5G ACTIVITIES IN BROADBAND WIRELESS TECHNOLOGIES LAB

Benoit Miscopein, head of laboratory

LETI WIRELESS LABS APPROACH

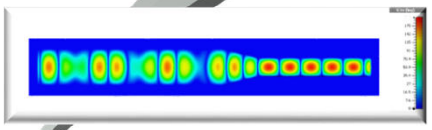
Field trials

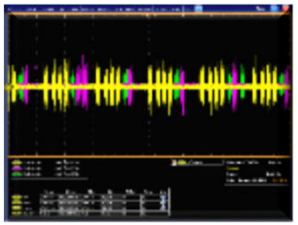
System validation

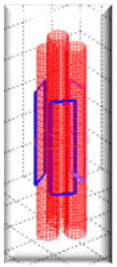
PoC design: custom/cots board prototyping, embedded software, RF & antenna integration

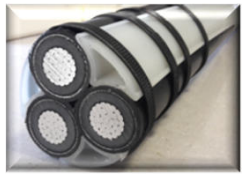
Theoretical studies: signal processing, protocols and algorithms

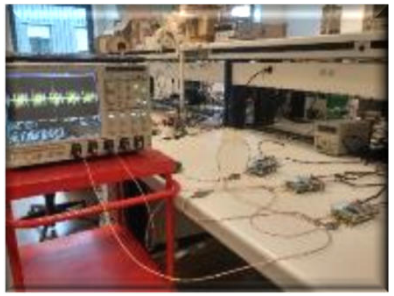
Propagation measurements and models



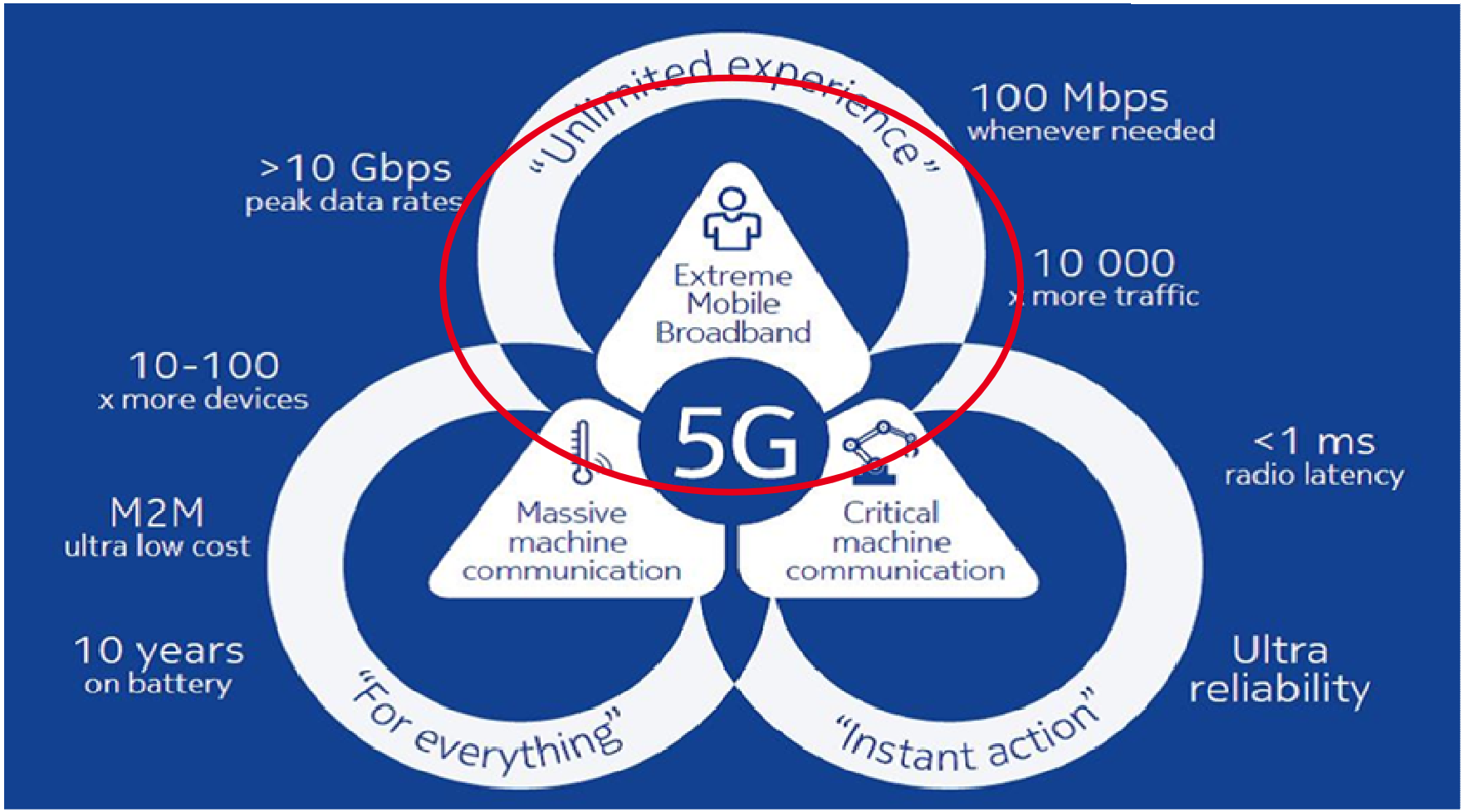






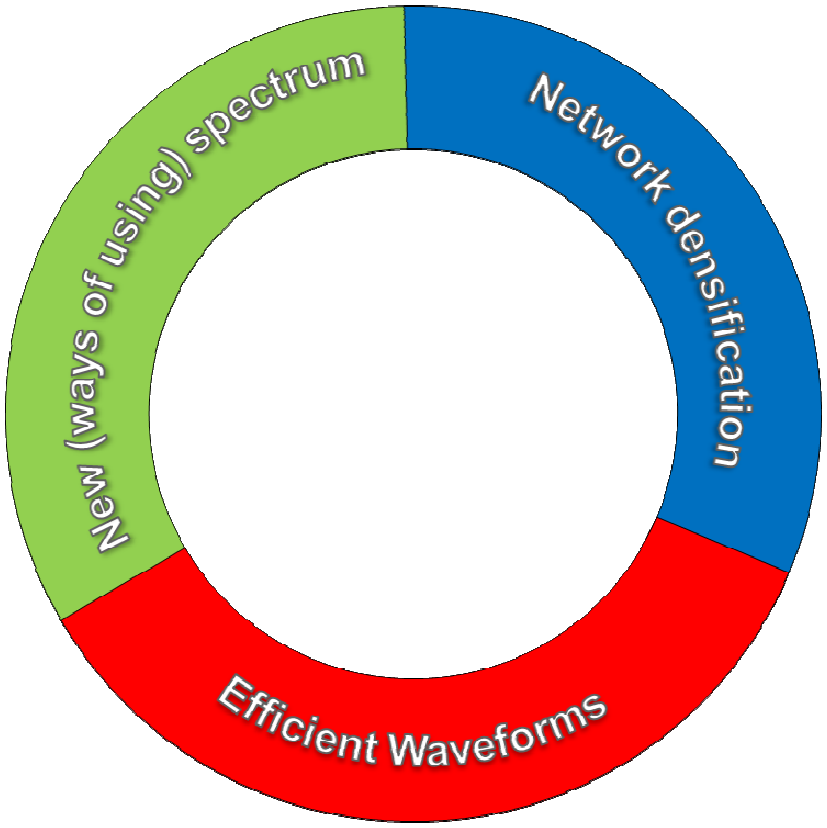


CURRENT PLAYGROUND



APPROACH OF 5G IN CEA-LETI

- **Telco industry says that 5G capacity improvement can be obtained thanks to**
  - Efficient waveforms to maximise spectrum usage
  - Dense heterogeneous networks deployment
  - Need for new spectrum and new ways of accessing spectrum



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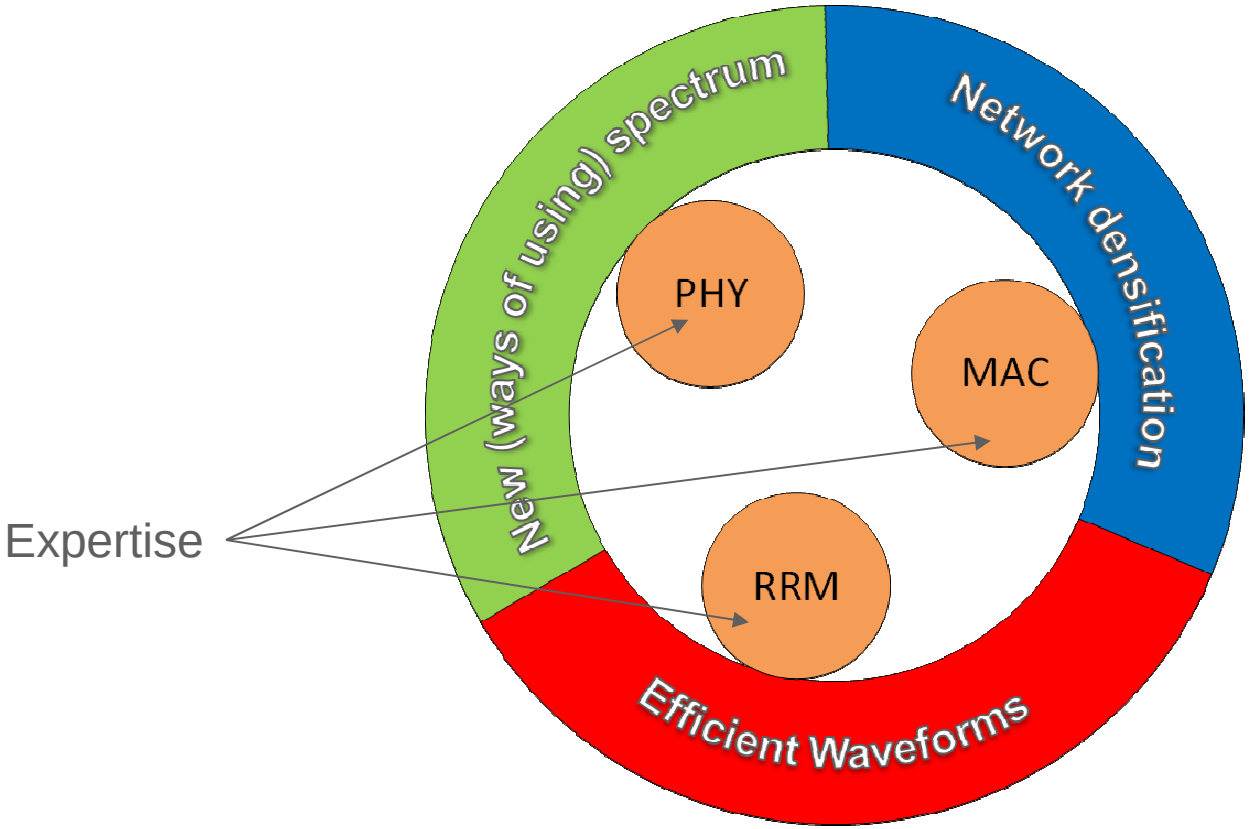

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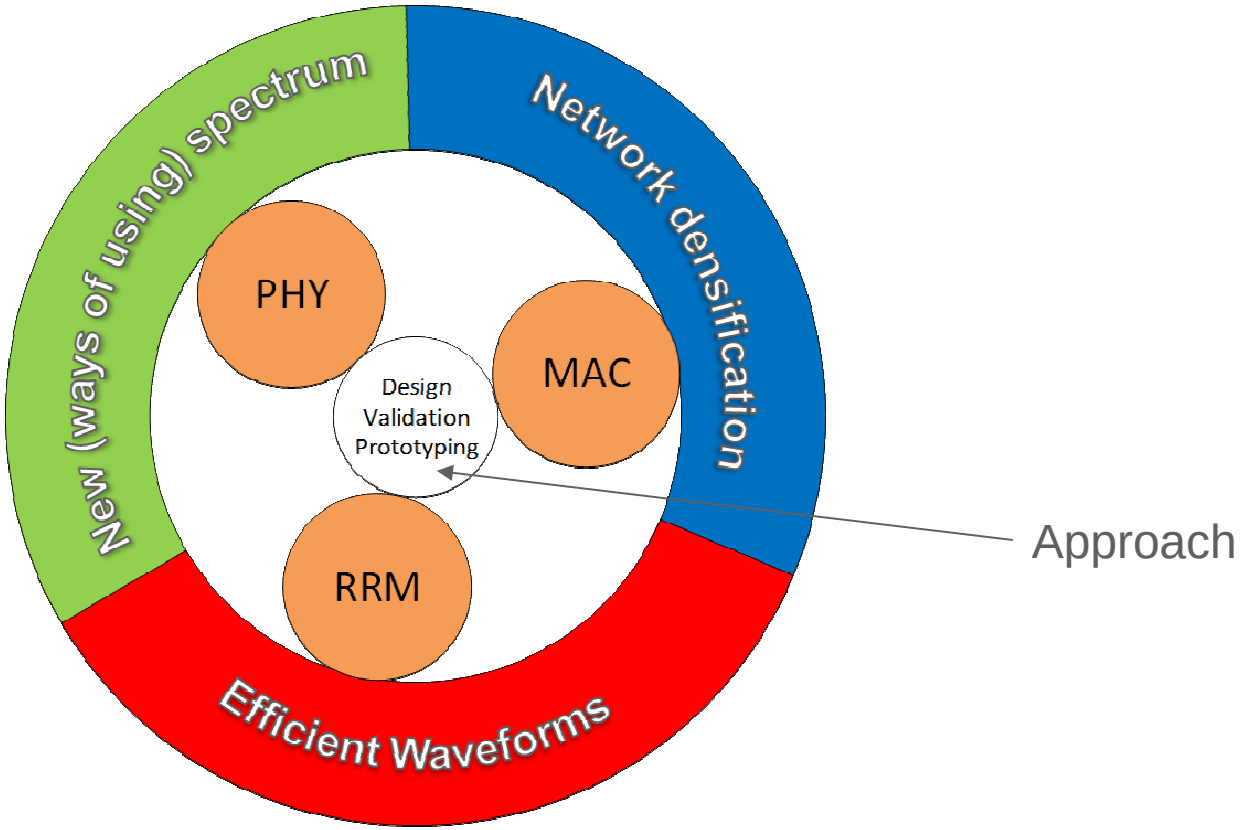
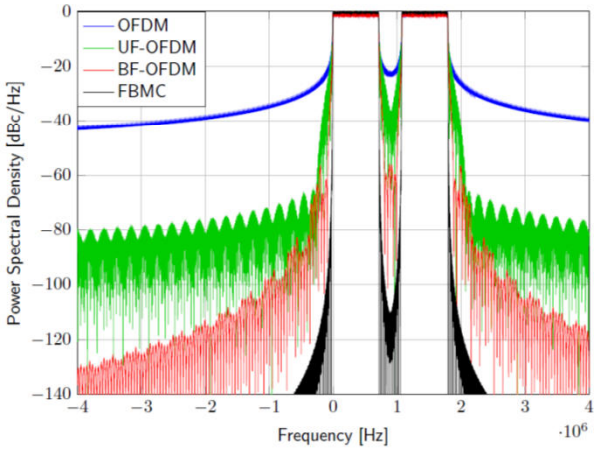
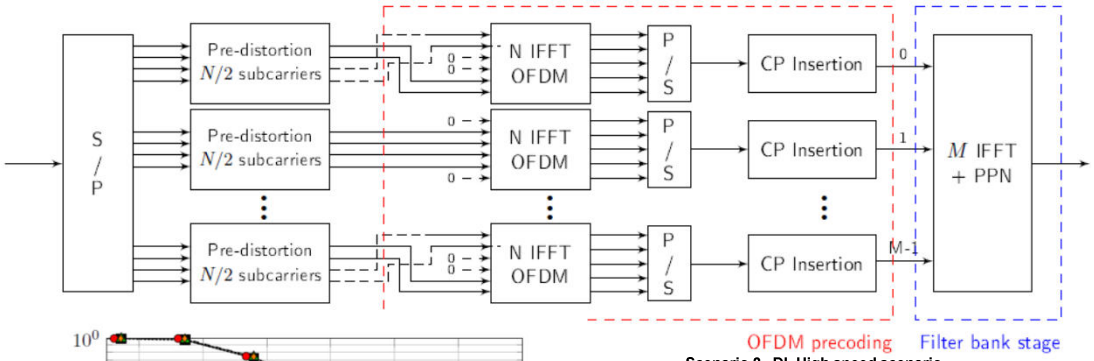


EFFICIENT WAVEFORMS

- **LETI has a long track record in post-OFDM PHY design**
  - FBMC (starting 2010) for secondary usage of spectrum chunks (TV-WS)
  - Recent work on 5G PHY with BF-OFDM ; ability to accommodate services of 5G coexisting in a single 20 MHz-carrier
    - Block-Filtered OFDM, rewarded as Best Paper of IEEE International Conference on Communication, in 2017





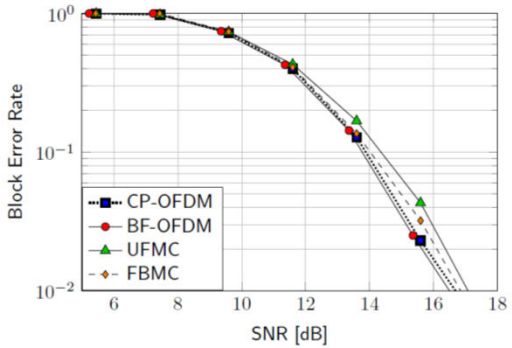
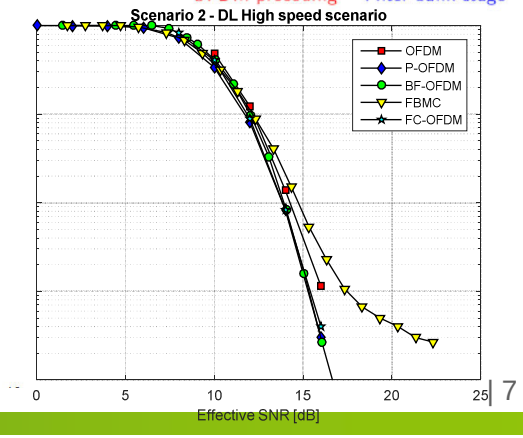
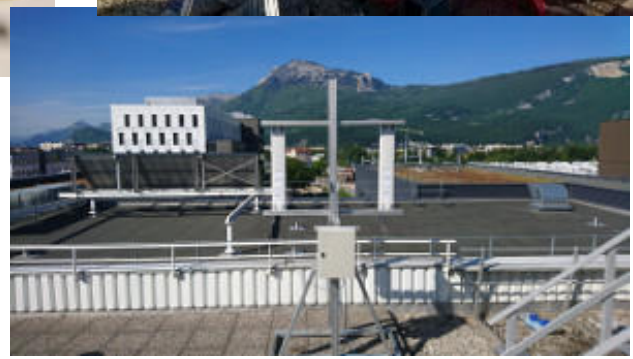


Figure 6: TDLC Channel Model (1000 ns) with speed of 3 km.h^{-1}



ACHIEVEMENTS AND PERSPECTIVES

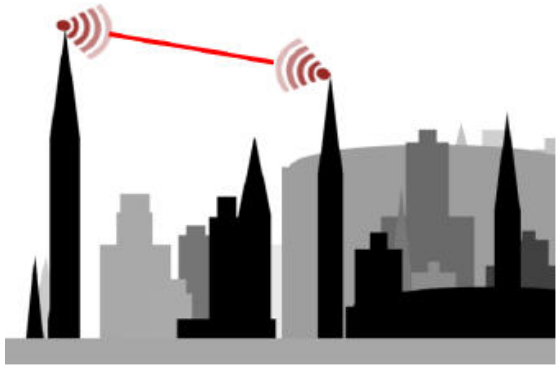
- **BF-OFDM has been validated field trials on different scenarios**
  - 5G multi-service support on the same 20 MHz carrier
  - High speed rural internet (Scotland)



- **On-going work on low-latency support, wideband operation for satellite communications**

SUB-THZ COMMUNICATIONS

- **Long term use for super high speed backhauling or offloading**

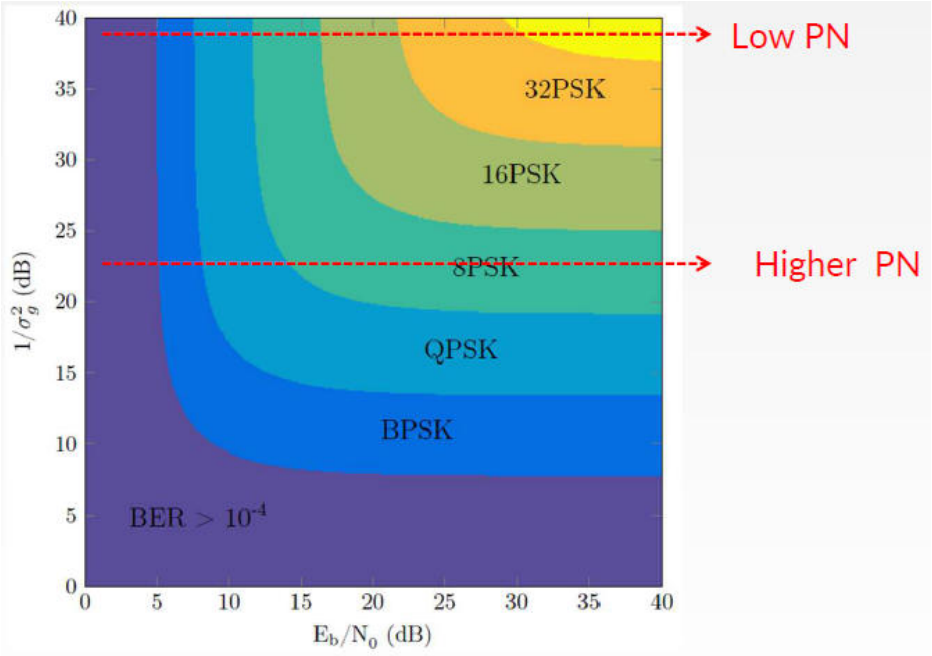


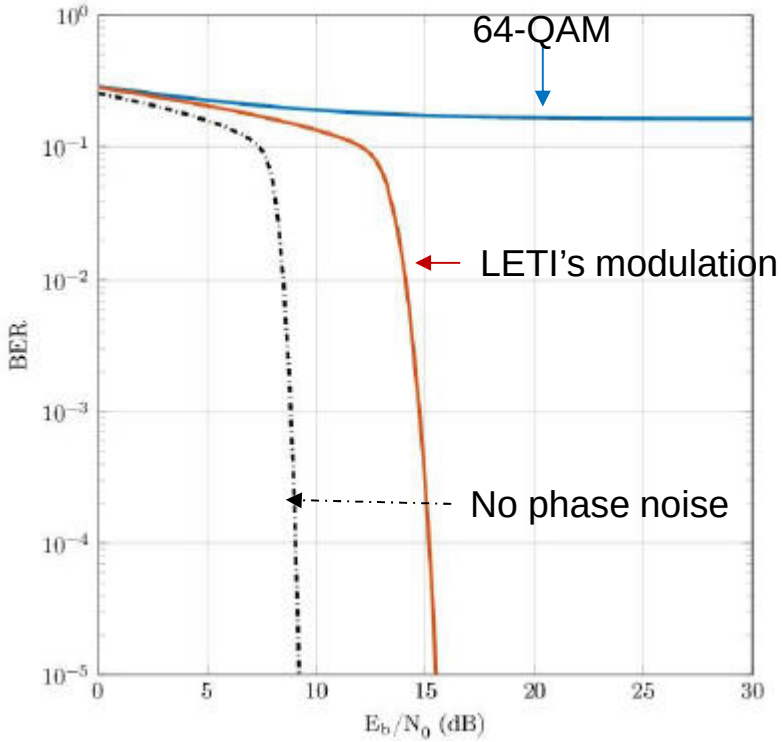
  - Sub-THz channels are flat
  - RF impairments may be dramatic (e.g. phase noise of oscillators)

- **Question explored : design of waveform robust to RF impairments**

SUB-THZ COMMUNICATIONS

- **Work status**
  - Definition of a digital modulation robust to phase noise (patent on-going)
  - Proposal of a link adaptation protocol to deal with various bands/noise levels (patent on going)



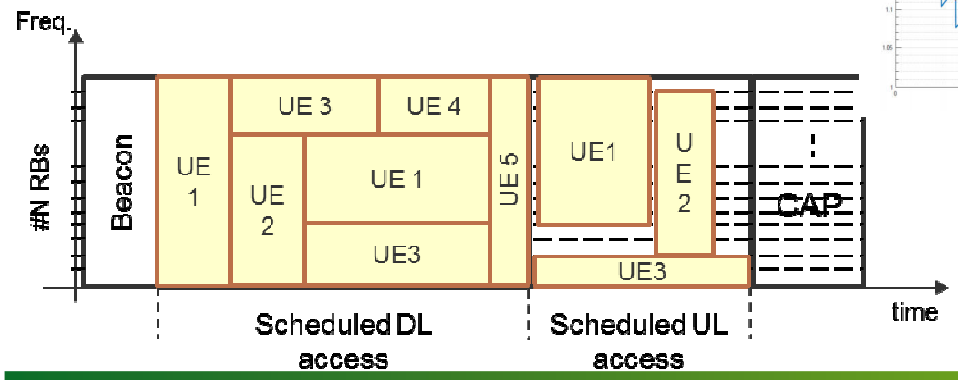


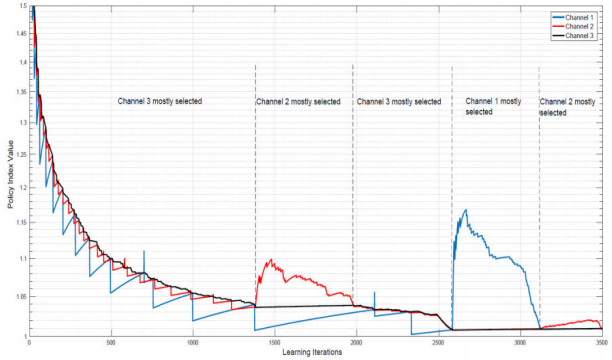
BER vs. SNR (w/ LPDC codes)

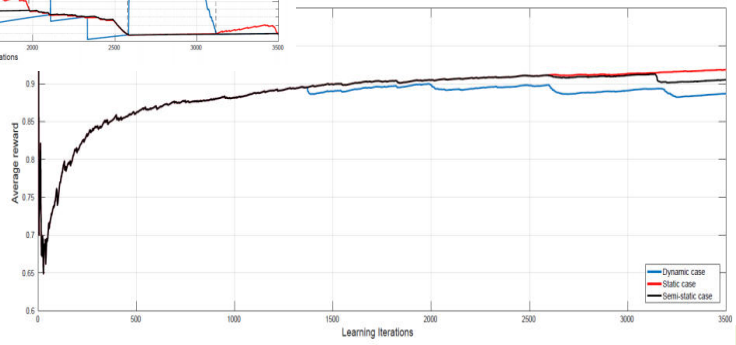
MAC DESIGN FOR UNLICENSED OFFLOAD

- **MAC design for unlicensed operation targeting traffic offload**
  - Opportunistic access for non demanding QoS services (traffic offload)
  - Joint access in unlicensed and licensed spectrum (carrier aggregation)

- **Main features**
  - Support of broadband traffic and dense scenarios
  - Fair coexistence with others systems thanks to listen-before-talk (LBT)
  - Dynamic selection of the best channel with reinforcement learning

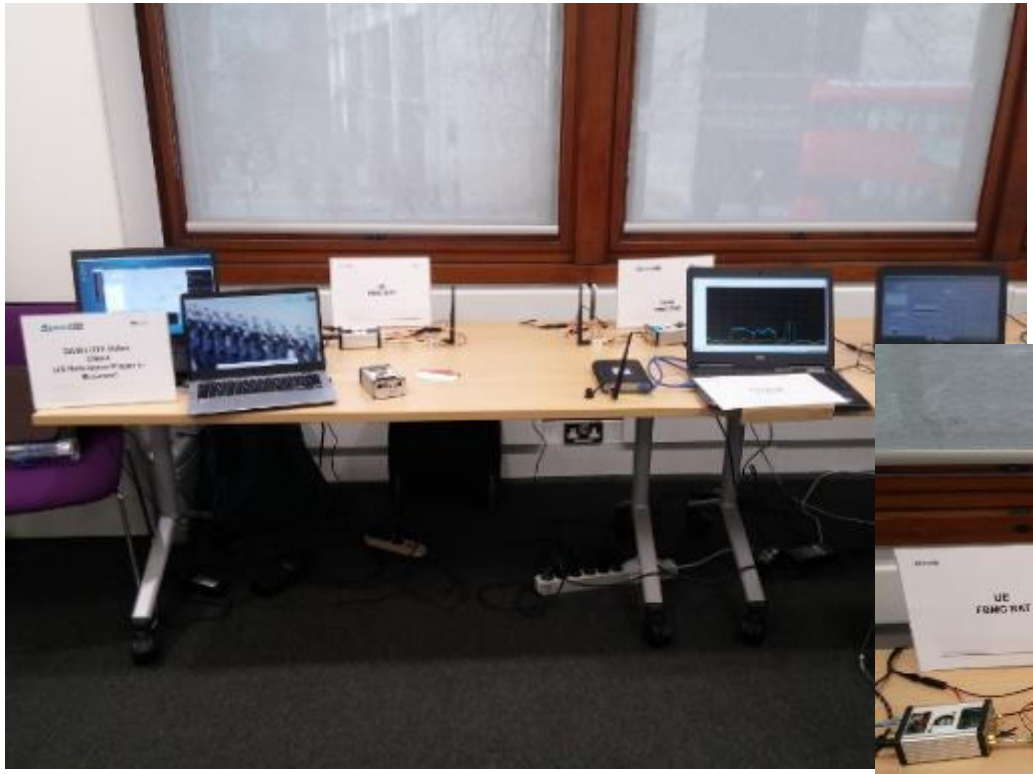


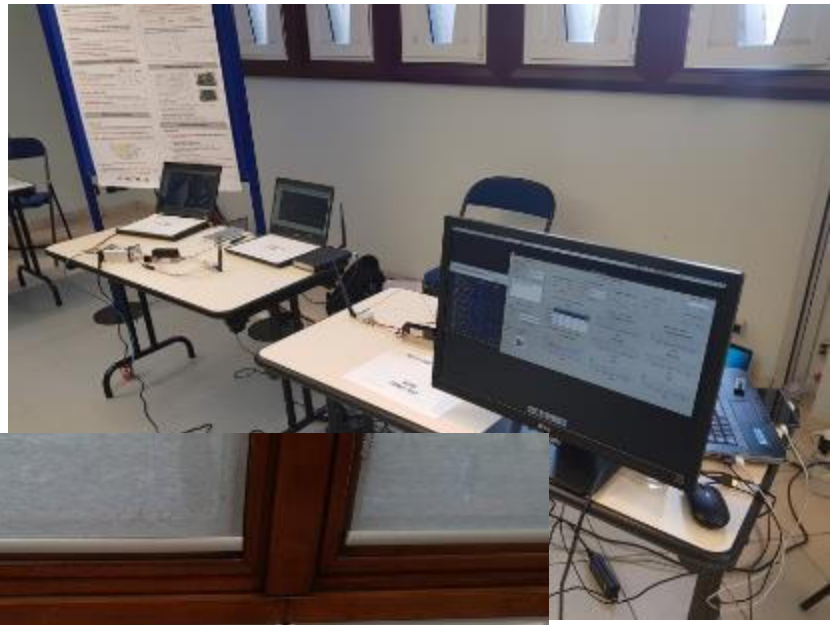




MAC DESIGN FOR UNLICENSED OFFLOAD

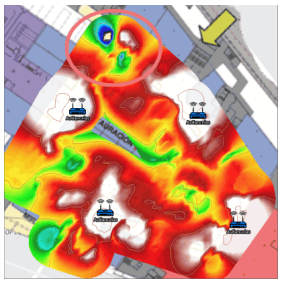
- SPEED-5G public event in London (March)
- ICT 2018 conference in Saint-Malo (June)



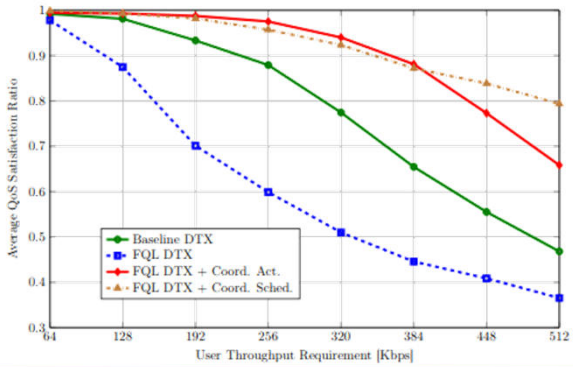


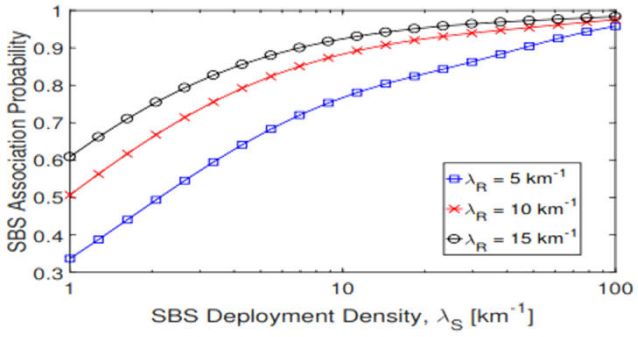
RESSOURCE MANAGEMENT IN DENSE NETWORKS

- **Network capacity improved by deployment of small cells**
  - Small cells may use the same resources than macro-cells or can be multi-RAT
  - Densification leads to unplanned interference varying in time and space



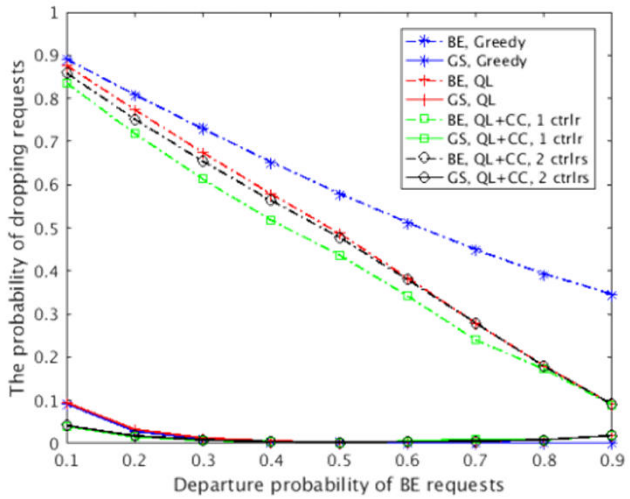
  - Main focus in LETI: **RRM algorithms for interference management**
    - Simulations and analytical approaches for network/performance assessment. E.g. for
      - Small cell association strategy and/or traffic offload in multi-RAT hetnets
      - Inter-cell coordination for DTX, under QoS and RAN/backhaul consumption constraints

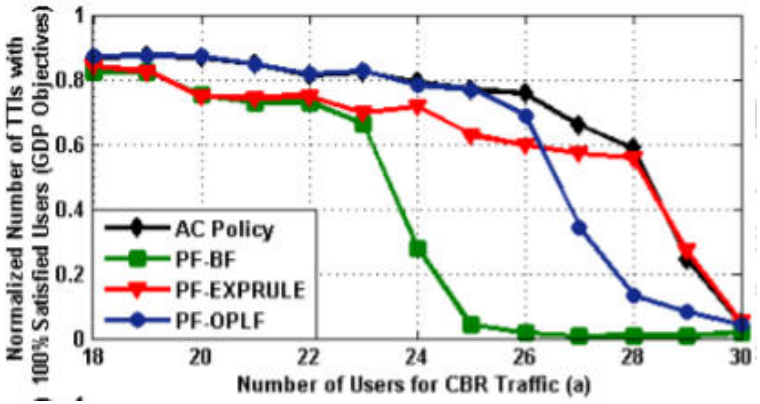




RESSOURCE MANAGEMENT IN DENSE NETWORKS

- **Learning methods applied to radio, energy, and cloud resource optimization. E.g. for**
  - Optimal **scheduling policy** for heterogeneous traffic
  - **Slice Admission and Congestion Control**
  - Dynamic **deployment of Virtual Network Functions in cloud RAN**
- **System optimization based on artificial intelligence**
  - Reinforcement learning for strategy design
  - Unsupervised learning for service classification and clustering
  - Neural Network, fuzzy logic, and tile coding as function approximators



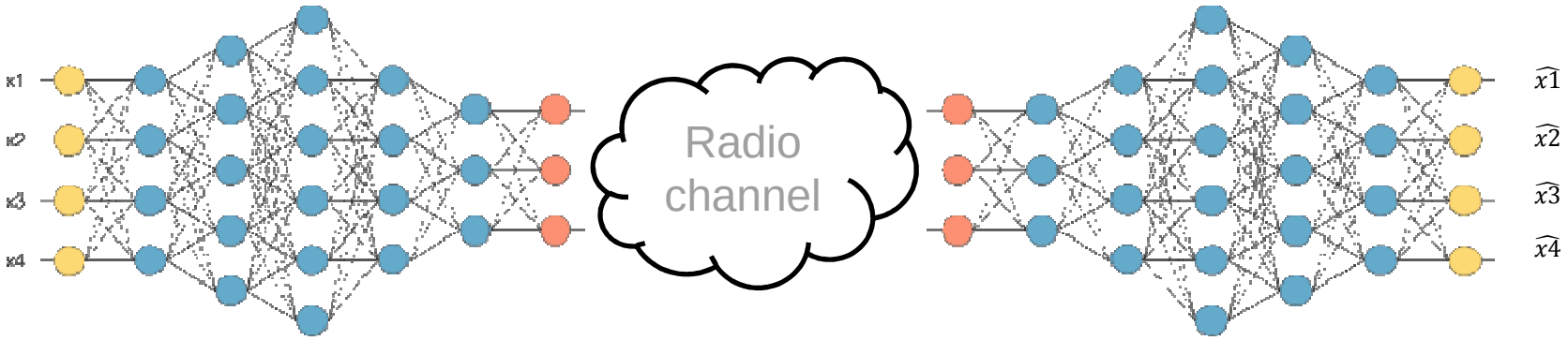


AS A TAKE-AWAY…

- **AI-based and learning based approaches are already used for RRM.**

- **Question: what AI can do for “beyond-5G” PHY/MAC design ?**

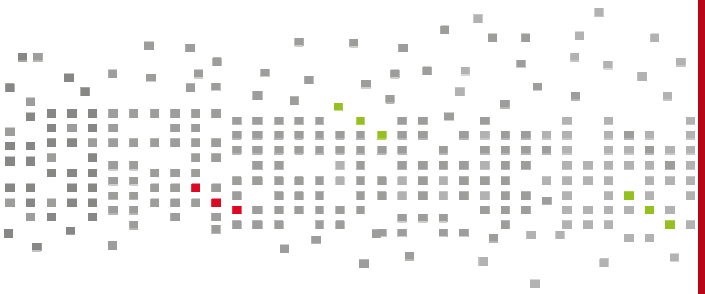
  - Can auto-encoders approaches provide new PHY design paradigm?
    - Proved to be able to cope with linear conditions with limited gains
    - How does this fit with non linearities (RF, ADC, …)



- **Get some updates during the LETI Innovation Days 2020**

AND WE DIDN'T MENTION

- Hybrid beamforming for sub-6GHz small cells
- URLLC operation through multi-channel LBT operation
- Full-duplex
- 5G-NR satellite communications
- LIFI communications hybridization with 5G networks
- Custom HW/SW fast prototyping board design
- …
- For any question: **benoit.miscopein@cea.fr**



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