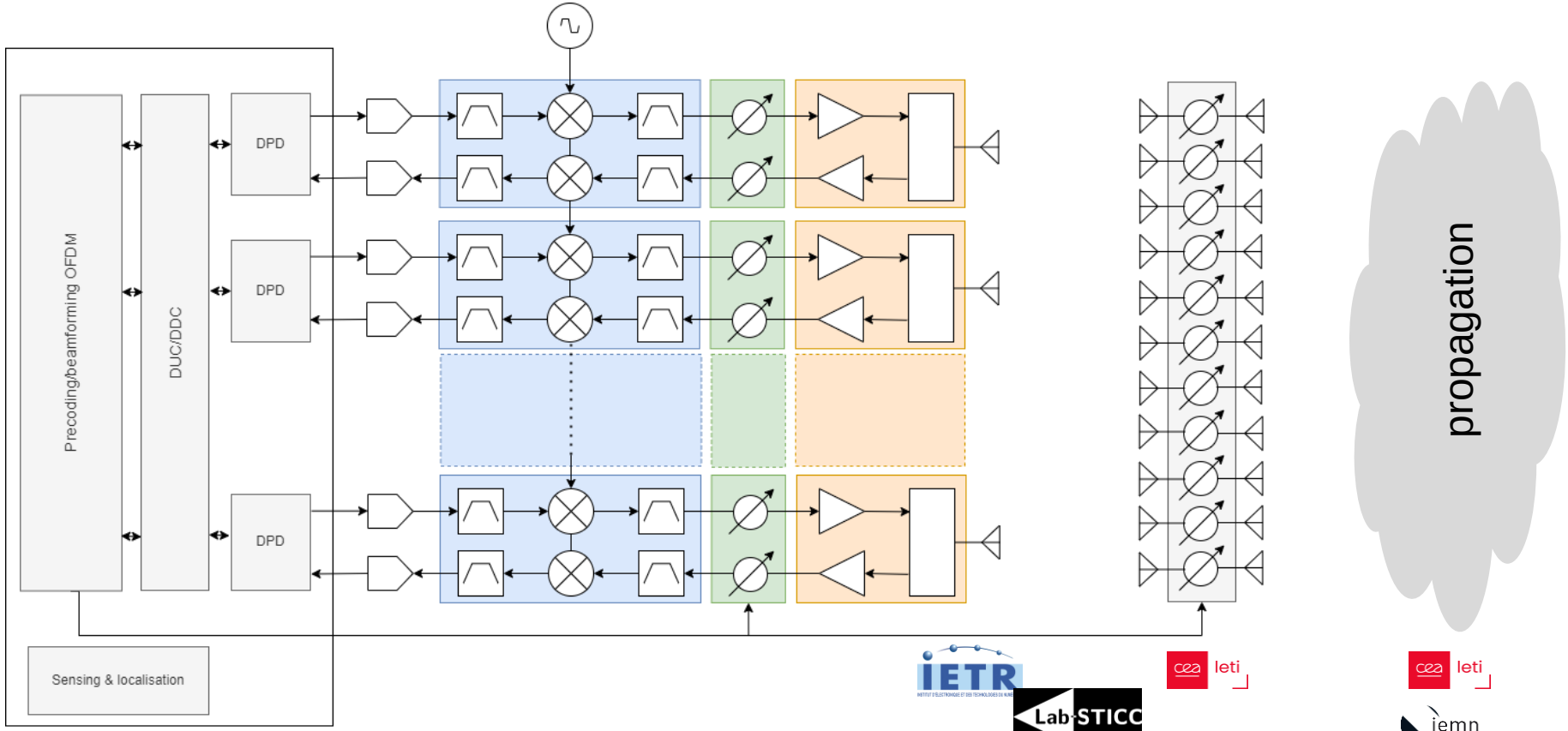
Architecture haut niveau – WP1



WP 1

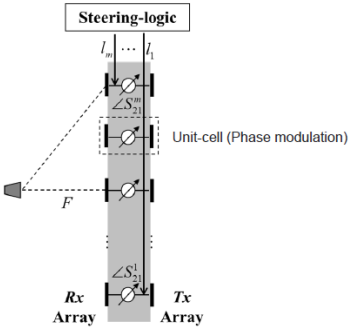

Energy efficiency
Reconfigurability
FEM GaN
DPD
SOI based Silicon IC
Architecure & Design
Architecture
Design
Integration
Architecture
Design

Architecture haut niveau – WP2



Sous-ensemble Lentilles & Propagation

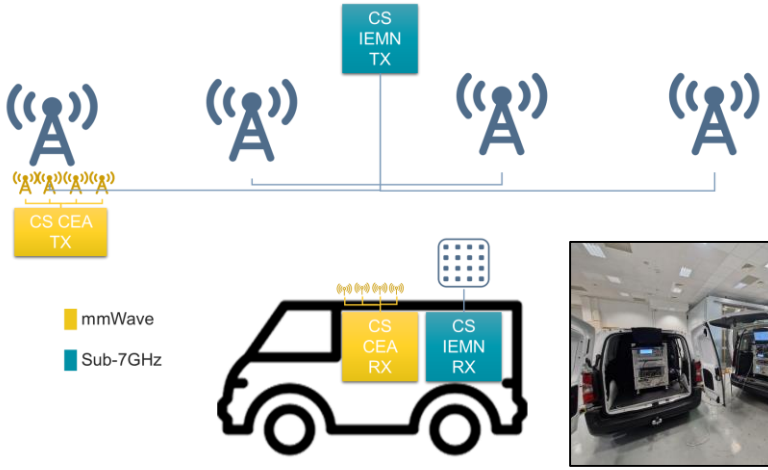
Reconfigurable Intelligent Surface (lens)



- Low-loss spatial feeding mechanism
- No feed blockage
- Low-cost planar fabrication process
- Energy-efficient electronic 2-D beam-steering using simple electronic devices
- Increased volume occupancy

→ Dual band, low-profile design, stacked lens

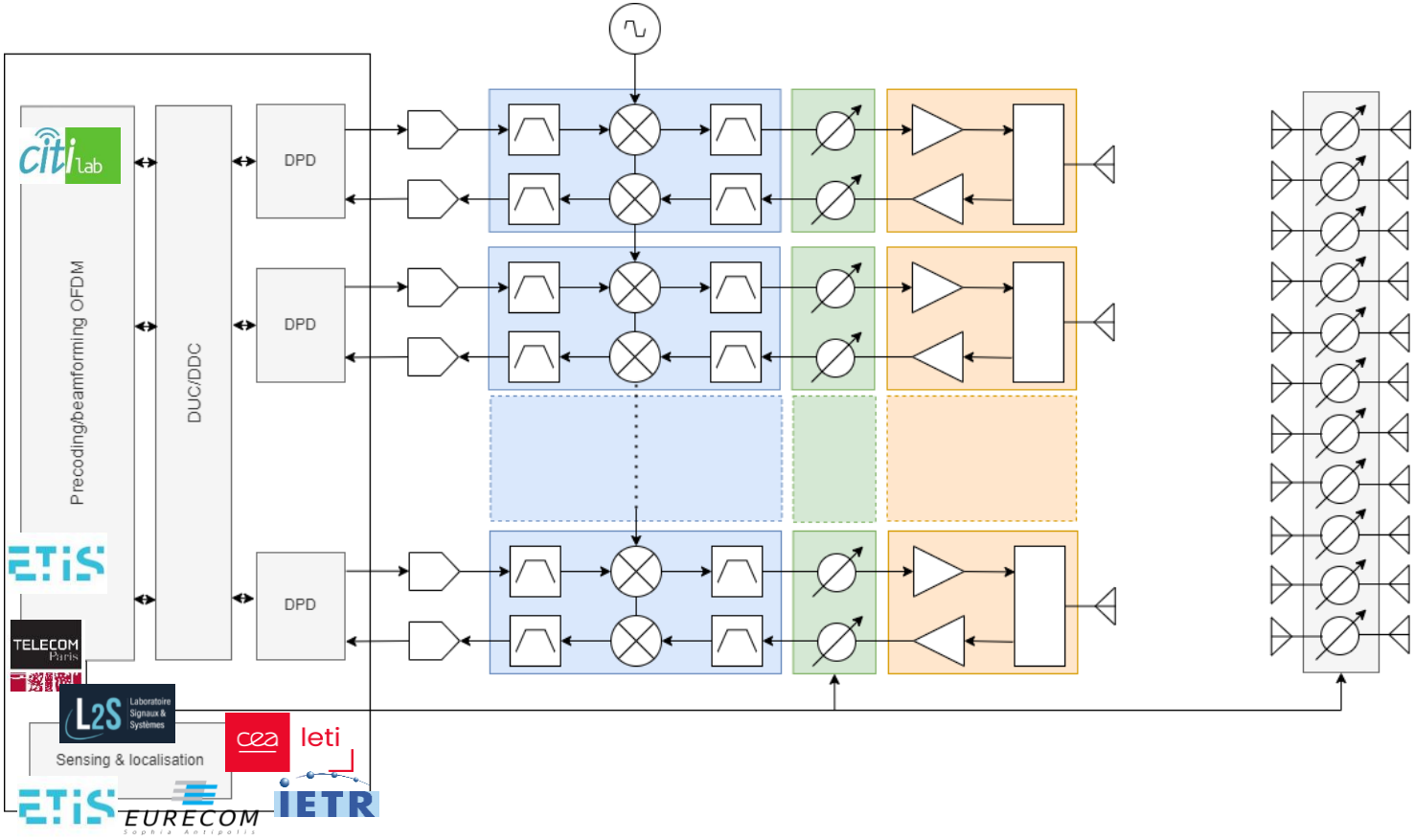
Propagation

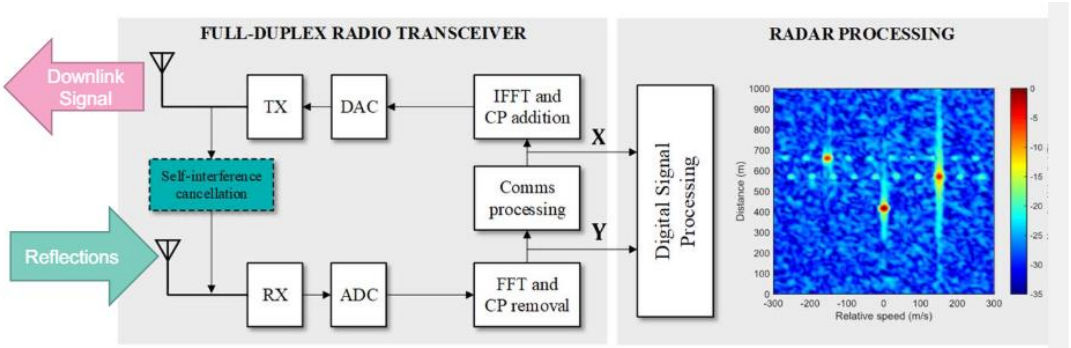


Shared multi-spectral campaign

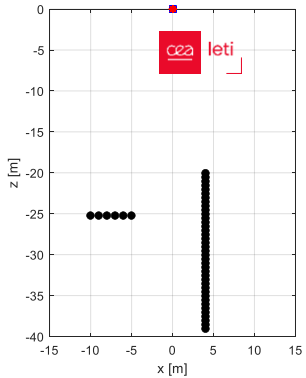
- sub-7GHz (IEMN/Université Lille)
- mmWave 26.5 GHz (CEA-Leti)

Architecture haut niveau – WP3

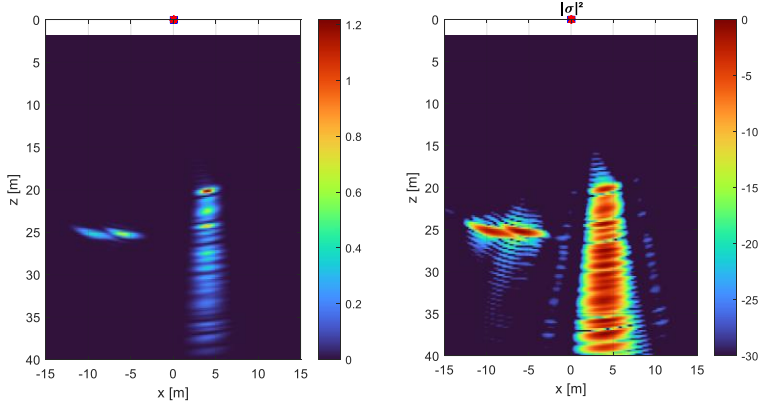




Joint Radio-based Sensing and Communications in 5G and Beyond: Prospects, Algorithms and Waveform Optimization, *Mikko Valkama et al*



26 GHz, 200MHz BW



SYSTERA

Guillaume Ducournau (IEMN)

SYSTERA - Devices and SYStems enabling Ultra High Data-rates links in sub-TERAhertz

Enjeux et Objectifs scientifiques

Techniques / écosystème

Répondre au besoin d'investigation des réseaux du futur dans les bandes « hautes »: beyond 90 GHz

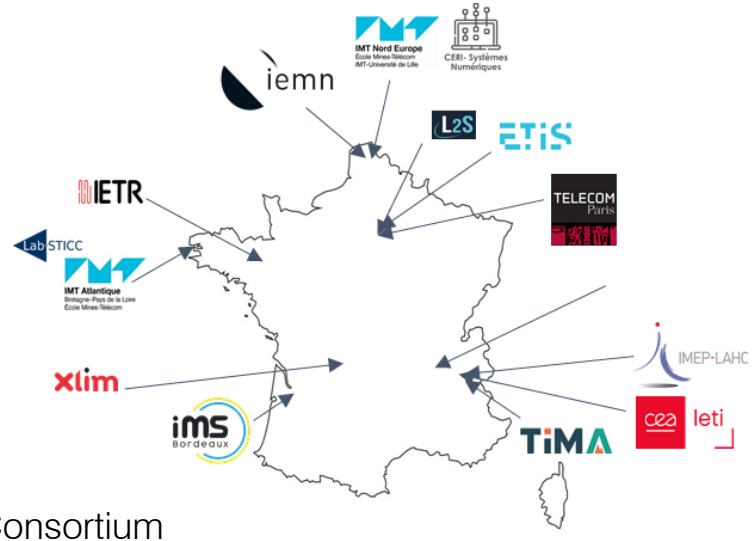
Mobiliser la communauté française de la « haute » fréquence

Champs d'application

Réseaux cœurs télécoms / couverture FWA

Fixed Wireless Accesses

Coordinateur: G. Ducournau, CNRS-Université de Lille



Consortium
8 labos CNRS, 2 sites IMT, CEA-LETI

SYSTERA - Devices and SYStems enabling Ultra High Data-rates links in sub-TERAhertz

Enjeux

Explorer les nouvelles bandes de fréquences pour les futurs cœurs de réseau sans fil: 140 GHz (2025-2027) et 300 GHz (2030-2035).

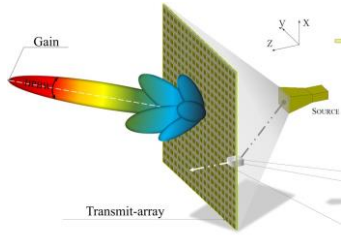
Objectifs: Démontrer les potentialités des bandes au-delà de 90 GHz:

- Architecture des systèmes possibles et formes d'ondes, Rayonnement efficace et contrôlé des ondes, RIS et caractérisations 140-330 GHz
- Propagation des ondes, traitement des faisceaux, matériaux adaptés
- Génération et amplification de signaux pour les bandes D (140-170 GHz) et H (250-320 GHz)
- Démonstrateurs utilisant les briques de base développées (bandes D & H)

Données de sortie

- Validation de prototypes (sources, amplificateurs, filtres, antennes) pour les applications télécoms > 90 GHz
- Réalisation de prototypes de systèmes de communication en bande D (140 GHz) et/ou H (280 GHz)

SYSTERA – Organisation du projet



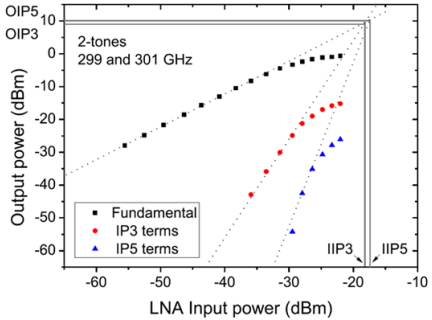
Transmit arrays

Architecture du projet

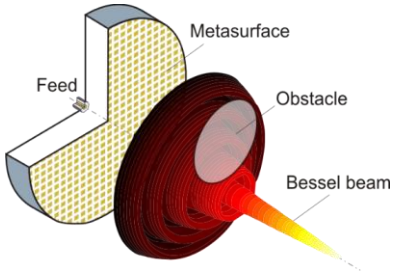
WP1. Key Enabling Technologies : circuits, antennas, waveforms.
WP2. Characterization, methods & Metrology, (also linked to PEPR plateforms project).
WP3. Integration/prototyping (SiP, additive 3D enabled packaging, heterogeneous integration).
WP4. Demonstrators.

Hetero integration

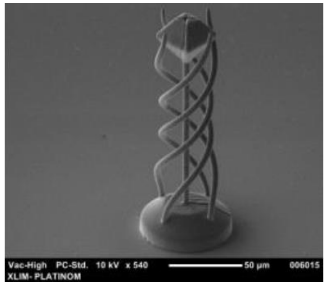
Outdoor demos



IP3 measurements @ 300 GHz



THz beam manipulation



μ3D integration

SYSTERA – Développements et technologies visées

- D-band PA design: linear response, linearization techniques

- D-band front ends (FEs)

- PAs performance assessment

- Integration of technologies (e.g. heterogeneous integration)

- Characterization tools developments, e.g. IP3 in the D-band, IQ analysis

- Material analysis response

- Transmit/Reflect arrays

- Beam Quint effects/beam-forming techniques

- Beam manipulation or channel management using RIS

SYSTERA – Contributions de la communauté

IEMN: D-band testbed (Tx/Rx ref tesbed) for meas/atmos effects. Demonstrators
IMS: power-amplifiers for D-band
CEA: intercos, channel aggregation, antenna, waveforms (WFs), Beam Formers, OFDM
TIMA: modeling intercos, 3D HI, mm-wave functions (VCOs, PS, …)
IETR: antennas: structured surfaces, beam formers (BF)/phase arrays
IMT-NE: WFs: hybrid beam-forming, power efficient schemes
L2S: holographic MIMO & RIS, optimal WFs
ETIS: low-NRJ design + localization
IMT-A: LTCC-based integration up to D-band, material charac
IMEP-LAHC: material charac experts, propag. studies: weather/RH, …
XLIM: passives functions (e.g. filters), using different techniques

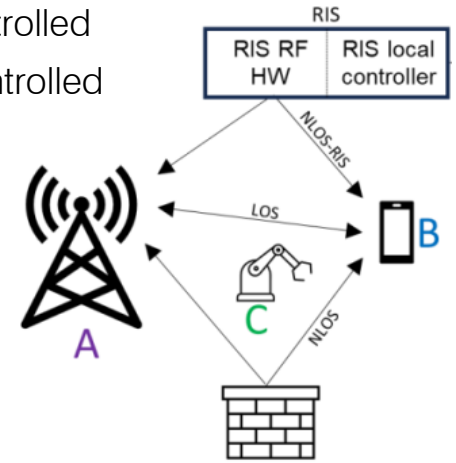
SYSTERA – Contributions de la communauté

Focus: RIS performance assessment

A: network controlled

B: terminal controlled

C: machine controlled



Deliverable D5.3 HEXA-X-II

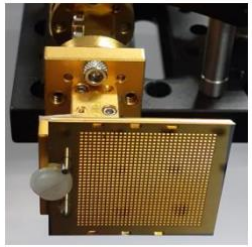
RIS approach: how to characterize it within a system?

In SYSTERA, we aim to contribute for > 90 GHz RIS validation:

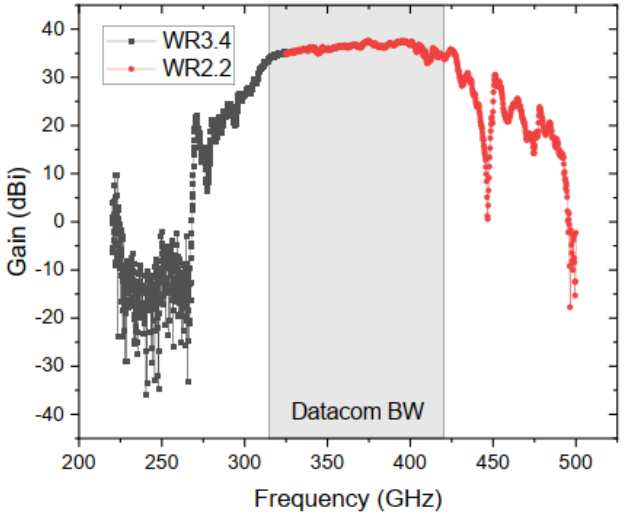
- OTA (Over The Air) validation
- Single device and up to system validation
- Many RIS approaches => need to make the link between RIS approaches and experimentations to validate the concepts.

SYSTERA – Contributions de la communauté

Focus: Antenna measurement

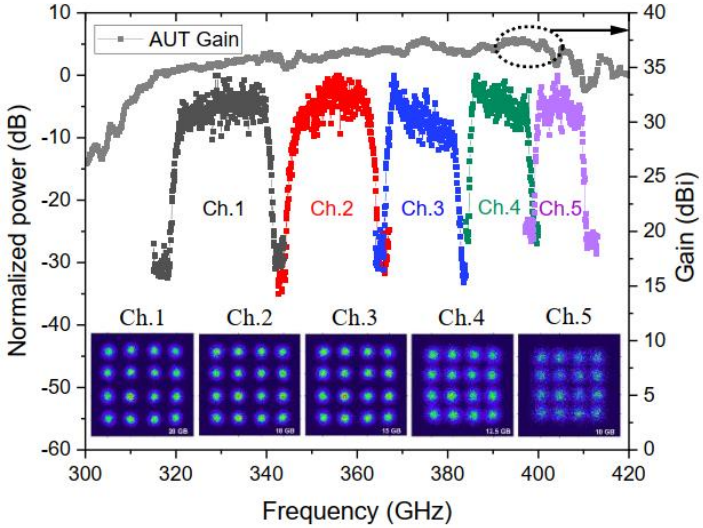


Stand-alone antenna



Methods for gain extraction

The antenna in the ‘use case’ (PHY-layer)



Validation of the antenna inside a THz system

Conference:
>100 sessions
>500 accepted papers
Exhibit:
> 300 companies, largest tradeshow ever for EuMW!

Registration starts June 4th

54th European Microwave Conference 2024
The 54th European Microwave Conference

EuMIC 2024
The 19th European Microwave Integrated Circuits Conference

EuRAD 2024
The 21st European Radar Conference

Stand PEPR-NF

www.eumweek.com

Forum 6G

6G-corner:
live demos of THz communications using RIS (Reflective Surfaces)

Contacts et informations

Site Web:

https://pepr-futurenetworks.fr/

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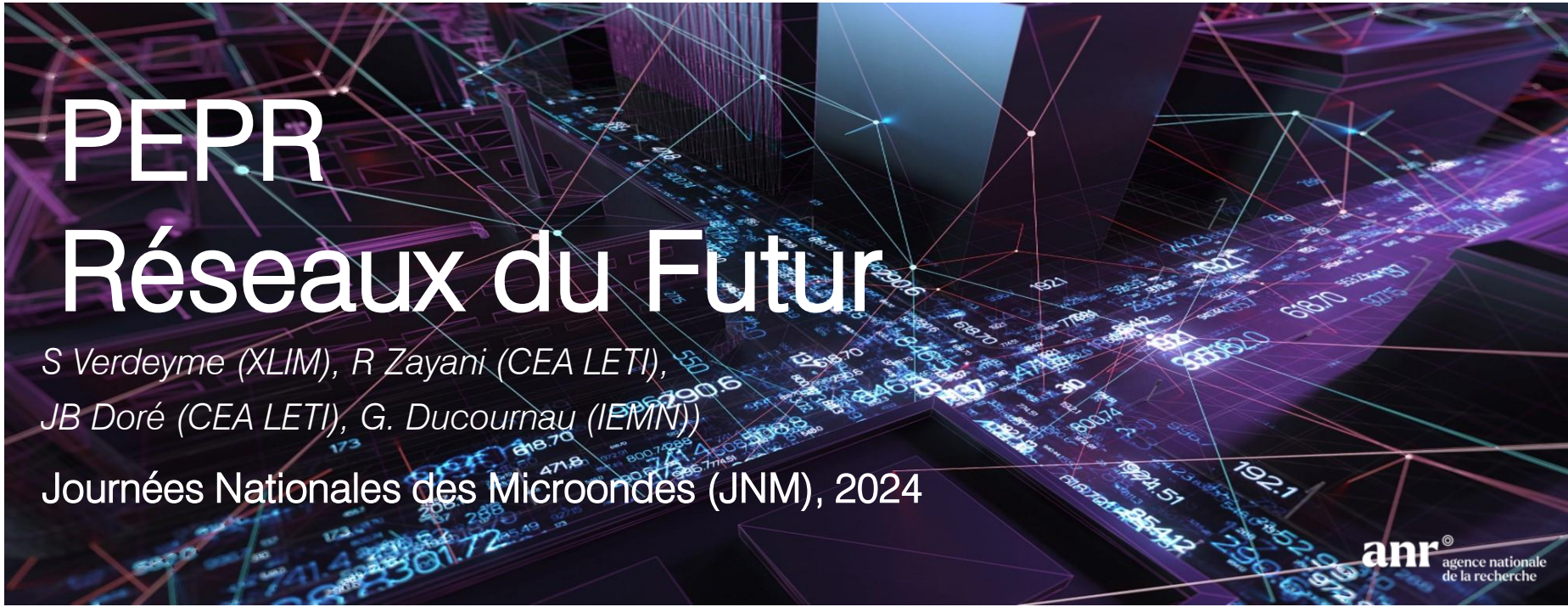

PEPR Réseaux du Futur

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