PREIN

Flagship for Photonics Research and Innovation (PREIN)

Annual Report 2025

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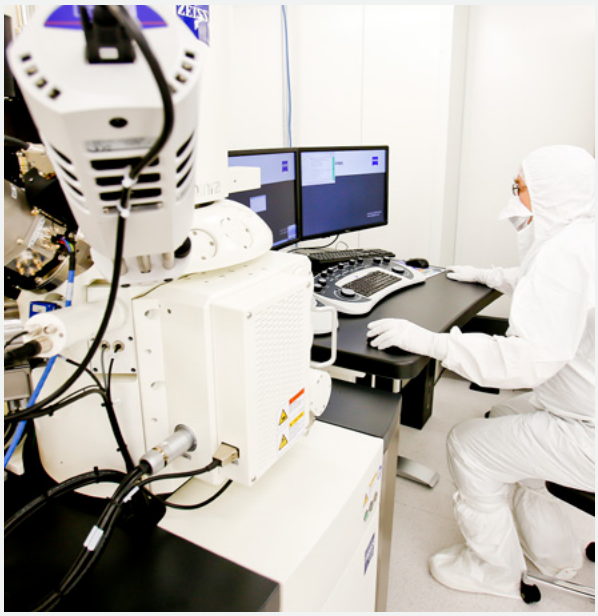
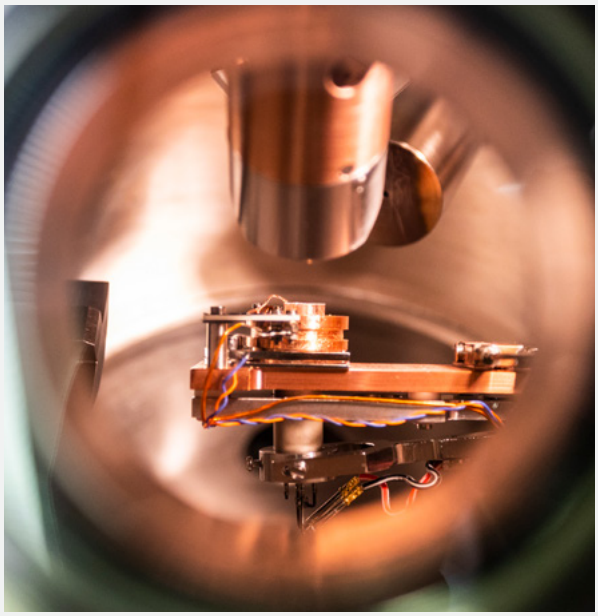




SUMMARY

As we enter the final year of the Flagship funding period (2019–2026), this is a timely moment to reflect on the achievements of our Flagship while looking ahead with ambition. Over the past year, PREIN Flagship for Photonics Research and Innovation has continued to deliver strong scientific, educational, and societal impact, confirming the maturity of the Finnish photonics ecosystem built during the Flagship period.

Throughout 2025, PREIN activities have remained at a consistently high level across all key dimensions. Our research is internationally visible and highly competitive, with 330 scientific publications during the year and a substantial fraction appearing in high-impact journals. Collaboration across partners continues to extend, with a growing number of jointly coordinated projects and co-authorship. In parallel, PREIN researchers have secured significant external funding and received wide international recognition through awards, fellowships, and leadership roles in major photonics organizations.

Education and talent development remain a central pillar of PREIN. Our master's and doctoral programmes continue to attract international cohorts, and the doctoral pilot I-DEEP – Innovative Doctoral Education Ecosystem for Photonics has further strengthened the national doctoral training landscape through joint courses, industry engagement, and industry mentoring. These activities directly support Finland's long-term competence in photonics.

Importantly, PREIN key performance indicators remain at an excellent level. The targets defined at the launch of the Flagship in 2019 have been exceeded across scientific output, degrees awarded, internationalisation, gender balance, innovations and industrial collaboration, and societal engagement. Maintaining this performance in the later stages of the Flagship demonstrates that PREIN will have a lasting impact rather than short-term gains.

The year 2025 was also marked by consolidation and visibility. PREIN played a central role in major international conferences and fairs, organized national events, and maintained a strong presence in outreach activities reaching schools, families, decision-makers, and the general public. These efforts reinforce the position of PREIN as a national hub connecting research, industry, education, and society, and clearly demonstrate the societal relevance of photonics.

At the same time, 2025 represents a strategic transition year. PREIN is actively preparing a re-application for a possible new flagship term beyond 2026. This effort builds on a demonstrated record of scientific excellence, impact, and collaborative culture across universities, research institutes, and industry. The objective is not only to sustain current activities, but to further develop PREIN's role in addressing emerging challenges and opportunities in communications, semiconductor and quantum technologies, smart photonic systems, health, digitalisation, dual-use and security.

We sincerely thank all PREIN researchers, partners, students, and stakeholders for their commitment and contributions. The achievements reported here are the result of collective effort and shared vision. As we approach to the end of current Flagship period, we do so with confidence for the future of PREIN and Finnish photonics.

Goëry Genty & Jyrki Saarinen

Research Council of Finland

FLAGSHIP PROGRAMME

IN BRIEF: PREIN – The Flagship for Photonics Research and Innovation

The Research Council of Finland's flagship initiative has been a long-standing funding programme which fosters high-impact research and bridges scientific excellence with societal and economic advances. In 2025 the program comprises of fourteen flagships forming a cornerstone of Finland's national innovation strategy.

The Flagship for Photonics Research and Innovation, PREIN, was one of the first six initiatives that received the flagship status in 2018-2019, receiving eight-year funding until 2026. Since then, two further rounds in 2020 and 2023 expanded the program to fourteen flagships in total.

The Research Council has announced a 120-million-euro preliminary budget for the fifth flagship call which will open in spring 2026 welcoming applications from both new and concluding flagship initiatives.

The PREIN Flagship operates as Finland's hub for photonics research and innovation, spanning foundational research to prototype development, industrial collaboration, and spin out creation. PREIN is dedicated to advancing top-tier education, particularly in the doctoral pilot programme (I-DEEP), shared infrastructure (FinnLight), and a vibrant innovation culture.

The consortium unites four leading institutions in light-based technologies:

- Tampere University (coordinator)
- Aalto University
- University of Eastern Finland
- VTT Technical Research Centre of Finland

PREIN continuously monitors its research, societal, and educational outcomes, summarising its progress annually and submitting comprehensive bi-annual updates to the Research Council. The most recent report to the Research Council, covering 2023–2024, was delivered in early 2025.

Tampere University

UNIVERSITY OF EASTERN FINLAND

Aalto University

VTT

ORGANIZATION

In 2025, the management and organizational structure of the PREIN Flagship remained stable, with only minor adjustments in personnel assigned to specific roles.

The PREIN Steering Committee brings together senior representatives from partner institutions who hold key decision-making positions. This body plays a central role in guiding the Flagship's strategic research and innovation agenda, monitoring progress, tracking performance indicators, and appointing Work Package leaders. Strong leadership and collaboration across organizations continue to be essential for the success of the Flagship.

The Steering Committee members representing Tampere University are Minnamari Vippola who serves as Vice Dean for Research in the Faculty of Engineering and Natural Sciences, and Esa Räsänen who is the Head of the Physics Unit. At the University of Eastern Finland, Jussi Pihlajamäki who was appointed Vice Rector for Research and Innovation in 2025, joined the Steering Committee, taking over from Tapio Määttä, who became Rector of the university. Kari Lehtinen continues as Dean of the Faculty of Science, Forestry and Technology and as UEF representative in the Steering Committee. At Aalto University, Jussi Ryynänen serves as Dean of the School of Electrical Engineering, and Matti Kaivola, who previously led the Department of Applied Physics, now contributes as Professor Emeritus in the Steering Committee. VTT is represented by Tauno Vähä-Heikkilä, Vice President for Microelectronics and Quantum Technology, and Kari Rönkä, Vice President for Sensing Solutions. The Steering Committee convened twice during the year 2025.

Academic leadership in the Flagship remained unchanged: Professor Goëry Genty from Tampere University continued as Director, and Professor Jyrki Saarinen from University of Eastern Finland, as Vice Director, focusing particularly on impact and economic growth. Each partner organization is represented in the Management Group by its institutional principal investigator. The Management Group oversees day-to-day operations, including recruitment, initiating new research topics, planning joint events, and coordinating Flagship-level funding proposals. In 2025, the group consisted of the Director, Vice Director, administrative coordinators, and the communications and impact experts from the partners. It met five times during the year.

The communications team support internal coordination and external visibility, while the outreach team engages schools and youth audiences through events on photonics, working closely with local outreach experts in the LUMA-centers. The innovation team continued to monitor commercialization opportunities and integrate promising results into the innovation pipeline in collaboration with WP6, the Work Package dedicated to impact.

Some personnel changes occurred in management and research roles. Abde Shafi replaced Faisal Ahmed as Aalto's representative in the Management Group and WP6. In other Work Packages, Teemu Hakkarainen succeeded Mircea Guina as Tampere University's WP3 representative, and Sanna Aikio took over from Timo Dönsberg as VTT's WP4 representative.

STRUCTURE

STEERING COMMITTEE

TAU:
Vice Dean Minnamari Vippola
Head of Unit Esa Räsänen

UEF:
Vice Rector Jussi Pihlajamäki
Dean Kari Lehtinen

Aalto:
Dean Jussi Ryynänen
Head of Department Matti Kaivola

VTT:
Vice President Tauno Vähä-Heikkilä
Vice President Kari Rönkä

BOARD OF STAKEHOLDERS

Maija Lönnqvist
Reijo Kangas
Timo Ahopelto
Matti Mannonen
Risto Linturi
Antti Sunnari
Jyrki Huttunen
Samuli Laukkanen
Eero Salmelin

SCIENTIFIC ADVISORY BOARD

Prof. Lluis Torner
Prof. Sergei Turitsyn
Prof. Maria-Pillar Bernal
Prof. Fedor Jelezko

PREIN

MANAGEMENT GROUP

Goëry Genty Director (TAU)
Jyrki Saarinen Vice Director (UEF)
Zhipei Sun (Aalto)
Jussi Hiltunen (VTT)
Timo Aalto (VTT)
Tea Vellamo Administration (TAU)
Abde Shafi Administration (Aalto)
Juha Purmonen Impact Manager (UEF)
Kristiina Pispala Communications (TAU)
Minna Luhtanen Finances (TAU)

WORK PACKAGES

WP1 Light Field Control

WP2 Materials and Structures

WP3 Advanced Photonic Components

WP4 Applied Research

WP5 Quantum Technologies

WP6 Technology Transfer

OUTREACH TEAM

Juniversity (TAU)
Aalto Junior (Aalto)
Luma Eastern Finland (UEF)

INNOVATION TEAM

Research and innovation services representatives

COMMUNICATION TEAM

Communications representatives

ADVISORY BOARDS

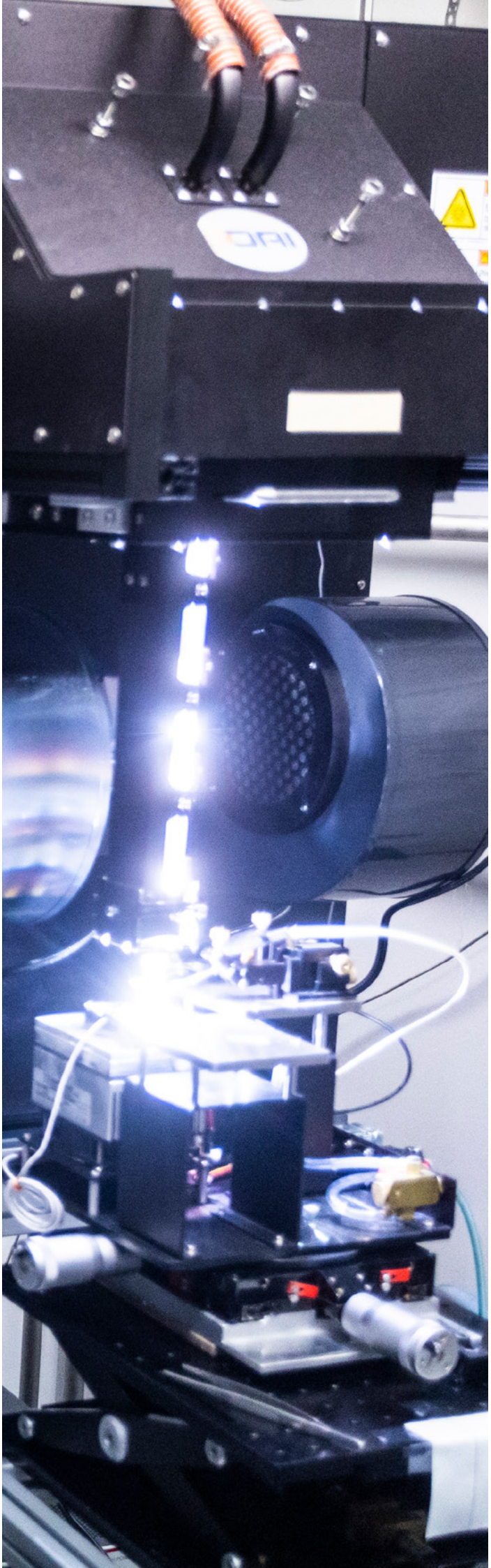
The Scientific Advisory Board and the Board of Stakeholders continue to provide strategic support to PREIN, ensuring strong links between research excellence and societal impact. The composition of the boards remained stable in 2025 and their role as trusted advisors continued. The participation of members from the Board of Stakeholders in the Flagship's annual event at Optics and Photonics Days offered an opportunity for dialogue on future directions and strengthened connections with key stakeholders in industry, and policy making.

Scientific Advisory Board

- Professor (UPC) and Director Lluis Torner, Institute of Photonic Sciences ICFO, Spain
- Professor and Director Sergei Turitsyn, Aston Institute of Photonics Technology (AIPT), United Kingdom
- Director Marial-Pillar Bernal, FEMTO-ST Institute Franche-Comté Electronics Mechanics, Thermal Science and Optics – Sciences and Technologies, France
- Director Fedor Jelezko, Institute for Quantum Optics, Ulm University, Germany

Board of Stakeholders

- Ministry of Economic Affairs and Employment: Director, Innovation Department Maija Lönnqvist
- Business Finland: Senior Director, Deep Tech and Innovation Funding Reijo Kangas
- Venture Capitalist: Founding Partner Timo Ahopelto, Lifeline Ventures
- Technology Industries of Finland: Director, Digitalization and Innovation Matti Mannonen
- Technology Visionary: Futurist Risto Linturi
- Start-up: Chief Executive Officer and Co-Founder Antti Sunnari, Dispelix
- Small and medium-sized company: Chief Executive Officer Jyrki Huttunen, Bevenic
- Large-scale commercial company in Finland: Director, Vaisala Life Science and Cleanroom Solutions Samuli Laukkanen, Vaisala
- Large-scale commercial company investing in Finland: Chief Technology Officer and Head of Strategy Eero Salmelin, Huawei Finland



RESEARCHERS

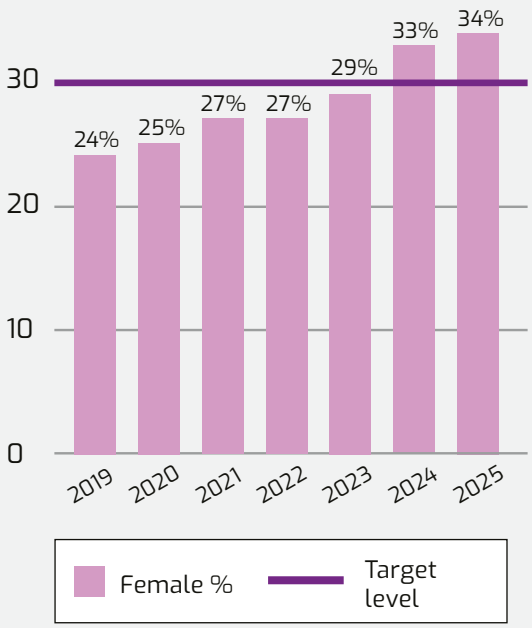
The number of academic staff associated with PREIN within the partner organisations has grown significantly during the Flagship period, with approximately 50 new researchers joining PREIN each year. As a result, the total number of researchers has increased from just over 300 in 2019 to nearly 550 in 2025. A substantial share of university recruitments has focused on doctoral researchers, who continue to represent the largest personnel group within the Flagship partner universities. The growth also reflects the involvement of additional research groups from partner organisations that have become engaged in PREIN activities over time.

At VTT, staff participation varies considerably because several research groups work across multiple projects, and many researchers contribute only part of their working time to photonics-related activities. For this reason, the contribution of VTT to PREIN activities is reported as full-time equivalents (FTE), even though the actual number of individuals involved in photonics research projects is higher.

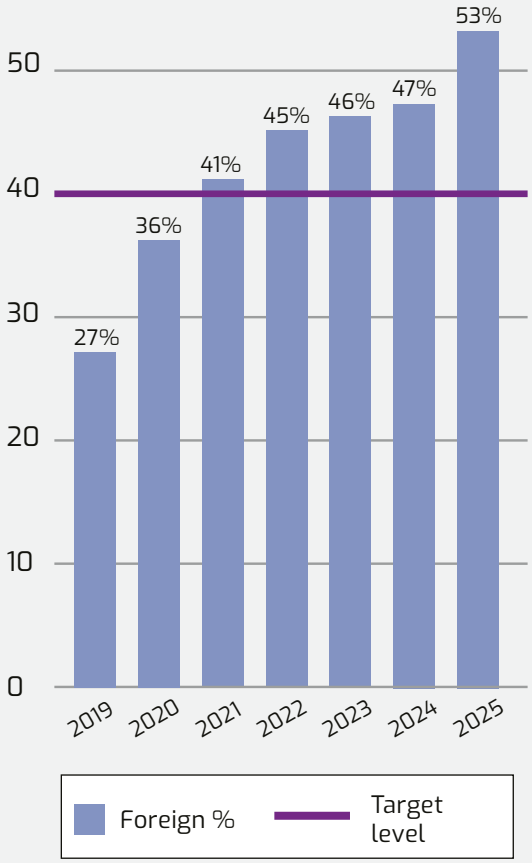
Increasing diversity among researchers has been a central objective of the flagship programme. Diversity is monitored primarily through the proportion of international and female researchers, and PREIN has made notable progress in both areas. The share of female researchers has risen steadily from 24 % in 2019 to 34 % in 2025 and exceeding the programme's targets before the end of the funding period. Most of the increase in female staff has occurred among doctoral researchers, while the proportion of female professors remains lower. Nevertheless, the flagship period has seen more women recruited into tenure-track positions and promoted to full professor roles. Strengthening diversity at the highest academic ranks will remain an important goal moving forward.

Internationalisation has also reached a high level. The share of foreign academics has grown substantially, increasing from 27 % in 2019 to more than 50 % in 2025. This development reflects both the strong degree of internationalisation within PREIN and the global attractiveness of the partner organisations as employers.

Share of Female Researchers



Share of Foreign Researchers



WORK PACKAGES AND KEY THEMES

Research in PREIN is structured into six interconnected Work Packages that combine independence with thematic synergy. The structure of six Work Packages, updated in 2022 with the inclusion of WP5 on Quantum technologies, remained consistent in 2025. Four Work Packages focus on fundamental research, one on applied research, and one on technology transfer. This structure ensures comprehensive coverage from basic science to industrial innovation while fostering collaboration across all partner organisations and research groups. Each member organisation designates representatives to the WPs. The WPs internally decide on the nominations for the WP chairs rotating the roles accordingly.

WP1 Light Field Control

WP chair Andriy Shevchenko/ Aalto

- Interferometry
- Optical metamaterials and metasurfaces
- Polarization and coherence control
- Artificial intelligence photonics
- Nanoscale localization

WP2 Materials and Structures

WP chair Harri Lipsanen/ Aalto

- Advanced materials
- Novel structures
- Photonics integration platforms
- Hybrid materials and structures

WP3 Advanced Photonic Components

WP chair Timo Aalto/ VTT

- Mid-infrared laser sources
- Visible laser sources
- High-energy pulsed sources for eye-safe wavelengths
- Single photon sources
- Cryogenic optoelectronic components
- Photonics Integrated Circuits (PICs)

WP4 Applied Research

WP chair Juha Toivonen/ TAU

- Environmental and medical sensing
- LIDAR technologies and remote sensing
- Solar energy

WP5 Quantum Technologies

WP chair George Thomas/ VTT

- Generation and detection of quantum light
- Advanced modulation of complex quantum states
- Emerging platforms for quantum technologies

WP6 Development and Transfer

WP chair Matti Virkki/ VTT

- Facilitate innovation transfer to companies
- Provide testbeds and prototypes for industry
- Promote photonics-based solutions to industry

RESEARCH HIGHLIGHTS

WP1 Light-Field Control

Overview

The objective of WP1 is to provide novel approaches to control the key properties of optical fields, such as spatial and temporal profiles, polarization, coherence, and spectrum. The WP contributes to applications in both classical and quantum optical technologies, ranging from optical sensing, detection, and imaging to optical communication and information processing.

Selected 2025 Highlights

- Spatial filtering of optical beams by ultrathin metasurfaces (Aalto): An ultrathin flat metasurface was designed to replace conventional spatial filters. The metasurface is insensitive to the transverse location of the beam spot and longitudinal position of the beam waist.
- Ultracompact photonic chips using higher-order modes (Aalto): Optical crosstalk between neighboring waveguides and other on-chip components was shown to be considerably reduced when azimuthally polarized modes are used instead of fundamental modes, potentially enabling to reduce the dimensions of photonic chips.
- On-chip polarization splitter using total internal reflection (VTT/Aalto): Total internal reflection of light in silicon waveguides on an optical chip was used to create a polarization splitter. The device exhibits a 15 dB polarization extinction ratio within an 80 nm bandwidth for TE and TM polarized light.
- High-Q sub-THz metamaterial (UEF): An unprecedented Q-factor of 3570 in the sub-terahertz range has been achieved using a novel dual-layer free-standing metamaterial. By suppressing radiation losses and isolating a dominant electric dipole moment, this design delivers exceptional energy confinement with minimal losses, with great promise for terahertz antennas, quantum technologies, and ultra-sensitive sensors.
- Talbot interference of whispering gallery modes (TAU): The Talbot effect for optical waves using whispering-gallery modes in multimode fibers has been studied both theoretically and experimentally. It can be exploited to implement a compact higher-order beam splitters useful for signal multiplexing.
- Nonlinear quantum electrodynamics of epsilon-near-zero nanocavities (TAU): A fully quantum framework to investigate the nonlinear properties of epsilon-near-zero materials at the single photon level has been developed. The findings establish a rigorous benchmark for understanding single-photon nonlinear optical effects in epsilon-near-zero nanostructures with losses.

Selected publications

1. B. Chen et al., "Spatial filtering with nonlocal non-Hermitian metasurfaces," Physics Review Applied 24, 024067 (2025)
2. B. Chen and A. Shevchenko, "Metasurface structures for spatial filtering of transverse electric optical waves and linearly polarized beams," Optics Letters 50, 7031 (2025)
3. F. Yousry et al., "Towards ultracompact photonic chips using higher-order modes in closely spaced waveguides," Journal of Physics Photonics 7, 045024 (2025).
4. S. Eyvazi et al., "Flat-band lasing in silicon waveguide-integrated metasurfaces", ACS Photonics 12, 1570 (2025)
5. X. Wang et al., "Expanding momentum bandgaps in photonic time crystals through resonances," Nature Photonics 19, 149 (2025)
6. M. Cojocari et al. "Free-standing sub-THz metamaterial with the high Q-factor isolated electric dipole response," Applied Physics Letters 126, 251701 (2025)
7. M. Tang et al., "Effect of partial polarization on Goos-Hänchen and Imbert–Fedorov shifts," Optics Letters 50, 447 (2025)
8. J. Hu et al., "Generalized angle–orbital angular momentum Talbot effect and modulo mode sorting," Nature Photonics 19, 392 (2025)
9. M. Eriksson et al., "Talbot interference of whispering gallery modes," APL Photonics 10, 010804 (2025)
10. L. D. Negro et al., "Nonlinear Quantum Electrodynamics of Epsilon-Near-Zero Nanocavities," Physical Review B 112, 165433 (2025).

(a)

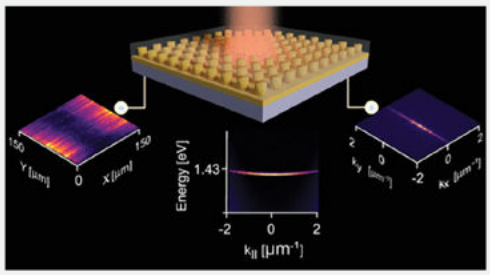
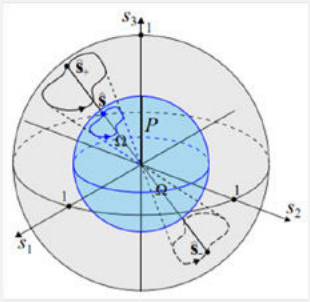


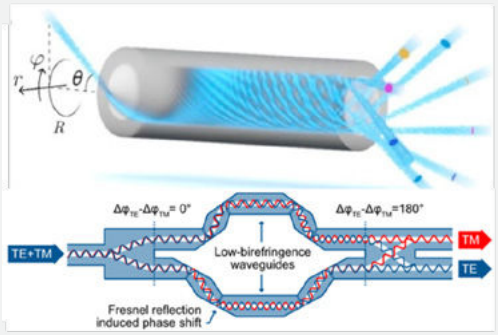
Figure 1: (a) Flat-band lasing in a metasurface.

(b)



(b) Behavior of the Poincaré vectors in a polarization-state evolution.

(c), (d)



(c) Talbot interference of whispering-gallery modes.
(d) On-chip polarization splitter.

WP2 Materials and Structures

Overview

WP2 focuses on developing optical and photoactive materials and structures essential for light-based technologies. We have expanded our research to include new materials such as 2D, perovskite, and up-/down-conversion materials, along with metasurfaces for enhanced optical responses in sensing and imaging. We also explore artificial atoms (e.g., gold nanoclusters, vacancy centers in diamond, or defects in 2D materials) for light emission and tandem hybrid structures for next-generation photovoltaics.

These advanced materials and novel structures enable energy-efficient, compact, and low-cost applications. WP2 bridges basic research from WP1 with the light sources and devices developed in WP3-WP4.

Selected 2025 Highlights

- Hybrid nanosystem (UEF, Aalto, TAU): A hybrid nanosystem comprising $MAPbBr_3$ perovskite encapsulated in carbon nanotubes exhibits single-wavelength light emission and unique optoelectronic behavior, including negative photoconductivity. These properties highlight its potential for energy-efficient photodetectors, optoelectronic switches, neuromorphic devices, photovoltaic enhancement, and flexible electronics.

- High-responsivity lnSe/TaSe2 photodetectors integrated on low-loss silicon nitride waveguides (UEF, Aalto): An InSe/TaSe2 heterojunction was fabricasted on a silicon nitride waveguide, achieving a responsivity of 2.54 A/W and a 20-fold enhancement in responsivity with laterally incident light. This highlights the potential of two-dimensional materials integrated with waveguides for applications in sensing, imaging, and communication systems.

- Light-management coating for perovskite solar cells (Aalto, TAU): We have developed a multifunctional, eco friendly light management coating, made from anisotropic pectin cryogels reinforced with PMMA and a brominated organic fluorophore, that boosts perovskite solar cell performance. The composite increases current and efficiency through haze, down conversion, and reduced reflectance, while also blocking UV light and limiting heat build up, resulting in improved stability, lower operating temperatures, and up to a 2.6 fold increase in device lifetime.

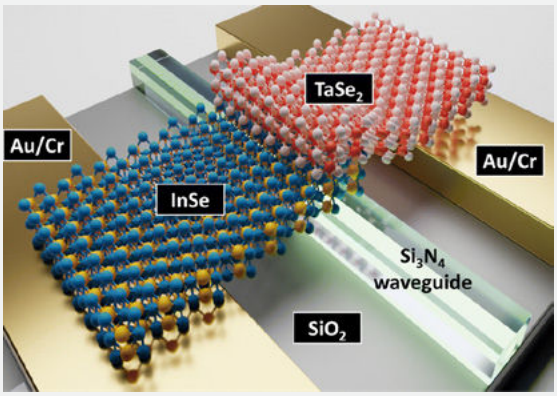


Figure 1: 3D schematic diagram of InSe/TaSe2 heterostructure transferred on top of a Si3N4 waveguide and pre-patterned Au/Cr metal contacts.

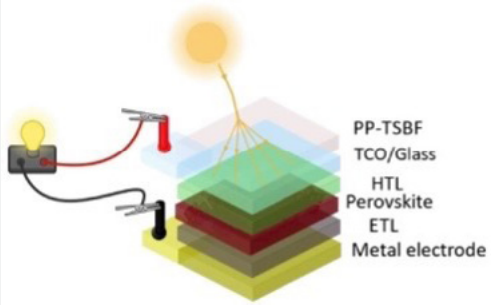


Figure 2: Perovskite solar cell structure with light-management coating.

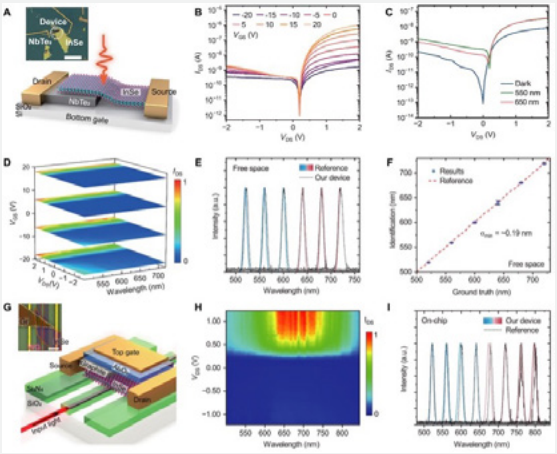


Figure 3. Narrow-band spectral sensing.

- Ultra-small spectral sensing device (Aalto, UEF, VTT): Accurate identification of different light spectra was achieved using an electrically tunable optoelectronic system measuring only 5 × 5 micrometers. Wavelength differences as small as 0.19 nanometers in free space and 2.45 nanometers on-chip could be resolved. Broadband spectral sensing was also demonstrated for identifying a wide range of materials, including dyes, metals, semiconductors, and dielectrics opening new prospectes for compact, low-cost, and scalable on-chip spectrocopic applications.

- AgMFPI -Ag-based MOEMS tunable filter for short-wave infrared (VTT): A tunable plasmonic nanostructure for near/mid IR for THz & IR hyperspectral imagers was developed, opening the way for the realization of MEMS Fabry-Perót devices in the 900-2500 nm spectral region.

Selected publications

1. V. A. Eremina et al., "1-D Light-Emitting MAPbBr3 Perovskite Encapsulated in Carbon Nanotubes," Advanced Functional Materials 35, 2503397 (2025)

2. M. Qureshi et al., "High-responsivity lnSe/TaSe2 photodetectors integrated on low-loss silicon nitride waveguides," Nanoscale Advances 7, 7352 (2025)

3. S. M Mousavi et al., "Enhancing the Performance and Photostability of Perovskite Solar Cells with a Multifunctional Light-Management Composite", Small Science 5, e202500330 (2025).

4. X.Cui et al., "Miniaturized Optical Spectroscopy with a Tunable Optoelectronic Interface," Science Advances 11, eado6886 (2025)

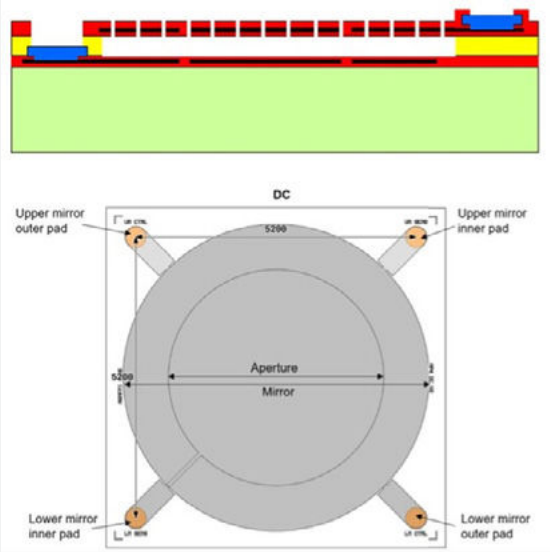


Figure 4. AgMFPI -Ag-based MOEMS tunable filter for short-wave infrared.

WP3 Advanced Photonic Components

Overview

This WP partly builds on the results from WP1-2 and develops the science and technology of advanced photonic components. Those components include advanced light sources, such as tunable and supercontinuum lasers, to generate light, as well as optical modulators and photodetectors to create and detect optical signals. They also include photonic integrated circuits (PICs) that combine a number of passive and active components on small optical chips. Furthermore, cryogenic optoelectronic components are developed in WP3 to support the development of quantum technologies in WP5.

Selected 2025 Highlights

- Broadband mid-IR optical gain beyond 2 µm (TAU): Flat broadband gain in GaSb-based semiconductor heterostructures was demonstrated using asymmetric GaInSb/AlGaAsSb quantum wells of varying thickness. By engineering carrier density and transition energies across multiple QWs, controlled gain tuning was achieved and validated experimentally. The approach provides a robust framework for mid-infrared broadband amplifiers and superluminescent diodes.
- Stimulated Brillouin scattering in a non-suspended thick-SOI platform (VTT): Stimulated Brillouin scattering was demonstrated for the first time in a non-suspended ultra-low-loss thick-SOI waveguide platform. Brillouin gain coefficients of 2.5 and 1.9 $m^{-1}W^{-1}$ at 37.6 GHz were measured for rib and strip geometries, respectively. This CMOS-compatible platform enables integrated narrow-linewidth lasers and microwave photonics.
- Passive optical phased arrays for LiDAR beam steering (VTT, UEF): A 512-waveguide passive OPA chip enabling beam steering solely via wavelength tuning was developed. The platform eliminates the need for phase modulators, reducing system complexity and power consumption.
- Light-emitting transistors with thermally activated delayed fluorescence materials (Aalto): Multilayer organic heterostructures incorporating thermally activated delayed fluorescence emitters were implemented in light-emitting transistors. Balanced charge transport enabled efficient singlet and triplet harvesting, while interface engineering allowed emission color tunability. The work demonstrates thermally activated delayed fluorescence materials as efficient and tunable on-chip light sources.

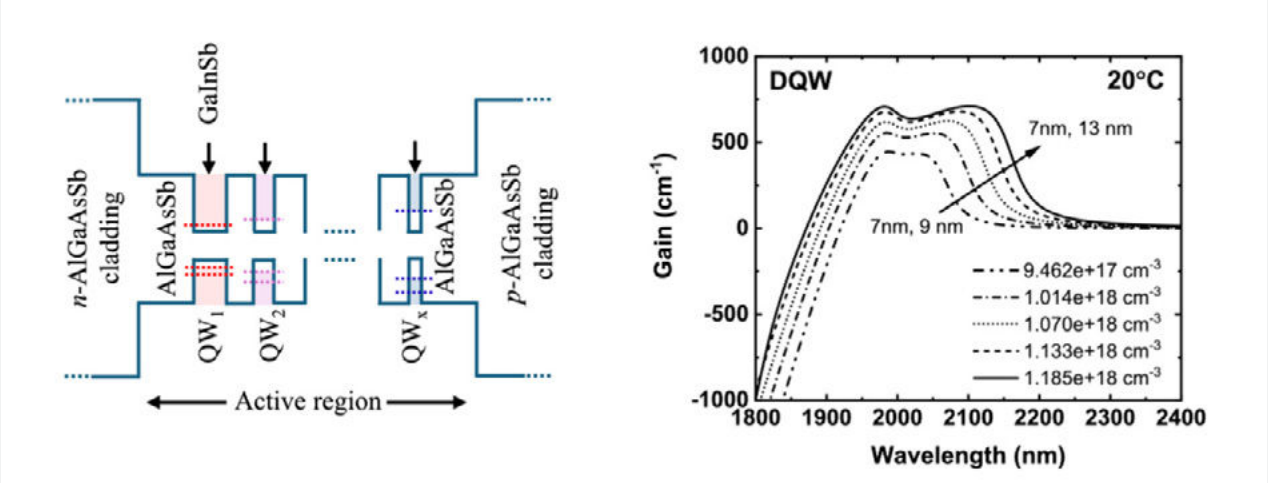


Figure 1. GaSb-based multi-quantum well structure (left) providing flat broadband gain (right).

- High-power tapered fiber amplifier (TAU, UEF): A compact all-glass spun tapered double-clad fiber amplifier was demonstrated for direct amplification of ps and ns pulses from mW to hundreds of watts average power and MW-level peak power in a single stage. The system achieved record output parameters across a broad repetition rate range.
- Polymer waveguides for high-Q microring resonators (TAU, UEF): UV-nanoimprint-fabricated polymer waveguides with propagation losses below 0.06 dB/cm enabled microring resonators with Q-factors exceeding 10^6. The platform leverages low-index claddings to minimize bending losses and targets applications in photoacoustic imaging and biosensing.
- Waveguide-integrated 2D material photodetectors (UEF, Aalto): An ultracompact coiled SiN waveguide architecture was developed to enhance light–matter interaction with integrated 2D materials. Fabricated using CMOS-compatible processes, the devices exhibit significantly enhanced absorption, responsivity, and external quantum efficiency compared to straight-waveguide designs.

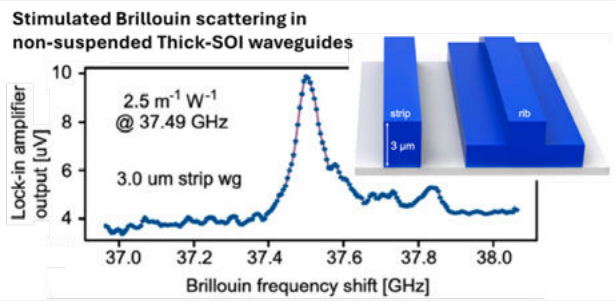


Figure 2. Stimulated Brillouin scattering in a non-suspended ultra-low-loss thick-SOI platform.

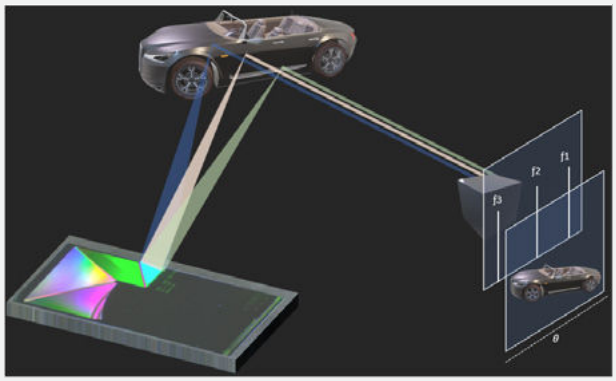


Figure 3. Beam steering and distance measurement was demonstrated with the combination of a passive 512-channel optical phase array (OPA) chip and an external tunable laser.

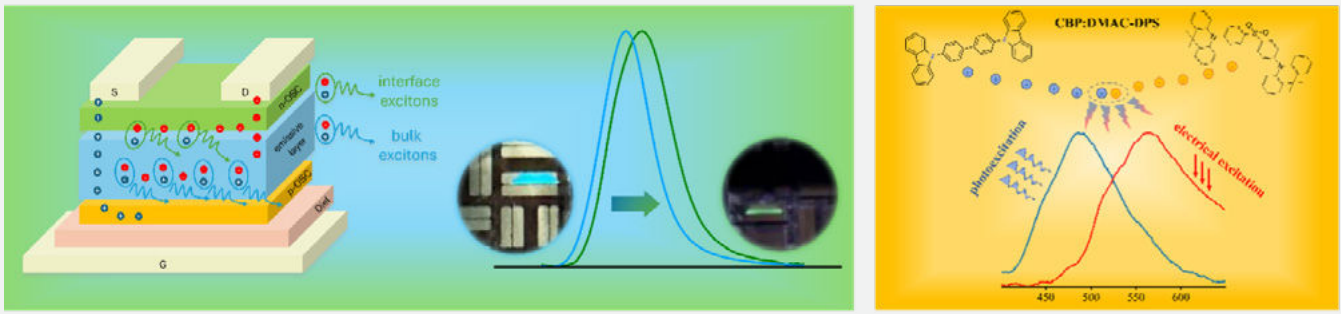
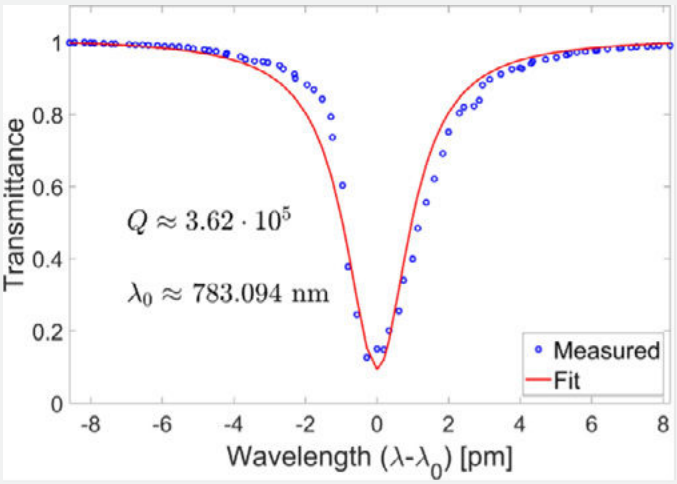


Figure 4. Tunability of emission in organic light-emitting transistor by (left): interface engineering and (right) electric field.



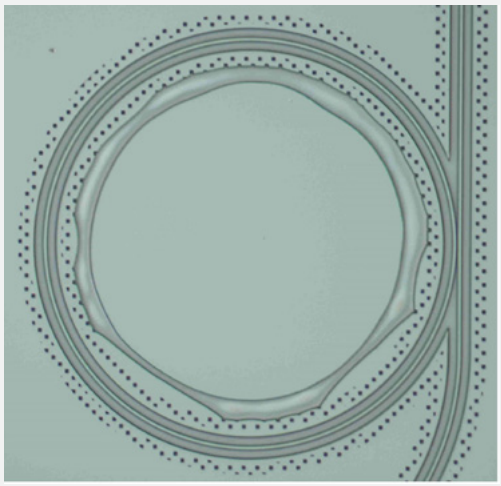


Figure 5. (left) Optical characterization of a single MRR with low index claddings. Radius of the ring is 60 µm. (right) Microscope image of a MRR with a bubble trap layer keeping the process related air voids away from the waveguides.

Selected publications

1. I. Khairul et al., "Design of broadband optical gain in GaSb-based heterostructures with asymmetric quantum wells," Optics Express 33(26), 54154-54165 (2025)
2. K. Ye et al., "Stimulated Brillouin scattering in a non-suspended ultra-low-loss thick-SOI platform," APL Photonics 10, 026108 (2025)
3. S. T. Muntaha et al., "Optical beam steering and distance measurement experiments through an optical phased array," Optics Express 33, 3685-3696 (2025)
4. C. Soldano et al., "Electroplex Emission in TADF-Based Organic Light-Emitting Transistors," ACS Photonics 12, 5858-5969 (2025)
5. H. Fathi et al., "Versatile high-power monolithic all-glass fiber amplifier for pulsed signals with a wide range of repetition rates," Scientific Reports 15, 44919 (2025)
6. S. Pandian et al. "Advancements in fabricating polymer-based microring resonators by nanoimprint lithography," Optics Continuum 4, 1368-1379 (2025)

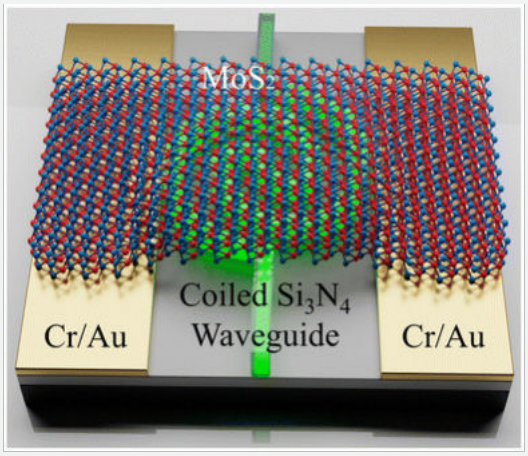


Figure 6. MoS_2 photodetector integrated on a coiled Si3N4 waveguide.

WP4 Applied Research

Overview

WP4 develops photonics applications and interacts strongly with all the other WPs. It operates in the photonic ecosystem by taking input from fundamental research (WP1-WP3) and providing scientific, societal and economic impact through technological development and innovation.

Selected 2025 Highlights

- Single-shot light-speed tensor computing (Aalto): A novel optical computing platform was demonstrated that performs high-order tensor operations in a single optical pass at the speed of light. By encoding multidimensional data directly onto structured light and engineered photonic responses, the system enables ultrafast, low-latency and energy-efficient inference without electronic bottlenecks. Experiments confirm accurate tensor multiplication and contraction with strong robustness to noise, establishing a scalable pathway toward real-time AI acceleration and practical photonic computing hardware. The work has attracted significant international attention across scientific and technology media.

- Fabrication of high-sensitivity IR detector (Aalto): A new infrared photodiode with 35% higher responsivity at 1.55 μm—the key telecommunications wavelength—has been developed compared to conventional germanium devices. The proof-of-concept outperforms both existing germanium and commercial indium gallium arsenide photodiodes while remaining fully compatible with standard manufacturing processes. The technology enables highly efficient, broadband infrared detection and can be readily integrated into existing photonic platforms, supporting widespread adoption in sensing and communication applications.

- Increasing efficiency and enhancing the longevity of the perovskite solar cells (PSCs) with bio-inspired multifunctional coating (Aalto/TAU): Different bio-inspired encapsulation methods for perovskite solar cells have been developed. As a highlight, in our most recent publication (figure on right and below), the current density of the functionalized PSC increased by an average of 4.4 ± 0.3% relative to pristine PSCs. The improvement was credited to the presence of haze, downconversion, and a 50% reduction in reflectance between 400 and 800 nm compared to glass.

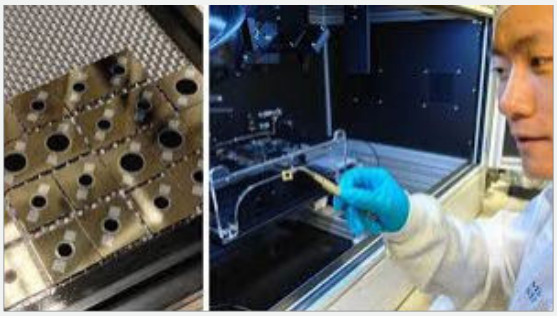


Fig 1. The new, more sensitive infrared sensor brings benefits to many different technologies. Photo: Aalto University / Xiaolong Liu

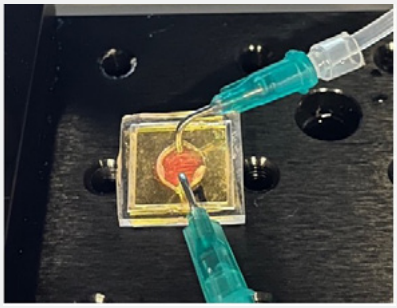


Fig. 2. Microfluidic flow cell attached on top of the nanophotonic SPR sensor chip to deliver sample solution to the chip's sensing area

- Diverging surface plasmons for single nanoparticle imaging with upconversion (UEF / VTT): Diverging surface plasmon polaritons were introduced as a new mechanism to image individual upconversion nanoparticles. An analytical model describing SPP coupling and propagation was derived and validated by numerical simulations, showing excellent agreement. Experiments demonstrated large-area single upconversion nanoparticles detection on gold substrates, establishing a novel route toward single-molecule digital biosensing.

- Plasmonics for biosensing (VTT/UEF): A compact surface plasmon resonance sensing platform was developed for multiplex biomolecule detection using a tunable laser and custom-designed nanophotonic sensor chips. Chips operating at 780 nm and 940 nm were successfully designed and fabricated, with measured plasmonic resonances matching simulations and target wavelengths. Initial advances were achieved in surface functionalization and integration of a microfluidic flow cell, establishing a foundation for practical, chip-scale biosensing.

- Eco-friendly flexible perovskite solar cells (VTT/ Aalto/TAU): Eco-friendly alternatives to gold top electrodes for flexible solar cells were developed, focusing on printable, semi-transparent metal-grid electrodes. Copper-based designs and screen-printing compatible inks were introduced to reduce cost and carbon footprint. Reference devices showed comparable efficiencies of 13.2% (gold) and 9.4% (copper), while solvent compatibility tests in perovskite solar cells are underway, advancing scalable and sustainable electrode solutions.
- Versatile indoor photovoltaic absorber (TAU): High-purity polycrystalline $Cs_2AgBi_2I_9$ thin films were developed and shown to exhibit unusually favorable optoelectronic properties for a bismuth-based PIM, including weak electron–phonon coupling, low exciton binding energy (40 meV), and highly mobile large polarons that slow hot-carrier cooling. Exploiting these features and the optimal 1.78 eV bandgap, efficient indoor photovoltaic devices were demonstrated with strong performance under varied LED illumination conditions.

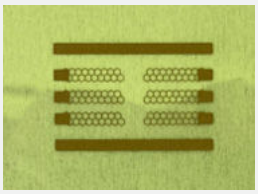


Fig. 3. Semi-transparent printed copper grid designed to be used as a solar cell top electrode

Fig. 4. Indoor photovoltaics that performs well across various indoor lighting conditions, making them versatile in diverse environments.

Selected publications

1. Y. Zhang et al., "Direct tensor processing with coherent light," Nature Photonics 20, 102-108 (2026).
2. H. Liu et al., "Near-infrared germanium PIN-photodiodes with >1A/W responsivity," Light: Science and Applications 14, 9 (2025)
3. S. M. Mousavi et al., "Enhancing the Performance and Photostability of Perovskite Solar Cells with a Multifunctional Light-Management Composite," Small Science 5, e202500330 (2025)
4. X. Liu et al, "Fs-laser significantly enhances both above- and below-bandgap absorption in germanium," Optics Material Express 15, 247-256 (2025)
5. H. Maltanava et al., "Eco-friendly preparation of titanium dioxide / carbon nitride nanocomposites for photoelectrocatalytic applications," Nanoscale Advances 7, 5601-5611 (2025)
6. D. Le et al., "Diverging Surface Plasmon Polaritons for Single Upconverting Nanoparticle Imaging," Laser & Photonics Reviews 19, e00426 (2025)
7. N. Lamminen et al., "Surpassing the 10% Efficiency Threshold in Perovskite-Inspired Indoor Photovoltaics," ACS Energy Letters 10, 3415 (2025).
8. V. Holappa et al., "Flexible Cu2AgBiI6-based perovskite-inspired solar cells using large-scale processing methods", npj Flexible Electronics 10, 6 (2026).
9. S. Das et al., "Nanoscale thickness Octave-spanning coherent supercontinuum light generation," Light: Science and Applications 14, 41 (2025)

WP5 Quantum Technologies

Overview

WP5 was established to aim at benefiting from the developed components to advance the research of foundations and applications of quantum photonics as well as delivering emerging photonic technologies to the broad field of quantum research and applications.

Selected 2025 Highlights

- Quantum state engineering at electromagnetic time interfaces (UEF): Quantum scattering of electromagnetic fields at abrupt refractive-index changes was analyzed using a two-mode squeezing framework. The study predicts photon-pair creation and annihilation, bunching and antibunching, and vacuum generation, enabling quantum state control in time-varying media. A circuit QED platform was proposed for experimental validation, advancing quantum photonics in dynamic materials.
- Geometric phase and wave–particle duality of the photon (UEF): A complementarity relation was derived linking the geometric phase of a photon in double-slit interference to its which-path information. The result quantitatively connects geometric phase and wave–particle duality, establishing a fundamental relationship between two core quantum concepts.
- Fluorescence dynamics of color centers in diamond needles (UEF): A 389 nm color center in single-crystal diamond needles was shown to exhibit an exceptionally long fluorescence lifetime (~30 ns), enhancing coherence and photon emission efficiency. Additional NV^0, NV^-, and SiV^- centers were characterized, demonstrating the potential of diamond needles as robust quantum light sources.
- Fast and bright deep-blue delayed fluorescence in carbene–metal–amide complexes (UEF): A new molecular design strategy incorporating a carbonyl group enabled suppression of parasitic triplet states in gold complexes, achieving exceptionally fast and intense deep-blue delayed fluorescence. The materials exhibit record-high radiative rates for this class, providing new design principles for next-generation blue emitters.
- Twisted van der Waals crystals on optical fibres for quantum sources (Aalto): Twist-phase-matched rhombohedral boron nitride flakes were integrated onto fibre facets to enable $\chi^{(2)}$ nonlinear optics in an all-fibre platform. The device achieved ~4.1% second-harmonic efficiency and fibre-integrated parametric down-conversion (~90 coincidence counts), enabling compact photon-pair generation without bulk optics. A graphene/boron nitride heterostructure cavity further demonstrated simultaneous mode-locking and intracavity frequency doubling.

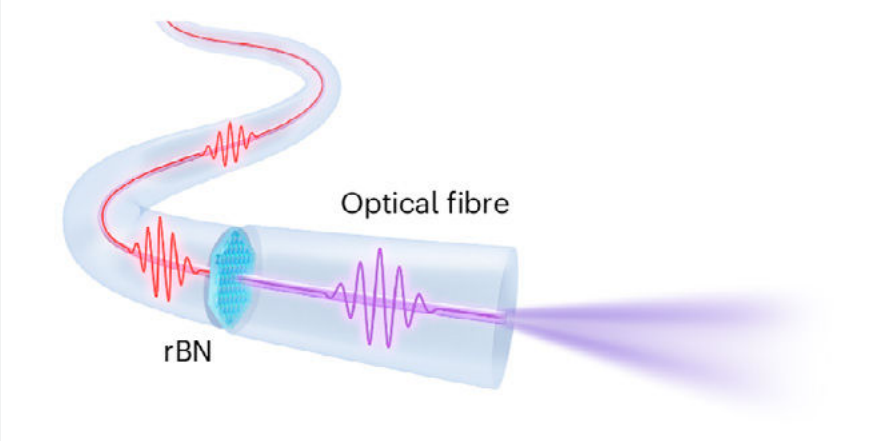
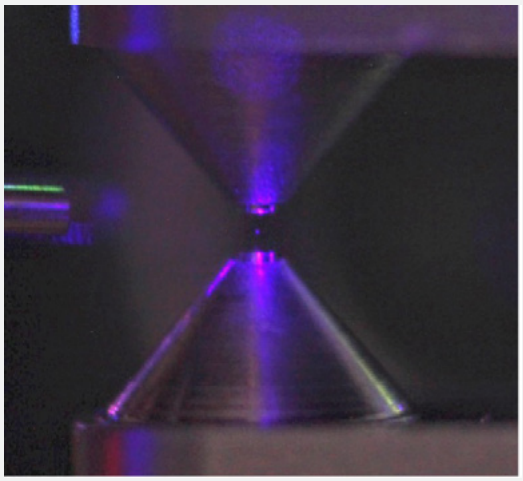


Figure: Van der Waals crystal integrated on optical fibre for quantum sources



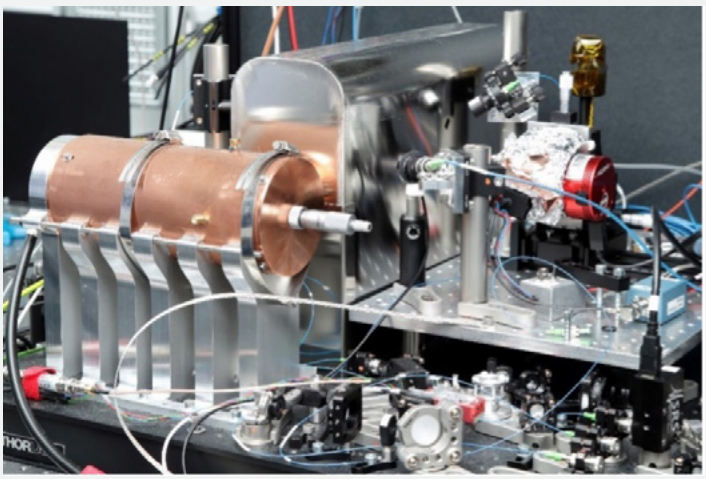


Figure: Left: A single 88Sr+ ion scattering light in the VTT ion trap (bright spot between electrode tips). Right: Physics package of the optical clock with radio-frequency helical resonator (left), magnetic shields surrounding the vacuum system (center), and optics (right).

- Optical atomic clocks with record-low uncertainty (VTT): A single-ion $88Sr^+$ optical clock reached a systematic uncertainty of 7.9×10^{-19}. A 10-month measurement against International Atomic Time achieved a total uncertainty of 9.8×10^{-17}, among the lowest reported. Improvements in blackbody radiation sensitivity and international clock comparisons further strengthened Finland's leadership in optical frequency metrology. [11–13]

- Conservation of angular momentum at the single-photon level (TAU): It was experimentally demonstrated that angular momentum is conserved in nonlinear quantum frequency conversion. When a single high-energy photon is converted into a photon pair, the joint orbital angular momen-tum of the pair equals that of the input photon. The result confirms a fundamental conservation rule at the quantum level and enables new routes toward high-dimensional biphoton and multiphoton entanglement.

Selected publications

1. S. Powley et al., "Phosphorescent isocyanide-metal-carboranyl complexes of copper(I) and gold(I): synthesis and radioluminescence," Chemisty- A European Journal 31, e202404575 (2025)

2. M. S. Mirmoosa et al., "Quantum state engineering and photon statistics at electromagnetic time interfaces," Physical Review Research 7, 013120 (2025).

3. E. Filonenko et al., "Fluorescence dynamics of color centers in diamond needles", Nanotechnology 36, 185702 (2025).

4. A. C. Brannan et al., "Deep-blue thermally activated delayed fluorescence from a CF3-substituted carbene-metal-amide complex," Physical Chemistry Chemical Physics 27, 14342-14349 (2025).

5. E. Pillinen et al., "Geometric phase and wave-particle duality of the photon," Physical Review A 111, 063709 (2025).

6. C. Riley et al., "Excited state modulation in carbene-metal-amides to design fast and bright blue delayed fluorescence," Advanced Functional Materials 31, e05661 (2025).

7. T. Lindvall et al., "Coordinated international comparisons between optical clocks connected via fiber and satellite links," Optica 12, 843 (2025).

8. L. Kopf et al., "Conservation of angular momentum on a single-photon level," Physical Review Letters 134, 203601 (2025)

RESEARCH OUTPUTS AND INTERNATIONAL RESEARCH COLLABORATION

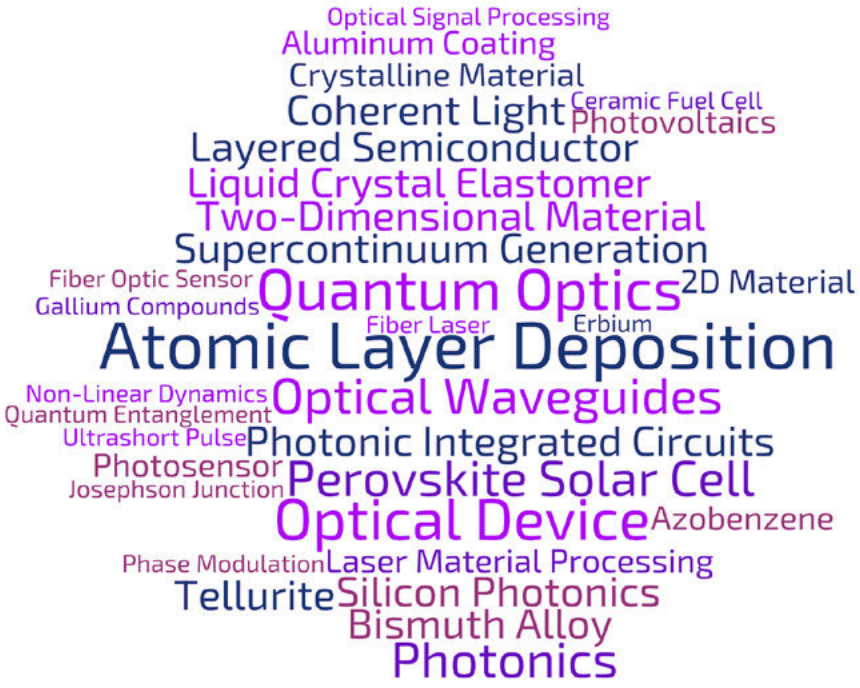
A comprehensive bibliometric assessment based on Scopus/SciVal data confirms that PREIN research stayed at a very high level of scientific quality and influence in 2025, continuing the strong upward trajectory observed throughout the Flagship programme period. Overall performance indicators show sustained excellence, with outcomes remaining at an exceptional level. The total volume of A-class publications in 2025 amounted to 330. High-impact publications account for a substantial share of output, at 41 %, and the field-weighted citation impact of PREIN affiliated publications is clearly above the national benchmark. The total number of A-class publications exceeds 2000 during the Flagship funding period (2019-2025).

PREIN researchers published extensively in a diverse portfolio of leading international journals. Across top Scopus journals, PREIN related research spans fundamental physics, advanced materials and nanotechnology, core photonics, chemistry and interfaces, applied engineering and interdisciplinary sciences. The journals where the largest number of publications occur reflect a strong research profile within PREIN in materials driven photonics, device physics, and application-oriented optical technologies. PREIN researchers publish in the highest prestige venues in materials science and nanotechnology (Advanced Materials, Small, Advanced Materials Interfaces, Advanced Functional Materials, Advanced Materials Technologies, Advanced Energy Materials, Nature Communications, Light: Science and Applications, ACS Nano, Nano Letters) as well as chemistry (Angewandte Chemie and Journal of Materials Chemistry A) and fundamental physics (Physical Review Letters stands as one of the highest-prestige physics journals globally). Publishing in these journals signals major scientific impact.

The share of publications appearing in open access journals in 2025 was 84 %, showing a significant growth compared with the previous years.

International research collaboration within PREIN remained strong and strategically focused in 2025, with further consolidation of key global partnerships. Collaboration continued to be particularly active with leading research communities in China, Germany, France, Sweden and the United States, alongside a broad network of partners across Europe. Overall, the international engagement of researchers in PREIN reflects a well established and balanced collaboration profile, supporting both scientific excellence and long term strategic objectives.

PREIN 2025 publications by journals



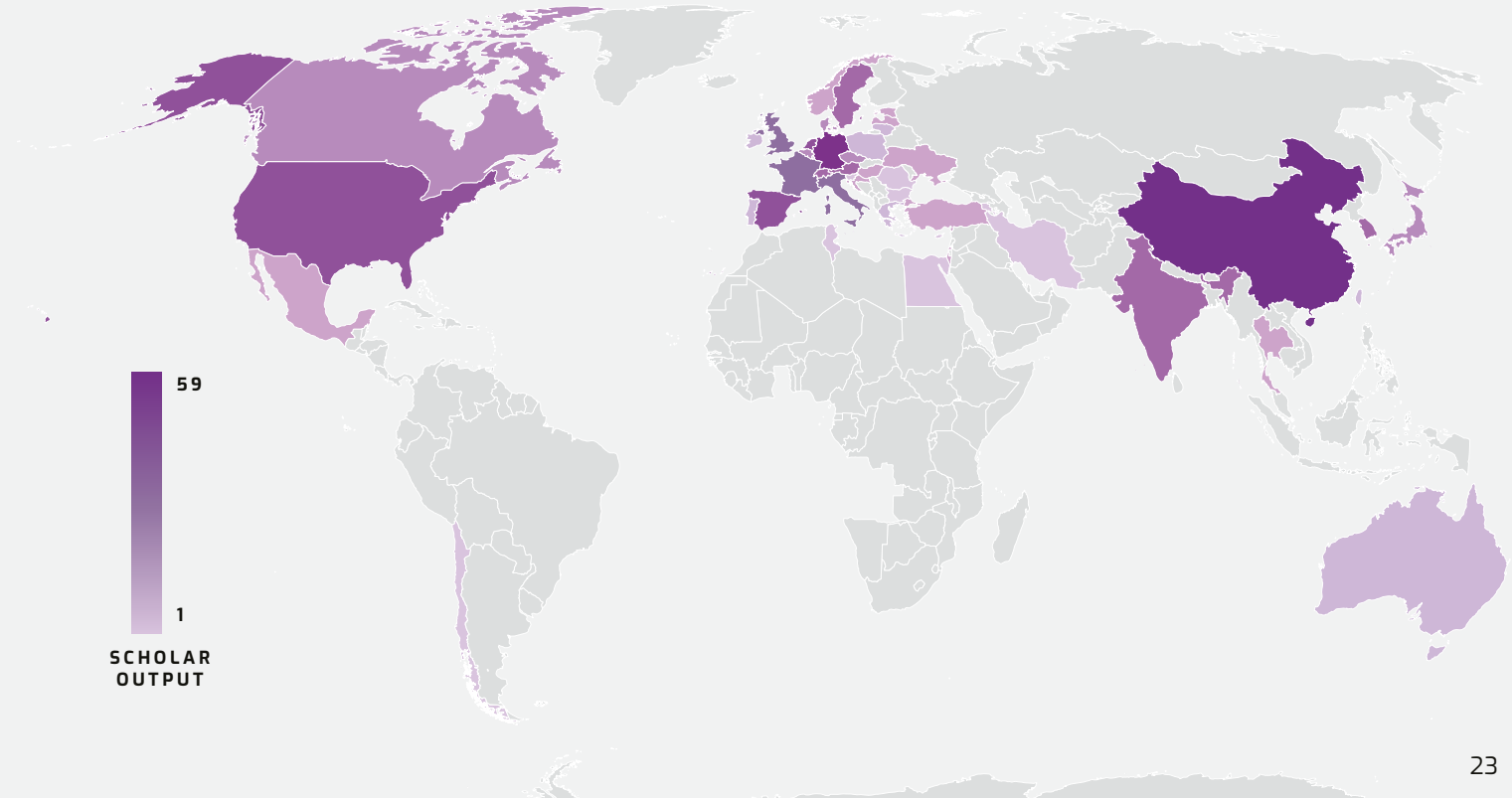
A-CLASS PUBLICATIONS **330**

OF PUBLICATIONS ARE OPEN ACCESS **84%**

OF PUBLICATIONS IN HIGH-IMPACT (IF>7) JOURNALS **40%**

OF PUBLICATIONS WITH INTERNATIONAL COLLABORATION **68%**

PREIN 2025 collaboration network



EVENTS

In 2025, PREIN Flagship organized 26 events. They included events ranging from large flagship-level conferences to smaller internal workshops and meetings. PREIN also actively contributed to 11 major Finnish events and to two international exhibition fairs. The national events linked to photonics applications were organized in collaboration with key PREIN partners Photonics Finland, Business Finland, Technology Industries of Finland, and other stakeholders, including other flagships and doctoral pilots.

Photonics Finland is a crucial partner as it complements the Flagship's academic participants by bringing the entire photonics ecosystem, including industry, to the events. PREIN and Photonics Finland also participated together in several international and national events and fairs, and small-scale targeted visits.

For PREIN, the Business Finland delegation visits are a new form of networking internationally. In 2025, PREIN was represented in the Business Finland delegation visits in September to Berlin and Dresden in Germany, and to Colorado, in November.

In addition, to events organized or co-organized by the PREIN Flagship, PREIN related research is featured annually in hundreds of academic conferences and seminars as researchers from partner organizations present their scientific work. In academic presentations PREIN is acknowledged and the visibility of the flagship is increasing internationally.

The outreach events are presented in detail in the Outreach section, whereas the events directly linked to education and training are presented in the Education section of this Annual Report. PREIN representatives are also often invited as speakers and panelists in public events related to photonics innovations and applications

Fairs

Fairs linked to major academic conferences are a platform for the Flagship to promote its research activities and build stronger links with industry, as well as connect with other academics, universities and national clusters. The fairs also bring together academics, students, companies, and decision-makers. These common meeting places lower the threshold for collaboration between different actors and increase opportunities for cooperation. In 2025, PREIN participated SPIE Photonics West event in the United States, that is the largest photonics fair globally and the primary exhibition for many Finnish photonics companies. PREIN also participated in the largest European photonics fair, Laser World of Photonics in Germany, which is accompanied by

the World of Photonics Congress, Europe's largest photonics congress.

SPIE Photonics West

PREIN has identified SPIE Photonics West as a key event to attend annually, as it is the largest photonics event globally. It features four thematic industry exhibition fairs, courses, networking events, and four academic conferences, showcasing more than 5 000 presentations. The four academic conferences are: BiOS, the largest biomedical optics and photonics event in the field; LASE, which focuses on advancements in industrial laser technologies and applications; OPTO, covering optoelectronic devices, components, and materials for commercial applications; and Quantum West, which showcases photonics as an enabling technology for quantum 2.0. In 2025, the fair and academic conferences and exhibition fairs were held on 25-30 January, and it attracted over 24 000 professionals from more than 75 countries and 1 588 exhibitors. Attendees remained steady, whereas the exhibitor numbers slightly increased from previous year. The number of countries represented increased from 70 to 75, suggesting slight expansion in international reach. PREIN participated in the Finnish Pavilion alongside Photonics Finland and photonics companies: Reflekron, Picophotonics, Emberion, Vexlum, Ampliconyx, Elfys, and OptoFidelity. Additionally, the PREIN partner VTT had its own stand. The academic conferences provided a platform for showcasing PREIN related photonics research, with 23 conference presentations from researchers affiliated with PREIN.

In connection with Photonics West, the Nordic Innovation House in Palo Alto organized a panel discussion on photonics on the last day of the fair. The event titled "Nordic Academic Meetup: What will Photonics do for us next?" included PREIN linked panelist, Dr. Timo Aalto, Research Team Leader at VTT, and was hosted by Tea Vellamo, Administrative Coordinator of the PREIN Flagship. The other panelists were Dr. Ausra Baradoke, CEO of Deep Scientific, Dr. Hugo Laurell, Postdoctoral Researcher at University of California, Berkeley and Remigijus Šliupas, Co-Founder and CEO of OPTOMAN.

Laser World of Photonics

Laser World of Photonics 2025 took place in Munich from 24 to 27 June, bringing together the global photonics industry for its largest European event. The fair hosted a record 1 398 exhibitors from 41 countries and attracted around 44 000 visitors from 74 nations. Key themes included integrated photonics, biophotonics, AI-driven optical technologies, and laser-based manufacturing, alongside the World of Quantum exhibition and the World of Photonics Congress featuring Nobel laureate plenaries.

Finnish participation was strong through the Photonics Finland Pavilion, which showcased Finnish photonics companies, Vexlum, Ampliconyx, Elfys, Picophotonics and Inkron. The pavilion served as a networking hub and highlighted Finland's expertise in photonics. A special Finnish Midsummer Networking Event, co-hosted by Business Finland, further promoted collaboration and investment opportunities.

There were 33 PREIN related academic presentations at the adjacent conference, the World of Photonics Congress, which featured five parallel scientific conference tracks and panels offering practice-focused sessions on real-world photonics uses. The World of Photonics Congress catered to scientists and

engineers focused on research on lasers, quantum optics, manufacturing, digital optics, metrology, and biomedical photon technologies.

Optics and Photonics Days

The Optics and Photonics Days has become a staple event in the Finnish photonics ecosystem, bringing together academics and industry representatives. The 2025 event took place in Oulu during June 3-5 gathering 350 participants and a sold-out exhibition with 41 exhibitors. The industrial program centered on four themes: automotive, MedTech, photonics for sustainability, and machine vision. The academic program focused on core research areas in photonics, including integrated optics, sensing and imaging, novel photonic materials and devices, and fundamental, classical and quantum photonics. The PREIN Annual Event was organized as a one-day event adjacent to the Optics and Photonics Days.

PREIN Annual Event at the Optics and Photonics Days

The PREIN event, organized on the first day of the Optics and Photonics Days, offered an excellent opportunity for industry representatives, academics from other institutions, and anyone interested in recent PREIN research achievements to learn about the Flagship activities.

The event was opened with remarks from Flagship Director Goëry Genty, followed by a presentation on PREIN highlights in 2024, showcasing key research milestones. The keynote by Reinhard Völkel from Focuslight Technologies emphasized entrepreneurship and industry collaboration, and stressed pathways for translating photonics research into commercial success. The infrastructure session featured updates from major Finnish photonics facilities, including FinnLight nodes in Tampere and Joensuu, and the PrintoCent and PhotonMed pilot lines in VTT Oulu premises, and advanced infrastructures of Micronova, OtaNano, and upcoming Kvanttinova and PIXEurope at VTT Espoo.

The event concluded with a panel discussion on cross-sector collaboration with industry and flagships, featuring representatives from the flagships PREIN, FCAI and GeneCellNano, and industry leaders from Peak PC and Vaisala. The panel also explored the synergies between photonics, AI, and biotechnology, highlighting opportunities for innovation and growth.

Industry Connect - Matchmaking in Photonics, Microelectronics and Quantum Event

As a part of the newly launched doctoral pilot programme Innovative Doctoral Education Ecosystem for Photonics (I-DEEP), the concept for connecting doctoral researchers with industry representatives was launched in 2024 when the first larger-scale Industry Connect networking event was organized. This model, first piloted by the three doctoral pilots, has since inspired similar initiatives coordinated by Technology Industries of Finland and involving other doctoral pilots.

On October 6, 2025, the doctoral pilot linked with the PREIN flagship, I-DEEP, together with two other doctoral education pilots focusing on Microelectronics and Quantum, organized the second Industry Connect matchmaking event in Helsinki. The event brought together around 20 company representatives and approximately 80 participants from the three pilots, mostly doctoral researchers, for a day of networking and collaboration. The programme included short presentations about the three doctoral pilots and focused on building bridges between research and industry, thematic discussions, and informal matchmaking sessions. Topics spanned photonics, microelectronics, and quantum technologies, highlighting opportunities for future careers in the field and possible research collaborations. The event strengthened industry-academia ties and showcased the growing relevance of these fields for Finland's high-tech ecosystem.

Academic Conferences

PREIN researchers organize academic conferences closely related to the Flagship's research themes and Work Packages within PREIN, while also inviting international academics to participate and contribute. PREIN is also involved as a sponsor in photonics conferences organized by PREIN partners.

Japan-Finland Joint Symposium on Optics in Engineering, Levi

The 15th Japan–Finland Joint Symposium on Optics in Engineering (OIE'25) took place in Levi, Finnish Lapland from January 6 to 9, 2025. This long-standing series, initiated in 1995 with locations alternating between Japan and Finland, aims to foster interactions between Finnish and Japanese scientists working in optics and photonics. The University of Eastern Finland featured prominently as the Finnish organiser of the event. The four-day symposium combined a series of technical sessions with networking opportunities. The OIE 2025 symposium presented a broad spectrum of contemporary optics and photonics research through six main thematic sessions, covering biophotonics, photonics materials, microstructures and spectroscopy, optical measurements, fundamental photonics, and photonics applications.

Non-Linear Photonics Workshop

On April 15–16, Tampere University organized the Non-Linear Photonics Workshop aboard the Silja Symphony cruise ship between Finland and Sweden. The workshop gathered around fifty participants, including researchers, doctoral students, and invited experts, to discuss cutting-edge developments in non-linear photonics such as advanced optical processes, novel materials, and emerging applications. The unique setting provided an inspiring environment for scientific presentations and networking, fostering collaboration across Finnish and international research communities.

Events Timeline

- OUTREACH EVENTS FOR PUBLIC
- MEETINGS
- THEMATIC OUTREACH EVENTS
- FAIRS
- PREIN WORKSHOP EVENTS

Spring

Jan 6-9 Japan-Finland Joint Symposium on Optics in Engineering, Levi

Jan 8–12 Tieteen päivät, Helsinki

Jan 25 Tiedon valoa -Event (TAU), Tampere

30 Jan-1 Feb Photonics West Fair, San Francisco, USA

18-19 March Ansys Zemax OpticStudio – training (TAU), Tampere

3 May Valoa perheille -Event (UEF), Joensuu

13 May I-DEEP Annual Event for New Doctoral Researchers (TAU), Tampere

13 May Spectroscope Outreach Workshop, (Aalto) on-line

16 May International Day of Light Workshops at Juniversity, Tampere

22-24 May SciFest (UEF), Joensuu

26 May PREIN Steering Committee Meeting, on-line

27 May Photonics 55 Years in Joensuu (UEF), Joensuu

12 Feb PREIN Management Group Meeting, on-line

28 Feb Research Council of Finland reporting

15-16 April Non-Linear Photonics Workshop 2025, Silja Symphony

28 April PREIN Management Group Meeting, Espoo

3-5 June Optics and Photonics Days, Oulu

3 June PREIN Annual Event, Oulu

24 June Panel Discussion: "Ihminen on riski: Fotoniikka turvaa itseohjautuvan liikenteen", Suomi Areena, Pori

24-27 June Laser World of Photonics, Munich, Germany

OUTREACH EVENTS FOR PUBLIC

MEETINGS

THEMATIC OUTREACH EVENTS

FAIRS

PREIN WORKSHOP EVENTS

Autumn

18-20 July Photonics Outreach Event, Ilosaari-rock (UEF), Joensuu

1-4 Sept Business Finland Delegation Visit to Berlin and Dresden, Germany

4 Sept Photonics Themed Journalist Day (TAU), Tampere

24 Sept TAU Thesis Fair (TAU), Tampere

30 Sept I-DEEP Mentoring Kick-off, hybrid event

8 Nov Valoa perheille – Event (UEF), Joensuu

11 Nov PREIN Research Symposium, Helsinki

12-13 Nov Business Finland Delegation Visit to Colorado, USA

23-24 Nov TEK Family Days (TAU), Tampere

27 Nov New Winds in Optics Design (UEF), Joensuu

29-30 Nov TEK Family Days (TAU), Tampere

JUL · AUG · SEP · OCT · NOV · DEC

10-15 Aug Markus Pessa International Summer School: New Frontiers in Optical Technologies (TAU), Tampere

18-22 Aug Summer School on Optics 2025: Innovation Skills in Photonics (UEF), Joensuu

19 Aug PREIN Management Group Meeting, on-line

25 Aug PREIN Steering Committee Meeting, on-line

6 Oct Industry Connect event: Photonics, Microelectronics and Quantum, Helsinki

9 Oct Spectral Imaging for Medical and Health Applications (UEF), Joensuu

8 Oct – 26 Nov Applications of Photonics –webinar (UEF)

25 Oct Open Otaniemi (Aalto), Espoo

27 Oct PREIN Management Group Meeting, on-line

31 Oct PREIN WP2 Materials and Structures and WP4 Applied Research Annual Event (UEF), Joensuu

11 Dec PREIN Management Group Meeting, on-line

New Winds in Optics Design

On November 27, 2025, the University of Eastern Finland hosted the New Winds in Optics Design seminar in Joensuu, organized in collaboration with PREIN, Photonics Finland, and Photonics Joensuu. The training was funded by the Regional Council of North Karelia under the national AURA structural fund programme, supporting to photonics skill development.

The event brought together researchers and industry professionals to discuss emerging trends in optical design, including meta-optics, integrated photonics, and advanced simulation tools. There were about 40 participants from academia and industry. Presentations featured both academic and industrial perspectives, complemented by a tour of UEF's photonics laboratories showcasing cutting-edge facilities.

PREIN Internal Events

The internal thematic events primarily cater to PREIN researchers, fostering collaboration across different partners and research groups within the Flagship. These events occasionally also invite key stakeholders with relevant expertise to join, offering opportunities for benchmarking, gaining external perspectives, and exploring new approaches to the selected themes.

PREIN Annual Research Symposium

On November 11, 2025, the Annual Research Symposium in Helsinki, brought together PREIN researchers from across the partners. The event served as a platform to present recent scientific achievements, discuss progress in PREIN's Work Packages, and explore future directions in photonics research and applications. In addition to technical talks and poster sessions, the symposium emphasized networking and collaboration, strengthening ties between the PREIN partners.

The program included summary, presentations on the progress of the PREIN internal research projects. To boost collaboration, there were Work Package breakout sessions including planning future collaboration. Suggestions on the future of the PREIN Flagship after 2026 were collected. Two keynote presentations provided strategic perspectives on expanding PREIN's scope. Professor Vesa Hytönen from Tampere University delivered the academic keynote Light-controlled biomolecules, highlighting how photonics can enable precise control of biological systems and open new opportunities in life sciences. From the industry side, Bernard Kress from Google presented insights on emerging applications in optics and photonics for consumer technologies and advanced computing, outlining trends that could shape PREIN's future research agenda.

PREIN WP2 Materials and Structures and WP4 Applied Research Annual Event

This internal PREIN event was held on 31 October 2025 at the University of Eastern Finland (UEF) in Joensuu. This internal Flagship meeting brought together researchers from two key Work Packages: WP2, focusing on advanced photonic materials and structures, and WP4, dedicated to applied research and industrial collaboration. The event featured presentations on recent scientific results, ongoing projects, and opportunities for cross-disciplinary cooperation, aiming to strengthen links between fundamental research and practical applications in photonics.

PREIN Meetings

Throughout 2025, PREIN organized regular meetings to oversee and monitor its activities. The PREIN Management Group convened times, while the Steering Group, comprising five institutional representatives from all PREIN partner organizations, held meetings. In addition to this, the Work Packages organized two of their own regular meetings. The Communications, Outreach, and Innovation teams held several collaborative sessions to plan and coordinate joint activities supporting PREIN objectives. These cross-functional meetings ensured alignment and strengthened the integration of activities across the Flagship.

EDUCATION

In 2025, collaboration in photonics education continued actively, with ongoing activities in both master's level education and doctoral training. The number of graduates in photonics at the master's level continued to rise in the PREIN partner universities, the University of Eastern Finland, Tampere University, and Aalto University.

The number of master's degrees has grown significantly during the Flagship funding period, increasing from fewer than 60 degrees in 2019–2021 to almost a hundred MSc degrees in 2025. Doctoral graduation numbers have remained relatively steady, with approximately 30 PhD degrees awarded annually over the past three years. However, the significant boost of the I-DEEP doctoral pilot with additional funding granted for 72 new doctoral researchers will significantly increase the number of doctoral graduates in the coming years.

Bachelor's and Master's Degree Education in Photonics

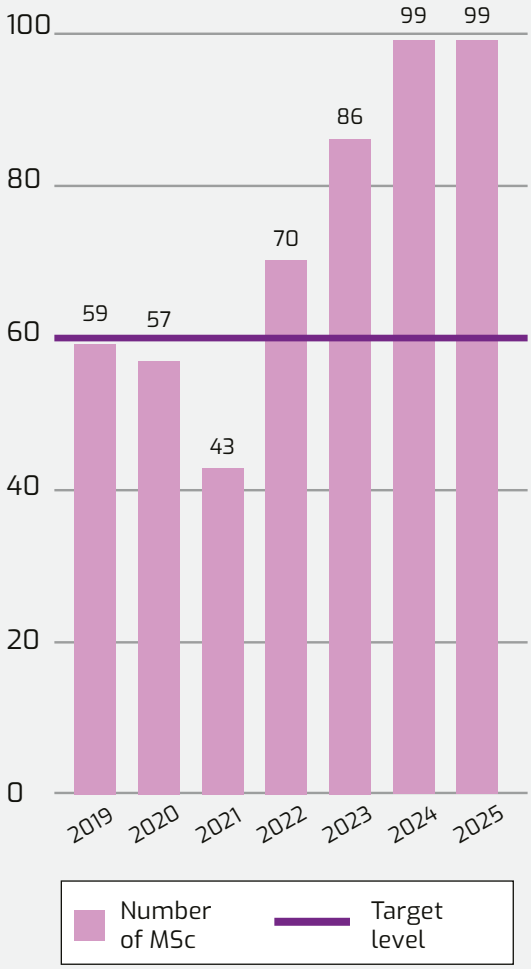
The photonics degree education offered by PREIN partner universities includes programmes taught in both Finnish and English. Altogether, there are currently nine photonics related degree programmes: one BSc programme at UEF and eight MSc programmes, four of which are international Erasmus Mundus joint programmes.

PREIN partners host several Erasmus Mundus funded international joint master's programmes: EUROPHOTONICS at Tampere University, and Computational Colour and Spectral Imaging (COSI), Intelligent Photonics for Security, Reliability, Sustainability and Safety (iPSRS), and Imaging and Light in Extended Reality (IMLEX) at the University of Eastern Finland. Each programme admits approximately 20 students, although mobility paths and participation among partner universities differ by programme.

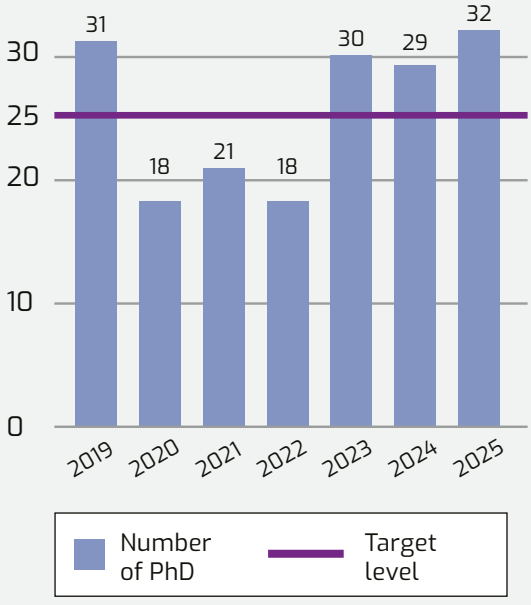
Doctoral Education in Photonics

In 2025, the doctoral pilot Innovative Doctoral Education Ecosystem for Photonics (I-DEEP) continued for its second year of activities. Although the programme was launched already in August 2024, many new doctoral researchers started their

Master's degrees



Doctoral degrees



contract only in 2025. Thus, activities during the year included onboarding of the doctoral candidates, planning and launching new joint courses and transferable skills trainings, and organizing networking events to connect students with companies in the photonics sector. The pilot also started the first round of industry mentoring in autumn 2025 to strengthen connections between academia and technology companies. A second round of the mentoring will be arranged in 2026.

Innovative Doctoral Education Ecosystem for Photonics Annual Meeting

The annual meetings organized for the doctoral pilot researchers focus on supporting their soft and transferrable skills as well as offer them a possibility to present their own research. A key element is also networking among the other doctoral researchers, learning about their research topics and strengthening links between the partner organisations and their diverse research groups.

The 2025 I-DEEP event organized in May offered training on poster presentations and the doctoral researchers also had the opportunity to present their first research posters linked with the doctoral research topics. There was a panel discussion with recent doctoral graduates who gave tips on managing the doctoral degree studies and insights to their current work and career trajectories.

Educational Collaboration

The PREIN universities have continued to strengthen their joint educational efforts at the master's level by offering shared courses in photonics. This collaboration ensures that students across institutions gain access to specialized expertise and resources, fostering a unified national approach to photonics education. Current joint course offerings include Applications of Photonics and Optical Design at UEF, and Solar Driven Chemistry at Tampere University. These courses provide students with both theoretical foundations and practical skills, supporting the development of a highly qualified workforce for Finland's photonics industry.

In addition to these courses, the Flagship partners actively explore synergies through national networks such as FYSNET, the Finnish Physics Network, which connects physics departments across Finnish universities. FYSNET includes a dedicated subgroup for Optics and Photonics, which promotes coordination of teaching resources, joint course development,

and shared learning environments. Through this network, PREIN partners have discussed opportunities for harmonizing curricula and creating virtual course platforms to increase accessibility.

Plans include expanding the joint course portfolio to cover emerging areas such as quantum photonics and integrated optics, introducing industry-led modules to strengthen practical relevance, and leveraging FYSNET to develop national-level teaching materials and shared laboratory exercises.

Summer Schools

Regular summer schools have been organized as a part of the doctoral education activities in PREIN, with an annual summer school in the University of Eastern Finland and a bi-annual summer school in Tampere University. In 2025 summer schools were organized in Joensuu by the University of Eastern Finland and Tampere University.

Markus Pessa International Summer School New Frontiers in Optical Technologies

In June 2025, Tampere University hosted the 12th Markus Pessa International Summer School on Optics and Photonics, continuing a long-standing tradition of advanced training for young researchers. The summer school gathered around 100 participants from Finland and abroad, including doctoral students, postdocs, and invited experts. The program featured lectures by leading scientists on cutting-edge topics in optics and photonics, interactive sessions, and networking opportunities aimed at fostering collaboration and knowledge exchange.

Summer School on Optics 2025: Innovation Skills in Photonics

In August 2025, the University of Eastern Finland organized the Summer School on Optics: Innovation Skills in Photonics, offering advanced training for doctoral researchers and students in photonics. The program combined lectures on cutting-edge optical technologies with practical sessions focused on innovation, entrepreneurship, and commercialization skills. Participants explored how photonics research can be translated into real-world applications, gaining insights into business development and industry collaboration. Participating students had the opportunity to learn from expert lecturers Heikki Immonen, Ana Gebejes, PhD, and former NASA astronaut Charles Camarda PhD, and to work on mini challenges provided by companies.

Continuous Education and Courses

Specific short-term courses directed at companies and employees in photonics industry have been planned according to the needs and requirements in companies.

Spectral Imaging and Its Applications Training

The training, held in January 2025, offered participants a hands-on introduction to the use of spectral imaging across science, industry, medicine, agriculture, forestry, and the arts. The one-day course demonstrated how spectral techniques enable users to distinguish between visually similar but materially different objects, and guided attendees through three practical modules: fundamentals of spectra and spectroscopy, the operation and application of spectral cameras, and spectral data processing using non-commercial software.

Ansys Zemax OpticStudio Training

In March 2025, PREIN organized a hands-on training on Ansys Zemax OpticStudio, a leading software for optical system design and simulation. The two-day session attracted over 35 participants, including researchers, doctoral students, and engineers from both academia and industry. The University of Eastern Finland hosted the intensive two day training focusing on freeforms, aspheres, optimization workflows, and best practices. The event was arranged in collaboration with Photonics Finland, EDRMedeso, and Ansys, and was financially supported by the Regional Council of North Karelia and the European Union. Industry collaboration was highlighted through contributions from Ansys and Finnish photonics companies, ensuring participants gained insights into real-world applications. The training introduced participants to the principles and practical use of spectral imaging technologies in diagnostics, biomedical research, and healthcare.

PREIN has also collaborated in 2025 with EU funded photonics career development programme 360 CARLA that seeks to provide training, mentorship and experiences opportunities across Europe to prepare university students and early stage researchers for future careers in photonics. The collaboration has resulted in two trainings in 2025.

360 CARLA Career Symposium on Biotech and Medical Photonics

As part of the Optics and Photonics Days, Finland hosted its first 360 CARLA Career Symposium in on June 6, 2025, bringing together more than 80 students, early career researchers, and professionals to explore career pathways in biotech and medical photonics. The program featured keynote talks, career insights from academia and industry, panel discussions, and postdoctoral testimonials, with participants reporting increased interest in photonics and entrepreneurship, marking a significant step in strengthening Finland's role in photonics talent development.

360 CARLA Spectral Imaging for Medical and Health Applications Training

On October 9, 2025, a specialized training session on spectral imaging for medical and health applications was held at the University of Eastern Finland Joensuu campus. The training was part of the collaboration with the 360 CARLA project. The training was a one day, hands on introduction to spectral imaging for medical and health applications, combining lectures, live demonstrations, and practical coding exercises. Participants learned the fundamentals of spectral imaging, operated spectral cameras, processed datasets in Python, and applied the methods to a biomedical use case involving dental spectral image analysis.

International Photonics Continuous Education

The University of Eastern Finland joined the Phortify network in 2025, a major EU-funded project creating a pan-European photonics education ecosystem, to train talent for the rapidly growing field of light-based technologies, with UEF focusing on skills analysis and industry collaboration for digital and photonics skills. Through Phortify, UEF leads labour-market and skills-needs analysis to co-create education modules that bridge academia and industry. Phortify is an initiative to build Europe's photonics talent pipeline with industry-aligned education, leveraging digital tools, mentorship, and micro-credentials for lifelong learning. In Phortify UEF's focus areas involve micro- and nanophotonics, meta-optics, and 3D-printed optics, bridging academia. Industry needs to ensure that Europe remains competitive in photonics, a key area for digitalization, by providing cutting-edge, accessible training. This major European research initiative is advancing quantum-enhanced imaging for healthcare, aiming to develop next-generation diagnostic tools using quantum photonics. UEF contributes expertise in biomedical optics and spectral imaging, focusing on applications that improve early disease detection and personalized medicine. Finland's involvement underscores its strong position in photonics and quantum technologies, bridging fundamental research and clinical innovation to create impactful solutions for medical diagnostics.

CEO Jussi-Pekka Penttinen, Vexlum

ECONOMIC IMPACT AND INDUSTRY COLLABORATION

In 2025, PREIN continued to strengthen its economic impact through close collaboration with photonics companies and with Photonics Finland. As a part of the national photonics ecosystem, PREIN and Photonics Finland work in alignment to support industry needs, accelerate innovation, and promote Finland's position in the global photonics market. This cooperation is reflected in joint contributions to the National Photonics Roadmap as well as in the biannual surveys that track the status, growth, and development needs of the Finnish photonics industry and research landscape.

A major European level milestone for Finland's photonics economy in 2025 was the decision to establish new photonics pilot lines in the country. These pilot lines will help bridge the gap between research and industrial deployment by enabling companies to test, scale, and commercialize photonics technologies. Their presence in Finland strengthens technological sovereignty, attracts international collaboration, and increases the competitiveness of Finnish companies.

University based start-ups also continue to play a central role in the economic impact of PREIN. By transforming cutting edge research into high value products and spin off companies, PREIN contributes to job creation and enhances long-term innovation capacity in Finland. Start-ups help ensure that knowledge generated within PREIN translates into tangible societal and economic benefits, reinforcing the national innovation pipeline and contributing to sustainable economic growth. During the Flagship funding period (2019-2025) PREIN has created 12 new start-ups. The achievement of generating these start-ups is a remarkable indicator of the innovation strength and economic relevance of PREIN as this level of start up creation demonstrates an exceptionally strong culture of commercialization, technology transfer and entrepreneurship, which is well above what is commonly observed in academic research environments.

Photonics Industry and Research Survey

Photonics Industry and Research Survey was carried out in 2025. The previous results were from 2023, and the new survey results were also published in the Photonics in Finland brochure which is an update of the 2023 brochure.

In 2025, PREIN, Photonics Finland and Business Finland conducted a comprehensive survey of the Finnish photonics industry and research organizations. The parallel surveys, was carried out by an independent, non-affiliated organisation to ensure neutrality and unbiased results. Tailored surveys were targeted at photonics companies and researchers in universities and research institutions.

The results confirm the growing visibility of PREIN among companies: over half of the respondents expressed a positive view of its activities, while about one-fifth were still unfamiliar with the Flagship. Companies highlighted joint events, collaborative research projects, and media promotion as the most valuable functions of PREIN and expressed a strong interest in deeper cooperation with research organizations.

The research survey mapped current focus areas and future needs, emphasizing materials science, metrology, sensing, and imaging as key themes. Photonics continues to play an essential role in education programs across Finnish higher education institutions.

Both industry and academia appreciate PREIN's role in strengthening collaboration, but the results underline the need for continued awareness-building and engagement. Joint activities with Photonics Finland, such as networking events and training, remain highly valued and are seen as effective measures to foster innovation and partnerships in the national photonics ecosystem.

Photonics National Roadmap

In June 2025, The National Photonics Roadmap 2025–2030 was launched. The roadmap provides a strategic vision designed to strengthen the country's position as a global leader in light-based technologies. The roadmap was developed through broad collaboration between academia, industry, and research organizations, and it sets clear priorities for advancing photonics research, innovation, and

commercialization, involving the industry researchers and PREIN representatives. PREIN Flagship also plays a pivotal role in implementing the strategy. The National Photonics Roadmap also emphasizes the importance of education, infrastructure, and international collaboration, which are areas where PREIN is actively engaged through training programs, pilot lines, and partnerships.

The PREIN Research Roadmap (2024-2026) aligns closely with the National Photonics Roadmap and compliments it from the research perspective. Together, Photonics Finland and PREIN and the National Photonics Roadmap and the PREIN Research Roadmap, respectively provide a strong foundation for innovation, supporting both scientific excellence and economic growth in Finland's photonics sector.

Business Finland Strategy

Business Finland's Strategy (2026–2030) published in 2025, reinforces the national commitment to long-term, targeted investment in high-impact growth areas. Photonics has been elevated to an independent strategic theme within the framework and recognized as both a rapidly expanding export sector and a critical enabling technology for security, clean transition, digital leadership, and quality of life. The Business Finland Strategy emphasizes raising national research and development ambition, channelling resources to areas with strong competitive advantages, and supporting ecosystems capable of global breakthroughs, and photonics is clearly highlighted as one. This strategic recognition strengthens the position of the PREIN Flagship and the Finnish photonics ecosystem.

PIXEUROPE – European Photonic Integrated Circuits Pilot Line

In 2025, Finland strengthened its role in the emerging European photonics manufacturing landscape through active participation in the European pilot line for advanced photonic integrated circuits, PIXEUROPE. Supported by the Chips JU initiative, PIXEUROPE brings together leading European actors to accelerate the development and industrial adoption of next generation photonic chip technologies. Supported by the EU Chips Act and coordinated by the Institute of Photonic Sciences (ICFO), PIXEUROPE is a 400-million-euro investment in Spain aimed at creating Europe's first open access ecosystem for PIC development, covering wavelengths from ultraviolet to the mid infrared and supporting applications in 6G, artificial intelligence, imaging, sensing, mobility and more.

As part of the Finnish national engagement, VTT contributed its expertise in silicon photonics and pilot line infrastructure, providing insight into European developments and growing capabilities in integrated photonics manufacturing in Finland. VTT brings in its expertise in low loss thick silicon on insulator (SOI) photonics to the consortium and by investing in new wafer processing equipment in the Micronova cleanroom to enhance waveguide patterning precision, surface quality, and heterogeneous material integration. The activities are led at VTT by Research Team Leader Timo Aalto, who also heads a key work package responsible for the development of all monolithic PIC technologies within the pilot line, forming the foundation on which complementary PIC materials and hybrid integration solutions will be built.

Through this contribution, VTT helps in aligning Finland with European efforts to scale photonic integrated circuit technologies, ensuring that Finnish research and industry can both influence and benefit from the continent-wide transition toward PIC based solutions.

PhotonMed – Pilot Line for Medical Devices

In 2025, VTT strengthened Finland's position at the forefront of photonics enabled medical technology through the launch of a new pilot line environment in Oulu, designed to accelerate the development and market readiness of next generation medical devices. With an investment of 3,4 million euros, the facility provides a state-of-the-art cleanroom and advanced manufacturing equipment capable of producing small and medium prototype batches that integrate photonic, electronic, microelectronic, and microfluidic components. Its core focus lies in advancing photonics-based health technologies, such as skin-like wearable sensors for continuous cardiovascular monitoring and ultra-sensitive biochemical sensors for early cancer diagnostics, enabling innovations that would traditionally be difficult to scale or certify in conventional research and development environments.

The Oulu pilot line also became a central operational platform for PhotonMed, a European initiative aimed at advancing and validating photonics technologies

PREIN participated in SuomiAreena, Finland's yearly largest societal discussion festival also in 2025. This year panelists discussed about autonomous traffic and photonics part of it. Panelists were (from the left) Mika Rytkönen, CCO Remoted; Aleksi Jäntti, MP; Teppo Vesalainen, Training Manager of Automobile Association; Pia Harju, Business Development Director, Distance; and Matti Kutila, Research Team Leader, VTT.

for medical applications. PhotonMed develops new photonics components, integration methods, and manufacturing processes up to TRL5, ensuring their industrial relevance through end user led pilot cases. These technologies are then incorporated into pilot line offerings under an open access model, shortening time to market for companies developing photonics enabled medical devices. In 2025, the Oulu pilot line coordinated a major PhotonMed linked pilot manufacturing effort involving 39 organisations, underscoring its role as a strategically important European hub for medical photonics.

New Photonics Start-ups

Spinning out start-ups from Flagship universities and research centres is essential for transforming high-quality research into new business opportunities and increasing economic and societal impact of the Flagship. The creation of new start-ups demonstrates how the Flagship successfully converts scientific excellence into industrial competitiveness and societal benefit.

One Tampere University related start-up Vailion was established in 2025. Vailion focuses on advanced photonics solutions for defence and security and aims to develop innovative systems that integrate photonics into next-generation defence technologies, such as sensing, imaging, and secure communication. The company is connected to Tampere University and leverages expertise from its photonics research community, with links to Professor Mika Valdén's work in optical technologies. Vailion aims at the intersection of academic research and high-tech industry, Vailion represents Finland's growing capability in applying photonics to strategic sectors, combining scientific excellence with practical solutions for demanding environments.

Agate Sensors is an Aalto University based start-up that builds directly on pioneering photonics research led by Professor Zhipei Sun. Its core innovation is an ultra miniaturised spectral sensor capable of delivering lab grade hyperspectral imaging on a single semiconductor pixel. The aim is to replace bulky optical components with nanoscale structures

Agate Sensors founders (from left): Chief Scientist Faisal Ahmed, CTO Andreas Liapis, CEO Tommi Leino, CBO Mikael Westerlund and Professor Zhipei Sun.

controlled electrically rather than through filters or prisms. Its broadband, filter free pixel architecture, combined with proprietary algorithms, allows devices to measure hundreds of wavelength bands with accuracy below 10 nanometres across visible and near infrared ranges. Agate is able to shrink traditional spectroscopy equipment from suitcase sized devices to a chip small enough for integration into smartphones, wearables, medical tools, and industrial systems, bringing light based intelligence into everyday technologies.

Agate Sensors has also secured significant financial backing to accelerate commercialisation. In 2025, the company raised a total of 5.6 million euros, consisting of equity funding led by Voima Ventures and LIFTT, alongside grants from Business Finland. This funding supports the scaling of chip level manufacturing, with first demonstration devices expected during 2026 and commercial wearable applications targeted for 2027. The company further strengthened its technological position by winning the Arm Flexible Access for Startups contest, receiving up to $250,000 in technology credit.

ColdXRay is a deep technology start up originating from the University of Eastern Finland. In 2023, the project received recognition in the Research Based Business Idea category of the Start Me Up competition, highlighting its strong scientific foundation and commercial potential. In 2024, the project received Research to Business (R2B) funding from Business Finland and was presented internationally in Germany, where founder Dr. Petr Obraztsov showcased the start-up company's technology and its global growth ambitions.

The company builds directly on photonics research transforming laboratory advances into commercially scalable solutions for next generation electron and X ray sources. Their graphene based cold cathode technology provides energy efficient, durable and instant start electron emission, offering an alternative to traditional heated cathodes in both space and medical X ray imaging applications.

SOCIETAL IMPACT

Communication Activities

In 2025, PREIN further strengthened the societal impact of photonics by systematically increasing the visibility and accessibility of photonics-related knowledge in education, industry, and public discourse. Communication activities were designed to support national competence development while positioning Finnish photonics expertise internationally.

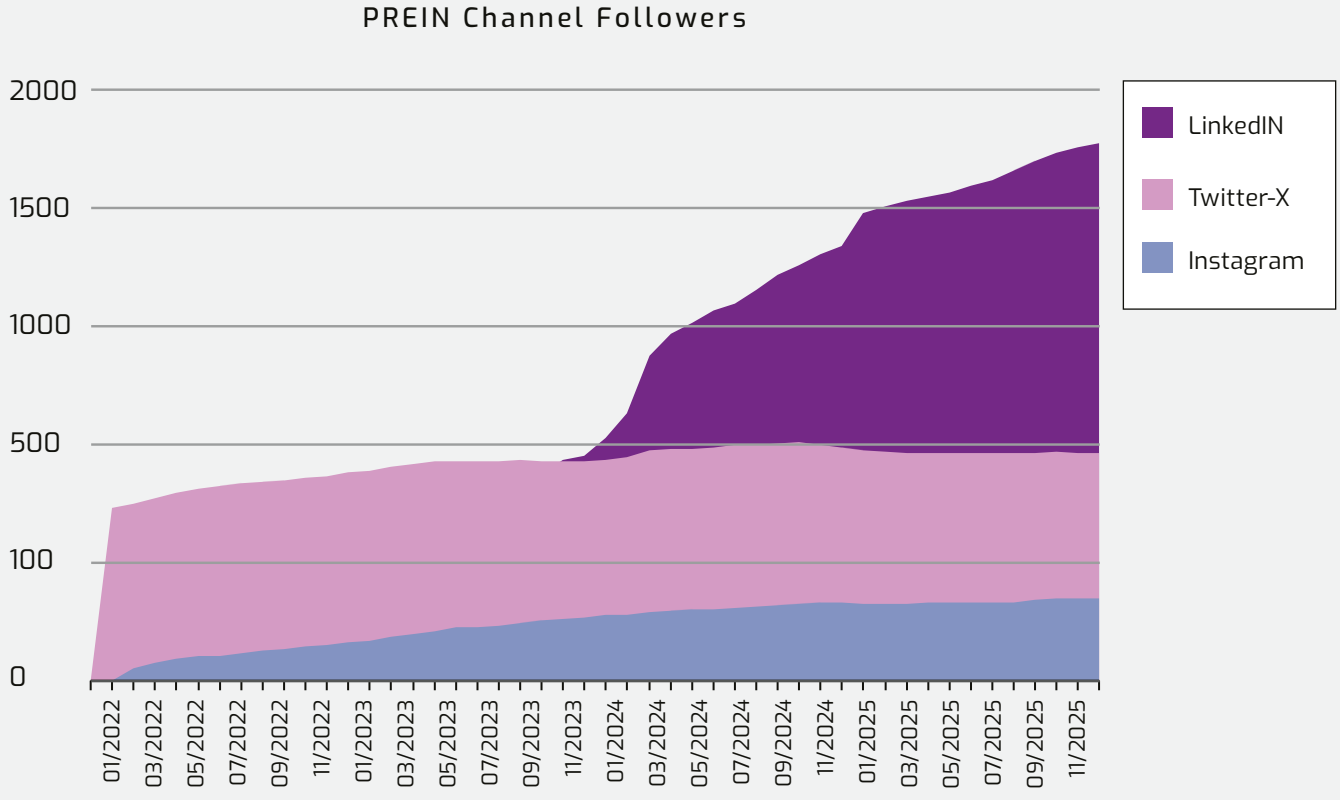
In response to increasingly fragmented media consumption, PREIN maintained a targeted and data-driven presence across selected digital channels. In addition to its website, PREIN focused on LinkedIn, Instagram, X (formerly Twitter), and YouTube, with LinkedIn serving as the primary channel for engagement with photonics professionals, researchers, and industry stakeholders.

Social Media Reach and Audience Development

During 2025, communication focused on concise and timely social media posts directing audiences to in-depth content on the PREIN website. Changes in audience composition continued to reflect broader trends in platform use. While follower numbers on X showed a slight decline, LinkedIn followers increased by nearly 20%, confirming its central role in professional and industry-oriented communication. Instagram continued to attract students and early-career researchers, with a 6% increase in followers.

The professional profile of PREIN's LinkedIn audience further diversified during the year. Among followers:

- 25.9% were researchers (15.3% in 2024),
- 12.6% had higher education backgrounds (30% in 2024),
- 9.4% represented engineering professions (5.3% in 2024),
- 5.9% worked in business development, and
- 4.4% in operational roles.
- and the remainder came from various other industrial fields.



The increased representation of engineering, business development, and operations professionals indicates strengthened engagement with photonics-related industry and applied innovation ecosystems.

Media Engagement and Strategic Partnerships

Media outreach remained a key instrument for increasing public understanding of photonics and its societal relevance. In 2025, PREIN introduced more structured media engagement practices to enhance national visibility of photonics research and innovation.

A central activity was a media event organized in September in collaboration with Technology Industries of Finland at Tampere University. The event brought together nearly 40 journalists from technology-focused media and representatives of the Photonics Finland Association. The event programme provided an accessible overview of the role of photonics in Finnish society and industry, complemented by an industrial case example from Cense Analytics, presented by Professor Juha Toivonen. The event led to new media coverage targeting a broad, non-specialist audience, eg. periodical Tekniikan maailma and Lämmöllä-magazines.

In cooperation with Photonics Finland, PREIN produced an updated brochure, Photonics in Finland, presenting national photonics education, research, and industrial capabilities. The brochure is used in international contexts to support Finland's attractiveness as a location for education, research collaboration, and investment in photonics.

Contribution to Public Dialogue

PREIN continued its participation in the Suomi Areena public discussion series in 2025, contributing expert perspectives to societal debate. The panel discussion addressed the role of photonics in autonomous traffic and transport safety, linking research outcomes to societal challenges. The discussion received national media coverage via MTV3 and MTV Katsomo, supporting wider public awareness of photonics-enabled solutions.

Communication Outputs

PREIN's social media communication covered both PREIN-led activities and broader developments within the Finnish photonics ecosystem. During 2025, nearly 100 social media posts were published. These activities generated measurable reach, including more than 47,000 impressions on LinkedIn (26,000 in 2024), demonstrating increased visibility of photonics research and innovation among professional audiences.

Full house of journalists at PREIN Media Day organized together with Technology Industries of Finland

Suomi Areena 2025 with a theme "Photonics in Autonomous Vehicles Securing the Traffic"

OUTREACH

In 2025, PREIN and its partner universities intensified efforts to make photonics visible, relevant, and engaging across Finland. Activities targeted the general public, schools, teachers, children, and families, combining hands on demonstrations with talks, workshops, and cross disciplinary programmes. Outreach was delivered in close collaboration with LUMA-centers at Aalto University, Tampere University, and the University of Eastern Finland, ensuring strong regional presence and continuity. Some activities focused exclusively on photonics, while others integrated light based science into broader science, culture, or community events to reach diverse audiences. Across 2025, our outreach activities reached thousands of people across Finland.

Events for the General Public

The aim of events aimed at the public is to bring photonics to broad and diverse audiences by embedding light based science into popular science events, festivals and cultural events as well as regional community programmes.

Tieteen päivät

In November 2025, PREIN contributed to Tieteen päivät (Science Days), Finland's largest recurring public science festival, by participating in the event organised at University of Eastern Finland, Joensuu campus. Professor Pasi Vahimaa from UEF delivered an accessible presentation on humanity's longstanding relationship with light and the transformative role of modern photonics, illustrating how light based technologies shape communication, health, sustainability, and everyday life. The event brought contemporary photonics research to a general audience within a multidisciplinary science festival framework.

Photonics 55 Years in Joensuu – Anniversary Seminar

To celebrate 55 years of photonics research in Joensuu, the University of Eastern Finland organised a public anniversary seminar in May 2025. The programme highlighted the evolution of the Joensuu photonics cluster, from early optics research to a vibrant ecosystem of research groups, companies, and education. Presentations from academia, industry, and local authorities explored future directions in photonics research, regional strengths, and the global competitiveness of the photonics community in Joensuu.

Photonics 55 Years in Joensuu celebration

Photonics Outreach at Ilosaarirock

To reach entirely new audiences, PREIN aligned photonics outreach with Ilosaarirock, one of Finland's largest and oldest music festivals, drawing tens of thousands of visitors to Joensuu. The three day

event in July provided a high visibility platform for informal and creative engagement with photonics concepts. Leveraging the atmosphere of the festival, the PREIN partner University Eastern photonics activities were featured in Tiedenurkka (Science Corner) at the festival offering light related discussions to spark curiosity among festival goers. Photonics Professor Pasi Vahimaa presented an accessible exploration of light, highlighting both its role in human history and its modern technological applications.

Outreach for Schools, Children and Families

Outreach aimed at schools, children and families plays an important role in how universities open their research and educational opportunities to the wider public. By engaging young people with hands on science and relatable demonstrations, universities help build early awareness of scientific fields and inspire future study paths at an age when interests begin to form. To promote interest among children and young people PREIN organised events or participated at events targeted to these groups. Particularly recurring workshops and activities form a core pillar of the school outreach strategy for PREIN.

Tiedon valoa

The Tiedon valoa science and arts event in Tampere in January offered public lectures, concerts, and an extensive interactive exhibition area. The Tampere University exhibition included photonics demos, robotics, and bioprinting, offering hands on experiences for visitors of all ages. The photonics demonstrations allowed children and adults to experience hands on some of the research-related photonics demos and to play an exciting escape game designed to encourage curiosity, where participants get to steer laser beams using mirrors and lenses, observe how everyday objects glow under ultraviolet light, play with colourful shadows, and to use colour filters and polarizers to solve the challenges. PREIN participation in the Tampere University exhibition in the event has become an established annual practice.

Valoa perheille – Light for Families

The Valoa perheille – Light for Families has become an established and re-occurring part of the PREIN outreach activities in Joensuu organised by the University of Eastern Finland and the local LUMA Centre. The event's continued growth underscores strong community interest in photonics and it was organised twice during 2025.

In May 2025, the spring Light for Families event at Botania, Joensuu welcomed families to explore Planet Botania through light themed problem solving activities, crafts, and demonstrations. Designed especially for children, the event also offered a Mother's Day craft using simple photonics materials which is an approachable introduction to a photonics application.

Returning for its fifth edition, the autumn Light for Families event in November at Botania focused on insects viewed through light, demonstrating how photonics can reveal hidden features of nature. Activities included child friendly optical investigations, guided workshops, and a photonics enabled Father's Day craft.

International Day of Light Events

To celebrate UNESCO's International Day of Light in May, PREIN coordinated school targeted activities across Finland. In Espoo, Aalto University Junior delivered an online remote workshop in which school classes built simple spectroscopes to learn how light can be split into its component wavelengths. The outreach organisation Juniversity at Tampere University hosted secondary school workshops titled "Communicating with Light", introducing refraction, total internal reflection, and optical fibre communication through hands on challenges. In Joensuu, UEF LUMA Centre linked the Light for Families May event to the International Day of Light.

SciFest

Hosted annually at the University of Eastern Finland, SciFest is a free science festival offering hands on workshops for school groups and families. The 2025 edition again highlighted STEM curiosity through discovery based learning. PREIN contributed with activities on colour, light, and photonics, giving children practical experiences with lenses, filters, lasers, and spectra.

Open Otaniemi

Aalto University opened its campus for a large community day in October 2025, offering workshops, demos, tours, and artistic experiences. Photonics featured prominently through two interactive activities: the "Physics of Light" demonstration showcasing laser interference, diffraction, and polarization and a workshop to build your own LED bracelet using conductive yarn, enabling participants to create wearable light emitting designs while learning basic principles of LEDs and circuitry. These activities

highlighted Aalto's ability to blend design, technology, and photonics education in engaging, hands on formats.

TEK Family Days

At Tampere University's Hervanta campus, TEK (a professional community of academic engineers and architects in Finland) organised four Science Day for Families sessions featuring accessible, hands on science stations. The photonics station allowed children to steer laser beams with mirrors and lenses, observe fluorescence under UV light, explore shadow formation, and solve light themed puzzles. These activities provided approachable entry points into optics and photonics for younger learners. The event spanned two weekends and attracted over 1000 registered participants.

PRIZES AND ACKNOWLEDGEMENTS

Several PREIN researchers received notable recognition during 2025 in international and national contexts. In addition, to the more esteemed nominations, numerous researchers received poster and presentation awards in international conferences.

Optica Fellow Nominations

The Optica Fellow designation is one of the highest honors given by Optica to its members. It recognizes individuals who have made significant and sustained contributions to the field of optics and photonics. The Board of Directors of Optica elected 121 members from 27 countries to the Society's 2025 Fellow Class. Optica Fellows are selected based on several factors, including outstanding contributions to research, business, education, engineering, and service to Optica and our community. Fellows are Optica members who have served with distinction in the advancement of optics and photonics. The Fellow Members Committee reviewed 217 nominations submitted by current Fellows. The Committee thanks all the nominators and references for supporting this important program. As Fellows can account for no more than 10 percent of the total membership, the election process is highly competitive. Candidates are recommended by the Fellow Members Committee and approved by the Awards Council and Board of Directors. The new Fellows will be honoured at Optica conferences and events throughout 2025. The 2025 Optica Fellows include **Laeticia Petit** from Tampere University, who was nominated for her achievements in optical material science and education, and leading optical fibre development in academia and industry for biophotonic applications

Photonics100 list

PREIN Director **Goëry Genty** at Tampere University has been named to the Photonics100 list of 2026 by Electro Optics magazine. The list celebrates the achievements of 100 leading professionals driving innovation in photonics and optical technology worldwide. The Photonics100, curated by a panel of industry experts, highlights scientists, engineers, and business leaders whose work is reshaping sectors from aerospace and telecommunications to quantum technologies and healthcare. Professor Genty is recognized for his leadership in ultrafast photonics and ML enhanced light sources.

Photonics21 Members

In 2025, Photonics21 welcomed 23 newly elected members of the Photonics21 Board of Stakeholders. A total of 145 Photonics21 members participated in the two-week online election for the Photonics21 Board of Stakeholders. Of the selected 23 representatives to Photonics21 Board of Stakeholders Ari Alastalo from VTT Technical Research Centre of Finland was one. **Ari Alastalo** works as a Research Manager at VTT and holds a title of Docent in Applied Materials Physics from Aalto University. He has authored 81 journal and conference articles and holds 12 patents. In his current position as a Research Manager, he is responsible for the strategy, roadmaps and public project portfolio of VTT in the area of microelectronics and integrated photonics. Alastalo is also involved in VTT's Chips-JU pilot line activities.

Ambassadors for the ERC Nomination

The European Research Council (ERC) and the Association of ERC Grantees (AERG) have introduced a new initiative for promoting the visibility of high-quality, frontier research. The Ambassadors for the ERC spread the message about the importance of funding fundamental science and the significance of research for society. There are 32 new Ambassadors for the ERC from the EU member states and five Horizon Europe associated countries. All Ambassadors are ERC Grantees, selected from more than 200 applicants. The Ambassador serves a term of one year at a time and may continue serving for a maximum of six years. Professor **Arri Priimägi** was selected as the Ambassador for the ERC in Finland. Professor Priimägi works at Tampere University, where his group studies soft functional materials. He is part of the Research Council of Finland's Centre of Excellence in Life-Inspired Hybrid Materials (LIBER) and the Finnish Flagship for Photonics Research and Innovation (PREIN).

Science Academy of Finland Nominations

The Finnish Academy of Science and Letters, founded in 1908, is a general scientific society whose mission is to promote scientific research and serve as a link between researchers representing high-level science. The Academy also aims to promote evidence-based decision-making. The Finnish Academy

of Science and Letters is a broad-based learned society the members of which are invited based on scientific merits. Membership of the Finnish Academy of Science and Letters, in common with membership of any other academy of science, is looked on as a considerable achievement in a person's academic career. The Finnish Academy of Science and Letters can have at most 333 members under the age of 65 at any one time. The Academy has invited five top researchers from Tampere as new full members. A total of 33 researchers were invited as full members on April 25. The Academy selects distinguished scientists for membership. Being invited is considered a prestigious achievement in a researcher's career. Membership is for life.

Professor **Mircea Guina** was invited as a full member of the Finnish Academy of Science and Letters in 2025 which is an honour extended by one of Finland's most prestigious scientific bodies. Professor Guina was honoured for his outstanding contributions to photonics, elected as a full member. Mircea Guina is Professor of Photonics and Director of the Optoelectronics Research Centre at Tampere University. He is one of Europe's leading researchers in optoelectronics. Guina's work has advanced the development of semiconductors, photonics, and quantum technology in Finland.

Professor **Harri Lipsanen** from Aalto University's Department of Electronics and Nanoengineering has been appointed as a lifelong member of the Finnish Academy of Science and Letters. This prestigious recognition is granted to individuals with exceptional academic achievements and contributions to advancing science and research. Professor Lipsanen is internationally known for his work in electronics and nanotechnology, driving innovation and fostering collaboration in cutting-edge research. His appointment underscores Aalto University's commitment to excellence and its role in shaping the future of technology and science.

Pirkanmaa Cultural Foundation Award

The 2025 award of the Pirkanmaa Fund of the Finnish Cultural Foundation has been granted to Professor of Chemistry **Arri Priimägi** for his work on the interaction of light and material, and for boundary-crossing research leaps. The award is valued at 15 000€. Professor Arri Priimägi from the Chemistry and Advanced Materials at Tampere University received the 2025 Pirkanmaa Fund Award for his groundbreaking research at the intersection of light and material sciences. Professor Priimägi is a bold and boundary-defying researcher whose field lies at the intersection of chemistry, materials science, and photonics.

Professor Arri Priimägi, Tampere University

Priimägi has established and leads the international, multidisciplinary, and high-level research group Smart Photonic Materials. The group focuses on soft, light-responsive materials that change their properties when exposed to light. Together with his team, Priimägi conducts fundamental research on materials and methods that may potentially be applied in a wide range of fields and environments, such as soft robotics, advanced optical systems, and biomedical applications. Concrete applications could include autonomous soft robots, display technologies for augmented and virtual reality, human physiology modelling, complex disease research without animal testing, and smart drug delivery systems.

Honorary Member of Photonics Finland

Professor, PREIN Vice Director, **Jyrki Saarinen** was appointed as an Honorary Member of Photonics

Finland in June 2025. This recognition was announced at the Photonics Finland Spring Meeting. The nomination honours Professor Saarinen's exceptional contributions to Finland's photonics sector and to the growth of Photonics Finland. Professor Jyrki Saarinen is the director of Finland's largest photonics research center and a key developer and visionary of the Finnish photonics ecosystem across research, industry, and internationalization. He served as the first secretary of the Finnish Optical Society and the first chair of Photonics Finland. Under his leadership, an academic network evolved into a strong cluster uniting research and industry. As founder and former CEO of Heptagon, Professor Saarinen helped bring Finnish photonics expertise to international markets. His research has advanced optical miniaturization, artificial intelligence applications in photonics, and 3D-printed optical components.

Professor Emeritus **Ari T. Friberg** from the University of Eastern Finland was appointed as an Honorary Member if Photonics Finland. Professor Friberg is an internationally respected researcher and educator in theoretical optics, with a career in photonics research spanning more than five decades. His work has focused on the coherence and polarization properties of light, and he has trained several generations of optics researchers in Finland and Sweden. Friberg is a founding member and the first chair of the Finnish Optical Society and played a major role in the Society's internationalization. He has served in several leading international scientific organizations, is a Fellow of Optica and SPIE, and chaired the founding meeting of Photonics21.

Finnish Photonics Company of The Year and Best Doctoral Dissertation

The national annual prizes for best photonics doctoral dissertation and the photonics company of the year were awarded at the Optics and Photonics Days in May 2025.

Exceptional doctoral-level research in photonics by awarding its annual prize for the best dissertation. The award for Best Doctoral Thesis in Photonics 2024 was presented to **MD Gius Uddin** from Aalto University for his groundbreaking research titled: "Fabrication and characterization of two-dimensional material-based devices for photonics and electronics." His work advances the integration of 2D materials into photonic and electronic devices, paving the way for next-generation technologies in optical communication and sensing.

CEO Tapio Kallonen, Specim – Photonics Company of the Year

Simultaneously, Photonics Finland presented its **Photonics Company of the Year 2024 award to Specim, Spectral Imaging Ltd**, highlighting the company's sustained innovation and leadership in hyperspectral imaging technologies. These distinctions emphasize Finland's strength in advancing both academic excellence and industrial innovation in photonics. Specim, a global leader in hyperspectral imaging solutions, has demonstrated exceptional innovation, growth, and impact across diverse sectors, including environmental monitoring, food quality control, and industrial applications. The award highlights Specim's commitment to advancing photonics technology and strengthening Finland's position as a hub for cutting-edge optical solutions.

EXTERNAL FUNDING

External research funding from competitive sources such as the Research Council of Finland and Business Finland is a strong indicator of scientific impact. These grants are awarded through rigorous peer review, demonstrating that the research meets high international standards and is expected to generate significant knowledge and innovation. Competitive grants prioritize projects with potential for broad influence, such as advancing technology, addressing global challenges, or fostering industry collaboration.

Research Council of Finland Funding

In addition to the Flagship funding, the Research Council of Finland granted funding for PREIN partners in 2025 consisting of Academy Research Fellowships, Proof of Concept Funding and funding from a specific thematic call. In total five PREIN related projects were funded by the Research Council of Finland in 2025.

Research Fellow Funding

The Research Council's Research Fellow funding provides four year support for early career researchers to help them advance toward more senior research positions. The following two PREIN researchers received the funding in 2025.

Jin Zhang Aalto University: Non-Hermitian Moiré Photonics

Moiré patterns, often observed as rippling effects when photographing a screen with a phone, are familiar to many people. In physics, however, these patterns are not merely visual artifacts but powerful tools for material control and tuning. By stacking graphene layers with a specific twist angle, Moiré superlattices can be created, enabling novel energy band modulations. This project extends the concept of Moiré superlattices to non-Hermitian photonic devices, offering unprecedented control over multi-degree coupling of light transmission. This advancement enables dynamic light manipulation capabilities far beyond conventional devices. Immediate applications include hyperband holography and ultrasensitive sensing. By bridging cutting-edge physics concepts with state-of-the-art nanomaterials, this project aims to pave the way for next generation integrated photonic chips, optical imaging systems, and advanced biosensing technologies. Funding is granted for 2025-2029.

Antti Moilanen, University of Eastern Finland: Spin-Polarized Nanolasers Based on 2D Materials

One of the biggest challenges in photonics is developing small, energy-efficient coherent light sources that can be integrated directly onto a chip. Traditional lasers are often inefficient in power usage and too bulky for compact devices. This project aims to develop nanoscale lasers using atomically thin 2D materials. It will explore ways to control the polarization of light in these lasers, as polarization modulation can be achieved faster and with less power than conventional intensity modulation. The research will advance our understanding of 2D materials and their integration into photonics. On-chip integrated nanolasers have the potential to significantly improve speed and efficiency in telecommunications, artificial intelligence, and cloud computing. The work will be carried out at the University of Eastern Finland, Joensuu, in collaboration with Aalto University, University of Turku, ETH Zürich and PSI (Switzerland), University of St. Andrews (UK), and LMU Münich (Germany). Funding is granted for 2025-2029.

Proof of Concept Funding

The Finnish Research Council Proof of Concept funding supports researchers in testing and advancing research results toward practical application, commercialisation, and broader societal impact, building on work previously funded by the Council. It enables piloting technologies and developing new approaches for industry and advancing commercialisation possibilities. Two PREIN related projects were funded in this scheme in 2025.

Mika Prunnila, VTT: Infrared Vision Technology

The project develops advanced uncooled infrared (IR) detector imaging microsystems, designed to benefit multiple markets from traffic and environment monitoring to drones, spectroscopies, and medical and defence applications. Leveraging our cutting-edge nano-thermoelectric bolometer technology, the project focuses on creating a high-performance, cost-effective imager that operates efficiently without the need for cooling as in the corresponding state-of-the-art technologies. The competitive advantages of the technology are the cost-effective

Professor Hele Savin, Aalto University

IR detectors which, due to the utilization of thermoelectric and optical nano-membranes within an integrated design, operate at far greater speeds and higher sensitivity than the state-of-the-art uncooled detectors. The project demonstrates the use of the imager for industrially relevant applications and contributes to the broader goal of enhancing traffic safety, environment awareness, health, and defence through technological innovation. Funding is granted for 2026-2027.

Hele Savin, Aalto University: Nanostructured silicon CCDs for astronomical imaging

Astronomy seeks to uncover the physical nature of distant objects by detecting the faint light they emit, often millions of times dimmer than what the human eye can see. Astronomers rely on large telescopes that collect as much light as possible, coupled with highly sensitive electronic detectors that record incoming photons. Our multidisciplinary project connects nano-engineers and astronomers from Aalto and Turku Universities, and collaborating companies, to enhance the efficiency of these detectors. By re-engineering the surface of the detector at nanoscale, taking advantage of the nanostructure of black silicon, we significantly increase the ability to convert light into measurable signal. The resulting new generation of revolutionary highly sensitive detectors will be tested in a real-world setting on the Nordic Optical Telescope. Beyond new astronomical discoveries, this innovation may also lead to technological advances in other scientific fields and industrial applications. Funding is granted for 2026-2027.

Other Thematic Research Council of Finland Funding

The thematic call for Research into Forest Biomass in Finland supports projects that advance sustainable, high value uses of forest based materials, particularly in line with national goals to strengthen bioeconomy and reduce reliance on fossil resources. It is part of the Climate Synergy Academy Programme, which funds thematic research that promotes climate friendly technologies and contributes to Finland's long term sustainability and industrial competitiveness. One PREIN related project received funding in this call in 2025.

Riikka Suhonen, VTT: High-Performance Bioinspired Conductive Cellulose Films for Thin Film Solar Cells

The main goal of BIOSOL is to develop novel high performance conductive cellulose films for optoelectronics and thus open new lines of products for forestry industry. Cellulose allows detaching from fossil resources and utilizing renewable material streams that does not interfere global food production. Cellulose films can deliver very high transparency and can withstand high temperatures as well as enable functionalization. The research group ambitiously demonstrate printing of perovskite solar cells on these novel flexible substrates as well as pilot production of the novel conductive cellulose substrates. BIOSOL bridges highly ambitious scientific goals and creation of significant societal impact and the work requires a multidisciplinary team with different types of institutes with complementary skillsets. The funding is granted for 2026-2029 from the Call for research into forest biomass in Finland.

Business Finland Funding

Business Finland provides targeted funding to strengthen the link between research and commercialization in Finnish universities through different funding programmes.

Rise to Challenge Project Funding

A new funding scheme the Rise to Challenge was launched by Business Finland in 2025 with two calls during the year. The theme of the 2025 calls was digital solutions that promote security. The new programme seeks the most ambitious and innovative research ideas from research organizations.

In the first 2025 call a total of 60 research ideas were submitted, out of which 16 project teams were invited to submit funding applications, and of which

five projects were selected for funding and 10 million euro in funding was granted in total. In 2025, one project which unifies the expertise of three PREIN partners received funding in the Rise to Challenge call.

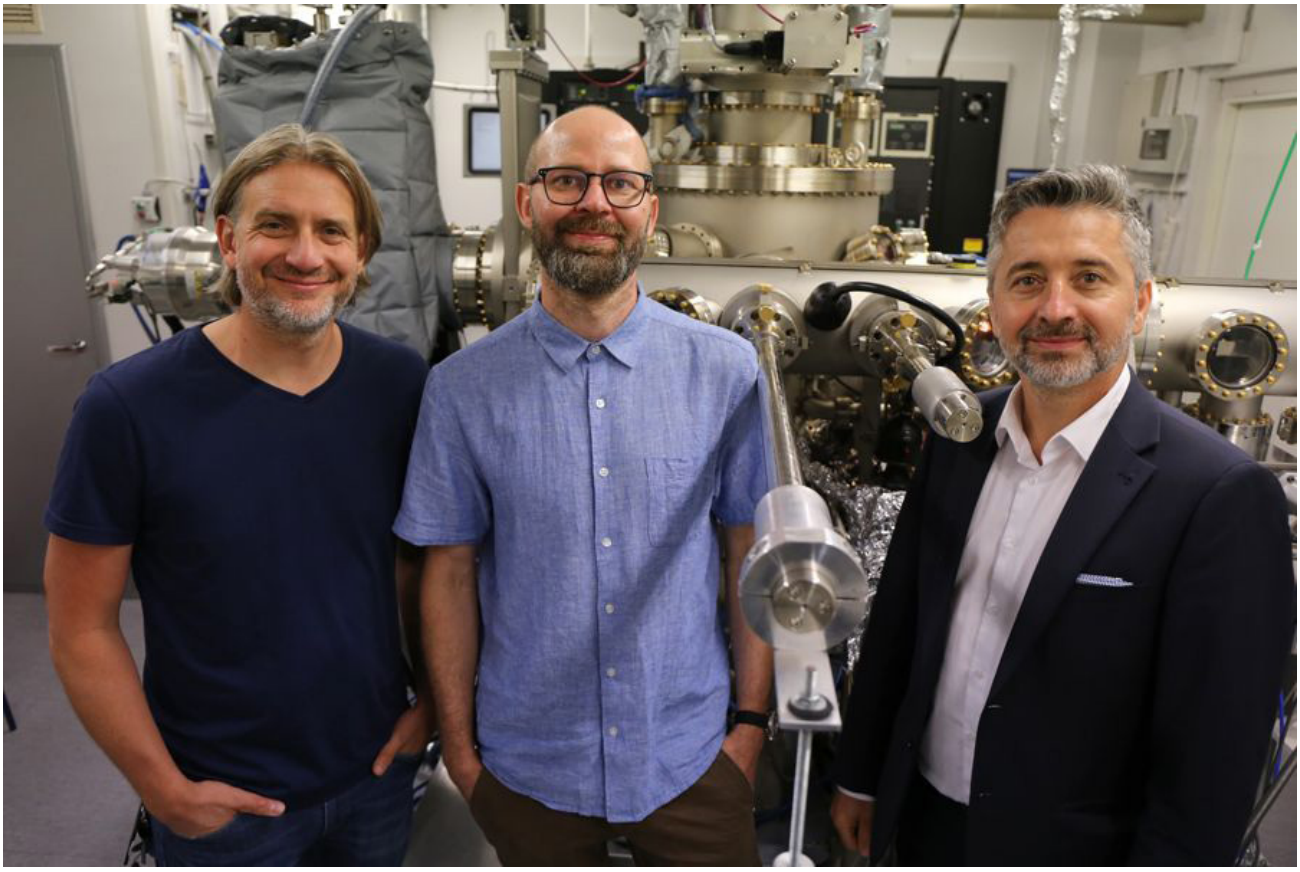
Tampere University, VTT, Aalto University: Telecom Wavelength Quantum Communication with On Demand Quantum Light Sources (TeleQuant)

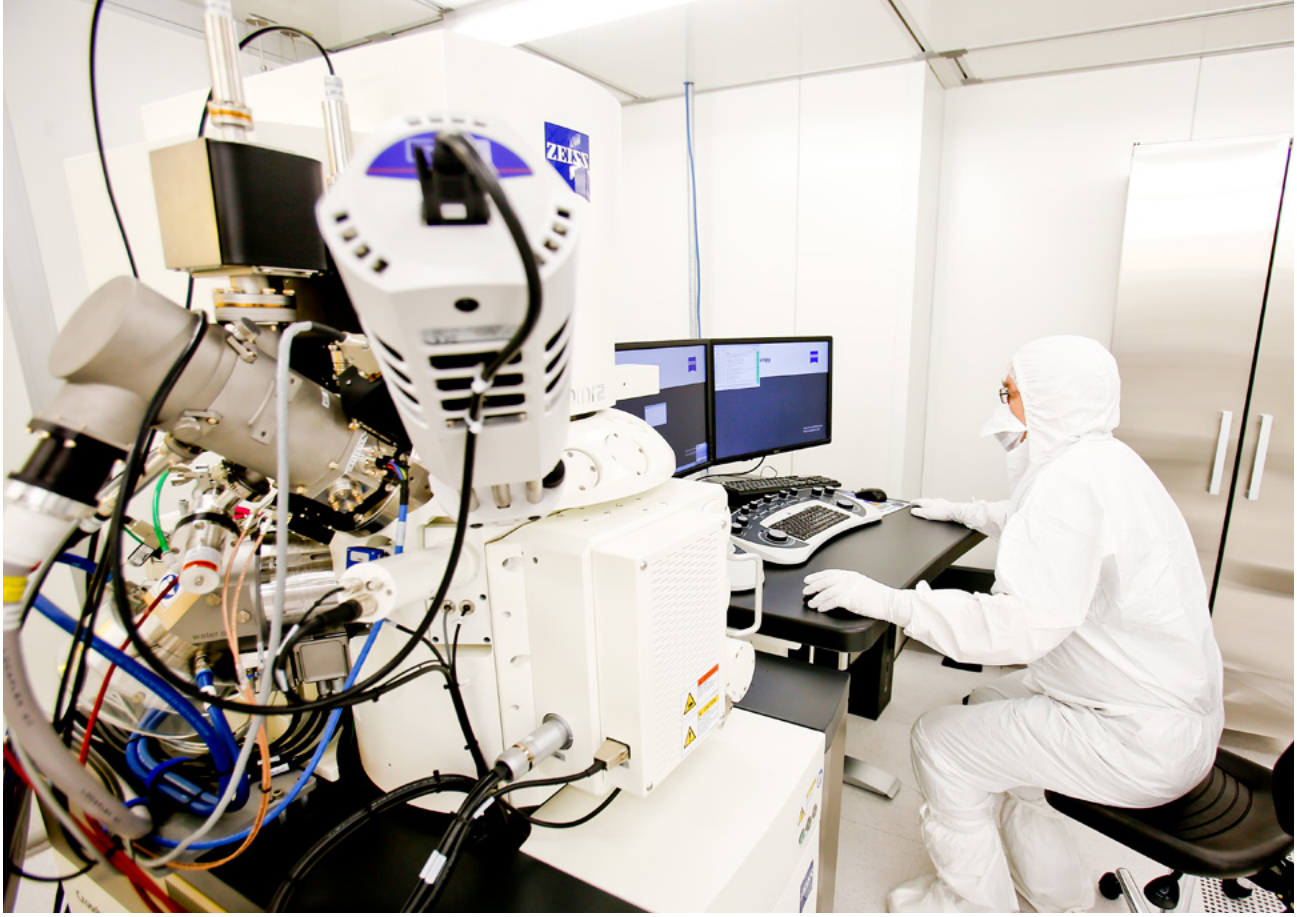
The TeleQuant project builds on semiconductor quantum light sources developed at Tampere University and superconducting single photon detection technologies from VTT and Aalto University. Its objective is to develop key components and systems for next generation quantum communication by applying photonics. TeleQuant, led by Tampere University, received €780,000 in funding through the Business Finland Rise to the Challenge call, which supports high impact research initiatives. The project brings together PREIN partner expertise in photonics, semiconductor technologies, and superconducting detection to advance fiber compatible quantum communication, with the long term aim of strengthening Finland's data resilience and technological independence as quantum technologies evolve.

At Tampere University, research is carried out by the Optoelectronics Research Centre (ORC) under Professor Mircea Guina and the Experimental Quantum Optics (EQO) group headed by Professor Robert Fickler. Professor Guina serves as the consortium coordinator, and Senior Research Fellow Teemu Hakkarainen coordinated the pre award phase.

VTT contributes core know how in photonics and superconducting quantum technologies, led by Research Scientist George Thomas, who serves as Project Manager for TeleQuant at VTT, and supported by Research Manager Anu Kärkkäinen, who oversees VTT's broader quantum technology activities. Additionally, Kalle Hanhijärvi participates as a VTT expert in developing key quantum communication components. Aalto University is represented by Professor Mikko Möttönen, a leading figure in superconducting quantum circuits, who contributes Aalto's expertise in advanced quantum detection technologies. TeleQuant unites PREIN partner experts to develop quantum secure communication infrastructure that meets emerging cybersecurity and telecommunications needs.

Professor Robert Fickler, Associate Professor Jukka Vihriälä, and Professor Mircea Guina, Tampere University





Co-Innovation Project Funding

The Business Finland Co-Innovation In Co-Innovation joint projects, research projects by research organizations and R&D projects by companies are carried out simultaneously in close cooperation.The joint projects promote high-quality research and accelerate the renewal and international growth of Finnish companies, as well as the building of competitive ecosystems.

VTT and Tampere University: Efficient Photonics for Sustainable Imaging and Sensing (EPheS)

In 2025, Business Finland granted 4,2 million euros to fund the EPheS project, a major national investment advancing sustainable photonics technologies for next generation imaging and gas sensing solutions. Led by VTT with Tampere University partner, the three year initiative is a PREIN partner project focusing in metaoptics, MEMS technologies, and integrated photonic systems to create compact, high performance sensing platforms.

The EPheS project is coordinated by Aapo Varpula, Research Team Leader at VTT, whose team develops the MEMS based tunable infrared filters and leads component fabrication in VTT's 200 mm cleanroom. At Tampere University, Professor Humeyra Caglayan's research group design the project's metaoptic components, that enable compact, high precision infrared imaging and gas sensing functionality. Researchers at Tampere University have designed metalenses and metasurfaces, that manipulate light with nanoscale precision to deliver advanced sensing functionalities in miniaturized form factors.

Technically, EPheS integrates flat, nanostructured metalenses with electrically tunable Fabry–Pérot MEMS filters operating in the long wave infrared (LWIR) regime, allowing highly selective and sensitive detection of gases and materials. The project also emphasizes sustainability by relying on abundant, non toxic silicon instead of the rare or hazardous materials traditionally used in infrared optics. Combined with photoacoustic spectroscopy, where gases are identified via acoustic signals generated by infrared absorption. These technologies enable compact, robust, and environmentally responsible sensing systems suitable for high volume production.The innovations may have applications ranging from hazardous gas monitoring and green energy processes to food and pharmaceutical safety and medical diagnostics.

Through the coordinated effort of VTT and Tampere University, EPheS strengthens Finland's strategic leadership in metaoptics and integrated photonics and contributes to building national competence within the growing Chip Zero ecosystem.

FUNDING SUMMARY

In 2025, the total funding of PREIN increased to 64.8 million euros, continuing the upward trend. The overall growth reflects both sustained institutional commitment and a diversified expansion of external funding sources. All funding is reported based on the funds utilized.

Institutional funding from universities and research institutes grew notably, reaching 28.9 million euros and accounting for nearly 45 % of total funding. This demonstrates PREIN's strong integration in the partner universities' strategic investments.

EU funding rose significantly, further accelerating the strong upward trajectory noted already in 2024. This continued growth is closely linked to PREIN partners' increasing participation in major European initiatives such as ERC projects, and Horizon Europe actions.

Business Finland support increased to 5.39 million euros illustrating heightened national interest in photonics innovation and strengthened collaboration with innovation funding agencies. Direct business contributions remained substantial, reflecting continued engagement from industry stakeholders.

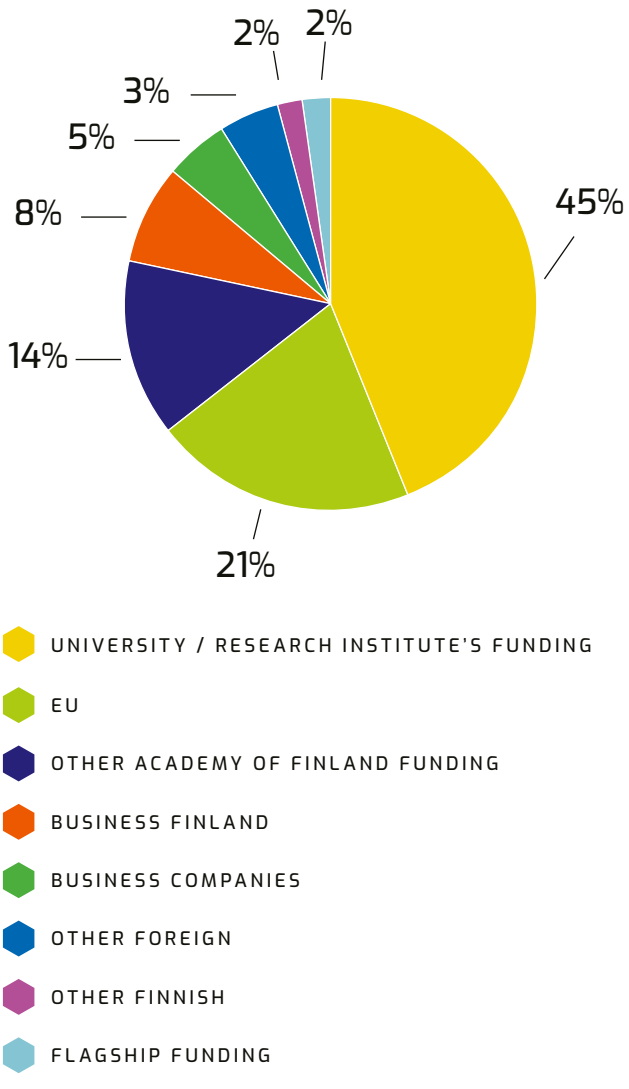
Research Council of Finland funding rose to 8.76 million euros, reinforcing the position of the Research Council as a major national contributor showing stable support. Although a smaller portion, the Flagship funding remains an important cornerstone of basic operations.

Compared to the previous years, the 2025 figures highlight both incremental strengthening across nearly all funding categories and notable expansion in EU and Business Finland support.

By 2025, the overall funding volume of the PREIN Flagship has increased significantly, and the distribution has shifted in ways that reflect growing maturity. Comparison with the start of the Flagship funding period (2019) and 2025, shows that PREIN's funding profile has broadened and stabilised with a more balanced mix of national institutional investment and international funding streams.

Funding source	M€
University/research institute's own funding	28.94
EU	13.35
Other Academy of Finland funding	8.76
Business Finland	5.39
Business companies	3.54
Business companies	2.4
Other foreign	1.94
Other Finnish	1.34
Flagship funding	1.24
Total	**64.81**

2025 funding sources



Photonics Research
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FLAGSHIP PROGRAMME

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