



PHOTONICS PUBLIC PRIVATE PARTNERSHIP

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PICaboo Project Presentation

Call identifier: H2020-ICT-2020-2

Topic: ICT-37-2020: Advancing photonics technologies and application driven photonics components and the innovation ecosystem

Scope: Novel Photonics Integrated Circuit (PIC) Technology building blocks

Type of Action: Research and Innovation Action

Contract No: 101017114

Duration: 36 months

Start Date: 1st January 2021

End Date: 31st December 2023

Requested EC contribution: € 4,907,666.25

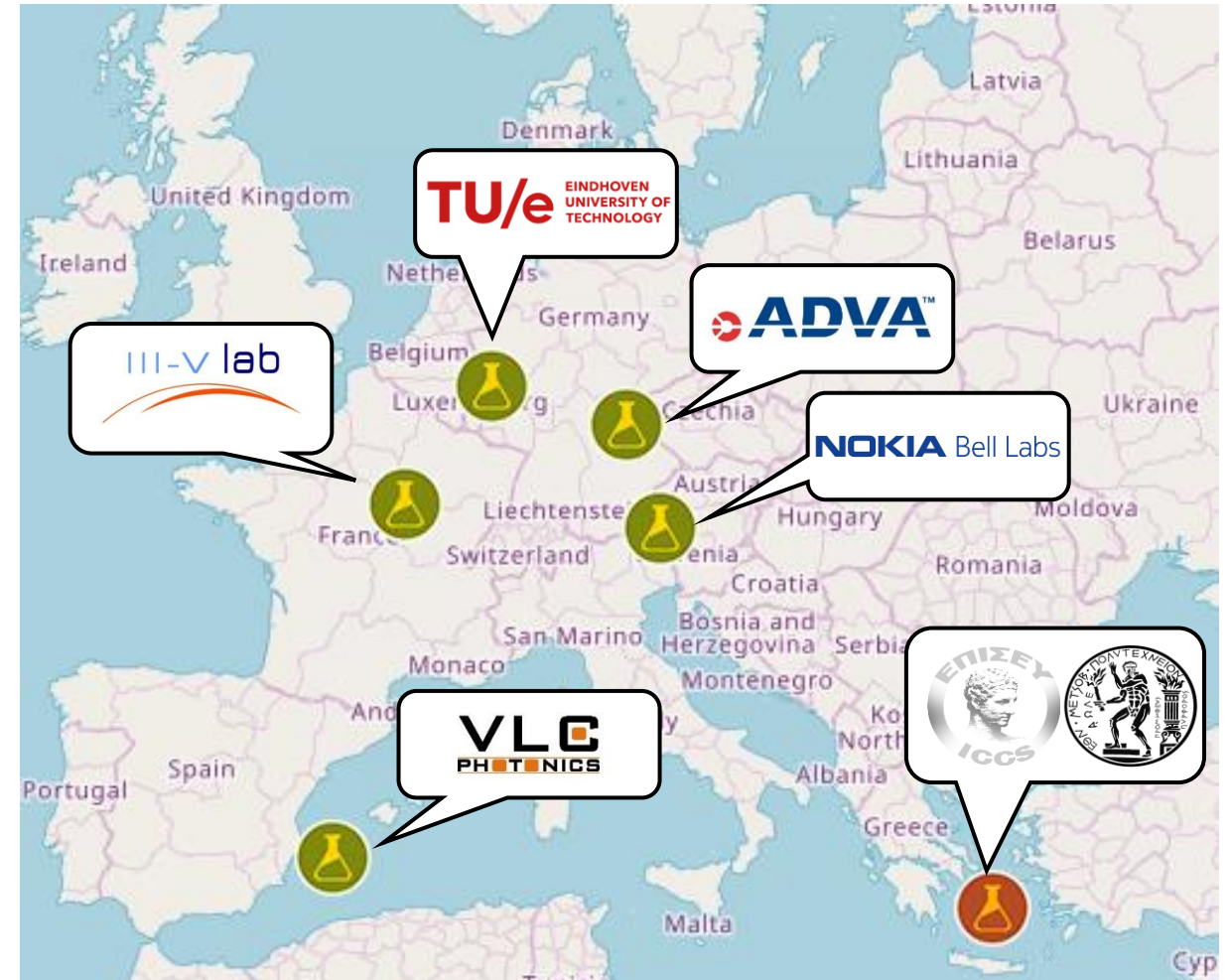
Website: <https://ict-picaboo.eu/>

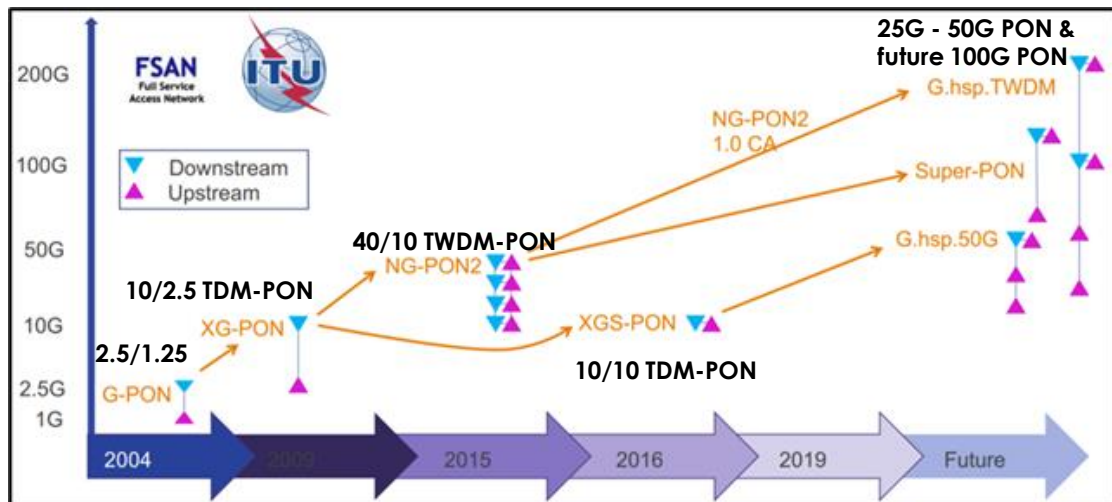


6 partners

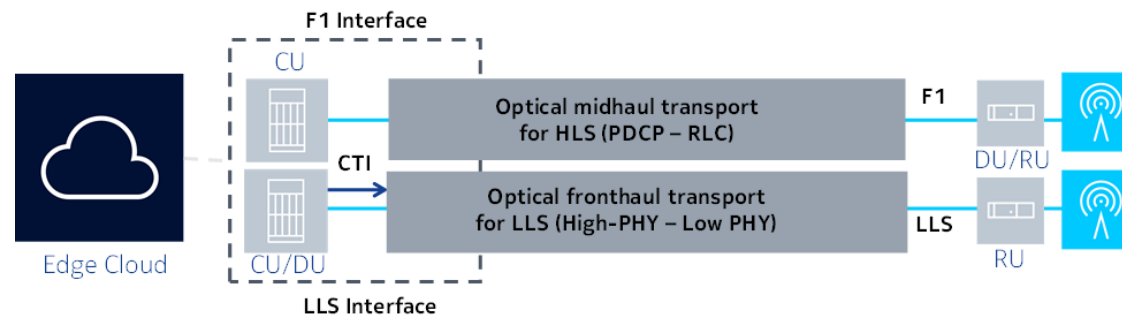
- **Project Coordinator:** Institute of Communications & Computer Systems, **ICCS (GR)**
- Technische Universiteit Eindhoven, **TU/e (NL)**
- III-V Lab, **III-V LAB GIE (FR)**
- VLC Photonics Sociedad Limitada, **VLC (ESP)**
- NOKIA Solutions and Networks GmbH & Co KG, **NSN (DE)**
- ADVA Optical Networking SE, **ADVA SE (DE)**

5 countries





Passive Optical Networks (PON) standardization trends:
www.calix.com/node---connexions-2019/the-time-is-now-for-next-gen-pon.html

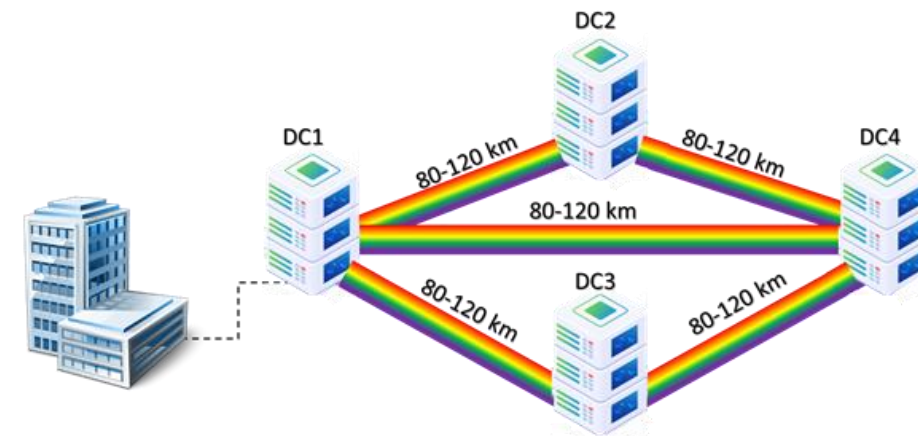
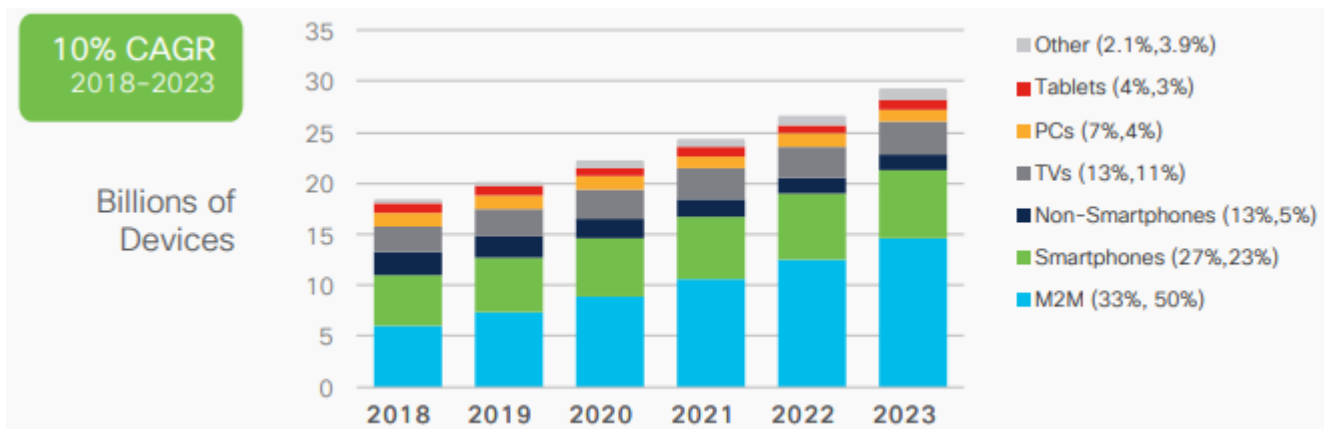


Virtualized Radio Access Network – xhaul: www.nokia.com

- The path towards 50/100Gb/s and beyond PON systems can follow two directions by increasing: a) the line rate per wavelength and b) the overall system capacity via channel bonding.
- **100G PON** will be the next standard to support future 6G services and cloud IoT applications
- High-capacity and low-latency optical transport solutions are required for future vRAN networks → different PON flavors may apply

Low-cost optical metro networks and DCI

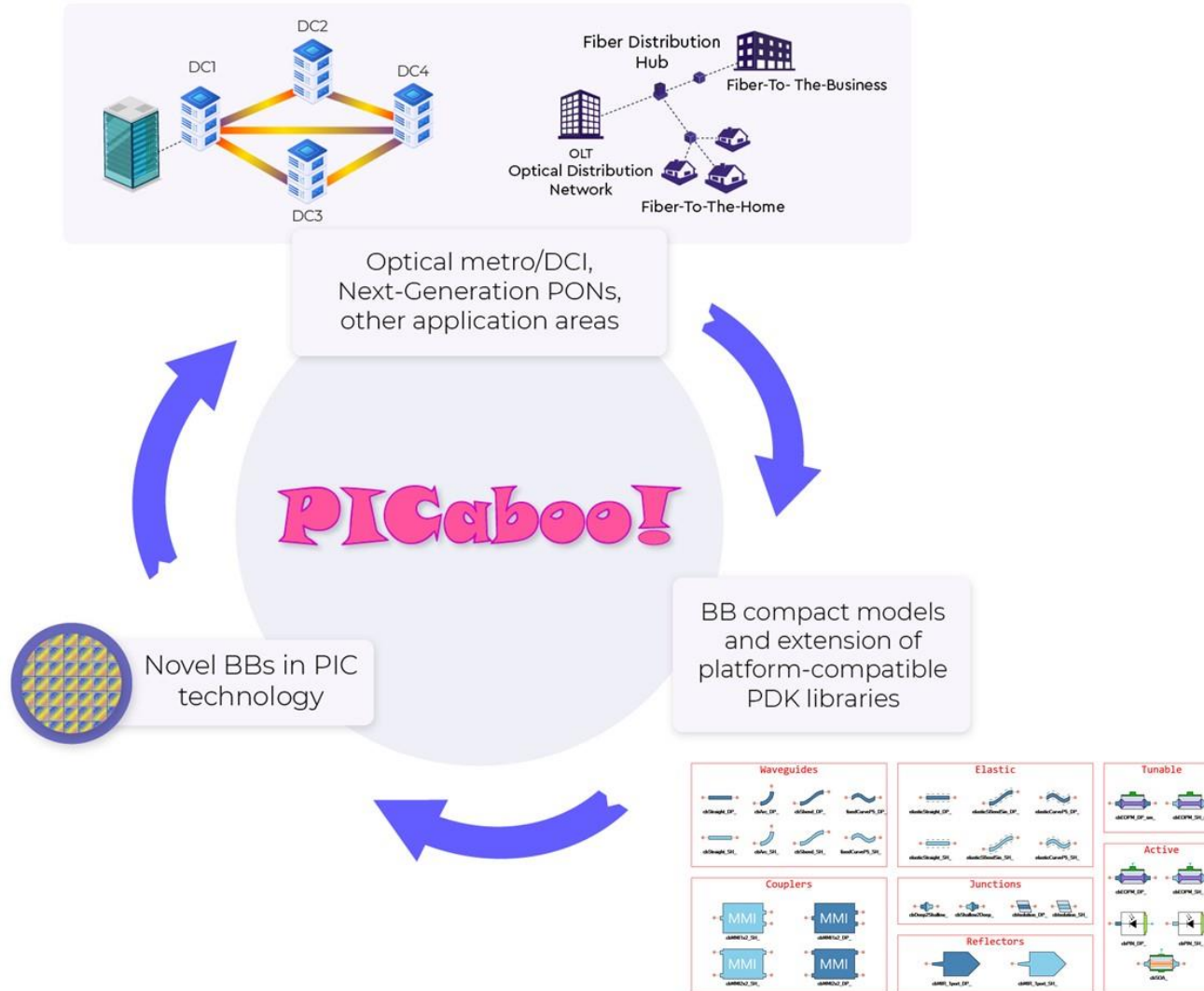
PICaboo!



Source: Cisco Annual Internet Report (2018-2023)

<https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.pdf>

- Global IP traffic is expected to reach **4.8 zettabytes** per year by **2022**.
- Almost **30 billion devices and connections** by the end of **2023**.
- Datacentre operators are building **new facilities** within the distance of **10-80 km**
- **Metro networks** typical employ **coherent DWDM** technologies over **80 km**
- **DCI** is based on PAM4 **IM/DD** technologies for **2km** and **10km**
- **DCI** beyond 10 km requires **advanced DSP**, optical dispersion compensation and optical signal amplification increasing power consumption
- 400ZR is a new standard aiming to bridge the gap between short DCI and metro-edge based on low cost and low power consumption technologies.

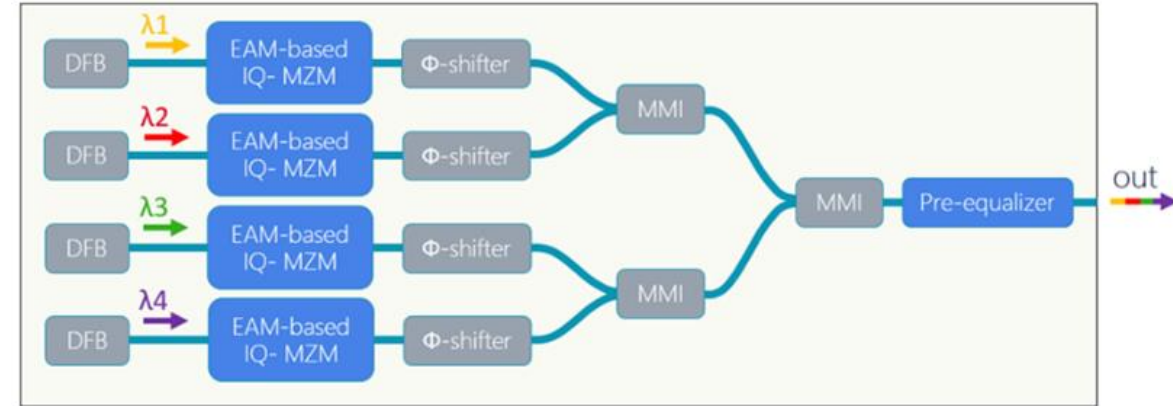


- ✓ To develop novel optical building blocks exploiting the generic foundry paradigm
- ✓ To extend the InP photonic integration platforms of TUE and III-V Lab with PDK-compatible libraries for the novel BBs
- ✓ To develop PICs with significantly enhanced functions on-chip for next generation PONs and metro/DCI networks.
- ✓ To explore the use of the novel BBs in a wide range of applications in which photonic integration is considered a key enabling technology

PICaboo objectives

1. Exploit **InP PIC technology** platforms of TUE and III-V Lab for the **development of novel photonic components**.
2. Develop integrated **polarization handling elements** on the InP platform of TUE for full manipulation of signal polarization **on-chip**.
3. Develop high-speed balanced photodetectors and widely tunable low-linewidth laser on the InP platform of TUE
4. Extend the **high-speed operation** of III-V Lab's InP SIBH technology platform in the **O-band** via **SAG** technology
5. Develop **high-performance active and passive building blocks** on the novel **O-band SAG-SIBH** platform of III-V Lab
6. Generate **physical models** of building blocks and circuits in the form of **PDK-compatible libraries**.
7. Develop **coherent receiver PICs** for metro/DCI applications with **all-optical DSP functions**.
8. Develop **EAM-based transmitter PICs** with on-chip **optical pre-equalization** for high speed PON networks and 5G/future 6G systems.
9. Demonstrate up to **1.6 Tb/s transmission over 20-60 km** via laboratory experiments and real metro-access and DCI network scenarios.
10. Demonstrate the **receiver capabilities in a 400 Gb/s** coherent testbed using commercial equipment.

- **PICaboo will enable 100G and beyond PON technologies by increasing component EO-bandwidth and by performing critical signal processing functions in the optical domain**
- **III-V Lab platform enhancements and novel BBs**
- High speed SAG-SIBH platform (transform from C-band to O-band)
 - 65 GHz EMLs → single and IQ EAM-MZMs
 - Gain chips → DFB laser
- Development of passive layer
 - MMIs, ring filters
 - Optical equalization circuit
- Precise λ control over 100 nm using SAG
 - Arrayed PICs



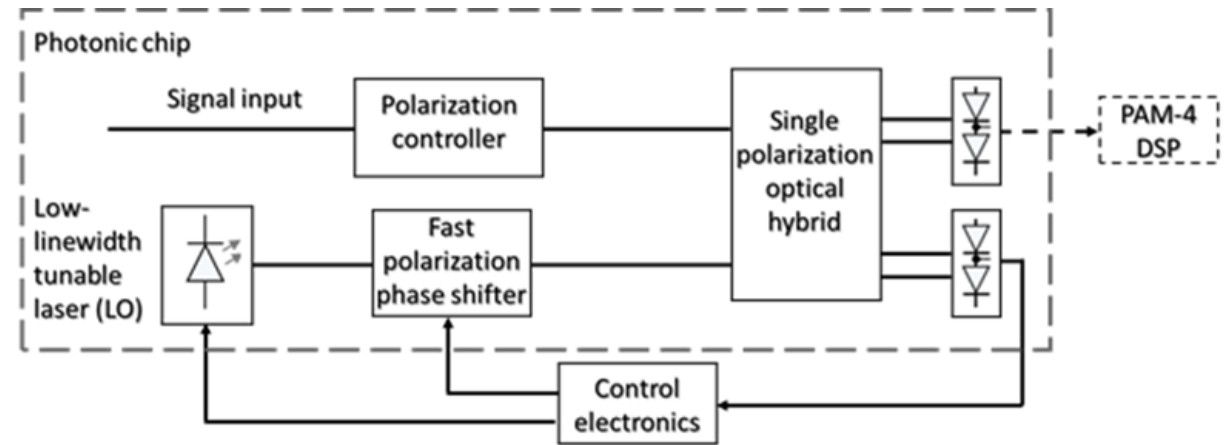
PIC demonstrator #6- 4-array EAM-IQM transmitter with optical EC

Tx PIC demonstrators*	Operating Baud rate [Gbaud]	Modulation format	Total Tx Capacity [Gb/s]	BBs	On-chip equalization	Operating Band	Target application**
PIC dem #3	50	OOK/PAM4	50/100	35 GHz EAMs, DFB, MMIs (Gen 1)	NO	O-band	25G/50G TDM-PON, 5G fronthaul
PIC dem #4	100	OOK/PAM4	100/200	65 GHz EAMs, DFB, MMIs (Gen 2)	NO	O-band	100G and beyond TDM-PON, 5G fronthaul
PIC dem #5	100	QPSK/16QAM	Up to 400	65 GHz EAMs, DFB, MMIs, SOAs, RRs (Gen 2)	YES	O-band	100G and beyond TDM-PON, 5G/6G fronthaul
PIC dem #6	100	QPSK/16QAM	Up to 1.6T	65 GHz EAMs, DFB, MMIs, SOAs, RRs (Gen 2)	YES	O-band CDWM (TBD)	100G and beyond TWDM-PON, 5G/6G fronthaul

➤ PICaboo targets to off-load power hungry coherent DSP functions into the optical domain

TUe platform enhancements and novel BBs

- Extend the operating range of polarization components over 100 nm (C-band + S-band)
- Enhance the polarization handling toolbox of TUe with novel functions
 - Polarization phase shifter
 - Polarization controller
- Extend platform speed capabilities
 - 35 GHz balanced photodetectors

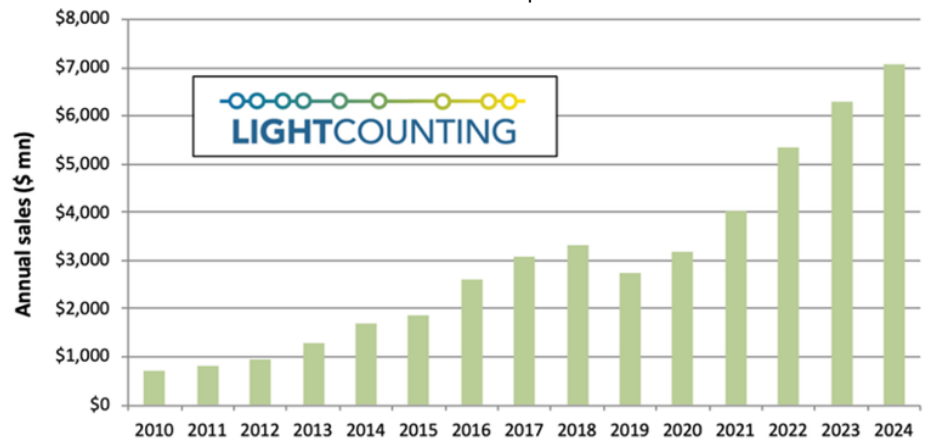


PIC demonstrator #1 - single pol coherent Rx with phase and pol control

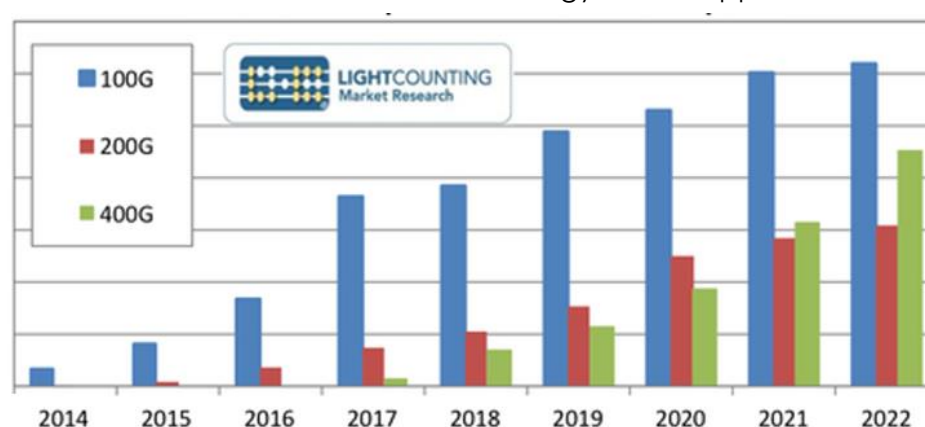
Rx PIC demonstrators*	Operating Baud rate [Gbaud]	Modulation format	Total Rx Capacity [Gb/s]	Polarization Multiplexing	BBs	Operating Band	Target application
PIC dem #1	50	QPSK/16QAM	100/200	NO	Single pol optical Hybrid, LO, Balanced PDs, pol converter, polarization phase shifter (Gen 1)	C-band	Optical metro/DCI
PIC dem #2	50	QPSK/16QAM	200/400	YES	Single pol optical Hybrid, LO, Balanced PDs, pol converter, reset-free pol phase shifter (Gen 2)	C-band	Optical metro/DCI

PICaboo technologies will penetrate high value markets...

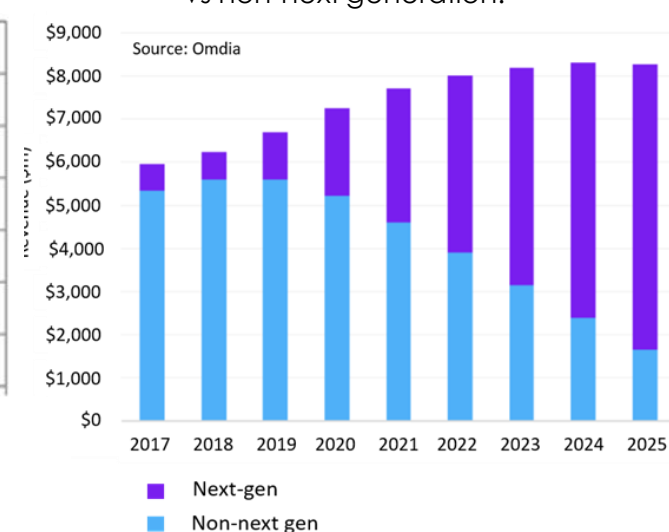
Global sales of Ethernet optical transceivers.



Market forecast of DWDM technology for DCI applications.



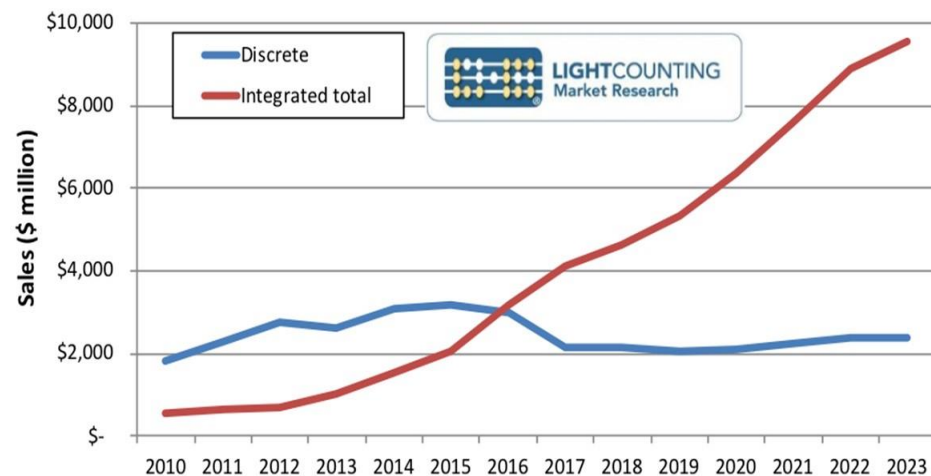
PON equipment market next-generation vs non-next generation.



... and will leverage significant power & cost reductions

- PICaboo single EAM-MZM transmitter and the coherent EAM-IQM transmitter PICs will leverage **power consumption reduction of 50% and 65%** respectively, compared to 50G EML-based solutions. Further, both will demonstrate an overall **cost reduction by almost 20%**.
- PICaboo dual polarization **coherent receiver PIC demonstrator** will **reduce** the overall transceiver **power consumption by more than 30%** with concurrent **cost benefits of 3.6x** compared to standard coherent transceivers.

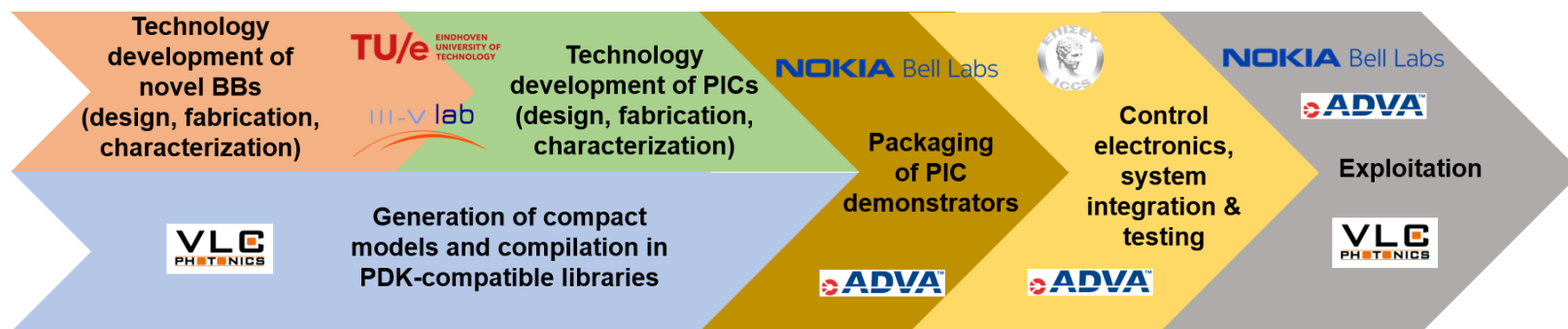
PICaboo BBs leverage large exploitation potential & broad market opportunities



- Lidar transceiver for self-driving cars (coherent receiver)
- Intra-DC interconnects (EAMs)
- Sensing and metrology (Polarization handling components)
- Neuromorphic photonics (optical ring filters, tunable lasers)

PICaboo value chain

- ✓ Secure pathway to market
- ✓ Industrially compatible technology platforms
- ✓ Addresses the whole value chain



Contact

Project Coordinator: Hercules Avramopoulos
Professor, ICCS/NTUA
Email: hav@mail.ntua.gr
tel: +30 210 772 2076



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