“Fiber Optics communications in the ATHENA Photonics Hub”

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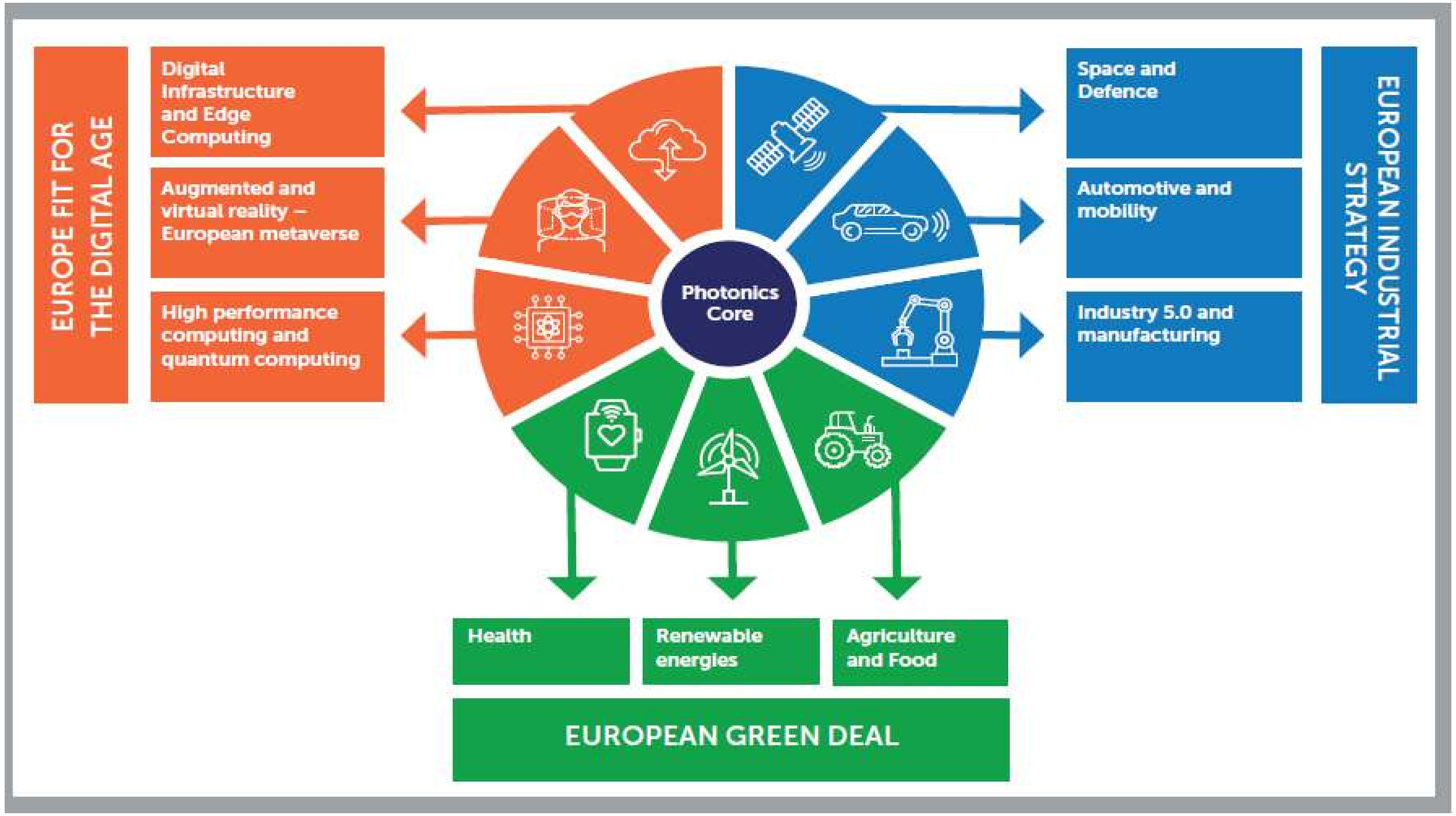
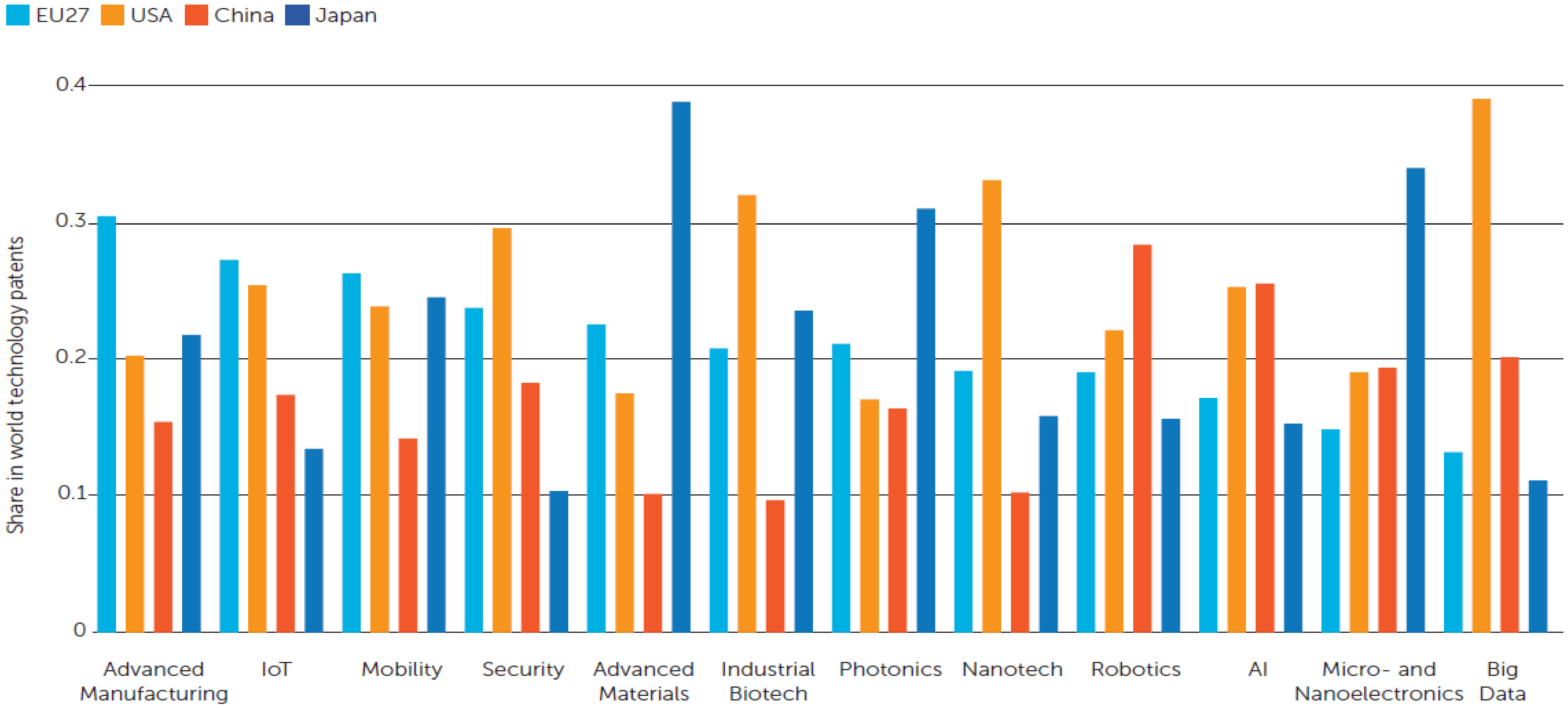
Photonics technologies

- Photonics is a key technology for achieving European strategic autonomy in existing and future emerging economic sectors.



Photonics technologies

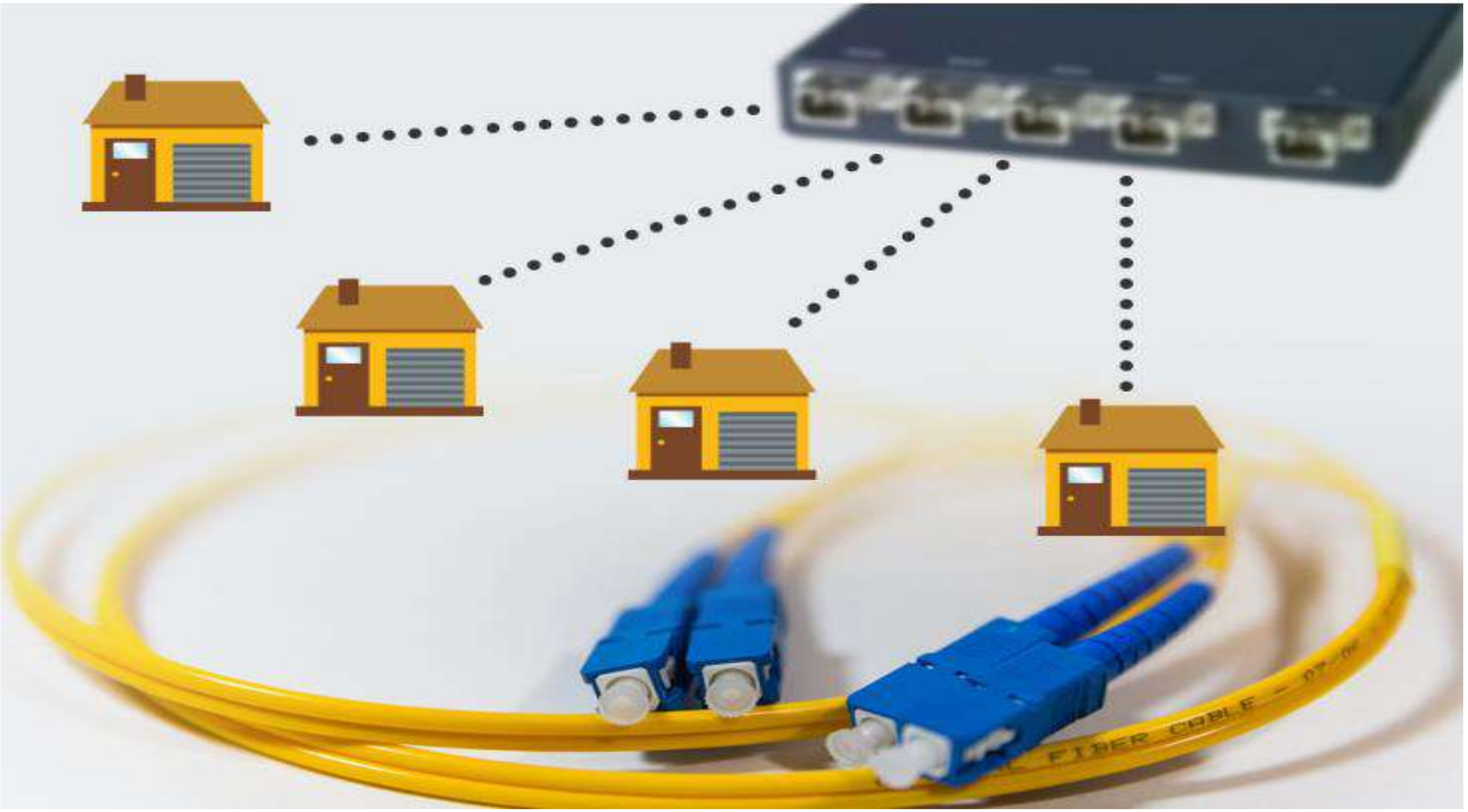
- The European photonics ecosystem has over **5000 SMEs** and a number of large companies. These technology-intensive Photonics companies directly employ over **400,000 people** within the EU.



Source: Advanced Technologies for Industry project

Research in Fiber Optic Communications: PONs

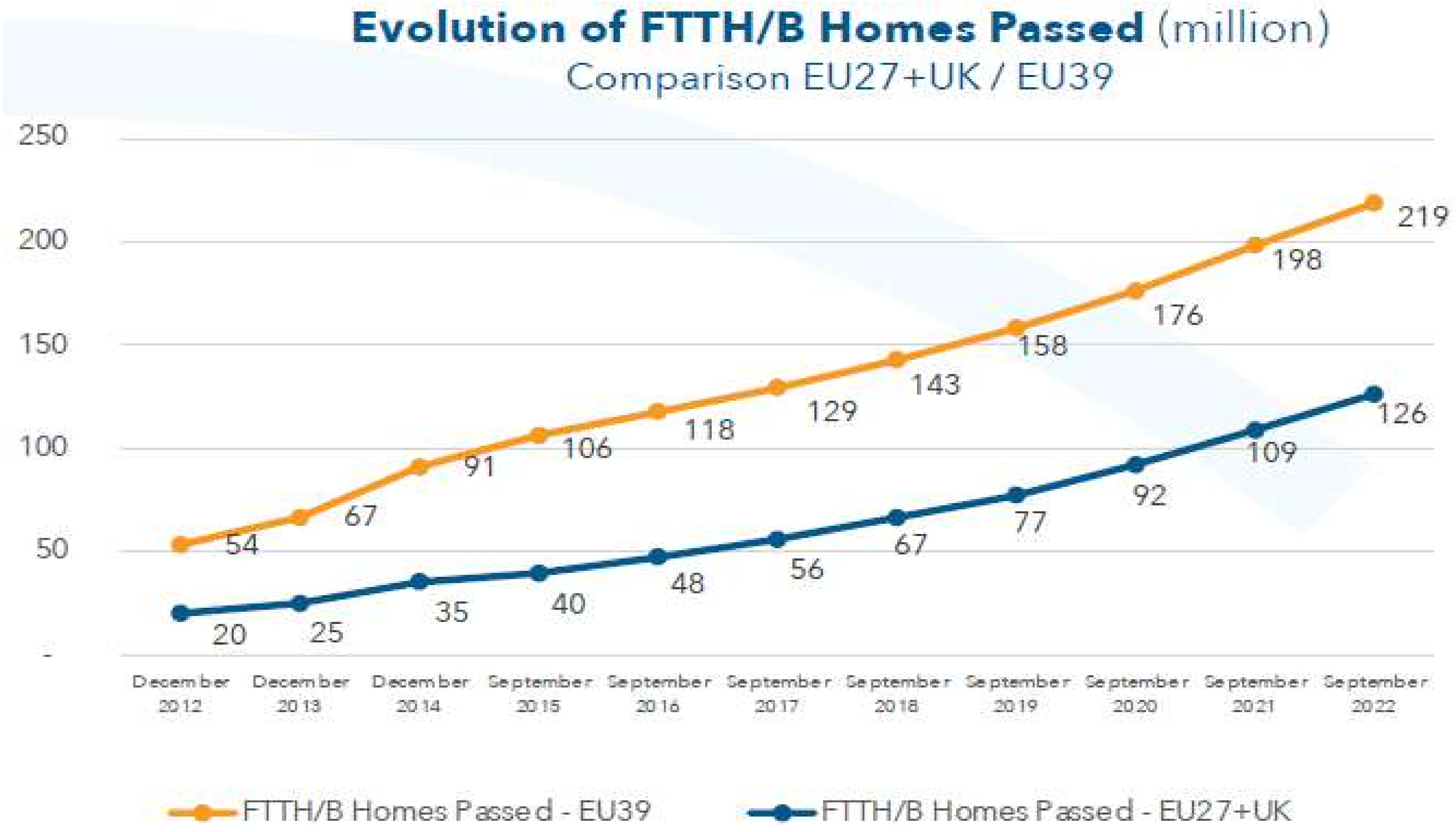
Performance evaluation of combo Passive Optical Networks (PONs)



Research in Fiber Optic Communications: PONs

Evolution of FTTH/B coverage rate: Homes passed – as a proportion of total households

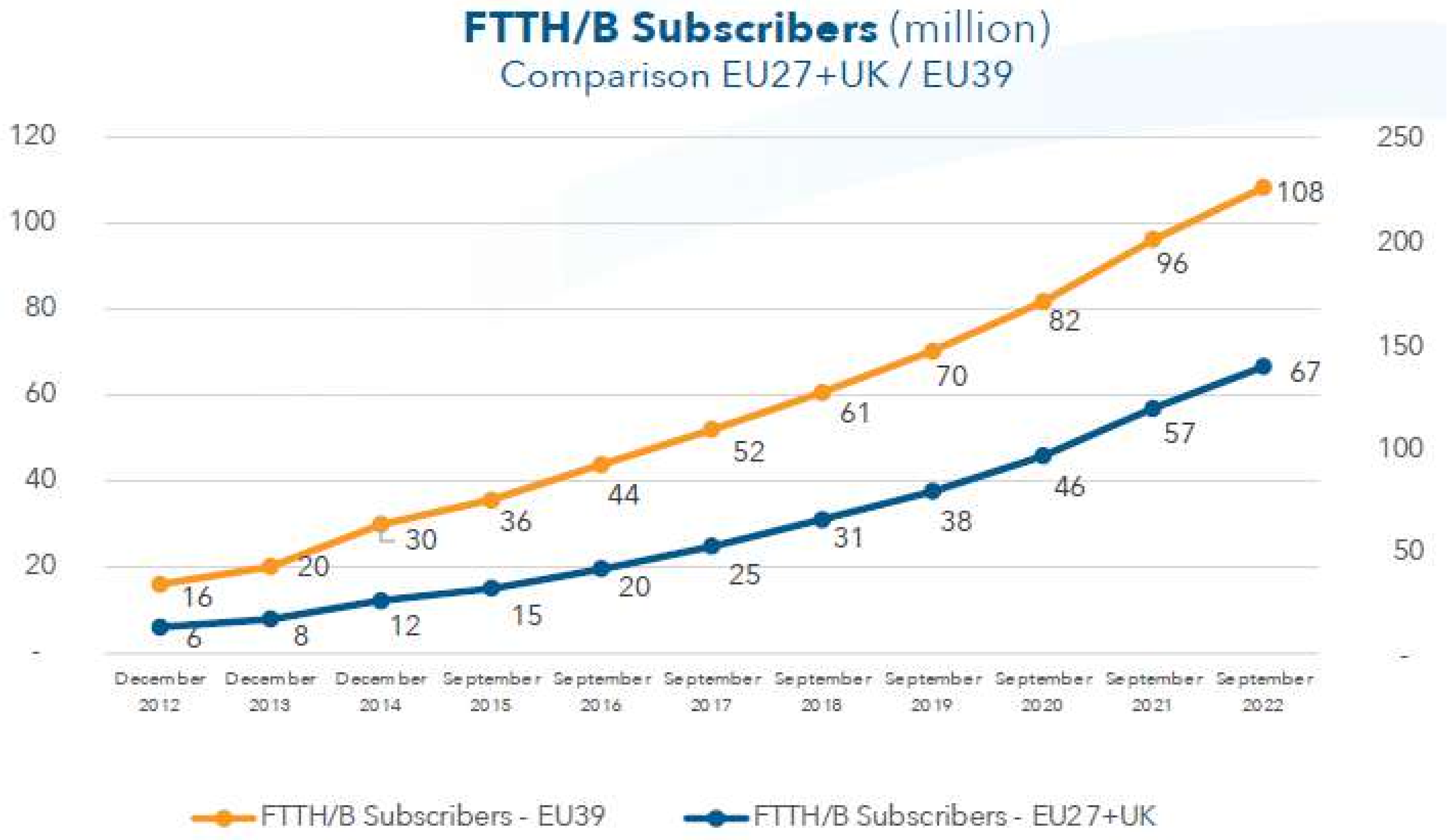
(Source: FTTH Council Europe, September 2022)



Research in Fiber Optic Communications: PONs

Evolution of FTTH/B subscribers

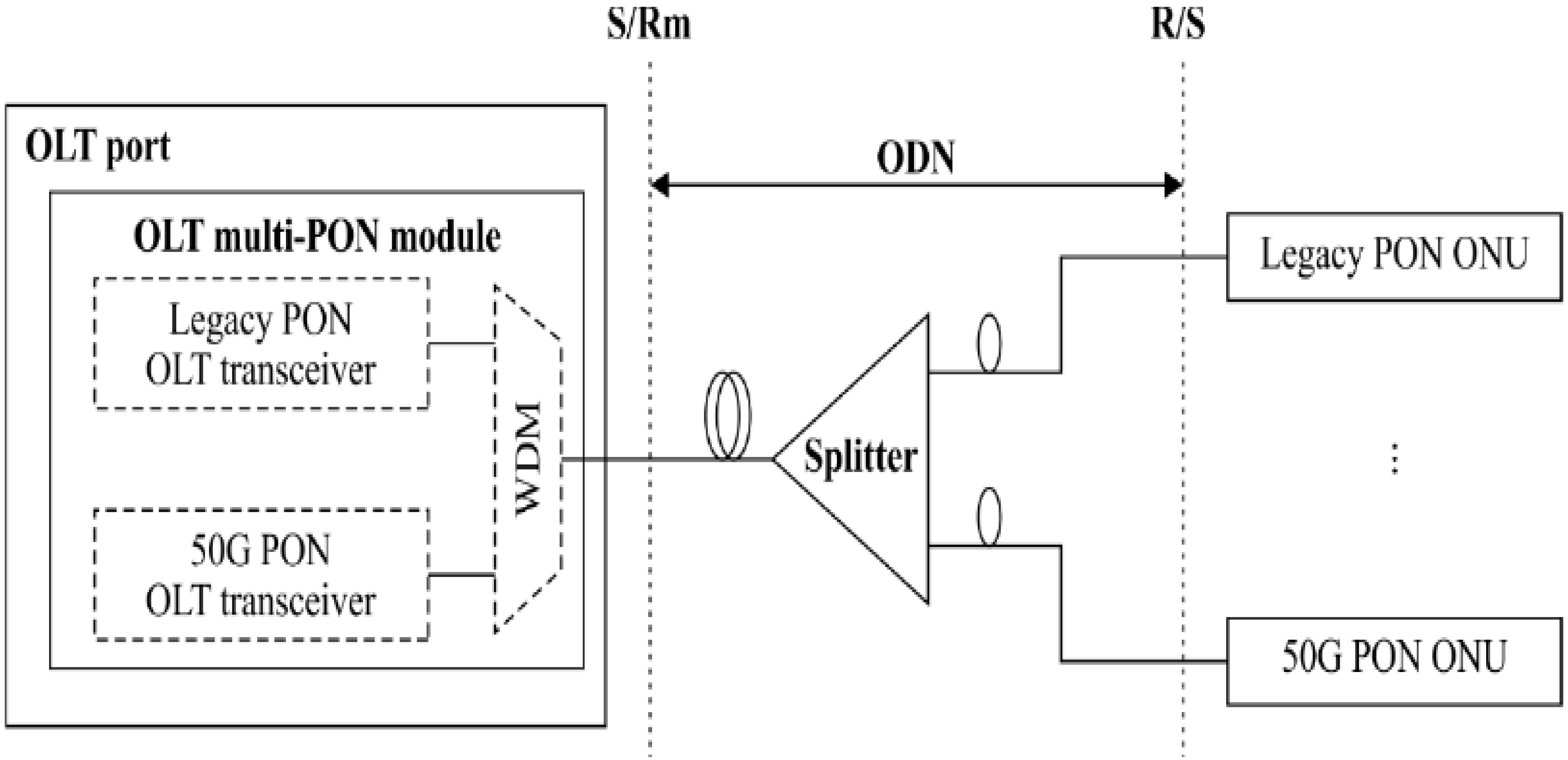
(Source: FTTH Council Europe, September 2022)



Research in Fiber Optic Communications: PONs

General architecture for PONs' coexistence

(Multi-PON module method, ITU-T G.984.5)



Research in Fiber Optic Communications: PONs

Wavelength plans for major ITU PON standards

Standard	Downstream rate (Gbps)	Upstream rate (Gbps)	Downstream wavelength (nm)	Upstream wavelength (nm)
G-PON	2.488	1.244	1480-1500	1290-1330
XG(S)-PON	9.952	9.952 2.448	1575-1580	1260-1280
50G-PON (ITU-T G.9804.x)	49.7664	*49.7664* 24.8832 12.4416	1340-1344	1260-1280 (US1) or 1290-1310 (US2-wideband: 1300+/-10nm or US2 narrowband: 1300+/-2nm)

Research in Fiber Optic Communications: PONs

The “combo PON” concept

•The concept has been introduced for the coexistence and evolution from G-PON to XG-PON.

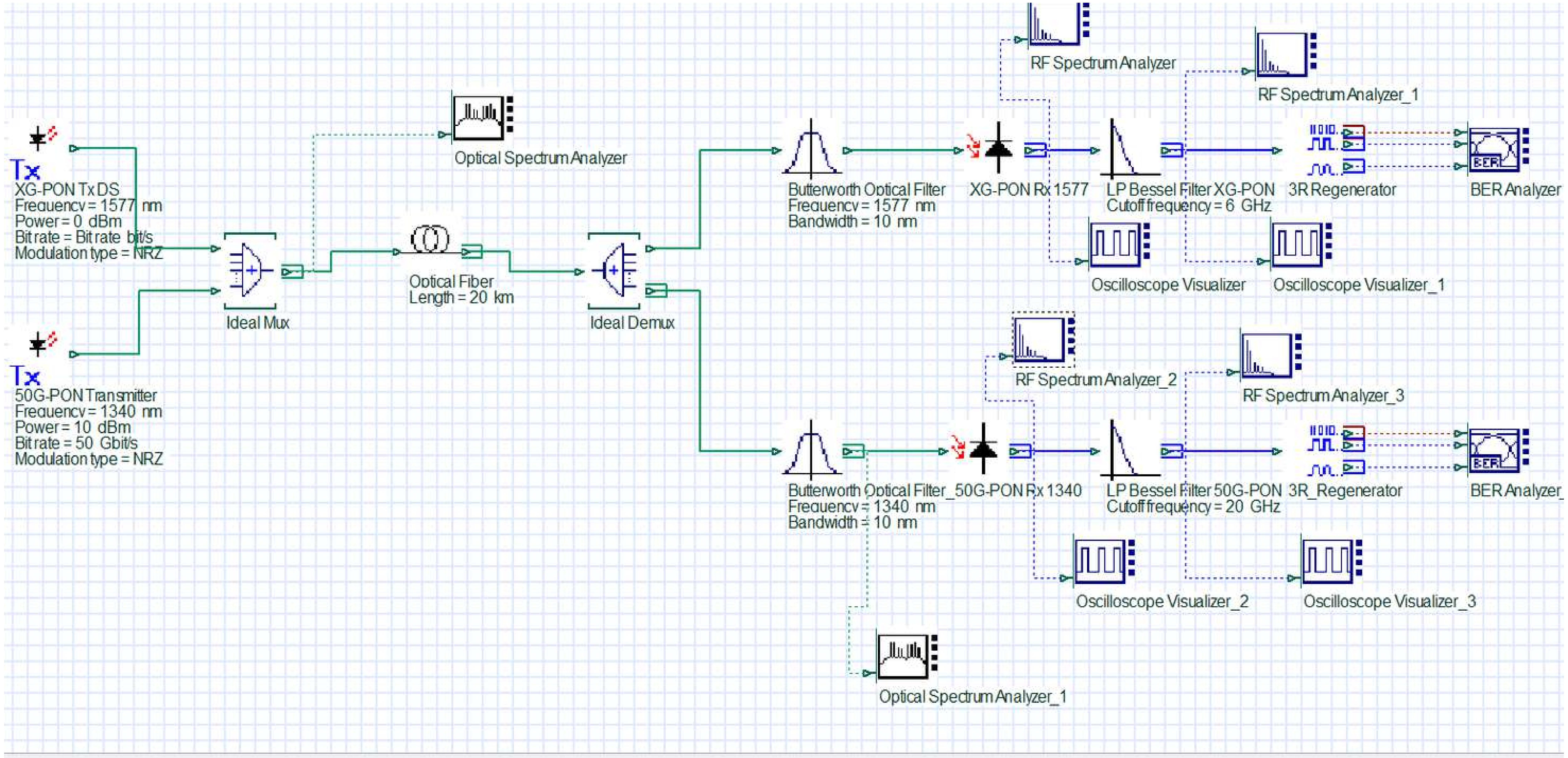
• Coexistence refers to the ability for two or more system generations to operate simultaneously on a common fiber section (i.e., ODN).

• Diverse coexistence scenarios can be implemented according to an operator’s need.

• The combo PON of XG-PON and 50G PON becomes an important evolution direction in the post 10G PON era.

Research in Fiber Optic Communications: PONs

Simulation model of combo PON (in OptiSystem 14.2.0)



Research in Fiber Optic Communications: PONs

Simulation results: XGPON vs 50G PON

ITU-T G.9804.3	DD20	DD40
Maximum fiber differential distance	20km	40km

Transmitter @ OLT	Launch Power (dBm)	Receiver Max Q Factor	Receiver Min. BER
XGPON (PIN) (1577 nm)	5	10,2358	5,9593e-15
50G PON (APD) (1340 nm)	7	3,74383	7,59161e-05
50G PON (PIN) (1340 nm)	7	3,72608	8,0457e-05

Research in Fiber Optic Communications: PONs

Simulation results: NRZ vs RZ coding for 7dBm launch power

ITU-T G.9804.3 Recommendation			
	Unit	Value	
Nominal line rate	Gbps	49.7664	
Operating wavelength	nm	1340-1342	
Line code	-	NRZ	
ODN Class		N1	C1+
Mean launch power minimum	dBm	+5.5	+8.5
Mean launch power maximum	dBm	+11	+14

Line Coding	Max Q Factor (APD)	Min BER (APD)	Max Q Factor (PIN)	Min BER (PIN)
NRZ	3,69341	9,04215e-05	3,74428	7,5767e-05
RZ	3,10389	0,000713574	3,14291	0,000642101

Research in Fiber Optic Communications: PONs

Simulation results: Effect of transmission distance

Main assumptions:

Launch Power (dBm)	7
Gain APD	10
Responsivity APD (A/W)	10
Responsivity PIN (A/W)	1
LPF Cutoff (GHz)	20

Fiber Distance (km)	Max Q Factor (APD)	Min BER (APD)	Max Q Factor (PIN)	Min BER (PIN)
20	2,4287	0,00506179	2,43021	0,00504793
25	3,6036	0,000147088	3,58323	0,000158451
30	3,583	0,000156311	3,60786	0,000143995
35	4,07412	1,81072e-05	4,08831	1,73585e-05
40	3,69341	9,04215e-05	3,74428	7,5767e-05
45	3,67626	0,000103736	3,59282	0,000136261
50	3,54888	0,000145057	3,55643	0,000140993

Research in Fiber Optic Communications: PONs

Conclusions and Further Directions

• Simulation results are highly affected by the power depletion and crosstalk induced by Stimulated Raman Scattering (SRS).

• NRZ line coding is superior than RZ line coding either using PIN or APD detectors.

• A more “realistic” simulation model (including RX DSP processing and FEC algorithms at the receiver) will be devised in order a holistic performance evaluation analysis of ITU-T G.9804.x 50G(S) PONs to be carried out.

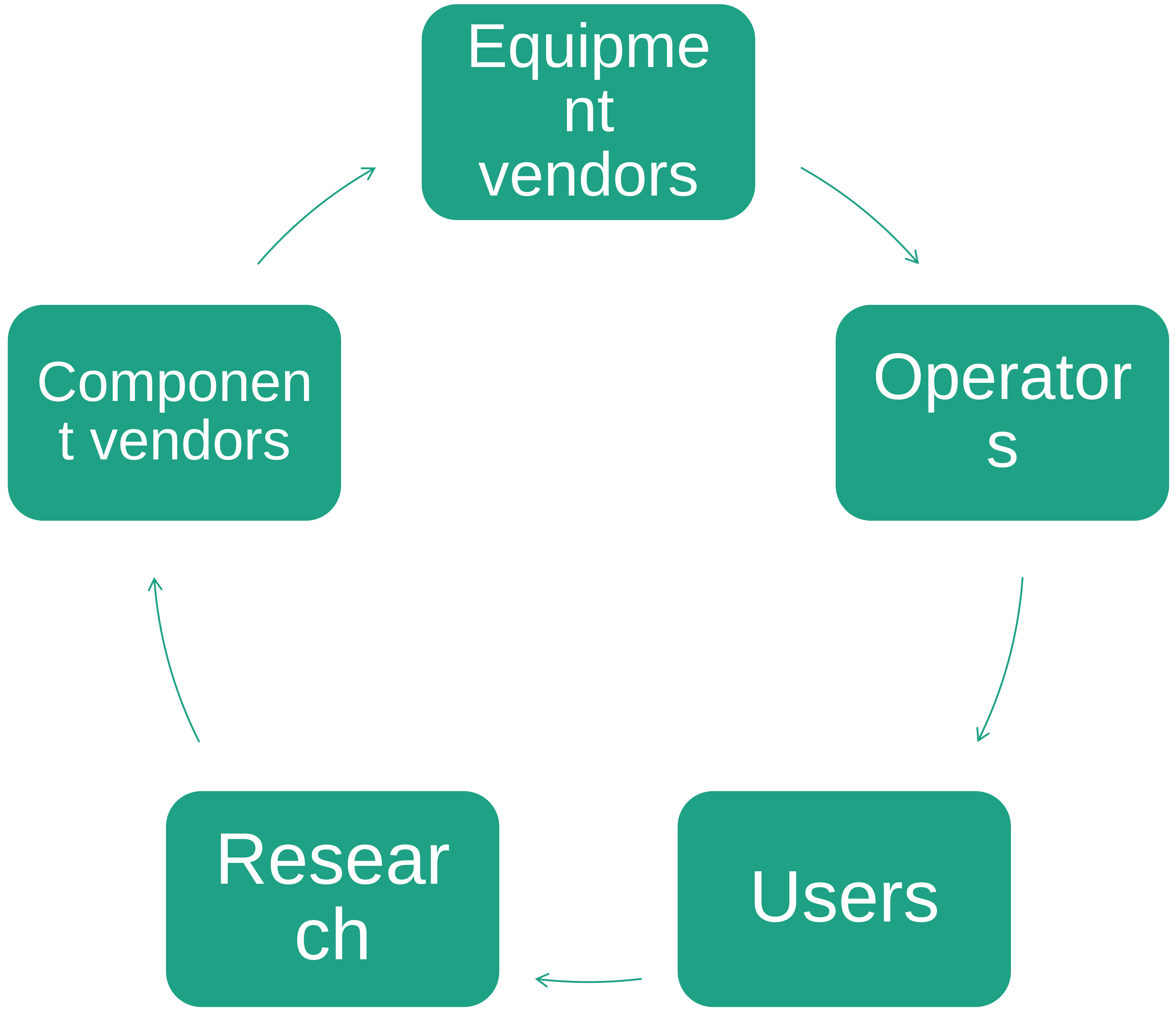
• Triple combo scenarios with legacy PONs and ITU-T G.9804.x 50G(S) PON may arise and, thus, should be studied.

• Examination of the combo concept with ITU-T G.9804.x 50G(S) PONs and other PON technologies envisaged (coherent PONs, SuperPON).

• Smooth evolution of PON technologies is required in order the most valuable part of the access network (i.e., the ODN) to be fully exploited.

From Photonics research to PON commercialization

- 50G PON services, once fully productized and commercialized, will be supported by a robust component and equipment supplier ecosystem. 50G PON standard was initially ratified in **September 2021** for asymmetric operation. Field trials and product announcements are projected in late 2023, with **volume production starting in 2024.**



ATHENA Photonics Hub

The motivation: The ATHENA European Alliance Photonics Hub brings together the photonics community within and beyond the Alliance to boost scientific collaboration in Photonics **and** to organize outreach activities for different audiences.

Objectives:.

- To bring together the scientists of Photonics & identify opportunities of collaboration
- To inform the community of the available modules and programs in Photonics
- To jointly organize modules, intensive programs and minor programs in this technology
- To bring together with the industrial and academic Photonics communities, and create inclusive pan-European photonics career camps aimed at university students and early-stage researchers.

Indicative ATHENA Photonics Hub Actions

- **Design and Deliver a joint module in Laser Physics Fundamentals**

Target Audience: Undergraduate students from Physics and Engineering Departments

Duration: 14-16 asynchronous online lectures (maximum of 60 minutes)

Part of Outline:

The various Pumping Schemes, the small gain coefficient, and the Optical Resonator - Dr. Konstantinos Petridis.

The Spectral Broadening Mechanisms - Dr. Kontantinos Petridis.

Stability of an Optical Resonator Longitudinal & Transverse Modes of a LASER - Dr. Konstantinos Petridis.

The Mode-Locking and the Q-Switching Techniques for the generation of ultrashort laser pulses - Dr. Nektarios Papadogiannis.

Nonlinear Optics Fundamentals - Dr. Ivan Biaggio.

An Introduction to Photonic Crystals - Dr. Mario Agio.

Fundamentals of CW Optical Parametric Oscillators - Dr. Armando Piccardi.

Fundamentals of Pulsed Optical Parametric Oscillators - Dr. Francisco Perreira.

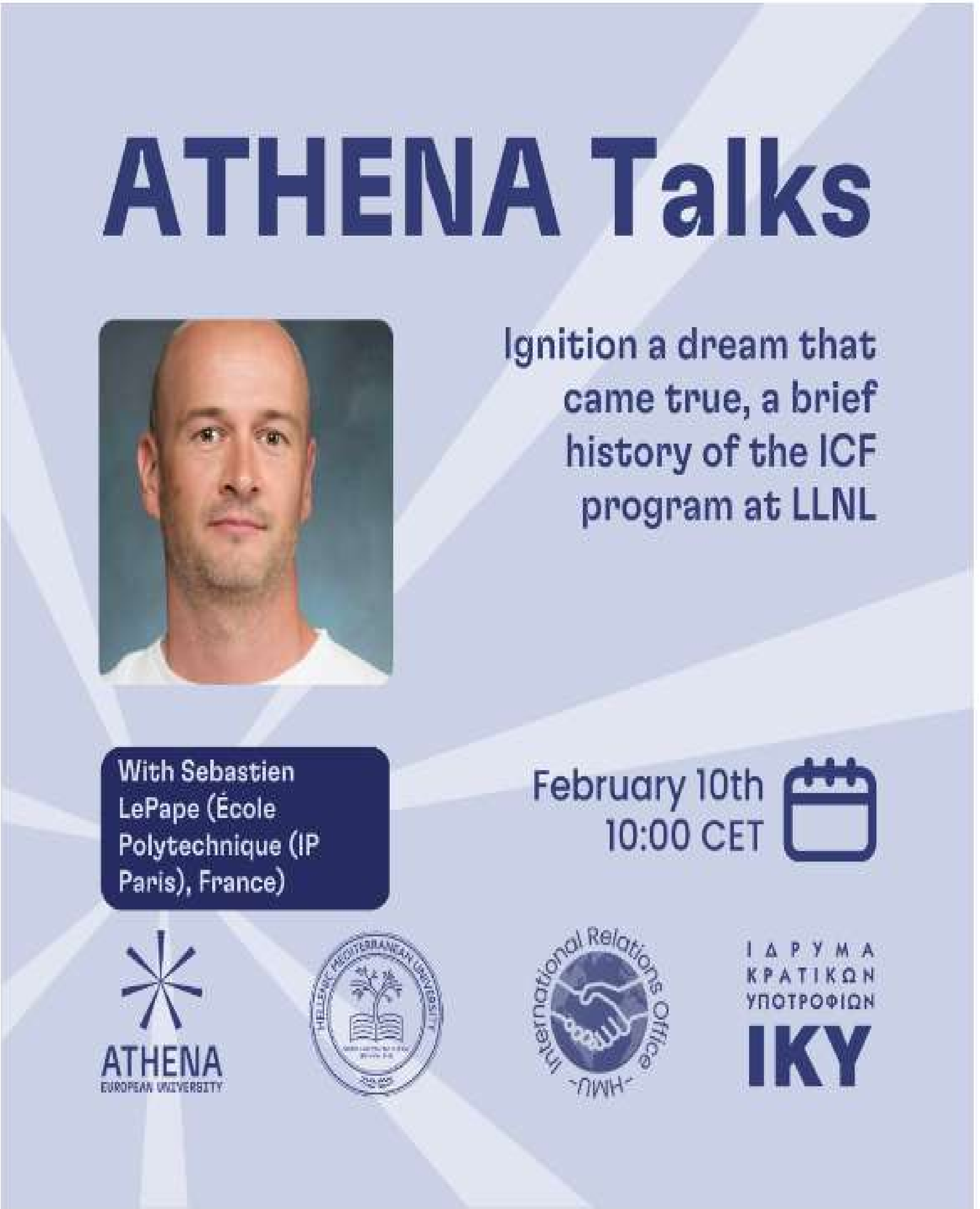
Applications of Lasers in Cultural Heritage - Dr. Santiago Pozo.

An Introduction to Optical Sensors - Dr. Denis Donlagic.

An Introduction to Optical Communications - Dr. George Liodakis.

Indicative ATHENA Photonics Hub Actions

- **Organize COIL activities to related modules within the Alliance**
- **Organize invited talks by PhD students and Postdoctoral Fellows in the field**



Prof. Sebastien LePape (Ecole Polytechnique, France)

Date: 10th of February, 2023.

Title: Ignition a dream that came true, a brief history of the ICF program in LLNL.

Abstract:

Fusion energy has been the driving force in the High Energy Density (HED) community for more than fifty years but especially since the start of the National Ignition Campaign in 2009 at the National Ignition facility (LLNL, USA). The National Ignition Campaign, though a marvel in terms of laser technology and data quality in this challenging regime, still needs to achieve ignition. This failure has shed light on gaps in our understanding of fundamental plasma properties such as thermal transport or emissivity. Following these initial difficulties, the evolution of the design (higher adiabat, new ablator, new hohlraum conditions) has significantly improved implosion performance over the years and Ignition. I will review these evolutions and why they led to the recent successes obtained on the NIF.

Indicative ATHENA Photonics Hub Actions

- **Inform the Alliance Community of the Research Facilities in the field**

✓ Hellenic Mediterranean University (Institute of Plasma Physics and Lasers)

✓ University of Siegen (Nano-Optics Group, Institute of High Frequency and Quantum Electronics, Center for Sensor Systems)

✓ University of Vigo (Group of Engineering Physics, LASERING Group)

✓ Lehigh University (Center of Photonics and Nanoelectronics)

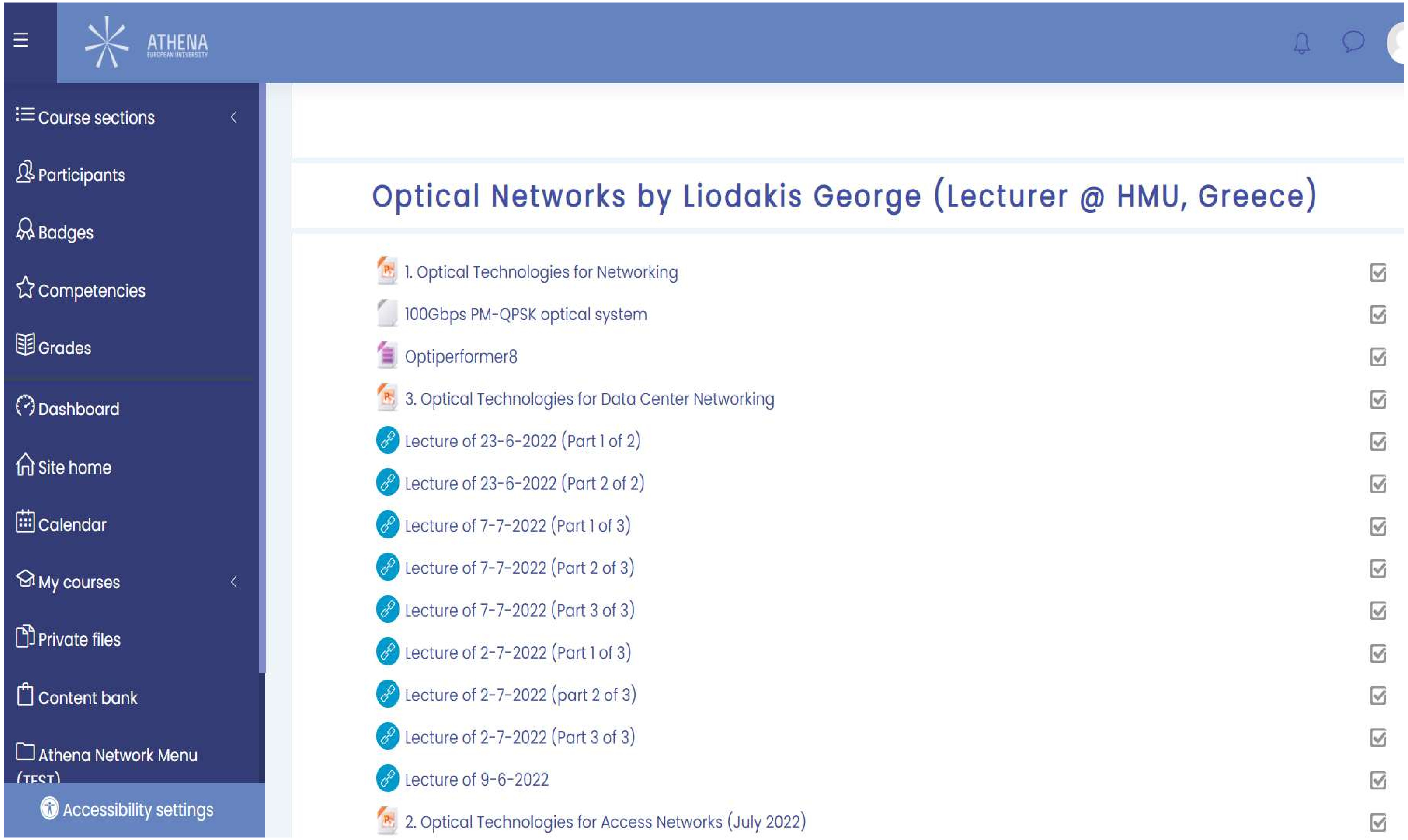
- **Disseminate PhD opportunities and Job Vacancies in the field**

- **Support of graduate courses & programs in Photonics**

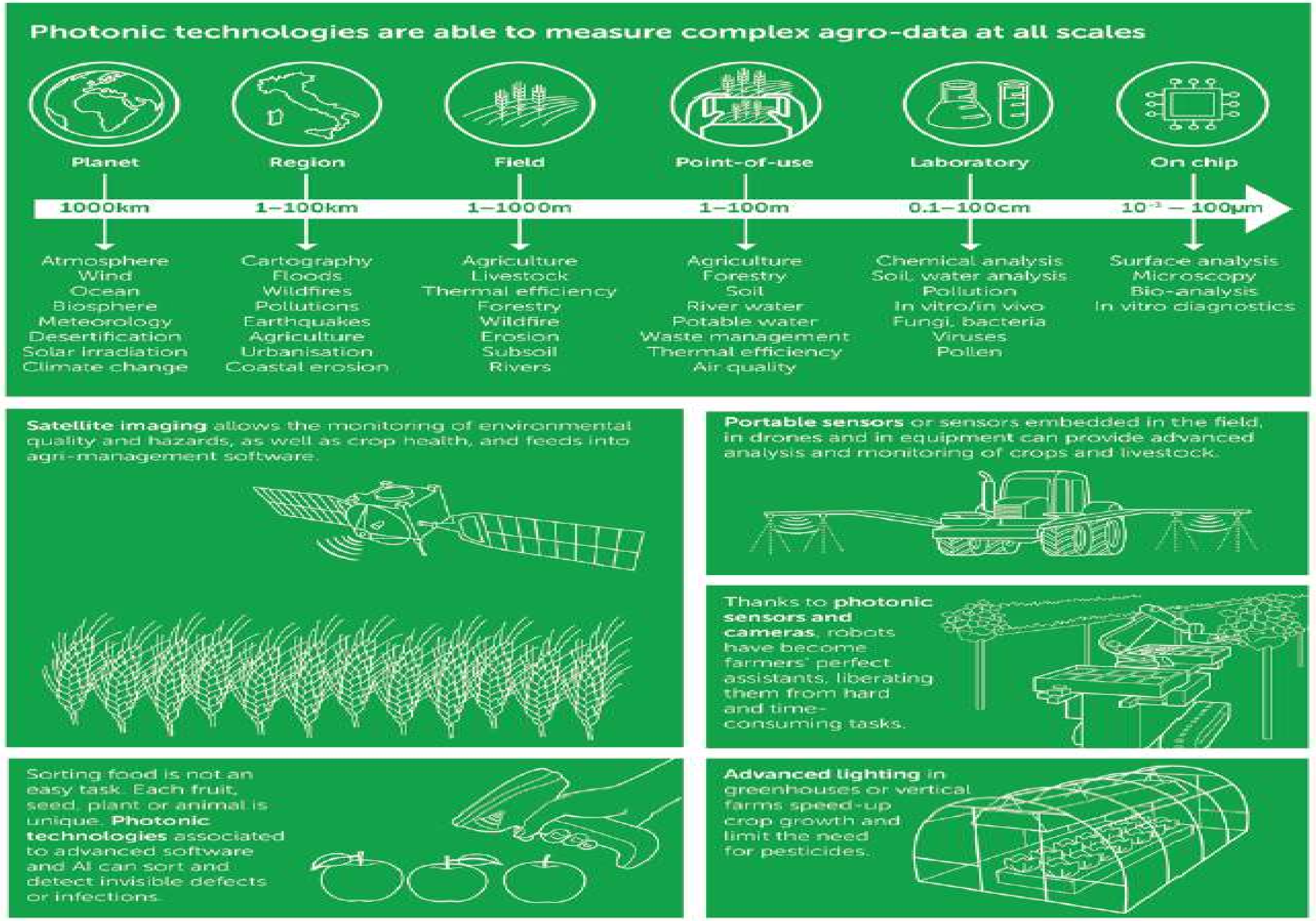
✓ Graduate course “Optical Networks & Optoelectronic Systems (ONOS)” at ATHENA European University

Instructors: Dr. Francisco Pereira (Polytechnic of Porto), Dr. Francesco Scotognella (Politecnico di Milano), Dr. Kostas Petridis, Dr. Papadogiannis Nektarios, Dr. George Liodakis (HMU).

Indicative ATHENA Photonics Hub Actions



Photonics and Agriculture & Food sector



Photonics and Agriculture & Food sector

- **Precision agriculture,** is now advocated as the preferred EU response to two challenges: **minimizing** agricultural inputs whilst **maximizing** outputs for given conditions.
- Precision agriculture technologies and solutions include geographic information systems, satellite image processing, drones, robotics and sensors. **All these agri-tech products use or leverage Photonics technologies.**
- **Photonics technologies are present at all stages of an advanced (high intensity) farming value chain** from the inputs needed for primary production to packaging and cold storage as well as food processing, distribution and marketing, culminating in the end user.
- **Photonics can therefore help to supply safe, nutritious and affordable food for all and establish a sustainable value chain from farm to fork.** By using ever more precise sensors and measuring devices, farmers, food processors and ordinary consumers will be able to monitor and certify the safety, quality, content and even the origin of the food supply chain.