

ENOVA PARIS 2015
LIFI – CHALLENGES & OPPORTUNITIES.

MARTIN GALLEZOT

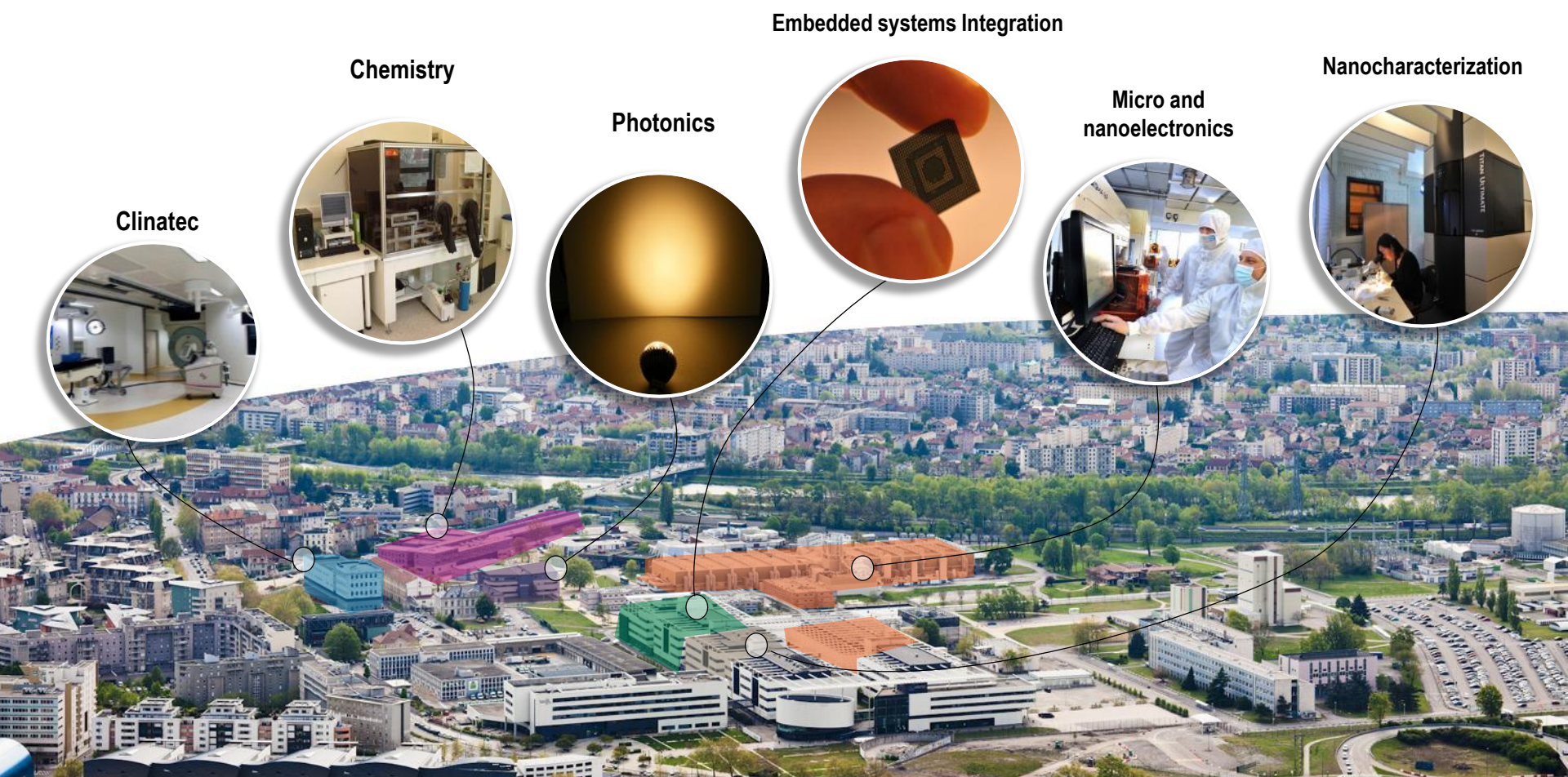
SEPTEMBER 24, 2015

- **CEA Institute founded in 1967**
- **Director : Dr Marie-Noëlle Semeria**
- **1,800 collaborators**
1,270 permanent staff
250 PhD + 40 post-doc, 37% foreign students
- **2800 patents**
311 registered in 2014
40% under licensing
680 publications per year
- **Budget : 318 M€**
CapEx: 39 M€
80% from external revenue
- **8,500 m² clean rooms**
For 200 and 300 mm wafer fab, operated 24/7



- **16 000 collaborators**
 - 10 % PhD and post-doc
- **10 research centres**





LED Lighting: Energy efficiency and more than lumen



Lighting = 20% of world electricity consumption

Efficient sources

Smart use of the light

Solid State Lighting



Lighting systems

- Luminaire network
- Communication: *luminaire to luminaire, luminaire to building...*



Luminaire

- Light source
- Optics : *no glare, beam quality, flux, efficiency...*
- smart sensors integrated: *presence, ambient light, activity, time...*
- Driver, dimming, CCT adjustment...
- Communication means

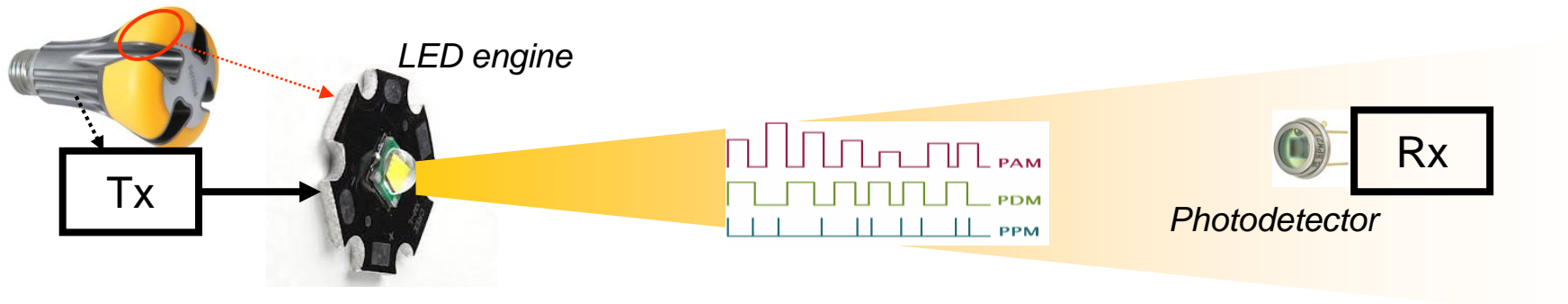
- LED chip
- Heat management
- Smart devices



LED

Intensity Modulation on LED forward current

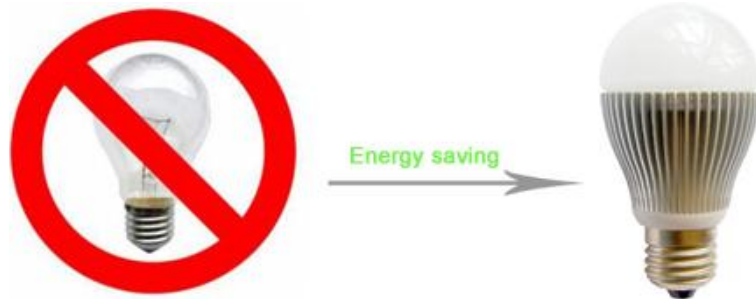
- LiFi uses a real baseband signal to achieve intensity modulation on LED current with direct detection at the receiver



- Goal: use good properties of LED to be modulated at high frequency to transmit information at very high data rate and/or high ranges
- Digital modulations
 - OOK, NRZ, ...
 - Pulse: PAM, PPM, PWM,...
 - CSK
 - Multi-Carrier modulation: OFDM, DMT, ...
- Standardization (IEEE 802.15.7): no multi-carrier waveform up to now



RF spectrum saturation and growing demand



LEDification in progress



SSL offers a dense network

- In every place
- A strategic position
- Energy for free

- Transmission with no RF emission
- No sensitivity to RF interferences
- Will benefit from LED massive deployment: 70% of lighting market in 2020
- Security: walls block LiFi signals
- “You see what you get” effect

APPLICATIONS

Retail/Museums



Indoor GPS



Hospitals



Aeronautic



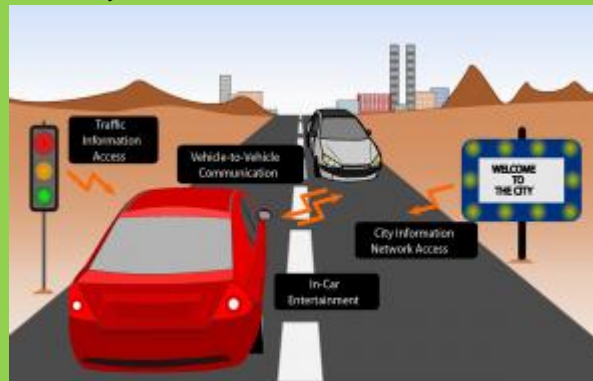
Home high data rate access



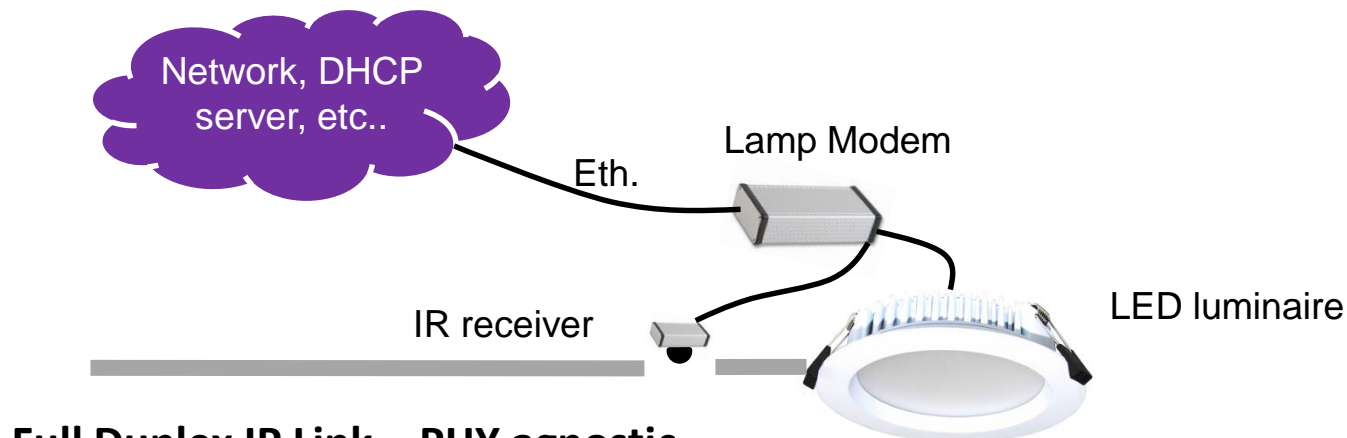
Access in Office



V2V, V2Infra communications



Pour transmettre des données en LiFi, une LED posée au plafond et un capteur intégré à la tablette suffisent. © PSA Peugeot Citroën



Full Duplex IP Link – PHY agnostic

Lighting specs

- 1000 lm
- 120 lm/W
- CRI 85
- 3-5m distance

Downlink PHY :

Multicarrier waveform – 8MHz BW

- QPSK up to 64 QAM modulation
- Synchronization, AGC, channel equalization,

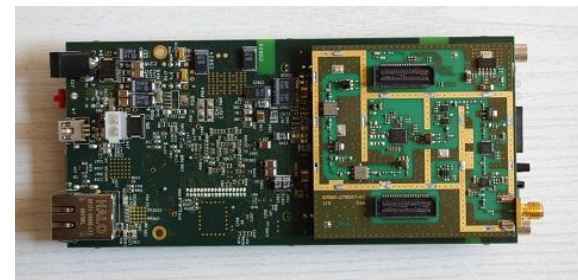
Uplink PHY :

PAM waveform

Visible, 20Mb/s

IR, 5Mb/s

User Modem

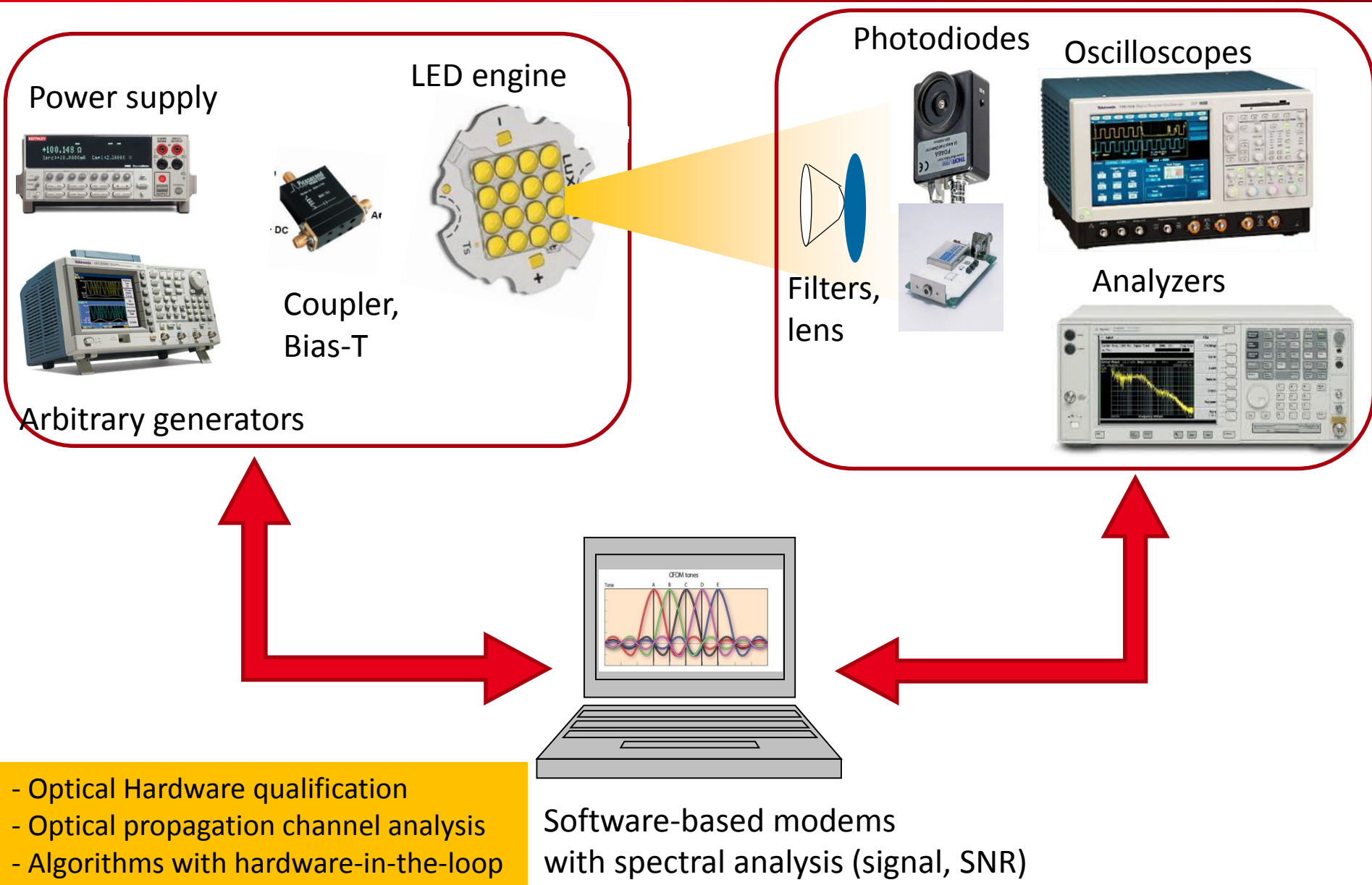


- **MAC Layer :**
 - Multi-users : up to 15 users per lamp access point
 - Handover from one access point to another
 - Throughput/Distance automatic adaptation

- **Integration & cost reduction**
 - Current form factor 70x45x17 mm³
 - FPGA & ARM based -> ASIC migration

- **Optical**
 - Optical front-end characterization
 - Infra-red receiver integration

- **Power Consumption**
 - User's modem is USB powered (2.5W)



Communication

- Uplink above 10Mbps
- Downlink above 100 Mbps
- Channel Interferences
- Bandwidth
- Throughput / Range
- Dimming compatibility
- Backhaul
- Secure link

Optical

- Eye safety, flickering
- color rendering, temperature
- Maintain life span of LED
- AC LED
- RGBA Tx and Rx
- High-speed LED process technology