

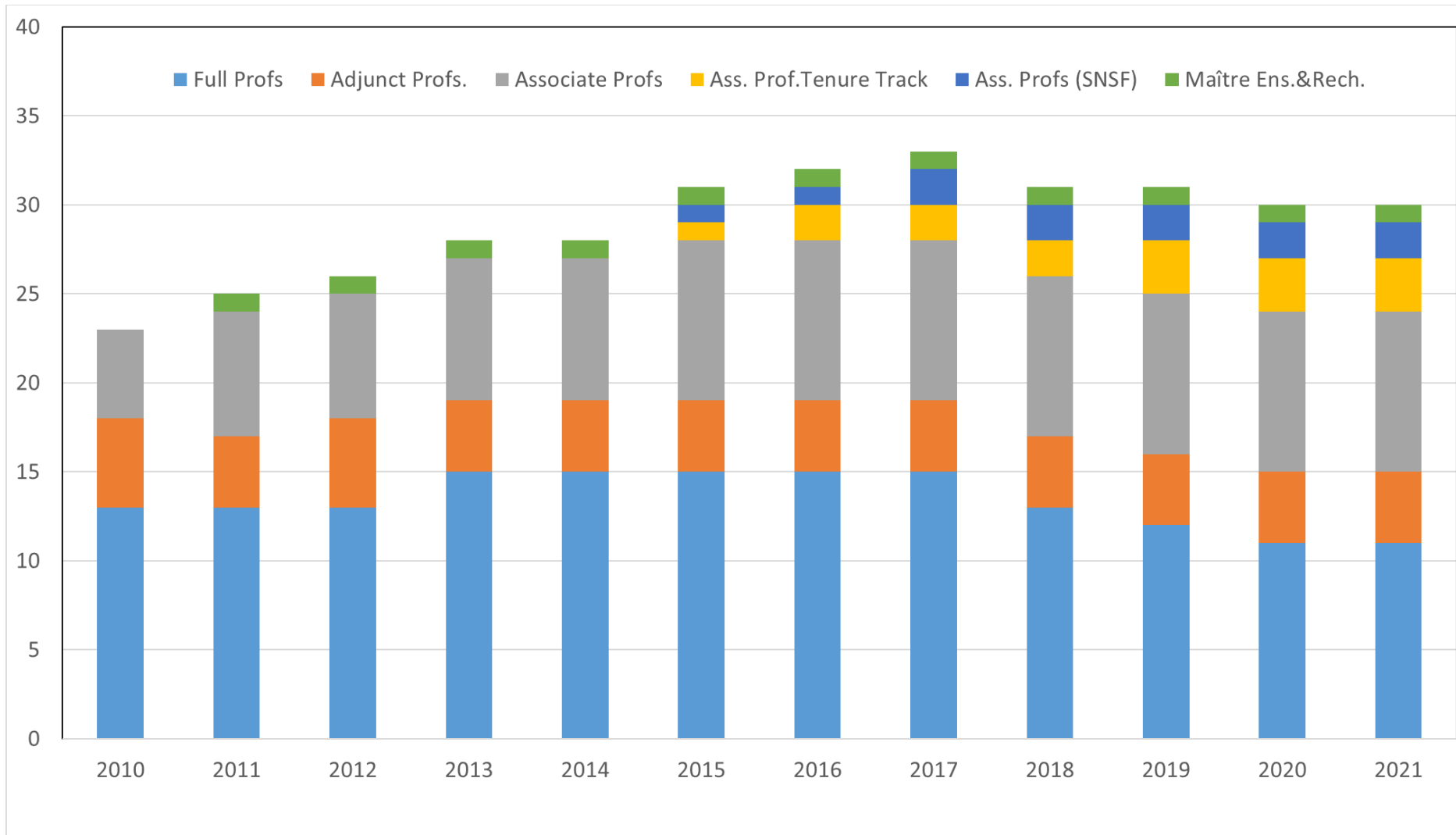
# Photonics @ EPFL

Pierre-Yves  
Fonjallaz  
EPFL &  
Swissphotonics

Swissphotonics  
Lunch Chat

12 October  
2021

# EPFL Photonics Chairs @EPFL 2010-2021

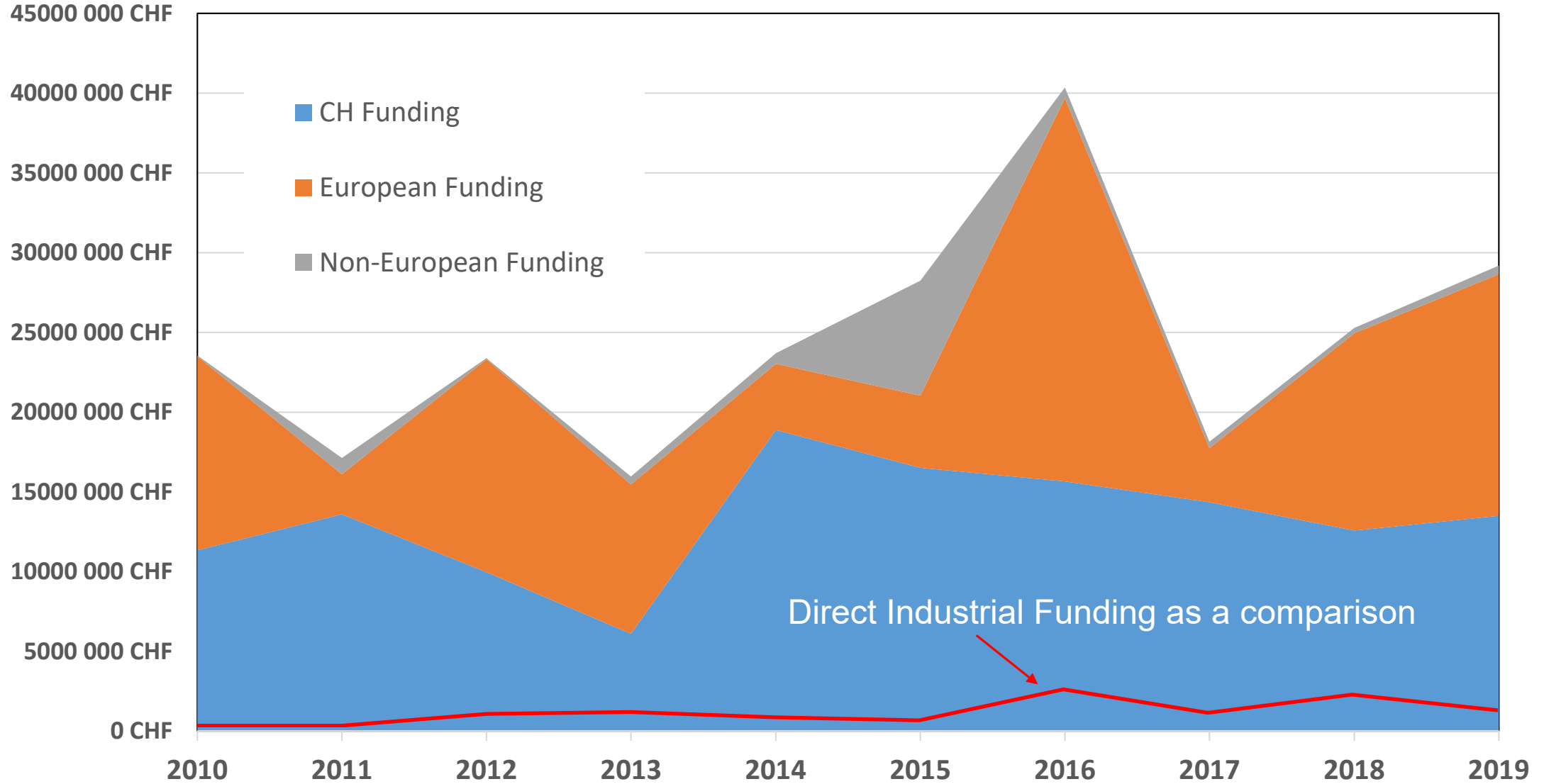


## Recent updates:

- Majed Chergui retiring on Oct. 1, 2021.
- Niels Quack leaving to Univ. Of Sydney.
- New Professors (2022):
  - PATT Cristina Benea-Chelmus (from Harvard)
  - Full Prof. Kirsten Moselund (also PSI)



# Public Funding of Photonics Chairs



Direct Industrial Funding as a comparison



The image shows a screenshot of the Photonics@EPFL website. At the top, there is a navigation bar with the EPFL logo and links for About, Education, Research, Innovation, Schools, Campus, and Coronavirus Info. Below this is a breadcrumb trail: Home > Research > Research domains > Photonics@EPFL. A sidebar on the left lists navigation options: Home, Projects, Cooperation, Education, and Contact. The main content area is divided into two sections. The first section, titled 'Photonics@EPFL', features a collage of images showing people working with optical equipment. Below the images is a text block defining photonics as a Key Enabling Technology (KET) and mentioning its collaboration with Swissphotonics. The second section, titled 'Photonics in Romandy', features a large aerial photograph of the EPFL campus in Lausanne, Switzerland, with a text block explaining the French-speaking part of Switzerland and listing the EPFL campuses in Lausanne, Sion, Geneva, Neuchâtel, and Fribourg.

**Photonics@EPFL**

Photonics (the combination of photons with electronics, is a Key Enabling Technology (KET), radically transforming the traditional industrial base and revolutionizing many products. This site made in collaboration with Swissphotonics shows the various addresses and diversity of the photonics at EPFL, set around.

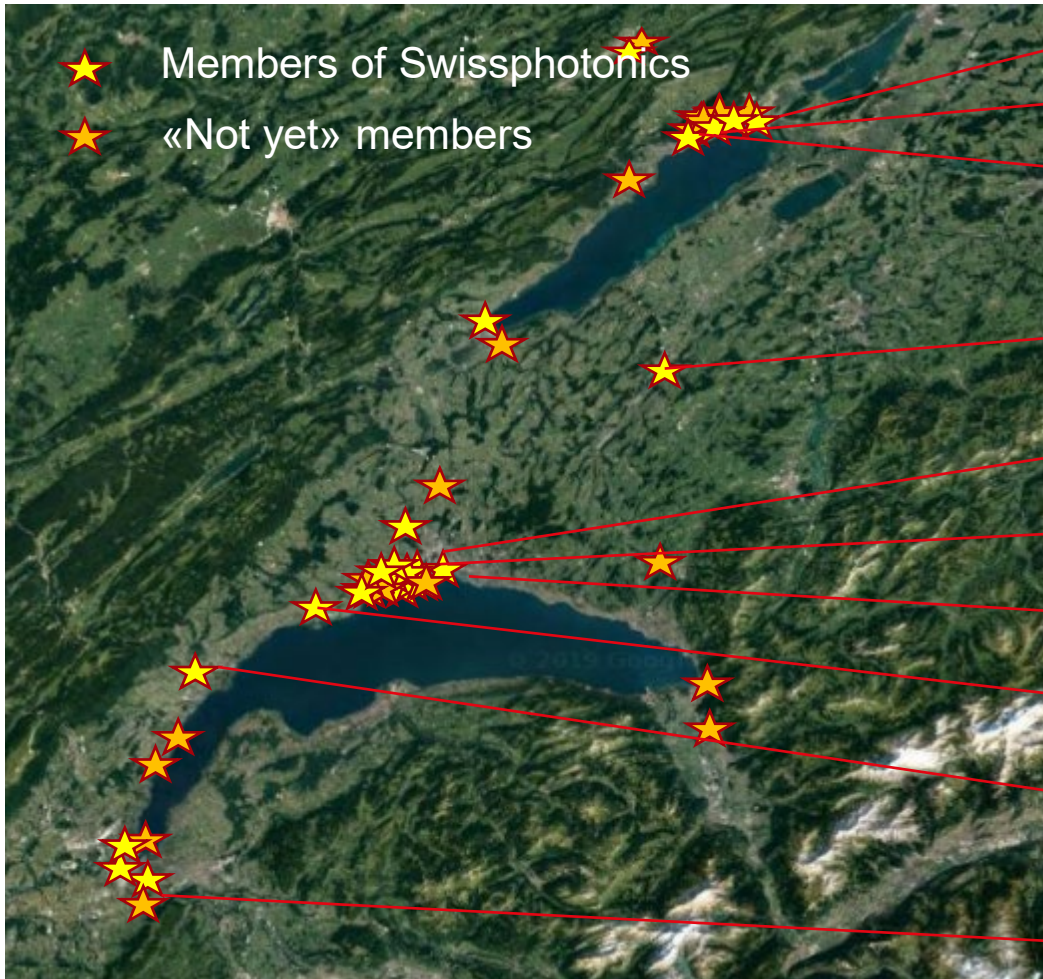
**Photonics in Romandy**

Find photonics related competence and academic and innovation actors active in the photonics field in the French-speaking part of Switzerland. The links to the broader Swiss network, in particular through the national platform **Swissphotonics**, are also presented. The French-speaking part of Switzerland, also called **Romandy**, represents 14% of Switzerland's inhabitants, 1/5 of its territory and is composed of 7 cantons where French is spoken: Geneva, Vaud, Neuchâtel, Jura, Fribourg, Valais and Bern. The main campus of EPFL is at Lausanne with 4 other associated campuses in Sion (Valais), Geneva, Neuchâtel and Fribourg.

# EPFL Photonics companies in Romandy

> 80 companies strongly related to Photonics

10 examples:



ALPES  
LASERS

QC Lasers for IR sensing

SUSS  
MicroTec

Micro-optics on wafers

sercalo  
microtechnology ltd

Microtechnologies (MEMS)

cpa

Automation

LIGENTEC

Photonic Integrated Circuits (PICs)

LESSE

Lighting (cars etc.)

insolight

Photovoltaics

omnisens  
Securing asset integrity

Fibre sensing

SYNOVA

Material processing

IDQ

Quantum Communication & Sensing

# Startups related to Photonics 2010-2020

2020



2019



2018



*Candlelight Systems*

2017



2016



2014



2015



2013



2010



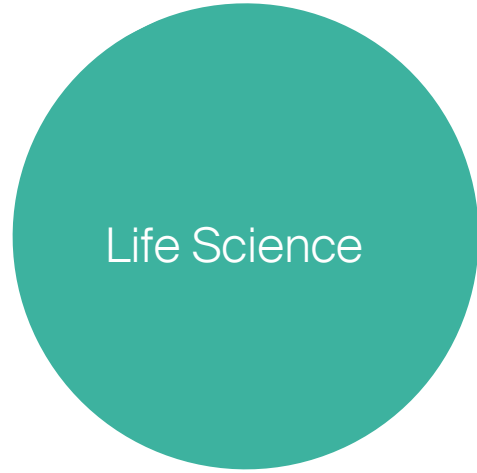
2011



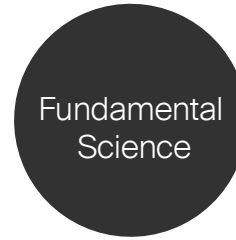
2012



Laser  
manufacturing

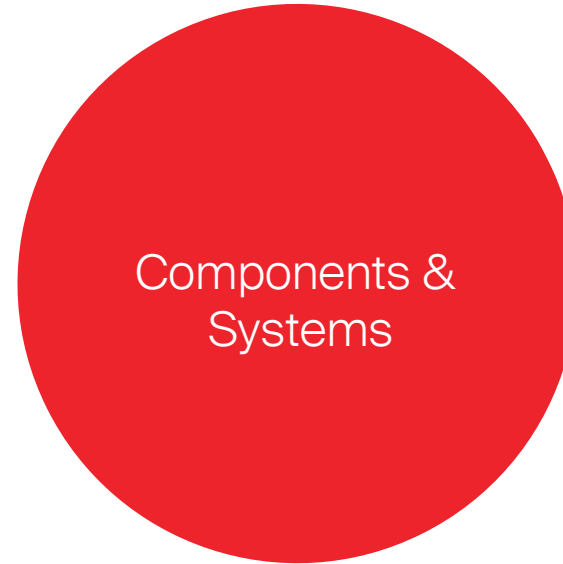


Life Science



Fundamental  
Science

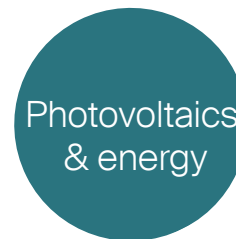
# EPFL Photonics



Components &  
Systems



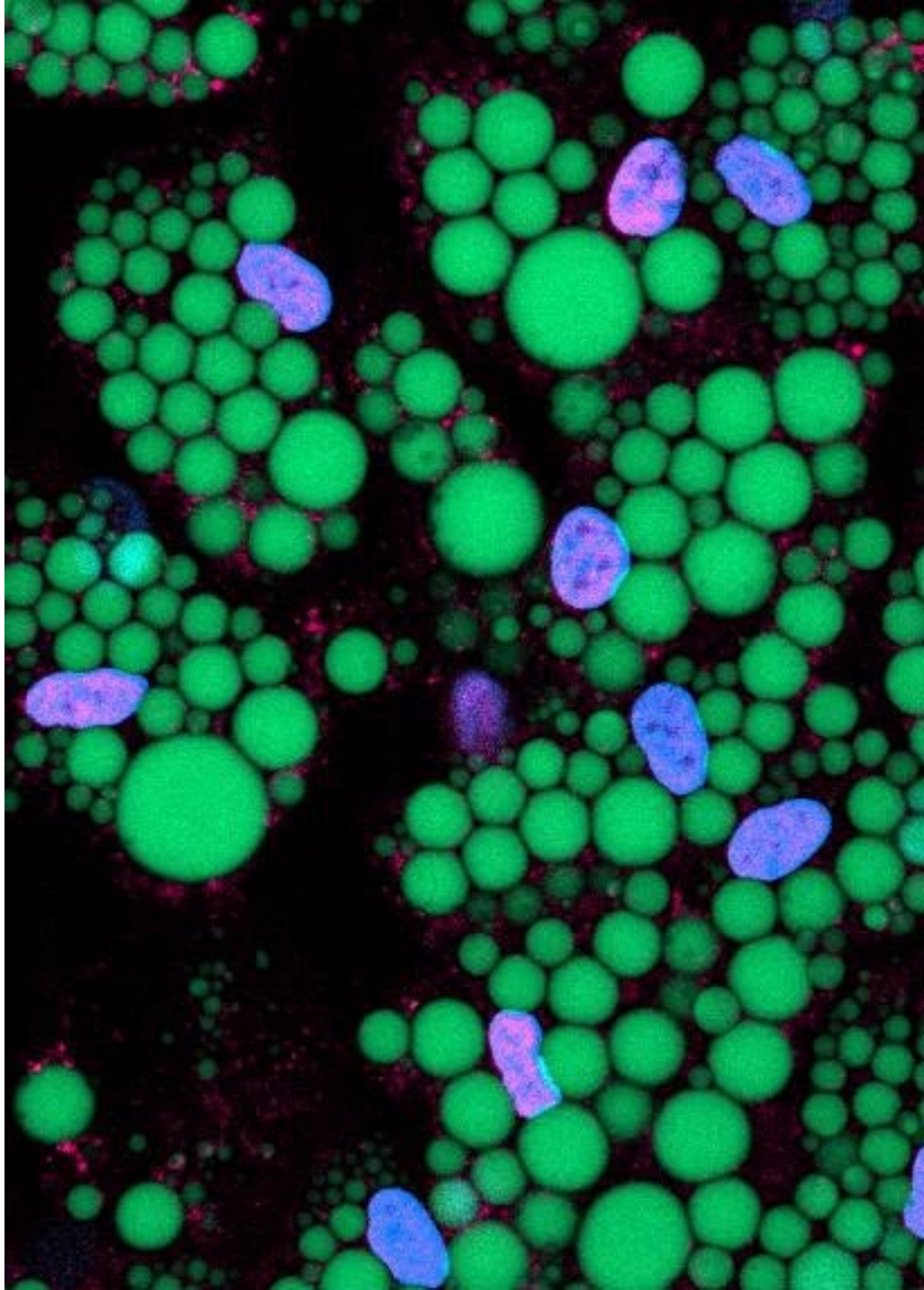
Imaging



Photovoltaics  
& energy

> 30 laboratories and  
research groups

2 Platforms / infrastructures



# Life science

10 Professors

10 Labs







### **Prof. Hatice Altug**

BIOS - Bionanophotonic Systems Laboratory

- Nanophotonics and its application in optical devices, biosensing, bioimaging & Mid-IR spectroscopy
- Lab-on-a-chip integration of photonics, microfluidics and data science for disease and point-of-care diagnostics
- Novel nano/microfabrication and bionanopatterning methods



### **Prof. Ardemis Boghossian**

LNB - Laboratory of Nanobiotechnology

- Synthetic biology and protein engineering to engineer light-harvesting bioenergy
- Laser-excited fluorescence of single-walled carbon nanotubes (SWCNTs) used for optical biosensing and bioimaging for near-IR in-vivo applications



### **Prof. Suliana Manley**

LEB - Laboratory of Experimental Biophysics

- Super-resolution fluorescence microscopy (PALM, STORM, PAINT, SIM).
- High-throughput, automated, and intelligent microscopy.



**Prof. Christophe Moser**

LAPD - Laboratory of Applied Photonics Devices

- Volumetric 3D printing method based on tomography (entire solidification at once). 3D printing of functional human tissues (ENLIGHT project).
- High-resolution retinal imaging with new technique called trans scleral optical phase imaging.

**Prof. Demetri Psaltis**

LO - Optics Laboratory

- Optical imaging techniques for the diagnosis of hearing loss due to deterioration of colchea.
- Imaging in complex media such as biological tissues.

**Prof. Aleksandra Radenovic**

LBEN - Laboratory of Nanoscale Biology

- Single-molecule manipulation using optical tweezers and optical wrench.
- New modalities in super-resolution microscopies capable of molecular-scale resolution (SMLM, SIM and SOFI)\*





### Prof. Sylvie Roke

LBP - Laboratory of Fundamental BioPhotonics

- Develop nonlinear optical technology such as second harmonic scattering, sum frequency scattering, wide-field multiphoton microscopy, ultrafast spectroscopy
- Generating molecular level understanding of aqueous systems & interfaces driven by new technology.



### Dr. Arne Seitz

BIOP - BioImaging and Optics Platform

- The BioImaging and Optics Platform (BIOP) provides instruments and expertise to solve challenging (biological) questions with modern light-microscopy.



### Prof. Michaël Unser

LIB - Biomedical Imaging Laboratory

- Development of new algorithms and mathematical tools for biomedical imaging
- Advanced image reconstruction
- Super-resolution microscopy
- Phase imaging (diffraction tomography, unwrapping)
- Deep learning for inverse problems .





### **Dr. Georges Wagnières**

LIFMET - Laboratory for  
Functional and Metabolic  
Imaging

- Cancer detection and characterization by fluorescence spectroscopy and imaging.
- Light dosimetry and tissue optical spectroscopy.
- Photobiomodulation and Photodynamic therapy.
- Study of the metabolism by time-resolved luminescence spectroscopy.



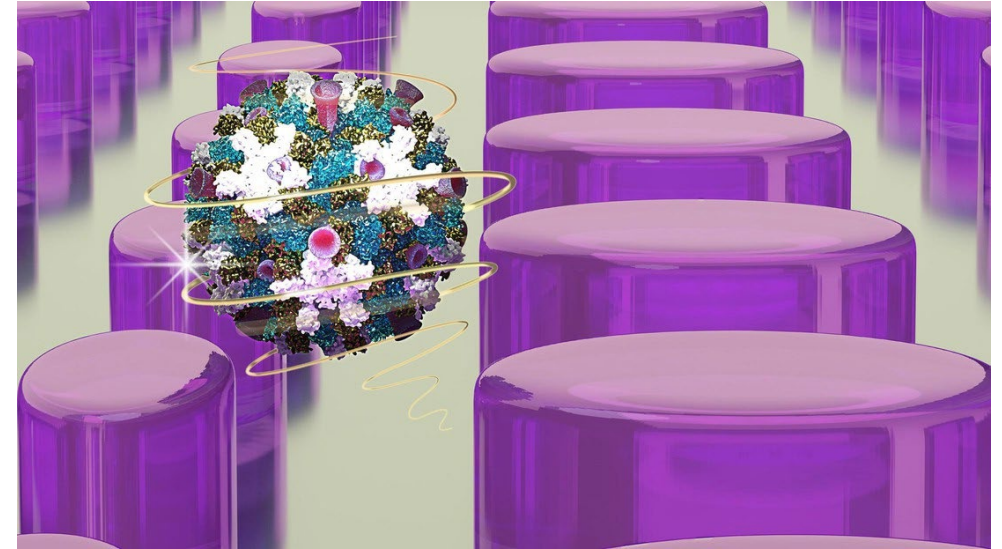


Hatice Altug and A. Belushkin

**Portable device helps doctors diagnose sepsis faster, 2020.**

<https://youtu.be/sDjux6M0evw>

In EPFL News: [Link](#)



"Imaging-based spectrometer-less optofluidic biosensors based on dielectric metasurfaces for detecting extracellular vesicles", Y. Jahani et al. Nature Communications, 31 May 2021.

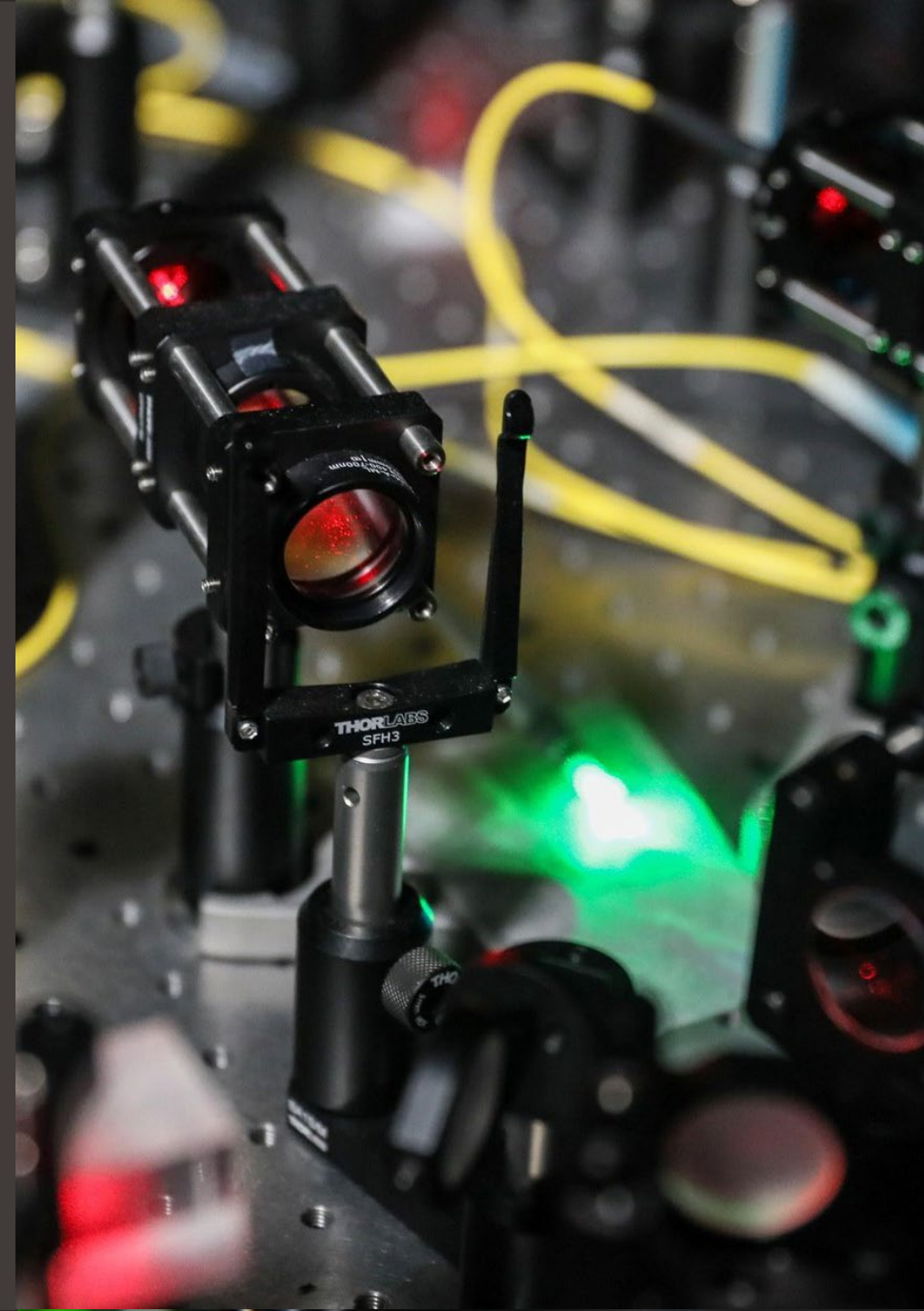
In EPFL News: [Link](#)



# Fundamental science

5 Professors

5 Labs





**Prof. Jean-Philippe Brantut**  
LQG - Chair in Physics of  
Quantum Gases

- Cavity quantum electrodynamics
- Ultra-cold and strongly correlated quantum matter
- Quantum simulation with neutral atoms



**Prof. Majed Chergui**  
LSU - Laboratory of Ultrafast  
Spectroscopy

- Probing in “real-time” the structural evolution of crystals, molecules or proteins in the course of a phase transition, a reaction or a (bio)chemical function.
- Optical domain ultra-fast spectroscopy, and time-resolved X-ray spectroscopy.



**Prof. Christophe Galland**  
LQNO - Laboratory of Quantum  
Nano-Optics

- Quantum optics, spectroscopy of nanoscale hybrid systems
- Frequency conversion
- Quantum sensing





## Prof. Tobias Kippenberg

LPQM1 / K-LAB - Laboratory of Photonics and Quantum Measurements

- Discovery of chip-based frequency combs ('Microcombs') in different photonic platforms i.e.  $\text{Si}_3\text{N}_4$  and GaP
- Developed cavity quantum optomechanics, techniques to manipulate mechanical oscillators in the quantum regime
- Superconducting circuit electro-mechanics



## Prof. Vincenzo Savona

LTPN - Laboratory of Theoretical Physics of Nanosystems

- Study and modeling of open quantum systems, i.e. influenced by the surrounding environment in the form of driving, losses, and phase noise.
- Modelling and optimization of artificial photonic nanostructures (e.g. with machine learning).





# Kippenberg/k-lab - Cavity Quantum Optomechanics

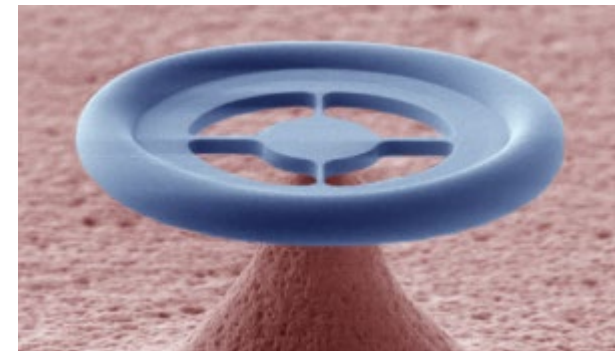
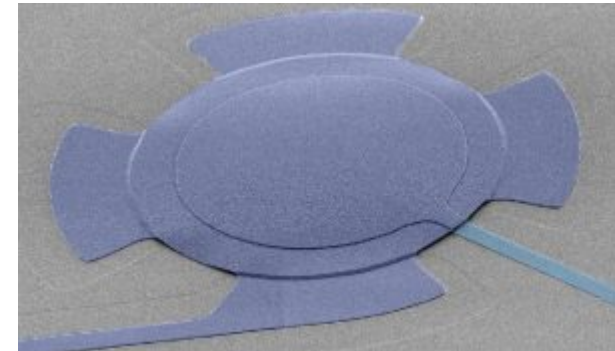
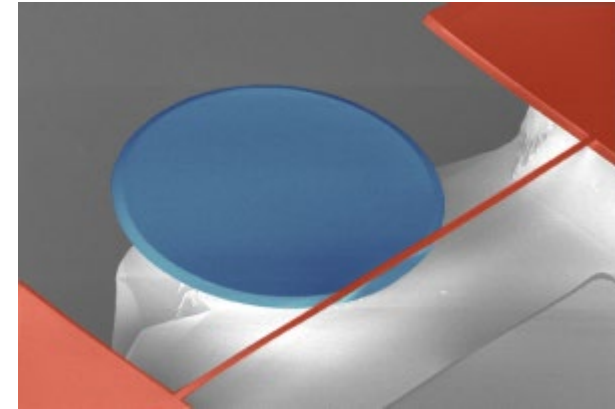
## Quotes from Literature:

“A major achievement of the past decade has been the realization of macroscopic quantum systems by exploiting the interactions between optical cavities and mechanical resonators”<sup>52</sup>

“Since this first demonstration, resolved-sideband cooling has been the workhorse of most experiments aimed at observing quantum effects in macroscopic mechanical resonators”<sup>17</sup>

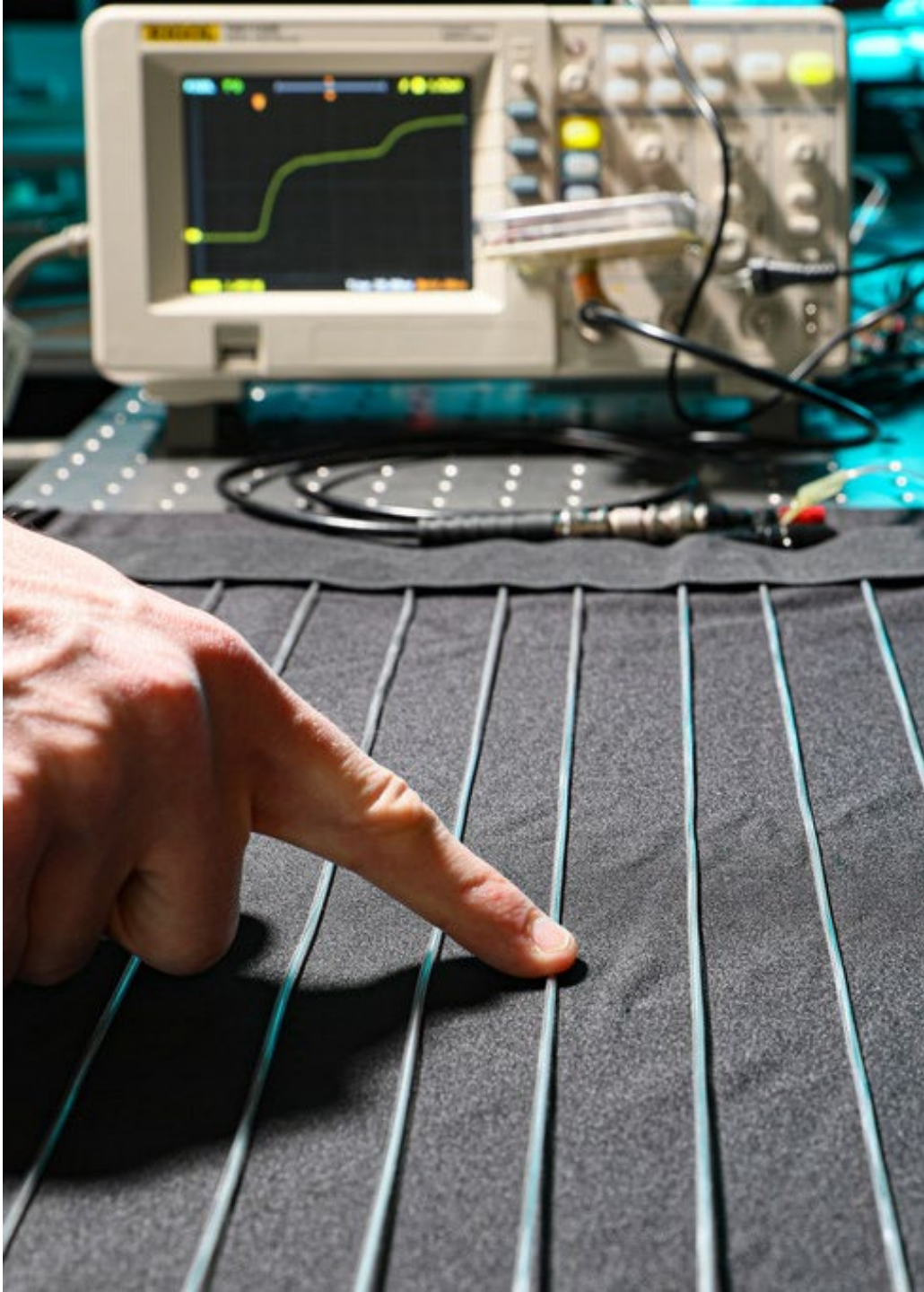
<sup>52</sup>Alba, R. D. *et al.* Tunable phonon-cavity coupling in graphene membranes. *Nat Nano* **11**, 741–746 (2016).

<sup>17</sup>Jayich, A. B. Ten years of Nature Physics: Frozen motion. *Nat Phys* **11**, 710–711 (2015).



Mechanical systems in the quantum regime utilizing cavity optomechanical and electromechanical coupling for past research at EPFL





# Components & Systems

13 Professors

13 Labs





**Prof. Camille Brès**

PHOSL (IEL) - Photonic Systems Laboratory

- Optical waveguide engineering for enhancing nonlinear optical processes and light generation
- Integrated nonlinear optics for frequency conversion
- All-optical signal processing
- Versatile fiber lasers
- Supercontinuum, optical frequency combs



**Prof. Edoardo Charbon**

AQUA - Advanced Quantum Architecture Laboratory

- Single Photon Avalanche Diodes (SPADs) for Light Detection And Ranging (LiDAR), Microscopy and Quantum random number generation and other quantum applications.
- Superconducting Nanowire Single Photon Detectors (SNSPD) for quantum applications.



**Prof. Anna Fontcuberta i**

**Morral** LMSC - Laboratory of Semiconductor Materials

- Synthesis and characterization of novel materials and structures (nanowires) for semiconductor technologies for e.g. solar energy harvesting and next generation computing.





**Prof. Nicolas Grandjean** LASPE -  
Laboratory of Advanced Semiconductors  
for Photonics and Electronics

Wide bandgap semiconductors (group-III nitrides) for:

- Quantum Dots and Nanostructures
- 2D and 1D Photonic Crystals
- Short-Wavelength Optoelectronics



**Prof. Romuald Houdré**  
SCI-SB-RH - Group of Prof.  
Romuald Houdré

- Optical trapping in photonic crystal structures
- Non-linear optics in photonic crystal structures



**Prof. Tobias Kippenberg**  
LPQM Laboratory of Photonics  
and Quantum Measurements

- Chip-based frequency combs ('Microcombs') in different photonic platforms i.e.  $\text{Si}_3\text{N}_4$  and GaP
- Cavity quantum optomechanics, techniques to manipulate mechanical oscillators in the quantum regime
- Superconducting circuit electro-mechanics





**Prof. Andras Kis**

LANES - Laboratory of Nanoscale Electronics and Structures

- Science and technology of 2D semiconductors and heterostructures for optoelectronic, electronic and spintronic device applications
- Growth and integration of 2D materials



**Prof. Olivier Martin**

NAM - Nanophotonics and Metrology Laboratory

- Nanophotonics and in particular plasmonic structures with applications in optical signal processing, integration and biosensing.
- Techniques: heterodyne SNOM, spectroscopy and time-resolved measurements, etc.



**Prof. Christophe Moser**

LAPD - Laboratory of Applied Photonics Devices

- Volumetric 3D printing method based on tomography. 3D printing of functional human tissues.
- High-resolution retinal imaging with new technique called trans scleral optical phase imaging.
- Optical fiber imaging using multimode fibers and neural networks.





**Prof. Demetri Psaltis**

LO - Optics Laboratory

- Optical imaging techniques for the diagnosis of hearing loss due to deterioration of colchea.
- Imaging in complex media such as biological tissues.



**Prof. Fabien Sorin**

FIMAP - Laboratory of Photonic Materials and Fiber Devices

- Nano-scale fabrication on unconventional substrates (large area, 1D, flexible, stretchable, etc.) via fluid flow engineering
- Micro- and nanostructure-based photonic devices and Metasurfaces
- Multi-material fibers for energy harvesting, sensing and actuation



**Prof. Luc Thévenaz**

GFO - Group for Fibre Optics

- Distributed optical fibre sensing
- Opto-acoustics in optical fibres
- Light-atom interaction using optical fibres





## Prof. Yves Bellouard

GALATEA - Galatea Laboratory

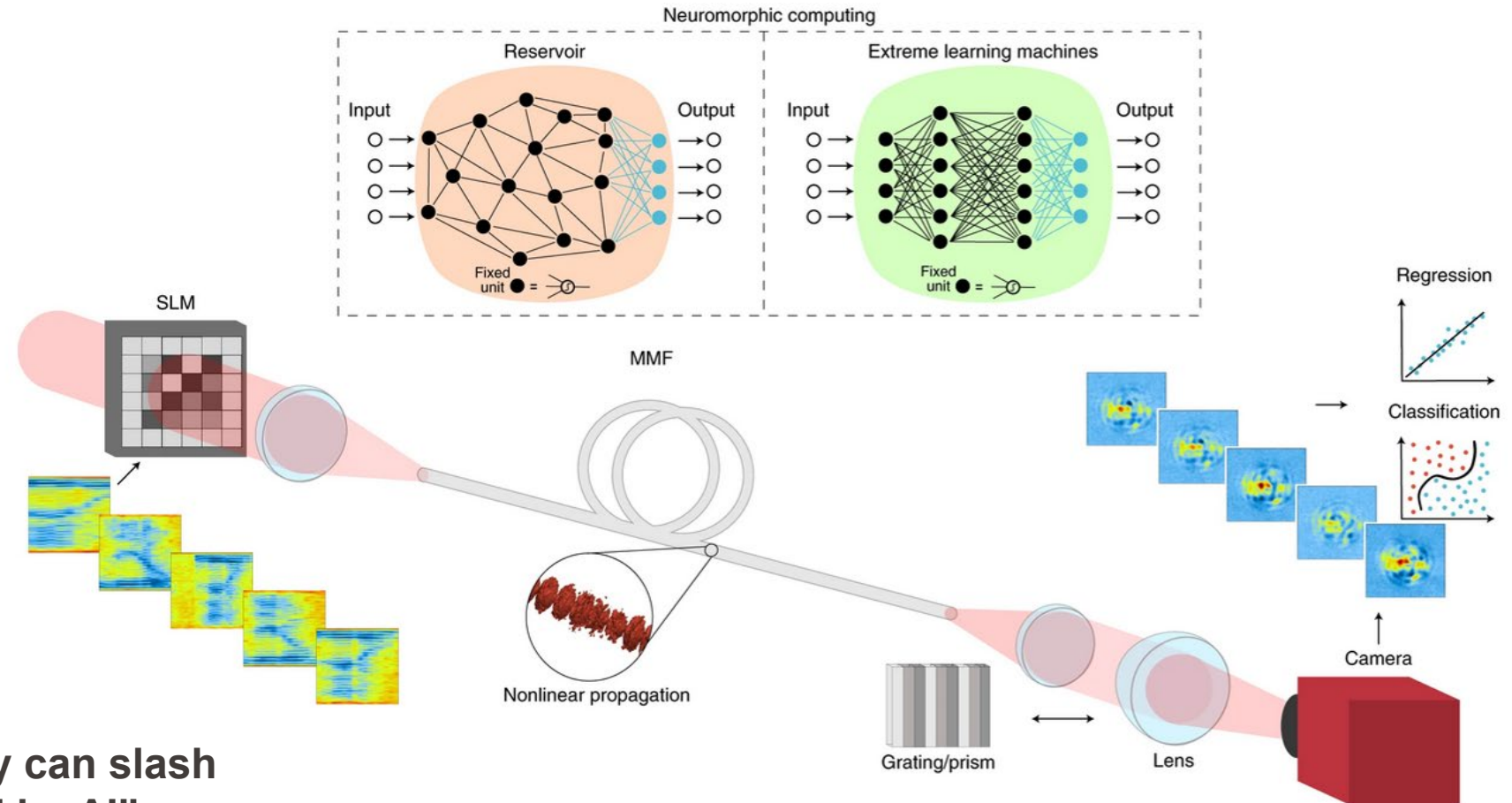
- 3D Manufacturing
- Systems made out of single monoliths
- Packaging of complex optical systems
- Transforming materials locally with lasers



# C. Moser/LAPD & D. Psaltis/LO – Analog Optical Computer with multimode fibres

“These studies show that the analog optical computer based on the MMF is power efficient, versatile and obtains performance comparable with that obtained by digital computers when solving the tasks we investigated.”

“Optical technology can slash the energy required by AI”  
([EPFL News, August 2021](#))



Article in *Nature Computational Science*, 20 August 2021

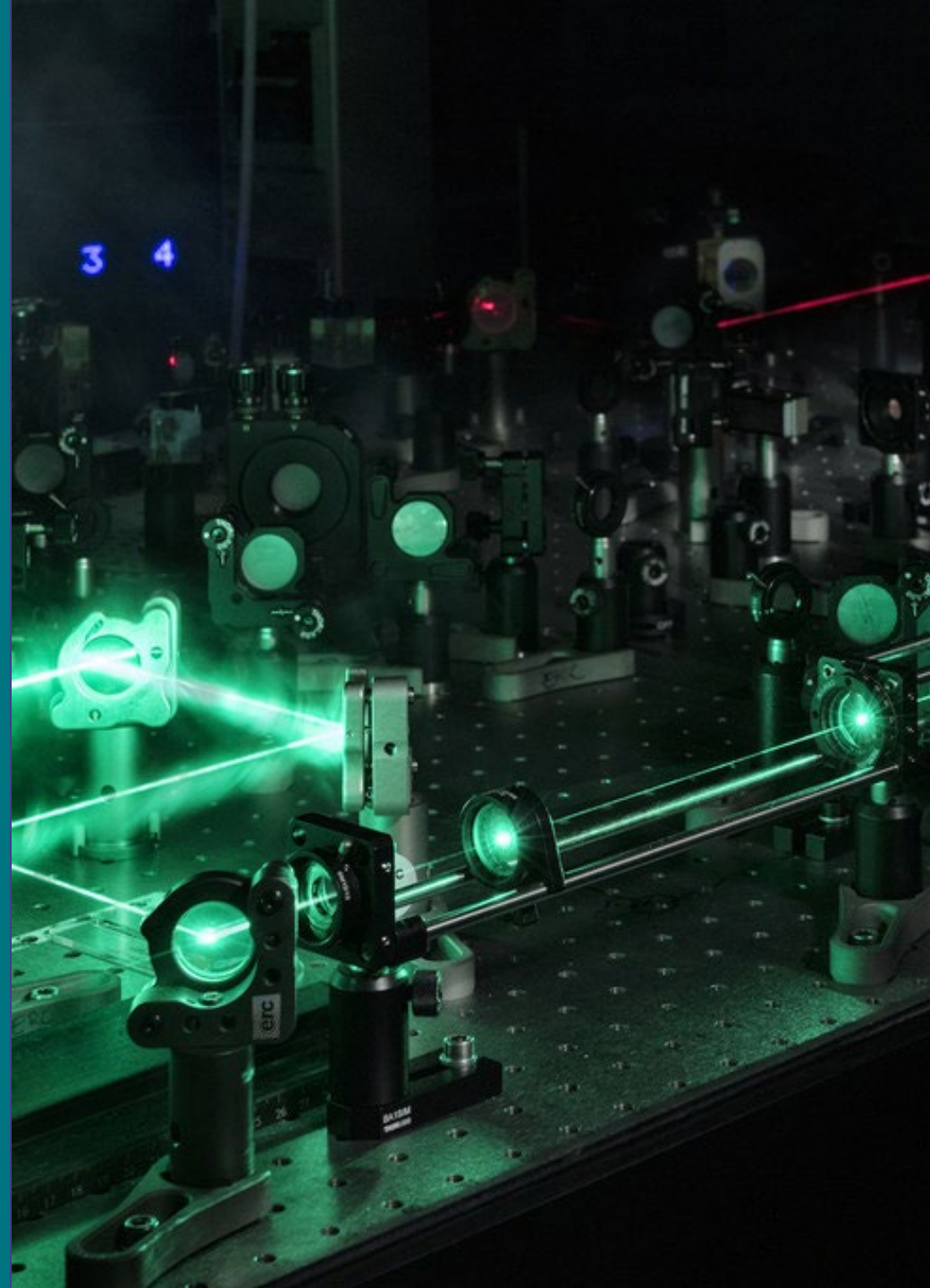




# Photovoltaics & Energy

6 Professors

6 Labs





**Prof. Christophe Ballif**  
PVLAB - Photovoltaics  
Laboratory

- Thin-film technology, semiconductors, TCOs, light management
- Manufacturing processes, production technologies for PV and small-scale production for solar cells and modules
- Specialty filters, colored photovoltaic cells and panels, packaging polymers and reliability



**Prof. Michaël Graetzel** LPI -  
Laboratory of Photonics and  
Interfaces

- Graetzel cells: Dye-sensitized solar cells with adjustable transparency (installed on the Swiss Tech Convention Center)
- Metal halide perovskite solar cells: ultra-thin active layers, high efficiencies, low cost, stability issues to be solved
- Generation of chemical fuels from sunlight.



**Prof. Jacques-Édouard Moser**  
GR-MO - Photochemical Dynamics  
Group

- Ultrafast photoinduced charge and quasi-particle dynamics
- Development of novel spectroscopic techniques





**Prof. Mohammad K. Nazeeruddin**  
GMF, SCI SB MN - Group for Molecular  
Engineering of Functional Materials

- Molecular engineering of functional materials for photovoltaic and light-emitting applications.
- Compositional and structural optimization of dye-sensitized and perovskite solar cells.
- Organic light emitting diodes (OLEDs) by engineering highly phosphorescent emitters.



**Prof. Giulia Tagliabue**  
LNET - Laboratory of Nanoscience  
for Energy Technologies

- Perfect light absorbers for photothermal and photochemical energy conversion devices
- Fundamental understanding of plasmonic hot carrier photodetectors and photocatalysts
- Design of tunable metalenses



**Prof. Anna Fontcuberta i Morral** LMSC - Laboratory of  
Semiconductor Materials

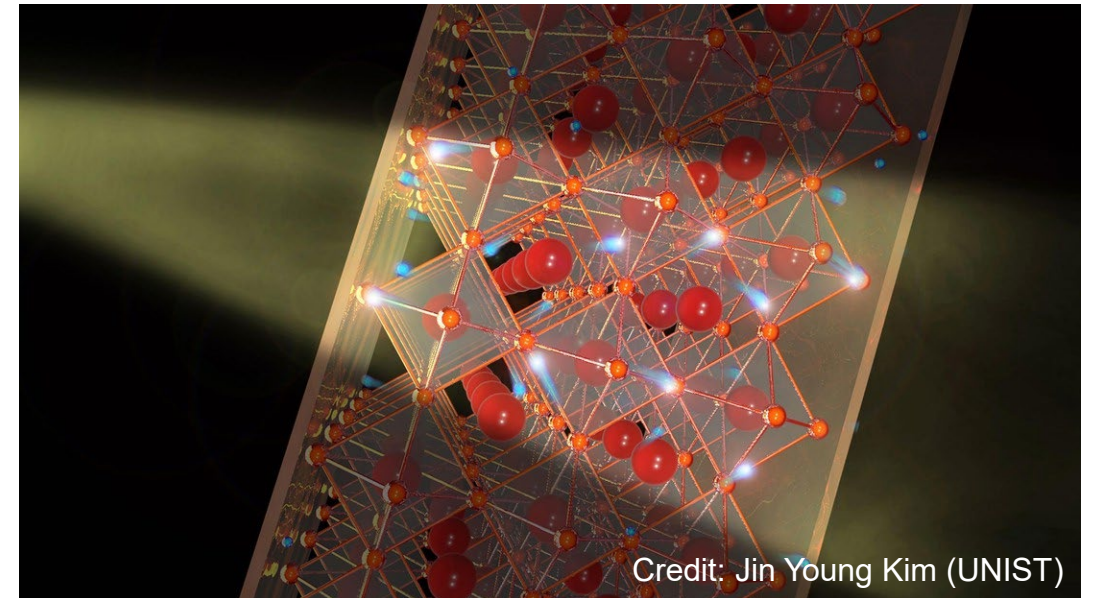
- Synthesis and characterization of novel materials and structures (nanowires) for semiconductor technologies for e.g. solar energy harvesting and next generation computing.

# EPFL Michael Grätzel/LPI – Dye Sensitized Solar Cells

“Exactly 30 years ago, in 1991, Michael Grätzel and his research group realized a new kind of solar cell: the dye-sensitized solar cell, DSC, or Grätzel cell.<sup>5</sup>”



Power-conversion efficiency of 25.6% and operational stability at least 450 hours of perovskite solar cells

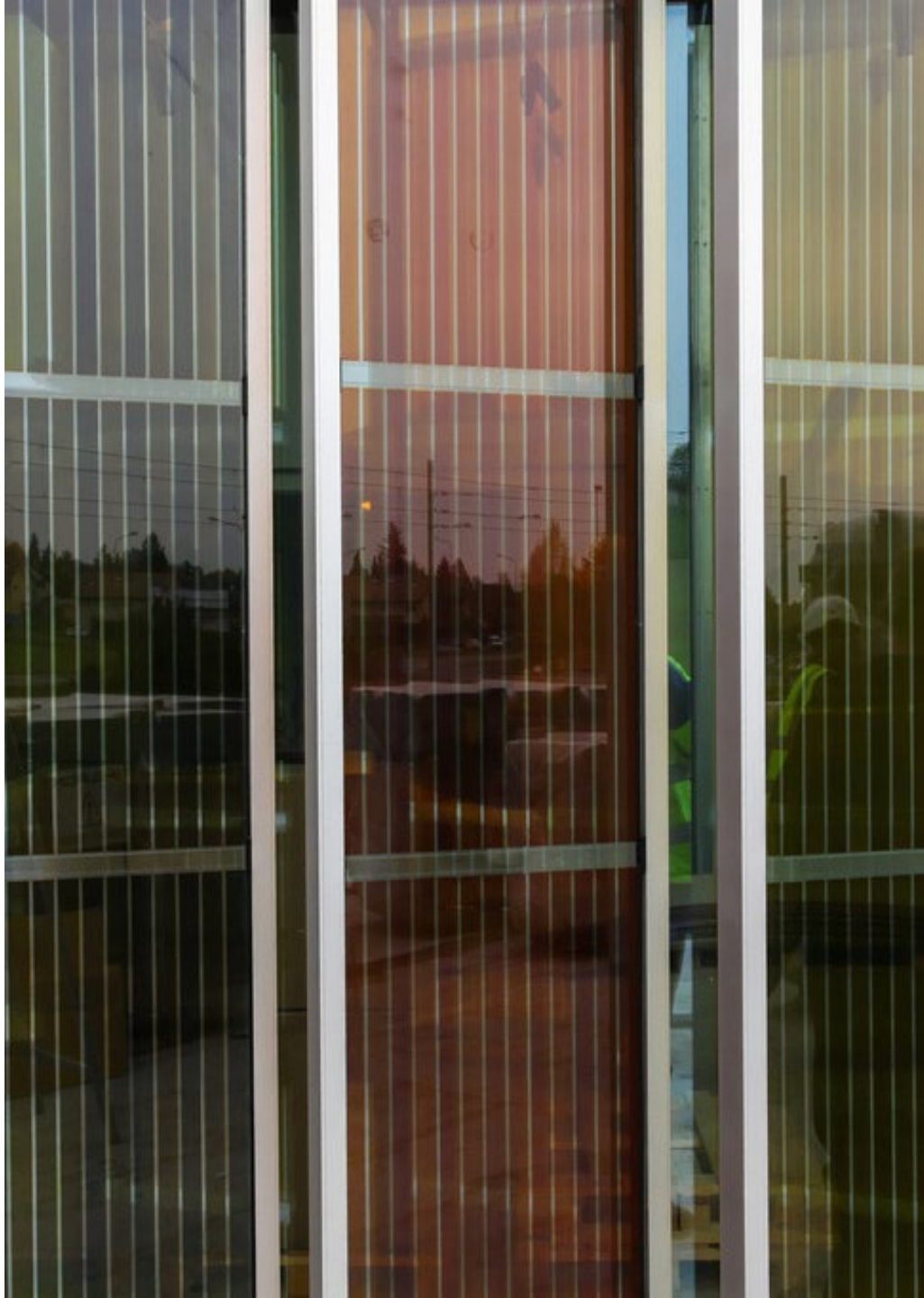


Cf. Review article in Chemical Society Reviews 2021 ([Open Access](#))

<sup>5</sup>B. O'Regan and M. Grätzel, Nature, 1991, 353, 737–740.

News EPFL, 20 April 2021





# Laser manufacturing

2 Professors

2 Labs





**Prof. Yves Bellouard**  
GALATEA - Galatea Laboratory

- 3D Manufacturing
- Transforming materials locally with lasers



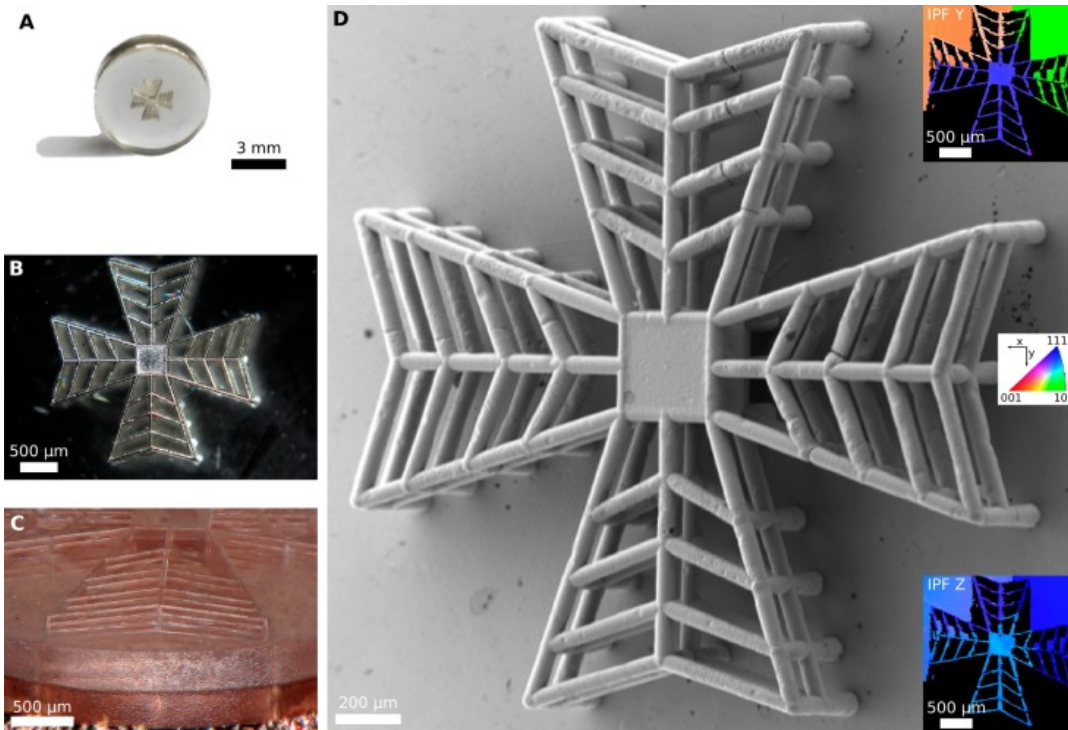
**Prof. Christophe Moser**  
LAPD - Laboratory of Applied  
Photonics Devices

- Volumetric 3D printing method based on tomography. 3D printing of functional human tissues.



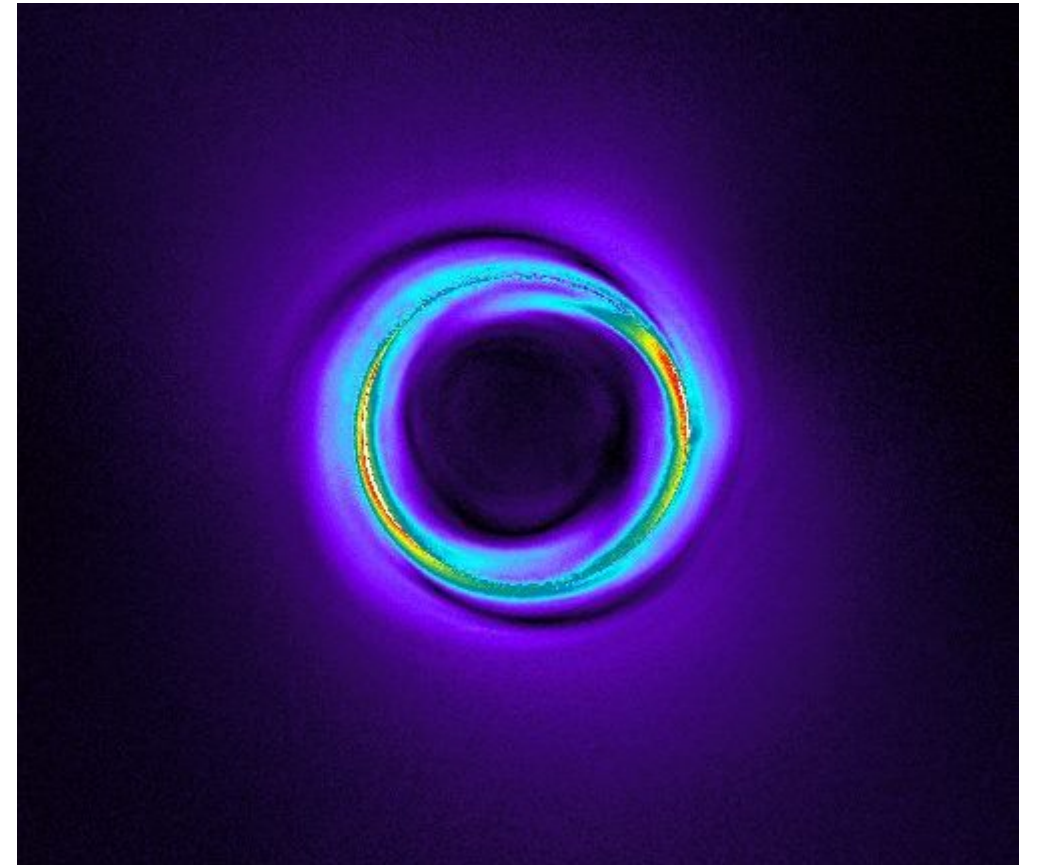
# Yves Bellouard/Galatea – Ultrafast laser 3D manufacturing and transforming

## 3D metal freeform micromanufacturing



Complex (Maltese cross) 3D structure produced in pure silver and pure copper (from a quartz glass mold)

## Tailoring stress states and mechanical properties of transparent materials





**Prof. Fabrizio Carbone**  
LUMES - Laboratory for  
Ultrafast Microscopy and  
Electron Scattering



**Prof. Romuald Houdré**  
SCI-SB-RH - Group of Prof.  
Romuald Houdré



**Dr. Georges Wagnières**  
LIFMET - Laboratory for  
Functional and Metabolic  
Imaging



**Prof. Christophe Moser**  
LAPD - Laboratory of Applied  
Photonics Devices



**Prof. Demetri Psaltis**  
LO - Optics Laboratory



**Prof. Aleksandra Radenovic**  
LBEN - Laboratory of Nanoscale  
Biology

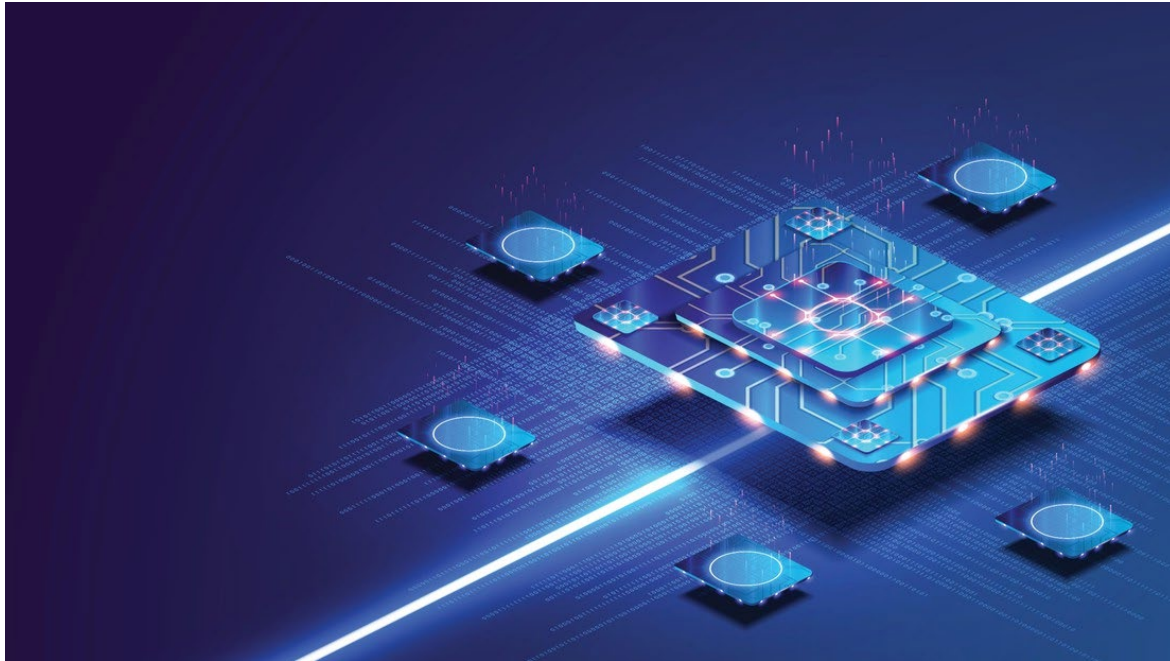


**Dr. Arne Seitz**  
BIOP - BiImaging and  
Optics Platform





# Center for Quantum Science and Engineering



EPFL launches new Center for Quantum Science and Engineering: [Article](#) (31 August 2021)

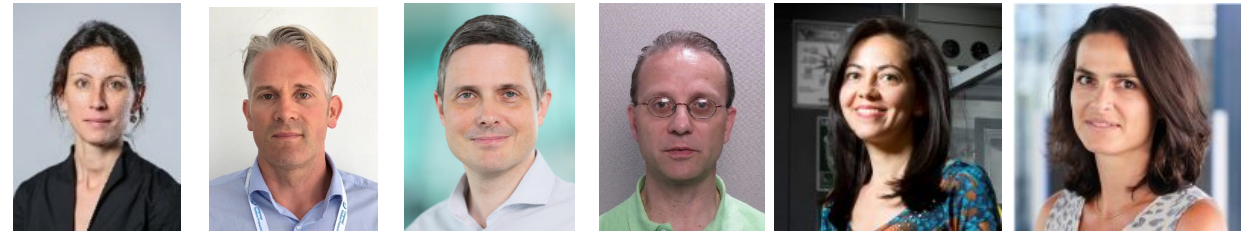


Dir. Vincenzo Savona

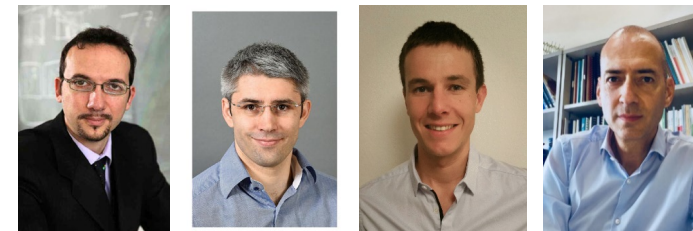


Dep. dir. Cristina Benea-Chelmus

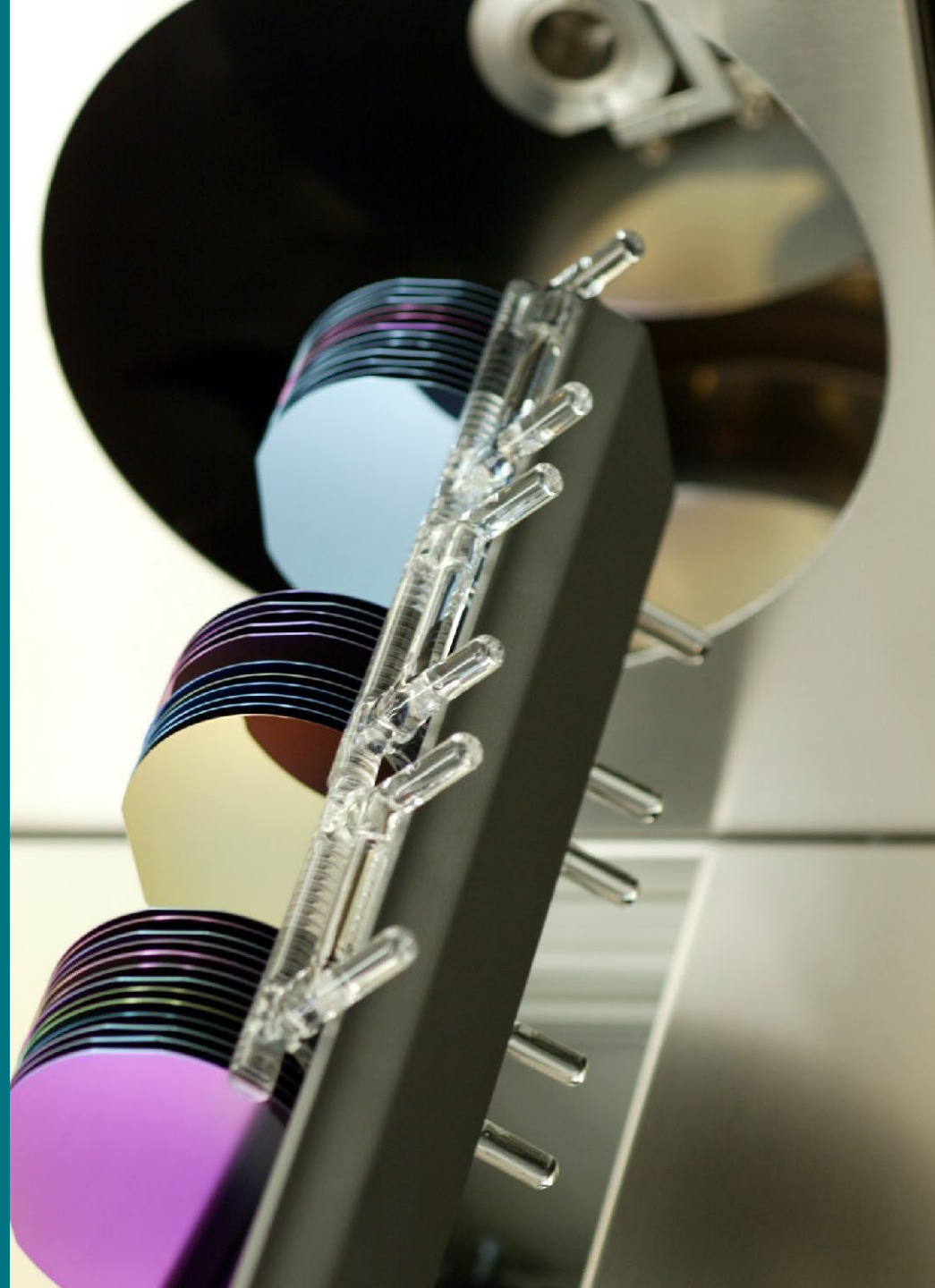
## Other Photonics Professors in the governance of the center

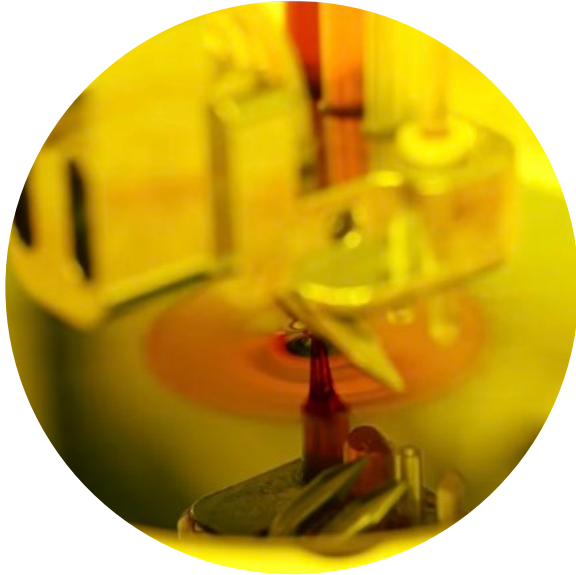


## Other Photonics Professors active in the field



# Platforms / infrastructure / Centra





## Center of MicroNanoTechnology (CMI)

The CMI is a complex of clean rooms and processing equipment for the training and scientific experimentation devoted to the users of microtechnologies.



## Clean Rooms

IPHYS has extensive facilities for micro- and nano-fabrication and characterization, including specialized III/V lab clean rooms, thin films deposition, dry etching, lithography, electron and atomic force microscopy, and photo- and cathodo-luminescence. These are also open for use by interested researchers from other Institutes at EPFL.



- PhotonHub is THE Digital Innovation Hub for the field of Photonics in Europe
- Largest Photonics EU project ever! (H2020) – 19 M€ grant
- European Commission's aim: spread photonic technologies in innovative SMEs' products
- Comprehensive support to SMEs:
  - Training
  - Test before invest (prototyping/upscaling/manufacturing)
  - More competitive products
  - Find investments
- Swiss partners (and 3<sup>rd</sup> party):
  - EPFL, CSEM, Ligentec (and Swissphotonics)



**PhotonHub  
Europe®**

PHOTONICS INNOVATION HUB  
FOR EUROPE

[www.photonhub.eu](http://www.photonhub.eu)



# EU-Funding to help SMEs take up photonic technologies



## PhotonHub Europe®

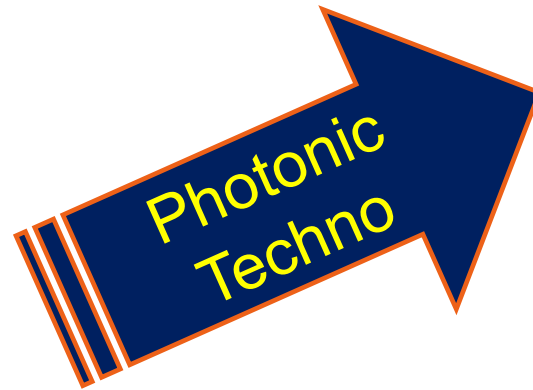
PHOTONICS INNOVATION HUB FOR EUROPE

[www.photonhub.eu](http://www.photonhub.eu)

5000 + photonics SMEs



Associated to 100s of Universities and RTOs



## 260.000 high-potential SMEs for photonics innovation

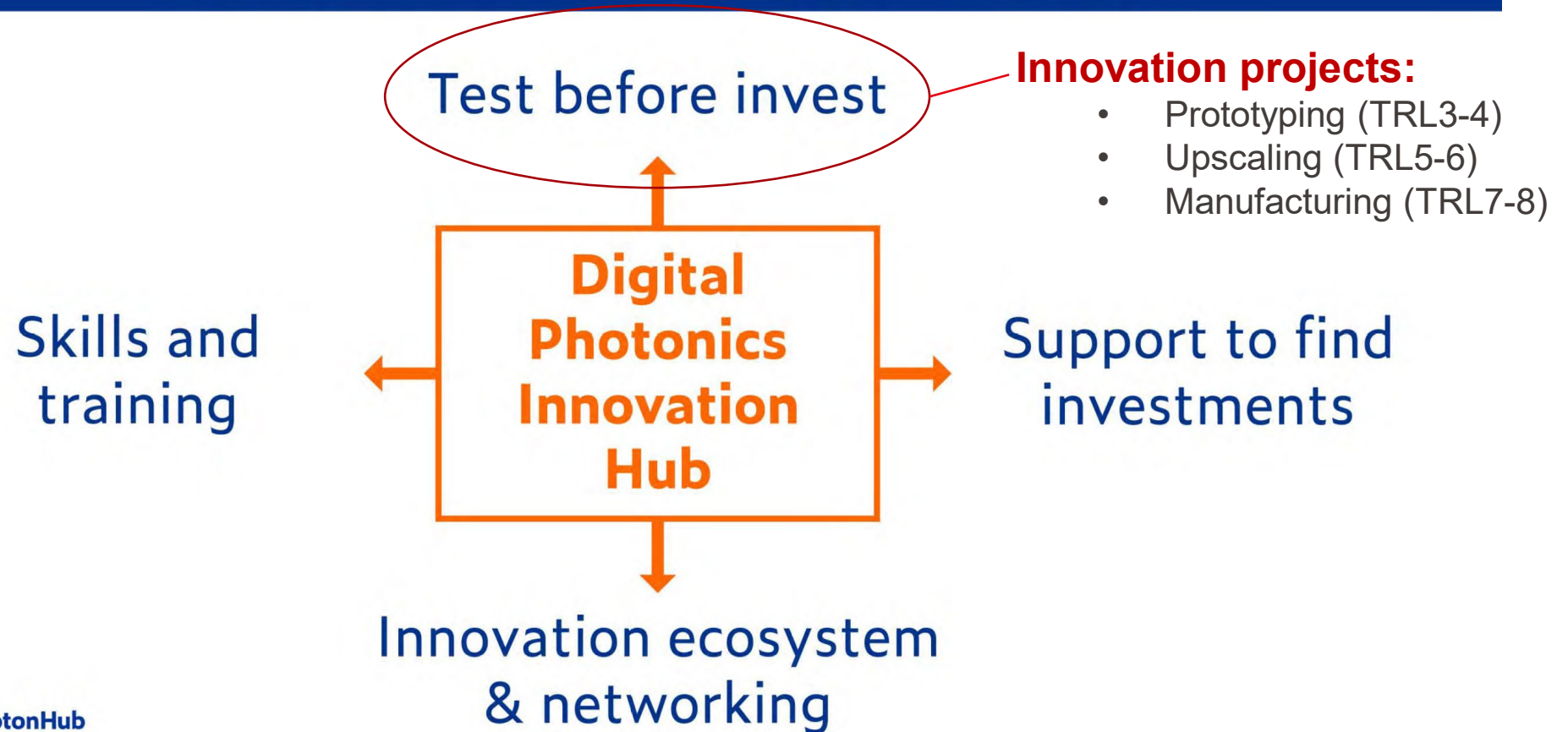
The SME sector in Europe



# 260,000

are classified as Innovative Enterprises by the EC<sup>1</sup>.

## Single One-Stop-Shop



# EU-Funding to help SMEs take up photonic technologies

## Innovation projects:

Project Level	Anticipated Average Innovation Project Budget	PhotonHub Subsidy	Max. Subsidy	No. of projects permissible
Prototyping (TRL3-4)	40k€	<b>For SMEs:</b> 100% of the first 30K€; thereafter (incl. follow-on projects) 75% subsidy with the company contributing 25% in-cash <b>For LSCs:</b> 50% subsidy on all costs	100K€ per innovation project	Max. of 1 follow-on project per company at the prototyping level
Upscaling (TRL5-6)	161K€	<b>For SMEs:</b> 50% subsidy for first users & early adopters <u>at this level</u> , with the companies contributing 50% in-cash; 0% subsidy if the company is not a first user or early adopter <b>For LSCs:</b> 0% subsidy on all costs	250K€ per innovation project, of which of which cascade funding can be provided up to a maximum of 150K€	Max. of 1 follow-on project per company at the upscaling level
Manufacturing (TRL7-8)	2K€	100% subsidy for all companies	2K€	1 subsidised engagement only

## Introductory online courses in Photonics Innovation:

<https://www.photonhub.eu/introductory-photonics-innovation/>

EPFL: Nov.17, 14:00-18:00

Ligentec: Dec. 7, 9:30-13:30

CSEM: Dec. 15, 14:00-18:00

Innovate with the technology of light: Apply [here!](http://www.photonhub.eu) ([www.photonhub.eu](http://www.photonhub.eu))

Contact the EPFL team for guidance, advice & support: [PhotonHub@epfl.ch](mailto:PhotonHub@epfl.ch)

# THANK YOU!

Introductory  
online courses  
in Photonics  
Innovation:

<https://www.photonhub.eu/introductory-photonics-innovation/>

EPFL: Nov.17, 14:00-18:00

Ligentec: Dec. 7, 9:30-13:30

CSEM: Dec. 15, 14:00-18:00

**SWISS PHOTONICS**

**Pierre-Yves Fonjallaz** PhD  
Responsible Romandy  
Specialist EU funding  
c/o EPFL AVP-R-ReO  
BI A2 435, Station 7  
CH-1015 Lausanne  
+41 21 693 41 18

EPFL team for PhotonHub Europe:  
[PhotonHub@epfl.ch](mailto:PhotonHub@epfl.ch)

Elisa Guillermain, Project manager  
Prof. Yves Bellouard, PI EPFL  
P-Y Fonjallaz, Swissphotonics