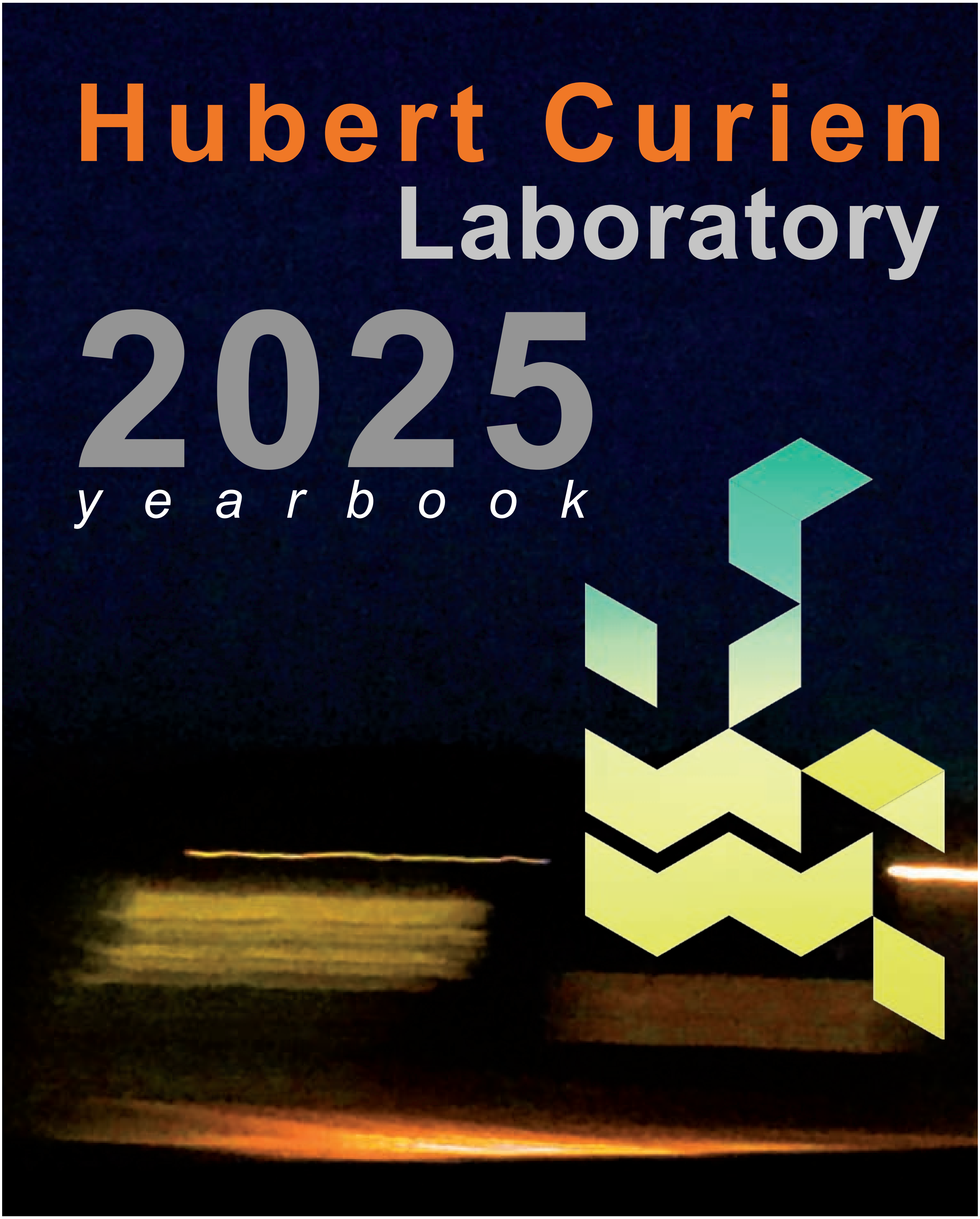
Hubert Curien Laboratory

2025 yearbook



Université Jean Monnet Saint-Étienne

INSTITUT D'OPTIQUE

50 years 1976-2026

Laboratoire Hubert Curien

UMR • CNRS • 5516 • Saint-Étienne


E D I T O

We are delighted to present the 2025 edition of the Hubert Curien Laboratory Yearbook, which offers a comprehensive overview of a year marked by sustained scientific engagement, innovation, and collaboration.

This edition is particularly significant for two reasons. First, it coincides with a transition in the laboratory's leadership: on 1st January 2026, François Royer took office as Director, succeeding Florence Garrelie after 10 years of dedicated service. Second, 2026 marks the 50th anniversary of the laboratory, a major milestone in its history. The Yearbook opens with a section presenting the program of celebrations planned for the year, an historical timeline tracing the lab's development since its creation in 1976, and a detailed presentation of its current research activities.

It further highlights a selection of major projects and scientific achievements from 2025. These examples illustrate not only the remarkable diversity of our research but also one of the lab's defining strengths: the rich interactions and productive synergies between its various research domains and areas of expertise.

As in previous editions, we have highlighted a few selected research findings and key academic partnerships, thereby underscoring the central role that education, research, and innovation play in shaping our current scientific mission. The year was also notably marked by the arrival of Yuko Hara, newly appointed CNRS Research Director, who joined us from Japan. We are particularly thrilled by this appointment that strengthens the international dimension of our research environment.

2025 also coincided with the laboratory's HCERES evaluation. This process represented a substantial collective endeavour requiring significant commitment from all members of the lab. We thank the entire staff for their involvement, and the HCERES evaluation committee for its rigorous and thorough assessment.

Finally, we thank the University Jean Monnet, CNRS and IOGS for their continued support, as well as all our institutional and industrial partners for their invaluable trust and collaboration. Above all, we extend our deepest gratitude to all members of the Hubert Curien Laboratory. This Yearbook stands as a tribute to the quality, dedication, and impact of their work.

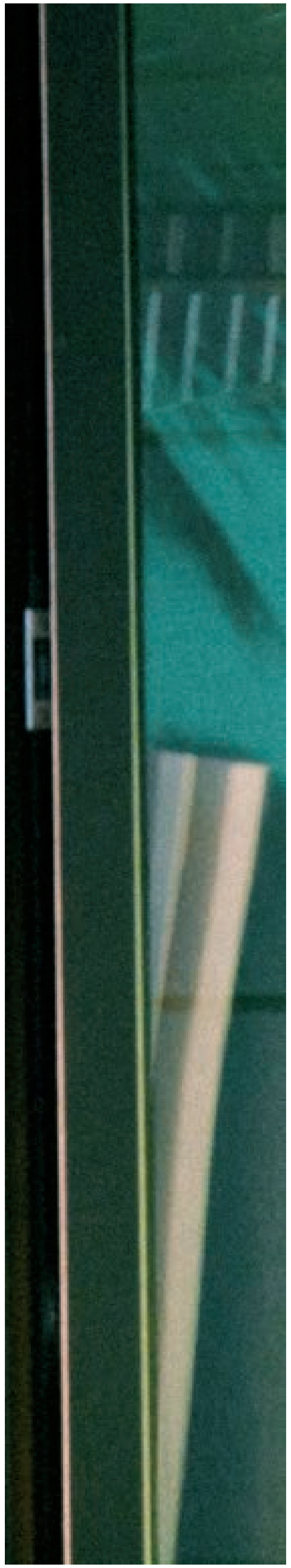
"I would like to express my sincere gratitude to all members of the laboratory and our partners for their commitment and collaboration over the past 10 years. It has been a great honour and pleasure to lead the lab alongside my team during this period. I wish our new Director every success in his new role, and I am confident that the Hubert Curien Laboratory will continue to thrive and contribute new scientific insights into the major societal challenges of the years ahead."

Florence Garrelie
LabHC Director (2016 to 2025)

"I am honored to take over the leadership of such a dynamic laboratory, whose members are deeply committed to the collective interest and driven by a clear scientific vision that addresses some of today's most pressing societal challenges.I warmly congratulate Florence Garrelie and her team on the remarkable achievements and outstanding quality of their work over the past decade. I am also sincerely grateful to her for ensuring such a smooth and thoughtful transition."

François Royer
LabHC Director (Since Jan. 2026)

CONTENT



1976 - 2026
anniversary

50 years 1976-2026
Laboratoire
Hubert Curien
UMR ▪ CNRS ▪ 5516 ▪ Saint-Étienne

The laboratory is celebrating its 50th anniversary in 2026 !
Three levels of events are planned throughout the year:
an institutional anniversary day to launch the festivities in July 2026,
a series of seminar days spread over the second part of the year,
and a public outreach day in October 2026.

celebrate with us !

Université Jean Monnet Saint-Étienne

cnrs

Institut d'Optique Graduate School ParisTech

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50 years 1976-2026

Laboratoire Hubert Curien
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our PROGRAM of CELEBRATIONS

Launch Day Celebrations

A full day of events featuring speeches, testimonials, presentations, and a keynote lecture by:

Professor Hugo Thienpont
(Vrije Universiteit Brussel - VUB):
«Key-Enabling Technology to Accelerate Innovation for Industrial Growth in Europe»

Programme Highlights
10:00 - Welcome
10:30 - Speeches and testimonials
12:30 - Buffet lunch
13:30 - Presentation of research themes
14:00 to 15:30 - Lecture by Prof. Hugo Thienpont

By invitation only

An event sponsored by :

Université Jean Monnet Saint-Étienne · SAINT-ÉTIENNE la métropole · cnrs · Institut d'Optique Graduate School

Cité du Design
Espaces réceptifs de la Platine
3, rue Javelin Pagnon
42000 Saint-Étienne
THURSDAY 9th JULY 2026 - 10am

Science Festival

An afternoon of demonstrations and activities for younger audiences, including a special session for UJM staff families, followed by presentations for the general public

Registration required
The lectures will be available on line

Bâtiment des Forges
Université Jean Monnet
11 Rue Dr Rémy Annino
42000 Saint-Étienne
THURSDAY 1st OCTOBER 2026 - 2pm

Seminar Series

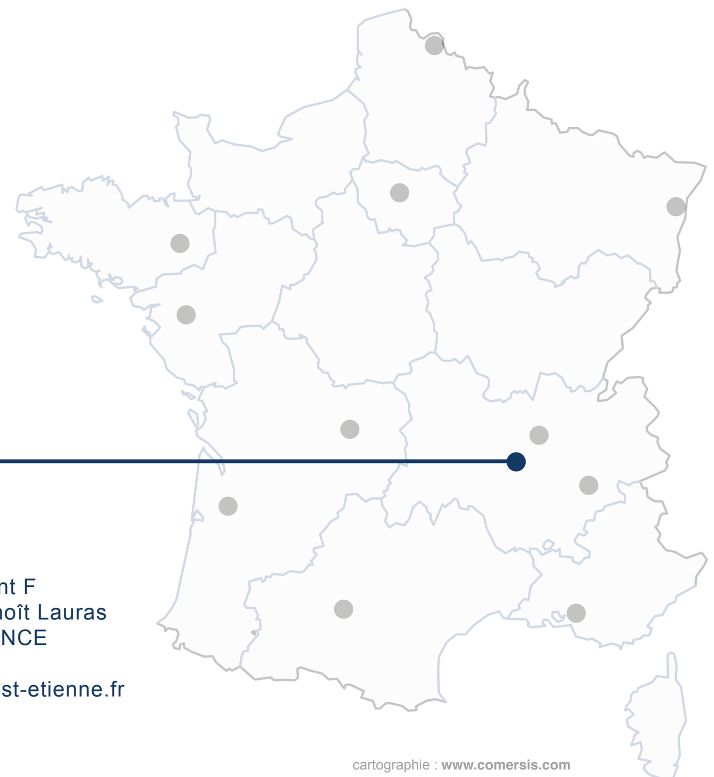
7 thematic seminars for the scientific community, featuring presentations by our teams and an invited lecture

Registration required
The lectures will be available on line

Bâtiment des Forges
Université Jean Monnet
11 Rue Dr Rémy Annino
42000 Saint-Étienne
SEPT. to DEC. 2026 - 1:30pm

LOCATION

The Hubert Curien Laboratory is a joint research unit of the Université Jean Monnet Saint-Étienne and CNRS, with the Institut d'Optique Graduate School as secondary institutional sponsor. It is located in Saint-Étienne, the 2nd largest city of the Auvergne - Rhône - Alpes Region, in an environment particularly favourable to the development of its research and innovative activities.



Université Jean Monnet Saint-Étienne

Laboratoire Hubert Curien
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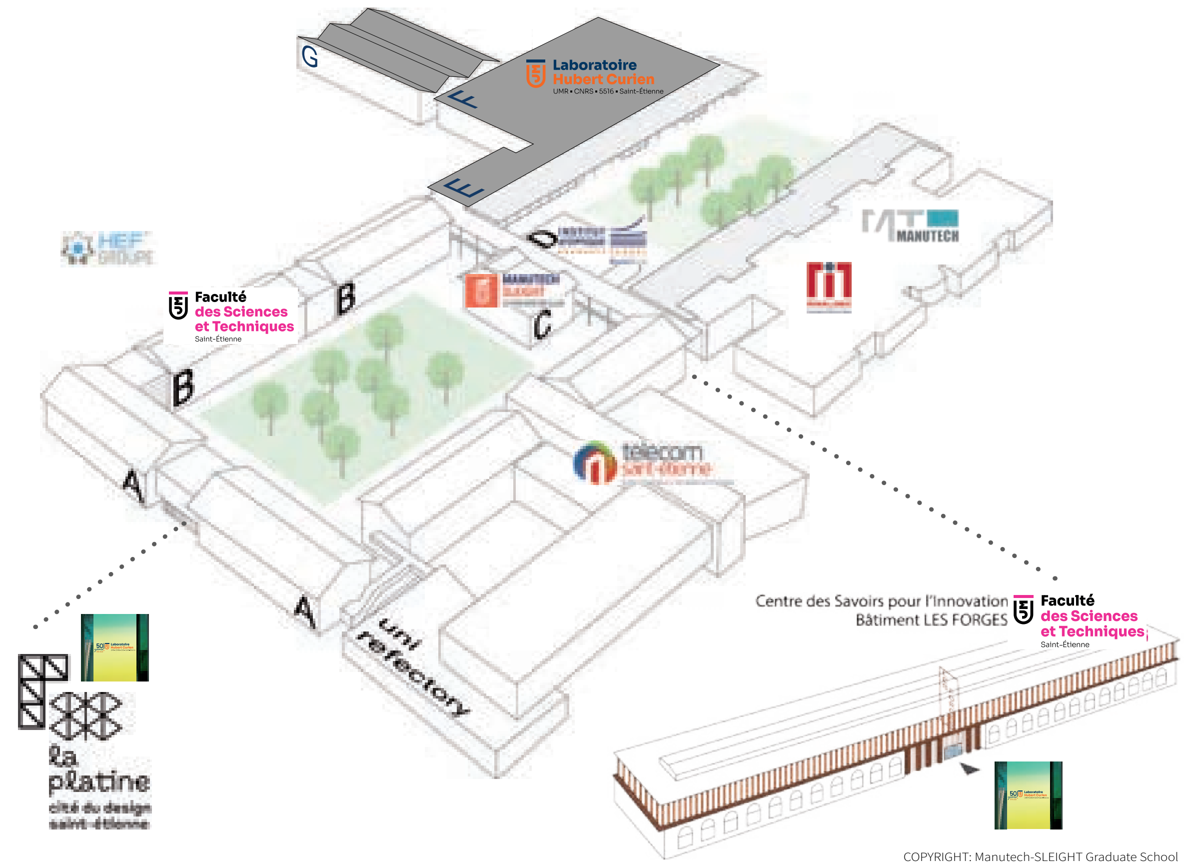
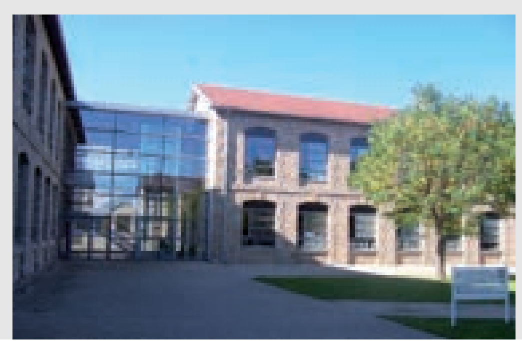
Laboratoire Hubert Curien
UMR CNRS 5516, Bâtiment F
18 Rue du Professeur Benoît Lauras
42000 Saint-Étienne, FRANCE
Tel : +33 (0)4 77 91 57 80
email : lab.h.curien@univ-st-etienne.fr

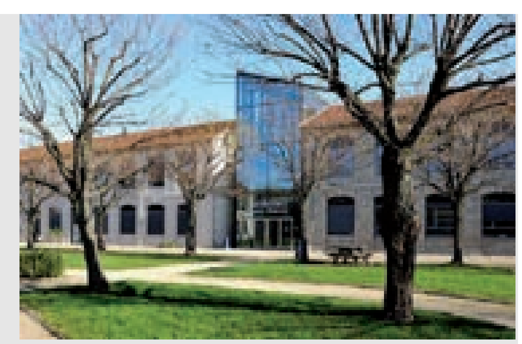


The Manufacture Campus houses the university's Faculty of Science & Technology, its Physics & Computer Science departments and its «Télécom Saint-Étienne» engineering school. In 2003, it was selected by the Institut Optique Graduate School to set up a branch outside Paris. Minalogic, a local industrial «competivity cluster» occupies the site, as well as the Economic Interest Group GIE Manutech USD. The company HEF R&D (surface engineering and micro/nanostructuring) has established its premises on the site, reinforcing the status of the Manufacture Campus as an emblem of an ecosystem that closely links the university and the business world.

Manufacture Campus aerial view
(Imagery ©2023 CNES / Airbus, Maxar Technologies, Map data ©2023)

The Hubert Curien Laboratory is situated at the heart of the «Manufacture Campus», established on the historic site of the former Saint-Étienne's arms factory. The lab benefits from exceptional surroundings including cultural, industrial, educational and research activities, as well as housing, sport and leisure facilities.





TIMELINE.....................1976 to 2026

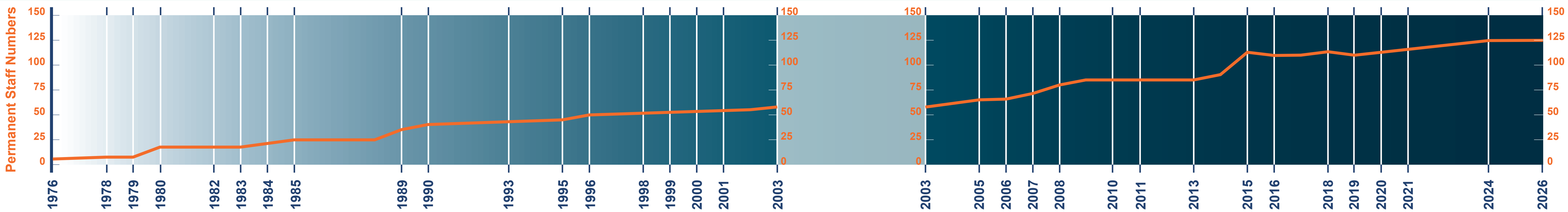
Innovation

- Pôle Optique et Vision & technology platforms
- Labex Manutech-SISE
- Equipex Manutech-USD
- GIE Manutech-USD
- LabH6 Joint lab (IxBlue/Exail)
- LAMCID Joint lab (HID/Toppan Security)
- COMETA Joint lab (HEF Groupe)
- OPERA Joint lab (Orano)

Research

- Guided Optics, Optical Instrumentation, Optical Fibers
- + Signal Processing
- + Optical Materials
- + Image Processing
- + Optical & EM Modeling
- + Spectroscopy
- + Biological & Medical Engineering
- + Optical Fiber Sensors
- + Diffraction Gratings
- + Optoelectronics
- + Vision
- + Femtosecond Laser Technologies
- + Photosensitivity
- + Surface Engineering
- + Micro-nano Structuring
- + Light-Matter Interaction
- + Surface Engineering
- + Micro-nano Structuring
- + Light-Matter Interaction
- + Hardware Security
- + Machine Learning & Data Mining
- + Colour
- + Lighting, Visual Rendering, Opto-numerical Security
- + Embedded Systems Security
- + Micowaves, Magnetic Materials
- + Photonics in Extreme Radiative Environments
- GDR CNRS Appamat (Materials Appearance)
- + Physics-Informed ML

Permanent Staff Numbers



1976 · 1978 · 1979 · 1980 · 1982 · 1983 · 1984 · 1985 · 1989 · 1990 · 1993 · 1995 · 1996 · 1998 · 1999 · 2000 · 2001 · 2003 · 2003 · 2005 · 2006 · 2007 · 2008 · 2010 · 2011 · 2013 · 2015 · 2016 · 2018 · 2019 · 2020 · 2021 · 2024 · 2026

Directors

- Jean-Noël MASSOT
- Jean-Pierre GOURE
- Alain CACHARD
- Pierre LAPORTE
- Pierre LAPORTE
- Florent PIGEON
- Florence GARRELIE
- François ROYER

Key events

- Laboratory foundation with UJM affiliation (Université Jean Monnet Saint-Étienne)
- Installation in Saint-Étienne (Métare Campus)
- CNRS association
- New building (Métare Campus)
- New building (Métare Campus)
- New building extension (Inaugurated by Hubert Curien & Georges Charpak)
- UMR CNRS creation
- New building (Manufacture Campus)
- New building (Manufacture Campus)
- EURISE lab fusion (UJM)
- TSI becomes *Laboratoire Hubert Curien*
- LIGIV lab fusion (UJM)
- LT2C + ISCOD (École des Mines) labs fusion
- IOGS secondary affiliation
- Manutech-SLEIGHT Graduate School
- Inria team MALICE foundation

Laboratory logos

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OUR ACTIVITIES
at a glance

Training

9 Master tracks coordinated by researchers from the lab

incl. 4 new Master Erasmus Mundus

incl. 6 international tracks

Manutech-SLEIGHT Graduate School coordination

~ 80 interns hosted every year (~60 % Master students)

Manutech-SISE Labex coordination

Involved in PRIMES & MILyon Labex

GDR CNRS Appamat coordination (renewed)

Research

4 IUF members

involved in 5 PEPR with 7 financed projects

776 papers of which 589 in peer-reviewed international journals +187 CORE confs

44% in international collaboration (12,5% USA, 5% Canada, 67% Europe)

+4M€ self-generated ressources in 2024

4 Programmes d'Investissement d'Avenir of which 1 coordinated by the lab

18 european projects incl. 1 H2020 coordinated by the lab + 2 EIC FetProAct & PathFinder projects

4 Technology platforms

68 CIFRE thesis or equivalent industrial thesis

47 ANR projects incl. 22 projects coordinated by the lab

8 other international grants

Innovation

37 Patents (filed or published)

incl. 5 new patents filed in 2024

incl. 32 patents with international extensions

98 Industrial contracts

4 Joint Laboratories With: Exail, Toppan Security, HEF, ORANO

Several Innovation projects incl. 8 FUI projects, 3 iDémo projects, 3 BPI Plan de Relance projects

4 Startups founded

KEY FIGURES
2019 to 2024
(HCERES evaluation period)

Laboratoire Hubert Curien
UMR • CNRS • 5516 • Saint-Étienne
50 years 1976-2026

KEY FIGURES
year 2025

127	98	29	115	33
permanent staff members	researchers	engineers, technicians & admin	PhD students	Post-docs

MANUTECH · Inge'LySE · FRAMA · Fédération Informatique de Lyon · Institut Carnot Télécom & Société numérique · MANUTECH SLEIGHT Université de Lyon · LABEX MILYON · LABEX PRIMES · LABEX MANUTECH-SISE

involved in 8 partnerships of the Lyon/St-Étienne ecosystem and 1 Institut Carnot

FRANCE 2030 · CYBER SECURITY · QUANTUM TECHNOLOGIES · ELEC-TRONICS · ORIGINS · LUMA

implication in 5 PEPR

exail · TOPPAN Security · HEF GROUPE · orano

4 industrial joint labs

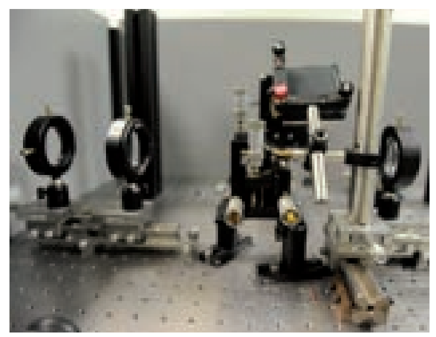
The QA Company · KERANOVA · Qiova · DEFENDER · safehear · newclin

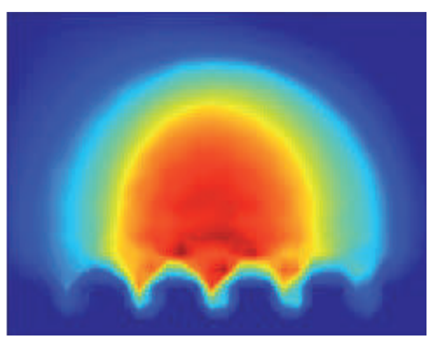
6 startups originated from or affiliated with the lab since 2011

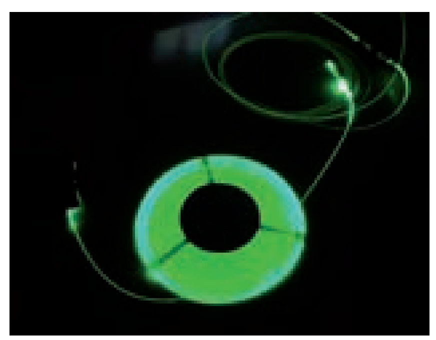
OUR RESEARCH *themes*

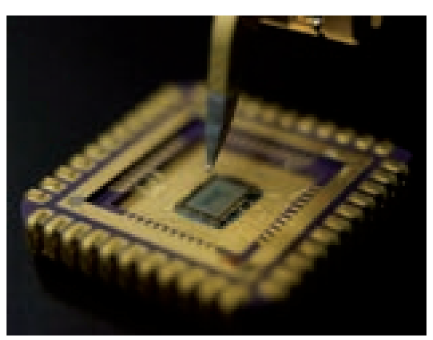
7 research teams

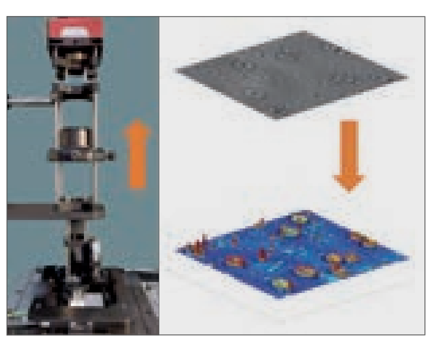
The lab covers a spectrum of research activities structured around 2 scientific departments: «Optics, Photonics, Surfaces» and «AI, Security, Image».
Our main expertise lies in Surface engineering, 2D & 3D materials' micro/nano structuring, Ultrafast laser processing, Electromagnetic modelling, Photonic materials and devices in harsh environments, Machine learning, Complex data analysis, Unconventional imaging, Computer vision, Material appearance and Hardware security. Many research projects at the interface of these disciplines lead to innovations and scientific breakthroughs.

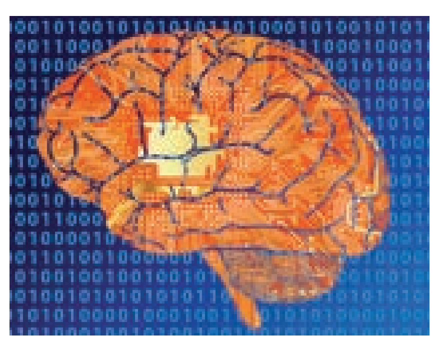












OPTICS, PHOTONICS, SURFACES DEPARTMENT

> Functional Materials & Surfaces (MSF)

Micro-nanostructuring, Laser-nanoparticle interaction, Photonic/electromagnetic devices, Nanocomposite functional materials, Color & control of visual appearance, Thin film elaboration by sol-gel processes, Magneto-optical devices, HF/RF integrated components, Resonant grating, Plasmonics(SPR), Metasurfaces, Transition metal nitride (TiN, ZrN…)

> Materials for Optics & Photonics in Extreme Radiation Environments (MOPERE)

Ionizing radiations, Optical fibers & fiber sensors, Photonic & opto-electronic technologies, Materials for photonics, Monte Carlo simulations, Dosimetry, Point defects spectroscopies

> Photoinduced Reactive Dynamics in Computational Theory (PREDICT)

Numerical simulation, Multiscale & multiphysics modeling, Nonequilibrium dynamics, Advanced photonics, Materials response to photoexcitation, Materials & surfaces design

> Laser Matter Interaction (ILM)

Ultrafast photophysical & photochemical laser processes, Smart laser manufacturing, Modeling of ultrafast laser interaction with matter, Laser engineering & process control, Beam engineering, Extreme scales, Plasma dynamics, Laser spectroscopy & imaging, Functional surfaces, Embedded 3D photonic systems & metasurfaces

AI, SECURITY, IMAGE DEPARTMENT

> Image Science & Computer Vision (IMAGE)

Material appearance, Optical design, Microscopy, Unconventional imaging, Image reconstruction inverse problems, Image/video analysis and understanding, Deep learning, Interpretable/explainable models algorithm implementation, Federated learning

> Machine learning (ML)

Learning theory, Ethical AI, ML for science, Physics-informed ML, Generalization & robustness, Alignment & fairness, Multimodality graphs/text/image/vector, Generative models, LLMs, Missing data and uncertainty, Federated learning, Interpretability (XAI), Optimization, Frugal AI

> Secure Embedded Systems & Hardware Architectures (SESAM)

Hardware security, Secure-by-design heterogeneous SoC, Random number generation in logic devices (TRNG & PUF), Post-quantum cryptography, Security of embedded AI

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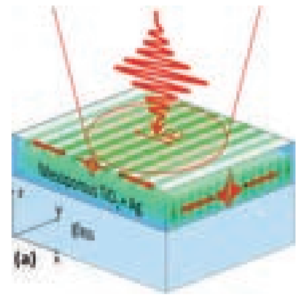
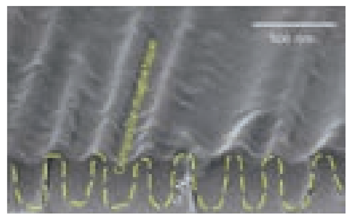
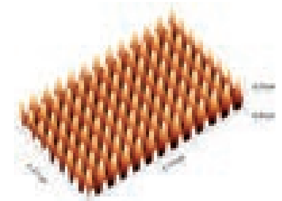
50 years 1976-2026

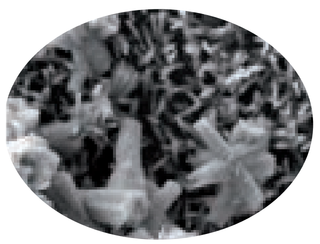
the MSF team

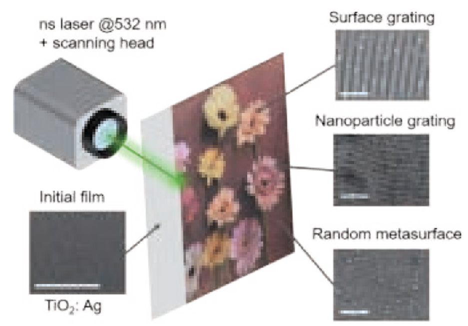
Functional Materials & Surfaces





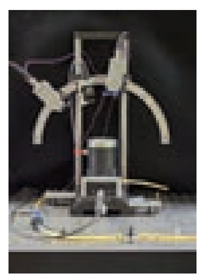


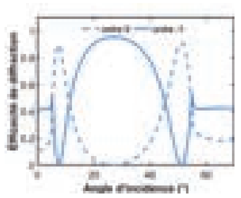


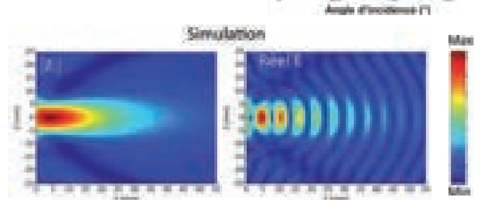


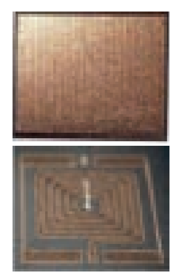
Permanent team members:

Jean-Philippe Banon
Bernard Bayard
Marie-Françoise Blanc-Mignon
Stéphane Capraro
Jean-Pierre Chatelon
Nicolas Crespo-Monteiro
Yuliya Dadoenkova
Maxime Darnon
Nathalie Destouches
Christophe Donnet
Emilie Gamet
François Goutaland
Christophe Hubert
Tatiana E. Itina
Damien Jamon
Yves Jourlin
Victor Kalt
Emmanuel Marin
Nadège Ollier
Olivier Parriaux
David Pietroy
Stéphane Robert
Jean-Jacques Rousseau
François Royer
Maxime Royon
Bruno Sauviac
Eric Verney
Isabelle Verrier
Didier Vincent
Francis Vocanson









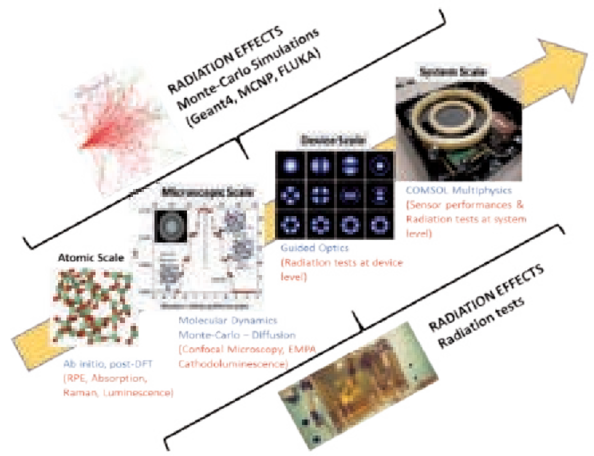
Team leaders
Yves Jourlin (2019 - 2025)
Maxime Darnon (Since Jan. 2026)

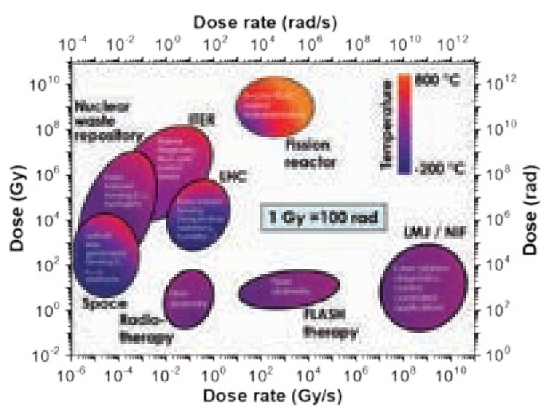
The MSF team originates from the Instrumentation and Optical Microsystems (IMO) team of the TSI laboratory. The core of its historical activities lies in optics, and particularly in the control of light. Research on diffraction gratings, developed from the late 1990s - especially for high-power laser applications - has given the team strong recognition in the field of photolithography and in the fabrication of large-area diffraction gratings. Work on plasmonic nanoparticles complemented the team's activities in the early 2000s, with the development of nanoparticle localization methods that opened the way to multiplexed images with structural colors. Over the years, the team expanded its activities, first into sol-gel materials in the early 2010s, and then into the RF (high-frequency) domain and magnetic materials with the arrival of colleagues from LT2C in 2015. This research led to the development of nanocomposite materials which properties, enhanced by nanostructuring, enable exceptional quality factors.
The team's activities span from upstream to downstream, combining modeling and fabrication to conduct breakthrough research, from fundamental aspects to applications. Today, the Functional Materials and Surfaces team primarily focuses on controlling and shaping electromagnetic waves using functionalized materials and surfaces. The team's expertise covers material development (sol-gel materials, composite materials, ferrites), surface structuring (lithography, nanoimprinting, laser structuring), light-matter interaction mechanisms (diffraction, resonances, magneto-optics, plasmonics, electromagnetic jets), applications exploiting these phenomena (security, sensors, energy, etc.), as well as the associated modeling and characterization.
The team's work is organized around three main scientific themes: the development of functional materials, surface structuring, and applications.
The development of functional materials is a well-established theme within the team, relying on broad and unique expertise involving thin films derived from sol-gel or glass matrices, functionalized through doping, incorporation or growth of nanoparticles (metallic, magnetic, etc.) or molecules (e.g., luminophores), thermal treatments under specific atmospheres (e.g., nitriding), or laser functionalization (e.g., nanoparticle growth). Beyond exploiting the functional materials developed by the team, their research also aims at new functionalities (e.g., hyperthermia, photomagnetism), new synthesis methods, and new materials (e.g., phase-change materials).
Surface structuring is also central to the team's activities, with the development of methods to control surface topography across multiple scales (from macro to micro/nano), particularly through non-conventional lithography processes (interference lithography, nanoimprinting, colloidal lithography). These structuring methods, developed with an integrative approach (compatible with large areas and low temperatures) for components, open new ways to control and exploit electromagnetic waves.
The team can rely on the NanoSaintÉtienne platform for its technological developments (platform labelled Renatech+ and CNRS in 2019), as well as on the electron microscopy platform *(see p.31)**. Both are open-access facilities available to external users.*
Finally, the team bridges fundamental and applied research to leverage its findings for applications based on extreme resonances (e.g., dielectric switches, bound states in the continuum) and on correlations between surface structuring, functionalization, and electromagnetic responses. These applications target various fields such as security (e.g., multiplexed images), sensors (e.g., electromagnetic jets, PFAS detection), and optical and magneto-optical metasurfaces.

the MOPERE team

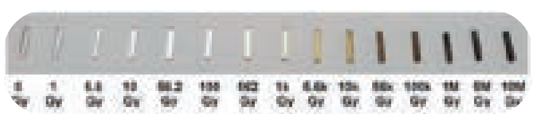
Materials for Optics and Photonics in Extreme Radiation Environments

© NASA / ESA / CNES





Permanent team members:
Hugo Boiron
Aziz Boukenter
Maxime Darnon
Matteo Ferrari
Sylvain Girard
Emmanuel Marin
Adriana Morana
Youcef Ouerdane



MOPERE

Team leader
Sylvain Girard (Since 2020)

The MOPERE research team (Materials for Optics and Photonics in Extreme Radiation Environments) has developed, since its creation, a scientific activity focused on understanding and controlling the effects of harsh environments, especially radiation environments, on optical and photonic materials, components and systems. It builds on the historical expertise of its members in optical materials, optical fibers and fiber-based sensors.

Its positioning relies on a close connection between fundamental research and applications, enabled by the CESARE approach, developed within the team. This multi-scale methodology combines experiments and simulations to identify the physical mechanisms responsible for radiation-induced degradation, whether related to ionization processes or atomic displacements. This knowledge is then used to design robust photonic solutions adapted to complex environments involving constraints such as temperature, pressure or chemical atmosphere.

MOPERE's activities are structured around several major research axes. The first focuses on fundamental mechanisms affecting glasses and optical fibers, with major contributions to the understanding of induced defects and their evolution kinetics. The second axis addresses the development of optical fibers and fiber sensors for extreme environments, especially for nuclear, aerospace, high-energy physics and fusion applications. The third, rapidly growing axis concerns optical dosimetry and beam instrumentation, relying on phenomena such as radiation-induced attenuation or radioluminescence. Finally, the team is extending its expertise toward emerging photonic technologies including silicon photonics, radiophotoluminescent glasses and advanced optoelectronic devices.

During the recent period, MOPERE has experienced strong growth in both scientific output and visibility. With more than 130 recent publications in international journals and a strong presence at major conferences in the field, the team has established itself as a leading player at national and international levels. This visibility also relies on a dense collaboration network involving major research organizations, space agencies, industrial partners and large-scale infrastructures. Long-term partnerships, notably through the joint laboratories LabH6 with Exail and OPERA with ORANO, provide access to unique experimental resources and enable the team to address complex applied challenges.

Among its key achievements, several advances illustrate MOPERE's ability to cover the full value chain, from material to system. The team has contributed to the development of radiation-hardened optical fibers deployed in major research facilities, as well as distributed sensors for monitoring nuclear infrastructures. In the space field, the LUMINA project led to the design and operation of an onboard optical dosimeter aboard the International Space Station.

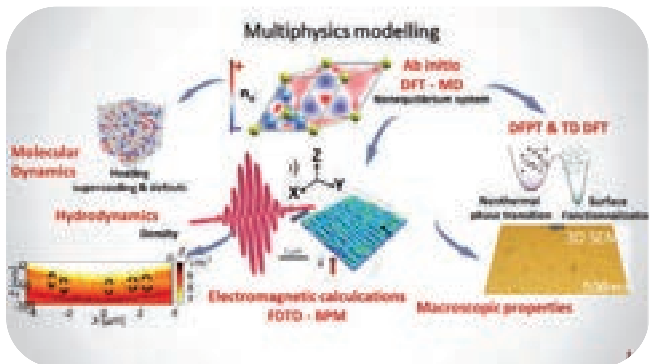
The deployment of distributed dosimetry systems in particle accelerators and embedded sensing solutions for drones also demonstrates the technological maturity reached. These successes are accompanied by significant academic recognition and a strong capacity for attraction and training, notably through the international master program RADMEP, renewed as RADMEP+ in 2025.

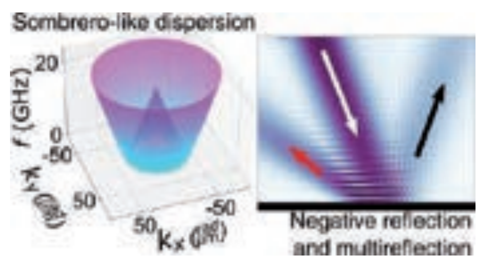
Building on these achievements, MOPERE is looking to the future with clear and structured ambitions. The team aims to consolidate its historical activities while expanding toward new technologies and scientific challenges, particularly in integrated photonics and innovative materials. Strengthening approaches combining simulation and experimentation remains a priority. In a context marked by renewed nuclear programs, the growth of space applications and increasing needs for advanced instrumentation, MOPERE aims to remain a key player in the field.

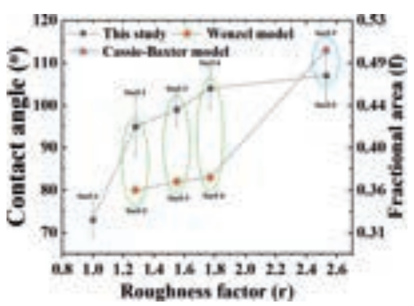
The team relies on the PETRA platform (see p.31), which it helps develop, and which offers access to external users.

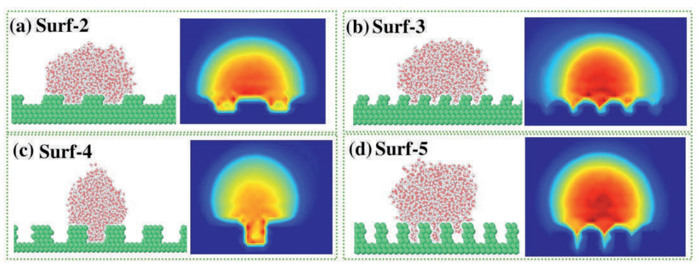
the PREDICT team

Photoinduced Reactive Dynamics in Computational Theory

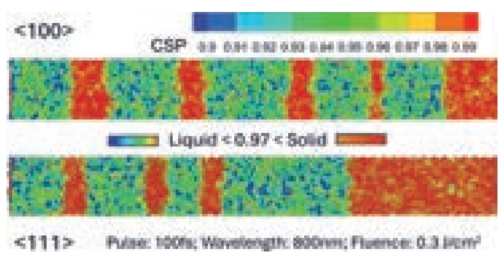


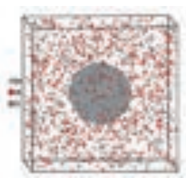


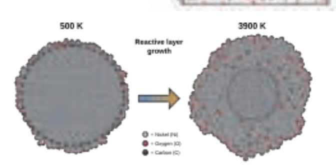


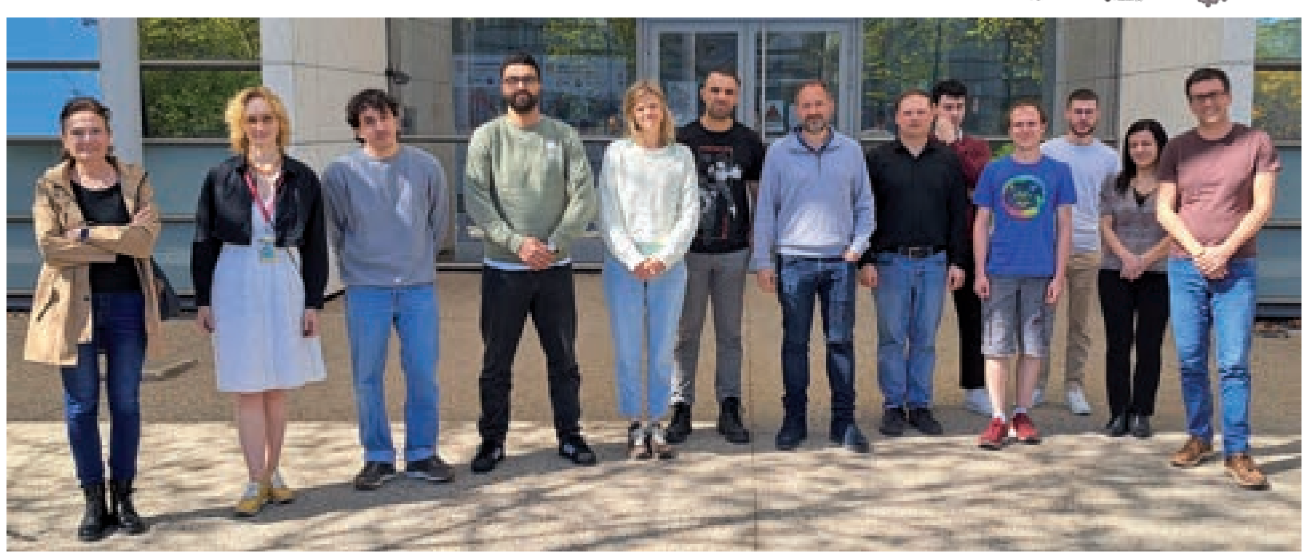


Permanent team members:
Jean-Philippe Banon
Jean-Philippe Colombier
Yuliya Dadoenkova
Emilie Gamet
Tatiana E. Itina
Elena Kachan
Anton Rudenko
Victor Kalt







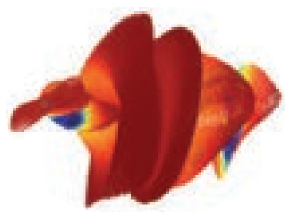
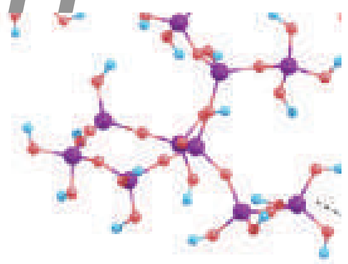
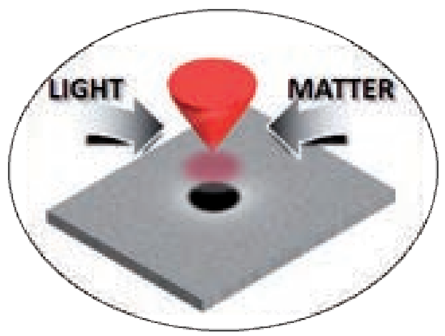


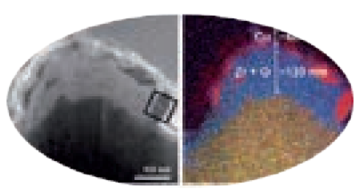
PREDICT

Team leader
Tatiana E. Itina (Since Jan. 2026)

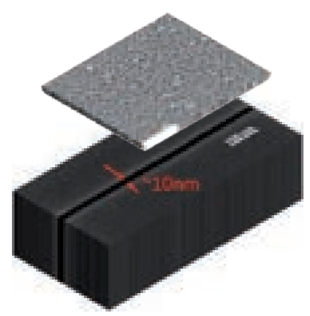
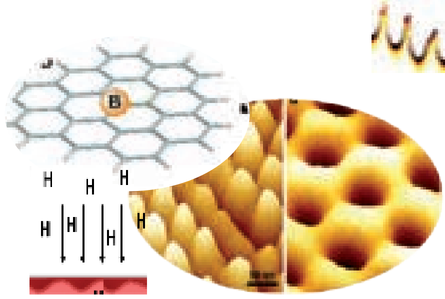
The PREDICT team addresses a central challenge in contemporary materials science: how to reliably predict the transformations of matter under intense and ultrafast external stimuli, in particular laser irradiation. The recent creation of the team in January 2026 builds on a long and recognized history of physical and optical modeling within the laboratory, where theoretical approaches have continuously accompanied experimental developments for several decades.
These activities were historically developed across several research groups, including work related to laser-matter interaction, nanostructures and nanoparticles, photonics, magneto-optics, and wave propagation. In particular, electromagnetic modeling has long represented an important strength of the laboratory, notably through activities dedicated to optical nanostructures, photonic systems, and wave-matter interactions.
Since the 2000s, the lab has further consolidated its numerical and theoretical research on laser-matter interaction, ultrafast processes, electromagnetic modeling and predictive tools. More recently, complementary developments have focused on modeling the magneto-optical properties of nanostructures, and on extending the spectrum to UV, IR and RF domains. This collective scientific heritage now converges within PREDICT and includes expertise in laser–matter interaction, ultrafast phenomena, electromagnetic simulations, atomistic modeling, and materials behavior under extreme conditions.
Building on this long-standing expertise, the team brings together complementary skills in theoretical physics, numerical modeling, and data-driven approaches in order to structure and amplify research efforts in multi-physics and multi-scale simulations. Our ambition is to bridge the gap between fundamental theoretical descriptions and predictive, quantitative simulations that can directly support experiments and technological developments. At the heart of our approach lies the coupling of electronic excitation, energy transport, atomistic motion, and chemical reactivity within unified frameworks.
By connecting ultrafast processes occurring on femtosecond timescales to structural and functional evolutions over much longer times, we aim to provide an integrated understanding of complex out-of-equilibrium phenomena. PREDICT focuses on a broad range of systems, including semiconductors, metals, and nanostructured materials, with particular attention to laser-induced oxidation, phase transitions, nanoparticle formation in liquids, and plasmon-mediated processes. These topics are not only scientifically challenging, but also highly relevant to current societal needs, such as the development of advanced photonic devices, sustainable material processing, and functional nanomaterials for energy and biomedical applications.
A distinctive feature of the team is its strong commitment to coupling modeling with experiments. By working in close interaction with experimental groups, we aim both to interpret observed phenomena and to guide the design of new experiments. This dialogue is essential for developing truly predictive models, capable of identifying optimal processing conditions and uncovering new physical mechanisms.
In parallel, PREDICT invests in the development of advanced multi-scale numerical models and methodologies. This includes hybrid atomistic–continuum approaches, two-temperature and non-equilibrium models, ab initio methods, as well as electromagnetic simulations of complex photonic structures. Increasingly, these physics-based models are complemented by machine learning strategies, enabling efficient exploration of high-dimensional parameter spaces and opening the way to inverse design of materials and processes.
The creation of PREDICT also reflects a strategic vision: to strengthen the role of modeling as a driving force within the laboratory and to enhance its visibility at the national and international levels. By fostering collaborations with academic partners, research institutions, and industry, the team contributes to a dynamic and interdisciplinary research environment.
Ultimately, the team aims to move from understanding to prediction, and from prediction to control. By developing robust and versatile simulation frameworks, we seek to enable the rational design of materials and processes under extreme conditions, contributing to the emergence of innovative technologies and to a deeper comprehension of matter far from equilibrium.

the ILM Laser-Matter Interaction team


Permanent team members:
Florent Bourquard
Hugo Bruhier
Jean-Pierre Chatelon
Jean-Philippe Colombier
Ciro D'Amico
Vincenzo De Michele
Christophe Donnet
Florence Garrelie
Elena Kachan
Anne-Sophie Loir
Florent Pigeon
Anton Rudenko
Razvan Stoian
Alain Trouillet

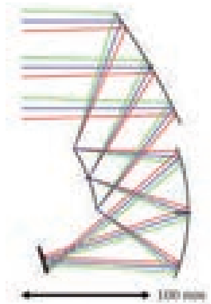




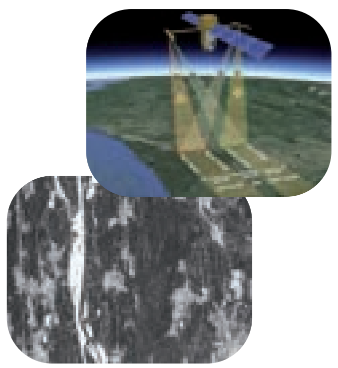

Razvan Stoian
(Team leader since 2008)

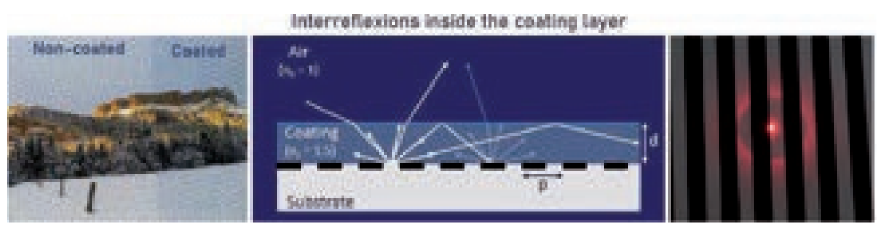
In an international context marked by the rapid acceleration of flexible, high-performance, and increasingly miniaturized laser sources, alongside continuous innovation in laser-based processes reaching down to nanometric scales, novel industrial applications are expanding at an unprecedented pace. In this evolving landscape, the central challenge is to design a new generation of controllable laser structuring tools capable of delivering extreme precision. This ambition now clearly defines the roadmap of the international scientific community. It drives research efforts toward the development of adaptable laser sources, the design of irradiation strategies capable of controlling structures beyond the diffraction limit, the digitalization of processes, and the strengthening of technological maturity across emerging application domains. These advances span a wide range of fields, including optics, photonics, mechanics, health, energy, as well as quantum technologies and information storage, and contribute to structuring the global scientific landscape and major research centers. Pioneering work carried out in the 2000s on surface engineering using ultrashort lasers has generated a strong dynamism in ultrashort laser processing, which remains a flagship activity of the laboratory today. Building on its strong scientific influence, the laboratory has played a leading role in initiating and coordinating three major "Investments for the Future" programs: LabEx Manutech-SISE (Surface and Interface Science Engineering), EquipEx Manutech-USD (Ultrafast Surface Design), and EUR Manutech-SLEIGHT (Surfaces Light Engineering Health & Society), in which laser processing occupies a central role and in which all other teams of the laboratory are involved. In this context, the ILM team has established itself as a key international reference in the field of ultrashort laser processing. A central aspect of our research lies in structuring matter to create innovative materials. The ability to engineer materials through controlled structuring has become a powerful lever in areas related to security, energy, and health. By tailoring the organization of matter, we can control, enhance, and even transform its physical properties. In particular, structuring at mesoscopic scales opens new pathways for functionalization in optics, thermal transport, chemistry, and contact-related phenomena. At the same time, progress in materials engineering relies critically on the availability of structuring tools that are fast, precise, and contactless. Achieving high fabrication speeds, maintaining pattern accuracy, and ensuring compatibility with a wide variety of materials and surface geometries remain major challenges. In this respect, ultrashort laser technologies offer unique opportunities. The ultrafast, nonequilibrium phenomena they involve enable the exploration of new irradiation regimes capable of reaching unprecedented levels of precision in the engineering of functional structures. These approaches provide powerful means to redefine mechanical, thermal, and optical material properties, which explains the sustained level of international research investment in this area. The team relies on the Femtosecond laser platform (see p.31), which it helps develop, with access also available to external users. It also makes use of the electron microscopy platform. Ultrashort laser manufacturing is therefore a particularly vibrant field of research and innovation, structured around two major scientific challenges that engage the international community. The first is to enhance process efficiency through the development of laser sources that are more powerful, faster, and more versatile. The second, which is the primarily focus of the ILM team, is to master structuring down to the smallest possible scales through advanced control of the underlying processes. Ultimately, both challenges converge toward a common objective: achieving a deep understanding and precise control of light-matter interaction at the smallest spatial and temporal scales. We develop advanced ultrashort laser processes, together with the associated instrumentation and control methodologies. In parallel, we investigate the fundamental mechanisms of light-matter interaction through direct observation, modeling, and multiscale analysis in both time and space. A particular emphasis is placed on exploring ultimate scales. Our objectives are to contribute to the emergence of a new generation of advanced laser structuring tools, to deepen our understanding of ultrafast phenomena, and to design innovative devices that harness the unique properties of ultrashort light.
To meet these ambitions, our activities are organized around several complementary research themes. Together, they form a coherent and integrative framework of expertise in laser processing, grounded in a comprehensive approach to laser–matter interaction and structuring.

the IMAGE team

Image Science & Computer Vision

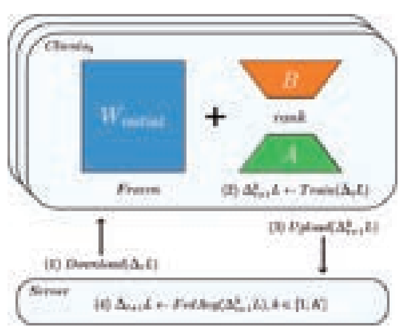


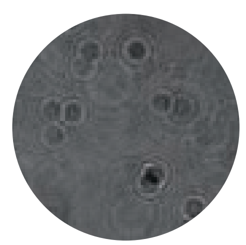




Permanent team members:

Olivier Alata	Virginie Fresse
Jean-Marie Becker	Mathieu Hébert
Pierre Chavel	Michel Jourlin
Raphaël Clerc	Hubert Konik
Philippe Colantoni	Anne-Claire Legrand
Loïc Denis	Thierry Lépine
Eric Dinet	Fabien Momey
Christophe Ducottet	Baptiste Moine
Thierry Fournel	Alain Trémeau
Corinne Fournier	Thomas Olivier





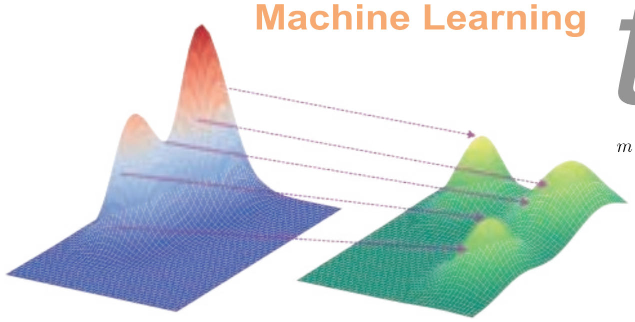
IMAGE

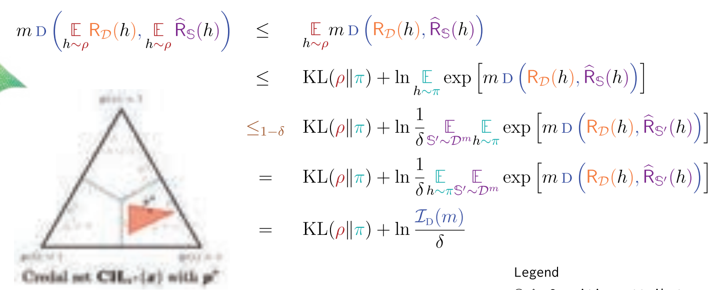
Team leaders
Thierry Fournel (2014 - 2025)
Loïc Denis (Since Jan. 2026)

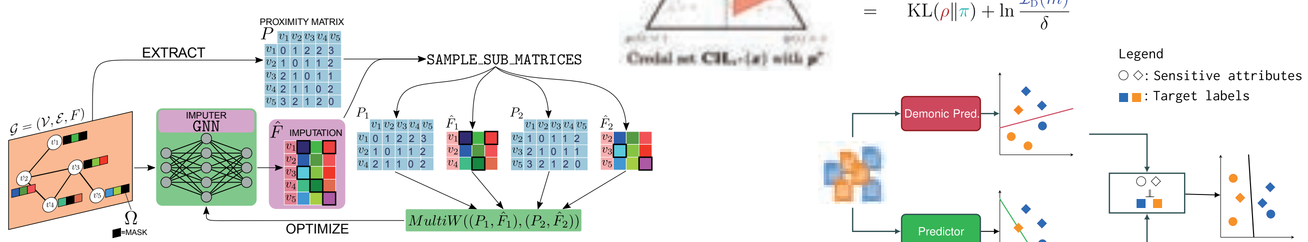
As early as 1983, the laboratory initiated novel research activities focused on image processing. At that time, it developed grayscale morphological processing, which led to close collaborations with the École des Mines de Paris, the birthplace of mathematical morphology. That same year, the Image team, together with the École des Mines de Saint-Étienne, created one of the very first (if not the first) postgraduate university degrees entirely dedicated to imaging: the DEA "Image Analysis and Processing, Image Synthesis, Artificial Intelligence." The late 1980s saw rapid developments in imaging and specialized parallel computing for various scientific fields. During this period, the Image team, in collaboration with CPE Lyon, developed award-winning tools for segmentation and 3D navigation within anatomical structures, particularly in the dental field, as well as biological structures such as HIV-infected T4 lymphocytes. Between 1989 and 2007, the team focused on velocimetry and granulometry in quantitative fluid mechanics, notably through the EUROPIV project, the first European contract signed by the university. Among its major contributions were the digital analysis of holograms and later digital holography, which became precursors to the current team's "reconstruction" research axis. At that time, the first digital cameras were also under development.
In 2005, the laboratory's electronics researchers joined the team to develop vision architectures and a high-speed digital camera before shifting, with the support of the entire laboratory, toward security architectures. This led to the creation of an independent team in 2010 (AMTES). That same year, the laboratory established, together with the Institut d'Optique, a research theme focused on lighting, visual rendering, optical imaging, and opto-digital security. This theme was positioned at the interface between the "Optics-Photonics" and "Computer Science-Telecommunications-Image Processing" departments. The "Image Processing" component brought together activities in automatic image analysis and image understanding, to which the UJM's LIGIV research group contributed through its expertise in color processing by joining the laboratory a year earlier.
In 2014, all activities related to "Image Science and Computer Vision" were consolidated into a single research team, defining the current outline of the Image team. While the GDR IASIS - Signal, Image, Vision, Machine Learning - has served as a natural framework for its research activities since its creation in 1988, its work – led to the creation in 2019 of the GDR Appamat on Material Appearance, coordinated by the team with the laboratory's support.
Today, the Image team conducts internationally recognized research in unconventional imaging, ranging from microscopy to astronomical imaging, as well as in the detection, extraction, and interpretation of visual information through a close integration of physical modeling and image analysis. Its approach combines imaging physics and cutting-edge machine learning techniques to push the limits of current systems and develop methodologies capable of addressing computer vision tasks that open new perspectives across many application domains.
In line with its long-term trajectory and through its three project teams, the Image group is now particularly focused on designing imaging systems that integrate non-standard optical elements or that enable the reconstruction of multivariate images for scientific imaging. At the same time, it seeks to characterize material surfaces beyond color attribute by analyzing texture, gloss, and translucency through the optical properties of materials, with the goal of supporting interpretable image analysis and prototyping. The team is also working on finding adapted lighting solutions to improve visual perception, while developing and implementing explainable and resource-efficient machine learning models, as well as analyzing human expressions and behaviors within their spatio-temporal context.
Across all these activities, a common thread lies in the complementarity between artificial intelligence and imaging physics. The inversion of physical models enables the characterization of imaged objects, while self-supervised training strategies and approaches that facilitate generalization are being adapted to various research domains addressing major societal challenges. These efforts are pursued within the broader objective of developing responsible AI, notably through the partitioning of deep models across different embedded systems.

the ML team

Machine Learning

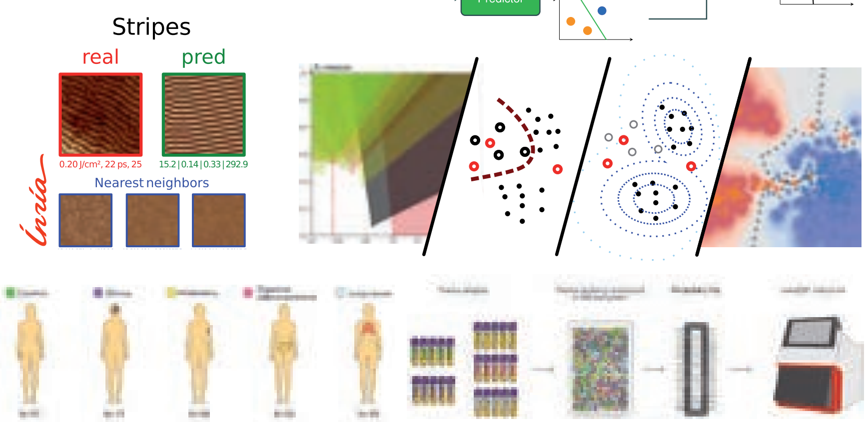






Permanent team members:

Marc Bernard
Quentin Bertrand
Eduardo Brandao
Farah Cherfaoui
Catherine Combes
Rémi Emonet
Rémi Eyraud
Mathias Géry
Benjamin Girault
Antoine Gourru
Christophe Gravier
Amaury Habrard
François Jacquenet
Baptiste Jeudy
Christine Largeron
Pierre Maret
Emilie Morvant
Fabrice Muhlenbach
Jordan Patracone
Marc Sebban
Kamal Singh
Haifei Zhang



ML

Team leaders
Amaury Habrard (2015 - 2025)
Rémi Emonet (Since Jan. 2026)

The laboratory's work in artificial intelligence dates back to 2006 with the creation of a team specializing in Data Intelligence, following the integration of the UJM-affiliated EURISE team into the UMR. About a decade later, the team expanded its activities to cover the entire data modeling and processing chain. The team grew and started to incorporating more statistical aspects, developing a strong focus on machine learning and data mining. This evolution took the form of the new ***Data Intelligence*** *team that focused on data mining, information retrieval, unsupervised learning, and statistical learning, thereby covering a spectrum of expertise ranging from data analysis and knowledge discovery to machine learning. These themes were developed within the context of two foundational projects: Data Mining and Machine Learning.*

The team established a strong expertise on the theoretical foundations of machine learning, on one side, and on the analysis of graphs, communities, social networks, user preferences on the the other side. To highlight this last specificity of handling non-vector data, graphs, sequences or text, we renamed the Data Mining project into the Complex Data Analysis project, at the beginning of the previous contract.

The statistical machine learning project consolidated its activities in transfer learning and generalization guaranties but also developed core work in optimal transport, optimization and at the intersection of physics and machine learning, with the creation of the Inria team MALICE.

Over the years, the team has engaged in numerous scientific collaborations, naturally with other leading machine learning research teams, but also with industrial and societal actors, and with other disciplines. The team is particularly involved in the following applications, with several approaches that have been deployed in real systems: anomaly and fraud detection, natural language processing, fair recommendations, graph and network analysis, physics-guided applications, computer vision, surface engineering, security and side-channel attack, biology and medicine with bioacoustics, medical, health and sport data analysis.

A particularity of the team is its central role in the laboratory. This comes from the potential of machine learning and artificial intelligence to impact other domains. For more than two decades the team has established collaboration within the laboratory, starting mainly with collaborations with the image and computer vision team, a domain which was one of the first to massively adopt machine learning and later deep learning, replacing hard-coded algorithms by machine learning models. Still in the computer science department, we developed a strong collaboration with the SESAM team, with a focus on using machine learning for designing and mitigating new side-channel attacks. In the last contract, we established many collaborations with the Optics, Photonics & Surfaces Department, ranging from predictive models to replace expensive experiments to knowledge discovery in laser-matter interaction.

Thanks to the cross-disciplinary synergies made possible by the unique environment that is our laboratory, we were able to create, in close cooperation with specialists of laser /radiation-matter from our ILM, MSF and MOPERE teams, the Inria MALICE team that focuses on the intersection of physics and machine learning for surface engineering.

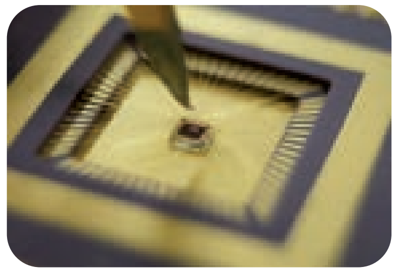
In 2026, we renamed the team to ***Machine Learning*** *as all members are machine learning specialists and identify to this name. In the continuity of previous evolutions, the team drives research activities organized around two complementary and tightly interlinked projects. These two new projects can be thought as the refinement of the former Complex Data Analysis and Machine Learning projects.*

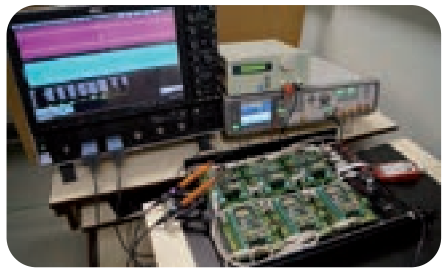
The Responsible and Trustworthy Machine Learning (RTML) leads research focused on ensuring the ethical and reliable deployment of modern AI. This includes critical work on fairness, bias detection and mitigation, model explainability, and robustness, with particular attention to complex data types like text, sequences, and graphs.

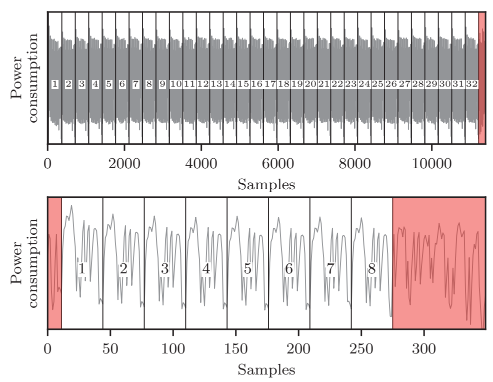
The Fundamentals and Theory of Machine Learning (FTML) drives research into the core principles underpinning modern AI. This involves deep investigations into statistical learning theory, optimization algorithms, and unsupervised learning techniques. Our specific interests lie in areas such as PAC-Bayesian theory, generative modeling, and the theoretical understanding of learning representations and operators.

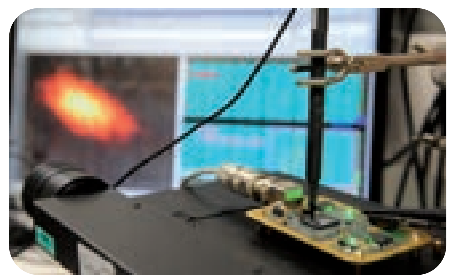
the SESAM team

Secure Embedded Systems & Hardware Architectures

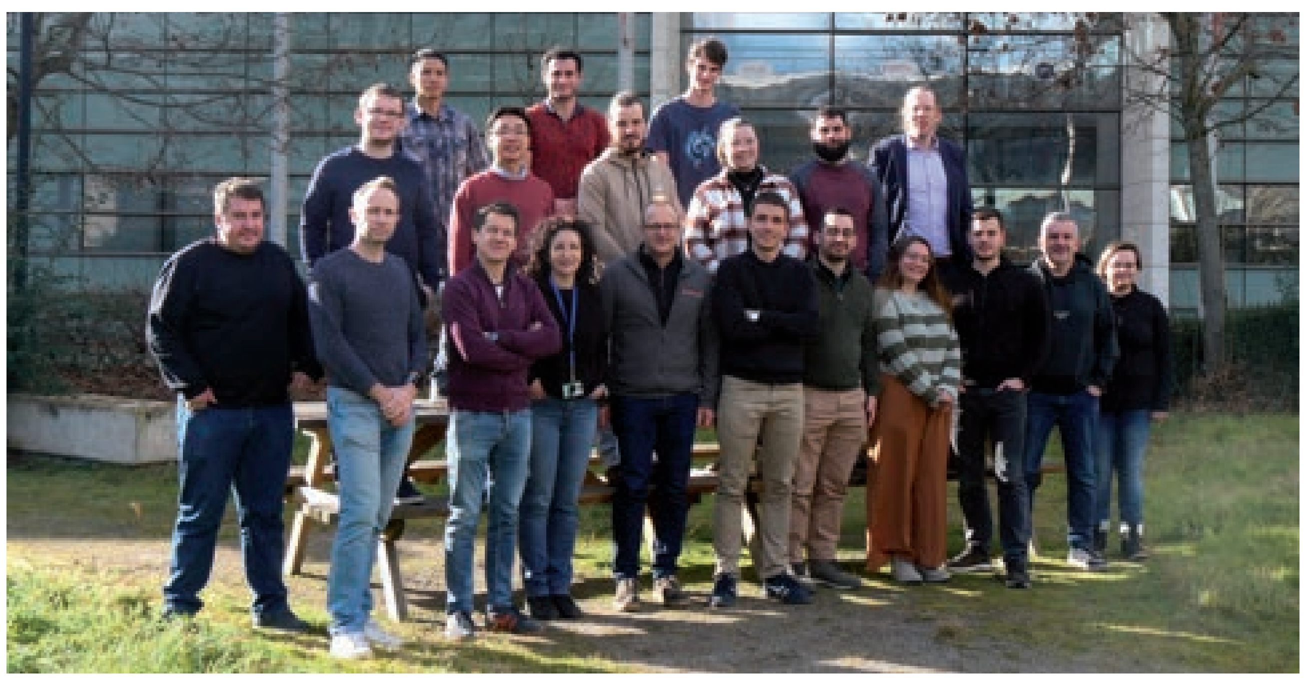








Permanent team members:
Alain Aubert
Florent Bernard
Nathalie Bochard
Lilian Bossuet
Pierre-Louis Cayrel
Brice Colombier
Viktor Fischer
Vincent Grosso
Yuko Hara
Cédric Killian



Team leaders
Lilian Bossuet (2015 - 2025)
Cédric Killian (Since Jan. 2026)

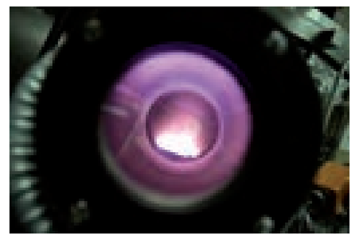
The SESAM tteam was established in 2005 as a research theme within the architecture group of the Image team, to which its permanent members were then assigned (one Professor, one Associate Professor, and one Research Engineer). In 2010, the team became an independent entity and adopted the name AMTeS (Hardware Architecture for Telecommunications and Security). It then focused its research on the hardware implementation of cryptographic functions and random number generation. Within two contractual periods, the SESAM team had recruited additional members and structured itself around the single theme of hardware security, a field that was gaining considerable importance both nationally and internationally. The team's ambition was to assume a leading national role in this domain — a position it holds today.
Once consolidated, the team leveraged the multidisciplinary environment of the laboratory by initiating collaborative projects with the ML, ILM, and MOPERE teams.
Over the years, the scientific activities of the SESAM team have evolved to focus on the central challenge of hardware system security. These activities are organized along four major complementary and interconnected themes: the generation of random numbers in integrated electronic circuits — whether through dynamic randomness generation using True Random Number Generators (TRNGs) or static randomness generation using Physical Unclonable Functions (PUFs) — and their applications; the design of trusted systems-on-chip; physical attacks via side-channel analysis and fault injection; and the secure hardware implementation of classical and post-quantum cryptographic algorithms. This field of expertise draws upon competencies in embedded systems, microelectronics, applied mathematics, and cryptography, all brought together within the SESAM team.
The SESAM team also contributes to the structuring and animation of the scientific community in hardware security, notably through its active involvement in the "Security of Hardware Systems" working group of the GDR SoC2 and the GDR Sécurité Informatique. Since 2003, it has organized the international CryptArchi workshop (International Workshop on Cryptographic Architectures Embedded in Logic Devices), which annually brings together specialists in the field to discuss topics related to hardware security and cryptography. These activities reflect a strong commitment to structuring the domain and fostering connections between academic and industrial stakeholders.
In continuity with this trajectory, the team's scientific orientations remain within a stable framework while integrating rapid technological developments and evolving threats. Future work will continue along the four structuring axes, with particular emphasis on improving the understanding and characterization of randomness sources, developing new attack methods and countermeasures, and advancing security-by-design approaches together with the integration of security into design tools. Greater attention will be paid to the security of complex and heterogeneous architectures, particularly in the context of systems-on-chip, as well as to the hardware-software interface. Furthermore, the emergence of new application domains — such as artificial intelligence architectures and post-quantum encryption systems — opens important research perspectives for the team. These developments are supported by state-of-the-art experimental tools gathered within the Electronics and Hardware Security platform (see p.31), which enable the exploration of novel attack scenarios and the evaluation of system robustness. In this context, the team will continue to strengthen its academic and industrial collaborations in order to maintain a leading position and contribute effectively to the scientific and technological challenges associated with hardware system security.

our technology
PLATFORMS

Most research activities of the Hubert Curien Laboratory are supported by several technology platforms fitted with specific state-of-the-art experimental tools. The equipment is operated, supervised and maintained by experienced technical and scientific staff working closely with our research teams.

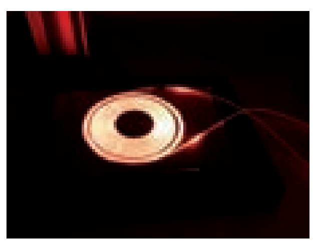
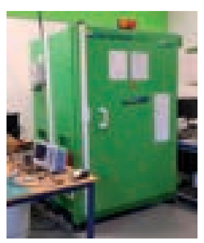
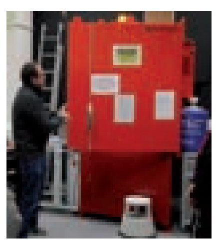
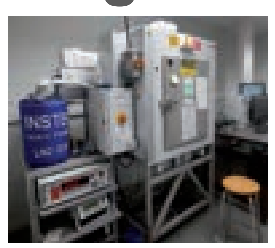
NanoSaintÉtienne



Our *Renatech+* affiliated NanoSaintÉtienne platform includes planar technology instruments dedicated to 5 main activities: gratings elaboration, thin film deposition, substrates processing, profile analysis and spectrometry.
Managed by a team of 7 people, this micro-nano technological facility is **open to industrial and academic partners**.

PETRA - Radiation Testing

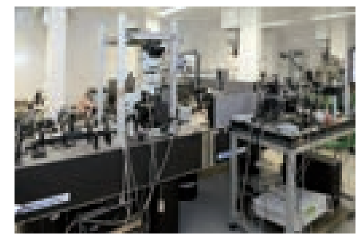
PETRA (Experimental Platform for Radiation Tests) brings together our lab's irradiation and radiation testing equipment. Built around 3 X-ray irradiation installations, it enables in-operando testing of materials, components and systems, across a wide temperature range (-120 to +400 °C) and under controlled atmospheric conditions. PETRA is **open to external users**.

Electron Microscopy



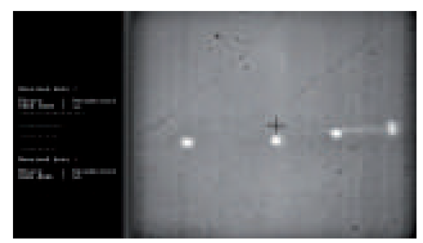
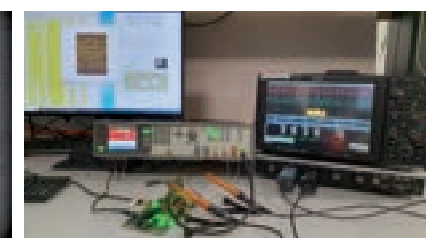
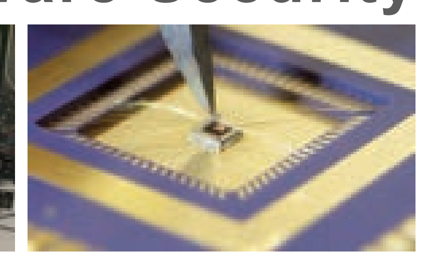
Our Electron Microscopy platform is dedicated to improve the knowledge of condensed matter structure from atomic to microscopic scale, in order to support the activities of our research teams. It is fitted with state-of-the-art equipment, including a CLYM affiliated JEOL NeoARM 200F Transmission Electron Microscope (TEM) - equipped with EDS and EELS - and a JEOL IT 800 SHL Scanning Electron Microscope (SEM). This facility is **open to external users**.

Femtosecond Laser



Our Femtosecond Laser platform features 6 ultrashort lasers with varying wavelengths, repetition rates and energy levels, covering all working environments. It supports devices such as OPAs for tunability, burst modes and variable frequencies, along with high-precision stages and scanners, spatial, temporal and polarization shaping of ultrashort laser pulses, or ultrafast spectroscopy systems. Primarily supporting the teams of our Optics, Photonics & Surfaces Department, the facility is **open to external partners**.

Electronics and Hardware Security

Originally founded to support the activities of the SESAM team, our Electronics and Hardware Security platform is available to all other teams within the laboratory. It includes various high-performance electronic instruments and acquisition systems, comprising both custom-developed solutions and commercial kits. Combined, these elements form specialized tools for analyzing embedded cryptography systems.

Access to IXR-Imaging & Extended Reality

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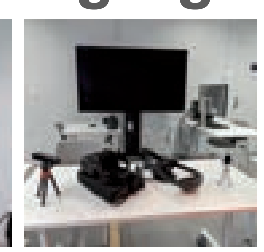
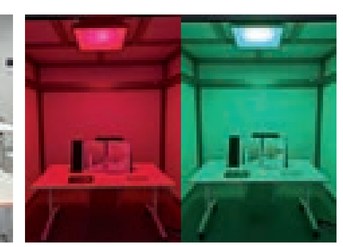
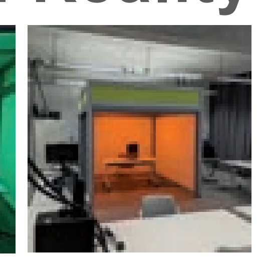
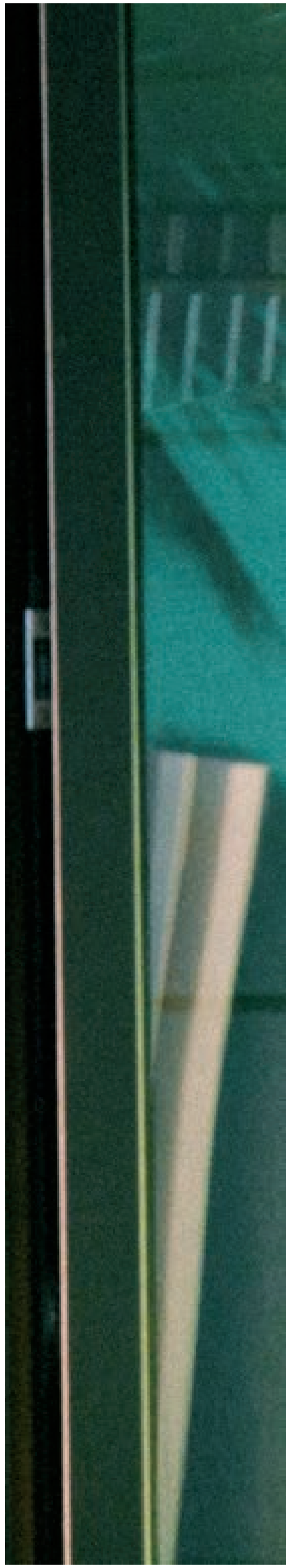




Managed by Jean Monnet University, the IXR platform is a modular space located within the Centre des Savoirs pour l'Innovation. It provides equipment dedicated to Imaging and eXtended Reality with AR/MR/VR devices, innovative screens, and a wide range of imaging sensors: color, stereo, LIDAR, multi- and hyper-spectral, 360° and 3D scanners. Sensors, screens and XR devices can be combined with innovative lighting, such as a 24-channel spectral light or motion capture system.



1976 - 2026 anniversary

50 years 1976-2026

Laboratoire Hubert Curien
UMR • CNRS • 5516 • Saint-Étienne

Drawing up an exhaustive list of all the partners who have accompanied and supported our laboratory over the past 50 years would be an impossible task. Throughout these decades, countless institutions, companies and colleagues have contributed to our scientific journey, our achievements, and our growth.
On the occasion of this 50th anniversary, we would therefore like to express our warmest and most sincere gratitude to all of you.
Your trust, collaboration, support, and shared commitment have been essential in shaping the history and success of our laboratory.
Thank you for sharing this journey with us, and for contributing to what comes next !

thanks to all !

Université Jean Monnet Saint-Étienne

cnrs

Institut d'Optique Graduate School ParisTech

50 years 1976-2026 Laboratoire Hubert Curien UMR • CNRS • 5516 • Saint-Étienne

2025 HIGHLIGHTS

Last year was once again marked by several significant events and projects for the Hubert Curien Laboratory. The following pages present the most important ones.

THREAD Project
THermite REactions Assisting satellite Demise

MOPERE team / Local Project Head: Matteo Ferrari

In May 2025, the european THREAD project was officially launched. Coordinated by the Aerospace Science and Technology Department of Politecnico di Milano in Italy, this ambitious initiative brings together a strong international consortium - including the University of Saint-Étienne and our laboratory's MOPERE team - with the goal of making satellite reentry safer, more controlled, and more sustainable by applying thermite-for-demise (T4D) concepts.

The THREAD project - Thermite Reactions Assisting Satellite Demise - funded under HORIZON-EIC-2024-PATHFINDER, offers an innovative solution to the challenge of the growing number of decommissioned satellites returning to Earth and surviving re-entry, which poses safety risks and environmental concerns on the ground. It is the first EU-funded initiative aiming to introduce the Thermite-for-Demise (T4D) concept directly into the satellite design and manufacturing process.
The idea is to exploit localized exothermic reactions to support the controlled destruction of satellites during reentry. The technology relies on small, non-explosive thermite charges - composed of metal and metal oxide - embedded at key structural points within the satellite. These charges are designed to ignite without any external input and generate intense localized heat that enhances the breakup of the structure, even when satellites are no longer active. Thus, this approach aims at greatly improving safety outcomes on the ground.

The project is coordinated by Politecnico di Milano and led by Professor Filippo Maggi of Aerospace Science and Technology Dept. The THREAD Consortium accounts for nine organisations from four European Countries, including the Université Jean Monnet Saint-Étienne.
THREAD aims to validate T4D technology through material development, wind tunnel testing, and cost-benefit analysis, paving the way for safer and more sustainable satellite disposal within the emerging space economy.

(Words by Politecnico di Milano)

European Innovation Council
Funded by the European Union

Funded by the European Union through the European Innovation Council (EIC) within the THREAD project (Grant Agreement ID: 101186901). Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or European Innovation Council (EIC). Neither the European Union nor the granting authority can be held responsible for them.

Image credits: https://www.aero.polimi.it/it

With its long-term involvement in studies on the response of materials to extreme radiation environments, our MOPERE team will focus on the behaviour of components and systems in space. It will analyse the radiation's effects on thermites with the support of Monte Carlo simulation tools such as PHITS and Geant4, to calculate the typical doses absorbed in-flight by those materials in various operation scenarios. Based on these analyses, a test matrix will be produced for the characterisation of thermite materials. Experimental testing campaigns will be shared between the THREAD partners, including thermal cycles, irradiation in different particle fields, and characterisations including thermomechanical tests, micro- to nanoscale structural and chemical analyses.
According to Matteo Ferrari, who is leading the project for our lab, "THREAD is a disruptive, multi-scale, multidisciplinary project that will complement and potentiate the existing and emerging research activities of our laboratory. Within the MOPERE team, it will particularly reinforce our research axis on the radiation effects on materials, allowing an original use of our irradiation and spectroscopy testing facilities for the characterisation of thermites. The project has a strong environmental impact, and will push the space industry to transition towards a greener paradigm, reducing waste, minimizing the risk of casualties and optimising the used resources".

Further reading :

Thread project dedicated website

Cordis EU webpage

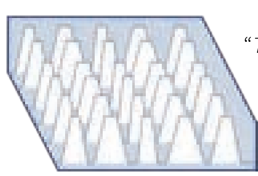
COMETA Joint Lab
Fostering Optical Innovation with Metasurfaces

Functional Materials & Surfaces + Laser-Matter Interaction teams
Project Head: Maxime Darnon

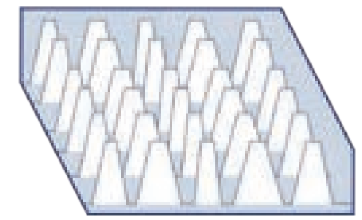
Pictured above:
Representatives of the leading and partner institutions.
Credits: Arnaud Salanon, UJM.

On 14th May 2025, in partnership with Jean Monnet University, CNRS, and HEF Group, our laboratory inaugurated COMETA, a new joint research structure dedicated to the development of next-generation optical components based on metasurfaces. This milestone marked the beginning of a strategic collaboration built on 20 years of shared research and a common ambition: to bring cutting-edge optical components to the market.

Optical components are already omnipresent in everyday devices - mobile phones, vehicles, microscopes, medical instruments, and cameras. COMETA, short for "Composants Optiques à base de METAsurfaces" (Optical Components Based on Metasurfaces), aims to take these technologies a step further by leveraging the unique properties of metasurfaces.
Metasurfaces are micro- and nanostructured surfaces engineered directly onto materials, capable of manipulating light in entirely new ways. These structures allow for a significant reduction in size and weight compared to traditional optics, while also introducing unprecedented design flexibility. This opens the door to optical behaviors that were previously inaccessible.
With these advances, COMETA seeks to enable a new generation of optical systems, paving the way for innovation across multiple sectors including healthcare, digital technologies, defense, space, and environmental monitoring.



"*This is a game-changer,*" explains Maxime Darnon, a member of our lab in charge of COMETA. "*With structures a thousand times smaller than a human hair, we're gaining control over light in ways that push the boundaries of physics and imagination.*"



At COMETA, our lab's scientific expertise in laser physics, photonics, and nanostructure fabrication is combined, for at least the next five years, with the technological and industrial experience of IREIS, the R&D subsidiary of HEF Group. HEF, originally from Saint-Étienne and our next-door neighbour on the Manufacture site, is a global leader in surface materials engineering. The company employs over 3,200 people worldwide, operates 90 industrial sites, and is present in 21 countries.
COMETA aims to develop and manufacture new optical concepts based on metasurfaces, using advanced techniques such as nanoimprint lithography, photolithography, plasma, and laser etching, to engineer thin-film materials with custom optical properties.

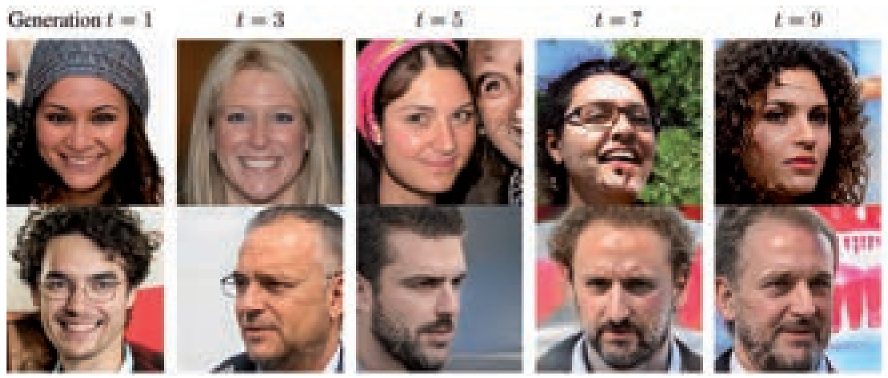
The first major R&D focus involves nanostructured LIDAR windows for autonomous vehicles. Other promising projects in biophotonics and optical sensing are also underway. COMETA is not only a hub for scientific discovery but a driver of industrial innovation.
"*The goal is to create an entire industrial ecosystem around these emerging technologies*," says Laurent Dubost, Head of Photonics R&D at HEF.
More than just a joint laboratory, COMETA represents a vision of photonics as a strategic industrial pillar. Its mission is to become a reference center for foundry-type photonic surfaces, delivering high-end services to European and global partners for the development of advanced optical components.
COMETA is the fourth joint research structure established by our laboratory, continuing a tradition of strategic partnerships that bridge scientific research and industrial innovation. It follows:

- LabH6 (2018) with Exail, a photonic device developer,
- LAMCID (2022) with Toppan Security (formerly HID Global), a specialist in secure identity and access solutions, and
- OPERA (2024) with Orano, a major player in the nuclear energy sector.

With COMETA, we aim to further this dynamic, building on our proven model of innovation in close collaboration with industry. Supported by public institutions, including Saint-Étienne Métropole that contributed to its creation, COMETA is set to make a lasting impact.

LSD and Dynamo Projects
2 new Inria Associate Teams

Data Intelligence / MALICE Inria team
Project Heads: Quentin Bertrand and Jordan Patracone



Since its inception in early 2024, the MALICE Inria project-team, part of our Data Intelligence group, has been conducting research in machine learning and physics-informed models. Inria's Associate Teams program provides one of its main tools for supporting bilateral scientific collaborations and strengthening strategic partnerships abroad. An Associate Team, funded for three years, is a joint research project between an Inria project-team and a partner research group abroad, jointly defining a scientific objective, a research plan, and a program of bilateral exchanges. Within this framework, two MALICE-led projects, LSD (Leveraging Synthetic Data from Generative Models) and Dynamo (Dynamical systems, Analysis, and Machine learning for self-Organization of matter), have been approved as Inria Associate Teams for 2025–2027. These projects foster international collaborations with institutions in Canada and Italy, addressing generative artificial intelligence and physical system modeling, with implications for data management and material simulation.

The LSD project, coordinated by Quentin Bertrand (Data Intelligence team/MALICE Inria), addresses issues in generative modeling, which aims to capture data distributions to produce new samples. Examples include variational autoencoders, generative adversarial networks, and diffusion models, which generate content such as text, images, audio, and video. Models such as DALL-E, Stable Diffusion XL, and Midjourney are trained on large datasets, but these datasets increasingly include synthetic content from prior models. For instance, the LAION-5B dataset includes images generated by earlier systems such as BigGAN, StyleGAN, or DALL-E.
Retraining generative models on synthetic data presents both opportunities and challenges. Synthetic data can support augmentation in tasks including de novo protein generation and natural language processing, such as text generation and prompt-based learning. Fine-tuning large language models on selected synthetic datasets has achieved notable performance in reasoning tasks. However, repeated training on self-generated data can lead to model collapse, where outputs lose diversity, accumulate biases, and deviate from the original distribution.
The LSD project partners MALICE with Mila (Quebec AI Institute) at Université de Montréal, a collaboration that stems from Bertrand's three-year postdoctoral work at Mila, which resulted in publications on topics such as generative model stability, multi-agent reinforcement learning, and optimization methods.
The project's research plan begins with the establishment of theoretical foundations for self-consuming generative models, examining stability in recursive training and proposing measures to avoid collapse. The following phase will focus on strategies for curating data, employing reinforcement learning and optimization to select synthetic samples that improve performance in subsequent tasks. The final stage will apply these approaches to practical settings, such as vision and text-to-image generation, assessing effects on model outputs and bias mitigation.

The Dynamo project, led by Jordan Patracone (Data Intelligence team/MALICE Inria), investigates self-organization, where ordered patterns arise spontaneously from disordered states. In surface engineering, ultra-short laser pulses interact with materials to induce nanoscale patterns. This laser-driven self-organization, controlled by precise laser settings and surface properties, creates patterns with potential for hydrophobic, antibacterial, or microbiological applications, promising advancements for industries needing specialized materials. Modeling these processes is complex, as they involve dynamics governed by partial differential equations (PDEs), which traditional solvers handle inefficiently due to fine computational grids, limiting scalability for high-resolution or multi-scale simulations.
Dynamo will develop a framework for learning dynamical systems characterized by self-organization, with a focus on the laser-matter interaction task. The project specifically addresses low-data and low-model regimes, where training data are scarce, physical models only partially describe ultrafast dynamics, and femtosecond interactions prevent observing intermediate states. Unlike other dynamical systems, this setting precludes applying existing physics-informed machine learning methods directly.
The project aims to design reliable, efficient, and interpretable algorithms to predict the distribution of resulting nanoscale patterns from initial conditions, despite data scarcity and the chaotic nature of the dynamics. This will be achieved by integrating data-driven and physics-informed approaches with theoretical advances in stability and generalization.
The project involves collaboration between our MALICE Inria project-team and the Istituto Italiano di Tecnologia (IIT) in Genoa, building on Patracone's prior IIT postdoctoral work and joint publications in statistical learning.

The LSD and Dynamo projects embody MALICE's commitment to integrating artificial intelligence with physical sciences, addressing critical challenges in data science and material engineering. Through partnerships with Mila and the Istituto Italiano di Tecnologia (IIT), these projects leverage complementary expertise - Mila's proficiency in generative models will enhance LSD's optimization strategies, while IIT's knowledge of statistical learning and dynamical systems will strengthen Dynamo's focus on laser-driven self-organization. Supported by the Inria's Associate Team framework, both projects will facilitate researcher exchanges, joint PhD supervisions, and the development of open-source tools. MALICE aims to organize workshops in Saint-Étienne, Montreal, and Genoa to foster knowledge sharing and plans to disseminate findings through publications in top-tier conferences such as NeurIPS and ICLR. These efforts align with our laboratory's diverse research areas, contributing to advancements in AI reliability and material simulation, with potential impacts: across industries from healthcare to sustainable technologies.

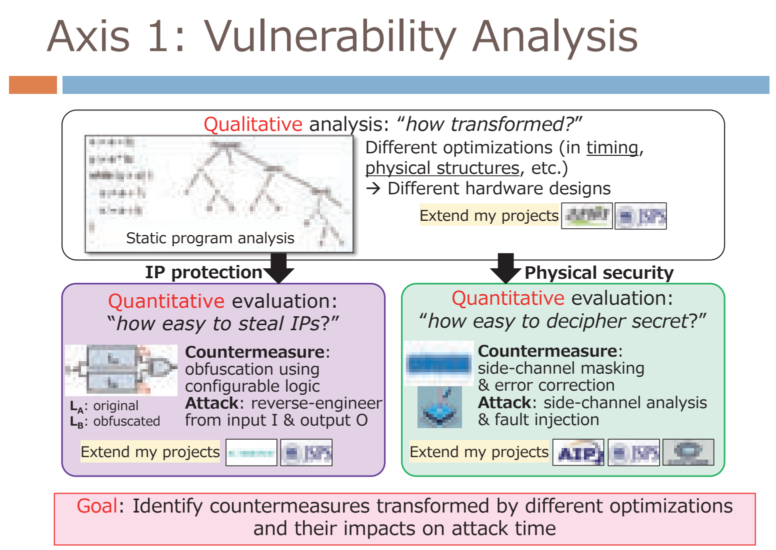
- Highlights -

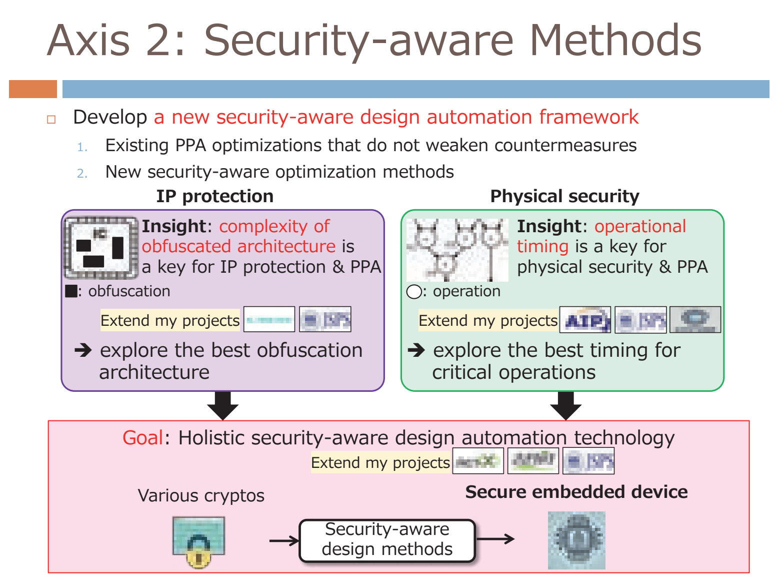
Newly appointed CNRS Research Director Professor Yuko Hara *joins our lab's SESAM Team*

In November 2025, our laboratory welcomed researcher Yuko Hara, who joined us from the Institute of Science Tokyo. Her integration project focuses on "Hardware Security-aware Design Automation Technology."
In this article, Yuko answers a few questions about her background, her research, and her motivation for joining our lab.

"To get a senior foreign researcher recruited at the CNRS is very challenging, but we succeeded thanks to the relevance of Yuko's scientific project and her impressive career path. This is a great opportunity for the SESAM team and the lab to expand its expertise by incorporating system security from the design stage, as well as extending its international reach."

Lilian Bossuet,
Head of the SESAM team (2015-2025)





1. Can you tell us a few words about your academic background?

My research background lies in system-level Electronic Design Automation (EDA) technologies - mainly high-level synthesis and hardware/software co-design for embedded systems. Because design decisions at these higher-level abstractions of embedded systems have major impacts on the final embedded systems designs, best decisions are always critical. Also, as the technology advances, more design metrics are taken into account in these automation technologies. This naturally expanded my research from basic trade-off exploration (e.g., circuit area vs. performance) toward more advanced optimization techniques addressing power/energy consumption, fault-tolerance, and security.

2. What has been your motivation for moving to France and joining our laboratory?

My expertise lies in EDA, but I'm still relatively new to the field of security. I started some hardware security related projects about 5-6 years ago in Japan, but I feel that there are still so much to learn. I admire the theoretical and practical approaches taken by researchers in this lab and the SESAM team. If I could add the EDA essence to these perspectives, we would have many more various and thrilling things to work on together. This type of collaboration is what I have been longing for.

3. Can you explain your project within the SESAM team?

My current research interest is to automate security-aware embedded systems designs. When it comes to embedded systems security, there are a variety of phases and several types of vulnerabilities to address. I am currently mainly interested in two areas:
- The supply-chain security: "how can we protect hardware intellectual properties (IPs) against IP thefts such as reverse engineering and counterfeiting?", and:
- The physical side-channel security: "how can we prevent sensitive information from leaking through side-channel analysis?". Countermeasures for these security issues are complex, time-consuming (they have been manually applied), and costly – so introducing automation in order to reduce time-to-market and enable the exploration of a trade-off with other design metrics are important. I consider these topics challenging but truly exciting to work on.

4. What has your experience been like settling into life and work in France so far?

Frankly speaking, moving to France from Japan was very challenging and required a lot of energy. Still, I wanted to challenge myself and find an environment where I could collaborate with diverse researchers on a daily basis. In the current multidisciplinary era, such collaborations and mobilities are really essential in research. I also remember how excited I was after my initial discussions with members of the SESAM team, which motivated me to seize this opportunity. The warm support from my colleagues has facilitated my transition from life in Japan to Saint-Étienne.

Unveiling Laser-Induced Structural Transformations
A review by Razvan Stoian & Tatiana E. Itina

Laser Matter Interaction team

With a focus on designing states of matter and thus new material properties using lasers, the Laser-Matter Interaction (ILM) group at the Hubert Curien Laboratory advances the understanding on the intimate mechanism by which intense laser light can reshape materials at the nanoscale and below. Combining real-time observation, advanced microscopy, with cutting-edge simulations, the ILM team has promoted new insights into laser-induced structural transitions in materials of practical interest, opening opportunities for designing new materials and functionalities.

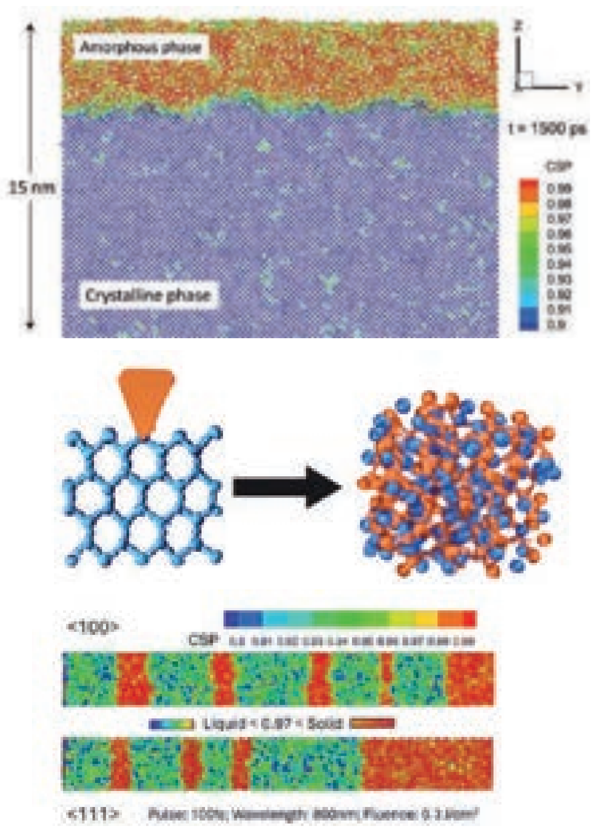
The starting point is the fundamental observation that ultrashort, intense femtosecond laser pulses can drive materials into exotic, non-equilibrium states that reorganize the electronic energy landscape, the bonding between atoms and molecules, and eventually restructures the solid into new structural arrangements. Uncovering this phenomenological complexity, ILM progressed into understanding how electronic excitation can disorganize solids and determine melting and gas/plasma transformation on ultrafast scales, including the formation of fleeting amorphous layers and even prompting surfaces to self-sculpt into intricate patterns. Their research has dissected the mechanisms that govern these transformations, revealing how phenomena such as confinement and extreme cooling can stabilize structural states that were previously deemed unattainable in familiar materials like silica, sapphire or silicon.

Pushing up the fundamental understanding with unprecedented resolution, matching the optical cycle, the ILM group has delved into the underlying electronic dynamics that govern these laser-induced transformations. The recent study published in npj Computational Materials (2024) unveiled, using state-of-the-art computational techniques, the intricate interplay between laser excitation and electronic structure, demonstrating how laser pulses can selectively excite specific electronic states, leading to targeted material modifications and design at the nanoscale. By harnessing sophisticated quantum simulations, the ILM team mapped dramatic changes in key electronic parameters - such as heat capacity, pressure, and effective mass - as a function of the excitation dose. These findings have revealed how orbital distortions orchestrate energy relaxation and phase evolution, providing key knowledge for optimizing energy-efficient material modifications impacting 3D photonics, high-density optical storage and nonlinear photonics. (Tsaturyan et al., Comp. Mat., 2024; Tsaturyan et al., Adv. Physics Res., 2025).

Harnessing the interplay between electrons, phonons and structure, ILM's research extends to atomistic modeling. A prominent example shows how to define the precise conditions required for achieving nanometric amorphization of silicon using ultrashort laser pulses. By seamlessly linking atomistic molecular dynamics with continuum transport models, the team have developed the ability to not only describe and predict, but also to ultimately control the formation of functional disordered layers. This level of control is pivotal for advancing microelectronics and data storage solutions, where cooling profiles and electron-phonon coupling play critical roles (Itina et al., ChemPhysChem, 2025; Tatiana E. Itina, Nanoscale Adv., 2024).

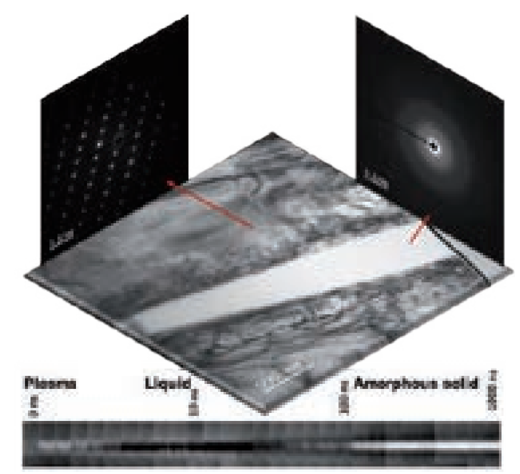
Their innovative approaches, applied to self-organized nanostructures on various materials, show the potential for large-area fabrication of metamaterials and other advanced functional surfaces (Omeje et al., Surf. & Interfaces, 2025) including the correlation between structural and chemical evolution (P. Dominic et al., Appl. Surf. Sci., 2024).

Right: Itina et al., ChemPhysChem, 2025;
T.E. Itina, Nanoscale Adv., 2024.
(See p. 11 for further details)



The predictive simulation approach is intrinsically related to observing the transformation in space and time, aiming to observe the formation of new, exotic structural states of matter. In a recent highlight, the ILM team demonstrated the remarkable ability to induce dynamic ultrafast laser-induced structural changes and extreme nanostructuring in hard dielectric materials. By meticulously controlling femtosecond laser pulses, they can create complex material morphologies and intricate nanostructures, opening exciting new avenues for the creation of advanced optical components. (Nguyen et al., Ultrafast. Sci., 2024; Dwivedi et al., ACS Photonics, 2025). New high-density forms of amorphous and crystalline materials polymorphs can be created from melt-quench under ultrafast irradiation and stress confinement even if the probability is, in standard conditions, low (Dwivedi et al., ACS Photonics, 2025; A. Yedigaryan et al., Appl. Phys A, 2025). As the dimensional scale shrinks to the nm level, new challenges are foreseen in defining the drivers of a phase transition intermediated by electronic excitation. Pushing the dimensionality to 2D, recent work on laser-induced exfoliation of 2D materials has also generated significant interest, offering a rapid and scalable method for reorganizing atoms in two dimensions and for producing e.g. high-quality graphene and other nanomaterials (Omeje et al., ACS Appl. Nano Mater., 2024); Tatiana E. Itina, Nanoscale Adv., 2024).

Right: Dynamics of amorphisation of sapphire under confinement via ultrafast time-resolved phase imaging and structural probing of the final material state.



- Highlights -

i-Démo SOFTEN Project
Advancing energy efficiency in ski resorts

Image Science & Computer Vision
+ Data Intelligence teams
Project Head: Christophe Ducottet

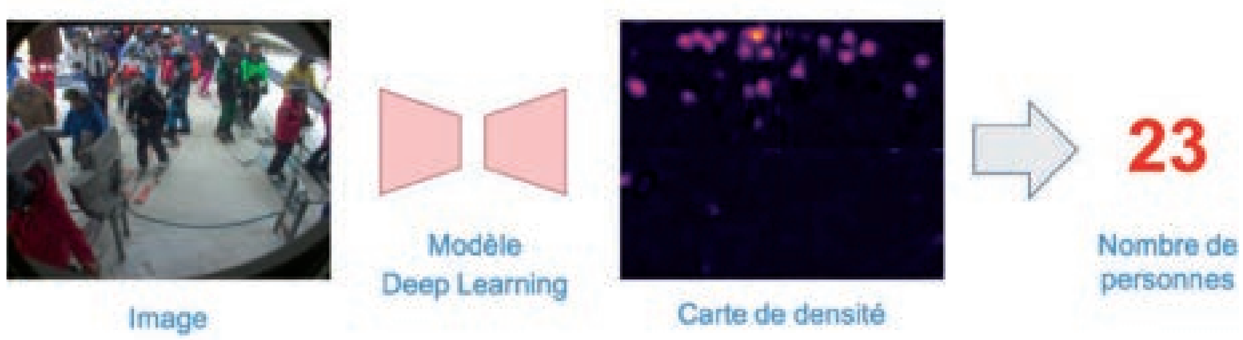
Our world is undergoing profound climatic, geopolitical, and economic transformations. Tourism, directly impacted by these factors, is evolving in response. As access to resources changes dramatically, ski resorts are no exception: they must reinvent their appeal and sustainability. One of the most pressing challenges for ski areas today lies in their high energy consumption, particularly their use of electricity. Resorts are already facing steep and volatile increases in energy costs, adding to a long-term rise in the amount of energy required to meet growing customer expectations for a high quality of service. It has therefore become essential to rethink the mountain resort of the future, first and foremost through the lens of its relationship with resources. Field feedback following the installation of Grenoble-based company Bluecime's flag-ship system, SIVAO, in numerous French and international ski resorts, has demonstrated that intelligent systems can both encourage more responsible skier behaviour and simplify the work of resort operators. Building on the success of the MIVAO project (FUI AAP 23), completed in 2021 and involving our laboratory, Bluecime - a developer of innovative image-processing and AI solutions for ski resorts - initiated a new partnership in 2023 with academic research teams and ski resorts, leading to the SOFTEN Project (Solution for the Optimization of Skier Flow for the Energy Transition of Ski Areas). Funded within the framework of France 2030 plan's regionalized i-Démo program, SOFTEN aims to reduce electrical energy consumption in ski resorts by up to 20%, equivalent to savings of approximately 57,6 MWh (~ 15 K€ -estimation for 2022) per chairlift over a winter season.

The SOFTEN consortium includes, in addition to our laboratory and project coordinator Bluecime, the following partners: G-SCOP Lab (INP - UGA Université Grenoble Alpes), Domaine Skiable de Valmorel, SOFIVAL Group.
The work focuses on developing a comprehensive and predictive understanding of skier movements across entire ski domains, with the objective of achieving significant reductions in electrical energy consumption.
These savings will be enabled by:

- **Continuous, real-time adjustments to the speed of each ski lift**, based on both current and predicted skier traffic across the entire resort, without compromising the visitor experience;
- **The design of optimized skier routes** that promote smoother, more energy-efficient use of ski lifts, and a high level of skier satisfaction;
- **The provision of measured, predictive, and statistical indicators to resort operators**, enabling the design of short- and long-term strategies to optimise overall energy consumption and improve infrastructure management - for example, by targeting on-site interventions by specialised staff, anticipating slope bottlenecks, and informing investment decisions.

The project embodies three complementary ambitions:

- **ecological**, by promoting the efficient use of energy resources;
- **technological**, by leveraging advanced computer vision and artificial intelligence to foster innovation in ski resorts;
- and **societal**, by seeking a sustainable balance between responsible resource management and the pursuit of comfort and enjoyment in leisure.



At our lab, SOFTEN is led by Christophe Ducottet (Image Science & Computer Vision team), working alongside Rémi Emonet (Data Intelligence team), Damien Muselet (L3I, La Rochelle), PhD student M'Saydez Campbell, and postdoctoral researcher Cyril Li. Our contributions primarily address the accurate quantification of people in lift queues, and the analysis of skier flow on slopes using video feeds. The lift queue evaluation task involves deep learning models that generate density maps from images, from which the number of persons present is derived (see Figure 1). The process begins with a pre-trained model on generic datasets, followed by fine-tuning on domain-specific data from ski resorts. To enhance robustness, training data is augmented by simulating varied weather conditions such as fog or snow, emulating the visual challenges encountered in mountainous environments. This approach proposed by Cyril Li achieves high accuracy counting. It is already integrated in a new commercial product that Bluecime started deploying in 2025 in several ski resorts. This extension allows resort operators to monitor lift queues in real time. Beyond queues, our lab tackles skier flow analysis on slopes. This presents unique challenges such as occlusions from trees or lifts, different sizes of bounding boxes enclosing people, and variable speed of skiers. In a first study, M'Sayzed Campbell proposed a video tracking dataset containing a set of fully annotated skier tracks, as well as a benchmark to evaluate the performance of state-of-the-art tracking methods on this dataset. The project, spanning four years with a €3.337 million budget, anticipates the first commercialisation of the full solution in 2027, creating 8 jobs during development and 27 long-term. Looking ahead, SOFTEN's technologies extend beyond skiing, to urban transport or crowd management in events. By bridging computer vision with energy transition, this project not only advances sustainable tourism but also reinforces our laboratory's role in societal impact.

Figure 1, opposite: Deep learning model for lift queue evaluation

RESEARCH CONTRACTS & PARTNERSHIPS

Our lab is consistently pursuing a policy of very active engagement in national and international projects.
In this section, we compile our on-going projects supported by the European Commission, the ANR, the Auvergne-Rhone-Alpes Region and by our industrial partners. A short selection of these projects are also developped here.

In 2025, our research teams were involved in nearly 180 funded projects, including 7 European and 37 ANR-funded projects, as well as 7 projects financed by the Auvergne-Rhône-Alpes Region. Several of our doctoral students are pursuing their PhDs under CIFRE agreements or other industrial doctoral contracts.

ongoing 2025 ANR PROJECTS

Project acronym *& title*		Ref. no: ANR-	Team
ROIi	*Rey's Ornament Image investigation*	20-CE38-0005	ISCV
TAUDOS	*Theory and Algorithms for the Understanding of Deep learning On Sequential data*	20-CE23-0020	DI
MUDIALBOT	*Multi-party perceptually-active situated Dialog for human-robot interaction*	20-CE33-0008	ISCV
GESPAD	*Ge-based Single Photon Avalanche Diodes: from comprehensive characterization to advanced simulation*	20-CE24-0004	ISCV
FIDELIO	*Fiber-based In-vivo Realtime Dosimetry for Pulsed Radiotherapy*	20-CE19-0024	MOPERE
NOEMR	*Nano-structured smart hybrid polymeric composites with internal architecture towards improving ultra-high absorbance of ElectroMagnetic Radiation*	20-CE06-0003	FMS
DIKÉ	*Bias, fairness and ethics of compressed NLP models*	21-CE23-0026	DI
CRUMBLE	*Chromium-based coatings for lasers*	21-CE24-0034	FMS
UNDERNEATH	*Understanding Deep Neural Networks with Game Theory*	21-CE23-0022	DI
ASTRAL	*Statistical learning for multi-dimensional SAR imagery*	21-ASTR-011	ISCV
NITRURATION	*Manufacturing process of micro-nanostructured metal nitrides*	21-CE08-0042	FMS
DENSE	*Dense structures on the nanoscale*	21-CE08-0005	LMI
POP	*Power-OFF laser attacks on security Primitives*	21-CE39-0004	SESAM
SAFE	*Controlling networks with safety bounded & interpretable machine learning*	21-CE25-0005	DI
AWOCAT	*Toward a switchable bio-activity of metallic glass surfaces by ultrashort laser irradiation*	22-CE08-0030	LMI
COULEURS	*Resonant Microstructured luminescent layers*	22-CE39-0013	FMS
LAST_FLOW	*Femtosecond Laser Structuration for Functionalization of Optical Windows*	22-CE24-0026	FMS
PROPHY	*Algorithmic protections against physical attacks*	22-CE39-0008	SESAM
ATICS	*Advanced Three-dimensional Imaging of Complex particulate Systems*	23-CE51-0023	ISCV
FAMOUS	*Fair Multimodal Learning*	23-CE23-0019	DI
FLUOSICCA	*Double fluorescent Staining of the Ocular Surface in dry eye disease*	23-CE19-0022	ISCV
LAMORSIM	*Laser-forming of ultrathin amorphized Si layer for microelectronics applications*	23-CE08-0029	LMI
SCAMA	*Secure-by-Design Computing Against Microarchitectural Attacks*	23-CE39-0011	SESAM
SLICID	*Secured laser printing of color images in identity documents*	23-CE39-0006	FMS
MAGMAA	*Machine learning to improve neonates' General Movements Assessment*	23-SSAI-0005	ISCV
CANDYCE	*Magnetic composites based on gold-functionalized YIG or Ce-YIG nanoparticles*	24-CE09-7888	FMS
MELISSA	*Methodological contributions in statistical learning inspired by surface engineering*	24-CE23-7140	DI
ULTRAVIBE	*Unravelling ultrafast heat transfer in glasses by direct MIR probing of anharmonic vibrations*	24-CE08-3983	LMI
ULTRAZO	*Ultimate laser-driven restructuring and defect formation dynamics in doped ZnO thin films*	24-CE08-7917	FMS
INSEPTION	*Investigation of nonlinear propagation of ultrafast infrared laser pulses inside narrow-bandgap semiconductors*	24-CE92-0007	LMI
GENIE	*Generative Network Intelligence and optimization Ecosystem*	24-IAS1-0005	DI
VO2Random	*Vanadium Dioxide-Based Films for Randomizing Integrated Circuits Photonic Emission and Absorption*	23-CE39-0004	LMI
ACOULAK	*Underwater Acoustic Pollution in Peri-Alpine Lakes: Characterization and Ecological Impacts*	25-CE34-1339	DI
CAPFAS	*Optical Sensor for PFAS Detection*	25-CE04-5930	FMS
DATES	*Domain Adaptation on Time Series*	25-CE23-6035	DI
MONALISA	*Monotone Operators and Neural Architectures: Leveraging Interactions for Physically Structured Approximations*	25-CE23-5511	DI
SPINNACH	*Secured Spiking Neural Network for Autonomous Architectures*	25-CE25-3772	SESAM

KEY TO TEAMS:

FMS	**Functional Materials & Surfaces**
MOPERE	**Materials for Optics & Photonics in Extreme Radiation Environment**
LMI	**Laser Matter Interaction**
ISCV	**Image Science & Computer Vision**
DI	**Data Intelligence**
SESAM	**Secure Embedded Systems & Hardware Architectures**

50 ongoing 2025 **INDUSTRIAL PROJECTS**
21 ongoing 2025 **CIFRE theses**

ongoing 2025 EUROPEAN COMMISSION PROJECTS

Project acronym *& title*		Team
RADNEXT	*RADiation facility Network for the EXploration of effects for indusTry and research*	MOPERE
PHOTONHUB	*Services to support your innovation in Photonics*	MOPERE
CIRCULIGHT	*Circulating light on any photonic platform*	FMS
RAVEN	*Revolutionary Accuracy in waVeguide- and photoacoustic-ENabled atmospheric sensors*	FMS
xDDIFF	*Multidimensional optical diffusion for the measurement of appearance*	ISCV
RETURN	*Recovering Electronics Parts and Materials for Maximum Resource Efficiency*	ISCV
THREAD	*Thermite reactions assisting satellite demise*	MOPERE

ongoing 2025 AURA REGION PROJECTS (Auvergne-Rhône-Alpes)

Project acronym *& title*		Team
SLIM	*Innovative Laser Additive Synthesis for Magnetic Materials*	FMS
PAI 2021	*Lighting and mixed reality for the assistance of the visually impaired*	ISCV
SECURE-RISC-V	*Secure version of the Risc-V architecture*	SESAM
CAPTHY	*Optical Sensors for Hydrogen detection*	FMS
BOOSTER QABOT	*Question Answering & Chatbot*	DI
PAI 2024	*Micro Nano structuration de surface pour le photovoltaïque*	FMS
PAI 2025	*Explainable AI and Bias mitigation with Complex Data*	DI

new 2025 ANR projects

In 2025, a total of 5 projects submitted by the Hubert Curien Laboratory were selected for an ANR AAP 2025 funding. The list of these projects reflects the variety and quality of the research carried out in our lab.

JCJC PROJECT: MONALISA
Partners: Italian Institute of Technology, Sapienza University of Rome, Université Lumière Lyon 2, Hubert Curien Lab
Project coordinator: Hubert Curien Lab
Coordinator: Jordan Patracone
Data Intelligence team

MONALISA - "Monotone Operators and Neural Architectures: Leveraging Interactions for physically Structured Approximations"
MONALISA investigates physics-informed neural operators for modeling complex, high-dimensional dynamical systems governed by PDEs. These operators capture continuous mappings between function spaces, enabling faster predictions than traditional solvers. The project aims to understand and control their complexity by leveraging monotone operator theory, designing architectures guided by physical laws, and applying both explicit and implicit regularization at layer and training levels. Theoretical guarantees will be derived from monotone operator theory and reproducing kernel Banach spaces. A key application is laser-matter interaction, where structured operators are crucial due to limited data.

PRC PROJECT: SPINNACH
Partners: IRISA Université de Rennes, LEAT Université Côte d'Azur, Hubert Curien Lab
Project coordinator: Hubert Curien Lab
Coordinator: Cédric Killian
SESAM team

SPINNACH- "Secured Spiking Neural Network for Autonomous Architectures"
The SpiNNAch project focuses on energy-autonomous IoT nodes, addressing the combined challenges of energy efficiency, adaptive quality of service (QoS), and security. It aims to develop secured, adaptive Spiking Neural Networks (SNNs) that adjust QoS based on user needs and the availability of harvested energy, enabling autonomous operation under unpredictable energy conditions. The project will explore trade-offs between latency, accuracy, and energy consumption for efficient SNN hardware, design energy managers leveraging adaptive SNN behavior, and evaluate security vulnerabilities tied to SNN parameters and architecture. Countermeasures will be proposed to ensure node security while respecting strict energy and area constraints.

PRCE PROJECT: DATeS
Partners: IRISA Université de Rennes, Ericsson France, Hubert Curien Lab,
Project coordinator: Hubert Curien Lab
Coordinator: Rémi Emonet
Data Intelligence team

DATeS - «Domain Adaptation on Time Series»
The DATeS project tackles domain adaptation for time series, where shifting data distributions over time and across contexts challenge traditional machine learning assumptions. Time series data introduces specific difficulties such as temporal drift, class imbalance, correlations, and multi-scale patterns. DATeS addresses three key challenges: aligning temporal and domain shifts using generalized optimal transport and conditional flow matching; handling missing data and source-free adaptation; and performing unsupervised adaptation by selecting optimal models, sources, and hyperparameters without labeled target data. By developing methods tailored to these challenges, the project aims to advance domain adaptation for time series and inspire broader innovations applicable to other domains.

PRCE PROJECT: CAPFAS
Partners: MAPIEM - Université de Toulon, EFS, Hubert Curien Lab,
Project coordinator: Hubert Curien Lab
Coordinator: Yves Jourlin
Functional Materials & Surfaces team

CAPFAS - «Optical Sensor for PFAS Detection»
From January 2026, regulations will require monitoring drinking water for PFAS. The CAPFAS project aims to develop a new generation of miniaturized optical sensors capable of detecting PFAS at levels below 0.01 µg/L. The technology combines a patented optical transducer based on surface plasmon resonance with functional molecularly imprinted layers, enabling high sensitivity and selectivity. Building on proofs of concept from the ANR CAPTAIN project, CAPFAS will leverage expertise from the MAPIEM laboratory for functional layer development and from EFS for sensor integration and commercialization. This integrated approach addresses the challenge of real-time, precise PFAS detection in drinking water.

PRC PROJECT: ACOULAK
Partners: CRNL, Carrtel Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement, Hubert Curien Lab
Project coordinator: CRNL
Lab's PI: Marc Sebban
Data Intelligence team

ACOULAK- "Underwater acoustic pollution in peri-alpine lakes: Characterization and ecological impacts"
Lakes provide vital ecosystem services, but rising recreational activities, especially motorized boating, are causing increasing acoustic pollution both above and below water. This project focuses on underwater sound pollution in peri-alpine lakes, aiming to characterize spatial and temporal patterns using passive acoustic monitoring and machine learning. It will also assess impacts on dreissenid mussels and Eurasian perch larvae through lab and field playback experiments, testing whether elevated sound levels trigger stress responses. By combining expertise in ecology, animal behavior, limnology, and computer science, the project will generate fundamental knowledge, international publications, a comprehensive freshwater soundscape database, decision-support tools for lake managers, and public outreach materials to support sustainable lake management.

PEPR projects

Many members of the Hubert Curien Laboratory are involved in the follow-up of the «France 2030» programs, initiated in 2021 by the French Government. As such, Priority Research Programs and Equipment (PEPR) aim to build or consolidate French leadership in scientific fields linked to technological, economic, societal, health or environmental transformation, which are considered as priorities on a national and European levels. We present here a list of the selected programs in which our lab is involved.

PEPRs exist in 2 forms: "national acceleration strategy PEPRs" and "exploratory PEPRs". These programs benefit from a state financial support, and are managed by the National Research Agency (ANR). Each scheme is either an existing, already mature project for which a contract binding a coordinating establishment and the ANR is established, or a project selected following an open call for proposals (AAP) or calls for expressions of interest (AMI), and related to the program's thematic.

National Acceleration Strategy PEPRs:
These PEPRs support transformations already underway with well-identified products, services, uses and actors. Approximately 20 acceleration strategy PEPRs have been identified, most of which are piloted or co-piloted by the CNRS.

Cybersecurity PEPR:
With a budget of 65M€, this PEPR aims to support upstream cybersecurity research by exploring new avenues potentially leading to breakthrough innovations to the benefit of the French sector.
The Hubert Curien Laboratory's SESAM team is involved in this program through the 550k€ "Secure architectures for embedded digital systems" (ARSENE) project, headed by Lilian Bossuet. The project focuses on hardware security and heavily constrained processors for embedded computing, such as headsets or on-board computer systems in cars.

Quantum Technologies PEPR:
For reasons of national and European sovereignty, the French state is seizing on the problem of quantum technologies' development. It seeks to reach the highest level of international scientific and industrial competition, and hopes for France and Europe to gain their independence in this key area thanks to a 150M€ program that should enable the development of its own solutions.
With its «Post-quantum padlock for web browser» project, our SESAM's team is contributing to resolving the problematic of this program.

Electronics PEPR:
Electronics is a core issue regarding the digital functionalities of products and services in our societies. This 86M€ program is aimed at generating innovations to accelerate growth and relocate the manufacturing of certain products to France or Europe.
Our NanoSaintÉtienne (RENATECH+) platform benefits from part of the 39M€ of this PEPR dedicated to support the equipment of the CNRS RENATECH / RENATECH+ infrastructures.

Our lab is also involved in the Artificial Intelligence PEPR and the TASE-Advanced Energy Systems Technologies PEPR.

Exploratory PEPRs
With these PEPRs, the State intends to support the exploration of emerging transformations' potentials. Projects should here follow a scientific policy aligning with national and European interests, with potential multiple outcomes.

Origins PEPR:
This 45 M€ PEPR intends to remove scientific barriers related to the study of life and the universe, with a view towards multiple implications on the national technological expertise and, consequently, on the country's economy, health and environment.
Our lab is involved in this program as part of a work package, led by Loïc Denis, grouping AI activities for the processing of multivariate data for the detection and characterization of exoplanets and disks. His «Unsupervised A0 Control» and «AI Data Analysis» projects are featured pages 20 and 21.

LUMA PEPR - Promoting Light-Matter Interactions:
Light, omnipresent in our natural and technological environment, is the subject of this 40M€ program. LUMA aims to study, understand and develop this unique tool as a means of exploring and controlling physico-chemical and biological systems, at the interfaces between physics, chemistry, engineering and life sciences, and between health and environmental / climate science.
This program is divided into 4 major work packages: Moonshot projects, Infrastructure, Innovation/incubators and Management/coordinated actions. Nathalie Destouches, together with Dario Bassani from ISM Bordeaux, is co-hosting the Moonshot Project MP2 "Smart Photoprocesses at Ultimate Space and Time Resolutions". This PEPR also funds the access (50 days/year) to the lab's NanoSaintÉtienne and Ultrafast Laser technology platforms.

Our lab further contributes to the Diademe - Integrated Devices for Accelerating the Deployment of Emerging Materials PEPR and the Spin - SPINtronics innovations for a frugal, agile and sustainable digital technology PEPR.

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

Collaboration with ST Microelectronics

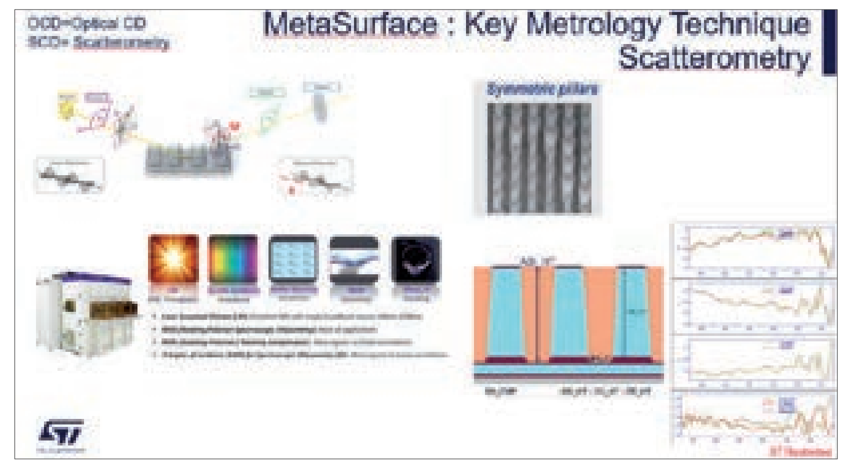
3 new CIFRE contracts

ST Microelectronics is a global integrated device manufacturer and a European leader in semiconductor chips manufacturing. Three new collaborative research activities started between this company and our laboratory in 2024/2025, within the framework of the PhD theses of Chahida Belhadj-Youcefi, Damien Maître and Giorgio Zuccalà. Microelectronics manufacturing relies on inspection and metrology techniques to detect wafer defects and monitor key physical parameters at various process steps. Inspection focuses on locating and classifying defects - often using AI - while metrology tools like ellipsometers and scatterometers assess film thickness and pattern dimensions.

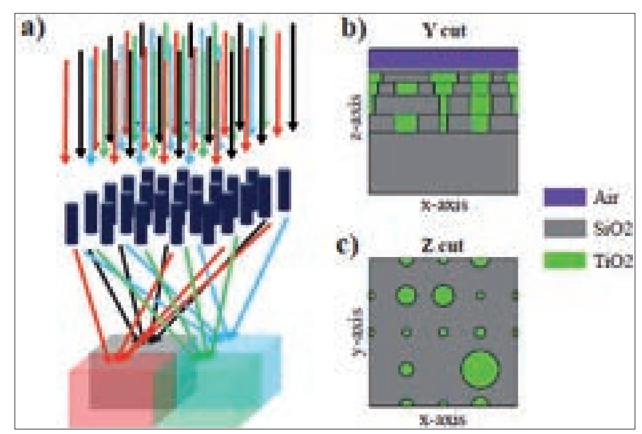
The thesis of Chahida Belhadj-Youcefi focuses on new approaches of optical metrology techniques using spectroscopic ellipsometry to inspect optically-active structures such as metasurfaces. Indeed, optical metasurfaces fabricated using CMOS-compatible methods present a huge potential for integration of advanced optical components within opto-electronic circuits like imagers. Designing such devices requires finding an optimal configuration to address the challenges of metasurfaces metrology (see figure).

In this context, the thesis of Damien Maître consists in implementing automatic differentiation optical modeling methods to reduce computation time and favor the convergence towards optimal design. Other optical components based on silicon photonics are developed and commercialized by ST microelectronics. Such devices are used for critical applications such as datacenters, automotive, space missions and nuclear facilities, where reliability is a key aspect.

During the thesis of Giorgio Zuccalà, we will assess the reliability of silicon photonic technologies exposed to a variety of radiation environments and identify radiation-related failure mechanisms of this innovative technology. Based on the acquired knowledge, the vulnerability of silicon photonics will be evaluated and radiation hardening techniques applied when needed.

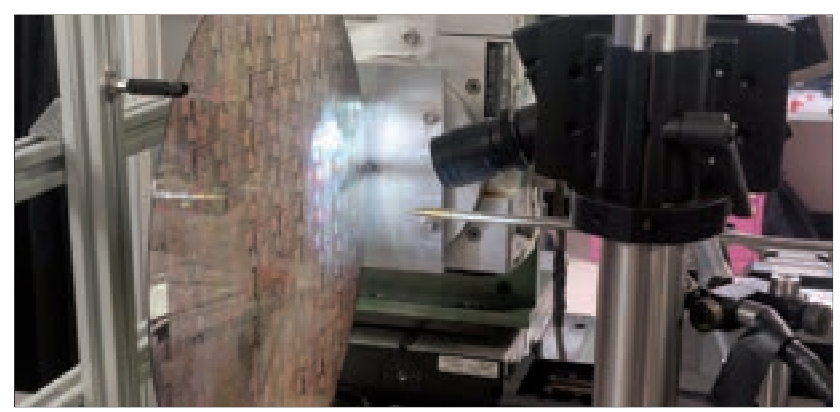


Project 1
(Chahida Belhadj-Youcefi)
Functional Materials & Surfaces team.
Local Scientific contacts:
Y. Jourlin, V. Kalt, D. Jamon.
Period:
February 2025 to 2028.



Project 2 (Damien Maître)
Functional Materials & Surfaces +
Image Science & Computer Vision teams.
Local Scientific contacts:
M. Darnon, R. Clerc, J.P. Banon.
Period: December 2024 to 2027.

Figure, left: Example of optical metasurface used as color router to improve imagers efficiency: the metasurface displayed on the right-hand side (cut and top view) directs lights towards various parts of the pixel depending on the color. [Maitre et al. SISPAD conference 2025]



Project 3
(Giorgio Zuccalà)
MOPERE team.
Local Scientific contacts:
S. Girard, E. Marin, M. Darnon.
Period: May 2025 to 2028.

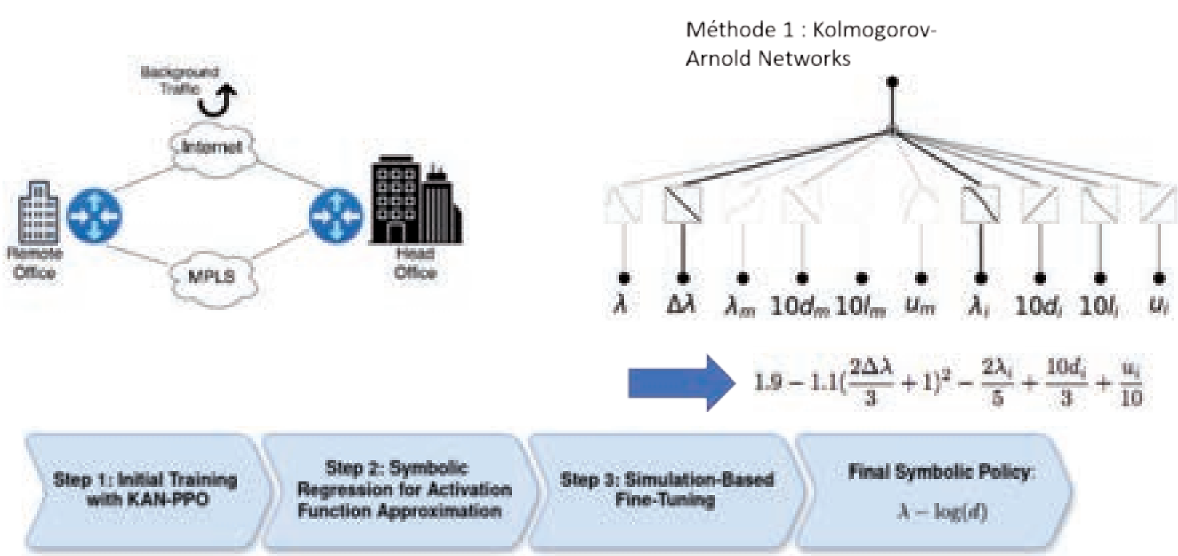
Image credits:
@Victor Malherbe - STM

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

SAFE

ANR PRCE Project

In the ever-evolving field of communication networks, traditional control methods are insufficient as they require extensive knowledge of system and user behaviors. Data-driven AI approaches, while flexible, lack safety guarantees and interpretability. SAFE (Controlling Networks with Safety Bounded and Interpretable Machine Learning) is a 4 year project started in 2022, funded by ANR France that aims to bridge this gap by creating an innovative approach that combines the best of both worlds. In this project, the intelligence is distributed in the network between a global AI (at the central level) and local AIs (at the edge level) collaborating with each other by integrating traditional models with graph neural networks and reinforcement learning. The approach, developed for partially or completely observable/controllable environments, will natively integrate safety bounds, interpretability and provide self-adaptive systems for routing, traffic engineering and scheduling.



Data Intelligence team
Scientific leader: Kamal Singh
Contract duration: 56 months
Start Date: March 2022
Partners: Hubert Curien Lab (coordinator) + IRISA, Université de Rennes, Université Cote D'azur, Université de Poitiers, Huawei, QoS Design,
Total budget: 734 k€

Thus, this project focuses on designing safety bounded and interpretable ML solutions for controlling networks. This will help service providers to trust the designed solutions.

Hierarchical architecture: Assuming modern network architectures, we will design a ML architecture based on global AI (running at central controller level) and local AI(s) (running at edge device level) for decision-making in partially as well as fully observable and controllable environments. Global AI will be able to control, configure and install policies on local AI.

- Algorithms for partially observable environments: We will design new safety bounded and interpretable algorithms for intelligent path selection, automatic queueing and scheduling algorithms for partially observable and controllable environments. These methods find use cases in SD-WAN (Software-Defined Wide Area Networks), where edge devices present at customer premises need to collaboratively operate in overlay on top of uncontrollable and only partially observable core networks.
- Algorithms for fully observable environments: We will investigate the application of the global and local AI architecture for fully observable and controllable environments. Specifically, we will design new safety bounded and interpretable algorithms for flow scheduling, software-defined routing and traffic engineering, which find use cases in data centers as well as private WANs connecting multiple data centers, and perform closed loop actions to improve network utilisation and optimise network metrics such as QoS and QoE.
- Results: We have achieved safety and control for SDWAN. This helps us converge more quickly towards the optimal solution. We have also achieved interpretable reinforcement learning, shown in the figure, to control SDWAN by using Kolmogorov-Arnold Networks while maintaining performance similar to black box approaches.

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

MELISSA *ANR Project*

Data Intelligence
+ Laser Matter Interaction teams
Scientific leader: Marc Sebban
Contract duration: 4 years
Start Date: February 2025
Partners: Hubert Curien Lab (coordinator)
+ Inria, ISIR
Total budget: 753 k€

MELISSA (Machine lEarning for Laser-matter Interaction Surrogate SimulAtion) is a new research project funded by the ANR, involving 3 research teams: Inria MALICE (Hubert Curien Lab), Inria MAGNET (CRIStAL) and MLIA (ISIR Institute). The project focuses on the development of Physics-informed Machine Learning (PiML) methods for solving parameterized partial differential equations (PDEs). Despite progress in numerical simulation, solving these equations - which govern the dynamics of many physical systems remains computationally expensive and complex. PiML aims to combine physical laws with data-driven learning to develop efficient surrogate models. Recent approaches in deep learning have incorporated physical knowledge through physics-regularized loss functions, informed initialization, architecture design, and hybrid modeling. Open problems remain in areas such as generalization guarantees, learning from limited data, incorporating partial physical laws, modeling uncertainty, and building foundation models for physics. MELISSA will address these challenges from both theoretical and algorithmic perspectives, with a focus on the application to laser-matter interaction, where data is limited and physical models are incomplete.

The kick-off meeting for the project was held in May at the Château de Valinches in Marols. Over 2 days, participants met to define the project's objectives and plan collaborative work.

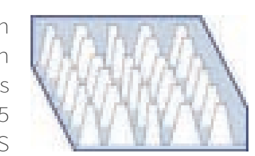
SCAMA *ANR Project*

SESAM team
Local Scientific contact: Brice Colombier
Contract duration: 48 months
Start Date: February 2024
Partners: Hubert Curien Laboratory
+ Télécom Paris (Coordinator), LabSTICC, LIRMM
Total budget: 575 k€

The ANR SCAMA project is set within the context of modern, complex digital electronic systems, where performance is critical. To achieve this requirement, many performance-enhancing features are integrated into the processor's microarchitecture. However, in recent years, these features have been shown to introduce security vulnerabilities into the system that can be exploited through microarchitectural attacks against security functions performed by the processor.
The goal of the SCAMA project is to design countermeasures against these attacks, focusing on finding the optimal balance between security and performance. Achieving this balance requires considering both software and hardware aspects. The Hubert Curien Laboratory, with the help of PhD student Jorge Andres Hoyos Ramirez, focuses on the hardware aspect, developing countermeasures either independently or in conjunction with software solutions. The team is also responsible for developing the demonstrator for the project.

Metasurface components for LIDAR applications *new CIFRE contract*

Functional Materials & Surfaces team
Local Scientific contacts:Nicolas Crespo-Monteiro, Maxime Darnon
Contract duration: 36 months
Start Date: January 2025
Partners: Hubert Curien Laboratory + IREIS



In January 2025, Antoine Bouchut started his Ph.D. thesis in collaboration between IREIS (HEF Group) and the Hubert Curien Laboratory. This marks the first doctoral project launched within the framework of COMETA, the joint research lab dedicated to metasurface-based optical devices.
Antoine's research focuses on the design, fabrication, and characterization of metasurface components for LIDAR applications. He uses amorphous silicon, deposited at IREIS, as a high-refractive-index and IR-transparent material. By applying rigorous coupled-wave analysis (RCWA), he is building a library of metaatoms capable of locally controlling the phase of incident light. From this library, he will design a functional optical component, which will then be fabricated using the facilities of HEF Photonics, the NanoSaintÉtienne platform at Hubert Curien, and the Renatech technological network. The component will be characterized at the laboratory. By covering the full chain, from design to characterization, Antoine's thesis is laying the foundations for COMETA's future developments and opens the door to applications beyond LIDAR.

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

INSEPTION
Investigation of nonlinear propagation of ultrafast infrared laser pulses inside narrow-bandgap semiconductors
ANR-DFG PRCI Project

Laboratoire Hubert Curien
UMR • CNRS • 5516 • Saint-Étienne

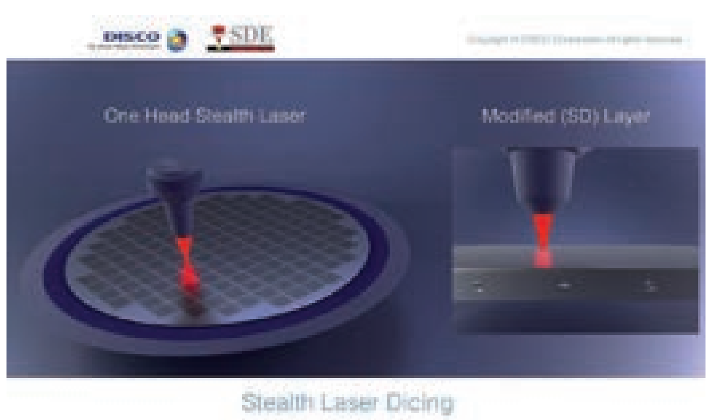
Institute of Applied Physics
Friedrich-Schiller-Universität Jena

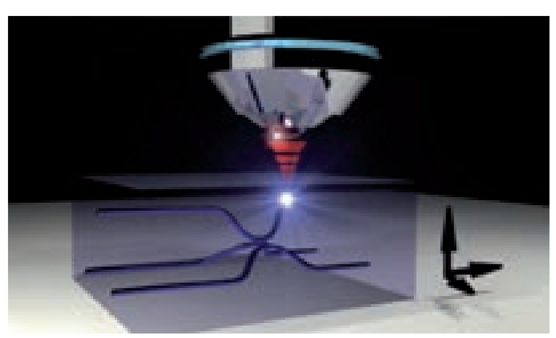
Ultrashort laser pulses are widely used for 3D precision processing of dielectrics in integrated optoelectronics, lab-on-a-chip devices, data storage, etc. Although narrow-gap semiconductors are transparent for infrared radiation, the 3D laser processing of materials such as silicon (Si) and gallium arsenide (GaAs) in this frequency domain is challenging due to extreme nonlinear absorption and refraction. Despite their importance in state-of-the-art electronic devices, the energy deposition sufficient to reach the internal modification regime in these materials could not be yet realized due to nonlinear propagation effects, only surface 2D modifications are thus possible. Moreover, the current theoretical models used for dielectrics are inadequate for describing the nonlinear propagation of ultrafast infrared laser pulses inside semiconductors due to oversimplified semi-classical approximations.
The main objective of the INSEPTION project is thus to better understand the nonlinear propagation of ultrashort infrared laser pulses inside narrow-gap semiconductors in order to maximize energy deposition in these materials. To achieve this, our lab will develop a computationally efficient quantum-mechanical model that will couple the unidirectional pulse propagation equation (UPPE), semiconductor Bloch equations (SBE), and density functional theory (DFT).
The model will be refined and validated using novel experimental techniques developed by the German Institute of Applied Physics (IAP, Jena). Subsequently, the model will be used to predict the optimal laser conditions, and plan new experiments to achieve exalted energy deposition. The original solutions proposed in this project consist of spatial, temporal, and spatio-temporal shaping.
The team in Jena has been working on this subject for almost 10 years and has compiled a large database of unexplained and unpublished results. Meanwhile, the quantum-mechanical model proposed in the project is yet to be developed by our lab team. This represents an exciting challenge – both to advance 3D laser writing inside semiconductors and to push forward cutting-edge high-harmonic generation applications. The project has already achieved preliminary results on quantum simulations and measurements of semiconductor nonlinear properties.

Laser-Matter Interaction team
Coordinator: Elena Kachan
Contract duration: 36 months
Start Date: September 2025
Partners: Hubert Curien Lab
+ Institute of Applied Physics, Jena, Germany
Total budget: 260 k€

Current theoretical models used for dielectrics are inadequate for describing the nonlinear propagation of ultrafast infrared laser pulses inside semiconductors.

Illustrations below:
Left: 2D silicon chip laser cutting. (©DISCO Corp.)
Right: 3D waveguide laser writing in glass (©Thomas Meany)



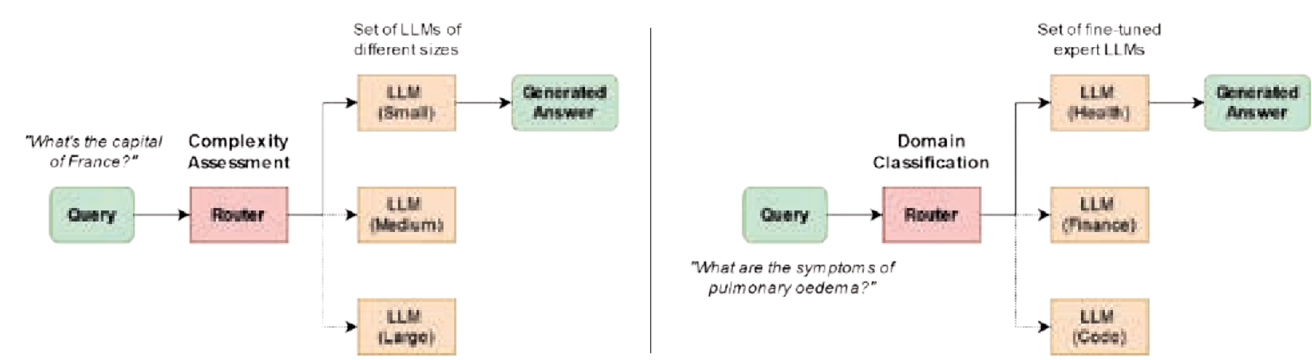


Frugal Routing Strategies for Large Language Models
new CIFRE contract

Data Intelligence team
Local Scientific contacts: Antoine Gourru + François Jacquenet
Contract duration: 2025 to 2028
Partners: Hubert Curien Laboratory (coordinator) + Wikit

Large Language Models such as GPT-4 or LLaMA offer strong performance in natural language processing. However, they are costly to run and have a high environmental impact. This PhD project aims to reduce these costs by designing frugal routing strategies. The goal is to select the most suitable model for each query, balancing quality and cost. Instead of using one large model for all tasks, the router chooses between multiple models, some smaller, some specialized, based on the input. This improves efficiency and sustainability in real-world applications. The project is a collaboration between the Hubert Curien Laboratory and Wikit, a company specialized in AI-powered chatbots. PhD student Clovis Varangot-Reille will be supervised by both lab members Antoine Gourru and François Jacquenet, together with Christophe Bouvard from Wikit.
This is the second collaborative project linking our Data Intelligence team and Wikit, after the regional R&D Booster project QABot which was completed at the end of 2024.

Figure below: Routing as pre-generation step
The schema shows a pre-generation routing system that assesses query complexity or topic to select the most suitable LLM. Before generating an answer, each LLM's ability to provide an appropriate answer is assessed based on the user's query's complexity and/or topic. Dotted arrows represent non-selected LLM candidates. Rectangles with straight edges represent the router and routing candidates, while rectangles with rounded corners represent input/output components (user requests and results).

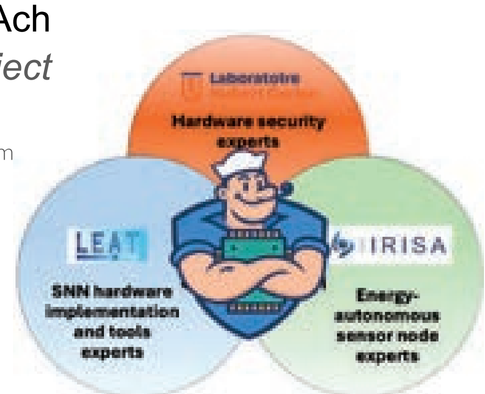


This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

SpiNNAch

new ANR project

SESAM team
Local scientific contributors: Cédric Killian (Head), Brice Colombier, Lilian Bossuet, Vincent Grosso
Contract duration: 48 months
Start Date: November 2025
Partners: Hubert Curien Lab (coordinator)
+ LEAT, Université Côte d'Azur
+ IRISA, Université Rennes
Total budget: 636 k€



The ANR SpiNNAch (Secured Spiking Neural Network for Autonomous Architectures) project aims to develop energy-autonomous IoT nodes that embed Spiking Neural Networks (SNNs), a bio-inspired neural network model. Mimicking how the brain processes information through spikes, SNNs operate sparsely and asynchronously, offering high energy efficiency ideally suited for embedded, low-power systems.
SpiNNAch focuses on enabling these nodes to predict available energy and dynamically adapt their Quality of Service (QoS) accordingly. By leveraging energy forecasts, the system will adjust SNN computations in real time to balance accuracy, latency, and power use. At the same time, SpiNNAch tackles hardware-level security, a key challenge as autonomous nodes are physically exposed. Potential attackers could exploit side-channel leakage to infer network structure or sensor data, inject faults to corrupt inferences, or conduct oracle-style probing to extract secrets from outputs. The project will evaluate these threats specifically for SNNs, whose sparse, time-varying activity patterns both complicate and reshape the attack surface, and design lightweight, context-aware countermeasures that maintain energy autonomy.
SpiNNAch is organized around four main objectives:

- Develop hardware-efficient SNN architectures with dynamic QoS.
- Create energy managers that leverage SNN adaptivity under harvested-energy constraints.
- Assess security vulnerabilities specific to SNN hardware implementations.
- Design countermeasures balancing security, energy, and area constraints.

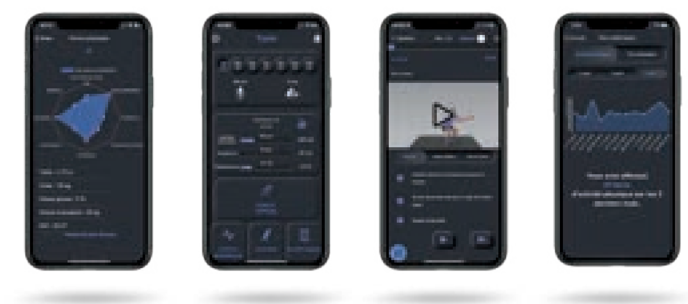
By integrating adaptive AI, energy harvesting, and embedded security, SpiNNAch seeks to establish the foundations of the next generation of secure, energy-autonomous AI-based nodes for the Internet of Things.

PERSON-AGE

new PhD contract

Data Intelligence team
Project coordinator : Mathias Géry
Contract duration: 3 years
Start Date: October 2025
Partners: Hubert Curien Lab (coordinator)
+ Inter-University Laboratory of Human Movement Biology (LIBM)
Total budget: 113 k€

The Research Group (GDR) on Sports and Physical Activities, created in 2019 in preparation for the Paris 2024 Olympic and Paralympic Games, is a collaborative platform bringing together researchers from higher education and research institutions around the topics of sport and physical activity.



Illustrations
Above: Artist's visualisation of the EvaLife mobile self-assessment station.
Right: Screenshots of the mobile app's personal profile, virtual coach recommendations and progress monitoring.

PERSON-AGE is a doctoral research project conducted within the broader EvaLife initiative - a collaboration between our lab and the Inter-University Laboratory of Human Movement Biology (LIBM). EvaLife aims to develop a digital ecosystem for the autonomous evaluation and personalized prescription of physical activity, targeting populations that require adapted exercise programs: older adults, sedentary individuals, and patients with chronic conditions. PERSON-AGE focuses specifically on older adults, who represent a rapidly growing share of the population and face multiple barriers to regular exercise, including reduced mobility, fear of injury, and limited access to coaching or suitable facilities.
The project investigates how advances in user modeling and recommender systems can be leveraged to deliver safe, personalized, and adaptive training programs. It relies on data collected through the EvaLife self-assessment station, which autonomously measures multiple components of fitness (strength, endurance, flexibility, balance, coordination). These data feed a comprehensive user model that integrates physical strengths and weaknesses, exercise preferences, environmental context (indoor, outdoor, gym), available equipment, and physiological vulnerabilities (e.g., joint fragility, muscular imbalance, or cardiovascular limitations).
From a computer science perspective, PERSON-AGE explores how established concepts in recommender systems, dynamic user modeling, and adaptive personalization can be extended to the health domain. Unlike traditional applications (e.g., e-commerce or media), exercise recommendation must account for safety constraints, physiological relevance, progressive adaptation, and long-term adherence. The project aims to design a multidimensional and dynamic representation model linking user capabilities, contextual factors, and feedback. The recommendation algorithms will progressively adapt training sessions based on perceived effort and adherence, while integrating collaborative mechanisms that generalize effective training strategies across users with similar profiles.

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

Laboratoire Hubert Curien
UMR • CNRS • 5516 • Saint-Étienne

PhLAM
Physique des Lasers Atomes et Molécules

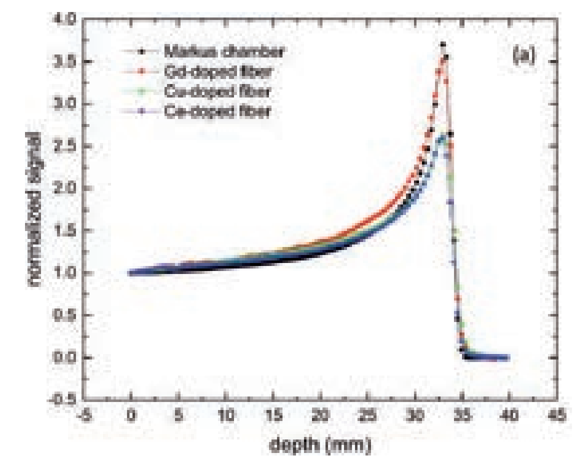
PhLAM / LabHC Collaboration

Shaping the Future of Optical Dosimetry

MOPERE team

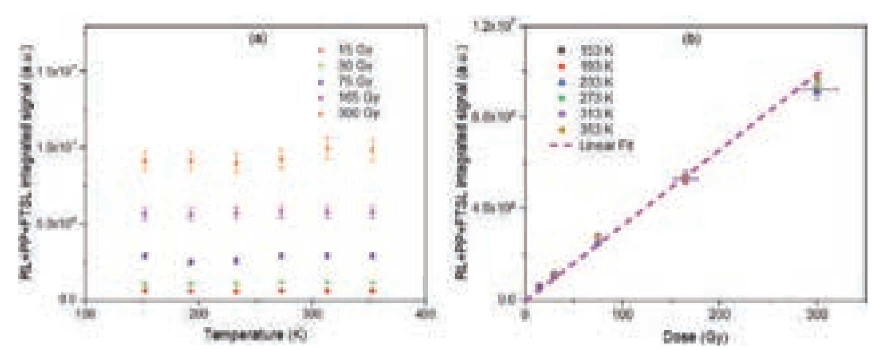
For many years, our MOPERE team and the Photonics Research Team at PhLAM (Laboratory of Physics of Lasers, Atoms and Molecules, CNRS/University of Lille, UMR 8523) have collaborated on the development of innovative optical sensing and dosimetry solutions designed for operation in severe radiation environments. While PhLAM holds unrivaled expertise in the fabrication of specialized optical fibers - including rare-earth-doped fibers used for radioluminescence studies - supported by the capabilities of its FiberTech Lille platform, our MOPERE group is internationally recognized for its research achievements in extreme radiation environments. In the last 5 years, this collaboration has resulted in more than 20 co-authored publications in leading peer-reviewed international journals, reflecting both the productivity and the impact of their shared research activities.
Looking ahead, the partnership will be further strengthened through the 2025–2029 ANR-funded DOLFIN project - Dedicated Optical Fibers for Sensitive and Selective Neutron Dosimetry - conducted jointly with the industrial partner Sodern (PI: Adriana Morana for LabCH). DOLFIN aims to design a fiber-based neutron dosimeter capable of delivering accurate, real-time measurements of neutron flux and fluence, especially for MeV-energy particles. To achieve this, the team will harness the radioluminescence properties of inorganic materials and rare-earth-doped silica glass, such as Gd3+ and Ce3+, integrated into fiber geometries. The sensors will undergo industrial-site testing at Sodern, and their performance will be benchmarked against established neutron-measurement reference instruments. The targeted applications of this technology extend across several fields in which neutron dosimetry plays a key role. By offering an alternative to current solutions, the DOLFIN project could open new perspectives in the space, nuclear, and medical sectors.
This latest initiative once again illustrates the strength of the LabHC-PhLAM partnership in fostering major technological developments, reaffirming the exemplary, productive, and enduring quality of their collaboration.

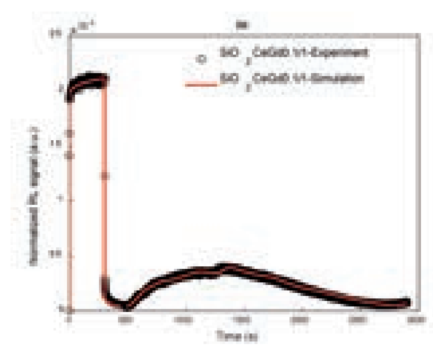
1. Example of application in medicine-radiotherapy: a breakthrough.
(Experience conducted at the TRIUMF Proton Therapy facility, CANADA)
Scientific Reports, Volume 9, Article number: 16376 (2019)



Figure, left:
Depth-dose profile of a raw-Bragg peak of a 74 MeV proton beam deposited in a reference water phantom, normalized to the entrance signal. The peak-to-entrance ratio of the Markus chamber in air is 3.7 while the peak-to-entrance ratio of the Gd3+-doped fiber is 3.5.

2. Comparison of simulation/experiment for the response of a Gd-Ce doped fiber irradiated under X-rays: contributions from radioluminescence (RL), phosphorescence (PP), and thermally stimulated luminescence (TSL). Access to the doses deposited in our materials regardless of temperature!
Sensors, Volume 25, Issue 10, Article number: 30055 (2025)





Above: Sum of the integrated RL, PP and FTSL signals (a) as a function of irradiation temperature for different doses and (b) as a function of the dose for different temperatures.

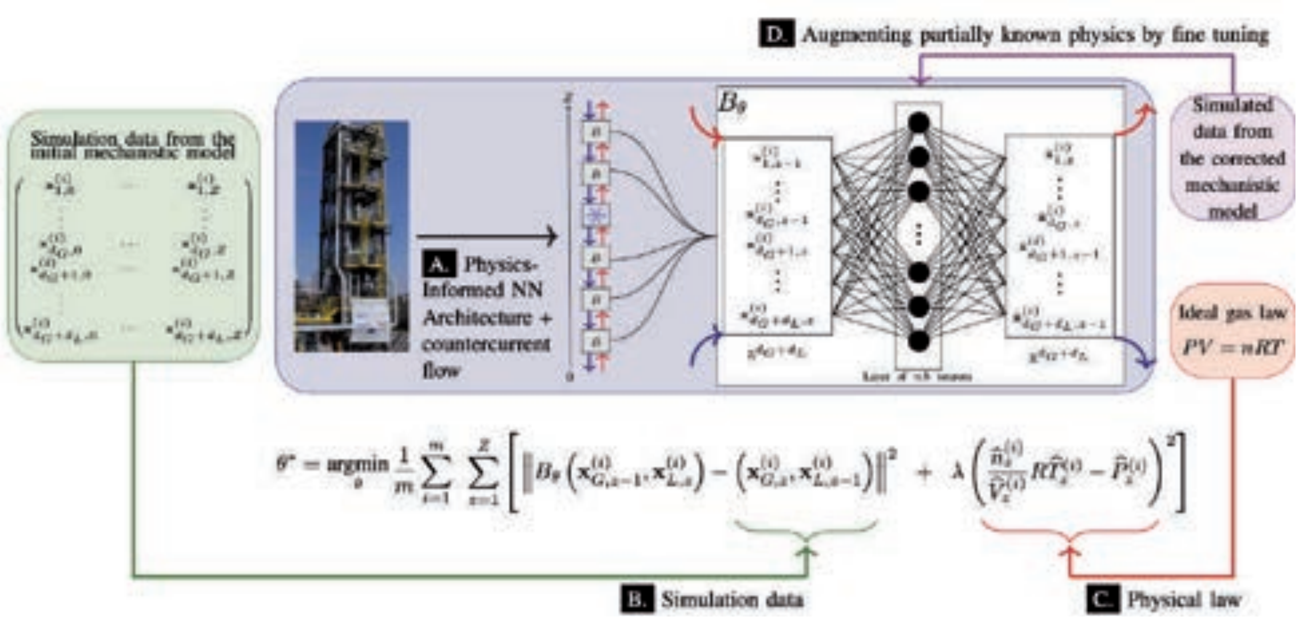
Above: Measured and simulated RL + PP + FTSL signals under X-rays with 50 trap ranging from 0.43 to 1.5 eV under conduction band and two recombination centers for a dose rate of 100 mGy/s (accumulated dose 30 Gy) at temperature of 153 K for SiO2CeGd0.1/1.

This section showcases a selection of collaborative projects that members of the Hubert Curien Laboratory are either leading or actively participating in.

Development and evaluation of physics-informed machine learning approaches for CO_2 capture modeling

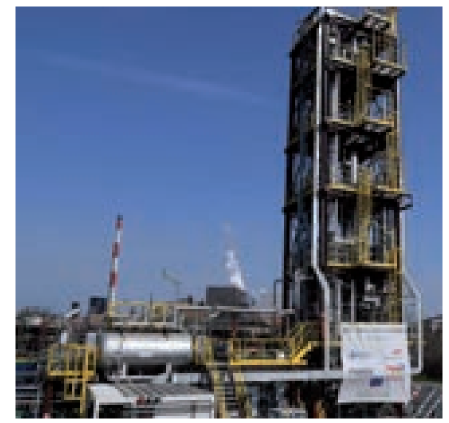
Inria / IFPEN collaborative project

Data Intelligence (MALICE Inria) team
Project coordinator: Marc Sebban
Contract duration: 3 years
Start Date: October 2025
Partners: Hubert Curien Lab (coordinator) - MALICE Inria team + IFPEN Solaize
Total budget: Thesis grant + 42 k€



Figure, above: Overview of our PiML method which embeds three levels of physical knowledge in the objective function:

A. a physics-informed architecture inspired by the DMXTM absorber,
B. simulation data from the numerical solver of the initial mechanistic model,
C. the ideal gaz low as regularization term,
D. illustrates the fine-tuning of the pre-trained surrogate to better adapt to real data and obtain an augmented model.



Left: View of the CO_2 DMX™ demonstrator at the ArcelorMittal industrial plant, Dunkirk, France.

Started in October 2025 and spanning three years, Development and Evaluation of Physics-Informed Machine Learning Approaches for CO_2 Capture Modeling is one of the 2 projects funded in 2025 under the 2020 strategic national partnership between Inria and IFP Energies Nouvelles (IFPEN). This partnership seeks to accelerate the development of new competitive and environmentally-friendly technologies, aligning with the ambitions of the French National Low-Carbon Strategy (SNBC).
Coordinated by Marc Sebban, a member of our Data Intelligence team and head of the Inria MALICE project-team, this project focuses on advancing Physics-Informed Machine Learning (PIML) methodologies. PIML represents a new generation of deep-learning architectures that integrate physical laws with data-driven techniques, offering enhanced interpretability, robustness against outliers, and adherence to physical principles compared to traditional machine learning models. The project targets post-combustion carbon capture, a critical process for mitigating greenhouse gas emissions in hard-to-abate industrial sectors. Specifically, it aims to improve the modeling of the absorption column, a key component in CO_2 capture units. Current rigorous models, which describe the physical mechanisms of acid gas transfer to liquid solvents, fail to fully predict experimental trends observed in industrial settings, with discrepancies that remain unexplained by specific phenomena. By leveraging hybrid PIML approaches, this initiative seeks to enhance the precision of absorption column models, addressing these limitations and advancing the reliability of CO_2 capture technologies.
Mickael Gault, a new PhD student funded by IFPEN, is taking part in the project.

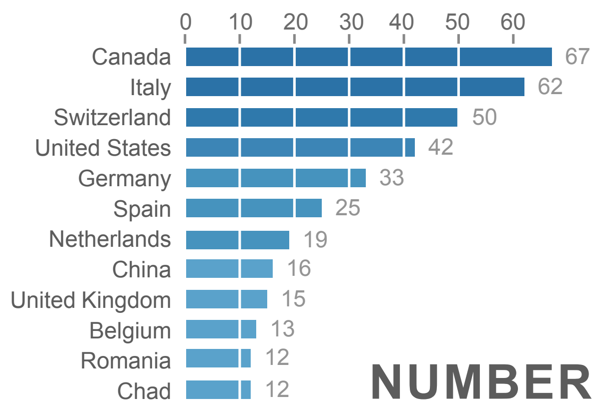
RESEARCH

SCIENTIFIC PUBLICATIONS

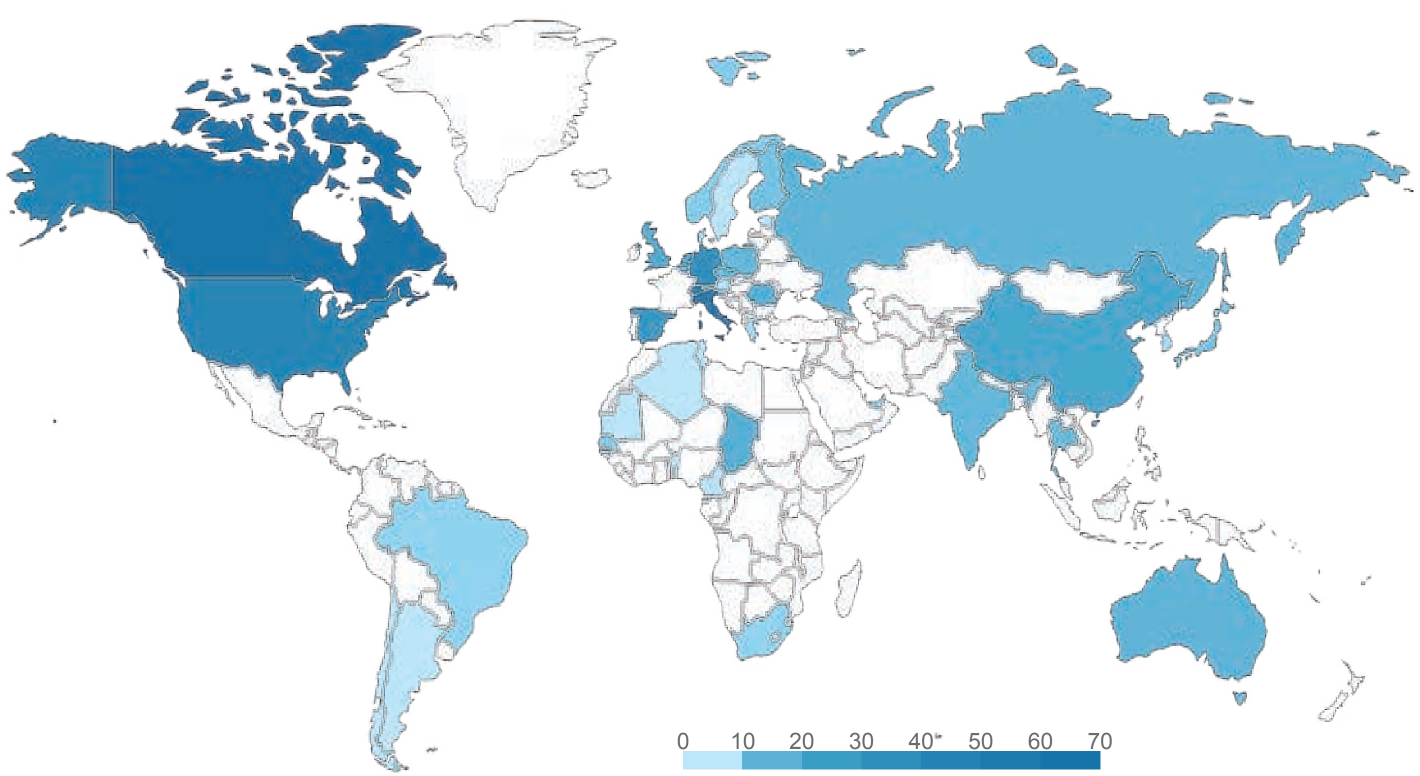
The Hubert Curien Laboratory is an internationally recognised and highly productive research institution.
The following pages present an overview of our international publishing influence, as well as a selection of a few key papers published over the year 2025.

PUBLICATIONS
overview

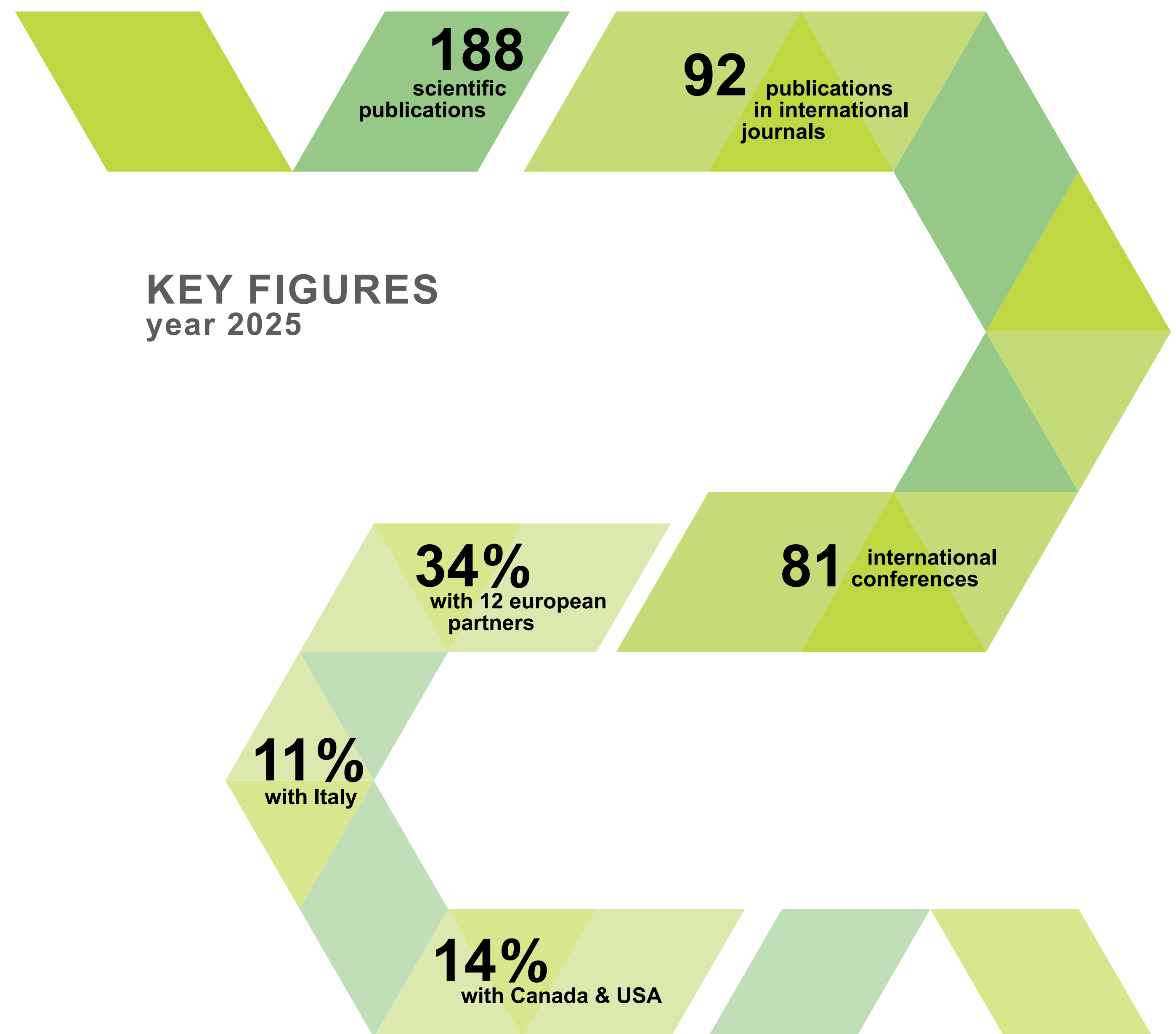
Our research collaborations are considerably spreading beyond the national stage to reach all continents.
Below are some graphics illustrating the geographical location of the institutions we have published with since 2021, also indicating the number of publications by individual country.



NUMBER of publications with an author from this country
last 5-year period - 2021 to 2025 (non-exhaustive list)



KEY FIGURES
year 2025



Optical Engineering

Automatic detection of a sinusoidal grating shape during a manufacturing process

Moustapha Godi Tchéré, Stéphane Robert, Julie Dutems, Bernard Bayard, Yves Jourlin and Damien Jamon

Optical Engineering, a leading journal published by SPIE, focuses on the advancement of optical systems, photonics, and imaging technologies. The article, published by our Functional Materials & Surfaces team in March 2025, introduces a novel method for the automatic identification of sinusoidal grating shapes during the manufacturing process.

In the field of precision manufacturing, ensuring the accurate detection of complex surface patterns, such as sinusoidal gratings (figure 1), is critical for quality control and performance optimization. For example, it is essential to use a perfectly sinusoidal grating profile to ensure an optimal plasmonic effect. By leveraging machine learning techniques applied on ellipsometric measurement, the proposed approach enables real-time, high-precision identification of grating characteristics, addressing challenges related to surface irregularities and production efficiency. A periodic grating profile can be expressed as an infinite sum of trigonometric sinusoidal functions through Fourier decomposition. When multiple harmonics are present in the frequency spectrum, it indicates that the profile is not purely sinusoidal but may still satisfy the desired shape requirements. The influence of these harmonics is quantified using a criterion, β, defined as the ratio of the amplitudes of the second, third, and fourth harmonics to the fundamental harmonic. The value of β varies almost linearly (figure 2) with the geometrical deviation from an ideal sinusoidal profile. A Multilayer Perceptron (MLP) named Regβ, operating in regression mode (figure 3), is used to identify a specific sinusoidal shape from an input ellipsometric signature. Regβ calculates the criterion β and the residual layer hr. The training dataset includes target sinusoidal profiles and various geometrical profiles classified as defects, without specific constraints on the boundaries between different models.Regβ is trained on 8,000 theoretical samples and features a simplified architecture with only 10 hidden neurons. The experimental methodology involves rigorous testing of the detection algorithm under varied manufacturing conditions, demonstrating its robustness and applicability to industrial settings. The proposed method was successfully tested on plasmonic-based sensor samples printed on a photoresist layer using the LIL process. A key advantage of this technique is that it does not require prior knowledge of the number or type of profile defects. The study further validates the method's effectiveness through improved detection accuracy and faster processing times, facilitating its integration into existing manufacturing workflows.

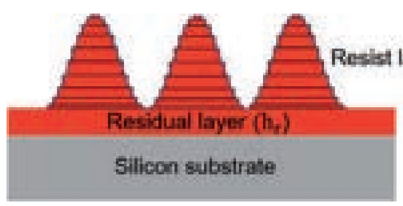


Figure 1, above: Targeted geometrical structure manufactured by LIL.

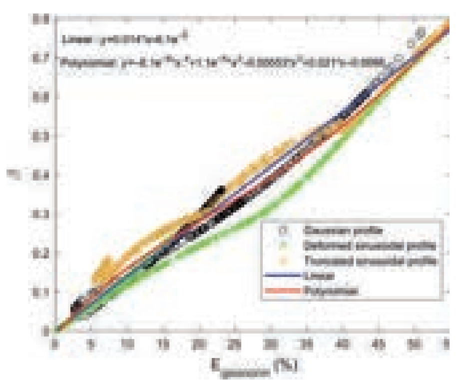


Figure 2, right: Representation of β as a function of geometrical deviation from a perfect sinusoidal profile for different periodic non-sinusoidal structures: Gaussian (black), distorted sinusoidal (green), and truncated sinusoidal (gold). Approximate models are also shown: linear (blue) and polynomial (red).

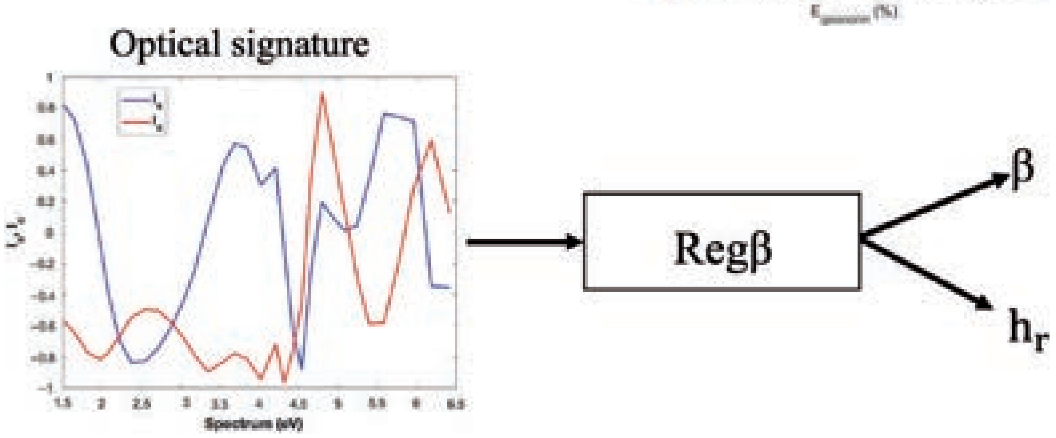


Figure 3, right: Schematic diagram of the MLP regressor estimating output parameters hr and β from the optical signature.

Optical Engineering, Vol. 64, Issue 3, Article 037101 (2025)

Journal of European Optics Society

Image quality metrics for restricted gamut images produced by laser-induced printing on plasmonic films

Robin Mermillod-Blondin, Nicolas Dalloz, Alain Tremeau, Aldi Wista Fadhilah, Rémi Emonet and Nathalie Destouches

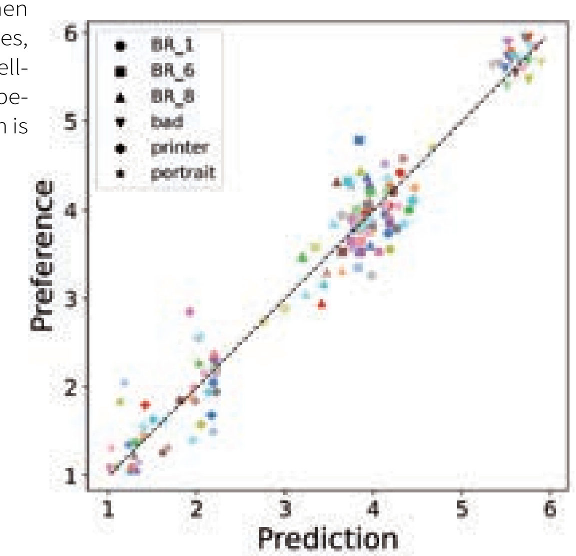
Members of our Functional Materials & Surfaces team co-authored a paper published in May 2025 in the Journal of the European Optical Society. The journal highlights the growing impact of optics and photonics across diverse fields by publishing high-quality scientific articles that showcase recent breakthroughs, emerging technologies and research addressing current challenges. The work was conducted in collaboration with our lab's Data Intelligence and Image Science & Computer Vision teams, as well as TOPPAN Security SAS.

Which reproduction of this image below is the best ?

Figure, above: The reference image (on top) is displayed alongside three reproductions (bottom) generated using different constrained color gamuts. Observers were asked to rank the reproduction from the best to the lowest quality. This example highlights the visual ambiguity that can arise when comparing images reproduced with limited color ranges. In such cases, subjective judgment alone may be inconsistent or difficult. Hence, well-chosen objective metrics are useful to repeatedly guide evaluations, especially in applications where visual fidelity is critical but color reproduction is constrained by physical limitations.

The figure, right, illustrates a metric that was designed to predict the accuracy of the observer ranking (R^2 = 0.97)

Recent advances in laser-induced coloration of semi-transparent plasmonic metasurfaces have enabled the creation of multiplexed images—where different images are revealed under varying observation conditions using a single printed surface. These images rely on finely controlled structural colors, generated by metallic nanoparticles that strongly interact with light. This technique is especially promising for security applications, like anti-counterfeiting, because it's fast, versatile, and difficult to replicate. However, one key limitation is its narrow color range: unlike traditional printers that use vivid inks like cyan, magenta, and yellow, ink-less laser-induced printing techniques cannot replicate the full range of colors. In this study, we applied gamut mapping techniques to adapt full-color images to the limited color range of ink-less laser printing. We then asked observers to choose which reproduction looked most faithful to the original. Using, statistical methods like ANOVA and AIC, we analyzed how well different metrics aligned with human judgment. Our findings not only help optimize the laser settings for clearer, more faithful images, but also pave the way for designing future visual security features that are both faithful and hard to fake.



J. Eur. Opt. Society-Rapid Publ., Vol. 21, Issue 2, Article 36 (2025)

IEEE Sensors Journal

Theoretical Investigation of Refractive Index Detection Limit in the Surface Plasmon Resonance-Triggered Switch Effect

Hugo Bruhier, Isabelle Verrier, Jérôme Brunet, Christelle Varenne, Frédéric Celle and Yves Jourlin

A paper co-authored by our Functional Materials & Surfaces team was published in IEEE Sensors Journal, a peer-reviewed publication that covers the theory, design, fabrication, manufacturing and applications of devices for sensing and transducing physical, chemical and biological phenomena, with an emphasis on the electronics and physics of sensors and integrated sensors-actuators.

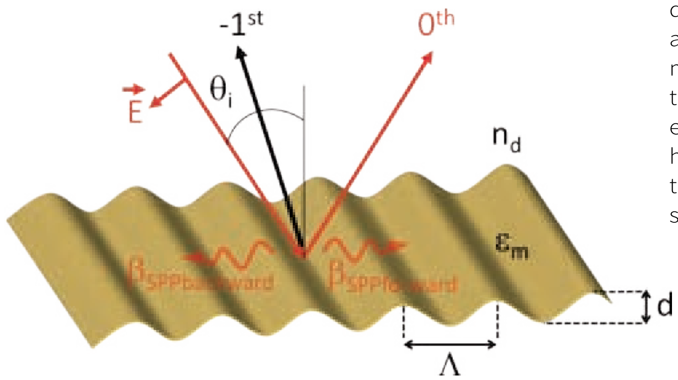


Figure 1, above: Schematic of the sensing setup featuring the gold diffraction grating, the two diffracted orders and the plasmonic waves.

Over the past few years, our lab's team dedicated to the study of diffraction gratings has managed to introduce and utilise an unusual optical effect in the field of plasmonic sensors. These sensors typically use electromagnetic waves confined at the interface between a metal and water or air, to achieve extremely high resolution in measuring low quantities of pollutants or biological markers. The team has published several papers demonstrating that sensors developed with this new effect are simpler to use and yet experimentally as achieve performance comparable to the best plasmonic sensors reported in the literature. This paper aims to provide a robust metrological explanation of how sensors using this effect can exhibit such high resolution while using low-cost material, and to compare these results with existing studies on conventional plasmonic sensors.

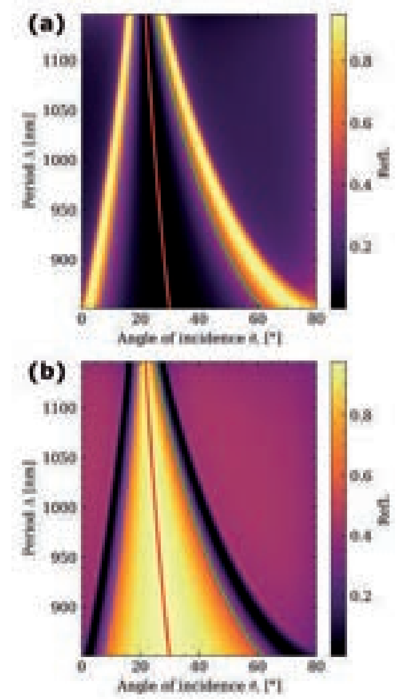


Figure 2, right: (a) 0th and (b) -1st diffracted orders of optimized structures for each considered diffraction grating depth. Blue and green lines showing the angular positions for sensing.

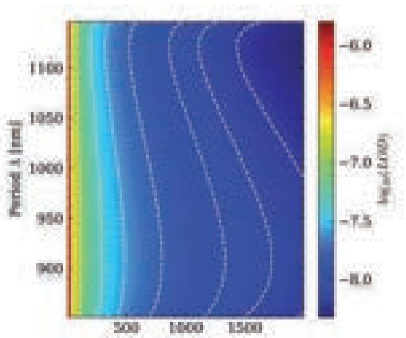


Figure 3, left: Limit of Detection of the refractive index modification in the sensing medium, depending on the grating depth and filter used in signal processing.

IEEE Sensors Journal, Vol. 24, Issue 24, pp. 40659-40668 (Dec. 2024)

Journal of Applied Physics

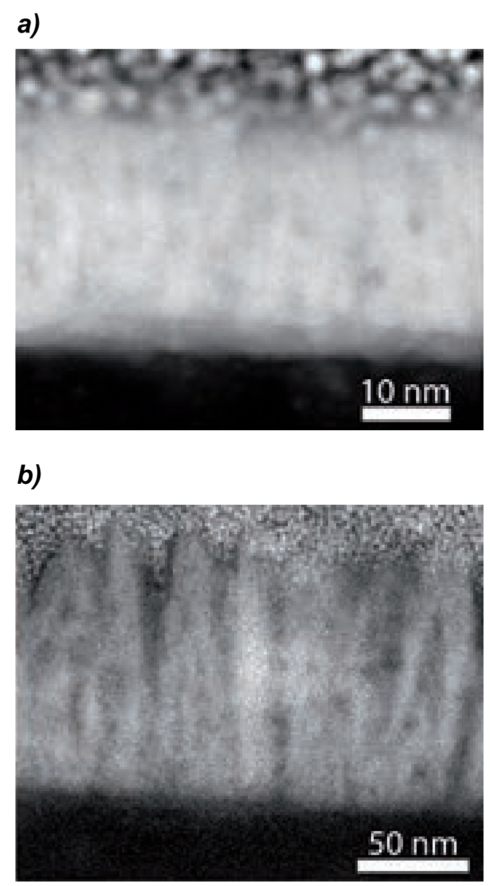
Magneto-optical properties of cobalt and Co3O4 thin films: Influence of microstructural properties

Gerges El Haber, François Goutaland, Dominique Luneau, Damien Jamon, Jean Pierre Chatelon, Jean Yves Michalon, Nadège Ollier, Christophe Donnet,Yannick Bleu, Yaya Lefkir, Stéphanie Reynaud and François Royer

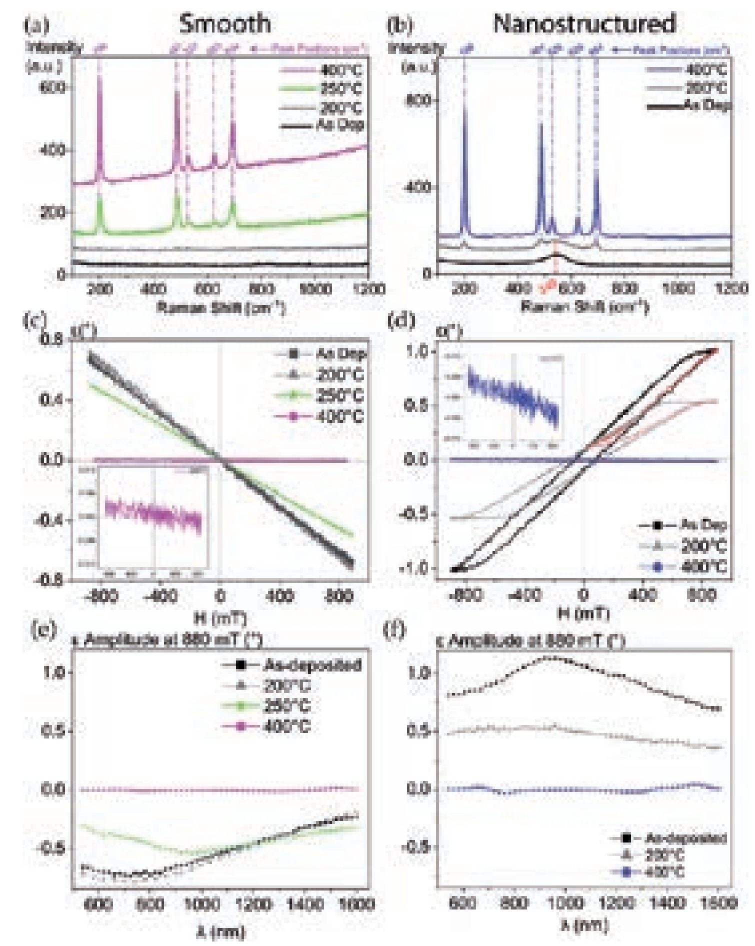
Journal of Applied Physics is an international journal that publishes significant new experimental and theoretical results in applied physics research. An article co-authored by our Functional Materials & Surfaces appeared in its March 2025 issue.

Dramatic increases in data storage capacities are urgently needed as they are being outpaced by exponential growth in data generation, driven by use of the internet, social media, and cloud computing. Cobalt thin films sputtered on a substrate with thicknesses in the order of few tens of nanometers are among the most promising media towards data storage magnetic recording. The achievement of high recording performance requires the tiny control of the microstructure of the film, which strongly influences the magnetic properties of the films.

Two different kinds of cobalt thin films of very different microstructure have been obtained by varying the experimental parameters of the sputtering deposition process. Their magnetic properties have been investigated and turned out to very different. In the second part of the paper, the oxidation of both kinds of films into Co3O4 crystalline phase after annealing at around 400°C has been achieved. Despite their different initial microstructure, both oxidized films have shown magneto-optical responses for the first time in the literature, which opens new experimental routes towards the control of the propagation of light through them.



Figure, above:
STEM-HAADF images of the smooth (a) and nanostructured (b) cobalt thin films.



Figure, above:
Raman spectra of the smooth (a) and nanostructured (b) cobalt thin films for different annealing temperatures;
Magneto-Optical behaviour of the smooth (c) and nanostructured (d) cobalt thin films.

J. Appl. Phys. Vol. 137, Issue 12, Article 123907 (2025)

Optics Express

Ppb detection level's hydrogen sensor using a SPR grating in the triggered switching configuration

Pascal Giraud, Christelle Varenne, Jérôme Brunet, Amadou Ndiaye, Isabelle Verrier, Hugo Bruhier, Arnaud Meyer, Irvin Girault, Frédéric Arnould, Frédéric Celle, Salma Rajab Pacha, Valentin Gaté, Daniel Turover and Yves Jourlin

Optics Express is an open access electronic journal publishing significant innovations in all areas of optics and photonics. In July 2025, our Functional Materials & Surfaces team published an article presenting a novel plasmonic-based approach that significantly lowers the detection limits for hydrogen leaks in optical sensors, from ppm (Parts per millions) to ppb (Parts per billions). This study and its results were carried out within the framework of the CAPTHY project (Pack Ambition Recherche, Région Rhône-Alpes Auvergne), in close partnership with the Institut Pascal (Clermont-Ferrand University) and the NAPA company.

Hydrogen is a key energy carrier, but highly flammable, necessitating extremely sensitive leak detectors. Existing optical sensors, particularly those based on plasmonic technologies, often have insufficient detection limits. A novel approach, based on a plasmon triggered switching phenomenon, aims to overcome these limitations for achieving very low detection levels. With a simple, compact, and low-cost design, the sensor consists of a deep sinusoidal gold grating coated with a thin hydrogen-selective palladium layer.

This structure, illuminated by a laser diode, enables the excitation of the plasmon triggered switching phenomenon, where the sensor's response is simply evaluated by measuring light intensity via two photodiodes. Despite its simplicity, the sensor has demonstrated exceptional performance, with a raw detection limit of 0.2 ppm (2.10-5 % Vol), and down to 0.2 ppb (2.10-8 % Vol) with the aid of digital signal processing. This promising approach is targeted for further improvement through sensor miniaturization, optical fiber integration, and the exploration of palladium alloys to improve response times and sensitivity.

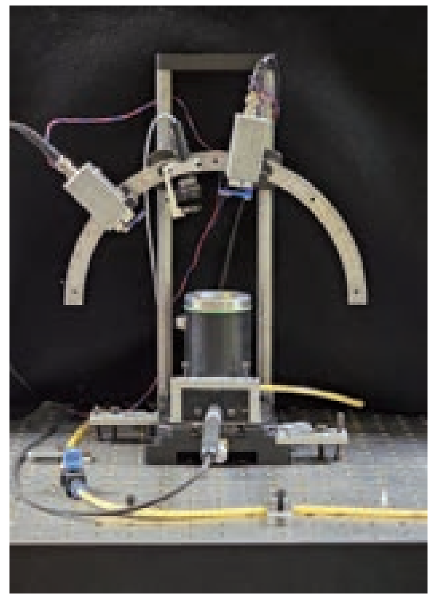


Figure 1, above:
Picture of the optical sensor setup

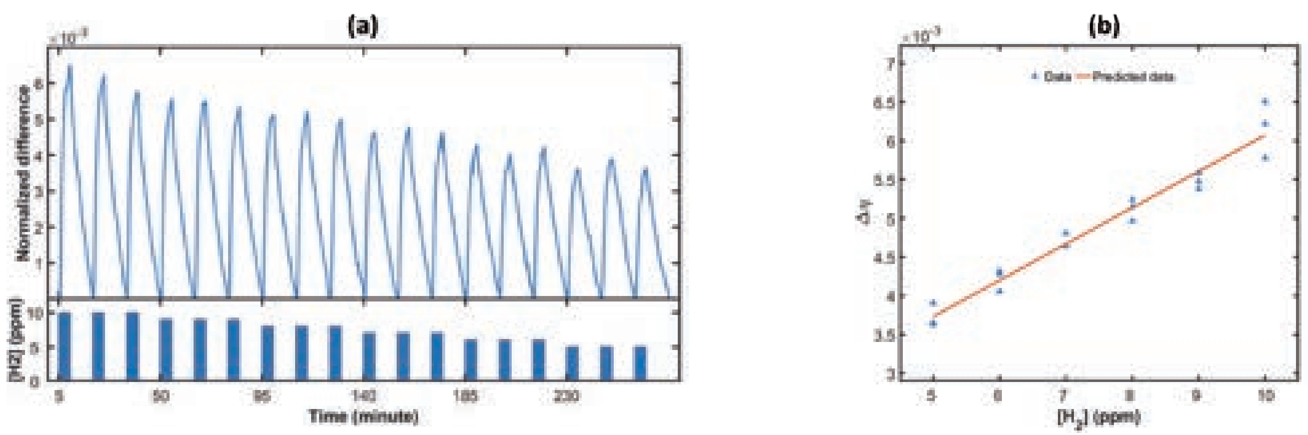


Figure 2, above:
(a) Response to stepwise decrease in H2 concentration (10-5 ppm for 254 minutes and then to clean dry air and
(b) the responses for 10 cycles) composed of 3 cycles for each H2 concentration in filtered air for 5 minutes and clean dry air for 10 minutes.
(b) Measured Δ η as a function of H2 concentration derived from (a) where the plotted orange curve is the linear regression computed with the different Δη.

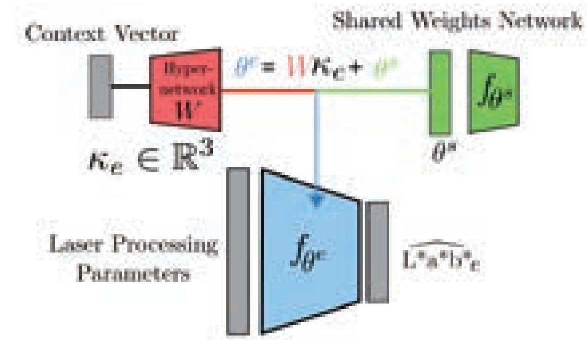
Optics Express Vol. 33, Issue 14, pp. 29648-29665 (2025)

European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases - ECML PKDD 2025

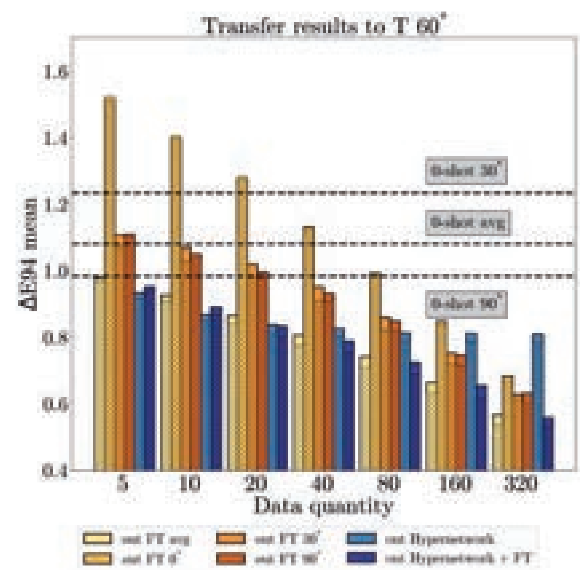
Contextual Hypernetwork for Adaptive Prediction of Laser-Induced Colors on Quasi-Random Plasmonic Metasurfaces

Thibault Girardin, Nathalie Destouches and Amaury Habrard

Our Functional Materials & Surfaces and Data Intelligence teams collaborated on an on article presented at the 2025 edition of ECML PKDD, a leading European conference on machine learning and data mining, which was held in Porto, Portugal. The paper contributes to advancing the use of deep learning and domain adaptation techniques for improving the reproducibility of color prediction in laser-processed metasurfaces.



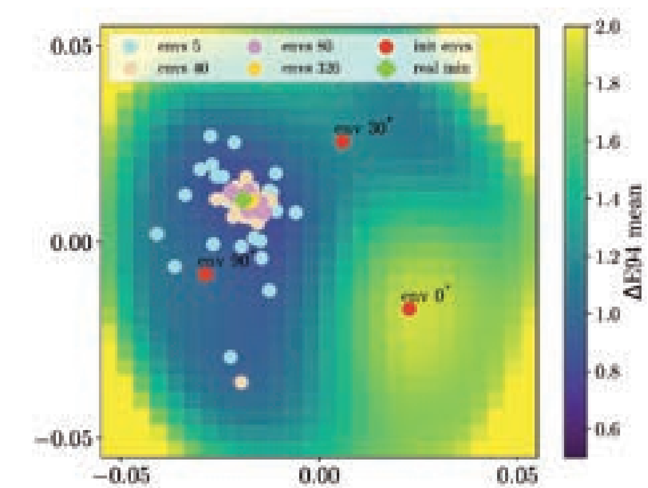
Figure, above: Neural Network architecture used. Adaptation to a new condition is done under the assumption that given a few data only a small weights update is required. The adapted model is the sum of weights that are common to all the conditions and the condition specific update.



Figure, abve: Numerical results highlighting that hypernetwork based domain adaptation outperforms finetuning on very low data regimes.In higher data regimes, finetuning the adapted model still outperform the other methods.

The latest breakthroughs in laser-induced semi-transparent metasurface processing have enabled the controlled production of various structures that exhibit unique interactions with light. Their properties make them promising candidates for high-grade anti-counterfeiting applications. However, the lack of accurate simulation models and issues with reproducibility remain critical challenges. While neural networks can compensate for the lack of simulation tools, they cannot be directly applied to new metasurfaces, as changes in their optical properties cause slight variations in the resulting colors. This work targets at solving this non-reproducibility issue using Neural Networks and Domain Adaptation technique. We first deploy a model that is trained simultaneously on different source datasets corresponding to different experimental conditions to predict the resulting colors from the processing parameters and to learn a shared representation space where each dataset is localized by a coordinate context vector. The representation space is then used to effectively adapt on a target new case with few data corresponding to unseen experimental condition. This technique offers better adaption compared to standard methods and also gives information on how adaptation is done by comparing the optimized vector from the target to the source one.

Figure, below: Projection of the coordinate vectors. Green diamond is the global optimum for the target task. Red dots are the coordinates found for the training experimental conditions. Color dots are the coordinates optimized for the given new condition the model is trying to adapt to given different batch sizes of data.



Proceedings of the European Conference on Machine Learning and Knowledge Discovery in Databases, Porto, Portugal, Sept.2025

Physical Review B - American Physical Society

Noninvasive temperature measurement of magnetic hyperthermia investigated through optical properties

Hai Hoang Thi Thanh, Damien Jamon, Chloé Landreau, James Hainsworth, Adriana Marana, Laure Bsawmaii, Emmanuel Marin, Sophie Neveu, Florent Bourquard, Patrick Ganster, Nicolas Moulin and François Royer.

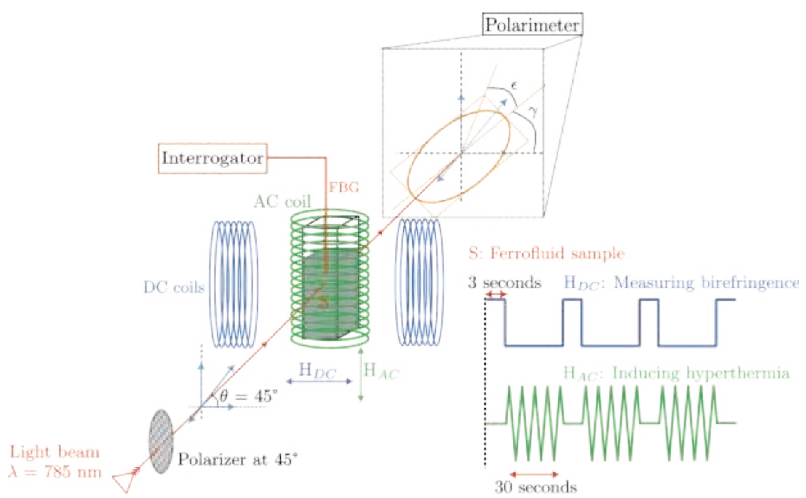
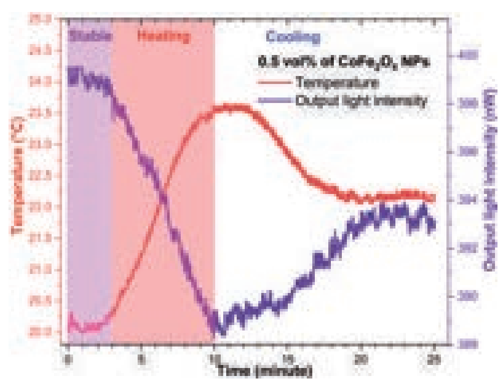


Figure 1, left: Experimental setup for optical properties probing magnetic hyperthermia temperature.

Figure 2, below: The varying absorption of 0.3% volume fraction of CoFe2O4 NPs as a function of time in terms of changing temperature by hyperthermia.

Members of our Functional Materials & Surfaces, Laser-Matter Interaction and MOPERE teams co-authored a paper published as an Editor's Suggestion in October 2025 in Physical Review B, by the American Physical Society (APS). The journal highlights significant developments in condensed matter, materials physics and related subfields including: Electronic structure, photonics, magnetism and nanoscience. This work was conducted in collaboration with the Laboratoire Georges Friedel (École des Mines).

When exposed to an alternating magnetic field, the magnetic nanoparticles induce heat due to the reversal of their magnetic moments, a phenomenon known as magnetic hyperthermia, which has a wide range of applications such as cancer treatment, magnetic resonance imaging (MRI), and microfluidic chips. However, existing methods for probing temperature through optical properties have disadvantages including direct contact (optical fiber sensor), potential destructiveness to the sample by adding colour indicators (fluorescence thermography), or sensitivity to environment and sample condition (infrared thermography). In contrast, the advancement in this study is using the optical properties of ferrofluid composed of CoFe2O4 NPs (birefringence and absorption) as noninvasive and nondestructive methods for real-time temperature monitoring. In order to investigate these optical properties while simultaneously inducing hyperthermia, a dedicated setup has been designed (See Figure 1, opposite). These findings may contribute to a novel noninvasive method for measuring temperature in magnetic hyperthermia.



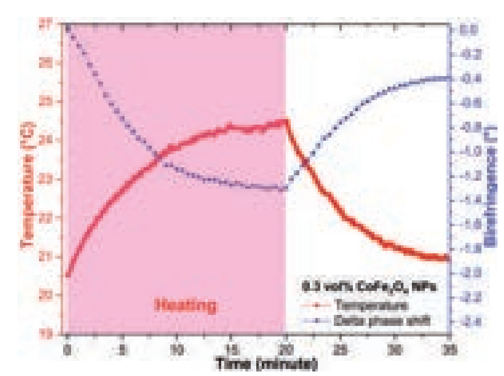


Figure 3, above: Birefringence at HDC = 6 mT as a function of the temperature variation induced by an AC magnetic field (f = 300 kHz, HAC = 2.45 mT) with 0.3% volume fraction of CoFe2O4 NPs.

Phys. Rev. B , Vol. 112, Issue 15, Article 155107 (2025)

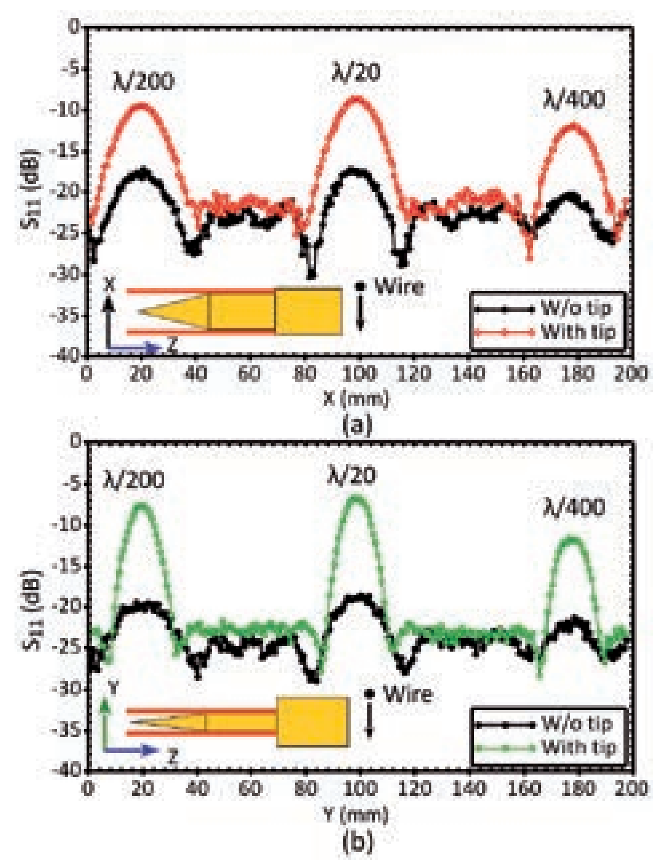
IEEE Journal of Selected Areas in Sensors

High-Sensitivity Microwave Detection of Subwavelength Objects Using a Dielectric-Loaded Waveguide With Electromagnetic Jet Lens

Antoine Deubaibe, Ali Ghaddar, Baraka Mahamout Mahamat, Bernard Bayard and Bruno Sauviac

The IEEE Journal of Selected Areas in Sensors (JSAS) is a recently started open access technical journal that publishes papers related to the theory, design, simulation, fabrication, manufacturing and application of devices for sensing and transducing physical, chemical, and biological phenomena, with emphasis on the electronics, physics and reliability aspects of sensors and integrated sensor-actuators. An article co-authored by our Functional Materials & Surfaces team was published in September 2025, presenting a novel approach to subwavelength microwave sensing with enhanced spatial resolution and sensitivity.

Figure, below:
Comparison of electromagnetic jet characteristics across different domains at frequencies below THz.



This study presents a compact microwave sensor that detects objects far smaller than the wavelength by generating a highly focused electromagnetic jet inside a dielectric-loaded waveguide. The device uses a PTFE-filled rectangular waveguide and a tailored dielectric lens to form a subwavelength focal spot, enabling strong near-field confinement and high detection sensitivity. Experiments show it can identify objects as small as λ/400, significantly surpassing classical open-ended waveguide probes, which are generally limited by diffraction and weaker field localization.
Compared with traditional nondestructive evaluation tools, this architecture offers improved spatial resolution, reduced insertion losses thanks to an optimized impedance transition, and easier integration due to its single-piece dielectric component. Its fully guided structure also enhances robustness compared with free-space microwave inspection systems.
Practical applications include the detection of micro-defects in composites or plastics, fine-scale inspection in electronics manufacturing, and localized dielectric characterization for materials processing. Its non-contact, high-resolution capabilities make it well suited for industrial sensing scenarios requiring precise, noninvasive inspection of small features.

COMPARISON OF ELECTROMAGNETIC JET CHARACTERISTICS ACROSS DIFFERENT DOMAINS AT FREQUENCIES BELOW THZ

Ref	Object	System	Freq	FWHM	FLHM
[24]	Sphere	FS	0.81 THz	0.491λ	2.21λ
[25]	Cylinder	FS	8-13 GHz	0.65λ	1
[26]	Metamaterial	FS	3.66 GHz	0.48λ	
[27]	Acoustic ball	FS	1.01 MHz	0.52λ	2.22λ
[16]	Elliptic	GW	30 GHz	0.5λ	
[9]	Multirectangular	GW	30 GHz	0.5λ	
[21]	Cylindrical lens	FGW	30 GHz	0.6λ	2.7λ
[13]	paralelepiped	FGW	0.3 THz	> 0.5λ	2.21λ
This work	paralelepiped	FGW	15 GHz	0.41λ, 0.50λ	1.75λ

Abbreviations in the "system" column: FS — Free-space plane-wave; GW — Guided wave with external excitation; FGW — Fully guided wave with integrated excitation.

Table, above:
Reflection coefficient measured with and without PTFE electromagnetic jet lens when the wires mounted on the frame are moved in (a) x-direction and (b) y-direction. Insets illustrate the wire being moved vertically in front of the jet along the (a) x-direction and (b) y-direction.

iEEE Journal of Selected Areas in Sensors, Vol. 2, pp. 303-309 (2025)

Results in Optics Journal

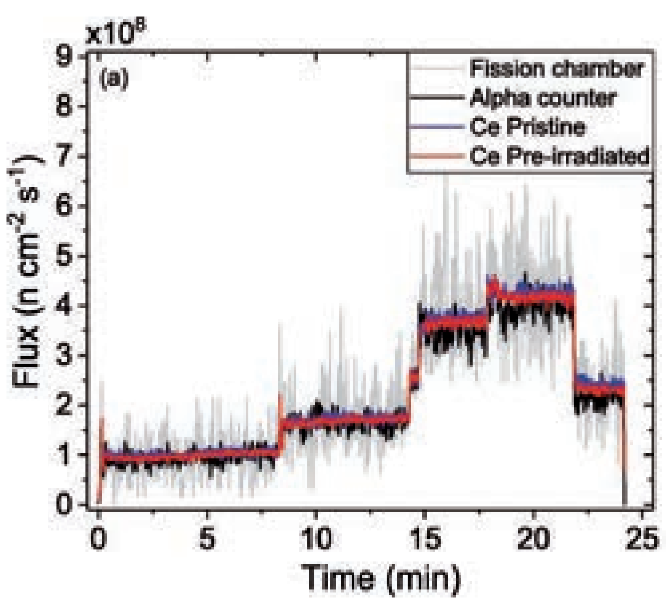
Potential of radioluminescent silica-based optical fibers for 14 MeV neutron beam monitoring

Luca Weninger, Adriana Morana, Andrea Colangeli, Fiammetta Fricano, Youcef Ouerdane, Emmanuel Marin, Aziz Boukenter, Stefano Loreti, Antonino Pietropaolo and Sylvain Girard

A paper co-authored by our MOPERE team appeared in the May 2025 issue of Results in Optics, an open access journal dedicated to all fundamental, interdisciplinary and applied areas of Optics and Photonics.

For decades, researchers have dedicated efforts to replicating the self-sustaining stellar fusion rate in a quest to obtain a nearly limitless source of low-carbon and clean energy. In stars, gravitational forces provide the natural conditions necessary for fusion. The fundamental obstacle to realizing a fusion energy source remains the difficulty in confining plasma under the conditions required for ignition.
Two main approaches are being investigated worldwide to overcome this obstacle: magnetic confinement and inertial confinement. Both solutions are characterized by very challenging environmental constraints around the reaction volume. These include a mix of very high temperatures, strong electromagnetic fields and high fluxes of neutrons, among others. The 14 MeV neutrons produced by the D–T fusion reaction, central to the technology, will be in the order of 10^{19} n/s once ignition is achieved. These neutrons are effectively the output of the fusion reaction, and measuring them in real time can provide an estimate of its efficiency.
In our paper, we propose the use of radioluminescent optical fibers to measure the real-time flux and fluence of 14 MeV neutrons. The idea is to exploit the intrinsic resistance of silica-based fibers to the environmental constraints inherent to fusion experiments, as well as their good performance as dosimeters, which our group has demonstrated in the past.
Our fibers were then tested at the Frascati Neutron Generator in Italy, where a Deuteron accelerator is used to strike a Tritiated target to obtain 14 MeV neutrons. Our results show the capability of our dosimeter to measure neutron flux and fluences in real time, with even less fluctuation than the reference counters used at the facility.

Illustration above :
The Frascati Neutron Generator facility. Here, the deutons are accelerated from the high voltage generator on the right, through the quadrupoles in the centre, and to the tritiated target in front of which our fibers were placed (in yellow).



Figure, above :
Real-time measurement of the neutron flux obtained with our optical fibers, and the reference counters of the facility.
The graph illustrates how the reduced fluctuations in the fiber signal allow for better tracking of neutron emission kinetics, compared to those in the reference counters.

Results in Optics, Vol. 19, Article 100807 (2025)

IEEE Sensors Journal

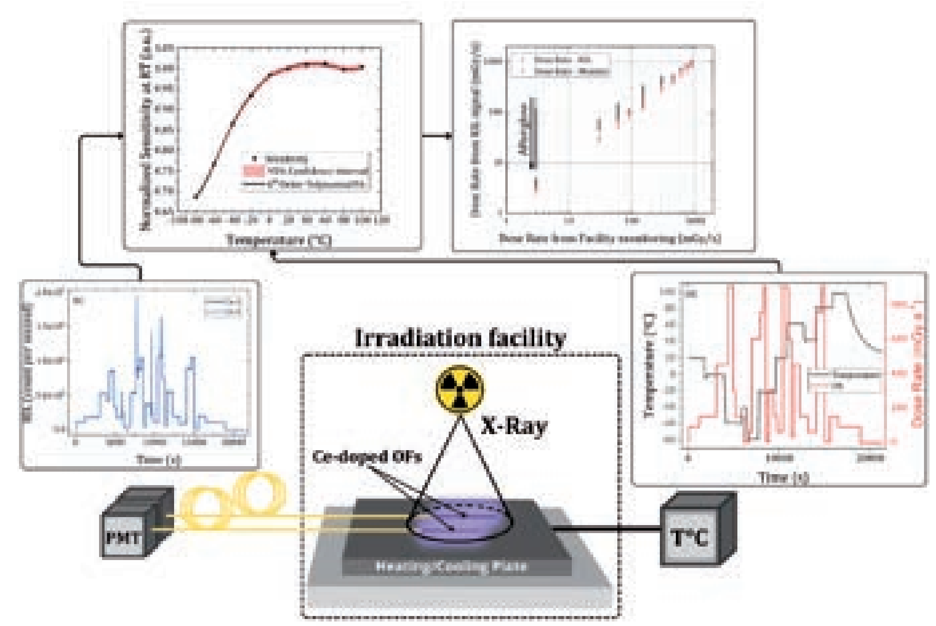
Temperature Impact on a Radioluminescent Silica-Based Optical Fiber Dosimeter for Space Applications

Selyan Acid, Fiammetta Fricano, Adriana Morana, Nourdine Kerboub, Marine Aubry, Hicham El Hamzaoui, Julien Mekki, Jeremy Guillermin, Youcef Ouerdane, Maxime Darnon,Bruno Capoen, Mohamed Bouazaoui, Aziz Boukenter and Sylvain Girard

A paper co-authored by our MOPERE team was published in May 2025 in IEEE Sensors Journal, a peer-reviewed publication that covers the theory, design, fabrication, manufacturing and applications of devices for sensing and transducing physical, chemical and biological phenomena, with an emphasis on the electronics and physics of sensors and integrated sensors-actuators.

Space is an extreme environment characterized by three main conditions: severe temperature fluctuations, vacuum conditions, and intense radiation from solar flares, galactic cosmic rays and the Van Allen radiation belts. In the context of long-duration missions, accurate radiation measurement - known as dosimetry - is essential to ensure the safety of astronauts and the integrity of electronic equipment. Optical fiber-based dosimeters are promising candidates for space applications due to their compact size, low weight, and minimal power consumption. At the Hubert Curien lab and in collaboration with the French Space Agency (CNES), the industrial TRAD and the University of Lille, the MOPERE team works to develop an innovative dosimeter that exploits the radiation-induced emission (RIE) phenomenon, a light signal emitted by certain fiber types when exposed to radiation. RIE is directly proportional to the instantaneous radiation level, or dose rate. In our most recent study, we examined the influence of the temperature of irradiation on the RIE signal by testing our dosimeter across a wide range, from -80°C to 100°C. We observed that the signal diminishes below 0°C. To mitigate this effect, we devised a calibration method to correct the RIE from its temperature dependence. Nonetheless, one significant challenge remains: thermoluminescence - an additional light emission triggered by rapid temperature changes - which can compromise accurate dose rate measurements without a more advanced calibration, on which the consortium is working. This research already marks a significant step toward the development of reliable, real-time dosimetry solutions for future space missions.

Figure, below:
Graphical abstract of the research article



IEEE Sensors Journal, Vol. 25, Issue 9, pp. 15065-15070 (2025)

Journal of Lightwave Technology journal

Characterization and Radiation Testing of an Embedded, Distributed Fiber Dosimetry System for Space Applications

Arnaud Meyer, Adriana Morana, Martin Roche, Nourdine Kerboub, Julien Mekki, Gilles Mélin, Thierry Robin, André Champavère, Frédéric Saigné, Jérôme Boch, Tadec Maraine, Cornelia Hoehr, Camille Bélanger-Champagne, Aziz Boukenter, and Sylvain Girard.

The Journal of Lightwave Technology, co-published by IEEE and Optica, is one of the reference publications for research on optical waveguides and their applications, from integrated photonics to optical networks. In July 2025, our MOPERE team published a paper on characterization and radiation testing of a miniature optical fiber interrogation device to perform distributed dosimetry for space applications.
The research was conducted in collaboration with Exail, CNES, IES Université de Montpellier, GuidOptix, and TRIUMF.

Optical fibers have enabled new means of performing dosimetry, i.e. measurement of radiation dose and/or dose rate. One of these applications, called distributed dosimetry, involves an Optical Time-Domain Reflectometer (OTDR) to measure dose on every point of an optical fiber line that can extend to several kilometers. This principle, first introduced in the early 2000s, has been further developed for monitoring particle accelerators at CERN, through several PhD theses operated by our lab's MOPERE group. This article investigates portability of distributed dosimetry for the space environment. Among the many strict requirements of such applications are the need of lightweight, compact devices, able to operate in a radiation environment. We investigated two embedded, miniature OTDR devices with three types of experiments: metrological evaluation of measurement uncertainties, calibration of the measurement on a phosphorus-doped optical fiber irradiated with γ- and X-rays, and tolerance of the device itself to ionizing radiation, under γ rays for Total Ionizing Dose (TID) and under high-energy protons for Single-Event Effects (SEE). All results indicate that such embedded OTDR devices, and especially the micro iOTDR, are good candidates to perform distributed dosimetry for space applications such as low Earth orbit satellites.

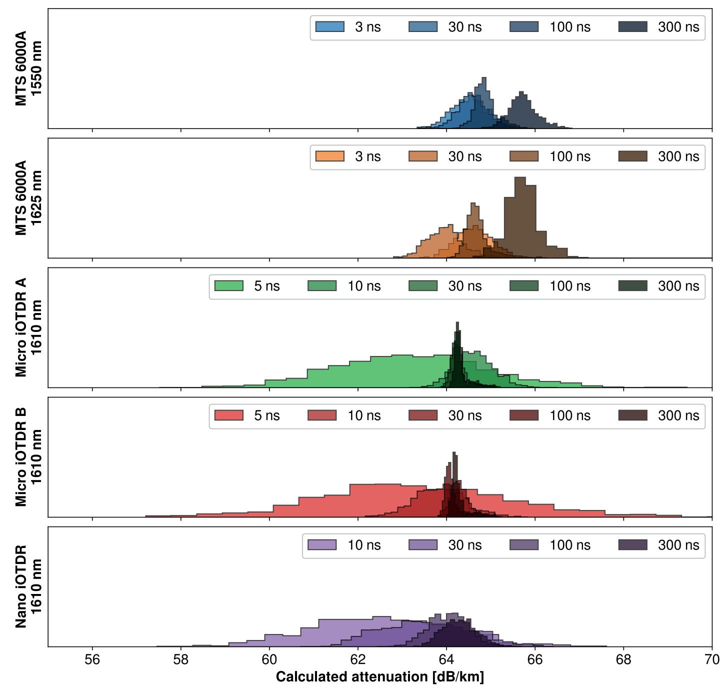


Figure 1, above: Histograms of attenuation values measured by different OTDR devices with different pulse width settings on a same attenuating optical fiber, with ~1200 repeated measurements for each combination.

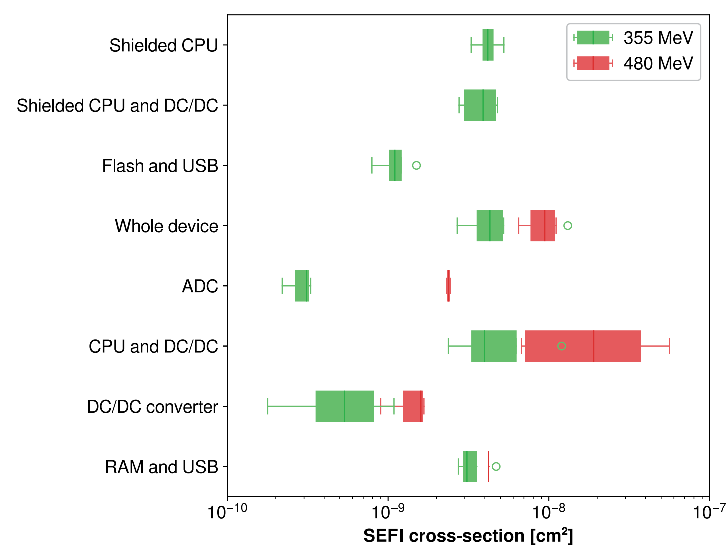


Figure 2, right: Single-Event Functional Interrupts (SEFI) cross-sections obtained from experimental proton irradiation (355 MeV in green ; 480 MeV red) targeting different components of a Micro iOTDR device.

Journal of Lightwave Technology, Vol. 43, Issue 17, pp. 8474-8483 (2025)

Sensors

Numerical and Experimental Study of Mode Coupling Due to Localised Few-Mode Fibre Bragg Gratings and a Spatial Mode Multiplexer

James Hainsworth, Adriana Morana, Lucas Lescure, Philippe Veyssiere, Sylvain Girard and Emmanuel Marin

In October 2025, a paper by our MOPERE team was published online in the international journal Sensors (MDPI). The work, carried out in collaboration with the IRT Saint-Exupéry in Toulouse, explores advanced optical fibre sensing using fibre Bragg gratings in few-mode fibres and demonstrates new strategies for enhancing sensing performance and multiplexing capacity.

Our work focuses on a common optical fibre sensor called a fibre Bragg grating (FBG). This grating reflects light over a narrow-band of wavelength known as the Bragg peak. When the fibre is strained or heated, this peak shifts, which makes FBGs highly effective for measuring strain and temperature. In this study, we explore a more complex form of FBG. Instead of a simple single-mode fibre (that creates a single Bragg peak), we use a few-mode fibre (supporting multiple light-paths, called modes) which produces multiple Bragg peaks spread out over the transmission and reflection spectra. This spectral complexity makes few-mode fibres difficult to use for temperature and strain sensing.

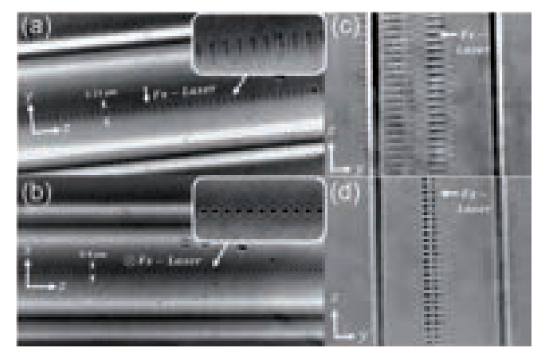


Figure 1, above: Images of FBGs written within the fibre core, showing:
(a) a side and
(b) a top view of a localised FBG taken with a phase contrast microscope, bright-field images of:
(c) a double refractive index modification due to a high femtosecond pulse power and
(d) multiple modifications forming due to re-passing the laser several times during inscription.

To tackle this, we inscribe localised FBGs (written only in a small portion of the fibre core) in order to force complex modal interactions. We combine this with a spatial mode multiplexer, a device that allows us to selectively excite certain modes in the fibre. Using both simulations and experiments, we study how all these extra degrees of freedom influence the interaction between modes, how the grating reflects/transmits light, and a way to simplify or exploit these effects for sensing. We find that while the transmission spectrum remains somewhat complex and not ideal for sensing purposes, the reflection spectrum after modal-filtering shows promising simplification. Applying this method and observing the reflection spectrum allows for large numbers of FBGs to be written into the same fibre for quasi distributed sensing. This is done via a technique known as wavelength division multiplexing (WDM), something previously achievable to limited effect few-mode fibres, due to their spectral complexity.
Furthermore, by carefully positioning the gratings within the fibre core so that they only interact with specific modes, we are able to achieve modal multiplexing of FBGs. This technique may prove complementary to WDM for enabling densely packed sensing arrays in few-mode fibres.

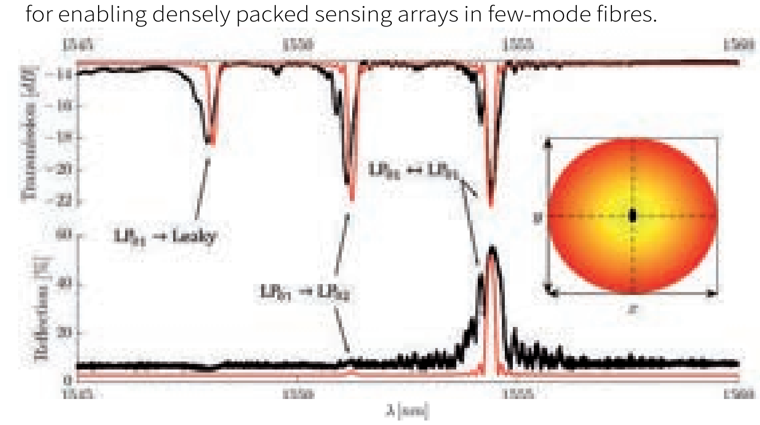


Figure 2, above: Experimental (black line) and simulation (red line) transmission (top) and reflection (bottom) spectra for a centric FBG, dy = dx = 0 µm, excited solely by HG00.
The inset depicts the FBG transverse location within the fibre core.

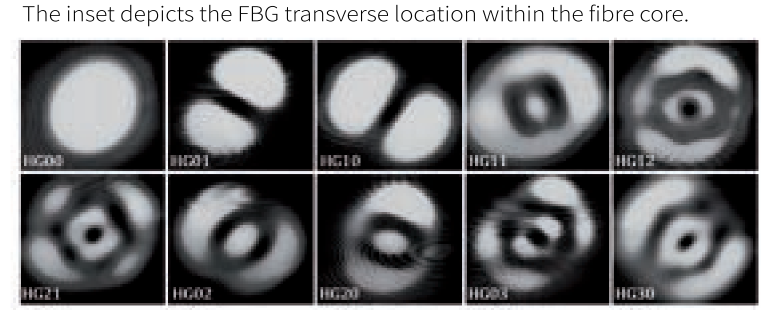


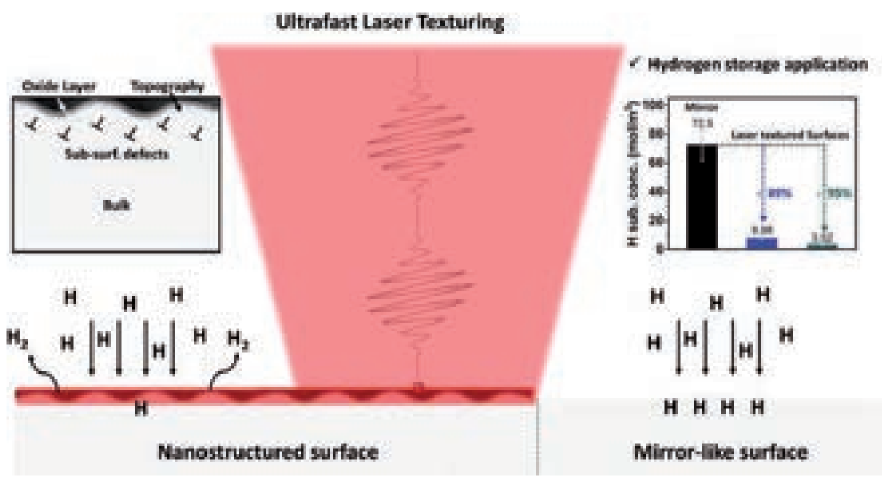
Figure 3, above: The far-field images taken of each HG mode at the cleaved end of the Proteus output fibre. Here, only one mode was selectively excited for each of the output photos.

Sensors, Vol. 25, Issue 19, Article 6087 (2025)

Acta Materialia

Periodic laser surface texturing limits hydrogen ingress in Fe-Cr alloy

Anthony Nakhoul, Alixe Dreano, Claire Maurice, Vincent Barnier, Matthieu Lenci, Florence Garrelie, Jean-Philippe Colombier and Frédéric Christien



An article by our Laser-Matter Interaction team was published in June 2025 in Acta Materialia, a journal dedicated to original papers and commissioned overviews that advance the in-depth understanding of the relationship between the processing, structure and properties of inorganic materials.
The work, done in collaboration with École des Mines Saint-Étienne, explores the way light can help metals resist hydrogen damage.

Hydrogen is a clean and promising energy source, but it also presents a hidden risk: it can penetrate metals and weaken them by degrading their mechanical strength. This phenomenon, known as hydrogen embrittlement, can lead to cracks and failures, raising major safety concerns. So how can we prevent hydrogen from entering metals?
In our study, we explored a novel solution: using ultrafast laser pulses to precisely shape the surface of a metal at the nanoscale. We applied this technique to an iron-chromium alloy and created tiny, regular patterns. Each pattern measures just a few tens of nanometers, which is approximately the size of a DNA strand . These nanostructures significantly reduced the amount of hydrogen absorbed by the material. Interestingly, it was not only the surface shape that that played a key role. A very thin oxide layer, similar in thickness to the natural oxide that forms on metals in air, also appeared during the laser process and acted as an effective barrier. In addition, the sharp peaks created by the laser-induced texture may help atomic hydrogen recombine into molecular hydrogen (H_2), making it less likely to enter the material. By tuning both surface geometry and chemical composition, we showed that it is possible to protect metals without adding any coatings. This opens new perspectives for making materials safer and more reliable in hydrogen-based technologies.

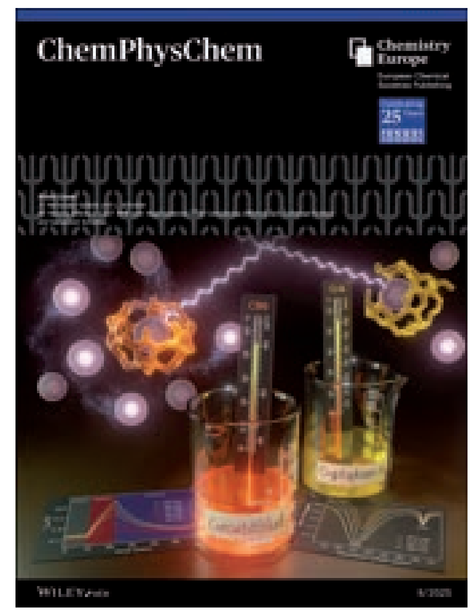
Acta Materialia, Vol. 291, Article 120995 (2025)

ChemPhysChem

Synthesis and Modeling of Alloy Nanoparticles

Daniel Forrer, Tatiana E. Itina and Vincenzo Amendola

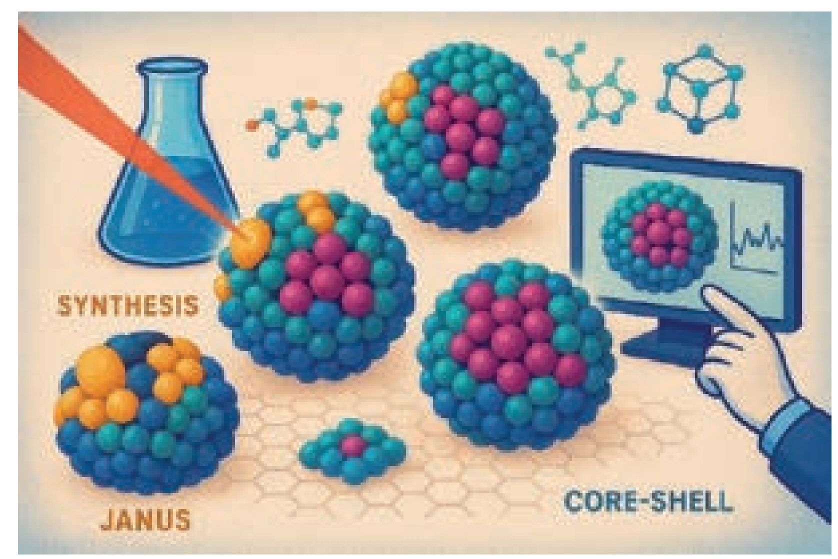
Nanoalloys occupy a focal point of research across many fields. A special collection of articles providing an overview of current studies on their synthesis, modeling, and applications was compiled by Tatiana E. Itina, a member of our Laser-Matter Interaction team, in collaboration with colleagues from the University of Padua, University of Naples Federico II, and the CNR ICMATE Institute in Padua. The collection was published in ChemPhysChem in April 2025, a journal dedicated to cutting-edge international research in physical chemistry and chemical physics.



Illustration, above:
ChemPhysChem Cover,
Volume26, Issue8
April 14, 2025

The synthesis and modeling of alloy nanoparticles have become crucial in advancing numerous scientific fields, including energy technologies, environmental science, and healthcare. Alloy nanoparticles, composed of two or more metals, exhibit unique physicochemical properties that arise from their specific composition and structure, making them highly versatile for a wide range of applications. These nanoparticles are key components in the development of efficient fuel cells, batteries, and solar cells, and are also instrumental in catalysis and water treatment. Additionally, in the medical field, alloy nanoparticles are explored for applications in imaging, drug delivery, and biosensing. The successful design and production of these nanoparticles rely on both experimental and computational techniques, such as molecular dynamics and density functional theory, to predict and enhance their properties. This article provides insights into the latest advancements in alloy nanoparticle synthesis, highlighting the integration of new synthetic methods, such as laser-assisted approaches, and the role of computational models in understanding and optimizing their structure and function. It introduces a special collection of papers in ChemPhysChem depicting a panorama of the ongoing research about nanoalloys, stimulating the next advancements in the experimental validation and theoretical predictions of their physical and chemical properties, synthesis, equilibrium or non-equilibrium formation mechanism, and the promises for a wealth of different applications.

Figure, below:
Illustration of synthesis and modeling of various nanoparticles: alloys, core-shells, Janus, study of their structure, morphology and properties.



ChemPhysChem, Vol. 26, Issue 8, pp. e202500033, (2025)

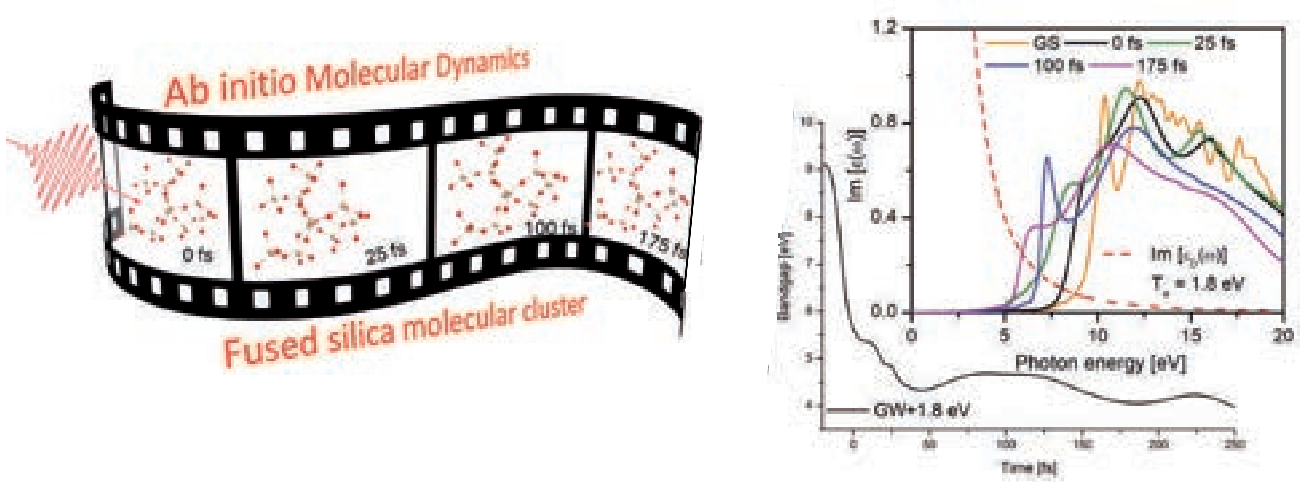
Advanced Physics Research

Excited State Dynamics and Optical Properties of Silica Under Ultrafast Laser Irradiation

Arshak A Tsaturyan, Elena Kachan, Razvan Stoian and Jean-Philippe Colombier

Advanced Physics Research is an open access journal dedicated to high-quality experimental and theoretical work across the full spectrum of applied and fundamental physics. In a study published in the February 2025 edition of the journal, members of our Laser-Matter Interaction team investigate how ultrafast laser pulses can reshape the properties of silica glass, uncovering new ways to harness light's power at the atomic scale.

Silica glass is everywhere - from optical fibers to smartphone screens - but what happens when you blast it with ultrafast laser pulses? These incredibly brief bursts of light lasting just femtoseconds push silica into exotic states where electrons and atomic structure behave in unexpected ways. In this study, the authors decode these ultrafast processes, mapping how energy floods the material, distorts its electronic landscape, and ultimately reshapes its optical properties. Their findings zoom in on the critical early stages of laser-matter interaction, where fleeting electron dynamics set the stage for permanent modifications. This isn't just about damage, it's about control. By revealing how silica responds at these extreme timescales, the work opens new doors for precision laser machining, advanced photonics, and even ultrafast data storage. For anyone pushing the limits of laser-based material design, these insights are a roadmap to harnessing light's power at the atomic scale.



Figure, above: Calculations of optical properties of fused silica irradiated by ultrafast laser pulse.
The contribution of both electronic and atomic factors to bandgap narrowing is estimated using DFT and GW approaches.
The dielectric function Im[ε(ω)] is evaluated within the framework of the Bethe-Salpeter equation approximation and Drude model.

Advanced Physics Research, Vol. 4, Issue 2, pp.2400106 (2025

Laser & Photonics Reviews

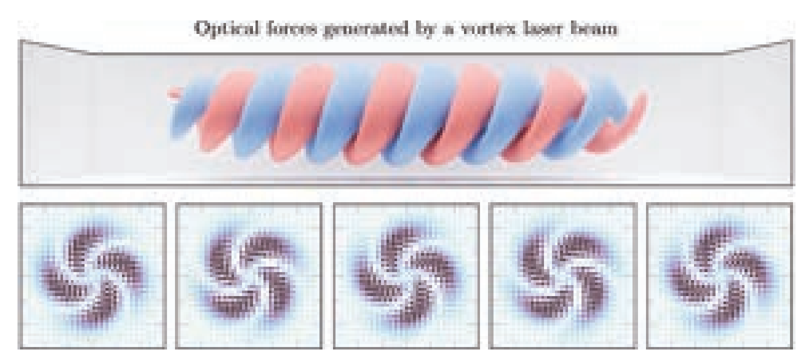
Chiral Patterning of Rough Surfaces with Vortex Laser Beams: From Structured Polarization to Twisted Forces

Vladimir Yu. Fedorov and Jean-Philippe Colombier

Released in February 2025, an article by our Laser-Matter Interaction team appeared in Laser & Photonics Reviews, an interdisciplinary journal at the interface of photonics and optics. The publication covers recent breakthroughs, specific technological developments and novel applications, both theoretical and experimental.

The interaction between light and matter has long been a playground for exploring novel surface structuring techniques, but controlling chirality, left- or right-handedness, in laser-induced patterns remains a frontier challenge. In this work, we theoretically explore how vortex laser beams, characterized by their twisted polarization and helical wavefronts, can imprint chiral patterns onto rough metallic surfaces. Through advanced numerical simulations, our study reveals how structured light fields, especially those carrying orbital and spin angular momentum, can shape not just energy absorption but also the forces that reorganize material at the nanoscale.These findings shed new light on how to engineer asymmetric, chirality-sensitive surface features, potentially expanding applications in nanophotonics, biosensing, and beyond.

Figure 1, left:
This fundamental work presents an in-depth exploration of the potential for laser-induced surface chirality, relying on the resolution of Maxwell's equations to examine the roles of orbital angular momentum and spiral polarization in sculpting and twisting irradiated material surfaces. Electric field intensity of the vortex beam (top), the snapshots of optical force at times t within an optical period T and the total force or focused laser pulses carrying an OAM.



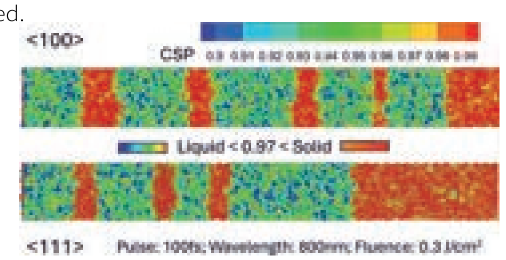
Laser Photonics, Vol. 19, Issue 11, Article 2401540 (2025)

Physical Chemistry Chemical Physics

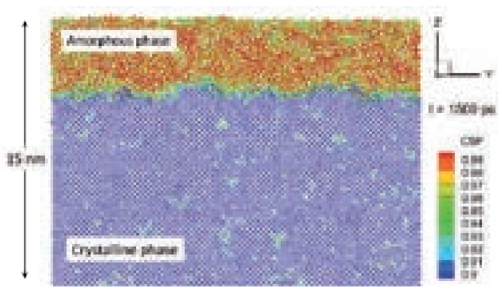
Unveiling Ultrafast Dynamics:
Atomistic-Continuum Modeling of Laser-Induced Phase Transitions in Silicon

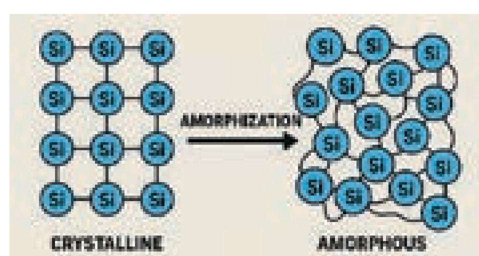
Dmitry S Ivanov and Tatiana E Itina

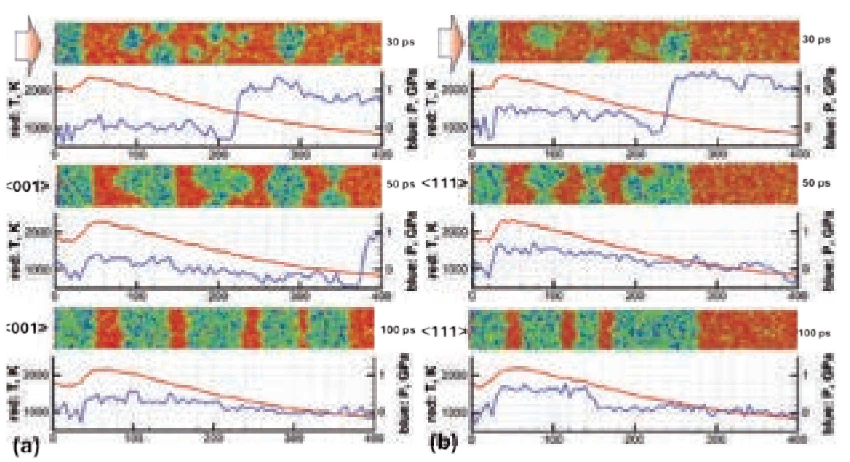
PCCP is an international journal co-owned by 19 physical chemistry and physics societies from around the world. This journal publishes original, cutting-edge research in physical chemistry, chemical physics and biophysical chemistry. An article by our Laser-Matter Interaction team, published in July 2025, presents a hybrid atomistic-continuum modeling approach to study femtosecond laser-induced phase transitions in silicon.
Laser technology has opened up new possibilities for material modifications at the atomic scale, especially in semiconductors like silicon. This article explores the application of advanced computer modeling to understand what happens to silicon when struck by extremely fast, intense laser pulses - how its surface melts, rearranges, and cools in fractions of a second. By combining detailed atomic simulations with broader-scale models, the researchers reveal how factors like crystal orientation and cooling dynamics affect the ultimate transformation. The proposed hybrid approach offers more reliable predictions than traditional single-method models, and sheds light on how laser bursts can finely shape silicon surfaces, an essential step for tomorrow's electronics and nanotechnologies. These insights help bridge the gap between fundamental research and practical advances in laser-processing of materials, impacting both experimental and industrial applications.
In particular, modern semiconductor applications demand precise laser processing at the nanometer scale, requiring a detailed understanding of phase transition and structural modification mechanisms. Accurate control over laser-induced processes in semiconductors is essential for generating predesigned surface structures and modifying the surface properties. In this study, we present a numerical investigation of non-equilibrium laser-induced phase transitions in silicon (Si) using a hybrid atomistic-continuum model. By using TTM-MD model, we explore femtosecond laser-induced melting of Si and show the difference between <111> and <100> configurations. Conditions required for a thin layer amorphization are also discussed.



Figure, right : Top: Two sets of atomic configurations illustrates the differences in the laser-induced melting process for Si samples: (i) <100> (upper image) and (ii) <111> crystal orientations.
Bottom: Si amorphization: the obtained in simulations presurface amorphous state of Si was achieved through a cooling process of the melted region with a certain rate. Atoms are color-coded by the Central Symmetry Parameter (CSP), indicating that amorphization occurred due to the prolonged immobility of the solid-liquid interface, even after the sample temperature dropped to 1000 K, well below the melting point of 1687 K.







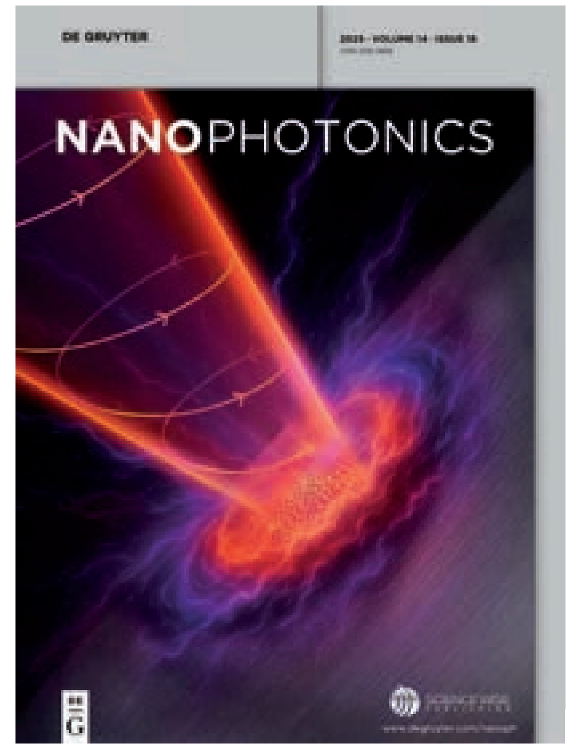
Figure, left : Two sets of sequences of atomic configurations illustrates the differences in the laser-induced melting process for Si samples: (i) <001> (left) and (ii) <111> (right) crystal orientations. Both samples were irradiated with a 100 fs pulse at 800 nm, using the same incident fluence of 0.3 J/cm². Snapshots are presented at identical time intervals (30ps, 50ps, and 100ps) for both cases, with atoms color-coded according to the Central Symmetry Parameter (CSP), enabling the distinction between solid (CSP > 0.97) and liquid (CSP < 0.97) phases. The corresponding profiles of lattice temperature and pressure are added for a quantitative analysis.

Phys. Chem. Chem. Phys., Vol. 27, Issue 42, pp.22408-22423 (2025)

Nanophotonics

Exploring 2D-LIPSS formation under circular polarization in ultrafast laser processing

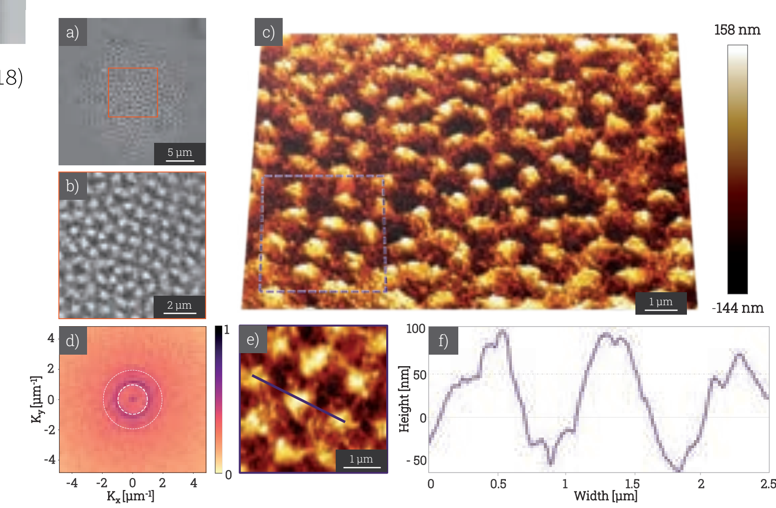
Sylvain Georges, Anthony Nakhoul, Vladimir Fedorov, Paul Saby, Nicolas Faure, Hugo Bruhier, Nicolas Compère, Yoan Di Maio, Xxx Sedao and Jean-Philippe Colombier



Illustration, above: Journal cover (Volume 14, Issue 18) as a visual representation of the article's research.

Nanophotonics is an international journal that highlights cutting-edge research, significant advances, and innovative applications in the field. Published in partnership with Sciencewise, it is recognized as one of the leading journals in nanophotonics. An article co-authored by members of our Laser-Matter Interaction team in collaboration with the GIE Manutech-USD was published in the journal's September 2025 issue and selected for the cover.

When ultrafast laser pulses interact with metals, they can create periodic surface patterns at the nanoscale, known as LIPSS (Laser-Induced Periodic Surface Structures). Most commonly, these patterns are aligned in a single direction, dictated by the laser's linear polarization. In this study, we demonstrate that using circular polarization enables the formation of isotropic two-dimensional structures, arranged as pillar-like features interconnected by fine radial filaments. Remarkably, this approach allows the production of such patterns over large surface areas, thanks to the self-organization process where scattered surface waves combine with the incident laser field without a preferred orientation. Beyond providing new insights into ultrafast light-matter interaction, these findings open promising perspectives for engineering functional surfaces with applications in optics, tribology, and even biomedicine.



Illustration, above right:
Topographic characterization of 2D-LIPSS.
(a) SEM image of structures formed on a FeCr(001) surface under 50 fs laser pulses with circular polarization (DOCP > 99 %) at a peak fluence of 0.14 J/cm2.
(b) Higher-magnification SEM image corresponding to the orange-marked region in (a), highlighting periodic HSFL and LSFL structures.
(c) AFM image of the structured area, revealing an average feature height of approximately 150 nm.
(d) Fourier transform of the SEM image in (a), with white dashed circles indicating the characteristic wavelengt and half-wavelength.
(e) High-resolution AFM scan from (c), with an extracted cross-sectional profile. (f) Topographic chart of the cross-section extracted from (e), showing height variations.

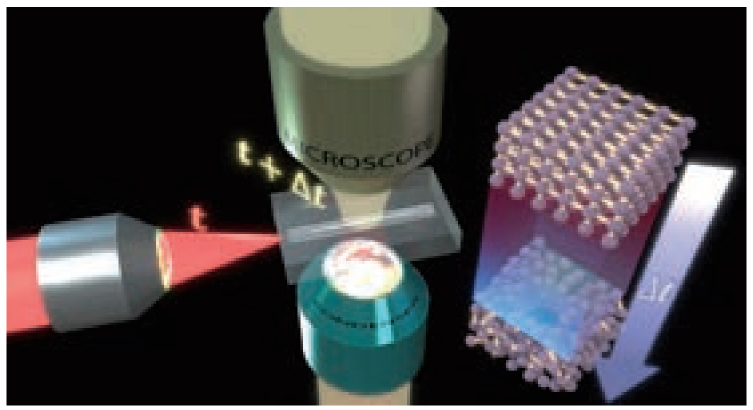
Nanophotonics, Vol. 14, Issue 18, pp. 2993-3007 (2025)

ACS Photonics

Dynamic Ultrafast Laser-Induced Structural Changes and Extreme Nanostructuring in Hard Dielectric Materials

Rajeev Dwivedi, Huu Dat Nguyen, Sergio Sao Joao, Anne-Magali Seydoux-Guillaume, Thirunaukkarasu Kuppan, Ciro D'amico, Guillaume Kermouche and Razvan Stoian

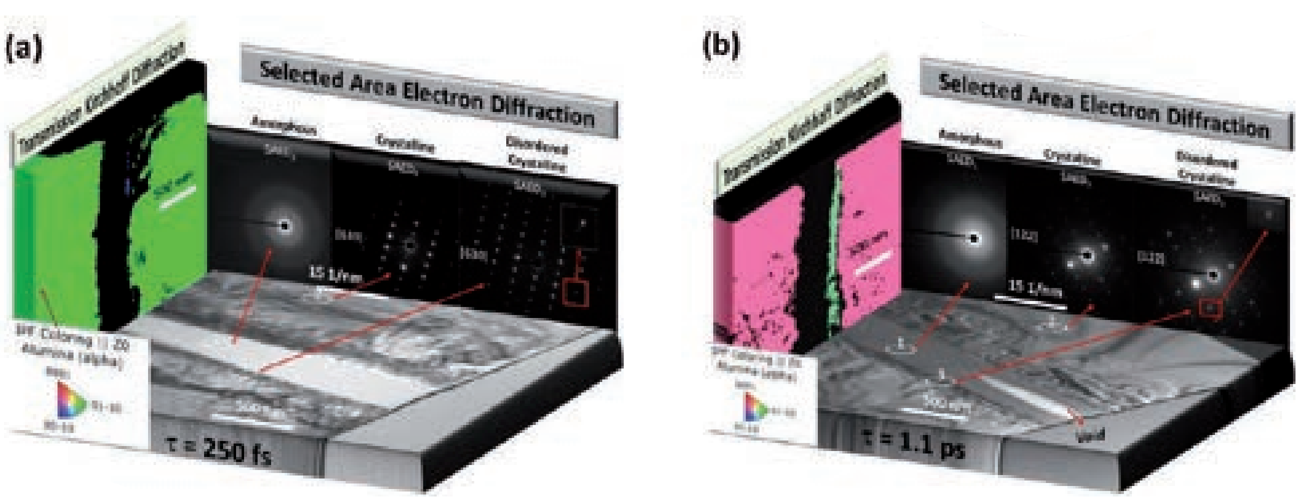
ACS Photonics is an interdisciplinary forum to communicate on the latest advances in the field of photonics, all the way from basic research to applied research and technology. An article co-authored by members of our Laser-Matter Interaction team was published in the July 2025 edition of the journal, exploring phase transformation mechanisms during ultrafast laser-induced modification of bulk sapphire.



Hard crystals like sapphire have proved to be a key element in a vast range of applications, including industrial, optical and aerospace research. However, attaining precision in processing them remains an arduous task due to their exceptional tolerance to high pressure and temperature. In this study, we observe the dynamics of structural and morphological changes in bulk sapphire using quantitative optical phase microscopy. The thermo-optic dynamics reveal the process of phase transformation from crystalline to amorphous and the manifestation of void inside bulk single-crystal sapphire. Furthermore, the scanning and transmission electron microscopy indicate the presence of a nano-void of around 150 nm and a thin layer of disoriented crystals at the interface of the amorphous and crystalline inside the bulk sapphire. This study will be beneficial in understanding the light-matter interaction in hard crystals and help in achieving precise control of the high-aspect-ratio volume modifications inside hard photonic crystals.

Illustration, above: Conceptual schematic of the pump-probe experiment, revealing the temporal dynamics of crystalline to amorphous transition with time, Δt.

Figure, above:
(a) and (b) transmission electron microscopy and selected area electron diffraction images showing diffraction patterns at different locations on the prepared lamellas and for τ = 250 fs, and τ = 1.1 ps, respectively.
Locations mentioned as 1, 2 and 3 correspond to the amorphous, crystalline and disordered crystalline regions, respectively. The transmission Kikuchi diffraction images indicate crystal plane orientation at each pixel grain.



Ultrafast Science

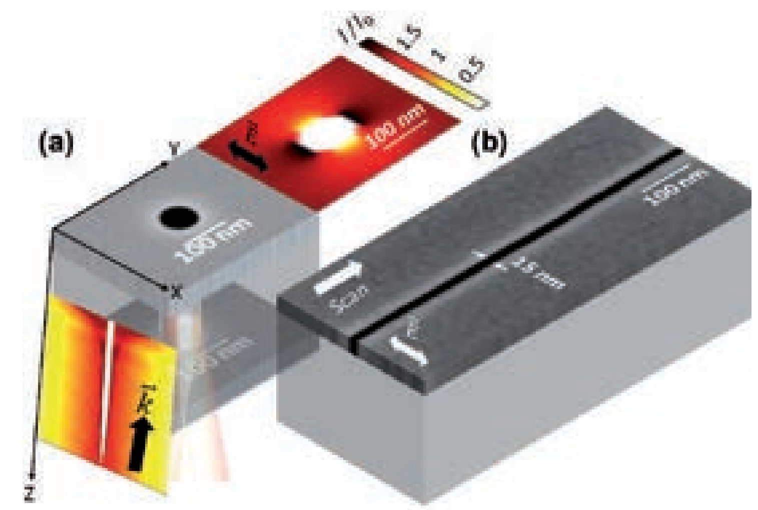
Ultrafast laser high-aspect-ratio extreme nanostructuring of glass beyond λ/100

Guodong Zhang, Anton Rudenko, Razvan Stoian and Guanghua Cheng

Ultrafast Science offers international scientists a platform for new theories, concepts, ideas, technologies and progress in the field. An article published in the journal's June 2025 edition by our Laser-Matter Interaction team, in collaboration with colleagues at Xi'an Northwestern Polytechnical University, reports a breakthrough in direct laser writing by exploiting ultrashort Bessel-Gauss beams.

Direct laser writing is a scanning technique to engrave arbitrary structures on a material's surface without physical contact by high-power laser. So far, the laser-written structures have been limited to sizes exceeding 100 nm and aspect ratios < 100, not competitive with nanolithographic techniques for nanofabrication. In this work, a collaborative effort between researchers of Xi'an Northwestern Polytechnical University and Laboratoire Hubert Curien has allowed to overcome this limitation by developing a new method, exploiting ultrashort laser Bessel-Gauss beam. Such non-diffracting laser beam with energy slightly exceeding the damage threshold can induce a few micron-deep void-like modification on the back glass surface with width ~15 nm. Upon multi-pulse scanning perpendicular to laser polarization, the modification is replicated, following the near-field enhancement around the existing nanohole. This way, a deep-engraved line with a nanometric width and high-aspect ratio can be written and controlled by pulse duration, scanning direction and speed. For specific conditions, it is even possible to write several nanolines simultaneously. The experiments are accompanied by multi-pulse simulations describing field enhancement near the void structure, electronic excitation, heating and ablation, that explain the modifications observed in experiments. Such super-resolved laser-processing techniques open new opportunities for metasurface designs on extreme scales.

Figure, below:
(a) A nanohole engraved deep in bulk fused silica by single short pulse nondiffractive Bessel–Gauss beams. The illumination of such a structure generates near-field evanescent components with the poles oriented perpendicular to the laser field. The color map indicates the intensity enhancement relative to the incident value for an infrared beam scattered by a void channel of similar geometry. One notices that the field level increases perpendicular to the incident optical field. These waves are perpetuated in the bulk, all along the channel, with a distribution of intensities given in the insert.
(b) A nanoline written by linear scan of a laser with a 15 nm-width.



Optics Letters

Iterative phase retrieval algorithm for space-variant PSF in optical systems with aberrations

Dylan Brault, Corinne Fournier and Tatiana Latychevskaia

An article by our Image Science & Computer Vision team and Tatiana Latychevskaia of the University of Zurich (Switzerland) was published in the March 2025 issue of Optics Letters. The journal, published by the Optical Society of America, is renowned for cutting-edge research in optics and photonics.

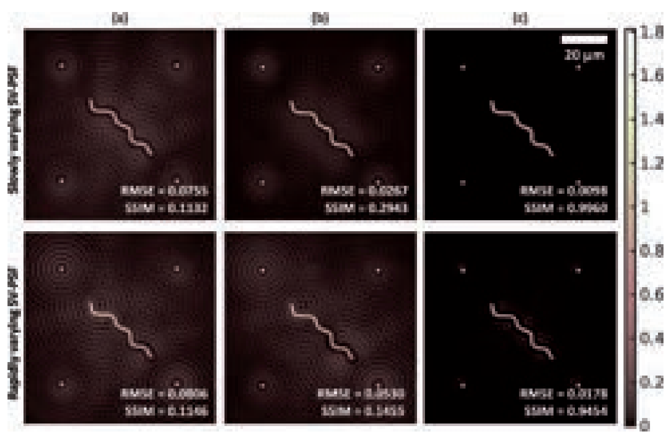


Figure 1, above: Phase distributions reconstructed from the simulated hologram.
(a) with classical IPR algorithm,
(b) with the SI-PSF IPR algorithm, and
(c) with the SV-PSF IPR algorithm (P = 49, Q = 15).

This research proposes enhanced IPR algorithms that integrate a novel propagation function to account for optical aberrations, significantly improving the accuracy of wavefront reconstruction in applications such as digital holography and electron holography. The study details how these algorithms mitigate the limitations posed by lens imperfections, which often degrade image quality in optical systems. By incorporating space-variant PSFs, the method achieves superior reconstruction results compared to traditional approaches, as demonstrated through experimental validations using latex beads. The proposed technique offers a computationally efficient solution, reducing artifacts like the twin image problem and enhancing resolution in systems constrained by aberrations. This advancement holds potential for broad applications, including high-resolution imaging in electron holography, where lens aberrations are a primary limiting factor.

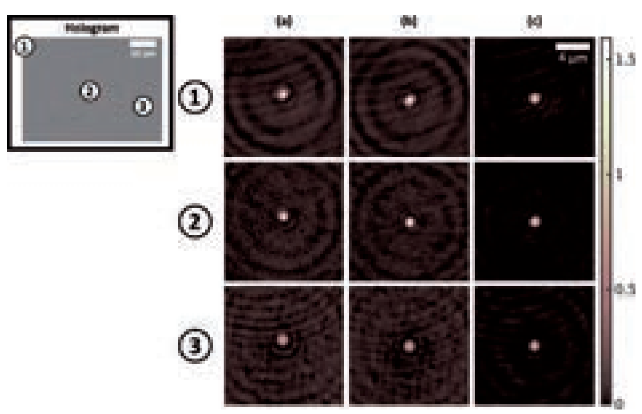


Figure 2, right:
Phase of the reconstruction on three regions in the FOV obtained
(a) with the classical IPR algorithm, with the IPR algorithm
(b) with SI-PSF, and
(c) with SV-PSF (P = 28, Q = 15).

Table 1, below: Reconstruction Quality Criterion with the Three Hologram Formation Models with Limited Convolution Budget (400 Convolutions)[a].
[a] "conv." stands for "convolution"

	IPR	SI-PSF IPR	SV-PSF IPR		
N	200	200	40	20	10
Q			5	10	20
# of conv.	400	400	400	400	400
RMSE	0.0755	0.0267	0.0126	0.0114	0.0206
SSIM	0.1132	0.2943	0.9853	0.9827	0.9457

Optics Letters, Vol. 50, Issue 6, pp. 1767-1770 (2025)

IEEE Transactions on Geoscience and Remote Sensing

Just Project! Multi-Channel Despeckling, the Easy Way

Loïc Denis, Emanuele Dalsasso and Florence Tupin

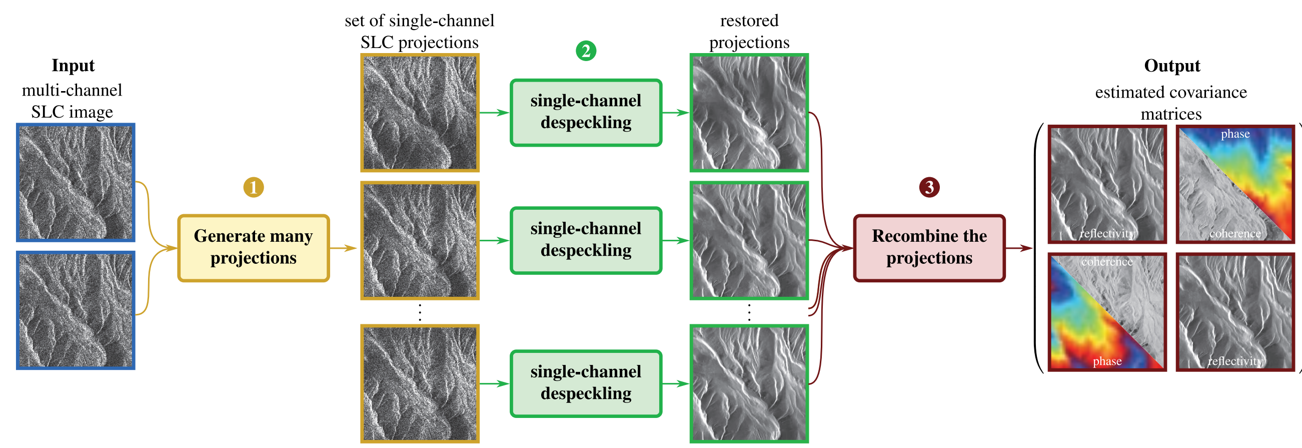
A research study led by Loïc Denis, member of our Image Science & Computer Vision team, appeared in the January 2025 issue of IEEE Transactions on Geoscience and Remote Sensing (TGRS). The journal publishes technical papers disclosing new and significant research related to the theory, concepts, and techniques of science and engineering as applied to sensing the land, oceans, atmosphere, and space. The work explores innovative self-supervised learning techniques to enhance interferometric synthetic aperture radar (InSAR) imaging.

Deep learning has vastly improved the reconstruction of interferograms in synthetic aperture radar imaging (SAR). Yet, supervised training suffers from several drawbacks: building the training set is difficult, generalization to actual SAR images is imperfect due to speckle noise model mismatch and the presence of unseen structures during training. Self-supervised learning seems like a perfect solution to these problems. We developed recently such self-supervised learning strategies to despeckle single-channel SAR images. Our approach is based on the decomposition of SAR images into two statistically independent components (the real and imaginary parts of the complex-valued SAR image). Unfortunately, the extension of these approaches to multi-channel SAR images such as interferograms cannot work (the components are statistically dependent).

This new work shows that it is possible to reduce the problem to the single-channel case by linear projection. Once projections are denoised using a self-supervised despeckling algorithm, the solution to the original problem, the estimation of the interferometric covariance matrices, can be obtained by inversion.

This study was conducted thanks to a 6 months research sabbatical granted to Loïc Denis by Jean Monnet University.

Figure, below:
Principle of our method: starting from an interferometric pair, we generate several single-channel images by projection, restore separately these projected images, and in a last step combine these images to recover the interferometric information.



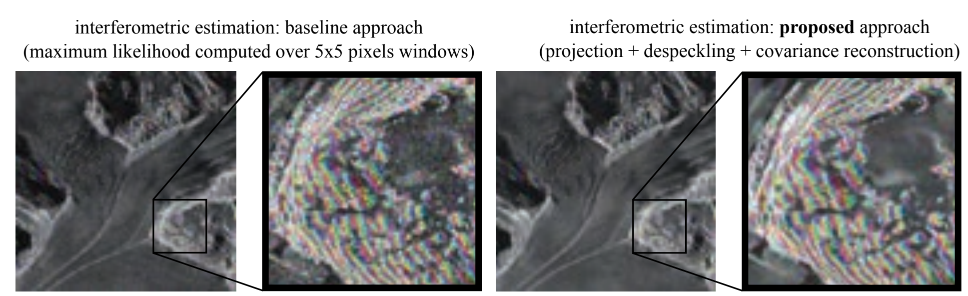


Figure 2, left: Estimation of the interferometric phase, directly connected to the topography, from a pair of satellite images close to the Jungfrau summit in Switzerland (TerraSAR-X, ©ESA): top, standard estimation (phase is represented in color); bottom, our estimation.
Note that the colored fringes are smoother and that thin fringes are much better restored by our method.

IEEE Transactions on Geoscience and Remote Sensing, Vol. 63, pp. 1-11, Article 5204311 (2025)

Journal of Imaging

Experimental Protocol for Color Difference Evaluation Under Stabilized LED Light

Sofiane Vernet, Éric Dinet, Alain Trémeau and Philippe Colantoni

Journal of Imaging is an international, multi/interdisciplinary, open access, peer-reviewed journal that publishes reviews, original research articles, communications, case reports, letters, and short notes across all fields of imaging research. In January 2025, our Image Science & Computer Vision team published a paper putting forward an innovative approach for producing custom color patches and an advanced stabilization method for multichannel LED lighting systems.

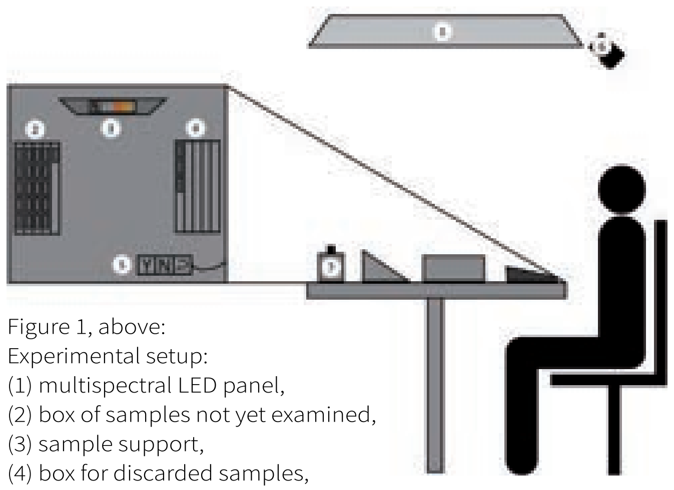


Figure 1, above:
Experimental setup:
(1) multispectral LED panel,
(2) box of samples not yet examined,
(3) sample support,
(4) box for discarded samples,
(5) three button keypad,
(6) camera,
(7) spectroradiometer.

As part of our research on how lighting influences color perception in individuals with low vision, we designed psychophysical experiments in which participants perform specific visual tasks under carefully controlled conditions. To ensure the reliability of these experiments, we addressed two major challenges: producing colorimetrically accurate color samples as well as generating stable and repeatable light spectra.

To tackle the first challenge, we integrated a tabulated color space with advanced sampling techniques, allowing us to create precise color combinations that remain within the gamut of the target printer. This ensured the consistency and suitability of color stimuli used in our psychophysical experiments.

To address the second challenge, we developed an algorithm to stabilize multispectral LED lighting. By analyzing the spectral output and dynamically adjusting the power levels of each independent LED channel, our system delivers tailored illumination that resists drift caused by temperature changes and other environmental factors.

These advancements not only improve the quality of our psychophysical studies but also offer broader applications. Our methods support the development of accurate color charts for calibrating imaging systems and contribute to the design of adaptive lighting solutions that benefit both visually impaired people and the general population.

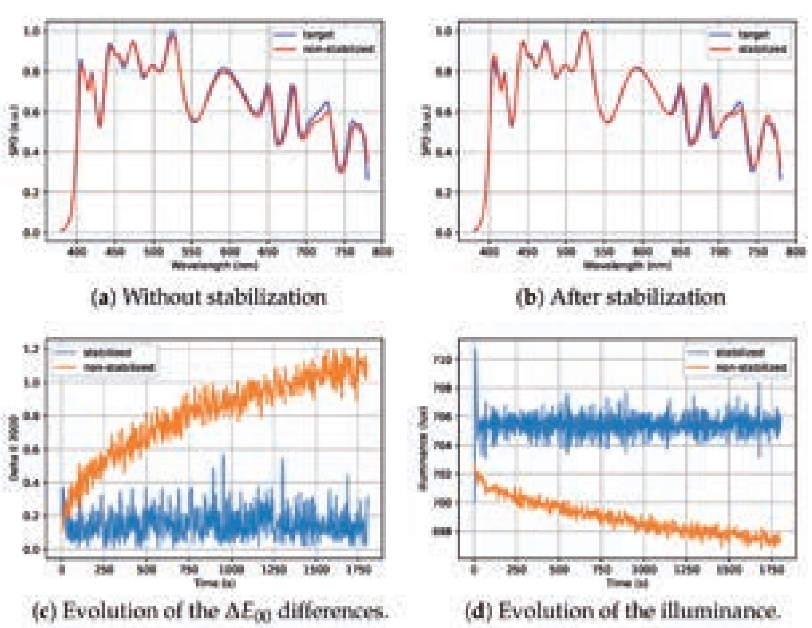


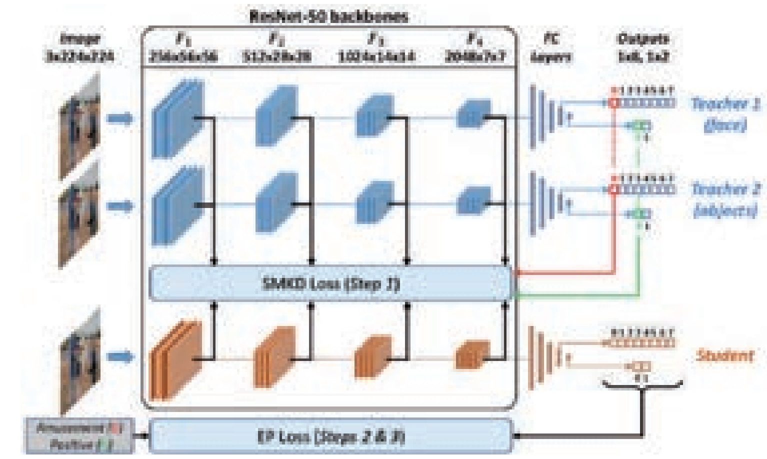
Figure 2, left
Illustration of the performance of the multispectral LED lighting stabilization algorithm.
Blue plots represent the stabilized output while red and orange ones show the unstabilized output.

J. Imaging , Vol. 11, Issue 1, Article 4 (2025)

Pattern Analysis and Applications

Visual emotion analysis using skill-based multi-teacher knowledge distillation

Tristan Cladière, Olivier Alata, Christophe Ducottet, Hubert Konik and Anne-Claire Legrand



In February 2025, our Image Science & Computer Vision team published an article in Pattern Analysis and Applications, a journal focused on novel pattern analysis techniques and their industrial and medical applications.

In recent years, sharing experiences, emotions and opinions by posting images on social media has become commonplace, leading to a growing interest in Visual Emotion Analysis (VEA). VEA aims to recognise the emotions induced by visual content and has many potential applications in the real world, such as smart advertising, opinion mining and treatment of mental health conditions. However, the gap between pixel-level information and high-level emotional semantics remains a challenging issue. Therefore, to obtain robust predictions, it is necessary to extract discriminative features that take into account a variety of cues. Early approaches relied on hand-crafted features such as colour, texture, composition and balance. However, with recent advances in deep learning, Convolutional Neural Networks (CNNs) have emerged as the new trend, as they can automatically extract emotional representations in an end-to-end manner. The latest approaches even include multi-branch architectures, fusion, and attention modules, resulting in complex yet promising frameworks. In our paper, rather than experimenting with larger models, we explored a different approach for reconciling effectiveness and simplicity by leveraging Knowledge Distillation (KD). Our proposed Skill-based Multi-Teacher Knowledge Distillation (SMKD) training scheme comprises three steps to ensure that the student model can not only extract the most relevant features, but also use them for robust emotion recognition. During the first step, the student model's backbone learns to reproduce features extracted by several specialised teachers. The SMKD loss gives more or less importance to teachers depending on their relevance to a given input, ensuring the student focuses on the most important information. Once the student is finally capable of gathering useful cues, the next two training steps follow, with the first serving to learn its classifier for emotion recognition, and the second to further refine the whole model end-to-end. Figure 1 gives an overview of the approach. This approach was validated on two VEA databases and produced competitive results while requiring only a single basic CNN for inference. As illustrated by Figure 2, knowledge from 4 teacher models, trained using different data, was efficiently filtered and transferred to the student model, which ultimately achieved the best separation between emotional classes.

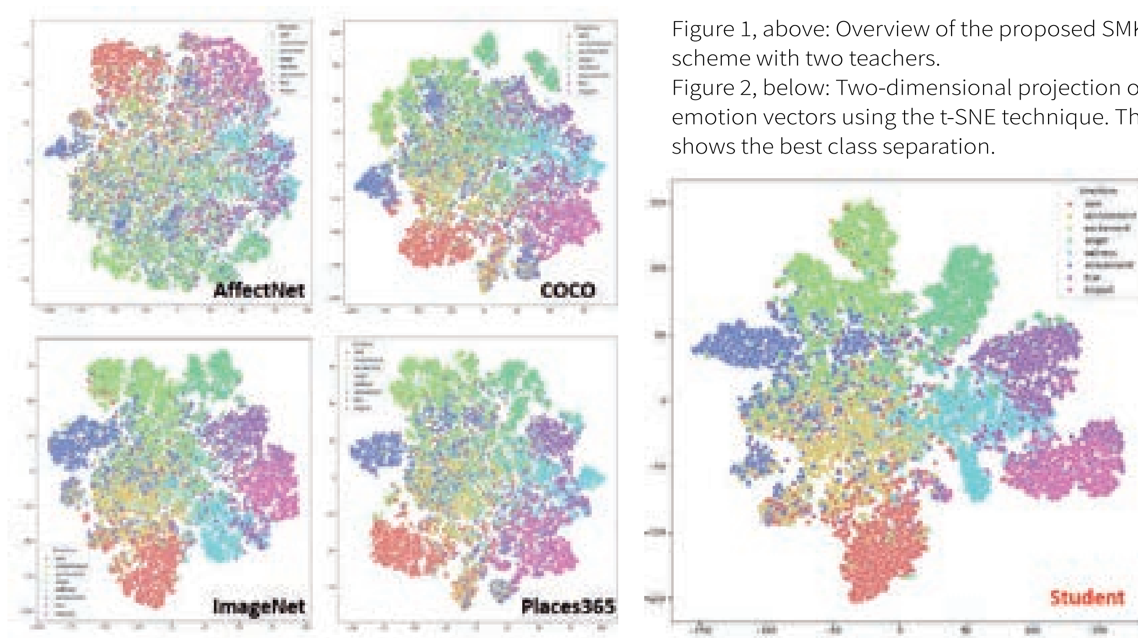


Figure 1, above: Overview of the proposed SMKD training scheme with two teachers.
Figure 2, below: Two-dimensional projection of predicted emotion vectors using the t-SNE technique. The student model shows the best class separation.

Pattern Anal Applic, Vol. 28, Article 49 (2025)

International Conference on Computer Vision Theory and Applications - VISAPP 2025

Targeted Test Time Adaptation of Memory Networks for Video Object Segmentation

Isidore Dubuisson, Damien Muselet, Christophe Ducottet and Jochen Lang

VISAPP is a flagship event for researchers, engineers and practitioners working in the area of computer vision methods, systems, and applications. An article co-authored by our Image Science & Computer Vision team was presented at VISAPP 2025, exploring the topic of visual object tracking. The work was carried out as part of a collaboration with the University of Ottawa (J. Lang), and funded by the France Canada Research Fund.

Figure 1: General memory-based pipeline.
It consists on a query encoder, a memory encoder and a decoder. Note that the mask information is provided by the previous memory features.

Figure 2: Our architecture for test-time finetuning.
Left: We insert a small predecoder that is trained to predict a good mask for the frame 0, allowing to adapt the generic features to the current context. The predecoder is trained once on the frame 0 and frozen for all the other steps.
Right: Each time a frame/mask pair is inserted in the memory, we adapt the mask so that the encoded pair promotes a good prediction of the mask of the initial frame, in order to avoid mask drift.
The red arrows represent gradient back-propagation.

Visual object tracking has been a constantly evolving challenge for decades. Nowadays, the challenge consists of segmenting every image in real time for augmented reality, video editing or autonomous driving applications. Additionally, the ability to adapt visual tracking to any object in any environment has become mandatory. This is how the Semi-Automatic Video Object Segmentation (SVOS) task was born. The SVOS task aims to segment a few objects in a video based on the annotation of those objects in the first frame only. Even if the semantic class of the object has never been seen before during model training. The state of the art in this field is memory-based models. Memory-based models subsequently predicts the estimation of the current frame by using a U-Net-like architecture for segmentation. In addition to the information provided by the current frame, they use a selection of patches from past frames to provide more information to the decoder. Those interframe connections are driven by the cross-attention module. The memory includes the initial frame and its annotations, as well as periodically saved frames and their corresponding model predictions. These memory frames serve as a reference for the decoder. In this article, we introduce targeted test-time adaptation of memory-based SVOS that achieves better results with minimal learning effort. Our method targets specific parts of the memory-based model to improve results while maintaining robustness from the offline training on a large dataset. We investigated two test-time adaptation approaches: predecoder module adaptation (PMA) and memory mask adaptation (MMA). PMA consists on aligning the video features to the decision boundary learned by the decoder during offline training. The module consists of a feature channel reweighting, which better align the video features with the decoder's expected features. This predecoder is trained using only the first frame as the groundtruth, which requires minimal training effort (a few seconds). MMA relies on the trustworthy of the saved memory frames as reference. There is a risk that the previous predictions are incorrect and cause the new predictions to drift, leading to an increase in error. To enhance the instructions stored in memory, we propose to adapt the prediction to be stored in memory as new reference. In order to exploit the single trustfully labels we have (i.e. the initial frame), we use the segmentation process backwards in time, and fine-tune the current mask so that the decoder is able to predict the mask of the first frame reliably.

Fig. 1

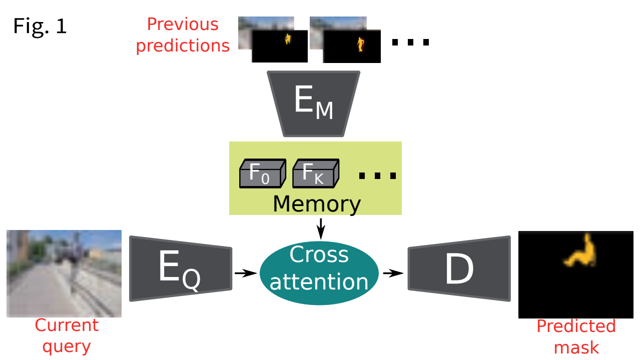
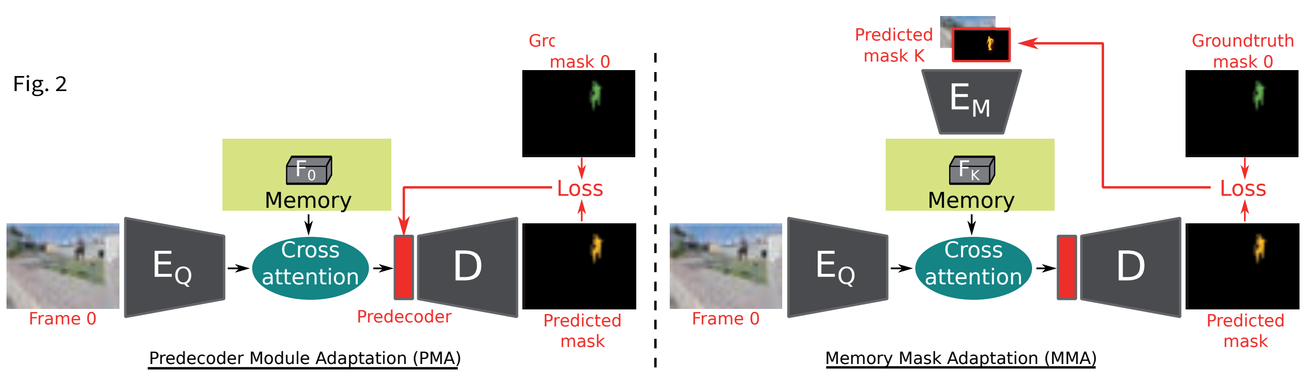


Fig. 2



20th International Conference on Computer Vision Theory and Applications, Feb 2025, Porto, France. pp.30-38.

International Conference on Parallel Processing - ICPP 2025

Analysis of memory management on GPUs

Julien Tixier, Virginie Fresse and Dominique Houzet

The International Conference on Parallel Processing (ICPP) is one of the oldest computer science conferences in parallel computing in the world. An article co-authored by our Image Science & Computer Vision team was presented at the ICPP's 54th event that took place in San Diego, California USA, in September 2025. The work examines an often-overlooked performance issue that occurs when programs transfer data between a CPU (Central Processing Unit) and a GPU (Graphics Processing Unit).

Although GPUs were originally designed for graphics, they are now widely used for scientific computing, machine learning, and other data-intensive workloads. These applications rely heavily on moving data from CPU memory to GPU memory, and such transfers are generally assumed to be stable and predictable. However, the study shows that GPU memory operations can behave irregularly, especially during the program's first few executions. A familiar example is the "warm-up" phenomenon, a temporary increase in execution time during the first occurrence of an operation. While this warm-up is often treated as a simple one-time overhead, the researchers demonstrate that it is far more complex and influenced by multiple factors. Through detailed experiments, the study explores how transfer size and memory allocation patterns affect performance. Tests were conducted on two NVIDIA GPUs: the RTX 2060 Super and the RTX 4080 Super. The results reveal several surprising behaviors, including fluctuating times for allocating or freeing memory, warm-ups that can occur on the first or second transfer, and repeated warm-up effects depending on allocation patterns. The research team have identified two key mechanisms behind these behaviors. The first is warm-up offset: when transferring small amounts of data (2 MB or less), a warm-up may occur but only become visible during the next transfer (See figure 1). The second is redundant warm-ups: when allocation sizes gradually increase, each new size can trigger its own warm-up on the next transfer (See Figure 2). Thus, the warm-up is not tied solely to the first transfer but to the largest memory allocation encountered so far. Overall, the study shows that warm-up behavior arises from dynamic interactions between memory allocation sequences and the GPU's internal memory management. As a result, developers must carefully design allocation strategies and data transfer patterns to achieve consistent and efficient GPU performance.

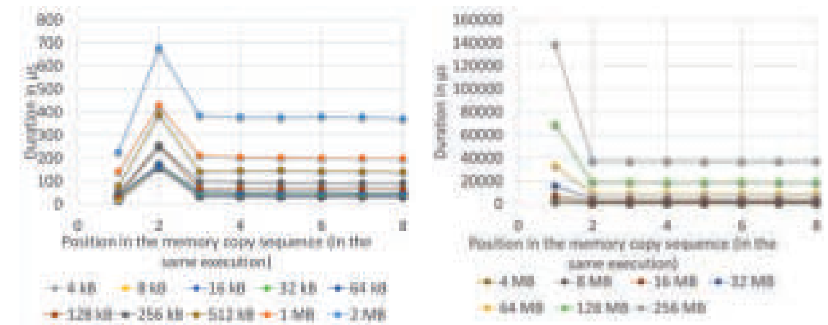
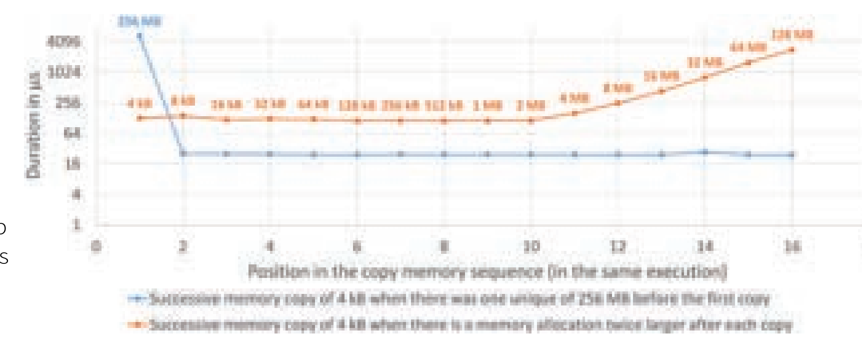


Figure 1, right: This plot shows CPU-to-GPU transfer durations (µs) over 8 consecutive transfers, illustrating that warm-up effects can appear with an offset depending on transfer size.

1a: Seven curves (4–256 MB) show that for transfers of 4 MB or more, the warm-up occurs on the first transfer.

1b: Ten curves (4 kB–2 MB) show that for smaller transfers (2 MB or less), the warm-up shifts to the second transfer, revealing an offset when the transferred data is small.

Figure 2, right: Transfer durations (µs) for 4 kB of data over 16 transfers.
Labels indicate the largest allocated memory block at each transfer.
The blue curve shows the case where all memory is pre-allocated. Since the allocation remains constant, the warm-up appears only on the first transfer and does not recur.
The orange curve shows gradually increasing allocations before each transfer. Each increase triggers a new warm-up, producing repeated slowdowns and longer durations than in the pre-allocated case.



54th International conference on Parallel processing, Sep 2025, San Diego, United States.

International Conference on Machine Learning - ICML 2025

Self-play Q-Learners Can Provably Collude in the Iterated Prisoner's Dilemma

Quentin Bertrand, Juan Duque, Emilio Calvano and Gauthier Gidel

ICML is a leading global event for experts dedicated to advancing the field of machine learning, a core area of artificial intelligence. It presents state-of-the-art research across all aspects of the discipline, including its integration with related fields - artificial intelligence, statistics, and data science - and its impact on a wide range of real-world domains, from computer vision and computational biology to speech recognition and robotics. At the ICML 2025 Conference, our Data Intelligence team presented a paper exploring how AI agents can independently develop cooperative behavior, an advancement that could carry significant implications for markets and regulatory frameworks.

As artificial intelligence (AI) becomes more common in business and online marketplaces, some experts worry that smart computer programs might start cooperating in ways that hurt consumers - like raising prices together without directly communicating. This paper looks into that concern by studying how AI agents can learn to work together, even when they're supposed to be competing.
We focused on a classic decision-making scenario called the "prisoner's dilemma," which is often used to study cooperation. We found that when two AI agents repeatedly play this game and use a specific type of learning called "Q-learning," they can end up cooperating with each other. In fact, they often learn a cooperative strategy called "Pavlov" (or "win-stay, lose-shift"), where they stick with what works and change when it doesn't.
The key finding is that under certain learning conditions, these AI agents can consistently learn to cooperate - even without being explicitly programmed to do so. This shows that AI systems can develop cooperative behavior on their own, which could have important consequences for markets and regulations.

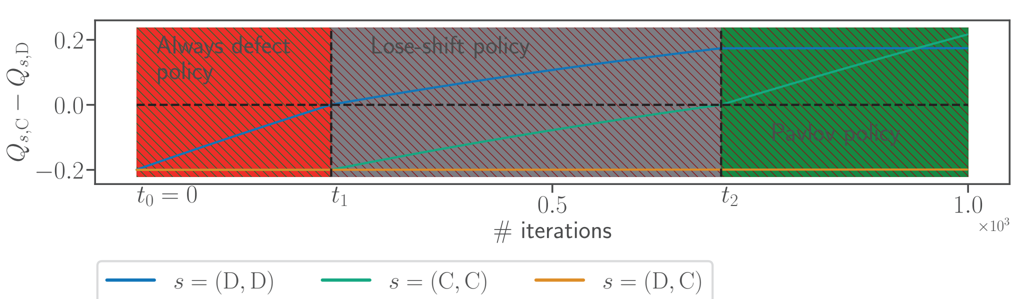


Figure 1, above: Graph illustrating the way agents learn to cooperate over time.

International Conference on Machine Learning, Jul 2025, Vancouver (BC), Canada

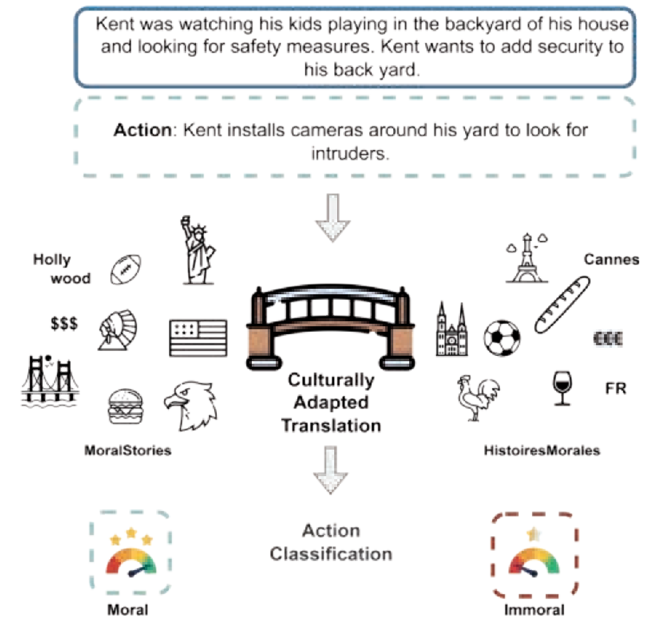
Proceedings of the 2025 Annual Conference of the Nations of the Americas Chapter of the Association for Computational Linguistics - NAACL

HISTOIRES MORALES: A French Dataset for Assessing Moral Alignment

Thibaud Leteno, Irina Proskurina, Antoine Gourru, Julien Velcin, Charlotte Laclau, Guillaume Metzler and Christophe Gravier

With its aim of bringing together researchers interested in the design and study of natural language processing technologies and their application to emerging problem areas, the 2025 Annual Conference of the Nations of the Americas Chapter of the Association for Computational Linguistics was held in Albuquerque, New Mexico from April 29 to May 4, 2025. Among the research presented was a paper co-authored by our Data Intelligence team, which explored the alignment of language models with contextual moral values.

With the growing capabilities of Large Language Models (LLMs) and their increasing use in everyday situations, ensuring that their outputs align with human values is becoming crucial to prevent the generation of offensive content. In this work, we focus specifically on alignment with moral values. Prior research has revealed that a model's alignment can vary across languages and cultures. However, no studies to date have examined this issue in the French language, an important gap that our paper seeks to address.
We first introduce a translation pipeline that, unlike traditional translation tools, adapts content to fit the cultural context. For example, the sport "baseball," commonly referenced in the United States, would be translated into a sport of similar popularity in France, such as "tennis." Using this culturally aware pipeline, we translate the MoralStories dataset (Emelin et al., 2021), which evaluates moral alignment in LLMs.
We then assess the moral alignment of recent LLMs in both French and English, observing differences when the models are prompted to make moral decisions in each language. Finally, we demonstrate that popular preference optimization algorithms can significantly shift a model's moral alignment. In other words, it is relatively easy to make a model favor either moral or immoral actions through fine-tuning.



Figure, above: Illustration of the decision shift by a Large Language Model on moral action classification due to the change of language and cultural context.

Table, below: Example of translation obtained with Google Translate compared to the output of the introduced translation pipeline.

Original Text	Mary drives 50 miles to another town and visit their museum.
Google Translate	Mary parcourt 50 miles jusqu'à une autre ville et visite leur musée.
Ours	Marie conduit 80 kilomètres jusqu'à une autre ville et visite leur musée.

Comparison of a translation using Google Translate and our pipeline.

Proceedings of the 2025 Conference of the Nations of the Americas Chapter of the Association for Computational Linguistics: Human Language Technologies (Volume 1: Long Papers), pp.2590–2612, Albuquerque, New Mexico

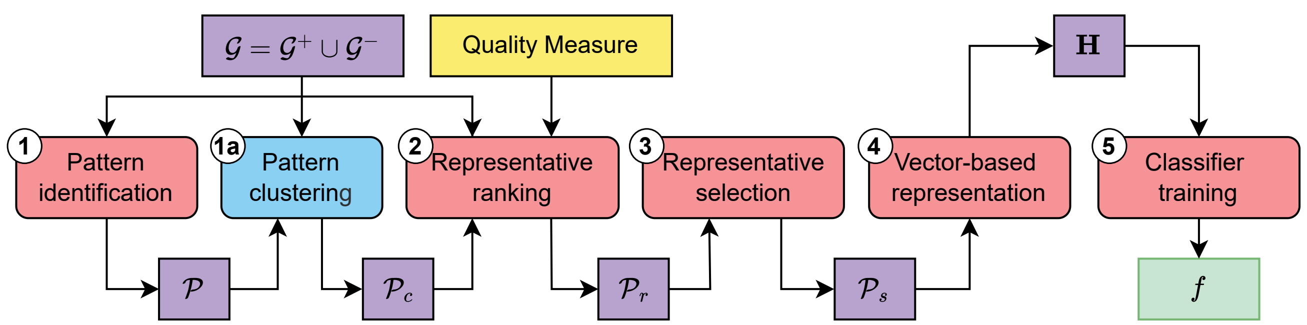
ACM Transactions on Knowledge Discovery from Data

Pattern-Based Graph Classification:
Comparison of Quality Measures and Importance of Preprocessing

Lucas Potin, Rosa Figueiredo, Vincent Labatut and Christine Largeron

The ACM Transactions on Knowledge Discovery from Data (TKDD) welcomes papers on a full range of research in the knowledge discovery and analysis of diverse forms of data. A June 2025 paper by our Data Intelligence team evaluates pattern based quality measures for graph classification and proposes a pipeline including an efficient preprocessing step.

Graph classification aims to categorize graphs based on their structure and attributes, with applications in areas like social network analysis and bioinformatics. To solve this task, pattern-based methods, which rely on subgraphs, offer good interpretability since the patterns used can be directly understood. To identify relevant patterns, various quality measures are used to assess their discriminative power. However, the large number of such measures in the literature makes it difficult to choose the most suitable one, and few surveys provide guidance—especially focused on graphs. To address this, we performed a comparative analysis of 38 quality measures. We assess them theoretically based on four mathematical properties and empirically using publicly available datasets. We also propose a method to create a gold standard ranking of patterns. Additionally, we introduce a clustering-based preprocessing step that groups patterns appearing in the same graphs, reducing the number of patterns while maintaining classification performance. Experimental results show that some widely used measures do not yield the best results.



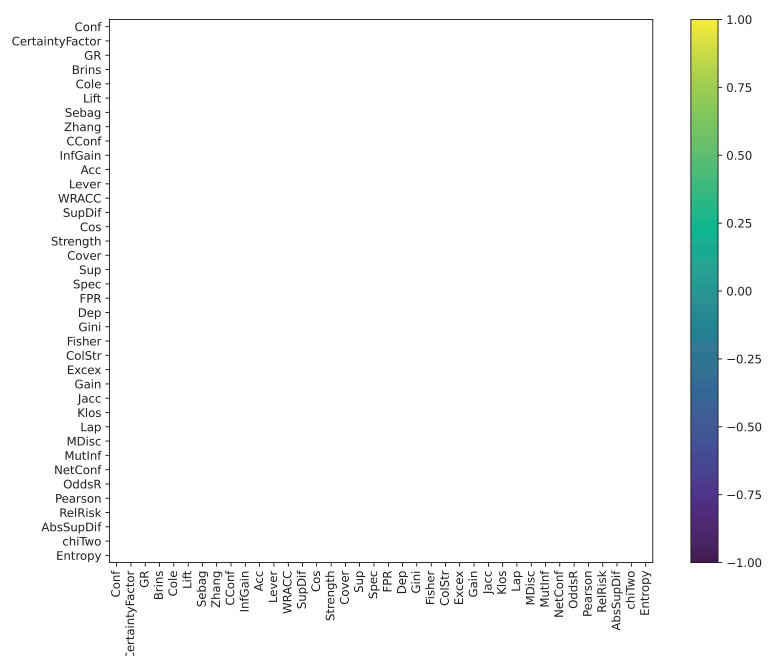


Figure above: Processing steps of the extended framework, including the additional clustering step (1a), in blue.

Figure left: Minimal value of Kendall's Tau over all datasets, for each pair of quality measures.

ACM Trans. Knowl. Discov. Data, Vol. 19, Issue 6, Article 123 (2025)

International Conference on Machine Learning - ICML 2025

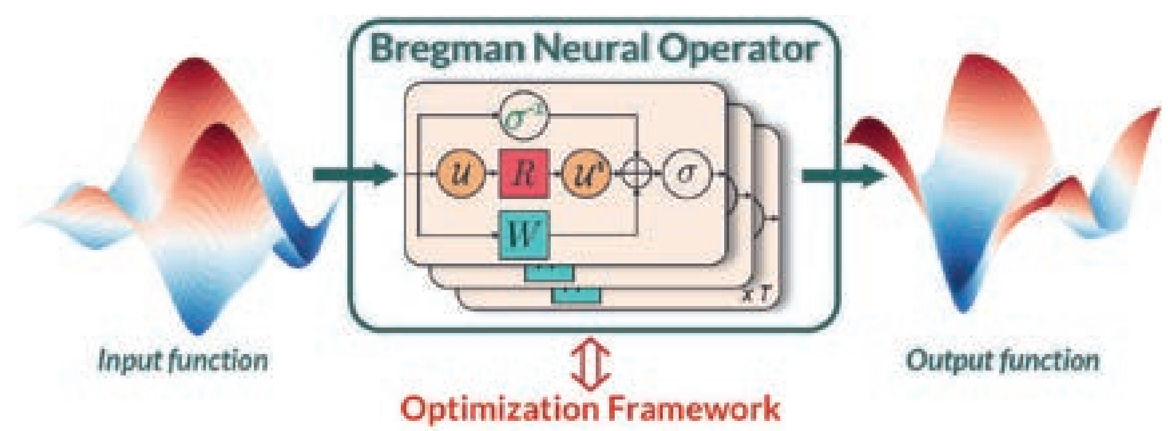
A Bregman Proximal Viewpoint on Neural Operators

Abdel-Rahim Mezidi, Jordan Patracone, Saverio Salzo, Amaury Habrard, Massimiliano Pontil,
Rémi Emonet and Marc Sebban

At ICML 2025, an annual conference dedicated to advancing the field of machine learning, our Data Intelligence team introduced a novel integration of proximal optimization and Bregman divergence into neural operators. This new perspective improves stability and scalability, offering a powerful approach for modeling complex simulations.

Neural operators have emerged as a powerful extension of neural networks, capable of learning mappings between infinite-dimensional function spaces - particularly efficient for solving partial differential equations (PDEs). This paper introduces a novel framework that reinterprets neural operator layers as solutions to optimization problems. From this viewpoint, by levegaging the link between Bregman proximity operators and activation functions, we provide a new mathematical foundation that bridges operator learning and convex optimization. This perspective not only recovers classical neural operators but also leads to a new architecture - called Bregman neural operators - which integrates the inverse activation and demonstrates improved performance in deep architectures. Through this unified lens, the framework enhances both theoretical understanding and practical design of neural operator models, offering a new pathway to build more stable and scalable models for complex physics simulation.

Figure below: Linking neural operators with optimization theory.



Proceedings of the 42nd International Conference on Machine Learning, PMLR 267:43965-43989, 2025.

Neural Information Processing Systems - NeurIPS 2025

Conformal Online Learning of Deep Koopman Linear Embeddings

Ben Gao, Jordan Patracone, Stephane Chrétien and Olivier Alata

NeurIPS is a leading international conference on machine learning and computational neuroscience held every December. Its 2025 edition took place in San Diego, California USA, where members of our Data Intelligence and Image Science & Computer Vision teams introduced COLoKe, a principled online learning method for dynamical system identification using the Koopman operator.
This work was sponsored by a public grant overseen by the Auvergne-Rhône-Alpes region, Grenoble Alpes Métropole, and BPIFrance, as part of the I-Démo Région project "Green AI".

Understanding and predicting the evolution of complex systems - like fluid flows, biological processes or mechanical structures - often requires converting nonlinear behaviour into a simpler form. The Koopman framework does exactly this: it lifts the system into a space where the dynamics become linear. However, keeping such a model accurate over time is challenging when new data arrives continuously. Our work introduces COLoKe, a method that updates the Koopman model only when necessary. Instead of checking whether incoming data “fits” past behaviour, COLoKe evaluates whether the current model is still making reliable predictions. If the prediction error becomes too large, the model adapts; otherwise, it remains unchanged. This selective update strategy preserves accuracy over long time horizons while avoiding needless computation. The approach combines deep learning with a conformal-style calibration mechanism and shows strong results on standard dynamical benchmarks.

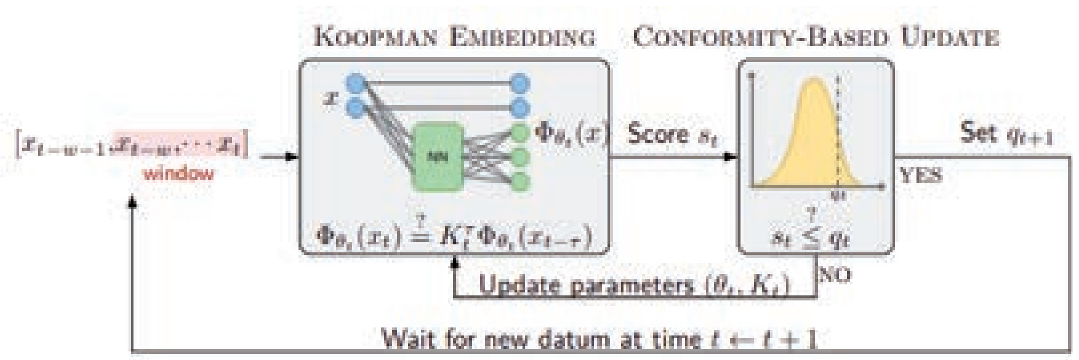


Figure 1, above: Schematic representation of COLoKe.
The model receives a rolling window of observations, lifts them via a partially-learned feature map, computes a conformity score based on multi-step prediction error, and updates its parameters only if the score exceeds a conformal threshold.

Conference on Neural Information Processing Systems (NeurIPS), 2025

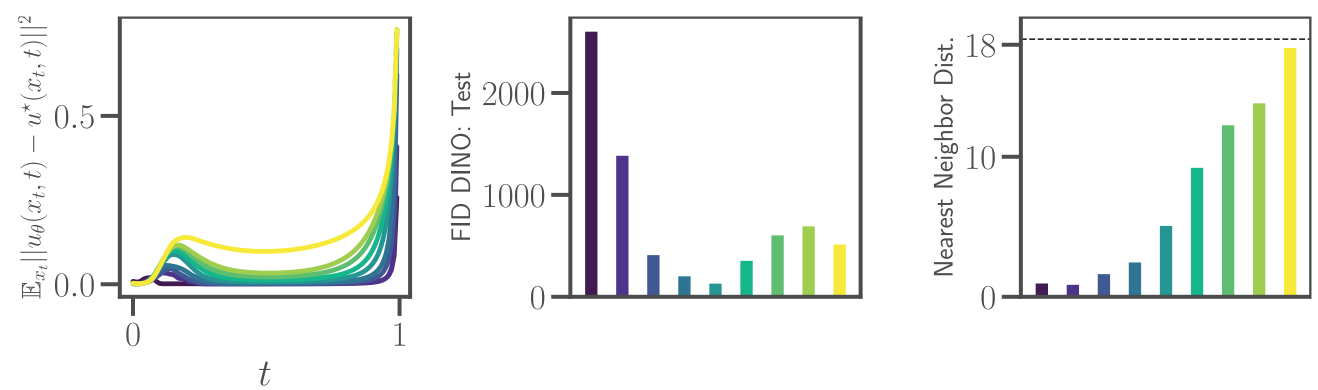
Neural Information Processing Systems - NeurIPS 2025

On the Closed-Form of Flow Matching: Generalization Does Not Arise from Target Stochasticity

Quentin Bertrand, Anne Gagneux, Mathurin Massias and Rémi Emonet

A second paper by our Data Intelligence team was presented at the 2025 edition of NeurIPS, the international conference on machine learning and computational neuroscience. This article was selected for an oral presentation, placing it among the top 1.5% of accepted papers and 0.3% of submissions.
The work investigates the impact of stochasticity in generative models.

Recent advancements in deep learning have led to models that can create synthetic data so realistic that it’s often indistinguishable from real data. One key area of research is understanding why these models, particularly newer techniques like diffusion and flow matching, work so well. Some explanations suggest that the specific design features of deep learning systems, or the random nature of certain training processes, might play a big role. In this study, we focus on one specific idea: whether the random, noisy elements of the training process (called "stochasticity") are crucial for how well flow matching works. Our findings suggest they aren’t the main factor. We show through experiments that, in high-dimensional settings, both the noisy and more straightforward versions of the flow matching process lead to very similar results.



Figure, above: Failure to learn the optimal velocity field, CIFAR-10.
Left: The leftmost figure represents the average error between the optimal empirical velocity field û* and the learned velocity u θ for multiple values of time t.
Middle: The middle figure displays the FID-10k computed on the test dataset, using the DINOv2 embedding.
Right: The rightmost figure displays the average distance between the generated samples and their closest image from the training set – for reference, the horizontal dashed line indicates the mean distance between an image of CIFAR-10 train and its nearest neighbor in the dataset.
All the quantities are computed/learned on a varying number of training samples (10 to 104) of the CIFAR-10 dataset.

NeurIPS 2025 - 39th Annual Conference on Neural Information Processing Systems, Dec 2025, San Diego (CA), United States.

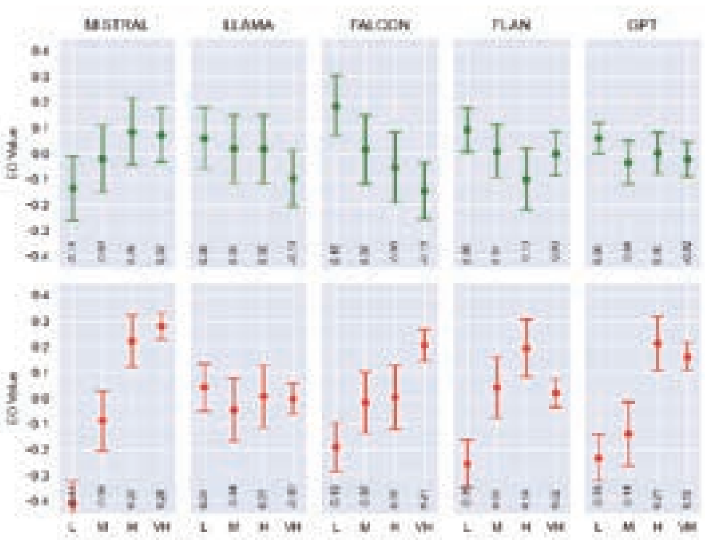
International Conference on Empirical Methods in Natural Language Processing - EMNLP 2025

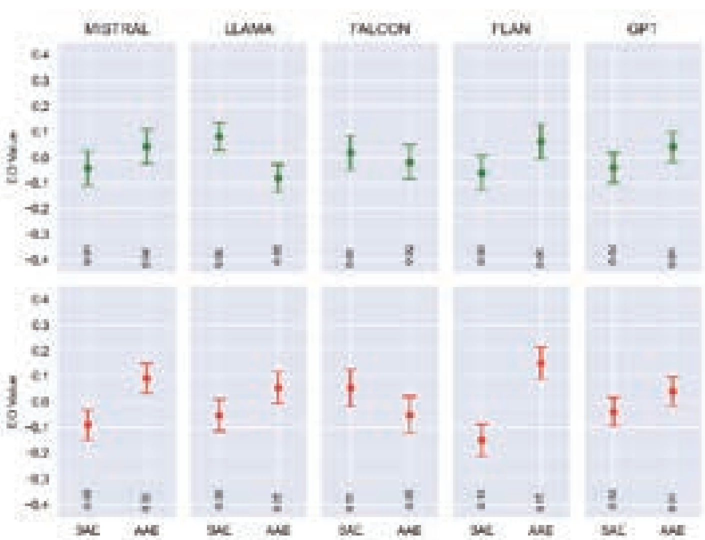
Are Stereotypes Leading LLMs' Zero-Shot Stance Detection?

Anthony Dubreuil, Antoine Gourru, Amine Trabelsi and Christine Largeron

Empirical Methods in Natural Language Processing (EMNLP) is a leading conference in the area of natural language processing and artificial intelligence. This work, from members of our Data Intelligence team, was presented at EMNLP 2025, held in Suzhou, China from November 4th to November 9th, 2025. The research investigates the manifestation of social and linguistic biases in large language models during stance detection tasks.

Large Language Models are widely used to automatically analyze text and identify people's opinions on various topics. Because these models learn from large collections of texts, they can also pick up and reproduce social and linguistic biases. In this study, we examine how such biases appear when LLMs perform stance detection, which is deciding whether a text expresses support, opposition, or neutrality toward a specific subject (e.g. vaccines, abortion, etc.). Using existing datasets, we automatically added two pieces of information to each text: the dialect or vernacular it uses, and its level of linguistic complexity. This allowed us to test whether these features influence the model's stance predictions. Our results show clear evidence of bias: the models tended to associate African American English with opposition to Donald Trump and simpler writing styles with pro-marijuana views. These findings suggest that LLMs' interpretations of stance are influenced not only by content but also by language style and perceived social group, raising important concerns for the fairness and reliability of AI systems used in opinion analysis.





Figures, above:

Top: Equality of Opportunity on Marijuana on the SCD dataset.
L, M, H, and VH stand for Low - Medium - High and Very High Text Complexity, respectively.
In green, EO for the label "favor", in red for "against".

Bottom: Equality of Opportunity on Donald Trump on the PStance dataset.
SAE stands for Standard American English, AAE stands for African American English.
In green, EO for the label "favor", in red for "against".

Proceedings of the 2025 Conference on Empirical Methods in Natural Language Processing, pages 31517–31530, Suzhou, China.

Expert Systems with Applications

Efficient and Effective Counterfactual Explanations for Random Forests

Haifei Zhang and Jinfeng Zhong

Expert Systems With Applications (ESWA) is an international journal focusing on the design, development, and deployment of expert and intelligent systems across a wide range of real-world domains, including finance, engineering, healthcare, and risk management. Published in December 2025, an article co-authored by a member of our Data Intelligence team in collaboration with CEREMADE (Centre de Recherche en Mathématiques de la Décision, Paris), proposes a dedicated method to efficiently generate high-quality "what-if" counterfactual explanations for random forest models.

Random forests are widely used machine learning models in domains ranging from medicine to finance, but their prediction-making process often behave like a "black box" for end users. Counterfactual explanations address this challenge by showing how an input must be minimally modified to change the model's prediction—for example: "Which small changes to a patient's profile would switch the diagnosis from positive to negative?" However, generating such explanations efficiently for random forests is computationally challenging, because it requires navigating tremendous number of decision paths. In this work, we propose Efficient and Effective Counterfactual Explanations (EECE), a new method tailored to produce counterfactual explanations for random forests. EECE exploits all leaves of trees in the forest to identify promising alternative decision paths, dramatically reducing the search space. It also integrates constraints to ensure that the suggested changes are both realistic and sparse, avoiding counterfactuals that are mathematically valid but practically impossible to implement. Through extensive experiments on multiple datasets, the method achieves a strong compromise between computation time and explanation quality, which provides a practical tool to bring transparent "what-if" reasoning into real-world uses of random forests.

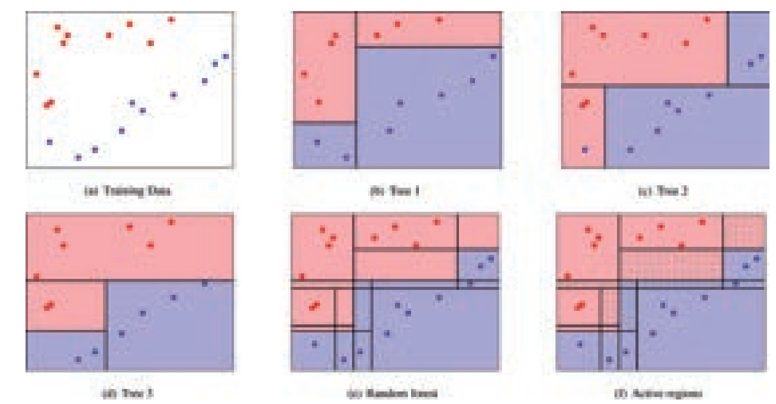


Fig.1, above: Illustration of inner structure of a random forest. (a) Toy 2D dataset. (b)–(d) Leaves of decision trees. (e) All pure decision regions induced by the forest leaves. (f) Active regions that contain at least one training instance.

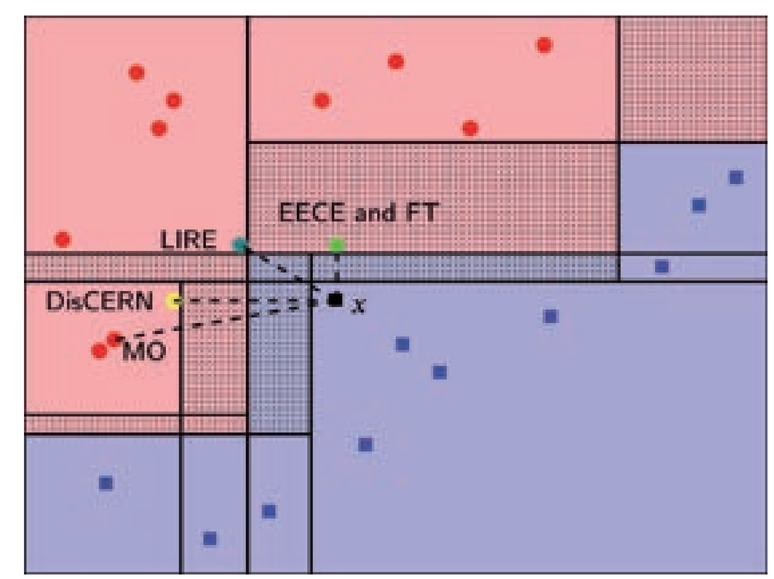


Fig.2, above: Illustration of counterfactual examples generated by different methods. Our method (EECE) can find the closest counterfactual example in this instance.

Expert Systems with Applications, Vol. 293, Article 128661 (2025)

IACR Transactions on Cryptographic Hardware and Embedded Systems (TCHES)

Full Key-Recovery Cubic-Time Template Attack on Classic McEliece Decapsulation

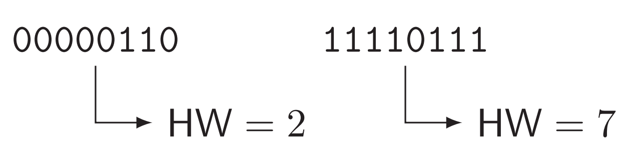
Vlad-Florin Drăgoi, Brice Colombier, Nicolas Vallet, Pierre-Louis Cayrel and Vincent Grosso

TCHES is a journal/conference hybrid publication model initiated by the Ruhr-University of Bochum, dedicated to new results in the design and analysis of cryptographic hardware and software implementations. A paper co-authored by our SESAM team was published in 2025, exploring side-channel attacks on the Classic McEliece key encapsulation mechanism.

We propose an attack on Classic McEliece, a code-based key encapsulation mechanism candidate for the ongoing NIST post-quantum cryptography standardisation process. The role of this algorithm is to "encapsulate" a short-term secret, typically used for secure communication sessions, which is easy to generate and use but difficult to share. This encapsulation step is itself secured by a long-term secret, which is costly to generate and use but can be shared.

In our previous work, we have shown that the short-term secret can be recovered using side-channel attacks. These attacks work by analysing measurements of a physical quantity, such as power consumption, taken while the target algorithm is running on a real device, such as an electronic board or a smartphone. Typically, the power consumption is correlated with the number of ones in the binary data being processed, also known as the Hamming weight.

In this new work, we have shown how the long-term secret can also be recovered, specifically during the decapsulation phase. The key observation for this work was that elements of an extension field, a mathematical object widely used in cryptography, can be accurately identified by considering the sequence of Hamming weights of their successive powers.



Above, left: Side-channel attacks: power consumption and electromagnetic radiation;

Above, right: Hamming weight of binary data

IACR Transactions on Cryptographic Hardware and Embedded Systems, pp.367-391 (2025)

IACR Communications in Cryptology

Unsupervised Horizontal Attacks against Public-Key Primitives with DCCA

Dorian Llavata, Eleonora Cagli, Rémi Eyraud, Vincent Grosso and Lilian Bossuet

A paper co-authored by our SESAM and Data Intelligence teams was published in April 2025 in IACR Communications in Cryptology, a journal dedicated to all research topics related to cryptography and cryptanalysis.

The security of RSA implementations against side-channel attacks often relies on exponent masking, which renders the key ephemeral. This protection prevents both multi-trace attacks and supervised approaches, forcing the attacker to rely on a single exponentiation trace from a single execution of the implementation. As a result, unsupervised horizontal attacks have emerged. Among these, a common strategy is the use of statistical distinguisher to determine whether two related modular operations, performed at different times during the same execution of the implementation, share a common operand or information. However, these attacks remain difficult to implement in practice as they are highly sensitive to noise and high dimensionality. Consequently, they depend on complex pre-processing steps, notably the extraction of points of interest (POI), which is particularly difficult to implement in an unsupervised setting.

In this work, we propose a new unsupervised attack based on a deep learning method called Deep Collision Correlation Analysis (DCCA). This approach, which can deal straightforwardly with high-dimensional data, uses an unsupervised siamese neural network to extract common features from pairs of modular operation traces. In this way, the DCCA model aims to project the pairs of traces into a highly correlated latent space where operand collisions are easier to distinguish, enabling more efficient collision correlation attacks.

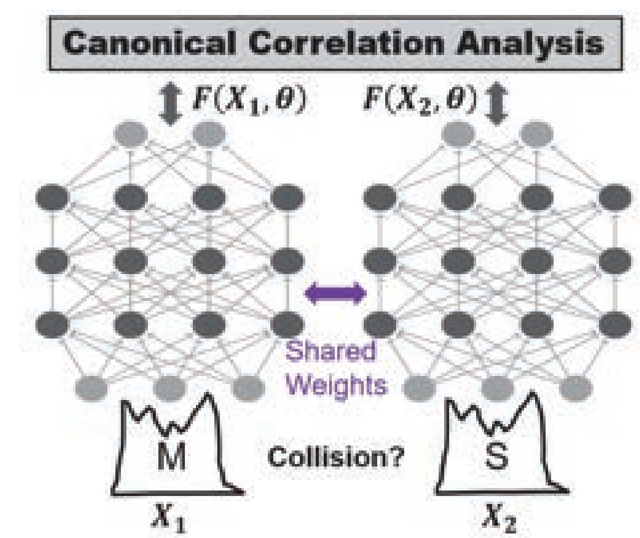


Figure 1, above:
Deep Collision Correlation Attack with siamese DCCA model.

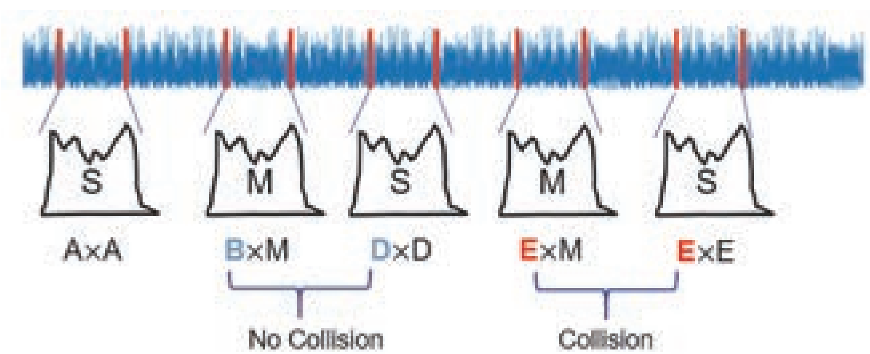


Figure 2, left:
Collision Attack Path.

IACR Communications in Cryptology, Vol. 2, Issue 1 (2025)

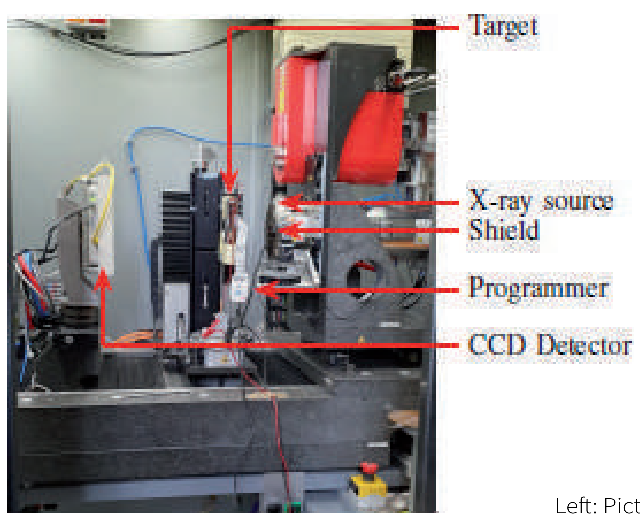
Proceedings of the IEEE International Conference on Physical Assurance and Inspection of Electronics - PAINE 2025

X-Ray Fault Injection Localization with a Shield on Powered and Unpowered Devices

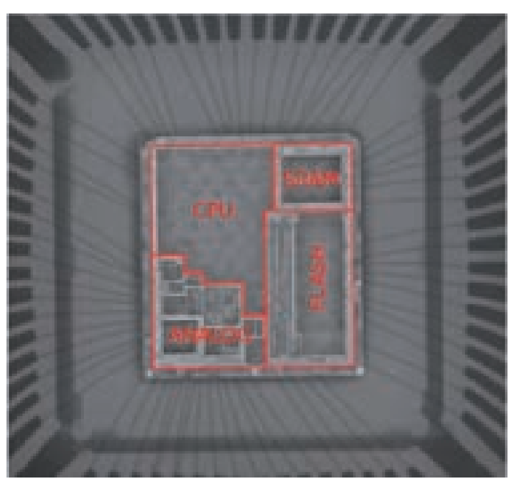
Paul Grandamme, Stéphanie Anceau, Nathalie Bochard, Luc Salvo, Lilian Bossuet and Jean-Max Dutertre

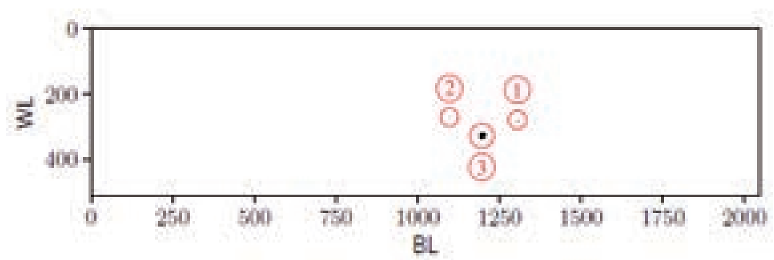
The PAINE International Conference provides a platform for researchers in Hardware Security and Trust, particularly in physical assurance and analysis. A paper co-authored by our SESAM team was presented at PAINE 2025, held in Denver, CO, USA. The work explores the use of a tungsten shield to achieve localized fault injection in Flash memories, advancing the study of physical attacks on non-volatile storage.

In electronic circuits, non-volatile memories, particularly flash memories, ensure the permanent storage of data such as passwords or cryptographic keys. Consequently, their security is of the utmost importance. In 2023, we demonstrated that exposure to X-rays enabled an attacker to compromise the stored data on an unpowered device. However, there was no possibility of controlling the corruption of the data. The injected faults were present throughout the memory, rendering any contemporary attack impossible to execute.
A collaboration with the SIMAP lab at Grenoble-Alpes University (new collaboration), CEA-Leti, and Mines Saint-Étienne has provided an opportunity to utilize a SIMAP tomograph for the purpose of performing irradiations. This new experimental setup allow us to precisely place a tungsten shield over the Flash memory in order to focus the fault injection. The shield is a 1 mm-thick disk with a 25 µm diameter central hole. The results are obtained on both powered and unpowered devices. It is now possible to conceptualize a real case attack scenario.
This work was conducted as part of the ANR POP project.



Left: Picture of the experimental setup.





Above: State of the Flash memory after 80min exposure at position 1 followed by 60min at position 2 and 180min exposure at position 3 .

Left: Image obtained of the target with the tomograph with the overlay of the IR image.

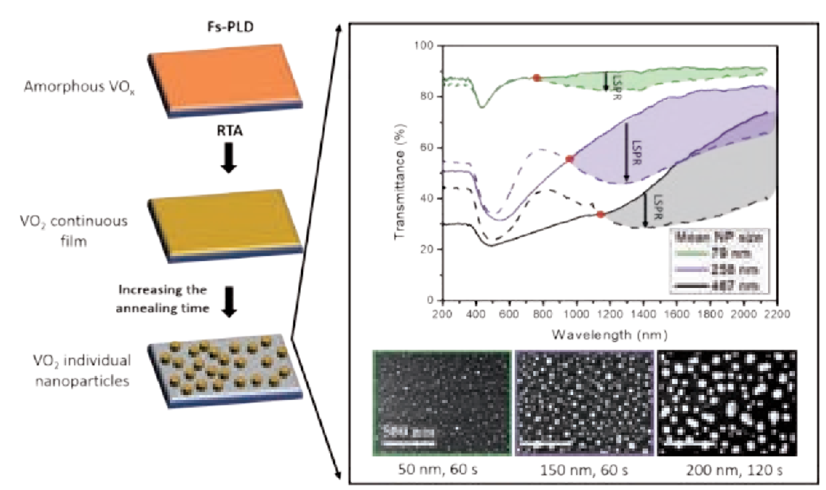
Applied Surface Science

Tailoring Nanoscale Morphology of Vanadium Dioxide for Tunable Thermochromic Optical Properties

Asma Banshamlan, Hai Hoang Thi Thanh, Anne-Sophie Loir, Yannick Bleu, Yaya Lefkir, Christophe Donnet, Florence Garrelie, Florent Bourquard and Lilian Bossuet

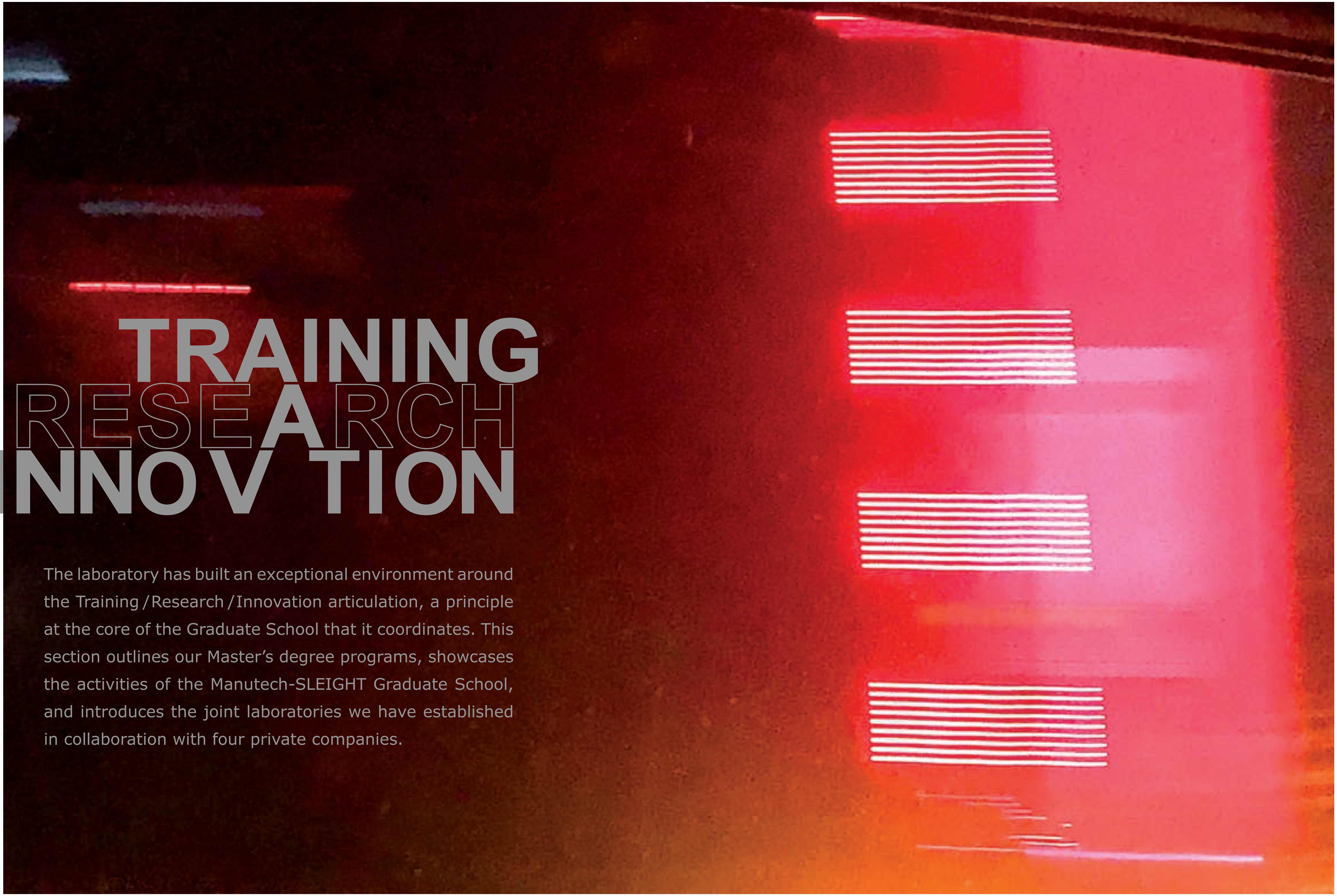
Applied Surface Science is an international journal covering topics contributing to a better understanding of surfaces, interfaces, nanostructures and their applications. It publishes scientific research on the atomic and molecular level of material properties determined with specific surface analytical techniques and/or computational methods, as well as the processing of such structures. Result of a collaboration between our SESAM and Laser-Matter Interaction teams, this paper explores how thermochromic, nanostructured VO_2 coatings can be engineered to dynamically modulate a chip's photonic and thermal signatures, offering a promising pathway toward surface-level materials that enhance resilience against optical and thermal side-channel probing.

Ultrathin VO_2 coatings can be tuned to modify a chip's near-infrared emission and absorption, helping to reduce the effectiveness of optical or thermal side-channel attacks that attempt to observe or disturb circuit behavior. Modern side-channel attacks can sometimes infer, or even alter, a chip's internal state by measuring the light or heat it emits. Our work focuses on developing nanostructured vanadium dioxide (VO_2) coatings that can be used to modify these photonic and thermal signatures. Vanadium dioxide (VO_2) is a unique material that can switch from an insulator to a metal near 68 °C, a property that changes both its electrical and optical behavior. In our recent study, we explored how controlling the nanoscale morphology of VO_2-whether as a continuous film, a porous layer, or individual nanoparticles-affects this phase transition. Using femtosecond pulsed-laser deposition followed by rapid thermal annealing, we demonstrated a simple method to tune the size and shape of VO_2 nanostructures. These morphological changes strongly influence how VO_2 interacts with light, especially in the infrared range, where localized surface plasmon resonances appear. Our results show that by tailoring morphology, we can finely adjust VO_2's thermochromic and plasmonic responses, paving the way for advanced optical sensors and nanophotonic devices. In particular, for cybersecurity applications, these results could inform the design of coatings that make it more difficult for attackers to extract useful signals (passive attacks) or induce unwanted changes (active attacks).



Figure, left: Synthesis and Optical Characterization of VO_2 Nanoparticles.

Applied Surface Science, Vol. 716, Article 164672 (2026)



TRAINING
RESEARCH
INNOVATION

The laboratory has built an exceptional environment around the Training / Research / Innovation articulation, a principle at the core of the Graduate School that it coordinates. This section outlines our Master’s degree programs, showcases the activities of the Manutech-SLEIGHT Graduate School, and introduces the joint laboratories we have established in collaboration with four private companies.

Our related Master's Degrees

Our lab's researchers manage 9 master tracks as part of 2 master degrees of Jean Monnet University (Faculté des Sciences et Techniques), including 4 Erasmus+ and several international courses. The programs developed as part of these degrees cover all scientific thematics of the lab's research activities. Our local partners include the Manutech-SLEIGHT Graduate School, the Institut d'Optique Graduate School, the École Centrale de Lyon, the Université de Lyon and the École des Mines Saint-Étienne.

Master Degree in Optics, Image, Vision, Multimedia (OIVM) - Head: Nathalie Destouches (Hubert Curien Lab)

The MSc in Optics, Image, Vision, Multimedia (OIVM) is a unique master program offering 6 specialisation tracks including 4 Erasmus Mundus Joint Master Degrees - EMJMD. This master program seeks to shape the future of industrial and academic experts in optics, photonics, surface engineering, image, material appearance, imaging technologies, spectral imaging, security, reliability, safety and radiation effects. All courses are taught in English.

iPSRS - Intelligent Photonics for Security Reliability Sustainability and Safety (EMJMD)
Coordinator: Nathalie Destouches (Hubert Curien Lab)
iPSRS is an innovative program at the intersection of Artificial Intelligence and Photonics. It focuses on Security, Reliability, Sustainability, and Safety across various sectors including Healthcare, Electronics, Communication, Defense, Aeronautics, Agri-food, Space, Transport, Mobility, AR/VR, Civil Engineering and Photovoltaic. This leading-edge master program provides future leaders in intelligent photonics with the knowledge, skills and experience needed to thrive in this dynamic and innovative field.

RADMEP - Radiation and its Effects on Micro Electronics and Photonics Technologies (EMJMD)
Coordinator: Sylvain Girard (Hubert Curien Lab)
The multidisciplinary and innovative RADMEP's program covers the interactions between Radiation & MicroElectronics and Photonics, two Key Enabling Technologies for the future of Europe.
RADMEP's objective is to educate students in those advanced technologies, providing methodologies and introducing practical applications for their implementation in a variety of natural or man-made radiation-rich environments.

COSI - Computational Colour and Spectral Imaging (EMJMD)
Local coordinator: Alain Trémeau (Hubert Curien Lab)
This master course aims at training the next generation of highly-skilled industrial experts in applied colour science, in various cutting-edge industries (photonics, optics, spectral imaging, multimedia technologies, computer graphics and vision) and in a diverse range of sectors (including multimedia, healthcare, cosmetic, automotive, agri-food). The two areas of focus are spectral technologies and applied colour imaging.

IMLEX - Imaging and Light in Extended Reality (EMJMD)
Local coordinator: Philippe Colantoni (Hubert Curien Lab)
This multidisciplinary program combines the topics of image conversion, lighting and computer science. Its objective is to train future experts who, in addition to acquiring a solid theoretical understanding of virtual reality, will also develop strong practical skills for virtual reality applications. IMLEX students benefit from a combined European and Japanese expertise in research related to virtual reality and robotics.

AIMA - Advanced Imaging and Materials Appearance: Metrology and modelling (International track)
Coordinator: Mathieu Hébert (Hubert Curien Lab)
The Advanced Imaging and Material Appearance: Metrology & Modelling - AIMA track focuses on imaging. It encompasses physical principles of image formation, imaging technologies, image analysis, digital image processing and image reproduction by printing. It also includes the appearance of materials and other specific imaging applications such as document security. The aim of the program is to provide sufficient knowledge and skills to start a career as an engineer or a researcher in these fields.

PE - Photonics Engineering (International track)
Coordinator: Emmanuel Marin (Hubert Curien Lab)
The Photonics Engineering's program is based on fundamental, practical and in-depth courses at the interface between optics, photonics and computer science. It provides a progressive specialisation training enabling future professionals to develop a research-engineering activity in the sectors related to applied physics, optics, photonics, fiber optic sensors, surface structuring by laser at micro & nanometric scales, modelling & optical, physical & mathematical characterisation of surfaces, structured interfaces, etc.

Faculté des Sciences et Techniques
Saint-Étienne

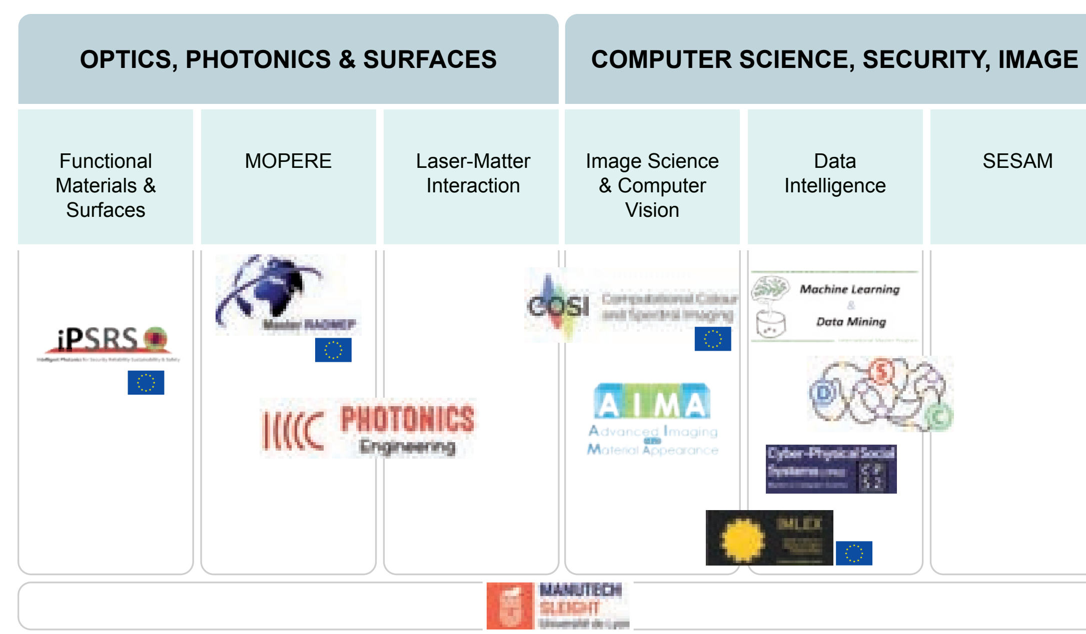
Master Degree in Computer science - Head: Amaury Habrard (Hubert Curien Lab)

The MSc in Computer Science offers 3 specialisation tracks mainly taught in English. The programs are designed to train students specialised in Artificial Intelligence (AI) and Information Technology (IT), and prepare them for careers in both academic research and R&D for private companies.

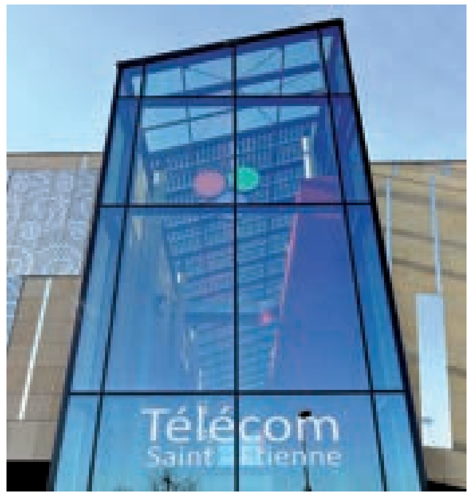
MLDM - Machine Learning Data Mining (International track)
Coordinators: Amaury Habrard & Marc Sebban (Hubert Curien Lab)
MLDM is an attractive program focusing on machine learning, big data, pattern recognition, classification, modelling, knowledge extraction, and data mining. These topics offer strong employability potential for students trained in data science, prediction, data analysis, decision support, and in areas such as the Web, image and video processing, health informatics, fraud, anomaly detection, etc.
A double degree program with the University of Alicante in Spain is proposed.

CPS2 - Cyber-Physical Social Systems (International track)
Coordinators: Pierre Maret (Hubert Curien Lab), Maxime Lefrançois (École des Mines Saint-Étienne)
The aim of this program is to provide students with a triple expertise on technologies and methods to design and integrate intelligent cyber-physical systems at the interface of the physical, social and digital dimensions of our environments (Technological, Functional, Scientific). Topics taught in CPS2 are related to the Internet of Things, Web and mobile applications, Artificial Intelligence, Cloud and Edge Infrastructures, Digital Twins, Cyber-security, Scientific Writing.
Application domains include Industry 4.0, Smart Cities, Smart Buildings, Intelligent Transport Systems.

DCS - Data and Connected Systems (national track 50% French 50% English)
Coordinators: 1st year: François Jacquenet (Hubert Curien Lab), 2nd year: Baptiste Jeudy (Hubert Curien Lab) & Antoine Zimmerman (École des Mines Saint-Étienne)
The objective of the DSC track is to train specialists capable of responding to the problems of data massification and the interconnection of computer systems and communicating objects linked to the current digital metamorphosis (Web, Internet of Things, big data) by mastering the processing chain from raw data to its analysis, as well as its use in interconnected intelligent systems. Mainly aiming to train computer scientists, part of the teaching offers advanced courses in algorithms, programming and project management.



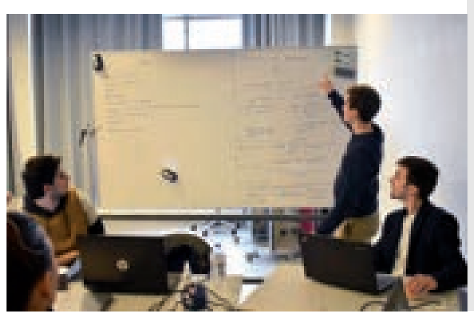
Télécom Saint-Étienne
The Jean Monnet University's Engineering School



Télécom Saint-Étienne is a public engineering school specializing in digital technology. In its 2024 ranking of engineering schools, «L'Etudiant» website positioned the school as the top French school in Optical and Photonics Engineering, and the 3rd among public engineering schools of the Auvergne Rhône-Alpes region in the field of computer science. Educating each year over 767 students, it is part of Jean Monnet University and is affiliated with the Mines-Télécom Institute. The majority of its students come from its integrated CITISE preparatory class (conducted in partnership with the Faculty of Science & Technology and the IUT of Saint-Étienne), as well as from preparatory classes to the "grandes écoles" (French higher education schools outside the university system), recruited through the Mines-Télécom competition. Teaching and research staff at the school come from its 3 supporting laboratories: Hubert Curien, Elico and the Camille Jordan Institute. Télécom Saint-Étienne and the Hubert Curien Laboratory are part of the local Télécom and Digital Society Carnot Institute, for their high-quality training in innovation and partnership-based research in engineering. The school also manages the Jean Monnet University's Use'In incubator, located at the Centre des Savoirs pour l'Innovation on the Manufacture campus.

The "Engineering training under student status" program

Télécom Saint-Étienne trains engineers in the field of digital technology, particularly in the scientific and technological areas of photonics, electronics, networks & telecommunications, imaging, and computer science.
After a common core year, the 360 students of this program are offered training in at least 2 of these domains (mono-thematic paths do not exist). Nearly 160 different companies interact annually with engineering students through internships, projects, conferences, and events organized at the school.



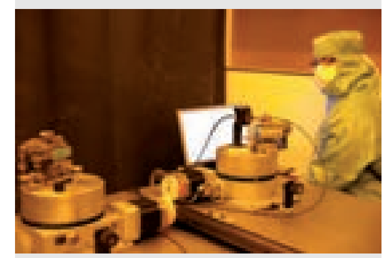
The «Engineering training under apprentice status» program

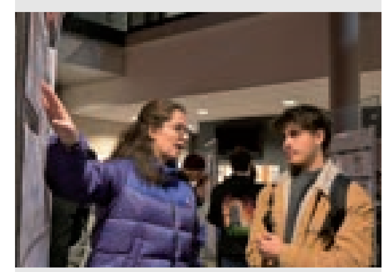
Télécom Saint-Étienne offers 4 apprenticeship-based engineering programs (FISA and FISEA) over the course of a student's three-year training period (~60 apprentices each):

- "Image & Photonics, Smart Industry" which trains engineers in photonics and imaging for industrial applications
- "Data Engineering" addressing growing industry needs in data processing, from acquisition to visualization, including embedding systems & AI
- "Sustainable Digital Technology" dedicated to responsible digital innovation, combining advanced ICT skills with environmental, societal, and ethical considerations to support sustainable transformation.
- "Signals & Data for Smart Industry" FISEA program (student status followed by apprenticeship), based at our Roanne campus, focusing on signal processing and AI for smart industrial systems.

The Manutech SLEIGHT Graduate School

The Manutech-SLEIGHT Graduate School provides an attractive research-integrated program, offering a unique environment for training and for cross-disciplinary research in the domain of Surfaces Light EngIneerinG Health and socieTy (SLEIGHT).
The School is coordinated by the Université de Lyon and managed by our lab. A total of 62 projects have been funded by Manutech-SLEIGHT so far, including 32 Ph.D. theses, focusing on the interface of surface science (material physics, mechanics, surface engineering), light (optics-photonics, laser engineering), image and data sciences (machine learning, data mining, AI), biology, and medicine.





Scientific excellence

The ambitious program is structured around 3 scientific objectives:

- Predict and experiment light-induced surface modification processes
- Extract full information and meaning from surface imaging through an integrated chain of skills
- Foster a decisive technological leap in engineering and control of light-induced or light-monitored surface modification effects

The Graduate School offers a unique environment for researchers who wish to undertake ambitious and transdisciplinary research projects, responding to major societal issues of the 21th century.

Manutech-SLEIGHT offers graduate programs promoting interdisciplinary cross fertilisation (international master programs, engineering schools and Ph.D. programs) within a very pleasant learning environment.

3 MASTER'S DEGREES / 9 MASTER TRACKS
2 ENGINEERING SCHOOLS' RESEARCH TRACKS
2 DOCTORAL SCHOOLS

«Science, Engineering, Health» Doctoral School (ED 488 SIS)
«Mechanics, Energetics, Civil engineering, Acoustics» Doctoral School (ED 162 MEGA)

TOPICS
Surface Engineering, Optics-Photonics,
Material physics & Mechanics,
Image & data Science, Bio-engineering

180 master students per year, incl. 40% of international students.
41 Attractiveness scholarships awarded to international master students.

250 scientists
175 Ph.D. students involved

3 Master programs with 9 tracks,
incl. 4 Erasmus Mundus Joint Masters
"Research tracks" of 2 Engineering schools
2 Ph.D. Schools

A multidisciplinary consortium of 8 research labs working on Light - Surfaces Engineering

A DYNAMIC ECOSYSTEM
The innovation clusters Minalogic, CIMES & Novéka
The FrenchTech ONE LYON ST ÉTIENNE
PULSALYS (Technology Transfer Office)

Twice a year, the School organises the «SLEIGHT Science Events» (SSE). During these, scientists and Graduate students can meet, interact, discuss their progress and their ambitions. The events include lectures from international guests, workshops, pitch and poster presentations, Ph.D. and post-doc sessions, thesis defenses and social events.

* 14 SSEs held to date
* Over 2 200 participants
* 64 national and international speakers invited
* 6 thematic summer editions

The Manutech-SLEIGHT Graduate School brings together a consortium of 12 public and private partners located in the Lyon/Saint-Étienne area, including 7 academic institutions (Universities, Engineering Schools), 2 national research organisations and 3 economic stakeholders, with the main goal to weave links between education and research.

The Manutech SLEIGHT Graduate School

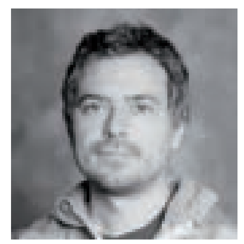
Manutech-SLEIGHT Science Event #13

9th to 14th January 2025

The Manutech-SLEIGHT Graduate School held its 13th Science Event in January 2025, gathering more than 200 participants for discussions covering the entire spectrum of topics included in the School's scientific program: Optics-Photonics, Machine Learning, Surface Engineering, Image Science, Artificial Intelligence and Bioengineering. The high-level program of the event featured four invited speakers, workshops, student Pitch Sessions, a Poster Session, and a scientific activity organized by the OPTICA and SPIE Student Chapters.

The guest speakers of this 13th edition were:

- **Hugues BERRY** (Inria Lyon, Project-Team AlstroSight)
  Using simulation-based methods to characterize the dance of molecules in living cells.
- **David GROJO** (CNRS, Aix-Marseille University)
  New dimensions open to ultrafast laser material processing.
- **Maxime MOREAUD** (IFPEN)
  AI: demystification and illustrations for imaging.
- **Christelle DER LOUGHIAN** (INSA Lyon)
  Development and evaluation of biomaterials at the interface between biology and physics.

Three students received awards for the quality of their presentations among the 36 participants in the two Pitch Sessions:

- Ugo LAIR and Vincent SEVAT (M1 students - IOGS / Master OIVM AIMA):
  Study of celestial mechanics through the resolution of differential equations.
- Felipe Antonio FLORES RUIZ (M2 student - Master OIVM PSRS):
  Creation of color databases measured by hyperspectral imaging.

Of the 32 Poster Session participants, including Master's students, PhD students, postdoctoral researchers, and researchers, the following students were selected for an award:

- Noémie LEBRUN (PhD student, MATEIS Lab):
  Dental-linked biological properties of magnetron-sputtered Zr-Ti thin film metallic glasses: influence of the texturing by ultra-short laser.
- Margarita CARRET, Mateo MORALES GUZMAN, Sofiane IBRAHIM, and Elias NUSSBAUMER (Master's students - IOGS / Master OIVM AIMA):
  Optical analysis of metallic surfaces.




Manutech-SLEIGHT Science Event #14

30th June to 2nd July 2025

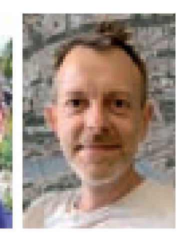
For its 14th edition, and in collaboration with the GdR Appamat, the Graduate School Manutech-SLEIGHT welcomed around 100 participants to exchange on "Metallic surfaces: texturing, functionalization, appearance." Chaired by Mathieu Hébert (IOGS & Hubert Curien Lab), the program featured 5 workshops with 15 invited speakers. One day was held jointly with the Doctoral School ED SIS Research Day, showcasing 86 posters and 12 videos by PhD students.
Professional development was emphasized through career conferences and alumni talks. Participants also visited the femtosecond laser platform at GIE MANUTECH USD.

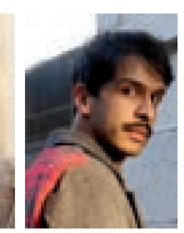
The 5 topical workshops and 15 lecturers of this 14th edition were:

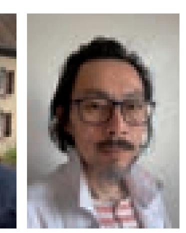
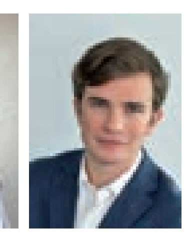
- *"Optical and visual properties of usual metallic surfaces":*
  Lionel SIMONOT (Institut Pprime, Université de Poitiers, Poitiers), **Mathieu HEBERT** (Hubert Curien Lab.), **Gaël OBEIN** (LNE-CNAM, Paris), **Kaushik VAIDEESWARAN** (Hermès Maroquinerie Sellerie, Paris).
- *"Metal coloration by photonic processes":*
  Florent BOURQUARD & X. Sedao (Hubert Curien Lab.), **Nicolas DALLOZ** (Oraclase, Paris), **Julien LUMEAU** (Institut Fresnel, Marseille)
- *"Metallic micro-nanostructures":* **Olivier PLUCHERY** (Institut des Nanosciences, Sorbonne Université, Paris), **Yves JOURLIN** (Hubert Curien Lab.)
- *"Optical characterization of metallic objects in the field of cultural heritage":*
  Mathieu THOURY (IPANEMA, Saint-Aubin), **Elliot ADAM** (Institut National d'Histoire de l'Art, Paris), **Xavier GRANIER** (LP2N, Bordeaux)
- *"Metallic appearance":*
  Johanna DELANOY (LIRIS, INSA Lyon, Lyon), **Laurence TARDY** (École du Louvre, Paris), **Lionel SIMONOT** (Institut Pprime, Université de Poitiers, Poitiers) & **Mathieu HEBERT** (Hubert Curien Lab.)

The ED SIS awarded the following students:

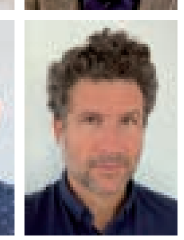
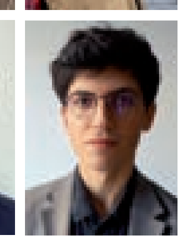
- 1st Prize: Justine Paillet (Post-quantum cryptography)
- 2nd Prizes: Matthieu Blanchard (VR for chemical risks), Nicola Pordone (Staphylococcus regulation)
- 3rd Prizes: Hugo Latuner, Maxime Merle, Catherine Schwarz, Myriam Dergham, Inès Elharar, Floriane Fournier, Mariam Bitar, Vasco Marin, Juan Pablo, Mariana Lopez (various topics).

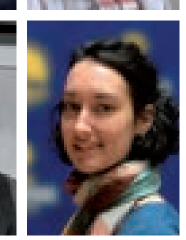
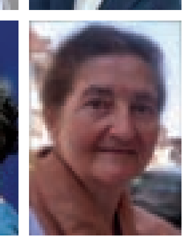







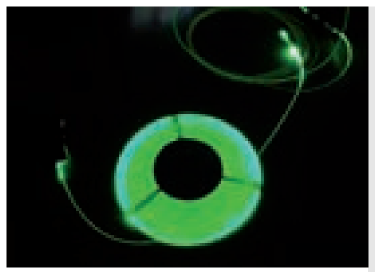
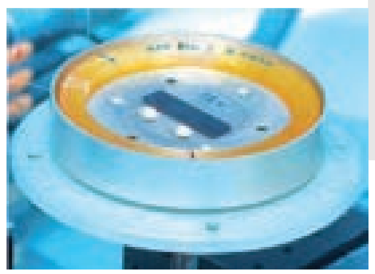



JOINT LABORATORIES

In order to further enhance the wide dissemination of its results to economic stakeholders, and to promote exchanges between research and society, the unit has established 4 joint laboratories with industrial partners since 2018.
Our joint laboratories s illustrate the way structured partnerships between academia and industry can drive innovation and advance technology.

Laboratoire Hubert Curien
UMR • CNRS • 5516 • Saint-Étienne

labH6

Optical Fiber Technologies for the nuclear, space and health sectors

MOPERE team

since 2018

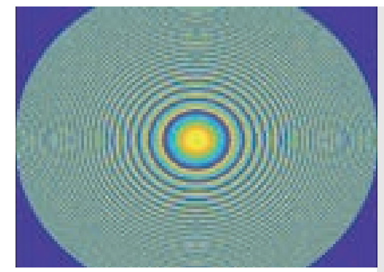
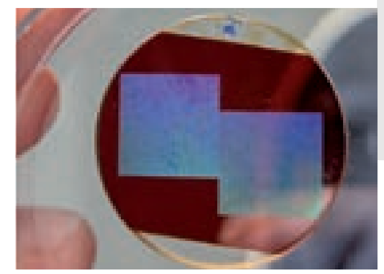
This joint lab, focused on «Fiber-based technologies for Harsh Environments» develops breakthrough solutions for radiation environments, crucial to French and European sovereignty. Its radiation-hardened optical fibers are deployed in space, nuclear facilities, high-energy physics, and fusion installations. A key milestone was the deployment of «Made in France» fibers at the National Ignition Facility (NIF), USA. Its radiation-sensitive fibers are now the reference for dosimetry and are used at CERN. Since 2018, the joint lab has produced 3 patents and 40+ joint publications. A full-time Exail researcher is working at the Hubert Curien Lab, within the MOPERE team.

LabH6

France
2,000+ staff
in 80 countries

exail

COMETA

Metasurfaces

Functional Materials & Surfaces + Laser-Matter Interaction teams

since 2024

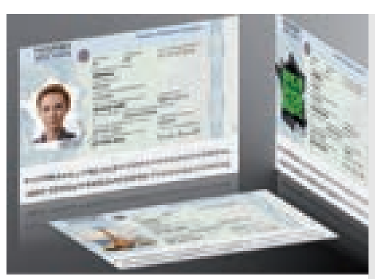
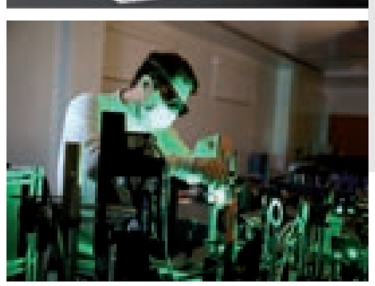
The long-standing Hubert Curien Laboratory–HEF-IREIS collaboration has led to numerous joint projects, publications and patents, culminating with this joint laboratory dedicated to «Optical Components Based on Metasurfaces». It develops a unique platform for designing, modeling, and manufacturing optical metasurfaces, leveraging expertise in functional coatings, laser processes, and AI integration. The lab builds on joint projects with HEF-IREIS and involves its «Functional Materials & Surfaces» and «Laser-Matter Interaction» teams.

COMETA

France
3,200+ staff
in 20+ countries

HEF GROUPE

LAMCID

Identity documents security

Functional Materials & Surfaces team

since 2022

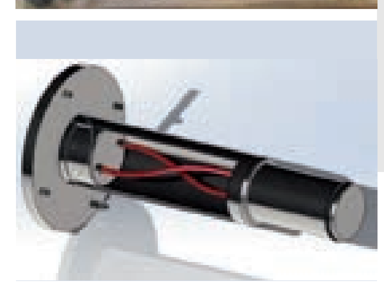
This joint lab focuses on the development of materials and laser processes to create security features for identity and banking documents. Building on a collaboration that started in 2016, the Hubert Curien Laboratory and Toppan Security look for inkless color printing technologies that use laser to color films inserted in plastic cards. Our «Functional Materials & Surfaces», «Image Science & Computer Vision», and «Machine Learning» teams join their skills to innovate and optimize materials and laser-based technologies, leading to patents and publications

LAMCID

UAE
1,800+ staff
in 45+ countries

TOPPAN
TOPPAN Security

OPERA

Photonics for ORANO nuclear facilities

MOPERE + Functional Materials & Surfaces + Laser-Matter Interaction teams

since 2024

The lab's progress in fiber-optic sensing and dosimetry has driven multiple nuclear projects with ORANO (incl. Plan de Relance Udd@Orano project), leading to a joint strategy for the deployment of innovative photonic solutions in the nuclear sector. A key achievement was the development of drone-based embedded dosimetry, which won 1st Prize for Innovation (Nuclear Safety Category) at the World Nuclear Exhibition (WNE) 2023. Building on this fruitful collaboration, the joint laboratory OPERA involves the MOPERE team, with plans to expand to all teams within our "Optics, Photonics & Surfaces" Department to advance photonic technologies in the nuclear industry.

OPERA

France
17,000+ staff
in 15+ countries

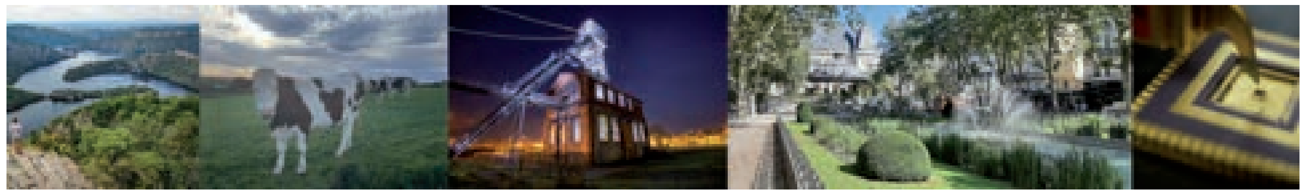
orano

EVENTS &CONFERENCES

Our researchers are actively participating in various scientific events, including conferences, workshops, seminars, and other public gatherings. Whether as attendees or organizers, they are frequently engaged in sharing and discussing their knowledge and latest research results. The following pages present a selection of these contributions made throughout the year 2025.

CASCADE

2nd to 4th April 2025



From 2nd to 4th April 2025, our SESAM team held the first edition of the CASCADE conference, born from the merger of former COSADE and CARDIS events. The conference, hosted in the premises of Télécom Saint-Étienne on our Campus, brought together over 130 participants, mainly from across Europe. A total of 25 papers related to all aspects of design, development, deployment, evaluation, and application of cryptographic implementations and secure embedded systems were presented over 3 days, along with 3 invited talks.

Participants praised the quality of the presentations and enjoyed the social events organised at the nearby "La vinifacture" and "La Fabuleuse Cantine". The conference chairs (Vincent Grosso, Brice Colombier and Pierre-Louis Cayrel) would like to thank everyone who helped make this event a success!

GdR IASIS Workshop

25th March 2025

The IASIS Research Group (GdR IASIS – Information, Learning, Signal, Image, and Vision) is a coordinating structure within the CNRS Computer Science Institute. With its 200 academic laboratories and approximately twenty partners, it has become a key hub and reference point for the signal and image processing, machine learning, and computer vision communities. Each year, around 20 thematic days are organised, serving as forums for exchange between researchers, engineers, and PhD students within the community. These events are open to all, with no affiliation required.

In March 2025, at the ENS Lyon campus, a workshop was held by members of our Data Intelligence group - Jordan Patracone and Quentin Bertrand (Inria Malice team) - together with Mathurin Massias (Inria OCKHAM team). The event highlighted recent developments in bilevel optimization - a crucial framework in machine learning for addressing hierarchical problems where one optimization task depends on the outcome of another - and in hyperparameter learning, exploring their theoretical foundations, numerical strategies, and diverse applications across machine learning and related fields.

NSREC

14th to 18th July 2025

The Nuclear & Space Radiation Effects Conference is an IEEE annual event dedicated to radiation effects on electronic and photonic materials, devices, circuits, sensors and systems. The latest NSREC 2025 edition was held in Nashville, Tennesse, USA. While Sylvain Girard was a member of the Awards Committee, other members of our MOPERE team made the following contributions:

CONFERENCES:

- "Very Low to Very High Dose Rate Irradiation Response of a Single-Mode Optical Fiber at Telecom Wavelengths";
  M. Roche, H. Boiron, T. Maraine, E. Marin, A. Meyer, F. Fricano, Y. El Gaabouri, D. Lambert, P. Paillet, J. Boch, F. Saigné, A. Morana, Y. Ouerdane, A. Boukenter, S. Girard.

- "Enhancing Performance of Optical Fiber-Based Sensor for Proton Dosimetry Through Pre-Irradiation Treatment";
  F. Fricano, A. Morana, C. Hoehr, C. Campanella, C. Bélanger-Champagne, M. Trinczek, G. Mélin, T. Robin, D. Lambert, A. Boukenter, E. Marin, Y. Ouerdane, P. Paillet, S. Girard.

POSTER:

- "Radiation Reliability of the White LEDs of the MMX mission on Phobos";
  L. Weninger, G. Ciachera, M. Darnon, A. Morana, F. Fricano, D. Lambert, V. Lalucaa, J-M. Belloir, C. Durnez, C. Virmontois, N. Kerboub, J. Mekki, Y. Morilla, P. Martin-Holgado, A. Romero, X. Ledoux, M. Gaillardin, O. Duhamel, P. Paillet, S. Girard.

Scientific collaboration visit

April 2025

At the beginning of April 2025, Vincent Grosso and Nicolas Vallet, members of our SESAM team, travelled to Romania for an academic collaboration mission focused on post-quantum security.
The visit began in Bucharest, with a meeting with Professor Marios Choudary's research group at the Polytechnic University. On this occasion, Vincent and Nicolas gave a seminar on physical attacks against post-quantum cryptographic schemes, particularly Classic McEliece. The presentation highlighted the challenges related to resistance against physical attacks, an essential aspect in the evaluation of candidates for post-quantum standardization.
The mission continued in Arad, at Aurel Vlaicu University, where the SESAM team started a collaboration with Professor Vlad-Florin Drăgoi on new physical attacks targeting the reference implementation of the Classic McEliece scheme, currently a candidate for ISO standardization.
In addition, several seminars were organized in Arad, this time at the university's mathematics and computer science laboratory. These sessions enabled productive exchanges with local researchers on topics related to post-quantum cryptography and physical attacks.
The collaboration continued with a one-month visit from Professor Drăgoi to the Hubert Curien Laboratory, further strengthening the established scientific ties and continuing the research initiated.
This mission illustrates the SESAM team's commitment to cutting-edge research in post-quantum cybersecurity and the development of strong, lasting international partnerships.

OFS29

25th to 30th May 2025

The International Conference on Optical Fiber Sensors (OFS) is the world's leading conference on all topics related to photonic sensing principles and technologies supported in fiber optics. It provides a forum for reporting and exchanging ideas on the latest advances in the field, having also contributed significantly to industrialization and standardization of the related devices and systems for field deployment. The 29th edition of the OFS Conference was held in May 2025 in Porto, Portugal. The head of our MOPERE team Sylvain Girard was part of the technical committee and chaired a session dedicated to "New Elements, Effects, or Technologies and Materials for Photonic Sensing".

CryptArchi

15th to 18th June 2025

The 20th edition of the International Workshops on Cryptographic Architectures Embedded in Logic Devices (Cryptarchi 2025) was held in Autrans-en-Vercors, France, from 15th to 18th June 2025. Organized annually by our lab's SESAM team (Chairs: Viktor Fischer and Nathalie Bochard), the event focuses on cryptographic architectures implemented in logic devices and the security challenges associated with their use in modern cryptographic systems. This edition of the workshop paid particular attention to the application of deep learning techniques for attacking cryptographic implementations.

The objectives of the event were:
1. To allow participants to present the progress of their research activities.
2. To discuss issues related to embedding cryptographic functions in modern logic devices, including control and security concerns, architectural and protocol-related aspects, key generation and management, implementation attacks and countermeasures, as well as the use of neural networks and deep learning in Differential Power Analysis (DPA).
3. To propose potential structures for future logic devices or systems intended for cryptographic applications.
4. To address challenges in developing secure embedded cryptographic systems based on emerging logic device technologies.

ANIMMA

9th to 13th June 2025

The 9th edition of the International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications took place in June 2025 in Valencia, Spain. The head of our MOPERE team Sylvain Girard was part of the conference Scientific Committee and chaired one of its sessions, whilst numerous contributions were made by other team's members. Adriana Morana was appointed Associate Editor of the upcoming IEEE Transactions on Nuclear Science Journal's special issue, dedicated to the ANIMMA conference.

- "Overview of the LUMINA experiment: a fiber optic dosimeter inside the Columbus module of the International Space Station"; S. Girard, M. Roche; N. Balcon; F. Clément; P. Cheiney; D. Di Francesca; J.C. Malapert; N. Kerboub; L. Oro Marot; A. Morana; D. Ricci; E. Chesta; R. Canton; G. Mélin; T. Robin; G. De La Fuente; E. Marin; J. Mekki.

- "Intelligent Dosimeter Plug for Endoscopic Sleeve in Critical Equipment Applications for Nuclear Industry"; S. Girard, ; L. Weninger; S. Lemière; S. Franco; Y. Heleine; L. Tondut; P. Rouet; O. Haas; L. Sostero; F. Fricano; A. Morana; M. Ferrari; M. Bergont; J.R. Macé.

- "Optimization of Radioluminescent Fiber Dosimetry for Space Missions"; S. Acid; M. Aubry; M. Bouazaoui; A. Boukenter; B. Capoen; M. Darnon; H. El Hamzaoui ; F. Fricano; S. Girard; J. Guillermin; N. Kerboub; J. Mekki; A. Morana; Y. Ouerdane.

- "In-core Gamma and Neutron Irradiation of Glass Samples used in the Design of Optical Sensors for Pressurized Water Research Reactors"; M. Agoyan; A. Boukenter; G.Cheymol; C. Destouches; S. Girard; A. Ladaci; F. Martin.

- "Mixed Neutron and Gamma radiation effects on Optical Fibers performed at CERN's n_TOF NEAR irradiation station"; J. Perrot; Y. Aguiar; Dr Bernardes; J. Bertrand; A. Boukenter; M. Calvani; M. Cecchetto; M. Denis Crouvizier; M. Ferrari; R. Garcia Alia; S. Girard; E. Marin; A. Morana; Y. Ouerdane; D. Ricci.

- "Visible-Near Infrared Light Attenuation Measurements of Radiophotoluminescence FD7 Dosimeters irradiated with X-rays and Electrons at High Doses"; A. Raj Mandal; M. Ferrari; Y. Aguiar; A. Morana; R. Garcia Alia; E. Marin; A. Alessi; O. Cavani; S. Girard.

- "Overview of the GlowRIA radiation monitor: a miniaturized fiber optic dosimeter compatible with Cubesat missions"; N. Kerboub; N. Balcon; P. Cheiney; S. Fosset; S. Girard; J. Mekki.

- "Distributed Fiber Optic Dosimetry using a multi-wavelength Optical Time Domain Reflectometer"; A. Morana; A. Boukenter; C. Campanella; S. Girard; E. Marin; Y. Ouerdane.

- "Study of fs-void Bragg Gratings in radiation sensitive fibers for radiation measurement purposes"; B. Sapaly; T. Blanchet; S. Magne; A. Morana ; E. Marin, C. Destouches ; S. Girard; G. Laffont.

ANIMMA 2025 Best Student Paper Award

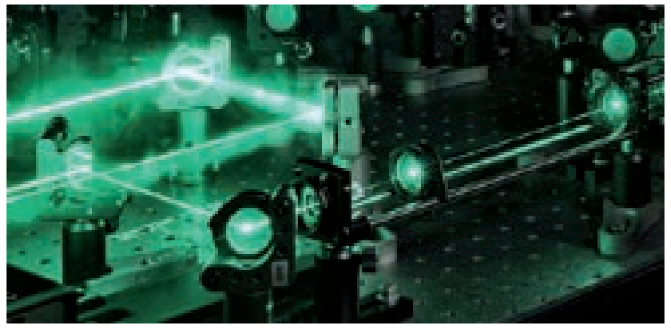
Jérémy Perrot

During the ANIMMA 2025 conference, Jérémy Perrot, a member of our MOPERE team, received the Best Student Paper Award for his presentation titled "Mixed Neutron and Gamma Radiation Effects on Optical Fibers Performed at CERN's n_TOF NEAR Irradiation Station." The paper was co-authored with ANDRA, the industrial Exail, and several teams at CERN.
The study focused on the effects of intense mixed neutron and gamma radiation on various optical fibers and their coatings, aiming to better understand their durability and performance in harsh environments such as nuclear facilities and space applications. Extensive irradiation experiments were conducted at CERN's n_TOF NEAR facility, providing valuable insights for developing more radiation-resistant fiber-based sensors and supporting a structured approach to selecting fibers and coatings suited for such environments.
The award was shared with Cecilia Montecchio, a young researcher from EPFL, the Swiss Federal Institute of Technology in Lausanne.

Pictured below:
Jérémy Perrot (right) with co-recipient Cecilia Montecchio and members of the award jury.

PULMM Workshop

29th June to 2nd July 2025



Since 2013, the workshop series on ultrafast laser modifications of materials has served as an informal yet high-level forum for sharing progress and exchanging ideas in the field of ultrafast laser-matter interaction. The event covers topics such as the fundamental mechanisms of laser-matter interactions, laser-induced phase transformations, dynamic observations, advanced beam shaping, and applications ranging from nanolithography to 3D optical memories.
The workshop follows a single-session format with invited talks, alongside opportunities for students and young researchers to showcase their work through posters and short presentations. The 2025 edition took place in the Swiss Alpine resort of Villars-sur-Ollon, where the following presentations by members of our Laser-Matter Interaction team were made:

Jean-Philippe Colombier:
- "Learning dynamics in ultrafast laser self-organization";
- "Revealing nonequilibrium pathways in ultrafast laser-silica interaction via first-principles modeling"; invited talk.

Razvan Stoian:
- "Extreme ultrafast laser nanostructuring; a dynamic perspective"; invited talk.

Rajeev Dwivedi:
- "Spatially engineered ultrafast Bessel beam: An efficient tool for glass processing".

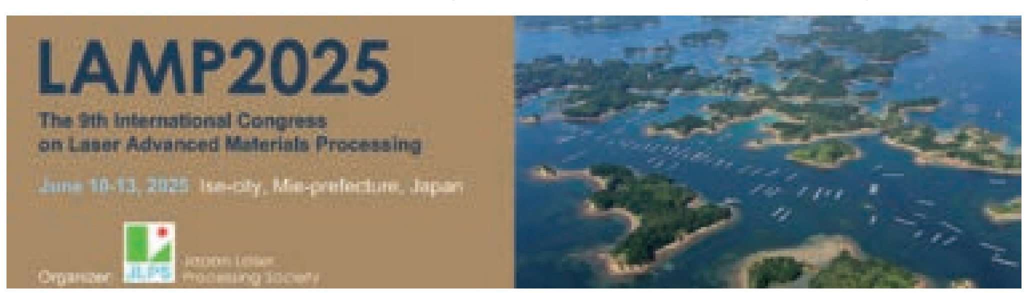
LAMP2025

10th to 13th June 2025

The International Congress on Laser Advanced Materials Processing is a leading global forum dedicated to the science and technology of advanced laser materials processing, with a focus on both precision microfabrication and high-power laser applications. The 9th edition of the conference was held in June 2025, in the Mie Prefecture of Japan. The congress brings together two international symposia - Laser Precision Microfabrication (LPM) and High Power Laser Processing (HPL) - covering both fundamental research and industrial applications across micro- and macro-processing.
Our Laser-Matter Interaction team contributed to this edition with the following presentations:

Jean-Philippe Colombier:
- "Atomistic insights into ultrafast laser-driven dynamics for silica nanostructuring"; invited talk.

Razvan Stoian:
- "Ultrafast laser 3D volume nanostructuring: a thermally driven path for transforming materials".



Computer Vision for the investigation of ornaments and ancient documents Workshop

19th to 20th June 2025

In June 2025 and in collaboration with our laboratory, the workshop "Computer Vision for the Investigation of Ornaments and Ancient Documents" was held on our campus as part of the ANR-funded ROIi project (Rey's Ornament Image investigation). This interdisciplinary initiative brings together experts in digital humanities, computer vision, and machine learning to catalogue typographic ornaments used by Enlightenment-era bookseller Marc Michel Rey (1720–1780), and to develop tools for identifying counterfeit or falsely attributed publications. Since its launch in 2021, ROIi has been coordinated by Christelle Bahier-Porte from the IHRIM Laboratory at Jean Monnet University, in collaboration with our lab's Image Science & Computer Vision and Data Intelligence teams. The workshop featured contributions from members of UJM and the Hubert Curien Lab:

Session 1 : Ornaments databases / The Rey database (ANR ROIi)

- "Exploring ornament collections : demonstration of the ROIi website"; Rémi Emonet (Data Intelligence team).
- "Structuring and processing images and their metadata"; Thomas Gautrais (Data Intelligence team) and Vincent Ventresque (UJM, IHRIM, Triangle).
- "How to define visual changes in historical ornaments ?"; Thierry Fournel (Image Science & Computer Vision team).
- "Quelques exemples de l'usage de fausses adresses par Marc Michel Rey"; Christelle Bahier-Porte (UJM, IHRIM) and Fabienne Vial-Bonacci (CNRS, IHRIM).

Session 2 : Ornaments database;
moderated by Christelle Bahier-Porte (UJM, IHRIM).

Session 3 : Historical ornament collection analysis; moderated by Amaury Habrard (Data Intelligence team)

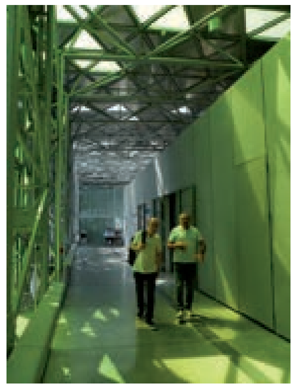
- "A tour of approaches for automatic ornament decomposition"; Rémi Emonet (Data Intelligence team).

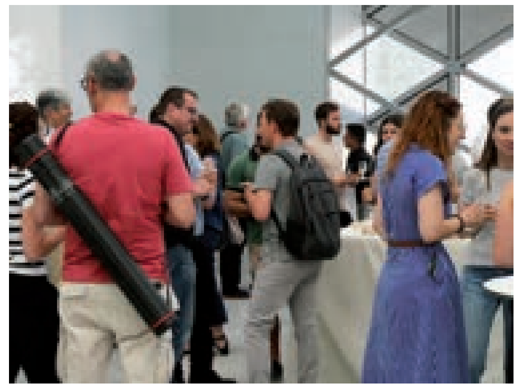
Session 4 : Imaging and pattern analysis of ancient documents

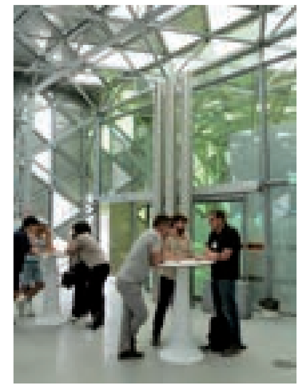
- "Inked surfaces : optical and graphical aspects"; Mathieu Hébert (Image Science & Computer Vision team).
- "How effective can unsupervised source separation be in handwriting when letters are covered with loops ? Digital experiments"; Jean-Marie Becker and Thierry Fournel (Image Science & Computer Vision team).
- "Unsupervised in-place change localization in historical ornaments"; Sayan Kumar CHAKI (Image Science & Computer Vision team).

SiO_2 Symposium

23rd to 26th June 2025







15th Symposium SiO_2, Advanced Dielectrics and Related Devices

Since 1996, the biennial SiO_2 symposia series has served as an international forum on the science and technology of silica-based systems, including new dielectrics and related device applications. The 2025 edition of the conference took place on our campus and at the nearby Cité du Design in Saint-Étienne. The event brought together experts, researchers, and professionals from around the world to explore and discuss the latest experimental and theoretical advancements in SiO_2 and other advanced materials for photonics and microelectronics applications. For the first time, a one-day short course was held the day before the start of the conference, focusing on Multi-Scale, Multiphysics of Materials for Photonics and Microelectronics.

The rich program of oral and poster presentations covered the following main topics:

- Electronic and atomic structures of materials
- Optical and electronic properties of materials
- Defect generation and transformation
- Radiation (including laser) effects on materials
- Materials for dosimetry
- Functionalization of materials
- Fiber optics and fiber-based devices
- Microelectronic devices
- New theoretical and experimental tools and techniques for material studies
- Nanomaterials and nanocomposites for applications in electronics, photonics and optoelectronics.

Université Jean Monnet Saint-Étienne

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The local committee for the 2025 edition was largely composed of members from our MOPERE team. The event was launched by Youcef Ouerdane and Aziz Boukenter, long-standing members of our lab, and concluded with a visit to our laboratory. All are grateful to the SiO_2 2025 participants, sponsors, and lab members for making this edition a great success! The 2025 committee, along with all participants, extends sincere appreciation to the University of Palermo for undertaking the organization of the next SiO_2 Symposium, to be held in 2027.

exail

ANDRA

EMJMD RADMEP

MANUTECH SLEIGHT Université de Lyon

LABEX MANUTECH-SISE UNIVERSITÉ DE LYON

RADECS

POPILSS Workshop

19th June 2025

The "Journées Parcimonie, Optimisation et Problèmes Inverses Lyon Saint-Étienne Savoie" (POPILSS) bring together students and researchers from Lyon, Saint-Étienne, and Annecy working in optimization, inverse problems, and sparsity. The event seeks to foster a regional collaborative dynamic by encouraging interdisciplinary exchanges and identifying opportunities for cooperation.

The 2025 edition marked the second occurrence of the workshop. It took place at Polytech Annecy and was once again co-organised by Jordan Patracone, a member of our Data Intelligence team/MALICE Inria.

RADECS

29th September to 3rd October 2025

The RADiation Effects on Components and Systems Conference (RADECS) is an annual international scientific and industrial forum dedicated to the study of radiation and its effect on electronics and photonics materials, devices and systems.

The 2025 edition of RADECS was held in Antwerp, Belgium, where Sylvain Girard, head of our MOPERE team, served as Co-General Chair of the conference, and Adriana Morana chaired the Photonics session. Several members of the team presented the following research results:

CONFERENCES

- "LED Lighting Influence on the Radiation Response of Erbium Doped Fiber Amplifiers"; A. Facchini, L. Weninger, A. Morana, L. Mescia, T. Robin, J. Mekki, N. Kerboub, A. Boukenter, E. Marin, Y. Ouerdane, S. Girard.

The excellent evaluation of Albert Facchini's abstract for this paper earned him a grant from the European Space Agency (ESA), covering his conference registration.

- "Toward Accurate Monitoring of 14 MeV Neutron Flux: Investigation on a 6Lithium Glass Scintillator"; F. Fricano, L. Weninger, A. Morana, A. Colangeli, S. Loreti, D. Lambert, P. Paillet, B. Capoen, H. El Hamzaoui, D. Labat, M. Bouazaoui, Y. Ouerdane, E. Marin, A. Boukenter, A. Pietropaolo, S. Girard.

- "Optimizing the Performances of Optical Fiber Dosimeters Operating in the Visible Domain"; M. Roche, A. Morana, F. Fricano, N. Kerboub, J. Mekki, G. Mélin, T. Robin, E. Marin, A. Boukenter, Y. Ouerdane, D. Lambert, P. Paillet, S. Girard.

POSTER

- "Radiation-Induced Degradation of Red, Green and Blue in Commercial Light-Emitting Diodes"; G. Ciachera, L. Weninger, D. Lambert, M. Darnon, A. Morana, V. Lalucaa, J-M. Belloir, C. Durnez, C. Virmontois, N. Kerboub, J. Mekki, Y. Morilla, P. Martin Holgado, A. Romero-Maestre, M. Gaillardin, P. Paillet, S. Girard.

CLEO

4th to 9th May 2025

CLEO is a leading international conference showcasing the latest research and technologies in lasers and electro-optics. Covering topics from quantum computing to advanced imaging, it connects science and industry across the fields of lasers and photonics. Nathalie Destouches, a member of our Functional Materials & Surfaces team, was invited to present a lecture entitled "Understanding and Exploiting Plasmonic-Photonic Hybridization in Laser-Induced Quasi-Random Plasmonic Metasurfaces" at the 2025 edition of the conference, held in Long Beach, California, USA.

CLEO®/Europe-EQEC

23rd to 27th June 2025

CLEO®/Europe-EQEC stands as Europe's premier event for optics and photonics, gathering leading researchers, engineers and innovators from around the globe. The conference drives groundbreaking advancements in laser physics, optical engineering, real-world laser technology, nonlinear optics, and quantum science. Its 2025 edition was held in Munich, Germany, where the following contributions were made by members of our Laser-Matter Interaction and Functional Materials & Surfaces teams:

Laser-Induced Periodic Surface and Volume Structures Session

- "Photo-patterned plasmonic multilayers exhibiting different vivid colors in specular and diffuse reflection"; Nicolas Jacquot, William Ravisy, Laurent Dubost, Christophe Hubert, Jialin Hu, Kevin Vynck, Nathalie Destouches.

- "Ultrafast laser surface nanostructuring with programmable temporal polarization shaping"; Thirunaukkarasu Kuppan, Anthony Nakhoul, Huu Dat Nguyen, Rajeev Dviwedi, Ciro D'Amico, Razvan Stoian.

Laser Processing of Semiconductors Session

- "Ultrafast Laser Filamentation in Semiconductors"; Maxime Chambonneau, Markus Blothe, Vladimir Yu. Fedorov, Stelios Tzortzakis, Stefan Nolte.

Our colleague Nathalie Destouches also chaired the Early-Stage Researcher (ESR) Poster Pitches, as well as the Laser-Based Surface Functionalization session.

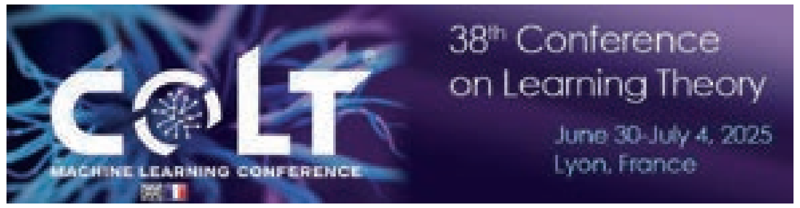
PERMolMat Workshop

17^{th} to 19^{th} March 2025

From 17^{th} to 19^{th} March 2025, ENS Paris-Saclay hosted PERMolMat – Japan-France Workshop on Photo-Electro-Responsive Molecules and Materials, bringing together researchers to explore how molecular systems respond to stimuli such as photons and electrons. Co-organized by IRP NanoSynergetics, the PEPR LUMA program, the GDR Photo Electro Stimulation (PES) and Japan's "Meso-Hierarchy" project, the workshop welcomed a delegation of 15 Japanese researchers and featured keynote lectures, oral presentations, and posters across 3 days. Functional Material & Surfaces team member Nathalie Destouches, involved in the PEPR LUMA initiative, was invited to present a lecture on "Laser-Induced Self-Organization of Plasmonic Nanoparticles."

COLT Conference Tutorial

30^{th} June 2025

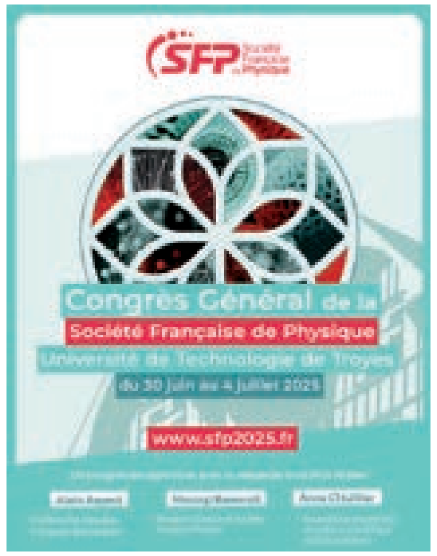


The 38^{th} Annual Conference on Learning Theory (COLT 2025) took place at the end of June 2025 in Lyon. As a leading event on the theory of machine learning and artificial intelligence, the conference offers a rich programme of presentations, workshops, tutorials and community events.

A tutorial on "How to Make Use of Learning Theory to Learn Efficient ML Models: From PAC-Bayesian Generalization Bounds to (Self-Bounding) Learning Algorithms" was presented by Emilie Morvant from our Data Intelligence team, together with Paul Viallard, former member of our lab and now Junior Scientist at Inria Rennes/MALT team.

Congrès Général de la Société Française de Physique

30^{th} June to 4^{th} July 2025



The 27^{th} General Congress of the French Physical Society (SFP) took take place in 2025 at the University of Technology of Troyes (UTT). Held every 2 years, the SFP Congress offers a comprehensive, multidisciplinary overview of the latest advances in physics across all fields. A key event for the French physics community, it gathers approximately 650 participants, including a significant proportion of PhD students and postdoctoral researchers. The 2025 edition was particularly prestigious, featuring the participation of 3 Nobel Laureates: Alain Aspect (Institut d'Optique, France - 2022 Nobel Prize in Physics), Moungi Bawendi (Massachusetts Institute of Technology, USA - 2023 Nobel Prize in Chemistry), and Anne L'Huillier (Lund University, Sweden - 2023 Nobel Prize in Physics).

Among the invited speakers was Nathalie Destouches, a member of our Functional Materials & Surfaces team, who delivered a lecture on "Multi-timescale dynamics of plasmonic nanocomposite thin films under high-repetition-rate femtosecond laser-induced transformation."

LIPSS workshop 2025

29^{th} to 31^{st} October 2025

The annual LIPSS Workshops are dedicated to recent advances and studies on the formation mechanisms of Laser-Induced Periodical Surface Structures, covering a wide range of materials and using various laser sources.

The 13^{th} edition of this international event was held at the University of Twente in the Netherlands in October 2025, with contributions from Hugo Bruhier, a member of our Laser–Matter Interaction team, as well as X. Sedao, engineer for our Femtosecond Laser platform.

X. Sedao:
"Biological Materials on Ultrafast Laser Induced Periodic Surface Structures".

H. Bruhier:
"Modification of Biological and Hydrophilic Properties Of Zirconium Based Thin Film Metallic Glasses under Femtosecond Laser Irradiation"..

Journées 2025 du GDR EMILI

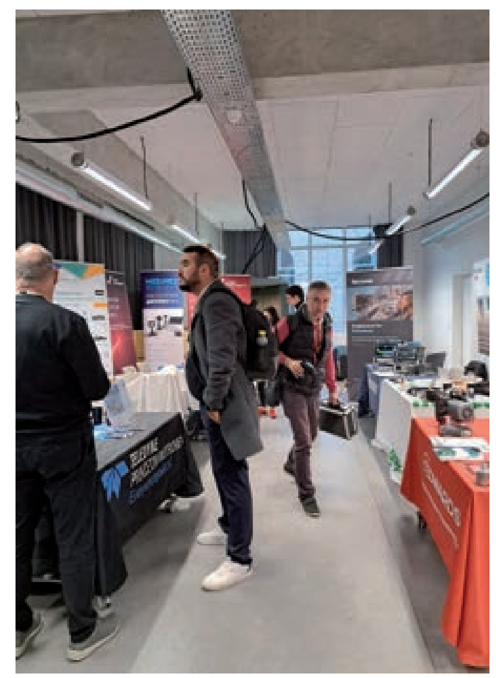
27th to 30th October 2025

Since its creation in January 2021, the GDR EMILI has provided a framework for exchanges on the scientific and technological challenges associated with cold plasmas generated by discharges and lasers, while supporting the integration of young researchers into the field.

The program of the 2025 event included plenary lectures, review talks, presentations by young researchers, and thematic sessions. Interactive workshops addressed key research issues, while a poster session encouraged informal discussions. Specialized companies also presented their products and services. Social gatherings and laboratory visits contributed to strengthening professional connections.

With 80 participants from 25 different laboratories, the event successfully concluded the first five-year cycle of the GDR EMILI. The conference highlighted ongoing innovations and current challenges in the field, while fostering knowledge sharing and the emergence of new collaborations. Registration was open to researchers, engineers, and interested students.

The event was organized by the Steering and Program Committees of the GDR, with the support of the local organizing committee: Tatiana Itina (Hubert Curien Lab), David Amans (Institut Lumière Matière), Stéphane Criedlich, Patrick Vincent, Assia Madjid, Véronique Réveillé, Ciro D'Amico, and Yaya Lefkir (Hubert Curien Lab). Florence Garrelie introduced the event, while a tour of our laboratory was led by Ciro D'Amico, Yaya Lefkir, Aziz Boukenter, and Arnaud Meyer. The committee would also like to thank Achour Beloucif and Jonathan Hugon for welcoming the event at the Forges Building.



PEPR LUMA Infrastructure Committee visit

12th September 2025

In September 2025, the Board and Infrastructure Committee of the LUMA PEPR visited our laboratory to meet the team in charge of our platform dedicated to surface structuring and functionalization using femtosecond lasers and UV lithography. Identified through the Wave 1 Call for Expressions of Interest (AMI) for platform projects, and subsequently expanded through Wave 2, this platform is now fully integrated into the LUMA PEPR. It provides the scientific community with access to advanced equipment for investigating light–matter interactions, within the framework of the LUMA ULTRAFAST access program.
The delegation was welcomed by Arnaud Meyer, head of the platform, together with Florence Garrelie, Aziz Boukenter, Razvan Stoïan, Nicolas Faure and François Royer. The visit included a presentation of the platform's technical capabilities and access conditions, and provided an opportunity to highlight two main infrastructures. Our femtosecond-laser platform enables surface structuring and functionalization at nanometric and micrometric scales, being equipped with high-precision positioning stages, galvanometric scanners for high-throughput processing over large areas, and options for environmental control via vacuum chambers. Four experimental setups based on Pharos (1030 nm) and Legend (800 nm) ultrafast laser sources allow access to a wide range of wavelengths and temporal regimes, including femtosecond pump-probe and phase-contrast microscopy experiments. For larger samples and applications with higher technology readiness levels, complementary equipment from the GIE Manutech-USD is accessible through the lab. The visit also covered our NanoSaintÉtienne platform, which offers a broad set of lithography techniques (mask-based, interferometric, colloidal, and laser lithography) for micro- and nano-structuring of functional layers on large or complex surfaces. These capabilities are complemented by deposition tools and a range of optical, microscopic, and spectroscopic characterization methods.
The femtosecond-laser and UV-lithography platform at our lab is open to the entire national scientific community.

Annual PEPR LUMA days

1st and 2nd October 2025

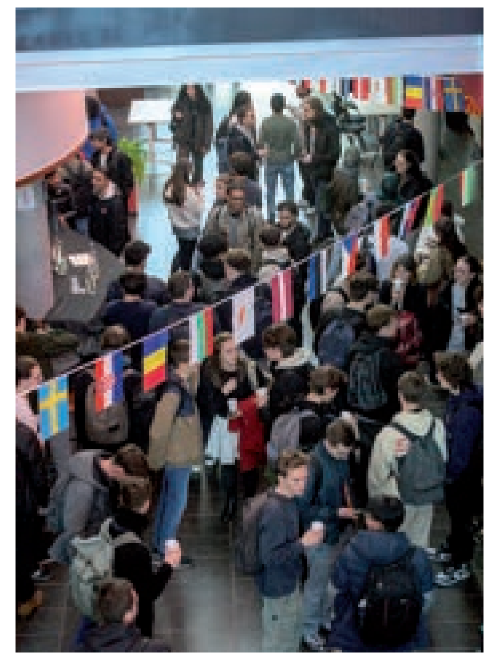
The annual PEPR LUMA Days took place in October 2025 at Sciences Sorbonne Université. This two-day event brought together the LUMA community for collective exchanges on the scientific themes of the PEPR, including conferences, a roundtable, and poster sessions.
The first day was open to the wider community working in the field of light–matter interactions.
A scientific symposium included a presentation by Dario Bassani (ISM) and member of our laboratory Nathalie Destouches, highlighting their ongoing research as part of the Moonshot SUNRISE project from the Photochemistry & Materials axis. SUNRISE is a project aimed at overcoming the intrinsic limitations of excited states in order to improve the efficiency and spatial resolution of photoinduced processes.
The General Assembly provided an overview of the AAP-funded projects, with a presentation from member of our Laser-Matter Interaction team Jean-Philippe Colombier, of the FLASH project on laser-matter modeling.

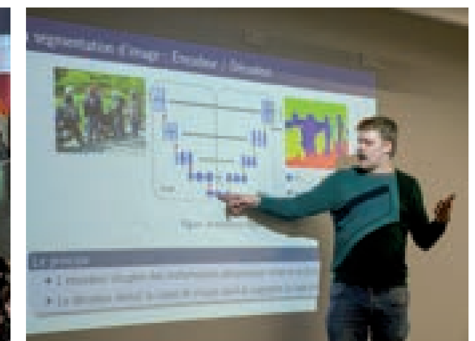
The Saint-Étienne IEEE Student Branch Innovation Day

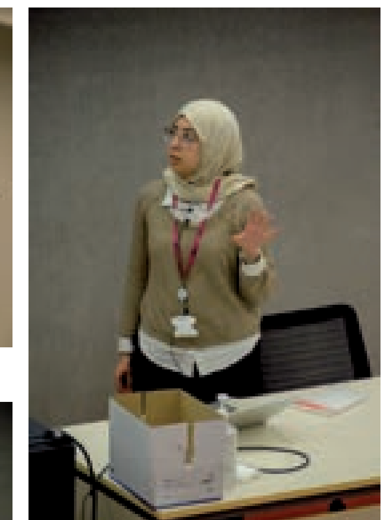
4th November 2025

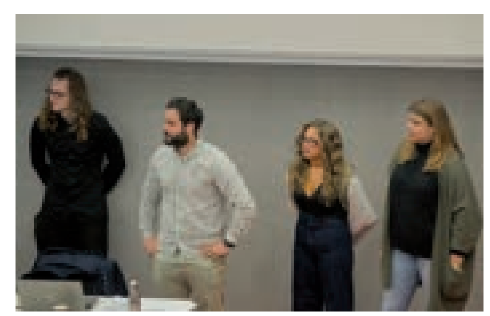
The Institute of Electrical and Electronics Engineers (IEEE) is a professional association dedicated to electronics and electrical engineering, as well as related disciplines. For many years, it has supported the establishment and operation of IEEE Student Branches worldwide. The activities of these branches include organizing social events, inviting guest speakers, conducting field trips, offering tutorials, and publishing newsletters. The Saint-Étienne IEEE Student Branch was founded in 2021 by Marine Aubry, a former PhD student in our laboratory and now a research engineer at TRAD-Tests & Radiations. Its most recent event, organized in collaboration with ASESLEIGHT (Optica and SPIE student chapters) and Télécom Saint-Étienne, attracted over 140 participants, primarily bachelor's and master's students. The event offered a unique platform to explore careers in electronics, optics and photonics, artificial intelligence, and digital imaging.

The day featured talks and interactive sessions during which 20 speakers - ranging from young researchers to experienced professionals, and representing both academia and industry - shared their career paths and candid insights into research life. An industry-focused session, featuring organizations such as CEA, CNES, STMicroelectronics, Exail, and SEDI-ATI, enabled students to network with potential employers and discover diverse career opportunities. The poster session showcased student projects, generating lively discussions and valuable feedback from experts. A special session entitled "Sweet Equality: How Equality Fuels Innovation", organized with the support of Matteo Ferrari, was dedicated to open discussions on equality in research, highlighting how diverse voices and shared experiences can drive innovation.









The organizers would like to thank Télécom Saint-Étienne, the Institut d'Optique Graduate School (IOGS), and RADMEP+ for their support in making this successful event possible.

Pint of Science 2025

12st May 2025

Bringing science to the people

In 2025, our lab once again participated in the Pint of Science Festival, a global event that brings researchers into local pubs, cafés and other public venues to share their scientific discoveries.
In Saint-Étienne, the event was hosted at the Méliès Café and the Six Nations Pub, with two evenings of talks featuring researchers from various institutions, including 3 members of our laboratory.

Optical Fiber: Our Ally for Safely Exploring Space

by Selyan Acid (PhD student at CNES + Hubert Curien Lab-MOPERE team)

Radiation in our solar system is primarily generated by the Sun and travels through space, sometimes causing visible effects such as the northern lights. While these phenomena are beautiful, they are also dangerous. They can disrupt—or even destroy—our electronic systems onboard satellites and pose a health risk to astronauts. This is why it is essential to detect and measure this radiation accurately in order to protect ourselves during future space missions. It is in this context that optical fibers, coupled with optoelectronic detectors, are being used as a means of radiation detection for space applications.

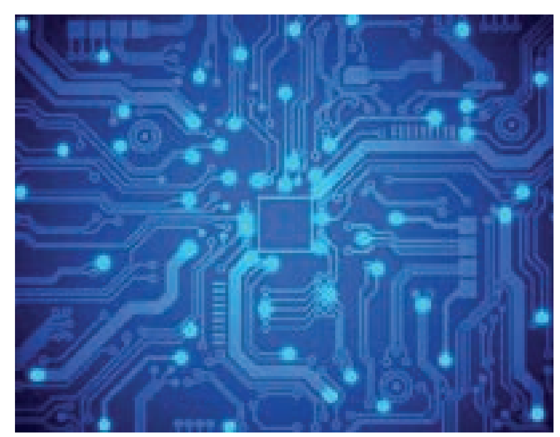
What Does It Mean to Learn Well?

by Amaury Habrard (Data Intelligence team)

How can artificial intelligence understand things from data and be able to generalize its knowledge to new situations? We will explore this question by examining three approaches to machine learning: classification, reinforcement learning, and generative AI. Along the way, we'll highlight their usefulness in various applications and discuss future research perspectives.

Is Artificial Intelligence Really Intelligent?

by Rémi Eyraud (Data Intelligence team)



In 2025, the short answer is clear: no! What computer science researchers have achieved is getting machines to learn, from large amounts of data, how to automatically perform specific tasks. In just 20 minutes, using a simple example, we'll see that this does not require any capacity for thinking or reasoning—and therefore, no real intelligence.

Fête de la Science 2025 - Nuit de la Recherche

3rd October 2025

The "Nuit de la Recherche" is part of the French national "Fête de la Science" program. Since 2019, it has been coordinated by La Rotonde-Mines Saint-Étienne for the Auvergne-Rhône-Alpes region. In collaboration with Jean Monnet University, ENISE - Centrale Lyon, Saint-Étienne Métropole and many higher education institutions in the area, a rich program of events was organised at the Musée de la Mine in Saint-Étienne in October 2025. The event, involving more than 100 researchers, offered the general public an opportunity to discover the world of research in an entertaining and surprising way.

In 2025, our lab once again took part in the event, with contributions from researchers, technicians and students, including Brice Colombier, Pierre-Louis Cayrel, Fabien Momey, Hugo Bruhier, Nicolas Aimé, Justine Paillet, Simon Baissat-Chavent, Alexandre Ortéga, Selyan Acid, Antoine Bouchut, Valentin Devin, Marie Traynar, Laura Montes Montañez, Agathe Cavanna, Bassma Jmyi, Asma Banshamlan.

Journée de la Recherche
Doctoral School 488 Sciences Ingénierie Santé

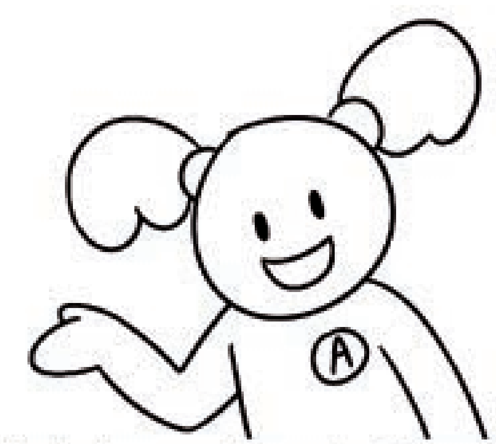
Ma thèse en 180 secondes - A video by Justine Paillet

2nd July 2025

Justine Paillet is a doctoral student in our lab, working as part of our SESAM team. In July 2025, she was awarded 1st prize for the outreach video during the ED 488 SIS Doctoral School's Journée de la Recherche. "The challenges of research in post-quantum cryptography? Alice explains everything…", is a clear and engaging video, accessible to a wide audience. It presents her PhD thesis work, which focuses on post-quantum cryptography implementations - cryptographic schemes designed to run on classical computers while remaining resistant to attacks from future quantum computers.

Created in collaboration with her sister, who is an animator, the video brilliantly combines scientific rigor with creative storytelling.

Watch the video here :



Les enjeux de la recherche en cryptographie post-quantique ? Alice vous explique tout ...

MEMBERS NEWS

As with any academic institution, we are proud each year to see our students graduate and our permanent members advance in their careers. In this section, we list our newly awarded doctors, HDR graduates, and all personnel who have joined or retired over the past year.

Promotions

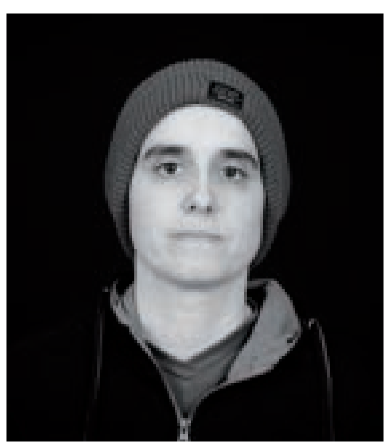
Adriana Morana was promoted to Full Professor in September 2025. She joined our MOPERE team in 2010, at the start of a Ph.D. focused on the effects of Gamma-Rays and Neutrons on Optical Fibers and Bragg Gratings for Temperature Sensors. Over the years, she has actively participated in numerous research projects within our lab, contributing to teaching activities at Jean Monnet University. Adriana plays a crucial role in the UJM-coordinated Erasmus Mundus Joint Master Degree RADMEP, a multidisciplinary and innovative program covering interactions between radiation, microelectronics, and photonics. In December 2023, she achieved accreditation to supervise research (HDR), with a presentation on 'Integration of optical fiber sensors in extreme radiation environments.'

Adriana Morana

Rémi Emonet was promoted to the rank of Full Professor in September 2025. He joined Jean Monnet University and our lab's Data Intelligence team in 2013, following a PhD in software architectures for intelligent environments at Inria and a postdoctoral fellowship at the Idiap Research Institute (EPFL) in Switzerland. Rémi's research focuses primarily on Machine Learning, Optimal Transport, and Computer Vision. He also teaches a broad range of subjects, from programming fundamentals and advanced web applications to probabilistic models. In October 2023, he was appointed junior member of the Institut Universitaire de France and successfully defended his accreditation to supervise research (HDR) in February 2024.

Rémi Emonet

New HDR

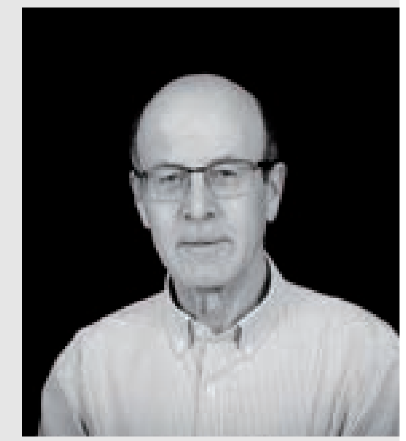


Emilie Morvant successfully defended her habilitation to supervise research (HDR) in April 2025. Associate professor at Jean Monnet University since 2014 and member of the Data Intelligence team, Emilie conducts research in a wide range of machine learning topics from the perspective of statistical learning theory, including PAC-Bayesian theory, supervised learning, domain adaptation, fairness and bias, and robustness to adversarial examples. Before joining Jean Monnet University, Emilie completed a postdoctoral fellowship at the Institute of Science and Technology Austria (ISTA), after earning a PhD from Aix-Marseille University on majority vote methods for supervised classification and domain adaptation. In addition to research activities, Emilie is also involved in teaching and academic coordination, with responsibility for the second year of the university's Computer Science BSc program.

Emilie Morvant

Emeritus Professorship

After earning his doctorate in Lyon and completing a postdoctoral fellowship in Germany, Youcef joined the University of Saint-Étienne in 1989. He began his research in the laboratory alongside Pierre Laporte and Jean-Pierre Goure, before co-founding the 'Milieux Optiques Actifs' group, which later evolved into the 'Composants à fibre optique et photosensibilité' team - precursor of our MOPERE team, which he went on to lead before handing over the responsibility to Sylvain Girard. Over the years, Youcef has taken on numerous collective responsibilities: Director of the Physics Department at the Faculté des Sciences Techniques and member of its council, member and Vice-President of the Scientific Council of the University of Saint-Étienne, deputy director of our lab, member of the National University Council (30th section), expert for the ANR, as well as serving on scientific and organizing committees for several major conferences, including UVX, JNOG and SiO2.
Youcef has guided several generations of students and researchers, supervising around 20 doctoral theses and authoring nearly 400 publications. Many of these works were carried out in collaboration with teams beyond his own, and notably with the majority of colleagues in the 'Optics, Photonics & Surfaces' department of the Hubert Curien Lab. Since his official retirement on August 31, 2025, Youcef is pursuing his involvement in our lab as Professor Emeritus. We warmly thank him for his remarkable contributions and wish him a fulfilling and well-deserved retirement!



Youcef Ouerdane

New recruit

Hugo Bruhier was recruited as a Lecturer at Jean Monnet University in 2025, to work in the GEII (Electrical Engineering and Industrial Computing) Department of the IUT. He is also a member of our Laser–Matter Interaction team, conducting research primarily on material functionalization through ultrashort-pulse laser processing.
After earning a University Diploma of Technology in Physical Measurements at the IUT of Saint-Étienne, with a focus on instrumental techniques, Hugo obtained an engineering degree from Télécom Saint-Étienne, specializing in photonics and industrial vision. He then completed the UJM's Masters program in Optics, Image, Vision, & Multimedia, with a specialization in Surface and Interface Science and Engineering. He subsequently undertook a doctoral thesis in Optics, Photonics & High Frequencies, which he completed in June 2023. His research was focusing on the "Development of a Plasmonic Sensor for Air-Quality Monitoring". Hugo then held two postdoctoral research positions, conducted jointly at the MatéIS Laboratory and our lab, funded by EUR MANUTECH SLEIGHT. His role focused on the laser texturing of thin metallic-glass films and their multiphysical characterization.

Hugo Bruhier

Our new doctors

Volodimir Mitarchuk
Data Intelligence
January 17th, 2025

Saturation in Recurrent Neural Networks: Expressivity, Learnability and Generalization

Thesis supervisors

Rémi Eyraud
Hubert Curien Lab, Supervisor

Amaury Habrard
Hubert Curien Lab, Co-supervisor

Rémi Emonet
Hubert Curien Lab, Co-supervisor

Paul Grandamme
SESAM
February 3rd, 2025

Advanced techniques for fault injection attacks on integrated circuits

Thesis supervisors

Lilian Bossuet
Hubert Curien Lab, Supervisor

Jean-Max Dutertre
École des Mines Saint-Étienne, Supervisor

Luca Weninger
MOPERE
March 21st, 2025

Optical fiber dosimetry and beam instrumentation

Thesis supervisors

Sylvain Girard
Hubert Curien Lab, Supervisor

Adriana Morana
Hubert Curien Lab, Co-supervisor

Gerges El Haber
Functional Materials & Surfaces
January 21st, 2025

Study of laser-induced oxidation and magneto-optical properties in cobalt thin films deposited on glass

Thesis supervisor

François Goutaland
Hubert Curien Lab, Supervisor

François Royer
Hubert Curien Lab, Co-supervisor

Dominique Luneau
LMI Lab, Lyon, Co-supervisor

Fiammetta Fricano
MOPERE
March 6th, 2025

Real-time Dosimetry: Feasibility and Optimization of Radioluminescent Optical Fiber Sensors

Thesis supervisors

Aziz Boukenter
Hubert Curien Lab, Supervisor

Fatos Torba
Data Intelligence
March 26th, 2025

Natural Language Processing in the Context of Responding to Complex Tenders

Thesis supervisors

Christophe Gravier
Hubert Curien Lab, Télécom-Saint-Étienne, Supervisor

Charlotte Laclau
Télécom-Paris, Institut Polytechnique de Paris, Co-Supervisor

Abderrahmen Kammoun
AItenders, Co-Supervisor

Julien Subercaze
AItenders, Co-Supervisor

Victor Vallejo-Otero
Functional Materials & Surfaces
April 24th, 2025

Rapid Thermal Nitridation Process of Titanium and Zirconium Oxides sol-gels

Thesis supervisors

Yves Jourlin
Hubert Curien Lab, Supervisor

Emilie Gamet
Hubert Curien Lab, Co-supervisor

Nicolas Crespo-Monteiro
Hubert Curien Lab, Co-supervisor

Victor Lesko
Functional Materials & Surfaces
May 23rd, 2025

Development of a laser-based additive manufacturing process for magnetic materials: application to yttrium iron garnet

Thesis supervisor

Bernard Bayard
Hubert Curien Lab, Supervisor

Olivier ISNARD
LMI Lab, Lyon, Supervisor

David Pietroy
Hubert Curien Lab, Co-supervisor

Cédric Maron
Image Science & Computer Vision
August 27th, 2025

Optimizing CNN Architectures to Edge Resources: A Federated Approach for Continual Knowledge Distillation

Thesis supervisors

Virginie Fresse
Hubert Curien Lab, Supervisor

Mathieu Orzalesi
Segula Technologies, Co-supervisor

Ana Florencia Juarez Saborio
Laser-Matter Interaction
June 25th, 2025

Deterministic Graphene Folds: An Innovation Using Ultrafast Lasers

Thesis supervisors

Florence Garrelie
Hubert Curien Lab, Supervisor

Alfonso San-Miguel
UCBL Lyon, Supervisor

Florent Bourquard
Hubert Curien Lab, Co-supervisor

Fabien Vialla
UCBL Lyon, Co-supervisor

Isidore Dubuisson
Image Science & Computer Vision
September 12th, 2025

Test-time adaptation of memory-based network for Semi-Automatic Video Object Segmentation

Thesis supervisors

Christophe Ducottet
Hubert Curien Lab, Supervisor

Jochen Lang
Université d'Ottawa, Canada, Co-supervisor

Damien Muselet
La Rochelle Université, Co-supervisor

Our new doctors

Mathis Granger
Functional Materials & Surfaces
September 16th, 2025

Experimental Measurement and Modeling of Electromagnetic Shielding Using Filled Polymer Composites

Thesis supervisors

Bernard Bayard
Hubert Curien Lab, Supervisor

Bruno Sauviac
Hubert Curien Lab, Co-supervisor

Chloé Landreau
MOPERE
September 26th, 2025

Use of optical fibre for vibration data acquisition in radiation environments

Thesis supervisors

Emmanuel Marin
Hubert Curien Lab, Supervisor

Adriana Morana
Hubert Curien Lab, Co-supervisor

Thomas Le Gall
Avnir Energy, Co-supervisor

Anis Fellah Touta
SESAM
September 26th, 2025

Cybersecurity of heterogeneous systems-on-chip against internal physical attacks

Thesis supervisor

Lilian Bossuet
Hubert Curien Lab, Supervisor

Pascal Giraud
Functional Materials & Surfaces
November 27th, 2025

Optical sensors for hydrogen detection

Thesis supervisor

Yves Jourlin
Hubert Curien Lab, Supervisor

Christelle Varenne
Institut Pascal, Univ. Clermont-Auvergne, Co-Supervisor

Sayan Kumar Chaki
Image Science & Computer Vision
November 6th, 2025

Equivariance in Vision for Unsupervised Low Data Regimes

Thesis supervisors

Thierry Fournel
Hubert Curien Lab, Supervisor

Rémi Emonet
Hubert Curien Lab, Co-Supervisor

Thibaud Leteno
Data Intelligence
December 3rd, 2025

Contributions to Fair and Aligned Large Language Models

Thesis supervisors

Christophe Gravier
Hubert Curien Lab, TSE, Supervisor

Antoine Gourru
Hubert Curien Lab, Co-supervisor

Charlotte Laclau
Télécom Paris, Co-supervisor

Martin Blanchard
Image Science & Computer Vision
December 8th, 2025

Self-explainable prototype-based deep models in computer vision: Application to cellular imaging

Thesis supervisors

Christophe Ducottet
Hubert Curien Lab, Supervisor

Damien Muselet
L3I Lab, Co-supervisor

Olivier Delezay
Univ. Jean Monnet St-Étienne, Co-supervisor

Sofiane Vernet
Image Science & Computer Vision
December 18th, 2025

Contribution of lighting and mixed reality for the assistance of low-vision people

Thesis supervisors

Alain Trémeau
Hubert Curien Lab, Supervisor

Eric Dinet
Hubert Curien Lab, Co-supervisor

Philippe Colantoni
Hubert Curien Lab, Co-supervisor

Fayad Ali Banna
Data Intelligence
December 15th, 2025

From Energy Absorption to Self-Organization: A Physics-Informed Machine Learning Approach to Laser-Matter Interaction

Thesis supervisors

Rémi Emonet
Hubert Curien Lab, Supervisor

Jean-Philippe Colombier
Hubert Curien Lab, Co-supervisor

Viet Sang Nguyen
Data Intelligence
December 19th, 2025

Physical Attacks against Symmetric Cryptography Standards

Thesis supervisors

Pierre-Louis Cayrel
Hubert Curien Lab, Supervisor

Vincent Grosso
Hubert Curien Lab, Co-supervisor

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Laboratoire Hubert Curien
UMR CNRS 5516, Bâtiment F
18 Rue du Professeur Benoît Lauras
42000 Saint-Étienne, FRANCE
Tel : +33 (0)4 77 91 57 80
email : lab.h.curien@univ-st-etienne.fr

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A Laboratory Committed to Sustainable Mobility

In 2025, the Hubert Curien Laboratory was awarded the Gold level of the *Label Employeur Pro-Vélo* (Pro-Bike Employer Label), granted by the *FUB - Fédération française des Usagers de la Bicyclette* (French Federation of Bicycle Users). This distinction is awarded to only a limited number of organizations and reflects a collective effort led by our internal Sustainable Development Working Group, with the support of Jean Monnet University.

Thank you for your support !

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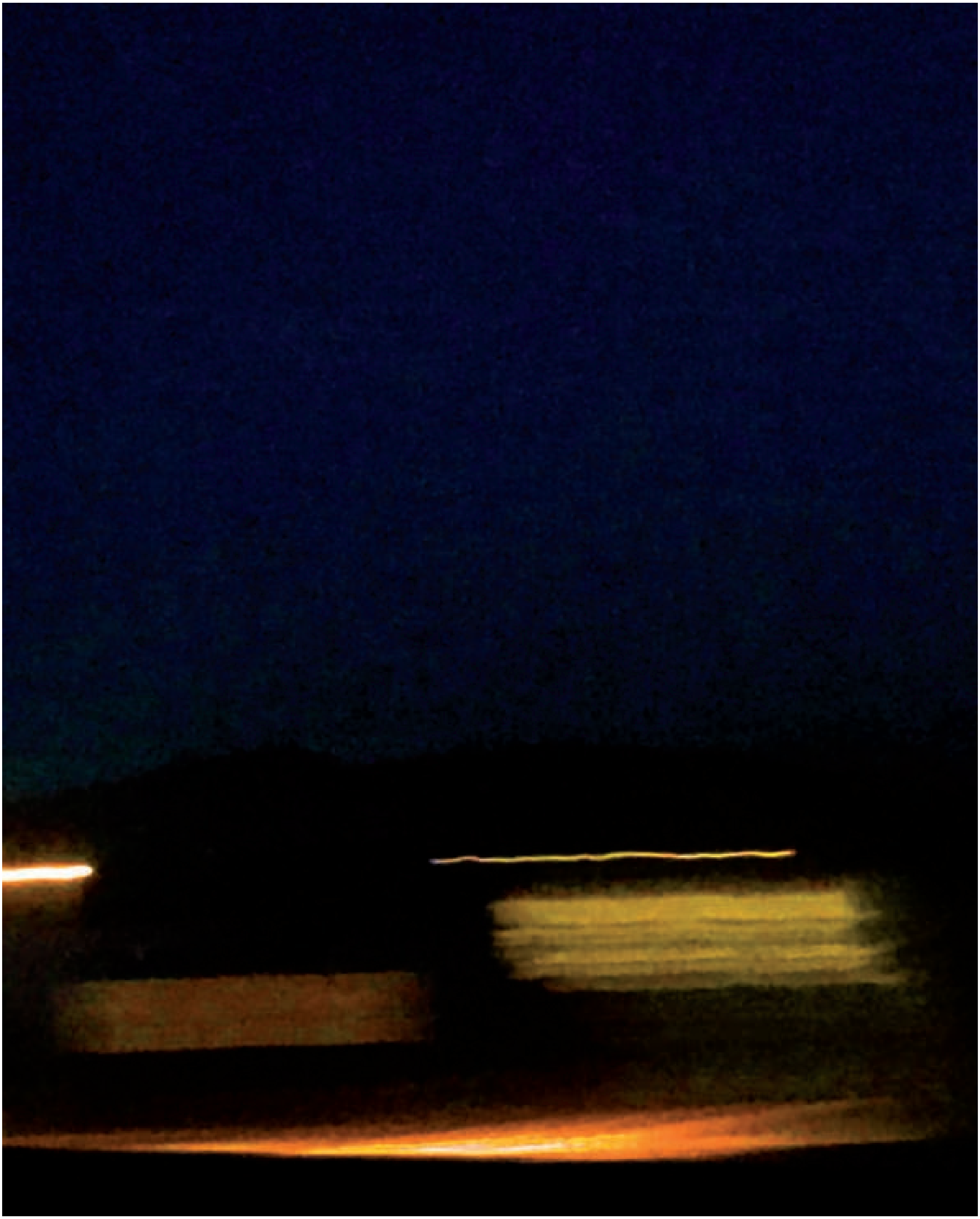

WEBSITE

Laboratoire Hubert Curien
UMR CNRS 5516
Bâtiment F
18 Rue du Professeur Benoît Lauras
42000 Saint-Étienne, FRANCE

Tel : +33 (0)4 77 91 57 80
email : lab.h.curien@univ-st-etienne.fr