

INFN Pisa

Fabrizio Palla

FCC-ee Vertex R&D Workshop - Pisa 30 October 2025

Expertise and interests on FCC-ee

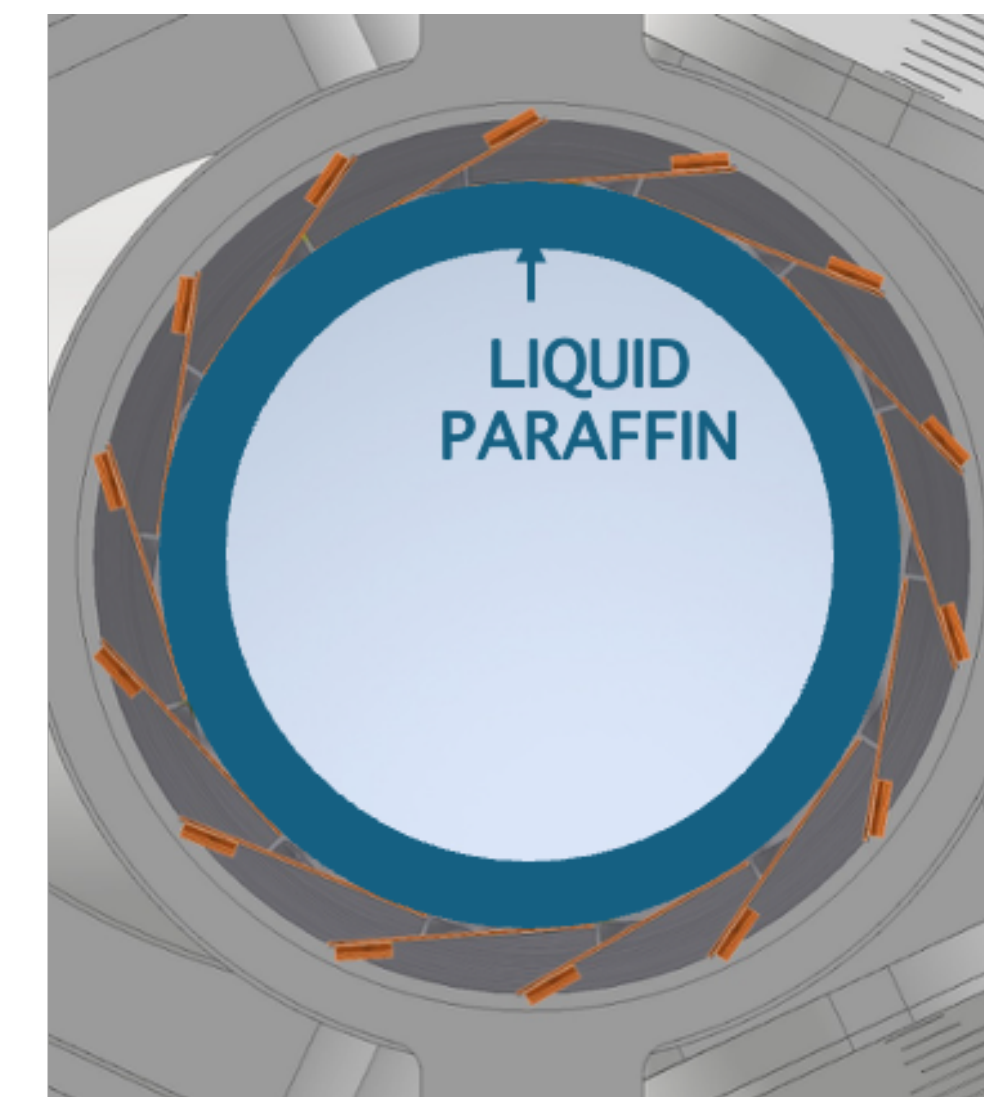
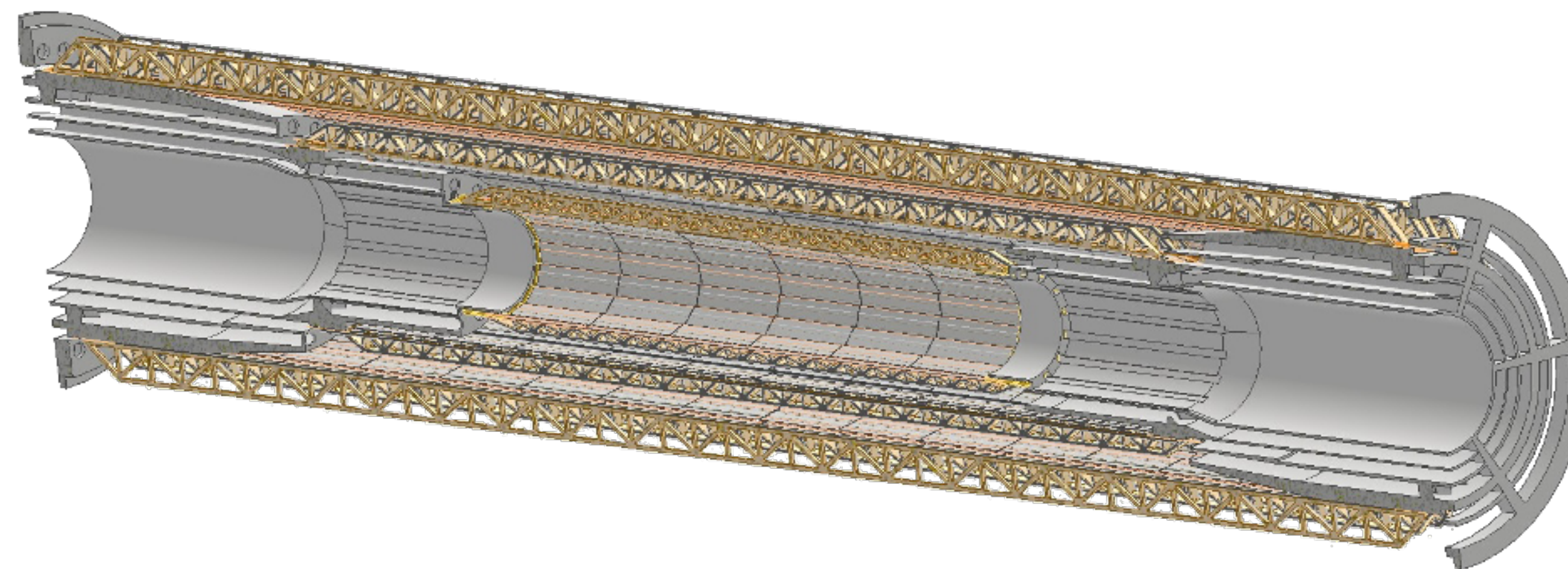
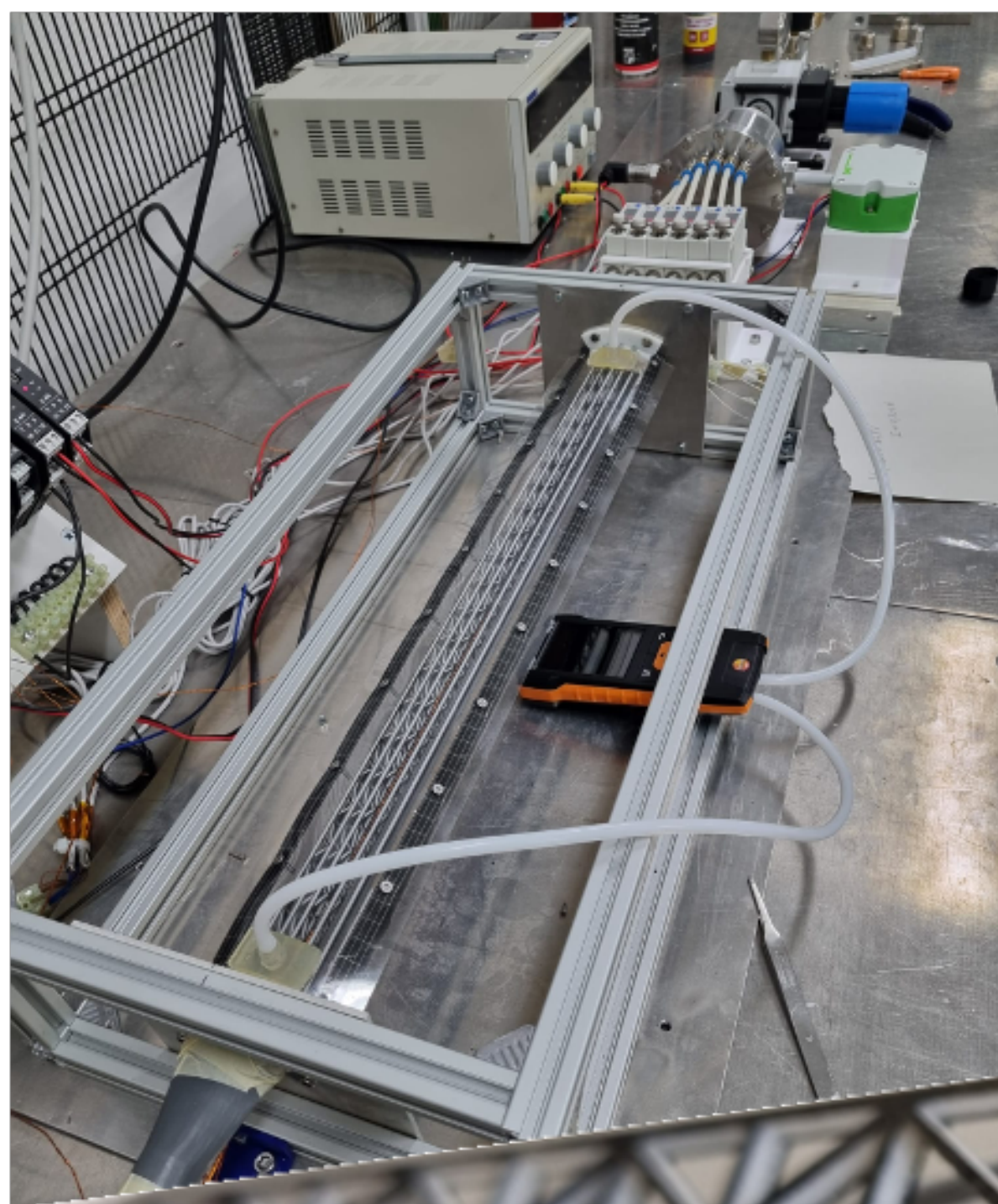
- **Longstanding experience in vertex detectors design, manufacturing and operations:**
 - ALEPH, BaBar, Belle-II, CDF, CMS
- **Vertex detector and integration studies for IDEA**
 - Layout studies, including curved geometries (DRD8)
 - Integration with beam pipe and Drift-chamber (DRD8)
 - Vertex detector cooling (DRD8)
 - Optical Wireless Communications for outer vertex (DRD7, WADAPT)
 - Silicon photonics links activities in DRD7 (ring modulators design)
- **Physics related studies and MDI**
 - Tracking, Hadron Calorimeter, MDI, TDAQ, EW, B- and τ -physics.
 - IDEA and ALLEGRO Detector Concepts
- **Mechanical engineers**
 - Gherardo Ammirabile (INFN and UniPisa doctoral student 100% on FCC-ee)
 - Daniele Benvenuti (INFN - research associate - mostly on CMS pixel HiLumi)
 - Filippo Bosi (INFN - senior engineer FCC-ee)
 - Andrea Moggi (INFN senior engineer - also ALICE, Belle II, CMS and MUonE)
 - Maurizio Massa (INFN senior engineer - also ALICE, Belle II and MUonE)
 - Collaboration with University of Pisa Mechanical and Aeronautics department
- **Electronic engineers**
 - Roberto Beccherle (front-end)
 - Elena Pedreschi (back-end)
 - Franco Spinella (back-end)
 - Collaboration with S. Anna University Pisa, and IMEC

The Laboratories

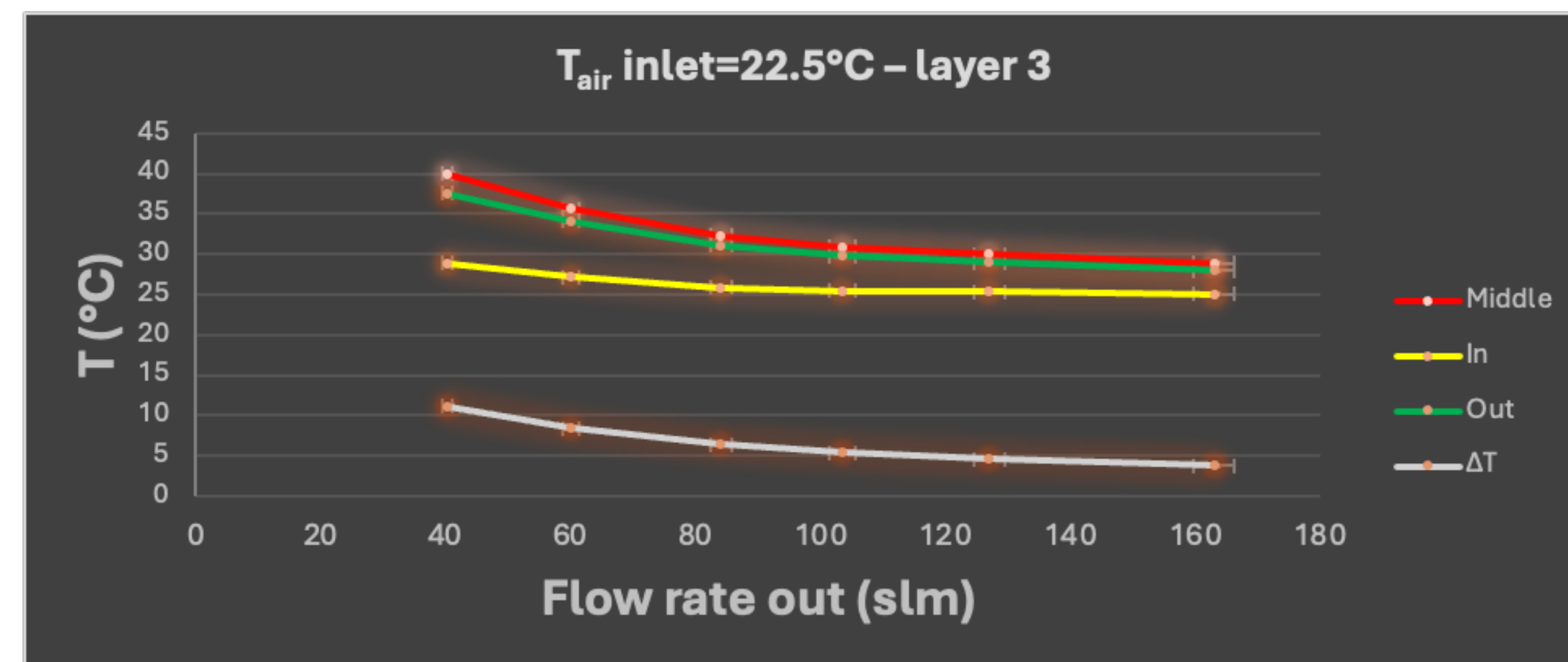
INFN Pisa clean rooms

- ~400 m² class 100 000, 150 m² class 10,000, and 7 small areas (~1.5 m²) class 100
- Bonding machines and probe stations, thermo mapping, gluing lab
- Several hundred m² electronics labs

Funding within INFN RD_FCC



Vertex layout and air-cooling



SiPh chips in FALAPHEL

Technology: Imec's iSiPP50G

PICv1

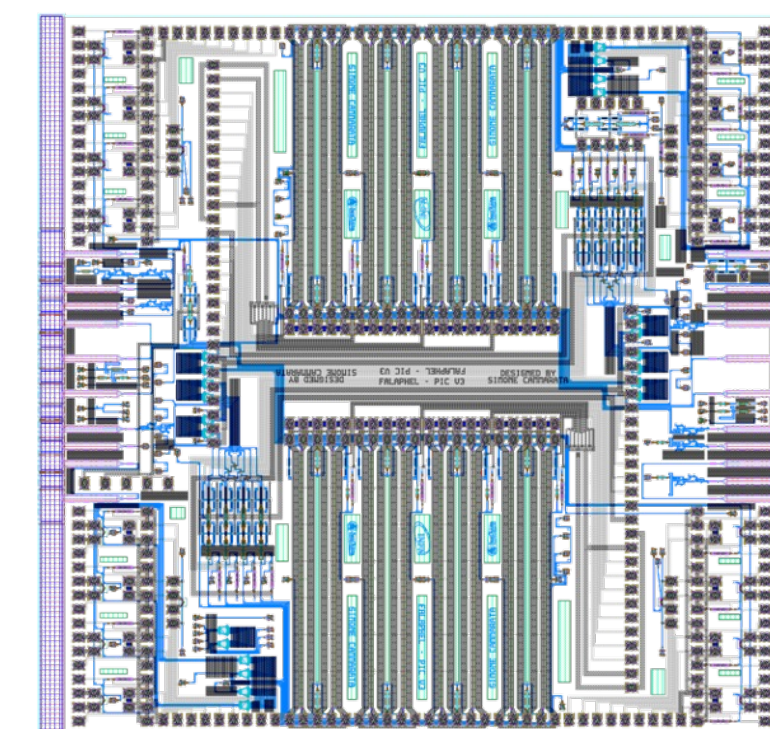
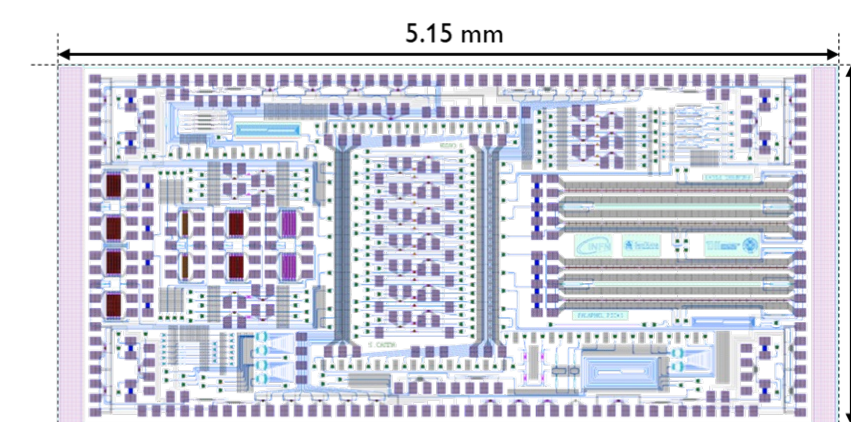
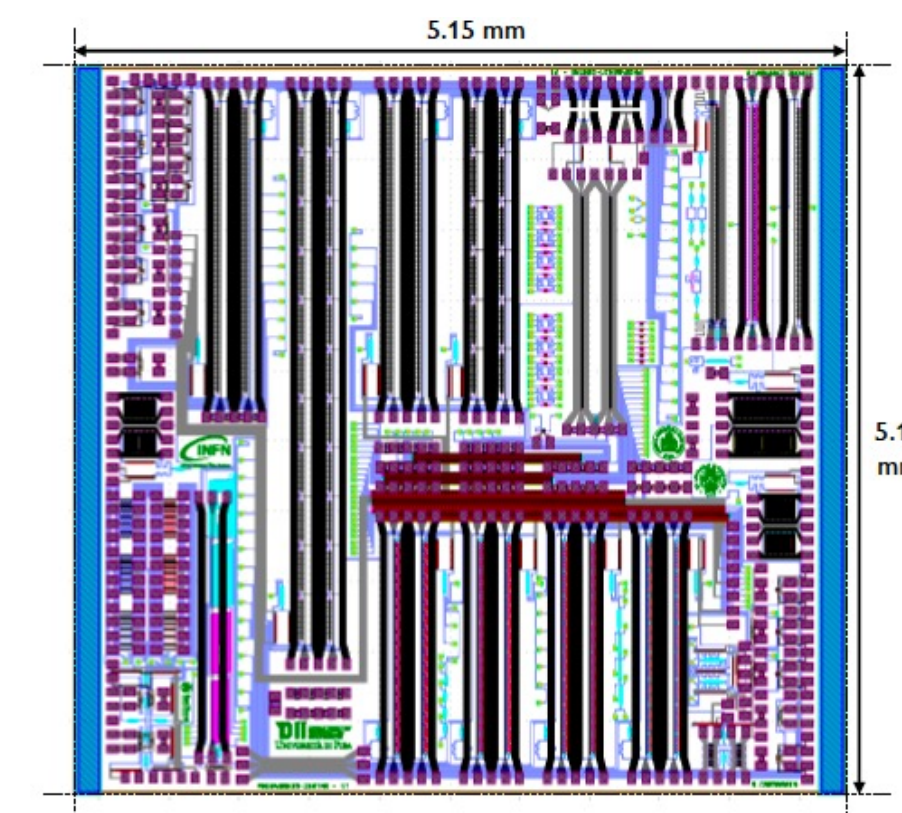
- single MZM, Folded-MZM, RM and EAM
- Tested TID up to 1.2 Grad

PICv2

- submitted Nov 2022, delivered Jan 2024
- Four 2-WDM RM based structures (50 Gb/s)
 - 4 different variants

PICv3

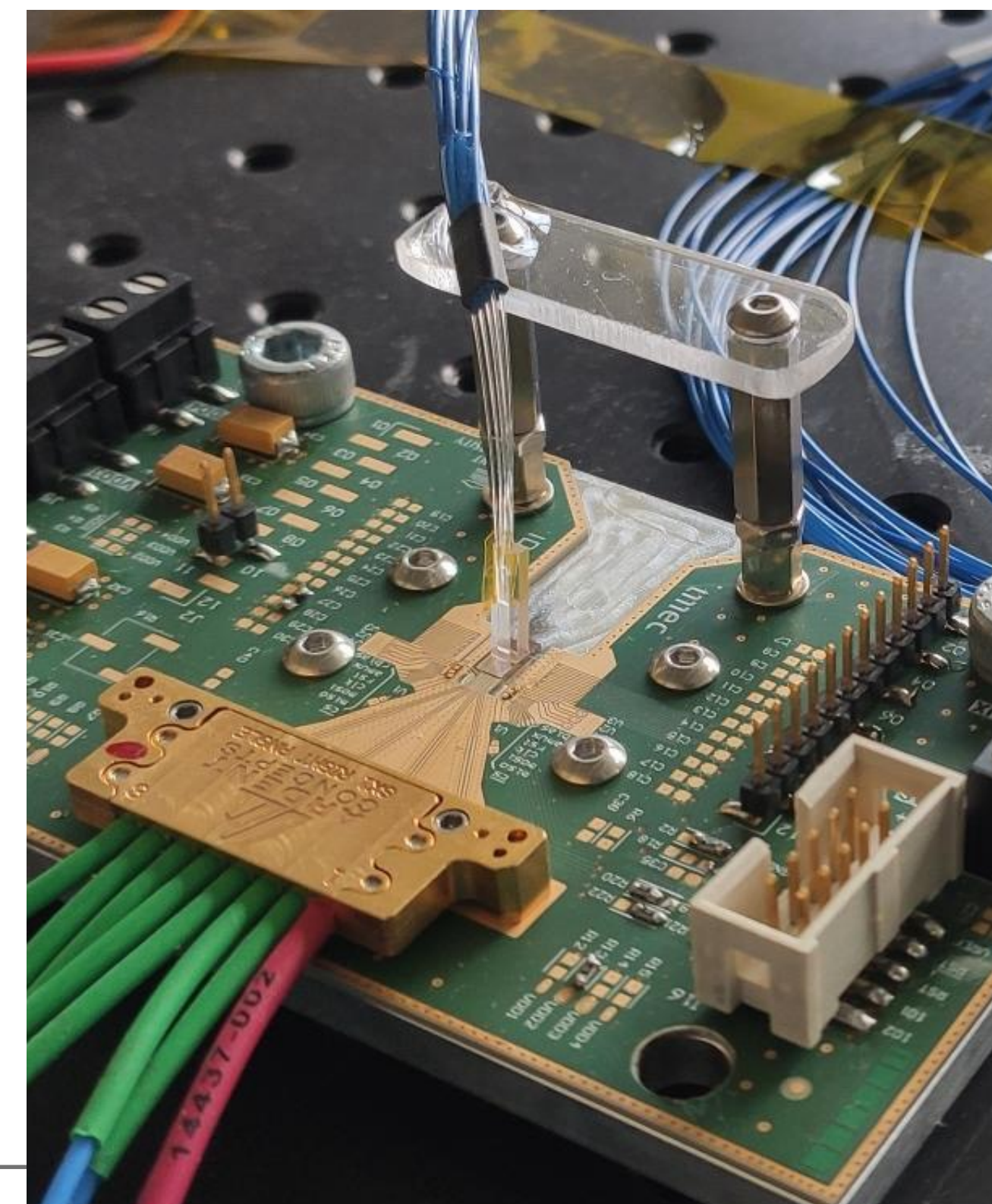
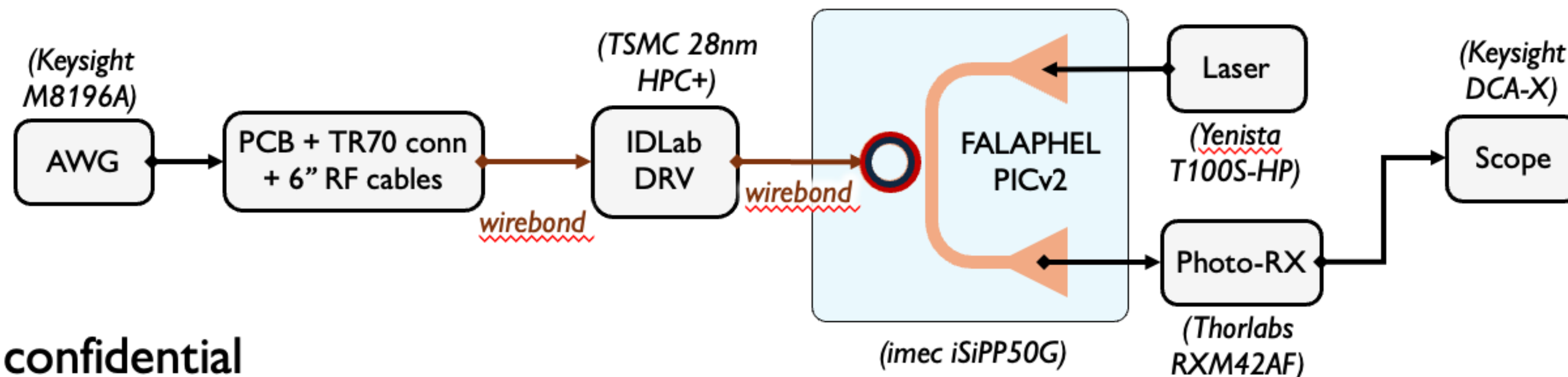
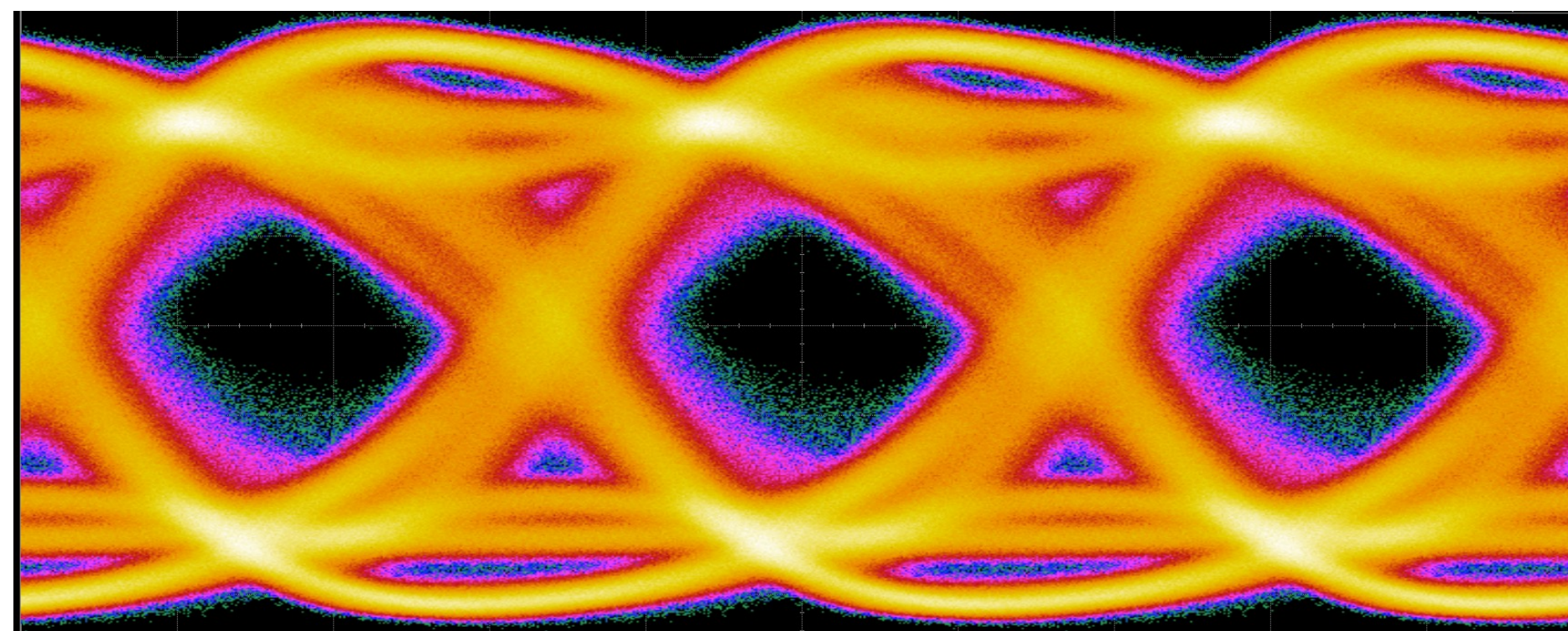
- Four 4-WDM RM based structures
- Submitted in Sept 2024



56 Gb/s NRZ SiPh Transmitter

- IDLab driver integrated with FALAPHEL PICv2 (INFN designed custom RM)
 - Wirebonded on RF PCB (IDLab)
 - Optical packaging with fiber array (IDLab)
- Preliminary single-lane high-speed EO time-domain results (IDLab) – no RX equalization

Data-rate	56 Gb/s
Optical power @ photo-RX	-0.5 dBm
ER	2.7 dB

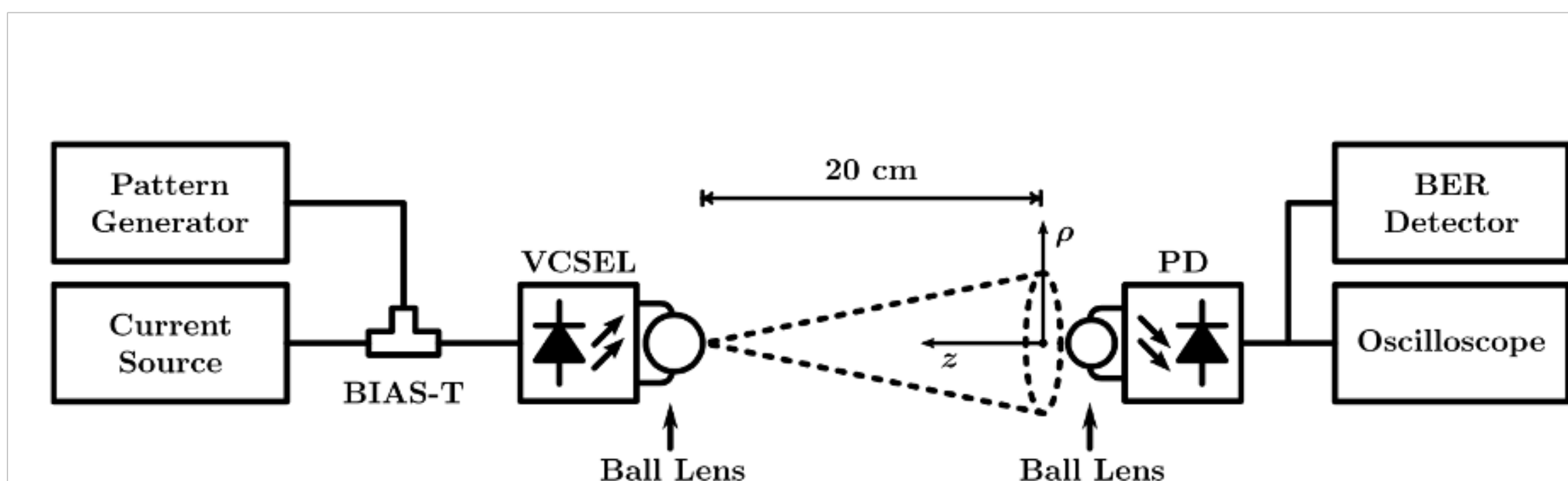


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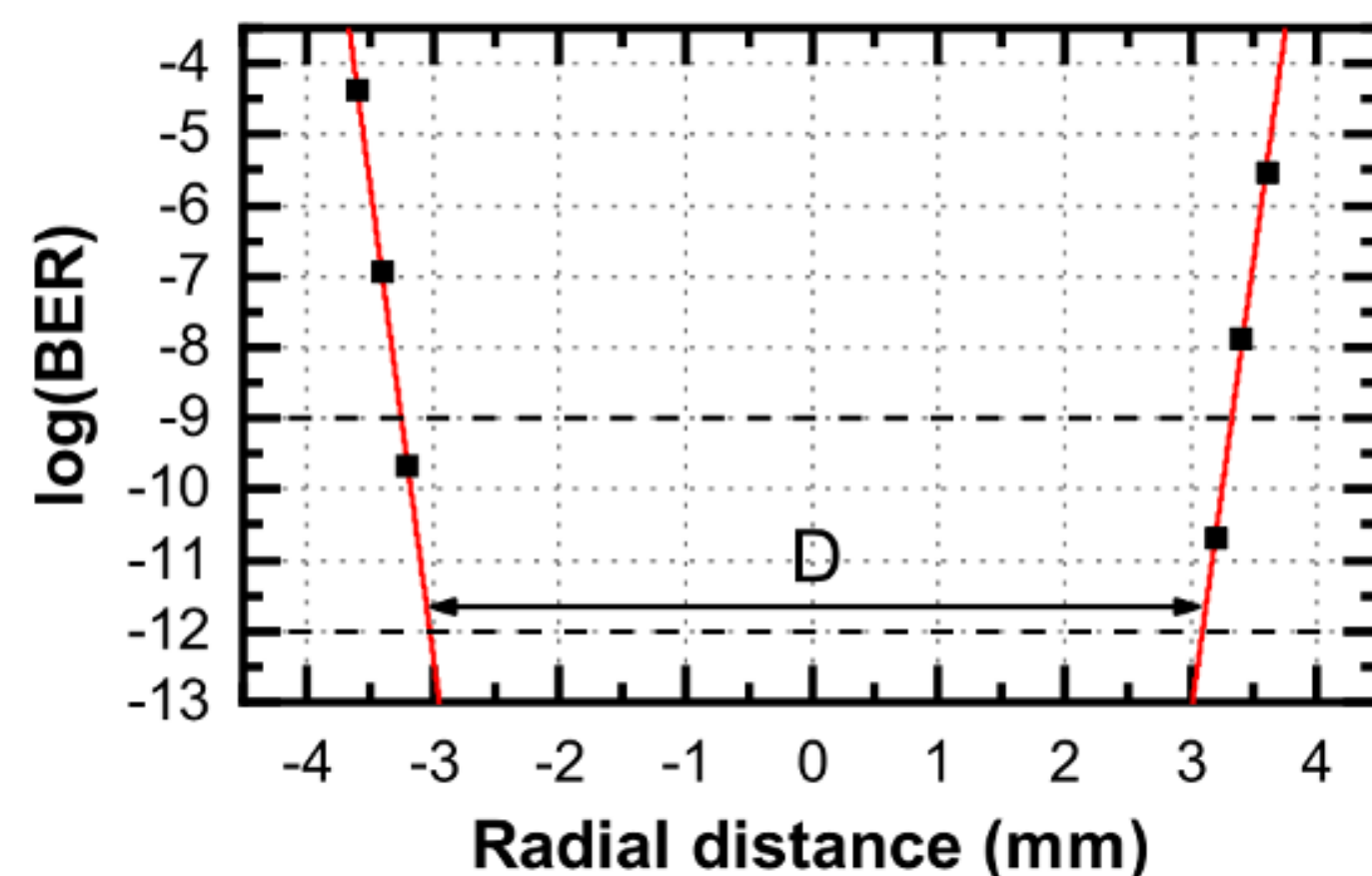
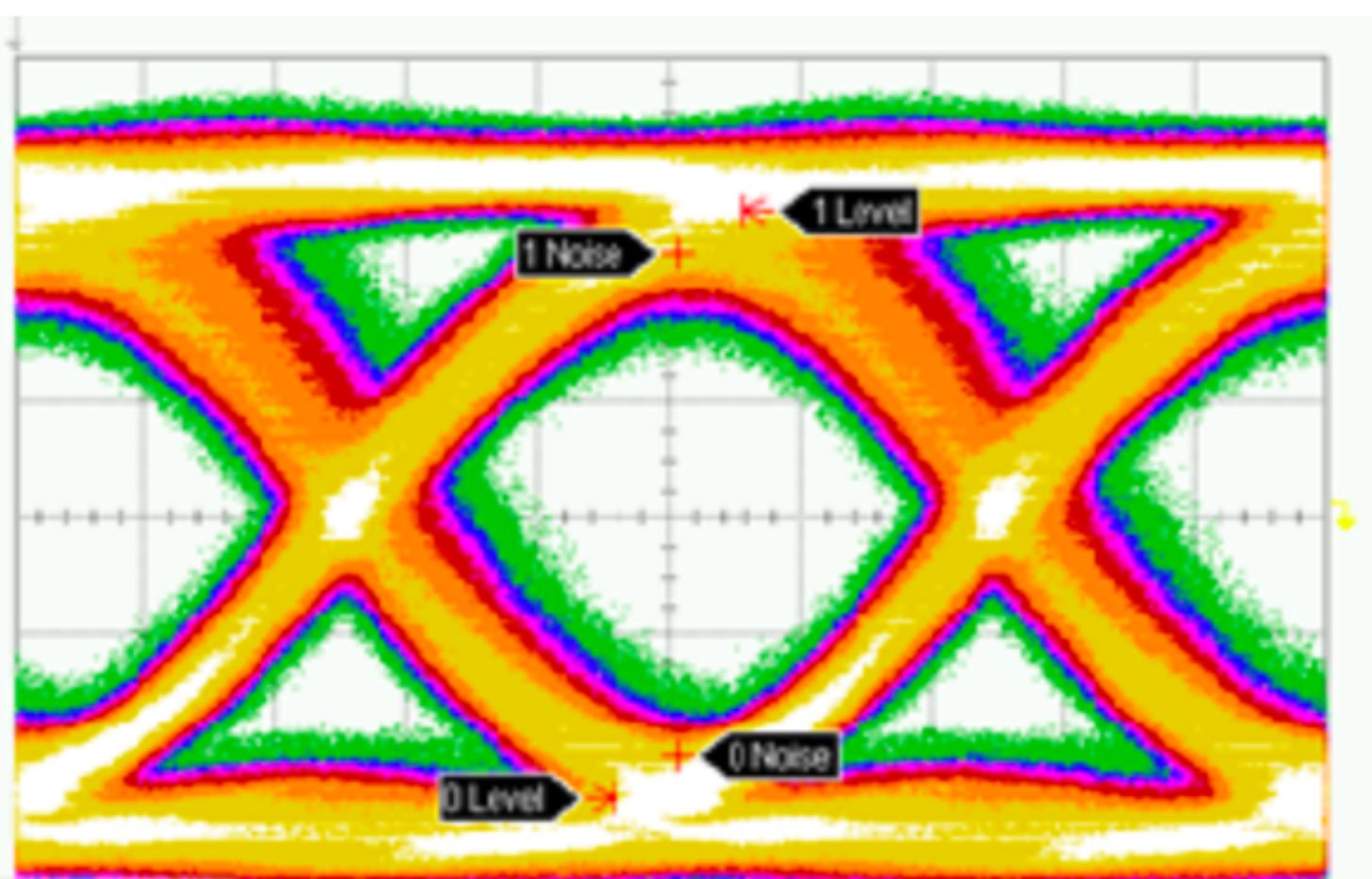
Optical wireless communications

Phos4Brain INFN project

A. Messa *et al.*, "Optical Wireless Systems for High Energy Physics: Design and Characterization", 2019 21st International Conference on Transparent Optical Networks (ICTON), Angers, France, 2019, pp. 1-4, doi: 10.1109/ICTON.2019.8840158.



- VCSEL 10 Gb/s 1310 nm, 2 mW output optical power (7.5 mA forward current) + beam collimation ball lens
- PIN diode (50 μm diameter, -3dB bandwidth 12 GHz, TIA integrated) + focusing ball lens



BER $< 10^{-12}$ for 10 Gb/s at 20 cm distance
Tested up to 238 Mrad TID and 10^{14} $n_{\text{eq}}/\text{cm}^2$